IOWA

GEOLOGICAL SURVEY

VOLUME XVI

ANNUAL REPORT, 1905

WITH

ACCOMPANYING PAPERS

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DES MOINES
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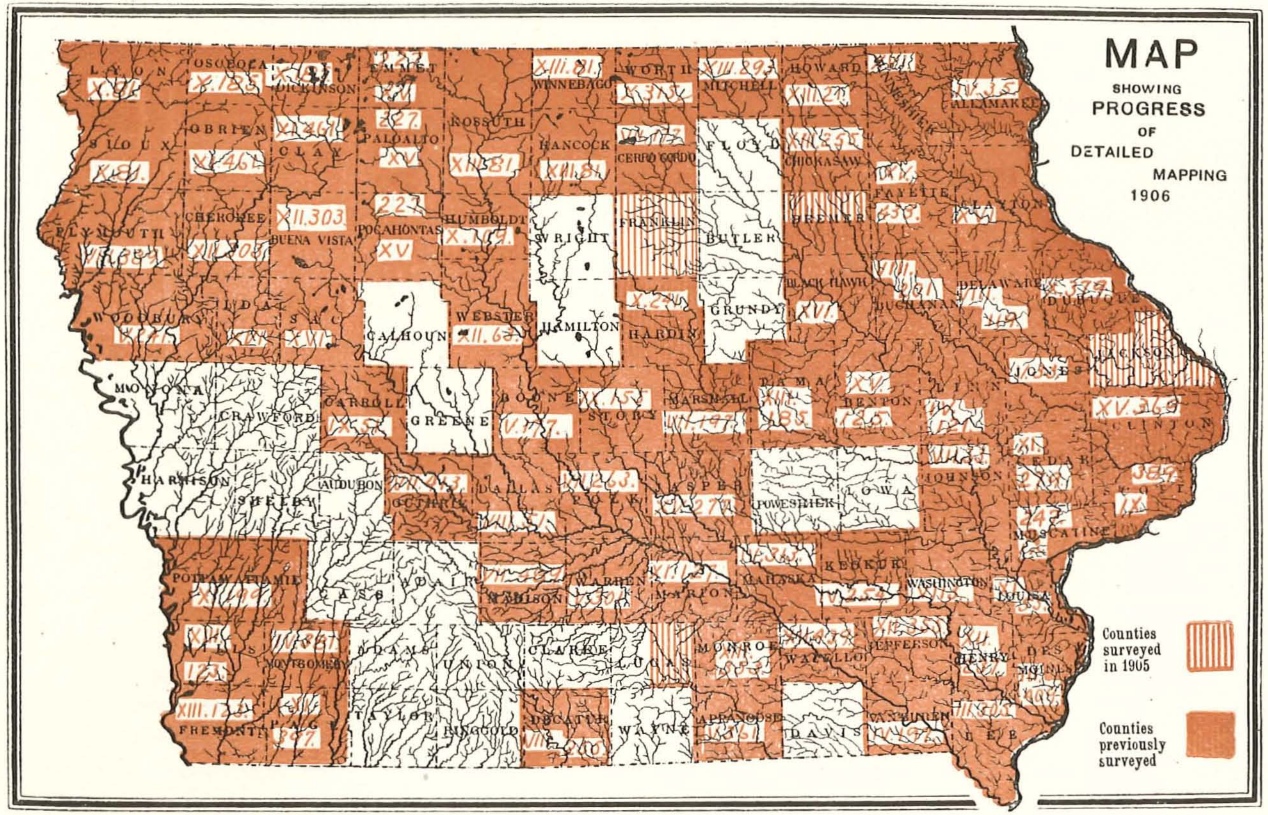
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FOURTEENTH ANNUAL

Report of the State Geologist

IOWA GEOLOGICAL SURVEY,
DES MOINES, DECEMBER 31, 1905.

To Governor Albert B. Cummins and Members of the Geological Board:

GENTLEMEN:—I take pleasure in presenting a brief summary of the work carried on by the Geological Survey during the past year. I must rely upon your personal examination of the volume which contains the results of the year's work in the field, to give you a correct impression of the methods employed in the investigations of the Geological Survey, and the lines along which valuable results are obtained.

Unpublished work:—A large part of the work of the Survey, however, does not appear in its published annual report. It is to this phase of Survey activity that I would particularly direct your attention. There is a large and steadily increasing demand on the Survey made by residents of the state, for assistance in investigating problems, and examining specimens which seem to have economic significance. I have no doubt that in this way the Survey at this stage in its development will render its greatest returns to the state, and the Director and his assistants have not hesitated to give freely of their time in answering appeals for examinations of mineral localities. In the earlier history of the Geological Survey, it was of greatest importance to collect the facts, scientific and economic, which would permit of an intelligent discussion of the geology of the state, and the possibilities of industrial development based on the state's mineral resources. The Survey is now in possession of a sufficient amount of information to enable it to speak positively with reference to most matters to which its attention may be directed. Consequently the economic aspects of its work are at present particularly important, and will become increasingly important in the future.

Portland cement:—A year ago the Survey published its first preliminary report on Portland Cement Materials, written by Eckels and Bain. This report showed that without question Iowa has an abundance of high grade material suitable for Portland cement. It was sent about the state generally, to the Industrial agents of the various railroads entering the state, and to the cement experts and engineers throughout the country. As a consequence two months had not elapsed before the Industrial agent of the Illinois Central railroad brought into the state parties who desired to locate a large cement mill in Iowa if suitable conditions could be found. Fort Dodge was first visited and careful tests were made of the limestones and shales to determine their quality and quantity. At this point material of admirable quality was found, but the quantity that could be readily obtained did not meet the requirements of the large mill that was proposed. The conditions at Mason City were later examined and all of the requirements were met by the limestones and shales that are abundant, not only at that point but at a great number of localities in Cerro Gordo county. When the Geological work on this county was completed by Professor Calvin in 1897, attention was called to the abundance of cement materials; the ease with which they could be secured; and their probable chemical fitness. At that time the dry process for making cement had not come to the front and the development of the situation has waited till this time. During the past summer Professor Beyer, who is preparing a monograph on Portland Cement for the Iowa Geological Survey, investigated the conditions at Mason City, secured material for analysis and directed the tests which enable the Survey to endorse the Mason City project.

It becomes at once evident that the Geological Survey has aided the cement plant at Mason City, in two ways; first in directing investors to the deposits of cement materials in Iowa, and bringing them into the state; and secondly in reporting authoritatively to the public in regard to the natural conditions that exist at the point where the erection of the cement plant is proposed. In these two ways the Survey is useful to the state, not only in connection with the cement industry but in connection with all industries that are based on the mineral wealth of the state.

Portland cement material is admirably distributed through the state, and Iowa is a large consumer of the finished product. The establishment of a second mill within the state may fairly be predicted.

Peat:—The Survey has published a preliminary bulletin on the Peat Resources of Iowa and on the Tests of Iowa Coals made at the Government Testing Plant at Saint Louis. During two months of last summer Mr. Wood located 22,000,000 tons of peat, the amount being estimated on the basis of the dried peat. This probably represents less than half of the peat that exists in northern Iowa, under conditions that may render it of value. Great interest in peat exists at present, on account of the growing success connected with the mechanical methods that are being developed for putting peat on the market in the form of an acceptable fuel. A particularly interesting line of inquiry in connection with peat that is being prosecuted just now deals with the possibility of making producer-gas from peat. Experiments are now being conducted at the Government testing plant at St. Louis, and, should the results be satisfactory, an important development of Iowa peat in the near future would seem to be assured. I would recommend that the investigation of the peat beds be continued during the coming summer.

Gypsum:—The gypsum industry of Iowa has flourished during the past year, and the Survey officials have not hesitated to point out to inquirers, that this industry is still in its infancy. The new mill that was erected last year prospered from the start, and is already increasing its capacity. Two new mills are now under consideration. The extent of the gypsum beds was demonstrated by the Geological Survey in 1899, at a time when the Gypsum Trust proposed if possible to get control of the entire territory. The Survey's report indicated that the beds, which had heretofore been recognized only over three or four square miles, probably could be found throughout twenty times this area. As a consequence the field has remained open for independent capital, and, although a number of mills have engaged successfully in the gypsum industry since that time, the field is still large, and the promise of good returns attractive.

Natural gas:—It would be very pleasant to make a similar report in regard to the attempts to develop gas in commercial quantities in Iowa. In this connection, however, the Survey has found it necessary to discourage an enthusiasm that was based on superficial knowledge of conditions that exist within the state. Limited quantities of gas are found near the surface, within the glacial drift, near Muscatine and elsewhere. The Survey has pointed out repeatedly that this gas is no indication of gas in the underlying rock strata. It has pointed out that the Trenton limestone, to which promoters have urged the sinking of deep wells for gas, outcrops in the northeastern part of the state, and is encountered in a number of the deep wells already existing within the state, and nowhere shows signs of either fuel gas or oil. It is hoped that the case has been made sufficiently clear and that the proposed plans for deep borings for gas will be laid aside.

Water horizons:—The Survey has been called on to give estimates in regard to the depth to which drilling should be carried and the quantity and quality of water that may be expected, at a number of points where artesian wells have been proposed. The Waterloo city well is now completed, and the estimates made by Professor Norton, in advance of the drilling, have been fully verified. The Survey's estimates were useful as a basis for letting bids for the Fort Dodge well now under construction. A careful watch is being kept on this well to determine when the water horizons that are sought have been reached.

Special assistants:—Professor Calvin has continued to act as consulting geologist for all of the members of the Survey staff. He has examined and reported on all paleontological material collected, and has gone into the field when necessary to aid in the work of correlation. In addition to this general work he has completed the field work and prepared the manuscript for Winneshiek county, which is presented herewith. In the field work he was aided by Mr. J. H. Lees.

Professor Beyer has continued his work on Portland cement, and his work is presented in the small bulletin which the Survey is now publishing. This bulletin describes localities which seem worthy of the careful examination of any who are interested in establishing Portland cement plants in Iowa. Chemical analyses are given and a description of the beds; their structure; the amount of stripping required; nearness to railroads, towns, and fuel supply; and other economic considerations are presented.

Professor Beyer's complete report on Portland cement will be presented as the annual report for 1907.

The second volume of Professor Pammel's report on The Grasses of Iowa, has been well received by the public and by scientists in general. Professor Charles E. Bessey, in Science, for December 1905 says: "The two volumes must prove of great value to the farmers of the state, and the second one especially must be helpful to students and others who are interested in grasses."

Professor Shimek has a report on the Loess in preparation, and it will be available for publication at no distant date. A brief paper on this subject was planned for last year's annual report and a few plates were purchased for the purpose of illustrations. It seemed best to make the report more complete and publication has been temporarily postponed.

Annual report:—The mineral statistics appear, as usual, in the annual report for this year. In addition I take pleasure in submitting the following county reports:

Black Hawk county, prepared by Professor M. F. Arey.
Ida and Sac counties, prepared by Professor T. H. Macbride.
Clayton county, prepared by Dr. A. G. Leonard.
Winneshiek county, prepared by Professor Samuel Calvin.
Franklin county, prepared by Mr. Ira A. Williams.
Jackson county, prepared by Mr. T. E. Savage.
Bremer county, prepared by Professor W. H. Norton.

The reports on Black Hawk, Ida and Sac, and Clayton counties were proposed for last year's volume, but were finally held over in order that the volume might not be too large.

Educational bulletins:—I would submit for your consideration the question of the desirability of aiding the Science work in the schools of the state by publishing brief bulletins which present simply and clearly some of the more important geological phenomena that the young people in our schools may see, if their attention is once directed to them.

I take the liberty of quoting from a personal letter from Prof. Davis of Harvard. "I hope that you may find it practical to put into application in Iowa a scheme which I have long wished to see carried out by our state Surveys. This is to prepare for the especial use of school teachers brief reports, to be issued perhaps semi-annually and widely distributed, upon the more elementary and significant geological features of the state. My experience has been that the more professional geological reports, such as those issued by Iowa and other states, do not suffice to present the problems of which they treat to the average school teacher; and that inasmuch as the profession of school teaching is one of the most important under the state organization, it seems eminently proper that some part of the state Survey's report should be addressed particularly to that class of persons."

The specimens of Iowa rocks, minerals and fossils sent by the Iowa Geological Survey, to Iowa High Schools last year, were so heartily welcomed by the teachers that there is abundant ground for believing that they will gladly receive and make practical use of educational bulletins of the sort that Professor Davis recommends.

Topographic maps:—Another line of work that the Survey should carefully consider, and if means are available should undertake, is that of topographic mapping.

A topographic map presents precise information that may be grasped almost at a glance in regard to relative elevations in the area included within the map. This is accomplished by means of contour lines which connect all points on the map having a common elevation. All points in the region about Des Moines, for instance, which are 600 feet above sea level are connected by a common line. Another line connects all other points 620 feet above the sea and so on. In Iowa the contour interval, or vertical distance between points connected by adjacent lines, is appropriately 10 to 20 feet, while in rougher country the interval is greater. The general relief of a district is made plain by the slightest inspection of a map prepared in this way, while a detailed study of such a map will throw very great light on any engineering problem into which the relative elevations of the country enter as a factor.

Some of the benefits that Iowa would derive from a topographic map may be briefly noted. If the state were covered by a series of topographic sheets drawn on the scale ordinarily used by the United States Geological Survey, viz., an inch to the mile, with the contour interval of 20 feet, the installation of electric interurban lines would be greatly stimulated. Much of the preliminary or reconnaissance survey work would be obviated, and the engineer could sit in his office with the topographic sheets before him, and virtually outline the general course that his road should take. The citizens of Iowa generally feel, I think, that one of the most promising solutions now in sight for the troublesome railroad question, is to be found in the interurban road. Certainly the happy experience of the communities along the Great Lakes, where already a net work of interurban electric roads exists, furnishes a basis for this feeling. In Iowa the interurban is still a novelty, but the experience of all cities within the state that now enjoy interurban service is thoroughly satisfactory.

The construction of sewerage plants and the choosing of reservoir sites is greatly simplified in the district that is covered by a topographic map.

In connection with the development of the natural mineral resources of Iowa, topographic maps will be of the greatest value. In Polk county, for instance, an attempt should be made to correlate the various coal beds, yet this work, important as it is, even though the attempt should show that correlation is impossible, cannot be undertaken except at very great expense, without the aid of topographic maps. A coal bed at one point, for instance, is found 200 feet below the mouth of a given shaft. At the next mine, say five hundred feet away, the coal lies 300 feet below the surface. If the beds in the two cases are of the same general thickness and quality there is a certain sort of basis for the inference that they constitute a single bed which may be found throughout the intervening territory. The apparent difference in depth may be merely a difference in elevation of the mouths of the shafts. This fact, however, can be determined only by running levels if topographic maps are not at hand. The most thorough prospecting for coal undertaken in the state has been carried on in Lucas county during the past four years. Hundreds of holes have been put down with a diamond drill, and the level of the surface above sea at each drilling station has been accurately determined. When the log of the driller is plotted, therefore, it is possible to determine, other factors being taken into account, the persistence of the coal beds through large areas. The expense of this work would have been greatly reduced, had the elevations of the drilling stations been given on a topographic map.

The topographic map forms the most suitable base map on which to represent the distribution of rocks; minerals; soils; waters; artesian basins; undrained areas; and peat beds; and as a basis for maps for public lands and parks. The buying and selling of land for agricultural purposes are greatly facilitated by such maps, and correct inference of great importance in regard to the fitness of land for agriculture may be drawn from them. Culture details may best be shown on such a map, and the correct representation of roads and towns with reference to topograhic features is of prime importance. Automobile clubs throughout the state would welcome these maps, which next to an actual improvement in the roads themselves, would do most to simplify extended country travel.

In the schools, colleges and universities these maps would be of constant use in the study of geography and geology.

Surveyors throughout the state would be greatly aided by the numerous base lines that would be established during the making of the maps, and the numerous bench marks. The laying out of ditches, highways, and other improvements which involve the matter of relative elevations would be greatly simplified.

Admitting the desirability of such maps the practical question remains as to how they may be obtained. Their preparation involves a considerable outlay of money and requires the service of a company of expert topographers. The expense, when the benefits to be derived are considered, is not excessive. A topographic map of Iowa, with a contour interval of 20 feet and a horizontal scale of one inch to the mile, will cost about $12 per square mile. The United States Geological Survey is already actively engaged in such work, and the benefits to be derived from such maps may best be extended to Iowa by the system of co-operation which this Survey offers to the several states. By this plan the United States Government duplicates any sum that the state appropriates for topographic work. It furnishes men from its corps of skilled topographers to direct the work and assumes the main burden of expense in connection with publication.

The following details as to methods used in mapping are quoted from the United States Geological Bulletin on Co-operation in Topographic Work between the United States and the various states.

"The appropriations made by the states for co-operative surveys are accepted chiefly for actual field work, in which are included the services of temporary employees, who are usually residents of the state, and for the living and traveling expenses of the field force. It may be used in paying office salaries only in so far as is necessary to equalize the expense of both parties to the co-operation. Thus the larger part of the amount appropriated by the state is returned to the people thereof. The appropriation of the Federal Government is devoted chiefly to paying salaries of the permanent employees, a small portion of it being expended on general administration and a considerable portion on field and office work. The field work of the co-operative topographic surveys is invariably in charge of topographers or assistant topographers of the United States Geological Survey, who are appointed, on the recommendation of the United States Civil Service Commission, by the Secretary of the Interior. All assistant surveyors, as level-men, transit-men etc., and such helpers as rod-men, teamsters and cooks are employed under regulations of the Department of the Interior in the locality in which the work is being done, and under the terms of a signed application and agreement, which they must file when seeking such employment."

"These topographic maps are based upon geodetic determinations of position, either by means of an accurate system of primary triangulation or by primary traverse based upon astronomic locations. The fundamental positions so determined are marked by monuments of stone, or by metal posts bearing suitable bronze tablets. Spirit levels of a high degree of accuracy are run with such frequency as to permit of the establishment of permanent metal bench marks in every three linear miles, while numerous elevations of less accuracy are obtained by levels run in all directions.

The maps that result from these co-operative surveys, show in different colors, both in the manuscript and in the published edition, the following principal facts:

1. Public culture, printed in black, including roads, lanes, paths, railroads, streets, dams, public boundaries, names, etc.

2. The hydrography, or water, printed in blue, including all lakes, rivers, streams, swamps, marshes, reservoirs, springs, etc.

3. The relief of surface forms, printed in brown, including the shapes of the hills, valleys, and ravines, their elevations and depressions, and the slopes of every rise or fall in the surface of the land.

The topographic maps produced by co-operative surveys are engraved on copper and printed from stone. The co-operating states have the benefit of this publication without further expense, and the residents of the state, as well as its officials, may purchase the maps at rates of 5 cents per sheet or $3.00 per hundred."

The following states have completed or are engaged in co-operative topographic surveys:

	DOLLARS.	SQ. MILES.
Alabama	$ 51,540.00	3,455
California	158,360.00	1,704
Connecticut	4,990.00	All
Kentucky	40,000.00	852
Louisiana	45,420.00	1,110
Maine	33,040.00	2,614
Maryland	12,210.00	9,585
Massachusetts	8,315.00	All
Michigan	57,430.00	1,687
Mississippi	46,340.00	196
New Jersey	7,815.00	All
New York	49,170.00	34,623
North Carolina	52,250.00	3,637
Ohio	42,050 00	11,097
Pennsylvania	45,215.00	9,746
Rhode Island	1,250.00	All
Texas	262,290.00	1,620
West Virginia	28,780.00	5,534

A limited amount of topographic work has already been completed in Iowa, for the most part in the eastern portion of the state. During the past summer, at the suggestion of the State Geologist, work was begun on a quadrangle having Des Moines as its center. This area was chosen on account of the growing importance of Des Moines as an industrial center, and that the attention of the state as a whole might be more definitely directed to the work and might pass judgment on its actual value. A line of precise levels is being run from the Mississippi to the Missouri river, crossing Iowa from east to west through Des Moines.

The topographic sheets of the United States Survey lying wholly or in part within Iowa, and already published, number 36. The sheets are 16½x20 inches in size, the earlier ones being fifteen minute sheets, that is, drawn on a scale 1:62500 while the later sheets are thirty minute sheets or 1:125000. While the earlier sheets were imperfect the later sheets are models of topographic accuracy. The counties covered by these sheets are Allamakee, the greater part of Winneshiek and Fayette, Clayton, Dubuque, Delaware, the most of Buchanan and Jackson, Clinton, Scott, Cedar, Johnson, Linn and portions of Muscatine, Iowa and Benton. In the west, portions of Pottawattamie and Mills counties are included within the Omaha sheet.

If the state would appropriate from $3,000 to $5,000 for co-operation with the United States Geological Survey the work of topographic mapping could be accelerated three-fold at least. The state naturally looks to the engineers of Iowa to take the initiative in matters of this sort, for they are best able to determine the value of such work to the commonwealth.

The state Geological Survey is generally entrusted with the duty of looking after the interests of the state in this co-operative work, and the organization of the Iowa Survey fits it well to assume this responsibility, since its governing board includes the Governor of the state and the Presidents of the two State Institutions where engineering is taught.

The Survey at present has no money that can be directed to this line of work. An annual increase in its income of $3,000 would permit of an excellent beginning, and later, when the county surveys have been completed, a larger sum would be allotted to topographic mapping.

REPORT OF THE ASSISTANT STATE GEOLOGIST.

IOWA GEOLOGICAL SURVEY.
DES MOINES, DECEMBER 31, 1905.

DEAR SIR:—I have the honor to submit to you the following report of my work for the year 1905:

During this year more time than usual was taken up with proof reading and supervising the publications of the Survey. The supplementary report on the Grasses of Iowa was ready for the press early in the year. Oversight of the work of illustrating and printing this book occupied several weeks. In leisure intervals during this time the preparation of the manuscript for the report on the geology of Fayette county was completed, and was published in volume XV of the annual reports.

As early in the year as the data could be obtained, the maps and plates for the illustrations in volume XV were prepared, and that report was put through the press during the months of June and July.

The greater portion of August, September and October was spent in the field studying the geological problems presented in Jackson county. This county is of more than usual interest from the fact that here, as at no other point in the state, there is shown a strong folding of the uppermost strata of the Maquoketa shale. There is also evidence of unconformity between the deposits of the Maquoketa stage and the overlying Niagara limestone. The geology of Jackson county is also of more than usual economic interest because of the fact that more than three-fourths of all of the lime burned and marketed in the state is produced in this county. The report on the geology of Jackson county is now in preparation, and will appear in volume XVI of the Survey reports.

During the latter part of September, in company with Dr. S. W. Beyer, an excursion was made into the counties of Jackson, Jones and Fayette for the purpose of investigating and correlating some of the different geological horizons in northeastern Iowa; and of collecting samples from such quarries as promised to furnish suitable materials for the manufacture of cement, or to become sources of other important products. Rock samples have also been collected from other points in the state that seemed likely to furnish a good quality of cement materials.

Much of the time during November and December was occupied in the preparation of a short report on the results of the tests of Iowa coals made by the Government coal-testing plant at the Louisiana Purchase Exposition, St. Louis; and of a preliminary report on the Peat Resources of Iowa, the data for which latter paper were gathered during the past summer by Mr. L. H. Wood. These two short papers were printed in December, and published as Bulletin No. 2 of the Iowa Survey.

The volume of correspondence in the office has been considerably increased during the past year, owing to the investigations which the Survey has carried on with regard to the location, in the state, of deposits suitable for manufacture into Portland cement, and of marshes containing large accumulations of peat. Interest in both of these lines is active on the part of prospective investors of capital. The location of a cement plant at Mason City is assured, and there is no doubt that, as a direct result of the efforts and investigations of the Survey, some new industries will soon be developed in our state.

As usual during the past year a large number of specimens have been sent to the office for identification, as well as numerous samples concerning the economic value of which information was desired. A very large number of letters have also been received asking for maps and information with regard to the location of suitable beds of stone, clays and shales for various purposes, and deposits of coal and other minerals The appropriate replies to all of these requests involved a large amount of time and labor, neither of which were spared in the endeavor to furnish to the sender of each the information for which he sought.

Belief in the presence of oil and gas in the deeper strata of Iowa still persists. Inquiries have come in with regard to the probability of finding oil and gas if deep borings were put down at certain points in the state. We have on file in the office the records of a large number of deep wells each of which is in reality a test hole for oil or gas in that locality. It has been proposed to make borings for gas at points on all sides of which we have records of deep wells within a distance of a few miles. Both our data of deep wells and our knowledge of the character and position of the sedimentary rocks of Iowa compel us to discourage any expectation of finding oil or gas in large quantities, either in the superficial deposits or in the deeper indurated strata of the state. The discouragement of efforts that promise only disappointment is one of the unpleasant phases of Survey work, but in doing this the Survey renders as real service to the people of the state as in its endeavor to promote the development of resources that give every promise of ample returns for the money expended.

During 1905 there has been collected and turned into the State Treasury from the sale of reports, as required by law, and from the sale of sets of geological specimens for High Schools, $142.52.

The demand for the reports, maps and bulletins of the Survey is large, and is constantly increasing. This fact furnishes the best evidence as to the appreciation of the work of the Iowa Geological Survey on the part of the people of the state.

Very truly yours,

T. E. SAVAGE,

Assistant State Geologist.

To PROFESSOR. FRANK A. WILDER,

State Geologist.

MINERAL PRODUCTION IN IOWA

IN 1905

BY

S. W. BEYER.

VALUE OF MINERAL PRODUCTION.

1903.

Coal	$10,439,139
Clay	3,033,586
Stone	636,735
Gypsum	523,010
Lead	3,013
Total	$14,637,480

1904.

Coal	$10,439,496
Clay	3,487,376
Stone	542,170
Gypsum	469,432
Lead	2,619
Sand-lime brick	13,907
Total	$14,955,000

1905.

Coal	$10,495,593
Clay	3,408,547
Stone	533,509
Gypsum	589,055
Lead	1,500
Sand-lime brick	38,642
Mineral water*	36,200
Total	$15,103,046

*Mineral paint is combined with mineral water.

MINERAL PRODUCTION IN IOWA FOR 1905.

BY S. W. BEYER.

The value of the mineral products produced and marketed in Iowa during the year 1905 exceeded fifteen millions of dollars. This was an increase of less than one per cent over the preceding year, but was the greatest in the history of the state. There was a slight falling off in the total sales of clay and stone products but these deficiencies were more than made good by increased production of coal, gypsum and sand-lime brick. No zinc or iron ore was sold during the year and the amount of lead ore produced was almost a negligible quantity.

The number of producers shows a marked decrease in nearly every department. The number of producers for the various mineral industries of the state is shown below in parallel columns for the years 1900 to 1905 inclusive.

	1900	1901	1902	1903	1904	1905
Coal	231	242	274	271	269	229
Clay	381	349	329	296	331	311
Stone	170	229	273	197	258	213
Gypsum	7	7		8	8	5
Sand-lime Brick	......	......	......	......	2	3
Mineral Water	......	......	......	......	......	3
Lead and Zinc	6	10	8	8	5	3
Iron	1	1	......	......	......	......
Mineral Paint	......	......	......	1	1	1
Total	796	838	891	781	874	768

The value of the total mineral production and the number of producers is shown in table number I.

TABLE NO. I.

VALUE OF TOTAL MINERAL PRODUCTION BY COUNTIES FOR 1905.

COUNTIES.	Number of producers.	Total coal.	Total clay.	Total stone.	Miscellaneous.	Total.
Adair	3		$ 16,800			$ 16,800
Adams	15	$ 28,885	21,137			50,022
Allamakee	5			$ 4,567		4,567
Appanoose	53	1,569,291	17,800			1,587,091
Audubon	1					
Benton	12		25,624	431		26,055
Black Hawk	9			11,114		11,114
Boone	16	536,115	72,141			608,256
Bremer	1					
Buchanan	1					
Buena Vista	2		26,654			26,654
Butler	1					
Calhoun	3		30,000			30,000
Carroll	1					
Cass	4		13,389			13,389
Cedar	2					
Cerro Gordo	8		318,884	17,610		336,494
Clarke	6			2,400		2,400
Clay	1					
Clayton	11		7,500	12,747		20,247
Clinton	12		20,260	2,251		22,511
Crawford	2		13,300			13,300
Dallas	13	19,786	157,663			177,449
Davis	1					
Decatur	8		3,750	9,611		13,361
Delaware	7		9,343	1,473		10,816
Des Moines	16		24,232	34,500		58,732
Dubuque	16		31,828	28,029		59,857
Emmet	1					
Fayette	7		8,946	1,358		10,304
Floyd	6			1,375		1,375
Franklin	1					
Fremont	5		7,097			7,097
Greene	8	39,228	57,102			96,330
Grundy	1					
Guthrie	11	32,055	9,451			41,506
Hamilton	3		46,270			46,270
Hancock	1					
Hardin	16		61,600	21,246		82,846
Harrison	6		13,870			13,870
Henry	5		17,935			17,935
Howard	4			571		571
Humboldt	3			384		384
Ida	1					
Iowa	6		37,040			37,040
Jackson	8			64,339		64,339
Jasper	17	480,629	24,700			505,329
Jefferson	5	7,558	54,000			61,558
Johnson	7		34,450	648		35,098
Jones	15		14,157	92,919		107,076
Kossuth	1					
Keokuk	22	25,885	55,003	1,071		81,959

TABLE NO. 1—CONTINUED.

VALUE OF TOTAL MINERAL PRODUCTION BY COUNTIES FOR 1905.

COUNTIES.	Number of producers.	Total coal.	Total clay.	Total stone.	Miscel-laneous.	Total.
Lee	17		$ 12,705	$ 25,184		$ 37 889
Linn	13		34 173	17,200		51,373
Louisa	7		6.600	1,788		8,388
Lucas	4	$ 207,572				207,572
Madison	7			32,524		32,524
Mahaska	28	1,009,140	66 546			1,075 686
Marion	23	431,899	48,895	1,144		481 938
Marshall	10		35,560	23,674		59,234
Mills	4		12,290			12,290
Mitchell	3			1,195		1,195
Monroe	11	3.076,009				3,076,009
Montgomery	10		38,739	550		39,289
Muscatine	12		30,715			30,715
Page	10	38,536	61,500			100,036
Plymouth	1					
Pocahontas	3		113,950			113,950
Polk	44	2,025,723	544,368			2,570,091
Pottawattamie	8		74,616			74,616
Poweshiek	3		21,295			21,295
Ringgold	3		6,398			6,398
Scott	20	13,444	50,622	58,805		122,871
Shelby	1					
Sioux	3		8,440			8,440
Story	4		20,550			20,550
Tama	9		72.746	160		72,906
Taylor	8	50,512	7,397			57,909
Union	2		23,954			23,954
VanBuren	13	12,947	2,788	1,159		16,894
Wapello	17	443,637	74,899	24,651		543,187
Warren	3	13,252				13,252
Washington	14		43,003	3,057		46 060
Wayne	12	212,752	7,183			219,935
Webster	33	220,738	272,070	875	$594,855	1,088,538
Winneshiek	2					
Woodbury	6		309,658			309,658
Worth	1					
Wright	4		46 460			46,460
Single Producers			108,501	32,899		141,400
Sand-Lime Brick	3				38,642	38,642
Mineral Water	3				30,400	30,400
Totals	768	$10,495,593	$3,408,547*	$533,509	$663,887	$15,103,046†

*Includes $877 raw clay sold.

†Includes $1,500 lead produced.

Coal.

The coal production shows a three and a half per cent increase in total tonnage and but a slight increase in total value owing to a slight falling off in average price per ton. Again

Monroe county heads the list in total tonnage, producing upwards of a million tons more than Polk, her nearest competitor. Monroe also shows the greatest total gain although Jasper county shows a greater percentage of increase, amounting to nearly twenty per cent as compared to about thirteen per cent for Monroe. Keokuk, Lucas, Marion, Wapello and Webster of the important coal producers show a falling off in production. Keokuk has really dropped from the list of important producers. Extensive development continues in Lucas, Monroe, Jasper and Polk counties. The Consolidation Coal Company contributed most to the increased production in Monroe county and are still extending their facilities for handling a large output.

Table No. II gives the number of companies producing coal, distribution of coal, total value, average price per ton, average number of days worked and number of men employed, arranged by counties.

TABLE No. II.

COAL OUTPUT BY COUNTIES FOR 1905.

COUNTIES.	Number of mines.	Tons loaded at mines for shipment.	Sold to local trade or used by employes.	Used at mine for steam and heat.	Total tons produced.	Total selling value at mine.	Average price per ton.	Average number of days worked.	Average number of employes during the year.
Adams	10	....	12,726	33	12,759	$ 28,885	$ 2 26	142	98
Appanoose	50	833,950	31,818	9,480	875,248	1,569,291	1 79	163	2,770
Boone	11	264,269	18,975	9,415	292,659	536,115	1.83	196	821
Dallas	2	1,538	8,562	350	10,450	19,786	1.89	180	29
Greene	6	2,500	15,902	1,656	20,058	39,228	1.96	168	64
Guthrie	8	2,184	13,229	....	15,413	432,055	2.08	155	72
Jasper	10	277,577	20,334	12,320	310,231	80,629	1.55	242	706
Jefferson	2	....	3,779	....	3,779	7,558	2.00	97	18
Keokuk	6	700	14,320	1,440	16,460	25,885	1.57	198	28
Lucas	3	128,065	9,913	9,115	147,093	207,572	1.41	144	456
Mahaska	21	664,513	34,601	19,827	718,941	1,009,140	1.41	232	1,292
Marion	16	289,575	18,259	8,732	315,866	431,899	1.36	229	627
Monroe	11	1,994,567	183,382	49,228	2,227,177	3,076,009	1.38	236	3,871
Page	3	....	14,007	6	14,013	38,536	2.75	192	64
Scott	4	....	6,722	....	6,722	13,444	2.25	138	31
Taylor	5	11,547	10,783	15	22,345	50,512	2.26	225	84
Van Buren	5	4,180	2,007	5	6,192	12,947	2 09	98	33
Polk	25	959,094	211,305	34,918	1,205,317	2,025,723	1 67	238	2,453
Wapello	8	223,251	61,014	4,095	288,360	443,637	1 75	204	662
Warren	2	852	5,024	....	5,876	13,252	2.09	199	27
Wayne	8	93,004	19,100	445	112,549	212,752	1.89	213	389
Webster	13	90,782	19,284	3,327	113,393	220,738	1.95	206	364
Total	229	5,842,148	735,046	164,407	6,740,901	$ 10,495,593	$ 1.557	212	14,959

The wage scale adopted by the joint committee of operators and miners in 1904 continued two years and undoubtedly operated to keep up the price of coal during 1905. In the smaller producing counties the price remained about the same while in most of the large producers the average price per ton fell off from three to five per cent, although in Polk the price remained constant. The average price per ton is essentially on a mine run basis, and is dependent upon the system of mining practiced. This fact must be kept in mind when comparing prices for the different counties. In Appanoose and Boone the prevailing system of mining is "long wall" and very little powder is used, while in Monroe, Jasper and Polk counties "room and pillar" is the rule and "shooting from the solid" is the universal practice. As a consequence there is a minimum percentage of small coal produced in the former and a maximum percentage in the latter. The price of lump coal is much more uniform for the entire state that that of mine run coal. Sufficient data are not at hand to definitely fix the average price per ton on that basis.

According to the authority of the United States Geological Survey, Iowa ranks ninth in total tonnage and seventh in total value of coal produced in 1904, as in the preceding year. The ten leading producers of bituminous coal for 1904 were as follows:

STATE.	TONNAGE.	VALUE.
1 Pennsylvania	97,952,267	$ 94 434,219
2 Illinois	36 475,060	39,941,993
3 West Virginia	32,602,819	28,807,420
4 Ohio	24 334,812	26,588,476
5 Alabama	11,262,046	13,480,111
6 Indiana	10,934,379	12,105,709
7 Kentucky	7,566,482	7 857,691
8 Colorado	6,658 355	* 8,751,821
9 Iowa	6,519,933	10,504,406
10 Kansas	6 333,307	9,640,771

*Includes 48,245 tons of anthracite mined.

The production, value, average price, average number of days worked and number of men employed, in Iowa, during the past seven years were as follows:

YEAR.	TOTAL TONS.	VALUE.	AVERAGE PRICE.	AVERAGE NUMBER OF DAYS WORKED.	AVERAGE NUMBER MEN EMPLOYED.
1899	5,177,479	$ 6,397,338	$ 1.24	229	10,971
1900	5,202,939	7,155,341	1.38	228	11,608
1901	5,617,499	7,822,805	1.39	218	12,653
1902	5,904,766	8,660,287	1.47	227	12,434
1903	6,365,233	10,439,139	1.64	232	13,583
1904	6,507,655	10,439,496	1.60	213	15,373
1905	6,740,901	10,495,593	1.557	212	14,959

The scale adopted by the joint committee of operators and miners in April, 1906, which is to be operative two years, is practically the same as the 1904 scale and it may be confidently predicted that there will be no great reduction in price of coal during 1906 and 1907.

Clay.

There was a slight falling off in total production of clay products for 1905 as compared with the preceding year. The shrinkage was due to a falling off in the sales of structural brick and burnt clay ballast. The production of the latter product has always been very variable and none was manufactured during 1905. The rapid growth in the manufacture of lime and cement brick and cement block has been responsible, doubtless, for the decreased production both of structural brick and building stone. In the manufacture of drain tile there was an increase of more than fifteen per cent over 1904. Outside of drain tile and burnt clay ballast there are no important changes to record. The production was distributed as follows:

	1904.		1905.	
	THOUSANDS.	VALUE.	THOUSANDS.	VALUE.
Common brick..........	207,750	$ 1,430 581	170,067	$ 1,367,742
Front brick	8,330	101,558	5 937	63.137
Paving brick	15,925	199,528	12,963	130,003
Ornamental.........	....	972	....	......
Fire brick	20	300	50	869
Drain tile	....	1,321,745	....	1,531 376
Sewer pipe	....	94,800	....	90.000
Hollow block...........	....	164.658	....	134.418
Railway ballast	....	100,000	....	....
Pottery	....	66,050	....	68.659
Miscellaneous...........	....	7 184	....	21,466
Total		$ 3,487,376		$ 3,408,547*

* Includes $877 raw clay sold.

While the production of common brick declined, the price shows a marked increase. Pavers and front brick declined in price. The average prices for the principal grades of brick manufactured in Iowa are given below for 1905 and the two preceding years.

	Iowa			Whole United States
	1903	1904	1905	1904
Common brick...	$ 7.08	$ 6 89	$ 8.03	$ 5.97
Front brick......	10 63	12.17	10 63	12.80
Paving brick....	10.62	12.53	10.03	10.24

The distribution of clay products by counties, showing the common brick and total brick in thousands, the value of common brick and of total brick, value of drain tile and total value of clay products are shown in table No. III.

TABLE No. III.

CLAY PRODUCTION BY COUNTIES FOR 1905.

COUNTIES.	Number of producers.	COMMON BRICK. Quantity in Thousands.	COMMON BRICK. Value.	TOTAL BRICK. Quantity in Thousands.	TOTAL BRICK. Value.	DRAIN TILE. Value.	TOTAL VALUE.
Adair	3	1,050	$ 9,800	1,050	$ 9,800	$ 7,000	$ 16,800
Adams	5	1,285	9,737	1,285	9,737	11,400	21,137
Appanoose	2	2,420	17,360	2,424	17,400	400	17,800
Audubon	1						
Benton	6	1,245	8,960	1,245	8,960	16,364	25,624
Black Hawk	1						
Boone	5	3,411	24,279	5,568	44,902	25,438	72,141
Buena Vista	2	250	2,000	250	2,000	24,654	26,654
Butler	1						
Calhoun	3	100	800	100	800	29,000	30,000
Carroll	1						
Cass	4	1,593	11,420	1,593	11,420	1,969	13,389
Cedar	1						
Cerro Gordo	4	3,761	23,619	3,761	23,619	264,200	318,884
Clark	1						
Clay	1						
Clayton	3	1,135	6,900	1,135	6,900	600	7,500
Clinton	4	2,730	16,760	2,730	16,760	3,500	20,260
Crawford	2	1,400	10,0[illegible]0	1,700	13,300	..	13,300
Dallas	10	3,067	22,243	3,113	22,793	131,870	157,663
Davis	1						
Decatur	2	450	3,300	450	3,300	450	3,750
Des Moines	4	2,059	15,525	2,420	19,132	4,500	24,232
Delaware	3	511	3,643	511	3,643	2,700	9,343
Dubuque	4	4,965	31,828	4,965	31,828	..	31,828
Emmet	1						
Fayette	3	1,071	6,446	1,071	6,446	2,000	8,946
Floyd	1						
Franklin	1						
Fremont	5	1,025	7,0[illegible]7	1,0[illegible]5	7,097	....	7,097
Greene	2	55	495	55	49[illegible]	54,807	57,102
Grundy	1						
Guthrie	3	507	3,941	507	3,94[illegible]	4,79[illegible]	9,451
Hamilton	2	1,165	9,195	1,165	9,195	34,45[illegible]	46,270
Hancock	1						
Hardin	5	275	2,550	331	3,250	57,550	61,600
Harrison	6	2,055	13,870	2,055	13,870	....	13,870
Henry	5	330	2,469	330	2,469	15,466	17,935
Howard	1						
Humboldt	1						
Ida	1						
Iowa	6	2,870	18,440	2,870	18,440	18,600	37,040
Jackson	1						
Jasper	6	2,075	14,400	2,125	14,900	9,800	24,700
Jefferson	3	900	7,200	900	7,200	46,800	54,000
Johnson	5	4,150	28,450	4,150	28,450	6,000	34,450
Jones	4	555	4,245	555	4,245	9,9[illegible]2	14,157
Kossuth	1						
Keokuk	8	1,472	11,167	1,472	11,167	43,836	55,003
Lee	4	1,647	11,180	1,747	12,080	625	12,705

TABLE No. III—Continued.

CLAY PRODUCTION BY COUNTIES FOR 1905.

Counties.	Number of producers.	Common Brick.		Total Brick.		Drain Tile.	Total Value.
		Quantity in Thousands.	Value.	Quantity in Thousands.	Value.	Value.	
Linn	7	3,510	$ 24,520	3,510	$ 24,520	$ 9,653	$ 34,173
Louisa	2	175	1,200	175	1,200	5,400	6,600
Lucas	1						
Mahaska	6	2,839	21,834	4,839	41,834	24,012	66.546
Marion	5	2,570	18,295	2,570	18,295	30,600	48,895
Marshall	8	2,006	13,295	2,006	13,295	15,065	35,560
Mills	4	1,570	12,290	1,570	12,290	....	12,290
Montgomery	8	3,274	25 337	3,334	26,118	7,505	38,739
Muscatine	12	3,721	21,154	3,721	21,154	2,000	30,715
Page	7	5,680	40,750	5,680	40,750	20,750	61,500
Plymouth	1						
Pocahontas	2	465	4,120	465	4,120	109,830	113,950
Polk	19	29,062	222,157	38,775	324,718	78,050	544,368
Pottawattamie	8	10,358	74,506	10,358	74,506	110	74 616
Poweshiek	3	610	4,900	610	4,900	16,145	21,295
Ringgold	3	810	6,218	810	6,218	180	6,398
Scott	5	3,599	22,870	3,639	23,370	3,000	50,622
Shelby	1						
Sioux	3	1,180	8,440	1,180	8,440	....	8,440
Story	4	475	3,425	725	5,575	14,975	20,550
Tama	6	4,226	27,076	5,614	40,576	32,170	72,746
Taylor	3	773	5,702	773	5,702	1,695	7,397
Union	2	2,222	17,554	2,222	17,554	6,400	23,954
Van Buren	2	384	2,788	384	2,788	....	2,788
Wapello	4	6,157	41,758	6,575	45,448	25,215	74,899
Warren	1						
Washington	6	1,232	8,204	1,232	8,204	34,799	43,003
Wayne	4	990	7,183	990	7,183	....	7,183
Webster	11	4,623	32,701	5,794	45,066	149,964	272,070
Winneshiek	1						
Woodbury	6	18,707	287,487	19,522	295,729	13,904	309,658
Worth	1						
Wright	4	245	1,960	245	1,960	44,500	46,460
Single Producers	....	7,017	50,699	7.017	50,696	56,7[illegible]	[illegible]08,501
Total	311	170.064	1.367,742	*189.017	$ 1,561,748	$1,531,376	†$3,408 547

*Includes 24,000 paving brick produced.

†Includes $877 raw clay sold.

According to the United States Geological Survey, Iowa ranks ninth in the production of clay products for 1904, producing 2.64 per cent of the total production of the United States. According to advance sheets from the United States Geological Survey, Iowa has not changed her rank for 1905 but produced

2.73 per cent of the output of the entire country. For 1904 she ranked eighth in the manufacture of paving brick, fourth in hollow building block and first in the manufacture of drain tile. In the last named product she bids fair to hold her supremacy for some time to come. The ten leading clay producers for 1904 were as follows:

RANK.	STATE.	NUMBER OF PRODUCING FIRMS REPORTING.	TOTAL CLAY.
1	Ohio	819	$ 25,647,783
2	Pennsylvania	529	16 821,863
3	New Jersey	161	13.304 047
4	Illinois	492	10,777 447
5	New York	240	10,543.070
6	Indiana	465	5 902 589
7	Missouri	232	5,481.504
8	California	121	3.624 734
9	Iowa	327	3 487.376
10	Kentucky	120	2,087.277

The center of production of clay wares is moving slowly toward the northwestern portion of the state. New factories are being built in the north and west while a considerable number of old plants are idle in the south and east portions of the state. This shifting is due largely to the great demand for drain tile in the Wisconsin drift portion of the state. The leading products are tabulated showing the changes in the industries during the past six years.

YEAR	COMMON BRICK.	TOTAL BRICK.	DRAIN TILE.	POTTERY	TOTAL CLAY.
1900	$ 1,386,641	$ 1,621,604	$ 377,586	$ 31.339	$ 2.291.251
1901	1,611,040	1.944,351	534,935	26,200	2,737,825
1902	1,575,959	1 891.366	672.212	43,387	2 843.336
1903	1,396,088	1,703,050	1 009,933	55,762	3 033.583
1904	1,430.581	1,732,719	1.321,745	66 050	3.487.076
1905	1,367,742	1,561.742	1.531,376	68,659	3,408 547

The outlook for 1906 is favorable for drain tile and probably for the entire clay output. The Barber Asphalt Company are installing an up-to-date equipment in their Des Moines plant and promise to materially increase the output of paving brick in the near future. The Mason City Brick and Tile Company have added a third section to their plant, thus increasing their capacity fifty per cent. Both improvements will affect the output for the current year.

Stone.

The stone industry appears to be still on the decline although the falling off amounted to less than two per cent when compared with the production for 1904. The greatest falling off was in the manufacture of lime and the sale of rough stone. Both building stone and crushed stone show good increases. Many of the smaller quarries were idle during the year or were operated only intermittently.

The production for 1905 was distributed as follows:

LIMESTONE USED FOR:	VALUE 1903.	VALUE 1904.	VALUE 1905.
Building purposes	$ 204.769	$ 162.577	$ 171,041
Flagging & curbing	13,793	8,970	17,161
Lime	113.195	91,008	76,704
Crushed stone			
Road making	102,403	53,082	70,411
Railway ballast	12,243	5,549	13,025
Concrete	68,763	97 274	90,634
Rubble & riprap	102,403	113 568	80,747
Miscellaneous	2,158	1 565	6 043
Sandstone	17,008	8,575	7.743
Total	$ 636,735	$ 542,168	$ 533,509

The completion of the Historical Building in Des Moines contributed to the increase in the output of building stone. Another encouraging symptom was the use of Iowa stone for bridge purposes. Nearly $5,000 worth of stone was reported sold for bridge work. Portland cement and imported limes are largely responsible for the decline in the production of domestic limes. Table No. IV gives the production of limestone by counties and specifies the various grades of stone put upon the market.

TABLE No IV.

PRODUCTION OF LIMESTONE BY COUNTIES FOR 1905.

COUNTIES.	Number of producers.	Building.	Flagging and curbing.	Lime.	Crushed Stone.			Rubble and riprap.	Miscellaneous.	Total Value.
					Road-making	Railway ballast.	Concrete			
Allamakee	5	$ 4,123	$ 24	$	$	$	$	$ 420	$	$ 4,567
Appanoose	1									
Benton	6	334	....	....	....	....	.....	97	....	431
Black Hawk	7	9,962	296	....	391	....	40	425	....	11,114
Bremer	1									
Buchanan	1									
Cerro Gordo	4	6 214	120	6,500	1,400	....	3,075	301	....	17,610
Clark	5	1,450	900	....	10	....	....	40	....	....
Cedar	1	....	....	....	....	....	....	....	....	2,400
Clayton	8	6 445	3,427	1,350	1,000	....	....	....	....	12,222
Clinton	7	1,103	....	....	1,079	....	....	39	10	2,231
Dallas	1									
Decatur	6	1,444	13	....	1,500	....	6,582	165	....	9,604
Delaware	4	602	251	....	....	....	20	500	100	1 473
Des Moines	12	10,343	600	....	1 175	....	....	20,097	....	32,215
Dubuque	12	13,384	2,350	5,360	2,701	475	1,125	2,634	....	28,029
Fayette	4	1,300	....	30	....	....	....	28	....	1,358
Floyd	5	605	20	....	....	....	....	750	....	1,375
Hamilton	1									
Hardin	11	1,809	7	....	4,800	....	13,000	625	....	20,241
Howard	3	471	....	....	100	....	....	....	....	571
Humboldt	2	384	....	....	....	....	....	....	....	384
Jackson	7	467	....	63,464	108	....	....	300	....	64,339
Jasper	1									

Johnson	2	448			200					648
Jones	11	36 788	8,808	....	953	2,410	16,528	21,696	4,656	91,839
Keokuk	8	975	....	....	....	....	40	24	....	1,039
Lee	13	9,166	121	....	3,011	....	7.567	2,675	1,256	23 796
Linn	5	1 830	....	....	340	....	15.030	....	....	17,200
L u sa	5	1 700	25	....	50	....	....	13	....	1,788
Madison	7	8,520	....	....	13,018	3,30	7,100	470	16	32,524
Mahaska	1									
Marion	2	309	....	....	75	....	....	760	....	1,144
Marshall	2									
Mitchell	3	1,195	....	....	....	....	....	....	....	1,195
Montgomery	2	550	....	....	....	....	....	....	....	550
Pocahontas	1									
Scott	11	16,192	....	....	21,038	6 600	9,097	5 860	....	58,787
Tama	3	77	....	....	....	....	....	....	....	77
Van Buren	6	1.083	....	....	....	....	....	76	....	1.159
Wapello	5	13.491	....	....	....	....	5,240	5,9 0	....	24,651
Washington	7	1,955	50	....	....	....	15	875	....	2,895
Webster	3									
Winneshiek	1									
Single Producers	....	16 322	149	....	17 462	240	6,175	15.957	5	56,310
Total	213	$171,041	$ 17.161	$ 76 704	$ 70.411	$ 13.025	$ 90,634	$ 80 747	$ 6 043	$ 525 766

Fourteen counties with twenty-five producers reported sandstone. The production for 1905 amounted to $7,743 and was used almost wholly for building purposes. Small amounts were used for curbing and flagging and for road work. Jones and Scott are the only counties showing an increased production of limestone and rank first and second respectively in total productions. Jackson remains at the head of the list of lime producers. The table below gives the condition of the stone industry during the past seven years.

YEAR.	LIMESTONE.				SANDSTONE.	TOTAL STONE.
	BUILDING.	LIME.	CRUSHED STONE	RUBBLE AND RIPRAP.		
1899	$ 312,595	$ 102,611	$ 158,917	$ 139 064	$ 24 348	$ 809 928
1900	248 833	110,589	153,920	58,493	19,063	605,473
1901	272,501	221,760	183,902	85,343	14,341	791,827
1902	195,009	114,051	153,372	176,927	15,061	665,048
1903	204 769	113,195	144 643	102,403	17,008	636,735
1904	162,577	91,008	153,372	113,568	8,575	542,168
1905	171,041	76,704	174,070	80,747	7,743	533,509

The fluctuations in production of rubble and riprap seem to be dependent on the Mississippi river improvements. The Government quarries near Burlington were idle during 1905 and were operated vigorously during 1902.

Gypsum.

The gypsum production for 1905 shows a splendid increase in both tonnage and value. The gross output of crude gypsum for the year was reported to be 179,016 tons valued at $108,833, an increase in production of more than twenty per cent. The selling price of the manufactured product shows a slight increase over the preceding year. In the table below is given the distribution of the product for 1905 as compared with the two preceding years.

	1903		1904		1905	
	TONS	VALUE	TONS	VALUE	TONS	VALUE.
Wall or cement plaster..	87,397	$411,503	94 811	$399 281	119,252	$558,992
Plaster of Paris.........	30,306	100,744	19,540	64,112	4,566	17,983
Land plaster...........	2,098	9,229	933	1,816	2,723	2,723
Sold crude.........	703	1 534	2,013	4,223	4,867	9,357
Total..............	120,504	$523,010	117,297	$469,432	131,408	$589,055

One and possibly three new companies are about to organize and plants may be built during the present year.

Lead and Zinc.

The lead and zinc industry in Iowa is practically a negligible quantity at the present time. But little zinc ore has been produced and none marketed in the state during the past two years. Good zinc ore in commercial quantity will undoubtedly be found in Iowa in the deeper levels but these levels are not being exploited at the present time.

The report for lead is but little more encouraging. The Watter's Smelter was in operation and turned out its usual amount of business but nearly all of the ore treated was purchased from the Wisconsin and Illinois producers. Iowa contributed scarcely a hundred tons of lead ore for the entire year 1905. Dubuque county was the only producer. The price of ore remained about the same as for the preceding year; about $27.00 per thousand pounds.

Sand-Lime Brick.

The sand-lime brick industry shows a substantial growth in the state for the year 1905 but not the mushroom growth some of the enthusiastic manufacturers of sand-lime brick machinery predicted. Three plants were in operation during the year and a fourth was installed and will contribute to the total for 1906. The plants in operation at the present time are located at Clinton, Cedar Rapids, Waterloo and Sioux City.

The production for 1905 was distributed as follows:

	THOUSANDS.	VALUE.
Common brick	3,974	$ 28,783
Front brick	625	7,675
Fancy brick	40	800
Block		1,384
Total		$ 38,6[illegible]2

The output for 1904 was: brick 1,962,000 valued at $13,907.

Mineral Water.

Iowa is fast becoming an important producer of mineral water. While by far the larger number of wells and springs producing mineralized waters produce for home consumption only, three localities, of which Colfax is the most important, bottle and ship the water. The gross sales for 1905 amounted to 303,500 gallons valued at $30,400.

Iron.

The steady demand for iron and iron products has brought the iron knobs in Allamakee county again into prominence. Iron Hill and two other hills near Waukon, known to be capped with bodies of iron ore, have been thoroughly prospected during the past year. The test pits and drill holes bear out fully the previous reports of the Iowa Geological Survey as to the extent and richness of these ore bodies. It is the intention of the company holding the options to explore thoroughly all of the known ore bodies of the district. No ore was marketed during the year.

Portland Cement.

Ever since the organization of the present survey, raw materials suitable for the manufacture of Portland cement have received attention from the various members in their county and special reports. That the state contained suitable materials was established beyond a doubt but only recently has any substantial progress been made toward their utilization.

During the early part of the present year options were taken on extensive tracts of the limestone and shale in the vicinity of Mason City in Cerro Gordo county and the Northwestern States Portland Cement Company was organized with headquarters in Minneapolis. This company has optioned and purchased sufficient raw materials to last them several generations and at this time is erecting a modern Portland cement plant, with a daily capacity of 4,000 barrels. The completed plant is assured in the shortest time possible to build a plant of that magnitude. Conservative business men are backing the enterprise and the suitability of the materials has been thoroughly demonstrated by the Survey, both chemically and by actual burning tests. Several other Portland cement companies are searching diligently for suitable locations in Iowa; and one at least has already secured options preliminary to location. Iowa promises to contribute her share toward the cement industry in the near future.

GEOLOGY OF WINNESHIEK COUNTY.

BY

SAMUEL CALVIN.

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CONTENTS.

INTRODUCTION.

GEOGRAPHIC AND GEOLOGIC RELATIONS.—AREA.

In some respects Winneshiek* is the banner county of the state. By virtue of its location it possesses a greater variety of soils and offers a greater range of agricultural possibilities than most of the other counties; it has more geological formations than any other; it presents an unusual number of scientific and economic problems for the consideration of the geologist. Geographically the county lies in the northeastern part of the state; it is separated from the Mississippi river by one county, Allamakee, which bounds it on the east; its northern boundary is the state line between Iowa and Minnesota, the parallel of 43° 30′ north latitude; on the south lies the great county of Fayette; while the counties of Chickasaw and Howard bound Winneshiek on the west. Winneshiek is one of the larger counties of the state, embracing, as it does, twenty congressional townships. The northern townships, however, measure only about five miles from north to south, each lacking the northern sections 1 to 6; the sections along the west side of Lincoln and Orleans townships are fractional; the area of the county is approximately 690 square miles.

Topographically and geologically the location of the county is such as to give this area unusual interest. Along its eastern border, and generally throughout the whole belt traversed by the Upper Iowa or Oneota river, the surface presents the rugged characteristics and conditions of the "Driftless Area" with its

*The spelling of the name of this county has varied fron *Winneshek* to *Winneshiek*. The first spelling is not uncommon, especially on the older maps and in the earlier publications relating to this part of Iowa; but the second spelling is that authorized by the United States Board on Geographic Names and used in all the official publications of the Federal Government. See *Second Report of the United States Board on Geographic Names 1890-1899, Second Edition*, page 140, Washington, March, 1901.

deep, rock-cut valleys and stony, barren hills. The uplands in the northeastern two-thirds of the county are characterized by the strongly undulating topography which everywhere accompanies the old, eroded Kansan drift with its veneer of loess. In the west and southwest are gently undulating areas of the uneroded, younger Iowan drift. The ill defined border land between the driftless and drift-covered portions of the state passes through the county, and the county is also traversed by the rather sharply defined, sinuous line which marks the abrupt transition from the younger Iowan to the older Kansan.

The claim of Winneshiek to being, geologically, the banner county of the state might well rest on the number of distinct formations represented by the indurated rocks. In the extreme eastern edge of the county the Jordan sandstone. the uppermost member of our Upper Cambrian, occupies some small areas in the valley of Bear creek and along the Upper Iowa river, and this is followed in succession by the Oneota, the New Richmond, the Shakopee, the Saint Peter, the Platteville, the Galena, the Maquoketa, the Niagara, and, finally, the Wapsipinicon and Cedar Valley stages of the Devonian. Within the limits of our area the Maquoketa presents a number of unique features not seen elsewhere, and wholly unlike anything appearing at the type localities in Dubuque county. As a matter of fact the Maquoketa proves to be the most variable and versatile of all our geological formations, changing in lithological and faunal aspects from county to county in the most surprising and unexpected ways, and some of its most striking variations occur in Winneshiek. Here, in the middle of the formation, to give a single illustration, are forty feet or more of hard crystalline dolomite, cherty in places, so entirely different from the typical Maquoketa shales of White* that some very competent geologists have mistaken the beds for the Galena, and some for the Niagara limestone. The Niagara also presents some unusual characteristics. Lithologically it differs from the Niagara of the counties farther south, and it is quite erratic in its distribution. While it is present in some prominent knobs and higher uplands on the east

*Report on the Geological Survey of the State of Iowa, by Charles A. White, M.D., Volume I, page 180, Des Moines, 1870.

side of the Turkey river a few miles southeast of **Fort Atkinson,** it is entirely absent west of a line drawn through Fort Atkinson and Ridgeway. In this western part of the county the soft, magnesian Devonian—with its spirifers, productellas and other fossils represented by casts and clear cut impressions—overlaps on eroded Maquoketa. The complete disappearance of the Niagara and the unexpected relations of the Devonian to the Ordovician are features which, as already shown*, Winneshiek shares with Howard county.

The greater part of Winneshiek county is located in the small drainage area which is set off from the general drainage of the eastern slope of Iowa by the Cresco-Calmar ridge. The significance of this ridge and its relations to the drainage of northeastern Iowa are discussed in the report on the Geology of Mitchell County, pages 297 and 298, published in volume XIII of these reports.

PREVIOUS GEOLOGICAL WORK.

As compared with many of the other counties of Iowa, Winneshiek has received a fair degree of attention from official geologists. It is quite certain that the territory embraced within the limits of our area was visited by D. D. Owen in 1847. In his "Report of a Geological Reconnoissance of the Chippewa Land District, etc.", published in 1848, Owen, on page 24, mentions a bend in the Upper Iowa river "where the stream flows over solid ledges of magnesian limestone", which place he locates "eight or ten miles below the Big Spring, and by water about sixty miles above the confluence of the upper Iowa with the Mississippi." Reference is made to essentially the same locality on page 35 of the same report.+ Now the only points where the Upper Iowa river flows over ledges of the lead-bearing, magnesian limestone which Owen had in mind, are to be found between Decorah and the eastern border of the county. At Decorah the stream flows over the lower beds of the Platteville

*Geology of Howard county, by Samuel Calvin, pp. 25 and 38, Iowa Geological Survey, Vol. XIII, Des Moines, 1903.

+ This locality is mentioned in essentially the same terms on page 63 of the enlarged *Report of a Geological Survey of Wisconsin, Iowa and Minnesota* by David Dale Owen, Philadelphia, 1852. In this publication he ledges over which the stream flows are specifically stated to be "Lower Magnesian Limestone"; and the adjective part of the name of the stream is capitalized, making it the "Upper Iowa".

limestone and the upper beds of the Saint Peter sandstone. A few miles below Decorah the Saint Peter is cut through to the Shakopee or Upper Oneota, and before the east line of the county is reached the stream has cut through the whole thickness of Owen's Lower Magnesian limestone, down into his Lower sandstone, the Saint Croix. From the west line of Allamakee county to its mouth, the Upper Iowa flows in a channel cut in the Saint Croix sandstone.

In Hall's Geology of Iowa there is a report on "Winnesheik County" by J. D. Whitney* in which he recognizes a succession of strata "from the Lower Sandstone as far up in the series as the lower beds of the Galena." The hard crystalline dolomite at Fort Atkinson, now known to belong to the middle of the Maquoketa or Hudson-River stage, is spoken of as "undoubted Galena limestone." Nothing higher than the Galena is positively recognized in the county, but later formations are suggested by finding "in the extreme southwest corner of the county, an elevated ridge, running parallel with the course of the Little Turkey, in which no rock is exposed, but which, from its position and relations to the rocks known to exist in the neighboring counties, is undoubtedly the outcrop of the Niagara limestone."

In Dr. White's report on the Geological Survey of the State of Iowa, published in 1870, there are no references to Winneshiek county as such, but on page 80 of volume I there is a very good description of the ice cave at Decorah.

Winneshiek county is embraced in the area studied by McGee and reported on in detail in his *Pleistocene History of Northeastern Iowa.* In this memoir, which forms the major part of the Eleventh Annual Report of the United States Geological Survey, 1891, there are descriptions of the topography, drainage, soils, rocks and well sections of this county. The hard, Maquoketa dolomite at Fort Atkinson, however, seems to be counted as part of the Niagara escarpment.

Numerous articles on the Decorah ice cave have appeared from time to time in the newspapers and magizines. An article

*Report on the Geological Survey of the State of Iowa by James Hall, *State Geologist*, and J. D. Whitney, *Chemist and Mineralogist;* Vol. I, Part I, pp. 312-317, 1858.

by A. F. Kovarik in the *Scientific American Supplement* for November 26, 1898, is of especial interest. Mr. E. S. Balch refers at some length to the ice cave at Decorah in his exhaustive volume on *Glacieres or Freezing Caverns,* published in Philadelphia, 1900.

PHYSIOGRAPHY.

TOPOGRAPHY.

It is probably true that no county in Iowa presents a greater range of topographic forms than Winneshiek. The county lies within the limits of maximum preglacial uplift for this part of the Mississippi valley; and so, before the advent of the earliest glacial ice, the drainage streams had carved deep trenches and gorges in the indurated rocks. At least two of the great ice sheets from the Keewatin centers of dispersion—the Kansan and the Iowan—invaded the county, and each has left its impress on the topography. It was only the attenuated margins of these ice sheets, however, that reached the territory we are considering, and in each case the amount of detrital material carried was comparatively small. The result was that the very thin mantle of drift deposited over the county produced practically all of its effects on the uplands, so far as it was effective in modifying and disguising the old topography. Along the main drainage courses it was quickly swept away, leaving all the larger valleys, and the territory immediately contiguous to them, in possession of their preglacial characteristics. Preglacial topography, or Driftless Area topography, for example, is illustrated along the whole course of the Upper Iowa or Oneota river in Winneshiek county. The stream flows in a deep, rock-cut canyon from the point where it enters the county, near the northwest corner, until it takes its final departure, near the mouth of Canoe creek, in section 25 of Pleasant township. The part of the valley about Decorah and thence northwestward to the county line, is walled with bold, precipitous and picturesque cliffs of the Galena limestone, and all the tributaries entering the stream in this part of its course flow in steep-sided, rocky gorges. The bluffs about Decorah, rising sheer in places to hights of more than 100 feet, and continuing to rise in rounded slopes for another 100 feet or more, are typical of those seen at other points along the upper courses of the river in this county. The general direction of the stream northwest of Decorah is nearly parallel to the strike of the strata, and for this reason the same beds and the same general type of escarpments recur at all the numerous points where cliffs are developed. Such variations as do occur in the appearance of cliffs arise from the fact that in following the windings of the river the cliff faces are sometimes parallel to the master joints that cut through the limestone in an east-west direction, and in other cases are at right angles to these joints. The very impressive, regular and smooth surfaced wall (Fig. 8) that rises sheer from the water's edge, layer upon layer, at Bluffton, coincides with a great joint face; while the more picturesque cliff above the bridge (Fig. 9), less than a mile away, and looking as if made up of massive, clustered columns, owes its striking peculiarities to the fact that its trend is at right angles to the joints. Weathering has eaten in along the joints, widening them, dissolving and trimming off the angles, and leaving the rounded, protuberant faces of the intervening blocks as semi-cylindrical pilasters supporting the massive wall. At Plymouth Rock, a few miles farther up the stream, there is another great cliff parallel to that above the bridge near Bluffton, and here, for the same cause, the same striking, columnar features are developed (Fig. 10).

A short distance below Decorah the stream turns at right angles to the course previously followed and flows in a direction opposite to the dip. The beds below the Galena are quickly cut through, one after the other, and each affects the width of the valley and the character of the bluffs. Owing to the presence of the friable Saint Peter sandstone, the valley widens out and the slopes are less steep for a short distance above and below Freeport. From section 9 of Glenwood township to the east county line, the Shakopee and Oneota dolomites form bold steep cliffs between which the river flows. At the mouth of Canoe creek, in section 25 of Pleasant township, the channel has been cut to a depth of thirty or forty feet in the Jordan sandstone, but the Oneota limestone asserts itself in the castellated crags and scarps that make up the greater part of the walls of the valley.

The same type of topography, unaffected by the drift and expressed in bold, precipitous, rocky cliffs due to preglacial erosion, occurs along Canoe creek in Canoe and Pleasant townships; and also along Bear creek in Highland township, from above Highlandville to the county line. In this northeastern part of the county the principal cliff-forming formation is the Oneota limestone. There are numerous low cliffs of Galena limestone along the gorges in the southern half of Glenwood township, and the upper beds of the Galena form a vertical wall twenty-five to thirty feet in hight in the banks of the Yellow river, near the county line, in section 13, Bloomfield township.

Throughout the eastern portion of the county there are occasional patches of typical, weathered Kansan drift on the uplands, but there are extensive areas in which no drift is seen, and the topography in general is that of the Driftless Area. The drift here is so thin, so patchy, so given to appearing in unexpected places, that, notwithstanding its inefficiency in modifying the preglacial topography, and notwithstanding the fact that over more than eight-tenths of the eastern half of the eastern townships the loess rests directly on dark residual clays, it is not deemed advisable to attempt to set off the driftless, from the drift covered parts of the county by a definite line.

The Saint Peter sandstone forms a number of conspicuous knobs, ridges and scarps in Highland, Hesper, Canoe, and Pleasant townships. The deposit, though very friable, is insoluble, and, if not exposed to mechanical disintegration, will stand indefinitely. One of the most conspicuous of the ridges occurs in section 8 of Highland township. In this case, however, there is a thin capping of the Platteville limestone on the highest points. The slopes are steep, rising abruptly from a comparatively level area which coincides very nearly with the upper surface of the Shakopee limestone. Practically the whole thickness of the Saint Peter is included between the base and summit of the ridge. An escarpment of the sandstone sends out very prominent and conspicuous salient in section 12 of Hesper township (Fig. 5). A few rods south of the Norwegian Lutheran church in the northern part of section 3 of Pleasant township, there occurs a very characteristic sandstone ridge which rises abruptly from the level region on the north to a hight of sixty or seventy-five feet. Another equally good illustration of the peculiar topography, controlled by the Saint Peter sandstone, is seen in the great ridge running through sections 14, 15 and 16 of the same township, northwest of Sattre. Some prominent, conical knobs or monadnocks of Saint Peter are seen in section 21 of Pleasant township; while in Canoe township there are many knobs and ridges and other conspicuous topographic forms due to the presence of the Saint Peter sandstone. Some in the southern part of section 13 deserve especial mention. Knobs and ridges having the same structure and the same general characteristics are found north of the state line, in Minnesota; and it may be remarked that the presence of so many prominent remnants of a sandstone as friable and as ready to yield to mechanical disintegration as the Saint Peter, would indicate that the glacial ice which spread the scattered patches of drift so generally found in all of this region, was not very effective as an agent of erosion. The Jordan sandstone of the Saint Croix stage of the Cambrian affects but a very small area in Winneshiek county and is not an important factor in controlling the topography. Nevertheless, the stream valleys that cut into the eastern edge of sections 24 and 25 of Pleasant township and section 25 of Highland township, present decided, though low, vertical cliffs of the friable Cambrian sandstone.

The Shakopee and Oneota limestones are traceable in the topography over extensive areas in the northeastern part of the county. Along the stream valleys they, together, form bold, picturesque, vertical cliffs, as already noted; but in the interstream areas the Shakopee gives rise to wide, nearly level unbroken spaces which coincide with the upper surface of the formation and surround the abruptly sloping hills of Saint Peter sandstone. From the tops of some of the Saint Peter ridges the spaces controlled by the dolomite may look like very broad, flat bottomed valleys. The Shakopee limestone is capable of resisting both solution and mechanical erosion quite effectively. On the other hand the Saint Peter, when cut through by stream corrasion, recedes rapidly on account of the readiness with which it yields to mechanical wear. This wear is always greatest on the steep slopes at the exposed edges of the body of sandstone; and so the flat spaces referred to as determined and controlled by the Shakopee are areas from which the sandstone has been progressively stripped off, down to the surface of the more resistant, underlying formation.

The Platteville and Galena limestones produce their most pronounced effects, topographically, along the stream valleys. They yield quite readily both to corrasion and solution. Their influence is not conspicuous in the surface configuration of the interstream spaces, except so far as they are responsible for the countless numbers of sink holes which occur in the eastern part of the area of their distribution, in a region where the drift mantle is comparatively thin.

The beds of the Maquoketa stage occupy a much larger area in Winneshiek county than any other formation of the indurated rocks, and throughout the greater part of this large area there are no very marked topographic features due to the presence of this formation. The beds, though much more indurated than the Maquoketa of Dubuque county, break down quite generally under the effects of weathering, and so cliffs, knobs or ridges of the Maquoketa stage are exceptional. Furthermore, the Maquoketa area has been covered with a comparatively thick mantle of drift which has modified and concealed to a large extent the effects of preglacial sculpturing of the bed rock. About the middle of the formation, however, there is in this county, as there is in Fayette, a series of hard, crystalline, dolomitic beds, the Fort Atkinson limestone (Fig. 12), forty feet in aggregate thickness, which gives rise to some conspicuous ridges and escarpments. The best example of the effect of the Fort Atkinson beds is seen in the high prominence on which stand the old buildings of the fort at the town of Fort Atkinson. The platform on which the village of Festina is built is held up by the Fort Atkinson limestone, and a very marked escarpment (Fig. 1) facing the small stream valley southwest of the village

Fig. 1–Steep slopes due to the Fort Atkinson limestone, seen along a small valley southwest of Festina, Washington township.

is due to the same formation. Along Ten Mile creek, in sections 7 and 18 of Madison township, there are some very unusual topographic forms. Here is found a unique and wholly unrelated assemblage of hills, prominent salients and steep slopes, rising from the narrow valley, and all constructed of the more shaly beds of the Maquoketa. Some of the hills stand well above the general level of the surrounding country, being remnants of strata once more widely distributed, remnants which, for some cause, have escaped the processes of denudation which brought the surrounding country to its present level. At present no explanation of the peculiar character and complete isolation of this strange bit of topography can be offered.

The Niagara limestone controls the character of the surface forms in the southeastern part of Washington township. In sections 35 and 36 the Niagara rises in a broad plateau 250 feet above the platform of Fort Atkinson limestone on which the village of Festina stands. Southwest of Festina, about on the line between sections 23 and 26, there is a point which rises even higher than the plateau to the south. This is part of an extensive mass or ridge of Niagara which, on its western side, runs out into a series of bold and prominent salients facing the valley of the Turkey river in sections 26 and 27. A large isolated cone of Niagara in the western edge of section 35 is but another example of the characteristic topography controlled by the Niagara in this part of Washington township. There is another very prominent conical hill of this formation west of Festina, about on the line between sections 22 and 23 (Fig. 13). This cone stands apart from the other uplands of the Niagara, overlooking the lower plain which stretches away to the north, and is the most northerly outlier of this formation observed in Iowa. A long, elliptical hill in sections 28 and 33, with an elevation of 200 feet above the river valley, is the only marked bit of topography dependent on the Niagara, observed on the west side of the Turkey river.

There are some quite pronounced topographic features in the western part of the county, due to the Devonian limestone. In this region the Devonian overlaps on the Maquoketa. Beginning in the southwest corner of Fremont township and traversing the western edge of Orleans, are well defined, sinuous escarpments of Devonian, rising with convex, rounded slopes to a hight, in places, of fifty feet above the plain occupied by the more shaly underlying formation. In sections 1 and 12 of Jackson township there are some features characteristic of many of the hills around Fort Atkinson. Two nearly parallel and horizontal belts of rock (Fig. 16), due to the outcropping of harder ledges, appear on the slopes about twenty feet apart vertically. The upper one is the outcrop of dolomitized Devonian, the lower is produced by the uppermost ledges of the Fort Atkinson limestone belonging to the middle of the Maquoketa.

The effects of the Pleistocene deposits on the topography are much less in Winneshiek county than in parts of Iowa covered with a heavier mantle of drift. A comparatively small area in the western part of the county is occupied by drift of the Iowan stage. The remainder, and much the larger part of the county, so far as surface configuration is determined by Pleistocene deposits at all, shows the characteristic features of what has been called the Loess-Kansan topography. This type of surface is thoroughly drained and is carved by storm waters into an intricate system of branching ravines with well rounded intervening ridges. On the uplands, outside the influence of the drainage courses, topography of the Loess-Kansan type is well illustrated throughout the greater part of the southeast quarter of Winneshiek county. The type is especially well marked on both sides of the railway between Castalia and Ossian. Another area of the same character embraces practically all of the townships of Hesper and Burr Oak with adjacent parts of Highland and Fremont.

The line between the Loess-Kansan and Iowan areas is very irregular and does not admit of ready description. The very erratic and curiously lobulate character of the margin of the Iowan ice sheet is well exemplified in this county. Beginning on the west side of the Turkey river at the point where this stream passes into Fayette county, the Iowan border line follows the river northward almost to Fort Atkinson. It passes a short distance west of the town named and then bears northward to Spillville. East of Spillville there is a short, broad lobe of Iowan which pushes southeast almost to Calmar, from which point the Iowan boundary passes around west of Conover, and thence northeastwardly to the southeast corner of section 35, Madison township. From the point last named the line extends northwest for a distance of twelve or thirteen miles when, near the middle of section 32, Orleans township, it makes a sharp curve and returns southeastwardly, parallel to its former course, to near the southeast corner of section 12, Lincoln township. Here, curving sharply to the northwest for a short distance and then looping back so as to form two small lobules of Iowan, it finally reaches a point near the northwest corner of section 35, Orleans township. With another very sharp curve the line turns to the southeast, which course it follows with but little deflection for a distance of about seven miles, to near the center of section 3, Madison; and then changing abruptly to the northwest it follows a rather simple, sinuous course of thirteen or fourteen miles to the west county line, in section 30 of Fremont. West of this line, the peculiarities of which will be best appreciated by reference to the map of Pleistocene deposits, the surface, so far as it is controlled by the drift, is characterized by the gentle undulations of the uneroded, young Iowan till. The surface remains to-day essentially as it was left when the ice of the Iowan stage disappeared from the region. There has been no general erosion of the surface since; no loess has been deposited; there are many large, granite bowlders strewn over the area; where the Iowan ice deposited sufficient drift, the pre-Iowan topography is completely obscured; where the load carried and deposited by the ice was small, the effects of pre-Iowan, and, in some cases, of preglacial, erosion are still manifest. The escarpments of Devonian limestone in Orleans township, for example, are features of the surface due to rock sculpturing before the coming of the earliest ice, features which were not masked or destroyed by either of the drift sheets or by both combined. Another case of the same kind is seen north of the center of section 21 in this same township, where some steep hills are controlled by the cherty dolomite of the Fort Atkinson beds.

As usual, within the Iowan area and near its margin, there are many of the peculiar topographic forms called paha by McGee. These are loess-covered knobs or hills rising out of the Iowan plain and usually containing no Iowan drift. As examples there may be noted a chain of paha, blending in places into a practically continuous ridge, stretching across the north side of section 33, and another parallel chain a short distance north, in the adjacent section 28, Orleans township. The most symmetrical of these forms is a small, beautifully rounded paha which stands alone in the southeast corner of section 36, Sumner township.

There are some topographic features due to comparatively recent shifting of the mantle rocks which deserve attention. Throughout that part of the county lying east of the Iowan margin, there are evidences of a time of active aggradation of the small valleys, during which all were filled to a greater or less extent with clays and more or less angular rock fragments, some to depths of fifteen or twenty feet. The effect was to render the bottom of the valleys broadly concave, a feature that still persists in many instances. Quite recently, however, the drainage waters have been cutting deep trenches in the deposits referred to, and practically all the smaller valleys and upland sags in the surface show the effects illustrated in figure 2.

Fig. 2—Re erosion of an aggraded valley in the northeast quarter of section 21, Glenwood township.

When the county is looked at as a whole, there are a few topographic features of commanding importance. One of these is the Cresco-Calmar ridge to which reference is made in the Introduction. It is followed by the line of the Chicago, Milwaukee and Saint Paul railway as it crosses the county on the way from Postville to Cresco. The highest point of the ridge in Winneshiek, 1269 feet above tide, is reached at Ossian. The crest of the ridge forms a watershed, northeast of which lies the drainage basin of the Upper Iowa or Oneota river, another surface feature on a large scale, which may be taken as a single geographic unit. On the same side of the ridge, in the southeast corner of the county, is a small area which forms part of the Yellow river basin. Southwest of the ridge lies the broad basin of the Turkey river.

Following is a list of elevations above sea level, taken along the ridge from Postville in Allamakee county to Cresco, Bonair and Lime Springs in Howard:—Postville 1195, Castalia 1245, Ossian 1269, Calmar 1257, Ridgeway 1209, Cresco 1300, Bonair 1309, Lime Springs 1246. Decorah, in the valley of the Upper Iowa, has an elevation of 875 feet, the Upper Iowa at the east county line, 760 feet. The highest point noted in the county occurs a short distance west of Hesper, with an elevation of 1360 feet. The maximum relief in Winneshiek county is about 600 feet.

DRAINAGE.

The drainage of the county is divided into two systems by the Cresco-Calmar ridge. A little more than two-thirds of the surface lies northeast of the ridge and is drained almost wholly by the Upper Iowa or Oneota river. From the northwest corner of the county the general course of the master stream is parallel to the ridge and at an average distance of about eight miles from the crest. From Decorah to the Allamakee county line the direction is nearly at right angles to that previously followed. The ridge on which Hesper is located constitutes the northeastern rim of the basin drained by the Upper Iowa. The two ridges are about equally distant from the axial stream; their sides are drained by a number of small creeks, none of which, under ordinary conditions of precipitation, attain any considerable importance. Canoe creek, which drains the larger part of Canoe and Pleasant townships, is the largest stream in the county tributary to the Upper Iowa. Nearly the whole of Highland township is drained by the initial branches of Bear creek, which becomes a stream of some importance before its confluence with the Upper Iowa in Allamakee county. Of the remaining streams on the north side of the basin Pine creek and Silver creek, which gather the storm waters from Burr Oak township, are most deserving of mention. South of the main river there are Ten Mile creek in Madison township, Trout creek draining Springfield township and the southern part of Decorah, and another Trout creek which drains most of Glenwood township and the northern part of Frankville. Altogether the tributary streams on both slopes of the Upper Iowa basin are small. Most of them are intermittent, all have steep gradients in some parts of their courses and hence are found carrying destructive torrents on the occasion of heavy rainfall. During periods of drought the steep, stony beds are dry. Throughout all of this region the drainage is mostly underground. In times of normal precipitation the water quickly disappears from the surface, descending through countless sink holes, and in other ways, to passages in the much shattered and jointed underlying limestones. So much of this water as finds its way to the river emerges again in the many springs for which the valley is noted. The numberless terminal twigs of the upper branches of the Yellow river are spread out, fan-like, over the greater part of Bloomfield, and the southern sections of Frankville township, and carry off the surface waters from this small basin in the southeastern part of the county.

A narrow strip, embracing a few sections of land along the northern edge of Highland and Hesper townships, lies beyond the north rim of the Upper Iowa basin and drains into the Root river system in Minnesota. Southwest of the Cresco-Calmar ridge the surface is drained by the Turkey river, which flows almost parallel to the upper course of the Upper Iowa and, like the Upper Iowa, has few tributaries of any importance in Winneshiek county. Practically all of Jackson township and the western part of Sumner present the characteristic topography of the typical Iowan drift plain. There has been no erosion, and drainage is effected by the flow of surface waters along very broad, shallow sags, products of glacial moulding and not of erosion, which here take the place of definite stream courses.

STRATIGRAPHY.

Geographic Relations of the Strata.

Winneshiek county, as already noted, has a greater number of geological formations than any other county in the state; and owing to the fact that the drift mantle is thin or wholly absent along, or near to, the main drainage courses north and east of the Cresco-Calmar ridge, the rock exposures in this part of our area are numerous and in the main satisfactory. The greater number of the formations have their outcrops in the northeastern part of the county. All the exposures from which our knowledge concerning six of the geological units recognized among the indurated rocks of this area is derived, are grouped in Highland, Hesper, Canoe, Pleasant, Glenwood, and Decorah townships. Two more formations, the Galena and the Maquoketa, have outcrops within these same townships, and so the remaining fourteen townships add but two additional units to the list, the Niagara and the Middle Devonian limestones.

Residual cherts and the dark, tough residual clays, called geest by McGee, are best developed in the eastern townships where the drift is thin or never was deposited. In the western part of the county the residual materials, which constituted the preglacial soils, were either scoured away by the earlier ice sheet, or were covered and concealed by the load of detritus which it carried and deposited. Kansan drift and loess, as surface deposits, are seen only east of the very irregular line which marks the border of the Iowan; the Iowan drift is thin, scarcely ever seen in vertical sections, and is limited, geographically, to the western portion of the county. Along the valley of the Upper Iowa or Oneota river below Decorah there are extensive valley trains and terrace deposits, some belonging to the time of melting of the Kansan ice, some of much later age to be correlated with the Iowan.

SYNOPTICAL TABLE.

GROUP	SYSTEM	SERIES	STAGE	FORMATION
Cenozoic.	Pleistocene	Recent		Alluvium.
		Glacial	Iowan	Iowan loess.
				Iowan sand terraces.
				Iowan drift.
			Kansan	Post-Kansan loess.
				Buchanan gravels.
				Kansan gravel terraces.
				Kansan drift.
				Residual materials, Geest.
Paleozoic	Devonian	Middle Devonian	Cedar Valley	Lithographic limestone, etc.
			Wapsipinicon	Up. Davenport limestone.
	Silurian	Niagara	Hopkinton	Hopkinton limestone.
	Ordovician	Trenton	Maquoketa	Brainard shale.
				Ft. Atkinson limestone.
				Clermont shale.
				Elgin shaly limestone.
			Galena	Galena limestone.
			Platteville	Decorah (Green) shale.
				Platteville limestone.
		Canadian	Saint Peter	Glenwood shale
				Saint Peter sandstone.
			Lower Magnesian limestone of Owen	Shakopee limestone.
				New Richmond sandstone.
				Oneota limestone.
	Cambrian	Potsdam	Saint Croix	Jordan sandstone.

New Names Used in the Synoptical Table.—In the foregoing table some new names are used. The reasons for their introduction will appear in connection with the discussion of the individual formations to which they apply. The term Post-Kansan Loess is used for an old, altered loess deposit which lies on the Kansan drift, but is much older than the better known and more widely distributed Iowan loess. This old loess has been noted by Shimek in some recent papers, but this is the first time it has been recognized in these reports. The Hopkinton stage of the table is the same as the Delaware stage of earlier reports. Delaware, as a name for a geological formation, was preoccupied, having been used by Professor Orton for a member of the

Devonian system of Ohio, in 1878, and the term, Hopkinton, is here substituted for it as a designation for the phase of the Silurian represented in Delaware county, Iowa. The formation is well illustrated in the bluffs and quarries near Hopkinton. The unique development of the Maquoketa in Fayette and Winneshiek counties, as will appear from the general description of this formation in pages following, requires the use of four terms to denote the several units into which it is naturally divided in this part of Iowa. The persistent body of shale between the two parts of what has generally been called the Trenton limestone, is named Decorah shale from the city in which it is typically developed. Heretofore it has been recognized as a distinct geological unit under the name "Green Shales", first applied to it by the geologists of Minnesota. The term, Platteville, has recently been proposed by Bain to denote the lower part of the assemblage of strata for which the term, Trenton limestone, has been so generally used by Wisconsin, Minnesota, and Iowa geologists. The body of shale between the Saint Peter and Platteville, described as the "Basal Shale" in earlier reports and supposed to represent the initial phase of the Trenton series, is developed to a thickness of fifteen feet in Glenwood township, and there shows streaks and bands of sand which indicate relationship with the Saint Peter sandstone. The three units which in the earlier reports on the geology of Wisconsin and Iowa have been grouped under the single term of Lower Magnesian limestone, or Oneota limestone, are here recognized as sufficiently distinct to deserve separate names, and, following McGee and Bain, the term Oneota is limited to the lower division, and New Richmond and Shakopee are used for the other two units with the limitations given to them in the later reports on the geology of Minnesota. Owen's original name, the Lower Magnesian Limestone, which has so long been used and is so universally known among geologists, is tentatively retained for the stage represented by these three distinct units. This will occasion no confusion, and may be allowed to stand until some acceptable geographic term has been proposed as a substitute. All the other names in the table have been used in earlier reports.

Four systems of indurated rocks, the Cambrian, Ordovician, Silurian and Devonian, are represented in Winneshiek county. Three of these, however, the Cambrian, Silurian and Devonian, are not here developed with any degree of completeness; the beds belonging to each are, in the aggregate, very thin, and the areas which they respectively occupy are relatively small. The main body of rocks in the area under consideration belongs to the Ordovician. The total thickness of the Ordovician sediments is more than 800 feet; the aggregate thickness of the other three systems, so far as they are developed within the limits of the county, does not exceed 300 feet.

CAMBRIAN SYSTEM.

Potsdam Series.

JORDAN SANDSTONE.

The Jordan sandstone, the upper member of the Saint Croix stage of the Upper Cambrian, is confined to two small areas in the eastern edge of the county. One of these is in the valley of Bear creek, in the eastern part of section 25, Highland township. For about one-fourth of a mile west of the county line the upper twenty or thirty feet of the Jordan is exposed at the base of the bluffs which rise from the edge of the water on the south side of the creek. On the north side of the valley the bluffs are some distance from the stream, the slopes are comparatively gentle, and the beds are largely concealed with rock waste and sod; but at one point, in the southeast quarter of the northeast quarter of the section named, the wagon road has cut into, and exposed the sandstone. In the lower part of the exposures the formation is composed of coarse, friable, quartz sand, without very definite bedding, imperfectly cemented, and dull and dingy in color. Higher up there are beds of sandstone alternating with limestone or dolomite, and there are other beds consisting of clean quartz sand, with grains well rounded and water worn, embedded in a calcareous matrix. These last beds constitute the "calcareo-siliceous oolite" referred to by Owen in his "Report of a Geological Survey of Wisconsin, Iowa, and Minnesota", pages 49 and 52. They are limited to a zone of about twenty feet immediately below the overlying Oneota magnesian limestone, and represent the somewhat gradual transition from conditions favoring the accumulation of sandstone to the deeper, clearer, more quiet seas in which the formation of limestone became possible. At Quandahl, about a fourth of a mile east of the county line, the purely sandstone phase of the Jordan is exposed for a thickness of thirty feet. Owing to the fact that the valley of the stream descends rapidly to the east while the beds have a slight dip to the west, only a few feet of the sandstone below the transition beds are seen at this locality in Winneshiek county. In reality the strata in this part of the county have a northerly, as well as westerly dip. There are many springs along the south side of the valley of Bear creek in this immediate vicinity, but none on the north.

The second exposure of the Jordan sandstone occurs in sections 24 and 25 of Pleasant township. The upper fifty feet of the sandstone, including the transition beds, are exposed in the bluffs of the river, near the county line, in the northeast quarter of the northeast quarter of section 25 of the township named. The river bluffs here are simply an extension of the bluffs on the north side of the valley of Canoe creek, for at the point where the river receives the tributary, it turns so as to flow for a short distance parallel to the course of the smaller stream. The beds here dip strongly to the west, and in consequence the sandstone disappears in the bluffs of Canoe creek a short distance above its mouth. Exposures of the Jordan extend up the valley of the small stream that traverses section 24, almost to the center of the section, where, owing to the increasing hight of the valley and the westward dip of the formation, the sandstone passes out of sight beneath the basal ledges of the Oneota. The characteristics here are the same as in the valley of Bear creek. The Jordan sandstone has no economic significance; it has furnished no fossils in this county; it adds no special feature to the topography.

ORDOVICIAN SYSTEM.

Canadian Series.

ONEOTA LIMESTONE.

The Jordan sandstone, described above, is the upper part of the Potsdam of the earlier writers on the geology of Iowa and Wisconsin, the upper part of Owen's "Lower Sandstone", the upper part of the "Saint Croix Sandstone" of the more recent reports on the geology of Minnesota and Iowa. Between the top of the Jordan and the base of the Saint Peter sandstone there lies an assemblage of beds, mostly dolomites, all of which were included by Owen in his "Lower Magnesian Limestone." The term, Lower Magnesian Limestone, has been used in the same sense in which it was used by Owen in later works by Hall, White, Chamberlin and many others. The fact that the formation described by Owen under the designation noted was, in places, divided into three distinct units by the interpolation of a thin deposit of sandstone between an upper and a lower body of magnesian limestone, seems to have been overlooked by the earlier geologists. This arenaceous member, however, varies greatly in thickness, and in some cases it appears to be entirely absent; but when it is present it is the practice, in recent literature, to follow the Wisconsin and Minnesota geologists and call it "The New Richmond Sandstone." The body of dolomite between the New Richmond and the Saint Peter formations has been named "The Shakopee Limestone" in the geological reports of Minnesota, while McGee has proposed the name "Oneota Limestone" somewhat indefinitely, but apparently for the heavy deposits of dolomite lying between the Jordan and New Richmond sandstones. It is true that in his table of formations in the region covered by his memoir on *The Pleistocene History of Northeastern Iowa*, on page 334 of the *Eleventh Annual Report of the United States Geological Survey*, Part I, McGee uses the term, Oneota, as the equivalent of all the formations between the Potsdam and the Saint Peter, but McGee's Saint Peter is not the Saint Peter of Owen or of authors generally who have written on the geology of this part of the Mississippi valley. On page 332, and elsewhere in the work cited, he extends the Saint Peter downwards so as to make it include the Shakopee and New Richmond formations, thus leaving only the lower member of the old "Lower Magnesian Limestone" to which the term Oneota was applied.

The Saint Peter sandstone, as defined by Owen, is a natural and consistent geological unit sharply set off from the beds both above and below it. It has nothing genetically or structurally in common with the Shakopee limestone on which it rests, nor has it anything more than the fact that it is composed of quartz sand to ally it to the New Richmond. Accordingly, in the recent reports on the Geology of Iowa, the term Saint Peter has been restricted to the definite and characteristically individual body of sandstone to which it was originally applied by Owen. At the same time, owing to the inconstancy of the New Richmond, its frequent entire absence, and the consequent occasional blending into one of the two bodies of dolomite between which it normally lies, McGee's term Oneota was extended to make it the exact equivalent of Owen's "Lower Magnesian Limestone." In Winneshiek county, however, as well as in many other portions of the area over which it is distributed, the New Richmond sandstone is very persistent, and in some places it attains a thickness entitling it to recognition as a distinct stratigraphic unit. For which reasons, as well expressed by Bain in his report on the *Zinc and Lead Deposits of Northwestern Illinois,* Bulletin No. 246, U. S. Geological Survey, page 18, "It seems well to go back to McGee's definition so far as restricting Oneota to the lower or main dolomite is concerned, and to adopt the Minnesota terms, New Richmond and Shapokee, for the upper beds." Following this suggestion, the term Oneota is here used to denote the great body of dolomite lying between the Jordan and the New Richmond sandstones. Thus limited, the Oneota limestone has a thickness in Winneshiek county of 150 feet. For thirty or forty feet above the base of the formation the dolomite is evenly and regularly bedded, is light buff in color, of fairly uniform texture, is easily shaped by the art of the stone cutter and may be obtained from the quarry in blocks of almost any desired dimensions ranging up to thirty inches in thickness.

The exposures of this quarry horizon in Winneshiek county are not numerous. The beds are seen in the bluffs facing the valley of Bear creek from Highlandville to the county line. Near the mouth of Canoe creek, in section 25 of Pleasant township, the beds are seen above the exposures of the Jordan sandstone, and from the east line to beyond the center of section 24 of the township last named, there are outcrops of the same horizon. The best exposures of the Oneota quarry beds in Iowa are to be found along Bear creek and its branches in Allamakee county.

At Highlandville, a few rods above the north bridge over Bear creek, the upper layers of the quarry beds are seen at the level of the stream. North of the village the higher portion of the Oneota limestone is exposed in a series of bold, vertical cliffs, a part of the system of picturesque scarps and towers and castles which crown the sides of the valleys, with practical continuity, from this point to the Mississippi river. The exposed portion of the limestone begins at the top of a steep talus slope, seventy-five feet above the level of the stream. The rock is a hard buff-colored, vesicular, crystalline dolomite, lacking uniformity, however, with bedding planes largely obscured or completely obliterated, and presenting an appearance of solidity and massiveness. It tends to break into shapeless pieces owing to lack of lamination or bedding planes. No fossils were observed. About ten feet above the base of the cliff there is a band, twelve to fourteen inches in thickness, characterized by numerous lens-shaped vesicles lined with drusy quartz. The vesicles are so arranged as to fall in definite horizontal planes and, at the same time, in vertical columns. Those in one plane are separated from the next above or below by laminæ from one-eighth to one fourth of an inch in thickness. This vesicular zone is continuous for a distance of forty or fifty feet, when it runs into the hillside and disappears. The hight of the cliff is about thirty feet. Above the vesicular layer the rock is more homogeneous and crystalline, and more resistant to the weather, than near the base of the exposure. There are some bands and scattered nodules of chert irregularly distributed through the limestone. The more crystalline parts of the deposit would make a good grade of lime.

In its distribution the Oneota is limited to the deeper valleys in Highland, Pleasant, and Glenwood townships. Exposures in Highland township occur along the north branch of Bear creek, beginning near the southwest corner of section 9; and along Bear creek itself there are many castles and cliffs of this formation, from the center of section 29 (Fig. 3) to the Allamakee

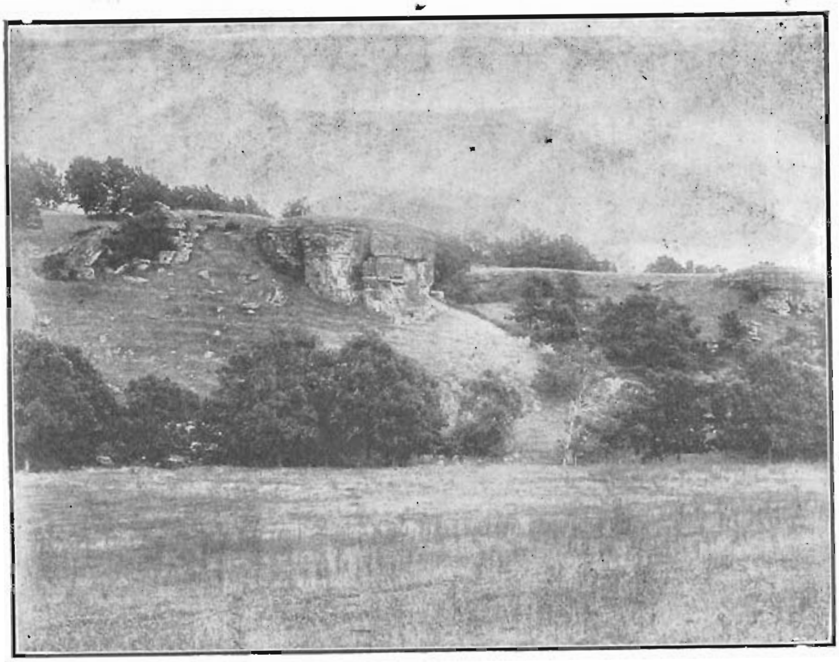


Fig. 3—Castles of Oneota limestome near the center of section 29, Highland township.

county line. In Pleasant township, in section 26, near the village of Canoe, there are characteristic cliffs of Oneota, among the best to be seen in the county. From this point exposures occur along Canoe creek to its confluence with the Upper Iowa river. The valley of the Upper Iowa is bordered by mural cliffs of this lower limestone in sections 25, 35 and 36 of Pleasant township, and in sections 2 and 3 of Glenwood. South of the Upper Iowa the only exposures of Oneota noted occur along the small valley in sections 2, 3, 11, 12 and 13 of Glenwood township.

NEW RICHMOND SANDSTONE.

Like the Oneota formation, the New Richmond sandstone is limited in its distribution in Winneshiek county to Highland, Pleasant and Glenwood townships. One of the best exposures of this sandstone occurs on the north side of the road, a few yards west of the wagon bridge crossing a small stream east of the center of the northwest quarter of the northwest quarter of section 13 in the township of Glenwood. West of the exposure the road ascends with a steep grade and in a short distance rises through the whole thickness of the Shakopee and Saint Peter formations and up into the Platteville limestone. Down the creek a short distance are picturesque precipices of the cliff-forming Oneota. At this point the New Richmond has a thickness of twenty-five feet. Unlike the Saint Peter sandstone, it is regularly and evenly bedded in comparatively thin courses, the courses ranging from two inches to nearly two feet in thickness. The surface of many of the layers is beautifully ripple marked. The whole formation is quite ferruginous, although in some of the thicker layers the iron staining is confined to an inch or two next to the upper and lower surfaces, while the middle portion of the beds is comparatively clean and white. The beds near the bottom are thinner and softer than those near the top of the exposure. Owing to cementation by deposition of dissolved silica in the interstices of the original layers of sand, some of the beds are quite hard, almost quartzitic. Fragments from all the beds sparkle in the sunshine in a characteristic way, due to the fact that, even in beds which are yet quite friable, all the sand grains have suffered secondary enlargement. Each grain became a nucleus around which silica was deposited from solution, and the new growth assumed the crystalline form, with regular crystalline facets. The myriads of such facets catch and reflect the sunlight, giving rise to the peculiar sparkling which distinguishes the New Richmond from all the other sandstones of Iowa. It is true that other sandstones exhibit this same peculiarity, but on a very small scale and in an exceedingly feeble way as compared with the New Richmond. The upper, thicker, harder beds, at the locality under consideration, show the effects of the secondary growth of sand grains more perfectly than the softer, thinner beds below. In the valley of Village creek and along the other streams in the central and eastern part of Allamakee county, the New Richmond shows the characteristics caused by secondary enlargement even better than they are shown in Winneshiek.

There are good exposures of the New Richmond in the dry bed of an intermittent stream, a few rods southwest of the locality in section 13, Glenwood township, described above. Here the water has cut around masses of the sandstone, which show vertical faces six or eight feet in hight (Fig. 4). In the bed of

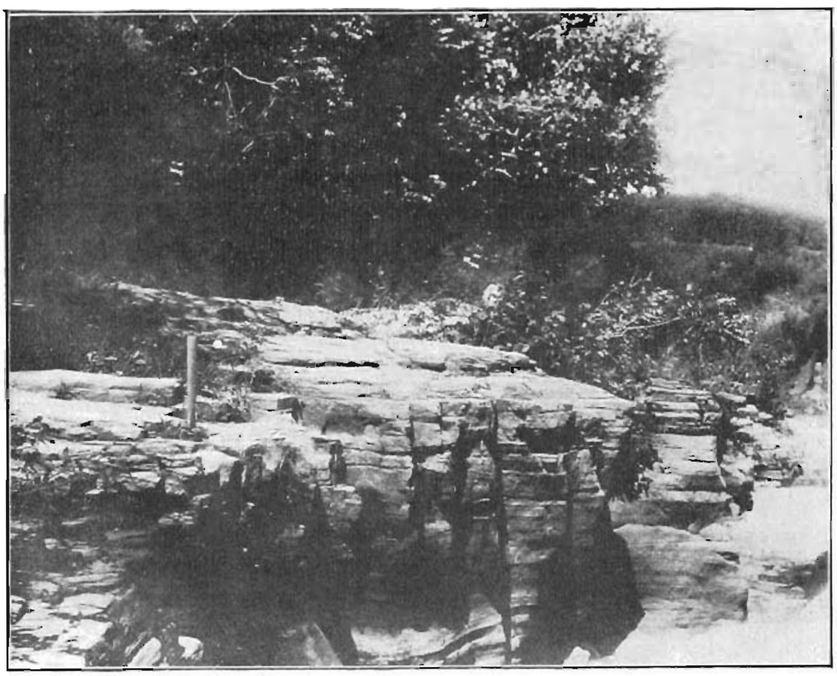


Fig. 4—Exposure of New Richmond sandstone in the northwest quarter of the northwest quarter of section 13, Glenwood township.

a small stream, east of the road, south of the center of section 33, Pleasant township, there is another typical exposure of the New Richmond sandstone. For some distance the sandstone forms the bottom of the channel, but near the line passing east and west through the center of the section it is cut through, and the water flows over the upper surface of the Oneota dolomite.

There is a thin shaly parting between the Oneota and the New Richmond. In the bottom and sides of the little stream channel the whole section of the sandstone is here well disclosed. As usual, it is very ferruginous, it is evenly bedded, ripple marked surfaces are common, and the effects of secondary enlargement of the sand grains are quite well displayed. About the middle of the section there is a calcareous or dolomitic band, four feet in thickness, which weathers very rapidly. It is composed, in large part, of layers in which there is a relatively small amount of clean, clear, quartz sand embedded in a calcareous matrix. The resemblance to some portions of the transition beds between the Jordan sandstone and the Oneota, is quite exact. Commingling and interbedding of arenaceous and calcareous layers occur toward the top of the sandstone, making a gradual transition from the New Richmond to the overlying Shakopee. There are good sections of the New Richmond on the north side of the small stream valley passing through the southwest quarter of section 10, Pleasant township.

There are numerous other exposures of the New Richmond sandstone in the county, most of which have been brought to light by the wash and wear along the public roads. Not very many of them, however, show the characteristics and thickness of the formation very satisfactorily. One near the village of Canoe, not far east of the center of the southeast quarter of the southeast quarter of section 27, Pleasant township, exhibits the pecularities due to secondary enlargement of the constituent grains rather better than most of the other outcrops. Probably the most westerly exposure of this sandstone is that in the southwest quarter of the northwest quarter of section 30, Pleasant township. In Highland township there are exposures of New Richmond as far west as the center of section 30, but these are fully one-fourth of a mile east of that noted in the next township south. North of Highlandville the New Richmond crops out at numerous points as the road ascends and descends the hills and the line of relief intersects the plane in which the sandstone lies. Of these the one near the northeast corner of the southeast quarter of the northeast quarter of section 21, shows the beds most perfectly. The exposures near the center of section 30, Highland township, show a fairly good section of New Richmond, twenty feet in thickness. Here are all the usual characteristics of thin even beds with ripple marked surfaces and the others noted above. Toward the top the sandstone is interbedded with cherty limestone.

SHAKOPEE LIMESTONE.

The Shakopee limestone has essentially the same distribution as the Oneota and the New Richmond. Outside of the townships of Highland, Pleasant and Glenwood there are a few exposures in the valley of the Upper Iowa, in section 12 of Decorah township. In general the Shakopee resembles the Oneota in color, texture and composition. Everywhere it is dolomitic or strongly magnesian. In some cases, however, it is lighter in color, softer, less granular, less crystalline than the Oneota. It has no beds capable of furnishing a very desirable grade of quarry stone, and few that can be recommended for the manufacture of lime. On the whole it shows less tendency to form scarps and cliffs; it is more frequently rounded off into slopes covered with rock waste; owing to lack of cliff-forming qualities, good natural sections are very rare. In thickness it varies from fifty to eighty feet. The base of the Shakopee is not very sharply defined for the reason that, through a thickness of several feet, there are calcareous beds interstratified with beds of sandstone, or the limestone layers are composed of quartz sand embedded in a calcareous matrix. On the other hand, at the top of the Shakopee, in at least one instance—namely, a short distance west of the center of section 21, Glenwood township—the transition to the Saint Peter is made through a series of thin alternating calcareous and arenaceous layers.

In the bed and banks of a dry gully, where it is crossed by a bridge in the northwest quarter of the northeast quarter of section 27, Glenwood township, there are exposures which show the following succession of strata:

	FEET.	INCHES
9 Thin bedded dolomite, rather soft, non-crystalline...	2	
8 Dolomitic bed crowded with the peculiar problematic fossil which, in the report on Allamakee county, was referred to Hall's genus Cryptozoon	1	2
7 Thin bedded, soft, earthy limestone................	3	
6 Soft, yellowish, earthy limestone in irregular layers, containing some specimens of Cryptozoon....... ...	2	
5 Thin band of shale................................		1
4 Sandstone, some of it quite hard, almost quartzitic in places, not uniform........................		3
3 Bluish green shale..................		6
2 Gray, porous, calcareous rock showing numerous small cavities about the size of sand grains.........	2	
1 Arenaceous shale......	1	

Numbers 1 to 5 of the above section constitute part of the beds of transition from the New Richmond to the overlying dolomite. Beds 6 to 9 belong to the Shakopee. The peculiar structures referred to the genus Cryptozoon, which occur in Nos. 6 and 8, are quite characteristic of this lower part of the Shakopee in northeastern Iowa and the adjacent parts of Wisconsin and Minnesota. Each colony is made up of superposed, broadly and gently arching laminae, while each lamina is ornamented on its upper surface with numerous contiguous monticules which vary in different colonies from half an inch to two inches in diameter. Some of the colonies attain a large size, measuring six to eight feet in length and width and more than a foot in thickness. The general appearance is that of gigantic stromatoporoids.

Erosion by the wet weather stream which carries off storm waters from the little valley followed by the road in the west half of the southeast quarter of section 16, Glenwood township, has revealed the Cryptozoon bed, No. 8 of the foregoing section, and in the hillside, twenty to thirty feet higher are outcropping, thick ledges of hard crystalline dolomite in which are many pockets of calcite. Farther up the slope there are unsatisfactory exposures of the Saint Peter sandstone, but the Shakopee beds above and below the hard outcropping ledges just mentioned, are concealed by the mantle of waste.

The Shakopee limestone, with an indicated thickness of eighty feet between the base of the Saint Peter and the top of the New Richmond, is exposed in small isolated patches along the state line road, on practically the north line of section 8, Highland township. The same thickness is indicated between outcrops of the two sandstones in sections 24 and 25 of the same township. In the northwest quarter of the northwest quarter of section 13, Glenwood township, there is only fifty feet of vertical space for the Shakopee between the two sandstones cropping out on the eastward facing hill slope, and in section 10 of Pleasant township the Shakopee appears to be reduced to even less than fifty feet in thickness. The formation is indeed quite variable in all of its characteristics.

SAINT PETER SANDSTONE.

The Saint Peter sandstone is one of the most consistent and most easily recognized of all the geological formations in Iowa. Normally it is made up of clean, transparent, well rounded and polished grains of quartz. Owing to the almost universal presence of a small amount of iron oxide in this sandstone in Winneshiek county, the color here is red, yellow or brown instead of the pure white, which prevails in the absence of any staining agent. Cementation is imperfect. Cohesion is so feeble that the deposit may be dug into with pick and spade quite as easily as in the case of some mantle rocks. Specimens collected for the museum are likely to crumble into loose grains of sand before reaching their destination. There is no definite lamination or bedding; the whole deposit, in many instances, may be looked upon as a single, homogeneous, massive bed of sand that was laid down without break or interruption between the beginning and the end of the process. Occasionally there are obscure indications of bedding planes at intervals of ten or fifteen feet, but there is no such division into definite layers as may be seen in the thin-bedded, ripple-marked New Richmond. Secondary enlargement of the sand grains is something very unusual.

The Saint Peter forms rather steep slopes at all of its exposures. For a few inches beneath the sloping surface exposed to the air the sand is dried, and a small amount of cementing material has been precipitated, with the result that the outer shell is a little firmer than the moister, deeper parts which have been saturated with water ever since the sand was deposited. Wherever the sandstone is exposed, a sort of pseudo-lamination is developed nearly parallel to the sloping surface. Not infrequently this gives an appearance of cross bedding as a feature of the original structure, but it is due in all cases to a process akin to exfoliation. The dried, outer shells, of practically uniform thickness, scale off from the moister sand beneath. The upper surface of the Saint Peter, for a few inches or a few feet, may be firmly cemented with iron oxide. This is particularly true in areas from which the overlying Platteville and Galena limestones have been removed by solution. These limestones normally contain quite an amount of pyrite which, during the process of weathering and liberation by solution, is oxidized, and the oxide is carried downward and deposited in the upper portion of the insoluble sand. At the lower limit of the formation there is, in at least the one case noted in the discussion of the Shakopee, an interbedding of sand and dolomite.

At all exposures of the Saint Peter there is a bed of shale of variable thickness and texture between the mass of sandstone and the overlying Platteville limestone. Since this shale is usually quite smooth and plastic, without traces of sand, and in all respects identical with beds of shale found at various horizons throughout the Trenton, in the reports on Allamakee and Dubuque counties it has been regarded as the lowest member of the Trenton series. At Specht Ferry, twelve miles above Dubuque, this shale does not exceed three feet in thickness; in Allamakee it rarely has a thickness of more than five or six feet. At Minnehaha falls and in the gorge of the Mississippi below Minneapolis the shale bed is even thinner than at any observed point in Iowa. All the observations so far published indicate the most abrupt transition from the conditions recorded by the typical phase of the Saint Peter sandstone to conditions favoring the accumulation of sediments characteristic of the next overlying series. In the southeast quarter of the southwest quarter of section 6, Glenwood township, there is an exposure which shows some features of the upper part of the Saint Peter not heretofore recorded. The sandstone phase is overlain by a bed of shale fully fifteen feet in thickness, and the lower eight or ten feet of this is highly arenaceous. Some thin bands at intervals of a foot or more are almost pure sand. The sand grains in the shale are of the same clear, worn and polished type as those making up the main body of the sandstone deposit. The upper part of the shale bed is quite free from sand and resembles the "basal shale" referred to the Trenton series in Allamakee and Dubuque. The lower arenaceous part should, without any doubt, be regarded as the closing phase of the Saint Peter stage. Owing to the unusual thickness which it here attains it seemed desirable, in order to show the exact succession of stratigraphic units, to give the shale a place in the column of formations in the synoptical table on page 60, and hence it appears under the name of Glenwood shale. The great development of arenaceous characters has led to placing it with the Saint Peter. Below the shale bed, sandstone of the normal phase of the Saint Peter is exposed for a thickness of about thirty feet. The deposit is all stained with iron oxide to a greater or less extent. Over parts of the exposed surface exfoliating laminae are developed; elsewhere the deposit breaks down into incoherent sand without passing through a laminated stage.

One-fourth of a mile north of the locality described above, the entire thickness of the Saint Peter is exposed in a steep ravine which, beginning on the west side of the road and extending to the east shows:

		FEET
11	Galena limestone in courses of variable hickness. Only the lower beds exposed	20
10	Decorah shales, gray, greenish or bluish in color, with embedded thin layers, lens-shaped slabs and nodules of limestone; near the top it contains Prasopora and related bryozoa, with *Orthis tricenaria*, *Orthis subaequata* and other "Green Shales" types farther down	15
9	Platteville limestone in a number of hard ledges ranging from three to eight inches in thickness	4
8	Thinner Platteville, brittle bluish layers with thin shaly partings, the "glass rock" of some authors	20
7	Platteville limestone represented by yellow magnesian layers rarely more than eight inches in thickness. The "Lower Buff Beds" of authors	5
6	Glenwood shale between the Platteville limestone and the normal phase of the Saint Peter sandstone, arenaceous toward the bottom, more purely argillaceous above. Should probably be divided into two parts, the upper to be classified as Platteville, the lower as Saint Peter	10
5	Iron-stained Saint Peter sandstone without definite bedding, presenting the normal characteristics of the formation except that there is more than the usual amount of coloring	30
4	Iron-stained Saint Peter sandstone, not separated from No. 5 by any definite bedding plane, but distinguished by the presence of great numbers of vermicular tubes one-fourth of an inch in diameter; some partly open, but generally they are filled with darker, more ferruginous sand	10
3	Iron-stained Saint Peter sandstone distinguished from No. 4 by the absence of the "worm burrows"	20
2	Basal part of Saint Peter, not well exposed	10
1	Ledges of dolomite belonging to the upper part of the Shakopee limestone	4

It is possible that No. 2 may not all belong to the Saint Peter sandstone, but in any event the thickness of the formation at this point is between sixty and seventy feet. Near the middle of the south line of the southwest quarter of section 10, Pleasant township, there is an exposure of the sandstone showing a thickness of seventy feet. At this point the formation contains a great number of cylindrical or fusiform concretions, a feature quite unusual in this county. In the northwest quarter of the northwest quarter of section 13, Glenwood township, the thickness of the sandstone, as ascertained by repeated barometric measurement, is only sixty feet. Near the northeast corner of the southeast quarter of section 20, Glenwood, there is a good exposure of the upper part of the sandstone showing contact with the Platteville. The lower part is concealed in the long, gentle slope occupying the space between the steep bluffs in the eastern edge of section 20 and the stream which flows north through section 21. What appears to be the upper surface of the Shakopee limestone is exposed near the stream, a very good exposure occurring in the low, steep banks south of the road, and barometric readings show a difference of only fifty-five feet between the Platteville beds on the one hand and the Shakopee on the other. The apparent diminution in the thickness of the Saint Peter at this point is accounted for, in part at least, by the dip of the strata toward the south and west. At the other observed localities where the Saint Peter is exposed in this county, the thickness of the formation is not definitely indicated. Usually the upper surface is clearly defined, for, in general, the sandstone occurs in ridges or affects steep slopes, and may, or may not, be capped with the Platteville limestone; the contact with the underlying dolomite is generally concealed by the gradually thickening mantle of rock waste toward the foot of the declivity.

As to distribution, it may be said in general that the Saint Peter sandstone is exposed in an area lying southwest of the outcrops of the formations previously noted. The regular southwest dip of the strata, which prevails generally throughout eastern Iowa, is interferred with by a low anticline passing northwestwardly through Sattre and Locust in the northeastern part of Pleasant township. North of this axis the dip is toward the northeast; on the other side the dip is regular and throws the exposures of the Saint Peter toward the southwest. The belt in which the sandstone comes to the surface passes northwestward through the central part of Glenwood township, includes the northeastern corner of Decorah, the eastern part of Canoe and Hesper, the central parts of Pleasant, and the northwestern part of Highland. Owing to the reversal of the dip the Saint Peter is overlain by beds of the lower Trenton series in the northeast corner of Highland township. Outcrops of the Saint Peter sandstone have been already noted in sections 6, 13 and 20 of Glenwood township. Others were observed in the stream valleys in sections 21, 27 and 28. Northward to the Upper Iowa river, the valleys are cut below the level of this formation; the higher land toward the south is occupied by the Platteville and Galena limestones. In Decorah township exposures of the sandstone begin in the bluffs of the river between Decorah and Freeport. A few rods northwest of the Freeport bridge there is a steep cliff made up in part of the Saint Peter and in part of the Platteville limestone. The top of the sandstone has an altitude of seventy feet above the water in the river, and the thickness exposed to the top of the talus slope is fully forty feet. The overlying shale bed is less arenaceous than in section 6 of Glenwood township, and the thickness is reduced to twelve feet. The lower part of the bed is leaner and more gritty than the "basal shale" of the counties of Allamakee and Dubuque. Red, yellow and brown colors prevail in the sandstone; very little of it is white. Other exposures of the sandstone in this township occur in the low valleys tributary to the river below Freeport. On the south side of the river there is quite a cliff of the sandstone parallel to the road in the northern and northeastern part of section 24. The southwest dip is here very strong, and though the sandstone rises seventy feet above the stream at Freeport, it has descended below the bottom of the river at Decorah. The sandstone is well exposed in the eastern part of Canoe township. The most extensive continuous cliffs of this formation seen anywhere in the county occur in the southern part of section 13 and the northeastern part of 15. The last exposure of the Saint Peter, toward the northwest, was seen in a little valley on the state line, in section 10 of Hesper township.

Some of the surface features controlled by the Saint Peter sandstone have been previously noted in the chapter on Topography. The prominent salient (Fig. 5) in section 12,

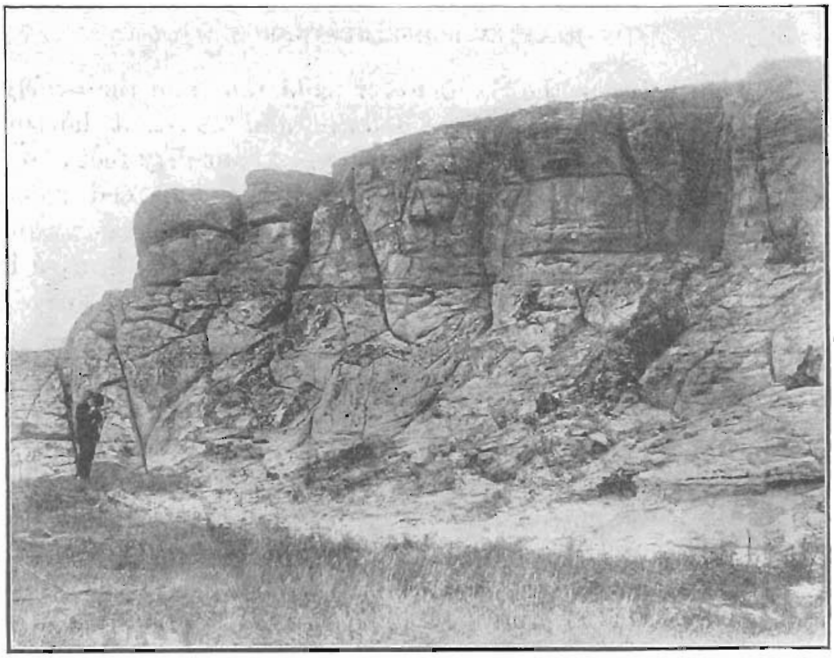


Fig. 5 Salient of Saint Peter sandstone, showing numerous joints, in the northwest quarter of section 12, Hesper township.

Hesper township, is from twenty-five to thirty feet in hight. It is jointed and seamed far more than is usually the case in this formation. It illustrates the tendency of this sandstone, uncemented and incoherent though it is, to form cliffs and steep slopes, to recede by wasting from the side rather than from the top. Extending for quite a distance all around the foot of the exposure, the soil is simply a bed of loose sand, and here flourish desert plants or sand-loving plants of kinds found nowhere else in Iowa except in waste from the Saint Peter sandstone.

From an economic point of view the Saint Peter sandstone of Winneshiek county has but little to offer. At none of the observed exposures was it free enough from staining matter to make it suitable for the manufacture of clear white glass, a use to which it is well suited and extensively applied in many other localities.

Trenton Series.

PLATTEVILLE LIMESTONE.

The shale between the Saint Peter sandstone and the overlying limestones marks a very definite and constant horizon throughout the upper Mississippi valley. About fifty feet above the top of the sandstone there begins another shale bed which, in the geological reports of Minnesota, has been generally referred to as the "Green Shales." The same name is used in the report on Dubuque county, Iowa; Iowa Geological Survey, Volume X. This second shale bed is equally constant and equally definite, and has the further advantage of being characterized by a distinct fauna of which Conrad's *Orthis tricenaria* and *Orthis subaequata* are perhaps the most common and most easily recognized types. Between the two shale beds lies a body of limestone; and a second, thicker body of limestone overlies the "Green Shales." Disregarding for the moment the first shale, which lies immediately on the Saint Peter, there are here three formations sharply set off one from the other, and having an aggregate thickness of approximately 300 feet. While the faunal relations of the three are quite intimate, they are each sufficiently distinct and sufficiently important stratigraphically to deserve rank as separate geologic units.

In the past there has been an unusual amount of confusion relative to the names which should be applied in this part of the geological column, either to the assemblage of strata as a whole or to its several parts. In the report on Dubuque county, Volume X, pages 402-411, the reader will find a discussion of the discrepent views expressed by geologists concerning the limits within which certain terms may be applied, together with the probable causes which have led to such remarkably wide differences of opinion. While the work of Hall in Iowa and Wisconsin, with its masterly insight into paleontological relationships, led, properly enough, considering the state of the science at that time, to the almost universal practice of calling some or all of these beds Trenton, it is not now certain that all together, or any part of them, can be regarded as the exact equivalent of the Trenton limestone of New York. Furthermore, as will be seen by a perusal of the literature cited in the report on Dubuque county, the "Trenton" as defined in one state or county in the Mississippi valley, has not always been the exact equivalent of the "Trenton" as defined in some other state or county not far away. The body of limestone above the "Green Shales" varies greatly in lithological characters, a fact that seems to have been overlooked by the earlier workers. In places it is a heavy-bedded, crystalline dolomite throughout its entire thickness, in other places only part of it is dolomitic; in still others it is a thin-bedded, unaltered limestone from top to bottom. Where completely dolomitized, as in the lead-bearing region around Dubuque, it was separated from the "Trenton" and called Galena limestone, a name that seems to have been based at first on lithology rather than on life zones or on any definitely recognized stratigraphic limits. Accordingly the term, Galena, has been used with as much indefiniteness as the term, Trenton. The more recent work of Winchell, Norton, Bain and others has made it clear that the three stratigraphic units referred to above, while individually showing quite a range of variation in thickness and lithological characters, are yet stratigraphically clearly defined and easily recognized throughout the entire area of their distribution in the upper Mississippi valley. In the interest of clearness it is greatly to be desired that a definite name should be applied to each of these definite units.

Bain has led the way toward definiteness by proposing to divide the assemblage of strata to which the names Galena, Trenton, or Galena-Trenton have been more or less vaguely applied, calling all below the top of the "Green Shales" Platteville* and all above that very definitely marked horizon the Galena limestone. In the region about Platteville, Wisconsin, whence the name, Platteville, is taken, the shaly member seems to be more calcareous than in Iowa or Minnesota, and so the term is made to cover both the shale and the underlying limestone. While retaining the term in the sense in which Bain has used it, it is yet desirable to distinguish between the calcareous

*_Zinc and Lead Deposits of Northwestern Illinois._ By H. Foster Bain, U. S. Geol Surv., Bulletin No. 246, pp 17-20 Washington, 1905 and the argillaceous parts of the deposit, and for the present the limestone member will be called the Platteville limestone, and the overlying argillaceous beds the Decorah shales.

The limestone member of the Platteville is divisible, somewhat arbitrarily, into three parts,—(1) Lower Buff Beds, (2) Thin, Brittle Beds, (3) Thicker, Quarrystone Beds. As a whole, the Platteville limestone is much thinner in Winneshiek county than in Dubuque. The lower Buff Beds, which near Specht Ferry are from sixteen to twenty feet in thickness, are here limited to five or six feet, the individual layers rarely exceeding eight inches; while in Dubuque county, as shown in Plate 5, opposite page 412, some of the beds have a thickness of almost as many feet. The heaviest courses in the Lower Buff Beds in Winneshiek county were seen near Freeport where layers two feet in thickness are found directly above the Glenwood shale. These beds are highly magnesian, yellowish or buff in color, rather soft and earthy as compared with the typical dolomitic phase of the younger Galena but still capable of offering admirable resistance to the disintegrating effects of the weather. Where they have greater thickness and are favorably located with respect to market, they deserve attention as a source of good building stone. No fossils have been found in this portion of the Platteville limestone in Iowa.

The lower Buff Beds are followed by limestone in thinner layers, which are rarely more than three inches in thickness. These beds are bluish in color on fresh fracture; though weathering to gray; fine grained, hard and brittle; not so highly magnesian as the beds below, and quite fossiliferous. The prevailing fossils are small forms of *Rafinesquina alternata* Conrad, and normal forms of *Plectambonites sericea* Sowerby. All the fossils are firmly embedded in the fine grained limestone. Shaly partings of varying thicknesses separate the individual layers. The total thickness of these thin, hard, brittle beds is about twenty feet. They are quarried at a few points, the most important being a large opening at the base of the bluff on the north side of the river at Decorah, but they have little of economic importance to recommend them.

A series of layers varying from four to eight feet in thickness, overlies the thin brittle beds just described. The stone here is evenly bedded as shown in figure 6. It is bluish in color, fine

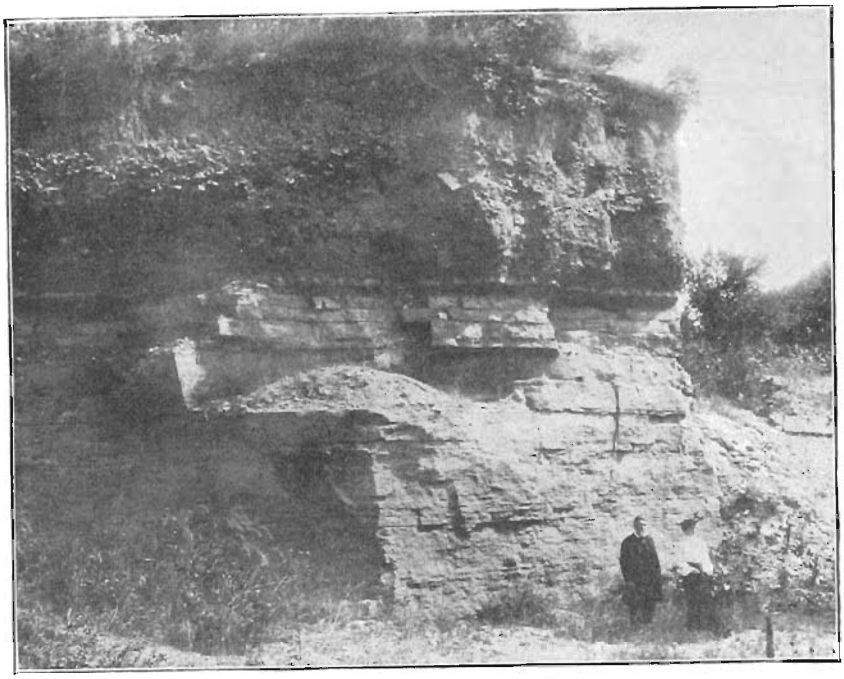


Fig 6 Quarry face in the Platteville limestone; showing the regular bedding toward the top; a small amount of undisturbed Decorah shale overlies the limestone; the upper part of the section is made up of rock waste and loess. Near the north end of the Ice Cave bridge, Decorah.

grained, hard and compact, and is capable of withstanding the disintegrating effects of the atmosphere or alternations of temperature. The layers range in thickness from six to eight inches, and owing to the uniform character of the individual beds and the comparative freedom from joints it is possible to obtain pieces of almost any desired surficial dimensions. In some respects this is the most important quarry horizon in the Trenton series in Winneshiek county. It has been worked quite extensively on the north side of the river at Decorah, in the northeast quarter of section 16. One of the quarries operated by M. T. Halloran in the northeast quarter of section 15, makes use of these same beds. There are a number of quarries worked at this horizon in the vicinity of Hesper, the most active operations at the time the region was visited being carried on at the Weber quarry south of the village. Mr. Weber has been quarrying here for about twenty years, taking out stone at the rate of 250 to 300 cords a year. Since the aggregate thickness of the workable beds is not very great, the area worked over is, consequently, quite considerable. At all the localities where this phase of the limestone is worked, the large orthoceracone which is usually referred to *Endoceras proteiforme* Hall*, occurs not infrequently. Some of the individuals of this gigantic species must have attained a length of twelve or fifteen feet. A fragment of one of these great shells, donated by Dr. Fordyce Worth of Hesper, is five feet in length, ten inches in diameter at the larger end and five inches at the smaller. The entire fragment belongs to the septate part of the shell, no part of the living chamber being included. The depth of the air chambers is relatively small; from twenty-seven to thirty occur in the space of one foot. Another fragment collected near Decorah is three feet long, seven and a fourth inches in diameter at the larger end, and tapers at the rate of one and one-fourth inches to the foot. A piece more than two feet in length, fitting on to the larger end of this specimen, was left in the quarry, and disappeared with the ordinary rubble stone before it could be cared for. Other determinable fossils are rare. The beds are composed chiefly of finely comminuted and firmly cemented brachiopod shells. On the north side of the river near Decorah, large blocks of the compact stone from this horizon were formerly sawed into thin slabs and polished by machinery, the power being furnished by the waters of a large spring which issues from the hillside, thirty feet or more above the level of the valley. The product was a very pleasing quality of "marble" suitable for table tops and interior decorations.

DECORAH SHALE.

Within the limits of the city of Decorah, at numerous points within a short distance of the city, and at practically all the localities where the limestone last described comes to the surface, the shaly member of the Platteville stage is well exposed. The

*In *The Geology of Minnesota, Vol. III, Part II, of the Final Report*, page 777, Professor John M. Clarke refers this species to Conrad's genus Cameroceras.

Decorah shale ranges from twenty-five to thirty feet in thickness. It is everywhere very calcareous, with numerous bands and nodules of limestone distributed through it. A very typical exposure of the shale (Fig. 7) is seen at the foot of the bluff on

Fig. 7 Exposure of the Decorah shale with the overlying basal ledges of the Galena limestone, at the Dugway, Decorah

the left of the "Dugway", the road leading southwest along the river from the west end of Main street. Practically the whole thickness of the beds is here shown. The deposit is more argillaceous toward the base of the section, and becomes quite calcareous toward the top. The contact with the firm, well-bedded, overlying Galena limestone appears in the upper part of the view. Fossils are numerous in the shales. The species noted embrace *Streptelasma corniculum* Hall, *Prasopora simulatrix* Ulrich, and other species of monticuliporoids, some hemispherical, others branching, Lingula, represented by fragments which render specific identification uncertain, *Strophomena incurvata*

Shepard, *Plectambonites sericea* Sowerby, *Orthis tricenaria* Conrad, *Orthis testudinaria* Dalman, *Orthis subaequata* Conrad, *Orthis plicatella* Hall, *Rhynchotrema inaequivalvis* Castelnau, Liospira, species undetermined, and an undetermined species of Orthoceras. The Prasopora is most abundant in a zone, two or three feet in thickness, immediately below the Galena limestone; brachiopods are more common in the middle and lower part of the section.

The Decorah shales were exposed in grading Winnebago street east of the court house, and quite a portion of the deposit may still be seen at this point; they were also cut into during the progress of street work in other parts of the city. They come to view on the north side of the river at and near the mouth of the Mill spring ravine. A short distance east of the ravine, near the residence of John O. Vold, the shale is much more argillaceous, more slippery and sticky and more impervious to water than at the Dugway, and a number of small springs, coinciding in position with the upper surface of the shales, issue from the hillside. The shales overlie the limestones in the west quarry of Mr. Halloran, east of the Ice cave bridge. They are seen at the east end of North street in West Decorah, where they have been exposed by the grading of the roads leading out of the city. There is a good exposure along the roadside in the southwestern part of section 9, Decorah township, and another excellent outcrop is seen near the center of the northeast quarter of section 5. Near the center of the southwest quarter of the northeast quarter of section 20, Glenwood township, and at the same level around the valleys converging towards the central portion of this township, there are numerous points where these shales come to the surface. There are also many exposures of the shales in a belt extending northward through the central part of Canoe township; and in Hesper township the outcrops are many. The lower part of this deposit, underneath some glacial material and local rock waste, occurs above the quarry stone in the Weber quarry, just south of Hesper. The characteristics here are more like those seen in these shales near Waukon in Allamakee county. The shaly part is quite argillaceous, and the calcareous constituents take the form of thin lenses of limestone in some cases composed almost wholly of the unbroken valves of brachiopods cemented together. The very perfect valves of *Orthis subaequata* are by far the most common. *Orthis tricenaria* occurs occasionally; *Orthis testudinaria* and *Plectambonites sericea* are not rare; while very conspicuous, though less numerous than some of the other species, are detached valves of *Strophomena incurvata* and *Strophomena planumbona**. In some instances the limestone lenses are made up of compacted masses of branching monticuliporoids. It is possible that, by proper management, the Decorah shales might become economically valuable in the manufacture of Portland cement. Otherwise, as far as known at present, they are without commercial importance.

GALENA LIMESTONE.

In point of thickness and areal distribution the Galena is the most important body of limestone in Winneshiek county. Its firm, relatively thick basal ledges are sharply set off from the underlying Decorah shales. As a geological unit it is fairly uniform in characteristics throughout our area and throughout its entire thickness. There are some local departures from uniformity to be noted later, but they do not affect the general statement. As a rule the bedding is thin; layers equalling a foot in thickness are rather exceptional. The total thickness of the formation will average about 225 feet.

All the bold, picturesque cliffs facing the valleys around Decorah, are composed of Galena limestone, for the shales below the base of the Galena rise but little above the platform on which the city is built. From the northwest corner of the county to Decorah the Oneota or Upper Iowa river flows, in general, in the direction of the strike of the strata, from which fact it would result that, were it not for the grade of the stream, the floor of the river valley would lie in a plane practically parallel with the base of the Galena. As it is the water in the river and the lower beds of the limestone are at the same level a short distance above Decorah, and from this point northwestward the stream level

*By many authors the *Strophomena planumbona* Hall, has, of late years, been regarded as identical with *S. rugosa* Rafinesque, but the reason for so regarding it is not convincingly apparent.

rises very gradually above the base until, at Florenceville in Howard county, it coincides with the upper beds of the Galena formation. One of the results of the relation existing between the course of the river and the strike of the beds is that the great vertical cliffs which rise at intervals along the sides of the valley between Decorah and Kendallville are all repetitions of a single section; all reveal essentially the same horizons and pass through the same life zones.

In the matter of distribution the Galena limestone appears at the surface in two areas in Winneshiek county. One of these is very small and unimportant, and occupies only a few acres in the valley of the Yellow river, in the northeast corner of section 13, Bloomfield township. The other area is much larger and lies in the northern and northwestern part of the county. The great trench which forms the valley of the Oneota or Upper Iowa river has been cut in this area near its southwestern edge. The belt on the south of the stream is rather narrow; the dip is at right angles to the main course of the valley, and the formation soon disappears beneath the shales and shaly limestones of the Maquoketa stage. In section 9 of Frankville township and section 10 of Springfield the larger area of the Galena reaches its greatest extension toward the south and southeast. North of the river the area, on the average, is wider. It extends to the state line in Fremont and Burr Oak townships, and on northward into Minnesota. Toward the northeast it includes the village of Hesper.

Lithologically the Galena limestone of Winneshiek county differs from the typical Galena around Dubuque in being composed almost wholly of non-dolomitic limestone. There are a few exposures in the northwestern part of the county in which this formation is magnesian and assumes the general aspect of the massive, buff colored, completely dolomitized beds of Galena in the mining regions of Dubuque county, but these outcrops are few and the area in which they occur is quite limited. One of the outcrops is seen a rod or two east of the county line and not far from the south line of section 18, Fremont township. This occurrence is noted in the report on Howard county, Vol. XIII, page 43. Other good examples of the dolomitic phase of the Galena occur in the same township near the southeast corner of section 7. In general, however, the Galena limestone in the northern part of Iowa is not a dolomite. In texture the non-magnesian part of the formation is of much finer grain than the coarsely granular Galena of the lead mining regions farther south. In color it ranges through varying shades of blue, drab or dark gray on freshly broken surfaces, but it weathers to lighter gray, or even buff, under protracted exposure. With the exception of an occasional stratum, or small group of strata, the several layers in the non-magnesian phase of the Galena tend, on exposure to weather or alternations of temperature, to split up into very irregular, thin laminae, which break again transversely into small, shapeless chips. Some portions of the old retaining wall around the court house square in Decorah illustrate this tendency. In the southeast quarter of the southwest quarter of section 9, Bluffton township, there is an exposure showing a few layers of Galena limestone ranging from twelve to fourteen inches in thickness. These show practically no effect of weathering; they are capable of furnishing a very desirable quality of building stone. The heavy ledges just noted are interbedded with shale, one of the shale bands being fully twelve inches in thickness. In the last twenty or thirty feet of the formation toward the top, the layers quite generally show a curiously mottled appearance due to the presence of irregular, yellowish spots, from an inch to an inch and a half in diameter, mingled with the prevailing drab or blue. While this feature is not strictly limited to the upper zone, it is more common there than at other horizons. The stone in these spots is granular and vesicular, easily broken down, and differs conspicuously from the fine grained, compact portions of the limestone surrounding them. In localities where this phase of the limestone has been long exposed, these softer, porous portions have been washed and weathered away leaving the beds marked by irregular pits and caverns and curious tortuous channels. Wherever the observer finds this phase of the Galena limestone well developed, he may be sure that he is not far from its upper limit, from its contact with the overlying Maquoketa.

Good sections of parts of the Galena limestone may be seen in all the bluffs along the river and its few tributaries, from

Decorah northwestward. At no place is the whole thickness to be found in a single exposure. In the vertical scarp at the "Dugway", in the city of Decorah, the basal portion of the formation is seen; and in the slopes above the scarp there are outcrops at intervals up to 160 feet above the base. The highest beds coming to the surface in this vicinity belong to the Gastropod zone described in the report on Dubuque county, and furnish such diagnostic species as *Maclurea bigsbyi* Hall, and *Hormotoma major* Hall. *Receptaculites oweni* Hall, occurs in loose fragments at the gastropod horizon. There are from fifty to sixty feet of the upper part of the Galena not exposed in and around Decorah. Probably the most impressive section of this limestone is to be seen at Bluffton. Here, on the south side of the river, is a great vertical cliff (Fig. 8) more than 100 feet in hight.

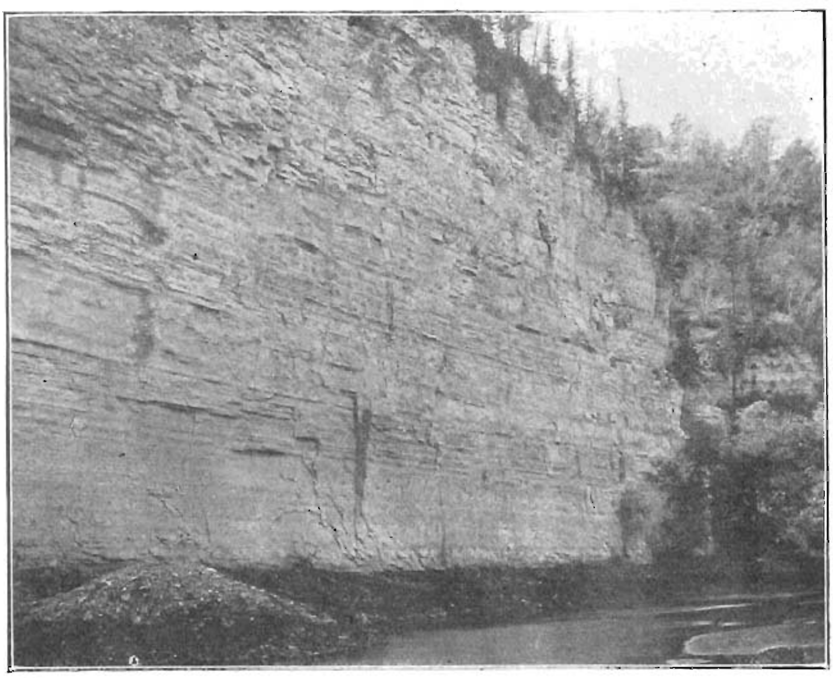


Fig. 8-Cliff of Galena limestone at Bluffton. The face of the cliff coincides with the face of one of the master joints which cut the formation.

It rises sheer from the edge of the water in the river, and its base is only about twenty-five feet above the top of the Decorah shales. The flat, even, vertical face of the scarp coincides with one of the great east-west joints which divide the limestone into massive blocks. The stone is fairly homogeneous throughout the whole front of the cliff, all showing about the same color and the same effects of weathering. There are, however, some softer bands that recede faster than the rest, and between forty and fifty feet above the base there occur the firm, heavy ledges interbedded with shale, noted above as seen in the southwest quarter of section 9. Following the Bluffton-Cresco road, the

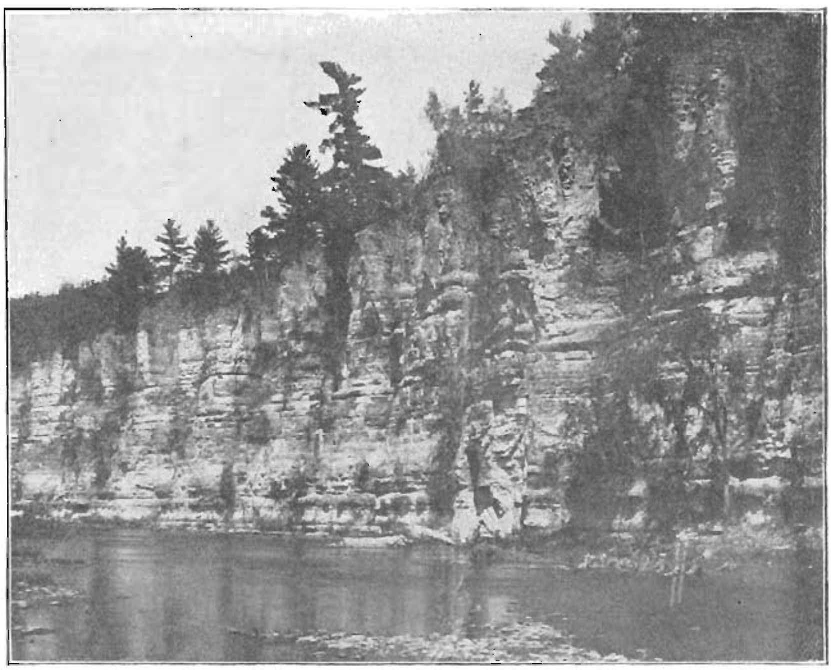


Fig. 9—Cliff of Galena lime tone above the bridge northwest of Bluffton, showing the effects of joints at right angles to the face of the cliff.

gastropod zone with its large forms of Maclurea, Maclurina and Hormotoma, is encountered in the northwest quarter of section 16, at an elevation of 150 feet above the river. *Receptaculites oweni* Hall, occurs here at the same horizon. At the angle of the road, one-fourth of a mile west of the center of section 16, the top of the Galena is reached, and the overlying Maquoketa attains a thickness of forty feet between the plane of contact with the Galena and the summits of the surrounding knobs and ridges. Above the bridge west of Bluffton there is a cliff of Galena trending north and south through the middle of the east half of section 9, in which the limestone is developed into strikingly regular columns on account of solution and weathering along the east-west joints which here cut the face of the cliff at right angles. The effect of these joints will be appreciated if this cliff (Fig. 9) is compared with the one trending east and west (Fig. 8) a short distance below. East of the village of Plymouth Rock, in section 35, Fremont township, the river flows southward at the foot of a cliff (Fig. 10) having the same direc-

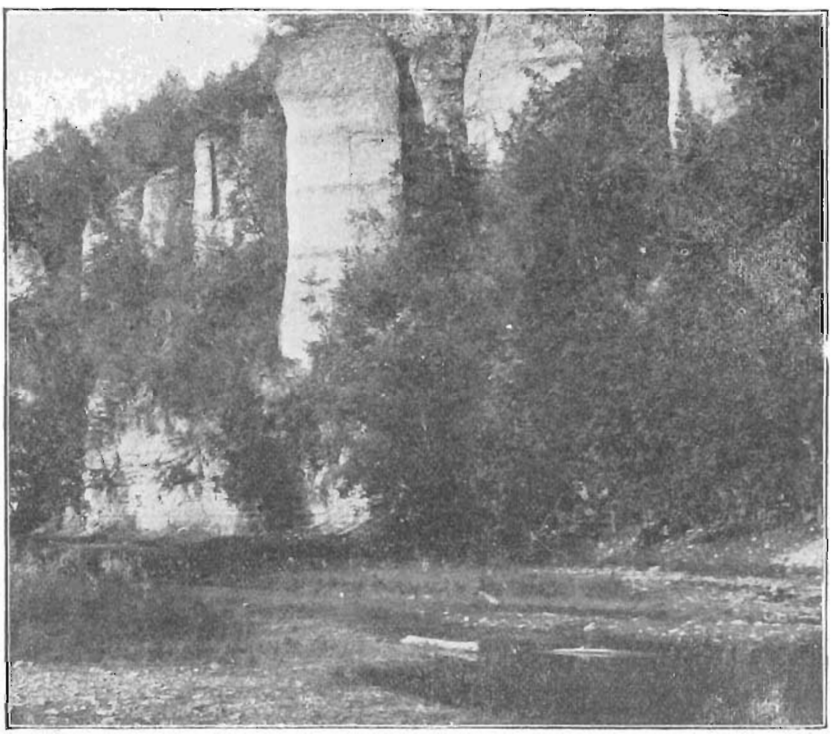


Fig.10—Columns of Galena limestone at Plymouth Rock, produced by weathering along joints which cut the rock at right angles to the face of the cliff

tion and the same general appearance as that above the bridge at Bluffton. The great rounded columns, due, as in the preceding case, to the influence of joints which cut the beds at right angles to the cliff face, are, in some respects, even better developed than at the locality farther down the stream. As usual the beds show only very slight differences in characteristics from top to bottom of the section; the greatest departure from the prevailing type of fine grained, light gray or pale buff limestone is found in a zone fifteen feet in thickness, ranging from sixty-five to eighty feet above the base of the cliff, in which the rock approaches a dolomite in general appearance. The contact of the Galena with the Maquoketa, which may be seen in a number of erosion gullies on the slopes east of the brow of the cliff and is well displayed about the middle of the west line of section 36, occurs at an elevation of 120 feet above the level of the river. This would leave about 100 feet of the formation unexposed below the bed of the stream.

In the badly weathered layers near the foot of the cliff, at Plymouth Rock there are a few corals belonging to the genus Streptelasma and an occasional specimen of *Hormotoma trentonensis* Ulrich & Schofield. Thirty feet above the base there are beds containing *Fusispira elongata* Hall, and *Hormotoma major* Hall. The upper Receptaculites zone begins about ten feet higher, and the species, *Receptaculites oweni* Hall, ranges through a thickness of fifteen feet. Some specimens of Maclurina occur in beds overlying the zone of Receptaculites.

There are a few rather conspicuous and persistent life zones ranging through the Galena limestone in Winneshiek county. Two of these are characterized by the abundance of *Receptaculites oweni* Hall. The lower Receptaculites zone occurs between fifty and sixty feet above the base of the formation. It is well exposed in the upper quarry of Mr. M. Halloran, north of the center of section 15, Decorah township. The colonies are unusually large and well developed for this lower horizon; as a rule they are smaller and less numerous here than in the upper zone. Specimens more than a foot in diameter are abundant in some of the layers of the quarry, and many are weathered out on the adjacent slopes. The same horizon may be recognized in the vertical face of the cliff above Mill spring on the north side of the river at Decorah, and it will be found again in the steep ravines which make it possible to study the successive beds which make up the lower and middle portions of the Galena formation above the "Dugway." The upper Receptaculites zone occurs from 150 to 160 feet above the top of the Decorah shales, from fifty-five to sixty feet below the top of the Galena limestone. This upper zone is much better developed in Dubuque county than in Winneshiek; throughout the city of Dubuque it is crowded with robust colonies of this peculiar fossil, while in the lower zone specimens are decidedly rare. *Ischadites iowensis* Owen, occurs about midway between the two zones. In some instances it is present locally in very large numbers, but it is far less persistent than its larger relative.

Ten feet below the upper Receptaculites bed there is a zone rich in gastropods, among which the more conspicuous forms are *Maclurea bigsbyi* Hall, *Hormotoma major* Hall, *Trochonema umbilicata* Conrad, *Fusispira elongata* Hall, and *F. inflata* Meek & Worthen. *Rafinesquina alternata* Conrad, and *Plectambonites sericea* Sowerby, come up from the Platteville limestone and range through the Galena and on to the top of the Maquoketa. Near Bluffton there is a small zone about seventy feet above the base of the Galena, which is unusually rich in Plectambonites. Of the two persistent brachiopods mentioned the evidence at hand would indicate that they were not uniformly distributed at any particular time over the old sea bottom, but seem to have been grouped more or less in local colonies. It must be said, however, that fossils are not common in the Galena limestone of Winneshiek county.

MAQUOKETA BEDS.

The Galena limestone ends abruptly and is followed in ascending order by the formation, 200 to 240 feet in thickness, which, since 1870, has been called in works on Iowa geology the Maquoketa shales. The formation was first recognized by Hall, and in his report on the Geology of Iowa it was called the Hudson-River group. This name, or some of its equivalents, such as Hudson-River shales or Hudson-River formation, has been used almost exclusively in the geological reports of Wisconsin and Minnesota. In the reports on the Geology of Illinois, 1866 to 1890, Meek and Worthen's name, Cincinnati group or Cincinnati shales, has been employed for the beds which are equivalent to the Maquoketa shales of Iowa. The term, Maquoketa shales, was used by White in his report on the Geology of Iowa, 1870, on the assumption that the beds, as developed in Iowa, represented only some "particular epochal subdivision" of the Cincinnati group of Meek and Worthen. That the formation under consideration is not the exact equivalent of the "Cincinnati group" or of the "Hudson-River group", as these are known farther east, becomes apparent when the numerous local variations and peculiarities of this most erratic assemblage of geological strata are studied in the field. Furthermore, it is not possible to correlate the Maquoketa of Iowa, or the corresponding beds in states adjacent, with any particular subdivision of the upper member of the Ordovician system, which may be recognized in the type localities of Ohio or New York. More than that even, it is not possible in Iowa to correlate the horizons of the Maquoketa as seen in one locality with those of some other locality only a few scores of miles away. The Ctenodonta and Orthoceras beds of Dubuque county, for example, have no equivalents, either lithologically or faunally, in Fayette and Winneshiek. On the other hand the Isotelus beds near Elgin possess peculiarities that are not exactly duplicated, even at the same stratigraphic horizon, outside of a radius of a few miles, while the heavy beds of dolomite at Clermont in Fayette county (Iowa Geol. Surv., Vol. XV, p. 476, Fig. 41) or at Fort Atkinson in Winneshiek county (Fig. 12) have no representative in the type region for the Maquoketa about Graf. Not a single feature of the lower half of the formation as it is seen in Dubuque county is repeated, even approximately, in Fayette and Winneshiek. At what would seem to be the same stratigraphic horizon the beds are lithologically and biologically so different that it is impossible to say that they were contemporaneous in age or that one in any way represents the other. Since, therefore, it is not possible, within the limits of a single state, to correlate the Maquoketa horizons of different but not very widely separated localities, it would seem useless to attempt correlations between the formation in Iowa and any part or parts of an assumed stratigraphic equivalent in Ohio or New York.

A local name is needed for the peculiar assemblage of beds lying between the Galena and the Niagara limestones, a name that is non-committal concerning eastern equivalents, and the term Maquoketa, which has been in use since 1870, may be allowed to stand for the latest sediments of the Ordovician system in the region bordering the Mississippi river.

So long as the conception of the formation under discussion was based on the characteristics displayed at the type locality along the Little Maquoketa river in Dubuque county, the name "Maquoketa shales" possessed no element of incongruity; but studies in Fayette and Winneshiek counties have shown some seventy feet of limestone and dolomites—some shaly, some of average purity and induration—making up the basal portion of the formation*. Separated from the basal calcareous beds by ten to fifteen feet of bluish plastic shales there are heavy beds of dolomite aggregating forty feet in thickness, which furnish a fair quality of building stone and are quite extensively quarried (Fig. 12). In view of the prevalence of limestones and dolomites in the lower and middle portions of the formation the lithological part of the old name is no longer appropriate, and the less restrictive term, "Maquoketa beds", is here employed.

In the matter of distribution in Winneshiek county it may be said that, with the exception of two or three square miles in the southeastern corner of Fremont township, the sediments of the Maquoketa stage are all found in a large, irregular area south and southwest of the Upper Iowa or Oneota river. The general trend of the line of contact with the Galena limestone is nearly parallel with the stream and, in the northwestern part of the county, is separated from the stream by only a few miles at most. The distance increases toward the east, and on the Allamakee county line the northern edge of the Maquoketa area is more than six miles south of the river. Excepting the very small area of Galena in section 13 of Bloomfield township, the Maquoketa is spread continuously over the four southeastern townships south of a line passing through the northern part of Springfield

*Fayette county offers more satisfactory exposures of the northern phases of the Maquoketa than any other, and for a full detailed description of this formation as it occurs in Fayette the reader is referred to the report of Savage, *Geology of Fayette County*, Iowa Geological Survey, vol. XV, pp. 463 to 486.

and Frankville. The Cresco-Calmar ridge is capped with a narrow tongue of overlapping Devonian, but between the crest of the ridge and the Upper Iowa the Maquoketa extends in a broad belt having an average width of about four miles. Nearly all of Washington township has some phase of the Maquoketa for the bed rock immediately beneath the mantle of loose materials which constitute the soils. Some small outliers of Niagara break up the continuity of the Maquoketa area in the southeastern part of the township, while over a few square miles in the southwest the formation in question is overlain unconformably by the Devonian. The Maquoketa extends up the broad valley of the Turkey river to a point about on the line between Winneshiek and Howard. The area thus covered is larger than that over which the Galena limestone is distributed, and these two formations together form the bed rock over much the greater part of the county.

It is not easy to describe the lithological characters of the Maquoketa in Winneshiek county for the reason that it varies greatly in this respect at different horizons, and beds holding the same stratigraphic position may take on quite different characteristics in passing from one locality to another. There are, however, but very few good sections of the Maquoketa in Winneshiek county, and a very large proportion of the exposures that are available for study are singularly barren in the matter of fossils. By reference to the excellent general section given by Savage on pages 484-486 of Volume XV of these reports, and based on studies made in Fayette county, it will be seen that the formation in this northern part of the state is naturally divided into four members as follows:

4 *Brainard Shales.*—Blue and bluish-gray shale, with some intimately associated beds of limestone at the top and bottom of the division. Includes numbers 11-13 of the General Section. It is proposed to designate this member by the name of the small railway station in Fayette county near to which it has its most typical development. Thickness about 120 feet.

3 *Fort Atkinson Limestone.*—Massive, yellow, cherty dolomite and associated beds of limestone. Numbers 7-10 of Savage's section. The corresponding beds are well developed in Winneshiek county, the best exposures occurring at Fort Atkinson (Fig. 12). Thickness forty feet.

2 *Clermont Shale.*—Bluish colored, plastic, fine grained shale, well developed below the Fort Atkinson limestone at Clermont in Fayette county, where it has been extensively used in the manufacture of brick and tile. Number 6. Thickness fifteen feet.

1 *Elgin Shaly Limestones.*—Limestones, dolomites and shaly limestones with beds of calcareous shales and thin partings of bluish, less calcareous clays; quite variable in character and fossil contents, but generally yellowish, decidedly calcareous and more indurated than the blue, plastic shales of 2 and 4. Includes numbers 1-5 of the section by Savage. Near Elgin the Isotelus beds at the base of this member are largely blue, hard, fine grained limestone. Thickness of entire member seventy feet.

Near Elgin the lower fifteen or twenty feet of the Maquoketa is composed of rather hard, bluish or drab colored, calcareous beds, some of which would rank as a fairly pure limestone and others as a very calcareous shale or shaly limestone. The more indurated layers are separated by partings of dark colored shale, and some of the partings are rich in the small linguloid species, *Leptobolus occidentalis* Hall. Most of the indurated beds are crowded with pygidia and other parts of the dismembered skeletons of *Isotelus maximus* Locke, the form described by Owen as *Asaphus* (*Isotelus*) *iowensis*. The corresponding beds are exposed at many localities in Winneshiek county. They are everywhere, however, yellow in color, much softer and more argillaceous than in Fayette, and the more indurated layers are separated by yellow, marly, non-plastic shale. As in Fayette county the beds are cut by two systems of joints which intersect at oblique angles, and the harder layers may be taken out in large, even surfaced slabs ranging from two to six inches in thickness. Figure 11 shows the characteristic appearance of these beds as they are seen in a roadside gully one-half mile east of Nordness, near the southeast corner of the northwest quarter of section 11, Springfield township. The base of the view is not more than three or four feet above the top of the Galena, which last is well exposed in a large quarry at Nordness and appears along or near the road almost continuously between the village and the exposure illustrated by the view. Fossils of

Fig. 11—Exposure of Isotelus beds, Maquoketa stage, one-half mile east of Nordness.

any kind are rather rare in the beds here exposed. There are some imperfect impressions of a small Lingula resembling *L. riciniformis* Hall, and an occasional glabella or pygidium of *Isotelus maximus*. One fairly perfect specimen of this last species was found here, but on the whole the scarcity of the remains of this trilobite is in striking contrast with their remarkable profusion at the same horizon around Elgin. A section forty feet in thickness may be studied here, and the great horizontal range of the exposure, together with the very large number of loose slabs and fragments, afford unusual facilities for observing the fossil contents, provided there were any; but with the exception of the rare occurences above noted, the whole deposit here is remarkably barren. All the beds, whether belonging to the Isotelus horizon or lying above it, present the same yellow color; all, even the more shaly portions, are decidedly calcareous.

The Isotelus beds are seen at many points along the border line between the Maquoketa and Galena areas; at all the outcrops the same yellow color prevails; everywhere there is the same alternation of indurated beds with soft marly shale; the same clean cut joints divide the deposit into rhombic blocks. In the southwest quarter of the northwest quarter of section 9, Madison township, there is an outcrop of the Isotelus beds which split readily into thin laminae and disclose numerous impressions of graptolites associated with *Lingula riciniformis* Hall, and detached plates from the armor of *Isotelus maximus*. Some of the beds furnish great numbers of *Leptobolus occidentalis* Hall, a form which is very abundant in some of the dark, slaty, carbonaceous shales at the type localities near Graf in Dubuque county. The graptolites are biserial, belonging to the genus Diplograptus, and may be referable to the species *D. peosta* Hall, but they are too imperfectly preserved for exact determination. This is one of the most satisfactory exposures of the Isotelus beds in the county. The specimens of Lingula, the numerous graptolites, and the great numbers of Leptobolus recall some of the features of the section at Graf, but the lithological characters are very different, and the presence of Isotelus introduces a feature wholly unknown at this horizon in Dubuque county.

Near the northwest corner of section 20, Bluffton township, the Isotelus horizon is again exposed, but no specimens of the trilobite were found; Lingula is more common here than at the other exposures mentioned; graptolites are also present; there are many specimens of *Conularia trentonensis* Hall; and there is at least one species of Orthoceras. An outcrop of the Isotelus beds, which is typical of many others throughout the county, occurs in the bank of an intermittent creek near the center of the northwest quarter of section 18, Springfield township. At this point the yellow calcareous rock has been quarried in a small way, and quite an amount of it was piled up near the breast of the opening. The rock comes out in slabs three to four inches in thickness. The intersecting joints are the same as elsewhere at this horizon. The stratigraphic position and the lithologic features leave no doubt that these beds belong to the Isotelus zone, but the most careful search failed to reveal a single fossil of any kind.

Beds practically barren of fossils, but lying at the stratigraphic level of the Isotelus zone, as determined by the lithologic characters and the near by outcrops of the upper surface of the Galena limestone, occur in the bed of a small creek in the southeast quarter of section 25, Madison; in the northeast quarter of section 18, Springfield; and in the northwest quarter of section 15, Frankville. About the middle of the line between sections 11 and 12, Bloomfield township, there is a good outcrop of the Isotelus zone with some of the overlying beds, and there is another south of the bridge over the Yellow river in the northeast quarter of section 13, but the absence of fossils is one of the most striking characteristics. The upper surface of the Galena is exposed at the south end of the bridge, and the contact with the Maquoketa occurs only a few yards farther south. For eight or ten feet above the contact the Maquoketa is a soft, yellow, marly shale, but this is followed by the typical indurated and jointed layers of the Isotelus zone.

The cases noted in the foregoing paragraphs are sufficient to show the general features possessed by the Maquoketa of Winneshiek county in the zone which includes the first twenty feet above its contact with the Galena. This part of the formation is fairly uniform throughout the county so far as color and lithology are concerned; but there are marked variations in the faunal characteristics; in certain localities there are no records of life; elsewhere the beds are fossiliferous, but at the best fossils are never abundant, and the list of species from one outcrop may not be the same as that from any of the others. When comparison is made with the Isotelus zone as it is developed near Elgin in Fayette county, the differences are strikingly great; when the comparison is extended to the corresponding beds in Dubuque county, it is almost impossible to find any resemblances whatever. Diplograptus, Leptobolus and Lingula embrace about the only life forms common to the Dubuque and Winneshiek outcrops of this basal part of the Maquoketa; lithologically these beds in the two counties named could scarcely present more decided differences.

Throughout the greater part of the area in which the Maquoketa is distributed the beds of the Elgin formation that lie above the Isotelus zone, are soft, yellow, marly shales interbedded with harder layers which, in some instances, are firm enough to rank as limestones or dolomites. Over entire townships there may be scarcely a trace of a fossil except occasional impressions of *Plectambonites sericea* Sowerby. This barren phase is particularly marked in Madison and adjacent townships. Unfossiliferous beds of this horizon, aggregating twenty to forty feet in thickness, may be seen in disconnected outcrops on many of the hill slopes in Madison township. A good example occurs on the line joining the centers of sections 5 and 8. Another, but less satisfactory, occurs on the road passing south from the middle of the north line of section 26. Others may be seen in sections 13, 21 and 35. The most remarkable exposures of this horizon of the Maquoketa are found along the southern edge of section 7 and in parts of the adjacent section 18. Here are curious hills and knobs of uneroded Maquoketa, more than 100 feet in hight, facing the broad, flat bottomed valley of Ten Mile creek, and rising well above the level of the surrounding uplands. The tops of the knobs are rounded and sodded over, but a continuous section more than thirty feet in thickness is exposed on the north side of the road passing between the two sections named. The whole deposit here is yellow, calcareous shale or a partly dolomitic shaly limestone. *Plectambonites sericea* occurs very sparingly and was the only fossil recognized. A short distance west, near the northwest corner of section 13, Lincoln township, the same yellow, granular, shaly limestones and marly shales appear, but fossils are now, individually at least, much more numerous and include such common forms as *Plectambonites* *sericea* and *Orthis testudinaria* with occasional individuals of a small variety of *Orthis* (*Platystrophia*) *biforata.* Passing toward the northwest from the point last noted, in the direction of the strike, there is encountered, near the southeast corner of section 17, Orleans township, an outcrop of Maquoketa which shows a wide departure from the ordinary phase of the Elgin formation. The beds here are a non-magnesian, crinoidal limestone, but some of the thin layers are crowded with well preserved shells of *Plectambonites sericea.* There are also some branching monticuliporoids and an occasional pygidium of Isotelus. An outcrop similar to the one just noted occurs on the east side of the road between Winneshiek and Howard counties, near the middle of the west line of section 30, in Fremont township. This was described in the report on Howard county, Volume XIII, pages 48 and 49. The deposit, as in the preceding case, is non-magnesian, largely crinoidal, but some of the layers carry fossils of types found near Lebanon and Morrow, Ohio. The large, well marked forms of *Rafinesquina alternata* Conrad, together with the variety *nasuta,* occur here, and there are also typical individuals of *Rhynchotrema capax.* The universal Ordovician species, *Plectambonites sericea* and *Orthis testudinaria,* are also represented. The crinoidal remains are not perfect enough for identification. In the report on Howard county this exposure was regarded as belonging to "the very uppermost beds of the Maquoketa." They are, in fact, the uppermost for this locality, for only a few rods to the south they pass beneath beds of Devonian age. Their real position, however, is below the middle of the Maquoketa. The enormous erosion and the consequent length of the great time gap representd by the unconformity between the Ordovician and the Devonian in this part of Iowa, are very much greater than was realized when the Howard county report was written.

So far as relates to Winneshiek county, the best exposures of the upper part of the Elgin substage occur near Fort Atkinson. East of the bridge over Rogers creek, at the south end of Tenth avenue, there is a good section of yellow shales and shaly limestones overlain by gray, drab or bluish shales of the Clermont substage. The harder limestone beds here contain large and small forms of *Rafinesquina alternata* and occasional specimens of *Strophomena planumbona, Orthis testudinaria, O. subquadrata, O. whitfieldi* and *Hormotoma gracilis.* A single example of an Orthoceras, three inches in diameter, was observed, and fragmentary remains of *Isotelus gigas* were noted. South of the bridge over the same creek east of the town, there are layers with large and beautifully preserved individuals of *Rafinesquina alternata* indistinguishable from the robust forms found in the Cincinnati shales of Ohio and Indiana. In addition to the species named the ubiquitous *Plectambonites sericea* and *Orthis testudinaria* are present, together with a few individuals of *Orthis insculpta.* Near the level of the water there are beds of hard, blue limestone; one layer about three feet above the base of the low cliff is charged with fragmentary remains of a trilobite which seems to be referable to *Nileus vigilans.* Stem segments of crinoids are common, and mingled with them are some plates of cystids. All the fossils, except occasional brachiopods, are too imperfect for specific identification. Mud cracks on some of the layers, the comminuted condition of most of the fossils and a certain irregularity in the bedding would indicate that the formation at this point represents an old beach deposit.

One mile east of Fort Atkinson, above and below the bridge crossing the river in the northern part of section 16, Washington township, there are other good exposures of the Elgin phase of the Maquoketa. The horizon is lower than that seen on Rogers creek; the beds are harder; some of the ledges are twelve inches in thickness. Fossils are rare or entirely absent in the lower part of the section. The rock is partly dolomitic, but it is not homogeneous; the bedding surfaces are very irregular, nodular, knobby and uneven; the prevailing color, as usual, is yellow; thin shaly bands are interstratified with the harder layers. The Nileus layer, with the armor of the trilobite reduced to small fragments, occurs on the hillside east of the bridge, about thirty feet above the level of the stream. The Elgin beds crop out at intervals in the valley of the Turkey river all the way from Fort Atkinson to the Howard county line. They appear on both sides of the narrow tongue of Devonian which caps the Cresco-Calmar ridge.

The Clermont shale is not well exposed in Winneshiek county. The lower part of it is seen overlying the Elgin beds along Rogers creek near Fort Atkinson. It comes to the surface in the valley of a small creek, less than one-fourth mile north of the center of section 15, Washington township. Its whole thickness of twenty feet is exposed, though imperfectly, along the road in the northeast quarter of the southwest quarter of section 4 of the same township. It is seen at a number of points in the southern part of the township, one of the best exposures occurring in the eastern part of section 28. The shale is indicated by springs and gentle slopes, as well as demonstrated by actual outcrops, along the roads and in the stream valleys in section 1 of Jackson township and sections 19, 30 and 31 of Calmar. In the banks and beds of the streams which traverse the southern sections, 31 to 35, of Military township, the blue, plastic Clermont shale is seen in small outcrops at a great many points. It is usually the upper part of the formation that is here exposed, a thickness of a few feet only appearing from beneath the protective covering of hard dolomite belonging to the Fort Atkinson limestone. It is only in proximity to the scarps formed by the underlying Elgin beds, or the overlying Fort Atkinson, that the Clermont shale appears in natural exposures. On the intervening slopes the shale is soon concealed by the mantle of waste. As a concrete illustration, typical of many others in the southern part of Military township, the exposure near the center of the southwest quarter of section 33 may be cited. Facing a ravine at this point there is a steep scarp due to the Fort Atkinson limestone, and at the foot of the scarp, and, for a short distance, in the bottom of the ravine, the blue Clermont shale is exposed. Crumbled by exposure to the weather and continually moistened by escaping spring water, it is reduced on the surface to a soft, slippery, plastic clay. The overlying Fort Atkinson, as at a number of other points in this and adjacent sections, is quarried for building stone. In Winneshiek county no fossils were found in the Clermont shale, a fact probably due to the lack of thorough and systematic search. In Clayton and Fayette a number of the common species having a wide geographic range in the upper part of the Ordovician system, are found at this horizon. The shale is not developed economically at any point in Winneshiek.

The Fort Atkinson limestone overlies the Clermont shale. It is composed of magnesian beds varying in thickness from two or three inches to three feet or more. Nodules of chert disposed in more or less regular bands are common, and in some cases, as at the quarry three-fourths of a mile southwest of Ossian, the chert may form thin continuous layers extending from side to side of the exposure. The thickness is forty feet, and the rock is firm enough and thick enough in some of its layers to be used for massive permanent masonry. There is nothing in the typical Maquoketa section near Graf and Lattners in Dubuque county to correspond in any way to this hard crystalline dolomite. Its presence in the midst of a formation that only a short distance toward the south is made up wholly of shale, has led to errors of correlation on the part of a number of geologists. In Hall's Report on the Geology of Iowa, page 314, Whitney correlates the limestone at Fort Atkinson with the Galena and says that "It possesses all the characteristics of this rock as exhibited in the lead region; its color is the same and it weathers in the same irregular, ragged manner." On page 80 of the report on Allamakee county, published in volume IV of the present series of reports, the writer was led into the same error and correlated the buff, dolomitic Fort Atkinson limestone with the Galena near Dubuque. All the statements in the Allamakee county report relating to the Galena limestone, need modification to bring them into harmony with present knowledge of the structure of the Galena and Maquoketa formations. On pages 324 and 385 of the *Eleventh Annual Report of the United States Geological Survey,* in his memoir on *The Pleistocene History of Northeastern Iowa,* McGee evidently correlates the massive Fort Atkinson dolomite with the scarp-forming Niagara limestone.

The type exposure of the limestone under consideration is the quarry west of the old fort at the town of Fort Atkinson (Fig. 12). The rock is a buff colored granular dolomite resembling some phases of the Niagara in Delaware county, or of the dolomitized Galena about Dubuque. As shown in the view, there are from twenty to thirty feet of the limestone exposed in the quarry. The clean cut vertical faces of the quarry are due to some of the numerous joints which cut the formation vertically. Near the bottom of the quarry face the layers, comparatively free from chert, range from two to four feet in thickness; near the top the thickness varies from two to four inches. Chert is more abundant in the middle and toward the upper part of the

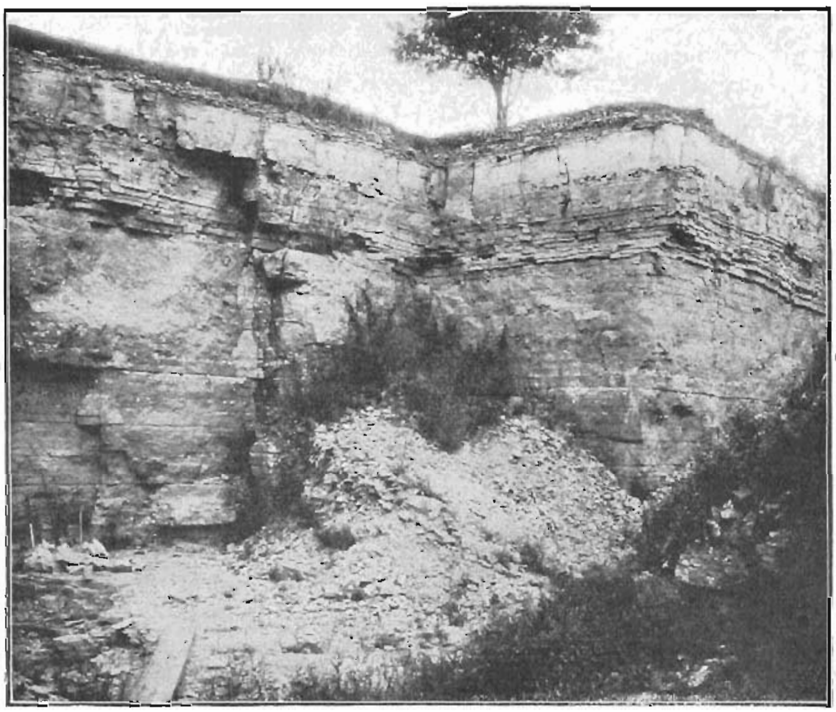


FIG. 12—Quarry in the Fort Atkinson limestone, at the town of Fort Atkinson, a few rods west of the old fort.

quarry. Fossils are not very plentiful; the most common species are *Rafinesquina alternata, Plectambonites sericea* and *Rhynchotrema capax*. *Orthis insculpta* occurs, but very sparingly. At a quarry in this limestone, near the center of the southwest quarter of section 33, Military township, the beds in the lower part of the working are from six to ten inches thick, bluish in the center and buff colored toward the bedding surfaces. In the upper part of the quarry the layers are thin and cherty. The fossils include *Rafinesquina alternata, Orthis testudinaria, O. insculpta, O. plicatella, O. subquadrata,* a small Orthoceras like *O. sociale,* and a large, Orthoceras unnamed. There are many exposures of the Fort Atkinson limestone in the southern sections of Military township and along the streams flowing down the slope from the Cresco-Calmar ridge. The profile of the surface on this slope coincides very nearly with the southward dip of the strata. A quarry is worked in the northern part of section 15, about three-fourths of a mile southwest of Ossian. The beds here are composed of coarse dolomite with more than the usual amount of chert. A thickness of fifteen feet is exposed. A solid band of chert, four inches thick, runs through the quarry about ten feet from the base. Among the fossils are many stem segments of crinoids with some body plates of Glyptocrinus, *Lingula iowensis, Rafinesquina alternata, Orthis insculpta, O. testudinaria, Rhynchotrema capax,* a large annulated Orthoceras and a pygidium of Calymene. There are other exposures of the Fort Atkinson in section 8 of Military township, some of which have been quarried on a small scale. The Fort Atkinson is seen at a number of small outcrops on the northeastern slope of the ridge, notably at some quarries in the northwest quarter of the northwest quarter of section 5, Bloomfield township. Quite an amount of fairly good building stone has been taken out at this point. The organic remains are rather fragmentary, but it is possible to recognize the body plates of Glyptocrinus, the shells of *Rafinesquina alternata, Plectambonites sericea, Orthis insculpta, O. subquadrata, Rhynchotrema capax,* and *R. perlamellosa,* together with parts of the armor of a large *Isotelus gigas.* On the whole, however, the Fort Atkinson limestone is found to become softer and to undergo decomposition more readily as it is traced northward and eastward from its typical exposures near Fort Atkinson.

The Brainard shale is present at only a few points in Winneshiek county. At Patterson's Spring and other of the type localities near Brainard in Fayette county, this shale and associated beds attain an aggregate thickness of fully 100 feet. At no point in Winneshiek county, so far as observed, does its exposed thickness exceed ten or fifteen feet. One of the best of the natural outcrops noted occurs along the roadway in the southeast quarter of the southeast quarter of section 1, Jackson township. The shale here lies between two dolomites, the Fort Atkinson limestone below, and the Devonian limestone above. Throughout the western part of the county the Maquoketa is overlain unconformably by beds belonging to the Wapsipinicon stage of the Devonian. The unconformity is one of overlap due to the transgression of the Devonian sea upon an extensively eroded surface. During the interval of erosion the upper part of the Maquoketa was cut away to such an extent that in some places the overlapping Devonian rests on beds belonging to the middle of the Elgin substage; in other places it rests on Fort Atkinson limestone; in section 1 of Jackson township there are ten or fifteen feet of Brainard shale between the Devonian and the Fort Atkinson. Near the southwest corner of section 5, Calmar township, this shale is seen between the same two limestones, but the thickness is reduced to three or four feet. It occurs in the same relations to the limestones near the middle of the north line of section 33, Lincoln township. It is quite probable, indeed almost certain, that the full thickness of this upper shale still persists beneath the small patches of Niagara limestone in the southeastern part of Washington township, but no outcrops were seen on the long slopes between the Fort Atkinson and Niagara limestones. In general it is represented in this county by nothing more than a few scattered remnants. Normally it is blue, fine grained, plastic, unfossiliferous. The few remnants observed have no commercial value, but large bodies of it might easily be opened up on the hill sides below the outliers of the Niagara.

SILURIAN SYSTEM.

Niagara Limestone.

The Niagara limestone is represented in Winneshiek by a few small outliers in the southern and southeastern part of Washington township, all of which may be referred to the lower or Hopkinton stage of the series. A prominent knob of Niagara

(Fig. 13), covering less than forty acres, stands out prominently on the line between sections 22 and 23, about three-fourths of a mile west of Festina. The village is built on a plaform of Fort Atkinson limestone. A long slope due to the presence of the Brainard shale leads toward the summit of the knob, and at a level 100 feet above the level of the platform there is an old quarry which has been worked in a hard, granular dolomite identical in characteristics with some phases of the Niagara farther south. The summit of the outlier rises about twenty feet

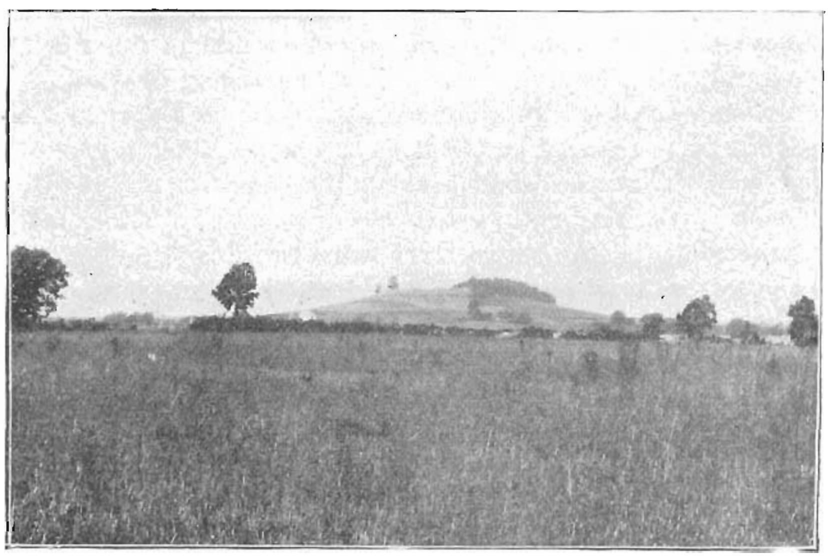


Fig 13—Conical knob, the most northerly outlier of Niagara limestone in Iowa, one mile west of Festina, Washington township

above the top of the quarry. The exact plane of contact with the Maquoketa could not be made out, but the thickness of the Niagara at this point is not more than forty feet. No fossils were found, a fact not surprising, however, for in Dubuque, Delaware and other counties where the basal part of the Niagara may be studied, the lower zone is practically unfossiliferous. This outlier has the distinction of being the most northerly exposure of the Niagara limestone in Iowa.

The largest of these outliers in Washington township begins about a mile south of Festina and occupies portions of sections

25, 26, 35 and 36. The greatest thickness of the Niagara, approximately 75 feet, occurs near the northeast corner of section 35. The road in the northwest quarter of section 35 angles around a very characteristic cliff of the Niagara limestone (Fig. 14), and a bold salient of this limestone (Fig. 15) faces the valley of the Turkey river in section 26. This larger area forms a flat topped mesa with steeply sloping sides. Its outline is quite irregular; its total area does not much exceed a single square mile. A

Fig. 14—Cliff of Niagara limestone north of center of section 35, Washington township Photo by Lees.

ridge capped with Niagara, trending northeast-southwest, begins in the northeast quarter of section 27 and extends to a point east of the center of section 23. A very symmetrical conical outlier, occupying only a few acres, rises from the level of the valley in the southwest quarter of section 35; and another, which forms an elongated butte with flat top and steep sides, extends obliquely across the line between sections 28 and 33. This last is the only known remnant of Niagara in this county on the west side of Turkey river.

In the main the Niagara here is a cream colored, magnesian limestone; though in the larger area, in section 35, there is a bed of soft, yellow dolomite, ten feet in thickness, about forty feet from the top; and some of the layers in the old quarry at the outlier west of Festina, are composed of hard, buff, crystalline dolomite matching the best type of this limestone in the counties of Dubuque and Delaware. At the cliff in the northwest quarter of section 35 there are some obscure stromatoporoids about the middle of the section, and an imperfect glabella resembling that

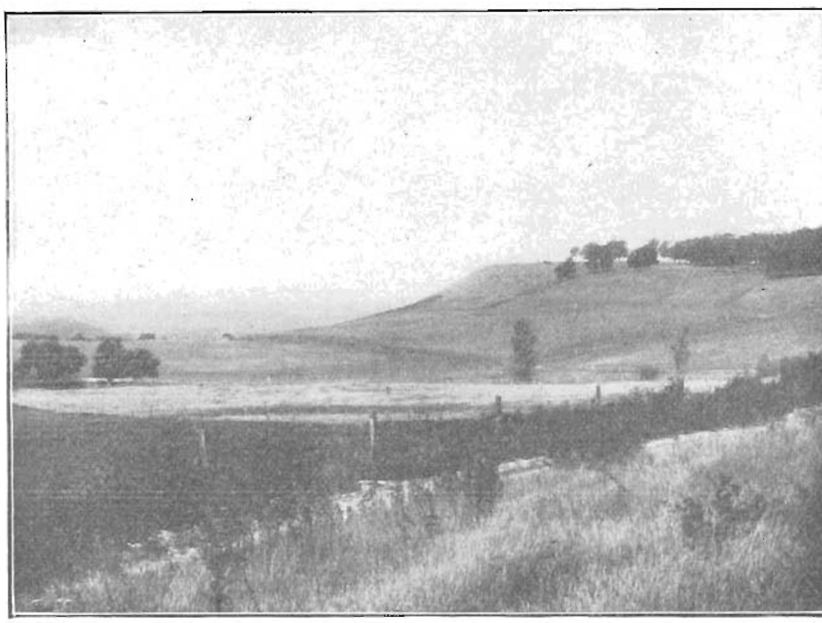


Fig 15 Salient of Niagara limestone facing the valley of the Turkey river in the southwest quarter of section 26, Washington township.

of *Illaenus insignis,* was found in the upper beds. The grounds on which these outliers are referred to the Niagara are chiefly lithologic and stratigraphic; but the evidence from these two criteria finds strong support in the geographic relations of the outliers to the Niagara of Fayette county, which, toward the south, is continuous with the great Niagara area, and toward the north is found to diminish rapidly in thickness and areal distribution. The last remnants of the formation in Iowa, toward the northwest, are found in these small isolated areas.

DEVONIAN SYSTEM.

Middle Devonian Series.

WAPSIPINICON AND CEDAR VALLEY LIMESTONES.

Beds belonging in part to the Wapsipinicon stage, and in part to the Cedar Valley stage of the Middle Devonian occur in the western part of Winneshiek county. Owing to the small size of the individual exposures and the scarcity of fossils, it is not possible to separate the two stages with any degree of definiteness. The area occupied by the deposits of the Devonian period includes practically all of Jackson township, the greater part of Sumner, and portions of Lincoln, Orleans and Fremont. A narrow tongue of Devonian enters Winneshiek from Howard county and extends as a capping along the Cresco-Calmar ridge as far as Calmar. As noted above in this report, the Devonian lies unconformably upon an eroded surface. There was an eastward transgression of the Devonian sea after the beginning of the period, and our territory was not reached till near the close of the Wapsipinicon stage. The earliest beds of the Iowa Devonian—the Otis, Independence and Lower Davenport—are accordingly missing in this part of Iowa, and the beds which come in contact with the Maquoketa belong to a horizon above the Gyroceras zone at Independence. The most characteristic fossils of the lowermost strata of the Devonian in Winneshiek county are ***Productella subalata*** Hall, and *Spirifer pennatus* Owen. A small Spirifer like *S. subumbonus* Hall, is occasionally found near the line of contact.

The exposures of the Devonian in Winneshiek county are numerous, but the formation is distributed in the part of the area covered with the deepest drift and is seen on the surface only in small, isolated patches. Unless distinctive fossils are present, the correlation of one outcrop with another is not always possible. Nearly the whole formation, as it appears in this part of the state, is a soft, yellow, earthy, magnesian limestone, or imperfect dolomite, in which the embedded life forms are preserved, if at all, in the condition of internal casts. It is not quarried at any point in the area studied, nor is any of it suitable for quarrying. Where it has been stripped and cut into by erosion, instead of forming cliffs which might be studied in detail, it breaks down into rock strewn slopes, with the more persistent ledges asserting themselves in a feeble way, as shown in figure 16. The view shows the hard Fort Atkinson limestone near the foot of the slope, with some of the harder beds of the

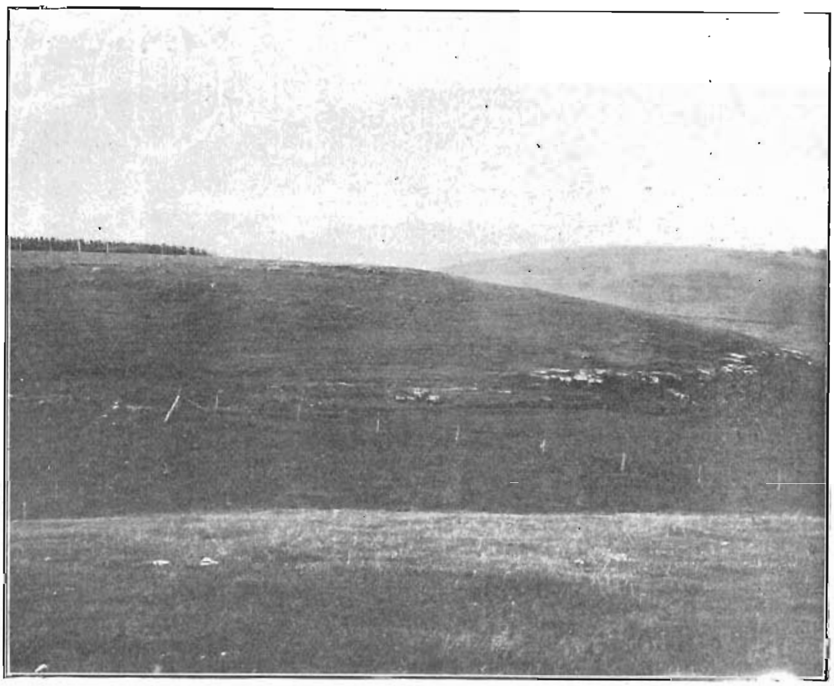


Fig. 16 -View near Fort Atkinson showing outcropping of Devonian dolomite near the top of the hill, and Fort Atkinson limestone, of the Middle Maquoketa, near the base. There are ten or fifteen feet of Brainard shale between the two limestones, but no Niagara. Photo by Lees.

Devonian expressing themselves in ragged, fragmentary outcrops toward the top. Ten or fifteen feet of Brainard shale separate the two limestones, but its presence is not indicated by the topography. Fragments of weathered Devonian limestone are sprinkled over the entire hillside. The Devonian at the point shown in the illustration, near the southeast corner of section 1

Jackson township, is, as usual at this horizon, soft, yellow, magnesian, not very fossiliferous, but yielding to persistent search the casts of *Productella subalata* Hall, *Spirifer subumbonus* Hall, and *Spirifer pennatus* Owen.

The same Productella beds are seen in numerous small outcrops—wherever, in fact, the drift is absent—on the west side of the valley of the Turkey river, all the way to the Howard county line; they are present on both slopes of the Cresco-Calmar ridge in Calmar, Madison and Lincoln townships; they appear in contact with the Lower Maquoketa in the small Devonian areas which enter our county from Howard in Orleans and Fremont townships. For a few concrete illustrations there may be noted the outcrops of Devonian crowded with casts of Productella, which occur in the road between sections 15 and 22, Lincoln township. The best locality is just west of a small valley passing through the sections named. Devonian outcrops are more or less continuous for three-fourths of a mile farther west, but near the middle of the south line of 16 the Fort Atkinson dolomite appears from beneath the Devonian in the gentle descent toward the Turkey river. Between the point last named and the stream, the Maquoketa is seen at intervals, carrying such fossils as *Lingula iowensis*, *Leptaena unicostata*, *Plectambonites sericea*, *Orthis whitfieldi* and *O. testudinaria*. The Devonian, only a few feet higher, furnishes casts of two Atrypas, one large Spirifer, *S. pennatus* Owen, *Cyrtina hamiltonensis* Hall, and *Paracyclas elliptica* Hall, in addition to the common Productella. Less than a quarter of a mile west of the river the Devonian again appears above the Maquoketa, good exposures being found near the southeast corner of section 17 and along the east side of 20. At the bridge over the Turkey river on the line between Howard and Winneshiek, there is a good example of the Productella beds, which was noted in the report on Howard county. The deposit presents the usual lithologic characteristics, but the grading for the road has exposed a section of several feet in thickness and afforded better opportunities than occur at the natural exposures for an investigation of the fauna. Fossils, in the first place, are not abundant, and, secondly, the obscure casts that do occur are not always identifiable. It is possible, however, to make out the Productella and large Spirifer which prevail at this horizon, and in addition are casts of *Stropheodonta demissa, Atrypa reticularis, Spirifer subumbonus, Cyrtina hamiltonensis,* some undetermined gastropods and the pygidium of Phacops. Shales of the Maquoketa stage occur in the bed of the stream immediately below the bridge.

In Howard county the Productella zone is overlain by beds almost barren of fossils, but characterized by the presence of occasional colonies of Acervularia and great numbers of irregular pockets filled with calcite. Following down the stream from the county line bridge referred to above, the Devonian limestone is found to be continuous in the bluffs in the southern part of section 6, Lincoln township. The slopes are strewn with loose fragments of the soft, earthy, magnesian limestone, and quite a number of these contain *Acervularia davidsoni* Ed. & H. The corals were not seen in place, for the upper part of the bluffs is rounded back and covered with a heavy mantle of detritus; but it is clear that the beds above the Productella zone are present in this locality. Beds of this overlying horizon, with its irregularly shaped masses of calcite, may be seen in places near the northeast corner of section 16, Jackson township, and in the southwest quarter of the northwest quarter of 28, Calmar. Beds belonging to the next higher zone occur in section 31 of Jackson township. In the road passing south from the center of this section, a few rods north of the Fayette county line, there is an exposure showing from eight to ten feet of soft, yellow, earthy dolomite containing *Dielasma iowensis* Calvin, *Atrypa reticularis* Linne, and *Spirifer subvaricosus* Hall & Whitfield. In the northeastern part of the section the same horizon is indicated by the same fauna at the crossing of the creek one-fourth of a mile southwest of Navan, and again in the railway cut a short distance west of the small station.

The highest beds of the Devonian in Winneshiek county are seen on the east side of the county line road, less than a fourth of a mile south of the northwest corner of section 7, Orleans township. They were not noted at any other locality. Here the limestone is non-magnesian, light gray or white in color, fine grained or lithographic in texture. Some of the beds are very much crackled as if they had been exposed to air drying while yet soft and plastic.

The fossils are mostly stromatoporoids of the types found associated with the lithographic zone from Johnson county to Mitchell. Colonies of a small digitate Favosites occur with the stromatoporoids, an association that is practically universal in Iowa. In Johnson county the lithographic limestone lies practically at the top of the Cedar Valley stage; but if these beds in section 7 of Orleans township are traced toward the southwest, they will be found in Howard county to pass beneath heavy, magnesian layers such as are seen in the quarries on the higher ground around Vernon Springs. By reference to the report on Chickasaw it will be found that in the county south of Howard there are fifty feet of these magnesian beds above the lithographic horizon. In Mitchell county, in the Lewis quarry and at the Chandler cliff section for example, there are some soft, yellow magnesian beds, a few feet in thickness, above the lithographic limestone, which may be regarded as remnants of the heavy, overlying layers in Howard and Chickasaw. These upper beds seem to have no equivalents at Iowa City or elsewhere in the southern part of the Devonian area. The light colored, lithographic, non-magnesian phase of the Devonian attains its greatest known thickness in the vicinity of Mason City, as may be seen by reference to the report on Cerro Gordo county. Samples taken from this horizon in Mitchell county were analyzed by A. B. Hoen of Baltimore and were found to contain only a trace of Aluminum-iron oxide and but .07 of one per cent of Magnesia. Such a stone is especially well fitted for use in the manufacture of Portland cement. There is not enough of the non-magnesian zone in Winneshiek county to be of commercial value, but the great development which these beds attain in the counties south and west of the area under consideration renders them worthy of careful consideration by the makers of Portland cement, and places them high in rank among the important geological resources of the state.

THE MANTLE ROCKS.

RESIDUAL MATERIALS—GEEST.

The mantle of rock waste forming the soils and subsoils of Winneshiek county, may be divided into (1) Residual Materials or Geest, and (2) Transported Materials which make up the many phased deposits of the Pleistocene System. The geest belongs to no one age or period, but is a product of destructive processes which have been in continuous operation throughout all the periods since northeastern Iowa first rose above the sea. It does not occur in large bodies at any points within the limits of the county, corrasion and removal have been able to keep pace with the processes of production. The residues resulting from the disintegration of local bed rock vary with the composition of the beds, but it may be said that the characteristic geest of this county is that derived from the decay of limestones. This is usually a very dark colored ferruginous clay enclosing numerous fragments of chert and occasional fragments of undissolved limestone. Geest is best seen in the eastern part of the county, in the regions where the drift is thin or wholly absent. It cannot be said that the geest mantle is continuous even in regions of no drift; it occurs as mere remnants of a mantle, often in fissures in the bed rock. In the drift covered regions it has been quite effectually swept away, the greater part of that which remains being protected in fissures into which it had been worked before the coming of the glacial ice. Among the largest and most typical bodies of residual materials are those seen near the center of section 26, Glenwood township. These bodies are of dark red residual clay, in some cases two or three feet in thickness, in and upon which are large quantities of residual chert. The chert represents insoluble nodules in the Galena limestone, and the great amount of it would indicate the removal by solution of nearly the whole thickness of this formation.

Residual materials from the Oneota limestone, a crystalline dolomite, may be seen a short distance east of the center of section 19, Highland township. Here are all stages of rock decay from partly disintegrated bowlders of the Oneota to gray dolomitic sand and dark, ferruginous residual clay. All the crystalline dolomites, such as the Niagara in Delaware county, the Galena around Dubuque, and the Oneota in the northeastern counties, break down, by solution of the cementing substance, into loose granules representing the constituent crystals of the deposit. The product resembles ordinary, incoherent sand. Decayed Galena in Dubuque county, and Niagara in Delaware, have given rise to considerable bodies of loose, dolomitic sand many feet in thickness; and here in section 19 of Highland township, as well as at many other places in Winneshiek county, the Oneota is seen passing through the same phase of decomposition. The final result in all such cases, however, is the solution of all that is soluble in the granules and the conversion of the finer insoluble constituents of the dolomite into a dark red, ferruginous, tenacious clay in all respects like that derived from the non-magnesian phase of the Galena. The residual clays from the Maquoketa beds are, on the whole, less ferruginous than the geest from the Galena and Oneota limestones. The residue from the Saint Peter sandstone is simply a bed of incoherent quartz sand practically equal in volume to the body of sandstone that has suffered disintegration. A typical illustration of such geest occurs around the base of the salient of Saint Peter (Fig. 5) in section 12 of Hesper township.

PLEISTOCENE SYSTEM.

KANSAN STAGE.

Kansan Drift.—Only two drift sheets have been recognized in Winneshiek county, the Kansan and the Iowan. The drift mantle, even where both sheets are present, is comparatively thin. The older Kansan, weathered, iron stained, deeply eroded and covered with loess, is found in the eastern two-thirds of the county. In the eastern one-third there are areas of considerable extent where the drift occurs in patches; in the intervening vacant spaces the loess rests directly on bed rock or on residual clays and cherts. The heavier and more continuous bodies of Kansan drift are found on the uplands. North of the Oneota river the drift is well developed along the high divide passing through the northern townships, a fact that is apparent in the western part of Hesper township and the northeastern part of Burr Oak. South of the river the most typical and characteristic areas of the Kansan occur on the high ground in Springfield, Frankville, Military and Bloomfield townships. The drift is thin, patchy, or wholly absent over considerable areas about the headwaters of the Yellow river in Bloomfield and Frankville townships. The same statement may be made relative to the whole of Glenwood and Pleasant townships, and to the greater part of Decorah, Canoe and Highland. In Bloomfield township, for example, there is the large area of Kansan on the upland of which Castalia is the center. This is continuous with the main body of the formation toward the west and northwest; but among the numerous branches of the Yellow river the drift is reduced to mere shreds and isolated remnants, as is well illus-

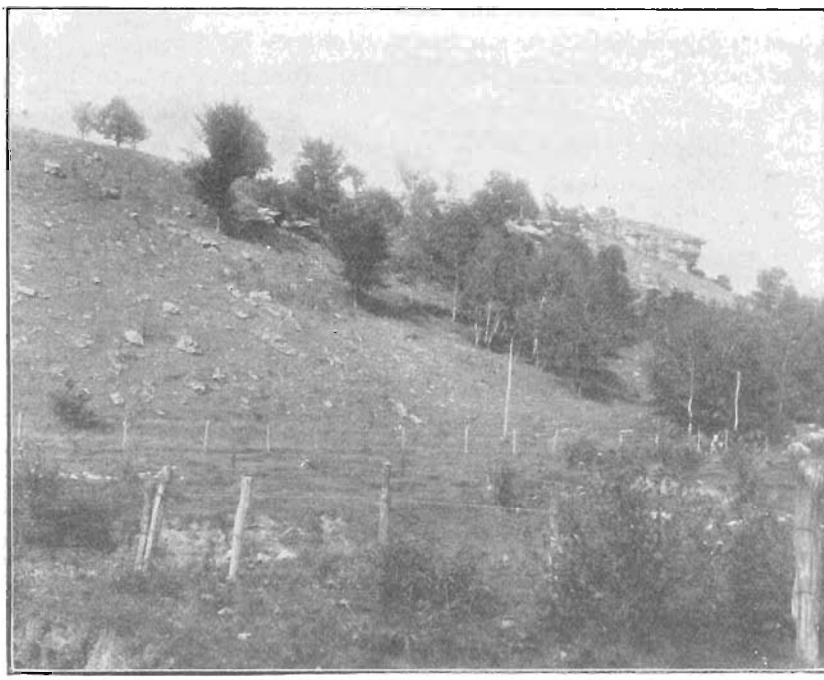


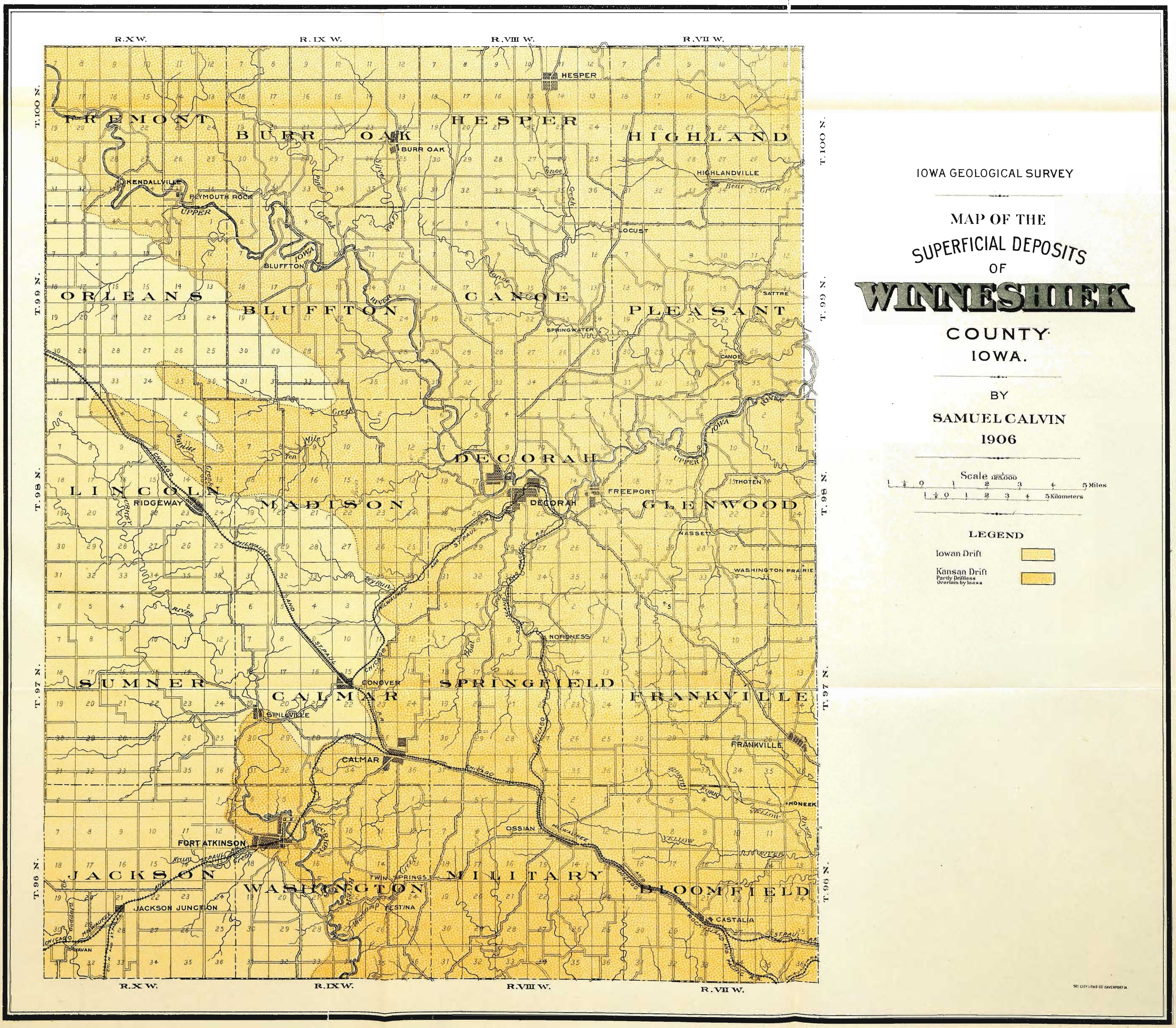
Fig 17—Driftless hills in sections 23 and 24, Pleasant township. The slopes are covered with waste from the Oneota limestone.

trated by the detached body occupying a small ridge near the center of section 13 and another near the northwest corner of section 12. In Canoe township there is a detached mass of drift of considerable extent and several feet in thickness, south of the center of section 2. In Pleasant township there is quite an area of the older drift south and east of Locust Lane, but in the small valley traversing sections 23 and 24, the hill slopes are covered with local waste (Fig. 17), and there is no evidence that glacial ice had ever invaded the region. In general it may be said that, in the eastern third of the county, the valleys, even of the smaller, intermittent streams, have the topographic features and surficial mantle of the Driftless Area, while the divides, even the smaller ones, show some traces of the Kansan drift. It is possible that the whole region, embracing both valleys and uplands, may have been covered to an equal extent with the Kansan glacier, and that erosion during, and subsequent to, the period of ice melting may have carried away from the valleys whatever detrital material the ice deposited. On the other hand it is probable, at least possible, that the ice coming from the higher lands to the northwest, moving here in the direction of the drainage, and very much attenuated at its margin as it approached the Driftless Area, pushed out on the ridges, its continuity with the main body of the living glacier uninterrupted, while it broke down and became dead at the heads of the valleys. The ridges were in fact a continuation of the surface to the westward, upon which the ice moved as an unbroken sheet; but the valleys, all of them preglacial, were depressions below that surface, and the thin margin of the ice broke down into detached, dead fragments wherever, in this critical part of its area, such depressions were encountered. According to this view these valleys never were invaded by living glaciers, never received any mantle of drift. The same conditions are indicated by the distribution of the Kansan in the marginal part of its area in Dubuque county.

At all the exposures of Kansan drift noted in Winneshiek county the formation is weather stained and oxidized throughout its whole thickness. The color is red, not infrequently quite brilliant. The smaller remnants in the eastern part of the county are very pebbly or sandy, and in some cases they grade into deposits which might be classed as Buchanan gravels. This pebbly phase of the Kansan is well illustrated at many points along the road passing north and south through sections 21 and 28, Decorah township; but the feature is so common, especially throughout the eastern townships, as practically to include all observed exposures, and further mention of particular cases is unnecessary. The normal, blue, unweathered phase of the

Kansan was not seen in any of the outcrops during the progress of the survey, but McGee in his *Pleistocene History of Northeastern Iowa,* page 519, publishes the record of a well located in section 7, Orleans township, which showed—pebbly yellow clay, 6 feet, and compact, laminated blue clay with striated pebbles, 10 feet. This well is located in the western edge of the county where the glacial deposits are thickest, and in an area where both drift sheets are present. The yellow clay undoubtedly belongs to the Iowan stage; the blue clay presents the normal aspect of the unweathered Kansan. Another well reported by the same author is located in section 16, Burr Oak township. Here the record shows—loess, 14 feet; laminated sand, coarser below, 10 feet; gravelly and sandy brown clay, 6 feet. In the last case the well is located in the loess covered Kansan area, some distance beyond the extreme limits of the territory covered by the later Iowan ice. The drift is overlain by stratified sands of the age of the Buchanan gravels. The brown color of the glacial clay indicates profound weathering of the deposit, and the presence of the weathered zone shows that the surface has not been disturbed by glaciers since the materials were deposited and exposed to the air. In the erosional topography which is so prominent a characteristic of this locality, in the weathering and complete oxidation of the drift, and in the overburden of loess there may be recognized the features which everywhere distinguish the loess-Kansan portions of the great drift-covered area of Iowa.

Buchanan Gravels.—When the Kansan glaciers were melting and making their final slow retreat from this part of the state, large volumes of water flowed out from the margin of the ice upon the region which the ice retreat had just laid bare. This water was loaded with detrital material, coarse and fine, and the load was sorted and deposited along the courses followed by the streams. Sheets and trains of gravel were thus laid down, some of them upon the surface of the Kansan drift more or less remote from the major drainage courses, some of them strewn along the larger valleys. Two distinct phases of these gravels have been noted in previous reports, one the upland, the other the valley phase. The probable genesis of the two phases is


IOWA GEOLOGICAL SURVEY
MAP OF THE
SUPERFICIAL DEPOSITS
OF
WINNESHIEK
COUNTY
IOWA.
BY
SAMUEL CALVIN
1906
Scale 1/125,000
5 Miles
5 Kilometers
LEGEND
Iowan Drift
Kansan Drift Partly Driftless Overlain by loess
R.X W.
R.IX W.
R.VIII W.
R.VII W.
T.100 N.
T.99 N.
T.98 N.
T.97 N.
T.96 N.
FREMONT
BURR OAK
HESPER
HIGHLAND
ORLEANS
BLUFFTON
CANOE
PLEASANT
LINCOLN
MADISON
DECORAH
GLENWOOD
SUMNER
CALMAR
SPRINGFIELD
FRANKVILLE
JACKSON
WASHINGTON
MILITARY
BLOOMFIELD
HESPER
BURR OAK
KENDALLVILLE
PLYMOUTH ROCK
HIGHLANDVILLE
LOCUST
BLUFFTON
SATTRE
SPRINGWATER
CANOE
THOTEN
FREEPORT
DECORAH
RIDGEWAY
NASSET
WASHINGTON PRAIRIE
NORDNESS
CONOVER
SPILLVILLE
CALMAR
FRANKVILLE
FORT ATKINSON
OSSIAN
TWIN SPRINGS
FESTINA
JACKSON JUNCTION
CASTALIA
HAVAN
TRI CITY LITHO CO. DAVENPORT IA.

discussed in the report on Howard county, volume XIII, page 67. Both types occur in Winneshiek, the upland gravels being found at a number of points in almost every township in the county, the valley phase, so far as observed, being best developed along the river in the southwest quarter of section 7, Glenwood township. For concrete illustrations of typical exposures of the upland gravels reference may be made to the deposit a short distance south of the northwest corner of section 22, Hesper township, to the gravel ridge in the southwest quarter of section 36, Madison, and to the sheet of gravel on the upper slopes of the high bluffs, on land belonging to Mr. Halloran, in the northeast quarter of section 15, Decorah township. At the point named in Hesper township a section of gravel, five feet in thickness, has been laid bare by the cutting of a gully along the side of the road. The material is very ferruginous, rusty, weather stained, and many of the pebbles and cobbles are in an advanced state of decay. In the Madison township example there is a mixture of coarser and finer fragments, a condition that is very commonly observed wherever the materials have been deposited in close proximity to the edge of the ice. The assortment is always better where the load had been carried for longer distances. Pebbles, cobbles, and small bowlders up to a foot in diameter, occur together at the same level. The beds, as usual, are very ferruginous, and a large proportion of the rock fragments are badly decayed. The materials have been used to some extent in improving the local roads. On the Halloran land the gravels occur 100 feet above the river and lie in a broad sheet which in places attains a thickness of fourteen feet. The very rusty appearance of the deposit led to the making of a number of test pits by encouraging the hope of finding a bed of iron ore. Remnants of similar beds are found on the slopes of the bluffs at numerous points around Decorah.

At the locality mentioned above in the southwest quarter of section 7, Glenwood township, the road, for some distance, has been cut through a broad sheet of rather fine gravel which occupies the bottom of the valley of the Upper Iowa or Oneota river. The deposit, which typically illustrates the valley phase of the gravels, occurs at intervals for a number of miles up and down the valley. It is composed of pebbles which have an average diameter of half an inch. These are mostly smooth, well rounded, polished quartz. There is quite a proportion of sand mixed with the pebbles, and the deep ferruginous stain indicates that rock fragments containing iron bearing minerals were primary constituents of the deposit. Nearly all the mineral species except the quartz are partly or wholly decomposed.

Deposits of Uncertain Age, Probably Kansan.—The history of the Kansan drift and the intimately associated Buchanan gravels is fairly clear, but there are some deposits in the larger valleys, possibly belonging to the Kansan stage, which it is more difficult to understand. The gorge of the Upper Iowa and all the other stream trenches of any consequence in the county are preglacial in age. The Kansan drift comes well down into the valley on the sides of the bluffs around Decorah, and some of the gravels deposited by floods from the melting Kansan ice, lie in the very bottom of the gorge. The valley was not only completely excavated before the Kansan, but it was even deeper than it is to-day; for during the time of the Kansan floods aggradation took place to a depth of not less than fifteen or twenty feet. Now from Decorah eastward to the county line there are extensive terraces of sorted and stratified materials, well up on the sides of the valleys, from thirty to fifty feet above the present flood plain. The materials composing these terraces differ markedly from those making up the Buchanan gravels in that they are largely of local limestones and cherts. In most cases less than ten per cent of the fragments are of crystalline rocks. Along the river from the county line westward, in the southeast quarter of section 36, Pleasant township, the terraces are well developed. Not far from the line the stratified terrace materials have been undercut by the river so as to show a fresh section forty feet in hight. Near and below the middle of the section there are many coarse blocks from the Oneota and Saint Peter formations, but the main body of the deposit consists of rounded fragments of chert and local limestone, with some pebbles of quartz, diorite, granite and other northern crystallines, all embedded in quartz sand. Some small streaks made up almost exclusively of northern pebbles and quartz sand are iron stained and resemble the ordinary Buchanan gravels. Between section 36 of Pleasant township and section 16 of Decorah, there are many remnants of the same terrace deposits. In section 12 of Decorah the terrace has been cut into by a small wet weather tributary exposing a fresh surface of the same materials found farther east. The deposit is well stratified. Some streaks of clay are intermingled with the gravels. There is also a considerable amount of quartz sand; and rounded fragments of crystalline rocks occur, varying from small pebbles a fraction of an inch, to cobbles eight or nine inches in diameter. The major part of the material, however, consists of fragments of sedimentary rocks from the local formations. The larger crystalline cobbles are very rare. On the left bluffs of the river opposite Decorah, between Mill spring ravine and the Ice cave, the terrace material takes the form, in part at least, of irregular, only partially worn chips of limestone arranged in definite bands, with what seems to be washed residual clay in the interstices; while mingled with the local fragments are small numbers of crystalline pebbles. Toward the base of the deposit the limestones are worn and well rounded; foreign pebbles are present in larger proportional numbers than higher up; all the fragments are embedded in clean quartz sand; and the whole is bound together with calcareous cement into a firm conglomerate. The base of the terrace is here thirty feet above the present flood plain, and on a platform between the terrace and the river are many remnants of very much weathered, ferruginous Kansan drift.

Along with the deposits of uncertain age one at the mouth of Mill spring ravine should perhaps be mentioned. While some of the materials here are the same as those composing the terraces described above, it is very probable that the deposit is due to the working over and re-deposition of a variety of materials at a much later date. The section exposed occurs at the side of the road and is twenty feet in hight. The arrangement of the materials is without definite order. Small bodies of stratified, oxidized, iron stained gravels are shown; there are irregular local masses of gravel composed of limestones and cherts; large blocks of calcareous tufa, probably a precipitate from the springs of the immediate neighborhood, are disposed without order throughout the face of the section; there are yellowish and ashen silts, some containing such land shells as Succinea and Polygyra; and there are others containing the shells of aquatic types such as Physa. Impressions of leaves resembling those of the modern elm and hazel are found in some of the blocks of calcareous tufa. The whole appears to be but a remnant of a much larger deposit that once may have filled the ravine from side to side for some distance above its mouth.

Post-Kansan Loess.—There are evidences of two distinct loess deposits distributed throughout the county. Between the two the differences in age are very great. The older loess is related to the Kansan drift, though the time of its deposition may have been very much later than the appearance and withdrawal of the Kansan ice. Its exact age can not be determined from the knowledge now at hand. It lies on an eroded surface of Kansan till, which would imply that its deposition did not immediately follow the disappearance of the Kansan glaciers; that this loess was old, weather-stained and altered before the second, or Iowan loess was laid down upon it, is also clearly indicated. The old loess is blue or gray in color. It is much more plastic than the yellow Iowan loess. Evidences of age and alteration before it was covered by later deposits are found in the segregation of the iron in the form of large, ferruginous, concretionary "pipes", and in the great numbers and large size of the loess kindchen which indicate the leaching and re-deposition of the calcareous constituent. Where the deposit is trenched by rain cut gullies, the ferruginous "pipes" are shown to be not only very numerous, but to be hard enough to bear complete separation by washing from the softer matrix and resistant enough, for some time, to cumber the bottom of the trench by scores and hundreds. The concretionary process evidently began around plant roots, but it went on, building up concentric rings, until diameters ranging from three to five inches were attained. Shimek* has referred to the particular case observed near the northwest corner of section 20, Bluffton township. In 1903 one of the best exposures in the county was to be seen at this point. The older loess was exposed in a steep sided trench to a depth of four feet,

*_The Loess and the Lansing Man._ By B. Shimek, _Bulletin from the Lab. Nat. Hist. of the State University of Iowa_, Vol. V, p. 340. Iowa City, November 19, 1904.

and above it was a bed of fresh, yellow, Iowan loess having a thickness of eight or ten feet. The locality is on a hillside sloping to the north, and both loess deposits are thickest near the top of the slope. The older deposit, in fact, thins out and disappears in a short distance, and before the middle of the slope is reached the younger loess rests directly on yellow shaly limestones belonging to the Maquoketa stage. Both older loess and Kansan drift had been removed by erosion before the last episode of loess deposition began. The alteration of the older loess was all finished before the deposition of the later, for the overlying bed of ten feet in thickness would effectually protect the lower from further change. Except at the surface, there are no evidences of change in the upper bed since it was laid down. The locality noted above is but one of scores showing the same relations of two distinct beds of loess. When seen in a clean vertical section, the line between the two deposits is quite sharply drawn as shown in figure 18, reproduced from a view by Shimek taken in section 3, Decorah township.

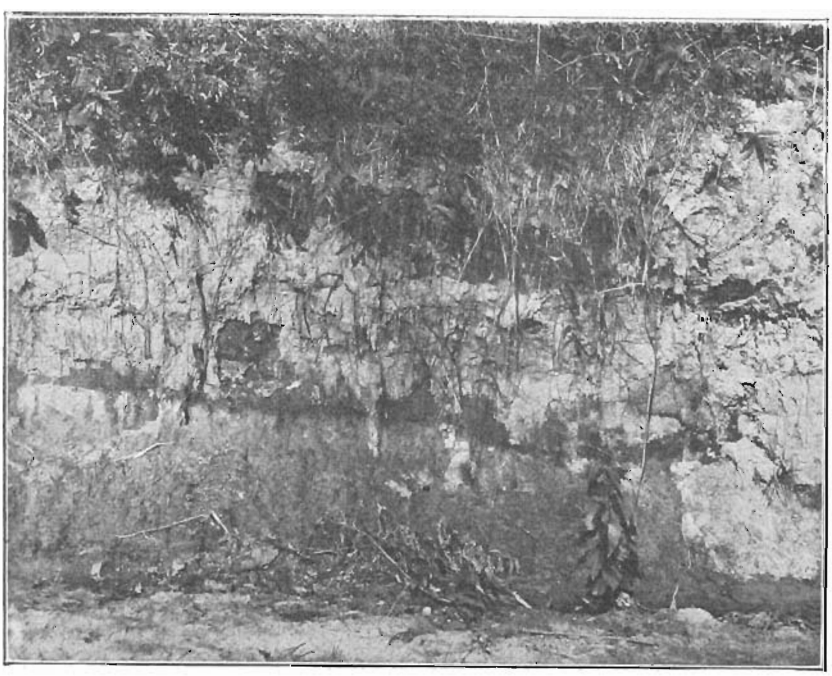


Fig. 18—An older and a younger loess in section 3, Decorah township. The dark band below the middle of the view separates the two deposits. Photo by Shimek

IOWAN STAGE.

Iowan Drift.—The Iowan drift covers less than one-third of the total area of Winneshiek county. It pushes over into Winneshiek from Howard and Chickasaw and terminates quite abruptly along a very irregular line before advancing far, at any point, beyond the limits of the western townships. The erratic line which marks the extreme eastern limits of the Iowan ice sheet, is described in the chapter on topography, and is shown on the map of the Pleistocene deposits. West of this line the surface is, in general, a very gently undulating plain, contrasting strongly with the deeply dissected surface of the Kansan drift, or of the region in which the present topography is due to preglacial erosion. The inequalities of the Iowan surface are not due to water sculpture in post-Iowan time, but to the irregular manner in which the drift materials were deposited by the Iowan ice. In Winneshiek county, as elsewhere, the Iowan drift is very thin near its margin and fails in many cases to conceal the effects of pre-Iowan erosion, but in general this younger drift plain, with its broad, shallow sags and low, flat, intervening swells, shows none of the characteristics of a water carved surface. The deposit under consideration is characteristically developed over the major part of Jackson and Sumner townships and the west central part of Orleans.

The Iowan till is yellow, comparatively free from cobbles and pebbles, moderately calcareous, and its surface is strewn with large, coarse grained, light colored granite bowlders. Usually the Iowan area has no loess; the till shows scarce any signs of oxidation or leaching; its bowlders are fresh; its surface has not been modified in any appreciable degree by erosion; its materials remain practically as the retreating Iowan glaciers left them.

Along its border the Iowan drift plain is usually abruptly set off from the Kansan by a conspicuous ridge of loess. The Kansan area is always loess covered; the surface is carved by drainage waters into a branching and re-branching system of ravines which diminish in depth and importance as the number of branches is increased, and finally fade into scarcely perceptible, shallow depressions on the divides; over the ridges and ravines loess is spread as a veneer, showing that the erosion was complete before the yellow loess was deposited; the upper surface of the till is reddened by oxidation which took place during the long pre-loessial period of exposure; the lime carbonate has been leached from the upper zone; many of the few small bowlders which occur are so far decayed as to crumble of their own weight or under very slight mechanical force; the contrast between the old, eroded, weathered and loess covered Kansan and the young, fresh, uneroded Iowan is very great, and it is all the more striking when the two areas are seen in close proximity, as along the Iowan margin. The differences are sufficient to arrest the attention of any intelligent observer.

Iowan Sand Terraces.—Deposits of fresh, white, clean sand are strewn along the valley of the Upper Iowa, and are particularly well displayed in sections 13 and 24, Decorah township, and 7, 8 and 18, Glenwood. The sand overlies the rusty Buchanan gravels, in areas of some width, on the east side of the road leading from Freeport to the bridge in section 7 of Glenwood; but it seems to have been deposited chiefly in comparatively narrow belts along the lower slopes of the bluffs. It is referred to the time of flooded streams connected with the melting of the Iowan ice on the basis of its fresh appearence, its stratigraphic relations to the old, weathered Buchanan gravels and its evident identity with sand beds of Iowan age in counties ranging from Johnson to Mitchell. In connection with the record of sand trains along the main drainage course of the county, it will be appropriate to note a number of Iowan bowlders in the northeast quarter of section 21, and the northwest quarter of 22, Fremont township, at some distance from the Iowan border. There is here a sharp curve in the river changing the flow from the northeast toward the southwest, and on the outside of the curve there is a low, flat area extending eastward for a distance of half a mile. The bowlders, fair in size and more than a dozen in number, are located on this flat space upon which the stream would be projected at high water. It is easy to see that floating masses of Iowan ice carrying bowlders would be swept out of the main channel and stranded at such a point, when the swollen stream was transporting and depositing the Iowan sands. At its maximum, the Iowan ice lay deep in the valley of this river, and in all its drainage basin, west of Foreston in Howard county, and it was from this region that the bowlders near the northeast corner of section 21, Fremont township, came.

Iowan Loess.—Intimately related to the coming and going of the Iowan ice sheet was the deposition of the young, fresh, yellow loess which begins at the Iowan border and is spread to indefinite distances over the region lying outside of that margin. The whole county, excepting the area of Iowan drift, is covered with it. The loess is very young as compared with the other phenomena of the area upon which it lies. It varies in thickness from a few inches to ten, fifteen or twenty feet, but in general it conforms to all the erosional inequalities which had been developed on the surface before the time of its deposition. If, therefore, it could all be swept away, the topographic features of the region would not differ essentially from those of the present. This loess is a fine, yellow dust, evidently derived from the yellow Iowan till to the westward, often containing numerous fossils in the form of the fragile shells of land snails, and furnishing occasional small limy nodules, the loess kindchen. The more extensively and thoroughly the loess is studied, the stronger grows the evidence that it is simply wind-blown dust, a true aeolian deposit. Usually the formation shows no evidence of stratification, but bedding planes are indicated in not a few instances. When seen at all, they conform to the surface slopes or present the irregularities sometimes seen in drifts of snow or bodies of aeolian sand. A case of very complex bedding is seen near the center of the west half of the northwest quarter of section 33, Calmar township.

Alluvium.

Fine alluvial deposits occur in the valleys of the principal streams. In that part of the Upper Iowa or Oneota valley between the northwest corner of the county and Decorah there are many small areas and narrow belts of alluvium, well shown at Plymouth Rock, Bluffton, and other points where the walls of the valley recede from the stream and true flood plains are developed. Below Decorah there are a number of similar areas, but the coarser sands and gravels connected with the effects of melting glaciers, have choked up the valley and preoccupied the space which might have been covered with alluvium, to a much greater extent below Decorah than above. Alluvial plains of no very great size occur along Bear creek and Canoe creek in the northeastern part of the county, and along the Turkey river in the southwest.

Soils.

The soils of Winneshiek county are very varied. There are stony residual soils without loess in the hilly driftless portions of the county, in the eastern parts of Glenwood, Pleasant and Highland townships, as illustrated in figure 17; in the same part of the county there are residual deposits covered with loess; in the central and western portions of the Kansan area the soil is loess underlain by Kansan drift; in the Iowan area the soil is a dark loam derived directly from the Iowan till, without loess; and in the stream valleys there are the small areas of alluvial deposits, furnished with the most fertile and most desirable type of soil in the county. Large bodies of superior farming lands, with loess-Kansan soils, are found in the county in two distinct areas. One of these includes the northern parts of Fremont, Burr Oak, Canoe and Pleasant townships, together with the whole of Hesper and the western part of Highland. The other covers the central part of Frankville township; from fifteen to twenty square miles in the eastern and central parts of Madison; and the uplands on the summit and sides of the Cresco-Calmar ridge from the Iowan border near Calmar to the southeast corner of the county. In these areas the surface is more or less rolling and naturally well drained, the soil is loose and mellow, free from rock fragments, easy of cultivation. The slopes are not so steep but that a fertile loam is developed. In the other parts of the loess-Kansan area, in proximity to streams, the surface is characterized by steep sided ravines and narrow intervening ridges, the land is easily trenched and gullied by rains, humus is washed away as fast as developed, and the soil is less fertile and less easily cultivated than on the uplands farther from the drainage courses.

Iowan drift soils are found in the western portion of the county, over the whole or part of Orleans, Lincoln, Calmar, Sumner and Jackson townships. The surface is less rolling than in the loess-Kansan area, for which reason the surface drainage is not so universally perfect. A deep, black, fertile loam is developed, rich in lime carbonate as well as in organic matter. There is sand enough to make the soil warm, mellow and easily cultivated. Granite bowlders are scattered over the surface, but they are not sufficiently numerous to be troublesome. Lack of drainage in very wet seasons is the only disadvantage which these soils have as compared with those of other parts of the county, and this is nowhere serious. It is probably true that the most valuable farming lands of Winneshiek are found in the area of Iowan drift. The distribution of the small areas of alluvial soils has been noted under the head of Alluvium.

Unconformities.

In discussing the stratigraphy of the county reference was made to the very pronounced unconformity between the Productella beds of the Devonian and the Maquoketa formation of the Ordovician. The Silurian is absent. The Niagara limestone may never have been deposited in the northern part of the county, or it may originally have been very thin and, in this area, was removed by erosion before the beginning of the Devonian. The few small outliers of Niagara in Washington township would indicate that the Niagara probably was present, at least in the southwest part of our area, and that erosion must be reckoned as one of the factors in accounting for its absence between the Maquoketa and the Devonian at points only a few miles from the outliers, on the west side of the Turkey river.

The unconformity here is due to overlap. During the Silurian the shore line was moved westward to an unknown distance, and at the beginning of the Devonian the sea was still remote from Winneshiek county. At the most it was only the lower part of the earlier division of the Niagara that was deposited in this area before the waters receded to the west. The greater part of what has been called the Delaware stage of the Niagara is absent, as well as the whole of the Gower, which is so conspicuously developed and attains its maximum thickness in Scott, Cedar and Jones counties. On the other hand the lower part of the Devonian is missing. During the time represented by the Otis, Independence, Lower Davenport, and most of the Upper Davenport beds, as these have been described by Norton in reports on Linn, Scott, and Cedar, the region was still undergoing erosion. The Devonian horizon that lies in contact with the Maquoketa in Winneshiek and Howard counties is that of *Productella subalata* Hall, and *Spirifer pennatus* Owen, a horizon equivalent to that of the city quarry and other quarries in and around Independence, a horizon well above the Fayette breccia, even above the Gyroceras beds of the Upper Davenport. The uplift which caused the waters to recede probably came to an end about the beginning of the Devonian, and a slow subsidence allowed a transgression of the sea upon an eroded surface. The movement reached its maximum about the close of the time represented by the Upper Davenport beds of Norton. The crustal warping which made the transgression possible faded out toward the southeast; there are no indications of it in Cedar county where the several divisions of the late Silurian and early Devonian seem to follow each other without any break, but the abnormal eastward trend of the Devonian margin in Muscatine and Scott counties may be indicative of some corresponding movement in the region south of Cedar.

The other unconformities in the county are connected with the deposition of the successive formations belonging to the Pleistocene. The Kansan drift is unconformable on all the formations of the Paleozoic rocks with which it comes in contact. The Iowan drift was spread over a deeply eroded surface of the older Kansan. The Iowan loess is unconformable on Kansan drift in some localities, and on the older indurated rocks in others.

Economic Products.

BUILDING STONE.

Winneshiek county is fairly well supplied with building stone. The lower part of the Oneota limestone as exposed in the valley of Bear creek from Highlandville to the east county line, is capable of furnishing a superior grade of quarry stone, and all it lacks is development. The same beds come to the surface along Canoe creek in sections 25 and 26, Pleasant township, and a mile farther north, in a small valley which traverses sections 23 and 24, they are again exposed. The stone is a light cream colored dolomite in very regular layers, durable, easily worked and suitable for use in the construction of the higher grades of public and private buildings. Owing to distance from markets no effort has been made in this county to operate quarries at this horizon; but it should be known that the formation is, in all respects, the same as that which, in Minnesota, has won deserved reputation under the trade name of Kasota limestone.

Most of the quarries about Hesper and Decorah are worked in the upper beds of the Platteville limestone. For a thickness of five or six feet below the base of the Decorah shales (the "Green Shales" of authors) the Platteville lies in regular beds from three to eight or ten inches in thickness. The stone is not dolomitic, but is firm and compact, with fine even grain, gray or drab or bluish in color on fresh fracture, but bleaches to lighter shades on exposure to the weather. Stone from layers at this horizon is quite durable and has been used extensively, particularly in the construction of the earlier buildings, in Decorah. In the neighborhood of Mill spring, and between the spring and the Ice cave, a large amount of good building material has been taken from these beds. The lower quarry of Mr. Halloran, located northeast of the city, is worked in the Platteville limestone. Another quarry near the north end of the Ice cave bridge (Fig. 6) has furnished quite an amount of material from the same formation. Joints are so distributed that pieces ten to twelve feet in length and nearly as many feet in width may be taken from the quarries, and the superior resistance of the rock to weather and mechanical wear fits it admirably for door steps and flag stones.

A number of quarries have been opened in the Platteville limestone around Hesper. The one which has been worked most constantly is located south of the village and is operated by Mr. E. H. Weber. Several hundred cords are taken out annually and sell at the quarry for $4.50 a cord. Mr. Weber has been operating here for twenty years. The lower part of the Decorah shale is in position above the quarry stone and has to be stripped in carrying on the work. In the species and grouping of the fossils, the shale here resembles that near Waukon in Allamakee county more than that near Decorah. Only the beds for a few feet in thickness below the shale are taken out by the quarrymen, and, during the many years of operation, the stone has been removed over an area of some acres.

In the lower part of the Platteville formation the beds are thicker and more magnesian than in the quarries described. There are found here the "Lower Buff Beds" of the Wisconsin and Iowa geologists. This horizon is capable of furnishing a superior grade of building stone, especially suited, where the beds are thickest, for bridge piers and other heavy structures. In point of durability and resistance to weather the Lower Buff beds have few superiors. At no points in the county have these beds been utilized to any considerable extent. Individually and in the aggregate their thickness is much less in Winneshiek than in Dubuque county. The heaviest ledges of the Lower Buff beds in Winneshiek county were seen in the valley of the Upper Iowa in the vicinity of Freeport and farther east.

A number of quarries have been opened in the Galena limestone, above the level of the Decorah shale. Many are small and were operated only temporarily to supply some immediate local need. At no point does quarrying in the Galena assume commercial importance. The upper quarry of Mr. Halloran is worked at the level of the lower Receptaculites zone, about fifty feet above the Decorah shales. The quality of the stone is not as good as that from the upper part of the Platteville. The bedding is not so regular; the texture is less uniform; much of the stone is liable to split into small chips on long exposure to the weather. There is a large quarry at Nordness which is opened in the upper beds of the Galena. The Maquoketa begins only a few feet above the exposure. The upper beds are badly checked and weathered, but below these there are some quite firm ledges varying from ten to fourteen inches in thickness, with which there is associated a ten inch band of shale. About the middle of the quarry face there is a belt of irregularly bedded concretionary limestone, three feet in thickness, altogether lacking in the homogeneity requisite for good quarry stone. Below this belt there are six feet of more regular and more homogeneous beds, with some of the individual courses fully ten inches in thickness. Another quarry at the same horizon as that at Nordness is opened on the south side of the Yellow river, in the north half of the northeast quarter of section 13, Bloomfield township, on land belonging to the estate of Mr. Melvin Green. The characteristics are the same as at Nordness except that there are several bands of shale, ranging from two or three, to ten inches in thickness, interstratified with the limestone. Another quarry which includes the uppermost beds of the Galena is located on the south side of the diagonal road in the southwest quarter of section 17, Bluffton township. There are other small quarries, worked temporarily or intermittently to supply the purely local demands, near Kendalville, Plymouth Rock and Burr Oak. In the southeast quarter of section 7, Fremont township, are some small quarries opened in beds of dolomitized Galena, a phase of the formation resembling that at Dubuque. Dolomitization here is local, being restricted to an area of three or four square miles. The many other small openings in the Galena limestone are too numerous to be individually noted.

Much of the Galena limestone is very unreliable. When quarrying has been carried into the hillside beyond the zone of weathering, the ledges may appear to be thick, firm, durable, suitable for any kind of construction; but after being placed in walls and exposed to alternations of temperature and the chemical effects of air and moisture they split into thin laminae and eventually break up into small, irregular chips. The effect is well shown in the portions of the old retaining wall still standing around the court house square.

Quite an amount of quarrying has been done in the Maquoketa formation. The Isotelus zone is very regularly and evenly bedded, and in a few instances it is firm enough to serve for building stone. One quarry at this horizon, located in the northeast quarter of Springfield township, was noted in connection with the general discussion of the Maquoketa beds. In some cases the strata lying between the Isotelus zone and the Clermont shale are capable of furnishing a fair grade of building material for rough walls and foundations; but the principal quarry horizon in the Maquoketa is that of the Fort Atkinson limestone. This, not infrequently, is a hard, granular, crystalline dolomite comparable to some phases of the Galena limestone in Dubuque county. At Fort Atkinson quarries have been worked in this formation for many years, and one of these, located a few yards west of the old fort (Fig. 12), is capable of yielding blocks of any desired dimensions up to three feet in thickness. Another quarry in the same limestone, on the east side of the fort, has been operated intermittently for some time and has furnished quite an amount of fairly good material. In the southwest part of Military township there are many quarries and natural exposures in the Fort Atkinson beds. The small quarry near the center of the southwest quarter of section 33 and that near Ossian in the northwest quarter of section 15, will be found noted with some detail in the part of this report which treats of the Fort Atkinson limestone. On the north side of the Cresco-Calmar ridge the Fort Atkinson formation comes to the surface and is quarried near the center of the southwest quarter of section 27, Springfield township, and about sixty rods south of the northwest corner of section 5, Bloomfield. At the point last named the rock is yellower, softer, less crystalline than at Fort Atkinson. The rocks of this horizon become more earthy or shaly toward the northeast, and gradually lose the qualities of a pure dolomite which distinguish them at the type localities in Fort Atkinson and Clermont.

A small amount of material has been taken out at a few points from the Niagara limestone. The old quarry in the small Niagara outlier west of Festina, near the northeast corner of section 22, Washington township, has been noted in discussing the Silurian System. No stone for any useful purpose has been taken from any phase of the Devonian.

Lime.

While no lime is now manufactured in Winneshiek county, the materials for making a high grade product are not wanting. The upper two-thirds of the Oneota is particularly well suited for this purpose. This is a hard, granular, crystalline dolomite of much the same character as the Galena limestone which is so successfully made into lime at Eagle Point, Dubuque. At Waterville in Allamakee county lime is made and shipped extensively, and the stone used is the Oneota, the same stone that is so well developed at Highlandville and Canoe, and along the river below Freeport, in Winneshiek county. The non-dolomitic Galena formation in Winneshiek would make an excellent lime if it were used soon after it is burned, but it will not keep as well as lime made from the Oneota dolomite. It is liable to deteriorate by becoming air slaked if kept in stock for even a comparatively short time, and, if in this condition it is used for mortar, it is easily crumbled and washed out of the joints. The greater part of the Niagara limestone should make a good grade of lime. There is nothing in the Devonian that can be recommended for lime making, unless it may be the small amount of the lithographic phase in section 7 of Orleans township.

Clays.

There are two brick yards operated in Decorah, and these make practically all the clay products manufactured in the county. The raw material used is loess. This clay is worked as it is taken from the pit. The brick are sand moulded and dried on the yard. About 500,000 are made annually. The loess is abundant and widely distributed throughout the county, being found everywhere except in the small area of the Iowan drift. Loess clay might be used in making a high grade of pressed brick. The Maquoketa clays, the Clermont and Brainard shales, are not used at any point, though it should be possible to obtain Clermont shale with little difficulty in the vicinity of Fort Atkinson. This is the clay that has been used for many years in making brick and tile at Clermont in Fayette county.

Road Materials.

Materials for the improvement of the country roads and village streets are abundant in the form of limestones and gravels. Limestone, easily crushed to form macadam, may be found convenient to almost every locality in the county; but the natural stores of road materials occur in the beds of Buchanan gravels which are so widely and generally distributed as to be present in practically every neighborhood. The most abundant deposits of these gravels, as already noted, are along the stream courses, beds notable for their extent occurring in the valley of the Upper Iowa below Freeport.

Water Supplies.

Streams and springs, the natural sources of water supplies, are well distributed throughout the county. Shallow wells in the surface deposits are important sources of supply in portions of the county where the drift mantle attains considerable thickness, and the deeper wells drilled in the underlying rock are usually successful at moderate distances from the surface. The great aquifer, the Saint Croix sandstone, which underlies the whole state and supplies the greater part of our artesian waters, may be reached at any point in Winneshiek county with no great amount of drilling.

With a few possible exceptions along Bear creek, the springs of the county are all fed by ground waters which have never reached a depth of more than a few score of feet beneath the surface. For example, the most important spring horizon is at the base of the Galena limestone. This formation is cut by numerous intersecting joints along which the ground waters move with great freedom. The large number of sink holes that pit the surface over much of the area where the Galena is the bed rock, constitute one of the ways whereby water finds access to the fissures referred to. The descent of the waters below the base of the Galena is stopped by the impervious bed of Decorah shale. When valleys are cut below this horizon, the waters find exit, and always on the side where the rocks are dipping toward the valley. Cold spring, a few miles northwest of Bluffton, are Mill spring, on the north side of the river opposite Decorah, are among the noted springs of the county, whose position is determined by the Decorah shale. In both cases the waters come to the surface a few feet above the level of the shale horizon. There are a few small springs along the plane between the Glenwood shale and the Platteville limestone.

There are springs of the shallow type represented by those from the Galena limestone in the eastern part of section 1, Jackson township. At this point, however, the jointed limestone is the Fort Atkinson, and the impervious bed beneath is the Clermont shale. At least one spring in Washington township, in the northeast quarter of the northwest quarter of section 35, is due to ground water in fissures in the Niagara limestone finding exit on top of the Brainard shale.

The contact plane between the Jordan sandstone and the Oneota limestone is another horizon along which springs occur. The spring at Highlandville, and other springs between Highlandville and Quandahl, are due to waters from the Jordan sandstone, which probably rise as a result of hydrostatic pressure and flow out because corrasion of the valley has cut into the upper part of the aquifer.

Water Powers.

The streams of Winneshiek county are capable of furnishing a large amount of water power. Power has been developed on the Oneota or Upper Iowa river at Kendallville, Plymouth Rock, Bluffton, Decorah and Freeport. Some of these plants have been allowed to fall into decay, but the possibilities are there still, and in the future all available sources of water power are certain to be in demand. There are good power properties on the Turkey river at Spillville and Fort Atkinson. Along the smaller streams, such as Bear creek and Canoe creek, there are opportunities for developing and maintaining water powers very much greater than have yet been realized. Mill spring near Decorah is an example of a fair sized stream issuing on the hillside, many feet above the valley, and affording head sufficient to do quite an amount of useful work.

Gold.

Winneshiek is one of the counties in which reports of the discovery of gold in the stream gravels have been in almost constant circulation since the earliest occupation of the territory by the white man. Quite an amount of work was done in attempts to recover gold between 1855 and 1865, and there was a very active interest in the subject as late as 1903. No substantial basis for the remarkable claims made by the gold hunters could be discovered, and it is safe to say that none ever existed. A few flakes of gold may possibly occur in sands and gravels derived from the drift, the precious metal having been brought from the auriferous ledges of the Rainy lake region by the glacial ice; but it would require unusual patience and persistence on the part of the prospector to discover even a single "color." The citizens of Winneshiek may rest assured that neither in their county nor in any part of Iowa will gold mining in any form ever become a profitable industry.

Caves.

The Galena limestone is notable for the great number of fissures and caverns which it contains. Openings in the formation appear in the faces of bluffs, and their presence is indicated over extensive areas of upland by the great numbers of sink holes which pit the surface. Enlargement of fissures has given rise to caverns or caves.

The Glenwood cave is typical of its kind. The location is in the face of a bluff, less than one-fourth of a mile south of the center of section 34, Glenwood township. There is here a large grotto forty feet high in front and diminishing rapidly in hight to about eight feet, at a distance of sixty feet from the entrance. At this point the cave proper ends, and the opening beyond that is reduced to a comparatively small fissure. The mouth of the cave is a pointed arch which is nearly thirty feet wide at the base. The limestone forming the roof and walls is shattered to small chips by weathering, and the appearance is somewhat rough and ragged. The floor of the cave is not far above the level of the Decorah shale, which appears in the bed of the creek a short distance to the north. The lower zone of *Receptaculites oweni* Hall, is involved in the walls and roof, fragments of the fossil being found amongst the fallen waste which strewed the floor. The cave affords exit for one of the numerous underground streams which traverse the fissures of the Galena limestone.

Mill spring at Decorah issues from a somewhat similar cave, but tumbled blocks from the walls and roof obstruct the entrance. The geological horizon is the same as at the Glenwood cave. The floor is a few feet above the Decorah shale, and *Receptaculites oweni* is seen in the face of a bluff a short distance above the level of the spring pool. Cold spring, a few miles northwest of Bluffton, flows out of a low roofed cavern in the Galena limestone.

The Decorah Ice cave is the most noted of the caverns in this county, the most noted in the state of Iowa. The location is in the face of the bluff on the north side of the river, opposite Decorah. The cave is entered from a recess at right angles to the trend of the cliff, and the direction taken by the chamber is practically parallel to the outer surface. The opening is in fact an enlarged fissure, one of the numerous east-west joints which cut through the Galena. The cliff face is merely a joint face, and the cave is opened along the next parallel joint. The mass of limestone between the cavern and the front of the cliff has settled and slipped outward at the base, the movement being due to the yielding of the underlying Decorah shale. A short distance east of the Mill spring ravine, not far from the home of Mr. John O. Vold, there is an exposure of Decorah shale, and on the slope above the shale there is a great column of Galena limestone which has crept out at the base on the yielding, slippery shale and assumed a nearly horizontal position. The relations of the strata involved in the displaced mass remain practically undisturbed. The widening of the Ice cave is due to similar creep, but the amount of the movement has been very much less.

The Ice cave has attracted attention from the fact that the walls are dry and bare in the late autumn and the first two months of winter, and are coated with ice during the spring and early summer. Ice is formed commonly on the north wall. The amount varies greatly from year to year, but generally the maximum thickness is attained between the first and the middle of June. Later in summer the ice is gradually melted, and it may disappear completely early in August. No two seasons, however, are necessarily just alike, so far as relates to the thickness of the ice, or the times of its appearing and disappearing.

Much depends on the intensity and duration of the cold of the preceding winter. Dr. C. A. White, when serving as State Geologist of Iowa, visited the cave on June 1, 1869, and he records in his report, Vol. I, page 80, that "the ice seemed dry and well frozen, and was evidently accumulating at the time of our visit." On the 22nd day of July, 1877, the writer found the north wall covered with a thick sheet of ice, and, under the conditions of very low temperature then existing, several weeks must have elapsed before the ice was all melted. Some of it may have been present until well on into September.

Between July 1, 1897, and July 16, 1898, Mr. A. F. Kovarik of Decorah carried on a series of observations on the Ice cave, the most important that have yet been made. The results of his work were published in the Scientific American Supplement, No. 1195, issued for November 26, 1898. From this paper I quote freely the facts which follow. The cave divides into two branches at a distance of twelve meters from the entrance, one branch leading southward into a small chamber having an opening upward to the outer air; the other leading westward into the ice chamber. At six meters from the division is the point where the ice accumulates to the greatest thickness, a point called by Mr. Kovarik the "Locus Glacialis." According to the excellent report before me the greatest thickness in 1897 was attained July 1, when it was about 25 cm., or ten English inches. From then the thickness gradually decreased, so that July 17, it was only 15 cm.; July 24, 10 cm.; and by September 3 all the ice had disappeared. After September 3, the temperature gradually rose until October 16, when it reached its highest point, +8.3° C., or about the temperature of a cold spring; from thence, a gradual decrease in temperature continued till the time of the lowest point. This was February 26, 1898, when the thermometer showed —6.6° C. In 1898 the ice at Locus Glacialis first appeared about May 29. Two weeks before that time water was dripping from the crevices between the north and south walls. Beginning with May 29, the ice rapidly increased in mass, and by June 12, the time of maximum quantity, the ice covered the wall for a width of nearly two meters, having the greatest thickness of 29 cm. The decrease was rapid in 1898; July 16, only a small quantity was found, and by August 1 all the ice had disappeared.

The following table is quoted from the paper of Mr. Kovarik; the temperatures are given in degrees Centigrade.

TIME.	IN THE VALLEY. (SHADE)	DIVISION.	LOCUS GLACIALIS.	END.
July 1, 1897	+33.3	+ 2.2	0.0	0.0
July 27, 1897	+21.1	+ 5.0	0.0	0.0
August 14, 1897	+32.2	+ 5.8	+3.1	0.0
September 3, 1897	+32 2	+ 7.2	+3.1	+8 3
September 18, 1897	+33.9	+ 8 6	+6.1	+8.3
October 16, 1897	+24 0	+10.0	+8.3	+8 3
October 30, 1897	+10.0	+ 7.2	+4.7	+5.0
December 11, 1897	— 2.2	— 2.7	—1.1	—2.2
January 8, 1898	0.0	— 2.7	—3.9	0 0
January 22, 1898	— 5.0	— 6.1	—3.9	—3.9
February 26, 1898	0.0	— 6.6	—6.6	—5.0
March 12, 1898	+ 2.8	— 1.6	—2.7	—2.7
March 26, 1898	+ 8.8	— 1.7	—1.6	—1.1
April 16, 1898	+25.6	— 1.4	+1.1	—1.1
April 30, 1898	+13.9	+ 1.1	—1.1	—1.1
May 28, 1898	+17.2	+ 1.7	—0.3	0.0
June 9, 1898	+25.0	+ 1.7	—0.3	0 0
June 18, 1898	+28.3	+ 1.7	—0.2	0.0
July 16, 1898	+35.0	+ 7.2	0.0	+2.2

From this table it will be seen that the popular notion that ice melts in the cave in winter and freezes in summer is not quite correct. It is true that freezing does take place in the summer, but the table shows the impossibility of anything like melting in the winter. Early in the winter the temperature in the cave reaches the freezing point, about as early as it is reached in the air outside; and with rare exceptions a freezing temperature is maintained until late in the following summer. After the ice disappears in late summer the temperature rises above the freezing point, and so long as this condition lasts no ice can be formed. By the middle of December, when the temperature of the cave has fallen below freezing, all moisture near the surface has been sealed by frost, circulation is stopped, no water finds its way into the cave, no ice is formed, though the temperature is low enough to congeal water if only it were present. The formation of ice begins when the ground thaws in spring and the released waters can percolate into undergound fissures and caverns. The cold that freezes ice in May or June is the cold of the preceding winter. The walls of the caverns may be chilled for some distance from the surface to a temperature many degrees below the zero of our ordinary Fahrenheit thermometers and water may be congealed by simple contact with such a surface. The Ice cave, however, is but a part of the great system of intersecting fissures and caverns that cut through the Galena limestone in many directions, the master joints being here, as elsewhere, east and west. There are miles of these joints connecting one with another in the hills about Decorah, and they represent millions of cubic feet of air space. If the winter should be severe and the cold protracted, these spaces may be filled with air having a temperature below zero Fahrenheit. With the advent of warm weather the colder, denser air flows out and may maintain a low temperature in the openings through which it escapes for some time after summer has fairly set in. As shown by McGee, the rapid expansion of this air as it issues from an orifice, would tend still further to reduce the temperature as in the case of an artificial ice machine, but the main cause of the freezing observed in glacieres like the Decorah Ice cave will be found in the stored up "cold" of the preceding winter.* That there is a movement of air into the cave in winter and outward in summer is confirmed by the observations of Mr. Kovarik. On July 1, 1897, he found a cold breeze coming from the cave, which was noticeable thirty meters from the entrance. At the entrance the breeze was so strong as to make it impossible to light an ordinary match, and, near the floor, it would blow out the flame of a candle. From December 11, 1897, till February 26, 1898, he found the air flowing into the cave. In this way we

*For explanation of the phenomena of Freezing Caverns, and especially of the Decorah Ice Cave, the reader may consult the following references:

WHITE.—Report on the Geol. Surv. of the State of Iowa, By Charles A. White, M. D., Vol. I, page 80. Des Moines, 1870.

KOVARIK.—The Decorah Ice Cave and its Explanation, By Alois F. Kovarik. Scientific American Supplement, No. 1195, page 19158, November 26, 1898.

BALCH.—Glacieres and Freezing Caverns, By Edwin Swift Balch, pages, 88, 89, 177. For general discussion of causes of subterranean ice, see pages 136-161. Philadelphia, 1900.

KIMBALL.—Ice Caves and Frozen Wells as Meteorological Phenomena, By H. H. Kimball. Monthly Weather Review, Vol. XXIX, page 366. Washington, 1901.

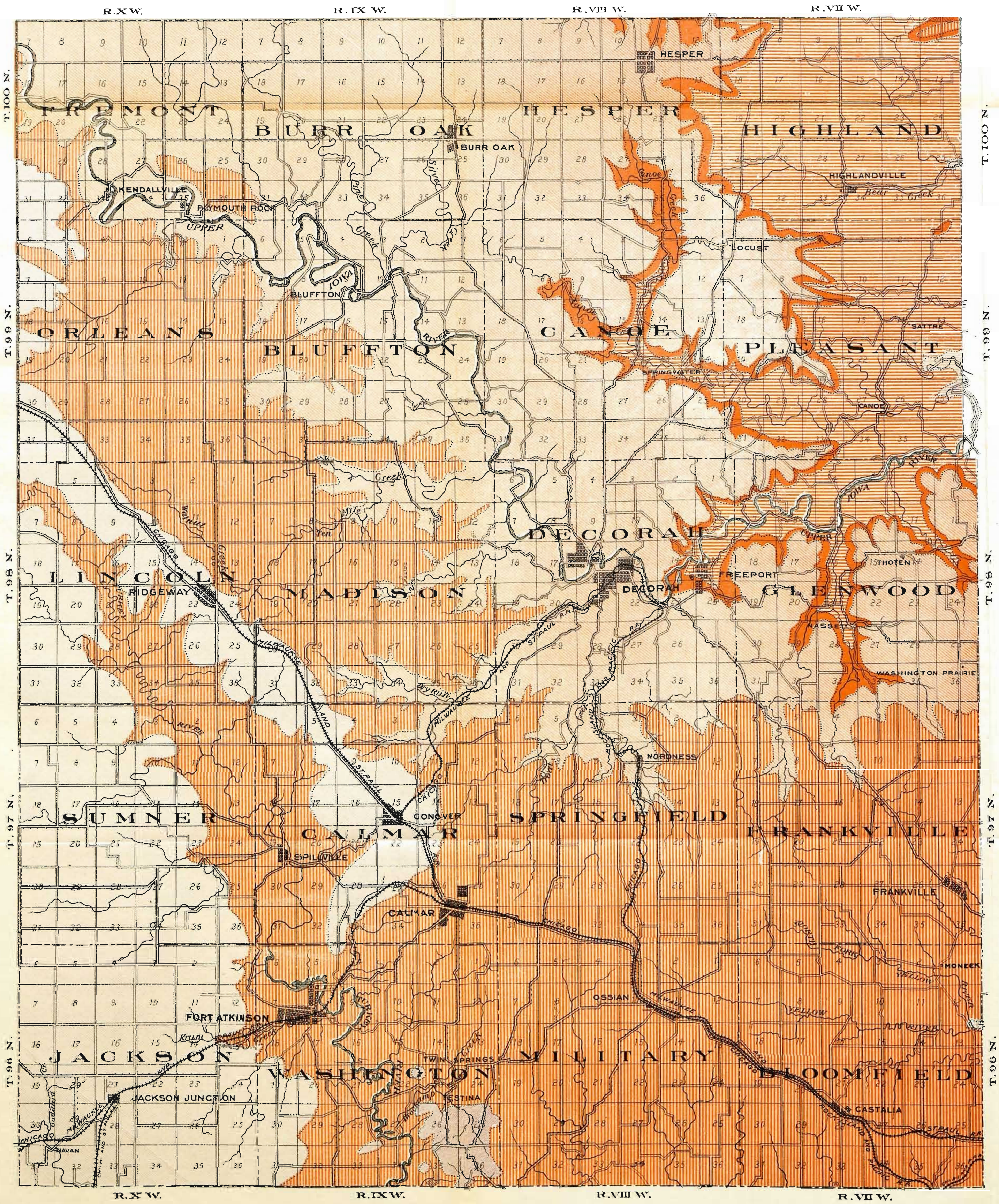
McGEE.—Ice Caves and Frozen Wells, By W J McGee. The National Geographic Magazine, Vol. XII, page 433. New York, 1901.

KIMBALL—Ice Caves and Freezing Wells, By H. H. Kimball. Monthly Weather Review, Vol. XXIX, page 509. Washington, 1901.

can imagine the great limestone chambers were filled with air at a temperature below the freezing point. The later outward movement of this stored up winter air maintained in the cave a temperature at, or near to O °Centigrade, throughout the months of spring and early summer.

Acknowledgments.

In prosecuting the survey work in Winneshiek county the writer had the assistance of Professor M. F. Arey of the State Normal School during the season of 1903, and of Mr. J. H. Lees of the University of Chicago in 1905. Many citizens of the county have, for many years, taken an intelligent interest in their local geology, and these have been able to render valuable service by directing the representatives of the Survey to characteristic outcrops and typical exposures. Of these, Dr. F. Worth of Hesper deserves especial mention. As acknowledged in the preceding pages, free use has been made of the excellent paper on the Decorah Ice Cave by A. F. Kovarik. The limitations of the working season preclude the possibility of making continuous observations for a sufficient length of time, by members of the staff of the Survey, and such work as that done by Mr. Kovarik is a contribution to knowledge of the greatest value. The Survey is indebted to Professor B. Shimek for the following excellent paper on the Botany of Winneshiek county. The paper represents a large amount of painstaking work, and the part relating to the trees and shrubs which are adapted to the soils and climate of the county will be found especially valuable. It is a pleasure here to acknowledge the value of the topographic work done by the United States Geological Survey. Free use has been made of advance proofs of the topographic sheet of the Decorah quadrangle, both in the field and in the office. Without this work as a base, the mapping of the geological formations would have been practically impossible. To the individuals and organizations contributing to the success of the survey of the county, the writer acknowledges his obligations and extends sincerest thanks.



IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF

WINNESHIEK COUNTY, IOWA.

BY SAMUEL CALVIN

1906

Scale 1/125,000

5 Miles

5 Kilometers

LEGEND

GEOLOGICAL FORMATIONS

Formation	Group	Series	System
Cedar Valley, Wapsipinicon	Middle Devonian		
Niagara	Silurian		
Maquoketa		Trenton Series	Ordovician
Galena, Decorah, Platteville		Trenton Series	Ordovician
Saint Peter		Canadian Series	Ordovician
Lower Magnesian		Canadian Series	Ordovician
Saint Croix, Jordan		Potsdam Series	Cambrian

TRI CITY LITHO CO DAVENPORT IA

THE PLANTS OF WINNESHIEK COUNTY.

BY B. SHIMEK.

Winneshiek county presents a flora of unusual richness. Both because of its geographic position and its varied surface features it offers conditions which have made possible the development of a variety of plants scarcely equalled in any other county of the state. Its northerly position and its rough topography, especially along the Upper Iowa or Oneota river have brought a northerly flora, such as belongs to the heavily wooded regions of Minnesota and Wisconsin; its wooded knobs and ridges along the Turkey and the head waters of the Yellow rivers remind one of the rough wooded areas of southern Iowa; while the prairies are but a continuation of the greater prairies of the west. Each of these territories presents a variety of conditions. The roughest includes the driftless area and the drift border, with their deep gorges with narrow alluvial bottoms, their exposures of both sandstones and limestones, their shaded mossy banks and wooded slopes with not infrequent small bogs, and their drier wooded ridges with occasional treeless barren summits; the more southerly timbered ridges present somewhat similar conditions, but without the prominent rock-exposures, and with floral areas less sharply defined than those which characterize a region cut by deep gorges; and the treeless areas include both the rich level prairie and the prairie bogs of the Iowan drift, and the more rolling and drier prairie of the Kansan. The soils are derived chiefly from loess and drift (which are discussed elsewhere in this report), and therefore vary comparatively little in chemical composition. Occasionally coarser, sandy material appears on the ridges, but on the whole a finer soil prevails, its fertility, however, varying with topography and plant-covering, and with the consequent possibility of retaining the humus-laden surface soil. Alluvial tracts are not, for the most part, of great extent in the county, being limited by the narrow valleys. In the rougher parts sandy and rocky tracts are frequent.

The investigations upon which this report is chiefly based were carried on largely during the spring, summer and fall of 1903. Every township in the county was visited, and certain typical localities were more thoroughly studied. Thus Moneek and Ft. Atkinson were selected for the study of the flora of the rougher territory of the two principal river systems in the southern part of the county; the vicinity of Calmar for the southerly prairie, and Orleans township and Bluffton for that in the western part of the county; for the rougher wooded region the entire gorge of the Oneota was traversed a number of times across the county, Decorah, Bluffton and Kendallville being the main centers of investigation, while the hilly country bordering Canoe creek and Bear creek received some attention; and the vicinity of Hesper, with its woods and prairies, and unique exposures of St. Peter sandstone proved the richest and most interesting single locality in the county.

The flora of this county had received some previous attention. Arthur's "Flora of Iowa"* contains numerous references to plants from this county, which are based, at least in large part, on material furnished by Mrs. M. C. Carter of Hesper, and Mr. E. W. D. Holway, formerly of Decorah; individual references are also made to Winneshiek county plants by a number of other authors who did not secure the material themselves, but received it from others—chiefly from Mrs. Carter, and Messrs. E. W. D. Holway, Herbert E. Goddard, Thos. E. Savage, Alois Kovarik, and E. Orr.†

*Contributions to the Flora of Iowa, J. C. Arthur, 1876, with continuation, Nos II VI in the Proceedings of the Davenport Academy of Natural Sciences, Vols. III and IV

†Such are the following:

Cerastium arvense var. *oblongifolium* n. var., Hollick and Britton, Bull. Torr Bot Club, Vol. XIV, 1887

Notes on the Aquatic Phenogams of Iowa,—R. I. Cratty, Bull Lab. Nat. Hist., State Univ of Iowa, Vol III, 1896

An illustrated Flora, etc., Britton and Brown. 3 Vols., 1896-1898.

The Cyperaceæ of Iowa, R. I. Cratty, Bull. Lab. Nat Hist, State Univ. of Iowa, Vol. IV, 1898.

The Iowa Pteridophyta, B Shimek. ibid., Vol. V, 1901

The Vascular Cryptogams of Iowa, etc., L. H. Pammel, Proc. Ia. Acad. Sci., Vol. IX, 1902, also reprint, as Cont. No. 20, Bot. Dep't, Ia. S. Col. of A. and M. A.

Manual of Botany of the No. U. S.,—Asa Gray, several editions.

Manual of the Flora of the U. S.,—N. L. Britton, 1st ed., 1901, 2nd ed., 1905.

Aside from the resident students of botany the most extensive collectors have been the following:

Mr. T. J. Fitzpatrick, who made a trip down the Upper Iowa in company with Dr. Paul Bartsch in the summer of 1895. He has published, in part jointly with Mrs. Fitzpatrick, a number of reports on the plants collected,* including, however, a large number of plants obtained from other collectors.

Prof. Thos. E. Savage, who visited the county in the spring of 1899. A small part of his collection was noted in some of the references cited, but the greater part is here reported for the first time.

The present writer, who made a number of trips to the county in 1902 and 1903. His collections and those of Prof. Savage are now in the Herbarium of the State University. They include a large number of lower cryptogams, especially fungi, lichens and mosses, a report upon which cannot be here included. Two short reports treating of the plants of the county have been published by the writer,* and in the present paper it is purposed to report upon all the plants obtained in the field, and also to include such as have been definitely reported from the county by others.

All the papers treating of Winneshiek county plants which have been heretofore published, have been little more than mere annotated lists. Very little attention has been paid to the economic value of the native plants, though this is often noteworthy, and the public has treated them rather as an undesirable encumbrance which must be removed as soon as possible to make way for the plants of the field and pasture. Aside from the use which we may make of individual plants or their products, the native flora has a vastly more important function whose influence extends far beyond the limits of any particular tract of land upon which it is developed, especially in a territory with a much broken surface such as is found in this county. It develops a better soil, conserves moisture, and prevents erosion and the

*Notes on the Flora of Northeastern Iowa,—Proc. Ia. Acad. Sci., Vol. V, 1898.
Manual of the Flowering Plants of Iowa, 1899.
The Orchidaceæ of Iowa,—Proc. Ia. Acad Sci., Vol. VII, 1900.
The Scrophulariaceæ of Iowa,—Proc. Ia. Acad. Sci., Vol. X, 1903.

*The Flora of the St. Peter Sandstone in Winneshiek County, Iowa, Bull. Lab. Nat. Hist., S. U. I., Vol. V, 1904
Notes on Some Iowa Plants,—Proc. Dav. Acad Sci., Vol. X, 1904.

consequent clogging of our streams with sand and mud. It is superior to any aggregation of cultivated or pasture plants for the reason that it is not removed to leave the soil bare during a large part of the year, as is the case with cultivated crops, and it is not eaten or tramped upon by cattle as in the case of pastures. Moreover, through long adjustment to existing conditions the native plants are perfectly adapted to the various surfaces upon which they occur, and they have become more pliant under the varying moods of our uncertain climate. They are, therefore, more certain of persisting, and thus continuing their benificent influence. In a rough country the dangers from erosion and desiccation are great, not only to the land itself, but to the streams and water-courses. The steeper slopes should never be cleared of their covering of native vegetation, either by cultivation or by pasturing, for not only will they not be profitable, but they will be a menace to better lands and to valuable springs and streams.

But aside from these uses to which all our native plants lend themselves more or less readily, many of them more directly, and therefore more appreciably, affect the interests of man. Among the questions to which this usefulness of plants gives rise may be mentioned the problems of the forests, weeds, ornamental plants, medicinal plants, and consideration of rusts, smuts and other fungi which attack plants. The last subject has received much attention locally from Mr. Holway and will not be discussed here.

I. The Forest Problem.

Originally not less than one-fourth of the surface of Winneshiek county was covered with forest. This was sometimes scant, as upon the rocky slopes and drier hill-tops, or consisted of trees of but little value, as upon the narrow lower bottom lands. Here, as elsewhere, the forest was developed chiefly upon poorer soils. The sandy alluvial bottom lands, the rocky slopes, the gravelly or clayey hills—these formed the favorite habitat of trees. Even where a veneer of rich soil and leaf-mould appeared it was the effect rather than the cause of the forest. The forest prevented erosion; it retained moisture which made easier the disintegration of both organic and inorganic materials; it annually contributed its leaves to the accumulating soil; it harbored worms and other burrowing animals which brought fine soil-materials to the surface; and in its shelter the burden of dust-laden winds was deposited. So man thought that he saw alluring promise in the richness of the forest soil, and this coupled with the prospect of immediate gain from its products, led him to remove the forest. But an awakening has already come, and men realize that with the removal of the riches of the forest they also lose the richness of the soil, for the rains and melting snows quickly strip it from the hillsides. The land is then practically worthless, for it will make neither field nor pasture—it is fit only for growing trees, as it has grown trees in the past. Few counties in the state have suffered more than Winneshiek in this respect. The principal forest areas were in the roughest territory, unsuited to the ordinary purposes of agriculture. Man's greed and thoughtlessness combined in many cases to strip the best, if not all, of the forest from these hillsides, but this was not the gravest error, for if left to its own resources the forest would renew itself. But an attempt was made in many cases to cultivate or pasture the stripped areas, and this was done on the steepest slopes with uniformly disasterous results. More acres were cultivated that still other acres might be secured, under the pretext that the children of the land-holder must not be left without inheritance. The desire for immediate gain was, however, responsible for this, for men had not yet learned that a growing forest is one of the most splendid legacies which they may leave to their children. The best of the legacy which we ourselves received has been dissipated, in Winneshiek county as elsewhere, but conditions for the renewal of the forest are here very favorable. There are three distinct forest areas in the county, drained respectively by the Upper Iowa, the Turkey and the Yellow rivers. Of these the first is much the largest within the county, but all agree in having a relatively large amount of adjacent rough land, as has been noted. Much of this land is worthless, or at least of little value, for agricultural purposes, and it would entail but little present loss, and would vastly benefit posterity, if given over to the cultivation of timber. This would not require a large amount of expensive nursery stock, nor great labor in the cultivation of the soil, nor assiduous attention to the welfare of the trees. The territory is so well adapted to the growth of trees that it is necessary only to strew seed on the ground in suitable places, and *to keep out stock and fires,* and the forest will take care of itself. For this purpose seed should be gathered in considerable quantity, preferably from nearby trees, and should not be permitted to become too dry. Seed maturing in spring or early summer may be scattered at once if the land is not devoid of other vegetation, or it may be covered with a thin layer of sand or soil in a shady place and left until fall. Seeds and fruits which mature in autumn should be scattered just before the leaves begin to fall. They will thus be better protected both against the severity of winter, and against squirrels and chipmunks. Less than one-half the seed sown in this manner will germinate, and for that reason it should be scattered liberally. With a little care it may be secured in abundance from native or acclimated trees, practically without expense, in connection with a pleasant summer or autumn outing. If a little trouble is taken each year to re-seed where the stand is thin, to remove rotting wood in order that it may not spread its infection by scattering countless spores of fungi, to trim out excessive underbrush, and to protect the trees against domestic animals and fires, the forest will be a vast improvement upon those which the first settlers found.

Native trees will be found most satisfactory for reforestation, for as yet no introduced forest tree has demonstrated its superiority over the native species. Moreover, in a county as well timbered as this both quantity and variety may be secured with comparative ease. In order that some conception of the range of choice may be given, a list of the native trees and shrubs is here presented, the species being grouped according to habitat. In selecting trees for any tract it is well that heed be given to the character of its surface in order that an appropriate choice may be made from species occupying similar stations elsewhere.

The following list contains the native trees and shrubs of the county. Their distribution, abundance, full scientific names, etc., may be determined from the systematic list which makes up the closing part of this paper.

TREES AND SHRUBS.

1. *Species belonging to bogs and wet places.*—The species are shrubs, the last two, only, becoming small trees. They are: the meadow-sweet (*Spiraea*), red-osier dogwood (*Cornus stolonifera*), button-bush (*Cephalanthus*), shiny willow (*Salix lucida*) and pussy willow (*S. discolor*).

2. *Species of the low alluvial bottoms.*—The shrubs are: the false indigo (*Amorpha fruticosa*), sandbar willow (*Salix interior*) and heart-leaved willow (*S. cordata*), the willows sometimes becoming small trees. The soft maple (*Acer saccharinum*), red birch (*Betula nigra*), almond-leaved willow (*Salix amygdaloides*) and black willow (*S. nigra*) are trees.

3. *Species of higher rich alluvial bottoms.*—The wild grape (*Vitis vulpina*) and poison ivy (*Rhus radicans*) are woody vines, the latter sometimes a low shrub; the elder (*Sambucus canadensis*), flowering currant (*Ribes floridum*) and the wahoo (*Euonymus*) are shrubs, the last sometimes a small tree; all the species of haws (*Crataegus*) and the sheep-berry (*Viburnum lentago*) are small trees, the latter sometimes a shrub; and the following species are trees: the box-elder (*Acer negundo*), hackberry(*Celtis*), the ashes (*Fraxinus,* except *F. pennsylvanica*), honey locust (*Gleditsia*), the butternut and walnut (*Juglans*), cottonwood (*Populus deltoides*) and white elm (*Ulmus americana*).

4. *Species of upland thickets.*—The Missouri gooseberry (*Ribes missouriensis*) and the hazel (*Corylus americanus*) are shrubs, and the haws (*Crataegus*) and wild crab (*Malus*) are small trees.

5. *Species of wooded rocky banks and open slopes.*—The following are woody vines: the purple virgin's-bower (*Atragene*), climbing bittersweet (*Celastrus*) and the two honeysuckles (*Lonicera*). The shrubs are: the American yew (*Taxus*), shad-bush (*Amelanchier botryapium*), the dogwoods (*Cornus alternifolia, amomum, asperifolia* and *circinata*), shrubby cinquefoil (*Dasiphora*), dwarf cherry (*Prunus pumila*), leather-wood (*Dirca*), prairie nine-bark (*Opulaster*), wild gooseberry (*Ribes

cynosbati), the wild roses (*Rosa blanda* and *humilis*), wild black raspberry (*Rubus occidentalis*), dewberry (*Rubus procumbens*), wild red raspberry (*R. strigosus*) red-berried elder (*Sambucus pubens*), bladder-nut (*Staphylea*), high bush-cranberry (*Viburnum opulus*) and arrow wood (*Viburnum dentatum*). The following species are often shrubs, but also become small trees: hoary alder (*Alnus*), alder-leaved June-berry (*Amelanchier alnifolia*), round leaved June-berry (*A. rotundifolia*), panicled dogwood (*Cornus candidissima*), choke cherry (*Prunus virginiana*), staghorn sumach (*Rhus hirta*), prickly ash (*Xanthoxylum*) and black haw (*Viburnum lentago*). The June-berry (*Amelanchier canadensis*) and blue beech (*Carpinus*) are small trees. The following species are forest trees: the balsam (*Abies*), red cedar (*Juniperus viginiana*), white pine (*Pinus*), hard maple (*Acer saccharum*), cherry birch (*Betula lenta*), canoe birch (*Betula papyrifera*), red ash (*Fraxinus pennsylvanica*), balm of Gilead (*Populus candicans*), American aspen (*Populus tremuloides*) and rock elm (*Ulmus racemosa*).

6. *Species of upland, mostly rather open woods.*—The iron wood (*Ostrya*) is a small tree, and the following are forest trees: the hickories (*Hicoria*), large-toothed aspen (*Populus grandidentata*), all the oaks (*Quercus*), the white oak (*Q. alba*) preferring deep woods, and red elm (*Ulmus fulva*).

7. *Species of deep upland woods.*—The hispid greenbrier (*Smilax hispida*) and the Virginia creeper (*Parthenocissus*) are woody vines; the following are trees: red oak (*Quercus rubra*), white oak (*Q. alba*), black cherry (*Prunus serotina*) and basswood (*Tilia*). All the species of the preceding group may also be found in deeper woods.

8. *Species of prairie and forest borders.*—Most of the species of this group are shrubs, as follows: juniper (*Juniperus communis*), lead plant (*Amorpha canescens*), New Jersey tea (*Ceanothus americana*), red root (*Ceanothus ovatus pubescens*), bush honeysuckle (*Diervilla*), prairie rose (*Rosa arkansana*), wild rose (*R. humilis*), prairie willow (*Salix humilis*), and wolf-berry (*Symphoricarpos occidentalis*). The blackberry (*Rubus nigrobaccus*) is also found along borders, but extends to deep woods, and the smooth sumach (*Rhus glabra*) is found along borders, in open woods, on dry slopes, etc. But one small

tree, the wild red cherry (*Prunus pennsylvanica*), properly belongs to this group.

In addition to the foregoing species, which are native, the red currant (*Ribes rubrum*) and the black locust (*Robinia pseudacacia*) may be found in waste places or openings, having escaped from cultivation. The red currant appears to be native.

Not all the species here listed are of like value, nor are all usable for the same purposes. The most useful *lumber trees* are the ashes, butternut and walnut, red and rock elms, cherry birch, black cherry, the hickories, the oaks, red cedar and white pine. For *ties* and *posts* the white oak, bur oak, honey locust and black locust are most servicable. The most valuable native *shade trees* are the hard maple, hackberry, ashes, American elm, basswood, canoe birch and white pine. The most useful species for *windbreaks* and *shelter belts* are the soft maple, ashes, boxelder, cottonwood, balm of Gilead and red cedar. All of these are used more or less for fuel.

Among the native *ornamental trees* and *shrubs* the hard maple, Virginia creeper and the sumachs are remarkable for the splendor of their autumn foliage; the bittersweet for its bright fruit; the June-berry, crab-apple, hawthorns and black locust for their flowers; the false indigo, honeysuckles, wild roses, elderberries, atragene, bladdernut, dogwoods, black haw, sheep-berry, New Jersey tea and nine-bark for flowers and foliage; and the white pine, balsam fir, shining willow and red-osier dogwood for the beauty of the foliage and crown.

As already noted these native species are eminently suitable for all purposes for which trees and shrubs are used, but nevertheless, numerous species have been introduced in cultivation for ornamental purposes. Among the introduced conifers are the Scotch and Austrian pines, Norway spruce, European larch, arbor-vitæ and hemlock, and among the deciduous trees the silver poplar, Lombardy poplar, buckeye, catalpa, mountain ash and white willow. In this connection a report on a tree-census of a portion of the city of Decorah, including several blocks and streets in the residence part, may be of interest. The number to the right in each case indicates the number of trees found within the territory selected:

Hard maple	97	Red cedar	11
Soft maple	86	Balsam fir	7
Box elder	64	Walnut	5
American elm	62	Red elm	4
Cottonwood	51	Catalpa	3
White pine	45	Black locust	3
Norway spruce	36	European larch	2
Bur oak (native)	20	Scotch Pine	2
Mountain ash	15	Buckeye	2
White cedar	14	Choke cherry	1
		Hackberry	1

Also several specimens of silver and Lombardy poplars and Austrian pine.

It is interesting to note that notwithstanding the abundance of splendid available native species, such forms as the soft maple, box elder, cottonwood, silver poplar and Lombardy poplar are commonly planted. Indeed in some cases fine native species were first removed, and these less desirable kinds were set out.

II. Ornamental Plants.

In addition to the ornamental trees and shrubs already discussed, there are numerous native herbaceous plants which are well worthy of cultivation. While not many of them lend themselves readily to use in formal flower-beds, all may be used to advantage in various nooks and corners, to hide unsightly places, such as bogs and sand ridges, to replace weeds along garden fences, and to be mingled in fern-beds, either on the north side of the house, or in well-shaded rock-ferneries.

Perhaps the most adaptable of these species are the columbine, common blue violet, wild phlox, Jacob's ladder (blue-bell), shooting star (*Dodecatheon*) and lungwort (*Mertensia*) but even these will do better in their natural habitats. For convenience the native ornamental herbs are here grouped under their respective habitats, which suggest the kind of places in which they should be cultivated.

1. *Water.*—For artificial or natural ponds the most suitable species are the yellow pond lily (*Castalia*) and the white water crow-foot (*Batrachium*).

2. *Shaded bogs.*—The fringed gentian and greater lobelia are well adapted to seepy banks.

3. *Open bogs and wet meadows.*—For larger bogs the cat-tail and Iris are satisfactory, while for smaller boggy places the oak-leaved fern (*Onoclea*), shield-fern (*Nephrodium thelypteris*), Canada lily, the fringed orchis (*Blephariglottis*) and marsh marigold (*Caltha*) are very desirable.

4. *Open prairie, etc.*—The following more or less showy species are adapted to open places: red lily (*Vagnera stellata*), pasque-flower (*Pulsatilla*), shooting star (*Dodecatheon*), downy gentian (*G. puberula*), prairie phlox, horse mint (*Monarda*), both blazing stars (*Lacinaria*), prairie violet (*Viola pedatifida*), foxglove beard-tongue (*Pentstemon*), bushy goldenrod (*Euthamia*), the wild asters (*A. novae-angliae, laevis* and *exiguus*) and the two prairie clovers (*Kuhnistera*). On dry ridges the early buttercup (*Ranunculus fascicularis*) will be attractive because of its early flowering. In open sandy places the corydalis (*Capnoides*), blue-eyed grass (*Sisyrinchium*) and bird--foot violet (*Viola pedata*) will do well.

5. *Moderate shade.*—This naturally grades into both the preceding and the following groups, and therefore is not sharply defined. Its most satisfactory plants are the following: the ostrich fern (*Struthiopteris*), smooth Solomon's seal (*Salomonia*), starry campion (*Silene*), hepatica, rue-anemone (*Syndesmon*), white virgin's bower (*Clematis*), hydrangea, common blue violet (*Viola papilionacea*), spiked willow-herb (*Chamaenerion*), wild phlox (*P. divaricata*), lungwort (*Mertensia*), the goldenrods (*Solidago speciosa* and *serotina*) and *Aster shortii.*

6. *Deep shade.*—Plants of this group are best cultivated in places suited to our ordinary ferns. Our flora includes the following: the lady fern (*Athyrium*), the shield ferns (*Nephrodium*), bladder fern (*Cystopteris fragilis*), maiden-hair fern (*Adiantum*), flowering fern (*Osmunda*) moonwort (*Botrychium*), bellwort (*Uvularia*), dogtooth violet (*Erythronium*), false Solomon's seal (*Vagnera racemosa*), the larger species of *Trillium*, the ladies'-slippers (*Cypripedium*), spring beauty (*Claytonia*), false rue-anemone (*Isopyrum*), crane's-bill (*Geranium*), yellow violet (*Viola pubescens*), the gentians (*G.*

andrewsii and *flavida*), Jacob's ladder (*Polemonium*), may apple (*Podophyllum*), white snake-root (*Eupatorium ageratoides*) and a goldenrod (*Solidago ulmifolia*).

7. *Shaded rocky banks.*—Most of the species in the preceding group may be included here, with the following additional species: the early wake-robin (*Trillium nivale*), nodding wild onion (*Allium cernuum*), both species of *Bicuculla,* American vetch (*Vicia*), blood-root (*Sanguinaria*), water-leaf (*Hydrophyllum virginicum*) and the heart-leaved aster (*A. cordifolius*). The species of the following group may also be planted with the foregoing.

8. *Rocky fernery.*—Well shaded heaps or ledges of limestone, with scant soil intermingled, will produce very pleasing effects. While many of the plants of the two preceding groups may be used in such places, the following are especially suitable: the bulb-bearing fern (*Cystopteris bulbifera*), bishop's cap (*Mitella*) and wild columbine (*Aguilegia*).

As all the plants here listed as suitable for cultivation are perennial, with persisting roots or underground stems, it is possible to transplant them from their native habitats. This should be done early in the spring before growth has advanced, or after the plant has matured its fruit. Seed should also be collected, and sowed freely in suitable places. This may be done immediately upon the maturing of the seed, or the seed may be kept until spring. Where the fruit (or seed) is dry it may simply be kept in a box or paper in a moderately dry cool place. Where the fruit is pulpy it may be set in a cool cellar in a small box of sand, which must be kept barely moist, and in the spring sand and seed may be scattered. However, in most of these cases it will require at least two years to mature the plant. Usually a combination of the two methods, transplanting and seeding, will give the best results. In the case of all plants which require shade, leaf-mould should be liberally supplied, and in all cases some attention must be given to weeds, as they will otherwise over-run the wild-flower bed. Blue grass is perhaps the most dangerous of these weeds, and is fatal to practically all wild flowers.

III. Forage Plants.

None of the native or naturalized forage plants take rank with red clover, timothy and blue grass, which are cultivated for this special purpose. Nevertheless there are among them many species which contribute liberally to the forage supply of the county. Indeed during dry seasons all species which are not protected by harsh structures, such as spines, etc., or by poisonous, or at least disagreeable, products with repelling taste and odor, are eaten more or less by cattle. Formerly the native herbs, especially grasses, which covered the prairies, formed valuable pasture and hay, but so little of the original prairie remains that most of these species have disappeared, or are found only sparingly. With the exception of the clovers the best forage plants are grasses. The most valuable species of prairie and meadow were *Cinna, Calamagrostis* and the two species of *Andropogon*. Of less value are *Bromus ciliatus* and *kalmii,* and *Agropyron tenerum* and *occidentale*, while coarser, harsher grasses like *Muhlenbergia mexicana* and *glomerata, Spartina* and *Leersia* have little beyond bulk to recommend them. Among introduced plants, in addition to the ubiquitous blue grass and timothy, *Agrostis alba, Dactylis* and *Setaria glauca* have some fodder value, the last chiefly in stubble fields.

IV. Weeds.

All plants which have sufficient persistence and adaptability to become weeds are of public interest. Among the plants of Winneshiek county there are not only many introduced weeds, but some of the native plants have so far changed their habits that they, too, have become pernicious weeds. Among the most vicious of the former, both because of abundance and persistence, are the following: black bind-weed (*Polygonum convolvulus*), curly dock (*Rumex crispus*), the species of *Amaranthus,* plantain (*Plantago major*), both species of *Brassica,* shepherd's purse (*Bursa*), both sweet clovers (*Melilotus*), round-leaved mallow (*Malva rotundifolia*), wild parsnip (*Pastinaca*), ground ivy (*Glecoma*), chickweed (*Alsine media*), purslane (*Portulaca*), the thornapples (*Datura*), dandelion (*Taraxacum*), prickly lettuce (*Lactuca scariola*), dog-fennel (*Anthemis*), burdock (*Arctium*), field-thistle (*Carduus lanceolatus*), Canada thistle (*C. arvensis*) and the panic grasses (*Panicum crus-galli* and *glabrum*). Blue grass (*Poa pratensis*) is often a persistent weed. The less pernicious, or less abundant, introduced weeds are: the panic grasses (*Panicum sanguinale, capillare* and *dichotomum*), the fox-tail grasses (*Setaria glauca* and *viridis*), *Eragrostis major,* both kinds of chess (*Bromus secalinus* and *racemosus commutatus*), orchard grass (*Dactylis*), St. John's-wort (*Hypericum perforatum*), lamb's quarters (*Chenopodium album*), hedge mustard (*Sisymbrium officinale*), false flax (*Camelina*), low hop clover (*Trifolium procumbens*), sheep-sorrel (*Rumex acetosella*), patience dock (*R. patientia*), Russian thistle (*Salsola*), mullein (*Verbascum*), speedwell (*Veronica peregrina*), hemp (*Cannabis*), black nightshade (*Solanum nigrum*), ground cherry (*Physalis pubescens*), motherwort (*Leonurus*), chicory (*Cichorium*), tansy (*Tanacetum*) and sow-thistle (*Sonchus*).

The following native weeds are more or less troublesome: squirrel-tail grass (*Hordeum*), wire grass (*Juncus tenuis*), water dock (*Rumex brittanica*), smart-weed (*Polygonum pennsylvanicum*), pepper-grass (*Lepidium virginicum*), partridge-pea (*Cassia chamaecrista*), white clover (*Trifolium repens*), three-seeded mercury (*Acalypha*), the native spurges (*Euphorbia*), velvet-leaf (*Abutilon*), yellow oxalis (*Oxalis stricta*), evening primrose (*Onagra biennis*), milkweed (*Asclepias syriaca*), the dodders (*Cuscuta*), nyctelea (*Macrocalyx*), beggar's lice (*Lappula*), the verbenas (*Verbena*) both species of *Scrophularia,* Rugel's plantain (*Plantago rugeli*), slender nettle (*Urtica gracilis*), bur-weed marsh-elder (*Iva*), both ragweeds (*Artemisia trifida* and *artemisaefolia*), cocklebur (*Xanthium*), horse-weed (*Leptilon*), daisy flea-bane (*Erigeron strigosus*), tall cone-flower (*Rudbeckia laciniata*), several species of sunflowers (*Helianthus annuus, grosse-serratus, rigidus,* etc.), Spanish needles (*Bidens*) and fire weed (*Erechtites*). *Muhlenbergia mexicana* sometimes becomes a weed, and the sand-bur (*Cenchrus*) is often troublesome in sandy fields. For additional notes on all these species see the annotated list.

Individual effort avails but little in the conflict with weeds. Until concerted systematic and intelligent action is taken against them men will continue to suffer great loss from this source. Fire, the plow, and the scythe or mower are the most effective weapons, and they should be used to prevent, as far as possible, the development of seeds.

V. Medicinal Plants.

This is by no means the least interesting part of the flora. The products of more than forty native species are recognized as official by the U. S. Pharmacopæia. In addition to these, many species are used as substitutes, or as home remedies. Some of the official species are not found in sufficient quantity to be of commercial value, but their occurrence in the county is of interest. Various parts of plants contribute the official product, and the best season of the year for collecting the materials will vary with the part used. It may be stated as a general rule that rhizomes and roots should be collected in late summer or early autumn; the bark of *Ulmus* in early spring, and other barks (of both root and stem) in spring or autumn; the herbs and leaves are usually best just before flowering has commenced; the flowering tops when the first flowers are about to fruit; the flowers just after opening; and the fruits when mature. The distribution in the county, and the habits of the species discussed in this connection are given in the annotated list. The species are here grouped according to the part of the plant yielding the official drug, the official name preceding the name of the plant, which is given in parenthesis.

1. *The herb* (*leaves and young stems*).—Oil of Erigeron (*Leptilon canadense*), Pulsatilla (*Pulsatilla hirsutissima*) and Scutellaria (*Scutellaria lateriflora*).

2. *Flowering tops.*—Eupatorium (*Eupatorium perfoliatum*), Hedeoma (*Hedeoma pulegeoides*) and Lobelia (*Lobelia inflata*).

3. *Leaves.*—Chimaphila (*Chimaphila umbellata*), and Rhus Toxicodendron (*Rhus radicans*), the latter fresh.

4. *Flowers.*—Sambucus (*Sambucus canadensis*).

5. *Fruit.*—Rhus Glabra (*Rhus glabra*), Humulus (*Humulus lupulus*), Oil of Juniper (*Juniperus communis*) and Raspberry (*Rubus occidentalis* and *strigosus*).

6. *Seeds.*—Sinapis Nigra (*Brassica nigra*).

7. *Bark of stem.*—Hamamelis Bark (*Hamamelis virginiana*), Canada Balsam (from *Abies balsamea*), Oil of Betula

(from *Betula lenta*), Salicin (from all the species of *Populus* and the larger species of *Salix*), Ulmus (*Ulmus fulva*), Viburnum (*Viburnum opulus*), Viburnum Prunifolium (*Viburnum prunifolium*), Quercus (*Quercus alba*), Prunus Virginiana (*Prunus serotina* and *virginiana*), and Xanthoxylum (*Xanthoxylum americanum*).

8. *Bark of root.*—Euonymus (*Euonymus atropurpureus*), Juglans (*Juglans cinerea*) and Rubus (*Rubus nigrobaccus* and *procumbens*).

9. *Root.*—Apocynum (*Apocynum cannabinum*), Asclepias (*Asclepias tuberosa*) and Senega (*Polygala senega*).

10. *Rhizome* (*rootstock*).—Calamus (*Acorus calamus*), Caulophyllum (*Caulophyllum thalictroides*), Cypripedium (*Cypripedium hirsutum* and *parviflorum*), Geranium (*Geranium maculatum*), Hydrastis (*Hydrastis canadensis*), Iris (*Iris versicolor*), Leptandra (*Leptandra virginica*), Menispermum (*Menispermum canadense*), Podophyllum (*Podophyllum peltatum*) and Sanguinaria (*Sanguinaria canadensis*).

The common names of all the medicinal plants are given in the annotated list.

VI. Systematic Annotated List of Plants.

In the following list no attempt is made to define species, as this is not necessary in view of the number of available descriptive manuals. Brief notes upon distribution, habits and abundance are given under each species, and locality names are given where specimens were preserved, or where a report was published. In case the record is not based on the writer's own material the name of the collector or recorder follows in parenthesis. Messrs. Savage and Goddard did not publish lists, but the writer examined their material. In all other cases the published record is accepted. The scientific nomenclature for the following plants is in the main that of Britton's Manual,* for ferns that of the writer's paper on Iowa Pteridophyta,† and for grasses that of Pammel's "Grasses of Iowa."‡ These may not in all cases be entirely satisfactory, but they are available to Iowa workers, and, moreover, the question of exact

*Manual of the Flora of the Northern U. S and Canada, by N L Britton, 2nd Ed. 1905.
†Bull Lab Nat. Hist., State Univ. of Iowa, Vol. V, 1901, pp. 145-170.
‡Iowa Geol. Sur., part II, Sup. Report for 1903.

nomenclature is of no great inportance in a mere geographical list. Gray's Manual is still widely used in this state, and the earlier plant lists published by the Survey were based on it. For that reason, in cases in which the name here adopted differs from that of the Manual, the latter follows in parenthesis.

SUBKINGDOM PTERIDOPHYTA, FERNS, ETC.

Family 1. Equisetaceæ. Scouring Rushes.

Equisetum arvense L. Field Horsetail. Quite common in sandy and clay grounds. Decorah (Goddard), Hesper.

Equisetum robustum A. Braun. Great Scouring-rush. Common on moist banks, etc. Decorah.

Equisetum laevigatum A. Br. Prairie Scouring-rush. Quite common. Decorah (Goddard).

Equisetum hyemale L. Scouring-rush. Not common. Calmar.

Family 2. Ophioglossaceæ.

Botrychium virginianum (L.) Swz. Moonwort. Not rare in deep woods. Hesper, Moneek.

Family 3. Filicaceæ.

Osmunda claytoniana L. Flowering-fern. Common in deep woods. Moneek, Decorah, Hesper.

Polypodium vulgare L. Polypody. Rather rare, on moss-covered ledges along Canoe creek.

Woodsia ilvensis (L.) A. Br. Rare, in crevices of St. Peter sandstone near Hesper.

Onoclea sensibilis L. Oak-leaf Fern. Locally common in moist meadows and ravines. Hesper.

Struthiopteris struthiopteris (L.) (*Onoclea strythiopteris* Hoffm.) Ostrich fern. Locally abundant on alluvial grounds. Along Bear and Canoe creeks.

Cystopteris fragilis (L.) Bernh. Bladder-fern. Quite common in rich woods. Decorah.

Cystopteris bulbifera (L.) Bernh. Bulb-bearing Fern. Very common on rocky banks and ledges. Decorah, Highlandville.

Phegopteris robertiana (Hoffm.) Fee. (*P. calarea* Fee.) Beech Fern. Rather rare, on shaded rocky banks. Decorah (Goddard).

Nephrodium thelypteris (L.) Desv. (*Aspidum thelypteris* Swartz.) Shield-fern. Locally common in open bogs. Hesper.

Nephrodium goldieanum (Hk.) Hk. & Gr. (*Aspidium goldianum* Hk.) Goldie's Fern. Not common, in rich woods. Decorah (Goddard).

Athyrium filix-foemina (L.) Roth. (*Asplenium filix-foemina* Bernh.) Lady-fern. Common in woods. Hesper, Calmar.

Camptosorus rhizophyllus (L.) Link. Walking Fern. Not common, on mossy ledges. Decorah (Savage); Canoe creek.

Pteridium aquilinum (L.) Kuhn. (*Pteris aquilina* L.) Common Brake. Common in open woods. Hesper, Calmar; Decorah (Fitzpatrick).

Pellaea atropurpurea (L.) Link. Rock Brake. Common on exposed limestone ledges. Decorah, Kendallville, north fork of Bear creek, Highlandville.

Cryptogramma stelleri (Gmel.) Prantl. (*Pellaea gracilis* Hook.) Smaller Cliff-brake. Locally common on shaded limestone ledges. Highlandville; Decorah (Savage).

Cheilanthes feei Moore. (*C. lanuginosa* Nutt.) Lip-fern. Not common, on exposed rocks. Decorah (Calvin).

Adiantum pedatum L. Maidenhair Fern. Common in deep wods. Decorah (Goddard), Hesper.

Family 4. Lycopodiaceæ. Club Mosses.

Lycopodium lucidulum Michx. Club-moss. Reported by Arthur from Hesper. The species occurs in damp woods.

Family 5. Selaginellaceæ.

Selaginella rupestris (L.) Spring. Locally common. Dry rocky soils and sandstone ledges. Hesper, north fork of Bear creek.

SUBKINGDOM SPERMATOPHYTA. FLOWERING PLANTS.

Class 1. Gymnospermæ. Conifers.

Family 1. Pinaceæ.

Pinus strobus L. White Pine. Locally frequent in upland woods especially above rocky ledges, along the Upper Iowa Upper Iowa river. Most abundant near Kendallville and along Pine, Bear and Canoe creeks. Groves of white pine occur in Fremont township.

Abies balsamea (L.) Mill. Balsam Fir. Not rare, along rocky slopes and above ledges along the upper course of the Upper Iowa river. Most abundant near Kendallville and Bluffton.

Juniperus communis L. Juniper. Locally common on dry rocky hilltops. Kendallville, Bluffton, Canoe creek, both forks of Bear creek.

Juniperus virginiana L. Red Cedar. Common on dry hillsides and rocky slopes. Kendallville, Bluffton, Decorah, Canoe creek, both forks of Bear creek, Hesper.

Family 2. Taxaceæ.

Taxus canadensis Marsh. American Yew. Locally common on steep shaded slopes and above ledges. Kendallville, Canoe creek, south fork of Bear creek.

Class II. Angiospermæ.

SUB—CLASS I. MONOCOTYLEDONES.

Order I. Graminales.

Family 1. Gramineæ. **Grasses.**

Andropogon provincialis Lam. (*A. furcatus* Muhl.) Bluestem. Still common where the native prairie flora is not wholly destroyed. Ft. Atkinson.

Andropogon nutans L. (*Chrysopogon nutans* Benth.) Indian Grass. Common in dry borders and openings. Ft. Atkinson, Hesper.

Panicum crus-galli L. Barnyard Grass. A naturalized weed, in waste places. Decorah (Goddard), Calmar, Ft. Atkinson.

Panicum glabrum Gaud. Smooth Crab-grass. Common introduced weed. Freeport.

Panicum sanguinale L. Finger Grass. Introduced weed, in cultivated places. Near Hesper, etc.

Panicum capillare L. Old Witch Grass Common native weed, in waste and cultivated grounds. Ft. Atkinson.

Panicum latifolium L. Porter's Panicum. Rather common in open woods. Ft. Atkinson.

Panicum scribnerianum Nash. (*P. scoparium* Gray, in part.) Scribner's Panicum. In dry soil. Decorah (Savage).

Panicum dichotomum L. Reported by Fitzpatrick.

Panicum unciphyllum Trin. Finger Grass. In dry places. Decorah (Goddard).

Setaria glauca (L.) Beauv. Yellow Fox-tail. An introduced weed, common in fields and waste places. Ft. Atkinson, Calmar, near Hesper.

Setaria viridis (L.) Beauv. Green Fox-tail. A common introduced weed. Ft. Atkinson, etc.

Setaria germanica Beauv. (*S. italica* Kunth.) German Millet. Introduced. Ft. Atkinson.

Cenchrus tribuloides L. Sand-bur. An annoying native weed in sandy places. Not rare. Ft. Atkinson.

Leersia oryzoides (L.) Swartz. Rice Cut Grass. In open places along ditches and swamps. Ft. Atkinson.

Aristida basiramea Engelm. Tufted Triple Awn-grass. On dry sandy ridges and sandstone ledges. Near Hesper.

Stipa spartea Trin. Porcupine Grass. Reported by Fitzpatrick.

Muhlenbergia mexicana (L.) Trin. Mexican Dropseed. Sometimes a weed. The variety *filiforme* Muhl. was collected at Decorah.

Muhlenbergia glomerata (Willd.) Trin. Marsh Muhlenbergia. Common in moist places. Calmar, Ft. Atkinson, Hesper, Freeport.

Muhlenbergia sylvatica (Muhl.) Torr. Woodland Dropseed. In dry open woods. Ft. Atkinson, Kendallville.

Oryzopsis melanocarpa Muhl. Black-fruited Mountain-rice. Common in woods. Decorah, Canoe creek, Hesper, Ft. Atkinson.

Phleum pratense L. Timothy. Very generally escaped from cultivation. Calmar, etc.

Alopecurus geniculatus L. Marsh Fox-tail. In wet places, locally common. Calmar.

Sporobolus cuspidatus (Torr.) Wood. Prairie Rush-grass. In dry open places. On sandy ridge near Freeport.

Cinna arundinacea L. Indian Reed-grass. In woods, not rare. Hesper.

Agrostis alba L. Red-top. In low grounds. Pammel (l.c.) marks this as occurring in Winneshiek county in the map on p. 166, but mentions no locality in this county in the text.

Calamagrostis canadensis (Michx.) Beauv. Blue Joint. In low meadows. Still quite common. Ft. Atkinson, Calmar.

Spartina cynosuroides (L.) Willd. Slough-grass. Common in wet alluvial soils. Ft. Atkinson.

Bouteloua curtipendula (Michx.) Torr. (*B. racemosa* Lag.) Grama Oats. Locally common in dry sandy or rocky places. Ft. Atkinson, Hesper.

Koeleria cristata (L.) Pers. Koeleria. On dry sandy ridges, etc. Calmar; Decorah (Goddard).

Eragrostis frankii Steud. Short-stalked Meadow-grass. On dry sandy ridges. Freeport.

Eragrostis major Host. Candy Grass. A common introduced weed, in waste and cultivated places. Decorah, etc.

Eragrostis purshii Schrad. Southern Spear-grass. In dry soils. Decorah (Goddard); Ft. Atkinson, Calmar.

Eatonia pennsylvanica (DC.) A. Gray. Eaton's Grass. Moist woods. Decorah, Ft. Atkinson.

Melica mutica Walt. Narrow Melic Grass. Rich soil. Reported by Fitzpatrick.

Dactylis glomerata L. Orchard Grass. Introduced, and common in shaded places. Hesper.

Poa pratensis L. Kentucky Blue Grass. Introduced, and now crowding out most of the common grasses, even in deep woods. Hesper, etc.

Glyceria nervata (Willd.) Trin. Nerved Manna Grass, in wet grounds along creeks, etc. Hesper.

Glyceria americana (Torr.) Pam. (*G. grandis* Wats.) Reed Meadow Grass. In moist places. Hesper (Arthur).

Festuca octoflora Walt. (*F. tenella* Willd.) Slender Fescue Grass. Dry sandy soils, locally common. Calmar, sandstone ledges near Hesper.

Festuca nutans Willd. Nodding Fescue. Frequent, in woods. Hesper.

Bromus purgans L. (*B. ciliatus var. purgans* Gray.) Brome Grass. Locally common on dry, sparsely wooded banks. Decorah, Ft. Atkinson.

Bromus ciliatus L. Fringed Brome Grass. Common in open woodlands. Fort Atkinson, Decorah, Canoe creek, Hseper.

Bromus kalmii Gray. Kalm's Brome Grass. In moist thickits. Decorah.

Bromus secalinus L. Cheat. An introduced weed, quite common. Calmar.

Bromus racemosus commutatus L. (*B. asper* L.) Upright Chess. An introduced weed, not rare. Decorah (Savage), Calmar.

Agropyron tenerum Vasey. (*Agropyrum.*) Slender Wheat-grass. In dry, open places. Locally common. Decorah, Calmar.

Agropyron occidentale Scrib. (Not in Gray.) Colorado Blue-stem. Quite common on dry prairie. Calmar, Ft. Atkinson.

Agropyron repens Beauv. (*Agropyrum.*) Couch-grass. A common introduced weed. Calmar.

Agropyron caninum (L.) R. & S. (*Agropyrum.*) Awned Wheat-grass. In rich soil. Introduced(?). Calmar.

Hordeum jubatum L. Squirrel-tail Grass. Very common in pastures, waste places, etc. Calmar, etc.

Elymus striatus Willd. Slender Lyme-grass. Rather common in woods. Decorah, Hesper.

Elymus canadensis L. Canada Lyme-grass. Common, on shaded banks. Decorah.

Elymus robustus S. and S. (*E. canadensis* L., in part.) Robust Wild Rye. Not rare, on moist banks. Calmar.

Asprella hystrix Willd. Bottle-brush Grass. Locally common on wooded banks. Ft. Atkinson, Calmar, Decorah, Hesper.

Family 2. Cyperaceæ. Sedges.*

Cyperus diandrus Torr. Low Cyperus. Marshy places. Decorah (Cratty).

Cyperus schweinitzii Torr.. Schweinitz's Cypress. In sandy soils. Decorah (Goddard).

Cyperus esculentus L. Yellow Nut-grass. Locally common in moist, open places. Hesper, Ft. Atkinson.

Cyperus filiculmis Vahl. Slender Cyperus. Frequent on dry open ridges, etc. Decorah (Goddard); Hesper.

Eleocharis ovata (Roth) R. & S. Ovoid Spike-rush. In wet soil, quite common. Ft. Atkinson.

Eleocharis palustris (L.) R. & S. Creeping Spike-rush. Swamps and edges of ponds. Decorah (Savage).

*Most of the specimens here listed were examined by Mr. R. I. Cratty.

Scirpus americanus Pers. (*S. pungens* Vahl.) Chairmaker's Rush. In water, etc. Decorah (Savage).

Scirpus validus Vahl. (*S. lacustris* L.) Great Bull-rush. Locally common, in swamps, etc. Moneek.

Scirpus atrovirens Muhl. Dark-green Bull-rush. Common in swamps and bogs. Decorah (Goddard); Hesper, Calmar.

Scirpus cyperinus (L.) Kunth. (*Eriophorum cyperinum* L.) Wool-grass. Frequent, in swamps. Ft. Atkinson.

Carex lupulina Muhl. Hop Sedge. Swamps and ditches. Decorah (Goddard).

Carex hystricina Muhl. Porcupine-sedge. Common in bogs. Hesper.

Carex stricta Lam. Tussock Sedge. In swamps. Decorah (Goddard).

Carex longirostris Torr. Long-beaked Sedge. On moist shaded banks. Decorah (Goddard).

Carex amphibola Steud. (*C. grisea var.* (?) *rigida* Bailey.) Narrow-leaved Sedge. In dry soil. Decorah (Goddard).

Carex albursina Sheldon. (*C. laxiflora var. latifolia* Boott.) White-beaked Sedge. Not rare, on shaded slopes. Decorah.

Carex pennsylvanica Lam. Early Sedge. Common in dry open woods. Decorah (Goddard).

Carex stipata Muhl. Awl-pointed Sedge. Reported by Fitzpatrick.

Carex gravida Bailey. Heavy Sedge. In moist places. Decorah (Goddard). This is the form which Cratty reports as var. *laxiflora* Bailey.

Carex vulpinoidea Michx. Fox Sedge. Common along edges of swamps and in wet meadows. Hesper, Calmar.

Carex rosea Schk. Stellate Sedge. In woods. Decorah (Goddard).

Carex sparganioides Muhl. Bur-seed Sedge. Not common, in moist woods. Decorah.

Carex cephalophora Muhl. Oval-headed Sedge. In dry places. Decorah (Goddard).

Carex tribuloides Wahl. Blunt Broom Sedge. Common in meadows. Calmar.

Carex cristatella Britt. (*C. tribuloides var. cristata* Bailey.) Crested Sedge. Frequent, in meadows and moist shaded places. Calmar.

Carex tenera Dewey. (*C. straminea var. aperta* Boott.) Marsh Straw-sedge. Reported by Fitzpatrick.

Carex festucacea Willd. (*C. straminea var. brevior* Dewey.) Fescue Sedge. Decorah (Goddard).

Order 2. Pandanales
Family 1. Typhaceæ.

Typha latifolia L. Common Cat-tail. In swamps. Not rare. Decorah (Cratty), Moneek.

Family 2. Sparganiaceæ.

Sparganium eurycarpum Engelm. Common Bur-reed. In marshy places. Reported by Fitzpatrick.

Order 3. Naiadales.
Family 1. Naiadaceæ.

Potamogeton foliosus Raf. (*P. pauciflorus* Pursh.) Leafy Pondweed. Common in ponds. Ft. Atkinson.

Potamogeton lonchites Tuck. (*P. fluitans* Roth.) Long-leaved Pondweed. Upper Iowa river (Fitzpatrick).

Family 2. Alismaceæ.

Alisma plantago-aquatica L. (*A. plantago* L.) Water-plantain. Common in shallow water or mud. Decorah (Cratty), Hesper.

Sagittaria latifolia Willd. (*S. variabilis* Engelm.) Broad-leaved Arrowhead. Common in mud and shallow water along ponds and sluggish streams. Decorah, Ft. Atkinson.

Sagittaria rigida Pursh. (*S. heterophylla* Pursh.) Sessile-fruited Arrowhead. Reported by Fitzpatrick.

Family 3. Vallisneriaceæ.

Philotria canadensis (Michx.) Britt. (*Elodea canadensis* Michx.) Ditchmoss. Common in ponds. Decorah (Cratty).

Vallisneria spiralis L. Eel-grass. In the Upper Iowa river. Bluffton (Cratty).

Order 4. Arales.
Family 1. Araceæ. Arums.

Arisaema triphyllum (L.) Torr. Indian Turnip. Common in rich woods. Decorah (Savage, Cratty); Calmar.

Arisaema dracontium (L.) Schott. Dragon-root. Less abundant, in alluvial woods. Decorah (Cratty).

Spathyema foetida. (L.) Raf. (*Symplocarpus foetidus* Salisb.) Skunk Cabbage. Common in shaded bogs. Decorah (Cratty), Bluffton, etc.

Acorus calamus L. Calamus. Locally common in swamps and bogs. Decorah (Cratty), Hesper, said to be introduced.

Family 2. Lemnaceæ. Duckweeds.

Spirodela polyrrhiza (L.) Schleid. Greater Duckweed. Floating on still water, abundant locally. Decorah (Cratty).

Lemna trisulca L. Duckweed. Not rare, in still water. Decorah (Cratty).

Order 5. Xyridales.
Family 1. Commelinaceæ.

Tradescantia bracteata Small. (*T. virginica* L., in part.) Long-bracted Spiderwort. Common in sandy soil. Decorah (Savage); Ft. Atkinson.

Tradescantia reflexa Raf. (*T. virginica* L., in part.) Reflexed Spiderwort. Common, in sandy soil. Calmar.

Order 6. Liliales.
Family 1. Juncaceæ. Rushes.

Juncus tenuis Willd. Slender Rush. In hard soils, common. Calmar; Decorah (Goddard).

Juncus vaseyi Engelm. Vasey's Rush. Not rare. In moist open places. Ft. Atkinson.

Juncus nodosus L. Knotted Rush. Common along edges of ponds and in open boggy places. Ft. Atkinson.

Family 2. Melanthaceæ.

Zygadenus elegans Pursh. Glaucous Zygadenus. Not common. Decorah (Goddard).

Uvularia grandiflora J. E. Smith. Common Bell-wort. Common in rich woods. Hesper, Ft. Atkinson; Decorah (Goddard).

Uvularia sessilifolia L. (*Oakesia sessilifolia* Wats.) Sessile-leaved Bell-wort. Reported by Fitzpatrick.

Family 3. Liliaceæ. Lilies.

Allium tricoccum Ait. Wild Leek. Locally common in rich woods. Hesper.

Allium cernuum Roth. Nodding Wild Onion. On shaded banks, etc. Not rare. Hesper; Decorah (Arthur).

Allium stellatum Ker. Prairie Wild Onion. Common on rocky banks and slopes. Hesper.

Lilium umbellatum Pursh. (*L. philadelphicum* L., in part.) Western Red Lily. Formerly very abundant, but now restricted by cultivation of prairies. On dry prairie. Hesper.

Lilium canadense L. Wild Yellow Lily. Locally common in prairie bogs and meadows. Calmar.

Erythronium americanum Ker. Yellow Adder's Tongue. In rich woods. Hesper (Arthur).

Erythronium albidum Nutt. White Dog-tooth Violet. Reported by Fitzpatrick.

Family 4. Convallariaceæ.

Asparagus officinalis L. Asparagus. Naturalized in woods and elsewhere. Decorah.

Vagnera racemosa (L.) Morong. (*Smilacina racemosa* Desf.) Wild Spikenard. Common in rich woods and thickets. Calmar.

Vagnera stellata (L.) Morong. (*Smilacina stellata* Desf.) Smaller False Solomon's Seal. Common on moist prairie, etc. Calmar.

Unifolium canadense (Desf.) Greene. *Maianthemum canadense* Desf.) False Lily-of-the-Valley. Rather common in rich woods. Decorah (Savage), Hesper.

Salomonia commutata (R. & S.) Britt. (*Polygonatum giganteum* Dict.) Smooth Solomon's Seal. In moist soils, on banks, along borders, etc. Common. Decorah (Savage), Calmar, Ft. Atkinson.

Trillium nivale Rid. Early Wake-robin. Not rare, on shaded banks and slopes. Decorah (Savage), Bluffton.

Trillium erectum L. Ill-scented Wake-robin. Locally common on wooded banks. Decorah (Arthur), Ft. Atkinson.

Family 5. *Smilaceæ.* Smilax.

Smilax herbacea L. Carrion-flower. Common in thickets, etc. Decorah (Savage), Calmar.

Smilax ecirrhata (Engelm.) S. Wats. Upright Smilax. Reported by Fitzpatrick.

Smilax hispida Muhl. Hispid Greenbrier. Common in woods and thickets. Decorah (Savage).

Family 6. Amaryllidaceæ.

Hypoxis hirsuta (L.) Cov. (*H. erecta* L.) Star-grass. In open woods, etc. Common. Decorah (Savage).

Family 7. Dioscoreaceæ.

Dioscorea villosa L. Wild Yam-root. Reported by Fitzpatrick.

Family 8. Iridaceæ.

Iris versicolor L. Blue Flag. Locally common in marshes and wet meadows. (Fitzpatrick).

Sisyrinchium angustifolium Miller. Blue-eyed Grass. Common in open, especially sandy places. Freeport, Hesper.

Order 7. Orchidales.
Family 1. Orchidaceæ. Orchids.

Cypripedium reginae Walt. (*C. spectabile* Salisb.) Showy Lady's slipper. Not common, in deep moist woods. Bluffton.

Cypripedium candidum Willd. Small White Lady's Slipper. In bogs, rare. Decorah (on authority of Holway).

Cypripedium hirsutum Mill. (*C. pubescens* Willd.) Large Yellow Lady's Slipper. Rather common, in deep woods. Canoe creek, Decorah, Hesper.

Cypripedium parviflorum Salisb. Small Yellow Lady's Slipper. With the preceding, but less common. Scarcely a distinct species. Hesper.

Galeorchis spectabilis (L.) Rydb. (*Orchis spectabilis* L.) Showy Orchis. In rich woods, not common. Canoe creek, Hesper.

Coeloglossum bracteatum (Willd.) Parl. (*Habenaria bracteata* R. Br.) Long-bracted Orchis. Reported by Fitzpatrick.

Limnorchis hyperborea (L.) Rydb. (*Habenaria hyperborea* R. Br.) Leafy Green Orchis. Rare, in deep upland woods. Hesper (Arthur).

Lysias hookeriana (A. Gray) Rydb. (*Habenaria hookeri* Torr.) Hooker's Orchis. Locally common in deep upland woods. Hesper, Canoe creek.

Blephariglottis leucophaea (Nutt.) Rydb. (*Habenaria leucophaea* Gray.) White Fringed-Orchid. Prairie bogs and wet meadows. Not common. Ft. Atkinson.

Gyrostachys gracilis (Bigel.) Kuntze. (*Spiranthes gracilis* Bigel.) Slender Ladies' Tresses. Decorah (Arthur).

Peramium pubescens (Willd.) MacM. (*Goodyera pubescens* R. Br. Rattle-snake Plantain. In deep upland woods. Not rare. Hesper.

Acroanthes unifolia (Michx.) Raf. (*Microstylis ophioglossoides* Nutt.) Green Adder's Tongue. In deep woods. Decorah (Arthur), Hesper (Arthur).

Leptorchis liliifolia (L.) Kuntze. (*Liparis liliifolia* Rich.) Large Twayblade. Not rare. In deep upland woods. Kendallville, Hesper.

Aplectrum hyemale (Muhl.) Torr. Putty-root. Locally common in deep woods southward. Ft. Atkinson.

Corallorhiza multiflora Nutt. Large Coral-root. Very common in deep upland woods northward. Hesper.

SUB-CLASS II. DICOTYLEDONES.

Series I.

Order 1. Salicales.

Family Salicaceæ. Poplars; Willows.

Populus alba L. Silver-leaf Poplar. Naturalized in waste places. Decorah.

Populus candicans Ait. (*P. balsamifera var. candicans* Gray.) Balm of Gilead. Seemingly native on banks and slopes along the Upper Iowa. Kendallville, Calmar (cultivated).

Populus deltoides Marsh. (*P. monilifera* Ait.) Cottonwood. Common along streams. Decorah (Savage), Calmar. Also observed at Ft. Atkinson, Kendallville, Bluffton, etc.

Populus grandidentata Michx. Large-toothed Aspen. In upland woods. Not common. Decorah (Savage), Hesper, north fork of Bear creek. Also observed at Moneek. Kendallville, Canoe creek, and south fork of Bear creek.

Populus tremuloides Michx. American Aspen. Very common in thickets, upland woods, etc. Decorah. Observed at all the other localities in the county.

Salix nigra Marsh. Black . Willow. Not rare. In low grounds along Turkey river. Ft. Atkinson. Observed at Bluffton.

Salix amygdaloides Anders. Almond-leaved Willow. Common along streams, etc. Decorah, Fort Atkinson (a form approaching *S. nigra*). Observed at Canoe creek, both forks of Bear creek, Bluffton and Kendallville.

Salix lucida Muhl. Shining Willow. Locally common in wet grounds. Ft. Atkinson, Freeport (some are small trees). Observed at Canoe creek and Bluffton.

Salix alba L. White Willow. Occasionally naturalized. Decorah (Savage).

Salix cordata Muhl. Heart-leaved Willow. Very common in low grounds. Kendallville, Hesper. Observed at Canoe creek, etc.

Salix missouriensis Bebb. Missouri Willow. (Probably included with *S. cordata* by Gray.) In low grounds, not rare. Decorah, Hesper.

Salix interior Rowlee.(*S. longifolia* Muhl.) Sandbar Willow. Common on sandbars, etc. Decorah. Observed at Hesper, Canoe creek, and Ft. Atkinson.

Salix petiolaris J. E. Smith. Slender Willow. In low grounds. Not common. Calmar.

Salix discolor Muhl. Glaucous Willow, Pussy Willow. Common in bogs, etc. Decorah (Savage), Kendallville, Canoe creek, Hesper, etc.

Salix ericocephala Michx. Pussy Willow. (Included with the preceding by Gray.) Rather common, in low grounds. Decorah, Hesper. (The latter may be a hybrid, *S. humilis*+*S. discolor*.)

Salix humilis Marsh. Prairie Willow. Common in dry open places. Calmar, Decorah, north fork of Bear creek. Also observed at Canoe creek, Moneek and Ft. Atkinson.

Order 2. Juglandales.
Family Juglandaceæ.

Juglans nigra L. Black Walnut. In rich grounds. Decorah (Savage). Also observed at Hesper and Moneek.

Juglans cinerea L. Butternut. Rather common, on lower slopes, etc. Decorah. Also observed at all the other localities excepting Calmar.

Hicoria minima (Marsh.) Britt. (*Carya amara* Nutt.) Bitternut. In rather rich soil, quite common. Decorah, Moneek. Also observed at Hesper, Canoe creek, both forks of Bear creek, Bluffton and Kendallville.

Hicoria ovata (Mill.) Britt. (*Carya alba* Nutt.) Shell-bark Hickory. Rather abundant, in rich soil. Decorah. Also observed at Hesper, Canoe creek, both forks of Bear creek, Bluffton, Kendallville and Moneek.

Order 3. **Fagales.**
Family 1. Betulaceæ.

Carpinus caroliniana Walt. Blue Beech. Quite common on moist banks, etc. Canoe creek, Hesper. Also observed at Kendallville, and both forks of Bear creek.

Ostrya virginiana (Mill.) Willd. Iron-wood. Common in higher woods. Decorah, Hesper, Ft. Atkinson. Also at all other localities here named except Calmar.

Corylus americana Walt. Hazel-nut. Common in thickets, etc. Kendallville, Hesper, Calmar. Observed at all other localities.

Corylus rostrata Ait. Beaked Hazel-nut. Very rare. Found only at Kendallville, in rich soil.

Betula papyrifera Marsh. Canoe Birch. Common on rocky slopes, etc. Hesper, Canoe creek, both forks of Bear creek, Kendallville, Bluffton, Decorah.

Alnus iccana (L.) Willd. Hoary Alder. On rocky banks and slopes, not abundant. Bluffton, Coldwater Spring, Canoe creek.

Family 2. Fagaceæ.

Quercus rubra L. Red Oak. Quite common, chiefly in upland woods. Typical specimens were obtained at Decorah, Freeport, Hesper, Highlandville and Plymouth Rock. A variety with typical leaves, but narrow acorns with convex or almost obconical cups was found at Moneek and Hesper. It may be a distinct species.

Quercus schneckii Britt. Schneck's Red Oak. (Not in Gray. Sargent calls this *Q. texana* Buckl.) This and the two following species have been indiscriminately reported as *Q. coccinea* in Iowa. The writer has not been able to find true *Q. coccinea*

Muench. in the state. The inner bark of the three species here recognized is yellow, never red. Common in upland woods. Specimens from Canoe creek, Kendallville, Moneek and Decorah seem to be typical, while others from Hesper, Moneek, Freeport, Calmar and Ft. Atkinson approach *Q. velutina* in the character of the acorn. The series is interesting, and needs further study.

Quercus borealis Michx. (*Q. coccinea var. ambigua* Gray.) Gray Oak. Specimens which appear to be typical, and which agree exactly with Engelmann's specimens labelled *Q. ambigua* in the herbarium of the St. Louis Botanical Garden, were collected at Hesper and Sattre, and observed throughout the northeastern part of the county in upland groves remote from streams, and frequently in the company of the preceding species. The leaves are like the moderately lobed, broad, typical leaves of *Q. rubra,* while the acorns resemble those of *Q. velutina,* but the scales of the cup are appressed. The bark is comparatively smooth, thin and very brittle, and the general aspect of the tree is different from that of any other Iowa oak. Sargent refers *Q. ambigua* (which is the same as this species) to *Q. rubra,* but judging from the specimens here reported this is certainly an error.

Quercus velutina Lam. (*Q. coccinea var. tinctoria* Gray.) Yellow Oak; Black Oak. This species is rather common in the southern part of the county. It was obtained at Decorah, and observed at Ft. Atkinson, etc. The species is replaced northward by the two preceding species.

Quercus alba L. White Oak. Common in upland groves and deep woods, especially near streams. Decorah (Savage), Bluffton, Highlandville. Also observed at Hesper, Canoe creek, both forks of Bear creek, Kendallville, Moneek and Ft. Atkinson. Our most valuable forest tree.

Quercus macrocarpa Michx. Bur Oak. Common in upland woods. Collected at Decorah and Calmar, and observed in all parts of the county where collections were made. This tree is very variable in the size and form of the leaves and acorns, according to habitat.

Order 4. Urticales.
Family 1. Ulmaceæ.

Ulmus americana L. White Elm. Common in alluvial woods. Decorah, north fork of Bear creek. Observed at all the stations.

Ulmus racemosa Thomas. Cork Elm. Rather common, on rocky slopes. Canoe creek, north fork of Bear creek. Observed at Highlandville and Bluffton.

Ulmus fulva Michx. Red Elm; Slippery Elm. Common in upland woods. Decorah, Kendallville.

Celtis crassifolia Lam. (*C. occidentalis* L., in part.) Hackberry. Rather common, often on higher grounds. Decorah. Observed at Bluffton and Kendallville.

Family 2 Moraceæ.

Cannabis sativa L. Hemp. Common in waste places. Introduced. Ft. Atkinson, etc.

Family 3. Urticaceæ.

Urtica gracilis Ait. Slender Nettle. Common in rather dry places. Canoe creek, Calmar.

Urticastrum divaricatum (L.) Kuntze. (*Laportea canadensis* Gaud.) Wood Nettle. In rich woods. Common. Hesper, etc.

Adicea pumila (L.) Ref. (*Pilea pumila* Gray.) Richweed. Low places, quite common. Hesper.

Parietaria pennsylvanica Muhl. Pennsylvania Pellitory. Dry rocky banks. Locally common. Decorah.

Order 5 Santalales.
Family Santalaceæ.

Comandra umbellata (L.) Nutt. Bastard Toadflax. Locally common on dry hills and prairies. Decorah (Savage).

Order 6. Aristolochiales.
Family Aristolochiaceæ.

Asarum acuminatum (Ashe) Bick. (*A. canadense* L., in part.) Longtipped Wild Ginger. Common on shaded mossy (rocky) banks. Decorah, Hesper.

Asarum reflexum Bick. (*A. canadense* L., in part.) Shortlobed Wild Ginger. Locally common in alluvial woods. Decorah.

Order 7. Polygonales.
Family Polygonaceæ.

Rumex acetosella L. Sheep Sorrel. Common in dry fields and waste places. Calmar, Hesper.

Rumex verticillatus L. Swamp Dock. In swamps. Reported by Fitzpatrick.

Rumex altissimus Wood. Tall Dock. Common in low places. Decorah (Savage), etc.

Rumex patientia L. Patience Dock. Common in waste places. Introduced. Calmar.

Rumex brittanica L. Great Water-dock. Common in wet places. Calmar, etc.

Rumex crispus L. Curled Dock. Introduced. Decorah (Arthur).

Fagopyrum fagopyrum (L.) Karst. (F. *esculentum* Moench.) Buckwheat. Not uncommonly naturalized in waste places. Ft. Atkinson, etc.

Polygonum amphibium L. Water Persicaria. Aquatic. Reported by Fitzpatrick.

Polygonum emersum (Michx.) Britt. (*P. muhlenbergii* S. Wats.) Swamp Persicaria. Locally common in ponds. Ft. Atkinson.

Polygonum incarnatum Ell. (*P. lapathifolium var. incarnatum* Wats.) Pink Persicaria. Common in wet soils. Decorah, Ft. Atkinson.

Polygonum lapathifolium L. Pale Persicaria. Common in waste places. Introduced.

Polygonum pennsylvanicum L. Pennsylvania Smartweed. Common in moist soil. Decorah, Hesper, Calmar.

Polygonum persicaria L. Lady's Thumb. Introduced weed. Calmar, etc.

Polygonum hydropiper L. Smartweed. In moist grounds, common. Ft. Atkinson, etc.

Polygonum virginianum L. Virginia Knotweed. Rather common in woods. Decorah (Goddard), Canoe creek.

Polygonum aviculare L. Doorweed. A common introduced door-yard weed. Calmar, Hesper, etc.

Polygonum camporum Meisn. Prairie Knotweed. In dry, sandy soil. Near Hesper.

Polygonum tenue Michx. Slender Knotweed. Locally common in dry sandy soil. Decorah (Holway), the St. Peter sandstone region near Hesper.

Polygonum douglasii Greene. Douglas' Knotweed. (Not included in Gray.) With the preceding in the vicinity of Hesper, and even more abundant.

Polygonum convolvulus L. Black Bindweed. A common introduced weed. Calmar, Hesper, etc.

Polygonum scandens L. (*P. dumetorum var. scandens* Gray.) Climbing False Buckwheat. Reported by Fitzpatrick.

Polygonum sagittatum L. Arrow-leaved Tear-thumb. In low grounds. Reported by Fitzpatrick.

Order 8. Chenopodiales.
Family 1. Chenopodiaceæ.

Chenopodium album L. Lamb's Quarters. A common introduced weed. Reported by Fitzpatrick.

Chenopodium glaucum L. Oak-leaved Goosefoot. A common introduced weed. Calmar.

Chenopodium hybridum L. Maple-leaved Goosefoot. Common in woods. Decorah.

Salsola tragus. Russian Thistle. Introduced. Not common. Calmar.

Salsola kali L. Salt-wort.

Family 2. Amaranthaceæ.

Amaranthus retroflexus L. Rough Pigweed. A very common introduced weed. Ft. Atkinson, Decorah (Goddard).

Amaranthus blitoides S. Wats. Prostrate Pigweed. Introduced from the west. A common weed. Ft. Atkinson, etc.

Family 3. Nyctaginaceae.

Allionia nyctaginea Michx. (*Oxybaphus nyctagineus* Sweet.) Wild Four-o'clock. Common in dry open places. Calmar.

Family 4. Azoiaceæ.

Mollugo verticillata L. Carpet-weed. Common in sandy and waste grounds. Ft. Atkinson.

Family 5. Portulacaceæ.

Claytonia virginica L. Spring Beauty. In rich alluvial woods. (Fitzpatrick.)

Portulaca oleracea L. Purslane. A common introduced weed. Calmar, etc.

Family 6. Caryophyllaceæ.

Agrostemma githago L. (*Lychnis githago* Scop.) Introduced weed. Reported by Fitzpatrick.

Silene stellata (L.) Ait. Starry Campion. Along borders of thickets, etc. Common. Calmar.

Silene alba Muhl. Western White Campion. In moist grounds, along borders of thickets. Not rare. Calmar, etc.

Silene antirrhina L. Sleepy Catchfly. In dry places. Reported by Fitzpatrick.

Lychnis alba Mill. (*L. vespertina* Sibth.) White Campion. Introduced weed. Decorah (Arthur), Hesper.

Saponaria officinalis L. Soapwort. Introduced. Locally common in waste places, etc. Ft. Atkinson.

Vaccaria vaccaria (L) Britt. (*Saponaria vaccaria* L.) Cowherb. Introduced. Reported by Fitzpatrick.

Alsine media L. (*Stellaria media* Smith.) Common Chickweed. Common weed in waste places, etc. Introduced. Hesper, etc.

Alsine longifolia (Muhl.) Britt. (*Stellaria longifolia* Muhl.) Long-leaved Stitchwort. Common in wet meadows, etc. Decorah (Goddard).

Cerastium longipedunculatum Muhl. (*C. nutans* Raf.) Nodding Chickweed. Common in moist woods, etc. Decorah (Savage), Hesper, Ft. Atkinson.

Cerastium arvense L. Field Chickweed. Reported by Fitzpatrick.

Cerastium arvense oblongifolium (Torr.) Holl. & Britt. In rocky places. This variety was founded on Winneshiek county material.* Decorah (Holway).

Moehringia lateriflora (L.) Fenzl. (*Arenaria lateriflora* L.) In moist, shaded places. Decorah (Savage).

*See Bull. Torrey Bot. Club, Vol. XIV, p. 48, 1887.

Order 9. Ranales

Family 1. Nymphæaceæ.

Nymphaea advena Sol. (*Nuphar advena* Ait. f.) Yellow Pond-lily. In permanent ponds. Not common. Ft. Atkinson.

Castalia odorata (Dry.) W. & W. (*Nymphaea odorata* Ait.) Sweet-scented White Water-lily. In permanent ponds. Rare. Ft. Atkinson.

Family 2. Ranunculaceæ.

Hydrastis canadensis L. Orange-root Golden Seal. Rare, in deep woods. Canoe creek.

Caltha palustris L. Marsh-marigold. In bogs and wet meadows. Not common. Hesper.

Isopyrum biternatum (Raf.) T. & G. False Rue-anemone. In rich alluvial woods. Decorah (Savage).

Actaea rubra (Ait.) Willd. (*A. spicata var. rubra* Ait.) Red Baneberry. Not rare, in deep woods. Hesper, Decorah.

Actaea alba (L.) Mill. White Baneberry. Rich woods Hesper.

Aquilegia canadensis L. Wild Columbine. Common on shaded rocks. Decorah (Savage), Calmar.

Delphinium carolinianum Walt. (*D. azureum* Michx.) Prairie Larkspur. Still frequent on rather dry prairie west of Ft. Atkinson.

Anemone cylindrica A. Gray. Long-fruited Anemone. Common on prairie and in open places. Calmar.

Anemone virginiana L. Tall Anemone. Common in open woods. Calmar, etc.

Anemone canadensis L. (*A. pennsylvanica* L.) Pennsylvania Anemone. In moist grounds. Common. Decorah (Savage), Calmar.

Anemone quinquefolia L. (*A. nemorosa* L.) Wood Anemone. In woods. Reported by Fitzpatrick.

Hepatica acuta (Pursh.) Britt. (*H. acutiloba* DC.) Heart Liver-leaf. Common on wooded banks and slopes. Decorah (Savage), Hesper.

Syndesmon thalictroides (L.) Hoffm. (*Anemonella thalictroides* Spach.) Rue-anemone. In open woods. (Fitzpatrick).

Pulsatilla hirsutissima (Pursh.) Britt. (*Anemone patens var. nuttalliana* Gray.) Pasque-flower. On prairies and dry ridges. Not rare. Bluffton, Decorah.

Clematis virginiana L. Virgin's Bower. Common along borders of thickets, etc. Ft. Atkinson, Decorah, Hesper.

Atragene americana Sims. (*Clematis verticillaris* DC.) Purple Virgin's Bower. Shaded rocky banks. Found at Decorah by Holway and Goddard.

Ranunculus ovalis Raf. (*R. rhomboideus.*) Prairie Crowfoot. In open places. Reported by Fitzpatrick.

Ranunculus abortivus L. Kidney-leaved Crowfoot. In moist shaded ground. Common. Decorah (Savage), etc.

Ranunculus recurvatus Poir. Hooked Crowfoot. In rich woods, locally frequent. Hesper.

Ranunculus pennsylvanicus L. f. Bristly Crowfoot. Reported by Fitzpatrick.

Ranunculus septentrionalis Poir. Marsh Butter-cup. Common in low grounds. Decorah (Savage).

Ranunculus fascicularis Muhl. Early Butter-cup. Reported by Fitzpatrick.

Batrachium trichophyllum (Chaix.) Bossch. (*Ranunculus aquatilis var. trichophyllus* Gray.) Common White Water Crowfoot. Abundant in Bear creek near Highlandville.

Thalictrum dioicum L. Early Meadow-rue. Common on wooded slopes. Decorah (Savage), Hesper.

Thalictrum purpurascens L. Purplish Meadow-rue. Common in open places. Calmar, Decorah (Goddard), etc.

Family 3. Berberidaceæ.

Caulophyllum thalictroides (L.) Michx. Blue Cohosh. Rather common, in deep woods. Hesper.

Podophyllum peltatum L. May Apple. In deep woods. Not common. (Fitzpatrick.)

Family 4. Menispermaceæ.

Menispermum canadense L. Moonseed; Yellow Parilla. Quite common, in woods. Decorah (Savage), Hesper.

Order 10. Papaverales

Family 1. Papaveraceæ.

Sanguinaria canadensis L. Bloodroot. On well-wooded slopes and banks, not rare. Decorah (Savage), Hesper.

Bicuculla cucullaria (L.) Millsp. (*Dicentra cucullaria DC.*) Dutchman's Breeches. In rich woods. Decorah (Goddard).

Bicuculla canadensis (Goldie.) Millsp. (*Dicentra canadensis* DC.) Squirrel Corn. Reported by Fitzpatrick.

Capnoides micranthum (Engelm.) Britt. (*Corydalis micrantha* Gray.) Small-flowered Corydalis. In woods. Decorah (Goddard).

Family 2. Cruciferæ.

Lepidium virginicum L. Wild Pepper-grass. A common weed. Hesper, Calmar, etc.

Lepidium apetalum L. (*L. intermedium* Gray.) Apetalous Pepper-grass. A weed. Decorah (Savage).

Sisymbrium officinale (L.) Scop. Hedge Mustard. A common naturalized weed. Calmar, etc.

Sinapis alba L. (*Brassica alba* Boiss.) White Mustard. An introduced weed. Not common. Calmar.

Brassica nigra (L.) Koch. Black Mustard. A common introduced weed. Calmar, etc.

Brassica arvensis (L.) B. S. P. (*B. sinapistrum* Boiss.) More common than the preceding, and observed at several stations. (Fitzpatrick.)

Iodanthus pinnatifidus (Michx.) Steud. (*Thelypodium pinnatifidum* Wats.) Purple Rocket. Reported by Fitzpatrick.

Roripa palustris (L.) Bess. (*Nasturtium palustre* DC.) Marsh Cress. In low grounds. Calmar.

Roripa nasturtium (L.) Rusby. (*Nasturtium officinale* R. Br.) Water Cress. In clear streams. Canoe creek, Decorah.

Roripa armoracia (L.) A. S. Hitch (*Nasturtium armoracia* Fries.) Horse-radish. Run wild. (Fitzpatrick.)

Cardamine bulbosa (Schreb.) B. S. P. (*C. rhomboidea* DC.) Spring Cress. In bogs, etc. Decorah (Savage).

Cardamine hirsuta L. Bitter Cress. In moist grounds. (Fitzpatrick.)

Dentaria laciniata Muhl. Pepper-root. Rich woods. (Fitzpatrick.)

Bursa bursa-pastoris (L.) Britt. (*Capsella bursa-pastoris* Moench.) Shepherd's Purse.. A very common introduced weed. Decorah (Savage), Calmar, etc.

Camelina sativa (L.) Crantz. False Flax. An introduced weed. (Fitzpatrick.)

Draba caroliniana Walt. Carolina Whitlow-grass. In sandy places. (Fitzpatrick.)

Sophia intermedia Rydb. (*Sisymbrium canescens* Nutt., in part.) Western Tansy-mustard. On dry ridges, etc. Decorah (Savage).

Arabis lyrata L. Lyre-leaved Rock-cress. On rocks, etc. Locally common. Decorah.

Arabis dentata T. & G. Toothed Rock-cress. In rocky places. Decorah (Savage).

Arabis laevigata (Muhl.) Poir. Smooth Rock-cress. On rocky slopes, etc. Decorah (Savage).

Arabis canadensis L. Sickle-pod. In woods, etc. (Fitzpatrick.)

Arabis brachycarpa (T. & G.) Britt. (*A. confinis* S. Wats.) Purple Rock-cress. In rocky places. (Fitzpatrick.)

Erysimum cheiranthoides L. Worm-seed Mustard. Along borders and on banks. Not rare. Decorah, etc.

Berteroa incana (L.) DC. Hoary Alyssum. Not common. Decorah.

Family 3. Capparidaceæ.

Polanisia trachysperma T. & G. Large-flowered Clammy-weed. In sandy places. Ft. Atkinson.

Order 11. Rosales.

Family 1. Penthoraceæ.

Penthorum sedoides L. Ditch Stonecrop. In low wet places. Locally common. Decorah, etc.

Family 2. Parnassiaceæ.

Parnassia caroliniana Michx. Grass of Parnassus. Quite rare, in bogs near Hesper.

Family 3. Saxifragaceæ.

Saxifraga pennsylvanica L. Swamp Saxifrage. Not rare, in bogs. Hesper.

Sullivantia sullivantii (T. & G.) Britt. (*S. ohionis* T. & G.) Sullivantia. Locally common, on faces of cliffs. Highlandville.

Heuchera hispida Pursh. Rough Heuchera; Alum-root. Common, on prairie. Calmar.

Mitella diphylla L. Two-leaved Bishop's Cap. Common, on shaded banks. Decorah (Savage), Hesper.

Chrysosplenium iowensis Rydb. (*C. alternifolium* L.) Iowa Golden Saxifrage. Rare, on shaded mossy banks. Decorah (Goddard). Also found in Dubuque county.

Family 4. Grossulariaceæ.

Ribes cynosbati L. Wild Gooseberry. Locally common, on rocky banks. Decorah. Also observed at Canoe creek, both forks of Bear creek, Highlandville and Ft. Atkinson.

Ribes missouriensis Nutt. (*R. gracile* Michx., in part.) Missouri Gooseberry. Common on banks and in open thickets. Decorah, Hesper. Also observed at Canoe creek and Ft. Atkinson.

Ribes floridum L'Her. Wild Black Currant. Not rare, in low rich woods. Decorah. Also observed at Hesper, Canoe creek, and north fork of Bear creek.

Ribes rubrum L. Red Currant. Rare, in deep woods at Hesper. May be introduced, but appears to be native.

Family 5. Platanaceæ.

Platanus occidentalis L. Sycamore; Plane-tree. In low woods. Rare, observed only at Bluffton.

Family 6. Rosaceæ.

Opulaster intermedius Rydb. (*Physocarpus opulifolius*, in part.) Common on wooded banks and in thickets. Decorah. Also observed along Canoe creek, north fork of Bear creek, and at Bluffton and Kendallville.

Spiraea salicifolia L. American Meadow-sweet. In swamps. Decorah. Also observed at Ft. Atkinson.

Rubus americanus (Pers.) Britt. (*R. triflorus* Rich.) Dwarf Raspberry. Swamps. (Fitzpatrick.)

Rubus strigosus Michx, Wild Red Raspberry. Rather common, on rocky banks. Decorah.

Rubus occidentalis L. Black Raspberry. On wooded banks and in thickets. Decorah.

Rubus nigrobaccus Bailey. (*R. villosus* Ait.) Blackberry. Common in thickets. Decorah.

Rubus procumbens Muhl. (*R. canadensis* L.) Dewberry. In sandy or rocky soil, not common. Decorah, Hesper. The specimens from the latter locality have an unusually large number of leaves having but one large leaflet. This form was reported by the writer under the name of *R. baileyanus*,* a species which, so far as known, does not occur in Iowa.

Drymocallis arguta (Pursh.) Ryd. (*Potentilla arguta* Pursh.) Tall Cinquefoil. On dry prairie and hills, locally common. Ft. Atkinson.

Dasiphora fruticosa (L.) Rydb. (*Potentilla fruticosa* L.) Shrubby Cinquefoil. Rare. Decorah (Arthur).

Sibbaldiopsis tridentata (Soland.) Rydb. (*Potentilla tridentata* Soland.) Three-toothed Cinquefoil. Very common on the St. Peter sandstone exposures northeast of Hesper.

Fragaria virginiana Duches. Wild Strawberry. In open places, locally common. (Fitzpatrick.)

Fragaria americana (Port.) Britt. (*F. vesca* L.) Wood Strawberry. Locally common, in rocky places. Decorah (Savage), Canoe creek, Ft. Atkinson.

Potentilla monspeliensis L. (*P. norvegica* L.) Rough Cinquefoil. Rather common, on banks and in thickets. Calmar.

Potentilla canadensis L. Five-finger. Common in dry soils. Moneek, Canoe creek, etc.

Geum virginianum L. Rough Avens. Moist woods. More common than the preceding at Hesper.

Geum macrophyllum Willd. Large-leaved Avens. In moist woods. (Fitzpatrick.)

Sieversia ciliata (Pursh.) Rydb. (*Geum triflorum* Pursh.) Reported by Fitzpatrick.

Agrimonia hirsuta (Muhl.) Bick. (*A. eupatoria* L.) Common in woods. Hesper, etc.

Rosa blanda Ait. Smooth Wild Rose. Not rare, on shaded banks, etc. Decorah.

* See Trans. Iowa Hort. Society, Vol. 38, p. 463; Proc. Dav. Acad. of Sciences, Vol. X, 1904.

Rosa sayi Schwein. Prickly Rose. Common on banks and in thickets. Canoe creek, Bluffton, Calmar, Ft. Atkinson.

Rosa woodsii Lindl. Wood's Rose. Not common, in open places. Bluffton.

Rosa humilis Marsh. Pasture Rose. Reported by Fitzpatrick. A specimen collected by the writer at Calmar is probably this species.

Family 7. Pomaceæ.

Malus iowensis (Wood) Britt. (*Pyrus coronaria* L., in part.) Western Crab-apple. Common in thickets at all the stations named, excepting Calmar.

Aronia nigra (Willd.) Britt. (*Pyrus arbutifolia var. melanocarpa* Hook.) Black Choke-berry. Very rare. Found only upon an exposure of St. Peter sandstone near Hesper.

Amelanchier canadensis (L.) Medic. June-berry. Rather common, along river-bluffs, etc. Decorah (Goddard), Bluffton. Observed at Hesper, Canoe creek, south fork of Bear creek and Kendallvillle.

Amelanchier botryapium (L. f.) DC. (*A. canadensis var. oblongifolia* T .& G.) Shad-bush. Local, on shaded rocky banks. Decorah (Goddard), Bluffton.

Amelanchier rotundifolia (Michx.) Roem. (*A. canadensis var. rotundifolia* T. & G.) Round-leaved June-berry. On wooded banks and slopes. Rather common locally. Hesper, Bluffton.

Amelanchier alnifolia Nutt. Northwestern June-berry. Locally frequent on dry slopes. Decorah (Savage), Freeport. Also observed at Hesper.

Crataegus punctata Jacq. Large-fruited Thorn. Very common in thickets. Decorah, Bluffton, Canoe creek, north fork of Bear creek, Hesper, Ft. Atkinson. This is the most common red-haw in the county. Fitzpatrick also reports *C. crus-galli*, but one of his specimens in the University herbarium, so labelled, is certainly *C. punctata*. The writer's notes contain references to *C. crus-galli*, and the species probably occurs, but all the specimens which were collected are typical *C. punctata*.

Crataegus coccinea L. Scarlet Haw. What has usually been called *C. coccinea* is rather common in thickets. It is evidently

C. pruinosa K. Koch, as recognized by Sargent, and should probably be called by that name. Kendallville, N. fork of Bear creek.

Crataegus macracantha Lodd. Long-spined Thorn. Rather common in thickets. Decorah (Savage), Canoe creek, Moneek.

Crataegus tomentosa L. Pear Haw. Quite common in thickets. Canoe creek, north fork of Bear creek, Hesper.

Family 8. Drupaceæ.

Prunus americana Marsh. Wild Plum. Common in thickets. Decorah, Ft. Atkinson. Also observed at all the stations excepting Calmar and Moneek.

Prunus pumila L. Dwarf Cherry. Very rare. Found only on an exposure of St. Peter sandstone near Hesper, with *Aronia*.

Prunus pennsylvanica L. f. Wild Red Cherry. Common along borders and in thickets. Hesper, Canoe creek. Also observed at Decorah, Bluffton and north fork of Bear creek.

Prunus virginiana L. Choke Cherry. Locally common, on rocky banks, etc. Decorah. Also observed at Hesper, Canoe creek, both forks of Bear creek, Bluffton and Kendallville.

Prunus serotina Ehrh. Wild Black Cherry. Common in upland woods. Hesper, Canoe creek. Also obresved at all the other stations, excepting Calmar.

Family 9. Cæsalpinaceæ

Cassia chamaecrista L. Partridge Pea. A common weed, in dry soils. Decorah. etc.

Family 10. Papilionaceæ.

Baptisia bracteata Ell. (*B. leucophaea* Nutt.) Large-bracted Wild Indigo. Open places. (Fitzpatrick.)

Baptisia leucantha T. & G. Wild Indigo. Locally common on rich prairies. Calmar.

Lupinus perennis L. Wild Lupine. Collected by Holway at Decorah.

Melilotus alba Desv. White Sweet-clover. A common introduced weed. Calmar, etc.

Melilotus officinalis (L.) Lam. Yellow Sweet-clover. Introduced. Less common than the preceding. (Fitzpatrick.)

Trifolium arvense L. Stone Clover. Introduced. (Fitzpatrick.)

Trifolium pratense L. Red Clover. Everywhere escaped from cultivation. Calmar, Hesper, etc.

Trifolium hybridum L. Alsike Clover. Becoming quite common in waste places. Ft. Atkinson, etc.

Trifolium repens L. White Clover. Common everywhere. Calmar, etc.

Amorpha fruticosa L. False Indigo. Along streams, rather common. Decorah. Observed at Bluffton, etc.

Amorpha canescens Pursh. Lead-plant. Common on dry prairies and ridges. Hesper, Freeport, Calmar, Ft. Atkinson, Highlandville. Observed at Kendallville, etc.

Kuhnistera candida (Willd.) Kuntz. (*Petalostemon candidus* Michx.) White Prairie Clover. Local, on prairies and dry ridges. Calmar.

Kuhnistera purpurea (Vent.) MacM. (*Petalostemon violaceus* Michx.) Purple Prairie Clover. With preceding. Calmar.

Cracca virginiana L. (*Tephrosia virginiana* Pers.) Goat's Rue. Reported by Fitzpatrick.

Robinia pseudacacia L. Black Locust. Common, evidently introduced. Observed at Hesper, Bluffton, Kendallville, etc.

Astragalus carolinianus L. (*A. canadensis* L.) Milk Vetch. On open banks and slopes. Not rare. Calmar.

Meibomia pauciflora (Nutt.) Kuntze. (*Desmodium pauciflorum* DC.) Few-flowered Tick-trefoil. Rare. In deep woods near Hesper.

Meibomia grandiflora (Walt.) Kuntze. (*Desmodium acuminatum* DC.) Tick-trefoil. Common in deep woods. Decorah.

Meibomia longifolia (T. & G.) Vail. (*Desmodium* —not mentioned in Gray's Manual.) Long-leaved Tick-trefoil. In thickets, etc. Decorah (Goddard), Calmar.

Lespedeza capitata Michx. Tall Bush-clover. Common on dry prairies and ridges. Calmar, Ft. Atkinson, Freeport.

Lespedeza leptostachya Engelm. Prairie Clover. Reported from this county in Fitzpatrick's Manual.

Vicia cracca L. Cow Vetch. Reported by Fitzpatrick.

Vicia americana Muhl. American Vetch. Common in rather moist open grounds. Decorah (Savage), Calmar.

Vicia sativa L. Common Vetch. Introduced, in waste places. Calmar.

Vicia angustifolia Roth. Smaller Common Vetch. Introduced. Fitzpatrick reports one specimen.

Lathyrus venosus Muhl. Veiny Pea. In rich, rather moist, open places. Not frequent. Calmar.

Lathyrus ochroleucus Hook. Cream-colored Vetchling. On hillsides. Not common. Decorah (Goddard).

Falcata comosa (L.) Kuntze. (*Amphicarpaea monoica* Nutt.) Hog Pea-nut. Not rare, in woods. Ft. Atkinson.

Falcata pitcheri (T. & G.) Kuntze. (*Amphicarpaea pitcheri* T. & G.) Pitcher's Hog Pea-nut. More common than the preceding, and in similar places. Hesper; Decorah (Goddard).

Apios apios (L.) MacM. (*A. tuberosa* Moench.) Ground-nut. Not rare, in rather moist grounds. Calmar, Hesper.

Order 12. Geraniales.

Family 1. Geraniaceæ.

Geranium maculatum L. Wild Crane's-bill. In upland woods. Decorah (Savage).

Family 2. Oxalidaceæ.

Oxalis violacea L. Violet Wood-sorrel. Not rare, in sandy and rocky places. (Fitzpatrick.)

Oxalis stricta L. (*O. corniculata var. stricta* Sav.) A common weed, in open places. Calmar, etc.

Family 3. Linaceæ.

Linum usitatissimum L. Flax. Escaped from cultivation, chiefly along railway right-of-way. Ft. Atkinson, etc.

Linum sulcatum Riddell. Grooved Yellow Flax. Common, in dry places. Hesper, Ft. Atkinson.

Family 4. Rutaceæ.

Xanthoxylum americanum Mill. Prickly Ash. Common, in thickets and on rocky banks. Decorah (Savage), Highlandville. Also observed at Canoe creek, both forks of Bear creek, and Bluffton.

Family 5. Polygalaceæ.

Polygala verticillata L. Whorled Milkwort. In dry open places. Not common. Ft. Atkinson.

Polygala viridescens L. (*P. sanguinea* L.) Field Milkwort. Rather common, on prairies and in meadows. Hesper, Ft. Atkinson.

Polygala senega L. Seneca Snakeroot. On rocky slopes. Not common. Bluffton.

Family 6. Euphorbiaceæ.

Euphorbia maculata L. Milk Purslane. A common weed. Calmar.

Euphorbia nutans Lag. (*E. preslii* Guss.) Upright Spurge. A common weed. Decorah (Goddard), Ft. Atkinson.

Euphorbia corollata L. Flowering Spurge. Common in dry, open places. Calmar, etc.

Euphorbia commutata Engelm. Tinted Spurge. Reported from Decorah by Arthur.

Euphorbia cyparissias L. Cypress Spurge. Introduced, locally common. Decorah.

Order 13. Sapindales.

Family 1. Anacardiaceæ.

Rhus hirta (L.) Sudw. (*R. typhina* L.) Staghorn Sumach. Locally common, on rocky slopes. Decorah, Freeport.

Rhus glabra L. Smooth Sumach. Very common in thickets and along borders, chiefly in dry places. Decorah (Savage), Calmar. Observed at all the stations.

Rhus radicans L. (*R. toxicodendron* L.) Poison Ivy. Common along borders, and in low grounds. Both bushy and climbing forms are common—the former chiefly in dry places. Decorah. Also observed at Hesper, Bluffton, Kendallville, etc.

Family 2. Celastraceæ.

Euonymus atropurpureus Jacq. Burning Bush; Wahoo. In alluvial grounds, and on banks. Not rare. Decorah. Also observed at Bluffton.

Celastrus scandens L. Climbing Bittersweet. Rather common, in woods and along borders. Decorah. Also observed at Hesper, Canoe creek and at Bluffton.

Family 3. Staphyleaceæ.

Staphylea trifolia L. Bladder-nut. Not rare, on rocky banks. Decorah. Also observed at Hesper, Canoe creek and Bluffton.

Family 4. Aceraceæ.

Acer saccharinum L. (*A. dasycarpum* Ehrh.) Soft Maple. Common on alluvial grounds. Kendallville. Observed at Canoe creek, Decorah, Ft. Atkinson and Bluffton.

Acer saccharum Marsh. (*A. saccharinum* Wang.) Hard Maple. Very common in upland woods, and on bluffs. Decorah. Observed at all stations excepting Calmar and Moneek.

Acer negundo L. (*Negundo aceroides* Moench.) Box Elder. Common, especially in alluvial soils. Decorah (Savage), Calmar. Observed at all the stations.

Family 5. Balsaminaceæ.

Impatiens biflora Walt. (*I. fulva* Nutt.) Spotted Touch-me-not. In moist grounds. Locally common. Ft. Atkinson, Hesper.

Impatiens aurea Muhl. (*I. pallida* Nutt.) Pale Touch-me-not. In moist places, but rather less common than the preceding. Decorah (Savage).

Order 14. Rhamnales.

Family 1. Rhamnaceæ.

Ceanothus americanus L. New Jersey Tea. Common on dry prairies and ridges. Decorah, Calmar. Also observed at the north fork of Bear creek, Canoe creek, Bluffton and Kendallville.

Ceanothus ovatus pubescens T. & G. (The variety is not mentioned in Gray.) Downy Red-root. Rare. On dry prairie ridges at Decorah.

Family 2. Vitaceæ.

Vitis vulpina L. (*V. riparia* Michx.) Common Wild Grape. Very common along streams and ascending slopes. Decorah (Savage), Calmar. Also observed at all the other stations.

Parthenocissus quinquefolia (L.) Planch. (*Ampelopsis quinquefolia* Michx.) Virginia Creeper. Very common in thickets and deep woods. Calmar. Observed at all the other stations.

Order 15. Malvales.

Family 1. Tiliaceæ.

Tilia americana L. Basswood. Common in rich woods, especially on lower slopes. Decorah. Observed at all the other stations excepting Calmar.

Family 2. Malvaceæ.

Malva rotundifolia L. Round-leaved Mallow; Monkey-cheese. A common introduced weed, in waste places. Decorah, etc.

Malva crispa L. Curled Mallow. An introduced weed. One specimen reported by Fitzpatrick.

Napaea dioica L. Glade Mallow. In moist grounds. Not common. (Fitzpatrick.)

Abutilon abutilon (L.) Rusby. (*A. avicennae* Gaertn.) Velvet-leaf. An introduced weed, common in waste places, etc. Decorah, etc.

Order 16. Parietales.

Family 1. Hypereicaceæ.

Hypericum ascyron L. Great St. John's-wort. Locally common in rather moist, open places. Hesper, Decorah.

Hypericum sphaerocarpon Michx. (*H. cistifolium* Lam.) Round-fruited St. John's-wort. Not common, on rocky slopes. North fork of Bear creek.

Hypericum maculatum Walt. Spotted St. John's-wort. Common, in rather moist soil. Hesper, Ft. Atkinson.

Hypericum canadense L. Canadian St.John's-wort. On moist, sandy banks, etc. Not abundant. Ft Atkinson.

Family 2. Cistaceæ.

Helianthemum majus (L.) B. S. P. (*Lechea major* Michx.) Hoary Frostweed. Quite common, on dry ridges, etc. Hesper, Calmar, etc. This species was reported from the county by Fitzpatrick under the name *H. canadense* Mx.

Lechea stricta Leggett. (Not included in Gray's Manual.) Prairie Pinweed. Locally common on dry sandy or rocky ridges. Hesper, especially on the St. Peter sandstone exposures.

Family 3. Violaceæ.

Viola pedatifida Don. Prairie Violet. Locally still common on prairies. Calmar.

Viola pedata L. Bird's-foot Violet. On dry, sandy slopes and ridges. Not rare. Hesper, Ft. Atkinson.

Viola papilionacea Pursh. (*V. palmata var. cucullata* Gray.) Common Blue Violet. Common, usually in thickets or along borders, sometimes in open places. Decorah (Savage), etc.

Viola scabriuscula (T. & G.) Schwein. (*V. pubescens var. scabriuscula* T. & G.) Common Yellow Violet. Common in rich alluvial woods. Hesper, etc.

Viola canadensis L. Canada Violet. Locally common in rich woods, especially on lower banks and slopes. Hesper.

Order 17. Thymelales.
Family Thymeleaceæ.

Dirca palustris L. Leatherwood. Rare and local. Canoe creek.

Order 18. Myrtales.
Family Onagraceæ.

Ludwigia polycarpa Short & Peter. Many-fruited Ludwigia. Locally common in wet grounds, often in water. Ft. Atkinson.

Chamaenerion angustifolium (L.) Scop. (*Epilobium angustifolium* L.) Great Willow-herb. Locally common in dry open places. Calmar, Moneek.

Epilobium coloratum Muhl. Purple-leaved Willow-herb. Common in swampy grounds. Ft. Atkinson.

Epilobium adenocaulon Haussk. Northern Willow-herb. In wet grounds. Rather common. Decorah.

Onagra biennis (L.) Scop. (*Enothera biennis* L.) Common Evening Primrose. In dry soils and waste places. Common, often a weed. Ft. Atkinson, Calmar, etc.

Meliolix serrulata (Nutt.) Walp. (*Enothera serrulata* Nutt.) In dry places. (Fitzpatrick.)

Gaura parviflora Dougl. Small-flowered Gaura. Not rare, in dry soils. Ft. Atkinson.

Circaea lutetiana L. Enchanter's Nightshade. Common in deep woods. Hesper, etc.

Circaea alpina L. Smaller Enchanter's Nightshade. In deep woods. Not common. Decorah (Goddard), Canoe creek.

Order 19. Umbellales.
Family I Araliaceæ.

Aralia racemosa L. American Spikenard. Not rare, in deep upland woods. Decorah.

Aralia nudicaulis L. Wild Sarsaparilla. Common on rocky, well-shaded banks. Decorah (Savage), etc.

Panax quinquefolium L. (*Aralia quinquefolia* D. & P.) Ginseng. Becoming rare. In deep rich woods. Hesper, Decorah.

Family 2. Umbelliferæ.

Sanicula marylandica L. Sanicle. Common in rich woods. Decorah (Savage), Calmar, Hesper.

Eryngium aquaticum L. (*E. yuccaefolium* Michx.) Button Snake-root. Not rare, on dry prairies, but also occurring in moist grounds. Calmar.

Washingtonia claytoni (Michx.) Britt. (*Osmorrhiza brevistylis* DC.) Woolly Sweet Cicely. Common in deep woods. Hesper, Decorah.

Conium maculatum L. Poison Hemlock. In waste places. Introduced. Decorah (Goddard).

Zizia aurea (L.) Koch. Golden Meadow Parsnip. In rather moist open places. Decorah (Savage), Calmar.

Cicuta maculata L. Water Hemlock. Not rare, in swamps. Calmar; Decorah (Goddard).

Deringa canadensis (L.) Kuntze. (*Cryptotaenia canadensis* DC.) Honewort. Very common in woods. Hesper, Decorah, etc.

Taenidia integerrima (L.) Drude. (*Pimpinella integerrima* B. & H.) Yellow Pimpernel. Common on rocky slopes. Decorah (Savage), etc.

Sium cicutaefolium Gmel. Water-parsnip. Common in swamps. Ft. Atkinson, Hesper.

Pastinaca sativa L. Wild Parsnip. A common weed in waste places. Introduced. Calmar, Decorah.

Heracleum lanatum Michx. Cow-parsnip. In rather moist soil. Not rare. Decorah (Goddard).

Family 3. Cornaceæ.

Cornus circinata L'Her. Round-leaved Dogwood. Common on shaded rocky slopes. Decorah, Bluffton, Highlandville.

Cornus stolonifera Michx. Red-osier Dogwood. Common, in wet places. Decorah, Bluffton, Canoe creek, Hesper.

Cornus candidissima Marsh. (*C. paniculata* L'Her.) Panicled Dogwood. Common on shaded banks, etc. Ft. Atkinson, Decorah, Hesper.

Cornus alternifolium L. f. Alternate-leaved Dogwood. Common on wooded slopes and banks. Decorah, Canoe creek, north fork of Bear creek, Hesper.

Series II.

Order 1. Ericales.

Family 1. Pyrolaceæ.

Pyrola elliptica Nutt. Shin-leaf. Common in deep upland woods. Decorah (Savage), Ft. Atkinson, Canoe creek, Hesper.

Pyrola secunda L. One-sided Wintergreen. Rare, in deep woods. Hesper, Decorah (Holway).

Chimaphila umbellata (L.) Nutt. Pipsissewa. Rare, in upland woods. Hesper.

Family 2. Monotropaceæ.

Monotropa uniflora L. Indian Pipe. Very abundant in deep upland woods. Hesper, Canoe creek.,

Hypopitys americana (DC.) Small. (*Monotropa hypopitys* L.) Pine-sap. Very abundant in deep upland woods at Hesper.

Order 2. Primulales.

Family 1. Primulaceæ.

Steironema ciliatum (L.) Raf. Fringed Loosestrife. Common in wet prairies. Calmar.

Steironema quadriflorum (Sims.) Hitch. (*S. longifolium* Gray.) Prairie Loosestrife. In moist low places. Decorah (Goddard).

Dodecatheon meadia L. Shooting Star. On prairies and treeless ridges. Not rare. (Fitzpatrick.)

Order 3. Gentianales.

Family 1. Oleaceæ.

Fraxinus americana L. White Ash. Fitzpatrick reports this as frequent in rich woods, but the writer saw no specimens which could be so referred with certainty. Most of the specimens reported under this name from Iowa undoubtedly belong to the following species.

Fraxinus lanceolata Borck. (*F. viridis* Michx.f.) Green Ash. Common on alluvial grounds, but also extending into upland forests. Decorah, Kendallville. Observed in all the forest-covered parts of the county.

Fraxinus nigra Marsh. (*F. sambucifolia* Lam.) Black Ash. Quite common in upland woods. North fork of Bear creek, Hesper.

Family 2. Gentianaceæ.

Gentiana crinita Froel. Fringed Gentian. Locally common in shaded boggy places. Bluffton, Fremont Twp., Canoe creek.

Gentiana quinquefolia occidentalis (A. Gray.) A. S. H. (*G. quinqueflora var. occidentalis* Gray.) Stiff Gentain; Western Ague-weed. Chiefly on dry, rocky slopes. North fork of Bear creek, Decorah, Kendallville.

Gentiana puberula Michx. Prairie Gentian. On dry prairies. (Fitzpatrick.)

Gentiana andrewsii Griseb. Closed Gentian. In moist woods. Not common. Hesper.

Gentiana flavida A. Gray. (*G. alba* Muhl.) Yellowish Gentian. Not common. In deep woods. Bluffton.

Family 3. Apocynacecæ.

Apocynum androsaemifolium L. Spreading Dogbane. In thickets, etc. Common. Calmar, Moneek.

Acopynum cannabinum L. Indian Hemp. On prairies and in open places. Not rare. Calmar.

Family 4. Asclepiadaceæ.

Asclepias tuberosa L. Pleurisy-root. On dry prairies and ridges. Common. Ft. Atkinson.

Asclepias incarnata L. Swamp Milkweed. Common in swamps and wet meadows. Decorah.

Asclepias syriaca L. (*A. cornuti* Dec.) Common Milkweed. In open and waste places. Common. Calmar.

Asclepias exaltata (L.) Muhl. (*A. phytolaccoides* Pursh.) Tall Milkweed. In thickets. (Fitzpatrick.)

Asclepias verticillata L. Whorled Milkweed. Common on dry prairies, etc. Ft. Atkinson.

Ipomoea pandurata (L.) Meyer. Wild Potato Vine. Dry soil. (Fitzpatrick.)

Order 4. Polemoniales.

Family 1. Convolvulaceæ.

Convolvulus sepium L. Hedge Bindweed. Common in fields and waste places. Decorah (Goddard), Calmar.

Convolvulus arvensis L. Small Bindweed. In fields and waste places. Introduced. Calmar.

Family 2. Cuscutaceæ.

Cuscuta cephalanthi Engelm. Dodder. On coarse herbs, etc. Common. Decorah.

Cuscuta gronovii Willd. (*C. gronovii var. latifolia* Engelm.) The variety *latifolia* was reported from Hesper by Arthur.

Cuscuta paradoxa Raf. (*C. glomerata* Chois.) Glomerate Dodder. Reported by Fitzpatrick.

Family 3, Polemoniaceæ.

Phlox pilosa L. Prairie Phlox. Common on prairies, and open ridges. Decorah, Ft. Atkinson.

Phlox divaricata L. Wild Blue Phlox. Common in alluvial woods. Decorah (Savage).

Polemonium reptans L. Jacob's Ladder. Common, in woods. Decorah, Hesper.

Family 4. Hydrophyllaceæ.

Hydrophyllum virginicum L. Virginia Water-leaf. Common, in rich woods. Decorah (Savage).

Hydrophyllum appendiculatum Michx. Appendaged Water-leaf. In rich woods. (Fitzpatrick.)

Macrocalyx nyctelea (L.) Kuntze. (*Ellisia nyctelea* L.) Nyctelea. Common in moist, shaded places. Becoming a weed. Decorah (Savage), etc.

Family 5. Boraginaceæ.

Lappula lappula (L.) Karst. (*Echinospermum lappula* Lehm.) Burseed. Introduced. In waste places. Decorah.

Lappula texana (Scheele) Britt. (*Echinospermum redowskii var. occidentale* Wats.) On dry ridges and slopes. Common. Decorah (Arthur), Highlandville.

Lappula virginiana (L.) Greene. (*Echinospermum virginicum* Lehm.) Beggar's Lice. Along borders, in open woods, etc. (Fitzpatrick.)

Mertensia virginica (L.) DC. Smooth Lungwort; Smooth Blue-bell. In alluvial woods. (Fitzpatrick.)

Mertensia paniculata (Ait.) G. Don. Tall Lungwort. In woods. Decorah (Goddard; Arthur).

Lithospermum latifolium Michx. American Gromwell. In dry thickets, etc. (Fitzpatrick.)

Lithospermum gmelini (Michx.) A. S. H. (*L. hirtum* Lehm.) Hairy Puccoon. In dry, usually open places. Decorah (Savage).

Lithospermum canescens (Michx.) Lehm. Hoary Puccoon. In dry places. Decorah (Savage).

Lithospermum linearifolium Goldie. (*L. angustifolium* Michx.) Narrow-leaved Puccoon. In dry soil. (Fitzpatrick.)

Onosmodium molle Michx. (*O. carolinianum var. molle* Gray.) Soft-hairy False Gromwell. On dry prairie. (Fitzpatrick.)

Family 6. Verbenaceæ.

Verbena urticifolia L. White Vervain. Common introduced weed. (Fitzpatrick), etc.

Verbena hastata L. Blue Vervain. Common in moist places. Calmar, Hesper, etc.

Verbena stricta Vent. Hoary Vervain. Common on dry prairie, etc. Ft. Atkinson, etc.

Verbena bracteosa Michx. Large-bracted Vervain. In dry and waste places. Calmar, etc.

Family 7. Labiateæ.

Teucrium canadense L. Wood Sage. In moist grounds. Decorah.

Isanthus brachiatus (L.) B. S. P. (*I. caeruleus* Michx.) False Pennyroyal. On sandy or rocky slopes, etc. Decorah (Holway).

Scutellaria lateriflora L. Mad-dog Skull-cap. In low places. Not rare. Decorah.

Scutellaria cordifolia Muhl. (*S. versicolor* Nutt.) On wooded banks. (Fitzpatrick.)

Scutellaria parvula Michx. Small Skull-cap. On sandy and rocky slopes. Hesper.

Agastache nepetoides (L.) Kuntze. (*Lophanthus nepetoides* Benth.) Catnip. Giant-Hyssop. Along borders and in thickets, not common. Hesper.

Agastache scrophulariaefolia (Willd.) Kuntze. (*Lophanthus scrophulariaefolius* Benth.) Giant Hyssop. In thickets and woods. Common. Hesper.

Nepeta cataria L. Catnip. In waste places. Introduced. Common. Calmar, Hesper.

Glecoma hederacea L. (*Nepeta glechoma* Benth.) Ground Ivy. A common introduced weed. Decorah (Savage), etc.

Prunella vulgaris L. (*Brunella vulgaris* L.) Heal-all Moist woods, waste places, etc. Native, or thoroughly naturalized. Calmar, Canoe creek.

Physostegia virginiana (L.) Benth. False Dragon-head. On alluvial banks, etc. (Fitzpatrick.)

Physostegia parviflora Nutt. (Not given in Gray.) In moist places. Not abundant. Ft. Atkinson.

Galeopsis tetrahit L. Hemp-nettle. Not rare. Calmar, Canoe creek.

Leonurus cardiaca L. Motherwort. Introduced weed, in waste places. Decorah (Savage), Canoe creek.

Stachys palustris L. Hedge Nettle. Wet places. Especially common on borders of prairie ponds or swamps.

Stachys aspera Michx. Rough Hedge-nettle. In wet places. (Fitzpatrick.)

Monarda scabra Bick. (*M. fistulosa var. mollis* Benth.) Pale Wild Bergamot. Prairies and borders. Common. Calmar.

Blephilia hirsuta (Pursh) Torr. In woods. (Fitzpatrick.)

Hedeoma hispida Pursh. Rough Pennyroyal. Dry grounds. (Fitzpatrick.)

Koellia flaxuosa (Walt.) MacM. (*Pycnanthemum linifolium* Pursh.) Narrow Leaved Mountain-mint. In thickets, along borders, etc. Hesper, Calmar.

Koellia virginiana (L.) MacM. (*Pycnanthemum lanceolatum* Pursh.) Dry borders and thickets. (Fitzpatrick.)

Lycopus virginicus L. Purple Bugle-weed. In wet places. Not rare. Hesper.

Lycopus americanus Muhl. (*L. sinuatus* Ell.) Water Hoarhound. In swamps and bogs. Common. Calmar, Hesper.

Mentha canadensis L. American Wild Mint. Common in wet places. Ft. Atkinson, Hesper.

Family 8. Solanaceæ.

Physalis philadelphica Lam. Ground-cherry. In rich soil. (Fitzpatrick.)

Physalis lanceolata Michx. Prairie Ground-cherry. Dry places. (Fitzpatrick.)

Physalis virginiana Mill. Virginia Ground-cherry. In open places, fields, etc. Common. Ft. Atkinson.

Family 9. Scrophulariaceæ.

Verbascum thapsus L. Mullein. Common introduced weed, in waste places. Decorah, etc.

Linaria linaria (L.) Karst. (*L. vulgaris* Mill.) Butter-and-eggs. Introduced, in waste places. Calmar.

Scrophularia marylandica L. (*S. nodosa var. marylandica* Gray, in part.) Maryland Figwort. In woods and thickets. Common. Decorah, etc.

Scrophularia leporella Bick. (*S. nodosa var. marylandica* Gray, in part.) Along borders and on prairies. Common. Decorah (Savage), Calmar, etc.

Chelone glabra L. Snake-head. In bogs near Hesper. Local.

Mimulus ringens L. Monkey-flower. Borders of streams, etc. Common. Decorah, etc.

Mimulus jamesii T. & G. Moist grounds. (Fitzpatrick.)

Gratiola virginiana L. Clammy Hedge-hyssop. In upland woods, according to Fitzpatrick.

Veronica anagallis-aquatica L. (*V. anagallis.*) Water Speedwell. Edges of streams and ponds. Not rare. Decorah.

Veronica peregrina L. Purslane Speedwell. A common weed, in fields, etc. Decorah (Goddard; Savage).

Veronica arvensis L. Corn Speedwell. An introduced weed. Hesper (Arthur).

Leptandra virginica (L.) Nutt. (*Veronica virginica* L.) Culver's Root. Moist prairies, thickets and borders. Locally common. Calmar.

Gerardia aspera Dougl. Rough Purple Gerardia. Rare, on dry ridges near Highlandville.

Gerardia purpurea L. Large Purple Gerardia. In moist places. Quite common. Ft. Atkinson.

Gerardia tenuifolia Vahl. Slender Gerardia. In dry woods. (Fitzpatrick.)

Castilleja coccinea (L.) Spreng. Painted-cup; Indian-pink. In open thickets, etc. (Fitzpatrick.)

Pedicularis lanceolata Michx. Swamp Lousewort. Locally common, in swamps. Decorah, Ft. Atkinson.

Pedicularis canadensis L. Common Lousewort. Dry ridges and prairies. Common. Hesper, Calmar.

Family 10. Lentibula iaceæ.

Utricularia vulgaris L. Greater Bladderwort. In ponds. Local. Ft. Atkinson.

Family 11. Phrymaceæ.

Phryma leptostachya L. Lopseed. Common in upland woods, and in thickets. Hesper, Calmar.

Order 6. Plataginales.

Family 1. Plantaginaceæ.

Mitchella repens L. Partridge-berry. Rare, in deep upland woods. Hesper.

Galium aparine L. Cleavers. Common, chiefly in moist places. Decorah (Goddard; Savage), etc.

Galium boreale L. Northern Bedstraw. Common on rocky slopes. Decorah, Calmar.

Galium concinnum T. & G. Shining Bedstraw. Not rare, in upland dry woods. Decorah.

Galium asprellum Michx. Rough Bedstraw. Common in moist places. Calmar, Canoe creek, Hesper.

Family 2. Caprifoliaceæ.

Sambucus canadensis L. American Elder. Common in alluvial soils. Observed at Decorah, Canoe creek, Bluffton, Kendallville and Hesper.

Sambucus pubens Michx. (*S. racemosa* L.) Red-berried Elder. Not common, on rocky banks. Decorah, Bluffton.

Viburnum opulus L. Cranberry-tree. Not common, on rocky slopes. Hesper, Decorah.

Viburnum pubescens (Ait.) Pursh. Downy-leaved Arrow-wood. On rocky slopes. Not common. Canoe creek.

Viburnum dentatum L. Arrow-wood. On moist banks. Not common. The specimens referred to this species may be a form of the preceding. Decorah.

Viburum lentago L. Sheep-berry; Black Haw. Common in alluvial soils and on lower slopes. Decorah (Savage), Canoe creek, Kendallville.

Triosteum perfoliatum L. Horse-Gentian. Reported by Fitzpatrick. Possibly an error. The writer was able to find only the following species.

Triosteum aurantiacum Bicknell. (*T. perfoliatum,* in part.) Red-fruited Horse-Gentian. Common in upland woods. Decorah, Bluffton, Ft. Atkinson.

Linnaea americana Forbes. (*L. borealis* L.) Twin-flower. In upland woods, not common. Decorah.

Symphoricarpos racemosus Michx. Snowberry. Not common. On rocky slopes. Kendallville.

Symphoricarpos occidentalis Hook. Wolfberry. Locally common in dry places. Ft. Atkinson, Hesper.

Lonicera dioica L. (*L. glauca* Hill.) Glaucous Honeysuckle. Common, on rocky slopes and banks. Decorah, Bluffton, Highlandville.

Lonicera sullivantii A. Gray. Sullivant's Honeysuckle. On wooded slopes and along borders. Not rare. Decorah, north fork of Bear creek.

Lonicera tatarica L. Tartarian Bush Honeysuckle. On rocky wooded slopes. Decorah (Fitzpatrick).

Family 3. Adoxaceæ.

Adoxa moschatellina L. Musk-root. Rocky woods. Rare. (Fitzpatrick.)

Order 8 Valerianales.

Family 1. Cucurbitaceæ.

Micrampelis lobata (Michx.) Greene. (*Echinocystis lobata* T. & G.) Wild Balsam Apple. Chiefly in low woods. Common. Decorah, Ft. Atkinson.

Family 2. Companulaceæ.

Campanula rotundifolia L. Arctic Harebell. Locally common on rocks and rocky slopes. Decorah.

Campanula aparinoides Pursh. Marsh Bellflower. In grassy swamps. Not common. Hesper.

Campanula americana L. Tall Bellflower. On moist wooded banks and slopes. Common. Hesper, Canoe creek, etc.

Specularia perfoliata (L.) A. DC. Venus' Looking Glass. On dry slopes, etc. (Fitzpatrick.)

Lobelia spicata Lam. Pale Spiked Lobelia. In dry open places. (Fitzpatrick.)

Lobelia leptostachys A. DC. Spiked Lobelia. In dry prairie. Not common. Calmar.

Lobelia inflata L. Indian Tobacco. Common in dry and waste places. Decorah (Goddard), Highlandville, Ft. Atkinson.

Family 3. Cichoriaceæ.

Cichorium intybus L. Chicory. A roadside weed, locally common. Decorah.

Adopogon virginicum (L.) Kuntze. (*Krigia amplexicaulis* Nutt.) Cynthia. Common in upland woods. Hesper, Decorah.

Taraxacum taraxacum (L.) Karst. (*T. officinale* Web.) Dandelion. A common introduced weed. Calmar, etc.

Sonchus asper (L.) All. Spiny Sow-thistle. A common introduced weed. Decorah, Hesper, etc.

Lactuca scariola L. Prickly Lettuce. An introduced weed, spreading rapidly. Calmar, Hesper.

Lactuca canadensis L. Wild Lettuce. On moist prairies, etc. Common. Calmar.

Hieracium canadense Michx. Canada Hawkweed. Common in dry woods, etc. Bluffton, Canoe creek.

Heiracium scabrum Michx. Rough Hawkweed. On rather open wooded slopes. Hesper, Ft. Atkinson.

Nabalus albus (L.) Hook. (*Prenanthes alba* L.) Rattlesnake-root. Common in rocky woods. Decorah, Hesper.

Nabalus racemosus (Michx.) DC. (*Prenanthes racemosa* Michx.) Glaucous White Lettuce. On moist prairies. Ft. Atkinson, Orleans Twp.

Family 4. Ambrosiaceæ,

Iva xanthiifolia (Fresen.) Nutt. Burweed; Marsh Elder. In moist prairie soils, becoming a common weed. Decorah, Ft. Atkinson.

Ambrosia trifida L. Great Ragweed. A common weed in low places, along roadsides, etc. Decorah, Hesper, Calmar, Ft. Atkinson.

Ambrosia trifida integrifolia (Muhl.) T. & G. Entire-leaved Ragweed. This variety is found in dry places. Decorah.

Ambrosia artemisiaefolia L. Ragweed. A common weed, along roads, in fields, etc. Hesper, Calmar etc.

Xanthium echinatum Murr. (*X. canadense* Mill., in part.) Cocklebur. In sandy soil. A common weed. Decorah.

Family 5. Compositæ.

Veronia fasciculata Michx. Western Iron-weed. A common weed in alluvial pastures, etc. Ft. Atkinson, etc.

Eupatorium maculatum L. (*E. purpureum* L., in part.) Spotted Joe-pye Weed. In moist places, rather common locally. Ft. Atkinson.

Eupatorium rydbergii Britt. (*E. purpureum* L., in part.) Rydberg's Joe-pye Weed. In moist soils. Not rare at Hesper.

Eupatorium altissimum L. Tall Boneset. In bogs, etc. Quite common. Ft. Atkinson.

Eupatorium ageratoides L. f. White Sanicle. In rich woods, common. Decorah, Highlandville.

Kuhnia glutinosa Ell. (*K. eupatorioides var. corymbulosa* T. & G.) Prairie False Boneset. In dry open places. Ft. Atkinson.

Lacinaria cylindracea (Michx.) Kuntze. (*Liatris cylindracea* Michx. and *Liatris graminifolia* Willd.) Cylindric Blazing Star. Rare, on dry prairies and ridges. Hesper, Highlandville.

Lacinaria pycnostachya (Michx.) Kuntze. (*Liatris pycnostachya* Michx.) Prairie Blazing Star. Common on moist prairies and in meadows. Ft. Atkinson.

Lacinaria scariosa (L.) Hill. (*Liatris scariosa* Willd.) Large Blazing Star. Common on drier prairies. Hesper, Ft. Atkinson, Calmar.

Solidago flexicaulis L. (*S. latifolia* L.) Zigzag Goldenrod. Common in rich woods. Decorah, Canoe creek, north fork of Bear creek, Hesper.

Solidago hispida Muhl. (*S. bicolor var. concolor* T. & G.) Hairy Goldenrod. In dry places. Hesper.

Solidago uliginosa Nutt. Bog Goldenrod. In bogs, not common. Kendallville.

Solidago speciosa Nutt. Showy Goldenrod. Common in upland woods, etc. Bluffton.

Solidago rigidiuscula (T. & G.) Porter. (*S. speciosca var. angustata* T. & G.) In dry open places. Not common. Decorah.

Solidago ulmifolia Muhl. Elm-leaved Goldenrod. Common in deep woods and thickets. Hesper, Decorah, Ft. Atkinson.

Solidago serotina Ait. Late Goldenrod. In moist grounds, common. Canoe creek, etc.

Solidago serotina gigantea (Ait.) A. Gray. Giant Goldenrod. In moist grounds. Not rare. Hesper, Decorah.

Solidago missouriensis Nutt. Missouri Goldenrod. Common on dry prairies. Hesper, Calmar, Ft. Atkinson.

Solidago canadensis L. Canada Goldenrod. In rather dry places, not rare. Canoe creek.

Solidago nemoralis Ait. Field Goldenrod. Common in dry places. Hesper, Decorah, Ft. Atkinson.

Solidago rigida L. Stiff Goldenrod. Common on dry prairies and ridges. Hesper, Moneek, Canoe creek, Decorah, Ft. Atkinson.

Euthamia graminifolia (L.) Nutt. (*Solidago lanceolata* L.) Bushy Goldenrod. In moist open places. Not rare. Moneek, Ft. Atkinson.

Euthamia caroliniana (L.) Greene. (*Solidago tennuifolia* Pursh.) Slender Fragrant Goldenrod. On dry prairies, etc. Hesper.

Aster azureus Lindl. Sky-blue Aster. On prairies, etc. (Fitzpatrick.)

Aster shortii Hook. Short's Aster. Borders of woods, etc. Not common. Decorah.

Aster drummondii Lindl. Drummond's Aster. In dry woods and thickets. Common. Decorah, Hesper.

Aster sagittifolius Willd. Arrow-leaved Aster. In dry woods, etc. Not common. Ft. Atkinson.

Aster novae-angliae L. New England Aster. Common on prairies, etc. Ft. Atkinson, Canoe creek. The form with rose-red flowers was also found at Canoe creek.

Aster puniceus L. Purple-stem Aster. Common in bogs. Decorah (Goddard), Hesper, Bluffton. Some of the Hesper specimens approach *var. lucidulus* A. Gray. The Bluffton specimens are almost smooth.

Aster prenanthoides Muhl. Crooked-stem Aster. Common along moist borders, etc. Decorah, Canoe creek.

Aster laevis L. Smooth Aster. Common on dry prairies, etc. Calmar, Decorah, Hesper.

Aster sericeus Vent. Silky Aster. On dry banks and slopes. Local. Sattre, Highlandville.

Aster ptarmicoides (Nees) T. & G. Upland White Aster. Rare, on rocky ridges. Highlandville.

Aster salicifolius Lam. Willow Aster. In moist open places. Common. Decorah (Goddard), Moneek, Ft. Atkinson.

Aster paniculatus Lam. Panicled Aster. In moist places. Canoe creek. Not rare.

Aster tradescanti L. Michaelmas Daisy. In moist and open places. Not rare. Hesper.

Aster lateriflorus (L.) Britt. (*A. diffusus* Ait.) Starved Aster. In open places, along borders, etc. Decorah.

Aster exiguus (Fernald) Ryd. (*A. multiflorus* Ait., in part.) Ciliate-leaved Aster. Common on dry prairies, etc. Decorah.

Erigeron pulchellus Michx. (*E. bellidifolius* Muhl.) Robin's Plantain. On dry slopes etc. (Fitzpatrick.)

Erigeron philadelphicus L. Philadelphia Fleabane. Common in woods and along borders. Ft Atkinson.

Erigeron annuus (L.) Pers. Daisy Fleabane. In fields and open places. Common. Decorah, Hesper, Calmar, Ft. Atkinson.

Erigeron ramosus (Walt.) B. S. P. (*E. strigosus* Muhl.) Daisy Fleabane. Very common in meadows and fields. A troublesome weed. (Fitzpatrick), etc.

Leptilon canadense. (L.) Britt. (*Erigeron canadensis* L.) Horse-weed. A very common weed in waste places and fields. Hesper, Calmar, Ft. Atkinson, etc.

Doellingeria umbellata (Mill.) Ness. (*Aster umbellatus* Mill.) Tall Flat-top White Aster. In moist prairie. Local. Orleans Twp.

Doellingeria humilis (Willd.) Britt. (*Aster umbellatus var. latifolius* Gray.) Broad-leaved Flat-top White Aster. In moist places, Hesper.

Antennaria plantaginifolia (L.) Rich. Plantain-leaf Everlasting. Common on dry ridges, etc. Decorah (Savage), etc.

Gnaphalium obtusifolium L. (*G. polycephalum* Michx.) White Balsam. In dry open places. Common. Hesper, Sattre, north fork of Bear creek.

Inula helenium L. Elecampane. Introduced. Not common, along roadsides. Canoe creek.

Polymnia uvedalia L. Yellow Leaf-cup. In rich soil. Not common. Calmar.

Polymnia canadensis L. Small-flowered Leaf-cup. Common on shaded rocky slopes at Decorah.

Silphium perfoliatum L. Cup-plant. Common in wet places. Ft. Atkinson.

Silphium laciniatum L. Compass-plant. Still common on prairies. Hesper, Calmar.

Parthenium integrifolium L. American Fever-few. In dry places. Not rare. Calmar.

Heliopsis scabra Dunal. Rough Ox-eye. Common on dry prairies, etc. Decorah, Calmar.

Rudbeckia triloba L. Thin-leaved Cone-flower. In thickets, etc. (Fitzpatrick.)

Rudbeckia hirta L. Black-eyed Susan. Common in rather dry open grounds. Calmar.

Rudbeckia laciniata L. Tall Cone-flower. Common on moist pastures, etc. Calmar.

Ratibida pinnata (Vent) Bernh. (*Lepachys pinnata* T. & G.) Gray-headed Cone-flower. Common on dry prairies. Calmar, etc.

Helianthus annuus L. Common Sunflower. Introduced, in waste places. Ft. Atkinson. etc.

Helianthus scaberrimus Ell. (*H. rigidus* Desf.) Stiff Sunflower. On dry prairies and ridges. Common. Calmar, Ft. Atkinson, etc.

Helianthus occidentalis Ryd. Few-leaved Sunflower. In dry open places. Common. Decorah (Goddard), Calmar, Ft. Atkinson.

Helianthus grosse-serratus Martens. Saw-tooth Sunflower. In moist open places. Common. Bluffton, Calmar.

Helianthus decapetalus L. Wild Sunflower. In moist shaded places. Not common. Decorah.

Helianthus strumosus macrophyllus (Willd.) Britt. (*H. strumosus var. mollis* T. & G.) Wood Sunflower. Common in open woods, etc. Decorah, Hesper, Ft. Atkinson.

Coreopsis palmata Nutt. Stiff Tickseed. On dry prairies and ridges. Common. Calmar, etc.

Bidens cernua L. Nodding Bur-marigold. Common in wet places. Ft. Atkinson, etc.

Bidens connata Muhl. Swamp Beggar-ticks. Reported by Fitzpatrick.

Bidens frondosa L. Spanish Needles. In moist soil, waste places, etc. Common. Decorah, Calmar.

Helenium autumnale L. Sneeze-weed. In moist places. A common weed in low pastures. Decorah, Hesper, Ft. Atkinson.

Achillea millefolium L. Yarrow. In dry open places. A common weed. Calmar, etc.

Anthemis cotula L. Mayweed; Dog-fennel. A common introduced weed. Decorah, Calmar, etc.

Chrysanthemum leucanthemum L. Ox-eye Daisy. An introduced weed, not yet abundant. Calmar.

Tanacetum vulgare L. Tansy. Escaped from gardens. Hesper, Highlandville.

Artemisia caudata Michx. Tall Wormwood. In dry open places. Quite common. Decorah, Ft. Atkinson.

Artemisia dracunculoides Pursh. Linear-leaved Wormwood. On dry ridges. Not common. Highlandville.

Artemisia biennis Willd. Biennial Wormwood. Moist banks. (Fitzpatrick.)

Artemisia serrata Nutt. Saw-leaf Mugwort. On prairies. Quite common. Calmar, Hesper.

Artemisia gnaphalodes Nutt. (*A. ludoviciana* Nutt., in part.) In dry soils. (Fitzpatrick.)

Erechtites hieracifolia (L.) Raf. Fire-weed. Common in waste places and clearings. Hesper, north fork of Bear creek.

Mesadenia reniformis (Muhl.) Raf. (*Cacalia reniformis* Muhl.) Great Indian Plantain. Quite common, in woods. Decorah, Bluffton, Canoe creek.

Mesadenia tuberosa (Nutt.) Britt. (*Cacalia tuberosa* Nutt.) Tuberous Indian Plantain. In moist places. Not common. Ft. Atkinson.

Mesadenia atriplicifolia (L.) Raf. (*Cacalia atriplicifolia* L.) Pale Indian Plantain. In rich soil. Rare. Calmar.

Synosma suaveolens (L.) Raf. (*Cacalia suaveolens* L.) In rich woods. Rare. Ft. Atkinson.

Senecio aureus L. Swamp Squaw-weed. In bogs. Not rare. Hesper.

Senecio balsamitae Muhl. (*S. aureus var. balsamitae* T. & G.) Balsam Groundsel. In dry places. Bluffton, etc.

Arctium lappa L. Great Burdock. Introduced weed. Calmar.

Arctium minus Schk. (*A. lappa var. minus* Gray.) Common Burdock. Common introduced weed. Decorah, etc.

Carduus lanceolatus L. (*Cnicus lanceolatus* Hoffm.) Common Field Thistle. Introduced weed. Common. Ft. Atkinson, etc.

Carduus altissimus L. (*Cnicus altissimus* Willd.) Tall Thistle. Common in thickets, etc. Canoe creek, Kendallville.

Carduus discolor (Muhl.) Nutt. (*Cnicus altissimus var. discolor* Gray.) Field Thistle. Common along borders, etc. Decorah, Ft. Atkinson.

Carduus iowensis Pammel. (*Cnicus altissimus* Willd., in part.) Iowa Thistle. Along borders and in thickets. Not common. Hesper.

Carduus hilli (Canby) Porter. (Not given in Gray.) Hill's Thistle. On rich prairies. Not common. Calmar.

Carduus muticus (Michx.) Pers. (*Cnicus muticus* Pursh.) Swamp Thistle. Common in bogs near Hesper.

Carduus arvensis (L.) Robs. (*Cnicus arvensis* Hoffm.) An introduced weed. Fortunately not common. Ft. Atkinson.

GEOLOGY OF CLAYTON COUNTY.

BY A. G. LEONARD.

Geology of Clayton County.

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CONTENTS.

INTRODUCTION.

LOCATION AND AREA.

Clayton county is in many respects one of the most interesting counties in the state. Situated as it is largely within the driftless area, its surface is deeply trenched by the streams and its scenery is diversified and picturesque. There are few more attractive scenes along the Mississippi than those to be observed from the bluffs bordering the great river along the eastern boundary of this county.

The many deep valleys afford numerous outcrops and excellent opportunities for the study of the various formations. Three geological systems are represented by the indurated rocks, the Cambrian, Ordovician and Silurian, while the deposits left by the Pleistocene ice sheets belong to three widely separated periods of time and are very different in character. The soils of the area yield bountiful crops, while clays and building stones of excellent quality are abundant.

Situated in the northeastern corner of the state Clayton county is separated from the Minnesota line by Allamakee, is bordered on the west by Fayette and on the south by Delaware and Dubuque counties, while the Mississippi river forms the eastern boundary. It has an area of approximately 780 square miles which is divided into twenty-two civil townships.

The earliest settlement in Iowa, next to that of Julien Dubuque, was made near the point where North McGregor is now located. In 1795 Basil Giard obtained from the Lieutenant Governor of Louisiana a grant to a tract of land in the northern part of Clayton county, known as the "Giard Tract" or "Spanish Claim." This is still represented on many of the maps of the county. It contained 5860 acres and was occupied several years. When Louisiana was acquired by the United States a patent was issued to Giard by the Government, which was the first legal title obtained by a white man to land within the limits of Iowa.*

*B F. Gue, Hist of Iowa, Vol. I, p 116. New York City, 1903.

PREVIOUS GEOLOGICAL WORK.

The earliest geological investigations in the region of which Clayton county forms a part were carried on under the direction of David Dale Owen. With a large number of assistants he made an examination of the mineral lands of Iowa, Illinois and Wisconsin in 1839, the survey extending as far north as the mouth of the Wisconsin river. The field work therefore covered the greater part of what is now Clayton county and represents the earliest study of the rocks of the area. The report* embracing the results of the autumn's work was published in preliminary form without maps and illustrations in 1840 and later, in 1844, a revised edition appeared. In this report there appear detailed observations on the various townships, with brief descriptions of the timber, nature of the soils and kinds of rocks and minerals. Ten years later the region was again visited by Owen and his assistants and in his report of 1852 he describes briefly some of the geological formations occurring in the area under discussion, but there is no reference to localities in Clayton county.†

In 1855 James Hall, then State Geologist of Iowa, made a geological reconnoissance along the Mississippi river, for the purpose of studying the formations so well exposed near that stream. His report,‡ published three years later, contains references to various localities in the county and to the character of the rocks. Sections are given of the Trenton beds at Pikes Peak, opposite the mouth of the Wisconsin river, at the town of Clayton and at Guttenberg, as well as of the Galena strata at Elkader. Mention is also made of the Potsdam (Saint Croix), Calciferous limestone (Lower Magnesian) and Saint Peter sandstone occurring in the bluffs along the river.

J. D. Whitney§ has a brief account of some of the geological formations of Clayton county in the same volume, and in his discussion of the economic geology of the state refers to the occurrence of lead in the vicinity of Buena Vista and Guttenberg.

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*House Rep. Exc. Doc., 26th Cong , 1st. Sess., No. 239, 161 pp. Washington, 1840
†Rept of a Geol. Surv. of Wis., Iowa and Minn., pp. 48-76. Philadelphia, 1852.
‡James Hall: Report on the Geol. Surv. of Iowa, Vol. I, Pt 1, pp. 47-65, 1858.
§*Ibid.* pp. 297-302 and pp. 458, 459.

In the report of C. A. White on the Geology of Iowa there are a few scattered references to Clayton county in the chapters on general geology.*

Clayton county lies for the most part within the driftless area which has been described by Chamberlin and Salisbury.† It also forms part of the region discussed by W. J. McGee in his Pleistocene History of Northeastern Iowa.‡ The latter paper mentions certain topographic features of the area and gives several sections of the older drift.

The present writer visited in 1894 the different localities in the southern part of the county where lead has been mined and describes these briefly in his report on the lead and zinc deposits of the state.§

PHYSIOGRAPHY.

TOPOGRAPHY.

The greater portion of Clayton county is included within the limits of the driftless area, and its surface has not been affected by the ice sheets which modified so profoundly the topography of the entire state with the exception of this northeastern corner. Elsewhere the ice tended to level up the rough preglacial surface by wearing down the ridges and divides and filling the valleys with drift. But as it moved down from the north the ice sheet failed to override this area in northeastern Iowa and contiguous parts of Wisconsin and Illinois, and the surface was left as it had been sculptured by weathering and erosion.

Two very different kinds of topography are exhibited in the county. In the driftless area the surface features are the result of erosion acting on nearly horizontal strata of varying degrees of hardness. On the other hand the Iowan drift area in the southwestern corner has undergone very little erosion and the topography is constructional instead of erosional. The flat or gently rolling, bowlder strewn drift plain presents a sharp contrast to the deeply dissected driftless area with its steep-sided valleys and high intervening ridges.

*Rept. on the Geol. Surv. of Iowa, by C. A. White, Vol I, p. 167, 1870
†Sixth Ann. Rept., U. S. Geol. Surv., pp 199-322.
‡Eleventh Ann. Rept., U S G. S., Pt. 1, pp. 189-577.
§Iowa Geol. Surv., Vol VI, pp 51-53

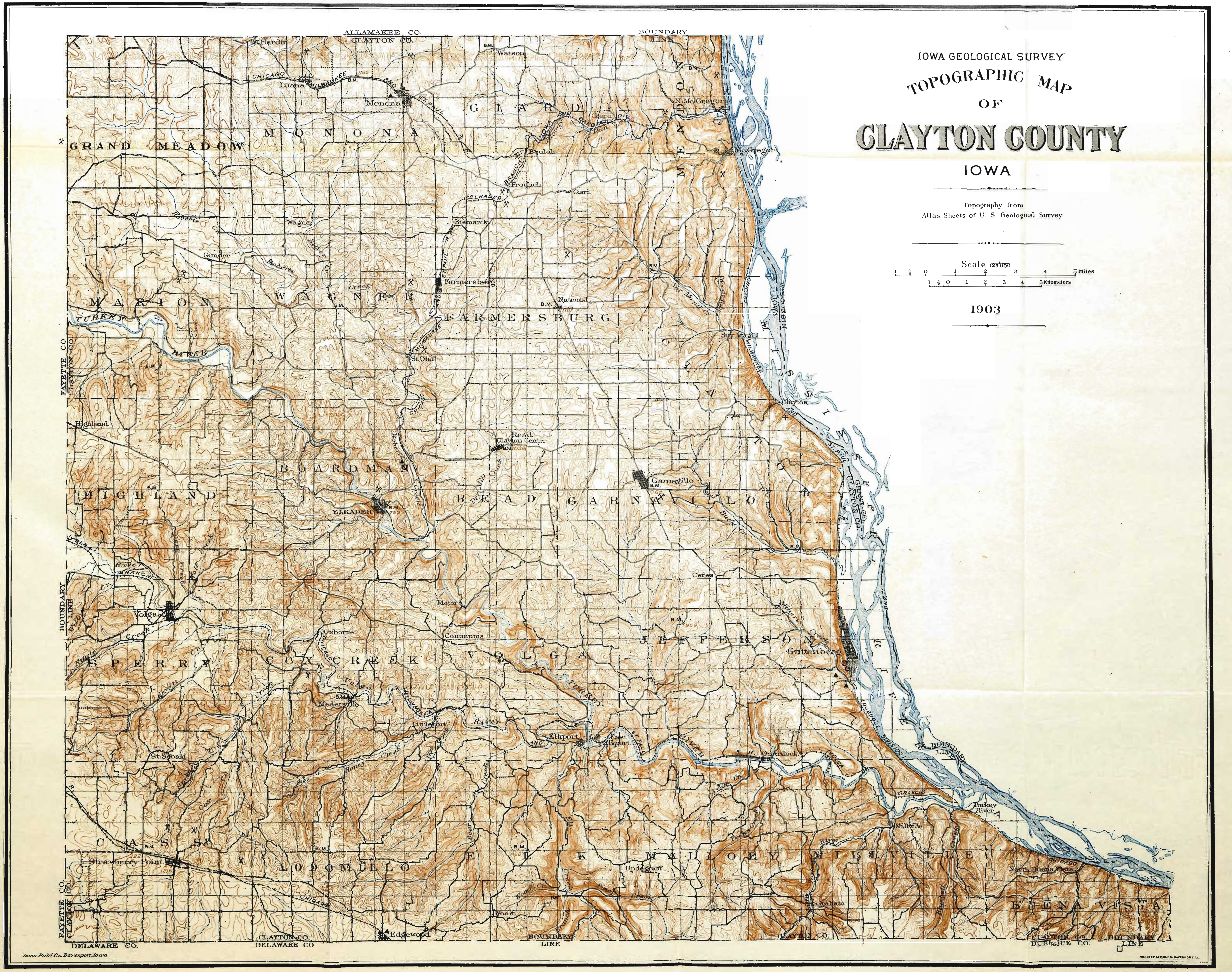
THE DRIFTLESS AREA.

In this discussion the area covered by the Kansan drift is included with the driftless portion since that drift is in this region too thin to affect materially the surface features. From a study of the latter alone it would be difficult to discriminate between the driftless and the Kansan areas and hence they are naturally considered together.

The most prominent topographic feature of the region is the broad, bluff-lined valley of the Mississippi, while of only less importance are the deep trenches cut by the Turkey and Volga rivers. These valleys and their chief tributaries are sunk from 500 to 600 feet below the general level of the upland, the latter having an elevation of from 1100 to 1200, or 1250 feet above the sea. The difference in elevation between the bottom of the Mississippi valley just below Buena Vista, and the upland eight miles west, between Bluebell creek and Little Turkey river, is nearly 650 feet, or more than one-half as much as the relief of the entire state.

Another conspicuous feature in the topography of the county is the high ridge between the Turkey and Volga rivers. The road from West Union to Elkader follows this ridge, which extends southeast from Highland, near the Fayette county line, to within two miles of Communia. The road leading from Osborn on the Volga river, to Elkader on the Turkey, climbs 450 feet in crossing this divide between the two streams. From its summit one has a wide outlook for many miles in all directions, the view extending to the hills on the farther side of the broad depressions made by the above rivers.

North and east of the Turkey river, between that stream and the Mississippi, the surface is mostly upland. In the vicinity of the rivers this has been deeply eroded, and narrow gorge-like valleys have been carved in it. But away from the larger streams the upland is gently rolling. It may be seen from the railroad between Postville and Monona, and upon it are located the towns of National and Garnavillo. The surface is made up of a series of gentle curves convex toward the sky and with a gradual slope toward the drainage lines. The convex curves are the units of which the general surface is composed. There is scarcely an


IOWA GEOLOGICAL SURVEY
TOPOGRAPHIC MAP
OF
CLAYTON COUNTY
IOWA
Topography from
Atlas Sheets of U. S. Geological Survey
Scale 1/125,000
5 Miles
5 Kilometers
1903
ALLAMAKEE CO.
CLAYTON CO.
BOUNDARY LINE
GRAND MEADOW
MONONA
GIARD
MENDON
MARION
WAGNER
FARMERSBURG
BOARDMAN
HIGHLAND
READ
GARNAVILLO
CLAYTON
SPERRY
COX CREEK
VOLGA
JEFFERSON
CASS
LODOMILLO
ELK
MALLORY
MILLVILLE
BUENA VISTA
Monona
Luana
Watson
N. McGregor
McGregor
Beulah
Froelich
Giard
Bismarck
Wagner
Gunder
Farmersburg
National
St. Olaf
Read
Clayton Center
Garnavillo
Elkader
Highland
Volga
Osborne
Communia
Motor
Ceres
Guttenberg
Mederville
Elkport
East Elkport
Millville
Turkey River
St. Sebald
Strawberry Point
Edgewood
Wood
Osterdock
Updegraff
Graham
North Buena Vista
FAYETTE CO.
CLAYTON CO.
DELAWARE CO.
DUBUQUE CO.
Iowa Publ. Co. Davenport, Iowa

acre of perfectly flat land, but the gentle slopes lead down to the drainage channels which ramify to all parts of the surface. The streams divide, subdivide and divide again until they have modified by their erosion the entire area.

At several points flat-topped hills rise above the general level of the upland. These are outliers of Niagara limestone which have been left by the erosion of the surrounding strata. One of the most prominent of these hills of circumdenudation is one mile southwest of Gunder, in Marion township. It rises fifty to sixty-five feet above the adjacent region. Another is located four miles south of Postville on the western edge of Grand Meadow township and extends into Fayette county.

South of the Volga and Turkey rivers the country is very rough and much cut up by the many streams joining these rivers from that direction. The Niagara escarpment, produced by the outcropping edges of the beds of this formation, here forms a conspicuous topographic feature. It has been deeply incised by the numerous streams which have cut their valleys far back into the Niagara, making its line of outcrop a very sinuous one winding back and forth along the sides of the valleys and extending out in the ridges and divides between these. At the escarpment the surface rises abruptly from 100 to 200 feet. The precipitous slope is commonly wooded and covered by huge masses and blocks of limestone broken off from above. The roads often follow along near the base, and where they climb to the top they are steep and rocky.

The valley of the Mississippi has been mentioned as forming the most prominent topographic feature of the region. It has a width from bluff to bluff of from one and a quarter to three miles and the river flows now on one side, now on the other.

The preglacial valley was considerably deeper than the present one as shown by the record of the deep well at Prairie du Chien. In drilling this well 147 feet of sand and gravel were penetrated before striking the bed rock, showing that the river during glacial times filled its old valley to this depth with sediment.

The town of Guttenberg is situated on the flood plain and extends for more than two miles between river and bluff. One of the common features of flood plains is well exhibited here, namely, the outward slope away from the river. During times of flood the deposition of sediment goes on most rapidly next the channel where the current is first checked, and therefore that portion of the plain is built up more than the remainder. The town is located largely on the higher part of the plain next the river and between it and the side of the valley the land is four or five feet lower. When there is high water this depression is overflowed to a depth of several feet. Where the Wisconsin river enters the valley of the Mississippi it has formed an extensive deposit of sand and has forced the main channel over against the Iowa shore. When the water is low large sand bars appear at this point.

The bluffs rise abruptly from the flood plain to a height of from 300 to 400 feet and then the surface has a gradual ascent to 600 feet and more above the river. On the Iowa side these slopes are for the most part heavily wooded, but on the Wisconsin side they are largely bare of timber, and the ledges of the indurated rocks are exposed. For some distance above and below McGregor the Oneota limestone is seen forming perpendicular cliffs, at the base of which the Saint Croix sandstone appears. In the vicinity of Clayton the Saint Peter sandstone outcrops toward the base of the slope and above it are cliffs of Galena-Trenton, or Galena-Platteville, limestone. This limestone composes the entire height of the bluffs at Guttenberg and also forms cliffs at many points between here and Buena Vista.

These rocky cliffs, fifty to one hundred feet high, with their talus slopes at the base, form a striking feature of the valley. Except where the strata outcrop to form perpendicular walls, the sides are covered with a heavy growth of timber, shrubs, ferns and other plants. One of the highest points along the river is Pikes Peak, two miles south of McGregor, opposite the mouth of the Wisconsin. It rises 450 feet above the water and standing on its grassy summit one looks out upon a marvelous picture. The broad valley of the Mississippi lies spread out beneath bordered by its picturesque bluffs. On the more distant Wisconsin shore the smooth slopes are verdure clad, except where cliffs stand out like giant walls of masonry against the green background. Those nearer by are heavily wooded and only occasionally do the towers, pinnacles and crags of gray rock appear amidst the trees. The luxuriant vegetation of the river is a vivid green, with darker stripes of the same color formed by the fringes of timber along the edges of the water channels. Threads of blue intersect the level plain in a network of water courses which in places widen out into broad lakes and lagoons. Variety is added to the scene by an occasional river steamer pushing before it a huge lumber raft, or a scow heavily loaded with clam shells for the button factories farther down the river. The boats of the clammers dotting the surface of the stream appear as specks in the distance. Just opposite, the Wisconsin empties its waters into the Mississippi and brings down the sediment forming the sand bars which extend far out into the river. One can look for miles up the wooded valley of the minor stream bordered on the south by high, steep bluffs and on the north by low hills. Above the confluence and on the opposite side of the valley stretches the broad flat plain upon which is located the historic old town of Prairie du Chien. To the south of the town the land is divided into rectangular, cultivated fields, each a different shade of color and giving the plain the appearance of a huge checker board.

In striking contrast to the widely extended view obtained from Pikes Peak is the wooded glen known as "Pictured Rocks" which is reached by a winding and precipitous path following along the north slope. Clambering down through a tangle of ferns and wild flowers one reaches the bed of a small stream just below where it tumbles twenty feet over a lichen-covered ledge. The steep walls dotted with mosses, harebells and rock ferns, rise to such a height as to exclude all save the noonday sun and bury the gorge in fragrant coolness. The glen has been carved in the Saint Peter sandstone, which here has the exceptional thickness of 100 feet. The bright and varied colors of this rock add beauty and interest to the place. Numerous tints of red, yellow and gray shading into white prevail, arranged in bands or irregular patches.

At the mouth of Turkey river erosion has left a long, narrow, steep-sided ridge between the valleys of that stream and the

Mississippi. It extends for nearly three-quarters of a mile with its summit scarcely wide enough to afford space for a foot path, and on either side are perpendicular cliffs of Galena limestone from 100 to 200 feet high. Here and there are picturesque pinnacles, towers and battlements of the same rock, which has weathered into countless fantastic forms. The end of this ridge is shown in Plate V. The rocky and uneven summit is well seen from Millville station, two miles above the mouth of the Turkey river. A similar narrow ridge is found just below Guttenberg, at the mouth of Miners creek (Fig. 19). In both cases these

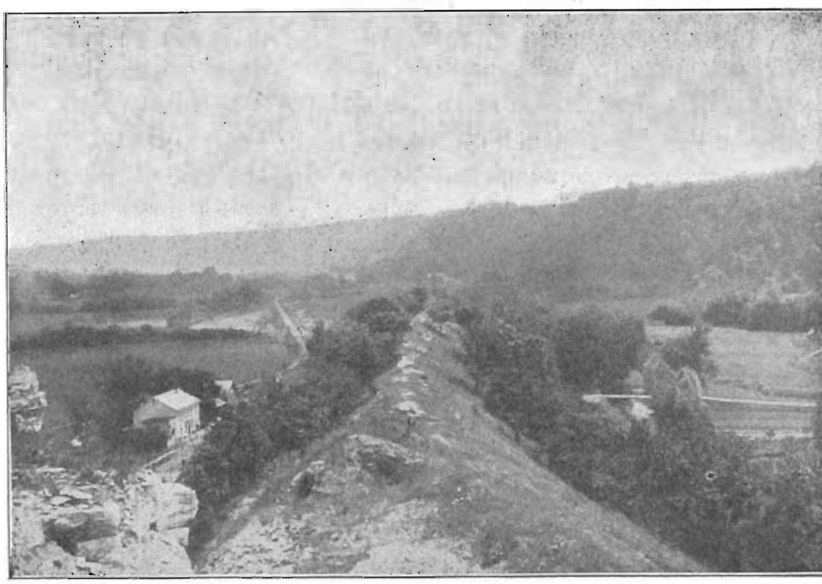


Fig. 19.—Ridge between Mississippi and Miner creek, Guttenberg.

sharp ridges are caused by the minor valley joining that of the Mississippi at an acute angle.

The valleys of the Turkey and Volga rivers are conspicuous features in the topography of the county. They have been cut to a depth of 400 or 500 feet, and in places the flood plain is more than one-half mile wide. Cliffs of Galena limestone outcrop along the sides at numerous points, with here and there isolated turrets or towering castle-like forms. These are well shown at Motor, on the Turkey river, and at Mederville, Littleport, Elkport and elsewhere on the Volga. Throughout most of their extent the valleys have been eroded chiefly in Galena-Platteville beds, but toward the western border of the county the Maquoketa shale outcrops in the bottom of the stream-cut trenches. Where they have been cut in the soft shales of the Maquoketa there is a very noticeable broadening out of the valleys. This is best seen in the case of the Volga river, which, from a mile or more below the town of Volga to the Fayette county line, flows through a broad valley with gently sloping sides rising gradually to the Niagara cliffs one or two miles back from the river. At Mederville on the other hand the river flows in a narrow rock-walled gorge which is little wider than the channel itself. In this portion of its course the sides rise abruptly eighty or one hundred feet to the top of the Galena beds, whence there is a more gradual slope to the Niagara escarpment. But when the Maquoketa shales are reached in the vicinity of Volga, where the Galena-Platteville is below river level, these soft and easily eroded shales have enabled the stream to cut a much broader valley with gently sloping sides. The weathering of the shale is comparatively rapid and results in a widening of the gorge.

The marked difference in the character of the valley at Mederville or Littleport and Volga is therefore due wholly to the difference in the nature of the rock in which it has been carved. The same peculiarity is found in the valley of the Turkey river near the western border of the county, though the Maquoketa beds are not as shaly along that stream, and hence the change in the topography is less marked.

The valley of Bloody Run, at the mouth of which is located the town of North McGregor, though little more than ten miles long, forms a steep sided gorge 300 to 400 feet in depth, which is followed by the Chicago, Milwaukee and St. Paul railway in passing from the flood plain of the Mississippi to the upland 600 feet above. Toward the lower end of the valley the Oneota limestone forms picturesque, gray cliffs rising precipitously along the sides while farther up, deeply weathered crags and towers of Galena dolomite appear. In an expansion at its mouth, and within the limits of the town of North McGregor, a hill of circumdenudation rises 110 feet above low water in the Mississippi and forty-five feet above the terrace of silt which partially encircles the knoll. The latter is composed, in part at least, of Oneota limestone which has been quarried on a small scale near the summit. At the time the terrace was being built the hill must have formed a rocky island about which the deposit of stratified silt accumulated in the quiet water near the shore. Similar hills of circumdenudation are not uncommon throughout the county, being found in the vicinity of Volga, Elkader, Motor and elsewhere. The Stoops quarry, at Elkader, is located near the top

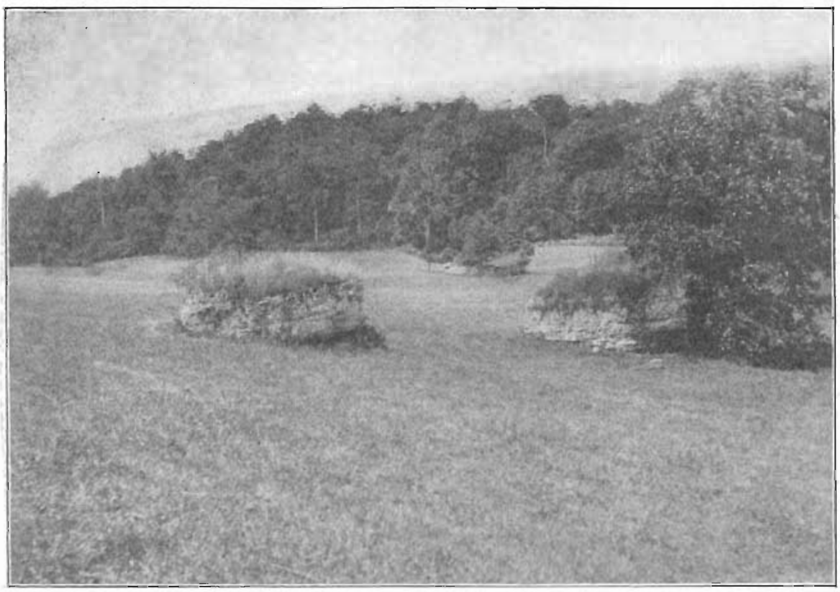


Fig. 20 Blocks of Niagara limestone which have slipped down the Maquoketa slope Elk creek valley, section 23, Elk township.

of such a hill which has been left between two valleys entering that of the Turkey within a short distance of each other. One of these is no longer occupied by a stream and is partially filled by river deposits and materials from the hillsides.

Little Turkey river and Elk creek have cut narrow, steep sided gorges far back into the Niagara escarpment to a depth of 300 to 400 feet. In the valley of Elk creek the difference in the topography of the Maquoketa shales and Niagara dolomite is especially well shown, though it is seen at numerous other points south of the Volga, and also between that stream and the Turkey river. Four or five miles south of Elkport the shales occur in the bottom of the valley and rise some distance above until the heavy overlying limestone ledges are reached. Below, in the Maquoketa beds, the slopes are gentle, rounded, and occupied by cultivated fields and meadows. The Niagara, on the other hand, forms cliffs and abrupt slopes which are too steep and rocky for cultivation and are almost always heavily wooded.

Fig. 21.—Maquoketa slope leading up to Niagara escarpment, section 13, Sperry township.

Great masses of limestone (Fig. 20) have been broken off by undermining, by frost or other destructive processes and agencies, and have slipped down the smooth clay slopes of the Maquoketa until they are often found far away from the parent ledges. These huge limestone blocks, some of them as large as the ordinary country school house, are very characteristic of the Maquoketa slopes. They are frequently found in large numbers near the base of the Niagara escarpment, the masses being tilted at all angles, though sometimes the original horizontal position of the beds has been maintained, even where the blocks have traveled long distances.

The roads often follow close to the base of the rocky, wooded and precipitous slopes of the Niagara escarpment, thus affording a broad outlook over the gently rolling Maquoketa surface with its fields, meadows and orchards.

Other localities where these topographic features are well shown are in section 13 of Sperry township, section 29 of Highland and in parts of Cox creek, Elk, Mallory and Millville townships. They are seen also in the vicinity of Volga, where the gently rounded slopes of the broad river valley are in the soft and easily eroded shales, while farther back the massive, heavy ledges of Niagara dolomite outcrop toward the summit of the hills.

From the foregoing it is evident, as previously stated, that the topography of the driftless portions of the county is the result of the action of erosion and weathering on nearly horizontal strata of varying degrees of hardness. The influence of the character of the rocks upon the results produced is well exhibited by the land forms occurring in the areas of the Galena-Platteville, Maquoketa and Niagara respectively. The cliffs, towers, crags and other fantastic forms assumed by the first named of these formations are seen in the bluffs of the Mississippi from Clayton to Buena Vista and below; along the Turkey and Volga rivers throughout their courses to within four or five miles of the western border of the county; along Buck and Miners creeks and many of the minor streams of the area. Where the Maquoketa is composed chiefly of clay shales, as in the neighborhood of Volga and south of the river of the same name, it is a region of low, gently rounded slopes which rise gradually from the Galena-Platteville beds to the Niagara cliffs. The sinuous outcrop of the latter, marked by abrupt, rocky slopes, produces the conspicuous escarpment which is such a marked topographic feature south of the Volga and Turkey rivers. It also caps the high ridge between those streams and forms the prominent hill near Gunder. The Niagara formerly covered a much larger area than at present and probably extended over the greater portion, if not all of the county, but it has been very much affected by erosion. The Highland ridge was once continuous with the main mass of the Niagara south of the river, as were also the Gunder and other outliers, but the Turkey and Volga rivers have cut their valleys through the formation and left widely separated remnants. The escarpment is not stationary, but is constantly being pushed back through weathering and stream erosion.

The uplands and ridges represent an old peneplain in which the existing valleys have been cut. This was probably formed toward the end of the Cretaceous or possibly during Tertiary times. The former land surface was worn down by the streams into a comparatively level plain with only a few minor inequalities remaining. The streams had cut down to base level and flowed in broad, wide bottomed valleys with low and very gently sloping sides and flattened intervening divides. Later this old peneplain was elevated 600 or 700 feet, and the rivers began cutting their present valleys. These have reached a new base level, and their flood plains represent the beginning of a second peneplain which will be completed in the course of time if there is no elevation or depression before the cycle is brought to an end.

IOWAN DRIFT AREA.

The Iowan drift area occupies portions of Cass and Lodomillo townships in the southwestern corner of the county. The topography is here in marked contrast with that of the remainder of the area since it is constructional and produced by the accumulation of drift instead of being the result of erosion. The border of the Iowan drift is followed in a general way by the Chicago, Milwaukee and Saint Paul railroad, though northwest of Strawberry Point the boundary lies from one to two miles north of that road. Strawberry Point is located very near the edge of the drift sheet, and Edgewood lies one mile south, while the wagon road between these two towns follows the border closely the entire distance.

Throughout most of its course in this county, as well as elsewhere in the state, the Iowan border is marked by a ridge or a series of ridges and hills of drift and loess rising fifty to sixty feet above the drift plain. For a distance of one mile east of Strawberry Point there is a single ridge, and it is upon this that the cemetery is located. Farther east the drift has been heaped up into irregular hills forming a belt about one-half mile in width. From some point of vantage on top of this ridge, as near the school house one mile east of town, or at the crossroads in the southwest quarter of section 27, or in the southeast quarter of section 28 of Lodomillo township, one may compare the drift plain on the inside with the driftless area outside the border. The surface of the Iowan plain is flat and poorly drained, with shallow depressions or swales and low, rounded elevations (Fig. 22). Scattered over it are numerous large, coarse-grained granite bowlders, many of which, however, have been gathered

Fig. 22—The Iowan drift plain near Strawberry Point.

from the fields and used in the construction of stone fences. The loess which mantles the surface elsewhere in the county is absent from this area and the soil is a rich black color.

Turning to the north and looking in the opposite direction the country exhibits a topography of an entirely different kind. Here the land is rough and cut by the streams into deep valleys and steep sided ridges, until little flat surface remains. The roads, instead of being straight, and laid out along the section lines, follow either the divides between the streams or the bottoms of the valleys. A thick mantle of loess covers the bed rock and there is almost an entire absence of large bowlders. On this side are the erosional features of the driftless area, on the other the level drift plain, but slightly modified by erosion and resulting from the accumulation and heaping up of materials by the ice sheet. The streams have cut only shallow channels in the Iowan drift plain. The valley formed by the headwaters of the Maquoketa, for instance, has a depth of little more than sixty feet and is bordered by cliffs of Niagara limestone, the drift being thin in many places along the sides.

These two types of topography are so strikingly different as to attract the notice of even a casual observer, though he may not stop to inquire the cause. At many points along the border and just inside the ridge or belt of hills marking the boundary there is a low, swampy and poorly drained area. Such a swale may be seen at Edgewood, between the town and the bordering ridge lying to the north. Northwest of Strawberry Point the edge of the Iowan drift is not marked by a ridge of hills and is less easily traced since it has been modified by erosion of the streams flowing northeast into the Volga.

DRAINAGE.

The Turkey and its tributaries drain over three-quarters of the county; less than one-fifth of the area is drained by small streams flowing directly into the Mississippi; portions of Cass and Lodomillo townships are tributary to the Maquoketa, and a small strip along the northern border drains north into the Yellow river.

The Mississippi forms the eastern boundary and has influenced the drainage of the entire region. This major stream by cutting its valley to a depth of more than 600 feet has established a base level which controls the depth to which its tributaries have been able to cut their channels. Beginning at the north the following streams empty into the Mississippi: Bloody Run, Sny Magill creek, Buck creek, Miners creek and Turkey river. All of these flow in a southeasterly direction except the first named which has a course nearly due east. Bloody Run rises on the upland near Monona and has a fall of about 550 feet before reaching its mouth, eleven miles distant.

The Turkey river enters the county nine miles from the northern border and crosses it in a general southeasterly direction to its confluence with the Mississippi not far from the southern boundary. The descent from the west county line to the mouth is 180 feet, or 3.6 feet per mile. The Volga after entering Clayton county has an average fall of almost six feet to the mile above its junction with the Turkey at Elkport. The chief tributary of the latter stream is Robert creek, which has its source in the northwestern corner of the area, near Postville, and with a very winding course flows first southeast and then almost due south until it joins the Turkey river a few miles below Elkader. Robert creek and its different branches, including Dry Mill creek and the other large tributary entering the Turkey from the north (Cedar creek) afford excellent examples of dendritic drainage systems. Their secondary and tertiary branches spread out in all directions like the limbs of a tree until they dissect and drain a large territory. Other streams of the area exhibit the same dendritic character, though perhaps not so perfectly and symmetrically. The principal tributaries of the Turkey river from the south are Elk creek, Little Turkey river and Bluebell creek, the head waters of all three being across the line in Dubuque and Delaware counties. The first named flows almost due north, the other two northeast.

The Volga also receives a number of important streams from the south, including Bear, Honey, Cox, Hewett and Nagle creeks, all of which have northeasterly courses. Their sources are close to the border of the Iowan drift plain, upon which they are slowly encroaching by the headward erosion of the streams. This process results in the extension of the valleys in that direction, and the divide is gradually being shifted to the south and west, since the streams flowing into the Volga have a greater fall and swifter current than those entering the Maquoketa. They are therefore enabled to erode more rapidly and are taking possession of the territory now draining south into the Maquoketa river. Hewitt and Spring creeks, the latter a branch of Cox creek, have already extended their valleys some distance into the Iowan drift, the one near the west line of the county, the other just north of Strawberry Point. Between the last mentioned town and Edgewood the ridged border of the Iowan drift forms the divide separating the headwaters of the streams tributary to the Volga and those emptying into the Maquoketa. Three of the creeks, Bear, Honey and Cox, though they enter the major stream at points three to seven miles apart have their sources within a mile of each other in sections 21 and 22 of Lodomillo township.

STRATIGRAPHY.

GENERAL RELATIONS OF THE STRATA.

So far as known there is but one other county in Iowa, Winneshiek, which has so many geological formations as Clayton. There are no less than seven represented by the indurated rocks, and in addition to these, two drift sheets cover portions of the area, while other deposits dependent upon the ice invasion also occur. Then too the conditions are very favorable for the study of the strata of different ages. The deep valleys cut by the streams afford numerous outcrops in all parts of the county and the absence of drift over a large portion of the district adds to the number of rock exposures. Many of these afford vertical sections 300 to 400 feet thick and include beds belonging to several different formations.

No one of the twenty-two townships is without its outcrops, frequently continuous for long distances, and bringing to view the character of the various beds. The oldest strata, the Saint Croix, Oneota and Saint Peter are confined to the northeastern corner of the area, the two last named extending as far south as Guttenberg in the valley of the Mississippi. The Trenton, using the term in the sense in which it is used in the Dubuque county report, Vol. X, is confined almost wholly to the stream valleys and the same is largely true for the Galena, though this dolomite also forms the bed rock over several of the northwestern townships. The Maquoketa has a wide distribution and with the Niagara covers by far the greater part of the area. With the exception of several outliers the Niagara is confined to the region south of the Turkey river, while the Maquoketa shales are found not only south of that stream but occupying a belt from six to ten miles wide north and east of the Turkey river.

In going up the valley of Bloody Run from its mouth to the station of Beulah one sees almost a continuous section extending from the Saint Croix sandstone at North McGregor through the Oneota, exposed in the numerous railroad cuts and in the cliffs, Saint Peter sandstone, Trenton and Galena limestones. The same succession of formations is found along the sides of the ravines in which is located the town of McGregor.

Though the Kansan drift is exposed at a number of widely separated points and covers considerable areas in the county it is so thin as to modify but slightly the preglacial topography. The Iowan drift is confined to the southwestern corner, where it exhibits all the characteristics which distinguish it in other parts of the state.

The following synoptical table shows the relations of the various formations:

GROUP	SYSTEM	SERIES	STAGE
Cenozoic	Quaternary	Recent	Alluvium
		Pleistocene	Wisconsin-terrace
			Loess
			Iowan drift
			Buchanan gravels
			Kansan drift
			Residual products
Paleozoic	Silurian	Niagara	Hopkinton
	Ordovician	Trenton	Maquoketa
			Galena
			Trenton
		Canadian	Saint Peter
			Lower magnesian
	Cambrian	Potsdam (Saratogan)	Saint Croix

In this table "Hopkinton" has been substituted for the term "Delaware" of the earlier reports, to designate the phase of the Niagara limestone which makes up the great basal member of the formation below the Le Claire and Anamosa phases seen in Jones, Cedar and Scott counties, Iowa. The name "Delaware" was preoccupied, having been used by Orton in 1878 for a portion of the Devonian system of Ohio. The terms "Galena" and "Trenton" in the table, and, later in the text, the compound "Galena-Trenton", are used as they were employed by Calvin and Bain in the report on Dubuque county. The recent suggestion of Bain (U. S. Geol. Surv., Bulletin No. 256: *The Zinc and Lead Deposits of Northwestern Illinois*) to divide the "Galena-Trenton" stratigraphically is to be commended. If the suggestion is followed, all above the "Green Shales" of the Minnesota geologists will be called "Galena" regardless of lithological characters, while the "Green Shales" and underlying limestones will, together, be known as the "Platteville". In the earlier reports of this Survey the term "Oneota" was used as the exact equivalent of Owen's "Lower Magnesian Limestone". McGee, however, as indicated in the following Comparative Table, proposed "Oneota" for the lower member only of Owen's "Lower Magnesian", and the terms "New Richmond" and "Shakopee" have been accepted more or less generally for the upper members. It seems to some advisable to restore "Oneota" to the body of limestone for which McGee proposed it, in which case the three distinct units making up the formation covered by Owen's name will be designated by convenient terms, definite and precise. For the present the original term "Lower Magnesian" may be retained for the formation represented by the three units combined, until some more acceptable term has been proposed.

COMPARATIVE TABLE OF GEOLOGICAL FORMATIONS.

MINNESOTA	MINNESOTA	WISCONSIN	IOWA	IOWA (*Previous Reports*)
N. H. Winchell	Hall & Sardeson		McGee	Geological Survey
St. Peter	St. Peter	St. Peter		St. Peter
Shakopee limestone	[Magnesian series] Shakopee	[Lower Magnesian Limestone] Willow River	St. Peter	
New Richmond sandstone	New Richmond	New Richmond		Oneota limestone
Main Body of Limestone	Oneota	Main body of Limestone	Oneota	
[St. Croix] Jordan sandstone	Jordan	[Potsdam] Madison sandstone		[Saint Croix] Jordan
St. Lawrence limestone	St Lawrence	Mendota limestone		St. Lawrence
Shales		Calciferous sandstone	Potsdam Sandstone	
Dresbach sandstone		Shale		Basal Sandstone
Shales	Potsdam	Sandstone		
Hinkley sandstone				

CAMBRIAN SYSTEM.

SAINT CROIX SANDSTONE.

The Saint Croix sandstone is the oldest rock found in Clayton county and with one exception is the oldest in the state. It belongs to the Potsdam series, which is the upper or younger division of the Cambrian. The formation has been called the Saint Croix sandstone by N. H. Winchell.

The rock as exposed in Clayton county is a medium coarse-grained, massive sandstone often showing cross-bedding and of a prevailing yellow or buff color, though white, light gray, brown, chocolate, green and other shades are seen. When examined closely it is seen to be composed of clear, transparent, rounded grains of quartz with very little cementing material between them. The rock is thus for the most part a very pure sandstone with only small amounts of calcareous or ferruginous material. In places it forms a soft, incoherent bed of sand which can be removed with a shovel; in other places the grains are cemented together to form hard beds. The rock weathers irregularly, the softer layers wearing away more rapidly and leaving the harder portions projecting. Only the upper eighty feet of the Saint Croix are exposed in Clayton county but nearly the entire thickness has been penetrated by the deep wells at McGregor and across the river at Prairie du Chien. The record* of the well at the latter place shows the presence of the three members which compose the formation, namely the Basal Sandstone, Saint Lawrence limestone and Jordan sandstone of N. H. Winchell, Norton, Calvin and others, or the Potsdam sandstone, Mendota limestone and Madison sandstone of Irving. One of the wells at Prairie du Chien went down 1040 feet without reaching the bottom of the Saint Croix and the first well drilled at McGregor has a depth of 1006 feet in the sandstone, though it starts some distance below the top of the formation. This gives the sandstone a thickness of at least 1050 feet. It is only a part of the upper member or Jordan sandstone that is exposed above river level in this area. At the north county line it rises eighty

*Iowa Geol. Surv., Vol. VI, pp. 187, 188, Des Moines, 1897.

feet above the Mississippi, at McGregor seventy feet above low water and two miles below, at the mouth of the Wisconsin, the Saint Croix disappears beneath the river level.

This sandstone outcrops only in the northeastern corner of the county, in Mendon township, where it is seen in the bluffs of the Mississippi, along Bloody Run and the ravines in which McGregor is located. There are good outcrops just below North McGregor, along the wagon road between that place and McGregor, and at Point Ann, just south of the latter town. The rock is also well exposed on the north side of the main street of McGregor where it has been excavated to make room for buildings (Fig. 23).

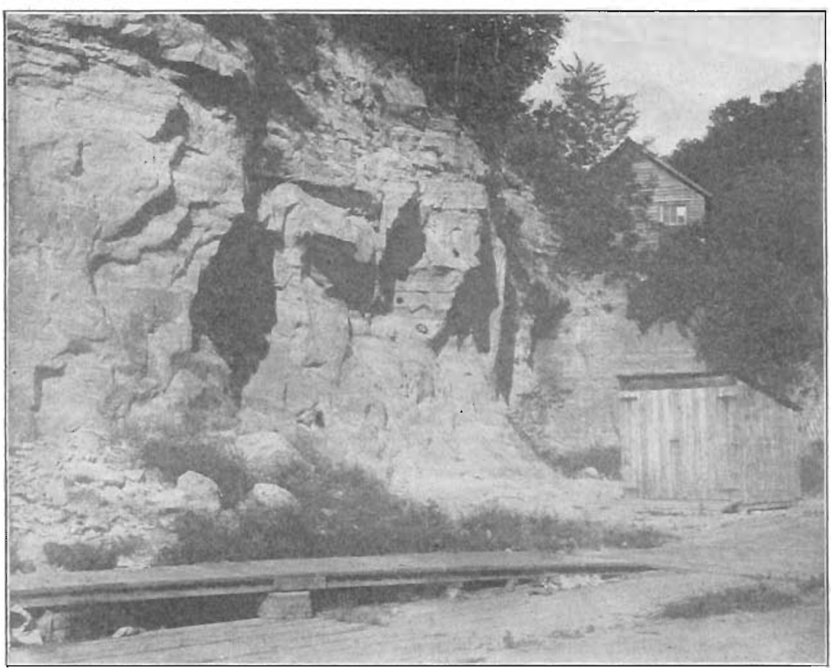


Fig. 23.—Saint Croix sandstone at McGregor.

No fossils have been found in the Saint Croix sandstone of this area and the conditions existing at the time of its formation were not favorable to the preservation of animal or plant remains. The sediments were accumulated near the shore and the sands were subjected to the action of waves and currents, as is shown by the cross-bedding. Even the hard calcareous shells of the mollusks would be ground to powder and only occasionally would evidence of their existence be preserved.

ORDOVICIAN SYSTEM.

LOWER MAGNESIAN LIMESTONE.

(ONEOTA LIMESTONE OF PREVIOUS REPORTS,)

This limestone was first described by Owen and in his report of 1852 is termed the Lower Magnesian limestone. It will be seen by reference to the preceding comparative table of formations that the Oneota as formerly used in these reports includes the Main Body of Limestone, New Richmond sandstone and Shakopee limestone of N. H. Winchell, but does not correspond to the Oneota of McGee which comprises only the Main Body of Limestone. The present tendency is to restrict the term "Oneota" to this lower division, as defined by McGee. See Report on Winneshiek county, this volume.

As was shown by Calvin in his report on Allamakee county* no persistent sandstone formation is found in Iowa equivalent to the New Richmond of Minnesota and Wisconsin, but in places there seems to be an almost continuous succession of dolomitic beds extending from the top of the Saint Croix to the Saint Peter sandstone. Hence the name Oneota limestone has been employed by the present Survey in such wise as to include the entire assemblage of strata lying between the above mentioned sandstones and is equivalent to Owen's Lower Magnesian limestone. For the present it seems desirable to revert to Owen's name, and restrict "Oneota" to the lower member, as noted above.

The Lower Magnesian is not marked off sharply from the underlying Saint Croix, but there is a transition from the one to the other through from fifteen to twenty feet of calcareous sandstone or siliceous oolite. This rock is composed of clear, rounded grains of quartz cemented by lime carbonate. In some beds this cementing material is quite abundant, in others there

*Iowa Geol. Surv., Vol. IV, pp. 62-63, Des Moines, 1894.

is only enough to hold together the grains. The ledges vary in thickness from a few inches to two or three feet. This siliceous oolite is well exposed in an old quarry in the river bluff one and one-half miles above North McGregor. The transition beds are also seen in the section at Point Ann, just below McGregor. Here there are alternating layers of sandstone and limestone and some oolite similar to that described above.

The Lower Magnesian formation is for the most part composed of a massive, coarse, vesicular dolomite showing few bedding planes. Its color is light gray and white to bluff. The lower portion, for a thickness of thirty to forty feet above the Saint Croix, is in ledges two to four feet thick and has been quarried at a number of points. At some horizons, particularly toward the top, the strata contain abundant chert nodules. Some of the beds carry much crystalline calcite, filling the cavities in the dolomite. Above the quarry ledges the rock is more massive, coarse-textured and rough to the touch, and weathers with an uneven, pitted surface not unlike the Galena limestone.

Along Bloody Run several sandstone beds are exposed not far from the top of the formation. In the railroad cut one-quarter of a mile below Giard station and not more than twenty or thirty feet below the Saint Peter sandstone are three sandstone beds from eight inches to one foot thick separated by limestone layers. The rock is formed of clear quartz grains with little cementing material.

Near Clayton the upper fifty feet of the Lower Magnesian is seen to contain thin-bedded sandy and shaly layers. These have a thickness of about fifteen feet and are overlain by brecciated beds.

These arenaceous beds are doubtless the equivalent of the New Richmond sandstone of Minnesota and Wisconsin, but it will be noted that the sandstone member is here unimportant and the dolomitic strata form practically a continuous series between the top of the Saint Croix and bottom of the Saint Peter.

South of McGregor the Lower Magnesian limestone is often brecciated, but this feature was not observed north of that place. This brecciation is especially well shown in the ravine at the sand pit just below Clayton. Here the upper ninety feet of the limestone are well exposed and the lower portion of the section is formed of the usual massive dolomite, here having a thickness above low water in the Mississippi of forty feet. Above this are fifteen feet of sandy and calcareous shales and earthy, impure limestone in thin, irregular beds. This rock is soft and weathers more rapidly than the overlying dolomitic strata, which form overhanging ledges.

Composing the upper portion of the Lower Magnesian section as here exposed are the brecciated and concretionary beds lying immediately below the Saint Peter sandstone and having a thickness of about forty feet. The angular fragments of the breccia vary in size from one inch to one foot in diameter. In some places what appear to be the original bedding planes are clearly seen and the layers, from a fraction of an inch to an inch and more in thickness, are much fractured. Portions of the rock are composed almost wholly of concretionary masses. The nucleus of the concretions is a very compact magnesian limestone and enclosing it are a number of concentric layers or shells one to two inches thick and less. The majority of these masses are from one to two feet in diameter, though some were seen with a diameter of six feet. Each one of the concentric layers is finely laminated and formed of alternately gray, compact bands and yellow bands, less compact.

Calvin, in his report on Allamakee county,* mentions similar concretion-like masses composing some of the beds near the top of the formation and notes their resemblance to some forms of Stromatoporoids.

The Lower Magnesian formation, including the Oneota proper, New Richmond and Shakopee, varies in thickness from 200 to 230 feet. In the ravines about McGregor it is not more than 200 feet, but two miles below, opposite the mouth of the Wisconsin river, it measures 230 feet. At no point is the entire thickness exposed in continuous section. Along the lower course of Bloody Run vertical cliffs of this dolomite, from fifty to 100

Iowa Geol. Surv., Vol. IV. p. 67, Des Moines, 1894.

feet high, appear along the sides of the valley (Fig. 24). At the base of these cliffs, however, the beds are covered by talus, and the upper slopes are commonly overgrown with vegetation. At Point Ann, just below McGregor, there is a good section in the face of the bluff, where at least 100 feet of this limestone are exposed.

Fig. 24—Cliffs of Oneota limestone on Bloody Run two miles west of North McGregor.

This formation appears at the surface only along the valley of the Mississippi and its tributaries and therefore does not cover a large area within the county. It disappears below the level of the river near the northern limits of Guttenburg. At McGregor the dolomite rises 255 feet above low water in the Mississippi and at Clayton ninety feet, the average dip of the strata between these points being nearly eighteen feet to the mile. Perhaps the best exposures of this rock to be found in the area are in the numerous railroad cuts of the Chicago, Milwaukee and Saint Paul railroad in the valley of Bloody Run. The beds from top to bottom are well shown in these cuts between North McGregor and Giard. They are also exhibited in the numerous ravines about McGregor, the lower quarry beds being well shown in the abandoned quarry near the park, and along Sny Magill creek. The excellent outcrops of the upper strata at the Clayton sand pit have already been described.

Fossils are extremely rare in this formation, and none were found during the course of the field work, although search was made for them. They have been found, however, by Mr. F. H. Luthe, formerly of McGregor, in the bands and masses of chert which occur in the upper half of the Lower Magnesian. Mr. Luthe's collection was studied and described by Calvin* who found the following forms: *Metoptoma alta* Whf., *Straparollus claytonensis* Calvin, *S. pristininiformis* Calvin, *Raphistoma pepinense* Meek, *R. multivolvatum* Calvin, *R. paucivolvatum* Calvin, *Holopea turgida* Hall, *Orthoceras primigenium* Vanuxem, and *Cyrtoceras luthei* Calvin. These were all collected from the formation in Allamakee and Clayton counties.

The large laminated, concretionary masses occurring in the beds of the upper part of the formation have already been mentioned. Their resemblance to some of the Stromatoporoids makes it possible that they may be of organic origin. N. H. Winchell has described somewhat similar but smaller masses from the same horizon in Minnesota and has referred the specimens to the genus Cryptozoon of Hall. But it has not yet been established that these structures are organic and they may be a kind of concretion.

It has been shown both on stratigraphical and paleontological evidence that the Lower Magnesian limestone is the equivalent of the Calciferous sandstone of New York. The fossils of the two areas are either identical or resemble each other closely and show that the formation in which they occur belongs to the Ordovician system.

SAINT PETER SANDSTONE.

Overlying the Oneota limestone and resting conformably upon it is the Saint Peter sandstone. This is a very pure and rather coarse-grained sand rock composed of more or less well rounded grains of clear quartz. The particles of sand are

*Bull from. Lab. Nat. Hist, of State Univ. of Iowa, Vol II, No. 2, pp. 189-193 and Am Geol Vol X, pp. 144-148.

commonly very loosely held together and in many places the formation is little more than an incoherent bed of sand. With an increase of cementing material the rock becomes less friable and passes occasionally into quite a hard sandstone. At the sand pit below Clayton the material is so incoherent that large fragments are readily broken up with a pick, and the smaller pieces are disintegrated by turning upon them a stream of water from a hose.

At a few points the Saint Peter sandstone has sufficient coherence to be used for building stone, as near Guttenberg where the rock has been quarried on a small scale for this purpose. The sandstone has a wide range of colors, varying from the more common white or light gray through many shades of yellows, red, chocolate brown, etc. The coloring is due to small amounts of iron oxide which is deposited around and between the sand grains by percolating waters, the iron being derived from the overlying Trenton limestone. The colors are not distributed uniformly through the rock: sometimes they are arranged in alternating layers or stripes, giving the rock a banded appearance; sometimes they are in blotches or patches of various shapes and sizes. The tints of the Saint Peter are as a rule brighter than those of the Saint Croix.

As shown by the following analysis the Saint Peter is a very pure sand rock containing almost ninety-nine per cent of silica. The sample analyzed was from the sand pit at Clayton and the sand had been washed while being carried along the trough from the pit to the tank at the railroad. This washing has doubtless removed a portion of the more soluble impurities.

ANALYSIS OF SAINT PETER SANDSTONE.

Silica, ($Si\ O_2$)	98.94
Alumina ($Al_2\ O_3$) and ferric oxide ($Fe_2\ O_3$)	.60
Calcium oxide ($Ca\ O$)	.33
Magnesium oxide ($Mg\ O$)	.14

J. B. WEEMS, Analyst.

In Clayton county the Saint Peter ranges in thickness from forty to eighty-five feet, with an average of probably sixty feet. At McGregor it is fifty feet thick; several miles to the northwest along Bloody Run, it shows a thickness of seventy feet and at the Clayton sand pit it is eighty-five feet.

The Saint Peter sandstone appears at the surface only in the bluffs of the Mississippi and along the valleys of Bloody Run, Sny Magill and Buck creeks and the ravines about McGregor and Clayton. Elsewhere it is covered by the Galena-Trenton and overlying formations.

The sandstone outcrops as a comparatively narrow belt along the valley sides, the area of the exposed surface varying with the steepness of the hillside, the widest outcrop occurring on the more gradual slope where it has considerable lateral as well as vertical extent. The areal distribution is difficult to represent on a small scale map since the width of the belt horizontally is comparatively insignificant and is necessarily somewhat exaggerated. At McGregor the base of the Saint Peter lies 255 feet above the river and the sandstone is found therefore well up toward the top of the hillsides. It occurs just below the bottom of Boyle's quarry and outcrops for some distance along the road leading west through West McGregor. This sand rock is not found in Point Ann or "The Heights" above McGregor, these points of the Mississippi bluffs not extending up to the horizon of this formation. The Saint Peter sandstone overlying the Shakopee division of the Lower Magnesian limestone is occasionally confused with the Saint Croix sandstone lying below the Oneota of McGee, and the two have been considered as one formation. But a brief study of any of the hillsides about McGregor will show that the two sandstones are separated by nearly 200 feet of dolomite. At Clayton the Saint Peter has descended to ninety feet above the Mississippi and at Guttenberg it disappears below water level near the south end of town. The sandstone extends up Bloody Run for a distance of five miles and at the school house near Giard Station it forms a vertical cliff thirty or forty feet high. The rock appears at many points in the bluffs along the Mississippi, particularly in the vicinity of Clayton and between there and Guttenberg. One of the best places to see this brightly colored sandstone is at the well known "Pictured Rocks" two miles below McGregor and opposite the mouth of the Wisconsin (Fig. 25). At this point a wooded gorge extends back from the river and along the sides and bottom of this the many tinted sands are finely exhibited. The cool, shady glen, carved in the sandstone, with its clear tumbling brook, is a favorite spot for picnics, and is yearly visited by great numbers of people, who seldom fail to climb Pikes Peak, near at hand, and look upon the picture spread out before them from that elevated point. Reference has been made on a previous page to the view from here.

Fig. 25 —Cliff of Saint Peter sandstone at "Pictured Rocks."

Another excellent exposure of the Saint Peter is found at the sand pit just below Clayton where in a ravine opening into the main valley the sandstone has been quarried for many years. In the face of the pit a vertical section of over forty feet is exposed (Fig. 26), the sand here being white and quite free from all coloring matter.

This sandstone afforded no traces of organic remains and fossils are seldom found in the formation. Those listed by Sardeson* from the Saint Peter near Minneapolis are similar to the fossils of the Trenton and indicate that the sandstone is to be correlated with the Chazy of New York.

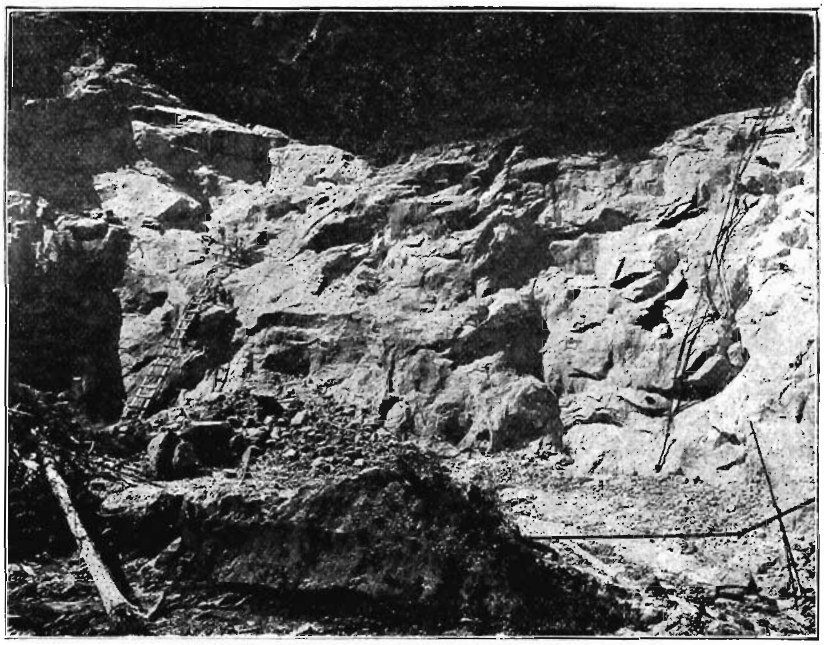


Fig. 26 - Sand pit in Saint Peter sandstone, Clayton, Iowa.

A discussion of the life of the Saint Peter sandstone is contained in the Allamakee county report† to which the reader is referred.

TRENTON AND GALENA LIMESTONES.

(THE GALENA AND PLATTEVILLE OF BAIN, SEE REPORT ON WINNESHIEK COUNTY.)

The Trenton Limestone.—At the top of the Saint Peter sandstone there is an abrupt change in the character of the rock and the Trenton limestone of most writers on the geology of the Mississippi valley, succeeds the sand formation without any intermediate transition beds. The line of contact between the

*Bull. Minn. Acad. of Sci., Vol. III, p. 318.
†Iowa Geol. Surv. Vol. IV, pp. 72, 73, Des Moines, 1894.

two is sharply marked and forms a very definite horizon. Ever since the name was first used by Hall in 1858 the Trenton has been applied to the non-dolomitic and rather thin-bedded limestones overlying the Saint Peter. It has also been customary to apply the term Galena to the heavy dolomitic beds occurring just above and to consider the Galena and Trenton as two separate formations. But it was pointed out by N. H. Winchell* in 1895 that there is a close relation between the Trenton and Galena as shown by a study of their fossils and that the latter is only a phase of the former. Much the same view was expressed by Norton† two years later, and he suggested that the beds designated as Galena and Trenton belong to a single formation to which the name Galena-Trenton was given. Abundant proof of the fact that we are dealing here with only one formation which has been more dolomitized at some points than others was found by Calvin and Bain in Dubuque county and for an exhaustive discussion of the relation existing between the Trenton and Galena the reader is referred to the report on that county†. The writer found in Clayton county much additional evidence of the wide variation in the amount of dolomitization which has taken place in these strata.

The non-dolomitic Trenton varies in thickness from eighty to 165 feet within a distance of fourteen miles or less, and in some parts of the county no portion of the Galena-Trenton has undergone dolomitization, the Galena dolomite apparently being absent. At a number of points the upper twenty-five to seventy-five feet of the formation are composed of pure, thin-bedded, non-magnesian limestone and if any of the strata have been changed to dolomite they lie a considerable distance below the Maquoketa.

At Clayton, and at Pikes Peak, opposite the mouth of the Wisconsin river, the non-dolomitic Trenton is only eighty feet thick, while at Elkader the thickness is 165 feet as shown by wells. The dolomitic Galena beds appear to be nearly, if not wholly, absent in Wagner and Marion townships and the upper

*Am. Geol., Vol. XV, p. 33, Minneapolis, 1895
†Iowa Geol Surv, Vol VI, p 146, Des Moines, 1896
†Iowa Geol Surv, Vol X, pp. 402-431, Des Moines, 1900

portion of the Galena-Trenton formation is represented by rather thin-bedded, non-magnesian limestones. These are well exhibited along Robert and Silver creeks in Wagner township and in the quarries in the vicinity of St. Olaf.

In section 14 of Wagner township non-magnesian strata have an exposed thickness of seventy-five feet and are seen to be overlain by the Maquoketa shales. Between six and seven miles to the south and at the same horizon the dolomitic beds are found at Elkader, with a thickness of at least 120 feet. At Volga the strata lying immediately beneath the Maquoketa are non-dolomitic, and along the Turkey river in Marion township similar beds are exposed at many points in the same position. At Osborne, only a little over four miles east of Volga, eighty feet of heavily-bedded dolomite are exposed just below the shales of the Maquoketa.

It is evident from these facts that we are concerned here with only one formation and that the Galena is simply the dolomitized phase of the Trenton limestone. The change in the character of rock has gone on unequally over the area. In some places little or none of the limestone lying between the Saint Peter and Maquoketa has undergone dolomitization, while at others the dolomite has a thickness of from 100 to 200 feet. The change usually begins at the top and progresses downward to a greater or less depth. But sometimes dolomitic limestones are found interstratified with the pure, unaltered limestones. Thus in the southwest quarter of section 9, Volga township, along the Turkey river, several ledges of dolomite occur beneath six to eight feet of typical, thin-bedded, compact and fossiliferous unaltered limestone. Above the latter the dolomitic Galena is seen in heavy beds. At this point the dolomitization did not affect all the beds but for some reason passed over several of them and attacked those below. In the lower part of the section exposed at the large springs in the northwest quarter of section 30, Read township, there are twenty feet of mottled, magnesian limestone in layers three to twelve inches thick. Lying above these are pure and unchanged beds having a thickness of fifty to seventy-five feet and overlain by typical Galena dolomite.

These examples illustrate in what an irregular manner the Trenton formation has been dolomitized and emphasize the fact that the Galena is simply a lithological phase of that formation and is not stratigraphically distinct.

Occasionally the change appears to take place first along bedding planes and joints. A bed two inches thick was observed which had been partially altered to magnesian limestone on the upper and lower surfaces while the inner portion was unaffected. In other cases the alteration had commenced in that portion of the rock immediately surrounding the fossils, an Orthoceras, for example, being encircled with a ring of magnesian limestone. In the instances just mentioned it seems probable that the dolomitization has been initiated where the percolating waters bearing the magnesium salt most easily had access, as along bedding planes and joints. Commonly, however, the magnesian portions are scattered irregularly through the rock, giving it a blotched or mottled appearance. The unchanged limestone is a light gray color, very compact and often quite fossiliferous while the magnesian patches are buff colored, contain eighteen per cent or more of magnesium carbonate and the fossils have been obliterated. These partially dolomitized beds were seen at many points in the county and always lay between the pure limestone usually called Trenton and the Galena dolomite. Rarely are they separated from the typical heavily bedded dolomite by non-magnesian strata, as was the case, already mentioned, in the Dry Mill creek section.

Though it will be convenient for the purposes of description to treat the Trenton and Galena separately, applying the former term to the pure, thin-bedded limestones and shales and the latter to the dolomitized beds, it should be borne in mind that they are parts of one formation. It was found impracticable to map them separately on account of the irregular way in which the Galena dolomite occurs and its absence from some areas of the Trenton. On the geological map accompanying this report they are therefore represented by the same color and are designated as the Galena-Trenton.

Lithological Character and Subdivisions of the Trenton.—The Trenton formation varies widely in character in different parts of the area. It is composed of limestones and calcareous shales and clays, the first named forming by far the larger part of the strata in this region. The limestones are mostly very fine-grained and compact, occurring in rather thin beds of uneven thickness, blue, gray or buff in color, and frequently rich in fossils.

At the base of the Trenton and resting immediately upon the Saint Peter sandstone are the Basal Shales of the Allamakee county report with a thickness of two or three feet. These are exposed at McGregor, Clayton and just above Guttenbery, where

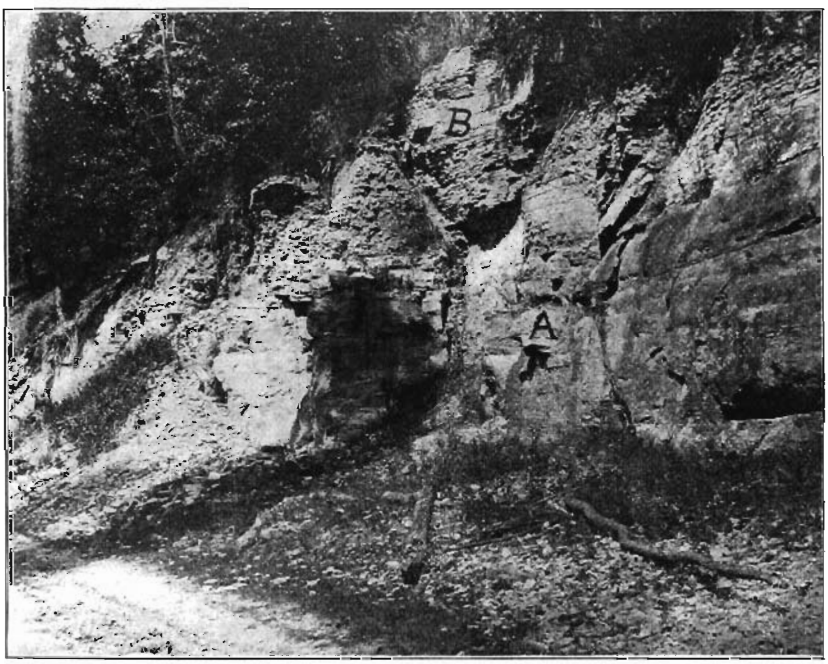


Fig. 27—Lower Buff Beds (A) overlain by thin bedded limestone (B) near Guttenberg. Platteville stage

the contact of the two formations is well exposed. Overlying the basal shales are from fifteen to twenty-five feet of maguesian limestone in beds eight inches to two or three feet thick, weathering to buff. These are the Lower Buff Beds of the Wisconsin geologists, and they seem to occur quite uniformly at the base of the Trenton in Iowa, Wisconsin, Illinois and Minnesota. This compact magnesian limestone breaks readily into layers of almost any desired thickness and makes a very good building stone. In these beds are located the quarries at Guttenberg (Fig. 27) and McGregor. These are succeeded by thin-bedded, very fine-grained and compact fossiliferous limestone in uneven layers one to two inches thick. The rock is brittle, usually breaks with a conchoidal fracture and is light gray and blue. Sometimes the beds are separated by marly partings one or two

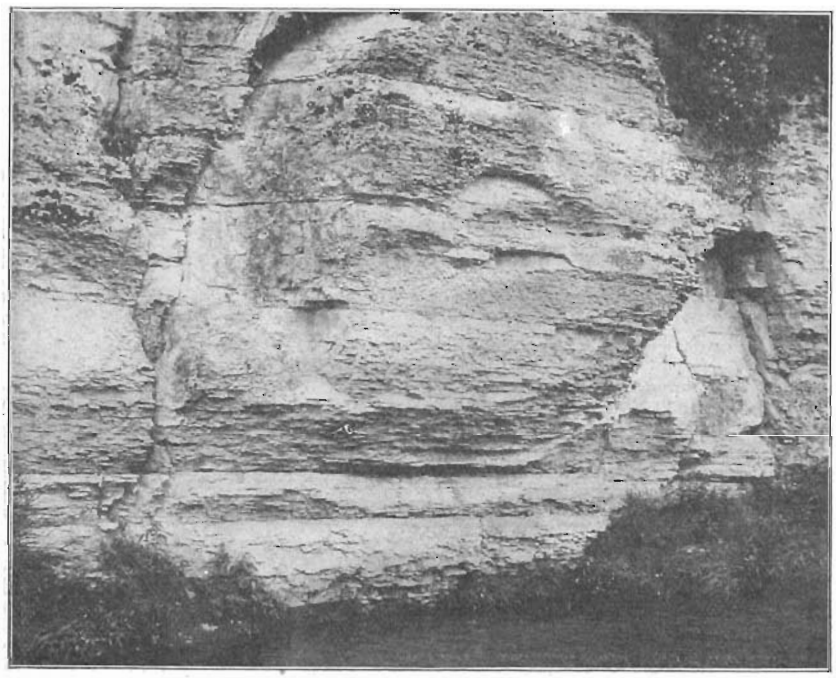


Fig. 28—Thin bedded Platteville limestone exposed on Dry Mill Creek, section 19, Read township.

inches thick. The irregularity in the thickness of the limestone layers is caused by the undulating bedding planes. Vertical or nearly vertical joints are frequently present and the thin-bedded character of the rock is especially well brought out by weathering. The thickness of this member of the Trenton varies greatly and in some places it makes up the main bulk of the formation above the Lower Buff Beds. The succession of strata above the latter subdivision is not at all constant, but at least from twenty-five to thirty-five feet of the compact and thin bedded limestone is commonly present. Above this is frequently found a green shale five to six feet in thickness and lying about fifty feet above the Saint Peter sandstone. This is, in part at least, the equivalent of the "Green Shales" of the Minnesota geologists, though the formation seems to be much thinner here than farther north. The shale is often quite calcareous and contains lenses and bands of limestone rich in fossils. The most common species is *Orthis subaequata,* which is characteristic of the Green Shales of Minnesota and Dubuque county. Associated with this are branching monticuliporoids. This argillaceous member is well exposed in the ravines about McGregor, at Clayton, and one-quarter of a mile above Buena Vista, but it does not seem to be at all persistent, since it is absent in many sections. Thus at Guttenberg, where the entire thickness of the Trenton beds is present in the bluff, the shale does not appear, although the outcrop is almost continuous from top to bottom. Again, at Millville, five to six miles south of here, where nearly 120 feet of the thin-bedded Trenton limestone is exposed, no shale member is present. This serves to illustrate the variation in the character of this formation and the occurrence of strata in one locality which are absent from another.

The shale is succeeded by limestone in thin beds, compact, fine-grained and fossiliferous with a thickness of twenty-five to forty feet or more, and resembling that found below the argillaceous member. When the shale is wanting there is a succession of these limestone strata in beds one to six inches thick extending without interruption from the Lower Buff Beds to the Galena dolomite and even to the Maquoketa where dolomitization has not affected them. Mention has already been made of the fact that in Wagner and Marion townships these non-magnesian limestones extend up to the Maquoketa shale and compose nearly the entire Galena-Trenton formation.

The upper beds of the Trenton, overlain by the Galena, are well exposed at McGregor, Clayton, Guttenberg, Buena Vista, Millville, Elkader and near the mouth of Dry Mill creek. At Clayton they have a thickness of only twenty-five feet, at

McGregor of forty feet, and at Elkader they rise seventy-five feet above the Turkey river below the dam. At the latter place they form the ledges outcropping just above the stone bridge and in the old quarry near the creamery. This limestone of the upper Trenton is also well exposed along the small creek about one mile southwest of Elkader, where the beds contain abundant fossils.

From this locality the following species were collected in strata lying from ten to fifteen feet below the Galena dolomite and about 120 feet below the Maquoketa.

Rafinesquina minnesotensis N. H. Winchell.
Rafinesquina alternata Conrad.
Hormotoma trentonensis Ulrich.
Liospira vitruvia Billings=*Pleurotomaria lenticularis* or *Raphistoma lenticulare* of authors.
Orthis (*Platystrophia*) *biforata*.
Isotelus gigas DeKay.
Fusispira elongata H.
Calymene sp.
Illaenus americanus.
Trochonema umbilicata.
Clionychia lamellosa Hall (*Ambonychia*).
Fusispira inflata Meek & Worthen.
F. angusta Ulrich.
Oncoceras pandion Hall.
Orthoceras sp.
Ischadites iowensis Owen.
Cyrtodonta grandis Ulrich (?)
Parastrophia schofieldi Ulrich.
Anastrophia hemiplicata Hall.
Lophospira bicincta Hall.
Eccyliopterus sp.
Monticuliporoids (branching).
Bellerophon sp.

Ischaditis iowensis is abundant at this locality and is confined to a layer two to three inches thick, in which large numbers are packed closely together. *Rafinesquina alternata* was observed at many localities and always near the top of the Trenton, only a few feet below the Galena dolomite. *Rafinesquina minnesotensis, Hormotoma trentonenis* and *Liospira vitruvia* were also found at several other localities in the same upper strata of the Trenton.

At the same horizon occur *Orthis testudinaria* Dalman, *Liospira lenticularis* Sowerby, *Strophomena rugosa* Raf., *Hormotoma salteri* Ulrich and *Lingula iowensis* Owen. *Orthis testudinaria* is also found near the top of the Galena-Trenton formation, just under the Maquoketa.

At the top of the Galena-Trenton, immediately below the Maquoketa shales, and at the horizon elsewhere occupied by the Galena dolomite, there are at some points dull gray, crinoidal limestones together with nodular or concretionary beds. These are described more in detail in the sections on succeeding pages. They are well exposed near Volga, on the Volga river; on the Turkey river in section 19 of Marion township, near the Fayette county line; on Robert creek and its tributaries in sections 9, 14 and 16 of Wagner township; in the vicinity of St. Olaf and elsewhere. Some of these strata contain *Lingula iowensis*.

The general character of the Trenton is shown in the following sections. The first is found in the ravine back of the town of Clayton.

		FEET.
8.	Green shale at the top of the Trenton	2-3
7.	Limestone, similar to No. 5	8
6.	Bluish green shale	2
5.	Limestone in regular beds four to eight inches thick, very fine-grained and compact, blue and buff in color. Occurs in thicker layers than No. 3	15
4.	Green calcareous shales containing lenses and bands of limestone rich in fossils. Among the most common are *Orthis subæquata* and branching *Monticuliporoids*	5
3.	Limestone, thin-bedded and compact, with marly layers one to two inches thick separating many of the beds. Latter are irregular in thickness and range from one to three inches. The marly partings do not always appear on fresh joint faces but stand out on weathered surfaces	25
2.	Limestone, dolomitic, compact, blue when fresh but weathering to buff on exposure, in even beds eight inches to two feet thick, contains few or no fossils. The quarry beds at Guttenberg and McGregor and the "Lower Buff Beds" of some writters	25
1.	Green shale immediately overlying the Saint Peter sandstone	2

No. 1 represents the "Basal shale" of the reports on Allamakee and Dubuque counties; the rest of the section belongs to the Platteville formation as defined by Bain No's. 2 and 3 are the "Platteville limestone," and No's. 4-8 represent the Decorah shale of Winneshiek county, the entire thickness of the Trenton at this locality is eighty-five feet.

A complete section of the formations exposed at Clayton is as follows:

		Feet.
4.	Galena dolomite (exposed)	150
3.	Trenton limestone (The Decorah shales and Platteville limestone of the Winneshiek county report)	85
2.	St. Peter sandstone	85
1.	Lower Magnesian limestone, exposed above low water in Mississippi	90

Section exposed in ravine near McGregor, in the northwest quarter of Section 33, Mendon township:

		Feet.
6.	Limestone, fine-grained, compact, blue and gray in color, very fossiliferous, in layers one to four inches thick	40
5.	Green calcareous shale with limestone bands very rich in fossils among which *Orthis subæquata* is common	6
4.	Fine-grained and compact limestone, light blue to buff in color, not so fossiliferous as No. 6	34
3.	Dolomitic limestone in ledges one to four feet thick, blue when fresh but weathering to buff, contains some fossils, the "Lower Buff Beds	10-20
2.	Basal shale	3
1.	Saint Peter sandstone.	

Numbers 3 and 4 are well shown in Boyle's quarry, located well up on the side of one of the ravines at McGregor (Fig. 29).

SECTION OF GALENA-TRENTON AT GUTTENBERG.

		Feet.
5	Dolomitic limestone in heavy ledges, vesicular, coarse, buff colored, the typical Galena-dolomite	100
4	Magnesian limestone in beds two and three inches to one foot thick, mottled gray and buff, only partially dolomi ized and containing sixteen per cent of magnesium carbonate; part of the rock is very fine-grained, compact and gray colored, while other portions are buff and have a rough, coarser feel. Contains some chert in bands and scattered nodules. In these beds are located the quarries supplying rock for the limekilns at the base of the bluff	60
3.	Non-magnesian limestone, fine-grained, compact, in thin and uneven beds, gray. Lower portion not well exposed on the ridge, since it is partially covered with talus and soil	85
2.	Dolomitic limestone, blue when fresh but weathering to buff, beds eight inches to two feet thick. In these "Lower Buff Beds" the quarries are located	15
1	Saint Peter sandstone, not exposed here, but known to rise ten feet above the river	

As stated on a previous page the upper portion of the Galena-Trenton is not dolomitic in some parts of Clayton county and the pure non-magnesian limestones of the Trenton series extend up to the Maquoketa shale. These limestone beds outcrop on Robert creek, in the northwest quarter of section 14, Wagner

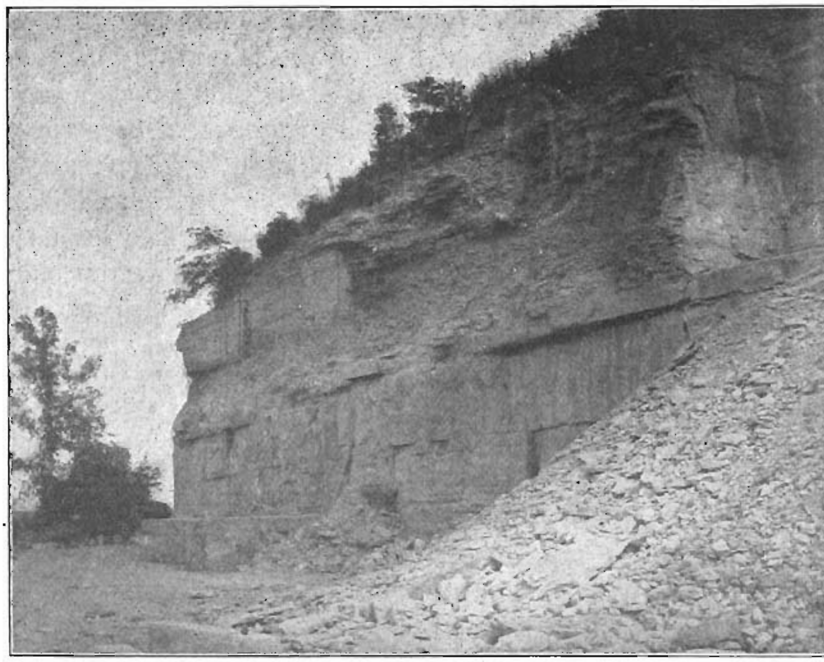


Fig. 29—Quarry in Lower Buff Beds, McGregor. Thin-bedded limestone is seen at top.

township, where they rise seventy-five feet above the creek in a steep cliff. Near this cliff, in a small gully washed in the hillside, the following section is exposed:

		FEET.
6.	Maquoketa shale.	
5.	Non-magnesian, gray limestone in beds three to twelve inches thick; the upper layers, lying immedtately beneath the Maquoketa, are dull, almost earthy in appearance	20
4.	Limestone, gray, in thin, flexuous beds one to three inches thick	15
3.	Non-magnesian, gray limestone in layers three to eight inches thick, not well exposed	25
2.	Beds containing abundant *Receptaculites oweni* and lying sixty feet below Maquoketa	1
1.	Gray limestone in beds three to eight inches thick	15

In sections 9 and 16 of Wagner township the Maquoketa shales are seen resting directly upon a dull gray, crinoidal limestone, compact and thin bedded. This rock is well exposed at the bridge over Robert creek in the north half of section 16,

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Wagner township, where the limestone rises twenty-four feet above the stream and is overlain by the shales of the Maquoketa. These beds represent the non-dolomitic upper portion of the Galena-Trenton. The Thoresen quarry, three miles east of the above outcrop, in the northwest quarter of section 13, Wagner township, is in strata lying twenty-five to thirty-five feet below the Maquoketa. The rock is a blue and gray limestone occurring in beds two to fifteen inches thick, separated by marly partings from one-half to two inches thick, and of a reddish color. The latter contain many crinoid stems and other fossils.

The upper beds of the Galena-Trenton are exposed in an old quarry near the center of the south line of section 21, Marion township, where twelve feet of non-magnesian, gray, compact limestone appear in the face. The lower eight feet occur in layers three to six inches thick, separated by marly partings, while the upper ledges are nodular. These same beds are exposed along the small stream entering the Turkey river in the southeast quarter of section 19, Marion township, where immediately below the Maquoketa shale there are ten feet of nodular limestone of brownish color, overlying ten feet of thin and unevenly bedded gray limestone.

Distribution and Thickness.—The typical non-dolomitized limestone which has heretofore, regardless of its stratigraphic position, been called Trenton, has a wide distribution in Clayton county in the stream valleys. It is found along the Mississippi all the way from McGregor to the southern border of the area, being especially well exposed in the ravines back of McGregor and Clayton, and in the bluffs at Guttenberg. It outcrops in the valley of Turkey river throughout its course in the county and the beds are well shown in the vicinity of Elkader and on Dry Mill creek. They are also found at many points along Robert creek in Wagner township.

As previously stated the non-dolomitic limestone which authors have called Trenton, varies widely in thickness in this region. At Clayton it is eighty-five feet thick; at Pikes Peak, opposite the mouth of the Wisconsin river, eighty feet; at Guttenberg and McGregor 100 feet and at Elkader, where it rises seventy-five feet above the river below the dam, its thickness is shown by wells to be 165 feet. The total thickness of the entire Galena-Trenton at Elkader is 285 feet.

*Galena Limestone**.—As previously stated, this is merely the dolomitized portion of the Galena-Trenton, or Galena-Platteville as the total assemblage of beds may hereafter be called, and is not to be considered a separate formation. But for convenience in discussion the dolomitic and non-dolomitic portions of the formation are treated separately. The change is usually not an abrupt one but there is a gradation through the mottled transition beds already described. These were observed in numerous localities where the base of the Galena dolomite was exposed. The quarries in the ridge back of Guttenberg, which supply rock for the lime kilns below them are in these transition beds, which here have a thickness of fifty to sixty feet. The limestone is mottled gray and buff and occurs in beds two or three inches to one foot thick.

An analysis of this rock† shows that it contains 80.81 per cent of carbonate of lime and 16.11 per cent of carbonate of magnesia. Above these mottled limestone beds is the more heavily bedded and true Galena dolomite, which extends to the top of the ridge. About two miles east of Garnavillo, at the old Dehn quarry on Buck creek, the same beds appear and have been quite extensively quarried. The rock is in ledges two to six inches thick and is readily separated along the bedding planes into thin slabs. *Orthis testudinaria* is a common fossil here. The limestone was broken into small fragments and the gray, compact portion resembling the typical Trenton rock separated from the buff and dolomite-like portion. Separate analyses were then made of each, and the one was found to contain 97.46 per cent of lime carbonate and 4.31 per cent of magnesium carbonate, while the other contained 60.97 per cent of lime carbonate and 18.28

*In this report as stated on a preceding page, the nomenclature of the report on Dubuque county has been followed. If the suggestion of Bain is accepted, the Galena limestone will be separated stratigraphically from the beds below it. The name will be applied to all beds of certain horizons without regard to lithological characters. The division will come at the top of the "Green Shales" of the Minnesota geologists, at the top of the 'Decorah Shales" of the report on Winneshiek county, published elsewhere in this volume. The beds below the line of division above indicated constitute the "Platteville formation" of Bain.

†Analysis made by Prof. J B. Weems of Iowa State College.

per cent of magnesium carbonate. Overlying this thin-bedded rock of intermediate composition lies 200 feet of dolomitic Galena of the Dubuque county type, while along the creek below the quarry the non-dolomitic phase appears.

There is an interesting outcrop of the mottled beds on Dry Mill creek in the northwest quarter of section 30, Read township, where 100 feet of Galena-Trenton strata are seen forming a vertical cliff. At the base of the section are twenty to thirty feet of transition strata. In these the unaltered gray limestone forms the bulk of the rock and the yellow magnesian patches form but

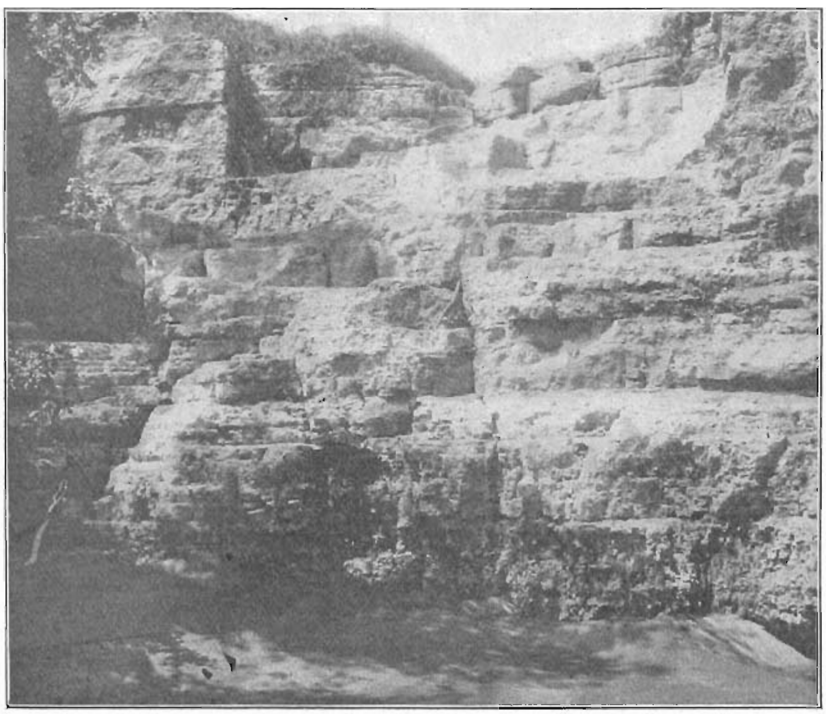


Fig. 30—Beds of Galena dolomite at Littleport, on Volga river.

a small portion of the mass. The beds are from three or four, to twelve inches thick. In the limestone portions of the rock the fossils are well preserved, but in the dolomitized parts they have been obliterated. *Receptaculites oweni* is common in these mottled beds, having been observed both here and on Miners creek. Above these partially dolomitized strata there are at this point from fifty to seventy-five feet of unchanged limestone, thin-bedded, gray, compact and fossiliferous. The following species were found: *Hormotoma salteri* Ulrich, Isotelus sp., *Liospira lenticularis* Sowerby, *Liospira vitruvia* Billings (*Pleurotomaria lenticularis*), *Rafinesquina minnesotensis*, and *Rafinesquina alternata* Conrad. These sttata are overlain by typical Galena dolomite in ledges one or two feet thick. The mottled transition beds usually lie immediately below the dolomite, between that and the unaltered beds, and it rarely happens that any thickness of unaltered limestone intervenes, as in the above section on Dry Mill creek.

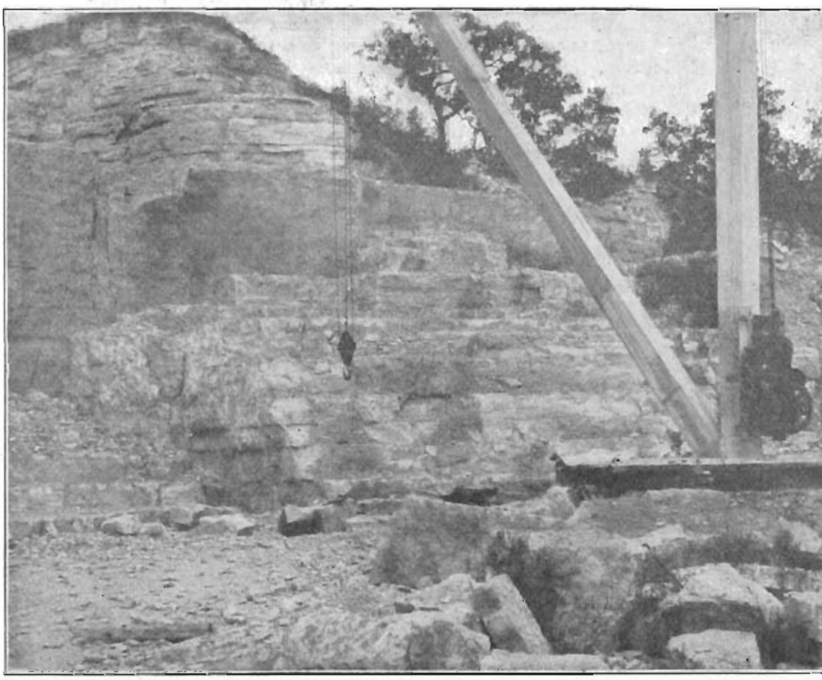


Fig. 31 Quarry in Galena dolomite, Elkader.

Throughout a large part of the county the upper strata of the Galena-Trenton are formed of heavily bedded dolomite in every way similar to that comprising the Galena around Dubuque. The rock where typically exposed is crystalline, rather coarsely granular, more or less vesicular, and of a buff color. It weathers very irregularly, which gives the dolomite its characteristic rough, pitted surface when long exposed (Fig. 30). The beds vary in thickness from six inches to five feet and more, giving the Galena a massive appearance in striking contrast to the thin-bedded non-dolomitic limestone below. But the dolomite varies considerably in character at different horizons throughout its thickness, as is shown by the following sections.

The Galena is well exposed at Elkader, where it has been extensively quarried. In Stoop's quarry (Fig. 31) and below it to the river the following section is exposed:

		FEET.
5.	Light blue dolomite, rather compact and in ledges six inches to two feet thick. Some of the upper strata are separated by thin layers of reddish fissile shale......	25
4.	Light gray to buff dolomite, containing many small cavities, ledges varying in thickness from one to five feet, most of them being over two feet thick.........	25
3.	Dolomite, buff, weathers irregularly, forming pitted surfaces, massive..........	70
2.	Unexposed	35
1.	Non-magnesian limestone in thin beds, compact, fossiliferous contains chert nodules arranged in bands, exposed to river..............	25

The quarry is in Nos. 4 and 5.

The strata near the top of the Galena are exposed in the quarry on Hickory creek, one-half mile north of Luana. The rock is here light blue or gray in color, is more compact and less vesicular and granular than the typical dolomite. It occurs in beds varying in thickness from four to eighteen inches.

The upper, thin-bedded part of the Galena is exposed along Cox creek in the southwest quarter of section 16, Cox Creek township, where the following section occurs.

		FEET.
3.	Dolomite in even ledges six to twelve inches thick, exposed in face of quarry................	12
2.	Unexposed..................	20
1.	Heavily bedded Galena dolomite in ledges two to four feet thick, exposed to creek.....................	10

The Maquoketa outcrops on the creek one mile above this quarry.

As shown by these and other exposures the upper portion of the Galena is composed of comparatively thin bedded dolomite and is not in such heavy ledges as the main part of the formation.

Reference has already been made to the absence of the Galena dolomite in Marion and Wagner townships where the strata for a thickness of fifty to seventy-five feet below the Maquoketa are formed of non-magnesian, very compact and thin-bedded limestone. These beds lying immediately beneath the Maquoketa shales are also well exposed in section 11 of Sperry township, along the river one to two miles below Volga. Near the east line of the section the Galena dolomite is seen rising about twenty feet above the Volga river. One-half mile west of here, near the railroad bridge, the following section is exposed along the small stream entering the river from the **south**:

		FEET	INCHES.
9.	Typical Maquoketa shale, blue when fresh, but weathering to yellow or buff; breaks with conchoidal fracture	20	
8.	Dull, gray limestone in uneven layers three to eight inches thick	5	
7.	Ledges of gray limestone		12-14
6.	Nodular or concretionary bed similar to No. 4, but the marly material in which the concretionary masses are inbedded is more abundant. The marl is a chocolate brown color	1	
5.	Gray limestone in two ledges four to six inches thick; contains abundant crinoid stems and other fossils		10-12
4.	Bed of nodular or concretionary limestone, dull and earthy, red to brown in color. Shows wavy lines due to laminæ bending around concretionary masses. Contains many brachiopods and crinoid stems		8-10
3.	Chocolate brown marl in undulating layer separating numbers 2 and 4		2
2.	Bluish gray limestone in beds four to six inches thick, with some marly partings. Contains *Lingula iowensis* Owen, and crinoid stems; also minute particles of iron pyrites	5	
1.	Unexposed to river but must be largely Galena dolomite which outcrops less than one-half mile east of here	10	

Distribution.—The dolomitic phase of the limestone, here called Galena, is found not only along the stream valleys but underlies a considerable area of the uplands along the northern and eastern border of the county. It forms the bed rock over most of Giard, Mendon and Clayton townships as well as a portion of Garnavillo, Monona and Grand Meadow townships. It is this rock which forms the picturesque cliffs, towers and pinnacles along the Turkey and Volga rivers and their tributaries and along Bloody Run, Sny Magill and Miner creeks. The Galena is well displayed along the Volga from Osborne to Elkport and below. At Mederville the river flows through a narrow, rock walled gorge of dolomite which rises ninety feet above the river. The long, high, narrow ridge at the mouth of the Turkey river lying between the valley of the latter stream and the Mississippi, is formed almost wholly of Galena, as is the upper portion of the similar ridge back of Guttenberg. On Bloody Run between Beulah and Monona there are many outcrops of the same rock and it is a conspicuous feature of the Mississippi bluffs along the eastern border of the county. On the Turkey river there are good exposures at Motor and in the vicinity of Elkader, where the beds have been quite extensively quarried.

Thickness.- As may be inferred from the previous discussion the dolomitized beds vary in thickness from a few feet to 200 feet. The minimum measured thickness was near the northwest corner of Boardman township, where the dolomite is not more than 100 feet. Five miles northeast of here the beds for at least seventy-five feet below the Maquoketa are non-dolomitic, so that the dolomite is probably entirely absent. At Elkader it is 120 feet, and it has about the same thickness in Volga township. In the vicinity of Garnavillo the dolomite is 200 feet thick.

The uneven manner in which the dolomitization has progressed is shown by the fact that at Elkader the Galena dolomite extends up to the base of the Maquoketa while six miles north on Robert creek seventy-five feet of non-magnesian limestone is exposed directly below the Maquoketa. The same peculiarity is shown by an examination of the bottom of the formation. In Dubuque county heavily bedded dolomite begins directly on top of the "Green Shales".* At Clayton it is thirty feet and at McGregor forty feet above these shales, or eighty to ninety feet above the Saint Peter sandstone, while at Elkader the bottom of the dolomite is 165 feet above the sandstone. Still farther north in Allamakee county the dolomitized Galena begins about 240 feet above the Saint Peter†. But although the Galena is so variable the combined thickness of the two divisions of the Galena-Trenton formation is quite constant, where one is thick the other is thin and *vice versa*.

*Iowa Geol. Surv., Vol. X, p. 409

†Ibid, p. 409.

All the evidence bearing on the subject points to the conclusion that the Galena dolomite is derived from non-dolomitic limestone by alteration which has taken place subsequent to the deposition of the strata. This is the conclusion reached by Calvin and Bain from their studies in Dubuque county.* But the relations between the two portions of the Galena-Trenton formation are somewhat different in Clayton county from those in the counties adjoining on the north and south. In Dubuque county, for example, a bed of shale lies at the base of the dolomite and separates it from the unchanged limestone below. Such a shale, dividing the dolomitic from the non-dolomitic beds was seen in the area under discussion at only one locality, near the town of Clayton, though the bottom of the dolomite was exposed to observation at numerous points. Instead there were found the mottled transition beds already described which occupy a place intermediate, both in position and composition, between the dolomitic and non-dolomitic divisions of the formation. These furnish in themselves strong evidence of the secondary origin of the dolomite. The gray, compact, fossiliferous portions of the mottled rock contain only a little over four per cent of magnesium carbonate, while the buff, less compact and unfossiliferous patches contain over eighteen per cent of magnesium carbonate. It has been shown on a previous page that the alteration of the original non-dolomitic limestone has in some instances taken place first along bedding planes and joints where the magnesia-bearing waters would circulate most freely. The absence of these mottled beds from the adjoining counties is doubtless explained by the presence of the shale beds in the Trenton formation of those areas, which has prevented the waters from descending to a greater depth and has abruptly stopped the dolomitization at the horizons of the shale. These shales are largely absent from Clayton county and here the transition beds commonly occur at the base of the dolomite and there is thus a gradual passage from the altered to the unaltered

*Iowa Geol. Surv., Vol. X, pp. 492-497.

divisions of the Galena-Trenton formation. What it is that has limited the dolomitization below and why the change has extended to greater depths at some points than at others it is impossible to say.

The Galena dolomite contains few fossils; among those which are found *Receptaculites oweni* is by far the most common. *Maclurina cuneata* is also present.

MAQUOKETA.

It is doubtful whether any other geological formation in the state appears under such a variety of aspects as does the Maquoketa. In Dubuque county it is composed almost wholly of clay shales. At other localities it is formed of calcareous shales and non-magnesian limestones, while at still others it is represented by beds of true dolomite, often resembling those of the Galena or Niagara. It is therefore not always easy to separate on lithological grounds the Maquoketa from the formations above and below, although a careful examination commonly makes this possible, aided by the fossils characteristic of the Maquoketa.

In Clayton county the Maquoketa is distinctly calcareous and is in this respect very different from the beds as they occur farther south in Dubuque county. This calcareous phase of the formation is also strongly marked in Fayette county. The clay shales of the southern part of the region are thus found to be represented by limestone and dolomite toward the north and west. All phases of the Maquoketa are well represented in Clayton county, where the strata cover a large portion of the area and are deeply trenched by the streams.

The character of the formation is made apparent by the sections which follow. The best outcrops are found in the southern and western part of the county, in the vicinity of Volga and Strawberry Point and on the Turkey river in Marion township, near the Fayette county line.

ST. SEBALD SECTION.

This section, about one-half mile north of St. Sebald, is in the northeast quarter of section 33, Sperry township, on one of the small tributaries of Hewitt creek.

		FEET.	INCHES.
11.	Niagara limestone.		
10.	Blue and buff, impure dolomite in even layers four to twelve inches thick, the transition beds of the Maquoketa	25	
9	Blue clay shale which weathers into a plastic clay	12	
8.	Ledge of impure limestone		8
7.	Blue clay shale similar to No 9	2	
6	Calcareous shale in thin uneven layers. contains numerous fossils, including *Orthis Whitfieldi*, *O insculpta*, *O occidentalis*. *Rhynchonella neenah*, *Rhynchotrema capax*, *R. perlamellosa*	1	6
5.	Blue clay shale only slightly calcareous	3	
4.	Impure limestone, hard, in layers two to three inches thick	2	
3.	Clay shale, similar to No. 5	3	
2.	Impure argillaceous limestone in beds one or two inches thick, containing many fossils similar to those in No. 6	1	4
1.	Bluish green clay shales exposed at intervals along sides of the ravine	65	

It will be observed that over one hundred feet of the upper portion of the Maquoketa are here displayed and that below the dolomitic transition beds there are about twenty-five feet of alternating shales and limestones. At the base of the section there is a considerable thickness of nearly pure clay shales which appear to be quite free from calcareous beds. An analysis of this shale is given later under the subject of clays.

The impure dolomitic strata at the top of the Maquoketa (No. 10) appear at a number of points where the contact of this formation and the Niagara can be observed both in this and Dubuque county. They occur near the bottoms of the valleys of Spring, Cox and Bear creeks, a few miles north of the towns of Strawberry Point and Edgewood and are quite constant both in thickness and lithological character.

On Elk creek, in the northwest quarter of section 23 of Elk township, the beds near the base of the Maquoketa are well exposed. The Galena dolomite outcrops along the creek less than a mile below this locality.

ELK CREEK SECTION.

		FEET.
5.	Argillaceous limestone in layers three to twelve inches thick; breaks with conchoidal fracture; contains specimens of Orthoceras	15-20
4.	Ledge of impure limestone, dark brown color on fresh surface, contains many small cavities	2
3.	Dark brown, argillaceous limestone in several ledges separated by fissile shale	1
2.	Fissile shale, blue when weathered, chocolate brown when fresh: irregularly jointed; contains crystals of iron pyrites	7-8
1.	Gray limestone in uneven layers two to three inches thick, exposed in bed of creek	2

The basal portion of the Maquoketa is exposed at various points in Jefferson, Garnavillo and Volga townships. In these outcrops the rock is light yellow and contains many layers of indurated calcareous shale which often makes up the bulk of the beds. These yellow, stony, calcareous strata are characteristic of the formation in many parts of the area, the associated shales also having a yellow color upon exposure. The indurated layers, which are from three to eight inches thick, contain a rather high percentage of lime carbonate and some of them are impure limestones.

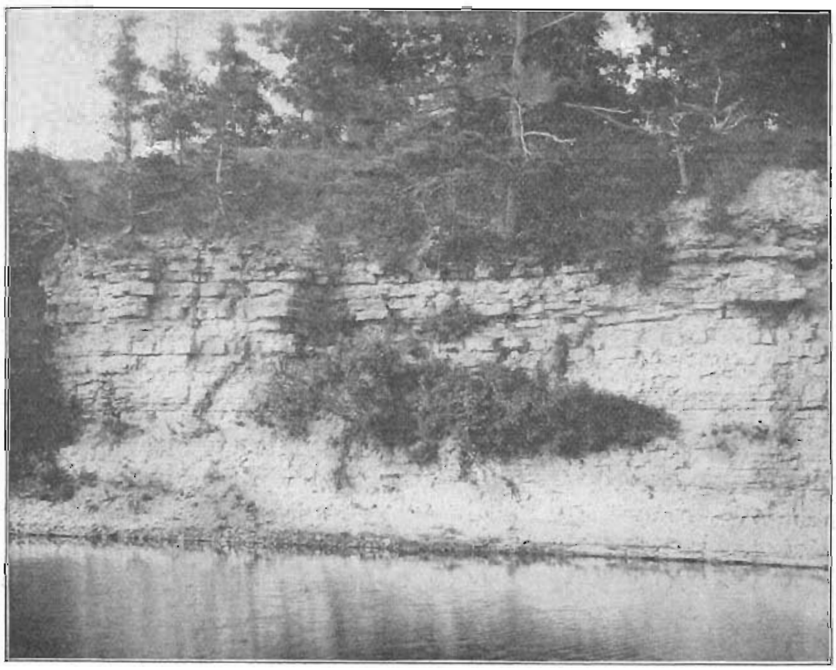


Fig. 32—Cliff of Maquoketa limestone and shale on Volga river at Volga.

The Maquoketa appears along the road just north of Osborne, where a thickness of eighty feet is exposed immediately above the Galena dolomite. The lower portion is composed of clay shales containing large numbers of iron concretions varying in size from that of a walnut to six and eight inches in diameter. When these are weathered they exhibit concentric layers and finally break up into small fragments of impure limonite. The upper twenty to thirty feet of the section is formed of the indurated layers of calcareous shale.

The cliff (Fig. 32) which overhangs the river just above the dam at Volga affords an excellent opportunity to examine the Maquoketa strata. The upper ledges of the Galena-Trenton appear in the bed of the river below the dam and above these are seen over sixty feet of shales and limestones belonging to the overlying formation.

VOLGA SECTION

		FEET.	INCHES
15.	Blue clay shale, exposed	3	
14.	Unexposed	10	
13.	Limestone in ledges six to eight inches thick separated by thin shaly partings	10	
12.	Dark gray to brownish, weathering to buff, crystalline dolomitic limestone in well defined beds eight to eighteen inches thick	14	
11.	Blue and gray argillaceous limestone in layers one to two feet thick; where exposed in face of cliff the ledges are much weathered and the rock has a rough, pitted surface	10	
10.	Impure limestone, not occuring in well-defined beds, but in uneven and obscure layers of varying texture as seen on weathered surfaces. Some portions more crystalline than others and the crystalline patches are lens shaped and elongated parallel to the beds. This rock contains some crystalline calcite and calcareous nodules	7	
9.	Clay shale containing three bands of clacareous nodules similar to those of No. 8	1	4
8.	Thin seam composed of flattened calcareous nodules. These are white on outer surface and resemble chert nodules but when broken they are seen to be composed of very compact non-crystalline calcite		½
7.	Clay shale in single layer	1	3
6.	Blue clay shale which breaks into irregular fragments with conchoidal fracture	6	
5.	Calcareous shale in thin beds	1	
4.	Yellow clay shale		4
3.	Limestone ledge		4
2.	Clay shale	2	4
1.	Limestone exposed in bed of river. (Galena-Trenton.)		

The most noticeable feature of this section is the predominance of limestone strata, more than three-quarters of the beds being composed of this rock.

About one mile east of this outcrop the Galena-Trenton is seen overlain by twenty feet of clay shale, blue when fresh but weathering to a yellow color. Pieces of this shale are often blue on the inside and yellow on the outside next to the bedding or joint planes. In places this shale shows a tendency to assume a concretionary structure. No calcareous layers appear in the shale at this point.

Perhaps the best locality in the county for the study of the Maquoketa formation is in the valley of the Turkey river in sections 18 and 19 of Marion township and adjoining parts of Fayette county. The beds are exposed at a number of points in the sides of the valley, which has here been cut through the Maquoketa to the Galena-Trenton. On the south side of the river in section 19, the lower part of the formation is well shown. The following section is not all seen at any one point but is formed by combining several outcrops in close proximity.

TURKEY RIVER SECTION.

		FEET.
4.	Yellow and gray calcareous shales and argillaceous limestones in layers three to eight inches thick; contain large numbers of siliceous and calcareous nodules which are rich in fossils-trilobites, gastropods and Orthoceratites being especially common. These nodule-bearing beds are very similar to those occurring above the dam at Volga. As at that locality the nodules are white on the outside but on being broken open the majority are found to be composed of gray calcite. Some contain a large percentage of silica. They are all very compact in texture, brittle, break with conchoidal fracture, and lie with their longest axes parallel to the bedding planes. These beds contain *Nileus vigilans* in considerable numbers and may therefore be designated the Nileus beds...	20
3.	Indurated and highly calcareous shales interbedded with fissile shales. The indurated layers break readily into thin slabs and are separated by from six to eight inches of clay shale. The stony calcareous beds are rich in fragments of *Isotelus maximus* Locke and contain also Conularia, Graptolites and Orthoceratites..........	10
2.	Concretionary limestone similar to that observed near Volga and elsewhere at the top of the Galena-Trenton	10
1.	Thin and unevenly bedded, compact, earthy gray limestone resembling the non-magnesian portion of the Trenton limestone. exposed to river....	10

Numbers 1 and 2 of the above section undoubtedly represent the top of the Galena-Trenton formation, while the Isotelus beds (No. 3) form the bottom of the Maquoketa. These latter are characterized by the presence of great numbers of *Isotelus maximus*, the fragments of which fairly cover the surface of the slabs. It is seldom that an entire individual is found but head shields, pygidia and cheek spines are very common. The large eyes are often perfectly preserved and exhibit the facets clearly. These Isotelus beds are well exposed in the bed of the small stream near the bridge in the northwest quarter of the southeast quarter of section 19, Marion township (Fig. 33). They were also observed four and one-half miles southeast of here, in the northeast quarter of section 35, at an elevation of 110 feet above the river, and also along the road between sections 22 and 23.

Fig. 33 Isotelus beds at base of Maquoketa, near center of Section 19, Marion township

Number 4 of the above section and the beds overlying it are exposed on the south side of the river in the dry run just across the line in section 13 of Fayette county.

COUNTY LINE SECTION.

		FEET
4.	Unexposed to base of the Niagara except some blue clay shales at bottom	90
3.	Buff dolomite in irregular beds, with much chert	30
2.	Greenish blue clay shale weathering into a plastic clay. Used in making brick at Clermont, exposed	10
1.	Very calcareous shales and argillaceous limestone which correspond in part to No. 4 of the previous section. Occurs in thin beds two to six inches thick and contains numerous impure cherty and calcareous nodules. The rock breaks readily into thin slabs along the lami ation planes. The fossils observed were *Nileus vigilans Calymene senaria*, cystidean plates and Orthoceras. This member is not exposed continuously along the ravine and may be made up in part of clay shales similar to No. 2	100

The peculiar feature of this section is the presence of the cherty dolomite (No. 3) included between clay shales and the great thickness of calcareous strata at the base.

Numbers 1, 2 and 3 are well exposed near Clermont, Fayette county, between the town and the residence of ex-Governor Larrabee.. The road leading up the hill is cut through the Nileus beds, above which lies the blue clay used in brick making at Clermont. The latter is seen to be overlain by the dolomite of No. 3. This is heavily bedded, massive and very cherty. It has a coarse, uneven texture, is vesicular, buff in color and resembles the dolomite of the Galena or Niagara. But it carries characteristic Maquoketa fossils and lies between blue clay shales. The following fossils occur in the dolomite: *Orthis subquadrata, O. testudinaria, O. insculpta, Rafinesquina alternata* (of Maquoketa type), *Plectambonites sericea, Rhynchotrema capax, Leptaena unicostata* and Orthoceras.

There is another interesting exposure of the Maquoketa strata at Patterson's spring, four and one-half miles west of the Clayton county line, in the southwest quarter of section 20, Pleasant Valley township. Here below the Niagara limestone there are seventy feet of blue clay shales. But between the two several beds of non-magnesian, argillaceous limestone occur. These beds are three or four feet thick and very fossiliferous. The following species are common: *Leptaena unicostata, Orthis occidentalis, Tentaculites sterlingensis, Plectambonites sericea,* and Monticulipora.

The different outcrops occurring near the western boundary of Clayton county may be combined to form a general section of the Maquoketa formation as it appears in the northwestern part of the county. The following subdivisions are quite clearly defined.

GENERAL SECTION OF MAQUOKETA.

		FEET.
5.	Clay shales, not well exposed except near the top and bottom (well exposed at Patterson's spring in Fayette county)	90
4.	Cherty dolomite beds	30
3.	Blue clay shales, seen at county line section and the clay pit at Clermont	10-70
2.	Nileus beds, calcareous shales and impure limestones	40-100
1.	Isotelus beds forming the base of the Maquoketa, very calcareous, indurated shale	10

It is evident from the above section that in this vicinity from one-third to one-half of the Maquoketa is composed of calcareous shales, limestone and dolomite. Another noticeable feature is the rapid variation in the thickness of the several divisions of the formation. The Nileus beds appear to vary in thickness from thirty or forty to one hundred feet.

The foregoing sections bring out in a striking manner the variability in the lithological character of the Maquoketa. In the southern part of the county the upper portion of the formation is composed of buff, impure dolomite in even layers, the entire thickness of these transition beds being twenty-five feet. The presence in them of *Orthis testudinaria* leaves little doubt that they are to be included in the Maquoketa rather than the overlying Niagara. These strata were not observed in the northwestern part of the area and they are probably absent from that region.

Below these dolomitic beds of passage, or where these are wanting, below the Niagara, the formation is composed chiefly of clay shales, with some limestone layers at the top, having a thickness of from ninety to 100 feet. These shales appear in the St. Sebald and County Line sections. They may doubtless be correlated with the Upper Maquoketa of Dubuque county which is formed of "plastic clay shales with some indurated fossiliferous bands near the top", and including the transition beds has a thickness of 160 feet.*

The Lower Maquoketa of Clayton county on the other hand, is composed very largely of calcareous strata, and clay shales form an unimportant part of this division. Numbers 1 to 4 of the general section may be considered as belonging to this lower member of the formation.

*Geology of Dubuque County, Iowa Geol. Surv., Vol. X, p. 443, Des Moines, 1899.

At Osborne the basal portion is represented by fifty or sixty feet of clay shales containing abundant iron concretions, but less than five miles west, at Volga, the strata of this horizon are for the most part calcareous shales and limestones. The presence in this county of any considerable thickness of clay shale at the base of the Maquoketa is exceptional, since wherever observed the beds are commonly very calcareous and indurated.

The lithological differences between the Lower and Upper Maquoketa are here more marked than in Dubuque county and furnish additional grounds for the separation of the formation into two subdivisions, as suggested by Calvin and Bain.* The faunal differences are also quite noticeable and important, though some forms are common to both horizons.

The Isotelus beds are considered as marking the base of the Maquoketa since below them is both a lithological and faunal change. The strata underlying those containing the trilobite remains are pure limestones resembling the undoubted Galena-Trenton rock found near Volga and elsewhere. The Isotelus beds are distinctly argillaceous and shaly, the more indurated layers being only two or three inches thick, breaking readily into thin slabs and separated by fissile shale. The fossils, comprising *Isotelus maximus, Leptobolus occidentalis,* and numerous graptolites, are unlike the forms occurring in the underlying limestones. The small *Leptobolus occidentalis* Hall, which here occurs in dark shaly partings between the more indurated Isotelus-bearing beds, is a characteristic fossil of the dark shales in the lower part of the Maquoketa formation at Graf and elsewhere in Dubuque county. For these reasons the lower limit of the Maquoketa is placed at the bottom of these Isotelus beds.

The thickness of the formation varies from 200 feet in the southern part of the county to 240 feet in the northwestern townships. In Dubuque county the thickness is 200 feet and the formation becomes thicker toward the north and west.

The Maquoketa, as will be seen from a reference to the geological map accompaning this report,has a wide distribution throughout Clayton county. With the probable exception of several in the northeastern corner it is found in every township

*Ibid. p. 442.

in the area. It forms the surface rock of the uplands in Jefferson, Volga, Garnavillo, Read, Farmersburg, Wagner, Marion, Monona and Grand Meadow townships. Between the Volga and Turkey rivers it covers large areas where the overlying Niagara has been removed by erosion, and south of the Volga it occurs in the valleys cut back into the Niagara escarpment by the many tributaries entering into the major stream from the south. In the uplands back from the streams the Maquoketa is covered by the Niagara dolomite.

SILURIAN SYSTEM.

Niagara Limestone.

The youngest of the indurated formations occurring in Clayton county is the Niagara limestone which overlies the Maquoketa shale. It does not attain its full thickness in the

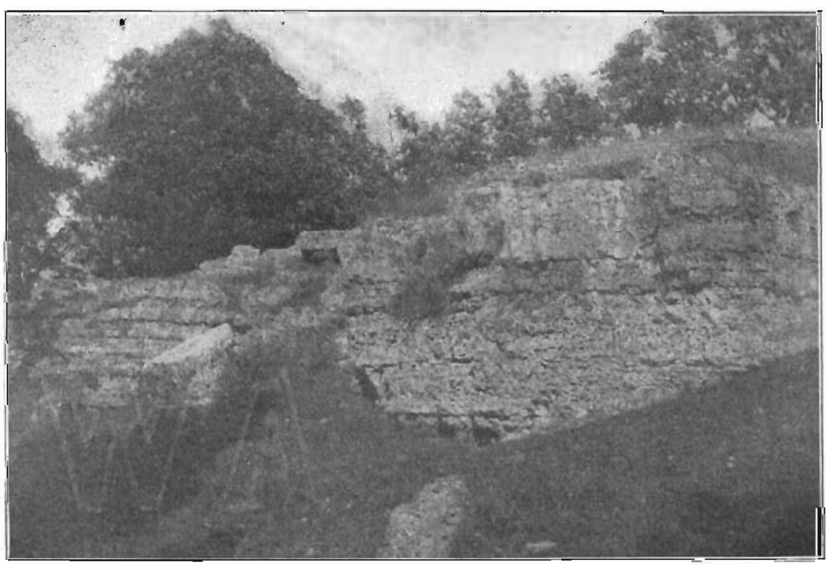


Fig. 31—Outcrop of Niagara limestone in the Gunder outlier, section 15, Marion township.

region under discussion, however, since the upper portion appears to be absent. The beds cover a large area in the southwestern part of the county but the exposures most favorable for study occur in the valleys formed by the headwaters of Spring, Cox and Bear creeks, in the vicinity of Strawberry Point and Edgewood. Cliffs of the Niagara dolomite also form the sides of the valley of the Maquoketa river in the extreme southwestern corner of Cass township.

The character of the rocks shows considerable variation both vertically and horizontally but the typical Niagara is a yellow or buff, heavily bedded dolomite. It often resembles closely the Galena and might easily be mistaken for the latter formation were it not for its fossils and stratigraphic position. In outcrops which have been long exposed to weathering the beds usually have very rough and pitted surfaces, as shown in Fig. 34.

The basal beds of the Niagara are seen in Cass and Lodomillo townships and also in several outliers in Grand Meadow township, one of which extends across the line into Fayette county. As shown by these exposures the strata at the base of the formation are in rather heavy ledges two to four feet and more in thickness. These are well shown in "The Dolomite Quarries" four miles southwest of Postville and just over the line in Fayette county. The section here is as follows:

		FEET.	INCHES.
4.	Dolomite in a single bed with some chert nodules. Suitable only for rubble and broken stone.........	1	6
3.	Dolomite furnishing good quarry stone and quite free from chert....................................	6	
2.	Ledge of dolomite very uniform in character and constant in thickness; rock resembles No. 1.		20
1.	Single ledge of even textured, finely granular, buff colored dolomite. In places has a clay parting one inch thick dividing the bed into two layers. Varies in thickness from five to eight feet, but where examined in face of quarry at time of the writer's visit it measured...........................	6	4

No. 1 of the above section rests on the blue clay shales of the Maquoketa from which it is separated by a thin parting of calcareous shale. The beds contain *Platystoma niagarense*, Orthoceras and other fossils. Similar basal beds of the Niagara are exposed in the quarries near the section line between sections 10 and 15, Marion township, where heavily bedded, compact, buff dolomite overlies the Maquoketa shale.

In the southern part of the county the strata at the base of the Niagara are seen in the vicinity of Strawberry Point and Edgewood. They here rest on the calcareous transition beds of the Maquoketa, already described in the discussion of that formation. Where exposed in the northwest quarter of section 14, Cass township, the rock is a heavily bedded, coarse-textured, crystalline dolomite. The ledges are three to four feet thick. The same strata are exposed along the valley in the northwest quarter of section 26, Lodomillo township. The thickness of these basal beds is from thirty to forty feet.

These heavy ledges at the base of the Niagara are succeeded by the quarry beds in which all the quarries in the southern part of the county are located. The character of the rock is well shown in these. In the Sousley quarry (Fig. 35), located in the northwest quarter section 15, Cass township, the following section appears:

		FEET.
2	Coarse-textured, buff dolomite containing chert nodules, in ledges eighteen inches to three or four feet thick	8-10
1.	Light gray, almost white, finely crystalline dolomite free from chert, in layers from four to eighteen inches and two and one-half feet in thickness. The thicker ledges can be split into any desired thickness along lamination planes. The rock is soft when first quarried and grows hard on exposure	6-8

In the northwest quarter of section 24, Cass township, the quarry beds have been opened on the land of Mr. F. Glass and exhibit the following section:

		FEET.	INCHES.
6.	Soil		
5.	Weathered, thin-bedded rock	2	
4.	Dolomite in layers two to six inches thick not suitable for building stone since the beds are too thin and cherty	2-3	
3	Light gray and buff, fine-textured dolomite in four ledges ten, fourteen, fourteen and thirty inches respectively; the thirty inch ledge in places separated into three beds. These four ledges contain the best quarry stone	5	8
2.	Thin layers one to four inches thick containing much chert		14
1.	Ledge of dolomite at base of quarry		22

The same light gray to almost white, fine-grained and rather soft rock of the quarry beds is seen in the other quarries of this vicinity and it will not be necessary to duplicate the sections already given. This division of the Niagara has a thickness of twenty to twenty-five feet.

Above the quarry beds the strata, for a thickness of about fifty feet, are not exposed. They probably belong in part at least to the *Syringopora tenella* beds found to the south in Delaware county at about this horizon.

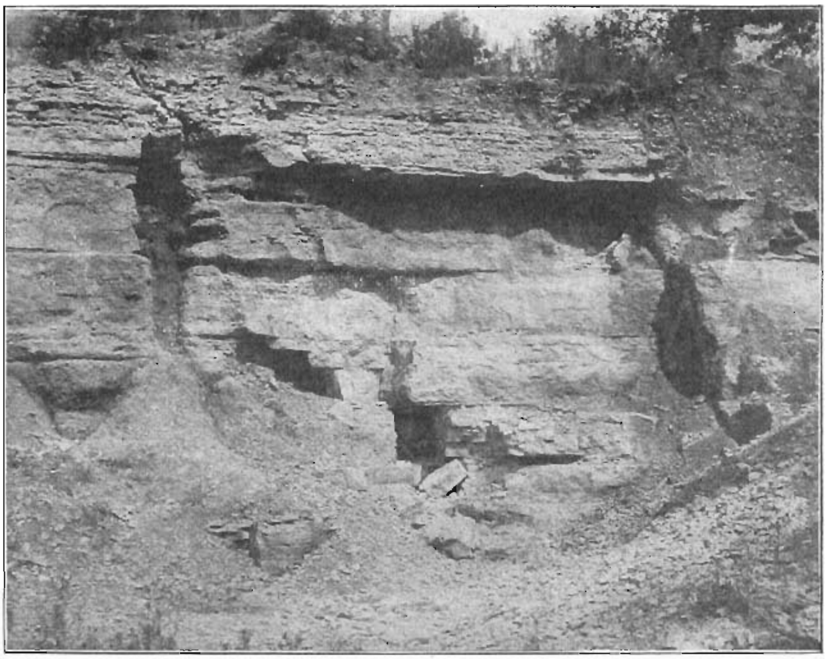


Fig. 35—Quarry in Niagara dolomite near Strawberry Point.

One mile north of Edgewood, along the road leading down to Bixby's Park, in the southwest quarter of section 26, Lodomillo township, the beds for 100 feet above the base of the Niagara are exposed. The rock is a very coarse grained, rough, vesicular and uneven textured dolomite, gray and buff in color and in heavy, massive ledges five, six, and eight feet thick. It contains many corals among which *Halysites catenulatus, Zaphrentis* probably *Z. stokesi* and Favosites are common. The weathered dolomite has the rough, pitted surface characteristic of the Niagara in many of its outcrops. The thickness of this division is about forty feet. Along the Maquoketa river in the extreme southwestern corner of the county, the cliffs forming the sides of the valley are composed of strata similar to those occurring near Edgewood. The dolomite is massive, coarse grained, vesicular and contains the same corals. In addition *Pentamerus oblongus* occurs in the beds here. Between two and three miles to the south at the "Backbone" in Delaware county, about twenty feet of the *Syringopora tenella* beds and seventy feet of the *Pentamerus oblongus* beds are exposed.* The ledges forming the cliffs along the Maquoketa in Clayton county are believed to belong to the horizon of the *Syringopora tenella* beds as found in Delaware county. It is probable that the upper portion of the Niagara, the equivalent of the *Pentamerus oblongus* beds farther south, has only a slight thickness in this area. In northern Delaware county the latter beds begin 150 feet above the Maquoketa, while the total thickness of the entire Niagara formation in Clayton county is little more than this. The *Syringopora tenella* beds therefore probably form the upper member of the Niagara formation in the region under discussion.

The Niagara limestone covers a large area in the southern and southwestern townships, having a wider distribution than any other formation except the Maquoketa. It lies for the most part south and west of the Turkey river, occurring both between that and the Volga river and south of the latter stream. But several detached areas or outliers are present north of the Turkey. Two of these are in the vicinity of Gunder, in northeastern Marion township. The dolomite forms the top of a ridge rising fifty to seventy-five feet above the surrounding surface. Several quarries have been opened in the rock near the southern end of the ridge. Another outlier is found on the western edge of Grand Meadow township, extending across the line into Fayette county. In this is located the large "Dolomite Quarries" known also as the Williams quarry, to which reference has already been made.

The Niagara occupies a considerable area between the Turkey and Volga rivers. It forms the prominent ridge extending from Highland postoffice southeast almost to Communia. The streams have deeply trenched this divide and the dolomitic beds have suffered much erosion, exposing the underlying Maquoketa shale over a large portion of the region.

*Iowa Geol. Surv., Vol. VIII, p. 148, Des Moines, 1897.

The main body of the Niagara lies south of the Volga and Turkey rivers, occupying the uplands of the southern tier of townships and also of Sperry and Cox Creek townships. The prominent escarpment produced by the outcropping edges of the strata forms an extremely sinuous line extending north on the divides almost to the Volga, and south many miles from the river where the streams have cut valleys back five to ten miles into the Niagara limestone. The line of wooded cliffs which marks the edge of the formation constitutes a conspicuous topographic feature. At the base of these cliffs are huge masses of dolomite which have fallen from above and are tilted at all angles. Many of these blocks have moved down the gentle Maquoketa slopes and now lie at a considerable distance from the parent ledges. The cliffs are constantly being worn back by undermining and weathering and are thus slowly retreating.

The Niagara does not attain its full thickness in Clayton county, the upper beds either never having been present or having suffered removal by erosion. The maximum probably does not exceed 160 feet. The formation has about this thickness in the vicinity of Strawberry Point and Edgewood. In the ridge in Highland township, between the Turkey and Volga rivers, the dolomite is about 140 feet thick, and elsewhere it is less than this.

There is little doubt that the Niagara limestone formerly covered the greater part of the county and that what are now detached portions and outliers once belonged to a continuous area. But the streams of the region have cut their valleys through the formation, removing the strata over large areas.

The limestone weathers into a brown or red ferruginous clay filled with large numbers of chert fragments. The presence of the Niagara can frequently be detected by the occurrence of this cherty red clay even when there is no outcrop. It appears along the roads in many places, as in Highland, Boardman and Cox Creek townships.

RESIDUAL MATERIALS.

Prior to the glacial period and the invasion of the ice sheet the rocks of this region were subjected for many ages to the various weathering agencies. Through their action the strata were decomposed and became covered with a mantle of residual materials representing the products of decay.

In the case of the limestones and dolomites a large part of the substance of the rock (the lime carbonate) was dissolved and carried away in solution by the waters, leaving behind the insoluble constituents, consisting chiefly of clay. The rocks are commonly covered by a mantle of soil and subsoil resulting from their decay, the thickness varying from a few inches to many feet. Resting on the indurated beds of the county these residual materials are often observed, though they are usually covered by a younger deposit associated with the drift, the loess.

In those areas where the Maquoketa formation constitutes the bed rock, the decomposition product is a clay differing little in composition from the original shale. Since these shales weather and break down rapidly they are soon concealed by a covering of clay soil and good outcrops are not common. The Niagara limestone, as already indicated, weathers into a red or brown, ferruginous clay containing many chert fragments. These red, cherty residual clays, or geest, were seen at many points on the high ridge between the Turkey and Volga rivers, as well as south of the latter stream.

PLEISTOCENE SYSTEM.

KANSAN STAGE.

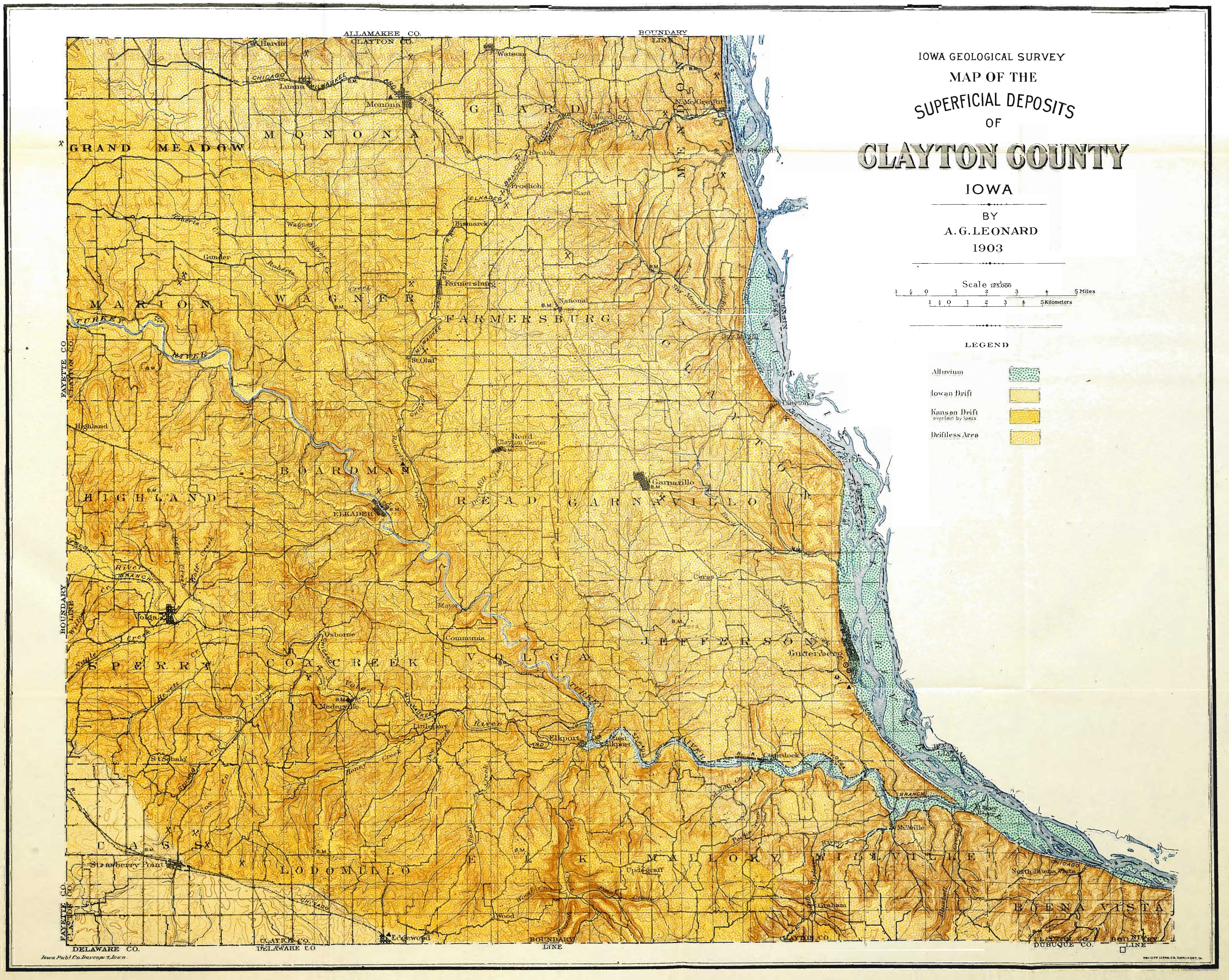
Kansan drift.—Although the Kansan drift covers a large portion of Clayton county it nowhere reaches any considerable thickness, seldom more than five or six feet. On this account it has had but slight effect on the topography of the area, the preglacial surface receiving only a thin veneer of Kansan drift and the topography of the entire county, beyond the border of the Iowan drift, is that of the driftless area. The surface features are the result of erosion and the glacial deposits are not thick enough to modify these materially. In the discussion of the topography of this region the area of the Kansan drift has therefore been included with the driftless area, since there is little or no difference between the two.

When fresh and unweathered the Kansan is composed of blue till or bowlder clay, mixed with more or less sand and gravel containing large and small bowlders of igneous rock. Near the surface the drift is red and oxidized from long exposure and since it has no great depth in this county the till has this character wherever exposed. It is overlain by loess. Perhaps the best outcrops occur in the vicinity of Communia, in Cox Creek and Volga townships. Near the school house in section 12 of the former township the following section is exposed:

	FEET.	INCHES.
5. Brown, sandy clay with small bowlders and pebbles..	2	
4. Gray, rather sandy clay containing streaks and lenses of sand; also filled with numerous small bowlders of rotted granite..................................	1	
3 Brown sandy layer		6
2. Dark brown gravel, rather coarse and containing much rotted granite, diabase, diorite, etc....	1	6
1. Gray, somewhat sandy clay similar to No 4, in which are bowlders of granite and other igneous rock................	2	

The drift here shows planes of stratification which are evidence of water action, probably of the streams flowing from the melting ice. Granite bowlders one foot in diameter occur here, most of the rocks being in an advanced stage of decomposition. Southwest of this locality, in the east half of section 14 of the same township, there are exposed five feet of mottled gray and brown bowlder clay overlain by one foot of loess. Pebbles and small bowlders of granite, hornblende schist, diabase, chert, etc., were observed.

Drift outcrops in section 17, Volga township, where at the base there are four or five feet of coarse, brown ferruginous sand overlain by gray and brown mottled till, carrying pebbles and bowlders of granite, diabase, diorite and other material. The clay shows some lines of stratification. Only a short distance from here four feet of brown bowlder clay is exposed, above which there are two feet of coarse ferruginous sand. Many bowlders four to eight inches in diameter were seen here, some flattened, polished and striated on one or more sides.


IOWA GEOLOGICAL SURVEY
MAP OF THE
SUPERFICIAL DEPOSITS
OF
CLAYTON COUNTY
IOWA
BY
A. G. LEONARD
1903
Scale 1/125,000
5 Miles
5 Kilometers
LEGEND
Alluvium
Iowan Drift
Kansan Drift overlain by loess
Driftless Area
ALLAMAKEE CO.
CLAYTON CO.
BOUNDARY LINE
FAYETTE CO.
CLAYTON CO.
DELAWARE CO.
DUBUQUE CO.
GRAND MEADOW
MONONA
GIARD
MARION
WAGNER
FARMERSBURG
BOARDMAN
READ
GARNAVILLO
HIGHLAND
JEFFERSON
SPERRY
COX CREEK
VOLGA
CASS
LODOMILLO
ELK
MALLORY
MILLVILLE
BUENA VISTA
Monona
Farmersburg
St. Olaf
Elkader
Garnavillo
Volga
Guttenberg
Elkport
Strawberry Point
Edgewood
Millville
North Buena Vista
Iowa Publ. Co. Davenport, Iowa

About one-half mile south of East Elkport, along the road leading up the hill in the southeast quarter of section 36, Volga township, the Kansan drift, with great numbers of bowlders, occurs. The till is brown, leached, highly oxidized and filled with pebbles and bowlders. A little ferruginous sand is mingled with the clay. At no other locality in the Kansan area are bowlders so numerous as here. Those two or three feet in diameter are common and some were observed four or five feet in diameter. Fine-grained granite predominates but diabase, hornblende schist, gabbro, diorite and greenstone are found. The drift covers the side of the valley from top to bottom, indicating that the latter was formed before the deposition of the drift and is therefore preglacial. In Mallory township brown bowlder clay is exposed along the road in the southwest quarter of section 21 and near the center of section 33. The drift is covered with loess which conceals it from view for the most part. The Kansan appears beside the road in the northwest quarter of section 14, Sperry township, less than two miles south of Volga. It outcrops near the school house two miles west of Garnavillo, where two feet of brown till containing pebbles and small bowlders of granite, diorite, greenstone, etc., were seen. One of the granite bowlders was one foot in diameter. The drift is exposed at several points in the vicinity of St. Olaf and Farmersburg. One-half mile north of the former town three feet of red bowlder clay occur overlain by five feet of loess. Bowlders six inches to one foot in diameter are present. Five miles north of here the Kansan drift appears in a railroad cut near the center of section 32 of Giard township. Five feet of brown bowlder clay containing pebbles of granite, greenstone and diorite are exposed. Some drift is found in Grand Meadow township but it is unlike the typical Kansan in being light colored instead of brown. It contains many small bowlders and is overlain by loess.

The margin of the Kansan drift in Clayton county is not marked by any ridge, due to the thickening of the deposit along the border, as in Dubuque county. The drift fades out so gradually that it is possible to determine only approximately where the margin is located. The eastern and northern boundary as represented on the Pleistocene map which accompanies this report probably does not correspond exactly with the actual border, but the thinness of the drift and its covering of loess prevents any accurate mapping of the margin of the Kansan.

The drift is undoubtedly wholly absent from some portion of the Kansan area, since in this county it is everywhere thin and might readily be removed from considerable areas. It is not continuous but has an irregular, patchy border. In Highland township, and on the ridge in southern Boardman and northern Cox Creek townships, no drift was seen. At a number of points the residual clays of the Niagara appear at the surface or are covered only by a layer of loess. But since the extent of these areas within the Kansan border is unknown they have not been mapped as driftless, except in the case of the valley of the Little Turkey river where they are more clearly defined.

Buchanan Gravels.—When the ice sheet which had formed the Kansan drift began to melt and withdraw from the surface the streams flowing from it were loaded with sand and gravel. These materials were deposited and accumulated as beds of gravel resting on the older drift, or when the latter is absent, on the bed rock. These have been named the Buchanan gravels by Calvin from their occurrence in the county of the same name.* The best exposure of these found in Clayton county is a little over one mile south of Elkader, in the northeast quarter of Section 34, Boardman township. The gravel is reddish brown in color, is highly ferruginous, mixed with considerable coarse sand, and contains pebbles and small bowlders of rotted granite, diabase and other igneous rocks. Most of the pebbles are composed of quartz in the form of chert, derived no doubt from the Niagara limestone. From long exposure the deposit has become greatly oxidized and is deeply iron stained. So abundant is the iron that the gravel is in places cemented by it. The bed as exposed shows a thickness of ten to fifteen feet, extends along the road for 200 to 300 feet and lies nearly 200 feet above the Turkey river. It is covered by one or two feet of loess. The same coarse ferruginous gravel appears along the road one mile

*Iowa Geol. Survey, Vol. VIII, p. 241.

west of Volga, where it contains numerous small bowlders. It is seen resting on the Maquoketa shale in the valley of the Turkey river in the southeast quarter of section 19, Marion township. Many large Kansan bowlders, some four or five feet in diameter, occur along the creek near by. The Buchanan gravels were observed at other points in the region, always presenting the appearance of having been much weathered and oxidized.

IOWAN STAGE.

Iowan drift.—The Iowan drift covers only a small area in Clayton county, including parts of Cass and Lodomillo townships and one or two sections in southwestern Sperry. The area is represented on the Pleistocene map accompanying this report. The border lies from one-quarter to two miles north of the Chicago, Milwaukee & St. Paul railroad, the road following the level plain of the Iowan drift. As was stated in the discussion of the topography of this region, the margin is marked in most places by a ridge or a series of hills and ridges composed of drift and loess, rising fifty to sixty feet above the surrounding surface. The marginal ridge is well shown at Strawberry Point, in the eastern part of town, and continuing for a mile or more in the same direction.

The Iowan drift presents a very different appearance from the Kansan. It is gray in color, not having suffered the oxidation of the older till, its granite bowlders are fresh and little affected by weathering, it is not covered by loess, except near the margin, and its surface is characterized by the presence of numerous large bowlders of coarse-grained granite. The contrast between the two drift sheets is always striking. The reddish brown Kansan drift is covered by loess which forms a light colored soil, while that of the Iowan drift is black, the surface is dotted with large bowlders and there is no covering of loess. The older drift has undergone much erosion and streams have cut deep channels, while the younger has a level and poorly drained surface.

The character of the Iowan drift is well exhibited in several outcrops in the vicinity of Strawberry Point. Beside the road just north of town six feet of gray bowlder clay are exposed, overlain by three feet of loess. The clay has suffered very little leaching and effervesces strongly with acid; its iron constituents are not oxidized and the granite bowlders are not decomposed. One composed of biotite gneiss was seen here with its feldspar and other minerals still fresh and bright. Only near the margin is the Iowan drift covered by loess, as in the above exposure, and elsewhere this gray mantle is absent. The light yellow bowlder clay is also seen just south of the school house on the line between sections 23 and 24 of Cass township, where the wagon road cuts through the marginal ridge. At this point the drift is overlain by ten feet of loess. The numerous large bowlders which are such a conspicuous feature of the Iowan surface are well displayed in section 6 of Cass township, along the roads southwest of Strawberry Point and elsewhere. In some parts of the Iowan area the drift is wanting, the Niagara limestone or its residual clay outcropping at the surface. Such small driftless areas were observed in sections 5, 6, 8, 9 and 16 of Cass township.

The thickness of the Iowan drift at some points near the border is shown by wells to be from 100 to 170 feet while at other points it is nothing. The well at Strawberry Point went through 125 feet of drift and loess before reaching the Niagara and another located on the ridge one-half mile east of town penetrated 172 feet of loess and till before striking bed rock. The thickness is probably somewhat less than this back some distance from the border where the drift has not been heaped up into morainal hills and ridges; and in some areas, as stated above, it is very thin and even absent. A well sunk about two miles north of the Iowan margin, in the northwest quarter of section 18, Lodomillo township, went through only fifty feet of loess and Kansan drift.

Loess.—The fine, light yellow, homogeneous silt known as loess forms the superficial deposit over nearly the entire county. In the driftless area it rests on the residual clays and sands while in that of the Kansan it overlies the reddish brown, oxidized till or the ferruginous Buchanan gravels. The only portion of the region from which the loess is absent is the Iowan drift plain in the southwestern corner. This light colored deposit, which is fresh and unleached, presents a sharp contrast to the weathered, brown and oxidized clays on which it rests. It is believed that the loess was deposited during the time that the Iowan ice sheet was at its maximum development, or shortly after its retreat, and thus that it is of about the same age as the Iowan drift. The fine materials of the deposit were spread out over the surface beyond the Iowan margin either by wind or water or by the combined action of both agents. Recent investigations point to the wind as the chief factor in the transportation and deposition of the loess. The character of the fossils, which are almost invariably the shells of land snails, and certain peculiarities about the distribution of the deposit, lead to the belief that in many instances at least, if not in all, the wind was instrumental in the formation of the loess. Little evidence of stratification was observed in the loess in Clayton county. In thickness it varies considerably, ranging from zero to twenty feet. The average thickness is probably not over ten feet.

Terraces.—At many points along the Turkey and Volga rivers gravel terraces form conspicuous features of the valleys. They were formed when the streams had a larger volume than today and were loaded with an abundance of coarse sediment, such as sand and gravel. Through the deposition of these materials the floors of the valleys were built up. Later, when the rivers carried less sediment, they began to cut into their former flood plain deposits, leaving the remnants of the latter as terraces along the sides of the valleys.

On the Turkey river the broad and well preserved terrace near the Fayette county line has a height of fifty feet above the river. It is exceptionally well exhibited in the vicinity of Elkader, where it rises fifty-five feet above the water below the dam. The two cemeteries, the Court House and much of the town east of the river are built on this terrace. The sand and gravel pit near the railroad station is located in it. About three-quarters of a mile below town, along the railroad, the terrace has been cut into by gullies and has been badly washed by hard rains, so that the gravel and sand are excellently shown (see Fig. 36).

Many of the pebbles composing it are of igneous rock similar to those of the drift. In the bend to the west, just south of town, the stream is cutting into and undermining the gravel deposit. At Osterdock the terrace is sixty feet above the river.

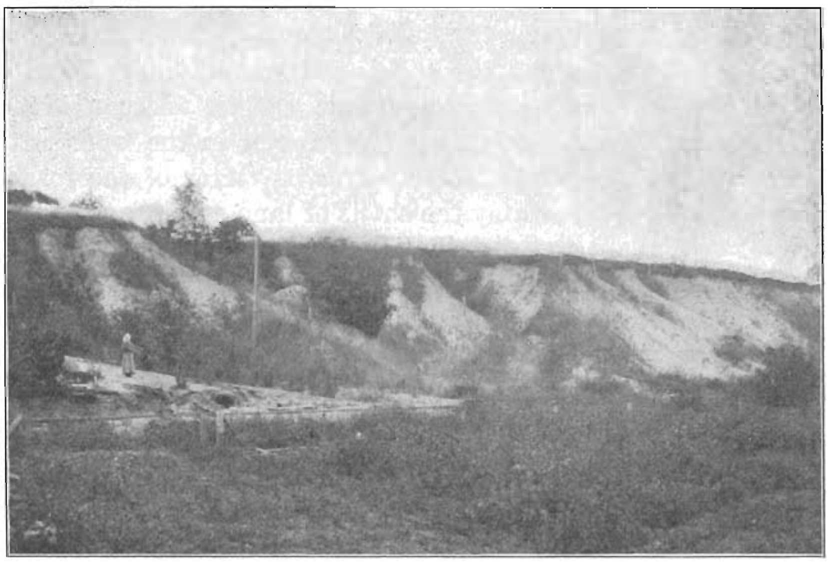


Fig. 36—Gravel terrace on Turkey river, one mile below Elkader.

Terraces appear at numerous points along the Volga. At the town of this name there is a broad and conspicuous terrace thirty feet above the stream and a lower one or second bottom, with an elevation of ten feet. Large numbers of agates here occur among the pebbles of the terrace. At Osborne it is forty-five feet, at Mederville fifty feet, and at Elport seventy-five feet above the river. Near the confluence of the Turkey and Volga, at Elkport, there is an upper and lower terrace, the one seventy-five, and the other forty feet high.

These gravels exposed along the Turkey and Volga rivers are probably of glacial origin but with what drift sheet they correspond in age is uncertain. They do not resemble the ferruginous Buchanan gravels since they are fresh and light colored. They are similar to the gravels of the Wisconsin ice sheet, but the latter did not invade the drainage areas of any of the Clayton county rivers except the Mississippi, so that the outwash material of the ice sheet could hardly reach the valleys of the district. They did, however, fill the preglacial valley of the major stream to a depth of 147 feet, as shown by the deep well at Prairie du Chien. These Wisconsin gravels appear in the gravel pit just below Guttenberg, beside the railroad track.

ALLUVIUM.

Alluvial deposits are found on the flood plains of the larger streams, covering considerable areas along the Mississippi, Turkey and Volga rivers. These deposits are composed of the fine and coarse sediments laid down by a river on its valley bottom during times of flood. Occasionally the thickness of the alluvium deposited during a single flood is sufficient to raise the level of the plain very perceptibly. During the high water of the summer of 1903 the town of Elkport was several times flooded and when the waters receded the surface was seen to be covered by a layer of black, slimy mud from one to six inches and more in thickness, the thickest deposit being near the river. Where material had been washed down from the sides of the valley the addition to the flood plain was in places as much as two or three feet, half burying fences so that only the tops of the posts project above the mud layer. Over wide areas the thickness of the fresh alluvium was nearly a foot.

There are extensive alluvial bottoms along the Mississippi and narrower ones bordering the Turkey and Volga rivers along parts of their courses in Clayton county. Only the larger areas can be represented and these are shown on the Pleistocene map.

Deformations and Unconformities.

The strata of this region have been but slightly disturbed from their original horizontal or nearly horizontal position. They have a very gentle dip to the southwest and there are one or more low anticlinal folds. In the vicinity of Sny Magill creek, between McGregor and Clayton, the presence of a gentle anticline is indicated by the increased dip of the beds on one side and the lessened dip on the opposite side.

The indurated rocks form a continuous series conformable among themselves but between them and the drift there is a distinct unconformity. The Pleistocene deposits were laid down on an old eroded land surface that for ages had been exposed to denudation. The two drift sheets are likewise unconformable between themselves, the Iowan drift and loess resting unconformably upon the Kansan.

ECONOMIC GEOLOGY.

Soils.

Several varieties of soil are found in Clayton county. Covering by far the larger part of the area is the loess, which forms a light, loose and porous soil. This rests either on the Kansan drift or on the residual clay of the driftless area. The porous and usually quite calcareous loess affords an excellent soil for agricultural purposes and is adapted to the growth alike of grasses, grains and fruits. The Kansan drift is everywhere covered by a greater or less thickness of loess and the same deposit forms the soil of the driftless area except where erosion has removed it from the steeper slopes.

The Iowan drift of the southwestern townships forms a rich, dark, loamy soil of great fertility. The level character of the surface of the Iowan makes its cultivation less difficult than the rough portion of the driftless area or even of the Kansan. Still a third variety of soil is furnished by the alluvium of the stream valleys. This is unexcelled for productiveness and its continual replenishment during times of flood causes it to maintain its fertility.

Building Stone.

Clayton county is abundantly supplied with excellent building stone, the Niagara, Galena-Trenton and Oneota formations all being quarried at a number of points. The attempt has not been made to locate all the quarries on the map, there being many which are abandoned or worked occasionally, and only the larger and more important ones are given.

Quarries in the Oneota.—The outcrops of the Oneota limestone are confined to the bluffs of the Mississippi and the tributary valleys in Mendon and Clayton townships. The rock has been quarried about one and a half miles above North McGregor, on Bloody Run, and in McGregor. The quarries are located near the base of the formation thirty feet or less above the Saint Croix sandstone. A small opening has been made in these beds near the public park at McGregor, where there are six feet of excellent dolomite.

Quarries in the Galena-Trenton.—There are several horizons in this formation which furnish building stone. One of these lies near the base. in the "Lower Buff Beds". The rock is a fine-grained limestone, blue weathering to buff, lying in beds from eight inches to two, three, or four feet in thickness. It breaks readily along the bedding planes into slabs of almost any thickness and in places is cut by vertical joints. These lower beds are worked in the Boyle quarry at McGregor and in the quarries along the base of the bluff at Guttenberg. They have a thickness of from fifteen to twenty feet.

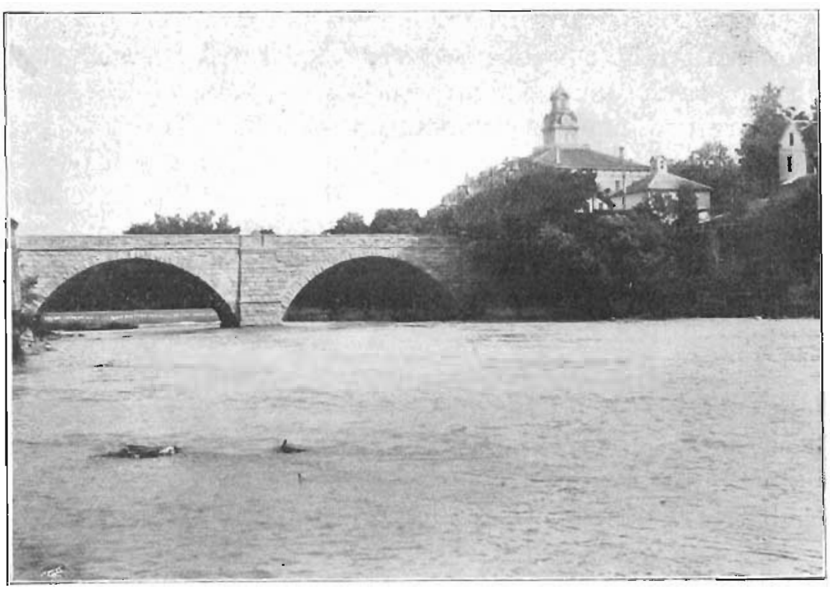


Fig. 37—Stone bridge at Elkader; built of Galena limestone.

The Galena dolomite is quarried at numerous points, most of the quarries being near the top of the formation. In this upper horizon are the Stoops quarry at Elkader, where the rock for the stone bridge (Fig. 37) was taken out; the Ferguson quarry one and a half miles north of Monona and that near Luana; the Stickfort quarry southeast of Garnavillo and the

Schoulte quarry one and a half miles north of National. The Thoreson quarry, about one mile west of Farmersburg, is in beds which lie twenty-five to thirty-five feet below the top of the Galena-Trenton and the Embertson quarry, east of St. Olaf, is about sixty-five feet below the Maquoketa shale. The rock in these two quarries is a blue and buff, compact, non-dolomitic limestone occurring in beds two to fifteen inches thick. Many of the layers are separated by reddish marly partings from a fraction of an inch to two inches thick. The Galena dolomite is quarried at several points in Cox Creek township; in the southwest quarter of section 16 and in the northeast quarter of section 20. The transition beds at the base of the Galena dolomite have been quarried at the old Dehn quarry, about two miles east of Garnavillo, and these beds also furnish the stone for the limekilns at Guttenberg.

Quarries in the Niagara.—The Niagara limestone is quarried at two different horizons in widely separated portions of the county. In the small Niagara outlier just southwest of Gunder there are two quarries belonging to Mr. R. L. Rierson. They are located in beds at the base of the formation and fifteen feet of dolomite are exposed. The rock is in heavy beds, compact and buff colored. The large Wilkes Williams quarry, five or six miles northwest of here and close to the line between Clayton and Fayette counties, is in these same strata immediately overlying the Maquoketa shale. At the bottom is a single ledge of even-textured dolomite ranging in thickness from four feet, eight inches to eight feet, with a one inch clay parting in places. Overlying this is a persistent twenty inch bed of very uniform character and constant thickness and then above are seven and a half feet of quarry beds, though the upper eighteen inch layer is cherty and suitable only for rubble and broken stone.

The quarries in the vicinity of Strawberry Point are in a horizon sixty to seventy feet above the base of the Niagara. The quarry of W. S. Sousley, which has been worked thirty-five years, is on the side of the valley formed by the headwaters of Spring Creek, in the northwest quarter of section 15, Cass township. From fifteen to twenty feet of rock are exposed in the quarry. The best stone lies at the base, where the dolomite is almost white, free from chert and in ledges from three or four inches to one and a half or two and a half feet. This rock is soft when first removed but grows hard upon exposure. Above the white beds is a buff, coarse-textured dolomite containing some chert, and occurring in ledges from one and a half to four feet thick. The Glass quarry, which is in the same horizon, is located in the northwest quarter of section 24, Cass township.

Most of the stone quarried in Clayton county is used locally and little or none is shipped except from the Williams and Boyle quarries.

Clay.

Several of the formations occurring in the area under discussion furnish clays which are suitable for the manufacture of brick, tile and other clay products, but these are not at the present time utilized as much as they might be. The loess, alluvium and Maquoketa shale are used in the several brick yards. The Trenton limestones contain shale beds at several horizons, but these have not been made use of either in Clayton or any of the adjoining counties. From two to three feet of shale occur at the base of the formation and these are exposed at McGregor, Clayton and just above Guttenberg. They are not of sufficient thickness to be available for making brick. About fifty feet above the base of the Trenton series is a second shale member, corresponding to the shale at Decorah, five or six feet in thickness. This might furnish a good clay in some places but it commonly contains lenses and bands of fossiliferous limestone and calcareous nodules which render it unsuitable. It is well exposed in the ravines about McGregor, Clayton and one-quarter of a mile above Buena Vista.

The Maquoketa formation, on the other hand, furnishes clay of excellent quality for the manufacture of various clay products. The upper Maquoketa contains from sixty to ninety feet of shale and good outcrops of this occur near St. Sebald, three miles north of Strawberry Point; at Newberry Park, one mile and a half northeast of the same place; at Bixby's Park, one mile and a half north of Edgewood; in the vicinity of Volga and on the Turkey river near the Fayette county line.

The following is an analysis of the shale from near St. Sebald, in the northeast quarter of section 33, Sperry township, on one of the small tributaries of Hewett creek.

Silica	52.29
Alumina	20.64
Combined water	5.17
Clay and sand	78.10
Iron oxide	5.16
Lime	1.89
Magnesia	1.12
Potash	2.77
Soda	8.27
Total fluxes	19.21
Moisture, sulphur trioxide and carbon dioxide	2.76
Rational Analysis.	
Clay substance	70.65
Feldspar	2.57
Quartz	26.78
	100.00

This clay is well adapted to the manufacture of the common clay products but is especially well suited to the production of hollow ware.

Edgewood.—The brick and tile plant of Myron Mellon is located at Edgewood. Blue Maquoketa shale and loess are used. The shale is obtained two miles north of town just above Bixby's Park on Bear creek. It is from the top of the Maquoketa formation. This clay shale is mixed with varying proportions of loess procured from the ridge just north of Edgewood. For brick and three inch tile the proportion is one-third Maquoketa clay and two-thirds loess; for six and eight-inch tile it is one fourth clay shale and three-fourths loess. The more of the Maquoketa clay that is used the harder the brick or tile. This material alone makes an extremely hard brick.

The plant has a Brewer Brick and Tile Machine, a Penfield crusher, thirty horsepower engine and thirty horsepower boiler. The product is burned in a downdraft kiln, after drying in large drying sheds. The clay burns to a salmon red color and the brick and tile are hard and of good quality.

An analysis of the Maquoketa shale used here shows a composition differing considerably from that of the clay near St. Sebald. It is as follows:

Silica	44 39
Alumina	13.72
Combined water	12.18
Clay and sand	70,29
Iron oxide	7.80
Lime	7.88
Magnesia	6 05
Potash	1 56
Soda	5.29
Total fluxes	28.58
Moisture	0 89

Rational Analysis.

Clay substance	40 61
Feldspar	4.62
Quartz	28.00
Lime and Magnesia Carborate	26.77

It will be seen that this clay contains a strikingly high percentage of lime and magnesium carbonate but it produces a strong and durable ware when properly burned.

Monona.—The Monona Brick works are operated by George J. Jenkins and have been running twelve years. The plant is located in the west edge of town beside the Chicago, Milwaukee and St. Paul track. The material used is loess clay and twelve feet of this are exposed in the pit. The upper eight feet are yellow or buff and the lower four feet are blue and somewhat sandy. The brick burn to a red or dark brown color and are of good quality, being durable and keeping their color well. They find a ready sale in Monona and the surrounding region. A Quaker brick machine, made at Wellington, Ohio, is used and has a capacity of 16,000 brick a day. The moulds are sanded to prevent the clay from sticking to them, a fine river sand from Dubuque being employed. The brick are first dried on the ground in the sun and are later transferred to sheds open at the sides. They are burned in two dowudraft and two updraft kilns.

Guttenberg.—There are two brickyards near this place, both located around the point of the bluff in the valley of Miner creek. One of these is owned by Mr. M. Burr and has been in operation five years. An alluvial clay is used, part of it obtained from the bottom along the creek and part from a terrace near by in which the material is a stratified clay and sand deposit. It is sandy towards the top but near the bottom of the pit is quite a stiff clay. These materials are mixed in the proportion of two-thirds of black alluvium to one-third of the sandy clay of the terrace. The brick are made in an Anderson brick machine manufactured at Anderson, Indiana, dried in two drying sheds and burned in a temporary kiln. The yard is operated five or six months of the year and employs seven or eight men.

The second brickyard, owned by I. K. Kohler, is located near the cemetery. The clay is here obtained from a terrace rising fifty feet above Miner creek and composed of a stratified sandy clay. The material exposed in the pit varies from a stiff clay, through sandy clay to almost pure sand. The brick are hand made, dried in sheds and burned in temporary kilns.

Lime.

Clayton county is well supplied with magnesian limestones suitable for lime, and these are burned at several points. There are two kilns at Guttenberg, one two miles northeast of Elkader, and lime was formerly burned by John Dehn at his place about two miles east of Garnavillo. At Guttenberg the rock used by Frank Stoeffler and George Koehler in their kilns is from the mottled transition beds lying between the non-dolomitic limestone and the completely dolomitized Galena. Analysis shows that the rock contains about 16 per cent of magnesium carbonate and is therefore intermediate in composition between true dolomite and pure limestone. The beds are quarried in the bluff above the lime kilns located at the base, are broken into small fragments and the rock is allowed to slide down the steep slope to the top of the kilns.

Charles Lee has a lime-kiln near Elkader and the limestone burned here is from the thin bedded Trenton formation.

The other magnesian limestone formations of the county would make good lime. The Oneota dolomite has been burned in Allamakee county, and the Niagara at various points in Delaware county, affording an excellent lime. The large and well equipped plant at Eagle Point, Dubuque, uses forty feet of Galena dolomite lying fifty feet above the top of the "Green Shales".

Glass Sand.

The Saint Peter sandstone furnishes a sand of such purity that it is suitable for use in the manufacture of glass.

The following is an analysis of a sample from Clayton after the material has been washed:

Silica (SiO_2)	98.94
Alumina (Al_2O_3) and ferric oxide (Fe_2O_3)	.60
Calcium oxide (CaO)	.33
Magnesium oxide (MgO)	.14

The chief locality in Clayton county where the sand is obtained is a large pit near Clayton. This is located in a ravine a short distance back from the river where thirty to forty feet are exposed. The sand is easily dug with a pick and broken into fragments five or six inches in diameter. Then a strong current of water is turned on, which causes the pieces to crumble and the sand is washed into a long wooden trough leading to the railroad. As it is carried along this trough by the water it is thoroughly washed and is conveyed into a large tank. Here the water is drawn off and the sand is loaded directly on the cars.

This pit is owned by Mr. J. H. Buhlman and much material has been removed. There is a large abandoned pit just east of the one at present worked. Sand has been taken from this locality for thirty years. It is shipped to the glass factories at Clinton, and to Milwaukee for use in several malleable iron works there.

Throughout much of the extent the Saint Peter sand is colored by iron oxide but there are a number of places in the bluffs of the Mississippi where it is white and pure enough to furnish glass sand.

Road Materials.

Good materials for road building are found in many parts of the county, but little use has yet been made of them. The limestones of the Lower Magnesian, Galena-Trenton and Niagara when broken up would furnish stone for macadam and the supply is inexhaustible. The glacial gravels are another source and these are ready for use. The ferruginous gravels near Elkader have already been mentioned; the iron is so abundant as to form a cement and the material packs well. The terrace gravels along the Turkey and Volga rivers could be used to advantage and have been employed to some extent at Elkader and elsewhere. There are two large gravel pits a short distance below Guttenberg. From the one just south of the railroad bridge over Miner creek the Chicago, Milwaukee and St. Paul road has taken large quantities of gravel for ballast.

Lead.

Lead has in the past been mined in considerable quantities at two points in Clayton county, Guttenberg and Buena Vista. At the present time it is mined only on a small scale. The work is carried on mostly by laboring men who have no other work during the winter months and put in their spare time prospecting for galena. Hardly enough lead is obtained to pay for the labor of getting it out

At Buena Vista mining was begun in 1851 in township 91 north, range I west, section 28, northeast quarter. Two nearly east and west ranges have been worked, and both are formed by three main parallel crevices with several minor ones. The ore in the south range occurred in a large body at the surface. The mine was on a side hill where the overlying strata have been eroded, leaving the deposit exposed. It was worked by an open cut and yielded lead in generous measure. The crevice was followed 700 feet west of the ore body, but without further discoveries. The fissure is open up to the surface, where it is from one to three feet wide, and is filled with clay and soil. One crevice in the north range has been worked by a level run into the hillside. Mining has been carried on here at intervals for over thirty years, and although no record has been kept, the mine is known to have produced large quantities of galena. Some zinc carbonate occurs in this same locality, but not in paying amounts. Several specimens of the lead carbonate, cerussite, were obtained here, and one of them analyzed by

G. E. Patrick yielded 69.67 per cent of lead. It occurs only in small quantities and has been derived by alteration from the galena. For many years little has been done in these mines, although some prospecting has been carried on from time to time. The deposits are lower in the Galena limestone than at Dubuque, but not at the base of the formation as at Guttenberg.

The Guttenberg mines are about three miles northwest of town on Miner Creek. The larger diggings were in section 7, township 92 north, range II west, but there were others in section 18, same township and range and in sections 11 and 12, township 92 north, range III west. The lead is found in the lower part of the Galena beds, occurring in the mottled, magnesian limestone forming the transition beds already referred to. Miner creek and its tributaries have cut deeply into the Galena formation, and the mines are located chiefly on the sides of the valleys which have in places cut across the east and west crevices. The partially dolomitized limestone is found along the creek as far as Mr. Rodenberg's place and some distance beyond.

For some years the Holmes mine was the largest in the district. The opening, which is in places fifty feet wide, was followed 2,000 feet. The cap rock forms a flat roof without fissure. The lead ore lay loose on the crevice material occupying the cavity, and was easily removed without blasting. Crossing the Holmes range was a ''quartering'' northeast and southwest, which was rich in ore. A north and south fissure close by also carried considerable amounts. The mineral in the Holmes, as not unfrequently occurs in the mines, ''jumped'' from one east and west to another parallel crevice of the same range. In this case the opening in the crevice followed became narrow and the galena gradually disappeared, but only to reappear in the other crevice. In all the specimens seen from the Guttenberg district the lead was crystallized not in simple cubes, but in combination forms of the cube and octahedron, the latter form often predominating or occurring alone. This locality formerly produced considerable lead, and two smelters were at one time in operation on Miner creek. After a few years' working the deposits gave out in the majority of the diggings and they are now practically abandoned.

About three miles southeast of Buena Vista and less than half a mile south of the Dubuque county line, the Fitzpatrick Lead Mining Company opened a mine in 1903. It is located in the northwest quarter of section 2 of Concord township, Dubuque county. Lead was discovered here by Mr. Fitzpatrick in 1900 and 36,000 pounds are said to have been taken out. The galena was about twenty feet below the surface and imbedded in clay in a ravine.

Water Resources.

An abundant water supply can always be assured by going down to the Saint Peter sandstone and in the central and northern portions of the county many wells have been drilled to this formation. Wells 400, 500 and 600 feet deep are not uncommon. On the ridge between the Turkey and Volga rivers one well has been sunk 666 feet to the Saint Peter, passing through the Niagara, Maquoketa and and Galena-Trenton formations. Water is also often struck in the Galena-Trenton beds, and many farm wells obtain their water supply from this source. McGregor secures its water from the Saint Croix sandstone, while Strawberry Point and the adjacent region draw supplies from the Niagara limestone. There are also shallow wells in the drift at many points.

Two flowing wells furnish Elkader with water. These are twenty-five feet apart and are 182 and 184 feet deep respectively. They extend thirty feet into the Saint Peter sandstone and give an abundant supply. The water is pumped into a reservoir on a hill nearly 300 feet above the town, giving a strong pressure in the mains. A third flowing well is at the Fair Grounds just below town.

McGregor has four flowing wells, the deepest a little over 1000 feet. The water supply for the town is obtained from a well less than 400 feet deep. The water is pumped into a reservoir on a hill and is very pure and free from mineral substance.

The following facts regarding the wells at McGregor and Prairie du Chien are taken from W. H. Norton's report.

WELLS AT McGREGOR.†

	WELL NO. 1.	WELL NO. 2.	WELL NO. 3.
Owner.	Town	Town.	J. Goedert.
When drilled.	1876-1877.	1890.	1889.
Depth	1,006 feet.	520 feet.	294 feet.
Diameter.	6 in. reduced to 3 in.	6 in. reduced to 3 in.	6 inches.
Elevation of curb.*	632 feet A. T.	618 feet A. T.	622 feet A. T.
Head of water.	694 feet A. T.	638 feet A. T.	644 feet A. T.
Flow per minute.	20 barrels.		
Temperature.	54° Fahr.	52° Fahr.	52° Fahr.

From this locality, including Prairie du Chien, on the Wisconsin side of the Mississippi river, there are reported some twelve artesian wells; and it is gratifying to learn that notwithstanding the great volume of water daily poured from the basin, well No. 1, one of the pioneer wells of the state, has suffered no preceptible change in its flow. In this well four-inch copper casing is used to a depth of forty feet, the original six-inch iron casing having been destroyed within two years by the corrosion of the saline water. No packing was used and it is thought that there is some leakage at the base of the casing. Well No. 2 was also recased, reducing the diameter from six inches to three inches, as the original casing was poorly done and the water leaked out through the joints. The second casing extends to 215 feet, and is packed at the base with a rubber gasket. In each of the wells the first flow was struck at 315 feet A. T., and from this to the base all sandstone beds were water-bearing. At a little over 520 feet from the surface brine was found in four feet of white sandstone. The two town wells supply fire protection, several public drinking places and the two finest fountains in the state. Three-eighths of a mile of pipe are laid through the business portion of the town, with five hydrants and a number of public taps. The water of the deeper well corrodes iron so rapidly as to be entirely unfit for steam purposes. Although somewhat saline it is palatable to most persons. The water of well No. 2 has no corrosive effect on boilers, but forms a slight scale.

†Reported by Mr. C. W. Walker and Hon. Horace Beach

*With the elevation of the Chicago, Milwaukee & St. Paul railway station at 612 feet A. T. according to Gannett as datum.

Several chemical analyses have been made of the waters of the McGregor artesians. The following by Joseph Henry of the Smithsonian Institution, is given as published in the North Iowa Times, March 15, 1887.

"The * * * * analysis of the water of the McGregor artesian well No. 1, is found to be a saline water, holding in solution in round figures 136 grains of solid matter to the gallon as follows:

Silica.	Potassium.	Sulphuric acid.
Iron.	Sodium.	Phosphoric acid.
Alumina.	Lithium.	Boracic acid.
Lime.	Chlorine.	Carbonic acid.
Magnesia."		

Scarcely more satisfactory is the analysis of the same well made by Hinrichs, January, 1879.

Specific gravity at 19½° C	1.0014
Total mineral matter, grains per gallon	157 0 gr.
Carbonate of lime, grains per gallon	22.4 gr.
Sodium carbonate and magnesium sulphate	134 6 gr.

"The water also contains a very small amount of lithium chloride, the lithium lines being visible but faint when the residue of the water is examined by means of the spectroscope."

Official Analyses.

	NUMBER 1.		NUMBER 2.	
	Grains per U. S. gallon.	Parts per million.	Grains per U. S. gallon.	Parts per million.
Silica (SiO_2)	323	5.571	.398	6 857
Alumina (Al_2O_3) } Ferric oxide (Fe_2O_3) }	.348	6.000	.124	2.143
Lime (CaO)	13.200	227,571	4.524	78.000
Magnesia (MgO)	2,443	42.286	2.834	48 857
Potash (K_2O)	...	......,	Trace	Trace
Soda (Na_2O)	55 083	949.714	3.695	63.714
Chlorine (Cl)	56.136	967.857	2.088	36 000
Sulphur trioxide (SO_3)	22.504	388 000	2.618	45.143
Carbon dioxide (CO_2)	10.664	183.857	10.705	184.572
Water in combination (H_2O)	1 069	18 428	1.732	29.857
Free (CO_2)	[9.305]	[160.428]	[4.350]	[75.000]
UNITED AS FOLLOWS.				
Calcium carbonate ($CaCO_3$)	....	....	5.245	90.429
Calcium bicarbonate ($CaH_2(CO_3)_2$)	17.930	309 143	4.549	78.429
Magnesium bicarbonate ($MgH_2(CO_3)_2$)	......	... . .	9 868	170 143
Calcium sulphate ($CaSO_4$)	17.002	293 143	....	....
Magnesium sulphate ($MgSO_4$)	7.325	126,286	.332	5.714
Sodium sulphate (Na_2SO_4)	13 539	233 428	4,276	73 714
Sodium Chloride (NaCl)	92.634	1597.143	3.455	59.571
Alumina (Al_2O_3) and Ferric Oxide (Fe_2O_3)	.348	6 000	124	2.143
Silica (SiO_2)	.323	5.571	.398	6 8-57
Oxygen replaced by chlorine (O)	12.677	218.570	.472	8 143
Solids	161.778	2789 284	28 720	495.143

Analyst: Prof. J. B. Weems, Ames, Iowa. Date: June 16, 1896.

RECORD OF STRATA,

The following record of a well at Prairie du Chien* will illustrate the geological section at McGregor.

		THICKNESS.	DEPTH.
16.	Sand and gravel	147	147
15	Clay, fine, light blue	½	
14.	Limestone, hard arenaceous	2	149
13.	Grit, blue	6	155
12.	Shale, bluish green, arenaceous	107	262
11.	Sandstone, white, friable, alternating with hard streaks	118	380
10.	Grit, blue	35	415
9.	Slate rock	65	480
8.	Sandstone, reddish and yellow ochery	6	486
7.	Shaly rock	24	510

*Geology of Wisconsin, vol. IV, p. 61.

		THICKNESS.	DEPTH.
6.	Sandstone, white, carrying brine	4	514
5.	Slaty rock	75	589
4.	Sandstone	310	899
3.	Sandstone, red	45	944
2.	Conglomerate, white waterworn quartz pebbles	5	949
1.	Sandstone, coarse	10	959

The curb is near the summit of the Saint Croix. No. 16, the alluvial filling of the preglacial valley of the Mississippi, supplies the place of the upper sandstone of the Saint Croix, the Jordan. No. 14 is the remnant left after erosion of the Saint Lawrence dolomite. Nos. 12 and 13 are the Saint Lawrence shales. Preceding numbers represent the basal sandstone of the Saint Croix. Another well at Prairie du Chien was sunk to a depth of 1,040 feet without reaching the Algonkian.* †

Monona gets its water from a well 459 feet deep and reaching the Saint Peter sandstone. This well supplies the railroad and town in part. The water is pumped into the railroad water tank and some pressure is thus secured in the pipes. The town has three miles of mains. A portion of the supply is obtained from a large spring near by. The water is collected in three or four basins and from these pumped by wind mill and gasoline engine into a tank.

Strawberry Point is supplied with water from two wells 160 feet deep and ten feet apart. The water is pumped into a standpipe. The record of the wells shows that 125 feet of loess and drift were penetrated and thirty-five feet of Niagara limestone. The water is not very hard and is good both for drinking and for boiler use. About one-half mile east of town near the center of section 23, a well sunk on the ridge marking the border of the Iowan drift, passed through 172 feet of loess and drift. It went fourteen feet into the Niagara limestone, when a good flow of water was found. In the vicinity of Strawberry Point water is obtained in the Niagara at depths of from 160 to 250 feet.

*Iowa Geol. Surv., Vol. VI, 1896, p. 185-188.
†Private letter from Hon. Horace Beach.

Water Power.

The larger rivers of the county are capable of furnishing a plentiful water power and this has been utilized at several points. A dam on the Turkey river at Elkader supplies power to a large and well equipped mill. There is also a stone mill at Motor, between four and five miles below Elkader. On the Volga river power is secured for flour mills by dams at Volga City and Mederville. At the latter place the conditions for constructing a dam were especially favorable. The river here flows in a narrow rock-walled gorge, the sides of Galena dolomite rising abruptly from the water's edge. Two miles north of Strawberry Point is a stone mill with a turbine wheel run by water from a large spring near by. The stream flowing from the spring is dammed, and from the pond thus formed a sluice and iron pipe carry the water to the wheel pit.

Clams.

No account of the economic products of Clayton county would be complete without some mention of the clams of the Mississippi river which yield shells for the manufacture of pearl buttons. This has grown to be an important industry in many river towns of the upper Mississippi, and during the clamming season hundreds of men are employed in gathering the shells. For this purpose they are equipped with a boat and two iron rods made from ordinary gas pipe. From these rods at regular intervals are suspended short pieces of rope or stout twine to which hooks are attached. These rods are let down by ropes into the mud at the bottom of the river and dragged for a short distance. Whenever one of the hooks enters an open clam shell the two valves close tightly upon it. If the haul is a good one every rope will have a clam dangling from the end of it, and, since the rod has several dozen of hooks attached to it, each catch represents a large number of shells.

Clamming in the vicinity of McGregor began in the spring of 1898. In the early days of the industry one man could catch a ton of shells in a day, and these were carefully selected shells, for the poor ones were thrown back into the river. The clams are now becoming much reduced in number and at present a man cannot catch more than 500 pounds at best in a day. The shells now (1903) sell for $20.00 a ton, whereas the price in the early days of clamming was only $6.00 or $7.00 a ton.

The season lasts about two months, since the clams do not "bite" well when the warm weather begins. The best time is from about the middle of April to the middle of June and this may be considered the clamming season. During these months the river is thickly dotted with the boats of the fishermen, and the shores are lined with their tents. They come here from places as distant as Ohio and Tennessee.

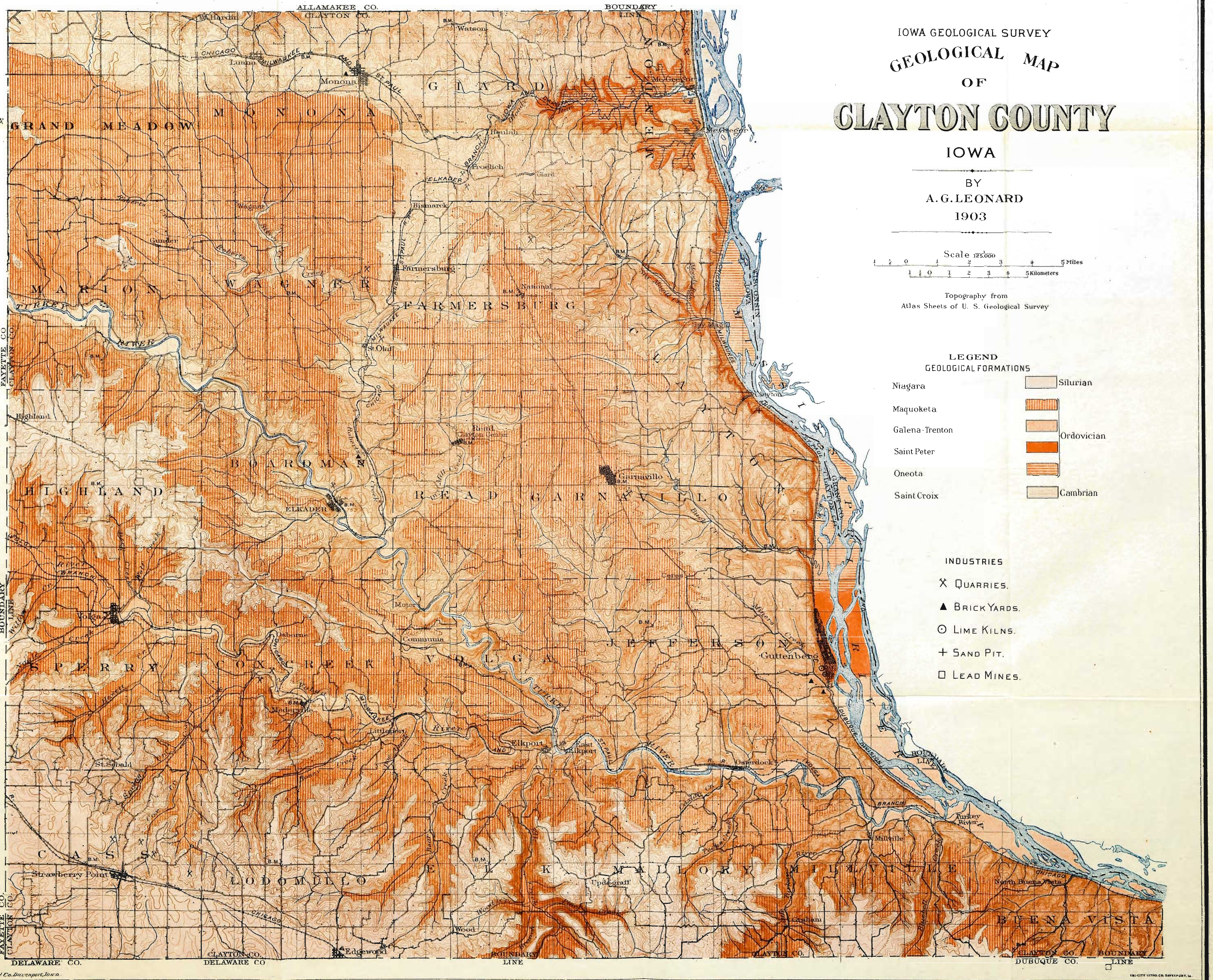
The clams are valuable not only for their shells but for the pearls and "slugs" they yield. These are found in the mantle or between the mantle and the shell. The pearls are discovered when the shells are being cleaned after having been first steamed to open the valves. They are felt for in the soft parts of the animal as these are being removed.

Many of the pearls equal the South Sea Island variety in luster and purity of color. They vary in color from the purest white to various shades of pink, and occasionally a black one is found. It is not uncommon to find pearls which sell for from $100 to $1000, and occasionally one is found which brings as high as $3000.

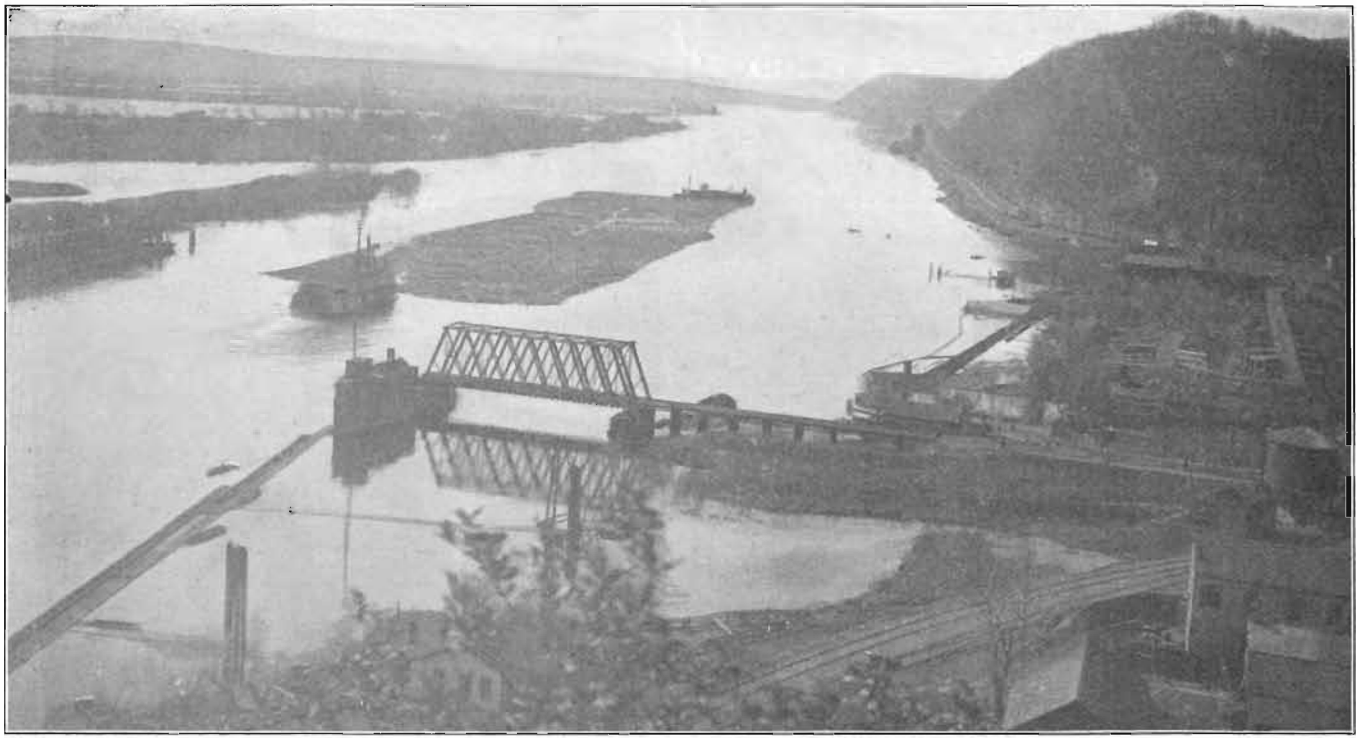
Those which are imperfect in any way, as in form texture or color, are known as slugs. These are the "baroque pearls" of the jeweler, which are now in such high favor. Some of these are of great beauty and may lend themselves to great variety and beauty of design. The pearls and slugs too small for other purposes are sold under the name of seed pearls. These are perforated by minute holes, strung on the finest thread and used in ornamenting lace and embroidery.

Acknowledgments.

The thanks of the Survey are due the many citizens of the county who showed their interest in and appreciation of the work by supplying whatever information was in their possession. The fossils were kindly identified by Professor Samuel Calvin and


IOWA GEOLOGICAL SURVEY
GEOLOGICAL MAP
OF
CLAYTON COUNTY
IOWA
BY
A. G. LEONARD
1903
Scale 1/125,000
5 Miles
5 Kilometers
Topography from
Atlas Sheets of U. S. Geological Survey
LEGEND
GEOLOGICAL FORMATIONS
Niagara
Silurian
Maquoketa
Galena-Trenton
Ordovician
Saint Peter
Oneota
Saint Croix
Cambrian
INDUSTRIES
QUARRIES.
BRICK YARDS.
LIME KILNS.
SAND PIT.
LEAD MINES.
ALLAMAKEE CO.
CLAYTON CO.
BOUNDARY
LINE
GIARD
GRAND MEADOW
MONONA
MARION
WAGNER
FARMERSBURG
BOARDMAN
HIGHLAND
READ
GARNAVILLO
SPERRY
COX CREEK
VOLGA
JEFFERSON
CASS
LODOMILLO
ELK
MALLORY
MILLVILLE
BUENA VISTA
FAYETTE CO.
CLAYTON CO.
DELAWARE CO.
DUBUQUE CO.
WISCONSIN
Monona
Luana
Watson
McGregor
Farmersburg
Elkader
Garnavillo
Guttenberg
Volga
Strawberry Point
Edgewood
Elkport
Millville
North Buena Vista
Highland
Iowa Pub. Co. Davenport, Iowa.

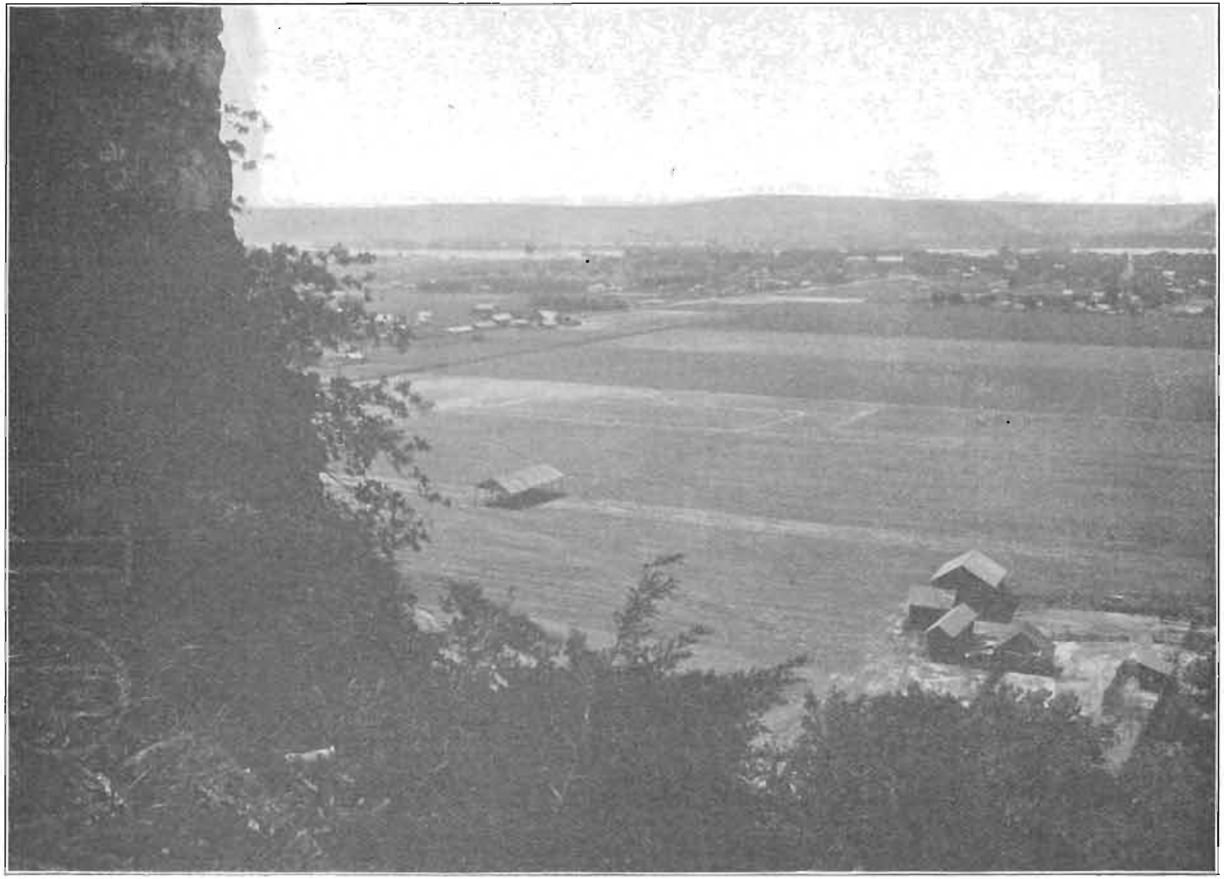
for this and many helpful suggestions the writer is under special obligation. Assistance was also rendered by Mr. J. C. Flenniken whose intimate acquaintance with many portions of the region made his help especially valuable and much appreciated. The great value of the topographic work of the United States Geological Survey should be here acknowledged. The topographic features represented on the accompanying maps of the county have been copied from the sheets of the United States Survey, and without these the mapping of the geological formations would have been a work of infinite labor.



The bluffs of the Mississippi below North McGregor.

p 310

View looking up the Mississippi Valley from Pikes Peak, two miles below McGregor.



The broad flood plain of the Mississippi at Prairie du Chien, looking toward the Iowa shore

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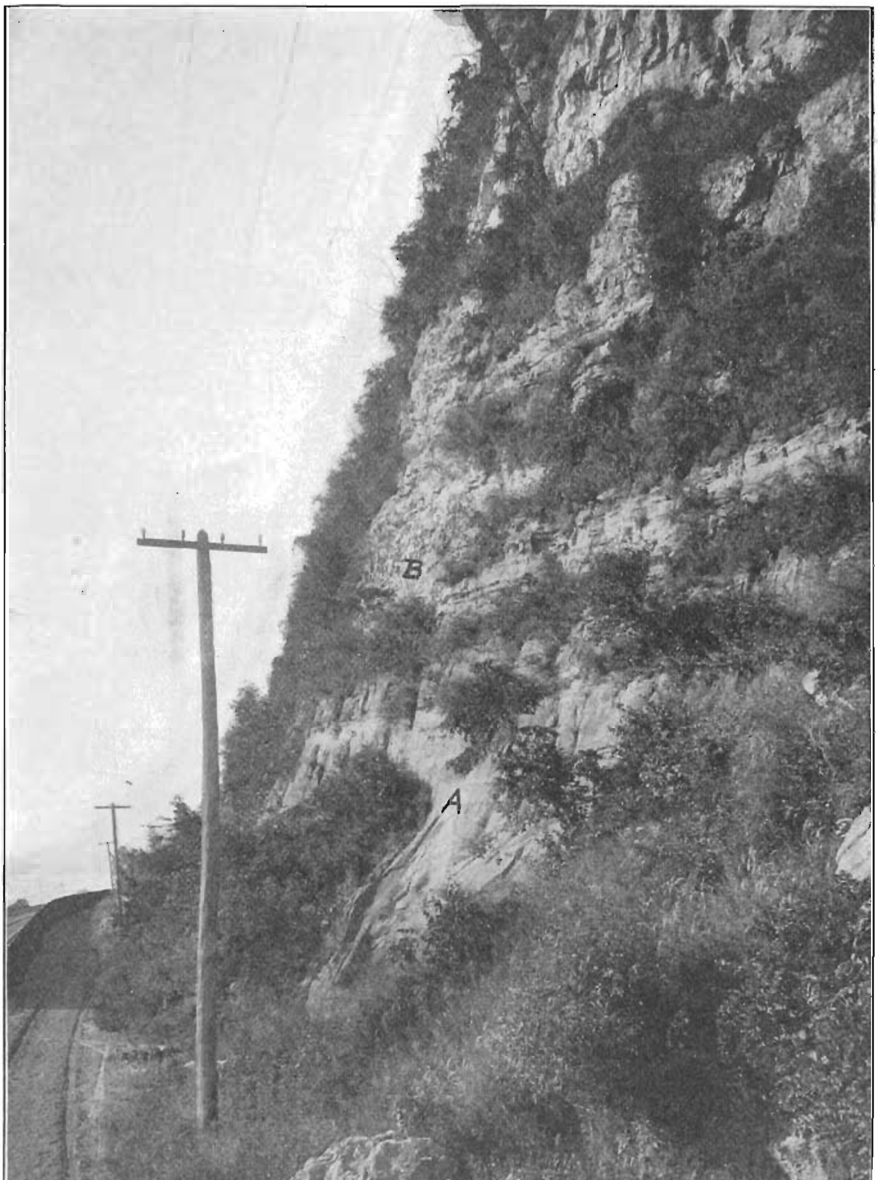
Narrow ridge formed of Galena-Trenton limestone at the mouth of the Turkey river



Point Ann, just below McGregor A is the Saint Croix sandstone B is the Oneota limestone

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GEOLOGY OF BREMER COUNTY.

BY

WILLIAM HARMON NORTON.

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GEOLOGY OF BREMER COUNTY.

BY WM. H. NORTON.

CONTENTS.

INTRODUCTION.

LOCATION AND AREA.

Bremer county bears the name of the distinguished Swedish novelist and traveler, Fredrika Bremer, being the only county of the state which thus honors one eminent in literature. Miss Bremer's Christian name is recorded on the county maps, though with an unfortunate interpolation of a letter, in the township and village of Frederika.

Bremer county is situated in northeastern Iowa. Two counties, Chickasaw and Howard, intervene between it and the Minnesota line and two, Fayette and Clayton, lie between it and the Mississippi river. Comprising townships 91, 92, and 93 of ranges 11, 12, 13, and 14 west of the 5th principal meridian, it is a rectangle twenty-four miles long from east to west and eighteen miles wide from north to south, with an area of 432 square miles. While Bremer county includes twelve congressional townships, it is subdivided into fourteen civil townships. Township 93, range 12, is divided between Frederika and Leroy townships, the valley of the Wapsipinicon falling to the former and the valley of the East Wapsipinicon to the latter. In order to bring the city of Waverly within a single township the boundaries of Washington and the townships adjacent are made irregular, although not deviating from section lines.

Bremer county lies for the most part upon the outcrop of the limestones and shales of the Devonian system, a broad belt extending diagonally across the state from Worth and Howard counties on the northwest to Muscatine and Scott counties on the southeast. It occupies a somewhat central position upon the wide sheet of glacial deposits known as the Iowan drift. Furthermore, it stretches across the valleys of three goodly rivers, which extend for many miles beyond its limits. Any description, therefore, of either the geology or the physiography of this restricted area must include features shared with other counties as well as some perhaps peculiar to itself. A large number of the problems presented by the rocks and superficial deposits of the area have been solved elsewhere and many of the phenomena which occur here have been elsewhere described and interpreted.

Hence the student of the local geology may profitably extend his reading to the descriptions of similar areas as given in the annual reports of the Iowa Geological Survey, such as the reports on the geology of Cerro Gordo, Mitchell, Chickasaw and Johnson counties by Calvin, Benton and Fayette counties by Savage, Black Hawk county by Arey, and Linn, Cedar and Scott counties by Norton.

PREVIOUS GEOLOGICAL WORK.

Before the organization of the present Survey Bremer county received little attention from professional geologists. No mention is made of the county in the reports of the Geological Surveys of Iowa conducted by Hall and Whitney and by Chas. A. White. Fossils collected at Waverly either by R. P. Whitfield, or by Orestes H. St.John and examined by Hall led to the mention in the 23d Annual Report of the New York State Cabinet of Natural History, Albany, 1873, of the fact that nearly the same series of fossils occur at Waverly as at Independence.

McGee, in the Pleistocene History of Northeastern Iowa (Eleventh Annual Report, U. S. G. S., Washington, 1891), quotes a description by Shimek of two species of fossils from the loess six miles southeast of Waverly, and mentions an unusually large bowlder two and one-half miles north of Sumner.

PHYSIOGRAPHY.

RELIEF.

Bremer county is included in the wide plain of northern Iowa. So slight is the relief that it would be hardly noticeable when represented on section or model drawn without great exaggeration of the vertical scale. The maximum local relief can hardly exceed one hundred and fifty feet. The highest point of the county whose altitude is known, the crest of the prairie upland, about two and one-half miles northwest of Sumner, is 1128 feet above tide, according to the profile of the Chicago Great Western Railway, and stands about 250 feet higher than the lowest point, the Cedar river at Janesville.

Nowhere is the plain of Bremer county entirely level. Shallow sags and low irregular swells diversify the surface even where it most closely approaches horizontality. In places, as east of Waverly, bold, isolated, rounded hills surmount it. In eastern Jefferson township and the adjacent part of Washington the plain gives way to a sharply dissected upland. Moreover the plain is trenched by the valleys of the streams, and over considerable areas by the systems of numerous and fairly deep lateral ravines.

All the same the prevalent type of the Bremer county landscape is the gently undulating plain. It thus stands in strong contrast with several other typical Iowa landscapes. A few miles to the east lies the maze of deep valleys of eastern Fayette county and of Clayton, and all the mature erosion topography of the driftless area. To the southeast, from Jones and Clinton counties westward, lies the singularly fluted landscape of the ridged drift, where wide belts of undulating lowland, stretching from northwest to southeast parallel with the river courses though often not occupied by the master streams, alternate with long ridges and uplands of well dissected drift. Farther south is found the typical landscape of the Illinoian and Kansan drift of southeastern Iowa, where the dominant topographic form is the tabular divide, flat as a floor, and separated from adjacent similar remnantal levels by the comparatively narrow valleys which streams have carved upon the initial plain. The divides of Bremer county never have the flatness of the Kansan and Illinoian drift of southeastern Iowa, nor do the wide long vistas seen from the crests of the ridged drift of east-central Iowa anywhere here meet the eye.

The slight local relief of the county is indicated by any road map. The straight roads almost everywhere follow the section lines without deviation. In exception we may note the diagonal stretches of the road from Waverly southeast to Denver, following the trend of the peculiar hills at whose base they lie, the short stretches of road in the hilly region of sections 17 and 18, township 91, range XIII, which leave their direct courses to obtain an easier grade, and the diagonal road which follows the side of the Wapsipinicon valley south of Tripoli for a short distance.

TABLE OF ALTITUDES.

The following table gives the elevation above tide water of those points in the county whose altitude has been determined, with the authority for the same.

Bremer	1044 feet.	Profiles of C. G. W. Ry.
Denver Junction	1015 feet.	Profiles of C. G. W. Ry.
Janesville	891 feet.	Gannett's Dict. of Altitudes.
Plainfield	941 feet.	Gannett's Dict. of Altitudes.
Potter's Siding	1056 feet.	Profiles of C. G. W. Ry.
Readlyn	1042 feet.	Profiles of C. G. W. Ry.
Sumner, C. G. W. Ry	1060 feet.	Gannett's Dict. of Altitudes.
Tripoli	1025 feet.	Profiles of C. G. W. Ry.
Waverly, I. C. and G. W. Ry. crossing	936 feet.	Gannett's Dict. of Altitudes.

DRAINAGE.

Three master streams, the Cedar, the Shell Rock and the Wapsipinicon rivers, pursue a south-southeasterly course across Bremer county. The Shell Rock transects the southwestern corner of the county with a winding course of about seven miles in length, and joins the Cedar a mile or more south of the county line. As in the case of the Iowa and Cedar rivers, so here it is the smaller and shorter stream which aligns itself with the course below the confluence, while the larger and longer stream suddenly diverges from its parallel track to meet the axial stream at a high angle. In nomenclature the two cases cited are quite opposite. In the case of the Iowa and Cedar, the course below the confluence takes the name of the axial stream, to which the larger stream is thus made tributary. In the case of the Cedar and the Shell Rock the smaller stream, though axial, is called the tributary of the larger.

The tributaries of the three rivers named as a rule maintain subparallel courses with their master streams until near the confluence. The interstream area between the Little Wapsipinicon river and Buck creek is from two to four miles wide. Buck creek, rising in the northern tier of sections, flows along side the Wapsipinicon across the county, the divide between the valleys in the southern townships seldom exceeding a mile and a half or two miles in width. The East Wapsipinicon holds its parallel course in northern Leroy township about three miles distant and then flowing southwest joins its master stream. Crane creek crosses nearly the entire county along a track from three to five miles west of the Wapsipinicon and flows into that river in Black Hawk county. The next two creeks, Quarter Section run and Baskin run, flow side by side about three miles apart and at about the same distance from their trunk stream, the Cedar river, on the west, and from Crane creek on the east.

A glance at the drainage map of the county shows the eccentric behavior of one of the streams just named, Quarter Section run. In the normal development of a river system the affluents are expected to join their trunk stream as twigs their stems, at somewhat less than a right angle, and such are all the other confluences in our area. Quarter Section run, however, suddenly departs from its southeastern course about two miles below Denver and turns abruptly to the northwest. Flowing for five or six miles in a direction opposite to that of all the other streams, it picks up Baskin run and meets the Cedar at the sharp bend where the latter turns to join the Shell Rock. Thus we have here a T whose horizontal bar is made of Quarter Section run on the one side and of the Cedar on the other, flowing from the opposite directions, and whose stem is formed of the Cedar below the confluence. To find explanation of this singular fact we must await the description of the topography of the area.

In summation, Bremer county is drained by a series of subparallel streams whose general course is directed somewhat east of south and which are so spaced that their tracks lie seldom more than three or four miles apart. On interstream areas so narrow and, as we are to see later, so immature, no laterals have developed worthy of name upon the county maps.

In anomalous contrast with the south-southeastward courses of the streams is the strong southwestward slope of the country, as Calvin has already shown in his reports on Mitchell and Chickasaw counties. From the high divide which extends from eastern Howard and southwestern Winneshiek counties across Fayette county west of the Volga river, through Strawberry Point and Edgewood, to the vicinity of New Vienna in Dubuque county—to follow it no farther beyond the limits of our field,

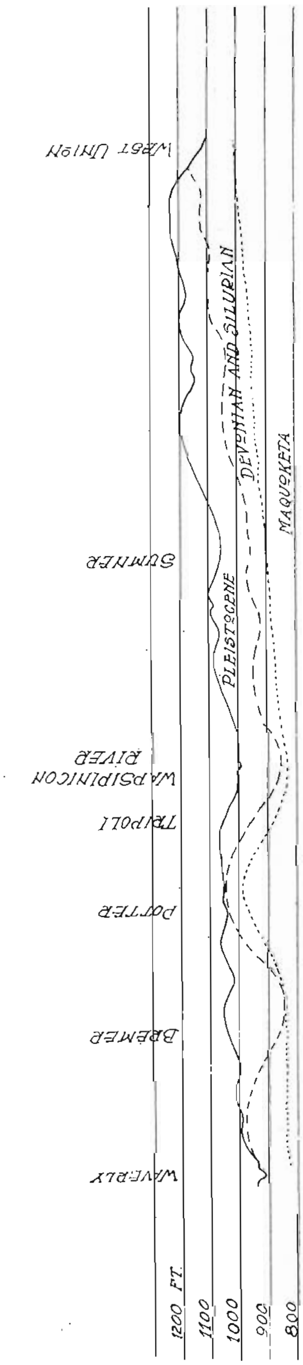


Fig. 38—Profile from West Union to Waverly showing the southwesterly slope of the surface.

the land slopes everywhere southwestward toward the great trough of the Cedar. This is shown graphically in the accompanying diagram based on the profile of the Waterloo, Cedar Falls and Northern Ry., from Waverly to Sumner, and on the topographic maps of the U. S. Geological Survey thence to West Union. On this northeast-southwest line the upland gradually declines from 1240 feet A. T. on the high prairie overlooking West Union, to 1100 feet at Sumner, to 1065 feet west of Tripoli, to 1045 feet at Bremer, and to 1010 feet on the prairie west of Baskin run,—an average slope of about seven feet to the mile.

The same strong slope appears on a similar profile of the upland south of our area,—from Farley in Dubuque county southwest to Linn Junction in Linn county. The Iowan drift plain stands at 1160 feet A. T. about Farley, at 1040 feet between the Maquoketa and the Wapsipinicon near Prairieburg, while between the Wapsipinicon and the Cedar the same plain has declined from 980 feet near the former river to 840 feet A. T. near the latter,—a gradient from Farley to Linn Junction of seven feet to the mile measured outside the immediate valleys of the rivers.

Contrast this with the comparatively slight fall of the streams whose courses bear to the southeast and with the descent of the

Iowan drift plain in the same direction. According to Gannett, the elevation of Waverly is 936 feet A. T. and that of Cedar Rapids is 732 feet, each being built on the flood plain of the river at about the same height above the stream. The fall of 204 feet gives here a gradient of three feet per mile in a straight line, neglecting the winding course of the river. From Tripoli to Stone City the Wapsipinicon falls 180 feet, a straight line gradient of 2.8 feet per mile. Taking the southeast slope of the Iowan plain from the high prairie near Tripoli, 1065 feet A. T., to the plain southwest of Stone City we have an average slope of two feet per mile. Thus the streams of the Iowan plain east of the Cedar river do not flow with the slope of the country. The major slope of the plain is southwest; the streams flow to the southeast.

In explanation of this exceedingly anomalous behavior several hypotheses suggest themselves. We may conceive that in Iowan times the great depression whose axis is now held by the Cedar river was filled brim-full of glacier ice and that the surface drainage of the stagnant ice was directed to the southeast, the general direction of the glacial flow. Cutting at last through the ice, these surface streams were let down upon a land whose slope was southwest, and on this they entrenched themselves both by corrasion of their channels, and by the deposition of waterlaid drift about their banks.

Again, streams which are younger than the Iowan drift, whose initial courses lay upon its surface on the melting of the Iowan glacier, may have had their tracks determined by long troughs of the drift surface due to phenomena either of modelling or of erosion connected with the southeastward movement of the ice. Deep preglacial buried channels, such as are known to exist throughout eastern Iowa, may have contributed largely to form these troughs upon the surface of the drift either because they were never filled to the level of the land on either side, or because the exceptionally thick drift laid in them settled and formed sags.

These explanations assume that the Cedar depression is preglacial and that the southwestern slope of the country antedates the origin of the present streams. An alternative theory may also be considered that on the melting of the Iowan ice the slope of the region was to the southeast, thus determining the courses of the initial consequent streams, the present inclination being due to later warping, to which the rivers are not yet adjusted.

THE VALLEY OF THE CEDAR RIVER.

The Cedar river enters the county from the north in a valley three quarters of a mile in width, whose flat floor lies about thirty feet above water level. Rock is exposed in places along the banks of the stream, but we have no knowledge as to whether these are local spurs or a part of a wide rock floor due to planation by the stream when flowing at a somewhat higher level and left covered with a veneer of alluvium. On either side rise hills of drift with moderate slopes eighty feet high or more above the river.

A mile north of Plainfield the lines of bordering hills swing out until they are four miles apart at Horton, which occupies an eastern reentrant of the river-plain where two creeks debouch. The flat fluvial floor continues with a width of about three miles well into Lafayette township. This wide old river-plain stands at the inner margin but about fifteen feet above the present flood plain of the river and rises almost imperceptibly on its outer margin to merge with the gentle slopes of the bases of the bordering hills. These second bottoms are prevailingly sandy. Shallow driven wells secure abundant water everywhere upon them. The shifting banks of the river show nothing here but alluvial deposits. Originally the river plain was well wooded, but much of the forest has been cleared to make room for pastures and plowed fields. Bowlders of the Iowan drift are seen out upon the plain in several places, and here the valley of the Cedar and those of the creeks which merge with it on the left bank near Horton are clearly older than this most recent ice invasion of the county.

In Lafayette township the valley constricts to a width of a mile and a half and a mile, while midway the township it narrows to less than half a mile. Rock outcrops in low ledges at a number of places a few feet above the flood plain on the bounding hill sides. Yet nothing like a gorge appears, and the aspect of the valley is still by no means youthful. On the left bank the hills now rise fifty or sixty feet above the stream, many of them sandy, especially near the river, and underlain with rock at no great distance from the surface. Approaching Waverly one sees on the left groups of the lenticular loess-capped hills called *paha*; the valley narrows until in the north part of the town rocky hills hem it in to a width of about eighty rods. Again the valley opens, leaving beneath the high loess hills with their rocky basements room for the business blocks of east Waverly on an ancient terrace of the river. On the west side the terrace is still more ample, widening to about half a mile, and is occupied by the chief residential portion of the little city. Even this

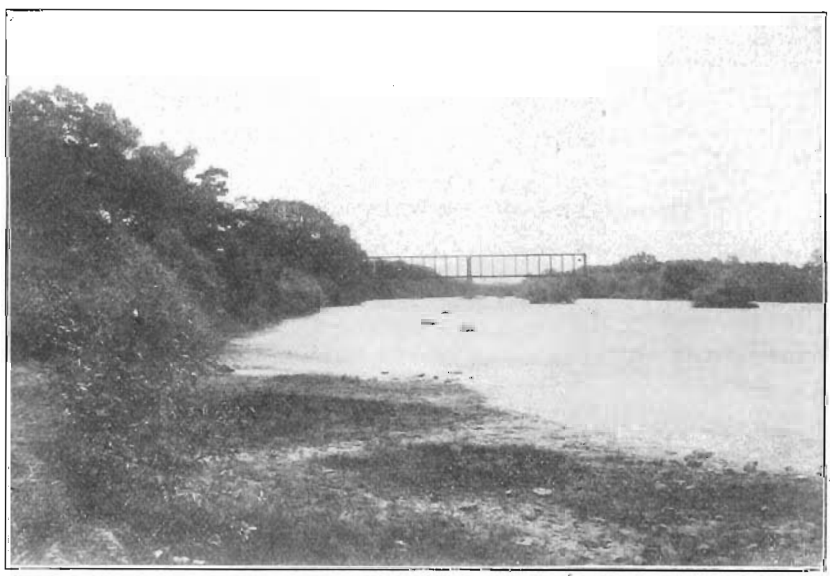


Fig. 39—Looking down the Cedar River at Janesville.

spacious remnant of the ancient flood plain has not been found sufficient, and the growing town has climbed the sightly slopes of the loess hills to the east and the fairly level Iowan drift plain which overlooks the terrace on the west. The terrace is underlain with rock which outcrops along the river banks, though not in cliffs. Here the stream flows swiftly over a rock bottom. If the reports of wells in Waverly are correct, a deeper channel, abandoned and filled, crosses the terrace on the east side of the town, where at the Creamery Supply Factory rock was found fifty feet below the surface. On the bottom lands southeast of town wells are reported to go nearly one hundred feet through river sands without reaching rock, thus disclosing a buried channel far older than the present course of the river through the city.

South of Waverly the Cedar occupies a comparatively narrow valley, seldom more than a quarter of a mile in width, the Iowan plain of thin drift underlain with the Devonian limestones overlooking it on either side. In the southern part of Washington township the river leaves the lower ground of the Iowan plain and plunges directly into a group of high loess capped hills with nuclei of rock. In Jackson township, leaving this rugged area behind, the river again makes use of a comparatively narrow valley bounded by the rock-basemented Iowan plain until at Janesville it finds on the right bank the wide, gravelly, ancient floodplain terrace which here parts it from the Shell Rock.

THE VALLEY OF THE WAPSIPINICON RIVER.

The Wapsipinicon enters the county from the north in a comparatively narrow valley, about one-half mile in width at Frederika, and bordered by low rocky hills. Immediately below Frederika the valley widens to one and a half and two miles and maintains or slighlty exceeds this width during the remainder of its course through the county. The valley is flat-floored, descending however by almost imperceptible degrees toward the thalweg or median stream-line from the base of the gentle slopes of the bordering upland which rises about sixty feet above the river plain.

The valley floor is one of aggradation, not of planation. It is strewn with sand and gravel to a depth of ten or twenty feet, and occasional bowlders, apparently of Iowan drift, are found well out upon it, as well as in large number upon the bordering hillsides. These erratics upon the river plain indicate either that the Iowan ice descended to the flood plain perhaps already fashioned at an earlier date, or that the swollen currents from the melting ice carried small bergs or ice cakes which here and there dropped their load of glacial drift. An earlier ice sheet than the Iowan seems to have found here a valley, and to have aggraded it with its ground moraines. Beneath the surface sands and gravel lies a bed of stony clay, fifty to eighty feet in thickness, the deposit of an ancient ice sheet, probably the Kansan. Underneath this is found a deposit of sand and gravel which may be referred to the Aftonian. These sands and gravels contain an inexhaustable supply of water under artesian pressure, whose head seems to be due to the rise of the aquifer on the sides of the ancient valley. No occasion has been found to drill through these water bearing gravels, so that what lies beneath them and how deep is the rock floor are both quite unknown.

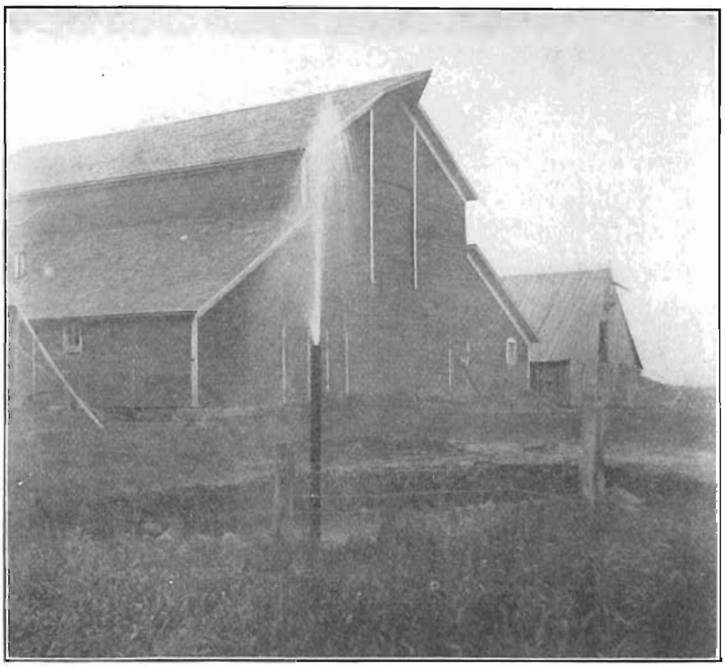


Fig. 40—An artesian well in the Wapsipinicon flood plain.

In this great valley, adequate for a Mississippi, the tiny Wapsipinicon, six or eight rods wide, is as out of place as a mouse in a lion's cage and the misfit is as apparent as a dwarf were in the clothing of a giant. The meanders of the little river, in the few places where it develops these symmetric bends, are hardly more than 800 or 1000 feet in transverse diameter. For the most part the river rolls its waters through a narrow network of inosculating channels, which wind among low, sandy islands, and new courses in channels excavated by the floods of recent years are not uncommon. In one instance the stream divides about a wooded, sandy elevation to form a low island three-quarters of a mile wide and nearly a mile and a half long, set well out from the borders of the valley on either side.

In one respect the Wapsipinicon valley is in marked contrast with the valley of the Cedar. The latter river has cut its present channel a number of feet below the level of the old valley floor. Its ancient flood plain has been left moderately well drained and dry enough for the growth of forests. These have been cleared away for the cultivated fields and pastures of numerous farmsteads, whose dwellings may stand within a few rods of the river banks. On the other hand the aspect of the Wapsipinicon bottoms is that of a wide savanna whose marshy grass lands are suitable only for pasture. Forests have invaded the area only along the natural levees or drained banks of the immediate vicinity of the stream. Farmsteads have gathered along the slopes of the bordering hills, but are almost wholly wanting over the valley. The roads which cross it are carried on well marked dikes ditched on either hand, and as the traveler looks out from them over the wide expanse of marshy grass-land with occasional ponds bordered with sedge and pickerel weed and covered with the yellow water lilies, he receives a vivid impression of the barrier which the "Wapsie bottoms" must have been to the pioneer before these causeways and their bridges had been built.

No village or town is located on the Wapsipinicon within the limits of the county, or indeed, from Bremer north to the state line, excepting the village of Frederika which has the vantage of the gentle slopes of low rocky hills which lift it out of the general wet.

The valley of the East Wapsipinicon repeats the features of the Wapsipinicon valley on a smaller scale. Its floor is about one mile wide and the valley has been filled with drift and aggraded with glacial outwash and alluvium to the depth of from eighty-five to more than one hundred feet. Deep lying gravels, referred to the Aftonian, supply artesian water in the lower reach of the valley.

The creeks of the county tributary to the master rivers rise in marshy sags of the Iowan drift plain, winding around low swells in indecisive courses and indistinct valleys, which widen where a basin has been aggraded and narrow where the overflow from slough to slough has cut its way across the intervening rim. From these humble beginnings the larger creeks, such as Crane creek, attain at last aggraded valleys a quarter or a half mile wide as measured across the flat sandy and marshy valley floors, and sunk forty feet or more below the bordering upland. At ordinary stages these sluggish creeks content themselves with channels a rod or so in width, but at flood they widely overflow the adjacent bottoms. An occasional low sand dune occurs upon the flood plains, and gravel terraces fifteen or twenty feet above the streams were noticed in places.

STRATIGRAPHY.

General Relations of the Strata.

The indurated rocks of Bremer county consist of sea-laid limestones and shales belonging to several different natural groups called formations. The lowest, and hence the earliest, of these which come to the rock surface in our area are shales belonging to a stage known as the Maquoketa. In Bremer county the Maquoketa shales are found only in deep drift-filled valleys, where the overlying strata have been removed by long preglacial erosion, and in deep borings beneath the cover of later formations. With the gentle rise of the strata of this region to the northeast the shales outcrop along a belt which stretches from Howard and Winneshiek counties as far south as northern Clinton county. These ancient sea muds testify to a time when our area lay beneath the sea, and when the sea was here clouded with fine waste washed from a not distant land, lying probably to the east and north. Fossils, the remains of ancient organisms, occur in profusion in the Maquoketa shales at many of their outcrops, as at Elgin in Fayette county, and these fossils show that the shales belong to a system of strata known as the Ordovician, deposited at a time so remote that so far as known no animals then tenanted the land, and fishes of a lowly type were the highest organisms to be found upon the earth.

Resting upon the Maquoketa shales are beds of limestone which prior to this survey were not known to extend into Bremer county. This limestone, as its fossils show, belongs to the Hopkinton stage of the Niagara series and to the Silurian system. Although it comes to the surface at only a few points, on Crane creek, Baskin run and Quarter Section run, it underlies, like the Maquoketa, the entire county. The Niagara limestone records a period of great length when by long denudation the neighboring lands had been worn so low that their sluggish streams now brought into the shallow Silurian sea little except soluble waste, or when the shores had become so remote by a transgression of the sea that little clay and sand was washed out so far from land as was our area. In such clear waters lime secreting animals, such as sea shells and corals, grew in great profusion, and from their remains extensive sheets of limey oozes were produced which are now found consolidated to firm rock. These strata outcrop at Hopkinton in Delaware county, whence they derive their name.

In Linn, Cedar, Scott and other counties lying south of our area, there rests upon the Hopkinton limestone another belonging to the same Niagara series and known as the Gower stage. In Bremer county as in Fayette the Gower limestone does not occur, suggesting that northern Iowa was land in Gower times.

Resting immediately upon the Hopkinton limestone occurs a body of limestone shown by its fossils to belong to the Devonian system. The Devonian limestones form the rock foundation of nearly the entire county, outcropping wherever the streams have cut through the superficial stony clays of later date. According to their lithological differences and included organisms the Devonian limestones have been divided into two stages, the Wapsipinicon and the Cedar Valley.

The Wapsipinicon, the lower of these stages, receives its name from its excellent outcrops on the Wapsipinicon river in Linn county, and there it presents a number of subdivisions, or sub-stages, not all of which have been discriminated in Bremer county. The Wapsipinicon limestones outcropping south of Waverly on the Cedar river and its tributary creeks, have been extensively broken by earth movements and their cemented angular fragments form what is known as breccia. From its occurrence at Fayette this zone of broken rock has long been known as the Fayette breccia. Since several formations are involved in this brecciation, which sometimes includes even the lower beds of the Cedar Valley stage, it has seemed best to the author to discard the term as a formation-name, notwithstanding its convenience in designating a zone extending from near the northern border of Iowa to Davenport.

The Devonian limestones tell of a shallow sea with shores either remote or so low that little insoluble waste was brought to the limits of our area. The brecciation of the Wapsipinicon records strong lateral pressures, and sudden yieldings to them by these brittle and thin layered rocks, causing, no doubt, great earthquakes to run through the adjacent lands.

The uppermost rocks of the Devonian system and of Bremer county belong to a stage which Iowa geologists have long known as the Cedar Valley, from its extensive outcrops along the Cedar river from near its mouth in Muscatine county to the Minnesota line. The Cedar Valley limestones abound in fossils—corals and allied lowly types, sea shells of many species and the remains of fishes. Our area was in these later times of the Middle Devonian a quiet sea in which, as off the coast of Florida today, great banks of limestone were slowly forming from the remains of the profuse organic life which flourished there.

The Devonian period was succeeded by the Carboniferous, when the coal beds of central Iowa and the eastern states were laid in dense jungles and peat swamps. Outliers of Carboniferous strata occur as far east and north as Linn, Cedar and Jackson counties, but none are known in Bremer, or the adjacent counties. Northeastern Iowa, including Bremer county, seems then to have been land during the entire Carboniferous period and to have been lifted sufficiently above the sea to avoid imperfect drainage and the formation of coal swamps. We may well imagine it covered with the luxuriant gymnospermous forests which formed the highest vegetal life of the time.

In the Mesozoic era the land of which our county formed a part suffered no doubt various oscillations and passed through successive cycles of erosion. In the Cretaceous period of this era the sea came in widely over the lowlands of the continents and the mediterranean which occupied the site of the Great Plains advanced its eastern margin over western Iowa. We have no evidence to show that this incursion reached Bremer county although in Black Hawk county, adjoining Bremer on the south, the presence of well preserved Cretaceous shells in the drift may possibly point to a local buried Cretaceous outlier instead of to a carriage of these shells from Cretaceous areas in southeastern Minnesota.

The Tertiary period witnessed a broad uplift of eastern Iowa and the carving of wide deep valleys in the upland. The drift-buried valleys of Bremer county record this portion of our history. During the Glacial epoch these channels were choked with glacial outwash of sand and gravel and with the stony clays with which the entire county was mantled. Of the successive ice invasions of which other parts of the state bear testimony only three, the pre-Kansan, or Jerseyan, the Kansan and the Iowan ice sheets, made incursions into our territory. Thrice the area was long buried beneath ice sheets comparable in size to that which now covers Greenland, and during two periods besides the near presence of continental ice fields produced a climate of arctic rigor.

With the retreat of the ice from North America the present geological epoch began, whose records are seen in the peat deposits of the sloughs, the humus of the soils, the silts spread by the rivers on their flood plains, hillocks of wind-blown sand and dust, the erosion done by rain and streams, and the disintegration and decay of the surface rocks under the action of the weather.

The following table presents the succession of all these various deposits ranging in age from those of tens of millions of years ago to those of yesterday.

SYNOPTICAL TABLE.

GROUP.	SYSTEM.	SERIES.	STAGE.	DEPOSITS OR SUB-STAGES.
Cenozoic	Pleistocene	Recent		Alluvial. Aeolian. Organic.
		Glacial	Iowan	Loess. Drift
			Yarmouth	Buchanan gravels
			Kansan	Drift.
			Aftonian	Gravels and sand.
			Jerseyan	Drift.
Paleozoic	Devonian	Middle Devonian	Cedar Valley	Limestone.
			Wapsipinicon	Lower Davenport limestone
				Otis limestone
	Silurian	Niagara	Hopkinton	Limestone or dolomite
	Ordovician	Trenton	Maquoketa	Shale.

ORDOVICIAN SYSTEM.

MAQUOKETA STAGE.

The lowest rock formation which reaches the surface of the indurated rocks is the Maquoketa shale of the Ordovician. Nowhere does it reach the present surface of the ground, being deeply covered by the drift. At Waverly it lies 120 feet below the surface and at Sumner 170 feet as well borings at these places have proved. But in the deep buried ancient river valley which passes through the county between the courses of the Cedar and the Wapsipinicon rivers the rocks overlying the Maquoketa have been removed and here the tools of the well driller find immediately below the glacial drift a shale, known popularly as "soapstone", which can be none other than the Maquoketa. Thus at Clausing's well at Denver the following section is given:

	THICKNESS IN FEET.	DEPTH.
Drift	66	66
Gravel and sand	10	76
Drift	86	162
Shale, dark blue, without grit	248	410

This well seems to be located in a tributary of the main old river valley. The abruptness of its banks is indicated by the fact that but a block away from the well just cited the drill found limestone at forty-two feet from the surface. Three blocks away on higher ground another well, Henry Bauman's, found at 124 feet from the surface four feet of limestone, presumably the Niagara, overlying shale. For eight feet below the limestone the shale was red, ocherous, and soft, suggesting unconformity—an interval of long weathering and oxidation of the Maquoketa as a land surface before submergence and the deposition of the Niagara upon it.

The deep well of August Buhr in Maxfield township (northeast quarter of the northwest quarter of section 8, township 91, range XII W.) gives an instructive section according to the driller's log.

	THICKNESS IN FEET.	DEPTH.
Yellow till	40	40
Blue till	150	190
Limestone (Niagara)	3	193
Shale (Maquoketa)	300	493
Limestone (Galena-Plattesville)	191	684

In Douglas township the following section of a well boring on the farm of C. Zwanziger, (southeast quarter of the southeast quarter of section 6, township 93, range XIII W.) is given by the driller.

	THICKNESS IN FEET.	DEPTH IN FEET.
Blue clay, till	200	200
Soft rock and shale, Upper Maquoketa	60	260
Hard rock, Middle Maquoketa	6	266

Well of H. Winzenberg (southwest quarter of the southwest quarter of section 27, township 93, range XIII W.).

	THICKNESS IN FEET.	DEPTH IN FEET.
Yellow clay	30	30
Blue clay	190	220
Limestone	10	230
Shale, Upper Maquoketa	87	317
"Sandstone", (limestone of Middle Maquoketa?)	20	337

Special interest attaches to the last well as it is located less than two and one-half miles from an outcrop of the Niagara at about the level of the well curb, thus showing the depth to which the buried valley was cut in rock. In this well, and that of the preceding record the shale has apparently thinned out from the sections given in townships south. But the Maquoketa itself carries dolomitic layers which would tally with the descriptions, as the hard, glittering sharp-cut sand of dolomite has often been mistaken for that of sandstone.

Much more common than the wells which strike the shale immediately below the drift are those which descend below the level of the upper surface of the Maquoketa without finding rock and end in glacial sands and gravels.

The Maquoketa is found beneath the drift also in a channel apparently tributary to the buried valley of the Wapsipinicon. The following section is of a well on the farm of J. McQuesney (northwest quarter of the northeast quarter of section 18, township 93, range XI W.).

	THICKNESS IN FEET.	DEPTH.
Drift	200	200
Shale	60	260
Lime rock	23	283

In the same section a well, belonging to August Schmidt and situated on the northeast quarter of the northwest quarter, found the shale below the drift.

	THICKNESS.	DEPTH.
Drift clays	135	135
Quicksand	60	195
Blue clay	25	220
Shale (Maquoketa)	2	222

It will be noted that the thickness of the shale as given in the above well records varies from 87 to 300 feet, taking only those wells in which shale is found inclosed between both upper and lower limestones. These wide differences are due probably to the fact that, as Savage has shown in Fayette county, the Maquoketa comprises both a lower and an upper shale parted by thick beds of limestone. Where the shale is found of the maximum thickness we may infer that the entire Maquoketa was passed through, the middle Maquoketa not being recognized in the records, while in the minimum thicknesses, we may suppose that the limestone in which the well ended is that of the middle Maquoketa. At Sumner the three members are well distinguished in the log of the city well, the total thickness of the Maquoketa being 220 feet. At Waverly the deep well section does not show the intercalary limestones, the total thickness being here 150 feet.

SILURIAN SYSTEM.

Niagara Series.

Local upwarps have lifted these limestones which overlie the Maquoketa shale so that they appear upon the surface at several points in the county—about three and a half miles west of Tripoli and, southeast of Waverly, on Baskin run and near the mouth of Quarter Section run.

No doubt the Niagara is concealed over considerable areas about these outcrops by the heavy mantle of glacial drift. In the southeastern portion of the county it is also highly probable that the Niagara immediately underlies the deep drift of the region, as it comes to the surface a few miles to the southeast at Fairbank. As in other counties so here detailed investigations of the present Survey have rectified the frontier between the Devonian and the Silurian largely at the expense of the former as drawn on the geological maps of the earlier surveys. Thus in Buchanan county Calvin found that a strong upfold of the strata had lifted the Niagara above the position which it naturally would occupy. To this upwarp is due the broad triangular salient of the Niagara in northern Buchanan and southern Fayette counties which brings it nearly the width of an entire county west of the general trend of its boundary line. The survey of Bremer county again advances the Niagara to the west by nearly a county breadth, bringing it to the Cedar river below Waverly. Nowhere above this point is the Niagara seen in the immediate valley of the Cedar, nor does it again appear to the south until one reaches the Niagara outcrops of southern Linn county below Cedar Rapids. The outcrop near Tripoli is aligned with the Oelwein-Fairbank anticline and is perhaps an extension of it. No rock outcrops between the Tripoli and Fairbank exposures, the entire country being buried beneath one hundred feet and more of drift.

SECTIONS OF THE NIAGARA.

Outcrop three and one-half miles west of Tripoli (southeast quarter of the southwest quarter of section 36, township 93, range XIII W.). The occurrence of Niagara dolomite so far within the Devonian boundaries as they have hitherto been drawn is of peculiar interest. Fortunately the presence of distinctive Silurian fossils leaves no possibility of doubt as to the age of the outcrop and forbids it to be mistaken for the lithologically similar Devonian dolomite which in northeastern Iowa had been sometimes confounded with it before the present survey. This outcrop lies on the left bank of Crane creek, and is disclosed by the cutting of the road along the south line of section thirty-six of Douglas township. The valley of the creek is here cut but about thirty feet below the nearly level surface of the Iowan upland.

		FEET.
2.	Geest, dark red, unctuous residual clay, with much yellow chert and fragments of silicified corals	1
1.	Dolomite, in weathered masses of buff color with hard subcrystalline gray cores, highly vesicular, in places containing nodules of flint, fossiliferous, with numerous casts and molds of crinoid stems, corals, etc	5

The following fossils were found to occur in this dolomite, so far as determinable:

Calymene niagarense.
Illænus, pygidium.
Halysites catenulatus Linn.
Favosites favosus Goldfuss.
F. hisingeri.
Heliolites subtubulatus.
Stromatopora sp.
Zaphrentis sp.
Streptelasma sp.

A chemical analysis of the rock shows it to be a typical dolomite.

SiO_2	1.53
Fe_2O_3	.48
$CaCO_3$	54.32
$MgCO_3$	43.41
H_2O	.26
	100.00

Section at Old Limekiln quarry (southwest quarter of the southeast quarter of section 17, township 91, range XIII W.).

		FEET.
3.	Breccia composed of sharp angular fragments of a drab, laminated limestone, of lithographic fineness of grain, the laminæ in places flexed and broken but retaining an approximate parallelism, matrix gray, nonfossiliferous, sparse in amount. Breccia of typical Lower Davenport type	1
2.	Sandstone filled with small angular fragments of white chert, in two or three layers, resting with apparent comformity on No. 1	½
1.	Dolomite, light buff, crystalline, vesicular, with cavities up to eight inches in diameter as from the removal of corals; in heavy, irregular, rough surfaced, horizontal beds up to two feet thick; main joints vertical, running North 13° East; fossiliferous with numerous *Halysites catenulatus*; general facies of the Hopkinton stage	13

The floor of the quarry lies about thirty feet above the level of Baskin run a few rods east. No. 1 is Niagara, and Nos. 2 and 3 are of the Wapsipinicon stage of the Devonian. This most interesting contact between the Silurian and Devonian will again be mentioned under the Devonian sections.

Section on Quarter Section run (southeast quarter of the southwest quarter of section 20, township 91, range XIII W.).

Here a small branch trenches the side of the valley of Quarter Section run displaying the following:

		FEET.
1.	Limestone, greenish yellow, subcrystalline, argillaceous, weathering to irregular, rough-surfaced layers, from one to four inches thick. Dip south, varying in amount, reaching as high as 13°. General facies that of the lower members of Hopkinton stage	8

The same beds recur a few rods east along the left bank of Quarter Section run (southeast quarter of the southwest quarter of section 20, township 91, range XIII W.), and in both cases are overlain by an interesting succession of beds of the Wapsipinicon stage of the Devonian.

The fossils of the Niagara here collected are as follows:

Leptaena rhomboidalis
Camerotoechia sp.
Orthoceras unionensis.
Encrinurus nereus.
Halysites catenulatus.
Stromatopora sp.
Favosites sp.

DEVONIAN SYSTEM.

WAPSIPINICON STAGE.

It has already been stated that the Devonian rocks of the county fall into two divisions, the Cedar Valley and the Wapsipinicon. The lower of these stages, the Wapsipinicon, has been subdivided in counties to the south of our area, where it is thickest and its terranes most fully represented, into several substages, the Upper Davenport, the Lower Davenport, the Independence, the Otis, and the Coggon, to name them in their order from the highest downward. The Upper Davenport has not been recognized in Bremer county. The Coggon limestone may be considered as merely a dolomitized or highly magnesian phase of the Otis, since it has been found to carry fossils characteristic of the Otis and known in no other substages of the Devonian of Iowa. Neither in this magnesian phase, nor in the phase of a non-magnesian limestone has the Otis been recognized in Bremer county. The two substages of the Independence and the Lower Davenport occur in some force on the Cedar at Janesville and from near the mouth of Quarter Section run up river to near Waverly and also up the small stream and its tributary ravines.

LOWER DAVENPORT SUB-STAGE.

Along nearly the entire outcrop of the lower strata of the Devonian in Iowa there has been recognized a group of beds of non-fossiliferous limestone of peculiar facies sharply set off from fossiliferous beds above and from shales or impure argillaceous and often cherty limestones beneath. These have been termed by the writer the Lower Davenport beds from their occurrence in their typical form at Davenport. In its commonest lithological type the Lower Davenport is a hard compact and homogeneous limestone, non-crystalline, of almost lithographic fineness of grain, brittle, breaking with smooth conchoidal or splintery fracture. In color it ranges from dark to light drab. It is often finely laminated, the laminæ usually being strongly coherent and their edges etched on weathered surfaces. Because of its brittleness this limestone has yielded by fracture in many places to lateral pressure, producing a crush or pressure breccia, consisting usually of a mass of small fragments set close at all angles without trace of bedding planes. The fragments retain a flint-like sharpness, and the matrix is commonly sparse and of much the same material, though more granular and slightly lighter colored and less resistant to the weather. Where the stresses were most severe, fragments of these beds have been mingled also with earthy yellow limestones beneath, and with fossiliferous limestones of higher stages. Outcrops of the brecciated Lower Davenport beds have been described at Davenport, at various localities in Cedar county, at Solon in Johnson county, at Independence in Buchanan county, at Fayette, between Vinton and Mt. Auburn in Benton county, and at a number of places along the Cedar and Wapsipinicon rivers in Linn county. With these brecciated beds the author has grouped beds of similar facies but slightly or not at all disturbed, such as those of the government reservation of Rock Island, at Gilbertville and Devil's Den near Davenport, and at Rochester in Cedar county. Here also should probably be placed the limestone weathering to thin plates and only slightly flexed which occurs beneath the brecciated beds at Fayette. The Lower Davenport thus includes massive as well as laminated limestones, a lateral alternation between the two occurring sometimes in the same stratum. The formation is bounded beneath by the Independence, and when this locally fails to appear it is difficult or quite impossible to distinguish the unbrecciated Lower Davenport from the Otis, when the latter is unfossiliferous, so like are the two formations lithologically.

INDEPENDENCE SUB-STAGE

In its typical exposure in a miner's shaft near Independence this formation was found to be a fine fissile and highly fossiliferous shale, varying in color from light gray to black. The rich and interesting fauna was described in detail by Calvin and a new formation added to the Devonian of the West. Since their early discovery, shales of the typical fossiliferous or carbonaceous type have been rarely found in the exploration of the Devonian during the progress of the present survey, the only outcrop known being that of a gray clayey shale carrying the typical Independence fauna in the cut of the Chicago, Milwaukee and St. Paul Railway west of Linn Junction in Linn county, where it is associated immediately with the breccia. The geological report on Linn county cites two instances where the same typical fossiliferous or carbonaceous shale was discovered by wells.* In a large number of localities, however, argillaceous limestones or calcareous shales have been found to underlie the Lower Davenport, or to rest upon the Otis, and these though unfossiliferous have been referred to the same horizon as the shale at Independence. Thus at Kenwood there occurs beneath the brecciated beds some thirty feet of variable clayey limestones and limy shales, and these outcrop in force at a number of places in and about Cedar Rapids. In Scott county rough brown earthy and ferruginous limestones are found resting upon the Otis along Crow Creek.† In Cedar county similar soft brown clayey limestones sometimes associated with shaly beds occur at various localities in the same relations.‡ In Benton county also, in Cedar township, Savage records the occurrence immediately beneath the brecciated Lower Davenport of impure buff magnesian limestone, in places arenaceous, and with two feet of gray calcareous shale.§ Moreover, the lowest phase of the brecciated beds of the Wapsipinicon as defined by the writer has as its abundant matrix an earthy buff or brownish limestone altogether similar to the underlying clayey limestones of the Independence.** This also has been distinguished widely over the Devonian area, as for example, in Johnson county by Calvin in the vicinity of Solon.††

A special feature of the Independence beds remains to be mentioned, their silicerous inclusions. These consist of angular siliceous fragments, varying from sand to fragments a few inches in diameter, and lenticular nodules reaching a foot or more in length, and are so common and so constant that they serve as one of the diagnostics of this horizon. With this mention of the characteristics of the lower strata of the Devonian in the areas where they are most fully represented, we are now prepared to consider their occurrence in Bremer county.

*Iowa Geological Survey, Vol. 4., p. 157, Des Moines, 1895.
†Iowa Geological Survey, Vol 9, p. 442, Des Moines, 1899.
‡Iowa Geological Survey, Vol. 11, pp. 333, 335. Des Moines, 1901.
§Iowa Geological Survey, Vol. 15, p. 159, Des Moines, 1905.
**Iowa Geological Survey, Vol. 4, p. 158, Des Moines, 1895.
††Iowa Geological Survey, Vol. 7, p 58. Des Moines, 1897

SECTIONS OF THE WAPSIPINICON STAGE

No. 1. Southeast quarter of the southwest quarter of section 20, township 91, range XIII W. In ravine tributary to Quarter Section run.

		FEET
6.	Limestone, massive, in one undivided layer weathering to scoriaceous surface in places and in other places to smooth surface. Color mottled, prevailingly a light brownish drab, weathering to lighter gray, slightly vesicular, fracture uneven	4
5.	Limestone of same facies as above in layers of about eight inches	2
4.	Concealed	15
3.	Limestone of facies of Nos. 5 and 6, but in separable laminæ	1
2.	Cherty sandstone; in layers from four to six inches thick, chert fragments angular, small, those of an inch and one-half being rare, sand fine, of moderately well rounded grains of clear quartz and of minute angular grains of cryptocrystalline silica, cement calcareous. Not seen in place but scattered in slabs over a slope of	5
1.	Niagara limestone, exposed a few rods down stream; described on page 344	8

No. 2. Farther to the west the same series outcrops on a bluff on the left bank of Quarter Section run, (southwest quarter of the southwest quarter of section 20, township 91, range XIII W.)

		FEET.
5.	Slope of hillside strewn with gray bowlders of weathering of facies of No. 6 of preceding section, but generally smooth surfaced	38
4.	Concealed	10
3.	Fragments of cherty sandstone, same as No. 2 of preceding section; scattered over slope	5
2.	Niagara limestone, No. 1 of preceding section but with layers horizontal	6
1.	Concealed to water's edge	2

Limestone of the Lower Davenport is also seen on Baskin run where four feet are exposed four feet above the bed of the creek. (Southwest quarter of the northwest quarter of section 28, township 91, range XIII W.)

No. 3. Section at Janesville on left bank of Cedar river.

2. Limestone, fossiliferous, Cedar Valley stage.
1. Breccia, matrix a soft yellow limestone in which the fragments are set without apposition, orientation or arrangement, fragments sharp-edged, showing no signs of water-wear, usually small, those exceeding an inch in diameter being rare, and many but from one to three millimeters in

diameter; fragments mostly of a hard, dense, drab limestone of finest grain, surfaces often crackled, laminated, but laminæ thoroughly coherent. Other fragments of a very different lithological type occur. These are composed of a buff earthly limestone similar to the matrix. Some of these are so arenaceous with sharp sand of chert and rounded grains of clear quartz as to deserve the name of sandstone. These latter are practically identical with the cherty sandstone of the preceding sections. (p. 340).

In places the breccia has weathered to a yellow calcareous clay with residual masses of dingy limestone highly vesicular from the removal by solution of the small angular limestone fragments; total exposure to water's edge. .... 14 FEET

The above section is not particularly well exposed, and is made out in part from bowlders of weathering, which seem to represent the rock ledge of their horizon. No. 2 is exposed only some rods above the mill dam; No. 1, both there and immediately below the dam.

Up the valley from Janesville there are several exposures of Devonian limestone along the river's banks in section 26, township 91, range XIV W., but all are of the Cedar Valley stage.

The Wapsipinicon stage recurs along the Cedar river north of the mouth of Quarter Section run, in the southwest quarter of the southeast quarter of section 18, township 91, range XIII W. The lowest bed here seen is a ledge five feet thick outcropping along the river at the water's edge and resembles lithologically in some respects Nos. 3, 5 and 6 of section No. 1, page 348. It lies in irregular, rough-surfaced layers, eight and twelve inches thick, composed of coherent laminæ, some hard and dense alternating with others of lighter color and either originally vesicular or weathered to this condition. These laminæ are irregular, undulating, and in places broken, giving here to the weathered rock a finely fragmental appearence.

A few rods north of this ledge, and apparently succeeding it vertically, is a breccia of the type of that at Janesville, outcropping at about eight feet above the river. A few rods south of the ledge first mentioned and twenty-five feet above water level outcrops a breccia composed of close-set drab fragments of the Lower Davenport type imbedded in a sparse matrix of similar color. This breccia is wholly of the second phase of the Fayette breccia as the author has defined it, while the Janesville type corresponds with the first phase.* Breccia of the second phase was found also two and one-half miles up river from these exposures (northwest quarter of northeast quarter of section 12, township 91, range XIV W.), below the quarry of the Cedar River Stone Co. Here a ledge about five feet thick outcrops three feet above water level, the breccia being composed of small fragments of hard dense brittle lithographic limestone, drab in color but weathering to lighter gray, set in a gray matrix. In places the long laminated fragments retain an approximate parallelism though detached and flexed fragments were also noted.

North of Waverly the breccia was not recognized, nor is it known to occur in Black Hawk county on the Cedar river. The outcrop of these beds of the Wapsipinicon and that of the Niagara in southern Bremer county is therefore due to an upwarp whose summit seems to lie in the southeastern sections of Washington and the adjacent northeastern sections of Jackson townships.

Comparing these sections of the Wapsipinicon stage in Bremer county with those of the counties along the southeastern outcrop of the Iowa Devonian, where the terrane is thicker and its subdivisions more clearly marked, we note first the strong resemblance of the cherty sandstone which rests immediately on the Niagara of the Limekiln section on p. 344, and that of sections 1 and 2 (p. 348) and the cherty fragments of the Janesville breccia to the cherty and arenaceous beds of the Independence as seen at Kenwood and many other localities. Assuming that these cherty beds in Bremer county are the equivalent of the Independence, all the higher beds of the Wapsipinicon fall into the Lower Davenport substage. If, however, the cherty sandstone in southern Bremer derived its cherts from the Niagara upon which it rests as a basal conglomerate, the above correlation can not be safely made, since the cherts of the Independence seem in all cases to be derived from its own cherty nodules.

The Wapsipinicon limestones of the county are characterized by the slightness of their magnesian content, as are the

*Iowa Geological Survey. vol. 4, p. 158, Des Moines, 1895.

Wapsipinicon limestones of the Otis and Lower Davenport substages in other areas. This is shown by their very ready and brisk effervescence in cold dilute HCl, and still more satisfactorily by the following analysis of No. 6, of section 1, page 348.

SiO_2	.71
Fe_2O_3 and Al_2O_3	.46
$CaCO_3$	96.57
$MgCO_3$	1.80
H_2O	.51
	100 05

Three wells in sections 20 and 21 of Lafayette township pierced the Independence shale in what appears to be its facies at Independence, if we may judge from the log of the drillers alone.

Well of B. Bennett, (southeast quarter of the southwest quarter of section 20, township 92, range XIV W.).

		THICKNESS IN FEET.	DEPTH IN FEET.
5.	Drift, yellow clay	10	10
4.	Blue clay	60	70
3.	Limestone	44	114
2.	Gray shale, Independence	10	124
1.	Limestone	14	138

Well of Wm. M. Colton, (southeast quarter of the northeast quarter of section 20, township 92, range XIV W.).

		THICKNESS IN FEET.	DEPTH IN FEET
4.	Drift	20	20
3.	Limestone	30	50
2.	Shale, black, Independence	15	65
1.	Limestone	27	92

Well of E. Chase, (northwest quarter of the southwest quarter of section 21, township 92, range XIV W.).

		THICKNESS IN FEET	DEPTH IN FEET.
4.	Drift	30	30
3.	Limestone	50	50
2.	Limestone and shale, several beds of shale four and five feet thick, Independence	40	120
1.	Limestone	10	130

CEDAR VALLEY STAGE.

The limestones of the Cedar Valley stage of the Devonian comprise a number of varieties, some of which are widely separated. Soft, earthy, granular, buff limestones with geodic cavities are perhaps most common. There are also exceedingly tough granular limestones, soft friable dolomites and dolomites of harder texture. The beds contain considerable magnesia, and are distinguished from the Wapsipinicon limestones which underlie them, by this feature as well as by their higher argillaceous content, by their coarser grain, and by the absence of brecciation.

Still more clearly are they demarked by their fossils. The assemblage of fossils characteristic of the highest Wapsipinicon substage has not been observed in Bremer county; the lowest fossiliferous beds observed carry the fossils associated with *Spirifer pennatus* at the Independence quarries and elsewhere.

SECTIONS OF THE CEDAR VALLEY STAGE.

We may consider first the beds exposed at Waverly, since these give a considerable vertical range, and are well seen in the numerous quarries opened in the vicinity of the town.

The lowest rocks here seen are those of the pit in process of excavation in 1905 for the City Power Plant at the foot of the dam on the left bank of the river, at a level of about eight feet below the water level below the dam. The normal type of this rock is a hard, ringing, yellow limestone containing many fossils. Cores of the stone are in places bluish, and considerable is much weathered and decayed, leaving perfect fossils easily disengaged from the whitish, clayey, rotten stone. *Atrypa aspera occidentalis,* of the coarse-ribbed type is very common, as are the large form of *Atrypa reticularis* and *Spirifer pennatus. Orthis iowensis* is not rare and with it occurs the variant of *O. Macfarlanei. Cyrtina hamiltonensis* and *Productella subalata* were also collected here. The horizon is clearly that of the *Spirifer pennatus* beds at Independence.

Several quarries have been worked for many years in the north part of Waverly along the left bank of the Cedar river. The following section taken at the quarries of A. S. Mores is typical.

Section No. 1. Mores' quarry, Waverly.

	FEET.
3. Limestone, yellow, fine grained, non-fossiliferous so far as observed, heavily bedded, crossed with close diagonal joints containing numerous geodic cavities up to six inches in diameter lined with dog-tooth spar, and concretionary balls marked with reddish concentric ferruginous stains......................	10

FEET.

2. Limestone, yellow, argillaceous. weathering above to calcareous plates one-half inch and upwards in thickness; below more massive, weathering to irregular chipstone, geodiferous, sparingly fossiliferous, only a small *Atrypa reticularis*, and *A aspera-occidentalis*, and a *Stropheodonta plicata* being noted, besides some unidentified fragments of fish remains.......... 8
1. Limestone, yellow, hard, tough, layers up to four feet thick, fossiliferous, in places a coquina, fossils difficult to disengage, among them *Spirifer pennatus*, *Orthis iowensis*, *O. macfarlanei*, *Gypidula comis*, *Productella subalata*, *Atrypa reticularis* and *A. aspera occidentalis*, to flood plain of river....... 10

Section No. 2. G. W. Beebe's quarry.

This quarry had recently been opened at the time of the survey. Though not developed sufficiently for a satisfactory section, it was seen that the rock is identical with No. 2 of Mores quarry. It contains a few flint nodules, besides calc-spar geodes up to eight inches in diameter.

North of Beebe's quarry, which is just outside the corporation limit, are a number of other quarries opened many years ago along the bluffs skirting the river. The following is a generalized section of these quarries:

Section No. 3—Old Quarries North of Waverly.

FEET.

5. Limestone, light yellow, fine grained, obliquely jointed, the master joints running north and south, bedding planes fairly regular and even, lower layers about one foot thick, upper portion weathers to layers of about four inches, geodes common, some a foot in diameter; fossils rare, *Atrypa reticularis*, *A. aspera occidentalis*, *Orthis iowensis*, and a Productus the only ones noted. Especially toward the summit of these beds crevices and seams of the rock are lined and filled with calcite (calcium carbonate) and with barite (barium sulphate).

   These chemical deposits are particularly heavy in places where the rock has been disturbed and fractured. On the sides of enlarged joints and on dislocated masses are found selvages up to a foot wide of interlocking calcite crystals, yellowish brown in color and with a strong odor of petroleum when struck with the hammer. Upon the calcite rests the barite as an inner and later deposit forming often vesicular masses up to one foot thick. On the other hand, geodes occur with a thin lining layer of barite covered with inward pointing crystals of calcite (dog-tooth spar)................. 24
4. Concealed........... 4

		FEET.
3.	Limestone, gray or bluish gray, weathered in places to buff, tough, hard, in heavy layers, geodiferous, in places sparingly fossiliferous, in places a coquina, irregular and discontinuous seams filled with calcite, fossils observed, *Atrypa reticularis*, *A. aspera occidentalis* and *Spirifer pennatus*	8
2.	Limestone, yellow, breaking into thin irregular laminæ on weathering, highly fossiliferous with *Spirifer pennatus*, *Orthis macfarlanei*, *Atrypa reticularis* and *Spirifer bimesialis*	2
1.	Concealed to water's edge in mill pond	8

In the southeast part of Waverly adjacent to the tracks of the Chicago Great Western Railway, a quarry was opened in 1905 by Peter Fosselmann at the base of a hill and at the level of the flood plain of the Cedar river. Below about seven feet of spalls there are exposed some ten feet of disturbed limestone dipping southwest 13 degrees. The lower layers are massive, a coquina of gray tough limestone, containing *Orthis iowensis*, *Spirifer pennatus*, and *Atrypa reticularis*.

One of the more important of the Waverly quarries is that of G. R. Dean, situated in the southern part of town on the southwest side of the river. The face of the quarry is fifteen feet. Below a stripping of five feet of sand and sandy humus including also a few inches of geest on top of the rock, the stone is a hard, ringing limestone with sub-conchoidal fracture, dressing to face, and durable. A stone house adjacent to the quarry, built from its surface stone, thirty years ago, shows no signs of weathering either in the way of rock decay or of cracking and breaking of the stone under frost and temperature changes. It is from this quarry that the sills and caps of the high school building were taken. One course near the bottom of the quarry is two feet thick, but the layers run as a rule a foot and less in thickness.

Section No. 4—Nichol's Quarry, Waverly.

		FEET.
6.	Soil, sandy	1½
5.	Sand, brown, somewhat indurated	2
4.	Geest, unctuous, fine, reddish and yellowish residual clay, mottled with gray where deoxidized, containing numerous residual fossils in silica, chiefly short fragments of the stems of Diphyphyllum, with *Favosites alpenensis*, and valves of *Pentamerella dubia*	1
3.	Limestone, weathered to friable rotten stone and loose rock-meal, with cores of harder rock	1¼

		FEET.
2.	Limestone, firm as a rule, but in places easily cut down with trowel, containing nodules of white chert	3
1.	Limestone, yellow, heavily bedded, in two layers; thin chert nodules occur along horizontal lines; widened joints and pipes filled with geest extend to the quarry floor	7

The cuts of the Chicago Great Western Railway, one-half mile east of the station and beyond, show also deeply decayed limestone due probably largely to preglacial weathering. Beneath a sandy humus and brown geest containing flints and some fossils, the limestone is disintegrated to meal for a distance of four feet from the surface. Underlying this is twenty-two feet of soft, buff, massive limestone, whose layers reach seven feet in thickness, with numerous geodes. The dolomitic nature of this stone is indicated in the following analysis:

Fe_2O_3	1.21
SiO_2	9.07
Al_2O_3	2.16
$CaCO_3$	34.99
$MgCO_3$	51.64
H_2O combined	.64
H_2O uncombined	.29
	100.00

The cuts near the quarry of the Cedar River Stone Co. show a firm, hard limestone with the following fossils: *Atrypa reticularis, A. aspera occidentalis, Spirifer pennatus, Stropheodonta demissa,* with Stromatopora, Favosites, Cladopora and Aulacophyllum as corals.

Higher horizons than those of the Waverly quarries occur near town. Thus a road cutting near the Harlington cemetery displays the horizon of the *Acervularia profunda* life zone, which, as Calvin has shown in a number of counties, overlies the *Spirifer pennatus* beds. Along with this characteristic coral occur specimens of Favosites and Aulacophyllum too imperfectly preserved for specific indentification.

The same horizon of the *Acervularia profunda* beds was found northeast of Waverly (southeast quarter of the northwest quarter of section 36, township 93, range XIV W.). Here the occurrence was noted also of two species of Favosites, Stromatopora, Diphyphyllum, and a specimen referred with some uncertainty to *Alveolites minima* Davis.

FISH REMAINS FROM WAVERLY.

The quarries north of Waverly have long been known for the well preserved remains of Devonian fishes which they contain. As early as 1875 an item published in a local paper, relating the finding of a *bona fide* fish at Waverly, attracted the writer's attention, and visiting the town he obtained the loan of the interesting object,—not indeed a fish, as its appearance, half imbedded in the stony matrix, suggested, but an immense fish tooth, identified by Newberry, to whom the writer carried it, as belonging to *Ptychtodus calceolus* N. & W. At the time the writer also made quite a collection of fish remains of the Waverly quarries, a collection whose value was greatly increased by generous contributions by Mr. Norris, a veteran quarryman of the town. All these were safely placed in the museum of Cornell college. It is to be regretted that further than the fact that they were obtained from the quarries north of town little is known of the exact horizons of the remains. It is wholly probable however that they belong for the most part to beds 2 and 3 of section 1, and bed 5 of section 3. Through the kindness and skill of Dr. C. R. Eastman of Harvard University, who has made a thorough study of the Devonian fishes of Iowa for the Survey, the Waverly remains have been identified as follows:

Holoptychius, scales, very similar to *H. flemingi* Ag.
Dinichthys pustulosus Eastman, palato-pterygoid dental plate, or "shear tooth".
Onychodus sp., presymphysial tooth.
Dipnoan tooth, resembling *Synthetodus* from State Quarry beds near Iowa City.
Ptychtodus calceolus N. and W., tritors.
Ptychtodus compressus Eastman, dental plate.
Rhynchodus occidentalis Newberry, dental plate.

Dr. Eastman reports also from the same horizon fin spines of *Heteracanthus politus* and tritors and dental plates of a large species of *Ptychtodus* probably *P. ferox* Eastman, from fossils collected at an early date by St. John.

In explanation of these rather formidable names it may be said of the fishes which thus are known to have inhabited the shallow sea whose limy oozes hardened to the rocks of the Waverly quarries, that *Holoptychius* was a "fringe-finned ganoid" whose body was covered with small overlapping bony enameled scales, and whose paired fins were lobed, with a scaly axis whose structure suggests that of the limbs of the higher vertebrates. *Dinichthys* was a ferocious monster eighteen feet long, equipped with powerful jaws and protected by heavy armor plate. *Onychodus*, covered with bony scales, reached a length in some of the species of fifteen feet. *Synthetodus* was a genus of lung fish, among whose modern representatives is the *Ceratodus* of Australia. *Ptychtodus*, *Rhyncodus* and *Heteracanthus* were sharks.

It is to be hoped that as the quarries are developed local collectors will take special pains to secure the fish remains of the Waverly limestones, and to preserve them for the service of science.

SECTIONS OF THE CEDAR VALLEY STAGE NORTH OF WAVERLY.

Limestones of this stage outcrop at uumerous points on both sides of the river from Waverly north to the county line.

Unfossiliferous limestone of the type of the upper beds of the Waverly quarries is seen along the north-south road in the north half of section 26 and the south half of section 23 of Lafayette township.

In the southeast quarter of the northwest quarter of section 22 of the same township a small quarry has been opened in the side of a rocky hill. In the brown and buff thin-layered limestones here exposed no fossils were seen except a rare Atrypa.

In the same township the following section is exposed in the road.

Section No. 5. (Southwest quarter of the southeast quarter of section 16, township 92, range XIV W.):

		FEET.
3.	Limestone, light brown, weathering to drab, hard, ringing, unfossiferous, laminated to plates one half inch thick..........	8
2.	Magnesian limestone, soft, buff, with casts of large *Atrypa reticularis*..........................	10
1.	Unexposed to flood plain of river	5

Unfossiliferous beds having the general appearance of the upper beds at Waverly occur in the northeast quarter of the northwest quarter of section 21 and in the northwest quarter of the southeast quarter of section 9 of Lafayette township.

North of Plainfield in the extreme northwestern section of Polk township are several interesting exposures. On the right bank of the Cedar river (northwest quarter of the northeast quarter of section 7, township 93, range XIV W.), there have been quarried at water level seven feet of non-fossiliferous, compact, buff, magnesian limestone, in layers from six to ten inches thick, containing small balls and irregular nodules, some with concentric ferruginous stains, and often fantastically aggregated. The stone becomes thin-layered and argillaceous for a few inches from the top. The dwelling house on this farm is built of stone from this quarry, and its excellent preservation shows the durable nature of the stone.

On the left bank of the river in section 8 of the same township (southwest quarter of the southwest quarter of section 8, township 93, range XIV W.) for five or ten feet above the flood plain of the Cedar, fragments of a fine grained slate-colored and in part brecciated limestone strew the hillside, and are apparently derived from a concealed ledge. These may represent the lithographic beds found well up in the Cedar Valley section by Calvin in Mitchell county. They resemble closely the Wapsipinicon, however, and it is not impossible that we have here a local upwarp which has brought the Lower Davenport to the surface. Somewhat in favor of the latter hypothesis are the beds which appear farther up stream. Here an old quarry (southwest quarter of the northwest quarter of section 8, township 93, range XIV W.), now so filled as to show no clear face, gives indication of a soft buff magnesian limestone or dolomite, and this appears clearly in an old lime kiln in the quarry in the northwest quarter of the northwest quarter of the same section. The numerous casts of fossils found here indicate according to Calvin a horizon just a little above the quarry beds at Independence. As these are near the base of the Cedar Valley stage, it is not difficult to believe that the Wapsipinicon may outcrop a few rods further south. The fossils of the dolomite are *Atrypa reticularis,* (very numerous), *Athyris vittata,* and a species of Paracyclas. The following analysis is of the rock quarried for lime in section 8 of Polk township.

SiO_2	3 28
Fe_2O_3	1.61
Al_2O_3	.51
$CaCO_3$	55 23
$MgCO_3$	39.03
H_2O combined	.23
H_2O hygroscopic	.16
	100.05

SECTIONS OF THE CEDAR VALLEY STAGE ABOUT FREDERIKA.

East of the western tier of townships crossed by the Cedar river, the rock formations of Bremer county are everywhere buried deep beneath the drift excepting in the vicinity of Frederika. In and about the town are a number of outcrops of the Devonian, and little more than four miles to the south occurs the anomalous outcrop of the Niagara already described (page 343). The most important of the quarries about Frederika is the following:

No. 6. Section of Quarry of James Brodie, Frederika.

This quarry on the bank of the Cedar river has a face of eighteen feet, the floor of the quarry standing three feet above water in the mill pond. The stripping of drift is very slight. The upper surface of the rock is fairly even although here and

Fig 41—Brodie's Quarry, Frederika.

there occur drift lined and geest filled pockets a foot or more in depth. The geest resting on the rock is from one to four inches thick and contains numbers of poorly preserved siliceous fossils, *Acervularia profunda* being the most important as it denotes a definite horizon.

		FEET.
3.	Limestone, yellow, shattered by the weather to coarse rhombic chipstone	9
2.	Limestone, hard, yellow, magnesian, in heavy courses up to three feet thick, not laminated; bedding planes quite even and regular; geodes up to six and eight inches in diameter not uncommon	6
1.	Limestone, bluish weathering to buff; hard, ringing, sub-conchoidal fracture, in two layers, the lower being one foot and the upper two feet thick. Sparingly fossiliferous with *Gypidula comis* and other species	3

The rocks of the quarry have a slight but perceptible dip to the south. Master joints run north 8 degrees east. The rock is strongly magnesian carrying more than 25 per cent of magnesium carbonate.

Several small quarries have been opened near Frederika, as in the northwest quarter of the northeast quarter of section 13, township 93, range XIII W.; in the southwest quarter of the northwest quarter and in the southeast quarter of the southwest quarter of section 18, township 93, range XII W., but their pits are now generally so filled as to make it difficult to get good sections.

The last two sections mentioned are situated on the estate of C. L. Rima. At the first named of these two are exposed six feet of a hard, fine grained rock whose layers run to six inches in thickness and are marked by some chert and varicolored flint concretions arranged linearly. These layers and the rock exposed in the road near by carry a gregarious Chonetes of an undescribed species, *Productella subalata,* and Favosites. The second of the two named quarries has been abandoned, and now but six feet are exposed of a buff limestone in six inch layers carrying *Atrypa reticularis* to the exclusion, so far as observed, of other species.

Geest.

For countless ages after the Devonian seas retired from our area a land surface was exposed to the disintegrating and dissolving action of the weather. The rock surface was thus everywhere roughened. Wherever roots pried apart the blocks of limestone, or where by any cause a way was made for the downward passage of water, there ground water, charged with carbon dioxide and the humus acids, dissolved the solid rock and opened pipes and chimneys, pits and cavities of various shapes and dimensions. Weathering also produced a residual clay, called geest, which can be referred to no specific geological age, although doubtless largely Tertiary, so far as it is not interglacial.

Slight though it may be, there is in all limestone an insoluble residue of fine quartzose, argillaceous and ferruginous matter. When the carbonates of lime and of magnesia are dissolved and carried away to the sea something of these insoluble ingredients of the limestone remains as fine unctous gritless clay. The iron compounds of the decaying rock are at the same time oxidized, and when concentrated in the residue of clay, give to it its deep shade of red or brown. In places these products of preglacial and interglacial rock decay have wholly been removed by glacial scour, but for the most part the rock surface and the geest upon it seem to remain much as they were at the beginning of the last ice invasion. Nichol's quarry and the various railway cuts about Waverly offer excellent examples of this ancient formation.

THE PLEISTOCENE SYSTEM.

PRE-KANSAN STAGE.

The ground moraine of the Jerseyan, or pre-Kansan, the earliest of the great ice sheets which invaded Iowa in Pleistocene times, is buried out of sight in Bremer county by later glacial deposits. In counties of southern Iowa where it is exposed by erosion and its physical characteristics have been noted it has been described as a dark blue or almost black stony clay, or till, fine-grained and friable, not jointed to any marked degree and rich in pebbles of granite. These physical characteristics, due to the lithological materials which compose the till and their relative proportions, obviously depend on the abrasion of the rocks over which the ice sheet passed. This is especially true of the ground moraine of the earliest ice sheet, an ice sheet which everywhere moved over the country rock and not over the ground moraines of previous ice sheets. The Jerseyan drift may be expected therefore to differ widely in regions so far apart as southwestern and northeastern Iowa where the country rocks of the one are of the Cretaceous and Coal Measures and of the other the systems of the earlier Paleozoic.

In well drillings and well records the Jerseyan can hardly be told from the unweathered Kansan till, which normally succeeds it, unless they are separated by the silts, soils, or vegetal deposits of the intervening interglacial epoch, the Aftonian. A few miles east of our area, in a cut of the Chicago Great Western Railway near Oelwein, the Jerseyan, ten feet thick, is overlain by such an old soil and peat bed four feet thick with its ancient moss perfectly preserved.

The few well sections where the Aftonian and Jerseyan seem to be indicated are the following:

Well of C. F. Schwem, Frederika township, (northwest quarter of the northwest quarter of section 32, township 93, range XII W.).

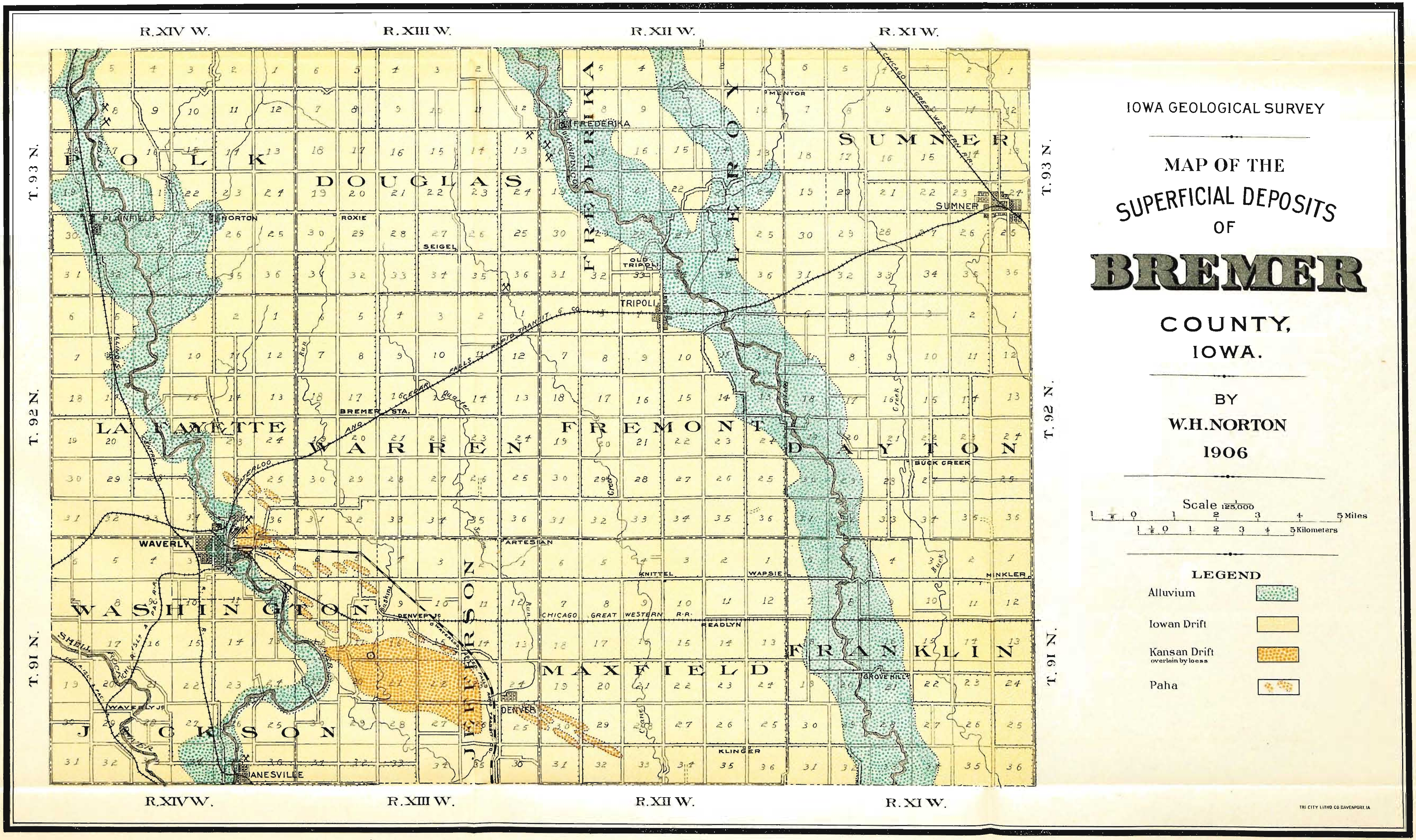
	THICKNESS IN FEET.	DEPTH IN FEET.
Yellow till	10	10
Blue till, Kansan	24	34
Sand, Aftonian?	16	50
Blue till, Jerseyan?	10	60
Rock	27	87

Well of C. E. Falcher, Leroy township, (northwest quarter of the northeast quarter of section 22, township 93, range XII W.).

	THICKNESS IN FEET.	DEPTH IN FEET.
Yellow till	12	12
Blue till, Kansan	63	75
Old soil, ill smelling, Aftonian?	20	95
Blue till, Jerseyan?	41	136
Rock	10	146

Well of Aug. Schmidt, Leroy township, (northeast quarter of the northwest quarter of section 18, township 93, range XI W.).

	THICKNESS IN FEET.	DEPTH IN FEET.
Drift clays	135	135
Quicksand, Aftonian?	60	195
Blue till, Jerseyan?	25	220
Shale, Maquoketa	2	222


IOWA GEOLOGICAL SURVEY
MAP OF THE
SUPERFICIAL DEPOSITS
OF
BREMER
COUNTY,
IOWA.
BY
W.H.NORTON
1906
Scale 1/125,000
5 Miles
5 Kilometers
LEGEND
Alluvium
Iowan Drift
Kansan Drift
overlain by loess
Paha
R.XIV W.
R.XIII W.
R.XII W.
R.XI W.
T. 93 N.
T. 92 N.
T. 91 N.
POLK
DOUGLAS
FREDERIKA
LE ROY
SUMNER
LA FAYETTE
WARREN
FREMONT
DAYTON
WASHINGTON
JEFFERSON
MAXFIELD
FRANKLIN
JACKSON
FREDERIKA
MENTOR
SUMNER
PLAINFIELD
HORTON
ROXIE
SEIGEL
OLD TRIPOLI
TRIPOLI
BREMER STA.
BUCK CREEK
WAVERLY
ARTESIAN
KNITTEL
WAPSIE
MINKLER
DENVER JC.
CHICAGO GREAT WESTERN R.R.
READLYN
GROVE HILL
DENVER
WAVERLY JC.
KLINGER
JANESVILLE
TRI CITY LITHO CO DAVENPORT IA

Well of M. Farrington, Jefferson township, (northeast quarter of the southeast quarter of section 35, township 91, range XIII W.).

	THICKNESS IN FEET.	DEPTH IN FEET.
Yellow till and gravel, Kansan and Aftonian?	30	30
Sand at		30
Blue till, Jerseyan? to		110
Rock	12	122

Well of Fred Schnoeder, Tripoli.

	THICKNESS IN FEET.	DEPTH IN FEET.
Yellow till	8	8
Blue till	62	70
Sand and gravel, Aftonian?	2	72
Blue till, Jerseyan?	6	78
Gravel	1	79
Rock	1	80

From the very few wells in which sand and gravel or old soils have been found intercalated with glacial clays, we may infer that the Aftonian formation is very scantily represented in the county. Even in several of these wells just listed the sands may be local accumulations of stratified Kansan drift.

Nearly all the wells of the county are reported to have found continuous till from the surface of the ground to rock or to the thin sands and gravels often found resting directly upon rock, and the only division in the till noted by the drillers, that of color, may be referred to the weathering to yellow of the blue till of the Kansan.

KANSAN STAGE.

KANSAN DRIFT.

The Kansan drift extends over nearly the whole of Bremer county. Even on the areas mapped as belonging to the later drift sheet, the Iowan, the Kansan is to be found a short distance beneath the surface and is exposed in road and railway cuts and other excavations and along the banks of eroding streams. In the areas referred on the map to the Kansan, it is more deeply buried and for the most part is concealed by loess.

In its normal unweathered aspect the Kansan till is a dense stony clay, jointed, and in color bluish drab. It effervesces freely in acid because of the considerable amount of limestone meal and flour which it contains, ground from the calcareous rocks which it has overridden. But so deeply has it weathered since the remote epoch of its deposition as the ground moraine of a continental glacier that one rarely finds an exposure deep enough to bring to light its normal unweathered aspect. The common exposures of Kansan till in Bremer county are of thoroughly weathered till. Percolating water has taken into solution the lime carbonate and the magnesium carbonate and carried them down to gather not infrequently in small hollow lime balls. The roots of plants and trees have also consumed these carbonates so that the Kansan till, for a number of feet from the surface, has been well leached of all easily soluble ingredients. Frost and the processes of chemical weathering have so altered the texture of the till that it readily crumbles on the surface to small particles. Still more conspicuous and deeper are the changes wrought by the alteration of the iron compounds of the drift. To a depth usually greater than the section opens for observation the stony clay has been changed in color by the oxidation of its iron compounds. From bright yellow or even a reddish brown at the surface it changes to paler shades until it passes into gray and bluish gray as the unweathered deeper portion of the till is reached. In the weathered zone pebbles of the less resistant rocks, such as the coarser granites, are often thoroughly rotten. The upper limit of the till is often marked by a washed surface on which pebbles are specially abundant, and perhaps correlated with this is the red loam, a reddish clay lying directly in places on the Kansan drift beneath the loess, from which it is distinguished not only by its color but also by its more clayey nature.

Sections of Kansan Drift.

Section in cut of Chicago Great Western Railway, two-thirds of a mile west of Denver Junction.

		FEET.
4.	Humus graduating into No. 3	2
3.	Yellow, sandy clay	1
2.	Till, yellow, pronounced line of pebble accumulation on upper surface, many of the pebbles being decayed, no ferretto, or zone of ferruginous accumulation, on upper surface; pebbles of till mostly fresh, but many rotted pebbles of granite; pebbles four inches and upwards not rare, with some cobbles and bowlders up to three feet in diameter. Till non-calcareous to four feet from its upper surface, graduating into No. 1	8

		FEET.
1.	Till, blue, dense and tough, breaking into flakes of one inch or less, with many small pebbles	3

Section by road at pahoid hill, southwest of Waverly. (Southeast quarter of the southwest quarter of section 17, township 91, range XIII W.)

		FEET.
3.	Loess, typical floury, yellow, with minute ramifying calcareous tubules	7
2.	Red loam, laminated, loessial in texture, with an occasional small pebble and rare small lime concretion	1½
1.	Till, bluish gray mottled with reddish, predominantly clayey, pebbles small, greenstones abundant, chert and limestones few, many calcareous concretions an inch or less in diameter, round and hollow, most numerous about eight inches from the surface but occur to base	3

Topography of the Kansan Drift.

The Kansan drift sheet makes its presence felt everywhere in the county as an important or decisive factor in the topography. In places it is more or less masked by the Iowan drift and by the loess, but perhaps in no instance can the relief of this heavy drift sheet be neglected in accounting for the topography of the present. We may recall here the fact that where the later drift sheets are wanting as in southeastern Iowa the Kansan surface presents several distinct topographic types. To mention one of the most important, the divides are tabular areas of considerable breadth, and of a remarkable flatness as though leveled in a body of static water. Such are the level prairies which form the divides between the Des Moines, the Skunk and the Iowa rivers, from Jasper, Poweshiek and Iowa counties southeast to the border of the Illinoian drift near the Mississippi river, to cite examples as near as possible to Bremer county. When the Iowan ice invaded northeast Iowa, these divides, we may infer, were somewhat broader and less worn than now. Nor have we any reason to believe that at this remote time the erosion cycle was more advanced in northeastern Iowa than in the southeastern portion of the state. Indeed, if the drainage of the long interglacial epochs which followed the retreat of the Kansan ice pursued in a general way the courses of our present rivers, the northern area about the headwaters of the trunk streams should have been considerably less dissected than were the areas adjacent to the baselevels of their graded lower courses. We may infer that at the epoch of the Iowan ice the divides of Bremer county, left by the long erosion which intervened between the Kansan and the Iowan epochs, were broader and less scored than those of southeastern Iowa are today. Whether the Kansan drift in northeastern Iowa was deposited with the monotonously level surface which still is left over much of southern Iowa is another question and one difficult to answer, since the northern Kansan is blanketed with heavy loess or veneered by the Iowan drift. Certainly there is no evidence that the Kansan of our county ever exhibited the marked reliefs of the hummocky moraines of the Wisconsin drift. But any fainter inequalities of surface which may once have marked it could not be expected to afford any evidence of their existence when covered by the deposits from a later, overriding ice sheet. We are at liberty, then, to believe that before the Iowan ice invasion, belts of upland little scored by running water and of very faint relief occupied the wide interstream areas between the rivers of our county. Such areas when covered with the veneer of the Iowan drift result in the gently undulating plains of Douglas, Warren, Fremont, Maxfield and Sumner townships. These plains are interpreted as due to the even surface of the underlying Kansan drift and not to the leveling effect of the Iowan drift in filling any considerable inequalities in the pre-Iowan surface.

A second type is that of the well dissected Kansan drift covered and partly masked by Iowan drift. The narrow interstream area between the Cedar and the Shell Rock rivers seems to have attained topographic maturity before the Iowan ice invasion. This narrow upland skirts the broad flood plain on the west with a sinuous line of projecting hills and deep and broad reentrants. West of Plainfield the hills rise sixty feet and more above the flood plain; west of Waverly they appear still higher. The wide, flat-floored and aggraded valleys which penetrate this upland tell of long continued subaerial erosion made effective by nearness to the main erosion levels of the two trunk streams and they and the undulating crest lines, together with the occasional bowlders seen even on the hill tops, show that here a well dissected Kansan upland has been overridden by a later ice sheet, its valleys partially filled and its summits heaped with drift.

Polk township has been similarly trenched by ravines tributary to the Cedar and to the three creeks which empty into it from the east. Frederika and Leroy townships have been largely reduced to rolling hills by storm waters seeking the Wapsipinicon, the East Wapsipinicon and Leroy creek, and narrow belts of well dissected upland border all the principal valleys. In these areas long and gentle slopes lead down from the upland; the subordinate water ways are all well opened, but show no recent trenching. Iowan bowlders and Iowan drift lie on these hillsides and even follow out upon the wide ancient flood plains of the Wapsipinicon and Cedar. Evidently the erosion of the ramifying valleys with which the upland is thus dissected near the major streams is older than the Iowan ice invasion by which they have been partly filled with drift. The immediate streamways have been aggraded notably by outwash. About the heads of the ravines there is a perceptible departure from the normal type as if the valley heads had been somewhat filled subsequent to their carving. The crests of the rolling Kansan-Iowan hills are uneven and the sky line undulating.

Another topographic type is that of the deeply dissected and loess covered Kansan. This common and oft described type occurs in long parallel belts of hilly upland scores of miles in length in the counties lying to the south and east, but in Bremer it occurs in but two isolated areas, one on the left bank of the Cedar at Waverly and one in northeastern Jackson township extending thence to Denver. The latter area of six or seven square miles we will first describe under the name of the

Denver Loess-Kansan Area.—This region touches the Cedar at the sharp bend where it turns from its normal course to join the Shell Rock and continuing the general trend of the river is bounded on the south by Quarter Section run in its anomalous course already mentioned. On the east it extends to Denver and on the northeast its limits are indicated by the diagonal Denver-Waverly road which skirts the bases of its hills. In contrast with the surrounding prairie this region is heavily wooded with hardwood trees, among which the white oak, the sugar maple and the hickory are most noticeable. It has long been known as the Big Woods.

Any of the roads leading through the Big Woods crosses a succession of deep, steep-sided valleys parted by narrow ridges with gently undulating crests which rise to about one common level. Steep, high and detached as seems the Briden hill, for example, (southeast quarter of section 28, township 91, range XIII W.) one standing on the summit sees the even crests of the hills to the east rise to an accordant level giving an even sky-line. A gigantic ruler laid across the area would touch the tops of practically all the major ridges with the exception of certain high hills at the extreme west. If the initial surface could be restored by filling the valleys with the material which has been washed out of them by running water, there would appear a nearly level upland plain.

The valleys which dissect the upland naturally differ in depth. The main streams have cut their channels to a depth of seventy-five feet and more below the upland level. Their short laterals draining southwest into Quarter Section run are somewhat less deep and the youngest and outmost twigs of this arborescent drainage system, the little gullies which trench the steep sides of the ravines, head on the summits of the divides.

Everywhere the area is heavily blanketed with loess. Just outside the area streams and roads give sections of Kansan till and rock, but within it the yellow roads everywhere climb the hills without disclosing the customary red ferretto of the underlying Kansan; the stream ways which begin within the area are clean of pebbles either of the country rock or of northern drift, and where they sap the valley sides show fresh scarps cut in loess to the water's edge.

To the west the upland narrows and culminates in a high ridge known in the neighborhood as Booth's hill, (northwest quarter of section 20, township 91, range XIII W.). The broad rounded summit rises by barometer 125 feet above the creek at its base and is distinctly higher than the upland to the east. The trend of the ridge is west-northwest by east-southeast, and is continued to the northwest by high short axised ridges set *en echelon* and parted by high cols. The Cedar river cleaves its way into the midst of these hills in a deep valley whose lower slopes are cut in rock. A narrow ridge of the same west-northwest trend is thus left on the right bank of the river. Instead of continuing on the comparatively low ground of the Iowan plain, the Cedar here goes half a mile out of its way to plunge into the loess-Kansan upland. The depth of the loess on the upland has not been sounded since the well drillers naturally have not discriminated the yellow loess from the yellow weathered Kansan which underlies it. Judging from other areas of like nature in northeastern Iowa, the thickness of the loess here may well reach forty or fifty feet.

The view from Booth's hill is singularly impressive. None in the county is bounded by horizons more remote, and none is filled with objects of greater beauty, or of greater interest to the geologist. To the south the eye ranges far over the Iowan upland plain to discover on the horizon some of the higher towers of the Iowa State Normal School at Cedar Falls, about twelve miles distant. To the southwest, beyond a few wooded hills, lies the low Iowan plain from which rise the white church spires of Janesville. To the west, beyond the maze of high wooded hills of the immediate foreground, the eye catches glimpses of the dissected Iowan upland which forms the divide between the Cedar and Shell Rock. Looking northwest the vision is bounded by the great Waverly hills lifting their long sweeping curves against the sky. The middle distance is here filled with the Iowan plain, much dissected because of the older uneffaced Kansan erosion, and also broken by detached boat-shaped hills called paha, too low to intercept the distant view. To the north and northeast the eye looks down the grassy slopes of the bold hill to a tiny pahoid ridge which lies at the base and rises upon its flank, ranges across an upland of Kansan facies strewn with bowlders left by the Iowan ice and gashed with numerous sharp valleys, but surrounded by pahoid hills and ridges, and rests in the far distance on the level horizon line of the high Iowan plain. To the east the view is intercepted for the most part by heavy forests, but here and there clearings enable one to catch glimpses of the even crests of the loess-Kansan upland.

At the time of the settlement of the county the dissected upland, with its paha hills, lying to the north was also covered with the heavy mesophytic forest of the Big Woods as far north, we are told, as the south line of sections 5 and 6 of township 91, range XIII W., while beyond this the smooth Iowan plain was prairie to the limits of the county and far beyond.

The loess-Kansan area at Waverly is much smaller than that west of Denver and is almost wholly comprised within the extended corporation limits. The high wooded hills of the First ward and those about that on which the city reservoir is built are included in this area. Their billowy crests, with little or no systematic arrangement, reach a height by barometer of 145 feet above the Cedar river. The loess lies thick upon them and its basal sections show the interstratified yellow sands characteristic of the loess when bordering the Iowan drift. These hills rest on a foundation or platform of rock which outcrops along the Cedar, but whether the rock rises to any greater height beneath them than on the surrounding Iowan plain is a matter on which no data were secured.

THE BUCHANAN GRAVELS.

Of those deposits of stratified aud waterlaid drift associated with the melting of the Kansan ice sheet, Calvin has distinguished in adjacent counties two separate phases,—an upland phase of outwash upon the interstream areas consisting of sand and gravel so well rotted and rusted that an age far greater than that of the surrounding or overlying Iowan drift is indicated, and second, a valley phase of quartzose sand and gravel, the valley trains of the Kansan ice. As an example of the former we may cite a section shown on a road cutting north of Waverly, (southeast quarter of the southwest quarter of section 14, township 92, range XIV W.) on the top of a hill about seventy feet above the adjacent creek. Underneath a foot and a half of sandy humus there are exposed six feet of reddish brown gravel intermixed with sand and partially cemented. Pebbles are small, few reaching the diameter of an inch, and the granite pebbles are thoroughly decayed. Interbedded with the gravels is a lens eight feet long and two feet thick of brownish clayey till containing few pebbles.

A similar deposit occurs a mile northeast of Waverly, (southeast quarter of the northwest quarter of section 36, township 92, range XIV W.) on the slope of a hill. North of Plainfield an interesting exposure of gravel occurs about thirty feet above the tracks of the Illinois Central Railway (northwest quarter of the northeast quarter of section 18, township 93, range XIV W.). Here five feet of gravel are exposed in a road cutting, the upper three feet being the coarser. The pebbles are chiefly of Devonian limestone of the type of the Lower Davenport of the Wapsipinicon, or of the Lithographic beds of the Cedar Valley stage, a dense drab limestone, in part brecciated. Pebbles six inches in size are common. These gravels resemble the Buchanan in that they are rusted and the granite pebbles thoroughly decayed, but the limestone pebbles are entirely sound.

The quartzose gravels which occupy the wide valleys of the Cedar, the Wapsipinicon, Crane creek and other streams are undoubtedly the extensions of the valley trains which Calvin in other counties crossed by these rivers has referred to the melting of the Kansan ice.

IOWAN STAGE.

IOWAN DRIFT.

The wooded loess-covered Kansan areas which we have just described are surrounded like islands by the wide prairie of the Iowan drift sheet which covers all the remainder of the county, excepting the flood plains of the river valleys, and stretches far beyond the limits of the county in all directions. The Iowan drift is very thin, forming as a rule scarcely more than a veneer. Three types of the unstratified drift may be discriminated,—a prevailingly sandy, brownish till with abundant pebbles whose loose texture has allowed it to become well oxidized and leached, second, a light yellow, clayey till unleached of lime to within the grass roots, and third, large bowlders superficial and in places apparently the only deposit of the ice.

An instance of the rather rarely recognized second type of Iowan drift was seen in a cut of the Chicago Great Western Railway east of Waverly (southeast quarter of the southwest quarter of section 8, township 91, range XIII W.).

		FEET.
3.	Humus graduating into yellow sandy clay with rare pebbles	2
2.	Till, upper two feet yellow and non-calcareous, lower three feet gray and calcareous, pebbles fresh and mostly small, limestones under an inch abundant, till massive, neither jointed nor flaky, not continuous throughout cut, being seen chiefly on north side of cut and at top of the low hill	5
1.	Till, clayey, dense, tough, breaking into small rhombs, oxidized to base, but calcareous to the top where tested, pebbles of limestone not so numerous as in No. 2, cobbles of six inches not rare and some bowlderets a foot in diameter, pebbles generally fresh but some of gray granite rotten, observed..............................	11

Resting on the surface a few feet away lies a pink granite bowlder seven feet long and nearly as broad. No. 1 of this section is apparently Kansan whose decalcified upper surface has been rubbed off by the Iowan ice. No. 2 and the clay of No. 3 are referred to the local deposits of the Iowan.

The bowlders of the Iowan are scattered throughout the county and no special and local aggregations of them were noted, such as bowlder walls or bowlder belts. While a great variety of the igneous and metamorphic rocks are represented, the large majority of the larger bowlders are of granite and gneiss. Thus out of twenty-two large bowlders from four to six feet in diameter in a wall near Horton, twenty are granites. In eighty cords of bowlders which had been hauled in to Janesville from the adjacent prairie, and piled near the mill, it was easily seen that granites and gneisses were far in excess of all other kinds together, diorites and diabases being comparatively few, and schists still fewer. While the majority of these bowlders were firm and undecayed, yet a number of large macrocrystalline granite bowlders were much disintegrated. In this collection it was also noted that a number of the stones showed faceted and scored surfaces. Such must have been dragged by the ice as part of the ground moraine; they were not englacial or superglacial stones deposited on the melting of the ice as part of an englacial or superglacial drift.

Very large bowlders are by no means rare in the county. One seen in the northeast quarter of the northeast quarter of section 35, township 93, range XIV W., measures ten by twelve by twelve feet. That of figure 42 has as its horizontal diameters twelve and fourteen feet, and is ten feet high above ground. A bowlder in section 1 of Douglas township northwest of Frederika, quadrate in shape, is twenty feet long, twelve feet wide, and eight feet high. A mile and a half southeast of Frederika another was measured whose diameters are twenty-two and fifteen feet and which is only four feet out of the ground. McGee mentions the monster two and one-half miles north of Sumner as the

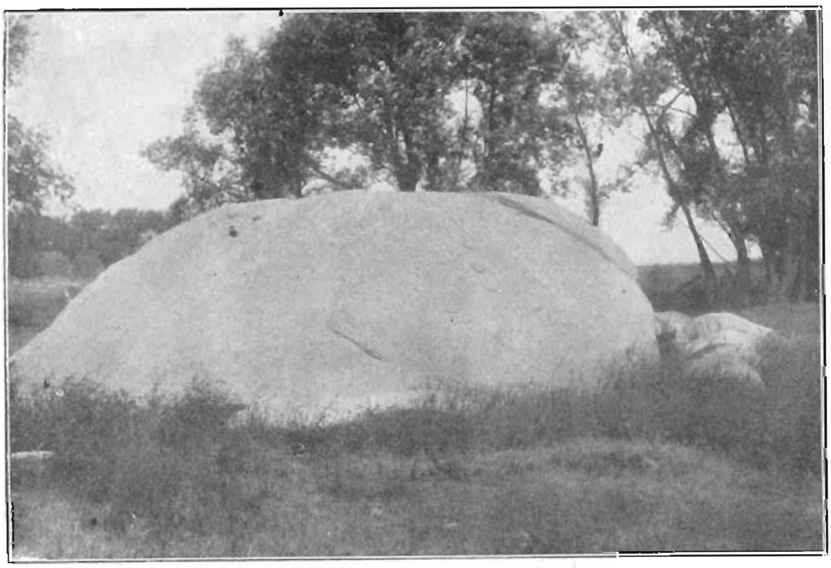


Fig. 42—Rounded Iowan bowlder, east of Waverly.

largest seen in Northeastern Iowa. At the time of his measurement—in 1890—its diameters at the surface were twenty-five by forty feet and its height above the surface eleven feet. But enough of it had been quarried to form foundations for two or three houses and the larger portion appeared to be buried in the drift.*

Bowlders affect the lower ground, the swales and draws, and are less often seen upon the low crests of the gently undulating plain. Many of the stones are well rounded, as for example those of figure 43. This is the shape to which a homogeneous stone is dressed by the long action of the weather, but that this rounding has not occurred since the melting of the Iowan ice is indicated by the fact that many of the bowlders of the drift are

*Pleistocene History of Northeastern Iowa, 11th Ann., Rept., U.S. Geological Survey, pt. 1, page 482.

angular although of the same lithological varieties as those well rounded. As a glacier facets instead of rounds when it affects at all the erratics which it carries, we must suppose either that the Iowan bowlders were brought from some area not previously overridden by glacier ice, and that they are the product of immensely long preglacial weathering or that the interglacial epoch intervening between the Iowan and the

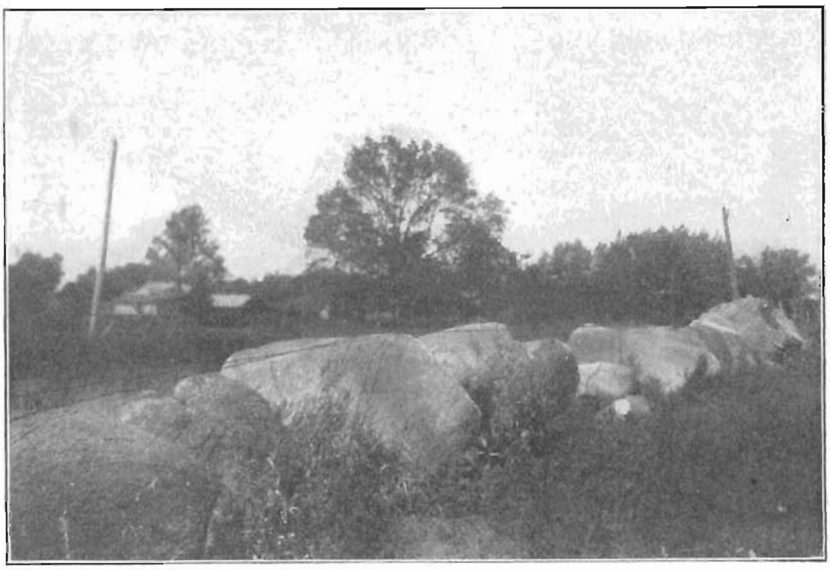


Fig. 43—Iowan bowlders set as a fence, Horton.

previous glacial stage whose ice sheet overran the same gathering ground was long enough for bowlders of weathering to develop on the rock surface glaciated by the earlier ice. The long time requisite in either case is suggested by the fact that the glaciated rock surfaces of our northern states and Canada are still comparatively fresh, notwithstanding the thousands of years which have elapsed since the final withdrawal of the Pleistocene glaciers.

The bowlders of Bremer county, while by no means rare, do not seem by any means as plentiful as those of the areas nearer the eastern margin of the Iowan drift. In very few cases are they thick enough to seriously interfere with agriculture. The views of figures 44 and 45 are quite exceptional. In many sloughs used for pasture only, bowlders have been left intact. Very many have been moved to the roadside to make way for the mower, the cost for limited areas thus cleared being in one case six dollars per acre.

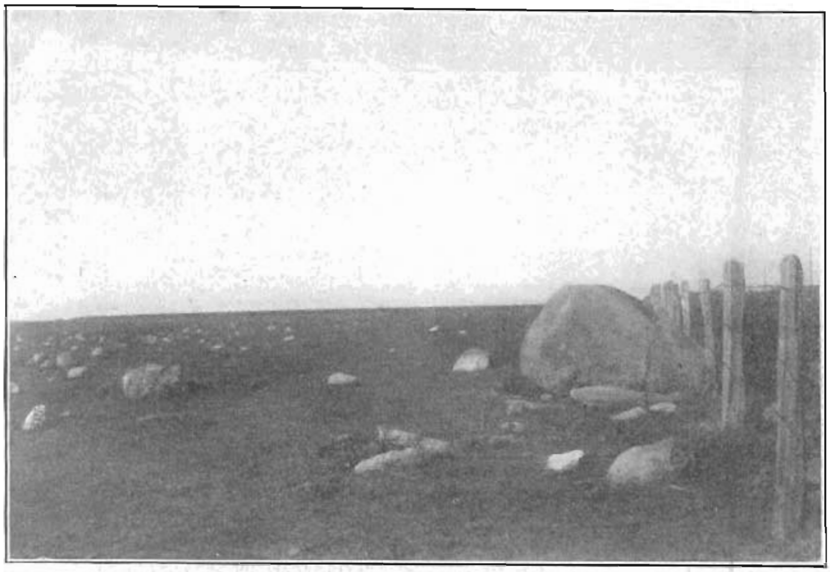


Fig 44—A swale on the Iowan Drift.

Throughout the county one may see the uses to which farmers have put these excellent building stones quarried by glacier plucking in northern Minnesota and Wisconsin and transported and delivered free of charge at their very doors. Although bowlders are everywhere used for foundations of the farmhouses, barns and granaries, and for abutments of the bridges of the minor streams, the supply is still far from being exhausted.

As unequiaxed bowlders may be expected to take the position of least resistance in the ice and like logs of wood in a stream to be carried for the most part end on and thus set down, their orientation is an index of the line of motion of the ice sheet. The observations of the orientation of the large bowlders of the county are not complete enough to be anything more than merely suggestive, as that of but twenty-three was taken. Of these eight bore west-east, and five north-south; five bore northwest-southeast and as many northeast-southwest.

LOESS.

The fine silico-argillaceous silt known as loess has already been mentioned as blanketing the areas where the Kansan drift is not covered by a later drift sheet. It also occurs upon the Iowan in cumulose deposits capping the peculiar hills called paha as will be shown in their description.

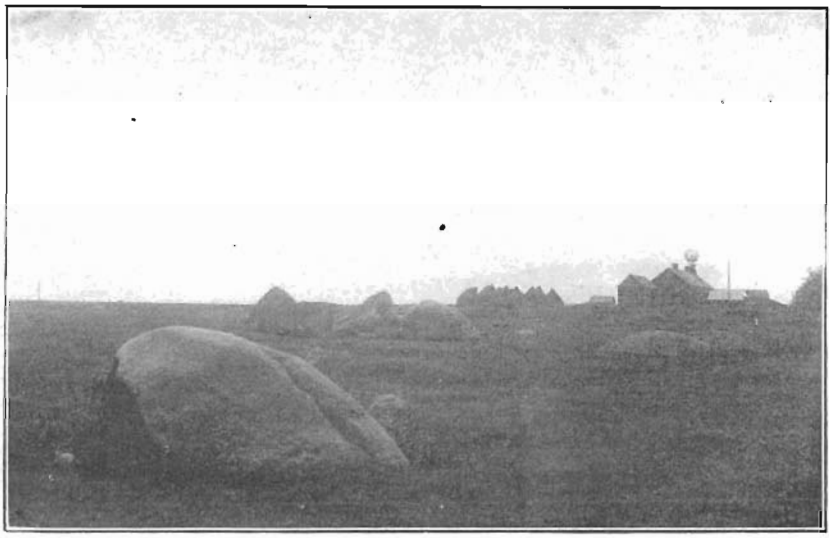


Fig. 45—Iowan bowlders, south of Tripoli.

The loess presents several phases, due in part at least to alteration since its deposit. The main body of the formation is a light buff loam, often mottled or streaked with gray, where it has either escaped oxidation or has been deoxidized by the presence of organic matter such as tree roots, which penetrate it deeply. Vertical cleavage is a notable characteristic. Lime carbonate occurs in minute branching tubules, in concretions sometimes called loess kindchen, and in small fossil shells, the latter being more numerous, however, in the ashen loess underneath Ferruginous nodules are not rare.

The loess is often underlain, as in many places in the Denver area, by a bluish gray or ashen loess sometimes obscurely laminated, more pervious than the loess above and usually more calcareous. In places it graduates into a reddish loess-like loam, more clayey than the loess, intermediate in nature between the loess and the residual clays of the geest or the weathered clayey and ferruginous surface of the Kansan till, on one or the other of which it rests.

About the Iowan margin the loess usually passes downward into sand by inter-stratified streaks and bands of sand and loess. Superficially the loess weathers into brown, minutely jointed clay, differing from the main body of loess in its higher oxidation and deeper color, in dark narrow bands of ferruginous stain which traverse it parallel with the upper surface, in greater induration, in finer particles due presumably to disintegration, in complete leaching and absence of fossils and in its tendency to break down into a slope of small crumbling fragments.

Paha.—These enigmatic hills, eminently characteristic of the border of the Iowan drift sheet where it meets either the main area of the Kansan drift or the numerous Kansan islands found within the Iowan limits, were first described by McGee in his classic treatise on the Pleistocene history of Northeastern Iowa. Of these lenticular hills, constituted in part or whole of loess and trending with the direction of the ice flow, McGee discriminated three or four types:—"the elongated swell of soft and graceful contour standing apart on the plain, or else connected with its fellows, sometimes in long lines, again in congeries, and locally merging to form broad loess plateaus."*

The last mentioned type in which paha merge in broad loess plateaus can hardly be recognized under the definition, and it is perhaps to the long belts of loess-Kansan upland often skirted with pahoid hills to which McGee here refers. The paha of Bremer county either stand somewhat apart on the Iowan plain, or are much more frequently connected in congeries, but in no case are they far away from the Kansan margin. The Kansan upland of the Denver area is fringed with short-axised, low, elliptical loess hills where it meets the bowlder-dotted Iowan plain descending to it from the north. Still more marked and noteworthy are the long strips of loess which trail out from this

*Pleistocene History of Northeastern Iowa, 11th Ann. Report., U. S. G. S., p. 397.

area across the high Iowan upland lying east of Denver. This upland rises about as high above Quarter Section run as does the Kansan upland on the west. A short distance west of Denver (sections 25 and 26, township 91, range XIII W.) lies a cluster of rather short paha with undulating crests, inosculating with several long narrow swells of loess hardly more than twenty feet in height which stretch straight away across the nearly level Iowan plain, elsewhere destitute of loess, to the edge of the valley of Crane creek in section 33 of Maxfield township, a distance of more than two miles. The compass direction of these interesting banks of loess, 20 degrees south of east, is readily taken with the help of the farmsteads which are located upon them.

North of Waverly a singularly bold and picturesque group of these unique boat-shaped hills rises abruptly from the Iowan plain in sections 25, 26 and 36 of township 92, range XIV W.

Fig. 46—A small Paha, southeast of Waverly.

The largest lift their great rounded backs, bare of forest, to about the height of the forested hills of Waverly. To the northwest they descend to a series of short axised, overlapping paha whose lateral slopes measure about seven degrees. Still lower and longer pahoid ridges continue the northwesterly trend nearly to the flood plain of the Cedar river. The Iowan plain surrounds this group, separating it from the forested paha which merge with the Waverly loess-Kansan area . To the southeast of this area also, for a distance of about three miles, a number of more or less well defined paha of decreasing height extend their straight courses over the Iowan plain with an inflexible trend of about twenty degrees south of east. Other paha ridges lie still further south connecting the Waverly paha with those north of the Denver loess-Kansan area.

The intimate structure of the paha is not shown in any deep sections in the county nor by any accurate well records. Some of the road sections which may be of slight assistance in elucidating their structure are the following:

Section at northwest end of paha about thirty-five feet high on west line of section 7, township 91, range XIII W.

		FEET.
4.	Loess, typical, yellow, pulverulent, with vertical cleavages, containing ramifying calcareous tubules, obscurely laminated, lower portion marked by a few thin discontinuous seams of fine sand	11
3.	Loess, ashen in color, sparingly fossiliferous with small molluscan shells, laminated, containing a few vertical ferruginous concretions	3
2.	Red loam	½
1.	Geest, red, containing Devonian cherts and some silicified corals, with a few pebbles of the northern drift, upper surface rising with slope of hill, rock beneath not seen, but inferred to be a few inches beneath	½

The lamination lines of Nos. 3 and 4 and the surface which separates them, are parallel with the surface slope of the hill. No. 4 grows coarser at it approaches the side of the paha on the north. The rock is near the surface in this area, and there may be a low rock nucleus to the hill. Upon this nucleus a considerable body of till may be molded in the center of the paha, as our section was taken at the end. At the southeast end of the paha a reddish sandy till is seen in a shallow road cutting, and the south road along section 7 indicates that the paha has a sandy margin. This ridge is somewhat more than one-half mile long, the long axis bearing between 20 degrees and 25 degrees south of east.

A section of a low pahoid ridge seen in a road cutting between the southeast and the southwest quarters of section 6, township 91, range XIII west, shows a central nucleus of till whose surface slopes with the hill, covered with reddish sand somewhat indurated, and a few feet of a pale calcareous loess beneath a sandy humus. On the margin the loess gives place to the reddish sand.

A section at the end of a paha on the road separating the southwest quarter of the southeast quarter and the southeast quarter of the southwest quarter of section 5, township 91, range XIII W., shows five feet of yellow loess, with small loess kindchen scattered through it, overlying ashen loess of which only two feet were disclosed.

As to the difficult problem of the origin of paha the survey of Bremer county adds little information. The problem resolves itself into two parts, that of the origin of the neucleus of till and of similar pahoid drift hills and ridges on which loess is absent, and second, the origin of the loess cap.

The elliptical profile of paha, their occurrence in groups and the parallelism of their major axes all suggest a close affinity with the lenticular hills of glacial till called drumlins. These hills are extremely abundant on the later drift, in parts of Wisconsin, Michigan, New York and Massachusetts, but have not been recognized in Iowa, nor on the Kansan or Iowan drift sheets, unless the paha are a subspecies of the class,—are drumlins capped with loess. The precise form of the till nucleus is seldom ascertainable. The shapes of some paha suggest that several mounds of drift, which may be far from drumlinoidal in their profiles, are concealed beneath the ample sweeping curves of the loess blanket. On the other hand in Cedar and in Benton counties drift hills have been reported, drumlinoid in axis and in some instances drumlinoid in form and immediately associated with paha. The distribution of paha differs from that of drumlins in other states. The former occur, as the latter are not known to do, in long belts alternated with strips of smooth drift plains. Paha are connected closely also with long parallel ridges of loess-covered drift of such dimensions and complexity as to remove them wholly from the category of drumlins. The difficult problem of the ridged drift may, when solved, be found to include the lesser problem of the paha. If these ridges are constructional they would seem to belong to some type of sublateral moraines, or to find their cause in the presence of underlying ridges of the country rock inherited from preglacial or interglacial times. If erosional these ridges must be regarded as remnants of an earlier drift sheet left in relief by the erosion of the intervening lower plains by the long tongues of glacier ice of a later ice invasion.

If the till nucleus of paha is drumlinoid, it may hypothetically be of either Kansan or Iowan drift, and three possibilities here present themselves,—the paha cores may be loess covered drumlins either accreted out of Kansan drift by Kansan ice, or accreted out of Iowan drift by Iowan ice, or eroded out of Kansan drift by Iowan ice. So far as observed the drift of paha has been referred to the Kansan. But it should be noted that the discrimination between the two drifts is not always easy in a few individual exposures and that the position of the axial drift of these hills relative to the ground water surface promotes a comparatively rapid oxidation and leaching, thus tending to an approach to the Kansan facies in these respects rather than to that of the Iowan till of low lying areas where ground water stands higher and its level fluctuates but little.

If paha cores are Kansan drumlins as the appearance of their till suggests, they can hardly be drumlins of accretion; for we could not possibly explain their restriction to the margin of a later drift sheet. If they are drumlins of erosion carved out of the preexisting Kansan drift sheet by the Iowan ice, we have here also a difficulty to meet, for the implication of any considerable erosion so near the margin of the Iowan ice is opposed not only by what is known of the behavior of ice scheets, which deposit rather than erode in such positions, but also by the current conceptions of the extremely limited amount of the drift deposited by the Iowan ice at any place either as ground or terminal moraine. Certainly a glacier able to erode an earlier drift so markedly should have been able to drag the eroded material a little farther on and leave it in a terminal moraine about its margin. This theory, however, of paha cores as remnantal masses of Kansan drift accounts for their distribution in connection with Kansan areas and their usual accordant height with the drift of Kansan uplands adjacent.

The problem of the presence of the loess on the paha and its absence on the surrounding Iowan plain from which they rise is entangled with the problem of the origin of the loess. Although the loess may be held to be an aqueous deposit, yet paha can not be called eskers of loess as some have done, for the lenticular paha are quite unlike the winding ridges of sand and gravel laid by subglacial streams and known as eskers. Some peculiar control must be posited in explanation of the parallelism of the paha axes and their constant trend over all of northeastern Iowa; the control of some single cause operant over this entire area. No such cause is now known to be in operation, but such a cause may be found in the constant direction of movement of an ice sheet covering the entire area, the direction with which the paha are aligned. McGee long since suggested that during the last stages of the ice which latest invaded this territory the glacial flow was checked in the lee of each prominence beneath, and a line of less rapid movement stretched away. Along these lines surface melting was more rapid and the surface was lowered (as in the lee of the nunataks of the Greenland ice cap). Here the courses of superglacial streams became established, here the ice was cut through, and here in ice-walled sluggish streams or ice-bound lakes the finer waste washed from the surface of the stagnant ice was in part laid as loess together with its interstratified and basal sands. In such crevasse-like openings in the stagnant ice which covered Bremer county we may entertain the theory that the paha which trail away so conspicuously in the lee of the loess-Kansan hills of the Waverly and the Denver areas received their cap of loess.

The distribution of the Loess.—The problem of the paha is inextricably entangled with the problem of the origin and distribution of the loess of the upper Mississippi valley. The latter problem presents itself in Bremer county in an unusually simple form and under special conditions. The loess of our area differs in its insularity from that found in counties to the south and east. It is not spread heavily and continuously over long belts of upland parallel to the rivers, nor does it occur as a comparatively thin sheet mantling all the land as over southern Iowa. Here it is seen only in the completely isolated and restricted areas which we have described. No theory of the origin of the loess can be satisfactory, therefore, which fails to explain the absence of the loess over the larger part of the region as well as its presence in these small islands far removed from any other deposits of loess east, west, north or south.

Except in distribution the loess of the county is entirely typical. It presents the same upper weathered zone, leached of lime, of browner color and more clayey composition, the same body of floury, calcareous, yellow silt, the same interlamination with streaks of fine sand increasing in width and number toward the base, the same fossils of small terrestrial mollusks, the same calcareous and ferruginous concretions, the same gradation beneath into ashen loess, into sand and gravel, or into red loam and geest, the same gradation in places outward also into peripheral sands,—the same phenomena in all respects as the loess of the loess-Kansan ridges and paha of east-central Iowa.

The theories of the loess may be mentioned here, if only to discover to what extent each may be able to explain the distribution of the loess in this region. These theories fall into two divisions as to the processes concerned—the eolian and the fluvio-lacustrine, the former accounting for the loess as a wind deposit, the latter as water-laid in lakes or by the sluggish currents of rivers. Each theory includes a number of different views as to the source of the material, the period of deposit and various modifying conditions. Thus the eolian theory finds the source of the material blown up to form the loess:

1. In the silt of river plains either
   - a—that of present rivers, the loess still being in process of formation or
   - b—that of the valley trains and outwash of glacial streams during the closing stages of an ice invasion.
2. In sheets of drift left exposed by the melting of glacier ice either
   - a—immediately after the recession of the ice sheet or
   - b—during an interglacial epoch of great aridity.
3. In superglacial moraines sheeting the margin of the ice, as that of the Malaspina glacier.

4. In the loose superficial deposits of arid western plains, either
   a—during the epoch of an ice sheet and deposited in part upon the ice after the manner of the dirt on the margins of the ice cap of Greenland or
   b—in a period succeeding the withdrawal of the ice.

The fluvio-lacustrine theory is much more limited in period of deposition and in sources of material. By this hypothesis the loess must have been deposited in a period of flooded lakes and rivers attending the closing stages of an ice invasion. The material of the loess can be sought for only in the finer silt washed from glacier drift, including any superficial dust deposits, and laid both in advance of the ice front and over any insular areas within the margin of the ice sheet.

The insularity of the loess in Bremer county is an objection to any one of these theories. as for example a and b of "1" of the eolian theory, which gives no explanation of the absence of the loess over the remainder of the county. For while the loess areas touch upon one of the rivers of the region, they touch upon it at the most narrow portion of its valley, where it has no wide flood plain from which loess could be blown up. And loess is wanting precisely where on this theory it might be most expected, that is, along the wide flood plains of the Cedar above Waverly and of the Wapsipinicon throughout the county. Both of these wide valleys were the channels of the floods attending the melting of the ice sheets of the Glacial epoch, and the Cedar, at least maintains its sandy plains of overflow which should long have been an ideal gathering ground for loess, if its origin were eolian.

If we are to assume that the peculiar distribution of the loess is due to anchorage, the loess being deposited only where the uneven surface of hilly ground caught and held the wind-driven dust, it is difficult to understand why the loess was not deposited on the valleyed uplands east and west of the broad flood plain of the Cedar at Horton as well as on the Kansan areas at Waverly and Denver. Or if the presence of forests be made the determining factor, it might be supposed that the forests of Leroy township between the wide bottom lands of the Wapsipinicon and the East Wapsipinicon rivers would have made as good a catchment area as any in the county. It is true that the loess areas are mostly forested, a fact usually attributed to the porous and well drained loess soil. The eolian theory, however ingeniously reverses the relation, holding that the forests are the cause of the deposition of the loess by checking the velocity of the dust-laden wind, and by anchoring the dust by means of its mattress of roots.

If the accumulation of such a forest loess were rapid it should include considerable vegetal carbonaceous matter; if slow, the loess should be both decalcified and deoxidized, since by hypothesis it has formed a part of the forest soil rich in decaying organic matter which would act as a reducing agent, and in humous acids and carbon dioxide to aid in the solution of lime carbonate. Moreover, the presence of loess over the prairies of southern Iowa shows that neither forest nor hilly country is a necessary condition to loess accumulation. It would seem that the loess, if of eolian derivation, should be as wide spread over the county as are the channelless currents of the air which laid it, unless it had some local source not yet discovered. The fluvio-lacustrine theory may be able to explain the insularity of the loess tracts by affording ice-barriered water bodies for its deposition and the absence of the loess over other tracts by the presence of overlying ice. We may thus suppose that during the waning of the Iowan ice the stagnant glacier which still lay over the remainder of the county, was removed from the Denver area where, because of the underlying hills of rock and drift its motion had been retarded and its surface lowered. Here the glacial Cedar was diverted from an earlier course and incised a narrow valley in the rock basemented hills. Here it spread its muddy waters in the wide lake-like expansion or embayment, the sluggish current being sufficient to carry away the finer clays and not strong enough to bring in coarser sands and gravels, thus leaving the glacial silt of intermediate texture, too coarse for clay and too fine for sand, and known as loess. The embayment may be conceived as being surrounded by gentle slopes of ice rather than by precipitous ice walls, if this would in any way help to explain the difficult point of why no coarse waste was washed in from the surface of the glacier and deposited with the loess or was dropped from bergs.

This theory of the loess of the Denver area perhaps offers an explanation of the anomalous course of Quarter Section run, which, as we have seen, flows round the border of the loess-Kansan area, diverging at right angles from its normal track. For the stream is seen to follow the eastern and southern edge of the ice barrier, which, by hypothesis, inclosed the area at the time preceding the final withdrawal of glacial ice from northeastern Iowa.

In age, the loess of Bremer county is clearly younger than the Kansan, whose weathered and eroded surface it overlies unconformably. The close association of its basal sands with the Iowan drift points to the Iowan epoch as the time of its formation. The same conclusion is indicated elsewhere in the state, where the loess is seen to be parted from the Illinoin drift by old soil beds, and to be overridden by the margin of the Wisconsin drift sheet, and is thus proven to be younger than the first named drift and older than the second, thus limiting its period to the Iowan and the interglacial stages following and preceding the Iowan.

PRE-GLACIAL TOPOGRAPHY.

It is a matter of common knowledge that the underlying rock surface, which seems to have been little affected by the glacial invasions, does not correspond with the relief of the surface of the ground today. In places in the county the rock basement appears in ledges on the hillsides; in others it is so deeply buried that the drill of the well driller is driven two and more hundred feet through drift before it grinds on solid rock. If the deposits of the ancient glaciers and their glacial waters could be stripped away, what would be the relief of Bremer county? Thanks to the records and the good memories of the well drillers of the county, we are able to sketch some of the outlines of the preglacial topography, although much is vague, some perhaps erroneous and many details are wanting. In a broad way it may be said that the evidence before us presents the northeastern counties of Iowa, such as Allamakee and Clayton, over which no glaciers ever passed, and like eastern Fayette county, where the glaciers left little drift,—a hilly area trenched deeply with broad valleys and intricately carved with branching gullies and ravines. We know that the floors of the preglacial valleys stand at a lower level than those of today. Not only have they been filled with drift as one might fill a watering trough with mud or sand, but even the preglacial uplands between the streams have been deeply buried. Nearly 300 feet above where a great river once flowed the farmer now drives his plow over gently rolling fields.

Such a deep buried valley crossed the county from northwest to southeast. It passed from Douglas township into Warren between Quarter Section run and Baskin run, passed under the site of Bremer station, then turning eastward followed the valley of Quarter Section run into Jefferson township, and crossing into Maxfield near Maxfield P. O. followed down the west side of Crane creek into Black Hawk county. It will be convenient to designate this as Bremer river

On the high divide between Crane creek and Quarter Section run in sections 17, 19 and 20 of Maxfield township are a number of wells from 240 to 273 feet in depth and all in drift. The divide here has an altitude of about 1035 feet above tide (taking the grade of the Chicago Great Western Railway one and a half miles north as datum), giving the floor of the buried valley an elevation of not more than 765 feet A. T., or 160 feet below the rock bed of the Cedar river at Waverly. The channel of this ancient stream has been completely obliterated, leaving no trace on the present surface, unless the broad valley of Crane creek occupies the sag due in part to a settling of the unusually thick drift of this belt.

The wide valleys of the Wapsipinicon and the East Wapsipinicon are also deep preglacial or interglacial valleys now filled with drift, though not to the height of that which buries the valley of Bremer river. The depth of the artesians drilled on the Wapsipinicon bottoms seldom exceeds 100 feet, but in only a single case is rock reported to have been struck. As the elevation of the Wapsipinicon bottoms is about 970 feet (where crossed by the Chicago Great Western Railway) the rock floor of the ancient valley can not be higher than about 870 feet.

The Cedar valley in its broad reaches north of Waverly is of unknown depth, drive wells furnishing abundant water at a few feet from the surface.

Further south, where the valley is of the same type, it has been sounded by the artesian borings at Vinton, and found to be filled to a depth of 115 feet, its rock floor lying at about 665 feet A. T.

We add some details of the thickness of the drift in the different townships of the county.

Sumner township.—The drift varies here from nearly 200 feet in the northeastern part, and 136 and 150 feet at Sumner, to a little over one hundred feet in the northwestern sections of the township. Little is known of the depth in the southwestern sections; one well (southwest quarter of section 21) ends in drift at 138 feet.

Franklin township.—East of the Wapsipinicon valley rock occurs from 100 and 120 feet from the surface, as at Minkler, to 160 and even 200 feet in the southeastern part of the township. On the west side of the Wapsipinicon, deep wells are reported in section 7, where two wells found rock at 192 and 200 feet and another is listed as ending in drift at 275 feet. At Key the drift was not drilled through by a well 130 feet in depth. These three wells are near the side of the Wapsipinicon valley, but their significance as related to any ancient course of the river is undiscovered.

Dayton township.—The southeastern township of the county is throughout an area of thick drift. On the east of the Wapsipinicon valley wells ending in drift are reported from 150 to 180 feet deep and the only one listed as striking rock discovered it at 190 feet. Rock occurs just east of the Wapsipinicon valley at from ninety to 120 feet.

Leroy township.—The divide between the Wapsipinicon and the East Wapsipinicon rivers rises a little more than 100 feet above the rock surface, and the divide between the latter stream and Leroy creek to nearly the same height. Statements as to the depth of the filling in the valley of the East Wapsipinicon are conflicting, one being that in the valley wells are from 150 to 180 feet deep and strike no rock. On the other hand, two wells are reported on the bottoms below the confluence of the stream with Leroy creek (sections 23 and 26) which find rock at eighty-five and ninety-five feet. A well in the valley in section 11 is reported to be 100 feet deep and ending in drift or in alluvium. An interesting group of wells is found in section 18 where rock is found at 200 and 220 feet below the surface. We have evidently here an old buried channel, but no deep wells in the vicinity enable us to trace its course.

Frederika township.—In the northeastern part of the township rock is found beneath the upland at a depth of from fifty to eighty feet at the north and farther south at less than 100 feet. The Wapsipinicon valley is filled to at least the depth of sixty and seventy feet, as wells ending in drift attest. Rock appears on the flood plain at Frederika, but west of old Tripoli it has sunk to sixty and 100 feet below the surface.

Douglas township.—The scanty data at hand suggest that two channels of Bremer river or the main valley and a tributary unite in the southern portion of the township, where the buried valley reaches a depth of 220 feet. Less than two miles and a half away in the southeastern part of the township the Niagara comes to the surface, giving the measure of the depth of the rockcut valley at more than 200 feet at this locality. The slight grounds for positing two channels in the north are a deep well reported as 190 feet to rock on the east (in section 2) and wells on the west of the township (sections 6 and 9) sounding rock at 200 and 178 feet, with rock at less depths between in in the center of the township. In the southwestern part of the township rock seems to lie about 150 feet below the surface.

Warren township.—In the southwestern part of the township the drift is from sixty to 100 feet in depth. Between Quarter Section run and Crane creek it is 105 feet deep at the Bremer County Poor Farm. But in the buried channel of Bremer river the drift lies at least 236 and 240 feet deep, as several drift wells of these depths attest.

Maxfield township.—Here Bremer river valley reaches a depth of at least 270 feet as several drift wells of this depth, or a little more, testify. East of this well-marked valley the rock rises, reaching to within eighty feet of the surface at Readlyn. In the southeastern part of the township it lies deeper, since drift wells are reported at from eighty to 100 feet in depth.

Polk township.—Little information was obtained regarding the thickness of the drift in the northwestern township of the county. Rock outcrops in the northwestern section and at Horton it lies but twenty feet below the surface. On the upland south of Horton wells eighty feet deep do not strike rock, and in section 24 a drift well 214 feet deep is reported, probably indicating a tributary valley of Bremer river.

Lafayette township.—On the upland west of the Cedar, drift seems to be about 100 feet thick, and about as thick on the upland east of the river. Rock outcrops at numerous places along the Cedar valley.

Washington township.—Here the rock is disposed much as in Lafayette township, lying from seventy-five to 100 feet below the crests of the hills west of the Cedar and at the same depth over the Iowan paha-dotted plain of the eastern sections, but outcropping along the course of the Cedar river.

Jefferson township.—The only outcrops of rock known are in sections 9, 21 and 28. The rock surface evidently descends toward the east to the valley of Bremer river, where drift wells 214 and 220 feet deep are reported. At Denver a lateral of Bremer river seems to be indicated, for here rock is found 162 feet below the level of the flood plain of Quarter Section run, while a block away rock lies but forty-two feet from the surface, indicating a precipitous slope of 120 feet in this short distance. In the southeastern part of the township rock is found at 110 feet (section 35). On the loess-Kansan area west of Denver wells are reported to find rock at from sixty to ninety feet.

Jackson township.—Rock outcrops along the Cedar river. Between the Cedar and the Shell Rock it lies from forty (section 28) to 100 feet (section 22). In the southeastern sections rock appears to be found from thirty to eighty feet below the surface of the prairie.

ECONOMIC PRODUCTS.

BUILDING STONE.

Small quarries capable of supplying stone suitable for ordinary building purposes are well distributed along the Cedar river from the northern to the southern limits of the county. East of the Cedar valley no rock outcrops except at or near Frederika. All of the building-stone quarries opened are in the Cedar Valley stage of the Devonian limestones. All are worked without the assistance of machinery and in a small way for the supply of the local demands, chiefly for foundations. These quarries have been described in detail under the geological sections of their formations.

CRUSHED STONE.

The Cedar River Stone Company has recently opened an important quarry one and one-half mile southeast of Waverly on the Cedar river connecting with the Chicago Great Western Railway by a short spur. Large contracts are being filled for crushed stone for ballast and macadam over the lines of this railway and in the cities which it reaches. A view of the plant is given in figure 47. Below the stripping, which is easily disposed of by dumping in the river, the stone is unusually tough, dense and unaffected by the weather, being one of the best limestones in the state for the purposes for which it is now used. There is an uniform run of twenty-five feet or more of good rock with no waste of soft stone or disintegrated rock meal. The following section is exposed:

		FEET
5.	Stripping, limestone, light gray, soft, broken by the weather into layers from 2 to 4 inches thick, fossils rare	9
4.	Limestone, dense, hard, tough, yellow-gray, lowest layers about 3 inches thick, divided above by diagonal joints and bedding planes into rhombic blocks 1 to 4 feet in diameter. Occasional geodic cavities an inch or so in diameter lined with drusy calcite; fossiliferous with many firmly imbedded *Atrypa reticularis*, *A. aspera occidentalis* and *Orthis iowensis*	25
3.	Concealed	12
2.	Breccia of Wapsipinicon stage, hard and dense	5
1.	Concealed to water's edge	3

Lime.

Lime is now burned in the county only at Brodie's quarry, in Frederika, in a small square pot kiln, using wood as fuel. The stone used is the buff magnesian limestone of the Cedar Valley stage of the Devonian, underlying the *Acervularia profunda* beds. The high magnesian content of the stone gives the lime its repute as a slow slacking, slow setting lime of excellent quality. Lime has been burned in the past at a num-

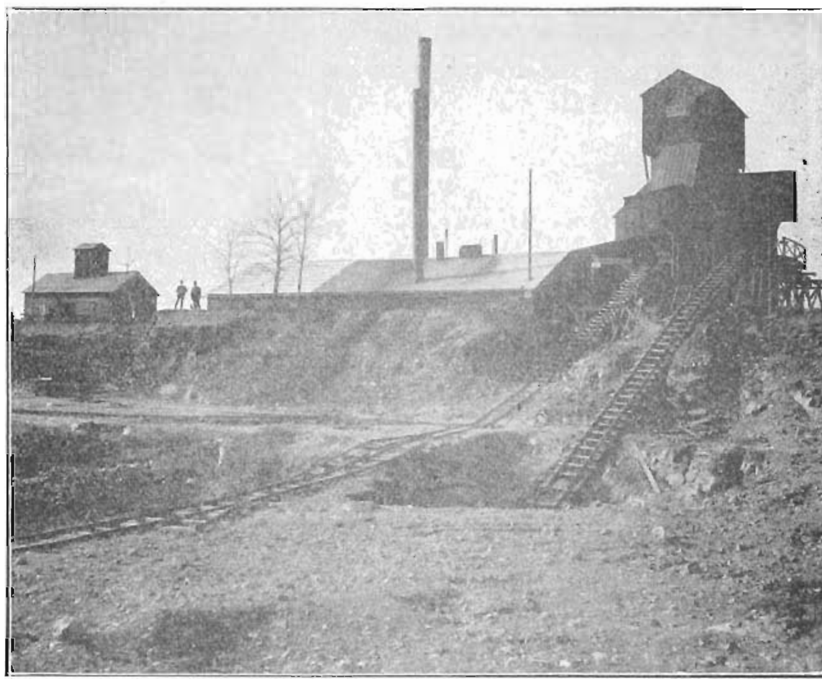


Fig. 47—Plant of the Cedar River Stone Company, Waverly.

ber of small pot kilns, as on the Niagara outcrop southeast of Waverly and on the Devonian northeast of Plainfield. The former site has a stone unexcelled in quality, with little stripping and is also near a large timber supply, but its distance from town is such that it has not been able to meet the close competition in this industry.

Clay.

The loess clay is utilized at Waverly in the manufacture of common brick, for which it is admirably adapted. In 1903, the two brick kilns in operation, that of the Waverly Brick and Tile Co. and that of Henry Cretzmeyer, reported an output of 273,000 brick valued at $2193.

Soils.

The soils of Bremer county may be grouped into three general classes, drift soils, loess soils and alluvium. The first class named occupies the areas mapped as Iowan drift. Over much of this area the topography is indecisive and the drainage imperfectly developed. A deep humus rich in nitrogen and carbon taken from the atmosphere has here accumulated in a black soil of unusual fertility. Where the unleached, clayey Iowan till forms the subsoil this contributes various mineral plant foods in a condition such as to make them readily available. Where, as is commonly the case, the upper surface of the drift is sandy, the effect is to produce a light, warm soil, readily drained and easily worked. In places where the Iowan is specially sandy either from glacial outwash or from the working over of the drift by the winds, there results a soil easily affected by drought but quickly responsive to fertilizers and favorable for maturing early crops and special agricultural products.

Loess makes a most admirable subsoil and when well mingled with abundant humus, no soil can yield more generously or with greater endurance. It absorbs like a sponge any excess of storm water and in drought gives it back to the surface by capillarity. Thus it neither drowns out in wet weather nor bakes in dry. Moreover, its mineral ingredients, drawn from an exceedingly large variety of rocks, are in a finely divided condition in which they are easily taken into solution and used by the plants. Owing to its porosity, loess is readily penetrated by plant roots, and it is thus available to greater depth than are most soils. In Bremer county, however, the loess has been laid upon the slopes of the paha and over deeply dissected uplands. Where unadvisedly the forests have been cut down and the loess hills placed under the plow, the humus, the careful savings of the virgin forests for ages past, is washed away and wasted in a few years, leaving the yellow hillside scarcely altered from the normal color of the loess by any carbonaceous admixture. Constant care is now needed to prevent the formation of gullies which, beginning where the grass has been destroyed by the tread of cattle or in the furrow of the plow, grow in a few years to be great arroyas. One farmer in this area reports that a month of his time is occupied each year in preventing these natural effects of rain and gravity on the soft loess silt of his hillsides. Even when the loess has been stripped of its humus, it still responds generously to fertilizers, but good economy strongly urges that the loess-Kansan areas be left for forests, for orchards, for vineyards and for pastures, for which they are best adapted by nature.

The rivers and creeks of the county are bordered with belts of soil derived from the materials washed down by streams and deposited over the valley floors at times of flood. There is also an extensive creep of the cream of the soil of the adjacent hills forming alluvial slopes which blend with the alluvial plains and whose soil differs but little from that of the flood plain except in the finer grain of its material. On the flood plains river silts are mingled with humus accumulated in place upon the level areas from the growth of vegetation and from that washed off the soils of the country and brought in by muddy floods. Thus to a depth of several feet the alluvial soil may be dark with rich carbonaceous matter and of corresponding fertility. Where the deposit has been laid in what was at the time the channel of the river, and by its rapid currents, the alluvium consists of sands and gravels, with little of intermingled, finer material, and it is far less fertile than are the finer deposits from the shallow and sluggish overflow upon the wide flats of the river bottoms.

Water Power.

The diversion of the rivers by the Pleistocene ice sheets from their ancient channels, setting them to flow over higher courses and rocky beds, gives excellent water power to each of the rivers of the county. The water power at Waverly was substantially improved in 1905 by raising the head, by repairs on the dam, and more especially by the installation of a large cement bulkhead, wheel-house, new wheels, and the excavation of a tail race, the total amount of these repairs being about $22,000. There are now installed in the wheel-house two wheels

(S. Morgan Smith Co., wicket gate), each furnishing at the normal stage of the water about 170 horse power at the wheel shaft. The normal head of water is from eight and one-half to nine feet. The incorporated town of Waverly owns in fee simple all the water power, having purchased all outstanding leases and water rights. The power is used in the operation of the municipal water works and the municipal electric plant, both owned and operated by the city, and a feed and flour mill owned by the city but leased to a miller. For all these purposes the power supplied by one wheel alone is amply suffcient. The power now available is thus greatly in excess of present demands. It can be largely increased in the future by the completion of the tail race and the installation of additional wheels.

An excellent water power has also been developed on the Cedar river at Janesville, where a large three story flour and feed mill has long stood. The equipment of the mill is now five run of buhr millstones and one set of rollers, with a capacity of 125 barrels in 24 hours. The head is reported as nine feet.

At Frederika, a dam across the Wapsipinicon river gives a head of seven feet, two wheels furnishing to the flour and feed mill there about fifty horse power.

Water Supply.

The rivers of the county afford a permanent and inexhaustible supply of stock water to the farms adjacent to their banks. The creeks are also utilized in this way, although their supply may fail in dry years, especially along their upper courses. Everywhere the wind engine forms a prominent feature of the landscape, thus attesting the prosperity of the farmers, and also the fact that the ground water of the country has lowered since its settlement and permanent and adequate supplies for stock are now to be secured only by deep wells.

Water is seldom found in sufficient quantities beneath the Iowan drift and above the Kansan. Wells are driven until they come upon water bearing sand or gravel either in or between the blue tills of the Kansan and Jerseyan. Water is occasionally found in gravels lying on the rock, but not infrequently the drill finds the drift dry throughout and is compelled to pass into the country rock. Where this is limestone, water is commonly found in the zone of broken rock within a few feet of the upper rock surface, although where the rock comes near the surface of the ground, the ground water level may lie deep. But over the considerable area of the buried valley of "Bremer river", where the drift is 200 feet thick and more, the drill may pass through the drift only to strike the Maquoketa shale. The boring must then continue through the Upper Maquoketa in order to find water in the limestones of the Middle Maquoketa. In an instance of one farm well even this resource failed, and the well was drilled through the entire Maquoketa, Upper, Middle and Lower, and into the Galena before sufficient water was obtained. In this area of deep drift another difficulty presents itself: in places heavy beds of fine sand are encountered, water-logged indeed, but impossible to sieve out. In this case it is only with much care and skill that the driller forges his way to the underlying gravels.

On the wide flood plain of the Cedar water is obtained by drive wells. Farms on the floor of the valley of the Wapsipinicon, and even some distance up the slopes of the bordering hills, obtain a most copious supply of excellent artesian water at a depth of about 100 feet, from glacial gravels underlying an impervious sheet of till. From Tripoli to the Black Hawk county line nearly every farm in the valley is thus supplied. The original head has been seldom measured, but in one well, located somewhat up from the bottoms, the head was found to be twenty-one feet above the curb. Although the head of the wells, some of which have been flowing for more than twenty years, has lowered considerably, and some on the hillsides have ceased to flow, the discharge is still ample, and is reduced usually to that of a three quarter inch pipe. Unlike some drift artesians, the water of the Wapsipinicon valley is both palatable and healthful. Flowing wells are obtainable also in the valley of the East Wapsipinicon, at least below the confluence of Leroy creek.

A high compliment is paid in recording the fact that each of the large towns of the county has supplied itself with artesian water, thus insuring the health of its citizens against those diseases of which drinking water is the vehicle. This fact is all the more noteworthy in that the county is removed to a considerable distance from areas where successful artesians had already been sunk and the sinking of these wells was without near precedents and examples, and no doubt seemed to their promoters something of an experiment.

The artesian well at Waverly, owned by the city, was begun and completed in 1899. It had been the intention of the city council to sink the well several hundred feet deeper in order to obtain the largest possible supply under the greatest possible head. The writer was called in when the well had reached its present depth, and as he advised against drilling deeper, because of the excellent supply already obtained, because of the danger of injuring the quality of the water by tapping veins of highly mineralized waters apt to be found at greater depths, and because the chief aquifers of the artesian field of northern Iowa had already been passed by nearly 500 feet, the boring was stopped at once. The supply was estimated by citizens at 200 gallons a minute. Analysis of the water showed it to belong to the finest class of mineral waters,—the calcic magnesic, containing about 37 grains to the gallon of calcium and magnesium carbonates. The small amounts of sulphate and carbonate of soda present are not unhealthful, and the little iron in the water has a distinct therapeutic value. No sulphate of lime is present, and the water ranks among the best drinking waters in the state.

The first water vein reported was encountered in the St. Peter at 730 feet. In the Upper Oneota from 840 to a little over 900 feet strong veins were found, giving an overflow at 840 feet. Other flows were found in the Jordan sandstone from 1120 to 1200 feet, below which the boring seems to have encountered no more water.

The supply has remained entirely adequate to the growing needs of the town. In the summer of 1905 the well was found to be leaking badly. When the cistern, 19 feet deep, into which the well discharges from a pipe seven feet from the curb was pumped down, a strong flow came in through the rock bottom of the cistern and the well ceased its discharge, resuming when on the cessation of pumping the cistern filled to near the level of the discharge pipe of the well. It was suggested that the well should be recased to near the Maquoketa shale. The temperature of the water, taken with some difficulty and possibility of error from the water discharging into the cistern was found in 1905 to be 53 degrees Fahr. Samples of the drillings were carefully saved as the work progressed and on their analysis the following geological section is based:

GEOLOGICAL SECTION OF THE WAVERLY ARTESIAN WELL.

	DESCRIPTION OF THE DRILLINGS.	DEPTH IN FEET.
48.	Limestone, buff, earthy, facies of Cedar Valley stage....	20
47.	Limestone, light buff, earthy....	30
46.	Limestone, dense, hard, brittle, brownish drab and light buff, of finest grain and conchoidal fracture; rapidity of effervescence in cold dilute HCl indicates a very slight percentage of magnesium carbonate; facies of Wapsipinicon stage of the Devonian....	40
45.	Limestone as No. 46, with a few chips of flint and some of light yellow arenaceous limestone....	50
44.	Limestone, light buff, earthy, rapid effervescence....	60
43.	Dolomite, or magnesian limestone, gray, earthy luster....	70
42.	Dolomite or magnesian limestone, in coarse chips, with flakes of bluish-white, subtranslucent, cryptocrystalline quartz....	80
41.	Dolomite or magnesian limestone, yellow gray, in fine sand....	90
40.	Dolomite in large chips, gray, luster earthy, with cryptocrystalline silica as No. 42....	100
39.	Dolomite, or magnesian limestone, soft, blue, subcrystalline....	110
38.	Shale, blue, with small nodules of pyrite, and fine sand of bluish limestone chippings....	120
37.	Limestone, soft, blue, saccharoidal, of brisk effervescence, pyritiferous....	130
36.	Shale, calcareous, bluish or greenish in color; samples at 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, and....	260
35.	Limestone, mottled light and dark drab, fine saccharoidal, magnesian....	270
34.	Flint, light drab, in large chips, with limestone, blue-gray, of rapid effervescence....	280
33.	Limestone, blue-gray, rapid effervescence, soft, argillaceous, with considerable flint; samples at 290, 300 and	320
32.	Limestone, white, light gray, and cream colored, often in thin flakes, rather soft, and often argillaceous, luster earthy, effervescence rapid; samples at 360, 390, 400, 410, 420, 430, 470, 480, 490, 500, 510, 540, 550, 560, 580, and...	590

DESCRIPTION OF THE DRILLING.		DEPTH IN FEET.
31.	Shale, green, with some fine chips of limestone	600
30.	Limestone, soft, earthy, non-magnesian, light gray, fossiliferous	610
29.	Limestone and shale, the latter green, (two samples for this depth, one of limestone of Trenton facies and one of Trenton shale as No. 31, may represent the interval between 610 and 630 feet)	620
28.	Shale, green, in angular chips, with some chips of light gray limestone as above..............................	630
27.	Limestone, soft, earthy, with much green shale; samples at 640, 650 and....................................	660
26.	Shale, green, bright, plastic, in large pieces of dried clay cleaned from drill; samples at 670 and..................	680
25.	Sandstone, white, soft, grains of pure quartz, moderately well rounded and rather fine; samples at 690, 700 and...	710
24.	Dolomite, gray, cherty, with chips of white saccharoidal sandstone and much quartz sand........................	720
23.	Dolomite, hard, crystalline, light gray or cream colored, in chips with much quartz sand; samples at 740, 760 and	780
22.	Dolomite, light yellow-gray, in chips mingled with much white sand; samples said to represent drillings from 790 to..	920
	(Another statement that here drillings washed away because of overflow at 840 feet).	
21.	Dolomite, white, crystalline, cherty, with much moderately fine quartz sand in sample of drillings; 930 and.....	940
20.	Dolomite, cream colored.....	950
19.	Sandstone, white, fine grained, calcareous cement, in small chips with some of pink dolomite and grains of sand.....	960
18.	Dolomite, light gray, cherty, arenaceous	970
17.	Dolomite, mostly in clean sand and chips, often vesicular, white, gray, pink, often cherty; samples at 980, 990, 1000, 1010, 1020, 1030, 1040, 1050, 1060, 1070, 1100, 1110 and....	1120
16.	Sandstone, white, soft, of clear quartz, grains rounded, general size of grains of last sample about ½ millimeter in diameter; samples at 1130, 1140, and......................	1150
15.	Sandstone, drillings consist in part of angular sand of what appears to the naked eye as a light yellow dolomite, effervescing freely in hot HCl. Under the microscope it is seen to consist of minute angular grains of limpid crystalline quartz with calcareous cement; much of the drillings consists of rounded grains of white sand; samples at 1160 and	1170
14.	Sandstone, quartz, moderately fine and well rounded, with chippings of gray dolomite.............................	1180
13.	Sandstone, calciferous as No. 15; samples at 1190 and.....	1200

DESCRIPTION OF THE DRILLINS.	DEPTH IN FEET
12. Sandstone, fine grained, white	1210
11. Sandstone, calciferous as No. 15 with some flakes of dolomite; 1220 and	1230
10. Dolomite, highly siliceous, with finely divided quartzose matter of angular particles and somewhat arenaceous, with bright green grains of chlorite; samples at 1240, 1250, 1260 and	1270
9. Chert and dolomite and siliceo-calcareous shale	1280
8. Dolomite, highly argillaceous and siliceous	1290
7. Dolomite, gray, siliceous, silica in form of minute angular crystalline particles constituting a large part of the rock; with some green grains of chlorite, samples at 1300, 1310, 1320, 1330 and	1340
6. Shale, bluish green, feebly calcareous; samples at 1410 1420, 1430 and	1440
5. Shale, pink, buff and green, non-calcareous	1450
4. Shale, blue-green; somewhat indurated, non-calcareous; samples at 1460, 1470,1480, 1490, 1500, 1510, 1520 and	1530
3. Sandstone, rather coarse grains, drillings contain clayey admixture, and dolomite chips; sample said to represent drillings from 1540 to	1580
2 Shale of various colors; yellow; a bright dark green set thickly with grains of chlorite; red, arenaceous, with small partially rounded quartz grains	1590
1. Shale, blue-green, with considerable red shale probably from above; samples at 1600, 1610, 1620, 1640, 1670, 1690, 1700, 1710 and	1720

ASSIGNMENT OF STRATA.

FORMATIONS.	NUMBERS.	THICKNESS IN FEET.	DEPTH IN FEET.	ELEVATION A T.
Devonian, Cedar Valley	48-47	40	40	890
Devonian, Wapsipinicon	46-44	30	70	860
Niagara	43-39.	50	120	810
Maquoketa	38-36	150	270	660
Galena and Platteville	35-26	420	690	240
St. Peter	25	30	720	210
Upper Oneota or Shakopee	24-20	240	960	-30
New Richmond	19-18	20	980	-50
Lower Oneota	17	150	1130	-200
Jordan	16-11	110	1240	-310
St. Lawrence dolomites and calciferous sandstones	10-7	170	1410	-480
St. Lawrence shales	6-1	310	1720	-790

It is not improbable that the magnesian limestone of No. 35 and the cherty limestones of Nos. 34 and 33 represent the limestones of the Middle Maquoketa seen in the Sumner well and outcropping in Fayette county as fully described by Savage.*

*Iowa Geological Survey, Vol. 15, p. 464.

In this case the Lower Maquoketa shales are either unrepresented in the samples of the Waverly well drillings, which unfortunately do not completely cover this horizon, or have thinned out to the west and are wanting in the western part of the county. The assignment of these strata to the Galena is, however, more in accordance with the thickness and dip of the formations.

Comparing the elevations above tide of the best distinguished horizons at Waverly and Sumner we may estimate the dip of the strata to the southwest in 20 miles.

	WAVERLY. FEET.	SUMNER FEET.	DIFFERENCES IN ELEVATION. FEET.
Summit of the Maquoketa	810	904	94
Summit of the St. Peter	240	340	100
Summit of Jordan	—200	—106	94
Summit of St Lawrence Shales	—480	—376	104

These results indicate a general dip of the Paleozoic strata in this area to the amount of about five feet to the mile to the southwest.

The deep well at Sumner was begun in early August 1899, but owing to the loss of tools in the well at 1770 feet which the contractors were not able to remove, the well was not accepted until January of 1902. Water was found in the Middle Maquoketa at 260 feet, with a temperature of 51 degrees Fahr., and a head of 1036 A. T. rising to within eighteen feet of the surface. Other veins were struck in the Galena from 420 to 660 feet. The head of eighteen feet below the curb was retained until the well was sunk to 1086 feet,in the Lower Oneota, when the water fell to the present height of -144 feet, owing to a strong inflow here at the low head of 910 feet A. T. The capacity of the pump installed is 200 gallons a minute, and continuous pumping for five days has not lowered the water below the cylinder, which is set 204 feet below the curb. The temperature of the water as taken from the pump is 50 degrees Fahr. The water has a slight sulphurous odor when first drawn, due no doubt to the presence of sulphureted hydrogen. But the rapid escape of the gas soon renders the water entirely free from any disagreeable taste or odor. The water ranks among the best artesian waters in the state.

It will be noted from the geological section of the well that here, as at Waverly, the boring was continued several hundred feet below the chief water bearing stratum or aquifer, the Jordan sandstone. In each case about one thousand dollars might have been saved by stopping the boring at the base of the Jordan, below which lay the dry dolomites and shales of the St. Lawrence, penetrated to a depth of between 450 and 480 feet. In case new wells are drilled at either Waverly or Sumner, the depth need not exceed 1240 feet at the former and 1280 at the latter town.

DESCRIPTION OF DRILLINGS, CITY WELL, SUMNER.

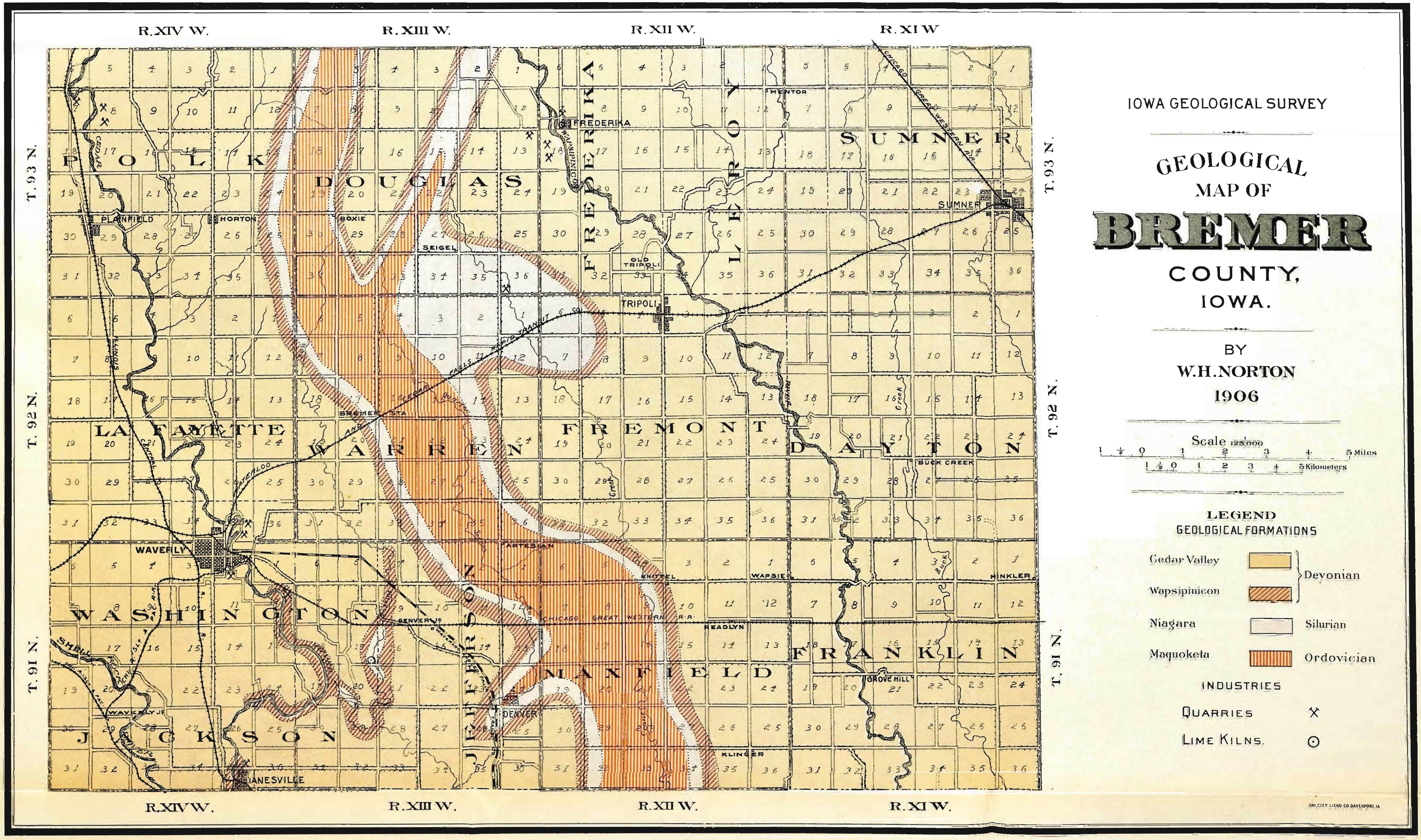
NO.	CHARACTER OF DRILLINGS.	DEPTH IN FEET.
44.	Sand and gravel, yellow	40
43.	Gravel, coarse, pebbles in sample up to three inches diameter	41
42.	Till, glacial stony clay, drab; samples at 50, 57, 70, 90 (sandy), 100, 110, and	120
41.	Limestone, largely drab, fine-grained, of Wapsipinicon type	128
40.	Limestone, hard, light buff, of rapid effervescence, samples at 135 and	140
39.	Limestone and shale; limestone light buff, of rapid effervescence, shale drab; samples at 150 and	160
38.	Shale, blue-green, plastic, calcareous; samples at 170, 190, 200, 210 and	220
	"hard rock" in driller's log at	230
	(Samples of drillings consist of drift, sand and gravel)	235
37.	Limestone, light blue-gray, earthy luster, mottled, of rapid effervescence in cold dilute HCl, with much chert of same color; samples at 250, 260, 270 and	280
36.	Limestone, soft, semi-crystalline, gray, rapid effervescence, cherty, one sample containing crinoid stem; samples at 290, 300 and	310
35.	Shale, light blue-green, calcareous; samples at 320, 330, 340, 350 and	360
34.	Limestone, blue-gray, of rapid effervescence; samples at 370, 380 and	390
33.	Shale, calcareous, drab; samples at 400 and	410
32.	Limestone, cream colored, soft, in thin flakes	410–420
31.	Limestone, light and dark gray, soft, earthy luster, rapid effervescence; samples every ten feet from 430 inclusive to	630
30.	Limestone, dark blue, highly fossiliferous; 640 and	650
29.	Shale, bright green, plastic, slightly calcareous; samples at 660, 665 and	668

NO.		DEPTH IN FEET.
28.	Limestone, mottled gray, fossiliferous, rapid effervescence; samples at 678, 683, 690, 700 and	710
27.	Shale, bright green (These shales at 665 and 710 are highly fossiliferous and fragments of them with bits of their characteristic fossil brachiopods, etc., occur in almost all the drillings below this.)	710-714
26.	Sandstone, of clean white quartz sand, grains well rounded, rather fine, at 720 some limestone chippings in the drillings; samples at 720, 730, 750, 760 and	770
25.	Dolomite, white, gray and light buff, in places cherty, crystalline; samples at 780, 790, 800, 820, 830, 840 and..	850
24.	Dolomite, cream colored, with much quartz sand in drillings	860
23.	Dolomite, pink, arenaceous, with minute rounded grains of crystalline quartz; samples at 870 and	880
22.	Dolomite, light buff and pinkish; samples at 890, 900 and	910
21.	Sandstone, and dolomite, drillings chiefly or largely fine grains of quartz sand, but with chips of light gray dolomite; 920 and	930
20.	Sandstone, fine grained, white, grains well rounded	940
19.	Sandstone, white, and dolomite, gray	950
18.	Dolomite, white or light gray, in places saccharoidal, in places with white chert, at 980 drillings contain considerable sand; samples at 960, 970, 980, 990, 1000, 1010, 1015, 1020, 1030, 1050, 1060, 1070 and	1080
17.	Sandstone, of white clean quartz grains well rounded, moderately fine	1090
16.	Dolomite, white and light gray and buff, with siliceous residues of finely divided quartzose matter, and at 1150 finely arenaceous; samples at 1120, 1140 and	1150
15.	Sandstone, fine grained, white, grains of clear quartz, well rounded; 1160 and	1170
14.	Sandstone, as above, but coarser, some grains reaching one mm. in diameter	1180
13.	Sandstone as No. 15; 1190, 1200 and	1210
	Drillings from 1230, 1236 and 1240 are indecisive, consisting at 1236 of highly calcareous shale resembling the Maquoketa, and at the two other depths of limestone clearly Trenton and fallen in the boring. Considerable quartz sand is mingled with the drillings, and while this may have fallen from above, it is the only material in the samples in which the drill apparently could have worked at 1230 and	1240
12.	Sandstone, fine, white, with Trenton limestone in the drillings; 1260 and	1270

NO.		DEPTH IN FEET.
11.	Dolomite, highly siliceous, with minute angular particles of crystalline quartz, in places with green grains of chlorite; samples at 1280, 1290, 1300, 1310, 1330, 1340, 1360, 1368, 1370, 1380, 1390, 1420 and	1425
10.	Shale, reddish, feebly calcareous	1430
9.	Shale, green, feebly calcareous; 1440, 1450 and	1460
8.	Shale, green, fossiliferous, practically non-calcareous, minutely quartzose; 1480, 1490, 1500, 15.0 and	1520
7.	Shale, bright and light green, highly arenaceous with minute grains of quartz, chloritic	1530-1550
6.	Sandstone, gray, fine grained, with chlorite grains	1560
	(Drillings only a few water worn fragments of shale)	1570
	(Drillings chiefly rusted chips of iron, from a fallen slush bucket, cut up by the drill)	1580
5.	Sandstone. gray, fine grained	1600
4.	Shale, dark and bright green, minutely arenaceous and chloritic; 1610 and	1620
3.	Sandstone, fine grained, mingled with some greenish argillaceous material; dried blocks set after pouring from slush bucket are readily friable	1630
2	Shale, light green, finely arenaceous, feebly calcareous, plastic	1640
1.	Marl, green, greenish yellow or greenish gray, highly arenaceous with almost impalpable quartz grains, calcareous and argillaceous, chlorite present in round grains of dark green color, some samples easily friable when dried, others more clayey and somewhat tenaceous; samples at 1660, 1670, 1680, 1690, 1700 1710, 1720, 1730, and	1740

ASSIGNMENT OF STATA.

NOS.	FORMATIONS.	THICKNESS IN FEET.	DEPTH IN FEET	ELEVATION A. T. FEET.
44-43	Alluvial sands and gravels	41	4	1013
42	Glacial till	87	128	926
41-40	Devonian or Silurian	22	150	904
39-38	Upper Maquoketa	80	230	824
37-36	Middle Maquoketa	90	320	734
35	Lower Maquoketa	50	370	684
34-27	Galena and Plattsville	344	714	340
26	St. Peter	66	780	274
25-22	Upper Oneota or Shakopee	140	920	134
21-19	New Richmond	40	960	94
18	Lower Oneota	200	1160	-106
17-12	Jordan.	120	1280	-226
11	St. Lawrence dolomites	150	1430	-376
10 1	St. Lawrence shales	310	1740	-686


IOWA GEOLOGICAL SURVEY
GEOLOGICAL MAP OF
BREMER
COUNTY,
IOWA.
BY
W.H.NORTON
1906
Scale 1/125,000
5 Miles
5 Kilometers
LEGEND
GEOLOGICAL FORMATIONS
Cedar Valley
Wapsipinicon
Devonian
Niagara
Silurian
Maquoketa
Ordovician
INDUSTRIES
QUARRIES
LIME KILNS.
R.XIV W.
R.XIII W.
R.XII W.
R.XI W.
T. 93 N.
T. 92 N.
T. 91 N.
POLK
DOUGLAS
FREDERIKA
LE ROY
SUMNER
LA FAYETTE
WARREN
FREMONT
DAYTON
WASHINGTON
JEFFERSON
MAXFIELD
FRANKLIN
JACKSON
PLAINFIELD
HORTON
BOXIE
SEIGEL
FREDERIKA
MENTOR
OLD TRIPOLI
TRIPOLI
SUMNER
BREMER STA.
BUCK CREEK
WAVERLY
ARTESIAN
KNITTEL
WAPSIE
HINKLER
DENVER
READLYN
GROVE HILL
WAVERLY JC.
KLINGER
JANESVILLE
CHICAGO GREAT WESTERN R.R.
TRI CITY LITHO CO. DAVENPORT, IA

ACKNOWLEDGMENTS.

In the prosecution of this survey the writer received much valuable assistance. He is particularly indebted to Dr. Samuel Calvin and Dr. Charles R. Eastman for their skill in the identification of fossils, and to Mr. D. A. Long of Waverly and Mr. John Koeberle of Sumner for their painstaking care in securing and preserving the data of the deep wells of their respective towns. The list of those who have given freely of their information and have aided in various ways in the collection of the facts embodied in this report is too long for further individual mention, but to each and all a grateful acknowledgment is tendered.

GEOLOGY OF BLACK HAWK COUNTY.

BY

MELVIN F. AREY.

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CONTENTS.

INTRODUCTION.

LOCATION AND AREA.

The fourth from the Mississippi river and also the fourth from the Minnesota line, Black Hawk county lies four square, the only irregularity in its outline being an offset of one mile made by the correction line which passes through the middle of the county. The row of sections immediately south of this line are reduced about one-fourth in area, thus making the area of the county about five hundred and seventy square miles. Bremer county bounds it upon the north; Buchanan on the east; Benton and Tama on the south and Grundy and Butler on the west. The only known indurated rock within its bounds is the Devonian: and of the unconsolidated materials, alluvium and Iowan drift are the only representatives at the surface excepting a small area of loess in Waterloo township. Wherever there is any considerable depth of mantle rock, however, its greater bulk is Kansan drift, the Iowan being everywhere comparatively thin.

In this county no very serious geological problems present themselves, nor does the rock or drift offer any unusually interesting phases of expression or development, yet to the observant and thoughtful no inconsiderable part of the wonderful geological story is told in a clear and very entertaining manner.

PREVIOUS GEOLOGICAL WORK.

Since neither the rock nor the surface of Black Hawk county affords striking or obviously important characteristics, such as would challenge the attention of those who were making an examination of an extensive region with limited opportunities at their command, the history of geological work within its bounds is a brief one.

Worthen passed through Cedar Falls in 1856 and in his report to Hall makes the following note: "At Cedar Falls the only rocks exposed are in the bed of the river, forming a ripple across the stream at this point. The lowest stratum exposed is a brown, arenaceous limestone from fifteen to eighteen inches in thickness, overlain by some thin strata of buff and gray limestone. No fossils were detected in the rocks here, and the exposure was not sufficient to afford an interesting section."*

*Report on the Geol. Surv. of Iowa, by James Hall and J. D. Whitney, Vol. I, Part 1, p. 181, 1858.

Mr. O. H. St. John, a resident of Waterloo, made some collections of fossils at that place, which contributed materially to the knowledge of the ancient life in this region. In 1866 Mr. R. P. Whitfield spent some time at Waterloo, Raymond and other localities in neighboring counties and made quite an extensive collection of specimens. In the 23d Annual Report on the State Cabinet of New York, from the data thus obtained, Hall and Whitfield attempted to correlate the rock formation of Black Hawk and adjacent counties with the Devonian formation of New York.

The futility of such an effort has been set forth very plainly by Calvin in his report on Buchanan county.* The present writer can do no better than to quote from Calvin. "It is worth noting that some years ago the quarry stone at Raymond was referred to the Schoharie, the coral-bearing beds at Waterloo were called Corniferous, the limestones at Independence were assigned to the Hamilton, and the Lime Creek shales were called Chemung. Now the Lime Creek fauna is found in shales below the Independence limestones, and so, judging from the fauna, the Independence shales are also Chemung. Furthermore, the coral-bearing beds of Waterloo are younger than the limestones at Independence, for they lie above them, and the quarry stone at Raymond is still younger than the coral beds that were referred to the Corniferous. Beginning with the Independence shales, the actual order of the strata of Iowa, according to the correlation referred to, would be (1) Chemung, (2) Hamilton, (3) Corniferous, (4) Schoharie- a complete reversal of the order observed in New York."

No allusion to Black Hawk county geology appears in White's report. McGee in his Pleistocene History of Northeastern Iowa† mentions the county along with many others in describing their streams, common characteristics, etc., much of which is interesting reading to the student of geology of the county. Calvin has visited portions of the county and makes incidental reference to its geology in some of his reports on sister counties.

*Calvin: Iowa Geol. Surv., Vol. VIII, p. 205, and 221-222.
†McGee: Eleventh Ann. Rept. U. S. Geol. Surv., pp. 202, 210, 223, 406, 481, et al.

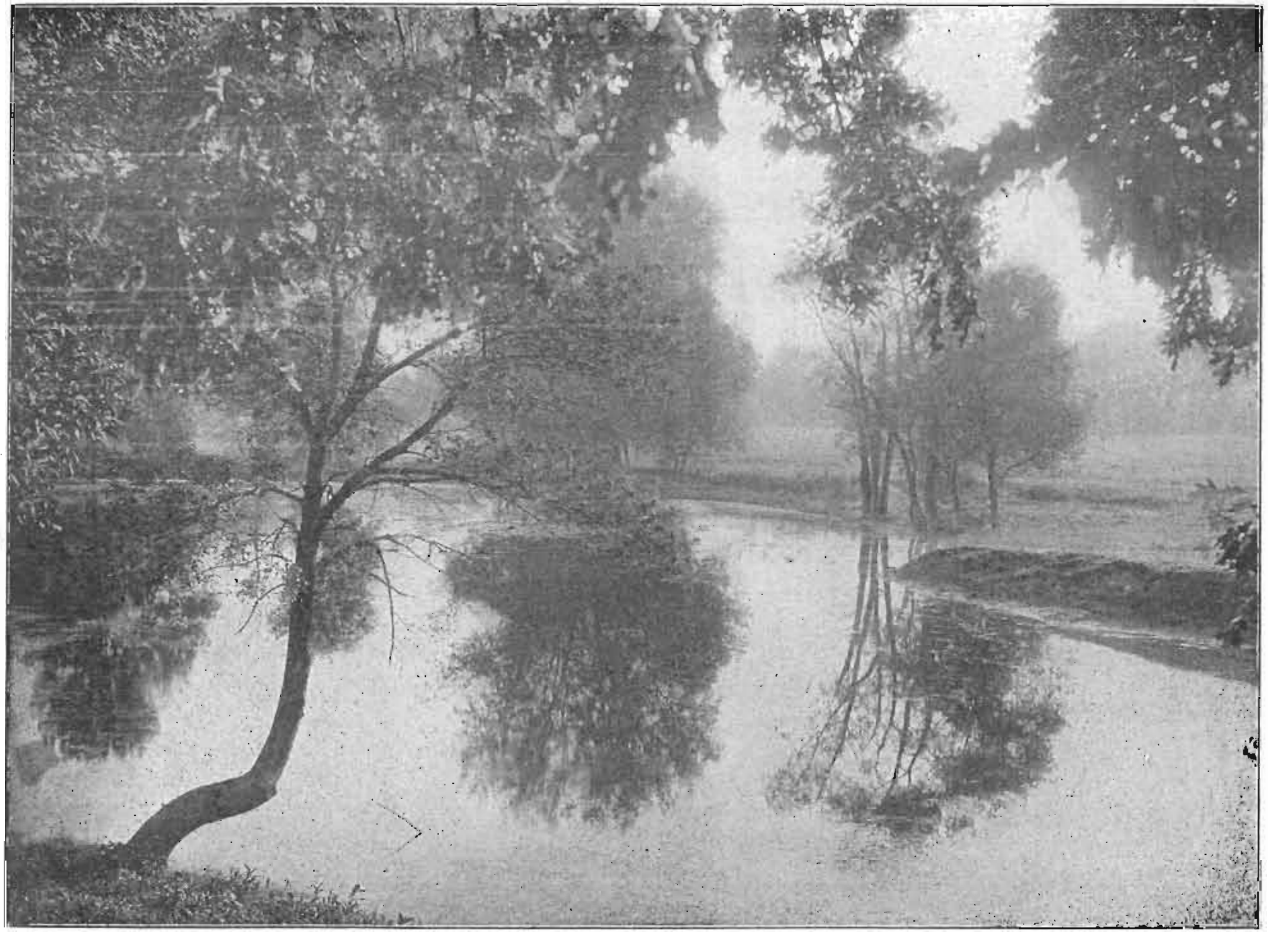
PHYSIOGRAPHY.

TOPOGRAPHY.

The surface of this county is made up chiefly of the valleys of the Cedar and the Wapsipinicon rivers and their larger tributaries, and the Iowan plains which lie between and on either side of these valleys. Low bluffs rise near the south side of the West Fork of the Cedar, and also along the south side of Beaver creek at a varying distance from the stream. These bluffs at first are low, but increase in height eastward, and merge into the higher and more precipitous bluffs of the Cedar. For two miles above Cedar Falls the bluffs rise immediately from the river banks to an average height of sixty feet. At Cedar Falls they sweep away from the river, leaving a level area on which the older part of the city is built. They then give way for the passage of the waters of Dry Run. Then at once recovering their height they pass in a southeasterly direction, receding from the river and gradually losing their height and steepness of slope. Beyond Waterloo they maintain a distinct line between the valley and the drift plain for many miles, though at a considerable distance from the river and with a marked diminution in altitude.

These bluffs are gashed by numerous ravines such as characterize the Kansan drift areas, and which evidently owe their origin to the pre-glacial erosion interval. Between Cedar Falls and Waterloo the Kansan drift features are further manifest in rounded hilltops crowned with loess, though Iowan drift appears in thin veneerings in the immediate neighborhood, and sound granitoid bowlders are frequently seen. Thus in sections 16, 17, 20 and 21 of Waterloo township the prevailing topography is essentially Kansan. The same can be said, though in a less emphatic way, of sections 11, 12, 13 and 24 of Orange township and of sections 18 and 19 of Cedar township. In the sections named, and in a more or less extended area adjacent to them, the Iowan drift deposit is thin at best and only partially, if at all, obliterates the effects of the extended erosion period preceding the Iowan ice invasion.

Once beyond the region mentioned above, the Iowan plain appears and constitutes the surface of the greater part of the



Mullens Pond—A portion of one of the old shut-in channels of the Cedar river Characteristic of the Cedar river valley. Near Cedar Falls.

townships of Cedar Falls, Orange, Cedar and Big Creek and the whole of Black Hawk, Lincoln and Eagle townships. The latter townships are remote from the river and, excepting the narrow, sinuous channels of a few small streams, scarcely show a scar anywhere upon their surface, so gently have the erosive agents dealt with them since the withdrawal of the last great ice sheet that visited this region.

On the north and east of the Cedar the valley plain rises very gradually and usually imperceptibly to the general level of the drift plain. It is for the most part three or four miles wide, level and sandy, and was once wood clad, but now much of it has been deforested. There are numerous indications that nearly every part of the valley proper has been traversed at some time by the river. Many large oxbows are still in connection with it at ordinary stages of the water. Narrow, curved bodies of water, locally known as lakes, some of them two or three miles in length, as in Cedar township, often in line and connected more or less completely, plainly locate former channels (Pl. VII). These lakes, often fringed with bushes and trees, contribute to the beauty of the scenery along the river and, being stocked with fish in many instances, are favorite resorts with those who would seek recreation apart from their wonted scenes of activity. Depressions of every gradation of size, but always similar in shape and trend, are so abundant as to make their occurrence a remarkable feature of this valley. At the time of freshets, not only does the river fill the old channels, but it occupies much of the intervening valley.

A little before the river leaves the county, the valley narrows and loses to some extent the characteristics it presents elsewhere. There is also a noticeable constriction of the valley at Waterloo. In the northeastern part of the county the entire townships of Union and Washington are in the valleys of the Cedar and its tributaries. The topography of Union township is materially different from that of any other. The winds seem to have had an unimpeded sweep previous to its settlement and gathered the sand into dunes of considerable height and extent, giving the region a broken aspect unlike that of any other part of the county. The poplars, burr oak and other trees and shrubs of similar habitat, have taken possession of many of these dunes, and all are now covered with vegetation of some kind, though the early settlers say that when first they knew the country, there were stretches of naked sand still at the mercy and sport of the winds.

The same features that characterize the valley of the Cedar may be observed, though in modified form, in the valleys of its larger tributaries, as well as in the valleys of the Wapsipinicon and its tributary, Crane creek. Spring creek which runs not far from the eastern border of the south half of the county is an exception in that its valley is narrow and with moderately sloping sides for most of its course, as if it had been the last born of the streams of the county.

In Bennington and Barclay townships, in the north half of Poyner and in the western two-thirds of Fox township, the Iowan drift plain appears at its best, there being no large streams to interrupt the seeming endless succession of low, wide-arched ridges and shallow concavities along the lowest part of which, grassy and most gently descending, the surplus water from the heavy rains and melting snows finds its way as best it can. The other townships are mostly within the valleys already described. In a part of East Waterloo, Poyner and Spring Creek townships the river approaches the eastern border of its valley and the level of the drift plain is reached by a somewhat abrupt slope, though at no such great height above the river valley as is the case on the other side of the river.

There is little in the topography of the county that is exceptional and distinct from the features described above. An occassional kettlehole occurs in Lester and Bennington townships and perhaps elsewhere, but they present nothing worthy of further notice. In the northwest quarter of section 24, Eagle township, is a prominent ridge extending northeast and southwest, having little soil upon its crest and upper slopes. The greater mass of the elevation is limestone and is the only rock in a wide area, embracing the whole southwest quarter of the county. It was doubtless one of those islands in the sea of Iowan ice mentioned repeatedly by Calvin in earlier volumes of the Iowa Geological Survey.

The other exceptional elevations in the county, which occur in Cedar, Orange and Waterloo townships, are capped with loess and are composed for the greater part, if not wholly, of Kansan till.

ALTITUDES.

The elevation of the principal places as given in Gannett's Dictionary of Altitudes, is as follows:

STATION.	FEET.	AUTHORITY.
Cedar Falls	854	B. C. R. & N. R. R.
Dewar	889	C. Gt. W. R. R.
Dunkerton	945	C. Gt. W. R. R.
E. Waterloo	843	C. Gt. W. R. R.
Hudson	883	C. Gt. W. R. R.
Jacobs Siding	982	I. C. R. R.
La Porte City	812	B. C. R. & N. R. R.
Mona Junction	865	I. C. R. R.
Normal Hill, Cor. Normal and 24th Sts.	937	T. R. Warriner
Norris	864	B. C. R. & N. R. R.
Raymond	885	I. C. R. R.
Washburn	827	B. C. R. & N. R. R.
Wilson Junction	870	C. Gt. W. R. R.
Winslow	884	B. C. R. & N. R. R.
Janesville	891	I. C. R. R.
Jesup	982	I. C. R. R.

Janesville and Jesup are reported, though not in the county, since they are close upon its borders. It is interesting to note that Jesup and Jacobs Siding, near the eastern and western limits of the county respectively and on nearly the same parallel, have the same altitude, 982 feet. Janesville on the Cedar at its entrance into the county has 891 feet, and La Porte City, seven miles from the place where it leaves the county, has 812 feet elevation, a difference of 79 feet. The winding course of the Cedar between the two points is about thirty-seven miles, making the average fall of the river about two feet per mile.

Jacobs Siding is the highest elevation given in the county. It is about two miles west of Cedar Falls on the Illinois Central Railway and has long been unfavorably known among the railroad men as the Cedar Falls Hill. Recently it has been avoided by the railroad company by the construction of a new line nearer the river, which reaches the level of the country between Cedar Falls and New Hartford by a much easier grade.

From the elevation of Fairbank, which is not far from the northeast corner of the county, that part of the county has an elevation equal to if not greater than, Jacobs Siding.

DRAINAGE.

The drainage of the county is accomplished almost wholly by the Cedar river system. The Wapsipinicon with its tributary, Crane creek, cuts the northeast corner of the county, the only townships affected by their agency being Lester, the east half of Bennington and the northeast corner of Barclay.

The Cedar, as it is known in Black Hawk county, is the product of the union of three nearly equal streams, the Cedar from the north and east, the Shell Rock from the northwest and the West Fork from the west. The two latter, however, effect a junction about one mile above their junction with the Cedar. From this point, which is within a mile and a half of the north line of the county, the Cedar pursues its way, in size and importance second only to the Des Moines among the rivers within the borders of Iowa. Excepting for a short distance below the dam at Cedar Falls and also at Waterloo, its bed is in unconsolidated material. Little indurated rock outcrops anywhere along its banks, even the high bluffs in the neighborhood of Cedar Falls and Waterloo being apparently made up wholly of drift material. Its course for the first four or five miles is nearly south, then southeast until at Gilbertsville it again takes a southward direction for four or five miles when it bends to the southeast keeping that direction for the remainder of its passage through the county.

Proceeding southward the tributaries from the west are Beaver, Dry Run, Black Hawk, Miller, Big and Rock creeks. On the east Elk, Indian and Spring creeks are the principal tributaries. It is worthy of note that each of these streams approaches the Cedar at nearly a right angle, in marked contrast with the tributaries of the Wapsipinicon and the Iowa. The hydrographic basin of the Cedar is therefore much wider proportionately than is that of either of the other rivers named. Along the north line of the south row of townships in Buchanan, Black Hawk and Grundy counties the Cedar valley extends fully sixty miles east and west. This width it maintains very nearly from the north border of the state to the neighborhood of Cedar Rapids, beyond which its valley narrows very rapidly by the approach of the Iowa with which it unites in Louisa county. The head waters of Spring and Elk creeks are within two miles of the Wapsipinicon river and Crane creek respectively, while the Black Hawk takes its rise within five or six miles of the Iowa. Thus it may be seen that the Cedar dominates nearly the entire territory between the Wapsipinicon and the Iowa.

Naturally those townships where the Iowan drift prevails are not so well drained as are those near the rivers. But nowhere are well established stream courses so remote that excessive surface waters may not be taken care of readily by artificial drainage.

GEOLOGICAL FORMATIONS.

General Relations of Strata.

The geological formations in Black Hawk county are few and comparatively simple in their manifestations. Heavy deposits of drift conceal the indurated rocks in the northeastern and southwestern parts of the county. The rock exposures are mainly along the margins of the valley of the Cedar or outcrop in the banks of the lower courses of its tributaries where they have cut their beds in order to reach the level of the main stream. The valley of Spring creek affords an exception as has been stated already, since rock is found throughout two-thirds of its course, the drift being thin and not concealing the erosive effects of the preglacial activities of this stream. Only rarely does indurated rock appear at the surface apart from the water courses.

In many exposures no fossils appear, or, if any are found, they are so fragmentary or indistinct as to render very little assistance in determining the relations of the rocks in which they occur. Fortunately, however, the frequent and widespread occurrence of the lithographic limestone, the lithological features of which are very constant and easily recognizable, makes it possible to fix the horizon in many instances where other means are wanting entirely.

The indurated rock belongs wholly to the Devonian system so far as is known, though it is quite probable from the trend of the eastern border of the Carboniferous as revealed elsewhere in the state, that rock of that system underlies the thick glacial deposits of the southwestern corner of the county. No material from the wells that have penetrated the rock of that region has been accessible, however, and therefore the Carboniferous appears only hypothetically in the table introduced below to show the taxonomic relations of the strata in Black Hawk county.

TABLE OF FORMATIONS.

GROUP.	SYSTEM.	SERIES.	STAGE.
Cenozoic	Pleistocene	Recent	Aeolian
			Alluvial
		Glacial	Loess
			Iowan
			Buchanan Gravel
			Kansan
Paleozoic	Carboniferous?	Mississippian?	Kinderhook?
	Devonian	Middle Devonian	Cedar Valley
			Wapsipinicon

DEVONIAN SYSTEM.

WAPSIPINICON STAGE.

The only definite, satisfactory exposure of rock observed belonging to this stage is a natural outcropping in the bed and slope of the bank of a small tributary of Spring creek in the northwest quarter of section 13, Fox township. It represents the uppermost part of this stage, the *Spirifer pennatus* beds. No section could be made as the exposures along the hillside were interrupted by deposits of soil. But a few feet above the stream bed, in the flat, rock surface of which fossil corals and brachiopods were quite abundant, were the *Spirifer pennatus* beds composed of the soft, light gray limestones so often referred to by Calvin. The fossils obtained here were *Cyrtina hamiltonensis* Hall, *Spirifer pennatus* Owen, S. *bimesialis* Hall, *Atrypa reticularis* Lin., fine ribbed variety, *A. aspera* Schloth and Paracyclas sp. In the road eight or ten feet above these beds, *Acervularia profunda*, one or more species of Favosites, Cyathophyllum and Zaphrentis occur. Evidently this is the

Acervularia profunda zone, the lowest member of the Cedar Valley stage. As stone appears occasionally in the road surface at several points in this neighborhood, a closer survey of it, possibly would reveal other outcrops of the *Spirifer pennatus* beds.

CEDAR VALLEY STAGE.

The lowest member of the Cedar Valley stage of the Iowa Devonian, the *Acervularia profunda* zone, is well represented in a quarry in the southeast quarter of section 25, Waterloo township.

The following section is shown:

		FEET.	INCHES
7.	Sandy soil	5	
6.	Geest with mingled fragments of limestone	4	6
5.	Shaly parting containing unusually large specimens of coarse-ribbed *Atrypa reticularis*		2
4.	Thin, irregularly bedded, buff limestone with much mingled residual earth, all highly ferruginous	4	6
3.	Soft, drab to buff, earthy limestone with a more or less well defined parting three feet from its lower limit. The upper three and one-half feet crowded with *Acervularia profunda*, a species of Favosites, *Cladopora magna*, *C. palmata*, Cystiphyllum sp., Zaphrentis sp. small branching corals, and a few brachiopods, all weathered and iron-stained	7	
2.	Shaly parting		2
1.	Soft, gray limestone with a narrow shaly parting near the middle	4	

A few rods farther eastward is another quarry affording a similar section. The stone is a little firmer in texture, and the beds have been exposed some two feet below the floor level of the former, without revealing anything of added interest, however. For many rods west of these quarries is a strip of waste ground grown up to weeds and bushes and showing scarcely a trace of rock in place, but from which stone has been taken until recently during nearly all of the years since the first settlement of Waterloo. It is a fossil coral reef and has been very rich not only in corals, but in brachiopods and other forms of Devonian life. Ever since the visits of St. John and Whitfield, its reputation has attracted geologists and curiosity seekers, and it may be looked upon almost as classic ground to the geologist. Whitfield's list of fossils gathered here and in the immediate vicinity is a surprisingly large one and as a matter of common interest is quoted below from the 23d Annual Report.*

"Among the most common forms at this place are *Stromatopora erratica* of this paper, *Acervularia Davidsoni, A. profunda,* Favosites, sp., like *F. polymorpha, Cystiphyllum Americanum.* C. n. sp., **Zaphrentis gigantea,* Chonophyllum sp. apparently the same one as in the Upper Helderberg of New York, and at the Falls of the Ohio,*Amplexus Yandelli, Streptelasma* n. sp., *Aulacophyllum sulcatinum,* Syringopora sp. having large cells, three species of Cladopora, two species of Aulopora, one very large. Of the brachiopoda we find the following; **Spirifer euruteines,* **S. oweni,* **S. manni, S. subvaricosa* n. sp., *S. pennatus* only one individual, *Cyrtina Hamiltonensis, Atrypa reticularis,* A. n. sp., *Pentameralla arata,* **P. obsolescens, Gypidula laeviuscula, Rensselaeria johanni, Terebratula romingeri,* **T elia,* **T. jucunda.* There are also several forms of fish teeth known to occur in these same beds."

Those of this list marked with an asterisk are species which according to Calvin do not occur in this county. A considerable number of others have not been recognized for this report, though a more diligent search might have revealed them. Undoubtedly the present quarry is not as rich in variety of forms as were the earlier ones.

In the report referred to above, Whitfield referred these beds to the Corniferous of New York. The error into which he fell in attempting to correlate the Devonian limestones of Iowa with those of New York is well set forth by Calvin in his report on Buchanan county. His language was quoted under the head "Previous Geological Work" and need not be repeated here.

In the southeast quarter of section 24, East Waterloo township, in the east angle between the track of the Chicago Great Western railroad and the track of the Illinois Central railroad running to the machine shops, is a pit-like quarry of the Acervularia zone, but ranging a little higher than the West Waterloo quarry.

*23rd Ann. Rept., N. Y. State Cab., Nat. Hist., p. 223, et seq. Albany, 1878.

If Calvin's section at Littleton, Buchanan county*, be taken as a standard. the section at West Waterloo seems to correspend to the Acervularia zone numbers 1 to 4, while the East Waterloo quarry seems to include numbers 5 to 7. In the latter the rock is firmer in texture and much less ferruginous. No good opportunity of examining the quarry has occured and no section was made. Careful study might change the estimate of its relations to the West Waterloo quarry.

In the northeast quarter of section 1 of Barclay township, very near the county line, is the only rock exposure in all the northeastern part of the county. Some fifteen or twenty years ago Mr. Purtell operated a small quarry here, but since its abandonment the loose earth has covered most of the quarry face, and bushes springing up have completed the effacement of the quarryman's work. The upper rock is a soft, yellow, argillaceous limestone, thin and irregularly bedded, below which is a harder, lighter colored rock somewhat crystalline and more heavily bedded. This exposure is in the edge of a low bluff rising above the narrow valley of the Wapsipinicon river, and is within three miles of an outcropping in the bluffs on the opposite side of this river in Buchanan county. From the meager data obtainable it may be inferred with reasonable assurance that the rock here is the same as that of the upper part of number 2 in the section "along the river bluff a short distance above Littleton"† made by Calvin and said by him to lie "above the beds described in the section below the mill at Littleton". On the same page Calvin incidently remarks "that this is the level of the quarry stone at Raymond, in Black Hawk county". The quarry here referred to is in the southeast quarter of section 36, township 88 N., R. 12 W., not more than half a mile east of Raymond station, and affords at the present time the following section:

		FEET.	INCHES.
9.	Residual soil with many rock fragments	1	6
8.	Drab, compact layer, breaking with a suggestion of lithographic stone	2	6
7.	Hard, brittle finely crystalline bed, gray on fracture, but yellow where exposed	1	6
6.	Thin layers of limestone similar to numbers 3 and 5, but softer, weathering more readily, becoming thinner above and more jointed below (thickness not determined).		

*Calvin: Iowa Geol. Surv., Vol. VIII, pp. 232-233, 1897.
†Calvin: Iowa Geol. Surv., Vol. VIII, p. 234.

		FEET.	INCHES.
5.	Rock similar to number 3, but with flattish, irregular cherty nodules many geode like (thickness not determined)		
4.	Fragile and very fissile rock		3
3.	Soft, yellowish-gray, heavy bedded rock	3	
2.	Beds everywhere buried in quarry debris	10	
1.	Quarry floor containing worn valves of *Stropheodonta demissa* everywhere over the surface, also a Spirifer, probably *S. parryanus*, *Atrypa reticularis*, Cladopora stems, etc.		

Nos. 5 and 6 represent a thickness of several feet, but it was not exactly determined. It would seem that number 1, represents number 8 of Calvin's section below the mill dam at Littleton, and his number 1 in the section along the bluff above Littleton, while the other members correspond in part to number 2 of the same section, judging from their superposition and lithological character. They are entirely unfossiliferous so far as could be observed.

Within one-half mile northwest of the last is another small quarry in which all the rock is quite similar, yellowish in color and barren of fossils. The lower three and one-half feet were much jointed while the rock above was so free from joints as to form a roof, overhanging in one place fully six feet. It corresponds to the upper part of number 2 mentioned above.

About one mile south of Raymond the east side of the road where a small creek had worn its bed into the weak rock, a section was obtained as follows:

		FEET.	INCHES.
5.	Black loam	1	
4.	A meager trace of Buchanan gravel		
3.	Clay much like Kansan till		6
2.	Geest with limestone layers more or less well defined in lower part	3	4
1.	Buff limestone, soft below with a thin, cherty layer, above which the rock contains calcitic nodules and *Stropheodonta demissa* as in the floor of the Raymond quarry, above the creek bed	5	

In the northwest quarter of section 14, East Waterloo township near the track of the Illinois Central railroad and a little above it is the Bartlett quarry, operated by the Waterloo Stone Company. The beds are unfossiliferous for the most part. A few crinoid stem fragments, a few specimens of *Atrypa reticularis,* coarse ribbed type, other fragmentary and indistinct forms, and an excellent specimen of the jaw and teeth of the ganoid fish, *Onychodus sigmoides,* have been found here (Fig. 48). The section shows the following:

		FEET.
5.	Iowan drift	6
4.	Geest, including stony fragments	4
3.	Firm, drab limestone of somewhat conchoidal fracture, freely intersected by calcite veins	1
2.	Soft limestone, the upper four feet of which is irregularly bedded	6
1.	Limestone, buff where weathered, but blue on fracture, quite heavily bedded and having flinty nodules and pockets of calcite in the upper eight feet	10

A little northeast of this is an old quarry showing a similar section but with some slight modifications of the texture of some of the beds.

Fig. 48—Jaw and teeth of an ancient fish—Onychodus sigmoides—from the Devonian limestone.

In the northeast quarter of section 14 is the Morganton quarry from which stone of good quality is taken. The lowest beds have numerous oblique, open joints in which deposits of a beautiful buff travertine occur. In the upper part is a firm, drab rock of the lithographic type and which is the same as number 5 in the Bartlett quarry. This bed affords the best stone in the quarry. In a yellowish, decomposing shaly limestone three feet above this bed is found the only fossil, an Atrypa very much resembling the fine ribbed variety of *A. reticularis*. In one part of the quarry this bed contains many large concretions which under the hammer often reveal a lining of unusually fine calcite crystals.

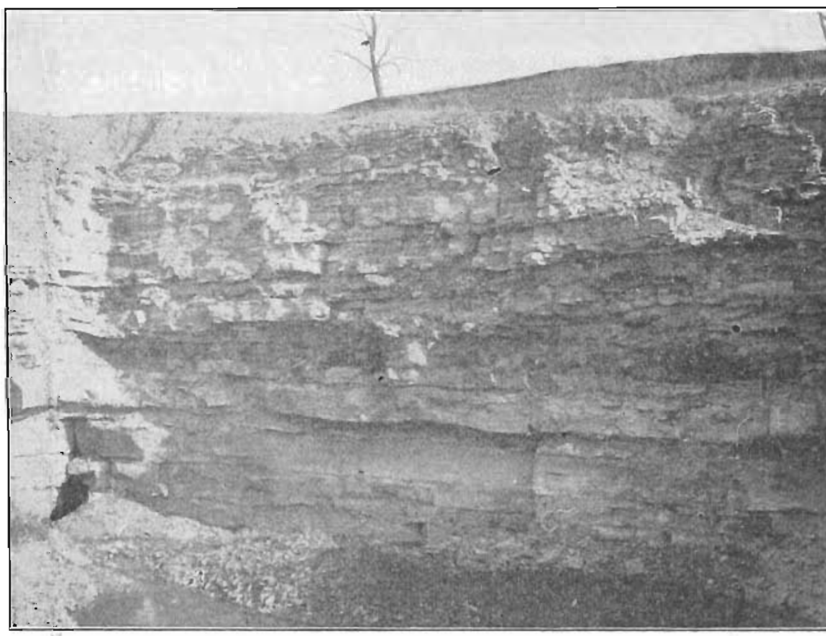


Fig. 49—Quarry in Cedar Valley limestone, Cedar Falls.

From the lithographic features and from the order of superposition, as compared with the quarry in the angle of the railroad tracks not far away, it is judged that the horizon of these quarries is the same as that of the quarry stone at Raymond.

In the road two and one-half miles due north from the Bartlett quarry is an outcropping of loose, shaly limestone not worthy of notice except as an evidence of the thinness of the drift in this vicinity.

In the northeast quarter of section 15, township 89 N., range XII W., a small quarry has been worked the rock in which is much broken up by oblique joints running at all angles, and the bedding planes of which are so confused as to render tracing of them impossible. Nowhere in the county is found better evidence of crushing than here. The exposure represents number 1 of the Bartlett quarry and possibly a part of number 2. Specimens of *Atrypa reticularis* appear sparingly.

In and around Cedar Falls are several quarries. One of these, the Carpenter quarry (Fig.49), has furnished a large quantity of stone, but it is no longer operated on account of the increasing cost of stripping, the work having advanced well into the high bluff. It is located a few rods south of the Dry Run wagon bridge near the center of section 13, Cedar Falls township. The following section appears:

		FEET.	INCHES.
12.	Coarse, ferruginous Buchanan gravel overlain by Iowan drift.		
11.	Thin-bedded, fragmental limestone such as is usually found at the top of the rock exposures in the county and which illustrates well the effects of weathering, wherever the drift is thin. The stone in these layers varies considerably from top to bottom as if originally they made up several distinct beds. Near the top are numerous small, simple stemmed corals and good specimens of *Idiostroma gordiaceum* A. Winchell..........	7	
10.	Thin, shaly parting.		
9.	Vesicular limestone, gray, brittle, the small cavities yellow lined...		7
8	Limestone, the lower half of which is in one layer, the upper in very many thin layers, about................	1	6
7.	Shale and rock intermingled promiscuously, the layers manifest in places and elsewhere lost. Color varied; weathering since exposure, in a weak, earthy rock may account for the peculiarly varied conditions of this bed..	3	10
6.	Hard, brittle rock with conchoidal fracture; yellowish..	1	6
5.	Greenish shale..		2
4.	Limestone, lower half compact and homogeneous, but upper half much checked and in some places nodular to such an extent as to appear like a conglomerate. Thickness undetermined.		
3.	Shale, in three layers, (c) green shale two inches, (b) whitish, somewhat indurated, calcareous shale four inches, (a) green, jointed shale twelve inches..........	1	6

		FEET.	INCHES.
2.	Limestone of variable appearance and texture. In general the upper half is a soft, yellowish, earthy rock, the lower a hard, dark drab, granular rock. In some places in the quarry this stone is in three or four layers, in other places it is in one bed, yet everywhere as it nears the top becoming more and more argillaceous until it blends with number 3	2	
1.	Variable bed, mostly firm in texture, drab below, yellowish and somewhat jointed and vesicular above. The line between the several layers everywhere markedly wavy........................	5	

Variability is the most striking feature of this quarry. Fossils are absent everywhere except in number 11, and, since these are in the beds that have been most affected by the agents of disintegration, they are generally imperfect. A few small colonies of Idiostroma have been well preserved, though deeply stained. Their presence is the only guide to the proper horizon of this exposure other than its position relative to the quarries of Waterloo. The Idiostroma horizon is just below the lithographic beds, and though the lithographic limestone is not well developed anywhere in Cedar Falls, it is found beyond question in a natural exposure in the bank of Dry Run one-half mile farther southwest. A few rods farther up the creek bed the stream has eaten into the bank. exposing a section of some interest. In the stream bed is a thin, whitish layer having over its surface many stems of the small coral found in number 11 of the Carpenter quarry, the rock, ringing clearly under the hammer and breaking freely with conchoidal fracture, promptly suggesting its relationship to the lithographic limestone. Above this are many thin layers, much jointed obliquely and vertically, usually lithographic in character, but evidently undergoing change by exposure. Near the top the coral stems appear again and six inches below these are imperfect casts of *Newberria johannis* Hall, the only brachiopod found in the rocks at Cedar Falls. A slight fold is evident in this rock. Four or five rods south is a quarry owned by Mr. C. A. Round. The floor of this quarry is very uneven showing marked unconformity with the beds above. A section represents the following:

		FEET.	INCHES.
13.	Thin layers of rock for the greater part lithographic in character...	4	
12.	Light gray, earthy rock in about seven layers.		9

		FEET.	INCHES
11.	Fissile, earthy limestone, having a narrow granular band midway	4	8
10.	Excellent lithographic bed in two layers	2	
9.	Bed in two layers the upper containing many small masses of Stromatopora two or three inches in diameter, much weathered upon the outside, but usually very compact and hard within		8
8.	Granular rock, with pockets of calcite, the upper three inches shaly and nodular. Partings occur, but not continuously, or uniformly	2	5
7.	Shaly partings		1
6.	Earthy rock, upper part more calcareous and firm, with pockets of calcite		11
5.	Shaly parting		1
4.	Gray limestone in numerous layers, becoming yellowish and earthy in places	2	
3.	Shaly parting		1
2.	Heavy-bedded limestone, gray to white, with rusty spots, granular and firm where gray, but earthy where white, in two beds with a shaly parting of five inches between.	4	
1.	A fairly good quality of limestone, lithographic in character, in three layers	1	3

In number 13 occur the coral stems referred to elsewhere. Stromatopora is abundant in places. Overlying the loose rock at the top of number 13 is about sixteen inches of Buchanan gravel and above this, three feet of sandy loam. Midway between the Round and the Carpenter quarries is a quarry belonging to the Harris and Cole Company. The rock here is softer, joints are wide, oftentimes filled with geest; small cavernous openings are not uncommon. Here were found a few massive stromatoporoids, and also a few colonies of Idiostroma among the weathered rock fragments in the eastern edge of the quarry and a single specimen of *Straparollus cyclostomus*. Lithographic features are not very manifest. Some layers are beautifully ornamented with dendrites, and in the creek bed near, at the same horizon as the upper layers of the quarry, are slabs containing numerous mud cracks.

A few rods northeast of the Carpenter quarry, between the Rapid Transit track and Dry Run, is a small quarry belonging to Mr. N. Olson, the floor of which is a little lower than that of the Carpenter quarry. A section is here given:

		FEET.	NCHES.
14.	Iowan drift	2	
13.	Buchanan gravel lower part highly oxidized, coarse, upper part less ferruginous, stratified, some layers a fine sand, uppermost layers much reddened	10	
12.	Jointed, geest-like clay, the base of which is red brown, the rest yellow		6
11.	Dark drab, crystalline rock		5
10.	More or less indurated shale	1	9
9.	A bed whose upper half is less compact and uniform than the lower	2	4
8.	Green shale	1	8
7.	Soft rock, whitish, saccharoidal, deteriorating upwards.	2	
6.	Very dark drab rock, compact and smooth on fracture...	1	
5.	Light gray rock, soft and in two layers, having much calcite finely distributed throughout	1	6
4.	Rock very much like number 1		8
3.	Soft, shelly, mud colored limestone	1	
2.	Dark drab, finely saccharoidal limestone	1	
1.	Dark drab, finely saccharoidal limestone, thickness not ascertained.		

There is little in common between this and the other quarries of Cedar Falls in the lithological character of the rock excepting in a general way. The horizon is believed to be in part the same. The lower eight feet of this quarry appear to lie below the floor of the Carpenter quarry. No fossils were recognized.

About one-eighth of a mile west of the Carpenter quarry, and also west of Main street, is J. Nielson's quarry which affords the following section:

		FEET.	INCHES.
18.	Firm, yellowish stone with intermingled geest, not continuous throughout	3	
17.	Lithographic limestone. somewhat nodular, more or less weathered and inconstant	2	
16.	Yellowish clay shale, with interbedded stone in places, very variable in thickness, averaging	1	4
15.	Limestone in three layers (a) finely laminated, slightly iron-stained, six inches, (b) like (a) but lighter in color, two inches, (c) gray, fine-grained, smooth, often weathering oddly near seams, makes good lime, averaging	1	6
14.	A variable stone, sometimes splitting easily into layers, sometimes firm and even textured, finely crystalline, with earthy streaks, rusty in patches, crystals in pockets and calcitic sheets intersecting one another and thus, being more resistant than the amorphous portion, making pitlike areas along the joint planes, averaging	1	

		FEET.	INCHES.
13.	Fine-grained, bluish-gray limestone with occasional patches of crystals, quarried in sheets, and used for window and door sills and caps, and ashlar		10
12.	Bluish gray stone of good quality, earthy at the lower surface		5
11.	Shaly parting		1
10.	Gray, finely brecciated limestone, with seams of crystals below, upper part yellowish, earthy. If quarried in cold weather, it is reduced to fragments readily, but, if dried out before freezing, it makes a durable stone		9
9.	Firm, fine-grained, bluish-gray limestone with occasional pockets of crystals, in two layers. Makes an excellent range stone. The lower layers yield fine large flags	1	
8.	Uniformly fine-grained limestone, yielding flags	7	
7.	Heavy-bedded limestone, shelly on the under side, abounding in crystals, bluish-gray	1	4
6.	Fine-grained limestone more or less streaked or banded		9
5.	Like number 6		11
4.	Lighter colored stone, with a possible parting in upper part along an irregular line		9
3.	Stone still lighter in color than number four, which often washes out in a remarkable way, yet makes a durable stone once it has been dried out		9
2.	Yellowish stone, full of pockets	1	
1.	Soft, chalky stone		

Numbers 1 and 2 are no longer quarried, not comparing favorably in value with the other beds. Numbers 3 and 1 are the same beds found under the open channel of Dry Run and which everywhere have extensive, tortuous canals dissolved out and worn away by attrition, making it possible for the water in the upper course of Dry Run to disappear from the surface channel in the lower course excepting in times of flooding.

North and northwest of Cedar Falls are a few rock exposures, all of limited extent. The horizon is about the same in every instance it being that of the Stromatoporas and lithographic limestone. In Union township just east of Finchford is Beatty's quarry. It is shallow, and little fresh exposure appears. Four feet of rock is noted. It is irregularly bedded, much jointed, finely granular, grayish on fracture, but yellowish on the surface, iron-stained in places, rough, the upper layers becoming mere fragments in the geest. Some of these fragments were somewhat spherical stromatoporiods with laminæ in very irregular wavy lines, and where broken the planes were thickly tubercled. Others were masses of small cylinders, rarely branching, running at various angles but incorporated together, stromatoporoid in structure, the stem always rising above the plane of the matrix wherever exposed. Immediately above the geest were six inches of Buchanan gravel. In the road one-half mile east and at a little greater elevation the rock is of a decidedly lithographic type in some layers. The dendroidal Stromatoporas were here, together with a few Cladopora stems.

In the northeast quarter of section 5, Union township, twenty five or thirty feet above the water of West Fork, is a hard, brittle, yellow rock. It has many crinoid stems, a few cyathophylloid corals, often weathered to the merest skeleton outline, brachiopods and traces of other fossil forms, embossed thickly over the surface, giving it a strangely harsh feel. The crinoid stems interpenetrate the rock at right angles to the bedding planes, as if the calcareous mud had filled about them while still *in situ.* Below two feet of this are three feet of limestone, whitish where exposed, but gray within. Dendroidal Stromatoporas plentifully emboss the surface, and sometimes make up nearly the whole substance of the rock . Where organic structure is not apparent the rock is lithographic in character, but very seamy and readily weathers into small irregular fragments rendering it unfit for any economic purpose. In a channel cut by a small stream were loose pieces of lithographic stone, but such rock was nowhere found in place. The fossils here would indicate that the dendroidal Stromatoporas were below the massive, laminated ones, and the crinoidal layers were above them.

One-half mile south of Winslow station a small quarry has been opened. The floor is about ten feet above the river, and about nine feet of rock in vertical section is shown. The rock is mostly in thin layers, often earthy, unfossiliferous. A few Stromatoporas were loose in the debris of the quarry floor, but none were found in place.

The only rock noted in Washington township was at a point a little north of P. Negley's residence, in the southeast quarter of section 10. Years ago some rock had been removed from an outcrop in a low bank, but loose soil and vegetation have healed the scar so nearly that little could be observed. Stromatoporoids were found. These and the lithological character of the rock fragments unite in confirming the evidence gained from the topographic relations that the horizon is the same as that of the exposure in Union township.

Along the western side of Mt. Vernon township are two old quarries from which have been taken a good quality of stone for local purposes. One is in section 18. No fossils were found here and the lithological character of the stone gives little clue to the horizon. In a small creek bed near by, a gray, firm, finely granular stone occurs, one bed of which by weathering develops an edge showing numerous laminæ with many minute pores, as if it were stromatoporoidal in structure, but a fresh surface gives no proof of such a structure unless faint, yellow lines near together and parallel, may be so regarded. The other quarry is in section 30. Much of the rock in place here was under water at the time it was visited. A specimen picked up at random is gray, firm, granular and effervesces reluctantly with cold acid. Traces of iron oxide are everywhere diffused throughout the stone. The behavior with acid is unusual with limestone in this county. Another specimen is of the concretionary, lithographic type.

In the southwest quarter of section 36, township 87 N., range XII W., is the Buchan quarry showing the following section:

		FEET.	INCHES.
2.	Limestone, full of seams and joints, so uncertain as to make any attempt at tracing of beds unprofitable. In the lower part occurs Acervularia, a cyathophylloid coral and *Cladopora prolifera*. A Favosites is dimly apparent in places....	8	
1.	Limestone, chiefly dark drab, but bluish in upper part, sometimes granular, with calcite crystals interspread at times making fine specimens of dog-tooth spar. The first five feet develop three or even four layers, but in the upper portion layers are uncertain The quality of the stone in this quarry is variable. It is soft, earthy and much broken in some beds, firm and comparatively free from joints in others	15	6

In the southwest corner of section 25, on land owned by J. Robertson, is a quarry from which much good stone has been taken. The flood of this quarry is clearly exposed over twenty-five or thirty square rods and shows a decided dip to the southeast. For thirteen feet above the base of the quarry is a limestone in about eight layers. A thin, shaly parting separates the fourth and fifth layers. The beds below this are blue on fresh faces, yellow or brown in the seams. All show numerous and sometimes large pockets of dogtooth spar or solid masses of calcite. The upper beds are buff, ironstained along seams. Parallel, yellowish-brown streaks run persistently through some

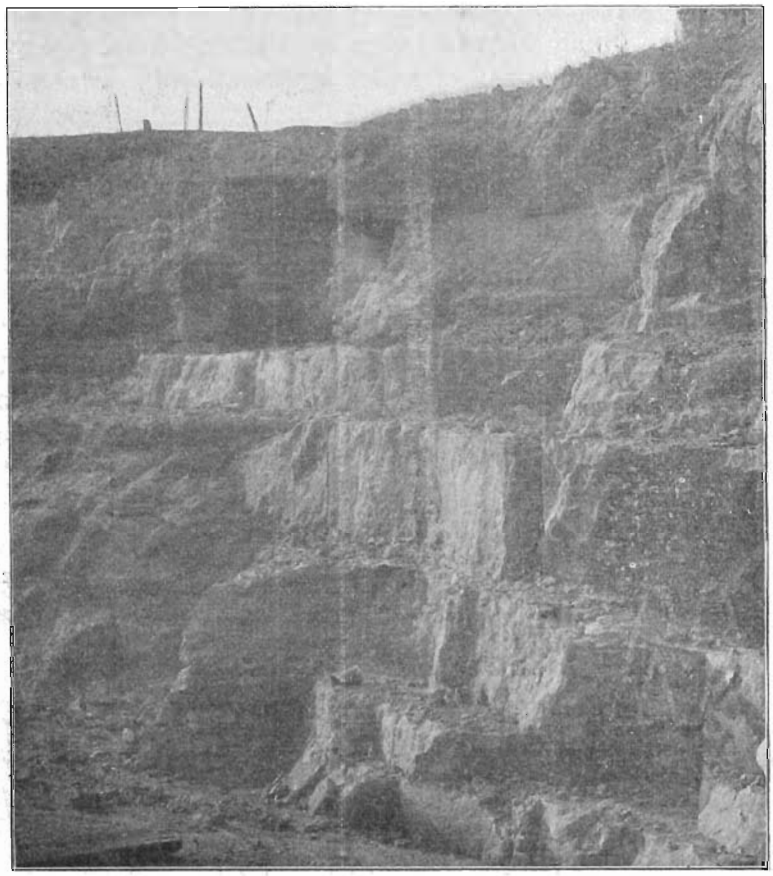


Fig. 50 Quarry in Cedar Valley limestone, near La Porte.

layers. The uppermost layer bears favosite, cup and acervularian corals, not in as good condition as in the West Waterloo quarry, but the stone is of better grade. A single specimen of *Atrypa reticularis* was found here. Above this layer are thin layers of bluff limestone, becoming thinner and more irregular toward the top and ending with a thin layer of chert in nodular masses, or in angular fragments.

In the northeast quarter of section 35, is a quarry belonging to A. K. Longaker (Fig. 50) which shows a section as follows:

		FEET	INCHES.
6.	Top soil with a few limestone fragments.		4
5.	Soft, light gray stone, much broken	2	
4.	Soft, buff stone with cherty nodules. The chert more dominant and the calcareous matrix softer as the upper layers are reached	2	6
3.	Rock similar to number 4, but with less chert	1	6
2.	Cherty layer, loose angular fragments, white or rusty brown		4
1.	Soft, buff stone, heavy-bedded, with joints running at various oblique angles with exposed faces, red-brown and with yellowish-brown streaks, usually parallel with the bedding planes, but sometimes wavy and even in concentric lines. Stone similar to this is found in Mitchell, Howard and other counties, but in this quarry some layers have an unusual development, making a very attractive appearance, about	4	

The floor of this quarry consists of a stone similar to number 1. No fossils were seen. The whole section is above the Acervularia bed of the Robertson quarry, the cherty layers at the top of the latter being the equivalent of number 2 in this quarry. The equivalent of the heavy beds of number 1, being near the top in the Robertson quarry, are thin-bedded and otherwise affected by their nearness to the surface.

In the northwest quarter of the northwest quarter of section 20, Spring Creek township, in the bluff rising from the river plain, is the Camp quarry from which considerable quantities of a good grade of stone have been taken, although no quarrying has been done here for some time. The stone is quite heavily bedded. The lower two and upper six feet are lithographic in character. These beds are known locally as limestone, while the intervening eight feet which are granular in texture, are called sandstone by the local observers. These upper beds are much jointed, especially in the higher layers, where they are yielding more or less to weathering influences, while the lower beds bear numerous calcitic patches in a gray, soft limestone. A quarter of a mile northwest is a quarry owned by C. R. Harmon. The lower layer is a gray, soft stone with calcitic blotches and lines everywhere throughout it. This bed is the equivalent of the beds in the Camp quarry lying immediately above the lower lithographic bed. Above this are seven feet of rock, gray below and buff above, the latter part being much jointed and somewhat weathered, thus very much resembling the similarly situated beds of the Camp quarry. No fossils were found in the last named, only the edges of the stone being exposed, but in the Harmon quarry this upper bed has *Atrypa reticularis* in it. A quarter of a mile still farther northwest is a small quarry where the same beds are exposed. Atrypa occurs here also.

In the valley of Indian creek, one mile above its junction with the Cedar, the lithographic beds are found in a natural outcrop. Loose blocks of this stone were observed in a roadside ditch one mile north of Gilbertville. They had the peculiar whitish color of this rock when weathered and evidently had been washed out of the gust so often found overlying a firmer rock, when near the surface.

In the southwest quarter of section 11, township 88 N., range XII W., a small quarry very nearly duplicates the upper part of the Camp quarry, having the granular calcite bearing beds below, then the beds more or less decayed, above which are lithographic beds. Here, however, the latter have distinct shaly partings not shown in the others.

On Mr. F. A. Buttke's land in section 15, Spring Creek township, a ridge has in it stone very near the surface and a local supply of building stone has been removed from two or three different places. The rock quarried was mainly of the lithographic type. The floor of one pit was a soft, buff, fissile limestone, above which were two feet of a yellowish, soft, calcite-bearing stone. The uppermost bed of this quarry contained stromatoporoid masses of all sizes up to a foot in diameter. There were also short, cylindrical stems roughening the surface, much resembling the dendroidal Stromatoporas of the outcrop on the West Fork in Union township. There are several other outcroppings along Spring Creek from near its mouth to the north border of the township, in all of which the lithographic stone appears. The occurrence of the Stromatopora and lithographic beds east of Cedar river, with Acervularia beds outcropping on both the east and west sides of them without any material change of elevation, would imply that they lie in a shallow syncline and this view is supported by the fact that at the Robertson quarry on the west is a very decided dip to the southeast. The dip of the Acervularia beds on the east could not be determined as only an outcropping in a bank was noted.

In the northwest quarter of the northwest quarter of section 24, Eagle township, is a ridge due to an outlier of limestone. The country north and west is unusually level, while that east and south presents very little unevenness of surface. Two quarries have been opened here from which large quantities of stone have been taken, since a wide extent of country finds here its only supply of stone except such as may come from the Iowan bowlders which in some sections are not plentiful. In a quarry in the field west of the road the following section is shown:

		FEET.	INCHES.
13.	Thin-bedded, broken stone	7	
12.	Two layers of limestone, blue where unchanged	4	6
11.	Three layers of hard, compact limestone, of good quality, durable, brittle, having conchoidal fracture, with drab nodules of varying sizes, and in the upper part with stromatoporoid masses thoroughly coalescent with the rest or the rock	5	
10.	Bluish, earthy limestone, much jointed and irregularly bedded	3	
9.	Dark drab stone, calcitic at top	1	6
8.	Blue stone, buff where exposed, calcite plentiful, in seven or eight layers	1	10
7.	Drab limestone		9
6.	Buff, earthy limestone, finely streaked with yellow lines	2	2
5.	Shaly partings with very wavy lines of contact above and below		3
4.	Hard, brittle, drab limestone, middle portion developing layers	3	2
3.	Blue limestone of good quality, firm, finely crystalline, with pockets of crystals, thickness not taken.		
2.	Gray, finely crystalline limestone, yielding good flags		6
1.	A good stone, gray, somewhat crystalline, fracture coarsely conchoidal	2	6

Below is given a section from the quarry east of the road:

		FEET.	INCHES.
7.	Thin-bedded stone such as usually occurs near the surface	7	

	FEET.	INCHES.
6. Like No. 5 in appearance, but readily weathers into fragments, joints readily developing	1	6
5. Good quarry stone, drab, dense, brittle, resistant to weathering influences	2	6
4. Buff, iron-stained, soft in places	5	
3. Thin-bedded, much jointed, buff, calcite bearing	1	6
2. Like No. 3, upper six inches very fragile and fissile	3	
1. Firm, drab, compact, in two layers, upper argillaceous.	4	

The stromatoporoid masses in number 11 of the west quarry, together with the lithological character of certain beds, makes it reasonable to conclude that the beds of these quarries are of the same horizon as those of the Cedar Falls quarries. Aside from the Stromatopora and an undetermined brachiopod very sparingly occurring in a part of number 3 of the east quarry, these beds are entirely barren. A characteristic of these barren beds, whether found in East Waterloo, Cedar Falls, or Eagle township, is the marked variability of most of the rock, sometimes even in the same quarry and always in near-by quarries. A very few features, like the pockets of crystals, yellow streaks in a soft, earthy stone, blue limestone, yellowing under the weather, may be traced at fairly well established horizons. Otherwise little can be used in correlation and even these without sure reliance, unless the Stromatopora and lithographic beds chance to be found overtopping them.

Stratigraphically the lowest horizon in the county is the outcropping in an intermittent stream bed in the northeast quarter of section 13, Fox township, which is referred to the upper part of the Wapsipinicon stage of the Devonian. No thickness can be assigned as only a partial section could be made. In the bank adjacent three or four feet of this zone were exposed.

GENERAL SECTION OF CEDAR VALLEY LIMESTONE.

A general section of the rocks of the Cedar Valley stage in Black Hawk county may be arranged in order as follows:

	FEET.
3. Lithographic and stromatoporoid beds, somewhat variable in character, but everywhere maintaining certain unmistakable features. In places a nodular or even brecciated phase is found. Excepting the stromatoporoids, few fossils occur	20

		FEET.
2.	Beds which, for sake of identification in reference to them may be called the Raymond quarry beds, since they have long been known there, distinctively barren, excepting an occasional coarse-ribbed *Atrypa reticularis*, a few fragments of another brachiopod, a few crinoid stems and the fish jaw found at the Bartlett quarry. Cherty layers, pockets of calcite and geode-like masses occur with considerable regularity	26
1.	The Acervularia beds which scarcely admit of definite differentiation in most of the places where rock of this zone occurs, unless it be in the outcropping above the Wapsipinicon horizon in Fox township	7

Number 2 is the horizon referred to by Calvin as being "Along the river bluff, a short distance above Littleton"* and which is there about sixty feet in thickness.

GEEST.

In no quarry has it been necessary to do much stripping in order to secure the stone needed to supply the local demands, the natural exposure that first attracted the quarryman's attention being located where the overlying unconsolidated material was thin. This condition, however, has favored rock decay in its various phases, with the result that the sound rock is invariably covered with the insoluable products of rock decomposition to a depth varying with the circumstances. In one instance five or six feet of this dark red, stiff, clayey residuum was observed. though usually from one to three feet measures the extent of the geest, as this form of rock waste is often called, and the lower half of this is mingled with the more resistant remnants of the original rock. Sometimes the activity of the erosive agents is continued along the joint planes to a depth of twenty feet or more, widening them out and leaving the spaces partially filled with geest.

PLEISTOCENE SYSTEM.

KANSAN STAGE.

Kansan drift.—The oldest observed representative of the Pleistocene is the Kansan drift. This covers almost four-fifths of the area of the county and in turn is covered practically everywhere with the Iowan. Its maximum thickness in the county

*Calvin: Iowa Geol. Surv., Vol. VIII, p. 234.

is not known, but in Lincoln township where the mantle rock has a thickness of 270 feet, the maximum for the county, more than nine-tenths of this material is Kansan till, judging from the few exposures made by the erosion of the streams and excavation of railroad cuts. The dense, blue clay which invariably forms the basis of this drift when unweathered, is accompanied always with other constituents, of ever varying nature, form, size and proporations, so that any section through or into it discloses to the careful observer some detail of special interest. Calcium carbonate, often too finely reduced to be noted with the eye, quartz grains, pebbles and larger masses of other minerals, especially of greenstone, and disintegrating granitoid masses are very common. Pockets of sand and gravel as well as streaks and layers of these materials, running in all directions, are numerous. This feature of the Kansan was unusually manifest in the excavations for the Auditorium and Gymnasium buildings of the State Normal School. Here, too, were found pieces of coal and other carbonaceous matter, calcareous septaria, ferruginous concretions with a clayey nucleus, sometimes reaching bowlder dimensions, and in one instance at least beautifully polished and striated. In the cut made by the Illinois Central railway one mile or more northwest of Cedar Falls a mass of native copper weighing four and one-half pounds was found deeply bedded in the Kansan till, giving unquestionable evidence as to the direction from which this part of the till must have come. When exposed, or near the surface, oxidation changes the color of the clay to a yellow, brown, or gray, the lime and some other ingredients are leached out and the granitoid masses readily fall in pieces.

Calvin, Savage and others note the presence of a layer of pebbles on the top of the Kansan drift, where it rises in ridges, and beneath the Iowan. This is very common in Black Hawk county, almost invariably to be seen where the roadmakers have cut into the more abrupt ridges, beginning part way up one side, passing over the top and partly down the other side. It seems to be a result of post-Kansan erosion. The soluble and finer constituents of the drift having been removed, the pebbles, having settled down together, readily attract attention.

Since the Iowan is everywhere coincident with the Kansan in this county, all distinctive topographical features of the Kansan have been obliterated over by far the greater part of the county. The high bluffs in the vicinity of Cedar Falls are gashed with short V-shaped ravines deeply cut into the Kansan by the pre-Iowan streams as they sought a passage to the river over the steep escarpment. As has already been stated under the head of Topography, for a distance of seven or eight miles southeast of Cedar Falls quite pronounced Kansan topography manifests itself through the thin veneer of the Iowan, if the latter be not entirely wanting in some parts of this area.

Buchanan gravels.—Since Calvin first recognized the Buchanan gravels as a distinct Pleistocene deposit, writers on the Pleistocene of northeastern Iowa have given them due attention. They are well described and their genesis closely and reasonably accounted for in the report on Howard county.* In every township one or both phases of these gravels may be found some of which to be sure are very thin and show little stain or other evidence of weathering, but their position makes their relationship quite certain.

Along the banks of Dry Run and its branches are numerous extensive deposits. The first to appear as one proceeds southwestward from its mouth is at N. Olsen's quarry where the upland phase has a thickness of ten feet . The lower part is deeply iron stained and coarse. The upper part is less ferruginous, stratified, some layers being a fine sand. The uppermost layers are highly ferruginous. At Carpenter's quarry the gravel is much thinner and lighter in color, but more uniformly coarse. On the east side of the creek one-half mile directly east of the Normal School is the most extensive deposit observed anywhere in the county (Fig 51). It is of the valley phase, very uniform in size of particles which is that of a fine gravel, or coarse sand, of a yellowish color and very distinctly stratified except in the upper part. Large quantities have been removed by the Chicago Great Western railroad company for ballast. It is twenty or more feet thick and is many acres in extent. In fact, the whole valley in this neighborhood along

*Calvin: Iowa Geol. Surv., Vol. XIII, pp. 64-68.

the main stream and its tributaries is more or less filled with this material. In one place it is a very dark red brown and hardened into rock-like sheets; in another it consists of pebbles and cobble-stones of chert, jasper and other forms of quartz, greenstone, etc., all deeply stained with iron. But for the most part it is rather of a sandy nature, though more deeply stained

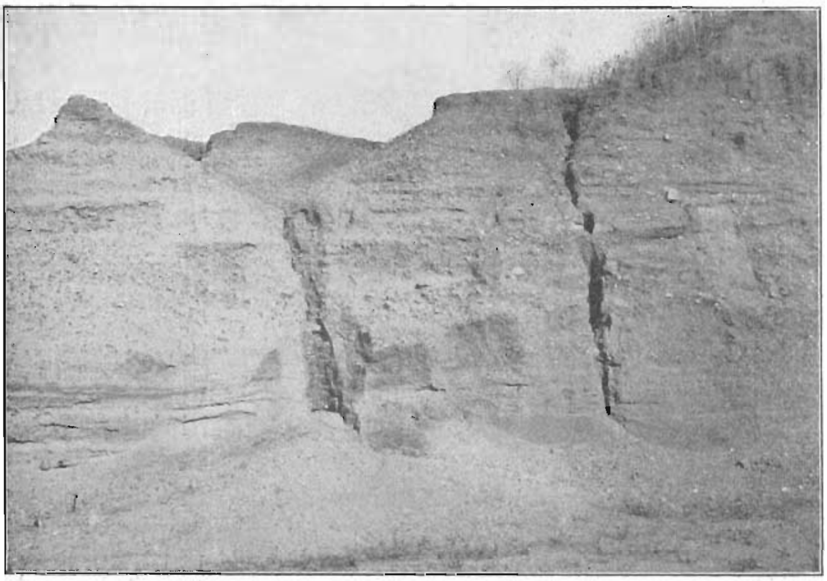


Fig. 51—Buchanan gravel, Cedar Falls, east of Normal School.

than in the pit of the railway company. At the time of the melting of the Kansan ice there must have been quite an area of still water here on reaching which the burdened floods at once deposited the coarser part of their loads. The upland deposits which overlie the limestone bounding the sides of the valley were deposited while the valley itself was still filled with ice.

On the interurban line of the Rapid Transit railway where it cuts into the bluff is a deposit ten feet in thickness, containing pebbles and cobblestones, rotten granite, iron concretions and cemented gravel, all deeply stained. In the gravel are masses of very fine grain, or without apparent grain, spherical. lenticular and plate-like in form. This deposit is interesting for the variations occurring within short distances, both in vertical and lateral extension.

In some localities the farmers have recognized the value of this material for improving the character of the roads. It is surprising that so many are still content to contend with mud, while in so many instances there is within easy reach so effectual a means of relief.

IOWAN STAGE.

Iowa drift.—There is nothing peculiar in the character of the Iowan drift deposit in Black Hawk county. Calvin's description in his report on Delaware county may well be accepted as most characteristic. "The Iowan drift is a light yellow, highly calcareous clay, unchanged by weathering and oxidation even at the surface."

As compared with the Kansan, it is everywhere very thin. On the bluffs between Cedar Falls and Waterloo and elsewhere along the margin of the Cedar valley it is scarcely a foot thick. Over the tops of the ridges even in the great Iowan drift plains, it is scarcely more in many instances. On the Normal School campus it is from five to seven feet thick. In the railroad cut one-half mile northwest of Voorhies the following section is shown:

		FEET.	INCHES
8.	Very light ash-colored clay with sand and pebbles	1	
7.	Darker, more clayey layer containing scattered pebbles	2	
6.	Ordinary Iowan drift	3	
5.	An extremely meager line of gravel, probably residual		2
4.	Oxidized Kansan	6	
3.	Light ash-colored layer	1	
2.	Dark gray layer	1	
1.	Less oxidized clay in which is a line of very irregular calcareous nodules sometimes with quartz pebbles included as in a conglomerate	4	

In a cut southeast of Voorhies the Iowan is four feet thick, below which are six feet of oxidized Kansan made up of clay, sand and gravel. Here, too, the nodules mentioned above occur. Under this is a somewhat indurated thin layer making an abrupt line in the slope, succeeding which are three feet of the blue Kansan till. These cuts are in the midst of a very characteristic part of the southwest Iowan drift plain, and, while the material in the upper part of the Iowan drift is not typical, its thickness may be taken as a fair average of the Iowan in the more elevated portion of this plain. One-half mile northeast of Voorhies, where the road crosses a small creek, Buchanan gravel appears under two and one-half feet of the Iowan. Similar conditions exist over the great Iowan plain between the Cedar and the Wapsipinicon rivers where it is most characteristic, as in Bennington and Barclay townships, and in the west half of Fox. There are localities where no drift of any kind can be found. Near the middle of the boundary between sections 34 and 35, Mt. Vernon township, in the road is an outcropping of limestone. In the next level above it is a thin layer of gravel and pebbles, Buchanan perhaps, and near are Iowan bowlders. There is nothing in the topography to account for this isolated outcropping of limestone, the topography all about it being the typical Iowan. Other localities where no drift appears have been mentioned under the head of Topography.

The Iowan drift abounds in bowlders. They are chiefly granitoid, though gneiss, greenstones, basalt, quartzite and even sandstone and limestone are more or less common. A large quartzite bowlder with surface corrugated with ripple marks slid out of the Iowan down the slope of the railroad cut just below Cedar Falls during a flooding rain in the summer of 1902. Blocks of sandstone very much like, if not of, the New Richmond sandstone, are occasionally found. Sometimes many of these kinds may be found scattered over a small area, though the parent ledges must have been at considerable distances apart, thus showing how thoroughly were these constituents of the drift mingled as they were detached and borne along by the resistless power of the great ice sheet. Their distribution over the county is by no means uniform. Long stretches of the plain are entirely destitute of them. Elsewhere their presence in great numbers and in notably large specimens is a striking feature of the landscape. Again they are few, small and scattered. Nearly every township gives proof of this unequal distribution, though Eagle, Lincoln and Big Creek seem to have larger areas free from bowlders than other townships, those which lie wholly or in large part in the river valleys being excepted.

Loess.—Covering all of the higher parts of the region of Kansan topography between Cedar Falls and Waterloo is a light gray, homogeneous material consisting of a fine clay and very minute grains of sand. Unquestionably it is a loess. It is noticeably without any tinge of yellow, usually so characteristic of the loess of Iowa. There are few places where the loess is penetrated to the underlying material. So far as observed there is a zone of light colored clay, bearing pebbles or even cobble stones, just below it. In the cut of the Rapid Transit railway mentioned under the head of Buchanan gravels, these gravels have immediately above them the pebble bearing till which must therefore be Iowan. The Iowan borders this whole region and tongues of it run up into the lower levels among the hills. It is probable that a thin deposit of Iowan drift underlies much of the lower loess deposit, if not all of it. The thickness of this loess is from one or two to eight feet at least. No loess occurs elsewhere in the county as far as observed.

ALLUVIUM AND TERRACES.

The larger valleys have been flooded at seasons of high water ever since they assumed their present character. Each overflow leaves its increment of sediment, usually a fine silt, the wash from the adjacent fields and bluff sides. Sand is the most abundant material of these valleys. Coarser sands and gravels are variously mingled in places where the stronger currents have run over the plains. Then, too, the shifting stream beds have left coarse materials in considerable quantities here and there throughout the river flats.

It is very difficult to determine accurately the depth or superficial area of the alluvial deposits, since tongues of Iowan clays sometimes underlie the sands, and the drift borders the alluvium with a very irregular line of lobes and sinuses. There is some reason to believe from wells and other excavations that a preglacial stream has cut its channel into the rock, well below the present rock bed of the Cedar, but the evidence is too meager to warrant any effort to trace its course.

Along the margins of these valleys low terraces occasionally appear, but nowhere are they a very noticeable feature of the topography of the county.

CRETACEOUS MATERIAL IN THE DRIFT.

In the first volume of the Survey reference is made to Cretaceous material found in the drift in different parts of the state.* As a contribution to the subject there discussed, the following items are given without any attempt to account for the occurrence of the finds in the locality and situation where they were discovered.

A small, soft, ferruginous sandstone well filled with casts of Pinnæ and gastropods of at least two species was found just above the blue clay, eight feet below the surface, in laying a sanitary sewer, on Olive street near Professor Parish's residence on Normal Hill. Small pieces of a conifer were found near it. A slender belemnite judged to be Cretaceous was unearthed in excavating for the new Gymnasium of the Normal School. An impression of what appears to be *Prionocyclus wyomingensis* was found in another excavation on the campus five feet below the surface.

Soils.

The soils of Black Hawk county may be placed in a general way mainly in two classes, that of the larger stream valleys and that of the Iowan drift plains. The latter, a rich, deep loam with a clay subsoil, has often been described in the reports on the counties where it prevails, and it presents no marked variation in this county. Those townships where the features of the Iowan drift dominate the landscape are readily recognized as rich farming districts by every indication by which we may judge of the prosperity of a community. The marvel is that any man in these days of labor saving machinery, rural free delivery and telephone consents to exchange the freedom and independence of such homes as abound over these portions of the county for the questionably superior advantages of the town, all things being taken into consideration.

The alluvial plains of the Cedar and its larger tributaries are productive in seasons when there is an average amount of rainfall well distributed through the growing time of the year, but suffer first in dry times and therefore are less to be depended upon for uniformly good crops than the more favored region of the Iowan drift plains; though where drainage is imperfect,

*Keyes: Iowa Geol. Surv., Vol. I, p. 125.

these latter are the sufferers in the wet years. The advantage lies with the latter, however, for tiling and ditching relieve the situation very readily in most cases. Already the bowlders that embarrassed the cultivator and to the thrifty eye disfigured the otherwise fair fields to a great extent, have been utilized in building, or have been removed to the boundaries of the farms, where, lying in grim ruggedness, they continue their mute testimony to the reasonableness of the glacial theory and the wonderful activities of nature in the days long gone by.

The drouth resisting capability of the drift plains is indeed remarkable and ought not to be disregarded in any mention of their characteristics. No better test of this could be made than the series of dry seasons that succeeded each other a few years ago. Though the farmers, disheartened by the long prevailing unfavorable conditions, long before harvest time gave way to gloomy foreborings, the crops were happily disappointing in the average results. The clays underlying the rich top soil, slowly but persistently, yielded up their store of moisture by capillarity, no matter to what depth the zone of ground water retreated.

While this cannot be true in the same degree of the valleys of the Cedar and Wapsipinicon, the sandy element which is in excess in some parts of them, by its readier drainage permits an earlier cultivation and by its greater warmth promotes a more rapid growth, thus making them specially adapted to the growth of some crops in the cultivation of which the farmer finds no slight compensation for those qualities of the drift plains which his land is denied. There are intermediate soil conditions between these two types the details respecting which need not be given here.

The comparatively small area of Kansan topography affords a third type of soil, which is fertile, warm, drains readily, has good capillarity and is easily worked. It is specially adapted to the growth of garden truck, small fruits and orchards as well as the standard field crops.

Deformations.

The rocks of this county have been little affected by folding. a low anticiline brings the Acervularia horizon into notice on the west side of the Cedar from Waterloo to the county line on the south, while the rocks on the east side of the river over the same distance are all of a higher horizon stratigraphically, though the altitude at which they occur is no greater than that of the rock on the west, if, indeed, it is as great in some places.

The Acervularia horizon reappears at the surface on the east along Spring creek. Small narrow folds appear in one or two places along Dry Run in Cedar Falls.

Unconformities.

The floor of the Round's quarry in Cedar Falls shows a distinct unconformity with the bed that had overlain it. Similar unconformities, presumably at the same horizon, were noted in several other localities, though, being in or near the base of the barren beds, no certain means of determining the exact horizon of the several unconformities present themselves.

ECONOMIC PRODUCTS.

Building Stone.

Rock outcroppings are so distributed over the county as to bring within easy reach of a large part of the population an abundant supply of stone suitable for all ordinary constructive purposes. Nowhere, however, is it of such a grade as to warrant quarrying operations on a scale beyond the supply of the immediate local demands. Stone buildings are not common. The few good ones, however, indicate the possibilities yet undeveloped. The best range rock and flagstones are obtained from the Neilson quarry already described. Naturally the quarries that have been worked most extensively are those in the vicinity of La Porte City, Waterloo and Cedar Falls. The Berry quarry in Eagle township supplies a wide range of country as it furnishes the only limestone occurring in that locality.

The Iowan bowlders furnish an excellent stone and are used quite largely both in the town and country. The walls of the First Presbyterian church in Waterloo are built of granite taken from a single bowlder two or three miles from town. The Congregational church in Cedar Falls is built of bowlders gathered from the neighborhood. These are not only most substantial buildings but pleasing to the eye as well. The range of the varieties of crystalline rocks in the walls of the Cedar Falls church is truly remarkable. Mr. A. D. Barnum of Cedar Falls contracted to furnish large blocks of stone necessary for the lower foundations of the state capitol, and filled his contract from a few large bowlders in the neighborhood of that city.

Lime.

No lime has been produced in this county for many years. Formerly there were kilns in several localities. The rock used was usually taken from the stromatoporoid horizon, and a good grade of lime for immediate use is reported, but its readiness to deteriorate in a short time destroyed its value for commercial purposes.

Brick Clay.

The glacial clays afford little promise at present of furnishing material for the manufacture of superior brick, and since other clays are not accessible in this county the prospects for brick making on an extensive scale are not very promising. The small loess region between Cedar Falls and Waterloo yields a material that is utilized by Stead Brothers and Guenther in the northwest quarter of section 21, Waterloo township, in the manufacture of a good quality of common brick. At present the round, down draft kilns are used. The stiff mud process is employed. A Freeze and Eagle repress machine is used. The present capacity of the plant is from fifteen to twenty thousand daily. A ready market is found for all their output and the proprietors are planning a considerable increase in the capacity and facilities of their plant.

The Waterloo and Cedar Falls Brick Company have a plant in the northeast quarter of section 13, Cedar Falls township. The material used here has been Iowan and Kansan drift. At present they are using loess with satisfactory results. They have four round, down draft kilns, ample first class drying facilities, use the stiff mud process and have a capacity of twelve thousand daily. They, too, find ready market for their entire product.

Road Materials.

Much of the limestone of the county is too soft to use as road material. Where used it has pulverized in a short time forming a limey dust that has proven very disagreeable to travelers. The stromatoporoid and lithographic beds, where available, would give better results. When this is not at hand, in place of crushed stone, the Buchanan gravel is available in many localities, and, as has been stated already, it is a most excellent material for improving the roads. Dry Run channel has afforded large supplies of superior gravel which has already been drawn upon freely for the improvement of the streets of Cedar Falls and the roads in its neighborhood. The Cedar and the Wapsipinicon and their larger tributaries have sorted and deposited in bars, so that it is easily accessible, large quantities of good gravel which in some instances has been used in repairing the roads of the vicinity. With judicious preparation of the roadbed by proper drainage and building up, most of the roads of the country in a few years could be made firm and dry at all seasons with little, if any, greater expenditure than is now employed. The work should be done on a well formed plan and adhered to throughout a series of years.

Water Supply.

No very large areas in this county are remote from perennial streams which afford water in abundance for all ordinary purposes. By wells, water of good quality is easily obtained in the great majority of cases. The wells in the river valleys reach a layer of gravel at a depth of ten to thirty-five feet and stop there. On the Iowan drift plain water is obtained at from sixty to two hundred and eighty feet. Some of these stop in the blue clay. Most of them reach a layer of gravel or pass into the rock a few feet before they terminate. The uniform excellence of the water in most cases is noteworthy.

In Waterloo the supply of water has been taken from the river, but this has not proved satisfactory and a deep well is being put down in the expectation that a copious supply of good water will be secured. A depth of 731 feet has been reached where a firm limestone has been struck just after leaving a shale. This undoubtedly is the Maquoketa shale, and the next advance will be in the Galena-Trenton. It is hoped by the company that an adequate supply of water will be found in the Saint Peter sandstone, but they are prepared to go into the water bearing strata below to the depth of 2500 feet if necessary. Waterloo is in the Dubuque-Sioux City section and there is reason to believe from the record of the wells already sunk in this section, that there will be a full supply of water without the necessity of pumping from any great depth. The United States Geological Survey and the Iowa Geological Survey are receiving sample borings as the work progresses, and in due time a complete section will be published.

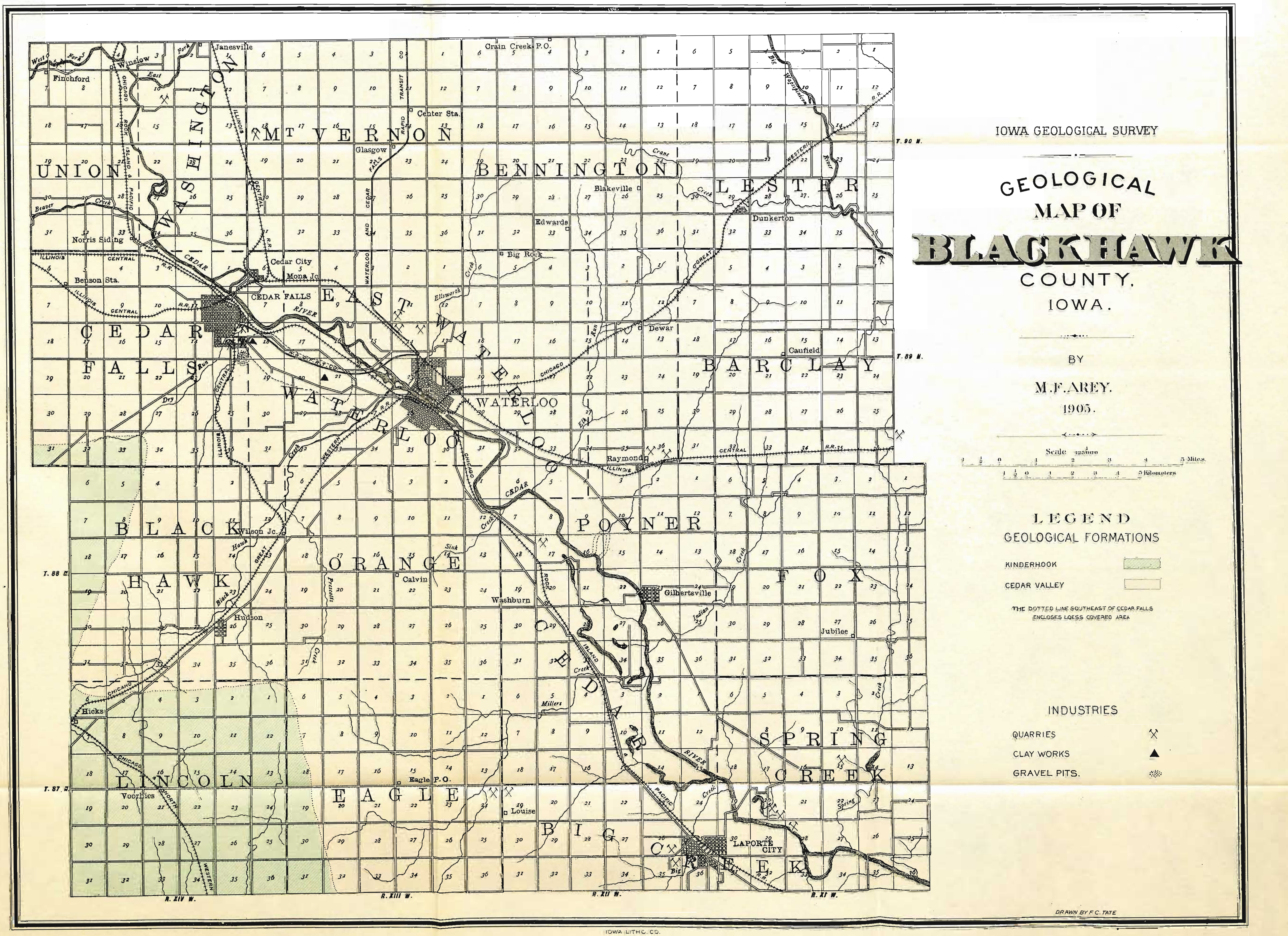
In Cedar Falls the water works are owned by the municipality. The supply is obtained from large fissure springs near the mouth of Dry Run. An analysis of the water made July 1902 gave total solids in solution 294 parts per million or 17.150 grains per gallon; January 22, 1905, 297 parts per million or 17.325 grains per gallon. No trace of organic matter appears. The supply is abundant. Even in the extremely dry seasons of a few years ago there was no perceptible diminution in the flow. It is difficult to determine the strata from which the water comes, but it is believed to be the Devonian. The lower beds in this neighborhood are much channeled, as if water currents were common. Limestone could not be expected to furnish so large an amount of quarry water and these channeled beds are suggestive of small subterranean streams that, following the dip, seem to center in the vicinity of these springs. The Union Mill Company in making improvements at one of their Cedar Falls mills in the fall of 1904, quarrying into the limestone, uncovered a considerable fissure from which issued a large stream of water. These streams must be fed from a considerable intake which is situated probably mainly on the east side of the river, as the bed from which the Mill company's spring broke out is below the river level. The sandy plain of the Cedar valley would give the proper type of soil for such an intake and would prove a complete filter, thus accounting for the absence of organic matter. While the waters of Dry Run disappear beneath the surface two miles or more above these springs, they do not reach them, as is indicated by the absence of organic matter which would certainly appear from surface waters passing so short a distance through well worn water ways. Nor could the flow in this small creek supply a tithe of the water daily pumped from these springs. Occasionally in times of very high water the immediate vicinity of the springs is overflowed and the city water is affected by this surface water, but this passes with the conditions that caused it. No city is more highly favored with an abundant supply of pure water than is Cedar Falls.

Water Power.

A dam across the Cedar has been maintained for many years at Cedar Falls and also one at Waterloo. The control of the power is in the hands of the Waterloo and Cedar Falls Union Mill Company. About 6000 horse power is available at each place and practically all of this is utilized in the operation of the mills belonging to the company. These flouring mills are thoroughly equipped with machinery of the latest approved type for the production of flour by the best modern methods. There is also a small mill at Finchford on the West Fork.

Acknowledgments.

The writer is under special obligations to Professor Samuel Calvin, former State Geologist, and to Professor Frank A Wilder, the present State Geologist, for assistance and advice which have been given very freely and without which this report would not have been prepared. Rodney M. Arey, Principal of Muscatine High School, was a valued volunteer assistant during the gathering of data from the field. To these and the many others who so readily assisted by giving information and material aid in other ways our hearty thanks are given.



IOWA GEOLOGICAL SURVEY
GEOLOGICAL
MAP OF
BLACKHAWK
COUNTY,
IOWA.
BY
M.F.AREY.
1905.
Scale 1/125000
5 Miles.
5 Kilometers
LEGEND
GEOLOGICAL FORMATIONS
KINDERHOOK
CEDAR VALLEY
THE DOTTED LINE SOUTHEAST OF CEDAR FALLS ENCLOSES LOESS COVERED AREA
INDUSTRIES
QUARRIES
CLAY WORKS
GRAVEL PITS.
UNION
WASHINGTON
MT VERNON
BENNINGTON
LESTER
CEDAR FALLS
EAST WATERLOO
WATERLOO
BARCLAY
BLACK HAWK
ORANGE
POYNER
FOX
LINCOLN
EAGLE
BIG CREEK
SPRING CREEK
Janesville
Winslow
Finchford
Crain Creek P.O.
Center Sta.
Glasgow
Blakeville
Dunkerton
Edwards
Norris Siding
Cedar City
Mona Jc.
Big Rock
Benson Sta.
CEDAR FALLS
Dewar
Caunfield
WATERLOO
Raymond
Wilson Jc.
Calvin
Washburn
Gilbertsville
Hudson
Jubilee
Hicks
Millers
Eagle P.O.
Voorhies
Louise
LAPORTE CITY
T. 90 N.
T. 89 N.
T. 88 N.
T. 87 N.
R. XIV W.
R. XIII W.
R. XII W.
R. XI W.
CEDAR RIVER
ILLINOIS CENTRAL R.R.
CHICAGO GREAT WESTERN R.R.
CHICAGO ROCK ISLAND & PACIFIC
WATERLOO AND CEDAR FALLS RAPID TRANSIT
DRAWN BY F.C. TATE
IOWA LITHO. CO.

GEOLOGY OF FRANKLIN COUNTY.

BY

IRA A. WILLIAMS.

GEOLOGY OF FRANKLIN COUNTY.

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CONTENTS.

INTRODUCTION.

LOCATION AND AREA.

Franklin county stands fifth from the Mississippi and seventh from the Missouri river in the third tier of counties from the Minnesota line. The county lies between Cerro Gordo and Hardin counties to the north and south respectively; while Butler and Wright counties form the east and west boundaries. In outline it is square and contains sixteen standard sized townships. It has an area therefore of 576 square miles or, 368,640 acres.

The county was organized in 1855, prior to which time it had been under the judicial rule of Chickasaw and later of Hardin county. The name Franklin was given in honor of Benjamin Franklin; the first county seat, which was located two miles south of the present site of Hampton, being called Benjamin.

EARLIER GEOLOGICAL WORK.

The area under discussion was traversed previous to 1852 by parties under the direction of David Dale Owen* in tracing the boundary between the Devonian and Carboniferous systems.

Dr. C. A. White† states that the Kinderhook limestone outcrops along the Iowa River in Franklin county. Careful search at the present time failed to reveal any exposures of this formation along the Iowa in the county. In Volume II of White's report‡ published the same year, a general review of the geology and natural resources of Franklin county is given. All the indurated rocks exposed in the area were by this author referred to the Kinderhook. The present study indicates the presence of Devonian rocks in West Fork and Ingham townships. Exposures of shales and limestones may be frequently observed in the neighborhood of the West Fork of the Cedar River, which bear typical Devonian fossils, thus leaving no question as to their identity.

The course of the Altamont moraine in Iowa has been traced by Warren Upham and a detailed description of the position and nature of its most conspicuous ridges in Franklin county is given in the Ninth Annual Report of the Geology and Natural History Survey of Minnesota, page 303.

*Geological Survey, Iowa, Wisconsin and Minnesota, p. 105, 1852.
†Geology of Iowa, Vol. I, p. 194, 1870.
‡Geology of Iowa, Vol. II, p. 239 et seq. 1870.

Of the counties adjacent to Franklin, Cerro Gordo to the north and Hardin on the south have received attention by members of the present survey. * †

The clays of Franklin county are briefly treated in Volume XIV of the present series of reports‡. A section of the Lime Creek shales exposed in a clay pit one-half mile south of Sheffield is described in some detail as the only exposure of these shales then known in the county.

The peat deposits of the county are described and some estimates made of the quantity and availability of this class of fuel by T. E. Savage** in a Bulletin of this survey.

PHYSIOGRAPHY.

TOPOGRAPHY.

The surface features of Franklin county are such that it can primarily be separated into two fairly distinct districts. The boundaries of these districts have been determined by the deposition of glacial detritus from the two ice sheets last to invade the territory. Essentially the eastern tier of townships and the two upper members, Ross and Mott, of the second row, are included in the area of Iowan drift. The remainder of the county, approximately five-eighths of its total area, is covered with the more recent Wisconsin glacial till, and its topography is, as a result, characteristically immature.

The boundary line between these two provinces is somewhat irregular, but with few exceptions the differences in surface configuration are so marked that there arises no question as to its location. Its course across the county is in general from west of north to east of south. Entering two and a quarter miles from the east border of Richland, and passing one mile to the west of the city of Hampton, it divides Reeve township diagonally nearly into halves and detaching somewhat more than one and one-half square mile from the northeast corner of Grant, makes its exit into Hardin county two and one-quarter miles east of the western boundary of Osceola township. To the suspecting observer, who is already familiar with the trend

*S. Calvin, Geol. Cerro Gordo Co., Ann. Rep. Iowa Geol. Survey, Vol. VII, 1896.
†S. W. Beyer, Geol. Hardin Co., Ann. Rep. Iowa Geol. Survey, Vol. X, 1899.
‡Clay Industries of Iowa, Ann. Rep. Iowa Geol. Survey, Vol. XIV, p. 402, 1904.
**Iowa Geological Survey, Bulletin No. 2, pp. 13 and 20, 1905.

of this dividing line in the counties to the north and south, there is much of suggestion as to its probable course in Franklin county to be obtained from the ordinary civil map which shows only legal boundaries, railroads and streams. Perusal of such a map will show the prevailing courses of the streams within the Wisconsin area to be eastward. Just before breaking through the moraine these streams, without exception, assume a northeasterly direction, with many sharp turns and windings, as though seeking a vulnerable point of egress. Outside of the Wisconsin they at once assume the uniform south of easterly direction of flow.

On closer inspection of each of these two areas, it will be found that they again break up into more or less well defined districts according to, and depending on, the particular type of land form predominating. The Iowan drift area may be considered in two parts, first, that portion whose surface features are due to the materials of the Iowan drift; and second, that part whose topography depends on the earlier erosion of the limestones and shales of the older formations and later modifications by loess deposition. The Wisconsin drift area is separable into the Altamont moraine and the more level portion of the drift surface to be designated the drift plain.

IOWAN DRIFT AREA.

About three eighths of the county are covered with drift of Iowan age. But the materials of this sheet of drift are not alone responsible for the topographic features of more than one-third of this area. The Iowan till sheet is relatively thin wherever observed in the state, and it becomes more attenuated near its southern border, which crosses eastern Hardin county some nine miles south from the Franklin county line. The thickness of this deposit in Franklin county is, over considerable areas in Ross, West Fork, Reeve and Osceola townships, sufficient to disguise largely pre-existing features and to exert a ruling influence on the present topography. Away from the streams in the townships mentioned the land surface is in general level, often monotonously so for miles, the characteristic Iowan drift plain. This is especially true of portions of Ross and West Fork townships. The surface is occasionally broken by the trenching of the smaller streams whose valleys are seldom cut to any considerable depth however, without exposing the underlying shales or limestones. The landscape is occasionally varied by the presence of the usual large fresh granite bowlders which characterize this drift.

In the vicinity of the larger streams and in fact over a good share of Mott, and especially in Ingham and Geneva townships, the land surface is more hilly and rugged. This would be expected as a result of the down-cutting of the streams no matter what the material in which they had to work; but here the relief is due very largely to the outcropping or barely covered ledges of Kinderhook limestone. Along the West Fork of the

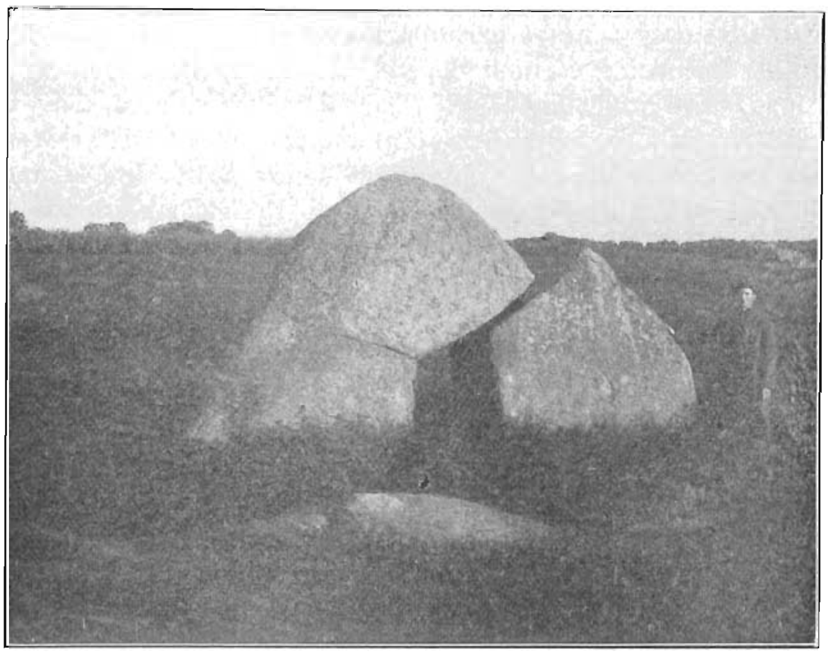


Fig. 52—Red granite bowlder of Iowan age, Southwest Section 25, Reeve township, on the farm of Mr. Jacob Kurtz.

Cedar river the Devonian strata are responsible for many of the prominent topographic features. East of this river hills of limestone underlain with shales form the bounding walls of the valley, and outcrops are common in the northwest part of West Fork township. The area westward from this stream to the border of the Carboniferous rocks has the characteristic mild topography of the Lime Creek shales, somewhat modified by the Iowan drift and loess, and is in contrast with the more pronounced reliefs imparted by the Kinderhook limestone as will be later noted.

The practical absence of the earlier Kansan drift as a factor of topographic importance may be accounted for by erosion preceding the Iowan stage. The indurated rocks are therefore the chief determining factors, but these, while commonly outcropping on the hill slopes and along the borders of the river valleys, are universally capped with a thin layer of drift and a greater or less thickness of loess.

The occurrence of loess overlying Iowan drift has been recorded by Calvin in Mitchell county,* by Beyer in Marshall† and by Savage in Tama‡ and Fayette** counties, and is known at various other points in the Iowan drift area. It is usually but a thin veneer and seldom sufficient to exert a controlling influence on topography. In the portion of the Iowan drift area in Franklin county just outlined, however, the characteristics of typical loess topography are unmistakeable. While the Iowan is in most places in this county covered with a loess-like material, it is here only that its presence becomes conspicuously noticeable. A series of loess covered hills, growing in prominence northwestward, extends from the county line in east Ingham to the southeast corner of Ross township. The hills are supported by limestone and represent the extreme northeasterly outliers of the Kinderhook. The more prominent eminences rise frequently fifty to sixty feet above water in the streams. A similar series of hills extends across northern Geneva into the southern part of Mott township. They are also to be found south of Mayne Creek in Geneva and north Osceola townships. In general, the larger streams are skirted by loess-erosional hills of this type.

In some respects these land forms resemble the paha described by McGee§ as occurring in Delaware, Fayette, Bremer, Benton and other counties in this section of the state. The

*13th Ann. Rep., Iowa Geol. Survey, p. 329.
†7th " " " " " Drift Map.
‡13th " " " " " p. 242.
**15th " " " " " p. 530.
§Pleistocene History Northeastern Iowa, 11th Ann. Rept. U. S. G. S., Pt. I, pp. 404, 451 and 457.

nuclei of such elevations are of indurated rocks, they are always crowned with loess and stand at times considerably above the level of the surrounding drift plain. T. E. Savage* describes the paha of Benton county as being hills of Kansan drift which were surrounded by the Iowan ice but were not submerged. Neither this explanation nor that of McGee which considered

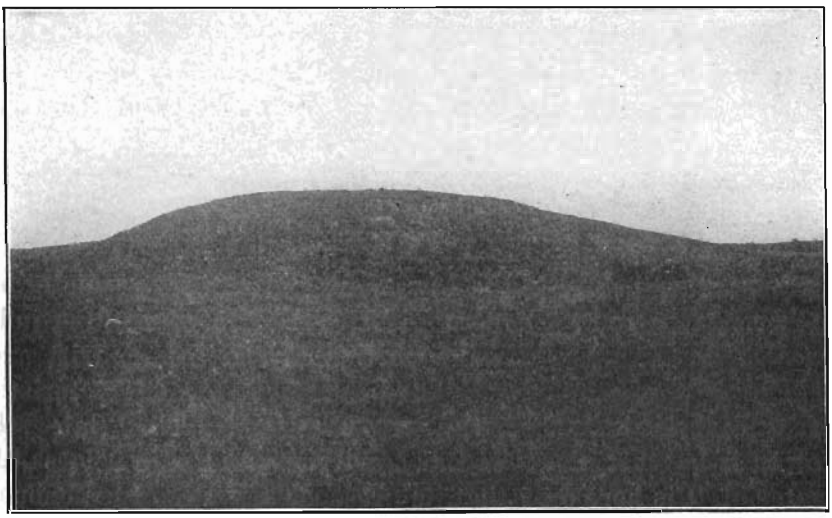


Fig. 53 An isolated knob of Kinderhook limestone in the valley of Mayne Creek, Section 18, Geneva township.

them due to glacial erosion of the drift or of the underlying indurated rocks appears to be applicable to the hills in Franklin county. Wherever observed in section, a moderately heavy mantle of loess rests on Iowan drift, which is usually thin, and reposes directly on the limestone of the Kinderhook. There is no evidence of ice moulding in the contours of the surface. The Iowan ice appears to have spread a thin stratum of detritus over hill and valley alike but not great enough in amount to conceal the irregularities of the pre-Iowan land surface. The nuclei of limestone, probably shaped to some extent by the movement of the ice upon them, and standing somewhat above the average level of the plain, were then objects or obstacles upon and around which the accumulation of the fine grained, wind drifted loess materials seems to have taken place.

*Iowa Geological Survey, Ann. Rep., Vol. XV, p. 142.

WISCONSIN DRIFT AREA.

Essentially five-eighths of the area of the county are included in the region occupied by the Wisconsin drift. This region displays two types of surface, the hilly, knobby tracts of the Altamont and Gary moraines and the relatively level drift plain.

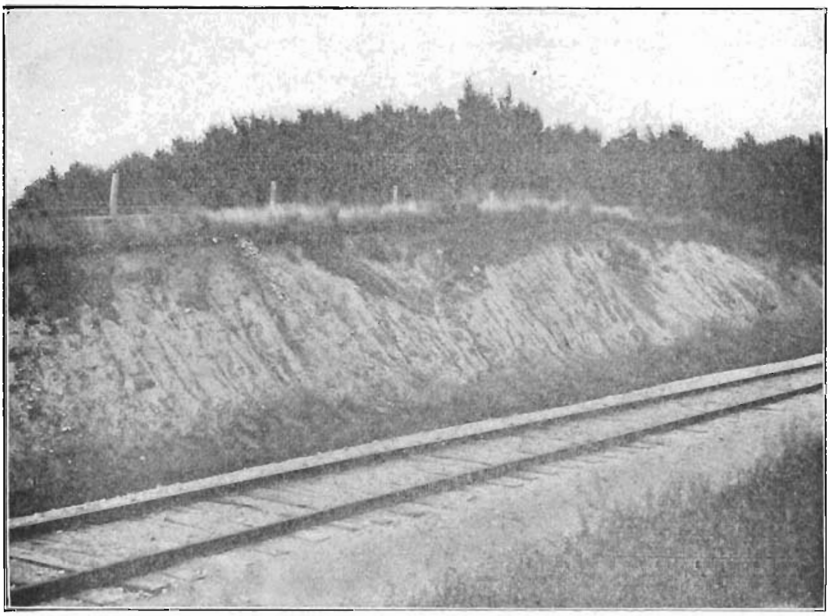


Fig. 54—Wisconsin drift showing gravel pockets, Chicago Great Western Railway cut two miles west of Hampton.

The Moraines.—The eastern border of the Wisconsin area is in general marked by a belt of hilly country varying in width from two to seven miles. In Richland and north Marion townships it has an average width of four to five miles, broadening southward so as to include practically the southern half of Marion and nearly three square miles in the southwest corner of Mott township. This outer zone of hills narrows in its course to the southeast across Reeve, and in Grant and Osceola townships is but two and a half to three miles wide.

The hills in this morainal area are not prominent, and the topography grows milder to the westward, gradually merging into the drift plain. This is especially true in Richland, Marion and Grant townships. Passing from the Iowan to the Wisconsin drift there is a rise in elevation of from twenty to eighty or ninety feet, the most noticeable relief being in the northern part of Reeve township. Here the rise is rapid to the summits of conspicuous ridges of drift that were deposited close to the ice border, and beyond which a fairly high slope leads to the level of the drift plain in north Hamilton township. Throughout this morainal tract the surface is one of mounds and rounded hills, knob-like in places, composed mostly of gravelly drift, and interspersed with ponds and marshy depressions. In fact, the presence of the latter must in some localities, for example west of Hampton in southwest Mott township, be largely depended on to establish the position of the edge of the Wisconsin. Occasional kame-like hills are found in portions of the moraine which, where they have been dissected, prove to be composed of partially stratified gravel and sand. Such are common in southwest Marion township.

The belt just described may be termed the outer moraine in contrast to the more pronounced marginal topography in the southwest townships of the county, and marks the extreme limit of the eastward advance of this ice sheet. To the west, and occupying portions of Morgan, Oakland, Hamilton, Lee and Grant townships is a series of crescentic ranges of morainal hills which exhibit on a grand scale the features of a terminal moraine. Reference to the Pleistocene map will show the position of the principal ridges. They as a rule fade away into the general upland to the north and cannot be traced far in this direction.

From the main range, which enters the county at the middle of the west side of Morgan township and is two miles wide, spurs lead off into north central Morgan and into west Hamilton townships. A more or less connected series extends from northwest Grant into southern Hamilton township. The central range extends through southern Morgan, across the northeast corner of Oakland and then swings due eastward across central Lee township where it joins with the spur from the northwest already mentioned. A crescentic spur from the main chain extends southeastward into east Oakland, and a similar though more prominent one, through south central Lee and into Hardin county.

Warren Upham has the following regarding the nature of this portion of the moraine;* "This belt is very rough, with many hillocks and short ridges, generally trending in the same direction with the series, composed of till with abundant bowlers, and divided by depressions which often contain sloughs or lakelets. Its height is fifty to seventy-five feet above the smooth areas of till on each side, and about one hundred feet above the Iowa river." The series of hills comprising this inner moraine is conspicuous for miles when approached from the north and especially so where they cross Lee township. In the northern part of this township in an area five or six miles long by one mile wide known as the "Big Slough". A body of water of some size seems to have been confined here at some former time by the wall of high drift hills to the south. One of the headwaters of Mayne Creek now flows through this depression.

The morainal features just described undoubtedly mark the position of portions of the ice margin during extended halts in the recession of the Wisconsin glacier. There appears to be little of system in the arrangement of these ridges, but in general it may be noted that the spurs leading from the central belt are concave to the west and that as a rule the more abrupt slope is to the east. The inner moraine closely approaches the outer in Hamilton and Reeve townships, but southwestward it again departs in its course through western Hardin county. Traced southward, it can be connected with the concentric chains of hills in northern Story county, which are recognized as belonging to the Gary moraine†. The Gary moraine represents a stage in the melting of the ice when its southern point stood at Mineral Ridge in northern Boone county and the position of the east edge of the lobe at that time is marked by a more or less continuous series of hills and mounds paralleling the outer moraine, the Altamont, and at times merging with it.

In the northeast corner of Hancock county it separates from the maze of hills of the Altamont and the Antelope moraine of Upham, to approach the former again in southern Franklin county. From here the two distinct moraines again stretch southward to join once more in northeast Story county.

*9th Ann. Rept. Geol. and Nat. Hist. Surv. Minn., p. 303, 1881.
†See S. W. Beyer, Iowa Geol. Survey, Vol. X, p. 28 and Vol. IX, p. 161.

Wisconsin Drift Plain.—Outside of the morainal belts the surface of the drift is substantially a plain varied only by occasional low ridges of drift or knobs of sand and gravel and the usual numerous ponds and marshy places. Drainage is practically lacking, except in close proximity to the larger streams. Such is the topography of Wisner and Scott townships. Portions of Morgan, Mamilton, Oakland, Lee and Grant townships are to be included in the drift plain, but the relief is in general greater because of the more or less promiscuous disposition of the morainal hills in these townships. South of the Iowa river in Oakland township the surface is unusually level, and shallow ponds and 'sour' places in the land are common.

ALTITUDES.

In the following table is compiled a list of the elevations of some of the principal points of the county.

LOCALITY.	ALTITUDE A. T.	AUTHORITY.
N. Co. line, one mile E. of N. W. corner..	1256 feet	C. G. W. Ry.
Alexander	1261 "	I. C. Ry.
W. Co. line, C. G. W. Ry	1239 "	C. G. W. Ry.
Coulter	1239 "	" "
Hampton	1137 "	" "
Hampton	1151 "	I. C. Ry.
Hansell	1029 "	C. G. W. Ry.
E. Co. line, C. G. W. Ry	991 "	" "
Dows	1167 "	C. R. I. & P. Ry.
Popejoy	1176 "	" "
Burdette	1196 "	" "
Sheffield	1084 "	I. C. Ry.
Chapin	1165 "	" "
Geneva	1110 "	" "
Faulkner	1113 "	" "
Ackley	1103 "	" "

The localities in the above list which have the greatest altitude are in the west and northwest portions of the county. They are situated on the Wisconsin drift plain. The part of the county occupied by this newer drift averages 75 feet higher than the Iowan drift area. No elevations are given of the highest portions of the morainal areas. It is safe to say that numerous points could be found in the moraine in Reeve, Morgan and Lee townships with altitudes at least fifty feet greater than the highest figures given in the table.

DRAINAGE.

The drainage of the county may be considered with reference to the two drift sheets which occupy its territory. There is a marked difference in the development of the streams in these two provinces. With the exception of the Iowa river, all the streams of any considerable size are practically confined to the Iowan drift area. Some of these head in the ponds and marshes of the Wisconsin drift but the areas drained by such headwaters are very limited.

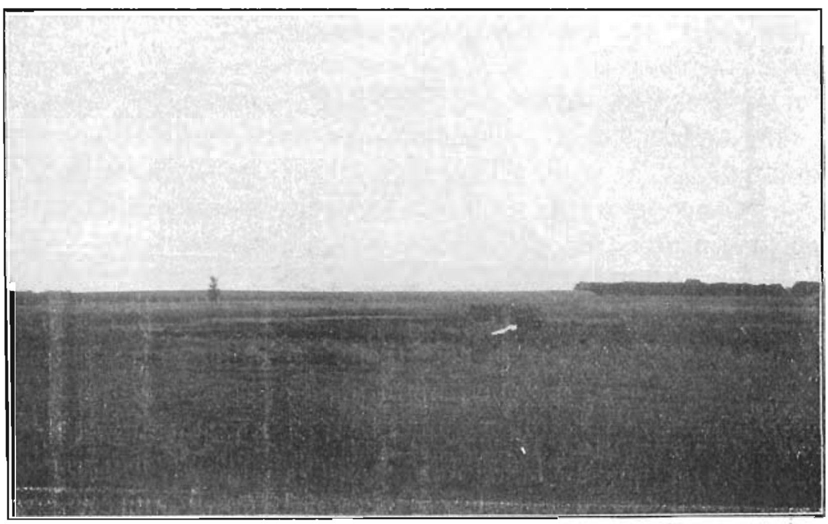


Fig. 55—The glacial pond and modern method of its elimination.

Viewed as a whole, the general direction of the streams indicates the slope of the country to be to the southeast. The figures given in the table likewise suggest an inclination in this same general direction. The maximum difference in elevation between any two points mentioned is two hundred seventy feet between Alexander and the county line at the east side of Ingham township, giving a gradient of approximately ten and one-half feet to the mile.

All the streams in the county, excepting the Iowa river, belong to the Cedar river system. The West Fork of the Cedar is the parent river and, while not the chief drainage way, is joined before it reaches the Cedar by Hartgrave and Mayne creeks, the most important waterways in the county. Beaver, with its branches, which tap a small area in the southeast corner of the county, flows directly into the Cedar in Black Hawk county some distance below its confluence with the West Fork.

West Fork of Cedar River.—This river with its several small tributaries, of which Bailey Creek is the most important, drains West Fork and Ross townships. It is the largest stream in the Iowan drift area, and traverses a broad depression excavated in this drift and the shales of the Lime Creek formation. It has long since ceased down-cutting and is now widening its valley by a process of tortuous meandering. The stream is skirted in places by narrow belts of alluvium which is found to overlie stratified sand and gravel. Broad gravel terraces border the stream channel throughout its course in the county. At the north line of section two, Ross township, where West Fork enters the county, this terrace is twelve to fifteen feet above the flood plain and lies to the west of the stream. In section 18, West Fork township, it is ten feet and although it is in evidence in places as low ridges in the stream valley until the east county line is reached, it thins almost to disappearance.

Bailey creek enters the county near the northeast corner of Richland and, flowing southeastward across northern Ross, joins the West Fork of the Cedar in section 19 of West Fork township. It is normally a small stream and occupies a narrow alluvial valley, but it has the reputation of rising very rapidly at times without warning, and accomplishing considerable damage by its overflow. A level gravel terrace flanks this stream to the north. The town of Sheffield is situated on this terrace which is here over a mile in width. The gravels border Bailey creek to its union with West Fork, and the coalescence of the two gravel benches here forms a very level wedge shaped tract of considerable extent. Several smaller branches effect the drainage of southern Ross township and enter the West Fork below the confluence of Bailey creek in West Fork township.

Hartgrave creek.—Hartgrave creek is formed by the union of Otter, Spring and Squaw creeks in southwest Ingham township.

The headwaters of Otter creek come from the Wisconsin drift in the northwest part of the county. Within this area they are aimlessly meandering prairie streams which accomplish little more in the way of drainage than to connect a series of swales or marshes. Buffalo creek, which rises in southeast Wisner and flows across northern Marion township, is the most important branch. Outside of the moraine Otter creek is confined within valley walls of Kinderhook limestone, which is found outcropping at intervals along its entire course.

Spring creek takes its rise in southeast Scott and leaves the Altamont moraine in western Mott township. It has a flood plain of moderate width outside of the moraine through Mott and into Ingham townships and is rock-bound with frequently outcropping ledges of limestone.

The source of Squaw creek is in the morainal belt. It meanders amongst the limestone hills of southwest Mott township as though leisurely seeking a line of least resistance. This stream seems not to have been an important waterway during the melting of the Wisconsin ice nor to have been long established in its present position; for there is no sign of the usual gravel deposit, and its channel is immediately bounded by Iowan drift which, with a loess-covering overspreads the pre-glacial features of the Kinderhook.

Otter and Spring creeks, outside of the Wisconsin drift, occupy pre-Iowan depressions and their valleys are marked by the presence of Wisconsin gravel trains. As a general rule the gravel benches disappear at the Wisconsin border, but conspicuous terraces are to be observed along both Spring and Buffalo creeks in Marion township some distance within the border of this drift. It is to be noted also that the gravels grow finer and are more perfectly assorted as the distance eastward from the moraine increases. In sections 23 and 24 of Mott township a broad flat connects the valleys of these two creeks which here approach each other to within one mile. A spur of loess covered limestone hills along the east edge of section 24 intervenes and the streams separate to join some four miles beyond to the southeast.

Again in section 33, Ingham township, a broad flat leads southward from the valley of Hartgrave creek across sections 4 and 9 of Geneva township and merges with the valley of Mayne creek. This flat-bottomed depression is bounded by loess capped limestone hills. It lacks drainage, and ponds are so numerous that cultivation is for the most part impossible. The gravel terraces become broader and more conspicuous along Hartgrave creek proper in the southeastern part of Ingham township, but their height above the flood plain level of the creek diminishes to practically zero at its exit from the county. This stream occupies a very wide erosional depression, out of proportion, it would seem to its present volume and capacity to do work. This, the main stream, together with its two principal contributary branches, flows in an ancient valley which the deposition of detritus by the Iowan glacier failed to obliterate.

Mayne creek.—Mayne creek issues from the moraine in section 26 of Reeve township. It has two principal branches in the Wisconsin area which unite in section 29, Reeve township. These are prairie streams with their sources in the hills and ponds of the inner moraine. The course of Mayne creek through the Altamont moraine in Reeve township is somewhat sinuous. It has not only excavated its way through the hills of Wisconsin drift but has eroded deeply into the Kinderhook rocks of the Lower Carboniferous. The valley is densely wooded in this portion of its course. Outside of the moraine this stream flows in a wide depression and is skirted by gravel terraces. The latter fail in western Geneva township, and the trend of the valley is such as to lead into the large bayou depression already mentioned as extending northward in northern Geneva township to the valley of Hartgrave creek. The valley occupied by Mayne creek to this point is earlier than, and out of proportion to the size of the present stream. Through sections 10, 11 and 12, Mayne creek flows in a valley seldom over a third of a mile in width and one of which the stream is unquestionably the author.

It is plain that an adjustment in the drainage lines has taken place in this vicinity during glacial times. The lower part of the course of Mayne creek through eastern Geneva township is not that followed by its pre-glacial ancestor. The main channel was then through the depression opening northward into Hartgrave creek; and Mayne creek through some exigency of glacial movement has been diverted from this ancient course. The diversion of Mayne creek will also aid to some extent in explaining the lack of harmony between the breadth of the valley of Hartgrave creek and the size of the stream. Doubtless a master stream occupied this wide valley prior to the Iowan ice and received tribute from an even larger tributary than the present Mayne creek.

Beaver creek.—The surplus waters in Osceola township are removed by Beaver creek and a number of small tributaries. The source of the Beaver is in Grant township where it effects a partial drainage of the eastern portion. The remainder of Grant township has no well developed drainage lines. Osceola township is but thinly covered with Iowan drift so that the stream courses outside of the Wisconsin are universally eroded in the limestone. Beaver creek itself is the only stream of appreciable size. In it the limestone is obscured by the loess and glacial gravels which skirt it eastward from the Wisconsin border. It has no flood plain of mapable width, but flows over a limestone bed in the lower part of its course in the county as do its tributaries to the north of it, which meet the Beaver in Butler county to the east.

Iowa River.—This river is itself the only representative of the Iowa river system in this county. From its random meanderings among the mounds and hills of the Gary moraine in Wright county, it enters Morgan township, Franklin county, two miles from its southern border and with a bold curve in the southwest corner of this township leaves it still one-half mile north of this same boundary. The town of Dows is situated in the curve to the west of the river, the main part of the corporation being in Wright county. With minor meanders along the county line on the west side of Oakland, the Iowa river angles across the southwest corner of the township from the middle point of its west boundary to an exit into Hardin county one mile west of the southeast corner. The Iowa river here is much diminished in size as compared with the same stream outside of the morainal district. It has no confluents of any importance and flows in a shallow channel in the Wisconsin drift plain. In places some alluvium has been put down and at intervals along its course heavy deposits of gravel have been made use of for road materials. From the river the land gradually rises to the northeast to the morainal belt in notheast Oakland and Morgan townships; while to the south the level drift plain stretches beyond the limits of the county.

Briefly recapitulating, the sufficiency of the drainage in Franklin county is seen to bear a direct relation to the two till sheets that cover it. The Iowan drift area, including much of the east half of the county, has nearly perfect drainage. Instances of arrested stream development during glacial times have been noted and areas thus affected are today not well drained. Another exceptional case of this nature is to be observed in sections 24 and 25 of West Fork township, where low sand ridges bar the natural flow of the meteoric waters, and ponded open water in places stands barely separated from a moderate sized stream. Streams of importance are sparsely distributed in the Wisconsin drift area. Pre-Wisconsin drainage lines were obliterated by this ice sheet and those now present are, with possibly Iowa river excepted, superimposed and flow out to the east upon the Iowan drift plain. The western tier of townships practically lacks drainage, with the exception of the parts of Morgan and Oakland townships that lie on the slopes of the Iowa river depression.

STRATIGRAPHY.

General Relations.

The geological formations in the region under consideration belong to three distinctly separate ages, representing two of the major divisions, or eras, of geological time. The Devonian rocks which underlie the northeastern portion of the county and the Lower Carboniferous limestones occupying the remainder belong to the Paleozoic era. The region has been land surface since its elevation from the sea bottom at the close of the Carboniferous and no deposits are present representing the enormous lapse of Mesozoic time. The till sheets which overspread all the older formations mark a period of recent dynamic activity. These glacial deposits were made in the later part, or Quaternary age, of the Cenezoic era, and belong to the geological time period in a later portion of which we now live.

In accordance with the general trend of the indurated rocks of Iowa, the members of the older series of rocks in Franklin county overlap each other with a gentle dip to the southwest and with a line of outcrop extending in a northwest-southeast direction. Exposures of these rocks are abundant along all the principal streams in the Iowan drift area and aside from their geological interest are of local economic importance.

A synopsis of the time periods and the corresponding rock formations that are represented in Franklin county is arranged in the subjoined table:

SYNOPTICAL TABLE.

GROUP.	SYSTEM.	SERIES.	STAGE.	FORMATION.
Cenozoic	Pleistocene	Recent		Alluvium Sand and gravel
		Glacial	Wisconsin	Drift
			Iowan	Loess Drift
Paleozoic	Carboniferous	Mississippian	Kinderhook	Limestone Shales
	Devonian	Upper Devonian	Lime Creek	Owen Limestone Shale Hackberry Shales
		Middle Devonian	Cedar Valley	Mason City Dolomite

The deep well at Hampton affords the only information obtainable regarding the strata older than the Devonian, that underlie the county. Professor W. H. Norton has kindly furnished the following record of the strata penetrated, with interpretation.

CITY WELL. HAMPTON, IOWA.

SAMPLE NO.		DEPTH OF SAMPLE, FEET.
65.	Till, pale yellow	20
64.	Sand, ocher-yellow, with ochreous clay	40
63.	Shale, blue	60
62.	Limestone, bluish-gray, subcrystalline, of rapid effervescence in cold dilute HCl; in coarse chips. Fragments of calc spar and sparry surfaces indicate that the rock is geodiferous. Platy fragments of drusy pyrite are found and in some the pyrite alternates with laminæ of black coaly shale	80
61.	Shale. blue; samples at 100, 120 and	140
60.	Limestone, dark greenish gray, earthy, of brisk effervescence, with argillaceous residue; in large chips, with some fragments of white finegrained crystalline limestone	160
59.	Limestone, dark drab, finegrained, crystalline, hard, residue black, moderately brisk effervescence, containing microscopic grains of crystalline quartz	180
58.	Limestone, white, compact, earthy luster, also gray and cream-colored, saccharoidal, in small chips and with much argillaceous admixture. Effervescence moderate, residue large, argillaceous and microscopically quartzose	200
57.	Shale, greenish, brisk effervescence	220
56.	Limestone, white, earthy, in fine sand, with some chips of shale	240
55.	Shale, greenish; samples at 260 and	280
54.	Limestone, white, brisk effervescence, crystalline, in fine sand masked by argillaceo-calcareous powder	300
53.	Limestone, vari-colored: dark bluish, saccharoidal, effervescence moderate, argillaceous residue; and buff, sub-crystalline, finegrained; compact, of brisk effervescence and little residue	320
52.	Limestone, light gray, fine-grained, subcrystalline, subtranslucent, of rapid effervescence, in large flakes	340
51.	Limestone, drab, much dark argillaceous residue, effervescence moderate	360
50.	Limestone, light gray, dense and fine grained, sub-crystalline, of brisk effervescence; with some chips of greenish, soft saccharoidal limestone	380
49.	Limestone, light buff, soft, compact, earthy, effervescence brisk	400
48.	Limestone, light bluish and light buff, of brisk effervescence, hard	420
47.	Limestone, light brownish, soft earthy, brisk effervescence, argillaceous residue	440
46.	Limestone, bluish gray, earthy luster, fine-grained and compact, brisk effervescence and dark argillaceous residue	460
45	Limestone, blue-gray, effervescence rather slow, large clayey residue; drillings contain also fragments of fossiliferous green shale	480
44.	Limestone, gray, sub-crystalline, in angular sand, effervescence brisk	500

SAMPLE NO.		DEPTH OF SAMPLE. FEET.
43.	Limestone, cream colored, very soft, earthy, effervescence moderate; some drab, argillaceous	520
42.	Limestone, light blue-gray, soft, rather large clayey residue, effervescence moderate	540
41.	Limestone as No. 42, but with chips of chert and siliceous limestone and of drab argillaceous limestone	560
40.	Limestone, white, soft, rapid effervescence, subtranslucent	580
39.	Shale, light chocolate-brown, calcareous	600
38.	Shale, reddish, no reaction for carbon or hydrocarbons in closed tube	620
37.	Shale, light greenish, calcareous	640
36.	Limestone, moderate effervescence, with much powder, argillaceous	660
35.	Shale, light buff, calcareous	680
34.	Drillings of gray chert, greenish shale and red calcareous shale, probably fallen from above	700
33.	Shale, greenish	720
32.	Sand, of vari-colored, briskly effervescent limestone with considerable shale, greenish	740
31.	Shale, dark greenish, calcareous	760
30.	Limestone, white, briskly effervescent; with much shale	780
29.	Shale, chocolate-brown; buff limestone; considerable yellow chert	800
28.	Limestone, gray and white, brisk effervescence; with much white chert and argillaceous powder, samples at 820 and	840
27.	Shale, green and brown, and gray chert	860
26.	Limestone, gray, briskly effervescent	880
25.	Limestone, cream colored, brisk effervescence, in fine sand with much argillaceous powder	900
24.	Limestone, light yellow, highly argillaceous; samples at 920 and	940
23.	Shale, light brownish, calcareous	960
22.	Limestone, light gray, some fossiliferous; cherty; brisk effervescence; in chips with much argillaceo-calcareous powder in some samples; samples at 980, 1000, 1020, 1040, 1060 and	1080
21.	Limestone, gray, of rapid effervescence, 1100, 1120 and	1130
20.	Green shale, with considerable fine chippings of gray limestone	1140
19.	Green shale in fine chips, indurated	1160
18.	Sandstone, white grains of clear quartz, well rounded, comparatively uniform in size, surfaces smooth; with some green shale probably from above; samples at 1180, 1200, 1220 and	1240
17.	Dolomite, gray, hard, cherty	1260
16.	Dolomite, gray, cherty, arenaceous	1280
15.	Sandstone, fine grained, white	1300
14.	Dolomite, light buff and gray, cherty, samples at 1320 and	1340
13.	Dolomite, light buff, arenaceous, considerable quartz sand in drillings	

SAMPLE NO. DEPTH OF SAMPLE FEET.

12. Dolomite, gray, arenaceous, considerable sand in drillings..1380
11. Dolomite, bluish gray..1400
10. Dolomite, bluish gray; and sandstone, large part of drillings quartz sand..1420
9. Dolomite, gray, with small fragments of arenaceous dolomite and quartz sand..1440
8. Sandstone and dolomite, sandstone of St. Peter facies (No 18) dolomite, gray..1460
7. Sandstone, white, fine grained, hard..1480
6. Dolomite, gray and white, cherty; samples at 1500 and......1520
5. Dolomite, gray, with residue of cryptocrystalline quartz....1540
4. Dolomite, blue-gray, with residue as above..........................1560
3. Dolomite, gray; samples at 1580, 1600 and..........................1620
2. Sandstone, of clean, white, well rounded grains of pure quartz of moderate size; samples at 1640, 1660 and..........................1680
1. Sandstone as No. 2, but somewhat harder as indicated by the larger proportion of fractured grains; samples at 1700 and 1709

ASSIGNMENT OF STRATA.

NOS.	STAGE OR SUB-STAGE.	THICKNESS, FEET.	DEPTH, FEET.	ELEVATION OF BASE A. T., FEET.
65-64	Pleistocene	52	52	943
63-55	Mississippian	228	280	715
54-44	Devonian	240	520	475
43-40	Silurian-Devonian	78	598	397
39-35	Maquoketa	82	680	315
34-19	Galena-Trenton	500	1180	-185
18	St. Peter	68	1248	-253
17-11	Upper Oneota or Shakopee	152	1400	-405
10-7	New Richmond	80	1480	-485
6-3	Lower Oneota	155	1635	-640
2-1	Jordan	74	1709	-714

The record of the Ackley well, which is located in Hardin county within one and one-half mile of the southeast corner of Franklin county, is summarized by Beyer as follows*:

STAGE OR SUB-STAGE.	THICKNESS, FEET.	DEPTH, FEET.	ELEVATION OF BASE A. T., FEET
Pleistocene	100	100	1010
Kinderhook	207	307	803
Lime Creek	28	335	775
Devonian (unclassified)	300	635	475
Niagara	180	815	295
Maquoketa	160	975	135
Galena-Trenton	385	1360	-250
Saint Peter	85	1445	-335
Upper Oneota	120	1565	-455
New Richmond	70	1635	-525
Lower Oneota	185	1820	-710
Jordan	210	2023	-920

*Iowa Geol. Survey, Vol. X, p. 263.

DEVONIAN SYSTEM.

LIME CREEK STAGE.

Representatives of the Devonian system are the country rock in approximately one and one-half townships, including portions of Ross and Ingham, and nearly all of West Fork townships, in the northeast corner of the county. Only beds belonging to the Lime Creek stage of the Upper Devonian are present and these consist mostly of magnesian and calcareous shales and limestones, the latter likewise usually containing magnesium in varying quantities. Certain of the shales and limestones are highly fossiliferous.

The uncertainty as to the proper reference of bodies of shale which lie beneath the Kinderhook limestone will be noted when the rocks of that stage are considered. It should be said here, however, that on account of the similarity of the strata lithologically, it has been impossible to locate definitely the dividing line which marks the upper limit of the Devonian. Professor Calvin has emphasized this fact in mapping the border of the Kinderhook in Cerro Gordo county. Fossils alone must be largely depended on, and unless good exposures are abundant, difficulty is experienced in determining the exact position of the border line. Fossils were collected from available outcrops in Franklin county of the rocks belonging to both stages and the plotting of the limits of the areas was based chiefly on paleontological evidence, supported in some degree by topographic and lithologic factors.

Hackberry shale.—The Hackberry beds of the Lime Creek stage are the oldest formation exposed in the county. These shales lie immediately beneath the drift and postglacial deposits in a large portion of the Devonian area. Bordering the east side of the valley of the West Fork of the Cedar and particularly conspicuous in the northwest part of West Fork township, the limestone of the Owen beds rests upon the Hackberry shales. No exposures were examined in which the contact between these two formations was evident but sections of each were frequently seen in close proximity to each other.

The best exposures of the Hackberry beds are found along Bailey creek (called Beaver creek in Cerro Gordo county) in

Ross township. One-half mile south of Sheffield, near the center of section 9, is the brick and tile plant of Mr. E. P. Fox. The pit section shows the following strata:

		FEET.
3.	Buff to yellow shale, slightly magnesian, containing irregular concretions of lime carbonate and thin bands of limestone at top. Non-fossiliferous	3
2.	Yellow, pink to red plastic shale	6
1.	Non-fossiliferous, plastic blue shale with some carbonaceous matter and occasional thin seams of selenite	6

The base of the pit is near the level of the creek. A well drilling at this plant encounters firm limestone about twenty feet below the bottom of the pit.

In a road cut south of Bailey creek on the west side of section 10, Ross township, higher beds are exposed:

		FEET.
4.	Soil and iron stained limestone residuum	1½
3.	Shale, light blue, with thin limestone partings, grading downward into yellow, highly fossiliferous, magnesian shale	5
2.	Shale, uniform yellow in color, gritty, with limestone laminæ	5
1.	Shale, blue, plastic and lacking concretionary matter, to road bed	1

One hundred yards east of the wagon bridge at this point thirty feet of the plastic blue shales are exposed at a bend in the creek. These are a continuation of the section in the road just noted, making in all a thickness of more than forty feet of Hackberry shales that is open to view. The lower argillaceous member has occasional bands of limestone running two to three inches in thickness and is non-fossiliferous. This stratum corresponds to the blue shale made use of at the E. P. Fox clay plant south of Sheffield.

The Hackberry shales form a terrace south of Bailey creek extending through sections 9 and 10 of Ross township and are exposed at a few other points by the cutting of this stream. The above described exposure of this formation is the best observed in the county. The sequence is the same as that found by Professor Calvin in Cerro Gordo county,* although the aggregate thickness of the beds is somewhat less.

*Iowa Geol. Survey, Vol. VII, p. 162.

Owen beds.—The Owen beds outcrop at various points along the east side of the West Fork of the Cedar river in the northeast corner of Ross and throughout its course in West Fork township. In section 7, West Fork township, a small quarry is opened from which some rock has been removed. These beds furnish a supply of building material which has been utilized locally at many points.

The quarry opening just north of the road along the south side of section 7, West Fork township, affords the following section:

		FEET.
2.	Yellow magnesian shale, with chert nodules and, near the base, interbedded sub-crystalline limestone, apparently dolomite. In places, definite bands of chert permeated with brachiopod impressions. *Spirifer whitneyi* most abundant	3½
1.	Thinly bedded, fossiliferous, partially crystalline, brown dolomite. Much shattered at top and badly rifted throughout. Exposed	7

Many other species of brachiopods appear in this section. In the top yellow shale besides *Spirifer whitneyi* Hall, a large *Productella*—allied to *P. lachrymosa* Conrad,—and *Camarotoechia orbicularis* Hall, are frequently seen. In the limestone layer a species of Spirifer related to *S. disjuncta* Sowerby, occurs besides those mentioned above.

Below the wagon bridge over West Fork at the south side of this section, twelve to fifteen feet of calcareous, more or less plastic, yellow shales crop out in the bank of the stream. These shales here form a conspicuous terrace to the east of the river upon which, about twenty feet above the water, rest the beds of dolomitic limestone described above. They appear at intervals along the stream both north and south of this locality and are apparently the upper argillaceous shales of the Hackberry beds.

Beds of weathered magnesian limestone of the Owen formation are exposed in the road through the east part of section 1, Ross township. Near the east line of this section yellow, weathered shale appears bearing casts of *Naticopsis gigantea* H. & W., a large gastropod which characterizes the Owen limestone in Cerro Gordo county. Just east of the West Fork, on the south side of section 35, a surface of nodular weathered limestone is exposed in the road gutter. Unidentifiable crinoid remains and casts of *Stropheodonta demissa* were noted. The same limestone occurs in the road east of the West Fork on the south side of section 1, Ingham township. It outcrops in the roadbed northward through the middle of this section, and the underlying beds are exposed for some distance along the stream in this vicinity. The limestone is compact, brown in color and rich in fossils, the common species being *Spirifer whitneyi*. *Atrypa reticularis*, *Naticopsis gigantea*. Ten to twelve feet of this rock are in view some thirty feet above the water in the river. The section is obscured to within ten feet of the water. Below this level along the bank of the stream four feet of marly to nodular, yellow, calcareous shale are exposed, rich in perfectly preserved fossils among which are: *Spirifer whitneyi* Hall, *S. orestes* H. & W., *S. Hungerfordi* Hall, *Atrypa reticularies* Linne., *A. aspera*, var. *hystrix* Hall var., *Orthis iowensis* Hall, *Stropheodonta arcuata* Hall, Orthoceras sp. This shale grades downwards into a nodular, argillaceous, dolomitic limestone containing similar species, and of which there are four and one-half feet. Above the water are two feet of yellow plastic clay. A large, never-failing spring flows out at this horizon. This section includes both Owen and Hackberry strata, the fossiliferous, calcareous shales being the equivalent of the upper member of the Hackberry section in Cerro Gordo county.*

The top limestone appears again on the county line near the southeast corner of section 1, Ingham township.

The exposures described outline in a general way the areas occupied by the two principal formations of the Lime Creek stage. Outside of the relatively narrow belt of country along the east side of the West Fork of the Cedar river the more resistant limestone beds of the Owen formation are believed to be absent. In the remaining portion of the Devonian area, as outlined on the map, the Hackberry shales are the country rock. A well drilling on the farm of Wm. Garber in section 2 of West Fork township, encountered solid rock, the Cedar Valley limestone, at eighty-five feet. A well near Aredale in the edge of

*S. Calvin, Iowa Geol. Survey, Vol. VII, p. 163.

Butler county reached the rock at eighty feet, passing through 'blue clay' to this depth. In the town of Sheffield, well sections indicate almost the entire absence of the Lime Creek shales, the terrace gravels, with a thickness of twenty to thirty feet, resting in some instances directly on the basement limestone. It is believed that the shales are not absent over any considerable area. They are lacking along Bailey creek on account of the early erosive work of this stream in excavating a wide valley which has later been in part filled by the deposition of gravels and alluvial materials.

It is of interest to note that well drillers in this part of the county invariably report a considerable thickness of 'soapstone' or blue clay after passing through an upper heavy stratum of limestone. In Sheffield, an approximate section is as follows: gravel, 28 feet; brown solid limestone, 27 feet; blue clay, 83 feet; rock, to 190 feet. At the well above mentioned in the northeast quarter of section 2, West Fork township: sand, 6 feet; blue clay, 79 feet; rock, 55 feet; clay, 78 feet; rock, to 260 feet. This bed of shale, interstratified with the limestone, appears to be equivalent to No. 6 in Professor Calvin's "Generalized Section of the Cedar Valley Limestone in Cerro Gordo and Adjacent Counties."* It does not appear as a distinctly argillaceous bed in the Hampton or Ackley well sections, and is somewhat anomalous in its occurrence. Professor Calvin has emphasized the extreme variability of this portion of the Cedar Valley section in the adjoining county to the north and it would seem probable that here is exemplified an extreme local variation in the conditions of sedimentary deposition in this period of Devonian times.

CARBONIFEROUS SYSTEM.

KINDERHOOK STAGE.

The Carboniferous rocks present in the county belong to the Kinderhook stage, the lowest member of the Mississippian Series. Although believed to be the country rock in the western part of the county, they are entirely obscured by the drift. To

*S. Calvin, Iowa Geol. Survey, Vol. VII, pp. 159 and 160.

the east, beyond the border of the Wisconsin, Kinderhook rocks are exposed along the channels of all the principal streams. As has already been intimated, the surface configuration of considerable areas in the Iowan drift is influenced in large measure by the underlying limestone.

The Kinderhook consists of limestones and shales, the former varying from soft, marly, argillaceous beds containing large quantities of chert, to compact, partially crystalline, fossiliferous or semi-oolitic dolomite. The shales range from magnesian and calcareous beds which in many instances represent the firmer limestones in a state of decay, to typical yellow or bluish plastic clays. Aside from certain thin interstratified beds of shale the limestone is in many places known to be supported by a greater or less thickness of similar beds. In the Hampton well, the lower eighty feet of the Kinderhook are highly argillaceous. Thirty feet of blue shales were encountered at this horizon in the Ackley deep well.* Below the limestone at Iowa Falls sixty feet of calcareous, gray-blue shales were referred by Professor Beyer to the Kinderhook. Shales are also recognized beneath the Le Grand beds in Marshall county where one hundred seventy-five feet of argillaceous beds are provisionally placed in the Kinderhook.†

These underlying shales outcrop at a few points in Franklin county but nowhere in any considerable thickness. They appear to be conformable with and, as in the deep well sections cited, a continuation of the Devonian shales below them. For this reason question arises as to the location of the lower limit of the Carboniferous rocks where the lower member or Louisiana limestone of the Kinderhook is absent. In well sections the formations cannot usually be differentiated and in the field where the exposures are available reliance must be placed on the fossil organic remains present to establish the line of demarkation.

The Hampton well section shows two beds of shale above this basal member, the upper but a few feet, and the lower some sixty feet in thickness. These beds occur at several points in the

*S. W. Beyer Iowa Geol Survey, Vol X, p. 200.
†S. W. Beyer Iowa Geol Survey, Vol. VII, p. 212.
‡Iowa Geol. Survey, Vol. VI, p. 149.

eastern part of the county and where not in view are frequently indicated by the presence of a line of springs at the base of exposed limestone layers.

TYPICAL SECTIONS.

Bailey creek.—This stream flows in a valley cut in the Kinderhook strata for two and a half miles from where it enters the county in Richland township, and exposures are common in this vicinity. In the northwest quarter of section 1, Richland township, at the county line bridge, ten feet of soft, shaly, magnesian limestone are to be seen. One-fourth mile south on the west bank of the stream the same strata are exposed overlain by fifteen feet of heavy bedded magnesian limestone. The contact is marked by a line of bog springs. Professor Calvin has noted the occurrence of characteristic Kinderhook fossils in this limestone.* The shaly limestone crops out in road cuts along the west side of section 1 of Richland township where the usual mantle of drift is practically absent. It weathers into a yellow, calcareous clay.

The weathered limestone is to be observed in road cuts on the west side of section 8, Ross township. Near the northwest corner of this section five to six feet of weathered plastic shale, yellow to light blue, and enclosing bands of limestone, are exposed in the channel of a small stream but a few rods from an outcrop of limestone twenty feet higher in the hillside. Close to the stream on the west line of section 5, twelve feet of the underlying shales appear. They may also be seen near the stream at the west edge of section 6, Ross township. No fossils were found, and it is believed that this is the basal member of the Kinderhook stage.

Otter Creek.—Rock is exposed almost continuously in the valley of this creek from section 30 of Ross to its union with Hartgrave creek in Ingham township. One mile west of Chapin at the southwest corner of section 29, limestone is quarried.

The following section may be viewed:

		FEET.
3.	Thin drift soil	1
2.	Badly weathered and iron stained argillaceous limestone	7
1.	Regularly bedded blue-gray to sugary-brown dolomitic limestone containing Orthothetes, related to *O. inequalis* Hall, and Orthis(?). Exposed	8

*Geol. Survey, Vol. VII, p. 170

Ledges of this rock form the east boundary of Otter creek valley and appear for some distance both north and south on both sides of the stream. One-half mile south of the above quarry weathered beds containing many flint chips and nodules of chert and bearing casts of *Spirifer subrotundatus* Hall, crop out in the road. Similar outcrops are to be found in the vicinity of Buffalo creek in sections 36 and 31 of Richland and Ross respectively; along the west side of section 6, and across sections 5 and 4 of Mott township, where the bordering hills are all supported by the limestone which stands twenty-five feet above the stream. Throughout the remainder of its course in Mott and Ingham townships, Otter creek valley is bounded by limestone walls, and evidences of its presence are to be seen, aside from natural outcrops and hillside talus, on nearly every section line where the public highway crosses this creek. At the north edge of section 19, Ingham township, a few feet of weathered, yellow, non-fossiliferous limestone are exposed, while along the east side of this section, just north of Otter creek, there is a partially obscured exposure of twenty feet of yellow calcareous shales containing brachiopod impressions preserved in thin bands of chert, and covered with shelly layers of this same limestone. The upper members here are higher in the section than those observed in Ross and Richland townships and contain much chert, in bands and nodules, some of which is chalky white and even pulverulent.

Limestone is also found along Spring creek in sections 21 and 22 and along Squaw creek in the north part of the city of Hampton. The following section may be observed in a small quarry opening west of the Hampton cemetery:

		FEET.
3.	Earthy, shattered and iron stained limestone with numerous bands of chert	5
2.	Thin bedded, earthy limestone permeated with chert in both bands and concretions; somewhat cavernous; brachiopod impressions preserved in chert	6½
1.	Heavier beds (6-8 inches) and less chert; caverns lined with botryoidal calcite	7

These strata stand high in the hills to the eastward among which Squaw creek makes its way for the rest of its course. In sections 1, of Reeve, 6 and 5 of Geneva and 32 of Ingham townships the slopes are angular and terraced, and the limestone crops out at many points.

There are innumerable exposures of the lower limestones and occasionally of the shaly beds not in the immediate vicinity of the streams, in the north central part of Ingham and in the corners of Mott and Ross townships, where the main features of the topography are expressed in these older rocks. In the northeast quarter of section 28, south of the railroad track, a small quarry is opened on the land of D. W. Mott. The sequence is:

		FEET.
3.	Soil and decayed limestone	4
2.	Plastic, light blue shale with very thin bands of limestone	2
1.	Fossiliferous, crystalline brown dolomitic limestone, exposed	8

The beds are much rifted horizontally and fractured by vertical joint planes.

Mayne creek.—The greatest thickness of beds is to be seen near the north side of section 21, Reeve township. The section is partially obscured by talus materials but it is approximately as follows:

		FEET.
8.	Drift	8
7.	Thinly bedded shattered limestone with much chert in oval nodules and more or less persistent bands	14
6.	Heavier bedded, arenaceous limestone carrying chert as above, and occasional caverns and calcite geodes	6
5.	Shaly limestone with bands of firmer rock	12
4.	Compact, resistant ledge of limestone	1
3.	Argillaceous limestone containing some chalky appearing chert nodules grading into No. 2	2
2.	Firmer but weathered and iron stained limestone	1½
1.	Compact, evenly bedded dolomitic limestone	3½

Judging from its lithologic character No. 1 appears to be equivalent to the rock quarried one mile west of Chapin.

Mayne creek has accomplished a considerable amount of erosive work since the close of the glacial period. Evidence of such work is found in sections 29 and 30 of Reeve township where thicknesses of twenty-five to thirty feet of Wisconsin drift overlying six to eight feet of shelly limestone may be observed at a number of points.

Across section 22 of Reeve township Mayne creek is bordered by a low terrace of shaly limestone similar to that exposed in section 21. Near the middle point of the north side of section 23 is an old quarry not now worked. Section:

		FEET.
3.	Shelly limestone containing chert bands	3
2.	Heavy bedded, subcrystalline and fossiliferous dolomitic limestone; stylolitic structure common	4
1.	Irregular and thin bedded, cavernous cherty limestone	5

This same stone is close to the surface in sections 14 and 13 of Reeve township, appearing in the road bed near the northeast corner and on the east side of the latter section. East of the road along the west side of section 18, Geneva township, is a conspicuous monadnock of the limestone. It stands thirty feet high in the valley of Mayne creek. West of the town of Geneva the limestone outcrops near the center of section 19.

In the southwest quarter of the northeast quarter of section 16, Geneva township, an artificial exposure shows six feet of badly weathered shaly limestone containing Orthothetes related to *O. inequalis* Hall, and a band of chert at the top. The rock is granular and earthy, but in fresh pieces it is brown, subcrystalline and fossiliferous. In the southwest quarter of the southeast quarter of section 10, Geneva township, just east of the wagon bridge over Mayne creek is a quarry belonging to Mr. Oren Benson of Geneva.

		FEET.
4.	Soil	1½
3.	Weathered magnesian limestone with abundant small flint nodules	5½
2.	Heavy bed showing no lines of separation; brown where weathered and fossiliferous (Productus bearing long spines being very abundant); interior of large blocks, light in color or mottled by pink interstitial calcite; distinctly oölitic in texture	10
1.	Calcareous shale resting on limestone	1

A few feet below the base of this quarry and eight feet above the water in the creek the top of the impervious shales is marked for some distance eastward along the south side of the valley by a line of springs. The drift covering is very thin and the limestone forms a ridge extending eastward into sections 11 and 14. In a quarry near the north boundary of section 14, on the land of Mr. H. H. Andrews, the same succession of strata may be observed as noted above in section 10. The beds are here broken by vertical jointing which has produced open fissures six to eight inches in places. *Athyris proutii* and the spiny Productus sp. are abundant. *Productella concentrica* Hall, and an undetermined species of Spirifer also occur. Unweathered samples of the lower stratum show an abundance of crystals of iron pyrite. The limestone rests on yellow shale which is exposed in the trench cut by a small stream a few hundred yards from the quarry.

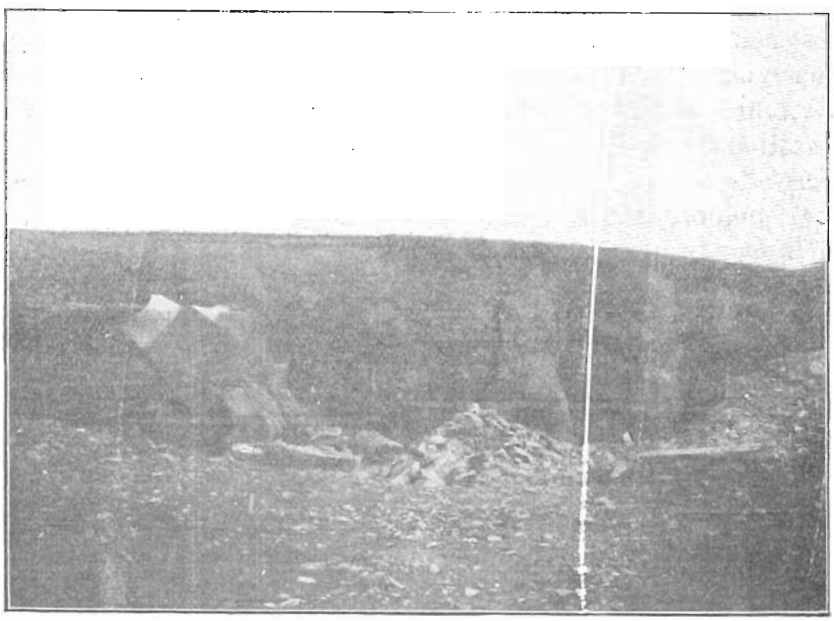


Fig. 56—Quarry in Kinderhook limestone, Section 11 Geneva township.

Nodular fossiliferous limestone outcrops in the road on the east edge of section 13, Geneva township. Water stands at this level which appears to be the top of the shale. All of the hills throughout east central Geneva township are capped with the limestone, and a spring line which is seen in many places indicates the contact between the two formations. Stratigraphically this shale seems to correspond in position to that encountered at 943 feet A. T., in the Hampton well.

The Kinderhook outcrops at various points in sections 35 and 36, Geneva township and in the east half of Osceola township, particularly along the branches of Beaver creek. A cherty limestone similar to that quarried at Hampton forms a conspicuous bench along a sharp draw leading from the east line of the county across the middle of section 12. Near the southeast corner of section 24 the limestone appears in the road south of the creek and is for the most part weathered to a marly, oolitic sand. Where freshly broken the stone is seen to be the same as that quarried in sections 10 and 14 of Geneva township. Large springs issue at the foot of the limestone escarpment near the water level in the creek and mark the top of the underlying shale. On the county line along the east side of section 25 of Osceola township, limestone appears in the road and in section 36 of a few rods west of the county line five feet of cherty limestone are exposed in the banks and bed of Beaver creek, ponding the stream and forming a rapids at this point. The upper two feet are weathered to a granular incoherent sand which is rich in branchiopod remains. Weathered limestone crops out at numerous other localities in the three eastern tiers of sections in Oceola townships. It appears in places as a shaly, chert impregnated limestone, and in others as an iron stained oolitic sand. As noted, however, both are frequently present, the former overlying the latter.

PLEISTOCENE SYSTEM.

KANSAN DRIFT.

Franklin county is included in the area which is believed to have been completely overspread with ice during the Kansan stage of glaciation. Deposits of the later, Iowan and Wisconsin, ice sheets have however entirely obscured any Kansan till that may be present. In the eastern part of the county the Iowan drift may be frequently observed resting directly on the Kinderhook and Devonian formations, so that practically all the material laid down by the Kansan glacier, however large or small in amount, has either been removed through erosive processes or was insufficient to exert any important influence.

All the older deposits in the western part of the region lie deeply buried beneath, presumably, a thin layer of Iowan, and a heavy mantle of the bowlder clay and sandy and gravelly materials deposited by the Wisconsin ice.

Buchanan gravels.—Although many of the country wells are sunk through the Pleistocene strata to 'rock', no records were obtained which had been kept with sufficient care to justify a differentiation of the different drift sheets. The most convincing evidence of an ice invasion earlier than the Iowan is found in the occasional presence in well sections of beds of gravel beneath till of Iowan age. At a few points in the central part of section 2 of Geneva township, outcrops of coarse, clayey and deeply iron stained gravels were observed, and they appear to underlie considerable areas. In the road running east and west through section 2, they are exposed near the east side of the section, and are covered by a few feet of loess. They may also be observed at various points in adjacent portions of Butler county. In appearance the gravels are relatively very old and this in conjunction with their stratigraphic position makes their reference to the Buchanan interglacial stage very probably correct.

IOWAN DRIFT.

The territory occupied superficially by materials belonging to the Iowan stage has been fully outlined under Topography. This area, which embraces approximately six and one-half townships in the eastern half of the county, bears evidence of having been quite generally covered by the Iowan glacier, but the amount of material put down appears to have been in many places very meager. An aggregate depth of over twenty feet of Iowan drift with its thin loess covering is rare, while throughout considerable portions of Ingham and Geneva townships, along the line of the Kinderhook escarpment, the latter formation reaches to the very grass roots.

Where observed in occasional road cuts and along the railroads in Mott and Ingham townships, the Iowan drift presents the usual characteristics. It is an unassorted, but slightly leached, yellow glacial till. Although in general well provided with the smaller bowlders of, principally, the lighter colored, more acid varieties of igneous rocks, the large fresh granites which are a constant characteristic of this drift sheet elsewhere are of importance only locally. Sections 35 and 36 of Reeve, and 13 of Mott township are notable in this particular. The prevailing type is a coarse-grained pink granite, and some of the bowlders are of enormous size.

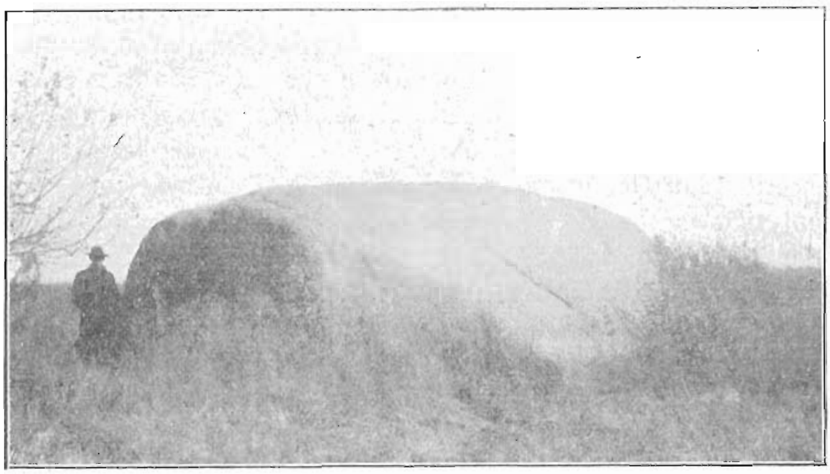
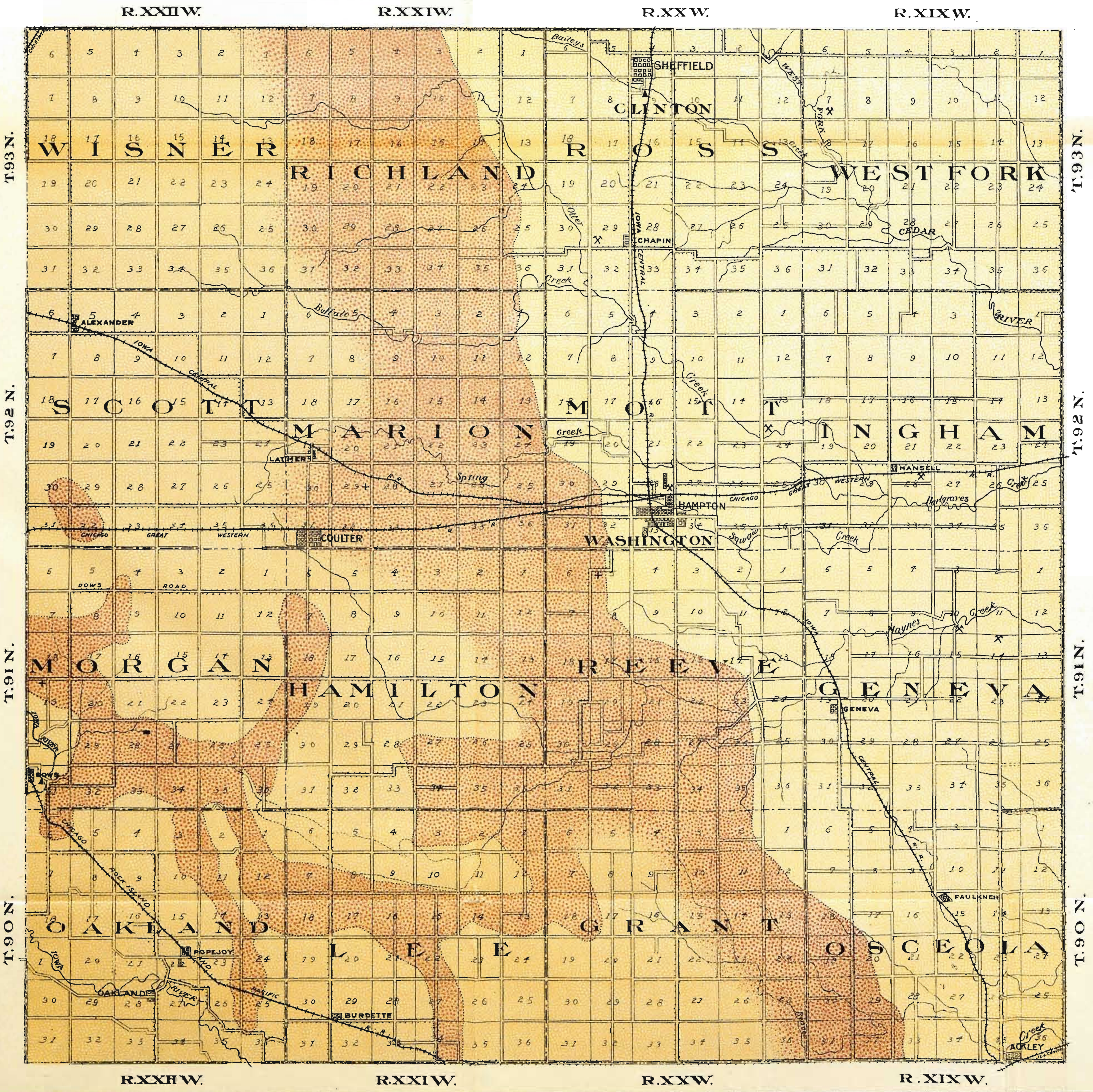


Fig. 57—Iowan boulder in Section 13, Mott township. It is a coarse grained red granite. Dimensions, 24x36x10 feet above ground.

Loess has been deposited over a considerable portion of the surface of the Iowan drift. It is most conspicuous where it covers the outstanding hills and ridges of the Kinderhook limestone in Mott, Ingham and Geneva townships. These outliers of the indurated rocks, which of themselves stand somewhat above the general level, seem to have served as obstructions that excited accumulation of eolian materials around them. The loess may be seen at times resting immediately upon the eroded surface of the limestone or shales and again supported by a greater or less thickness of undoubted Iowan drift. The loess attains a thickness of fifteen or more feet. Good exposures may be examined in sections 6 and 5 of Mott township, and at various points throughout northern Ingham and Geneva townships, notably along the east side of section 5 of the latter township. Concretions of lime carbonate are abundant in the deposit, but casual inspection does not reveal the presence of the



IOWA GEOLOGICAL SURVEY

MAP OF THE

SUPERFICIAL DEPOSITS

OF

FRANKLIN

COUNTY,

IOWA.

BY

IRA A. WILLIAMS

1906

Scale $\frac{1}{125,000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

LEGEND

Iowan Drift

Wisconsin Drift

Altamont Moraine

INDUSTRIES

Clay Pits ▲

Quarries ⚒

Sand and Gravel +

Peat ▬

TRI CITY LITHO. CO. DAVENPORT, IA.

usual remains of land mollusks. The dividing line between the loess and the Iowan till is frequently poorly defined and is never marked by the distinct ferreto band so characteristic of the Kansan drift. In fact, in many instances the change in coloration is so slight that, except for the absence of the gravel pebbles in the loess above, there appears to be almost a gradation into the underlying typical drift. In other sections the line of separation is plain both because of the difference in the

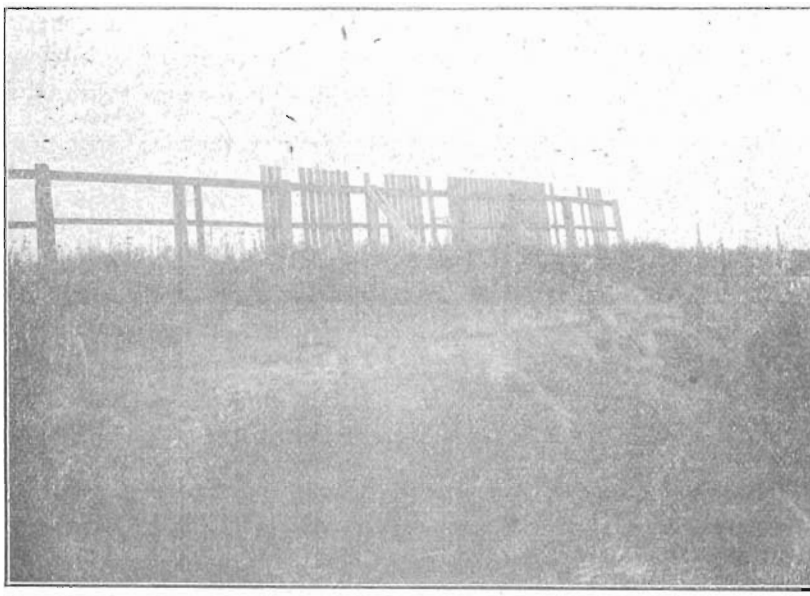


Fig. 58—Loess overlying Iowan drift in railroad cut, Section 25, Mott township.

nature of the materials and of the slope angle maintained by them. Loess overlying the Iowan may be seen in a railroad cut near the east edge of section 25 of Mott township (Fig. 58). The absence of the oxidized zone and of other evidence of an extended time interval following the retreat of the Iowan ice and preceding the deposition of the loess, suggests at least immediate succession, if not contemporaneity of loess accumulation with the wasting of the glacier. The loess was placed upon the fresh and unmodified surface of the till before climatic conditions had sufficiently ameliorated so that plant growth could gain an important foothold, or the weathering processes bring about appreciable chemical alterations.

WISCONSIN DRIFT.

The Wisconsin drift in this county presents the ordinary characteristics that have been many times detailed in the earlier reports of this Survey. On account of its comparatively recent deposition the materials are unleached and vary in color from yellow near the surface to light blue in depths beyond the limits of oxidation. It is typically composed of an extremely calcareous and sandy clay matrix which is filled with promiscuously distributed pebbles and bowlders of a wide range of sizes and varieties. The bowlders are often scattered over the surface. and in localities where they have been undisturbed are interesting features of the landscape. Bowlder fields are common in

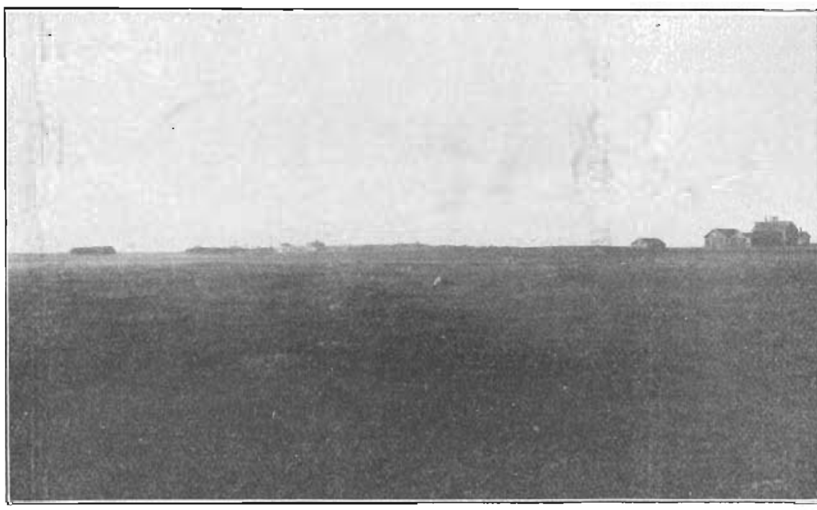


Fig. 59—Field of Wisconsin boulders in the southwest quarter of Section 27, Wisner township.

Wisner and Richland townships. Figure 59 shows such a field in the southwest quarter of section 27 of the former township. The varieties represented are mostly of the granite type although the gneisses and schists, some of them exhibiting beautiful contorted banding, are common. Occasional densely black "nigger heads" are observed.

From the typical bowlder clay the drift grades into clayey gravels, argillaceous sands, and in the morainal tracts where the action of water has been of greater importance, beds of perfectly assorted sand and gravel occur. Wells sunk in the Wisconsin drift area penetrate from fifty to one hundred sixty feet of Pleistocene strata. From obtainable information and a study of the older drifts in the eastern part of the county it would seem that a large proportion of this depth should be referred to the Wisconsin. Wells in Wisner township go one hundred feet to rock; in southern Scott, one hundred to one hundred sixty feet; at Latimer, one hundred feet, which depth decreases rapidly in eastern Marion township; and in Dows, eighty feet to the indurated strata. Exposures of any thickness of the Wisconsin drift are rare, but its general character may be observed at innumerable points along the public roads in the western half of the county.

Gravel Trains and Terraces.—All of the streams that issue from the moraine are bordered by more or less continuous layers of gravel which usually appear as valley terraces in the Iowan drift area. The gravels are especially noticeable on Bailey, Otter and Buffalo creeks, along which they may be frequently seen within the borders of the Wisconsin drift. They occur also along Mayne creek in Reeve and Geneva townships The materials are well sorted as a rule and are products of the streams while they were flooded during the melting of the Wisconsin glacier. More or less sand is always present and cross-bedding is a prevailing feature, indicating deposition from rapidly flowing currents. The fineness of the pebbles composing the gravels increases with the distance from the Wisconsin border—as would be expected with the decrease in declivity and hence carrying power of the streams.

Where the West Fork of the Cedar enters the county it is skirted by a gravel bench, twelve to fifteen feet higher than the flood plain. This terrace unites in section 18 of West Fork township with the Bailey creek terrace, which forms a very conspicuous bench along the latter stream throughout its course in the county, and is here ten feet above the flood plain level. Beyond section 28, West Fork township, the gravels are not conspicuous. The terrace in places extends a mile back from the stream, the town of Sheffield being built on such a flat to the north of Bailey creek. The gravels in Sheffield are twenty five to thirty feet thick. The gravels are also seen along Otter and Hartgrave creeks and vary in height above the water from fifteen feet at the moraine to disappearance in eastern Ingham township. The terrace on Mayne creek is not so conspicuous as are those along the other streams in the eastern part of the county and is not important beyond the eastern boundary of Reeve township. A gravel train flanks the Iowa river but does not occur as a bench, being seen only in road cuts and but little above the river. The gravel underlies the thin layer of alluvial silt that has been put down in places by this river.

Post-Glacial Deposits.

Under this caption should be mentioned the slowly accumulating alluvial materials that are even now being put down over the level bottoms in the stream valleys. Such deposition takes place during stages of high water when the overloaded streams are not confined to their channels but spread out covering areas of greater or less extent. The materials carried and deposited are usually the finer-grained soil particles that have been washed down from the slopes of the drainage basin of the stream. Although this process is unceasingly going on, none of the streams of Franklin county have flood plains of sufficient importance for mapping. It is true that all of the larger streams occupy depressions of considerable size, and some of them are in places bordered by broad flats which have been in the past undoubtedly many times flooded by sediment-carrying waters. But if, as seems advisable, we limit the application of the term flood plain to the area at present inundated during stages of high water, and alluvium to the sediment deposited outside of the channel during such inundation, these features are not of importance in the area under consideration. As mentioned, however, under Drainage, there are local areas of alluvium along the Iowa, the West Fork and, in fact, along all the major waterways that deserve notice.

Vegetable materials have been accumulating in the shape of peat beds in many of the upland ponds since the close of the glacial period. Thicknesses of ten to fifteen feet are at present found in some of these bogs. The accumulation takes place by the continuous growth of certain species of moss, and the plant remains that are brought in from the surrounding hillsides. Water is essential to the growth of the deposit as upon it depends not only the life of the species of mosses that compose the bulk of the peat bed, but also the partial preservation of the remains of these plants as they die year after year. Hence we find all peat bogs either in shallow ponds or marshes or on the sites of formerly wet places. At present much is being done to eliminate all ponds and marshes to prepare the land for agriculture, and there is perhaps little accumulation of peat going on because of the all but universal advent of the ditch and the drain tile.

Soils.

Franklin is pre-eminently an agricultural county. Farming is the vocation of the rural population and there are no tracts of any size that have not been disturbed by the implements of the tiller of the soil. The marshy peat bogs as well as the glacial ponds are giving way to modern drainage methods, while productive soils are slowly replacing the peat, and growing crops the worthless waste of sedge, rush and water willow. The general fertility of the soils of the county is attested by the flourishing crops that are to be seen on every hand during the growing seasons.

The soils may be primarily classified as residual and transported soils. The latter is the prevailing type, and may be subdivided into the drift, loess, alluvium and terrace varieties.

The drift soils occupy areas corresponding to the two till sheets that superficially cover the county. The soils of the western portion of the county are relatively new as the time which has elapsed since the deposition of the Wisconsin drift has been short. Surface modification by weathering has progressed to but slight depth and as a result the soil has a yellow or light brown color and is still very limy. It is also less porous than the older soils, which lack of porosity prevents thorough aeration and the free circulation of the soil moisture. It is recognized that the typical Wisconsin bowlder clay soil requires more thorough and deeper tillage to obtain the most favorable results. As weathering progresses and plant growth loosens up and alters the surface layer, many of the finer particles are carried down the slopes and accumulate in and around the marshes and ponds which, until recently have been very common. In this way have been produced the sticky, clayey, muck and impure peat soils that are well known in low undrained places. The so called 'sour' or alkaline spots are due to the impervious nature and undrained condition of such soils and these can be corrected only by the removal of the surplus moisture. In view of their origin it is evident that the marsh soils may vary from a fairly pure grade of peat to a mucky clay containing a greater or less amount of partially decayed organic matter. While not actually covered with water, such soils usually support a growth of uncultivated but nutritious grasses, but it often requires considerable patience, even after drainage is secured, to subdue them into perfect tractibility. This once accomplished, however, they become fertile and lasting because of the humus they contain.

The materials of the Iowan drift have been longer subjected to the action of the atmospheric agents, and a more perfect soil is the result. The Iowan drift soil, while still quite calcareous, is of darker color and more open texture than that of the Wisconsin drift, and is therefore better suited to tillage and to plant growth. As has been noted earlier, however, the Iowan is directly responsible for the soils of but limited portions of the area outside of the Wisconsin drift. It is for the most part buried by the silty, in places sandy, loess covering whose alteration forms the basis for most of the soil over the eastern part of the county. The loess is a clayey deposit of yellow to light brown color and entirely free from the gravel pebbles and coarse sand which permeate the drift clays. Rounded or irregular concretions of lime carbonate are abundant, but these are secondary and have been formed by the leaching action of water. It effervesces freely with acid, and microscopic examination shows a large proportion of angular particles which should perhaps be called very fine sand. Physically, the soil which is formed on the loess is permeable both to water and to the roots of plants. On account of the clay constituent and the readiness with which water both enters and dries from it, the loess soils are very apt to bake hard after wetting. For the same reasons they wash readily, and from unprotected fields tons of the richest portions of the soil may be carried away during heavy rainfall or the melting of the winter's snows. Plowed fields exposed to the unhindered sweep of the winds are likewise denuded by the drifting of loose soil particles. The loess affords a fertile soil, and the cereal and legume crops grown upon it rival those produced on any other class of soil. It is usually found expedient however to take some precautions in the rotation of crops in order to avoid the necessity of leaving the uncovered fields open to the attack of winds and rain.

It has already been stated that at a few points along the principal streams of the county bodies of alluvium have been deposited. The materials have come from the upland soils, and this type is therefore one of great richness. Alluvial soils are usually sandy, of dark or black color, and where developed are the most productive of the region.

Covering the gravel terraces wherever they are developed in the county is a very productive soil. It is of the nature of alluvium, somewhat modified by later additions of rich loamy materials, and was undoubtedly spread over the surface of the gravel beds at a time following the close of the glacial period, while the streams were still of large volume and in a manner similar to the deposition of alluvium over the flood plains of today. The permeable gravels below afford perfect underdrainage. The terrace soils require seasons of more than the common amount of precipitation to produce the very best results. They are sandy, open textured and warm soils and appear best suited to the raising of corn, but in ordinary years even this crop does better on the less porous, more clayey soils.

The residual soils are of minor importance although at some points the weathered limestones and shales have contributed largely to the elements necessary for plant growth. In the southeast corner of Mott and the southwest two sections of Ingham township the Kinderhook limestone is very thinly covered, and in many places along the angular terraces which border Squaw creek the soil layer appears to be due almost entirely to the decomposition of the limestone. To the south of Mayne creek in sections 10 and 11 of Geneva township a similar state of affairs obtains over small areas. In West Fork and Ross townships the Devonian shales have lent appreciably to soil formation in numerous localities. This is notably true along the west fork of the Cedar in section 7 of West Fork and section 1 of Ross township; and at various other points in Ross township south of Bailey creek. The presence near the surface of the shales is not so evident topographically as is the presence of the limestone. The characteristic yellow color and the marly nature of the shale soils are the distinguishing features. The limestone soils are highly impregnated with iron oxide and are therefore typically deep red to rust brown in color, and are found to grade downwards into the rotten and partially decayed limestone.

ECONOMIC PRODUCTS.

From the foregoing discussion it may be construed that Franklin county's most important asset is its fertile soil. On the soil the majority of its inhabitants depend and the products of the many prosperous farms are the chief articles of export. The county possesses besides, ample supplies of building stone, abundant clay resources from which are wrought most durable building material and drain tile which are at present so much in demand, and finally, a moderate supply of timber for fuel. In a way, therefore, it may be said that Franklin county is sufficient unto itself, and yet it depends, as do all other communities, for certain of the necessities, on neighboring fields having more abundant supplies that they are willing to exchange for articles which Franklin county is able to spare. Thus, coal must be shipped in, and lumber for building, while in return are sent out the bountiful products of the farm, the orchard and the dairy.

Building Stone.

Stone suitable for foundation walls and sidewalk flagging is quarried at a few points in the county. The best quality comes from the Kinderhook beds but a fair grade for rough work may be obtained at several localities from the Owen beds of the Devonian.

Kinderhook Beds.—A small quarry is worked by Mr. Wm. Low in the southwest corner of section 29 of Ross township. Considerable stone has been removed here and at a few other points along Otter creek in this vicinity. The quarry section has been given on page 483. A quarry face eight to ten rods in length is open. The usable portion of the section is covered by six to eight feet of argillaceous weathered rock which must be removed by stripping. The lower beds are regular and the individual layers vary from six to eighteen inches in thickness. The stone is granular and fossiliferous and ranges from brown

Fig. 60—Kinderhook limestone, one mile west of Chapin in section 29, Ross township.

to blue-gray in color. It yields readily to shaping for dimension work and affords the most durable building stone now produced in the county. A moderate local demand is supplied, none as yet being shipped.

Stone has long been quarried in the north part of the town of Hampton on Squaw creek. A poor grade of limestone is now being used from a new opening a few hundred yards west of the cemetery. The rock is weathered and contains intermittent bands of chert which cause it to break very irregularly. It is used for only the rougher masonry work and would not give satisfaction in exposed positions.

Although the Kinderhook limestone is removed for local use at a large number of points in Ingham, Geneva and Osceola townships, at but two localities have quarry openings been made of sufficient extent that the nature of the unweathered rock could be observed. In the southwest quarter of the southeast quarter of section 10 and the northwest quarter of the northeast quarter of section 14, Geneva township, are small quarries in which are exposed essentially similar strata. The former is owned by Mr. O. Benson of Geneva and the latter is on the land of H. Andrews. The overburden here consists of five to eight feet of cherty magnesian limestone. This rests on a massive bed of eight to ten feet of gray to brown subcrystalline limestone which displays decidedly oolitic facies. Away from the weathered parts the rock is light in color and compact, and resembles in general appearance the Bedford stone. In natural outcrops this bed separates into numerous laminæ, each a few inches thick; but where newly exposed, slabs of almost any desired size can be obtained.

A small amount of stone is removed each year from these quarries. It is believed that continued development might open up unweathered portions of the bed which would furnish very good building stone. It seems likely also on account of the extreme thinness of the drift that prospecting along Mayne creek in this vicinity would discover places where it would be possible to obtain desirable stone that is not buried beneath so great a thickness of weathered residuum which must be removed.

Owen Beds.—These beds afford very little stone which is sufficiently coherent to have any extended use for structural work. As has been noted, however, the Owen limestone has been quarried at a few points along the east side of the West Fork of the Cedar where occurs a firmer phase of the usually argillaceous, marly magnesian strata of this formation. Some small amount of rock has been taken out in the southwest quarter of section 7, West Fork township. Three and one-half feet of yellow, magnesian, cherty shale overlie seven feet of moderately thin bedded crystalline brown magnesian limestone. Only the lower bed can be made use of, and, on account of its coarsely granular and partially weathered condition, is not a durable material. It has been used to a limited extent for sidewalk flagging and in walls, where it is fairly satisfactory.

Clay.

Franklin county is generously supplied with clays suitable for making all the common grades of wares. Those which are readily available are the loess and river clays and the clay shales of the Devonian. The loess, which overlies the Iowan drift in the eastern part of the county, is not utilized at any point. This material is employed over the state more than any other class of clays for brick and tile manufacture, and good substantial products are made from it.

River or alluvial clay is made use of at Dows in the Wilson Bros. Tile Works. The plant is situated southeast of town near the C. R. I. & P. tracks. The clay is taken from the river bottom below the plant. It is black soil at the surface grading downward into gray and yellowish plastic clay. Gravel underlies the clay, so the depth of the pit is limited to about four feet. The clay is spaded from the bank and hauled to the works in two-wheeled carts. The clay is shoveled on to an inclined belt which carries it to a pair of corrugated conical rolls. The rolls remove any contained gravel, after which the clay is lifted by a belt provided with metal pans to the pug mill. Only drain tile are made. A J. D. Fate and Company auger machine provided with a rotary tile cutter is used. With the exception of 11-inch tile, all sizes to one-half inch are made, from three and one-half to twelve inches in diameter. From the cutting table the green tile are wheeled to the dryers, being carried to the upper floors by chain elevators. The dryer buildings have slatted floors and are three stories high. Three buildings are connected by covered runways and include a total of over 96,000 square feet of drying space. Both exhaust and live steam are used for drying, but only after shrinkage in the drying tile has ceased, as too rapid expulsion of the water is apt to cause cracking. Three weeks are ordinarily required before the tile are ready for the kiln. The plant is equipped with six round downdraft kilns—one of which is eighteen feet; two, twenty feet; two, twenty-two feet; and one, twenty-three feet in diameter. Three stacks furnish draft for the six kilns. The tile require thirty-six hours to water-smoke and thirty-six hours to complete the burn. The product is of a high class and the local demand is large. A considerable proportion of the output is also shipped into neighboring counties.

The Hackbery shales are utilized at the plant of Mr. E. P. Fox, one-half mile south of Sheffield. Both the yellow and the blue varieties of these shales are exposed in the pit. The upper two feet contain some limestone and calcareous concretions, but below this the clay is weathered and plastic and, excepting occasional blocks of friable magnesian limestone and some selenite scales, appears free from concretionary impurities. Approximately eight feet of the yellow, and three to four feet of the blue shales are removed for use. The clay is broken down and allowed to weather in the pit for six months or so. It is hauled by wagon and fed by hand into a "Little Wonder" auger machine made by the Wallace Mfg. Company. A single-wire hand cut-off is used for brick, tile and hollow block. All sizes of tile are made from three to eight inch inclusive, and this is the chief product. The ware is dried on racks under sheds having adjustable side walls for controlling the air circulation. Tile are safely dried in one week. The plant is equipped with one twenty-foot round down draft kiln. Power is supplied from a thirty horse power boiler and a twenty-four horse power Des Moines Iron Works engine. The ware produced is of fair quality. Incipient cracking sometimes ensues if the ware is too rapidly cooled in the kiln but the remedy for this is obvious. The presence of sulphates in the clay is evidenced in the finished product by a persistent scum or 'whitewash' which is often quite conspicuous by the finger marks produced in handling the green ware. This whitewash mars the appearance only, and in such materials as tile and brick that are well burned and are not to be used for outside work, should not diminish the value of the product.

These shales outcrop at various points along Bailey creek both above and below the town of Sheffield and in many places are practically free from overlying materials that would require removal. They constitute an inexhaustible supply of available raw material for the manufacture of the common clay wares.

Conditions appear especially favorable for drain tile manufacture on account of the location near the border of the Wisconsin drift—that great undrained stretch of country to the westward—where such an active campaign is now in progress to subdue the lakes, ponds and marshes of this new land surface. The demand for drain tile is strong and increasing and although railroad facilities are not the best, Franklin county raw materials are more accessibly situated than those of any competing area.

Sand and Gravel.

The terraces which skirt all of the larger streams in the eastern part of the county furnish excellent and abundant supplies of gravel and sand for road construction and concrete work. For road building the gravel beds are worked at many points where the public highways cross the stream valleys. Within

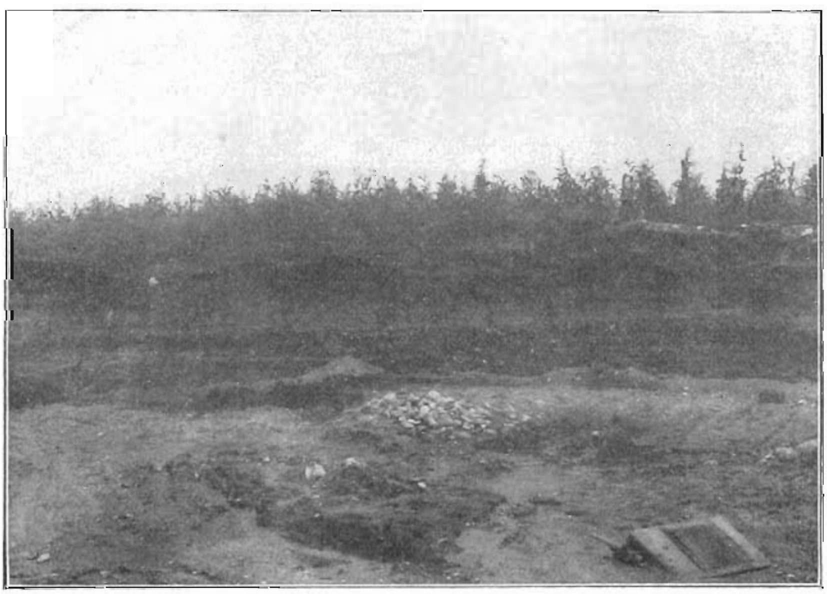


Fig. 61—Interstratified gravel and sand beneath partially assorted Wisconsin drift. Public highway between sections 5 and 6 of Reeve township.

the Wisconsin drift area extensive deposits are found along some of the streams and in the principal morainal belt in the southwest part of the county. On the road between sections 5 and 6 of Reeve township stratified sand and gravel occur beneath a thin layer of partially assorted Wisconsin drift. Six to eight feet of the deposit have been opened up and large amounts removed from both sides of the roadway. Gravel and sand are hauled from this pit to Hampton for use in the manufacture of cement blocks, and for filling material in other lines of constructive work.

In the northwest quarter of section 19, Morgan township, is a series of morainal knobs. Near the northwest corner of the section one of these hills has been dissected. It is composed of nicely stratified clean sand, quite free from iron stain and other impurities. The strata are not horizontal nor continuous but interrupted and irregularly tilted at all angles. The pure condition of the sand renders it available for use in plaster and mortar mixtures. Sand is taken from here for making cement building blocks in Dows. No sifting is necessary, the requisite sorting and sizing of the sand having been accomplished by the natural agents which deposited it.

Peat.

The peat beds of Franklin county contain a large supply of low grade fuel that may at some future time be utilized. At present it is removed for use at but one locality. Peat has been taken out for a number of years on the land of Mr. E. H. Capellen in the south half of the northeast quarter of section 28, Morgan township, for local use. An area of sixty acres is said to be covered with eight to nine feet of usable peat. A plant of small capacity is installed by the Iowa Fuel and Brick Company of Dows, for briquetting the material. The equipments consists of a No. 66 Horton Mfg. Company Hercules six-mold soft mud brick machine, a small engine and drying sheds. The peat is hauled on a track in cars by a cable from the bog about one-quarter of a mile from the plant. In the brick machine the product is of necessity but very slightly compacted over its spongy condition in the bog, but the peat is put into convenient shape for handling, and the mechanically held water is largely dried from it. It is said to make a desirable domestic fuel burning free from objectionable soot and clinkers. Some thirty tons have been produced in the past year. Following is a chemical analysis of an average sample dry peat brick.

	per cent.
Loss at 110°C	10 00
Volatile hydrocarbons	37.80
Fixed carbon	14 20
Ash	38.00

A calorimetric test of the same sample gives a fuel value of 4766 B. T. U., which means that one pound of the dry peat will produce enough heat in burning to raise the temperature of 4766 pounds of water one degree Fahrenheit.

Water Supply.

Ample supplies of good water are to be obtained from a number of different horizons in the geological formations that underlie this county. In the western part where the drift deposits are thick few wells are sunk below the base of the Pleistocene, and farm water supplies are frequently furnished by shallow wells, thirty to ninety feet in depth, which are fed from local sand pockets or intercalated beds of gravel, or by seepage from the bowlder clay itself. Such sources do not afford constant and unfailing supply, nor is the quality of the water the best. An abundance of water can usually be obtained at the base of the drift whose thickness runs from eighty to one hundred sixty feet. Gravel or quick sand, and in some instances hard pan, are found immediately over the Kinderhook limestone.

The town supply well of Latimer penetrates the rock one hundred feet, a porous member of the Kinderhook doubtless being the aquifer. The Dows well is eighty-four feet in depth and draws its water supply from gravel beds above the rock. Scattered over the south half of Morgan township are some fifteen flowing wells. They are obtained at thirty to eighty feet, and are said to all reach the solid rock. Some of these wells have a strong flow, while in others the water barely rises to the surface.

Outside of the Wisconsin drift area wells are quite universally sunk into the indurated strata of the Carboniferous and Devonian, although fairly dependable supplies can be obtained in places from the gravels and the alluvial deposits along the larger streams. In the vicinity of Sheffield and in general over the northeast part of the county it is necessary to go two hundred feet into the Devonian for water, and flows are sometimes to be had at this depth. In Ingham and Geneva townships the wells are frequently three hundred feet deep, and drillers report penetrating a bed of quick sand at about eighty, and another at three hundred feet.

The city of Hampton draws its supply of water chiefly from the deep well which penetrates seventy-four feet of the Jordan sandstone. The volume of water afforded by the Jordan is however not sufficient and is supplemented by that coming from the St. Peter sandstone. The water stands one hundred feet from the surface and is pumped from one hundred seventy feet. The mineral analysis of the deep well water is as follows:

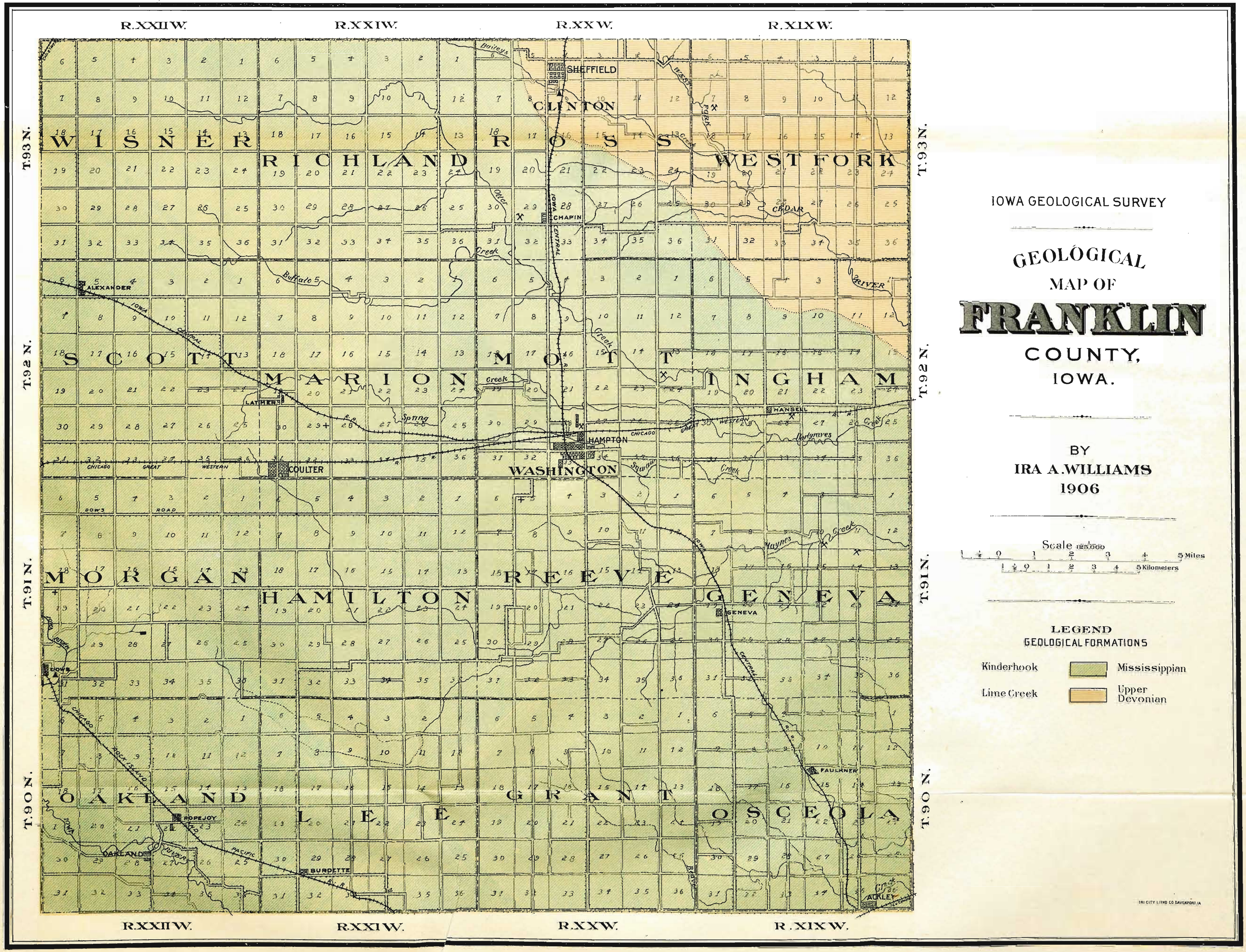
Analysis Hampton City Well.

	Parts per million.
SiO_2	13.0
Fe	none
Al	2.1
Ca	80.7
Mg	33.4
Na	21.4
K	7.6
CO_3	180.0
HCO_2	
SO_4	59.0
Cl	5.0

Analyst, W. S. Hendrixson,
June 29, 1905.

The water is hard and is corrosive when used in boilers. It is however of fair quality for drinking purposes.

The water supply for Hampton was formerly taken from two large springs which flow from the limestone in the bank of Squaw creek. These springs now flow into a large cistern and this supplementary supply is drawn upon quite regularly during certain hours each day.


IOWA GEOLOGICAL SURVEY
GEOLOGICAL MAP OF
FRANKLIN
COUNTY,
IOWA.
BY
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1906
Scale 1/125,000
5 Miles
5 Kilometers
LEGEND
GEOLOGICAL FORMATIONS
Kinderhook
Mississippian
Lime Creek
Upper Devonian
R.XXII W.
R.XXI W.
R.XX W.
R.XIX W.
T.93 N.
T.92 N.
T.91 N.
T.90 N.
WISNER
RICHLAND
ROSS
WEST FORK
SCOTT
MARION
MOTT
INGHAM
MORGAN
HAMILTON
REEVE
GENEVA
OAKLAND
LEE
GRANT
OSCEOLA
SHEFFIELD
CLINTON
CHAPIN
ALEXANDER
LATIMER
HAMPTON
WASHINGTON
COULTER
HANSELL
GENEVA
FAULKNER
POPEJOY
OAKLAND
BURDETTE
ACKLEY
DOWS
CEDAR
RIVER
Buffalo
Otter
Creek
Spring
Squaw
Maynes
Mayne
Bailey's
West Fork
TRI CITY LITHO CO. DAVENPORT, IA.

Water Power.

None of the streams of Franklin county have been utilized for water power with the exception of Spring creek. This stream has been ponded in section 19 of Mott township and a small lake formed by an artificial dam of some length across its valley. This body of water is known as Beed lake, and water is run from it through a race to the flour mill one-half mile below the lake. The other streams of the county have neither a sufficiently constant flow nor volume great enough to afford economical water power. Iowa river would perhaps be the only possible exception so far as the flow of water is concerned, but favorable mill sites along this stream are very rare.

ACKNOWLEDGMENTS.

It is a pleasure to acknowledge the uniform courtesy and response to requests for information accorded the writer by many citizens of the county. Thanks are due also to other members of this Survey for counsel and aid during the progress of the work. The author is especially grateful to Professors Calvin and Savage for assistance in the identification of fossils and to Dr. S. W. Beyer for advice and substantial aid in some of the problems met in the field.

GEOLOGY OF SAC AND IDA COUNTIES.

BY

THOS. H. MACBRIDE.

GEOLOGY OF SAC AND IDA COUNTIES.

BY THOMAS H. MACBRIDE.

CONTENTS

INTRODUCTION.

LOCATION AND AREA.

The two counties which form the basis of the present sketch are situate in the northwestern part of Iowa. They are separated from the north line of the state by the width of three counties, and from the western border by the length of one, Woodbury. Cherokee and Buena Vista counties lie immediately north, Calhoun on the east, Crawford and Carroll on the south. They are prairie counties, yet, as we shall see, not wholly without native forest, with the general topography of the state at large, yet possessed of features of peculiar interest, like all the counties round about, yet offering problems not a few to the thoughtful student, and affording in all that makes for surface description or definition, a physiognomy at once unique and full of interest.

PREVIOUS GEOLOGICAL WORK.

For such reasons, doubtless, these two counties received, thirty years ago, at the hands of our pioneer geologist, Dr. White, more than usual attention. Geological views have changed somewhat since his day, chiefly in the direction of the more exact delimitation of the superficial strata, but in geography and topography the descriptions in White's Report, here written by Mr. O. H. St. John, leave little to be desired.*

Dr. White also investigated very carefully and satisfactorily all the more important lakes of Iowa and give a good account of them.†

His explanation of the so-called "walled lakes", one of which occurs within our present limits, is very clear and he seems to have been the first to refer the accumulation of debris, gravel, bowlders, etc., in ridges around the borders of shallow lakes to its proper cause, namely the shoving of the expanding ice, winter after winter, acting upon the gently sloping shores. He even gives us a figure illustrating this.‡

*Report of the Geological Survey of the State of Iowa, by Charles A. White, M. D. 1870; Vol. 2, pp. 150-164

†Op. cit. Vol. 1, pp. 70-78

‡Op. cit. Vol. 1, p. 77.

Dr. Wilder has also discussed, more in the light of present knowledge, the same "walled" lake, and gives account of its relation to surrounding topography, in the proceedings of the Iowa Academy of Science.*

PHYSIOGRAPHY.

TOPOGRAPHY.

The topography of these counties, thus lying side by side in the midst of the northwestern Iowa prairie, is far from uniform. As already hinted it is everywhere suggestively diverse. The farmers of the region have long since distinguished between east and west Sac, for instance, and the hills and valley-lands of Ida. This diversity is referable, of course, to the recent geologic history of the whole northwest and simply finds in our present area a more conspicuous illustration.

If one begins with Ida county he finds a land of high prairie fields perfectly drained in almost every township by a divergent and far-spreading drainage system, from broad, ample valleys worked back and up almost to the last section. It is accordingly true that some of the highest land in the county is the flattest. The prairies about Holstein are in many places almost level, yet, as anyone who consults the map may easily see, not far removed from the sources of streams flowing north, south, east and west. A study of Griggs township and its topography affords a key to the whole drainage situation of this and several adjoining counties north and west. The Battle creek valley is a beautiful region with gentle slopes on every side, a comparatively broad flood-plain widening to meet that of the Maple. Perhaps the fairest view of a typical erosion system may be had from the cemetery hill in section 22 of Battle township: from this point the valley of the west fork of Battle creek stretches to the southeast on a summer day in unrivalled beauty; the flowing outlines blending; no flood-plain; simply a winding valley the sloping sides now covered with farms, groves and lines of cottonwoods, with meadows, fields of corn and wide spread crops of whitening grain. Below the United Presbyterian church, Battle township, the valley widens, and the creek winds about in alluvial soil.

*Iowa Academy of Science, Procedings, vol. 7, p. 77.

The valley of the Maple shows similar characteristics, especially in its tributaries. The Maple river crosses Ida county almost diagonally from northeast to southwest and on its way cuts through an old time plateau or ridge that trends in a direction almost at right angles to the course of the stream. Holstein occupies the crest of the plateau, but high hills representing the remains of the ridge may be traced southeastward through Logan and Blaine townships, through Richland, Wheeler, Levey and Viola townships of Sac county and on into Carroll county. Where the river cuts this old divide the hills are more precipitous and the valley narrows. This is especially noticeable above the mouth of Silver creek; but from this on southwest we have a distinct flood plain from one-half mile to a mile in width, in which the present stream winds back and forth, sometimes with considerable deposits of sand, as at the old town of Ida Grove and west. Here the river has cut down pretty well to base-level and Ida Grove is more than two hundred feet lower than Holstein.

South of Ida Grove is another divide, where the valley of Maple river is separated from that of Soldier river. Here again we have a characteristic erosional topography. There is probably not an acre not directly connected with the general drainage system. From the tops of the hills south of Ida Grove and the Maple valley one can see nearly the whole county. Along the south the valley of Soldier river stretches from east to west; northward and westward are the valleys of Battle creek and the lower valley of the Maple; northeast lies the valley of the Maple river proper with that of its principal tributary, Odebolt creek

From the hills in Logan township one can see all of Galva and Silver Creek townships; from the church hill in Griggs township the valley of the Little Sioux is plainly seen and the trains of the Illinois Central railway that move up and down from Cherokee; from two or three selected points one may see the entire limits of the county; surely this for a prairie is a land of beautiful landscapes.

The topography of Sac county is in part similar, in part extremely different. The northwest portion of the county is high and comparatively level, though generally well drained;

the southwest is quite hilly, while the center is described as a "gently rolling prairie" with long valleys trending generally to the south. In both counties the topography becomes more and more rugged as we move southwards; thus south and west of Odebolt and Arthur in the direction of Soldier river the landscape presents a succession of hills and narrow valleys indicative of recent and vigorous erosion.

The eastern half of Sac county is, however, very unlike all the rest. Here the country, except in the immediate vicinity of the streams, is poorly drained; marshes are not infrequent, and gravelly knolls often appear in curious disorder, lending little or no assistance in the problem of disposal of surface waters. Here are the lakes, the ponds, the slow creeks, the wide, flat, black prairies, (Fig. 62) the sandy fields, characteristic of

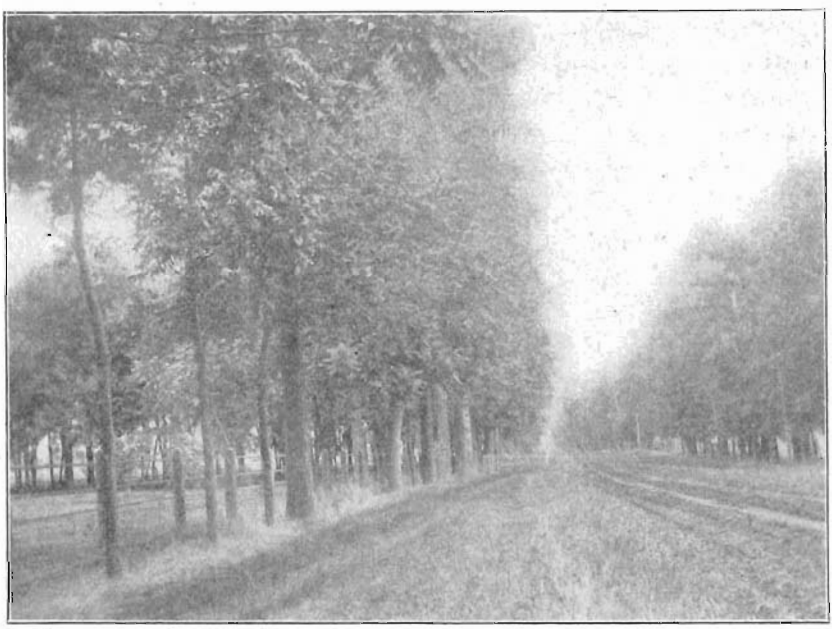


Fig. 62—View on the Wisconsin drift plain. A prairie highway.

all this section of Iowa to the east and north. Those who have read the present series of reports will immediately recognize here the characteristic features of our latest drift. The two sides of this county differ in topography by the weathered record of many thousands of years. In the immediate neighborhood of the Coon river, however, we have a number of well drained farms for reasons that may presently appear.

Wall lake.—But doubtless the most striking topographic feature of the prairie lands we now survey remains yet to be considered. Wall lake in Sac county, although perhaps not the only one of the name, is yet by far the most noteworthy. It is the largest of the walled lakes of Iowa and has been longest known to fame.

Here we have a handsome sheet of water a little more than two miles long from east to west, and about half as wide, with curving contour, headlands, bays, more or less of wooded shore, all exceedingly pretty on a fair summer day, attractive to the Indian of long ago, nor less to thousands of his supplanting white brothers who visit it year after year simply to enjoy the beauty of its transparent waters. Here and there are sandy beaches where one might bathe, small steam-boats and yachts ply back and forth in public service, and at the western end a strong perennial mineral spring affords remedial waters for the approval of all who still seek the fountains of perpetual youth and health. The following analysis of the waters here is furnished the passing visitor at Lake View. It may be observed that the principal minerals held here in solution are calcium and magnesium, the lime, as is to be expected, greatly preponderating. The bicarbonate in the case means simply that the springs issue where carbonic acid gas is in excess as is apt to be the case in or about the blue clay where there is organic matter slowly undergoing decomposition. The spring doubtless emerges just above the blue clay.

Each gallon of spring water contains:—

Sodium chloride (common salt)	1.124	grains
Potassium sulphate	285	"
Sodium sulphate	1.596	"
Calcium bicarbonate	18.111	"
Magnesium "	9.470	"
Sodium " (soda)	.336	"
Iron "	.032	"
Sodium phosphate	trace	
Alumina	.150	"

Silica	1.180 grains.
Organic matter	trace
Total	32.284 grains

The waters of the lake are not very deep, perhaps fifteen or twenty feet at deepest, and are maintained at permanent level by a dam across the outlet at the eastern side. There are furthermore several places along the shore where a slight excavation would seem sufficient to turn the waters out upon the lower lands around so that there is the semblance of an artificial embankment. One may drive along such a levee along the south shore of the lake. Furthermore, by all the testimony of the pioneer, the lake was one time walled; granite bowlders piled upon each other in series that often presented the appearance of definite order, were originally characteristic, as we are told, of a large part of the perimeter of this lake. Parts of this wall remain and are still pointed out to the interested traveler. Most of the wall has been hauled off piecemeal to make foundations for barns and houses, but still enough remains to satisfy the antiquary. A great bowlder near the spring may serve as sample of some corner stone, a tumbled group along the northern shore, (Fig. 63) might tempt us to imagine some titanic tower or cairn now gone to ruin, but at the east side of the lake some rods of what purports to be the original structure here may still be seen in place, bowlders of rather small and uniform size all ranged as stubborn rip-rap piled three or four feet high along the low curving shore.

Dr. White saw this thing and well understood its significance and I cannot do better here than quote from his report.*

"The lakes are almost without exception very shallow and the water in them is usually low in late autumn, so that when winter comes, it is frozen to the bottom over so wide a margin from the shore, as to leave in some of them very little unfrozen water in the middle. In some of the shallower ones, indeed, the water is occasionally all frozen and the fish killed by that means. This was the case a few years ago with Walled lake in Wright county, but it has since been partly re-stocked by the fry that reaches it from the rivers by way of the outlet at the time of overflow.

*Report of the Geol. Surv. of the State of Iowa, by Charles A. White, M. D., Vol. 1, pp. 75-76.

The ice, of course, freezes fast to everything upon the bottom, whether bowlders, sand, gravel, or mud, and the expansive power of the water in the act of freezing is exerted upon them, acting from the center of the lake in all directions towards its circumference. Those who are familiar with the expansive

Fig. 63—Part of the "Ancient Wall," north side of Wall Lake.

power of ice in the act of forming, will readily see that under such circumstances it would be more than sufficient to move the largest bowlder up the gentle slope of the bed of the lake. It is true that the motion resulting from one winter's freezing would hardly be perceptible, but the act repeated from year to year, and from century to century, would ultimately move everything upon the bottom beyond the reach of the ice. The tracks of bowlders thus moved have been observed, being as unmistakable in their character as are those which a mussel leaves behind it in the sand.

Thus it will be seen that whatever was originally upon the bottom of the lake within the reach of the ice, whether bowlders, sand, gravel or mud, has been constantly carried toward the shore, where we find them collected in perfectly natural disorder, and forming a ridge just where the expansive power of the ice ceased. Below the line of freezing the same kind of material would of course remain unmoved upon the bottom, because there is nothing to disturb it.''

But no description of Wall lake is adequate which does not take into account at the same time the great lake-like valley which extends from the west end of the lake southward and westward to the westward flexure of the Boyer river in Levey township near the little station McCloy. This large depression, until recently an undrained marsh, is four or five times as great in area as Wall lake itself and looks at first sight as if it might at one time have been part of it. There are yet many men ready to tell the traveler how in days gone by there were in the marsh abundant fish, and how its waters at times went into the southwest extension of the lake. At present the lake is cut off from the marsh by a low divide, scarcely perceptible, and drainage is in progress which will probably reduce the whole marsh some day to fertile fields. That lake and marsh are parts of the same basin there is no doubt. Both taken together constitute, it is most probable, part of an old river valley, possibly the old valley of the Boyer then flowing east, away from the divide, later herein described, now cut through between McCloy and Herring or in that neighborhood. It seems more than likely that the Boyer waters now going to the Missouri may have once contributed to the Des Moines. This view has been already discussed by the present writer.* It may now be added as confirmatory of this view that parts of the Coon river valley east of the lake are no doubt old, representative of a pre-Wisconsin channel, and the course of the present outlet seems to follow the line that would put the marsh, the lake and this older channel into direct communication.

This matter is still further discussed in describing the rivers and streams, under the head of drainage, but it is worth while to notice that we have here a most attractive problem that deserves, and will well reward, the effort of some intelligent

*Iowa Geological Survey Series, Volume 12, pp. 330, 331.

local student. Wall lake has an inscription written on the ground; the inscription may be read and interpreted to men in modern speech.

DRAINAGE.

The drainage of the region studied has been already more than once suggested. The greater part of the territory we describe slopes gently south and west. Thus from Holstein to Charter Oak, the fall is about two hundred feet from railway station to railway station, from Arcadia in Carroll county to Charter Oak, nearly the same, while from Holstein to Arcadia, almost directly southeast, the fall is only eighteen feet. Holstein is the highest point in Ida and Schaller the highest in Sac, and the former is only fifty feet higher than the latter. That is our counties lie upon the crest of the great divide recognized indeed by Dr. White, separating the waters of the Missouri from those of the Mississippi slope. For the trend of this ridge, with a map compare, for instance, the following points all upon the summit of the divide referred to: Boyden, 1425, Marcus 1455, Holstein 1438, Arcadia 1420, Templeton 1460, etc. This highland determines the drainage of the counties, with one remarkable exception hereinafter to be discussed,—the course of the Boyer river. All the streams rising west of the crest should flow south and west; all those taking origin east of the divide should flow south and east,—and in general they do but not without exception as we shall see presently.

The Maple river.—The Maple river crosses Ida county from northeast to southwest and so crosses apparently the line of the divide; really it takes rise on high prairies to the north of Holstein and Schaller where is one point higher than any in this section of the state, namely Alta, a station just west of Storm Lake, nearly one hundred feet higher than Holstein, and so able to send the waters gathered on its western side across the divide here sketched, but not without deep erosion. Witness the steep hills that flank the river on each side as it crosses the line of division just defined, as for instance from the south line of Logan township north for several miles. The station at Ida Grove, somewhat above the flood-plain of the river, is two hundred feet below that of Holstein and a little more than three hundred feet below that at Alta, so that the amount of fall is great, sufficient thoroughly to drain all the contiguous farms, as we see.

The waters of the Maple are perennial in liberal supply and have for years afforded sufficient water-power for a little mill still in active service at Ida Grove. The valley below the mouth of the Elk is wide and fine with a broad flood-plain, now occupied with beautiful farms.

The principal eastern tributaries of the Maple are Silver creek, Elk creek and Odebolt creek. Silver creek rises in Coon township of Sac county and with Elk creek, which has a similar origin, forms the drainage system for all the northwest part of Sac county. Their valleys are deep as they approach the Maple and are bordered by long and in some places rather steep hills. Odebolt creek is an important stream draining the central part of western Sac county and passing by a long deeply excavated valley almost directly west to enter the Maple at Ida Grove. Steep hills flank the valley on each side and are especially noticeable in the neighborhood of Arthur and near the county line. A succession of long valleys lead into the Odebolt from the south, coming down from a high ridge which forms a divide separating the valley of the Odebolt from that of Soldier river on the south. The latter stream bends up in a peculiar arch through the southern townships of Ida county, occupies a deep valley with many little tributary creeks from the north side, which make an extremely broken country, but all yielding easily to tillage. All the hills from top to bottom are year by year covered with corn. All these streams are remarkable for their deep erosion; all of them are said to be perennial, fed by seeping springs, which emerge probably, in many cases above the blue clay. The creek bottoms are alluvial soil, in which not a pebble or bowlder is to be seen. In many cases the bed of the stream is, however, black.

The Boyer river.—The drainage situation on the eastern side of the divide as here discussed is entirely different. The Boyer river and the Coon are the principal streams. The former rises in Buena Vista county south of Storm lake and occupies a shallow but well eroded valley that passes directly south through almost the center of Sac county. In the eastern part of Levey township and the western part of Viola, the stream enters upon a comparatively very wide flood plain two or three miles in either direction. Here seems to have been an old time center of erosion, produced by the convergence of many minor streams, the Boyer the largest, all uniting to form a river that then flowed *east*. As one follows the course of the present river westward he is at once struck with the narrowness of the valley which trends now almost directly southwest. The excavation in section 32, Levey township, is less than a mile wide and grows narrower as one descends the stream; at length, just about Boyer station on the line of the Chicago & Northwestern railway, the hills no more than half a mile, or even less, distant, the flood plain is less than forty rods wide.

Beyond this point the stream valley gradually widens as we should expect, though still very narrow as far down the stream as Deloit, the terrane to be eroded being the same as we descend toward the Missouri flood plains.

The high ridge or divide spoken of in discussing topography is cut through just about where the valley begins to narrow in its southwesterly course, and it seems likely that here the present river occupies the channel of a stream once coming from the southwest. The present channel of the Boyer west of the divide was at that time occupied possibly by a small stream flowing as now southwest. The damming of the waters about Wall lake, made at first a great lake of all this wide flood plain valley, already referred to, and its overflow and final escape seems to have cut out the narrow valley now occupied by the Boyer, as described, from Herring southwest to the neighborhood of Deloit.

The Coon river.—The Coon river rises in the marshes of Buena Vista county, receives, or did receive, a tributary from Storm lake, traverses Sac county by a tortuous channel in a general southeasterly direction, makes a horse shoe bend and emerges from the county flowing northeast, about five miles north of the southeast corner.

Above Sac City the valley is generally narrow, with steep sides furrowed by hundreds of sharp little ravines indicative of recent erosion and general newness of topography; below Sac

City the valley is at first considerably wider, where it joins that of Cedar creek, a stream of perhaps so far equal volume. Below the mouth of the Cedar the valley is very much wider, more than a mile in width, with abundant gravel trains and benches of gravel and sand among which the current has lately excavated a crooked channel. At the entrance of Indian creek there is, of course, a natural widening. At school house No. 8, Coon Valley township, the valley is a mile and a half wide between banks, but from this on, especially where the river turns directly south, it enters a rapidly narrowing valley. Immediately south of Grant City the distance from bluff to bluff is certainly not one-half a mile and the flood plain of the present stream not more than half of that. Beyond these narrows the river turns north and, as stated, presently leaves the county flowing northeast in a somewhat widened channel.

The principal tributary on the west is Indian creek, a perennial stream flowing almost parallel to the Coon, rising in marshes in the north part of the county that to all appearance might quite as well have drained into the Coon. The history and relations of these streams to each other will be argued farther on.

All these streams are fed by springs. When not surcharged by storm-water the currents are clear and cool. The springs are not large, some might be better called seeps; but they are numerous, especially along the valley of the Coon. One such, or rather a group of such springs, supplies Sac City with water. These emerge on a gentle slope a few feet above the bed of a small creek that enters the Coon river from the east. There are no exposures that enable the observer to trace the origin of these waters but from the data at hand it is probable that they come out over the omnipresent blue clay.

There are similar springs near Grant City, some of which have origin above blue clay, others above a different clay or shale to be later on described, but in every case the springs seem to represent surface waters from no distant gathering ground, waters that soak through the looser overlying clays, drift and gravel and are finally sent out as they encounter a less pervious though by no means indurated horizon. A fine little spring rises in the southwest quarter of section 14 in Sac township.

On the whole these two counties are exceedingly well drained; some parts of eastern Sac are, of course, undrained and there are flats here and there elsewhere that must be ditched or tiled, but the drainage of by far the greater part of our territory is complete.

STRATIGRAPHY.

The stratigraphy of the land we study is for the most part simple enough. We have the usual sheets of drift, whelming the country almost absolutely from side to side, their members appearing in the ordinary sequence, covered withal over large part of the area by the fine clay-like deposit, which White named the bluff deposit, but which men nowadays familiarly know as loess.

This we say is *almost* universal. There do occur, nevertheless, in the extreme southeastern part of our territory some slight exposures of older formations, sandstones and shales, and there are along the river channels here and there deposits that are neither drift nor loess, deposits left as a product of erosion of sweeping waters: these are alluvial. With these two slight exceptions all the surface of the two counties is either simple or loess-covered drift.

The following table shows the sequence of the geologic strata with which we have here to do as they are now generally recognized and named:

GROUP.	SYSTEM.	SERIES.	STAGE.	FORMATION.
Cenozoic	Pleistocene	Recent		Alluvium
		Glacial	Wisconsin	Gravel trains Wisconsin clay
			Peorian	Loess
			Kansan	Buchanan gravel Kansan drift
			Pre-Kansan	Pre-Kansan drift
Mesozoic	Cretaceous	Upper Cretaceous	Colorado	Benton { Prionocyclus shales Chalk Shale and clay
			Dakota	Sandstone

CRETACEOUS SYSTEM.

The Cretaceous rocks of the world were so named because as exposed along the coasts of France and England, where first they were studied, these rocks are largely chalk. On either side of the straits of Dover they stand as great crumbling walls of white so friable that the wonder is they have not long since disappeared. It is strange enough to find this same crumbling material piled up away here in the middle of the American continent and to find by its fossils that it has the same age and history, and represents the same stage in the upbuilding of the world. The most distinctive fossils are microscopically small, but extremely abundant: so abundant that they actually make up a large part of the substance of this most singular material. These tiny fossils, greatly magnified, are shown in Plate VIII.

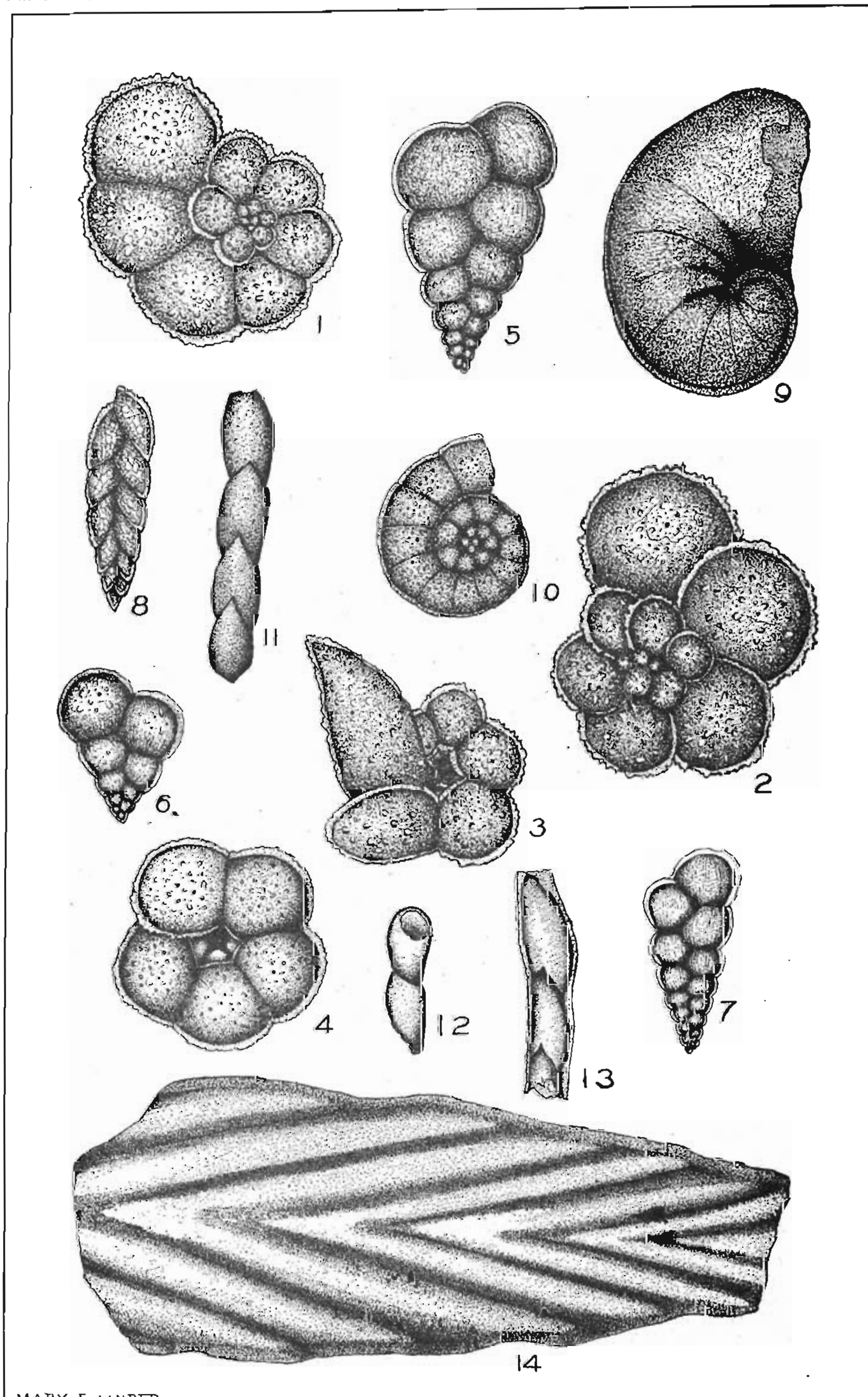
But these Cretaceous rocks are not all chalk. Mixed with the deposits of chalk are layers and sheets of limestone, beds of sandstone and clay and often thick deposits of marl and shale. In a very restricted area in southeastern Sac county we have a considerable variety of these deposits.

It remains to be said that the Cretaceous series of rocks often carries coal, sometimes of excellent quality, and that it probably immediately overlies, in many parts of Iowa, rocks of the Carboniferous or coal-bearing system, so that we are not surprised to hear reports of coal discovered by those who sink wells and other borings in our section.

DAKOTA STAGE.

The Dakota Sandstone.—The lowest strata of the Cretaceous rocks as we find them exposed in Sac county, are very friable, coarse-grained, yellow, heavy bedded sandstone. There is an exposure, some fifteen or twenty feet high, along the south bank of Coon river, just below Grant City. The beds appear to dip back under the hill in a southeasterly direction, but the exposure is so slight that this is not easily determined. The rock is so coarse and friable as to be easily crumbled in the hand, although it seems to harden somewhat in the weather. The lateral extent of this exposure is small. It may be definitely followed only for a few rods as here described; but the sandstone is reported by well diggers in many places in the vicinity, and is no doubt continuous far to the north and west.

Plate VIII. FORAMINIFERA FROM CREFACEAUS CHALK.



1, 2, 4 Globigerina cretacea d'Orbigny. 3. Globigerina digitata Brady. 5, 6, 7. Textularia globulosa Ehrenberg. Bolivina punctata d'Orbigny. 9. **Cristellaria complanata** Reuss. 10. Anomalina ammonoides Reuss 11, 12, 13. Nodosaria **consobrina d'Orbigny.** 14. Frondicularia sp?

This is the famous sandstone of western Nebraska and Dakota and all the eastern Rocky Mountain region. In the Black Hills, beds of it may be seen piled up hundreds of feet thick, so that our little Sac county exposure is only one of the most eastern outcrops of a vast formation, a formation that in this latitude underlies all the plains and prairies of the west.

Our little exposure has been brought to light by the erosion of the river valley here and is cut in two by a small ravine, now somewhat choked up by bowlders, sand and other debris. If one follows back a little way up this ravine he comes upon considerable beds of very tough clay, red and drab and white and yellow, sticky and plastic when wet, when dry almost as hard as rock and, where unaffected by the weather, possible of excavation only by a pick. This body of clay represents, probably, a formation known everywhere as overlying the Dakota sandstone, and called the Fort Benton shales. These clay or shale deposits as here revealed we now proceed to describe.

COLORADO STAGE.

Fort Benton Shales.—A few rods down the river from the point last named there is, next to the water's edge where the stream undermines the bank, a considerable exposure, ten or fifteen feet perhaps, of impure clay mixed with irregular laminæ and plates of hematite or iron ore, weathering and breaking up slowly into a confused mass to which the overlying soil and drift contributes. This formation probably forms here the bottom of the river, for across the river in the southeast corner of section 11, a little higher up the river, we have a similar exposure with intermingling layers of sandstone. Further west, but still in the southeast quarter of section 11, the clays and shales are exposed up some forty feet above the river and clearly high above the sandstone of section 12 as described in the preceding paragraph. Here we have a perfect exposure of the Benton shales. Materials from shafts sunk here by those looking for brick clay show a fissile, drab-colored fireclay-looking substance, to be excavated only with the pick, but weathering into fine clayey soil. In the material removed by digging was found a single fossil imprint, identified by Prof. Calvin as the imprint of *Prionocyclus wyomingensis,* a characteristic Fort Benton shales fossil, so that our horizon is so far determined.

Farther up the river, perhaps two miles, measured along the stream, we find at the water's edge a small exposure of pure bluish clay carrying a seam of jet black carbonaceous matter that seems to be largely clay as it refuses to burn when dry. The seam is about an inch and a half in thickness. There are similar outcrops here and there between the point last mentioned and that described in section 12, but none so pure or remarkable as this.

In lot 58 in the southwest of section 11, the face of the bluff shows a small but beautiful exposure of comparatively pure chalk. The material is white or cream colored, light, soft; so soft that it may be easily crushed in the fingers. The microscopic examination of this material reveals an abundance of the minute foraminifera which are characteristic of the chalk deposits of the world. The exposure at present shows only a few feet of the material, but it doubtless extends much deeper; probably down to some of the clay beds we have been considering since a spring hard by emerges apparently from the base of the chalk and above the impervious clay. This would indicate a chalk deposit of fifteen or twenty feet.

Above the chalk at this point we have lying in the surface detritus abundant fragments of limestone, evidently of local origin. The particular horizon to which these fragments belong was not discovered; we only know that it is above the chalk deposit just described. It is even possible that a section here might show chalk both above and below. At any rate the limestone fragments carry bits of the shells of *Inoceramus labiatus.* The topography does not indicate the presence in the bluff, of any considerable thickness of limestone. The hills are all eroded with comparatively gentle rounded slopes. It is probable that our *Inoceramus* beds here consist of no more than a single parting sheet or layer an inch or two in thickness.

A tentative table of the Cretaceous exposures at and near Grant City may be arranged in some such way as follows:

	FEET.
Inoceramus beds and impure chalk	?
Chalk	15
Pure blue clay with carbonaceous seams	5
Gray or drab colored shales, Benton	15
Coarse-grained sandstone, typical Dakota	12
Clays mixed with sandstones, with ferruginous plates and laminæ	10
	57

These are in every case moderate estimates. The total thickness, measured in altitude, may be less, but it seems that the Cretaceous came upon a surface already deeply eroded, so that one cannot reckon too closely upon successive horizons even where the rocky members evidently change.

PLEISTOCENE SYSTEM.

The isolated exposures thus far discussed, though sufficiently suggestive of what we may everywhere expect *beneath* the soils of these two counties, are insignificant indeed when compared to the vast bodies of clay and gravel, sand and drift to which we now give heed.

To the ordinary observer these are all alike, they are simply a confused mass in which rock of every description may be found in pieces of almost every size. It is, however, generally recognized that down under the surface soil at varying depths the color of the deposit changes. Everybody knows of the blue clay and refers to it as a datum line in connection with the search for water. This blue clay is also for the geologist a horizon of reference and marks for him the place of the most wide-spread member of the Pleistocene system.

KANSAN STAGE.

The Kansan Drift. The Kansan drift in Iowa is an almost universal thing and here underlies at various depths the entire surface of the two counties. As ordinarily exposed in different parts of the state the Kansan offers three phases;- *the blue clay,* an unweathered, exceedingly hard, tough or tenacious clay more or less sandy and filled with scattered pebbles and "nigger-heads" or hard bowlders, generally of moderate size, though sometimes quite large, with often pieces of half-rotten wood as well; *the yellow till,* simply the weathered phase of the blue clay and blending with it both in color and structure, through apt to be more decidedly intersected by curious irregular planes of cleavage, jointed, we say, the wood now all disappeared, and the joints stained by filtrations from above; and finally the *Buchanan gravel.*

As already intimated, the blue clay forms, in popular estimation, a sort of bottom to the whole surface series. Underneath it there is generally found a bed of sand or gravel with abundant water, and exploration ceases. These gravels have come to be known in American literature as Aftonian gravels and seem to indicate a still deeper sheet of drift.

The thickness of the blue clay varies greatly, as also the depth at which it lies beneath the surface. Wells are commonly reported in Sac county at twelve or fifteen feet where water is found above the blue clay. In some instances blue clay is reported at five feet below the surface. In Ida county the blue clay lies generally much deeper; often it is reported at twenty-five to forty feet. However, in Silver Creek and Galva townships the depth was given at ten or fifteen feet and about Holstein seven or eight. The thickness as quoted by well-diggers ranges from sixty to one hundred and fifty feet.

Exposures of the blue clay are seldom seen for the reason that the formation is naturally uncovered by erosion only. It is accordingly discoverable in the beds or banks of streams, in either locality generally covered by debris either from above or alluvial. However, there are exposures not a few, in all parts of the territory now before us. There are fine exposures along the banks of Porter creek in Ida county about the county line and below, where springs emerge above the clay. A cutting of the Chicago, Milwaukee and Saint Paul railway immediately north of Sac City reveals the blue clay at its base and in the ditch along the track. A seeping spring by the river, on the west side, near Grant City in the northeast of section 10, comes out from beneath a bed of remarkable ferruginous gravel and flows down over an exposure of very tough blue clay which appears to belong here.

*See Volume VIII of the present series of Reports, p. 215 and pp. 241-244. Also the Journal of Geology. Vol 6, pp. 176 et seq.

IOWA GEOLOGICAL SURVEY

MAP OF THE SUPERFICIAL DEPOSITS OF IDA COUNTY, IOWA.

BY

T. H. MACBRIDE.

1905.

Scale 1/125000

0 1 2 3 4 5 Miles.

0 1 2 3 4 5 Kilometers

LEGEND

ALLUVIUM

KANSAN DRIFT OVERLAIN BY LOESS

DRAWN BY F. C. TATE

IOWA LITHO. CO.

An exposure of the gravels in question was observed in section 27, Corwin township in Ida county, where in the valley of a small creek the following section was made out:

4.	Loess, yellow, of unknown thickness	
3.	Loess? bluish or blackish-blue	2 feet
2.	Ferretto zone	3 feet
1.	Gravel and sand	2 feet

The gravel pit used by Ida Grove, a mile or two southwest of the city is probably to be placed here, but the materials have been sorted over since.

An exposure of these gravels in Sac county has already received mention in connection with the blue clay near Grant City. Here the exposure is small and shows ferretto only. The iron is so abundant that it not only impregnates the water but forms immediate and extensive deposits in vegetation, on sticks and stones, all the way down to the river; in fact we have a chalybeate spring.

The most satisfactory exposures of the whole Kansan, indeed the whole Pleistocene system in this part of Iowa, are to be seen in Carroll county just south of our present field. Here in the recent cuts of the Chicage Great Western railway, east of Carroll, the face of the cutting is in some parts still fresh enough to enable us to read the succession of deposits.

Everywhere, however, the Kansan is represented by yellow or brownish-yellow till, made up of hard, jointed clays mingled with sand and bowlders or even with bowlders of sand revealed now by limited bodies or pockets of sand in the substance of the drift itself. These are not infrequently observed on the face of railway and highway cuttings. This phase of the Kansan is the common drift of Ida county, and in Sac county is discoverable everywhere west of Indian creek. East of Indian creek this whole formation is covered by a later drift presently to be described, but nevertheless exposures of Kansan yellow till are frequent, particularly on the west side of Indian creek and along the bluffs and banks of Coon river.

Buchanan Gravels.—The Buchanan gravels are less seldom observed than the Kansan drift. These followed in deposition immediately the withdrawal of the Kansan ice, were first subject to weathering and erosion, and are now represented in sectional exposures generally, by a line of sand or smaller bowlders capping the drift and separating it from the overlying loess. In many cases, however, the gravels rest immediately upon unmodified blue clay and seem not only unweathered and undisturbed themselves but seem also to have in some way prevented the oxidation of the lower member. These gravels are commonly heavily stained with iron, sometimes to the extent of consolidation more or less complete, forming dark or red-brown sheets and streaks extending horizontally sometimes for considerable distances. Such features have received the name *ferretto* zone (Italian *ferretto*, a small piece of iron).

From this locality the following section may be recorded:

5.	Wisconsin drift with bowlders	3 to 10 feet
4.	Loess with fossil shells	3 to 20 feet
3.	An old surface soil, more or less leached, carrying fossils, shells, bits of vegetation, etc	3 feet
2.	Ferretto zone	3 to 4 feet
1.	Kansan till, yellow	10 to 20 feet

A similar section may be studied just north of Sac City. This will be given farther on.

IOWAN STAGE.

The Loess.—Over all the hills and valleys of Ida county and the western half of Sac county, except the flood plains of the larger streams, there spreads a mantle of peculiar soil commonly named among the farmers as yellow clay, but, by White called bluff-material, because it abounds along the Missouri bluffs. In the present series of reports this yellow clay bears the name of *loess*, a word of German origin said to have been originally applied to certain calcareous, argillaceous or clayey deposits along the Rhine, but in the Mississippi valley applied to describe the wide-spread yellow surface deposits illustrated by the material now before us.

This loess forms the subsoil of the finest farming lands of Iowa. Its depth increases to the west, varying from a few feet in Sac county to many yards in Woodbury and Monona. Fine exposures are to be seen in every part of the region it affects, although sometimes on hillsides in the vicinity of the larger streams it seems to have been all denuded by storm water, or by the wind. In the cut immediately south of the Wall Lake station of the Illinois Central railway the Kansan drift is exposed for twenty feet or more, but there is no trace of loess, though here to be expected. The same thing is true of all the slopes and hilltops along the Boyer river in the neighborhood of the town of Wall Lake. In the southwest quarter of section 29, Wall Lake township, a well in process of excavation showed loess six feet. Eighty feet of drift was encountered here above the blue clay, and thirty feet below this lay a considerable forest bed.

Fine exposures of loess *conforming to an eroded* Kansan surface may be seen on the line of the Chicago Great Western railway,west of Carroll. The railway cuts in Ida county are too old to be of service here. But there is a fine exposure of loess lying immediately upon the Kansan drift at the bridge by the old mill near Ida Grove. A bowlder lies directly in the line of contact; there is no indication of weathered material and no gravel or ferretto. The loess is reported at twenty feet in thickness on the hill above.

On the heights south of Ida Grove, in south Corwin township, the loess is much lighter, full of *loess kindchen* or concretionary little lumps of lime, and sometimes passes into fine sand. Along the Odebolt, east of Ida Grove, there are considerable exposures of sand, and these are in some instances at least capped with loess of the more sandy type.

WISCONSIN STAGE.

The Wisconsin drift.—The whole of eastern Sac county, as already stated, has a peculiar topography; it has its own stratigraphy and history as well.

If one drives east from the town of Early two miles to the school-house No. 1, he will find just east of the school-house a small hill on the south side of the highway. The exposure or bank formed by the cutting for the road shows loess, such as just described, covered by about fifteen feet of drift. This drift is different from the Kansan, here far below, and extends eastward and northward and northwestward for many miles in northern Iowa. If we could turn north at the school-house named we should find a similar exposure on the north side of section 2 on the west of Indian creek, and we should find the same drift following the creek, about one-fourth of a mile east of school-house No. 7, Delaware township; while school-house No. 4 in the same township sits upon a low hill or mound of the same material, and school-house No. 3, two miles farther north, is just a little west of a swell of similar material.

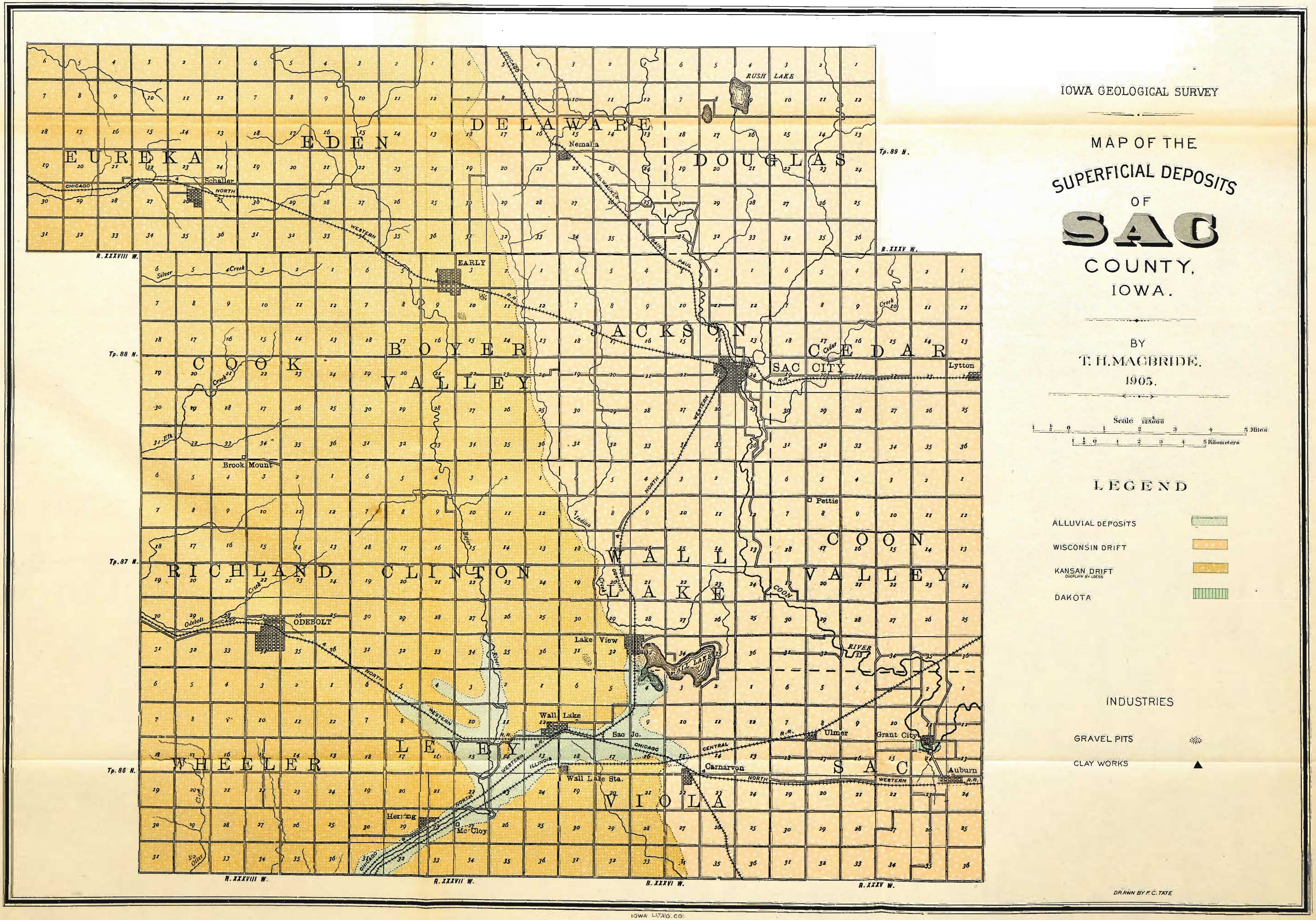
Could we turn south at the school-house first named, No. 1 in Boyer Valley township, we should be able to trace the same peculiar drift all the way down Indian creek, mounds of sand and gravel often appearing generally a little east of the stream, although evidences of the Wisconsin were traced in sections 23, 26 and 25, Boyer Valley township.

In fact, Indian creek is fairly the western border of the new drift all across Wall Lake township to the town of Lake View. Sometimes bowlders, gravel patches, etc., suggest that the Wisconsin ice reached the western slopes leading to the creek, but in general the west bank of this little stream is Kansan and the east Wisconsin.

But it is time we defined more particularly the drift last named.

The Wisconsin drift as shown in Sac county exhibits two phases, it is either in the form of a calcareous, grayish-yellow, pebbly clay, rather light and loose, never jointed or ferruginous; or it occurs as piles of fresh-looking gravel and sand often where cut through, cross-bedded and water laid.

An illustration of typical Wisconsin drift may be seen by anyone entering Lake View from the east along the north shore of the lake. The road cutting offers a fine exposure, ten or fifteen feet high. This section may be compared with the sections in the cut south of Wall Lake station on the Illinois Central railway, by anyone desiring to note the difference in composition and color between the newer and older, the Wisconsin and the Kansan drift-sheets. Wisconsin gravels may be seen in the gravel pits at Lake View as well as in many another section among the sandy hills north of the town, as in section 17, Wall Lake township. Where the Wisconsin drift is level, the


IOWA GEOLOGICAL SURVEY
MAP OF THE
SUPERFICIAL DEPOSITS
OF
SAC
COUNTY,
IOWA.
BY
T. H. MACBRIDE.
1905.
Scale
5 Miles
5 Kilometers
LEGEND
ALLUVIAL DEPOSITS
WISCONSIN DRIFT
KANSAN DRIFT
OVERLAIN BY LOESS
DAKOTA
INDUSTRIES
GRAVEL PITS
CLAY WORKS
DRAWN BY F. C. TATE
IOWA LITHO. CO.
EUREKA
EDEN
DELAWARE
DOUGLAS
COOK
BOYER VALLEY
JACKSON
CEDAR
RICHLAND
CLINTON
WALL LAKE
COON VALLEY
WHEELER
LEVEY
VIOLA
SAC
RUSH LAKE
Nemaha
Schaller
EARLY
SAC CITY
Lytton
Brook Mount
Pettis
ODEBOLT
Lake View
Wall Lake
Sac Jo.
Ulmer
Grant City
Carnarvon
Auburn
Wall Lake Sta.
Herring
Mc Cloy
Tp. 89 N.
Tp. 88 N.
Tp. 87 N.
Tp. 86 N.
R. XXXVIII W.
R. XXXVII W.
R. XXXVI W.
R. XXXV W.

soil is exceedingly black and rich, fine-grained and inclined to be sticky, "does not sour" says the farmer. There are sections of such soil on the flat prairie immediately west of Sac City.

The relations of this Wisconsin drift to the older Kansan are well shown in an exposure in the northern part of Sac City or just north of the city limits. Here on the west side of the Chicago, Milwaukee and Saint Paul railway tracks appears the section already noticed. The section is as follows:-

5.	Wisconsin drift, with calcareous pebbles, bowlders, etc., and surface soil	3 feet
4.	Loess, more or less leached, whitish	2 feet
3.	Ferretto, a ferruginous line	6 inches
2.	Kansan drift, yellow till	20 feet
1.	Blue clay, exposed by digging	

This exposure may be traced with more or less clearness along the west side of the railway tracks.

The exposure in the cut east of Carroll may now be compared. While the limits of the Wisconsin drift as overriding the older deposits may generally be fairly well determined by surface features, sections that show the actual situation are not common. The valley of the Coon river at Grant City to which we have already given so much attention affords another section of the same sort, although not quite so satisfactory since the loess is lacking. The exposure affording the section is found on the south side of the Hicks road leading west from the main road from Auburn to Grant City. The section here is as follows:

4.	Wisconsin drift	15 feet
3.	Gravel and sand	4 inches
2.	Kansan drift	30 feet
1.	Talus covering, unknown	10 feet

The town of Grant City rests apparently upon a bed of Kansan. Just above the mill the crest of the hill shows some very ferruginous gravel. Wells in the town are said to be twelve to eighteen feet in depth and to furnish abundant water from quicksand. This may represent the Buchanan stage. The soil in town is more loess-like and is successfully used in the manufacture of brick. The valley of the Coon here is very new; the channel of this peculiar bend was cut since Wisconsin times or during the time when the Wisconsin ice was receding. The drainage waters moving south from Sac City in what was probably the old channel of some stream, if one may judge by its size or width, were headed off on the southeast by the Altamont or terminal morainic hills which occur about Auburn. These hills are not high, but they are there, and were sufficient at the outset to shunt the southward flowing waters to the northeast, making the curious and otherwise inexplicable bend around the site of Grant City. The narrowness of the chaunel here, not this alone proclaims its newness; but all the tributary channels here as well. Look at the deep canyon-like valleys approaching from the south, their precipitous walls still uneroded. The east and west road south of Grant City bridge follows a "hog-back", in places just broad enough for the highway. It is to this newness that we owe the Mesozoic exposures already proved so curious and interesting. In an older valley these soft sandstones, chalks and shales had long since disappeared by the sweep of perpetual, long continued erosion. A fine morainic ridge extends east and west about the latitude of sections 25 and 26 in Sac township. Auburn owes its comparatively high location, locally high, to the moraine. The schoolhouse and the Roman Catholic church, are plainly on morainic swells, and behind the church, northward is a sand-pit telling the same story. These are morainic knobs. A singular marsh between Auburn and the river is another peculiar fact evidencing a recent disturbance of the original drainage of the country. Here are ponds of water within a short distance of the river and some of its tributary streams but yet undrained, draining possibly in the opposite direction to meet the river possibly farther down. There is a very pretty little mound north of the highway in section 13 of this same township. In fact when we come to look at the matter, all the geology of the two counties is centered here, or at least may be studied here within the area of a few square miles.

These Auburn hills and those already referred to along Indian creek, those about Wall lake, are part of the local terminal moraine; i. e. they mark in a general way the westward limit here of the sheet of ice that some thousand of years ago spread this newer drift. Had the ice pushed farther west, these hills had been all spread and flat like the marshy prairies farther east. It is interesting accordingly to know their limit. We have seen that in the north part of the county they are limited by Indian creek. Indian creek, however, north of Wall lake, turns east among the hills and finds its way into the Coon river, while the hills sweep on around the lake, curve around towards Carnarvon and leave the county somewhere about north of Breda. The reader may consult the accompanying map. These hills accordingly form part of a belt of such topographic features extending from Minnesota more or less continuously far south and southeast and we have but a section of this belt. It appears too that the Indian creek drains the outside, or western edge, of the general moraine, while Coon river follows the inside, or the eastern edge.

The Wisconsin Gravels.—It remains for us to describe still another formation in this connection. At the time of the melting of the Wisconsin ice considerable floods of water, we must believe, especially in summer, made their way from the front of the receding glacier. Not only so but these floods carried with them enormous quantities of gravel and sand, with finer silt as well, of course, which were carried and spread far down the principal channels of escape. Evidences of this are to be seen on every hand when one approaches a glacial border. Sac county is by no means without its typical illustrations.

In the first place the Coon river itself, acting in those days as a drainage channel, was filled with gravel, wherever an old channel existed, from side to side. As the new channel at Grant City was deepened and the floods at length subsided, the residual stream cut out the present channel for the current and its narrow flood plain and left the accumulations of gravel as high terraces all the way along its course. Sac City is situated upon one of these terraces, gravel trains they are called, and another may be seen at the crossing of the river between sections 29 and 32 in Coon Valley township, and indeed all the way along the wider part of this valley.

Again part of the Wisconsin drainage from the vicinity of Early seems to have gone out by way of the upper Boyer. This was apparently choked off somewhere about Carnarvon, for it became filled with gravel and sand from Early south to the great marsh already described, and occupies to-day in many places a channel re-excavated since that time. About Wall lake the escaping drainage was also slow, the current was not strong enough to carry it away, and vast bodies of gravel were deposited close to the glacier's front. Lake View is situated on this terrace and the excavations south of town give us some indication of the depth and amount. This deposit probably continues away to the bend of the Boyer already referred to.

There are signs too that the glacial drainage at first entered the upper Boyer from the country east and south of Storm Lake. In sections 1, 2 and 11 of Eden township is a widely excavated valley, probably part of some earlier stream-bed now filled with gravel, but occupied by a small creek fed by little springs that seep here and there from the banks. The present rivulet can hardly have excavated this abrupt valley, nor is it efficient now to do more than form a small winding channel in the wide bottom. About Early are considerable and not infrequent deposits of gravel that represent probably an over-wash from the drainage of the Wisconsin front. Thus the school-house rests upon a gravel mound. The cemetery east of town occupies such a hillock. In fact the town's supply of water is reported from gravel at a depth of 12 feet. One-half a mile east of town is a gravel pit with the following section:

4.	Surface soil	1 foot
3.	Yellowish gravel	4 feet
2.	Pale, buff-colored, sandy clay	1½ feet
1.	Gravel with ferretto streaks, of depth unknown; exposed	6 feet

This in section 10 of Boyer Valley township. In the southwest quarter of the same section is another gravel pit more extensive. Here we have the following section:

4.	Surface soil	1 foot
3.	Ferruginous gravel with rotten bowlders	6 feet
2.	Fresh looking gravel, mostly sand, no iron	5 feet
1.	Water-laid, cross-bedded sand of unknown depth; exposed	15 feet

Farther south in the southwest quarter of section 3 of Clinton township is more gravel and sand and so in different places along this part of the Boyer valley.

It is difficult to account for these exposures or deposits on any other theory than that possibly at one time or some time in course of the advance or recession of the Wisconsin ice this part of the present Boyer valley served as a drainage channel from its front. Perhaps at that time the ice had not covered the region of Wall lake and south, and the drainage was chiefly this way, but was later cut off to the east and south as already suggested, and the Boyer then first slackened in rapidity, then became entirely choked, making a lake not only where we find Wall lake now, but far to the west until at length an exit was found to the southwest by the way of the Deloit narrows.

For its confimation or rejection such speculation will require more exact and long continued study than has been possible in the present survey.

Alluvial Deposits.

Closely related to the deposition of gravels just described lies the latest deposit of all in the territory we discuss. But whereas the gravel was laid down under other conditions by floods that have long since ceased to act, the alluvium is a constant accumulation due to erosive forces acting since the ice retreated, and acting all the time. There is much alluvial soil in the valleys of the older streams. The wide flats of the Boyer valley and even some parts not so wide show great quantities of alluvial soil. In the neighborhood of Herring the Boyer winds about in a bed of deep black soil, does not often reach the underlying sands, and not a bowlder is to be seen in the whole flood plain. Everything is covered with alluvium. The same thing is true of the narrower valley of Soldier river, of the valley of Battle creek and to some extent also of the Odebolt and Maple. The accumulations from surrounding slopes and hills, held by vegetation through thousands of years, were gradually filling up their valleys faster than stream and storm water could carry the soil and sand away. In the vicinity of Ida Grove these alluvial deposits are as much as fifteen feet thick, and are probably nearly as extensive along the Boyer. Since the occupation of the country by civilization erosion on the slopes is much more rapid but the discharge of storm water unchecked by the old-time vegetation of grass and sedge is also more rapid and violent, so that alluvium is not only not accumulating, probably, at present, but is diminished year by year by the floods of spring.

Soils.

The soils of any locality, using the term to designate the loose surface materials appropriate to man's use in the cultivation of the earth, vary according to the nature of their origin. Soils arising from the decomposition of limestone rock will have one character; those from sandstone manifestly another. The soils of the counties we are studying are all so uniformly good that people sometimes think them all alike and yet they differ decidedly. We have before us soils of at least three distinct types: we have the soils developed upon loess, upon drift and the alluvial soils just described.

The loess soils prevail, as has been seen, over by far the larger part of our area. These soils are exceedingly fine in composition and excellent in fertility. There are probably no better soils in the world than those about Odebolt. Indeed, the whole of Ida and western Sac may be cited as a region unexcelled in natural adaptation to ordinary agriculture.

Eastern Sac, as has been shown, has a different history and shows a different though likewise excellent soil. Here the subsoil is always drift, either the Wisconsin pebbly clay rich in lime, or the lighter, more sandy body of the moraine. The latter gives the lightly tilled, warmer, quicker garden soil just east of Indian creek or south of Auburn: the former finds illustration in the black prairies just west of Sac City. The gravel trains in the wider parts of the Coon valley also afford a lighter, somewhat sandy soil.

About Grant City the hillsides are still exceedingly steep for reasons above set out. These steep bluffs were covered with forest and were better adapted to such purposes. They are too steep to cultivate, and even as pasture fields are comparatively worthless. If completely denuded, they will again yield to the forces of erosion not only to their own undoing but to the destruction of the fertile flood plain that lies below, covering this with masses of sand and gravel from the falling slopes.

Similar slopes covered with native wood appear at Ida Grove and here and there along the Maple river. Those near Ida Grove contribute much to the beauty of the locality and should for public reasons, if for no other, be kept wooded forever. Nature has herself indicated in such places the appropriate crop, and our wisdom shall not soon transcend hers. These steep hillsides and sharp ravines, very few indeed, constitute practically the only untillable parts of these favored counties. The few marshes in eastern Sac can be drained and then are tillable as any.

ECONOMIC PRODUCTS.

From an economic standpoint the soil of the field is the best thing to be found in these two counties; nevertheless we have already encountered several sorts of material which may be advantageously used in manufacture. Perhaps the first of these in relative importance is

Clay.

Clays suitable for making brick occur in many places. Indeed in the loess-covered part of our area there is no lack of material ready to hand. The loess of eastern Iowa is everywhere used for this purpose with satisfactory results. The same material is used in Lyon and Sioux counties. Nevertheless the manufacture of brick at Ida Grove seems not to have been a success. The material used was a rather sandy loess found a short distance east of the city. The reason for abandoning the enterprise could not be ascertained.

At Grant City, Mr. George Hicks has been burning brick on a limited scale for many years. The material is a sandy, light, silt-like soil found at the surface. The brick are of fair quality and have been used in construction of buildings in the village, buildings which present a very creditable appearance indeed. Last year (1904) Mr. Hicks burned about 50,000 brick. So far as could be ascertained this is the only brick-yard in Sac county. Wood is the fuel used.

The clays and shales which have been described as Benton shales on the pages preceding, are now being made the subject of experimentation. A very considerable body of this shale can be easily exposed a short distance southeast of Grant City, and, as the samples shown are entirely free from objectionable materials, there would seem to be no reason why brick and tile of the hardest and finest might not be made at Grant City. Fort Dodge coal is not far away by direct railway connection. This same material was successfully used five or six years since at Hawarden, making an excellent brick of "yellow red" color.

There are other clays in the neighborhood of Grant City that deserve attention; a bed above the sandstone in the southwest quarter of section 12 should be made the subject of experiment. Any of these exposures, if of sufficient extent, should be better than the pebbly clay of the Wisconsin drift, because free from lime.

Gravel.

The gravel beds of Sac county are of great extent and of no small economic value. At Sac City a bed near the Chicago, Milwaukee and Saint Paul railway station is used in the manufacture of artificial stone. In the absence of bedded rock and of clay suitable for making brick, in this vicinity, the manufacture seems very promising.

The gravel beds at Lake View have for many years furnished ballast for the Chicago & Northwestern railway, and hundreds of car-loads have been hauled away for such in all directions. Gravel for such purposes may be found all along the course of Coon river.

But perhaps the most important local value of these vast gravel deposits and banks lies in the increasing employment of such material in the construction of streets, highways and walks. The people of Iowa have just begun to build good roads, and once the movement becomes general, as it is sure to do, these piles of convenient gravel will be reckoned not the least of the economic resources of certain fortunate counties. Hardly a town in northwest Iowa but has somewhere its gravel pit, and even the country roads are beginning to show the effect of systematic gravel treatment. Lake View, a small town of six hundred people, has cement walks almost continuously on every street. This indicates the future of the gravel once deemed worthless. Such material in Ida county is not so abundant, but there are some pits already in use. One about two miles southwest of Ida Grove supplies that little city with constructive materials. Others of less importance are used by the farmers in different parts of the county.

Lime.

The Cretaceous chalk already described was at one time extensively mined on the north side of the bluff where occurs the present exposure and burned for lime. The excavations have long since been filled, and overgrown with small trees, but traces of the kiln may be seen. The lime was used by the pioneer of this section in lieu of better, but was unsatisfactory because of the rapidity with which it set, perhaps because of its purity, chalk being one of the purest forms in which lime, or calcium carbonate, occurs. The chalk at Grant City has not been analyzed, but would probably compare closely with that of Plymouth county, analyzed several times, and showing a large per cent of calcium carbonate and very little magnesium. Now it seems that the magnesian limestone makes a better lime, not a whiter lime or a purer lime but a lime more easily used. Our chalk beds are accordingly not of service in the manufacture of lime. Such chalk, however, is sometimes used as an essential constituent of cement, and it is possible that the deposit may one day be of value for this purpose; but this cannot be predicted without exact analysis..

Building Stone.

Bedded rock suitable for constructive work does not occur in either county. The Grant City sandstone is too soft and friable for the purpose. Bowlders are practically the only building rock to be had. In eastern Sac these were once common, but have been largely picked up, although a great many are still to be seen. They abound about Lake View, Wall Lake, as has been seen, and along Indian creek. In Ida county bowlders are comparatively scarce. Even a stream like Soldier river does not seem to uncover many so deep is the alluvium of the valleys.

Coal, Oil, Gas.

So far as can be ascertained there are no exposures of coal in this region. The nearest approach to coal that has been encountered is found in the seam of carbonaceous or black clay to be seen along the Coon river near the water's edge at Grant City. Coal has been reported again and again by those who have sunk shafts for the purpose of investigation. It appears that a company of practical miners at one time set up machinery and sank a shaft some hundreds of feet between Auburn and Grant City and found coal in veins of considerable thickness, but were deterred from further attempts on account of the fact that the overlying strata gave no promise of sufficient roof to make mining practicable or possible. The late Mr. J. P. Carr of Grant City reported the sinking of exploratory shafts in the north half of section 12. Coal was first encountered at a depth of 150 feet where a seven inch vein was pierced. At 160 feet a second vein was reached which proved to be twenty-three inches in thickness "very good coal". Disagreement among those in charge of the investigation led to the abandonment of the enterprise at this interesting juncture.

Similar explorations and results are reported from the neighborhood of Sac City. It appears that at one time the county supervisors offered a considerable prize for the discovery of coal in the county, "$4000 for a four-foot vein of coal" it is said; but the reward was never paid. There are however many men who are convinced that coal exists beneath a considerable amount of overlying drift.

As would appear from facts recorded, the rock formations immediately underlying the drift in Sac county are of Cretaceous age. Now the Cretaceous rocks do, in some parts of the country west of us, carry coal and good coal at that. But the Cretaceous of Iowa so far has yielded no good coal. In Plymouth county, almost directly west, the Cretaceous coal has been quite thoroughly explored. A vein of coal a foot and a half thick may be seen along the bluff by the Sioux river in section 32, township 91 N., range 48 W. This vein is, however, of poor quality, a lignite in fact; and careful investigation demonstrated that its mining would be unprofitable.*

*The student is referred to Vol. VIII of the present series of Reports, p. 361.

It is of course possible that better veins may be reached farther east in Cretaceous strata, but the probabilities are all the other way. It is furthermore possible that outlying bodies of coal belonging to the Fort Dodge coal fields may be found farther west, beneath these Cretaceous rocks; but it is very doubtful whether the Carboniferous rocks were ever laid down in northwestern Iowa at all; and, even if they were, it is yet to be shown that any that may exist below the Cretaceous contain coal. The chances that such is the case are believed to be small. A five-foot vein of coal was reached near Le Mars at a depth of 381 feet which it is thought may be Carboniferous.*

As for oil and natural gas, the state of the case is much the same. All that is known on the subject discourages expectation of profitable ventures in the oil industry. Every deep well that is sunk is a test along these lines. There are in northwest Iowa hundreds of these wells and not one so far has revealed the presence of bitumen or oil. Of course, the oil promoter has not omitted to visit various places in Iowa and to make all necessary finds, at Danbury, Manilla, Greenville and elsewhere; but in none of these cases was the outcome satisfactory to local interest. Certain gases are developed wherever organic matter undergoes decomposition. Such gases sometimes accumulate in pockets under and in the drift; usually in limited quantity. But generally speaking the conditions for the accumulation of gas and oil are lacking in this part of Iowa. The whole matter of gas production in Iowa rocks has been well discussed in the administrative report in Volume eleven of the present series, and need not be further elucidated here.

Water Supply.

The streams already described under drainage afford in these counties a constant source of water supply to the valleys through which they pass. The Maple river, Battle creek, Soldier river, Coon river, the Boyer are all perennial streams, largely fed by springs, but acting also as channels for the discharge of vast floods of storm water on occasion. Cedar creek in northeastern Sac county is also a fine stream of clear water the year round. so reported.

*Iowa Geol. Surv., Vol. VIII, p. 364.

As in other parts of the prairie country, however, the chief dependence for water is upon wells. Every little city almost has water-works supplied from a town well which is more frequently a large excavation in a convenient bed of gravel. This is the case at Lake View, Wall Lake, Odebolt, Ida Grove, and Early. Sac City has a fine supply in springs already described. while Holstein boasts one of the deepest wells in the country, 2004 feet deep. Ordinary wells are thirty to forty feet deep and the water rises to within seven or eight feet of the surface.

On the farms shallow wells are still in common use, ranging in depth from twelve to forty feet. In fact so far, the water supply has been abundant, good and easily accessible.

Water Power.

The Coon river and Maple are both sufficient in constant flow to be serviceable for water power. Dams have been erected at several places and those at Ida Grove on the Maple and at Sac City on the Coon are still serviceable. At Grant City the water power did service for a long time both for grinding and sawing, but the dam has been carried out in part and lies a ruin, while steam has lately been set to run the mill. The distance across the bend of the river is so short, much less than a mile, that a tunnel has been more than once suggested which would probably give us water power abundantly sufficient for electric light, and all purposes of manufacture.

ACKNOWLEDGMENTS.

Thanks are due to many persons living in the two counties, who have abundantly aided in the investigations here recorded: more especially to Mr. G. M. Parker, Mr. George Hicks, Auburn, Mr. Chas. Kent, Grant City, and Mr. Chas Pelumlder of the same village. Mr. Pelumlder has checked up the list of woody plants in the notes following. Thanks are also due for determination of fossils, to Professor S. Calvin, former director of the Survey.

FORESTRY NOTES FOR SAC AND IDA COUNTIES.

To one less familiar with the flora and natural resources of the State the presence of natural forest in the counties that make up the northwest prairie is a matter of continued surprise. There are to be found residents even, who will gravely assert that when the pioneer first visited many of the counties of the northwest there was "not a tree in the county fit for a fence-post." The pioneer himself, if he still survive, knows better; he was more observant. He will tell you that not a single county in the whole of Iowa was ever without some indications of native forest.

It is surprising, too, the variety of forest trees that still find foothold even in counties most lacking in forest conditions, and accordingly in native trees. All the prominent tree-groups are represented from one side of the State to the other, and from north to south. Of course, this does not mean that the State was forest-covered; far from that; it means simply that all the more common trees that characterize our northern woods could be found in all parts of Iowa if one took trouble to explore. The annual prairie-fires, where these had sway, usually moving from southwest or west, were hot enough to keep down all manner of perennial vegetation; that is, to keep it well below the surface of the ground. Only those plants whose persistent parts survive the winter underground could stand the usual prairie fire. Trees are perennial plants, but if they started on the prairie they were burnt off at the end of the first season and if a shoot came from the root, it suffered the same fate again, and so on, year after year. Some trees could endure in these circumstances, but comparatively few. The bur oak, for instance, held on in this way, often for years together, producing at length a peculiar stump-like growth just above the ground, known to the pioneer as a "bench-grub." Sometimes two or three favorable years following in sequence a shoot would manage to start towards treehood and by and by a veritable tree or cluster of trees made up the forest of the prairie, the open grove of stunted or dwarfed bur oaks.

It chanced, however, over all the wide prairie there were found here and there localities where conditions topographical checked more or less efficiently the sweep of the annual fires. There were localities over which the fire seldom or never passed. Tree seeds that found by any means lodgement in such places grew, grew as thriftily sometimes as anywhere, rainfall and other climatic conditions being the same. Such localities were lands protected by lakes or ponds or bending streams or sterile grassless rocks or dunes or precipitous banks of streams. In all such places, and there are such in every region of the State, trees and shrubs of many kinds found not incongenial home and persist today in spite of the fact that the soil-greed of men is today less sparing than the old-time annual fire.

In Ida and Sac counties were several of these sheltered nooks still marked by groves of native trees. Ida Grove, the county town of the first named county, still conveys by its very name a memory of primitive conditions. A steep bluff, facing the southeast, swept by the encroaching Maple river at its base, afforded on all its precipitous sides, and in all its tributary ravines and valleys a suitable home for trees; there they were and there they are. Other similar nooks and steep hillsides along the Maple further north in the same county offered groves of similar character which in turn gave shelter to the homes of the earliest pioneers, and some old trees of the primeval forest in these localities are reported as yet standing.

In Sac county, the Coon valley, cut in many places deep down through walls of drift, and seamed by sharp, short, gully-like valleys leading in the tributary waters, offered all along its course conditions suitable for the protection and establishment of the forest and there are evidences still that a real forest in such places was not lacking. Stumps of large trees are encountered all the way up and down the river and occasionally, on the land of some pioneer still living, some of the ancient trees may still be seen, the seed-trees of the present forest where this is allowed to grow.

It is noteworthy that native trees seem to have been never abundant about Wall lake. There is a small grove on the north side of the lake protected by the contour of the shore, and there are a few trees on to the east where many have been planted; but it is even reported that Wall lake had originally no trees at all. This is, however, a mistake; there were a few oaks, elms, and representatives of other species.

The following list includes the woody plants noticed in passing through the two counties described. It is probably not complete; but it is hoped that local students may take heed and be able to report additional species.

Tilia Americana Linn. Basswood. Linden. Linn. The linden grows abundantly in our wooded districts, and at the "settlement" of the country showed rather fine trees. Basswood lumber was at one time as common at the saw-mill as any other, except oak; but it is now seldom seen. The wood is fine-grained, soft, easily worked and useful for a great variety of purposes, durable enough if protected from the weather, but rotting in a year if left wet. The tree has an unpleasant way of coming up from the root which offers in the forest often three or four trunks in a place and makes the species less desirable for the street. Fine rows are, however, to be seen in many cities. The flowers of the linden afford food for bees and are the source of one of the most famous varieties of honey.

Xanthoxylum Americanum Miller. Prickly ash. The prickly ash is not an ash at all, nor at all thereto related. It is a rue, a family of plants little known among us. The hop-tree, not the hop, nor the hop-hornbeam, is a cousin. Our prickly ash is a shrub, common along creek and river-bottoms, with greenish flowers that come before the leaves and give rise later to dull reddish pods with one or two black seeds in each. Not without value, perhaps, as an ornamental shrub.

Acer Saccharinum Linn. *Acer dasycarpum* of authors. This is the common soft or white maple of all the prairie country. Probably native in all special localities above described, it has been universally planted and is still offered in nurseries. One of our most useful trees on account of its rapid growth, hardiness, freedom from insects, it has had a prominent part in the settlement of our State. The wood makes excellent fuel but is otherwise, at least in Iowa, of small value. The limbs are long and generally flexible, but suffer from the storms of summer unless the trees are in groves sufficient to protect and shelter one another. The practice of polling or topping this tree where planted for ornamental purposes, although now well-nigh universal, cannot be too strongly condemned. Such treatment simply ruins the tree, ruins its form to begin with, and sooner or later invites the destruction of decay.

Negundo Negundo (Linn.) Sudw. *Acer negundo* and *Negundo aceroides* of authors. Box elder.

The box elder, like the maple, was a favorite with the early planters. Like the maple it had in its favor hardiness, rapid growth, and a habit that affords abundant shade and shelter. Its wood also makes excellent fuel. As a lumber tree it has no value and in these later years it has been infested by a species of the Coreidae *Leptocoris trivittatus,* the box elder bug, to such an extent as to make the tree itself objectionable. Other and better species may henceforth well take the place of the maple, cottonwood and box elder, in the farmer's plantings.

Vitis Riparia Michx. Wild Grape.

The wild grape is common everywhere near streams and since the prairies have been cultivated, has become common also on farms, in planted groves, in hedges and even along the lines of barbed-wire fence, converting these betimes into more sightly green hedges. The fruit, late-ripening, is much esteemed for its fine flavor, not by birds and boys only, or such wild creatures, but by the cook as well, who finds no jelly quite equal in subtle aroma to that made from these native fruits of the thicket.

.*Ampelopsis Quinquefolia* Michx. Virginia creeper.

This is perhaps the most common woody vine in the State. It springs up everywhere along fences in field and garden and climbs over thicket and grove. Trained about the porch it is a permanent and handsome ornamental vine, attaching itself alike by tendrils and by very curious little clinging disks, by which these on occasion terminate, so that the Virginia creeper may cling to a dead stump, a wall, an unpainted house or barn, and well deserves the name "American ivy". Care must be taken to distinguish from this plant the so called "poison ivy" which has its *leaves in threes;* the Virginia creeper has *leaves in fives;* hence the scientific name; *quinquefolia* means five leaves.

Celastrus Scandens Linn. Climbing Bitter-sweet.

The bitter-sweet is a common vine in thickets along the Coon river. It is singularly destructive of smaller trees, practically choking them betimes, by the twisting of its coils about the stems. It springs up easily from bird-scattered seeds and also rises everywhere from far-spreading orange-colored subterranean stems or roots. In autumn the ripening yellow or orange pods break open to display to birds, and other keen-eyed lovers of the beautiful, the scarlet seeds and the vine becomes ornamental.

Amorpha Fruticosa Linn. Wild Indigo Bush.

This is rather a pretty shrub about six to ten feet high, common along water-courses in the wooded districts. The flowers in summer are rather showy, deep indigo blue with yellow centers. Their color and abundance make the bush attractive as a possible ornamental plant—its only known possible economic value.

Gleditschia Triacanthos Linn. Honey Locust.

The honey locust is one of the fine trees of our northern forest. It grows with rapidity in good soil, preferably sandy, and makes magnificent wood suitable for all sorts of purposes, posts, lumber, fuel. The thorns with which the trunk and branches are abundantly armed suggest a desert origin, and are the great objection to the cultivation of the tree. Nevertheless the honey locust is found throughout our northern woodland and is not in the desert, and we have a variety without thorns but otherwise indistinguishable. The thorny variety is sometimes kept low by trimming and makes a fair hedge; the thornless trees ought to find place in the farmer's wood-lot.

The black locust, *Robinia pseudacacia,* occurs here and there in cultivation. This is another valuable tree; unfortunately often affected by borers. Recently these seem less injurious. If we can get rid of the insects, there is no better tree for general purposes; spreads by the roots and makes a forest by itself.

The coffee-bean tree, *Gymnocladus canadensis*, is here to be expected, but was not observed nor reported.

Rhus Glabra Linn. Smooth Sumac. Sumac.

The sumac is an exceedingly common shrub, appearing even on dry hillsides apart from all forest growth but in places not swept by the hotter fires; useful only as an ornamental plant.

Its leaves in autumn have their own peculiar red to contribute to the general autumn splendor and the fruit its deeper crimson.

The staghorn sumac, or velvet sumac, *Rhus typhina,* deserves introduction. It extends west along the north to Winnebago county and is a handsome native ornamental tree.

The three-leaved ivy, or *poison ivy,* an unmitigated nuisance, is a sumac and belongs here. It no doubt occurs in this district but was not observed.

Ribes Missouriense Mx. Wild Gooseberry.

An extremely thorny and prickly bush is this, common along western streams where other woody species occur; the fruit is generally unarmed and is gathered freely by women and children. What the plant might offer in cultivation is not known. It might by crossing bring greater hardiness to our cultivated sorts, already worn, and certainly merits cultivation and experiment.

Ribes Floridum L'Her. Wild Currant.

The wild black currant is a thornless handsome shrub, ornamental and innocuous. The flowers in May hang in fine large racemes, abundant; the later fruit is smooth, black and as edible at least as the cultivated black currant, though smaller. The species certainly deserves protection and cultivation.

Prunus Americana Marshall. Wild Plum.

The wild plums of the country were the joy and consolation of the pioneer and his family in all this western land. Here was a fruit, offered by nature herself, ready to hand, like the wild strawberry, excellent in sweetness and flavor, abundant in the orchardless, gardenless wild, innocent of all the arts of the gardener yet surpassing these. In fact these are the plums of the country yet. These alone possess the constitutional vigor to endure our western climate. The wild goose plum and the Miner plum are but well selected varieties of our native stock. The former originated from *P. hortulana,* which is surely very near *P. americana* albeit now listed as a distinct species.

The present species has fruit somewhat larger than that of the following, ovoid or egg-shaped, with a somewhat thicker skin, often clear yellow, passing through orange to red.

Occurs along the Coon river about Grant City.

Prunus Chicasa Michx. Wild Plum.

This is the little wild plum of the thickets. The trees are somewhat smaller than those of the species just mentioned, and the fruit globular, red, thin-skinned and very sweet when ripe.

Both species grow in dense clumps and thickets about wet places in the middle or at the border of the woods and are worth preserving on every account. Their fruit, of course, elicits our approval, but they are not less attractive when in bloom, filling the air with sweet perfume, and all summer long their thorny intricate branches form a cheveux de frise, a wall of defense for the scores of warblers and beautiful summer birds.

Prunus Virginiana Linn. Choke-cherry.

With fruit black and shining but edible to birds alone, the choke-cherry yet has a place in all our northern woods; evidence, if such were needed, that all fruits were not made for man. The tree is small, of erect habit, rather ornamental, but spreading badly from the roots, and thus less desirable for the lawn. Common along streams.

Prunus Serotina Ehrhart. Wild Cherry.

Here is one of our most hardy and excellent trees. The trunk rises straight and smooth and attains considerable size, so that in the days not long gone by wild cherry lumber, or simply cherry, was prized in the markets of the world. The tree springs readily from the seed, comes up everywhere responsive to the sowing of birds and is a beautiful ornamental tree wherever it happens to stand.

Pyrus Iowensis Wood. *Pyrus coronaria* of authors. Iowa crab apple.

The crab apple, common by all our western streams where the forest obtains at all, is deserving of more attention than it has hitherto received. Its flowers in prolific abundance contribute no small share to the glory of our northern spring; its low rounded shape makes it an ornament in the field and where it stands in thickets cattle prefer its shelter. It forms the natural border of the grove and wood and is the home of all the familiar birds of song. There seems no reason why the crab might not be allowed to grow in the lowland alluvial pastures or by the country highway. In the latter situation it certainly contributes to the appearance of the landscape and screens in so far the poles of the lawless telephone company.

The June-berry, or Shad-bush, *Amelanchier canadensis,* ought to be found on steep banks along the Coon, but was not observed.

Crataegus Crus-galli Linn. Cock-spur thorn.

One of the many native haws or thorn-apples. The particular species is noteworthy by reason of its abundant aborted branches developed as sharp, slender thorns often three or four inches in length; hence the common name. The fruit is globular, dull red, rather small. Of no economic value. Noted only in the Coon valley.

Crataegus Punctata Jacquin. *Crataegus tomentosa* var. *punctata* of authors. Red haw.

The red haw is everywhere common along streams where forest conditions prevail at all, and persists in pasture-fields along the river-bottoms despite the browsing of cattle. The fruit larger, sometimes an inch in diameter, varying from red to yellow, pleasant flavored. Well worthy of preservation, alike for its rounded form and dense branching and foliage and for its pleasant fruit in autumn.

The species of Cratægus are at present in a condition of great confusion. The trees here mentioned are those familiarly known under the names quoted. The revisers may give us half-a-dozen species owing to the importance they attach to characters which are extremely variable, to say the least; probably, we shall eventually be content with the few species listed by the older manuals.

Fraxinus Americana Linn. White ash. Ash.

The ash commonly planted on the farms of western Iowa and a most valuable tree is of this species. A related form *Fraxinus lanceolata* Borch, is found abundantly native along the Coon about Grant City. The ashes are all good forest trees and should hereafter form an important element in every farmer's grove. They grow rapidly, although somewhat slow in starting. With white pine, oak, walnut and ash the grove on the farm will never lack in beauty or service as shelter and the marketable or economic value of its timber product will grow even more rapidly than the accumulation of material, since such products are, and for years will be, on a rising market.

Symphoricarpus Occidentalis Hooker. Wolfberry.

This is a common little shrub along the Coon, above Sac City and about Grant City; doubtless to be found along the Maple river as well. It is well worthy of cultivation for its showy axillary clusters of flowers in summer and the white fruit that hangs in fall, often long after the leaves have fallen. The snowberry in common cultivation is a near relative.

Sambucus Canadensis Linn. Elderberry. Elder.

This familiar shrub or tree is said to be native. It is so easy of distribution, once the prairie soils are broken or brought to tillage, that it is impossible today to ascertain the original distribution. Often planted for its somewhat attractive fruit, its seeds are carried everywhere by birds and spring up in every unoccupied corner of garden, farm or woodland.

Viburnum Prunifolium Linn. Black Haw.

This is a small tree fifteen or twenty feet high growing in thickets, appreciated for its sweet blue-black fruit ripe in late summer. Reported from the woods about Grant City by Mr. Pelumlder.

Ulmus Americana Linn. White Elm; American Elm.

The American elm is an exceedingly common tree, one of the hardiest and best; dispersed by flying seeds, it springs up in all sorts of places, although preferring as a habitat the rich soils of our alluvial plains. It is one of our most useful trees for planting; grows well when transplanted, has a fine shape, when well selected, and makes the best street tree in the world. The wood is hard and tough, useful for fuel and makes a valuable lumber.

Ulmus Fulva Michx. Slippery Elm.

The slippery elm is much less common than the white elm and much less valuable. Isolated trees occur in our riparian woods but it is nowhere abundant. It has a tough reddish wood, probably, in some cases, as valuable as the wood of the preceding species. A few trees were noted at Ida Grove and at Grant City.

Celtis Occidentalis Linn. Hackberry.

Found in the same forest with the elm, the hackberry, by careless observers, is not infrequently mistaken for it. It is, however, an entirely different, though related tree. It differs in bark, wood, foliage and fruit. Nevertheless the hackberry is a beautiful and useful forest tree. It is an elegant ornamental tree, though for the street-side not so good as the elm. The growth is at first slow, but later the wood accumulates rapidly and makes excellent fuel.

Juglans Nigra Linn. Black Walnut.

It is always a pleasure to discover this excellent species in far out-of-the-way places. A tree of the eastern forest, reaching noblest proportions in southern Ohio and the valley of the Wabash, it yet holds its own to the very western limits of Iowa and is known in the river-valleys farther west. Fine trees of this species once stood along the Coon and Maple rivers, and young trees twenty-five to thirty years old are to be seen today, though, in general, little cared for. Fine groves of walnut have been started in Battle Creek township in Ida county. The tree when cared for and planted in groves on rich or alluvial soil grows with great rapidity and promises much for the tree-culture of the near future. There is no use to plant the tree as a highway tree or in rows as is sometimes done. Especially is it idle to plant it alternately with cottonwood or Lombardy poplar. These trees will destroy and over-top the nobler sort. A successful planting of this species must imitate as far as possible the conditions in which the walnut occurs in nature; the seeds must be allowed to germinate where the trees are to stand and then the young trees must be somewhat protected, kept free from weeds until they get started. If planted on rich soil in a thick plantation, to be thinned as required, the young saplings will prune themselves, grow up straight and tall, and make wood as fast as an elm. There is a fine grove of this sort about one mile southeast of the town of Odebolt; but in general the walnut trees, so far planted in these counties, are wrongly placed and offer little encouragement to their owners.

Carya Alba Nutt. Hickory. Shell-bark Hickory.

The shell-bark hickory is common throughout Iowa but by no means abundant. It grows rapidly from the seed and may be associated with the walnut as a valuable tree for the plantation. The wood, for certain purposes in manufacture and on the farm is reckoned indispensable and for fuel is unexcelled, or indeed excels every other. The nuts also have a marketable value and contribute to the simple pleasures of the fireside on a winter evening. It is satisfactory to find native trees of this species in northwest Iowa. It means that we can have the best of our American forest trees in our prairie counties.

Corylus Americana Walt. Hazel. Hazel-nut.

The familiar hazel furnishes everywhere the undergrowth of the forest, the border of the thicket, the cover, even of the prairie hill-top. Hazel bushes in eastern Iowa were the fore-runners of more important species. Out of the hazel thicket sprang the quaking asp, the oak, the hickory, so that the bush has its relations to other forest-flora. It springs readily from nuts dropped by blue-jays and other creatures and comes up commonly in the farmer's grove and along the hedgerow. The nuts have an increasing market value.

Ostrya Virginica Willd. Ironwood. Hop-Hornbeam.

One of our commonest forest trees in Iowa and one less frequently recognized is this. Apparently, many people do not recognize the tree at all, while some even consider it a species of haw. The tree is bushy when standing in open places, round-topped and covered with rather abundant foliage, but here the resemblance ceases. Its fruit resembles that of the familiar hop; consists in fact of a cluster of small sacs arranged on an axis. Each sac contains one seed, and, strange to say, the sac itself corresponds to the cup of an acorn, so that the ironwood is thus close kin to the oak and is not related to the haw at all, which, on the other hand, is a kind of apple.

The wood of the hop-hornbeam is of the toughest, the hardest and toughest perhaps to be found in our northern forest. Its chief value is in the manufacture of tool handles, and for other purposes about the farm and shop where strong hard wood is needed in small pieces.

Populus Tremuloides Michx. Aspen. Quaking Asp.

The little quaking asp occurs along all streams that are so fortunate as to be shaded by forest at all. Of small economic value, it yet contributes to the cheerfulness and beauty of the spring and should be preserved if for ornament only.

Populus Deltoidea Marsh. *Populus monilifera* of the authors. Cottonwood.

This is essentially a prairie tree and isolated specimens are to be seen even yet in the middle of the field on farms once the open prairie. The cottonwood is a water-loving tree and in the elder days grew everywhere by sloughs and small streams and in low, undrained places, sometimes in rows, or scattered clumps but never in a grove or forest. Cultivation has not changed the nature of the tree. It has been planted in hundreds of places for grove and shelter, but only where the trees stretch out in lines along the highways do they show their natural vigor, majesty and beauty. When planted in groves or thickets, the trees of the interior presently die out and are generally unsatisfactory.

Trees thirty or forty years old, growing by the highway are now valuable as lumber-trees, and have been in many places cut for the mill. When properly sawed and dried the lumber is said to be excellent for framing and general construction.

The *Carolina poplar* offered now generally by peripatetic tree-sellers, is doubtless at best only a variety of the cottonwood. The tree is diœcious in flowering and it is said by some that the Carolina poplar is simply the staminate cottonwood.

The only objection to the cottonwood, its flying cotton when seeds mature, is obviated by planting staminate trees.

Of the trees above listed, maple, box-elder and cottonwood are essentially *the* trees of Iowa groves and prairie plantations; at least, such has been the situation. The time has come when better varieties should everywhere be sought out and planted.

Salix sp. Willow.

Several species of willow are native to the prairies of northwestern Iowa. Two, *Salix cordata* with broad leaves a little silvery below, and prominent stipules, and *Salix longifolia* with long narrow leaves are common by all streams. *Salix amygdaloides* has been everywhere commonly planted along the roadsides and to form part of the farmer's windbreak, but of late is being cut away as inconvenient and expensive in the amount of space necessarily occupied. All willows are useful as a crop for fuel purposes on wet and undrained areas; as the country becomes drier they yield place to other crops, whether of trees or other plants.

Quercus Rubra Linn. Red Oak.

The red oak is essentially a forest tree, does not push out as the bur oak beyond the forest area but grows only where forest conditions are, by the presence of other trees, already well set up. The red oak is a beautiful and valuable tree; as a lumber tree only less valuable than the white oak and bur oak, but much less desirable as a source of fuel.

Quercus Macrocarpa Michx. Bur Oak.

The bur oak is another widely-distributed and excellent tree, not half appreciated. It is the hardiest species we have, by far; the only one, in fact, that held its own through the milennia on these drift plains against the devastating fires. Bur oaks may be found in nearly every county of Iowa; often reduced by hardship and abuse, the stress of fortune and unequal climate —reduced to mere shrubs in size and habit—they receive the somewhat opprobrious title of scrub-oak and are deemed a cumbrance to the ground. These reduced forms on our western prairie hills are, it is true, of little value either present or prospective; but the bur oak under other conditions is a fine tree. If care be taken to plant acorns from the better style of tree, acorns from such trees as are found in better forest regions, the young trees resulting will grow rapidly and furnish in reasonable time a valuable product.

Fine young bur oaks were noted in all the wooded parts of both counties here considered and there are many quite large trees yet to be seen at various points along the Coon.

Smilax Hispida Muhl. Greenbrier. Cat-brier.

This plant is interesting as the only woody endogen known to our woodlands. It is abundant along the Coon river where its long green stems with black prickles, climb over the plum thickets and shine in singular attractiveness in the leafless season of the year.

Juniperus Virginiana Linn. Red Cedar. Juniper.

The juniper is the only native conifer in the northwest counties, but is well distributed throughout. Useful as an ornamental tree and wind-break, it has been very commonly picked up by farmers and others and transplanted to the grove and garden. Nevertheless the supply of seedlings still appears, no doubt planted by the migrating birds. Juniper grows rapidly in good soil and makes excellent post-timber. A cedar post is said to "last forever", but the statement lacks verification. At any rate juniper or cedar wood is the most durable known.

GEOLOGY OF JACKSON COUNTY.

BY

T. E. SAVAGE.

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CONTENTS.

INTRODUCTION.

LOCATION AND AREA.

The area embraced by Jackson county was a part of the territory purchased from the Indian Chief Black Hawk in 1832. It was originally included in the county of Dubuque from which it was separated in 1837, and named in honor of Andrew Jackson.

It lies near the middle line of the state from north to south, in the eastern tier of counties, and together with Clinton county, forms the most easterly projecting point of Iowa. Dubuque county bounds it on the north, Jones and Dubuque join it on the west, Clinton lies to the south, and its eastern border is formed by the channel of the Mississippi river.

The county is organized into 18 civil townships which are included within townships 84 to 87 north of the base line and ranges I to V east of the fifth principal meridian. It embraces an area of 638 square miles.

Jackson county is a region of bold relief where wagon roads wind up and down and around a monotonous succession of hills; where steep mural precipices border insignificant streams; and where the landscapes have a charming variety of picturesque ledges, wooded bluffs and fruitful fields. It was originally a forest-covered area such as the sturdy pioneer found an attractive place in which to build his home.

EARLIER GEOLOGICAL WORK.

In a report published in 1858 Professor J. D. Whitney* discussed briefly the topography and geological formations presented in Jackson county. He referred to deposits of iron ore reported to have been found in this region, and also to some diggings that had been made for lead along Morts creek. Dr. Charles A. White† mentions a few places in Jackson county, in describing the limits of the Maquoketa shale in eastern Iowa, but makes no further reference to points within the area.

In a monograph on the Pleistocene History of Northeastern Iowa,‡ W J McGee describes the thickness of the Maquoketa

*Geology of Iowa, Vol. I, part 1, pp. 282-285, 420 and 446, 1858

†White: Geology of Iowa, Vol. I, p. 80, 1870.

‡Eleventh Ann. Rept., U. S. Geol Surv , pp 216, 326, 327, 426, 427, 436, 532, 533 and 553 1890

shale, the topography, some gravel benches, loess deposits, and well sections at certain points in the area under consideration.

A paper by Professor Herbert Osborn* on "Some Carboniferous Fossils from Jackson county, Iowa", describes an outlier of Carboniferous sandstone near Monmouth.

In his monograph on the Illinois Glacial Lobe** Mr. Frank Leverett discusses in a general way the Pleistocene deposits of the southern portion of Jackson and the northern part of Clinton counties.

In the Proceedings of the Davenport Academy of Sciences mention is made of a number of Indian mounds that have been explored in Jackson county, and a description of the contents of these mounds is given in some detail.†

Professor W. H. Norton describes a number of isolated deposits of sandstone and shale occurring within the limits of Jackson county, in a paper on Certain Devonian and Carboniferous Outliers in Eastern Iowa.§

A few years ago Mr. Harvey Reid published a short Outline Geological History of Jackson county, as a basis for an exhibition of maps and rock specimens before the Jackson county Normal Institute.‡ Two of the topographic sheets published by the United States Geological Survey cover a portion of the area under consideration. The south half of the sheet known as the Peosta quadrangle includes the greater part of the west half of the county. The topography of a small area in the southeast corner is represented on the Savanna sheet.

PHYSIOGRAPHY.

TOPOGRAPHY.

Over the greater portion of Jackson county the surface is generally quite rugged and broken. The topography for the most part resembles that of the driftless area, although it seems probable that the margin of the Kansan ice sheet overspread almost the entire county. A narrow strip of prairie in the southern and southeastern portion, and another small area of

*Osborn: Proc. Iowa Acad. Sci., Vol. I, part 2, p. 115.
**Monograph XXXVIII U. S. Geol. Surv., pp. 144-147, 1899.
†Proc. Davenport Acad. Nat. Sci., Vol. II, p. 173 and Vol. VI, pp. 81-83.
§Norton: Iowa Geol. Surv., Vol. III, pp. 117-133, 1895.
‡Reid: Outline Geological History of Jackson County, pp. 1-8, 1903.

level land near the northwest corner, are the principal exceptions to the trenched and furrowed character of the surface.

In the north-central portion of Butler township a narrow lobe of Iowan ice extended southward from Dubuque county. covering an area about eight square miles in extent. Over this region the surface is comparatively level, or but moderately gullied by the streams. Fresh looking bowlders of Iowan age are conspicuous in sections 15 and 16 of this township. Further south and west the loess becomes deeper and the surface becomes more and more profoundly eroded as the channel of the North Fork of the Maquoketa river is approached.

The narrow divide that separates the basin of the North Fork from that of the South Fork of the Maquoketa river extends from near the hamlet of Iron Hill past the village of Emeline, and continues towards the northwest into Jones county. This watershed has an elevation of 980 feet above the sea. It rises nearly 300 feet above the bottoms of the basins which lie about two miles distant on either side.

The narrow channels of these rivers are bordered by almost no alluvial deposits. They are often bounded on the south by discontinuous bluffs of Niagara limestone which in many places rise precipitously to a height of from seventy-five to 140 feet. The bluffs in the north banks of these rivers are usually more gently sloping and are more generally composed of superficial materials than those on the south, probably because of the more rapid weathering of the south facing slopes than of those inclining towards the north.

The lateral branches that owe allegiance to these rivers in Brandon township are short, and have a steep gradient. Their waters have in many places carved gorges entirely through the Pleistocene materials and cut deeply into the underlying dolomite. Along these rock bound channels the waters flow swiftly in a series of shimmering ripples and turbulent cascades.

The northern portion of Monmouth township is also much dissected . Even the smaller streams are in many places bordered by low ledges of weathered dolomite. These channels are six to eight rods in width, and appear almost choked with the deposit of loess clay that mantles alike the summits, slopes and lowlands.

Across the central portion of this township a level plain, one to two miles in width, extends from the town of Monmouth, towards the southeast, past the villages of Baldwin and Nashville and across the southern portion of South Fork township. Near the town of Maquoketa this belt of prairie takes a more southward trend and expands to a width of from four to six miles. It is bordered both on the north and the south by hills which rise 80 to 100 feet above the level land. The hills contain drift of Kansan age and are usually covered with a blanket of loess several feet in thickness. Occasional low ledges of Niagara limestone appear near the base of the hills.

A short distance west of the middle of section 21, Monmouth township, just south of the point where the wagon road crosses the track of the Chicago and Northwestern Railroad, there are a number of bowlders scattered over the level lowland. These are mostly of pink or gray granites which show but little signs of decay. Both in its topography and in the character and distribution of the bowlders this restricted area presents the appearance of a typical Iowan drift surface. However, there is no well defined Iowan drift area connecting this strip with the lobe of Iowan which extends into the southeastern portion of Jones county. It seems possible that these bowlders might have been carried by ice floes from the margin of the Iowan glacier, when it stood a few miles to the northwest, and that they became stranded at this point where the valley becomes very much more expanded.

That this strip of prairie represents the channel of some preglacial stream is shown in the fact that near the town of Nashville, a short distance west of the middle of the north side of section 25, Monmouth township, a well boring passed through 225 feet of Pleistocene materials without encountering indurated rock. Low benches of Niagara limestone outcrop in the foothills both to the north and south of this point. One-fourth of a mile west of this well the rock outcrops near the top of a hill seventy-five feet above the altitude of the curb. Other wells over this lowland penetrate the surficial materials to water-bearing layers without reaching indurated beds.

In the southern portion of Monmouth township, below Mill Rock, is an area over which the surface is exceedingly rugged. Monuments of massive dolomite stand in ragged towers and jagged peaks bordering the water courses, while at several points along the channel of Bear creek, in sections 32 and 33, vertical escarpments rise sheer 100 to 130 feet above the water.

Over the north half of South Fork township, and the whole of the townships of Farmers Creek and Otter Creek, the topography is very broken, a change in altitude of 300 to 400 feet is often encountered within a distance of three to four miles. The surface is carved into an exceedingly irregular series of hills and ravines. Along the larger streams cliff-forming ledges of the resistant Niagara limestone stand in steep ramparts and rugged columns. This rock represents the upper portion of the *Pentamerus oblongus* horizon, and the Cerionites and crinoid-bearing zone immediately overlying that of Pentamerus. Some distance back from the bluffs the rocks are buried beneath a covering of loess. Even here, however, the ravines are numerous, the slopes are steep, and the summits of the hills often rise 100 feet above the minor valleys.

Near the middle of the north half of section 6, South Fork township, is an area known locally as "the caves". These consist of a series of natural bridges that have been developed by the waters of a small creek eroding a subterranean passage, and the subsequent partial caving in of the roof of the cavern.

The upper or most northerly bridge has a length of 150 feet across the gorge and a width of about sixty feet. The stream flows in a channel about ninety feet below the top of the bluffs. It has carved a passage fifty feet in height beneath the span of the bridge. About eight rods further down the stream a second arch crosses the ravine. This latter is several rods in width, but is so choked with silt and drift wood that the passage can only be followed with difficulty.

A few rods further down the creek there is a sink hole sixty feet in depth, having a diameter at the top of seventy-five feet.

Climbing down to the bottom of this shaft the explorer can readily follow an underground passage three hundred feet in length, forty to seventy feet in width and eight to twenty-five feet in height. At various points along this main passage there are to be seen entrances to smaller galleries which wind in and out along the sides and roof of the cavern. A beautiful spring, furnishing a stream of water four feet in width, issues from one

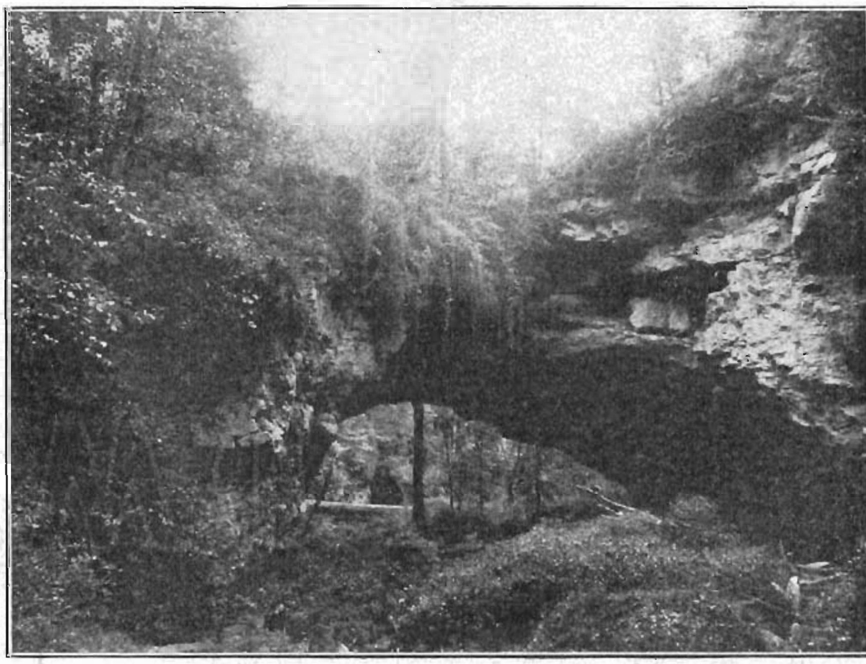


Fig. 64–Natural bridge formed by the erosion of an underground stream and the partial caving in of the roof. Section 6 of South Fork township.

of these lateral canals. At the lower end of the passage the stream emerges in a gorge whose bounding cliffs rise 125 feet on either side. This locality is a justly popular resort for drives and picnics for the people in all of the southwestern portion of the county.

In the southern part of Richland township, near the village of Cottonville, another series of caverns or underground passages have been developed.

Such channels are usually formed where streams having a steep gradient cut deeply into thick bedded limestones. Professor Shaler* has shown that their genesis also requires forest conditions. As the rain water filters through the leaf mould over woodland areas, it becomes charged with carbonic acid gas from plant decay. As this carbonated water slowly percolates along the crevices and joint planes of limestone strata, it gradually widens the fissures by taking into solution some of the material along the way. The amount of limestone thus dissolved by the water is always in direct proportion to the amount of carbonic acid gas that the water contains. As the passages become enlarged a larger volume of water follows them, and, in turn, the larger stream of water more rapidly increases the size of the channels by abrasion as well as by solution.

In the course of time the streams of such a region desert the surface, and find an outlet to their major streams through subterranean channels. If not too deep beneath the surface, the roof of these passages will eventually be broken through at some points giving rise to natural bridges. Gradually the underground channel may be converted into a gorge by the falling down of the roof along its entire course.

In section 6 of Prairie Spring township, the highest points have an elevation of 1190 feet above the sea, while at the middle of this township in the valley of Morts creek the altitude is only 740 feet. The uplands in the northern portion of Otter Creek township rise more than 250 feet above the beds of the streams. The divide between the Lytle creek basin on the west and that of Farmers creek on the east stands 1060 feet above the sea, while in Farmers Creek township the waters of these streams flow below the level of 700 feet.

A short distance back from the larger streams, and along the smaller tributaries in these townships, the bluffs and hills are composed of surficial materials. Deposits of loess are deep, and a considerable thickness of drift may in many places be seen along the water courses and on the flanks of the hills.

Over much of Maquoketa, Perry and Richland townships the same rugged type of topography prevails. At some points, as

*Shaler: Aspects of the Earth, p. 100.

along Brush creek in section 14 of Perry township, the waters of the streams wash the base of precipitous cliffs in which ledges of massive dolomite rise to a height of from ninety to 125 feet. In other places the banks are lower, and are crowned with weathered columns below and around which are strewn large, obdurate, fragmented masses of the slow disintegrating beds. From the top of the steeper bluffs the surface ascends

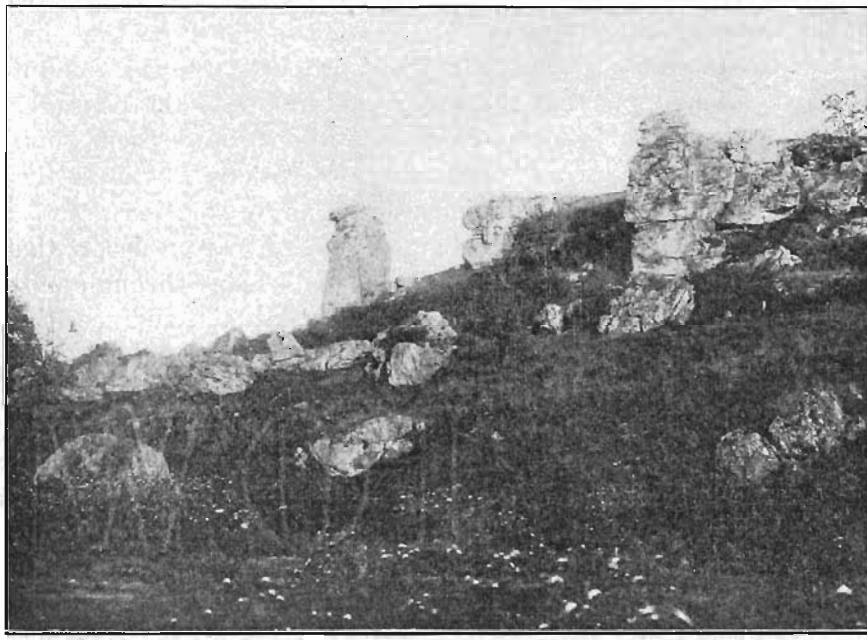


Fig. 65—View showing the manner in which the enduring bluffs of Niagara limestone slowly disintegrate and fall away.

in a succession of loess covered hills to an altitude 200 feet higher still. Notwithstanding the fact that the entire region is trenched and gullied by the streams, the loess mantled crests and slopes produce excellent crops of grass and grain in seasons of abundant rainfall.

In the extreme western and southern portions of Prairie Spring township the topography is such as is developed further south and west, as the result of water sculpture over regions whose surficial materials are underlain with beds of Niagara dolomite. In sections 4, 9 and 16 of this township springs abound. Their waters issue low down in the bluffs, and the Maquoketa shale appears in the beds of the streams. On following down the valley of Morts creek from the middle of Prairie Spring township the channel gradually increases in width. Along the foot hills a gentle gradient has been developed on the Maquoketa shale to a constantly increasing height. Above the shale the steep ramparts of Niagara limestone, which confront each other across the valley, become ever more widely separated.

At the village of St. Donatus, in Tete des Morts township, the valley has expanded to a width of from one to one-half mile. On either side of the stream disconnected escarpments of Niagara limestone, forty to sixty feet in height, crown the cliffs which stand two hundred feet above the water. From the tops of the immediate bluffs the slopes rise quite rapidly

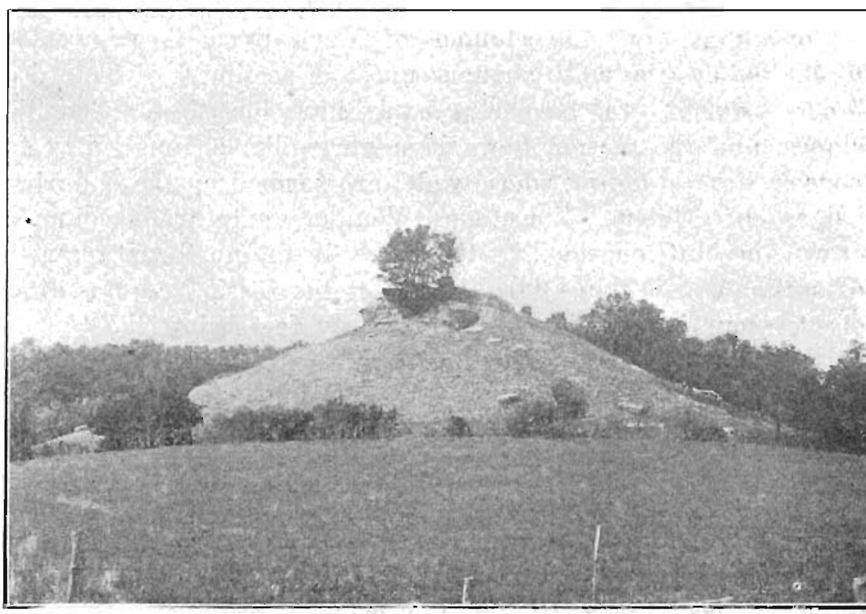


Fig. 66—Hill of circumdenudation in Tete des Morts township. The hill is protected by a cap of resistant Niagara.

250 feet higher, to the level of the ridges over the uplands. From the foot of the Niagara scarp the surface slopes gently down to the base of the Maquoketa shale for a distance of one-half mile on either side and to a vertical height of more than

100 feet. Over these gentle Maquoketa slopes large talus blocks of Niagara lie tilted at all angles, and each succeeding year they creep a little further downward towards the lowland plain.

At this place the flood plain of the creek is about forty rods in width. It is bordered on either side by a low bench or terrace of Galena limestone, twenty to twenty-five feet in height, which rises to the foot of the shales.

On the south side of the stream a large English Lutheran church overlooks the valley from a position near the top of the Maquoketa slope. At a corresponding position on the opposite bluff is a large Catholic church from which the worshippers have the inspiration of a like beautiful view over this charming valley. One hundred feet still above the site of the Catholic church a modest chapel lifts the cross towards heaven from the very summit of the bleak Niagara crest.

Continuing down the channel of Morts creek the character of the valley gradually changes until, in section 4 of Tete des Morts township, the bordering banks have lost the long gentle slopes, and the stream flows in a gorge-like channel, fifty to seventy feet in depth, whose walls are formed by the enduring ledges of Galena limestone. Weather-sculptured columns crown the bluff overlooking the valley in the northeast quarter of section 4 (see figure 68). Casts of the fossil *Receptaculites oweni* occur in abundance about twenty feet below the top of these resistant towers. Further down the channel the bounding walls of Galena rise constantly higher. Where this creek joins the Mississippi river, in section 3, the cliff on the north side of the gorge rises one hundred feet above the water.

Along the Iowa shore of the Mississippi river, south of the mouth of Morts creek, steep bluffs of Galena border the channel for several miles. The dip of the Galena strata towards the south and west brings the top of these beds constantly lower in the river bluff. At Gordons Ferry station the Galena cliff stands eighty feet above the water of the Mississippi river. Along the border of sections 11 and 13 these ledges rise only forty to fifty feet. Near the middle of the east side of section

24, the Galena is encountered in the north bank of a small stream to a height of sixteen feet. It again appears in the southeast quarter of section 36; and it is exposed at low water in the bed of Mill creek where that stream joins the river in the town of Bellevue.

Over all of the southeast portion of Tete des Morts township, water sculpture is conspicuous, but the precipitous character of the topography which prevails over the Galena and the Niagara areas is wanting. The surface rises and descends in gentle undulations such as are developed where stream erosion acts on the slightly indurated beds of the Upper Maquoketa shale. On the western horizon the interrupted Niagara scarp crowns the summits of the hills and forms the skyline some two to four miles back from the Mississippi river.

Along the middle portion of the east side of Bellevue township a thickness of thirty to fifty feet of Niagara limestone caps the bluffs and protects the underlying Maquoketa beds so as to form great cliffs 150 feet in height. Such a scarp overlooks the northwest corner of Bellevue, and another such rampart borders the channel of the Mississippi river for a distance of nearly one mile south of the limits of the town. In the south bluff, at the mouth of Mill creek, a complete section of the Maquoketa shale is exposed showing a thickness of more than 125 feet. Continuing down the river from this point the southward dip of the strata is more rapid than the fall of the river. The height to which the Maquoketa shale appears in the bluffs gradually decreases; the cap of the Niagara constantly increases in thickness; and the flood plain on the Iowa side of the river gradually expands. At Green Island the scarp stands more than two miles back from the immediate bed of the river. At this place the Maquoketa rises in the bluffs to a height of only about thirty feet above the river swamp, and it is succeeded by sixty to seventy feet of Niagara limestone.

About two miles east of Green Island, in section 29 of the civil township of Washington, the top of the Maquoketa appears about fifteen feet above the flood plain; while near Lainsville, four miles further eastward, the Niagara limestone may be seen down to the very base of the bluffs. Three miles still further down the river, an arch in the strata crosses sections 12 and 13 of Union township. In the anticline of this fold the Maquoketa shale is again brought many feet above the river's plain. In the northeast quarter of section 24 the Maquoketa appears in the bluff to a height of more than sixty-five feet. From this point the strata again dip quite rapidly to the southward, so that in the extreme southeast corner of Jackson county the top of the shale horizon is but a few feet above the foot of the bluff.

East of the town of La Motte, in Richland township, the headwaters of Mill creek have cut into beds that occupy a position near the base of the Hopkinton stage. Low, weathered ledges outcrop along the crest of the hills or appear as discontinuous ramparts bounding the channels of the streams. Near the line between section 1 of Richland and section 6 of Bellevue townships the numerous springs that issue near the level of the streams indicate a zone at the top of the Maquoketa shale. These springs are conspicuous on account of their abundance and because of the volume of water that they supply. Continuing down the channel of Mill creek the valley grows broader, the gentle Maquoketa slopes fringe the foothills with an ever wider border and to a constantly increasing height, and the Niagara crowned bluffs rise ever higher on either side.

Near the old village of Paradise the Niagara summits are separated more than a mile apart across the channel. This town was located by the pioneers in a sheltered valley of rich, alluvial land, which was abundantly watered by pure, perennial springs, and heavily wooded over both slopes and lowland. It was within a few miles of a settlement on the Father of Waters, the great line of travel and traffic in those early days. It is small wonder that the locality appealed strongly to the early settlers of the county. It is small wonder too, that they should name their settlement Paradise. Unhappily the hamlet is now almost deserted. Like the story of another Paradise its people have been led far away from the quiet and seclusion of this favored valley in their efforts to secure the fruits of knowledge and obtain larger rewards for their toil.

Towards Bellevue the valley becomes wider and the Niagara scarp is raised higher above the water, by the deeper cutting of the stream into the deposits of the Maquoketa stage. The waters of Little Mill creek, Duck creek and Pleasant creek have cut deeply into the Maquoketa shale and have developed topographic forms similar to those encountered along Mill creek. The uplands separating the basins of these streams rise 200 to 300 feet above their flood plains. They are trenched by the pinnately or bipinnately spreading branches of the major streams. The ridges are generally quite deeply loess covered, and it is but rarely that indurated rocks are exposed along the slopes bordering the secondary branches.

Below the junction of the North and South Forks of the Maquoketa river, in Maquoketa and Fairfield townships, the river flows in a comparatively narrow valley which is seldom more than one-half mile in width. There is usually a narrow belt of fluvial deposit on one or the other side of the channel. The bluffs that bound the south side of the river are generally more precipitous, and are more frequently composed of walls of dolomite, than those on the north.

For a distance of one mile or more south from the river the numerous hills are built largely of sand and the lowlands are mantled with the same material. North of the river the hills are not less abundant but the covering alike of the ridges and valleys is generally of loess.

In Van Buren and Washington townships the channel of the Maquoketa river is somewhat wider, but the topographic features presented in this portion of its course do not differ materially from those developed along the valley further west.

Alluvial areas.—At numerous points along the larger streams of the county narrow belts of fluvial material border the channels. However, these areas are generally small and they do not often form conspicuous topographic features.

In the south half of section 24 and the northern portion of section 25 of Farmers Creek township, there is a lowland area of several hundred acres that seems to have been developed as an alluvial plain. It is situated in the angle between Farmers creek and the North Fork of the Maquoketa river, and appears as an expansion of the creek and river bottoms at the confluence of these two streams. Sand bars abound over this low land, but it seems probable that the sand was in part at least, gathered from regions further westward and deposited here by the winds.

A small area of flood plain has been developed at the confluence of Otter creek with the channel of Lytles creek, in the northwest quarter of section 21 in Otter Creek township. Over this level lowland there are left a few small island areas of Niagara limestone that have escaped the degrading action of the streams. These monadnock-like ridges are longer than wide, and rise twenty-five to forty feet above the surrounding plain.

Another small monadnock mound occurs in the northwest quarter of section 31, Van Buren township, over the level area of the old Goose Lake channel.

In the southwest quarter of Van Buren township, and the southeast corner of Fairfield, there is a level plain that embraces eight or ten square miles. The area is underlain with Maquoketa shale, and is bordered more or less completely by hills or low ledges of Niagara limestone. This prairie area is at present drained by Deep creek. It extends eastward for some distance up the channel of Copper creek, and is continued westward along a tributary of Deep creek, in the southern portion of Fairfield township.

The plain represents a northward extension of the old Goose Lake channel. The great width of the valley at this place seems to be due to the fact that an arch in the underlying strata crosses the ancient channel at this point, bringing the easily eroded Maquoketa shales within reach of the denuding action of the streams. Between Spragueville and Green Island the temporary channel of the Mississippi is at present occupied by the Maquoketa river. Along this portion of its course the stream has cut into the obdurate Niagara limestone and hence its effects are much less pronounced than in that portion of the channel in the vicinity of Preston.

In the extreme southwest corner of Tete des Morts township, and the northeast portion of Bellevue, there is a region bordering the river over which sand dunes have covered the greater portion of the vegetation and rendered almost barren an area of several hundred acres. These sands are being constantly shifted by the winds. Beautiful wind furrows resembling the ripple marks on the shore of a sandy beach, appear in abundance over the drifting surface.

Fig. 67—Sand dune invading a forest, near the northwest corner of section 1, Bellevue township.

The area is a modified alluvial plain. The bank of the river at this place is formed of the Maquoketa shale whose incoherent materials have been denuded down to near the level of high water over a strip many acres in extent. On this belt of lowlands the winds have piled up hills of sand and then removed, only to build again, the ever changing line of shifting dunes.

From the north line of Washington township down to section 29 of Union there are marshy lowlands lying between the bluffs that border the valley and the immediate bed of the Mississippi river. This flood plain has its greatest expansion in the vicinity of Green Island where it is two and one-half miles in width. These lowland areas are often threaded with lagoons, especially in the southern part, and are subject to overflow during periods of high water. They are partially forest covered, but over the greater portion they appear as wide savannas supporting a luxuriant growth of marsh grass which furnishes a large amount of wild pasturage and hundreds of tons of native hay.

Terraces.—Remnants of a gravel bench are to be seen at a number of points bordering the channel of the Mississippi river, and for some distance up from the mouths of many of the tributary streams. Such a bank of gravel appears in the roadside near the southeast corner of section 1, Bellevue township. The wagon road between Sabula and Lainsville, just west of the railroad, follows on this old terrace twenty to twenty-five feet above the present flood plain.

About two and one-half miles east of Green Island, a gravel terrace twenty feet in height borders the valley and can be traced for some distance up the channel of a creek that joins the river at that point. Patches of such a terrace appear along a creek in section 1 of Iowa township, and at points near the mouths of other streams that owe allegiance to the Mississippi river in Jackson county. The terrace materials are composed of rather small and rounded water-worn pebbles, the age of which could not be definitely determined.

In the southwest quarter of Van Buren township, the flood plains of the present streams lie fifteen to eighteen feet below the level of the old Goose Lake channel. This terrace is in some places composed of sand and silt, while at others it consists of a low bench of Niagara limestone.

ALTITUDES.

The difference in elevation between the highest and the lowest points in the county is more than 600 feet. The surface relief in Prairie Spring township alone exceeds 500 feet.

The highest known point in the county is a short distance north of the middle of the east half of section 6 in Prairie Spring township, where the elevation reaches 1190 feet above the sea. The lowest point is on the flood plain of the Mississippi river in the extreme southeast corner of the county, where the altitude is about 570 feet. The elevations of towns, with railroads, given below are taken from Gannett's Dictionary of Altitudes in the United States, and give the height above sea level of the top of the ties at the several stations named. The other elevations furnished are taken from the topographic sheets of the United States Geological Survey.

TABLE OF ALTITUDES	FEET.
Andrew	870
Baldwin	712
Bellevue, C. M. & St. P. R. R Station	618
Mississippi river Com. H. W	598
Mississippi river Com. L. W.	578
Brandon township, middle	955
Bridgport	640
Butler township, middle	1010
Butler township, middle of south side section 18	1085
Canton	730
Cottonville	990
Crabb Hill	700
Duggan	830
Emeline	963
Farmers Creek township, middle	700
Fulton	745
Garry Owen	975
Gordons Ferry Station	610
Green Island	599
Hurstville	664
Iron Hill	940
Lainsville	597
La Motte, C. M. & St. P. R. R	911
La Motte, U. S. G. S	923
Maquoketa, C. and N. W. Station	684
C. M. & St. P. Station	692
Weather Bureau	688
Maquoketa township, middle	700
Miles	780
Mill Rock	715
Monmouth	761
Monmouth township, middle	790
Nashville	712
Otter creek	1025
Otter Creek township, middle	800
" northeast corner	1080
" middle of N. side section 4	1050
Ozark	728
Perry township, middle	870
Prairie Spring township, middle	740
near middle of E. half section 6	1190

	FEET.
Preston	660
Richland township, middle	840
middle of N. E. quarter section 3	1125
Sabula, Station	604
siding	595
bridge over river	607
Miss. river Com. L. W	576
Miss. river Com. H. W	593
St. Donatus, U. S. G. S	674
South Fork township, middle	660

A study of the above table shows that the surface of the county has a general slope towards the south and east. The divide that extends across the county in a north and south direction shows the following elevations: near the northwest corner of Prairie Spring township 1190, Cottonville 990, Andrew 870, and Maquoketa 684. Across the county from west to east we have the following altitudes: Emeline 963, Iron Hill 940, Andrew 870, and Green Island 599.

DRAINAGE.

The Mississippi river is the master stream of the county. It receives tribute in the area from the Maquoketa river and from Morts, Spruce, Mill, Duck and Pleasant creeks. The Maquoketa river and its branches drain the larger part of the south half, and the most of the northwest portion of the county.

Maquoketa river.—The Maquoketa river is formed by the confluence of the North and the South Forks of the Maquoketa, which meet in the northwest quarter of section 18 in Maquoketa township. It crosses in an east and west direction a short distance north of the middle of this township. Soon after entering Fairfield township it swings northward to near the north line, about the middle of which it again turns toward the southeast, entering Van Buren township not far from the middle of the west side of section 18. About one mile north of the village of Spragueville, in section 15 of this township, it meets the old Goose Lake channel. At this point the river departs from its general southeasterly trend, which is the characteristic direction of flow for the rivers of eastern Iowa, and swings strongly towards the northeast to its junction with the Mississippi river. It enters the flood plain of its master stream immediately above Green Island, and its waters join those of the Mississippi through two channels about two miles north of the last mentioned town.

Brush creek is the largest stream that joins the Maquoketa river from the north, while Prairie creek and Deep creek are its most important affluents from the south.

Goose Lake Channel.—The Goose Lake channel, which the Maquoketa river follows from Spragueville to Green Island, represents the temporary channel occupied by the Mississippi river during a portion, at least, of the Illinoian ice invasion. When the lobe of this glacier pushed over into the southeast corner of Iowa, from Illinois, the channel of the Mississippi river was blocked with ice, and its waters were forced to find a passage around the margin of the ice sheet. In seeking a new course to the west of the lobe of ice the river left its pre-Illinoian channel at Green Island. It followed up the pre-existing Maquoketa valley to a point near the middle of section 18 of Van Buren township. At this place the temporary Mississippi forsook the Maquoketa channel and continued southward across sections 19, 30 and 31 forming the broad valley which is at present occupied by Deep creek. This channel of the temporary Mississippi river passes southward across Clinton county. Near the south border of this county it swings towards the southwest, crossing the west side of Scott county, the southeast corner of Cedar, the west half of Muscatine and Louisa, and continues in this direction as far as the northwest corner of Henry. At this point it swings towards the south and southeast across the counties of Henry and Lee, and again enters its pre-Illinoian channel not far from the present city of Fort Madison.*

In Jackson county the bottom of the temporary Mississippi valley was twenty to twenty-five feet higher than the present bed of the Maquoketa river in the same portion of its course, and was several feet above the bed of Deep creek which now occupies the ancient valley in sections 19, 30 and 31 of Van Buren township. It seems probable that the divide between the headwaters of Deep creek and Brophys creek, in Clinton

*Leverett: *Illinois Glacial Lobe*, Monograph XXXVIII, U. S. Geol. Survey, p.

county, formed a barrier which the temporary Mississippi river never succeeded in cutting down to the level of the valley of the Maquoketa river in the vicinity of Spragueville. This is indicated by the fact that the present altitude of this divide where it is crossed by the temporary Mississippi channel a short distance south of Goose Lake, is about 665 feet above the sea, while ten miles farther north the elevation of the flood plain of the Maquoketa river, near Spragueville, is not far from 600 feet.

A bench of Niagara limestone that extends nearly across this channel on the north side of the wagon road, in the northwest quarter of section 19 of Van Buren township bears witness to the presence of some such obstruction. The remnants of a terrace of fluvial materials twenty-five feet in height that borders this old valley further south, in sections 30 and 31, also point to some probable obstruction further down the channel.

The presence of such a barrier probably explains why the Mississippi river returned to its pre-Illinoian channel soon after the melting of the Illinoian ice sheet. It also accounts in part for the fact that the Maquoketa river soon abandoned the course south from Spragueville, along the valley of the temporary Mississippi, and again developed an outlet to its master stream towards the northeast between Spragueville and Green Island, in a direction of flow opposite to that of the waters of the temporary Mississippi river.

North Fork of Maquoketa river.—The North Fork of the Maquoketa river enters Jackson county not far from the middle of the west side of section 31, Butler township. Near the southwest corner of section 32 it bends southward and continues to flow in this direction down to the old town of Ozark. At this place it swings eastward and with many meanders it passes across the northern portion of Brandon township, and as far east as the southeast quarter of section 9 in the township of Farmers Creek. From this point it trends southward for more than two miles whence it again swings eastward to a point nearly one mile east of Fulton. Here it once more bends to the south and meets the South Fork of the Maquoketa near the northwest corner of section 18, Maquoketa township.

In Brandon township this river flows in a narrow valley which in many places is bordered on one or both sides by precipitous cliffs of limestone, as in the southeast quarter of section 4. In Farmers Creek township, and southward to its junction with the South Fork, the valley of the river grows wider, the ledges of limestone that appear in the banks are lower and much less continuous, and become more nearly concealed by the mantle of surficial materials.

South Fork of Maquoketa river.—The South Fork of the Maquoketa crosses the Jones-Jackson county line a short distance north of the town of Canton, near the southwest corner of section 18 in Brandon township. With numerous curves to the north and the south the river persists in a general southeasterly course to the town of Maquoketa. At this place it swings northward for a distance of three-fourths of a mile, to its confluence with the North Fork above described.

Throughout the greater portion of their flow in Jackson county the courses of the North and the South Forks are practically parallel, and their channels are not more than four to five miles distant from each other. On account of the fact that this interstream area is so narrow the North Fork has no important affluents on the south, nor do any streams of importance render tribute to the South Fork from the north.

In the northwest portion of the county Lytles creek and Farmers creek owe allegiance to the North Fork of the Maquoketa, while Bear creek is the most important tributary to the South Fork in the area under consideration.

Lytles creek.—Lytles creek enters Jackson county near the northwest corner of Otter Creek township. It meanders across the west side of this township and meets the North Fork a short distance east of the middle of section 8 of Farmers Creek township. It drains an area of about fifty square miles, including the greater portion of the east half of Butler, and practically the whole of Otter Creek township. This creek has carved its bed in the resistant Niagara limestone. Low bordering ledges occur at frequent intervals in the northern portion of its course in the county, but they become more rare and are much more nearly loess covered along the lower portion of its flow.

Farmers creek.—The headwaters of Farmers creek are found in the trenches and gullies in the southwest quarter of Prairie Spring township. The stream flows for a distance of twenty-five miles in a general direction a little west of south. It joins the North Fork near the southeast corner of section 24, Farmers Creek township. It carries the run-off from the southwest quarter of Prairie Spring township, the west half of Richland, the northwest quarter of Perry and the northeast portion of Farmers Creek.

Bear creek.—Bear creek, with its branches, drains the greater portion of Monmouth township. It enters the county near the northwest corner of section 31 of this township. It flows a little south of east for a distance of two miles and then swings northward, entering the old Monmouth-Maquoketa valley not far from the southeast corner of the town of Baldwin. It follows eastward down this valley to near the middle of the east side of section 23. Instead of continuing farther down this natural waterway, the creek here swings strongly towards the north, cutting a channel one hundred feet in depth through the hills that border the valley in sections 13 and 24. It joins the South Fork of the Maquoketa not far from the center of section 13.

Near the middle of the east side of section 22, Bear creek receives tribute of a small stream from the west. This creek enters Monmouth township in the west side of section 8. It follows the preglacial valley eastward to a point one mile east of the town of Monmouth. At this place it forsakes this ready formed channel for no assignable reason, and makes a detour through the hills that bound the north side of the valley. It flows north for about three-fourths of a mile, whence it again takes a southeasterly course emerging once more into the ancient valley a short distance east of Baldwin. The hill around which this circuit is made rises 120 feet above the valley. It lies immediately to the northwest of the town of Baldwin and is a conspicuous topographic feature of this region.

Prairie creek.—Prairie creek is the largest affluent of the Maquoketa river from the south. It enters the county a short distance west of the middle of the south side of section 35 in South Fork township. It drains the southeast corner of this township and the southwest quarter of Maquoketa, and meets its major stream near the middle of the east half of section 17 of the latter township.

Deep creek.—Deep creek follows the old temporary Mississippi river channel from the south side of section 31 of Van Buren township to its junction with the Maquoketa river in the south half of section 18. A widely branching tributary of this creek on the east drains the larger portion of Van Buren township, while an affluent on the west flows across the southern portion of the township of Fairfield.

Brush creek.—The headwaters of Brush creek lie in the southeast quarter of Richland township. The stream meanders in a general southward direction down to the vicinity of Andrew whence it swings towards the southeast for half a dozen miles, joining the river near the northeast corner of section 5, in the township of Fairfield. It carries the excess of water from an area of about fifty square miles, which includes the southeast quarter of Richland township, the east half of Perry, and the west and the south portions of Jackson. At some points in Jackson township, and in sections 14 and 23 of Perry, the banks which border the outer side of the meanders of the stream consist of high dolomite cliffs, but in other places along its course the banks are low, and the ledges are mostly concealed by deposits of loess.

Morts creek.—A short distance west of the north side of section 4 of Prairie Spring township, Morts creek crosses the Dubuque-Jackson county line. It flows in a southeasterly direction down to the middle of the northeast quarter of section 22. At this point it swings towards the northeast crossing the east half of Prairie Spring and the north half of Tete des Morts townships. It meets the Father of Waters near the northeast corner of the county. This stream together with

Spruce creek in the southern portion of Tete des Morts township, drains practically the whole of the two northern townships of Jackson county.

Mill creek.—Mill creek rises in the northeast quarter of Richland township. It follows a general southeasterly course across Bellevue township and joins the river near the southeast corner of the town of Bellevue. This stream has exposed in its banks the lowermost fifty feet of the Niagara limestone and practically the entire section of the Maquoketa shale. It drains the north half of the township of Bellevue. Its largest tributary, Little Mill creek, drains the central and southwest portions of this township.

Other streams.—Duck creek drains eight or ten square miles in the southwest portion of Bellevue township and the northeast corner of Jackson. It has a flow of about eight miles, and joins the Mississippi river in the northeast quarter of section 29 of Bellevue township. Like the Mill creeks, it has exposed along its banks the basal beds of the Niagara and a thickness of many feet of Maquoketa shale.

The headwaters of Pleasant creek lie in the northwest quarter of Jackson township. The stream flows for a dozen miles in a direction slightly north of east. It enters the channel of the Mississippi river in the northeast quarter of section 4, Washington township. It carries the run-off from the larger part of the north half of Jackson township and the northwest quarter of Washington.

The greater portion of Iowa township is drained by the headwaters of Elk creek which flows southward into Clinton county, meeting the Mississippi river three and one-half miles below the southeast corner of Jackson.

A number of other minor streams render tribute to the Father of Waters from Jackson county, but the most of these are small and relatively unimportant.

STRATIGRAPHY.

General Relations of Strata.

The geological formations that are well exposed in Jackson county belong to four different systems; the Ordovician, Silurian, Carboniferous and the Pleistocene. Of the Ordovician system there are present rocks of the Trenton series which include the strata belonging to the Platteville-Galena and the Maquoketa stages.

Between the deposits of the Ordovician and those of the Silurian system there is evidence in Jackson county of an interruption in the sedimentation making an unconformity of overlap. At two or three different points the Niagara limestone appears to occupy an old channel of erosion which was carved in the Maquoketa shale prior to the deposition of the Niagara sediments. The Niagara series embraces all of the rocks which belong to the Silurian system in our area. Of this series there are present strata of the Hopkinton and the Gower stages. All of the rocks in the county which belong to the Niagara series are dolomites, being calcium-magnesium carbonates in composition.

At one point in the county a number of Devonian fossils have been found associated with a local bed of shale. These may represent an outlier of Devonian rocks or they may have been transported and deposited by the glacier when it moved down from the northwest. No outcroppings of undoubted Devonian strata were seen in Jackson county.

The deposits of the Silurian and the Carboniferous systems are separated by an enormous time interval and by a very conspicuous unconformity. The Carboniferous sediments of our region consist of small and scattered outliers of sandstone or sandstone and shale none of which are continuous over areas of any considerable extent. All of these outliers belong to the Upper Carboniferous series and represent deposits of the Des Moines stage.

Another gap of exceedingly great extent intervenes between the deposits of the Carboniferous system and those of the Pleistocene. The latter materials consist of unconsolidated beds, composed of drift, loess, alluvium and sand, which have been transported and deposited by the agencies of ice, wind and water. These beds belong to the Glacial and the Recent series. Of the former there are present over portions of our area sheets of drift that were spread out during the Kansan and the Iowan stages of glaciation. A portion of the deposits of loess, sand and alluvium also belong to the Glacial series, but these can not be differentiated from the corresponding materials that have been more or less worked over and re-spread by the action of wind and water since the permanent withdrawal of the glaciers from our state.

The following table shows the relations of the different geological formations that appear in Jackson county.

TABLE OF FORMATIONS.

GROUP.	SYSTEM	SERIES.	STAGE.
Cenozoic	Pleistocene	Recent	Soil, loess and alluvium
		Glacial	
			Iowan
			Kansan
Paleozoic	Carboniferous	Upper Carboniferous or Pennsylvanian	Des Moines
	Devonian?	Meso-Devonian?	Wapsipinicon?
	Silurian	Niagara	Gower
			Hopkinton
	Ordovician	Trenton	Maquoketa
			Platteville-Galena

ORDOVICIAN SYSTEM.

GALENA STAGE.

The Galena stage corresponds with what has formerly been referred to in the Iowa Geological Survey reports as the upper part of the Galena-Trenton. Inasmuch as it is now thought that the Trenton limestone of the upper Mississippi valley is not the exact equivalent of the Trenton beds in the type locality, Dr. Bain* has proposed, as a substitute for the term Trenton in our region, the name Platteville from the town of Platteville, Wisconsin, at which place the rocks of this horizon are well exposed. The term Platteville is to be restricted to the beds between the Saint Peter sandstone and the top of the "Green Shales," while all the beds above the "Green Shales" will be called Galena. This change in nomenclature has been adopted by Professor Calvin and it will be followed in the present report.

The rocks of the Galena stage that are exposed in Jackson county, represent the uppermost portion of the Galena as those

*Bain: Lead and Zinc Deposits of Northwestern Illinois, Bull. 246, U. S. Geol. Surv., p. 19.

rocks are developed in the neighboring county of Dubuque. With the exception of a thickness of a few feet near the top, the materials are subcrystalline, yellowish colored, thoroughly dolomitized limestones occurring in layers of considerable thickness. They are the equivalent of that portion of the Galena beds lying above the chert-bearing zone described in the report on the geology of Dubuque county.*

Distribution.—The upper typical phase of the Galena limestone is exposed at numerous points over sections 3, 4, 10, 11, 13, 14, 15, and 24 of Tete des Morts township. It appears in the channel of Morts creek from a point one-half mile west of St. Donatus to its mouth. It forms the conspicuous bluff bordering the west bank of the Mississippi river from the northeast corner of the county to section 24 of Tete des Morts township. It outcrops in a low ledge along the channel of Spruce creek, a short distance south of the middle of section 36 of this same township. The most southerly exposure of the rocks of this horizon occurs in the town of Bellevue where it may be seen along the bed of Mill creek during low water for a distance of a few rods above its junction with the Mississippi river.

Typical Exposures.—At a small quarry in the village of St. Donatus a thickness of more than twenty-five feet of the uppermost strata of the Galena appears at the foot of the Maquoketa slope. The section here exposed is as follows:

		FEET.
5.	Bed consisting of grayish-yellow dolomite in layers three to eight inches in thickness, which are separated by narrow partings of shale; containing a number of fossils in the form of casts or molds	5½
4.	Layer of yellowish colored dolomite similar to No. 5 above, and containing similar fossils	2
3.	Two layers of yellow dolomite each about eight inches in thickness, which are separated from each other and from those adjacent by two-inch bands of shale	1⅜
2.	Bed of rather hard dolomite which is imperfectly separated into layers respectively 2, ¼, 2, ¾ and 1½ feet	6½
1.	Yellow colored, fossiliferous and somewhat vesicular dolomite, consisting of layers 2, 3, 2½, ½ and 3 feet in thickness	11

All of the layers in the above section contain fossils which are in the form of casts or moulds, and are in many cases not

*Calvin and Bain: Iowa Geol. Surv., Vol. X, p. 425

well preserved. The following were identified by Professor Calvin from this exposure: *Streptelasma corniculum, Lingula iowensis, Orthis biforata, Plectambonites sericea, Rafinesquina deltoidea, Rhynchotrema capax, Hormotoma subangulata?* Ctenodonta sp., and Orthoceras sp.

About one mile southwest of St. Donatus a low ledge has been worked in the south bank of Morts creek. A quarry face is here exposed to a height of about ten feet above the water. The layers worked correspond with those of numbers 2 to 4 inclusive in the section at St. Donatus. The stone is a yellowish colored, fossil-bearing dolomite, occurring in rather thin layers which are separated by partings of shale quite similar to that in the St. Donatus exposure. The following fossils were collected at this place: Owenella sp., *Lingula iowensis, Orthis biforata, O. testudinaria, Plectambonites sericea, Rafinesquina deltoidea, Murchisonia gracilis,* and a few individuals of other species of gastropods.

Layers belonging to this same horizon outcrop along the wagon road near the southeast corner of section 23, and at several points in the west half of section 15 where they form a conspicuous bench along the streams. *Lingula iowensis* is very abundant at all of these exposures, and *Orthis biforata, Plectambonites sericea* and *Murchisonia gracilis* are usually present.

In following down the bed of a small stream that flows north from the wagon road, near the line between sections 13 and 14 of Tete des Morts township, a thickness of about sixty-five feet of blue colored, plastic shale is passed over. Below this shale there is encountered a thickness of about twenty-eight feet of yellowish-gray, rather fine-grained dolomite composed of layers which vary from three to eight or nine inches in thickness, and which are usually separated by partings of shale. These layers contain *Lingula iowensis, Orthis biforata, Murchisonia gracilis,* and fragments of a number of other fossils. They seem to be the equivalent of the rocks described in the section at St. Donatus.

Below the horizon of the layers described above, the rocks in the bed of the stream change to a darker yellow. They become more crystalline and vesicular, and contain numerous quite large, irregular and botryoidal cavities. The layers also increase in thickness, and partings of shale are not present. *Receptaculites oweni, Murchisonia major,* Bellerophon sp. and remains of a number of other small gastropods were collected from a zone about fifty-five feet below the base of the Maquoketa shale. The contact of the Galena beds with the Maquoketa shale is clearly exposed in this ravine, and the transition from the dolomite below to the plastic shale above is quite abrupt, but there is here to be seen no evidence of unconformity between the two formations.

In the northeast quarter of section 4, Tete des Morts township, the north bank of Morts creek is bordered by a scarp of

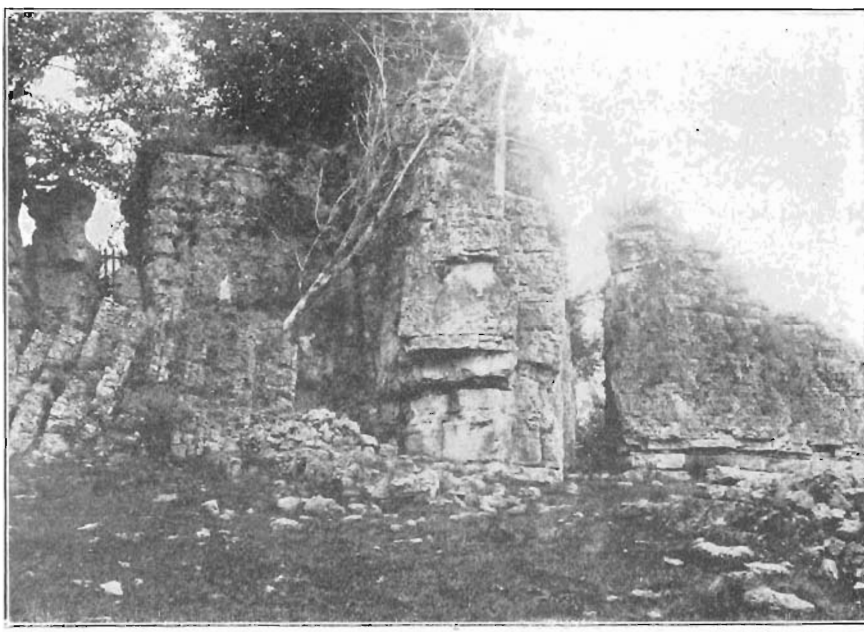


Fig. 68 - Weather-carved cliffs of Galena limestone. Section 4 of Tete des Morts township. Seventy feet above the bed of the creek.

Galena dolomite which rises sixty-five feet above the water. The upper portion of this ledge has weathered into a number of picturesque pinnacles and towers twenty to thirty feet in height, shown in figure 68. In a layer a few feet above the base of these columns there is a narrow zone in which remains of *Receptaculities oweni* are exceedingly numerous. Receptaculites is the characteristic fossil of this horizon and marks a zone about fifty-five or sixty feet below the top of the Galena beds in Jackson county. Imperfectly preserved brachiopod remains and some casts of gastropods are also present in this bed.

At the junction of Morts creek with the Mississippi river the scarp on the north side rises eighty to ninety feet in height. It consists of heavy, massive ledges of dolomite, in layers four to six feet in thickness. These are subcrystalline in texture and quite free from concretions of chert. This phase of the Galena forms the bluffs which border the Iowa side of the Mississippi river for some miles south from the mouth of Morts creek. It doubtless corresponds with numbers 12 and 13 of the section at the Eagle Point Lime Works, in Dubuque, as given in the Dubuque county report.*

A point of Galena limestone is exposed on the east side of the wagon road, in the northeast quarter of section 24, in this same township. The section shown is given below:

		FEET.
8.	Weathered ledge of hard, yellowish-gray dolomite which is indistinctly separated into layers and presents a very rough surface	6
7.	Three layers of hard buff colored dolomite respectively 3, 3 and 1 foot in thickness, the surface showing numerous small cavities	7
6.	Heavy layers of yellow dolomite, *Receptaculites oweni* abundant near the middle portion	5
5.	Layer of hard, sub-crystalline limestone, yellow in color, showing numerous cavities, fossils few and poorly preserved	4
4.	Bed similar in character to No. 5 above, which weathers into indistinct layers three to six inches in thickness	5
3.	Ledge consisting of two layers, each about two feet in thickness, containing a number of indistinct fossil remains	4
2.	Layer of hard buff colored dolomite similar to No. 3	3½
1.	Hard, massive ledge of yellow, vesicular dolomite, down to level of water	4½

In the above section number 6 represents the Receptaculites horizon which appears near the base of the columns in figure 68. It belongs about fifty-five feet below the top of the

*Calvin and Bain: Iowa Geol. Surv., Vol. X, pp. 423 and 424.

Galena limestone. The upper phase, in which the layers are narrow and partings of shale numerous, occurs above number 8 of the section last given.

MAQUOKETA STAGE.

In Iowa, the aggregate of strata that constitute the Maquoketa stage are exceedingly variable. They change in lithology and thickness within areas separated by only a few miles. The fossils that they carry are as lawless in their development and as local in their distribution as are the strata that enclose them.

The most constant phase of the Maquoketa consists of a heavy body of non-fossiliferous, bluish-gray, plastic clay shale, from 100 to 150 feet in depth. At the top of the shale bed there are generally present narrow layers of indurated limestone, three to six or eight inches in thickness, which are separated one from another by bands of shale of about equal thickness with the calcareous layers. The Niagara limestone often immediately succeeds this fossil-bearing phase of alternating shale and limestone layers without any other transitional beds. This is the case near Green Island, in an exposure near the middle of the south side of section 24, Washington township in Jackson county, and also at Patterson's spring, near the town of Brainard in Fayette county. At other points the very fossiliferous zone may be entirely wanting and the heavy body of blue shale is separated from the Niagara limestone by a thickness of twenty-five or thirty feet of transition beds which consist of indurated yellow-colored, impure limestone which weathers into thin bands and carries but few fossils. At still other points these transition, barren beds intervene between the fossil-bearing layers and the Niagara.

The middle and the lower beds of the Maquoketa stage are even more inconstant and variable than the upper. In Jackson county the heavy body of plastic shale passes downward quite abruptly into the thin-bedded dolomite phase of the Galena.

In Dubuque county Professor Calvin designates this plastic clay phase as the Upper Maquoketa and records for it a thickness of 150 feet.* Below the Upper Maquoketa beds there

*Calvin and Bain: Iowa Geol. Surv., Vol X, p. 443.

occur fifty to seventy feet of indurated shale and limestone layers which contain very numerous fossils, and which were referred to as the Lower Maquoketa.

A few miles farther northwest, in the counties of Fayette and Clayton, the upper Maquoketa phase consists of about 125 feet of plastic shale which is barren of fossils except in a narrow zone at the top. Below these Upper Maquoketa deposits there occurs about fifty feet of limestone which is usually thin bedded and contains very numerous chert nodules—the Middle Maquoketa of the Fayette county report and the Fort Atkinson limestone of Professor Calvin's report on Winneshiek county. Below the Fort Atkinson limestone, in these counties, there are present about 100 feet of shales and argillaceous limestones that are in places very fossiliferous and that belong to the Maquoketa stage. These constitute the Lower Maquoketa beds of the Fayette county report; and the Clermont shale, and Elgin shales and limestones of Calvin in Winneshiek county.

In Jackson county all of the deposits corresponding with the Middle and Lower Maquoketa divisions, which attain an aggregate thickness of more than 125 feet in Fayette and Clayton counties, are entirely wanting. The Maquoketa beds of our area, like the deposits of this stage in Delaware county, are argillaceous throughout, with the exception of the calcareous, fossil-bearing bands and the transition beds in the upper part. There is present here only the Upper Maquoketa phase, which is the equivalent of the Upper Maquoketa beds of the Dubuque and Fayette county reports, and corresponds with the Brainard shale of the report on the geology of Winneshiek county.

This bed consists of about 100 feet of blue, plastic shale which is barren of fossils throughout the greater portion of its depth. In the upper part there are usually present thin seams of limestone three to eight inches in thickness which are crowded with fossil remains. These calcareous layers are separated one from another by bands of shale which are also often very fossiliferous. At a few points in the county this fossil-bearing zone is succeeded by transition beds of yellow-colored, rather fine-grained, earthy limestone, with but few fossils, which break up into thin layers, under the influences of weathering. In other places, notably along Morts creek and the Mill creeks and in the vicinity of Bellevue in the northeastern portion of the county, the very fossiliferous zone of alternating shales and limestones is absent. The plastic shale is separated from the Niagara limestone by a thickness of twenty-five to thirty feet of indurated transition beds similar in lithology and texture to those referred to above.

Distribution.—The Maquoketa shale appears in the bluff which bounds the Mississippi river on the west from the town of Bellevue to the southern border of the county. It appears along Morts creek throughout all of its course in Prairie Spring and Tete des Morts townships. This deposit fringes a portion of all of the larger streams that render direct tribute to the Father of Waters from our area, and makes itself manifest in the gentle erosion curves to a variable distance from the river. It immediately underlies the Pleistocene deposits over a large portion of Tete des Morts township and a considerable area in the township of Bellevue. It extends in a narrow belt across the south half of the townships of Van Buren and Fairfield.

Typical Exposures.—Detailed description of the following exposures will make clear the character of the Maquoketa materials in Jackson county. The contact of the Maquoketa shale with the underlying Galena beds is best seen in the channel of a small stream, near the line between the south half of sections 13 and 14 of Tete des Morts township. Along this stream a thickness of sixty-five feet of the basal portion of the Maquoketa shale is well exposed. The material is a bluish colored, non-indurated shale, without fossils. At the bottom there is an abrupt change in the character of the materials at the line of contact of the Maquoketa with the Galena deposits.

The entire thickness of the Maquoketa sediments is present in the river bluff near the southeast corner of the town of Bellevue. The uppermost layers of the Galena dolomite appear in the bed near the mouth of Mill creek. At the summit of the scarp at this place there is a thickness of about thirty feet of Niagara limestone. The vertical distance from the base of the Niagara, at the top of the bluff, to the dolomitized layers of Galena in the bed of Mill creek is more than 100 feet.

A small affluent that joins the creek a few rods west of this point exposes along its bed about thirty feet of blue-gray shale which is barren of organic remains. Along a stream that comes down from the upland near the northwest corner of Bellevue the upper portion of the Maquoketa shale is well exposed. The succession of beds at this place is shown in the section given below:

		FEET.
8.	Bed of hard, massive, crystalline dolomite, in heavy layers three to six feet in thickness; indistinct remains of fossils not rare. Niagara limestone	13
7.	Yellowish-gray, rather fine-grained, impure limestone, in even layers four to fourteen inches in thickness, weathering into bands of one to two inches; carrying a few fossils; without chert nodules	14
6.	Bed of argillaceous, earthy limestone in layers two to six inches in thickness; containing a few fossils. On weathered faces thin partings of shale appear between the layers	19
5.	Ledge of yellowish colored, argillaceous stone, which is bluish-gray where not exposed to the action of the atmosphere; in layers one to three feet in thickness; weathering into narrow bands one to three inches thick. Occasional nodules of chert appear in lower part	15
4.	Bed of grayish-blue, indurated, calcareous shale, which weathers into thin bits; without fossils but carrying a few chert nodules	$3\frac{1}{3}$
3.	Layer of rather fine-grained yellow colored, impure limestone much decayed and showing numerous close lines of lamination	$\frac{2}{3}$
2.	Bluish-gray shale, somewhat indurated, weathering into small polygonal and irregular fragments, without fossils.	10
1.	Bed of blue colored, plastic, nonfossiliferous shale	30

In this section number 8 represents the basal portion of the Niagara limestone. It is harder and more resistant to weathering than the underlying beds and forms an overhanging shelf two to four feet in width. Numbers 1 and 2 are shale beds that represent the upper portion of the main body of plastic shale. Numbers 3 to 5 inclusive are indurated beds which were originally of a bluish color. They contain a large amount of argillaceous material. It seems probable that they represent a local modification of the shale deposit after the sediments were laid down. Number 6 also contains a large amount of argillaceous material. Numbers 6 and 7 together represent a transition phase from the Maquoketa shale to the Niagara dolomite. A few fossils were taken from the layers of numbers 6 and 7 among which were *Orthis testudinaria, Leptaena rhomboidalis,* Zygospira sp. and the pygidium of a trilobite resembling *Calymene mammilata* Hall. No traces of fossils could be seen in the beds below number 6 of the section. The materials of number 7 have been worked to some extent as a quarry horizon, supplying stone for local use.

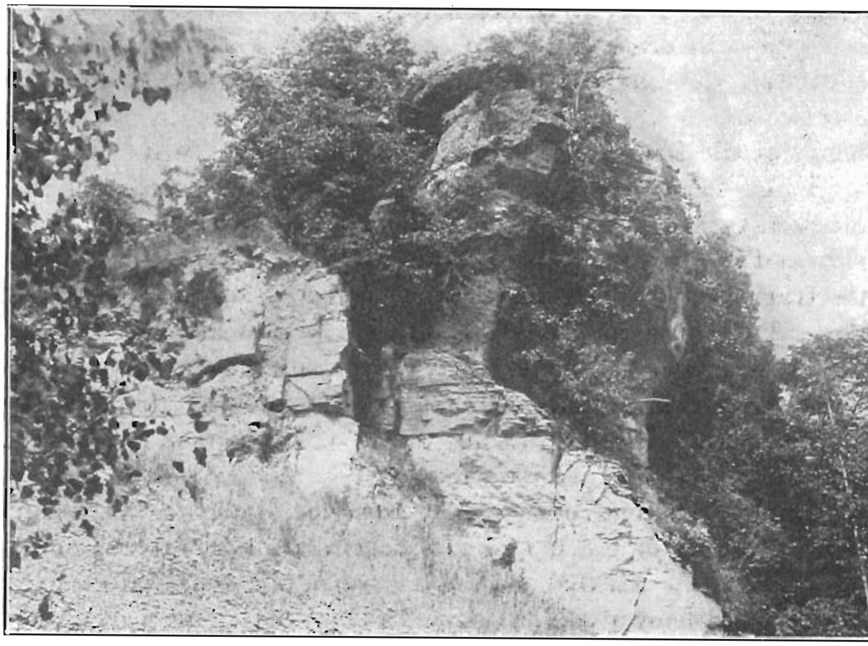


Fig. 69 View showing the unusual character of transition beds at the upper portion of the Maquoketa shale; near Bellevue. The cap at the summit is Niagara.

It seems probable that numbers 6 and 7 of the section represent the typical transition beds below the Niagara which are well developed in the counties of Delaware* and Dubuque.† These same beds are well exposed near the top of the bluff about one-half mile south of Bellevue, where they attain a

*Calvin: Iowa Geol. Surv., Vol. VIII, p. 141.
†Calvin and Bain: Iowa Geol. Surv., Vol. X p. 444.

thickness of thirty or thirty-five feet. They bear no fossils, but their characteristic manner of weathering may be clearly seen at the latter outcrop. See Fig. 69.

On following up the bed of a small stream that crosses the wagon road near the southwest corner of section 14, Prairie Spring township, there are passed over about fifty feet of blue, plastic shale. This body of shale is succeeded by about thirty feet of yellow, rather fine grained magnesian limestone, in thin layers which contain *Orthis testudinaria*. These layers also represent the transition beds of the Maquoketa. They are overlain by a ledge of massive dolomite forty feet in thickness which belongs to the Niagara series.

Along Mill creek, near the east side of section 1, Richland township, the Maquoketa transition beds are well developed. Fragments of these materials are conspicuous in the talus heaps at the foot of the ledges and along the beds of the streams. In every place where the uppermost strata of the Maquoketa are exposed over the north half of Bellevue township and in the townships of Prairie Spring and Tete des Morts the transition beds have a thickness of thirty or more feet. At none of these points were any of the fossil-bearing shale and limestone layers seen; nor were any fossiliferous fragments to be found along the channels of the streams, as they are in regions where the fossiliferous phase of the Upper Maquoketa deposit is normally developed.

About two miles south of the town of Bellevue the fossil-bearing layers of the Upper Maquoketa are encountered along the bed of a stream that joins the river in the southeast quarter of section 29, township 86 north, range V east. On walking up the channel of the stream a thickness of about 80 feet of blue colored, tenacious shale is encountered. This is overlain by a bed composed of alternating bands of shale and limestone which have an aggregate thickness of about twelve feet. Both the calcareous and the argillaceous layers are crowded with the characteristic fossils of the Upper Maquoketa stage, among which *Plectambonites sericea, Rafinesquina alternata, Leptaena* *unicostata, Orthis occidentalis, O. testudinaria, Rynchotrema capax* and *Tentaculites sterlingensis* are abundant. The transition layers were not observed at this place.

This fossiliferous phase of the Upper Maquoketa layers appears again along Duck creek, in the southern portion of Bellevue township. Numerous rock fragments resembling a brachiopod coquina, which came from this horizon, were seen in the bed of Pleasant creek and along the channels of the tributary streams over the north half of the township of Washington.

Near the middle of the north half of section 16 in the last named township, there is an excellent exposure of the uppermost layers of the Maquoketa beds. They outcrop in the banks of a stream on the west side of the wagon road and resemble quite closely the beds at Patterson's spring near Brainard in Fayette county. This is one of the most favorable places of our area in which to collect the fossils belonging to the Upper Maquoketa horizon. The indurated layers are four to six or eight inches in thickness and the intervening seams of shale are almost as crowded with fragments of shells as are the calcareous bands. The following forms occur in great abundance: Strophomena resembling *S. nutans,* an undescribed species of Strophomena, *Orthis occidentalis, O. testudinaria,* ***Rynchonella (?) anticostiensis, Rhynchotrema capax, Byssonychia radiata*** and a small, branching monticuliporoid. There are here no well developed transition beds between this fossil-bearing zone and the Niagara limestone.

Another good exposure of the upper layers of the Maquoketa deposits occurs in a ravine south of the wagon road near the middle of the south side of section 24, township 85 north, range V east, one fourth mile southwest from the town of Green Island. There is given below a section of the beds encountered in this exposure:

		FEET.
6.	Heavy layers of yellow dolomite, coarse grained and somewhat crystalline, carrying traces of a few fossils...........	15
5.	Bed composed of very uneven and irregular layers of yellow colored dolomite, two to four inches in thickness, which are cut at frequent intervals by conspicuous chert bands two to three inches thick......	25

		FEET.
4.	Bed of yellowish, rather fine-grained dolomite, free from chert, in layers that were originally eight to twenty-four inches in thickness, but which have weathered into narrow bands one to one and one-half inch	9
3.	Layer of blue colored shale	2
2.	Bed composed of alternating shale and limestone layers which carry in abundance the characteristic Upper Maquoketa fossils	20
1.	Blue colored, tenacious shale, without planes of stratification, carrying no fossils, but containing numerous nodules of iron pyrites	25

In the above section numbers 1 to 3 inclusive are the typical Upper Maquoketa deposits. Number 4 differs in lithological appearance and in its mode of weathering from the transition beds further north and it seems probable that this member represents the basal layers of the Niagara limestone as those materials are developed in the southern portion of Jackson county. No fossils could be found in this member, but it is quite uniformly present to a variable thickness underlying the chert-bearing horizon. Number 5 of the section is characterized by the presence of numerous bands of chert, which are intercalated between narrow layers of coarse-grained, earthy, yellowish colored dolomite. It is a well-marked horizon in the lower portion of the Niagara deposits over the greater portion of our area.

About one mile west of Sabula the upper portion of the Maquoketa appears near the top of the bluff just south of where the wagon road passes up the hill from the bottom land. There are about eighteen feet of the Niagara at the summit of this bluff, below which outcrops twenty-five feet of yellowish-gray, non-fossiliferous, impure limestone which presents many of the characters of the transition beds. This exposure is on the south slope of an arch that extends with a trend slightly south of an east-west direction from Savanna, Illinois, to near the east side of Fairfield township in Jackson county. Below the transition beds the surface inclines gently down to the flood plain of the river through a vertical distance of sixty-five feet. The gentle slope is so completely sodded over that few outcrops of the plastic shale are to be seen.

In the north part of the town of Savanna, across the river east from Sabula, the upper beds of the Maquoketa appear near the top of the bluffs almost 100 feet above the water. The fossil bearing layers are here well developed and contain *Streptelasma corniculum,* numerous biscuit-shaped colonies of some bryozoan, a branching monticuliporoid, *Leptaena unicostata, Plectambonites sericea, Rafinesquina alternata, Orthis occidentalis, O. testudinaria, O. biforata, Rhynchonella? anticostiensis* and *Rhynchotrema capax.* This zone is separated from the very cherty horizon of the Niagara by a bed of yellowish, non-fossiliferous, rather fine grained dolomite four to seven feet in thickness.

The fossiliferous phase of the upper beds of the Maquoketa appears again about eight miles west of Sabula, in the southwest quarter of section 13 in Van Buren township. A weathered bed of blue shale along the roadside furnished *Leptaena unicostata, Plectambonites sericea, Orthis occidentalis* and *Rhynchonella? anticostiensis.* This same phase of the Upper Maquoketa layers may be seen at a number of points in the wagon road which crosses the north half of section 23. At these outcrops the biscuit shaped bryozoan colonies are abundant. Some of these are flattened masses from two to five or six inches in diameter. Others have a more narrow cylindrical form, four or five inches in length, which shows at intervals rather deep annular constrictions as if the colony had experienced unfavorable conditions for growth which alternated with periods of more rapid development. Associated with the above were *Streptelasma corniculum, Plectambonites sericea, Orthis occidentalis, O. testudinaria, O. whitfieldi, Zygospira modesta, Rhynchonella? anticostiensis, Rhynchotrema capax, Byssonychia radiata, Cyrtolites ornatus?* and fragments of large individuals of a trilobite belonging to the genus Isotelus. One-half mile north of the town of Preston a bed of blue shale appears in the roadway and along the banks of a ravine near the foot of the hill bordering the old Goose Lake Valley. The fossils at this place are similar to those found in section 23, but aneroid readings gave the elevation at two points of the latter outcrops as respectively ninety and 115 feet higher than that of the exposure near Preston.

The upper portion of the Maquoketa beds is again encountered about four miles west of Preston, near the southwest corner of section 26 in Fairfield township, at an altitude eighty feet above the Preston exposure. The fossil-bearing layers are not exposed at this place, nor do fossiliferous rock fragments appear in the bed of the stream. However, a body of blue shale, the top of which determines a zone of springs, can be seen underlying the thin bedded cherty phase of the Niagara.

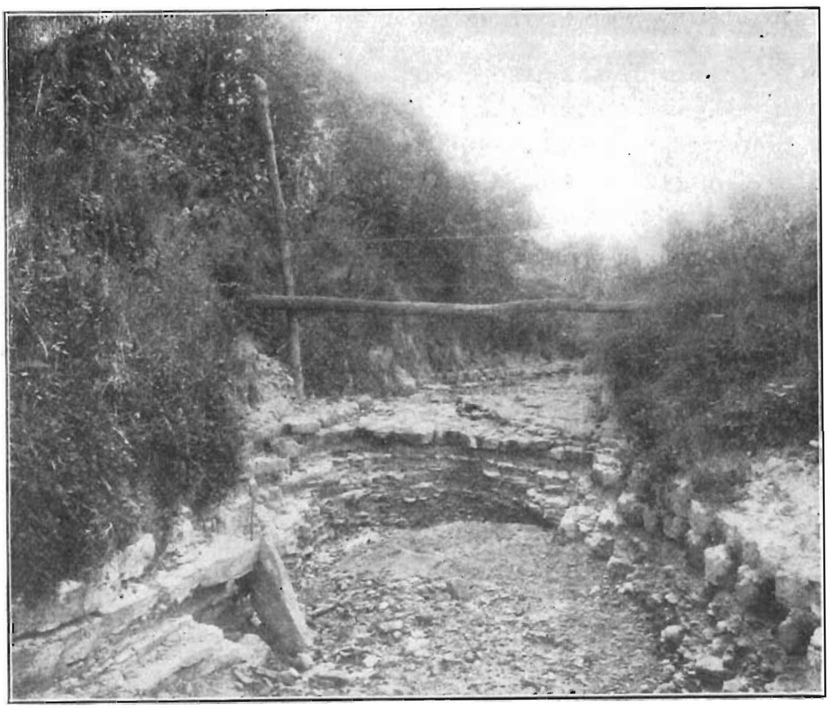


Fig. 70—Small fall due to hard layer underlain by weaker beds. Photo by Calvin.

In the channel of a stream that crosses the southwest quarter of section 28 and the southeast quarter of section 29, Fairfield township, the upper layers of the Maquoketa outcrop almost continuously for a distance of sixty rods. The beds include the very fossiliferous horizon of alternating shale and limestone bands. In the eastern portion of the exposure the layers incline quite uniformly towards the east, almost with the fall of the stream. At a few points they dip strongly towards the north at an angle varying from 15 to 35 degrees.

The floor of the stream channel is cut by numerous small, parallel joints that extend in a nearly east and west direction. These are crossed by another series of fissures trending at about right angles to the first. The joints are from ten to fifteen inches apart, and were doubtless induced by the local strains of tension at the time the deformation of the strata took place.

In the west half of the outcrop the layers are thrown into numerous small folds such as are developed in the crumpling of shaly materials under the influence of lateral pressure. In many places the layers are inclined as much as 45 degrees. At three points along this portion of the outcrop, the inclined Maquoketa layers may be seen abutting against a vertical wall of Niagara limestone. The Niagara beds are not in all cases level, but their departure from the horizontal is not great, nor does it seem to bear any relation to the arching and dipping of the adjacent Maquoketa layers.

There seems no doubt that at these points the Maquoketa shale had suffered erosion prior to the deposition of the Niagara sediments; that the later materials occupy a channel of erosion and are separated from the Maquoketa deposits by an unconformity of overlap. The elevation of the Upper Maquoketa layers here is 95 feet higher than that of the rocks of the corresponding horizon on the border of the Goose Lake channel near Preston.

The most westerly exposure of the Maquoketa shale in the south half of the county occurs at the western extremity of the anticline referred to above, in sections 29 and 30 of Fairfield township. Aneroid readings at both places gave the elevation here 175 feet above the old plain at Preston. The layers are best seen outcropping along the smaller affluents that flow southward to the major stream in this region.

Near the middle of the south side of section 29, the Upper Maquoketa beds appear in an unusual relation to deposits of the later Paleozoic series. Across the north side of section 32 the south side of a stream is bordered by a somewhat loess covered bluff of Niagara limestone forty or more feet in height. The low bank on the opposite side of the stream is composed of sandstone of the Des Moines stage. This sandstone ledge extends for a distance of thirty rods and has a height of eighteen to twenty-five feet. On following up the bed of a lateral stream that has cut through this ledge of sandstone, the arenaceous material soon gives place to shale, and a thickness of thirty-five feet of the Maquoketa beds may be seen within a distance of as many rods. The phase exposed here represents the upper, alternating shale and limestone layers that carry very numerous fossils. Some of the bands are composed largely of shells of a few species, and similar fossil zones recur a number of times. The following forms were collected at this place: *Streptelasma corniculum,* Orbiculoidea? sp., *Strophomena incurvata, S. planumbona,* Strophomena sp., *Plectambonites sericea, Leptaena unicostata, Rafinesquina alternata, Orthis occidentalis, O. biforata, O. testudinaria, O. whitfieldi, O. proavita, Zygospira modesta, Rhynchonella? anticostiensis, Rhynchotrema capax, Tentaculites sterlingensis, Byssonychia radiata, Pterinea demissa,* Megaptera sp., Modiolopsis sp., Cyrtodonta? sp., Lophospira sp., Liospira sp., Bellerophon sp., Orthoceras sp., *Calymene senaria* and *Isotelus gigas?*

These fossils are typical of the upper layers of the Maquoketa beds in the counties of Clinton, Dubuque, Clayton, Fayette, Winneshiek and Howard wherever in those areas the upper fossiliferous phase is developed. Professor Calvin* has shown that they are also similar to the fossils of the corresponding horizon in southeastern Indiana and southwestern Ohio.

Summary.—Of the deposits of the Maquoketa stage there are present in Jackson county only the Upper Maquoketa beds. The formation is argillaceous with the exception of twenty to thirty-five feet of the dolomitic transition beds or of fossiliferous, alternating shale and limestone bands. The total thickness of the Maquoketa beds in our area does not much exceed 100 feet. The thickness of the Maquoketa deposits increases towards the north, attaining its maximum in the

*Calvin: Iowa Geol. Surv., Vol. VIII, p 141 counties of Fayette, Clayton and Winneshiek. It then decreases rapidly towards the northern border of its extension in the state. In the southern portion of the Maquoketa area only the Upper Maquoketa beds are developed. In the extreme northern portion of its outcrop, the argillaceous part of the upper beds has faded out and there are represented only the calcareous, fossil-bearing horizon and the transition beds of the Upper Maquoketa, and beds corresponding with the Lower Maquoketa of Dubuque county.

SILURIAN SYSTEM.

Niagara Series.

The Niagara limestone forms the foundation rocks upon which is spread the mantle of Pleistocene materials over more than five-sixths of the surface of Jackson county. Its massive courses may be seen bordering all of the larger streams and many of the smaller water courses in the region outside the limits of the Ordovician deposits. They stand in precipitous ledges and steep escarpments, more than 100 feet in height, at points along Bear creek in Monmouth township; Brush creek, in Perry; in the vicinity of the "caves", in the township of South Fork; and at a number of other points over the area under consideration.

HOPKINTON STAGE.

With the exception of a deposit of limited extent in Brandon township, all of the strata of the Niagara series in our area belong to the subdivision known as the Hopkinton stage. These consist for the most part of very heavy layers, two to six or eight feet in thickness, which are but imperfectly separated by planes of stratification. They represent the basal portion of the Niagara limestone, the horizon of *Pentamerus oblongus*, and the Cerionites and crinoid beds that immediately succeed the Pentamerus layers.

The basal beds outcrop in the west bluff of the Mississippi river, almost continuously, from section 1 of Bellevue township to the southeast corner of Union. They appear just across the river from Sabula in the north part of the town of Savanna. They may be seen along the border of the Maquoketa shale in

Van Buren and Fairfield townships and they are exposed in the banks of all of the important streams that render tribute to the Mississippi river in Jackson county.

Typical Exposures.—A section of the beds exposed in the banks of a small stream near the middle of the south side of section 24, in Washington township, was given under the discussion of the Upper Maquoketa layers. At this place there is to be seen, overlying the uppermost zone of the Maquoketa, a bed of yellow, non-fossiliferous dolomite which is rather fine-grained in texture and is free from chert nodules. This zone varies in thickness from as low as four or five feet to as much as ten or twelve. It is generally present as the basal member of the Niagara limestone. It is probable that this zone corresponds with the basal Niagara beds of Calvin, which are better developed in Dubuque county.

Overlying the above member there is quite uniformly developed a bed of yellow-colored earthy dolomite, in rather thin layers, between which, at intervals of a few inches to one or two feet, there are intercalated bands of chert. These cherty beds have a thickness of eighteen or twenty feet and are especially prominent in the southeastern part of the county. They are conspicuous near the middle portion of the bluff from Sabula southward to Elk River Junction, in Clinton county, and they appear towards the top of the ledge at Green Island.

In section 36 of Washington township the dip of the strata brings this horizon down to the level of the flood plain. A creek that flows eastward through sections 2 and 1 of Iowa township, joining the river in section 6 of Union, shows no Maquoketa shale throughout its entire length. A quarry is worked in the Niagara limestone near the northwest corner of section 1, and the Niagara layers are clearly exposed at the level of the water near the middle of the east half of the same section. In section 13 of the civil township of Union, an arch in the strata once more brings the Maquoketa beds many feet above the water level. Along this anticline west of Sabula, the Niagara cliff recedes from the river for a distance of more than two miles. South of this line the strata dip strongly southward so that at the extreme southeast corner of the county, the

Maquoketa has generally disappeared from the bank of the river, and the Niagara is exposed almost to the level of the flood plain. The strong arching of the strata, and the relation of the cherty beds and the underlying even-bedded zone to the upper layers of the Maquoketa, are well shown in the north part of the town of Savanna, in Illinois.

Near the middle of the southwest quarter of section 30 in Union township, a ledge has been worked in the lower beds of the Niagara exposing a quarry face twenty feet in height.

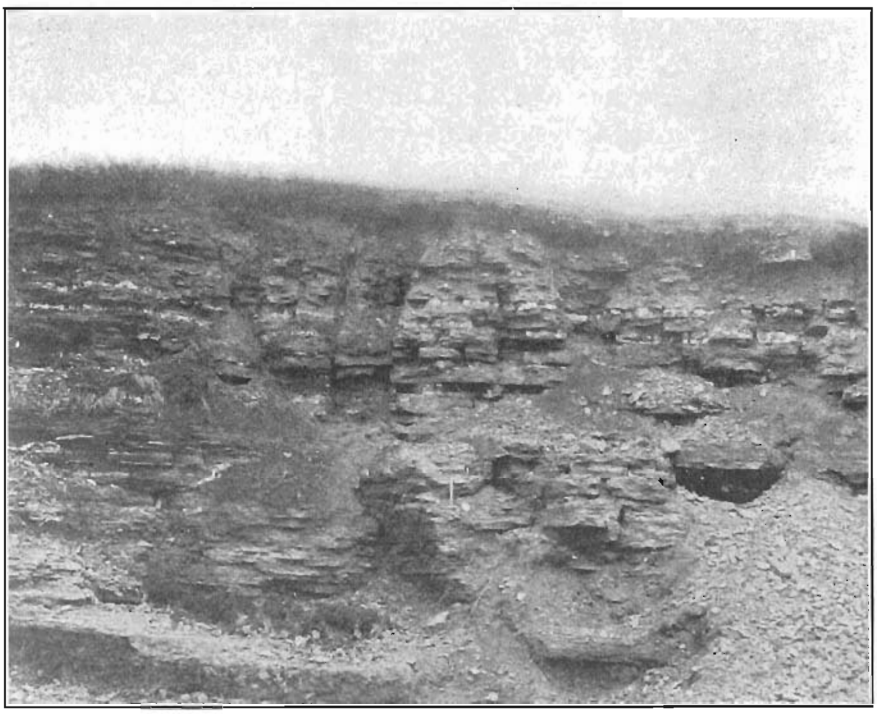


Fig. 71—Lowermost, cherty beds of the Niagara limestone in a quarry in the southwest quarter of section 30, Union township.

Bands of chert, two to four inches in thickness, are conspicuous in the upper half of the ledge. See figure 71. The stone is a yellowish-brown dolomite, in original layers six to eight inches in thickness, which on weathering are divided into bands one to two inches thick. Traces of a few coral remains were found at this place.

In passing up the hill that borders the old Goose Lake channel, about one-half mile north of Preston, a thickness of fourteen feet of chert-bearing layers is well exposed at a horizon twenty feet above the outcrop of Maquoketa shale described above. The rock here is a yellowish-brown, somewhat granular dolomite, in layers three to six inches in thickness. Between these bands there are intercalated seams of chert about equal in thickness to the layers of limestone. The strata here dip strongly toward the east and are inclined at a lesser angle towards the north. The layers carry no recognizable fossils. They represent the upper portion of the cherty beds. Residual cherts are abundant on the slopes in the roadsides and overlying the ledges in this vicinity. Near the crest of the next hill, a few rods further north, there is an outcrop in which the layers are heavy and contain a large number of small individuals of *Pentamerus oblongus,* and several species of corals. This Pentamerus horizon is about seventy-five feet above the top of the Maquoketa shale exposure that was seen at the foot of the hill about forty rods further south. The dolomite of this horizon is very granular and yields readily to weathering. In the upper part it is so thoroughly decomposed that a spade can be easily pushed down into the top of the beds.

The chert-bearing beds are also well exposed at the crossroads near the middle of section 22 of Van Buren township, and at a few other points in this vicinity, at a horizon not far above the top of the Maquoketa shale. The character of the materials here is similar to that of the beds exposed north of Preston. The layers also are strongly inclined, but the direction of dip is different in different parts of the outcrop. The cherty beds can be seen again in the hill near the southeast corner of section 27, in Fairfield township, a few feet above the Maquoketa shale outcrop in the bed of the stream.

Along the road crossing the north half of section 20 and the east half of 19 of Van Buren township, the granular phase of the dolomite appears in low cliffs to a height of thirty to forty feet. The beds are thick and do not weather into distinct layers. They carry numerous corals, among which *Halysites* *catenulatus, Favosites favosus* and Favosites sp. are the most common. This coarsely granular phase appears again in section 16 of the same township.

Over the north half of the county the lower beds of the Niagara are harder and more crystalline than in the southeastern portion. They do not yield readily to weathering, but stand in precipitous cliffs near the crests of the hills that bound the stream channels. In the lower portion there is a considerable amount of chert, above which, at the horizon of the somewhat granular beds further south, the layers are hard and enduring and carry numerous corals. On weathered surfaces these strata show rather thin layers in which *Halysites catenulatus, Favosites favosus, Lyellia americana* and *Syringopora* sp. are not rare. The beds appear in the east half of section 18 of Prairie Spring township.

This horizon probably corresponds with the Syringopora beds described by Calvin* in the report on the Geology of Dubuque county. A quarry near the northeast corner of the southwest quarter of section 20, Iowa township, shows the following succession of layers:

		FEET.
7.	Bed of decayed, earthy, yellow dolomite, containing much chert; the bedding planes destroyed by the breaking down of the rocks on weathering	10
6.	Ledge of yellow colored dolomite, very cherty, weathering into layers about one inch in thickness	3
5.	Layer of very cherty dolomite	2½
4.	Layer of earthy dolomite, with chert	2
3.	Bed of yellow dolomite bearing, near the center, a band of chert two inches in thickness. Weathering into thin layers one to two inches thick	2⅓
2.	Layer of yellow dolomite, free from chert	1½
1.	Yellow colored, rather fine grained dolomite, without chert, in a single layer	2

The above section is representative of the basal beds of the Niagara limestone. The lower part of No. 1 is very close to the top of the Maquoketa shale. Numbers 1, 2 and 3 represent the non-cherty, rather fine-grained and even-bedded layers at the very base of the Niagara. Numbers 4 to 7 inclusive represent the chert bearing layers which lie a few feet above the Maquoketa.

*Calvin and Bain: Iowa Geol. Surv., Vol. X, pp. 446 and 447.

The above outcrop is along the line of the anticline that extends westward from Sabula, which accounts for the lowermost Niagara beds being brought to the surface at this point.

Near the southeast corner of section 10, Butler township, a quarry has been opened in a hill on the north side of the wagon road, showing a vertical face thirty feet in height. The material is a yellow, non-fossiliferous dolomite. In the upper half of the exposure the layers are from three to six or eight inches in thickness. Lower down they thicken to as much as eighteen to twenty-four inches. Cherty materials form conspicuous bands between the layers. It seems probable that the beds here exposed correspond with the cherty phase encountered in the southeastern portion of Jackson county.

A short distance east of the middle of section 21, Otter Creek township, a small quarry has been operated in layers which contain *Halysites catenulatus, Favosites favosus, F. hisingeri, Lyellia americana* and Syringopora sp. Near the top of the bluff not far from the middle of the east side of section 19, Tete des Morts township, there were found among the residual cherts *Plasmopora follis, Alveolites undosus, Heliolites interstinctus, H. megastomus, Strombodes pentagonus, Halysites catenulatus, Favosites favosus, F. niagarensis* and *Orthis flabellulum*.

Near the middle of section 32, Richland township, ledges of Niagara limestone twenty to fifty feet in height, bound the channel of Farmers creek. These beds contain the corals *Halysites catenulatus, Favosites favosus, F. niagarensis, Lyellia americana* and a species of Syringopora. This coral zone is quite generally present at a horizon a few feet above the cherty phase of the lower Niagara beds. It doubtless corresponds with the *Syringopora tenella* beds of the Dubuque county report.

Along a ravine near the southeast corner of section 30, in Richland township, numerous corals are found among the chert fragments and residual materials. Among these the following are abundant: *Halysites catenulatus, Favosites favosus, F. hisingeri, F. niagarensis, Lyellia americana, Heliolites interstinctus, Cannapora annulata,* Syringopora sp., *Amplexus* *shumardi, Strombodes* sp. and *Cystiphyllum niagarense.* There seems no doubt that these corals came from the horizon of *Syringopora tenella.* This coral zone in our area varies in thickness from twenty to thirty feet. It occurs above the cherty phase and underlies the horizon of *Pentamerus oblongus.*

The *Pentamerus oblongus* beds consist of massive dolomite layers which are pre-eminently the cliff-forming ledges of the

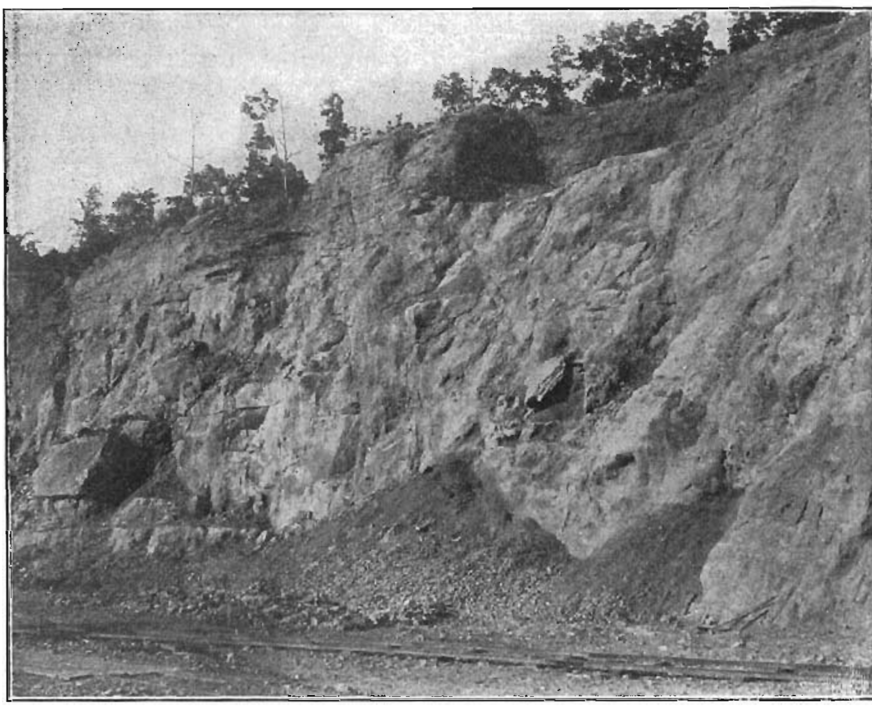


Fig 72 - Quarry furnishing stone for lime burning at Hurstville.

Niagara limestone in the county. The large lime works in our area quarry the upper portion of the Pentamerus horizon and the overlying beds containing crinoids and *Cerionites dactylioides.* Below is given a section of Hurst's lime quarry east of the river, at Hurstville.

		FEET.
3.	Ledge of somewhat decayed, yellowish-brown dolomite, weathered into layers from a few inches to three or four feet thick; containing Cerionites, crinoids and Pentamerus	15

		FEET.
2.	Massive ledge of yellow dolomite, imperfectly separated into layers six to eight feet in thickness, which contain crinoids and Halysites and Favosites besides numerous individuals of Pentamerus	30
1.	Ledge of buff colored dolomite crowded with rather small individuals of *Pentamerus oblongus*	8

The above ledge outcrops along the river for a distance of twenty-five rods. The entire thickness is used for lime burning. Below the first member of the section there occurs a heavy ledge, ten or twelve feet in thickness, which contains chert in considerable quantities making it unsuited for manufacture into lime. In the old quarry on the west side of the river there may be seen practically the same succession of beds as in the section given. The following fossils were collected from this quarry zone at Hurstville. *Cerionites dactylioides, Halysites catenulatus, Favosites favosus,* Syringopora sp., *Zaphrentis stokesi, Caryocrinus ornatus,* Culicocrinus sp., *Pentamerus oblongus, P. pergibbosus, P. maquoketa, Meristina nitida, Atrypa reticularis, Spirifer radiatus, Bucania chicagoensis, Pleurotomaria occidens,* Mandaloceras sp., and the form described by Whitfield as *Discoceras conoideus.*

The lime quarry of O. W. Joiner, located near the middle of the south side of section 20, South Fork township, is operated in beds which correspond with those at Hurst's quarry. From the upper half of Joiner's quarry there were collected *Cerionites dactylioides, Halysites catenulatus, Favosites favosus, F. hisingeri,* casts of Zaphrentis sp. and Lyellia sp., Culicocrinus sp., Melocrinus sp., Stropheodonta sp., *Orthis biforata, Pentamerus pergibbosus, P. maquoketa, Stricklandinia castellana,* Meristina sp. and fragments of a small species of Orthoceras. From the lower portion of Joiner's quarry the following were taken: *Cerionites dactylioides, Favosites favosus,* Zaphrentis sp., *Melocrinus verneuili,* Culicocrinus sp., *Leptaena rhomboidalis, Orthis biforata, Pentamerus oblongus, Stricklandinia castellana, Amphicoelia leidyi, Bucania chicagoensis, Platystoma niagarensis, Discoceras conoideus* and *Illaenus imperator.*

The beds represented in this quarry exposure are present in the bluffs that border the streams in all of this portion of the county. These rocks form the rampart that more or less continuously bounds the South Fork of the Maquoketa river. They appear in the weathered towers along Bear creek in the vicinity of Mill Rock. They stand in steep escarpments at the "caves" in South Fork township, and along Brush creek in section 14 of Perry. In short, wherever in the county very prominent cliffs are formed by Niagara ledges alone, the presence of the beds of this horizon may be looked for with confidence.

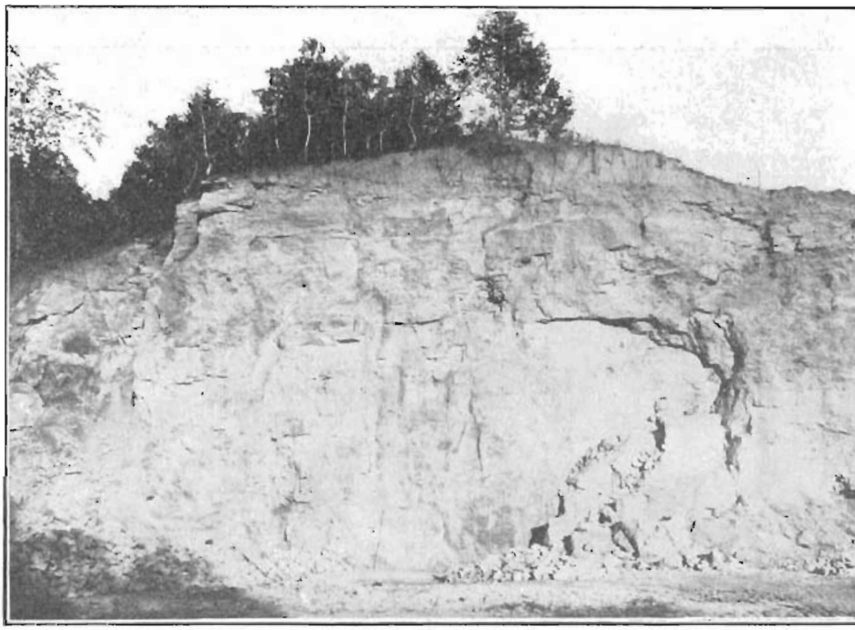


Fig. 73 Lime quarry working the Pentamerus horizon of the Niagara limestone, section 20, South Fork township

In the quarry of the Keystone Lime Company, near the middle of the west half of section 32, Monmouth township, the ledges worked embrace the above mentioned beds and include a layer of Pentamerus limestone, eight feet in thickness, which occurs below number 1 of the Hurst quarry section. In this quarry a thickness of forty feet of Pentamerus beds has formerly been exploited below the base of the layers now worked. These lower beds, however, contain too much chert to be profitably used for lime burning. They are largely composed of casts and moulds of very large individuals of *Pentamerus oblongus,* many of which can be broken from the matrix in an almost perfect condition. From calculations based on the log of two wells put down in the vicinity of this quarry, Mr. L. B. Stewart estimates a thickness of sixty feet of Pentamerus-bearing rocks in Monmouth townships and about ninety feet of Niagara limestone below the *Pentamerus oblongus* beds. This thickness seems to be a little greater than that of the corresponding beds in the eastern portion of the county.

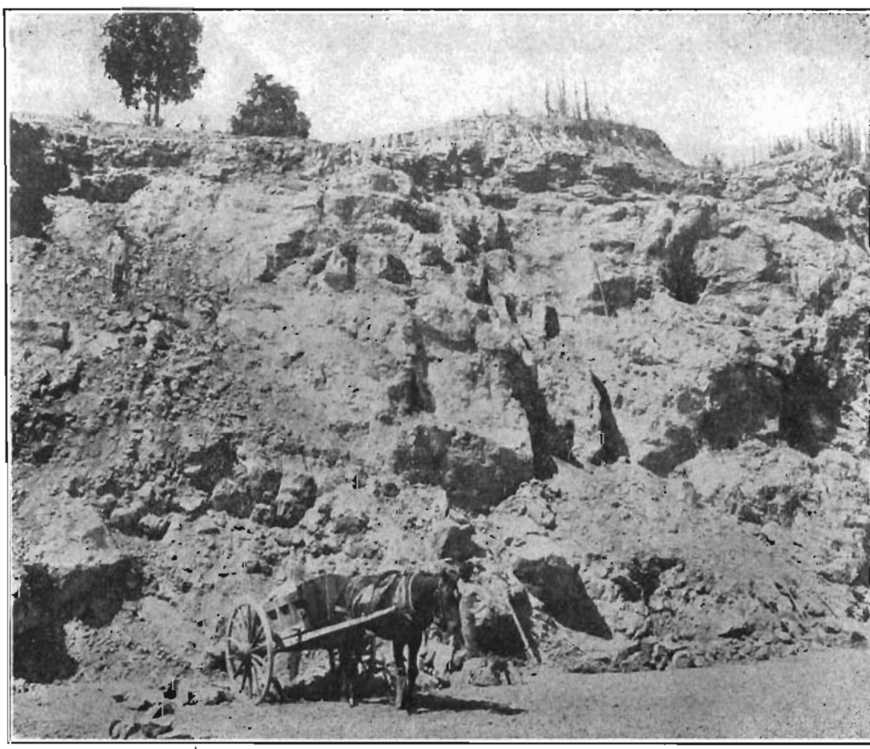


Fig. 74--Lime quarry in section 32 of Monmouth township.

Besides the fossils generally found in the rocks of this horizon there were taken from the Keystone quarry *Euomphalus tricarinatus* Calvin, *E. bicarinatus* Calvin, *Orthoceras crebrescens* Hall, and *Illaenus imperator* Hall.

Above the horizon of Cerionites there occur, in Brandon township, some few feet of massive dolomite layers which contain quite a number of the more common species of Niagara corals. This zone is developed only over limited areas in the northwest portion of Jackson county. At a few points in sections 9 and 10 of Brandon township it is overlain by the even-bedded quarry-stone layers of the Gower stage.

GOWER STAGE.

The rocks of the Gower stage in our area consist of even-bedded layers of yellow dolomite, without fossils. They outcrop at only a few points in sections 9 and 10 of Brandon township.

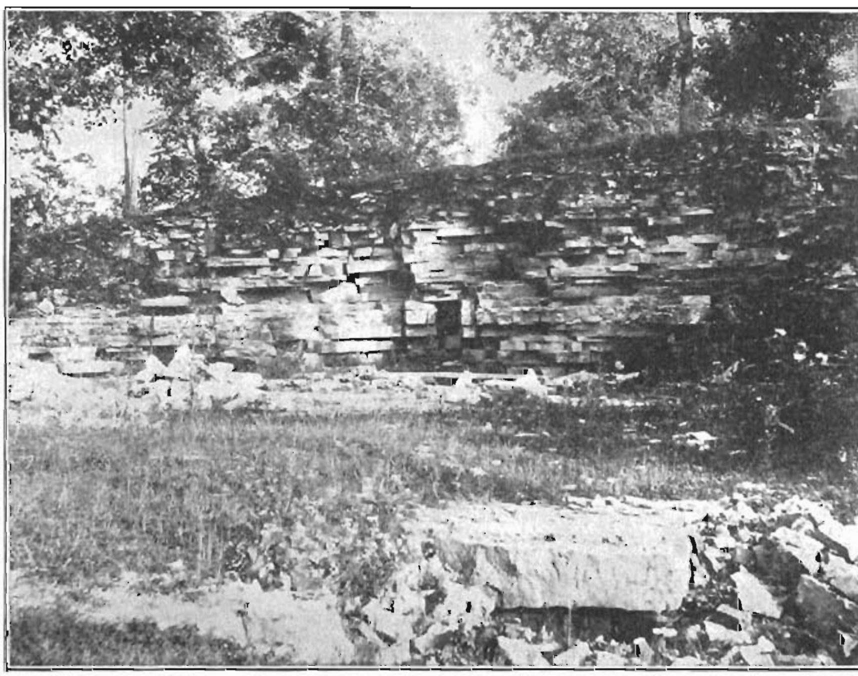


Fig.75-- Building stone quarry of the Gower stage; near the southwest corner of section 10, Brandon township.

A quarry on land owned by Mr. John Archibald, in the south bank of the North Fork of the Maquoketa river near the middle of the east side of section 9, has furnished considerable stone for local purposes. The section of the layers here exposed is given below:

		FEET
3	Bed composed of thin layers of yellow magnesian limestone, two to four inches in thickness, much weathered...... ...	0

		FEET.
2.	Yellow, rather fine-grained dolomite, in regular layers two to twelve inches in thickness, showing numerous fine lines of lamination	8
1.	Layers of yellow dolomite, eight to eighteen inches in thickness, finely laminated and splitting readily along the lamination planes	9½

The stone here is easily quarried and resembles the Anamosa type of stone found in Jones county. In its even bedding, finely laminated character, and it finely granular texture it differs very markedly from the quarry stone of the Hopkinton stage.

Near the southeast corner of section 9, a quarry on land belonging to Mrs. P. J. Fads shows the even character of the layers in this horizon. (See figure 75.) The section of the quarry is as follows:

		FEET.
3.	Bed of weathered and broken, finely laminated layers of yellow dolomite, one to three inches in thickness	4
2.	Even, fine-grained finely laminated layers, from two to eight or ten inches in thickness	10
1.	Three layers of yellowish-gray, laminated stone respectively 14, 10 and 16 inches in thickness	3⅓

The stone here is of excellent quality, and is readily accessible. It occurs at a horizon a short distance above that exposed in the quarry of J. W. McCullough, about one-half mile further west. At the latter place the following beds may be seen below the surficial materials:

		FEET.
3.	Layer of hard, yellowish-gray dolomite	1½
2.	Ledge of even-bedded finely laminated dolomite in layers two to four inches in thickness	6
1.	Bed composed of layers six to twenty inches in thickness, fine-grained and finely laminated	7⅔

This stone weathers into thin pieces where long exposed in contact with the ground, but it proves durable when laid in a wall. It can be quarried easily and dressed readily into elegant blocks of any dimensions desired. The layers in this quarry have furnished flagstones 8 x 12 feet x 14 inches and supplied excellent blocks for caps, sills, and water tables. A large proportion of the stone used in the western portion of the county comes from the above mentioned quarries in the Gower limestone. A thickness of seventy to ninety feet of deposits of the Hopkinton stage intervenes between the horizon represented in these quarries and the bed of the North Fork of the Maquoketa river.

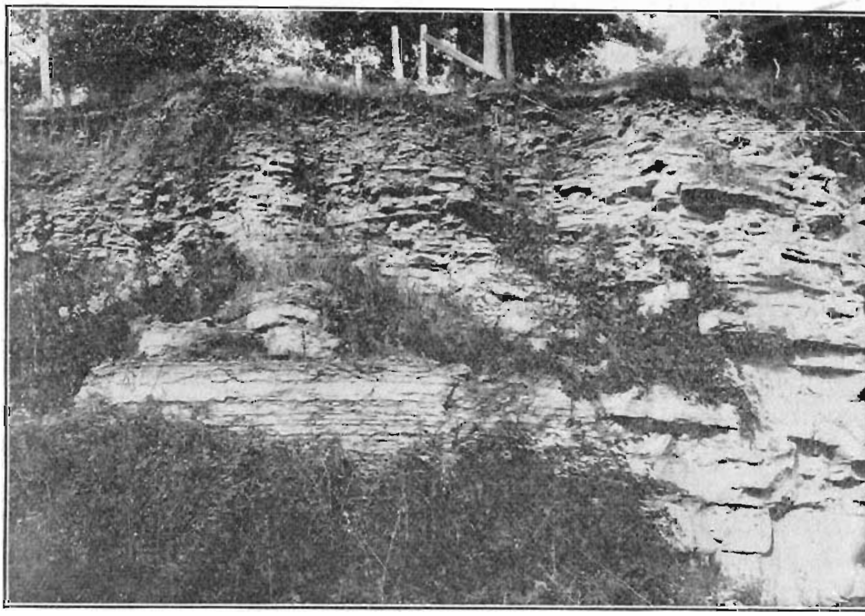


Fig 76- Quarry stone of Gower type which supplies building stone to a large portion of Butler township.

DEVONIAN SYSTEM. ?

No outcrop of rocks of undoubted Devonian age was seen in Jackson county. A bed of sandstone and shale which is exposed in the wagon road near the middle of section 18 in Brandon township, about one-half mile north of the village of Canton, has been tentatively referred to this system.

The sandstone showed beautiful ripple marks and contained impressions of plant remains. No fossils could be found in the shales as at present exposed. Professor Norton,* who studied the outcrop when the beds were better exposed than at present, writes as follows concerning this deposit:

"A yellowish-gray sandstone outcrops about half a mile north of Canton in Jackson county. It occupies a narrow shelf in the Upper Silurian limestone, sixty feet above the present flood plain of the Maquoketa river, and extends east and west

*Norton: Iowa Geological Survey, Vol. III, pp. 122-126.

along the south slope of the hill a distance of about eighteen rods. The total thickness as defined by outcrops of the Upper Silurian both above and below it, cannot be over twelve feet. As shown in a well on the crest of the hill the limestone there rises between twenty and thirty feet higher than the sandstone. The latter, which occurs in a field in scattered bowlders and with one or two ledges a foot or more high, presents nothing to differentiate it from perhaps a dozen or more other outliers of sandstone in northeastern Iowa. Fortunately, however, at the western end of the outcrop on the brow of a hill, a road crosses it, displaying a very interesting section. On the west side of the road there are noticeable some small, badly weathered bowlders of brecciated limestone which, in the structural and lithological characteristics of both fragments and matrix are indistinguishable from the lower portions of the Fayette breccia of the Devonian. Three of these bowlders were found and a half dozen rudely oval nodules of quartz with pitted surfaces, the latter peculiarly characteristic of the Kenwood shale, which in Linn county lies beneath the Fayette breccia. On the same side of the road the sandstone is exposed in a small gully for a distance of nearly two rods. Above this lies a stiff gray or greenish unctuous clay, in places highly arenaceous, in others nearly free from sand. It extends five rods up the hill. This clay had been scraped clean in working the road and the surface was substantially free from foreign material. On the weathered surface of the clay, fragments of silicified fossils are quite plentiful. They comprise *Acervularia davidsoni*, *Atrypa reticularis*, *Orthis iowensis*, a Stropheodonta, several species of Spirifers, one indistinguishable from fragments of a Spirifer at Bertram. Specially numerous were the rostral portions of the ventral valve of *Cyrtina umbonata* Hall, their preservation being due to the fact that this portion of the shell is strengthened by the cardinal area and mesial septum. Still more abundant were fragments of simple rugose corals and of favositids.

The occurrence of these remnants of Devonian beds of considerable thickness thirty miles east of their nearest outcrops was entirely unexpected. With the exception of the outliers above described, viz. Bertram, Lisbon and on Clear creek in Cedar county, no Devonian outliers had previously been known in the state and none had been found in this region resting on the rocks of an earlier geological age. It therefore becomes necessary to consider and, if possible, to disprove every other working hypothesis of the presence of these Devonian fossils and bowlders at Canton. Any suggestion of a fortuitous mingling of Devonian drift from northwestern outcrops with the sandstone and clay of a Carboniferous outlier was seen to be quite untenable. The fragments of fossils were siliceous, specifically identical with forms from the Devonian sandstone at Bertram. The distribution of Devonian rocks and fossils was exactly conterminous with the outcrop of sandstone and clay on the west side of the road, being found along its entire extent and entirely absent both above and below. Further, this outlier is situated near the margin of the driftless area. The drift here is thin and inconstant, forming a thin, pebbly layer resting on geest or intermingling with it. No drift appears along the outcrop of the sandstone and clay, but seven rods farther up the hill the rotten Upper Silurian limestone is overlain by a foot of residuary chert and clay mixed with pebbles of the northern drift. The bowlders of Devonian limestone and breccia show no indication of transportation by water or ice. Fossils and breccia fragments are in relief. The surfaces are irregular and pitted. The quartz nodules retain their original form and their surfaces are vesicular from the dissolution of associated calcite.

To be doubly sure of the relation of the fossils, breccia bowlders and quartz nodules to the clay and sandstone, a hole was dug in the undisturbed bank by the roadside, giving the following section:

		FEET.
3.	Soil passing below into clay	½
2.	Clay, stiff, reddish-brown, free from pebbles (passing below into number 1)	1
1.	Clay, stiff, greenish gray, sandy, non calcareous, containing silicified fragments of Devonian fossils	1½

The fossiliferous clay overlies a sandstone, which in turn rests upon a clay, as shown by the fact that a few years since an excavation was made in the middle of the road, and fire-clay was found to extend to a depth of six feet. The intimate association of clay and sandstone is shown by the following section on the east side of the road, where the bank is six feet higher than on the western:

		FEET.	INCHES.
6.	Soil, passing into loess	1	
5.	Loess, fine, buff loam, rather stiff, with the lower inch a transition in color and texture into number 4	3	
4.	Clay, fine, white, unctuous, with rounded fragments of sandstone		4
3.	Clay, light brown, resembling fire clay		2
2.	Clay, light-red, as above, with fragments of reddish sandstone	1	4
1.	Clay, white, as above	1	

On the same side of the road no Devonian limestone or fossils were found. The width of the outcrop is the same on both sides.

The little deposit of foreign rock on the brow of the Canton hill is full of meaning. Hitherto there has been no evidence that the Devonian sea ever trangressed the present western boundary of the Upper Silurian in Iowa. This outcrop affords proof that the ancient shore line must have extended at least as far east as Canton. It hardly can represent rocks deposited in some shallow estuary, connected with the Devonian ocean to the west. More probably it represents one or more distinct beds of the Devonian series elsewhere of considerable thickness and deposited under oceanic conditions. Quartz nodules are common only in the Kenwood shales, though one is sometimes found in the Fayette breccia. The hard drab limestone with conchoidal fracture which forms the fragments of the Canton breccia characterizes a definite horizon of Lower Devonian from Davenport to Fayette. It lies above the Kenwood shales of Linn county and, where its beds are disturbed, forms the lower portion of the Fayette breccia. It demands oceanic conditions for deposition and probably for brecciation. The fossils, if unassociated with sandstone and clay, would be referred to no horizon lower than the coralline beds above the breccia. The sandstone and clay are of doubtful position.

They may be the Montpelier, or they may be related to the arenaceous material sometimes found associated with the matrix of the Fayette breccia.

It seems, therefore, highly probable that the strata of the Lower Devonian, and perhaps some of the Upper Devonian were laid down as far east as the western part of Jackson county and have since been removed by secular decay and erosion. It is a mere accident that in one place, at least, their remains were preserved from the ice invasions on the lee of a hill of obdurate Upper Silurian dolomite, at the margin of the driftless area."

In the above discussion Professor Norton presents a possible interpretation of the presence of the Devonian fossils and of the fragments of Devonian limestone far to the east of their normal area of outcrop. There are a few Devonian corals in the Museum of the Iowa Geological Survey, at Des Moines, which were collected by Mr. Lonsdale and bear the locality label "One-half mile north of Canton, Jackson county." These were doubtless taken from the deposit described by Professor Norton. Unfortunately the rocks at this place can be studied at present over but a very small area and they are at best very imperfectly exposed. No fossils could be found at the time of the writer's visit. The sandstone and shale do not differ in any appreciable way from those seen in outcrops that are unhesitatingly referred to the Des Moines stage. Professor Norton has also stated a great difficulty in this connection in that these Devonian corals and other fossils do not normally occur associated with such beds of sandstone and shale. Inasmuch as Professor Norton studied this deposit under much more favorable conditions of exposure than the writer, it seemed best to give the interpretation of the facts as he presented them.

CARBONIFEROUS SYSTEM.

Upper Carboniferous or Pennsylvanian Series.

DES MOINES STAGE.

A number of outliers of Des Moines sandstone and shale occur within the borders of Jackson county. Individually they are of but a few acres in extent, and generally are of no great vertical thickness. One of the largest sandstone beds is found in sections 31, 32 and 33 of Monmouth township, about three miles south of the town of Monmouth. This outlier was first described by Professor Herbert Osborn,* and later by Professor Norton.†

The ledge extends interruptedly for a distance of more than two miles, in a northeast-southwest direction. It lies in the form of a crescent somewhat parallel with the course of Bear creek, and only a short distance south of that stream. It occupies a pre-Carbouiferous valley eroded in the Niagara limestone. This depression has a width of fifteen to twenty rods and a depth below the tops of adjacent Niagara ledges of fifty or more feet.

On the west side of the wagon road, near the southeast corner of section 31, a thickness of thirty feet of sandstone is exposed. The ledge consists of hard layers, one to four feet in thickness, which in places appear massive and show very distinct cross-bedded structure. In the corresponding bank that borders this small stream on the west there outcrops nearly as great a thickness of the sandstone. At the bottom of the Des Moines ledge at this place the sandstone merges into a coarse, pebbly conglomerate which is eight to twelve inches or more in thickness. The pebbles are mostly rounded nodules of chert which vary from one to three and one-half inches in diameter. They were probably derived from the decay of the Niagara ledges during the long interval of pre-Carboniferous erosion. Such a pebbly conglomerate at the base of the deposits of the Des Moines stage has been found at other points in Iowa, and it is very commonly encountered at that horizon further east and south in the state of Illinois.

The waters of Bear creek have cut out this sandstone ledge from the west half of section 33, but near the middle of the north half of this section the north end of the outlier is well exposed. The stone is iron-stained and the layers are hard and enduring. They have been quarried at a number of points for local use. Where the ledge is crossed by a small stream, the

*Osborn: Proc. Iowa Acad. Sci., Volume I, Part 2, p. 115.
†Norton: Iowa Geol. Survey, Vol. III, pp. 128-130.

thickness is about twenty feet. The basal conglomerate does not appear at this place. There are few fossils to be seen, and no shale is found associated with the sandstone layers in this deposit.

In the northwest quarter of section 17, Brandon township, there outcrops a ledge of sandstone overlain by a bed of plastic shale, both of which were thought to belong to the Des Moines stage. The exposure is in a ravine, on land owned by Mr. Charles Ross. The shale is two and one-half to three feet in thickness and is quite plastic. Some of this material was made into brick by Mr. Lyman Parshall, of Canton, and was used in constructing an arch for a charcoal oven. The brick endured the heat of burning the charcoal in this oven for a period of fifteen years. This outlier is less than one-half mile north and three-fourths of a mile east of the sandstone and shale exposure which Professor Norton referred to the Devonian system. It is possible that these beds also represent Devonian deposits, but there were found no fossils to indicate the age, and, since the lithological characters of the materials resemble those of the Des Moines stage rather than the Devonian, the beds are considered as belonging to the Carboniferous system.

In the southeast quarter of section 9 of Brandon township, there may be seen, in the roadway, near the top of the hill on the south side of the river, a low ledge of Des Moines sandstone. On turning east into the lane leading from the main road to the house of Mrs. P. J. Eads, a thickness of five feet of sandstone is passed over. At this place the sandstone occupies a depression in the quarry stone beds of the Gower stage. This outlier of sandstone is about one-fourth of a mile north, and one and three-fourths mile east of the last exposure mentioned above. It is about on a line with that deposit and with the sandstone and shale outlier one-half mile north of Canton, as will be seen by referring to the Geological map of Jackson county accompanying this report.

Near the southeast corner of section 13, Maquoketa township, a very pretty Carboniferous outlier is exposed in the slopes on both sides of a stream that crosses the wagon road along the east line of this section. A thickness of fifty feet of reddish-brown, coarse-grained sandstone outcrops below the mantle of Pleistocene materials. On following down this stream, towards the west, there appear reddish colored sandstone layers alternating with beds of gray or drab colored shale. The base of the outlier may be seen resting on a ledge of Niagara limestone. The total thickness of the shales and sandstones in this outcrop exceeds seventy feet.

About one mile south of the latter exposure the following layers outcrop along the north bank of a stream and in the wagon road, in the southwest quarter of section 19 of Fairfield township and the east-central portion of section 24 of Maquoketa:

		FEET.
9.	Bed of gray sandstone, much decayed	6
8.	Purplish colored, dry, fissile shale	4½
7.	Reddish gray sandstone	2
6.	Bluish colored shale	1
5.	Sandstone	3
4.	Band of slate colored, dry shale, breaking into thin bits on weathering	⅔
3.	Bed of iron-stained, coarse-grained sandstone, in layers one to three inches in thickness	20
2.	Drab colored to black shale	3
1.	Brown, coarse-grained sandstone in uneven layers eight to eighteen inches in thickness	3½

Another small outlier of sandstone and shale occurs along the middle of the west half of section 17 and near the center of the east side of section 18 in Fairfield township. Beds of ferruginous sandstone have been quarried at two or three different points along the channel of a stream in the northeast quarter of section 29 of the same township.

Across the north end of section 32 of Fairfield township, a ledge of Des Moines sandstone borders the channel of a stream, on the north, for a distance of several rods and to a maximum height of twenty-five feet. (See figure 77.) This bed of sandstone is rather coarse-grained in texture and is stained a reddish or yellowish brown by the presence of iron oxide. It is rather massive, showing imperfect planes of stratification at intervals of from six inches to two feet. This bed of Des

Moines sandstone rests upon and abuts against a bank of Maquoketa shale. Where small lateral streams have cut through the ledge it has a width of eight to ten rods. At the same level a bed of Niagara limestone forms the south bank of the creek and faces the sandstone ledge across the stream. This sandstone outlier, like most of the others above described, occupies a trough that was carved by the waters of some pre-Carboniferous stream. The materials were thus protected from complete denudation by the sides of the trough, between which they lie.

Fig. 77—Ledge of Des Moines sandstone abutting against a wall of Maquoketa shale and facing a bluff of Niagara limestone, twenty rods distant across a stream Section 32, Fairfield township

Another small outlier of sandstone was encountered in the northwest quarter of section 15 of Maquoketa township, and still another ledge of sandstone material was found in Perry township, about three miles north of the town of Andrew.

A Carboniferous outlier was reported to occur in the southeast quarter of section 4 in Maquoketa township, but this deposit was not seen.

The presence of these Carboniferous outliers, many of them occupying old erosion channels in the Niagara limestone, testifies to a number of oscillations in the relative level of the sea and land. After the deposition of the Niagara beds the region which now embraces Jackson county was elevated above the sea. For a long time this area remained a land surface subject to the denuding action of the agents of erosion. We have no means of estimating the thickness of sediments that were swept from the surface during the long period that intervened between the close of the Niagara and the laying down of the earliest sediments of the Des Moines stage. We know, however, that by the close of this period of erosion the surface of our land was trenched by the stream waters into hills and valleys much as we see it today. The deposition of the shales and sandstones of the Des Moines stage was initiated by a subsidence of all of this portion of Iowa. During this age a broad shallow mediterranean sea stretched far across the Illinois coal fields on the east and beyond the borders of Iowa towards the southwest. The pre-Carboniferous valleys were filled, and sediments were spread over all of this sea bottom probably to a depth of hundreds of feet. The deposition of the sediments of the Des Moines stage was closed by a movement of the earth's crust which resulted in bringing our area once more above the level of the sea. Ever since that long distant time the agents of weathering and erosion have been ceaselessly at work. The greater portion of the Des Moines sediments have been removed from the surface of Jackson county. Only a few scattered outliers of small extent remain, and these owe their preservation to the fact that they occupied depressions in the older limestones and thus were protected from the denudation that wasted the general surface.

RESIDUAL MATERIALS.

The submergence, during which the sandstones and shales of the Des Moines stage were deposited over Jackson county, was followed by a subsidence of the sea relative to the level of the land, and this region became a theater of erosion. For an exceedingly long interval our area was subject to the forces of degradation.

If the Rockville conglomerate* in Delaware county and the Pine Creek conglomerate† of Muscatine county belong to the Cretaceous system, it would seem probable that the great mediterranean sea that covered a large area in the interior of our continent during a part of the Cretaceous period overspread the whole of Iowa. It is possible that the region now embraced in Jackson county was then submerged. The fact of the occurrence, in this county, of a basal conglomerate underlying sandstones of undoubted Des Moines age at points much nearer the above mentioned outcrops than any known beds of Cretaceous sediments would suggest that possibly the small conglomerate outliers in Delaware and Muscatine counties might also represent remnants of coarse, clastic deposits of the Des Moines stage.

However this may be, it seems certain that if the Cretaceous sea ever overspread our area, all of the sediments that were then deposited were removed from the surface prior to the deposition of the Pleistocene materials. There are no means of definitely measuring the thickness of the mantle that was swept from this area during the long ages that it stood above the sea between the later portion of the Pennsylvanian period and the early part of the Pleistocene. Professor Calvin‡ has estimated that the thickness of the strata removed by solution and erosion from the summit of Iron Hill, in Allamakee county, was between 800 and 1000 feet.

The present streams of the region have carved their beds at least 700 feet below the tops of the more elevated points.

Professor Salisbury has found chert and silicified fossils, that have been derived from the Niagara beds, mingled with the gravels that cap the tops of the quartzite range of hills near Baraboo, Wisconsin.§ If these gravels, cherts and silicified fossils are of the nature of residual materials, as Salisbury suggests, they would indicate the removal from the tops of the mounds of all of the series of strata lying between the Baraboo quartzite and the Niagara limestone. This involves a vertical

*Calvin: Iowa Geol Surv., Vol. VII, pp. 160-164.
†Udden: Iowa Geol. Surv., Vol. IX, pp. 316-320.
‡Calvin: Iowa Geol. Survey, Vol IV, p. 99
§Salisbury: Journal of Geol , Vol III, p. 565.

thickness of at least 1000 feet of sediments. The larger streams of Wisconsin have cut their channels 700 to 800 feet below the tops of these elevations.

There seems abundant evidence that the streams of the upper Mississippi valley have denuded the land surface to a vertical depth of one-third of a mile. Much of this has probably been accomplished since the late Tertiary or early Pleistocene period. If the sea had successively withdrawn from the land as soon as an approach to peneplanation of the surface was accomplished, the depth of sediments denuded from our area during the entire Pennsylvanian-Pleistocene interval would be measured by thousands of feet.

At a number of places over the county there occurs, immediately above the Niagara ledges and underlying the Pleistocene materials, a mantle of geest which consists of stiff, red colored clay in which are mingled fragments of chert. This clay represents the very small proportion of argillaceous matter that was disseminated through a many times greater thickness of Niagara limestone, and which has been concentrated as the soluble portion of the beds was slowly removed by drainage waters. The chert fragments were derived from the obdurate siliceous nodules that were enclosed in the Niagara beds.

On a hill near the middle of the north side of section 5 in Brandon township, such red colored residual materials have a thickness of from one to three feet. They occur a short distance east of the middle of section 21 in Otter Creek township. They may be seen on a hill near the southwest corner of section 30, Richland township, and at many other places in the county.

The drift over portions of the townships of Van Buren, Fairfield and Maquoketa is very thin, and it is impossible to distinguish the part of this material that is of pre-Pleistocene age from that which has been disintegrated in post-glacial times.

It was upon a surface over which a considerable amount of geest or residual matter had been developed, and where uplands stood well above the valleys—the relief in Monmouth township was at least three hundred feet—that the protective mantle of Pleistocene materials was spread.

PLEISTOCENE SYSTEM.

Over large areas in the county the finer part of typical drift material is very thin or entirely wanting. The topography is essentially that of a driftless region. However, the presence and mode of distribution of the bowlders and bowlderets of foreign derivation, consisting of quartz, greenstones and granites, would indicate that a sheet of ice overspread practically the entire area.

Occasional glacial bowlders occur in the roadside near the southeast corner of section 28 of Prairie Spring township. They may be seen along the wagon road crossing the northwest quarter of section 30, in Tete des Morts township. A bed of drift, with a number of granite bowlders, one to two and one-half feet in diameter, appears in the roadside a short distance west of the village of St. Donatus, in the southwest quarter of section 7 in Tete des Morts township. South of these points there are considerable areas over which few signs of drift are exposed, but scattered glacial bowlders and remnants of a drift mantle are encountered so frequently and in such localities as to leave little doubt of the former presence of an ice sheet.

There is clear evidence that at least two ice sheets, the Kansan and the Iowan, invaded portions of Jackson county. These were separated from each other by a very long time-interval. The earlier of these incursions, known as the Kansan, was far the more widespread. It carried much the larger load of debris and covered much the greater portion of our area.

KANSAN STAGE.

Kansan drift.—The Kansan drift is deepest and most generally present over the southern and western portions of the county. The characteristics of this drift in Jackson county do not differ in any essential points from those of thin deposits of corresponding drift in other portions of the state. Where long exposed to the atmosphere the superficial portion is leached of its lime constituent and oxidized to a reddish-brown color for a depth of from one to four or more feet. Where the deposits are deep this ferretto zone grades downward through less perfectly leached and yellow colored material into the unchanged bluish-gray till of the main body of drift.

Excellent exposures of the ferretto phase may be seen along the wagon road crossing the middle of section 21 in Perry township. Reddish, pebbly drift overlain by a mantle of loess occurs near the middle of the east side of section 19, Richland township. It appears in the northwest quarter of section 31 of Otter Creek township, and at numerous other points in the south and west portions of the area.

Crossing the north side of Maquoketa township, in sections 3, 4 and 5, there is a belt of unusually heavy Kansan drift that carries a considerable number of bowlders. Many of these are of exceptionally large size for the drift of this age, the larger masses having a diameter of six to nine feet. The monument erected to the memory of Colonel Thomas Cox, in the cemetery at Maquoketa, consists of an undressed granite bowlder 6½ x 4½ x 3 feet in size, that was taken from this bowlder train.

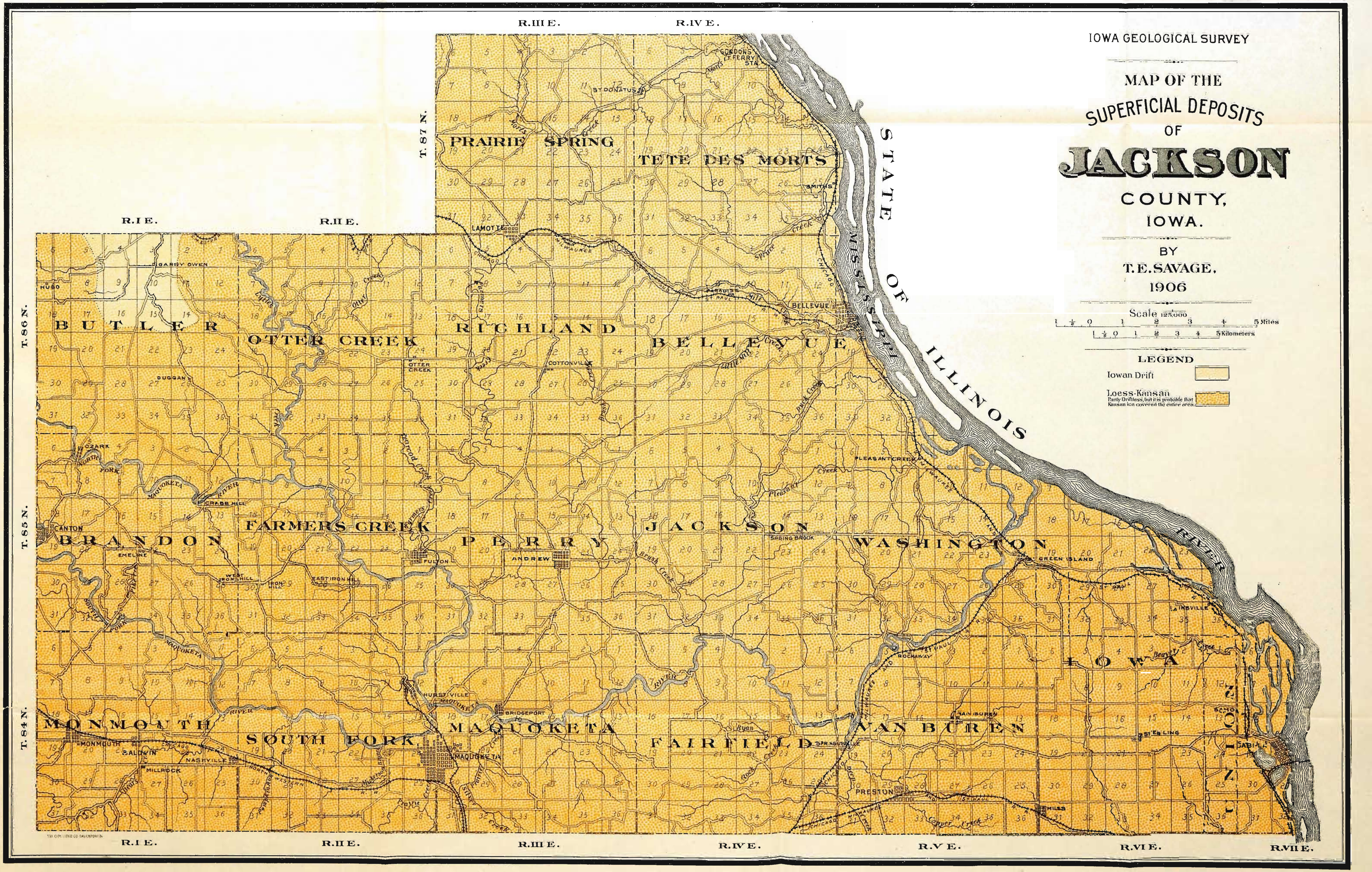
In putting down a well on the Henry Little farm, in the northwest quarter of section 25, Monmouth township, a thickness of 225 feet of surficial materials was penetrated without reaching indurated rock. Much the greater portion of this depth was through deposits of the Kansan stage. Such deep deposits of drift material are rare in the county, and are limited to the southern portion.

Occasional beds of ferruginous sand and gravel are encountered. The largest deposit of such coarse material that was seen underlies a portion of the town of Maquoketa.

As stated above, the finer constituents of normal drift are wanting over considerable areas. The chief witnesses to the former presence of an ice sheet in such regions are the pebbles and bowlders of foreign origin that appear at numerous points immediately overlying, or intermingled with, the residual materials. The distribution of these bowlders is such as to indicate that at least a thin body of Kansan ice overspread practically the entire surface of Jackson county.

IOWAN STAGE.

Iowan drift area.—A narrow tongue of Iowan ice moved southward beyond the limits of Dubuque county, spreading over a few square miles in the north-central portion of Butler township, in the county of Jackson. The eastern border of this lobe extends


IOWA GEOLOGICAL SURVEY
MAP OF THE
SUPERFICIAL DEPOSITS
OF
JACKSON
COUNTY,
IOWA.
BY
T. E. SAVAGE,
1906
Scale 125,000
5 Miles
5 Kilometers
LEGEND
Iowan Drift
Loess-Kansan
Partly Driftless, but it is probable that Kansan ice covered the entire area.
STATE OF ILLINOIS
MISSISSIPPI RIVER
R. I E.
R. II E.
R. III E.
R. IV E.
R. V E.
R. VI E.
R. VII E.
T. 87 N.
T. 86 N.
T. 85 N.
T. 84 N.
PRAIRIE SPRING
TETE DES MORTS
BUTLER
OTTER CREEK
RICHLAND
BELLEVUE
BRANDON
FARMERS CREEK
PERRY
JACKSON
WASHINGTON
IOWA
MONMOUTH
SOUTH FORK
MAQUOKETA
FAIRFIELD
VAN BUREN
ST. DONATUS
LAMOTTE
BELLEVUE
GARRY OWEN
HUGO
DUGGAN
OTTER CREEK
COTTONVILLE
OZARK
CANTON
CRABB HILL
EMELINE
FULTON
ANDREW
SPRING BROOK
GREEN ISLAND
PLEASANT CREEK
HURSTVILLE
BRIDGEPORT
MAQUOKETA
MONMOUTH
BALDWIN
NASHVILLE
MILLROCK
PRESTON
SPRAGUEVILLE
ROCKAWAY
SABULA
SMITHS
EAST IRON HILL
WEST IRON HILL
IRON HILL

southward across the west half of sections 2 and 11, and bends a little east of south in section 14 down to near the middle of the southeast quarter. From this point the margin trends towards the west across the southwest quarter of section 14, and passes near the south side of sections 15 and 16. It here swings towards the northwest and crosses the northeast corner of section 17 and the east half of sections 8 and 5.

The entire area of the Iowan plain in this portion of the county does not exceed ten square miles. The ice that passed over this region left but a scant covering of drift. Fresh looking granite bowlders, two to four or five feet in diameter, are occasionally encountered. Such masses are most abundant on the southeast quarter of section 16 and the southwest quarter of section 15. No satisfactory exposure of Iowan drift was seen. The entire area is covered with a thin veneer of loess. This fact would seem to indicate that possibly the ice mantle melted from this region previous to the withdrawal of the main body of Iowan ice that lay a few miles further towards the north and west.

In the west-central portion of Monmouth township there is an area of about 500 acres that possesses all the essential characteristics of an Iowan drift plain. It embraces the southern portion of section 17, the north half of section 20, and the northwest quarter of section 21. In the last section the bowlders that seem to belong to the Iowan stage are the largest and most abundant.

While this surface presents the appearance of an Iowan plain, it is isolated from any large body of Iowan drift. West of the town of Monmouth for some miles the only connection this area seems to have with a well defined Iowan lobe is down a valley at present occupied by a tributary of Bear creek. This valley is rather large for the present stream, but it has not the appearance of having been filled with a tongue of ice during the Iowan age. It seems more probable that this channel was the line of discharge of a large volume of water during the time the Onslow lobe of Iowan ice was melting. Under such conditions the bowlders may have been carried in masses of ice during periods of great flood, and become stranded where the stream debouched upon the broad lowland plain, one mile in width, in the vicinity of the village of Monmouth.

THE LOESS.

The greater portion of the surface of Jackson county is mantled with a deposit of loess which varies from two or three to as much as twenty-five or thirty feet in thickness. As in other portions of the state the fine material is spread over hills and valleys showing, if anything, a preference for the more elevated points. Notwithstanding its independence of topography and of the formations upon which it rests, the loess is by no means distributed uniformly over our area.

Distribution.—Over much of Monmouth township a deep body of loess covers the summits and slopes both to the north and the south of the Monmouth valley. While low ledges of dolomite appear more or less interruptedly in the immediate banks of the streams, the bottoms of the channels are often choked with fine, loess-like material. The dissected upland between the North and the South Forks of the Maquoketa is covered with loess which at some points has a thickness of fifteen feet. Loess is deep over the larger portion of Butler township, but the Iowan drift area here is not rimmed with such a conspicuous border of loess hills as is usually found around the margin of a well developed Iowan drift plain.

A thick blanket of loess covers the indurated rocks over much of the townships of Prairie Spring, Tete des Morts, Richland, Bellevue, Perry, Washington and Jackson, except in close proximity to the larger streams. Over this region the surface is very broken. The slopes are steep and the summits of the hills often rise more than one hundred feet above the minor valleys. Beds of typical drift are generally wanting; yet there are large areas over which the indurated rocks are completely buried by surficial materials. This fine-grained mantle deposit has a known maximum thickness of more than twenty-five feet. At some points, as in the exposure on Brush creek near the middle of the southwest quarter of section 29 in Jackson township, the loess carries numerous univalve shells. These fossils represent the common species of air breathing mollusks that are usually found in such deposits.

Quite a large area in the north and east portions of Farmers Creek township shows no loess, being covered with a blanket of sand, as also are several square miles in the central and western portions of Van Buren; a belt south of the Maquoketa river, in the township of Maquoketa; and a considerable area in the northeast corner of Bellevue township and the southeast corner of Tete des Morts.

Over the southern part of Van Buren, and extending east into Iowa township, there are considerable areas over which the dolomite ledges have received no covering of surficial materials. Even the residual products of decay have been removed by wind or wash as fast as disintegration of the rocks has proceeded. Other small patches having no loess or other mantle covering occur at a number of points in the southeastern part of the county, within a few miles of the Maquoketa river.

There seems little doubt that a portion of the loess material in Jackson county is of Iowan age, since it is somewhat continuous with the marginal belt of deep loess that borders the Iowan drift plain in the neighboring counties of Jones and Dubuque. It is probable too, that a portion of the material has been added in more recent times, as post-Iowan deposits of loess are known in other portions of the state. A portion of the materials may even be older than the Iowan stage of glaciation, for pre-Iowan loess has also been distinguished in Iowa.* No exposures of loess were seen in which the materials showed evidence of a long break in the continuity of deposition. However, if these deposits were formed by the wind, there seems no reason why a portion of the materials should not have been shifted, removed, or added as often as winds found access to such beds through the protective cloak of vegetation, or as constantly as dust-laden currents of air found, in these deposits, or in the vegetation that they supported, an obstruction in their path.

*See citations by Shimek in Bull. State Univ. of Iowa, Vol. V, No. 4, pp. 340 and 366-368 See also Geology of Winneshiek county, by S. Calvin, this volume, p. 126

Post-Glacial Deposits.

ALLUVIUM.

Beds of fluviatile materials that were, in part at least, laid down during the present age are found along the flood plains of the Mississippi and the Maquoketa rivers. The larger areas occur along the eastern border of the south half of the county. In the vicinity of Green Island this alluvial plain has a maximum width of nearly three miles. In our county the area of flood plain bordering the "Father of Waters" is about 19000 acres. Between Green Island and Spragueville the flood plain of the Maquoketa river has an average width of nearly one mile. A narrow belt of alluvial materials borders one or both sides of the Maquoketa river west of Spragueville, and occasional patches occur along the North and South Forks.

The surface of lowland prairie that stretches across the central portion of Monmouth township, the southern part of South Fork and the southwest corner of Maquoketa represents a modified alluvial plain, as does that of the old Goose Lake channel in the southwest quarter of Van Buren township. In addition to the above, small patches of flood plain are occasionally encountered along the larger creeks of the area.

EOLIAN DEPOSITS.

There seems no doubt that winds have been carrying and depositing materials over the surface ever since its emergence from the sea. The deposits that were thus formed prior to the Pleistocene period were largely removed when the glaciers moved over the region.

It is probable that all of the eolian deposits that can now be studied in Jackson county have been built since the retreat of the Kansan ice sheet, and possibly much of the present surface materials of these beds have been worked over since the close of the Pleistocene period. Materials of eolian origin in Jackson county consist of considerable deposits of sand and a somewhat discontinuous blanket of loess. It is probable that an appreciable portion of the finer materials of the alluvium and of the soils was also brought by the winds from more or less distant points. The areas over which the respective eolian materials are distributed at the surface have been outlined under the discussion of the alluvium and the loess.

Soils.

Four different types of soil are found in Jackson county. They may be designated as loess, sandy, alluvial and residual. Each of these types is determined by the character of the subsoil material upon which, and in which, the soil has been developed.

Loess soil.—The loess soil occurs over more than three-fourths of the area of the county. Over all of this region the surface is very much dissected. The slopes are so steep that little humus has been permitted to accumulate, so that the color of the soil is prevailingly yellow. The loess particles are intermediate in size between fine sand and clay, forming a fine loam. The soil is loose and porous, and at the same time sufficiently close to prevent rapid evaporation of its water, and to furnish a good degree of capillary action. The particles represent the finer parts of drift and alluvium or other surficial materials. They are rich in lime carbonate and other mineral constituents of plant food. Where a proper rotation of crops is practiced, and when the rain fall is abundant, this soil is surprisingly productive.

Sandy soil.—Because of its open texture sandy soil rapidly loses its water by evaporation. The inter-granular spaces are so large that water is not readily brought up to the surface from a considerable depth, hence crops in such soil early suffer from drought. When the particles of sand are composed of quartz or silicon dioxide there is but a small quantity of soluble matter in the soil, and the minerals that are essential to the growth of plants are often wanting. Even when fertilizers are applied, the open texture of the soil permits of rapid downward leaching of the important soil constituents, and they are soon lost. Such soils are generally infertile. The area of sandy soil in Jackson county would aggregate a few hundred acres, yet the proportion of sandy to the more fertile types of soil is small.

Alluvial soil.—A large portion of the alluvial land along the flood plain of the Mississippi river is covered by wide marshes and threaded with lagoons. The most of this area is too low to be successfully cultivated in ordinary seasons. Portions of the flood plain of the Maquoketa river are also subject to overflow so that its value for farming land is impaired. The alluvial soil generally contains some of the desirable constituents present in all of the types of soil occurring over the basin drained by the stream. It usually contains sufficient sand to render it porous, sufficient silt to insure proper retention of water, and sufficient humus or decaying organic matter together with the necessary soluble minerals to furnish abundant food for the rapid growth of vegetation. Where sufficiently high and efficiently drained, such soils are superior to almost any other in their durability and ease of cultivation, and in their productiveness. The fertility of the modified alluvial soil occurring over the lowland plain between Monmouth and Maquoketa and over the limited area of the old Goose Lake channel is equalled by no other soils of the county. These areas yield large harvests of corn and small grain even in unfavorable seasons of drought or flood.

Residual soil.—Limited areas of residual soil occur where the loess has for some reason failed to be deposited over the Niagara ledges. They are found in occasional patches of small extent over a belt four or five miles in width on either side of the Maquoketa river. In places the constituent particles consist of grains of quartz or dolomite, so that the soil partakes of the nature of sand. At other points the material is composed of heavy reddish clay mingled with chert fragments. Over these areas the depth of the loose material is insufficient to retain the moisture required for a crop, hence such soils are generally unproductive.

Deformations.

The conspicuous example of deformation that occurs in Jackson county consists of a low arch that extends in an east and west direction from Savanna, in Illinois, to the east side of section 30 in Fairfield township, a distance of about twenty miles. The strata involved in the deformation embrace the Maquoketa shale and the overlying beds of Niagara limestone.

The maximum measured height of the arch was in sections 29 and 30 of Fairfield township. At each of these points the aneroid readings gave the elevation of the upper layers of the Maquoketa as 175 feet above the corresponding layers in the vicinity of Preston. Readings at two different points in sections 22 and 23 of Van Buren township gave the altitude of the uppermost Maquoketa layers as 90 and 115 feet respectively above the equivalent layers near Preston. At some points over this arched belt, where the upper layers of the Maquoketa beds were best exposed, they seem to have been thrown into a series of small crumples at the time the main arch was raised. Where well exposed the layers are crossed by two series of small parallel fissures. These fissures are six to twenty-four inches apart and extend for a distance of one to three or four feet. Those of one series have a direction nearly at right angles to those of the other. When the Niagara layers were seen in an apparently undisturbed position against the inclined Maquoketa beds, the angle of dip was about thirty degrees. Between different points, and sometimes in the same outcrop, the dip varies widely as regards both direction and inclination. A portion of this variance is probably due to the fact that the Niagara limestone creeps or settles on the shale when inequality of support results from differential erosion.

Unconformities.

A number of breaks in the geological record occur in Jackson county as is shown by the presence of unconformities. Between the deposits of the Galena and those of the Maquoketa no line of unconformity was found, yet the abrupt change in the character of the materials, and the variable nature of the Galena surface upon which the Maquoketa rests at different points in the state, suggests a possible, though undiscovered, break.

At one or two points the Niagara limestone was seen in such relations to the Maquoketa shales as to indicate that the Niagara layers occupied a channel eroded in the Maquoketa beds previous to the deposit of the limestone. This would imply a discontinuity of sedimentation.

The deposits of the Des Moines stage were laid down over a much carved and deeply eroded surface. Remnants of these in the form of outliers are generally found occupying depressions that are bordered at no great distance by older strata. In our area the Niagara limestone usually forms the basin in which are found the Des Moines beds. At one point, in Fairfield township, the Des Moines sandstone rested unconformably against a bank of Maquoketa shale.

The Kansan drift was spread unconformably over the pre-Kansan surface; the Iowan drift was laid down unconformably upon the Kansan; and the mantle of loess rests unconformably upon long leached, strongly oxidized and deeply eroded materials of widely varying age.

ECONOMIC PRODUCTS.

Soils.

The product of the soils of Jackson county, like that of other portions of our favored state, will always be the greatest source of wealth to her intelligent and prosperous people. The total value of the annual products of the farms of the county as given in the census for 1905, aggregates 3,672,597 dollars. This sum is half a million dollars greater than the value of the total coal, clay and stone production of the county of Iowa ranking first in the output of those minerals. It is nearly double the value of all the mineral production of the county ranking second in its output.

The product of the farms of Jackson county for the year indicated by the 1905 census, would purchase more than one-third of all the gold mined in Alaska during that same period. Its value equals nearly one-half of all of the silver output of Colorado during that same year. It would buy nearly three times the crude petroleum produced by the famous Beaumont oil field of Texas during this year, and more than one-half of the Beaumont production during 1902, the year of its greatest prosperity.

Building Stone.

Practically all of the building stone produced in Jackson county is used within its borders. The building stone quarries are all small and are worked intermittently. The rocks of every stage that outcrops in this area contribute a small supply.

Galena limestone.—Small quarries have been operated in the upper portion of the Galena limestone at a number of points in Tete des Morts township. In the village of St. Donatus considerable stone has been quarried from these layers. A small quarry is at present worked in the south bank of Morts creek near the center of section 13 of Prairie Spring township. A limited quantity of this stone has been taken out near the middle of the north half of section 15; in the northeast quarter of section 24; and in the southeast quarter of section 36. Perhaps the largest quarry in the Galena beds works the upper layers near the top of the north bluff at the junction of Morts creek with the Mississippi river. A large amount of Galena limestone has been taken out of the bluff in the vicinity of Gordon's Ferry station, and used in the construction of wing dams along the river.

Maquoketa beds.—The transition beds from the Maquoketa to the Niagara have been quarried locally at Bellevue, and at a few other points in the northeastern portion of the county. The material is impure limestone. When exposed to the atmosphere this material soon crumbles into small bits and does not prove a durable stone.

Hopkinton stage.—A number of small quarries for building stone are worked in beds of the Hopkinton stage. A small quantity of stone for local use is taken from the ledge near the middle of the north side of section 24, and from a quarry near the middle of section 20, in Iowa township; from near the middle of the southwest quarter of section 30 of Union township; from near the middle of the south side of section 10 of Butler; and from the middle of the east half of section 21 in Otter Creek township. At a number of other points small quarries have been occasionally worked. The stone from this horizon is generally too massive to be readily quarried or dressed into usable shape. When the materials are in layers the beds contain so much chert in the form of bands and enclosed nodules that the ledges can not be profitably worked on a commercial scale.

Gower stage.—The local demand for building stone in the north-western portion of the county is supplied from the quarries in the Gower beds. These rocks are known to occur in our area over only about one square mile, in sections 9 and 10 of Brandon township. Occasionally they appear capping the west bluff of the North Fork of the Maquoketa river, along the west side of section 10, but they do not appear in the east bank.

Mr. John Archibald has formerly taken out a considerable quantity of stone from a ledge near the middle of the east side of section 9 of Brandon township. One-fourth of a mile south of the Archibald quarry the corresponding layers are worked on land owned by Mrs. P. J. Eads.

At the present time the greater portion of this stone is furnished by Mr. J. N. McCullough, from a quarry near the middle of the south side of section 9. The stone from this horizon occurs in even layers, two or three inches to as many feet in thickness. The material is a sub-granular, yellow colored and fairly durable magnesian limestone. The various layers can be quarried easily, and furnish dimension blocks one foot or more in thickness and flagstones of almost any size desired. The Gower beds yield much the best quality of stone for building and general construction purposes that is found in the county.

Des Moines sandstone.—Where the beds of Des Moines sandstone are thick the sand grains have often been cemented together by an interstitial deposit of iron oxide, so that the layers are much indurated. In such beds small quarries have been worked at a number of points in the county. The most important of these are in the Monmouth outlier in sections 31, 32 and 33 of Monmouth township. Considerable stone has also been taken from the Carboniferous outliers in the north half of section 29 of Fairfield township.

Lime.

Jackson county furnishes more than three-fourths of all the lime produced in Iowa. The value of the lime output for 1904 aggregated $69,550.00. The rock used for manufacture into lime is a dolomite, and comes from a zone about sixty feet in thickness which includes the upper thirty or forty feet of the *Pentamerus oblongus* ledge and the overlying beds containing such characteristic fossils as *Cerionites dactylioides*, *Caryocrinus ornatus* and Culicocrinus sp. The Hurst quarry section given on page 615 is representative of the lime quarry beds in Jackson county. A. Hurst and Company have operated a large lime burning plant at Hurstville for many years. Quarries are worked on both sides of the river and tracks are laid in such a manner that the loaded cars are brought by gravity to the foot of the incline up which they are drawn by horses to the top of the kilns. The plant is equipped with four patent continuous draw kilns. Each kiln is thirty-five feet high, six by eight feet in cross section, and has a daily capacity of 125 barrels. The lime is barreled and shipped over the Chicago, Milwaukee and Saint Paul railroad to various points in Iowa and all the adjacent states. Wood is exclusively used for fuel, one cord of soft wood burning 28 barrels of lime, or a cord of hard wood burning about 33 barrels.

The Maquoketa Lime Company operates a quarry at Pin Hook, one mile west of Maquoketa. This plant is also owned and managed by Alfred Hurst and Company, of Hurstville. At this point there are three kilns similar in kind and capacity to those at Hurstville. The stone is from the same horizon and the lime is essentially like that produced at the Hurstville plant. The output of the Pin Hook kilns is loaded on cars at a switch about one mile south of the quarry and is shipped

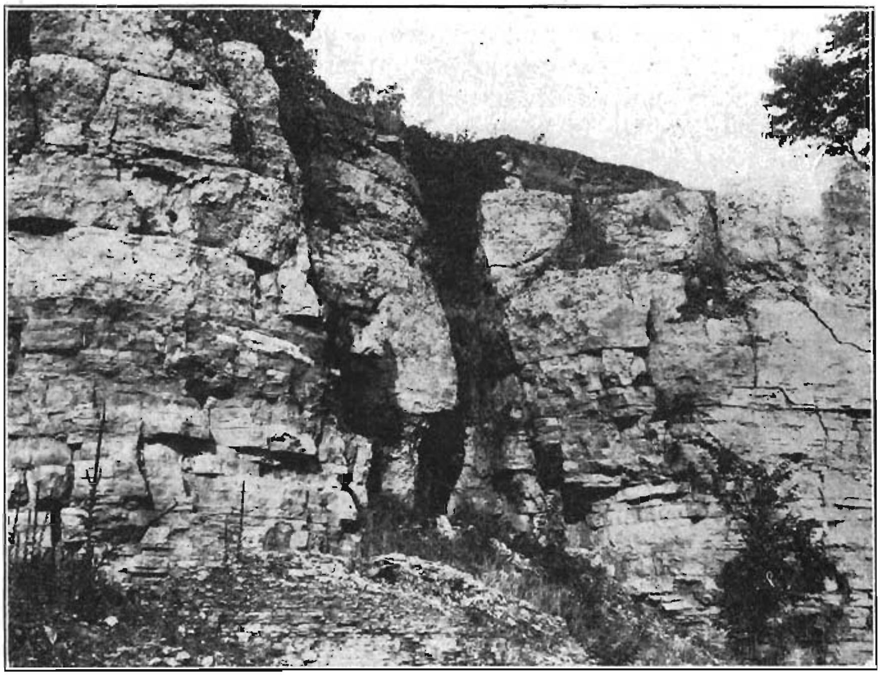


Fig. 78—Ledge of Niagara limestone in the east bank of the Maquoketa river, section 12 of South Fork township. This stone is excellent for lime burning.

over the Chicago and North-Western railroad. A large tract of timber near Green Island is owned by the Hurst company and furnishes the wood for lime burning on this extensive scale.

Joiner's lime works is located near the middle of the south half of section 20 in South Fork township. The plant is equipped with two patent continuous kilns having separate capacities of about 100 barrels. The lime is shipped over the Chicago and North-Western railroad.

The Keystone Lime Company's plant is located near the middle of the west side of section 32 in Monmouth township.

They have one patent kiln with a daily capacity of 100 barrels. The product is generally sold in bulk to contractors, a large portion of the output finding a market in Cedar Rapids.

Mr. Charles Hyler of Bellevue burns from 1500 to 1700 barrels of lime per year. The kiln is located a short distance south of the town. The stone comes from the upper transition beds of the Maquoketa and from the overlying Niagara ledge.

All of the lime marketed in the county is made from dolomite. The lime burning plants are in operation during nine or ten months of the year. Work is usually discontinued for a short time in midwinter. The patent kilns such as are used in the county can be fired continuously, the lime being drawn at intervals of six to twelve hours. Wood is the only fuel at present used in burning the product. Coal is not satisfactory for this purpose, as it is difficult to make an even burn with coal, and the color and the slacking qualities of the lime are also impaired by its use.

Sand.

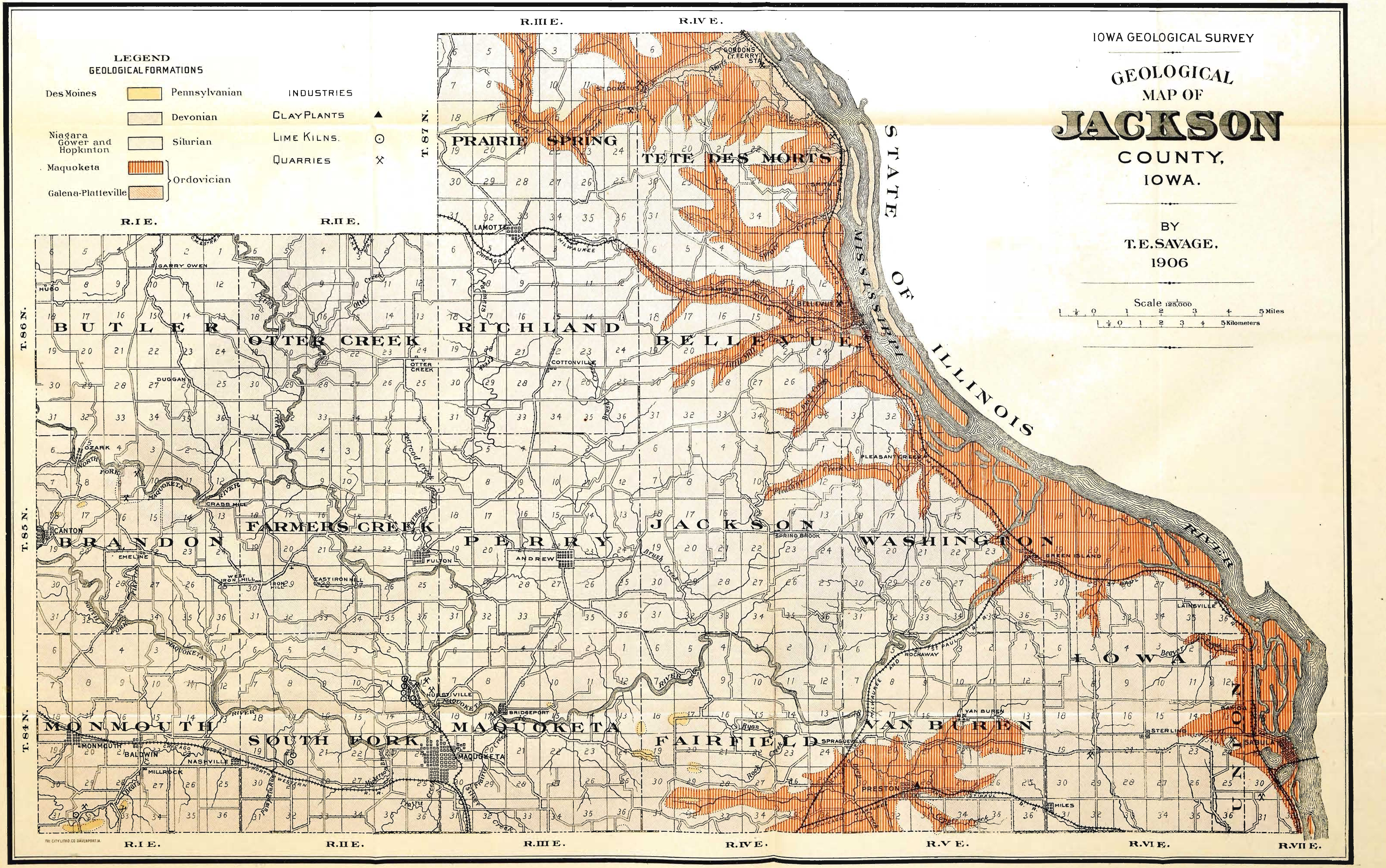
Abundance of sand suitable for use in common mortar, plaster and cement is found along the channel of the Maquoketa river and its branches. Locally sand is also taken from the beds of Farmers creek, Deep creek and other streams. A bank of sand twenty-two feet in height has been extensively worked near the southwest corner of section 18 in Maquoketa township.

Clays.

Three plants for the manufacture of the more common clay goods are operated in the county. Surface clays are exclusively utilized as a source of the raw materials.

Preston.—The only plant in the county that manufactures drain tile has been operated at Preston, by Mr. Charles Beamer, for a number of years. A Brewer stiff-mud tile machine is used, and the tile is air dried. The burning is made in a single round, down-draft kiln, having a capacity of 16000 to 17000. Tile varying in size from three to six inches is produced. The clay used is a modified alluvium that occurs over the surface in the old Goose Lake channel. No brick are manufactured. The demand is largely local, a part of the output being marketed in Lost Nation.

Maquoketa.—The Maquoketa Brick Company operates a brick the south part of Maquoketa. One Anderson soft mud brick machine is used. There are two square kilns of 200,000 capacity each. Loess clay is the raw material. At present only


IOWA GEOLOGICAL SURVEY
GEOLOGICAL MAP OF
JACKSON
COUNTY,
IOWA.
BY
T. E. SAVAGE.
1906
Scale 1/125,000
Miles
Kilometers
LEGEND
GEOLOGICAL FORMATIONS
Des Moines
Pennsylvanian
Devonian
Niagara Gower and Hopkinton
Silurian
Maquoketa
Galena-Platteville
Ordovician
INDUSTRIES
CLAY PLANTS
LIME KILNS.
QUARRIES
R. I E.
R. II E.
R. III E.
R. IV E.
R. V E.
R. VI E.
R. VII E.
T. 87 N.
T. 86 N.
T. 85 N.
T. 84 N.
PRAIRIE SPRING
TETE DES MORTS
BUTLER
OTTER CREEK
RICHLAND
BELLEVUE
BRANDON
FARMERS CREEK
PERRY
JACKSON
WASHINGTON
IOWA
MONMOUTH
SOUTH FORK
MAQUOKETA
FAIRFIELD
VAN BUREN
STATE OF ILLINOIS
MISSISSIPPI
RIVER
LAMOTTE
BELLEVUE
GARRY OWEN
HURSTVILLE
BRIDGEPORT
MAQUOKETA
MONMOUTH
BALDWIN
NASHVILLE
MILLROCK
CANTON
EMELINE
ANDREW
FULTON
COTTONVILLE
PRESTON
SPRAGUEVILLE
SPRING BROOK
PLEASANT CREEK
GREEN ISLAND
ROCKAWAY
SABULA
MILES
OZARK
CRABB HILL
WEST IRON HILL
IRON HILL
EAST IRON HILL
OTTER CREEK
DUGGAN
HUGO
ST. DONATUS
LAINSVILLE
STERLING
VAN BUREN
TRI CITY LITHO. CO. DAVENPORT, IA.

ordinary construction brick is produced, but plans are being made to manufacture pressed brick in the near future. The plant near the Chicago and North-Western railway station, in output is sold in Maquoketa and neighboring towns.

For a number of years common brick has been manufactured at Maquoketa by Mr. George Becker. The clay is a mixture of loess and alluvial material. Seven kilns of 100,000 capacity are usually burned each year. The home market takes a large share of his production.

Water Supplies.

Over all the northeastern portion of the county the numerous springs that issue at the upper surface of the Maquoketa shale furnish a perennial supply of excellent water. The Maquoketa river and the North and South Forks bring abundance of water to the regions through which they flow. All of the larger creeks of the area are permanent streams and carry stock water of the finest kind. Much of the potable water is obtained from shallow wells which range in depth from twenty or thirty to three hundred feet. The water supply for the town of Sabula is obtained from a well 973 feet in depth.

The curb of the well is a short distance below the horizon of the base of the Niagara limestone in which massive dolomite the river has here cut a gorge more than one hundred feet deep. In the first one hundred and sixty three feet the drill passed through unconsolidated sand and gravel which represents the pre-glacial channel of the Mississippi river, excavated in the Maquoketa and the upper beds of the Galena. The thickness and elevation above tide at the base of the formations penetrated are given by Norton as follows.*

		THICKNESS FEET.	ABOVE TIDE FEET.
7.	Alluvium, filling ancient channel	163	419
6.	Platteville-Galena	212	207
5.	St. Peter	75	132
4.	Upper Oneota	125	7
3.	New Richmond	25	-18
2.	Lower Oneota	175	-193
1.	St. Croix, penetrated	198	-391

It will be seen from the above table that the drill entered the St. Croix sandstone. When the well was completed the discharge measured 720 gallons a minute. The pressure of thirty-two pounds is sufficient to furnish water and fire protection to all parts of the town.

Below is given an analysis of the water of this well, made by J. B. Weems in 1896, the year after the well was completed.

*Norton: Artesian wells of Iowa, Iowa Geol. Surv., Vol. VI, p 259.

ANALYSIS.	GRAINS PER U S GALLON.	PARTS PER MILLION.
Calcium carbonate ($CaCO_3$)	7.764	133 857
Magnesium carbonate ($MgCO_3$)	.522	9 [illegible]0
Magnesium bicarbonate ($MgH_2(CO_3)_2$)	10 374	178 857
Sodium carbonate (Na_2CO_3)	605	10.428
Sodium sulphate (Na_2SO_4)	1.756	30 286
Alumina (Al_2O_3) and Ferric oxide (Fe_2O_3)	.331	5 714
Silica (SiO_2)	.174	3 000

Maquoketa.—The Maquoketa city water supply is obtained from a large well put down in the flood plain bordering the South Fork of the Maquoketa river. The well is located on the south side of the river in the northeast part of the town. It is thirty feet in depth, entirely in sand and gravel, and has a diameter of twenty-two and one-half feet. From the well a line of twenty-four-inch tile, without flanges, is laid up the valley for a distance of 600 feet, parallel with the course of the stream. The well is about 600 feet from the immediate bed of the river and the tile approaches within 100 feet of the stream at the nearest point. The water-works are equipped with one Worthington compound duplex pump, having a capacity of 1,500,000 gallons in twenty-four hours, and one Blake duplex pump with a daily capacity of 750,000 gallons. Since the tile was put in the well has furnished an ample supply of water for all the needs of the city. The stand pipe is 100 feet high. It stands on a hill about 140 feet above the curb of the well and furnishes a good water pressure throughout the town.

Following is a copy of an analysis made by Mr. Floyd Davis, of Des Moines, of a sample of water from the well of the Maquoketa city water works. The report bears the date of October 4, 1897:

	PARTS PER 1,000,000
Total solids	3[illegible]9 000
Loss on ignition*	76 000
Chlorine	18.500
Free ammonia	.060
Albuminoid ammonia	.070
Oxygen consumed (Kubel)	1.900
Nitrogen in nitrites	none
Nitrogen in nitrates	9.800

*No change in color, slight acid odor

ACKNOWLEDGMENTS.

Among the persons who aided in the prosecution of the field work on which the foregoing report is based the writer desires to acknowledge the generous assistance of Mr. Harvey Reid, of Maquoketa, whose extensive knowledge of local geology and geography, and whose unfailing enthusiasm in the work made his help especially valuable. Professor Calvin has also been a helpful advisor in the field, and has identified many of the more difficult fossils in connection with the stratigraphical study. To the above and to all others who contributed towards the success of the work, the most cordial thanks are extended.