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J. W. POWELL, DIRECTOR

CORRELATION PAPERS

THE NEWARK SYSTEM

BY

ISRAEL COOK RUSSELL

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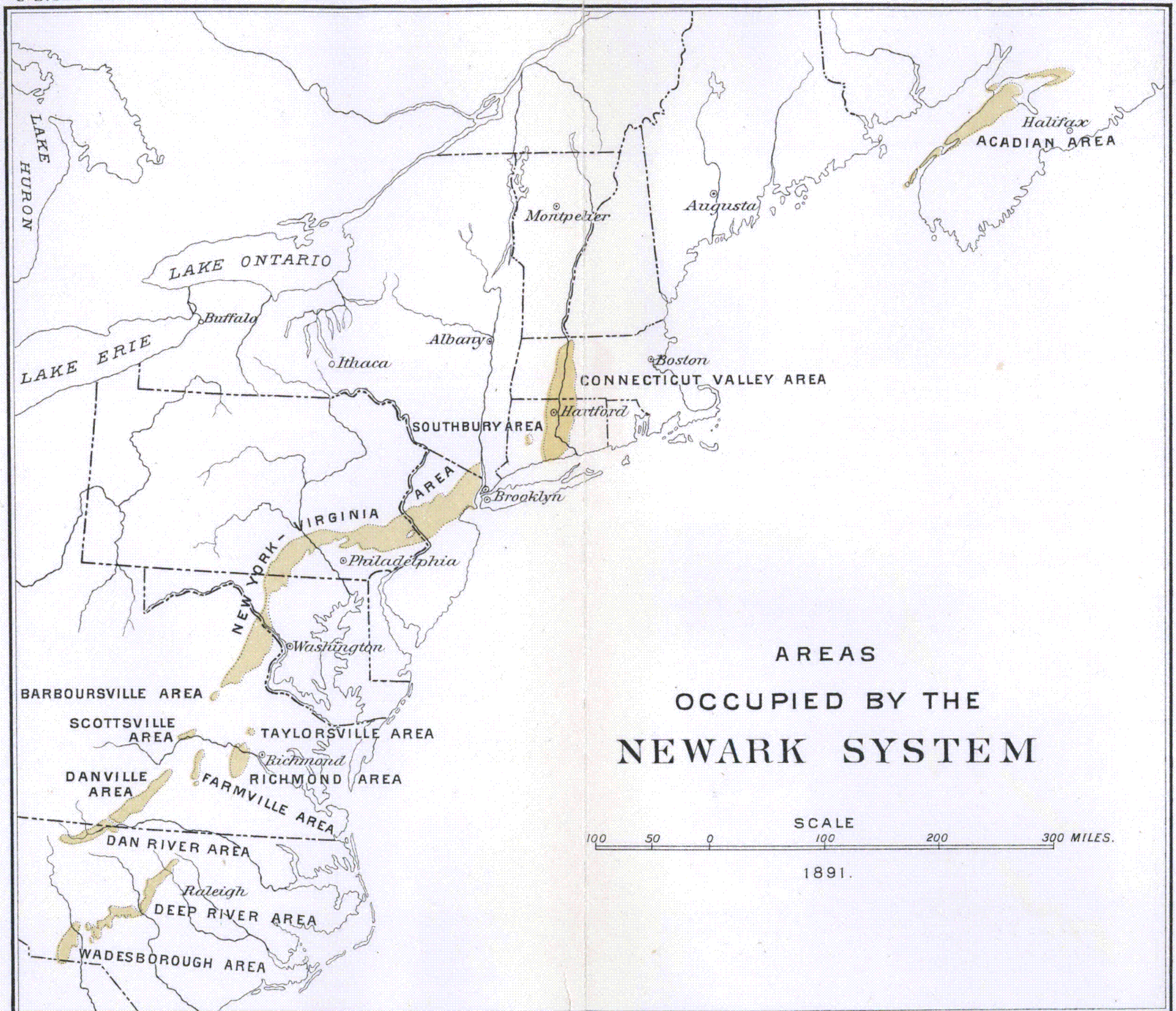

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DEPARTMENT OF THE INTERIOR,
U. S. GEOLOGICAL SURVEY,
DIVISION OF GEOLOGIC CORRELATION,
Washington, D. C., February 12, 1892.

SIR: I have the honor to transmit herewith a memoir by Mr. I. C. Russell on the Newark system, prepared for publication as a bulletin.

The Division of Geologic Correlation was created for the purpose of summarizing existing knowledge with reference to the geologic formations of North America and especially of the United States, of discussing the correlation of formations found in different parts of the country with one another and with formations in other countries, and of discussing the principles of geologic correlation in the light of American phenomena. The formations of each geologic period were assigned to some student already well acquainted with them and it was arranged that he should expand his knowledge by study of the literature and by field examination of classic localities and embody the results in an essay. The general plan of the work has been set forth on page 16 of the Ninth Annual Report of the Survey and on pages 108 to 113 of the Tenth Annual Report, as well as in the letter of transmittal of Bulletin No. 80.

The present essay is the sixth of the series, having been preceded by essays on the Carboniferous and Devonian, the Cambrian, the Cretaceous, the Eocene, and the Neocene, prepared severally by Messrs. Williams, Walcott, White, Clark, and Dall and Harris, and constituting Bulletins Nos. 80, 81, 82, 83, and 84.

The subject originally proposed for Mr. Russell covered the entire Jura-Trias of North America, and he was invited to discuss not only the correlation of American formations one with another and with European formations but also the question whether it was advisable in American geology to recognize the Jurassic and the Triassic separately as periods coordinate with the Devonian and the Carboniferous, or only to recognize the Jura-Trias as a single period. Circumstances subsequently led to important modifications of this arrangement. In the formulation of a plan for the preparation of the geologic atlas of the United States it was found necessary to adopt and define a scheme of geologic periods without awaiting the discussions contemplated in this series of essays, and, after due consideration, it was determined to recognize the Jura-Trias as a single period. One of the principal questions proposed for Mr. Russell's consideration was thus decided in advance so far as the most important work of the Survey was concerned. The acceptance by the Survey of an opportunity for Alaskan exploration by Mr. Russell left to this division the option of diminishing the scope of the present essay or of postponing its completion, and the former alternative was preferred. It was consequently arranged that Mr. Russell restrict attention to the Newark system and the principles of correlation involved in the discussion of its relations.

The rocks of the Newark system occur in a number of separate areas. In this essay these are correlated one with another primarily on physical, secondarily on paleontologic evidence. Through paleontologic evidence the system is compared with formations west of the Mississippi river and with formations in Europe, and it is concluded that homotaxial relations are approximately determined. The feasibility of determining relations of close synchronism is questioned.

Very respectfully, your obedient servant,

G. K. GILBERT,
Geologist in Charge.

Hon. J. W. POWELL,
Director U. S. Geological Survey.

OUTLINE OF THIS PAPER.

The aim of this paper is to review the progress of our knowledge concerning a well defined system of rocks on the Atlantic border, named the Newark system; to summarize the present state of information concerning it, and to discuss the bearing that its study has on principles of correlation.

Chapter I contains a historical summary of the numerous names by which the system has been designated from time to time, and also a statement of the author's reasons for adopting the term *Newark system* now used.

Chapter II contains a brief account of the geographical distribution of the various areas occupied by the system, and is accompanied by a series of maps on which the areas are shown, together with the relative age of the adjacent terranes.

Chapter III. The evidence as to the presence of Newark rocks on Prince Edward island is discussed and the conclusion reached that the system is not there represented.

Chapter IV. The lithological character of the sedimentary rocks of the system is described, and the evidence as to their thickness is presented. Coal is treated as a "rock," and some account given of its distribution and thickness.

Chapter V contains a discussion of the physical and climatic conditions under which the sedimentary rocks of the system were deposited. From an examination of the evidence bearing on the possible existence of glacial conditions in Newark times, the conclusion is reached that glaciers were not immediately concerned in the accumulation of any of the rocks of the system.

Chapter VI is a résumé of our knowledge of the life of the Newark period, as shown by the animal and plant remains that have been discovered.

Chapter VII deals with the igneous rocks which traverse the system in a great series of dikes and sheets. Following a description of the mineralogical and chemical composition of these rocks is a general account of the principal characteristics of dikes and sheets.

Chapter VIII is devoted to a description of the structure of the various Newark areas, and a discussion of its origin. The present inclination of the strata over broad areas is shown to be due principally to the tilting of faulted blocks. The effect of erosion on the upturned blocks is also considered. Original data are introduced concerning especially the structure of the more southern areas.

Chapter IX. The question of the original geographical extent of the system has been considered by several geologists, and diverse conclusions have been reached. In this chapter the opinions bearing on this question are summarized and classified under two heads: First, the "local-basin hypothesis," which includes those opinions based on the assumption that the stratified rocks of the system were deposited in several detached basins, the approximate boundaries of which are still traceable. Second, the "broad-terrane hypothesis," which embraces the conclusions of those who consider the detached areas of the system as remnants of possibly one broad terrane, which has been broken up by orographic movements and greatly eroded. The evidence is thought by the author to favor the second of these hypotheses.

Chapter X is devoted to a brief discussion of the general principles of correlation and of the relations of the Newark system to several other terranes.

Under general principles of correlation, the evidences from physical phenomena, such as superposition of strata, contained fragments, relation to folds and dikes, and to great unconformities, are considered. Under biological phenomena as a basis for correlation, the imperfections of the geological records and our incomplete knowledge of the records, such as they are, receive brief attention; as does also the bearing of evolution on the interpretation of the life history of the earth.

The difficulties in the way of correlating the rocks of America with those of other countries are indicated, and the conclusion is reached that the first aim in the study of the geology of a new country should be the definite determination of the sequence of rocks there represented, by physical phenomena, as a basis for the determination of the relative age of the faunas and floras they may contain. Subsequently, the fossils may be compared with those of distant terranes for the purpose of wider generalizations. It is pointed out that the life records in any restricted regions can not be accepted as a standard whereby to determine the age of fossil-bearing beds in other and especially in entirely disconnected terranes.

The chapter closes with a brief discussion of the relations of the Newark system to certain formations in the western part of the United States and in other countries.

THE NEWARK SYSTEM.

By Israel C. Russell.

CHAPTER I.

NOMENCLATURE.

The name "Newark system" has many synonyms. The body of rocks to which it is applied is naturally differentiated with peculiar clearness. It is separated from older rocks and from newer rocks by profound unconformities, and its boundaries are marked by strong lithological contrasts. For various reasons it is not easy to determine its precise position in the chronologic classification founded on the geologic systems of Europe. The synonymy has arisen not from doubt as to what should be included under one name, but from the fact that opinions as to correlation have been embodied in names, and these opinions have varied from time to time and from author to author. The name Newark is here preferred, because it is the oldest specific title not implying opinion as to geologic age. It was proposed by W. C. Redfield in 1856, in the following language:

> I prefer the latter designation [Newark Group] as a convenient name for these rocks [the red sandstone extending from New Jersey to Virginia], and to those of the Connecticut valley, with which they are thoroughly identified by footprints and other fossils, and I would include also the contemporaneous sandstones of Virginia and North Carolina.[1]

The term "group" used by Redfield and the term "system" here used do not imply any difference of conception, and the selection of one or the other is a matter of comparatively small importance. I have chosen system because it conforms approximately to the rule adopted by the International Congress of Geologists.

Something of the history of the study of the Newark system may be gathered from the following table, in which the various names by which it has been designated are arranged chronologically.

[1] Am. Jour. Sci., 2d ser., vol. XXII, 1856, p. 357; also in Am. Assoc. Adv. Sci., Proc., vol. X, Albany meeting, 1856, p. 181.

Names and correlations applied to the whole or to portions of the Newark system.

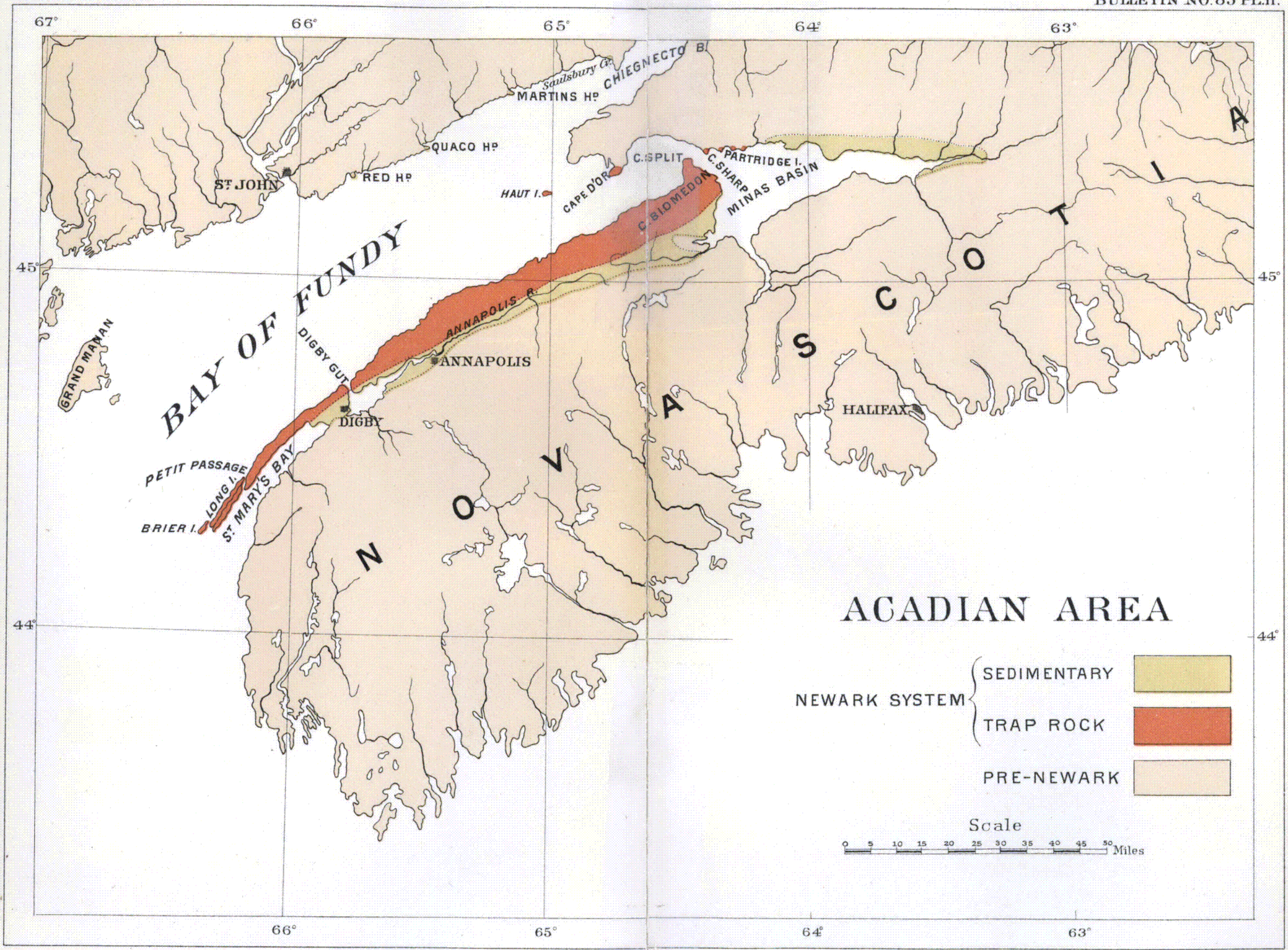
Date.	Name used.	Author.	Place of publication.
1817	Old red sandstone	Maclure, W	Am. Philo. Soc. Phila., Trans., vol. I, n. s., p. 20 and map.
1820	do	Silliman, B	Am. Jour. Sci., 1st ser., vol. II, p. 147.
1820	do	Nuttall, F	Acad. Nat. Sci. Phila., Jour., vol. II, p. 37.
1826	New, or variegated sandstone	Finch, J	Am. Jour. Sci., 1st ser., vol. X, p. 209.
1832	Old red sandstone and coal formation.	Hitchcock, E	Am. Jour. Sci., 1st ser., vol. VI, pl. op. p. 86.
1824	Freestone and coal formation of Orange and Chatham [N. C.].	Olmsted, D	Rep. Geol. N. C., p. 12.
1833	New red sandstone	Hitchcock, E	Rep. Geol. Mass., p. 206.
1835	Carboniferous	Taylor, R. C	Geol. Soc. Pa., Trans., vol. I, p. 294.
1836	Lias [?]	Redfield, J. H	Lyc. Nat. Hist. N. Y., Ann., vol. IV, p. 40.
1837	New red sandstone	Barratt, J	Am. Jour. Sci., 1st ser., vol. XXXI, p. 165.
1839	Silurian	Conrad, T. H	Am. Jour. Sci., 1st ser., vol. XXXV, p. 249.
1839	Middle secondary strata	Rogers, H. D	Third Ann. Rep. Geol. Pa., p. 12.
1842	Secondary formation	Percival, J. G	Rep. Geol. Conn.
1841	New red sandstone system	Hitchcock, E	Am. Jour. Sci., 1st ser., vol. XLI, p. 244.
1842	Keuper	Rogers, W. B	Am. Jour. Sci., 1st ser., vol. XLIII, p. 175.
1842	New red system; new red sandstone.	Emmons, E	Geol. of N. Y., part IV, p. 429.
1843	New red sandstone	Mather, W. W	Rep. Geol. of N. Y., part IV, p. 293.
1843	Old red sandstone and Coal Measures.	Cozzens, I	Geol. Hist. of Manhattan, p. 43.
1843	Permian	Murchison, R. I	Ann. Address Geol. Soc. London, p. 108.
1843	Oölite	Rogers, W. B	Assoc. Am. Geol. Nat., Trans., p. 298.
1844	New red sandstone	Silliman, B	Assoc. Am. Geol. Nat., Proc., pp. 14, 15.
1847	Triassic or Jurassic	Bunbury, C. J. F	Quar. Jour. Geol. Soc., Lond., vol. III, p. 288.
1847	Permian or Triassic	Lyell, C	Quar. Jour. Geol. Soc., Lond., vol. III, p. 275.
1847	Inferior Oölite?	do	Quar. Jour. Geol. Soc., Lond., vol. III, p. 278, 280.
1849	Keuper or Lias	Marcou, J	Géol. Soc. France, Bull., vol. VI, p. 575.
1849	Lower Carboniferous	Gesner, H	Industrial Resources of Nova Scotia, p. 244.
1850	Silurian	Jackson, C. T	Am. Jour. Sci., 1st ser., vol. III, p. 335.
1851	New red sandstone	Agassiz, L	Am. Assoc. Adv. Sci., Proc., vol. V, p. 46.
1851	Triassic	Lyell, C	Roy. Institution [of Gr. Br.], vol. I, p. 50.
1851	Post Permian	Redfield, W. C	Am. Assoc. Adv. Sci., Proc., vol. V, p. 45.
1853	New red sandstone or Keuper.	Marcou, J	Geol. Map of North America.
1853	Upper Permian	Lea, I	Phil. Acad. Nat. Sci., Jour., n. s., vol. II, p. 189.
1854	Jurassic	Rogers, W. B	Boston Soc. Nat. Hist., Proc., vol. V, p. 14.
1855	Oölitic	Taylor, R. C	Statistics of coal, 2d ed., p. 289.
1855	Near the Lias of Europe	Jackson, C. T	Am. Jour. Sci., 1st ser., vol. V, p. 186.
1856	Trias or new red sandstone.	Hitchcock, E	Outlines of the Geol. of the Globe, p. 96.
1856	Oölitic	do	Outlines of the Geol. of the Globe. Map.
1856	Newark Group	Redfield, W. C	Am. Jour. Sci., 1st ser., vol. XXII, p. 357.
1856	Triassic and Jurassic	Dana, J. D	Do.
1856	Trias and Permian	Emmons, E	Geol. Rep. N. C., p. 273.
1856	Jurassic	Rogers, H. D	Geol. Map of U. S. in Johnson's Phys. Atlas.
1857	Keuper	Heer, O	Geol. of N. Am. by J. Marcou, p. 16.
1857	Permian and Triassic	Emmons, E	American Geol., part VI, p. 1.
1857	Chatham series	do	Amer. Geol., part VI, p. 19.

Names and correlations applied to the whole or to portions of the Newark system—Cont'd.

Date.	Name used.	Author.	Place of publication.
1857	Keuper	Lyell, C	Cited by J. Marcou in Geol. of N. Am., p. 16.
1857	......do	Heer, O	In Geol. of N. Am., by J. Marcou, p. 16.
1858	Lias	Agassiz, L	In Geol. of N. Am., by J. Marcou, p. 15.
1858	Mesozoic red sandstone	Rogers, H. D	Geol. of Pa., 4to., vol. II, p. 667.
1858	Refers various portions of the system to the Keuper Trias and Jurassic.	Marcou, J	Geol. of N. Am., pp. 10-13 and map.
1859	Between the new red sand stone and the Oölitic.	Agassiz, L	Am. Assoc. Adv. Sci., Proc., vol. IV, p. 276.
1860	Mesozoic or new red sandstone.	Tyson, P. T	First Rep on Agr. Chem., Maryland, map.
1861	Carboniferous	Stevens, R. P	New York Lyc. Nat. Hist. Ann., vol. VII, p. 414.
1864	Trias	Hall, J., and W. E. Logan.	Geol. map of Canada.
1864	New red	Lesley, J. P	Am. Philo. Soc., Proc., vol. IX, pp. 478–480.
1865	Permian	Credner, H	Neues Jahrbuch, 1865, pp. 803.
1865	New red sandstone or Trias.	Matthew, G. F	Rep. on New Brunswick.
1866	Richmond coal field	Daddow, S. H., and Bannon, B.	Coal, Iron, and Oil, p. 395.
1866	Jurassic	Lyell, C	Elem. of Geol., 6 ed., p. 451.
1868	Triassic or red sandstone age.	Cook, G. H	Geol. of New Jersey, p. 173.
1869	Triassic period	Dana, J. D	Manual of Geol., p. 414.
1871	Trias	Lyell, C	Student's Elem. of Geol., p. 361.
1871	Triassic or Liassic	Shaler, N. S	Boston Soc. Nat. Hist., Proc., vol. XIV. p. 117.
1875	Triassic	Kerr, W. C	Rep. Geol. of North Carolina, p. 116.
1876	Permian	Owen, R	Quart. Jour. Geol. Soc. London, vol. XXXII, p. 359.
1876	Triasso-Jurassic	Lesquereux, L	Ann. Rep. U. S. Geol. and Geog. Surv., Hayden, for 1874, p. 283.
1878	Mesozoic formation	Heinrich, O. J	Am. Inst. Min. Eng., Trans., vol. VI, p. 227.
1878	Trias or new red sandstone.	Dawson, J. W	Acadian Geology, 3d ed., p. 86.
1878	Triassic	Russell, I. C	N. Y. Acad. Sci., Ann., vol. I, p. 220.
1878	Jura-Trias	Le Conte, J	Elem. of Geol., p. 439.
1879	Triassic-Jurassic	Dana, J. D	Am. Jour. Sci., 3d ed., vol. XVII, p. 330.
1879	Jurasso-Triassic	Rogers, W. B	Macfarlane's Railway Guide, p. 180.
1879	American new red sandstone.	Frazer, P	Am. Nat., vol. XIII, p. 284.
1879	Rhetic or Younger	Fontaine, W. M	Am. Jour. Sci., 3d ser., vol. XVII, p. 39.
1882	Triassic	Geikie, A	Text Book of Geol., p. 770.
1883	Older Mesozoic	Fontaine, W. M	Monograph No. VI., U. S. Geol. Surv.
1883	Rhetic	......do	Do.
1883	Triassic	Davis, W. M	Mus. Comp. Zool., Bull., vol. VII, No. 9.
1884	Jurasso-Triassic	McGee, W J	5th Ann. Rep. U. S. Geol. Surv., vol. II.
1884	Lower Jurassic, passing downward into Triassic.	Hotchkiss, Jed	[Reprint of Rogers's Ann. Rep., etc., of Va.], Map.
1885	Triassic	Cope, E. D	Philo. Soc. Proc., vol. XXIII, p. 403.
1885	Triassic or Mesozoic	Lesley, J. P	Geol. Atlas of Pa., vol. X, p. vii.
1886	Tria-Jurassic	Chapin, J. H	Meriden Sci. Assoc., Proc., vol. II, p. 23.
1886	Triassic	Hitchcock, C. H	Am. Inst. Min. Eng., Trans., vol. XV, pl. op. 486.

Names and correlations applied to the whole or to portions of the Newark system—Cont'd.

Date.	Name used.	Author.	Place of publication.
1887	Tria-Jurassic or Jura-Triassic.	Chapin, J. H	Meriden Sci. Assoc., Proc. and Trans., vol. II, p. 23.
1887	Trias	Emerson, B. K	Gazetteer of Hampshire Co., Mass., p. 18.
1888	Upper Trias	Zeiller, R.	Géol. Soc. France, Bull, 3d ser., vol. XVI, p. 699.
1888	Triassic	Newberry, J. S.	Monograph vol. XIV, U. S. Geol. Surv.
1889	Newark system.	Russell, I. C.	Am. Geol., vol. III, pp. 178–182, vol. VII, 1891, pp. 238–291.
1890	Triassic	Marcou, J.	Am. Geol., vol. V, p. 160.
1890	Connecticut, or Connecticut River sandstone.	Hitchcock, C. H.	Am. Geol., vol. V, pp. 200–202.
1890	Newark system.	Darton, N. H.	U. S. Geol. Surv., Bull. No. 67.
1891	Jura-Trias.	Dana, J. D	Am. Jour. Sci., 3d ser., vol. XLII, p. 79.



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CHAPTER II.

AREA OCCUPIED BY THE NEWARK SYSTEM.

In studying the Newark system it has been found convenient to give specific names to the several detached portions into which it is divided. The distribution of the principal areas, together with the names by which they are designated, are shown on the general map forming Pl. I (frontispiece). Each area is also shown on a larger scale on a separate map. These form Pls. II–VI, and in several instances indicate the positions of subordinate or secondary areas. Special names have previously been applied to some of these areas by Dana,[1] Fontaine,[2] Heinrich,[3] and others, and these will be retained so far as is practicable in the general scheme of classification now adopted.

The following descriptions of the various areas have been made brief, for the reason that the accompanying maps will enable the reader to determine their positions and boundaries more conveniently than could be done from detailed descriptions. The references given will serve to indicate where special information may be found.

ACADIAN AREA.

Acadian Area, Dana.

Under this name are included all the outcrops of Newark rocks in New Brunswick and Nova Scotia (Pl. II). In New Brunswick these rocks occur in small, detached areas at Red head, Quaco head, Martin head and Salisbury cove, on the west side of the bay of Fundy, each of which occupies probably less than 1 square mile.

In Nova Scotia it forms the east shore of the bay of Fundy from Blomidon to Brier island, a distance of about 120 miles. The width of this belt varies from 5 to 10 miles, excepting at the north, where it widens and forms a large part of the shores of the basin of Minas and Cobequid bay. A portion of Grand Manan island should perhaps also be included in this enumeration. The total extent of the Acadian area is approximately 1,050 square miles.

The distribution given above is shown in part by Dawson[4] on the map accompanying his "Acadian Geology," and in part on the geological atlas sheets published by the Geological Survey of Canada.[5]

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[1] Manual of Geology, 2d ed., New York, 1875, pp. 404–406.

[2] Notes on the Mesozoic of Virginia; in Am. Jour. Sci. 3d ser., vol. XVII, 1879, pp. 26–29, 31–37.

[3] The Mesozoic of Virginia; in Am. Inst. Min. Eng., Trans., vol. VI, 1879, pp. 228–238..

[4] Province of New Brunswick, Atlas sheets No. 1, N. E., and No. 1, S. E.

[5] The region occupied by the Acadian area is shown in part, on the Geological Map of Canada and Adjacent Regions, by James Hall and W. E. Logan, 1866; also on the map of the Dominion of Canada, geologically colored, from surveys made by the Canadian Geological Survey, 1842–1882.

The reason for not including Prince Edward island in this area, as has been done by many writers, is stated a few pages later.

CONNECTICUT VALLEY AREA.

Connecticut River Area, Dana.
Connecticut Valley Area, Dana.

This area occupies the Connecticut valley from a few miles south of the Massachusetts-Vermont boundary southward to Long Island sound, a distance of 110 miles. Near its eastern margin in Massachusetts there are two subordinate areas, one at Amherst and the other east of Turner Falls. Total extent about 2,000 square miles.

For the determination of the distribution of the Newark rocks in Massachusetts and Connecticut, we are indebted principally to the state surveys under the direction of Hitchcock and Percival. The map given on the accompanying plate has been compiled from Percival's geological map of Connecticut, and from a manuscript map of the geology of a portion of Massachusetts, kindly loaned by B. K. Emerson.[1]

SOUTHBURY AREA.

Southbury Area, Dana.

This outlier of the Connecticut valley area is situated 16 miles west of its western border, in the towns of Woodbury and Southbury, Connecticut. It is about 10 miles long, from north to south, and from 3 to 4 miles wide. Its outlines as shown on the accompanying plate (Pl. III) are from Percival's geological map of Connecticut, with some details added by W. M. Davis.

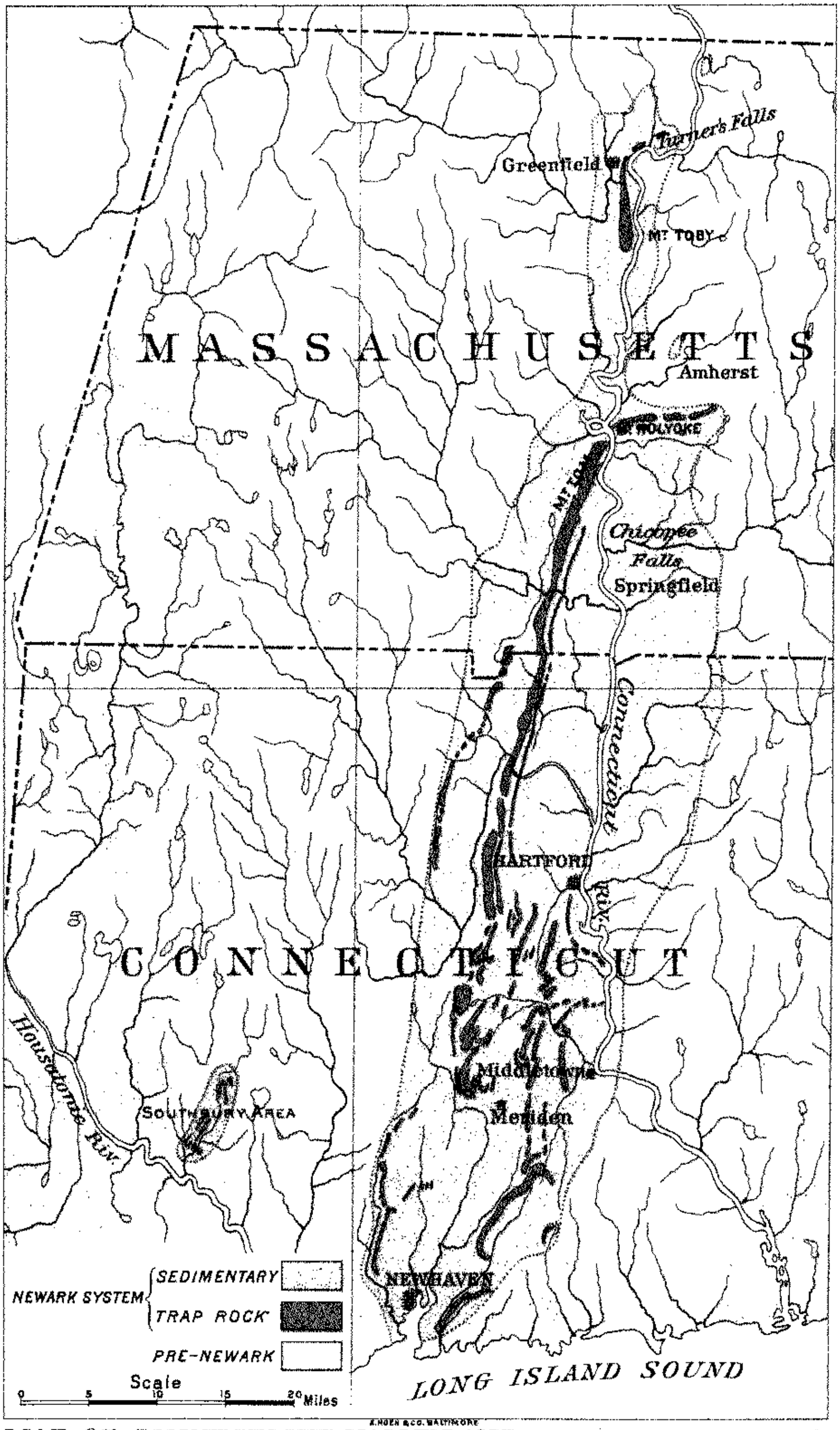
NEW YORK–VIRGINIA AREA.

Palisade Area, Dana.
New York Belt, Fontaine.
Potomac Deposit, Heinrich.

This area extends with unbroken continuity from the Hudson river, near Stony Point, New York, southward, through New Jersey, Pennsylvania, Maryland, and into Virginia as far as the Rapidan river, about 10 miles south of Culpeper (see Pl. IV). The distance in a straight line between its northern and southern extremities is about 300 miles. Its greatest width, where it is crossed by the Delaware, is 32 miles. Its area is about 5,000 square miles.

In Pennsylvania its width is greatly decreased, and the entire area bends westward and then southward. Its eastern margin is irregular, owing to deep erosion which has laid bare the Paleozoic rocks beneath. In Maryland it becomes again nearly north and south in trend, and west of Frederick, Maryland, is less than 3 miles broad. At the

[1] This map has since been published in Bull. Geol. Soc. Am., vol. II, pl. XVII.



MAP OF CONNECTICUT VALLEY AND SOUTHBURY AREAS.

NEW YORK-VIRGINIA
and other Newark areas
Scale.
0 5 10 15 20 25 30 35 40 Miles.
LEGEND
POST-NEWARK
NEWARK
SEDIMENTARY
TRAP ROCK
PRE-NEWARK
PENNSYLVANIA
NEW JERSEY
NEW YORK
DELAWARE
MARYLAND
VIRGINIA
PHILADELPHIA
BALTIMORE
WASHINGTON
RICHMOND
Frederick
Leesburg
Manassas
Culpeper
Charlottesville
Carbon Hill
Midlothian
Clover Hill
Farmville
CAPE MAY
C. CHARLES
OLD PT. COMFORT
C. HENRY
HUDSON RIV.
DELAWARE RIVER
DELAWARE BAY
SUSQUEHANNA RIVER
POTOMAC RIV.
CHESAPEAKE BAY
Rappahannock Riv.
James Riv.
79° 78° 77° 76° 75° 74°
41 40 39 38 37
A. HOEN & CO. BALTIMORE.

Potomac it increases suddenly in width to 17 miles, and terminates abruptly south of Culpeper.

The outline of this area, as shown on P. IV has been compiled from the geological maps published by the state surveys of New York, New Jersey, Pennsylvania, and Virginia. The boundaries in Maryland are from a manuscript map prepared by G. H. Williams, of the U. S. Geological Survey. The portion in Virginia has been corrected in part by N. H. Darton and Arthur Keith, of the U. S. Geological Survey, from recent observations.

The southern part of the New York-Virginia area, and all of the areas farther south in Virginia, described below, were mapped and studied by W. B. Rogers, during his survey of Virginia, and have since been described in detail by W. M. Fontaine and O. J. Heinrich, who availed themselves of previous observations in the same field. A map showing distribution of the various Newark areas in Virginia and the northern part of North Carolina, based largely on the work of Rogers, but containing some new data, was published by Heinrich in connection with his paper on the Mesozoic of Virginia.[1] The boundaries of the Newark rocks in Virginia are minutely described by Heinrich, and it is from his essay that most of the measurements of the Virginia areas given in this paper are obtained.

BARBOURSVILLE AREA.

Barboursville Deposit, Heinrich.

This area is really an outlier of the great New York-Virginia area, from the southern end of which it is separated by about 8 miles of crystalline rocks (Pl. VII). It is situated in Orange county, Virginia, to the west of Orange, and is named from the village of Barboursville, on its west border. It is elliptical in shape and measures about 9 miles from north to south and 2 miles from east to west. Its area is about 14 square miles.

SCOTTSVILLE AREA.

Buckingham Belt, Fontaine.
James River Deposit, Heinrich.

This area is situated immediately west of Scottsville, Virginia, and is probably composed of two or more detached belts, the boundaries of which are not definiteiy known (Pl. IV). The total area of the Newark outcrops in this vicinity, as computed by Heinrich, is from 40 to 45 square miles. They form a long, narrow belt, trending northeast and southwest, intermediate between the New York-Virginia area, already referred to, and the Danville area described below.

[1] Am. Inst. Min. Eng., Trans., vol, VI, 1873, pp. 227-274.

DANVILLE AREA.

Part of Pittsylvania Belt, Fontaine.
Danville Deposit, Heinrich.

This area begins at the north near Falling river, in Campbell county, and extends southward across Staunton river to the north side of Dan river, just above Danville, Virginia (Pl. VI). Its extreme length from north to south is 54 miles, its greatest width 8 miles, and its area between 260 and 270 square miles.

DAN RIVER AREA.

Part of Pittsylvania Belt, Fontaine.
Dan River Deposit, Heinrich.
Dan River Coal Field, of various authors.

The northern end of this area is in Virginia, near Cascade creek some 10 miles west of Danville. From there it extends southward to Germantown, North Carolina, a distance of about 40 miles. Its greatest width is 8 miles, and its area approximately 200 square miles. Lakeville, North Carolina, is situated near its northern end (see Pl. VI).

TAYLORSVILLE AREA.

Taylorsville Deposit, Heinrich.

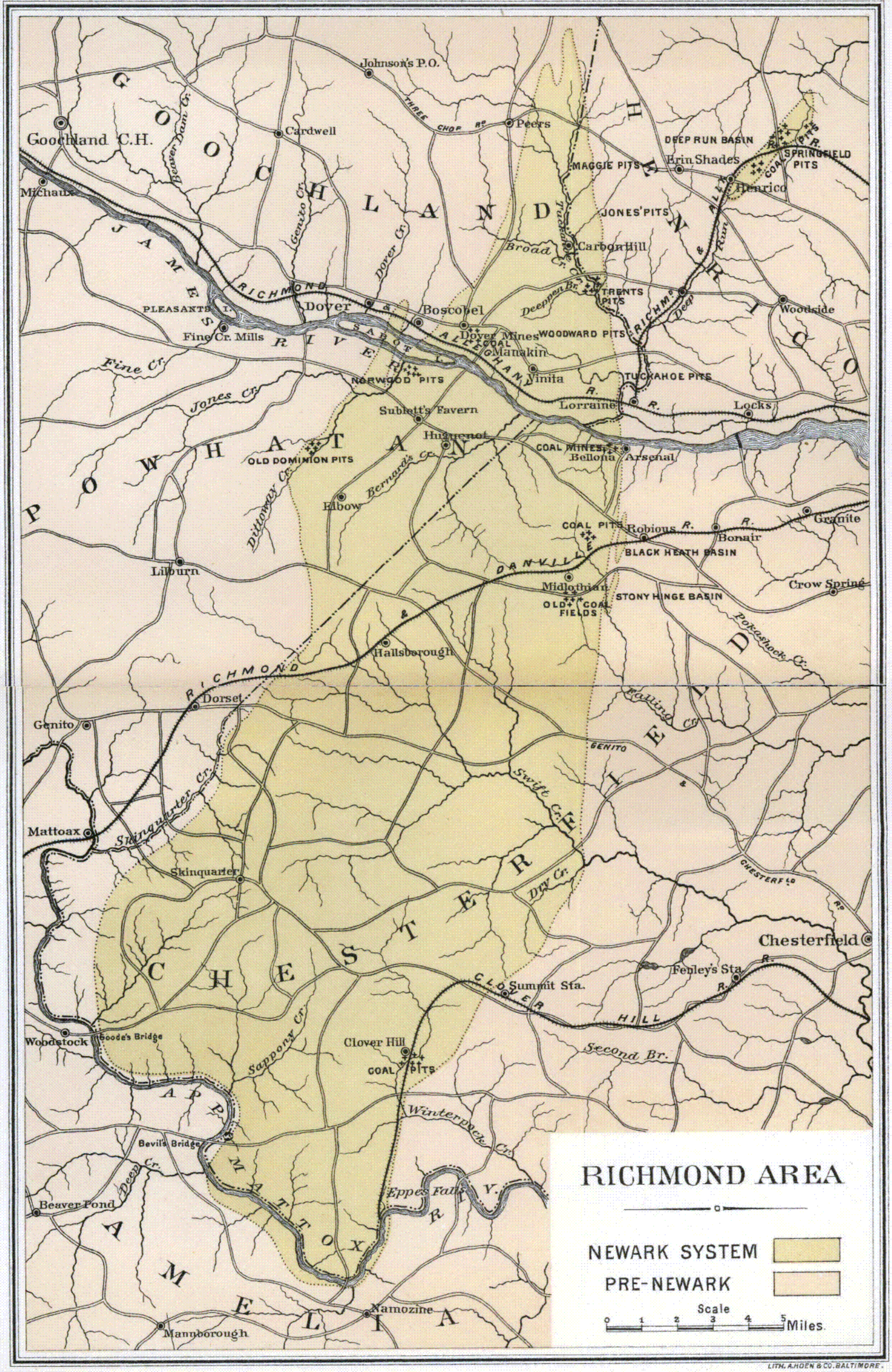
Taylorsville, Virginia, about 17 miles a little west of north of Richmond, is situated in the center of this area. Its width from east to west is about 8 miles, and its length from northwest to southeast approximately 10 miles. Its area is about 60 square miles (see Pl. V).

RICHMOND AREA.

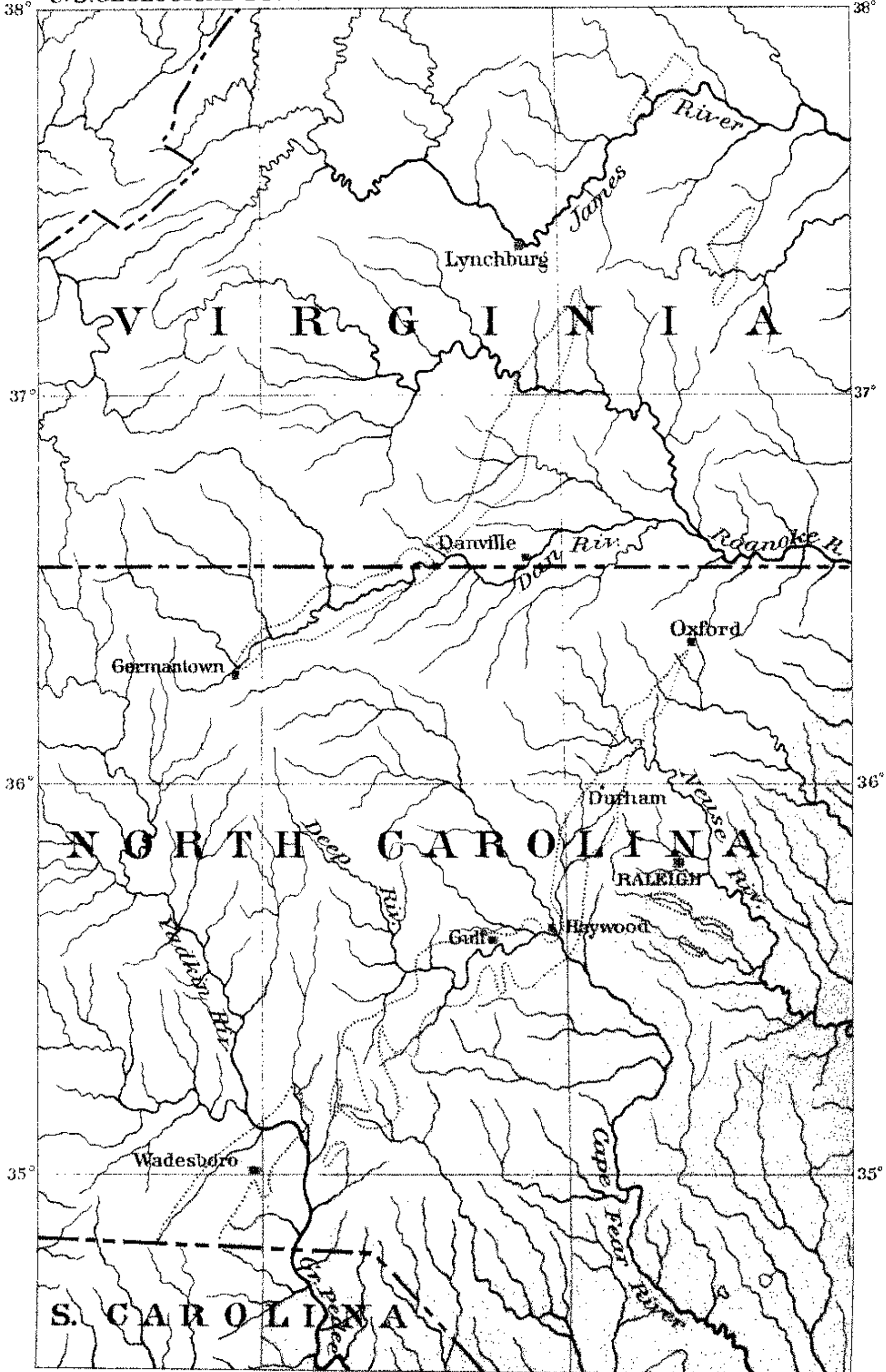
Richmond Area, Dana.
Richmond Deposit, Heinrich.
Richmond Coal Field, of various authors.

The east border of this area is 11 miles west of Richmond, Virginia (see Pl. V). It is crossed from east to west by the James river, and thus divided into two unequal parts, the larger of which is to the south. Its extreme length from north to south, including a narrow spur which projects into the crystalline rocks at the north end, is 31½ miles. The main field, as determined by Heinrich, is 24 miles long from north to south, and 7½ to 10 miles broad. Its area is about 189 square miles.

Included under the name here used are several small detached basins along the eastern border of the main area. The most distant of these is the one in which the Deep Run mines are located, about 6 miles east of the northern end of the main area. The deposit at Deep run is designated as the Springfield deposit by Heinrich, and is stated to have an area of about 1·6 square miles.



LITH. A.HOEN & CO. BALTIMORE.



NEWARK AREAS IN SOUTHWESTERN VIRGINIA AND NORTH CAROLINA.

POST-NEWARK NEWARK SYSTEM PRE-NEWARK

Scale 0 5 10 15 20 25 30 35 40 Miles.

FARMVILLE AREA.

Farmville Deposit, Heinrich.
Prince Edward Belt Fontaine.
Farmville Coal Belt of various authors.

Under this head are included two detached areas of Newark rocks, one on the south and the other principally on the north of the Appomattox river near Farmville, Virginia (see Pl. IV). The larger area lies to the northwest of Farmville and is crossed near its southern end by the Appomattox river; it is about 16 miles long from north to south, and 2 miles wide, and has an area of about 22 square miles. The smaller area is south of the river and is less than 2 miles long from north to south, and about a mile broad. The entire surface occupied by Newark rocks near Farmville measures about 24 square miles.

DEEP RIVER AREA.

Deep River Coal Fields, Emmons.
Part of "North Carolina Area," Dana.

This area is situated wholly in North Carolina, its northern terminus being near Oxford (See Pl. VI). It extends southward in an irregular belt for about 100 miles, and has an average breadth of approximately 8 miles, but its boundaries have never been accurately determined. Its area may be stated roughly at 800 square miles. Its outline, as shown on the accompanying map, is from Kerr's geological map of North Carolina, and as determined from a reconnaissance by the present writer is only approximately correct. Owing to the lack of topographic maps in this region, it has not been practicable up to the present time to determine its boundaries more accurately than was done by Kerr. I may state in passing, however, that its east border, near Raleigh, is distant about 8 miles from that city, instead of 16 miles as shown by Kerr.

The coal mines of Egypt, Gulf, etc., are situated in this area, and next to those of the Richmond area, are the most important in the Newark system.

On both the east and west borders of the main area there are detached basins occupied by Newark rocks, some of which are indicated on Kerr's geological map.

A description of the extent of this area was given by Emmons,[1] and portions of its outline were mapped by Wilkes.[2]

WADESBORO AREA.

Part of "North Carolina Area," Dana.

The northern end of this area is near Pekin, North Carolina. From that place it extends southward to the state line, a distance of about

[1] Geological Report on the Midland Counties of North Carolina, 1856, pp. 227–254.

[2] Report on the Deep River Country, in North Carolina; in Report of the Secretary of the Navy to the Thirty-fifth Congress, second session, Senate Ex. Doc. No. 26, 1858.

30 miles. Its width near Wadesboro, where it is crossed by the Carolina railroad, is about 16 miles (see Pl. VI).

It has been stated by several writers that its southern end is in South Carolina, and it is so indicated on Kerr's map, but my own reconnaissance in that region indicates that it ends in North Carolina, close to the state boundary. Associated with it are several secondary areas, some of which were mapped by Kerr. The boundaries of the Wadesboro area, like those of the others in North Carolina, are only approximately known. Its area is in the vicinity of 275 square miles.

The Newark areas in North Carolina were studied by Emmons and Kerr during their respective surveys of the state and were mapped by Kerr.[1]

SUMMARY—AREAS AND DISTRIBUTION.

The Newark system is confined to the Atlantic border, and occurs in narrow belts, the longer, larger axes of which trend in general northeast and southwest, their general course being parallel to the folds of the Appalachians.

The distance in a straight line from the most northerly to the most southerly exposure is about 600 miles. The bearing of a line joining their two extremities is about northeast. The entire area occupied by the system is, in round numbers, 10,000 square miles.

Some of the areas were indicated in an indefinite manner on the geological maps of the United States by McClure and Marcou. They also appear on the recent geological maps of the United States, compiled by Bradley, Hitchcock, and McGee.

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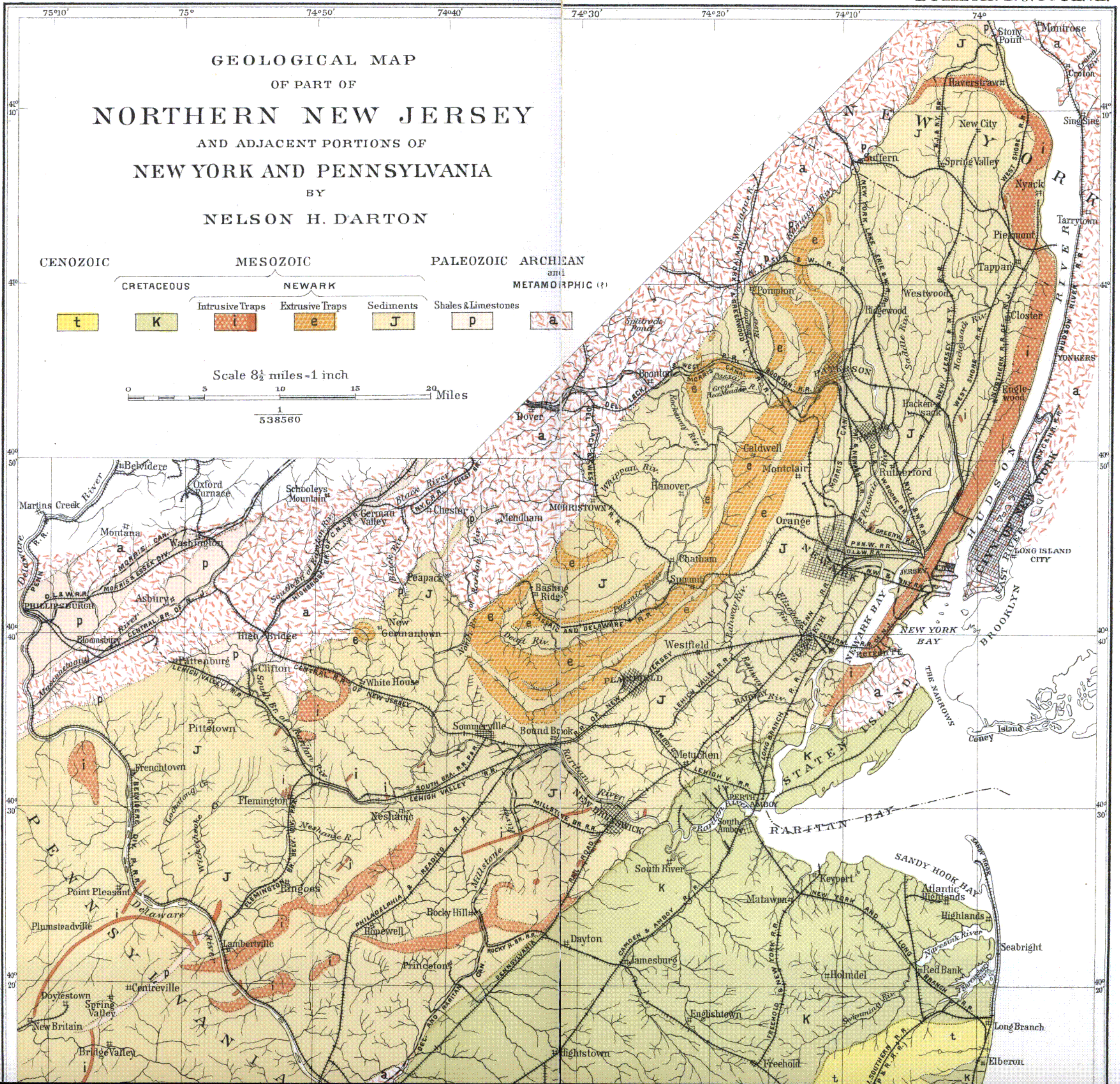
[1] Report on the Geology of North Carolina, vol. I, 1875, map.


GEOLOGICAL MAP
OF PART OF
NORTHERN NEW JERSEY
AND ADJACENT PORTIONS OF
NEW YORK AND PENNSYLVANIA
BY
NELSON H. DARTON
CENOZOIC
MESOZOIC
PALEOZOIC
ARCHEAN and METAMORPHIC (?)
CRETACEOUS
NEWARK
Intrusive Traps
Extrusive Traps
Sediments
Shales & Limestones
t
K
i
e
J
p
a
Scale 8½ miles = 1 inch
0
5
10
15
20 Miles
1/538560
75°10′
75°
74°50′
74°40′
74°30′
74°20′
74°10′
74°
NEW YORK
PENNSYLVANIA
HUDSON RIVER
NEW YORK BAY
RARITAN BAY
SANDY HOOK BAY
STATEN ISLAND
BROOKLYN
LONG ISLAND CITY
THE NARROWS
Stony Point
Montrose
Croton
Haverstraw
Sing Sing
New City
Suffern
Spring Valley
Nyack
Tarrytown
Piermont
Tappan
Westwood
Ridgewood
Closter
YONKERS
Pompton
Paterson
Boonton
Dover
Englewood
Hackensack
Caldwell
Montclair
Rutherford
Hanover
Morristown
Orange
Newark
Chatham
Summit
Mendham
Chester
Schooleys Mountain
German Valley
Belvidere
Oxford Furnace
Martins Creek
Montana
Washington
Phillipsburg
Asbury
Bloomsbury
High Bridge
Peapack
Basking Ridge
New Germantown
Pattenburg
Clifton
White House
Westfield
Plainfield
Elizabeth
Somerville
Bound Brook
Pittstown
Frenchtown
Metuchen
Flemington
Neshanic
New Brunswick
Perth Amboy
South Amboy
South River
Keyport
Matawan
Atlantic Highlands
Highlands
Seabright
Red Bank
Holmdel
Point Pleasant
Ringoes
Rocky Hill
Plumsteadville
Lambertville
Hopewell
Princeton
Dayton
Jamesburg
Doylestown
Centreville
Spring Valley
New Britain
Bridge Valley
Englishtown
Hightstown
Freehold
Long Branch
Elberon
Coney Island
Delaware River
Raritan River
Passaic River
Millstone River
Whippany Riv.
Rockaway Riv.
Lamington Riv.
Navesink River
Shrewsbury Riv.

CHAPTER III.

PRESENCE OR ABSENCE OF NEWARK ROCKS ON PRINCE EDWARD ISLAND.

HISTORICAL.

In the account of Prince Edward island given by Dawson in "Acadian Geology"[1] nearly all of the surface rocks, consisting mainly of sandstones and shales, are referred to the "Trias or New Red Sandstone;" but the occurrence of older rocks, considered as belonging to the Permian or to the upper portion of the Carboniferous, was noted at Gallas (Gallows) point, on the south side of the island. On the geological maps accompanying the various editions of the "Acadian Geology" the whole of the island, excepting the sand dunes along the northern shore and the trap rock of Hog island, is colored as "Trias or New Red Sandstone."

The island was reexamined by Dawson and Harrington[2] in 1871, and the classification previously established retained, but the area occupied by Carboniferous rocks was somewhat extended. On the map accompanying this report all of the island is colored as Triassic, excepting small areas at Gallas point and a narrow strip extending from West Point to Cape North, on the west shore. This distribution is retained by Dawson in the supplement to the "Acadian Geology" published in 1878. In this paper a typical section, 500 feet thick, at Oswald bay, adjacent to the Carboniferous area of Gallas point, is presented, in which the lower portion, it is stated, "may be referred to the lower division of the 'Bunter,' and the remaining to the upper division of the formation, or 'Keuper.'" That this classification was provisional is implied by the author, who remarks:[3] "The dips are so low, and the beds so much affected by oblique stratification, that those of the Trias can not be said to be unconformable to the underlying Carboniferous rocks; and for this reason, as well as on account of the similarity in mineral character between the two groups, some uncertainty may rest on the position of the line of separation. That above stated depends on fossils, on a somewhat abrupt change of mineral character, and on a slight change in the direction of the dip." The fossils on which this classification was based are referred to on a later page.

[1] Third edition, London, 1878, pp. 116–124.

[2] Report on the Geological Structure and Mineral Resources of Prince Edward island. Montreal, 1871, pp. 7, 8, 13–22, 45, 46, Pl. III.

[3] Supplement to the third edition of Acadian Geology. London, 1878, pp. 29, 30.

In 1881 some fossil plants were obtained by Bain[1] from localities on the south side of the island, in rocks previously regarded as Triassic by Dawson. These plants were identified by Bain and referred to the Permo-Carboniferous. These fossils led their discoverer to the inference that the Permo-Carboniferous formation is more extensively distributed on the south side of the island than had previously been supposed.

A few years later the geology of Prince Edward island was studied by Ellis.[2] In his report the extension of the lower series of rocks was greatly enlarged, and the conclusion reached that the area occupied by Triassic rocks was very limited. The evidence presented by this author suggests that all of the sandstones and shales of the island belong to one system. Ells states that he visited the greater part of the coast between Cape North and Oswald bay, on the south and west; various portions of the north side of the island were also carefully examined. The great similarity of the rocks at these localities to the Permo-Carboniferous rocks of New Brunswick is pointed out. It is also stated that the rocks differ in a marked manner from the Newark beds of the Minas basin, Nova Scotia. In a note on the margin of atlas sheet No. 5, S. W., accompanying this report, the author states:

> The examination made last fall showed that strata identical in character and in their contained plants, which were abundant at many points, extended around the entire south and west coast and a portion of the north of Richmond bay. The drawing of any line separating the Trias from the Upper Permo-Carboniferous in this area is not deemed practicable. The finding of the fossil reptile "*Bathygnathus*" in the rocks near New London, as well as several plants in the vicinity of Richmond bay, which have been recorded by Dr. Dawson as typical of a true Trias horizon, renders it possible that small areas of that age may occur, but their delineation will be very difficult. The great similarity of the strata of the eastern and northeastern portions of the island shows that the Triassic, if existing at all, occurs in isolated patches. It has been deemed best, therefore, to color the island uniformly Permo-Carboniferous, as most in accordance with the age of the greater portion of its strata. The great similarity of much of the formation to that seen in the northern portion of Cumberland and Colchester counties, in Nova Scotia, and which is undoubtedly the Upper Carboniferous, is very apparent.

The discussion of the geology of Prince Edward island was renewed by Bain and Dawson[3] in 1885. In the paper by these authors, Dawson refers to the conclusion cited above as follows: "Mr. Ells * * * not only extends the limits of the lower series, but regards the Trias as very limited and not clearly distinguishable from the Permo-Carboniferous; but in this last respect I can not but think he exaggerates the difficulty occasioned by the low dip of all the beds, and the strong mineral resemblance of the Trias to the underlying Permo-Carboniferous, from whose disintegration it has undoubtedly been derived." Dawson then presents the evidence furnished by fossils, and as I shall have occasion

[1] Note on fossils from the Red Sandstone System of Prince Edward island. In Canadian Naturalist, n. s., vol. IX, 1881, pp. 463–464.

[2] Report of Explorations and Surveys in the Interior of the Gaspé Peninsula, 1883. In Geol. and Nat. Hist. Surv. of Canada, Report of Progress, 1882–'83–'84. Montreal, 1885, pp. 11 E–13 E. (Accompanied by 9 atlas sheets.

[3] Notes on the geology and fossil flora of Prince Edward island. In Canadian Record of Science, vol. I, pp. 154–161.

to refer to the meagerness of these records, I quote his statement nearly entire, as it appears in the "Notes on the fossil flora of Prince Edward island," referred to above. The same evidence is presented also more or less fully in the writings of Dawson previously cited, and especially in the report of 1871. In describing the fossil plants Dawson says:

The beds at Miminigash, Gallas point, St. Peter island, Governor island, Rice point, and other places on the south coast contain plants which elsewhere characterize the Upper Carboniferous and Lower Permian. At certain points in the interior of the island and in the bays of the north coast, which represent troughs between the Permo-Carboniferous anticlinals, there are found plants indicating a higher horizon. Here the characteristic Carboniferous species are absent, and their place is taken by others, either Permian or Triassic. For example, the abundant coniferous wood of the Carboniferous species, *Dadoxylon materiarium,* is replaced by an entirely different type more characteristic elsewhere of the Trias, *Dadoxylon edvardianum.* Some of the fossils found in this by Mr. Bain are undoubtedly of Permian aspect, as, for instance, the Walchias and *Calamites gigas.* Others, like the Dadoxylon above referred to and the curious *Cycadoidea abequidensis,* are undoubtedly more Triassic in aspect.[1]

The description of these plants is continued as follows:

The few plants collected by Mr. Bain in the Upper Trias, or Trias proper, are especially interesting in consequence of the paucity of well preserved fossils in this formation. He finds in these beds a Calamites with very fine ribs of the type *C. arenaceous,* and which may be an internal cast of that Triassic species which, when perfect, is really an Equisetum rather than a Calamite, also certain Knorri-like branches different from Tylodendron, but probably branches of coniferous trees, and a species of Walchia apparently distinct from that of the lower beds. It has very stout and straight branches marked with interrupted furrows. Its branchlets are long, slender, and crowded, and at right angles to the branch. The leaves are closely appressed, triangular, and scale like. Detached branchlets have thus the aspect of the Mesozoic genus *Pachyphyllum,* but the habit of growth is that of Walchia. The species is near to *W. imbricata* of the European Permian, but sufficiently distinct to deserve a name, and I have therefore called it *W. imbricatula.* [Figure given.]

It is to be observed that in the red sandstones of Prince Edward island all the more delicate plants and even twigs of coniferous trees have completely lost their organic matter and are represented by mere impressions, stains, or casts in clay or sand, so that it is very difficult to ascertain their minute characters.

The general result, in so far as the subdivision of beds is concerned, would seem to be that the lower series is distinctly Permo-Carboniferous, that its extent is considerably greater than was supposed in 1871, that there is a well characterized overlying Trias, and that the intermediate series, whether Permian or Lower Triassic, is of somewhat difficult local definition, but that its fossils, so far as they go, lean to the Permian side. [Pp. 160, 161.]

DISCUSSION OF THE EVIDENCE.

The evidence advanced in favor of the presence of both the Permo-Carboniferous and Triassic systems on Prince Edward island is entirely paleontological. The absence of an unconformity between the lower and upper rocks and the similarity in their lithological characters are admitted by all. The evidence of the Newark age of the upper portion of the rock series is based on a small number of fossil plants and

[1] Op. cit., p. 158.

on a single reptilian fossil, which have been considered as indicating a parallelism with the Triassic Europe.

PLANTS.

The first of the fossil plants referred to by Dawson in the quotation given above is *Dadoxylon edvardianum*, determined from a microscopic study of fossil wood. It is related generically to other fossil woods found in the Carboniferous, and even as low down as the Devonian, and is represented by the Araucarias at the present day.

There is no reason why fossil wood should not be used as a means of determining geological horizons, if sufficient observations were recorded to determine the range of various genera and species. At present, however, only a few species of Dadoxylon are known, and these range from the Devonian upward to beyond the Mesozoic. The fact that the wood described by Dawson belongs to a hitherto unknown species of a genus of wide geological range does not indicate any definite horizon. As stated by Dawson, it has its nearest specific ally in the Trias of Europe, but also resembles a species from the Permian. If we knew the geological age of various species of this ancient pine more thoroughly, its evidence might have some weight; but at present it is a fact of interest, which it is proper to record, but can not be considered as having taxonomic importance.

The *Cycadoidea (Mantellia) abequidensis*, described by Dawson in the report for 1870, as evidence of the Triassic age of the sandstones of Prince Edward island, is based on a fragment of the trunk of a supposed Cycadeian plant, in which the structure has disappeared. It was found near Gallas point, in the immediate neighborhood of rocks that are admitted by all to be Permo-Carboniferous, and in rocks which Ells has since shown to belong to that system. Dawson refers this fossil, with doubt, to the Cycadoidea, for the reason that the limits of that genus are stated to be "less restricted than the genera *Mantellia* or *Carruthers*."

Besides the fossils just mentioned, the rocks under consideration have yielded certain obscure stems, for which Dawson creates the provisional genus "Knorria." These are stated to resemble closely certain Permian stems, described as *Schizodendron* of Eichwald, from the Permian of Europe. Whether related most nearly to the conifers or the cycads is uncertain.

In addition, there are certain flattened branches, referred to Sternbergia, and closing the list are obscure impressions referred to the fucoids.

The obscure condition in which these fossils are found is referred to by Dawson in the quotation given above. It is evident that their value as a means of determining geological age is small, on account of their imperfect preservation. There is not a single species in the list that has been found in other localities, and even the generic relations of all but the Dadoxylon are uncertain. In the rocks determined by Dawson as Permo-Carboniferous he finds Knorria-like stems and a species of *Sternbergia* which, from his description, can not be distinguished from those in the upper series. The genera *Walchia* and *Dadoxylon* also occur in the lower series. The specific identity of these plants is stated by Dawson to be different from those above; but to one reading his report the relation of the flora in the so-called Triassic rocks to the flora in the supposed lower series seems certainly more intimate than to any other flora cited by Dawson. Such relations as are pointed out seem more strongly Permian than Triassic.

To a geologist whose knowledge of paleobotany is but slight the evidence of geological age furnished by the plants in the upper portion of the sandstone of Prince Edward island seems to be very meager and unsatisfactory, but appears to tend toward Paleozoic rather than Mesozoic affinities.

While venturing to point out the small taxonomic value of the plants referred to above I do not wish to be understood as undervaluing the work of paleobotanists. By accumulating such evidence as has been recorded by Dawson and Bain we may ultimately have a reliable means of determining the identity of widely separated formations.[1]

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[1] Since writing the above I have had occasion to consult F. H. Knowlton of the U. S. Geological Survey in reference to certain specimens of fossil wood from the Newark system, and found that he had also examined the evidence as to the age of the rocks of Prince Edward island; his letter on this subject is here inserted:

I have examined the slides of the six pieces of fossil wood obtained by you from the Triassic of North Carolina, and, with the possible exception of one piece, have been able to identify them to my entire satisfaction with *Araucarioxylon arizonicum* Knowlton. This species was described (Proc. U. S. Nat. Mus., vol. XI, 1888, pp. 1-4, pl. I) from specimens collected in New Mexico and Arizona from the Shinarump group of Powell; I have also recently detected the same species, or at most only a slightly divergent variety of it, from the vicinity of the copper mines near Abiquiu, New Mexico.

This species is entirely unlike *Dadoxylon Edvardianum* described by Dawson from the so-called Triassic of Prince Edward island.

In regard to Prince Edward island, a portion of which has been referred to the Triassic by Dawson, largely upon paleobotanical evidence, I may say that I have been over the evidence with some care, and in the absence of the actual specimens for study and comparison, I think I am safe in saying that the data upon which he bases his conclusions are by no means sufficient or satisfactory. The only two forms to which he gives specific names are new to science and, *as species*, can of course have no weight in determinining stratigraphic position, but *as genera* they may have.

The first species, *Dadoxylon edvardianum*, is regarded by Dawson as being closely allied to two species from the Permian and one obscure species from the Keuper. Now, as at present understood the genus Dadoxylon does not come up into the Mesozoic, but is a Devonian or Carboniferous genus. Moreover, judging from the somewhat crude figures, it belongs decidedly to the more ancient forms showing the Araucaria-like structure characteristic of the Paleozoic, rather than the more highly differentiated forms which are now referred to Araucarioxylon.

Sternbergia is a Paleozoic genus and represents the pith of Cordaites, a genus which never goes above the Permian and had its maximum development in the Devonian and early Carboniferous.

Knorria is of no value in the present instance in determining age, since Dawson says they "very closely resemble the *Permian* stems to which Eichwald has given the name "Schizodendron," and further show internal structure similar to that of stems from undoubted Carboniferous strata (Gallas point) already referred to Dadoxylon.

Fucoids.—These are also of no value in the present case as they are very obscure and are doubtfully regarded as being fucoidal.

Cycadoidea.—This is the other form to which Dawson has given a specific name, and if it is really a cycad undoubtedly argues a Mesozoic age even later than the Triassic. But without the specimen in hand, and only judging from the figure of it, it seems not improbable that it may be a cone of some conifer, particularly when we remember the other things with which it is associated, and further than this the specimen is doubtfully from what he calls Triassiac. It is the only thing which is characteristically Mesozoic.

As for the value of the Dinosaurian remains (*Bathygnathus borealis*) I am of course unable to judge.

Very truly, yours,

F. H. KNOWLTON.

ANIMALS.

Vertebrate fossils.—In discussing the age of the sandstones of Prince Edward island the fossil reptile known as *Bathygnathus borealis* is frequently referred to. This is the only fossil besides plant remains now known from these rocks. The fossil bone with teeth, on which the genus and species mentioned were founded, was obtained by Dawson near New London, on the north side of the island, and described and figured by Leidy[1] in 1854. The remains were referred to the New Red Sandstone by Dawson and Leidy on geological determinations simply, and not on account of the zoological relations of the fossil. Even the family to which *Bathygnathus* belonged was not established until long afterwards, if it is now definitely fixed. In a later discussion of the age of the rocks in which this fossil was found, it is advanced as evidence that they are Triassic. This reasoning is not such a complete circle as it appears, however, as our knowledge of fossil reptiles has been greatly increased since *Bathygnathus* was described, and it has been determined by Cope that its nearest relation is to the Dinosaurs, which had their greatest development in Mesozoic time.

The fossil referred to was described by Leidy "as the right dental bone" of the lower jaw, with seven teeth attached. Its position was reversed, however, by Owen,[2] who claims that the bones are portions of the "skull, including the left maxillary, premaxillary, and nasal bone." It is considered by Owen as a Theirodont reptile, probably of Permian age.

Able paleontologists thus differ as to the zoological affinities of *Bathygnathus*, and as it is the sole representative of a genus, its value to the geologist as a means of identifying the horizons of the strata in which it occurs is not conspicuous. If a *Dinosaur*, as considered by several paleontologists, it would seem to indicate that the rocks in which it occurs are Mesozoic. If a *Theirodont*, as claimed by Owen, it would indicate a Permian age. To the geologist who must look to the paleontologist for the determination of the fossils he finds, the evidence of age furnished by *Bathygnathus* seems nearly equally divided between the Paleozoic and Mesozoic, but bending perhaps more strongly toward the latter.

OTHER INDICATIONS OF GEOLOGICAL POSITION.

Trap rock, undistinguishable from the similar rocks so abundant throughout the Newark system, occurs at a single locality on Prince Edward island. This has been considered by some as evidence of the Triassic age of the sedimentary beds with which it is associated. Elsewhere in this paper it is shown that the trap rocks of the Newark system belong to a vast series stretching for nearly 1,000 miles along the Atlantic coast. This series appears in the sedimentary beds of the

[1] On *Bathygnathus borealis*, an Extinct Saurian of the new red sandstone of Prince Edward island. In Philadelphia Acad. Nat. Sci. Jour., 2d ser., vol. II, 1850–1854, pp. 327–330, pl. XXXIII.

[2] Evidence of the Theirodonts in Permian deposits elsewhere than in South Africa. In Geol. Soc. of London, Quart. Jour., vol. XXXII, 1876, pp. 352–366.

Newark system as dikes and sheets, and occurs also in dikes in the rocks surrounding the various Newark areas, and cutting formations of all ages from the Archean upward to the base of the Potomac, but does not occur in rocks younger than the Newark. The only evidence of age, therefore, that can be claimed for the trap on Prince Edward island is that the rocks which it penetrates are presumptively not younger than the Newark system; they may belong to the Carboniferous or to any older series.

Throughout the various areas of the Newark system from North Carolina to Nova Scotia there is a great unconformity between the rocks of that system and those on which it rests. On Prince Edward island an unconformity between the rocks referred to the Permo-Carboniferous and those supposed to be of Newark age is wanting. While the absence of such an unconformity does not prove that there is but one system of rocks on Prince Edward island, it is strongly suggestive that such is the case.

In discussing the age of the rocks in question, nearly all comparisons have been made with the Triassic and other formations of Europe. What is of special interest, however, is their relation to the Newark system. This, it is to be presumed, can be better attained by a direct comparison than by comparisons through a more distant formation. Evidence of the relation of rocks of Prince Edward island to those of the Newark system may be looked for (1) in the fossils they contain; (2) in the lithological resemblances of the beds to those of the Newark system; and (3) their structural relations to other systems, the relations of which to the Newark are known:—

1. No fossils are known to be common to the rocks of Prince Edward island and to the Newark system.

2. Lithologically the rocks in question on Prince Edward island, as stated by Ells and others, differ widely from the rocks of the Newark system in the Acadian area, with which they are geographically nearest related; and besides, they bear a marked resemblance to the Permo-Carboniferous rocks on which they rest, and to those of New Brunswick.

3. Throughout all of the various Newark areas, as will be described later in this paper, there is a great unconformity between the rocks of the Newark system and the formations, some of which are Carboniferous, on which they rest.

CONCLUSIONS.

The absence of Newark fossils in the rocks of Prince Edward island; the close lithological similarity of the beds in the upper and lower portions of the sections there exposed, the lower rocks being Permo-Carboniferous; and the lithological difference of the rocks from the sandstone and shales of the Newark system, seem to me sufficient ground for not considering any portion of the stratified rocks of Prince Edward island as belonging to the Newark system.

CHAPTER IV.

LITHOLOGY AND STRATIGRAPHY.

The main portion of the Newark system is composed of conglomerate, breccia, arkose, sandstone, shale, and slate.[1] Of these sandstone and shale are by far the most abundant. There are besides a few thin limestone layers and deposits of coal. The igneous rocks are described in a separate section.

CONGLOMERATES AND BRECCIAS.

Coarse deposits, composed of both rounded and angular stones, occur especially at the base of the system, and along the borders of some of the areas.

Conglomerates have been reported by Emmons[2] in some of the southern areas in the medial portion of the system, or, at least, far above its base, but in some instances, as shown by my own observations, these exposures are portions of the basal conglomerate, brought to light by faulting. The prevailing structure of the system was not recognized at the time Emmons made his survey of North Carolina, and the hypothesis that the presence of conglomerates at the surface in the central portions of the Newark areas might be due to faulting was not considered. No unconformities by erosion have been recorded at the horizons where the conglomerates referred to are supposed to

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[1] Descriptions of the character and distribution of the clastic rocks of the Newark system may be found in the following works:

Acadian area: J. D. Dawson, Acadian Geology, 2d and 3d ed., pp. 86–124.

Connecticut valley area: J. G. Percival, Rep. Geol. Connecticut, 1842, pp. 426–452. Edward Hitchcock, Final Rep. Geol. Massachusetts, 1841, vol. II, pp. 441–446.

New York–Virginia area: W. W. Mather, Geol. of New York, 1843, pp. 285–289. H. D. Rogers, Description of the geology of New Jersey, Final Report, 1840, pp. 117–141. G. H. Cook, Geology of New Jersey, 1868, pp. 206–226. G. H. Cook, Geol. of New Jersey, Ann. Rep. for 1882, pp. 17–43. N. H. Darton, U. S. Geol. Survey, Bull. No. 67, 1890. H. D. Rogers, Geol. of Pennsylvania, 1858, vol. II, pp. 667–680.

New York–Virginia and other areas to the south: W. B. Rogers, A reprint of annual reports and other papers on the geology of the Virginias, 1884, pp. 323–328, 475–480. O. J. Heinrich, Mesozoic formation of Virginia; in Am. Inst. Min. Eng., Trans., vol. VI, 1878, pp. 227–274. W. M. Fontaine, Notes on the Mesozoic of Virginia; in Am. Jour. Sci., 3d ser., vol. XVII, 1879, pp. 25–39, 151–157. Ebenezer Emmons, Geological report of the midland counties of North Carolina, 1856, pp. 227–268.

The building stones of the Newark system have been described by S. W. Hawes, Report on the building stones of the U. S.; in Tenth Census of the U. S., vol. X, 1884, pp. 25–27, pl. 13. N. S. Shaler, Report on the building stones of the U. S.; in Tenth Census of the U. S., vol. X, 1884, pp. 126, 127, 141–144, 155–157, 177, 178, 179, 180, 181, 182, pls. 45, 46. S. P. Merrill, Collection of building and ornamental stones in U. S. National Museum; in Smithsonian Inst. Ann. Rep. for 1885–'86, pp. 277–648.

[2] Emmons, Ebenezer: Geol. Rep. of the midland counties of North Carolina, 1856, pp. 227–239; also, American Geology, part VI, Albany, N. Y., 1857, pp. 9–11.

occur, and additional study is necessary before such marked physical changes in the history of the system as would be implied by the presence of a widespread stratum of coarse material far above its base, can be accepted as proved.

The important and characteristic conglomerate of the system occurs at its base, and is quite generally exposed along the borders of the various areas toward which the rocks dip.

In the Acadian area the lower rocks are coarse, and form characteristic conglomerates, as is shown by exposures on the borders of the basin of Minas, and in isolated patches on the west side of the bay of Fundy.

In the Connecticut valley a coarse conglomerate, sometimes containing rounded bowlders 2 or 3 feet in diameter, occurs along the eastern margin of the area and about its northern end, but is seldom seen on its west border.

Coarse deposits also form the basal portions of the Southbury area.

In the New York-Virginia area a coarse brecciated conglomerate occurs at intervals all along the western margin. The same is true of the detached areas farther south, which fall in line with the New York-Virginia area. These are the Barboursville, Scottsville, Danville, and Dan river areas. On the east side of the New York-Virginia area coarse deposits are mostly wanting, but have been observed at a few localities in New Jersey and Pennsylvania. Beneath the Palisades along the west bank of the Hudson the basal conglomerate is represented by a coarse arkose, apparently derived from the waste of an area of feldspathic gneiss. Coarse brecciated conglomerates occur also in the more easterly areas in Virginia and North Carolina, but, contrary to what might perhaps be expected, are frequently exposed on their west borders and but seldom seen along their eastern margin. It is also frequently well exposed in small linear, outlying patches of Newark rocks, near the borders of the Richmond, Farmville, Deep river, and Wadesboro areas. These detached or secondary areas adjacent to the larger ones owe their preservation to the downward faulting of the Newark beds, which has carried portions of the basal member of the series below the plane of present denudation. The conglomerates exposed in these situations are clearly portions of the basal conglomerate.

The general absence of coarse conglomerates along the eastern border of the southeastern areas just mentioned is due, in part, to the presence of marginal faults, which bring fine offshore deposits of the Newark system in direct contact with the encircling crystalline rocks. In other places the junction of the Newark system with the crystallines is obscured by quite recent sedimentary beds and by the products of subaerial decay, so that it is difficult to determine the nature of the rocks near the line of contact.

A study of the voluminous reports and essays of various geologists, a portion of which are indicated in the foot note on page 32, aided by a personal reconnaissance, seems to warrant the conclusion that the basal portion of the system is generally a coarse brecciated conglomerate, having a thickness ranging from a few feet to perhaps 150 feet. Over considerable areas, especially along the west border of the Connecticut valley area and the east border of the New York-Virginia area, the lower beds are fine and must have been deposited at a distance from shore. The shore line against which the Newark rocks were deposited at various stages may frequently be distinguished by a marked thickening and an increase in the size of the fragments composing the basal conglomerate.

The marginal conglomerate is not a separate and independent formation capping the Newark system, as has been at times supposed, but is an extension and a local thickening of the basal conglomerate. Coarse deposits extended out from the ancient shore line in certain localities, as has been stated, and on their outer margins became interstratified with finer offshore sediments. The coarse shore deposits and the finer offshore deposits overlap and form a heterogeneous terrane.

In speaking of the former shore of the Newark estuary, it is not intended to convey the idea that the shore line at the last stage of deposition is still preserved. The whole region occupied by the Newark system has been upheaved since the last of its strata were laid down, and reduced to a base level by erosion. This process has possibly been repeated more than once. The result is that the marginal conglomerates now exposed belong in large part to the earlier stages in the deposition of the system. Neither do all of the shore deposits now exposed belong to a single horizon. As will be mentioned when the structure of the system is described, the plane of base-level erosion which determined the present surface of the Atlantic slope cuts deeper into the Newark rocks in North Carolina and Virginia than it does in New Jersey and the Connecticut valley. The marginal conglomerates are composed of both rounded and angular débris derived from adjacent portions of the encircling crystalline and Paleozoic terranes. In places it is highly calcareous, and is used for ornamental building stone and for the manufacture of lime. At other places it is largely composed of quartz pebbles and is sufficiently compact to be used for millstones. Again, it is made up of schists and slates, and can scarcely be distinguished, especially when somewhat decomposed, from the rocks of the adjacent gneissic areas from which its material was derived. The conglomerate, when calcareous and when largely composed of quartz pebbles, is usually light colored, commonly gray. It frequently carries the remains of tree trunks and branches, now changed to lignite, and obscure impressions of leaves. At other localities it is highly ferruginous, barren of fossils, and passes by insensible gradations into the ordinary brown sandstone, which is the most widely known rock of the system. In all cases, so far as can now be judged, the coarse deposits are of local origin and were derived from neighboring shores.

Associated with the coarse shore deposits, especially in the Connecticut valley and in New Jersey, there are fine, dark carbonaceous slates which contain fossil fishes and the impressions of plants.

SANDSTONES, SHALES, AND SLATES.

The greater part of the clastic rocks of the Newark system are reddish brown sandstones and ferruginous shales. These grade into each other so as to form a great variety of lithologic variations, ranging from a compact and almost vitreous sandstone to friable shales and clays so soft that they crumble between one's fingers.

Interstratified with these deeply colored rocks are occasional layers of gray sandstone and mottled shales. Although light colored strata are present in considerable thickness in certain localities, they are not sufficiently abundant to justify a modification of the statement that the characteristic color of the system is brown or brownish red.

The more compact sandstone is quarried at a large number of localities throughout the system, and is extensively used for architectural purposes in nearly all of the cities of the Atlantic coast. The reports on building stone mentioned in the footnote on page 32, give detailed information in this connection.

When the sandstones are examined under the microscope they reveal the fact that they are composed of a great variety of mineral and rock fragments, but in the main are formed of grains of quartz, feldspar, and mica. In the rocks having the characteristic ferruginous color, the individual grains are coated with a ferriginous, clayey incrustation, which also cements the particles one with another and imparts its color to the rocks.

It seems probable that the origin of the coloring matter is to be found in the subaerial decay of the crystalline and Paleozoic rocks from which the débris forming the strata were derived.[1]

Some of the strata of the Newark system are fine grained, black, highly bituminous slates. These occur to a limited extent in the Connecticut valley and New Jersey, but are present in great abundance in the Richmond, Deep river, and Dan river areas. In the southern areas these rocks are associated with coal seams, and in some instances pass into black-band iron ore of limited economic value.

LIMESTONES.[2]

The limestones are seldom more than a few feet thick and are mostly confined to a few localities in the Connecticut valley and the northern

[1] Russell, I. C.: Subaerial decay of rocks and the origin of the red color of certain formations. Bull. U. S. Geol. Surv., No. 52, 1889, pp. 45–56.

[2] Hitchcock, Edward: Geol. Massachusetts, Final Rep., 1841, vol. II, p. 444. Percival, J. G.: Geol. Connecticut, 1842, pp. 442–444. Mather, W. W.: Geol. of New York, 1843, p. 288. Rogers, H. D.: Description of the Geol. of New Jersey, Final Report, 1840, p. 134. Cook, G. H.: Geol. of New Jersey, 1868, pp. 214, 215.

part of the New York-Virginia area. Very impure limestone, scarcely distinguishable from carbonaceous slates, does occur, however, in connection with some of the coal-bearing strata at the south. These strata are distinct from the marginal calcareous conglomerates, and frequently occur at a distance of several miles from the borders of the system, and are interstratified with shales and fine-grained sandstones.

They are usually compact, light colored, fine-grained rocks, and are without fossils or other evidence of being of organic origin. Neither do they have the characteristics of chemically formed deposits. In some instances they seem to have originated from the deposition of calcareous mud derived from the erosion of adjacent limestone areas.

COAL.

In the New York-Virginia and more northern areas no coal seams have been found, although the presence of carbonized tree trunks, or other very limited quantities of carbonaceous material, have been reported from time to time as true coal seams. The usual high dip of the strata in the northern areas renders it evident that coal seams would be likely to reveal themselves did they exist. The presence of strata of highly carbonaceous shales in these areas is the only suggestion of the possible presence of coal that the geologist has to offer.

Workable beds of coal have been discovered in the Richmond, Farmville, and Deep river areas. The coal is bituminous except where alteration has occurred, owing to the heat of intruded igneous rocks.

QUALITY OF COAL.

In the Richmond field it is described by Heinrich[1] as being highly laminated, bright black, highly resinous, and composed of thick laminæ in thin layers alternating with dull black laminæ of less dimensions. On the fresh fracture, which is more or less conchoidal, it is jet black, luster resinous and splendent. It splits most readily parallel to the stratification, which is strongly marked by the alternate dark and bright layers.

This description would apply equally well to much of the coal of the Farmville and Deep river areas. As it is seen at the mines, the better grade is bright and compact, and indicates at once that it is a valuable fuel. This general impression is sustained by many tests that have been made, and by the favor with which the coal of the Richmond field, especially, has been received by those interested in gas and other industries in the city of Richmond.[2]

The average composition of eleven samples of coal from as many mines

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[1] The Mesozoic formation in Virginia: Am. Inst. Min. Eng. Trans., vol. VI, 1879, p. 243.

[2] Johnson, W. R.: A report to the Navy Department of the United States on American Coal, Washington, 1844, p. 448. Other analyses may be found in O. J. Heinrich's essay on the Mesozoic of Virginia; Am. Inst. Mining. Eng., Trans., vol. VI, 1879, p. 269.

in the Richmond coal field, is given in column I below, and the analysis of an average sample of coal from Farmville, in the Deep river area, in column II.[1]

Average composition of the coals of the Newark system.

	I.	II.
Specific gravity	1.436	....
Water, at 115° C	....	2.15
Sulphur	1.232	3.72
Volatile matter	29.432	28.88
Fixed carbon	58.113	52.56
Ash	10.903	12.69
	....	100.00

NATURAL COKE.

Besides the bituminous coal which is the characteristic fuel deposits of the areas here treated, there are beds of "carbonite," "natural coke," and "semianthracite," which are modifications of the normal coal due to the heat of intruded igneous rocks.[2] Of these the most interesting and important is the natural coke. This occurs both in the Richmond and Deep river coal fields, and is of considerable economic importance. It is iron black in color, porous, has a metallic luster, and resembles artificial coke. It has been mined especially at Carbon hill and Midlothian, on the east side of the Richmond area.

The average of five analyses by various chemists, gives the composition of this substance as follows:

Average composition of natural coke.

Volatile matter	12·50
Fixed carbon	79·93
Sulphur	0·26
Ash	6·55
	99·24

[1] This and other analysis of the coal of the Deep river area may be found in H. M. Chance's report on an exploration of the coal fields of North Carolina, Raleigh, 1885, pp. 33, 34.

[2] The history of our knowledge of this substance may be traced in the following works: W. B. Rogers: On the porous anthracite, or natural coke of eastern Virginia. In Am. Jour. Sci., vol. XLIII, pp. 175–176. Also in Am. Ass. Geol. and Nat. Proc., 1840, p. 60. Report of the progress of the Geol. Surv. of Virginia for 1840, p. 124.

Johnson, W. R.: [Remarks on the Natural Coke of Virginia.] In Acad. Nat. Sci., Philadelphia Proc., vol. I, 1842, pp. 223–224. Reprinted in The Coal Trade of British America, Washington and Philadelphia, 1850, pp. 155–156. "Natural Coke" from Tuckahoe, Virginia. In a report to the Navy Department of the United States, on American coals; Washington, 1844, pp. 138–151.

Lyell, C.: On the structure and probable age of the coal field of the James river, near Richmond, Virginia. In Quart. Jour. Geol. Soc. of London, vol. III, 1847.

Rogers, W. B.: [Observations on the natural coke of the Richmond coal field, Virginia.] In Boston Soc. Nat. Hist., Proc., vol. V, 1855, pp. 53–56.

Wurtz, Henry: Preliminary note upon the carbonite or so-called "natural coke" of Virginia. In Am. Inst. Min. Eng., Trans., vol. III, 1874–'75, pp. 456–458.

Heinrich, O. J.: The Mesozoic formation in Virginia. In Am. Inst. Min. Eng. Proc., vol. VI. 1877–'78, pp. 244–269.

Chance, H. M.: Report on the North Carolina coal field, Raleigh, 1885, p. 34.

RICHMOND AREA.

The coal seams of the Richmond field are irregular in thickness, and have been greatly disturbed by faulting, as will be explained in the section of this paper devoted to structure. The seams are not continuous throughout the field, although they occur at approximately the same horizon. There is no assurance that the seams worked on one side of the basin are individually the same as those explored on the opposite side, or even in adjacent mines. Seemingly the coal occurs in lenticular beds, the outlines of which have not been determined. The edges of these beds overlap, so that while the series as a whole may be continuous over comparatively large areas, individual beds die out and are replaced by others. What is a thin seam in one mine may thicken and become the most important bed in an adjacent mine. This hypothesis, it is true, has not been fully demonstrated, but it explains many peculiarities in the field.

In the Norwood mine on the west side of the area the coal is worked by means of "inclines," in which the following section was exposed in 1885:

	Feet.
Sandstone and shale, dipping W. 20 to 25	10 to 200
Coal, with medial partings of shale	5 to 7
Shales	10 to 12
Coal, with medial parting of shale	6

In the neighboring Powhatan mine there are five coal seams, the most important having a thickness at least locally of 7 feet.

The Old Dominion mines, a mile or two south of the Norwood mines, were worked several years ago by means of a shaft, but are now abandoned. At this locality the strata were penetrated to the depth of 125 feet and found to contain three coal seams. The upper one, where it outcropped at the surface, was about 4 feet 6 inches thick, but increased to 12 feet when followed down the dip. The second was from 18 to 24 inches thick near the surface, and increased to 4 feet in the lower part of the mine. The third was struck 4 feet below the second, and contained 3 feet of coal of inferior quality.

The mines of Manakin (Dover), on the west side of the Richmond area, north of the James, were worked for more than 50 years, and a large quantity of coal obtained. They are now abandoned and the shafts are in ruins. The "Sinking shaft" at this locality penetrated over 900 feet of strata, but failed to reach a workable coal seam. F. W. Stone, the former superintendent of this mine, informed me that there were two coal seams in the Dover region. No detailed account of these deposits is available.

Coal has been mined all along the east border of the area and in adjacent local fault basins, and a large amount of data concerning the thickness and association of the local seams is available.

The section at Carbon hill, north of the James, is as follows:[1]

Section at Carbon hill, Virginia.

	Feet.
Recent formation, soil	20
Alternating shales and sandstones	450
Cinders, so-called fire clay	195
Nodula pyrites	15
Shales and sandstones	60
Coke seam { coke, 2′ 4″ } { coal, 3′ 8″ }	6
Shale and sandstone	50
Coal seam	3
Shale, third seam	17
Coal	4·5
Shale and shale and sandstone, containing 6-inch coal seam, second seam	40
Coal seam, slope seam 8 to 10 feet, first seam	9
Sandstone and slate to supposed granite base	160
	1,032·5

An extremely detailed record of the strata passed through in exploring for coal with a diamond drill at Midlothian, in the central portion of the east border of the field, has been published by Heinrich, in the paper just cited. These explorations passed through 1,518 feet of Newark rocks, and reached the underlying granite. Four coal seams were penetrated, the lowest of which is 570 feet above the granite. The record of the coal-bearing portion of this section is here copied, with some slight verbal changes:

Section at Midlothian, Virginia.

Stratum.	Thickness.		Distance above granite.	
	Feet.	*In.*	*Feet.*	*In.*
Sandstone, arkose, light gray, hard, partially coarse	34	9	566	4
First coal seam, 3′ 6″ coal, 1′ 6″ slate	5	0	571	4
Slate and schistose sandstone, dark gray	6	2	577	6
Sandstone, arkose, light gray, partially schistose	4	3	581	9
Slate, dark gray	8	0	589	0
Sandstone, arkose, gray	9	10	599	7
Second coal seam	1	0	600	7
Slate, gray	9	0	609	7
Sandstone, arkose, gray, hard	9	0	618	7
Third coal seam, divided by slaty bands from 2 to 24 inches	12	0	.....	.....
Sandstone, gray, silicious, and gray slate	10	3	655	4
Fourth coal seam, divided by slaty bands	14	6	.....	.....
Slate, block and argillacious sandstone	4	0	659	4

At Clover Hill, in the southern part of the eastern border of the Richmond area, the character of the coal-bearing strata has been

[1] Heinrich, O. J.: The Mesozoic formation of Virginia. Am. Inst. Min. Eng. Trans., vol. VI, 1879, pp. 260, 261.

recorded by Fontaine.[1] There are three main coal seams, and four others of less thickness, designated in the section as local. The strata intervening between the lowest coal seam and the granitic floor on which the system rests has not been penetrated. The dip is here to the westward at an angle of about 25 degrees, and the coal beds outcrop at the surface.

Section at Clover Hill, Virginia.

	Feet.	Inches.
Coal seam, local (?) 18 inches to	4	0
Sandstone and shale	14	0
Coal seam, local	0	12
Sandstone and shale	12	0
Coal seam, local	0	14
Sandstone and shale	25	0
Coal seam, local	0	18
Sandstone and shale	40	0
Upper bed of main coal	5	0
Shale, of varying thickness	5	0
Main coal, lower bed	13–26	0
Sandstone and shale	40	0
Lower persistent coal bed	4	9
Sandstone and shale, about	250	0
Gneissic floor		

The section here given indicates the character of the coal seams about the border of the Richmond field. In the detached secondary areas along its eastern border the rocks have been so greatly disturbed that it is difficult to obtain reliable record of the strata. It has been stated that the coal seams in these basins were from 40 to 60 feet thick. The high inclination of the beds, however, and such descriptions of the mines as can be found in books or obtained from men who worked in the mines, render it evident that the thickness of the seams has been exaggerated, as will be shown in discussing the structure of the area.

The presence of workable coal beds in the central portion of the Richmond area seems probable, although that region has not been explored. The nearly horizontal position of the rocks over the central area is a promise that the coal, when reached, will be found in a much less disturbed and broken condition than on the borders of the field. The depth at which coal will have to be looked for in the central area is in the neighborhood of 2,500 feet. At present this depth would probably render economic mining impracticable, owing to the low price of coal in neighboring markets.

FARMVILLE AREA.

Coal was formerly worked in this area in a systematic way for several years, but the seams are thin, ranging from 6 to 30 inches, and are greatly disturbed. No definite records of the strata penetrated in the various mining operations are to be had.

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[1] Older Mesozoic Flora of Virginia. U. S. Geol. Surv., Monograph vol. 6, 1883, p. 6.

DEEP RIVER AREA.

There are reasons for considering the Richmond and Farmville areas in Virginia as having been formerly directly connected with the Deep river and Dan river areas of North Carolina. The coal-bearing rocks in the Deep river area have a striking analogy to the medial portion of the section obtained in the Midlothian mines. While it is presumable that the formations are continuous, there is no reason for surmising that the coal seams of one area represent individually the coal seams of the other.

At Egypt, North Carolina, in the central portion of the Deep river area, the section penetrated by what is known as the "Egypt shaft" was carefully recorded by Wilkes.[1] This shaft was 460 feet deep, and ended in black slate just below the lowest coal seam.

Section at Egypt, North Carolina.

	Feet.	Inches.
Sandstone (410 feet below surface)	3	0
Black slate	9	0
Coal	4	0
Black band, upper bed	1	4
Coal	1	1
Slate	0	6
Coal	0	7
Black bituminous slate	8	0
Gray sandstone and fire clay	16	0
Black band	1	5
Coal	1	0
Black band	3	0
Black slate	1	0

At Farmville, North Carolina, 2 or 3 miles west of the Egypt shaft, the coal-bearing strata come to the surface but are disturbed by faults and by dikes of igneous rock. The section at this locality, after Chance,[2] is as follows:

Section at Farmville, North Carolina.

	Feet.	Inches.
Upper coal (coal 3 feet, shale 2 feet, coal and slate 3 feet)	8	0
Slate and sandy fire clay	17	0
Coal	0	4
Slate and fire clay	6	0
Coal	1	0
Slate and fire clay	4	0
Coal	1	2
Slate and fire clay	4	0
Lower coal	2	0

[1] [Report on the Deep river country in North Carolina.] 35th Congress, 2d session. Senate Ex. Doc. No. 26.

[2] Report on the North Carolina coal fields, to the Department of Agriculture (of North Carolina), Raleigh, 1885, p. 22.

DAN RIVER AREA.

The rocks in this area are similar in nearly every respect to those of the Deep river area, but the shaly slates in the central portion of the series are thicker and perhaps of greater extent. They contain many bands of black bituminous and carbonaceous layers, which have been frequently mistaken for coal.

This area has been critically examined by Chance,[1] who reports that the coal occurs merely as sporadic deposits of limited extent and too thin, irregular, and uncertain to be of commercial value.

COMMERCIAL DEVELOPMENT.

Mr. Heinrich[2] states that coal was discovered in the Richmond area as early as 1700 and was then mined for local use. Systematic mining was begun about 1790. This was the first coal mined for shipment in the United States. The total production of the area from 1822 to 1878 is estimated at 5,647,621 tons. Since 1878 mining has been carried on at Clover Hill and at the Norwood and Powhatan mines, the annual output being about 700,000 tons.

Coal is reported to have been mined in a small way in the Farmville area[3] between 1855 and 1870, but no definite record of the operation is available. I have been informed that mining was resumed in 1890 with a promise of good results.

The coal seams of the Deep river and Dan river areas, like those near Richmond, outcrop at the surface. Coal was dug from open pits, for local use, early in this century, but no systematic mining was carried on until about 1850, when improvements in the navigation of Deep river rendered its shipment practicable. The most active period in the history of this field was just preceding and during the civil war.

When I visited the area in 1885 no mining was being done, although a systematic examination of the value of the coal seams near the Gulf was being made. At Egypt all work had been suspended for fully twenty years, and the deep shaft was in ruins.

In the Dan river area a little coal was mined during the war, for use in Danville.[4]

The reason for the unsatisfactory history of the Newark coal fields lies primarily in the great disturbances that the various areas have suffered on account of tilting, faulting, and igneous intrusions. The presence of "fire damp" in many of the mines and a tendency to spontaneous combustion have also added to the danger and expense of

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[1] Report on the North Carolina coal fields to the Department of Agriculture (of North Carolina), Raleigh, 1885, pp. 62–66.

[2] The history of this coal field and a detailed record of the amount of coal produced in various years is given by Heinrich. Am. Inst. Min. Eng., Trans., vol. VI, pp. 266–274.

[3] The history and character of this field and of related coal-bearing areas, is given by S. H. Daddow and B. Bannan, in "Coal, Iron, and Oil, etc," Pottsville, Pa., 1866, pp. 393–406.

[4] The history of these various fields has been summarized by H. M. Chance in report on the coal fields of North Carolina, made for the State Board of Agriculture, Raleigh, 1885, pp. 22–24.

working. In all the fields mining was begun at the surface. Water was thus admitted and the most valuable portions of the beds permanently injured. The lack of foresight in the early development of the mines has practically ruined large areas.

At present the cheapness with which coal can be furnished along the Atlantic border, from the extensive mines on the west slope of the Appalachians, practically closes competition in the mines of the Newark area, where mining is more expensive than in the great fields farther west, owing to the natural difficulties suggested above. Those best qualified to judge of the value of the Richmond field are of the opinion that it contains an important reserve supply of coal which will be utilized in the future.

The value of some of the highly carbonaceous slates associated with the coal, for gas manufacture, indicates that they too will ultimately be used.

The disturbed and broken condition of the rocks here considered precludes the hope that they will ever yield even limited supplies of oil or gas.

THICKNESS OF THE NEWARK ROCKS.

Many estimates have been made of the thickness of the Newark rocks, but owing to the faulted structure that characterizes the system no generally accepted results have been reached. It is possible to measure the thickness in the Danville, Dan river, and Wadesboro areas with a reasonable approximation to accuracy, but this has not been done. The only reliable evidence of the thickness of the system available is the records of various deep borings that have been made.

An artesian well at Northampton, Massachusetts, sunk in the lower sandstone of the system, reached a depth of over 3,000 feet without reaching the underlying crystalline rocks.[1] A well bored near New Haven, Connecticut, by the Winchester Arms Company, approximately 2 miles from the west border of the Newark rocks, reaches a depth of 2,400 feet without passing through the system.[2]

Many wells have been sunk in the Newark area of New Jersey in search of artesian water. The deepest of these is at Paterson and reached a depth of 2,100 feet, all but the upper 6 feet being in the sandstones, shales, etc.[3]

Explorations for coal with the diamond drill at Midlothian, Virginia, near the eastern margin of the Richmond area, reached the underlying granite at a depth of 1,518 feet.[4]

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[1] Emerson, B. K.: (Topography and Geology of Hampshire county, Massachusetts.) In Gazetteer of Hampshire county for 1854–1887. Compiled and edited by W. B. Gray, Syracuse, N. Y. (1888), p. 19.

[2] Hubbard, O. P.: New York Acad. Sci., Trans., vol. IX, 1889–1890, p. 3. It is stated by J. D. Dana that this well shows a depth of Newark rock of at least 3,100 feet. Am. Jour. Sci., 3d ser., vol. XLII, p. 442.

[3] Cook, G. H.: Geol. Surv. of New Jersey. Ann. Rep. for 1885, Trenton, N. J., 1885, p. 115.

[4] Heinrich, O. J.: The Mesozoic Formation in Virginia. In Am. Inst. Min. Eng., Trans., vol. VI, 1879, pp. 256–260.

At Durham, North Carolina, near the west margin of the Deep river area, a well was bored a few years ago to the depth of 1,600 feet, all in rocks of the Newark system.

The data in hand are not sufficient to determine the thickness of rock in the various Newark areas, but it is evident from the records of the Northampton well that an estimate of 4,000 feet could not be considered excessive. When it is remembered that great erosion has taken place, it is evident that the original thickness of the system must have far exceeded the amount just stated.

CHAPTER V.

CONDITIONS OF DEPOSITION.

In the present section, the manner in which the various beds of the Newark were deposited as well as the evidence they contain as to the character of the climate during the time of their accumulation, will be considered.

PHYSICAL CONDITIONS.

PREVIOUS INTERPRETATIONS.

A hypothesis proposed by Rogers,[1] which refers the deposition of the rocks of a large part of the Newark system south of New York to the action of a river rising in the Southern States and emptying into the ocean in the neighborhood of the present site of New York, has met with so little favor and is so inconsistent with later observations that it seems unnecessary to consider it at this time.

The rocks of the Acadian area are considered by Dawson[2] as having been deposited in a bay resembling the present Bay of Fundy, which was swept by strong tides and currents that carried away the argillaceous matter and prevented the deposition of muddy sediments.

In reference to the conditions of deposition of the Newark system in general, Dana[3] observes that the absence of radiates, the paucity of mollusks, and the presence of few species that are properly marine, prove that the ocean had imperfect access, where any, to the regions in which the rocks were deposited. The beds are not seashore formations like the Cretaceous and Tertiary, which goes far to confirm the idea that they are partially estuary and partly of lacustrine origin.

A little later in the same volume Dana states:[4]

> The position of the [Newark] beds on the Atlantic border shows that this part of the continent stood nearly at its present level. The strange absence of marine deposits along the Atlantic border may be accounted for by supposing that the dry land stretched farther out to the eastward, and that seashore deposits were formed which are submerged. A change of level of 500 feet would take a breadth of 80 miles from the ocean and add it to the continent.

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[1] Description of the geology of the state of New Jersey. A final report. Philadelphia, 1840, pp. 115, 166–171. The hypothesis proposed by Rogers is quoted by W. W. Mather in Geol. of New York, part 1, 1843, pp. 289–293, who agrees with Rogers in the main, but ascribes the deposition of the rocks of the Newark system in an inclined position to the meeting of equatorial and polar oceanic currents. The hypothesis proposed by Rogers is dissented from by E. Mitchell in "Elements of Geology, with an outline of the geology of North Carolina," 1842, p. 133.

[2] Acadian Geology, 2d and 3d editions, 1868, 1878, p. 111.

[3] Manual of Geology, 2d ed., 1875, p. 420.

[4] Ibid, pp. 422–423.

In this connection LeConte[1] writes:

During the Jura-Trias [Newark] the shore line to the north was still beyond what it is now, for no Atlantic border deposit is visible; and along the Middle and Southern States it was certainly beyond the bounding line of Tertiary and Cretaceous, for all the Atlantic deposits of this age have been covered by subsequent strata; and yet, probably not much beyond, for some of these Jura-Trias patches seem to have been in tidal connection with the Atlantic Ocean. It is probable, therefore, that the shore line was a little beyond the present New England shore line, and a little beyond the old Tertiary shore line of the Middle and Southern Atlantic States.

A little back from this shore line, and at the foot of the Appalachian chain, there was a series of old erosion or plication hollows stretching parallel to the chain. The northern ones had been brought down to the sea level, and the tides regularly ebbed and flowed there then as in the Bay of San Francisco or Puget Sound at the present time. In the waters of these bays lived swimming reptiles, Crocodilian and Lacertian, and on their flat, muddy shores walked great bird-like reptiles, and possibly reptilian birds. The more southern hollows seemed to have been been above the sea level, and were alternately coal marshes and fresh-water lakes, emptying by streams into the Atlantic; or, according to Russell, there may have been but one great sound stretching from Nova Scotia to North Carolina, in which the tides flowed and ebbed, the southern end being swampy or marshy. Since that time the coast has risen 200 or 300 feet, and these patches are therefore elevated so much above the sea level.

The physical conditions under which the rocks of the Newark system in New Jersey and the Connecticut valley were deposited, as described by Newberry,[2] are here cited:

Many of the beds show ripple marks, sun cracks, and rain drop impressions, which prove that they were once beaches or mud flats, sometimes exposed to the air. They are also frequently impressed by the tracks of large and small animals. Everything indicates that these tracks were made by animals that frequented the shores of bays and estuaries where the retreating tide left broad surfaces which were their feeding grounds. Inasmuch as many successive beds show ripple marks, sun cracks, and tracks, the conclusion seems inevitable that the areas where these strata were deposited were slowly sinking and that the land-wash spread by the tide constantly formed new sheets, upon which fresh records were inscribed.

CONCLUSIONS.

The generally accepted conclusions of geologists in reference to the mode of deposition of the rocks under discussion seem to be, that the beds were water laid and must have accumulated in land-locked estuaries and swamps. The suggestion many times advanced that these rocks are lacustral in origin has never been sustained by direct evidence.

The facts on which these conclusions are based may be summarized as follows:

(1.) Absence of characteristic marine or fresh water fossils, thus suggesting brackish water and unstable condition.

(2.) Fossil fishes closely allied to existing ganoids of rivers and lakes, which were, perhaps, migratory in their habits and, like salmon at the present time, were destroyed in large numbers at the mouths of the small streams which they frequented during the breeding season.

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[1] Elements of Geology, 1882, pp. 469–470.

[2] U. S. Geol. Survey, Monograph vol. 14, 1888, p. 5.

(3.) Rapid alternations of sediments which are frequently cross-bedded, and the presence of footprints, raindrop impressions, etc., indicating the prevalence of high tides.

(4.) The presence of land plants in the more carbonaceous portions of the deposit, and of fossil wood in many localities in the sandstone, indicating the proximity of land.

These facts favor the conclusion already stated, that the rocks, especially of the northern portion of the Newark system, were deposited in broad, shallow, tide-swept estuaries, in which broad expanses of mud were left exposed at low water. The southern part of the area of deposition was low and swampy, and received accumulation of carbonaceous matter. A slow subsidence during the period of deposition is shown, particularly in the northern areas, by the occurrence of footprints and raindrop impressions at many horizons.

CLIMATIC CONDITIONS.

Several expressions of opinion have been published respecting the prevailing climatic conditions during the Newark period. I will state the conclusions that have been reached, and then review briefly the evidence on which they rest.

In describing certain coarse deposits on the east border of the Deep river area in North Carolina, Kerr[1] suggested that they indicated a sub-Newark glaciation. But these deposits have been shown by Fontaine,[2] to belong at the end rather than at the beginning of the Newark period. A similar remark was made by Shaler, Davis[3] and Hitchcock,[4] in reference to the origin of the coarse conglomerates of the Newark system in the Connecticut valley.

It has been suggested by Dana[5] that the Connecticut valley had its violent floods during the Newark period, which may have been enlarged by the waters and ice of a semiglacial era.

GLACIAL HYPOTHESIS.

The most extended discussion of the glacial origin of the coarse conglomerates of the Newark system that has been made, is by Fontaine.[6] In order to give an impartial hearing to the hypothesis of Mesozoic glaciation, his conclusion is cited in full:

> I think that many of the features described in the preceding pages can best be explained by supposing that in Triassic and Jurassic times, the Appalachian mountain region was receiving supplies of snow too great to be removed by melting. Consequently the excess must have been discharged by glaciers. These must have advanced and receded more than once in the earlier periods, but did not penetrate to the sea. Toward the close of the Jurassic they advanced in such force that they

[1] Rep. of the Geol. Survey of North Carolina, vol. I, 1875, p. 146.
[2] Am. Jour. Sci., 3d ser., vol. XVII, 1879, p. 34.
[3] Illustrations of the earth's surface, Glacier, Boston, 1881, pp. 95–96.
[4] Geology of New Hampshire, Concord, 1878, vol. III, Part 3, p. 283.
[5] Am. Jour. Sci., 3d ser., vol. XVII, 1879, p. 330.
[6] Ibid., pp. 236–237.

reached the sea. In the intervening time, while the ice was gathering force, ice rafts, charged with stones and earth, floated down the streams which issued from the foot of the ice. To the frequent pushing forward, and the consequent abrasion of the matter accumulated at the foot of the ice, and in the upper course of the rivers, we must attribute much of the rounded and polished condition of the Potsdam stones now found so far to the east of their original position. This ice may have made its final advance over the whole of the portion of the Atlantic slope in which the features above described are found, or it may have issued from the Blue Ridge, mainly along the line of the Potomac and James, and then in its farther advance to the east have spread laterally, so near the border of the Azoic, as to have coalesced into one sheet. The facts observed rather favor the latter method of advance. From this supposition it would follow that the Mesozoic areas were fed by the cold waters issuing from the ice and snow on the mountains. This may account for the paucity of animal life, especially molluscan life, that they show. The only marine waters with which they could communicate contained forms that could not live in the cold inland waters.

It is probable that the courses of the present principal streams were marked out by this ice action, and hence comes their direct course and independence of the character of the rocks over which they flow. There is no difficulty in explaining the growth of the plants, now found fossil, at a time when the Appalachian mountain belt was covered with snow. All that was needed was a raising of the present winter temperature in the lowlands, for we shall show that for the formation of glaciers on the heights the climate need not have been colder than at present. Owing to the non-existence of the Rocky mountains, the cold western and northwestern winds of the present time would not by reflection from that chain then reach the eastern slopes. At the same time the greater extension of the Gulf waters northward would cause southerly winds to sweep over these slopes. These winds passing over the cold waters of the lakes and great rivers would form abundant fogs. Thus a mild, equable, and moist climate would be produced in the lowlands, even if the earth had its present amount of cold, causing the growth of ferns, cycads, etc., and covering the hills with the immense growth of coniferous trees which we know must have existed. This condition of things would also be eminently favorable for the production of coal. This was only brought to a close in the final advance of the ice at the end of the Jurassic period, when all the abundant forms of plants of that period were extinguished to appear no more. No other cause seems adequate to explain the total extinction of the Jurassic flora, and the complete change which we find in the succeeding Cretaceous flora.

But while the plants were growing in the lowlands and around the lakes, a very different condition of things prevailed in the high Appalachians. The stratigraphy of the formations composing this belt, and the amount of erosion which, as we know, took place, make it clear that in the early Mesozoic times much of this region must have stood above the snow line, and a still larger portion near it. If we recall the physical features of the North American continent which existed at that time, we shall see that even with our present climate then prevailing, the conditions would have been eminently favorable for the formation of glaciers. Along with a sufficient degree of cold we must have abundance of moisture to produce glaciers. This would be supplied by the western and southwestern winds. The latter would sweep unchecked from the Pacific over vast bodies of warm waters in the interior, and meeting the lofty mountain belt of the Appalachians, would give unlimited supplies of snow. The configuration of this elevated district with its broad slopes, and long valleys inclining in one direction, would be eminently favorable for the collection of snow and its discharge in the form of glaciers. Indeed this region must at that time have formed a perpetual storm center. We are not without evidence, however, that a period of cold greater than that now existing, prevailed toward the close of the Jurassic, and in this we find the explanation of the advance of the ice so far to the east at that time.

The statement has recently been made by J. D. Dana[1] that the Newark period "ended in a semiglacial era, as is admitted by all who have studied the beds." The evidence which is advanced to support this view "consists of thick deposits of stones and bowlders in which occur masses 2 to 4 feet in diameter, and therefore such as only ice could have handled and transported. They are situated along the west side of the area in Virginia, Maryland, and New Jersey (where the dip of the Jura-Trias [Newark] beds is westward),[2] and on the eastern, in Connecticut and Massachusetts (where the dip is eastward). Fontaine has found in Virginia and Maryland that they are the *later beds* of the formation." Beds north of Amherst, Massachusetts, containing bowlders 3 to 4 feet in diameter are referred to, and Edward Hitchcock's conclusion, that they are the upper beds of the series, is cited. Coarse deposits near East Haven, Connecticut, are also mentioned.

The considerations which are thought to maintain the hypothesis of glaciation during the Newark period may be briefly stated as follows:

(1) Presence of coarse conglomerates and breccias at many localities.

(2) Absence of fossil mollusks, radiates, etc.

(3) Unexplained phenomena in the drainage and relief of the Appalachians.

(4) Extinction of the fauna and great changes in the flora of the Atlantic border in the interval between the Newark and Cretaceous period.

Before discussing the value of this evidence let us see what records might reasonably be looked for in case glaciers did assist in the deposition of the Newark sediments.

PRESERVATION OF GLACIAL RECORDS.

All records of glaciation when not buried beneath subsequent deposits would certainly be destroyed by atmospheric decay and erosion during such a vast lapse of time as has intervened between the Newark period and the present day. An exception to this statement may possibly exist in the effects which glaciation might impress upon the drainage and topography of a region. It is possible that some of the seemingly abnormal features in the drainage of the Appalachians may be accounted for on the hypothesis that they are an inheritance from an ancient period of ice invasion.

Among the direct evidences of glaciation which might be preserved for indefinite ages are:

(1) Smooth and striated rock surfaces, characteristic of ice action. Such surfaces if buried beneath fine sediments might be preserved in their original condition; or casts of them might be made, in the same manner that impressions of foot-prints showing the most delicate markings, have been preserved.

(2) Bowlders, smooth and striated and faceted by glaciers, might

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[1] Am. Jour. Sci., 3d ser., vol. XL, 1890, p. 436.

[2] Ibid., vol. XLI, 1891, note of errata.

retain their peculiar markings for an indefinite period, especially when cemented with fine sediment or united by calcareous or other infiltrations.

(3) When a glacier enters a lake or estuary, morainal material is deposited in irregular, unassorted heaps about its foot. The distance seaward to which terminal moraines may be deposited, depends on the size of the glaciers and on the depth of the water bodies they enter. A shallow estuary or lake would offer but feeble resistance to the advance of a glacier, and might have moraines widely distributed over its bottom. On the other hand, a deep water body with precipitous shores, would retard the progress of a glacier or check its advance altogether. The result would be the formation of moraines near the water margin.

(4) When glaciers enter water sufficiently deep the ice breaks off and forms bergs which may transport stone and bowlders to great distances, and finally drop them in the fine sediments that accumulate in deep water.

(5) The effects of a glacial period on animal and plant life has received much attention, but it is difficult to indicate what permanent records of this nature might be expected. A long period of glaciation might revolutionize the fauna and flora of a region, while many alternations of warm and cold climates would produce even greater changes. Luxuriant forests, however, are known to grow close to existing glaciers. not only in tropical and subtropical regions, but in high latitudes, The Malaspina glacier, Alaska, is not only bordered by exceedingly dense forests, but the moraines resting upon its margin are covered over an area of many square miles with dense vegetation, and support forests of spruce trees, many of which are fully 3 feet in diameter. Plants indicating temperate and tropical conditions might easily be preserved in connection with glacial deposits, but such paradoxical records must, for the most part, occur in connection with the deposit of glaciers originating in lofty mountains, and not along the borders of continental glaciers like those that covered the northeastern part of North America during the Pleistocene.

The water into which large glaciers discharge either directly or after melting are cold and could not be inhabited by animals characteristic of tropical conditions. It is in the animal remains found in the fine deposits, intimately associated with glacial accumulations, that we should expect to find the best records of the climatic conditions under which the strata were deposited.

WEIGHT OF THE EVIDENCE OF GLACIATION.

Having in mind what records might reasonably be expected to occur in the rocks of the Newark system if glaciers had assisted in their deposition, let us see what the facts are:

(1) No smooth and striated rock surfaces have been discovered beneath the system.

(2) No glaciated bowlders have been observed in the coarse conglomerate.

(3) The bowlders in the conglomerates are usually rounded and are such as streams, especially if assisted by river ice, could transport. Large angular erratics are conspicuous by their absence.[1]

(4) The coarse material characteristic of portions of the system is confined principally to its bottom and sides. As the fine sediments closely associated with the coarse deposits are frequently ripple-marked and contain footprints and raindrop impressions, it is evident that the water bodies in which these beds were deposited were shallow. The water being shallow, there is no reason why glaciers should invariably stop at the shores and deposit their loads, instead of spreading widely over the basin. Besides, the coarse deposits do not have the heterogeneous character of moraines, but are frequently stratified and show current bedding, as if deposited by strong currents.

(5) Along the outer or seaward margins of the coarse layers they are interstratified with fine sediments which are not crumpled or contorted as would be expected had glaciers invaded the basins in which they were laid down.

(6) No scattered bowlders or large rock fragments, indicating iceberg drift, have been found in the fine sandstones and shales which make up the great bulk of the system.

(7) No fossils that are indicative of a cold climate have been found.

As stated in a previous paper,[2] it is not probable that the great numbers of reptiles, some of them of gigantic size, which lived during the Newark period, could have existed in estuaries that were partially occupied by ice and in which icebergs were floating. Coldblooded animals at the present day are confined to warm regions, and there is no reason to suppose that this law was reversed during the Newark period. The swarms of reptiles that formerly inhabited the Connecticut valley and New Jersey regions must have required a large amount of plant or animal food. This would imply also that the shores of the Newark basin were more like those of Florida than those of Greenland at the present time.

To make more specific objections to the hypothesis of glaciation, it may be remarked that paucity of molluscan life does not necessarily indicate a cold climate, as implied by Fontaine,[3] since, as is well known, many species of shells are found in the mud at the foot of existing glaciers which terminate in the sea. The same and allied species of mollusks occur in the Pleistocene glacial clays of both Europe and America, thus showing that the existence of glaciers is not necessarily attended

[1] Even angular rock masses 20 or 30 feet in diameter are not alone sufficient evidence of glacial action, since such masses occur in alluvial cones in the arid regions 2 or 3 miles from the outcrop from which they were derived.

[2] On the former extent of the Triassic formation of the Atlantic States. Am. Nat., vol. XIV, 1880, p. 710.

[3] Am. Jour. Sci., 3d ser., vol. XVII, 1879, p. 52.

with the extermination of the lower grades of marine life. Besides, the glacial hypothesis for accounting for the general absence of molluscan life in the Newark system is not the only one in the field; other more or less satisfactory explanations of the same phenomena have been offered, which do not imply an arctic climate.

From what has been stated in the last few pages it seems obvious that the only basis that can possibly be claimed for the glacial hypothesis under discussion, is the presence of coarse conglomerate along portions of the borders of the Newark areas. That the character and distribution of this conglomerate are such as would result from the action of waves and currents along a shore from which débris was being derived is seemingly sufficiently upheld by observations to exclude other hypotheses.

As shown elsewhere in this paper the coarse deposits are not confined to the present surface, but occur at the base of the system and interstratified with fine sediments along certain portions of the margins of the existing areas. Furthermore, the fine sediments associated with the coarse deposits are not crumpled or contorted, as would be expected had glaciers ridden over them. The rock masses forming the conglomerate are usually either rounded or subangular, and are such as high grade streams might sweep down into an estuary. Large angular masses like those occurring on many glaciers are notably absent.

In reference to the break in the succession of animal life and the great changes in the flora of the Atlantic coast between the deposition of the Newark beds and the next succeding formation, it is to be remembered that a great unconformity occurs at this horizon which makes a gap in the life records. How long this time was we have no means of judging, unless it is that during the interval the animals characteristic of the Newark become extinct and the flora greatly modified. As is well known, such breaks in stratigraphy are accompanied by equal marked modifications in the life records at many horizons in geological history. To assume that the changes in the flora and fauna between the close of the Newark and the beginning of the next period of which there is any record in the Atlantic coast region are due to a glacial epoch is doing violence to a general rule. Great breaks in stratigraphy are always accompanied by breaks in the life records.

INDICATIONS OF A MILD CLIMATE.

In an essay on the subaerial decay of rocks and the origin of the red color of certain deposits,[1] I have shown that there are reasons for considering the characteristic red color of the rocks of the Newark system as due to the subaerial decay of the débris of which they are composed previous to its deposition. It is also shown in the paper referred to that such decay occurs especially in warm humid regions. The suggestion was also made, as has been done in substance previously by Von Richthofen, that the decay indicated by the character of the ma-

[1] Bull. U. S. Geol. Survey, No. 52.

terial forming the Newark rocks may have occurred in a great measure during the Carboniferous. This hypothesis is not necessarily inconsistent with the hypothesis of glaciation, however, as the accumulated débris resulting from a long period of decay might have been removed and deposited during a subsequent period of glaciation.

The plants that have been found in the Newark system are represented at the present time mainly by Araucarian pines, ferns, equiseta, and cycads, thus suggesting a temperate or subtropical climate. Although this flora is not inconsistent with the contemporaneous existence of local glaciers, yet it may be taken as evidence that a decidedly glacial period like that of the Pleistocene did not occur during the time it flourished.

CONCLUSIONS.

The absence of glacial records seems to warrant the conclusion that glaciers did not enter the basins in which the Newark rocks were deposited. It does not follow, however, that the Appalachians were not occupied by local glaciers. The suggestion that those mountains were higher in the Newark period than now, and were covered with perennial snow, while the adjacent low lands enjoyed a mild climate, seems an attractive and very possible hypothesis, but definite evidence as to its verity has not been obtained. The proof that the climate of the Atlantic slope during the Newark period resembled that of Italy at the present day, with glaciers on the neighboring mountains, must be looked for in the drainage and sculpturing of the mountains, and the character and distribution of the débris washed from them. A period of long decay preceding the birth of the Appalachian glaciers would have prepared land to furnish abundant débris when the facilities for transportation were augmented.

RÉSUMÉ.

In this chapter an attempt has been made to show that the Newark sedimentary rocks including conglomerate, sandstones, and shales were probably deposited in tide-swept estuaries, while the carbonaceous shales and associated coal seams originated in basins more thoroughly shut off from the sea. The carbonaceous deposits are confined to the southern areas, and indicate that subsidence was there less rapid than farther north.

The eastern borders of the Newark estuary can only be determined in part; portions of an eastern shore are preserved in the Connecticut valley, and course conglomerates on the east side of the Deep river area seem to show that there was land to the eastward in that region, as has been suggested by Kerr. Further than this, the facts in hand do not warrant definite conclusions.

The climate of the period does not seem to have been marked by extremes. Certainly the evidence indicating glaciation is weak, while the suggestion of a mild climate has many considerations in its favor.

CHAPTER VI.

LIFE RECORDS.

The fossils now known from the system under review comprise two genera of Marsupialoid mammals; a large number of batrachians and reptiles, represented in part by bones and teeth, but principally by footprints; several genera of fishes; a few imperfectly preserved molluscan shells; a small number of insects, known from larvæ and tracks; crustaceans of the genera Estheria and Cladonia, and what are supposed to be the trails of higher forms, and a rich flora containing conifers, cycads, equiseta, and ferns.

The most abundant fossils are footprints and trails impressed upon the strata while in the condition of mud and sand and retained with wonderful fidelity. Records are thus preserved of many animals, some of them of gigantic size, no other relics of which have been found.

MAMMALS.

The mammalian remains thus far discovered consist of the jaws of insectivors, obtained by Emmons[1] at Egypt, in the Deep river area, North Carolina, some fifty years ago. These were described by Emmons under the name *Dronotherium sylvestre*, but have recently been revised by Osborn[2], and shown to belong to two genera, for one of which the name *Microconodon* is proposed. The mammalian remains now known are *Dronotherium sylvestre* Emm., and *Microconodon tenuirostris* Osb.

BATRACHIANS AND REPTILES.

The earliest discovery of fossil bones in the Newark system was at Phœnixville, Pennsylvania. The fossils there obtained were determined to be reptilian remains by Isaac Lea,[3] and described by him under the name *Clepsysaurus pennsylvanicus*. Clepsysaurus has since been referred to the *Dinosauria* by E. D. Cope.

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[1] American Geology, part VI. Albany, 1857, pp. 93–96.

[2] Observations upon the Upper Triassic mammals Dronotherium and Microconodon. In Philadelphia Acad. Nat. Sci., Proc., vol. XXXVIII, 1887, pp. 259–363. A new mammal from the American Trias. In Science, vol. VIII, 1886, p. 540. The Triassic mammals Dronotherium and Microconodon. In Am. Phil. Soc., Proc., vol. XXIV, 1887, pp. 109–111, pl. op. p. 111.

[3] Mentioned in Philadelphia Acad. Nat. Sci., Proc., vol. V, 1850–'51, p. 205. Described in Philadelphia Acad. Nat. Sci., Jour., 2d ser., vol. II, 1850–'54, pp. 185–202, pl. 17–19.

The next important discoveries were numerous reptilian teeth and fragments of bones obtained in North Carolina. These were studied by Leidy and Emmons, and descriptions and figures of them published.[1]

The Newark rocks near Phœnixville and Upper Milford, Pennsylvania, also yielded a number of vertebrate fossils, consisting of teeth and fragments of bone, which were studied and classified by Leidy and Lea.[2]

Reptilian bones were also found in the Connecticut valley and described by E. Hitchcock,[3] but these were too imperfect to admit of accurate determination.

Recently, the vertebrate fossils from the Newark rocks of North Carolina and Pennsylvania have been systematically investigated by E. D. Cope,[4] who has revised their classification and added several new names to the list.

One of the most important finds in recent years of Reptilian remains in the Newark rocks was near Manchester, Connecticut. This consisted of the skeleton of an animal 6 or 8 feet long, embedded in the ordinary brown sandstone of the region, which is supposed to have been nearly perfect when discovered, but owing to ignorance of its value, only portions were preserved. These have been described by Marsh[5] under the name *Anchisaurus major.* This was probably one of the reptiles that left their footprints in such abundance on the sandstones of the Connecticut valley, and encourages the hope that these rocks,

[1] Geological Survey of the Midland Counties of North Carolina. New York, 1856, pp. 293–322, pl. 5–8. American Geology, part VI. Albany, 1857, pp. 54–93, pls. 5a, 6a, 8, 10.

[2] Lea, Isaac: [On the finding of fossil reptile bones in a calcareous conglomerate near Upper Milford, Lehigh county, Pa.] In Philadelphia Acad. Nat. Sci., Proc., vol. V, 1852, pp. 171–172. Description of a Fossil Saurian of the New Red Sandstone formation of Pennsylvania, with some account of that formation. In Philadelphia Acad. Nat. Sci., Jour., 2d ser., vol. II, 1850–'54, pp. 185–202, pls. 17–19. Remarks on the teeth of a Sauroid Reptile from near Phœnixville [Pa.]. In Philadelphia Acad. Nat. Sci., Proc., vol. VIII, 1856, pp. 77–78. Abstract in Am. Jour. Sci., 2d ser., vol. XXII, 1856, pp. 122–123. [Remarks on fossils from near Phœnixville, Pa.] In Philadelphia Acad. Nat. Sci., Proc., vol. IX, 1858, p. 149. Leidy, Jos.: [Remarks on fossils found near Phœnixville, Pa.] In Philadelphia Acad. Nat. Sci., Proc., vol. XI, 1859, p. 110.

[3] Ichnology of New England: Boston, 1858, pp. 186–187. Supplement to the Ichnology of New England: Boston, 1865, pp. 39–40, pl. 9.

[4] The writings in which these fossils have been treated are noted below:

[Remarks on extinct vertebrates from the Mesozoic Red Sandstone of Pennsylvania.] Philadelphia Acad. Nat. Sci., Proc., vol. XVIII, 1866, pp. 249–250, 290.

Synopsis of the Extinct Batrachia, Reptilia, and Aves of North Carolina. Am. Phil. Soc., Trans., vol. XIV, 1871, pp. 1–252, pls. 1–14.

Observations on the Reptilia of the Triassic formations of the Atlantic region of the United States. Am. Phil. Soc., Proc., vol. XI, 1871, pp. 444–446.

Observations on the distribution of certain extinct Vertebrata in North Carolina. Am. Phil. Soc., Proc., vol. XII, 1871–'72, pp. 210–216, pls. 1–4.

Synopsis of the Vertebrata whose remains have been preserved in the formations of North Carolina. Report of the Geol. Surv. of North Carolina, vol. I. By W. C. Kerr, Raleigh, 1875. Appendix B, pp. 29–52, pl. 5–8.

Descriptions of extinct Vertebrata from the Permian and Triassic formations of the United States. Am. Phil. Soc., Proc., vol. XVII, 1878, pp. 182–196.

On some Saurians found in the Triassic of Pennsylvania by C. M. Wheatley. Am. Phil. Soc., Proc., vol. XVII, 1858, pp. 231–232.

[Vertebrate fossils of the Triassic beds of Pennsylvania.] In Sketch of the Geology of York County, Pennsylvania. By P. Frazer. In Am. Phil. Soc., Proc., vol. XXIII, 1886, pp. 403–404.

A contribution to the history of the Vertebrata of the Trias of North America. In Am. Phil. Soc., Proc., vol. XXIV, 1887, pp. 228–229, pl. 1, 2.

[5] Notice of New American Dinosauria. In Am. Jour. Sci., 3d ser., vol. XXXVII, 1889, pp. 331, 332.

usually so barren in organic remains, may yield other vertebrate remains in the future. Marsh has published a figure of the hind foot of this fossil, and states that it is nearly related to the animal whose remains were found at Springfield, Massachusetts, and described by Hitchcock[1] under the name of *Megadactylus polyzelus*. Both fossils are referred to the same genus by Marsh.

In studying the records that have been made from time to time of the vertebrate fossils of the Newark rocks, one is impressed by the large number of the genera and species that have been established on very fragmentary remains. It seems, at least to one who is not a paleontologist, that many changes in their classification must be expected when more complete material is in hand. The detached teeth and fragments of bone that have been found, however, are important in showing that the Newark period had an abundant and varied batrachian and reptilian fauna. This fact is also manifest from the numerous footprints discovered.

No bones or other remains of birds have been obtained. This, although negative evidence, supports in a measure the conclusion reached by various students of the subject, to the effect that the abundant footprints discovered in the Connecticut valley, New Jersey, and Pennsylvania were made by reptiles.

The batrachians and reptiles from the Newark system now known from fragments of their skeletons are as follows:

Name.	Localities.
BATRACHIA.	
Eupelor durur Cope	Phœnixville, Pa.
Pariostegus myops Cope	North Carolina.
Dictyocephalus elegans Leidy	Do.
REPTILIA.	
Anchisaurus major Marsh	Manchester, Conn.
Belodon pirscus Leidy	Emylsville and Phœnixville, Pa.
B. caroliniensis Emm	Egypt, N. C., Emylsville, and Phœnixville, Pa.
B. leaii Emm	Do.
B. lepturus Cope	Egypt, N. C., and Phoenixville, Pa.
Paleosaurus frazerianus Cope	Emylsville, Pa.
Suchoprion cyphodon Cope	Do.
S. aulacodus Cope	Do.
Clepsysaurus pennsylvanicus Lea	Phœnixville, Pa.
C. beatleianus Cope	Emylsville, Pa.
Palaeoctonus appalachianus Cope	Do.
Thecodontosaurus gibbidens Cope	Do.

FISHES.

A monograph by Newberry, on the fossil fishes of the Newark system, has recently been published, which contains all the information

[1] Supplement to the Ichnology of New England. Boston, 1865, pp. 39–40, pl. 9.

obtainable on the subject and renders it unnecessary at this time to refer to the works of previous writers in this connection. In the work referred to twenty-eight species of fossil fishes are described and referred to seven genera. The works of previous authors, including those of Emmons, W. C. Redfield, J. H. Redfield, and others, have been revised and a large amount of new material added. This important monograph places our knowledge of the fossil fishes of the Newark system on an equality with, if not in advance of, that of any other rock series in this country.

The fossils described and illustrated by Newberry were obtained from Boonton, New Jersey, Durham, Connecticut, and Turner Falls, Massachusetts. They occur for the most part in fine grained black shales, and are to be looked for anywhere in the Newark system, where rocks of this description occur. The localities now known from which fossil fishes have been obtained in greater or less abundance in the system under review are as follows: Clover Hill and Maniken, Virginia; Phoenixville, and Yerkes, Pennsylvania; Boonton, Pompton Furnace, Weehawken, Shady Side, Field's copper mine (near Dunellen; this locality is in Washington valley, 2 miles northwest of Dunellen, and is probably referred to as "Plainfield" by Newberry), and Washington Crossing (8 miles above Trenton), New Jersey; Durham, Westfield, Middlefield, Glastonbury, Middletown, Berlin, and Southbury, Connecticut; Amherst, Chicopee Falls, Hadley Falls, Middletown, Sunderland, Turner Falls, Deerfield, and West Springfield, Massachusetts.

All of the fossil fishes thus far discovered at these localities are Ganoids, and, with one exception, have small rhomboidal scales and belong to the order Lepidosteidæ. The exception is Diplurus, described by Newberry, which is referred to the order Crossopterygidæ.

The genera and species now known from these rocks are as follows:

Fossil fishes of the Newark system.

Name.	Locality.
Acentrophorus chicopensis Newb	Massachusetts.
Catopterus redfieldi Egt	New Jersey (?), Connecticut, Massachusetts (?).
C. anguilliformis W. C. R.	New Jersey, Connecticut, Massachusetts (?).
C. gracilis W. C. R.	New Jersey, Connecticut.
C. minor Newb	Connecticut.
C. ornatus Newb	Do.
C. parvulus W. C. R	New Jersey, Connecticut, Massachusetts.
Dictyopyge macrura Egt	Virginia.
Diplurus longicaudatus Newb	New Jersey, Connecticut.
Ischypterus agassizii W. C. R	New Jersey, Connecticut, Massachusetts.
I. alatus Newb	New Jersey.
I. braunii Newb	Do.
I. elegans Newb	Do.
I. fultus Ag	New Jersey, Connecticut, Massachusetts.
I. gigas Newb	New Jersey.
I. latus J. H. R	New Jersey, Connecticut.

Fossil fishes of the Newark system—Continued.

Name.	Locality.
I. lenticularis Newb	New Jersey.
I. lineatus Newb	Do.
I. macropterus W. C. R	Connecticut.
I. marshii W. C. R	Massachusetts.
I. micropterus Newb	New Jersey, Connecticut, Massachusetts.
I. minutus Newb	Do.
I. modestus Newb	New Jersey.
I. ovatus W. C. R	New Jersey, Connecticut, Massachusetts.
I. parvus W. C. R	New Jersey, Connecticut (?), Massachusetts.
I. robustus Newb	New Jersey.
I. tenuiceps Ag	New Jersey, Connecticut, Massachusetts.
Ptycholepis marshii Newb	Connecticut.

INSECTS.

The presence of insect life in the Newark period is recorded by the larva of a certain insect in considerable numbers in the rocks of the Connecticut valley, and by numerous trails and minute footprints on the glossy surfaces of certain strata in the same region. The larva referred to has been found at Turner Falls, Massachusetts, and was figured by Hitchcock[1] under the name *Mormolucoides articulatus*. It has been more recently described and figured by Scudder,[2] who concludes that it is probably the larva of a *Sialidan neuropteron*, and remarks that it has special interest from the fact that it is the oldest insect larva known.

In "The Ichnology of New England" the footprints of insects are included under one head with those supposed to have been made by crustaceans and myriapods, but in the "Supplement to the Ichnology of New England" they stand by themselves and include twenty-four species referred to eight genera. Some of these are illustrated by photographs by Hitchcock, and others are shown in a similar manner by Deane[3] in his beautifully illustrated work on the footprints of the Connecticut valley.

The classification proposed by Hitchcock for these delicate impressions is based wholly on the footprints themselves, and would no doubt be greatly modified if additional data were obtained. The markings are of great value, however, and record faithfully that there was an abundance of invertebrate life on the shores where the gigantic reptiles of the Newark period made their home.

[1] "The Ichnology of New England," pp. 7-8, pl. 7.

[2] The oldest known insect larva, *Mormolucoides articulatus*, from the Connecticut river rocks. In Boston Soc. Nat. Hist., Mem., vol. III, 1886, pp. 431-438, pl. 45. Republished in the Fossil insects of North America. New York, 1890. 4to, vol. I, pp. 323-330, pl. 19.

[3] Ichnographs from the sandstone of the Connecticut river. Boston, 1861. Pls. 40-41.

CRUSTACEANS.

In the fine black shales and slates, and sometimes in the reddish brown shales accompanying the coal seams of the Deep river, Dan river, and Richmond areas, are great numbers of small crustaceans, belonging to the genera Estheriæ and Candonia (cypridæ). The same fossils occur in abundance in the black shale at Phœnixville, Pennsylvania, and in the similar rocks beneath the Palisades in New Jersey. They have recently been found also by Nason[1] at many other localities in New Jersey, and are thought by him to belong to certain definite horizons, and therefore to be of value in deciphering the structure of the system. The occurrence of these fossils throughout a wide range in the fine grained strata at the south, has led the present writer to doubt their value in determining special horizons, and indicates that they may be expected almost anywhere in the system where fine grained rocks occur.

These fossils attracted the attention of the pioneer geologists of the Eastern states, and were described in part by Rogers, Lyell, Lea, Emmons, and others; but the most systematic and exhaustive study of them that has been made is by Jones.[2] In the important monograph by this author the descriptions and discussions of previous writers are reviewed, and the fossils themselves described and illustrated. The several genera and species proposed by previous writers are shown to belong to a single species of Estheriæ and two species of Cadonia (?). The classification of these fossils as it now stands is as follows: *Estheria ovata* Lea (including the *Posidonomya minuta*, of Rogers and Lyell; *Posidonia* Lea; *P. parva* Lea; *P. ovalis* Emm.; *P. multicostata* Emm.; *P. triangularis* Emm.); *Candona* (?) *rogersi*, Jones (including the *Cypris*, of Rogers, Leidy and Wheatley, and *Bairidia* and *Cypris*, of Emmons); *Candona* (?) *emmonsii* Jones (including the granulated species of *Cypris*, mentioned by Rogers and Wheatley). Full references to the writings of previous authors on these fossils will be found in the monograph just cited.

Besides the cases of minute crustaceans referred to above, fragments of a shell of *Limulus* and of other crustaceans have been reported by Wheatley[3] from the black shales near Phœnixville, Pennsylvania, but these remains seem to have been too imperfect to admit of more than a provisional classification.

Among the numerous tracks discovered on the sandstone of the Connecticut valley, there are a number which seem to have been made by crustaceans, some of them of large size, as was determined by Hitchcock. Several illustrations of these footprints are given by

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[1] Geol. Surv. of New Jersey, Ann. Rep. for 1888, pp. 28–30.

[2] A Monograph of the Fossil Estheriæ. Palæontographical Society, London, 1862. 4to. Pp. 81–89, 124–126, pl. 2.

[3] Remarks on the Mesozoic red sandstone of the Atlantic slope, and notice of the discovery of a bone-bed therein at Phœnixville, Pa., in Am. Jour. Sci., 2d ser., vol. XXXII, p. 43.

Hitchcock in his work on Ichnology. From the meager records left by these animals, it is manifest that we must wait for further evidence before their place in the zoological series can be assigned.

MOLLUSKS.

Molluscan remains are exceedingly rare in the rocks of the Newark system. The earliest record of the supposed occurrence of a shell is by E. Hitchcock, jr. The fossil referred to was found in the coarse sandstone of Mount Tom, Hampshire county, Massachusetts, and was thought by its discoverer to be allied to the *Rudistæ* of Lamarck, but the fossil was so imperfect that even its family relations could not be assigned with confidence. From the description and the rude figure published by Hitchcock,[1] it seems doubtful if the object referred to can even be classed among mollusks. Even if it is a shell, as supposed, its imperfect condition and the fact that no other specimens have been found, deprive it of nearly all taxonomic value. It was used by Hitchcock,[2] however, as evidence of the post-Triassic age of the rocks in which it was found.

Two species of *Astarte*, from near Washington, Middlesex county, New Jersey, were described as being from the rocks now under discussion, by T. A. Conrad,[3] but the rocks in which they were found have been shown by Whitfield[4] to belong to the Raritan clays, which are classed by McGee[5] in the Potomac formation. Conrad has also described a fossil shell, *Solemya triasina*,[6] from near Perkiomen creek, which empties into the Schyulkill near Valley Forge, Pennsylvania, and still another, the *Myacites pennsylvanicus*,[7] from Phœnixville, Pennsylvania.

Lewis[8] announced in 1884, the discovery of five distinct species of lamellibranchs at Phœnixville, Pennsylvania. Two of these are Unios somewhat resembling *U. calceolus* and *U. lanceolatus*, of Lea; the others were marine forms. In order to complete the record certain doubtful references of fossil shells to the Newark rocks may be mentioned. Isaac Lea[9] found small gasteropod shells in calcareous conglomerate, but those were probably in fragments of Silurian limestone contained in the conglomerate. Another discovery referred with doubt to this system, was

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[1] A new fossil shell in the Connecticut river sandstone, in Am. Jour. Sci., vol. XXII, 1856, pp. 239–240.

[2] Ichnology of New England, pp. 6–7, pl. 5.

[3] Descriptions of and references to Miocene shells of the Atlantic slope, and descriptions of two supposed Cretaceous species, in Am. Jour. Conch., vol. IV, 1868, p. 279.

[4] Brachiopoda and Lamellibranchiata of the Raritan clays and greensand marls of New Jersey; U. S. Geol. Surv., Monograph vol. IX, 1886, pp. 22–27.

[5] Three formations of the Middle Atlantic slope, in Am. Jour. Sci., 3d ser., vol. XXV, 1888, pp. 136–137.

[6] Descriptions of new fossil Mollusca, principally Cretaceous, in Am. Jour. Conch., vol. V, 1870, p. 102.

NOTE.—From the arrangement of this article it would appear that three other fossils, one of them from Haddenfield, N. J., were also referred to the Newark system, but it does not seem as if this could have been Conrad's intentions. I. C. R.

[7] Description of new species of Myacites, in Philadelphia Acad. Nat. Sci., Proc., vol. IX, 1857, p. 166, vol. XII, plate.

[8] Science, vol. III, p. 295.

[9] Phil. Acad. Nat. Sci., Jour. n. s., vol. II, 1853, p. 194.

made by W. M. Gabb,[1] at Warm Springs, Virginia; we now know that the beds at that locality are much older than the Newark.

The nearly complete absence of molluscan fossils and the total absence of sponges, corals, and other life records characteristic of oceanic conditions, as well as the discovery of Unios by Lewis is evidence that the waters in which the Newark beds were deposited were not in open communication with the ocean.

FOOTPRINTS.

Footprints in sandstone and shale have been found at a large number of localities in the Connecticut valley, New Jersey, and Pennsylvania. In the areas south of Pennsylvania no records of this character have yet been discovered. The numerous localities in the Connecticut valley in which footprints have been obtained are indicated in part on the map accompanying Hitchcock's work on Ichnology. In New Jersey these fossils have been found at New Vernon, Whitehall, Pompton Furnace, and Boonton, Morris county; underneath the Palisades at Weehawken, in Washington valley near Plainfield, near Princeton; and at Milford and Tumble station on the Delaware. The localities that have yielded the most abundantly are Whitehall and Milford.

In Pennsylvania fossil footprints were found many years ago and described by Lea.[2] More recently they have been found by Wanner[3] in considerable numbers, at Goldsboro, York county. Many of the footprints from New Jersey and Pennsylvania have been examined by C. H. Hitchcock, and found to belong to the species which occur in the Connecticut valley.

The history of the discovery of footprints in the Connecticut valley is well known and does not require more than brief mention at this time. The chief works on the subject are indicated below,[4] and in these references will be found to earlier publications.

In Hitchcock's great work on the Ichnology of New England, and in the supplement that followed, the footprints of more than one hundred distinct species of animals, some of them of gigantic size, were described and named. In this investigation the footprints alone were available for study, and on them a detailed classification was based. In this classification the footprints are referred to animals ranging from marsupialoid mammals, through birds, batrachians, lizards, turtles, crustaceans, myriapods and insects to annelids. There are besides certain peculiar markings which are supposed to have been made by fishes. In addition to the records of animal life, the surfaces bearing the footprints are frequently pitted with raindrop impressions, beautifully cor-

[1] Phil. Acad. Nat. Sci., Jour., vol. IV, 1860, p. 307.

[2] Philadelphia Acad. Nat. Sci., Proc., vol. VIII, 1856, p. 8.

[3] Annual Report of the 2d Geol. Surv. of Pennsylvania, for 1887, Harrisburg, 1889, pp. 31–35.

[4] Hitchcock, E.: Ichnology of New England, Boston, 1858, 4to, pp. I–XII, 1–220, pls. 1–60. Supplement to the Ichnology of New England, Boston, 1865, pp. I–X, 1–96, pls. 1–20. Deane, J. Ichnographs from the sandstone of the Connecticut river. Boston 1861, 4to, pp. 1–61, pls. 1–46.

rugated with ripple marks, and covered with a network of intersecting shrinkage cracks.

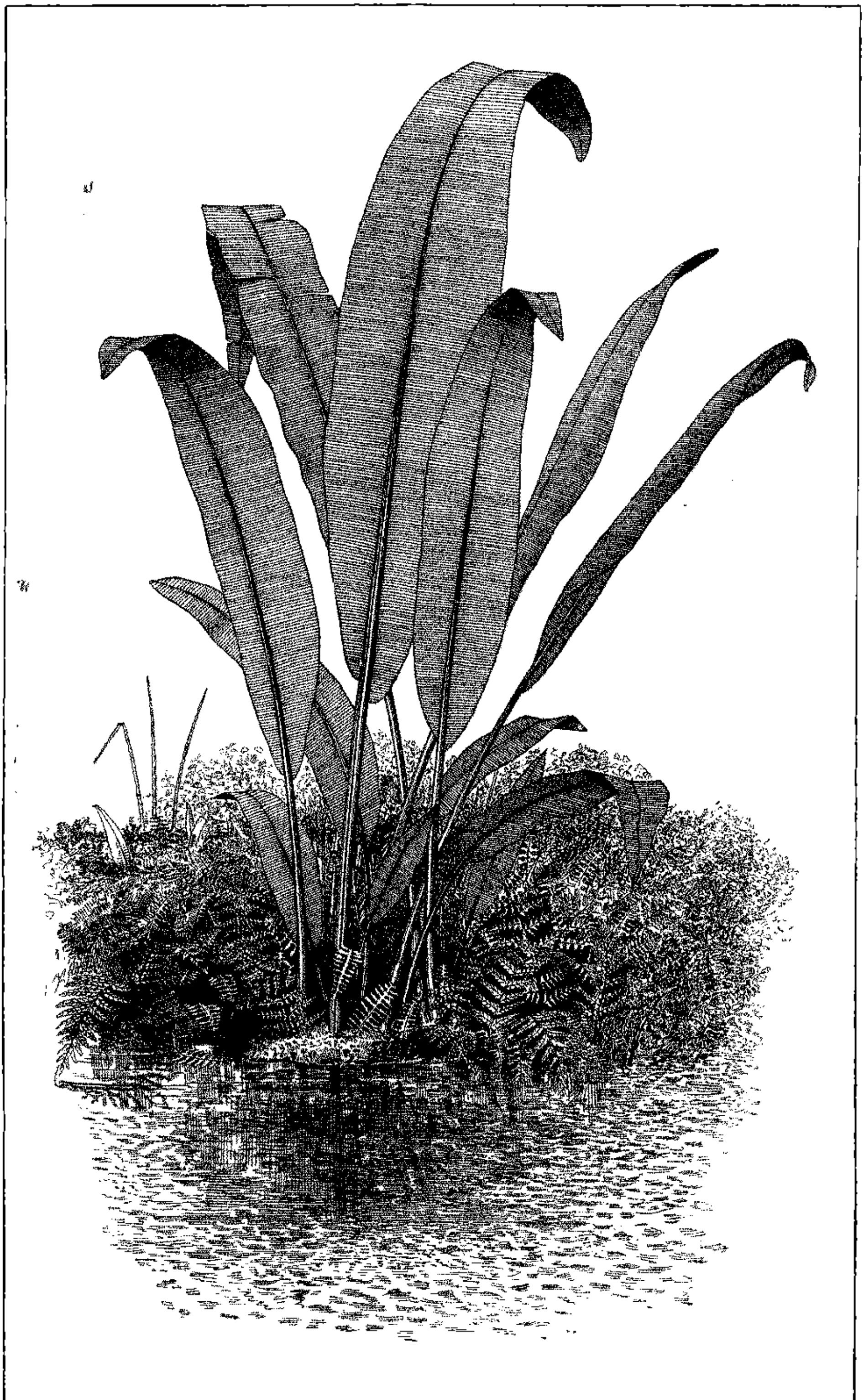
The majority of the tracks discovered by Hitchcock have three toes, and were supposed by him to have been made by birds. This conclusion has subsequently been greatly modified owing to the fact that four and five toed tracks have been discovered in such relation to the three-toed ones, as to show that the animals that made them were four footed. The true ornithic character of any of the tracks can not be considered as proved, and the opinion now prevails among those best qualified to judge in such matters, that the greater part of the tracks were made by reptiles and amphibians.

PLANTS.

Fossil plants have been found in several of Newark areas, from the Connecticut valley southward, but they occur in greatest abundance in connection with the coal seams of the Richmond and Deep river areas. In the Connecticut valley they have been found sparingly at Turner Falls and Sunderland, Massachusetts, and at Durham, Middletown and Portland, Connecticut. In New Jersey they occur in small numbers at Newark, Milford, Boonton, and a few other less important localities. In Pennsylvania a few have been found at Phœnixville, Guynedd, and Goldsboro. In the Richmond area they occur in great abundance at Clover Hill, and have been found at Midlothian and Manikin, Deep run, etc., where fine dark slates occur. They have been found also in the Farmville area, but no considerable collections have been made there. In the Deep river area they are abundant in the fine slates associated with the coal deposits near Egypt, and were found also by Emmons in considerable numbers near Locksville, in a dark slate intimately associated with coarse conglomerate.

In the northern areas the plant remains are largely in sandstone, and consist usually of the more durable portions of plants which could withstand long transportation. At several places in the Connecticut valley and New Jersey they consist of stems deprived of their leaves and bark and scattered through the sandstone. In such cases it is evident that they have been subjected to long transportation, and swept into the areas of deposition from neighboring highlands. In the south, however, the conditions in the majority of instances were different, the plants were preserved where they grew, and even the most delicate fronds were faithfully preserved. In some of the sandstone areas the silicified trunks of trees are preserved in considerable numbers. One of the most important localities is at Germantown, at the southern end of the Dan river area. Similar silicified trunks have also been found at Manassas, Virginia, and in Massachusetts.

Obscure vegetable remains from the Connecticut valley were described principally by Hitchcock, but were too imperfect to be of much value. The plants of the Richmond coal field attracted the attention of Rogers



MACROTÆNIOPTERIS MAGNIFOLIA.

and of Lyell, while those of North Carolina were described and illustrated by Emmons.

A few plants from the Richmond coal field found their way to Europe and were described in the classic works of Schimper and Brongniart. Recent studies of these fossils, however, have carried our knowledge of them far beyond the early attempts, and in the monographs of Fontaine[1] and Newberry[2] is contained our present knowledge of this flora.

In Fontaine's monograph descriptions and figures are given of forty-two species of fossil plants from the Richmond coal field, and it is supplemented by descriptions of about the same number from North Carolina by Emmons. The contributions to this flora from the localities mentioned in New Jersey and the Connecticut valley are few in number and consist principally of the leaves of cycads. The plants thus far found include conifers, cycads, equiseta, and ferns, besides a few species the relations of which have not been definitely determined. The most characteristic and at the same time the most abundant is a magnificent broad-leafed fern, referred to the genus *Macrotæniopterus*. The appearance of this beautiful plant as it grew beside the still waters of the ancient swamps of Virginia, is shown in Plate VIII. This restoration has the approval of Fontaine, and may help to render more real the usual fragmentary records from which our knowledge of this ancient flora is derived. The luxuriant subtropical vegetation of the lowlands of Virginia during the Newark period has its nearest analogue to-day in the silent fern forests of New Zealand. In Virginia the ground must have been thickly covered with lowly ferns, above which rose the graceful bending equiseta and those ferns which had broad, palm-like fronds. On the drier ground grew the stiff-leafed cycads with their immense cones. The uplands must have been clothed with a dark forest of pine resembling the beautiful Auracaia now growing in certain of the South Sea islands. This beautiful flora, which to us seems so strange, probably covered all the region adjacent to the basin in which the Newark rocks were being deposited. In the swamps of the South where the conditions were most favorable for its preservation abundant records were preserved, but in the North only occasional fronds and water-worn trunks were deposited in the accumulating sands.

The plants now known from the Newark system are indicated in the following list. In making this catalogue the works of Fontaine and Newberry have been followed, but Fontaine's monograph has recently been reviewed by Stur,[3] and many of the plants described in it identified with those of the Lettenkohlen of Germany. Should these identifications prove correct many of the names given in the list will have to be changed.

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[1] U. S. Geol. Surv., Monograph vol. 6, 1883.

[2] U. S. Geol. Surv., Monograph vol. 14, 1888.

[3] Die Lunzer-(Lettenkohlen-) Flora in den "older Mesozoic beds of the Coal Fields of Eastern Virginia." In Verhandlungen der K. K. geologischen Reichsanstalt, No. 10, 1888, pp. 203–217.

Plants from the Newark System.

Name.	Locality.
CONIFERÆ.	
Araucarites carolinensis	North Carolina.
Baiera multifida	Connecticut valley, North Carolina, Virginia.
B. münsteriana	Connecticut valley, North Carolina.
Pachyphyllum brevifolium.	Connecticut valley, New Jersey.
P. münsteri	Connecticut valley, New Jersey, Virginia.
P. peregrinum	North Carolina.
P. simile	Connecticut valley, New Jersey.
Palissya ——	New Jersey.
Palissya ——	North Carolina.
P. carolinensis	Do.
P. diffusa	Do.
ZAMIEÆ AND CYCADEÆ.	
Ctenophyllum braunianum, var. a.	North Carolina, Virginia.
C. braunianum, var. B	North Carolina.
C. emmonsi	Do.
C. giganteum	Virginia.
C. grandifolium	Do.
C. lineare	North Carolina.
C. robustum	Do.
C. taxinum	Do.
C. truncatum	Virginia.
Cycadites acutus	North Carolina.
C. longifolius	Do.
C. tenuinervis	Virginia.
Cycadinocarpus chapini	Connecticut valley.
Dioönites longifolius	North Carolina, New Jersey.
Otozamites brevifolius	Connecticut valley.
O. carolinensis	North Carolina.
O. latior	Connecticut valley.
Podozamites emmonsi	North Carolina, Virginia.
P. tenuistriatus	Virginia.
Pterophyllum, affine	
P. decussatum	North Carolina, Virginia.
P. inæquale	Virginia.
P. pectinatum	North Carolina.
P. spatulatum	Do.
Sphenozamites rogersianus.	North Carolina, Virginia.
Zamiostrobus virginiensis.	Virginia.
Z. emmonsi	North Carolina.

Name.	Locality.
EQUISETEÆ.	
Calamites arenaceus	Virginia.
Equisetum arundiniforme.	Do.
E. meriani	Connecticut valley.
E. rogersi	North Carolina, New Jersey, Virginia.
Schizoneura planicostata.	Connecticut valley, New Jersey, Virginia.
Schizoneura, sp.?	Virginia.
S. virginiensis	Do.
FILICES.	
Acrostichides densifolius.	Virginia.
A. ægyptiacus	North Carolina.
A. linnææfolius	North Carolina, Virginia.
A. microphyllus	Virginia.
A. rhombifolius	North Carolina, Virginia.
A. rhombifolius, var. rarinervis.	Virginia.
Actinopteris quadrifoliata.	North Carolina.
Asterocarpus penticarpas.	Virginia.
A. platyrachis	North Carolina, Virginia.
Á. virginiensis	Virginia.
A. virginiensis, var. obtusiloba.	Do.
Asplenites rösserti	North Carolina.
Cladophlebis auriculata	North Carolina, Virginia.
C. microphylla	Virginia.
C. obtusiloba	North Carolina.
C. ovata	Virginia.
C. pseudo-whitbiensis	Do.
C. rotundiloba	Do.
C. subfalcata	Do.
C. platyphylla	Connecticut valley, New Jersey, Virginia.
C. platyphylla, var. expansa.	Virginia.
Dicranopteris, sp?	Do.
Lacopteris emmonsi	North Carolina.
L. carolinensis	Do.
L. elegans	Do.
Lonchopteris oblongus	Do.
L. virginiensis	Virginia.
Macrotæniopteris crassinervis.	Do.

Plants from the Newark System—Continued.

Name.	Locality.	Name.	Locality.
FILICES—continued.		FILICES—continued.	
M. magnifolia	North Carolina, Virginia.	P. reticulata	North Carolina, Virginia.
Mertensides bullatus	North Carolina, Virginia.	Sagenopteris rhoifolia	North Carolina, Virginia.
M. distans	Virginia.	PLANTS OF UNDETERMINED RELATIONS.	
Pecopteris rarinervis	North Carolina, Virginia.	Dendrophycus triassicus	Connecticut valley.
Pseudodanæopteris nervosa.	North Carolina, Virginia.	L. simplex	Connecticut valley, Virginia.

Besides the plants catalogued above, a few minor discoveries may be noted: Isaac Lea[1] has recorded the discovery of a single plant resembling *Noeggerathia cuneifolia* Brog., near Phœnixville, Pennsylvania. A fucoid named *Palæophycus limaciformis* Lew., was found by Lewis,[2] at Milford, New Jersey. A stem with markings similar to those of Lepidodendron was found at Belleville, New Jersey.[3]

[1] Phil. Acad. Nat. Sci., Proc., vol. VIII, 1856, p. 78.
[2] Phil. Acad. Nat. Sci., Proc., vol. XXXII, 1880, p. 293.
[3] Geol. of N. J., Ann. Rep. for 1879. pp. 26–27.

CHAPTER VII.

ASSOCIATED IGNEOUS ROCKS.

Intimately associated with the sedimentary strata of the Newark system in nearly all its various areas, are dikes and sheets of igneous rock. The outcrops of these rocks are everywhere remarkably uniform in general appearance, and have but little variety in their mineralogical and chemical composition. They are classed as basalt and dolerite by petrographers, but have all been known as "trap rocks," a term sufficiently accurate for general use and which will be retained in this paper.

In the various Newark areas trap rock appears in two ways, either as dikes breaking across the sedimentary strata, or as sheets more or less uniformly interbedded with them. The sheets are either extrusive, and were spread out as overflows of lava before the accumulation of the sedimentary strata was completed, and subsequently buried beneath the shales and sandstones of later date; or intrusive, and forced in between the strata after their consolidation.

The trap rocks are not confined to the Newark areas, but, in the form of dikes, occur throughout nearly the entire Atlantic coast plain and in the adjacent Appalachians. The evidence showing that the trap dikes in the crystalline and Paleozoic rocks surrounding the Newark areas are a part of the same great system of dikes and sheets occurring within those areas, will be stated in describing their geographical distribution. The age of the trap rocks and their importance in a general study of the Atlantic coast region, will be considered in the summary at the end of this chapter.

MINERALOGICAL COMPOSITION.

As one sees the traps in the field, they are dense, heavy rocks, having a dull, nearly black color when somewhat weathered, but frequently appear bluish or greenish on fresh surfaces. They appear under two general aspects, compact and vesicular. The former occurs in dikes and sheets, and is frequently columnar, while the latter occurs almost entirely in sheets. The vesicular trap has frequently been changed to an amygdaloid by the filling of its cavities with a secondary mineral.

Determinations of specific gravity and mineralogical analyses of trap rock from various localities, from Nova Scotia to the Carolinas, have shown that they are remarkably similar throughout their entire extent.[1] Their essential elements in an unweathered condition, as shown by E. S. Dana, are pyroxene, labradorite, and magnetite, with occasionally some chrysolite and apatite; chlorite is often present as a result of local change.

It has been shown by Hawes that the feldspar element is not a single feldspar, but labradorite and another mineral having the ratio of andesine.

The iron, in places at least, is uncombined, as has been shown by Van Dyck, and elsewhere appears as magnetite and titanic iron. Among the minerals resulting from secondary alteration are a great variety of zeolites, calcites, etc.

As determined by Iddings,[2] the trap rocks are generally holocrystalline, and formed of lath-shaped basic feldspar, irregular grains and crystals of augite, grains of iron oxide, together with considerable green serpentine or chlorite, which is disseminated through the mass and is evidently the alteration product of a fourth primary constituent. Specimens collected at Orange, New Jersey, where the trap occurs in large, well defined columns, when examined in thin sections, however, were found not to be holocrystalline, but to contain a variable amount of glass base. The large serpentine blotches contain olivine in their centers, the primary mineral from which the serpentine is formed. This rock is in every way identical with many medium grained basalts which have been poured out at the surface in recent times, and should be called basalt. The coarser grained varieties are dolerite, as determined by E. S. Dana. The presence of hornblende as an essential constituent in the trap near Gettysburg, Pennsylvania, has been reported by Frazer.[3]

It has been shown by several petrographers that when the rock is somewhat altered, either during its extrusion, through the action of heated solutions, or by weathering after exposure at the surface, that hydration has taken place and various secondary minerals formed. When the trap rocks are more thoroughly decomposed, they form a tenaceous residual clay, usually yellowish or mottled in color, and showing no resemblance to the rock from which it was derived. In the unglaciated portions of the Newark belt the trap rocks are frequently completely decomposed to a depth of from twenty to fifty feet. Owing to their greater solubility than the adjacent sandstone and shales,

[1] Dana, J. D. [Density and composition of Newark Dolerites]: Am. Jour. Sci., 3d ser., vol. VI, 1873, pp. 106-107. Dana, E. S.: Trap rocks of the Connecticut valley. Am. Ass. Adv. Sci., Proc., vol. XXIII, 1874, pp. 45-47. Van Dyck [Native iron in the trap rocks of New Jersey]: Geol. Surv. of New Jersey, Ann. Rept. for 1874, p. 57. Frazer, P.: On the traps of the Mesozoic sandstone in York and Adams counties, Pennsylvania. Am. Phil. Soc., Proc., vol. XIV, 1875, pp. 402-414, 431; Pls. 1-4. Also, Second Geol. Surv. of Pennsylvania, vol. C, 1876, pp. 124-129; pls. 2, 3. Frazer, P.: A Study of the Igneous Rocks. Am. Inst. Mining Eng., Trans., vol. V, 1877, p. 146. On the physical and chemical characteristics of the trap occurring at Williams Point (Lancaster County, Pennsylvania). Am. Phil. Soc., Proc., vol. XVIII, 1880, pp. 96-103, and plate. Hawes, G. W.: On the mineralogical composition of the normal Mesozoic diabase upon the Atlantic border. U. S. Natl. Mus., Proc., vol. IV, 1881, pp. 129-134. Marsters, V. F.: Triassic traps of Nova Scotia. In American Geologist, vol. V, 1890, pp. 144-145.

[2] The Columnar structure in the Igneous Rocks of Orange Mountain, N. J.; Am. Jour. Sci., 3d ser., vol. XXXI, pp. 321-331, Pl. 9.

[3] Am. Phil. Soc., Proc., vol. XIV, 1875. p. 43.

they frequently give origin to depressions in the topography of the region they traverse.[1] In the glaciated region the outcropping edges of trap sheets usually stand in bold relief. The difference in their appearance in glaciated and unglaciated regions is due to the fact that while more resistant than the associated strata to mechanical erosion, they are usually much more susceptible to chemical changes.

CHEMICAL COMPOSITION.

Numerous analyses of the trap rocks have been made, principally from Connecticut valley, New Jersey, and Pennsylvania. It is not necessary to assemble these analyses here, as they may be found from the following references; but, in order to show the general composition of the rock, the average composition of eight samples of unaltered dolerite from New Jersey and the Connecticut valley, analyzed by G. W. Hawes, is inserted.

Average composition of unaltered dolerite.[2]

	Per cent.
Silica (SiO_2)	52·50
Alumina (Al_2O_3)	14·15
Ferrous oxide (FeO)	9·24
Ferric oxide (Fe_2O_3)	1·96
Manganous oxide (MnO)	0·45
Lime (CaO)	10·03
Magnesia (MgO)	7·48
Chromic oxide (Cr_2O_3)	
Soda (Na_2O)	2·30
Potash (K_2O)	0·69
Phosphoric acid (P_2O_5)	0·14
Titanic acid (TiO_2)	
Water (by ignition, (H_2O)	0·92
Total	99·86

[1] Bull. U. S. Geol. Surv., No. 52, pp. 15–18.

[2] Analyses of Newark trap rocks may be found as follows:

Cook, G. H.: [Name of analyst not given]. Analyses of trap from many localities in New Jersey; Geol. of N. J., 1868, pp. 215–218.

Tyson, S. T.: Analysis of West Rock, Conn. Am. Jour. Sci., 3d ser., vol. VI, 1873, p. 107.

Allen, O. D.: Partial analysis of trap from near lake Saltonstall, Conn. Am. Jour. Sci., 3d ser., vol. VI, 1873, p. 107.

Mixter, W. G.: Analysis of traps from the Palisades, N. J. Am. Jour. Sci., 3d ser., vol. VI, 1873, p. 106.

Hawes, G. W.: Analyses of trap from West Rock, Wintergreen lake, lake Saltonstall, South Durham mountain, Conn.; Mt. Holyoke, Mass., and Jersey City, N. J. Am. Jour. Sci., 3d ser., vol. IX, 1875, pp. 185–192, 454–457.

Frazer, P.: Discussion of the analyses of trap rock from West Rock, Conn., and from near York, Pa. Second Geol. Surv. of Pa., vol. C, pp. 118–124.

Genth, jr., F. A.: Analyses of trap rocks from Pennsylvania. In Second Geol. Surv. of Pa., vol. C 6, 1881, pp. 94–99, 134. Analyses of trap from Gulf Mills, Pa. Am. Phil. Soc., Proc., vol. XXII, 1885, p. 454. Analysis of trap from Cornwall iron mines, Pa. Ann. Rep. 2d. Geol. Surv. Pa., for 1885, pp. 498–499. Analyses of trap from Williams Point, Lancaster county, Pa. Am. Phil. Soc., Proc., vol. XVIII, 1880, p. 96.

Genth, F. A.: Analysis of trap from near York, Pa. Second Geol. Surv. of Pa., vol. C, 1876, pp. 122–124. Analyses of minerals and rocks from Bucks, Montgomery, and Philadelphia counties, Pa. Second Geol. Surv. of Pa., vol. C 6, 1881, pp. 94–99, 134.

Chatard, T. M.: Analyses of decomposed trap from North Carolina. Bull. U. S. Geol. Surv., No. 52, 1889, p. 18.

CHARACTERISTICS OF TRAP DIKES.

The general trend of the dikes throughout the Newark system and in the surrounding areas is northeast and southwest. Those in the crystalline rocks, as a rule, are narrower than those penetrating sedimentary strata. Where dikes occur in the Newark system a hardening and alteration in color of the adjacent sedimentary beds is noticeable. This change seems to be due directly to a baking of the strata; but in some sandstones, especially at the south, it appears to have resulted from the deposition of mineral matter by heated solution. Observations on the change in color and texture in the strata adjacent to trap dikes and sheets have been summarized by W. M. Davis,[1] who has shown that such alterations are confined to the immediate vicinity of the intrusion. The alterations in color consist frequently in the darkening of the rocks. A reddening is not common, and the fallacy of supposing that the general reddish color of the Newark rocks is due to an alteration in the iron they contain, by the heat of the intruded rocks, is clearly proved.

The observations of the present writer have shown that one of the most common changes in the color of the sandstones and shales adjacent to the trap dikes in Virginia and the Carolinas is an alteration to a deep purple color, which fades out into the normal brownish red tint of the Newark rocks at a distance, usually, of two or three feet. Many times the presence of a dike which is deeply decomposed and does not appear at the surface is indicated by two parallel bands of dark purple shale which define its boundaries. The hardened walls adjacent to the dikes resist weathering more effectually than the dikes themselves, and frequently stand in relief when the dike itself is depressed several feet below the general surface.

In some cases the dikes have a columnar structure at right angles to their walls, indicating the manner in which they were cooled and crystallized. In many instances the borders of the dikes show a fine, cryptocrystalline structure, while the central portion, owing to their cooling more slowly, is coarsely crystalline.

In the deeply decomposed dikes at the south a concentric structure is frequently developed by the decomposition. Rounded bowlders, resulting from disintegration, frequently occur scattered through yellowish clay in dikes that are partially decomposed; but when the alteration is more complete, the characteristics of the original rock entirely disappears and yellowish clay alone remains.

CHARACTERISTICS OF TRAP SHEETS.

The trap sheets interstratified with the sedimentary beds of the Newark system are of two classes, as has been shown especially by W. M.

[1] On the relation of the Triassic traps and sandstones of the eastern United States. In Mus. Comp. Zool., Harv. Coll. Bull., vol. VII, 1883, pp. 300-302.

Davis: First, contemporaneous sheets, or those formed by the surface eruption of igneous rocks and subsequently buried beneath sedimentary beds; second, intruded sheets or those forced in between the sedimentary strata subsequent to their consolidation.

The contemporaneous sheets are conformable with the stratified beds both above and below, while the intruded sheets, although conformable over large areas, in many instances break across the strata, forming dikes which connect the sheets at various horizons. The contemporaneous sheets have altered the sedimentary beds on which they rest, and are scoriaceous at their upper surfaces. The strata resting upon them are unaltered, and may contain fragments of the underlying trap or extruded scoria, volcanic tuff, and the finer products of eruption known as volcanic ash.

The intruded sheets have metamorphosed strata both above and below, and, cooling under pressure, are more compact throughout than the extruded sheets. They cooled most rapidly at their surface, and hence are compact and cryptocrystalline above and below, while their central portions are usually coarsely crystalline.

These characteristics have been discussed by Davis, in connection with the study of the trap sheets of the Connecticut valley, and have been applied by Darton[1] in the investigation of the trap sheets of New Jersey.

GEOGRAPHICAL DISTRIBUTION.

TRAP DIKES OUTSIDE THE NEWARK AREAS.

The great extent of the series of dikes intersecting the Newark areas and their extension into the surrounding areas of crystalline and paleozoic rocks have already been referred to; but it is only within the Newark areas themselves that the distribution of the traps has been approximately determined. Numerous dikes have been described and mapped in Newfoundland, Nova Scotia, New Brunswick, Maine, Vermont, New Hampshire, and eastern Massachusetts, some of which, it seems probable from the descriptions given, belong to the series which traverse the Newark system, but much study is required before this connection can be determined with certainty.

It has been stated by Hobbs[2] that certain diorite dikes near Boston have generally been considered as post-Newark in age, on account of their lithological resemblance to the diabases of the Connecticut valley.

On the geological map of Connecticut published by J. G. Percival in 1842, several narrow trap dikes, somewhat disconnected, are indicated as traversing the crystalline region outside the Newark area.

The work of the Second Geological Survey of Pennsylvania has shown the presence of several such dikes in crystalline and Paleozoic regions

[1] On the relations of the traps of the Newark system in the New Jersey region. U. S Geol. Survey, Bull. No. 67.

[2] On the petrographical characters of the dike of diabase in the Boston basin. In Mus. Comp. Zool., Harv. Coll. Bull., vol. XVI, 1888, p. 1.

of the eastern part of that State. One of the dikes starting just west of the border of the Newark area, near Holly Springs, Cumberland county, Pennsylvania, runs north with some breaks and irregularities, across Perry county and into Dauphin county, a distance of about 35 miles. Other dikes traversing Paleozoic and crystalline rocks occur in Lancaster county, a little south of the Newark area.

The most remarkable dike in this region, however, begins at the north, in Bucks county, and runs in a general southwesterly direction across Pennsylvania and into Maryland for a distance of 90 miles. This dike has been described and mapped by Lewis.[1] Its northern end is in the Newark system, but throughout the greater part of its course it traverses Silurian and crystalline strata.

Southwest of the southern end of the dike described by Lewis, and possibly a continuation of it, is another dike, more or less broken, the course of which has been traced by S. H. Williams for about 30 miles. This dike, as I have been informed by Williams, is later than any of the associated igneous rocks in the region, and was intruded after the crystalline rocks had their present attitude. Lithologically it is undistinguishable from the characteristic trap rocks of the Newark system. Williams has also traced the course of another dike beginning in the Newark area of Maryland, near the Pennsylvania boundary, and running southward to the Potomac. This dike leaves the Newark rocks about 10 miles north of Frederick, and for the remainder of its course traverses the crystalline area.

In Virginia, west of the southern end of the New York–Virginia area, there are trap dikes of the same character as those mentioned above, which trend a little west of north and cut across the folds of the Appalachians. Again, in the western part of Virginia, on the west side of the great Appalachian valley, several small trap dikes have recently been observed by Darton; specimens from these, examined by Diller, are found in all cases to be closely similar to, and in one instance identical with, those of the Newark system.

Farther north in Virginia and the Carolinas trap dikes outside of the Newark areas are of common occurrence but have not been mapped, and little is definitely known concerning their distribution. In South Carolina the same great system continues southward far beyond the last remnants of the sedimentary beds of the Newark, but still retaining all the geological and lithological characters that distinguish it in the north. The dikes of South Carolina were recognized by Tuomey[2] in his admirable report of 1848, and their relation to the series of similar dikes farther north fully understood. The author cited states that he traced the dikes referred to through Georgia, and as far as the Coosa river in Alabama, and also that the direction of the dikes in South Carolina is exceedingly uniform, varying between 15 and 35 degrees east of north,

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[1] A great trap dike across southeastern Pennsylvania. In Am. Phil. Soc. Proc., vol. XXII, 1885, pp. 438-456 and map.

[2] Report Geology of South Carolina, Columbia, S. C., 1848, 4to., pp. 65-68.

and that they are but slightly inclined from the vertical. My opportunities for observation in South Carolina, although limited, are sufficient to indicate that Tuomey's conclusions seem in every way correct. The reports of the State geologists of Georgia and Alabama contain brief accounts of trap dikes which are supposed to belong to the series under review. Such observations as have been made in this region show that the dikes are abundant, and probably much more numerous than in the northern part of the Atlantic coast plain. Their southern limit is unknown for the reason that, in common with the crystalline rocks they traverse, they disappear beneath the Cretaceous and Tertiary strata, wrapping around the southern end of the Appalachian mountains.

This hasty sketch of the extent of the trap dikes outside of the Newark system will serve to show their importance in the geology of the Atlantic slope and suggest future lines of investigation. The length of the series of dikes as now known is about 1,000 miles, and its width, although its eastern border is concealed by more recent geological deposits, and by the ocean, is not less than 200 miles.

TRAP ROCKS OF THE ACADIAN AREA.

The trap rocks belonging to the Newark system in Nova Scotia form a bold mountain ridge extending along the eastern shore of the bay of Fundy from Blomidon southward to Brier island, and also many bold headlands and picturesque islands in and about the basin of Minas and the waters connecting with it. These rocks have been studied by J. W. Dawson, especially, and it is to his well known work on Acadian geology that we owe the greater part of our information concerning them. The trappean mass bordering the bay of Fundy on the east is vesicular below and compact and basaltic above. It is considered by Dawson and Marsters[1] to have been poured out as a subaqueous lava flow. In a general way, at least, it is conformable with the sandstones and shales on which it rests, and dips westward beneath the waters of the bay of Fundy at an angle of about 15 degrees. Its relation to higher stratified beds is not known, as no upper contacts have been seen. The vesicular character of the lower part of the sheet and its marked contrast with the compact basalt forming the upper portion suggests the possibility that they are in reality two separate sheets, the lower one being a contemporaneous overflow, and the upper and intruded sheet of later date.

Many of the isolated trap masses in the Minas basin and elsewhere rest on sedimentary Newark beds, and are probably remnants of an extensive lava sheet. The structure in this region is imperfectly understood, and the possible presence of faults not fully investigated.

On the west side of the bay of Fundy, at the island of Grand Manan, trap rock again appears, which has been referred with more or less doubt to the Newark system.[2]

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[1] Triassic traps of Nova Scotia, Am. Geol., 1890, pp. 140-145.

[2] Geol. Surv. of Canada, atlas sheet, No. 1, S. W., note 7.

TRAP ROCKS OF THE CONNECTICUT VALLEY.

The trap rocks of this area have received greater attention than those of any other similar area, but diversity of opinion still exists as to the method of their occurrence. The history of the geological study of this area has been summarized by Davis[1] and need not be repeated here.

On the accompanying map (Pl. III) the outlines of the trap outcrops are shown as accurately as the scale of the illustration will allow. Those in Connecticut are from Percival's map, with some revisions by Davis, and those in Massachusetts are from a manuscript map kindly furnished by B. K. Emerson. All of the outcrops indicated are edges of trap sheets more or less conformable with the associated stratified rocks. Trap dikes are seldom seen and are too small to appear on the maps.

Davis's studies have shown that by far the larger part of the trap sheets were formed by overflows of volcanic rock during the deposition of the Newark strata. The trap sheet in the extreme northern part of the Newark area, near Turner's Falls, Massachusetts, is of this nature, and so also is the great trap sheet following Mount Holyoke and Mount Tom and extending southward as far as Meriden, Connecticut. The conclusion that this trap sheet was extruded at the surface and subsequently buried was advanced by Hitchcock during his survey of Massachusetts, and has since been sustained by Davis and Emerson.

Numerous trap ridges in the eastern part of the Newark area in Connecticut have also been shown by Davis to be extruded sheets, while the intruded sheets are confined to the western border of the area south of Massachusetts. This series begins at the south, at East Rock; a conspicuous bluff North of New Haven appears also in West Rock and forms the long broken ridge running northward. The same series of intruded sheets appears to outcrop again in the Barndoor hills of Granby, on the northern border of the state.

All of the trap sheets of Connecticut were considered as of intrusive origin by Percival, and his conclusion seems to have been accepted by all subsequent writers until Davis's study showed that there were strong reasons for believing that some of the sheets were extrusive and not intrusive. This opinion, although sustained by a large mass of the evidence, is not accepted by all students of the subject, and more detailed work evidently remains to be done before a final and generally accepted conclusion will have been reached. The trap sheet at Tariffville, Connecticut, has been shown by Rice[2] to be of extrusive origin.

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[1] On the relation of the Triassic traps and sandstones of the eastern United States. In Mus. Comp. Zool., Harv. Col., Bull. vol. VII, 1883, pp. 279-281.

The structure of the Triassic formation of the Connecticut valley, in Seventh Ann. Rep. U. S. Geol. Surv., 1885-86, pp. 455-490, Pl. 52.

The lost volcanoes of Connecticut. Pop. Sci. Mo., vol. XL, 1891, pp. 221-235.

[2] On the trap and sandstone in the gorge of the Farmington river, at Tariffville, Conn. In Am. Jour. Sci., 3d ser., vol. XXXII, 1886, pp. 430-433.

In a review of Davis's conclusions, Dana[1] refers to the uniformity in the character of the Connecticut valley as indicating a common mode of formation. The vesicular texture of the upper surfaces of some of the trap sheets is referred to an escape of vapor, but is not considered as necessarily showing that the lavas were extruded at the surface.

In a recent paper on some of the trap ridges of southeastern Connecticut, by Hovey,[2] the conclusion is reached that all of the trap rocks in that portion of the state—considered by Davis as extrusive—are intrusive.

TRAP ROCKS OF THE NEW YORK-VIRGINIA AREA.

In the central and northern part of this area, as in the Connecticut valley, trap rocks are abundant, and appear principally as sheets, conformable more or less thoroughly with the bedding of the associated stratified rocks. In the southern part of the area, in Maryland and Virginia, trap sheets are much less abundant than farther north, but dikes increase in number. This change accompanies a decrease toward the south in the thickness of the system as it now remains, and favors the conclusion, that when the Newark rocks are deeply eroded, trap sheets disappear and trap dikes take their place.

In New Jersey the outcropping edges of the trap sheets form bold ridges, trending in a general way, north and south and facing eastward. Their westerly slopes conform to the dip of the associated shales and sandstones, and are inclined westward at angles of about 15 degrees.

The studies of Davis, and later of Darton,[3] have shown that the trap sheets of New Jersey are of two classes, intrusive and extrusive. The intrusive sheets comprise the Palisade, and what is probably its southern extension, known as Ten Mile run, Rocky hill, Pennington mountain, etc., a few miles north of Trenton, and other associated ridges in the same region.[4] The sheets forming the Watchung mountains are extrusive and are high up in the stratified beds unless a fault along the base of the most easterly of these ridges, believed to exist by Darton, can be proved. If such a fault does exist, and the basal conglomerate

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[1] Am. Jour. Sci., 3d ser., vol. XXV, pp. 474-475. The origin of the trap rocks near New Haven, Conn., has been critically discussed by J. D. Dana, since this paper was written on some of the features of nonvolcanic igneous ejections, or illustrated in the four "rocks" of the New Haven region, West Rock, Pine Rock, Mill Rock, and East Rock in Am. Jour. Sci., 3d ser., vol. XLII, 1891, pp. 79-110, pl. 2-7, and "on Percival's map of the Jura-Trias trap belts of central Connecticut, with observations on the upturning, or mountain-making disturbance of the formation," in Am. Jour. Sci., 3d ser., vol. XLII, 1891, pp. 439-447, Pl. 16. Proofs that the Holyoke and Deerfield trap sheets which are contemporaneous flows has been given Ben. K. Emerson in Am. Jour. Sci., 3d ser., vol. XLIII, 1892, pp. 146-148.

[2] Am. Jour. Sci., 3d ser., vol. XXXVIII pp. 361-383, and map.

[3] U. S. Geol. Sur. Bull. 67.

[4] As stated by Darton, Am. Jour. Sci., 3d ser., vol. XXXVIII, 1889, p. 136, the intrusive sheets of New Jersey comprise those forming the Palisades, Sour Land mountain, Cushetunk mountain, Round mountain, and the series including Lawrence brook and Ten Mile Run mountain, Rocky hill, Pennington mountain, Bald Pate, and Jericho hill, and the outcrops at Point Pleasant, Snake hill, Arlington, Martin's Dock, Neshanic, Bell mountain, Granton, and Brookville.

The extrusive sheets include all the outcrops constituting First, Second, and Third Watchung mountain and the ridges to the westward and the outlying outcrop near New Germantown.

appears at the surface east of Paterson, it is probable that the extrusion of these rocks took place early in the history of the system.

The intruded sheets, although mostly near the eastern border of the area and near the base of the sedimentary series, are not all so situated. The trap of Cushetunk mountain is at the extreme western border and, in part, in contact with the bordering Paleozoic rocks. The generalization suggested by Davis, to the effect that the intruded sheets of the Newark system are all low down in the series, while the extruded sheets occur at higher levels, apparently can not now be applied in New Jersey; but when the structure of the New York-Virginia area is more thoroughly known, the hypothesis referred to may find support there as well as in the Connecticut valley.

Of the intruded sheets the most interesting is the one forming the Palisades. It is about 400 feet thick in Jersey City, and, as shown by Darton, rises northward by breaking across the bedding of the stratified rocks until, at the Hook mountains, in New York, its base is nearly a thousand feet higher than in Jersey City, and its thickness 850 feet. When followed westward to the extreme western end of the Hook mountain, it appears that the intruded rock reached the surface and overflowed.

Detailed observation regarding the nature and distribution of the trap rocks of New Jersey is given in the reports of the Geological Survey of New Jersey by Darton, in his article on the great lava flows and intruded trap sheets of the Newark system, and in Bulletin 67 of the U. S. Geological Survey, already referred to, and by Davis, in his paper on the relation of the Triassic traps and sandstones of the eastern United States.

The conclusion reached by Davis and Darton as to the extrusive origin of the traps of the Watchung mountains has not been accepted by the geologists of the New Jersey Survey, who urge that all of the trap sheets of New Jersey are intrusive.[1]

In that portion of the New York-Virginia area which crosses Pennsylvania, trap rocks are abundant and appear both as sheets and dikes, but little information is at hand to determine the nature of the sheets, though they are spoken of by the geologists of the Pennsylvania Survey as extrusive. The dikes are known to be numerous, and, as already stated, branch far out into the surrounding crystalline and Paleozoic rocks. In Maryland trap sheets are absent, but dikes occur which have been traced for many miles, principally in crystalline rocks. South of the Potomac several dikes have been observed, and intruded trap sheets are also present, as has recently been observed by Arthur Keith, but sufficient observation in this region has not been made to enable one to determine the distribution of their outcrop.

[1] N. J. Geol. Surv., Ann. Rep. for 1888, pp. 16–44; ibid., 1889, pp. 66–72. Frank L. Nason, On the Intrusive Origin of the Watchung traps of New Jersey, in Geol. Soc. Am. Bull., vol. 1, pp. 562–563.

TRAP ROCKS OF THE NEWARK AREAS SOUTH OF THE NEW YORK-VIRGINIA AREA.

Throughout the numerous areas of Virginia and North Carolina, south of the New York-Virginia area, trap dikes are abundant, but no trap sheets have been observed. Some of the trap rocks in the Richmond area appear to be interstratified with the coal-bearing beds, but sufficient observation has not been made to prove whether these are truly interbedded sheets or simply dikes breaking obliquely across the strata. Dikes in the southern areas are most abundant in the easterly, but are not entirely wanting in the westerly belt of Newark areas. The dikes observed are in general parallel with the strike of the rocks, and are approximately vertical. In width they vary from a few inches to 50 or 75 feet, and have produced alterations in the texture and color of the adjacent rocks for a few feet along the lines of contact. In many instances the dikes may be followed for several miles across the country, their courses being marked usually by black, weather-beaten bowlders, but in no instance have they been mapped, and their number and distribution are unknown. They are indistinguishable in general appearance and in lithological and chemical characteristics from the trap rocks forming the great sheets of New Jersey and the Connecticut valley, or from the dikes traversing the adjacent crystalline areas.

SUMMARY RESPECTING THE DISTRIBUTION AND AGE OF THE TRAP ROCKS.

That the trap rocks traversing the Newark system in dikes and sheets belong to the great series of dikes intersecting the Atlantic coast plain from Nova Scotia to central Georgia seems sufficiently well established. The trap series at the south, in common with the sedimentary rocks they traverse, pass beneath Cretaceous and Tertiary beds, and therefore their full extent in that direction is unknown. The eastern border of the belt they occupy is also concealed in part beneath the ocean and, in part, by Cretaceous and more recent deposits. On the west the series reaches out in long dikes across the folds of the Appalachian.

In the crystalline and Paleozoic areas deep erosion has occurred, and only dikes now remain. The overflows of lava which probably once existed have been entirely eroded away. In some portions of the Newark areas, however, where the trap rocks, in common with the sedimentary beds, have been depressed below the base-level of erosion, trap sheets of great thickness still remain, and in other portions, where erosion has spared but little of the Newark series, trap sheets are absent, but trap dikes are common.

There is a direct association of trap dikes with the faults of the Newark system, as is illustrated by the contacts in the great fault crossing Bucks county, Pennsylvania, and in the Wadesboro area, where the strata adjacent to the narrow dikes show diverse dips. From this coincidence and the fact that both dikes and faults are a result of fracturing of the earth's crust and are hence due to the action of similar forces, it seems safe to conclude that both the dikes and faults are closely related and were probably, in part at least, contemporaneous. There are good reasons for believing that faulting was common at the time the Newark beds were being deposited, as is indicated by the great thickness of the conglomerates along the borders of the areas toward which the strata dip, but the widely extended faulting which imparts the characteristic structure of the Newark system took place after the beds were deposited and before or during the period of erosion which preceded the deposition of the next succeeding series of stratified beds. It was in this interval, also, that the intruded trap sheets and dikes were injected into the stratified series. This is shown by the fact that the next succeeding Potomac formation rests on the upturned and eroded edges of the Newark strata and on the truncated edges of the trap dikes which traverse them. The trap dikes in the crystalline and Paleozoic areas surrounding the Newark system do not assist in determining the age of the intruded rocks, for the reason that these terranes are all older than the Newark.

CHAPTER VIII.

DEFORMATION.

INTRODUCTION.

Throughout the Newark system the structure is monoclinal over broad areas. In general the strata are inclined at angles varying from ten to twenty degrees, but higher dips are of frequent occurrence. There is an absence of folds such as characterize the adjacent Appalachian system, and the strata have not been crumpled, except locally along fault lines. Displacements trending in general in a north and south direction have been shown to exist in very many instances, and are the controlling structural elements of the system. There are also a few great faults which trend at right angles to the prevailing strike of the rocks.

The prevailing monoclinal structure was one of the first features to be observed when the study of the system began, and many explanations of its origin have been suggested. It has been explained by H. D. Rogers[1] as being the position in which the strata were originally deposited. A similar suggestion was made by J. D. Whitney, after studying the structure of portions of the Connecticut valley area. The explanation advanced by H. D. Rogers was accepted by W. B. Rogers,[2] W. W. Mather,[3] and others, in the early days of American geology. More recent investigations have shown that none of the various Newark areas have a uniform structure throughout, and besides, the varied composition of the rocks and their great thickness, as shown by direct vertical measurements, so completely exclude all hypotheses of oblique deposition that their discussion is unnecessary.

Neither is it desirable, in the present state of geologic knowledge, to discuss the various suggestions that have been made with reference to the existing Newark areas being basal remains of great anticlinal ridges, or that they owe their monoclinal structure to the tilting of segments of the earth's crust many miles in width, without the formation of secondary faults.

These and other provisional hypotheses have been reviewed by Davis,[4]

[1] Description of the geology of New Jersey. Philadelphia, 1840, pp. 166–171.

[2] Report of Progress, Geological Survey of Virginia, for 1839.

[3] Geology of New York, Albany, 1841, pp. 289-293.

[4] On the relations of the Triassic traps and sandstones of the Eastern United States; in Mus. Comp. Zoology, Harvard College, Bull., vol. VII, 1883, pp. 302–304.

and their failure to explain the facts observed fully demonstrated. As the study of the Newark system has advanced and become more detailed, a large number of observations have been recorded, which show that the various fragments of the system now remaining owe their preservation to the fact that they are below the horizon of present base-level erosion, and occupy that position in large part by reason of depression, or the elevation of contiguous area through faulting.

Each area is characterized by the presence of faults of all degrees of displacement up to many hundreds of feet, which have repeated the outcrops of individual strata. In many instances the fault blocks have been tilted in the same direction, so as to be easily mistaken for a continuous monoclinal dip. Closer study in certain instances, however, has shown that each of these supposed monoclinal areas is broken into many independent blocks.

The study of the structure of the system consists in determining what deformations have resulted from the faulting and tilting of horizontally stratified beds resting unconformably on much older rocks, which are generally metamorphosed and highly inclined. This being the direction in which recent investigation leads, let us see what evidence should be required to demonstrate that it is in reality the structure of the system under review.

It has been clearly shown by Davis, in discussing the structure of the Connecticut area, that the larger faults found in that region must affect the underlying crystalline rocks. My own studies have shown that the same conclusion may be extended to other areas of the system. Should the plane of erosion be depressed sufficiently, it is evident that at horizons near the base of the Newark system, the upheaved edges of fault blocks composed of crystalline rocks should appear at the surface as narrow belts intersecting the sedimentary beds. Owing to the greater resistance usually offered by the crystalline rocks to erosion, such protrusions would appear as ridges, standing in relief and dividing the superimposed beds. Bordering such ridges and resting on the crystalline rocks, one should find outcrops of the basal conglomerate of the Newark system, succeeded by sandstones and shales. On margins of the Newark areas where the line of junction with the surrounding crystalline rocks crosses the strike of the sedimentary beds, there should be long, narrow, finger-like extensions of crystalline rock, entering and dividing the sedimentary beds.

Another result of the deep erosion of faulted sedimentary beds resting on crystalline rocks would be the occurrence of narrow strips of sedimentary beds occupying the depressed borders of fault blocks and separated from larger areas by a ridge of the lower formation.

In the study of the various Newark areas peculiarities in outline and in topographic form which should be expected to result from the faulting and erosion of horizontally stratified beds resting on more resistant crystalline rocks as stated above have been found abundantly developed.

In the present chapter the available evidence in reference to the structure of the various Newark areas will be briefly summarized and the conclusion to which it points indicated. After ascertaining what the structure of the system is, the attempts that have been made to explain its origin will be considered.

STRUCTURE OF THE ACADIAN AREA.

For our knowledge of the structure of the Newark rocks of Nova Scotia we are indebted almost entirely to the writings of Dawson.[1] The general dip of the rocks along the eastern border of the bay of Fundy is northwest at an angle of about 15 degrees. On the New Brunswick shore there are several isolated areas belonging to the same system which dip northeastward at angles varying from 25 to 35 degrees. These inclinations have led to the conclusion that the Acadian area has a synclinal structure. That such is the case, however, can not be accepted as a final conclusion, for the reason that a faulting and tilting of the strata would account equally well for the observed dips. In the eastern part of the Acadian area, about the Minas Basin and Cobequid bay, the strata are much disturbed and dip toward all points of the compass, and at all angles from near horizontality up to 50 degrees or more. Some faults have been recognized in this region, but a characteristic fault structure, although indicated, has not been demonstrated. The structure is, however, certainly distinct from the great synclinal suggested by the opposite dips on the east and west shores of the bay of Fundy, and so far as recorded observations indicate falls in line with the prevailing fault structure characteristic of the more southern areas of the same system.

The presence of two ridges of trap at Digby neck, in the southern portion of the Newark area bordering the bay of Fundy on the east, can apparently be explained by a fault, as can also the presence of parallel submerged ridges in the adjacent portion of the bay of Fundy. Further field study is necessary, however, before the structure of this area can be considered as definitely determined; but the recorded evidence, supplemented by observations made during a brief reconnaissance by the present writer, certainly favors the hypothesis that the attitude of the Newark system in Nova Scotia has resulted from the tilting of faulted blocks.

STRUCTURE OF THE CONNECTICUT VALLEY AREA.

This area has been more thoroughly studied than any other in the series, and its general structure is known, although much detail work undoubtedly remains to be done. Our knowledge of its structure and of the nature of the trap sheets that traverse it has been greatly ad-

[1] Acadian Geology, 3d ed., London, 1878; pp. 86–127 and map. Supplement, pp. 28–30.

vanced during the last few years by the investigations of Davis.[1] In the southern portion of the area concerning which the most recent reports have been made the strata are broken by numerous faults, trending in general north and south with the strike of the rocks. The fault blocks, with some exceptions, are tilted eastward at varying angles up to 15 degrees. Other faults trend obliquely to the strike of the rocks in such a way at to throw the outcrops of hard beds out of line. There is good evidence for believing that in many portions of the eastern border of the area there are marginal faults which cause the eastward-dipping strata to abut against the adjacent crystalline rocks. The marginal faults belong to the same system as the strike faults in the central portion of the area, but deserve separate mention on account of their great importance in indicating the former extent of the stratified beds now claiming our attention.

The structure along the east margin of the Connecticut valley area, as illustrated by Davis, is shown in Fig. 1, in which a portion of the marginal fault mentioned above is indicated. The throw of this fault must be several thousand feet.

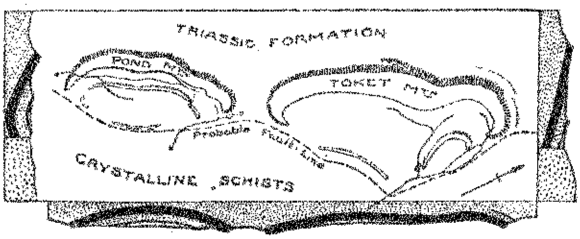

FIG. 1.—Fault on east side of Connecticut valley area, after W. M. Davis.

The determination of the structure of the Connecticut valley area has been rendered possible by the discovery of Davis that some of the trap sheets traversing it were extruded at the surface during the deposition of the Newark sediments and were buried by later deposits. In the deformation and erosion of the area they play the rôle of hard, sedimentary beds, and enable one to determine the structure in a manner more satisfactory than seems possible in other portions of the same system where sandstones and shales alone occur. Since these pages were written the structure of the Connecticut valley area has been still further discussed by Dana.[2]

STRUCTURE OF THE SOUTHBURY AREA.

This area may be considered as an outlier of the Connecticut valley area from which it is separated by about 16 miles of crystalline rocks.

[1] On the relations of the Triassic traps and sandstones of the Eastern United States; in Mus. Comp. Zoology, Harv. Coll. Bull., vol. VII, 1883, pp. 249-3[illegible], Pl. 9-11. Also "Triassic formation of the Connecticut Valley," U. S. Geol. Survey, Seventh Ann. Rep., 1885-'86, Washington, 1888, pp. 455-490, Pl. 52, and the lost volcanoes of Connecticut, Pop. Sci. Mo., vol. XL, 1891, pp. 221-235.

[2] "On Percival's map of the Jura-Trias trap belts of Central Connecticut, with observations on the upturning or mountain-making disturbance of the formation," in Am. Jour. Sci., 3d ser., vol. XLII, 1891, pp. 439-447, Pl. 16.

It is so far removed from the Connecticut valley area that its former connection is not usually admitted; but the fact that similar areas in detached fault basins are common in connection with the main areas in Virginia and North Carolina suggests that the Southbury area also occupies a local fault basin, and that its preservation is due to the depression by faulting of a small portion of the original Newark terrane below the present horizon of base-level erosion.

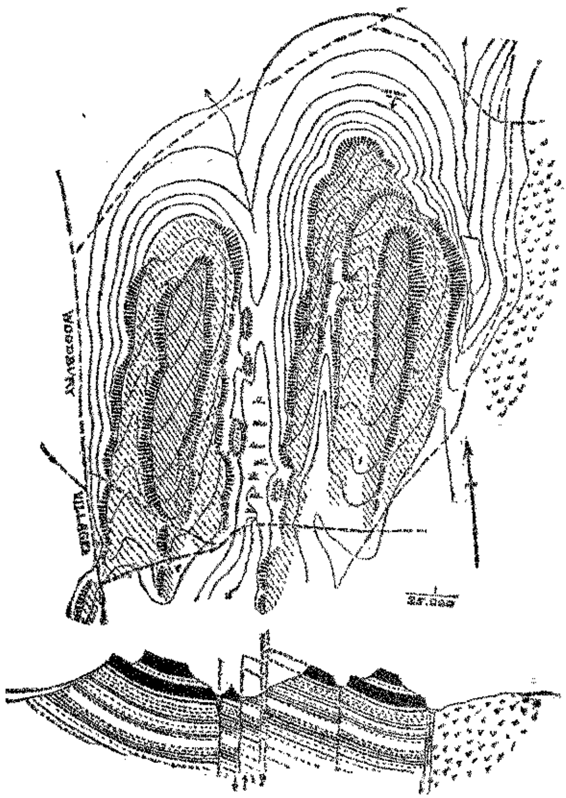

FIG. 2.—Map and section of Southbury area, after W. M. Davis.

This area has been studied by Davis,[1] and its structure illustrated by the accompanying map and section (Fig. 2). The rocks comprise several hundred feet of sandstone and conglomerates at the base; next, a thin, amygdaloidal trap; then 200 feet or more of shale and calcareous beds; then a heavy sheet of trap. Other superior members exist, but are mostly concealed by drift. The attitude of these beds is so well shown in the accompanying figure that further description may be dispensed with.

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[1] U. S. Geol. Survey, Seventh Ann. Rept. for 1885–'86. Washington, 1888, p. 468.

STRUCTURE OF THE NEW YORK-VIRGINIA AREA.

Although a large amount of time has been devoted to the study of this area, its structure has not been satisfactorily determined.

In New York and New Jersey the general dip of the strata is toward the northwest, but many exceptions have been recorded. As shown by Darton and Nason, the observations of dip indicate that the strata are broken into blocks which have a monoclinal structure. Only a few faults have been distinctly traced, however, and these are usually small. A great fault, having a throw of perhaps 2,000 feet, is supposed by Darton[1] to exist on the east side of the Watchung mountains, in the neighborhood of Paterson, which brings to the surface the characteristic basal conglomerate of the system.

There are several reasons for believing that the western border of the area, from near Morristown, New Jersey, northward to the Hudson, is determined by a displacement. Along this junction the Newark rocks dip uniformly westward to within a short distance of the line of contact, but the actual junction has not been seen, owing to the thickness of the superficial drift. The conditions are here apparently the same as along portions of the eastern margin of the Connecticut valley area, and at the junction of some of the Newark areas in Virginia and North Carolina with bordering crystalline rocks where marginal faults are known to exist.

The line of bluffs of crystalline rock overlooking the Newark area from Morristown to the Hudson continues eastward and forms a bold line of hills, when seen from the south, through Westchester county, New York, and into Connecticut. The presence of a fault along the base of these hills, I have been informed by Darton, is indicated by an abrupt change in the character of the rocks. This region has been studied by Smock,[2] who describes an abrupt change in the lithology, but does not explain its origin.

Perhaps I go too far in making the above suggestion, but there are several indications which lead to it as a working hypothesis which future students of the region would do well to bear in mind. The line of bluffs referred to northward of Morristown marks the shore line during certain stages of the deposition of the Newark rocks, which was possibly determined by a line of faulting that was in process, and increased its displacement from time to time during the deposition of the Newark beds.

The most important fault observed in the New York-Virginia area occurs in Bucks county, Pennsylvania, and in adjacent portions of New Jersey. The course of this fault is known for about 40 miles and probably has a greater length. Its general direction is north and south, but it is strongly curved, being concave toward the northwest. From

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[1] Bull. U. S. Geological Survey, No. 67, p. 18.

[2] A Geological Reconnaissance in the Crystalline Rock Region of Dutchess, Putnam, and Westchester counties, New York. 39th Ann. Rept. of the Trustees of the New York State Museum of Natural History, Albany, 1886, pp. 165–185.

near Lambertville, where it crosses the Delaware, for about 6 miles northwestward, it has brought to the surface a narrow outcrop of Silurian rocks on which rest the basal conglomerate of the Newark system. On the east side of the Delaware, in New Jersey, an outcrop of trap occurs in the midst of the fault rock which marks the course of the displacement, suggesting that the fracture was sufficiently deep to reach molten material. In general, on the north side of the fault the strata are inclined toward the northwest, while on the south they dip northeast. The rocks immediately adjacent to the displacement have been greatly fractured and slickensided, and in places where the exposures are obscure this fault rock enables one to trace the line of fracture with tolerable certainty. The strip of Silurian rocks brought up by this fault is represented on the large maps accompanying the reports of the First Geological Survey of Pennsylvania; but the structure of the region does not seem to have attracted special attention during the progress of the survey. Its position is shown on the accompanying map, forming Pl. IV. The facts here stated are principally from an account published by Lewis.[1] Secondary faults, at right angles to the prevailing strike of the Newark rocks of Pennsylvania are reported by Lewis, but these are of small importance in a study of the general structure.

In a section across the eastern rocks of southeastern Pennsylvania, from near Dillsburg, S. 47° 31′ E., to Beelers Cross Road, by Frazer,[2] a uniform southwesterly dip is given, ranging from 16 to over 40 degrees, excepting near the west end of the section, where a broad, gentle syncline is introduced. The dips and rock structure recorded in describing this section might apparently be equally well explained by the introduction of faults. Unless the exposures are as complete as represented by Frazer, it does not seem safe to assume such a great thickness as his section indicates, or to introduce a synclinal structure, which is exceptional for these rocks. A portion of the western border at Cornwall iron mine, near Dillsburg, has been shown by J. P. Lesley and E. V. d'Invilliers[3] to be determined by a great displacement, which brings the westward dipping strata of the Newark system in abrupt contact with Paleozoic strata.

The most recent studies of the Newark system in Pennsylvania have, in general, not indicated the presence of a faulted monoclinal structure. The absence of easily recognizable strata, as in many other parts of the system, unfortunately renders it difficult to determine the structure of the region. Many observations of dip and other phenomena have been recorded by the Second Geological Survey, but no digest or systematic study of these observations has been made. Until this is done by one

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[1] A great trap dike across southeastern Pennsylvania. In Am. Phil. Soc. Proc., vol. XXII, 1885, pp. 438–456. Map op. p. 40.

[2] Second Geol. Surv. of Pennsylvania, Report of Progress in the counties of York, Adams, Cumberland, and Franklin. Vol. C 2, 1875. Harrisburg, 1887, pp. 265–270. Pl. op. p., 264.

[3] Second Geol. Surv. of Pennsylvania. Ann. Rep. for 1885, pp. 496, 498, 506.

familiar with the region it is impracticable to draw any general conclusion from the many observations recorded.

The eastern border of the Newark system in Pennsylvania, Maryland, and Virginia is irregular, owing apparently to inequalities in the floor on which the stratified beds were deposited, or possibly to subsequent disturbances. These inequalities have been exposed at the surface by erosion, and indicate that along this border the Newark beds have but little thickness. In some places they have been cut through by stream erosion so as to expose the crystalline rocks beneath.

The structure of the southern portion of the New York-Virginia area has not been determined. The inclination of the beds south of the Potomac is in general northwestward, and to a casual observer the strata appear to have a continuous monoclinal dip from side to side. The rocks, however, are mainly shales and shaly sandstones, and the presence of faults would be difficult to determine.

At Brooklyn, a few miles west of Centerville, Virginia, there is a series of parallel ridges trending nearly north and south, which present sharp escarpments to the eastward. These ridges owe their prominence to the outcropping edge of a trap sheet which has been broken by faults. The trap sheets in each fault block have a dip of about 25° to the northwest, corresponding with the inclination of the associated shales and sandstones. The presence of trap sheets in this region, it is to be hoped, will assist in the future study of its structure in the same manner that similar sheets in the Connecticut valley have led to the determination of the deformations that there occurred.

STRUCTURE OF THE BARBOURSVILLE, STOCKVILLE, DANVILLE, AND DAN RIVER AREAS.

These areas fall in line with the southern extension of the New York-Virginia area, and have the same general structure. The strata of which they are composed dip westward, and in many places abut against the bordering crystalline rocks. The presence of marginal faults has not been determined by direct observation, but the persistent westward dip of the Newark strata, close to the line of junction, can not be explained unless such faults are postulated. In the Dan river area especially, the high dip of the Newark system, amounting in many instances to fully 50 degrees within a few rods of the line of junction with the crystalline rocks, is a very strong indication of marginal faulting. The western border of each of the areas here considered is composed of coarse conglomerate, derived from the crystalline rocks toward which the strata are inclined. In general the conditions are the same as along the northwestern border of the New York-Virginia area and the eastern border of the Connecticut valley area.

In the Barboursville area the structure is obscure and greatly disturbed. The presence of coarse conglomerates along both its western and eastern margins indicates that the strata have not great thickness.

The dips observed at several places are uniformly westward, at angles of about 20 degrees. No faults or folds have been discovered, but may exist, as the exposures are not good. The area is bordered on all sides by old hills, and forms a topographic basin which owes its origin to the greater ease with which the stratified rocks yield to erosion.

In the Scottsville area the dip is westward throughout, at angles varying from 15 to 20°. No structural features excepting the dip of the strata have been observed.

The Danville and Dan river areas are remarkable for the high inclination of the strata composing them. In many places, throughout continuous sections over a mile in length, the beds have a persistent westward dip at angles varying from 35 to over 50°. The White Oak mountains forming the most conspicuous portion of the Danville area are composed of sandstones and shales, and stand in relief and form an exception to the statement made on a preceding page to the effect that the Newark areas at the south are usually lower than the crystalline areas bordering them. The trend of the range is a little east of north, but does not coincide with the strike of the strata composing it, which is nearly northeast and southwest.

The Danville area terminates abruptly at the south, and appears to have been separated from the Dan river area by a profound displacement trending northwest and southeast, or at right angles to the prevailing strike of the rocks. The abrupt manner in which the strata at the northeast extremity of the Danville area abut against the crystalline rocks, when followed northwestward along the strike, is well shown near the little hamlet of Cascade. The junction of the two formations is a straight line at right angles to the strike of the Newark beds. Along the line of junction the Newark strata dip northwest at angles varying from 30 to 35°.

This locality has not been thoroughly studied, but from the reconnaissance made it seems as if the Newark strata had been depressed into the crystalline rocks along the junction of two faults which meet each other at nearly right angles. In a newly constructed mill race, situated between Cascade and the neighboring railroad station, the following detailed section was measured: The section is 1,370 feet long as measured at the surface, and runs at right angles to the strike of the rocks. The dip throughout is northwest 30 to 33°. The rocks were well exposed, and show no indications of faults or folds, excepting that the hard sandstone strata are very similar in composition, and are repeated with surprising regularity in certain portions. Only a few rods northeast of this section, i. e., in the direction of strike, the stratified beds end abruptly, and are replaced by crystalline rocks. The measurements given below show vertical thickness; the first or highest member in the series is at the west, where the dam from which the race starts is situated.

Vertical section, near Cascade, North Carolina.

	Feet.
Compact black slate, becoming sandy in weathered outcrops	33·0
Compact gray sandstone	2·5
Black shale, poorly exposed	122·0
Hard, gray sandstone	2·0
Thin-bedded sandy shale, passing into sandstone below	19·0
Compact gray sandstone	2·5
Sandy shale	3·0
Compact gray sandstone	2·0
Shale, light-colored, even-bedded	19·0
Hard sandstone, with partings of shale	3·5
Shale, yellowish, sandy	19·0
Sandstone, hard, bluish, resembling gneiss	3·5
Shale, yellowish	12·0
Sandstone, compact, somewhat broken	2·5
Shale	8·0
Sandstone, compact	3·0
Shale	12·0
Sandstone	2·0
Shale	6·0
Sandstone	2·0
Shale, broken, exposures obscure	8·0
Sandstone, hard, bluish, resembling gneiss	6·0
Shale	19·0
Sandstone, hard, bluish, resembling gneiss	6·0
Sandstone, compact	5·0
Sandstone, shaly	5·0
Shale, black	1·0
Sandstone, shaly	2·0
Sandstone, shaly, irregular, disturbed	3·5
Shale, black	1·0
Sandstone, compact, even-bedded	2·0
Sandstone and shale, in thin layers	4·0
Slate, black	2·0
Sandstone, compact	3·0
Shale or slate, black	5·0
Sandstone, in thin layers with shaly partings, even-bedded	15·0
Shale, yellowish, micaceous, black at bottom	3·5
Sandstone, compact, bluish	5·5
Slate, black, shaly	3·5
Sandstone, with shaly partings, passing below into slate	13·0
Shale, black	4·0
Sandstone, compact, bluish	2·0
Shale, black, yellowish on weathering	7·0
Sandstone and shale, in thin layers	9·5
Sandstone, shaly	5·0
Sandstone, compact, bluish	10·0
Shale, yellowish	20·0
Unexposed	100·0
Shale, sandy	22·0
Sandstone, compact, bluish	2·5
Total vertical thickness, about	473·5

Another section exhibiting the characteristics of the strata of the Dan river area occurs at Leekville, and resembles closely that given above excepting that on the west it passes into a heavy granitic conglomerate, which in limited exposures can not be distinguished from the undisturbed granitic terrane bordering the Newark area on the west.

The system throughout the Dan river area is characterized by the presence of heavy beds of black slate and of dark colored shales, resembling closely the medial portions of the Richmond and Deep river areas.

All through the Dan river area the rocks are inclined westward, and no faults of any considerable extent have been observed, although small ones in much disturbed sandstones and shales may be seen in cuts along the Cape Fear and Yadkin Valley railroad. A marginal fault, on the west side of the area near Leeksville, is suggested by the high westward inclination of the conglomerates close to their junction with the granitic rocks on the west. The Dan river area, as shown on Pl. I, is the most southern of the western belt of Newark areas, the northern terminus of which is on the Hudson. Throughout this entire series the general dip is westward, except in Pennsylvania, where the terrane curves to the west and the prevailing dip is northward. Throughout the entire belt, however, the dip is toward the ancient shore from which the debris forming the Newark beds was derived.

In Virginia and North Carolina there is another belt of Newark areas, to the eastward of the one here described, in which the prevailing dips are to the southeast. Between these two belts is the small Farmville area, in which the strata are greatly disturbed and dip sometimes to the westward and sometimes to the eastward.

STRUCTURE OF THE FARMVILLE AREA.

In crossing this area from east to west, one finds that the strata have diverse inclinations and change abruptly from northeast to northwest dips. During my reconnaissance of the area, in 1885, the presence of at least four north and south faults in the central portion of the area was determined. The area as a whole, however, is, topographically, a basin surrounded by hills of crystalline rocks, and exposures are too indefinite to admit of a ready determination of its structure. On its eastern border, about 2 miles north of Farmville, the presence of a heavy marginal fault is clearly shown in recent mining explorations. At this locality the Newark system is composed of fine, light colored sandstones and shales, with several much disturbed coal seams, and abuts against granite. The stratified rocks near the line of contact are much disturbed, broken, and slickensided. They are not shore deposits, no coarse conglomerates being present, but offshore and swamp accumulations. That their abrupt termination against the granite has resulted from displacement and is not due to original deposition is beyond question.

In the small detached area about 6 miles south of Farmville the rocks are principally shales, with some sandstone layers and occasional coal seams. Coarse conglomerates do not appear at the surface. The prevailing dip is northwest, 20 degrees. No folds exist, and the presence or absence of faults has not been determined.

STRUCTURE OF THE RICHMOND AREA.

PREVIOUS OBSERVATIONS.

In Lyell's well known essay on the Richmond coal field,[1] and in other writings by the same author, the rocks of this area are considered to have been deposited in a local basin of about the same extent as the present coal field, and to have a synclinal structure. These conclusions have been repeated by nearly all subsequent writers on the subject with the exception of W. M. Fontaine, whose work will be noticed later, and F. H. Newell,[2] who has shown that the coal seams were not accumulated in the restricted basin, and do not thin out at the outcrops, as previously considered, but are faulted and crushed.

The occurrence of a double line of coal outcrops along the eastern margin of this area was recognized by Rogers,[3] during his survey of Virginia, and considered to be a result of faulting. He believed, however, that the Newark strata in the Richmond area and elsewhere were deposited in an inclined position, as had been explained by H. D. Rogers, and did not determine its structure or advance any definite ideas concerning the deformations that had taken place.

The presence of faults on the eastern border of the area is indicated in a section published by Taylor[4] in 1835, unaccompanied by any discussion.

This area has been studied by Fontaine,[5] in connection with other areas of the same system. His conclusions respecting its structure are stated as follows:

> My examination of some of the finger-like remnants of the Mesozoic, now found at the northern end of this field, thrust out in the Azoic, put me in possession of what I think is the explanation of the peculiarities of the structure of this field, and of the interior belts. The history of these areas, briefly stated, seems to be as follows:
>
> The strata were laid down in depressions, which, originally shallow, were subsequently deepened by a more or less rapid subsidence. The subsidence was due, as previously stated, to the operation of a lateral thrust. It continued until faults and overturned anticlinals were produced. In the interior belts (the New York-Virginia, Barboursville, Scottsville, Danville, and Dan river areas) these operated to produce a constant northwest dip. This resulted from the fact that the western sides of the severed earth prisms dropped, producing, sometimes, by a roll of the prisms, an upthrow of the eastern side. This appears to occur in some of the faults of the Richmond coal field also. When the strain did not result in producing rupture and

[1] Geol. Soc. London, Quart. Jour., vol. III, 1847, pp. 261-280, Pls. 8, 9.

[2] The Richmond Coal Field, Virginia. Geol. Mag., London, Dec. 3, vol. VI, 1889, pp. 138-140.

[3] Reports on the Geology of Virginia for 1835, p. 55, and for 1840

[4] Pennsylvania Geol. Soc., Trans., vol. I, pp. 275-294, Pls. 16, 17.

[5] Notes on the Mesozoic of Virginia. Am. Jour. Sci., 3d series, vol. XVII, 1879, pp. 36-37.

faulting, it caused the development of an anticlinal, affecting but a narrow belt, which was overturned to the eastward, thus producing also a continuous northwest dip. Where the strata have suffered enormously from erosion, and where almost precisely similar beds are formed by the similar conditions of deposition found repeated at different horizons, as is often the case in the interior belts, it is almost impossible to detect reduplications by faulting and folding. When the period of faulting was reached eruptions of trap took place. It will thus be seen that the continuous dips would by no means give a true indication of the thickness of the series.

In the Richmond coal field the faults and narrow overturned folds are not of sufficient magnitude to produce, as in the interior belts, continuous dips, but suffice only to render very variable and uncertain the dip and position of the strata toward the center of the field. The general result seems to have been to flatten the dip here and to steepen it on the western side. Some of the twists in the strata produced by the overturned anticlinals are of extremely limited extent. I have seen them only a few feet wide.

The direction in which the lateral thrust operated in this field was from east to west, and it seems not yet to be exhausted, for this region is often affected by minor earthquakes, and at intervals of ten or fifteen years by very powerful ones; the last occurring a few years ago. The shocks pass from east to west. It is probable that the gradual depression of the coast is connected with this westward thrust.

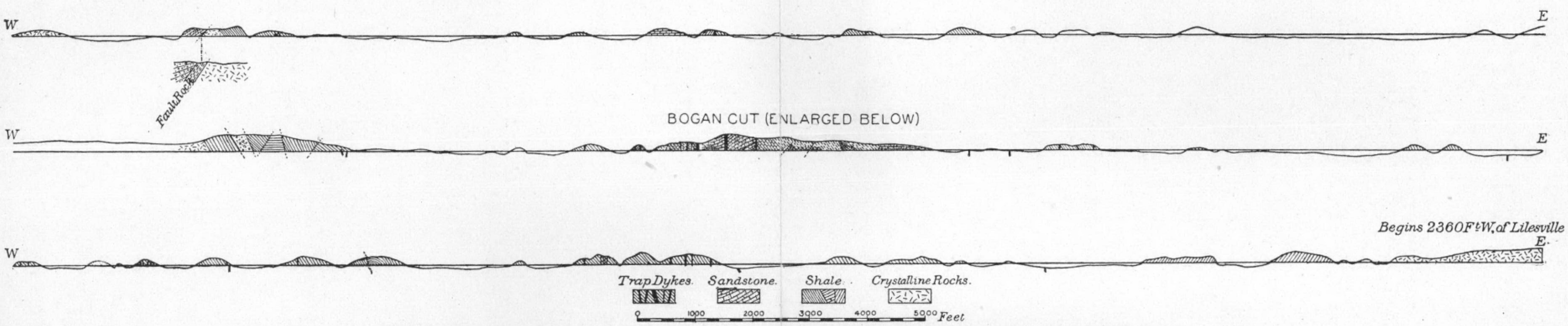
A detailed account of the strata penetrated during mining operations near Midlothian has been given by Heinrich[1] and the structure indicated in the plates which accompany his paper.

PERSONAL OBSERVATIONS.

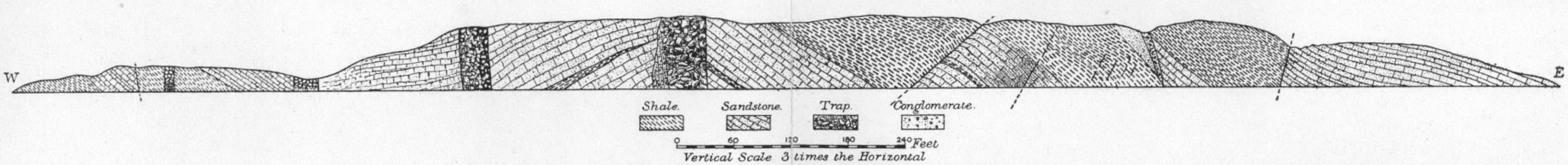
The observations of the present writer made in 1885 seem to warrant the conclusion that the Richmond area has been greatly disturbed by fracturing, especially along its eastern and western margins, and that as a whole it owes its preservation to faulting which carried the strata below the horizon of subsequent base-level erosion, or else elevated the contiguous areas. The faulting that has taken place along the margins of the area indicates that the strata were formerly more extended than now. Erosion has been great, and it is evident that what now remains of the Newark strata is but the remnant of their original extent.

Section along the James river.—The only natural section of any considerable extent in this area is along the left bank of the James from a point on the east nearly opposite the site of Bellona arsenal, westward to Dover, a distance of between 7 and 8 miles. At each end of this section the rocks are much disturbed and broken along north and south displacements. The general dip at each end is toward the center of the area, at angles varying from 15 to 70 degrees. In the central portion of the section, for a distance of about 4 miles, the strata form a broad, gentle synclinal, the central part of which is nearly horizontal, the dips on the eastern and western borders varying from 5 to 8 degrees. Near the west end of the section, at Boscobel, there is a mass of crystalline rocks included between highly inclined Newark strata. This is formed

[1] Mesozoic formation in Virginia. In Am. Inst. Min. Eng., Trans., vol. VI, 1879, pp. 221-224, Pls.1-2.



SECTION OF NEWARK ROCKS ALONG CAROLINA R.R THROUGH WADESBOROUGH N.C.



SECTION ON NORTH SIDE OF BOGAN CUT.

SECTIONS.

by the tongue-like prolongation of crystalline rock which enters the Newark area from the north and extends across the James river as shown on the map forming Pl. V. The presence of this wedge of crystalline rock, disturbing the continuity of the sedimentary strata, is due to a fault which has brought up the floor on which the Newark rocks were deposited, together with the basal conglomerate which rests upon it. On the east side of the wedge near the Dover mines the Newark rocks are disturbed and faulted, and have a general southwest inclination at angles varying from 15 to 20 degrees. On the west side the stratified rocks are also much disturbed and faulted, and in general dip eastward.

West border of the area.—The Dover mines, on the north side of the James, and the Powhatan, Norwood, and Old Dominion mines, on the south side of the river, are ranged in line along the west border of the area, and may be considered as constituting a single district. In this district, as has been demonstrated by mining operations, the inclinations of the rocks change abruptly from northwest at some localities to southeast at others near at hand, the inclinations varying from 15 to 20 degrees. This diversity is explained by the fact that the district has been broken by approximately north and south faults, and that the included beds have been variously tilted. The structure is especially well illustrated in the Norwood mine, in which the coal in certain of the fault basins has been worked out and the forms of the troughs demonstrated. These mines are located on the low bluff bordering the flood plain of the James, and the coal comes to the surface, although the lines of outcrop are concealed by superficial clays and gravels. The coal is worked by means of "slopes" following the dip of the seams. In the workings which were open in 1885 the dip is westward at an angle of from 20 to 25 degrees. The main slope had been excavated, following the inclination of the strata, for about 300 feet, and exposed sections of two coal seams, both of which are irregular in thickness, owing to disturbances along small faults. Three principal faults were exposed at the time of my visit, all remarkably uniform in strike and hade, and in the direction in which the fault blocks had been tilted. The displacement amounted to 5 or 6 feet in each instance, and the fault planes are inclined eastward at angles of from 60 to 70 degrees with a horizontal plane. Each of the fault blocks is tilted at an angle of 20 to 30 degrees toward the northwest. At the bottom of the slope another fault of greater magnitude was encountered, the hade of which is westward at an angle of 20 to 30 degrees. Along each line of faulting the coal had been pinched out to a mere "stringer" of comminuted and slickensided fragments. The fracturing and crushing were so complete near the lines of disturbance that the fragments of coal and associated shale are intimately mingled, much to the detriment of the former. In many cases the slickensided fragments, measuring an inch or two in diameter, can be removed with the hand.

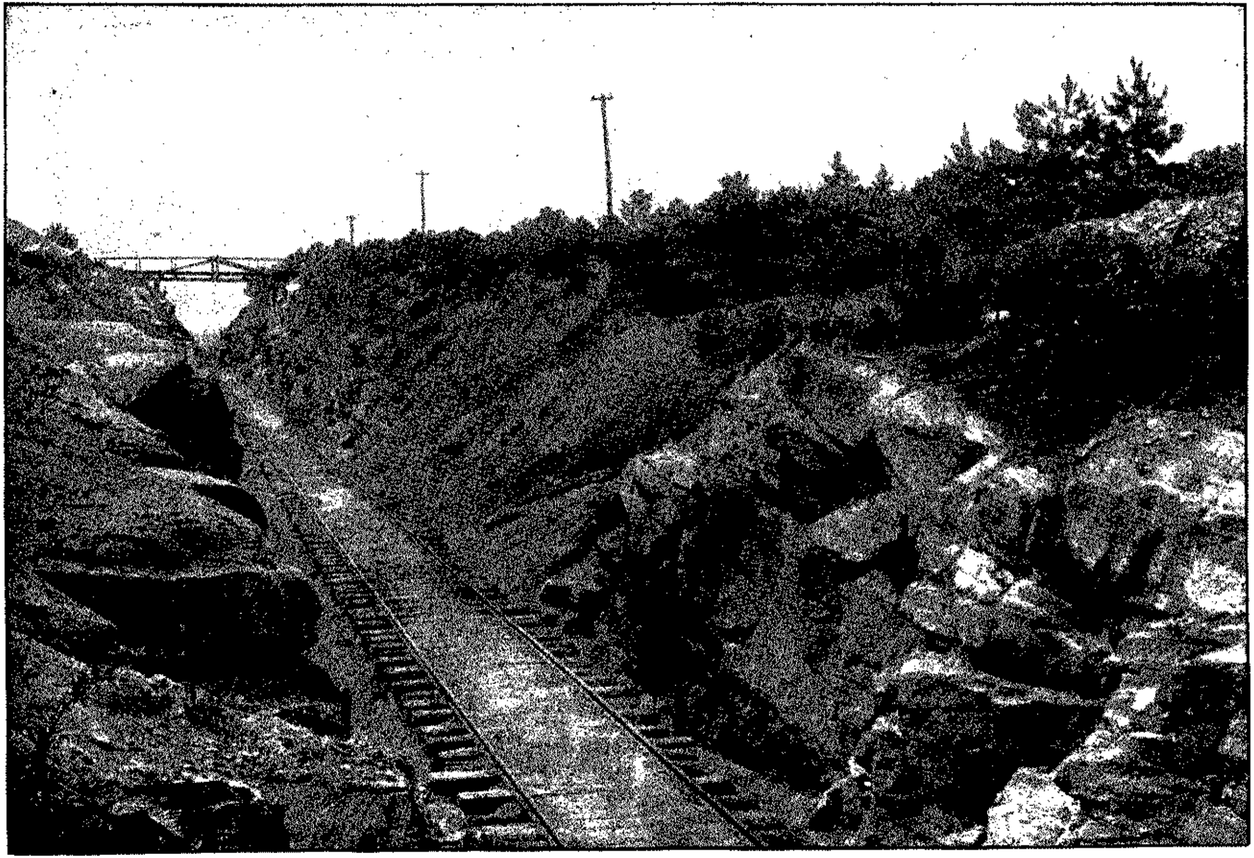
Owing to the drag of the strata on the thrown side of the faults, the dip of the beds seems to be in opposite directions from the lines of displacement, and decreases in inclination a few feet distant. This occurrence has led the miners of this district to apply the term "roll" to these disturbances. In some instances it was apparent that motion had taken place throughout a belt of comminuted and slickensided fragments or "fault rock," several feet broad, thus rendering it impossible to indicate a precise line of fracture.

These displacements are accompanied by a thinning of the coal adjacent to the planes of fracture and a thickening in the central portion of the fault blocks. This phenomenon has been observed in many other mines in the Richmond area and is probably the explanation of the great thickness reported in some of the coal seams along the eastern margin of the area and in detached basins adjacent thereto.

East border of the area.—In the neighborhood of Midlothian there is a double line of coal outcrops separated by a strip of crystalline rocks having a breadth of approximately 2,000 feet. The western line of outcrop marks approximately the boundary of the main coal field, while the eastern line is formed by coal seams in detached basins. Mining in this region has demonstrated that there are at least two separate basins in the outlying strip of coal-bearing rocks. These are the Black Heath and Green Hole areas, widely known during early mining operations in Virginia. Other small areas are indicated on some maps as falling in line with these, but whether they form separate basins or not is uncertain. So far as the dominating structure of the region is concerned, all of these small local areas may be considered as one.

In the eastern border of the main area at Midlothian the strata, although disturbed by many small faults, are inclined westward at an angle of between 15 and 20 degrees. In the outlying local basins the strata are reported to be inclined from each side toward the center, so that each stratum forms two parallel lines of outcrop. It is also reported that the coal seams are thin along their outcrops and thicker in the central part of the basins. The structure of these basins was not accurately recorded during the time that coal was being removed and it is now impracticable satisfactorily to renew their study. From such observations as I was able to make, aided by the writings of Lyell and the verbal reports of miners who helped to win the coal, I judge that the strata dip to the westward, but that the softer layers, including the coal, were dragged along the plane of faulting and thus simulate a sharply folded synclinal. The fault which cut off the basins follows their western border and hades eastward.

The small detached area in which the Deep river mines are situated, north of the James and about 3 miles east of the east border of the main area, is another illustration of the occurrence of a narrow strip of Newark rocks occupying a detached fault basin. The main fault to which this little area owes its depression, and consequent preservation, follows



BOGAN'S CUT, NORTH CAROLINA, LOOKING WEST.

its west border. The bluff of crystalline rocks overlooking it on the west is in reality the heaved side of the fault, the strike of which is about northeast and southwest and the hade eastward. In this area, as in the Green Hole and Black Heath basins, some of the soft strata appear to have parallel lines of outcrop. The line of supposed outcrop along the west side of the basin, however, is due to the drag of the coal and associated shales along the fault plane. As in similar basins south of the James, the coal is thin at the outcrops and thickens in the center of the fault blocks. As in the areas mentioned above, the structure simulates an abruptly folded synclinal, with strata thickening in the center. The coal in this area is much broken and slickensided, and secondary faults were encountered during mining operations. The roof of shale above the coal is in many places a mass of comminuted and slickensided fragments, which in some instances during mining operations flowed out from openings like so much gravel. Here, as elsewhere in the secondary areas and in the bordering outcrops of the Richmond coal field, the difficulties and uncertainties of mining were greatly enhanced by the faulting and crushing that the strata had suffered.

At Clover hill, in the southern part of the eastern border of the Richmond coal field, coal has been mined for a long series of years. In 1885, this was the only point at which active mining operations were being carried on. The "incline" which was being worked followed the slope of the coal seams for about 250 yards. The dip of the strata is northwest 20 to 35 degrees, and the strike S. 10° 30′ W., agreeing very nearly with similar measurements at Midlothian. At the date mentioned, mining operations were limited on the west by a fault, striking about north and south, the throw of which was undetermined but exceeds 50 feet. In the mines there are several minor faults, parallel to the one on the west, some of which have a displacement of 40 to 50 feet. The structure, although seemingly more regular than the Midlothian or Norwood, is essentially of the same character; that is, the rocks are faulted, but the strata in each fault block return with remarkable persistency to about the same dip.

A marginal fault along portions of the east border of the Richmond coal field, which brings the broken edges of the Newark strata in direct contact with the surrounding crystalline rock, has been determined. A cross fracture is indicated by a break and offset in the line of coal outcrops just east of Midlothian. The tongue of crystalline rock penetrating the main Richmond area at the extreme northern end, as shown on Pl. v, seems also to be due to a fault which has brought up the crystalline floor on which the Newark rocks rest. The actual presence of such a fault, however, has not been demonstrated by observation.

Failures in mining due to geological structure.—It is safe to say that a large part of the failures which have attended the working of the coal in the Richmond coal field are due to the faulting and crushing that the rocks have suffered. Mining has been attempted only along the immediate borders of the main area and in the small secondary basins, that is, in localities where the greatest amount of disturbance has occurred. The central and undisturbed portion has never been explored. A few drill holes midway between Midlothian and the Old Dominion mine would demonstrate whether the coal in the central portion of the field is sufficiently thick and of such a quality that it would repay mining at the considerable depth at which it occurs. While the central portion of the field is practically without faults, it is possible that it is traversed by sheets and dikes of trap, the effect of which on the coal, whether to decrease or increase its value, can not be predicted.

Absence of oil and gas.—Although mining in the Richmond coal field has been retarded by the escape of natural gas and by spontaneous combustion, the fact that it has been penetrated by mines and drill holes without developing any reservoirs of oil or gas of economic importance must be considered as sufficient evidence that such deposits do not exist. The broken condition of the strata and the attitude in which they occur are in themselves sufficient indication that reservoirs of oil and gas need not be looked for.

STRUCTURE OF THE DEEP RIVER AREA.

The most usual dip of the strata in this area is southeast at an average angle of perhaps 15 degrees. Faults are exposed in several of the excavations along the railroads crossing the area, and changes of dip occur adjacent to many of the trap dikes which break through the stratified beds, indicating that they were intruded along displacements.

On the east side of the area, near Carey, and again on the west border, a mile or two north of Egypt, there are notches in its outline which probably indicate the presence of faults. The junction of the Newark rocks and the adjacent crystalline rocks of the eastern border, where it is crossed by the Piedmont Air Line Railroad, 1½ miles west of Carey, is well exposed. The Newark strata at the junction consist of a coarse, brecciated conglomerate, dipping westward and resting on the crystalline terrane from which they were derived. These coarse beds belong to the basal conglomerate of the series, and agree in all essential features with the same stratum where exposed along portions of the west margin of the same area and in adjacent secondary areas. The most remarkable evidence of faulting in this region is furnished by a narrow strip of Newark strata adjacent to the west border of the main area, immediately west of Lockville. The trend of the axis of this outlier is parallel with the margin of the main area, and distant less than a mile from it. In the central part of the strip the strata dip a little east of north at an angle of 20 degrees. On the west side of the area, and resting on crystalline rocks, is the coarse basal conglomerate of the Newark.

FAULT IN BOGAN'S CUT, NORTH CAROLINA.

On Kerr's[1] geological map of North Carolina, three small detached areas of the Newark system are represented as occurring about 20 miles east of the eastern border of the main area and 10 miles south of Raleigh, but no observations on the character or structure of these outliers are known.

Without entering into a detailed account of observations made by the writer in the Deep river area, it may be stated that the evidence throughout is decidedly in favor of the prevailing fault structure. There is an absence of anticlinals and synclinals, and also an absence of a continuous monoclinal dip throughout the area, as has been stated.

STRUCTURE OF THE WADESBORO AREA.

In this, as in the Deep river area, the prevailing dip is southeast, but there are many exceptions in which the inclination is reversed along lines of displacements or adjacent to trap dikes. There are also outlying or secondary areas that still further illustrate the fault structure of the region.

The best section obtained in this area, and perhaps the most instructive that can be found anywhere in the Newark system, is exposed along the Carolina Central railroad from Lylesville westward through Wadesboro, to the western margin of the area. The width of the Newark rocks along this line, including two tongues of crystalline rock penetrating the sedimentary series from the north, is about 16 miles. The section referred to above, as measured during my reconnaissance in 1885, is shown on Pl. IX. On the same plate is a more detailed section of a portion of the general section, in which the characteristic structure of the Newark system is well illustrated. West of Lylesville for about 1 mile the rocks are granitic and deeply decomposed. Bordering the granite on the west are the Newark beds. The Newark strata adjacent to the eastern border of the area are composed of the débris of granitic rocks, plainly derived from the crystaline area on the east. At the immediate eastern end of the Newark section there are certain structureless, mottled clays, which were apparently deposited above the Newark strata and may possibly belong to the Potomac formation; but the relations of these deposits have not been satisfactorily determined. The dip of the Newark beds for about a mile westward from the eastern margin, as shown on the accompanying sections, is westward at angles varying from 10 to 20 degrees. The dip then changes abruptly near a trap dike, and the strata are inclined southeastward at an angle varying from 15 to 25 degrees. This general inclination prevails all the way across the remainder of the section until the crystalline rocks interrupting the continuity of the Newark beds just east of Browns creek are reached.

In this section over fifty trap dikes were observed, ranging from a few inches to over 50 feet in width, and at least fourteen displacements

[1] In Rep. Geol. Surv. of North Carolina. Raleigh, 1875.

of considerable but usually undetermined throw were noted. As the rocks were seen for less than half the distance included in the section, there being no exposures where the railroad is constructed by filling, it is probable that less than half the dikes and faults that exist have been seen. The most typical as well as the best exposed portion of this section is in Bogans cut, about 3½ miles west of Wadesboro, which is indicated at the bottom of Pl. IX. In this cut there are four well exposed faults, besides abrupt changes in the inclination of the strata adjacent to the trap dikes. The displacements in each instance have a throw of less than 50 feet, and with one exception are normal faults, hading westward. The exception is a reversed fault, as shown in the section, a photograph of which is reproduced in Pl. XII. Comminuted rock occurs along the immediate plane of the fault, and a triangular block of sandstone is included in it. The structure in Bogans cut is rendered unusually plain by the contrast of reddish brown shales and gray sandstones brought into abrupt contact by the displacement. The fault planes in each instance are smooth and slickensided; the striations on the smooth slopes record vertical movements.

A mile and a half west of Bogans cut the basal conglomerate of the Newark system comes to the surface with an easterly dip of about 25 degrees, and rests on crystalline strata. West of this junction the crystalline rocks are well exposed for nearly a mile to the eastern border of the valley of Browns creek. There is then an unexposed area about a mile broad occupied by flood plain deposits, but it is probably underlain by Newark strata. On the west border of the flood plain the Newark system again appears, dipping eastward at a high angle, and continues to be again exposed occasionally for 2½ miles along the railroad. In this portion of the section the rocks are shales and sandstones, traversed by many trap dikes and broken by several faults. The basal member of the series again appears, as shown on Pl. IX, with an easterly dip of about 40 degrees, and resting upon metamorphosed rocks. West of this junction the metamorphosed rocks form the surface for about 300 feet, when the basal conglomerate again appears, this time dipping westward at an angle of about 20 degrees. A fault between the Newark strata and the metamorphosed rocks is here plainly indicated by a band of comminuted fragments. The conglomerate on both sides of the upthrust slates is composed of the same rock in rounded and angular masses, and was evidently of local origin. West of the last exposure of the basal conglomerate, the characteristic shales and sandstones of the Newark system continue to be exposed westward along the railroad for several hundred feet. The crystalline rocks then begin and continue indefinitely.

In the section just described the basal conglomerate is exposed four times by faulting. There are also, as we have seen, many faults not of sufficient vertical extent to bring up the basal member of the system. The disturbances that the rocks have undergone are still further illustrated by the great number of trap dikes penetrating them.

FAULT IN BOGAN'S CUT, NORTH CAROLINA.

The Wadesboro area as a whole is depressed below the level of the surrounding plateau of crystalline rocks, thus indicating that the rocks composing it are more easily eroded than the surrounding terranes. When the crystalline rocks penetrate the Newark area, they form bold hills and by their relief enable one to judge of the structure of the rocks beneath. South of Bogans cut, near Whites store, there is a high north and south ridge composed of crystalline rocks traversing the Newark system, which is probably the upheaved side of a fault and may be an extension southward of the ridge which appears on the west side of Browns creek farther north.

The structure of the Wadesboro region is still further illustrated by two small outlying areas belonging to the same system. These are situated to the eastward and are indicated on Kerr's geological map of North Carolina. These were examined by the writer in 1885 and are supposed to occupy fault basins, as in the case of the numerous outlying areas previously noted. The first of these visited is about 3 miles east of the eastern border of the main area in the valley of Mountain creek. It is between 2 and 3 miles long from north to south and perhaps a quarter of a mile broad. The dip of the strata is in general southeastward at an angle of 10 degrees. South of this, and about 4 miles west of Rockingham, is another similar area, separated from the main area by about 8 miles of crystalline rock. In this intervening belt there are trap dikes identical with the numerous dikes of the Newark system, and in the Rockingham area there are other dikes of the same character. The area near Rockingham is nearly 2 miles broad, with possibly a ridge of metamorphosed rocks in the center, and coarse conglomerate is exposed along its western border. The strata above the conglomerate are normal sandstones and shales dipping eastward 15 degrees.

My notes show many other details of structure which are in harmony with the general conclusions presented above, and strengthen the hypothesis that the Wadesboro area, like others in the system to which it belongs, is characterized by diverse monoclinal structure due to the tilting of faulted blocks.

SUMMARY.

The brief account given in this chapter of our present knowledge of the structure of the Newark system, shows that it is monoclinal throughout. The structure is due to a fracturing of the rocks along lines having in general a northeasterly and southwesterly trend, and a tilting and perhaps overthrusting of the included blocks. In many instances the fault blocks are inclined in a uniform direction, and when the similarity in strata renders it difficult to detect repetitions, the system appears to be a continuous mass of vast thickness. Some of the faults observed are of sufficient magnitude to bring to the surface the crystalline or Paleozoic rocks on which the system rests. Others expose the basal conglomerate, but the greater number are small, and owing to the similarity of the strata affected by them are difficult and many times impossible to trace.

While faults are numerous, pronounced folds are absent. Broad, gentle undulations do occur, however, especially in the broader areas, and in the Connecticut valley and New Jersey, explain in part, the curvature of the outcrops of some of the trap sheets.

An examination of the entire system shows that faulting is as important an element in the structure of the Atlantic coast plain as it is in the Great basin. These two regions have this important difference, however: In the Great basin the fault scarps stand in relief and form mountain ranges, while along the Atlantic coast the relief has been subdued by erosion, and for the most part a featureless plain takes the place of the mountain uplifts that would otherwise appear.

It is to be supposed that the faults traversing the Newark rocks are but a portion of a great system which affects a large part, and perhaps the entire region of metamorphic rocks, in the midst of which remnants of the Newark system have been preserved.

ORIGIN OF FAULT STRUCTURE.

The only hypothesis that has been advanced in explanation of the characteristic fault structure of the Newark system was proposed by Davis,[1] in discussing the deformation of the rocks of that system of the

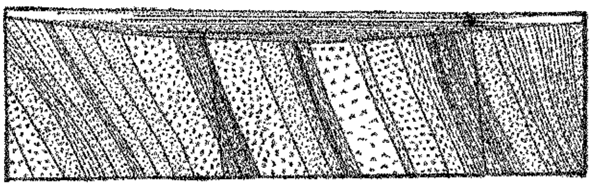
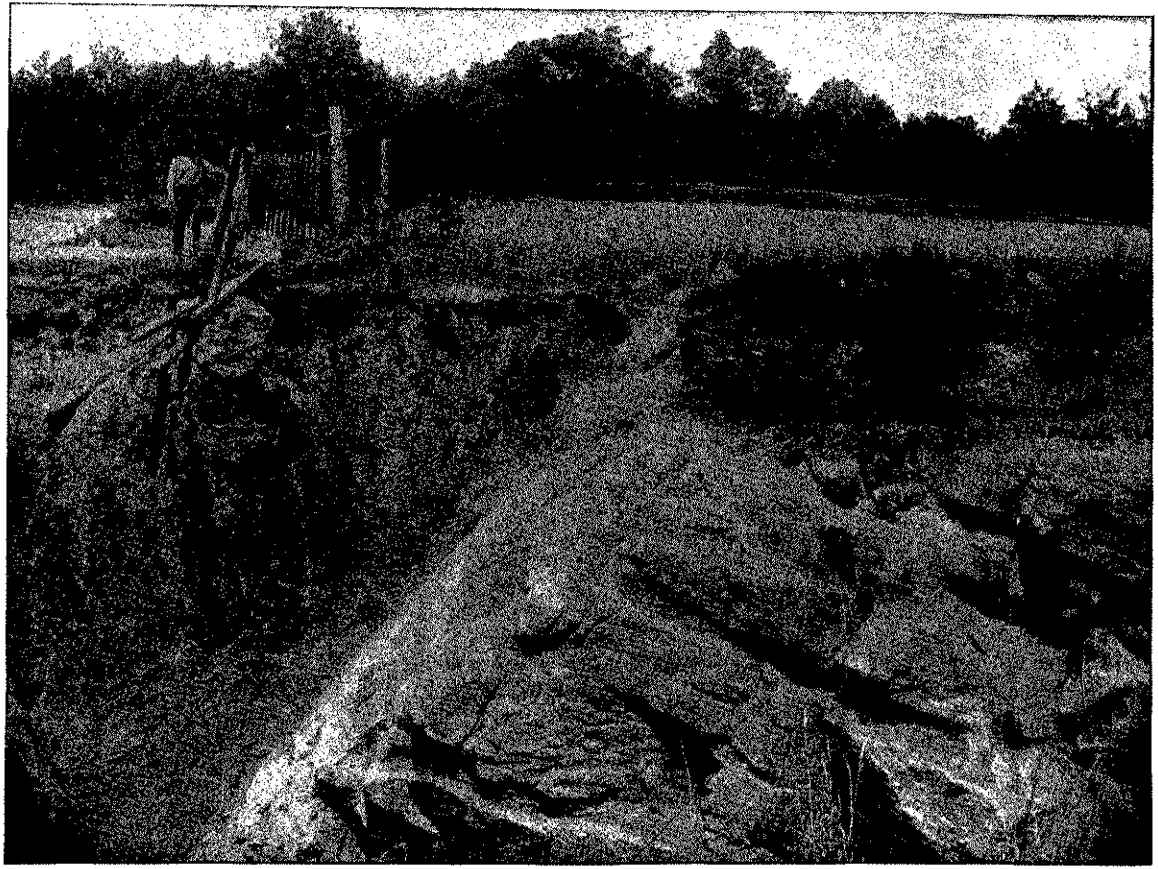


FIG. 3.—Ideal east and west sections of Connecticut valley area previous to deformation.

Connecticut valley. Starting with horizontal Newark strata deposited on the truncated edges of highly inclined crystalline beds, Davis shows that a force of compression, acting at right angles to the bedding of the crystalline rocks, would increase their inclination and cause the beds of which they are composed to slip one on another. The eroded surface forming the floor on which the Newark beds rest would thus become faulted along lines of strike. The faults would be carried upward through the superjacent stratified beds, and produce a series of monoclinal fault blocks, the prevailing dip of which would be in one direction.

This explanation will be readily understood by reference to the accompanying diagram (Fig. 3), copied from Davis's paper already referred to, in which the Newark strata of the Connecticut valley are shown in the attitude they held up to the initiation of their present structure. Two dikes have been introduced, one on the left to show the supposed source

[1] U. S. Geol. Surv., 7th Ann. Rpt., 1885-'86, Washington, 1888, pp. 486-490.



FAULT IN BOGAN'S CUT, NORTH CAROLINA.

of the intruded trap sheets, and one on the right to explain the successive overflows of trap that appeared at times during the depression of the Connecticut valley area and the accumulation of the Newark strata. Deposition is supposed to have continued as long as depression was in progress, but was stopped when the fundamental schists began to be affected by lateral compression. The compression caused the strata in the schist to slip one on another, thus increasing their dips, and in some instances carrying them over beyond the vertical.

The result of the compression and slipping of the schistose layers, as postulated above, on the stratified beds resting on them is shown in Fig. 4. The slabs in the underlying schists are separated by faults, and their beveled edges are canted over at an angle equal to their change of dip. The overlying beds, unable to support themselves on this uneven floor, have been broken into fault blocks and tilted in a uniform direction.

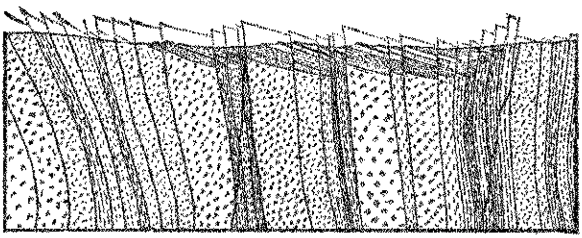


FIG. 4.—Ideal east and west section of Connecticut Valley area after deformation.

The occurrence of reverse faults has also been considered by Davis, and their origin explained by a curvature of the underlying schistose strata in place of the more regular bedding previously indicated, as shown in the following diagram:[1]

This attractive hypothesis finds some support outside of the Connecticut valley area, in the fact that the strike of the numerous faults in the Newark rocks south of Connecticut, is in a general way parallel with the trend of the strata in the associated crystalline rocks. The actual tracing of faults, however, from the Newark area into the adjacent crystalline, has not been done. The most favorable locality for continuing the study is unquestionably the Wadesboro area, where the structure of the crystalline floor beneath the Newark system can be determined with some degree of accuracy, and the conditions for tracing faults from stratified to crystalline rocks are better than in any other area.

As shown in a preceding section of this paper, a general study of the structure of the Newark system should include the consideration of the origin of the trap dikes and sheets which traverse it. Like the faults,

[1] For a more recent discussion of the structure of the Connecticut valley area see an article by J. D. Dana, On Percival's map of the Jura-Trias trap belt of central Connecticut, with observations on the upturning or mountain-making disturbance of the formation. Am. Jour. Sci., 3d ser., vol. XLII, pp. 439–447, Pl. XVI.

these are due to a disturbance and breaking of the strata. While it is highly probable that the faulting and injection of igneous rocks are portions of the same process, yet this has not been proved. It may be presumed, if the subsidence of the region of accumulation in Newark times was due to displacements, as is suggested by marginal faults along the borders of certain of the areas, that the contemporaneous overflows of igneous rock came to the surface through fissures thus formed. Subsequent faulting may have been accompanied by the injection of dikes and intrusive sheets. If such an association of faults and trap rock can be shown it follows, on the hypothesis of the origin of the faulted structure proposed by Davis, that the trap dikes in the crystalline area should follow lines of bedding. Observation in this connection is very incomplete; but so far as is known the dikes referred to do not follow the lines of bedding, but cross them in an irregular manner.

CHAPTER IX.

FORMER EXTENT.

Considerable diversity of opinion has arisen concerning the original extent of the rocks of the Newark system. The conclusions of geologists in this connection fall in two groups: First, those implying that the present detached areas of the system are local deposits which were originally but little, if any, greater than at present; second, those implying that the detached portions of the system as they now exist are remants of terranes much larger than any of the areas now remaining, a very large and perhaps the greater part of the original deposits having been removed by erosion. For convenience the common element of the first group of explanations will be called the *local-basin hypothesis*, and that of the second group the *broad-terrane hypothesis.*

THE LOCAL-BASIN HYPOTHESIS STATED.

This hypothesis has been advanced more or less definitely by a number of writers.

In describing the rocks of the Newark system about the Bay of Fundy, Dawson[1] states that when they were deposited, the form and contour of the country already made some approach to what it still retains, and that the sedimentary strata were deposited in a bay coinciding with the present Bay of Fundy, but a little wider and larger.

The Connecticut valley area and the much larger New York-Virginia area are also considered by a number of geologists as representing about the original boundaries of the estuaries or lakes which became filled with sediment during the Newark period.

This view is expressed by Newberry[2] in an essay on the geological history of New York, island and harbor, in the following language:

> The trough between the New York axis and the Blue Ridge was occupied by water, and in this trough the Triassic [Newark] shales and sandstones were deposited. A similar trough east of New York, where now is the valley of the Connecticut, was also a lagoon or estuary in which similar sediments accumulated.

These conclusions are again stated in a recent monograph of the fossil fishes and fossil plants of the rocks under consideration.[3]

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[1] Acadian Geology, 3d. ed., 1878, pp. 86, 87.

[2] Pop. Sci. Monthly vol, XIII, 1878, p. 644.

[3] U. S. Geological Survey, Mon., vol. XIV, 1888, p. 6.

Somewhat similar conclusions have been reached by Davis,[1] and may be found in his recent contribution to the study of the structure of the Connecticut valley region.

The most definite statement of the local-basin hypothesis that has been published is Emerson's graphic description of the condition of the Connecticut valley at the time it received its filling of sandstone:[2]

If one will picture the broad valley [of the Connecticut] from Pelham across to Westhampton [Massachusetts] as a half mile deeper than the present river, and imagine the rocky surface of the upland as half a mile higher than now, with the canal-like channel filled by the fiord waters to a height above the level of Mount Holyoke, while the bordering streams swept sand and gravel into the basin and strong currents spread the material over its bottom, he will have a rude outline of Triassic [Newark] times in the valley.

The picture suggested by this clear description is of a plateau region cut by a profound canyon a mile in depth, where now the Connecticut flows.

Percival[3] remarks that the two Newark areas of Connecticut are of a local, isolated character, each forming a complete system in itself, and apparently independent of any more extensive formation.

Dana[4] has expressed the opinion that the Connecticut valley was an estuary during the Newark period, and had its violent floods, which may have been for a part of the time enlarged by the water and ice of a semiglacial era. J. Le Conte[5] also considers the Connecticut valley to have been a restricted basin during the Newark period.

The small Newark areas in Virginia and North Carolina, which contain coal, have been regarded as owing their origin to the filling of local basins which were swamps during portions of the Newark period.[6]

Similar opinions have been expressed more or less definitely by other writers, but without making further quotations I will attempt a general statement of the local-basin hypothesis:

During the Newark period the Atlantic border of the continent was about in its present position, and the land had about its present relief. Then, as now, there was a Piedmont plain, and in this plain there were long, narrow basins, formed in the region of the Connecticut by erosion, apparently, but in the other cases probably by orographic movement, which held lakes, or being connected with the ocean, formed estuaries, fiords, etc. Into these basins the debris from the adjacent land surface, composed of crystalline rocks, was carried and deposited. Since the filling of the basins the strata accumulated in them have been tilted, but beyond this there has been no pronounced orographic movement and no very considerable amount of erosion.

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[1] U. S. Geological Survey, Seventh Ann. Rept., 1888, pp. 461–462.

[2] In Gazetteer of Hampshire county, Massachusetts. [From] 1654–1887. Compiled by W. B. Gray, Syracuse, New York. [1888] p. 18.

[3] Rept. Geol. of Connecticut, 1842, p. 430.

[4] Am. Jour. Sci., 3d ser., 1879, vol. XVII, p. 330.

[5] Elements of Geology, 2d ed., 1882, p. 453.

[6] Richmond Coal Fields, Virginia, by W. Clifford, Manchester [England] Geol. Soc. Trans., vol. XIX. 1888, p. 333.

THE BROAD-TERRANE HYPOTHESIS STATED.

The former connection of various Newark areas south of New York was implied in the explanation of the origin of the prevailing dips exhibited by these rocks in New Jersey and Pennsylvania, advanced by Rogers,[1] in 1840. This author states that the rocks referred to seem to have originated in a long, narrow trough, which had its source as far south at least as the eastern base of the Blue Ridge in Virginia and North Carolina, and probably opened into the ocean somewhere near the present position of the Raritan and New York bays.

The former extension of the rocks of the Newark system beyond the boundaries of the areas now remaining, although suggested by Maclure[2] as early as 1817, seems to have been first clearly indicated by Kerr,[3] who sought to explain the opposite dips of the rocks of the Deep river and Dan river coal fields of North Carolina on the hypothesis that the two areas were formerly united and owe their separation to the upheaval and erosion of the belt of country between them, the portions remaining being in a general way of the nature of bordering or basal remnants of a great anticlinal.

The union of the various areas south of New York, in which sediments were deposited during the Newark period, into one great estuary having its capes at Trenton, New Jersey, and Manhattan Island, New York, has been suggested by Lesley.[4]

The hypothesis proposed by Kerr in reference to the former union of the Deep river and Dan river coal fields, was received with favor by Bradley,[5] who extended it to the Connecticut valley and the New York-Virginia areas. Some arguments tending to show that the rocks of the Newark system in New Jersey and in the Connecticut valley were originally connected were advanced by the present writer several years ago, and need not be restated.[6] The various areas of the Newark system in Virginia, according to Heinrich,[7] were formerly connected, and their continuity was broken by a slow and unequal movement of the floor of crystalline rocks on which they were laid down, accompanied by the erosion of the elevations thus formed.

Briefly stated the broad-terrane hypothesis claims that the various areas of the Newark system now remaining are remnants of much broader terranes, and that many and perhaps all of them were originally united. More than this, the hypothesis implies that marked orographic movements, accompanied by upheaval, faulting, and diking, have affected the beds since they were deposited, and that they have suffered very greatly from erosion.

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[1] Description of the Geol. of New Jersey, final report, Philadelphia, 1840, 12mo., p. 115.
[2] Observations on the Geology of the United States, Philadelphia, 1817, p. 41.
[3] Rep. of the Geol. Surv. of North Carolina, vol. I; Raleigh, 1875, p. 141.
[4] Cited in Coal Regions of America, by J. Macfarlane, 3d ed., New York, 1877, p. 512.
[5] Am. Jour. Sci., 3rd ser., vol. XII, 1876, p. 289.
[6] New York Acad. Sci., Ann., vol. I, 1878, p. 220-244; also in Amer. Nat., vol. XIV, 1880, pp. 703-712.
[7] Am. Inst. Mining Eng., Trans., vol. VI, 1879, pp. 227-274.

With this brief statement of the case let us endeavor to determine on what facts the two hypotheses rest.

EVIDENCE FAVORING THE LOCAL-BASIN HYPOTHESIS.

No definite statement of observations tending to show that the various areas of the Newark system did not extend much beyond their present boundaries has been made and perhaps should not be expected. That the various areas are now isolated, and are formed of débris derived from crystalline rocks of the same character as those now bordering them, seems to be all the direct evidence there is that they were originally deposited in independent basins.

In reference to the Connecticut valley area, W. M. Davis states that "its original area was greater than at present, as there has been demonstrable loss by marginal erosion, but it is generally thought that the loss has not been very great." In continuing the discussion he says:[1]

> We are not, however, confined to this conclusion by a very strong line of argument. The rapid change from finer standstones and shales which generally appear in the central part of the formation to the coarse sandstones and conglomerates that characterize the margin is usually cited as implying a narrow limitation of the area of the deposits, but it is not yet demonstrated that the finer central strata are the equivalents of the coarser marginal layers. The latter may mark localities on the advancing shore during submergence that were favorable to the formation of coarse deposits, while the former may correspond to a later date of more general submergence; moreover, in some cases the finer shales approach close to the present margin of the formation. No isolated outliers of the formation have yet been discovered, unless the little Southbury-Woodbury area in western Connecticut be so regarded, but the region around the area that is still covered by the Triassic [Newark] rocks has been elevated to an altitude and during a time sufficient to have suffered much loss by post-Triassic erosion. The general freedom of the same surrounding region from the igneous rocks so closely associated with the Triassic formation in its various areas along the Atlantic slope may also suggest its escape from Triassic submergence; but in our present state of knowledge concerning the cause of this peculiar association it can hardly be employed in this argument. It therefore does not seem impossible that the original Triassic area may have been much larger than the present, but the burden of proof lies clearly in those who would contend for what now appears to be so far beyond the necessities of the case.

EVIDENCE FAVORING THE BROAD-TERRANE HYPOTHESIS.

The data on which this hypothesis rests have been presented in the preceding pages, and although it is not necessary to reassemble it, we may designate the classes into which it naturally falls. *First.* The stratigraphic incompleteness of all of the Newark areas now remaining. *Second.* The presence of marginal faults which have determined the limits of some of the areas in certain directions. *Third.* Evidence of great erosion since the Newark rocks were deposited.

It is well known that when water basins become filled by sediment

[1] Seventh Ann. Rep. U. S. Geol. Survey, 1888, pp. 461–462.

washed in from the shores, the material deposited has an orderly arrangement, the coarser portions being dropped near shore, while the finer portions are carried farther out. The slow subsidence of a basin which is being filled in this way would result in the formation of a basal conglomerate with layers of fine sediments superimposed upon it. A horizontal section of such a deposit taken at any horizon above the basal conglomerate first laid down would show a central area of fine material surrounded by a fringe of coarse detritus.

In no instance in the various Newark areas now remaining does such an arrangement appear. Along portions of the margins of some of the areas referred to coarse deposits are found, but in other parts of their borders the rocks are fine grained and of the nature of off-shore deposits. The necessary conclusion seems to be that the terranes now remaining do not represent the original extent of the deposits at any stage.

The presence of faults along the margins of several of the Newark areas show that their present limits have, in part at least, been determined by displacement and subsequent erosion. The marginal faults referred to frequently bring fine grained Newark rocks in direct contact with bordering areas of crystalline rock, thus proving conclusively that the original extent of the sedimentary beds was beyond the limits indicated by this present outcrop.

Evidence of great erosion since the Newark period is furnished by the topographic relief of the outcropping edges of intruded trap sheets, which were originally forced in among the sedimentary beds and cooled far below the surface. Since their intrusion, the system has been tilted and reduced nearly to a base level by subærial erosion. To bring about the conditions now prevailing very large portions of the original deposits must have been removed.

The occurrence of soft strata of shale and sandstone dipping in one uniform direction over large areas, which are now nearly at base level, demonstrates that much erosion has taken place. The amount of this erosion can not be quantitatively determined, but I think that every geologist who has studied the matter will agree with me that many hundreds and possibly thousands of feet of strata have been removed from the areas in question. This again implies that the areas now occupied by the system are remnants of the original deposits.

The Potomac formation rests unconformably on the Newark, the unconformity being due to the erosion of the lower rocks previous to the deposition of younger beds upon them.[1] There is also evidence that the Newark rocks were again exposed to erosion previous to the deposition of the Cretaceous. Another elevation of the Atlantic sea border, followed by a reduction to base level, followed the deposition of the Cretaceous rocks, and removed them from large areas now occupied by the

[1] Three formations of the Middle Atlantic Slope, by W. J. McGee. Am. Jour. Science, 3d series, vol. XXXV, 1888, p. 135.

Newark system, as has been quite clearly demonstrated by Davis.[1] During these various stages of erosion when the country, occupied in part by the Newark system, was being reduced again and again by sea level after upheavals, all of the Newark rocks above the horizon of base-level erosion were cut away. The port ons now remaining appear to owe their preservation, as previously stated, to their having been depressed along lines of displacement below the horizon at which subærial agencies could act.

The considerations mentioned, and some others which are more difficult to state briefly—as the relations of drainage on the Atlantic slope to the Newark areas, and the absence of overflow of volcanic rock on crystalline and Paleozoic terranes surrounding the islands occupied by the Newark system—all tend in one direction, and furnish cumulative evidence tending to show that the Newark rocks were formerly much more extensive than at present, and that many of them must have been united.

OBJECTIONS TO THE BROAD-TERRANE HYPOTHESIS.

Although the broad-terrane hypothesis has met with but a limited number of adherents, only a few specific objections have been made to it.

Newberry[2] observes that it seems scarcely probable that some thousands of feet of Triassic [Newark] rocks, including thick beds of hard and resistant trap, should have been so completely carried away from the interval of 100 miles now separating the Connecticut valley and the New York-Virginia areas that not a trace of them should anywhere be left. It should be borne in mind, however, in this connection, that an outlier—the Southbury area—does exist in the interval mentioned. This area is shown on Pl. III. It is situated 16 miles west of the west border of the Connecticut valley area, and probably owes its preservation to its having been depressed below the plane of base-level erosion to which the country has been reduced and to the numerous sheets of trap which traverse it. Whether other trap sheets existed in the interval mentioned is not known, and but scanty suggestions that such was the case can be derived from such studiesof this area as have been made.

It is implied in the objection cited above, that trap rock is much more difficult of erosion than the sandstones and shales with which it is associated in the Newark system. Under such climatic conditions as now prevail in Virginia and North Carolina this is not the case. The trap dikes are there deeply decayed, and frequently so soft, even at a depth of 50 feet from the surface, that they can be molded in one's fingers like potter's clay. Instead of forming prominent ridges their presence is not indicated in the relief of the country.

Not only are dikes under certain conditions easy of erosion, but it is

[1] The Geographical Development of Northern New Jersey, in Boston Soc. Nat. Hist. Proc., vol. XXIV, 1889, pp. 265-427.

[2] The Geol. Hist. of New York Island and Harbor. Pop. Sci. Monthly, vol. XIII, 1878, p. 646. Also U. S. Geol. Survey, Monograph vol. XIV, 1888, p. 6.

an accepted principal in geology that the amount of erosion in any region depends on time and opportunity rather than on lithological conditions. Were the rocks of the Newark system, including thick sheets of trap, elevated sufficiently to secure rapid transportation, their erosion would be certain. The laws of subærial decay and erosion apply to hard as well as to soft rocks; the length of time required for the removal of hard beds is great, but is not infinite.

The Cretaceous rocks of Long Island, it has been observed by Newberry,[1] rest directly on the crystalline schists, with no trace of the Newark system between. It is claimed that "this would indicate that the Trias [Newark] of the New Jersey basin never reached over that portion of the divide."

On a previous page of this paper I have cited evidence which shows that the rocks of the Newark system were upheaved and eroded to a base level before the deposition of the Potomac formation or the Cretaceous. Beneath portions of the Cretaceous of New Jersey, near its western border, as has been shown by Cook,[2] only a few feet of Newark sandstones and shales intervene between the Cretaceous and the crystalline rocks. This remnant is of fine material, not a coarse shore deposit. The absence of the Newark system in a similar position on Long Island seems clearly to indicate that the pre-Cretaceous erosion was there a little more complete than at the locality referred to in New Jersey.

The conclusion that there was a line of elevation through New York, Trenton, etc., after the Newark period and before the deposition of succeeding formations, certainly seems to be warranted from our present knowledge of the region. That this line of elevation has undergone post-Cretaceous movement is indicated by the present attitude of the Cretaceous beds.

CONCLUSION.

My conclusion from a study, not only of the writings of all who have published on this subject, but from personal observation, is that each of the Newark areas was originally much larger than now, and that there is a strong probability that all of the areas between Massachusetts and South Carolina were originally united. It is quite possible, also, that this great area was connected with the Acadian region, but observations to support this hypothesis are wanting.

[1] U. S. Geol. Survey, Monograph vol. XIV, 1888, p. 6.

[2] U. S. Geol. Survey, Monograph vol. IX, 1885, p. x. See also record of wells at Perth Amboy, N. J. Geol. Survey of New Jersey, Ann. Rep. for 1885, p. 111.

CHAPTER IX.

CORRELATION.

GENERAL PRINCIPLES.

The phenomena by means of which the relative age of terranes may be more or less definitely determined are of two principal classes, physical and biological.

PHYSICAL PHENOMENA AS A BASIS OF CORRELATION.

The physical evidence on which strata may be correlated is of varied character, but in general may be classed in the divisions given below:

Superposition.—The simplest case in which the relative age of strata may be determined is when they are comformably superposed one upon another. The highest in the series is then the youngest. The relative position of beds as is well known may be modified or even reversed by folding, faulting and overthrust, and in the correlation of strata by vertical sequence these modifying conditions have to be eliminated. Overflows of volcanic rocks and ejections of volcanic ash may play the role of sedimentary beds and form a time record by means of which the relative age of terranes not themselves in contact may be determined.

Contained fragments.—One series of rocks may contain recognizable fragments of another series. Manifestly the strata containing such fragments are newer than the strata from which they were derived. This is a common means of determining the relative age of conglomerates and is applicable also in some instances to volcanic rocks.

Relation to systems of folds, faults and dikes.—The relative age of rock series not in direct contact may sometimes be shown by their mutual relation to widely spread geological structure. For example, in the Appalachians a characteristic structure has been impressed upon the strata from the Coal-measures downward; consequently any rocks in this region not affected by the corrugations characteristic of the Appalachian structure, may be assumed to be of later date than the Coal-measures. In a similar way the relation of strata to a well determined series of faults or to a persistent system of dikes may be of service in indicating their relative age.

Relation to unconformities.—A series of rocks resting unconformably on a lower series in one region and conformably on a lower series in another region, the relative age of the two lower series may be inferred.

In such an instance the lower bed conformable with the upper would be expected to be later than the unconformable lower series, for the reason that great unconformities result from slow changes and are wide reaching in their effects. They leave a record which provisionally, at least, may be used as a time record. The conditions here postulated, while serving as a suggestion to the field geologist, would require additional evidence before being accepted as a definite means of correlation.

Relation to glaciation.—Widespread glaciation, by leaving characteristic records, enables the geologist to separate the beds deposited before its occurrence from those of subsequent date.

Lithological similarity.—The identity in age of various strata is sometimes suggested by their lithological similarity, but this is an uncertain indication, and except in regions of limited extent is apt to lead to erroneous conclusions. The lithological character of clastic rocks may depend on the physical conditions under which the debris composing them was formed. For example, the conditions which influence the disintegration of rocks are wide-reaching, and the characteristics of the rocks resulting from the assorting and deposition of such debris may be sufficiently constant over wide areas to be of assistance in determining relative age. To illustrate, the rocks forming the surface may suffer decomposition over a region of broad extent, and the resulting debris acquire certain characteristics, as a uniform red color, for example, due to the incrustation of ferruginous clay on the grains composing it. The removal and deposition of this incrusted material might produce rocks of similar appearance over broad areas and even in separate basins.

Rocks subjected to heat, pressure, crust movement, etc., have frequently acquired a schistose structure, due to rearrangement of the mineral matter composing them—that is, they are metamorphosed. Such alterations have been used as a basis for deciding on the age of strata, nearly all metamorphosed rocks having formerly been considered as Archean; but it is now known that strata of any age may have undergone the changes referred to above. Conditions may be postulated, however, under which metamorphism might be of service in determining the relative age of terranes. For example, a metamorphosed terrane may be considered as the record of a wide-reaching physical and chemical change, thus making a definite time record. Terranes found by contact or by contained fragments to be younger than the metamorphosed terrane may be assumed to be younger than other terranes with which they are not in contact, but which can be proved to be of the same age as or older than the metamorphosed terrane. True, the metamorphism of even the same stratum might not be confined to a single period, but to the field geologist such an association as suggested above would furnish a working hypothesis to be proved or disproved by additional evidence.

Summary concerning physical phenomena.—Besides direct contact of terranes and the evidence furnished by included fragments, which are the most definite means of correlation, the relative age of the elements in a geological series may be determined more or less accurately by their relation to physical events which were wide-reaching in their effects; among these the most common are folding, faulting, diking, volcanic eruptions, metamorphism, and glaciation. The degree of confidence to be placed on correlations depending on relations to these phenomena must be determined by the nature of the evidence in each case. Close correlation of strata, except by contact and unbroken stratigraphical succession, is not possible by means of the relations here indicated, but when these various methods are taken in connection with other records, they become important.

Chemical phenomena considered.—The classification of volcanic rocks, spring deposits, precipitates from inclosed lakes, etc., according to their chemical composition, is fruitful of results, but is foreign to the present discussion. The chemical changes involved in disintegration, decomposition, lithification, etc., may be included under lithological characters. In the lithological comparison of clastic rocks their mineralogical and chemical characteristics are considered, but the classification of strata with reference to relative age, on purely chemical grounds, has not been found practicable.

A sequence in chemical changes might accompany the cooling of a molten globe and result in the formation of a stratified crust having a definite chemical arrangement, but that such was the case with the earth has not been determined.

In the correlation of ordinary sedimentary beds chemical may be included with physical phenomena, and need not be separately discussed at this time.

LIFE RECORDS AS A BASIS OF CORRELATION.

The study of fossils has shown that life began on the earth in low, simple forms, and progressed with unbroken continuity throughout all subsequent geological ages, with the production of higher and higher forms and greater and greater specialization as it advanced. During this development many forms became extinct and were succeeded by other forms. The length of time during which individual species were persistent was sometimes short and at other times embraced geological ages; sometimes they even extended throughout nearly the entire life history of the earth. Biology thus furnishes a record extending from the dawn of life to the present day, by means of which the relative dates of various physical changes may be more or less definitely determined. It has been assumed that this record affords a ready and infallible means of determining the age of all rocks in which organic remains occur. This seemingly simple and direct method of correlation, however, has many limitations which it will be well to glance at before attempting to apply it.

Imperfections of the geological record.—Throughout the time that life has existed on the earth there has been land and water, and the land, wherever it appeared, has been subjected to disintegration and erosion. The débris thus formed has been carried into the sea and into lakes and contributed to the formation of sedimentary deposits. In these deposits the remains of plants and animals have been buried and preserved. Large portions of the strata with these records impressed upon them have been raised above the ocean and subjected to denudation, and the material removed from them contributed to the formation of later deposits, in which other life records were preserved. In many cases these later deposits were, in their turn, upheaved and another cycle of erosion and deposition initiated. In this way large portions of the material composing stratified rocks has been worked over and over and large portions of the life records obliterated. Again, large portions of the sedimentary rocks have been metamorphosed and all their fossils destroyed. In other instances the strata have been subjected to pressure and to the passage of solutions through them, and their organic records crushed and obliterated or removed in solution. The lack of dense tissues in many animals and plants renders it evident that the preservation of any records of their existence, even under the most favorable conditions, must be an extremely rare event; for this reason, if for no other, our knowledge of past floras and faunas must always be incomplete.

The life records, as we now find them, are also imperfect, owing to the fact that many animals and plants, especially those inhabiting the land, did not live in situations where their remains were likely to be preserved. The deep sea, also, has its fauna, which, owing to the slowness with which sedimentation takes place in the depth of the ocean, and to the persistence of oceanic basins, is even of rarer occurrence in a fossil condition than the fauna of the land. The animals whose remains are most frequently found in the rocks are those that inhabit the littoral zone, where sedimentation has always been the most active and where slow subsidence is frequently in progress.

In these several ways, and in others that might be mentioned, the records of the succession of plant and animal life found in the rocks are incomplete and fragmentary. It is not necessary at this time to do more than glance at this subject, as it has been ably treated by many writers, especially by Darwin, and the term "incompleteness of the geological record" has acquired a well understood meaning.

Imperfections of our knowledge of the geological record.—Besides the incompleteness of the geological record itself, there is the incompleteness of our knowledge of that record, such as it is, which must be considered in attempting to generalize upon the life history of the earth as now known. No better proof that our knowledge of the geological life record is incomplete can be asked than the volumes on paleobiology filled with descriptions of new forms of life which appear from year to year in increasing instead of diminishing numbers. Explorations in all parts of the earth are constantly bringing to light not only new species but new genera and new families, while our knowledge of the distribution of forms already known is constantly being modified and extended.

The fact that the greater part of the earth's surface is occupied by the sea shows that large portions of the life record lie so completely beyond the limits of search that man can never hope to see them. When it is remembered, also, that large portions of the land surface of the earth are geologically unexplored, and that new fossils are being found from year to year in those portions most thoroughly examined, the imperfections of our knowledge of the imperfect geological record becomes apparent.

Influence of distribution on the life records.—The usefulness of the life history of the earth as a means of correlating geological terranes is still further complicated by a principle inherent in life itself; that is, development has been in progress but has not taken place uniformly over the whole earth, but with local modifications depending upon local environment.

Whether life began at one or many centers there is no definite proof, but assuming as the simplest postulate that it spread from one center and during the lapse of ages expanded over the whole earth, advancing at the same time to higher and higher stages of development, the specific forms in various regions would, according to the principles of natural selection, be influenced and modified by the local conditions under which they live. Under similar conditions in various regions more or less similar forms would appear. The modified forms thus arising would, in their turn, originate new centers of distribution and lead to the establishment of distinct colonies, from which in their turn, again, new forms would be propagated.

The laws of development now accepted by biologists render it evident that life has not been uniform, the world over, at any one period; hence if sedimentation had been continuous over the whole earth, the organic remains entombed at any one time would have been diverse in various regions. We know from the distribution of organic forms at the present day that variations in temperature, changes in the character of the sea bottom, the abundance or scarcety of food, and many other conditions determine the character of the organic remains now being imbedded in sediments. Even in different portions of the same strata within limited areas the organic forms are diverse. These considerations and others that might be enumerated seemingly indicate that the life record has too many modifying conditions to render it available as a basis for geological correlation.

On the other hand, it may be urged that development in many instances has been exceedingly slow and that genera and even species of plants and animals, especially in the earlier stages of the earth's history, became widely spread, and hence afford a means of determining what strata were deposited at more or less definite periods in the life history. Taken in its general meaning, this proposition can not be advantageously disputed. It has been shown, however, that the appearance and disappearance of the same species or the same genera in widely separated regions could not have been the same. Species, and even genera and families, might become extinct in the region where they first appeared long before their migrations had carried them to distant regions. Hence the discovery of identical fossils in the rocks of two widely separated regions is not considered as proof of their identity in age, except within certain broad limits. This subject was long ago discussed by Huxley, who showed that rocks containing the same species of fossils at widely separated localities, while not necessarily of the same age, hold homologous positions in relation to the development of life, and proposed the word "homotaxis" in place of the term "contemporaneity" frequently used.

The life record continuous.—The value of paleontological evidence as a means of geological correlation may be considered in another way. As previously stated, the life current has been unbroken from the time of its first appearance to the present day. Development from a humble beginning has led to the gradual productions of higher and higher forms and an equally gradual extinction of species, genera, etc. It is thus evident that if a complete and unbroken record of the life history of the earth had been preserved, it would be continuous, without sharply defined natural divisions, from end to end. It may be asked, how is it possible in such a record to draw the lines connecting groups, systems, series, etc., as at present understood? Where would the limit between Paleozoic and Mesozoic, or between Mesozoic and Cenozoic, occur?

As a matter of fact, the physical breaks in the life record have been the principal means of establishing divisions in the scale. The greater the imperfections of record, the more important have been the divisions. In various land areas this system has been found not only practicable but highly advantageous. Next to vertical sequence of terranes, it is without question the most valuable means of correlation available. It has been assumed, however, that the breaks in the life records in one region agree in time with similar breaks in distant regions. Here lies the principal objection that can be raised to the manner in which the method has been applied.

This brings us to the consideration of the standard of geological correlation first used.

The European standard.—The fact that the life record of terranes in widely separated regions, although perhaps containing the same species of plants and animals, can not be considered as contemporaneous, except in a very broad sense, has already been referred to. We have also seen that even in regions of limited extent the lithological characters frequently of the same stratum undergo important changes and are accompanied by changes in the fossils found in it. When we add to these the further considerations that the rock series in no two regions can reasonably be expected to have the same sequence or to have been subjected to the same conditions of sedimentation, or affected by the same physical breaks, it is apparent that neither the succession of organic forms nor the succession of strata found in one region can be expected to occur in the same sequence in other regions. Hence the fallacy of assuming that the succession of life, the succession in sedimentation, or the physical breaks in any one region can be adopted as a rigid standard for comparison in other regions becomes apparent.

That geology was first studied in Europe is an accident so far as correlation is concerned, by which the succession of fossils and of strata there found have been assumed by many as a standard for all other regions. The error of this assumption has been pointed out by many writers, but the practice of attempting a detailed correlation of the rocks of distant regions with those of Europe, on the evidence furnished by fossils, sometimes of very indefinite character, is continued. The history of the numerous and persistent attempts that have been made to correlate the strata of America with those of Europe, even down to the smaller divisions of the scale, on the evidence indicated above, is a chapter of confusion, controversy, and failure. No better example of the diverse conclusions arrived at when such correlations are attempted can be asked than the history of the discussions that have occurred over the correlations of the Newark system, some account of which is given in the succeeding pages of this paper.

An essay on the flora of the Richmond area has come to hand, which illustrates the method followed by many paleontologists in attempting to correlate widely separated terranes. The paper referred to is a review of Fontaine's Monograph on the Older Mesozoic Flora of Virginia, by Stur,[1] director of the geological survey of Austria-Hungary, but contains also the results of an examination of a box of fossil plants from the Richmond area sent to him for comparative study. As determined by Stur, many of the fossil plants from the Richmond coal mines are specifically identical with those occurring in the Lettenkohlen group of Germany. The confidence placed in this evidence as a basis for detailed correlation between terranes of America and Europe is expressed in the following translation of an extract from the paper referred to:

> From the foregoing it becomes evident that even on the first comparison, made with no great care, between a box of American specimens and our specimens in hand, Clover Hill on the one hand and the Lunz sandstone on the other, have a great number of plant species in common, and should, therefore, be regarded as contemporaneous, particularly as most of the species that have thus far been regarded as peculiarly Virginian, are precisely the ones found at Lunz. The species enumerated,

[1] Die Lunzer (Lettenkohlen) Flora in den "older Mesozoic beds of the Coal Field of eastern Virginia." In Verhandlungen der k. k. geologischen Reichsanstalt, Nr. 10, 1888, pp. 203–217. The passages quoted were translated by Robert Stein, of the U. S. Geological Survey.

however, show also that Clover Hill comprises, besides the Lunz sandstone, also a part of the flora of the bituminous slate of Raibl (p. 211).

Thus we have recognized in the coal field of Richmond representatives of the Weng slate, the Aon slate, the Reingraben slate, the bituminous slate of Raibl, and the Lunz sandstone, that is, the equivalent of the Lettenkohle group of Germany.

What lies under it should represent the German Muschelkalk, possibly also the the Bunter Sandstone, while the roof of the Richmond Coal-measures should represent the German Keuper.

This remarkable result, furnishing a starting point for continued studies of the deposits that have been compared and identified and declared contemporaneous, could be obtained only through the assistance of our Washington geologists * * * (p. 212).

The result obtained is of a nature to set forth the utility of the procedure employed in this case.

I must not allow this occasion to pass without drawing further conclusions from the results obtained; that the flora of the Lunz strata, that is, of the Lettenkohle, appears in perfect identity at Richmond, Virginia, at a vast distance from the northern margin of the Alps.

This shows * * * that as late as the time of the Lettenkohle, the species of the flora then prevailing possessed an enormously vast distribution on an area of whose dimensions we may form an idea by drawing an air line drawn between Vienna, Germany (Lettenkohle), and Richmond, Virginia (p. 212).

Near the end of the essay, another passage, bearing on the correlation of American terranes, reads as follows:

* * * I am convinced that shipments of plants from the American Culm and Carboniferous, which may possibly be sent to me, will enable me to demonstrate the various divisions and series of strata in that country, just as I was enabled, by the shipment of Lunz plants from Richmond, to define the age of the Older Mesozoic flora on the James river in Virginia (p. 216).

Concerning the actual identity of many of the plants of the Newark system with those of the Lettenkohlen I am not able to offer an opinion; but such an exceptional occurrence, it seems to me, should be fully verified before being used as the basis for detailed correlation. If a large number of the plants of the Newark and of the Lettenkohlen are identical, is it necessary to conclude that they were contemporaneous? As already stated, it has been pointed out by Huxley and others that, even if the fossils in widely separated regions are of the same species, it does not follow that they lived at the same time. Their identity indicates a similar position in the geological scale, and nothing more. To go beyond this, and conclude that because of the occurrence of plants in the Richmond area identical with those of the Lunz sandstone the strata above the plant-bearing beds in the former region should be referred to the Keuper, and those below to the Muschelkalk, is to grant certain assumptions the verity of which is more than questionable. One of these assumptions is that sedimentation progressed in the same order in the Virginia region that it did in Central Europe. This implies that elevation and depression of the earth's crust producing changes in sedimentation occurred synchronously in the areas referred to. Such a coincidence is far from probable, and, even if it did occur, is not a logical basis for correlation. Such considerations, and the fact that the Newark after prolonged study has not been subdivided, so as to correspond with any portion of the European standards, point to the absence of a logical basis in the method of correlation indicated in the above quotations, and render it evident that we must be skeptical as to the accuracy of the very definite conclusions there reached.

That the strata of each separate land area should be studied and correlated so far as possible among themselves before attempting anything more than the most general correlation with the strata of other land areas is, in my opinion, well illustrated by the example just cited.

That even the groups found on this continent can not be definitely correlated with those of Europe, has been pointed out especially by White[1] in an essay on "The North American Mesozoic." It is there shown that the Chico-Tejon series of the Pacific coast, containing a well characterized Cretaceous fauna and an equally well characterized Tertiary fauna, has intermediate beds in which there is no stratigraphic break. The same principle is again illustrated in New Mexico, where an unbroken succession exists between Paleozoic and Mesozoic groups. Other instances of similar transitions between groups shown by their fossils to be closely similar to certain great divisions of European rocks, are known in India and New Zealand. These instances illustrate the fallacy of assuming that the life record or the stratigraphic sequence, in any two regions is the same. They show, too, the impossibility of applying an inflexible standard of classification determined from a study of the rocks and fossils of one region to the rocks and fossils of another region. This matter could be still further discussed and illustrated, did it seem advisable, but enough has probably already been said to indicate the weakness of the system criticised. The question, What is the most practicable method of correlating the terranes of widely separated regions, is still a matter for discussion.

PRINCIPLES ON WHICH WIDELY SEPARATED TERRANES MAY BE CORRELATED.

Of the physical and biological phenomena cited in the last few pages, by means of which terranes may be correlated, it is evident that the only infallible method capable of general application is based on the contact of strata. Sedimentation has gone on ever since life existed on the earth, but no universal sheet of sediment has been spread out. On the contrary, continuous sheets of sediments of like kind are frequently restricted to comparatively small areas. This is well illustrated by the manner in which sediments are now being deposited along the Atlantic border of America. These have recently been mapped by Alexander Agassiz from data obtained from soundings, and classed in thirteen divisions, ranging from the sands and clays of the littoral zone

[1] Am. Assoc. Adv. Sci., Proc., vol. XXXVIII, 1889, pp. 205-226.

to the ooze, and the red clay of the deep ocean, and in each deposit characteristic life forms are being entombed.

Moreover, in no region has sedimentation gone on without many changes and many breaks from the dawn of life to the present time, as is abundantly proved by the generally fragmentary condition of the geological series.

These considerations show in a general way, and without taking account of orogenic disturbances, that the sedimentary strata of which the earth's crust is largely composed may be considered as a series of irregular lenticular sheets, some of which are piled in an orderly sequence; others touch only on their edges; others are completely separated and connected by intermediate layers by which their relative age may be determined; others still have no physical connection, and their relative age must be determined by other means. The correlation of these various strata the world over is one of the problems that geologists have before them. What is the most practicable way of accomplishing the task?

In order to arrive at a general scheme of geological correlation for the whole earth it seems evident that each separate land area should be studied by itself and the sedimentary strata composing it arranged, so far as possible, in the order of their age as determined by physical relations.

When correlation by contact and relation to physical phenomena shall have been determined for the terranes over a large part of the separate land areas of the earth, and their corresponding life records determined, the correlation of these various fragmentary histories, with the object of determining the life history of the earth, may be practicable. Evidently the correlation of the strata forming separate land areas can not be made by contact, and it is doubtful if the relation of the strata to widely reaching physical phenomena will ever be valuable for this purpose. The only resource, therefore, is the comparison of life records. The great advances that have been made in paleontology are such as to indicate that when the life records of all the continents shall have been studied independently, and the strata in each correlated by contact, so far as possible, there will result a sufficient body of facts to enable paleontologists and geologists to formulate a somewhat complete history of the progress of life on the earth, showing the special modifications in various regions. Such a standard, when well advanced toward completion, could be used for the determination of the homotaxial relation of the terranes in various regions, and would serve as an important factor in determining what general scheme of classification is most advantageous for showing the approximate correlation of the more important rock series. But not until the relation of the systems composing the various continental land areas shall have been determined, so far as practicable, by contact and the character of their faunas and floras ascertained, can we hope to have a biological time scale by means of which the position of the rock systems forming various continents can be adjusted. Even when this ideal stage is reached it will probably be found that the correlation, even of systems in widely separated regions, will still be general and not specific.

In studying the geology of any region, the primary aim should be to establish the succession of rocks there found by means of their relation to each other and to wide-reaching physical phenomena. At the same time the varied physical events recorded in the rocks should be interpreted and their organic remains carefully studied. The fossils from various natural subdivisions should be preserved separately and submitted to the zoologist and botanist for the determination of their place in the zoological and botanical series. In all cases the relative age of the various faunas and floras should be determined by the relation of the strata containing them, and not the relation of the strata except in a general way and after many fossils have been collected from the contained organic records.

MANNER IN WHICH AMERICAN TERRANES HAVE BEEN CORRELATED.

From the beginning of geological investigation on this continent to the present time, one of the primary and immediate ends that many geologists have had in view was the close correlation of the terranes found here with those occurring in Europe. This correlation has frequently been attempted on the basis of a large number of fossils either specifically or generically identical with those found in Europe. In other cases but few fossils have been obtained, but great weight has been given to these in deciding on the age of the beds in which they occur. In still other instances mere lithological resemblances have been used as a basis for correlation. Again, in many instances, opinions have been expressed as to the position of our terranes in the European scale, and European names adopted in geological treatises and on geological maps, without any statement whatever of the facts on which the correlations were made, or of the principles of correlation which led to a decision. The result is that European names have been fastened especially on the larger divisions of the geological column, without adequate proof that the groups, systems, series, etc., thus designated correspond, except in the most general way, with those bearing similar names across the Atlantic. As the larger divisions in the geological column are supposed to be determined by great unconformities, or by almost complete breaks in the organic records, it is by no means probable that these lines of demarcation coincide in age with the dividing lines in the European standard. Who can say, for instance, that the upper and lower limits of the American Silurian or of the American Devonian corresponds to the upper and lower limits of the divisions bearing these names in Europe. The life histories of these groups undoubtedly coincide in a general way with the life histories of the similar groups in Europe, and in this sense their position is determined. But when the principles of correlation are carried to the smaller divisions in the column, as many geologists and paleobiologists have attempted to do, failure has resulted.

The firm manner in which the European names have been fastened to the American rock series compels their use at present, but always with a mental reservation that they do not strictly coincide with the terranes for which they have been named. As an example, the red beds of the far West and the strata immediately above and below them may be cited. These terranes have been classified as Permian, Triassic and Jurassic, and will have to be spoken of under these titles, although we know that their natural divisions are not the same, and that they can not be correlated except in the most general way, with European systems. It would have been just as logical to have named the strata referred to after terranes bearing somewhat similar fossils in Asia, Africa, or New Zealand as it was to give them the names by which they are now known. It is in fact only after the biological succession in these and other land areas shall have been worked out and compared that anything like a geological history of the earth can be written.

The correlation of the terranes of one with those of another land area is a matter for special consideration, not in the initiative, but in an advanced stage in the study of its geological history.

The adoption of the name "Newark system," proposed by Redfield for the great deposits of sandstone, shale, etc., along the Atlantic border, which form a sharply defined system, limited above and below by great unconformities, is an attempt to break away from the practice of correlating our strata with those of Europe on indefinite evidence and by illogical methods, and is a move toward the establishment of a definite American standard based on a natural system.

In thus venturing to indicate what I consider errors in the method commonly employed in correlation, I do not wish to be understood as attempting to detract in the least from the great importance of the study of the fossil plants and animals. On the contrary, I have the highest admiration for the grand results that have been reached in this direction, and wish to see the work continued. The value of fossils as a practicable means for correlating strata, after their relative age has been determined by superposition, is well established and thoroughly appreciated by every working geologist. It is, perhaps, possible that the life history of the earth is now sufficiently well known to be used at least tentatively in establishing the homotaxial position of terranes in widely separated areas. By applying and correcting the standard from time to time, more precision in the divisions of the scale will result.

CORRELATION OF THE NEWARK SYSTEM.

In the Acadian area the rocks of the Newark system rest unconformably upon the Carboniferous as has been determined by Dawson.[1] In the Connecticut valley the system is underlain unconformably by metamorphosed and crystalline rocks, believed to be in part of lower Silurian age. In the northern part of the New York-Virginia area the rocks beneath the Newark are also crystallized and their age as yet undetermined. In the southern portion of the western border of the system in New Jersey, however, the Newark rocks rest unconformably upon Silurian limestone, as has been determined by the Geological Survey of New Jersey, and a similar relation exists in Pennsylvania. In Maryland the rocks beneath the Newark system are in part Silurian and in part metamorphosed and of indeterminate age. Through all of the Newark areas south of the Potomac, the system rests unconformably upon more or less metamorphosed rocks, the age of which is as yet undecided.

As pointed out by Rogers, the Newark system in Pennsylvania is unaffected by the crumpling and folding impressed upon a large portion of the Appalachian region, and hence is of later date than what is known as the "Appalachian structure." As this structure was produced after the deposition of the Coal-measures, the relation of the Newark system to this crust movement is proof that the system is younger than the Carboniferous. This conclusion, as we have seen, is sustained by the unconformity between the Newark system and Carboniferous rocks beneath in Nova Scotia.

The nature of the unconformity at the base of the Newark system throughout is not only proof that the system is of younger date than the rocks on which it rests, but is evidence that a long period of erosion intervened between the deformation of the underlying beds and the depositions of the superior system.

The next series of rocks deposited in the Atlantic coast region after the Newark is the Potomac. As described by McGee,[2] this formation in Pennsylvania and New Jersey rests in part on the eroded edges of tilted Newark strata and on truncated trap dikes which traverse it. The unconformity between the Newark system and the Cretaceous rocks resting upon it along its eastern border in New Jersey was determined also by the Geological Survey of New Jersey. In Virginia the Taylorsville and Richmond areas are overlain unconformably by the Lafayette.

On the eastern edge of the Deep river and Wadesboro areas in North Carolina, there are sands of Tertiary or more recent date, which rest upon the eroded surfaces of the rocks of the Newark system. The presence of the Potomac formation in this region, resting unconformably upon the Newark, is also suspected, but has not been definitely determined.

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[1] Acadian Geology, 3d ed., London, 1878, pp. 86–113.

[2] Three formations in the middle of the Atlantic slope. In Am. Jour. Sci., 3d ser., vol. xxxv, 1888, pp. 134–136.

The evidence furnished by the formations resting unconformably upon the Newark system is such as to prove that the rocks of that system were upheaved, faulted, diked, and subjected to decay and deep erosion before the oldest of the overlying formations was deposited.

A long interval of land conditions, during which crust movements on a grand scale as well as decay and erosion took place, intervenes both between the Newark system and the rocks on which it rests, and between that system and the rocks which rest upon it.

So far as stratigraphy can be used in determining the age of the system, it proves that it is younger than the Carboniferous rocks of the Atlantic coast region, from which it is separated by a period of erosion, and older than the Potomac formation, from which it is also separated by a period of erosion.

There are no other terranes in the eastern part of the United States. falling in the interval which is shown by stratigraphy to be occupied in part by the Newark system, and there is, therefore, no necessity at this time for discussing the homotaxial relation of that system to neighboring terranes.

RELATION TO TERRANES IN THE WESTERN PART OF THE UNITED STATES.

There are several rock series in the Rocky Mountain region which have been shown by their stratigraphic relations to be intermediate between the Carboniferous and the Cretaceous. These have been referred to the Permian, Triassic, and Jurassic of Europe, on account of their stratigraphical position and the nature of the fossils which they contain. The accuracy of this correlation or the character of the evidence on which it rests, it is not necessary to discuss at this time. There is no physical connection between the Newark system and the terranes just referred to, by means of which their relative age can be determined. Only a few fossils have been found common to the two systems, and hence there is no adequate basis for close correlation.

A few plants collected by Newberry[1] at Abiquiu, New Mexico, were determined by him to be specifically identical with fossil plants found in the Newark system in Virginia and North Carolina. From this evidence it is believed by Newberry that the plant-bearing beds in the two areas referred to are of about the same age, and correspond with the upper Triassic of Europe. The similarity in age between the Newark system and the terrane at Abiquiu, New Mexico, is indicated also by specific identity of the silicified wood found in the two regions, as has recently been determined by Knowlton.[2]

A few fossil bones obtained by Cope, from the so-called Triassic rocks of New Mexico, have been determined by him to be closely allied to the

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[1] U. S. Geol. Surv., Monograph vol. XIV, pp. 14-15. See also by the same author, Report of the Exploring expedition from Santa Fé, N. Mex., to the junction of the Grand and Green rivers of the great Colorado of the West, in 1859, under the command of J. N. Macomb. Washington, 1876, pp. 141-148, pls. 4-8.

[2] Ante, p. 29.

reptilian remains of the Newark system, and in each case are referred to the upper Trias of Europe.

The rich reptilian and mammalian fossils discovered by Marsh at Como (Aurora), Wyoming, near Canyon City, Colorado, and at other points in the Rocky Mountain region, from so-called Jurassic rocks, are considered by their discoverer to be of younger date than the Newark system.

Other vertebrate fossils collected in the so-called Permian of the far West are considered by Cope to be of older date than the Newark.

So far as indicated by organic remains, therefore, the Newark system may be considered as occupying a place in the geological column similar to that occupied by the Triassic rocks or Red beds of the Rocky mountain region. That this correlation is extremely indefinite is shown by the fact that in the Rocky mountain region the rocks referred to the Permian, Triassic, and Jurassic belong to a natural system, in which there are no great unconformities and no persistent features by means of which they may be divided at various localities. Had they been studied in connection with the geology of the region in which they occur, independent of any preconceived notions of European correlation, there is no question that the lines of division would have been drawn differently than at present. The scarcity of fossils in that portion of the western system which coincides most nearly with the Newark system is such that a definite correlation with other similar faunas and floras at a distance must be accepted as provisional even by the most sanguine of those who believe in a detailed correlation of strata by means of fossil remains. The uncertainties arising from this cause are still further increased by the fact that the attempts which have been made to correlate the Newark system with the Triassic of the Rocky mountains, depend in large part upon the relation of the fossils of each of these systems to the Triassic fossils of Europe. It seems wise to conclude, therefore, that only a very general relation between the Newark system and the so-called Triassic rocks of the Rocky mountain region has been established, and to wait for further evidence before deciding that a close correlation is practicable.[1]

RELATION TO EUROPEAN TERRANES.

No other system in America has been the subject of so much discussion respecting its position in the European standard of classification as the one now under review.

I have made abstracts of such determinations and opinions of the age of this system as are based on paleontological evidence, not including

[1] Since this paper was written L. F. Ward, from a comparison of the fossil plants of the Newark and of the Trias of the Rocky mountain region, has reached the following conclusion: "As regards the western deposits, notwithstanding the poverty of their present known flora, there seems to be some indication that they were not laid down at the same exact epoch as those of the Atlantic coast; but, assuming such an asynchronism, the question as to whether they are earlier or later can not be profitably considered with the present insufficient data." Bull. Geol. Soc. Am., vol. XXIII, 1891, p. 28.

those in which mere opinions have been expressed without stating the basis on which they are founded. The number of these abstracts is over eighty.

Rejecting certain early correlations which referred the Newark system to Silurian, Carboniferous, and Devonian groups, which need not be discussed at this stage of geological study, the remainder of the determinations referred to, and especially the more recent ones, correlate the rocks in question, either wholly or in part, with the Triassic or the Jurassic systems of Europe. Without attempting to give the chronological history of the discussions and controversies that have arisen on this subject, and which are still being pressed in certain quarters, I shall try to indicate, so far as practicable, the nature of the evidence that has been obtained and the conclusions which have been derived from it.[1] The reader will then, at least to some extent, be in a position to judge for himself as to what is the safest position to maintain in reference to the age of the system we are studying.

Fossils of the Newark system, as has already been stated, consist of obscure molluscan remains, larvæ of insects, cases of minute crustaceans, fragmentary portions of the skeletons of mammals, batrachians, and reptiles, fossil fishes, footprints, and plant remains. Owing to the great rarity and to the obscurity of molluscan and insect fossils, the only organic record at present available as a means of correlation are vertebrates, crustaceans, and plants.

TESTIMONY OF THE VERTEBRATES.

Mammals.—The remains of small mammals were discovered by Emmons in the Newark rocks of North Carolina and referred by him to the Permian, on account, principally, of the reptilian fossils associated with them.[2] These remains were studied also by Leidy, who stated that they find very close representatives in the Purbeck beds of the Oolitic of England.[3] The fossil mammalian jaws described by Emmons have recently been reexamined by Osborn, who concludes that they are widely aberrant forms, and not closely related to any fossils hitherto discovered.[4] The investigations by O. C. Marsh in the Jurassic system of the Rocky mountain region have brought to light a large number of small mammalian fossils having a resemblance to the remains found in the Newark system, but these, as stated by their discoverer, are generally distinct.[5]

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[1] Some account of the various determinations of the age of the Newark that have been made is given by—

Lea, Isaac: Description of a fossil saurian of the New Red Sandstone formation of Pennsylvania, with some account of the formation. In Philadelphia Acad. Nat. Sci. Jour., 2d ser., vol. II, 1850–1854, pp. 185–189.

Newberry, J. S.: Fossil fishes and fossil plants of the Triassic rocks of New Jersey and the Connecticut valley. U. S. Geol. Surv., Mon. vol. XIV, Washington, 1888, pp. 8–15.

Marcou, J.: The Triassic flora of Richmond, Virginia, Am. Geol., vol V, 1890, pp. 160–174.

[2] American Geology, part 6, Albany, 1857, pp. 95–96.

[3] Philadelphia Acad. Nat. Sci., Proc., vol. IX, p. 150.

[4] Philadelphia Acad. Nat. Sci., Proc., vol. XXXIX, 1887, p. 291.

[5] Am. Jour. Sci. 3d ser., vol. XXXIII, p. 344.

The small number of mammalian remains thus far obtained from the Newark system, and the limited knowledge possessed at the present time of the early forms of mammalian life, renders it evident that they can not be used, except in a most general way, in determining the age of the strata in which they occur.

Batrachians and reptiles.—Fragmentary portions of the skeletons of large animals were discovered by E. Emmons in his early explorations of the Newark rocks of North Carolina, and determined by him and by Leidy to be most nearly related to the Permian vertebrates of the Old World. These same fossils were studied also by Isaac Lea in connection with similar remains from Pennsylvania, and considered to agree most nearly with similar remains found in the Triassic rocks of Europe.[1]

The fossils studied by Emmons, Leidy, and Lea have since been reexamined and their classification revised by Cope, who finds that certain of the genera found in the Newark rocks occur also in the Triassic rocks of New Mexico. After describing the vertebrate fossils of the New Mexico deposits, this author states that there is a close parallelism between them and the similar fossils from the upper Keuper of Wurtemberg. To quote the author's words:[2] "In both regions the genera Belodon and Tanystrophaeus are abundant and the Artosaurus of the former [Wurtemberg] is represented by the Tylothoras of the latter [New Mexico]. The association of such very diverse forms is good evidence of general identity of fauna, and is a sufficient basis for asserting taxonomic identity of the forms of the two regions."

Again, after studying the vertebrate fossils of the Newark rocks of Pennsylvania, Cope observes:[3] "Geologists have been inclined to identify these beds with the Upper Trias and the Lower Jurassic. The identification of the Belodon and Mastodonsaurus points most strongly to the age being that of the Keuper or upper divisions of the Trias."

The testimony of the fossil footprints so abundant in certain portions of the Newark system is less definite than that derived from the bones and teeth found in the same rocks and probably belonging in part to the same species. No fossil footprints found in other countries have a sufficiently close relation to those of the Newark system to be indentified with them, and, therefore, no close correlation can be based upon these interesting records of a vanished host. Paleontologists would probably agree if no other fossils than footprints were known from the Newark system, that the only admissable conclusion as to their age would be that they are probably somewhat younger than the Carboniferous.

The evidence from vertebrate remains evidently indicates that the position of the Newark beds in the geologic series coincides in a general way with that of the Upper Trias of Europe and with the horizon of the so-called Triassic beds of the Rocky mountain region.

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[1] Philadelphia Acad. Nat. Sci., Proc., vol. x, p. 92.

[2] Am. Phil. Soc. Proc., vol. XXIV, 1887, p. 227.

[3] Philadelphia Acad. Nat. Sci., Proc., vol. XVIII, 1866, p. 250.

Fishes.—The fossil fishes of the Newark system have been studied, especially by J. H. Redfield and W. C. Redfield, Agassiz, Edgerton, and Newberry. The conclusion reached by the Redfields,[1] father and son, was that the rocks could not be older than the Trias, but must be placed as low as the Lias and Oolite. Agassiz, on examining the fossil fishes of the Richmond area, suggested from their analogy with European forms, that they were of the age of the Lias.[2] Later, in discussing a paper on the Coal-bearing rocks of Virginia and North Carolina, by Johnson, he observes that the fossil fishes of the Richmond area and from "the so-called New Red Sandstone, indicate an age intermediate between the European New Red and the Oolite."[3] Still later he states that the fossils referred to do not agree either with the fossil fishes of the Trias of Southern Germany or with those of the Lias of England, but seem intermediate between the two, and is inclined to refer the Newark system to a group intermediate between the Trias and the Lias for which there is no equivalent in Europe.[4]

By far the most important contribution to our knowledge of the fossil fishes of the Newark system have been made by Newberry. His opinion with reference to the age of the system, based principally on fossil plants, is that it represents only the uppermost portion of the Triassic, and is the equivalent of the Rhetic beds of Germany. In reference to the bearing of the fossil fishes on the question of age, he says:[5] "The fishes so abundant in our Trias [Newark]—*Ischypterus* and *Catopterus*—have never been found in the Old World, and therefore throw no light on the question. But their affinities are more with the Mesozoic fishes (Jurassic and Cretaceous) than with *Palæoniscus*, etc., of the Permian. Much rarer fishes have recently been obtained by the speaker from the Connecticut Trias—*Dipleurus* and *Ptycholopis*—which, though new, represent groups confined to the Jura of the Old World."

The question of the geological equivalents of the Newark system is discussed at length in Newberry's recent monograph on the fossil fishes and fossil plants of the Newark system, but the value of fossil fishes as a basis of correlation is not specifically considered. The final conclusion in reference to correlation expressed in the volume mentioned is the same as previously stated, and places the Newark system on a parallel with the Rhetic of the Old World.[6]

TESTIMONY OF THE CRUSTACEANS.

The minute fossil crustaceans of the Newark system were studied to some extent by Emmons, Rogers, and others, and certain conclusions

[1] Am. Assoc. Adv. Sci., Proc., vol. IX, 1856, p. 185.
[2] Geol. Soc., London, Quart. Jour., vol. III, 1847, p. 275
[3] Am. Assoc. Adv. Sci., Proc., vol. IV., 1850, p. 276.
[4] Am. Acad. Proc., vol. III, 1852–1857, p. 69.
[5] New York Acad. Sci. Trans., vol. V, 1885–'86, p. 18.
[6] U. S. Geol. Surv., Mon. vol. XIV, Washington, 1888, pp. 8–15.

in reference to geological age based on them. The results reached by these authors were subsequently reviewed by T. Rupert Jones, with the aid of abundant specimens.[1] In summing up the evidence furnished by the crustaceans, this author says: "Whether or not these deposits have a Keuperian character, as Prof. O. Heer's late determinations of the Coal plants from Richmond, Virginia, seem to indicate, there is no doubt of their being the products of lagoons in the Lower Mesozoic period, and contemporary either with the marine formation intermediate to the Trias and Lias, namely, the Rhetic, or with the Upper Trias itself, and exactly equivalent to the Lettenkohle (carbonaceous shales at the base of the Keuper.)"[2]

The evidence furnished by the crustaceans, minute as they are, must evidently be considered as important and as sustaining the more recent conclusions reached from a study of the reptilian remains.

TESTIMONY OF THE PLANTS.

The resemblance of some fossil plants of the Richmond area to those of the Keuper of Central Europe led Marcou[3] to assign them to the same horizon as early as 1849.

The plants, like the reptilian remains, were studied at an early date by Emmons, who concluded from this and other evidence that the upper part of the Newark system in North Carolina represented the Keuper. This conclusion was based largely, however, on the opinion of Heer, who, from a study of a small collection of fossil plants, concluded that "Certain forms found in North Carolina are characteristic of the Keuper and Marnes Irisées of Germany, France, and Switzerland; and certain other forms are closely related to the species found in Europe in the Keuper and Lower Lias, but are all different specifically; but there are none which are really Oolitic either in Virginia or North Carolina."[4]

Rogers, in 1858, after reviewing all the available evidence as to the geological position of the Newark system, reached the following conclusion:[5]

> These strata are placed in parallelism with the Lower Mesozoic formation of Europe—the Upper Triassic and the Lower Jurassic rocks—not merely through the few European species which they possess, but quite as obviously by the general aspect or *facies* of nearly all the organic remains which they have hitherto disclosed. Every year is adding to this list, and, as they multiply, the impression produced leans more and more toward the conviction that they were created in a period which unites the Triassic and Jurassic ages.

Rogers, in an essay on the age of the Newark system, after a comprehensive review of all the evidence furnished by fossil plants at that time available, concludes that these fossil remains as a group bear a

[1] A Monograph on the Fossil Estheria. Paleontological Soc., London, 1862.
[2] Ibid, p. 126.
[3] The Triassic flora of Richmond, Virginia., Am. Geol., vol. v, 1890, pp. 163.
[4] Am. Assoc. Adv. Sci., Proc. vol. XI, 1858, p. 79.
[5] Geol. of Pennsylvania, 4to, Philadelphia, 1858, vol. II, p. 697.

remarkable resemblance to those of the Oolitic rocks of Europe. Some of the species are stated to be specifically identical with European forms, while others are very closely allied to certain species found in the Oolitic of the Old World (p. 299). In conclusion, Rogers states that he has no hesitation in referring the coal of eastern Virginia to a place in the Oolitic system on the same general parallel, and with the carbonaceous beds of Whitby and Brora, that is, in the lower part of the Oolite group [1] (p. 300).

A few vegetable remains found in the Newark rocks of the Connecticut valley were figured and described by Hitchcock, and considered by him to indicate a parallelism with the Jurassic of Europe. These remains were so imperfect, however, and so little was then known concerning the fossil floras of the systems with which they were considered to be most nearly related, that but little weight can be attached to this examination.[2]

Fossil plants collected in the Richmond field by Lyell were studied by Bunbury whose final conclusions in reference to their age, as stated by Lyell,[3] placed them on a parallel with the Keuper.

By far the most important contributions made to our knowledge of the fossil flora of the Newark system, is contained in a monograph by Fontaine.[4] As stated by this author there are 42 species of plants from the Richmond area sufficiently well preserved to be of some value in determining the age of the beds. Of these 21 appear to have no near relation in the European floras, but their general character points strongly to a Rhetic or Jurassic age. Three identical and 5 allied species, or 19 per cent, find their representatives in the Jurassic formation. The Jurassic element is much stronger than the Triassic, even without counting the plants of Jurassic generic type found in the species peculiar to Virginia (p. 95). There are 4 species identical with Rhetic forms, and 8 allied to them, or 28 per cent. The Rhetic can, then, claim the largest percentage of identical and allied species. Among them are some of the most abundant and characteristic forms of the Virginian flora. The great abundance and wide diffusion of the *Macrotaeneoptereis magnifolia*, and *Ctenophyllum braunianum* give these plants great weight.

Fontaine's conclusion from the facts briefly indicated above is that we must consider this flora as not older than the Rhetic, the only question being whether its strong Jurassic evidence ought to cause us to regard it as at least Lower Jurassic in age (p. 96).

In the same monograph there is contained a review of the fossil plants of the Newark rocks of North Carolina, described by Emmons, in which 49 species are identified. Of these, 9 are stated to be pecu-

[1] On the age of the coal rock of eastern Virginia. In Assoc. Am. Geologists and Naturalists, Trans., 1840-1842, pp. 299-300.
[2] Ichnology of New England, Boston, 1858, pp. 5, 6, 7.
[3] Elements of Geology, 6th ed., 1886, p. 452.
[4] U. S. Geol. Surv., Mon. vol. VI, Washington, 1883, pp. 92-96, 121-128.

liar to North Carolina, and have no very near allies in other countries. Fifteen species are found in the Newark rocks of Virginia. Assuming, as stated by the author, that the Rajmaahal group, India, is of Liassic age, there are 2 species identical with, and 6 nearly allied to Jurassic plants. Seven species are identical and 8 closely allied to Rhetic plants. Twenty-three per cent are peculiar to North Carolina, while 41 per cent are found in the Newark rocks of Virginia; 20 per cent are allied to or identical with Jurassic forms. Thirty per cent are identical with or allied to Rhetic species. After studying the fossil plants of both Virginia and North Carolina, Fontaine's final conclusion is that these floras are probably of the age of the Rhetic. In his own words: "We are, then, I think, entitled to consider that the older Mesozoic flora of North Carolina and Virginia is most probably Rhetic in age and certainly not older."

"Some authors hold that the Rhetic beds form the uppermost of the Triassic strata. Others think that they are transition beds having affinity with the Lower Lias. The latter view will, I think, be justified by a study of the flora, and I have, in this memoir, assumed its correctness" (p. 128).

Newberry, in his monograph on the fossil fishes and fossil plants of the Newark system already referred to, concurs with Fontaine in referring the flora of the system to the Rhetic (p. 13). He also says that several species of plants common in the Newark system are found at Abiquiu, New Mexico, and at Sonora, Mexico. The author states that this "indicated a parallelism between the plant-bearing beds of the Atlantic Trias [Newark] and those of New Mexico and Sonora, and go far to prove that all of our Triassic rocks which have yet yielded plants belong to the uppermost division of the system" (pp. 14–15).

Stur,[1] in a review of Fontaine's monograph on the flora of the older Mesozoic of Virginia, has identified a large number of the plants from the Richmond area with those of the Lunz sandstone of Germany, and concludes that the plant-bearing beds of the Newark are the equivalent of the Lettenkohle group of Germany. The great confidence that this author gives to his determinations is indicated in the quotations given in this paper on pp. 114–115.

B. Zeiller[2] has also reviewed Fontaine's monograph, and identified certain of the plants there described with those of the grès bigarré of Europe. This identification of species and also the absence in the Newark system of certain types that had an immense distribution during the Rhetian epoch, and as stated by Zeiller, have been found in nearly all the Rhetian deposits of Europe lead to a final conclusion in reference to correlation, which is stated as follows:

[1] Die Lunzer (Lettenkohlen) Flora in den "older Mesozoic beds of the coal-field of eastern Virginia." In Separatabdruck der Verhandlungen der k. k. geologischen Reichsanstalt No. 10, 1888, pp. 203–217.

[2] Sur la présence, dans le grès bigarré des Vosges, de l'Acrostichides rhombifolius, Fontaine. In Société géologique de France, Bull., 3e série, t. XVI, p. 693–698, séance 18 Juin, 1888.

Thus, without pretending, at so great a distance, to make a formal correlation, I think that one may, with great plausibility, arrange the coal-bearing strata of Virginia and North Carolina, with the Upper Trias, as was done by O. Heer, and to place them parallel with those of Bâle (Neue Welt), Stuttgart and Lunz; that is to say, at a level little different, on the whole, from that assigned to them by Mr. Fontaine, but yet a little higher (p. 698).

The evidence furnished by the fossil plants, while not interpreted in the same way by various paleobotanists, points on the whole to a somewhat higher division in the time scale of Europe than the vertebrate and invertebrate fossils.

Before closing the review it will be well to consider what may be classed as negative evidence. This is furnished by the remarks of Dana, made more than thirty years ago, in connection with a review of Emmons geological report of the Midland counties of North Carolina. He says:[1]

In the determination of the exact age of this sandstone, the only rock in this country east of the Mississippi occurring between the Carboniferous and the Cretaceous, we can not be too cautious in the use of evidence. One or two considerations are, therefore, here suggested. In the first place the fauna and flora of America of this modern epoch is represented in Europe, and quite strikingly, as has been shown by the fauna and flora of the later Tertiary of Europe. The life of corresponding ages in the two continents has thus been older in America than in Europe. This is one point to be well weighed. Again, in determining the age of a rock from its fossils, we should rather look to those which indicate the more recent period than those which bear the other way. This criterion would bring us right with regard to our own epoch, while by avoiding it we might be able to prove that we in America are of the Tertiary age of the world. Now, as Mr. Redfield has shown, the fossil fishes—the most characteristic species of any formation—are but *half* heterocercal and come nearer to the Jurassic type than the Triassic. There is hence reason for the opinion, notwithstanding the important evidence brought forward by Dr. Emmons, that the Lias period may be represented by the formation; and we may be nearest the truth if we regard the whole formation as corresponding to the Lias and the latter half to the Trias. The examinations by Mr. Heer accord with this conclusion. The European subdivisions of the Trias we should not look for on this continent, even if we had the whole of the formation, any more than the European subdivisions of the Devonian in the American Devonian. American geology is deeply interested in the decision of this question, and owes much to Prof. Emmons for all that he has done toward its elucidation.

SUMMARY.

The conclusions reached, as indicated above, by those best qualified to determine the nearest equivalents of the Newark system in the geological series of Europe, present some diversity.

The Batrachians and reptiles as shown by the most recent and most extended studies, that have been made, have their nearest known representatives in the Keuper of Germany.

The fossil fishes are not nearly related to those of any formation in Europe, but represent groups confined, so far as is now known, to the Jurassic.

[1] Am. Jour. Sci., 2d ser., vol. XXIX, 1857, pp. 429-430.

The crustaceans have their nearest representatives in the upper Trias or in the Rhetic.

The plants have been assigned to various horizons, but the most recent and probably the most reliable determinations, place them in the upper part of the Triassic or in the Rhetic; Heer, Stur, and Zeiller claiming them as belonging to the Keuper, while Fontaine and Newberry consider that they more nearly represent the flora of the Rhetic.[1]

This brief résumé of what must be considered the most trustworthy correlations now possible, shows that there is a closer accord in the various determinations than, perhaps, might have been supposed. The geologist who has to depend on the paleontologist for the correlation of strata in widely separated regions, is thus furnished with all the data available on which to base his conclusions. It is probable that the evidence, as it now stands, when considered by various persons, will be interpreted in two ways.

Those who are inclined to believe that a close correlation is possible between the divisions of the geological column in America and Europe, will probably demand further evidence and will continue the controversy as to the equivalency of particular horizons in the two countries.

Those who take the ground that the large natural division of the rock series in America and in Europe admit of correlation only in a broad, general way, will conclude that the correspondence reached from the comparisons already made are sufficient to show that the fossil-bearing strata of the Newark system may be placed in general parallelism with the upper part of the Triassic and the lower part of the Jurassic of Europe. As a system, however, it can not be considered as the equivalent of any definite portion of the European scale.

When the geological succession in the other portions of the earth shall have been determined, and the existing blanks in our knowledge of the succession of organic forms filled, at least in part, it may be possible to form a more comprehensive scheme of classification than any now known, in which the relative position of the strata in various widely separated localities may be some time definitely determined. Until such a standard of comparison approaches completion, we must conclude that the Newark system is a well defined unit in American geology, having a great unconformity both above and below, and that it belongs in the lower portion of the Mesozoic group of the American geological column. The Mesozoic itself, however, does not agree either as to its upper or lower limits with the Mesozoic of Europe, but repre-

[1]The most recent review of the relation of the fossil plants of the Newark to the Triassic flora of Europe which has come to hand is by L. F. Ward (Bull. Geol. Soc. Am., vol. III, 1891, pp. 23-31). The conclusion reached is that our present knowledge fixes the horizon of the Newark "with almost absolute certainty at the summit of the Triassic system, and narrows the discussion down chiefly to the mere verbal question whether it shall be called Rhetic or Keuper. * * * The beds that seem to be most nearly identical, so far as the plants are concerned, are those of Lunz, in Austria, and of Neue Welt, near Basle, in Switzerland. These have been placed by the best European geologists in the Upper Keuper. Our American Trias [Newark] can scarcely be lower than this, and it probably can not be higher than the Rhetic beds of Bavaria."

sents, as nearly as can be determined from our present knowledge of its organic remains, about the same relative position in the life history of the earth.

RELATION TO TERRANES OF ASIA AND CENTRAL AMERICA.

Direct comparisons have been made by Newberry between the fossil plants of the Newark system and similar fossils from China and from Honduras.

A comparison with fossil plants from China collected by Pumpelly in the Kwei basin on the Yangtse river, province of Hupeh, showed that one species is common to the two regions. Another species found in the Kwei basin agreed closely with a European Jurassic species. Another has a remarkable likeness to a fern which occurs both in the Liassic and Oolitic floras of Europe. The Kwei fossils were also compared with fossil plants from Abiquiu, New Mexico, and Sonora, Mexico, regarded by Newberry as Triassic. The conclusion reached from this study was that the plant-bearing beds of the Kwei basin were of Mesozoic age, but whether they should be considered as Triassic or Jurassic remained undecided. Only a very general conclusion as to the relation of the Newark system to the plant-bearing beds of the Kwei basin, is shown by fossils now known, but it is evident that interesting results might be expected from a continuation of the comparisons of the fossil floras of the two regions.[1]

A collection of fossil plants from San Juancito, Honduras, has recently been described by Newberry and shown to be related to the Rhetic of Europe. This collection contains at least one species that is very close to a plant described by Emmons from the Newark rocks of North Carolina. Others are closely related to the plants of Abiquiu, New Mexico, and Sonora, Mexico. After describing the Honduras fossils, Newberry refers to their relation to other floras in the following language:

"This discovery of a Triassic flora in Honduras is a matter of special interest, as nothing of the kind had before been met with in that section of the globe; but it is only another illustration of the uniformity of the vegetation of the world during the Triassic age. This uniformity was, however, only a development of the systematic progress of plant life. The reign of Acrogens ended with the Permian. The Rhetic epoch was, therefore, about the middle of the reign of Gymnosperms. No Angiosperms were yet in existence, for they began in the Cretaceous. * * *

"Where the Gymnospermous flora originated, or how it was developed from the Acrogens, if it was so developed, and through the exercise of what elements of superiority it superseded them, we are yet in ignorance. It is, however, a matter that may well excite our wonder that,

[1] Appendix No. 1 to geological researches in China, Mongolia, and Japan [etc.] by Raphael Pumpelly. Smithsonian Contributions to Knowledge, vol. VII, Washington, 1867, pp. 119-123.

migrating such immense distances from their place of origin, through every phase of soil and climate—through all the zones of the Eastern Hemisphere, and now, as we learn from this group of Honduras plants, through the New World—they march, holding so firmly to their original group of characters, generic and specific, that wherever we open their tombs we recognize them instantly as old friends. In their long marches some perish by the way, and here and there, their numbers were recruited by new forms, imported or developed; but the leading members of the troop in virtue of some occult protection against outside influences, preserved almost without alteration all the complicated characters of their vegetative and reproductive systems.

"We shall look now with eagerness to South America for the full identification there of this Mesozoic flora, which we have found in full development in Virginia, New Mexico, Sonora and now in Honduras. It had before been recognized in Australia—where it seems to emerge from the Paleozoic flora and perhaps began—New Zealand, India, Tonquin, China, Turkestan and various parts of Europe."[1]

[1] Rhetic plants from Honduras. In Am. Jour. Sci., 3d ser., vol. XXXVI, 1888, pp. 342-351.

INDEX TO THE LITERATURE OF THE NEWARK SYSTEM.

SOURCES OF INFORMATION.

In compiling this index the principal sources of information have been the national and state geological reports included in Frederick Prime's catalogue of official reports,[1] and all similar reports, published since the appearance of the second supplement of that catalogue, on the subjects referred to in this list. Included with these reports, and mentioned in part in Prime's catalogue, are the publications of the Smithsonian Institution, the U. S. National Museum, the U. S. Coast and Geodetic Survey, the U. S. Department of Agriculture, and handbooks of information published by various states. In addition all books and papers published unofficially, containing information relating to the Newark system, have been examined.

Besides these, the following serial publications have been examined:

CATALOGUE OF SERIAL PUBLICATIONS EXAMINED.

Name.	Published at—	Abbreviation.	Examined.
Albany Institute, Proceedings	Albany, N. Y	Albany Inst., Proc	Vols. 1-12.
Albany Institute, Transactions	Albany, N. Y	Albany Inst., Trans	Vols. 1-10.
American Academy of Arts and Sciences, Memoirs.	Cambridge and Boston, Mass.	Am. Acad., Mem	1st series: Vols. 1-5; 2d series: Vols. 1-15.
American Academy of Arts and Sciences, Proceedings.	Boston and Cambridge, Mass.	Am. Acad., Proc	1st series: Vols. 1-5; 2d series: Vols. 1-15.
American Association for the Advancement of Science, Proceedings.	Salem, Mass	Am. Assoc. Adv. Sci., Proc.	Vols. 1-37.
American Association of Geologists and Naturalists, Proceedings.	Boston, Mass	Am. Assoc. Geol. and Nat., Proc.	Meetings 1-6.
American Association of Geologists and Naturalists, Transactions.	Boston, Mass	Am. Assoc. Geol. and Nat., Trans.	Vol. 1 (1840-1842.)
American Chemical Journal	Baltimore, Md	Am. Chem. Jour	Vols. 1-9.
American Chemist	New York, N. Y	Am. Chem	Vols. 1-7.
American Geologist	Minneapolis, Minn	Am. Geol	Vols. 1-6.
American Institute of Mining Engineers, Transactions.	Easton, Philadelphia, Pa., and New York, N. Y.	Am. Inst. Mining Eng., Trans.	Vols. 1-17.
American Journal of Conchology	Philadelphia, Pa	Am. Jour. Conch	Vols. 1-7.
American (Monthly) Journal of Geology and Mineralogy (Featherstonhaugh).	Philadelphia, Pa	Am. Jour. Geol. and Min.	Vol. 1, Nos. 1-10.
American Journal of Science	New Haven, Conn	Am. Jour. Sci	1st series: Vols. 1-50; 2d series: Vols. 1-50; 3d series: Vols. 1-40.
American Mineralogical Journal (Bruce).	New York, N. Y	Am. Min. Jour. (Bruce).	Vol. 1.
American Museum of Natural History, Bulletin.	New York, N. Y	Am. Mus. Nat. Hist., Bull.	Vol. 1, 2.

[1] Am. Inst. Min. Eng., Trans., vol. VII, pp. 455-525. First supplement, vol. VIII, pp. 466-478. Second supplement, vol. IX, pp. 621-632.

Catalogue of serial publications examined—Continued.

Name.	Published at—	Abbreviation.	Examined.
American Naturalist	Salem, Mass., and Philadelphia, Pa.	Am. Nat	Vols. 1-24.
American Philosophical Society, Proceedings.	Philadelphia, Pa	Am. Philo. Soc., Proc.	Vols. 1-26.
American Philosophical Society, Transactions.	Philadelphia, Pa	Am. Philo. Soc., Trans.	1st series: Vols 1-6; 2d series: Vols. 1-16.
Annals of Science (Cleveland)	Cleveland, Ohio	Ann. Sci. (Cleveland)	Vols. 1, 2.
Annual of Scientific Discovery	Boston, Mass	Ann. Sci. Discov	1850-1871.
Appalachia	Boston, Mass	Appalachia	Vols. 1-5.
British Association for the Advancement of Science, Report.	London, England	British Assoc. Adv. Sci., Rep.	Vols. 1-59.
Boston Journal of Natural History	Boston, Mass	Boston Jour. Nat. Hist.	Vols. 1-7.
Boston Society of Natural History, Anniversary Memoirs.	Boston, Mass	Boston Soc. Nat. Hist., Ann. Mem.	1880.
Boston Society of Natural History, Bulletin.	Boston, Mass	Boston Soc. Nat. Hist., Bull.	Vols. 1-4.
Boston Society of Natural History, Memoirs.	Boston, Mass	Boston Soc. Nat. Hist., Mem.	Vols. 1-4.
Boston Society of Natural History, Occasional Papers.	Boston, Mass	Boston Soc. Nat. Hist., Occasional Papers.	Vols. 1-3.
Boston Society of Natural History, Proceedings.	Boston, Mass	Boston Soc. Nat. Hist., Proc.	Vols. 1-24.
Brookville Society of Natural History, Bulletins.	Richmond, Ind	Brookville Soc. Nat. Hist., Bull.	Nos. 1, 2.
Buffalo Society of Natural History, Bulletins.	Buffalo, N. Y	Buffalo Soc. Nat. Hist., Bull.	Vols. 1-5.
California Academy of Sciences, Bulletins.	San Francisco, Cal	California Acad. Sci., Bull.	Vols. 1, 2, Nos. 5-8.
California Academy of Sciences, Memoirs.	San Francisco, Cal	California Acad. Sci., Mem.	Vol. 1, parts 1, 2.
California Academy of Sciences, Proceedings.	San Francisco, Cal	California Acad. Sci., Proc.	Vols. 1-7; second series: Vols. 1, 2.
Canadian Institute, Proceedings	Toronto, Canada	Canadian Inst., Proc.	Vols. 1-5.
Canadian Journal of Industry, Science and Art.	Toronto, Canada	Canadian Jour. Ind., Sci. and Art.	Vols. 1-3; new series: Vols. 1-15.
Canadian Naturalist	Montreal, Canada	Canadian Nat	Vols. 1-8; new series: Vols. 1-10.
Canadian Record of Science	Montreal, Canada	Canadian Rec. Sci	Vols. 1-4.
Canada, Royal Society, Transactions and Proceedings.	Montreal, Canada	Canada, Roy. Soc., Trans. and Proc.	Vols. 1-4.
Central Ohio Scientific Association, Proceedings.	Urbana, Ohio	Central Ohio Sci. Assoc., Proc.	Vol. 1, parts 1, 2.
Chicago Academy of Sciences, Bulletin.	Chicago, Ill	Chicago Acad. Sci., Bull.	Vol. 1, No. 6.
Chicago Academy of Sciences, Proceedings.	Chicago, Ill	Chicago Acad. Sci., Proc.	Vol. 1.
Chicago Academy of Sciences, Transactions.	Chicago, Ill	Chicago Acad. Sci., Trans.	Vol. 1.
Cincinnati Society of Natural History, Journal.	Cincinnati, Ohio	Cincinnati Soc. Nat. Hist., Jour.	Vols. 1-10; Vol. 12, Nos. 1-3.
Cleveland Academy of Sciences, Proceedings.	Cleveland, Ohio	Cleveland Acad. Sci., Proc.	1845-1859.
Colorado Scientific Society, Proceedings.	Denver, Colo	Colorado Sci. Soc., Proc.	Vols. 1, 2.
Colorado State School of Mines, Reports.	Golden, Colo	Colorado State School of Mines, Rep.	1885-1887.
Columbia College (*see* School of Mines).			
Connecticut Academy of Sciences, Memoirs.	New Haven, Conn	Connecticut Acad. Sci., Mem.	Vol. 1, part 1.
Connecticut Academy of Sciences, Transactions.	New Haven, Conn	Connecticut Acad. Sci., Trans.	Vols. 1-7.
Cornell University, Scientific Bulletin	Ithaca, N. Y	Cornell Univ., Bull	Vols. 1, 2.
Cornwall Royal Geological Society, Transactions.	Cornwall, England	Cornwall Roy. Geol. Soc., Trans.	Vols. 7-9.
Dakota School of Mines, Report	Rapid City, Dak	Dakota Sch. Min., Rep.	1888.
Davenport Academy of Natural Sciences, Proceedings.	Davenport, Iowa	Davenport Acad. Nat. Sci., Proc.	Vols. 1-4.
Denison University Scientific Laboratory, Bulletin.	Granville, Ill	Denison Univ., Bull	Vols. 1-3.
Des Moines Academy of Sciences, Bulletin.	Des Moines, Iowa	Des Moines Acad. Sci. Bull.	Vol. 1, No. 1.
Dublin Geological Society, Journal	Dublin, Ireland	Dublin Geol. Soc., Jour.	Vols. 1-10.
Dublin Quarterly Journal of Science	Dublin, Ireland	Dublin Quart. Jour. Sci.	Vols. 1-6.
Edinburgh Geological Society, Transactions.	Edinburgh, Scotland	Edinburgh Geol. Soc., Trans.	Vols. 1-4.

Catalogue of serial publications examined—Continued.

Name.	Published at—	Abbreviation.	Examined.
Edinburgh (The) New Philosophical Journal.	Edinburgh, Scotland	Edinburgh New Phil. Jour.	New series, 1–4, 6, 8–19.
Elisha Mitchell Scientific Society, Journal.	Raleigh, N. C	Elisha Mitchell Sci. Jour.	1883–1889.
Elliott Society of Natural History, Journal.	Charleston, S. C	Elliott Soc. Nat. Hist., Jour.	Vol. 1.
Elliott Society of Natural History, Proceedings.	Charleston, S. C	Elliott Soc. Nat. Hist., Proc.	Vol. 1.
Essex Institute, Bulletin	Salem, Mass	Essex Inst., Bull	Vols. 1–18.
Essex Institute, Proceedings	Salem, Mass	Essex Inst., Proc	Vols. 1–6.
Essex Natural History Society, Journal.	Salem, Mass	Essex Nat. Hist. Soc., Jour.	Vols. 1–6.
France, Geological Society, Bulletin	Paris, France	France, Geol. Soc., Bull	1st series: Vols. 1–14; 2d series: Vols. 1–26; 3d series: 1–15.
France, Geological Society, Memoirs	Paris, France	France Geol. Soc., Mem	1st series: Vols. 1–5; 2d series: Vols. 1–10; 3d series: Vols. 1–4.
Franklin Institute, Journal	Philadelphia, Pa	Franklin Inst., Jour	3d series: Vols. 77–92.
Geological Association (*see* London Geological Association).			
Geological Magazine	London, England	Geol. Mag	1st series: Vols. 1–10; 2d series: Vols. 1–12; decade 3d: Vols. 1–6.
Geological Society of America, Bulletin.	New York, N. Y., and Washington, D. C.	Am. Geol. Soc	Vols. 1, 2.
Geological Society (of London) (*see* London Geological Society).			
Geologist, The	London, England	Geologist	Vols. 1, 2 (1842–1843).
Geologist, The	London, England	Geologist	Vols. 1–7 (1858–1863).
Great Britain (*see* Royal Institution of Great Britain).			
Hamilton Association, Journal and Proceedings.	Hamilton, Ontario	Hamilton Assoc., Jour. and Proc.	Vols. 1, 2.
Hartford Natural History Society, Transactions.	Hartford, Conn	Hartford Nat. Hist. Soc., Trans.	No. 1 (1836).
Harvard College, Museum of Comparative Zoology, Bulletin.	Cambridge, Mass	Harvard Coll. Mus. Comp. Zool., Bull.	Vols. 1–18.
Harvard College, Museum of Comparative Zoology, Memoirs.	Cambridge, Mass	Harvard Coll. Mus. Comp. Zool., Mem.	Vols. 1–15.
Illinois Natural History Society, Transactions.	Springfield, Ill	Illinois Nat. His. Soc., Trans.	Vol. 1.
International Congress of Geologists, American Committee, Report.		Internat. Cong., Geol. Am. Com., Rep.	
International Congress of Geologists, American Committee, Reports.	Philadelphia, Pa	Internat. Cong., Geol. Am. Com., Rep.	Report for the London meeting.
Iowa Academy of Sciences, Proceedings.	Des Moines, Iowa	Iowa Acad. Sci., Proc.	1887–1889.
Ireland, Royal Academy, Proceedings.	Dublin, Ireland	Ireland Roy. Acad., Proc.	Second series: Vols. 1–3.
Ireland, Royal Geological Society		Ireland Roy. Geol. Soc.	Vols. 1–14.
Ireland, Royal Geological Society, Journal.		Ireland Roy. Geol. Soc., Jour.	
Johns Hopkins University, Circular.	Baltimore, Md	Johns Hopkins Univ., Circ.	Vols. 1–7.
Kansas Academy of Science, Transactions.	Topeka, Kans	Kansas Acad. Sci	Vols. 1–7, 9–11.
Kirtland Society of Natural Science, Papers.	Cleveland, Ohio	Kirtland Soc. Nat. Sci., Papers.	1874.
Liverpool Geological Society, Proceedings.	Liverpool, England	Liverpool Geol. Soc., Proc.	Vols. 1–5.
London Geological Society, Proceedings.	London, England	London Geol. Soc., Proc.	Vols. 1–4.
London Geological Society, Quarterly Journal.	London, England	London Geol. Soc., Quar. Jour.	Vols. 1–44.
London Geological Society, Transactions.	London, England	London Geol. Soc., Trans.	1st series: Vols. 1–5; 2d series: Vols. 1–7.
London Geologists' Association, Proceedings.	London, England	London Geol's. Assoc., Proc.	1st series: Vol. 1; 2d series: Vols. 1–9.

Catalogue of serial publications examined—Continued.

Name.	Published at—	Abbreviation.	Examined,
London Royal Society, Philosophical Transactions.	London, England	London Roy. Soc., Phil. Trans.	From 1837 to 1884.
London, Edinburgh and Dublin Philosophical Magazine and Journal of Science.	London, England	London Philo. Mag.	5th series: Vols. 1-21.
Maclurean Lyceum, Contribution	Philadelphia, Pa	Maclurean Lyc., Cont.	Vol. 1.
Manchester, Geological Society, Transactions.	Manchester, England	Manchester Geol. Soc., Trans.	Vols. 1-25.
Manitoba Historical and Scientific Society, Transactions.	Winnipeg, Canada	Manitoba Hist. and Sci. Soc., Trans.	Vols. 1-29.
Maryland Academy of Sciences, Transactions.	Baltimore, Md	Maryland Acad. Sci., Trans.	1888, pp. 1-97.
Maryland Academy of Sciences and Literature, Transactions.	Baltimore, Md	Maryland Acad. Sci. Lit., Trans.	Vol 1.
Massachusetts Institute of Technology; Technology Quarterly (*see* Technology Quarterly).			
Meriden Scientific Association, Transactions.	Meriden, Conn	Meriden Sci. Assoc., Trans.	Vols. 1-4.
Minnesota Academy of Science, Bulletin.	Minneapolis, Minn	Minnesota Acad. Sci., Bull.	Vols. 1, 2.
National Academy of Science, Annual.	Washington, D. C., and Cambridge, Mass.	National Acad. Sci., Ann.	Vols. 1-4.
National Academy of Science, Memoirs.	Washington, D. C.	National Acad. Sci., Mem.	Vol. 1.
National Geographic Magazine	Washington, D. C.	Nat. Geog. Mag.	Vol. 1, No. 1-4.
National Institution, Bulletin of the Proceedings.	Washington, D. C	National Inst., Proc	1840-1844.
Neues Jahrbuch für Mineralogie, Geologie und Paleontologie.	Stuttgart, Germany	Neues Jahrbuch	Vols. 1836-1887. Beilage Bd. 1-4.
New Brunswick Natural History Society, Bulletin.	Fredericton, N. B	New Brunswick Nat. Hist. Soc., Bull.	Vols. 1-6.
New Orleans Academy of Sciences, Papers.	New Orleans, La	New Orleans Acad. Sci., Papers.	Vol. 1, No. 2.
New Orleans Academy of Sciences, Proceedings.	New Orleans, La	New Orleans Acad. Sci., Proc.	Vol. 1, No. 1.
Newport Natural History Society, Documents.	Newport, R. I	Newport Nat. Hist. Soc., Doc.	Documents 2-5.
New York Academy of Sciences, Annals.	New York, N. Y	New York Acad. Sci., Ann.	Vols. 1-5.
New York Academy of Sciences, Transactions.	New York, N. Y	New York Acad. Sci., Trans.	Vols. 1-10 (No. 1-3).
New York Lyceum of Natural History, Annals.	New York, N. Y	New York Lyc. Nat. Hist., Ann.	Vols. 1-11.
New York Lyceum of Natural History, Proceedings.	New York, N. Y	New York Lyc. Nat. Hist., Proc.	Vol. 1 (1870-'71) 2d series Vol. 1 to p. 156.
Nova Scotian Institute of Natural Science, Transactions.	Halifax, Nova Scotia	Nova Scotian Inst., Trans.	Vols. 1-7.
Orleans County Society of Natural Sciences, Transactions and Archives of Science.	Lunenburg, Vt	Orleans (Vt.) Soc. Nat. Sci., Trans.	Vol. 1, No. 1-6.
Ottawa Field-Naturalists' Club, Transactions.	Ottawa, Canada	Ottawa Field-Nat. Club, Trans.	Vol. 1, No. 1-4. Vol. 2, No. 5-7.
Ottawa Naturalist and Transactions of the Ottawa Field-Naturalists' Club.	Ottawa, Canada	Ottawa Nat. and Field-Nat. Club, Trans.	Vol. 1.
Pennsylvania Geological Society, Transactions.	Philadelphia, Pa	Pennsylvania Geol. Soc., Trans.	Vol. 1.
Petermann's Mittheilungen	Gotha, Germany	Petermann's Mitt.	Vols. 1-33; Ergänzungsbände 1-12.
Philadelphia Academy of Natural Sciences, Journal.	Philadelphia, Pa	Philadelphia Acad. Nat. Sci., Jour.	1st series, Vols. 1-8; 2d series, Vols. 1-8.
Philadelphia Academy of Natural Sciences, Proceedings.	Philadelphia, Pa	Philadelphia Acad. Nat. Sci., Proc.	Vols. 1-39, to 1890.
Philosophical Society of Washington, D. C. (*see* Washington Philosophical Society).			
Portland Society of Natural History, Journal.	Portland, Me	Portland Soc. Nat. Hist., Jour.	Vol. 1, No. 1.
Portland Society of Natural History, Proceedings.	Portland, Me	Portland Soc. Nat. Hist., Proc.	Vol. 1.
Pottsville Scientific Association, Bulletin.	Pottsville, Pa	Pottsville Sci. Assoc., Bull.	1855.
Royal Institution of Great Britain, Journal.	London	Roy. Inst. Gr. Br., Jour.	Vols. 1, 2.
Royal Irish Academy (*see* Ireland, Royal Academy).			

Catalogue of serial publications examined—Continued.

Name.	Published at—	Abbreviation.	Examined.
Royal Society, London (*see* London, Royal Society).			
Saint Louis Academy of Sciences, Transactions.	Saint Louis, Mo	Saint Louis Acad. Sci., Trans.	Vols. 1-4; Vol. 5, pp. 1-336.
School of Mines, Quarterly	New York, N. Y	School of Mines, Quart.	Vols. 1-11.
Science	Cambridge, Mass., and New York, N.Y.	Science	Vols. 1-14.
Science	New York, N. Y	Science (ed. by John Michels).	Vols. 1, 2.
Smithsonian Institution, Annual Report.	Washington, D. C	Smith. Inst., Ann. Rep.	1853-1887.
Smithsonian Institution, Contribution to Knowledge.	Washington, D. C	Smith. Inst., Cont. Knowl.	Vols. 1-25.
Smithsonian Institution, Miscellaneous Collections.	Washington, D. C	Smith. Inst., Misc. Coll.	Vols. 1-12.
Société géologique de France (*see* France, Geological Society).			
Technology Quarterly	Boston, Mass	Tech. Quart	Vols. 1-3.
Texas State Geological and Scientific Association, Bulletin.	Houston, Tex	Texas State Geol. and Sci. Assoc., Bull.	Vol. 1, No. 1-6.
Trenton Natural History Society, Journal.	Trenton, N. J	Trenton Nat. Hist. Soc., Jour.	Vol. 1.
United States Geological Survey, Annual Reports.	Washington, D. C	U. S. Geol. Surv., Ann. Rep.	1st-7th.
United States Geological Survey, Bulletin.	Washington, D. C	U. S. Geol. Surv., Bull.	No. 1-50.
United States Geological Survey, Mineral Resources.	Washington, D. C	U. S. Geol. Surv., Min. Resourc.	1883-1887.
United States Geological Survey, Monographs.	Washington, D. C	U. S. Geol. Surv., Mono.	Vols. 1-14.
United States National Museum, Bulletin.	Washington, D. C	U. S. Nat. Mus., Bull.	Vol. 1.
United States National Museum, Proceedings.	Washington, D. C	U. S. Nat. Mus., Proc.	Vols. 1-10.
Vassar Brothers' Institute, Transactions.	Poughkeepsie, N. Y	Vassar Brothers' Inst., Trans.	Vols. 1-4.
Virginias, The	Staunton, Va	The Virginias	Vols. 1-6.
Washburn College Laboratory of Natural History, Bulletin.	Topeka, Kans	Washburn Coll., Bull.	Vol. 1.
Washington Biological Society, Proceedings.	Washington, D. C	Washington Biol. Soc., Proc.	Vols. 1-3.
Washington Philosophical Society, Bulletin.	Washington, D. C	Washington Phil. Soc., Bull.	Vols. 1-10.
Wisconsin Academy of Science, Arts, and Letters, Bulletin.	Madison, Wis	Wisconsin Acad. Sci., Bull.	No. 1-5.
Wisconsin Academy of Science, Arts, and Letters, Transactions.	Madison, Wis	Wisconsin Acad. Sci., Trans.	Vols. 1-5.
Wyoming Historical and Geological Society, Proceedings and Collections.	Wilkesbarre, Pa	Wyoming Hist. and Geol. Soc., Proc. and Coll.	Vols. 1-3.
Zeitschrift der deutschen geologischen Gesellschaft.	Berlin	Deutsch., Zeitschr. geolo. Gesell.	Whole set.

PLAN OF THE INDEX.

This index consists of principal and secondary entries arranged in a single alphabetic series.

Principal entries.—These consist of the names of books and papers arranged under authors. The author's name is printed in **BLACK FACED** (capitals) type, with a date to the right in the same type. The date designates the year of publication, or, instead of this, in the case of many serials, the date at which the paper appeared, or was read. When two or more papers bear the same date, the second one is designated as *a*, the third as *b*, and so on. When a paper has been published in more than one edition, the edition given first in the description of the book is the one referred to.

The abstract following the description of a paper indicates briefly its contents so far as it relates to the Newark system. References are given to so-called Newark rocks on Prince Edward island, for the reason that the index was compiled before it was concluded that the Newark system is not there represented.

Secondary entries.—The chief words of the secondary or subject entries are printed in **black faced** (small letters) type and in these the reader is referred by author's name and date to the principal entries in **BLACK FACED** (capitals) type.

These secondary entries include:

(1) Places where observations on the Newark system have been made. In these entries the method of locating observations in use by each author has been followed. For example, a locality may be referred to in reference to its proximity to a town, a mountain, a river, etc., by different writers. This necessarily leads to lack of uniformity in the index, but when practicable, cross-references from one method of entry to others have been made.

(2) Under the names of states, the principal papers relating to the rocks of the Newark system within their borders.

(3) The works of authors cited in publications not their own. These are referred to under the name of the author cited, but the information contained in the reference or quotation is treated as a portion of the paper in which it appears.

(4) Under the head of Plants (fossil), Invertebrates (fossil), and Vertebrates (fossil), references to papers containing descriptions of species or genera.

(5) In structural and general geology, references to the following subjects whenever the information recorded seemed sufficiently definite:

Age (discussion or determination of).	Dip.	Oil.
Analyses.	Dike.	Raindrop impressions.
Anticline.	Fault.	Salt.
Arkose.	Footprints.	Sandstone.
Coal.	Gypsum.	Shale.
Coke, natural.	Limestone.	Shrinkage cracks.
Conformity.	Map, geological.	Strike.
Conglomerate.	Metamorphism.	Synclinals.
Copper.	Metamorphism, contact.	Trap.
	Minerals (principal papers only).	

In making references to the subjects mentioned above, as great consistency has been observed as the diversity of the papers indexed would allow.

Besides the subjects enumerated some irregular entries have been inserted, but not systematically noted for the whole body of literature examined. An effort has been made to complete the list up to 1891, but a few papers published in 1890 were received too late to be fully indexed. A further delay in publication has enabled me to introduce references to a few published in 1891, but for these only a limited number of secondary entries have been inserted.

When not otherwise indicated the papers referred to are octavo.

In preparing this index I have been greatly assisted by Mr. Nelson H. Darton, who has permitted unrestricted use of the manuscript of an unpublished "Author's Catalogue of North American Geology," and has assisted me in many other ways. I am also indebted to Prof. W. O. Crosby, for a short bibliographic list which has been used in verification.

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Trap dikes near (Hammond, 1884, p. 466).

ABBOT, [S. L.] Cited on fossil footprints. (E. Hitchcock, 1843*a*, p. 260).

Abbotstown, Pa. Character of strata near (H. D. Rogers, '58, vol. 2, p. 679).

Conglomerate near (H. D. Rogers, '58, vol. 2, p. 680).

Dip near (Frazer, '76, p. 101).

Acadia. Section of the rocks of (Dawson, '78 Pl. op., p. 20).

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ADAMS, C. B. **1846.**

Second annual report on the geology of the state of Vermont. Burlington Vt., pp. 1–267.

Contains a brief account of the Newark system in general, pp. 101–102. Discusses the amount of erosion indicated by the trap dikes of the Connecticut valley and of Vermont. States that some of the material forming the Newark rocks of the Connecticut valley came from the North, pp. 159–162.

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Elements of geology.

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Neuchatel, 5 vol. folio.

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In Am. Acad., Proc., vol. 3, 1852–1857, p. 193.

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Exploration for copper ore near (Frazer, '77, pp. 263–264).
On the occurrence of copper ore at (Frazer, '77*b*. Frazer, '80, p. 300).

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Boone's mill, Pa. Dip of strata, and exposure of trap near (d'Invilliers, '83, p. 216).

Boonton, N. J. Boundary of Newark at (Cook, '68, p. 175. Cook, '89, p. 11).
Brief record of the finding of a fossil footprint near (Russell, '79).
Character and origin of the Newark conglomerate at (Russell, '78, p. 253).
Coal in thin seams at (Cook, '78, p. 110).
Color of the strata near (Newberry, '88, p. 8).
Conglomerate composed of gneissic pebbles near (Nason, '89, p. 21).
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Contact of Newark rocks and gneiss near (H. D. Rogers, '40).
Dip in shale at (Cook, '82, p. 30.)
Dip of sandstone near (Cook, '68, p. 196. Cook, '79, p. 30).
fossil footprints from near (Cook, '68, p. 174. Cook, '79, p. 28. C. H. Hitchcock, '88, p. 122).
Footprints found near (Nason, '89, p. 28).
Mention of (Russell, '78, p. 223).
Fossil estheria and fish scales found near (Nason, '89, p. 30).
Fossil fishes from (Cook, '68, p. 174. Cook, '79, p. 27. Newberry, '88, p. 20).

Boonton, N. J.—Continued.
Fossil fishes from. Descriptions of (Newberry, '78. Newberry, '88. W. C. Redfield, '41).
Fossil fishes from, in New York State Cabinet (Anonymous, '54).
Fossil fishes from. List of (De Kay, '42).
Fossil fish from. Mention of (W. C. Redfield, '43).
Fossil footprints from near (Cook, '68, p. 174. Cook, '79, p. 28. C. H. Hitchcock, '88, p. 122).
Mention of the occurrence of ripple-marks, suncracks, raindrop impressions, and footprints at (Russell, '78, p. 225).
Plant remains in sandstone near (Nason, '89, p. 28).
Section from, to Jersey City, N. J. (Cook, '85, pl. op. p. 109).
Section from, to Passaic, N. J. (Cook, '68, p. 199, and map in portfolio).

Bound Brook, N. J. Copper mine near (Cook, '68, p. 677-678).
Dip in shale near (Cook, '79, p. 30. Cook, '82, p. 25).
Dip near (Cook, '68, p. 196).
Elevation of First mountain at (Cook, '82, p. 49).
Fossil estherias found near (Nason, '89, p. 30).
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Gap in First mountain near (Cook, '82, p. 50).
Mention of the occurrence of ripple-marks, suncracks, raindrop impressions, and footprints at (Russell, '78, p. 225.
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Trap hills near, brief reference to (H. D. Rogers, '36, p. 159).
Trap near, columnar (Cook, '68, p. 203).
Trap near, vesicular (Darton, '90, p. 28).
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[Note on the plates illustrating ichnographs from the sandstone of Connecticut river.]
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BRITTON, N. L. 1881.
On the geology of Richmond county, N[ew] Y[ork].
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[Remarks on fossil localities in the Newark rocks of New Jersey and Pennsylvania.]
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Mentions the discovery of fossil fish and specimens of Estheria at Weehawken, N. J. Refers also to specimens of fossil plants from Doylestown, Pa., and to casts of a bivalve shell from Phœnixville, Pa.

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[Remarks on the probable occurrence of Paleozoic limestone beneath the Newark system in New Jersey.]
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In New York Acad. Sci., Trans., 1886-1887, pp. 12-18.
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Histoire des végétaux fossiles, ou recherches botanique et géologique sur les végétaux renfermés dans les diverses couches du globe.
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Brief account of stone quarries near (Cook, '81, p. 59).
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Origin of trap rock near (Darton, '89, p. 138).
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BRUSH, J. G. Analysis of trap from East Rock, Conn., by (J. D. Dana, '73, vol. 6, p. 106).

Bryan Martin channel, B. A. Reference to Jurassic reptiles from (Hull, '87, p. 95).

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Buckhead, S. C. Description of trap dikes near (Tuomey, '44, p. 2).

Buck hill, Va. Mention of a trap dike at (Clifford, '88, p. 252).
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CHAMBERLIN, B. B. 1883.
The minerals of Weehawken tunnel (Bergen Hill, New Jersey).
In New York Acad. Sci., Trans., vol. 2, 1882-1883, pp. 88-90.
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CHAMBERLIN, B. B. 1887.
Minerals of Staten island [New York].
In New York Acad. Sci., Trans., vol. 5, 1885-1886, pp. 228-230.
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CHAPIN, A. B. 1835.
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In Am. Jour. Sci., vol. 27, pp. 104-112.
Several small dikes are described, and some account given of alteration in the adjacent beds.

CHAPIN, J. H. 1887.
The Hanging hills [Connecticut].
In Meriden Sci. Assoc., Proc. and Trans., vol. 2, 1885-1886, pp. 23-28.
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C[HAPIN], J. H. 1887a.
An interesting find [of fossil plants at Durham, Connecticut].
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CHAPIN, J. H.
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Cites W. M. Davis on the structure of the Newark system in the Connecticut valley. Describes a bed of ash and bombs near Meriden, Conn.

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Some geological features of Meriden [Connecticut].
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C[HAPIN], J. H. 1891a.
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In Meriden Sci. Assoc., Trans., vol. 4, 1889-1890, p. 62.
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[Review of J. W. Dawson's Acadian Geology].
In Canadian Jour., n. s., vol. 1, pp. 39-48.
Hypotheses concerning the deposition of copper in amygdaloids, etc., discussed, pp. 42-45.

CHAPMAN, E. J. 1872.
On the occurrence of copper ore in the island of Grand Manan, bay of Fundy.
In Canadian Jour., n. s., vol. 13, pp. 234-239, pl. op. p. 183.
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CHAPMAN, E. J. 1876.
An outline of the geology of Canada, based on a subdivision of the provinces into natural areas.
Toronto, 12°, pp. i-xxxii, 33-104, pl, 1-5, and 6 maps.
Contains a brief general account of the Newark rocks of Nova Scotia. A broad area of Newark rocks is stated to occur on Prince Edward island. Pp. 91-92.

CHAPMAN, E. J. 1878.
On the leading geological areas of Canada.
In Canadian Jour., n. s., vol. XV, pp. 13-22, 92-121.
Contains a brief summary of information concerning the Newark rocks of New Brunswick and Nova Scotia. The main area of Prince Edward island is referred to the Trias. Pp. 22, 106, 110-112, 120-121.

CONRAD, T[IMOTHY] A[BBOTT]. **1839.**
Notes on American geology.
In Am. Jour. Sci., vol. 35, pp. 237–251.
Contains a brief description of the Newark rocks along the Hudson, with the statement that they are probably of the Lower Silurian age, p. 249.

CONRAD, T. A. **1841.**
Fifth annual report on the paleontology of the state of New York.
In fifth annual report of the geological survey of New York, Albany, N. Y., 1841, pp. 25–57.
Brief statement in reference to the geological position of the Triassic rocks. Absence of brine springs and rock salt, pp. 43–44.

CONRAD, T. A. **1841*a*.**
Report on the ornithichnites or footmarks of extinct birds in the new red sandstone of Massachusetts and Connecticut, observed by Prof. Hitchcock of Amherst.
See Rogers, Vanuxem, Taylor, Emmons, and Conrad, 1841.

CONRAD, T. A. **1858.**
Description of a new species of Myacites.
In Philadelphia Acad. Nat. Sci., Proc., vol. 9, 1857, p. 166.
Describes *M. acites pennsylvanicus*, from Phœnixville, Pa.

CONRAD, T. A. **1868.**
Description of and reference to Miocene shells of the Atlantic slope, and descriptions of two new supposed Cretaceous species.
In Am. Jour. Conch., vol. 4, pp. 278–279.
A description of two fossil shells, *Astarte veta* and *A. annosa*, from Washington, Middlesex County, N. J., p. 279.
Fossils from the locality here mentioned have been examined by R. P. Whitfield, Monog. U. S. Geol. Surv., vol. 9, 1886, pp. 22–27, and shown not to be Newark. The formation to which they belong is referred to the Potomac, by W. J. McGee, Am. Jour. Sci., 3d ser., vol. 35, pp. 136–137.

CONRAD, T. A. **1870.**
Descriptions of new fossil mollusca, principally Cretaceous.
In Am. Jour. Conch., vol. 5, pp. 96–103.
Description of a fossil shell from near Perkiomen Creek, Pa., p. 102.

CONRAD, T. A., and WM. M. GABB. **1861.**
Illustrations of some fossils described in the proceedings of the [Philadelphia] Academy of Natural Science.
In Phila. Acad. Nat. Sci., Proc. [vol. 12], 1860, p. 55, pl. 1.
Gives a figure of *Myacites pennsylvanicus*, previously described by T. A. Conrad, pl. 1. [The plate referred to is numbered 7 by mistake.]

COOK, GEORGE H. 1864.

Report of Prof. George H. Cook upon the geological survey of New Jersey and its progress during the year 1863.

Trenton, N. J. Pp. 1–13.

Contains a brief notice of extent of Newark rocks in Hunterdon county, together with an account of prevailing dips, and a qualified statement of the age of the Newark system in New Jersey. Pp. 6–7.

COOK, GEORGE H. 1865.

The annual report of Prof. George H. Cook, state geologist, to his excellency Joel Parker, president of the board of managers of the Geological Survey of New Jersey, for the year 1864.

Trenton, N. J. Pp. 1–24, pl. 2.

East border of the Newark system in New Jersey defined, p. 5. Northwest border defined, pp. 6–8. Geological map, p. 21. Geological section, p. 22. Tabular statement to accompany geological map, giving principal rocks and localities where found, p. 24.

COOK, GEORGE H. 1868.

Geology of New Jersey.

Newark [N. J.]. Pp. i–xxiv, 1–900, pl. 6. Accompanied by a portfolio containing 8 maps in 13 sheets.

The following table indicates the contents of this volume so far as it relates to the Newark system:

COOK, GEORGE H. 1871.

[Annual report of the state geologist of New Jersey, for the year 1870].

New Brunswick, N. J. Pp. 1–75, pl. 4.

Deposits of copper ore described, pp. 55, 57.

COOK, GEORGE H. 1873.

Geological Survey of New Jersey. Annual report of the state geologist for the year 1873.

Trenton, N. J. Pp. 1–128, pl. 2.

Junction of Newark and Azoic rocks mentioned, pp. 13–14. Color given to Newark rocks on geological map, p. 22. Copper ores briefly mentioned, pp. 98–99. Part of the east boundary of the Newark system briefly described, p. 103.

COOK, GEORGE H. 1874.

Geological Survey of New Jersey. Annual report of the state geologist for the year 1874.

COOK, GEORGE H.—Continued.
Trenton [N. J.]. Pp. 1–115, with map.
Copper ores, p. 32. Junction of Newark and Cretaceous rocks mentioned, p. 43. Native iron in trap rocks, pp. 56–57.

COOK, GEORGE H. 1876.
Catalogue of the Centennial exhibit of the Geological Survey of New Jersey.
[Trenton, N. J.] Pp. 1–84.
Brief account of extent of the Newark system in New Jersey, with catalogue of 30 specimens of sandstones, shale, flagstone, conglomerate, and trap, pp. 24–25. Four other specimens of sandstone mentioned on p. 45.

COOK, GEORGE H. 1878.
Geological survey of New Jersey. Annual report of the state geologist for the year 1878.
Trenton, N. J., pp. 1–131, with map in pocket. Glacial markings in trap rock, p. 10. Soil formed from Newark shales, pp. 24–25, 29. Soil from trap rock ridges, p. 39. Coal in thin seams, p. 110.

COOK, GEORGE H. 1879.
Geological survey of New Jersey. Annual report of the state geologist for the year 1879.
Trenton, N. J., pp. 1–199, pl. 1, and geological map of New Jersey in pocket.

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COOK, GEORGE H. 1880.
Geological survey of New Jersey. Annual report of the state geologist for the year 1880.
Trenton, N. J., pp. 1–220, pl. 1, and folding map.

COOK, GEORGE H.—Continued.
Abstract in Am. Jour. Sci., 3d ser., vol. 22, pp. 77–78.
Contains an account of certain deep wells bored in the Newark rocks, including the record of a well at Paterson with analysis of water obtained, pp. 162–166. Brief statement concerning deep wells in Jersey City.

COOK, GEORGE H. 1881.
Geological survey of New Jersey. Annual report of the state geologist for the year 1881.
Trenton, N. J., pp. 1–87, 1–107, i–xiv, and map.
Brief account of reopening of copper mines, pp. 39–46. Description of the building stones of the Newark system, pp. 42–64.

COOK, GEORGE H. 1882.
Geological survey of New Jersey. Annual report of the state geologist for the year 1882.
Camden, N. J., pp. 1–191, pl. 1–6, and 3 maps.

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Little Falls, N. J., view of (Cook, '82, pl. 2).

COOK, GEORGE H. 1883.
Geological survey of New Jersey. Annual report of the state geologist for the year 1883.
Camden, N. J., pp. 1–188, pls. 1–8.
Abstract in Am. Jour. Sci., 3d ser., vol. 27, pp. 408–409.
Contains a brief review of a paper "On the relations of the Triassic traps and sandstones of the eastern United States," by W. M. Davis. The conclusion reached by Davis in reference to the extrusive origin of the Watchung mountain trap, is controverted, and facts presented with the view of showing that all the trap rocks of New Jersey are intrusive. In this discussion a summary is given of localities in New Jersey, where metamorphism adjacent to trap rock has been observed, pp. 22–26.
Native iron, and copper ores, pp. 162–166.

COOK, GEORGE H. 1884.

Geological survey of New Jersey. Annual report of the state geologist for the year 1884.

Trenton, N. J., pp. 1–168, pls. 1–5.

Abstract in Am. Jour. Sci., 3d ser., vol. 30, pp. 161–162.

Contains description with illustrations of an exposure of columnar trap at Orange, pp. 23–28.

Artesian wells with analyses of water, pp. 135–136.

COOK, GEORGE H. 1885.

Geological survey of the state of New Jersey. Annual report of the state geologist for the year 1885.

Trenton, N. J., pp. 1–228, pls. 1–13.

Abstract in Am. Jour. Sci., 3d ser., vol. 33, p. 79.

An incomplete list of localities in New Jersey, where fossils have been found, together with names of some of the specimens obtained, pp. 95–96.

Artesian and bored wells, with some account of the strata passed through, together with several analyses of the water obtained, pp. 111–123.

A section of Newark rocks between Jersey City and Boonton, on pl. op. p. 109.

COOK, GEORGE H. 1886.

Sketch of the geology of the Cretaceous and Tertiary formations of New Jersey.

In geological survey of New Jersey, brachiopoda and lamellibranchiata of the Raritan clays and greensand marls of New Jersey, by Robert P. Whitfield. Trenton, N. J., 4to., pp. i–xx, 1–338, pls. 1–35, with folding geological map of New Jersey.

Published also as Monograph IX, U. S. Geological Survey.

Junction of Cretaceous and Newark described, and shown in diagrams, p. x. On the map a portion of the Newark system is shown.

COOK, GEORGE H. 1887.

Geological survey of New Jersey. Annual reports of the state geologist for the year 1886.

Trenton, N. J., 1887, pp. 1–254, and two maps.

Reviewed in Science, vol. 9, 1887, pp. 595–596.

Describes briefly the general condition of the Newark rocks in New Jersey, and notices briefly the various explanations of their structure, character of trap sheets, etc., that have been suggested.

COOK, GEORGE H. 1888.

Report of the subcommittee [of the International Geological Congress] on Mesozoic.

In Am. Geol., vol. 2, pp. 257–261. Published also in International Cong. Geol. Am. Comm. Rep., 1888, pp. E1–E15.

Contains a brief review of the Newark system.

COOK, GEORGE H. 1889.

Geological survey of New Jersey. Annual report of the state geologist for the year 1888.

COOK, GEORGE H.—Continued.

Camden, N. J., 1889, pp. 1–87, pl. op. p. 42.

An introduction to F. L. Nason's paper on the Newark system in New Jersey (pp. 11–13). States briefly the boundaries of the system, its area, and the character of its principal rocks, mode of their formation, thickness, structure, etc. Presents two sections showing small faults.

COOK, GEORGE H. 1889 *a*.

On the International Geological Congress, and our part in it as American geologists.

In Am. Assoc. Adv. Sci., Proc., vol. 37, pp. 159–177.

Expresses belief that faults have been identified in the Newark system, which explain its structure and apparent great thickness. Refers also to the position of the system in the geological column.

COOK, G. H. Analysis of trap from New Jersey, by (J. D. Dana, '73, vol. 6, p. 106).

Cited on analysis of sandstone from New Jersey (Wurtz, '71).

Cited on columnar trap near Orange, N. J. (Iddings, '86, p. 329).

Cited on conglomerate near Paterson, N. J. (Darton, '90, p. 17).

Cited on curved form of certain trap ridges (W. M. Davis, '83, p. 307).

Cited on dips, indicating a fault in New Jersey (Lewies, '85, p. 451).

Cited on footprint localities in New Jersey (C. H. Hitchcock, '88, p. 122).

Cited on former extent of the Newark system (J. D. Dana, '83).

Cited on geology near Martin's dock, New Jersey (W. M. Davis, '83, p. 276).

Cited on the cause of the monoclinal structure of the Newark rocks of New Jersey (W. M. Davis, '86, p. 343).

Cited on the inclination of the red sandstone of New Jersey (Walling, '78, p. 196).

Cited on the occurrence of conglomerate along the Delaware in New Jersey (Russell, '78, pp. 235–236).

Cited on the origin and deposition of Newark strata (W. M. Davis, '83, p. 287).

Cited on the origin of the red color of the Newark sandstone (Russell, '89, p. 50).

Cited on the origin of prevailing dip of the Newark rocks of New Jersey (Wurtz, '70, pp. 99–100).

Cited on the tilting of sandstone and trap in New Jersey (W. M. Davis, '83, pp. 302, 303).

Cited on trap dikes in New Jersey (W. M. Davis, '83, p. 292).

Cited on upper contact of palisade trap sheet, New Jersey (Davis and Whittle, '89, p. 106).

Notice of work done by in New Jersey (Miller, '79–'81, vol. 2, pp. 157–158).

COOK, GEORGE H., and SMOCK, JOHN C. 1874.

Geological survey of New Jersey. [A geological map of] northern New Jersey, showing iron ores and limestone districts, scale 2 miles to 1 inch.

COOK, GEO. H., and SMOCK, JOHN C.—Cont'd.
New York. Two sheets in an envelope. [Revision of edition of 1868.]
Includes a portion of the area occupied by Newark sandstone and trap.

COOK, GEORGE H. and JOHN C. SMOCK. 1878.
Geological survey of New Jersey. Report on the clay deposits of Woodbridge, South Amboy and other places in New Jersey.
Trenton, N. J. Pp. 1–381, pls. 2, and map in pocket.
The references to the Newark system in this volume are brief and incidental to the description of the Cretaceous clays, etc. An unconformity between the Plastic clays at the base of the Cretaceous and the Newark rocks beneath is stated, pp. 5, 24, 39, 171, 172. Several localities are also described where the Newark has been reached in excavations begun in clays, pp. 304–305.

Cook's gap, Conn. Description of trap ridges near (Percival, '42, pp. 370–371, 373, 375, 376, 379, 381).
Detailed study of the geological structure near (W. M. Davis, '89).
Sketch map of (W. M. Davis, '89, pl. 5).

Coontown, N. J. Dip at (Cook, '68, p. 196).
Dip in shale near (Cook, '79, p. 30).

COOPER, THOMAS. 1822.
On volcanoes and volcanic substances with a partial reference to the origin of the rocks of the floetz trap formation.
In Am. Jour. Sci., vol. 4, pp. 205–243.
Contains a general account of the trap rocks of the Newark system from Massachusetts to North Carolina. The trap is considered of igneous origin, pp. 239–243.

Coopersburg, Pa. Dip near (Lesley, '83, p. 180).
Dip of shale at (H. D. Rogers, '58, vol. 1, p. 101).
Ripple marks at (H. D. Rogers, '58, vol. 1, p. 101).

Cooperstown, Pa. Boundary of the Newark near (H. D. Rogers, '41, p. 16, 39).
Boundary of the Newark near (H. D. Rogers, '58, vol. 2, p. 668).

COPE, [E. D.] 1866.
[Remarks on extinct vertebrates from the Mesozoic red sandstone of Pennsylvania.]
In Philadelphia Acad. Nat. Sci., Proc., vol. 18, pp. 249–250, 290.
Presents the results of an examination of certain vertebrate fossils from Phoenixville, Pa., and describes a new Mastodonsaurus; states that the fossils in question properly belong to the Keuper or upper division of the Trias.

COPE, EDWARD D. 1868.
Synopsis of the extinct reptilia found in the Mesozoic and Tertiary strata of New Jersey.
In geology of New Jersey; by George H. Cook. Newark [N. J.], 1868, pp. 733–737.
Brief remarks on the general character of *Clepsysaurus pennsylvanicus*.

COPE, EDWARD D. 1869.
Synopsis of the extinct batrachia, reptilia, and aves of North America.
In Am. Phil. Soc., Trans., n. s., vol. 14, 1871, pp. 1–252, pls. 1–14.
Abstract in Am. Jour. Sci., 2d ser., vol. 49, pp. 390–392.
Presents a synopsis of the batrachians and reptiles that have been described from the Newark system.

COPE, [E. D.] 1870.
Observations on the reptilia of the Triassic formations of the Atlantic region of the United States.
In Am. Philo. Soc., Proc., vol. 11, 1871, pp. 444–446.
Abstract of a paper in which several fossil reptiles from the rocks mentioned are reclassified and a new fossil reptile from Phœnixville, Pa., briefly described.

COPE, EDWARD D. 1873.
Observations on the distribution of certain extinct vertebrata in North Carolina.
In Am. Philo. Soc., Proc., vol. 12, 1871–1872, pp. 210–216, pls. 1–4.
Discusses the biological relation of certain fossil reptiles from North Carolina and Pennsylvania.

COPE, EDWARD D. 1875.
Synopsis of the vertebrata whose remains have been preserved in the formations of North Carolina.
In report on the geological survey of North Carolina, vol. 1, by W. C. Kerr. Appendix B, pp. 29–52, pls. 5–8.
Contains references to or descriptions of fossil fishes, batrachians and reptiles, pp. 30, 32, 34–35, pl. 8.

COPE, E. D. 1877.
Descriptions of extinct vertebrata from the Permian and Triassic formations of the United States.
In Am. Philo. Soc., Proc., vol. 17, 1878, pp. 182–196.
Describes a number of vertebrate fossils from Phœnixville, Pa.

COPE, E. D. 1877.
On some saurians found in the Triassic of Pennsylvania, by Mr. C. M. Wheatley.
In Am. Philo. Soc., Proc., vol. 17, 1878, pp. 231–232.
Describes fossil reptilian remains from Phœnixville, (?) Pa.

COPE, E. D. 1885.
[Vertebrate fossils of the Triassic beds of Pennsylvania.]
In sketch of the geology of York county, Pa.
In Am. Philo. Soc., Proc., vol. 23, 1886, pp. 403–404.
Presents a list of twelve species of vertebrate fossils from the rocks mentioned.

COPE, E. D. 1885a.
Marsh on American Jurassic dinosauria.
In Am. Nat., vol. 19, pp. 67–68.
A review of "The principal characters of American Jurassic dinosaurs," by O. C. Marsh.

Coprolites from the Connecticut valley. Analyses of (S. L. Dana and E. Hitchcock, '45).
Character of (Lyell, '66, p. 455).
Discussions of (E. Hitchcock, '44a, pp. 308-314. Warren, '54, p. 46).

CORNELIUS, ELIAS. 1818.
On the geology, mineralogy, scenery, and curiosities of parts of Virginia, Tennessee and the Alabama and Mississippi Territories [etc.].
In Am. Jour. Sci., vol. 1. pp. 215-226, 317-331.
Contains a brief description of the conglomerate (breccia) of the Potomac river; also a short notice of the general features of the Newark areas in Virginia, pp. 216-217.

Cornwall, Pa. Boundary of the Newark near (see Frazer, '82, p. 123).
Section of, near (H. D. Rogers, '58, vol. 2, pp. 718-719).
Sedimentary beds near (d'Invilliers, '86a, pp. 890-879).
Trap dikes near (H. D. Rogers, '58, vol. 2, pp. 718, 719).
Traprocks near (d'Invilliers, '86a, pp. 876-879).

Cornwall coal mine, Va. An account of (Grammar, '18, p. 127).

Cornwall ironworks, Pa. Boundary of the Newark near (H. D. Rogers, '58, vol. 2, p. 669).

Cornwallis, N. S. Manganese at (Gilpin, '85, p. 8).
Rocks of (Gesner, '36, p. 80).
Unconformity at base of the Newark in (Dawson, '78, p. 110).

Cornwallis valley, N. S. Dip of sandstone in (Dawson, '78, p. 91).
Erosion of (Dawson, '47, p. 56).

Cornwall mine, Pa. Association of magnetite with trap at (Frazer, '80, p. 27).
Detailed description of (Lesley and d'Invilliers, '85).
Iron ore of (H. D. Rogers, '39, p. 22).

Cornwell, S. C. Magnetic ore near (Tuomey, '48, p. 68).

CORYELL, MARTIN. 1875.
East Virginia coal field.
In Am. Inst. Mining Eng., Trans., vol. 3, pp. 228-231.
Gives a list of papers that have been published on the Richmond coal field, and also a section of coal seams at Carbon hill.

CORYELL, MARTIN. 1875.
[Remarks on mining and on natural coke in the Richmond coal field, Virginia.]
In the Engineering and Mining Journal, vol. 19, p. 35.
Discussion of a paper by O. J. Heinrich, on deep borings with a diamond drill, read before the American Institute of Mining Engineers, December 26, 1874. States that excellent coal in thick seams, exists in the Richmond coal field, Virginia, and also that the field has not been greatly disturbed. Describes a vein of natural coke or "carbonite" 5 feet thick on the north side of the James. Remarks were also made by O. J. Heinrich and T. S. Hunt.

Couch's coal mine, Va. Thickness of coal in (W. B. Rogers, '36, p. 53).

Cove, Westfield, Conn. Fossil foot prints at (E. Hitchcock, '58, pp. 50 et seq.).
Fossil fucoid from (E. Hitchcock, '41, p. 450, pl. 29).
Report of the discovery of foot prints at (E. Hitchcock, '37).

Coweta, Ga. Brief account of trap dikes in (Henderson, '85, p. 88).
Trap dikes in (Loughridge, '84, p. 279).

Cox's coal mine, Va. Analysis of coal from (Macfarlane, '77, p. 515).

Cox iron mine, Pa. Description of (d'Invilliers, '86, p. 1504-1505).

COZZENS, ISSACHAR. 1843.
A geological history of Manhattan or New York island [etc., etc.]
New York, pp. 1-114, pls. 1-9.
Describes the trap and associated sedimentary rocks on the west side of the Hudson, near New York city.

Cranberry point, N. S. Relation of trap, conglomerate, and sandstone at (Gesner, '43).

Cranche's colliery, Va. Analysis of coal from (Clifford, '87, p. 10).

Crane (U. S. C. S. station) N. of Montclair, N. J. Elevation of First mountain at (Cook, '82, p. 49).

Crane's gap, N. J. Boundary of First mountain trap near (Cook, '68, p. 181).
Dip at (Cook, '68, p. 195).

Crapaud, P. E. I. Description of fossil wood from (Dawson, '54).
Silicified wood at (Dawson and Harrington, '71, p. 16).

CREATH, A. S. Analysis of limestone from Dillsburg, Pa. (Frazer, '76c, p. 63c).

CREDNER, HERMANN. 1865.
Geognostische Skizze der Umgegend von New York.
In Zeitsch. Deutsch. geol. Gesell., vol. 17, pp. 388-398, pl. 13.
Describes diorite dike west of New York, with an account of its composition, structure, extent, and contact with sandstone on the west.

CREDNER, HERMANN. 1865.
Geognostische Reiseskizzen aus New Brunswick in Nordamerika.
Neues Jahrbuch, 1865, pp. 803-821.
Describes the rocks of Quaco, New Brunswick, referring them to the Permian. States that the Triassic and Jurassic formations are not known in New Brunswick.

CREDNER, HERMANN. 1866.
Geognostische Skizzen aus Virginia, Nordamerika.
In Zeitsch. Deutsch. geol. Gesell., vol. 18, pp. 77-85.
Gives a brief description of Clover hill coal basin, Virginia. Discuses differences of opinion as to the age of the coal and the impossibility of correlating with European formations.

DANA, EDWARD S.—Continued.

A preliminary microscopic examination of trap rock from more than a hundred localities.

DANA, EDWARD S. **1877.**

On the occurrence of garnets with the trap of New Haven, Conn.

In Am. Jour. Sci., 3d ser., vol. 14, pp. 215–218.

Describes the occurrence of garnets in the trap of West rock, East rock, and Mill rock, Conn.

DANA, EDWARD S. Cited as to the composition of trap rocks (W. M. Davis, '83, p. 284).

Cited on the optical properties of trap from Connecticut (Frazer, '75*b*).

Cited on the trap rocks of Connecticut (Hovey, '89, pp. 364–368).

Cited on trap (dolerite) in the Connecticut valley (Iddings, '86, p. 331).

Cited on tufaceous conglomerate in Massachusetts (W. M. Davis, '83, p. 263).

DANA, JAMES D. **1843.**

On the analogies between the modern igneous rocks and the so-called Primary formations, and the metamorphic changes produced by heat in associated sedimentary deposits.

In Am. Jour. Sci., vol. 45, pp. 104–122.

Cites H. D. Rogers in reference to contact metamorphism at Rocky Hill, N. J., pp. 113–115.

DANA, JAMES D. **1845.**

Origin of the constituent and adventitious minerals of trap and the allied rocks.

In Am. Jour. Sci., vol. 49, pp. 49–64.

Published also in Am. Assoc. Geol. and Nat., Proc., 6th meeting, pp. 26–28.

Abstract in Neues Jahrbuch, 1847, pp. 218–223.

Considers the "essential constituents of modern plutonic rocks" and "minerals occupying cavities and seams in amygdaloidal trap or basalt."

DANA, JAMES D. **1845a.**

On the minerals of trap and the allied rocks.

In Am. Assoc. Geol. and Nat., Proc., 6th meeting, pp. 26–28.

Published also in Am. Jour. Sci., vol. 49, pp. 49–64.

Discusses the origin of adventitious and secondary minerals in trap rocks.

DANA, JAMES D. **1847.**

On the origin of continents.

In Am. Jour. Sci., 3d ser., vol. 3, pp. 94–100.

Brief statement of a hypothesis to the effect that the trap dikes of the Newark system may be a result of contraction subsequent to the Carboniferous, pp. 99–100.

DANA, JAMES D. **1847a.**

Origin of the grand outline features of the earth.

In Am. Jour. Sci., 2d ser., vol. 3, pp. 381–398.

The trap ridges of the Connecticut valley are referred to as illustrating the view that certain grand features of the earth's surface have resulted from fissures, pp. 391–392.

DANA, JAMES D. **1847b.**

[Note on phalangial impressions in fossil footprints.]

See Silliman, Silliman, jr., and Dana, 1847.

DANA, JAMES D. **1847c.**

[Note on] Ornithichnites.

See Silliman and Dana, 1847.

DANA, [J. D.] **1855.**

[A note relating to a new fossil plant from the Connecticut valley sandstone.]

In Boston Soc. Nat. Hist., Proc., vol. 5, p. 212.

Brief reference to a letter relating to the finding of a specimen of Clathropteris in the sandstone of the Connecticut valley.

DANA, J. D. **1856.**

On American geological history: Address before the American Association for the advancement of Science. August, 1855.

In Am. Jour. Sci., 2d ser., vol. 22, pp. 305–334.

Published also in Am. Assoc. Adv. Sci., Proc., vol. 9, pp. 1–36.

States briefly the leading facts concerning the distribution, thickness, mode of formation, and geological position of the Newark system, pp. 321–323. A brief abstract is also given of the conclusions of previous writers in reference to the age of the deposits in question, footnote p. 322.

DANA, JAMES D. **1856a.**

Plan of development in the geological history of North America.

In Am. Assoc. Adv. Sci., Proc., vol. 10, 1857, pt. 2, pp. 1–18, and a map op. p. 9.

Contains a brief reference to the position of the eastern continental margin during the Newark period, p. 11.

DANA, JAMES D. **1857.**

Additional remarks [on E. Emmons' geological report of the midland counties of North Carolina].

In Am. Jour. Sci., 2d ser., vol. 24, pp. 429–430.

Remarks on the determination of the geological position of the Newark system.

DANA, JAMES D. **1858.**

[Note on a supposed fossil insect from Turner Falls, Mass.]

In Ichnology of New England, by Edward Hitchcock, pp. 7–8.

Gives a brief description of a supposed fossil insect from the Connecticut valley sandstone, subsequently named *Mormolucoides articulatus* by Hitchcock.

DANA, JAMES D. **1858a.**

[Note on supposed crustacean tracks in Connecticut valley sandstone.]

In Ichnology of New England, by Edward Hitchcock, p. 165.

An extract from a letter referring to certain drawings of footprints, supposed to have been made by crustaceans.

DANA, JAMES D. **1859.**

Reply to Prof. Agassiz on Marcou's Geology of North America.

In Am. Jour. Sci., 2d ser., vol. 27, pp. 137–140.

Reprinted in "Reply to the criticisms of James D. Dana" by Jules Marcou, Zurich, 1859, pp. 30–35.

DANA, J. D. **1862.**

Fossil larvæ in the Connecticut river sandstone.

In Am. Jour. Sci., 2d ser., vol. 33, pp. 451–452.

Quotes the opinion of John Le Conte in reference to the nature of the fossil in question.

DANA, J. D. **1865.**

[A letter relating to the footprints from the Connecticut valley described by Edward Hitchcock.]

In supplement to the Ichnology of New England, by Edward Hitchcock, pp. 33–34.

Contains statements in reference to the character of the footprint animals.

DANA, JAMES D. **1870.**

Excursion to the Hanging hills of Meriden [Connecticut].

In history of Wallingford, Conn. [etc., etc.], by C. H. S. Davis, Meriden, Conn., pp. 53–56.

A popular account of the leading geological features of the region about Meriden, Conn.

DANA, JAMES D. **1871.**

On the geology of the New Haven region, with special reference to the origin of some of its topographical features.

In Connecticut Acad. Sci., Trans., vol. 2, pp. 45–112, and map.

Describes the topography of the region about New Haven, Conn., and discusses briefly its relation to pre-Tertiary geology, pp. 45–47.

DANA, JAMES D. **1871a.**

[Review of "Historical notes on the earthquakes of New England, 1838–1839, by William T. Brigham."]

In Am. Jour. Sci., 3d ser., vol. 1, pp. 304–305.

Percival's determination of the intrusive character of the trap rocks of the Connecticut valley upheld. The eruptions were in all cases through fissures. An outcrop of "scoria" near Durham, Conn., shown to be scoriform sandstone. No eruptions since the Mesozoic, p. 305.

DANA, JAMES D. **1871b.**

[On the presence of albite and orthoclase in the Newark sandstone of New Jersey and Connecticut.]

In Am. Jour. Sci., 3d ser., vol. 2, pp. 459–460.

A notice of a paper by P. Schweitzer relating to the mineralogical composition of certain sandstones in New Jersey, in the Am. Chemist, July, 1871; see also Am. Jour. Sci., 3d ser., vol. 3, p. 57.

D[ANA,] JAMES D. **1872.**

[Note on the character of the trap of the Palisades, N. J., and of trap near New Haven, Conn.]

In Am. Jour. Sci., 3d ser., vol. 4, p. 237.

Review of a paper by Henry Wurtz, on the rocks of the Palisades, N. J. Compares the trap of the Palisades with similar trap in Connecticut.

DANA, JAMES D. **1873.**

On some results of the earth's contraction from cooling, including a discussion of the origin of mountains, and the nature of the earth's interior.

In Am. Jour. Sci., 3d ser., vol. 5, pp. 423–433, vol. 6, pp. 6–14, 104–115, 161–172.

Refers to the Newark system in illustration of various points in the discussion mentioned, vol. 5, pp. 427, 430–431, 432, 437; vol. 6, pp. 8, 9, 106, 108, 114.

DANA, JAMES D. **1874.**

Text-book of Geology [etc.].

New York and Chicago, 12mo., 2d ed., pp. i–vii, 1–358.

The condensed account of the Triassic and Jurassic systems contained in this text-book is essentially the same as is given in the Manual of Geology by the same author, to which references have been given in this index.

DANA, JAMES D. **1875.**

Manual of Geology.

New York, rev. ed., pp. i–xvi, 1–828, plate and map.

1st ed. Philadelphia, 1869, pp. i–xvi, 1–800, plate and map.

Contains a condensed summary of observations concerning the Newark system.

DANA, JAMES D. **1875a.**

On southern New England during the melting of the great glacier.

In Am. Jour. Sci., 3d ser., vol. 10, pp. 168–183, 280–283, 353–357, 409–438, 497–508.

Contains a brief statement in reference to the main topographic features of the Newark sandstone and trap in the vicinity of New Haven, Conn., pp. 170–171. Considers that the Connecticut valley was an estuary during the Newark period, p. 497. Describes the general togography of the valley, and origin of the trap ridge, character of drainage, etc., pp. 497–502.

D[ANA], J[AMES] D. **1878.**

On "indurated bitumen" in cavities in the trap of the Connecticut valley. From the report on the geology of Connecticut by Dr. J. G. Percival.

In Am. Jour. Sci., 3d ser., vol. 16, pp. 130–132.

Presents several extracts from the report mentioned in reference to the occurrence of a solid hydrocarbon in the eruptive rocks of Connecticut.

[DANA], J. D. **1879.**

[Review of] the physical history of the Triassic formation of New Jersey and the Connecticut valley by I. C. Russell.

In Am. Jour. Sci., 3d ser., vol. 17, pp. 328–330.

Reviews the hypotheses proposed in the paper referred to and advances arguments which oppose them.

DANA, JAMES D. **1880, 1881.**

On the geological relations of the limestone belts of Westchester county, New York.

DANA, JAMES D.—Continued.

In Am. Jour. Sci., 3d ser., vol. 20, pp. 21–32, 194–220, 359–375, 450–456; vol. 21, pp. 425–443; vol. 22, pp. 103–119, 313–315, 327–435.

Contains a map of Stony Point, N. Y., showing approximate junction of Newark system and the Cortland series, and also a note in reference to the beds beneath the Newark conglomerate at the same locality, vol. 22, pp. 112, 113.

D[ANA], J[AMES] D. 1881.

[Review of a paper by G. W. Hawes, on Doleryte (trap) of the Newark system.]

In Am. Jour. Sci., 3d ser., vol. 22, pp. 230–233.

Discusses the chemical and mineralogical composition of trap rocks from New Jersey and the Connecticut valley.

D[ANA], J[AMES] D. 1883.

The origin of the Jura-Trias of eastern North America.

In Am. Jour. Sci., 3d ser., vol. 25, pp. 383–386.

Notices briefly certain conclusions in reference to the former extent of the Newark system, published in the annual report of the state geologist of New Jersey for 1882, and presents a number of observations and theoretical considerations, with the view of showing that the rocks referred to were formed in various detached areas, at the mouths of rivers which were flooded owing to the prevalence of a cold climate similar to that which prevaled over the same region during the Pleistocene glacial epoch.

DANA, J[AMES] D. 1889.

Areas of continental progress in North America, and the influence of the conditions of these areas on the work carried forward within them.

In Geol. Soc. Am., Bull., vol. 1, pp. 36–48.

Refers to thick deposits of Newark strata in the southern half of the Connecticut valley, p. 38.

D[ANA], J[AMES] D. 1890.

[A review of a paper by I. C. Russell on the "Subaerial decay of rocks and origin of the red color of certain formations."]

In Am. Jour. Sci., 3d ser., vol. 39, pp. 317–319.

Discusses the origin of the prevailing red color of the sandstones and shales of the Newark system.

DANA, JAMES D. 1890a.

Long Island sound in the Quaternary era, with observations on the submarine Hudson river channel.

In Am. Jour. Sci., 3d ser., vol. 40, pp. 425–437.

Discusses the question of glaciation during the Newark period. Pp. 436–437.

DANA, JAMES D. 1891.

Some of the features of nonvolcanic igneous ejections, as illustrated in the four "rocks" of the New Haven region, West rock, Pine rock, Mill rock, and East rock.

DANA, JAMES D.—Continued.

In Am. Jour. Sci., 3d ser., vol. 42, pp. 79–110, pls. 2–7.

Consists of a critical study of the character of the igneous injections, by which the trap forming the rocks named was introduced among the inclosing sedimentary beds. The principal conclusions are:

The igneous eruptions took place after the tilting of the sedimentary beds inclosing them had been commenced.

The igneous material was not erupted at the surface, and it did not form overflow sheets.

The igneous rocks were injected from below, and made space for themselves by lifting the sedimentary beds, after the manner of laccolites. This took place at comparatively shallow depths.

The course and dip of supplying fissures was not determined by the foliation or bedding of the schist underneath the sandstone.

DANA, JAMES D. 1891a.

On Percival's map of the Jura-Trias trap belts of central Connecticut, with observations on the upturning, or mountain-making disturbances, of the formation.

In Am. Jour. Sci., 3d ser., vol. 42, pp. 439–447, pl. 16.

Presents facts which are thought to indicate that the trough in which the Newark rocks of the Connecticut valley area were deposited terminated at the south in what is now New Haven bay. Discusses the relative age of the trap ejections and the tilting of the inclosing sandstones, and the character of the mountain uplifts made at or near the close of the Newark period. Discusses the probability of fault planes being concerned in the monoclinal dip of the strata. Reproduces Percival's map of the southern portion of the Newark area of the Connecticut valley.

DANA, J. D. Cited on cause of the tilting of the Newark (W. M. Davis, '83, p. 303).

Cited on character of certain footprints from Turner Falls, Mass. (Deane, '56).

Cited on contact metamorphism in Connecticut (W. M. Davis, '83, pp. 300, 301).

Cited on coprolites from the Connecticut valley (Lyell, '66, p. 455).

Cited on curved form of certain trap ridges (W. M. Davis, '83, p. 307).

Cited on diabases of the Newark system (Hawes, '82, p. 129).

Cited on distribution of Newark areas (S. P. Merrill, '89, p. 446).

Cited on eruption of trap in Connecticut (Davis and Whittle, '89, p. 117).

Cited on extent of the Connecticut valley area (Shaler, '84, p. 127).

Cited on fossil footprints from the Connecticut valley (E. Hitchcock, '63, pp. 53, 55–57).

DANA, J. D.—Continued.

Cited on intrusive trap sheets in Connecticut (W. M. Davis, '83, p. 294).

Cited on Marcou's geological map of North America (Marcou, '59).

Cited on mode of deposition of the Newark rocks of Pennsylvania (Frazer, '77c, p. 653).

Cited on *Mormolucoides articulatus* (Scudder, '84, p. 431).

Cited on origin of Newark estuaries (W. M. Davis, '83, p. 282).

Cited on origin of the red color of the Newark sandstone (Russell, '89, p. 49).

Cited on origin of the trap rock of Connecticut (Hovey, '89, p. 376).

Cited on relation of trap and sandstone in Massachusetts (W. M. Davis, '83, p. 286).

Cited on similarity in the trap rocks from Nova Scotia to South Carolina (How, '75, vol. 1, p. 136).

Cited on supposed fossil insect from Turner Falls, Mass. (E. Hitchcock, '58, p. 7).

Cited on trap rock (S. P. Merrill, '89, pp. 433, 434).

Table of geological formations by (Macfarlane, '79, pp. 8, 50).

DANA, SAMUEL L. [and EDWARD HITCHCOCK]. **1845.**

Analysis of coprolites from the New Red sandstone of New England.

In Am. Jour. Sci., vol. 48, pp. 46–60.

Abstract in Neues Jahrbuch, 1848, pp. 368–369.

Gives result of analyses, and also a discussion based on the same.

DANBERRY, CHARLES. **1839.**

Sketch of the geology of North America [etc., etc.].

Oxford [England]. Pp. i–xviii, 1–73.

Contains a brief sketch of the Connecticut valley. Pp. 19–23.

Danboro, Pa. Trap dikes near (Lewis, '85, p. 453).

Dan river area. Brief account of (Emmons, '57, p. 4).

Coal of. Brief account of (Patton, '88, p. 23).

Dan river area, N. C. Brief description of (Kerr, '75, p. 141).

Coal of (Kerr, '75, pp. 145, 295).

Fossils of (Kerr, '75, p. 147).

Section of (Emmons, '57, p. 12).

Section of Newark rocks in (Jones, '62, pp. 89–90).

Thickness of (Kerr, '75, p. 145).

Dan river area, Va. Boundaries and area of (Heinrich, '78, pp. 237–239).

Dan river coal field, N. C. Account of (McGehee, '83, pp. 75–77).

Brief account of (Daddow and Bannan, '66, pp. 403–404. Emmons, '52, pp. 144–153. C. H. Hitchcock, '74. Kerr, '66, pp. 45–46. Le Conte, '82, pp. 457–459).

Detailed description of (Emmons, '56, pp. 254–261).

Detailed report on (Chance, '85).

Dan river coal field, N. C.—Continued.

Economic importance, age, extent, etc. (Macfarlane, '77, pp. 526–528).

History of the commercial development of (Chance, '85, pp. 23–24).

Observations in (McLenahan, '52).

Section showing age of (Emmons, '56, p. 273).

Statistical account of (Anonymous, '69, p. 104).

Dan river coal field, Va., and N. C. Brief account of (Heinrich, '78, pp. 283–289).

Danville, Va. Boundary of the Newark near (W. B. Rogers, '39, p. 76).

Dark harbor, Grand Manan island, N. B. Dip of sandstone beneath trap at (Bailey, '72, p. 47).

Darlington, N. J. Course of trap ridge near (Nason, '89, p. 34).

Trap hill near (Cook, '82, pp. 48, 49).

Darnley, P. E. I. Remarks on structures near (Bain and Dawson, '85, p. 156).

Darnley basin, P. E. I. Section at (Dawson and Harrington, '71, pp. 18, 19).

DARTON, NELSON H. **1882.**

Notes on the Weehawken tunnel [Bergen hill, N. J.].

In New York Acad. Sci., Trans., vol. 1, 1881–1882, pp. 129–131.

Describes certain minerals obtained from the locality referred to.

DARTON, NELSON H. **1882a.**

On a new locality for hayesine and its novel occurrence.

In Am. Jour. Sci., 3d ser., vol. 23, pp. 458–459.

Abstract in Neues Jahrbuch, 1883 (2), p. 161.

Describes the occurrence of the mineral mentioned at Bergen hill, N. J., and gives an analysis of it.

DARTON, N. H. **1883.**

On the disintegrated sandstone at New Durham, N[ew] J[ersey].

In New York Acad. Sci., Trans., vol. 2, 1882, 1883, pp. 117–119.

Describes an exposure of disintegrated sandstone at the west end of the Weehawken tunnel, Bergen hill, N. J., and gives several analyses of the sandstone, together with an analysis of the trap of Bergen hill, against which it rests.

DARTON, NELSON H. **1883a.**

On the indurated shales between Bergen hill and the Palisades, N. J.

In the Scientific American supplement, vol. 16, pp. 6513–6514.

Describes in detail the structure at King Point near Hoboken, N. J.

DARTON, NELSON H. **1885.**

On the occurrence of native silver in New Jersey.

In Am. Jour. Sci., 3d ser., vol. 30, pp. 80–81.

Describes the occurrence of native silver in the Bridgewater copper mine near Somerville, N. J.

DARTON, NELSON H. 1889.

On the great lava flows and intrusive trap sheets of the Newark system in New Jersey.

In Am. Jour. Sci., 3d ser., vol. 37, pp. 134–139.

The observations recorded embrace the whole of the Newark area of New Jersey. Concludes that the trap ridges of New Jersey were formed in part by extrusive and in part by intrusive sheets.

This is a preliminary publication of work reported more fully in U. S. Geol. Surv., Bull. No. 65, 1890.

DARTON, NELSON H. 1889a.

North American Geology for 1886.

In Smithsonian Inst., Ann. Rep. for year ending June 30, 1887, pp. 189–229.

Contains a review of investigations made in the Newark system in 1886, pp. 199–200.

DARTON, NELSON HORATIO. 1890.

The relations of the traps of the Newark system in the New Jersey region.

U. S. Geol. Surv., Bull. No. 67.

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DARTON, NELSON HORATIO. Cited on faults in the Newark rocks of New Jersey (Cook, '89, p. 14).

Cited on the structure of the Newark system (Cook, '87).

DARTON, NELSON H. and J. S. DILLER. 1890.

On the occurrence of basaltic dikes in the Upper Paleozoic series in central Appalachian region.

In Am. Jour. Sci., 3d ser., vol. 39, pp. 269–271.

Describes dikes of trap near Staunton, Va., which probably belong to system of dikes so largely developed in the Newark.

Petrographic notes by J. S. Diller.

Dauphin County, Pa. Brief report on (Lesley, '85, pp. XLV, XLVI, pl. 22).

Description of the Conewago hills in (Gibson, '20).

Davidson mill, N. J. Altered shale near (Cook, '68, pp. 213–214. Cook, '88, p. 23).

Altered shale near, used for building (Cook, '81, p. 55).

Trap boundary at (Cook, '68, p. 189).

DAVIS, CHARLES HENRY STANLEY. 1870.

[A sketch of the geology in the vicinity of Meriden, Conn.]

In history of Wallingford, Conn. [etc., etc.], by C. H. S. Davis, Meriden, Conn., pp. 36–53.

A popular sketch of the "physical history, geology, mineralogy, and mines" of the region mentioned.

DAVIS, CHAS. H. S. 1887.

The *Catopterus gracilis*.

In Meriden Sci. Assoc., Proc. and Trans., vol. 2, 1885–1886, pp. 19–22.

Contains an account of the occurrence of fossil fishes at Little Falls (Conn.), and a description of *Catopterus gracilis*.

DAVIS, W. M. 1881.

Illustrations of the earth's surface. Glaciers. Boston, folio, pp. 95–96.

See Shaler and Davis.

DAVIS, W. M. 1882.

Brief notice of observations on the Triassic trap rocks of Massachusetts, Connecticut, and New Jersey.

In Am. Jour. Sci., 3d ser., vol. 24, pp. 345-349.

Abstract in Neues Jahrbuch, 1884, pp. 231-232.

An account of a recent examination of the trap ridges in the regions referred to, with references to certain hypothesis proposed by previous writers concerning the origin of trap sheets, and the dip of the associated sedimentary beds. An announcement is made of new generalizations and hypothesis to account for the phenomena observed.

DAVIS, WILLIAM MORRIS. 1882a.

The structural value of the trap ridges of the Connecticut valley.

In Boston Soc. Nat. Hist., Proc., vol. 22, pp. 116-124.

Mentions the geographical extent of the Newark system. Considers the hypotheses that have been advanced to account for the uniform dip observed in certain of the Newark areas, and also the hypotheses concerning the former extent, especially of the Connecticut valley sandstone bed of the similar formation in New Jersey. Reasons are given for believing that many of the trap sheets of the Connecticut valley and of New Jersey are contemporaneous overflows and that they afford evidence of faulting and folding.

DAVIS, WILLIAM MORRIS. 1883.

On the relations of the Triassic traps and sandstones of the eastern United States.

In Museum of Comp. Zoöl., Bull., vol. 7, 1880-1884, pp. 249-309, pl. 9-11.

Reviewed by J. D. Dana in Am. Jour. Sci., 3d ser., vol. 25, pp. 474-475; and by G. H. Cook in Ann. Rep. Geol. of New Jersey, 1883.

Abstract in Science, vol. 1, p. 430; also in Neues Jahrbuch, 1884, pp. 230-232.

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DAVIS, WILLIAM MORRIS—Continued.

DAVIS, WILLIAM MORRIS. 1886.

The structure of the Triassic formation of the Connecticut valley.

In Am. Jour. Sci., 3d ser., vol. 32, pp. 342-352.

Reviews several hypotheses that have been advanced to account for the uniform easterly dip of the rocks of the Connecticut valley. Presents the results of exact observation in the same region, and advances a new hypothesis to account for the monoclinal structure in question.

DAVIS, WILLIAM MORRIS. 1888.

The structure of the Triassic formation of the Connecticut valley.

In Seventh Ann. Rep., U. S. Geol. Survey, 1885-1886, pp. 455-490, pl. 52.

Notice in Am. Geol., vol. 4, pp. 112-113.

CONTENTS.

DAVIS, WILLIAM MORRIS—Continued.

Some of the conclusions in reference to the origin of certain trap sheets in southern Connecticut, expressed in this paper, are controverted by E. O. Hovey, '89.

DAVIS, W. M. **1888a.**

Remarks on the mechanical origin of the Triassic monoclinal in the Connecticut valley.

In Proc. Boston Soc. Nat. Hist., vol. 23, pp. 339–341.

Abstract in Am. Assoc. Adv. Sci., Proc., vol. 35, pp. 224–227.

Abstract of a paper, the substance of which is contained in "The Structure of the Triassic formation of the Connecticut valley." U. S. Geol. Surv., Seventh Ann. Rep., 1885–1886, pp. 455–490. Describes the prevailing structure of the sandstone of the Connecticut valley, and proposes an explanation of their monoclinal structure.

DAVIS, W. M. **1888b.**

The topographical map of New Jersey.
In Science, vol. 12, pp. 206–207.

In describing the topographic map published by the New Jersey geological survey the topography of the Newark area is briefly referred to, and suggestions made as to its origin.

DAVIS, WILLIAM MORRIS. **1889.**

The faults in the Triassic formation near Meriden, Conn. A week's work in the Harvard summer school of geology.

In Museum Comp. Zool., Harvard College, Bull., vol. 16, pp. 61–87, pls. 1–5.

A detailed study of the geological structure near Meriden. The divisions of the essay are: Cross-section of Lamentation mountain, pp. 61–64; cross-section of

DAVIS, WILLIAM MORRIS—Continued.

Shuttle meadow, pp. 64–69; the great fault west of Lamentation mountain, pp. 69–73; faults north of Lamentation mountain, pp. 73–76; faults in the Hanging hills, pp. 76–82, and north of West peak, pp. 82–85; review, pp. 85–86. Illustrated by sketch maps, views, and sections.

DAVIS, WILLIAM MORRIS. **1889a.**

The rivers and valleys of Pennsylvania.
In Nat. Geol. Mag., vol. 1, pp. 183–253.
Notice in Am. Geol., vol. 5, p. 60.

In discussing the origin of the relief of eastern Pennsylvania the denudation that preceded the deposition of the Newark system is referred to, and also the manner in which the Newark rocks were deposited. The origin of the monoclinal structure of the Newark system in New Jersey and Pennsylvania is briefly considered, as is also the denudation that preceded the deposition of the next succeeding system, pp. 194–198, 229–236. General distribution of high and low land and drainage in early Jurassic time is indicated on p. 233.

DAVIS, WILLIAM MORRIS. **1889b.**

The ash bed at Meriden and its structural relations.

In Meriden Sci. Ass., Proc. and Trans., vol. 3, 1887–1888, pp. 23–30.

Contains an account of an ash bed near Meriden, Conn., and a discussion of the structure of the Newark system of the Connecticut valley.

DAVIS, W. M. **1889c.**

Topographical development of the Triassic formation of the Connecticut valley.

In Am. Jour. Sci., 3d ser., vol. 37, pp. 423–434.

Itinerary of Harvard summer school of geology: Faults in the Meriden region; cross-section of the district; means of detecting the unfaulted sequence of Triassic beds; mechanism of monoclinal faulting; topographical development of the Triassic belt; initial constructional stages represented by the faulted blocks of southern Idaho. [Oregon]. Mountain ranges of the Great Basin, equivalent to a later Jurassic stage; the whole region base-leveled in late Cretaceous time; the present valley worn in the Cretaceous base-level plain after its elevation.

Polygenetic topography: The origin of the Connecticut river outlet via Middletown. The Connecticut river was originally consequent on the monoclinal faulting, and still persists near the course then taken, but has entered a second cycle of life as a result of the elevation of the lowland that was produced in the first cycle.

DAVIS, W. M. **1890.**

[Filling of fissures from above.]
In Geol. Soc. Am., Bull., vol. 1, p. 442.

DAVIS, W. M.—Continued.

In discussing a paper on sandstone dikes, by J. S. Diller, Davis describes certain fissures in trap at Meriden, Conn., which were filled from above.

DAVIS, WILLIAM MORRIS. **1891.**

The lost volcanoes of Connecticut.

In Pop. Sci. Mo., vol. 40, pp. 221–235.

Contains a popular account of certain beds of volcanic ash near Meriden, Conn., and shows that the ash was probably extruded from volcanoes that have since been removed by erosion.

DAVIS, W. M. Cited on the absence of contact metamorphism at Feltville, N. J. (Darton, '89, p. 135).

DAVIS, WILLIAM MORRIS. Cited on the faults in the Newark rocks of New Jersey (Cook, '89, p. 14).

Cited on the geology of Connecticut (Hovey, '89).

Cited on metamorphism (Russell, '89, p. 50).

Cited on the origin of the trap hills of Connecticut, etc. (Chapin, '87, p. 26).

Cited on the origin of the trap of Connecticut (Hovey, '89, pp. 375–376).

Cited on the origin of trap sheets near Meriden, Conn. (Nason, '89, p. 66).

Cited on the structure of the Newark system (Newberry, '88, pp. 6–7).

Cited on the structure of the Newark system in the Connecticut valley (Chapin, '89).

Cited on the structure of the Newark system and the origin of its trap sheets (Cook, '87).

Cited on trap at Feltville, N. J. (Darton, '90, p. 26).

Cited on the trap rocks of Connecticut (Marsters, '90).

DAVIS, W. M., and S. WARD LOPER. **1891.**

Two belts of fossiliferous black shale in the Triassic formation of Connecticut.

In Geol. Soc. Am., Bull., vol. 2, pp. 415–430.

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DAVIS, W. M., and S. WARD LOPER—Cont'd.

DAVIS, W. M., and CHARLES LIVY WHITTLE. **1889.**

The intrusive and extrusive trap sheets of the Connecticut valley.

In Mus. Comp. Zool., Bull. Harvard College, vol. 16, pp. 99–138, pl. 1–5.

CONTENTS.

DAVIS, W. M., and J. WALTER WOOD. **1889.**

The geographic development of northern New Jersey.

In Boston Soc. Nat. Hist., Proc., vol. 24, pp. 365–423.

Describes the effect of erosion on the Newark rocks of New Jersey and endeavors to determine the geological history of the region from a study of its drainage. Given sections illustrating the structure of the Newark terrane.

Davisburg, Pa. Dolerite, etc., from (C. E. Hall, '78, p. 35).

DAWSON, JOHN [WILLIAM]. **1845.**

On the newer coal formation of the eastern part of Nova Scotia.

In London Geol. Soc., Quart. Jour., vol. 1, pp. 322–330 and map.

The Newark system about the east end of basin of mines (Cobdequid bay) is shown in a general way on the map accompanying this paper.

DAWSON, JOHN WILLIAM. **1847.**

On the New Red sandstone of Nova Scotia.

In London Geol. Soc., Quart. Jour., vol. 4, pp. 50–59, pl. 5.

Describes exposures of the Newark system about the shores of Minas basin and Cobdequid bay, Nova Scotia. Mentions the relation of the sedimentary to the igneous rocks associated with them, and discusses briefly the conditions under which the sandstones and shales were deposited. The trap of Blomidon is considered as extrusive.

DAWSON, J. W. **1848.**
On the coloring matter of red sandstones and of grayish and white beds associated with them.
In London Geol. Soc., Quart. Jour., vol. 5. 1849, pp. 25-30.
Describes red and gray sandstones in Nova Scotia, chiefly Carboniferous, and discusses the origin of their colors.

DAWSON, J. W. **1848a.**
A handbook of the geology and natural history of Nova Scotia.
Pictou, Nova Scotia, 12mo.
Not seen.

DAWSON, JOHN WILLIAM. **1852.**
Additional notes on the red sandstones of Nova Scotia.
In London Geol. Soc., Quart. Jour., vol. 8, pp. 398-400.
Describes sections near the mouth of Petite river, in which a marked unconformity between Carboniferous and Newark rocks is exposed

DAWSON, J. W. **1853.**
Fossil saurian bones from Prince Edward island.
In Am. Jour. Sci., 2d ser., vol. 16, p. 283.
An abstract of an article published in the "Eastern Chronicle" of Nova Scotia, describing the discovery of *Bathygnathus borealis*.

DAWSON, J. W. **1854.**
On fossil coniferous wood from Prince Edward island.
In Philadelphia Acad. Nat. Sci., Proc., vol. 7, pp. 63-64.
Describes briefly the resemblance of certain rocks on Prince Edward island to the Newark system in Nova Scotia, and records the results of a microscopical examination of fossil wood from Gallas point, Des Sables, and other localities.

DAWSON, J. W. **1854a.**
[On the discovery and geological age of Bathygnathus borealis from Prince Edward island.]
In Philadelphia Acad. Nat. Sci., Jour., 2d ser., vol. 2, 1850-1854, pp. 329-330.
Describes the rocks in which the fossil mentioned was found, and discusses their geological position.

DAWSON, J. W. **1856.**
On the parallelism of the rock formations of Nova Scotia with those of other parts of America.
In Am. Assoc. Adv. Sci., Proc., vol. 10, 1857, part 2, pp. 18-25.
Indicates briefly some of the leading characteristics of the Newark system in Nova Scotia and Prince Edward island. Pp. 20, 21.

DAWSON, JOHN WILLIAM. **1858.**
[A note relating to the age of the Newark system of North Carolina, Connecticut, etc., indicated by fossils obtained by E. Emmons in North Carolina.]
In Canadian Nat., 1st ser., vol. 3, p. 86.

DAWSON, JOHN WILLIAM—Continued.
Discusses briefly the probable age of the Newark system.

DAWSON, J. W. **1863.**
[Note on fossil plants from St. John county, New Brunswick.]
In Canadian Nat., vol. 8, pp. 259-260.
Brief note on fossil wood from near Gardner's creek, New Brunswick.

DAWSON, J. W. **1872.**
Notes on the geology of Prince Edward island, in the gulf of St. Lawrence.
In Geol. Mag., vol. 9, pp. 203-209.
This paper is essentially an abstract of Dawson and Harrington's report on the geological structure and mineral resources of Prince Edward island. See Dawson and Harrington, 1871.

DAWSON, J. W. **1872a.**
[The physical geography of Prince Edward island.]
In Canadian Nat., vol. 6, pp. 342-343.
Mentions the occurrence of sandstone above the upper coal formation, in which fossil plants and reptilian remains occur, considered of Triassic age.

DAWSON, J. W. **1873.**
The story of the earth and man.
New York, pp. i-ix, 1-403, and 12 plates.
Contains a popular account of the life of the Mesozoic ages, pp. 188-233.

DAWSON, JOHN WILLIAM. **1874.**
On the upper coal formation of eastern Nova Scotia and Prince Edward island in its relation to the Permian.
In London Geol. Soc., Quart. Jour., vol. 30, pp. 209-219.
The conformity of the Upper Carboniferous and so-called Newark beds on Prince Edward island is briefly stated, and also the evidence from fossil plants on which this generalization is mainly based. The views of Geinitz in reference to the Permian age of the newer red sandstone of Price Edward island are dissented from, pp. 209, 210, 217, 218.

DAWSON, J. W. **1874a.**
On the upper coal formation of eastern Nova Scotia and Prince Edward island, and its relation to the Permian.
In Geol. Mag., n. s., vol. 1, pp. 281-282.
States that the Carboniferous of Prince Edward island is overlain, apparently conformably, by the Newark system.

DAWSON [J. W.]. **1875.**
On the upper coal formation of eastern Nova Scotia and Prince Edward island, in its relation to the Permian.
In Canadian Nat., vol. 7, n. s., pp. 303-304.
From a study of the fossil plants contained in the younger sandstones of Prince Edward island the synchronism of these beds with the Permian of Europe is suggested. The name Permo-Carboniferous is proposed for these beds, which heretofore have been called Triassic.

DAWSON, JOHN WILLIAM. **1878.**

Acadian Geology. The geological structure, organic remains, and mineral resources of Nova Scotia, New Brunswick, and Prince Edward island.

London, 3d ed., pp. i–xxvi, 1–687, pls. 1–9, and map, supplement, pp. 1–102, pl. 1.

Second edition. London, 1868, pp. i–xxvi, 1–694, pls. 1–9 and map. Pages and plates numbered the same as in 3d ed.

The first edition bears the following title: Acadian Geology: An account of the geological structure and mineral resources of Nova Scotia. Edinburgh, 1855, 12 mo., pp. i–xii, 1–388, pls. 1–5 and map.

Abstract in Neues Jahrbuch, 1855, pp. 333–337.

Reviewed in Edinburgh New Philosophical Journal, n. s., vol. 2, 1853, pp. 380–392; also in Canadian Jour., n. s., vol. 1, pp. 39–48.

The following is a table of contents of the third edition so far as it relates to the Newark system:

DAWSON, JOHN WILLIAM—Continued.

DAWSON, JOHN WILLIAM. **1878a.**

Supplement to the second edition of Acadian Geology, containing additional facts as to the geological structure, fossil remains, and mineral resources of Nova Scotia, New Brunswick, and Prince Edward island.

In Acadian Geology, 3d ed., pp. 1–102, pl. 1.

Reviewed in Canadian Nat., vol. 8, pp. 472–475.

This supplement is bound with the third edition of the Acadian Geology, and contains new observations relating to the classification of the rocks of Prince Edward island, and indicates the difficulty of separating the Newark and Carboniferous, pp. 28–31. The fossils of the Newark on Prince Edward island are briefly discussed, p. 30. The occurrence of lignite at Martin's head, N. B., is noticed on p. 99.

DAWSON, WILLIAM. **1885.**

Notes on the geology and fossil flora of Prince Edward island (see Bain and Dawson, 1885).

DAWSON, JOHN WILLIAM. **1887.**

Presidential address: Some points in which American geological science is indebted to Canada.

In Canada Roy. Soc., Proc. and Trans., vol. 4, sec. 4, 1886, pp. 1–8.

Contains a brief historical reference to the study of the Newark system in Canada.

DAWSON, J. WILLIAM. **1888.**

The geological history of plants.

New York (The International Scientific Series), pp. i–viii, 1–290.

Contains a popular account of the early Mesozoic floras, pp. 175–190.

DAWSON, J. WILLIAM. **1888.**

On the Eozoic and Paleozoic rocks of the Atlantic coast of Canada in comparison with those of western Europe and of the interior of America.

In Quart. Jour. Geol. Soc., London, vol. 44, pp. 797–817.

States briefly that the rocks of the Newark system in Canada resemble the Triassic rocks of Europe. They contain no important marine limestones, and their fossils are limited to a single Dinosaurian reptile and a few plants. The flora and land and fresh water faunas seem to have been of southern origin, p. 815.

DAWSON [J. W.]. Cited as to the relations of trap and sandstone in Nova Scotia (W. M. Davis, '83, p. 285).

Cited on the age of the Newark system (Lea, '58).

Cited on the age of the red sandstone of Nova Scotia (Jackson, '50, p. 338).

Cited on the discovery of Bathygnathus on Prince Edward island (Owen, '76, p. 361).

Cited on the geology of cape Blomidon, N. S. (Marsters, '90).

Cited on the geology of Prince Edward island (Bain and Dawson, '85, pp. 156, 157).

Cited on the overflow trap sheets in Nova Scotia (W. M. Davis, '83, p. 297).

Cited on the tilting of sandstone and trap in Prince Edward island (W. M. Davis, '83, p. 302).

Cited on trap dikes in Prince Edward island (W. M. Davis, '83, p. 291).

Notice of work done by, in Nova Scotia, etc. (Miller, '79-'81, vol. 2, pp. 151, 152, 158-161, 223).

DAWSON, JOHN WILLIAM, and B. J. HARRINGTON. **1871.**

Report on the geological structure and mineral resources of Prince Edward island.

Montreal [Can.]: Pp. 1-51, pls. 1-3, together with a geological map (frontispiece) and one plate of sections.

Abstract in Neues Jahrbuch, 1872, pp. 439-441; also in Am. Jour. Sci., 3d ser., vol. 3, p. 222.

Contains a description of the character and extent of the red sandstones, red and mottled clays, calcareous sandstones and conglomerates, arenaceous limestones, dolomite and trap of the Newark system on Prince Edward island, pp. 13-22. Also a number of measured sections (pp. 33-34, and an account of the building stones and water supply. Analyses of limestones are given on page 41, and an account of fossils, comprising descriptions of fossil wood and fucoids; and remarks on a reptile, *Bathygnathus borealis*, pp. 45, 46.

Nearly all of the rocks described in this report as Triassic have been referred to the Carboniferous by later observers. See supplement to the second edition of Acadian Geology, by J. W. Dawson, London, 1878, pp. 32-33; Geol. Surv. Canada, Rep. of Progress for 1882-1883-'84, p. 16E; and a note on the margin of map No. 5 S W, which accompanies this report.

Day's point, N. J. Dip at (Russell, '80, p. 47).

Section at, showing junction of trap with sedimentary rocks beneath (Russell, '80, p. 47).

Dead swamp, Conn. Description of trap ridges near (Percival, '42, p. 374).

DEANE, JAMES. **1842.**

[Notice of the footprints of birds in the New Red sandstone of Connecticut.]

In London Geol. Soc., Proc., vol. 4, p. 22.

Describes very briefly some newly found bird tracks, rain marks, and other impressions in the red sandstone of Connecticut.

DEANE, JAMES. **1843.**

[A letter to G. A. Mantell relating to the fossil footprints of the Connecticut valley.]

In Am. Jour. Sci., vol. 45, pp. 177-188.

Contains a general description of certain footprints, and compares some of the fossil tracks with the tracks of living birds. Published by B. Silliman in a paper entitled Ornithichnites of the Connecticut river sandstones and the Dinornis of New Zealand.

DEANE, JAMES. **1844.**

On the fossil footmarks of Turners Falls, Massachusetts.

In Am. Jour. Sci., vol. 46, pp. 73-77, pls. 1, 2.

Abstract in Neues Jahrbuch, 1844, pp. 635-637.

Gives a general description of certain footprints found at the locality mentioned.

DEANE, JAMES. **1844a.**

On the discovery of fossil footmarks.

In Am. Jour. Sci., vol. 47, pp. 381-390.

Relates to priority in the discovery of fossil footprints in sandstone of the Connecticut valley.

DEANE, JAMES. **1844b.**

Answer to the "Rejoinder" of Prof. Hitchcock.

In Am. Jour. Sci., vol. 47, pp. 399-401.

Relates to the question of priority in the discovery of fossil footprints in the sandstone of the Connecticut valley.

DEANE, JAMES. **1848.**

Fossil footprints of a new species of quadruped.

In Am. Jour. Sci., 2d ser., vol. 5, pp. 40-41.

Abstract in Neues Jahrbuch, 1851, p. 497.

Describes and illustrates the tracks of a quadruped discovered in the sandstone at Turners Falls, Mass.

DEANE, JAMES. **1845.**

Description of fossil footprints in the New Red sandstone of the Connecticut valley.

In Am. Jour. Sci., vol. 48, pp. 158-167, pl. 3.

Describes four and five toed footprints near Turners Falls, Mass.

DEANE, JAMES. **1845a.**

Notice of a new species of Batrachian footprint.

In Am. Jour. Sci., vol. 49, pp. 79-81.

Abstract in Am. Assoc. Geol. and Nat., Proc., 6th meeting, p. 25.

Describes and figures the footprints of a quadruped found in the Connecticut valley sandstone.

DEANE, JAMES. **1845b.**

Fossil footmarks and raindrops.

In Am. Jour. Sci., vol. 49, pp. 213-215.

Describes the tracks of "birds" and "batrachians" found at Turners Falls, Mass., and gives a figure of a slab of sandstone with several series of tracks.

DEANE, JAMES. **1845c.**

Illustrations of fossil footmarks.

In Boston Soc. Nat. Hist., Proc., vol. 2, p. 32.

A notice of the presentation of a paper on the above title to the society.

DEANE, JAMES. 1845d.
Illustrations of fossil footmarks.
In Boston Jour. Nat. Hist., vol. 5, pp. 277–284, pl. 23.
Gives a general description of certain fossil footprints from the Connecticut valley.

DEANE, JAMES. 1847.
Notice of new fossil footprints.
In Am. Jour. Sci., 2d ser., vol. 3, pp. 74–79.
Abstract in Neues Jahrbuch, 1849, pp. 379–381.
Describes three, four, and five toed tracks found at Turners Falls, Mass.

DEANE, JAMES. 1847a.
[Note on fossil footprints from Turners Falls, Mass.]
In Am. Jour. Sci., 2d ser., vol. 4, pp. 448–449.
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DEANE, JAMES. 1849.
Illustrations of fossil footprints of the valley of the Connecticut.
In Am. Acad., vol. 4, pp. 209–220, pls. 1–9.
Presents general description, with figures, of a large number of footprints from the Connecticut valley. The matter contained in this paper is incorporated in Deane's later and larger work "Ichnographs from the sandstones of the Connecticut river," 1861.

DEANE, JAMES. 1850.
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In Philadelphia Acad. Nat. Sci. Jour., 2d ser., vol. 2, 1850–1854, pp. 71–74, pls. 8, 9.
A general description of fossil footprints from Turners Falls, Mass.

DEANE, JAMES. 1856.
On the sandstone fossils of the Connecticut river.
In Philadelphia Acad. Nat. Sci. Jour., 2d ser., vol. 3, 1855–1858, pp. 173–178, pls. 18–20.
Abstract in Neues Jahrbuch, 1857, pp. 877–878.
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DEANE, JAMES. 1861.
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Boston, 4to, pp. 1–61, pls. 1–46.
Notice in Am. Jour. Sci., 2d ser., vol. 36, pp. 126–127.

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Cited on fossil plant from Montague, Mass. (E. Hitchcock, '43*b*, p. 296, pl. 12).
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Dean's, N. J. Trap outcrops at (Cook, '82, pp. 59–60).

Dean's Pond, N. J. Boundary of Newark at (Cook, '68, p. 176).
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Deep river coal field, N. C. Age of, as indicated by fossil fishes (Agassiz, '53).

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East Meriden, Conn. Trap ridges near (Davis and Whittle, '89, p. 107).

East Millstone, N. J. Trap dike near (Darton, '90, p. 69).

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East Rock, Conn. Account of (Davis and Whittle, '89, p. 105).
- Analysis of trap rock from (J. D. Dana, '73, vol. 6, p. 106).
- Brief account of (E. Hitchcock, '23, vol. 6, p. 50. E. Hitchcock, '35, p. 417).
- Critical study of origin of (J. D. Dana, '91).
- Description of (E. Hitchcock, '23, vol. 7, pp. 2-3).
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- Quarries of trap rock at (Shaler, '84, p. 127).
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Easton, Pa. Fossil footprints and fossil plants at (Cook, '85, p. 95).
- Fossil footprints in museum of Lafayette College (C. H. Hitchcock, '88, p. 122).

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- Trap dike in (Frazer, '83, pp. 285, 286, 288).

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East Windsor, Conn. Fossil bones found at, account of (E. Hitchcock, '23, vol. 6, p. 43).
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- Note on (Silliman, '20. A. Smith, '20).
- Reference to (E. Hitchcock, '35, p. 237).

EATON, AMOS. 1818.

An index to the geology of the Northern States.

[Boston] 12mo, pp. 1-52, and 1 plate.

Contains a brief general account of the Newark system in the Connecticut valley, illustrated by a pictorial section.

EATON, AMOS. 1820.

An index to the geology of the Northern States.

Troy N. Y., 16mo, 2d ed., pp. i-xi, 1-286.

First edition not seen.

EATON, AMOS—Continued.

Contains a brief general account of the Newark rocks of the Connecticut valley and of New York and New Jersey, pp. 206-212, 215-221 and of the associated trap rock, pp. 249-256.

EATON, AMOS. 1824.

A geological and agricultural survey of the district adjoining the Erie canal.

Albany [N. Y.], pp. 1-163, pl. 1.

Contains a number of references to the sandstone and trap of the Connecticut valley, pp. 34, 92, 93, 146, 148.

EATON, AMOS. 1828.

Geological nomenclature, exhibited in a synopsis of North American rocks and detritus. (Continued under the title "General geological strata.")

In Am. Jour. Sci., vol. 14, pp. 145-159, 359-368, with 3 plates.

General remarks on lithological characters, etc., pp. 145, 152-155, 365-367, pl. op. p. 145.

EATON, AMOS. 1830.

[Note on the presence of oolite in Bergen county, N. J.]

In Am. Jour. Sci., vol. 18, p. 376.

Mentions that oolite occurs in large quantities at Franklin, Bergen county, N. J.

Eaton Hill, Conn. Description of (Hovey, '89, p. 366).

Economy Point, N. S. Dip at (J. W. Dawson, '79, p. 101).
- Rocks of (J. W. Dawson, '78, p. 101).

Edgefield, S. C. Brief account of contact metamorphism in (Tuomey, '48, p. 68).

Edge Hill, Pa. Conglomerate near (H. D. Rogers, '58, vol, 1, p. 161).

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Edgewater, N. J. Sandstone beneath trap at (Cook, '68, p. 177).

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EDWARDS, A. C. Footprints collected under the direction of (C. H. Hitchcock, '88, p. 121).

EDWARDS, A. M. 1871.

[Remarks on the cast of a tree stem in sandstone from Newark, N. J.]

In New York Lyc. Nat. Hist., Proc., vol. 1, 1870-'71, p. 155).

Brief notice of the occurrence of the fossil mentioned.

Cited on analysis of sandstone from New Jersey (Wurtz, '71).

EGERTON, P. de M. G. 1849.

Palichthyologic Notes No. 3, on the ganoidei heterocerci.

In London Geol. Soc., Quart. Jour., vol. 6, 1850, pp. 1-10, and 2 plates.

Discusses the taxonomic relation of certain fossil fishes from the Connecticut valley and New Jersey, described by L. Agassiz and J. H. Redfield. Establishes the genus Ischypterus and a new species of Catopterus. Concludes with a summary of genera and species which includes a number of American fossils.

EGERTON, P. Cited on age of the Jura-Trias rocks of eastern United States as indicated by fossil fishes (Lyell, '47, p. 278).
Cited on age of the Richmond coal field, Va. (Taylor, '48, p. 47).
Cited on fossil fishes (E. Hitchcock, '58, pp. 5-6. Lyell, '66, p. 456. Lyell, '71, p. 562. Newberry, '88, p. 20, 25).
Cited on fossil fishes from Richmond coal-field, Va. (Lyell, '47, pp. 275, 278).

EGLESTON, THOMAS. 1886.
The cause and prevention of the decay of building stone.
In Am. Soc. Civil Eng., Trans., vol. 15, pp. 647-704.
Refers to the use of trap rock for architectural purposes, p. 666.
Discusses the decay of sandstone, and especially of Newark sandstone, in New York city, pp. 676-680.
Cited on the decay of Newark sandstone in New York city (Smock, '90, p. 297).

Egypt, N. C. Analyses of coal from (Chance, '84. Chance, '85, p. 36. Emmons, '56, pp. 248-250. Genth, '71. Hale, '83, p. 226. Kerr, '75, pp. 293-294).
Analysis of iron ore from (Emmons, '57, pp. 32, 33. Kerr, '75, pp. 226-227).
Analyses of magnesian limestone from near (Emmons, '58).
Bituminous shale at (Kerr, '75, p. 295).
Boundary of the Newark near (Emmons, '56, p. 244).
Brief account of rocks near (Emmons, 57*b*, p. 76).
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Coal near, explorations for (Chance, '85, pp. 35-40).
Coal near, outcrop of (Wilkes, '58, p. 4).
Detailed account of shaft at (Wilkes, '58, p. 6).
Efflorescence of salt in (Jones, '62, p. 90).
Fossil mammalia from, reexamination of (Osborn, '86).
Fossil mammals from (Emmons, '57, pp. 93-96).
Fossil plants, description of (Emmons, 56, pp. 288-295).
Fossil reptilian bones from (Emmons, '57, pp. 79, 92).
Fossil shells from near (Emmons, '57, p. 134).
Fossils obtained at (Emmons, '57, p. 32).
Iron ore in shaft at (Emmons, '56, p. 262).
Iron ore near (Kerr, '75, pp. 225-230).
Position and depth of shaft at (Emmons, '57*a*, p. 7).
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Quarries of Newark sandstone at (Shaler, '84, pp. 181, 182).
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Egypt, N. C.—Continued.
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Elizabeth, N. J. Bored wells at (Cook, '85, p. 144. Nason, '89*b*).
Exposure of sandstone and shale near (Russell, '78, p. 224).

Elizabeth, Pa. Trap dikes near (Frazer, '80, p. 28).

Elizabeth copper mine, Pa. Trap dikes near (H. D. Rogers, 58, vol. 2, p. 707).

Elizabethtown, N. J. Reference to geology near (H. D. Rogers, '40, p. 129).

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Brief account of having seen basalt in (T. P. Smith, '99).
Trap dikes near (H. D. Rogers, '58, vol. 2, p. 687).

Elizabeth township, Pa. Report on the geology of (Frazer, '80, pp. 39-41).

Elk Run, Va. Brief account of a so-called copper mine at (Jackson, '59).

Elkton, Va. Detailed description of geology near (W. B. Rogers, '40, p. 66).

Ellington, Conn. Description of trap dikes in primary rocks near (Percival, '42, pp. 425, 426).
Report of the finding of coal at (E. Hitchcock, '23, vol. 6, p. 63).

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Elliott's limestone quarry, Conn. An account of the rocks at (Percival, '42, pp. 344, 363).

ELLS, R. W. 1880.
Report on the geology of southern New Brunswick, embracing the counties of Charlotte, Sunbury, Queens, Kings, St. John, and Albert.
See Bailey, Matthew, and Ells, 1880.

ELLS, R. W. 1884.
Report on explorations and surveys in the interior of the Gaspé peninsula, 1883.
In geological and natural history survey and museum of Canada, report of progress, 1882-'83-'84, Montreal, 1885, pp. 1E-34E. Accompanied by nine quarto sheets of a geological map of New Brunswick, Quebec, and Prince Edward island.
Describes the rocks of Prince Edward island and gives reason and observation for not considering them of Triassic age; but states that there may possibly be small outlines of this period on the island. Incidentally the Newark rocks of Nova Scotia are described. See pp. 11E-19E, and note on atlas sheet 1 No. 5, SW.

ELLS, R. W. 1885.
Report on the geological formations of eastern Albert and Westmoreland counties, New Brunswick, and portions of Cumberland and Colchester counties, Nova Scotia, by R. W. Ells, 1884. Montreal, 1885.

ELLS, R. W.—Continued.
In Geological and Natural History Survey of Canada. Annual Report (n. s.), vol. 1. Montreal, 1886, pp. 1E–71E, accompanied by map of the province of New Brunswick [sheet 2–SW]; [map of] Nova Scotia and New Brunswick [sheet 4–NW] and a plate of sections in portfolio.
In this report the outcrops of the Newark system along the north shore of Minas basin are briefly described on pp. 6E, 7E, and in connection with a description of the Lower Carboniferous north of Minas basin several references to this system are included, pp. 43E–51E.
Cited on the geology of Prince Edward island (Bain and Dawson, '85, p. 117).

EMERSON, BEN. K. 1882.
The Deerfield [Mass.] dike and its minerals.
In Am. Jour. Sci., 3d ser., vol. 24, pp. 195–202, 270–278, 349–359.
Describes the geographical extent of the dike mentioned, and certain associated faults, together with its lithology, decomposition, mineralogy, etc.

EMERSON, B. K. 1886.
The Holyoke range on the Connecticut.
In Am. Assoc. Adv. Sci., Proc. vol. 35, pp. 233–234.
Abstract in Am. Jour. Sci., 3d ser., vol. 32, pp. 323–324.
Abstract of a paper describing the structure and lithology of the Holyoke trap sheet.

EMERSON, BEN. K. 1887.
[Topography and geology of Hampshire county, Mass.]
In Gazetteer of Hampshire county, Mass., 1654–1887, compiled and edited by W. B. Gray, pp. 10–22.
Contains a sketch of the mode of origin of the sandstone and trap rock of the Connecticut valley and of their subsequent erosion, pp. 18–20.

EMERSON, B. K. 1891.
[Remarks on the basal conglomerate of the Newark in the Connecticut valley.]
In Geol. Soc. Am., Bull. vol. 2, p. 223.
Remarks on a paper by R. Pumpelly. Refers to secular disintegration before the deposition of the Newark. Gives thickness of arkose in Massachusetts.

EMERSON, B. K. Cited on a fault at Turner's Falls, Mass. (W. M. Davis, '88, pp. 469, 471).
Cited on the Newark system in the Connecticut valley (Newberry, '88, pp. xiii–xiv).
Cited on origin of limestone in the Newark rocks of Massachusetts (W. M. Davis, '89, p. 66).
Cited on origin of the red color of the Newark sandstone (Russell, '89, p. 50).
Cited on overflow trap sheets in Massachusetts (W. M. Davis, '83, p. 297. W. M. Davis, '88, p. 465).

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Emig's mill, Pa. Dip of sandstone at (Fraser, '76, p. 94).
Trap near (Fraser, '76, p. 94).

Emigsville, Pa. Conglomerate from (Fraser, '76, p. 153).
Dip near (Fraser, '76, p. 88).
Limestone conglomerate from (C. E. Hall, '78, p. 17).
Section through (Fraser, '76, op. p. 92).

Emilysville, York county, Pa. Fossil reptiles found at (Fraser, '85, p. 403).

Emmettsburg, Pa. Boundary of the Newark near (H. D. Rogers, '58, vol. 2, p. 669).
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Iron ore near (H. D. Rogers, '58, vol. 2, p. 691).
Trap dikes near (H. D. Rogers, '58, vol. 2, pp. 688, 691).
Trap from (C. E. Hall, '78, p. 61).

EMMONS, E. 1836.
Notice of a scientific expedition [to Nova Scotia and New Brunswick].
In Am. Jour. Sci., vol. 30, pp. 330–354.
Contains a general description of the trap on the southeast shore of the bay of Fundy, with occasional references to the associated sandstone, and a few records of dip, contact metamorphism, etc. A brief account of Quaco head, N. B., is also given.

EMMONS, EBENEZER. 1841.
Report on the ornithichnites or footmarks of extinct birds, in the New Red sandstone of Massachusetts and Connecticut, observed by Prof. Hitchcock, of Amherst.
See (Rogers, H. D., L. Vanuxem, R. C. Taylor, E. Emmons, and T. A. Conrad, 1841).

[EMMONS, E.] 1842.
Topography, geology, and mineral resources of the State of New York.
In a gazetteer of the state of New York.
Albany, 12mo, pp. 5–25.
Contains a brief account of the trap rock on the west bank of the Hudson, pp. 16–17.

EMMONS, E. 1842a.
Geology of New York [Part IV].
Albany, 4to, pp. i–x, 1–437, pls. 1–17.
Shows the position of the Newark system in the New York series of sedimentary rocks, p. 429.

EMMONS, EBENEZER. 1846.
Natural History of New York, Part V. Agriculture, vol. 1.
Albany, 4to, pp. i–xi, 1–371, and 21 plates.
Contains a brief account of the Newark rocks of Rockland county, N. Y., pp. 200–201.

EMMONS, EBENEZER. 1852.
Report of Prof. Emmons on his geological survey of North Carolina.
Raleigh, pp. 1–182.
Contains detailed description of the Deep river and Dan river coal fields, N. C., pp. 113–159.

EMMONS, EBENEZER. 1856.
Geological report of the midland counties of North Carolina.

EMMONS, EBENEZER—Continued.

New York and Raleigh, pp. i–xx, 1–351, and 18 maps and plates.

Reviewed by Charles Dewey, in Am. Jour. Sci., 2d ser., vol. 24, pp. 427–430.

Abstract in Neues Jahrbuch, 1858, pp. 358–359.

Reprinted in "In coal and iron counties of North Carolina," by P. M. Hale.

Contents relating to the Newark system.

EMMONS, EBENEZER. **1857.**

American geology, containing a statement of the principles of the science, with full illustrations of the characteristic American fossils, Part VI.

Albany [N. Y.], pp. i–x, 1–152, and 13 plates.

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EMMONS, EBENEZER. **1857a.**

Special report of Dr. E. Emmons, concerning the advantages of the valley of the Deep river [North Carolina], as a site for the establishment of a national foundry.

Raleigh, pp. 1–14.

Describes briefly the coal, iron, and building stone of the region referred to, pp. 6–11, 12.

EMMONS, E. **1857b.**

Fossils of the sandstones and slates of North Carolina.

In Am. Assoc. Adv. Sci., Proc., vol. 11, 1858, pt. 2, pp. 76–80.

Abstract in Ann. Sci. Discov., 1857, pp. 312–314.

Presents a generalized section of the Newark rocks of North Carolina, followed by a summary of results obtained from a study of their fauna and flora, and a discussion of their age as compared with certain formations in Europe.

EMMONS, EBENEZER. **1857c.**

Permian and Triassic systems of North Carolina.

In Edinburgh New Philosophical Journal, N. S., vol. 5, p. 370.

Abstract in Neues Jahrbuch, 1857, p. 343.

Abstract of a paper read at the Albany meeting of the American Association for the Advancement of Science, 1856. The Newark system in North Carolina is stated to belong to the Permian and Triassic systems. The fossils on which this classification is based are mentioned.

EMMONS, E. **1858.**

The chemical constitution of certain members of the Chatham series in the valley of Deep river, North Carolina.

In Am. Assoc. Adv. Sci., Proc., vol. 12, 1859, pp. 230–232.

Refers to divisions that have been made in classifying the Newark rocks of North Carolina, and presents three analyses of magnesian limestone from near Egypt.

EMMONS, E.—Continued.
Cited on age of the coal-bearing rocks of North Carolina (Chance, '85, p. 17. J. D. Dana, '56, p. 322. Jackson, '56*a*, pp. 31–32. Lesquereux, '76, p. 283. Macfarlane, '77, pp. 518–528. Macfarlane, '79, p. 42. Marcou, '88, p. 30. W. C. Redfield, '56, p. 188).
Cited on age of the Newark system (Hitchcock and Hitchcock, '67, p. 416. Lea, '58. Newberry, '88, p. 9. H. D. Rogers, '58, vol. 2, pp. 696–697).
Cited on cypridæ from North Carolina (Jones, 62, p. 125).
Cited on Deep river coal field, N. C. (Lyell, '66, p. 457).
Cited on efflorescence of salt in the Egypt shaft, N. C. (Jones, '62, p. 90).
Cited on extent of the Newark in North Carolina (Wilkes, '58, p. 2).
Cited on fossil bird bone from North Carolina (Mackie, '64).
Cited on fossil crustaceans from the Newark system (Jones, '62, pp. 86–87).
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Cited on fossil mammalians from North Carolina (Osborn, '86).
Cited on fossil mammalians in North Carolina (H. D. Rogers, '58, vol. 2, p. 761).
Cited on fossil plants in North Carolina (Marcou, '59, p. 25. Marcou, '90).
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Cited on geology of the midland counties of North Carolina (Marcou, '58, pp. 15–16).
Cited on geology of Virginia and North Carolina (Archiac, '58).
Cited on intrusive trap sheets in New Jersey (W. M. Davis, '83, p. 294).
Cited on Newark of North Carolina (Miller, '79–'81, vol. 2, pp. 225–227).
Cited on Older Mesozoic flora of North Carolina (Fontaine, '83, pp. 60, 62, 63, 88, 89, 97–128, pls. 48–54).
Notice of work by (Miller, '79–'81, vol. 2, pp. 152–154).
Reference to description of fossil mammal by (Osborn, '87).
Review of geological report by (Dewey, '57).

Enfield, Conn. Brief account of shale at (E. Hitchcock, '35, p. 217).
Coal found in (E. Hitchcock, '41, p. 139).
Fossil plants from (E. Hitchcock, '41, p. 453).
Mention of the finding of fossil plants at (A. Smith, '32, pp. 219–220).
Report of the finding of coal at (E. Hitchcock, '23, vol. 6, p. 63).
Red shale in (E. Hitchcock, '41, p. 443).
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Enfield bridge, Conn. Localities of fossil footprints near (E. Hitchcock, '41, p. 466).

Enfield falls, Conn. Description of fossil footprints from (E. Hitchcock, '58).

Enfield falls, Mass. Brief account of sandstone near (E. Hitchcock, '35, p. 221).

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Concerning coal near (E. Hitchcock, '35, p. 231).

Enfield ridge, Suffield, Conn. Fossil footprints at (E. Hitchcock, '58, pp. 50, et seq.).

Englewood, N. J. Boundary of trap outcrop at (Cook, '68, p. 177).
Description of the geology near (W. M. Davis, '83, pp. 269–271).
Dip of sandstone near (W. M. Davis, '83, p. 269).
Indurated shale near (Darton, '90, p. 52).
Mention of building stone near (Cook, '81, p. 43).
Outcrops of trap and sandstone near (Cook, '68, p. 178).
Sandstone on trap at (Cook, '68, p. 201).
Sandstone on west slope of Palisades at (Cook, '68, p. 208).
Sandstone quarries at (Cook, '79, p. 21).
Upper contact of Palisade trap sheet near (Davis and Whittle, '89, p. 106).

English company's colliery, Va. Analysis of coal from (Clifford, '87, p. 10).

English neighborhood, N. J. Boundary of trap outcrop at (Cook, '68, p. 177).

Ephrata, Pa. Boundary of the Newark near (Frazer, '80, pp. 43, 44. Lea, '58, p. 92. H. D. Rogers, '58, vol. 2, p. 668).

Ephrata hills, Pa. Boundary of the Newark near (Frazer, '80, p. 15).

Ephrata township, Pa. Report on the geology of (Frazer, '80, pp. 44–48).

Eppes falls, Va. Boundary of Newark area near (Heinrich, '78, p. 231. W. B. Rogers, '40, p. 71).

Erbs mill, Pa. Boundary of the Newark near (H. D. Rogers, '58, vol. 2, p. 668).

Evans, N. C. Exploration for coal near (Chance, '85, pp. 43–47).

Evans bridge, N. C. Boundary of the Newark near (Mitchell, '42, p. 130).
Fossil tree trunks found near (Emmons, '52, p. 148).
Unconformity of Newark and Taconic near (Emmons, '56, p. 242).

Evans mills, N. C. Section at (Emmons, '56, p. 231).

Evittstown, N. J. Character of the formation near (H. D. Rogers, '40, p. 131).

Ewingville, N. J. Dip in shale near (Cook, '82, p. 26).

Exeter, Pa. Contact metamorphism at (d'Invilliers, '83, p. 199).

EYERMAN, JOHN. **1886.**
Footprints on the Triassic [Newark] of New Jersey.
In Am. Jour. Sci., 3d ser., vol. 31, p. 72.
Brief description of fossil footprints from near Milford, Hunterdon county, New Jersey.

EYERMAN, JOHN. **1889.**
[Fossil footprints and fossil plants from Milford, New Jersey.]

Farmville area, Va.—Continued.
Brief review of the occurrence of coal in (Chance, '85, pp. 18–19).
General account of the coal of (Patton, '88, p. 23).

Faults. Brief discussion of (W. M. Davis, '88, pp. 469–481).

Faults in Connecticut. Discussion of (Hovey, '89, pp. 378–379. W. M. Davis, '89c).
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Map of, near Meriden (W. M. Davis, '89c, p. 424).
Possible existence of (E. Hitchcock, '58, p. 15).
South Britain (W. M. Davis, '88, p. 472).
Woodbury, section showing (W. M. Davis, '88, p. 472).
See, also, Connecticut valley.

Faults in Connecticut valley. (W. M. Davis, '82. W. M. Davis, '82a, pp. 120–124. W. M. Davis, '83. W.M. Davis, '88. W. M. Davis, '91. Davis and Loper, '91. Davis and Whittle, '89. Percival, '42, p. 300).
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Hypothetical section of (W. M. Davis, '86, p. 350).
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Origin of (W. M. Davis, '88a).
Systematic arrangement of (W. M. Davis, '88, pp. 474–477).
See, also, Connecticut and Massachusetts.

Faults in Massachusetts. At mouth of Fall river (Emerson, '82).
See, also, Connecticut valley.

Faults in New Jersey. (Cook, '79, p. 33. Cook, '82, p. 16. Cook, 83, p. 25. Cook, '87. Cook, '89, pp. 13–14. Darton, '90. W. M. Davis, '82. W. M. Davis, '83. Lesley '83, p. 181. Nason, '89, pp. 25, 32–33).
At Belleville (Cook, '81, p. 44).
Garret rock (Darton, '90, p. 23).
Haledon quarry (Cook, '83, p. 25, pl.).
Hudson county (Darton, '90. Russell, '80, pp. 32–33).
Lambertville (Lesley, '83, p. 181).
Palisades (Nason, '89, p. 26).
Paterson (W. M. Davis, '83, p. 309, pl. 11).
Plainfield (Cook, '68, p. 677).
General, absence of (Cook, '68, p. 202).

Faults in New York. In Palisade trap sheet (Darton, '90, pp. 41–45).

Faults in North Carolina. Deep river area (Chance, '85, p. 59).
Gulf (Emmons, '56, p. 241).

Faults in Nova Scotia. (Dawson, '78, p. 104).

Faults in Pennsylvania. (Frazer, '84. Lewis, '85, p. 440. H. D. Rogers, '58, vol. 1, pp. 86, 87).
Border of the Newark (Lesley, '63, pp. 188–189).
Bucks county (Lesley, '85, p. xxvii).
Cornwall iron mine (Lesley and d'Invilliers, '85, pp. 498–506).
Dillsburg (Frazer, '77, pp. 328–330. d'Invilliers, '86, p. 1503).
Yardleyville (Lewis, '82).

Faults in Pennsylvania—Continued.
Yellow springs (H. D. Rogers, '58, vol. 1, p. 88).

Faults in Virginia. Farmville (Daddow and Bannan, '66, p. 403).
Midlothian (Fontaine, '79, p. 36).
Richmond area (Fontaine, '79, pp. 35, 36. Newell, '89. W. B. Rogers, '36, pp. 55–56. Shaler, '71, pp. 114, 118).
Origin of, briefly considered (W. M. Davis, '89a, p. 196).
Producing overlap, diagrams showing (W. M. Davis, '88, p. 475).
Various observations cited (W. M. Davis, '83, pp. 304–305).

Fauquier county, Va. Character of conglomerate in (W. B. Rogers, '39, p. 72).
Description of the Newark in (W. B. Rogers, '40, pp. 64–69).
Reference to fossil fishes from (E. Hitchcock, '41, p. 440).

Fayettesville, Va. Boundary of Newark near (Heinrich, '78, p. 235).

Feltville, N. J. Absence of contact metamorphism at (Darton, '89, p. 135).
Baryta at (Cook, '68, p. 709).
Boundary of First mountain, trap at (Cook, '68, p. 182).
Boundary of Second mountain, trap at (Cook, '68, p. 183).
Copper ores near (Cook, '68, p. 676).
Description of the geology near (W. M. Davis, '83, pp. 274–276).
Dip at (Cook, '68, p. 196).
Dip in sandstone at (Cook, '82, p. 24).
Junction of trap and sandstone at (Russell, '78a).
Limestone at (Cook, '68, p. 214. Cook, '79, p. 18. Cook, '82, pp. 22, 42).
Limestone near (Nason, '89, p. 22).
Sandstone above trap at (Cook, '68, p. 201).
Section of trap sheet near (Darton, '90, p. 26).
Surface of trap sheet at (Darton, '90, p. 26).
Trap exposures near (W. M. Davis, '83, p. 309, pl. 11).

Ferrish's coal mine, N. C. Analysis of coal from (W. R. Johnson, '50, p. 165. Macfarlane, '77, p. 525).
Discovery of (W. R. Johnson, '50, pp. 161–162).

Fiddlers creek, N. J. Dip near (Cook, '68, pp. 197, 198).

FIELD, ROSWELL. 1855.
[On fossil footprints from Greenfield, Connecticut.]
In Boston Soc. Nat. Hist., Proc., vol. 5, pp. 160, 166).
Describes a slab of sandstone covered with footprints.

FIELD, ROSWELL. 1856.
[Note on the discovery of the footprint of a biped web-footed animal at Greenfield, Massachusetts.]
In Boston Soc. Nat. Hist., Proc., vol. 6, pp. 10, 11.
A brief extract from a letter relating to the discovery.

FONTAINE, WILLIAM M. 1879.
Notes on the Mesozoic strata of Virginia.
In Am. Jour. Sci., 3d ser., vol. 17, pp. 25-39, 151-157, 229-239.

FONTAINE, WILLIAM M.—Continued.
Reviewed by P. Frazer in Am. Nat., vol. 13, pp. 284-292.
Abstract in Neues Jahrbuch, 1881, pp. 137-138.
Classifies and describes the various Newark areas in Virginia, discusses the character and relations of their fossil plants, and presents theoretical considerations in reference to the causes which exterminate the "Jurassic" flora. The age of the two principal divisions of the Mesozoic of Virginia also receives attention.

FONTAINE, WILLIAM MORRIS. 1883.
Contributions to the knowledge of the Older Mesozoic flora of Virginia.
Washington (Interior Dep., U. S. Geological Survey, Monograph No. 6, pp. i-xi, 1-144, pls. 1-54).
Reviewed by D. Stur in Verhandlungen der k. k. geologischen Reichsanstalt, No. 10, 1888, and by J. Marcou in Am. Geol., vol. 5, pp. 160-174; see also The Virginias, vol. 6, pp. 38-40.
Abstract in Am. Jour. Sci., 3d ser., vol. 30, p. 162.
Contains a sketch of the geology of the Newark system, pp. 1-9. Describes and figures fossil plants collected mainly at Clover hill, Va., and consisting principally of ferns, together with a few specimens of Equisetæ; Schizoneura, fruits of cycads, and some undetermined plants, pp. 10-92. General observations on the relation of the flora to that of the Trias, Jura, and Rhetic of Europe, pp. 92-96. The Older Mesozoic flora of North Carolina, as treated in E. Emmons' "American Geology, Part VI," is also presented, pp. 57-121, followed by general remarks and conclusions, pp. 121-128. Explanation of plates, pp. 129-140.

FONTAINE, WILLIAM MORRIS. 1889.
The Potomac or younger Mesozoic flora.
U. S. Geol. Surv., Monog. No. 15, in two parts.
Refers to the unconformity of the Potomac with the Newark rocks beneath, in Virginia, part 1, pp. 58-59.

FONTAINE, W. M. Abstract of notes on the geology of Virginia. See Frazer, '82, p. 140.
Cited on age of the Newark system (Newberry, '88, p. 10).
Cited on fossil flora (Dawson, '88, pp. 176, 246. Marcou, '88, p. 33. Newberry, '88. Zeiller, '88).
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Review of work by (Stur, '88).

Fooshee, N. C. Exploration for coal near (Chance, '85, pp. 49-50).

Footprints, fossil. Brief sketch of (H. D. Rogers, '58, vol. 2, pp. 760-761).
Characteristics and paleontological value (E. Hitchcock, '60).
Classification of (E. Hitchcock, '36, pp. 315-317).

Footprints, fossil—Continued.
Classification of, with list of species (E. Hitchcock, '44*a*, pp. 316-318).
Comparative study of (E. Hitchcock, '58, pp. 24-45).
Compared with footprints of living animals (E. Hitchcock, '41, pp. 504-508, pls. 49, 50, 51).
Comparison of, with recent footprints (Desor, '49).
Credit given E. Hitchcock for the investigation of (H. D. Rogers, '44, pp. 249-250).
Description and illustrations (E. Hitchcock, '65).
Description of species (C. H. Hitchcock, '88, pp. 123-127. E. Hitchcock, '36, pp. 317-329. E. Hitchcock, '42).
Descriptive catalogue of, in the Hitchcock cabinet at Amherst college (C. H. Hitchcock, '65).
Discussion concerning (Murchison, '43).
Discussion of the nature of (E. Hitchcock, '36, pp. 313-316).
Discussion of the principles of classification (E. Hitchcock, '48).
Doubtful species of (E. Hitchcock, '65, p. 2).
Early observations on (Barratt, '45).
Evidence of having been made on a sloping surface (W. B. Rogers, '42*a*).
General account of (Emmons, '57, pp. 135-142, pl. 7).
Glossary of words used in description of (E. Hitchcock, '58, p. 207).
History of the discovery and description of (E. Hitchcock, '44*a*).
Illustrations of (Bouvé).
Inferences from (Cook, '68, p. 338).
Note in reference to the correct determination of (Deane, '47*a*).
Number of phalanges in the toes of (Silliman, Silliman, jr., and Dana, '47).
Of crustaceans (Agassiz, '58).
Physical conditions shown by (J. D. Dana, '75, p. 420).
Reference to (Newberry, '88, p. 5).
Remarks on the classification of (Cope, '69, p. 242).
Revised list of (C. H. Hitchcock, '71. C. H. Hitchcock, '88).
Sketch of progress in the study of (Warren, '55).
Species of, not reliable (E. Hitchcock, '65, p. 2).
Statements in reference to the nature of (J. D. Dana, '65).
Table showing classification of (E. Hitchcock, '48, pp. 165-168).

Footprints, fossil, from Connecticut. Additional localities (E. Hitchcock, '37*b*).
Greenfield, description of (Field, '55).
Middletown, mention of (Anonymous, '38*a*. Barratt, '37).
Reference to (Adams, '46*a*. Silliman, '37).

Footprints, fossil, from the Connecticut valley.
Account of (Danberry, '39, pp. 19-21. Deane, '61. Le Conte, '82, pp. 253-257).

Footprints of existing reptiles for comparison with fossil footprints. (Deane, '61, p. 44, pls. 21, 22).

Forestville, Conn. Sandstone quarries near (Shaler, '84, p. 127).

Forestville, Pa. Trap dike near (Lewis, 85, p. 447).

Fort Hale, Conn. Description of trap ridges near (Percival, '42, p. 329).

Fort Hans, N. Y. Boundary of trap near (Cook, '68, p. 192).
Elevation of Sourland mountain at (Cook, '68, p. 191).

Fort Lee, N. J. Boundary of trap outcrop at (Cook, '68, p. 177).
Character of trap ridge near (Darton, '90, pp. 38, 47-48).
Contact metamorphism at (Cook, '68, p. 208).
Copper ore under trap at (Cook, '68, p. 676).
Description of geology near (W. M. Davis '83, pp. 269-271).
Description of sandstone and conglomerate near (Cook, '68, p. 208).
Dip at (Cook, '68, p. 195).
Dip in sandstone at (Cook, '79, p. 30. Cook, '82, p. 24).
General account of geology near (Pierce, '20, pp. 182-184).
Section of the Palisades south of (Cozzens, '43, pl. 2).
Trap ridge near (Darton, '90, pp. 47-48).

Fort Washington, Pa. Boundary of the Newark near (C. E. Hall, '81, p. 75. Lesley, '85, p. lxxxi).
Conglomerate at (C. E. Hall, '81, p. 24).

FOSTER [J. W.]. **1851.**
[Remarks on the geological position of the Newark system and on the structure of the Connecticut valley sandstone.]
In Am. Assoc. Adv. Sci., Proc., vol. 5, p. 46.
Abstract in Ann. Sci. Discov., 1852, p. 266.
Remarks on a paper by W. C. Redfield, in reference to the age of the rocks mentioned, as indicated by stratigraphy. Discusses also the evidence of an unconformity in the sandstones of the Connecticut valley.

FOSTER, J. W. **1869.**
The Mississippi valley, its physical geography, [etc.].
Chicago and London, pp. i-xvi, 1-443.
Contains a brief account of the Newark system, p. 306, and a geological sketch map of the United States, pl. op. p. 273.

Fountainville, Pa. Trap dikes near (Lewis, '85, p. 453).

Franklin, N. J. Bored well at (Cook, '85, pp. 117-118).
Oolite at (Eaton, '30).

Franklin copper mine, N. J. Description of (Cook, '68, p. 679. H. D. Rogers, '36, p. 168. H. D. Rogers, '40, p. 161).

Franklin county, Mass. A study of stratigraphy in (Walling, '78).

Franklin county, Pa. Geological map of (Sanders, '81).
Report on the geology of (Frazer, '77).

Franklin lake, N. J. Boundary of Second mountain, trap near (Cook, '68, pp. 183, 184).
Dip in sandstone at (Cook, '82, p. 30).
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Sandstone quarry at (Cook, '79, p. 22).
Trap hill near (Cook, '82, p. 49).

Franklintown, Pa. Catalogue of specimens of sandstone, etc., near (Frazer, '77, pp. 332-381).
Concerning the mines at (Frazer, 77c, pp. 654-655).
Isolated area of schist in Newark rocks near (Frazer, '77c, p. 651).
Mention of various rock specimens from near (C. E. Hall, '78, pp. 33-36).
Section from near, to Wellsville (Frazer, '77, pp. 271-273, pl. op. p. 272).

FRAZER, PERSIFOR, Jr. **1874.**
Weathering of rocks [at Gettysburg, Pa.].
In Philadelphia Acad. Nat. Sci., Proc., vol. 26, p. 228.
Brief description of the weathering of trap rock (syenite) at Gettysburg.

FRAZER, P[ERSIFOR], Jr. **1874a.**
On exfoliation of rocks near Gettysburg.
In Am. Phil. Soc., Proc., vol. 14, 1874-1875, pp. 295-297.
Describes the weathering of trap rock (syenite) near Gettysburg, Pa.

FRAZER, PERSIFOR. **1875.**
On some thin sections of the Lower Paleozoic and Mesozoic rocks of Pennsylvania.
In Am. Inst. Mining Eng., Trans., vol. 3, pp. 327-328.
Brief general statement of the results of an examination of thin sections of sandstone and trap from York and Adams counties, Pa.

FRAZER, PERSIFOR. **1875a.**
On the traps of the Mesozoic sandstone in York and Adams counties, Pa.
In Am. Philo. Soc., Proc., vol. 14, 1876, pp. 402-414, pls. 1-4.
Discusses the chemical composition and optical properties of certain trap rocks from West Rock, Conn., and from near York, Gettysburg, and Dillsburg, Pa. Presents complete analyses of trap from West Rock and from near York.

FRAZER, PERSIFOR. **1875b.**
[Comparison of microscopical section and fragments of trap from near Gettysburg, Pa., with similar samples and sections of the trap rocks of Connecticut.]
In Am. Philo. Soc., Proc., vol. 14, pp. 430-431.
Presents the results of the comparison indicated in the title.

FRAZER, PERSIFOR. **1875c.**
On the Trias of York county, Pa.
In Philadelphia Acad. Nat. Sci., Proc., vol. 27, p. 123.
Brief remarks on the dip of Newark strata and on the unconformity of Newark and Silurian rocks in York county, Pa.

FRAZER, PERSIFOR, Jr. **1875d.**
On the Mesozoic red sandstone of the Atlantic states.

FRAZER, PERSIFOR, Jr.—Continued.
In Philadelphia Acad. Nat. Sci., Proc., vol. 27, pp. 440–442.
General considerations relating to the problems presented by the Newark system.

FRAZER, PERSIFOR, Jr. **1876.**
Second geological survey of Pennsylvania, 1874. Report of progress in the district of York and Adams counties [etc., etc.].
Harrisburg, 1876, vol. C. pp. i–viii, 1–198, with 10 plates and maps.
Contains brief reports of observation on boundaries, dip, trap dikes, etc., pp. 71, 88–89, 91, 92–93, 94, 95, 101, 102, 103, 122–129, 152, 153, 159, 160, pls. op. pp. 64, 92, 94, 112, 128, 196.

FRAZER, PERSIFOR. **1876a.**
Geological map of Adams county, Pa.
See Lesley and Frazer, 1876.

FRAZER, PERSIFOR, Jr. **1876b.**
Notes on two traps; a case of alteration of earthy sediments.
In Philadelphia Acad. Nat. Sci., Proc., vol. 28, p. 60.
Describes the appearance of a sandstone that has been altered by a trap intrusion.

FRAZER, PERSIFOR. **1876c.**
Notes on some Paleozoic limestones.
In Philadelphia Acad. Nat. Sci., Proc., vol. 28, pp. 60–63.
Gives an analysis of limestone from the Newark system at Dillsburg, Pa., p. 63.

FRAZER, PERSIFOR. **1876d.**
A study of the specular and magnetic iron ores of the New Red sandstone in York county, Pa.
In Am. Inst. Mining Eng., Trans., vol. 5, pp. 132–143, pl. 2.
Describes the character and mode of occurence of certain iron ores and of associated trap dikes near Dillsburg, Pa.

FRAZER, PERSIFOR. **1876e.**
A study of the igneous rocks.
In Am. Inst. Mining Eng., Trans., vol. 5, pp. 144–146.
Gives the mineralogical composition of a number of trap rocks from Adams and York counties, Pennsylvania, p. 146.

FRAZER, PERSIFOR, Jr. **1877.**
Second geological survey of Pennsylvania, 1875. Report of progress in the counties of York, Adams, Cumberland, and Franklin [etc., etc.].
Harrisburg [vol. CC], pp. 201–401, and 17 plates and maps.
Contains a detailed account of the Newark system in the counties mentioned, with special reference to the deposits of iron ore and to trap rocks. A large number of observations of dip are recorded, pp. 206–230, 239–317, 348–381, pl. op. pp. 232, 264, 272, 274, 298, 304, 328, and map.

FRAZER, PERSIFOR. **1877a.**
The position of the American New Red sandstone.
In Am. Inst. Mining Engi., Trans., vol. 5, pp. 494–501.
Reviewed by P. Frazer in Am. Nat., vol. 13, pp. 284–292.
Compares a section of the Newark rocks in Adams county, Pennsylvania, with general sections of the Permian, Triassic, and Jurassic rocks of England and Germany.

FRAZER, PERSIFOR, Jr. **1877b.**
On copper-bearing rocks of the Mesozoic formations.
In Philadelphia Acad. Nat. Sci., Proc., vol. 29, pp. 17–19.
Describes the occurrence of copper ore at Bonnaughton, near Gettysburg, Pa.

FRAZER, PERSIFOR. **877c.**
Regarding some Mesozoic ores.
In American Phil. Soc., Proc., vol. 16, pp. 651–655.
Mentions outliers of schist in Newark areas, and also outliers of Newark rocks in the bordering crystalline rocks of Pennsylvania. Considers the mode of formation of the Newark sandstones, and advances a hypothesis to account for the ores they contain.

FRAZER, P. **1877d.**
[Remarks on the Newark system in Pennsylvania.]
In Am. Phil. Soc., Proc., vol. 1–16, p. 664.
Brief abstract of remarks concerning the origin of the prevailing dip of the Newark rocks, and the occurrence of iron ores as a definite line in both the Newark and adjacent terranes.

FRAZER, PERSIFOR, Jr. **1878.**
On the physical and chemical characteristics of a trap occurring at Williamson's Point [Pennsylvania].
In American Phil. Soc., Proc., vol. 18, 1880, pp. 96–103, and pl. op. p. 96.
Discusses the optical properties and the chemical and mineralogical composition of trap from the locality mentioned, and presents a complete analysis of it. The colored plate accompanying this paper shows the appearance of a thin section of the trap in polarized light.

FRAZER, PERSIFOR, Jr. **1879.**
The Mesozoic sandstone of the Atlantic slope.
In Am. Nat., vol. 13, pp. 284–292.
A review of the following paper on the formation mentioned: "The position of the American New Red sandstone," by Persifor Frazer, jr.; "The Mesozoic formation of Virginia," by Oswald J. Heinrich; "Notes on the Mesozoic of Virginia," by Wm. M. Fontaine, and "The physical history of the Triassic formation of New Jersey and the Connecticut valley," by I. C. Russell.

FRAZER, PERSIFOR, Jr. **1880.**
Second geological survey of Pennsylvania. Report of progress in 1877. CCC. The geology of Lancaster county.

FRAZER, PERSIFOR, Jr.—Continued.
Harrisburg, pp. I-x, 1-350, with 12 plates and an atlas of 13 sheets of maps and sections.
Contains a detailed description of the boundaries of the Newark system and of local features of the sandstone, conglomerate, trap dikes, etc., composing the system, in the county mentioned.

FRAZER, PERSIFOR. 1882.
Mémoire sur la géologie de la partie sud-est de la Pennsylvanie. In Thèses présentées à la Faculté des Sciences de Lille Université de France pour obtenir le grade de docteur ès-sciences naturelles. Lille [France], 4to, pp. 1-179, and 4 plates.
Contains a description of the Newark system in Pennsylvania. Describes the extent of the system, its geological position, the character and origin of the copper and iron ores it contains, and also the extent and character of the trap rocks that traverse it. Discusses briefly the origin of the red color of the Newark sandstone. Gives analyses of copper and iron ores, and of trap rock. The geological map shows the distribution of stratified and igneous rocks of Adams and Lancaster counties.

FRAZER, PERSIFOR. 1883.
Geological notes in the several townships of Chester county [Pa.].
In second geological survey of Pennsylvania, vol. C[4], pp. 215-245 and maps in pocket.
Preliminary remarks on the varieties of rock in Chester county, including the sandstone, shale, and trap, p. 219. Distribution and general character of the Newark in various towns, pp. 220, 221, 222, 223, 224, 226, 235, 236, 244.

FRAZER, PERSIFOR. 1884.
Trap dikes in Archean rocks of southeastern Pennsylvania.
In Am. Phil. Soc., Proc., vol. 21, pp. 691-694.
A review of a paper by H. C. Lewis, on "A great trap dike across southeastern Pennsylvania." See Lewis, 1885.

FRAZER, PERSIFOR. 1885.
General notes, sketch of the geology of York county, Pa.
In Am. Phil. Soc. Proc., vol. 23, 1886, pp. 391-410, and a map.
Describes the extent and character of the Mesozoic rocks of York county, Pa. Discusses the evidence of their thickness and quotes E. D. Cope, in reference to their age.

FRAZER, P. Cited on amount of iron in trap rocks (Russell, '89, p. 51).
Cited on composition of trap rocks (W. M. Davis, '83, p. 284).
Cited on a great trap dike in southeastern Pennsylvania (Lewis, '85, p. 456).
Cited on intrusive trap sheets in Pennsylvania (W. M. Davis, '83, p. 294).
Cited on iron-ore mines near Dillsburg, Pa. (d'Invilliers, '86, pp. 1502).

FRAZER, P.—Continued.
Cited on trap dike in Pennsylvania (Lewis, '85, p. 444. Macfarlane, '79, p. 43).

Frederick, Md. Account of a search for coal near (Ducatel, '37, p. 36).
Occurrence of conglomerate south of (Lea, '53, p. 190).
Potomac marble from (Shaler, '84, p. 177).

Freedman ford, Va. Boundary of Newark near (Heinrich, '78, p. 235).

Freetown, P. E. I. Limestone near (Dawson and Harrington, '71, p. 34).

French cove, N. S. Minerals of (Gesner, '36, pp. 197, 198).

French cross, N. S. Description of (Gesner, '36, pp. 196-198).

French cross cove, N. S. Description of (Jackson and Alger, '33, pp. 248-251).

Frenchtown, N. J. Detailed description of sandstone and shale near (H. D. Rogers, '36, pp. 151, 152).
Dip near (Cook, 68, p. 198).
Dip of red shale near (Cook, '79, p. 29. Cook, '82, p. 27).

Fresh Kills, N. Y. Trap rock at (Cook, '68, p. 178).

Fritz mill, Pa. Detailed account of dips near (d'Invilliers, '83, p. 212).

Fritz island, Pa. Conglomerate from (d'Invilliers, '83, p. 392).

Fritz island mine, Pa. Detailed account of (d'Invilliers, '83, pp. 333-342).

GABB, WM. M. 1860.
Description of new species of fossils, probably Triassic, from Virginia.
In Philadelphia Acad. Nat. Sci., Jour., n. s., vol. 4, 1858-1860, pp. 307, 308.
Describes several species of mollusks from Bath county, Va. [Do not belong to the Newark system].

GABB, WM. M. 1861.
Illustrations of some fossils described in the proceedings of the [Philadelphia] Academy of Natural Science.
See Conrad and Gabb.

Gabel hill, Pa. Dip near (d'Invilliers, '83).
Trap dike (d'Invilliers, '83, pp. 200, 201).

Gabel mine, Pa. Analysis of ore from (d'Invilliers, '83, pp. 331-333).
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Gale, (——). Cited on fossil fish from New Jersey (W. C. Redfield, '39).
Cited on the discovery of fossil fishes in New Jersey (Silliman, '39).

Gallas point, P. E. I. Analysis of limestone from (Dawson and Harrington, '71, p. 41).
Anticlinal at (Dawson and Harrington, '71, p. 16).
Description of (Dawson, '78, p. 116).
Description of fossil wood from (Dawson, '54).
Dip at (Dawson, '78, p. 116).
Fossil plants from (Bain and Dawson, '85, pp. 156-158. Dawson and Harrington, '71).
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Reference to geology of (Chapman, '76, p. 92).

Germanton, N. C.—Continued.
Dip of sandstone with coal at (McLenahan, '52, p. 170).
Fossil plants from (Emmons, '57, pp. 27, 28, 145).
Fossil tree trunks at (Emmons, '56, p. 256. Kerr, '75, p. 143).
Fossil wood near (Olmsted, '27, p. 127).
General section of Newark rocks near (Jones, '62, p. 89).
Newark rocks near (Macfarlane, '77, pp. 527, 528).
Saurian remains from (Emmons, '57, p. 145).
Section at (Emmons, '56, pp. 259-260).
Section of shale and coal at (Emmons, '52, p. 152).
Southern limit of Newark area near (Olmsted, '27).

Germantown, N. J. Boundaries of Newark system near (Cook, '89, p. 11).
On the occurrence of conglomerate at (Lea, '53, p. 190).

Germantown, Va. Boundary of Newark near (Heinrich, '78, p. 335).
Detailed description of geology near (W. B. Rogers, '40, p. 67).

Gerrish mountain, N. S. Brief account of trap of (Honeyman, '74*a*).
Copper at (Dawson, '78, p. 102).
Height of (Dawson, '78, p. 101).
Iron at (Dawson, '78, p. 102).
Red sandstone and conglomerate beneath amygdaloid at (Dawson, '47, p. 52).
Traces of plants near (Ells, '85, p. 7E).
Trap on sandstone and conglomerate at (Dawson, '78, p. 101).

GESNER, ABRAHAM. 1836.
Remarks on the geology and mineralogy of Nova Scotia.
Halifax, N. S. 12mo, pp. i-xl, 1-265, pl. 2 and a map.
In this report pages 71-101 are devoted to a description of the "red sandstone district," in which the author includes the Newark areas proper, and also much of the region about the basin of Mines, which is now known to be Carboniferous (see map accompanying Dawson's Acadian Geology). Pages 169-265 are devoted to a description of the "trap district," in which all the trap outcrops of the province receive attention. In this portion of the report considerable space is devoted to the description of the occurrence of minerals in the trap.

GESNER, ABRAHAM. 1839.
First report on the geological survey of the province of New Brunswick. St. John [N. B.], 12mo, pp. 1-87.
Devoted principally to a description of the geology of the coast of New Brunswick between St. Andrews and St. John. In this and in four subsequent reports by the same author the Newark and other systems have not been separately described, but treated as new red sandstone. For this reason but few references to the report in question will be found in this catalogue. For more recent reports on the region referred to see "Observations on the geology of southern New Brunswick," by L. W. Bailey, 1865, and a report on the new red sandstone or Trias in the same volume; also geological map accompanying J. W. Dawson's Acadian Geology, and "Map of the Dominion of Canada, 1842 to 1882," accompanying a "Descriptive sketch of the physical geography and geology of the Dominion of Canada," by A. R. C. Selwyn and G. M. Mason, Montreal, 1884.

GESNER, ABRAHAM. 1840.
Second report on the geological survey of the Province of New Brunswick.
St. John [N. B.], 12 mo, p. i-xii, 1-72.
Contains a description of the Newark rocks of Quaco Head. Other localities where rock is found supposed by Gesner to belong to the Newark system are also described. (See Gesner, '39).

GESNER, ABRAHAM. 1841.
Third report on the geological survey of the province of New Brunswick.
St. John [N. B.], 12 mo, pp. i-xiv, 1-83.
Contains brief accounts of the Newark rocks at Quaco and Red Heads and describes several other localities where rocks which Gesner supposes to be of the same age occur, pp. 14, 15, 16, 33.

GESNER, ABRAHAM. 1842.
Fourth report on the geological survey of the Province of New Brunswick.
St. John [N. B.], 12 mo, pp. 1-101.
Contains brief references to strata that are called New Red sandstone, pp. 64, 88.

GESNER, A. 1843.
A geological map of Nova Scotia, with accompanying memoir.
In London Geol. Soc., Proc., vol. 4, 1845, pp. 280-281, and map.
Describes briefly the red sandstones and shales south and east of the basin of Minas, and the intrusive igneous rocks southeast of the bay of Fundy. States that the sandstones underlying and bordering the igneous rocks mentioned belong to the Old Red sandstone, p. 190, and map.

GESNER, ABRAHAM. 1843a.
Report on the geological survey of the Province of New Brunswick, with a topographical account of the public lands, and the district explored in 1842.
St. John [N. B.], 12 mo, pp. 1-88.
Contains a table showing the geological position of the red sandstone (Newark) and the character of the strata composing it. Also an account of the rocks referred to the New Red sandstone period, pp. 54, 61-63.

GESNER, ABRAHAM. 1849.
The industrial resources of Nova Scotia.

GESNER, ABRAHAM—Continued.
Halifax, N. S., pp. 1-111, 1-341, 1-17, 1-4, map and plate.
Contains a brief account of the Newark sandstones and trap rocks of Nova Scotia.

GESNER, A. Cited on age of the Newark rocks of Nova Scotia (Dawson, '78, p. 109).
Cited on age of the Newark system (Lea, '58).
Cited on geology of Blomidon, N. S. (Marsters, '90).

Gettysburg, Pa. Analysis of trap from near (Frazer, '77, pp. 309-312).
Boundary of trap near (H. D. Rogers, '58, vol. 2, p. 690).
Catalogue of specimens of trap rocks, etc., from near (Frazer, '77, pp. 332-381).
Conglomerate near (H. D. Rogers, '58, vol. 2, p. 684).
Contact metamorphism near (H. D. Rogers, '58, vol. 2, pp. 688, 689, 692).
Copper ore near (Frazer, '80, p. 300. Frazer, '82, pp. 131, 132).
Exfoliation of trap rock near (Frazer, '74*a*).
Exploration for ore near (Frazer, '77, pp. 263-264).
Mention of trap and other rock specimens from (C. E. Hall, '78, pp. 27-68).
Mention of trap quarries at (G. P. Merrill, '89, p. 436).
Minerals in trap near (H. D. Rogers, '58, vol. 2, p. 692).
Occurrence of copper ore near (Frazer, '77*b*).
Optical properties of rock from near (Frazer, '75*a*, p. 410).
Picture of Devil's Den near (Frazer, '80, pl. 9).
Section from, to Cashtown (Frazer, '77, pp. 295-299, pl. op. p. 298).
Section from, to Littlestown (Frazer, '77, pp. 299-304, pl. op. p. 304).
Section of dikes at, after H. D. Rogers (W. M. Davis, '83, p. 281, pl. 9).
Section of dikes near, after P. Frazer (W. M. Davis, '83, p. 281, pl. 9).
Trap dikes near (H. D. Rogers, '58, vol. 2, pp. 688, 689, 692).
Trap from (Frazer, '76, pp. 124-126).
Trap rock near (Frazer, '77, pp. 254, 255).
Weathering of trap rock at (Frazer, '74).

Getzendaner's quarry, near Frederick, Md. Potomac marble of (Shaler, '84, p. 177).

GIBSON, JOHN B. 1820.
Observations on the trap rocks of the Conewago hills near Middletown, Dauphin county, and of the Stony ridge near Carlisle, Cumberland county, Pennsylvania.
In Am. Phil. Soc., Trans., n. s., vol. 2, 1825, pp. 156-166.
Describes the trap rocks of the hills mentioned and considers the nature of their origin.

GIBSON, J. B. Cited on the presence of Jura-Trias in America (Lea, '53, p. 189).
Cited on the relation of trap and sandstone in Pennsylvania (W. M. Davis, '83, p. 287).

Giggstown, N. J. Reopening of copper mines near (Cook, '81, p. 39).

GILBERT, LUDWIG WILHELM. 1822.
[Concerning the native copper and copper slate in Connecticut.]
In Annalen der Physik [Gilbert], vol. 70, pp. 431-436.
Quotes B. Silliman, on the occurrence of native copper in the Connecticut valley, and publishes a letter from F. Hoffmann concerning the same subject, in which the copper-bearing slates of the Newark are compared with similar slates in Europe.

GILBERT, LUDWIG WILHELM. 1822a.
[Remarks on native copper and fossil fishes from the Connecticut valley.]
In Annalen der Physik [Gilbert], vol. 70, pp. 356-360.
Discusses the observations on native copper and fossil fishes from the Connecticut valley, communicated by A. Brongniart and B. Silliman.

Gill, Mass. Account of trap ridges in (E. Hitchcock, '35, p. 409).
Brief account of trap in (E. Hitchcock, '23, vol. 6, pp. 44, 48, 49).
Building stone quarried at (E. Hitchcock, '41, p. 181).
Coal found in (E. Hitchcock, '41, pp. 139-140. E. Hitchcock, '35, p. 231).
Description of footprints from (E. Hitchcock, '36, pp. 318-325. E. Hitchcock, '58).
Description of trap dikes in primary rocks in (Percival, '42, pp. 409, 423-424).
Early discovery of fossil footprints at (E. Hitchcock, '36, p. 308).
General description of trap ridges in (E. Hitchcock, '41, p. 648).
Localities of fossil footprints in (E. Hitchcock, '41, p. 465).
Locality for fossil footprints in (E. Hitchcock, '48, p. 132).
Mention of fossil footprints from (E. Hitchcock, '55*a*, p. 180).
Reference to schistose sandstone beneath trap in (E. Hitchcock, '35, p. 220).
Relation of the trap rock in, to associated rocks (E. Hitchcock, '41, p. 653).
Sandstone hills in (Percival, '42, p. 450).

Gill and Montague, Mass. Section between (E. Hitchcock, '35, p. 416. E. Hitchcock, '41, p. 654).

GILPIN, EDWARD. 1877.
Notes on some recent discoveries of copper ore in Nova Scotia.
In London Geol. Soc., Quart. Jour., vol. 33, pp. 749-753.
Refers to the writings of Lescharbot, published in 1609, who refers to native copper from the bay of Fundy.

GILPIN, EDWIN. 1885.
Notes on the manganese ores of Nova Scotia.
In Canada Roy. Soc., Proc. and Trans., vol. 2, sec. 4, 1884, pp. 7-13.
Contains a brief account of the occurrence of manganese at Cornwallis and Wolfville, N. S.

GRATACAP, L. P. 1886.

Fish remains and tracks in the Triassic rocks at Weehawken, N[ew] J[ersey].

In Am. Nat., vol. 20, pp. 243-246, pls. 12, 13.

Description of the occurrence of fossil fishes and fossil footprints, together with ripple marks and raindrop impressions in slate beneath the trap of the Palisades at the locality mentioned.

GRATACAP, L. P. Cited on fossils in the Newark system (Newberry, '88, p. 44).

Gravel hill, N. J. Boundary of Newark at (Cook, '68, p. 175).

Conglomerate of (Cook, '79, p. 19).

Dip in conglomerate near (Cook, '82, p. 27).

Supposed to be Newark in part (Cook, '68, p. 75).

GRAY [A.]. Cited on the character of certain footprints from Turners Falls, Mass. (Deane, '56).

GRAY, ALONZO, and C. B. ADAMS. 1860.

Elements of geology.

New York, 12mo, pp. i-xv, 1-354.

Contains a brief compilation in reference to the structure and fossils of the Newark system, pp. 241-252.

Great clove, N. Y. Faults near (Nason, '89, p. 25).

Great falls, N. J. Columnar trap (Cook, '84, p. 27).

Great notch, N. J. Fault at (Darton, '90, p. 23).

Great swamp, N. J. Bored well in (Ward, '79, p. 139).

Boundary of Long hill trap near (Cook, '68, p. 187).

Section from, Plainfield, N. J. (Cook, '68, p. 199, and map in portfolio).

Trap hill near (Cook, '68, p. 188).

Great valley river, N. S. Rocks near (Dawson, '78, pp. 100-101).

Great Village, N. S. Brief account of Newark rocks at (Honeyman, '78).

Great Village river, N. S. Account of (Dawson, '78, pl. op. p. 125).

GREEN, J. Stone quarry of, near Greensburg, N. J. (Cook, '81, p. 56).

Green brook, N. J. Boundary of First mountain trap near (Cook, '68, p. 181).

Referred to as a locality for copper ore (H. D. Rogers, '36, p. 166).

Greenfield, Mass. Conglomerate in (E. Hitchcock, '35, p. 214. E. Hitchcock, '41, p. 442).

Contact metamorphism in (E. Hitchcock, '35, pp. 423-424. E. Hitchcock, '41, p. 658).

Copper ore in (E. Hitchcock, '35, p. 229).

Description of Deerfield dike in (Emerson, '82).

Dip at (E. Hitchcock, '35, pp. 224, 423).

Dip of sandstone at (Emmons, '57, p. 22).

Discovery of a fossil footprint at (Field, '56).

Footprints found at (D. Marsh, '48, p. 272).

Footprints from (C. H. Hitchcock, '66. Warren, '55, pp. 305-306).

Fossil plants at (E. Hitchcock, '35, pp. 235-236. E. Hitchcock, '41, p. 456).

Greenfield, Mass.—Continued.

General description of fossil footprints found near (Deane, '44).

Geology of (W. M. Davis, '83, p. 259. E. Hitchcock, '18, pp. 105, 108).

Junction of Newark system with slate in (E. Hitchcock, '35, p. 214).

Locality for fossil footprints (E. Hitchcock, '48, p. 132).

Origin of the conglomerate in (E. Hitchcock, '35, p. 244).

Sandstone covered with footprints from (Field, '55).

Section near (Emmons, '57, pp. 5-7).

Thickness of strata at (Emmons, '57, pp. 5-6, 22).

Trap near (E. Hitchcock, '23, vol. 26, p. 46).

Trap ridges in (E. Hitchcock, '35, p. 409. Percival, '42, p. 409).

Trap ridges near (E. Hitchcock, '41, p. 648).

Greenhole shaft, Va. Analysis of coal from (Clifford, '87, p. 10. Macfarlane, '77, p. 515. Williams, '83, p. 82).

Depth of (W. B. Rogers, '43*b*, p. 534).

Situated in an isolated basin (Heinrich, '78, p. 232).

Thinning of coal seams in (Clifford, '88).

Greensburg, N. J. Building stone near (Cook, '68, p. 510).

Conglomerate at (Cook, '82, p. 22).

Description of quarries near (Cook, '81, pp. 55-58).

Dip at (Cook, '68, p. 197).

Dip in sandstone at (Cook, '82, p. 26).

Dip of sandstone at (Cook, '79, p. 29).

Folds near (Cook, '82, p. 16).

Quarries at (Cook, '81, pp. 55-58).

Sandstone at (Cook, '82, p. 20).

Sandstone quarries near (Cook, '79, p. 24. Shaler, '84, pp. 143-144).

Greensburg Granite and Freestone Co. Quarries of, near Greensburg, N. J. (Cook, '81, p. 57).

Greenstone. (See Trap.)

Green valley, N. J. Boundary of First mountain trap near (Cook, '68, p. 181).

Green valley copper mine, N. J. (Cook, '68, pp. 676-677).

Green Village, N. J. Dip in shale near (Cook, '79, p. 30).

Trap exposed at (Russell, '80, p. 36).

Trap hill near (Cook, '68, p. 188).

Trap ridges near (Cook, '82, pp. 57, 58).

Reference to geological features (H. D. Rogers, '40, p. 133).

Greenville, Pa. Boundary of the Newark in (Frazer, '80, p. 15).

Boundary of the Newark near (d'Invilliers, '83, p. 198).

Sandstone at (Frazer, '80, p. 46).

GREER, JAMES. 1871.

Oolite coal field of Virginia.

[A "separate;" place of publication not known.]

Contains an extract from C. Lyell's paper on the structure and probable age of the Richmond coal field, Virginia (see Lyell, 1847).

HALE, P. M.—Continued.
Raleigh, 12mo, pp. i–viii, 9–425, and map.
Contains voluminous extracts from the reports of Emmons, Wilkes, Laidley, and Kerr, pp. 11–181, 226–229.

Haledon, N. J. Boundary of First mountain trap near (Cook, 68, p. 181).
Boundary of Second mountain trap near (Cook, '68, pp. 183–184).
Building stone near (Cook, '68, p. 505).
Dip in sandstone at (Cook, '82, p. 30).
Lower contact of trap sheet at (Darton, '90, pp. 31, 32).
Quarries at, described (Cook, '81, p. 52).
Quarries near, described (Cook, '89, p. 52).
Reference to fault near (Cook, '89, p. 14).
Sandstone quarry near (Cook, '79, p. 22).

Haledon quarry, N. J. Contact of trap and sandstone at (Cook, '83, pp. 23–24, and pl.).

Hale's mills, Mass. Localities of fossil footprints near (E. Hitchcock, 41, p. 465).

Hales mine, S. C. Brief account of contact metamorphism in (Tuomey, '48, p. 68).

Halifax county, Va. Boundaries of the Newark in (W. B. Rogers, '39, pp. 74–76).

HALL, CHARLES E. **1878.**
Second geological survey of Pennsylvania, 1874–'75–'76–'77. Catalogue of the geological museum.
Harrisburg 1878 [vol. O], part 1, pp. 1–217.
A catalogue of rock specimens.

HALL, CHARLES E. **1880.**
The relations of the crystalline rocks of eastern Pennsylvania to the Silurian limestones, and the Hudson river age of the hydromica schists.
In Am. Phil. Soc., Proc., vol. 18, 1878–1880, pp. 435–443.
Accompanied by a small map showing the distribution of Newark rocks in Pennsylvania.

HALL, CHARLES E. **1881.**
Second geological survey of Pennsylvania, Report of Progress, C6. The geology of Philadelphia county and of the southern parts of Montgomery and Bucks (counties).
Harrisburg, pp. i–xx, 1–154, map in 3 sheets and 1 sheet of sections in pocket.
Describes the boundaries and notes some of the local features of the Newark system in the southern parts of Montgomery and Bucks counties. Notices also the course of a trap dike in Montgomery county.

HALL, CHARLES E. **1883.**
[Itinerary notes on] the South mountain gneiss [Pennsylvania].
In second geological survey of Pennsylvania, D3, vol. 1, pp. 215–258, pls. 2–4.
Contains a few observations of dip, character of rock, etc., in Lehigh county, Pa., pp. 232, 233, 247.

HALL, C. E. Cited on the trap dikes in Pennsylvania (Lewis, '85, pp. 439, 441).

HALL, JAMES. **1843.**
Natural History of New York, Part IV, geology. Comprising the survey of the fourth geological district.
Albany, 4to, pp. i–xxvii, 1–686, pls. 1–19, and geological map of the Middle and Western states.
A brief reference to the geological position of the Newark system is given on page 19. On the map the extent of the rocks referred to in New York, New Jersey and southward is shown.

HALL, JAMES. **1852.**
Key to a chart of the successive geological formations, with an actual section from the Atlantic to the Pacific ocean [etc.].
Boston, 16mo, pp. 1–72.
Contains a very brief account of the Newark system, p. 49, and a brief list of fossils from the Richmond coal field, Va., p. 66.

HALL, JAMES. **1855–1859.**
Natural History of New York, Part VI, Paleontology, vol. 3, pt. 1; text.
Albany, 1859, 4to, pp. i–xii, 1–533.
Contains a brief reference to the origin of the trap rocks of the Atlantic slope and the rapid accumulation of the associated sandstones, pp. 78, 79.

HALL, JAMES. **1882.**
Contributions to the geological history of the American continent.
In Am. Ass. Adv. Sci., Proc., vol. 31, pp. 29–69.
Remarks on the relation of the Newark system to the structure of the Appalachians, p. 54.

HALL, JAMES. **1886.**
Report on building stones [of the state of New York].
In thirty-ninth Ann. Rep. N. Y. State Muse. of Nat. Hist., pp. 186–225.
Describes briefly the building stones of the Newark system in New York, p. 198.

HALL, JAMES. Cited on the age of the Newark system (Marcou, '58, pp. 14–15).

HALL, JAMES, and LOGAN, W. E. **1866.**
Geological map of Canada and the adjacent regions, including parts of the United States.
Montreal, 8 sheets in portfolio, scale 25 miles to 1 inch.
On this map Prince Edward island is colored as Newark. In New Brunswick, Quaco head is the only Newark exposure colored. In Nova Scotia the sandstone and trap of the same system are shown. In Connecticut valley, New Jersey, and part of Pennsylvania the areas occupied by Newark rock are also shown.

HALL, JOHN. **1821.**
Fossil bones in East Windsor, Connecticut.
In Am. Jour. Sci., vol. 3, p. 247.
A brief reference to the finding of fossil bones.

Hallerstown, Pa. Boundary of the Newark near (H. D. Rogers, '41, pp. 16–30).

HARTT, C. FRED.—Continued.
In Am. Nat., vol. 1, pp. 169-176, 234-243.
Contains a popular description of recent footprints, raindrop impressions, etc., at the locality mentioned, and also a brief sketch of fossil impressions of a similar character elsewhere.

Hartford, Conn. Bitumen in trap near (E. S. Dana, '75).
Brief account of shale at (E. Hitchcock, '35, p. 217).
Brief account of trap near (E. Hitchcock, '23, vol. 6, pp. 44, 51).
Character of sandstone at (E. Hitchcock, '36, p. 329).
Concerning trap ridges near (Percival, '42, p. 377).
Contact metamorphism at (E. Hitchcock, '35, p. 424).
Contact metamorphism near (E. Hitchcock, '41, p. 657. Percival, '42, p. 320).
Description of Rocky hill near (Silliman, '30, pp. 122-131).
Description of trap ridges near (Davis and Whittle, '89, p. 115).
Discussion of the geological structure near (W. M. Davis, '86, p. 344).
Localities of fossil footprints near (E. Hitchcock, '41, pp. 466, 467).
Outlyer of primitive rock in Newark area near (A. Smith, '32, p. 219).
Red shale in (E. Hitchcock, '41, p. 443).
Report of the discovery of fossil footprints near (E. Hitchcock, '37*b*).
Special account of quarry near (Davis and Whittle, '89, pp. 120-122).

Hartley, N. J. Description of stone quarry near (Cook, '81, pp. 51-52).

HARTSHORNE, S. Well bored for, near Short hills, N. J. (Nason, '89*b*).

Hart's mills, Conn. Description of trap ridges near (Percival, '42, p. 384).
Limestone near (Percival, '42, p. 443).
Mention of the occurrence of bitumen at (Percival, '42, p. 443).

Hartzog's mill, Pa. Dip of strata and exposure of trap near (d'Invilliers, '83, pp. 218, 219, 220).

Hastings-on-Hudson, N. Y. View of Palisades opposite (Cook, '83, frontispiece).

Hatfield, Mass. Dip of lower beds of the Newark system in (E. Hitchcock, '35, p. 223).
Dip of sandstone in (E. Hitchcock, '41, p. 447).
Dip of strata at (E. Hitchcock, '23, vol. 6, p. 42. A. Smith, '32, p. 221).
Study of dips in (Walling, '78, p. 102).

Hatfield swamp, N. J. Trap hill near (Cook, '68, pp. 185, 186).

Haute island, N. S. Mention of (Marsters, '90). See also Isle Haute.

Haverstraw, N. Y. Analysis of sandstone from (Schweitzer, '71).
Brief account of trap rock near (Mather, '39, pp. 116-117, 122. Mather, '43, pp. 278-282. Pierce, '20, pp. 186-188).

Haverstraw, N. Y.—Continued.
Brief description of trap ridge at (Russell, '78, p. 241).
Conglomerate quarries near (Mather, '39, pp. 124-125. Nason, '89, p. 40).
Dip and strike of rocks in (Mather, '43, pp. 616-617).
Dip of sandstone and trap near (Darton, '90, p. 41).
Gap in trap ridge near (Darton, '90, p. 41).
Junction of trap and sandstone near (Darton, '90, p. 48).
Red marl near (Mather, '43, p. 288).
Section of Palisade trap sheet near (Darton, '90, p. 37).
Section of sandstone beneath trap near (Mather, '43, pl. 5).
Small trap sheet in arkose near (Darton, '90, p. 49).
Small trap sheet near (Darton, '90, p. 39).
Upper contact of trap and sandstone near (Darton, '90, p. 51).

HAWES, GEORGE W. 1875.
The trap rocks of the Connecticut valley.
In Am. Jour. Sci., 3d ser., vol. 9, pp. 185-192.
Compares the chemical composition of trap rocks from localities in the Connecticut valley and in New Jersey, and points out the changes that have taken place in rocks since their ejection.

HAWES, GEORGE W. 1875*a*.
On diabantite, a chlorite occurring in the trap of the Connecticut valley.
In Am. Jour. Sci., 3d ser., vol. 9, pp. 454-457.
Describes the occurrence and gives analysis of the mineral mentioned, from amygdaloidal cavities in trap in the Farmington hills, Conn.

HAWES, G. W. 1878.
[Note on the microscopical characteristics of a thin section of Jura-Trias sandstone from the Connecticut valley.]
In Geology of New Hampshire, by C. H. Hitchcock, vol. 3, pp. 239-240, pl. 12.
Remarks that all of the grains in the sandstone are coated with red oxide of iron, which cements them together and determines the color of the rock. The colored illustration accompanying this note shows the appearance of a thin section of sandstone when viewed through a microscope.

HAWES, GEORGE W. 1882.
On the mineralogical composition of the normal Mesozoic diabases upon the Atlantic border.
In U. S. Nat. Mus., Proc., vol. 4, 1881, pp. 129-134.
Abstract in Neues Jahrbuch, 1882, p. 44.
Reviewed by J. D. Dana in Am. Jour. Sci., 3d ser., vol. 22, pp. 230-233.
Discusses the mineralogical composition of trap rocks, diabase, from Bergen hill, N. J., and from West rock, Conn., with chemical analysis of constituent minerals.

HAWES, G. W. Analysis of trap by (E. S. Dana, '75).

HEINRICH, O. J.—Continued.

In Am. Inst. Mining Eng., Trans., vol. 2, pp. 241–263.

Refers to the method and cost of boring certain deep holes at Midlothian, Va.

HEINRICH, O. J. 1875.

[Remarks on trap dikes and on natural coke in the Richmond coal field, Virginia.]

In The Engineering and Mining Journal, vol. 19, p. 35.

A part of a discussion following the reading of a paper on deep boring with a diamond drill, read by O. J. Heinrich before the American Institute of Mining Engineers, Dec. 26, 1874. Describes the natural coke of the Richmond coal field, and states its connection with trap dikes. Remarks on the same subject were made by M. Coryell and T. S. Hunt.

HEINRICH, O. J. 1875a.

Deep boring with the diamond drill (supplementary paper).

In Am. Inst. Mining Eng., Trans., vol. 3, pp. 183–186.

Explains the method of boring, cost, etc., of certain diamond drill explorations made at Midlothian, Va.

HEINRICH, OSWALD J. 1876.

An account of an explosion of fire-damp at the Midlothian colliery, Chesterfield county, Va.

In Am. Inst. Mining Eng., Trans., vol. 5, pp. 148–161, pl. 3.

Accompanied by a section and plan of underground work of the colliery referred to.

HEINRICH, OSWALD J. 1876a.

The Midlothian, Va., colliery in 1876.

In Am. Inst. Mining Eng., Trans., vol. 4, pp. 308–316.

Gives a brief history of coal mining in the Richmond coal field, and describes the condition of the Midlothian colliery in 1876.

HEINRICH, OSWALD J. 1878.

The Mesozoic formation in Virginia.

In Am. Inst. Mining Eng., Trans., vol. 6, pp. 227–274, pls. 5–6.

Reviewed by P. Frazer in Am. Nat., vol. 13, pp. 284–292.

Republished in The Virginias, vol. 1, pp. 120–126, 142–145, 155, 176–177, 190–192.

CONTENTS.

HEINRICH, OSWALD J.—Continued.

CONTENTS—continued.

HEINRICH, O. J. Abstract of paper on the Mesozoic formation of Virginia (Frazer, '82, p. 139).

Analysis of coal from the Richmond area, Va. (Clifford, '87, p. 10).

Cited on borings in the Richmond area, Va. (Frazer, '85, p. 403).

Cited on the cause of the tilting of the Newark (W. M. Davis, '83, p. 303).

Cited on the commercial development of the Richmond area, Va. (Chance, '85, pp. 22–23).

Cited on the composition of coal from the Richmond area, Va, (Chance, '85, p. 19).

Cited on faults in the Richmond area, Va. (W. M. Davis, '83, p. 304).

Cited on the Newark of Virginia (Russell, '80*a*).

Cited on relation of trap and sandstone in Virginia (W. M. Davis, '83, p. 288).

Cited on section of coal-bearing rocks at Midlothian (Clifford, '87, p. 23).

Cited on thickness of Newark in Virginia (Frazer, '77, p. 270).

Cited on tilting of the sandstone and trap of the Richmond area, Va. (W. M. Davis, '83, p. 302).

Cited on value of the Richmond coal field, Va. (Hotchkiss, '80, p. 92).

Heists' mill, Pa. Dip of conglomerate near (d'Invilliers, '83, p. 214).

Heleura. Description of genus (E. Hitchcock, '58, p. 140).

Hemingway mountain, Conn. Description of (Hovey, '89, p. 366).

Discussion of the origin of (Hovey, '89, p. 381).

Henderson, Pa. Boundary of the Newark near (C. E. Hall, '81, pp. 22, 84).

HENDERSON, J. T. 1885.

The commonwealth of Georgia.

Atlanta, Ga., pp. i–viii, 1–397.

HITCHCOCK, CHARLES H. 1855.
Impressions (chiefly tracks) on alluvial clay, in Hadley, Mass.
In Am. Jour. Sci., 2d ser., vol. 19, pp. 391-396.
Describes a number of recent footprints and other markings, and in a footnote, p. 392, states briefly some of the various views that have been advanced in reference to the age of the Connecticut valley sandstone.

HITCHCOCK, CHARLES H. 1859.
[Report on copper mine at Flemington, New Jersey.] See Hitchcock, E., and C. Hitchcock, 1859.

HITCHCOCK, CHARLES H. 1865.
Preface [to supplement to the Ichnology of New England.]
In supplement to Ichnology of New England, by Edward Hitchcock, pp. ix-x.
Relates to the publication of the "supplement," and to specimens of footprints at Amherst college.

HITCHCOCK, CHARLES H. 1865a.
Descriptive catalogue of specimens in the Hitchcock ichnological cabinet at Amherst college.
In supplement to the Ichnology of New England, by Edward Hitchcock, pp. 41-93.
Describes specimens of footprints, and gives localities from which they were derived.

HITCHCOCK, CHARLES H. 1866.
Description of a new reptilian bird from the Trias of Massachusetts.
In New York Lyc. Nat. Hist., Ann., vol. 8, 1867, pp. 301-302.
Describes the footprints of Tarsodactylus expansus, from near Turners Falls, Mass.

HITCHCOCK, CHARLES H. 1867.
Elementary geology.
See Hitchcock and Hitchcock, 1867.

HITCHCOCK, CHARLES H. 1871.
Geological description [of Massachusetts].

HITCHCOCK, CHARLES H.—Continued.

In official topographical atlas of Massachusetts, by H. F. Walling and O. W. Gray. Boston, folio, pp. 17-23, and map.

Contains a brief sketch of the general geology of the state, accompanied by a colored geological map; also a list of fossil footprints found in the Newark system.

HITCHCOCK, CHARLES H. 1874.

The Coal Measures of the United States.

In statistical atlas of the United States, by Francis A. Walker, pp. 12-14, pls. 11, 12.

Contains a brief account of the coal fields of eastern Virginia and of North Carolina. Accompanied by two maps, one (pl. XI) showing the distribution of coal fields and the other (pl. XII) a general geological map of the United States, compiled by C. H. Hitchcock and W. P. Blake.

HITCHCOCK, CHARLES H. 1877.

The relation of the geology of New Hampshire to that of the adjacent territory.

In the geology of New Hampshire, by C. H. Hitchcock, vol. 2, pp. 3-36, pl. op. p. 8.

Contains a brief reference to the Newark rocks of the Connecticut valley, Nova Scotia, New Brunswick, etc. These areas are shown on the map op. p. 8.

HITCHCOCK, CHARLES H. 1877a.

Geology of the Connecticut valley district [of New Hampshire].

In geology of New Hampshire. Concord, vol. 2, 4to, pp. 271-407, 428-462, and 7 plates.

Refers briefly to the position of the north end of the Connecticut valley area, and the presence of a heavy conglomerate in Northfield, Mass.

HITCHCOCK, CHARLES H. 1881.

Geological map of the United States. compiled by C. H. Hitchcock.

New York. Published by Julius Bien.

A wall map; scale 20 miles to an inch.

Map, geological, of the United States (C. H. Hitchcock, '81).

HITCHCOCK, CHARLES H. 1886.

The geological map of the United States.

In Am. Inst. Mining Eng., Trans., vol. 15, pp. 465-488, map op. p. 486.

Contains an account of previously published geological maps of the United States and Canada, and shows the distribution of the Jurassic and Triassic systems of the United States.

HITCHCOCK, CHARLES H. 1888.

Recent progress in ichnology.

In Boston Soc. Nat. Hist., Proc., vol. 24, pp. 117-127.

Presents a revised list of the footprints of the Newark system, and gives descriptions of several new species. Notices also the localities where footprints have been found in New Jersey and Pennsylvania.

HITCHCOCK, CHARLES H. 1889.

[Remarks on a paper by Atreus Wanner, concerning the discovery of fossil tracks in the Newark rocks of York county, Pa.]

HITCHCOCK, CHARLES H.—Continued.

In Am. Assoc. Adv. Sci., Proc., vol. 37, p. 186.

States that fossil footprints recently discovered in rocks of the Newark system of New Jersey and Pennsylvania belong to the same genera as the tracks previously discovered in the Connecticut valley.

HITCHCOCK, CHARLES H. 1890.

The use of the terms Laurentian and Newark in geological treatises.

In Am. Geol., vol. 5, pp. 197-202.

Reviewed by I. C. Russell in Am. Geol., vol. 7, pp. 238-241.

A review of a paper on "The Newark System," by I. C. Russell. Gives reason for objecting to the use of "Newark" as a group name, pp. 200-202.

H[ITCHCOCK], C. H. Description of Grallator gracilis by (E. Hitchcock, '65, p. 8, pl. 9).

Note on Anomœpus gracillimus (E. Hitchcock, '65, p. 6).

Plants collected by, in the Newark system (Newberry, '88, p. 92).

Remarks on Brontozoum giganteum by (E. Hitchcock, '65, p. 23).

Remarks on the origin of the Connecticut valley sandstone (Whitney, '60).

HITCHCOCK, C. H., and W. P. BLAKE. 1874.

Geological map of the United States.

In Statistical atlas of the United States, based on the Ninth Census, 1870 [etc.], by Francis A. Walker, pls. 13-14.

First published in the reports of the Ninth Census of the United States, by F. A. Walker. Appeared also in the statistics of mines and mining, by R. W. Raymond, 1873; in "Special report on the Smithsonian Institution for the Centennial," Washington, 1876; and in "Atlas of the United States and the World," by Gray, Philadelphia, 1877.

A compiled map showing the distribution of geological formations in the United States.

H[ITCHCOCK], EDWARD. 1815.

Southampton lead mine and basaltic columns at Mount Holyoke, Mass.

In North American Review, vol. 1, pp. 334-338.

A popular letter on the subjects referred to in the title.

HITCHCOCK, EDWARD. 1818.

Remarks on the geology and mineralogy of a section of Massachusetts on Connecticut river, with a part of New Hampshire and Vermont.

In Am. Jour. Sci., vol. 1, pp. 105-116, 436-439, and map.

Describes in general terms the geology in the neighborhood of Mounts Holyoke and Tom, Mass., pp. 105, 108, and map.

HITCHCOCK, EDWARD. 1823.

A sketch of the geology, mineralogy, and scenery of the region contiguous to the river Connecticut; with a geological map and drawings of organic remains; and occasional botanical notices.

HITCHCOCK, EDWARD—Continued.

In Am. Jour. Sci., vol. 6, 1823, pp. 1–86, 201–236, pl. 9, and map op. p. 86; vol. 7, 1824, pp. 1–30, pl. 1.

Describes the Newark rocks of the Connecticut valley, in part under the name of the Old Red sandstone, vol. 6, pp. 39–42. The "greenstone dikes" in the Old Red sandstone are described on pp. 56–59, and their origin discussed on pp. 59–61. Another division of the Newark receives attention under the name of the "Coal formation," pp. 61–89. In vol. 7 the scenery of the Connecticut valley is described, and in this connection the relief of several trap hills receives attention.

H[ITCHCOCK], E[DWARD]. **1824.**

Notice of a singular conglomerate, and of an interesting locality of trap tuff, or tufa.

In Am. Jour. Sci., vol. 8, pp. 244–247.

Describes exposures of trap tuff on the east side of Mount Tom, Mass.

HITCHCOCK, EDWARD. **1824a.**

A geological and agricultural survey of the district adjoining the Erie canal in the State of New York, part 1, containing a description of the rock formations; together with a geological profile; extending from the Atlantic to Lake Erie.

Albany. 12mo, pp. 1–163, pls. 1–2.

The sections accompanying this report show the positions of the Newark rocks and associated traps of the Connecticut valley.

HITCHCOCK, EDWARD. **1828.**

Miscellaneous notices of mineral localities, with geological remarks.

In Am. Jour. Sci., vol. 14, pp. 215–230.

Refers briefly to an exposure of sandstone beneath trap on the east side of Mount Holyoke, Mass., p. 218, and records a few facts concerning the small outlying Newark area in Woodbury and Southbury, Conn., pp. 227–228.

HITCHCOCK, EDWARD. **1832.**

Report on the geology of Massachusetts; examined under the direction of the government of that state, during the years 1830 and 1831.

In Am. Jour. Sci., vol. 22, pp. 1–70, and map op. p. 1.

Contains a brief account of the sandstone along the Connecticut river, but refers principally to its value as a building stone. The formation is termed the New Red sandstone.

HITCHCOCK, EDWARD. **1835.**

Report on the geology, mineralogy, and botany of Massachusetts, in four parts; Part I, Economic geology; Part II, Topographical geology; Part III, Scientific geology; Part IV, Catalogue of animals and plants. Amherst, 1835. Second edition, corrected and enlarged, pp. i–xii, 13–702, accompanied by 4to atlas of 19 plates.

HITCHCOCK, EDWARD—Continued.

First edition of Part I, Economic geology. Amherst, 1832, pp. 1–70, and geological map of Massachusetts.

First edition of full report, Amherst, 1833, pp. i–xii, 1–692, and 4to atlas of 19 plates.

The contents of the 2d ed., so far as it relates to the Newark system, is as follows:

HITCHCOCK, EDWARD—Continued. Page.

HITCHCOCK, EDWARD. 1836.

Ornithichnology. Description of the footmarks of birds (Ornithichnites) on New Red sandstone in Massachusetts.

In Am. Jour. Sci., vol. 29, pp. 307–340, and 3 plates.

Abstract in Neues Jahrbuch, 1836, pp. 467–472.

Refers to early discussion of fossil footprints in Massachusetts, mentions several localities at which they occur, discusses the nature of the animals that made the tracks, and describes and figures several species.

HITCHCOCK, EDWARD. 1837.

Researches in theoretical geology by H. T. De La Beche, with a preface and notes by Prof. Edward Hitchcock.

New York. 12mo, pp. i–xv, 1–342.

Contains a note on the fossil fishes of the Connecticut valley, p. 267, and also on the fossil footprints of the same region, pp. 271–273.

HITCHCOCK, EDWARD. 1837a.

Fossil footsteps in sandstone and graywacke.

In Am. Jour. Sci., vol. 32, pp. 174–176.

Abstract in Neues Jahrbuch, 1837, pp. 602–603.

Mentions the advance that has been made in the study of the fossil footprints of the Connecticut valley and gives a list of species described.

HITCHCOCK, E. 1837b.

Ornithichnites in Connecticut.

In Am. Jour. Sci., vol. 31, pp. 174–175.

Brief mention of additional localities in Connecticut at which fossil footprints have been found. The footprints are described briefly and their names given in some instances.

HITCHCOCK, EDWARD. 1841.

Final report on the geology of Massachusetts.

Northampton, 4to, vol. 1, pp. i–xii, 1a–11a, 1–299, pls. 1–14 and a map; vol. 2, pp. 300–381, pls. 15–55.

The contents of this report, so far as it relates to the Newark system, is as follows:

HITCHCOCK, EDWARD—Continued. Page

HITCHCOCK, EDWARD—Continued. Page.
Greenstone (trap)—Continued.
Lithological character—Continued.
Amygdaloidal trap........... 644–645
Concreted trap................ 645
Tufaceous trap................ 645
Topography of the greenstone (trap)........................ 646–650
Situation of the greenstone in relation to other rocks........ 650–656
Dikes of greenstone......... 655–656
Chemical effects of greenstone on other rocks.................... 657–660
Mineral contents of greenstone (trap)........................ 660–663
Newark system...................... 712
Catalogue of specimens from the Newark system.................. 804–806
Catalogue of specimens of greenstone (trap)........................... 819–820

HITCHCOCK [EDWARD]. **1841a.**
[Remark on joints and fractures in the sandstone and trap of the Connecticut valley.]
In Am. Jour. Sci., vol. 41, p. 173, and also in Am. Assoc. Geol. and Nat., Proc., p. 25.
Brief abstracts of remarks on a paper, by Prof. Mather, concerning joints in rocks.

HITCHCOCK, EDWARD. **1841b.**
First anniversary address before the Association of American Geologists, at their second annual meeting at Philadelphia, April 5, 1841.
In Am. Jour. Sci., vol. 41, pp. 232–275.
States briefly the geographical distribution of the Newark system and discusses the question of its age, pp. 244–245. The "New Red sandstone system" is mentioned on p. 267.

HITCHCOCK [EDWARD]. **1842.**
On a new species of Ornithichnite from the valley of the Connecticut river, and on the raindrop impressions from the same locality.
In Am. Jour. Sci., vol. 43, p. 170; also in Am. Assoc. Geol. and Nat., Proc., p. 63.
Title of paper only, followed by remarks by Charles Lyell and H. D. Rogers, W. B. Rogers, Benjamin Silliman, jr. [C. W.] Redfield, and John L. Hayes.

HITCHCOCK, EDWARD. **1843.**
The phenomena of drift, or glacio-aqueous action in North America, between the Tertiary and Alluvial periods.
In Am. Assoc. Geol. and Nat., Trans., pp. 164–221, pls. 7, 8, 9.
Describes briefly the general geology and topographical features of the region about Mount Tom and Mount Holyoke, Mass.

HITCHCOCK, EDWARD. **1843a.**
Description of five new species of fossil footmarks, from the Red sandstone of the valley of Connecticut river.
In Am. Assoc. Geol. and Nat., Trans., pp. 254–264, pl. 11.
Devoted principally to the description of new species of footprints, obtained near Turners Falls, Mass., by James Deane.

HITCHCOCK, EDWARD. **1843b.**
Description of several species of fossil plants, from the New Red sandstone formation of Connecticut and Massachusetts.
In Am. Assoc. Geol. and Nat., Trans., pp. 294–296, pls. 12, 13.
Describes briefly the character of the rocks forming the small Newark area at Southbury, Conn., and gives the results of a microscopical examination of a specimen of fossil wood found there. Fragments of fossil ferns from localities in Massachusetts are also briefly described.

HITCHCOCK [EDWARD]. **1844.**
The trap tufa or volcanic grit of the valley of the Connecticut river, with inferences as to the relative age of the trap and sandstone.
In Am. Jour. Sci., vol. 47, pp. 103–104.
Abstract of remarks describing the character of the tufa, method of its formation, etc.

HITCHCOCK [EDWARD]. **1844a.**
Report on ichnolithology, or fossil footmarks, with a description of several new species, and the coprolites of birds, from the valley of the Connecticut river.
In Am. Jour. Sci., vol. 47, pp. 292–322, pls. 3, 4. Abstract ibid., pp. 113–114; also in, Neues Jahrbuch, 1845, pp. 753–757.
Reviews the discussion of the question of first discovery of fossil footprints in the sandstone of the Connecticut valley, describes several new species of footprints, and discusses the nature of certain coprolites.

HITCHCOCK, EDWARD. **1844b.**
Discovery of more native copper in the town of Whately, in Massachusetts, in the valley of Connecticut river, with remarks on its origin.
In Am. Jour. Sci., vol. 47, pp. 322–323.
Describes the occurrence of a mass of native copper in the drift at the locality mentioned.

HITCHCOCK, EDWARD. **1844c.**
Geological map of Massachusetts: Scale 5 miles to 1 inch, or $\frac{1}{316800}$, 1844.
On wall map of Massachusetts.

HITCHCOCK, EDWARD. **1844d.**
[On priority in the discovery of fossil footmarks in the sandstone of the Connecticut valley.]
In Am. Jour. Sci., vol. 47, pp. 390–399.
Devoted to the question of priority in the discovery of the footprints in question.

HITCHCOCK, EDWARD. **1844e.**
Explanation of the geological map attached to the topographical map of Massachusetts.
Boston, 12mo, pp. 1–22.
Contains a brief description of trap and trap-tuff or tufaceous conglomerate occurring in the Connecticut valley, and also refers to the distribution of the Newark sandstone in the same region.

HITCHCOCK, EDWARD. **1845.**

An attempt to name, classify, and describe the animals that made the fossil footmarks of New England.

In Am. Assoc. Geol. and Nat., Proc., sixth meeting, pp. 23-25.

Presents a list of families, genera, and species of the animals that made the footprints in the Newark rocks of the Connecticut valley. A revised classification based on a new set of measurements.

HITCHCOCK, EDWARD. **1845a.**

Remarkable facts respecting the magnetic polarity of trap rocks in New England.

In Am. Assoc. Geol. and Nat., Proc., sixth meeting, p. 32.

Brief abstract of a paper recording observations on the magnetic attraction of the trap rocks of the Connecticut valley.

HITCHCOCK, EDWARD. **1845b.**

Analysis of coprolites from the New Red sandstone of New England.

See Dana, S., and E. Hitchcock, 1845.

HITCHCOCK, EDWARD. **1845c.**

[Miscellaneous remarks upon fossil footmarks.]

In Am. Jour. Sci., vol. 48, pp. 62-64.

Brief remarks on very large footprints found principally in Northampton, Mass.

HITCHCOCK, EDWARD. **1847.**

Description of two new species of fossil footmarks found in Massachusetts and Connecticut, or of the animals that made them.

In Am. Jour. Sci., 2d ser., vol. 4, pp. 46-57.

Describes two new genera of footprints, represented by a single species each, from South Hadley, Mass. Discusses also the conditions under which the footprints in the sandstone of the Connecticut valley were made.

HITCHCOCK, EDWARD. **1847a.**

On the trap tuff, or volcanic grit of the Connecticut valley, with the bearing of its history upon the age of the trap rock and sandstone generally in that valley.

In Am. Jour. Sci., 2d ser., vol. 4, pp. 199-207.

Describes the lithological characters of the various trappean rocks of the Connecticut valley, explains the structure of mounts Tom and Holyoke, and the topography of the trap ridges; also considers certain organic remains associated with the trap; discusses the mode and the period of the production of the trap.

HITCHCOCK, EDWARD. **1848.**

An attempt to discriminate and describe the animals that made the fossil footmarks in the United States, and especially New England.

In Am. Acad., Mem., n. s., vol. 3, pp. 129-256, pls. 1-24, and a table op. p. 256.

Discusses the principles on which animals are classified from their footprints. Describes large number of genera and species. The matter contained in this paper is embodied in Hitchcock's later work on the "Ichnology of New England," 1858.

HITCHCOCK [EDWARD]. **1853.**

[Remarks on the fossil footprints of the Connecticut valley.]

Boston Soc. Nat. Hist., Proc., vol. 4, pp. 375-379.

Gives an account of a measured section across the Connecticut valley, showing a great thickness of strata. Thickness of rock above the highest footprint found is also stated. Considers that the dip of the sandstone containing footprints has not been caused by the intrusion of trap. Infers that the entire thickness of sandstone can not all belong to the Newark system.

HITCHCOCK, EDWARD. **1855.**

Description of several sections measured across the sandstone and trap of Connecticut river valley in Massachusetts.

In Am. Assoc. Adv. Sci., Proc., vol. 9, 1856, pp. 225-227.

Describes briefly the principal facts resulting from the measurement of three sections across the Connecticut valley, located at Turners Falls, Mount Tom, and Chicopee, Mass. The thickness of the rocks is stated as well as their probable age.

HITCHCOCK, EDWARD. **1855a.**

Elementary geology.

New York, 30th ed., 12 mo, pp. i-xviii, 19-424, pl. 1.

Earlier editions not noted.

Gives a brief account of columnar trap at Mount Holyoke, Mass., pp. 87-88.

Describes briefly the footprints and rain drop impressions of the Connecticut valley sandstones, pp. 181-190. Discusses the age of the Newark system, pp. 407-409.

HITCHCOCK, EDWARD. **1855b.**

Additional facts respecting the tracks of the Otozoum Moodii on the Liassic sandstone of the Connecticut valley.

In Am. Assoc. Adv. Sci., Proc., vol. 9, 1856, p. 228.

Describes certain features of the tracks mentioned, and states localities at which they have been discovered.

HITCHCOCK, EDWARD. **1856.**

Outlines of the geology of the globe.

Boston, 3d ed., pp. 1-136, pls. 1-6, and two maps.

Contains a short account of the Newark system and a brief discussion of its probable age, pp. 66-90.

HITCHCOCK, EDWARD. **1856a.**

Description of a new and remarkable species of fossil footmark, from the sandstone of Turners Falls, in the Connecticut Valley. [Part 2 of an article entitled "On a new fossil fish, and new fossil footmarks.]

In Am. Jour. Sci., 2d ser., vol. 21, pp. 97-100.

Abstract in Neues Jahrbuch, 1856, pp. 237-238.

Describes the genus Gigandipus, and the species *G. caudatus.*

HITCHCOCK [EDWARD]. 1857.

[On some regular, polygonal depressions found in the sandstone of the Connecticut valley.]

In Boston Soc. Nat. Hist., Proc., vol. 6, 1856–1859, p. 111.

Brief description of the depressions, with the statement that they might have been made by tadpoles.

HITCHCOCK, EDWARD. 1858.

Ichnology of New England. A report on the sandstone of the Connecticut valley, especially its fossil footmarks, made to the government of the commonwealth of Massachusetts.

Boston, 4to, pp. i–vii, 1–220, pls. I–LX.

Reviewed in Am. Jour. Sci., 2d ser., vol. 27, pp. 270–272.

Abstract in Neues Jahrbuch, 1859, and in Am. Jour. Sci., 2d ser., vol. 27, pp. 270–272.

The following is an abstract of the contents of this volume, as given on pages v–viii:

HITCHCOCK, EDWARD—Continued.

The plates accompanying this volume are as follows:

HITCHCOCK, E. 1859.

[Catalogue of rocks, minerals, and fossils in the Massachusetts state cabinet.]

In sixth annual report of the secretary of the Massachusetts Board of Agriculture [etc.], Boston, 1859, appendix, pp. i–lxix.

Contains a list of specimens, including samples of rock, fossil plants, fossil fishes, and footprints, from the Newark system in Massachusetts and Connecticut.

HITCHCOCK, EDWARD. 1860.

Additional facts respecting the Clathropteris of East Hampton, Mass.

In Am. Assoc. Adv. Sci., Proc., vol. 14, 1861, pp. 158–159.

HITCHCOCK, EDWARD—Continued.

Records some of the characteristics of the fossil fern mentioned.

HITCHCOCK, E. **1860.**

Remarks upon certain points in ichnology.

In Am. Assoc. Adv. Sci., Proc., vol. 14, 1861, pp. 144-156.

Refers to the characteristics of fossil footprints and their paleontological value.

HITCHCOCK, EDWARD. **1863.**

New facts and conclusions respecting the fossil footmarks of the Connecticut valley.

In Am. Jour. Sci., 2d ser., vol. 33, pp. 46-57.

Records additional observations and conclusions concerning the fossils mentioned.

HITCHCOCK, EDWARD. **1865.**

Supplement to the Ichnology of New England.

Boston, 4to, pp. i-x, 1-96, pls. 1-20.

Notice in Am. Jour. Sci., 2d ser., vol. 40, p. 392.

CONTENTS.

Plates 1-12, 20, are lithographs, and remainder are photographs.

HITCHCOCK, E. Cited on the age of the coal fields of North Carolina (Emmons, '56, p. 271).

Cited on the age of the Connecticut valley sandstone (J. D. Dana, '56, p. 322. Jackson, '50, pp. 335, 338).

Cited on the age of the Newark system (C. H. Hitchcock, '71, p. 21. Mather, '43, pp. 293-294. Newberry, '88, p. 9. H. D. Rogers, '44, p. 248. H. D. Rogers, '58, vol. 2, p. 693).

HITCHCOCK, E.—Continued.

Cited on the cause of the tilting of the Newark (W. M. Davis, '83, p. 303).

Cited on coarse deposits in Massachusetts (J. D. Dana, '90, p. 436).

Cited on contact metamorphism in Massachusetts (W. M. Davis, '83, p. 300).

Cited on the dip of the Newark of the Connecticut valley (W. M. Davis, '83, p. 306).

Cited on the distribution of conglomerate in the Jura-Trias of the Connecticut valley (Russell, '78, pp. 231, 238).

Cited on the early discovery of fossil fishes in the Newark system (Newberry, '88, p. 19).

Cited on the extrusive trap sheets in the Connecticut valley (Davis and Whittle, '89, p. 99).

Cited on the first discovery of the Triassic in America (Marcou, '88, p. 31).

Cited on fossil fern from the Connecticut valley (Fontaine, '83, p. 57. E. Hitchcock, '55*a*, p. 407).

Cited on fossil fishes from the Connecticut valley (Eaton, '20, pp. 215-216. Harlan, '34, pp. 92-94. J. H. Redfield, '36. Silliman, '21, pp. 221-222).

Cited on fossil fishes of the Newark system (Newberry, '88).

Cited on fossil footprints (Murchison, '43).

Cited on fossil footprints from the Connecticut valley (Deane, '45, pp. 159, 160, 161, 166, 167. D'Orbigny, '49, vol. 1, pp. 27-32. Gray and Adams, '60, pp. 247-252. Lea, '53, pp. 185, 186, 187, 188, 189, 193-194. Lyell, '66, pp. 453-456. Lyell, '71, p. 361. Owen, '59, pp. 325-327. Pictet, '53, vol. 1, p. 403. W. C. Redfield, '38. H. D. Rogers, '58, vol. 2, p. 694. Russell, '78, p. 231. Winchell, '70, pp. 182-185).

Cited on fossil plants from the Connecticut valley (Lyell, '47, p. 279).

Cited on the geology of the Connecticut valley (Danberry, '39, pp. 19, 21).

Cited on the mode of formation of the Newark rocks of the Connecticut valley (Lea, '53, pp. 191-192).

Cited on Mormolucoides articulatus (Scudder, '68, p. 218. Scudder, '84, p. 431).

Cited on the names of certain fossil footprints from Turners falls, Mass., figures by James Deane (Silliman and Dana, '47).

Cited on the nature of the trap of the Connecticut valley (Cooper, '22, pp. 242-243).

Cited on the number of joints in the toes of fossil footprints (Silliman and Dana, '47).

Cited on the number of phalanges in the toes of birds (Silliman, Silliman, jr., and Dana, '47).

Cited on the occurrence of fossil fishes at Sunderland, Mass. (Brongniart and Silliman, '22. Silliman, '21*a*).

Cited on the occurrence of fossil footprints at Middletown, Conn. (Anonymous, '38*a*).

Cited on the origin of the Newark rocks of the Connecticut valley (J. D. Dana, '83),

HITCHCOCK, E.—Continued.

Cited on the origin of the red color of the Newark sandstone (Russell, '89, p. 49).

Cited on the origin of the trap of Connecticut (Hovey, '89, p. 376).

Cited on the original horizontal deposition of the sandstones of the Connecticut valley (Wurtz, '70, p. 100).

Cited on peculiar raindrop impressions (Anonymous, '39).

Cited on the relation of trap and sandstone in the Connecticut valley (Stodder, '57. W. M. Davis, '83, p. 285).

Cited on the source of the conglomerate at the north end of the Connecticut valley (Adams, '46, p. 160).

Cited on the stratigraphy near Mount Toby, Mass. (Walling, '78).

Cited on supposed tadpole nests from South Hadley, Mass. (Shepard, '67, pp. 99, 100).

Cited on the tracks of a tailed "giant biped" (Hitchcock, '55, p. 305).

Cited on trap dikes in Connecticut (W. M. Davis, '83, p. 292).

Cited on trap dikes in Massachusetts (W. M. Davis, '83, pp. 291–292).

Cited on tufaceous conglomerate in Massachusetts (W. M. Davis, '83, p. 263).

Credited with the study of the footprints of the Connecticut valley (H. D. Rogers, '44, p. 249).

Excursion with, in the Connecticut valley (Lyell, '45, vol. 1, pp. 251–255).

List of fossil fishes from New Jersey and the Connecticut valley described by (De Kay, '42).

Notice of work by (Miller, '79–'81, vol. 2, pp. 146–147, 148, 152, 153, 154).

Reference to fossil bones found by, in the Connecticut valley (Marsh, '89, p. 331).

Referred to in connection with fossil footprints (Macfarlane, '79, p. 63).

Report on footprints observed and described by (Rogers, Vanuxem, Taylor, Emmons, and Conrad, '41).

Work of, referred to (C. H. Hitchcock, '71, p. 20).

HITCHCOCK, EDWARD, and CHARLES H. HITCHCOCK. **1859.**

[Report on Hunterdon copper mine, Flemington, New Jersey.]

In report on the geological survey and conditions of the Hunterdon Copper Company's property, Hunterdon county, New Jersey, Philadelphia [Pa.], p. 20.

Presents a brief general account of the geological position of the mine referred to, with character of rock, ore, etc.

HITCHCOCK, EDWARD, and C. H. HITCHCOCK. **1867.**

Elementary geology.

New York, 12mo, new ed., pp. i–xiv, 15–430, pl. 1.

Table showing geological classification, p, 43. Trap rock at Mount Holyoke, p. 87. Fossil fern from East Hampton, Mass., p. 295. Brief account of the footprints and

HITCHCOCK, EDWARD and C. H. HITCHCOCK—Continued.

raindrop impressions of the sandstones of the Connecticut valley, pp. 309–320. Older Mesozoic systems briefly discussed, pp. 415–416.

HITCHCOCK E[DWARD], Jr. **1855.**

Description of a new species of Clathropteris, discovered in the Connecticut valley sandstone.

In Am. Jour. Sci., 2d ser., vol. 20, pp. 22–25.

Describes the fossil plant referred to in the title and draws certain conclusions from it in respect to the age of the Connecticut valley sandstone.

HITCHCOCK, E., Jr. **1856.**

A new fossil shell in the Connecticut river sandstone.

In Am. Jour. Sci., 2d ser., vol. 22, pp. 239–240.

Notice in Edinburg New Philo. Jour., n. s., vol. 6, 1857, pp. 185–186.

Describes and figures the form referred to in the title.

HITCHCOCK, Jr., E. Cited on Clathropteris from Connecticut valley (J. D. Dana, '56, p. 322. Fontaine, '83, p. 57. E. Hitchcock, '55, p. 227. C. H. Hitchcock, '55, p. 392. W. C. Redfield, 56*a*, p. 357.

Cited on a fossil fern from Massachusetts (Hitchcock and Hitchcock, '67, p. 416).

Cited on the discovery of fossil fern at Mount Tom, Mass. (Wells, '56).

Discoveries relative to the age of the Connecticut valley sandstone (2 Hitchcock, '58, p. 6).

Hoboken, N. J. Bored well in (Ward, '79, p. 132).

Boundary of trap outcrop at (Cook, '68, p. 177).

Description of indurated shales near (Darton, '83*a*).

Dip in sandstone at (Cook, '82, p. 24).

Faults in trap ridge near (Darton, '90, pp. 42, 43, 44).

Lower contact of trap sheet near (Darton, '90, p. 44).

Possible origin of the arkose near (D. S. Martin, '83).

Section of trap ridge near (Darton, '90, p. 44).

Trap at (Credner, '65, pp. 392–394).

Hockersville, Pa. Description of brownstone quarries near (d'Invilliers, '86, pp. 1567–1566).

HOFFMANN, F. **1822.**

[A letter to L. W. Gilbert concerning the occurrence of native copper in the Connecticut valley.]

In Annalen der Physik [Gilbert], vol. 70, pp. 432–436.

Compares the copper-bearing slates of the Newark system in the Connecticut valley with similar rocks in Europe.

Hog island, P. E. I. Joints in rocks of (Dawson and Harrington, '71, p. 21).

Mention of trap rock on (Chapman, '76, p. 92. Chapman, '78, p. 121. Dawson and Harrington, '71, p. 21. Dawson, '72, p. 203).

HOLLICK, ARTHUR. **1889.**
[Remarks on the pressure of Newark rocks on Staten island.]
In Am. Nat., vol. 23, pp. 1033-1034.
Describes the occurrence of Newark rocks on the north shore of Staten island at Mariner's harbor.

HOLLICK, ARTHUR. **1889a.**
[Exposures of Newark rocks on Staten island, N. Y.].
In Staten Island Nat. Hist. Assoc., Proc., Oct. 10, 1889.
Refers briefly to exposure of Newark rocks.

HONEYMAN, D. **1867.**
Geology of Antigonish county, N[ova] S[cotia].
In Nova Scotia Inst., Proc. and Trans., vol. 1, pt. 4, pp. 106-120.
Contains brief references to the Newark system, pp. 108, 118.

HONEYMAN, D. **1874.**
Nova Scotian geology. Intercolonial railway.
In Nova Scotia Inst., Proc. and Trans., vol. 3, pp. 345-356.
Brief account of certain Newark rocks near Truro, N. S., pp. 45, 46.

HONEYMAN, D. **1874a.**
Nova Scotian geology.
In Nova Scotia Inst., Proc. and Trans., vol. 3, pp. 385-393.
Contains brief references to the trap of Gerrish mountain, Blomidon, Briar island, etc., pp. 386, 387, 388.

HONEYMAN, D. **1878.**
Nova Scotia geology, pre-Carboniferous, lower Carboniferous, etc., retrospective to 1859.
In Nova Scotia Inst., Proc. and Trans., vol. 4, pp. 139-487.
Contains brief references to the Newark rocks of Five islands, Great Village, etc., p. 471.

HONEYMAN, D. **1879.**
Nova Scotian geology. Kings county.
In Nova Scotian Inst., Proc. and Trans., vol. 5, pp. 21-31.
Includes a short account of the sandstones, trap, amygdaloid, volcanic ash, etc., in the neighborhood of cape Blomidon, N. S., pp. 27-28.

HONEYMAN, D. **1883.**
Notes on a polariscopic examination of crystalline rocks of the Yarmouth gold-bearing series.
In Nova Scotia Inst., Proc. and Trans., vol. 6, pt. 1, pp. 7-8.
Contains a brief petrographical comparison of the rocks of cape Blomidon with certain rocks at Jebogue point, N. S., p. 7.

HONEYMAN, D. **1885.**
Notes of a polariscopic and microscopic examination of crystalline rocks of Nova Scotia and Cape Breton.
In Nova Scotia Inst., Proc. and Trans., vol. 6, pp. 121-130.
Contains a general account of the petrography of the trap rocks of Blomidon and vicinity, pp. 121-122.

HONEYMAN, D. **1888.**
Geology of Aylesford, Kings county, N[ova S[cotia].
In Nova Scotian Inst., Proc. and Trans., vol. 7, 1886-'87, pp. 7-12.
Contains a brief account of amygdaloid and associated trappean rocks near Morden, on the east shore of the bay of Fundy.

HOOKER [J. D.]. **1847.**
[Note of vegetable structure in coal from the Richmond coal field, Virginia.]
In London Geol. Soc., Quart. Jour., vol. 3, pp. 268-269.
Results of a microscopical examination of coal, reported to Charles Lyell.

HOTCHKISS, JED. 1883.
The natural coke of V[irgini]a, reply to Dr. Raymond.
In The Virginias, vol. 4, p. 164.
Refers to the observations of W. B. Rogers and C. Lyell in reference to the origin of the coke referred to.

[HOTCHKISS, JED.] 1883a.
The Richmond, Va., coal field.
In The Virginias, vol. 4, p. 171.
Quotes an anonymous article from the Mining Herald of Shenandoah, Pa., in which a brief account is given of the work now being done in the Richmond coal field.

HOTCHKISS, JED. 1884.
Virginia minerals for the New Orleans Exposition.
In The Virginias, vol. 5, pp. 139–140, 153.
Includes specimens of coal from the Richmond coal field.

HOTCHKISS, JED. Cited on the production of coal in the Richmond coal field, Va. (Ashburner, '86, '69).

HOUGHTON [DOUGLASS]. 1844.
[On the connection of the metallic copper with other trap of Connecticut and Michigan.]
See Silliman, B., and D. Houghton, 1844.

House's quarry, N. C. Conglomerate at (Emmons, '56, pp. 237–238).
Conglomerate in (Wilkes, '58, p. 5).
Fossil plants from (Emmons, '56, pp. 328–329. Emmons, '57, pp. 119–132).

HOVEY, A. H. Opening of copper mine by (Cook, '81, p. 39).

HOVEY, EDMUND OTIS. 1889.
Observations on some of the trap ridges of the East Haven-Bradford region.
Am. Jour. Sci., 3d ser., vol. 38, pp. 361–383, pl. 9.
Abstract in Am. Assoc. Adv. Sci., Proc., vol. 38, pp. 232–233.
Contents: The topography of the region. Its trap belts and sandstone ridges. Position and forms of the trap belts. Particular description of Pond rock, and ridges east of it. Kinds of trap rock in different parts of the region. The amygdaloid, and its relation to that which is nonvesicular. The relation of the sandstone to the trap. Contact phenomena. Main theories which have been advanced to account for the occurrence of the trap. Special discussion of the theory of "contemporaneous overflow." The age of the trap. Concludes that all of the traps in the region described are intrusive.

HOVEY, E. O. Cited on coarse deposits in Connecticut (J. D. Dana, '90).

HOW, HENRY. 1861.
On gryolite occurring with calcite in apophyllite in the trap of the bay of Fundy.
In Am. Jour. Sci., 2d ser., vol. 32, pp. 13–14.
An analysis of gryolite is given.

HOW, HENRY. 1869.
The mineralogy of Nova Scotia.
Halifax, N. S. Pp. 1–217.
A brief description is given of the occurrence of copper ore on the shores of the bay of Fundy and the Minas basin, pp. 65–66, and at Indian point and Five island, p. 72. A catalogue of mineral localities on pp. 202–208 contains numerous references to Newark localities.

HOW, HENRY. 1875.
Contributions to the mineralogy o Nova Scotia.
In Philo. Mag., 4th ser., vol. 41, 1871, pp. —, 274, 5th ser., vol. 1, 1876, pp. 128–138.
Describes minerals from the trap rocks of Nova Scotia. Refers to the similarity in the traps of the Newark system from Nova Scotia to North Carolina. Gives specific gravities of certain trap rocks.

HOWE, A. B. 1876.
On gmelinite from Nova Scotia.
In Am. Jour. Sci., 3d ser., vol. 12, pp. 270–274.
Describes mineral mentioned; gives localities and analysis.
Analysis of minerals composing trap rocks (Hawes, '82, pp. 131–132).
Cited on mineral analysis of trap rock from Bergen hill, N. J. (Shaler, '84, p. 145).

HOWELL, M. A. Trap rock quarried by (Cook, '81, p. 62).

Howellville, Pa. Trap dike near (Lewis, '85, p. 444).

HUBBARD, OLIVER P. 1842.
Chemical examination of a large sample of bituminous coal from the pits of the Midlothian coal mining company, south side of James river, 14 miles from Richmond, Va., in Chesterfield county.
Silliman and Hubbard, 1842.

HUBBARD, OLIVER P. 1850.
The condition of trap dikes in New Hampshire an evidence and measure of erosion.
In Am. Jour. Sci., 2d ser., vol. 9, pp. 158–171.
States the amount of erosion that has taken place in the Connecticut valley and describes certain trap rocks in New Hampshire that are perhaps of the same age as the similar rocks of Massachusetts, etc., p. 170.

HUBBARD, OLIVER P. 1885.
Two varieties of the New Red sandstone used for building in New Haven, Conn.
In New York Acad. Sci., Trans., vol. 5, 1885–1886, pp. 12–13.
Refers briefly to the mineralogical composition and dip of a ridge of sandstone in East Haven, Conn., and to the durability of building stone derived from it.

HUBBARD, O. P. 1889.
[Note concerning a bored well near New Haven, Conn.]
In New York Acad. Sci., Trans., vol. 9, p. 3.
Gives the depth of a well bored by the Winchester Arms Co.

JACKSON, CHARLES T. **1837.**
First report on the geology of the State of Maine.
Augusta. 12mo, pp. i-viii, 10-190, accompanied by an atlas of 24 plates.
Certain rock in Maine which are traversed by trap dikes are described in this report as being of the age of the "New Red sandstone," but more recent investigations have shown them to be of older date. (The trap dikes of this region may possibly belong to the Newark system of intrusions.) Cross references to this report are not given in the present index.

JACKSON, CHARLES T. **1841.**
First annual report on the geology of the State of New Hampshire.
Concord, N. H. 12mo, pp. i-iv, 5-164.
Describes the occurrence of Newark rocks in Northfield, Mass., and considers the mode of formation of the Connecticut valley sandstone. The Newark rocks of the Connecticut valley, exclusive of the intrusive rocks, do not extend north of the Massachusetts-New Hampshire boundary.

JACKSON, C. T. **1841a.**
[Remarks on joints in the trap dikes of Nova Scotia.]
In Am. Jour. Sci., vol. 41, p. 173; also in Am. Assoc. Geol. and Nat., Proc., p. 26.
Abstract of remarks on a paper by Prof. Mather concerning joints in rocks.
Calls attention to the columnar structure of larger trap masses and the prevalence of a similar structure from side to side in small dikes. Refers these phenomena to manner of cooling.

JACKSON, C. T. **1845.**
Nature of the minerals accompanying trap dikes which intercept various rocks.
In Am. Assoc. Geol. and Nat., Proc., 6th meeting, pp. 28-31.
States that several systems of trap dikes occur in New England. Describes briefly those intersecting the Connecticut valley sandstone and notes the metamorphic effects produced on contiguous stratified beds.

JACKSON, C. T. **1850.**
[On the age of certain sandstones of the United States.]
In Boston Soc. Nat. Hist., Proc., vol. 3, pp. 335-336, 337-338.
Brief statement in reference to the supposed age of the sandstone of lake Superior, and of the sandstone of the Connecticut valley, New Jersey, etc. It is suggested that the latter may belong to the Silurian system. The occurrence of trap in the Connecticut valley is briefly described.

JACKSON, C. T. **1850a.**
Analysis of red marl from Springfield, Mass.
In Am. Assoc. Adv. Sci., Proc., vol. 4, pp. 337-338.
Presents an analysis of a highly ferruginous marl or shale adjacent to trap rock.

JACKSON, C. T. **1853.**
[Age and structure of the Deep river coal field, N. C.]
In Am. Acad., Proc., vol. 3, 1852-1857, pp. 68-69.
A brief abstract of remarks relating to the structure and possible age of the coal field mentioned. Followed by brief remarks by W. B. Rogers and L. Agassiz.

JACKSON, CHARLES T. **1853a.**
Sur les mines de cuivre et de houille de la Caroline du Nord.
In Geol. Soc. Trans. Bull., 2d ser., vol. 10, 1852-1853, pp. 505-506.
Extract from a letter to M. Delesse, giving a brief account of the Deep river coal field, N. C. Refers the rocks containing coal to the New Red sandstone. Cites Rogers and Agassiz in reference to the age of the Richmond coal field.

JACKSON, C. T. **1855.**
[On raindrop impressions in footprints.]
In Boston Soc. Nat. Hist., Proc., vol. 5, p. 189.
Remark on a paper by J. C. Warren.

JACKSON, C. T. **1855a.**
[On the identity in age of the coal-bearing rocks of Virginia and North Carolina.]
In Boston Soc. Nat. Hist., Proc., vol. 5, p. 186.
Remarks on a paper by W. B. Rogers. Suggests that the rocks of the Newark system may be the equivalent of the Lias of Europe.

JACKSON, C. T. **1856.**
[Trap dikes in relation to Zeolite minerals, native copper, etc.]
In Boston Soc. Nat. Hist., Proc., vol. 6, pp. 23-24.
Reference to the agency of trap rocks in producing various minerals.

JACKSON, CHARLES T. **1856a.**
[On the Deep river coal field, N. C.]
In Boston Soc. Nat. Hist., Proc., vol. 6, pp. 30-33.
Brief account of an exploration for coal near Egypt, N. C., with a section of the coal-bearing strata near the bottom of the Egypt shaft. Analyses of coal are given; also the result of some experiments in reference to the value of the coal for gas-making.

JACKSON [C. T.]. **1856b.**
[Remark on unconformable interruption.]
In Boston Soc. Nat. Hist., Proc., vol. 6, p. 184.
Mentions the occurrence of the Newark of the Connecticut valley resting on gneiss, granite, etc., as an illustration of interruption where the whole Paleozoic group is wanting.

JACKSON, C. T. **1859.**
[Note on the copper mines, so called, at Elk run, Fauquier county, Va.]
In Am. Assoc. Adv. Sci., Proc., vol. 6, 1856-1859, p. 183.
Brief statement of the occurrence of copper minerals in trap dike breaking through sandstone.

JACKSON, C. T. **1859a.**
[Amygdaloid minerals of the Nova Scotia and lake Superior traps.]
In Boston Soc. Nat. Hist., Proc., vol. 7, p. 46.

JACKSON, C. T. **1860.**
[On the age of the red sandstone of Perry, Me.; Nova Scotia; Keweenaw point, Mich.; Connecticut valley, etc.]
In Boston Soc. Nat. Hist., Proc., vol. 7, p. 396-398.
The sandstones at the various localities mentioned are briefly compared and certain general conclusions inferred as to their age.

JACKSON [C. T.]. Cited on the age of the Newark system (Lea, '53, pp. 185, 188. W. C. Redfield, '51).
Cited on analysis of coal from North Carolina (Genth, '71).
Cited on the extent of Triassic rocks in America (Archaic, '60, pp. 634-636, 646-655).

JACKSON, CHARLES T., and FRANCIS ALGER. **1828-1829.**
A description of the mineralogy and geology of a part of Nova Scotia.
In Am. Jour. Sci., vol. 14, 1828, pp. 305-330; map op. p. 305, vol. 15, 1829, pp. 132-160, pls. 1-2.
This paper was published with additions as "Remarks on the mineralogy and geology of Nova Scotia," in Am. Acad., Mem., n. s., vol. 1, 1833, and appeared as an independent publication under the title "Remarks on the mineralogy and geology of the peninsula of Nova Scotia; Cambridge, 1832, 4to. See Jackson, Charles T., and Francis Alger, 1833.

JACKSON, CHARLES T., and FRANCIS ALGER. **1833.**
Remarks on the mineralogy and geology of Nova Scotia.
In Am. Acad., Mem., n. s., vol. 1, pp. 217-330, pl. 4, and map.
Issued separately as "Remarks on the mineralogy and geology of the peninsula of Nova Scotia." Cambridge, 1832, 4to, pp. 1-116, pls. 1-4, and map. Published originally as "A description of the mineralogy and geology of a part of Nova Scotia" in Am. Jour. Sci., vol. 14, 1828, pp. 305-330, and map op. p. 305, vol. 15, 1829, pp. 132-160, pls. 1-2.
Reviewed by C. Moxon, in The Geologist [London], vol. 1, 1842, pp. 301-306.
Describes the trap outcrops along the east shore of the bay of Fundy and on the shore of Minas basin, etc. The presence of amygdaloid beneath trap at many localities is noted, and also the metamorphism of sedimentary rocks beneath the amygdaloid. A large portion of the report is devoted to describing the occurrence of minerals in the trap. The Newark sedimentary rocks are not clearly separated from similar Carboniferous rocks.

JACKSON and ALGER. Cited on lignite in Nova Scotia (Dawson, '78, p. 99).
Cited on the relation of trap and sandstone in Nova Scotia (W. M. Davis, '83, p. 285).
Cited on the trap of Nova Scotia (Beaumont, '34, pp. 247-248.

JACKSON, J. B. S. **1854.**
[Remarks on fossil footprints.]
In Boston Soc. Nat. Hist., Proc., vol. 5, 1854-1856, p. 30.
Brief remarks in discussion of a paper by Bouvé.

Jacksonville, N. J. Course of trap ridge near (Cook, '82, p. 55).
Description of conglomerate near (Kitchell, '56, pp. 144, 145).

Jacksonwald, Pa. Dip of strata, and exposure of trap near (d'Invilliers, '83, pp. 217-218, 219, 220).
Prevailing dip near (d'Invilliers, '83, p. 49).
Sandstone and trap at (d'Invilliers, '83, p. 203).
Trap dikes near (d'Invilliers, '83, pp. 200, 201).

JAMES, JOSEPH F. **1889.**
On variations; with special reference to certain Paleozoic genera.
In Am. Nat., vol. 23, pp. 1071-1087.
Refers to *Dendrophycus triassicus*, and states that it is probably an inorganic marking.

JAMES, THOMAS P. **1876.**
Handbook of the State of Georgia.
Atlanta, Ga., pp. i-vii, 1-256, and a geological map of Georgia.
Contains reference to trap dikes, pp. 38, 40, and map.

Jarrettown, Pa. Trap dike near (Lewis, '85, p. 441.

JOHNSON, JOHN. **1843.**
[Remark on shrinkage cracks at Middletown, Conn.]
In Am. Jour. Sci., vol. 45, p. 315.
Brief remark on a paper by W. C. Redfield.

JOHNSON, JOHN. **1854.**
Notice of some spontaneous movements occasionally observed in the sandstone strata in one of the quarries at Portland, Conn.
In Am. Assoc. Adv. Sci., Proc., vol. 8, 1855, pp. 283-286. See, also, National Magazine, vol. 3, 1853, p. 362.
Notice, with subsequent observations by W. H. Niles, Boston Soc. Nat. Hist., Proc., vol. 14, p. 86.

JOHNSON, JOHN—Continued.
Describes certain movements in the quarries mentioned which follow the cutting of trenches across the strata.

JOHNSON, JOHN. Cited on movements in the rocks at Portland, Conn. (Niles, '70, p. 86).

JOHNSON, W. C. **1839.**
[Description of the Richmond coal field.]
In report of the committee on a national foundry, Doc. 168, p. 41. Not seen.

JOHNSON, WALTER R. **1842.**
[Analysis of natural coke from the Richmond coal field, Va.]
In Philadelphia Acad. Nat. Sci., Proc., vol. 1, 1841-42-43, pp. 223-224.
Reprinted in the coal trade of British America [etc.], see Johnson, '50, pp. 155-156.
Describes the physical characters and gives analysis of the natural coke.

JOHNSON, WALTER R. **1844.**
A report to the Navy Department of the United States on American coals applicable to steam navigation and other purposes.
Washington, 28th Congress, 1st session, Senate, No. 386, pp. i-xii, 1-607, pls. 1-3.
Contains a detailed report of an extended series of experiments on the heating and other properties, of the coals of the Richmond coal field, Va.
Treated under the following heads:
"Natural coke" from Tuckahoe, Va., pp. 138-151.
Artificial coke from Midlothian coal, pp. 52-156.
Bituminous coal from Deep Run mines, pp. 309-327.
Bituminous coal from Crouch and Snead's mines, Henrico county, Va., pp. 325-337.
Bituminous coal from the mines of the Midlothian Coal Company, taken from shaft 900 feet deep, pp. 338-348.
Bituminous coal from the Creek Coal Company, Chesterfield county, pp. 349-362.
Bituminous coal from the Clover hill mines, on the Appomattox river, Virginia, pp. 363-377.
Bituminous coal from the Chesterfield Mining Company, Chesterfield county, Va., pp. 378-389.
Bituminous coal of average size sent by the Midlothian Coal Company, Virginia, pp. 390-404.
Bituminous coal from Tippecanoe pits, near Petersburg, Va., pp. 405-419.
Bituminous screened coal from the minings of the Midlothian Coal Company's "new shaft," pp. 420-431.
Midlothian average coal, taken promiscuously from a heap purchased for use in the smith shops at the Washington navy-yard, p. 447.
Synoptical view of the characters, composition and efficiency of Virginia bituminous coals, table CLIV, pp. 448-451.

KEMP, J. F. Cited on the microscopical character of the trap of Blomidon, N. S. (Marsten, '90).

KENDRICK, H. H. Fossil plants collected by, at Durham, Conn. (Chapin, '87*a*).

Notice of a fossil plant found by (Chapin, '91*a*).

Kennett, Pa. Mention of a trap dike in (Frazer, '84, p. 693).

Kensington, Conn. Brief account of geology near (Percival, '22).

Mention of fossil plants having been found near (Percival, '42, p. 442).

Kentville, N. S. Dip at (Dawson, '47, p. 56).

Unconformity at base of the Newark near (Dawson, '78, p. 92).

Kentville, Pa. Boundary of the Newark area of Pennsylvania near (Lea, '58, p. 92).

KERR, W. C. **1867.**

Report of the progress of the geological survey of North Carolina. 1866.

Raleigh. Pp. 1–56.

Refers briefly to coal, oil, fire clays, etc., in North Carolina, pp. 20, 46–47.

KERR, W. C. **1869.**

[Report of the progress of the geological survey of North Carolina, for the years 1866–1867.]

[Raleigh, N. C.]. Pp. 1–57.

States the failure to find sufficient phosphate of lime in the black shales associated with the coal seams of Deep river to be of economic importance, pp. 9–10.

KERR, W. C. **1874.**

Observations on the Mesozoic of North Carolina.

In Am. Assoc. Adv. Sci., Proc., vol. 23, 1875, pp. 47–49.

Compares briefly the characteristic features of the Newark rocks of North Carolina and of the Connecticut valley, and presents a brief account of the leading facts in the stratigraphy of the entire Newark system; discusses the probable structure and former extent of the formation.

KERR, W. C. **1875.**

Report of the geological survey of North Carolina. Physical geology, résumé, economic geology.

Raleigh [N. C.]. Vol. 1, pp. i–xviii, 1–325, 1–120, pl. 9, and a folding map.

Notice in Am. Jour. Sci., 3d ser., vol. 11, pp. 61–62.

Republished in part in "In the Coal and Iron Counties of North Carolina," by P. M. Hale, pp. 52–53.

The following is an expansion of the table of contents of this volume, so far as it relates to the Newark system:

KERR, W. C. **1875a.**

Observations on the Mesozoic of North Carolina.

In Am. Assoc. Adv. Sci., Proc., vol. 23, section B, pp. 47–49.

Contains general consideration relating to the dip, geographical distribution, trap, and organic remains of the Newark system. A former great extent of these rocks is inferred.

KERR, W. C. **1879.**

Physiographical description of North Carolina.

Raleigh, N. C. Pp. 1–32, and map.

Contains a very brief description of the extent of the Newark system in North Carolina, p. 11, and of the thickness and character of the coal seams occurring in it, p. 13.

KERR, W. C. **1879a.**

[Geological formations at railroad stations in North Carolina.]

In an American geological railway guide, by James Macfarlane, p. 186.

Indicates what stations in North Carolina are on the Newark system.

KERR, W. C. **1881.**

The minerals and mineral localities of North Carolina. Being chapter 1 of the second volume of the geology of North Carolina. See Genth and Kerr, 1881.

KERR, W. C. **1884.**

Report on the cotton production of the state of Virginia [etc.].

Washington (Interior Dep., Census Office), 4to, vol. 6, part 2, pp. 617–652. [Tenth Census.]

Contains a very brief description of the Newark areas of Virginia, with some mention of their soils, pp. 630, 631.

KERR [W. C.]. Cited on anticlinal structure of the two Newark areas in North Carolina (W. M. Davis, '86, p. 348).
Cited on the cause of the tilting of the Newark (W. M. Davis, '83, p. 303).
Cited on the Newark areas in North Carolina (Chance, '85, p. 15).
Cited on the Newark of North Carolina (Miller, '79-'81, vol. 2, pp. 225-227).
Cited on the opposite dips of the two main Newark areas of North Carolina (Russell, '78, pp. 252-253).
Cited on the origin and deposition of Newark strata (W. M. Davis, '83, p. 287).
Cited on the tilting of sandstone and trap in South Carolina (W. M. Davis, '83, p. 302).
Cited on trap dikes in North Carolina (W. M. Davis, '83, p. 293).
Discussion of the hypothesis by, explaining opposing dips (W. M. Davis, '82*a*, p. 119).
Newark sandstone from North Carolina collected by (Shaler, '84, p. 181).
Reference to estimate of erosion by (Bradley, '76).

Ketch's mills, East Windsor, Conn. Fossil bones found at (E. Hitchcock, '41, pp. 503-504, pl. 49).

Kidd's mill, Pa. Dolerite and sandstone from (C. E. Hall, '78, p. 47).

Kildare, P. E. I. Analysis of limestone from (Dawson and Harrington, '71, p. 41).
Limestone near (Dawson and Harrington, '71, p. 34).

KILLEBREW, J. B. 1887.
The elementary geology of Tennessee; being also an introduction to geology in general. Designed for the schools of Tennessee.
See Safford and Killebrew, 1887.

Kill von Kull, N. J. Trap exposed at (Russell, '80, p. 36).

Kimberton, Pa. Boundary of the Newark near (H. D. Rogers, '58, vol. 2, p. 668).

King of Prussia, Pa. Boundary of the Newark near (C. E. Hall, '81, pp. 22, 83-84).
Brief account of trap dike near (H. D. Rogers, '58, vol. 1, p. 214).

King iron mine, Pa. Analysis of ore from (d'Invilliers, '86, p. 1513).
Report on (Frazer, '77, pp. 212-214).

Kings, Va. Boundaries of the Newark near (W. B. Rogers, '39, p. 76).

Kings county, N. S. General account of the Newark rocks of (Honeyman, '79, pp. 27-28).

Kings point, N. J. Contact metamorphism at (Russell, '80, p. 38).
Description of structure at (Darton, '89*a*).
Exposures of trap at (Russell, '80, p. 38).
Faults in trap ridge near (Darton, '90, p. 42).
Small trap sheets near (Darton, '90, p. 39).
Unconformity of trap and sandstone near (Darton, '90, p. 47).

Kingston, N. J. Account of contact metamorphism near (H. D. Rogers, 36, pp. 163-164).
Analysis of soil from (Cook, '78, pp. 37, 39).

Kingston, N. J.—Continued.
Boundaries of Newark system near (Cook, '89, p. 11. H. D. Rogers, '40, p. 118).
Brief reference to trap hills near (H. D. Rogers, 36, p. 159).
Description of quarries at (Cook, '81, p. 55).
Description of sandstone strata near (H. D. Rogers, '40, p. 126).
Description of trap and altered shale near (H. D. Rogers, '40, pp. 149, 151).
Dip in sandstone near (Cook, '82, p. 25).
Dip near (Cook, '68, p. 196).
Quarry at (Cook, '81, p. 55).
Sandstone outcrop near (H. D. Rogers, '40, p. 121).
Sandstone quarry at (Cook, '79, p. 23).
Trap boundary near (Cook, '68, p. 190).

Kinseys mill, Pa. Boundary of the Newark near (H. D. Rogers, '58, vol. 2, p. 676).

Kinsey mountain, Pa. Dip of strata and exposure of trap near (d'Invilliers, '83, pp. 218, 219, 220).

KIPSEY'S, J. Quarry near Martinville, N. J., description of (Cook, '81, p. 54).

KIRKBY, J. W. Cited in reference to fossils of the Newark system (Newberry, '88, pp. 68-69).

KITCHELL, WILLIAM. 1856.
Report on the north division of the state [of New Jersey].
In second annual report on the geological survey of the state of New Jersey, for the year 1855, pp. 111-248).
Contains a description of a portion of the boundary line between the Newark and the gneiss bordering it on the northwest, pp. 144-145.

KITCHELL, W. Cited on the conglomerate of the Newark system in New Jersey (Cook, '89, p. 15).

Kittoctin mountain, Va. Boundary of the Newark near (W. B. Rogers, '40, p. 63).

Klinesville, N. J. Dip near (Cook, '68, p. 197).
Dip in shale near (Cook, '82, p. 28).
Evidence of faulting near (Nason, '89, p. 33).
Fossil crustaceans found near (Nason, '89, p. 30).

Knauerton, Pa. Boundary of Newark near (Lesley, '83, pp. 185, 191).
Recomposed rocks near (Frazer, '83, p. 235).

KOCHER BROS.' quarry at Newark, N. J., description of (Cook, '81, p. 48).

Kralltown, Pa. Catalogue of specimens of sandstone, etc., from near (Frazer, '77, pp. 332-381).
Dolerite from (C. E. Hall, '78, p. 47).
Shale and sandstone from (C. E. Hall, '78, p. 46).

Kuntz's limestone quarry, Pa. Report on (Frazer, '77, p. 225).

Kuntz's paint mine, Pa. Report on (Frazer, '77, p. 225).

Kurdsville, Va. Boundaries of the Newark near (W. B. Rogers, '39, p. 77).

LEA, ISAAC A.—Continued.

In Philadelphia Acad. Nat. Sci., Proc., vol. 5, 1852, pp. 171-172, 205.

Describes the position and character of the beds in which the fossil bones were found, and discusses the relation of the strata to outcrop of calcareous conglomerate found elsewhere in the Newark system, pp. 171-172. Remarks continued on p. 205, where the name *Clepsysaurus pennsylvanicus* for certain fossil bones is proposed.

LEA, ISAAC. 1853.

Description of a fossil saurian of the New Red sandstone formation of Pennsylvania; with some account of that formation.

In Philadelphia Acad. Nat. Sci., Jour., 2d ser., vol. 2, 1850-1854, pp. 185-202, pl. 17-19.

Abstract in Am. Jour. Sci., 2d ser., vol. 14, p. 451.

Presents a critical review of the works of previous writers on the paleontology and the geological position of the Newark system, followed by a description of a genus of fossil saurians, based on certain fossil bones found in upper Milford, Lehigh county, Pa.

LEA, ISAAC. 1855.

[Note on the tracks of crustaceans and other markings on the sandstone of Connecticut valley.]

In Boston Soc. Nat. Hist., Proc., vol. 5, pp. 276-277.

An extract from a letter referring to a slab of sandstone from Greenfield, Mass.

LEA, ISAAC. 1856.

Remarks on a tooth of a sauroid reptile, from near Phœnixville [Pa.].

In Philadelphia Acad. Nat. Sci., Proc., vol. 8, 1856, pp. 77-78.

Abstract in Am. Jour. Sci., 2d ser., vol. 22, pp. 122-123; also Neues Jahrbuch, 1857, p. 253.

Describes the tooth of a reptile to which a name is given. Names also two species of Posidonia, and a fossil footprint from the locality that yielded the reptilian remains.

LEA, ISAAC. 1857.

[Remarks on fossils from Phœnixville, Pa.]

In Philadelphia Acad. Nat. Sci., Proc., vol. 9, 1858, p. 149.

Brief abstract of remarks on a fossil bone and a coprolite from the tunnel at Phœnixville, Pa.

LEA, ISAAC. 1857a.

[Brief remarks on the identity of the rocks near Gwynned, Pa., with those at Phœnixville, Pa.]

In Philadelphia Acad. Sci., Proc., vol. 9, 1858, p. 173.

Brief record of remarks based on fossils from the localities named.

LEA [ISAAC]. 1858.

[Remarks on the age of the Newark system.]

In Philadelphia Acad. Nat. Sci., Proc., vol. 10, pp. 90-92.

LEA, I[SAAC]—Continued.

A brief statement of the opinions and conclusions of various geologists concerning the geological position of the Newark system.

LEA [I.]. Cited on the age of the Newark system (Lea, '58).

Cited on the age of the Newer Red sandstone of Prince Edward island (Leidy, '54, p. 330).

Cited on the age of the Red sandstone of Prince Edward island (Owen, '76, p. 361).

Cited on fossil crustaceans from the Newark system (Jones, '62, p. 86).

Cited on fossil plants from Turners Falls, Mass. (Emmons, '57, p. 134).

Cited on fossil reptiles from North Carolina (Emmons, '57, p. 73).

Cited on fossil reptiles from Pennsylvania (Emmons, '56, pp. 298, 308. Frazer, '77a, p. 497. H. D. Rogers, '58, vol. 2, p. 692-693).

Cited on fossil reptiles from Pennsylvania and New Jersey (H. D. Rogers, '58, vol. 2, p. 695).

Notice of the description of reptilian fossils by (Miller, '79-'81, vol. 2, p. 152).

Lead, at Berlin, Conn. (E. Hitchcock, '35, p. 232).

In Massachusetts, brief account of (E. Hitchcock, '41, p. 448).

Leakesville, Va. Boundary of the Newark near (W. B. Rogers, '39, p. 75).

Description of geology near (W. B. Rogers, '39, p. 78).

Leaksville, N. C. Analysis of coal from near (Chance, '85, pp. 64-65).

Boundary of the Newark near (Mitchell, '42, p. 134).

Brief account of the rocks near (Emmons, '52, p. 149).

Character and dip of rocks at (Emmons, '56, p. 255).

Coal at (Emmons, '57, p. 33. Kerr, '75, p. 145. Kerr, '75, p. 295. McGehee, '83, p. 77).

Conglomerate near (Emmons, '52, p. 152. Emmons, '56, p. 256).

Dip and strike at (Emmons, '56, pp. 257, 258).

Dip of coal at (McGehee, '83, p. 77).

General section of Newark rocks near (Jones, '62, p. 89).

Newark system near (Macfarlane, '77, p. 527).

Reference to fossil fishes from (E. Hitchcock, '41, p. 440).

Reptile remains from (Emmons, '56, p. 309. Emmons, '57, p. 81).

Section near (Emmons, '52, p. 149. Emmons, '56, p. 257).

Thickness of coal seams near (Chance, '85, p. 64).

Thickness of sandstone at (Emmons, '57, p. 22).

Lebanon, N. J. Analysis of trap near (Cook, '68, p. 218).

Boundaries of the Newark system near (Cook, '89, p. 11. H. D. Rogers, '40, p. 16. H. D Rogers, '40, p. 118).

Boundary of trap near (Cook, '68, p. 193).

LEIDY, JOSEPH. 1854.
On Bathygnathus borealis, an extinct saurian of the New Red sandstone of Prince Edward island.
In Philadelphia Acad. Nat Sci., Jour., 2d ser., vol. 2, 1850–1854, pp. 327–330, pl. 33.
Describes Bathygnathus borealis.

LEIDY, JOSEPH. 1854a.
[Remarks on Bathygnathus borealis from near Prince Edward island.]
In Philadelphia Acad. Nat. Sci., Proc., vol. 6, 1852–1853, p. 404; also in Am. Jour. Sci., 2d ser., vol. 6, pp. 444–445.
Abstract in Neues Jahrbuch, 1855, pp. 499–500.
Proposes the name given in the title.

LEIDY, J. 1857.
[Remarks on fossils from Phœnixville, Pennsylvania.]
In Philadelphia Acad. Nat. Sci., Proc., vol. 9, 1858, pp. 149–150.
Compares certain fossils from the locality mentioned with others from Virginia, North Carolina, and England, and suggests the age thus indicated.

LEIDY, J. 1857a.
[Remarks on fossils from the Gwynned tunnel, Pa.]
In Philadelphia Acad. Sci., Proc., vol. 9, 1858, p. 150.
Brief record of remarks on fossils from the localities named.

LEIDY, JOSEPH. 1858.
[Note on fucoids and footprints from the sandstone of the Connecticut valley.]
In Ichnology of New England, by Edward Hitchcock, pp. 165–166.
Extract from a letter referring briefly to certain drawings of fossils supposed to be in part fucoid impressions and in part footprints of crustaceans.

LEIDY, JOSEPH. 1860.
[Remarks on fossils found near Phœnixville, Pa.]
In Philadelphia Acad. Nat. Sci., Proc., vol. 11, 1859, p. 110.
Mentions briefly the fossils obtained at Phœnixville, Pa., including a new genus of reptile.

LEIDY, JOSEPH. 1869.
The extinct mammalian fauna of Dakota and Nebraska [etc., etc.].
In Philadelphia Acad. Nat. Sci., Jour., 2d ser., vol. 7, pp. i–viii, 9–472, pls. 1–30, and a map.
Contains a remark on Dromatherium sylvestre from North Carolina, p. 410.

LEIDY, [JOSEPH]. 1876.
Fish remains of the Mesozoic red shales [of Pennsylvania].
In Philadelphia Acad. Nat. Sci., Proc., vol. 28, p. 81.
Records the finding of obscure fish remains at Yerke's station on the Perkiomen railroad, in Montgomery county, Pa.

[L]EIDY, J. Cited on character of certain footprints from Turners Falls, Mass. (Deane '56).
Cited of fossil reptiles from North Carolina (Emmons, '57, p. 60).
Cited on fossil reptiles from Pennsylvania and North Carolina (H. D. Rogers, '58, vol. 2, p. 695–697).
Notice of the description of reptilian fossils by (Miller, '79–'81, vol. 2, p. 152).

LEITH-ADAMS, A. Cited on Jurassic reptiles from high northern latitudes (Hull, '87, p. 95).

Lemer's ore pit, Pa. Report on (Frazer, '77, p. 225).

Leonia, N. J. Indurated shale near (Darton, '90, p. 52).

Leopard, Pa. Trap dike near (Lewis, '85, p. 444).

Leprence, N. B. Age of rocks at (Bailey, '65, p. 5).

LESCHARBOT. Cited on native copper from the bay of Fundy (Gilpin, '77, p. 749).

LESLEY, J. P. 1856.
Manual of coal and its topography. Illustrated by original drawings, chiefly of facts in the geology of the Appalachian region of the United States of North America.
Philadelphia, 12 mo, pp. i–xii, 1–224.
Contains a brief account of the origin of the trap ridges of the Newark system of Pennsylvania and New Jersey, pp. 132–133. Refers to lamination in the trap of East and West Rocks, Conn., p. 162.

LESLEY, J. PETER. 1863.
[On an asphalt vein in West Virginia.]
In Am. Phil. Soc., Proc., vol. 9, pp. 183–197, pl. 3–4.
Contains theoretical consideration respecting the deposition and erosion of the Newark system, pp. 188–189.

LESLEY, J. PETER. 1864.
[On the discovery of lignite in Franklin county, Pa., and its bearing on the determination of the age of the present surface of the land.]
In Am. Phil. Soc., Proc., vol. 9, pp. 463–482, and 4 plates.
Discusses the manner in which the Newark rocks of Pennsylvania were deposited.

LESLEY, J. P. 1873.
[Remarks on iron ores near Doylestown, Pa.]
In Am. Philo. Soc., Proc., vol. 13, p. 264.

[LESLEY, J. PETER]. 1874.
Notes on the geology of Lehigh county, Pa.
In Second Geol. Surv. of Pennsylvania, 1874. Report on the Brown Hematite ore ranges of Lehigh county, vol. D, pp. 57–66.
Contains brief observations on the Newark rocks of Lehigh county, pp. 61–64.

LESLEY, J. P. 1880.
Geological map of Cumberland county, Pa.
In Second Geol. Surv. of Pennsylvania, vol. D, 5, atlas. No text accompanying.

LESLEY, JOSEPH PETER. 1883.
The geology of Chester county after the surveys of Henry D. Rogers, Persifor Frazer, and Charles E. Hall.
In second geological survey of Pennsylvania, vol. C, 4, pp. 1–54, 63–214, 351–354, pl. 2.
Unconformity at base of the Newark system with hypothesis to account for it, p. 22. Folding of the Appalachians previous to the Newark, p. 132. A general statement of the character of the Newark of Pennsylvania, compiled principally from reports of previous observers, pp. 178–215.

LESLEY, JOSEPH PETER. 1885.
Second geological survey of Pennsylvania. Report of progress.
A geological hand atlas of the sixty-seven counties of Pennsylvania, embodying the the results of the field work of the survey from 1874 to 1884.
Harrisburg, pp. i–cxii, pl. 1–61, and 2 maps.
Presents brief sketches of the geology of each county, in explanation of accompanying maps.

LESLEY, J. PETER. 1886.
Geology of the Pittsburg coal region.
In Am. Inst. Min. Eng., Trans., vol. 14, 1885–1886, pp. 618–656, and on map op. p. 656.
General remarks on the deposition of the Newark rocks of Pennsylvania, p. 630. Area occupied shown on the map op. p. 656.

LESLEY, J. P. 1891.
On an important boring through 2,000 feet of Trias, in eastern Pennsylvania.
In Am. Philo. Soc., Proc., vol. 29, pp. 20–25.
Gives a record of strata passed through in boring a well in Bucks county, 18 miles north of Easton, Pa. In remarks on the paper, B. S. Lyman states the rocks penetrated belong in the central portion of the Newark system, which is 2,100 feet thick.

LESLEY, J. P. Cited on former extent of the Newark system (Macfarlane, '79, p. 41).
Cited on mode of formation of the Richmond coal field, Virginia (Clifford, '87, pp. 6, 29–33).
Cited on overflow trap sheets in Pennsylvania (W. M. Davis, '83, p. 298).
Cited on relation of trap and sandstone in Pennsylvania (W. M. Davis, '83, p. 287).
Cited on structure and mode of formation of the Richmond coal field, Virginia (Macfarlane, '77, pp. 510–514).

LESLEY, J. P., and PERSIFOR FRAZER. 1876.
Geological map of Adams county, Pa.
In second geological survey of Pennsylvania, vol. D 5, atlas. No text accompanying.

LESLEY, J. P., and E. V. d'INVILLIERS. 1885.
Report on the Cornwall iron ore mines, Lebanon county, Pa.

LESLEY, J. P., and E. V. d'INVILLIERS—Continued.

In Ann. Rep. of the Geol. Surv. of Pennsylvania for 1885; Harrisburg, Pa., 1886, pp. 491–570, and plates.

Gives a detailed description of the iron ore body at the Cornwall mines, and states its relation to the trap and sedimentary beds of the Newark system. A fault having a throw of several thousand feet is stated to exist at the junction of the Newark rocks with the bordering formations on the west; strikes and dip, character of the trap dike, etc., are given.

LESQUEREUX, L. 1876.

On the tertiary flora of the North American lignitic, considered as evidence of the age of the formation.

In annual report of the United States geological and geographical survey of the Territories, embracing Colorado and parts of adjacent Territories, being a report of progress for the year 1874. By F. V. Hayden. Washington (Interior Dep.), pp. 275–365, pls. 1–8.

Contains a brief reference to the age of the Newark system as indicated by fossil plants.

LESQUEREUX, LEO. 1879.

[A fossil tree trunk found at Belleville, N. J.]

In [Annual report on the geology of New Jersey for 1879], pp. 26–27.

A quotation from a letter in reference to a photograph of a fossil tree trunk supposed to be a Lepidodendron.

Lesser cross roads, N. J. Copper ores near (Cook, '68, p. 678).

Dip in shale near (Cook, '82, p. 29).

Dip near (Cook, '68, p. 198).

Leverett, Mass. Note on conglomerate near (Nash, '27, p. 247).

Stratigraphy in (Walling, '78).

LEWIS, HENRY CARVILL. 1880.

A new locality for lignite.

In Philadelphia Acad. Nat. Sci., Proc., vol. 32, p. 281.

Describes the occurrence of lignite in Montgomery county, Pa., in what the author seems to regard as Newark beds.

LEWIS, HENRY CARVILL. 1880a.

The iron ores and lignite of the Montgomery county valley.

In Philadelphia Acad. Nat. Sci., Proc., vol. 32, pp. 282–291.

Contains a few observations on the Newark system in the region referred to.

LEWIS, HENRY CARVILL. 1880b.

On a new fucoidal plant from the Trias [of New Jersey].

In Philadelphia Acad. Nat. Sci., Proc., vol. 32, pp. 293–294.

Abstract in Neues Jahrbuch, 1882, p. 158.

Describes and figures the cast of what is described as a fossil fucoid, under the name of *Palæophycus limaciformis*, from Milford, N. J.

LEWIS, H. C. 1882.

On a fault in the Trias near Yardleyville, Pa.

In Philadelphia Acad. Nat. Sci., Proc., vol. 34, pp. 40–41.

Describes the occurrence of a dike of trap coincident with a fault between sandstone and conglomerate. Refers also to change in the dip of sandstone and shale produced by trap dikes.

LEWIS, H. CARVILL. 1882a.

The geology of Philadelphia.

In Franklin Inst. Journal, 3d ser., vol. 85, 1883 pp. 359–374, 422–427.

Includes a brief popular account of the general features of the Newark system near the locality mentioned, together with a reference to the reptilian fossils found in the same beds, and the mode of origin of the associated trap rock, pp. 426–427.

LEWIS, H. CARVILLE. 1884.

[Note on Newark fossils from near Phœnixville, Pa.]

In Science, vol. 3, p. 295.

States that two species of Unio, together with undetermined marine shells and remains of plants and animal, have been obtained near the town mentioned.

LEWIS, H. CARVILL. 1885.

A great trap dike across southeastern Pennsylvania.

Am. Phil. Soc., Proc., vol. 22, pp. 438–456, map op. p. 440.

Abstract in Science, vol. 4, p. 328; also in Am. Assoc. Adv. Sci., Proc., vol. 33, pp. 402–403, and in Neues Jahrbuch, 1887, p. 74.

Reviewed by Persifer Frazer in Am. Philo. Soc., Proc., vol. 21, pp. 691–694.

Describes in detail the course of a trap dike which enters Pennsylvania at Penmar at the southwest and extends nearly to the Delaware on the east. The course of the dike is shown on the map op. p. 440. The association of the dike with a great fault in Bucks county is discussed.

A criticism of this paper by P. Frazer is replied to, p. 456. For Frazer's rejoinder, see Frazer, 1884.

LEWIS, H. C. Review of a paper by, on a great trap dike across southeastern Pennsylvania (Frazer, '84).

Lewisburg, Pa. Contact metamorphism near (H. D. Rogers, '58, vol. 2, pp. 688–689).

Sandstone from (E. C. Hall, '78, p. 36).

Trap dikes near (H. D. Rogers, '58, vol. 2, p. 688).

Trap hills near (H. D. Rogers, '58, vol. 2, p. 688).

Leyden, Mass. Contact of Newark system and Primary rocks in (E. Hitchcock, '35, p. 223).

Description of the gorge and glen in (E. Hitchcock, '41, pp. 285–286).

Dip and strike at (E. Hitchcock, '41, p. 448).

Dip of sandstone in (E. Hitchcock, '35, p. 223).

Junction of Newark system and Primary rocks in (E. Hitchcock, '41, p. 448).

LOPER, S. WARD. **1891.**
Two belts of fossiliferous black shale in the Triassic formation of Connecticut.
See Davis and Loper, 1891.

LOUGHRIDGE, R. H. **1884.**
Report on the cotton production of the state of Georgia [etc.].
In Tenth Census of the United States, Washington (Interior Dept., Census Office), 4to, vol. 6, part 2, pp. 259–450).
States that the Newark system is probably represented in Georgia by trap dikes and by clay slates adjacent to the metamorphic region, p. 279.

LYELL, CHARLES. **1842.**
On the fossil footprints of birds and impressions of raindrops in the valley of the Connecticut.
In London Geol. Soc., Proc., vol. 3, 1838–1842, pp. 793–796.
Republished in Am. Jour. Sci., vol. 45, 1843, pp. 394–397.

LYELL, CHARLES—Continued.
Describes the sandstone formation of the Connecticut valley and New Jersey, with its fossil tracks and other impressions. Considers the conditions of its deposition, relation to the hypogene rocks, age, etc.

LYELL [CHARLES]. **1842a.**
[Remarks on the cause of the prevailing dip of the New Red sandstone of the Connecticut valley and of New Jersey and Pennsylvania.]
In Am. Jour. Sci., vol. 43, pp. 170, 172; also in Am. Assoc. Geol. and Nat., Proc., pp. 63, 64, 66.
Brief remarks on a paper by Edward Hitchcock.

LYELL, CHARLES. **1843.**
Fossil footprints.
In lectures on geology, delivered at the Broadway tabernacle, in the city of New York. Lecture VI, pp. 37–43.
Contains a brief account of fossil footprints, fossil fishes, etc., from New Jersey and the Connecticut valley.

LYELL, CHARLES. **1845.**
Travels in North America, with geological observations on the United States, Canada, and Nova Scotia.
London, 12mo, vol. 1, pp. i–xii, 1–316, pl. 1, 3–5, vol. 2, pp. i–viii, 1–272, pl. 2, 6–7.
Another edition of this work was issued in New York, 1845, in two volumes, 12mo, but without a number of the plates that accompany the edition mentioned above. A second English edition appeared in 1855. A German edition translated by Emil Th. Wolff, was published at Halle in 1846.
Reviewed in Quart. Jour. Geol. Soc., London, vol. 1, pp. 389–399, and by E. Emmons in Am. Quart. Jour. Agri. and Sci., vol. 2, pp. 265–267.
Refers briefly to the sandstone and trap near New Haven, Conn., vol. 1, p. 13, and to the same formation in New Jersey, p. 15. Describes also a visit to the Connecticut valley in Massachusetts, in company with E. Hitchcock, pp. 251–255. Mentions the occurrence of sandstone, trap, etc., at cape Blomidon, N. S., vol. 2, pp. 271–272. A colored geological map of the eastern portion of the United States forms the frontispiece of vol. 2. A geological sketch map of the United States forming plate op. p. 75, in vol. 1 of the New York edition, does not appear in the London edition. Mentions also the occurrence of sandstone, trap, amygdaloid, etc., at cape Blomidon, N. S., vol. 2, p. 271.

LYELL, CHARLES. **1847.**
On the structure and probable age of the coal field of the James River, near Richmond, Va.
In Quart. Jour. Geol. Soc., London, vol. 3, pp. 261–280, pls. 8–9.

LYELL, CHARLES—Continued.

Abstract in Am. Jour. Sci., 2d ser., vol. 4, pp. 113-115.

Geological structure of the coal field, p. 261. Vertical calamites, p. 262. Thickness of coal, p. 263. Section showing the geological position of the coal-bearing rocks, p. 263. Section of Midlothian coal mine, p. 265. Junction of coal and granite in Blackheath mines, p. 266. Organic structure and mineral composition of the coal, p. 268. Vegetable structure of mineral charcoal from Clover hill mines, p. 268. Analyses of coals and coke, p. 270. Beds of coal changed to coke by the action of trap, p. 270. Natural coke, p. 272. Position of the trap, p. 273. Age of the coals as determined by organic remains, p. 274. Fossil shells, p. 274. Fossil fishes, p. 275. Whether the strata are of marine or fresh-water origin, p. 278. Fossil plants, p. 278. The coal measures probably of the age of the inferior Oolitic and Lias, p. 279.

LYELL, CHARLES. **1849.**

A second visit to the United States of North America.

London, 1849, vol. 1, pp. i-xii, 1-368; vol. 2, pp. i-xii, 1-385.

Second ed. not seen.

Third ed., London, 1855, in two volumes, paged as in 1st ed. Contains an account of a visit to the Richmond coal field, Virginia, vol. 1, pp. 279-288.

LYELL, CHARLES. **1851.**

On fossil rain marks of the Recent, Triassic, and Carboniferous periods.

In Quart. Jour. Geol. Soc., London, vol. 7, pp. 238-247.

Describes raindrop impressions from Newark and Pompton, N. J. Gives figures of raindrop impressions and of hail impressions from Pompton, copied from C. W. Redfield, pp. 238, 242-244.

LYELL, C. **1851a.**

On the discovery of some fossil reptilian remains and landshells in the interior of an erect fossil tree in the coal measures of Nova Scotia, with remarks on the origin of coal fields and the time required for their formation.

In Roy. Inst. [London], Proc., vol. 1, pp. 281-288.

Gives a brief account of the area, remarks the absence of reptilian remains in, p. 283.

LYELL, CHARLES. **1851b.**

[Origin of raindrop impressions.]

In Am. Assoc. Adv. Sci., Proc., vol. 5, p. 74.

Quotation from a letter in a paper by W. C. Redfield.

LYELL, C. **1851c.**

On impressions of raindrops in ancient and modern strata.

Royal Inst. [of Great Britain], Proc., vol. 1, pp. 50-53.

Mentions raindrop impressions from New Jersey.

LYELL, CHARLES. **1852.**

Inferences deducible from the raindrop impressions in the Triassic and Carboniferous rocks.

In Ann. Sci. Discov., p. 261.

Brief extract from a lecture in which the impressions of raindrops and associated impressions on certain rocks are interpreted.

LYELL, CHARLES. **1854.**

Special reports on the geological, topographical, and hydrographical departments of the exhibition.

In general report of the British commissioners of the New York industrial exhibition in 1853, London, 4to, pp. 1-50.

Abstract in France, Geol. Soc., Bull., 2d ser., vol. 12, part 1, pp. 400-428.

Describes briefly the rocks of the Deep river basin, N. C., and of the Chesterfield basin (Richmond coal field), Va., referring to them as Oolite or Lias. The extent and characteristics of the Newark system in Massachusetts, Connecticut, New Jersey, and Pennsylvania, also receives attention, with special reference to their economic products. The character of the trap rocks in these states and their relation to associated stratified rocks is also treated.

LYELL, C. **1857.**

[Remarks on the age of the Richmond coal field, Va.]

In geology of North America, by Jules Marcou, Zurich, 1858, 4to, p. 16.

In a letter to C. Marcou, states that C. Bunbury has changed his statement as to the age of the plants of the Richmond coal field, on account of a change in the determination of the age of the beds with which they were compared.

LYELL, CHARLES. **1866.**

Elements of Geology.

New York, 6th ed., pp. i-xvi, 1-803.

Published previously as "A manual of elementary geology," several editions.

Contains a condensed description of the Richmond coal field, Va., the Deep river coal field, N. C., and of the sandstone, etc., of the Connecticut valley.

LYELL, C. **1871.**

The Student's Elements of Geology.

London, 12mo, pp. i-xix, 1-624.

Contents relating to the Newark sandstone of the Connecticut valley, p. 361.

Coal field of Richmond, Va., p. 362. Mammalian remains, p. 364. Low grade of early mammals favorable to the theory of progressive development, p. 364.

LYELL, C. Cited on age of certain rocks in Nova Scotia (Dawson, '78, p. 109).

Cited on age of Newark system (Dewey, '57. Lea, '58. Newberry, '88, p. 10).

Cited on age of the Newark system of Virginia (Horner, '46).

Cited on age of the Richmond coal field, Va. (Hull, '81, p. 460. Marcou, '49, pp. 273-274.

LYELL, C.—Continued.
Marcou, '58, p. 16. W. C. Redfield, '56, pp. 185, 187).
Cited on coal mining in the Richmond coal field (Fontaine, '79, pp. 35, 36).
Cited on fossil crustaceans from the Newark system (Jones, '62, pp. 85, 86).
Cited on the fossil fishes of the Newark system (Newberry, '88, p. 20).
Cited on fossil footprints (Murchison, '43).
Cited on the fossil plants of the Richmond area (De La Beche, '48. Fontaine, '83, p. 25).
Cited on geology of the Richmond coal, Virginia (Greer, '71. Taylor, '48, p. 47).
Cited on intrusive trap sheets in Virginia (W. M. Davis, '83, p. 294).
Cited on natural coke in Richmond coal field, Va. (Clifford, '87, p. 12. De La Beche, '48).
Cited on Newark flora (Marcou, '90).
Cited on origin of certain raindrop impressions found in New Jersey (W. C. Redfield, '51*a*, pp. 73, 74).
Cited on Posidonia from the Richmond coal field, Va. (Lea, '56, p. 78).
Cited on relation of trap and sandstone in Massachusetts (Davis, '83, p. 285).
Cited on Richmond coal field, Va. (Clifford, '87, pp. 2, 5, 7, 8, 13, 14, 23, 24).
Cited on Richmond coal field (Clifford, '88. Emmons, '57, pp. 11-13).
Cited on section in the Richmond coal field, Va. (Emmons, '56, p. 339).
Cited on trap dikes in the Richmond coal field, Va. (W. M. Davis, '83, p. 293).
Fossil fishes obtained by, from Connecticut (Egerton, '49, p. 8).
Notice of work by, in Virginia (Miller '79-'81, vol. 2, pp. 149-151).

LYMAN, B. S. 1891.
[Remarks on bored well in Bucks county, near Easton, Pa.]
In Am. Philo. Soc. Proc., vol. 29, pp. 24, 25).
[Remarks on paper by J. P. Lesley. See Lesley, '91, in which the section passed through by the boring referred to is given.]

Lynchburg, Va. Brief account of sandstone near (W. B. Rogers, '36, p. 82).

MACFARLANE, JAMES. 1877.
The coal regions of America; their topography, geology, and development.
New York, 3d ed., pp. i-xvi, 1-696, and 29 maps.
2d ed., New York. Not seen.
1st ed., New York. 1873, pp. i-xvi, 1-676, and 25 maps.
Contains a general account of the Richmond, Va., Deep river and Dan river, N. C., coal fields. Compiled principally from the report of E. Emmons, H. D. Rogers, and J. P. Lesley. Contains geological sketch map of the United States, pl. op. p. 3; a geological map of Pennsylvania, frontispiece; and a map of the United States showing distribution of coal fields, pl. op. p. 626.

MACFARLANE, JAMES. 1879.
An American geological railway guide.
New York, pp. 1-216 and a geological map.
Contains a brief sketch of the Newark system, and indicates what railroad stations are situated on it.

MACFARLANE, JAMES. 1885.
An American geological railway guide. [Being advance sheets of a second edition, relating to the Dominion of Canada.]
New York, pp. 52-82.
Refers briefly to the Newark rocks of Nova Scotia, p. 56.

MACFARLANE, J. Cited on the coal production of the Richmond coal field, Va. (Heinrich, '78, p. 268).
Cited on the value of the Richmond coal field, Va. (Hotchkiss, '80, pp. 91-92).

MACKIE, S. J. 1863.
The aeronauts of the Solenhofen age.
In The Geologist, vol. 6, pp. 1-8, pl. 1.
Refers briefly to the footprints of the Connecticut valley.

MACKIE, S. J. 1864.
Fossil birds.
In The Geologist, vol. 6, 1863, pp. 415-424, 445-455, pls. 22-24; vol. 7, 1864, pp. 11-24, 50-53, pls. 1-4.
Contains a brief account of the finding of fossil footprints in the Connecticut valley, followed by a "bibliography of Connecticut footprints," compiled principally from a similar list by Hitchcock in his Ichnology of New England. An extract is also given from Emmons's "American Geology" concerning a fossil bird bone from the Newark rocks of North Carolina.

MACLURE, WILLIAM. 1809.
Observations on the geology of the United States, explanatory of a geological map.
In Am. Phil. Soc., Trans., vol. 6, 1809, pt. 2, pp. 411-428. Republished in same, n. s., vol, 1, 1818, pp. 1-91, pls. 1-2; also as a separate volume, Philadelphia, 1817, 8vo, pp. i-ix, 10-130, pls. 1-2, and map. The map (as stated by Marcou) was reproduced in 1822 by P. Cleaveland as a frontispiece of an elementary treatise on mineralogy and geology, 2d ed., Boston, and also in 1843, in The Geologist.
Portions of the Newark rocks of New Jersey, Connecticut, etc., are considered in connection with other rocks west of the Appalachians, which are now known to be of much older date, under the head of "Secondary formation," and are so represented on the map.

MACLURE (—). Cited on the age of the coal fields of North Carolina (Emmons, '56, p. 271).

MACLURE [W.]. Cited on the age of the Newark system (Lea, '53, pp. 188, 189. Newberry, '88, p. 8. H. D. Rogers, '44, pp. 248, 251. H. D. Rogers, '58, vol. 2, p. 693).
Cited on the age of the Richmond coal field, Va. (Taylor, '35, p. 294).

McCara's Brook, N. S. Trap of (Dawson, '78, p. 316).

M'CLURE, WM. **1822.**
Comparative features of American and European geology.
In Am. Jour. Sci., vol. 5, pp. 197-198.
An extract from a letter relating to the extent and general character of the trap rocks of the Atlantic slope. The former connection of several of the Newark areas between the Connecticut and the Rappahannock is suggested.

M'CLURE, W. Cited on the extent of the Dan river area, N. C. (Olmsted, '27, p. 128).
Cited on the former extent of the Newark system (Olmsted, '24, p. 18).
Cited on the Newark of North Carolina (Olmsted, '20).

McClure iron mine, Pa. Analysis of ore from (d'Invilliers, '86, p. 1513).

McCormick iron mine, near Dillsburg, Pa. Brief account of (Frazer, '76d).
Description of (d'Invilliers, '86, pp. 1511-1512).
Report on (Frazer, '77, pp. 214-217, 228-229).

McCREATH, ANDREW S. **1879.**
Second geological survey of Pennsylvania, 1876-1878, MM. Second report of progress in the laboratory of the survey at Harrisburg.
Harrisburg, pp. i-xii, 1-438, and 2 plates.
Contains an analysis of coal from York co., Pa.

McCREATH, ANDREW S. **1881.**
Second geological survey of Pennsylvania, 1879-1880, M3. Third report of progress in the laboratory of the survey at Harrisburg.
Harrisburg, pp. i-xx, 1-126, map in pocket.
Contains analyses of limestones from near Dillsburg, York county, Pa.

McCREATH, A. S. Analysis of coal from the Richmond coal field, Va. (Clifford, '87, p. 10).
Analysis of iron ore from Pennsylvania by (d'Invilliers, '86, p. 1507).
Analysis of iron ores (d'Invilliers, '83, pp. 324, 325, 331-333, 341).
Cited on the composition of coal from the Richmond coal field, Va. (Chance, '85, p. 19).

McGEE, W. J. **1884.**
Map of the United States, exhibiting the present status of knowledge relating to the areal distribution of geologic groups.
In U. S. Geol. Surv., fifth annual report, 1883-1884, pl. 2, in pocket at end of volume.
A compiled map showing areas occupied by the Newark system.

McGEE, W. J. **1888.**
Three formations of the middle Atlantic slope.
In Am. Jour. Sci., 3d ser., vol. 35, pp. 120-143, 228, 330, 367-388, 448-466, pl. 2, 6-7. Reviewed in Am. Geol., vol. 2, pp. 129-131.
States that the Potomac formation rests unconformably on the eroded surface of the Newark, pp. 134, 135.

McGEHEE, M. **1883.**
Handbook of the State of North Carolina, exhibiting its resources and industries.
Raleigh, pp. i-vi, 1-154.
Contains a brief account of the Deep river and Dan river coal fields, pp. 24-25, 75-77, 82.

McKAY, A. W. **1866.**
The red sandstone of Nova Scotia.
British Assoc. Adv. Sci., Rep., No. 35.
A brief summary of facts and conclusions concerning the distribution, lithological character, fossils, geological age, etc., of the Newark rocks of Nova Scotia, pp. 66-67.

McKay's head, N. S. Rocks of (Gesner, '36, p. 254).

McKnightstown, Pa. Sandstone, conglomerate, etc., from (C. E. Hall, '78, p. 42).

McLENAHAN, S. **1852.**
[Observations and remarks on the Deep and Dan river coal fields, North Carolina.]
In report of Professor Emmons, on his geological survey of North Carolina (Executive document, No. 13).
Raleigh, 1852, pp. 168-173.
Describes briefly some of the local features of the coal fields mentioned, pp. 168-171.

Madison, N. C. Brief account of coal near (McGehee, '83, p. 76).
Coal near (Kerr, '75, p. 145).
Conglomerate near (Emmons, '52, p. 152).
Fossil tree-trunks found at (Emmons, '52, p. 148).
Section near (Emmons, '56, p. 259).
Sections with dips and strikes at (Emmons, '52, p. 151).
Thickness of sandstone at (Emmons, '57, p. 22).

Madison, N. J. Dip of sandstone near (H. D. Rogers, '40, p. 133).

Madisonville, N. J. Dip in shale at (Cook, '82, p. 30).

Magdalen islands. Mention of Newark rocks in (Marcou, '58, pp. 11, 65).
Possible Trias on (Richardson, '81, p. 8G).

MAHAN, D. H. **1871.**
[Trap rock as a building stone.]
In an elementary course of civil engineering, New York, p. 3.
Refers to the uses of the trap rock of the Palisades of New Jersey, and mentions its mineralogical composition (criticized by G. P. Merrill, see Merrill, '89, p. 435). Refers also to the sandstone of the Newark, pp. 4-5.

MAHAN [D. H.]. Cited on the mineralogical composition of trap rock (G. P. Merrill, '89, p. 435).

Maidenhead coal mine, Va. Account of (Wooldridge, '42, pp. 2-3).
Analysis of coal from (Clemson, '35. Clifford, '87, p. 10. Macfarlane, '77, p. 515. Williams, '83, p. 82).
Brief account of (Macfarlane, '77, p. 507).
Depth of (Taylor, '48, p. 49).
Explosion in (Taylor, '48, p. 49).

Map, geological, of North Carolina—Continued.
Showing outcrop of coal near the Gulf (Chance, '85, p. 38).
Showing position of coal-bearing areas (Kerr, '79).
Of Nova Scotia (Dawson, '45. Dawson, '78, 1st ed. Dawson, '78, map 2d and 3d ed. Gesner, '36. Jackson and Alger, '33).
Minas basin and Cobequid bay (Dawson, '47, pl. 5).
Of Pennsylvania (Frazer, '82, pl. [3]. Lesley, '86, op. p. 656. Lesley and d'Invilliers '85, frontispiece of volume. Macfarlane, '77, frontispiece. Putnam, '86c, pl. op. p. 179. H. D. Rogers, 58, vol. 2, in portfolio).
Adams county (Lesley and Frazer, '76).
Chester county (Frazer, '83, in pocket).
Cornwall iron mines near Lebanon (Lesley and d'Invilliers, '85).
Cumberland county (Lesley, '80).
Distribution of Newark rocks (C. E. Hall, '80, pl. op. p. 442).
Franklin county (Sanders, '81).
Fritz island mine (d'Invilliers, '83, in atlas).
Indicating drainage, etc., in Jurassic time (W. M. Davis, '89a, p. 233).
Iron mines near Boyertown (d'Invilliers, '83, in atlas).
Iron mines of Cumberland and York counties (d'Invilliers, '86, pl. op. p. 1437).
Iron ore deposits at Cornwall (d'Invilliers, 86a, p. 874).
Iron ore mines near Dillsburg (Frazer, '76d, pl. 2).
Lancaster county (Frazer, '80).
Lehigh and Northampton counties and a part of Berks county (d'Invilliers, '83, in atlas).
Mining districts of Chester and Montgomery counties (H. D. Rogers, '58, vol. 2, op. p. 674).
Near Philadelphia (C. E. Hall, '81, in pocket. C. E. Hall, '81, p. 21).
Newark rocks (Lesley, '64, op. p. 476).
Ore deposits in York and Adams counties (Frazer, '76, op. p. 64).
Pickering creek copper and lead mines (Lesley, '83, p. 177).
Portion of Montgomery and Bucks counties (Hall, '81, in pocket).
Trap dike across southeast Pennsylvania (Lewis, '85, pl. op. p. 440).
Trap dike near Flourtown, Pa. (C. E. Hall, '81, p. 23).
York county (Frazer, '80. Frazer, '85, pl. op. p. 391).
York and Adams counties (Frazer, '76, op. p. 196. Frazer, '77).
Of Prince Edward island, scale 25 miles to 1 inch (Dawson, '78, map, 2d and 3d ed. Dawson and Harington, '71, frontispiece. Ells, '84, accompanying).
Of South Carolina, Chesterfield county (Tuomey, '48. Lieber, '56, pl. 6).

Map, geological, of the United States.
(Brewer, '90. C. H. Hitchcock, '74, pl. 12. C. H. Hitchcock, '86. Hitchcock and Blake, '74. Macfarlane, '79, pl. op. p. 216. McGee, '84. Marcou, '55. Marcou, '58, frontispiece. Marcou, '58, frontispiece. Marcou, '58, pl. 9. H. D. Rogers, '56, pl. 8).
Of the United States and the British provinces (Marcou, '53, on map in vol. 2. Marcou, '55a).
Of the United States, Canada, etc. (Lyell, '45, vol. 2, pl. 2. Bradley, '75).
Of the United States, eastern part of (Cleaveland, '22, frontispiece. Le Conte, '82, p. 289. Maclure, '09).
Of Virginia (Hotchkiss, '76, op. p. 46. Hotchkiss, '80. Rogers, '84).
Black heath coal mines (Clifford, '87, pl. 4).
Deep run coal mine (Clifford, '87, pl. 5).
Eastern part of, showing distribution of Mesozoic rocks (Heinrich, '78, pl. 5).
Midlothian coal mine (Heinrich, '76, pl. 3).
Piedmont coal fields (Daddow and Bannan, '66, p. 395).
The Richmond coal field (Clifford, '87, pl. 1).
The western part of (Benton, '86, pl. op. p. 261).
Of the world (Prestwich, '86, vol. 1, pl. 1).
Showing Newark area (E. Hitchcock, '56).
Geological sketch, of the United States (Foster, '69, pl. op. p. 273. Lyell, '45, pl. op. p. 75 in New York edition. Macfarlane, '77, pl. op. p. 3. Steel, '74, frontispiece).
Of coal fields of the United States. Indicates the position of the Richmond, Deep river, and Dan river coal fields (Macfarlane, '77, pl. op. p. 626).
Newark area in the United States (Chance, '85, pl. op. p. 66).

Marble hall, Pa. Trap dike near (C. E. Hall, '81, p. 75. Lewis, '85, p. 441. H. D. Rogers, '58, vol. 1, p. 214).

March's mill, Pa. Dip of conglomerate at (d'Invilliers, '83, p. 202).
Strike and dip (d'Invilliers, '83, p. 213).

MARCOU, JULES. **1849.**
Note sur la houille du conté de Chesterfield, près de Richmond (État de Virginie).
In Bull. Soc. Géol. de France, 2d ser., vol. 6, 1848-1849, pp 572-575.
Reviews previous determination of the geological position of the Richmond coal field and proposes a new correlation based on additional evidence furnished by fossil plants and fishes.

MARCOU, JULES. **1853.**
A geological map of the United States and of the British provinces in North America; with an explanatory text, geological sections, and plates of the fossils which characterize the formations.

MARCOU, JULES—Continued.

Boston. [vol. 1], pp. i-viii, 1-92, pls. 1-8; [vol. 2], a geological map of the United States, etc.

For references to later editions of the geological map see Bulletin No. 7, 1884, of the U. S. Geological Survey.

Reviewed in Am. Jour. Sci., 2d ser., vol. 17, pp. 199-206; by W. P. Blake, ibid., vol. 22, pp. 383-388; by H. Agassiz, ibid., vol. 27, pp. 134-139.

Contains a list of synonyms of the Newark system and gives a brief account of the formation. A few characteristic fossils are figured, pp. 39-44, pls. 6-7.

Refers the Richmond area to the Trias, and the Newark rocks of North Carolina to the New Red sandstone.

MARCOU, JULES. 1855.

Résumé explicatif d'une carte géologique des États-Unis et des provinces anglaises de l'Amérique du Nord avec un profil géologique allant de la vallée du Mississippi aux côtes du Pacifique et une planche de fossiles.

In Bull. Soc. Géol. de France, 2d ser., vol. 12, pp. 813-936, pl. 21, and map.

Contains a general sketch of the characteristics, distribution, and stratigraphical relations of the Jura and Trias formations in North America. Discussion of the age of the Newark system.

MARCOU, JULES. 1855a.

Ueber die Geologie Vereinigten Staaten und der englischen provinzen von Nordamerika.

In Petermann's Mitth., vol. 1, 1855, pp. 149-159, and map 15.

Brief account of the extent and characteristics of the Newark system of North America.

MARCOU, JULES. 1858.

Geology of North America, with two reports on the prairies of Arkansas and Texas, the Rocky mountains of New Mexico, and the Sierra Nevada of California.

Zurich, 4to, pp. i-viii, 1-144, 1-8, pls. 1-9, and a geological map of the United States.

Contains many statements concerning the geological position of the Newark system.

MARCOU, JULES. 1859.

Reply to the criticisms of James D. Dana, including Dana's two articles, with a letter of Louis Agassiz.

Zurich, pp. 1-40.

A reply to certain criticisms in reference to Jules Marcou's observations on the geology of North America. Several reviews of Marcou's writings are reprinted.

MARCOU, JULES. 1875.

Explication d'une seconde édition de la carte géologique de la terre.

Zurich, 4to, pp. 1-222, pl. 1.

Contains a short sketch of general geology, in which brief references are made to the "Trias" and "Jura" of North America, pp. 43-55; and an account of the geology

MARCOU, JULES—Continued.

of North America in which brief notices are given of the writings of various geologists. On the small map at the end of the volume areas are indicated which are occupied by the "Trias" and "Dyas" combined.

MARCOU, JULES. 1888.

American geological classification and nomenclature.

Cambridge, Mass., pp. 1-75.

Refers briefly to the rocks of the Newark system, pp. 31-32, 73.

MARCOU, JULES. 1890.

The Triassic flora of Richmond, Va.

In Am. Geol., vol. 5, pp. 160-174.

A review of "Contribution to the knowledge of the older Mesozoic flora of Virginia," by W. M. Fontaine; "Sur la présence dans le grès bigarré, des Vosges, de l'Acrostichides rhombifolius, Fontaine" par René Zeiller; "Die Lunzen-(Lettenkohlens)-Flora in den "older Mesozoic beds of the coal field of eastern Virginia," by D. Stur; and "Fossil fishes and fossil plants of the Triassic rocks of New Jersey and the Connecticut valley," by J. S. Newberry.

MARCOU, J. Cited on the age of the Newark system (Dewey, '57. Jones, '62, p. 134. Lea, '58. Newberry, '88, p. 9. Zeiller, '88, p. 698).

Richmond coal field, Virginia (Hull, '81, p. 460).

MARCOU, J. Cited on extent of the Triassic rocks in America (Archiac, '60, pp. 633-638).

Geological map of North America (Marcou, '59, pp. 26-30).

Newark flora (Marcou, '90).

Reproduction of geological map of the world by (Prestwich, '86, vol. 1, pl. 1).

Review of geology of North America by (Agassiz, '59. J. D. Dana, '59).

Margaretville, N. S. Copper at (How, '69, p. 66. Willimott, '84, p. 20, L. ? 25, 26 L.).

Margerum's, S., quarry near Princeton, N. J. Description of (Cook, '81, p. 55).

Maria furnace, Pa. Iron ore near (H. D. Rogers, '58, vol. 2, p. 690).

Trap dikes near (H. D. Rogers, '58, vol. 2, p. 690).

Mariner's harbor, Staten island. Newark outcrop near (Hollick, '89).

Marion, N. J. Trap rock at (Ward, '79, p. 150).

Marion, Pa. Boundaries of the Newark in (C. E. Hall, '81, pp. 83-84).

Marlboro, Conn. Description of trap dikes in primary rocks near (Percival, '42, pp. 423-424).

Marls in North Carolina. (Kerr, '75, p. 187).

MARSH, DEXTER. 1848.

[On the discovery of footprints in the sandstone of the Connecticut valley.]

In Am. Jour. Sci., 2d ser., vol. 6, pp. 272-274).

Describes the finding of footprints at several localities in the Connecticut valley.

Massachusetts sections—Continued.

Showing junction of trap and sandstone (W. M. Davis, '83, pp. 305-307, pl. 10).

Through (Walling, '78, pl. op. p. 192).

West Springfield, showing trap and sandstone (W. M. Davis, '83, pp. 305-307, pl. 10).

MATHER, W. W. 1834.

[New locality for fossil fish in the Connecticut valley.]

In Neues Jahrbuch, 1834, pp. 531-532.

Describes a new locality for fossil fish 20 miles from New Haven, Conn., where the geological relations are the same as at Sunderland and Middlesex.

MATHER, W. W. 1838.

Report of W. W. Mather, geologist of the first geological district of the state of N[ew] Y[ork].

In second annual report of the geological survey of New York.

Albany, pp. 121-183.

Contains a brief reference to the trap rocks near Tompkinsville, Staten island, N. Y., p. 140.

MATHER, W. W. 1839.

Third annual report of W. W. Mather, geologist of the first geological district of the state of New York.

In third annual report of the geological survey of New York.

Albany, pp. 69-134.

Contains an account of the sandstone and associated trap of Richmond and Rockland counties, N. Y., pp. 116-117, 122-127, 132.

MATHER, WILLIAM W. 1843.

Natural History of New York, Part IV. Geology, Part I. Containing the geology of the first geological district.

Albany, 4to, pp. i-xxxvii, 1-655, pls. 1-46.

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On the physical geology of the United States east of the Rocky mountains and on some of the causes affecting the sedimentary formations of the earth.

In Am. Jour. Sci., vol. 49, pp. 1-20, 284-301.

Brief statement of hypothesis concerning the mode of formation of the Newark sandstone along the Hudson river, p. 14.

MATHER, W. W. Cited on the age of the Newark system (H. D. Rogers, '44, p. 250).

Cited on the cause of the tilting of the Newark (W. M. Davis, '83, p. 303).

Cited on the conglomerate of Rockland county, N. Y. (Lea, '53, p. 190).

Cited on the mode of formation of the Newark system (Lea, '53, pp. 191-192).

Cited on the Newark rocks on Staten island (Hollick, '89).

Cited on trap dikes under the Palisades, N. Y. (W. M. Davis, '83, p. 292).

Notice of work by (Miller, '79-'81, vol. 2, p. 148).

MATTHEW, G. F. 1863.

Observations on the geology of St. John county, New Brunswick.

In Canadian Nat., vol. 8, pp. 241-259.

Contains a small map showing Newark rocks at Quaco Head, p. 248.

Notices briefly the unconformity of the Newark near Gardner's creek with the upturned Carboniferous rocks beneath, pp. 256, 258. Appended is a note by J. W. Dawson on fossil plants.

MATTHEW, GEO. F. 1865.

[Report on the] New Red sandstone or Trias [of New Brunswick].

In observations on the geology of southern New Brunswick, made principally during the summer of 1864 by Prof. L. W. Bailey, Messrs. Geo. F. Matthew, and C. F. Hartt, prepared and arranged, with a geological map, by L. W. Bailey, pp. 123-125, 129, and map.

Some errors in reference to the age of certain rocks made by Abraham Gesner, in reports on the geological survey of New Brunswick, from 1839-1841, are pointed out. The localities of Newark rocks are described in detail, together with descriptions of lithological characters, dip, trap intrusions, etc., pp. 123-125. On p. 129 is a table giving a "classification of the sediments of southern New Brunswick on physical grounds."

MATTHEW, G. F. 1865a.

On the Azoic and Paleozoic rocks of southern New Brunswick.

In London, Geol. Soc., Quart. Jour., vol. 21, pp. 422-433, and map.

The map accompanying this paper shows the location of several Newark areas along the southeast shore of New Brunswick.

MATTHEW, G. F. **1878.**
Report on the slate formation of the northern part of Charlotte county, New Brunswick, with a summary of geological observations in the southeastern part of the same county.
In geological survey of Canada. Report of progress for 1876-'77.
Montreal, 1878, pp. 321-350.
A single paragraph on p. 339 refers to the relation of the Upper Silurian and Newark rocks of Grand Manan island, N. B.

MATTHEW, G. F. **1880.**
Report on the geology of southern New Brunswick, embracing the counties of Charlotte, Sunbury, Queens, Kings, St. John, and Albert.
See Bailey, Matthew, and Ells, 1880.

MATTHEW, S. F. Cited on overflow trap sheets on Grand Manan island (W. M. Davis, '84, p. 297).
Cited on trap dikes on Grand Manan island, N. B. (W. M. Davis, '83, p. 291).
Notice of work done by, in New Brunswick (Miller, '79-'81, vol. 2, p. 156).

May, Pa. Trap dikes at (Lesley, '85, p. lxiv.

MEADE, WILLIAM. **1827.**
Remarks on the anthracite of Europe and America.
In Am. Jour. Sci., vol. 12, pp. 75-83.
Refers to the supposed absence of coal in the Newark system.

Meads basin, N. J. Course of trap ridge near (Cook, '82, pp. 54-55).
Description of trap hill near (Cook, '68, pp. 185, 186).

Mechanic copper mine, N. J. Description of (H. D. Rogers, '40, pp. 163-164).

Mechanics grove, Pa. Description of trap dike near (Frazer, '80, p. 30).

Mechanicsville, Pa. Description of trap dikes near (C. E. Hall, '81, pp. 19-20, 84).
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Trap dikes near (C. E. Hall, '81, p. 19-20. Lewis, '85, p. 443).

Medford, Mass. Character of trap rock quarried at (G. P. Merrill, '84, p. 24).

Melick hill, N. J. Description of (Cook, '82, p. 65).

Melaphyre trap in New Jersey. Brief account of (Credner, '70).

Mendham, N. J. Boundary of the Newark near (H. D. Rogers, '40, p. 118).

Meriden, Conn. Ash bed near, popular account of (W. M. Davis, '91).
Brief account of trap near (E. Hitchcock, '23, vol. 6, p. 49).
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Description of quarry near (Davis and Whittle, '89, pp. 112-113).
Description of trap ridges near (Percival, '42, p. 371).
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Discussion of the origin of topographic features near (W. M. Davis, '89c).
Excursion to the Hanging hills of (J. D. Dana, '70).
Extrusive character of the Hanging hills near (W. M. Davis, '82a, pp. 122-123).
Faults near (W. M. Davis, '89b, p. 29).
Filling of fissures in trap (W. M. Davis, '90).
Map of trap ridges and faults near (W. M. Davis, 89c, p. 424).
Mines near (C. H. S. Davis, '70).
Notice of a bed of volcanic ash near (Chapin, '89).
Overflow trap sheets near (W. M. Davis, '88 p. 464).
Reference to exposure in quarry near (Davis and Whittle, '89, p. 121).
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Sketch map of Hanging hills in (W. M. Davis, '83, pp. 305-307, pl. 10).
Sketch of the geology of (C. H. S. Davis, '70).
Special account of quarries at (Davis and Whittle, '89, pp. 127-133).
Topographic form of trap ridge near (Percival, '42, p. 301).
Trap ridges near (Davis and Whittle, '89, pp. 107-110. Percival, '42, pp. 348, 349, 364).

Meriden, New Britain district, Conn. Map of, with cross-section and distant view (W. M. Davis, '89, pl. 5).

Meridian Hill, Conn. Amygdaloid at (E. S. Dana, '75).

Meriwether, Ga. Brief account of trap dikes in (Henderson, '85, p. 88).

Meriwether county, Ga. Trap dikes in (T. P. James, '76, p. 38 and map. Loughridge, '84, p. 279).

MERRICK [S. V.]. **1851.**
[Remarks on recent and fossil raindrop impressions.]
In Am. Assoc. Adv. Sci., Proc., vol. 5, pp. 74-75.
Compares recent raindrop impressions with fossil impressions which are believed to have had a similar origin.

MERRILL, FREDERICK J. H. **1890.**
Some ancient shore lines and their history.
Abstract in New York Acad. Sci., Trans., vol. 9, pp. 78-82.

MERRILL, FREDERICK J. H.—Continued.

Discusses the origin of the structure of the Newark rocks of New Jersey.

MERRILL, G. P. 1884.

Microscopical structure [of building stone].

In report on the building stones of the United States, and statistics of the quarry industry for 1880. In Tenth Census of the United States, vol. 10 [part 2], pp. 15–29, pls. 1–18.

Describes the microscopic characteristics of the trap rock and sandstone of the Newark system, pp. 24, 26, pls. 8, 13.

MERRILL, GEORGE P. 1889.

The collection of building and ornamental stones in the U. S. National Museum: a handbook and catalogue.

In Smithsonian Inst. Ann. Rep. for 1885–'86, pp. 277–648, pl. 1–9.

Describes the microscopical character of sandstone and trap, pp. 403–404, pl. 9, and gives brief accounts of the trap and sandstone quarries, pp. 433–436, 445–460, pl. 9; catalogue of samples of sandstone trap in U. S. National Museum.

Mertensides. Description of genus (Fontaine, '83, p. 35).

Metamorphism. Absence of, in connection with the trap dikes of the Richmond coal field, Virginia (Stevens, '73).

In Newark rocks of New Brunswick (Matthew, '65, p. 129).

Adjacent to the trap rocks of New Jersey (Cook, '87).

Below trap sheet in the Richmond area (W. B. Rogers, '54*b*).

Contact. As a means of distinguishing between extrusive and intrusive trap sheets (Davis and Whittle, '89, pp. 100–104).

Discussed (E. Hitchcock, '35, pp. 433–434. H. D. Rogers, '36, pp. 162, 165–166).

Contact, in Connecticut (Davis and Whittle, '89. Hovey, '89, pp. 369–375. Percival, '42, pp. 436–438, 441).

About New Haven described (J. D. Dana, '71, pp. 46–47).

At Enfield. A reference to coal altered by trap (E. Hitchcock, '41, pp. 139–140).

At Gaylords mount. Description of (W. M. Davis, '89*b*, p. 25).

At Rocky hill (Silliman, '30, p. 123–130).

In Connecticut valley (Emerson, '87, pp. 19–20. E. Hitchcock, '41, pp. 657–659).

In connection with trap dikes in the Primary rocks of (Percival, '42, p. 317).

In connection with the trap rocks, detailed description and discussion of (W. M. Davis, '83).

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In southern part of, description and discussion of (Hovey, '89, pp. 373, 374, 378).

Metamorphism, contact, in Connecticut—Cont'd.

Mention of Meriden areas (C. H. S. Davis, '70).

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Observations on, in connection with the trap sheets of (Davis and Whittle, '89).

In Massachusetts, an account of (E. Hitchcock, '35, pp. 421–425).

At the Simsbury copper mines (E. Hitchcock, '35, p. 229).

In brecciated conglomerate near Turners Falls (E. Hitchcock. '35, p. 216).

In New Jersey (Cook, '68, pp. 212–214, 679. Cook, '74, pp. 56–57). Cook, '82, pp. 60, 61, 62. Cook, '83, pp. 23–24. Cook, '83, pp. 23–26, 164–165, and plate).

Adjacent to trap sheets (Darton, '90).

At Belle mountain (H. D. Rogers, '40, pp. 151–152).

At Blackwell's mills (Cook, '68, p. 204).

At Goat hill (Rogers, '36, p. 156).

At Kings point (Darton, '83*a*).

At Paterson (J. H. Hunt, '90).

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At Point Pleasant (Cook, '68, p. 192).

At Rocky hill (J. D. Dana, '43, pp. 113–114).

At Round mountain (Cook, '68, p. 194).

At Sourland mountain (Cook, '68, p. 191. H. D. Rogers, '40, pp. 152–158).

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In connection with the trap rocks of (H. D. Rogers, '40, pp. 145–158).

In shales and sandstones beneath the trap of the Palisades (Russell, '80, pp. 35–45).

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Near Lambertsville (H. D. Rogers, '36, pp. 161–162).

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Near Plainfield, mention of (Russell, '80, p. 41).

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In New York, beneath the Palisades (Mather, '43, p. 285).

In Rockland county (Mather, '43, pp. 288–289).

Near Closter (Darton, '90, p. 51).

In North Carolina, brief reference to (Tuomey, '46, pp. 48, 68).

In the Deep river coal field (Wilkes, '58, p. 7).

In Nova Scotia (Chapman, '78, p. 112. Jackson and Alger, '33, pp. 266–267, 278, 280, 286).

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Section of rocks exposed in quarry at (Finch, '26, pp. 209–211).
Trap rock in driven well at (Ward, '79, p. 150).
Wells bored in, records of (Nason, '89*b*).

Newark bay shore, N. J. Boundary of trap outcrop along (Cook, '68, p. 177).
Exposure of Newark sandstone and shale in (Britton, '81, p. 168).
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Newark mountain, N. J. Description of (H. D. Rogers, '40, p. 146).
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New Baltimore, Va. Boundary of the Newark near (W. B. Rogers, '40, p. 63).

New Berlin, Pa. Trap dikes and dip of strata near (d'Invilliers, '83, p. 206).

NEWBERRY, J. S. 1866.
Description of fossil plants from the Chinese coal-bearing beds. In geological researches in China, Mongolia, and Japan during the years 1862–1865, by Raphael Pumpelly. Appendix, pp. 119–123, pl. 9.
In Smith. Inst., Contrib. Knowl., vol. 15, pp. 1–143, pls. 1–9.
The fossils described in this paper are stated to be of Jurassic or Triassic age, and are compared with similar fossils from Abiquiu, N. Mex., Sonora, Mexico, and North Carolina.

NEWBERRY, J. S. 1870.
[Remarks on the genesis of the Newark sandstones contiguous to the Palisades, N. J.]
In New York Lyc. Nat. Hist., Proc., vol. 1, 1870–1871, pp. 131, 133–134, 137.
Dissents from the hypothesis proposed by H. Wurtz, to the effect that the sandstones adjacent to the Palisades of the Hudson were derived from the disintegration of trap rock. Gives analysis of sandstone and trap.

NEWBERRY, J. S. 1873.
[Remarks on copper ores in the Triassic sandstones of the United States.]

NEWBERRY, J. S.—Continued.
In New York Lyc. Nat. Hist., Proc., 2d ser., vol. 2?, 1874, pp. 16–17.
Describes the frequent occurrence of the ores of copper in the Triassic sandstones of New Mexico and Texas, and mentions that a similar impregnation of sandstone with copper is common in the Newark system.

NEWBERRY, J. S. 1876.
Descriptions of the Carboniferous and Triassic fossils collected on the San Juan exploring expedition, under the command of Capt. J. N. Macomb, U. S. Engineers.
In report of the exploring expedition from Santa Fe, N. Mex., to the junction of the Grand and Green rivers of the great Colorado of the West, in 1859, under the command of Capt. J. N. Macomb, with geological report by Prof. J. S. Newberry, Washington (Engineer's Department, U. S. Army), 4to, pp. 135–148, pls. 1–8).
Some of the plants described are found also in the Newark.

NEWBERRY, J. S. 1878.
Description of new fossil fishes from the Trias.
In New York Acad. Sci., Ann., vol. 1, 1879, pp. 127–128.
Abstract in Am. Jour. Sci., 3d ser., vol. 16, p. 149; and in Neues Jahrbuch, 1879, p. 110.
Describes the negus Diplurus, represented by *D. longicaudatus*, from Boonton, N. J., and *Ptycholepis marshi*, from Durham, Conn. Concludes with brief remarks on the age of the system.

NEWBERRY, J. S. 1883.
[Remark on the intrusive character of the trap of Bergen hill, N. J.]
In New York Acad. Sci., Trans., vol. 2, 1882–1883, p. 120.
Refers to an investigation by P. Schweitzer, demonstrating the difference between the trap of Bergen hill and the associated sandstone.

NEWBERRY, J. S. 1885.
[Remarks on the geological position of the Triassic and Jurassic rocks of America.]
In New York Acad. Sci., Trans., vol. 5, 1885–1886.
States the geological position of the Newark system, as shown by the fossil plants and fossil fishes, pp. 17–20.

NEWBERRY, J. S. 1887.
[Remark on the former extent of the Newark system.]
In New York Acad. Sci., Trans., vol. 7, p. 39.
States that the occurrence of Cretaceous strata resting on the crystalline rocks of Staten island, indicates the existence there during secondary times, of a region of separation between the Newark areas of Connecticut and New Jersey.

NEWBERRY, JOHN S. **1888.**
Fossil fishes and fossil plants of the Triassic rocks of New Jersey and the Connecticut valley.
U. S. Geol. Surv., Monograph vol. 14, 4to, pp. i-xiv, 1-152, pls. 1-26, reviewed by J. Marcou, in Am. Geol., vol. 5, pp. 160-174.
Abstract in New York Acad. Sci., Trans., vol. 6, 1866-1887, pp. 124-128.
Notice in Am. Jour. Sci., 3d ser., vol. 37, pp. 77-78; and in Am. Geol., vol. 4, 187-188.
Gives a short account of the distribution and of the principal features of the Newark system; presents the views of previous authors as to its age; discusses its relations with similar terranes in the Rocky mountain region and in Europe, pp. 1-17.
Fishes: Reviews previous studies of the fossil fishes, and a list of those now known, pp. 19-23. Description of genera and species, principally from New Jersey and the Connecticut valley, pp. 24-76, illustrated by pls. 1-20.
Plants: Sketch of the flora with special reference to the fossil plants of the Connecticut valley and New York-Virginia (Palisade) areas, pp. 79-81. Description of genera and species, pp. 82-95, illustrated by pls. 21-26.

NEWBERRY, J. S. **1888a.**
Triassic plants from Honduras.
In New York Acad. Sci., Trans., vol. 7, 1887-1888, pp. 113-115.
Preliminary publication of a paper subsequently printed under the title Rhætic plants from Honduras, in Am. Jour. Sci., 3d ser., vol. 36, pp. 342-351, pl. 8.

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In Am. Jour. Sci., 3d ser., vol. 36, pp. 342-351, pls. 8.
Compares some of the fossils described with similar plants from the Newark.

NEWBERRY, J. S. **1890.**
On *Dendrophycus triassicus.*
In Am. Nat., vol. 24, pp. 1068-1069.
A reply to J. F. James, in reference to the fossil mentioned, being of organic and not of inorganic origin.

NEWBERRY, J. S. Cited in the cause of the red color of the Newark sandstones (Russell, '82, p. 52).
Cited on fossil plant from Connecticut (Chapin, '91*a*).
Review of report on fossil fishes and fossil plants by (Marcou, '90).

Newberry, Pa. Contact metamorphism near (H. D. Rogers, '58, vol. 2, p. 688).
Trap dikes near (H. D. Rogers, '58, vol. 2, p. 688).

New bridge point, Pa. Dip of Newark rocks near (Lewis, '85, p. 452).

New Britain, Conn. Detailed study of the geological structure near (W. M. Davis, '89).
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New Brunswick. Brief account of the Newark system in (Bailey, Matthew and Ells, '80, pp. 2-23D and maps. Matthew, '63).
Brief note on contact of Newark and Carboniferous in (Bailey, '85).
Brief note on fossil wood from Gardner's creek (J. W. Dawson, '63).
Brief reference to the geology of (Russell, '78, p. 220).
Catalogue of mineral localities in (Marsh, '63).
Copper ore on Grand Manan, occurrence of (Chapman, '35).
Description and discussion of Newark rocks of (Dawson, '78).
Description of Grand Manan island (Verril, '78).
Geological map of (Bailey, '65. Dawson, '78, map. Logan, '65, map No. 1. Matthew, '65, map).
Geological sketch of (Credner, '65).
Newark on Grand Manan island (Matthew, '78, p. 339).
Newark rocks of, reference to (Dawson, '78, pp. 86-87).
Report on (Matthew, '65).
Summary concerning (Chapman, '78, p. 106).
Newark system in, former extent of (Dawson, '78, p. 108).
General remarks on (Dawson, '78, pp. 109-113).
Observations on the geology of (Bailey, '65).
Report on the geological survey of (Gesner, '39. Gesner, '40. Gesner, '41. Gesner, '42. Gesner, '43*a*).
Sections, Gardner's creek (Gesner, '41, p. 14).
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New Brunswick, N. J. Abandoned quarries near (Cook, '81, p. 55).
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Dip in sandstone near (Cook, '82, p. 25).
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Minerals obtained near (Beck, '39).

Nova Scotia—Continued.
Topographic form of, remarks on the (Percival, '42, pp. 311-312).

NILES, W. H. 1870.
Some interesting phenomena observed in quarrying.
In Boston Soc. Nat. Hist., Proc., vol. 14, pp. 80-87.
Refers to Prof. John Johnson's observations on movements in the rocks at Portland, Conn., and describes the condition of the quarries at that locality as seen during a subsequent visit.

NILES, W. H. 1873.
On some expansions, movements, and fractures of rocks observed at Monson, Mas-s[achusetts].
In Am. Assoc. Adv. Sci., Proc., vol. 22, pp. 156-163.
Quotes observations by J. Johnson on spontaneous movements in rocks at Portland, Conn.

Nishisakawick creek, N. J. Dip at (Cook, '68, p. 198).
Dip in shale at (Cook, '82, p. 27).

Nissely's mill, Pa. Boundary of the Newark near (Frazer, '80, p. 35).

NUTTALL, THOMAS. 1821.
Observations on the geological structure of the valley of the Mississippi.
In Philadelphia Acad. Nat. Sci. Jour., vol. 2, pt. 1, pp. 14-52.
Contains a brief account of the Richmond coal field, Va., pp. 35-37.

NUTTALL, THOMAS. 1822.
Observations and geological remarks on the minerals of Paterson and the valley of Sparta, in New Jersey.
In Am. Jour. Sci., vol. 5, p. 239-248.
Describes briefly the sandstone and trap between Paterson and Pompton, N. J., pp. 239-241.

NUTTALL, T. Cited as to the age of the coal fields of North Carolina (Emmons, '56, p. 271).
Cited on fossil fishes from the Richmond coal field, Va. (W. B. Rogers, '43, p. 300).
Cited on fossil plants from the Richmond coal field, Va. (Taylor, '48, p. 46).
Cited on the Richmond coal field, Va. (Taylor, '35, p. 289).

Nyack, N. Y. Dip and strike near (Mather, '43, p. 617).
Earth, charcoal, bones, etc., beneath Red sandstone (Akerly, '20, pp. 36, 59-60).
Quarries near (Mather, '43, p. 287).
Sandstone quarries near (Mather, '39, pp. 125-126).
Supposed fossil bone found near, mention of (Mitchill, '28, p. 9).
Trap near, outcrops of (Darton, '90, p. 38).
Trap rock near, brief account of (Mather, '39, p. 117).
Unconformity of trap and sandstone near Darton, '90, p. 48).

Oak island, N. S. Dip of sandstone on (Dawson, '78, p. 92).
Exposure of Newark sandstone at (Dawson, '47, p. 57).

Oakland, N. J. Trap hill near (Cook, '82, pp. 48, 49).
Trap ridge near, course of (Nason, '89, p. 34).

Oak mountain, Ga. Trap dikes in (Loughridge, '84, p. 279).

Oil in North Carolina. Brief account of (Kerr, '66, p. 46. N. C. Land Co., '69, p. 104).

OLDHAM. Cited on the age of the Richmond coal field, Va. (Hull, '81, p. 460).

Oldham creek, N. J. Boundary of First mountain trap near (Cook, '68, p. 181).

Old Fuller iron mine, Pa. Description of (d'Invilliers, '86, pp. 1513-1514).

Old Provost quarry, N. J. Dip in sandstone at (Cook, '82, p. 25).

OLMSTEAD, D. 1820.
Red sandstone formation of North Carolina.
In Am. Jour. Sci., vol. 2, pp. 175-176.
Mentions the character and extent of the Newark rocks between Chapel Hill and Raleigh, N. C., and also the discovery of coal on Deep river, N. C.

OLMSTEAD, DENISON. 1824.
Report on the geology of North Carolina, conducted under the direction of the Board of Agriculture.
[Place of publication not given] pp. 1-44.
Review in Am. Jour. Sci., 2d ser., vol. 14, pp. 226-251.
Contains a brief, general account of the Deep river coal field.

OLMSTEAD, DENISON. 1827.
Report on the geology of North Carolina, 1825.
In papers on agricultural subjects, and Professor Olmstead's report on the geology of North Carolina. Raleigh, pp. 85-142.
Contains a brief account of the Dan river area; refers to the occurrence of building stone and coal, pp. 125-128.

OLMSTEAD, D. Cited on the Deep river coal field, N. C. (W. R. Johnson, '51, pp. 4-5).
Cited on the extent of the Newark in North Carolina (Wilkes, '58, p. 2).
Cited on trap dikes in North Carolina (W. M. Davis, '83, p. 293).

Olmstead's mill, N. J. Dip of shale at (Cook, '79, p. 30).

O'Neil's quarry, N. J. Boundary of Second mountain trap at (Cook, '68, p. 184).

One-mile run, N. J. Dip at (Cook, '68, p. 196).

Onslow, N. S. Newark rocks near (Marsters, '90).

Orange, N. J. Bored well and spring near, with analysis of water (Cook, '85, pp. 118-122).
Bored well at (Cook, '84, pp. 132-135).
Boundary of First mountain trap near (Cook, '68, pp. 180, 181).
Columnar trap at (Cook, '84, pp. 23-28. Darton, '90, p. 24).
Columnar trap near, description of (Iddings, '86).
Popular description of (Heilprin, '84).

Reamstown, Pa. Boundary of the Newark near (Frazer, '80, p. 43. H. D. Rogers, '58, vol. 2, p. 668).

REDFIELD, JOHN HOWARD. 1836.
Fossil fishes of Connecticut and Massachusetts, with a notice of an undescribed genus.
In New York Lyc. Nat. Hist., Ann., vol. 4, 1848, pp. 35-40, pls. 1-2.
Abstract in Neues Jahrbuch, 1839, pp. 248-253.
Refers to localities in the Connecticut valley where fossil fish have been obtained. Mentions previous studies of the fossils in question, and describes and figures *Catopterus gracilis*. Describes, also, another fossil fish, the name of which is not determined. Concludes with brief remarks on the age of the rocks from which the fossil were obtained.

REDFIELD, JOHN H. 1841.
[Zoölogical analogies of *Catopterus gracilis*].
In Final Report Geol. of Massachusetts, by E. Hitchcock. Amherst and Northampton, 1841, 4to, p. 440.
Extract from a letter to E. Hitchcock in which the characteristics of the tail of the fossil fish referred to are briefly discussed.

REDFIELD, JOHN H. 1856.
[Extract from a report to the American Association for the Advancement of Science on the fossil fishes of the United States].
In a paper on the relation of the fossil fishes of the sandstone of Connecticut and other Atlantic states to the Triassic and Jurassic periods, by W. C. Redfield.
In Am. Assoc. Adv. Sci., Proc., vol. 10, pp. 183-185.
Refers to the characteristics of the fishes of the Newark system, and states opinion with respect to geological age.

REDFIELD, J. H. Cited on the age of the Connecticut valley sandstone (J. D. Dana, '56, p. 322. E. Hitchcock, '58, p. 5).

REDFIELD, J. H. Cited on the age of the Newark, as indicated by fossil fishes (W. C. Redfield, '56, pp. 181-187).
Cited on Catopterus from Middletown, Conn. (E. Hitchcock, '41, p. 440).
Cited on *Catopterus gracilis* (C. H. S. Davis, '87, p. 20).
Cited on early discovery of fossil fishes in the Newark system (Newberry, '88, pp. 19-20).
Cited on fossil fishes (E. Hitchcock, '41*b*, p. 244. Newberry, '88. W. C. Redfield, '56*a*, pp. 357-361. H. D. Rogers, '44, p. 251).
Cited on fossil fishes from Connecticut (Anonymous, '38).
Cited on fossil fishes from the Connecticut valley (E. Hitchcock, '41, p. 460. H. D. Rogers, '58, vol. 2, p. 694).
Cited on fossil fishes from the Housatonic valley, Conn. (Redfield, '41, p. 27).
Cited on genus Catopterus (Egerton, '49, pp. 4, 8. W. C. Redfield, '56*a*, p. 361).
Extract from report on fossil fish (W. C. Redfield, '56*a*, pp. 359-361).

REDFIELD, J. H.—Continued.
List of fossil fishes from New Jersey and the Connecticut valley described by (De Kay, '42).

REDFIELD, J. H., and W. C. REDFIELD. 1857.
On the relation of the post-Permean fishes of Connecticut and other Atlantic states to the Triassic and Jurassic periods.
In Edinburg new Philosophical Journal, n. s., vol. 5, pp. 369-370).
An abstract of a paper read by W. C. Redfield at the meeting of the American Association at Albany, N. J. Published in Am. Assoc. Adv. Sci., Proc. [vol. 10], tenth meeting, 1856, pp. 180-188.

REDFIELD, J. H. and W. C. Cited on the age of the Newark (H. D. Rogers, '44, p. 248).

R[EDFIELD, W. C.]. 1838.
Newly discovered ichnolites [at Middletown, Conn.].
In Am. Jour. Sci., vol. 33, pp. 201-202.
Mentions discoveries of fossil footprints in the Connecticut valley, by E. Hitchcock and R. Warner.

REDFIELD, WILLIAM C. 1838a.
Fossil fishes in Virginia.
In Am. Jour. Sci., vol. 34, p. 201.
Brief note referring to a specimen shale with numerous fossil fishes on it, found in the Richmond coal field, Va.

R[EDFIELD, W. C.]. 1839.
[Note on fossil fishes from New Jersey.]
In Am. Jour. Sci., vol. 36, pp. 186-187.
Fossil fishes from Morris county, N. J., are stated to be *Catopterus gracilis* and a species of Palæoniscus, both of which have been found in the sandstone of the Connecticut valley. A previous notice of the fossils mentioned in this article may be found in Am. Jour. Sci., vol. 35, p. 192.

REDFIELD, W. C. 1841.
Short notices of American fossil fishes.
In Am. Jour. Sci., vol. 41, pp. 24-28; abstract in Am. Jour. Sci., vol. 41, pp. 164-165, and also in Am. Assoc. Geol. and Nat., Proc., 1840-1842, pp. 17-18.
Describes several species of Palæoniscus and Catopterus from the Connecticut valley and New Jersey. Remarks on the wide distribution of species in the Newark system.

REDFIELD [W. C.]. 1842.
[Concerning raindrop impressions, footprints, and fossil fishes from the New Red sandstone of New Jersey and the Connecticut valley.]
In Am. Jour. Sci., vol. 43, p. 172; also in Am. Assoc. Geol. and Nat., Proc., 1840-1842, p. 65.
Mentions an observation of fossil raindrop impressions at Newark, N. J.; and also notes the discovery of fossil footprints and fossil fishes in the sandstone of the Connecticut valley.

REDFIELD, W. C. 1842a.
[On some newly discovered ichthyolites in the New Red sandstone of New Jersey.]

REDFIELD, W. C.—Continued.
In London Geol. Soc., Proc., vol. 4, 1845, p. 23.
Mentions newly discovered fossil fish associated with tracks and rain marks.

REDFIELD, W. C. 1843.
Notice of newly discovered fish beds and a fossil footmark in the Red sandstone formation of New Jersey.
In Am. Jour. Sci., vol. 44, pp. 134–136.
Describes the occurrence of fossil fish, a fossil footprint, together with raindrop and hail impressions, and ripple marks produced by waves, at Pompton, N. J.

REDFIELD, W. C. 1843a.
Remarks on some new fishes and other fossil memorials from the New Red sandstone of New Jersey.
In Am. Jour. Sci., vol. 45, pp. 314–315.
Abstract of remarks concerning the age of the Red sandstone of New Jersey as indicated by fossil fish. Mentions also the occurrence of footprints and raindrop impressions.

REDFIELD, WILLIAM C. 1851.
On the post-Permian date of the Red sandstone rocks of New Jersey and the Connecticut valley, as shown by their fossil remains. (Abstract.)
In Am. Assoc. Adv. Sci., Proc., vol. 5, pp. 45–46.
Abstract in Ann. Sci. Discov., 1852, p. 259.
Reference to papers by C. T. Jackson, which assigned the Newark system to the Silurian, and also to the claim of unconformity in the Newark, suggested by D. A. Wells. The conclusion reached is that the Newark presents an unbroken series, and is characterized by a fauna and flora as recent as the Trias.

REDFIELD, W. C. 1851a.
On the fossil rain marks found in the Red sandstone rocks of New Jersey and the Connecticut valley, and their authentic character.
In Am. Assoc. Adv. Sci., Proc., vol. 5, pp. 72–75.
Describes fossil raindrop impressions found at Pompton, N. J., and discusses the nature of their origin.

REDFIELD, W. C. 1856.
On the relations of the fossil fishes of the sandstones of Connecticut and other Atlantic states to the Liassic and Jurassic periods.
In Am. Assoc. Adv. Sci., Proc., vol. 10, 1857, pt. 2, pp. 180–188.
Abstract in Edinburg New Philosophical Journal, n. s, vol. 5, 1857, pp. 369–370; also in Am. Sci. Discov., 1857, p. 338.
Reviews the evidence furnished by the fossil fishes of the Connecticut valley, New Jersey, etc., in reference to the age of the deposits containing them. Proposes the name Newark group.

REDFIELD, W. C. 1856a.
On the relations of the fossil fishes of the sandstones of Connecticut and other Atlantic states to the Liassic and Oölitic periods.

REDFIELD, W. C.—Continued.
In Am. Jour. Sci., 2d ser., vol. 22, pp. 357–363.
Abstract in Neues Jahrbuch, 1857, pp. 87–88.
Reviews the progress that has been made in the study of the fossil fishes of the Newark system, and discusses the question of the age of the system, as indicated by the fossils referred to above.

REDFIELD, W. C. 1857.
On the relation of the post-Permian fishes of Connecticut and other Atlantic states to the Triassic and Jurassic periods.
See Redfield and Redfield, 1857.

REDFIELD, W. C. Adoption of the name, "Newark system," proposed by (Russell, '89*a*).
Cited on age of the Connecticut valley sandstone (E. Hitchcock, '58, p. 5).
Newark system (Lea, '53, p. 193. Lea, '58. Taylor, '48, p. 46).
Red sandstone of New Jersey, Virginia, etc. (J. D. Dana, '56, p. 322).
Cited on Catopteris from the Richmond coal field, Va. (H. D. Rogers, '44, p. 251).
Cited on fossil fishes (C. H. Hitchcock, '71, p. 21. E. Hitchcock, '41*b*, p. 244. Newberry, '88, in many places).
Cited on fossil fishes from Boonton and Pompton, N. J. (Lea, '53, p. 193).
Connecticut valley (Lyell, '66, p. 456).
Richmond coal field, Va. (Lyell, '47, p. 276, pls. 8, 9. W. B. Rogers, '43, pp. 301, 315).
Cited on fossil footprints in New Jersey (E. Hitchcock, '43*a*, pp. 255, 303. Lea, '53, p. 185).
Cited on fossil plants at Little Falls, N. J. (Lea, '53, p. 193).
Cited on genus Catopterus (Egerton, '49, p. 8).
Cited on name "Newark" (C. H. Hitchcock, '71, p. 21).
Cited on Newark system in New York (De Kay, '42, p. 385).
Cited on raindrop impressions from New Jersey (Lyell, '51, pp. 238, 242–244).
List of fossil fishes from New Jersey and the Connecticut valley described by (De Kay, '42).
Notice of the study of fossil fishes by (Miller, '79–'81, vol. 2, p. 147).

Red head, N. B. Beach of magnetic sand near (Bailey, '72, p. 221).
Contact of trap with older sediments (Bailey, '72, p. 220).
Position of (Bailey, Mathews, and Ells, '80, map No. 1 S. E. accompanying).
Rocks of (Bailey, '72, p. 217. Bailey, Mathews, and Ells, '80, p. 21D. Gesner, '39, p. 51).
See also Gardners creek.

Red Hill, Pa. Conglomerate near (H. D. Rogers, '58, vol. 2, p. 680).

Red sandstone hill, Conn. Rock of (Percival, '42, p. 440).

Reids bridge, Va. Boundary of Newark near (Heinrich, '78, p. 237. W. B. Rogers, '39, p. 75).

Reids bridge and Charlotte, Va. Section between (W. B. Rogers, '39, pp. 79-80).

Reid's coal mine, Va. Depth of (Taylor, '48, p. 48).

RENWICK, EDWARD. Cited on fossil fish from New Jersey (W. C. Redfield, '39).

Reptiles, fossil. Distribution of, in time (Emmons, '57, pp. 56-57).

From Connecticut valley (Deane, '45*a*. H. D. Rogers, '58, vol. 2, p. 694. Wyman, '55).

From Newark system (H. D. Rogers, '58, vol. 2, p. 695).

From New Jersey (Cope, '68, p. 733).

From North Carolina (Cope, '75. Emmons, '52, pp. 141-142. Emmons, '56, pp. 293-320, 335-337, 347, pl. 5. Emmons, '57, pp. 54-93, 145-147, pl. 8. Emmons, '57*b*, pp. 77-78).

From Pennsylvania (Lea, '51, pp. 171-172. Cope, '85. H. D. Rogers, '58, vol. 2, pp. 692-693. Wheatley, '61, pp. 44-46. Wheatley, '61*a*).

From Prince Edward Island (Dawson, '78, p. 118. Dawson and Harrington, '71, p. 46).

Found at New London (Dawson, '53).

From Richmond coal field, Va. (W. B. Rogers, '43, p. 300).

Summary concerning (O. C. Marsh, '77. Miller, '79-'81, vol. 2, pp. 243-244).

Rhoad's mill, Pa. Boundary of the Newark near (H. D. Rogers, '41, pp. 16, 39).

Dip of conglomerate at (H. D. Rogers, '41, p. 39).

RICE, WILLIAM NORTH. 1886.

On the trap and sandstone in the gorge of the Farmington river at Tariffville, Conn.

In Am. Jour. Sci., 3d. ser., vol. 32, pp. 430-433.

Describes the outcrop of an overflowed trap sheet with a trap conglomerate resting upon it; and also of the occurrence of a breccia of trap and sandstone. The facts reported in this paper support the conclusion that some of the trap sheets of the Newark were overflows. See Davis, '83.

RICE, WILLIAM NORTH. Cited on origin of the trap hills of Connecticut (Chapin, '87, p. 26).

Cited on overflow trap sheets in Connecticut (W. M. Davis, '88, p. 465).

Rice coal mine, Va. Notes on (Taylor, '35, p. 284, 285).

Rice point, P. E. I. Fossil plants from (Bain and Dawson, '85, pp. 156-158).

Riceville, Va. Boundary of the Newark near (W. B. Rogers, '39, pp. 74-75, 76).

Riceville and Chalk Level, Va. Section between (W. B. Rogers, '39, p. 79).

RICHARDSON, JAMES. 1881.

Report of a geological exploration of the Magdalen islands, 1880-1881.

In Geological Survey of Canada. Report of progress for 1879-'80. Montreal. Pp. 1-11G.

States that there are some reasons for supposing that certain Red sandstones above the Carboniferous of the Magdalen islands may be of Permian or Triassic age, p. 8G.

Richmond, Va. Brief description of coal mines near (Lyell, '54, p. 12).

Richmond bay, P. E. I. Discovery of fossil reptile near (Ells, '84, p. 19E, note 2, on atlas sheet No. 5 S. W.).

Limestone near (Dawson and Harrington, '71, p. 34).

Trap at (Dawson, '78, p. 123. Dawson, '78*a*, pp. 29, 31).

Richmond coal field, Va. Additional notes on (Clifford, '88).

Age of, as indicated by fossil plants (Bunbury, '47, p. 287. Fontaine, '79, pp. 37-39. Foster, '51. E. Hitchcock, '56, p. 99. Lesquereux, '76, p. 283. Lyell, '47, p. 274-280. Lyell, '57. Marcou, '49. Marcou '88, p. 30. W. B. Rogers, '42*c*. W. B. Rogers, '55*a*. Shaler, '71, pp. 114, 115, 117. Zeiller, '88).

Analyses of coal from (Clemson, '35. W. R. Johnson, '50, pp. 175-176. W. R. Johnson, '51, p. 12. Silliman and Hubbard, '42, Williams, '83, p. 82).

Area of (Heinrich, '78, p. 232).

Boundaries of (Heinrich, '78, pp. 230-232).

Brief account of (Ashburner, '87, pp. 352-353. Clifford, '87. Coryell, '75. Daddow and Bannan, '66, pp. 395-403. Emmons, '57, pp. 3, 33, 34. C. H. Hitchcock, '74. Hotchkiss, '73. Hotchkiss, '81, p. 120. Hotchkiss, '83. Hull, '81, p. 460. Le Conte, '82, pp. 457-459. Lyell, '49, pp. 279-288. Lyell, '71, pp. 362-363. Macfarlane, '77, p. 507. Maclure, '09. Mitchell, '42, p. 59-60. Nuttall, '21, pp. 35-37. Patton, '88, pp. 22-23. Pierce, '28, pp. 57-58. W. B. Rogers, '37, pp. 5-6. W. B. Rogers, '40, pp. 71-72. W. B. Rogers, '43*b*, pp. 532-533. Silliman, '42. R. C. Taylor, '34. Williams, '85, pp. 97-98).

Coal from, examination of (W. R. Johnson, '44, pp. 308-451).

For the New Orleans exposition (Hotchkiss, '84).

General character and efficiency of (W. R. Johnson, '50, pp. 133-134, and table op. p. 134).

Organic structure of (Lyell, '47, pp. 268-269).

Coal, production of, in 1885 (Ashburner, '86, p. 69).

In 1887 (Ashburner, '88, p. 361).

In 1883-'84 (Williams, '85, pp. 97-98).

Coal in, brief review of (Chance, '85, pp. 18-19).

Coal mines in, account of (Grammar, '18).

Coal, thickness of (W. B. Rogers, '43).

Coke, natural, and trap dikes in (Heinrich, '75).

Coke, natural, from (W. R. Johnson, '42. Lyell, '47, pp. 270-274. Raymond, '83. W. B. Rogers, '42*b*. W. B. Rogers, '54*a*.

Origin of (Hotchkiss, '83. Stevens, '73).

Remarks on (Coryell, '75. T. S. Hunt, '75, Wurtz, '75).

Depth of shafts in (W. B. Rogers, '43*b*).

ROGERS, HENRY D. **1836.**

Report on the geological survey of the state of New Jersey.

Philadelphia, 1836, 2d ed., pp. 1-188, pl. 1.

First ed., Philadelphia, 1836; each edition is paged the same up to p. 174.

Contents relating to the Newark system:

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Newark system of New Jersey	144-170
General view	144-146
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ROGERS, HENRY DARWIN. **1839.**

Third annual report on the geological survey of the state of Pennsylvania.

Harrisburg, Pa., 16mo, pp. 4-119.

Name Middle Secondary strata applied to the Newark, p. 12. Unconformity between the Newark and underlying rocks (other examples are mentioned on p. 21). General dip of the strata; former extension of the Newark beyond its present limits, p. 17. The area occupied by the Newark given by counties, and its northern and southern boundaries described. Occurrence of variegated conglomerate, Red

ROGERS, HENRY DARWIN—Continued.

sandstone, and trap. Localities where variegated conglomerate occurs along the northern border of the area. The hypothesis is here advanced that the sedimentary rocks of the Newark in Pennsylvania, New Jersey, etc., were deposited in their present inclined position by a river rising in Virginia and flowing northward, pp. 18-23.

Trap dikes with accompanying dislocation and metamorphism in the adjacent beds, together with the occurrence of ores of iron and copper along the lines of contact, pp. 18-23.

ROGERS, HENRY D. 1840.

Description of the geology of the state of New Jersey, being a final report.

Philadelphia, pp. 1-301, pl. 1, and map.

Contents relating to the Newark system:

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Descriptions of the northwest boundary	16, 18
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ROGERS, HENRY D. 1841.

Fifth annual report of the geological exploration of the commonwealth of Pennsylvania.

Harrisburg, pp. 1-156, pl. 1.

Describes the Newark rocks bordering the South mountain, Pa., pp. 16-17, 38-39.

ROGERS, HENRY D. 1841a.

[Remarks on the columnar structure of the trap dikes of Pennsylvania and on the magnetic iron ores of New Jersey.]

In Am. Jour. Sci., vol. 41, p. 173; also in Am. Assoc. Geol. and Nat., Proc., 1840-1842, p. 26.

Brief abstract of a remark on a paper by Prof. Mather concerning joints in rocks.

ROGERS, H. D. 1842.

[Remark on the independent origin of the New Red sandstone of the Connecticut valley and of New Jersey and Pennsylvania.]

ROGERS, H. D.—Continued.

In Am. Jour. Sci., vol. 43, pp. 170, 171, 172; also in Am. Assoc. Geol. and Nat., Proc., 1840-1842, pp. 63, 64, 66.

Brief abstract of remarks to the effect that the Newark rocks of the Connecticut valley and of the New Jersey-Pennsylvania area was formed in independent basins.

ROGERS, H. D. 1843.

[Remarks in reference to the age of the Newark system.]

In Philadelphia Acad. Nat. Sci., Proc., vol. 1, p. 250.

States that Posidonomia minuta, from Prince Edward county, Va., indicates that the rocks in which it occurs are the New Red sandstone.

ROGERS, HENRY D. 1843a.

On the physical structure of the Appalachian chain, as exemplifying the laws which have regulated the elevation of great mountain chains generally.

See Rogers, William B. and H. D. Rogers, 1843.

ROGERS, [H. D.] 1843b.

[Remarks on the age of the New Red sandstone of the Connecticut valley and New Jersey.]

In Am. Jour. Sci., vol. 45, p. 315.

Abstract of remarks on a paper by W. C. Redfield.

[ROGERS, H. D.] 1843c.

[On the crescent form of the trappean dikes of the Newark sandstone regions of New Jersey and Connecticut.]

In Am. Jour. Sci., vol. 45, p. 334.

Abstract of remarks on the cause of the topographic form of the trap ridges referred to.

ROGERS, HENRY D. 1844.

Address delivered at the meeting of the Association of American Geologists and Naturalists, held in Washington, May, 1844.

In Am. Jour. Sci., vol. 47, pp. 137-160, 247-278.

Reviews the progress made in the study of the Newark system up to 1844.

ROGERS, H. D. 1848.

[Altered shales and sandstones at New Hope, Pa.]

In Boston Soc. Nat. Hist., Proc., vol. 3, 1848-1851, p. 30.

A brief record of contact metamorphism.

ROGERS, HENRY D. 1853.

[On the thickness of the Connecticut valley sandstone.]

In Boston Soc. Nat. Hist., Proc., vol. 9, 1851-1854, pp. 379-380.

Remarks on a paper by Edward Hitchcock, states that the Newark strata may have been deposited in an inclined position. Refers to instances where the system is not so thick as might be inferred.

ROGERS, H. D. 1853a.

[Remarks on the age of Connecticut sandstone.]

In Am. Acad., Proc., vol. 3, p. 70.

ROGERS, H. D. 1854.

[Remarks on fossil footprints.]

ROGERS, H. D.—Continued.

In Boston Soc. Nat. Hist., Proc., vol. 5, 1854–1855, p. 30.

Brief remarks in discussion of a paper by Bouvé.

ROGERS, H. D. 1855.

[Remarks on footprints and raindrop impressions.]

In Boston Soc. Nat. Hist., Proc., vol. 5, 1854–1856, pp. 182–185.

In describing certain Carboniferous footprints, refers to those of the Newark system, suggests that the so-called raindrop impressions may have been made by spray from breaking waves, p. 185.

ROGERS, HENRY DARWIN. 1856.

Geological map of the United States and British North America.

In The Physical Atlas of Natural Phenomena by Alexander Keith Johnson. New and enlarged ed., pp. 29–32, pl. 8.

Contains a condensed account of the Newark system, including geographical extent, organic remains, and geological age, dip and physical conditions attending its origin, trap rocks, metalliferous veins, coal formation, etc., p. 32.

History of the literature of the Newark system, p. 32.*

ROGERS, HENRY DARWIN. 1858.

The geology of Pennsylvania.

Philadelphia, vol. 1, pp. i–xxvii, 1–586, pl. 36; vol. 2, pp. i–xxiv, 1–1046, pl. 51. Accompanied by an atlas containing a geological map of Pennsylvania in three sheets, a topographical and geological map of the anthracite fields of Pennsylvania in two sheets, and two sheets of sections.

In describing the crystalline and Paleozoic rocks of Pennsylvania, in vol. 1, several references are made to the relation of the Newark system to older formations, and also to its lithological character, strike, dip, trap dikes, ores, etc., pp. 86–87, 88, 89, 90, 92, 101–102, 103, 151, 160, 164, 204, 214.

The following is a table of contents of vol. 2, in as far as it relates to the Newark system:

ROGERS, HENRY DARWIN—Continued.

ROGERS, H. D. Cited on age of the Connecticut valley sandstone (C. H. Hitchcock, '55, p. 392).

Cited on age of the Newark rocks of Pennsylvania (W. C. Redfield, '56*a*, p. 357).

Newark system (Lea, '53. Lea, '58. Mather, '43, pp. 293–294. Newberry, '88, p. 9. W. C. Redfield, '56, pp. 181).

Richmond coal field, Va. (W. B. Rogers, '43, p. 301).

Cited on conglomerate in New Jersey (Cook, '89, p. 15). York county, Pa. (Frazer, '85, p. 403).

Cited on conglomerate of Virginia (W. B. Rogers, '36, pp. 81–82).

Cited on contact metamorphism in New Jersey (W. M. Davis, '83, p. 301).

New Jersey, at Rocky Hill (J. D. Dana, '43, pp. 113–114).

Cited on curved form of certain trap ridges (W. M. Davis, '83, p. 307. Silliman, '44).

Cited on deposition of the Newark system in inclined strata (W. B. Rogers, '42).

Cited on divisions of the "Middle secondary rocks" of the Atlantic slope (Lea, '53, pp. 191–192).

Cited on extent of Triassic rocks in North America (Archaic, '60, pp. 633–645).

Cited on fossil plants (Marcou, '90. Newberry, '88).

Cited on geological map of the United States (Marcou, '59, pp. 31–35).

Cited on geological position of the Newark system (E. Hitchcock, '41, p. 438).

Cited on intrusive trap sheets in Pennsylvania (W. M. Davis, '83, p. 294).

ROGERS, H. D.—Continued.

Cited on iron ores in Pennsylvania (Frazer, '77, p. 317).

Cited on mode of deposition of the Newark rocks of Pennsylvania (Frazer, '77*a*, p. 653. Lea, '53, pp. 191–192. E. Hitchcock, '41, pp. 527–529. Mather, '43, pp. 288–292. Mitchell, '42, p. 133).

Cited on monoclinal structure of the Newark (W. M. Davis, '83, p. 302. W. M. Davis, '86, pp. 342–343).

Cited on native silver in New Jersey (Darton, '85).

Cited on Newark system in New Jersey and Pennsylvania (Jones, '62, pp. 88–92).

Pennsylvania (Frazer, '77*a*, p. 995).

Cited on origin and deposition of Newark strata (W. M. Davis, '83, p. 287).

Cited on origin of the dip in the Newark rocks of Pennsylvania (Macfarlane, '79, p. 41).

Cited on origin of the trap rock of New Jersey (Hovey, '89, p. 376).

Cited on overflow trap sheets in Pennsylvania (W. M. Davis, '83, p. 298).

Cited on prevailing dip of the Newark (W. M. Davis, '83, pp. 305, 306).

Cited as prevailing dip of the Newark in New Jersey and Pennsylvania (W. B. Rogers, '39, p. 72).

Cited on relation of trap and sandstone in New Jersey (W. M. Davis, '83, p. 287).

Pennsylvania (W. M. Davis, '83, p. 287).

Cited on reptilian remains in Newark rocks at Phœnixville, Pa. (Wheatley, '61 p. 42).

Cited on structure of the Newark system (Cook, '87).

Cited on thickness of the Newark in Pennsylvania (Frazer, '77*a*, pp. 496, 498–499).

Cited on trap at Feltville, N. J. (Darton, '90, p. 26).

Cited on trap dikes in New Jersey (H. D. Rogers, '58, vol. 2, p. 685).

Pennsylvania (W. M. Davis, '83, p. 292. Lewis, '85, pp. 438–439, 441, 443).

Cited on "variegated calcareous conglomerate" of New Jersey (Lea, '53, p. 190. Russell, '78, p. 231–232).

Description of fossil Estheriæ, collected by (Jones, '62, pp. 123–126).

Discussion of hypotheses by, explaining the uniform dip (W. M. Davis, '82*a*, p. 118).

Hypothesis proposed by, to account for the general inclination of the Newark rocks of New Jersey (Russell, '78, p. 228).

Notice of work by (Miller, '79–'81, vol. 2, p. 147).

Reference to explanation of the structure of the Newark system, by (See Cook, '89*a*, p. 170).

ROGERS, HENRY D., LARDNER VANUXEM, RICHARD C. TAYLOR, EBENEZER EMMONS, and T. A. CONRAD. **1841.**

Report on the ornithichnites or footmarks of extinct birds in the New Red sandstone of Massachusetts and Connecticut, observed and described by Prof. Hitchcock, of Amherst.

ROGERS, HENRY D., LARDNER VANUXEM, RICHARD C. TAYLOR, EBENEZER EMMONS, and T. A. CONRAD—Continued.

In Am. Jour. Sci., vol. 41, pp. 165–168; also in Am. Assoc. Geol. and Nat., Proc., 1840–1842, pp. 18–21, and in final report on the geology of Massachusetts, by E. Hitchcock, Amherst and Northampton, 1841, 4to, vol. 1, pp. 2*a*–3*a*.

Abstract in Neues Jahrbuch, 1841, pp. 739–740.

Report of a committee appointed from the members of the Association of American Geologists and Naturalists, and relates especially to the evidence of the animal origin of the footprints found in the sandstone of the Connecticut valley. The conclusion announced by Hitchcock as to the ornithic character of many of the footprints is sustained.

ROGERS, WILLIAM B. **1836.**

Report of the geological reconnoissance of the state of Virginia.

Philadelphia. Pp. 1–143, pl. 1.

Reprinted in a reprint of annual reports and other papers on the geology of the Virginias, by the late William Barton Rogers. New York, 1884, pp. 21–122, pl. 1.

Contains a detailed account of the Richmond coal field, pp. 52–61, and a brief notice of the presence of sandstone suitable for building purposes in Orange, Nelson, and Amherst counties.

ROGERS, WILLIAM B. **1837.**

Report on the progress of the geological survey of the state of Virginia for the year 1836.

[Richmond.] 4to, pp. 1–14.

Reprinted in a reprint of annual reports and other papers on the geology ot the Virginias, by the late William Barton Rogers. New York, 1880, pp. 123–145.

Contains a brief account of the Richmond coal field, and also of the Newark area in northern Virginia, pp. 5–6, 7.

ROGERS, WILLIAM B. **1839.**

Report of the progress of the geological survey of the state of Virginia for the year 1839.

Richmond, 1840. Pp. 1–161, pls. 1–2.

Reprinted in a reprint of annual reports and other papers on the geology of the Virginias, by the late William Barton Rogers. New York, 1889, pp. 285–410, pl. op. p. 276, and pl. 1.

Contains a description of the Newark areas in Pittsylvania, Campbell, Appomattox, Prince Edward, Halifax, Buckingham, and Cumberland counties, Va. The contents are as follows:

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Igneous rocks, and associated metamorphism 81–83

ROGERS, WILLIAM B. **1840.**

Report of the progress of the geological survey of the state of Virginia for the year 1840.

Richmond, 1841. Pp. 1–132.

Reprinted in a reprint of annual reports and other papers on the geology of the Virginias, by the late William Barton Rogers. New York, 1884, pp. 411–435.

Contains a description of the boundaries and principal characteristics of the Newark areas in northern Virginia, included in Orange, Culpeper, Prince William, Fauquier, Fairfax, and Loudoun counties, pp. 59–69; and also a description of the boundary of the northern part of the Richmond area, pp. 71–72. On p. 124 a short notice of the occurrence of coke in the Richmond coal field is given.

ROGERS, W. B. **1842.**

[On the prevailing dip in the various areas of New Red sandstone of the Atlantic slope.]

In Am. Jour. Sci., vol. 43, p. 171; also in Am. Assoc. Geol. and Nat., Proc., 1840–1842, pp. 64–65.

An abstract of remarks on the prevailing dip of the Newark system, especially in Virginia, and the slight effect of intrusive rocks on the associated sedimentary beds. The hypothesis proposed by H. D. Rogers, in reference to the strata of sandstone and shale composing the system having been deposited in their present inclined position, is sustained.

ROGERS, W. B. **1842a.**

[Observations tending to show that the footprints on the sandstone of the Connecticut valley were made on inclined surfaces.]

In Am. Jour. Sci., vol. 43, p. 173; also in Am. Assoc. Geol. and Nat., Proc., 1840–1842, p. 66.

Calls attention to the appearance in certain footprints of a slight sliding of the foot which made the impression.

ROGERS, WM. B. **1842b.**

On the porous anthracite or natural coke of eastern Virginia.

In Am. Jour. Sci., vol. 43, pp. 175–176; also in Am. Assoc. Geol. and Nat., Proc., 1840–1842, p. 68.

Brief abstract of a paper describing the structure and mode of formation of the natural coke of Virginia.

ROGERS, W. B. **1842c.**

[On the geological age of the Richmond coal field, Va.]

In Philadelphia Acad. Nat. Sci., Proc., vol. 1, p. 142.

A brief announcement that the rocks of the Richmond coal field are equivalent in time to the Lias of Europe.

ROGERS, WILLIAM BARTON. **1843.**

On the age of the coal rocks of eastern Virginia.

ROGERS, WILLIAM BARTON—Continued.

In Am. Assoc. Geol. and Nat., Trans., 1840–1842, p. 298–316, pls. 13, 14.

Abstract in Am. Jour. Sci., vol. 43, 1842, p. 175; also in Am. Assoc. Geol. and Nat., Proc., 1840–1842, p. 68.

Republished in "A reprint of annual reports and other papers on the geology of the Virginias," by the late William Barton Rogers. New York, 1881, pp. 645–656, and plate.

Describes briefly the rocks of the Richmond coal field, discusses their probable age, and gives descriptions and figures of a number of fossil plants found in them.

ROGERS, W. B. **1843a.**

Observations of subterranean temperatures in the coal mines of eastern Virginia.

In Am. Assoc. Geol. and Nat., Trans., 1840–1842, p. 532–538.

Abstract in Am. Jour. Sci., vol. 43, p. 176; also in Am. Assoc. Geol. and Nat., Proc., 1840–1842, p. 69.

Describes briefly the stratigraphy of the Richmond coal field, thickness of coal, dip of strata, etc., and gives observations of temperature in various mines, the depths of which are stated.

ROGERS, WILLIAM B. **1851.**

[Difficulty of determining the age of the coal beds of North Carolina and Virginia.]

In Am. Assoc. Adv. Sci., Proc., vol. 4, p. 275.

Discussion of a paper by W. R. Johnson.

ROGERS, W. B. **1853.**

[Age of the Deep river coal field, North Carolina.]

In Am. Acad., Proc., vol. 3, 1852–1857, pp. 69, 70.

Abstract of remarks in reference to the similarity of the Newark system in North Carolina, Virginia, and Pennsylvania. Followed by remarks on the age of the same system, by L. Agassiz and T. C. Jackson.

ROGERS, W. B. **1854.**

[Remarks on fossils from the Middle Secondary strata of North Carolina, Virginia, Pennsylvania and Massachusetts.]

In Boston Soc. Nat. Hist., Proc., vol. 5, pp. 14–18; also in Am. Jour. Sci., 2d. ser., vol. 19, 1855, pp. 123–125.

Abstract in Ann. Sci. Discov., 1855, pp. 330–333, and in Am. Jour. Sci., 2d. ser., vol. 19, pp. 123–125.

Describes briefly several of the Newark areas and makes a comparison of their fossils. The conclusion is reached that the fossils indicate a Jurassic age.

ROGERS, WILLIAM B. **1854a.**

[Observations on the occurrence of natural coke in the Richmond coal field, Va.]

In Boston Soc. Nat. Hist., Proc., vol. 5, pp. 53–56.

Reprinted in The Virginias, vol. 4, pp. 158–159.

Abstract in Ann. Sci. Discov., 1855, pp. 320–322.

ROGERS, WILLIAM B.—Continued.

Describes the occurrence of natural coke and its relation to igneous injections. The presence of baked fire clay associated with the coke is also mentioned.

ROGERS, W. B. **1854b.**

[On natural coke in the Richmond coal field, Va.]

In Am. Acad., Proc., vol. 3, 1852-1857, pp. 106-107.

Describes the natural coke and its relation to a trap sheet. The trap is supposed to have been extruded before the rocks above it were deposited.

ROGERS, W. B. **1855.**

[On lignite from Lancaster county, Pennsylvania, and from the Richmond coal field, Va.]

In Boston Soc. Nat. Hist., Proc., vol. 5, pp. 189-190.

From the similarity of specimens of lignite from the localities mentioned in the title it is concluded that the rocks from which they were obtained are of the same age.

ROGERS, WM. B. **1855a.**

[Remarks on the age of the coal-bearing rocks near Richmond, Va., and of the Newark areas in North Carolina.]

In Boston Soc. Nat. Hist., Proc., vol. 5, p. 186.

The age of the deposits mentioned is considered the same, judging from specimens of lignite from each.

ROGERS, WILLIAM B. **1855b.**

[On a new locality for Posidonomaya in the Mesozoic rocks of Virginia.]

In Boston Soc. Nat. Hist., Proc., vol. 5, pp. 201-202.

From the discovery of specimens of Posidonomaya near the junction of the Bannister and Dan rivers, Virginia, the rocks containing them are correlated with the Mesozoic strata of Prince Edward county and other localities.

ROGERS, WILLIAM B. **1855c.**

[Local metamorphism produced by trap dikes in Prince William county, Virginia.]

In Boston Soc. Nat. Hist., Proc., vol. 5, pp. 202-204.

Describes the character and general strike of the trap dikes of the region mentioned, together with the alteration they have produced on the adjacent shales and sandstones. From the evidences of alteration in sedimentary beds similar to that adjacent to the dikes, over a large area, the hypothesis is suggested that the rocks in question were formerly covered by a trap sheet which has been eroded away.

ROGERS [W. B.]. **1859.**

[Who first discovered the footprints in the Connecticut valley sandstone.]

In Boston Soc. Nat. Hist., Proc., vol. 7, 1859-1861, p. 53.

Relates to the claims of Deane and Hitchcock to priority in the discovery of the footprints in question. Remarks in discussion of a paper by T. T. Bouvé.

ROGERS, W. B. **1860.**

[Remark on the deposition of the inclined strata of the Newark system.]

In Boston Soc. Nat. Hist., Proc., vol. 7, 1859-1861, p. 274.

Refers briefly to the Newark system as an example of the manner in which inclined strata may be deposited.

ROGERS [W. B.]. **1860a.**

[On a block of Red sandstone from Portland, Connecticut, containing impressions of bones, apparently ornithic.]

In Boston Soc. Nat. Hist., Proc., vol. 7, p. 396.

ROGERS [W. B.]. **1860b.**

[On the age of the sandstone on the St. Croix, New Brunswick, and at Perry, Me.]

In Boston Soc. Nat. Hist., Proc., vol. 7, pp. 398-399.

The rocks at the localities mentioned in the title are not admitted to be of Newark age.

In discussion of a paper by C. T. Jackson.

ROGERS, WILLIAM B. **1879.**

List of geological formations found in Virginia and West Virginia.

In American geological railway guide, by James Macfarlane, pp. 179-185.

Describes briefly the Newark (Jurasso-Cretaceous and the Jurasso-Triassic) rocks of Virginia, and indicates their position in the geological column, p. 180.

ROGERS, W. B. **1880.**

The iron ores of Virginia and West Virginia.

In The Virginias, vol. 1, pp. 128-130, 138-140, 152-153, 160-161.

Contains an account of the Mesozoic iron ores of Virginia.

ROGERS, WILLIAM B. **1880a.**

Table of the geological formations found in V[irgini]a and W[est] V[irgini]a.

In The Virginias, vol. 1, pp. 14-15. (Republished in The Virginias, vol. 3, p. 61.)

Indicates the position of the Newark system in the geological column.

ROGERS, WILLIAM BARTON. **1884.**

A reprint of annual reports and other papers on the geology of the Virginias, by the late William Barton Rogers.

New York. Pp. i-xv, 1-832; with 7 plates in volume and 8 plates and 1 geological map in pockets.

Reviewed by J. L. and H. D. Campbell in Am. Jour. Sci., 3d ser. vol. 30, pp. 357-374, vol. 31, pp. 193-202.

The reports and paper in this volume which contain matter relating to the Newark system have been noticed in this index as originally published. The geological map of Virginia, and some of sections on pls. 7-8 were not published originally with the reports.

ROGERS, WILLIAM BARTON. Analysis of coal from the Richmond coal field, Va. (Clifford, '87, p. 10).

ROGERS, WILLIAM BARTON—Continued.

Cited on age of the Newark system (Dewey, '57. C. H. Hitchcock, '71, p. 21. E. Hitchcock, '55*a*, p. 407. Hitchcock and Hitchcock, '67, p. 416. Lea, '53, p. 188. Mather, '43, pp. 293-294. Newberry, '88, p. 9. W. C. Redfield, '56, pp. 180-181. Stur, '88, p. 205. Zeiller, '88, p. 698).

Cited on age of the Newark in the Connecticut valley (E. Hitchcock, jr., '55, p. 25).

In New Jersey, Virginia, etc. (J. D. Dana, '56, p. 322).

In North Carolina (Emmons, '56, p. 272. Macfarlane, '77, pp. 517, 528).

In Virginia (Fontaine, '83, pp. 12, 15, 16, 28, 37, 89. E. Hitchcock, '58, p. 6. Horner, '46. Lyell, '47, pp. 261, 279, 280. Lyell, '49, pp. 280-281. Marcou, '49, pp. 273-274. Marcou, '58, pp. 13-15. Macfarlane, '77. W. C. Redfield, '56*a*, p. 357. H. D. Rogers, '58, vol. 2, pp. 693, 696).

Cited on faults in the Richmond coal fields, Va. (W. M. Davis, '83, p. 304).

Cited on footprints from Turners Falls, Mass. (Deane, '56).

Cited on fossils of the Richmond coal field, Va. (Heinrich, '78, p. 264).

Cited on a fossil crustacean from Va. (Jones, '62, pp. 123-126. H. D. Rogers, '43).

Cited on fossil crustaceans (Jones, '62, p. 85).

Cited on fossil plants (Marcou, '90).

Cited on geological position of the Newark system (E. Hitchcock, '41, p. 438).

Cited on intrusive trap sheets in Virginia (W. M. Davis, '83, p. 294).

Cited on mode of formation of the Newark system (E. Hitchcock, '41, pp. 527-529).

Cited on origin of the conglomerate "Potomac marble" on the west border of the Newark of Maryland and Virginia (Lea, '53, p. 189).

Cited on origin of the natural coke of the Richmond coal field, Va. (Hotchkiss, '83. Stevens, '73).

Cited on origin of the Newark system (Cook, '89, p. 13).

Cited on origin of the prevailing dip of the rocks of the Newark system (Newberry, '88, p. 6).

Cited on *Pecopteris whitbyensis* (Emmons, '56, p. 326).

Cited on relation of trap and sandstone in Pennsylvania (W. M. Davis, '83, p. 287).

Cited on Richmond coal field, Va. (Clifford, '87, pp. 4, 25. Taylor, '48, p. 46).

Cited on Tæniopteris from Richmond coal field (Bunbury, '47, p. 281).

Cited on temperatures in coal mines of Richmond coal field, Va. (Taylor, '48, pp. 49-50).

Cited on the tilting of the sandstone and trap of the Richmond coal field, Va. (W. M. Davis, '83, p. 302).

Cited on trap dikes in Virginia (W. M. Davis, '83, p. 292).

Geological map of Virginia (Hotchkiss, '80).

Notice of work by, in Virginia (Miller, '79-'81, vol. 2, p. 149).

ROGERS, WILLIAM BARTON—Continued.

Section of the Richmond coal field, Va. (Hotchkiss, '80).

ROGERS, WILLIAM B., and HENRY D. ROGERS. **1843a.**

On the physical structure of the Appalachian chain, as exemplifying the laws which have regulated the elevation of great mountain chains generally.

In Am. Assoc. Geol. and Nat., Trans., 1840-1842, pp. 474-531, pl. 3.

Describe an unconformity between the Newark system and the crystalline rocks on which it rests, p. 523.

Roger's head, N. B. Rocks of (Gesner, '40, pp. 16, 17).

Roger's mills, N. J. Synclinal axis near (H. D. Rogers, '40, p. 128).

Roger's point, N. B. Rocks of (Gesner, '41, p. 14).

Rogerstown, Pa. Boundary of the Newark near (H. D. Rogers, '58, vol. 2, p. 668).

Rosemont, N. J. Dip in shale at (Cook, '82, p. 26).

Rosstown, Pa. Contact metamorphism near (H. D. Rogers, '58, vol. 2, p. 679).

Trap dikes near (H. D. Rogers, '58, vol. 2, p. 688).

Trap ranges near (H. D. Rogers, '58, vol. 2, p. 679).

Rossville, Pa. Catalogue of specimens of sandstone, trap, etc., from near (Frazer, '77, pp. 332-381).

Mention of various rock specimens from near (C. E. Hall, '78, pp. 39-69).

Rothville, Pa. Boundary of the Newark near (Frazer, '80, p. 44).

Round mountain, N. J. Description of (Cook, '68, pp. 193-194. Cook, '82, pp. 63-64. Darton, '90, pp. 62-65).

Diverse dips near (Nason, '89, p. 18).

Origin of trap of (Darton, '89, p. 138).

See also Pennington mountain (Cook, '68, p. 190).

Round Top, Pa. Analysis of trap from (Frazer, '77, p. 310).

Contact metamorphism at (H. D. Rogers, '58, vol. 2, p. 687).

Trap dikes at (H. D. Rogers, '58, vol. 2, p. 687).

Trap from (C. E. Hall, '78, pp. 29, 39).

Round valley, N. J. Dip in (Cook, '68, p. 199).

Dip in indurated shale at (Cook, '82, p. 28).

Small sandstone area near (Cook, '68, p. 75).

Round valley hill, N. J. Described briefly as a trap outcrop (H. D. Rogers, '36, p. 159).

Round valley mountain, N. J. Analysis of trap from (Cook, '68, p. 218).

Character of the formation near (H. D. Rogers, '40, p. 132).

Description of (Cook, '68, p. 193. Cook, '82, pp. 64-65).

Dip in shale near (Cook, '82, p. 29).

Dip southwest of (H. D. Rogers, '40, p. 132).

Trap outcrop at (Cook, '82, p. 19).

Rowlet's coal mine, Va. Notes on (Taylor, '35, p. 285).

RUSSELL, I. C. 1877.
Concerning footprints.
In American Nat., vol. 11, pp. 406-417.
Contains a popular account of the fossil footprints of New Jersey and the Connecticut valley.

RUSSELL, I. C. 1878.
On the physical history of the Triassic formation in New Jersey and the Connecticut valley.
In New York Acad. Sci., Ann., vol. 1, 1879, pp. 220-254.
Reviewed by P. Frazer, in Am. Nat., vol. 13, pp. 284-292, and by J. D. Dana in Am. Jour. Sci., 3d ser., vol. 17, pp. 328-330.
Indicates briefly the distribution of the various areas of Newark system, pp. 220-222. Describes the Red sandstones and shales, variegated conglomerate, and eruptive rocks of the New Jersey area, pp. 222-246. In treating of this division of the subject numerous details are mentioned, and the conclusion reached that the Newark rocks of New Jersey and of the Connecticut valley were united at the time of their deposition, upheaval and erosion having since separated the two areas.

RUSSELL, ISRAEL COOK. 1878a.
On the intrusive nature of the Triassic trap sheets of New Jersey.
In Am. Jour. Sci., 3d ser., vol. 15, pp. 277-280.
An attempt to prove that certain trap sheets in New Jersey are intrusive sheets and not interbedded overflows of igneous rocks.

RUSSELL, ISRAEL COOK. 1878b.
On the occurrence of a solid hydrocarbon in the eruptive rocks of New Jersey.
In Am. Jour. Sci., 3d ser., vol. 16, pp. 112-114.
Abstract in Am. Nat., vol. 13, pp. 198-199.
Describes the occurrence of a solid hydrocarbon in the trap of the First Newark mountain, N. J., and refers to previous discoveries of similar substances. See also pp. 130-132 of same volume.

RUSSELL, I. C. 1879.
Footprint in the Mesozoic rocks of New Jersey.
In Am. Jour. Sci., 3d ser., vol. 18, p. 232.
Brief record of the finding of a fossil footprint near Boonton, N. J.

RUSSELL, ISRAEL C. 1880.
On the geology of Hudson county, New Jersey.
In New York Acad. Sci., Ann., vol. 2, 1882, pp. 27-80, pl. 2.
Republished in part in Science (ed. by J. Mitchels), vol. 2, 1881, pp. 63-65.
Describes the sandstones and shales of Hudson county, N. J., and the trap rocks that have been intruded among them.

RUSSELL, I. C. 1880a.
On the former extent of the Triassic formation of the Atlantic states.
In Am. Nat., vol. 14, pp. 703-712.

RUSSELL, I. C.—Continued.
Assembles various observations which are considered by the writer as indicating that the various Newark areas were originally connected and have since been separated by erosion.

RUSSELL, ISRAEL COOK. 1885.
North Carolina coal fields.
In Science, vol. 6, pp. 548-549.
Notice of a report on the coal fields of North Carolina, by H. M. Chance.

RUSSELL, ISRAEL COOK. 1889.
Subaerial decay of rocks and origin of the red color of certain formations.
U. S. Geol. Surv., Bull. No. 52, pp. 1-65.
Reviewed by J. D. Dana in Am. Jour. Sci., 3d ser., vol. 39, pp. 317-319.
Discusses the origin of the prevailing red color of the sandstones and shales of the Newark system, pp. 44-55.

RUSSELL, I. C. 1889a.
The Newark system.
In Am. Geol., vol. 3, pp. 178-182.
Reviewed by C. H. Hitchcock in Am. Geol., vol. 5, pp. 200-202.
Gives a list of names and correlations applied to the Red sandstone, shale, etc., which occur in detached area along the Atlantic coast. Suggests that the name, Newark system, proposed by W. C. Redfield, in 1856, be used to designate the system of rocks referred to.

RUSSELL, ISRAEL COOK. 1891.
Has "Newark" priority as a group name.
In Am. Geol., vol. 7, pp. 238-241.
A reply to criticisms by C. H. Hitchcock.

RUSSELL, I. C. Cited on cause of the tilting of the Newark (W. M. Davis, '83, p. 303).
Curved form of certain trap ridges (W. M. Davis, '83, p. 307).
Fossil footprints in New Jersey (C. H. Hitchcock, '88, p. 123).
Former connection of the Newark system in New Jersey and Connecticut valley (Le Conte, '82, pp. 470, 600).
Former extent of the Newark system (Newberry, '88, p. 6).
Geology near Feltville, N. J. (W. M. Davis, '83, p. 275).
Intrusive trap sheets in New Jersey (W. M. Davis, '83, pp. 295, 296. Russell, '78, p. 243).
Newark of New Jersey (Miller, '79-'81, vol. 2, p. 235).
Origin of the red color of Newark sandstones (J. D. Dana, '90, p. 319).
Solid hydrocarbon in the igneous rocks of New Jersey (J. D. Dana, '78).
Structure of the Newark system (Cook, '87).
Trap at Feltville, N. J. (Darton, '90, p. 26).
Trap ridges (Frazer, '82, p. 141).
Discussion of the hypothesis by, explaining opposing dips (W. M. Davis, '82*a*, p. 119).

Ruth mine, Pa. Detailed account of (d'Invilliers, '83, pp. 350-352).

SCHIMPER, W. PH. 1874.
Traité de Paléontologie végétale [etc.].
Paris, vol. 1, 1869, pp. i-iv, 1-738, vol. 2, 1870-1872, pp. 1-968, vol. 3, 1874, pp. i-iv, 1-896 and a folio atlas of 110 plates, 1874.
Contains descriptions of a few fossil plants from the Richmond coal field, Va., vol. 1, pp. 276, 610.

SCHWEITZER, P. 1870.
Analysis of Newark sandstone.
In New York Lyc. Nat. Hist., Proc., vol. 1, 1870-'71, p. 136).
Presents an analysis of sandstones from the quarries at Newark, N. J.

SCHWEITZER, P. 1871.
Notes on the felsites of the Palisade range.
New York Lyc. Nat. Hist., Proc., vol. 1, 1870-'71, pp. 244-252.
Published also in Am. Chem., vol. 2, pp. 23-25.
Gives analysis of five samples of sandstones and shales from the Newark system in New Jersey.

SCUDDER, S. H. **1867.**
[Remarks on an insect larva, *Mormolucoides articulatus*, from the Newark rocks of Massachusetts.]
In Boston Soc. Nat. Hist., Proc., vol. 11, 1866–1868, p. 140.
States that the fossil mentioned is probably the larvæ of Coleoptera.

SCUDDER, SAMUEL H. **1868.**
The fossil insects of North America.
In Geol. Mag., vol. 5, pp. 172–177, 216–222.
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SCUDDER, SAMUEL HUBBARD. **1886.**
Systematic review of our present knowledge of fossil insects, including Myriapods and Arachnids.
In U. S. Geol. Surv., Bull. No. 31, pp. 1–128.
Mentions the occurrence of *Mormolucoides articulatus* in the sandstone of the Connecticut valley, p. 56.

SCUDDER, SAMUEL H. **1884.**
The oldest known insect larva, *Mormolucoides articulatus*, from the Connecticut river rocks.
In Boston Soc. Nat. Hist., Mem., vol. 3, 1886, pp. 431–438, pl. 45.
Republished in The Fossil Insects of North America. New York, 1890. 4to, vol. 1, pp. 323–336, pl. 19.
Presents a detailed description of the larva referred to, based on the study of a large number of individuals.

SELWYN, ALFRED R. C., and G. M. DAWSON. **1884.**
Descriptive sketch of the physical geography and geology of the Dominion of Canada.
Montreal. Pp. 55, accompanied by a geological map of the Dominion of Canada, 1842–1882, in two sheets, scale 45 miles to 1 inch.
The extent of both the sedimentary and volcanic rocks of the Newark system in Nova Scotia are shown. Prince Edwards island is colored as Carboniferous.

SEYMOUR, E. **1868.**
List of minerals in New Jersey.
In Geology of New Jersey, by George H. Cook, 1868. Appendix D, pp. 743–750.
Contains a list of minerals found in New Jersey, including many from the Newark.

Shale. In Connecticut, bituminous, with the coal seams (Percival, '42, pp. 228, 442).
Detailed description of (Percival, '42, pp. 441-446).
In Massachusetts, brief account of (E. Hitchcock, '35, pp. 216-218).
Description of (E. Hitchcock, '41, p. 443).
In New Jersey (and sandstones), alternation of (Cook, '82, p. 33).
Analysis of (Cook, '68, pp. 384-385. Darton, '83*a*. Schweitzer, '71).
Brief account of (Nason, '89, pp. 16-17, 21).
Colors of (Cook, '82, p. 20).
Description of (Cook, '82, pp. 18, 19-20).
Description of, in Hudson county (Russell, '80).
Detailed description of (H. D. Rogers, '36, pp. 150-159).
Details of (Cook, '68, pp. 212-214).
Dip of (Cook, '79, pp. 29-30).
General account of (H. D. Rogers, '40, pp. 114-117. Russell, '78, pp. 223-231).
Indurated near trap (Cook, '83, pp. 23-24).
Lithological description of (Cook, '68, pp. 206-207).
In New York, in Rockland county (Mather, '43, p. 288).
In North Carolina, in Dan river coal field (Emmons, '52, pp. 156-158).
Deep river coal field (Emmons, '52, pp. 123, 126-127. Wilkes, '58, pp. 8-9).
In Pennsylvania, detailed description of (H. D. Rogers, '58, vol. 2, pp. 672-679).
In Virginia (and slates), detailed description of (Heinrich, '78, pp. 242-243).
Origin of the red color of (Russell, '89, pp. 44-55).

SHALER, N. S. 1871.
On the causes which have led to the production of cape Hatteras.
In Boston Soc. Nat. Hist., Proc., vol. 14, pp. 110-121.
Refers to the structure and age of the Richmond coal field, pp. 114-115, 117. Structure of the Connecticut valley area, p. 118.

SHALER, N. S. 1875.
Notes on the investigations of the Kentucky geological survey during the years 1873, 1874, and 1875.
In Kentucky geological survey, Reports of Progress, 2d ser., vol. 3, 4to, pp. 129-282.
Contains brief references to the structural features associated with the Newark system in Virginia and the Connecticut valley, p. 229.

SHALER, N. S. 1884.
Description of quarries and quarry regions.
In report on the building stones of the United States and statistics of the quarry industry for 1880, in Tenth Census of the United States, vol. 10, part 2, pp. 107-229, pls. 27-58.
Describes the Newark sandstone quarries of Connecticut, pp. 126-127; New Jersey, pp. 141-144; Pennsylvania, pp. 156-157; Maryland, p. 178; Virginia, p. 179; and North

SHALER, N. S.—Continued.
Carolina, pp. 181-182; the trap rock quarries of Connecticut, p. 177; New Jersey, pp. 145-146, and Virginia, p. 179; and the Triassic limestone quarries of Pennsylvania, p. 156, and Maryland, p. 177.

SHALER, N. S. 1885.
A first book in geology.
Boston, 12mo, pp. i-xvii, 1-255.
Contains a brief account of the life of the Jurassic and Triassic periods, pp. 217-224).

SHALER, N. S. 1885a.
[Administrative report of Atlantic coast division of the U. S. Geological Survey.]
In U. S. Geol. Surv., Sixth Ann. Rep. of the, pp. 18-22.
States that the Tertiary strata of Martha's Vineyard are in part composed of Newark débris, p. 21.

SHALER, NATHANIEL SOUTHGATE, and WILLIAM MORRIS DAVIS. 1881.
Illustrations of the earth's surface. Glaciers.
Boston. Folio, pp. i-vi, 1-198, pls. 1-25.
Suggests that the Newark conglomerate of the Connecticut valley may be of glacial origin, pp. 95-96. Section showing ancient periods of glaciation, p. 102.

Sharp island. Mention of (Marsters, '90).

Shell, fossil. From Mount Tom, Mass. (E. Hitchcock, '58, pp. 6-7, pl. 5).
From near Mount Tom, Mass., description of (E. Hitchcock, jr., '56).
From Richmond coal field (Lyell, '47, pp. 274-275).
From Sunderland, Mass. (E. Hitchcock, '23, vol. 6, p. 79).

SHELLEY, J. Y. Discovery of fossil saurian bones in Upper Milford, Lehigh county, Pa., by (Lea, '53, pp. 188, 195).

Shelley's coal mine, Va. Notes on (Taylor, '35, p. 284).

Shelley's ore bank, Pa. Report on (Frazer, '77, p. 222).

Shirley, (—). Cited on thickness of coal seams at Evans, N. C. (Chance, '85, p. 44).

SHEPARD, C. U. 1832.
Datholite and iolite in Connecticut.
In Am. Jour. Sci., vol. 22, pp. 389-391.
Describes the occurrence of datholite, etc., in trap at Middlefield and Haddam, Conn., and compares these localities with similar localities in New Jersey.

SHEPARD, CHARLES UPHAM. 1837.
Report on the geological survey of Connecticut.
New Haven, Pp. 1-188.
Abstract in Am. Jour. Sci., 1st ser., vol. 33, pp. 151-175.
Devoted mainly to mineralogy, but contains a brief discussion in reference to the probability of finding coal in Connecticut, pp. 61-62; also a brief description of the building stones of the Newark area, including trap rocks, pp. 98-100. List of Newark specimens collected to illustrate the geology and mineralogy of the state, pp. 165-169.

SHEPARD, CHARLES UPHAM. **1867.**
On the supposed tadpole nests or imprints made by the *Batrachoides nidificans* (Hitchcock), in the red shale of the New Red sandstone of South Hadley, Mass.
In Am. Jour. Sci., 2d ser., vol. 43, pp. 99-104.
Discusses the origin of the markings referred to.

Shoolie, N. S. Relation of trap, conglomerate, and sandstone at (Gesner, '43).

Shooter's island, N. Y. Exposures of Newark sandstone and shale on (Britton, '81, p. 168).

Short Hills, N. J. Record of well bored in (Nason, '89*b*).

Short mountain, Conn. Description of (Percival, '42, p. 375).
Detailed study of the geological structure near (W. M. Davis, '89).
Sketch map of (W. M. Davis, '89, pl. 5).

SHRUMP, F. W. Stone quarry of, near Verona, N. J. (Cook, '81, p. 52).

Shuttle meadow, Conn. Detailed study of cross-section at (W. M. Davis, '89, pp. 64-69).

Shuttle meadow mountain, Conn. Anterior trap ridge of (Davis and Whittle, '89, p. 109).

Shuttle meadow reservoir, Conn. Sketch map of (W. M. Davis, '89, pl. 2).
View of fault gap near (W. M. Davis, '89, pl. 2).

Siccomac, N. J. Boundary of First mountain trap near (Cook, '68, p. 180).
Watchung mountain, end at (Cook, '82, p. 49).

Siddonstown, Pa. Trap dike near (H. D. Rogers, '58, vol. 2, p. 689).

Sidney church, N. J. Conglomerate at (Cook, '82, p. 41).
Deformed strata at (Cook, '83, p. 25).
Dip in conglomerate and shale near (Cook, '82, p. 28).
Faults and folds near (Cook, '79, p. 33).
Faults near (Cook, '82, p. 16).
Folds near (Cook, '82, p. 17).
Limestone at (Cook, '82, pp. 22, 42).

Sidney mills, N. J. Dip in shale near (Cook, '82, p. 28).

Sillery, J. Stone quarry of, near Prallsville, N. J. (Cook, '81, p. 59).

SILLIMAN, BENJAMIN. **1810.**
Sketch of the mineralogy of the town of New Haven [etc.].
In Connecticut Acad. Arts and Sci., Mem., vol. 1, pp. 83-96.
Contains a general account of the trap exposures near New Haven, Conn.

SILLIMAN, BENJAMIN. **1814.**
Mineralogical and geological observations on New Haven and its vicinity.
In Am. Min. Jour., vol. 1, pp. 139-149).
Abstract in Jour. de phys., de chim. [etc.] Par J. C. Delamétherie, Paris, Tome 75, 1812, pp. 75-79.
Notice in Am. Jour. Sci., vol. 1, 1818, pp. 55-56, and in Elementary treatise on Mineralogy and Geology by Parker Cleaveland, 1822, p. 555.
Describes the geology about New Haven, Conn., especially of east and west rocks. Records the finding of a large mass of native copper on the Hamden hills, Conn.

[SILLIMAN, BENJAMIN.] **1818.**
Native copper [found near Wallingford, Conn.].
In Am. Jour. Sci., vol. 1, pp. 55-56.
Describes the finding of a mass of native copper.

[SILLIMAN, BENJAMIN.] **1818a.**
New localities of agate, chalcedony, chabazite, stilbite, analcite, titanium, prehnite, etc.
In Am. Jour. Sci., vol. 1, pp. 134-135.
Describes the occurrence of minerals at Deerfield, Mass., and at East Haven and Woodbury, Conn.

SILLIMAN, BENJAMIN. **1820.**
[Note on the discovery of fossil bones in sandstone at East Windsor, Conn.]
In Am. Jour. Sci., vol. 2, p. 147.
Gives a brief account of the Newark (called Old Red sandstone) of the Connecticut valley; and remarks on the nature of the animal to which the bones referred to belonged.

[SILLIMAN, BENJAMIN.] **1820a.**
Sketch of a tour in the counties of New Haven and Litchfield, in Connecticut, with notices of the geology, mineralogy and scenery, etc.
In Am. Jour. Sci., vol. 2, pp. 201-235.
Describes West rock, Connecticut, pp. 202-203, and also the character of the small Newark basin in Woodbury and Southbury, Conn., pp. 231-233.

[SILLIMAN, BENJAMIN.] **1821.**
[Remarks on letters from Alexander Brongniart in reference to fossil fishes and native copper from near Middletown, Conn.]
In Am. Jour. Sci., vol. 3, pp. 221-222.
Refers to the finding of fossil fishes, and to the working of copper ore.

[SILLIMAN, BENJAMIN.] **1821a.**
[Note on the finding of fossil fish at Sunderland, Mass.]
In Am. Jour. Sci., vol. 3, pp. 365-366.
States that a large number of fossil fish were obtained by Edward Hitchcock, at Sunderland, Mass.

SILLIMAN, B. **1824.**
Remarks made on a short tour between Hartford and Quebec in the autumn of 1819.
New Haven, 2d ed., 12mo., pp. 1-443, and 9 plates.
First edition, New Haven, 1820, 12mo., pp. 1-407, and 9 plates.
Contains a general account of the scenery and geology of the Connecticut valley.

SILLIMAN, BENJAMIN. **1827.**
[Note on the presence of bituminous coal in the Connecticut valley.]
In Am. Jour. Sci., vol. 12, p. 76).
States that coal has been found at several places in the Connecticut valley.

[SILLIMAN, BENJAMIN.] 1830.
Igneous origin of some trap rocks.
In Am. Jour. Sci., vol. 17, pp. 119-132, and plate.
Describes the contact of trap with sandstone beneath, at Rocky Hill near Hartford, Conn. The effect of the heat of the trap on the sandstone is discussed, pp. 122-131, and plate.

[SILLIMAN, BENJAMIN.] 1837.
Bird tracks at Middletown, Conn., in the New Red sandstone.
In Am. Jour. Sci., vol. 31, p. 165.
Brief abstract from a letter stating that footprints as well as bones and fossil plants have been found at the place named.

[SILLIMAN, BENJAMIN.] 1839.
Fossil fishes in the sandstone of New Jersey.
In Am. Jour. Sci., vol. 35, p. 192.
Notice of the finding of fossil fishes in Morris county, N. J.
Further information regarding these fossils is given by "R." in Am. Jour. Sci., vol. 36, pp. 186-187.

[SILLIMAN, BENJAMIN.] 1842.
[Note on the Richmond coal field, Va.]
In Am. Jour. Sci., vol. 43, p. 14.
A brief reference concerning specimens received from the Midlothian coal mine, Virginia, value of the coal of that field, etc.

[SILLIMAN, B.] 1843.
Ornithichnites of the Connecticut river sandstone and the Dinornis of New Zealand.
In Am. Jour. Sci., vol. 45, pp. 177-188.
Publishes letters from J. Deane, G. A. Mantell, and R. Owen relative to the fossil footprints of the Connecticut valley.

SILLIMAN, BENJAMIN. 1844.
Dr. Percival, the original observer of the crescent-formed dikes of trap in the New Red sandstone of Connecticut.
In Am. Jour. Sci., vol. 46, pp. 205-206.
Relates to an omission to give credit to Percival in a report of a meeting of the Association of American Geologists and Naturalists, published in the Am. Jour. Sci., vol. 45, p. 334.

SILLIMAN, B. Cited on certain polygonal depressions in sandstone from Connecticut valley (E. Hitchcock, '56, p. 111).
Cited on curved form of certain trap ridges (W. M. Davis, '83, p. 307).
Cited on fossil fish from Connecticut (J. H. Redfield, '36).
Cited on fossil footprints (Deane, '45, p. 159).
Cited on metamorphism contact at Rocky hill, Mass. (E. Hitchcock, '35, pp. 422-423).
Cited on native copper in the Connecticut valley (Hoffmann, '22).
Cited on origin of the sandstones of the Connecticut valley (E. Hitchcock, '35, p. 241).
Cited on relation of trap and sandstone in Connecticut (W. M. Davis, '83, pp. 285-286).
Cited on trap rocks near Hartford, Conn. Davis and Whittle, '89, p. 121).

SILLIMAN, B., B. SILLIMAN, jr., and JAMES D. DANA. 1847.
[Note on phalangeal impressions in fossil footprints.]
In Am. Jour. Sci., 2d ser., vol. 3, p. 276.
Calls attention to a statement by L. Agassiz in reference to the number of phalanges in the toes of birds, and cites similar observations by E. Hitchcock and J. Deane.

[SILLIMAN, B., and J. D. DANA.] 1847.
[Note on] ornithichnites.
In Am. Jour. Sci., 2d ser., vol. 3, p. 276.
Notes the observations of Hitchcock, Agassiz, and Deane on the number of joints in the toes of fossil footprints from the Connecticut valley. The names of certain fossil footprints found at Turners Falls, Mass., by James Deane, and described in the Am. Jour. Sci., 2d ser., vol. 3, pp. 74-79, are supplied by Hitchcock.

SILLIMAN [BENJAMIN], and [DOUGLASS] HOUGHTON. 1844.
On the connection of the metallic copper with the trap of Connecticut and Michigan.
In Am. Jour. Sci., vol. 47, p. 132.
A brief discussion of the origin of native copper, frequently associated with trap.

SILLIMAN, B., and O. P. HUBBARD. 1842.
Chemical examination of bituminous coal from the pits of the Midlothian coal-mining company, south side of James river, 14 miles from Richmond, Va., Chesterfield county.
In Am. Jour. Sci., vol. 42, pp. 369-374.
Gives in detail the result of an examination of a large sample of coal from the locality named.

SILLIMAN and HUBBARD. Analysis of coal from the Richmond coal field, Va. (Clifford, '87, p. 10).

SILLIMAN [B.], Jr. 1841.
[Remark on rhombic structure in the sandstone of the Connecticut valley.]
In Am. Jour. Sci., vol. 41, p. 173, also in Am. Assoc. Geol. and Nat., Proc., 1840-1842, p. 26.
Brief abstract of remark on a paper by Prof. Mather, concerning joints in rock.

SILLIMAN, BENJAMIN, Jr. 1842.
[On the cause of the prevailing dip of the New Red sandstone of the Connecticut valley.]
In Am. Jour. Sci., vol. 43, p. 171; also in Am Assoc. Geol. and Nat., 1840-1842, p. 64.
Refers the prevailing dip of the sandstone of the Connecticut valley to upheaval, connected with outbursts of trap. Brief abstract of remarks on a paper by Edward Hitchcock.

SILLIMAN, BENJAMIN, Jr. 1842a.
[Trap eruption causing upheaval of adjacent strata.]
In Am. Assoc. Geol. and Nat., Proc., 1840-1842, p. 64.
A brief remark in which the inclination of the sandstones of the Connecticut valley is referred to the eruption of trap.

SILLIMAN, BENJAMIN, Jr. 1844.
Report on the intrusive trap of the New Red sandstone of Connecticut.
In Am. Jour. Sci., vol. 47, pp. 107–108.
Abstract in Neues Jahrbuch, 1845, pp. 728–729.
An abstract of a report to the Association of American Geologists and Naturalists, concerning, 1st, the dip of the Connecticut valley sandstone; 2d, the manner in which the trap rocks were intruded, and 3d, the erosion of the formation. The age of the strata is stated to be the "period of the New Red sandstone."

SILLIMAN, B., Jr. 1847.
On fossil trees found at Bristol, Conn., in the New Red sandstone.
In Am. Jour. Sci., 2d ser., vol. 4, pp. 116–118.
Describes the finding of the trunk mentioned.

SILLIMAN, B., Jr. 1847a.
[Note on phalangeal impressions in fossil footprints.]
See Silliman, Silliman, jr., and Dana, 1847.

SILLIMAN, B., Jr., and J. D. WHITNEY. 1855.
Notice of the geological position and character of the copper mine at Bristol, Conn.
In Am. Jour. Sci., 2d ser., vol. 20, pp. 361–368.
Devoted principally to the economic importance of the mine, but describes also its geological position, section of the ore body, etc.

Silver, native, at the Bridgewater copper mine, N. J. (Darton, '85).

Silver Hill, N. J. Description of (Cook, '68, p. 194. Cook, '82, p. 65).
Dip in shale near (Cook, '82, p. 29).

Simsbury copper mine, Mass. Brief account of (E. Hitchcock, '35, pp. 71, 229).

Simsbury, Conn. Building stones in (Percival, '42, p. 439).
Description of sandstone ridge near (Percival, '42, p. 440).

Sindle's mill, N. J. Basaltic columns near (Cook, '68, p. 203).

Skillman station, N. J. Dip in shale at (Cook, '82, p. 25).

Slate, bituminous, in North Carolina (Emmons, '56, p. 268).
Black, in Dan river coalfield, N. C. (McLenahan, '52, p. 171).
With coal, near Leaksville, Va. (W. B. Rogers, '39, p. 78).

Slate Ridge, Pa. Description of trap dike near (Frazer, '80, p. 31).

Slickensides, at North Belleville, N. J. (Cook, '82, p. 16).

SMITH, ALFRED. 1832.
On the water courses, and the alluvial and rock formations of the Connecticut river valley.
In Am. Jour. Sci., vol. 22, pp. 205–231, and map op. p. 205.
Gives the extent and boundaries of the Newark rocks of the Connecticut valley, with a description of principal trap ridges. Refers briefly to the fossils that have been collected, and presents theoretical discussions as to the mode of formation of the sedimentary beds and the origin of the trap.

SMITH, A. Cited on the character of the rocks at Enfield Falls, Conn. (E. Hitchcock, '41, p. 447).

SMITH, EUGENE A. 1878.
Outline of the geology of Alabama.
In handbook of Alabama [etc.], by Saffold Berney, pp. 129–196.
Refers to igneous rocks which are considered as belonging to the Newark system of dikes, pp. 139, 142.

SMITH, EUGENE A. 1883.
Geological survey of Alabama. Report for the years 1881 and 1882.
Montgomery, Ala. Pp. i–xvi, 1–615, and 8 maps.
States that stratified rocks of the Newark system are not known in Alabama, but that the trap dikes of the metamorphic region are usually referred to that period, p. 556.

SMITH, NATHAN. 1820.
Fossil bones found in Red sandstone.
In Am. Jour. Sci., vol. 2, pp. 146–147.
Records the finding of fossil bones at East Windsor, Conn.

SMITH, O. R. Cited on depth of artesian well at Durham, N. C. (Venable, '87).

SMITH, THOMAS P. 1799.
Account of crystallized basalts found in Pennsylvania.
In Am. Philo. Soc., Trans., vol. 4, 1804, pp. 445–446.
A brief account of having seen basalt (trap) near Elizabethtown and Campbellstown, Pa.

SMITH, T. P. Cited on the presence of Jura-Trias in America (Lea, '53, p. 189).

SMITH, W. Discovery of saurian bones by, at Springfield, Mass. (E. Hitchcock, '58, p. 186).

Smith iron mine, N. C. Brief account of, with sketch (Willis, '86, p. 305).

Smith's Ferry, Mass. Brief account of a visit to (Lyell, '45, vol. 1, p. 252).
Dip of rocks at (Lyell, '42).
Fossil footprints at (E. Hitchcock, '58, pp. 50 et seq.).
Relation of conglomerate, trap, and sandstone at (Lyell, '42, p. 794).
Section of rocks at (Lyell, '42).

Smith's hill, N. J. Described briefly as a trap outcrop (H. D. Rogers, '36, p. 159).
Description of trap and sandstone near (H. D. Rogers, '36, p. 156).
Detailed description of (H. D. Rogers, '40, p. 151).
Quarries of trap rock at, mention of (G. P. Merrill, '89, p. 436. Cook, '79, p. 26. Cook, '81, p. 62).

Smithville, N. J. Description of sandstone outcrops near (H. D. Rogers, '36, p. 153).

Spencer's Island, N. S. Copper at (How, '69, p. 65).
Description of (Gesner, '36, p. 239-240. Jackson and Alger, '33, p. 265).
Trap of (Dawson, '78, p. 106).

Sporting Hill, Pa. Boundary of the Newark near (Frazer, '80, pp. 13, 37).

Spring Garden, Pa. Description of trap dike near (Frazer, '80, p. 29).

Springfield, Conn. Dip at (Wells, '50, p. 340).
Section across Connecticut valley at (E. Hitchcock, '58, pl. 2).
Unconformity in the Newark at (Wells, '50, p. 340).

Springfield, Mass. Analysis of a ferruginous shale from (Jackson, '50*a*).
Bones in Red sandstone at (E. Hitchcock, '58, p. 186).
Description of fossil footprints from (E. Hitchcock, '41, pp. 478-501).
Localities of fossil footprints in (E. Hitchcock, '41, p. 466).
Reference to fossil bones from (Wells, '56).
Remarks on fossil footprints found at (E. Hitchcock, '45*c*, p. 63).
Section through (Walling, '78, pl. op. p. 192).

Springfield, N. J. Brief reference to trap hills near (H. D. Rogers, '36, p. 159).
Elevation of First mountain at (Cook, '82, p. 49).
Reference to geology near (H. D. Rogers, '40, p. 129).

Springfield area, Va. Description of (Heinrich, '78, p. 230).

Springfield coal basin, Va. Brief reference to (W. B. Rogers, '40, p. 72).

Springfield coal pits, Va. Brief account of (Clifford, '87, p. 25).

Springfield mountain, N. J. Sandstone on (Cook, '68, p. 181).

Springfield township, Pa. Report on the geology of (C. E. Hall, '81, pp. 80-83).

Spring Hill, Pa. Trap dike near (Lewis, '85, pp. 442, 443).

Spring mills, N. J. Boundary of Newark near (Cook, '68, p. 175).
Character of the formation near (H. D. Rogers, '40, p. 131).
Description of variegated conglomerate near (H. D. Rogers, '36, p. 147).
Detailed description of calcareous conglomerate near (H. D. Rogers, '40, pp. 140-141).
Dip in shale near (Cook, '82, p. 27).
Occurrence of conglomerate at (Lea, '53, p. 190).

Springtown, Pa. Boundary of the Newark near (H. D. Rogers, '58, vol. 2, p. 668).
Conglomerate near (H. D. Rogers, '58, vol. 2, p. 681).

Springville, Pa. Description of trap dike near (Frazer, '80, p. 29).

Spruce Hill, Pa. Description of a fault near (Lewis, '85, p. 450).

Squiertown, N. J. Trap hill near (Cook, '68, pp. 185, 186).

Stanton, N. J. Description of Round mountain near (Cook, '68, pp. 193-194).
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The age and structure of the deposit are also considered.

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Clover Hill (Clifford, '87, pl. 2. Fontaine, '83, p. 9. Lyell, '47, p. 271).
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Walnut grove, N. C. Analysis of coal from near. See Clarke, '87, p. 146.
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