CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

The following file is part of the Grover Heinrichs Mining Collection

ACCESS STATEMENT

These digitized collections are accessible for purposes of education and research. We have indicated what we know about copyright and rights of privacy, publicity, or trademark. Due to the nature of archival collections, we are not always able to identify this information. We are eager to hear from any rights owners, so that we may obtain accurate information. Upon request, we will remove material from public view while we address a rights issue.

CONSTRAINTS STATEMENT

The Arizona Geological Survey does not claim to control all rights for all materials in its collection. These rights include, but are not limited to: copyright, privacy rights, and cultural protection rights. The User hereby assumes all responsibility for obtaining any rights to use the material in excess of "fair use."

The Survey makes no intellectual property claims to the products created by individual authors in the manuscript collections, except when the author deeded those rights to the Survey or when those authors were employed by the State of Arizona and created intellectual products as a function of their official duties. The Survey does maintain property rights to the physical and digital representations of the works.

QUALITY STATEMENT

The Arizona Geological Survey is not responsible for the accuracy of the records, information, or opinions that may be contained in the files. The Survey collects, catalogs, and archives data on mineral properties regardless of its views of the veracity or accuracy of those data.

COLORADO SCIENTIFIC SOCIETY PROCEEDINGS

VOLUME 12
No. 11

PUBLISHED BY THE SOCIETY
DENVER, COLORADO
1931

[Presented before the Society April 26, 1930]

THE PALEONTOLOGY OF THE DENVER QUADRANGLE COLORADO

J. HARLAN JOHNSON[1]

INTRODUCTION

During the seventies, eighties, and early nineties of the last century, a number of publications appeared containing information on the paleontology and geology of the region around Denver. The Denver monograph of Emmons, Cross and Eldridge[2] assembled the information as known up to about 1890. Since that time numerous new fossils have been collected and much has been learned about the stratigraphic range and occurrence of many forms.

The object of this paper is to present lists of all the fossils known from the Denver quadrangle, arranged according to the formations in which they were found, and to discuss interesting and important facts concerning some of them.

The information presented has been obtained from published literature, from material in the collections at the University of Colorado, Colorado School of Mines, the Colorado Museum of Natural History, and United States National Museum. The writer wishes to thank Junius Henderson, F. M. Van Tuyl, Harold Cook, E. W. Berry, J. B. Reeside, Jr., C. W. Gilmore and H. Koener for information supplied and courtesies shown.

LOCATION AND GENERAL GEOLOGY

The area considered is that included in the U. S. Geological Survey topographic sheet of the Denver quadrangle. The table given below shows the formations present, their sequence, thickness, and general character.

[1]Associate Professor of Geology, Colorado School of Mines, Golden, Colorado.
[2]Eldridge, G. H., Emmons, S. F., and Cross, W., Geology of the Denver Basin: U. S. Geol. Survey, Mon. 27, 1896.

AGE	FORMATION	THICKNESS	GENERAL CHARACTER
Recent			Gravels along streams.
Quaternary			Alluvium and terrace gravels, and loess.
Eocene (?)	Denver	1400	Sandstone, conglomerate, chiefly andesitic debris.
	Arapahoe	600	Sandstone, conglomerate, and clay.
			[Disconformity]
Upper Cretaceous	Laramie	600+	Sandstones, shales, clays and lignite seams.
	Fox Hills	800+	Friable sandy shales. Sandstone at the top.
	Pierre	4500	Lead-gray shales, sandy near the top. Lenticular limestone and sandstone layers.
	Niobrara	450	Gray calcareous shales, thin chalky limestone, yellow to buff shales near the top.
	Benton	400	Dark, lead-colored shales.
	Dakota	50	Hard, massive sandstone, hard with fissile shale.
		150	Conglomerate at base, hard massive sandstones, sandy shales, and fire clays.
			[Disconformity]
Jurassic	Morrison	200	Green to gray shales, lenticular limestone and friable sandstone.
			[Disconformity]
Permian (?)	Lykins	600	Brick red sandy shales and sandstone. Thin limestone and gypsum beds.
Pennsylvanian	Lyons	200	Massive cross-bedded, cream-white sandstone.
	Fountain	1200—	Red sandstones and conglomerate with interbedded shales.
			[Unconformity]
Algonkian and Archean			Gneisses, schists, and granites.

PALEONTOLOGY

Fountain Formation—To date no fossils have been found in this formation within the limits of the Denver quadrangle. Marine fossils of Pennsylvanian age are known from the western part of the Fort Collins quadrangle about 75 miles to the north, and both land plants and marine fossils have been obtained in the area west of Colorado Springs to the south.

Lyons Sandstone—No fossils have been obtained in the Lyons in the Denver quadrangle. A few footprints of Amphibians have been found north of Boulder near the town of Lyons.

Lykins Formation—A few marine fossils of Permian age have been found in the Lykins in northern Larimer County, but none have been obtained in the area considered in this paper.

Morrison Formation—The Morrison formation is a continental deposit. The fossils found in the Denver quadrangle include plants and vertebrates. In adjoining areas, fresh water invertebrates have been obtained.

Numerous plant fragments can be found in some of the shales around Golden and Morrison. No determinable specimens have been collected from the lower portions to the writer's knowledge. A number of years ago, W. T. Lee obtained a small collection of plants from beds which Cannon declared were included in the upper portion of the type section at Morrison as originally divided. However, Knowlton, who studied the plants, declared that they were typically Dakota, and Lee on stratigraphic grounds has questioned the Morrison age of these beds. The plants will be discussed under the Dakota flora.

The outcrops at Morrison were early famous for their dinosaurs, this being one of the first localities in which large dinosaurs were found in the West.

The following list shows the known vertebrate fossils from the Denver quadrangle:

Antrodemus atrox (Marsh) ("Creosaurus")
Apatosaurus ajax Marsh
Apatosaurus laticollis Marsh
Atlantosaurus immanis Marsh
Atlantosaurus montanus Marsh
Camarosaurus agilis (Marsh) ("Morosaurus")
Camarosaurus grandis (Marsh ("Morosaurus")
Camarosaurus sp? ("Morosaurus")
Diplodocus lacustris Marsh
Diplodocus longus Marsh
Diplosaurus felix Marsh
Stegosaurus armatus Marsh
Stegosaurus stenops Marsh
Stegosaurus ungulatus Marsh

In general this represents a somewhat localized fauna of dinosaurs and crocodiles. Several members of the group deserve mention.

The first specimen of *Atlantosaurus* discovered was found by Captain H. C. Beckwith and Arthur Lakes in 1877. It was found in place in the upper Morrison along the hogback south of Golden. During the following ten years, other specimens and species were found near the same locality and southward to Morrison, where the largest known species of *Atlantosaurus* was discovered (in 1888). This animal reached a length of about 70 feet and a height of about 20 feet.

Species of *Brontosaurus* roamed in the Denver region at this time which represented the largest land animals known from North America.

Dakota Formation—Land plants represent the fossils commonly found in the Dakota in this region. Plant fragments may be obtained in practically all beds, but good specimens seem to have been found at only two horizons, one near the base and another about the middle of the formation. A careful search of good outcrops would probably disclose other horizons, especially in the lower and upper portions.

Knowlton[3] gives the following list from "the hard white sandstone at Morrison" apparently about the middle of the formation.

---

[3]Knowlton, F. H., The fossil plants of the Denver Basin: U. S. Geol. Survey, Mon. 27, pp. 463-473, 1896.

Abietites dubius? Lesquereux
Aralia formosa Heer
Aralia concreta Lesquereux
Bambusinum sp.
Carpites liriophylli Lesquereux
Ficus beckwithii Lesquereux
Ficus magnoliaefolis Lesquereux
Inga cottae? Ettingshausen
Laurus nebrascensis Lesquereux
Laurus proteaefolia Lesquereux
Laurus modesta Lesquereux
Laurus primigenia? Ung
Leguminosites cultriformis Lesquereux
Liriophyllum populoides Lesquereux
Liriophyllum beckwithii Lesquereux
Liriophyllum obcordatum Lesquereux
Lomatia saportanea longifolia Lesquereux
Magnolia speciosa Heer
Magnolia capellini Heer
Magnolia sp. (fruit)
Proteoides daphnogenoides Heer
Quercus morrisoniana Lesquereux
Salix proteaefolia Lesquereux
Sapindus morrisoni Lesquereux
Sequoia reichenbachi Heer
Sequoia condita Lesquereux
Sterculia aperta Lesquereux
Torreya oblanceolata Lesquereux

Of this group, about one-third have not been found outside the Denver Basin; others are known from Kansas, New Jersey, and the northern Mississippi Valley. In general, the flora is very similar to the large flora known from Kansas and Nebraska and is a typical Dakota flora.

Lee collected a number of plants at Morrison from beds included in the Upper Morrison as originally divided. They were:

cf. Eucalyptus dakotensis Lesquereux
Ficus daphnogenoides (Heer) Berry
Ficus magnoliaefolia Lesquereux
Phyllites sp.
Phyllites sp.
Salix sp. cf. S. protoaefolia Lesquereux

Knowlton, who studied the plants, says, "I do not think there is any doubt about the 'Morrison' plants being in the Upper Cretaceous flora."[4] They are common Dakota plants.

[4]Knowlton, F. H., A dicotyledonus flora in the type section of the Morrison formation: Am. Jour. Sci., 4th Ser., Vol. 49, pp. 189-194, March, 1920.

Lately, a number of specimens of leaves have been obtained from the outcrops and old quarries along Coon Creek by students at the Colorado School of Mines. This material has not yet been studied.

Several finds of dinosaur remains from the Dakota have been reported but the statements were very general and the writer has not been able to confirm them. However, dinosaurs are known from the Dakota at several points in the Rocky Mountain Region. In 1926, Professor H. W. Gardner, of the Colorado School of Mines, discovered some large dinosaur tracks in the upper Dakota at the Bear Creek water gap just east of Morrison. These were three-toed and about fifteen inches long. Unquestionably, dinosaurs were present in the region during Dakota time.

The other known fossils from the district include some fish scales from the fire clays near the middle of the formation found about four miles south of Golden, and some very poorly preserved casts of bivalves seen on the uppermost sandstones just north of Bear Creek.

Cannon[5] (p. 247-248) mentions small reptilian footprints and some marine and brackish water shells but gives no reference or locality.

Benton Formation—In the Denver region, the Benton usually is not subdivided lithologically as it is south of Colorado Springs. In general, it consists of black shales. However, a thin limestone bed has been noted above the middle of the formation which may represent the upper Greenhorn, and a sandy layer about a foot thick occurs at the top, apparently corresponding to the Carlile.

Fossils are rare in the Benton in this district and are poorly preserved. They are listed below:

Inoceramus fragments
Inoceramus labiatus Schlotheim
Ostrea fragments
Prionotropis woolgari (Wantell)?
Selachian teeth.

All of these are marine and all but the second came from the upper sandstone.

[5]Cannon, G. L., The geology of Denver and vicinity: Colo. Sci. Soc. Proc., Vol. 4, pp. 235-270, 1893.

Niobrara Formation—The Niobrara is well exposed east of the hogbacks. Years ago numerous quarries were opened in the lower limestones. Many fossils were obtained from these.

The forms known from this area are given in the following list:

Baculites sp? (Upper)
Discina sp?
Fish scales
Fish teeth, vertebrata, etc.
Foraminifera
Inoceramus deformis
Inoceramus sp?
Inoceramus stantoni Sokolow?
Ostrea congesta Conrad
Ostrea fragments
"Radiolites" austinensis Roemer

All of these except the baculite, fish scales, and foraminifera are from the lower part. The fish teeth are very common in the basal layer of the formation. *Inoceramus deformis* and *Ostrea congesta* are common in the limestones, especially 15 to 30 feet above the base. The other forms are known from single specimens. Foraminifera are abundant in the upper shales. Mr. W. A. Waldschmidt, of the Colorado School of Mines, is doing some work on these but so far as the writer knows, nothing has been written on foraminifera from this area.

In 1891, a specimen of *"Radiolites" austinensis* was found in the quarry half a mile north of Bear Creek.[6]

Pierre Formation—The Pierre outcrops over considerable areas in the Denver quadrangle. From time to time fossils have been collected and studied. Most of them come from the upper third of the formation, where calcareous concretions occur which are often highly fossiliferous.

Eldridge[7] (p. 78-79) in his paper gives a table of the species known up to about 1888. Unfortunately, he does not state the localities from which they were collected. The Colorado School of Mines has a number of good specimens from

[6]Cannon, G. L., Notes on a discovery of Radiolites austinensis Roemer (?); Colo. Sci. Soc. Proc., Vol. 4, pp. 75-76, 1892.

[7]Op. Cit.

Ralston Creek. The writer visited this locality and found numerous fragmentary concretions scattered around on the north side of the creek almost opposite the northeastern end of Ralston dike. Similar concretions were found along the east side of the dike. This horizon is well up in the Pierre. Other material has been obtained at a slightly lower horizon, about half a mile north of Van Bibber Creek, and about the same distance east of the Dakota hogback.

The following list shows the total reported fauna from the district:

(M) Anchura americana Evans and Shumard
Baculites sp.
(1) Baculites anceps Lamarck
(M-U) Baculites compressus Say
(U) Baculites ovatus Say
(U) Callista sp?
Callista dewyi Meek and Hayden
(U) Caryophyllis sp?
(U) Dentalium sp?
Eutrephoceras dekayi (Morton)
(U) Haminea ? occidentalis Meek and Hayden
(U) Heliolites sp?
Inoceramus sp.
Inoceramus (actinoceramus) fibrosus (Meek and Hayden)
(U) Inoceramus altus Meek
(M U) Inoceramus barabini Morton
(U) Inoceramus proximus Thomey
(U) Inoceramus sublaevis Hall and Meek
(U) Lingula nitida Meek and Hayden
Lucina sp?
(U) Lucina occidentalis Morton
(U) Mactra sp?
(U) Mactra canonensis Meek
(U) Mactra holmesii Meek
(U) Nucula sp?
(1) Ostrea congesta
Pteria haydeni Hall and Meek
(U) Scaphites cheyennensis Owen
(U) Scaphites nodosus Owen
Serpula sp?
(U) Solen sp?
(U) Sphaeriola sp?
Fish teeth, scales and bones.

In 1925 the operators of the clay pits at Golden drove an exploratory drift into the strata lying to the west of their workings. In the course of their work they encountered a dark gray shale bearing mollusks which still retained much of the original pearly shell. A number of these were obtained

Myrica dubia Knowlton
Myrica oblongifolia Knowlton
Salix myricoides Knowlton
Salix wyomingensis Knowlton
Salix brittoneana Knowlton
Populus? distorta Knowlton
Quercus praeangustiloba Knowlton
Quercus stramineus Lesquereux
Quercus eximia Knowlton
Quercus viburnifolia? Lesquereux
Artocarpus lessigiana (Lesqueruex) Knowlton
Artocarpus liriodendroides Knowlton
Ficus? smithsoniana (Lesquereux) Knowlton
Ficus pealei Knowlton
Ficus planicostata Lesquereux
Ficus cockerelli Knowlton
Ficus planicostata magnifolia Knowlton
Ficus praeplanicostata Knowlton
Ficus impressa Knowlton
Ficus coloradensis Cockerell
Ficus dalmatica Ettingshausen
Ficus neodalmatica Knowlton
Ficus? leyden Knowlton
Ficus posttrinervis Knowlton
Ficus cannoni Knowlton
Ficus navicularis Cockerell
Ficus multinervis? Heer
Ficus denveriana? Cockerell
Ficus crossii Ward
Ficus cowanensis Knowlton
Ficus berryana Knowlton
Ficus arenacea Lesquereux
Ficus? apiculatus Knowlton
Aristolochia brittoni Knowlton
Nelumbo tenuifolia (Lesquereux) Knowlton
Magnolia marshalli Knowlton
Magnolia lakesii Knowlton
Anona robusta Lesquereux
Anona coloradensis Knowlton
Laurus lanceolata Knowlton
Laurus lakesii Knowlton
Laurus wardiana Knowlton
Malapoenna louisvillensis Knowlton
Cinnamomum affine Lesquereux
Cimmamomum laramiense Knowlton
Platanus platanoides (Lesquereux) Knowlton
Leguminosites? coloradensis Knowlton
Leguminosite columbianus Knowlton
Leguminosites? laramiensis Knowlton
Mimosites marshallensis Knowlton
Cassia? laramiensis Knowlton
Cercis eocenica Lesquereux
Celastrinites alatus Knowlton
Celastrinites eriensis Knowlton
Celastrinites cowanensis Knowlton

Cannon[14] in an early publication of this Society expresses his amazement at such an unholy union.

It should also be noted that the age of the Arapahoe-Denver formation has been a much debated matter among geologists and paleontologists for over fifty years. The combination of typical Cretaceous dinosaurs with an equally typical Tertiary flora has been a perplexing problem. Cope[15] summarized his views on the matter in the statement (p. 16) which has been frequently quoted:

"There is then no alternative but to accept the result that a Tertiary flora was contemporaneous with a Cretaceous fauna."

More recently the suggestion was made of the possibility of a Cretaceous fauna being contemporary with Tertiary flora, and this is the idea which has more or less been adopted by local geologists for the last 15 or 20 years. Then, this fall, Dobbin and Reeside have reopened the question by expressing the opinion, backed by some evidence, that the Arapahoe and at least part of the Denver are equivalent to the Lance, which is considered to be Cretaceous.

Quaternary Formations. The local post-Tertiary deposits have been divided by Cannon into four divisions[16] (p. 51):

4. Terrace epoch
3. Loessial epoch-Loess } Glacial times
2. Loessial epoch-River drift } Glacial times
1. Erosional epoch-(Late Pliocene to glacial)

No fossils of the first division are known.

From the second division numerous teeth and bones have been obtained, especially during excavations for foundations and sewers in Denver. They include elephants of several species, bison, and a camel-like animal.[17] Berthoud[18] and Rockwell[19] describe the discovery of an elephant tusk in Clear

[14]Cannon, G. L., On the Tertiary Dinosauria found in the Denver beds: Colo. Sci. Soc. Proc., Vol. 3, pp. 142-143, 1890.
[15]Cope, E. D., Review of the vertebrata of the Cretaceous period found west of the Mississippi River: U. S. Geol. and Geog. Survey Terr. Bull. 1st Ser., No. 2, pp. 1-51, 1874.
[16]Cannon, G. L., The Quaternary of the Denver Basin: Colo. Sci. Soc. Proc., Vol. 3, p. 51, 1890.
[17]Cannon, G. L., Colo. Sci. Soc. Proc., Vol. 3, p. 59; Vol. 4, p. 264.
[18]Berthoud, Captain, Tusk of an elephant or mastodon found in Colorado: Amer. Jour. Sci. Ser. 3, Vol. 3, p. 302, 1872.
[19]Rockwell, A. P., Discovery of the tusk of an elephant in Colorado: Am. Jour. Sci. 3rd Ser. Vol. 3, pp. 373-374, 1872. (In Clear Creek Valley, 5 miles above Golden.)

Lull, R. S., Dinosaurian distribution: Amer. Jour. Sci., 4th Ser., Vol. XXIX, pp. 1-39, 10 figs., 1910. (Correlation tables and discussion of the Morrison and other faunas.)

Marsh, Othniel C., Vertebrate fossils, Denver Basin: U. S. Geol. Survey, Mon. 27, pp. 473-527, Illust., 1896.

Mook, C. C., A study of the Morrison formation: N. Y. Acad. Sci. Annals, Vol. 27, pp. 39-191, pl. VI, 1916.

Newberry, J. S., Notes on the later extinct floras of North America with descriptions of some new species of fossil plants for the Cretaceous and Tertiary strata: N. Y. Lyceum Nat. Hist. Annals, Vol. 9, pp. 1-76, 1868.

——The Laramie group. Its geological relations, its economic importance, its fauna and flora: N. Y. Acad. Sci. Trans., Vol. 9, pp. 27-32, 1890. Abstract (by author) Geol. Soc. Am. Bull., Vol. 1, pp. 524-527. Also Am. Geol., Vol. 5, p. 118, 1890.

Newberry, J. S., and Hollick, A., The later extinct floras of North America: U. S. Geol. Survey, Mon. 35, 295 pp., 68 pl., 1898.

Stanton, T. W., Invertebrate Fauna of the Morrison formation: Geol. Soc. Am. Bull., Vol. 26, No. 3, pp. 343-348, 1915.

——The Morrison formation and its relations with the Comanche series, and the Dakota formation: Jour. Geol., Vol. 13, pp. 657-669, 1905. Abstracts: Sci., New Ser., Vol. 22, 755-756, 1905.

Ward, Lester F., Synopsis of the flora of the Laramie group: U. S. Geol. Survey, 6th Ann. Rept., pp. 399-557, Illust., 1885. Abstracts: Am. Nat., Vol. 21, pp. 1011-1012; Am. Geol., Vol. 2, pp. 56-58, 1888; Science, Vol. 10, pp. 150-151, 1887.

——Types of the Laramie flora: U. S. Geol. Survey Bull. 37, 1887.

for the Colorado School of Mines collections, and a representative collection was sent to Dr. J. B. Reeside, Jr., for identification. He reported the following species:

Anchura americana Evans and Shumard
Discoscaphites conradi (Morton) var. intermedius Meek.
Haminea aff. H. subcylindrica Meek
Inoceramus (actinoceramus) n. sp.
Lunatia dakotensis Henderson
Nucula cancellata Meek and Hayden

and made the following statement concerning the collection:[8]

"The most significant species in the lot is the *Discoscaphites*. Its usual stratigraphic position is in the Fox Hills formation, though at a number of localities it has been found just beneath the Fox Hills in a thin transition zone associated with some of the normal Pierre species like *Scaphites nodosus* and the large baculites. We have no species of *Inoceramus* (*actinoceramus*) on record from the later Montana beds except *I. fibrosus* Meek and Hayden (*Pteria fibrosa* of literature), which is a more slender shell than your specimen. It occurs in the latest Pierre and Fox Hills. The other species are known in both Pierre and Fox Hills. I suspect this collection to be of very late Pierre age, though it could be Fox Hills."

In 1928, Messrs. B. S. Butler and T. S. Lovering of the U. S. Geological Survey, engaged in co-operative geologic work, discovered some interesting fossils along the east side of the hogback at Coon Creek about two and one-half miles south of Golden. These occurred in a black shale about 60 feet above the Dakota sandstone, supposedly in the Benton. The material was turned over to the writer, who also, on a casual inspection, considered it to be of Benton age. However, more material was collected which later was studied carefully and then submitted to Dr. Reeside for check. He reported most of the fauna were distinctly middle to upper Pierre. A careful study of the quarry, where new excavations had been made, showed that actually a fault passed through the pit and Pierre was in contact with lower Benton.

Fox Hills Formation. Several fossiliferous outcrops of the Fox Hills formation are known to the west and north of Golden. A list of the forms known to date is given below:

Anchura americana Evans and Shumard
Baculites sp.
Callista deweyi Meek and Hayden
Callista (Dosinopsis) owenana Meek and Hayden

[8]Personal communication, October 5, 1925.

Cardium whitei Dall
Crenella elegantula Meek and Hayden
Cylichna sp?
Dentalium sp?
Fasciolaria cheyennensis Meek and Hayden
Fusus sp?
Liopistha (Cymella) montanensis Henderson
Mactra alta Meek and Hayden
Mytilus subarcuatus Meek and Hayden
Nucula cancellata Meek and Hayden
Pseudobuccinum nebrascense Meek
Pyropsis bairdi Meek and Hayden
Sphaeriola cordata Meek and Hayden
Selemya subplicata Meek and Hayden
Tancredia americana Meek and Hayden
Tellina scitula Meek and Hayden
Turitella sp?
Veniella humilis Meek and Hayden
Halymenites major Lesquereux

Along the irrigation ditch about one-third mile west of the School of Mines at Golden, Colorado, a yellow sand of Fox Hills age outcrops. From this outcrop numerous fossils are collected annually. The variety is rather small but the locality has added a number of species to the list published by Eldridge.

Laramie Formation. Fossil plants are abundant in the Laramie in the Denver Quadrangle. Collections, some of them quite large, have been obtained from the following localities:

1. Clay pits at west end of 12th Street, Golden.
2. Clay pits at west end of 20th Street, Golden.
3. Clay pits about one mile north of Golden on east side of road to brick yard.
4. Clay pits on east side of road about one mile south of Golden.
5. Outcrops along road about one and one-half miles south of Golden.
6. Murphy coal mine on Ralston Creek five and one-half miles north of Golden.
7. Hoyt's coal mine one mile south of Golden.
8. Leyden Gulch six and one-half miles north of Golden.
9. Coal mines at Leyden.
10. Cut of Denver and Salt Lake Railroad about eight miles north of Golden.
11. Outcrops of sandstone about three miles south of Golden.
12. Pits to south of road from Rock Rest to Morrison, about one-half mile east of Dakota Hogback.
13. Mount Carbon, about three miles east of Morrison, Colorado.
14. Associated Industries coal mine on southwest side of Green Mountain, about six miles south and two miles east of Golden.
15. Coal mines north of Clear Creek near Golden.

ADDITIONAL BIBLIOGRAPHY

Cannon, G. L., Fossil woods of the Platte River Valley: Colo. Sci. Soc. Proc., Vol. 7, 1903.

——Notes on some fossils recently discovered near Denver: Colo. Sci. Soc. Proc., Vol. 8, pp. 194-198. Illust., 1905-07.

——Sauropodan gastroliths: Science, New Ser., Vol. 24, p. 116, 1906.

Cope, E. D., On the vertebrata of the Dakota epoch of Colorado: Paleontological Bull. No. 28, printed Jan. 12, 1878; also Amer. Philos. Soc. Proc., Vol. XVII, pp. 233-247, 16 figs., 1878.

Dobbin, C. E., and Reeside, J. B., Jr., The contact of the Fox Hills and Lance formations: U. S. Geol. Survey Prof. Paper 158, pp. 9-25, 1929. (Express opinion Arapahoe and at least part of Denver formations are equivalent to Lance-Cretaceous.)

Gilmore, C. W., Osteology of the Jurassic reptile Camptosaurus, with a review of the species of the genus and descriptions of two new species: U. S. Nat. Mus. Proc., Vol. XXXVI, pp. 197-332, 15 pls., 47 figs., 1909.

Johnson, J. Harlan, Bibliography of the geology of the Denver Basin: Colo. School of Mines, Circular of Information, 8 pp., 1921.

——Bibliography of the geology of Northeastern Colorado: Colo. School of Mines, Circular of Information, 12 pp., 1925.

——The geology of the Golden area, Colorado: Colo. School of Mines Quarterly, Vol. 20, No. 3, 25 pp., Illust., July, 1925.

Jones, Olive M., Bibliography of Colorado geology and mining with subject index, from the earliest explorations to 1912: Colo. Geol. Survey Bull. 7, 493 pp., 1914.

Knowlton, F. H., Catalogue of the Cretaceous and Tertiary plants of North America: U. S. Geol. Survey Bull. 152, pp. 1-247, 1898.

——The Cretaceous-Tertiary boundary in the Rocky Mountain region: Geol. Soc. Amer. Bull., Vol. 25, pp. 325-340, 1914.

——A catalogue of the Mesozoic and Cenozoic plants of North America: U. S. Geol. Survey Bull. 696, 815 pages, 1919.

——Type section of the Morrison formation: Am. Jour. Sci., 4th Ser., Vol. 49, pp. 183-188, 1920.

Lee, Willis T., Recent discovery of dinosaurs in the Tertiary: Am. Jour. Sci., 4th Ser., Vol. 35, pp. 531-534, 1913.

——Type section of the Morrison formations: Am. Jour. Sci., 4th Ser., Vol. 49, pp. 183-188, March, 1920.

Lesquereux, Leo., Catalogue of the Cretaceous and Tertiary plants of North America with reference to their descriptions: U. S. Geol. and Geog. Survey Terr. Ann. Rept., 1876, pp. 487-528, 1878.

——Contributions to the fossil flora of the western territories. Part 2. The Tertiary flora: Hayden Survey Mon., Vol. 7, 366 pp., Illust., 1878.

——The Cretaceous and Tertiary Floras: U. S. Geol. and Geog. Survey Terr. Rept., Vol. 1, pp. 109-126, 1883.

——Fossil plants collected at Golden: Harvard Coll. Mon. Comp. Zool. Bull., Vol. 16, No. 3, pp. 43-59, 1888.

Creek Valley about 5 miles above Golden in 1872. It occurred either in division 2 or 4, probably 2.

Emrich[20] describes the discovery of bones which he considers mastodon during the excavations for a sewer in Golden during July, 1908. It also probably came from this division.

"The Loess division is poorly adapted for the preservation of organic remains and with the exception of bones, fossils are rare."[21]

The recorded fossils include:

Physa sp.
Planorbis sp.
Succinea sp.
Pupa sp.
Linnea sp.
Bones of several kinds of elephant, camel, horse, and numerous rodents, snakes, and frogs. The last three are probably Recent.

The terrace deposits have yielded some bones, mostly of relatively recent types of animals. As far as known to the writer, no one has made a careful study of material from this horizon.

Vegetal material has been found in all of these Quaternary deposits, but, with the exception of a few carbonized fragments of wood, it was in too fragmentary a condition, or too poorly preserved, to be studied.

[20]Emrich, Clarence T., Mastodon bones (from Golden, Colorado): Colo. School of Mines Bull., Vol. 5, No. 1, pp. 36-37, Illust., 1909.
In making excavations for a sanitary sewer at Golden, Colorado, July 20, 1908, in Quaternary wash about 15 feet below surface, workmen uncovered some large bones which C. T. Emrich and the civil engineer on the job call Mastodon.

[21]Cannon, G. L., The Geology of Denver and Vicinity: Colo. Sci. Soc. Proc., Vol. 4, pp. 235-270, 1893.

The mines forming Localities 6, 7 and 15, have been abandoned and caved in for years so are no longer available to collectors.

Most all of the material obtained in recent years has come from Localities 1, 2, 3, 4 and 12.

It is interesting to note that Knowlton did not know of these newer localities and did not have any material from them to use in preparing his monograph on the Laramie Flora of the Denver Basin.

The writer has obtained several hundred specimens from Localities 1 and 2. The leaves obtained come from a horizon near the top of the Laramie.

The following list names the described forms:[9]

Delesseria fulva Lesquereux
Onoclea fecunda (Lesquereux) Knowlton
Dryopteris georgei Knowlton
Dryopteris laramiensis Knowlton
Dryopteris lesquereuxii Knowlton
Dryopteris carbonensis Knowlton
Phanerophlebites pealei Knowlton
Asplenium martini Knowlton
Pteris goldmani Knowlton
Pteris, sp.
Anemia elongata (Newberry) Knowlton
Anemia supercretacea Hollick
Anemia sp?
Lygodium? compactum Lesquereux
Equisetum perlaevigatum Cockerell
Dammara sp.
Sequoia acuminata? Lesquereux
Sequoia reichenbachi (Geinitz) Heer
Sequoia longifolia Lesquereux
Cycadeoidea mirabilis (Lesquereux) Ward
Cyperacites? hillsii Knowlton
Cyperacites? tessellatus Knowlton
Cyperacites? sp.
Phragmites laramianus Cockerell
Smilax? inquirenda Knowlton
Sabal montana Knowlton
Juglans leydenianus Knowlton
Juglans newberryi Knowlton
Juglans laramiensis Knowlton
Juglans leconteana Lesquereux
Juglans praerugosa Knowlton
Hicoria angulata Knowlton
Hicoria minutula Knowlton
Myrica torreyi Lesquereux

[9]Knowlton, F. H., The Laramie flora of the Denver Basin, with a review of the Laramie problem: U. S. Geol. Survey Prof. Paper 130, 175 pp., 1 fig., 28 plates, 1922.

It should be noted that all the plants are found in the Denver flora and that all the dinosaurs are also known in the Denver, as can be seen by comparing with the Denver lists given below.

Inasmuch as Eldridge seems to have rather arbitrarily divided the Arapahoe from the Denver, because of a misconception as to its age, and, since Richardson has shown that both grade laterally into the Dawson Arkose of the Castle Rock Quadrangle, it would seem advisable to discard the name Arapahoe altogether.

Denver Formation. Abundant plant fossils are known from the Denver formation. Some are splendidly preserved. Collections totaling hundreds of specimens have been obtained from a number of localities in the vicinity of Golden, and plant remains can be obtained in almost any of the sandy layers.

Most of the described material has been collected along the south sides of South Table Mountain and from the northwestern base of Green Mountain. The total known flora includes about 225 species. They are listed below:[12]

Acorus brachystachys Heer
Allantodiopsis erosa (Lesquereux) Knowlton and Maxon
Alnus auraria Knowlton and Cockerell
Amelanchier typica var. Lesquereux
Andromeda linearifolia Lesquereux
Aralia notata Lesquereux
Artocarpus pungens (Lesquereux) Hollick
Arundo gopperti? Munster
Arundo? obtusa Lesquereux
Asimina eocenica Lesquereux
Asplenium crossii Knowlton

Berchemia multinervis (Al. Braun) Heer
Berrya racemosa (Knowlton) Knowlton
Betula gracilis? Ludwig
Betula schimperi Lesquereux

Carex Berthoudi Lesquereux
Carpites coffeaeformis Lesquereux
Carpites costatus Lesquereux
Carpites alurineus Lesquereux
Carpites minutulus Lesquereux
Carpites myricarum Lesquereux

[12]Knowlton, F. H., and Berry, E. W., Flora of the Denver and associated formations of Colorado: U. S. Geol. Survey Prof. Paper 155, 1930.

Carpites oviformis Lesquereux
Carpites rostellatus Lesquereux
Carpites triangulatus Lesquereux
Carpolithes corrugatus (Lesquereux) Cockerell
Castanea intermedia Lesquereux
Celastrinites artocarpidioides Lesquereux
Celastrinites populifolius Knowlton
Celastrus gaudini Lesquereux
Chrysobalanus coloradoensis Knowlton
Cinnamomum sp.
Cissus coloradoensis Knowlton and Cockerell
Cissus corylifolia Lesquereux
Cissus duplicato-serrata Lesquereux
Cissus lesquereuxii Knowlton
Cissus lobato-crenata Lesquereux
Cissus obovata Knowlton
Cornus denverensis Knowlton
Cornus holmesii Lesquereux
Cornus impressa Lesquereux
Cornus lakesii Knowlton
Cornus studeri? Heer
Crataegus antiqua Heer
Crataegus betulaefolis Lesquereux
Crataegus englehardti Lesquereux
Crataegus holmesii Lesquereux
Crataegus myricoides Lesquereux

Daphnogene anglica? Heer
Diospyros brachysepala Al. Braun
Diplazium crossii (Knowlton) Knowlton
Dombeyopsis grandifolia? Unger
Dombeyopsis obtusa Lesquereux
Dryopteris arguta (Lesquereux) Knowlton
Dryopteris lakesii (Lesquereux) Knowlton
Dryopteris nigricans (Lesquereux) Knowlton
Dryopteris polypodioides (Ettingshausen) Knowlton

Equisetum, 2 species
Eriocaulon? porosum Lesquereux

Ficus aguilar Knowlton
Ficus andraei Lesquereux
Ficus berthoudi Lesquereux
Ficus coloradoensis Cockerell
Ficus eldridgi Knowlton
Ficus denveriana Cockerell
Ficus lakesii Knowlton
Ficus martini Knowlton
Ficus occidentalis (Lesquereux) Lesquereux
Ficus neoplanicostata Knowlton
Ficus planicostata clintoni (Lesquereux) Knowlton
Ficus planicostata goldiana Lesquereux
Ficus planicostata problematica Knowlton
Ficus pseudopopulus Lesquereux
Ficus subtruncata Lesquereux

Ulmus antecedens Lesquereux
Ulmus quercifolia Unger

Viburnum goldianum Lesquereux
Viburnum? heterodontum Knowlton
Viburnum lakesii Lesquereux
Viburnum richardsoni Knowlton
Viburnum solitarium Lesquereux

Woodwardia latiloba Lesquereux

Zingiberites dubius Lesquereux
Zizyphus beckwithii Lesquereux
Zizyphus daphnogenoides Knowlton
Zizyphus distortus Lesquereux
Zizyphus fibrillosus (Lesquereux) Lesquereux
Zizyphus hesperius Knowlton
Zizyphus resquereuxii Knowlton
Zizyphus meekii Lesquereux

Silicified and more or less carbonized wood is quite common. Some large logs have been noted. Silicified palm stumps, 18 inches to 2 feet in diameter, have been found around the Table Mountains and Green Mountain.

The animal remains reported from the Denver formation include:

Dinosaurs:	Ceratops alticornis (type)
	Ornithomimus velox Marsh
	Triceratops horridus
	Clasosaurus annectens
	Palaeoscinus latus Marsh
Turtles:	Compsemys victus
	Trionyx feveatus
Crocodile:	Crocodilus humilus
Fish:	Lepidotus occidentalis
Mammal:	Several teeth and fragmentary bones

Cannon[13] records the finding of a few imperfect fresh water shells near Cheltenham Heights by T. W. Stanton, and names the following species:

Viviparus trochiformis
Goniobasis tenuicarinata
Corbicula sp. ?
Physa sp. ?
Unio sp. ?

It is interesting historically to note that the first ceratopsian dinosaur fragments, collected from the Denver, were identified by Marsh as a dinosaur of typical Jurassic stegasaurian type and a bison of late Pliocene character. Mr.

[13]Cannon, G. L., The geology of Denver and vicinity: Colo. Sci. Soc. Proc., Vol. 4, p. 261, 1893.

Negundo brittoni Knowlton
Pistacia eriensis Knowlton
Pistacia hollicki Knowlton
Ilex laramiensis Knowlton
Ceanothus eriensis Knowlton
Rhamnus goldianus? Lesquereux
Rhamnus salicifolius Lesquereux
Rhamnus minutus Knowlton
Rhamnus marshallensis Knowlton
Rhamnus belmontensis Knowlton and Cockerell
Rhamnus brittoni Knowlton
Rhamnus? pealei Knowlton
Rhamnus sp.
?Paliurus zizyphoides Lesquereux
Zizyphus coloradensis Knowlton
Zizyphus hendersoni Knowlton
Zizyphus corrugatus Knowlton
Zizyphus minutus Knowlton
Apeibopsis? laramiensis Knowlton
Cornus suborbifera Lesquereux
Cornus praeimpressa Knowlton
Cornus sp.
Hedera lucens Knowlton
Diospyros berryana Knowlton
Fraxinus? princetoniana Knowlton
Apocynophyllum taenifolium Knowlton
Dombeyopsis obtusa Lesquereux
Dombeyopsis trivialis Lesquereux
Dombeyopsis? sinuata Knowlton
Dombeyopsis ovata Knowlton
Carpites lakesii Knowlton
Carpites lesquereuxiana Knowlton
Carpites rhomoidalis Lesquereux
Phyllites leydenianus Knowlton
Phyllites marshallensis Knowlton
Phyllites trinervis Knowlton
Phyllites dombeyopsoides Knowlton
Phyllites sp.
Phyllites sp.
Phyllites sp.
Palaeoaster? similis Knowlton

Besides these there are a number of undescribed forms in local collections.

In looking over a collection of these plants, one is struck by the familiar appearance of many forms such as poplar, hickory, beech, and other very modern temperate zone forms, together with a surprising abundance of figs, palms, magnolias, and similar tropical and subtropical types. Palm leaves up to five feet long are found every year in the clay pits outside of Golden. Very plainly they indicate conditions of cli-

mate and physiography for the region vastly different from those now existing, or, less likely, a very different adaptability of the organisms.

Very little trace has been found of the animal life of Laramie time in this area. To date, a piece of amber containing an insect fragment, has been found near Golden. A fragment of an unio, and some specimens of *Ostrea glabra* have been reported from north of Leyden, while Eldridge mentions an undetermined dinosaur but gives no locality.

Arapahoe Formation. There is considerable doubt in the mind of the writer as to the justification for considering the Arapahoe as a distinct formation. He would consider it as merely a portion of the Denver. However, the term has been in use for forty years and a number of fossils have been reported from it. These are remains of land plants and dinosaurs.

The dinosaurs reported are:

Thespesius occidentalis (?) Leidy
Triceratops Alticornis Marsh
Triceratops galeus Marsh
Ceratops montanus Marsh

The localities from which the dinosaurs were obtained is not known, but it is believed to have been from the general vicinity of Golden. Specimens have been found in the Denver formation near Green Mountain.

Dr. Gilmore says of these:

"The specimen of *Thespesius occidentalia* (?) Leidy was originally given the name *Agathaumas milo*, but later the materials were identified as pertaining to the *Hadrosauridae* * * * It is extremely doubtful if the specific determination of *occidentalis* is to be relied upon, as the specimen was quite framentary."[10]

The exact locality is unknown.

The type specimen of *Triceratops galeus* Marsh was found near Brighton.

The identity of the specimen referred to as *"Ceratops montanus* Marsh" is open to considerable question as the type of this species is of Montana age.

Several years ago, Messrs. E. Russell Lloyd and Chas. W. Henderson called the attention of the writer to portions of a

[10]C. W. Gilmore. Personal communication, April 24, 1930.

Platanus raynoldsii Newberry
Platanus raynoldsii integrifolia Lesquereux
Platanus rhomboidea Lesquereux
Populus denverensis Knowlton
Populus nebrascensis Newberry
Populus jacksoni Knowlton
Populus lacoeana Knowlton
Populus nebrascensis acute-dentata Lesquereux
Populus nebrascensis grandidentata Lesquereux
Populus nebrascensis longifolia Lesquereux
Populus nebracensis rotunda Lesquereux
Populus subrotunda Lesquereux
Populus tenuinervata Lesquereux
Populus ungeri Lesquereux
Populus zeilleri (Lesquereux) Knowlton
Populus sp.
Protoficus zeilleri Lesquereux
Pteris pseudopinnaeformis Lesquereux
Ptericarya americana Lesquereux (Formation doubtful)
Pterocarya retusa Lesquereux
Pterospermites grandidentatus Lesquereux
Pterospermites sp. Lesquereux

Quercus celastrifolia Lesquereux
Quercus coloradoensis Lesquereux
Quercus crossii Lesquereux
Quercus eucalyptifolia Ettingshausen
Quercus haidingeri Ettingshausen (Formation doubtful)
Quercus? leonis Knowlton
Quercus viburnifolia Lesquereux
Quercus whitei Lesquereux

Rhamnus alaternoides Heer
Rhamnus cleburni Lesquereux
Rhamnus crenulatus Knowlton and Cockerell
Rhamnus deformatus Lesquereux
Rhamnus goldianus Lesquereux
Rhamnus obovatus Lesquereux (Formation doubtful)
Rhamnus praealaternoides Knowlton
Rhamnus rectinervis Heer

Sabal? eocenica (Lesquereux) Knowlton
Sabalites fructifer Lesquereux
Sabalites grayanus Lesquereux
Saccaloma gardneri (Lesquereux) Knowlton
Salpichlaena anceps (Lesquereux) Knowlton
Sapindus caudatus Lesquereux
Sapindus? obtusifolius Lesquereux?
Sclerotites rubellus (Lesquereux) Meschinelli
Selaginella berthoudi Lesquereux
Sequoia? sp. Lesquereux
Sterculia saportanea Knowlton
Sterculia libbeyi Knowlton
Styrax ambra Unger
Styrax laraminense Lesquereux

Ficus tiliaefolia (Braun) Heer
Ficus zizyphoides Lesquereux (Formation doubtful)
Ficus sp. (2)
Fraxinus praedicta Heer
Fraxinus eocenica Lesquereux

Geonomites goldianus (Lesquereux) Lesquereux
Geonomites graminifolius Lesquereux
Geonomites tenuirachis Lesquereux
Geonomites? sp.
Ginkgo? truncata (Lesquereux) Knowlton
Grewiopsis tenuifolia Lesquereux

Hicoria antiquora (Newberry) Knowlton
Hymenophyllum confusum Lesquereux

Ilex? ovata Knowlton

Juglans denveriana Knowlton
Juglans rhamnoides Lesquereux
Juglans rugosa Lesquereux
Juglans schimeri Lesquereux
Juglans thermalis Lesquereux

Laurus primigenia Unger
Laurus schmidtiana Heer
Laurus socialis Lesquereux
Leguminosites? arachioides (Lesquereux) Lesquereux

Magnolia magnifolia Knowlton

Negundo decurrens Lesquereux
Nelumbo lakesiana (Lesquereux) Knowlton
Nelumbo tenuifolia (Lesquereux) Knowlton
Nyssa denveriana Knowlton
Nyssa europaea Unger
Nyssa lanceolata Lesquereux
Nyssa? obovata Knowlton
Nyssa? racemosa Knowlton

Paloreodoxites plicatus (Lesquereux) Knowlton
Paliurus coloradoensis Lesquereux
Paliurus zizyphoides Lesquereux
Palmocarpon? corrugatum Lesquereux
Palmocarpon lineatum Lesquereux
Palmocarpon palmarum (Lesquereux) Knowlton
Palmocarpon subcylindricum Lesquereux
Palmocarpon truncatum Lesquereux (Formation doubtful
Palmodyloncannoni stevens
Persea brossiana (Lesquereux) Lesquereux
Phyllites cyclophyllus (Lesquereux) Hollick
Phyllites denverensis Knowlton
Piper heerii Lesquereux
Pisonia chlorophylloides Berry
Platanus aceroides Goppert
Platanus guillelmae Goppert
Platanus haydenii Newberry

dinosaur skull exposed in the Arapahoe basal conglomerate in the 12th Street clay pits at Golden. Examination revealed a number of other bones scattered in the conglomerate nearby. These have been turned over to Mr. Harold Cook of the Colorado Museum of Natural History. It is expected that a description and discussion of them will be ready for publication about October, 1930. This find is of particular interest as it is almost the only one in which the exact geographic and stratigraphic location are definitely known.

Several small collections of plants from localities around Denver have been reported by early writers. Unfortunately, the localities given are vague and it has been demonstrated that these writers had several misconceptions as to stratigraphy, so that it seems more than probable at present that most of these actually came from the Denver. The one collection regarded by Knowlton[11] as most probably Arapahoe comes from the Douglas mine near the type locality of the Arapahoe. It comprises the following flora:

Acer sp.
Allantodiopsis erosa (Lesquereux) Knowlton and Maxon
Asimina eocenica Lesquereux
Berchemia multinervis (Al. Braun) Heer
Cissus coloradensis Knowlton and Cockerell
Cissus lobato-crenata Lesquereux
Dennstaedtia crossiana Knowlton
Diospyros brachysepala A. Braun
Dombeyopsis obtusa Lesquereux
Dombeyopsis? sedaliensis Knowlton
Dryopteris lakesii (Lesquereux) Knowlton
Dryopteris richardsoni Knowlton
Ficus? alata Knowlton
Ficus neoplanicostata Knowlton
Laurus primigenia Unger
Nelumbo crossii Knowlton
Nelumbo lakesiana (Lesquereux) Knowlton
Phyllites aristolochoides Knowlton
Platanus haydenii Newberry
Quercus? sedaliensis Knowlton
Viburnum richardsoni Knowlton
Woodwardia latiloba Lesquereux

Knowlton makes the following comment:

"It will be seen at once that this is essentially a Denver flora, with only two species that occur in the Laramie—*Dombeyopsis obtusa* and *Ficus planicostata.* Both of these species have already been several times mentioned as passing from Laramie into post-Laramie beds."

[11]Op. Cit.