Outline of the GEOLOGY and PALEONTOLOGY of

SCOTTS BLUFF NATIONAL MONUMENT

By William L. Effinger

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U. S. Department of the Interior
NATIONAL PARK SERVICE
FIELD DIVISION OF EDUCATION
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INTRODUCTION

PURPOSE

The object of this report is to present the results of a search of the geologic and paleontologic literature for facts and inferences concerning the geological and paleontological history of the region surrounding Scotts Bluff National Monument. The information presented has been obtained principally from the literature, the sources of which are frequently referred to and are all included in the bibliography. Much of the information was obtained from personal interviews with members of the staff of the Museum of Vertebrate Paleontology and the Department of Paleontology at the University of California. Free use was made of the library of the University of California, the Geology Library, and Matthew Library. This work was done under the direction of the Field Division of Education of the National Park Service.

LOCATION AND PHYSIOGRAPHY

Scotts Bluff National Monument is located near the center of Scotts Bluff County in Western Nebraska, and borders the North Platte River. It is situated near the towns of Gering and Scotts Bluff and may be reached by a branch of the Union Pacific System, the Chicago, Burlington and Quincy Railroad, or by an automobile road extending through the North Platte Valley. The monument has a total area of 1,893.83 acres which includes the conspicuous promontory of Scotts Bluff, a celebrated and historic landmark of the early days of travel along the Oregon Trail. It was created as a National Monument by Congress December 12, 1919.

This region is situated in the western portion of North America known as the Great Plains, an extensive, eastwardly sloping surface extending from the foothills of the Rocky Mountains to the western margin of the Mississippi basin.

To the north this plain terminates in Pine Ridge, a northward facing escarpment extending from Southern South Dakota thru Northwestern Nebraska and into Wyoming, beyond which the old surface had been largely destroyed by the erosive action of the White and Cheyenne Rivers. To the south the plain has an extensive development in Western Kansas and Texas. In Western Nebraska the surface of the high plain is confined to the larger interstream areas such as that lying between the Niobrara River and the North Platte River, that between Pumpkinseed Valley and Lodgepole Creek, and that lying to the south of Lodgepole Creek. In the region of Scotts Bluff, isolated remnants of this surface are represented in the irregular ridge lying to the south of the valley of the North Platte and separated from the main portion of the tableland to the south of Pumpkinseed Valley. Although the summit of this ridge lies about ten miles south of the North Platte River, several lateral ridges extend almost to the river and form conspicuous bluffs, these being Scotts Bluff, Castle Rock, and Chimney Rock. Headward erosion of some of the streams draining this area resulted in the removal of materials from behind, leaving the projecting portions of former spurs standing as isolated pinnacles or mesas. An explanation of the complete isolation of this ridge and of the wide depression to the south now occupied by Pumpkin Creek has been proposed by Darton. (Darton, N. H., 1903, p. 22.) Along the sides of Pumpkinseed Valley, at levels considerably above the present valley floor, have been found rather extensive deposits of coarse gravels derived from the Rocky Mountains and similar in character to those found in the terraces of the North Platte River. It seems very probable that at one time a branch of the North Platte River flowed thru Pumpkinseed Valley making the ridge lying to the north an island in the midst of a wider Platte River. Subsequently the north channel of the river became more deeply eroded causing the river to confine all of its waters to that channel just as at present.

In the latitude of Scotts Bluff the surface of the Great Plains has an elevation of about 4300 feet above sea level at the one hundred and third meridian and gradually increases in elevation westwardly to nearly 5000 feet in the vicinity of the Wyoming line. In the southwest Banner County and in the extreme portion of Nebraska, altitudes of over 5300 feet are attained, these constituting the highest land in the state. Scotts Bluff, at one time believed to be the highest point, (Yard, R. S., Nat. Parks Portfolio 6th ed. revised by Isabelle F. Story, U. S. Govt. Printing Off. Washington, 1931.) has an elevation of 4662 feet.

One of the most interesting physiographic features of the Northern Great Plains is the badland topography so extensively developed in the Big Badlands of South Dakota and Northwestern Nebraska as well as in numerous smaller areas such as that developed at the base of Scotts Bluff. The name "Badlands" apparently had its origin in the literal translation of <u>Mauvaisos Torros</u> of the early French Canadian trappers who in turn derived it from the still earlier <u>Mako</u> <u>Sicha</u> (Mako, land; <u>Sicha,</u> bad) of the Dakota Indians. (O'Harra, C. C., 1920, p. 19).

Badland topography is solely an expression of erosive agoncics acting in such a way as to produce a labyrinth of steep-side, irregular gullics branching and rebranching into smaller and smaller rivulots until usually little level surface ramains. The region also is often studded with symmetrical columns or with grotesque shaped mounds and tables. Topography of this sort is the result of erosion controlled in part by climatic conditions and in part by the stratigraphic and lithlogic nature of the deposits. The chief factors in its formation are: a climate with low rainfall usually concentrated into heavy showers; a scarcity of deep-rooted vegetation; slightly consolidated and nearly homogeneous, fine-grained sediments lying at a considerable height above the main drainage channels and in a nearly horizontal position. Such a country offers innumerable difficulties for travel and one can easily understand why the name, Mauvaises Torros.

PALEONTOLOGIC EXPLORATION AND IMPORTANCE

Long before the coming of the white man to this region, fossil remains had been observed by the Indians and had found their way into many of their legends. Captain James H. Cook, United States Army Scout, in his manuscript, "Sketches of the Life of Red Cloud", tells of a visit to the Red Cloud Agency located on the White River in Northwestern Nebraska where he was shown a perfectly petrified tooth three inches or more in diameter. "American Horse explained that the tooth had belonged to a 'Thunder Horse" that had lived 'away back' and that then this creature would sometimes come down to earth in thunderstorms and chase and kill buffalo. His old people told stories of how on one occasion many, many years back, this big Thunder Horse had driven a herd of buffalo right into a camp of Lacota people during a bad thunderstorm, when these people were about to starve, and that they had killed many of these buffalo with their lances and arrows. The 'Great Spirit' had sent the Thunder Horse to help them get "food" when it was needed most badly."

The first formally recorded notice of fossil remains from this region is that of Dr. Hiram A. Prout of St. Louis. It consists of a figure and description of a lower law of a "gigantic Palootherium", (American Journal of Science, 1847.) The specimen was sent to Dr. Prout by a representative of the American Fur Company and is now known to represent the lower maxillary of one of the large Titanotheres, Menodus giganteus.

Later in the same year Dr. Joseph Leidy described in the Proceedings of the Academy of Natural Sciences of Philadelphia a fairly well preserved skull of an ancestral camel, calling it Poebrotherium.

A great deal of interest was aroused by these discoveries and in 1849 Dr. John Evans visited the region under the direction of the Owen Survey for the United States Government, for the purpose of determining the character and age of these deposits. The geography and geology with a popular account of the fossil animals found were published in a report by David Dale Owen in 1852.

The next year (1850) Mr. Thaddeus A. Culbertson visited the same region under the auspices of the Smithsonian Institution and made a good collection of fossil material. The United States Geological Survey of the Territories made by Meek and Hayden, especially the explorations of 1853, 1855, 1857, and 1866 were exceedingly productive in unraveling the main geologic features of the country and in obtaining many new specimens of vertebrate fossils. The detailed study of most of the fossil material so far obtained was entrusted to Dr. Joseph Leidy of Philadelphia, who was recognized as the best authority at this time on fossil mammals in America. Many papers were published by him during these years; in 1869 his monumental work, "The Extinct Mammalian Fauna of Dakota and Nebraska," brought together all that was known of these forms at this time, and established the White River Badlands as one of the great fossil vertebrate repositories of the world.

A new epoch of vigorous investigation followed with new men entering the field and numerous institutions sending out exploring and collecting expeditions. In 1870 Yale University was represented by a party, under the direction of Professor O.

C. Marsh, which used refined methods of collecting and assembling dissociated fossil material so that a number of fairly complete skeletons were obtained. Later expeditions were sent to this region in 1871, 1873, 1874, 1886, 1887, 1888, 1889, 1890, 1894, 1895, 1897, 1898, and 1908. The United States Geological Survey aided in much of this work. Part of the material collected is in the Peabody Museum and part in the National Museum.

Princeton University sent at least four expeditions into the Nebraska Territory beginning in 1882. These were under the direction of Professor W. B. Scott and Mr. J. B. Hatcher. The results were of great importance and have been described principally by Professor Scott.

Beginning in 1892 the American Museum of Natural History sent numerous expeditions into the field, and they have had great success in obtaining many complete skeletons. Some of these have been mounted and restored in the flesh with the greatest of detail and care for scientific accuracy, and they present as nearly as possible a life-like image of those animals as they appeared million of years ago. Professor H. S. Osborn has been in charge of most of this work and to his efforts is due much of the success.

Among the many other institutions which have sent geologic and paleontologic expeditions into this region and which have achieved noteworthy success are: University of Nebraska with Professor E. H. Barbour in charge of the expedition and aided by J. E. Todd of the University of South Dakota; Carnegie Museum expedition under the direction of Mr. J. B. Hatcher and O. A. Peterson, being the first to develop the Agate Springs Quarry; Amhorst College expeditions in charge of F. B. Loomis; the Field Columbian Museum with O. A. Farrington in charge; United States Geological Survey renewed investigation, the work of N. H. Darton being particularly important; and the South Dakota State School of Minos which has been sending a party into the field every year since 1899. Not to be overlooked are the private collectors who through their own enterprise have added greatly to the material now known.

As a result of these expeditions, the Badland regions of Western Nebraska and South Dakota have become world famous for their representation of mammalian life. It is interesting that the remains of such animals as the large Titanotheres, three-toed horses, camels, aquatic and cursorial rhinoceroses and predacious carnivores are found here. One factor that makes this record of the greatest importance is its completeness. Numerous other localities are known in which fossil mammals very often occur, but generally these represent only a very short interval of geologic time, and are so isolated as to be difficult to tie into the correct sequence of events. Although there are still breaks in this record, it is believed that these will be filled by research, which is now being done or will be done in the future.

HISTORICAL GEOLOGY AND PALEONTOLOGY

It is essential in all historical studies to discover the order in which events have succeeded one another, for this permits an analysis of cause and effect. Although time is continuous it is punctuated by important events, so for convenience we divide it into separate units for easy reference. A study of the rocks over large areas of the earth's crust have led to the discovery of a chronological series of events through which our planet has passed. In working out this history in any particular region the superposition of beds is greatly relied upon to furnish the sequence of events of the time during which they were being deposited. As is well shown in Scotts Bluff, where a series of horizontal beds may be seen, one bed overlying another in succession, the lowest formation is known to be the oldest and succeeding strata, are of successively younger age. In other words each formation has its peculiar group or assemblage of species which is known as its fauna. In regions such as that surrounding Scotts Bluff, where the formations are not seriously disturbed by earth movements, a study of the fossils contained in superimposed beds reveals a faunal succession.

Since the beginning of geologic time no region on the continental areas has been the site of continuous deposition. The rocks in any one region may give a portion of geologic history or several portions, separated by breaks during which time no sediments were being deposited. These fragments of different regions may be pieced together by various means of correlation, either by the use of faunas or faunal succession, by tracing key beds, or by using some inorganic means of correlation. As a result, the major events in the history of the earth have been arranged into a chronologic chart called the Geologic Time Scale.

The only clock the geologist has to go by in estimating the length of the periods of geologic time which offers any degree

GEOLOGIC TIME SCALE (Modified from Schuchert)

Eras	Periods	Duration	Biologic and Climatic Changes	Ages
CENOZOIC	Pleistocene (Epoch)		Periodic glaciations. Dawn of social life and industry among men. Extinction of large mammals.	Age of Man
	Pliocene (Epoch)	5 %	Cooling climate. Changing of man ape into man.	Age of Mammals
	Miocene (Epoch)	5 %	Culmination of mammals and land floras.	
	Oligocene (Epoch)	2 %	Rise of Anthropoids. Last of archaic mammals.	
	Eocene (Epoch)		Spread of modernized mammals. Dawn of modern life. Rise of grasses, cereals, fruits. Expansion of archaic mammals.	
MESOZOIC	Cretaceous	4 %	Last of the Ammonites, Extinction of Dinosaurs, Pterodactyls, and toothed birds. Rise of archaic mammals and birds. Spread of flowering plants and modern insects.	Age of Reptiles and Ammonites
	Jurassic	2 %	Rise of toothed birds and spread of Pterodactyls. Spread of primitive mammals. Culmination of ammonites.	
	Triassic	1 %	Rise of Dinosaurs, Pterodactyls, and primitive mammals. Spread of cycads and conifers.	
PALEOZOIC	Permian	2 %	Periodic glaciations in southern hemisphere. Extinction of Trilobites and Paleozoic corals. Primitive insects.	Age of Amphibians
	CARBONIFEROUS: Pennsylvanian	2 %	Warm humid climate with extensive coal making. Dominance of spore floras. Spread of reptiles.	
	CARBONIFEROUS: Mississippian	2 %	Spread of ancient sharks and culmination of crinoids.	
	Devonian	2 %	Rise of amphibians, marine fishes, and primitive ammonites. First spread of forests.	Age of Fishes
	Silurian	1 %	Rise of air-breathing invertebrates. Spread of Paleozoic reef-corals. First known occurrence of land plants.	
	Ordovician	3 %	Rise of fresh-water fishes and of corals. Spread of molluscs. Culmination of trilobites.	Age of Marine Invertebrates
	Cambrian	4 %	Rise of shell-bearing molluscs. Dominance of trilobites. First appearance of well-known marine faunas.	
Proterozoic Era		75 %	Era of primitive marine life. An early and late glacial period.	
Archeozoic Era			Era of the oldest known life. Geologic history very obscure.	Age of Larval Life

of accuracy is that of the disintegration of radioactive minerals found in certain rocks. By this means he has estimated the earth to be at least two billions of years old. An older method commonly used until the discovery of radioactivity was the determination of the present rate of deposition for various kinds of sediments and the application of this to the known thickness of the older formations. Breaks in the record and discrepancies in the rate of deposition introduced great errors in this method, the age of the earth being estimated at 500, 000,000 years.

The formations so excellently exposed at Scotts Bluff and in the surrounding area were found to have been deposited during the most recent era of geologic time, the Cenozoic. The almost horizontal beds represent extensive sheets of sandstone, shale and conglomerate deposited in this region as sediments by streams which drained the higher land to the west. Underlying this thick blanket of Cenozoic deposits are older formations representing much of Mesozoic and Paleozoic time. They are hidden from view in the Scotts Bluff region but exposed in the Black Hills and Rocky Mountains where folding and uplift have occured followed by erosion. From detailed studies of these rocks in the surrounding regions a great deal may be inferred as to what was happening in the Scotts Bluff locality. As a background for the more important events of the Cenozoic which are so magnificently represented in this region, it may be well to review briefly the history leading up to the more important Cenozoic Era.

Early and Middle Paleozoic

The early and middle Paleozoic history of this region is very incomplete. It is believed that the extensive invasions of the sea which extended over a large part of the interior of North America during the Late Cambrian, the Ordevician, the Silurian, and Devonian did not cover this region. (Schuchert, Chas., 1933, pp. 125, 146, 175, 196-197. Darton, N. H., U. S. Geol. Sur. Folio No. 87, Scotts Bluff Folio, states that the Late Cambrian sandstone may underly this region. The Silurian and Devonian are very thin or absent in the region to the north and west, their presence here being doubtful.

Late Paleozoic and Early Mesozoic

Carboniferous limestones, shales, and sandstones are believed to underly all of Nebraska. They are known to the north and northwest about the Black Hills and on the slopes of the Rocky Mountains as well as in Eastern Nebraska where they form cliffs along the Platte River from Ashland to Plattsmouth. The deposits consist of limestones, shales and sandstones and contain thin coal beds in some localities.

During the Carboniferous, widespread transgression of the ocean extended over the Central Great Plains region in which were deposited thick beds of limestone. In the later portion of this period uplift occurred, disminshing the extent of this sea and causing it to shallow so that coarse sediments appear in the record represented by sandstones, sandy limestone and red shale. Emergence was even greater during the Permian when an extensive inland basin was formed across the western portion of the Central Great Plains and extended far to the northwest; however, it remained above sea level. In it was deposited great masses of red shale and gypsum, products of an arid climate. These conditions of deposition and aridity continued into the Jurassic.

Middle and Late Mesozoic

In late Jurassic time a sea covered this region again and its deposits are known to occur in the Laramie and Big Horn Mountains, in the Black Hills and probably extended beneath the younger formations over Northwestern Nebraska. Mostly fine materials were deposited, but locally, red beds occur indicating the position of old shore lines. In some regions there was a short return to continental conditions during the Middle Jurassic. However, during the Upper Jurassic there was a return of the sea, for we find thick deposits of shale, and thin beds of limestone indicative of deeper water. (Sundance formation)

This incursion of the sea was of short duration however, for it was followed by widespread uplift in the latest Jurassic time. In the region extending from Montana to Oklahoma the deposits consisted principally of clays of the Morrison formation. It is probable that the Morrison formation was deposited over Western Nebraska, but the eastern margin of this formation has not been definitely located. The Morrison is known to contain more than one hundred and fifty kinds of terrestrial animals and plants including the greatest of all dinosaurs.

The Jurassic was followed by a long period of non-deposition and erosion, but in Middle Cretaceous time the seas again inundated the region. The first deposits, formed as the sea encroached

TABLE OF GEOLOGIC FORMATIONS IN NEBRASKA

Pleistocene	Alluvium Sand hills Loess Drift Equus beds	
Pliocene	- Ogalalla formation	- Snake Creek beds, etc.
Miocene	Arikaree formation Gering formation	Nebraska beds Harrison beds Rosebud Monroe Creek beds
Oligocene	Brule clay Chadron formation	Protoceras beds Oreodon beds - Titanotherium beds
Cretaceous	Laramie formation Pierre clay Niobrara formation Benton shale Dakota sandstone	
Paleozoic Carboniferous	Permian limestone Cottonwood limestone Wabaunsee formation	

over the land, were rather coarse sandstones known as the Dakota Sandstone. This formation underlies the entire central northern Great Plains and is a source of artesian water supplies. Sandstone was followed by a rapid change in the deposition to clays, even more extensive in their distribution than the Dakota Sandstone. These make up the Benton, Niobrara and Pierre formations which record the maximum extent of the seas throughout this region. These clays are finally capped by more sandstones indicating a return of shallow waters and a final retreat of the sea from this region. Marine waters have never since spread over this region. In the wake of the retreating sea brakish water lagoons and bays formed, which in the course of time finally became entirely fresh water. The deposits formed in them represent the transitional state of time between the Cretaceous and Cenozoic.

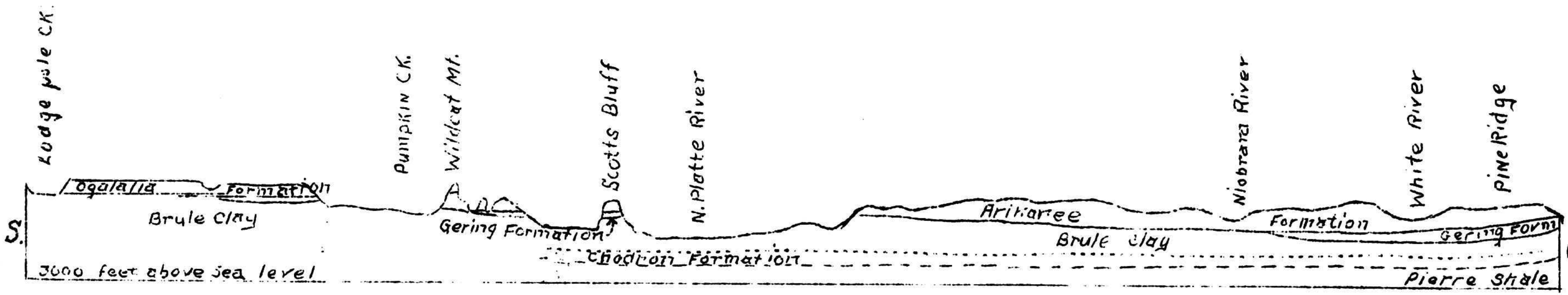
Extensive crustal unrest marked the closing stages of the Mesozoic Era. The floor of the greater part of the basin which has so recently been covered by the Cretaceous sea became the scene of folding and thrusting on a colossal scale, resulting in the Rocky Mountains and the Black Hills. This mountain belt extended from Alaska to Mexico, and was approximately five hundred miles wide from east to west in the United States. This great disturbance of the earth's crust is known as the Larimide Revolution. Its effects were not felt in the Great Plains region, for here the older beds still lie in almost a horizontal position.

Genozoic

With the opening of the Cenozoic the condition of interior North America was somewhat as at present. The Rocky Mountains, which had been formed at the close of the Cretaceous, constituted an extensive highland to the west which was undergoing rapid erosion. Within this mountainous region were several large basins similar to the present "parks" of the Colorado Rockies, and in which were deposited much of the debris from the erosion of the surrounding mountains during the early part of the Cenozoic. Eastward from the Rocky Mountain front lay an extensive lowland or plain sloping gently eastward from the foothills and across which flowed the streams draining the eastern slope of the Rockies. During the early part of the Cenozoic this lowland plain did not receive any extensive deposits. It may have been that the intermountain basins trapped most of the erosional debris so that very little reached the plains region. (Schuchert

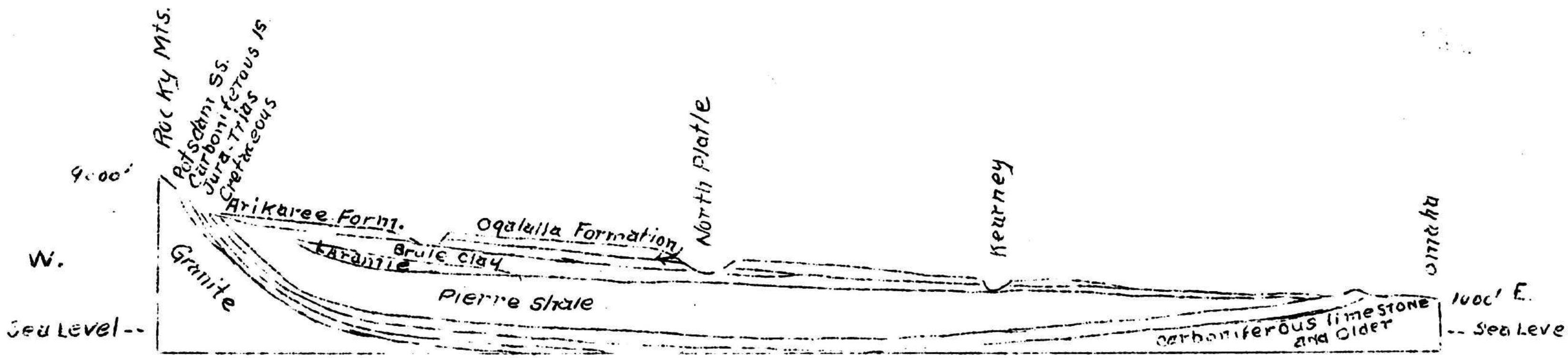
1933, p. 391) A more plausible explanation is that the plains were high enough so that the streams crossing them had sufficient gradient to carry not only their entire load of sediments but were able to abrade their channels, and strip off parts of the Cretaceous deposits.

Beginning with the Oligocene Epoch the major sites of deposition were changed. Almost no Oligocene sediments are known from the Rocky Mountain region but in the Great Plains one of the most complete records of this time is furnished by substantial thicknesses of sands, gravels and clays. What is true for the Oligocene may also be said for the Miocene and Pliocene. Many rivers and streams originating in the Rocky Mountains and flowing through deep and rugged channels with swift currents carrying abundant erosional debris, rather suddenly emerged upon the gently sloping surface of this plain. As a result of a loss of gradient, the currents no longer were able to carry their loads and began building great alluvial aprons. As the stream channels became clogged the streams migrated slowly back and forth spreading sands and gravels over the plain. Torrential downpours of rain at times caused sheets of water to spread far and wide over the lowland between the stream channels, each flood leaving an additional thin sheet of silt. At times there seems to have been abundant vegetation along the stream courses and on the higher ground. The plains evidently were grassy and gave support to herds of roaming wild beasts which were preyed upon by predacious animals. Local lakes existed during the time of greatest humidity and were inhabited by flourishing algal growths, fresh water invertebrates, and fish. Primitive alligators and fresh water turtles inhabited the streams while land tortoises must have been numerous. There were changes in climate; at times aridity caused a drying up of the lakes, and encrustations of salt and gypsum were formed over the dessicating muds; while at other times the climate seems to have been mild and moderately humid. There were short times when erosion predominated over deposition, resulting in short breaks in the record; however, many hundreds of feet of deposits were laid down during the Cenozoic, fortunately enclosing the remains of many animals and plants. We therefore have in this region a record of events, the completeness of which, for all except the earliest Cenozoic, is second to no other known. We can now proceed to take up a more detailed examination of this record, attempting to portray as completely as possible a picture of each of the important epochs of geologic time represented here.



Cross Section From Lodgepole Cr. to Pine Ridge

Through Scotts Bluff, Nebraska



Cross Section From Rocky Mts. to Omaha

across Nebraska

Oligocene

The Oligocene deposits of the Scotts Bluff region consist of extensive sheets of sandstone and clays with local lenses of gravels. These have been referred to as the White River Beds because of their extensive exposures in the White River basin of South Dakota where they have a total thickness of about 675 feet. The White River Beds have been separated into two formations, the Chadron Formation below and the Brule Clays above.

The Chadron Formation, often referred to as the Titanotherium beds, does not outcrop at Scotts Bluff proper, for here the river has not yet cut its channel deep enough to allow it to be exposed. It does outcrop in the valley of the North Platte about four miles above Scotts Bluff in the vicinity of Caldwell and Mitchell, from whence it extends on either side of the valley westward into Wyoming. The formation is widely exposed in the Big Bedlands of South Dakota and along the northerly facing escarpment of Pine Ridge, which extends from South Dakota thru northwestern Nebraska and into Wyoming. These beds are known to underline an extensive area of later formations in western Nebraska and northeastern Colorado.

This formation (Desc. by Darton, N. H., U. S. G. S. Prof. Pap. No. 17., pp. 40-41) is composed predominantly of sandy clay of light greenish-gray color, usually with coarser beds at the bottom, including deposits of gravel, often several feet thick. The beds above these gravels are of bright dark-red color, notably in the region about Adelia. Locally they contain thin beds of volcanic ash intercalated with the sediments. The thickness of the formation varies from thirty to sixty feet. Where the bottom of this formation is seen, it is usually lying on the irregular, black or generally rusty surface of the Pierre shale,

This formation is very often referred to by a much older name, Titanotherium beds from the name of the large, extinct animals whose bones occur in it so abundantly. Professor H. F. Osborn made a monographic study of the Titanotheres working out in the greatest detail their occurrence, structure, evolution, environment and habits. His work is our principal source of information on this important group of mammals. In it may be found excellent illustrations of skeletons and restoration drawings, of not only the Oligocene, but also the older Eocene forms. An excellent portreyal of a herd of these animals showing their environment during Chadron time is given in the frontispiece.

A list of illustrations of several of the best known species which lived during Chadron time are given below:

Brontotherium platyceros-From the Upper Chadron

Restoration line drawing-Osborn,	1929,	Vol. 1,	p. 10
Head	"	"	p. 32
Cross section of horn	"	"	p. 468
Restoration	"	Vol. 2, Plate VLXXXVIII, CLXXXIX	

Brontops robustus-From Upper Chadron Formation

Head	Osborn, 1929,	Vol. 1,	p. 32, fig. 24-A
Line drawing	"	"	p. 469, fig. 400
Cross section, horn	"	"	p. 468, fig. 399
Pes	"	"	p. 697
Skeleton	"	"	pl. 33-B
Skeleton	"	"	pl. 34-A, B
Skeleton	"	"	pl. 35
Musculature	"	Vol. 2,	pp. 722-723
Manus and pes	"	"	pl. CCXXVII
Large Skeleton mount	"	"	pl. CCXXIX
Restoration	O'Harra, 1920, pl. 39		
Skeleton	"	fig. 52, p. 113	

Menodus giganteus-From Upper Chadron Formation

Head	Osborn, 1929,	Vol. 1,	p. 32, fig. 24-B
Section of horn	"	"	p. 468, fig. 299
Line drawing	"	"	p. 469, fig. 400-B
Manus	"	"	p. 693

Brontotherium gigas-From Upper Chadron Formation

Skull	Osborn, 1929,	Vol. 1,	p. 37
Manus	"	"	p. 695
Restoration	"	"	p. 725
Group restoration	O'Harra, 1920,		pl. 40

The Titanotheres are the largest animals found in the White River Badlands, their size being comparable to that of the present day elephant. With the exception of turtles and Oredons, they are also the most abundant forms. In general appearance the Titanothere showed some resemblance to the rhinoceros, particular the head. The limbs are stouter, especially the fore limbs which have some resemblance to those of the elephant but are shorter and more supple. There are four short, thick-hoofed toes on the front foot corresponding to the second, third and fourth digits. On the hind foot only the second, third and fourth are present. The body is short, as in the elephant; the shoulder is conspicuously high, caused by the elongation of the spinous process of the anterior dorsal vertebrae. The neck is thick and extremely muscular, due to the aggressive use of the nasal protuberances. The skull is long, low and saddle-shaped with remarkable nasal prominences at the extreme end, bearing in the later forms, long protuberances. The skull varies greatly in different species and in the sexes. The ears are placed far to the rear while the eyes are surprisingly near the front. The teeth, usually thirty-eight, are large, especially the molars. The incisors are rudimentary or lacking in the later forms, being replaced by the development of a prehensile upper lip for nipping off twigs and grass. The nature of the thick skin is not positively known but is believed to be similar to that of modern forms, showing similar characters and habits.

The Titanotheros had their origin in Early Eocene time and reached the culmination of their development in Lower Oligocene time, suddenly to become completely extinct at the end of that time. The cause of the sudden extinction of such a seemingly well adapted group is puzzling. Changes in the Climate at the close of Chadron time may have been indirectly responsible. However, Professor Osborn states that it may have been due to certain diseases which these animals were unable to combat.

The Middle and Upper Oligocene is represented by the Brule Clays. (Darton, N. H., 1903, pp. 37-40) This thick mass of sediment underlies the greater part of the region and consists of massive clays, or a mixture of fine sand and clay, of pale flesh color, containing numerous fossil beds characteristic of the Oredon series of the White River group. It is widely exposed in the Valley of the North Platte River and Pumpkinseed Creek, extends along the lower portion of the northern slope of Pine Ridge, and is bared in the narrow depression of Lodgepole Creek and Sidney Draw. There are extensive exposures of the Brule Clay in the northern face of Scotts Bluff, where from the base of the overlying Gering beds to the river, there is a vertical interval of 500 feet of continuous outcrop and the formation has a small additional thickness below the level of the river. (Darton, N. H., 1903, pls. 30 & 31)

The lower portion of the Brule Clays is often referred to as the Oredon beds because of the abundant remains of Oredons found in them. These animals are the commonest fossil mammals of the White River Beds. They originated in the Eocene, ranged through the Oligocene and Miocene, and became extinct in the lower Pliocene. They are distinguished by many primitive characters and according to Cope they constitute one of the best marked types of mammalia the world has seen. They occupy a position somewhat intermediate between the ruminants (cud-chewing animals) and the suilline pachyderms (pig-like, thick-skinned animals). Leidy, in his description of the Oredon, suggested that it might very appropriately be called a "ruminating" hog. The most common form found in the Middle Oligocene is Oredon culbertsoni, a restoration of which may be seen in Scott. (1913, p. 259, fig. 136). A complete articulated specimen may be found in the Museum of Paleontology at the University of California. This species is a little larger than the red fox. These animals evidently roamed the woods and plains in great herds, probably feeding upon the more tender grass of the forested areas.

The remains of two primitive types of rhinoceroses are found in the Middle Oligocene deposits, one an aquatic form, and the other an agile, fast running type, well adapted to the plains. To the former type belongs Metamynodon, a heavily built form with short toes in front, eyes and nostrils much elevated for convenience in deep wading, canine teeth enlarged into recurved tusks, and a prehensile upper lip apparently tending toward proboscoid development. This animal much resembled the present day hippopotamus both in build and habit. The skeleton measures nine and one-half feet in length and stands four and one-half feet high at the shoulders. An excellent restoration painting has been made by Knight for the American Museum of Natural History, illustrations of which are available in the Matthew Library, University of California; or may be obtained from the American Museum of Natural History. Reproductions may be found in O'Harra (1920, pl. 29). Of the cursorial rhinoceroses of this time Hyracodon is well known. It was a small, light-chested, swift-footed, hoofed, harmless creature much resembling the Miocene horses and evidently well fitted for living on the grass-covered higher lands. Restorations may be found in Scott. (1913, p. 341, fig. 180).

Of the Middle Oligocene horses one of the commonest and most typical was Mesohippus bairdi. The adult animal averaged about eighteen inches in height, was slender limbed and well adapted for speed; the hind limbs were much longer than the fore.

In the fore foot were three digits, the median one enlarged and supporting most of the weight; however, the lateral digits touched the ground and were not entirely functionless; in addition there was a small splint, the rudiment of the fifth digit. The hind foot had also three toes.

Many specimens of Canidae (dogs, wolves, etc.), have been found in the White River Badlands but most of the material is fragmentary. Recently, however, a few complete skeletons have been obtained. Of the several species, Cynodictis gregarius and Daphaenus felinus are the best known. Cynodictis gregarius was most abundant and, as the name implies, seems to have roved the country in packs. It was smaller than the red fox. Daphaenus felinus reached approximately the size of a coyote. (O'Harra, 1920, pp. 78-82, and Scott, 1913, pp. 520-530).

The cat family is well represented in the fossil fauna of the Middle and Upper Oligocene. Two genera are of particular importance namely Haplophoneus and Dinictis. (Illus., O'Harra, 1920, figs. 31, 32; pl. 27; Scott, 1913, figs. 264, 265). These are early forms of what are commonly known as saber-tooth cats, or tigers, a name given to them by reason of two great sword or saber-like canine teeth of the upper jaw. They were not as large as some of the later forms of this group but nevertheless were vicious creatures. Hoplophoneus was the largest of the two, doubtless fully as large as the present day leopard and apparently much more powerful. In Hoplophoneus the fangs were very long and slender and the projecting flange on the lower jaw correspondingly deep. Dinictis had shorter canines and less prominent flange. The cause of the development of these abnormally powerful upper canines and the uses to which they were put have been the cause of much speculation. It may have been that this was an adaptation of the canines to a particular method of attack. (Matthew, W. D.). The lower jaw is so shaped as to allow the mouth to be opened to an unusual extent so as to give greatest freedom to the saber tooth in stabbing the prey. Hoplophoneus, in addition, had a strong body, stout neck and legs, and highly developed strong retractile claws. His food must have been in large measure the thick-skinned rhinoceroses, clotheres, oredonts, and other similar animals. The somewhat smaller Dinictis probably preyed more successfully on the smaller swift-footed animal.

In the Upper Oligocene, Eusmilus dakotensis, a large saber-tooth cat approaching the size of the African lion was the largest known carnivore of its time. (O'Harra, 1920, pp. 83-87.)

Rodents are known from the Middle and Upper Oligocene and include ancestral squirrels, rabbits, beavers, and rats. Many other interesting forms are found in the Upper Oligocene beds, but for lack of time and space not all can be described. (See check lists).

The conditions under which the Oligocene deposits were laid down have been described by Hatcher as follows: "The distribution, state of preservation, nature, and character of the animal and plant remains found in the clays and sandstones, as well as the distribution of the latter, absolutely precludes the possibility of their having been deposited in a vast lake, and favors the presence of streams meandering through low, broad, level, open, or wooded valleys, subjected in part at least to frequent inundations, conditions very similar to those at present prevailing in the interior of South America, about the headwaters of the Orinoco, the Amazon, the Paraguay, and Parana Rivers. . . . Molluscs from the Titanotherium and Oredon clays include such characteristically shallow water forms as Chira, Limnaea, Physa and Planorbis . . . which according to Drs. Dall, Pilsbry, and Stanton are forms inhabiting swamps and small ponds. Dr. Knowlton, who has examined the plants, finds in great abundance the stems and seeds of Chira, which as all know is distinctly an inhabitant of small springs, shallow ponds and brooks. . . . Moreover, remains of forests were found at several places and at different horizons throughout these beds. At various localities in the Hat Creek basin in Sioux County, Nebraska, I discovered remains of the silicified trunks of trees and seeds belonging especially to Hicoria and Celtis. These were found at various horizons from the middle of the Titanotherium beds to the very top of the Loup Fork; and in South Dakota, some 12 miles north of White River, opposite the mouth of Corn Creek, I discovered the remains of a not inconsiderable forest."

Wanless (1923, p. 244), after a careful study of the stratigraphy of the White River beds, states that at the beginning of Oligocene time the streams were slightly entrenching themselves in the old floor of the plain in rather steep-sided valleys. Gradually these were widened and soon a more gentle relief caused the streams to wander somewhat upon the surface of the valley floor depositing sands in their channels and steeply cross-bedded silts as lateral delta terraces on the sides of the valleys. With perhaps a slightly more arid climate the streams gradually aggraded the valleys. When the streams of the Titanotherium age had aggraded to the level of the old plain they were no longer bound by valley walls and were free to wander at will across the plain. Thus when torrential downpours brought sheets of water from the mountains, it spread far and wide leaving layers of silt. The climate was evidently mild and fairly humid.

At the close of Titanotherium time, and with the initiation of the Middle Oligocene, climatic conditions swept to an arid extreme which may have caused the disappearance of a large part of the cover of vegetation. This climatic change may have been responsible for the sudden disappearance of Titanotherium. In the sediments this change is represented by a marked increase in the amount of calcareous cement. Again shallow streams meandered across the plain and spread sheets of silt many miles away from their channels. A large and varied fauna roamed over the greasy plains, and an aquatic fauna typified by the massive rhinoceros, Metamynodon, frequented the river channels. Several times after a period of flood, the surface of the plain remained dry, perhaps for many years, and the surface silts were cemented to a hard caliche or nodular layer.

After a long period of caliche development, there was a change to a somewhat more humid climate. Stream channels became more numerous, and again local ponds with fresh-water faunas characteristic of the Middle Oligocene were developed over the surface of the plain. It was still, however, apparently more arid than in Titanotherium time.

Gradually another factor was imposing itself on these previous rhythms of climate and deposition, namely, increasing contributions of volcanic dust from outside this region. This was in the form of wind-blown material and is believed to have come from the Rocky Mountains and Black Hills where it is known that lacolithic intrusion was occuring on a large scale during Cenozoic times. It becomes an increasingly more important constituent in the Oligocene sediments.

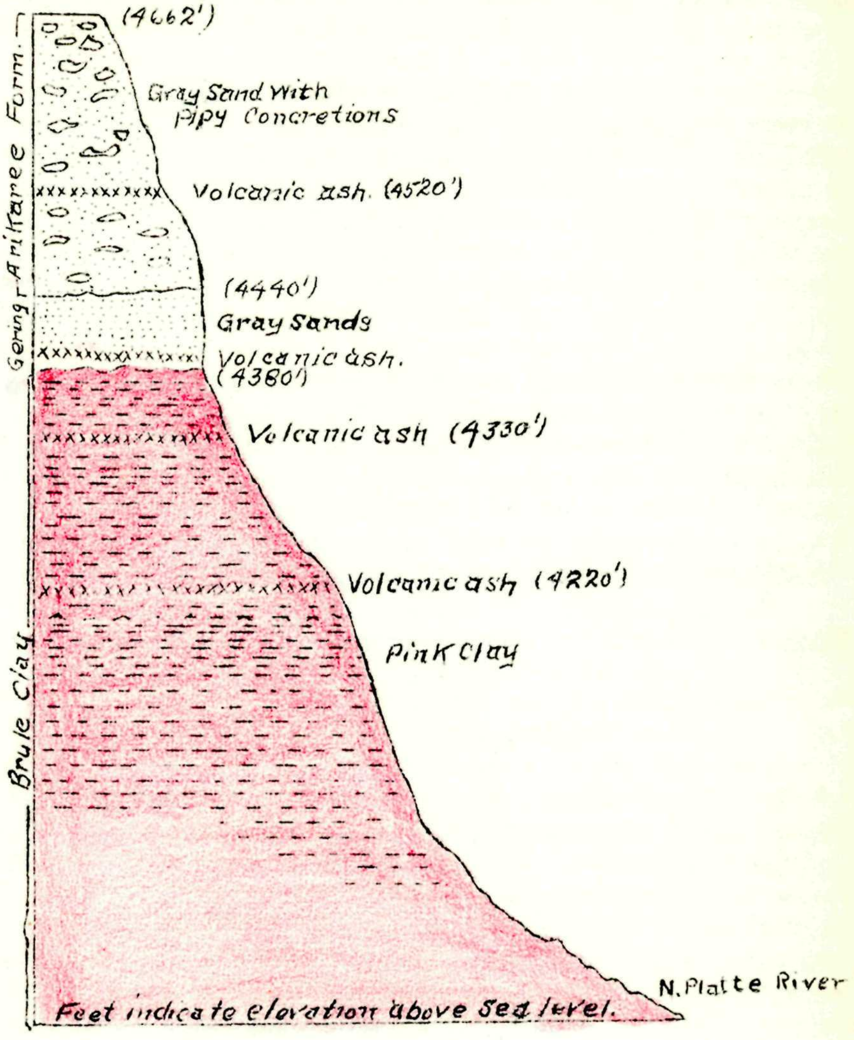
At the beginning of Upper Oligocene time there seems to have been a slight return to more humid conditions as stream channels became more abundant and extensive, but there soon ensued another period of caliche formation resulting in another series of levels of nodules, probably each representing old land surfaces. The only difference between the Middle and Upper Oligocene caliche nodules is that in the latter volcanic ash generally forms fifty per cent or more of the clastic material of the sediments.

From the occurrence of hackberry fruits said to occur in millions in the Oreodon beds (Middle and Upper Oligocene) Chaney (Chaney, R. W., pp. 54-56. one plate) has postulated the nature of the climate of these times as not unlike the drier parts of the West at present time. A variety of common hackberry is found today along the streams in Western South Dakota. The more common associates of the hackberries in these regions are several species of Populus and Salix, but there is little liklihood under present climatic conditions of any of the leaves becoming a part of the fossil record, since in most cases they become dried and decayed before they have left their prints in the sediments accumulating along the streams. The hackberry and cherry, both having hard shelled seeds might be expected to occur as fossils. The presence of a large number of hackberry fruits indicates beyond question the abundance of those trees along the sites of deposition during the Oligocene, and also the Miocene in the Great Plains. At the same time the absence of hackberry leaves and of leaves of other species which may be supposed to have lived in the same situation, is a strong suggestion of a climate so arid as to prevent their entrance into the sedimentary record.

Miocene

At the close of the Oligocene the Rocky Mountains and Black Hills were slightly uplifted, this time without folding. The rejuvenated streams again began to deposit great quantities of sandstone and clays over the Great Plains, and there appears to have been a recurrence of conditions similar to those during the Upper Oligocene. This series of sediments represent the Miocene epoch and has been divided by various workers into several distinct time intervals. Due to the more or less lenticular nature of the Miocene deposits they are not easily traced from one region to another so that the various divisions have received different names in different areas. (See generalized section).

The Miocene beds occurring in Scotts Bluff region have been called by Darton the Gering Formation below, and the Arikaree Formation above. Both these formations are exposed in the nearly vertical face of Scotts Bluff, the Gering having a thickness of about 60 feet and overlying the Brule clays, while the Arikaree has a thickness of 220 feet, capping the bluff. Although the Gering formation is rather sharply distinct from the Arikaree in this region, studies made over a broader area



SECTION OF THE NORTH FACE OF SCOTTS BLUFF (From Darton) seem to show that much of the material comprising the Gering is little more than non-continuous river sandstones and conglomerates, contemporaneous in origin with the lower Arikaree formation.

The Arikaree formation consists (Darton, 1903, p. 25) mainly of fine sand containing characteristic layers of hard, fine-grained, dark-gray concretions, often consisting of aggregations of long, irregular, cylindrical masses. These are commonly called "pipy concretions" and vary in thickness from a few inches to several feet. Owing to the presence of these, the formation is very resistant and generally gives rise to ridges of considerable prominence.

Among the interesting structures of the Arikaree formation, few have given rise to more speculation concerning their origin than the so called "Devil's corkscrews." These consist of usually upright, tapering, spirals, twisting to the right or left indiscriminately. The spirals sometimes enclose a cylindrical body known as the axis. The spiral may end abruptly below, or may have one or two obliquely ascending bodies placed much as the rhizones of certain plants. The size varies considerable, the height of the "corkscrew" portion often exceeding the height of a man. (Illus. O'Harra, 1920, p. 47 and figs. 13 and 15).

"Devil's Corkscrews" or Daemonelix, as they are technically called, occur in the Upper Arikaree beds and in some of the overlying formations. They are not distributed throughout the formations but occur at certain localities. Some of the largest and best developed forms occur in Sioux County, Nebraska. The origin of these structures is still the subject of much debate. Barbour, among others, considers them to represent some kind of plant life, either in the form of algae growths or higher plants in which all has decayed away except the cortical layer. Professor Peterson seems to offer a well founded explanation in that at least some of them may have been the burrows of fossorial rodents. Numerous cases have been observed where fossil remains of burrowing rodents have been found within the corkscrews."

According to Stirton (Stirton, R. A. Unpub. Manuscript U. C.), who has been working on these rodents; no rodent is known which makes a burrow as symetrically and vertically spiralled as some of the specimens of Daemonelix, and it may have been that rodents lived in some of the structures and yet were not responsible for their formation.

There are several well marked faunal zones in the Miocene deposits, each zone being characterized by a rather distinct faunal assemblage. The Lower and Middle Miocene zones are pretty well established, and the faunas are well known. The faunas from the Upper Miocene, Lower Pliocene, and Middle Pliocene are still in need of much revision. The exact occurrence of many of the forms listed from these horizons is doubtful.

One of the most interesting of the Miocene faunas is that from the Agate Springs fossil quarry in Sioux County, Nebraska. (Desc. of Quarry and Fossil Remains from Matthew, W. D., 1923, p. 368) This quarry was discovered by James H. Cook in 1877 and is one of the greatest fossil quarries in America. The bones are in a layer from six to twenty inches thick, packed closely together. The bones are seldom articulated, but most of the bones of a single skeleton lie near together. The quarry is in the Lower Harrison Formation of Early Miocene age.

Matthew attributes the great accumulation of bones here to an eddy in the old river channel. A pool probably formed at this eddy with quicksand at its bottom and many animals that came to drink at the pool in dry seasons would be trapped and buried in the sand. The covering of sand would protect the bones from decay and prevent them from being rolled and waterworn. However, the shifting sand disarticulated and displaced the bones, but would leave the skeletons complete and undamaged.

The bones from this quarry almost wholly belong to three species, the dwarf pair-horned rhinoceros, Diceratherium cookii the calicothere, or clawed ungulate, Moropus elatus; and the entelodont, or giant pig, Dinohyus hollandi.

The rhinoceros is by far the most abundant. A block, five and one-half by eight feet, taken from this quarry in 1920, and now on exhibition in the American Museum, contains twenty-two skulls, an uncounted number of skeleton bones, all of the little rhinoceros. This form had a pair of horns placed side by side on the nose instead of the single horn of the Indian rhinoceros, or the "tandem" arrangement of the horns seen on the two African rhinoceroses. This species was a little larger than a pig with somewhat the same proportions of body but very different head. The horns were probably not long and pointed but were stout, blunt nubs.

Moropus belongs to the Calicotheroidea, an extinct family of mammals of the order Perissodactyla and about equally related to the horse, the rhinoceros, the tapir, and the titanothere. The neck and general shape of the head remind one of the horse; the short arched back, sloping hips, and the rudimentary tail suggest the tapir. The limbs and feet resemble the proportions and construction of the modern rhinoceroses, except that the fore-limbs are longer. The grinding teeth are most like those of the extinct titanothere, while the front teeth are those of a ruminant. The toes are the most remarkable of this old beast for they are tipped with claws instead of hoofs. This feature, in an animal, that certainly is one of the ungulates, as shown by every other character of its skeleton, is unique and difficult to explain. Calicatheres are scarce among the fossils of Europe and Asia, and very rare in North America except in this quarry. A number of incomplete skeletons were obtained by the Carnegie Museum, and seventeen complete skeletons by the American Museum.

Dinohyus is the largest of the entelodonts. These extinct animals are commonly called giant pigs, although they are not very pig-like in appearance and were not related to the pigs any more closely than the ruminants. They were tall, but compactly proportioned, with two toed feet like a bison's, very large heads with long muzzles and large powerful tusks. The tusks and all the front teeth are much more like wolves, or other large carnivores, than like those of any living herbivores, while the back teeth are of omnivorous type. These beasts were probably omnivorous but well equipped to pursue and attack animal prey.

Another quarry two or three miles from the Agate Quarry and of the same age has yielded great numbers of skeletons of the gazelle-camel, Stenomylus, a small slender creature of the size and proportions of the vicuna. No other animals are associated with it in this quarry. Matthew states that there are good reasons for believing that the Stenomylus quarry was the bedding ground of this extinct animal. Many of the skeletons are completely articulated, suggesting an entirely different means of preservation than that in the Agate Springs Quarry.

The camels originated in North America and it is here that the earliest and most primitive forms are found. This group of animals, so foreign to North America at present, had nearly the whole of its development on this continent, and did not migrate to other countries before late Miocene or Pliocene time. The whole family, however, disappeared from North America in the

Later Pleistocene or at the time of the great Ice Age. The Miocene forms, Procamelus, has long been known and is believed to have been the ancestor of the camels and llamas of today. In general it may be said that the Miocene forms became increasingly more cameloid, became larger, the side toes disappeared, the metarsal bone became more fully united, and rugusites of the hoof bones indicate the presence of a small foot pad. (See check list for more complete list of animals known from this epoch).

Pliocene

The Pliocene is represented in the great plains region by the Ogalalla formation which extends from Kansas and Colorado far into Nebraska, but which does not now extend into the immediate region of Scotts Bluff. It may have occurred here at one time but since has been removed by erosion. It is extensively developed in the western part of Nebraska in the region of Lodgepole Creek and south. The extent of this formation in the northern part of Nebraska has not been ascertained; however, Pliocene faunas are known from this region.

In its typical development (Darton 1903, p. 1) the Ogalalla formation is a calcareous grit or soft limestone containing a greater or less amount of interbedded and intermixed clay and sand, with pebbles of various kinds sprinkled through it locally, and sometimes with a basal red conglomerate.

Faunas from the Pliocene are not very abundant, or at least are not well known. However, in deposits of this epoch are found the first appearance of the more modern single toes horse, Pliohippus, its high, crowned teeth attesting to a diet of hard grasses from the plains. Rhinoceroses were still abundant and roamed the plains, apparently in herds, while camels of larger and more modern types than those of the Miocene still flourished.

Pleistocene

During the Pleistocene the Great Plains as well as the Rocky Mountains experienced extensive uplifting which resulted in their present elevations. This increase in elevation caused a much greater precipitation and the streams began a period of renewed activity sinking their courses deeper in the mountain region and entrenching themselves below the surface of the plain. The eastern portion of the plain has been completely removed, perhaps due to extensive glacial floods. With the rising of the Black Hills there was deeper erosion around it and the High Plains in that region have been largely removed, their present northern edge being represented by Pine Ridge.

Erosion is still in progress, especially in the smaller streams where the water has sufficient declivity to carry its load. In the larger streams, the valleys are beginning to be built up, as in the Middle Cenozoic, because the volume of water is not adequate to carry away the waste from the adjoining slope.

The great diastrophic movements which occurred at the close of Pliocene time and continued during the Pleistocene might be considered as ushering in the present. The Pleistocene is principally distinguished from the recent by its great ice sheets which spread over nearly one-sixth of the existing lands. So recent is this last great episode of geologic time that the ice sheets have not yet completely disappeared, being still very much in evidence in Antarctica and Greenland. In North America, glaciation centered in Canada, and during its maximum stages is believed to have covered eastern Nebraska. Numerous local centers of glaciation also existed in the Rocky Mountains.

The great changes in relief and climate caused the extinction of many older groups of animals, and during the Pleistocene modern groups, including man, make their appearance.

List of Fossil Mammals Found in the Tertiary Deposits

of

The Central Great Plains*

LOWER OLIGOCENE (TITANOTHERIUM ZONE)

Daphoenus dodgei (Scott)
Dinictis fortis (Adams)
Trigonias osborni (Lucas)
Leptaceratherium trigondum (Osborn & Wortman)
Caenopus cf. platycephalus (Osborn & Wortman)
Caenopus mitis (Cope)
Colodon occidentalis (Leidy)
Mesohippus proteulophus (Osborn)
" hypostylus
" celer (Marsh)
Titanotherium prouti (Leidy)
" helocerus (Cope)
" trigonoceras (Cope)
Megacerops dispar (Marsh)
" tichoceras (Scott & Osborn)
" robustus (Marsh)
" brachycephalus (Osborn)
" bicornutus (Osborn)
" marshi (Osborn)
Allops serotinus (Marsh)
" crassicornis (Marsh)
" amplus (Marsh)
Symborodon montanus (Marsh)
" copei (Osborn)
Brontotherium ramosum (Osborn)
" dolichoceras (Scott & Osborn)
" leidyi (Osborn)
" hatcheri (Osborn)
Elotherium (Entelodon) crassum (Marsh)
Hypotamus (Anacodon) americanus (Leidy)
Merycoidodon hybridus (Leidy)
" affinis (Leidy)
" bullatus (Leidy)
Heteromeryx dispar (Matthew)

*These Lists Compiled Largely from Matthew (1909), O'Harra (1920), and Hay's bibliography and catalog of the Fossil Vertebrata of N. America U. S. G. S. Bulletin 1902, 1930.

MIDDLE OLIGOCENE (OREODON ZONE)

Hyaenodon horridus (Leidy)
Hyaenodon cruentus (Leidy)
Hyaenodon crucians (Leidy)
Hyaenodon paucidens (Osborn & Wortman)
Hyaenodon leptocephalus (Scott & Osborn)
Hyaenodon mustelinus (Scott)
Daphoenus vetus (Leidy)
" hartshornianus (Cope)
" felinus (Scott)
" nebrascensis (Hatcher)
" inflatus (Hatcher)
Cynodictus gregarius (Cope)
" lippincottianus (Cope)
Dinictis felina (Leidy)
" squalidens (Cope)
" paucidens (Riggs)
Hoplophoneus primaevus (Leidy)
" occidentalis (Leidy)
" oreodontis (Cope)
" marshi (Thorpe)
" molussus (Thorpe)
Proterix loomisi (Matthew)
Leptictis haydeni (Leidy)
Ictops dakotensis (Leidy)
Ictops porcinus (Leidy)
Ictops bullatus (Matthew)
Protosorex crassus (Scott)
Eutypomys thomsoni (Matthew)
Ischyromys typus (Leidy)
Eumys elegans (Leidy)
Paleolagus haydeni (Leidy)
Palaeolagus haydeni (Leidy)
Palaeolagus turgidus
Hyracodon nebrascensis (Leidy)
" major (Scott & Osborn)
Metamynodon planifrons (Scott & Osborn)
Caenopus occidentalis
" copei (Osborn)
" simplicidens (Cope)
Leptaceratherium trigonodum (Osborn & Wortman)
"Hyracodon" planiceps (Scott & Osborn)
Colodon procuspidatus (Osborn & Wortman)
" dakotensis (Osborn & Wortman)
" longipes (Osborn & Wortman)

Protapirus simplex (Wortman & Earle)
Mesohippus bairdi (Leidy)
" obliquidens (Osborn)
" trigonostylus (Osborn)
Elotherium mortoni (Leidy)
" ingens (Leidy)
Perchoerus probus (Leidy)
" nanus (Marsh)
Anthracotherium curtum (Marsh)
Hypotamus rostratus (Scott)
Leptochoerus spectabilis (Leidy)
" gracilis (Marsh)
Stibarus quadricuspis (Hatcher)
Agriochoerus antiquus (Leidy)
" latifrons (Leidy)
Merycoidodon culbertsoni (Leidy)
" gracilis (Leidy)
" sp. cf bullatus (Leidy)
Hypertragulus calcaratus (Cope)
Leptomeryx evansi (Leidy)
Hypisodus minimus (Cope)
" alacer (Troxell)
Poebrotherium wilsoni (Leidy)
" labiatum (Cope)
" andersoni (Traxell)
Paratylopus primaevus (Matthew)

UPPER OLIGOCENE

Cynodictis temnodon (Wortman & Matthew)
Dinictis bombifrons (Adams)
Hoplophoneus insolens (Adams)
Eusmilus dakotensis (Hatcher)
Stenofiber nebrascensis (Leidy)
Agnocastor praeteraedens (Stirton) (in Manuscript)
Caenopus tridactylus (Osborn)
" platycephalus (Osborn & Wortman)
Protapirus obliquidens (Wortman & Earle)
" validus (Hatcher)
Mesohippus intermedius (Osborn & Wortman)
" metulophus (Osborn)
" brachystylus (Osborn)
Miohippus validus (Osborn)
" gidleyi (Osborn)
" crassicuspis (Osborn)
Colodon copei (Osborn & Wortman)
Elotherium cf ingens (Leidy)
" crassus (Marsh)

Elotherium bathrodon (Marsh)
Perchoerus robustus (Marsh)
" platyops (Cope)
Anthracotherium karense (Osborn & Wortman)
Hyopotamus brachyrhynchus (Osborn & Wortman)
Agriochoerus major (Leidy)
" gaudryi (Osborn & Wortman)
" migrans (Marsh)
Eporeodon major (Leidy)
Eucrotaphus jacksoni (Leidy)
Protocecas comptus (Marsh)
" cristatus (Marsh)
Calops cristatus (Marsh)
Calops consors (Marsh)
Pseudolabis dakotensis (Matthew)

MIOCENE

Nothocyon gregorii (Matthew)
" vulpinus (Matthew)
" annectens (Peterson)
" lemur (Cope)
Daphoenodon superbus (Peterson)
" periculosus (Cook)
Mesocyon robustus (Matthew)
Enhyrocyon crassidens (Matthew)
Cynodesmus thomsoni (Matthew)
" minor (Matthew)
Temnocyon venator (Cooke)
" percussor (Cook)
Borocyon robustum (Peterson)
Paroligobunis simplicidens (Peterson)
Oligobinis lepidus (Matthew)
Megalictis ferox (Matthew)
Aelurocyon brevifacies (Peterson)
Nimravus sectator (Matthew)
Arctoryctes terrenus (Matthew)
Euhapsis brachyceps (Peterson)
Paleocastor simplicidens
Stenofiber fossor (Peterson)
Stenofiber barbouri (Peterson)
Entopychus formosus (Matthew)
" curtus (Matthew)
Lepus primigenius (Matthew)
" macrocephalus (Matthew)
Diceratherium cooki (Peterson)
" niobrarensis (Peterson)
" arikarensis (Barbour)

Diceratherium petersoni (Loomis)
" shiffi (Loomis)
Metacaenopus egregius (Cook)
" stigeri (Loomis)
Epaiphelops virgasectus (Cook)
Moropus elatus (Marsh)
Moropus cooki (Barbour)
" petersoni (Holland)
" hollandi (Peterson)
" matthewi (Holland & Peterson)
" parvus (Barbour)
Miohippus equinanus (Osborn)
" gemmarosae (Osborn)
Parahippus pristinus (Osborn)
" pawniensis atavus (Osborn)
" nebrascensis primus (Osborn)
" aff crenidens (Scott)
" nebrascensis (Peterson)
" tyleri (Loomis)
Kalobatippus agatensis (Osborn)
Gomphotherium conodon (Cook)
Dinohyus hollandi (Peterson)
Desmathyus sioxensis (Peterson)
" pinensis (Matthew)
Anacodon leptodus (Matthew)
Mesoreodon megalodon (Peterson)
Promerychoerus carrikeri (Peterson)
" vantasselensis (Peterson)
Phenacodoelus typus (Peterson)
Merychyus elegans (Leidy)
" harrisonensis (Peterson)
" minimus (Peterson)
Leptauchenia decora (Leidy)
" major (Leidy)
" nitida (Leidy)
Stenomylus gracilis (Peterson)
" hitchcochi (Loomis)
" crassipes (Loomis)
Protomeryx halli (Leidy)
" cedrensis (Matthew)
" leonardi (Loomis)
Oxydactylus longipes (Peterson)
" brachyceps (Peterson)
" longirostris (Peterson)
" lulli (Loomis)

Oxydactylus gibbi (Loomis)
" campestris (Cook)
" brachydontus (Peterson)
Syndoceras cooki (Barbour)
Hypertragulus calcaratus (Cope)
Blastomeryx advena (Matthew)
" primus (Matthew)
" olcotti (Matthew)

UPPER MIOCENE & PLIOCENE

Aelurodon saevus (Leidy)
" haydeni (Leidy)
Ischyrocyon hyaendus (Matthew)
Potamotherium lacota (Matthew)
Lutra pristina (Matthew)
Eucastor tortus (Leidy)
Mylagaulus (Cope)
Aphelops brachyodus (Osborn)
Hypohippus affinis (Leidy)
Protohippus perditus (Leidy)
Protohippus placidus (Leidy)
Bliohippus supremus (Leidy)
" pernix (Marsh)
" simus (Gidley)
Procamelus occidentalis (Leidy)
" robustus (Leidy)
Blastomeryx wellsi (Matthew)
Blastomeryx marshi (Lull)
Aletomeryx gracilis (Lull)
Pliohippus lullianus (Troxell)
" pernix (Marsh)
" robustus (Marsh)
" leidyanus (Osborn)

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