GEOLOGICAL SKETCH

OF THE

ESTUARY AND FRESH WATER DEPOSIT FORMING THE BAD LANDS OF JUDITH RIVER,

WITH SOME REMARKS UPON THE SURROUNDING FORMATIONS.

By F. V. HAYDEN, M. D.

(*Read before the American Philosophical Society, March 4th*, 1859.)

EXTINCT VERTEBRATA FROM THE JUDITH RIVER,

AND

GREAT LIGNITE FORMATIONS OF NEBRASKA.

By JOSEPH LEIDY, M. D.

(*From the Transactions of the American Philosophical Society.*)

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ARTICLE XII.

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NEAR the mouth of the Judith River, not far from the sources of the Missouri, in Lat. 47½°, Lon. 109½°, is a wild, desolate and rugged region which I have called the "Bad Lands of the Judith," in contradistinction to those of White River. No other portion of the Upper Missouri country exhibits the effects of erosion and denudation on so large a scale, and to add to the picturesque effect of the scenery, the variegated strata are distorted and folded in a wonderful manner by the action of the subterranean forces that have elevated the mountain masses in the vicinity. The surface of the country occupied by the deposit I am about to describe, is cut up into ravines and cañons, with nearly vertical sides, rising to a height of 400 to 600 feet above the bed of the river, with scarcely a tree or a shrub to greet the eye of the explorer. A few scattering pines cap the summits of the hills and draw a scanty nourishment from a thin dry soil, but it may be regarded for the most part as an inaccessible desert suited only as a retreat for the buffalo and mountain sheep.

The area occupied by this peculiar basin I could not determine with precision, but have estimated it at about forty miles from east to west, and from fifteen to thirty from north to south, and it is separated into two nearly equal portions by the Missouri. The Judith River rises in the Judith Mountains, pursues a course nearly due north, for the most part through cretaceous strata, and empties into the Missouri in Lat. 48°, Lon. 106°. The Judith River forms the northern boundary of this basin. The Muscle Shell River also rises near the Judith Mountains, but takes a course a little east of north, flows through Cretaceous Formation No. 4, and empties into the Missouri near Lat. 47½°, and Lon. 108°.

That portion of the "Bad Lands" which is formed of the estuary deposit under consideration, lies between these two streams. About thirty miles north of the entrance of the Judith River into the Missouri, is the Bear's Paw Mountain, a small range, the highest peak of which is elevated about 2000 feet. On the same side of the Missouri, and in nearly a north-easterly direction, are the Little Rocky Mountains; a range similar to the Bear's Paw, though apparently disconnected from it. On the south side of the Missouri, about fifteen miles south-west of the mouth of the Judith, the Square Buttes may be seen rising 400 or 500 feet above the surrounding prairie, and are the nearest upheaval of trappean rocks to the Missouri in this region. From thirty to fifty miles south, is quite an extensive range, called the Judith Mountains, which have not yet been explored geologically. Here comparatively small local upheavals seem to represent the dying out of the intense subterranean forces which uplifted the vast Rocky Mountain chain. It will be important to understand the geographical position of these mountains in order to fully appreciate the sources of the power which has disturbed the strata of the more recent fossiliferous rocks, a point which will be again referred to in this paper.

Lewis and Clarke in their interesting account of an expedition to the sources of the Missouri, give a brief but accurate description of the physical features of this remarkable region, but dwell more in detail on the picturesque portions near the "Stone Walls," which are composed of the basis strata upon which the estuary deposits of the "Bad Lands" of the Judith rest, which are doubtless of the age of Cretaceous Formation No. 1, or Upper Jurassic. The Prince of Neuwied also notices this unique scenery, and in his folio atlas of Plates are some beautiful delineations of the external features of the country.*

On page 228, he says:—"Near Lewis and Clarke's Big Horn Island, we again saw most singular summits on the hills. Entire rows of extraordinary forms joined each other, and in the lateral valleys we had interesting glimpses of this remarkable scenery, as we were now approaching the most interesting part of the Mauvaises Terres. I have already described these mountains when speaking of the White Castles, but here they begin to be more continuous, with rough tops, isolated pillars, having flat slabs or balls, resembling mountain castles, fortresses, and the like, and they are more steep and naked at every step. Often one may plainly perceive hills or mountains that have evidently sunk into the marshy valley. Many strata are inclined at an angle of 30° to 60°, and others perfectly horizontal. The course of the Missouri among these mountains is pretty strait, only narrow plains or prairies covered with artemisia and the prickly bushes of the pulpy thorn, lie on its banks before the mountains, which frequently come very near the river, with large blocks of sandstone at their foot, between which fragments of selenite are seen.

* Travels in the interior of North America: By Maximilian, Prince of Wied, with a folio atlas of eighty-one plates. English Edition.

It were to be wished that the geologist and the painter might devote a considerable time to examine this part of the country, step by step; they would furnish a work of the highest interest."

Again, in speaking of the sandstone (No. 1,) which forms the "Stone Walls," about thirty miles above the mouth of the Judith River, page 236: "This sandstone formation is the most striking when it forms the tops of more isolated mountains, separated by gentle valleys and ravines. Here on both sides of the river, the most strange forms are seen, and you may fancy that you see colonnades, small round pillars, with large globes or a flat slab at the top, little towers, pulpits, organs with their pipes, old ruins, fortresses, castles, churches with pointed towers, &c., &c.; almost every mountain bearing on its summit some similar structure."

Lieutenant Grover, United States Army, in his Report* to Governor Stevens, thus speaks of this region:—"On leaving camp to-day, we took leave for a while of many wild beauties of nature which lay scattered along the river in an ever-varying panorama, to take a view of the other side of the picture of Nature's wild deformities, a master-piece in its way. The Mauvaises Terres or Bad Lands which this section is very appropriately called, are characterized by a total absence of any thing which could by any possibility give pleasure to the eye or gratification to the mind, by any associations of utility. Not an island nor a shrub of any account—nothing but high bare piles of mud, towering up as high as they can stand, and crowding each other for room. The banks, varying from 200 to 300 feet in height, were of this nature on both sides of the river all day."

The external features of the country have thus been described with great accuracy and fulness, but none of these writers seem to have given us any clue to the geological age of these deposits. During the writer's explorations of this region in the summer of 1855, he observed the basin-like form of this deposit and the limited area which it occupied, also the difference in its lithological character from the Cretaceous strata which surrounded it, and the Miocene beds which reach their most northern limit, some distance below the mouth of the Muscle Shell River.

From a small collection of vertebrate fossils made at that time, and placed in the hands of Dr. Leidy for examination, he (Dr. L.) was inclined to the opinion that the deposit in which these remains were found was of the age of the Wealden of Europe. Many species of Molluscous fossils were also obtained, but as they seemed more allied to Tertiary than Wealden types, the evidence became conflicting in its character. I will, however, present all the facts as yet secured in regard to its age or position, leaving the final determination to be made after a more thorough and detailed exploration which I hope to accomplish during

* Pacific R. R. Report, Vol. I., page 492.

the coming season. The want of proper facilities for exploration, the wild and desolate character of the country, the numerous bands of roving Indians which were constantly wandering over this region on their predatory excursions, rendered it impossible for me to make any thing more than a mere superficial examination of this locality.

So intimately do the Estuary beds at the mouth of the Judith seem to be connected with Cretaceous Formation No. 1, that it will be important to present such facts as are known in regard to it; and, in order to show their true relations to other geological formations of the Upper Missouri, I will briefly review the boundaries of these formations as they are revealed along the Missouri River. At the mouth of the Platte River we have the limestones of the Upper Coal Measures with their characteristic fossils. Thirty miles west on the Platte, these limestones are succeeded by a coarse, friable, ferruginous sandstone of Cretaceous age. About twenty-five miles north of the mouth of the Platte, on the Missouri, these same limestones are succeeded by the same sandstone just mentioned, which sandstone extends up the river to a point about ten miles above the mouth of Big Sioux. The Cretaceous rocks of the Upper Missouri have been separated into five divisions upon lithological and palæontological grounds, and the sandstone formation at the mouth of Big Sioux and below, forms the type of No. 1. Nos. 2 and 3 are seen reposing upon No. 1 at the mouth of Big Sioux, and near the mouth of the Niobrara River, No. 4 appears upon the summits of the bluffs, surmounting No. 3. At the foot of the "Big Bend," No. 3 passes beneath the water level of the river, and is succeeded by No. 4, which occupies the country to Grand River, where No. 5 makes its appearance on the summits of the hills. Near the mouth of the Cannon Ball River, the Lignite Tertiary beds begin to overlap the Cretaceous strata, but do not entirely conceal them along the banks of the river until we reach "Square Buttes," about thirty miles below Fort Clarke. From this point to Milk River in Lat. 48°, Lon. 106°, only the Miocene beds of the Great Lignite basin are exposed. The country in the vicinity of the mouth of the Yellow Stone River is covered by the Tertiary beds of the Lignite basin alone, containing their peculiar Fauna and Flora. The Tertiary beds continue uninterrupted until we reach the mouth of Milk River, where, by a reversed dip of the strata, the Cretaceous Formation rises to the surface from beneath the Tertiary. The Tertiary beds continue to overlap the Cretaceous, gradually thinning out upon the summits of the hills, until we reach the mouth of the Muscle Shell River, where the Cretaceous bed, No. 4, occupies the whole country. We thus see that in ascending the Missouri, the dip of the strata is north-west as far as Fort Union or some point in that vicinity, and on reaching Milk River we can very distinctly observe the dip south or south-east, by which the underlying Cretaceous beds are exposed. We can also note the basin-like form in which both Tertiary and Cretaceous rocks were deposited. Passing the mouth of the Muscle Shell we soon observe a somewhat remarkable bed rising

above the water level of the Missouri, near the mouth of Little Rocky Mountain Creek, which, from its lithological character and position, we have hitherto considered as belonging to Formation No. 1. It first makes its appearance as a seam of carbonaceous grit, of a dull reddish colour, very light and loose, like ashes, about one foot in thickness, separating No. 4 from a bed of sandstone beneath. As we ascend the river, a bed of sandstone rises rapidly above the water level, very variable in its lithological character. It is a yellowish gray friable sandstone, with small concretions of iron in yellow seams, layers of fine grained compact rock, turning reddish brown on exposure, also gray coarse grained concretions of sandstone. No fossils were found at this point, though some local seams of lignite occur, from one to two inches in thickness. Just below Ammel's Island, is an excellent exhibition of lignite and sand bed. The dip toward the south-east is at least ten feet to the mile.

Section of Beds in Descending Order.

1.—Cretaceous Formation, No. 4, with its usual lithological characters and a great profusion of fossils, *Ammonites, Baculites, Inoceramus, Ostrea, &c.*

2.—Lignite. 1st. Dark gritty shale, 4 inches. 2d. Excellent coal, bituminous, very hard, of a jet black colour, 1 inch. 3d. Coarse gritty lignite with small seams of carbon disseminated through it, which have a somewhat crystalline appearance, also considerable selenite in crystals, 5 inches.

3.—A variable sandstone, generally gray or ash-coloured, coarse grained and friable, with compact fine grained concretions. But throughout the bed are streaks or seams of ferruginous sand, some small globular masses of oxide of iron, and occasionally a local seam of lignite one or two inches in thickness, 50 to 80 feet.

About five miles above Ammel's Island, on the left bank of the Missouri, we have the following section descending:

1.—Cretaceous Formation, No. 4, capping the hills.

2.—1st. A seam of lignite, 10 inches. 2d. Stratum of clay, 15 inches. 3d. Earthy lignite, 12 inches.

3.—Grayish brown ferruginous sandstone, containing numerous fossil mollusca of undescribed species, 60 to 80 feet.*

4.—A bed of earthy lignite, rising just above the water's edge, 2 feet.

A little farther up the river, the lower bed of lignite becomes three feet in thickness, and of a purer quality. The bed of sandstone varies from 80 to 100 feet in thickness. Where No. 1 first appears near the mouth of Little Rocky Mountain Creek, the upper seam of lignite separates No. 4 from the bed of. sandstone. Fifty miles farther up the river, the same lignite bed is overlaid by 40 to 60 feet of ferruginous arenaceous clays with concre-

* Nearly all the fossils collected from this bed were unfortunately lost.

tions of sandstone. The evidence is quite clear that the surface of No. 1 was much eroded prior to the deposition of No. 4. We also find that Formations Nos. 2 and 3 which are so well developed between the Great Bend and mouth of Big Sioux River, are entirely wanting in this region. Some uncharacteristic fragments of large bones were found in the debris near the water's edge, which appear to have been washed from No. 1, and doubtless belong to some immense saurian animal. Thus far up the river we have observed no indications of disturbance of strata by subterranean influences; but on reaching a point about five miles above Grand Island, a great thickness of rocks not before seen, is uplifted so as to exhibit the beds, inclining at every angle from a horizontal to a vertical position. The beds are composed of variegated sands, clays, and earthy lignite, and some of them are fully charged with organic remains. Toward the north the Bear's Paw and Little Rocky Mountains are full in view, rising out of the midst of the prairie, and toward the south we can see the Square Buttes, Judith, Girdle and Snowy Mountains, revealing at once the fact that the elevating forces, which uplifted these mountain peaks, disturbed the surrounding strata also.

The local sections already given, will show with sufficient clearness the lithological characters of the formation upon which the fresh water and estuary beds rest. A large number of local sections of the fresh water and estuary strata were taken at different points, and from them the following general section has been constructed; which, though future examination may modify to some extent, will be sufficiently accurate for our present purpose.

Section of Fresh Water and Estuary Deposits at the Mouth of the Judith River.

A	80 feet.	Yellow arenaceous marl passing downwards into gray grit, with seams of impure lignite; contains great numbers of a species of *Ostrea*, like *O. subtrigonalis* of the lignite basin, *Cyrena occidentalis*, *Melania convexa*, *Paludina Conradi*, &c. This bed caps the hills, and varies much in thickness.
B	10 feet.	Impure lignite, containing much sand; a few specimens of *Ostrea* like the above, with much silicified wood.
C	80 feet.	Alternations of sand and clay with particles of lignite; also reddish argillaceous concretions with a few saurian teeth and fresh water shells.
D	20 feet.	Alternate strata of sand and clay, with impure lignite and silicified wood, in a good state of preservation.
E	100 feet.	Variable bed, consisting of alternations of sand and clay, with large concretions, containing great numbers of *Melania*, *Paludina*, *Helix*, *Planorbis*, *Cyclas*, &c., &c., associated with saurian remains resembling the *Iguanodon* and *Megalosaurus*, and *Trionyx*, &c.
F	25 feet.	Alternations of impure lignite and yellowish brown clay, the latter containing great numbers of *Unio*, *Paludina*, *Melania*, *Cyclas*, and the fish remains referred by Dr. Leidy to the genus *Lepidotus*.
G	100 feet.	Ferruginous sand and clay, having in the upper part a seam 3 or 4 inches in thickness, composed mostly of shells of *Unio*. Lower part ferruginous, and coarse gray grit, with a seam near the base entirely composed of remains of *Unio Danai*, and *U. Deweyanus*, and *U. subspatulatus*.

All the beds vary in their lithological characters at different localities. At one point, bed A. contained large ledges of reddish concretionary sandstone, in which were most beautiful fragments of silicified wood, sometimes in nearly cylindrical masses, twelve inches in diameter and several feet in length. Near Cow Island vast quantities of shells occur in argillaceous and arenaceous concretions, in a very comminuted condition, as if they had been transported from a distance, very few of the fossils being sufficiently perfect to show clearly their specific characters. The beds of lignite in the Estuary deposit are very impure, containing a large proportion of coarse sand; they have ignited spontaneously in few localities. The lignite beds of the Marine Formation No. 1, are quite pure in many places, and exhibit the action of fire in the same manner as the lignite beds on the Yellow Stone and those on the Saskatchewan, so minutely described by Sir John Richardson.

About ten miles below the mouth of the Judith River, the Marine strata of No. 1, are seen to rise rapidly from beneath the Estuary and fresh water beds, and on reaching the mouth of the Judith we have the following vertical section of No. 1, the Estuary and fresh water beds only capping the hills and soon ceasing to appear.

1.—Yellowish and reddish, rather coarse grained sandstone, becoming deep red on exposure, containing *Inoceramus ventricosus, Mactra alta, Cardium speciosum, &c., &c.*—20 to 25 feet.

2.—Mixed pure and impure lignite—whole bed containing many crystals of selenite and a yellowish substance like sulphur. The masses of lignite when broken, reveal in considerable quantities small reddish crystalline fragments of a substance having the taste and appearance of rosin.—6 to 8 feet.

3.—Variable strata of drab clay, and gray sand and sandstone; upper part containing large numbers of *Ostrea glabra.* Near the middle, there are gray or ash-coloured clays, with very hard bluish gray granular silicious concretions, containing *Hetangia Americana, Panopœa occidentalis, Mactra formosa, &c.*—80 to 100 feet.

The above section will show very clearly both the lithological and palæontological differences in the two deposits under consideration. It will be seen that the beds represented by the last section contain only marine fossils, while the fresh water and estuary beds, with one exception, have furnished only terrestrial and fluviatile, with a few estuary shells. In regard to the age of the marine strata, it is still impossible to arrive at a positive conclusion. Most of the fossils as yet obtained, have a decided Cretaceous aspect, a species of Mactra found here being so closely allied to a species occurring in No. 1 near the mouth of Big Sioux, which we think we have proved to be of Cretaceous age, that we can find no well marked characters to distinguish them. A species of Baculite is also found in these beds, scarcely distinguishable from *B. ovatus* (Say.) This genus has hitherto been considered in the Old World as restricted to the Cretaceous epoch; while, on the other hand, the genus Hetangia which occurs in bed 3 of section, has never been found in the Old World in formations newer than the Lias. With evidence so conflicting before us, it would be premature to give any decided opinion, and we can only wait for the results of a second exploration of this interesting region. As we have already said in a former paper,* "We are inclined to think they hold a position near the base of the Cretaceous system, and are probably on a parallel with the Neocomien of the Old World, though they may be older." That well marked Jurassic beds occur at many places along the eastern base of the Rocky Mountains from the Saskatchewan to New Mexico, we have little doubt.

In regard to the age of the fresh water and estuary deposit, the evidence is even more

* Proceedings of Academy of Natural Sciences, Pa., Memoir by F. B. Meek and F. V. Hayden, 1857, 125.

conflicting. Mr. Meek and the writer have expressed in several papers an opinion based upon an inference drawn by Dr. Leidy from an examination of the vertebrate remains, that it might be contemporaneous with the Wealden of England. In a recent letter Dr. Leidy has very kindly given me the evidence upon which he based his inferences, with the permission to use it in this paper.

1st.—"*Trachodon* and *Deinodon*, two remarkable genera, are most closely allied with *Iguanodon* and *Megalosaurus* of the Wealden."

2d.—"In both formations remains of *Lepidotus* are found."

3d.—"Remains of *Crocodiles* and *Turtles* are discovered in both."

4th.—"The remaining two genera from the Judith, *Palæoscincus*, an herbivorous lacertian, and *Troodon*, another lacertian, are peculiar, and would not be unfit companions for the denizens of the Wealden world."

Again, the Molluscous fossils, though of a somewhat similar character, terrestrial, fluviatile and estuary, in most instances referrible to the same genera, do not seem to belong to types very closely allied to those characterizing the Wealden of England. On the contrary, they appear more related to tertiary types, and two species are very nearly identical with species common in the Lignite basin which we regard beyond a doubt as of the age of the Miocene Tertiary. *Paludina vetula* of the Judith deposit is so like *P. multilineata* of the Lignite basin, that it is with much hesitation we have regarded them as distinct, the only difference observable is that the volutions of *P. vetula* are a little more compressed and the umbilicus a little more open. *Paludina Conradi* of the Judith deposit is so closely related to *P. peculiaris* of the Lignite basin that almost no well marked differences can be pointed out. Indeed, had they been found associated in the same strata, we should have considered them identical. Fragments of a Trionyx occurring in bed E. of section, are undistinguishable from similar fragments found in the Lignite strata, near Square Buttes, below Fort Clarke. On the other hand, the only strictly marine fossil is scarcely distinguishable from *Ostrea subtrigonalis* from the upper cretaceous beds on Moreau and Grand Rivers.

Again, in no portion of the Upper Missouri have we met with any disturbance of strata belonging to well known Tertiary beds. The Tertiary beds of the White River deposit are found in the region of the Black Hills and Laramie Mountains, resting unconformably upon all rocks, from granite to Upper Cretaceous, and in no instance have the strata been disturbed. As far as my observations have extended, the same remark may be made of the Great Lignite Basin. We have, therefore, arrived at the conclusion, that the last great convulsion that uplifted the fossiliferous rocks on the Missouri, occurred after the Cretaceous epoch and prior to the deposition of the Tertiary. The fresh water and estuary beds at the mouth of the Judith, as has already been mentioned, are tilted at every angle, from

a horizontal to a vertical position. It is also evident that the convulsion was synchronous with that which uplifted the surrounding Cretaceous strata of No. 1, and that the mountains in the vicinity were raised up by the same forces that elevated the Black Hills, Laramie Mountains, &c. These facts strengthen the opinion that the deposits of the Judith basin, if not an American representation of the Wealden of Europe, are, at least in part, as old as Cretaceous.

Table Showing the Stratigraphical Position of the Fossils from the Bad Lands of the Judith.

VERTEBRATA.

		A	B	C	D	E	F	G
Palæoscincus costatus,	Leidy.					*		
Trachodon mirabilis,	"				*	*		
Troodon formosus,	"					*		
Deinodon horridus,	"				*	*		
Crocodilus humilis,	"				*	*		
Trionyx foveatus,	"					*		
Lepidotus occidentalis,	"						*	
Lepidotus Haydeni,	"						*	

MOLLUSCA.

		A	B	C	D	E	F	G
Cyrena occidentalis,	Meek and Hayden.	*						
Corbula subtrigonalis,	"	*						
Corbula perundata,	"	*						
Physa subelongata,	"						*	
Paludina vetula,	"	*						
Paludina Conradi,	"	*						
Melania subtortuosa,	"							
Melania omitta,	"			*				*
Melania sublævis,	"							*
Melania invenusta,	"	*						
Vitrina obliqua,	"					*	*	
Helix occidentalis,	"						*	
Helix vitrinoides,	"						*	
Planorbis tenuivolvis,	"							
Planorbis amplexus,	"			*				
Unio Danai,	"							*
Unio Deweyanus,	"							*
Unio subspatulatus,	"							*

The remains described by Dr. Leidy in this Memoir from the Great Lignite Basin, were obtained from the lower beds, which partake somewhat of an estuary nature. In order that the lithological characters of this deposit may be understood and comparisons made with the other deposits of a somewhat similar character, I have added a section of the strata, mostly constructed from a local section taken about ten miles above Fort Clarke on the Missouri River. A few localities showing the geographical distribution of the beds which occur at this point, are also given, but it is impossible with the materials in our pos-

session at the present time, to construct a complete general section. The immense area occupied by this basin is shown on a geological map* published in the Proceedings of the Academy of Natural Sciences, June, 1858. Even yet it has not been fully explored, only the south-eastern and north-western boundaries being known by actual observation. I have traced its south-eastern outlines as they overlap the Cretaceous strata from the Missouri to the Black Hills, up the Yellow Stone River as far as the mouth of the Big Horn, but its northern and western limits are as yet unknown. In a former paper I estimated the area occupied by this basin at about 60,000 square miles, and at the same time expressed the opinion that when more fully examined, this estimate would be found too low, and I am now satisfied that it will be found to cover a much larger surface. It is a very interesting feature in the geology of Nebraska, that within the limits of the same territory there should be found such remarkable deposits with some characters in common, but so far as we know, entirely independent of each other. These basins may be characterized briefly as follows:

1st.—Bad Lands of the Judith; fresh water and estuary deposit; strata composed of friable or indurated sands, clays, and very impure earthy lignite; contains estuary, fresh water and land shells, with much silicified wood and a few leaves of dicotyledonous trees; chiefly remarkable for its peculiar saurian fauna. It is the upper portion of this deposit that seems to possess the estuary character.

2d.—Great Lignite Basin; also composed of loose sands and indurated layers, with many arenaceous and argillaceous concretions disseminated throughout the deposit; is chiefly remarkable for the beauty and extent of its fossil flora, only the lowest beds exhibiting an estuary character, gradually passing up into purely fresh water strata. It contains many beds of lignite, more or less pure, varying from one inch to seven feet in thickness, and in the vicinity of the lignite are found great quantities of silicified wood.

3d.—Tertiary Basin of White River; light and flesh-coloured indurated clays and grits, with many calcareous and argillaceous concretions; remarkable for its Mammalian and Chelonian fauna. This deposit is purely fresh water or lacustrine, and the few species of Mollusca which have been obtained from it, belong to the same genera and the same types as those living in the tributaries of the Missouri at the present time. The only indications of vegetable remains are a few fragments of silicified wood.

The Molluscous fossils of the Lignite Basin, though in many instances belonging to the same genera with those occurring in the White River deposit, are of quite different types. "It is an interesting fact, that the most nearly allied living representations of many of

* Explanations of a Second Edition of a Geological Map of Nebraska and Kansas. Proceedings Academy Natural Sciences of Philadelphia, June, 1858.

these species are now found inhabiting the streams of Southern Africa, Asia, China and Siam; apparently indicating the existence of a tropical climate in these latitudes at as late a period as the tertiary epoch."* The flora is also of quite a modern type, many of the leaves very strongly resembling those of our existing forest trees, and seem to belong to the genera *Platanus, Acer, Ulmus, Alnus, Populus, Betula, Smilax, &c.*, and to be of a sub-tropical character. The following section of the strata, as revealed by the channel of the Missouri at Red Spring, near Fort Clarke, will show quite clearly the lithological characters of the beds of the Lignite Basin, and comparisons can be made with sections of the other two deposits.

* Remarks, &c., by F. B. Meek and F. V. Hayden. Proceedings of Academy of Natural Sciences, Philadelphia, June, 1856.

Vertical Section, Exhibiting a Portion of the Strata of the Great Lignite Basin, near Fort Clarke, on Missouri.

A	30 feet.	Ferruginous sandy marl, passing downwards into variegated argillaceous grits; contains *Paludina Leai, P. retusa, P. Leidyi, P. trochiformis.*	Fort Union, Yellow Stone, Red Spring, ten miles above Fort Clarke.
B	2 inchs'.	Seam of impure reddish lignite.	Red Spring to Fort Union.
C	10 to 12 feet.	Yellowish gray, friable grit, with numerous argillaceous concretions in horizontal layers, containing beautiful impressions of leaves of the genera, *Platanus, Acer, Ulmus*, and *Ferns.*	Best developed and most fossiliferous at Red Spring, ten miles above Fort Clarke. It occurs also along the Missouri to Fort Union, where it contains fine impressions of Ferns as well as Dicotyledonous leaves.
D	3 inchs'.	Seam of lignite, very much mixed with clay and sand.	Red Spring and up the Missouri.
E	10 feet.	Yellowish gray grit, very friable, and containing layers of argillo-calcareous concretions, charged with leaves of the same species of plants, as in bed C.	Red Spring, &c.
F	3 inchs'.	Seam of earthy lignite.	Red Spring, &c.
G	15 feet.	Yellow and drab clay and friable sandstone, containing argillaceous concretions, with impressions of leaves like those in beds C. and E.	Red Spring to Fort Union.
H	4 inchs'.	Dark reddish, earthy lignite.	Red Spring, &c.
I	20 feet.	Yellow arenaceous grit, very friable, with some small *Paludinas, Corbulas*, &c.	Red Spring.
J	15 feet.	Alternations of lignite and clay. This bed is variable in thickness as well as in the proportions of the materials at different localities; contains large quantities of fresh water shells.	Fort Clarke, Red Spring, and other localities along the Missouri.
K	40 feet.	Heavy bedded gray and ferruginous friable sandstone, with great numbers of fossils, forming seams of shell marl; *Melania Nebrascensis, Paludina multilineata, P. peculiaris, Bulimus limneaformis, Corbula mactriformis*, with numerous impressions of Dicotyledonous leaves in argillo-calcareous concretions.	Very largely developed at Fort Clarke, Red Spring; is also seen where the Tertiary beds are exposed along Missouri and Yellow Stone.
L	2 feet.	Seam of impure lignite, probably local.	Red Spring; not seen at many localities.
M	4 feet.	Gray argillaceous friable grit, usually passing downwards into a dark brown carbonaceous clay.	Fort Clarke, Red Spring, and along Missouri.
N	2 feet.	Lignite, purest in the section.	Fort Clarke to Fort Berthold, to Fort Union.
O	6 feet.	Very dark carbonaceous clay passing down into very bluish gray arenaceous clay, contains at Fort Berthold a species of *Paludina*, also *Planorbis fragilis*, and a few impressions of leaves, petrified wood, &c.	Fort Clarke, Red Spring, Fort Berthold and Fort Union. It is also seen above Fort Union along the Missouri.
P	2 feet.	Rather pure lignite. This bed is local.	About 70 miles below Fort Clarke, near the point where the Tertiary beds first appear in ascending the Mo.
Q	40 to 60 feet.	Gray compact or somewhat friable concretionary sandstone; contains *Cyrena Moreauensis, C. intermedia, Thespesius occidentalis, Compsemys victus*, &c.	Near Long Lake on the Missouri. On Moreau River and Cherry Creek.

VERTEBRATA.

Thespesius occidentalis, Leidy.	Proc. Acad. Nat. Sci., Pa.,	VIII.	p.	311.
Ischyrotherium antiquum, "	"	"	"	89.
Compsemys victus, "	"	"	"	312.
Emys obscurus, "	"	"	"	312.

MOLLUSCA.

Cyclas formosa, Meek and Hayden.	Proc. Acad. Nat. Sci., Pa.,	VIII..	p.	115.
Cyclas fragilis, "	"	"	"	
Cyclas subellipticus, "	"	"	"	
Cyrena moreauensis, "	"	"	"	
Cyrena intermedia, "	"	"	"	116.
Corbula mactriformis, "	"	"	"	117.
Unio priscus, "	"	"	"	
Bulimus teres, "	"	"	"	
Bulimus vermiculus, "	"	"	"	118.
Bulimus limneaformis, "	"	"	"	
Bulimus nebrascensis, "	"	"	"	
Pupa helicoides, "	"	"	"	
Limnea tenuicosta, "	"	"	"	119.
Physa longiuscula, "	"	"	"	
Physa nebrascensis, "	"	"	"	
Planorbis subumbilicatus, "	"	"	"	120.
Planorbis convolutus, "	"	"	"	
Planorbis fragilis, "	"	"	"	
Velletia (Ancylus) minuta, "	"	"	"	120.
Paludina multilineata, "	"	"	"	
Paludina Leai, "	"	"	"	121.
Paludina retusa, "	"	"	"	122.
Paludina peculiaris, "	"	"	"	
Paludina trochiformis, "	"	"	"	
Paludina Leidyi, "	"	"	"	123.
Valvata parvula, "	"	"	"	
Melania minutula, "	"	"	"	
Melania Anthonyi, "	"	"	"	124.
Melania multistriata, "	"	"	"	
Melania nebrascensis, "	"	"	"	
Melania Warrenana, "	"	"	1857,	137.

Melania tenuicarinata, Meek and Hayden. Proc. Acad. Nat. Sci., Pa., 1857, 137.
Cerithium nebrascensis, " " " " " viii. p. 125.

Explanation of the Geological Map.

I am indebted to the kindness of Lieutenant G. K. Warren, U. S. Topographical Engineers, for the beautiful Geographical Map which accompanies this paper.

A large portion of the map has been coloured inferentially, and therefore can hardly be accurate in detail. The formations along the Missouri River to Fort Benton are laid down correctly from the result of my own observations. It will be seen that I have represented no rocks of any age between Igneous and Cretaceous. The reason of this is, that we have no positive evidence of the existence of any intermediate deposits in that region. The discoveries in the Black Hills have rendered it more than probable that not only Jurassic, but Carboniferous Silurian, and perhaps rocks of other epochs are exposed by upheaval around the mountain elevations. If they are revealed they occupy but a small area, in the form of a narrow belt engirdling the metamorphic rocks which constitute the nucleus of elevation. I know, from personal observation, that the broad prairie country, very near to the foot of the mountains, is underlaid, for the most part, with Formations 1 and 4 of the Cretaceous Period; and it is quite probable that future explorations will not make any important changes in the map, excepting in the immediate vicinity of the mountains. The Cretaceous Formations 1 and 4 are represented by one colour, from the fact that we have comparatively little knowledge of their boundaries in that region.

NOTE.—Through the kindness of my friends, Prof. Baird and Mr. Drexler, I am permitted to refer to an exceedingly interesting group of fossils, recently obtained by the latter in the neighbourhood of Fort Bridger, and presented to the Smithsonian Institution. In a hasty examination of this collection some weeks since by my associate, Mr. Meek and myself, we at once recognised *Halysites catenulata*, (*Catenipora escharoides.*) In a subsequent examination recently, I think I was able to detect three other species of corals, referrible to the genera *Favosites*, *Syringopora*, and *Streptelasma*, an association of fossils which at once points to the existence of Silurian rocks in this far western locality. The fossils are completely silicified, and the matrix is a compact siliceous limestone, corresponding very closely in its mineralogical characters to the description given by Prof. Hall of the Niagara limestone in New York and Iowa. The locality where these fossils were obtained, is about twenty miles east of the South Pass.

A still more interesting group of fossils, with reference to this paper, forms a portion of the collection of Mr. Drexler, discovered near Fort Bridger. The material is composed

of an aggregation of casts of *Melanias* and large bivalves like *Unios*, held together by a slightly coherent, fine, gray calcareous clay, and indicates a fresh water deposit in that region very similar to that of the Bad Lands of the Judith. Mr. Drexler informs me, that the strata were uplifted and tilted in every direction like the beds of the Judith deposit, and the evidence indicates to my mind a fresh water formation of Lower Cretaceous or Upper Jurassic Age. We can thus see, that we have, as yet, but caught a glimpse of the interesting discoveries which await the geological explorer in the Far West.

ARTICLE XIII.

EXTINCT VERTEBRATA FROM THE JUDITH RIVER AND GREAT LIGNITE FORMATIONS OF NEBRASKA.

BY JOSEPH LEIDY, M. D.

THE present communication consists of descriptions, apparently of twelve new extinct species of fishes, saurians, chelonians, and mammals, from the territory of Nebraska. All of the fossil remains upon which these species are founded, with the exception of a single specimen, were discovered by Dr. F. V. Hayden, the zealous geologist and naturalist. The single specimen referred to, was obtained by Captain Alfred Sully, U. S. A., and was by him presented to the Academy of Natural Sciences of this city.

Of the fossils collected by Dr. Hayden, those referred to, *Trachodon*, *Deinodon*, *Palæoscincus*, *Troodon*, *Crocodilus*, *Lepidotus*, and part of those of *Trionyx* were obtained from the vicinity of the Judith River, one of the tributaries near the source of the Missouri River. The other specimens were obtained from the Great Lignite Formation, considered to be of Miocene Tertiary age by Messrs. Meek and Hayden, and were collected by the latter gentleman, during an expedition to Nebraska, under the command of Lieutenant G. K. Warren, Top. Eng. U. S. A., by whose permission the author has examined and described them.

The association of the remains of *Trachodon*, *Deinodon*, *Crocodilus* and *Lepidotus*, corresponding with the association of the remains of the closely allied *Iguanodon*, *Megalosaurus*, *Crocodilus*, and *Lepidotus* of the Wealden Formation of England, led the author to suspect the Judith River Formation was of cotemporary age, though he was fully aware of the

fact, that totally dissimilar animals have occupied different portions of the earth at the same period. The recent discovery of remains of the *Hadrosaurus*, another animal allied to the *Iguanodon*, in the Green Sand Formation of New Jersey, now inclines us to suspect that the Judith River Formation forms part of the great Cretaceous series of Nebraska, though we should not feel surprised if future explorations should determine it to be of Tertiary age.

1. *Extinct Vertebrata from the Judith River Formation.*

SAURIA.

Trachodon mirabilis.

With comparatively few exceptions, the living reptiles, whether turtle, saurian, serpent, or batrachian, are carnivorous in habit, and so far as we have been able to learn, such also appears generally to have been the case with the extinct forms of the same class, if we may judge from the anatomical structure of their remains.

In all the living forms of reptile life, when they are in possession of teeth, these organs are observed to be constructed for the penetration and cutting of food, whatever the nature of the latter may be; and in no known instance are they adapted to the crushing or mastication of substances. Even in the family of Iguanians, in which we find genera, such as the *Iguana** of South America and the *Amblyrhynchus* of the Galapagos Islands, using exclusively vegetable food, the teeth with their trenchant, jagged crowns, together form an instrument adapted to cutting like a saw, rather than one intended to bruise substances.

In the same category indicated in the preceding paragraph, it had been ascertained that all extinct reptiles belonged, until the discovery in the Wealden Deposit of England, by Dr. Mantell, of the great *Iguanodon*. It was therefore not at all surprising when the illustrious Cuvier first observed a tooth of the latter, that he pronounced it to be the incisor of a *Rhinoceros*, more especially as the specimen, which was in a much worn condition, really bore a strong resemblance to the corresponding tooth it was supposed to be. Nor did the determination at the time excite any degree of wonder, though it was a matter of much surprise that remains of the *Rhinoceros* should have been found in a formation so ancient as the Wealden.

Dr. Mantell afterwards, having sent a number of teeth of the *Iguanodon* for the examination of Cuvier; the latter was led to remark,—"It is perhaps not impossible that they may belong to a saurian, but to one more extraordinary than any of which we pos-

* In an *Iguana tuberculata* from St. Thomas, W. I., I found the stomach distended with vegetable matters alone, consisting of entire seeds, berries, fragments of soft stems, leaves and flowers.

sess knowledge. The character which renders them unique, is the wearing away of the crown transversely, as in the herbivorous quadrupeds."

Subsequent researches of Dr. Mantell led to the conclusion that the *Iguanodon* was a huge herbivorous saurian, which masticated its food in the manner of the existing pachyderm mammals.

Among the most interesting palæontological discoveries of Dr. Hayden in Western America, are several fossil specimens from the Judith River, which prove the former existence of a large herbivorous lizard, nearly allied to the great extinct *Iguanodon* of Europe.

The specimens, consisting of the unworn crown of a tooth, and portions of several much-worn teeth, at the time they were sent to the author for examination, were noticed in the Proceedings of the Academy of Natural Sciences of this city, as characteristic of a new genus of extinct herbivorous saurians, with the name of TRACHODON MIRABILIS. Subsequently a large collection of remarkably well preserved remains of another huge saurian, closely allied to *Trachodon* and *Iguanodon*, were obtained by our fellow member, W. Parker Foulke, Esq., from the green sand clay, in the neighbourhood of Haddonfield, New Jersey, not far distant from this city. The collection was presented by Mr. Foulke to the Academy of Natural Sciences, and was the subject of a short communication, in which the animal was characterized with the name of *Hadrosaurus Foulkii*.

Of the specimens of teeth referred to *Trachodon*, the unworn crown is the most important. It is represented in plate 9, figures 1—3, and is conical in form and slightly curved in its length. An examination of more perfect teeth of *Hadrosaurus* has led me to consider the specimen as having belonged to the lower jaw. Its inner face, (fig. 1,) is alone invested with enamel, is lozenge-shaped in outline, and is divided by a prominent median carina or ridge. The surfaces between the latter and the lateral borders of the crown are slightly depressed, smooth and shining.

The upper borders of the lozenge-like enamelled surface are the longer, but are neither serrated nor tuberculated, though they are slightly rugose towards the outer aspect of the tooth. The apex of the latter as formed by the enamelled surface is rounded, the lateral angles are obtuse, and the inferior angle is notched.

The portion of the tooth exterior to the enamelled surface is subtrihedral above and becomes pentahedral below, (figs. 2, 3,). The lateral or innermost divisions of the pentahedral portion of the crown, apparently exhibit the impress of the summits of laterally succeeding teeth, (fig. 2, *a*,) and the remaining surfaces of the exterior of the tooth are roughened with granular tubercles.

The broken base of the specimen is irregularly hexahedral in outline, and presents at its middle the open pulp cavity in the form of an ellipsoidal figure, with the long diameter

directed from without inwardly. The walls of the cavity are from one to one and a half lines thick, and appear quite roughened on their interior surface.

A transverse section of the crown, about the middle, gives an outline such as is exhibited in figure 4, a section of the bottom of the crown, as in figure 5, and a section of the broken extremity of the specimen, as in figure 6.

The measurements of this specimen are as follows:—Length of the enamelled surface, 13 lines; greatest breadth at the lateral angles of this surface, 5½ lines; diameter at base of crown, from within outwardly, 5 lines; diameter, laterally or antero-posteriorly, 4 lines.

Three much worn specimens of teeth of *Trachodon*, (figs. 7—15,) are apparently the remains of fangs; the crowns or portions of the teeth faced with enamel having been worn away. The specimens have the form of transverse fragments of a parallelogram, with concave sides, and with one border bevelled off. The triturating surface (figs. 9, 12, 15,) is concave, and presents a slightly elevated crucial ridge, with smaller diverging branches. The ridge is of a harder substance than the including dentine, and was no doubt intended to preserve a rough condition of the triturating surface as this is worn away. The under part of the specimens, (fig. 8 *e*,) is more or less hollowed, apparently from the pressure of succeeding teeth.

The length of the specimens is from 3 to 4 lines; the breadth of the triturating surface, from the parallel sides, from 2½ to 3 lines.

Two additional specimens, (figs. 16—20,) found with the preceding, may perhaps belong to a different animal, but it is quite probable also that they belong to a different part of the jaws of the same animal.

One of these specimens, (figs. 18—20,) consists of the crown of a tooth with a small portion of one side broken away. The crown is a broad four-sided pyramid, with an acute summit rising to a short point. The outer surface, as it is presumed to be, is nearly vertical, devoid of enamel, and elevated into a longitudinal ridge on one side, as represented in figure 20. This surface has been slightly roughened, but is worn smooth for part of its extent from attrition of an opposing tooth. The inner surface, (fig. 18,) is concave, and elevated into a longitudinal ridge, opposite that on the outer surface; besides which, it has three short ridges extending from the summit of the tooth. On the unbroken side of the specimen, it is likewise embraced by a ridge, curving from the summit to the base of the crown. The unbroken side of the latter, (fig. 19,) is triangular, convex, and tuberculated; is separated from the inner surface of the tooth by the curving ridge just mentioned; and from the outer surface by a ridge, which is transversely notched in the manner of the lateral borders of the teeth of *Iguanodon*. Below this side of the crown, the base of the specimen presents a sort of osseous envelope or thickening, which becomes obsolete on the outer face of the specimen. The base of the crown beneath and on each side is hollowed, apparently from the pressure of three successors.

The length of this specimen, on the outer side, as represented in figure 20, is 5½ lines; the breadth, 4 lines; the width at base, 4¾ lines.

Another specimen consists of the longitudinal fragment of a tooth, as represented in figure 16. The triturating surface, (figure 17,) is level and smooth, and corresponds with the transverse section of the fragment. This section is quadrate, with one of the sides formed by the broken border of the tooth. The other sides are concave, with the intervening angles prolonged; one of them being bevelled, and the other doubly so. The base of the fragment is enveloped in a thick, rugged osseous layer.

Explanation of Figures, Plate 9.

Figures 1—20, Teeth of TRACHODON MIRABILIS.

Figures 1—6, of the size of Nature.

Figures 7—20, magnified two diameters.

Figure 1. Inner view of an inferior tooth, exhibiting the lozenge-shaped enamel surface divided by a median carina. The form of the fang restored in outline.

Figure 2. Lateral view of the same specimen, exhibiting the roughened outer surface, and at *a* a portion of the surface impressed by the crown of a lateral successor.

Figure 3. Outer view of the same specimen.

Figure 4. Section of the crown at the position marked *b*, fig. 1.

Figure 5. Section at the position marked *c*, fig. 1.

Figure 6. Section at the broken extremity *d*, fig. 3.

Figure 7. Remains of a much worn tooth, apparently from the upper jaw, external view.

Figure 8. Internal view of the same specimen, exhibiting at *e* the hollowed base.

Figure 9. Triturating surface of the same specimen, exhibiting the crucial ridge of harder dentinal substance.

Figures 10, 11, 12. Similar views to those last indicated, of another tooth.

Figures 13, 14, 15. Similar views of a third tooth.

Figure 16. Outer view of the remainder of a much worn tooth; the base enveloped by a thick osseous crust.

Figure 17. Triturating surface of the same specimen.

Figure 18. A slightly worn tooth, of peculiar form; apparent inner view.

Figure 19. Lateral view of the same specimen.

Figure 20. Outer view.

DEINODON HORRIDUS.

In association with the remains of the huge herbivorous *Iguanodon*, Dr. Mantell found remains of a fit carnivorous cotemporary, the *Megalosaurus*. This great saurian, named by Dr. Buckland, and first discovered by him in the Oolitic Formation of England, possessed sabre-shaped teeth, with trenchant serrated edges, over three inches in length and an inch in breadth, supported in the jaws by an outer parapet wall, and passing one an other like the blades of scissors.

With the remains of *Trachodon*, Dr. Hayden likewise discovered those of a representative of the *Megalosaurus*, to which the name of *Deinodon* has been applied.

The specimens upon which the latter genus is based, consist of fragments of about a dozen teeth, of which three-fourths are nearly identical in form with those of *Megalosaurus*, while the others are more or less peculiar. The uniformity in shape of the teeth of *Megalosaurus* would appear to indicate that the three-fourths of the specimens alluded to, belonged to, at most, another species of the same genus, while the remaining specimens would typify a distinct genus. However, from the variety in form of the latter specimens, together with the fact that all the specimens present the same general appearance, as regards colour, texture, and constitution, I have been induced to regard them as belonging to a single animal, and feel that it must be left for further discovery to ascertain whether such a view is correct.

The teeth of *Deinodon*, resembling in form those of *Megalosaurus*, (figs. 21—34,) are laterally compressed conical, with a curvature backward, and with the anterior and posterior borders trenchant and crenated. In transverse section they are quadrately elliptical, with acute poles corresponding with the trenchant edges of the teeth. These specimens, as indicated in figures 25, 29, are generally worn off at the summits, the borders extending therefrom, and in several instances at the sides. The attrition of the teeth indicates those of the upper and lower jaws to have closed upon one another like the blades of scissors, so that they were well adapted for penetrating, tearing and cutting their animal food.

Of the remaining specimens of teeth, whose form is peculiar in comparison with that of the others, one is the crown of a conical tooth, with feeble lateral compression, and is represented in figures 46, 47. Its transverse section, (figure 48,) is quadrately rotund, with two acute angles, corresponding with crenated ridges, one of which occupies the inner side of the tooth, while the other is situated postero-externally. The summit of the specimen is worn off in a sloping manner anteriorly. The tooth probably occupied a position in the back of the jaw.

A second specimen, represented in figures 37—40, consists of the greater portion of the crown of a tooth whose transverse section forms the half of an ellipse. The anterior border is obtusely rounded; the sides are compressed, and the posterior border forms a plane, elevated at the middle and bounded by acute crenated margins. The apex of the tooth is worn off in a sloping manner posteriorly.

A third specimen, represented in figures 35, 36, consists of a small fragment of a large tooth, like that just described. The latter two specimens perhaps represent canine teeth.

The last of the aberrantly formed specimens, represented in figures 41—45, consists of the crown of a comparatively small tooth, possessing nearly the shape of the two teeth

just mentioned, but its posterior margins are not crenated, and the intervening back surface is more elevated. The apex of the specimen is worn off in a sloping manner anteriorly. This tooth I suspect to represent an incisor.

As the entire dentition of *Megalosaurus* has not yet been ascertained, it may turn out to be the case, that in other parts of the jaws than those known, it possesses teeth like the ones above described as peculiar. Should on future discovery such a condition of things be proved to exist, *Deinodon* would then cease to be any thing more than a second species of *Megalosaurus*.

As anatomical and geological evidence favour the view that *Iguanodon*, *Trachodon*, and *Hadrosaurus*, were amphibious, it is not unlikely that *Megalosaurus* and *Deinodon* infested the shores, upon which the former quietly grazed or browsed, and proved to them fierce and destructive enemies. The two carnivorous saurians perhaps held the same office in relation to the more bulky herbivorous lizards, that we find to exist between the larger existing feline animals, and the pachyderm solipedal and ruminant mammals.

Explanation of Figures, Plate 9.

Figures 21—48, Teeth of DEINODON HORRIDUS; all the size of Nature.

Figure 21, *f. g.* Two fragments of a large sabre-shaped tooth; lateral view.

Figures 22, 23. Transverse sections at the positions marked *f. g.*

Figure 24. Front view of the same fragments.

Figure 25. Summit of a sabre-shaped tooth.

Figure 26. Section at *h.*

Figure 27. Summit of another specimen.

Figure 28. Section at *i.*

Figure 29. Lateral view of the summit of a sabre-shaped tooth, exhibiting the enamel partially worn off.

Figure 30. Section of the tooth at *j.*

Figure 31. A similar tooth.

Figure 32. Section at *k.*

Figure 33. A small tooth of the same form.

Figure 34. Section at *l.*

Figure 35. Fragment of a large tooth, with its posterior border forming a plane surface as indicated in the section, Figure 36, taken at *m.*

Figure 37. Lateral view of the summit of a tooth like the preceding specimen.

Figure 38. Posterior view of the same specimen.

Figures 39, 40. Sections at *n. o.*

Figure 41. Posterior view of the crown of a tooth, perhaps an incisor.

Figure 42. Lateral view of the same.

Figures 43, 44, 45. Sections from the positions indicated.

Figure 46. Postero-internal view of a conical tooth.

Figure 47. Antero-external view of the same specimen.

Figure 48. Section at *p.*

Crocodilus humilis.

With the remains of Trachodon and Deinodon, Dr. Hayden discovered half a dozen teeth, apparently of a small species of Crocodile, though they may probably belong to an acrodont lacertian reptile.

Five of the teeth, (figures 9—17, plate 11,) are conical and moderately curved; and on their inner part, in front and behind, they present the usual pair of acute ridges. About the middle of the crown, their enamelled surface is slightly folded, especially on the inner side of the teeth. They are solid, except that a small conical cavity occupies the centre of their base. The latter is slightly concave and eroded in appearance; the borders only being broken, indicating that the teeth were about to be shed or actually were so, although most of them appear unworn.

One of the specimens of teeth, (figures 18, 19,) is mammilliform, slightly compressed, and finely rugous in the length of the crown. It is likewise solid, and has the base presenting the same appearance as the other specimens.

Explanation of Figures, Plate 11.

Figures 9—19. Teeth of Crocodilus humilis, of the size of Nature.
Figures 9, 10. Inner and lateral views of a conical tooth.
Figure 11. Section of the same at base.
Figures 12, 13. Inner and lateral views of another conical tooth.
Figure 14. Section at base.
Figures 15, 16, 17. Inner, lateral, and sectional views of a third tooth.
Figures 18, 19. Outer and lateral views of a mammilliform tooth.

Palæoscincus costatus.

In association with the remains of the great extinct saurians, *Trachodon* and *Deinodon*, Dr. Hayden discovered the tooth of a true and gigantic representative of the family of Iguanians. The tooth is constructed on the same general plan as those of the existing Iguanas, consisting of a sub-palmate crown, with a compressed cylindrical fang.

The crown of the fossil tooth, (figs. 49—52, plate 9,) is compressed pyramidal with the apex truncated, and is broader than long. Its base is elevated into a ridge; and from the sides, ridges extend to the free borders of the crown, where they end in points, some of which are acute and others are blunt. From the basal ridge of the crown, the tooth gradually narrows into a compressed cylindrical, hollow fang, the lower part of which, in the specimen, is broken away.

The breadth of the crown of the fossil tooth is 4 lines; its length from the basal ridge is 2½ lines; and its thickness in the position of the latter, is 1½ lines. The breadth of the fang at its broken end, is 2 lines; its width, 1¼ lines.

In structure, the tooth appears wholly composed of dentinal substance, and exhibits no trace of enamel upon the crown.

A proportionate increase in length of *Palæoscincus* with the size of the teeth, in comparison with those of *Iguana tuberculata*, would give the animal a length of over thirty feet, which is however not probable, as we observe no necessary relation of length of animals in proportion with the size of their teeth.

In the same formation from which the tooth of *Palæoscincus* was obtained, there were found about a dozen vertebral bodies, which may belong to the same animal, and if this is the case, we may obtain from them a more just idea of the size of the latter. These vertebral bodies are cylindroid, comparatively slightly constricted, and have the extremities slightly concave. In the true Iguanas the vertebral bodies have a totally different form, as they interlock with one another by a ball and socket joint; this, however, is no positive evidence that the fossil specimens do not belong to *Palæoscincus*. Some of these vertebræ are represented in figures 56—61, and they measure from 7 to 9 lines in length.

Accompanying the vertebral bodies, there is an ulna, represented in figure 8, plate 11, which is solid, and perhaps belongs to the same animal.

Palæoscincus, probably like the marine *Amblyrhynchus* of the Galapagos Islands, was aquatic and fed upon plants.

Explanation of Figures, Plates 9, 11.

Figures 49—52. Tooth of PALÆOSCINCUS COSTATUS; magnified two diameters.
Figures 49, 50. Outer and inner views.
Figure 51. Apparently the forward view.
Figure 52. Section at the broken extremity of the specimen.
Figures 56—61. Vertebræ; of the size of Nature.
Figure 56. Anterior view of a dorsal vertebral body.
Figure 57. Lateral view.
Figure 58. Anterior view of an anterior caudal vertebra.
Figure 59. Lateral view.
Figure 60. Anterior view of a posterior caudal vertebra.
Figure 61. Lateral view.
Figure 8, plate 11. An ulna, natural size, suspected to belong to *Palæoscincus costatus*.

TROODON FORMOSUS.

In association with the remains previously described from the Judith River, Dr. Hayden discovered the tooth of a large Monitor, to which the above name has been applied. Probably aquatic like many of the living Monitors, the voracious *Troodon* was most likely a troublesome enemy to the peaceful plant-eating *Palæoscincus*.

The fossil tooth (figs. 53–55, plate 9,) bears much resemblance to one of the lateral denticles of the teeth of the great extinct shark, *Carcharodon angustidens*, and under other circumstances might readily have been mistaken for such.

The specimen is black and shining, and is laterally compressed, conical, and curved backwards, as observed in the *Monitor ornatus*. The margins of the tooth are trenchant, and strongly denticulated; the denticles possessing the same form as the crown itself. On the convex border of the tooth there are eleven denticles, and on the concave border, seven; and on both borders the points of the denticles diverge upwardly.

The broken base of the crown is elliptically trapezoidal, and is hollowed on the interior. The crown is invested with enamel, which on one side of its summit is worn off by the attrition of an opposing tooth passing it like the blades of a pair of scissors. The length of the specimen is 3 lines; its antero-posterior diameter at base, 2 lines; and its transverse diameter, 1½ lines.

I have no evidence that part of or all of the vertebræ supposed to belong to *Palæoscincus*, do not really appertain to *Troodon*. This question must be left for future investigation to determine.

Explanation of Figures, Plate 9.

Figures 53—55. Tooth of TROODON FORMOSUS; magnified three diameters.

Figure 53. Outer view.

Figure 54. Inner view, exhibiting the enamel worn from the summit.

Figure 55. Section at the base of the specimen.

CHELONIA.

TRIONYX FOVEATUS.

Among the fossils of Dr. Hayden's Judith River Collection, there are a number of small fragments of costal and sternal plates, having much resemblance to the corresponding parts of our living soft-shelled Turtles, forming the genus *Trionyx*.

The exterior surface of the fragments of costal plates, (figure 2, plate 11,) is impressed with shallow pits, except near the borders of the plates. The pits are smaller and rounded at the vertebral extremities of the latter, and become larger outwardly, assuming a polyhedral, often oblong and reniform outline. The fragments of the sternal plates, (figure 1, plate 11,) have their exterior surface covered with short vermicular ridges, which recall a remote appearance to Arabic letters. One of the fragments of a costal plate, apparently the third or fourth, represented in figure 2, is almost 11 lines wide, and 2 lines thick. Two fragments of a hyposternal plate, (figure 1,) are 3 lines in thickness.

In association with the remains of several other genera of Turtles, and of some other animals in the Great Lignite Tertiary Basin, near Long Lake, below Fort Clark, Nebraska, Dr. Hayden obtained small fragments of the carapace or osseous shell of a Turtle, not distinguishable from those referred to, *Trionyx foveatus*. The specimens are too imperfect positively to determine whether they actually belong to the same species. Fragments of a last costal plate, represented in figure 3, plate 11, measures 4 lines in thickness, and are closely foveated on the exterior surface, in the manner described in the account of the corresponding plates of *Trionyx foveatus* from the Judith River.

Explanation of Figures, Plate 11.

Figures 1—3. Fragments of the carapace and sternum of TRIONYX FOVEATUS, of the natural size.

Figure 1. Two fragments of a hyposternal plate; an ideal outline given in the restored condition.

Figure 2. Fragment of a left costal plate.

Figure 3. Fragment of the last right costal plate, supposed to belong to the same species as the preceding.

FISHES.

LEPIDOTUS OCCIDENTALIS.

The genus of ganoid fishes *Lepidotus*, appears to have come into existence during the Liassic period, to have extended through the Oolitic, Wealdean, and Cretaceous periods, and to have become extinct in the Eocene Tertiary period.

As if to keep up the association, in the manner that Dr. Mantell found together in the Wealdean deposits the remains of *Iguanodon*, *Megalosaurus*, *Crocodilus*, and *Lepidotus*, Dr. Hayden discovered with the remains of *Trachodon*, *Deinodon*, and *Crocodilus*, a half dozen ganoid fish scales, which appear to belong to the genus *Lepidotus*. The specimens may indicate two species, but with equal probability they may appertain to a single one.

Four of the scales, (as represented in figures 20, 21, plate 11,) are lozenge-shaped, with their root prolonged from one side in the direction of the longest diameter of the lozenge. Two of the scales, (as represented in figures 22, 23,) are square, with their root projecting from one of the longer sides. All the specimens are invested with thick, shining, enamelled substance; and one of the square scales exhibits on its free surface, parallel square lines of growth.

The largest lozenge-like scale has the sides of its free or enamel surface about 4 lines long; and the smallest has two of the sides 3 lines long, the other sides 2 lines long. The larger square scale has its long sides 5 lines, and its short sides 3½ lines.

Explanation of Figures, Plate 11.

Figures 20—23. Scales of LEPIDOTUS OCCIDENTALIS, of the natural size.

2. *Extinct Vertebrata from the Great Lignite Formation.*

MAMMALIA SIRENIA?

ISCHYROTHERIUM ANTIQUUM.

Among the most enigmatic fossil remains of vertebrata collected by Dr. Hayden, in Nebraska Territory, are a number of fragments of bones, obtained from an out-lyer of the Great Lignite Tertiary Formation, between the Moreau and Grand Rivers.

The specimens consist of two vertebral bodies, the half of a third one, two apparent transverse processes, and numerous fragments of ribs. We cannot positively determine the affinities of the animal represented by these bones, but from their solidity of structure and the cylindroid form of the ribs, we suspect *Ischyrotherium* to be more nearly allied to the Manatee than to any other known animal.

The vertebral bodies, (figs. 8—11, plate 10,) apparently posterior dorsal, are segments of a cylinder compressed from above downward, so that their articular faces are transversely oval in outline. They are comparatively slightly constricted at the middle; and in this position present a number of orifices of large vascular canals, which converge to the centre of the bodies. Both articular faces are slightly concave, with obtuse margins. The dorsal surface, (figure 8, plate 10,) exhibits a narrow tract corresponding with the spinal canal, and on each side, a broad, concave, porous articular surface for conjunction with the sides of the vertebral arch.

The broken vertebral body, (figure 11, plate 10,) presents an equally dense structure throughout, except at the articular surfaces, which are finely porous. The large vascular canals are seen in this specimen converging from the middle circumference to the centre of the bone, and smaller ones are observed pursuing a like course from the borders of the articular surfaces.

The specimens of transverse processes, (figs. 12, 13, 14, plate 10,) are remarkable for their robust character and cylindroid form. The outer extremity of the longer specimen, though abruptly truncated, appears nevertheless to be entire. The inner extremity of the specimens, inferiorly, presents a broad, convex, porous, articular surface, for conjunction with the corresponding surfaces of the vertebral bodies. Above this surface, there is a smooth arching one forming the side of the vertebral canal and overhung by the abutment for the articular and spinous processes.

The numerous fragments of ribs, generally indicate these bones to have a curved fusiform shape, as seen in fig. 15, plate 10, representing one of the more perfect specimens. In structure they exhibit the same remarkable solidity noticed in the corresponding bones of the Manatee.

Though I have supposed the remains above described to indicate the former existence of a mammal allied to the Manatee, they yet appear to me of such a singular character, that I have suspected they may have belonged to an aquatic reptile, unlike any known, and perhaps foreshadowing in its constitution the Sea Cows, just as Iguanodon appears to have foreshadowed the herbivorous pachyderms of the Eocene Tertiary Period.

Explanation of Figures, Plate 10.

Figures 8—15.—Vertebræ and rib of ISCHYROTHERIUM ANTIQUUM; two-thirds the diameter of nature.

Figure 8. Dorsal view of vertebral body. Articular surface on each side.

Figure 9. Anterior view of the same vertebral body.

Figure 10. Ventral view of a second and similar specimen.

Figure 11. Broken surface of a third specimen, exhibiting its dense structure and converging nutritious canals.

Figure 12. Inferior view of a vertebral half arch and transverse process, exhibiting the articular surface, adapted to a corresponding one of figure 8.

Figure 13. Anterior view of same specimen as the last.

Figure 14. Anterior view of another specimen like that indicated in figures 12, 13.

Figure 15. Fragment of a rib, with outline sections (16, 17,) of the size of nature, from the upper end and middle.

SAURIA.

THESPESIUS OCCIDENTALIS.

Several vertebræ, together with a first phalangial bone, from Nebraska, appear to indicate a deino-saurian as colossal as the *Iguanodon* of England, or the *Hadrosaurus* of New Jersey. Two of the specimens are exceedingly like mammalian lumbar vertebræ, especially those of the Elephant or Mastodon, and might readily be taken for such, were it not that they possess well marked processes for the articulation of chevron bones.

One of the vertebræ from near the trunk, and another, which I suspect to belong to the same animal, from near the end of the tail, together with the phalanx, were discovered by Dr. Hayden, in the Great Lignite Formation, at Grand River, Nebraska. Another large vertebra from near the trunk, was obtained by Captain Alfred Sully, U. S. A., from an Indian, and presented to the Academy of Natural Sciences of this city. This specimen Dr. Hayden supposes to have been derived from the same locality in which he discovered the others.

The bodies of the two large vertebræ, viewed in front, (fig. 2, plate 10,) are quadrately oval in outline, and notched above; the notch corresponding with the spinal canal. One of them measures about 5 inches transversely and vertically; the other, 4½ inches transversely and 4½ vertically; and their length is about 2¾ inches. They are narrowed concavely from their articular borders, (fig. 1,) and are bounded below (fig. 3) by articular processes, for chevron bones, an inch in diameter. Their anterior articular face, (figs. 1, 2,) is moderately convex; and their posterior face concave, with a depth of nearly

half an inch. Robust transverse processes broken off in the specimens, projected from the conjunction of the vertebral arch and body. The spinal canal, retained entire in the smaller specimen, is circular and one inch in diameter.

The smaller caudal vertebral body, (figs. 6, 7,) has its anterior surface nearly plain or slightly depressed, while its posterior surface is moderately concave. Its length is about equal to its height, which is 2 inches, while its breadth is 2¾ inches.

The first ungual phalanx, (figs. 4, 5,) resembles the corresponding bones of *Iguanodon* and *Hadrosaurus*. It is 5 inches long; 4½ wide at base, by 3½ thick; and 4 inches wide at the distal end, by 2½ thick. Deep concavities exist each side of the distal extremity for the attachment of lateral ligaments. The proximal articular surface is a transverse reniform concavity; the distal articulation a transverse convexity slightly depressed towards its middle.

Had the bones of *Thespesius* been found in association with the remains of *Trachodon* or *Deinodon*, or in the same geological formation, I would have suspected that they belonged to one of the latter.

Explanation of Figures, Plate 10.

Figures 1—7. Vertebræ and phalanx of THESPESIUS OCCIDENTALIS; one half the diameter of nature.

Figure 1. Lateral view of an anterior caudal vertebra.

Figure 2. Anterior view of same specimen as the last one.

Figure 3. Ventral view of same specimen, exhibiting the articular processes of the chevron bones.

Figure 4. Upper view of a first phalangial bone.

Figure 5. Lateral view of the same.

Figure 6. Lateral view of a posterior caudal vertebral body.

Figure 7. Posterior view of the same specimen.

CHELONIA.

COMPSEMYS VICTUS.

The above name is proposed for a species of turtle, indicated by several fragments of a carapace, obtained by Dr. Hayden, from the Great Lignite Tertiary Basin, near Long Lake, Nebraska. The more characteristic specimens consist of a vertebral plate, and the greater portions of the fifth and last right costal plates.

The vertebral plate, (fig. 5, plate 11,) is about an inch in its antero-posterior and transverse diameters. The fifth costal plate, (figs. 6, 7, plate 11,) is much arched, is an inch and a quarter wide, two lines thick, and when perfect, appears to have been about four inches long. The fragment of a last costal plate is three lines thick.

Marks upon the fifth costal plate, of the fourth and fifth vertebral scutes, indicate these to have been about two inches in width.

The peculiarity of the specimens which has led to the proposal of the genus, consists in

their exterior surface being closely studded with uniform granular tubercles, which give to them a shagreened appearance, quite different from any thing I have had the opportunity of seeing in other turtles.

Explanation of Figures, Plate 11.

Figures 5, 6, 7. Fragments of plates of the carapace of COMPSEMYS VICTUS, of the natural size. The carapace represented as partially but ideally restored, with the relative position of the fossil fragments.

Figure 5. A vertebral plate. Figure 6. A portion of a right costal plate.

Figure 7. Marginal view of the same specimen as the last, giving an idea of the curvature of the carapace.

EMYS OBSCURUS.

Associated with the remains of *Compsemys*, and fragments of the shell of another turtle previously mentioned as not being distinguishable from those of *Trionyx foveatus*, Dr. Hayden found fragments of a carapace, sufficiently characteristic only to determine that they indicate a species of *Emys*. The best of the fragments, represented in figure 4, plate 11, consists of the greater portion of a costal plate, which is sixteen lines wide, a line and a half thick, and in its perfect state may have been about five inches long.

Explanation of Figure, Plate 11.

Figure 4. Fragment of a right costal plate of EMYS OBSCURUS; restored in outline.

FISHES.

MYLOGNATHUS PRISCUS.

The very singular-looking fish, *Chimæra*, of the European seas, was represented during the Miocene period in Nebraska, by a genus for which the above name has been proposed. Its former existence is indicated by specimens of dental plates, like those of *Chimæra*, adapted to the crushing of mollusca and crustacea, used as food. The specimens, consisting of an upper maxillary and a premaxillary plate, were obtained by Dr. Hayden from the Great Lignite Basin near Long Lake, Nebraska.

The upper maxillary plate, (figs. 24, 25, 26, plate 11,) consists of a narrow triangular bone, containing two teeth. The specimen is broken at its two extremities, and when perfect appears to have been a little over an inch in length. Its posterior part is 3¾ lines wide, and about 4½ lines thick. The free convex surfaces of the peculiar porous teeth, occupy nearly the entire length and breadth of the bone, (fig. 25, plate 11,) and are separated from each other by an oblique, linear tract. The anterior tooth is lozenge-shaped in outline, and when perfect appears to have been about ½ an inch in length, and 1¾ lines

in breadth. The posterior tooth, somewhat ellipsoidal in outline, appears, when perfect, to have been about 8 lines long, and is three lines wide.

The premaxillary dental plate, (figs. 27—30, plate 11,) is irregularly lozenge-shaped in its vertical outline antero-posteriorly, is a little over an inch in its long diameter, 5 lines in its depth, and 3 lines in its greatest thickness. Its anterior border is convex, the inner and outer surfaces are vertical, slightly depressed planes, and the crushing surface is concave.

Explanation of Figures, Plate 11.

Figures 24—30. Upper maxillary plates of MYLOGNATHUS PRISCUS, of the natural size.

Figure 24. Inner view of the maxillary plate, exhibiting the surfaces of the two teeth projecting below.

Figure 25. Oral or inferior surface of the same.

Figure 26. Posterior extremity of the same, exhibiting the columnar structure of the teeth.

Figures 27, 28. Outer and inner view of a pre-maxillary plate.

Figures 29, 30. Triturating surface and upper view of the same.

In Commodum Lectoris, Synopsis Generum et Specierum Quæ in hoc Opere et Alibi Discribuntur.

MAMMALIA SIRENIA?

1. ISCHYROTHERIUM ANTIQUUM, Leidy; Proc. Acad. Nat. Sci., Phila., 1856, 89.

SAURIA.

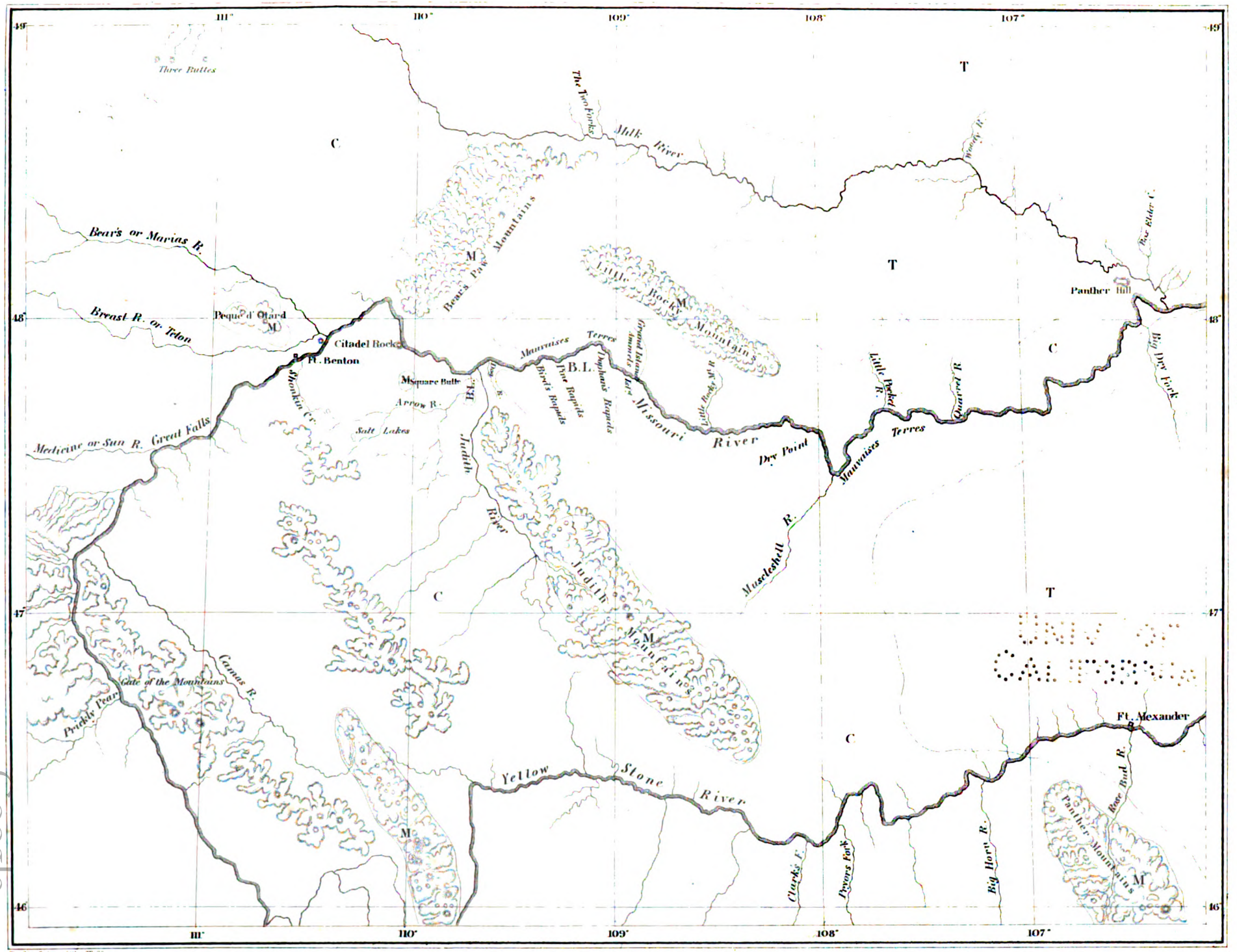
2. TRACHODON MIRABILIS, Leidy: Proc. Acad. Nat. Sci., Phila., 1856, 72.
3. DEINODON HORRIDUS, Leidy: Ibidem.
4. PALÆOSCINCUS COSTATUS, Leidy: Ibidem.
5. TROODON FORMOSUS, Leidy: Ibidem.
6. CROCODILUS HUMILIS, Leidy: Ibidem.
7. THESPESIUS OCCIDENTALIS, Leidy: Ibidem, 311.

CHELONIA.

8. TRIONYX FOVEATUS, Leidy: Proc. Acad. Nat. Sci., Phila., 1856, 73, 312.
9. COMPSEMYS VICTUS, Leidy: Ibidem.
10. EMYS OBSCURUS, Leidy: Ibidem.

PISCES.

11. LEPIDOTUS OCCIDENTALIS, Leidy: Proc. Acad. Nat. Sci., Phila., 1856, 73. *Lepidotus Haydeni*, Leidy: Ibidem.
12. MYLOGNATHUS PRISCUS, Leidy: Ibidem, 312.



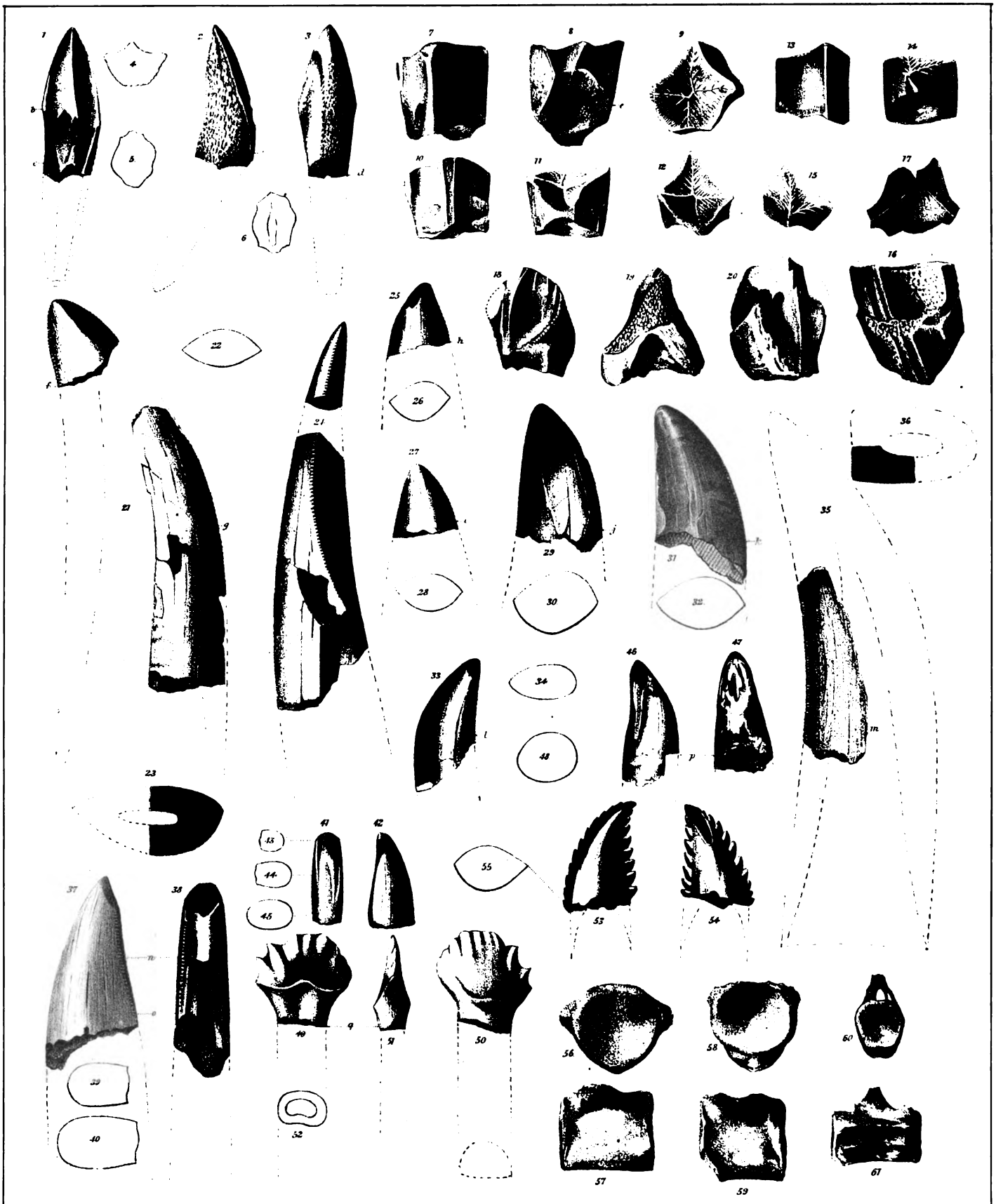
T. Sinclair's lith. Phila.

T Tertiary

C Cretaceous

M Metamorphic

B.L. Bad Lands of the Judith

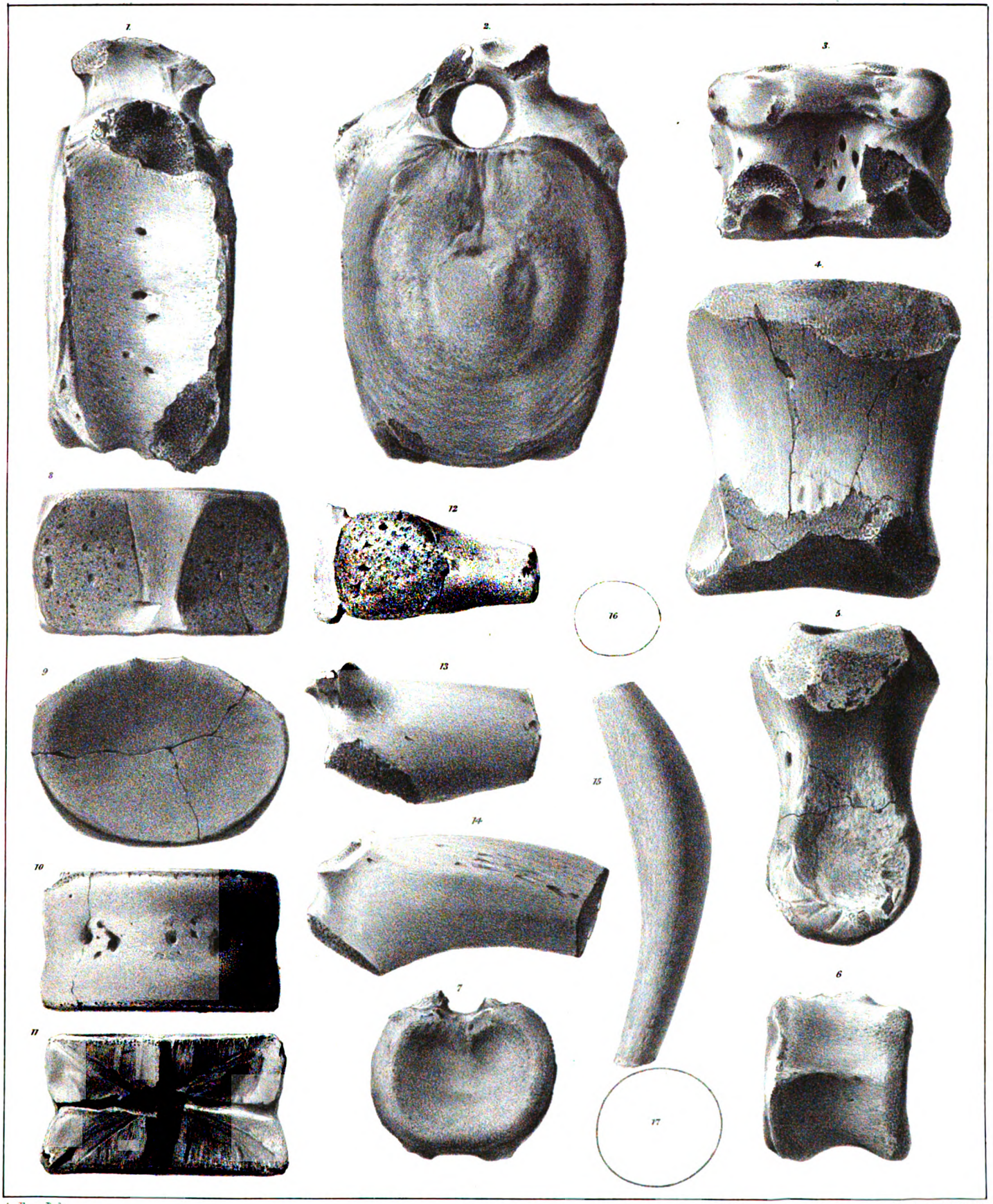


Jos. Leidy. Del.

On Stone by A. Frey

T. Sinclair's lith. Phil.a

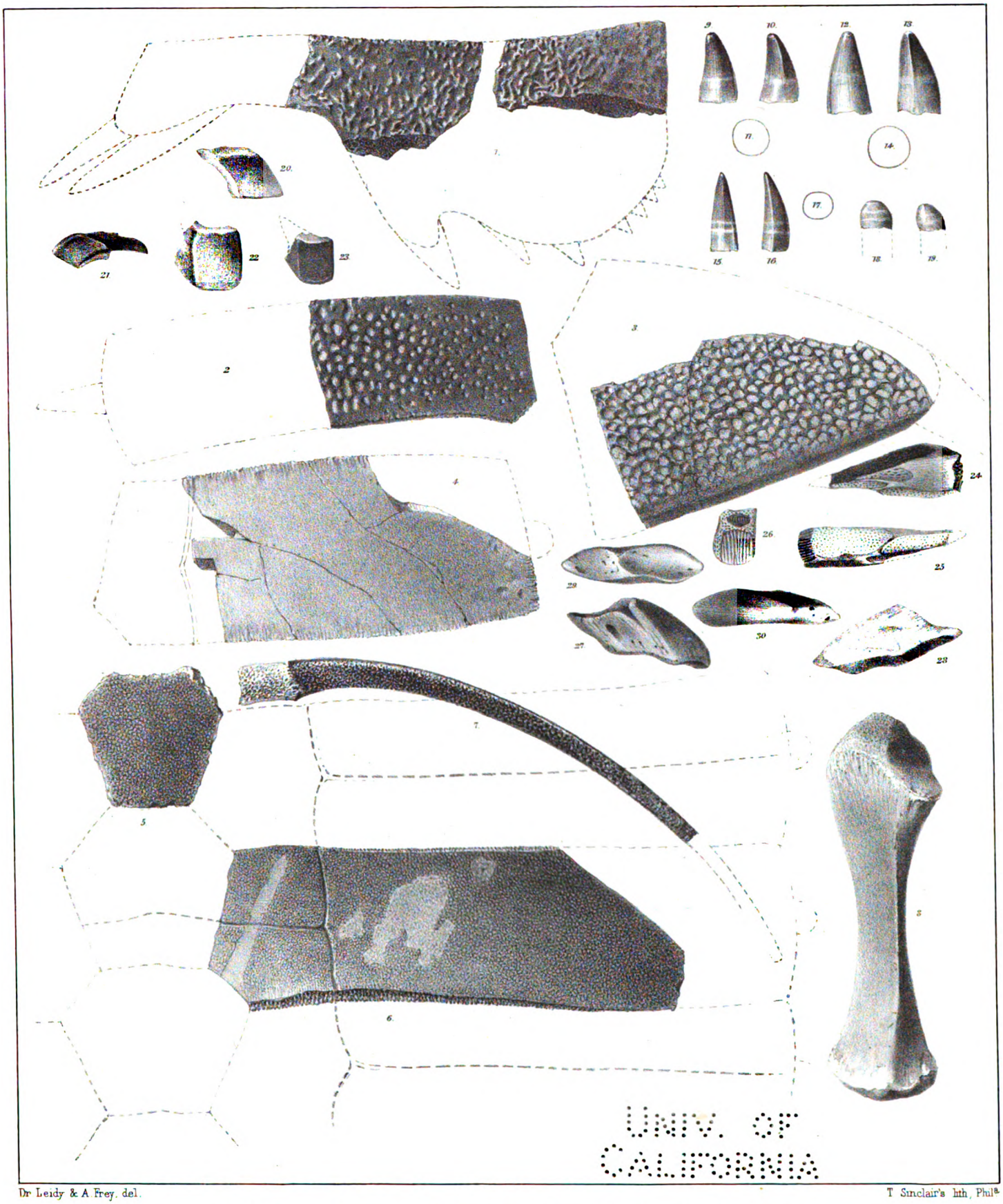
1–20. Trachodon mirabilis 21–48 Demodon horridus.
49–52 Palaeoscincus costatus 53–55 Troodon formosus



A. Frey Del

T. Sinclair's lith. Phil.a

1–7. Thespesius occidentalis. 8–17 Ischyrotherium antiquum.



Dr Leidy & A Frey. del.

T Sinclair's lith, Phila

1–3. Trionyx foveatus 4 Emys obscurus 5–7. Compsemys victus
9–19 Crocodilus humilis. 20–23, Lepidotus occidentalis 24–30 Mylognathus priscus.