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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BY F. V. HAYDEN, M. D.

Read March 4th, 1859.

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. subtriyonalis* 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.

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 subtropical 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.

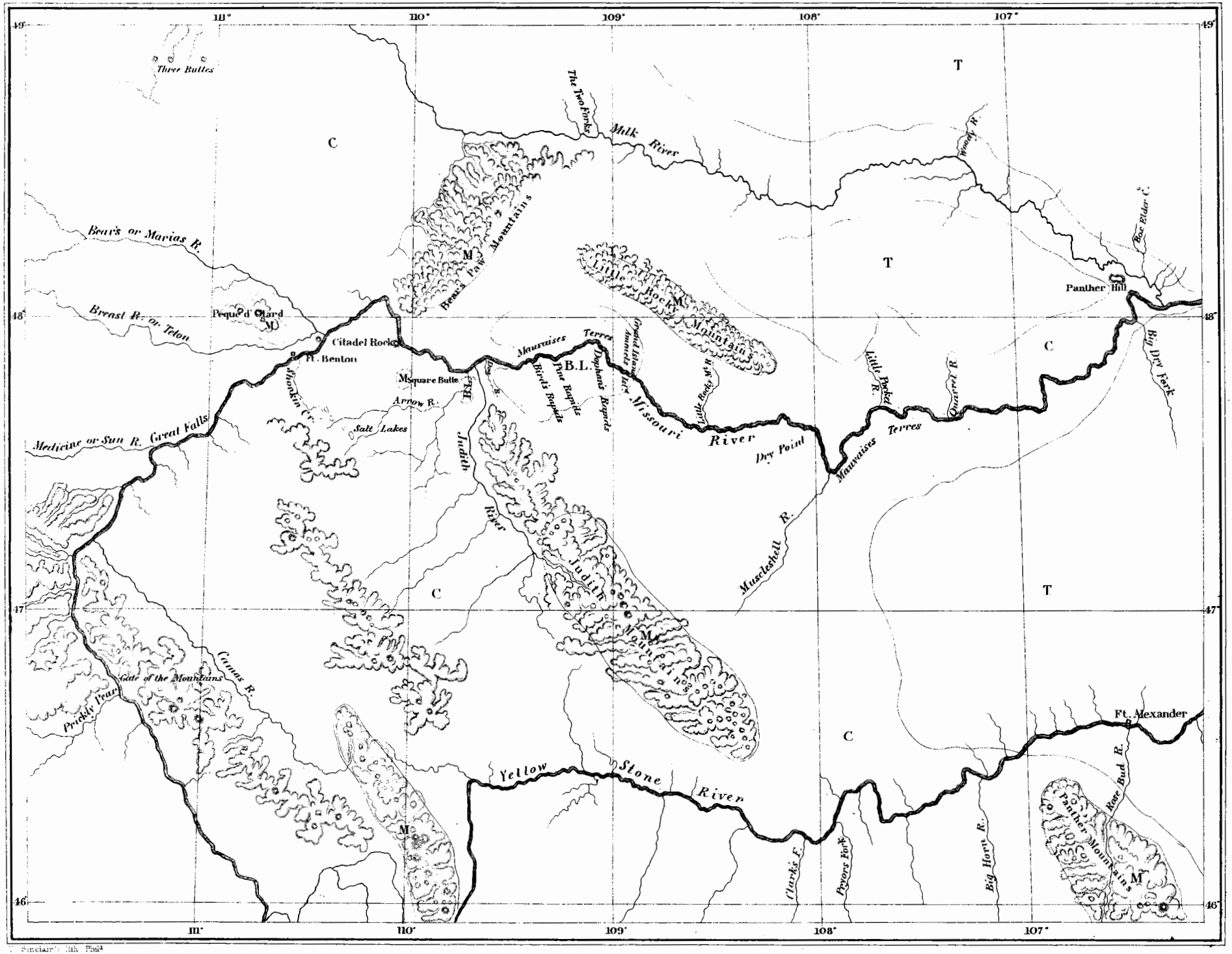
I am indebted to the kindness of Lieutenant G. K. Warren, U. S. Topographical Engineers, for the beautiful Geographical Map which accompanies this paper.

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.

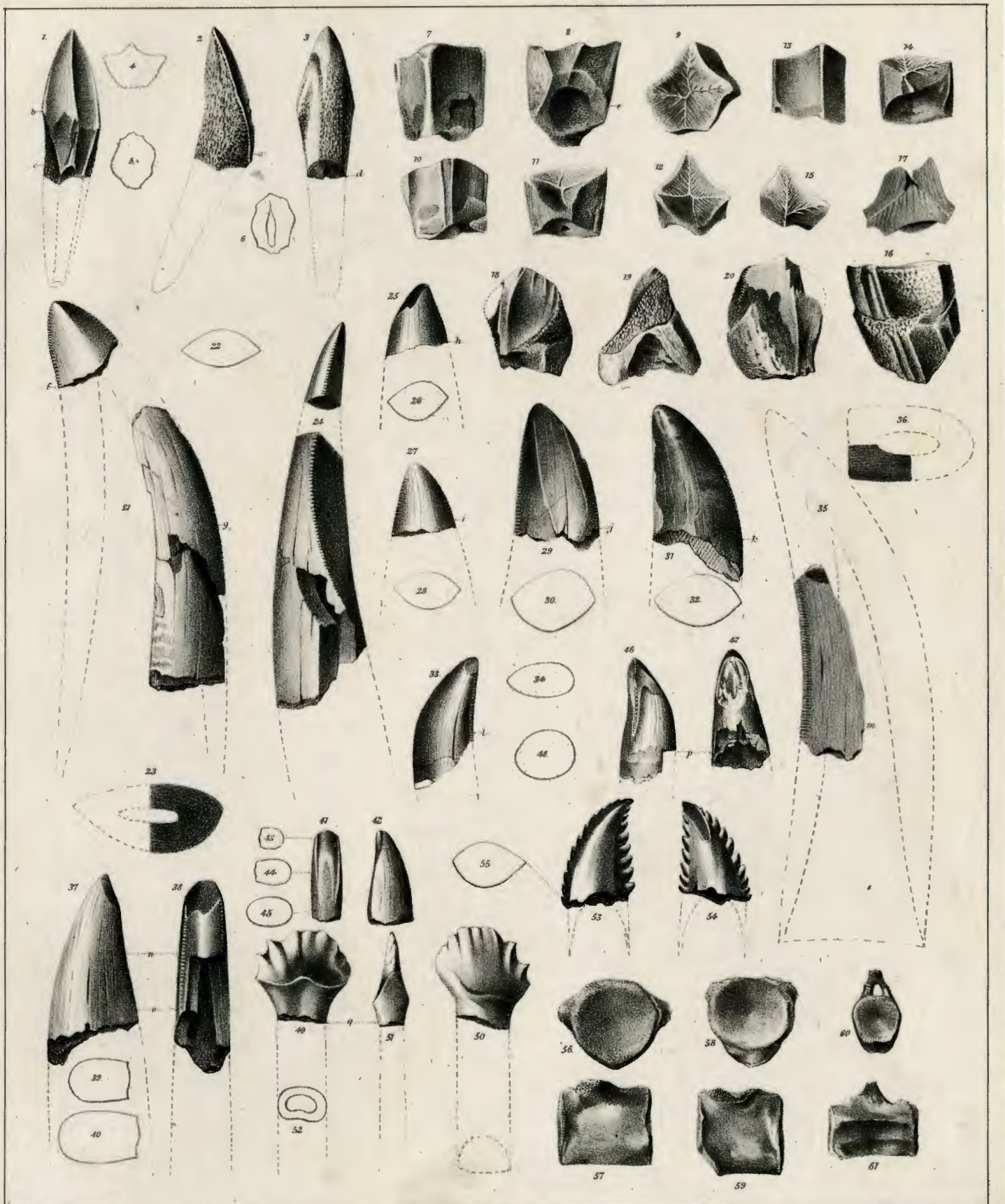
A still more interesting group of fossils, with reference to this paper, forms a portion of the collection of Mr. Drexler, discovered near Fort Bridger. The material is composed

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.



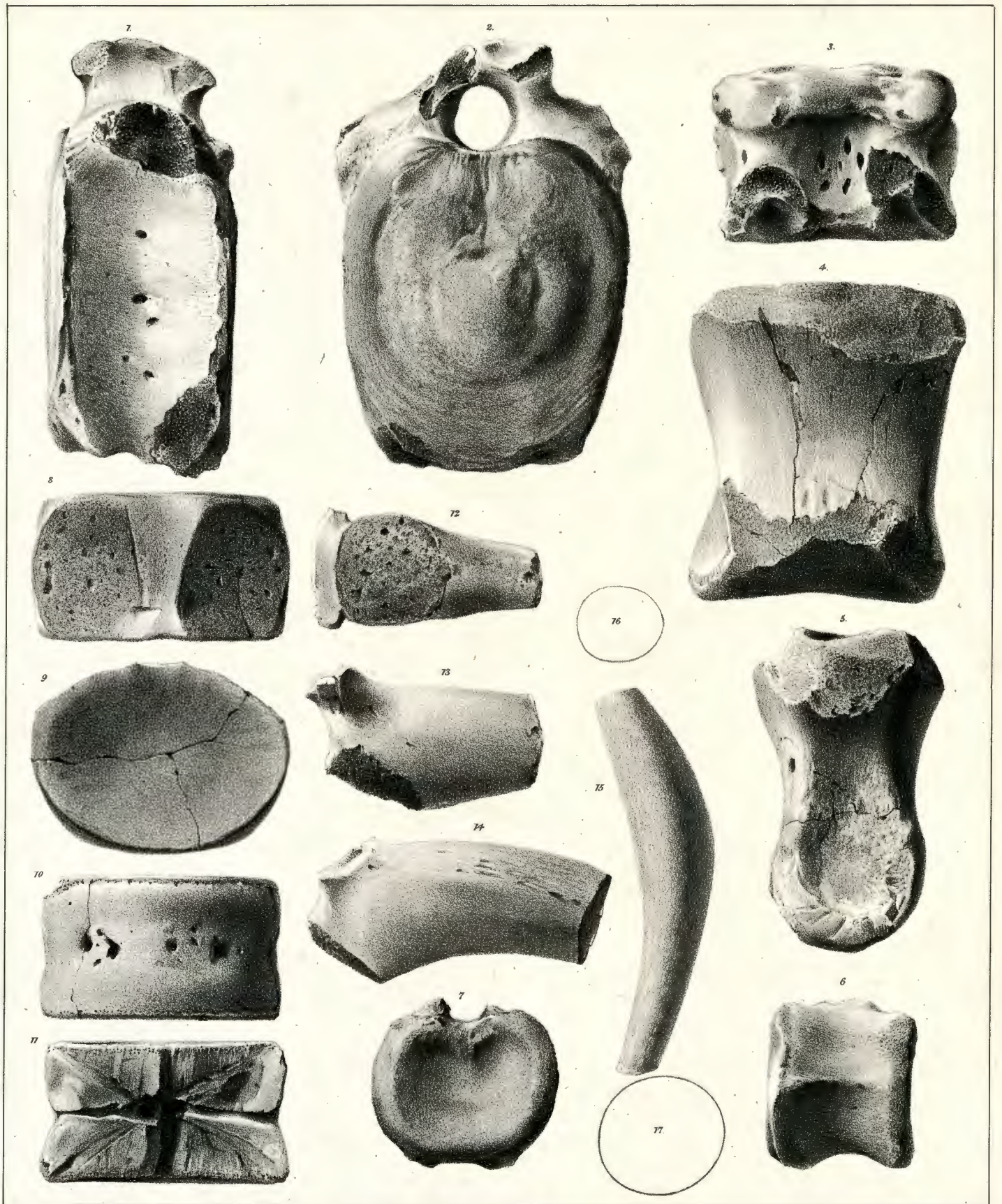
Sinclair's Lith. Phila.

Trans. Am. Phil. Soc. Vol. XII.



Jos. Leidy, Del. On Stone by A. Frey. T. Sinclair's lith, Phil.a

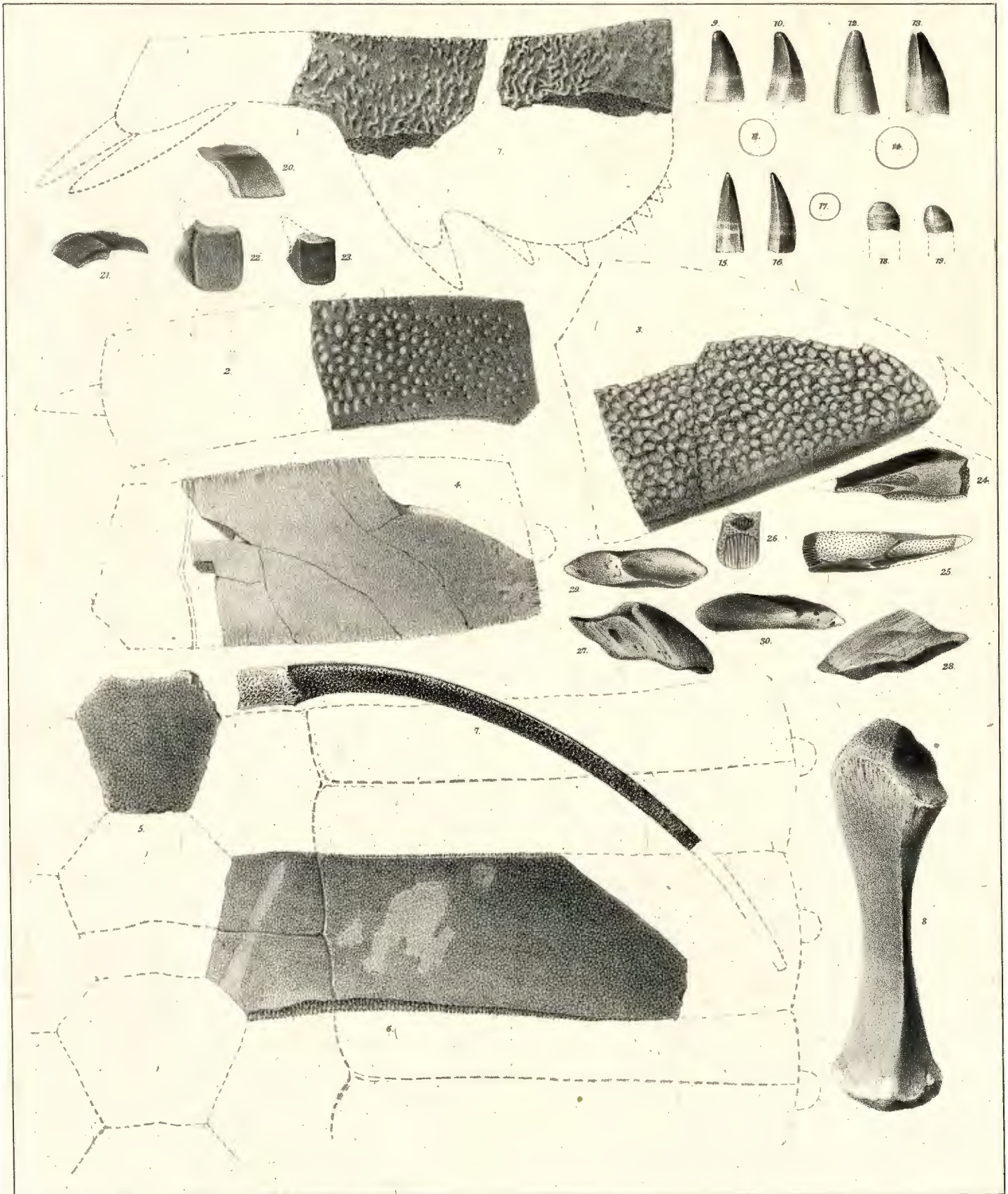
1–20. Trachodon mirabilis. 21–48 Deinodon horridus.
49–52. Palaeoscincus costatus. 53–55. Troodon formosus



A. Frey, Del.

T. Sinclair's lith, Phila.

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.