ART. IX.—*Remarks on the Mesozoic Red Sandstone of the Atlantic Slope, and notice of the Discovery of a Bone Bed therein, at Phœnixville, Penn.;* by CHARLES M. WHEATLEY, M.A.

[Read before the Connecticut Academy of Arts and Sciences, Feb. 20, 1861.]

No question in American geology seems more difficult of elucidation, than the age and geological position of the so-called "New Red Sandstone" of the Atlantic slope; some geologists referring it to the Oolitic or Liassic periods, others to the Trias, and others still lower, to the Permian. The true position may probably be determined like the San Casciano beds, intermediate between the Triassic and Liassic periods forming a separate group containing like those beds, its own peculiar fossils. No true Permian forms—characteristic of that formation have yet been discovered; the fishes formerly referred to Palæoniscus, are now placed in the genera Catopterus, *Redfield,* and Ischypterus, *Egerton*, their tails being more homocercal than heterocercal. The Clepsisaurus, *Lea*, once considered a Thecodont Saurian and analogous to *Thecodontosaurus antiquus* of Riley and Stutchbury from Redland, near Bristol, England, (found in dolomitic conglomerate referred to the Permian, but now considered not older than the Triassic,) is stated by Dr. Leidy (Proc. Acad. Nat. Sci. Phila., 9 June, 1857,) to be "not properly a Thecodont reptile but may form the type of a new species as its teeth are inserted

in the jaws by solid conical fangs." The whole formation is moreover destitute of beds of rock salt and gypsum which characterize mineralogically the Permian system, not only in Russia but wherever recognized. Sir R. I. Murchison (Quar. Jour. Geol. Soc., Lond., vol. i, p. 82,) says, "The Triassic system does not contain a single Palæozoic form whether animal or vegetable whilst the fauna and flora of the Permian are both so connected with the Carboniferous and inferior systems, that they evidently constitute the last remnant of the same era. In the whole geological series, therefore, no two systems are more completely separated than the Permian and the Trias, the one forming the uppermost Palæozoic stage, the other the base of the Secondary deposits."

Prof. Henry D. Rogers in his final Report on the Geology of Pennsylvania, vol. ii, part 2, p. 695, says, under the head "Organic Remains of Main Red Sandstone belt of Atlantic slope," "Reptiles,"—"the main formation or that which alone passes across Pennsylvania, has thus far disclosed the remains of several interesting species: two of these the *Clepsisaurus Pennsylvanicus* and *C. Leai, were first discovered as already intimated in Pennsylvania:* and a species, probably the first named, has been since recognized in the Deep River coal field at North Carolina nearly a prolongation of the same, by Dr. Emmons, who has added several other species of reptiles as belonging to the deposit in North Carolina, namely *Rutiodon Carolinensis, Palæosaurus Carolinensis,* and *Palæosaurus sulcatus.* In New Jersey the formation has disclosed the remains of another reptile of the same general structure as the Clepsisaurus; it has been named by Mr. Lea who discovered it, the *Centemodon sulcatus.*"

Prof. Rogers has mistaken the localities, the only Saurian bones discovered in Pennsylvania at the date of his remarks were, vertebra, ribs, and teeth found in the calcareous conglomerate near Hassacs Creek, upper Milford Township, Lehigh county, by Dr. I. Y. Shelley, who presented them to the Academy of Natural Sciences, Phila., Nov., 1847, and upon which Mr. Lea founded his *Clepsisaurus Pennsylvanicus,* (Journal Acad. Nat. Sci. Phil., Part 3, 1853, page 185, &c.); a visit to the locality by Mr. Lea "with Dr. Shelley failed to discover the smallest indication of further specimens," and until my discovery of the bone bed at Phœnixville in October, 1860, these were the only Saurian bones found in the State, with the exception of a portion of a rib sent by the writer to Mr. Lea, noticed in Proc. Acad. Nat. Sci. Phil., 2 June, 1857.

Clepsisaurus Leai Emmons, (*Omosaurus perplexus* Leidy) American Geology, part 6, page 81, fig. 51, mentioned by Prof. Rogers as *first discovered in Pennsylvania, has never yet been recognized in this State,* but was described by Prof. Emmons from Saurian bones found in the Dan River formation near Leaksville,

North Carolina. Prof. Leidy thinks Omosaurus probably a distinct genus from Clepsisaurus. Prof. Emmons gives Omosaurus perplexus, *Leidy*, as a synonym of both Clepsisaurus Leai, and Rutiodon Carolinensis.

Centemodon sulcatus, Lea, stated by Prof. Rogers as discovered by Mr. Lea in *New Jersey*, was described from a single tooth, found by Mr. Lea in the black bituminous shales of *Phœnixville Tunnel, Pennsylvania*, (Proc. Acad. Nat. Sci. Phila., viii, p. 77, March, 1856), no other remains of Centemodon have as yet been described.

The following fossils have been noticed in the "Mesozoic Red Sandstone" of Pennsylvania:

PLANTS.

Equisetum columnare, Brong., 15 to 16 inches long, and 7 inches circumference in sandstone of a dark grey color, with iron pyrites, Phœnixville.

Pterozamites longifolius, Emmons, in grey micaceous sandstone, with iron pyrites, Phœnixville.

Gymnocaulus alternatus, Emmons, in light micaceous sandstone, Phœnixville.

Fir-Cones, 6 in. long, 1 in. wide, Isaac Lea, this Jour., [2], vol. xxii, p. 123, 1856, in black bituminous shales, Phœnixville.

Plant resembling that fig. by Emmons, as *Calamites punctatus* in black bituminous shales, Phœnixville.

Plant resembling Noeggerathia at Gwynned, I. Lea (Am. Jour. of Sci., vol. xxii, 1856, p. 123,) probably same as fig. by Emmons (N. Car. Rep. pl. 1, fig. 3,) as Dictyocaulus-striatus, and which Prof. O. Heer (this Journal, [2], vol. xxiv, p. 428,) says "has an obvious resemblance to Noeggerathia." Leo Lesquereux says the genus Noeggerathia, Göpp., entirely disappears at or before the beginning of the coal epoch, (this Jour., [2], vol. xxx, p. 380.)

A number of plants, seed vessels, &c., have been found in the grey micaceous sandstone and black shales, at Phœnixville, the genera of which are yet undetermined.

CRUSTACEA.

Estheria ovata, (Posidonia ovata, *Lea.*)

Estheria parva, (Posidonia parva, *Lea*,) in black bituminous shales, Phœnixville.

Cypris, two species, one smooth, the other beautifully granulate, in black shales, Phœnixville, Rogers, also at Gwynned, J. Leidy, (Proc. Acad. Nat. Sci. Phil., 16 June, 1857).

Limulus? Fragment of Shield probably Limulus, black bituminous shales, Phœnixville, other remains probably Crustacean have been found in black shales, Phœnixville.

MOLLUSCA.

Myacites Pennsylvanicus, Conrad, Proc. Acad. Nat. Sci. Phil., 1857, p. 166, and 1860, plate 1, fig. 3.

FISHES.

Single ganoid scale, in black bituminous shales, at Gwynned, Isaac Lea, this Jour., [2], vol. xxii, 123, 1856, "more like *Pygopteris mandibularis* Ag., than any other which had come under Mr. Lea's notice."

Scales, bones and teeth of ganoid fishes are abundant in black bituminous shales at Phœnixville. Scales have been found by Dr. Leidy also at Gwynned, Proc. Acad. Nat. Sci. Phil., 9 June 1857.

Turseodus acutus, Leidy, Proc. Acad. Nat. Sci. Phil., June, 1857, page 167, "This genus and species are founded upon a left dental bone with teeth, probably of a ganoid fish which I obtained from the black shale of what have been usually considered the Triassic rocks from near Phœnixville, Chester Co., Pa. The dental bone is 20 lines long, by 4 lines in depth; posteriorly, it is straight, and its outer surface is covered with fine, interrupted ridges, such as are observed upon small ganoid scales, found in the same series of rocks at Gwynned."

"Upon the dental border of the specimen there may be counted the remains of 20 teeth, situated at irregular intervals, they have measured from $\frac{1}{2}$ to 1 line long, they are columnar in form, slightly curving inward; have a spreading base, and an abrupt, conical, enamel summit, the fish may be allied to Belonostomus, or Eugnathus, but I am unable to ascertain the exact form of the teeth in these genera."

Radiolepis speciosus, Emmons. *Family Cœlacanthi*, scale discovered at Gwynned, by Isaac Lea, in black bituminous shales, Proc. Acad. Nat. Sci. Phil., 7 July, 1857, also at Phœnixville.

Catopterus gracilis, Redfield. Scales, bones and teeth similar to those from Richmond, Va., and North Carolina, are found in bituminous shales at Phœnixville.

REPTILIAN REMAINS.

Clepsisaurus Pennsylvanicus, Lea, Journal, Acad. Nat. Sci. Phil., new series, vol. ii, 1853, p. 185, founded on vertebra, ribs and teeth discovered in calcareous conglomerate, upper Milford Township, Lehigh county, teeth supposed to belong to this reptile have been discovered by Dr. Leidy in black bituminous shales at Phœnixville, Proc. Acad. Nat. Sci. Philad., 1859, p. 110.

Eurydorus serridens, Leidy, Proc. Acad. Nat. Sci. Phil., 1859, p. 110, founded on tooth "large size, compressed, conical, opposite acute serrulated borders," discovered by Prof. Leidy in black bituminous shales, Phœnixville.

Composaurus —— ? Leidy, Proc. Acad. Nat. Sci. Phil., 1859, p. 110, founded on tooth discovered by Prof. J. Leidy in black bituminous shales at Phœnixville, "borders without serrulations, base fluted" "resembles the teeth of Composaurus of the coal of Chatham Co., North Carolina, but nevertheless belongs to a different species."

Centemodon sulcatus, Lea, Proc. Acad. Nat. Sci. Phil., vol. viii, p. 77, March, 1856, founded on a single tooth discovered by Mr. Lea in black bituminous shales at Phœnixville, described in this Journal, [2], vol. xxii, p. 123.

Bones and teeth probably Batrachian, found by Dr. Leidy at Gwynned, Proc. Acad. Nat. Sci. Phil., 16 June, 1857, in black bituminous shales, also at Phœnixville.

REPTILIAN REMAINS.

Coprolites, very abundant in black bituminous shales at Phœnixville, some of them containing fish remains.

Foot-Tracks, Chelichnus Wymanianus, *Lea*, on dull red limestone? Phœnixville, Isaac Lea, Proc. Acad. Nat. Sci. Phil., viii, 77, 1856.

Ripple marks are also found in the red shale, Montgomery county, opposite Phœnixville.

Section of Strata at Phœnixville Tunnel, Penn., beginning at Eastern entrance, and running about two-thirds through, dip Northwest.

	ft.	in.
Red shale,	5	
Green shale,	6	
Black bituminous shale, containing Saurian bones, coprolites in abundance, Estherias,—remains of ganoid fishes, and Cypris, there are clay concretions about one inch in thickness on upper part, this layer is *full of fossils*	1	10
Red and green shales, the green slightly calcareous, with traces of Estherias and iron pyrites	11	
Black bituminous shale with scales of ganoid fishes, Estherias and Cypris, fossils not very abundant	1	
Dark green, hard, compact shale, full of clay concretions, traces of Cypris		9
Red micaceous sandstone,	7	10
Brown sandstone, with calcite veins and quartz crystals,	3	6
Hard, compact, red and green shale, with nodular concretions of Limonite, abundantly distributed all through it, forming a "*Hæmatitic conglomerate*,"	5	8
Red sandstone, with remains of plants,	5	6
Red and green shale,	5	2
Red shale, with coprolites and plants, the coprolites inclosing scales of ganoid fishes		10
Grey sandstone with veins of carbonate of lime,	5	5
Fine-grained, red and green variegated shale,	24	0
Black bituminous shale, with Estherias and fish remains in upper part,	6	
Grey compact fine-grained shale,	11	
Olive green shale, with red veins,	1	
Red shale,	7	
Clay concretions in three layers, 1 inch each,		3
Sandstone with veins of dolomite and calcite—in cleavage which is quite vertical,	11	3
Fine-grained micaceous sandstone, estimated,	20	
Fine-grained compact do do	25	
'Vug' or cavity 5 feet wide at bottom of Tunnel, 21 feet high running to a point about two feet above the back of Tunnel, filled with red and green shales, talcose and micaceous *crushed to powder*,		
White talcose shale vertical, 5 feet wide at bottom, 4 ft. at top of Tunnel.		
Red shale fine-grained, compact,	6	8
Strata very irregular for some distance,		
Shale with clay concretions and oxyd of iron,		10
Bone bed, full of Saurian bones, no other fossils noticed,		6
Black bituminous shale with Estherias and coprolites,		6
Fine-grained, hard, compact sandstone, full of stems of plants,	6	

The "bone bed" is situated about 100 feet in the Tunnel from the western end, and is not more than 6 inches thick. Fragments of Saurian bones occur rather abundantly all through the

layer, but the more perfect bones are found at the bottom of the bed where they are collected together forming from two to three inches of the layer, a seam of white or pink carbonate of lime underlies them and is from $\frac{1}{8}$ to $\frac{1}{2}$ inch in thickness. Under this is a very thin seam of black carbonaceous matter, which is grooved and polished like slickensides, evidently showing great disturbing force since the deposition of the bed.

The material composing the bone bed is formed almost entirely of the remains of *Cypris*. No Estherias, Myacites, coprolites or fish-remains, have been observed associated with the Saurian bones in many tons of the shale carefully broken up and examined.

Above the bone bed is about 6 inches of bituminous shale with Estherias and coprolites, over this from 5 to 6 feet of hard, fine-grained sandstone with plants. The bed is underlaid by ten inches of shale with clay concretions which are mostly geodes containing yellow pulverulent oxyd of iron, and under this a compact, fine-grained red shale from six to seven feet to the bottom of the Tunnel.

Near the above in a micaceous dolomitic sandstone of a light grey color, occasionally so calcareous as to effervesce freely in acids, occur Saurian bones—and part of a *jaw* seven inches in length, $\frac{7}{10}$ in. wide, and about $\frac{6}{10}$ in. deep, with seven alveoles about $\frac{3}{10}$ of an inch apart, a *cranial plate* radiated and sculptured $1\frac{1}{2}$ inches long and $1\frac{2}{10}$ in. broad, and an *Icthyodorulite* 3 inches long $\frac{3}{10}$ in. wide at base, remains probably of Batrachians, Estherias, bones, scales, and teeth of ganoid fishes, the scales are large, thick, beautifully ornamented, and coated with a layer of transparent (ganoin) enamel.

Casts of two shells, one may probably be referred to either Pholadomya or Cardita, and the other to Unio or Potamomya and also large quantities of *Saurian teeth*, some of which are full $1\frac{1}{2}$ inches in length, curved, smooth, or finely striated, probably belonging to *Clepsisaurus Pennsylvanicus*, Lea, others curved and sulcate, answering to the description of *Centemodon sulcatus*, Lea. Another perhaps may be *Composaurus*, Leidy, and another of "large size, compressed, conical, with opposite acute serrulated borders" which doubtless is that described by Prof. Leidy as *Eurydorus serridens*. These teeth are found twenty or thirty together and are well preserved, sometimes the teeth are converted into iron pyrites for one half their length, or the pulp cavity alone filled with pyrites, and occasionally small seams of dolomite, calcite, or sulphuret of iron, cross them transversely without disturbing their position. It is remarkable that while the black bituminous shales have afforded but few Saurian teeth, and none have as yet been discovered in the "bone bed," so many should have been collected together and deposited in this

strata of dolomitic sandstone as to give it the appearance of an osseous conglomerate or bone breccia.

In some instances *the casts* only of the teeth remain, the substance of the tooth being converted into *dolomite* but retaining the exact form of the tooth with the sulcations as distinct as in the original, twenty teeth of probably three or four genera of Saurians, *all converted into dolomite!* occur on a piece of sandstone 6 by 3 inches. It is a singular fact, that while the teeth are dolomitic casts only, the bones in the same stone remain unchanged, retaining their original structure.

Associated with the above fossils in the sandstone are numerous plant remains, mostly of a broad sulcated stem without joints or branches, as far as noticed they retain the same width their entire length, and are from one half to two inches broad and from six to eight inches long.

The shales, sandstones, and fossils of the Phœnixville Tunnel bear a remarkable resemblance to those of Nagpur and Mangali, Central India, described by Messrs. Hislop and Hunter, Quarterly Journal Geological Society, London, vol. x, p. 472, and vol. xi, p. 371, and referred by them to the lower Jurassic age. The following is the descending order of the series according to the observations of the authors:

1. Soft ferruginous sandstone, sometimes hard, with iron bands, and plants.
2. Fine and coarse argillaceous sandstones, rich, with plant remains, these have afforded:—
   Labyrinthodont reptile, Brachyops-laticeps, Owen.
   Fishes, ganoid scales, and small jaws.
   Crustaceans, Estheria.
   Plant remains.
   Fruits and seeds, numerous and undescribed.
   Leaves, Conifer, Zamites, Poacites and Ferns, (Pecopteris, Glossopteris, Tœniopteris, Cyclopteris, Sphenopteris).
   Stems, exogenous and endogenous.
   Acrogens, Aphyllum, Equisetites, Phyllotheca, Vertebraria.
3. Red shales 50 feet, green shales, 30 feet. In the former of these there were observed at Korhádi:—
   Reptilian foot tracks.
   Worm tracks, and intestine shaped evacuations, these were also found in the *green shales.*
   Phyllotheca?
4. White and colored dolomitic limestones.
   Bituminous shales with fossils.
   Sandstone.
   Indurated clay stone.
   Green shale.
   Bituminous shale with fossils.

The plant-bearing sandstone of Phœnixville Tunnel, though not containing all the genera of plants found in the Mangali strata, is far richer in Saurian remains. Crustaceans (Estherias and Cypris) parts of ganoid fishes, and shells. The green shales of the Tunnel have worm tracks, and the intestine shaped evacuations. The bituminous shales are rich in organic remains. The remains of Conifers, Zamites, Equisetites and probably fruits and seeds, with dolomitic sandstones, indicate a very great similarity with the lower Jurassic Central Indian formation.

Phœnixville, Penn., Feb. 1861.