

ART. IX.—*Ancient Lake basins of the Rocky Mountain Region ;*
by Prof. O. C. MARSH.

THE existence of several large fresh water lakes in the Rocky Mountain region, during Tertiary time, is now well established, mainly through the researches of explorers whom the striking scenery of the "Bad Lands," or the extinct animals entombed in them, have attracted thither. The geological age of some of these lakes, however, seems to be still in doubt, at least widely different opinions on this point are freely expressed. The extent of these various lake-basins, and their relations to each other, are likewise a subject on which information is especially desirable, and hence the results of some recent observations are here presented.

The deposits left in these old lakes show them to be of Eocene, Miocene, or Pliocene age, the fauna of each formation being entirely distinct, as well as quite different from existing species.

I. *Eocene Lake-basins.*

The oldest of the great Tertiary lake basins of the West are of Eocene age. The one first discovered and best known, which has been called the Green River basin, lies between the Rocky Mountains and the Wasatch range, in the depression now drained by the Green River. It has the Uintah Mountains for its southern border, and extends north at least as far as the Wind River range. This basin was visited by the writer in 1868, but first explored in 1870, when he traced its deposits for several hundred miles, and from the rich vertebrate fauna fully determined its Eocene age.* These same beds have since been pronounced Miocene by Prof. Hayden and others, but the 150 species of extinct vertebrates now known from them prove them Eocene as conclusively as any single formation has yet been determined in this country. A comparison of almost any group of these fossils with the corresponding one from the Paris basin will afford sufficient evidence on this point. Some of the extinct mammals, indeed, indicate a still lower horizon, or one nearly equivalent to the Lignite beds of France.

The Tertiary deposits in the Green River Basin are all of fresh-water origin, and of enormous thickness,—6000 feet at least. They are nearly or quite horizontal, and as a rule rest unconformably on the Cretaceous coal-bearing rocks below. The latter are in part brackish water beds, containing, with some characteristic Cretaceous fossils, many remains of plants, which have led Hayden, Lesquereux, and others to regard them as Tertiary. The evidence from the fossil plants is far from conclusive, while the Cretaceous age of essentially the same

* This Journal, vol. i, p. 191, March, 1871.

beds has been clearly made out at several different localities. At one of these, in 1870, the writer found above a seam of coal *Ostrea congesta* Conrad, a typical Cretaceous fossil, and a crinoid allied to *Marsupites* of the English Chalk. Below the coal, but in the same series, were remains of fishes and turtles, both of Cretaceous types, and teeth of a Dinosaur.* Nearly as conclusive evidence has since been found at other localities. In considering a question of this kind, where the evidence from fossils appears conflicting, it should especially be borne in mind that vertebrates afford a much more accurate guide to climatic and other geological changes than invertebrates, and vastly more so than plants.

This Eocene lake basin remained dry land during all of Miocene time, and perhaps much longer. It was then again submerged for a short period, and its eroded surface covered with water-worn debris from the surrounding mountains. The evidence of this is seen in the coarse conglomerate crowning the highest buttes, which have thus escaped in part the enormous denudation most of the deposits in this basin have suffered.

South of the Uintah Mountains, a second and larger lake existed in the Eocene. It was 2,000 feet or more lower than the northern lake, and received part of its waters from that source. It had the Rocky Mountains for its eastern border, the Wasatch range on the west, and extended from the Uintahs far to the southward, doubtless quite to the present territory of New Mexico. This basin was first explored, and its Eocene age established, in 1870, by the writer, who finding it distinct from the Green River basin on the north, named it the Uintah basin.† These two lakes were contemporaneous, for a long period at least, and undoubtedly were connected together east of the present Green River cañon. There is evidence that the southern lake continued for some time after the northern one dried up. The deposits of the Uintah basin are of very great thickness, and are underlaid by Cretaceous beds, in some places much inclined.

The fauna entombed in both these Eocene lakes is essentially the same, and indicates a tropical climate. This is seen especially in the great number of Tapiroid mammals, monkeys, crocodiles, lizards and serpents. Remains of *Dinocerata*, the largest of Eocene mammals, have as yet been found only in the northern basin, and there are some other important differences at present, which future discoveries may remove.

There are indications of another Eocene lake in Eastern Oregon, west of the Blue Mountains, but as only a few plants have hitherto been found in its deposits, its relations in time to the great central Eocene lakes cannot as yet be determined.

* This Journal, vol. i, p. 195, March, 1871.

† Loc. cit., p. 196.

II. *Miocene Lake-basins.*

The Tertiary lake-basin first made known in the Rocky Mountain region is that south of the Black Hills, so long famous for its "*Mauvaises Terres*" or "Bad Lands," and for its wonderful vertebrate fauna, which Prof. Hayden has done so much to bring to light. This ancient lake, which was comparatively shallow, appears to have extended south from the Black Hills to near where the Republican River now is, or from about the 44th to the 40th parallel of latitude. Its western border was the Rocky Mountains, and its eastern margin probably not far from the 99th meridian. The strata in this basin are all nearly horizontal, and indicate quiet waters. They are lighter in color, and much less arenaceous than those of the Eocene lakes. The best exposures of these Miocene beds are seen near the White River, and this name has very appropriately been used by Prof. Hayden to distinguish the lake basin in which they were deposited. In Northeast Colorado the same formation is well developed. The "Bad Lands" there were discovered and first explored by the writer in 1870.* These Miocene strata rest with more or less unconformity, on an extensive series of lignite-bearing beds, which in many respects resemble those beneath the Eocene basins. The age of these beds, also, is in dispute, but the remains of Dinosaurs and some other typical Mesozoic vertebrates, which have now been found at many widely separated localities, leaves little doubt that they should be placed in the Cretaceous, the great coal-bearing formation of the Rocky Mountains.

After this Miocene lake was filled up, and its surface more or less eroded, a great subsidence took place, and a second larger lake was formed, in which extensive beds of clay and sand were deposited over the same area. As both series of strata are essentially horizontal, and of nearly the same color, the dividing line in many places can be made out only by means of the vertebrate fossils they contain. In this way, the writer has recently ascertained, by personal observation, that most of the upper beds (D and E), 500 feet at least in thickness, which were called Miocene by Prof. Hayden,† are deposits of the more recent Pliocene lake. This would leave for the true Miocene beds a thickness of about 300 feet. The upper strata will be again referred to in considering the Pliocene lake.

The fauna of the White River lake-basin is now well known to naturalists. It indicates a climate much less tropical than that of the Eocene lakes, as is seen in the absence of monkeys and scarcity of reptilian life. The *Brontotheridæ*, the largest known Miocene mammals, are peculiar to the lower strata of this basin. They fully equalled the Eocene *Dinocera* in size.

* This Journal, vol. 1, p. 292, Sept., 1870.

† Transactions American Phil. Soc. vol. xii, p. 105, 1862.

A still more ancient Miocene lake existed, in about the same latitude, on the Pacific slope, near the central part of the present State of Oregon. The Blue Mountains formed the eastern and southern shores of this lake, but its other limits are difficult to ascertain, as this whole country has since been deeply buried by successive outflows of volcanic rocks. It is only where the latter have been washed away that the lake deposits can be examined. The discovery and first explorations in this basin were made by Rev. Thomas Condon, the present State geologist of Oregon. The typical localities of this Miocene basin are along the John Day River, and this name may very properly be used to designate the lake-basin. The strata in this basin are more or less inclined, and of great thickness. One section, near the John Day River, examined by the writer in 1871, and again in 1873, seems to indicate a thickness of not less than 5,000 feet. The upper beds alone of this series correspond to the deposits in the White River basin. The lower portion also is clearly Miocene, as shown by its vertebrate fauna, which differs in many respects from that above. Beneath these strata are seen, at a few localities, the Eocene beds containing fossil plants, mentioned above. They are more highly inclined than the Miocene beds, and some of them show that they have been subjected to heat. The inferior strata elsewhere are Mesozoic, and apparently Cretaceous. Above the Miocene strata, Pliocene beds are seen in a few places, but basalt covers nearly all.

III. *Pliocene Lake-basins.*

At the close of the Miocene, a subsidence took place east of the Rocky Mountains. A great Pliocene lake was thus formed directly over the eastern Miocene basin, having nearly the same boundaries on the north and west, but extending much farther east, and stretching south nearly to the Gulf of Mexico. It covered an area at least five times as great as the older lake, while its deposits attained a thickness of nearly or quite 1,500 feet. This lake basin may with great propriety be called the Niobrara basin, since the Niobrara River cuts through its typical strata for more than 200 miles of its course.

The beds in this basin lie nearly horizontal. They are light in color, and much more arenaceous than the Miocene below. The upper strata consist of hard sandstones or calcareous grits, which weather but slowly, and hence still form the great table-lands over much of the area of the basin. The writer has traced these high plateaux and the intervening isolated buttes from near the Black Hills south to the Arkansas River, and found them all of Pliocene age. South of the Smoky Hill River these strata rest directly on the Cretaceous.

The fauna of this lake-basin indicates a warm temperate climate. The more common mammals are a mastodon, rhinoceroses, camels and horses, the latter being especially abundant.

[To be continued.]