ART. XXXVIII.—*On the Lignites and Plant-Beds of Western America*; by J. S. NEWBERRY.

IN the Geological Report of Prof. F. V. Hayden for 1872, Mr. Leo Lesquereux gives a comprehensive review of the fossil flora found associated with beds of lignite, in various localities through the western portion of our continent. The views advanced in this paper are so inconsistent with the facts observed by myself, that I venture to call in question the accuracy of some of them. By Mr. Lesquereux, much the greater part of the fossil plants found at the west are referred to the Eocene, whereas, to my certain knowledge, a considerable portion of the flora which he calls Eocene is Cretaceous, and another considerable portion is of Miocene age. This question will be discussed in a report on the fossil plants of New Mexico, Dakota, Oregon, etc., which I am preparing for Prof. Hayden, and I will now only allude to some of the facts which are incompatible with Mr. Lesquereux's views.

The earliest and best known of the plant-beds of the far west are those of the region of the plains, in Nebraska, Kansas and the Indian Territory, of which those of Black Bird Hill, Fort Harker, Walnut Creek and Whetstone Creek may be taken as examples. These were at first pronounced by Prof. Heer to be Miocene, and in this view he was defended by Mr. Lesquereux, while I asserted that they were Cretaceous.* It is now universally conceded that the latter view was correct. From this horizon, we have obtained a large number of fossil plants, and this, the first angiospermous flora known, has proved to be of great richness and interest. It has, however, passed out of discussion, and requires no further notice here.

During my explorations of New Mexico and Arizona, I found beds of lignite at various localities; those of the San Juan, for example, attaining a thickness of from thirty to fifty feet. With these lignites are many fossil plants. Dr. Hayden, who in 1869 made a reconnaissance as far south as Santa Fe, touching these plant-beds on Galisteo Creek, referred them to the Tertiary. Following him, Mr. Lesquereux has reported all the New Mexican lignite and plant-beds to be of Eocene Tertiary age. Having spent nearly two years in this region, constantly occupied in the study of its geology, I feel authorized to state that all the lignite beds yet known in New Mexico are unmistakably of Cretaceous age. Fossil plants are found at several different horizons in the Cretaceous, but none whatever in the Tertiary. In fact, the only Tertiary strata known in

* This Journal, vol. xxviii, p. 85; xxix, pp. 208, 434.

New Mexico are the chalky fresh-water marls deposited in basins of the present topography, and without fossil plants.

The lignites of Colorado, which are so largely developed in the Raton Mountains, at Trinidad, Golden, Marshall's, etc., have been studied by Mr. Lesquereux in place, and by him they, with their associated plant-beds, are regarded as constituting typical examples of our American Eocene deposits. As I have not visited that portion of Colorado where this great lignite formation is exposed, I will not venture to deny the truth of the conclusions arrived at by Mr. Lesquereux. I may say, however—1st, That the flora of these Colorado lignite-beds has almost nothing in common with that of the European Eocene. Its botanical aspect is certainly entirely different, and, in my judgment, not a single species and scarcely any genera are found in both. 2d, That the tuberculated fucoid (*Halymenites*), considered by Mr. Lesquereux as diagnostic of the Eocene, is in New Mexico the most characteristic fossil plant of the *Cretaceous* sandstones. 3d, That Profs. Meek, Marsh, Cope and Stevenson, guided by the molluscan and vertebrate remains found in the Colorado lignite deposits, consider them Upper Cretaceous.

The age of the lignites of Wyoming and Utah—of Carbon Station, Rock Springs, Coalville, Hallville, Evanston, Bear River, &c.—has been discussed at length by Messrs. King, Emmons, Meek and Cope. While it is admitted by all that there are wide-spread Tertiary deposits in Wyoming and Utah, and some of them contain lignite and fossil plants, it is claimed and apparently proved, by the gentlemen whose names are cited above, that the lignites of the localities named are Cretaceous.*

In regard to the Bitter Creek lignites, Mr. Meek shows that the evidence, if not conflicting, is at least indecisive of their age.

The strata of Wyoming, which contain the newly discovered and wonderful vertebrate fauna described by Profs. Leidy, Marsh and Cope, are thought by these gentlemen to be clearly Eocene. But, though so rich in animal remains, they contain few plants, and these throw little light on the discussion. The Green River plant-beds are placed by Mr. Lesquereux in the Miocene; but a small group of plants which I have from these beds includes palms (*Manicaria*) and other plants not found elsewhere in the Miocene of America. Mr. Lesquereux is disposed to regard palms as diagnostic of Eocene, but they are common enough in the Miocene of Europe, and they should have grown in Wyoming when the luxuriant Miocene flora covered Alaska and Greenland.

* A very comprehensive review of the question is given by Mr. F. B. Meek in the chapter of Prof. Hayden's Report which succeeds the paper of Mr. Lesquereux.

From the great lignite basin of the Upper Missouri, a large number of fossil plants have been brought to me by Prof. Hayden, the Sully expedition and others. Many of these have been already described, and the flora which they represent I have pronounced Miocene.* In the review to which I have alluded, Mr. Lesquereux refers all the plants from the Upper Missouri lignite-beds to the Lower Eocene. This conclusion I am unable to accept, from the fact that the general facies of the Missouri lignite-flora is altogether unlike that of the European Eocene, and it is identified with the Miocene flora of Arctic America, Iceland, the Hebrides and Central Europe, by most of its genera and by a considerable number of well-marked identical species. It also contains some species which are living at the present day. Among these latter may be mentioned our deciduous cypress (*Taxodium distichum*) and the sensitive fern (*Onoclea sensibilis*). This fern also occurs in Greenland, and is that described by Edward Forbes, from the plant-beds of the Island of Mull, under the name of *Filicites Hebridicus*. Among the plants common to the Upper Missouri lignite-beds and other well known Miocene deposits, are *Corylus McQuarrii* Forbes, *Glyptostrobus Europæus* Ung., *Sequoia Nordenskiöldi* Heer, *Carya Antiquorum* Newb., (= *Juglans nigella* Heer), *Populus cordata* Newb., (= *P. Zaddachi* Heer), *Tuxites occidentalis* Newb., *Thuia interrupta* Newb., etc.

The coals and fossil plants of Vancouver's Island are stated by Mr. Lesquereux to be of Tertiary age; but the evidence that they are Cretaceous is overwhelming. Some of the species found in the locality were at first supposed by Prof. Heer and Mr. Lesquereux to be identical with European Miocene species, but we now know that this identification was made upon insufficient evidence. Among the fossil plants which I have seen from Vancouver's Island, there is only one which I can certainly identify with a species found elsewhere, and that is *Sequoia Reichenbachii*, which occurs in numerous localities in the Cretaceous of Europe and in the Arctic. The Cretaceous age of the Vancouver coal was known to me as early as 1858, when I received the first collections made there by the late Mr. George Gibbs, and it was demonstrated in the paper on the fossils collected by him, published in the Proceedings of the Boston Natural History Society, in 1863. Interstratified with and overlying the beds of coal at Nanaimo, are strata containing great numbers of well marked Cretaceous mollusks, *Ammonites*, *Baculites*, *Inoceramus*, etc. With our present knowledge of paleontology, very few geologists would consider the question of the age of strata which contain these genera open to discussion.

* "Our Later Extinct Floras"—Annals Lyc. Nat. Hist., N. Y., vol. ix, 1868.

The plant-beds of Birch Bay, from which collections were made by Prof. Dana, when connected with the U. S. Exploring Expedition; those of Burrard Inlet, and those of Eastern Oregon, from which such extensive collections have been made by the Rev. Thomas Condon, are, in my judgment, all Miocene. The same may be said of those of Alaska and McKenzie's River; at least, in all these, as well as in those of the Upper Missouri, we find species which recur in Greenland, Iceland and continental Europe, in what has been universally called the Miocene flora.

The Eocene flora of Europe, as exhibited in the Island of Sheppey, at Monte Bolca, etc., has a distinctly tropical and Indo-Australian character; and we must say that, up to the present time, no similar group of plants has been found in America. In a botanical point of view, therefore, we are quite safe in the statement that the Eocene flora has not yet been recognized in this country. Looking at the question, however, from a geological stand-point, it assumes a somewhat different aspect. It is certain that we find on this continent Tertiary deposits which correspond in position with the Eocene of the Old World, and these contain many Eocene mollusks. If, now, fossil plants were found associated with these, we should be compelled to regard them as forming an Eocene flora, whatever their botanical character might be; just as our Cretaceous flora is none the less Cretaceous, though somewhat more closely allied to the Tertiary flora than are the plants found in the Cretaceous of Europe. Yet we find, with our Cretaceous plants, great numbers of well marked Cretaceous animal fossils, and these have very properly outweighed the modern facies of our Cretaceous flora. But have we found in or with the plants, supposed by Mr. Lesquereux to form our Eocene flora, any satisfactory internal or external evidence of their Eocene age—that is, have we among them any unmistakable Eocene plants or associated with them any unmistakable Eocene mollusks or vertebrates? So far as regards the central and western portions of the continent, I should say we had not. In the plant-beds which I have regarded as Miocene, the whole aspect of the flora is that of the Miocene of Europe, and it contains a very considerable number of well marked Miocene species, and not one, so far as I know, which deserves to be called Eocene. The lignites and plant-beds of New Mexico which I have called Cretaceous, but which are referred by Mr. Lesquereux to the Tertiary, are for the most part derived from the lower portions of our Cretaceous series, and are overlaid by many hundred feet of strata unquestionably Cretaceous, in which all the typical forms of Cretaceous animal life are abundantly represented. Whether the great lignite deposits of Colorado

should be considered Tertiary or Cretaceous, it is perhaps not yet possible to decide; but, in the absence of any distinctive or unmistakable Eocene plants, if the strata which contain them shall be found to include vertebrates or mollusks which have a decidedly Mesozoic character, we shall be compelled to include them in the Cretaceous system. Mr. Lesquereux has met the statements of Profs. Meek, Cope and Marsh, that Cretaceous mollusks had been found in and overlying the Colorado lignite deposits, by pointing to his 250 species of fossil plants, claiming that they far outweigh the testimony of the animal remains. In fact, however, these fossil plants have very little bearing on the question. They are probably all distinct from European Cretaceous and Eocene species, and the genera to which they are supposed to belong afford only negative evidence of the strata that contain them.*

It is by no means insisted that we must find in America the plants of the European Eocene, before we can be said to have an Eocene flora, since, during the Eocene period, the physical geography of Europe was such as to give it a very different flora from any that *ever* grew on the North American continent. During the deposition of the Eocene strata, the great mountain barrier which extends from the Bay of Biscay to the China sea—formed by the Pyrenees, Alps, Carpathians, Caucasus and Himalayas—existed, if at all, only in embryo. The Mediterranean communicated with the Indian Ocean, the south shore of Europe was washed by a tropical sea, and the land was covered with a sub-tropical, Indo-Australian flora. When, however, the great mountain barrier, to which I have referred, was raised, these Austral influences were cut off, the climate of Europe was rendered temperate, and the surface was gradually covered with a temperate flora which, because it included a large number of American plants, *Liriodendron*, *Liquidambar*, *Magnolia*, &c., we may call the *American* flora. This was the flora of the Miocene, of which we have illustration in the fossil plants of Fort Union in Dacotah, Greenland, Iceland, Oeningen, &c. This flora seems to have possessed Europe up to the advent of the ice period. By the advancing cold, it was driven to the shores of the Mediterranean, and there exterminated. When the glaciers were withdrawn, and a milder climate supervened, Asiatic plants seem to have come in and taken possession of the vacant territory. In our country, the history of our vegetation shows no such vicissitudes. From the close of the Triassic period to the present time, our continent has apparently been occupied by plants which form an

* It is an important fact, in this connection, that Lesquereux identifies a number of the species of plants of the Lignite beds with *Miocene* species of Europe. See the last volume of this Journal, page 448.—Eds.

unbroken succession. The north and south reach of our continent has given to the flora a connected belt of territory extending from Central America to the Arctic Sea, over which it could march and countermarch as impelled by alternations of temperature. We need not expect, therefore, to find here any such contrast between the flora of the Eocene and Miocene as is recorded in the Tertiary strata of Europe. Still we have reason to believe that, during the Eocene period, our climate was warmer than during the Miocene, and we may expect to find, in the two floras of the Tertiary, differences of degree if not of kind. In the fruits of the Brandon lignites, in the Palm (*Calamopsis*) and Cinnamon of the Mississippi Tertiaries, and in the palm (*Manicaria*) of the Green River beds, we have, perhaps, some indication of this elevation of temperature and some traces of an Eocene flora. Whatever plants are found with *Zeuglodon cetoides*, *Cardita planicosta*, *Orbitoides Mantelli*, etc., etc., we must accept as Eocene, even should they have no intrinsic Eocene characteristic. So in regard to our Cretaceous flora. While it is altogether new, its varied character and modern aspect simply gives us a new revelation in regard to the vegetation of the Cretaceous world; for, while the fauna of that world contains *Ammonites*, *Baculites*, *Inoceramus*, &c., we are forced to call it Cretaceous. It is not *impossible* that the physical conditions of our continent may have remained so constant that the Cretaceous age faded gradually into the Tertiary. It is not *impossible*, therefore, that we may find some Cretaceous forms of life interlocking with those of the Tertiary age, but truth requires us to say that, up to the present time, *no such connecting links have been found*. The lignites of New Mexico are covered with thousands of feet of sediments, sometimes largely made up of the remains of all the typical Cretaceous forms of life. Possibly in Colorado, beyond the reach of the Cretaceous sea, or where the land was exposed by the retreat of that sea, the Cretaceous flora may have grown on and on into the Tertiary; but as yet we have no evidence of this. Above the lignite beds, a break in the stratification and a conglomerate (Echo Cañon conglomerate) mark the beginning of a new era. Without asserting that this new era was the Tertiary, and the one which had gone before was the Cretaceous, I feel justified in saying that such will probably prove to be the case; or, at least, that no evidence has been yet found which disproves it.

To whatever conclusion, in regard to the age of the plant beds of the west, the facts may lead, when they are all gathered in, that result will be cheerfully accepted by every right-minded man. It is important, however, for the true progress of science, that no conclusion should be accepted until it is sustained by ample proof.