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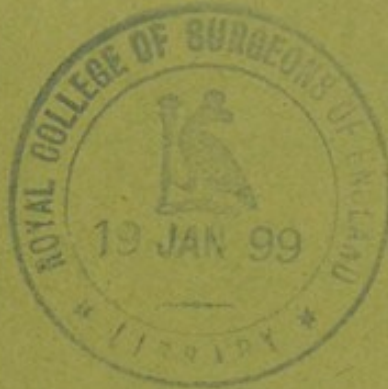
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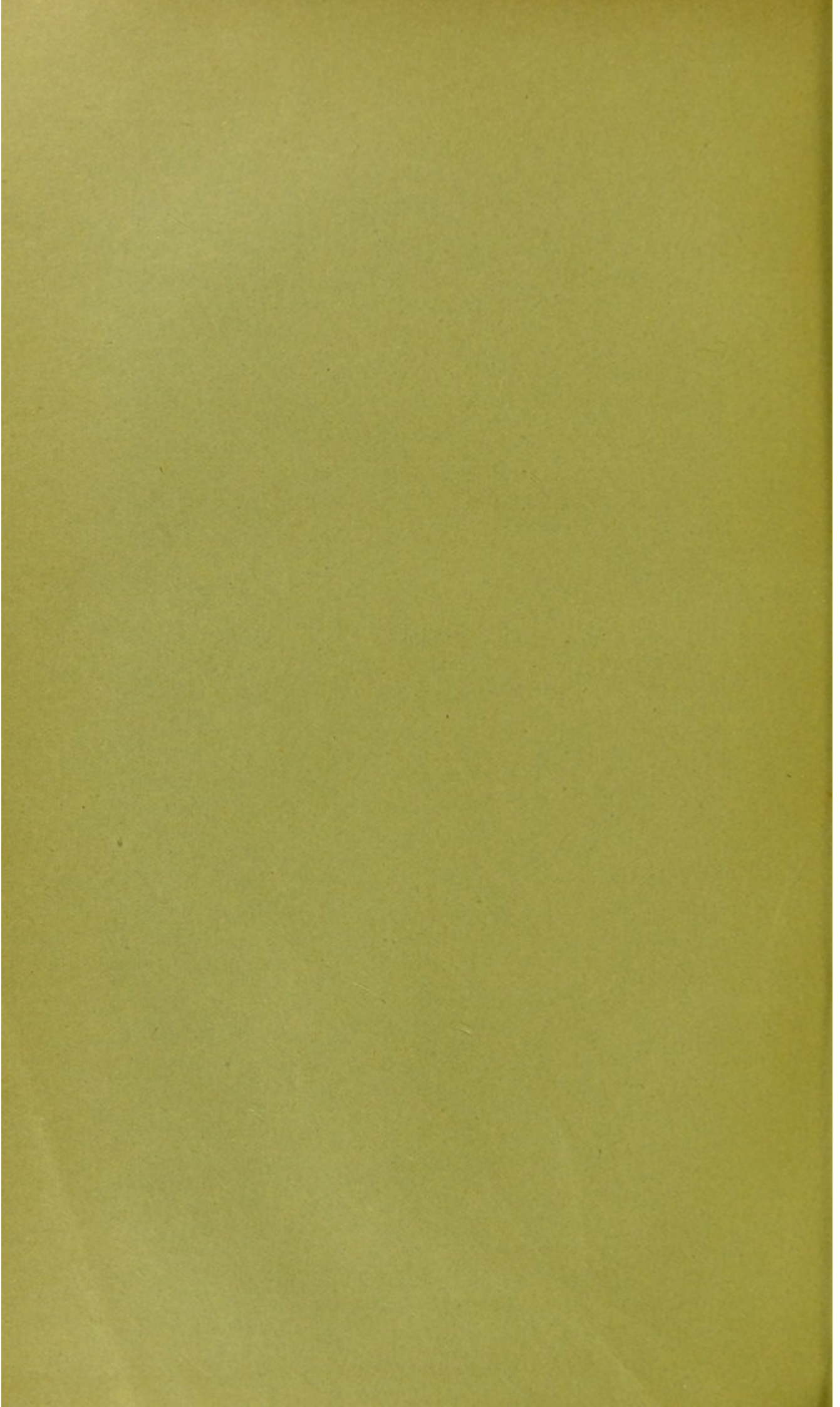
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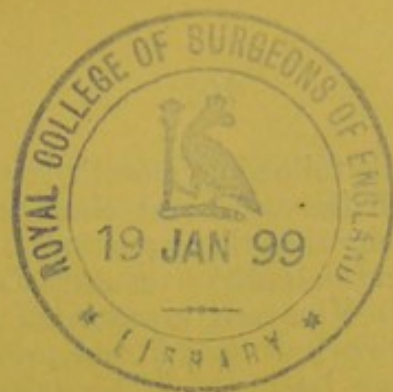


[FROM THE AMERICAN JOURNAL OF SCIENCE, VOL. VI, AUGUST, 1898.]

THE JURASSIC FORMATION ON THE
ATLANTIC COAST.—SUPPLEMENT.

By O. C. MARSH.





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*The Jurassic Formation on the Atlantic Coast.—
Supplement;* by O. C. MARSH.*

AT the autumn meeting of the National Academy last year, in New York, I made a communication entitled "The Jurassic Formation on the Atlantic Coast."† In this paper I brought together the results of a careful investigation which I had been conducting for several years, going to prove that the Jurassic formation, generally supposed to be wanting on the Atlantic border, was represented by a definite series of strata in the exact position where such deposits were to be expected. Accompanying this communication, I exhibited a number of drawings and sections illustrating the Jurassic deposits of the West, which I had long before investigated and fully described; namely, the Baptonodon beds, consisting of marine Jurassic strata with many characteristic fossils, mostly invertebrates, and above these the fresh-water *Atlantosaurus* beds, which have yielded such vast numbers of gigantic reptiles and other characteristic vertebrates. Sections showing the relative position of these deposits, with the strata above and below them as they are seen at several localities in Wyoming and Colorado, were also exhibited.

In comparison with this great development of the Jurassic in the West, I next discussed the so-called Potomac formation in Maryland, in which I had found a corresponding vertebrate fauna that proved the strata containing them to be also of Jurassic age. I then gave a brief account of my researches

* Abstract of communication made to the National Academy of Sciences, Boston meeting, November 18, 1897.

† This Journal, vol. ii, p. 433, December, 1896; and Science, vol. iv, p. 805, December 4, 1896. See also, this Journal, vol. ii, p. 295, October, and p. 375, November, 1896.

during that season, in following essentially the same strata to the eastward through Delaware and New Jersey, and likewise presented evidence showing that apparently the same Jurassic beds were to be found in position beneath Long Island, Block Island, and Martha's Vineyard, represented by the variegated basal clays of these islands, which had previously been supposed to be of much later age. The evidence seemed conclusive that in this series we had remnants of an extensive formation of fresh-water origin, the strata consisting mainly of soft sandstones and plastic clays of great thickness. In their physical characters, and especially in their variegated brilliant colors, these deposits differed widely from any others known on the Atlantic border, and were only equalled in this respect by the Jurassic beds of the Rocky Mountain region. The presence on the Atlantic coast of such an extensive formation, with its massive beds of plastic clay, all of fresh-water origin, clearly proved the former existence of a great barrier between the basin in which these clays were deposited and the Atlantic Ocean, a barrier that has long since disappeared through subsidence, or was broken down by the waves of the Atlantic, which are still rapidly removing the remnants of the formation along its eastern exposure, as may be seen on Block Island, and at Gay Head on Martha's Vineyard.

In discussing the age of this formation, its position above the Triassic and below the marine Cretaceous, its characteristic physical characters, distinct from those above and below, and its western extension into the strata of undoubted Jurassic age in the Potomac beds of Maryland, all pointed to the conclusion that its members belong to the same general epoch, and were deposited during Jurassic time.

In the paper thus cited, I confined myself strictly to the Potomac formation north of the Potomac River, and what I believed to be its eastern extension as far as Martha's Vineyard, all of which I had personally explored. I particularly avoided any discussion of the so-called Potomac beds south of the Potomac River, although I had been over these deposits at various points along the Atlantic border and around the Gulf as far as the Mississippi River. I closed the paper with the promise of taking up that part of the subject later.

As the question was a difficult one and still under investigation, I likewise guarded myself against expressing the opinion that all the so-called Potomac deposits were Jurassic. My words on this point were as follows:

"It cannot, of course, be positively asserted at present that the entire series now known as Potomac is all Jurassic, or represents the whole Jurassic. The Lias appears to be wanting, and some of the upper strata may possibly prove to belong to the Dakota."*

* This Journal, vol. ii, p. 436, 1896.

The Dakota Sandstone.

In regard to the sandstone known as Dakota, and generally considered of Cretaceous age, I also spoke cautiously, as behooves anyone who has seen this formation at many of its outcrops over a wide range of territory in the West, where its physical characters are striking, and its fossil remains are mainly detached leaves of plants.

In figure 1 of my paper, showing geological horizons and designed especially to represent the succession of vertebrate life in the West during Mesozoic and Cenozoic time, and so defined in the text, I left a blank space above the Jurassic for the Dakota, exactly where I had found a sandstone, regarded as Dakota, in place at many widely separated localities. I said little about the Dakota itself, as I did not wish then to raise questions outside the scope of my paper.

Had the occasion been appropriate, I might have said that the group termed Dakota in my section, I consider as more extensive than the single series of sandstones defined as Dakota by Meek and Hayden in 1861. The original locality of this sandstone was the bluffs near the Missouri River in Dakota County, Nebraska, and these authors included with this the supposed southern extension of the sandstone in eastern Kansas. This placed the Dakota on the eastern margin of the great Cretaceous basin which extended westward to the Rocky Mountains. The attempt of Meek and Hayden to identify the Dakota further north, near the mouth of the Judith River, is now known to have failed, but the name transferred to certain sandstones along the flanks of the Rocky Mountains has been accepted, and this term has long been in use for these strata from Canada to Mexico. With this so-called Dakota sandstone, however, have been included other deposits, the upper part of which may be Cretaceous, while the rest I regard as Jurassic, and with good reason. These intermediate beds may be seen at various places, especially around the border of the Black Hills and along the eastern flanks of the Rocky Mountains in Colorado. As I shall refer to this point later in the present communication, I will not discuss it here.

Opinions of Various Geologists.

The paper I have now cited, I regarded as the preliminary statement of an important case, and not its final demonstration. When presented to the Academy, it received the general approval of the members interested in the subject, and one of them, the late Professor Cope, who was best qualified to weigh the evidence of paleontology, fully endorsed my conclusions, and added that he himself had long suspected that the strata under discussion would prove to be of Jurassic age.

When an abstract of my communication was published, although without the main illustrations shown to the Academy, I received further endorsement from geologists familiar with the subject, but from others, marks of disapproval predominated. This I had anticipated in a measure, especially from the paleobotanists, whom I believed responsible for much of the confusion that had so long delayed the solution of similar questions, East and West. This point I brought out in my paper, but in an impersonal manner that I hoped would offend none of the craft.

The prompt and vigorous rejoinders that even my first informal announcement drew from two paleobotanists, A. Hollick and L. F. Ward,* showed that I had trespassed upon their bailiwick, and that some of the questions raised they had settled to their own satisfaction. As their ideas in regard to the value of fragmentary fossil plants as evidence of geologic age differed so widely from my own and from those of many paleontologists, no specific reply on my part seemed necessary, and I have none to make now. Professor Ward has admitted that the plants found with the vertebrates in the Potomac beds of Maryland may be Jurassic, and that removes one of the main points at issue between us. His words are as follows:

"If the stratigraphical relations and the animal remains shall finally require its reference to the Jurassic, the plants do not present any serious obstacle to such reference." (Loc. cit., p. 759.)

That the more eastern beds may represent a somewhat higher horizon, I can readily believe, but I must doubt the evidence that would separate so characteristic and homogeneous a series of sands and plastic clays into two sections, one Cretaceous and the other Jurassic. The few imperfect plant remains that we are told authorize this separation must be reinforced by other testimony to obtain even the support of probability, especially when paleobotanists differ so widely among themselves as to the real significance of the fragmentary remains they describe.

Next in order among my reviewers was R. T. Hill,† well known for his researches in the geology of Texas, but apparently not familiar with the typical Jurassic, East or West. He evidently had not read my paper carefully, though he criticises it at length, mainly to confirm his own conclusions as to the Cretaceous age of certain deposits in Texas, which he seems to imagine I do not endorse. As I especially avoided expressing any opinion on that point, or in regard to the Dakota being the base of the Cretaceous in this country, as I have already stated, no reply at present seems called for on my part, although I hope later to refer to the question he raises about the age of the so-called southern Potomac.

* Science, vol. iv, p. 571, and p. 757, 1896.

† The same volume, p. 918, 1896.

I took it for granted, in my paper cited, that American geologists who were not familiar personally with the great development of the Jurassic formation in Europe, or who had had no opportunity of examining typical sections of this formation in western America, or of seeing its deposits in place full of characteristic fossils and extending hundreds of miles in half a dozen states, were at least sufficiently acquainted with the literature of the last twenty years to know that two of the best-marked Jurassic horizons in any part of the world existed in this country.

Although my communication, as printed, was in fairly clear English, I find it was misunderstood in various other points, as subsequent reviews soon showed. If these marks of disapproval had been recorded by fireside geologists, who so often differ with those who furnish facts, I should have followed my usual rule and made no reply. They were, however, mainly written by field geologists who had seen something of the West, and ought evidently to have seen more, for the facts I stated can be readily verified at any of the localities mentioned and at many others. The failure to do so well illustrates a law of human nature; namely, that men see what they have eyes to see. The West is an extensive country. The plant men who go there seem to see only fossil plants; the invertebrate collectors notice only their own favorites, and as both classes are numerous, the extinct vertebrates are too often overlooked or only peculiar and striking specimens secured. Thus the most valuable evidence as to the age of strata is neglected, and the decision rendered has so frequently to be reversed. This neglect is not confined to field work alone, where fossil vertebrates should be found, but too often extends to the literature of the subject.

Let me illustrate this by a short quotation from a well-known work:

"The Jurassic system, which is so largely developed in Europe, containing the remains of huge swimming and flying reptiles * * is but sparingly represented in American geology, and none of the gigantic vertebrates have as yet been found here."*

The above extract may fairly be taken as representing the information on the subject known to the authors, or at least to the editor, when this work was published. It is, moreover, a fair sample of much that has since been written about the Jurassic formation of this country and its fossil contents, especially by those not familiar with this subject, but whose work in allied fields should at least have made them acquainted with the main results of our vertebrate paleontology, which had become a part of the world's scientific knowledge.

* *Geology of the Black Hills*, by Newton and Jenney; edited by G. K. Gilbert; p. 151, 1880.

For example, at the time the above work was published, one of the most fruitful horizons of vertebrate fossils ever discovered had been known for several years in the Jurassic of the West. Many tons of gigantic fossil vertebrates had been collected from several localities, and the principal forms described and figured, while the illustrations had been reproduced even in text-books. Moreover, the Jurassic horizon in which these and other remains were found had been definitely determined and named the *Atlantosaurus* beds, and a geological section showing their position and characteristic genera had been published several times. The fossils thus discovered embraced mammals, birds, reptiles, and fishes, nearly all of well-marked Jurassic types.

Since 1880, when the statement I have quoted was made, other discoveries have followed in rapid succession, and the Jurassic vertebrate fauna of the West is now known to be a most rich and varied one, far in advance of that from any other part of the world. More than one hundred and fifty species of extinct vertebrates, some of them represented by hundreds of specimens, have been brought to light, and over one hundred of these have already been described, and the more important have been refigured and republished in various parts of the world, including text-books, so that anyone with even an elementary knowledge of the subject can see that they are Jurassic in type. Nevertheless, a number of American geologists whose studies have kept them in other fields still appear to be ignorant of nearly all that has been made known about vertebrate paleontology in this country during the last quarter of a century, and seem to think that the Jurassic formation here is of small importance, and that its area should be restricted rather than enlarged.

Another of my reviewers was G. K. Gilbert, editor of the work from which I have just quoted. Whether he intended his remarks on my paper to be taken seriously is not clear. Apparently he wished to start an academic discussion on correlation, and under the circumstances this would probably have led from the Rocky Mountains to the Mountains of the Moon, one of his latest fields of investigation. If he is really in doubt about the methods of correlation of vertebrate fossils, he can perhaps find the information he needs in text-books.

First of all, however, I must question the accuracy of some of the statements in his review of my paper. One of these is as follows:

"Through a comparison of vertebrates from the Potomac formation with vertebrates from other formations he has inferred the Jurassic age of the Potomac; but he gives no hint of the character of his evidence or the course of his reasoning."*

* *Science*, vol. iv, p. 876, 1896.

Had this critic read the whole of my paper, he would have found the following statement bearing on this point:

"The Jurassic age of the *Atlantosaurus* beds of the West has now been demonstrated beyond question by the presence of a rich fauna of mammals, birds, reptiles, and fishes. Among these, the *Sauropoda* were dominant, and the other Dinosaurs well represented.

"In the Potomac beds of Maryland, the same Jurassic vertebrate fauna is present, as shown by the remains of five different orders of reptiles already discovered in them. Among the Dinosaurs are the *Sauropoda*, the *Theropoda*, and the *Predentata*, the first group represented by several genera and a great number of individuals. One of these genera is *Pleurocoelus*, which has also been found in the Jurassic of the West. Besides the Dinosaurs, characteristic remains of *Crocodylia* and *Testudinata* are not uncommon, and various Fishes have been found. The remains of these six groups already known are amply sufficient to determine the age of the formation, and still more important discoveries doubtless await careful exploration."*

Mr. Gilbert's next statement, which is likewise without real foundation, is as follows:

"The conclusion that the *Atlantosaurus* and other horizons of the Rocky Mountain region are Jurassic was announced in the same way, without citation of evidence."

The announcement of the *Atlantosaurus* beds as Jurassic was accompanied by a section showing their exact position in the geological scale, and the characteristic genera of Reptilia which then indicated their Jurassic age.† This was followed by descriptions in rapid succession of many other vertebrate fossils, proving beyond question that the horizon was Jurassic. The *Baptanodon* beds were also defined, and their position in the geological series established by characteristic fossils. The demonstration on this point, I have already given above, and need not repeat here.

Another point needs correction, as Mr. Gilbert evidently consulted my recent classification of the *Dinosauria*‡ without appreciating the evidence it contained. This is shown by the following quotation from his review:

"The closest affinity of the European and American formations seems to be expressed by the statement that there is one American genus which falls in the same family with a European genus."

* This Journal, vol. ii, p. 445, 1896.

† Proceedings American Association, Nashville meeting, p. 220, 1878; see also Popular Science Monthly, p. 520, March, 1878.

‡ The Dinosaurs of North America, 16th Annual Report, U. S. Geological Survey, p. 238, 1896.

The genera named in my recent classification were mainly typical forms, and I had no intention of making a complete catalogue of all the known genera, as anyone familiar with the subject could readily see. By way of further instruction, let me repeat here what I have recently said about one of these typical forms.

"*Pleurocoelus* is one of the most characteristic genera of the Sauropodous *Dinosauria*, and its value in marking a geological horizon should therefore have considerable weight. It is now known from the two European localities mentioned above, both in strata of undoubted Jurassic age. The same genus is well represented in the Potomac deposits of Maryland, and has been found, also, in the *Atlantosaurus* beds of Wyoming, thus offering, with the associated fossils, strong testimony that the American and European localities are in the same general horizon of the upper Jurassic."*

Had Mr. Gilbert been familiar with the subject discussed in his review, he would have known that, so far as present evidence goes, there are other genera of Dinosaurs common to Europe and America, found in apparently the same Jurassic horizon, and that this is true also of various other reptiles and of fishes. More important still is the correspondence between the genera of Jurassic mammals of the two continents, which in itself is sufficient to demonstrate that they belong in essentially the same horizon.

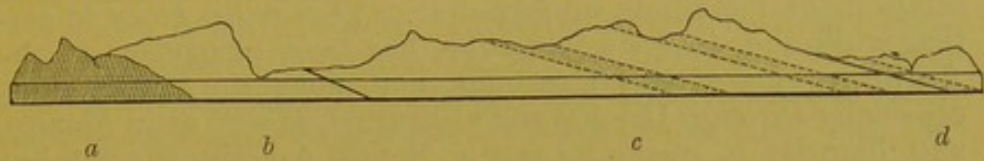
The last point Mr. Gilbert raises in his review is a geological one, and even here he has missed the mark. His words are as follows:

"The physical relations of the beds afford a presumption in favor of their Cretaceous age. Prof. Marsh mentions that the Potomac formation in New Jersey passes by insensible gradation into marine Cretaceous above."

The two statements in this quotation are, in my opinion, both erroneous, and the second is contrary to the idea I intended to convey. The physical relations of the beds in question are in favor of their Jurassic age, and the Potomac strata do not pass by insensible gradation into the marine Cretaceous above. Although the two are apparently conformable, the passage from one to the other was a change from fresh-water to marine deposits, which in itself implies a break that may represent a long period of time, perhaps the entire lower Cretaceous. This break was clearly indicated in the geological section that I gave in my paper (figure 2), and to make this point clear, the same section is here repeated.

* This Journal, vol. iv, p. 415, December, 1897.

This typical section represents the successive Mesozoic and more recent formations, from New Brunswick, New Jersey, on a line southeast, through Lower Squankum to the Atlantic. The distance indicated is about forty miles.



Geological Section in New Jersey.

a, Triassic; *b*, Jurassic; *c*, Cretaceous; *d*, Tertiary; *T*, tide level.

My explanation was as follows:

"The change from the fresh-water plastic clays of New Jersey to the marine beds containing greensand over them proves not only the breaking down of the eastern barrier which protected the former strata from the Atlantic, but a great subsidence also, since glauconite, as a rule, is only deposited in the deep, still waters of the ocean."*

Since my paper was published, I have been over part of this section several times, and found clear indications of the break itself. Moreover, Professor W. B. Clark, of Baltimore, informs me that he finds distinct unconformity between the marine Cretaceous and the underlying Potomac, along the junction of these two formations, at various other points further south. This fact furnishes a strong argument that the marine Cretaceous belongs to a separate formation from the older fresh-water clays, here regarded as Jurassic.

Another geologist who has written much about the West, but seems to have failed in comprehending the evidence afforded by the vertebrate fossils from well-marked Jurassic horizons, is C. A. White, and as his opinion is frequently quoted, it may be well to correct one of his statements which bears on the question here discussed. In speaking of the *Atlantosaurus* beds, in 1889, he made this statement:

"If it were not for their dinosaurian faunas their Jurassic age might well be questioned."†

When this statement was made, more than one hundred species of vertebrate fossils besides the Dinosaurs were known from these same *Atlantosaurus* beds, and among these, the Crocodilians, the Testudines, and the various smaller reptiles would have been sufficient to demonstrate the Jurassic age of the strata containing them. More important still, several hundred specimens of Jurassic mammals had been found, over a score of species were already described and figured, and these alone were sufficient to prove the horizon Jurassic.

* This Journal, vol. ii, p. 441, 1896.

† Proceedings of the American Association, Toronto meeting, p. 213, 1890.

Following these well-known writers, others of less experience in the West have repeated their statements or followed the earlier geologists as to the age of western horizons, and thus tended to continue the confusion where the facts themselves made the whole subject clear. Thus it has come to pass that while the Jurassic formation has been recognized in the Arctic regions of this Continent, and along the Pacific coast, especially through Oregon and California, as well as in Mexico, and likewise in various parts of South America, its development in the Rocky Mountain region has received little attention except from those especially engaged in its investigation. It is not strange, then, that those who have not seen how extensive the Jurassic formation is developed in Europe, and have not examined its characteristic exposures in the West, should fail to recognize it on the Atlantic coast where its features at many points are obscure.

In my paper on this subject last year, I endeavored to show that the burden of proof must rest upon those who denied the existence of the Jurassic formation on the Atlantic border. The evidence against it is still based mainly upon fragmentary fossil plants, in regard to the nature of which the paleobotanists themselves are not in accord.

Cycad Horizons.

I have recorded elsewhere my opinion of the comparative value of different kinds of fossils,—vertebrates, invertebrates, and plants,—as evidence of geological age, and have endeavored to show that plants, as usually preserved and described, are the least valuable witnesses. The evidence of detached fossil leaves and other fragments of foliage that may have been carried hundreds of miles by wind and stream, or swept down to the sea-level from the lofty mountains where they grew, should have but little weight in determining the age of the special strata in which they are imbedded, and failure to recognize this fact has led to many erroneous opinions in regard to geological time. There are, however, fossil plants that are more reliable witnesses as to the period in which they lived. Those found on the spot where they grew, with their most characteristic parts preserved, may furnish important evidence as to their own nature and geological age. Characteristic examples are found among the plants of the Coal Measures, in the Cycads of Mesozoic strata, and in the fossil forests of Tertiary and more recent deposits.

As bearing directly on the question here discussed, the Cycads of the Jurassic period afford instructive examples of the evidence that may be derived from fossil plants under favorable circumstances. The Cycad trunks of the upper Jurassic of England have long been known, and are especially

interesting from the fact that many of them are found imbedded in the original soil in which they grew, thus marking a definite horizon, the age of which has been ascertained by independent testimony.

On the Atlantic border of this country we have a corresponding horizon, determined to be such by its position and by the vertebrate fossils it contains. At various localities in this horizon, especially in Maryland, Cycad trunks have long been known, and within a few years numbers of very perfect specimens have been found under circumstances that serve to fix the horizon in which they occur, and confirm the evidence as to its geological age.

In the Rocky Mountain region, especially around the margin of the Black Hills, a definite horizon likewise exists, in which great numbers of Cycad trunks are found in remarkable preservation. These Cycads resemble most nearly those from Maryland, found in what I term the *Pleurocœlus* beds of the Potomac formation. In the Black Hills, the age of the horizon has not been accurately determined, but present evidence points to its Jurassic age. The strata here containing these characteristic fossils has long been referred to the Dakota, but, as I have already shown in the present paper, the beds so termed in the Rocky Mountain region are not the equivalents of the original Dakota, and some of them are evidently Jurassic. Until recently the Cycads of the Black Hills, although of great size and remarkable preservation, have not been found actually in place. In the large collection of Cycads belonging to the Yale Museum, a few have been discovered apparently where they grew, and systematic investigation will doubtless show that the various localities where these fossils have been found around the Black Hills are all in one horizon. The evidence now available indicates its Jurassic age, and suggests that it is essentially the same as that of the Cycad beds in Maryland, which I regard as a near equivalent of the well-known Cycad horizon in the Purbeck of England.*

In conclusion, I have only to say that the year which has passed since my first communication to the National Academy on the Jurassic of the Atlantic border has brought no important evidence against the view I then maintained, but much additional testimony in its favor, especially in the region north of the Potomac River that I then discussed. I still hope to return to the subject later, and take up the question of the extension of the same formation along the Atlantic coast further south, and around the gulf border to the southwest, where new evidence is now coming to light.

* W. H. Reed, formerly my assistant in the West, informs me that he has found Cycads in the Jurassic of Wyoming, both in the Freeze Out Hills, and also near the Wind River Range. In the former region, they occur about forty feet above the *Baptanodon* beds, so named from a genus discovered by Mr. Reed.

