ART. XXIX.—*Notes on the Jurassic Strata of North America ;*
by CHARLES A. WHITE.

AT various places in Colorado, Wyoming, Dakota, Utah, Montana and other western Territories, there are frequent and large exposures of a formation which geologists and paleontologists have agreed in referring to the Jurassic period. It has received recognition as of that age in all the official reports which have noticed it; and from all members of the U. S. Geological survey who have written upon the subject. Professors Marcou, Newberry and Hayden and other early explorers recognized the formation as Jurassic, but it is to the late Mr. F. B. Meek that is due the credit of giving the first exposition of its claims to that recognition, based upon a publication of its invertebrate fauna. It is true that this fauna, even as it is at present known, is a meager one, but its character, together with the position of the formation in relation to those which underlie and overlie it, has been deemed sufficient warrant for the opinion referred to.

The formation in question is usually spoken of simply as Jurassic, but it has received local names by some authors, and some of its divisions have also received subordinate names. Some geologists have also grouped the whole formation together with a large series of underlying beds which have been generally considered as of Triassic age, under the compound name of Jura-Trias. Major Powell called the Jurassic portion, the Flaming Gorge Group: and Professor Marsh, dividing the Jurassic beds into two parts, has given the upper part the name of *Atlantosaurus* beds, and the lower part the name of *Sauranodon*, or *Baptanodon* beds.

It is in the lower division only, so far as I am aware, that any invertebrate fossils have been found: and it is upon these that was based the earliest published opinion as to the Jurassic age of the formation. But from both divisions there has been obtained an exceedingly rich and remarkable vertebrate fauna. This fauna has been brought out mainly by Professor Marsh, who has published the results of his investigations in this Journal from time to time during the past eight years. It is mainly reptilian, but it also embraces many mammalian forms. Professor Marsh refers all this remarkable fauna unhesitatingly to the Jurassic period, and all paleontologists agree with him in this respect. Let it be remembered that a part of this vertebrate fauna is associated in the same layers with the invertebrate fauna which has been referred to, and a part of it comes from layers which overlie them.

The discovery of this great vertebrate fauna seemed to settle the question of the Jurassic age of the formation in the minds of paleontologists generally; but Mr. J. F. Whiteaves, Paleontologist to the Canadian Geological Survey, has lately published in one of the volumes of that survey, views which are entirely adverse to those hitherto held by all others.* In that work he describes and figures some fossils which were collected by Mr. James Richardson and Dr. G. M. Dawson at Queen Charlotte Islands, on the west coast of British Columbia. The fossils are reported to have come from a series of strata some 13,000 feet in thickness, all of which are referred to the Cretaceous period. The principal fossiliferous horizon of this series is about its middle, and it bears an abundant and characteristic Cretaceous molluscan fauna, which is regarded by Mr. Whiteaves as equivalent with that of the Gault or Middle Cretaceous.

Among this Middle Cretaceous fauna Mr. Whiteaves announces his identification of eight or nine molluscan species with forms that are common in our Jurassic rocks, to which reference has already been made. He therefore regards our Jurassic formation not only as of Cretaceous age, but he places it in the middle of that series. With sincere regard for the paleontological ability of Mr. Whiteaves, I quite fail to agree with him either as to the Cretaceous age of those strata, or with his identification of any of its species in the British Columbian rocks. He has stated his case plainly in the publication referred to; and upon the occasion of a late visit to the museum of the Canadian Survey at Ottawa he kindly permitted me to examine the British Columbian collections, including the specimens which he regards as identical with species found in our Jurassic rocks. The following is a list of the species to which he refers them; following which are my remarks, based upon an examination of his specimens and a considerable familiarity with the type specimens of those species.

1. *Belemnites densus* Meek & Hayden.
2. *Lyosoma Powellii* White.
3. *Myacites (Pleuromya) subcompressa* Meek.
4. *Astarte Packardii* White.
5. *Arca (Cucullæa) inornata* M. & H.
6. *Modiola (Volsella) subimbricata* M. & H.
7. *Pteria (Oxytoma) mucronata* M. & H.
8. *Camptonectes extenuatus* M. & H.
9. *Gryphæa Nebrascensis* M. & H.

(1.) *Belemnites densus*. Mr. Whiteaves's collection contains only one specimen which he refers to this species, and that is

* See Volume i, Part III, Mesozoic Fossils. Dawson Brothers: Montreal, April, 1884.

too imperfect to be satisfactorily identified as belonging to any particular species out of many that might be mentioned. See his figure of it (loc. cit.)

(2.) *Lyosoma Powellii*. Mr. Whiteaves was in doubt as to the true identity of this form with his *Vanikoro pulchella*. I am confident that the two shells are not only specifically different, but that they belong to separate families; the *Vanikoro* to the Neritopsidæ, and the *Lyosoma* to the Velutinidæ.

(3.) *Myacites (Pleuromya) subcompressa*. The British Columbian collection contains many specimens of the form which Mr. Whiteaves refers to this species, showing a wide range of variation; but they are all in such a state of preservation as to show only the external form and surface characters of the shell. They also belong to a type of shells which, so far as can be determined from the fossils as they are usually found, ranges from the Carboniferous to the Cretaceous inclusive. Indeed this type is so constant in general character that its variation in any part of its great chronological range is scarcely greater than is the interspecific variation which Mr. Whiteaves has shown to exist among his British Columbian specimens. Therefore I regard the identification of a species belonging to this type as unreliable if opposed by contrary evidence.

(4.) *Astarte Packardii*. The British Columbian specimens which Mr. Whiteaves refers to this species are certainly very closely like the type specimens of *A. Packardii*, so far as external form and surface characters are concerned. It is also in these respects much like an unpublished form which I have seen among a collection of Cretaceous fossils from New Mexico. The hinge and interior markings of this form, as well as that of *A. Packardii*, are unknown; and they cannot therefore be compared in these important respects with the British Columbian specimens.

(5.) *Arca (Cucullæa) inornata*. Mr. Whiteaves's specimens are not in a condition to show the hinge, nor are their external characters well preserved. He refers his shell to the genus *Grammatodon*, but I could discover none of the characters by which its exact generic relations may be known among the numerous divisions of the Arcidæ.

(6.) *Modiola (Volsella) subimbricata*. Only three specimens were obtained at Queen Charlotte Islands, and these are distorted and too imperfect for satisfactory specific identification.

(7.) *Pteria (Oxytoma) mucronata*. Mr. Whiteaves had only one imperfect specimen of one valve. The most that can be said of it is that it apparently indicates a form which is much like the *P. (O.) mucronata* of Meek & Hayden.

(8.) *Camptonectes extenuatus*. Mr. Whiteaves refers his specimen, a single valve, with doubt to this species. In view of the

imperfection of his material and the slight range of specific variation in this genus I think his doubt is well founded.

(9.) *Gryphæa Nebrascensis*. Every paleontologist knows how unsatisfactory is specific identification among the Ostreidæ. Even if the resemblance between the British Columbian and Dakota specimens is really as great as Mr. Whiteaves thinks it is, there would still be room for doubt as to specific identity, especially in view of conflicting evidence. In fact, however, they differ from each other quite as much as many recognized species do; and the British Columbian form is more nearly like *Gryphæa navia* of the Cretaceous of Texas, than the *G. Nebrascensis* of Meek & Hayden.

A glance at the foregoing list will show that nearly all the genera there represented are noted for the small range of variation which is observable among the species of each. In fact they are just such forms as those upon the specific identification of which one ought least to rely; especially in case the specimens are not numerous and perfect, and the incidental evidence is conflicting.

There is another important fact which deserves great consideration in this connection. The British Columbian specimens are associated with numerous characteristic Cretaceous forms, the latter constituting the more distinctive feature of that fauna. On the contrary, not one of those, or any other distinctively Cretaceous types has ever been found in our Jurassic strata at any of the many hundreds of localities, extending over many thousands of square miles, at which fossils have been collected from it. And our Jurassic molluscan fauna is also very constant in its character at all the places where it has been found. Furthermore, Mr. Whiteaves does not claim to have discovered any of our Jurassic Ammonitidæ, nor Jurassic vertebrates, in the British Columbian rocks.

Whatever may be the true geological age of the formation which all American geologists have hitherto referred to the Jurassic, its identity with any of the strata from which Mr. Whiteaves' fossils came is, in my opinion, in no measure proved by any of the species he has shown them to contain. Still, such challenges of received opinions as he has made are not only the privilege of every paleontologist, but they serve an excellent purpose in causing men to examine more closely into the ground of their opinions, and call for a public statement of their reasons for holding them.

Although I do not regard the evidence which Mr. Whiteaves has presented as at all supporting his position, there are two circumstances which apparently favor the doubt which the publication of his views may have raised as to the true age of the formation which we have always regarded as Jurassic.

First, the invertebrate fauna of that formation is meager. Second, there is, as I believe, always an *apparent* conformity between the Dakota Group of the Cretaceous series and the Jurassic formation, wherever they have been found in contact. While I do not think that this conformity really proves that there is no hiatus between the two formations, I think the circumstance of its existence more worthy of consideration than the assumed specific identification of the fossils which I have commented on. I regard these circumstances as at most only slightly opposing the evidence in favor of the Jurassic age of the strata in question which is afforded by its fossils, especially its vertebrate fauna.

These Jurassic strata are evidently not homotaxially related to the other North American strata which have by some authors been referred to the Jurassic. I refer to the Aucella-bearing rocks and their equivalents, which have been found in California, Washington Territory, British Columbia, Alaska, and the east coast of Greenland. Mr. Whiteaves follows Eichwald in referring these strata to the Neocomian; and I have suggested that they occupy a position upon the confines of the Neocomian and Jurassic. These west coast and arctic beds appear to have no true equivalents in the United States to the eastward of the Pacific Coast region.