

ART. XLIV.—*On the Puget Group of Washington Territory*; by CHARLES A. WHITE.

[Published by permission of the Director of the U. S. Geological Survey.]

ABOUT two years ago, Prof. J. S. Newberry placed in my hands for study a small collection of fossil mollusca which he had obtained from the coal-bearing formation in Puget Sound basin in Washington Territory. This collection represents a hitherto unpublished brackish-water fauna, which characterizes a formation that possesses unusual interest. All the discovered species of this fauna will be described and illustrated in Bulletin 50 of the U. S. Geological Survey, where also the formation will be discussed. Twelve species have been recognized, of which the following is a list: *Cardium* (*Adacna*?)—?, *Cyrena brevidens*, n. s., *Corbicula Willisi*, n. s., *C. Pugetensis*, n. s., *Batissa Newberryi*, n. s., *B. dubia*, n. s., *Psammobia obscura*, n. s., *Sanguinolaria? caudata*, n. s., *Teredo Pugetensis*, n. s., *Neritina* —?, *Cerithium* —? and an undetermined gasteropod.

The formation from which these fossils were obtained is known to occupy a large part of Puget Sound basin, and to extend upon the western flank of the Cascade range, which forms the eastern side of the basin; but all the boundaries of the area which it occupies are not at present known. Besides these strata which lie to the west of the Cascade range, other similar deposits are found upon its eastern flank, as well as at certain localities among its higher mountains. All these deposits are believed to belong to one and the same formation, although those within, and east of, the Cascade range have not yet furnished any molluscan fossils similar to those found upon the western side of the range. Certain unique features of the fauna referred to show that the strata in which the remains were found were deposited in a body of water which was quite separate from that in which was deposited any one of the coal-bearing formations in the Pacific Coast region or elsewhere. Its zoological character indicates that the body of water in question was an estuary; and the extent of the district within which the deposits have been found shows that that estuary was a very large one.

The most complete information that has yet been published concerning this formation appeared in volume xv of the reports of the Tenth U. S. Census, pp. 759–771, plates LXXXII–CII. That publication, which is entitled “A Report on the Coal Fields of Washington Territory,” is by Mr. Bailey Willis, who accomplished the work upon which his report is based under

the auspices of the Northern Transcontinental Survey. The special object of his report having been the presentation of the coal resources of that region, the discussions are confined mainly to its coal-bearing formations; and the report therefore does not embrace a full account of the geology of the whole region. Still, Mr. Willis has given some comprehensive facts as well as many elaborate details concerning this formation in the report referred to; and as my own field labors upon the Pacific coast have not extended to the northward of the Columbia river, my knowledge of many of the facts which are stated in the following remarks has been derived from him, and from Professor Newberry.

The orogenic elevations of the Pacific Coast region extend in two lines which are approximately parallel with each other and with the coast. The eastern line consists of the Sierra Nevada in California and of the Cascade range in Oregon and Washington Territory. The western line, known as the Coast range in California, is more or less distinctly recognizable through western Oregon, and extends northward of the Columbia river into Washington Territory; but it there sinks to low hills before reaching the Olympic cluster of mountains, which forms the northern end of the line. This cluster is a prominent feature of that district, its higher peaks rising to more than 8000 feet above the sea level.

The relief of this great strong-featured Pacific Coast region is the product of several uplifts, differing in time, extent and locality, the whole history of which is not yet clearly understood but the facts of interest in this connection may be provisionally stated as follows. The Cascade range, which has been recognized as distinct in structure and origin from the Sierra Nevada range, although in a general line continuous with it, has been considered to be itself simple; but it is in reality quite complex. In Oregon it is composed of erupted material, often of great thickness, which has been observed to rest upon nearly horizontal sedimentary strata of Cretaceous age; and in southern Washington Territory it consists of enormous masses of erupted rocks overlying highly flexed sedimentary strata of late Mesozoic or early Tertiary age. In the northern half of the same Territory the range is made up entirely of granite, crystalline schists and volcanic rocks. As bearing upon the subject in hand, it may be stated here that the Tertiary rocks, which prevail in the Coast range generally seem to be wanting in the Olympics which, in this respect and in their composition, resemble the northern portion of the Cascade range.

Between the two long lines of orogenic elevation before referred to, lie the great valleys of the Sacramento and San Joa-

quin rivers in California, of the Willamette in Oregon, and of Puget Sound (known as Puget Sound basin) in Washington Territory. The latter valley was the scene of deposition of the coal-bearing series of strata which is characterized by the molluscan fauna already mentioned.

Mr. Willis describes this formation as consisting of "alternating beds of yellow and fine grained sandstones and very fine arenaceous shales interstratified with many beds of carbonaceous shale and coal: the individual strata of sandstone and shale, from 20 to 200 feet thick, maintain the same general character wherever observed." He further says that a section measured near the town of Wilkeson in Puget Sound basin "gives a minimum thickness of 13,200 feet, with a probable maximum of 14,500 feet." The surprise that one feels upon learning of the extraordinary thickness of this estuary deposit is increased by Mr. Willis's statement that, so far as he could observe, the contained molluscan fauna ranges vertically through the whole formation.

This is surely a remarkable deposit for one of estuary origin, but it is so regarded in consideration of the following facts: No trace of an open sea fauna has been found in it, while all the molluscan remains that have been found in it are related to estuary forms. These remains embrace species of the Corbiculidæ, the members of which family are known to range from brackish to fresh waters. These forms are associated with certain others whose living congeners are known to range from marine to brackish waters but not into fresh waters; and the strata of this deposit contain an abundance of vegetable remains, which doubtless came from local swamps and adjacent shores.

No specimens of this fauna have yet been discovered beyond the present limits of Puget Sound basin, nor in any other formation than those from which Professor Newberry's collection was made. But if, as is inferred from a general similarity of lithological characters, the absence of marine fossils, the presence of coal beds and of identical species of plant remains, and from similarity of position with relation to older and later formations, the deposits which are found upon the eastern side, as well as within the body, of the Cascade range in southern Washington Territory, constitute parts of the same formation which is found upon the western side, the scene of its deposition extended much beyond the limits of Puget Sound basin.

This conclusion of course implies that the portion of the Cascade range upon which those strata are found was not then elevated, as was the northern portion, and that the outline of the area within which this deposit was made was very different from

what would be suggested by any of the present topographical features of the region. That the present topographical features of that region differ greatly from those which prevailed during the Puget epoch is indicated by other observations of Mr. Willis. For example, he noted the absence of the Puget Group high up in both the Olympic, and the northern Cascade mountains, which leads him to believe that while that formation was being deposited, the former mountains constituted an island, and the latter, a peninsula. It is hardly to be supposed, however, that the topographical features of that region were permanent throughout the whole of the Puget epoch, because the range of the molluscan fauna through the whole thickness of the formation, as already mentioned, indicates that there was a constant subsidence over the whole area within which the deposit took place, during the whole time of its accumulation. Certain topographical changes in that neighborhood at least, must have accompanied such a subsidence.

In the report of Mr. Willis, already referred to, he not only regards this formation as equivalent with the Laramie Group, but he provisionally applies the same name to it. His reasons for doing so, in addition to the fact that, like the Laramie, this group apparently rests directly upon upper Cretaceous marine strata, appears in the following paragraph which he has kindly furnished me from an unpublished report of his upon a district which lies to the eastward of Puget Sound basin.

"The Laramie? of the Wenatchie Valley."

"The Wenatchie river cuts a section across unmetamorphosed conglomerates and sandstones bent in broad folds over axes having a general north and south trend. This formation flanks the Peshastan range on both sides, occurring on the south on Schwak creek, and in the Klealim valley, and forms some of the high crests of the Cascade range north of Natchez. It is the last formation deposited before the elevation of the Cascade range and its spur, the Peshastan, and is thus identified, as well as lithologically and in its stratigraphic relations, with the Puget Sound Coal measures, the latter having been assigned to the Laramie by Prof. J. S. Newberry on the evidence of the leaf impressions."

I think that all the known evidence is strongly in favor of the view taken by Professor Newberry and Mr. Willis as to the equivalency and probable contemporaneity of the Puget Group with the Laramie; but it may be regarded as certain that these two formations were deposited in separate bodies of water and under materially different conditions; and that they were separated by a land area of considerable breadth. The area, however, was not so broad as to make it unreasonable to suppose

that an arboreal flora extended entirely across it, and scattered its autumnal leaves into the Laramie sea upon the one hand and into the Puget estuary on the other. Possibly it may yet appear that terrestrial vertebrate, and molluscan faunas also extended across the same area by the discovery of their remains in both the Laramie and Puget groups.

Besides the evidence which is furnished by the character of the gill-bearing fossil mollusca of the Laramie and Puget groups respectively that they were deposited in separate bodies of water, satisfactory evidence exists that the Laramie outlet was upon the Atlantic side of the continent, and that the Puget outlet was upon the Pacific side. Admitting that these conditions existed there seems to be little probability that the two faunas had a common origin. Under such circumstances I think it better to use separate names for the two formations; and I have accordingly proposed the name of Puget Group for the formation which forms the subject of this article.

As to what were the original boundaries of the Puget estuary deposit comparatively little is definitely known, as already intimated. It is probable also that much will always remain unknown upon this point owing to the great erosion which the strata have suffered, and to the presence of large portions of the volcanic outflows which have so largely covered them. Taking into consideration the extreme points at which strata of this group have been found, including those which lie to the east of, and among the Cascade mountains, the present indications are that the Puget Group originally occupied an area of several thousand square miles.

That the body of water in which the Puget Group was deposited was an estuary, and not a land-locked sea, as was the Laramie, is indicated, as already shown, by its molluscan fauna.* But in what manner the Puget estuary was separated from the open ocean we have as yet little information. A natural inference would be that the Olympic island formed part of such a barrier, but the discovery of marine fossils in the valley of Dwamish river, the strata inclosing which were presumably formed contemporaneously with at least a portion of the Puget Group, would seem to show that the estuary barrier was, a part of the time, at least, to the eastward of Olympic island.

Although the contemporaneity of the Puget and Laramie groups apparently need not be questioned, the stratigraphical relation of the former to the Teton Group, which is presumably of approximately the same age, has not been satisfactorily determined. Vertebrate and vegetable paleontology have fur-

* The apparent absence of this peculiar fauna from the more eastern strata suggests that they were deposited nearer to the influx of fluvial waters, which being therefore entirely fresh did not afford a congenial habitat for the species which prevailed in the western and brackish part of the estuary

nished no evidence upon this point. The invertebrate remains which each formation has furnished afford no means of comparison because those of the Puget Group are estuarine and those of the T  jon Group marine: and because the estuarine types of molluscan life are always of little if any value as indicating geological age. Therefore we are reduced to stratigraphic evidence alone in attempting to correlate the Puget, with the T  jon Group.

Mention has just been made of the discovery of strata containing marine fossils at a locality on Dwamish river in Puget Sound basin, and not far from typical exposures of the Puget Group. A considerable proportion of the fossils found there have been identified with T  jon species, and those Dwamish valley strata doubtless represent a part of the T  jon Group.

Mr. Willis, who has studied the stratigraphy there in connection with his work before referred to, regards the position of these marine strata with reference to those of the Puget Group as having been deposited not earlier than those of the upper portion of that group. This view of the stratigraphical relations of the Dwamish river strata with those of the Puget Group, together with the fact that the fossils of the former are of marine origin, suggests that they were deposited in marine waters towards the close of the great subsidence that accompanied the deposition of the Puget Group, and indicates that the latter group is a local, although a large, chronological representative of a part, or the whole, of the Chico-T  jon series.*

Now if the strata of the Puget Group were deposited, even in part, contemporaneously with the Chico-T  jon series, it is probable that some of the species of that series which were capable of entering brackish waters may yet be found in the Puget strata, and that some of the Puget fauna which were capable of entering marine waters may yet be found associated with Chico-T  jon species. As a matter of fact, however, no evidence of such a commingling of the species of the two faunas has yet been discovered. So far, therefore, we have no paleontological evidence of the contemporaneity of the Puget Group with the Chico-T  jon series.

Although no serious doubt is entertained that the Puget Group was deposited in estuarine waters there are certain facts which are somewhat perplexing when considered in connection with an acceptance of that view. The known area within which strata of that group occur shows that the Puget estuary was of such great extent that it is difficult to understand how so large a body of water could have been uniformly kept so

* It also seems to indicate that the western barrier of the Puget estuary was at that time and place, not far from the middle of the present Puget Sound basin, but it is probable that the position of the barrier was shifted from time to time, during the existence of the estuary.

nearly fresh as to afford a congenial habitat for such a molluscan fauna as it is known to have possessed, and as was necessary for the accumulation of the great thickness of strata in which the remains of that fauna are found, during so long a period of time.

That is, it is difficult to understand how that comparatively narrow portion of the continent between the then existing Laramie hydrographic basin on the east, and the Puget estuary on the west could have furnished a sufficient flow of fluviatile water to keep nearly fresh so large an estuary, and keep off the encroachment of adjacent marine waters. Even so large a flow as is now discharged by the Columbia would seem to have been insufficient unless the outlet of the great estuary was greatly narrowed by land barriers.

Again, the evidence presented by Mr. Willis, and also that afforded by the fossils, which range without material change through a large part of the vertical series, seems to be conclusive that essentially uniform estuarine conditions were preserved over the whole area now occupied by the Puget Group from the time of the deposition of its earliest, to that of its latest strata. This evidence also discloses the remarkable fact that during that time there was a constant subsidence over the whole area, until it had reached a maximum of not less than twelve thousand feet.

It is certainly difficult to understand how so great a subsidence could have taken place without such a simultaneous elevation of the adjacent land area as would have materially changed the character and uniformity of the supply of fluviatile waters to the estuary, or have added a land area to the westward of it. Indeed, it is difficult to understand how even a less subsidence could have taken place without materially modifying the character of the great estuary itself, or even submerging its whole area beneath marine waters.

The biological relations of this Puget fauna to other faunas possess peculiar interest. For purposes of comparison one instinctively turns to the molluscan fauna of the Laramie Group; but in doing so important differences appear. It is true there are two species of *Corbicula* in the Puget fauna that are so closely like Laramie forms as to suggest specific identity upon casual examination; but the differences between the two faunas are strikingly shown by the family and generic characters of the other members of the Puget fauna as compared with the Laramie fauna.

For example, a species of *Teredo* has been found in the Puget Group, but no member of the *Teredinidæ* has yet been found in the Laramie. Two species of the Puget fauna are referred to the *Tellinidæ*, but no member of that family has

yet been found in the Laramie. But the generic form which gives an especially unique character to the Puget fauna is that of *Batissa*. This genus has not hitherto been known to occur in North America, in either a fossil or living condition; nor has it been found nearer to this continent than certain of the Pacific islands. Still the hinge characters observable in these Puget estuary specimens leave no room for reasonable doubt that they are strictly congeneric with *Batissa*. Indeed a species of that genus which is now living upon the Fiji Islands is closely related to this fossil form.

Certain interesting relationships between Asiatic and North American faunas have been noticed by naturalists, which are recalled by this occurrence of *Batissa* in the Puget fauna. Assuming that these relationships are those of genetic succession, we naturally desire to know the direction of the lines along which their geographical dispersion took place. For example, was it toward, or from the present North American continent that the dispersion of *Batissa* has occurred? If it was from this continent, it is remarkable that none of its progeny have survived in any of the present continental waters; and it is equally remarkable that no evidence of its former existence in North America has been discovered except that which the Puget fauna has furnished. If the dispersion of *Batissa* was toward this continent, it seems to have only reached the present Pacific coast region about the close of the Cretaceous period, and to have there and then become extinct; while it has continued its existence on certain islands of the Pacific to the present time. But all the known facts concerning the genus *Batissa* are insufficient to throw much light upon its geological history or geographical dispersion. Even the Corbiculidæ, the family to which *Batissa* belongs has a less completely known geological history in North America than has the Unionidæ.