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ON THE
MESOZOIC AND CENOZOIC PALEONTOLOGY

OF

CALIFORNIA

BY



CHARLES A. WHITE M. D.



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NOTES ON THE MESOZOIC AND CENOZOIC PALEONTOLOGY OF CALIFORNIA.

BY CHARLES A. WHITE.

GENERAL REMARKS.

Having been for a number of years engaged in the study of those Mesozoic and Cenozoic formations of the United States which lie between the one hundredth and one hundred and fourteenth meridians, it became desirable that I should make some comparisons of them with the formations of similar age which are known to constitute important portions of the geological series as it is developed in the Pacific coast region. Dr. G. F. Becker, in charge of the Pacific division of the Survey, in the course of his investigations also found it necessary to the proper elucidation of certain of the problems involved in his work that some special paleontological studies should be made in connection with it. I therefore, by request of the Director, devoted the season of 1884 to such investigations as have a direct bearing upon the Mesozoic and Cenozoic formations of California, extending my field observations to numerous localities within that State and to certain localities in Oregon also. These investigations were pursued in association with Dr. Becker, who gave his attention to the more purely geological questions with which they are intimately connected. The results of our respective studies are published in companion bulletins of the Survey, Nos. 15, (the present one,) and 19.

While only a few months have been given especially to this work upon the Pacific coast, I have had the advantage of a previous acquaintance with the results of the labors of all other authors who have written upon the paleontology of California; and these advantages I deem sufficient warrant for the conclusions which I have reached, and for their publication in the present form. Upon undertaking this work the questions which seemed more especially to demand my attention were, first, the true geological age of the T^éjon Group of the California geologists, and its relation to such of the associated groups as they had also recognized, that is, the relation of that group to the Miocene above and to the Chico and Shasta Groups beneath; second, the relation between the Chico and the Shasta Groups; third, the relation of the Shasta Group to the other

Cretaceous formations, and to the so-called Auriferous Slates of California.

One of the principal obstacles to the satisfactory accomplishment of this work has been found in the fact that the fossil faunas of the Pacific coast region differ so greatly from those which are presumably of the same age respectively in other parts of the continent. Indeed, a conspicuous feature of the paleontology of that western region, at least as regards the formations from the Shasta, to the T^ejon Group, inclusive, is the great paucity, and perhaps the entire absence, of fossil species in those formations respectively which are identical with any that are found in formations presumably of the same age which lie to the eastward of that region.¹ Similar remarks will also apply to the Miocene and later deposits of the Pacific coast. Furthermore, the Carboniferous fauna of that region, so far as it is known, presents marked differences from that of any of the divisions of the Carboniferous series as it is known in other parts of North America. Therefore, in the paleontological study of the Pacific coast formations one must discuss their respective equivalent formations in other parts of the continent and in other parts of the world mainly with reference to the generic and family types which are represented in their respective faunas. This dissimilarity between the fossil faunas of corresponding formations of the Pacific coast region and of the central and eastern portions of this continent is quite as great as it is between corresponding formations in Eastern North America and Europe. In many cases, indeed, one may discuss questions concerning the equivalencies of formations in Eastern North America and Europe, respectively, with more confidence than similar questions concerning the formations of eastern and western portions of North America.

In discussing the paleontological questions here proposed I shall have frequent occasion to refer to geological structure; and it will be necessary for me to use in this connection the classification of strata which was proposed by the State geological survey of California for that region, and which has become generally accepted by geologists. A portion of that classification, however, was not regarded by the geologists of the California survey as fully established, and it was proposed by them only provisionally. It is proper for me to say in this connection that not only do these provisional portions of that classification still remain unsettled, but that I also find the limits, both faunal and stratigraphical, of a part of the formations which they fully recognized to be indefinite and of doubtful character.

My season's field work upon these formations has been in a good de-

¹ Some Chico fossils have, however, been found to the eastward of the Cascade Mountains, in Oregon; but the extent of the formation which contains them there, and its relation to the Cretaceous strata further eastward, is not known. See remarks on subsequent pages concerning the identification of California fossils with Eastern species; also remarks on the separation of contemporaneous Cretaceous faunas.

gree satisfactory, because I was able to collect in person many of the species of fossils which characterize the respective groups of strata, and because I was able to verify numerous unpublished observations previously made by Dr. Becker, besides many others which were made still earlier by Prof. J. D. Whitney, the results of which are published in the State Geological Reports of California.² In fact I have verified so many of the published observations of Professor Whitney that I do not hesitate to accept his statements in such other cases as I shall find it necessary to refer to in the following discussions.

I find the case somewhat different, however, as regards the work done by Mr. W. M. Gabb in connection with the geological survey of California; but the adverse views which I have formed in relation to it refer much more to the conclusions which he reached than to the published details of his observations and of his descriptive paleontology.³

Taking up the subjects which it is proposed to discuss in this article, in the order in which they are mentioned in a previous paragraph, we have first to consider the T^éjon Group. In his studies of the Mesozoic and Cenozoic formations of California, Mr. Gabb recognized four groups of strata as referable to the Cretaceous period; and this classification was officially adopted by the geological survey of that State. As one looks through the published writings of Mr. Gabb in relation to the grouping of the California strata, and their age and relations to the recognized groups of North America and Europe, a certain want of harmony appears in regard to the statements which he has made. I think it is only just to say that I regard this as largely due to the modification which his views necessarily underwent during the progress of his work, although he appears not to have made any explicit statements to that effect in any of his later publications. I shall therefore refer more especially to his later utterances, as I find them in the various publications to which he has contributed, especially in Vol. II, Paleontology of California, omitting as far as practicable material reference to his earlier views, although many of the discussions which have arisen in relation to them refer to the latter.

The following paragraphs, copied from Professor Whitney's preface to Vol. II, Paleontology of California, pp. xiii and xiv, give a concise account of those formations in accordance with Mr. Gabb's later views and as they were finally adopted by the State survey. It is these formations alone that I propose to discuss in this article, and I shall consider the other formations of that region only in their relation to these.

1. The T^éjon Group, the most modern member, the Division B of Paleontology, Vol. I, is peculiar to California. It is found most extensively developed in the vicinity of

²See Vols. I and II, Paleontology, and Vol. I, Geology of California.

³Mr. Gabb's work on the fossils of California is mainly contained in Vols. I and II of the Paleontology of California, but the following papers may be referred to for other discussions which relate to his work in that State: American Journal of Conchology, II, pp. 87-92; V, pp. 5-18; American Journal of Science, (2), XLIV, pp. 226-229; Proceedings of the California Academy of Science, III, pp. 301-306; V, pp. 7-8.

Fort Téton and about Martinez. From the latter locality it forms an almost continuous belt in the Coast Ranges to Marsh's, 15 miles east of Monte Diablo, where it sinks under the San Joaquin Plain. It was also discovered by different members of the survey at various points on the eastern face of the same range as far south as New Idria, and in the summer of 1866, by Mr. Gabb, in Mendocino County, near Round Valley, the latter locality being the most northern point at which it is yet known. It is the only coal-producing formation in California.

This group contains a large and highly characteristic series of fossils, the larger part peculiar to itself, while a considerable percentage is found to extend down into the next group, and several species still further down into the Chico Group. Mr. Gabb considers it as the probable equivalent of the Maestricht beds of Europe.

2. The Martinez Group is proposed provisionally, to include a series of beds, of small geographical extent, found at Martinez and on the northern flank of Monte Diablo. It may eventually prove to be worthy of ranking only as a subdivision of the Chico Group.

3. The Chico Group is one of the most extensive and important members of the Pacific coast Cretaceous. Its exact relations with the formation in Europe have not been fully determined, though it is on the horizon of either the Upper or Lower Chalk and may prove to be the equivalent of both. It is extensively represented in Shasta and Butte Counties and in the foot-hills of the Sierra Nevada as far south as Folsom, occurring also on the eastern face of the Coast Ranges bordering the Sacramento Valley, at Martinez, and again in Oristimba Cañon, in Stanislaus County. It includes all the known Cretaceous of Oregon and of the extreme northern portion of California, and is the coal-bearing formation of Vancouver's Island.

4. The Shasta Group is a provisional name, proposed to include a series of beds of different ages, but which, from our imperfect knowledge of the subject, cannot be separated; it includes all below the Chico Group. It contains fossils, seemingly representing ages from the Gault to the Neocomian, inclusive, and is found principally in the mountains west and northwest of the Sacramento Valley. Two or three of its characteristic fossils have been found in the vicinity of Monte Diablo, and one of the same species has been sent from Washington Territory, east of Puget Sound. Few or none of its fossils are known to extend upwards into the Chico Group.

THE CHICO-TÉJON SERIES.

It appears from Mr. Gabb's later publications that he recognized that all the strata from the base of the Chico Group to the top of the Téjon form an unbroken portion of the great geological series. And yet, with perhaps the exception of his Martinez division, which he proposed provisionally, he always discussed those divisions as if they were as distinctly definable as geological formations usually are. Geologists will probably always find it convenient to retain the names Téjon and Chico for the upper and lower portions of this series, respectively, but I have not been able to find any good reason for retaining the name Martinez Group for any portion of it. I shall therefore reject the Martinez Group so far as my own discussions of the series here referred to are concerned.

The first published fossils of that series of strata which afterward received from the California survey the name of Téjon Group were obtained by parties of the Pacific Railroad surveys, some thirty years ago. These fossils were described by Mr. T. A. Conrad in the reports of that survey, and by him referred to the Eocene Tertiary.⁴ So far as I am aware, he never changed his mind as to the geological age of these fossils, nor of the group of strata from which they and many others were afterward obtained. On the contrary, he repeated the publication of his views⁵ and strongly contended for their accuracy. Mr. Gabb alone, so far as I am aware, has published any of the fossils of the Téjon Group as of Cretaceous age; and this he did with a positiveness of assertion which, while it left no doubt as to his views, is only warranted in cases where the evidence is abundant and unquestionable from any reasonable standpoint.⁶

The publication of Mr. Gabb's views with the sanction and in the reports of the geological survey of California gave the matter so much the air of authority, that various authors accepted those views as to the Cretaceous age of the Téjon Group, and for several years after Conrad's death it was not seriously called in question.

Professor Dana, however, has practically called those views in question, suggesting that the Téjon Group is of Eocene age, and probably equivalent with the Laramie Group.⁷

⁴See Pacific Railroad Reports, Vol. V, pp. 317-329.

⁵See Amer. Jour. Sci., (2), XLIV, pp. 376-377; Amer. Jour. Conch., I, pp. 362-365; II, pp. 97-100; Smithsonian Check-List of Eocene Fossils.

⁶See especially Proc. California Acad. Sci., III, p. 301.

⁷See Dana's Manual of Geology (1876), p. 491.

In 1882, however, Prof. Angelo Heilprin, having access to the greater part of the type specimens of Mr. Gabb's species of the Téton Group, took up the study of the subject, and reached the conclusion that this group, as it was recognized by the California survey, is of Eocene Tertiary and not of Cretaceous age, and published his views in the Proceedings of the Academy of Natural Sciences of Philadelphia.⁸

This is the most elaborate and important paper that has been written upon the subject, and, as it accords mainly with the conclusions which I have reached, the reader is referred to it for many details which it is impracticable to present in this article. In that publication Professor Heilprin groups together all the species which have been referred to the Téton Group by Mr. Gabb, and shows that, although fragments of *Ammonites* have been found among them, being such as are usually referred to the Cretaceous, much the larger part of the species are such as are commonly regarded as distinctively tertiary.

A few months after the publication of Professor Heilprin's paper, Prof. Jules Marcou published in the Bulletin of the Geological Society of France, an article on the geology of California, as the results of his personal studies in that State several years ago. In this article Professor Marcou also contends for the Tertiary age of the Téton Group.⁹

The fossils published by Mr. Gabb in the two volumes of the Paleontology of California as characterizing the Téton Group comprise a large number of molluscan species. A small part of those species are so suggestive of a Cretaceous fauna, according to the hitherto accepted standards, that no paleontologist, viewing them separately, would hesitate to pronounce the strata from which they came as of Cretaceous age. Others of these fossils belong to genera which have so wide a range in time, that they are not relied upon by paleontologists as definite indices of geological periods. But the greater part of these published Téton species belong to genera which paleontologists are generally agreed upon as indicating the Tertiary age of the strata which bear them, as has been shown by Professor Heilprin.

Since in all other parts of the earth where the Mesozoic and Cenozoic strata have been fully studied the boundary, both faunal and stratigraphical, between the Upper Cretaceous and Lower Tertiary has been found to be well defined, many persons, apparently regarding that condition as the natural or normal one, have believed that the commingling of the Tertiary and Cretaceous types which was shown by Gabb's publications really did not originally exist in nature, but that it was due to some accidental or adventitious causes.¹⁰ While the commingling of Cretaceous with Tertiary types in the same strata probably does not

⁸See Proc. Acad. Nat. Sci. Philad. for 1882, pp. 195-214. This paper is also reproduced in Professor Heilprin's Contributions to the Tertiary Geology and Paleontology of the United States, 4^o, Philadelphia, 1884.

⁹See Bulletin de la Société Géologique de France, (3), t. XI, 1883, pp. 407-435.

¹⁰See Conrad's remarks, Am. Jour. Conch., II, pp. 98 *et seq.*

exist to as extreme a degree as seems to be indicated in some of Mr. Gabb's earlier writings, I am satisfied that such a commingling does exist to a large extent, as before indicated, and that an alternate commingling of species exists throughout the whole of the Chico-Téjon series. That the upper part of this series is almost purely of Eocene character, and that the lower part is as distinctly Cretaceous, is, I think, undeniable. Still, I am satisfied that no definable horizon exists in that series which will separate all the Cretaceous from the Tertiary, and that no lines can be drawn which will separate a median portion of the series, in which all the commingling of types takes place.

In all the publications of the California survey the fact is made apparent that no distinct line of demarkation, either paleontological or stratigraphical, has been recognized in separating the Téjon from the Chico Group; and yet Mr. Gabb constantly refused to admit that the California strata in question might really constitute a continuous series, embracing both Cretaceous and Tertiary strata.¹¹ Indeed, at that time such views would probably have found little favor among paleontologists if he had entertained and published them. He seems to have considered it necessary that any unbroken series of strata, however great, should be referred to one and the same period; and in this instance he chose the Cretaceous; while Professor Marcou seems to have chosen the Tertiary, and with quite as much if not more reason.

The results of my field work in California, including an examination of the localities from which Mr. Gabb obtained many of his type specimens of both Téjon and Chico species, have convinced me of the general accuracy of his statements as to the horizons from which his fossils came when he collected them himself. They have also confirmed my opinion that the unbroken series of strata which comprise the Chico and Téjon Groups of the California geologists represent together the closing epoch of the Cretaceous period and the opening or Eocene epoch of the Tertiary.

The most satisfactory illustration of the intimate stratigraphical connection between the Chico and Téjon Groups which I have examined occurs near New Idria, Fresno County, California, where an extensive series of strata embracing these two groups is fully exposed. My attention was called to this series by Dr. Becker, who had studied it as a part of the geology of the New Idria district, which he has investigated in connection with his work on the quicksilver deposits of the Pacific coast. The strata in question had also been studied by members of the State geological survey of California, and they embrace one or more of the localities from which Mr. Gabb obtained the types of some of his Téjon species of fossils. This series of strata is there well exposed, being comparatively free from soil or *débris*; is composed mainly of sandstones and sandy shales, and lies on the northern slope of the range of

¹¹ See especially Proc. Cal. Acad. Nat. Sci., III, pp. 302.

hills, the central mass of which is composed of the metamorphic strata which bear the quicksilver deposits of the New Idria mines. They dip to the northward, the angle of dip being high near their contact with the metamorphic series, upon which they rest unconformably, as shown by Dr. Becker; but the dip materially diminishes to the northward. From its contact with the metamorphic rocks the series in question extends northward a distance of about four miles, where it is apparently terminated by a fault, so that its connection with the Eocene is not there shown. From the contact with the metamorphic rocks before mentioned the thickness of this whole series of strata is estimated by Dr. Becker to be about 10,000 feet, and in my opinion it is no less.

Dr. Becker, with his assistants, carefully searched this whole series of strata for the purpose of collecting its fossils, and also to ascertain the conditions of its stratification. Upon the latter subject he reached the opinion that this whole assemblage of strata, nearly two miles in thickness, forms one continuous series from top to bottom, and that the sedimentation which resulted in the production of these strata was uninterrupted from the beginning to the end of the time in which it occurred. After a somewhat careful personal study of this series upon the ground, I have accepted Dr. Becker's conclusions as to the points just mentioned.

Although this New Idria series is understood to be practically an unbroken one, there is near its middle a recognizable change in the aspect of the strata, so that in appearance, and to some extent in the character of the stratification, the upper half differs from the lower half. It is upon this indistinctly definable horizon that Dr. Becker divided the series into two groups, for the purpose of arranging the results of his studies of them. So far as can be determined, this indistinct line accords with the necessarily artificial division that has been made of the series into the Chico and Téton Groups, since the series is recognized as containing only these two groups, and the line of demarkation between them, as before shown, cannot be expected to be distinct. Fossils were collected by Dr. Becker's party from various horizons in the series, but in a large portion of it none were found, and those from the lower or Chico portion are very few. These latter are, however, of characteristic types, being species of *Ammonites*, *Baculites*, *Trigonia*, *Inoceramus*, and *Lima*. It is proper to mention that in this New Idria series of strata no commingling of the Cretaceous species above referred to with Tertiary types of fossils was actually observed; but very few fossils of any kind were obtained at this locality, especially in the lower portion of the series. Still, the intimate relation of the Chico and Téton Groups for this particular locality is well shown by the unbroken character of the series of strata which here constitutes both groups.

The exact equivalents of this New Idria series of rocks are found in the vicinity of Martinez, in Contra Costa County, as well as in other parts of California. At Martinez and other localities a commingling of Cretaceous and Tertiary types such as has already been referred

to actually occurs ; but in all cases the Tertiary types appear to increase towards the upper part of the series and the Cretaceous types towards the lower part. In other words, it appears that the base of the series has a preponderance of Cretaceous types, and the upper part a preponderance of Tertiary.

Besides the evidence afforded by the character of the contained fossils, the opinion that the T \acute{e} jon Group really represents the Eocene is further supported in that no other representative of the strata of that epoch has been discovered in California, and also the Miocene strata everywhere rest conformably upon the T \acute{e} jon. This conformity was recognized by the members of the State geological survey of California, and it has also been observed in numerous cases by Dr. Becker, as well as in several instances by myself. One of these observations I made at the well-known T \acute{e} jon and Miocene locality at the head of Vallecitos Ca \acute{n} on, near the place mentioned as "Griswold's" in the California reports, which is only a few miles from the New Idria locality, just referred to.¹² I there satisfactorily traced the strata from one formation to the other, and found that not only is the conformity of the two formations with each other clearly apparent, but no break in the order of stratification could be detected between those layers which contain characteristic T \acute{e} jon fossils, on the one hand, and those which contain equally characteristic Miocene fossils, on the other. In short, I found no room there for the existence of any Eocene strata other than the T \acute{e} jon.

The character of the fossils which are found in the formation thus resting conformably upon the T \acute{e} jon is such that their Miocene age has never been called in question ; and the California geologists who regarded the T \acute{e} jon Group as of Cretaceous age necessarily considered the Eocene as unrepresented among the strata of that State. It is proper to say, however, that the difference between the T \acute{e} jon and Miocene faunas, as regards specific forms, is well marked ; so that, so far as I am aware, none of the species of the former pass up into the latter formation. A few of the species of each of the two formations are closely related, and it is possible that some of them may yet prove to be specifically identical. While the Miocene strata of California seem to have been deposited upon the T \acute{e} jon Group by continuous sedimentation, these two groups are not so intimately related by their fossils as the T \acute{e} jon and the Chico Groups are. Still, I am of the opinion that this faunal difference between the T \acute{e} jon and the Miocene strata does not necessarily represent a material difference of time.

From the foregoing remarks it will be seen that there exists in California a conformable and intimately connected series of strata representing the latest epoch of the Cretaceous period to the Miocene, inclusive. The base of this series, as shown by Dr. Becker, rests unconform-

¹² See Geology of California, Vol. I, p. 56.

ably upon all the other rocks with which it has been found in contact, and, as shown by the California reports, the Pliocene rests unconformably upon the Miocene.

No proposition seems to me to be more reasonable than that wherever any portion of the great geological series is complete the line of demarcation between any of the formations must necessarily be indistinct, and that there will be a commingling of the species which any two adjacent formations contain, upon both sides of any such line as may be recognized. Such a condition of things would as naturally exist in strata representing the confines of any two geological ages as in the case of those of any two formations of any one age. Therefore, if the geological series is complete, there ought to be no greater break between the Cretaceous and the Tertiary than between any of the subdivisions of either. It is nevertheless true that geologists have always recognized a marked paleontological break between the uppermost Cretaceous and the lowermost Tertiary strata, both in this country and in Europe. Sir Charles Lyell remarks as follows upon this subject, and the statements of other European authors are to the same effect:

The marked discordance in the fossils of the Tertiary as compared with the Cretaceous formations has long induced many geologists to suspect that an indefinite series of ages elapsed between the respective periods of their origin. Measured, indeed, by such a standard, that is to say, by the amount of change in the fauna and flora of the earth effected in the interval, the time between the Cretaceous and the Eocene may have been as great as that between the Eocene and Recent periods.¹³

The Maestricht, Faxoe, and other beds of Europe, although they are intermediate between the Upper Chalk and the Eocene, are too closely related by specific and generic forms to the Chalk to be regarded as separate from the Cretaceous proper. Their faunal relations to the Eocene are also too remote to allow of their being regarded as in any proper sense transitional between the Cretaceous and Tertiary. In New Zealand, however, it appears probable from the reports of the Government geological surveys that there is in those great islands a true transition from the Cretaceous to the Tertiary, similar to that which occurs in California.

I think the evidence which has been adduced to show the Eocene age of the upper or T^éjon portion of the Chico-T^éjon series is as conclusive as any evidence of that kind can be. Now, if we apply the paleontological standard for indicating the age of formations which is generally accepted by geologists, we necessarily refer the fossils of the lower or Chico portion of that series to the Cretaceous. The question then arises: to what portion of the full Cretaceous series, as it is recognized in other parts of the world, is the Chico Group really equivalent? If the T^éjon Group is Eocene, it is plain that the Chico Group represents the upper portion of the Cretaceous, and it necessarily represents the very latest portion of that period. My opinion, therefore, is that it

¹³ See Lyell's *Elements of Geology* (1871), p. 281.

is, at least in part, later than any formation that has yet been referred to the Cretaceous period either in Europe or in America; and that it practically fills the gap which is indicated by the passages just quoted from Sir Charles Lyell.

An examination of the figures and descriptions of the fossils which Mr. Gabb has referred to the Chico Group, together with his catalogue of California Cretaceous fossils,¹⁴ shows that while a considerable portion of them, especially the Cephalopoda, are of types which indicate their Cretaceous age, a large part of them are of genera which are known to range from the early Cretaceous to the present time, and some of them belong to genera which are generally accepted as not older than the Tertiary. Therefore there appears to be no inherent reason why this Chico fauna, even as it is represented by Mr. Gabb, should not be regarded as belonging to the very latest portion of the Cretaceous period. The fact that one or two Mesozoic types of Cephalopods pass up from these strata into those of the Téjon portion does not necessarily prove that the latter ought also to be referred to the Cretaceous, any more than the discovery of *Ammonites* in the Carboniferous of Texas and of India ought to require us to refer those strata to the Mesozoic.

The intimate relation to each other of all the strata of this great Chico-Téjon series, as shown by the mixed character of its fossils, is very perplexing when that condition is considered in relation to the established taxonomy of the formations, but it is very suggestive when considered with reference to a search after the complete sequence of geological events. Indeed, such a condition of things is what one ought to expect to find somewhere; but hitherto no other part of the world, if we except New Zealand, has furnished so striking an example of the intimate connection of two geological ages, or at least of such connection between the Cretaceous and the Tertiary.

¹⁴ See Vols. I and II, Paleontology of California, for the figures and descriptions, and Vol. II, pp. 209-254, for the catalogue.

THE SHASTA GROUP.

When Vol. I of the *Paleontology of California* was published it appears that the Shasta Group was not recognized by the California geologists. At that time Mr. Gabb divided the rocks which he referred to the Cretaceous period into two portions, which he designated respectively as Divisions A and B.¹⁵ His line of separation between these two divisions was the same as that by which he afterwards separated his Téjon and Chico groups.¹⁶ A part of the fossils which he published in Vol. I as belonging to Division A belong really to the Shasta Group,¹⁷ the separate existence of which he had not then recognized. He did not then recognize these Shasta fossils as belonging to the age of the Gault or Neocomian, as he afterwards did, but he regarded all the Cretaceous strata of California as representing the epoch of the White Chalk of Europe.¹⁸ For this classification of the California strata, however, he afterward, in Vol. II, substituted that which has already been quoted on page 9. In Vol. II the Shasta Group is proposed to receive all the Cretaceous strata of that region which are older than the Chico Group. The entire separateness of the Shasta from the Chico Group is there recognized, and it is also stated to embrace strata of different epochs, probably representing a range from the Gault to the Neocomian.¹⁹ This latter view I am disposed to adopt as at least approximately correct, although it is not yet clear what division ought to be made of the strata that have been grouped together under the name of the Shasta Group; but this question will be discussed further on.

Whatever may be the relation of the Shasta strata among themselves, it seems to be certain that there is an abrupt hiatus, both stratigraphical and paleontological, between the Shasta Group and the Chico Group, the former representing a portion of the period not later than its middle, and the latter its closing portion. It has been generally understood that the marine Cretaceous deposits of the United States, as they are found in the Atlantic, Gulf border, and interior regions, represent only the Upper Cretaceous of Europe, none of them probably being any older than, if so old, as the Gault. If, then, the Chico is, as it is

¹⁵ See *Paleontology of California*, I, p. xix, and *Proceedings of the California Academy of Sciences*, III, p. 302.

¹⁶ See *Paleontology of California*, II, p. xiii.

¹⁷ See especially the *Cephalopoda*, published in Vol. I, *Paleontology of California*.

¹⁸ See *Paleontology of California*, I, p. xix.

¹⁹ See *Paleontology of California*, II, p. xiv.

here assumed to be, later than any other Cretaceous strata known in Europe or America, and the Shasta Group is as old as the Gault, or older, we have a hiatus in the California Cretaceous series which is equal to all the time in which all the other known Cretaceous deposits of the United States were formed. Although such a conclusion seems to be a plausible one from our present methods of reasoning, we unfortunately lack the proof of it which specific identity of Cretaceous fossils on each side of the Sierras would afford. It is proper in this connection also to state that Mr. Gabb reports three species of Cephalopoda as common to the Shasta and Chico Groups, namely, *Ammonites batesii*, *A. renundii*, and *Ancylloceras lineatus*.²⁰ If Mr. Gabb is correct in these references, it seems to point to a closer faunal relation between the Chico Group and the Horsetown beds of the Shasta Group than would be expected were the hiatus between them as great as is implied by referring the latter to the age of the Gault and the former to the latest portion of the Cretaceous period.

The strata which received the name of Shasta Group from the geologists of the State survey of California occupy only a few isolated areas in that State. Each of these areas is not only of small geographical extent, but the strata in every case are either unconformable with the rocks both above and below them, or they are so much disturbed that their stratigraphical relations are obscure. The strata of these separated portions of the Shasta Group of California, judged by the fossils which they respectively contain, seem to represent at least two epochs of the Cretaceous period. Our knowledge of those strata and their fossils is not quite sufficient to warrant the formal separation of the former into two distinct groups, in the sense in which that name for assemblages of strata is generally used, but two divisions are plainly indicated by the fossils. I shall therefore, for the present, retain the name of Shasta Group in the general sense in which it was used by the geologists of the California survey; but for the purpose of convenience in the references which I must necessarily make in this article to those two divisions, I shall designate them as the Horsetown beds and the Knoxville beds, respectively. These names are suggested by the two localities from which the best collections of the fossils of each of these two divisions were obtained.

The Horsetown beds have been found mainly in Shasta County and the Knoxville beds mainly in Lake, Colusa, Contra Costa, and Santa Clara Counties. These two divisions have never been found in contact, nor under such circumstances as will enable us to say with certainty which of the two is the older. From paleontological considerations, however, the character of which will appear further on, I am inclined to regard the Knoxville beds as older than the Horsetown beds. The

²⁰ Mr. H. W. Turner has also found an Ammonite in the Chico Group near Monte Diablo which, if not specifically identical with *Ammonites stoliczkanus* Gabb, is very closely related to it. The original specimens came from the Shasta Group.

latter, although they have a much less known geographical extent, certainly contain a more abundant and varied fauna than the former. It is especially rich in the Cephalopoda, as will appear by referring to the California reports, where the fossils of this division are recorded as coming from "the North Fork of Cottonwood Creek, Horsetown," etc. Furthermore, many of the types which the fauna of the Horsetown beds embraces are such as paleontologists use with more confidence as indices of the geological position of the strata containing them than they do any of those which are embraced by the fauna of the Knoxville beds, as it is at present known.

The following species which were published by Mr. Gabb in the California reports are regarded as having come from the Knoxville beds at different localities in California. The interrogation marks after three of them express a doubt as to the correctness of my identification of the species, Mr. Gabb having obtained his type specimens of those species from the Horsetown beds. All the other species which are mentioned in Gabb's Catalogue of California Cretaceous Fossils as belonging to the Shasta Group²¹ I regard as having come from the Horsetown beds.

The following is a list of the species just referred to:

- Ammonites ramosus* Meek ?
- Belemnites impressus* Gabb.
- Palæotractus crassus* G.
- Cordiaera mitraiformis* G.
- Atresius liratus* G.
- Potamides diadema* G. ?
- Ringinella polita* G.
- Liocium punctatum* G.
- Modiola major* G.
- Aucella piochii* G.
- Rhynchonella whitneyi* G.
- Lima shastaensis* G. ?
- Pecten complexicosta* G.

In addition to these published species the following have been generically recognized among the collections which have been obtained by Dr. Becker and his party from Knoxville, Cal., all the specimens of which are, however, too imperfect for specific determination: *Ammonites*?, *Margarita*?, *Dentalium*, *Arca*, *Nuculana*, and *Rhynchonella*. Besides all these forms there are fragments among the collections from Knoxville which indicate two or three other molluscan species which are not considered in my enumeration of the fauna of the Knoxville beds. The specimens which have been referred to as probably representing a species of *Ammonites* are only a few small fragments, which show only portions of the sides and periphery of the shell. These seem to indicate a species

²¹ See Paleontology of California, II, pp. 209-254.

related to the *A. newberryi* of Meek. The *Dentalium* is probably undescribed, as are also probably the *Arca* and *Nuculana*. The *Rhynchonella* is apparently an undescribed species, and seems to be identical with one which I discovered last summer at Horsetown.²² The collection contains only one fragment of the shell which I have referred with doubt to *Margarita*.

The specimens of *Ammonites* which in the foregoing list of published species I have referred with doubt to *A. ramosus* Meek consist only of the small inner whorls, none of them reaching an inch in diameter. The form, surface markings, and septa of the shell, so far as these characters are shown by the Knoxville specimens, seem, however, to agree well with those of the species as it is described by both Meek and Gabb. Meek's type specimens came from Vancouver's Island, but Gabb identified the species in the Horsetown beds of the Shasta Group of California.²³ The specimens of the shell which in the foregoing list I refer with doubt to the *Potamides diadema* of Gabb are imbedded in compact rock, so that all its characters cannot be observed. They are probably identical with Gabb's species, which he describes as coming from the Horsetown beds. Finally, so far as the specific identity of any *Belemnites* can be determined, there seems to be comparatively little reason to doubt that the specimens which have been found in the Horsetown and Knoxville beds, respectively, and referred to *Belemnites impressus* Gabb, are specifically identical.

Comparing these nineteen species of fossils now known to exist in the Knoxville beds with those from the Horsetown beds, or, in other words, with all the other species which Gabb refers to the Shasta Group,²⁴ we find that all except six of them are certainly different from any of the latter. One of these six, the *Ammonites newberryi*??, offers only a mere suggestion of identity; four are probably, but not certainly, identical, namely *Ammonites ramosus*?, *Potamides diadema*?, *Lima shastaensis*?, and *Rhynchonella* — ?; and the specific identity of one, *Belemnites impressus*, has been regarded as certain. Detracting somewhat from the certainty of the last identification we have the fact that the *Belemnites*, as a rule, do not present salient or even satisfactory features by which to determine specific differences.

The dissimilarity between the faunas of the Knoxville and the Horsetown beds is still further shown by the abundance of *Aucella* in the former and its absence from the latter, so far as is now known, and also by the greater abundance of the species which characterize the Horsetown beds and their general dissimilarity when compared with the few species which are yet known from the Knoxville beds. It is

²² This form is closely like the *R. oxyoplicata* of Fischer, from the Jurassic of Moscow.

²³ See Bull. U. S. Geol. Sur. Terr. (1876), II, p. 371, Pl. V, Fig. 1; also Paleont. California, I, p. 65, Pl. XI, Fig. 13, and Pl. XII, Fig. 12b.

²⁴ See Gabb's Catalogue Paleont. California, II, pp. 209-254.

possible that the *Aucella* may yet be found to range up into the Horsetown beds, but even in that case there would remain a material difference between the faunas of the two divisions.

These differences between the faunas of the Knoxville and the Horsetown beds seem to indicate plainly that they were not synchronously deposited; but, as before remarked, there is yet no known stratigraphical proof as to which is the older. The character of the fossils of the respective faunas seems to indicate, however, that the Knoxville are older than the Horsetown beds; that is, the fossils of the Horsetown beds appear to represent the Gault, while the presence of *Aucella* in the Knoxville beds only would seem to indicate an age for them at least as early as the Neocomian. Furthermore, the affinities of some of the fossils of the Horsetown beds are with those of certain of the later Cretaceous formations to the eastward of the Sierras, while no such affinities have been recognized for any of the Knoxville fauna, with the doubtful exception of *Ammonites complexus*. In this article I shall take the foregoing view of the relative ages of the Knoxville and the Horsetown beds, although it implies the probable existence of a considerable hiatus between the two divisions of what is now known as the Shasta Group.

RELATIONS OF THE SHASTA GROUP TO STRATA BEYOND THE LIMITS OF CALIFORNIA.

Certain of the species which characterize the strata of the Shasta Group in California have been recognized among the collections which have been reported by different persons from Washington Territory and British Columbia, and also from Alaska and the Aleutian Islands. But none of the species of that group have been found in any North American strata to the eastward of the Pacific coast region, if we except Greenland. While it is probable that the Horsetown beds of California are represented in those northern localities which have been referred to, it is more especially the equivalent of the fauna of the Knoxville beds that has been recognized as existing there. This recognition is mainly through the identification, among the collections which have been made there, of the *Aucella*, which so strongly characterizes the Knoxville division of the Shasta Group in California. Specimens which I regard as specifically identical with the form which Mr. Gabb published under the name of *Aucella piochii* have been presented to the Survey by Prof. Thomas Condon, which he collected at Puget Sound, Washington Territory. Mr. Whiteaves refers to the same species as being abundant at Tatlayoco Lake and other places in British Columbia;²⁵ and Professor Eichwald, Dr. P. Fischer, and myself have pub-

²⁵ See Trans. Roy. Soc. Canada, Sec. IV, 1882, p. 84.

lished forms which I regard as specifically identical with it, from different parts of Alaska.

Among the fossils collected in Alaska by Peter Doroschin, Eichwald²⁶ recognized all the forms of *Aucella* which Keyserling had published as occurring in Russia, namely, *A. concentrica* Fischer, *A. mosquensis* Von Buch, *A. pallasi* and *A. crassicollis* Keyserling. The last two he regards as only varieties of *A. concentrica*. Dr. Fischer²⁷ recognized only one species among Pinart's Alaskan collections, which he referred to *A. concentrica*.

I also recognized only one species among the collections brought from Alaska by Mr. Dall. Although the specimens were numerous, and presented quite a wide variation of form, I regarded them all as representing a variety of *Aucella concentrica*.²⁸ Mr. Whiteaves (loc. cit.) recognized only one species among the collections from British Columbia, and this he referred to *Aucella mosquensis*.

In the Knoxville beds of California there are two recognizable varieties of *Aucella*, which, while they are connected together more or less closely by intermediate forms, are still quite different in extreme examples. It is usually the case also that one variety will be found to prevail in certain layers of rock sometimes almost exclusively, and the other variety in other layers.

Adult examples of one of these varieties are large, robust, and often inflated. These I regard as approaching the typical forms of *A. concentrica* more nearly than the others. Those of the other variety are smaller, more slender, and have a more delicate appearance. They seem to correspond more nearly with the type of *A. mosquensis*. Still, after examining numerous examples from Alaska, British America, Washington Territory, and California, besides some Russian examples of *A. concentrica* and *A. mosquensis*, which I regard as being authentic, in the collections of the Smithsonian Institution, I am of the opinion that all of them represent only one species. Indeed, I am disposed to regard as at most only varieties of one species all the forms which have, from various authors, received the names *Aucella concentrica*, *A. mosquensis*, *A. pallasi*, *A. crassicollis*, *A. piochii*, and *A. erringtonii*. However, it will be convenient, when discussing the *Aucella*-bearing strata of California, to retain the names *A. concentrica* and *A. mosquensis* to indicate the more robust and the more elongate forms, respectively, as they occur in that State.

Before dismissing this reference to *Aucella*, it is well to note how wide is the geographical distribution of the variable form which has been known under the various names which have just been mentioned. This

²⁶See Geognost. Palaeont. Bemerkungen ueber die Halbinsel Mangischlak und die Aleutischen Inseln, pp. 185-187, Pl. XVII.

²⁷See Voyage à la côte Nord-Ouest de l'Amérique, par M. Alph.-L. Pinart, pp. 33-36, Pl. A.

²⁸See Bull. U. S. Geol. Survey, No. 4 (1884), pp. 13, 14, Pl. VI.

shell was first known in various parts of Russia, and subsequently upon the eastern coast of the Caspian Sea,²⁹ in Northern Siberia,³⁰ on the island of Spitzbergen,³¹ on Kuhn Island (off the east coast of Greenland),³² and in Alaska, British Columbia, Washington Territory, and southward to Central California, as mentioned on previous pages of this article. Although it is so variable in certain of its features, so constant is it in its general characteristics and its separateness from related forms that paleontologists are now generally agreed upon its identity in all the widely separated localities which have just been indicated.

RELATION OF THE FAUNA OF THE AURIFEROUS SLATES TO THAT OF THE SHASTA GROUP.

The opinion that *Aucella erringtonii* and *A. piochii* Gabb are specifically identical has been formed after having had better advantages for investigating the subject than seem to have been enjoyed by any other person who has written upon the paleontology of California. I have not only examined the original types of those two forms, but hundreds of other specimens of *A. piochii* from Gabb's original and from other localities. Furthermore, I made a personal visit to the locality on the Mariposa Estate where the type specimens of *A. erringtonii* were obtained, and collected better specimens of it from the Auriferous Slates there and in the immediate neighborhood than have before been known. Dr. Becker and his assistant, Mr. H. W. Turner, accompanied me on that visit, when we also obtained from the same slates some fragments of an Ammonite, some impressions of a shell apparently the *Pholadomya orbiculata* of Gabb, others that represent a species of the Pectinidæ, perhaps the *Amusium aurium* of Meek, and still others which are undeterminable. Add to these the *Belemnites pacificus* of Gabb, and we have a fauna of the Auriferous Slates of the Mariposa Estate which amounts to at least five species of mollusks. It is true that only the *Aucella* has been satisfactorily identified as occurring in both the Auriferous Slates³³ and

²⁹See Eichwald's Geognost. Palaeont. Bemerkungen ueber die Halbinsel Mangischlak und die Aleutischen Inseln, p. 53.

³⁰See Middendorf's Reise in den aussersten Norden und Osten Sibiriens, erster Band, Theil I, p. 255.

³¹See Lindström, Om Trias-och Juraförsteningar från Spetsbergen. Kongl. Svenska Vetenskaps-Akad. Handlingar, VI, No. 6, p. 14.

³²See F. Toula, Die zweite deutsche Nordpolarfahrt, II, pp. 497-505; also Quart. Jour. Geol. Soc. Lond., XXXIV (1876), p. 560.

³³Some of the specimens found in the Auriferous Slates of the Mariposa Estate show more or less distinct radiating lines, and I have observed the same peculiarity among examples from the Knoxville beds, as well as among Russian and Alaskan examples.

the Shasta Group, but there is nothing in the character of the other four species of mollusks from the Auriferous Slates which would render inconsistent their reference to the age of the Knoxville beds.

The specimens of *Aucella* and other Auriferous Slate species just referred to were obtained by us from the rocks *in situ*; those found near the left bank of the Merced River, Mariposa County, California, about a quarter of a mile below Benton's Mills, being especially satisfactory, as regards both their position in the strata and their condition of preservation. Here the strata have an almost vertical dip, and they are plainly an integral part of the great Auriferous Slate series. A part of our collection, as well as some of those which were collected by King, Gabb, and Miss Errington, were obtained from within a few feet of the famous great quartz vein which traverses the Mariposa Estate, and which is inclosed in the Auriferous Slates.

I did not obtain any specimens of *Belemnites* from the Auriferous Slates, as Gabb and King did, and I have not seen a specimen of Gabb's *B. pacificus*, which he obtained from that formation, but which he did not figure. Judging from his description of that species, it seems probable that it is identical with my subsequently published *B. macritatis*. This last-named form was obtained by Mr. Dall in Alaska, where he found it associated with an abundance of specimens of the shell which I described in the same publication as *Aucella concentrica* var.,³⁴ and which, as already stated, I regard as identical with both *A. erringtonii* and *A. piochii*.

The great Auriferous Slate series is an immensely thick one, and in Northern California it is known to include strata of Carboniferous age. In Shasta County there is a considerable thickness of strata, apparently a portion of that great series which holds a position below the Carboniferous and between it and the Granite. These strata perhaps represent a still older Paleozoic formation; but no fossils have been found in them. The strata of the great Auriferous Slate series which are actually or presumably referable to Paleozoic age it is not my present purpose to discuss. Indeed, my only object with reference to that great series is to show that at least a part of it is of the same age as the Knoxville beds of the Shasta Group. This I think is proved by the identity of *Aucella piochii* and *A. erringtonii*, supported by the general character of the other fossils which the strata of both respectively bear. It is true that this is the only specific identification that has been made; but the species in question is one of extraordinarily wide geographical range, and it is also one of great constancy and exclusiveness as regards its distinguishing characteristics.

³⁴ See Bull. U. S. Geol. Survey, No. 4, p. 13, Pl. VI.

THE GEOLOGICAL AGE OF THE AUCELLA-BEARING STRATA OF CALIFORNIA.

Now, as to the true geological age of the *Aucella*-bearing strata of California I think the evidence is not wholly satisfactory. A discussion of this question for the Pacific coast region really involves a discussion of the whole question of the age of the *Aucella*-bearing rocks of Europe, Asia, and North America. In view of my want of personal knowledge of the geology of those distant regions, and the great difference of opinion on this subject among geologists of repute, I am not prepared to discuss the question fully. Still, I am inclined to hold the view which I expressed in Bulletin No. 4, that these California strata and their Alaskan and British Columbian equivalents occupy a position upon the confines of both the Jurassic and the Neocomian. I suspect that the difference of opinion which has been referred to has arisen largely from the equivocal character of the faunas which are associated with *Aucella* in those districts concerning the strata of which the disputes have arisen. Eichwald and Whiteaves both contend that all the strata which bear *Aucella concentrica* and *A. mosquensis* are certainly of Neocomian age. On the other hand, Keyserling, Trautschold, D'Orbigny, and others as confidently assert that they are of Jurassic age; and paleontologists generally have hitherto regarded *Aucella* as an exclusively Jurassic genus. Even so late as the past year, Mr. A. Pavlow, a member of the official geological commission of Russia, has, in a brief publication, placed the well-known strata which in eastern and other parts of Russia bear *Aucella concentrica* in the Jurassic series, as the earlier Russian geologists also did.³⁵

I do not think that any satisfactory evidence has yet been presented to show that the genus *Aucella* is exclusively confined to either the Jurassic or the Neocomian, and I know of no reason why we may not expect to find species of it in both Jurassic and Neocomian strata. There seems to me also to be no good reason why *Aucella concentrica* and *A. mosquensis* may not exist in Jurassic strata in Europe and Asia and in the Neocomian in America. It is well known that a considerable number of the Lower Carboniferous species of Europe are found in the Upper Carboniferous of North America; and also that certain species pass from the Devonian to the Carboniferous.

If it shall finally appear that those strata of the Auriferous Slate series which bear *Aucella erringtonii*, together with their equivalents, must be referred to the Neocomian rather than to the Jurassic, the existence of Jurassic strata in California is exceedingly doubtful, because all the other strata in that State which have been referred to the Jurassic are probably equivalent with these.

³⁵ See Bull. Soc. Géol. de France, t. XII (sér. 3), June, 1884, pp. 686-696.

CERTAIN CRETACEOUS STRATA WHICH APPARENTLY BELONG BETWEEN THE SHASTA AND CHICO THE GROUP.

Dr. Becker has obtained from strata exposed near the sea-shore at Wallala, Mendocino County, California, a small collection of fossils which are evidently of Cretaceous age, but all the species of which are apparently new, and different from any of those which have been found in either the Chico, or Shasta the Group. They seem to represent a different group of strata from any other fauna of which has yet been published; and as the Rudistæ are usually regarded as characteristic of the median Cretaceous, this small fauna is supposed to belong to a series of strata which intervenes between the Shasta, and Chico the Group. Dr. Becker found no contact between the Chico and these beds, which lie unconformably upon metamorphic rocks, probably of the Knoxville series. The specimens are all in a bad state of preservation, but the following genera have been recognized: *Sphærulites?*, *Ostrea*, *Inoceramus*, *Pecten*, *Cylichna*, *Turritella*, and *Solarium*.

Only two of these species, the *Inoceramus* and *Sphærulites*, appear to be sufficiently characteristic to call for any special remarks. The *Inoceramus* is a very large, subelliptical, subdiscoidal form. The specimens are all much broken, but some of them indicate that the valves sometimes reached nearly a foot in diameter.

It is possible that the form which I have regarded as a species of *Sphærulites* belongs to the genus *Radiolites*, but so far as its generic character can be determined from the crushed and fragmentary specimens, it appears to belong to the former genus. Upon comparing them with some specimens which were sent to the U. S. National Museum by Mr. C. R. Orcutt, from Todos Santos Bay, near San Diego, California, I am quite confident they belong to the same species. The other species which Mr. Orcutt found associated with the San Diego specimens were few, but they are suggestive of certain forms found in the Gosaugebilde of Europe.

REMARKS UPON CERTAIN CALIFORNIA FOSSILS WHICH HAVE BEEN IDENTIFIED WITH EASTERN SPECIES.

Reference has already been made to those species found in California rocks which have been either definitely or provisionally identified with species already known in Cretaceous strata east of the Sierra Nevada. The following is a list of them, together with such remarks as seem to be called for in this connection:

NAUTILUS TEXANUS Shumard.

Dr. Shumard's type specimens of this species were from Texas. He described it in the transactions of the Saint Louis Academy of Science,

I, p. 590, but it was never figured by him. Mr. Gabb referred his California specimens only provisionally to *N. texanus*, and also doubtfully to the Shasta Group.³⁶ After examining specimens from Shumard's original locality which I presume to belong to this species, I think it is not identical with the California form.

AMMONITES PERUVIANUS Von Buch.³⁷

Mr. Gabb, with much doubt, referred a fragment which he obtained from the Chico Group of California³⁸ to the above-named species, as it has been recognized in Texas and the adjacent region. After an examination of Mr. Gabb's specimen, and also several authentic examples of the Texan form, I think Mr. Gabb might have expressed his doubts in even stronger terms.

AMMONITES COMPLEXUS Hall & Meek.³⁹

This species was originally described from the Cretaceous No. 4 of Meek & Hayden, at the Great Bend of the Upper Missouri River. Meek afterwards recognize a variety of it among some collections from Vancouver's Island, to which he gave the variety name *suciaensis*.⁴⁰ Gabb found a fragment of an Ammonite in the Chico Group of California which he identified with that variety.⁴¹

There is much reason to doubt whether the Upper Missouri form and that of Vancouver's Island are specifically identical. Also the identification of the Californian and Vancouver's Island forms is not quite satisfactory, although it may be correct.

VOLUTILITHES NAVARROENSIS Shumard.⁴²

Shumard's shell was described from Cretaceous strata in Texas which are equivalent with the Ripley Group of Mississippi and Alabama. It has never been figured, and Mr. Gabb's comparisons were made only with Shumard's description.⁴³ He mentions some differences, and it is probable that others would appear if good and authentic specimens from both the eastern and the western strata could be compared.

TURRITELLA SAFFORDI Gabb.⁴⁴

From the figures given by Gabb in the two publications here cited, it is evident that the eastern and western forms are closely related, and it may be that it will not be practicable to say that they are different.

³⁶ See Paleontology of California, I, p. 59, and II, p. 209.

³⁷ See Marcou's Geology of North America, p. 34, Pl. V. Fig. 1.

³⁸ See Paleontology of California, I, p. 63.

³⁹ See Memoirs Am. Acad. Arts and Sciences, V (n. s.), p. 394.

⁴⁰ See Proc. Acad. Nat. Sci. Philad. for 1861, p. 317.

⁴¹ See Paleontology of California, I, p. 69, and II, p. 133.

⁴² See Proc. Bost. Soc. Nat. Hist., VIII, p. 192.

⁴³ See Paleontology of California, I, p. 102, Pl. XIX, Fig. 56.

⁴⁴ See Paleontology of California, I, p. 135, Pl. XI, Fig. 93; also Jour. Acad. Nat. Sci. Philad. (n. s.), IV, p. 392, Pl. LXVIII, Fig. 12.

TURRITELLA SERIATIM-GRANULATA Roemer.⁴⁵

Mr. Gabb, in his Catalogue of the Cretaceous Fossils of California,⁴⁶ records this species, which was originally described from Texas, as among the fossils of the Shasta Group; but he gives neither description nor figure of the California shell.

TURRITELLA UVASANA Conrad.

This is one of the most common and characteristic species of the Téjon Group of California. In Vol. IV, United States Explorations and Surveys West of the One Hundredth Meridian, p. 195, pl. XVIII, figs. 1, *a* and *b*, I identified a shell from the Cretaceous of Southern Utah with this species. I am now satisfied that this reference was not correct, and also that the Utah shell comes from quite a different horizon.

NUCULANA GABBI Conrad.

Gabb originally described and figured this shell from the Cretaceous of New Jersey, under the name of *Leda protexta*.⁴⁷ The specific name being a synonym, Conrad changed it to *gabbi*, and placed it under *Nuculana*. Gabb referred a shell from his Martinez and Téjon Groups, in California, to this species.⁴⁸ A comparison of Gabb's figures of the two forms (loc. cit.) will, I think, convince any one that they furnish no ground for the opinion that they are specifically identical.

GRYPHÆA VESICULARIS Lamarck.

Of this species Gabb says, in Paleontology of California, Vol. I, p. 205: "A few small specimens of this species were picked up not *in situ*, near San Diego, by Dr. Cooper. It has not been found elsewhere on the west coast."

From the foregoing statements with regard to these fossils, it is plain that the identification which has been made of them is of too doubtful a character to base any generalizations upon it as to the equivalency of any of the California Cretaceous strata with any strata of that period in Central and Eastern North America. Perhaps, with our present limited knowledge of the subject, one would not be fully justified in saying positively that Mr. Gabb was wrong in all these identifications; but the proof of identity is not satisfactory in the case of any of the species. That they are closely similar to the species to which he refers them is true, but satisfactory proof of such identity as would indicate the contemporaneous origin of the strata respectively containing them is certainly wanting.

⁴⁵ See Kreidebildungen von Texas, p. 39, Pl. IV, Fig. 12.

⁴⁶ See Paleontology of California, II, p. 227.

⁴⁷ See Jour. Acad. Nat. Sci. Philad. (n. s.), IV, p. 303, Pl. XLVIII, Fig. 23.

⁴⁸ See Paleontology of California, I, p. 199, Pl. XXVI, Fig. 185; also II, p. 250.

ON THE SEPARATION OF CONTEMPORANEOUS CRETACEOUS FAUNAS
IN WESTERN NORTH AMERICA.

Of the various conditions which limit the distribution of marine faunas, the intervention of land-barriers may be regarded as necessarily the most effective, and if such barriers are of great extent they may be well nigh absolute. And yet it is well known that certain fossil as well as living species of marine mollusks have reached an almost world-wide distribution, notwithstanding the intervention of great continental areas. Still, if in the course of the paleontological investigation of any region we find that certain formations in different parts of it which are presumably of the same geological age present a marked difference in the marine molluscan species which each formation respectively contains, it is natural to infer that those faunas, when living, were separated by a land barrier of considerable extent.

The facts which I have observed in Western North America indicate that such a barrier existed during the Mesozoic age in the form of a comparatively narrow continental belt, having a northward and southward trend, which then almost, if not quite, completely separated the respective marine faunas which simultaneously existed upon either side. The former existence of a western continental area, which finally blended with the remainder of the continent, has long been recognized, and I shall not in this connection discuss its existence previous to the Cretaceous period further than to say that there are marked differences between the Carboniferous fauna of California and that of the great continental area to the eastward of the Pacific coast region. At the close of the Knoxville (probably Neocomian) epoch, the western edge of the continental area cannot have been far removed from its present position. At the beginning of the Chico epoch its western boundary was not further westward than the western base of the Sierra Nevada, and at the close of the Lower Cretaceous its eastern boundary was not further eastward than the eastern base of the Rocky Mountain Range in Montana to the northward, and the western base of the Sierra Madre to the southward; that is, the Pacific coast Cretaceous strata now reach to the western base of the Sierra Nevada, while the Missouri Valley Cretaceous reaches as far west as the eastern base of the Rocky Mountains in Montana, and the Texas Cretaceous reaches as far west as the western base of the Sierra Madre in Mexico.

Since the faunas on each side of the site of that belt are distinctly different, although they are presumably of the same age, it seems necessary to infer that the belt was a very long one; otherwise the faunas might easily have become distributed around it. The eastern and western boundaries of the belt were no doubt irregular in trend, and the eastern one especially varied greatly from one epoch to another until all beyond to the eastward became a part of the present continent.

The trend of the western coast during the Chico epoch of the later Cretaceous was quite irregular, as shown by the localities at which its fossils have been found. As before intimated, it passed along the western base of the Sierra Nevada; then, sweeping around the northern end of the area which is now occupied by that mountain range, it extended into Eastern Oregon as far as longitude 120°, latitude 44°. This is the most easterly point at which fossils of the Chico Group have been found, and it is much further eastward than any point at which any other of the Pacific coast Cretaceous or of the Téton deposits have been discovered. It thus appears that while the present site of the Sierra Nevada was within that continental belt during the Chico epoch, the Cascade Range was then either submerged under the Pacific or was broken through by the entrance to a large gulf.

Again, the trend of the western border of that belt did not during the Cretaceous period coincide with the present trend of the Pacific coast to the southward. Such a trend would have thrown the site of the Sierra Madre of Mexico within or to the westward of the continental belt; whereas the existence of eastern Cretaceous deposits upon the western side of that range shows that its place was then in the Cretaceous sea, upon the eastern side of the belt. It is therefore probable that the peninsula of Lower California occupies the site of that portion of the belt which extended southward from the Sierra Nevada.

The bearing of these paleontological data upon the orography of Western North America is obvious; but it is not my present purpose to discuss that question, and I will close these remarks by rehearsing a few facts and indications which I think favor the views which I have advanced as to the extreme length and long continuance of the ancient continental belt of Western North America:

First, the fauna of the Knoxville beds of the Shasta Group extends from Alaska southward at least as far as Central California; second, some fossils which have been sent to the U. S. National Museum from Southern Mexico apparently come from strata of similar age; third, no rocks of the age of that group are known to exist to the eastward of probable site of that belt; fourth, the Jurassic fauna of the strata which lie to the eastward of the assumed site of the belt is entirely different from that of the reputed Jurassic strata to the westward of it.

CONCLUSIONS.

The conclusions which I have reached concerning the questions that are discussed on the foregoing pages may be summed up briefly as follows:

The strata which constitute the Téton, Martinez, and Chico Groups

of Gabb, form one unbroken series, which I have called the Chico-Téjon series, and which rests unconformably upon all the rocks beneath it, and upon which the Miocene rests conformably. The Téjon portion of this series represents the Eocene, and the Chico portion the closing epoch of the Cretaceous. But there is an alternate commingling of types throughout the whole series, so that no horizon can be designated which will separate all the Cretaceous types on the one hand and all the Tertiary types on the other. In other words, there is an unbroken faunal and stratigraphical continuity from the Cretaceous to the Tertiary portion of the series.

The Shasta Group is separable into two divisions, which I have designated as the Knoxville beds and the Horsetown beds, respectively. The latter probably represent the age of the Gault of Europe, and the former apparently the age of the Lower Neocomian, or strata upon the confines of the Jurassic. There is probably a hiatus between these two divisions, such as is indicated by the last remark, although a small number of species appear to be common to both.

A small number of species also appear to be common to both the Chico Group and the Horsetown beds of the Shasta Group, although so wide a hiatus is indicated by the types of a large part of their respective fossils, as already mentioned.

The *Aucella erringtonii* of the Auriferous Slates is, with considerable confidence, identified with the *A. piochii* of the Knoxville beds of the Shasta Group. Therefore, those Auriferous Slates are regarded as of the same geological age as the Knoxville beds. It is true that this opinion is reached mainly upon the identification of one fossil species, but that species is one of the most persistent and widely distributed ones in the whole range of the geological series.

The Knoxville beds are regarded as having been synchronously deposited with those widely known *Aucella*-bearing strata which have been found at various points along the northwest coast of North America, and also as homotaxially equivalent with those which in Northern Europe and Asia bear the same species of *Aucella*.

No species of fossils yet found in the California Cretaceous rocks have been satisfactorily identified with any which occur in strata to the eastward of the Sierra Nevada.

This difference in the respective faunas which existed simultaneously at successive epochs is believed to have been due to the presence of a comparatively narrow but long continental belt which existed in the region which now comprises that of the Pacific coast, continuously from a time at least as early as the earliest epoch of the Cretaceous period.

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NOTICE.

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This bulletin will be included in Volume III.