SUCCESSION AND DISTRIBUTION OF LATER MESOZOIC INVERTEBRATE FAUNAS IN NORTH AMERICA

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IX

EARLIER MESOZOIC FAUNAS

In early Mesozoic time the marine invertebrate faunas of North America were closely confined to the borders of the present continent, and particularly to the western border. The land-area, or at least the area above sea-level, was nearly as large as it is now. The early Triassic sea with a rich ammonite fauna extended as far as eastern Idaho but its area was apparently restricted and its most probable connection with the ocean was through Utah, Nevada, and southern California. Later Triassic marine faunas are not known east of western Nevada and eastern Oregon in the United States. They occur also at many localities in British Columbia and Alaska, and in a very limited area near Zacatecas, Mexico. The occurrence of fresh-water shells (Unio) in the Upper Triassic of New Mexico, and the character of the vertebrate remains found there and at other points farther north, attest the non-marine character of the Triassic deposits in the Rocky Mountain region. The scanty invertebrates found in the Newark group of the east also indicate non-marine deposits. Early Jurassic (Liassic) faunas are apparently restricted to an area still smaller than that of the marine Trias.[1]

LATE JURASSIC FAUNAS

Marine fauna.—At or near the close of the Middle Jurassic the sea again invaded the continent and covered a large part of the Rocky Mountain region. It extended east to the Black Hills, south to southern Utah, and covered much of Montana, Wyoming, and Utah, with the northwest corner of Colorado, part of Idaho, and a considerable

[1] A full discussion of the marine Trias may be found in the published writings of Professor James Perrin Smith. See especially *Proc. Cal. Acad. Sci.*, 3d Ser., "Geology," Vol. I, No. 10, 1904; and *Von Koenen Festschrift*, pp. 377–434, 1907.

area in British America. The fauna of this Rocky Mountain Jurassic sea is characterized by *Cardioceras cordiforme*, Cadoceras, *Belemnites densus*, and a rather varied though not large fauna consisting mostly of bivalves. It has long been recognized by Neumayr and others to be of boreal type and hence as indicating a connection either direct or indirect with the Arctic region. The fauna shows some local variations, usually associated with variations in the character of the sediments; but it appears to be essentially a unit throughout the entire area. It is believed that the deposits were all formed in one basin and within a comparatively brief period. Their maximum thickness is usually only a few hundred feet.

As there are no other marine Jurassic formations in the region and the section is known to be incomplete it is necessary to go to other areas where similar faunas occur to determine the exact position of this one in the general column. In the Upper Jurassic the following stages are recognized by De Lapparent who gives them universal application:

Portlandian { Purbeckian / Bononian
Kimmeridgian
Sequanian
Oxfordian
Callovian

The Jurassic of the Rocky Mountain region, as far as can be determined from the fauna, represents the Oxfordian and perhaps the Callovian in whole or in part. That is, it is the lower part of the Upper Jurassic. In a large part of its area it rests on the Carboniferous, and the youngest marine fauna found beneath it anywhere is in the Lower Trias, while the oldest succeeding marine fauna is Upper Cretaceous. It is obvious, therefore, that neither the ancestors nor the descendants of its species are found in the same area, but fortunately its stratigraphic position is fairly well determined in the much fuller Alaskan section. On the shores of Cook Inlet the Middle and Upper Jurassic are represented by about 10,000 feet of strata with at least three distinct marine faunas[1] which are largely still undescribed. The strata have been almost equally divided into the

[1] Stanton and Martin, "Mesozoic Section on Cook Inlet and the Alaskan Peninsula," *Geol. Soc. Am. Bull.*, Vol. XVI, pp. 391–410.

Enochkin formation below and the Naknek formation above. The upper part of the Enochkin formation is characterized by a great development of the ammonite genus Cadoceras, indicating the boreal facies of the Callovian stage, while the Naknek formation contains Cardioceras near the base and an abundance of Aucella with Lytoceras, Phylloceras, etc., in the overlying beds. The fossils indicate that the horizon of the Rocky Mountain Jurassic is near the boundary between the Enochkin and Naknek formations. In other words this Rocky Mountain epicontinental sea, which W. N. Logan has discussed,[1] was drained before the deposition of the Jurassic "Aucella beds" which have such a great development in Alaska and farther south on the Pacific coast as well as in Russia and in many areas of the boreal region. Its fauna is clearly boreal, as has already been stated, and there was marine connection either directly with the Arctic Ocean, or, as the known distribution of the rocks makes more probable, indirectly through the north Pacific somewhere between Vancouver Island and Cook Inlet. There seems to have been no direct connection with the contemporaneous sea of California which had a different, though imperfectly known, fauna more closely related to middle European faunas.

After the sea had retreated from the Rocky Mountains the boreal Aucella fauna which occurs in the Naknek formation extended down along the Pacific coast into Oregon and California where it characterizes the Mariposa slate and equivalent formations, continuing through a great thickness of strata to the top of the Jurassic and passing without any striking change into the Lower Cretaceous.

In Mexico no faunas are known that belong to the Middle Jurassic, or to the Callovian and Oxfordian stages of the Upper Jurassic, but the later stages, or at least the Kimmeridgian and Portlandian, are well represented near Mazapil in the state of Zacatecas and in adjacent portions of neighboring states. Burckhardt who has recently described the fauna[2] states that it resembles the faunas of central Europe and the Mediterranean but that it also contains forms that show relationship with the Russian or boreal fauna and others that connect it with the Jurassic of the South American Cordillera. He

[1] *Jour. of Geol.*, Vol. VIII (1900), pp. 241–73.

[2] Instituto Geológico de Méjico, *Boletín No. 23*, 1906.

concludes that there must have been direct marine connection with all these regions. The most striking example of the introduction of a new element in the fauna is the intercalation of a thin Aucella bed in the midst of strata containing the Mediterranean type of fauna in the upper Kimmeridgian. The Aucella must have come in from the Pacific where, as we have seen, the boreal type of fauna extended at least as far south as middle California. The nearest recorded occurrences of Aucella in the other direction are on the east coast of Greenland and in England. On the other hand this Mexican fauna as a whole is so unlike that of California and so related to that of Europe, and the geographic position of the beds is such that connection with the Gulf of Mexico seems most reasonable. The area should therefore be mapped as included in the Atlantic sedimentation though it is probable that the Pacific waters bearing the Aucella found temporary access to it from some point south of the Gulf of California. If the exact position of this temporary Pacific connection is still indicated by sediments they have not yet been recognized.

Farther south in Mexico a somewhat different facies of the Upper Jurassic fauna found in the state of Oaxaca has been described by Felix[1] but according to Cragin[2] this has some species in common with the Malone Jurassic fauna of western Texas which on the other hand shows some relationship with the fauna of Catorce, San Luis Potosi, and hence also with that of Mazapil. The Malone fauna shows no connection whatever with the Rocky Mountain Jurassic because it belongs to a later stage and to a different province. It probably lived in an arm of the Gulf of Mexico directly connected with the area in Zacatecas and San Luis Potosi, and including the locality near Cuchillo Parado, Chihuahua, reported by Aguilera.[3] Some of the elements of the Malone fauna show decided Cretaceous affinities and thus strengthen the evidence that it is latest Jurassic.

In Europe Neumayr recognized three marine faunal provinces in the Jurassic which, as he believed, indicated climatal zones. These are the Mediterranean or Alpine, the Middle European, and the boreal

[1] *Palaeontographica*, Band XXXVII (1891), pp. 172–80.

[2] U. S. Geol. Surv., *Bull. 266*, 1905.

[3] *Aperçu sur la geologie du Mexique*, p. 8, 1906.

or Russian, each characterized by different types of ammonites and other invertebrates. For example, the ammonite genera Lytoceras and Phylloceras are abundant in the Mediterranean province, occur sparingly in the Middle European, and are practically absent from the Russian Jura. Coral reefs and important limestones also are not found in the boreal Jurassic formations.

In America there is no difficulty in recognizing a boreal fauna in the Upper Jurassic which, as we have just seen, temporarily extended far south in the Rocky Mountain region and at a later stage still farther south along the Pacific coast. It is like the Russian fauna in its essential features although it does contain the Mediterranean types Lytoceras and Phylloceras in Alaska. There is likewise no difficulty in recognizing a southern or Mexican fauna in which are commingled many of the types which in Europe are separated and considered characteristic of the Middle European and Mediterranean provinces. Finally the Mexican fauna received by way of the Pacific a few immigrants from the boreal fauna.

Variations in the lithologic development are worthy of note. Limestones form a large proportion of the sediments in Mexico while they are relatively inconspicuous in all the areas where the boreal fauna is dominant.

Jurassic (?) freshwater fauna.—The marine Jurassic beds throughout the Rocky Mountain region of the United States are immediately overlain by the continental freshwater or marsh deposits of the Morrison formation which also extend south through Colorado into New Mexico beyond the limits of the marine Jurassic beds. Its large and varied dinosaur fauna was originally assigned to the Jurassic without question, but during the last few years some paleontologists have referred it to the Cretaceous. Its stratigraphic position is consistent with either reference as the interval otherwise unrepresented comprises a considerable part of each system. Its invertebrate fauna consists of several species of Unio, Vivipara, Planorbis, etc., all of modern freshwater types which do not assist in discriminating between Jurassic and Cretaceous. The fact that the Morrison is overlain by the Kootenai on the north and by the marginal deposits of the Comanche on the south tends to place it early in the transition interval.

EARLY CRETACEOUS FAUNAS

At the beginning of the Cretaceous the two faunal provinces which have just been indicated were even more sharply defined than they had been in the Jurassic, and in each area the characteristic elements of the fauna are developed from the fauna that preceded it. The Shasta fauna on the one hand and the Comanche fauna on the other are always sharply contrasted, though each exhibited several facies. When compared with European faunas, one is in the beginning chiefly boreal and the other Mediterranean; one is associated with shales, sandstones, and conglomerates, the other, mainly with limestones.

Shasta faunas.—The boreal Aucella fauna of the Knoxville formation is the earliest one in the Shasta series. It is distributed from the Arctic coast of Alaska to southern California but south of the Yukon never extending as far east as the late Jurassic fauna did. Cretaceous Aucella beds have been reported from Catorce, San Luis Potosi, Mexico, but it is probable that these are Jurassic on about the same horizon at which Aucella occurs at Mazapil.

The succeeding Horsetown fauna though at first showing a transition from the Knoxville fauna is, as a whole, remarkably distinct from it. It is characterized by the great abundance and variety of ammonites of types which in Europe are considered distinctive of the deeper water facies of the Mediterranean province. The boreal element is wanting, or at least inconspicuous. This early Horsetown fauna is much less widely distributed than the Knoxville. In its typical development it is known in a relatively small area in northern California and in Oregon. Toward the close of the Horsetown the fauna was greatly modified by the introduction of many types that show relationship with the Cretaceous faunas of southern India and also with those of Japan. This relationship was continued in the succeeding Upper Cretaceous faunas to such an extent that it is appropriate to speak of an Indo-Pacific province or region. This later Horsetown fauna was more widely distributed along the Pacific border and is well developed as far north as the Queen Charlotte Islands.

The marked change at the close of the Knoxville when the fauna ceased to have a distinctively boreal character was probably due to a northern uplift which closed Bering Strait and other direct connections

between the Arctic and Pacific Oceans. The closing of these connections would modify the currents, change the climate, and permit immigration of faunal elements from other areas without any other geographic changes.[1]

Comanche faunas.—The whole of the Comanche series is here treated as Lower Cretaceous, because in the Texan area the top of the Comanche is the only natural and satisfactory major plane of division in the Cretaceous. Stratigraphic, lithologic, and paleontologic studies all lead to the same conclusion. Many European paleontologists believe that the upper or Washita portion of the Comanche is of Cenomanian age and hence referable to the Upper Cretaceous of European standards and the Mexican geologists, while adopting this view, advocate for their country a threefold division of the Cretaceous and call the upper part of the Comanche, including the Fredericksburg and Washita groups, Middle Cretaceous. These varying views as to the classification and correlation of the formations are not important in the present discussion of the succession and distribution of the faunas which are grouped under the term Comanche. These faunas show many facies varying from time to time and from place to place. There are littoral faunas, reef faunas, and deeper-water faunas, but the reef facies is perhaps the most striking and characteristic. And yet these different facies are all so intimately connected either by common species or by stratigraphic relations that it is appropriate to speak of the Comanche fauna as a whole. When the Comanche fauna is examined either as a whole or in detail it proves to be very similar to the Cretaceous fauna of the Mediterranean province in southern Europe, and it is strikingly contrasted with the Shasta fauna of the Pacific coast, although the Comanche area in Mexico closely approaches the present Pacific coast throughout that country. On a previous occasion I have called attention to the character of the differences between the Shasta and Comanche faunas.[2] They are not made up of related forms differing specifically, but they consist mainly of different classes of animals so that they present

[1] See *Von Koenen Festschrift*, p. 433, where J. P. Smith has suggested that periodic opening and closing of these connections are sufficient cause for the changes in Mesozoic and later faunas of the Pacific coast.

[2] *Jour. of Geol.*, Vol. V (1897), p. 608.

totally different facies, bespeaking very dissimilar conditions. If there had been direct and free marine connection between the two areas it is probable that the conditions could not have been so different and the faunas would have shown less contrast. That the two faunas were approximately contemporaneous and that there was no important break in the sedimentation of either area during this epoch are well determined facts. It is believed, therefore, that there was a long land mass approximately parallel to the present west coast separating the two provinces.

In considering the Comanche area, as mapped, it should be remembered that a long period during which thousands of feet of limestone were formed is represented, and that the sea was advancing toward the north. The best-known early Comanche fauna is found near Tehuacan in the state of Puebla. It has been suggested with some reason that this is possibly in part somewhat older than the Trinity group which forms the base of the Comanche in Texas. It is largely a reef fauna consisting of corals and other sessile animals with other forms that are usually associated with them. Farther north one facies of the Trinity group fauna is characterized by an abundance of Orbitolina, while another facies has more of a littoral character. Trinity strata and fossils are found as far west as Bisbee, Arizona, and north to southwestern Arkansas and southern Oklahoma.

The succeeding fauna of the Fredericksburg group also has both littoral and reef facies. The latter is characterized by an abundance and great variety of Rudistae, Chamidae, and Caprinidae with Nerinea, etc., usually occurring in very pure limestone, but this facies is in some areas repeated in the Washita group so that the two faunas are sometimes hard to distinguish. The reef facies does not reach the northern boundary of Texas and the Fredericksburg fauna as a whole is not definitely recognized beyond that line though it is possibly represented at the base of the Kiowa shale of southern Kansas.

The reef facies of the Washita fauna is not found north of southern Texas but the littoral facies extends far beyond the limits of the Trinity and the Fredericksburg into northeastern New Mexico, southern Colorado, and middle Kansas. The thin Comanche deposits in all these areas belong exclusively to the Washita group and probably to the upper Washita. They rest at some localities on the

Morrison formation and in others on older formations down to the Carboniferous. They are always directly overlain by the Dakota sandstone.

Early Cretaceous freshwater faunas.—The Morrison fauna which may possibly be Cretaceous has already been referred to in discussing the Jurassic. The coal-bearing Kootenai formation of southern Canada and Montana which is determined by its stratigraphic position and by its flora to be Lower Cretaceous has yielded a few Unios and freshwater gastropods, mostly of simple modern types. These, like the similar forms in the Morrison, are interesting chiefly from the fact that they were probably the direct ancestors of some of the modern American freshwater forms, their successors having been preserved in the rivers of the adjacent land whenever the larger area previously occupied by them was submerged in the sea.

LATER CRETACEOUS FAUNAS

Chico fauna.—On the Pacific coast the Horsetown fauna is succeeded by the littoral Chico fauna which is distributed from the Yukon River to Lower California, occurring on the lower Yukon, the Alaska Peninsula, Queen Charlotte and Vancouver islands, in middle and southern Oregon, in the Sacramento valley and the coast ranges of California to San Diego, and on the peninsula of Lower California as far south as latitude 31° 30′. There are considerable local variations in this fauna as would be expected in view of its great range in latitude. The assemblage of forms found on the Yukon is quite different from that occurring in the Sacramento valley, and still another facies is found in southern California, but these are all connected by common species so that there is no hesitation about referring both the northern and the southern facies to the Chico fauna. The fauna as a whole, like the later Horsetown fauna, is Indo-Pacific in its affinities, and is strikingly different from the faunas of the Atlantic border and interior regions of North America. Whiteaves[1] and F. M. Anderson[2] have argued for a connection during Chico time between the Pacific and interior seas, but the evidence brought forward in support of this view is based on types that have a world-wide distribution and on those that are only similar, not specifically identical.

[1] *Mesozoic Fossils*, Vol. I (1879), pp. 186–90.

[2] *Proc. Cal. Acad. Sci.*, 3d Ser., Vol. II (1902), p. 59.

In my opinion direct connection has not been proved. In time range the Chico fauna apparently began somewhat earlier and continued somewhat later than the Colorado fauna of the interior sea but it did not extend to the end of the Cretaceous, and latest Cretaceous time is probably not represented by marine deposits on the Pacific coast.

Colorado fauna.—On the Atlantic side of the continent and in the interior region the greatest marine invasion of Mesozoic time occurred after the close of the Comanche. The sedimentation began with the Dakota sandstone but the first distinctive marine fauna is found in the overlying Benton shale of the Colorado group. The Colorado fauna as a whole is easily distinguished, although it is developed in several distinct faunal zones and local facies. It is characterized by *Inoceramus labiatus* and several other specific types of Inoceramus, by certain forms of Scaphites, and by the keeled ammonites known as Prionotropis, Prionocyclus, and Mortoniceras, which are sometimes referred to Schloenbachia in the broad sense. The fauna has a very great distribution, extending from Mexico and Texas throughout the Great Plains and Rocky Mountain regions as far north as Peace River in Canada. It is considered probable, though the faunal evidence is too meager for positive assertion, that there was marine connection entirely through from the northern interior to the Arctic Ocean. No marine faunas of Colorado age are known in the Atlantic and Gulf borders east of western Arkansas, unless possibly the imperfectly known fauna of the Eutaw or "Tombigbee" sand of Mississippi belongs to its latest phase. If the Colorado sea covered that area its deposits have been overlapped by later beds. The earliest marine fauna, that of the Magothy or "Cliffwood," in New Jersey, is apparently later than Colorado.

In the eastern and southeastern parts of the Colorado sea where the later Colorado deposits are calcareous, constituting the Austin chalk and the Niobrara formation, the fauna of these beds is different in character from that of the underlying Benton shale, and the Austin fauna is much larger and more varied than that of the Niobrara though their correlation is fixed by a sufficient number of identical species. The calcareous Niobrara is characteristically developed east of the mountains in Colorado and Kansas, and northward to the Black Hills and Manitoba, but farther west and northwest the

Niobrara is represented by shale, and is not lithologically separable from the Benton. The fauna is here correspondingly modified and a number of Niobrara and Austin species are associated with an assemblage of other forms peculiar to the region, together with a few that show closer relationship with the Benton fauna.

A horizon near the top of the Benton in Texas, New Mexico, and southern Utah is characterized by an abundance of ammonites belonging to the genus Metoicoceras Hyatt, formerly referred to Buchiceras, together with a number of other forms not known elsewhere. A littoral facies of the Benton fauna is developed in Utah and western Wyoming, and locally in southern Colorado, associated with sandstones and, except in Colorado, with coal-beds.

These local or temporary differences in the Colorado fauna may be attributed to differences in depth, in proximity to the shore, and possibly to variations in climate conditioned on ocean currents. With a shallow sea and an open connection with the Arctic the southern local facies in the Benton and the Niobrara would probably correspond with the area directly influenced by the equatorial or gulf current. Certain important forms, however, like *Inoceramus labiatus* and *Prionotropis woolgari* are distributed throughout the entire area.

In the Athabasca region of northwestern Canada a peculiar ammonite fauna has been described from the Peace River sandstone, and the Loon River and Clearwater shales, all of which are referred to the Colorado group; but the question of their age and relationship should be left open until the geology and paleontology of the region are known more in detail. It has been suggested that they may be older than Colorado.

Montana fauna.—From New Mexico northward the Montana group has nearly the same distribution and extent as the Colorado group. It varies greatly in character, from all marine in some areas to largely brackish and freshwater deposits in others, and its faunas are correspondingly differentiated. A considerable element of its marine fauna is evidently derived directly from the Colorado fauna but a large proportion of it is apparently composed of immigrants from other areas, probably in part Arctic and in part Atlantic. In the north a littoral facies associated with sandstones and a deeper-water facies (the Pierre fauna) in shales may be distinguished. The littoral

facies is typically developed in the Fox Hills sandstone at the top of the group but a closely similar fauna occurs at several lower horizons.

Ripley fauna.—Toward the south in New Mexico the littoral facies of the Montana fauna blends with the Ripley fauna which is well developed in the latest Cretaceous formations of Texas, Mississippi, and Alabama, and throughout the Atlantic coastal plain to New Jersey. The Ripley and Montana faunas have many species in common and many others that are closely related and yet their aspect is unlike because their dominant types are different. In the Montana fauna the genus Inoceramus is very abundant and varied and ammonoids—especially Placenticeras, Baculites, Scaphites, and other evolute types—are abundant while the Ostreidae, Veneridae, Cardiidae, etc., and gasteropoda play an unimportant rôle. In the Ripley fauna on the other hand ammonoids and Inoceramus are relatively rare and the Ostreidae, Veneridae, Cardiidae, and many types of gasteropoda, including Volutidae, are greatly developed. The Ripley fauna is more varied and luxuriant, so to speak, than the Montana and apparently indicates a warmer, or at least a more favorable climate. There was almost certainly direct connection between the areas occupied by the two faunas, but the life conditions were sufficiently different to determine distinct faunal facies. The Montana fauna probably received some of its elements directly from the Arctic, while the Ripley fauna came in from the Gulf of Mexico and the Atlantic. With the connection between the Atlantic and Pacific closed in the Mexican and Central American region as at present, the Gulf stream would give similar conditions and would distribute the Ripley fauna along the coast from Texas to New Jersey. It is noteworthy that the European fauna most closely related to the Ripley is found at Aachen in Germany and that the most natural route of migration, with such a configuration of the continent as is here assumed, would be from the American Atlantic coast northeastward to Europe.

A peculiar Cretaceous fauna, apparently contemporaneous with the Ripley, has recently been described by Böse[1] from Cardenas, San Luis Potosi, Mexico. It contains a few typical Ripley species like *Exogyra costata* and *Gryphaea vesicularis*, together with many

[1] Instituto Geológico de Méjico, *Boletín No. 24*, 1906.

corals, Rudistae, Actaeonella, etc., which suggest the Cretaceous of Jamaica. It may be considered a reef facies of the Ripley fauna.

All the late Cretaceous marine faunas that have been briefly mentioned are still typically Mesozoic, although it is true that they contain many generic types that continue on through the Tertiary. The succeeding Tertiary faunas, whether on the Pacific coast, the Gulf border, or the Atlantic coastal plain, show a very striking change from the Cretaceous faunas that immediately precede them. The specific types are practically all different.

Non-marine later Cretaceous faunas.—In the Rocky Mountain region throughout later Cretaceous time there was a great development of freshwater and brackish-water deposits alternating with marine formations. They are usually coal-bearing, and yield invertebrate faunas frequently associated with land vertebrates and plants.

The invertebrate fauna of the Dakota sandstone is too meager to be of much value. It consists of a few brackish-water species with Unio and a few other freshwater shells in other strata and at the top some marine species that probably really belong with the succeeding Colorado fauna. The freshwater species show relationship through the genus Pyrgulifera with the fauna of the Bear River formation which is apparently about on the horizon of, or a little later than, the Dakota. The Bear River fauna is distributed over a considerable area in southwestern Wyoming, and is unique among western non-marine faunas in that it contains a number of types that have left no descendants in later formations of the region. The most distinctive forms are freshwater species, but the fauna also contains brackish-water elements. The submergence beneath the Colorado sea which immediately followed the deposition of the Bear River formation seems to have been so complete in this region that the freshwater forms were not able to survive. But in the Colorado group itself along the western margin of the sea, especially in Utah and western Wyoming, there are intercalations of coal-bearing beds which contain a few Unios and other freshwater shells and brackish-water types like Ostrea, Anomia, Corbula, and Modiola, some of which recur in identical or closely similar forms at several horizons to the top of the Cretaceous.

In the Montana group there are local more or less distinctive non-

marine faunas in the Mesaverde, Eagle, Claggett, and Judith River formations. The last-named formation in its typical area has a considerable fauna with a number of species that are not known in other horizons, associated with others of wider range.

The Laramie fauna, which is the last of the conformable Upper Cretaceous series, does not differ materially from the non-marine faunas that preceded it except in specific details. The brackish-water and freshwater elements of its faunas are, of course, seldom mingled in the same stratum but alternate with each other. The brackish-water species have survived from earlier formations in the same region by living in the marine waters or advancing with the sea margin when the submergence came. The freshwater types must have been preserved in the streams of the adjacent lands when marine or even brackish waters covered the larger part of their habitat. A considerable number of freshwater types were thus enabled to survive into the Tertiary and there are some Laramie *species* that continue without perceptible change in the Fort Union or earliest Eocene. With the brackish-water forms of the Laramie the case is different. They could not exist for any appreciable period much above sea-level and when the final uplift came that drained the interior region and brought the Cretaceous to a close, the last oysters and other brackish-water mollusks of the interior region died. Hence in areas of non-marine deposition where the line between Cretaceous and Eocene has not been sharply drawn, because the erosion plane that is supposed to separate them has not yet been located, the occurrence of an oyster-bed, or a stratum full of Corbula, is sufficient evidence that the rocks are still Cretaceous and below the major unconformity that separates Cretaceous from Tertiary.

The very few freshwater shells that are known from the Denver and Livingston formations in their type areas are not distinctive, but the beds which bear the Triceratops vertebrate fauna in Converse County, Wyoming, and the strata with the same vertebrates in eastern Montana, locally known as the "Hell Creek Beds," have a highly differentiated molluscan fauna of Unios, and other freshwater shells which is much more closely related to the preceding Cretaceous faunas than to that of the typical Fort Union which follows. The evidence of the invertebrates as well as of the vertebrates is strongly in favor of assigning these so-called "post-Laramie beds" to the Cretaceous.