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## Derivation of the Unione Fauna of the Northwest

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the Iowa strata than any of the other writers mentioned, and recognized outliers as far east as Guthrie county and as far south as Montgomery county.

Recently numerous deep well records and field observations have shown that the Cretaceous deposits cover a much larger area than has hitherto been recorded. The northwestern fourth or fifth of the State may now be regarded as occupied by deposits of Cretaceous age. White, in considering the Iowa Cretaceous, divided the beds as found in the Sioux river region into the Woodbury shales and sandstones and the Inoceramus beds. As recently shown by Calvin the Woodbury shales are equivalent to the Dakota sandstone and the Fort Benton shales of Meek and Hayden and the Inoceramus beds are the same as the Niobrara of the same authors. Thus three of the formations differentiated by Meek and Hayden are known to be well represented in Iowa. During the past season another formation of the Cretaceous age has been found to extend into Iowa. This is the Fort Pierre shale. It was first noticed in the State by Mr. H. F. Bain, who found it well developed in the vicinity of Hawarden, in Sioux county, where it attains a considerable thickness. The easternmost location heretofore known showing the Fort Pierre beds has been Yankton, South Dakota, at which place the deposits are used largely in the manufacture of Portland cement.

There is another division of the Cretaceous of the upper Missouri valley which Meek and Hayden have recognized. This is the Fox Hills group. It will be seen, therefore, that four out of the five Cretaceous formations of the region are now known to extend into the State of Iowa.

Incidentally it may be mentioned that the Niobrara chalks have been recently recognized as far east as Auburn in the southeastern part of Sac county, eighty miles east of any hitherto reported locality. The Cretaceous deposits have also been extended southward by Mr. E. H. Lonsdale nearly to the Missouri line. The gypsum deposits of Webster county, Iowa, are also thought to belong to this age. It may not be out of place here to mention the fact that in the drift of northwestern Iowa boulders have been found consisting of soft friable ferruginous sandstone, highly fossiliferous, the organic remains being characteristic Fox Hills forms. As remarked by White the presence of the friable sandstone blocks indicates that they are not far removed from their original localities. It would not, therefore, be wholly unexpected should outliers of the Fox Hills group yet be found within the limits of Iowa.

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#### DERIVATION OF THE UNIONE FAUNA OF THE NORTHWEST.

BY CHARLES R. KEYES.

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One of the most striking features in the zoological history of the Mississippi basin is the exceedingly rich and varied moluscan fauna, which is characterized particularly by the Unio family, including all the common river mussels. The great abundance of individuals, the large number of

forms and the wide geographic range of many of the varieties has perhaps no parallel elsewhere. The first of these statements requires no further proof to one who has worked anywhere within the limits of the region under consideration. The second proposition finds ample evidence in collections of more than sixty different kinds of these mollusks from a single locality. Altogether more than seven hundred species of the family Unionidæ have been described from North America—over four-fifths of the entire number known to exist in the world. Having such a large number of closely related forms to deal with, it has become very convenient, and indeed very necessary, to separate the chief genus into a number of subordinate groups, naming each after its leading species; thus the sections are known as the “gibbosus,” “undulatus” groups, etc.

The distribution in space of the uniones of the continental interior has been shown to be in many respects very peculiar. As the problem finds no satisfactory solution in an ordinary zoological treatment, an inquiry has naturally been made in regard to how far the present regional disposition of the various groups may have been determined by the conditions of former geological epochs. This involves by far the most important factor in the consideration of the present geographic distribution of organisms, and one which continually assumes greater and greater prominence in dealing with facts pertaining to that subject.

It has also been clearly shown in other zoological families that the range of many genera and species in time is very much more extended than has been generally regarded, and that some of the living types have a high antiquity. The recent discoveries of rich land and freshwater fauna in the Mesozoic and later deposits of the Northwest have done much toward elucidating the early history of American fluviatile mollusks. White\* has already intimated in a general way the probable close genetic relationship of these fossil uniones and the forms now living in the waters tributary to the Mississippi river, but no specific references were made to the mollusks now existing. Later† it was incidentally mentioned that among the Laramie Unionidæ were found the prototypes of *Unio ligamentinus*, *U. undulatus* and other groups.

In the upper Mississippi region the Unionidæ are easily separable into three grand sections which are commonly ranked as genera: Anodonta, Margaritana and Unio. The generic distinctions are based entirely upon the characters of the hinge “teeth;” but there are also other good structural features to support this separation; and the transitions are few and not well marked. The leading North American groups of Unio may be typified by the following species: *Unio ligamentinus* Lam., *U. undulatus* Barnes, *U. ellipsis* Lea, *U. gibbosus* Barnes, *U. tuberculatus* Barnes, *U. pustulosus* Lea and *U. parvus* Lea, besides others which have no bearing in the present connection. Of these at least five groups are known to have fossil representations in some portion of the western Cretaceous or Tertiary strata. In the present consideration no forms from rocks earlier than the Mesozoic age are considered, for the reason that so much doubt at present exists concerning the shells referred to the Unionidæ from the Devonian and Carboniferous of this country. As regards the Tertiary forms described under Anodonta and

\*U. S. Geol. Sur., 3rd Ann. Rep., 1883.

†Keyes: Annot. Cat. Iowa Mol., Bul. Essex Inst., vol. xx, 1889.

Margaritana considerable confusion also prevails; and it is quite certain that some of the species have been wrongly referred to these genera.

It has been stated by Binney and others that among the living land mollusks a wide geographic distribution is indicative of a high antiquity for the group. This observation has lately\* been extended to certain Carboniferous mollusks. By carefully reviewing the American Unionidæ it will be found that the generalization is applicable to this family also. Those (subgeneric) groups having the widest geographical range at the present time in the basin of the Mississippi river are the ones which are best represented in the Mesozoic strata of the upper Missouri region. As examples, *Unio ligamentinus*, *U. ellipsis*, *U. undulatus* and *U. rectus* are the most prominent, perhaps. These four species range from Ottawa, Canada, and western New York, to southwestern Kansas and Texas, and from Alabama to northern Minnesota and Dakota. All four groups, along with others, are present in considerable numbers in the freshwater Laramie deposits of the Northwest.

Of the group typified by the first species mentioned—*Unio ligamentinus*—there are a number of forms now known among the fossil Uniones. The shell of the living representative is exceedingly variable, as might naturally be expected of a species occurring under the many diverse conditions of environment such as are imposed by its wide geographical distribution. Throughout its range many specific terms have been applied to the various varietal forms. In some localities this species has a very thin and fragile shell; in others the shell is very thick and massive, with large, heavy hinge-teeth, and rough, deep, muscular impressions, resembling in many respects the early described *Unio crassidens* of Lamarck. To the latter category the majority of the Laramie forms of the group appear most closely to approach, particularly such shells as *Unio vetustus* Meek, from southwestern Wyoming. *U. priscus* M. and H., seems also to belong to the group. The type continued through the Eocene as *U. shoshonensis* White.

*Unio ellipsis* is the type of a rather large and variable group of shells. The beaks in this species are far forward, even extending beyond the anterior margin of the shell. It is thus a representative of a series having but few examples among the forms at present living, but which was almost universal among the Laramie species, as was first pointed out by White. The most nearly related of the fossil species now known is perhaps *U. prouitus* W., but in the former the "teeth" are somewhat heavier and the outline more rotund. Other forms of this type are found in *U. cryptorhynchus* and *U. propheticus*.

*Unio gonionotis* White, is evidently one of the "undulatus" group; but it more closely resembles some other members of this section rather than the leading species itself. *U. belliplicatus*, while differing considerably from the type of the group, is believed to have a close relationship with other members of the section, particularly certain forms that have recently been noted from Kansas.

The *Unio rectus* group is characterized by rather large, elongate forms, having heavy shells, rounded in front, and more or less attenuated behind. The Laramie representatives are best known under *U. conesi* W., and perhaps also *U. danae* M. and H. In the Eocene *U. clinopisthus* appears to have flourished as the descendant of the early "gibbosus," or "rectus" type.

\*Proc. Acad. Nat. Sci., Phila., 1888, p. 245.

Among the fossils already alluded to are a number of Anodontæ, the most prominent of which is *A. prepatioris*, a member of the "grandis" group. Margaritana has been reported from the Cretaceous, but at present there is much doubt as to the correct reference of the form to this genus.

At present the oldest American form of Unio is *U. cristomensis* Meek. It was described from a horizon doubtfully referable to the Triassic, and was first figured by White. The type specimens are imperfect, but show distinctly the generic characters.

White\* has expressly called attention to the fact of the extreme shortening of the Laramie Uniones in front of the beaks, or rather the forward position of the umbones as compared with the modern shells. This fact is of great interest in its bearing upon the phylogeny of the group, as it is an important consideration in support of Neumayr's recently advanced suggestion concerning the derivation of the Uniones from the Trigonidæ. Should this near relationship of the two families be established it is very probable that the view just mentioned would require some slight modification. For the two families had already, in the Cretaceous, become very much differentiated, so that the two types were probably derived from a common, but rather remote ancestor, rather than one from the other.

A most remarkable feature concerning the Unione fauna of North America is the striking individuality of the forms of each drainage basin, however limited it may be. This peculiarity is so marked that one acquainted with the American species of the family has little difficulty in telling from which particular portion of the country, or indeed the stream, a given series of shells was taken, even when the most widely distributed species are under consideration. It was probably this fact more than any other that occasioned the vast multiplication of species by Lea whose wide familiarity with these bivalves enabled him from the external characters alone to readily determine the locality of the various forms of Unionidæ brought to his notice. It is, perhaps, one of the best known examples showing how persistent, how exclusive, how united a particular fauna of a limited geographic area may be, when the physical conditions are seemingly quite diverse. It also illustrates how well the peculiarities of two contiguous basins may be fully preserved even when the conditions of environment are presumably the same. A hint towards a partial explanation of these phenomena is derived from geological data concerning the permanency of river basins; for it has been satisfactorily shown that the water courses are among the longest lived of all the topographical features of a region. This being the case the Unionidæ would be admirably adapted to flourish through long periods of time and undergo but slight structural modifications, and this certainly seems true of these bivalves in the Missouri basin, for they have come down from Mesozoic times almost unchanged.

The distinctness of unione fauna in separate drainage basins has some striking illustrations in the upper Mississippi valley. One in particular has recently been brought into notice in the case of the Des Moines and Iowa rivers, which flow parallel to one another southeastward across the State of Iowa. The peculiar distribution of the lamellibranchs in the eastern and western portions of the State was pointed out some time ago in an annotated catalogue of the Mollusca of Iowa. Of the species found in

\*U. S. Geol. Sur., 3rd Ann. Rep., p. 431, 1884.

the Des Moines river there are seven that do not occur in the Iowa, while in the latter stream there are twenty-one forms that are not found in the former; twenty-six species are common to both rivers. Of the latter, four are rare in the Iowa but abundant in the Des Moines, while two are rare in the last mentioned water course and common in the eastern stream.

Now the molluscan fauna of the Iowa is identical with that of the Minnesota river, suggesting that an intimate connection may have existed, at a period not very remote, between the latter stream with some one of the drainage basins of eastern Iowa. That the connection was probably of a comparatively recent date is shown by the distribution of the living Unionidæ in the upper Mississippi valley which points strongly to the wide-spread influence of certain peculiar agencies during glacial times which modified the former range of the mollusks of the region. The present topography, however, of southern Minnesota, does not seem to exhibit any direct indications of such a relation as is above alluded to, except in the central part. But it is probable, as has been urged by Chamberlain, McGee and others, that during the glacial period the elevation above the sea level of the region under consideration was very different from that of the present time. The objection raised by the previous statement therefore loses most of its force.

The persistence, with such slight structural modifications, of the members of the Unionidæ for the long period of time that must have elapsed since the close of the Cretaceous appears to indicate a high antiquity for this type of molluscan life. But since so very little or nothing is known concerning the internal characters of the shells of the Paleozoic lamellibranchs, it is very probable that a number of other Unio representatives will be found among forms already described under genera not at all related. On the other hand future research will doubtless bring to light new types connecting more closely the family with others. In this connection it is of interest to note that Whiteaves has lately described some lamellibranchs from the Coal Measures of Nova Scotia which with little doubt possess characters which would cause great difficulty in the attempt to separate the forms from typical Unio.

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#### PROCESS OF FORMATION OF CERTAIN QUARTZITES.

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BY CHARLES R. KEYES.

(*Abstract.*)

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In the extreme northwestern corner of Iowa there is a small area of very hard, thoroughly vitreous rock, which has been known for more than a quarter of a century as the Sioux quartzite. The mass is also well exposed in the adjoining portions of Minnesota and South Dakota. The Sioux "granite," as it is now locally called among quarrymen, is of considerable