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CRASSATELLINA HOLLANDI N. SP. (BIVALVIA: ASTARTIDAE) FROM THE FOX HILLS FORMATION (MAASTRICHTIAN, CRETACEOUS) OF NORTH DAKOTA AND SOUTH DAKOTA

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ABSTRACT—Two relatively complete specimens and several fragments of a very large bivalve from the Fox Hills Formation in North Dakota and South Dakota are assigned to the family Astartidae, subfamily Eriphylinae, and form the basis for description of a new species, *Crassatellina hollandi*. The specimens were collected from the upper part of the Timber Lake Member which has been assigned a Maastrichtian age based on associated ammonites and palynomorphs. Association with other mollusks indicates that *C. hollandi* inhabited the moderately high energy environment associated with the landward side of a prograding barrier island.

INTRODUCTION

THE bivalve and gastropod assemblages of the Fox Hills Formation in North Dakota have recently been studied by Feldmann (1972) and Erickson (1974), respectively. These studies in conjunction with detailed stratigraphic and paleontologic work in the type area of the formation in South Dakota (Waage, 1968; Speden, 1970), have provided relatively complete information regarding the fauna of the unit. Nevertheless continued collecting in these areas still yields new and interesting fossils. In 1963, Feldmann collected a single specimen of new and exceptionally large crassatellinid bivalve from the Fox Hills Formation in Logan County, North Dakota, and subsequently discovered fragments of what appears to be the same species in Emmons County, North Dakota. A third specimen was located in the stratigraphic collections of the U. S. National Museum of Natural History. The purpose of this paper is to describe this new bivalve, to discuss its systematic relationships to the subfamily Eriphylinae and the family Astartidae, and to interpret its paleoecology.

GEOGRAPHIC AND STRATIGRAPHIC SETTING

Specimens of *Crassatellina hollandi* were collected from three localities (Text-fig. 1) in North Dakota and South Dakota. All of the specimens were collected from medium-grained glauconitic sandstone in the Timber Lake Member of the Fox Hills Formation. Specimens collected from all three localities appear to have come from the uppermost portion of the member, although at localities 1 and 3 no direct evidence of overlying Bullhead Member sediments was observed. The stratigraphic position at locality 1 was based primarily on the associated fauna that commonly occurs (Feldmann and Palubniak, in press) at the top of the Timber Lake Member. At locality 2, Bullhead Member sediments occur about five feet above the level at which fragments of *C. hollandi* were collected, therefore, precise stratigraphic placement is possible. The specimens collected from locality 3, Dewey County, South Dakota, were collected from a unit, nearly 18 feet thick, containing abundant oysters and oyster fragments. The oysters, *Crassostrea glabra* (Meek and Hayden), and associated organisms are similar to those collected at the other localities. Further, the matrix surrounding the specimen is medium-grained glauconitic sandstone, typical of the upper part of the member.

Description of the location of collecting sites is as follows:

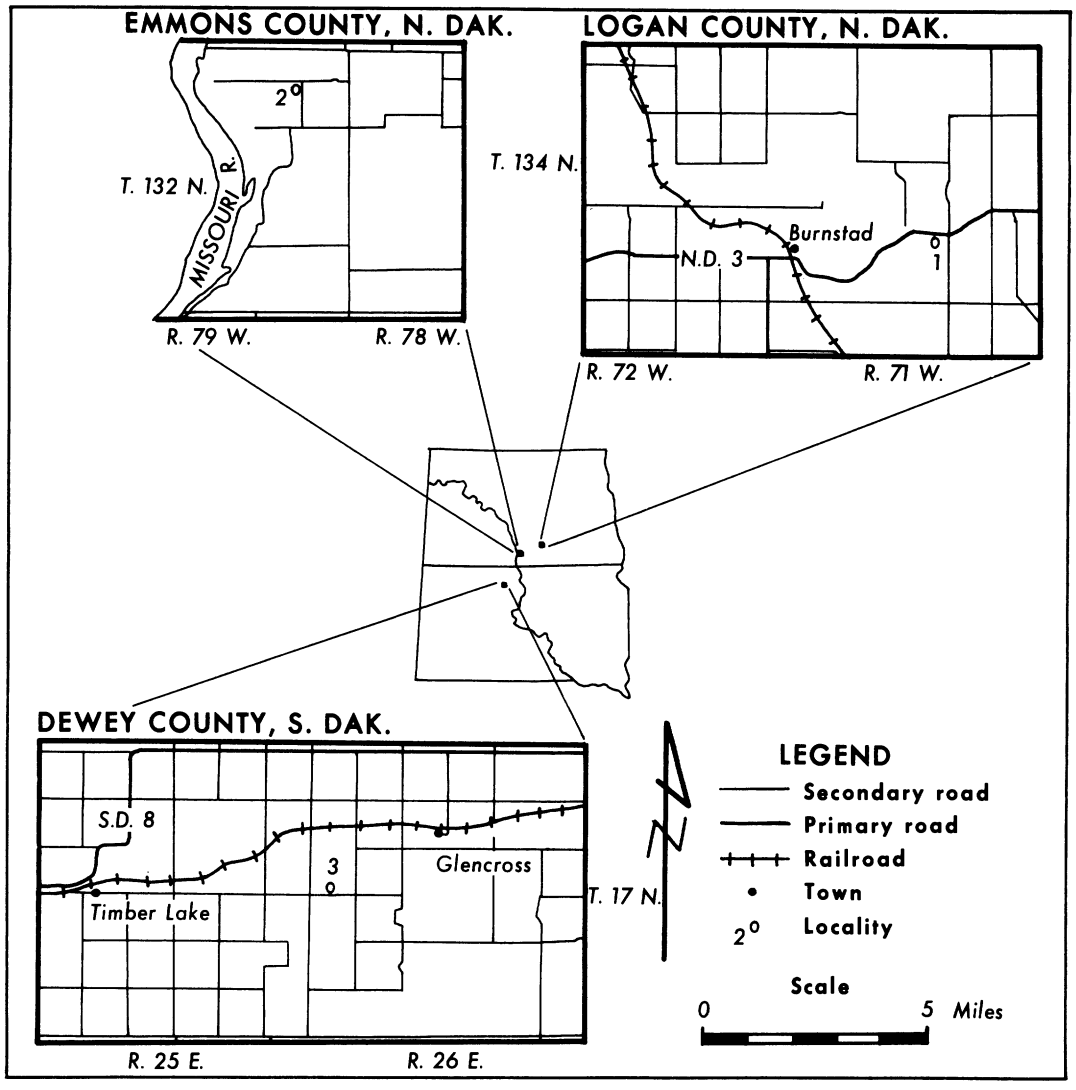
Locality 1. Road cut on south side of road, Center sec. 26, T.134N., R.41W., Logan County, North Dakota. Coll. R. M. Feldmann, 7/63.

Locality 2. Road cuts on west side of road, NE¼ sec. 11, T.132N., R.79W., Emmons County, North Dakota. Coll. R. M. Feldmann, 7/63.

Locality 3. Butte tops SE¼ SW¼ sec. 18, T.17N., R.26E., Dewey County, South Dakota. Coll. V. H. Barnett, 5/28/09.

SYSTEMATIC PALEONTOLOGY

Class BIVALVA Linnaeus, 1758
Subclass HETERODONTA Neumayr, 1884
Order VENEROIDA H. and A. Adams, 1856
Superfamily CRASSATELLACEA Ferussac, 1822
Family ASTARTIDAE d'Orbigny, 1844
Subfamily ERIPHYLINAE Chavan, 1952
Genus CRASSATELLINA Meek, 1871



TEXT-FIG. 1—Location map showing the sites in North Dakota and South Dakota from which *Crassatellina hollandi* has been collected.

CRASSATELLINA HOLLANDI, n. sp.
Pl. 1, figs. 1–6; Text-fig. 2

Description.—Shell very large (measurements in Text-fig. 2), moderately compressed, subtrigonal. Shell thick; anterior margin smoothly and moderately rounded; dorsal margins nearly straight, sloping away from the beak at angles of about 38° (anterior) and 27° (posterior), apical angle of about 115°; the posterodorsal margin intersecting truncated posterior margin near posterior terminus of adductor insertion area at an angle of about 155°; anterodorsal margin intersecting anterior margin in a smoothly increasing curve; beak located just anterior to midline, small, prosogyral. Prosopon of fine, subequal, evenly spaced growth lines, about 1.53 growth lines per mm; posterodorsal region separated from rest of shell by a sharp umbonal ridge extending from beak to ventral termination of truncated posterior margin; lunule absent; escutchean weakly developed, extending from beak to posterior termination of hinge.

Hinge plate moderately broad, thickened, well developed. Hinge of right valve with two cardinal teeth; largest median cardinal tooth triangular, projecting and curving posteroventrally from beak, with very broad base narrowing to a ridge, bounded dorsally and posteriorly by a shallow narrow socket projecting

nearly full length of the tooth, and anteriorly by a deep, triangular socket whose long axis projects anteroventrally and curves posteriorad in adult specimens. Small anterior cardinal tooth trigonal, anterior to the anterior socket, expressed as low swelling on hinge plate; anterior portion of hinge plate broad, flat, bounded ventrally by an elongate swelling—the remnant of an anterior lateral tooth. Posterior hinge plate edentulous, narrowing abruptly toward the posterior terminus. Hinge of left valve with two cardinal teeth; anterior cardinal tooth large, triangular, very broad at base and narrowing to a ridge projecting anteroventrally from the beak and curving posteriorad in adult specimens; tooth bounded dorsally and anteriorly by a shallow narrow socket projecting nearly the full length of tooth; bounded posteriorly by a deep, triangular socket whose long axis projects and curves posteroventrally; posterior cardinal tooth small, ridge-shaped, situated posteriorad from large triangular socket and projecting posteroventrally from beak, sitting upon a broad swelling of the hinge plate anteriorad from the nymph. Anterior lateral portion of hinge plate broad, flat, with a shallow elongated socket for anterior lateral tooth of right valve; posterior hinge plate of left valve edentulous, narrowing abruptly posteriorly. Ligament groove external, ensiform, located posteriorad from beak, deeply incised; strong prominent nymph projecting posteriorly from the beak along dorsal margin. Hinge formula (Boyd and Newell, 1968)

Posterior RV –n 0 1 0 1—1 Anterior
LV –n 1 0 1 0—0 (1)

Adductor muscle insertion areas subequal; anterior area smoothly rounded ventrally, attenuated dorsally, its dorsal half surrounded by a thickened buttress extending from middle of hinge plate to slightly beyond its anterior termination. Posterior adductor muscle insertion area larger than anterior area, nearly circular, indistinct. Pallial line simple, without sinus, separated from ventral margin by a distance equal to about 25% of shell height. Moderately large pedal retractor muscle insertion area deeply impressed into thickened anterodorsal portion of the shell, located below hinge and adjacent to dorsal termination of anterior adductor muscle insertion area.

Etymology.—The species is named in honor of Dr. F. D. Holland, Jr., Professor of Geology, University of North Dakota.

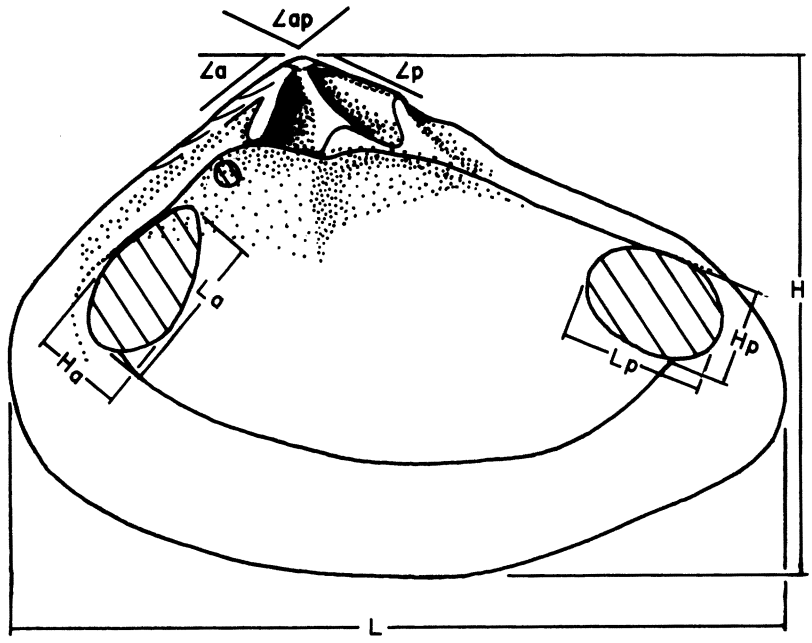
Types.—The holotype, an adult right valve, USNM 211141, was collected from the upper part of the Timber Lake Member of the Fox Hills Formation at locality 1 (Text-fig. 1), Logan County, North Dakota. The paratype, USNM 211142, was collected from the Timber Lake Member of the Fox Hills Formation at locality 3, Dewey County, South Dakota. Small fragments, KSU 2149, were collected from the top of the Timber Lake Member at locality 2, Emmons County, North Dakota.

Age.—The age of the Timber Lake Member in its type area in South Dakota, based on studies of ammonites (Jeletzky, 1960) is Early Maastrichtian (Upper Cretaceous). Recent studies on palynomorphs (Artzner, 1974) suggest a Middle to Late Maastrichtian age for the unit in southcentral North Dakota. The most precise possible age determination for *C. hollandi*, therefore, would be Maastrichtian.

DISCUSSION

Based on a broken but well preserved right valve from locality 1 in Logan County and fragments from locality 2 in Emmons County, North Dakota, Feldmann (1967, unpub. doctoral dissertation, Univ. of N. Dak., p. 228) previously questionably placed this species in the genus *Astarte*. *Astarte*? sp. nov. was again mentioned by Feldmann in 1972. Careful morphological study of these specimens and the U. S. National Museum specimen subsequently suggested that the species should be placed in *Crassatellina* (Eriphylinae).

The placement of *Crassatellina hollandi* in the Eriphylinae is based primarily on the position of the ligament and the nature of the dentition. The external ligament on these specimens is the most significant character. Boyd and Newell (1968, p. 21) regarded the position of the ligament as the discriminating difference between the Astartidae and the Crassatellidae. The external ligament of the Astartidae is considered to be the more primitive. It is noteworthy that the specimens of *C. hollandi* also have some features similar to those in specimens referred to the Crassatellidae. They are the unusually large size, the crassatelliform outline, and the dentition. However, the absence of an internal ligament, and a resilifer would seem to exclude *C. hollandi* from the Crassatellidae. The species possesses an external ligament and a nymph, primary characters of the family Astartidae. Among the Astartidae, members of the Eriphylinae seem most closely comparable to *C. hollandi*. Eriphylinae typically possess two cardinal teeth in the right valve and one or two cardinal teeth in the left valve with the anterior car-



USNM NO.	L	H	W	La	Ha	Lp	Hp	∠ap	∠a	∠p
RIGHT VALVE HOLOTYPE (211141)	148.6	98.3	27.2	33.0	12.4	28.2	17.9	115°	36°	29°
RIGHT VALVE PARATYPE (211142)	ca. 99	65.1		25.3	12.3			118°	34°	28°
LEFT VALVE PARATYPE (211142)	ca. 100	67.2						116°	32°	32°

TEXT-FIG. 2—Sketch of the interior of the right valve of *Crassatellina hollandi* showing the orientation of measurements taken. Linear measurements given below the sketch are in mm.

dinal tooth in the right valve. This is in contrast with the subfamily Astartinae, members of which have three cardinal teeth in the right valve and two cardinal teeth in the left valve (Boyd and Newell, p. 22).

The placement of this new species with the genus *Crassatellina* Meek, 1871, was based on development of: a.) an external ligament, b.) prominent nymph, c.) two cardinal teeth in each valve, with the anterior cardinal tooth in the right valve, d.) simple pallial line and subequal adductor muscle insertion areas, and e.) a crassatelliform outline. Further, *Crassatellina* is known from the Late Cretaceous of the midcontinent of North America, which is consistent with the stratigraphic position of *C. hollandi*. *Crassitellina oblonga* Meek, 1871, differs from *C. hollandi* by the bifid nature of the anterior cardinal tooth of the left valve and the posterior position of the cardinal tooth in the right valve. *C. oblonga* is typically 1–2 cm in length, whereas *C. hollandi* is known to range between 10–15 cm in length in adult specimens. There is some difficulty defining the more subtle morphology of *C. oblonga* as the only known specimens are preserved as casts and molds. *C. oblonga* is the only other known species of *Crassatellina*.

It is interesting to note that earlier workers placed the Eriphylinae, including *Crassatellina*, in the Crassatellidae. Meek (1876, p. 118) reported the similarities between *Crassatellina* and *Crassatella* Lamarck, 1799. Meek stated (1876, p. 118): "The typical species of the genus (*Crassatellina*) has the general external appearance of *Crassatella*, from which genus, however, it is clearly removed by its hinge characters, though evidently belonging to the

same family." Dall (1903, p. 933) stated that the Eriphylinae is a fringe group of the Crassatellidae, with the ligament deeply sunk internally in the Crassatellidae, while in the Eriphylinae the process is just beginning. Modern classification (Boyd and Newell, 1968; Cox, et al., 1969) puts greater emphasis on the position of the ligament and, therefore, places the Eriphylinae, because of the ligament, in the Astartidae.

Scott (1970, p. 71–2) recently redescribed and redefined *C. oblonga* from Meek's original material of molds and casts, and molds and casts he found. He concluded (p. 72) from this material that the "interpretation of fragmentary molds is significantly different from Meek's (1871), who described two cardinal teeth in each valve and a posterior socket divided by a thin lamina. Apparently Meek interpreted the convex surface of the hinge plate as a posterior cardinal tooth. His own sketch (Fig. B, p. 201) shows the surface to be only slightly raised. The groove posterior to the thin lamina is interpreted as a ligament attachment area because of its great length and shallow, narrow, unexpanded shape. It is quite different from the deep and rounded cardinal sockets. The thin lamina probably was more useful in ligament attachment than in articulation because of its great length, low height, and fragile, narrow shape. Thus, the genus *Crassatellina* is characterized by one cardinal tooth and two sockets on the LV, and two cardinal teeth and one socket on the RV, by an internal ligament, and by one anterior and one posterior lateral tooth on each valve."

As far as the authors are aware, the right valve of *C. hollandi* is the only known complete shell of *Crassatellina*. The external ligament is visible on this well preserved valve whereas it would probably be indistinct on an internal mold such as that with which Meek originally worked. Scott inferred that the thin lamina in *C. oblonga* was for ligamental attachment. The same lamina is slightly posteriorad in *C. hollandi*, where it sits on the posterior edge of the posterior socket of the left valve, rather than in the socket, and is interpreted by us as a posterior cardinal tooth. It has no function in ligamental attachment, and the right valve possesses a complimentary socket. Meek recognized that this structure might not be interpreted as a tooth. Originally, (1871, *in* Meek 1876, p. 119), he considered it to be a thin lamina, fitting into the furrow along the posterior cardinal tooth of the right valve. He later (1876, p. 119) reinterpreted it as a cardinal tooth, possessing a corresponding socket on the right valve. The socket is posteriorad to the posterior cardinal tooth of the right valve. The posterior lateral tooth is possibly a variable character for it is absent on *C. hollandi*.

This specimen may well suggest that the Eriphylinae belong with the Crassatellidae on the basis of dentition, shell form, and size. However, the ligament seems to be the best distinguishing feature between the two families and has generally been used to define them while dental formulas have by comparison shown progressive modification (Boyd and Newell 1968, p. 28).

PALEOECOLOGY

Crassatellina hollandi was very probably an inhabitant of a restricted marine, shallow water, moderately high energy environment. At each of the localities from which this species was collected, *Crassostrea glabra* whose modern counterparts are dominately brackish water inhabitants, has been found intimately associated with it. In addition to the oysters, other restricted marine organisms occur in association with *C. hollandi*. At all three localities they include *Pachymelania wyomingensis*, *P. insculpta*, and *Anomia micronema*. At locality 1 and 3, *Corbicula cytheriformis* and *C. moreauensis* also occur in association with this form. These organisms have been interpreted (Feldmann and Palubniak, in press) as indices of a low salinity, marginal marine environment which developed on the landward side of prograding barrier islands adjacent to the region in which Bullhead lagoonal sediments were accumulating. The sediments in these regions were subjected to high energy water movement during storm washover but were ultimately deposited adjacent to the relatively quiet water environments behind the barriers.

As with many other astartids (Stanley, 1970, p. 76), *C. hollandi* appears to have been a shallow burrower. The life habit is indicated by the generally compressed cross-section and smooth exterior. Absence of a pallial sinus indicates that, if the animal was an infaunal organism, the posterior margin would have to be situated at, or above, the substrate. Stanley (1970, p. 75) indicated that many bivalves occupying this niche and possessing truncated posterior margins lie in such position that the posterior truncation parallels the sediment surface. This would seem to be a likely life position for *C. hollandi*.

The extraordinary size of this species is also of note. This appears to be one of the largest, if not the largest, astartid on record (Cox, et al., 1969). It is approached by species of *Cardiniopsis*, also in the Eriphylinae, but is clearly larger than any other bivalve in the Fox Hills Formation. This large size is, however, not uncommon for shallow burrowing bivalves, in other families, in Cenozoic and Recent faunas. Experimentation with this large size in the Astartidae, however, seems to have been short lived as no subsequent members of the family are known to attain a size approaching that of *C. hollandi*.

As would be expected for organisms inhabiting an infaunal niche in a reduced salinity environment, activity by epibionts is relatively limited. The only example of organic association is that of a crushed pustule located on the posterior third of the holotype. The region in question lies just below the posterior muscle scar and has a length, approximately parallel to the long axis of the shell, of 3.6 millimeters and a height of 1 mm. The excavation, visible on Plate 1, fig. 4 appears to have originally been closed over by a thin layer of calcium carbonate and subsequently crushed during preservation. The shell material surrounding the excavation is somewhat above the general level of the shell. The radius of this elevation is approximately 6 mm. Such swellings and pustules have been observed on other Fox Hills bivalves in the same association and have been interpreted (Feldmann and Palubniak, in press) as polydorid worm blisters.

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EXPLANATION OF PLATE 1
All figures ×¾

FIGS. *1–6*—*Crassatellina hollandi* n. sp. *1*. Mold of the interior of both valves of paratype (USNM 211142) collected from the Timber Lake Member of the Fox Hills Formation at Locality *3*. *2*. Latex cast of hingement of left valve taken from paratype (USNM 211142). *3*. Latex cast of hingement of right valve taken from paratype (USNM 211142). *4–6*. Interior, exterior, and dorsal view of right valve of holotype (USNM 211141) collected from the Timber Lake Member of the Fox Hills Formation at Locality 1.

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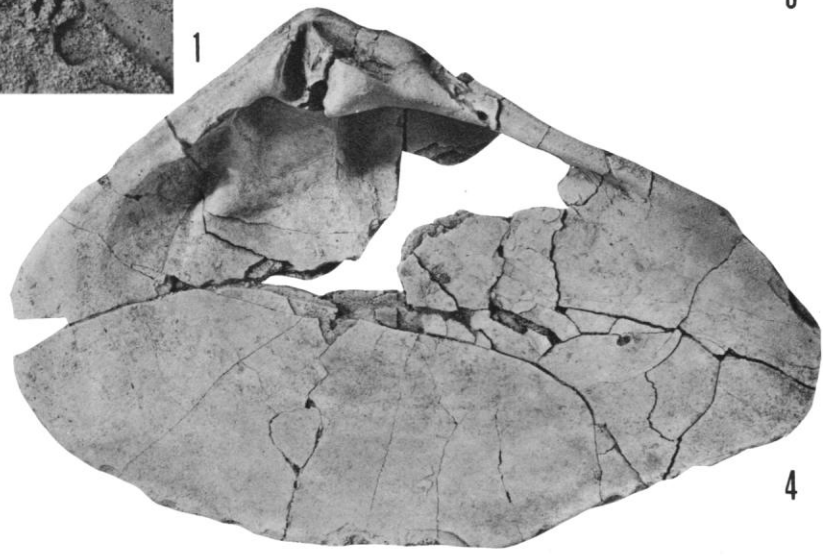

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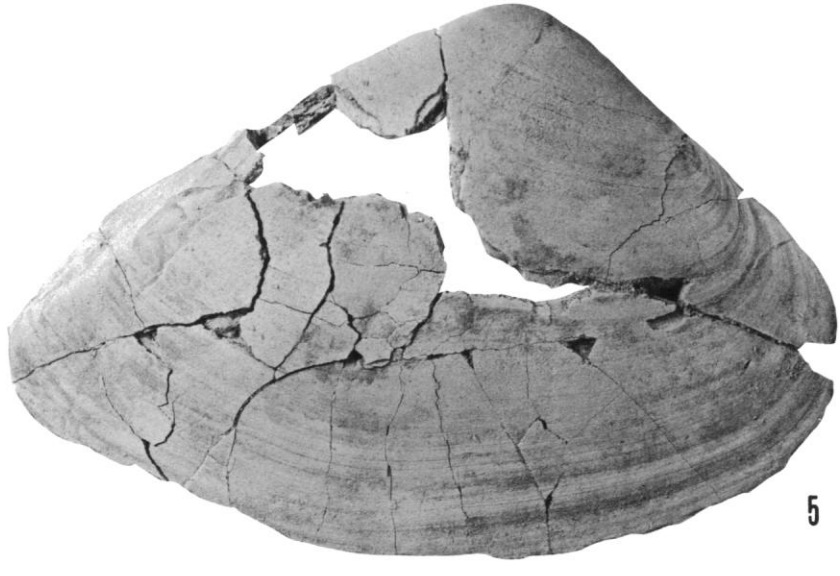

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