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The Genus *Aphanaia* Koninck, 1877, Permian Representative of the Inoceramidae

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Several poorly known, late Paleozoic and Mesozoic, monomyarian, bivalve mollusks externally similar to *Inoceramus* Sowerby, 1814, have been referred to various genera and families. The late Paleozoic representatives are commonly referred to *Posidonia* Bronn, 1828; *Myalina* Koninck, 1842; *Atomodesma* Beyrich, 1865; *Aphanaia* Koninck, 1877; and *Posidoniella* Koninck, 1885. Some were originally described as species of the genus *Inoceramus,* but, since the more characteristic species of that genus are Cretaceous in age, and the Inoceramidae are considered to be a Mesozoic family, the Paleozoic representatives generally have been transferred to other genera.

In only two of the Paleozoic genera in question, *Myalina* (Newell, 1942) and *Atomodesma* (Waterhouse, 1963), are the morphological characters fairly well known. *Posidonia* has been tentatively considered to be a pectinoid with affinities close to certain mid-Paleozoic forms such as *Pterinopecten* Hall, 1883 (Newell, "1937" [1938]). The others are commonly regarded as belonging to the Myalinidae and are characterized by a short hinge, concentric undulations, duplivincular (that is, longitudinally furrowed) ligament area, and more or less terminal beaks. Probably all the genera in question had prismatonacreous shells, but imperfect preservation makes such a probability uncertain.

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FIG. 1. *Aphanaia mitchellii* (Koninck), Sedgwick Museum, Cambridge University, No. E10731. Right valve, lectotype, internal mold, showing form and ornamentation and the impression of the inner surface of the hinge plate below the ligament area. Photograph courtesy of A. G. Brighton. ×1.

The characteristically late Mesozoic family Inoceramidae, on the other hand, is characterized by prismatonacreous shells and a multivincular ligament (multiple resilifer pits, as in *Isognomon*). Elsewhere, one of us (Newell, 1942) has suggested that the multivincular ligament may readily have evolved from either the duplivincular or the alivincular type, or from both. The time sequence of the appearance of these kinds of ligaments in different phyletic groups seemingly supports this hypothesis (e.g., *Pterinopecten-Aviculopecten; Leiopteria-"Pteria"-Bakevellia;* and so on).

It now appears that a similar sequence exists in the series *Posidoniella-Atomodesma-Aphanaia,* usually regarded as myalinids. The last-named genus is externally indistinguishable from *Atomodesma,* and the two have been considered synonymous (Dickens, 1956; Waterhouse, 1958). Dickens (1956) concluded that *Aphanaia* is indistinguishable from *Atomodesma;* therefore, *Aphanaia,* the younger of the two names, should be considered a junior subjective synonym of *Atomodesma.*

The holotype of the type species of *Aphanaia* now at the Sedgwick Museum, Cambridge University, does not reveal the hinge characters satisfactorily. As described by Dickens (1956, p. 23), the hinge has an undifferentiated single ligament furrow, but we believe that the preser-

vation does not permit such a conclusion. The furrow in question is the impression of the lower, smooth, surface of the hinge plate (fig. 1). We are now in a position to show by means of a topotypic specimen that *Aphanaia* is not a myalinid but a member of the Inoceramidae with a multivincular ligament. In fact, it may well be indistinguishable from one or more of the many Mesozoic "genera." *Atomodesma*, on the other hand, apparently possesses several elongate ligament grooves rather than vertical resilifers of the multivincular type (Waterhouse, 1963).

NEW EVIDENCE

The type specimen of *Inoceramus mitchellii* McCoy, 1847, on which *Aphanaia* was based (fig. 1), and many other fossils, were collected long ago by W. B. Clarke at Glendon, on the Hunter River, in New South Wales, Australia, as shown by the evidence of Clarke's notebooks. The rocks at this place are now considered to be Permian in age. Before sending his collection to Cambridge University in England, Clarke had sketched the type specimen named by McCoy *Inoceramus mitchellii* and many other specimens in notebooks to which he later made published reference (Clarke, 1878, p. 153). We have had the opportunity of examining his notebooks and verifying that one of the drawings illustrates the type specimen of *Aphanaia mitchellii* (fig. 1) figured by McCoy in 1847, by Koninck in 1877, and again by Dickens in 1956. Recognizable specimens of other fossils are also figured in the notebooks.

Many of the specimens lent by Clarke to Sedgwick at Cambridge University between 1876 and 1898 were returned to the owner and on Clarke's death were purchased by the Government of New South Wales. Unfortunately, a few years later part of this invaluable collection was destroyed by fire on the burning of the Garden Palace on September 22, 1882. It is now certain from the notebook evidence that at least some of Clarke's specimens were salvaged. One of these is the important topotype specimen of *Aphanaia mitchellii* before us (figs. 2–4). This was not figured by McCoy or Koninck nor is it included among Clarke's sketches, but strong circumstantial evidence suggests that it is indeed a topotype of McCoy's species collected by Clarke from Glendon on the Hunter River in New South Wales.

The specimen of *Aphanaia mitchellii* now under consideration is one of several fossil invertebrates at the University of Sydney bearing numbers in red paint for which no catalogue is now available. Some of these specimens are illustrated by pencil drawings in the notebooks of the collector, W. B. Clarke. These specimens came to the notice of the senior author when she was in charge of paleontology in the Department of

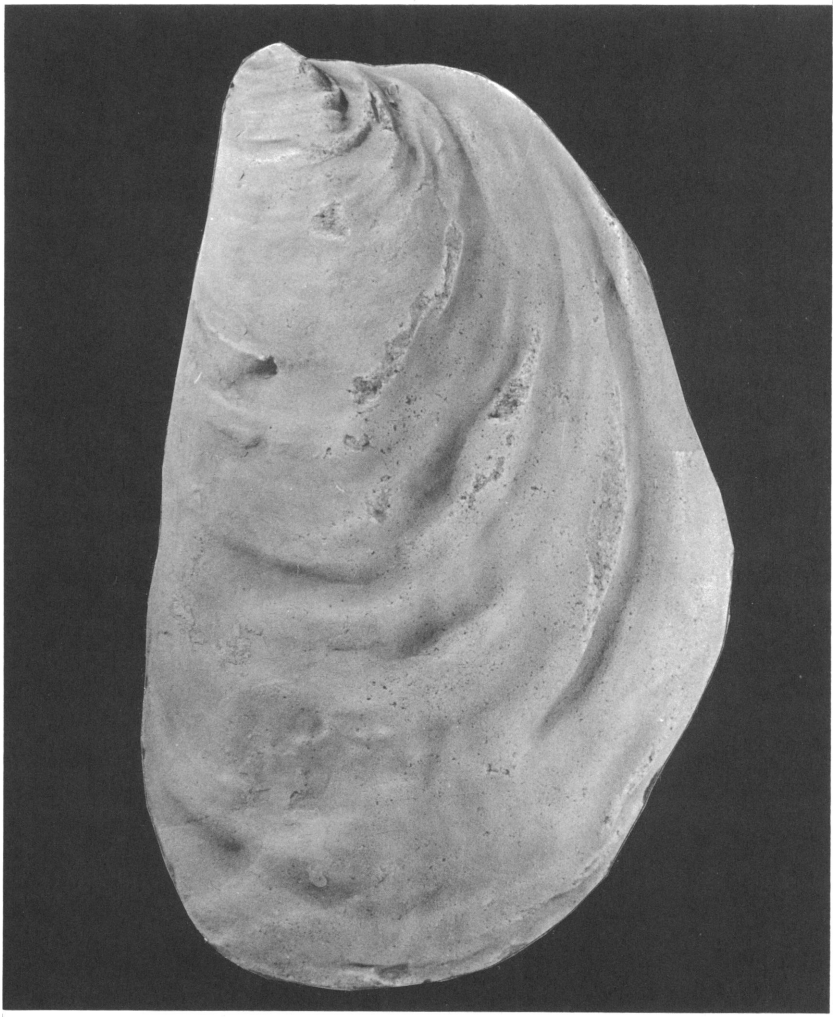

FIG. 2. *Aphanaia mitchellii* (Koninck), Sydney University Geology Department No. 2171. Left valve, plaster cast of internal mold, showing form and ornamentation characteristic of the Inoceramidae. Same specimen as is shown in figures 3 and 4. ×1.

Geology at that institution. The umbonal region of the crucial specimen at hand was covered with friable sandy matrix which was carefully removed to show the ligamental structure which had not previously been described for *Aphanaia.* This specimen is numbered 2171 and is now

FIG. 3. *Aphanaia mitchellii* (Koninck), Sydney University Geology Department No. 2171. Right valve, plaster cast of internal mold. Small ligament pits visible to left of beak. ×1.

being transferred to the Australian Museum, in Sydney, with the approval of the authorities at Sydney University. The rock material of which it is composed resembles other specimens collected by the senior author at Glendon and is lithologically identical with the several speci-

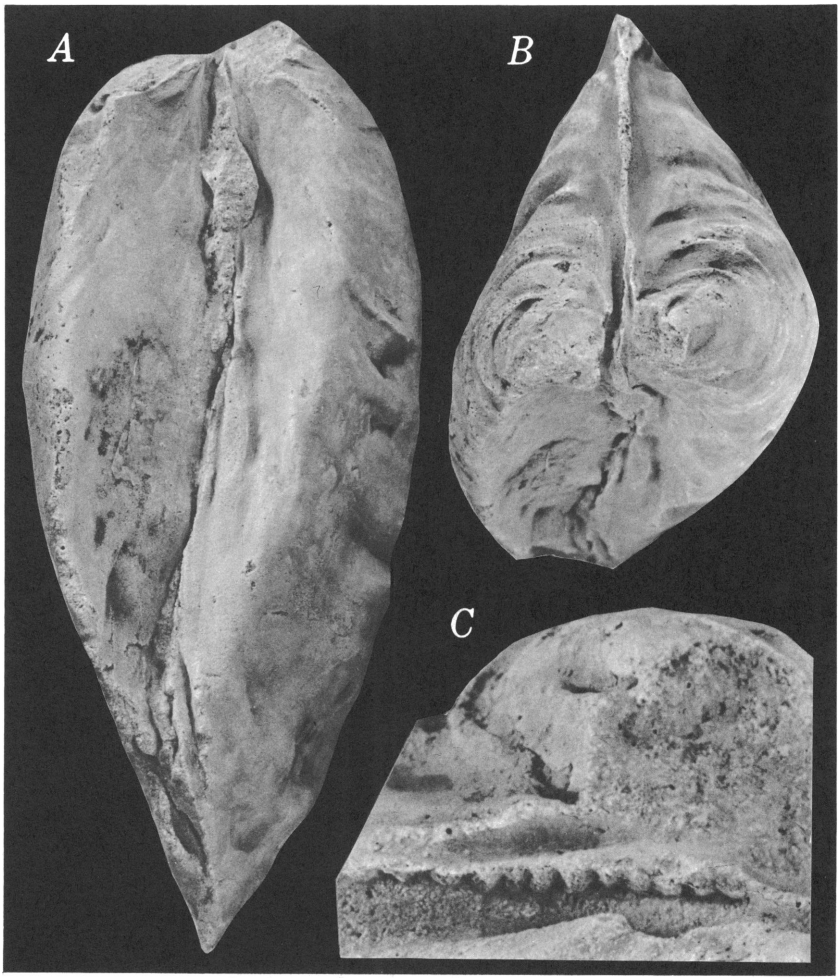

FIG. 4. *Aphanaia mitchellii* (Koninck), Sydney University Geology Department No. 2171. Views of plaster cast of internal mold. A. Front view, showing broad lunule and suggestion of byssal aperture and sinuosity below beaks. ×1. B. Dorsal view, showing slightly greater convexity of left valve. ×1. C. Ligament pits of right valve. ×4.

mens from that locality figured in Clarke's notebooks, including the type specimen of *Aphanaia mitchellii.*

Many of the drawings of Permian fossils in Clarke's notebooks are numbered within the range 2000 to 2856 and agree with the red numbers painted on the corresponding specimens. The pre-Permian inverte-

brates are numbered from 1000 to 2000, and fossil plants of various ages are numbered from 3000 on. A specimen of the Permian brachiopod *"Spirifer" subradiatus,* under study by the senior author, is also sketched in Clarke's book and bears the number of the corresponding drawing. We believe that these specimens form at least part of W. B. Clarke's collection of Permian fossils from the Glendon locality.

It is probable that the specimen of *Aphanaia* and similar specimens were borrowed by T. W. E. David for teaching and research purposes after his appointment to the chair of geology at the University of Sydney in 1891. He had joined the Geological Survey of New South Wales in 1882, four years after the death of W. B. Clarke, and David was engaged

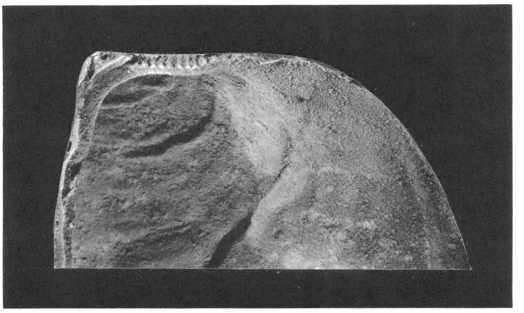

FIG. 5. *Aphanaia mitchellii* (Koninck), Sydney University Geology Department No. 2171. Latex cast of ligament area of right valve. ×1.

in a study of the geology of the Hunter River district, the results of which were not published until 1907. David had a lifelong interest in the geology of the Hunter River district, and it is not surprising that Clarke's notebooks were found in David's room in the Geology Department at the University of Sydney after his death and may explain why the notebooks and many of Clarke's specimens escaped destruction in the fire.

THE GLENDON FOSSIL LOCALITY

Glendon was a favorite collecting spot of early geologists, including Clarke, who sent many specimens to Sedgwick at Cambridge University, who in turn made them available to McCoy and Koninck for study. Glendon was then the name of a grazing property on the left bank of the Hunter River below Singleton, about 5½ miles south of east of Singleton. A small village has now developed near the original house, which is still standing and which has been owned by the Shearer family

for more than 100 years. Access from Maitland was by road and probably by ford and later by low-level bridge across the Hunter River.

David was well acquainted with this fossil locality, and it was indicated in the northwestern portion of his geological map (David, 1907) showing the road from Corinda to Glendon crossing the Hunter River and marking Upper Marine (Permian) sediments dipping gently to the north.

GEOLOGIC AGE OF THE GLENDON BEDS

David represented the Glendon outcrop on his map as Upper Marine (Permian), but he did not distinguish the stratigraphic subdivisions at this locality as he had done so carefully over the main area of his map. More detailed recent investigations by members of the Geological Survey of New South Wales have limited the horizon of the Glendon outcrop to the Muree Formation about the middle of the Upper Marine Series.

The Muree Formation was named by W. B. Clarke and described in considerable detail by David (1907) and others. David further divided the Upper Marine Series into the (lower) Branxton beds and (upper) *Chaenomya*-crinoidal beds, with the Muree beds placed at the top of the Branxton beds. In 1950, David considered the Muree Stage as a separate division between the Branxton and Mulbring or crinoidal stages. The exact placement of these beds in the international scale of Permian strata is somewhat uncertain, but the consensus seems to be that these rocks are probably highest Artinskian or Kungurian of early Permian age (Smith, 1964).

The significance of our discovery is that a characteristic member of the Inoceramidae was already living in Australia in Permian time, doubtless having been derived from some such myalinid ancestor as *Posidoniella* or *Atomodesma.* Accurate discrimination from similar forms must depend on the discovery of well-preserved material that shows hinge characters. Some examples that have been referred to *Atomodesma, Kolymia, Intomodesma,* and others may actually belong to *Aphanaia.*

GENUS *APHANAIA* KONINCK, 1877

TYPE SPECIES: *Inoceramus mitchellii* McCoy (1847); Permian, Australia; subsequent designation by Newell (1942).

Ovate to subpyriform, prosogyrate, subequivalved, with right valve very slightly less convex than left; ornamentation of irregular concentric undulations; lunule shallow, broad, and elongate; hinge edentulous, short, without umbonal septum; resilifer pits numerous, closely spaced; posterior wing and anterior ear lacking. Permian; Australia, Japan.

Aphanaia mitchellii (McCoy), 1847

Figures 1–5

Inoceramus mitchellii McCoy, 1847, p. 299, pl. 14, fig. 1.
Aphanaia mitchellii: Koninck, 1877, p. 164, pl. 21, fig. 5.
?Aphanaia gigantea Koninck, 1877, p. 165, pl. 21, fig. 6.
?Mytilus bigsbyi Koninck, 1877, p. 150, pl. 21, fig. 1.
?Mytilus crassiventer Koninck, 1877, p. 150, pl. 21, fig. 2.

The type specimen of *Aphanaia mitchellii* (fig. 1) appears to be a poorly preserved juvenile which does not provide an adequate understanding of the species. If it were not for the circumstantial information supplied by associated specimens, it could not be confidently assigned to any of several similar genera. The University of Sydney Geology Department No. 2171 (figs. 2–5) is evidently a topotype of *Aphanaia mitchellii.* Numerous ligament pits are well shown on the mold of the right valve, and these are distributed as about 10 in a distance of 11.5 mm. The dimensions of the specimen, an internal mold, are as follows: height, 123 mm.; length, 79 mm.; thickness, 53 mm.; hinge length, 30 ± mm.

Discussion: *Aphanaia gigantea* Koninck, based on a large individual some 265 mm. in maximum dimension, and the smaller type specimens of *Mytilus bigsbyi* Koninck and *M. crassiventer* Koninck, are very possibly conspecific with *A. mitchellii.* They are similar and are of about the same geologic age. However, the originals of the first three are poorly preserved, and they may have come from a different locality (stated by Koninck to be Branxton, New South Wales). Furthermore, all are somewhat more oblique than the type and topotype specimens of *Aphanaia mitchellii.* All these specimens should be reviewed with the aid of extensive series of topotypes. The long prisms of the outer shell layer often reported as from certain species of *Inoceramus* and *Atomodesma* are not yet confirmed in *Aphanaia* but may very well be anticipated.

The relationship between *Aphanaia* and post-Paleozoic Inoceramidae is uncertain, and it is not at present clear how they may be distinguished. The purpose of this paper has been to show that *Aphanaia* possesses a hinge and the general form of the Inoceramidae and is not a member of the Myalinidae, as has been supposed. A specimen described by Hayami (1960, p. 327) from the mid-Permian of Japan as *"Isognomon"* sp. is closely similar to *Aphanaia mitchellii.* The two are probably congeneric.

ACKNOWLEDGMENT

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