

# AUSTRALIAN MUSEUM SCIENTIFIC PUBLICATIONS

Fletcher, Harold O., 1943. The genus *Conocardium* from Australian Palaeozoic rocks. *Records of the Australian Museum* 21(4): 231–243, plates xiii–xiv. [22 December 1943].

doi:10.3853/j.0067-1975.21.1943.537

ISSN 0067-1975

Published by the Australian Museum, Sydney

nature culture **discover**

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# THE GENUS *CONOCARDIUM* FROM AUSTRALIAN PALAEOZOIC ROCKS.

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(Plates xiii-xiv.)

## Introduction.

This paper deals with the known species of *Conocardium* from Palaeozoic rocks in Australia. Reference is made to the rather limited records of the genus in literature, and new species are described from the Lower Middle Devonian (Murrumbidgee Series) of New South Wales, from the Upper Middle Devonian (*Atrypa* limestone) of Western Australia, and from the Permian of New South Wales and Queensland.

The material examined is in the collection of the Australian Museum, with the exception of three specimens, described as *Conocardium gogoense*, sp. nov., from the collection of the University of Western Australia. I am indebted to Dr. Curt Teichert for the opportunity of describing this interesting species.

The known geological range of the genus in Australia extends from the Silurian to the Upper Permian.

The genus *Conocardium* embraces one of the early highly specialized types of shell and was first recorded from Permian rocks in Australia by McCoy (1847, p. 300). Opinion is divided regarding the position of the animal within the shell and the correct orientation is still a subject of discussion. Some workers in this group consider the short truncated end of the shell to be anterior, while others are certain it should be considered the posterior end.

Tryon (1884, p. 195), comparing the shell with *Adacna*, concluded that the conical and gaping end was anterior, the aperture being for the passage of the foot and the function of the long tube or rostrum being siphonal. This view, held by a number of authors, was elaborated by Hind (1900, pp. 452-453) who, after a close examination of the internal characters of a perfect specimen of *Conocardium herculeum*, brought forward several reasons in support of it. He considered the external ligament of *Conocardium* to be restricted, occupying a depression between the umbones and the long rostrum. He remarks: "This surely cannot be placed anterior to the umbones." Other authors, however, are of the opinion that the ligament is amphidetic or paravincular—types one would rather expect in a shell of this type. Hind also states that in bivalves the anterior adductor scar is usually the deeper and better marked, and in many genera, as in *Conocardium*, is bounded behind by a ridge of shell. In *Cucullaea* and other genera, however, we find the exact opposite, the posterior adductor scar being well defined and with a strongly developed ridge.

The pallial line in *Conocardium* is simple and the assumption that it is a siphonate form appears to be attributed to the gape, the presence of the elongated rostrum or analogies with other siphonate genera which have no pallial sinus. These are exceptional, and as a general rule siphonate forms are always recognized by the presence of a pallial sinus. This fact raises the question: what definite evidence have we that *Conocardium* is a siphonate genus?

Hind is of the opinion that the gaping aperture was used for the extrusion of the foot and with this I agree. He states, however, that the foot would be unlikely to protrude over the prominent or sharp interlocking teeth of the valve. In many genera this is exactly what occurs, a case in point being *Cardium*, in which the foot protrudes over much heavier teeth than are present in *Conocardium*.

After a study of the evidence in favour of the truncated end of the shell being posterior, and after several interesting discussions with Mr. Tom Iredale, Conchologist.

at the Australian Museum, on the behaviour of recent shells, I conclude this view should be accepted with a great deal of reservation. Any suggestion that the tubular process or rostrum was used for the passage of siphons appears untenable, the extreme length and small diameter of the tube being strong evidence against it. No reasonable suggestion can be put forward as to the function of the rostrum, unless it was for some respiratory purpose. Certainly it was not for a byssus, as the shell was obviously a mobile sand-burrower and not a sedentary byssiferous type.

The general appearance of *Conocardium* affords the best evidence regarding the orientation of its shell. The winged, conical and gaping end, through which the foot protruded, is obviously the burrowing end and when the shell was at rest would remain buried in the sand or mud. It is impossible to visualize the blunt, truncated end being used for this purpose. Making analogies with other burrowing genera, it is found in almost every case that the posterior end of the shell is used for burrowing and is developed structurally towards that purpose.

For the present, therefore, I am following the authors who consider the truncate end, provided with a tubular prolongation, as the anterior portion.

#### Systematic Position of the Genus.

The family Conocardiidae has been adopted almost universally to receive the single genus *Conocardium*. The systematic position of the family is still very much in doubt. In dealing with specialized or degenerate genera it is difficult and often misleading to arrive at definite conclusions by analogies with other bivalve groups. They are usually a law unto themselves. Hind rightly stated that it is difficult, if not impossible, to assign the family to a correct systematic position.

#### Historical Notes on the Genus in Australia.

McCoy (1847, p. 300) described and figured a shell as *Pleurorhynchus australis* from Permian rocks, stating the species was "not uncommon of larger size in the sandy schists of Wollongong, New South Wales". Dana (1849, p. 701) recorded the same species from Glendon, but referred it to the genus *Cardium*. He wrongly suspected that McCoy's specimen did not come from Wollongong but was collected at Glendon. Dana also described and figured one end of a shell as *Cardium ferox*. Etheridge (1881, p. 250) thought this may be another species of *Conocardium*, but an analysis of Dana's description reveals that the large size of the shell, the thickness of the valves, and the character of the muscle scars preclude any reference to *Conocardium*.

De Koninck (1877, p. 109) recorded *Conocardium sowerbyi* from "the black argillaceous limestone of the Yass District" which he rightly considered to be Devonian in age. He also (1877, p. 146) recorded *Conocardium australe*? McCoy, from a railway cutting between Maitland and Stony Creek, an horizon almost certain to be the Branxton Stage of the Upper Marine Series. De Koninck was not confident his shell was identical with McCoy's species, though his description reveals few points of dissimilarity. The specimen was not figured, and as De Koninck's type material was destroyed in the Garden Palace fire of 1882, the true identity of this shell must remain doubtful.

Etheridge (1881, p. 250) described a single specimen as *Conocardium*, sp. indet., from the Murrumbidgee Series, Lower Middle Devonian, at Bungaralaby, Lake Bathurst, near Goulburn, New South Wales. This shell is considered to be identical with *Conocardium sowerbyi* De Koninck.

Two species, *Conocardium bellulum* and *C. costatum*, were described by Creswell (1893, p. 43) from the Lilydale limestone in Victoria. The descriptions are very limited, but fortunately the figures are good. The Lilydale limestone, previously considered Upper Silurian in age, is now known to be Middle Devonian (Hill, 1939, p. 219).

Chapman (1908, p. 45) recorded both the Victorian species with additional localities.

The only Queensland record of the genus is that of Etheridge (1892, p. 278), who described a shell from the Gympie Series as *Conocardium australe* McCoy. Later (1902, page 68) he stated: "The shell I formerly figured from the Permo-Carboniferous of Queensland as *C. australe* I now know is not that species; it is separated therefrom by

the characters of its anterior end." The Queensland shell is distinct from the typical *C. australe* and has been named *Conocardium gympiense*, sp. nov.

Etheridge (1902, p. 68) described *Conocardium australe* from the Upper Marine Series at Hartley, New South Wales. This shell is an inflated type now renamed *Conocardium robustum*, sp. nov.

Dun (1907, p. 265) described two specimens from the Upper Silurian rocks at Oakey Creek, near Molong, New South Wales, as *Conocardium davidis*. Another specimen from the Upper Silurian Lower Limestone bed of the Bowring Series at Limestone Creek near Silverdale, was exhibited by Mitchell (1906, p. 262) at a meeting of the Linnean Society of New South Wales. The shell was of small size, not more than half an inch along the hinge-line; unfortunately the shell has been mislaid and its occurrence must remain solely as a record.

Walkom (1913, p. 137) recorded *Conocardium australe* in a list of fossils from the upper part of the Branxton Stage, and also listed it as occurring in the Muree Stage.

The genus *Conocardium* has been recorded from several localities in Western Australia. Etheridge (1907, p. 33) recorded a small shell, differing from *C. australe* McCoy, from Permian beds of the Irwin River district. Teichert (1941, p. 377) records it from the Fossil Cliff limestone. Other records have been listed by Glauert (1910, p. 91) including *Conocardium ? hibernicum* Sowerby, an unlikely species in Australian rocks, from the Kimberley district.

The occurrence of the genus in Carboniferous rocks is restricted to a single specimen from Clarence Town, New South Wales. The specimen is in the collection of the Australian Museum (F.40893) and consists of a small portion of the anterior cordiform area, the anterior ridge, and part of the median region. It differs considerably from other species of the genus, but is too incomplete for description and has been mentioned merely as a record of its occurrence.

A collection of fossils from Muswellbrook, New South Wales, was identified by Dun (1937, p. 155), and included among them was *Conocardium*, sp. nov. This specimen has since been examined and identified as *Conocardium australe* (McCoy).

Following is a list of the known species of *Conocardium* occurring in Australian rocks, showing their stratigraphical distribution.

Species.	Lower Silurian. (Mabourian.)	Upper Silurian. (Terremerian.)	Middle Devonian.	Upper Devonian.	Carboniferous.	Permian.					
						Lochinvar Stage.	Allandale Stage.	Farley Stage.	Branxton Stage.	Muree Stage.	Mulbring Stage.
<i>Conocardium costatum</i> (Creswell)	x ?		x								
„ <i>bellulum</i> (Creswell)		x	x								
„ <i>davidis</i> Dun.		x									
„ sp. <sup>1</sup>		x									
„ <i>sowerbyi</i> de Koninek			x								
„ <i>mundulum</i> , sp. nov.			x								
„ <i>abscissum</i> , sp. nov.			x								
„ <i>laseroni</i> , sp. nov.			x								
„ sp. indet. <sup>2</sup>			x								
„ <i>gogoense</i> , sp. nov.				x							
„ <i>gympiense</i> , sp. nov.						x					
„ sp. indet. <sup>3</sup>					x						
„ <i>robustum</i> , sp. nov.									x		x
„ <i>australe</i> (McCoy)							x		x		x
„ <i>truncatum</i> , sp. nov.							x				

<sup>1</sup> Specimen collected by Mitchell (1906, p. 262).

<sup>2</sup> A small portion of a shell from Tarago, New South Wales, denotes the presence of a large undescribed species of *Conocardium* in the Murrumbidgee Series of the lower part of the Middle Devonian. Australian Museum collection (F.40892).

<sup>3</sup> Referred to earlier in this paper. From Clarence Town, New South Wales.

From this table it will be seen that all the species of the genus have an apparent short vertical range. *Conocardium* is by no means a common shell and a good many of the species are represented by single specimens which are, however, well preserved. It is always desirable to have series of specimens in describing new species, but at times even fragmentary material should be utilized if sufficient distinctive characters are present. Only in this way will the palaeontology of any area become known and at the same time collectors stimulated to greater efforts in their search for further specimens.

For the purposes of description in this paper I have followed Barrois and Whidborne in dividing the shell of *Conocardium*, from anterior to posterior, into the following regions: (1) rostrum, with the exception of short basal portions, not preserved on any Australian shells; (2) anterior cordiform slope; (3) anterior keel; (4) median region; (5) median ridge; (6) posterior slope; (7) posterior sinus; (8) conical aliform protuberance.

#### Description of Species.

Family CONOCARDIIDAE Neumayr.

Genus *Conocardium* Bronn.

*Conocardium costatum* (Creswell). (Plate xiii, figs. 1-2.)

1893. *Pleurorhynchus costatus* Creswell, Proc. Roy. Soc. Vict. (N.S.), v, p. 43, pl. lx, fig. 5.

1908. *Conocardium costatum* Chapman, Mem. Nat. Museum, Melbourne, No. 2, p. 45.

The original description of this species is "about half-an-inch long, with nine simple ribs on the anterior part of each valve, and about seventeen on the hinder part".

Chapman did not add to this description, but from Creswell's figures it is clearly seen to be unlike any other species of the genus.

*Occurrence*.—Cave Hill, Lilydale, Victoria. Chapman doubtfully records a damaged specimen from the Domain Road sewer, Melbourne, from Lower Silurian beds of Melbournian age.

*Horizon*.—Lower part of the Middle Devonian.

*Holotype*.—No. 910, National Museum, Melbourne.

*Conocardium bellulum* (Creswell). (Plate xiii, figs. 3-4.)

1893. *Pleurorhynchus bellulus* Creswell, Proc. Roy. Soc. Vict. (N.S.), v, p. 43, pl. lx, fig. 6.

1908. *Conocardium bellulum* Chapman, Mem. Nat. Museum, Melbourne, No. 2, p. 45.

The original description of this species is as follows: "About one-third of an inch long, with the body of the shell more oblique than the hinge-line, more prettily banded and ribbed than *C. costatum*, the ribs being crossed with striae and the valves having a distinctly fenestrated appearance at the posterior end."

I have not had an opportunity of examining any specimens of the Victorian species, but Creswell's original figures, republished in this paper, show few points of similarity with other species of the genus. Chapman compares this species with *C. dipterum* Salter and *C. cuneus* Conrad sp., var. *nasutum* Hall, species in which the shell is anteriorly broad and abruptly truncated.

*Occurrence*.—Cave Hill, Lilydale, Victoria; abundant at Deep Creek, a tributary of the Thompson River, 7 miles north of Walhalla, Gippsland, Victoria. Chapman recorded a single specimen from a mudstone at the junction of the Woori Yallock and the Yarra, Melbourne, Victoria.

*Horizons*.—The geological age of the beds at Walhalla is now thought to be Lower Devonian and not Upper Silurian. Hill and Jones came to this conclusion after an examination of the corals of that area (1940, p. 198). The Cave Hill limestone at Lilydale is now placed in the lower part of the Middle Devonian, so that *Conocardium bellulum* ranges from the Upper Silurian (Yeringian) to the Middle Devonian.

*Holotype*.—No. 911, National Museum, Melbourne.

**Conocardium davidis** Dun. (Plate xiii, figs. 5-6.)

1907. *Conocardium davidis* Dun, Records Geol. Survey of N.S.W., viii, 3, p. 268, pl. xl, figs. 6, 6a.

The two specimens originally described by Dun are the only ones known of this small Upper Silurian species. The only other reference to the genus from Silurian rocks in New South Wales is that of Mitchell (1906, p. 262) from Silverdale, near Bowning, referred to earlier in this paper.

*Conocardium davidis* has some points of similarity with *C. mundulum*, but is distinguished by several characters. It is a slightly deeper shell in comparison with the length and is not as oblique. The broad ribs on the median region of both species are similar, but in *C. davidis* they radiate directly towards the ventral margin, whereas in *C. mundulum* they extend obliquely forward and at the base are all anterior to the umbo.

The anterior keel is prominent, broadly rounded and slightly concave. Anterior cordiform area not large, gently concave and smooth, with three to four radiating ribs centrally situated.

The densely crowded, fine growth lines are characteristic, prominent on the conical aliform protuberance, becoming less noticeable on the inflated median region.

Shell gaping at the posterior portion, but not widely.

The dimensions are: Pl. xiii, fig. 5, length 10 mm., height 8 mm., thickness 6 mm.; Pl. xiii, fig. 6, length 9 mm., height 5.5 mm., thickness 4 mm.

The specimen figured by Dun (pl. xl, figs. 6, 6a) is the holotype of the species and has been reproduced in this paper on Pl. xiii, fig. 5. The second specimen is figured on Pl. xiii, fig. 6.

*Occurrence*.—Oakey Creek, Parish Barton, County Ashburnham, New South Wales.

*Horizon*.—Upper Silurian.

*Holotype*.—F.40820, Australian Museum, Sydney.

**Conocardium mundulum**, sp. nov. (Plate xiii, figs. 7-9.)

*Description*.—Shell small, equivalve, inflated, truncated anteriorly and conically depressed posteriorly. The long tubular rostrum on the truncated surface not preserved.

Umbo prominent, recurved anteriorly. Hinge-line long, straight, slightly arched posteriorly, sunk below the dorsal margin. Anterior margin produced to form the rostrum above, straight but extending forward below and meeting the curved basal margin of the median region at about two-thirds the depth of the shell. Posterior margin oblique, straight and meeting the hinge-margin at an acute angle.

Anterior cordiform slope elongated and narrow; concave between the base of the rostrum and the anterior keel, less so between the anterior margin and the keel. Ornamented by five gradually increasing rounded ribs, of which the outer two are shortened by the anterior keel.

Anterior keel prominent, curved and does not nearly reach the lowest point of the shell. Median region inflated, narrow and convex, ornamented by five coarse, faintly lamellated, sub-angular radiating ribs, separated by interspaces equal to them in width. The ribs originate at the apex of the umbo and radiate forward and downward to the ventral margin so that the base of the last rib is anterior to the umbo. A small fine rib is interpolated between the anterior keel and the first coarse rib.

The posterior slope inclines rapidly from the median region, becoming more or less flattened at the gaping, conical aliform protuberance. The surface is ornamented by at least seventeen radiating ribs, fine on the posterior slope and increasing in size towards the extremity. The interspaces between the ribs are marked by lamellose concentric striae or growth lines.

The dimensions of the holotype are: length 10 mm. (incomplete), height 7 mm., thickness 6 mm.

*Observations*.—This species is represented by a single specimen which has portion of the posterior gape broken away, but is otherwise excellently preserved. It is very

easily distinguished from other species of the genus by its small size, general form, and the forward trend of the strong ribs on the median region.

*Occurrence*.—The specimen was collected by Mr. C. F. Laseron from a limestone at Lake Bathurst Railway Station, twenty miles south of Goulburn, New South Wales.

*Horizon*.—Murrumbidgee Series, lower part of the Middle Devonian.

*Holotype*.—F.30189, Australian Museum, Sydney.

*Conocardium sowerbyi* De Koninck. (Plate xiii, figs. 17–18.)

1877. *Conocardium sowerbyi* De Koninck, Foss. Pal. Nouv.-Galles du Sud, pt. 3, p. 109.

1881. *Conocardium*, sp. ind., Etheridge, Journ. Proc. Roy. Soc. of N.S.W., xiv, p. 250, pl., fig. 9.

De Koninck was of the opinion that the two shells he described from a black argillaceous limestone in the Yass district were identical with *Cardium aliforme* (var.) Sowerby (1840, pl. 56, fig. 2) and with *Pleurorhynchus aliforme* Phillips (1841, pl. 17, fig. 51). He placed these two species as synonyms of *Conocardium sowerbyi*, the name applied to the Australian shell.

De Koninck considered that *Cardium aliforme* (var.) Sowerby had been confused with the exclusively Carboniferous species *Conocardium aliforme* Sowerby, which differed from it in a number of essential characters.

This change in nomenclature for the two British Devonian forms has been apparently overlooked by workers on this group, but later Whidborne (1892, p. 27) referred Sowerby's shell to *Conocardium phillipsii* d'Orbigny, and *Pleurorhynchus aliforme* of Phillips to *Conocardium clathratum* d'Orbigny.

The change in synonymy of the British species does not affect the status of *Conocardium sowerbyi* of De Koninck as the description of this species was compiled from the Australian shells and the name is retained for them. Many Australian fossil shells have been identified in the past as British and European species, but it is now generally recognized that the existence of world-wide species must be looked upon with suspicion.

De Koninck did not figure his specimens, and as they were destroyed in the Garden Palace fire of 1882 we must depend on the description to identify further specimens and establish his species.

Several distinguishing features were pointed out by De Koninck; one of the most important is the large number of concentric ribs on the anterior cordiform slope. Over the remainder of the surface the ribs, about twenty in number, are fairly regular and almost all the same thickness, the last few, covering the posterior and gently gaping portion of the shell, being a little less thick and more flattened than the others.

The dimensions are as follows: length 15 mm., height 13 mm., thickness 11 mm.

The single specimen described by Etheridge as *Conocardium*, sp. ind., is considered to be identical with *C. sowerbyi*. The author makes no mention of the pronounced concentric markings, but an additional specimen from a nearby locality shows them distinctly. This specimen from Tarago, New South Wales (Pl. xiii, figs. 17–18), and Etheridge's specimen agree in all essential characters with De Koninck's species from beds of the same age but about sixty miles to the west.

The species is characterized by the ornamentation being composed of regular and uniform radiating ribs. On the alate posterior protuberance, which is swollen and convex, the ribs are slightly more flattened. In between the ribs, twenty-seven in number, concentric markings give the shell a cellular appearance, a feature stressed by De Koninck. The anterior cordiform area is heart-shaped, concave within the angle of the anterior keel, convex in the middle, and produced above to form the rostrum. The rostrum, although broken from the shell, is preserved in the matrix and is 5 mm. in length. In the concavity of the anterior cordiform slope there are six radiating ribs, slightly heavier than the remainder of the ribs, and these follow the curve of the keel. On the convex portion which forms the base of the rostrum the radiating ribs are finer and for the most part have disappeared through weathering, leaving a smooth surface. The numerous concentric striae are very distinct. Anterior keel broad and well defined.

The dimensions are as follows: Neotype, length 10 mm., height 6.5 mm., thickness 6 mm.; specimen from Bungaralaby, length 19 mm., height 14 mm., thickness 14 mm.

As the holotype and co-type of this species were destroyed, the specimen from Tarago, figured in this paper, has been selected as the neotype. It is a small shell, but exhibits very clearly the characters outlined by De Koninck in the original description of *C. sowerbyi*.

*Occurrence*.—The specimens described by De Koninck were collected in the black argillaceous limestone of the Yass district. A single specimen, described by Etheridge, was collected at Bungaralaby near Lake Bathurst from an horizon which was thought, at that time, to be Carboniferous in age. The neotype was collected at Tarago, a few miles south of Lake Bathurst, New South Wales.

*Horizon*.—Lower Middle Devonian (Murrumbidgee Series).

*Neotype*.—F.40891, Australian Museum, Sydney.

***Conocardium abscissum*, sp. nov.** (Plate xiii, fig. 10.)

*Description*.—Shell small in size, obliquely triangular in outline, as wide as high. Abruptly truncated anteriorly, acutely conical posteriorly.

Median region narrow, rounded and inflated, almost pointed inferiorly and ornamented by five prominent, flattened, radiating ribs originating at the umbo. Each rib possesses a shallow central groove and is almost at right angles to the straight hinge-line, the radiation of the main ribs being very slight. There appears to be no distinct anterior keel, its place being taken by one of the main ribs; on the anterior slope of the median region there is one rib, on the posterior slope three ribs. The interspaces are equal in width to the ribs and are ornamented with very fine and numerous wavy concentric lines.

Inferiorly the median region is bluntly pointed. The posterior margin slopes rapidly from it in a straight line and meets the hinge margin at an acute angle. Posterior slope of the median region steep, forming a shallow sinus at the junction with the compressed, slightly convex and gaping posterior aliform protuberance. Ornamented by 10–12 ribs which originate from the hinge-line near the umbo. These ribs do not nearly attain the thickness of the ribs on the median region.

The dimensions are as follows: height 11 mm., length 10 mm., thickness 7 mm.

*Observations*.—The only representative of this species is a single incomplete specimen found associated with *C. mundulum* and *C. laseroni*. The truncated, anterior cordiform slopes are obscured by matrix and partly missing, while the extremity of the conical aliform protuberance is also imperfect. The median region and ornamentation are well preserved and show striking differences from other species of the genus. It is a very distinct form, and there is no other species with which it can be confused.

*Occurrence*.—Collected from a weathered limestone at the Lake Bathurst Railway Station, 20 miles south of Goulburn, New South Wales.

*Horizon*.—Murrumbidgee Series, lower part of the Middle Devonian.

*Holotype*.—F.39761, Australian Museum, Sydney.

***Conocardium laseroni*, sp. nov.** (Plate xiii, figs. 11–13.)

*Description*.—Shell of medium size, obliquely triangular, strongly inflated, longer than high. Beaks prominent, incurved, situated anteriorly. Hinge-line straight for two-thirds its length, sloping downwards posteriorly. Anterior cordiform slope concave, recessed well below the bordering anterior keel, and ornamented by fine ribs which follow the curve of the keel. The keel itself is prominent, strongly curved, and increases in width inferiorly. Rostrum aperture almost centrally situated.

Median region strongly inflated, ornamented by 6–7 coarse ribs with wide interspaces marked with well defined concentric striae. This region is bluntly carinated with steep slopes formed on either side. Viewed anteriorly the slope is as wide as the enclosed cordiform slope and bears three coarse ribs. Posteriorly the slope of the median region is narrower, ornamented by three coarse ribs; a shallow but distinct sinus is formed at its junction with the main posterior slope of the shell. The posterior slope is



separated from the conical aliform protuberance by a well defined shallow sinus; the former is a well rounded, convex area, the latter a smaller and flattened area at the posterior extremity.

The posterior slope is ornamented by eight fine ribs, originating from behind the beak and curving towards the inferior margin, where they increase in width. The flattened aliform portion possesses nine similar ribs which follow the curve of the dorsal margin. The whole surface of the valve is covered with fine, elevated, concentric striae, closely arranged and giving the shell a cancellated appearance.

The dimensions of the shell are: length 15 mm., height 10 mm., thickness 10 mm.

*Observations.*—This outstanding species of the genus is represented by a single mould of a left valve. It is well preserved, and a prepared cast shows very clearly the ornamentation and general outline of the shell.

Five species of *Conocardium* are found in the Murrumbidgee Series of the Middle Devonian. Three of these, *C. laseroni*, *C. abscissum* and *C. mundulum*, are characterized by possessing coarse ribs on the median region, while *C. sowerbyi* has uniform ribbing over the whole surface of the valves. The present species falls into the first group, but is very easily distinguished by the deeply recessed cordiform slopes and position of the anterior keel.

*Occurrence.*—The single specimen was collected by Mr. C. F. Laseron from a weathered limestone near the Lake Bathurst Railway Station, 20 miles south from Goulburn, New South Wales. The complete shell which came from the described mould was collected by Mr. C. F. Laseron, but unfortunately was mislaid.

*Horizon.*—Murrumbidgee Series, lower part of the Middle Devonian.

*Holotype.*—F.30160, Australian Museum, Sydney.

***Conocardium gogoense*, sp. nov. (Plate xiii, figs. 14–16.)**

*Description.*—Shell small, sub-angularly ovate, equivalve, with a rounded, slightly flattened anterior portion, and widely gaping, conical, posteriorly.

Valves convex, with the greatest convexity in the median region. Umbo small, slightly incurved. Hinge-line straight, sunk below the rounded superior margins. Well marked lunule, ligament external.

Anterior margin produced to form the rostrum, slightly above the hinge-line, gently curved below. Inferior margin narrow, rounded. Posterior margin oblique, practically straight, meeting the hinge margin at an angle of about 45°.

Anterior keel fairly prominent, not curved, and formed by a fold or thickening of one of the ribs. It is situated in the centre of the median region and reaches to the lowest portion of the shell. The anterior cordiform slope, anterior of the keel, is large and hardly differentiated from the remainder of the valve, and is slightly flattened and concave near the hinge margin. Ornamented by 13–14 close, low rounded ribs originating at the apex of the beak and curving away from the anterior keel.

Median region narrow, ornamented by four coarse ribs with wide interspaces. The posterior slope of the shell is horizontally oblique, convex, ornamented by thirteen ribs, similar in appearance, with interspaces as wide as or wider than the ribs. The conical, aliform protuberance not well defined. Along the gaping inferior margin the radiating ribs continue into the interior of the valve, strengthening them considerably. Shell widely gaping posteriorly.

The dimensions are as follows: holotype, length 8 mm., height 8.5 mm., thickness 6 mm.

*Observations.*—This interesting Western Australian species is represented by three well preserved and complete specimens. The holotype, of which the measurements are given, is the smallest; the others attain slightly larger proportions, but do not exceed a length or height of 10.5 mm. A large Carboniferous species, *Conocardium hibernicum* Sowerby, has been recorded from the Kimberley area; this form, though the determination is most doubtful, is totally unlike the present species and could not have been confused with it.

The characteristic ornamentation and the anterior keel passing vertically downwards from the apex of the beak and forming a large cordiform area which hardly differs from the remainder of the valve, make it an outstanding and characteristic Australian species. The rostrum is not preserved in its entirety, but in one specimen a good deal of the base remains, revealing a very minute aperture.

*Occurrence*.—Gogo Station, Kimberley Division, S.S.W. of No. 10 Bore, about one-third of a mile off the limestone escarpment, Western Australia.

*Horizon*.—Upper Middle Devonian (*Atrypa* limestone).

*Holotype*.—C.57, University of Western Australia.

***Conocardium gympiense*, sp. nov.**

1892. *Conocardium australe* Etheridge (non McCoy) in Jack and Etheridge, Geol. and Pal. Q'ld. and New Guinea, p. 278, pl. 14, fig. 6.

*Observations*.—Etheridge (1902, p. 68) concluded that the single shell he had described as *C. australe*, from the Gympie beds of Queensland, was not that species. In his original description he stated it was larger than McCoy's figure, but resembled it in outline and figure, except that the two diverging impressed lines on the shorter end of the shell are not visible. Etheridge says: "The difference in the strength of the striae on the portions which would be bounded by these impressed lines, is, however, quite apparent, and as described by McCoy." In 1902, he stated the Queensland shell is not *C. australe*; "it is separated therefrom by the characters of the anterior end".

The specimen described by Etheridge is possibly housed in the collection of the Geological Survey in Brisbane. I have not been able to examine it, so the conclusions arrived at in this paper have been deduced solely from Etheridge's figure. To my knowledge the only other specimen of *Conocardium* known from the Permian of Queensland is a specimen recorded by Reid (1930, p. 74) from the Middle Bowen beds at Logan Downs.

In the Permian beds of New South Wales the species of *Conocardium* show considerable variation in shape and consequently their specific limits are not readily defined. Even so, an examination of Etheridge's figure reveals several distinctions, although it is very similar to *C. australe*. The anterior keel and the median region in the Queensland shell are not as oblique as in *C. australe*. A line drawn from the apex of the umbo to the inferior margin, at right angles to the hinge-line, encloses a portion of the median region between it and the anterior keel. This is very pronounced in the majority of specimens, whereas in the Queensland shell the anterior keel projects to the rear of a similar parallel line and the base of the keel is almost immediately below the umbo. The ornamentation also shows points of distinction. On the posterior conical alate portion of the shell the ribs are much finer and greater in number than on *C. australe*. The posterior inferior margin is also more concave than in *C. australe*. The number of fine ribs on the posterior slope of the Queensland shell is greater than on *C. australe*.

These distinctions are sufficient in my opinion to separate Etheridge's specimen from *C. australe*, and as Etheridge considered them two distinct species, the Queensland shell has been named *C. gympiense*. It is to be hoped that in the near future additional specimens will be collected from Gympie and so prove whether this procedure has been premature or not.

The dimensions of the specimen, taken from Etheridge's figure, are as follows: length 32 mm., height 21 mm.

*Occurrence*.—Gympie, Queensland.

*Horizon*.—Gympie Beds, Lower Permian.

***Conocardium australe* (McCoy). (Plate xiv, figs. 1, 8-9.)**

1847. *Pleurorhynchus australis* McCoy, Ann. Mag. Nat. Hist., xx, p. 300, pl. 16, fig. 4.

1849. *Cardium australe* Dana, Report Wilkes U.S. Exploring Exped., x, Geol., p. 701, pl. 18, fig. 2.

1877. *Conocardium australe* De Koninck, Foss. Pal. Nouv.-Galles du Sud, pt. 3, p. 284.

*Description.*—Shell of medium size, length 26 mm., oblique, truncated anteriorly, conical posteriorly. Umbo prominent, situated anteriorly. Hinge-line elongate, straight.

Anterior margin straight, nearly perpendicular below the base of the rostrum; inferior margin of median region slightly curved, continuing posteriorly, almost straight but obliquely to the hinge-line which it joins at an angle of about 70°.

Anterior cordiform slope flattened, ornamented by at least 20 fine radiating ribs, which are divided into three divisions by two furrows originating at the apex of the umbo. Anterior keel curved, fairly prominent, not reaching the lowest portion of the shell. The median region is narrow, inflated and oblique, ornamented by four to five ribs with wide interspaces. The posterior slope of the valve is inflated and convex, becoming flattened at the conical aliform posterior extremity. A wide, shallow sinus separates the two portions. The convex portion is ornamented by 12–14 fine ribs of uniform size, closely packed, originating from behind the umbo. The flattened extremity, slightly rolled, or convex, possesses nine broad, flattened ribs, with narrow interspaces, which arise from the hinge-margin.

The whole surface is covered with fine concentric lines of growth which give the shell a cancellate appearance.

The dimensions are as follows: Pl. xiv, fig. 9, length 26 mm., height 19 mm., thickness 10 mm.; Pl. xiv, fig. 8, length 31 mm., height 17 mm., thickness 9 mm.; Pl. xiv, fig. 1, length 40 mm., height 32 mm., thickness (approx.) 14 mm.

*Observations.*—The above description was taken from a plaster cast of the holotype which is housed in the Sedgwick Museum, Cambridge. Etheridge (1902, p. 68) suspected that the shells described by Dana and McCoy did not belong to the same species, because of the following reasons. McCoy in his description stated "the anterior face obliquely sub-truncate, convex, divided into three nearly equal tumid compartments by two impressed furrows from the beak. . . . Anterior face finely striated longitudinally". Dana, on the other hand, states "anterior to the carina, the surface a little concave and finely striate longitudinally".

Etheridge appeared to place too much importance on the concavity or convexity of the cordiform slope. He remarks: "In Dana's figure the anterior end of the shell is so remarkably concave that I am led almost to believe that the authors in question dealt with two distinct species." He stresses this point, although Dana describes the surface as being "a little concave". The convexity of the cordiform slope in McCoy's specimen is not great, in fact it is almost flattened. Furthermore, even though Dana did not mention the presence of the impressed furrows, dividing the ribs into three groups, they are clearly seen on his figure. There is no doubt that Dana's and McCoy's specimens are the same species.

Etheridge (1902, p. 68), in describing a specimen from Hartley, stated it did not possess the arrangement of ribbing on the posterior portion of the shell as laid down by Dana, i.e. "four broad, nine to ten much narrower, and the following again broader". His specimen has been identified as *C. robustum*, a new species from the Upper Marine Series characterized by the anterior portion of the shell being strongly inflated. The ornamentation varies from *C. australe*, but not to any great extent.

The shell doubtfully referred to *C. australe* by De Koninck (1877, p. 146) differs only in size and seems to be a typical specimen of the species.

The specimen figured (Pl. xiv, fig. 1) is a large specimen of *C. australe* from Buchanan, New South Wales. Most of the posterior portion of the valve is missing.

The species, *C. australe*, is an unmistakable one and the only other form with which it can be compared is *C. robustum*. It differs in the anterior portion of the shell not being nearly as inflated as in that species.

It has a geological range from the Allandale Stage in the Lower Marine Series to the Mulbring Stage in the Upper Marine Series.

*Occurrence and Horizon.*—New South Wales: Lower Marine Series, Allandale Stage: Pokolbin. Upper Marine Series: Wollongong, Berarra, Wyro, near Ulladulla (South

Coast); Mount Vincent, Glendon, Muswellbrook, railway cutting between Maitland and Stony Creek (Hunter Valley); Rylstone.

*Holotype*.—Sedgwick Museum, Cambridge, England.

**Conocardium robustum**, sp. nov. (Plate xiv, figs. 2-7, 10.)

1902. *Conocardium australe* Etheridge (non McCoy), Rec. Geol. Survey of N.S.W., vii, 2, p. 68, pl. xviii, figs. 8-9.

*Description*.—Shell large, oblique, strongly inflated and truncated anteriorly, compressed, conically produced posteriorly. Umbones not prominent, flattened and incurved, widely separated. Hinge-line straight, sunk below superior rounded margins. Anterior margin produced to form the rostrum above, convex below. Inferior margin of the median region curved, and continuing posteriorly in an almost straight line to the hinge margin which it joins at an oblique angle. Anterior keel fairly prominent, curved well forward and does not reach the lowest part of the shell.

Anterior cordiform slope wide, flattened, slightly concave between the apex of the umbo and the base of the rostrum. Ornamented by twenty, closely packed, fine ribs, divided into three unequal areas by two shallow, radiating furrows, which originate at the apex of the umbo.

The median region is very obliquely produced anteriorly, narrow, convex and ornamented by five coarse ribs with wide interspaces. The posterior portion of the shell rapidly decreases from the swollen median region to form a narrow elongated, slightly rounded, extremity, with a wide gape. The posterior slope is ornamented by about 14 fine ribs originating in front of the beak, and followed by five or six coarse ribs with wide interspaces. The ribs are strengthened along the inferior margin, giving it a strongly crenulated appearance.

The surface of the valve is covered with heavy concentric growth lines which give the shell a strongly reticulated appearance. This is not noticeable on weathered internal casts.

The dimensions are as follows: Pl. xiv, figs. 5-7, length 47 mm. (incomplete), height 25 mm., thickness 32 mm.; Pl. xiv, figs. 2-4, length 50 mm. (incomplete), height 21 mm., thickness 39 mm.; Pl. xiv, fig. 10, length 33 mm., height 24 mm., thickness 19 mm.

*Observations*.—In association with *C. australe*, and occurring only in the Upper Marine Series, is this remarkable species with a strongly inflated and oblique anterior cordiform slope. In comparison, the posterior alate protuberance is markedly compressed, narrow and elongated. In most cases the widely gaping posterior extremities have been broken from the valves. A wide lunule is well developed. The anterior inferior surface of the shell is broad, flattened or slightly convex. It is impossible to confuse this species with *C. australe*, the only other species of *Conocardium* with which it can be compared.

The specimen described by Etheridge as *C. australe* from Hartley is a typical example of this species. The holotype was collected from the Upper Marine Series at Gerringong.

*Occurrence*.—New South Wales: Rylstone, Mount Vincent, Gerringong, Wyro, near Ulladulla, Hartley.

*Horizon*.—Upper Marine Series, Permian.

*Holotype*.—F.40916, Australian Museum, Sydney.

**Conocardium truncatum**, sp. nov. (Plate xiv, fig. 11.)

*Description*.—Shell cone-shaped; flatly truncated, inflated anteriorly; convex, conical posteriorly. Very inequilateral. The anterior cordiform slope is flat, almost at right angles to the anterior keel. Ornamented with numerous very fine ribs which follow the curve of the keel. The anterior keel practically at right angles to the hinge-line. A median region is not defined, the valve gradually and evenly sloping from the anterior keel to the posterior extremity. Vertically the posterior region is evenly convex. The inferior margin extends obliquely from the anterior keel, the lowest point of the shell, to the straight and long hinge-line, which it meets at an acute angle.

The dimensions are as follows: length 32 mm., height 27 mm., thickness, 20 mm.

*Observations.*—This species is represented by a single cast of a left valve. The only ornamentation preserved is the fine ribs on the anterior cordiform slope. The shell, however, is so totally unlike any other species of the genus in Australian Permian rocks that it is worthy of specific status, even though the specimen is poorly preserved and the description, as a result, very limited.

The species is distinguished by the flattened anterior cordiform slope, which is at right angles to the hinge-line and to the almost vertical anterior keel which extends to the lowest portion of the valve. The median region, if defined by the ornamentation, does not differ from the rest of the posterior portion, as the surface slopes gradually and evenly from the anterior keel to the posterior extremity.

*Occurrence.*—Collected by Mr. A. H. Voisey, M.Sc., at "Colrairie", Kimbriki, Manning River, northern New South Wales.

*Horizon.*—Macleay Series (Lower Marine Series), Permian.

*Holotype.*—F.37827, Australian Museum, Sydney.

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#### EXPLANATIONS OF PLATES.

##### PLATE XIII.

##### *Conocardium costatum* (Creswell).

Fig. 1.—The holotype (after Creswell) showing general outline and ornamentation of the shell.

Fig. 2.—Anterior view of Figure 1, showing cordiform slopes and position of the rostrum.

##### *Conocardium bellulum* (Creswell).

Fig. 3.—The holotype (after Creswell) showing anterior cordiform slopes and the almost central position of the rostrum.

Fig. 4.—Side view of Figure 3, showing general outline.

##### *Conocardium davidis* Dun.

Fig. 5.—Left valve of the holotype showing outline and ornamentation of the valve. (F.40820.)

Fig. 6.—Left valve showing ornamentation on anterior cordiform slope. (F.40821.)

##### *Conocardium mundulum*, sp. nov.

Fig. 7.—Side view of the holotype showing different types of ornamentation and general outline. Posterior extremity missing. (F.30189.)

Fig. 8.—Dorsal view of Figure 7, showing anterior keel and enclosed anterior cordiform slopes.

Fig. 9.—Dorsal view of same specimen showing straight hinge-line and inflation of the anterior portion of the shell.

*Conocardium abscissum*, sp. nov.

Fig. 10.—Side view of the holotype showing characteristic ornamentation. The anterior cordiform slopes and the posterior extremity are missing. (F.39761.)

*Conocardium laseroni*, sp. nov.

Fig. 11.—Anterior view of the holotype showing strongly curved anterior keel and recessed cordiform slope.

Fig. 12.—Side view of Figure 11, showing well marked median region and strongly convex posterior slope.

Fig. 13.—Ornamentation on the posterior alate prolongation of Figure 11. This mould is the holotype, figures 11 and 12 being a cast prepared from it. (F.30160.)

*Conocardium gogoense*, sp. nov.

Fig. 14.—Basal view of the holotype showing the widely gaping nature of the shell and the crenulated inferior margin. (C.57, University of W.A.)

Fig. 15.—Dorsal view of Figure 14, showing well developed lunule and straight hinge-line.

Fig. 16.—Side view of Figure 14, showing general outline of the shell and wide cordiform slope.

*Conocardium sowerbyi* De Koninck.

Fig. 17.—Side view of neotype showing characteristic ornamentation. (F.40891.)

Fig. 18.—View of Figure 17, showing anterior cordiform slope with concentric striae and partly weathered radial ribs.

## PLATE XIV.

*Conocardium australe* (McCoy).

Fig. 1.—A side view of a large valve with most of the posterior portion missing. (F.40897.)

*Conocardium robustum*, sp. nov.

Fig. 2.—A dorsal view showing the exceptionally wide anterior cordiform slopes and position of the rostrum. (F.17750.)

Fig. 3.—Basal view of Figure 2, showing gape and flattened surface.

Fig. 4.—Side view of Figure 2, showing oblique anterior keel and the length of the shell in comparison to the height.

Fig. 5.—Basal view of the holotype showing the gaping nature of the shell and the crenulated inferior margins. (F.40916.)

Fig. 6.—Dorsal view of Figure 5, showing anterior cordiform slopes, lunule and widely separated umbones.

Fig. 7.—A side view of Figure 5, showing the general outline and the oblique median region.

*Conocardium australe* (McCoy).

Fig. 8.—A side view showing the anterior keel and ornamentation. (F.29924.)

Fig. 9.—The holotype (after McCoy) showing impressed furrows on the cordiform slope.

*Conocardium robustum*, sp. nov.

Fig. 10.—An internal cast showing fairly well preserved ornamentation. (F.21928.)

*Conocardium truncatum*, sp. nov.

Fig. 11.—A side view of the holotype. An internal cast showing the flattened cordiform slope and even convexity of the remainder of the valve. (F.37827.)

The dimensions of all figured specimens are given in the text.

Photographs by Mr. G. C. Clutton.

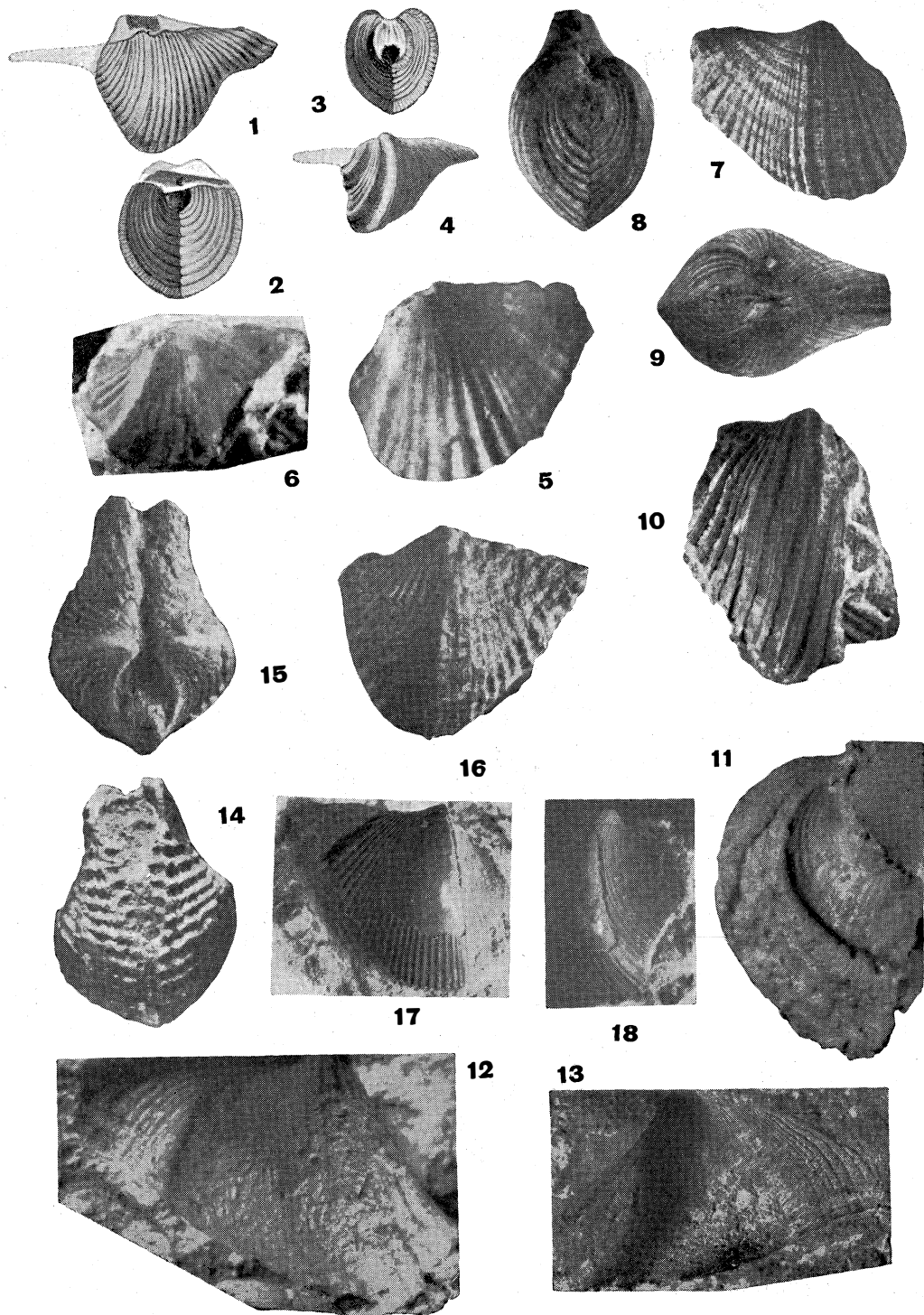


Photo.—G. C. Clutton.

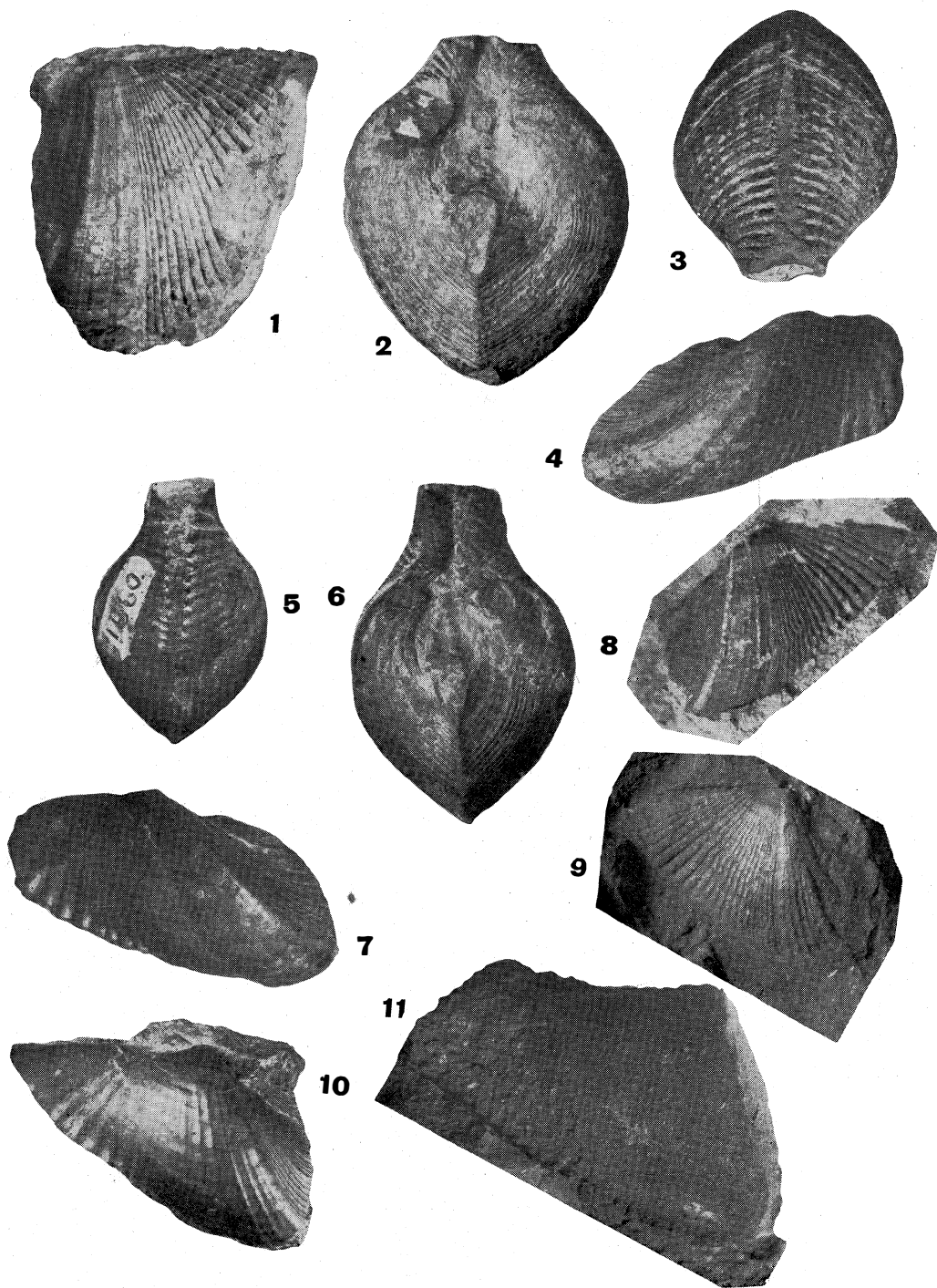


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