UPPER JURASSIC AND LOWER CRETACEOUS PINNIDAE (BIVALVIA) FROM SOUTHERN ALEXANDER ISLAND

By L. E. WILLEY

ABSTRACT. Five species of Pinnidae (Bivalvia) are recorded from the marine sediments of Upper Jurassic (Tithonian)–Lower Cretaceous (Albian) age in southern Alexander Island. Three new species are described and one formally named. The stratigraphical distribution of the family in Alexander Island is discussed.

PINNIDAE first occur in the Lower Carboniferous (Cox, 1969, p. *N*114) and appear to have been cosmopolitan. Living species of *Pinna* have a world-wide distribution in tropical or sub-tropical seas (Cox and Hertlein, 1969, p. *N*281). Stanley (1972, p. 186) has suggested that the Pinnidae appear to represent an "early pteriacean offshoot whose triangular shape is an adaptation for a more deeply buried life position than that of their ancestors". If this is their correct classification, they are unusual in being orientated in life with the saggital plane vertical and in retaining a primative symmetry in relationship to their upright life position (Stanley, 1970, p. 22).

Cox (1969, p. *N*9) concluded that the genus *Pinna* combines byssal attachment with a burrowing form of life. The anterior part of the shell has been greatly drawn out along the hinge line to form a point which penetrates the sediment. This streamlining enables them to move deeper into the sediment during their life by pulling against the anchored byssus (Stanley, 1970, p. 28). An apparent exception to this mode of life is the reported recovery of a specimen of *Pinna pectinata* by Boekschoten (1967, p. 315, text-fig. 4) from the Adriatic Sea "covered all over with epibionts" which he concluded must indicate that this species "lived completely free on the bottom".

The Alexander Island specimens, several of which were found in life position (Taylor and others, 1974, pl. VIIId), were almost all obtained from dark marine mudstones. Hallam (1960), following a study of Liassic *Pinna*, has concluded that despite the sessile existence this genus may in fact favour conditions of high sedimentation. Once established, *Pinna* cannot withdraw from the sediment, but the rapidity with which it can repair a damaged shell (Yonge, 1953, p. 361) suggested to Taylor and others (1974) a possible mechanism for keeping pace with sedimentation, assuming that the soft parts were able to grow fairly rapidly. Therefore, whilst the presence of *Pinna* in life position may indicate a lack of mechanical re-working of the sediments at that time and place within the trough, it does not necessarily suggest a slow rate of sediment accumulation.

SYSTEMATIC DESCRIPTIONS

ORDER MYTILOIDA FERUSSAC 1822

SUPERFAMILY PINNACEA LEACH 1819

FAMILY PINNIDAE LEACH 1819

Genus *Pinna* Linnaeus 1758

Pinna cf. *kotsinensis* Packard and Jones 1965

Fig. 2a

cf. *Pinna kotsinensis* Packard and Jones, 1965, p. 912, pl. 108, figs. 3 and 4.

Material

One incomplete internal mould (KG.719.23) in a dark mudstone from the Ablation Point area (Fig. 1).

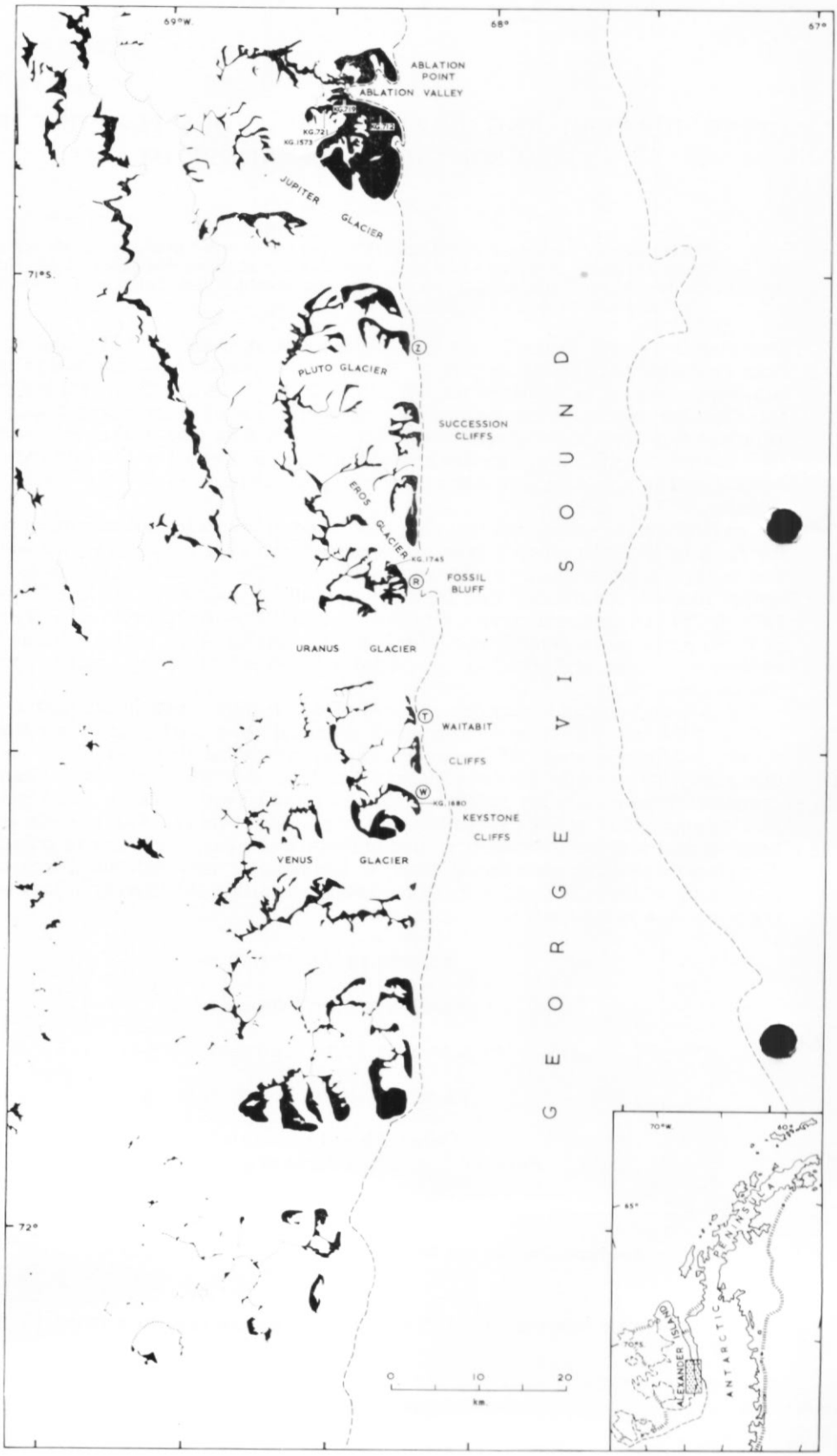

Fig. 1. Sketch map of part of Alexander Island showing the area discussed and the locations from which the specimens of Pinnidae were obtained.

Description

This is an incomplete internal mould of a small individual about 60 mm. long (Fig. 2a). The valves are only slightly inflated, the median ridge is indistinct and the apical angle is about 18°. The dorsal area is ornamented by an unknown number of longitudinal ribs with narrow interspaces. On the upper part of the convex ventral area are seven longitudinal ribs, separated by broader interspaces; below these and on the posterior part of the flank is a series of oblique growth ridges or folds. These folds meet the first rib at an acute angle then they swing to cross the other ribs at nearly a right-angle, producing a fine reticulate pattern.

Remarks

This specimen closely resembles examples of *Pinna kotsinensis* Packard and Jones from the Hauterivian of Alaska (Packard and Jones, 1965, p. 912, pl. 108, figs. 3 and 4). However, the Alexander Island specimen does not show enough of the dorsal surface of the valve for a closer comparison to be made and the apical angle appears to be slightly more obtuse.

Overall similarities are also apparent with examples of *Pinna pacifica* Skwarko, from the Lower Cretaceous of New Guinea (Skwarko, 1966, p. 93, pl. 12, figs. 11 and 12), but the latter have a greater number of longitudinal ribs, the growth ridges or folds are coarser and the cross-section of the shell is sub-rhomboidal.

Pinna cf. *robinaldina* (d'Orbigny 1843–47)

Fig. 2b and c

cf. *Pinna robinaldina* d'Orbigny, 1843–47*a*, p. 251.
cf. *Pinna robinaldina* d'Orbigny; d'Orbigny, 1843–47*b*, pl. CCCXXX, figs. 1–3.
cf. *Pinna robinaldina* (d'Orbigny); Woods, 1904–13, p. 97.

Material

Three incomplete specimens; a slightly distorted internal mould, with small areas of test adhering, from locality T, one internal mould from station KG.1680 (near locality W) and one external mould fragment from station KG.1745 (north-west of Fossil Bluff).

Description

All three specimens are of fairly large individuals, specimen KG.68.7 is 142 mm. long, with straight margins and an apical angle of about 25°. They are sub-trigonal in lateral view (Fig. 2b) and sub-rhomboidal in cross-section. The valves are divided into two parts by a median ridge, the slightly wider dorsal part being ornamented with about eight strong narrow ribs separated by broad concave interspaces. The ventral part of the shell is slightly convex and bears five or six radial ribs which are separated by concave interspaces of irregular width. These radial ribs and interspaces are all crossed by fine concentric ridges producing a fine crenulation along the radial ribs (Fig. 2c). Fragments of test adhering to one specimen (KG.68.7) are 1 mm. thick.

Remarks

These specimens are incomplete but appear to be closely comparable to *Pinna robinaldina* (d'Orbigny 1843–47*a*, p. 251, 1843–47*b*, pl. CCCXXX, figs. 1–3) as re-described, from examples from the Lower Greensand of England, by Woods (1904–13, p. 97). However, in the examples illustrated by Woods the spacing of the ribs on the ventral slope appears more regular and the dorsal and ventral slopes of the shells are of equal width.

Specimens from Lower Cretaceous sediments of Japan of *Pinna* sp. cf. *P. robinaldina* d'Orbigny (Hayami, 1965, p. 281, pl. 89, figs. 2 and 3) are also closely comparable to the Alexander Island specimens.

Pinna antarctica sp. nov.

Fig. 2d and e

Pinna sp.; Taylor and others, 1974, pl. VIIId.

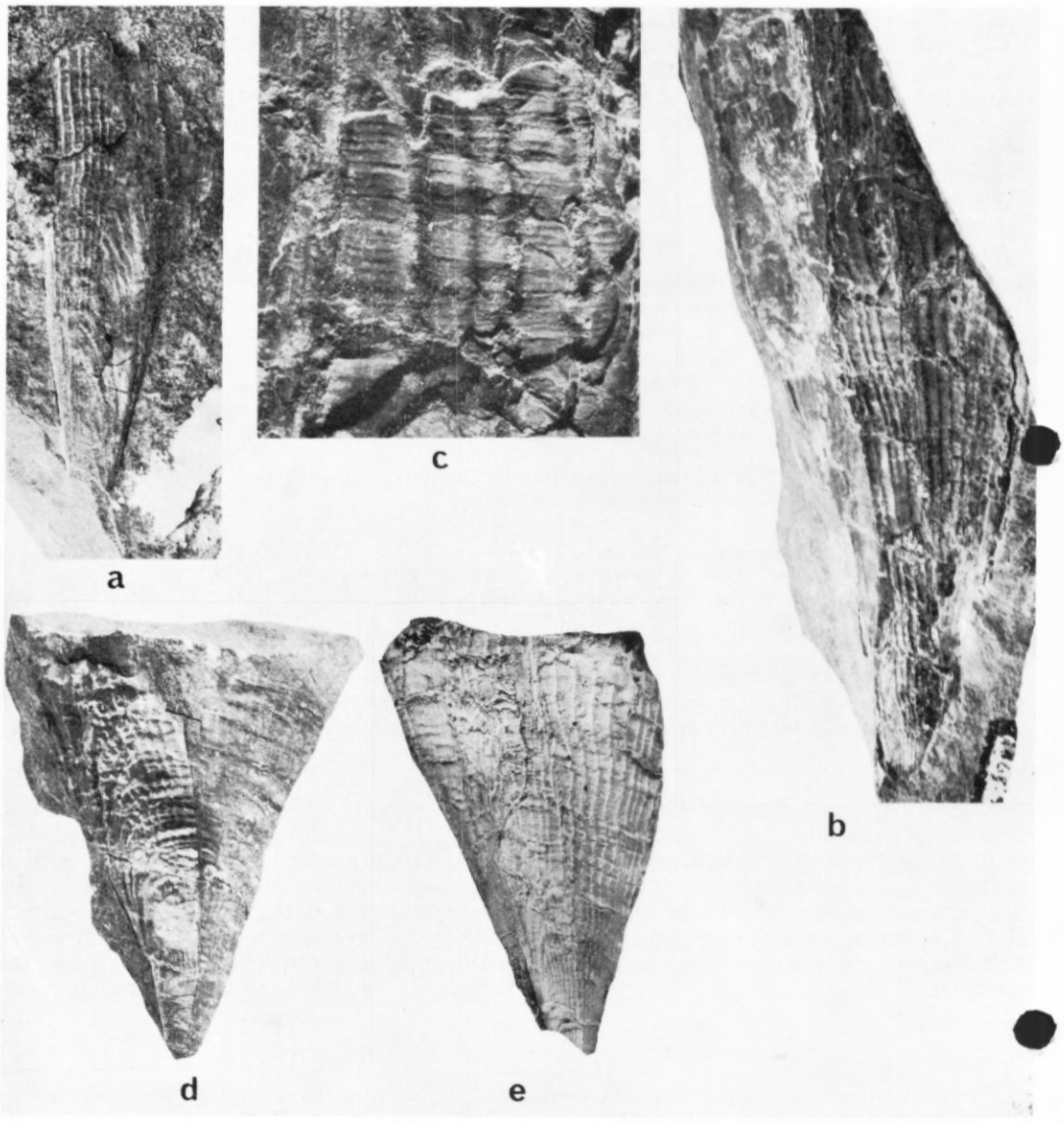

Fig. 2. a. *Pinna* cf. *kotsinensis* Packard and Jones; an incomplete internal mould preserved in a dark mudstone, collected from the southern side of Ablation Valley; ×1 (KG.719.23).
b. *Pinna* cf. *robinaldina* d'Orbigny; an incomplete, slightly distorted internal mould preserved in a dark mudstone, collected from locality T; ×0·75 (KG.68.7).
c. *Pinna* cf. *robinaldina* d'Orbigny; a small fragment of test adhering to the mould showing the external ornamentation; ×4 (KG.68.7).
d. *Pinna antarctica* sp. nov.; the holotype, the right valve of an articulated internal mould, collected from locality Z; ×1 (KG.401.650).
e. *Pinna antarctica* sp. nov.; latex cast of a natural mould showing the external ornamentation, collected from locality Z; ×1, coated (KG.401.502).

Material

One internal cast and six external and four internal moulds. One specimen was collected from the Ablation Point area (KG.721) and the remainder from locality Z. Specimen KG.401.650, an articulated internal mould from locality Z, is designated as the holotype.

Diagnosis

The shell is medium-sized for the genus. The apical angle is moderately acute. Lateral outline sub-trigonal, cross-sections near the anterior end sub-quadratic, those near the posterior end sub-rhomboidal. The valves are divided into two parts by a median ridge; the dorsal slope is relatively flat and the ventral one slightly convex. Ornamentation consists of a series of radial ribs, about 10 to 15 on the dorsal slope and five to eight on the ventral slope. A series of oblique growth undulations occupies the lower posterior area and swings sharply to cross the ribs and, together with growth lines, produces a crenulated effect along the surface of the ribs.

Description

These specimens are distinct from previously described material. The shell is medium-sized for the genus. The apical angle is moderately acute (43° in the holotype) and the margins are slightly concave producing, in lateral view, a sub-trigonal outline (Fig. 2d). A median ridge divides the valve into two parts; the relatively flat, narrower dorsal slope is ornamented with 10 to 15 compressed and elevated radial ribs separated by wide smooth grooves (Fig. 2e). The ventral, slightly convex slope is marked by five to eight radial ribs. Occupying the lower posterior area is a series of oblique growth undulations; these swing sharply to cross the ribs and, together with growth lines, produce a crenulated effect along the surface of the ribs. Cross-sections near the anterior end of the shell are sub-quadrate and those at the posterior end sub-rhomboidal.

Measurements

Specimen number	*Height* (mm.)	*Length* (mm.)	ϕ
KG.401.502	37	80*	40°
KG.401.620	50	95*	40°
KG.401.622	34	60	36°
KG.401.650†	42	60*	43°

*Estimated. †Holotype. ϕUmbonal or apical angle.

Remarks

These specimens closely resemble an example of *Pinna kewhiana* Marwick, from the Oxfordian of New Zealand (Marwick, 1953, p. 97, pl. 13, fig. 14) in both outline and general ornament. However, the ribbing on both flanks of the New Zealand example is neither as coarse nor as closely spaced as that in the Alexander Island specimens.

A comparable ornament to that of *Pinna antarctica* is developed in examples of *Pinna romanikhae* Zakharov, from the Berriasian–Valanginian of northern Siberia (Zakharov, 1966, p. 73, pl. XVIII, fig. 7, pl. XXI, fig. 1, pl. XXII, figs. 1 and 2, text-fig. 12a–c). However, the Siberian examples have a more acute apex, are more elongate and tend to flatten out in the later stages of growth.

Similarities are also apparent with the holotype of *Pinna sandsfootensis* Arkell, from the Upper Calcareous Grit of Weymouth (Arkell, 1927–35, p. 223, pl. XXIX, figs. 4 and 4a), but in Arkell's specimen the ornament is more delicate and the shell more acute.

Pinna sp. *A*

Fig. 3a

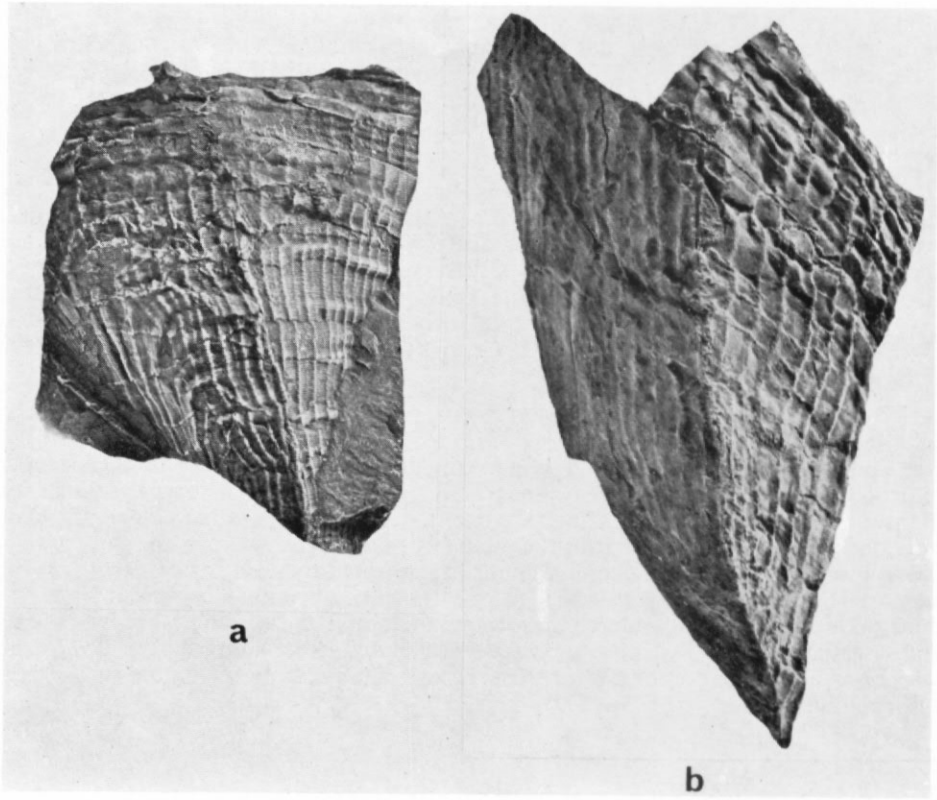

Fig. 3. a. *Pinna* sp. nov. *A*; latex cast of a natural mould showing the external ornamentation, collected from the southern side of Ablation Valley; ×1, coated (KG.712.21).
b. *Pinna* sp. nov. *B*; internal mould of a specimen collected from the south-western edge of Ablation Valley; ×1 (KG.1573.10).

Material

One external mould in a dark mudstone from the Ablation Point area (KG.712).

Description and remarks

This incomplete fragment from the right valve of a medium-sized individual (length=90 mm.) (KG.712.21) is too poorly preserved for specific identification, but it differs from the previously described examples in the following respects. The apical angle is fairly obtuse (55°) and the lateral outline of the shell is trigonal (Fig. 3a). The shell is poorly inflated. A median longitudinal ridge sets the dorsal and ventral slopes of the valve at an angle of about 145°. The dorsal slope is slightly concave and is ornamented with seven major radial ribs separated by wide flattened grooves each containing a centrally positioned intercalary rib. The convex ventral slope is marked by five major radial ribs, two of which contain intercalary ribs, and by oblique growth ridges or folds which occupy the lower and posterior area. The growth ridges curve as they near the first rib and cross at nearly a right-angle. Growth ridges and fine concentric growth lines cross the ribs on both dorsal and ventral slopes, creating a crenulated appearance along the ribs.

The distinctive crenulated ornamentation and the development of intercalary ribs on this specimen are similar to that shown by *Pinna arata* Forbes, from the Lower Cretaceous of

southern India (Stoliczka, 1871, p. 384, pl. XXIV, fig. 5, pl. XXV, fig. 1, pl. XXVI, fig. 5). However, the Indian examples are more elongate and inflated.

Pinna sp. *B*

Fig. 3b

Material

One incomplete internal cast from the Ablation Point area (KG.1573).

Description

This incomplete medium-sized specimen (KG.1573.10) has a length of 100 mm., height of 52 mm. and the thickness of both valves is 33 mm. (Fig. 3b). It differs from the previously described species in the following respects. The shell is rhomboidal in cross-section. The margins are slightly curved, the line of the dorsal margin is slightly concave and that of the ventral margin slightly convex. The valves are divided into two almost equal parts by an angulated ridge (120°); the dorsal area is convex and the ventral area slightly concave. Ornamentation on the dorsal slope consists of seven coarse radial ribs separated by broad concave interspaces. The ventral surface has five radial ribs, separated by narrower interspaces; the lower and posterior area is occupied by a series of oblique growth ridges or folds which intersect the first rib at an acute angle. The ridges then swing to cross the other ribs at nearly a right-angle and produce a coarse crenulation along the surface of the ribs.

Remarks

The Alexander Island specimen is similar in outline and general form to examples of *Pinna equivillana* Anderson, from the Lower Cretaceous of California (Anderson, 1938, p. 98, pl. 2, fig. 1; Packard and Jones, 1965, p. 913, pl. 107, fig. 3, pl. 108, fig. 5). However, the Californian examples have a greater number of radial ribs on the ventral slope and the apical angle appears to be more acute than that of the present specimen.

A specimen of *Pinna morenoi* Wilckens, from Cretaceous sediments of southern Patagonia (Wilckens, 1907, p. 123, pl. V, fig. 2a and b), is similar to the Alexander Island specimen but it lacks the development of crenulation along the ribs and the shell is poorly inflated.

The external ornamentation of the North American species *Pinna quadrifrons* Cragin, from the Jurassic Malone Formation of Texas (Cragin, 1905, p. 49, pl. VIII, figs. 1–8), is much finer and more closely spaced than that in the Alexander Island specimen.

Stratigraphical Discussion

The first record of Pinnidae from the Antarctic Peninsula area was by Wilckens (1910), who described specimens of *Pinna andersoni* Wilckens from Upper Cretaceous sediments on Snow Hill and Seymour Islands, north-eastern Graham Land (Wilckens, 1910, p. 11, pl. 1, figs. 5 and 6). Bibby (1966, p. 24) subsequently reported the collection of *Pinna andersoni* and *Pinna* sp. from Vega Island, north-eastern Graham Land.

In eastern Ellsworth Land, *Pinna* sp. occurs in Upper Jurassic sediments at the Weather Guesser Nunataks associated with a varied bivalve fauna including *Myophorella*, *Astarte*, *Grammatodon*, *Pleuromya*, *Inoceramus* sp. aff. *brownei* Marwick, the belemnite *Belemnopsis* and the gastropod *Aporrhais* sp. (Laudon and others, 1969).

The first reported occurrences of *Pinna* in Alexander Island were by Taylor and others (1974) but no descriptions of these specimens have been given until this paper. The ages of the species described here have largely been determined from associated ammonites (Thomson, 1971, 1974), belemnites (Willey, 1972, 1973) and *Inoceramus* (Thomson and Willey, 1972) in stratigraphically equivalent or near-equivalent horizons (Table I).

Pinna cf. *kotsinensis* Packard and Jones closely resembles a species from sediments of Hauterivian age in Alaska (Packard and Jones, 1965, p. 912) and is also considered to be similar to *Pinna pacifica* Skwarko from the Lower Cretaceous sediments of New Guinea

TABLE I

Age		*Pinnidae species*	*Remarks and associated stratigraphically significant faunas*
Albian		*Pinna* cf. *robinaldina*	From beds equivalent to those at locality W containing an ammonite fauna correlated with the Lower Albian fauna from locality B, and stratigraphically above beds at locality T containing an uppermost Aptian–Albian fauna
Aptian		*Pinna* cf. *robinaldina*	At locality T associated with the ammonites *Eulytoceras* aff. *polare* (Ravn) and *Sanmartinoceras patagonicum* Bonarelli, the belemnite *Peratobelus* sp. (*?*) nov. and the bivalve *Grammatodon* (*Indogrammatodon*) *alexandra* Willey From beds laterally equivalent to those at locality R containing a rich fauna of Aconeceratinae including specimens of *Aconeceras* and *Theganeceras*
Neocomian	Barremian Hauterivian Valanginian		Not yet proven in Alexander Island
	Berriasian	*Pinna antarctica*	At locality Z below beds containing *Bochianites gracilis* Thomson and with a varied fauna including the ammonites *Phyllopachyceras* (*?*) sp., *Phylloceras* sp., *Substreblites* sp., *Neocosmoceras* aff. *sayi* (Simonescu), *Himalayites* (*?*) sp., *Sarassinella* aff. *hondana Haas*, a *Belemnopsis*/*Hibolithes* assemblage and several bivalves including *Grammatodon* (*Indogrammatodon*) aff. *fyfei* Marwick, *Inoceramus pseudosteinmanni* Thomson and Willey and *Myophorella alexandra* Willey At station KG.721, at the south-western edge of Ablation Valley, associated with the ammonites *Bochianites* aff. *versteeghi* (Boehm) and *Haplophylloceras strigile* Blanford (*?*) and the belemnites *Hibolithes subfusiformis* (Raspail) and *Hibolithes* cf. *compressus* Stolley
		Pinna sp. *B*	At station KG.1573, at the south-western edge of Ablation Valley, in beds equivalent to those at station KG.721
		Pinna cf. *kotsinensis*	At station KG.719, at the southern side of Ablation Valley, in sediments with a similar fauna to that at station KG.721 but stratigraphically about 300 m. lower in the succession
Tithonian		*Pinna* sp. *A*	In association with an ammonite fauna dominated by species of *Virgatosphinctes* and *Aulacosphinctoides* from station KG.712 on the southern side of Ablation Valley
Kimmeridgian to **Upper Oxfordian**			

(Skwarko, 1966, p. 93). The Alexander Island example was obtained from sediments on the southern side of Ablation Valley in beds equivalent to those containing a varied fauna including:

Bochianites aff. *versteeghi* (Boehm)
Haplophylloceras strigile (Blanford) (*?*)
Raimondiceras sp. nov.
Spiticeras aff. *spitiensis* (Blanford)
Belemnopsis alexandri Willey
Belemnopsis aff. *uhligi* Stevens
Hibolithes subfusiformis (Raspail)
Myophorella alexandra Willey
Grammatodon subrectangulus Willey
Grammatodon (*Indogrammatodon*) aff. *fyfei* Marwick
Grammatodon (*Indogrammatodon*) *falcatus* Willey
Grammatodon (*Indogrammatodon*) *antarctica* Willey

This fauna is believed to be Berriasian in age (Willey, 1973, 1975*a*, *b*; Elliott, 1974; Taylor and others, 1974).

Pinna robinaldina (d'Orbigny), a well-known species from Lower Cretaceous marine sediments of Europe (e.g. d'Orbigny, 1843–47*a*, p. 251; Woods, 1904–13, p. 97), and *Pinna* sp. cf. *P. robinaldina*, from Lower Cretaceous sediments of Japan (Hayami, 1965, p. 281–82), are very similar to the Alexander Island examples of *Pinna* cf. *robinaldina*. One of these specimens was obtained from beds equivalent to those at locality W (Keystone Cliffs) containing an ammonite fauna with strong Upper Neocomian appearances (Thomson, 1971). However, a re-assessment of these ammonites suggested that they were more closely correlated with the Albian faunas of locality B (Thomson, 1974). Taylor and others (1974) have also suggested that the "thrust zone" (Horne, 1967, p. 4) beneath the ammonite-bearing sequence is "essentially a gravitational slide or slump phenomenon" and that, in accord with field evidence, these beds lie stratigraphically above the uppermost Aptian–Lower Albian beds in the upper parts of the sequence at Waitabit Cliffs (locality T). At locality T, a specimen was collected from the lower parts of the measured section associated with an Aptian fauna which includes the ammonites *Eulytoceras* aff. *polare* (Ravn) and *Sanmartinoceras patagonicum* Bonarelli, the belemnite *Peratobelus* sp. (*?*) nov. and the bivalve *Grammatodon* (*Nanonavis*) *alexandra* Willey (Thomson, 1971, 1974; Willey, 1972, 1975*a*; Taylor and others, 1974). A third specimen was collected from sediments north-west of Fossil Bluff (KG.1745) in beds laterally equivalent to those at locality R which contain a fauna of Aptian age rich in Aconeceratinae including specimens of *Aconeceras* and *Theganeceras* (Thomson, 1971, 1974; Taylor and others, 1974).

Pinna antarctica sp. nov. is similar to several species described from Upper Jurassic and Lower Cretaceous sedimentary sequences in New Zealand, Siberia and England (p. 125). One example was collected from station KG.721, at the south-western edge of Ablation Valley, from beds stratigraphically above those containing *Pinna* cf. *kotsinensis* and associated with a fauna of Berriasian age including the ammonites *Bochianites* aff. *versteeghi* (Boehm) and *Haplophylloceras strigile* (Blanford) (*?*), and the belemnites *Hibolithes subfusiformis* (Raspail) and *Hibolithes* cf. *compressus* Stolley (Willey, 1973; Elliott, 1974; Taylor and others, 1974). Several specimens were collected from locality Z in beds below those containing *Bochianites gracilis* Thomson and associated with a varied Berriasian fauna including:

Phyllopachyceras (*?*) sp.
Phylloceras sp.
Substreblites sp.
Neocosmoceras aff. *sayi* (Simionescu)
Himalayites (*?*) sp.
Sarasinella aff. *hondana* Haas
Belemnopsis alexandri Willey
Belemnopsis gladiatoris Willey
Belemnopsis aff. *uhligi* Stevens
Hibolithes subfusiformis (Raspail)
Hibolithes antarctica Willey
Hibolithes aff. *marwicki mangaoraensis* Stevens
Grammatodon (*Indogrammatodon*) aff. *fyfei* Marwick
Inoceramus pseudosteinmanni Thomson and Willey
Myophorella alexandra Willey

Thomson, 1971, 1974; Thomson and Willey, 1972; Willey, 1973, 1975*a*, *b*; Taylor and others, 1974).

Pinna sp. *A* is similar to *Pinna arata* Forbes from Lower Cretaceous sediments of southern India (Stoliczka, 1871, p. 384). The Alexander Island specimen was collected from beds on the southern side of Ablation Valley containing a mainly molluscan fauna, of Tithonian age, dominated by species of *Virgatosphinctes* and *Aulacosphinctoides* (Elliott, 1974; Taylor and others, 1974).

Similarities have been noted between *Pinna* sp. *B* and several species from Lower Cretaceous sediments of California, Texas and Patagonia (p. 127). The Alexander Island specimen was collected from beds of probable Berriasian age at station KG.1573, south-west of Ablation Valley, and laterally equivalent to beds at station KG.721 from which *Pinna antarctica* was obtained (p. 125).

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