UPPER JURASSIC AND LOWER CRETACEOUS *Inoceramus* (BIVALVIA) FROM SOUTH-EAST ALEXANDER ISLAND

By M. R. A. Thomson *and* L. E. Willey

Abstract. Nine species of *Inoceramus* (Bivalvia) are described from sediments of Upper Oxfordian–Kimmeridgian to Upper Aptian age on the south-eastern coast of Alexander Island. Most of the species appear to be new and two, *I. pseudosteinmanni* sp. nov. and "*I*". *trapezoidalis* sp. nov. are preserved well enough to be formally described. The stratigraphical distribution of the species in Alexander Island is discussed.

Species of *Inoceramus* occur commonly in argillaceous sediments of the marine Mesozoic sequence which is exposed on the southern part of the east coast of Alexander Island (Fig. 1). External and internal moulds or fragments of the prismatic test are frequently present at all levels throughout thicknesses of several tens of metres and in other places they tend to be concentrated in clusters. An unusual feature of their occurrence is that at some levels they are entirely absent from sediments which appear to be lithologically similar to others in which they abound. This is surprising in view of the wide range of sedimentary environments which *Inoceramus* is known to have inhabited (e.g. Reeside, 1957), and there seems to be no obvious explanation for its absence from parts of the Alexander Island succession. However, the examples described by Reeside are all of Albian or later age and it is possible that this genus did not become particularly adaptive and diversified until the Upper Cretaceous. The concentration of previous studies on Upper Cretaceous members of the genus is probably a true reflection of the latter considerations, although it may also be argued that the pre-Upper Cretaceous species have received less than the proportional amount of study due to them. In the present instance, the fragmentary preservation of the great majority of *Inoceramus* specimens has enabled only a cursory study of the species present in Alexander Island to be made, and it is possible that there are species not represented in the collections because they appeared to be too poorly preserved in the field and were overlooked.

Systematic Descriptions

Family Inoceramidae Giebel 1852

Inoceramus haasti Hochstetter 1863
Fig. 2

Inoceramus haasti Hochstetter; Zittel, 1864, p. 33, pl. VIII, fig. 5a–c.
Inoceramus haasti Hochstetter; Trechmann, 1923, p. 275, pl. XV, fig. 3.
Inoceramus haasti Hochstetter emend. Zittel; Wandel, 1936, p. 473, text-figs. 4 and 5, pls. XIX and XX.
Inoceramus haasti Hochstetter; Marwick, 1953, p, 91, pl. 12, fig. 1.

Material

One slab (KG.701.74) bearing the internal moulds of two individuals, from the scree 50–100 m. above the base of the cliffs on the south side of Ablation Valley.
Age: Upper Oxfordian–Kimmeridgian.

Description and remarks

The largest mould (Fig. 2) on the slab carries a distinctive bold ornament of relatively sharp, widely spaced, concentric plicae, which appear terrace-like in cross-section. It so closely resembles examples of *Inoceramus haasti* from New Zealand and Misol (Wandel, 1936) that there can be little doubt of its identity with that species, even though the mould is incomplete. A small fragment to one side of the large mould has more closely spaced plicae which are nevertheless of the same type as those of the latter; it is probably part of a young individual of the same species (cf. Zittel, 1864, pl. VIII, fig. 5c; Wandel, 1936, pl. XX, figs. 1 and 2).

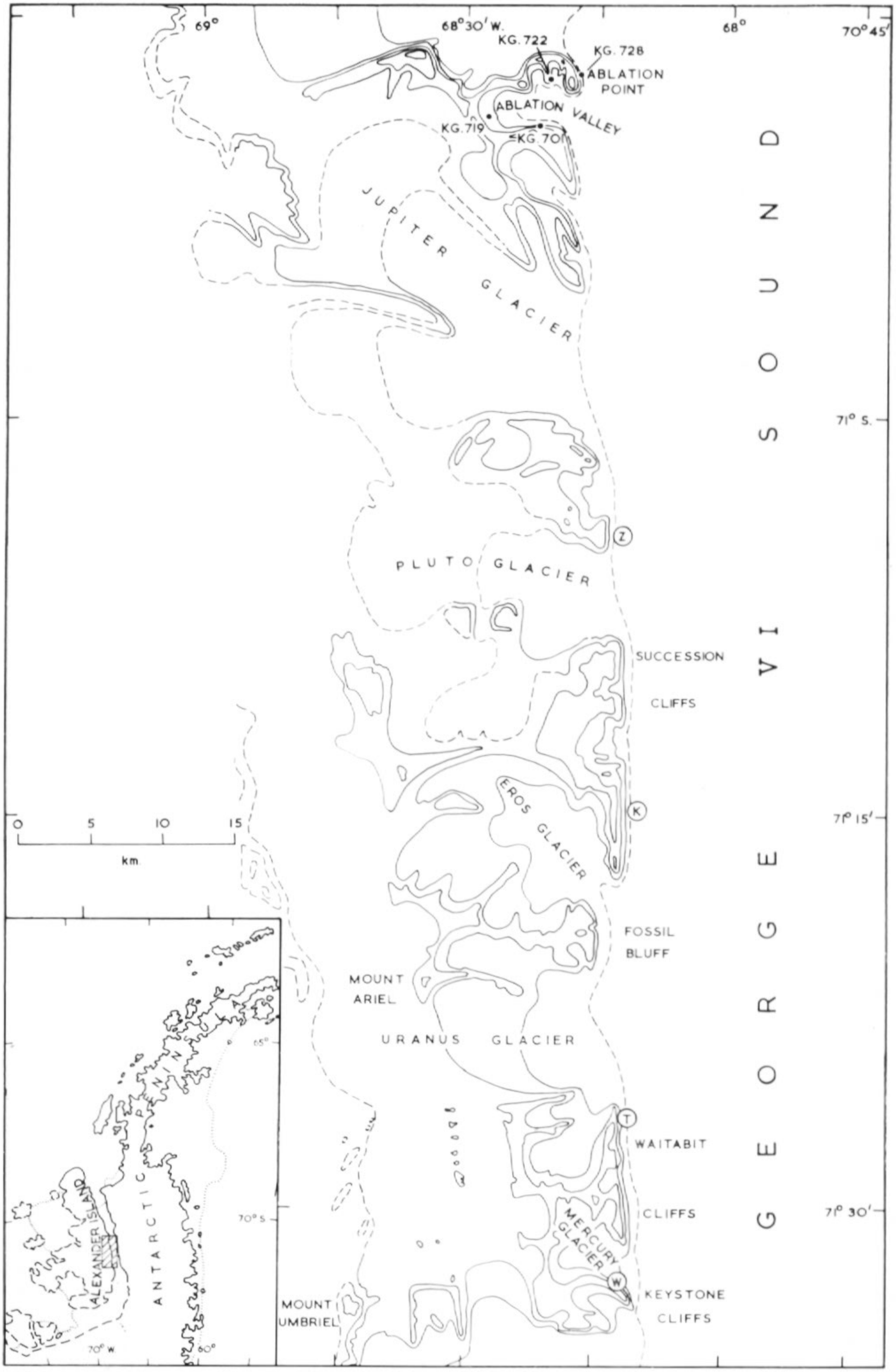


Fig. 1. Sketch map of part of the south-east coast of Alexander Island, showing the localities from which specimens of *Inoceramus* were collected.

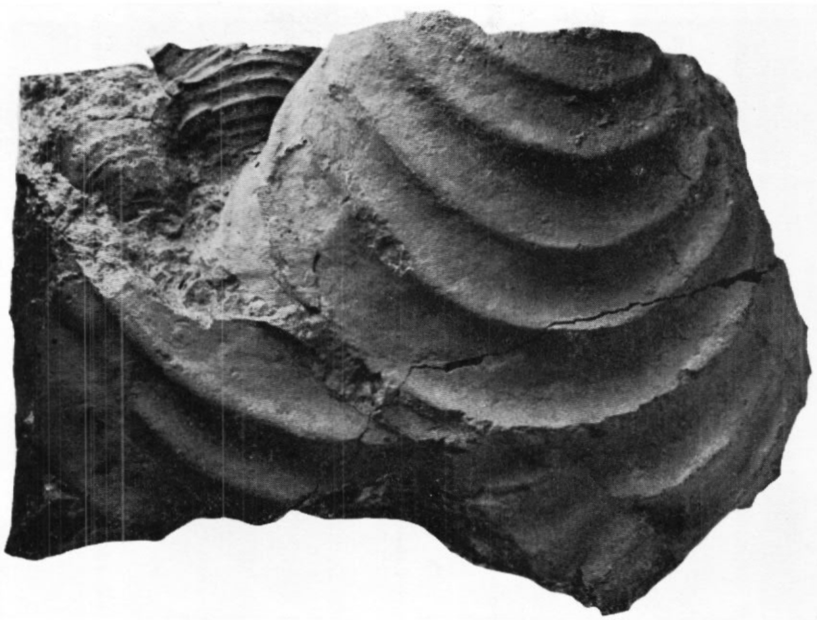


Fig. 2. *Inoceramus haasti* Hochstetter; internal moulds of a large specimen and also a (?) young stage; ×1, coated (KG.701.74).

Inoceramus aff. *subhaasti* Wandel 1936

Fig. 3

aff. *Inoceramus subhaasti* Wandel, 1936, p. 469, text-fig. 3, pl. XV, figs. 1 and 2; pl. XVI, fig. 5a and b; pl. XVIII, figs. 1–3.
(?) *Inoceramus* sp. "G" Sornay; *in* Routhier, 1953, p. 56, pl. II, fig. 7.

Material

A large but incomplete external mould (KG.701.76) from the scree 50–100 m. above the base of the cliffs on the south side of Ablation Valley; a second external mould (KG.701.75) may, or may not, belong to the same species.
Age: Upper Oxfordian–Kimmeridgian.

Description and remarks

The mould (Fig. 3) is from a large specimen which has been crushed and may also have undergone a slight degree of lateral compression. Its ornament is similar to that of *I. haasti* described above except for the presence of secondary concentric ribs on the flanks of the coarser plicae. Although the hinge margin is not preserved to orientate the valve precisely, the form and arrangement of the plicae suggest that the shell was more oblique than *I. haasti* and of mytiliform appearance. The narrow shell form of this species (possibly accentuated somewhat by lateral compression) suggests affinities with *I. galoi* Boehm,* but the ribbing is too sharp and too widely spaced for that species and the specimen compares more closely with *I. subhaasti* Wandel, and particularly *I. subhaasti* var. *intermedia* (Wandel, 1936, pl. XVIII, fig. 3a).

Inoceramus sp. "G", of possible Oxfordian age, from New Caledonia (Routhier, 1953, pl.

* *I. galoi* reported from the Callovian of Argentina (Stehn, 1924, p. 139, pl. V, figs, 4a, b and 5) has much sharper and coarser ribbing than the typical *I. galoi* of Indonesia (Boehm, 1907, pl. X, figs. 1a–c and 2), and in this respect it is more like *I. subhaasti* Wandel. However, it is doubtful whether the Argentinian specimens can truly be referred to either of these species.

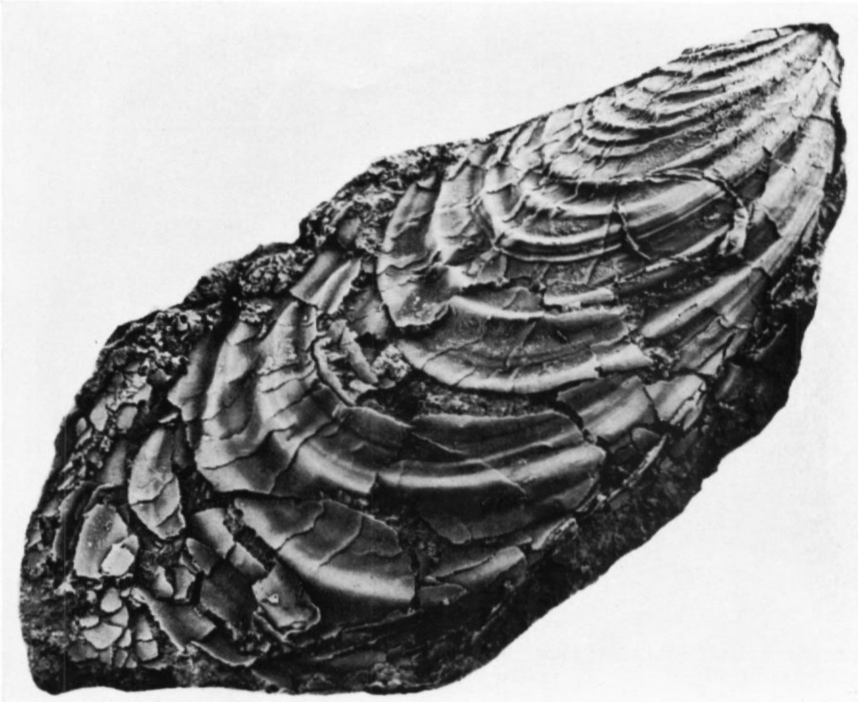


Fig. 3. *Inoceramus* aff. *subhaasti* Wandel; latex cast from the external mould of a crushed example; south side of Ablation Valley; ×1, coated (KG.701.76).

II, fig. 7) resembles the present example in general shell form and ornament but it lacks the secondary ribbing. This difference may only be apparent, because the Antarctic specimen is an external mould and the New Caledonian one is an internal mould. A feature of *I. subhaasti* not demonstrable on either of these specimens is the strongly projecting umbo normally found on both valves.

Inoceramus sp. γ

Fig. 4a

Material

One internal mould of a left valve (KG.722.9) from the north side of Ablation Valley, collected 50 m. above the base of the cliffs.
Age: Tithonian.

Description and remarks

The mould of the valve is approximately square in outline (Fig. 4a). Behind a terminal umbo is a flat, triangular postero-dorsal wing which is disproportionally large in the specimen because part of the ventral and posterior areas of the shell, corresponding in development to the posterior part of the wing, has been broken off. The form of the growth plicae indicates well-rounded ventral and posterior margins. The direction of maximum growth trends from the umbo at an angle of about 50° to the hinge margin and more or less corresponds with the most inflated part of the shell. Anteriorly, the shell drops steeply to the plane of commissure and postero-dorsally the inflation decreases more gradually towards the wing. Ornament consists of coarse concentric plicae of *I. haasti* type which appear step-like in cross-section; in a few instances there are one or two minor concentric plicae on the steeper ventral slopes of the coarser plicae.

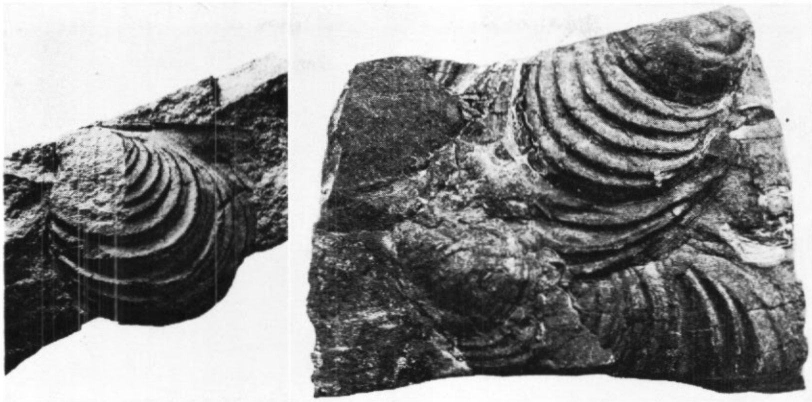


Fig. 4. a. *Inoceramus* sp. γ; an internal mould from the north side of Ablation Valley; ×1 (KG.722.9).
b. *Inoceramus* sp. δ; three internal moulds on a slab from a moraine 1·7 km. north of Ablation Point; ×1 (KG.728.11).

This small specimen is distinct from the other Alexander Island species described here and it does not appear to be closely comparable with described forms.

Inoceramus sp. δ
Fig. 4b

Material

Two small slabs (KG.728.10 and 11) bearing moulds of this species, from a moraine on the edge of George VI Sound, 1·7 km. north of Ablation Point. The matrix is a distinctive blue-black platy mudstone and similar slabs at the same locality have yielded the ammonites *Lytoceras* sp. and *Virgatosphinctes* cf. *frequens* Uhlig.
Age: Probably Tithonian.

Description and remarks

The best specimens are three internal moulds on specimen KG.728.11 (Fig. 4b) but even these are too incompletely preserved for identification. None shows details of the hinge line or any corresponding indications of the presence or absence of a postero-dorsal wing. These examples are probably of similar age to *Inoceramus* sp. γ described above but they differ from the latter in having more rounded concentric plicae which also suggest a more symmetrical and linguiform shell.

Inoceramus pseudosteinmanni sp. nov.
Figs. 5a–h, 6a–c and 7a

Inoceramus cf. *steinmanni* Wilckens; Feruglio, 1936, p. 26, pl. II, figs. 3, 4, 5, 7, 8, (?) 6, 11, *non* 9 and 10.
Inoceramus; Katz and Watters, 1966, p. 336, fig. 7.

Material

Two external and seven more or less incomplete internal moulds and 15 additional fragments of internal moulds from locality Z. Specimen KG.401.520, an internal mould of a left valve, is designated as the holotype.
Age: Lower Neocomian.

Diagnosis

Shell small to medium-sized for the genus, apparently equivalve and obliquely inflated; valve outline quadrate; umbones terminal, inflated and incurved. Depressed wing-like area developed posteriorly to the umbo. Ornament of concentric corrugations with a rounded cross-section and an amplitude which increases in proportion to the distance from the umbo.

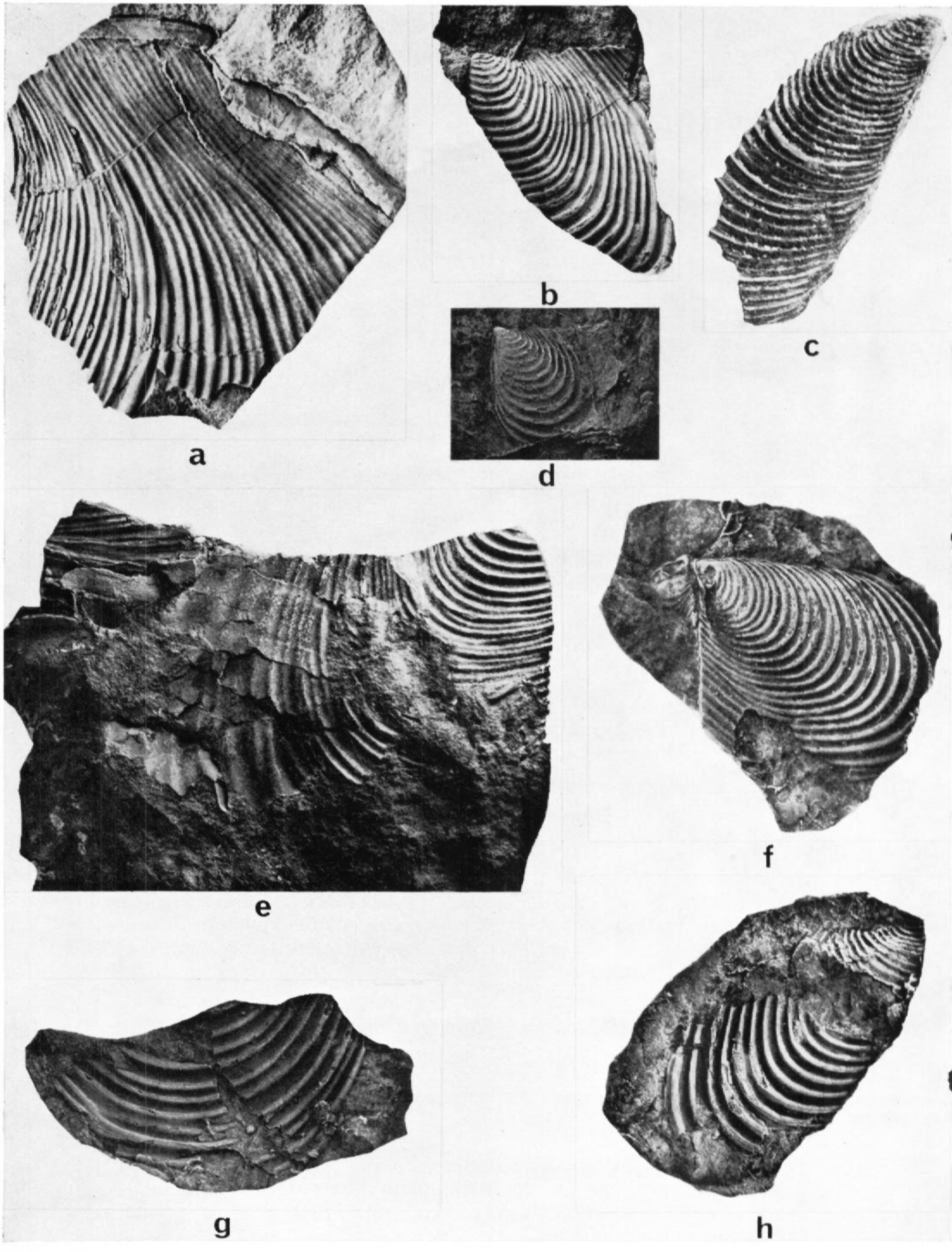


Fig. 5. *Inoceramus pseudosteinmanni* sp. nov. from locality Z.

a. Internal mould of the postero-dorsal area of a left valve; ×1, coated (KG.401.514).
b. Latex cast from the holotype; an external mould of a left valve; ×1, coated (KG.401.520).
c. Internal mould of a part of a right valve; ×1 (KG.401.515a).
d. Latex cast of a small left valve; ×2, coated (KG.401.521).
e. Internal mould of the postero-ventral area of a large right valve; ×1 (KG.401.524).
f. Latex cast from the external mould of a right valve; ×1·5, coated (KG.401.526).
g. Latex cast from an external mould of a fragment of the ventral part of a shell, showing fine growth lines superimposed on the coarser ornament; ×1, coated (KG.401.523).
h. Latex cast from the external mould of a broken right valve; ×1, coated (KG.401.522).

Description

All of the available material of this species is in a fragmentary condition and the description is based on observations from a large number of the fragments. The holotype (KG.401.520; Fig. 5b) is a fragmentary external mould of an adult left valve comprising the umbo and postero-dorsal half of the shell. It is obliquely inflated and appears to have had a subquadrate outline with a long straight hinge line which meets the straight anterior margin at about 90°. The umbo is terminal, acute and moderately inflated. Postero-dorsally, the shell flattens out into a broad wing-like area which is not clearly demarcated from the inflated main body of the shell. The direction of maximum growth or *Wachstumsrichtung* (Seitz, 1935) varies irregularly with increase in size; near the umbo it is directed at an angle of about 40° to the hinge line and later it increases to about 55°. The ventral margin is missing from the holotype but on a smaller specimen (Fig. 5d) it is broadly rounded.

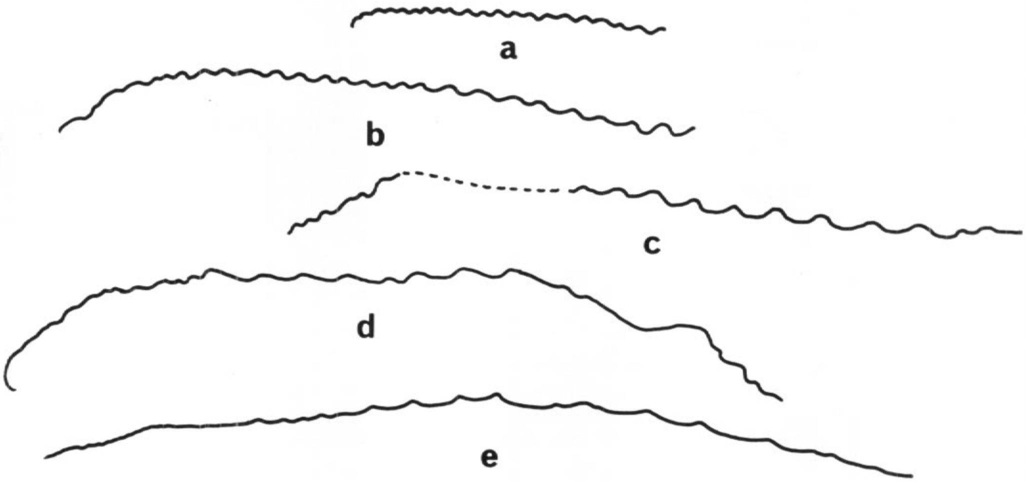


Fig. 6. Profiles of *Inoceramus* to show the ornament pattern. The profiles are all drawn along the axis of maximum growth and they are all orientated with the umbo towards the left. All examples ×2.
a. *I. pseudosteinmanni* sp. nov.; from an external mould of a small left valve (KG.401.526).
b. *I. pseudosteinmanni* sp. nov.; from the holotype, an external mould of a left valve (KG.401.520).
c. *I. pseudosteinmanni* sp. nov.; from the external mould of a broken right valve (KG.401.522.)
d. "*I.*" *trapezoidalis* sp. nov.; from the holotype, an internal mould of a left valve (KG.18.31).
e. *I.* aff. *concentricus*; from an internal mould of a right valve (KG.103.158).

The ornament consists of concentric corrugations with a symmetrically rounded cross-section (Figs. 5a–h and 6a–c) which increase in size towards the ventral margin. Across the main body of the shell they are all simple but near the dorsal margin they are somewhat crowded and several are fused together.

The right valves (Fig. 5c and f) have a similar overall outline and form to their left counterparts but they are less inflated. The hinge margin is approximately equal in length to the height of the shell and meets the straight anterior margin at about 90°. The direction of maximum growth increases steadily with increase in size from about 40° near the umbo to about 55° in the adult stages. Ornament is closely similar to that of the left valves and the corrugations on the postero-dorsal wing meet the hinge margin at an angle of 50–60°.

In several of the larger specimens (Fig. 5a and e) the ornament becomes slightly irregular near the ventral margin and on the dorsal wing where the corrugations become less prominent after fusing together. Stages of coarser ornamentation on one specimen (Fig. 5c) are believed to have formed as the result of external influences which affected the growth rate of the shell. A fine concentric line is developed on the dorsal slope of the concentric corrugations in several of the larger specimens (Fig. 5g and h); this is similar to the *Anwachslinie* of Heinz (1928, p. 15).

Measurements

Conventional methods of measurement for bivalve shells (Shrock and Twenhofel, 1953, p. 372) are unsuitable for the present species because the closely similar values obtained for the length and height merely indicate that the shell is quadrate in outline. The oblique inflation of the species is better represented by using the measurement system devised by Seitz (1935) for mytiliform species of *Inoceramus* and in which the measurements are related to the direction of maximum growth. The measurements of specimens are given in Table I.

TABLE I

Specimen number	l* (mm.)	h† (mm.)	h/l	α‡
	Left valves			
KG.401.520	12	10	0·83	42°
(holotype)	28	20	0·71	42°
	37	28	0·76	55°
KG.401.521	8	6	0·75	44°
	11	8	0·73	55°
	Right valves			
KG.401.526	13	9	0·69	40°
	17	12	0·70	46°
	29	24	0·82	53°
(?) KG.401.504	9	7	0·77	42°
	17	13	0·76	65°

* Length of the valve measured along the direction of maximum growth at a selected growth stage.

† Height measured at right-angles to l and at the same selected growth stage.

‡ Direction of maximum growth (*Wachstumsrichtung* of Seitz (1935)) measured as an angle with respect to the hinge margin and at the same growth stage as h and l were measured.

Thickness measurements on several small pieces of test were all about 1 mm.

Remarks

Neocomian specimens, figured by Feruglio (1936, pl. II, figs. 3, 4, 5, 7, 8, (?) 6 and 11) from the Lago Argentino area of Patagonia as *Inoceramus* cf. *steinmanni* Wilckens, closely resemble those from locality Z and are considered to be conspecific with them. However, Wilckens' (1907, p. 102, pl. II, figs. 4 and 5) original examples of *I. steinmanni* are characterized by having an ornament of alternate large and small corrugations, whereas the present species has only one size of corrugations. Leanza (1967, p. 147–48) has suggested that Feruglio's collection included at least two species which were represented by the examples in Feruglio's (1936) pl. II, figs. 3, 4, 5, 7 and 9, and figs. 6, 8, 10 and 11, respectively, and which he re-identified as *Inoceramus* spp.

This distinction has not been entirely adopted here. Feruglio's figs. 9 and 10 specimens are separated from the remainder because of their distinct ornament; in one (fig. 9) an acute asymmetrical type of concentric plicae is developed, whereas in the other (fig. 10) the ornament consists of a series of closely spaced acute plicae separated by smoothly rounded furrows. Those specimens in Feruglio's figs. 6 and 11 are doubtfully referred to *I. pseudosteinmanni* because their ornament is distorted, probably as a result of post-burial crushing, and the plicae are now depressed and overlapping.

A slab of flaggy argillite (Katz and Watters, 1966, p. 366, fig. 7) from the Yahgan Formation of Navarino Island, southern Chile, bears the imprints of two fragments of *Inoceramus* valves of which the left-hand one is almost identical to specimen KG.401.522 (Fig. 5h) both in size and ornament. The second imprint represents part of the depressed post-umbonal area and closely resembles specimen KG.401.514 (Fig. 5a) in having corrugations which fuse together as they approach the hinge margin and are crowded together. These two examples are considered to be conspecific with the specimens here assigned to *Inoceramus pseudosteinmanni*.

The sediments from which the Navarino Island specimens were obtained have been correlated with the main transgressive cycle in the Patagonian geosyncline and a Tithonian–Neocomian age has been suggested for them (Katz and Watters, 1966, p. 341).

The ornament of *Inoceramus* aff. *everesti* from the Middle Kimmeridgian of New Zealand (Marwick, 1953, p. 92, pl. 12, fig. 4) is similar to that on the present holotype (Fig. 5b) but in the New Zealand form the length of the hinge line in comparison to the height of the valve is much shorter, the angle between the hinge line and the anterior margin is more acute, the outline is sub-ovate and the valves are only very slightly inflated.

Other species resembling the present one include *Inoceramus* sp. nov. *a* cf. *I. anglicus* Woods from the Neocomian of Western Australia (Brunnschweiler, 1960, p. 26–27, pl. 2, figs. 3 and 6, text-fig. 19a–c). The ornament of the two species is similar but, in the Australian examples, the length of the hinge line compared to the overall height of the shell is much shorter, the angle between the hinge line and the anterior margin is more acute and neither of its valves is inflated to any degree.

Among the Alexander Island examples, which are included in the present species, is one specimen (KG.401.504; Fig. 7a) in which the corrugations are more widely spaced and which has an anomalously high angle for the direction of maximum growth. In these respects it appears to be more closely related to an example of *I. everesti* Oppel from the Upper Jurassic of the Himalayas (Holdhaus, 1913, pl. XCVII, fig. 12).

Inoceramus pseudosteinmanni sp. nov. thus seems to represent a species which has a position in the lineage of the genus between the broadly corrugated species of the Upper Jurassic, such as *I. everesti*, and the early Cretaceous species which are more acute and elongate in outline than *I. pseudosteinmanni*.

Inoceramus sp. *a*
Fig. 7b and c

Material

An incomplete internal mould of an articulated example from locality Z (KG.401.51) which still has a little of the test adhering to it, and a second distorted specimen (KG.719.15) from the bluff at the head of Ablation Valley.

Age: Lower Neocomian, Berriasian.

Description

The valves of both specimens (Fig. 7b and c) are sub-elliptical in outline and are obliquely inflated. The inflation of the shell is greatest in the umbonal and dorsal regions, and decreases rapidly both anteriorly and posteriorly while slowly flattening out ventrally. Close to the umbo the direction of maximum growth lies at an angle of about 25° to the hinge line but this angle increases to nearer 40° at the ventral margin. The umbo is terminal and, judging from the Ablation Valley specimen (Fig. 7c), projected. The hinge line and the anterior margin meet at an angle of 70–75°. On internal moulds the ornament consists of broad, poorly defined plicae separated by asymmetrical furrows, both of which are overlain by a series of much finer, regularly spaced concentric threads. On the external surface of the test, the threads correspond to flat or feebly convex areas which are subdivided by a series of fine concentric grooves spaced 2–3 mm. apart. The hinge line of specimen KG.401.51 is marked by a furrow, extending about half the length of the shell, on the dorsal surface of the mould; on specimen KG.719.15 the dorsal commissure is visible but not the ligament pits.

Measurements

No precise measurements can be given. Specimen KG.401.51 has an overall height of about 82 mm., a length of 55 mm. and a total thickness of 32 mm. Fragments of test adhering to the mould are about 1 mm. thick.

Remarks

These two specimens are easily distinguished from the rest of the collection by their ornament

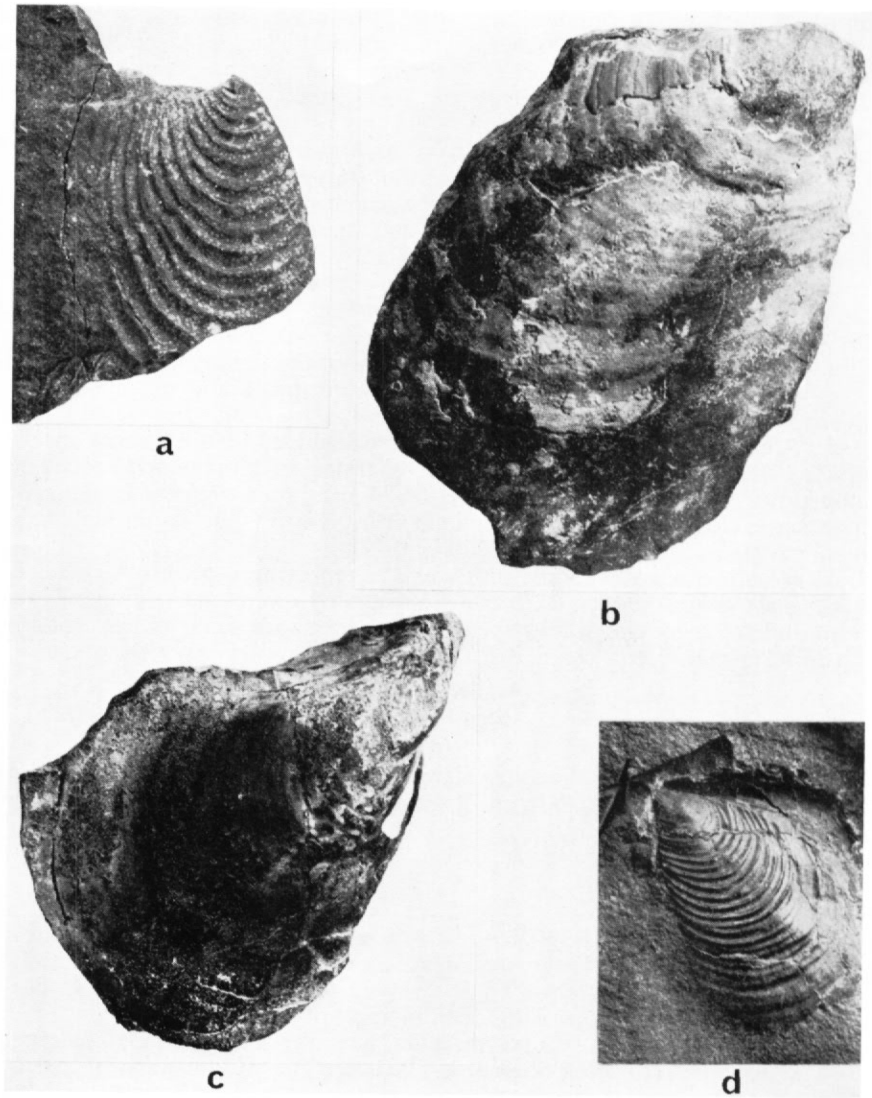


Fig. 7. a. *Inoceramus pseudosteinmanni* (?) sp. nov.; internal mould of a right valve showing an anomalously high angle for the direction of maximum growth and the widely spaced plicae; locality Z; ×2 (KG.401.504).

b. *Inoceramus* sp. α; internal mould of an articulated specimen, showing the right valve. Some of the test is still adhering; locality Z; ×1 (KG.401.51).

c. *Inoceramus* sp. α; a distorted internal mould from the head of Albation Valley; ×1 (KG.719.15).

d. *Inoceramus* sp. β; internal mould of a left valve showing the ligament pits; locality W; ×1 (KG.106.3).

of broad concentric plicae and superimposed fine concentric ornament. Similar ornament is present on some Upper Cretaceous species, e.g. *I. labiatus* (Schlotheim) from the Middle Cretaceous of England (Woods, 1904–13, pl. L, figs. 1–6) and *I. flavus* Sornay (1965, pl. A, figs. 1 and 2a–c) from the Cenomanian of the Malagasy Republic, but both of these species have a different shell form and have a small posterior wing, not present on the Alexander Island species. *I. marwicki* from the Callovian of New Zealand (Speden, 1970, especially fig. 24) has the same type of ornament and has only a very small posterior wing but its outline is more linguiform and the coarse plicae are less marked.

Inoceramus sp. β
Fig. 7d

Material

One internal mould of a left valve from just above the major thrust plane exposed at locality W. The specimen (KG.106.3) shows details of the hinge area and ligament pits.
Age: Upper Neocomian, probably Barremian.

Description

The shell form (Fig. 7d) is inequilateral, sub-quadrate and slightly inflated. The hinge line is straight and about half as long as the total height of the shell; it meets the straight anterior margin at an angle of a little more than 90°. The ventral and posterior margins are broadly rounded. Although the mould is incompletely preserved, the umbo appears to terminate at the angular junction between the hinge line and the anterior margin. Behind the umbo the dorsal part of the mould is flattened into a narrow wing-like area which is strongly depressed in relation to the main body of the shell; this depressed area was originally filled with the thickened part of the shell which carried the ligament pits. The most inflated part of the shell extends from the umbo in the direction of maximum growth and is directed posteriorly downwards at an angle of 45° to the hinge line.

Ornament consists of strong, rather closely spaced ridges separated by asymmetrical furrows which have their steepest slopes on the ventral side of the concentric ridges; some concentric ridges bifurcate across that area of the shell where the rate of growth was greatest. Around the ventral margin of the mould, the concentric ridges are much broader and less sharply defined such that it appears as if one broad ridge was formed by raising the level of the shell between two successive ordinary ridges.

The hinge bears the imprint of a dozen or more ligament pits. Most of these are quadrate in outline but close to the umbo there is a triangular one similar to those described on a specimen from Crabeater Point on the east coast of the Antarctic Peninsula (Thomson, 1967, p. 9, fig. 5). The pits are crossed by a few ridges parallel to the hinge line (? growth lines) and also by fine lines perpendicular to it. The latter reflect the prismatic structure of the test and are similar to markings described from the Crabeater Point specimen.

Remarks

In inequivalve species of *Inoceramus* it is the left valve which becomes more inflated and whose umbo becomes more enrolled; thus the flat form of the present left valve is suggestive that it came from a more or less equivalve species. An example of *I. anglicus* from the Albian of England (Woods, 1904–13, pl. XLV, fig. 9) shows superficial similarities and has a pattern of ornament which is comparable to that of the earlier part of the present mould. Closer inspection reveals the following differences:

i. The umbo of *I. anglicus* projects beyond the anterior termination of the hinge line.
ii. The hinge line of *Inoceramus* sp. β is relatively longer.
iii. There is a modification of ornament in the later growth stages of *Inoceramus* sp. β.

I. pseudosteinmanni sp. nov. (p. 5) from a lower stratigraphical horizon has a broader postero-dorsal wing and a more regular ornament in which the corrugations have an evenly rounded cross-section. *Inoceramus* sp. nov. *b.* cf. *I. anglicus* Woods from the Neocomian of Western Australia (Brunnschweiler, 1960, p. 28, pl. II, fig. 5, text-fig. 20) has a less oblique shell form and a more constant pattern of ornament than the example described here.

"*Inoceramus*" *trapezoidalis* sp. nov.
Figs. 6d, 8a and b

Material

One rock slab from locality K bearing several internal and external moulds, the best of which (KG.18.31) is the largest example on the upper surface and is selected as holotype.
Age: Probably Lower Aptian.

Diagnosis

Shell small to medium-sized for the genus, probably equivalve, outline trapezoidal, umbones inflated and incurved. Hinge line short, straight and probably situated entirely behind the umbones; small dorsal wing below hinge. Ornament of coarse concentric plicae which are distinctly finer in the early stages and have a shallow sinus in the antero-ventral position.

Description

The holotype (Fig. 8a), an internal mould of a left valve, has a trapezoidal outline which is about twice as high posteriorly as anteriorly. The mould is obliquely inflated and has a broad,

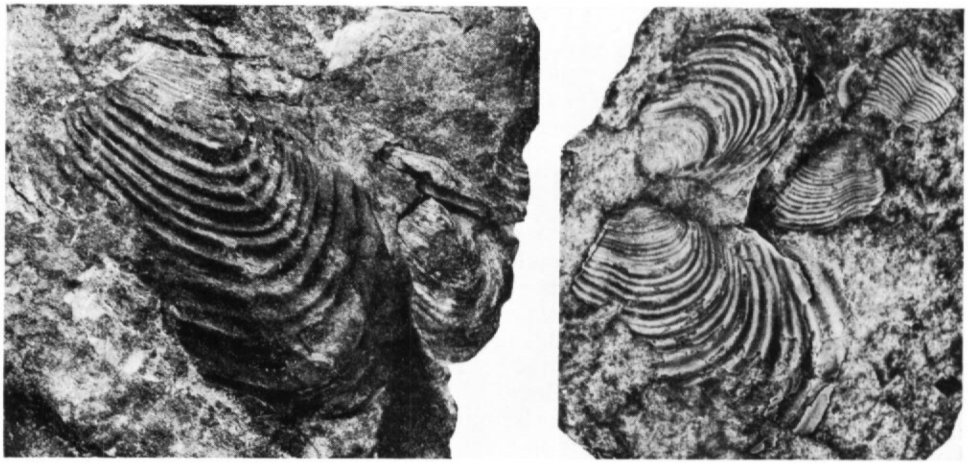


Fig. 8. "*Inoceramus*" *trapezoidalis* sp. nov.; locality K.
a. The holotype preserved as an almost complete internal mould of the left valve; ×1 (KG.18.31).
b. Latex cast from external moulds on the reverse side of the slab containing the holotype; ×1, coated (KG.18.31).

dorsally projecting and incurved umbo placed in the anterior third. The hinge line is short and straight and does not appear to extend anteriorly beyond the umbo; the anterior and posterior margins are rounded and the ventral margin is almost straight and slopes diagonally downwards toward the postero-ventral corner of the shell. Beneath the hinge line is a small, smooth dorsal wing which is marked off from the main body of the shell by a sulcus. On the back of the slab containing the holotype is an external mould of two incomplete shells which appear to be valves of one individual opened out flat (Fig. 8b). The valves were probably more or less the same size and, although the right one is more inflated than the left, this could have been caused by differential crushing during fossilization.

Ornament consists of concentric plicae of which two types are present. In the early stages (Fig. 8b), up to a shell length of about 17 mm., the plicae are fine and have a faint kink or shallow sinus in the antero-ventral position; the depth of the sinus decreases with increase in size of the shell and finally disappears. Above a shell length of 17 mm. the plicae rapidly become coarser and more widely spaced; the maximum development of this ornament is seen in the postero-ventral corner of the holotype (Figs. 6d and 8a). External moulds on the back of the slab (Fig. 8b) show that, on the outer surface of the test, the dorsal slope of each of the coarser plicae bears a single fine, concentric growth line. The resultant ornament is closely comparable to the *Anwachswellen* with superimposed *Anwachsmarken* illustrated by Heinz (1928, p. 17, text-fig. 3).

None of the specimens shows recognizable remains of the ligament pits. Pieces of the test adhering to the mould have a distinct prismatic structure.

Measurements

The maximum length of the holotype, measured parallel to the hinge line, is 58 mm. and the maximum height is 43 mm. The angle between the hinge line and the antero-ventral margin is about 40°.

Remarks

As it is now understood (Cox, 1969, p. *N*314–21), the family Inoceramidae includes several subgenera of the genus *Inoceramus* itself and a variety of related but morphologically distinct genera. The specimens described here have gross morphological features typical of the family, such as the coarse plicate ornament and the thin prismatic test, but they are different enough to be not only regarded as a new species but probably also as a new subgenus or genus. Two superficially similar subgenera, *Cateceramus* Cox and *Haenleinia* Böhm, have no posterior wing and the anterior part of the shell does not project so strongly forward as in *I. trapezoidalis* sp. nov. *Haenleinia* differs further in having a radial sulcus which is directed postero-ventrally downwards from the umbo and approximately follows the direction of maximum growth. Both *Cateceramus* and *Haenleinia* are Upper Cretaceous (Senonian) forms and the present examples are from Lower Cretaceous (Aptian) sediments. The Upper Jurassic genus *Anopaea* Eichwald has a posteriorly enlarged shell and a broad antero-ventral sinus which persists even in the adult stages; also there is no postero-dorsal wing.

Inoceramus aff. *concentricus* Parkinson 1819
Figs. 6e, 9a and b, 10

Material

Five internal moulds in a generally poor state of preservation from locality T, Waitabit Cliffs.

Age: Upper Aptian.

Description The two best specimens, KG.103.158 and 181, are internal moulds of a right and left valve, respectively. The right valve (Fig. 9a) is sub-circular in outline and flat except near the umbo where it is slightly inflated; the umbo is positioned slightly anterior of the mid-line. Ornament consists of concentric plicae separated by wide asymmetrical furrows (Fig. 6e); two of the plicae bifurcate across the posterior half of the mould. Anterior to a line drawn perpendicularly through the umbo, the mould bears a series of radial threads which are probably equivalent to the *Striemen* described by Heinz (1928, p. 21) and which would normally have appeared as fine grooves on the internal surface of the test. The hinge line is indicated by a short straight margin behind the umbo and a few coarse ligament pits are preserved (Fig. 9b) on the mould above the umbo. These are placed on the dorsal surface of the ligament plate and bear extremely fine striations arranged perpendicular to the hinge line.

The left valve (Fig. 10) has a greater relative height than the right one, is somewhat drop-shaped and possesses a curved hook-like umbo. The concentric plicae are perhaps a little more rounded than those on the right valve, and in the early stages there is a tendency towards grouping.

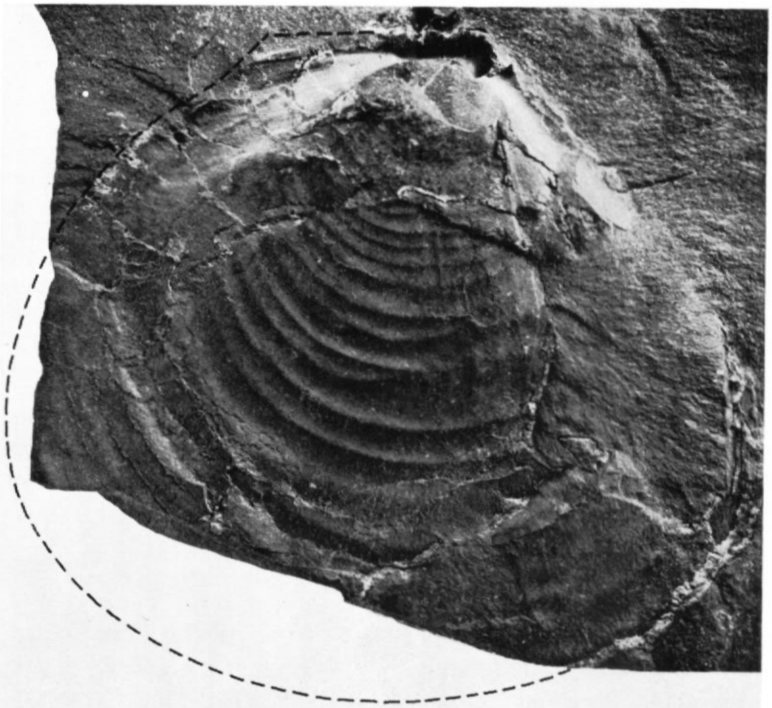
Measurements

No precise measurements can be given but many examples seen in the field had an original shell height of 100 mm. or more and the left valve described here must have been about 120 mm.

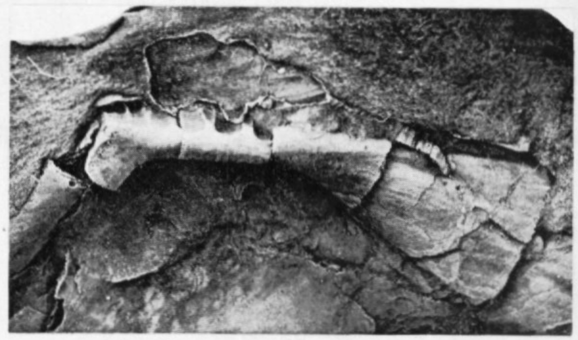
Remarks

It could not be proved by direct observation that the two valves described here belonged to the same species because no articulated specimens were found. However, their association in the same part of the succession suggests that they are valves of the same species.

Specimen KG.103.158 (Fig. 9a) is similar to an indeterminate specimen of *Inoceramus* from the north face of the hook at Ablation Valley (Cox, 1953, pl. II, fig. 1) except that the latter shows no radial ornament. Cox compared his specimen to those figured by Feruglio (1936, pl. II, figs. 3–11) from the Lago Argentino area of Patagonia and identified as *I.* cf. *steinmanni*



a



b

Fig. 9. a. *Inoceramus* aff. *concentricus*; internal mould of a flat right valve; locality T; ×1 (KG.103.158).
b. A latex cast from the same specimen showing the ligament area situated on the dorsal surface of the hinge margin and details of the ligament pits; ×2 (KG.103.158).

Wilckens. However, *I. steinmanni* is characterized by having an ornament of alternate large and small concentric ribs (Wilckens, 1907, pl. II, figs. 4 and 5), and is also a Senonian species, whereas Feruglio's specimens were found at the same locality as Neocomian ammonites. There is a considerable variation among Feruglio's specimens of so-called *I.* cf. *steinmanni* but only one example (Feruglio, 1936, pl. II, fig. 10) seems to bear any resemblance to the example described by Cox.

The left valve (Fig. 10) is not unlike an example of *I. concentricus* var. *porrectus* [=*I. tawhanus* Wellman, 1959, p. 159] from the Ngaterian (Cenomanian) of New Zealand (Woods, 1917, pl. IV, fig. 1b) but it differs from the latter in its tendency towards grouping of the

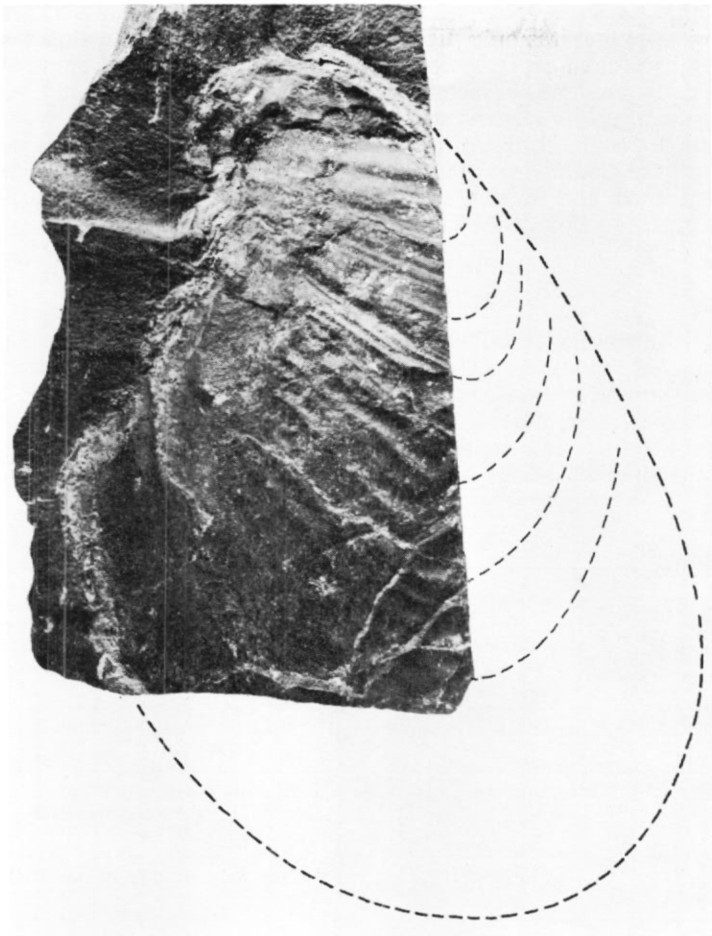


Fig. 10. *Inoceramus* aff. *concentricus*; internal mould of a tall inflated left valve; locality T; ×1 (KG.103.181).

concentric plicae and in possessing a more enrolled umbo. Similarly, it appears to have the same gross morphology as some of the larger forms of *I. concentricus* from the Gault of England (Woods, 1904–13, pl. XLV, fig. 11). The probable sub-gryphaeid form, enrolled umbo of the left valve and the relatively simple concentric ornament of the present species indicate close affinities to the group of *I. concentricus*, although it is not possible to identify it with any known species.

Sornay (1966, p. 62) has pointed out that the hinge area of *Inoceramus* has been poorly studied. However, evidence presented below suggests that the positioning of the ligament of the right valve described here on the dorsal surface of the valve margin is a further indication that it belongs to a strongly inequivalve species, rather than an equivalve one. Airaghi (1904) examined the arrangement and form of the ligament pits in several Cretaceous species but no one appears to have commented on the *position* of the ligament area. A brief examination of specimens of *Inoceramus* in the collections of the British Museum (Nat. Hist.) suggests that, in those species which are virtually equivalve, the ligmaent area is placed more or less in the plane of commissure but at a slight angle to it such that the area faces inwards and slightly upwards. In an excellent specimen of *I. crippsi*, the ligament areas of both valves are more steeply inclined (i.e. at about 40° to the commissure) leaving a clearly defined V-shaped trough along the dorsal margin of the shell which was once occupied by the ligament. In *I. lamarcki* the inclination of the ligament area with respect to the plane of commissure and its shape vary throughout growth. At first it is only slightly inclined and space for the ligament was achieved by having the ligament area excavated or gutter-like; later it becomes narrower and more or less parallel to the commissure. In inequivalve gryphaeid forms, like *I. concentricus* and more particularly *I. involutus*, the ligament area is placed on the dorsal margin of the flatter right valve (i.e. at about 90° to the commissure) and in the larger and enrolled left valve it is inclined at a steep angle to the commissure. The inclination of the ligament area of both valves may vary throughout growth and from one individual to another; further space for the ligament may be effected by excavation of the ligament area.

Stratigraphical Distribution

While most of the species described here have been assigned an age on the basis of the ammonites associated with them (Thomson, 1971), and the collections are at present too limited to give much indication of vertical distribution, there are indications that *Inoceramus* in Alexander Island may be of some stratigraphical value (Table II). This is not unexpected in view of the known distributions of this bivalve in the rest of the world.

Only two of the present species have been precisely identified with previously described

Table II

Age		*Inoceramus species*	*Remarks and associated ammonites*
Upper Aptian		*I.* aff. *concentricus*	Occurs below beds with *Eotetragonites* sp. and above beds with *Sanmartinoceras patagonicum*. Locality T
Lower Aptian		*I. trapezoidalis* sp. nov.	No associated ammonites collected. Locality K
Neocomian	(?) Barremian	*Inoceramus* sp. β	*Silesites* sp. nov. and *Phyllopachyceras aureliae*. Locality W
Neocomian	Hauterivian Valanginian		Not yet proven in Alexander Island
Neocomian	Berriasian	*I. pseudosteinmanni* sp. nov.	Occurs above beds with *Sarasinella* aff. *hondana* and below beds with *Himalayites* (?) sp. and *Neocosmoceras* sp. Locality Z
Neocomian	Berriasian	*Inoceramus* sp. α	At locality Z it occurs below beds with *I. pseudosteinmanni* and in association with *Substreblites* sp. At the head of Ablation Valley it occurs with *Hypophylloceras strigile* (?), *Bochianites* aff. *versteeghi*, *Raimondiceras* sp. and *Spiticeras* sp.
Tithonian		*Inoceramus* sp. γ	In association with a *Virgatosphinctes*/*Aulacosphinctoides* fauna. North side of Ablation Valley
Tithonian		*Inocdramus* sp. δ	In a moraine about 1·7 km. north of Ablation Point
Upper Oxfordian to Kimmeridgian		*I. hasti* *I.* aff. *subhaasti*	(?) From disturbed sediments on southern side Ablation Valley, (?) equivalent to those from which *Perisphinctes* cf. *transatlanticus* was obtained (Howarth, 1958)

specimens. *I. pseudosteinmanni* sp. nov. from locality Z (Fig. 1) is considered to be conspecific with *I.* cf. *steinmanni* (Feruglio, 1936, *pars*) from Lago Argentino, and *Inoceramus* (Katz and Watters, 1966) from Navarino Island, but the precise stratigraphical age of neither of these Patagonian occurrences is known. Evidence available at present suggests that, in Alexander Island, it is found in sediments of Lower Neocomian age. Such an age does not appear to be incompatible with the South American finds, those from Lago Argentino having come from a scree on which there were also Upper Tithonian–Berriasian ammonites, and the Navarino Island examples having come from the Yahgan Formation of supposed Jurassic–Cretaceous age.

I. haasti Hochstetter is the only species which has been used to date the sediments from which it came. The specimen was collected from scree but it almost certainly came from the zone of disturbed sediments present in the basal 150 m. of the cliffs where it was found (personal communication from M. H. Elliott). These beds are thought to be equivalent to those from which *Perisphinctes* (*Orthosphinctes ?*) cf. *transatlanticus* was obtained (Howarth, 1958). In the East Indies, *I. haasti* occurs in sediments assigned to the lower Upper Oxfordian (Wandel, 1936) and in New Zealand in the Middle Kimmeridgian (Fleming and Kear, 1960). Howarth (1958) suggested that *P.* cf. *transatlanticus* indicated an Upper Oxfordian–Lower Kimmeridgian age.

The fragments described as *I.* aff. *subhaasti* Wandel were found at the same locality as *I. haasti* and probably came from the same level as the latter. In both Misol and New Zealand, *I. subhaasti* occurs at a slightly lower level than *I. haasti.*

On the basis of ammonite evidence (Table II), *I.* aff. *concentricus* occurs high in the Aptian succession at Waitabit Cliffs (locality T) but the species proper in Europe, and its close relatives in the rest of the world, are more typical of the Albian and Cenomanian stages.

The general Upper Tithonian–Berriasian age, assigned to the sediments at locality Z (Thomson, 1971) on the basis of the Ammonoidea occurring there, was far from satisfactory because the specimens available were so few and so poorly preserved. However, the presence of *Inoceramus* sp. α at the base of the sequence examined at locality Z and at the top of the sequence so far measured on the southern side of Ablation Valley may be of significance here. Because of the general south to south-westerly dip of the sediments along the southern east coast of Alexander Island, there is a general tendency, on going south, for the sediments of successive cliff blocks to be slightly younger than those to the north. In the absence of faulting (which may sometimes interrupt this general sequence), it might be expected that the sediments of locality Z are of similar or slightly younger age than those of the highest stratigraphical levels on the southern side of Ablation Valley.

At the last locality, *Inoceramus* sp. α was found with the ammonites, *Haplophylloceras strigile* (?) (Blanford), *Bochianites* aff. *versteeghi* Boehm, *Raimondiceras* sp. nov. and *Spiticeras* aff. *spitiensis* Uhlig, a fauna which in turn lies about 1,000 m. above a good Tithonian fauna with *Virgatosphinctoides* and *Aulacosphinctoides*. There seems little doubt, therefore, that *Inoceramus* sp. α is of early Berriasian age at Ablation Valley and that it might be expected to be of similar age at locality Z. In the absence of conclusive ammonite evidence, it would seem that the base of the section may be approximately correlated with the upper part of the sequence at Ablation Valley. More detailed studies of the Belemnoidea from locality Z indicate the presence of the following species: *Belemnopsis* sp. nov. α [=*Belemnites* (*Belemnopsis*) *patagoniensis* Feruglio *non* Favre], *Belemnopsis* sp. nov. β, *Hibolithes subfusiformis* (Raspail), *Hibolithes* sp. nov. α and *Hibolithes* sp. aff. *marwicki mangaoraensis* Stevens, a fauna compatible with an early Neocomian age.

Although it has not been possible to match them with known species and use them directly for estimating the age of the sediments, *Inoceramus* spp. β, γ and δ are distinct in themselves and may be dated by the ammonites found with them. "*Inoceramus*" *trapezoidalis* sp. nov. is an *Inoceramus s.l.* of an unusual type, well enough preserved to warrant description as a new species, and perhaps distinct enough to be separated from *Inoceramus s.s.* as a new genus. Of all the species described here, it is the most unsatisfactory from the point of view of estimating its age. No ammonites were collected with it but the sequence measured at locality K probably lies in the lowest part of the Aptian succession as it is represented in Alexander Island (Thomson, 1971).

Acknowledgements

The authors wish to thank Professor F. W. Shotton for making available the facilities of the Department of Geology, University of Birmingham, and Dr. R. J. Adie for his guidance throughout the preparation of this paper. The assistance of Dr. N. J. Morris and Mr. R. Cleevely, British Museum (Nat. Hist.), is gratefully acknowledged.

Specimens from the Ablation Point area were collected by M. H. Elliott, and the specimen from locality K was collected by Dr. B. J. Taylor.

MS. received 25 May 1971

REFERENCES

Airaghi, C. 1904. Inocerami del Veneto. *Boll. Soc. geol. ital.*, **23**, 178–99.

Boehm, G. 1907. Beiträge zur Geologie von Niederländisch-Indien. I. Abt. Die Südküsten der Sula-Inseln Taliabu und Mangoli. 3. Abs. Oxford des Wai Galo. *Palaeontographica*, **4** (supplement), Abt. 1, Lief, 2, 59–120.

Brunnschweiler, R. O. 1960. Marine fossils from the Upper Jurassic and the Lower Cretaceous of Dampier Peninsula, Western Australia. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.*, No. 59, 53 pp.

Cox, L. R. 1953. Lower Cretaceous Gastropoda, Lamellibranchia and Annelida from Alexander I Land (Falkland Islands Dependencies). *Falkland Islands Dependencies Survey Scientific Reports*, No. 4, 14 pp.

———. 1969. Family Inoceramidae Giebel, 1852. (*In* Moore, R. C. (*with* Teichert, C., McCormick, L. *and* R. B. Williams), *ed. Treatise on invertebrate paleontology. Pt. N, Vol. 1. Mollusca 6: Bivalvia.* Lawrence, Kansas, The Geological Society of America, Inc. and the University of Kansas, *N*314–21.)

Feruglio, E. 1936. Palaeontographia patagonica. Pt. 1. *Memorie Ist. geol. miner. Univ. Padova*, **11**, 1–192.

Fleming, C. A. *and* D. Kear. 1960. The Jurassic sequence at Kawhia Harbour, New Zealand (Kawhia sheet, N73). *Bull. geol. Surv. N.Z.*, N.S. No. 67, 50 pp.

Heinz, R. 1928. Über die bisher wenig beachtete Skulptur der Inoceramen-Schale und ihre stratigraphische Bedeutung. Beiträge zur Kenntnis der oberkretazischen Inoceramen IV. *Mitt. miner.-geol. StInst. Hamb.*, Ht. 10, 3–39.

Holdhaus, K. 1913. Fauna of the Spiti Shales (Lamellibranchiata and Gastropoda). *Mem. geol. Surv. India Palaeont. indica*, Ser. 15, **4**, Pt. 2, Fasc. 4, 397–456.

Howarth, M. K. 1958. Upper Jurassic and Cretaceous ammonite faunas of Alexander Land and Graham Land. *Falkland Islands Dependencies Survey Scientific Reports*, No. 21, 16 pp.

Katz, H. R. *and* W. A. Watters. 1966. Geological investigation of the Yahgan Formation (Upper Mesozoic) and associated igneous rocks of Navarino Island, southern Chile. *N.Z. Jl Geol. Geophys.*, **9**, No. 3, 323–59.

Leanza, A. F. 1967. Anotaciones sobre los fósiles jurásico-cretácicos de Patagonia austral (colección Feruglio) conservados en la Universidad de Bologna. *Acta geol. lilloana*, **9**, 121–88.

Marwick, J. 1953. Divisions and faunas of the Hokonui System (Triassic and Jurassic). *Palaeont. Bull., Wellington*, No. 21, 141 pp.

Reeside, J. B. 1957. Paleoecology of the Cretaceous seas of the western interior of the United States. (*In* Ladd, H. S., *ed.* Treatise on marine ecology and paleoecology. Vol. 2. Paleoecology. *Mem. geol. Soc. Am.*, No. 67, 505–41.)

Routhier, P. 1953. Étude géologique du versant occidental de la Nouvelle Calédonie entre le Col de Boghen et la Pointe d'Arama. *Mém. Soc. géol. Fr.*, N.S., No. 67, 271 pp.

Seitz, O. 1935. Die Variabilität des *Inoceramus labiatus* v. Schloth. *Jb. preuss. geol. Landesanst. BergAkad.*, **55** (for 1934), Ht. 1, 429–74.

Shrock, R. R. *and* W. H. Twenhofel. 1953. *Principles of invertebrate paleontology.* 2nd edition. New York, Toronto, London, McGraw-Hill Book Company Inc.

Sornay, J. 1965. La faune d'Inocérames du Cénomanien et du Turonien inférieur du sud-ouest de Madagascar. *Annls Paléont.*, Invertébrés, **51**, Fasc. 1, 1–26.

———. 1966. Idées actuelles sur les Inocérames d'après divers travaux récents. *Annls Paléont.*, Invertébrés, **52**, Fasc. 1, 59–92.

Speden, I. G. 1970. Three new inoceramid species from the Jurassic of New Zealand. *N.Z. Jl Geol. Geophys.*, **13**, No. 3, 825–51.

Stehn, E. 1924. Beiträge zur Geologie und Paläontologie von Südamerika. XXV. Beiträge zur Kenntnis des Bathonien und Callovien in Südamerika. *Neues Jb. Miner. Geol. Paläont. BeilBd.*, **49**, Ht. 1, 52–158.

Thomson, M. R. A. 1967. A probable Cretaceous invertebrate fauna from Crabeater Point, Bowman Coast, Graham Land. *British Antarctic Survey Bulletin*, No. 14, 1–14.

———. 1971. Ammonite faunas of south-eastern Alexander Island and their stratigraphical significance. (*In* Adie, R. J., *ed. Anatrctic geology and geophysics.* Oslo, Universitetsforlaget, 155–60.)

Trechmann, C. T. 1923. The Jurassic rocks of New Zealand. With an appendix on ammonites from New Zealand by L. F. Spath. *Q. Jl geol. Soc. Lond.*, **79**, Pt. 3, No. 315, 246–312.

Wandel, G. 1936. Beiträge zur Paläontologie des Ostindischen Archipels. XIII. Beiträge zur Kenntnis der jurassischen Molluskenfauna von Misol, Ost-Celebes, Buton, Seran und Jamdena. *Neues Jb. Miner. Geol. Paläont. BeilBd.*, **75**, Abt. B, Ht. 3, 447–526.

Wellman, H. W. 1959. Divisions of the New Zealand Cretaceous. *Trans. R. Soc. N.Z.*, **87**, Pt. 1 and 2, 99–163.

WILCKENS, O. 1907. Die Lamellibranchiaten, Gastropoden etc. der oberen Kreide Südpatagoniens. *Ber. naturf. Ges. Freiburg. i. B.*, **15**, 97–166.

WOODS, H. 1904–13. A monograph of the Cretaceous Lamellibranchia of England. Vol. 2. *Palaeontogr. Soc.* [*Monogr.*], 473 pp.

———. 1917. The Cretaceous faunas of the north-eastern part of the South Island of New Zealand. *Palaeont. Bull., Wellington*, No. 4, 41 pp.

ZITTEL, K. A. 1864. Fossile Mollusken und Echinodermen aus Neu-Seeland. (*In* UNGLER, F., ZITTEL, K., SUESS, E., KARRER, F., STOLICZKA, F., STECHE, G. *and* G. JAEGER. Paläontologie von Neu-Seeland. Beiträge zur Kenntnis der fossilen Flora und Fauna der Provinzen Auckland und Nelson. *Novara-Expedition. Geologischer Theil*, **1**, Abt. 2, 17–68.)