

LATE JURASSIC FOSSILS FROM LOW ISLAND, SOUTH SHETLAND ISLANDS

By M. R. A. THOMSON

ABSTRACT. A mixed volcanic and marine volcanoclastic sequence on Low Island, South Shetland Islands contains fossil Mollusca and trace fossils. Mollusca collected *in situ* favour a late Jurassic age, and the presence of the ammonite *Epimayites* aff. *transiens* (Waagen) points more specifically to a late Oxfordian age. Belemnites in a moraine suggest that beds of a slightly younger age may be present under the ice cap of Low Island. The palaeogeographical distribution of the Mayitidae is briefly discussed.

LOW ISLAND, South Shetland Islands (Fig. 1) is the latest in a series of localities in the Antarctic Peninsula area at which marine fossils have been discovered in strata associated with volcanic successions. Although fossils from these occurrences (Taylor and others, 1979; Thomson, 1969, 1972, 1975) are often poorly preserved, they provide useful first-hand information on the precise age of a widespread group of volcanic rocks frequently assigned to the Upper Jurassic but correlated on petrological grounds alone. Although these rocks have been referred to as 'Jurassic Volcanics' (Hawkes, 1961) or more commonly as 'Upper Jurassic Volcanic Group' (Adie, 1962, table 4; and most subsequent literature), they are believed to have a wider age range (Taylor and others, 1979) and the less subjective term Antarctic Peninsula Volcanic Group has been proposed (Thomson, in press). Jefferson (1980) has reported early Tertiary angiosperms from supposed Jurassic volcanic rocks at Cape Alexandra, southern Adelaide Island, and Lower Cretaceous marine rocks in Alexander Island contain abundant tuffaceous detritus (Taylor and others, 1979).

The geology of Low Island has been described in detail by Smellie (1980). Lavas and marine volcanoclastic rocks of presumed Jurassic age occur at a number of localities on Cape Wallace and south-eastern Low Island. Lavas both overlie and are possibly interbedded with the sedimentary rocks and, although the precise stratigraphical relationships of sequences exposed in the various headlands is unknown, they are probably all of broadly the same age. On the eastern side of Cape Wallace poorly preserved marine fossils were found in two areas:

1. In-situ faunas in a sequence of gently dipping, indurated black mudstones, exposed below HWM (1a), and at the back of the beach (1b) on the south-eastern coast of the headland (Fig. 1). The two localities are separated by an area without rock exposure.
2. An erratic fauna in loose blocks of tuffaceous mudstone in a moraine 400 m south-east of the in-situ occurrence (Fig. 1).

PALAEONTOLOGY

In writing this section the author is indebted to Dr L. E. Willey for descriptions and an assessment of the belemnites.

In-situ fauna (locality 1a and 1b)

Bivalvia

Genus *Retroceramus* Koschelkina 1963

Retroceramus sp. ex. gr. *haasti* (Hochstetter 1863)

Fig. 2a

A single fragmentary external mould of a (?) right valve from locality 1a has the characteristic coarse concentric ornament seen on many late Jurassic inoceramids in the Southern Hemisphere. A latex cast (Fig. 2a) shows a series of sharp, extremely prominent concentric ribs or plicae, separated by wide, deeply excavated interspaces. The curvature of the ornament suggests that the original shell form was relatively narrow and somewhat oblique.

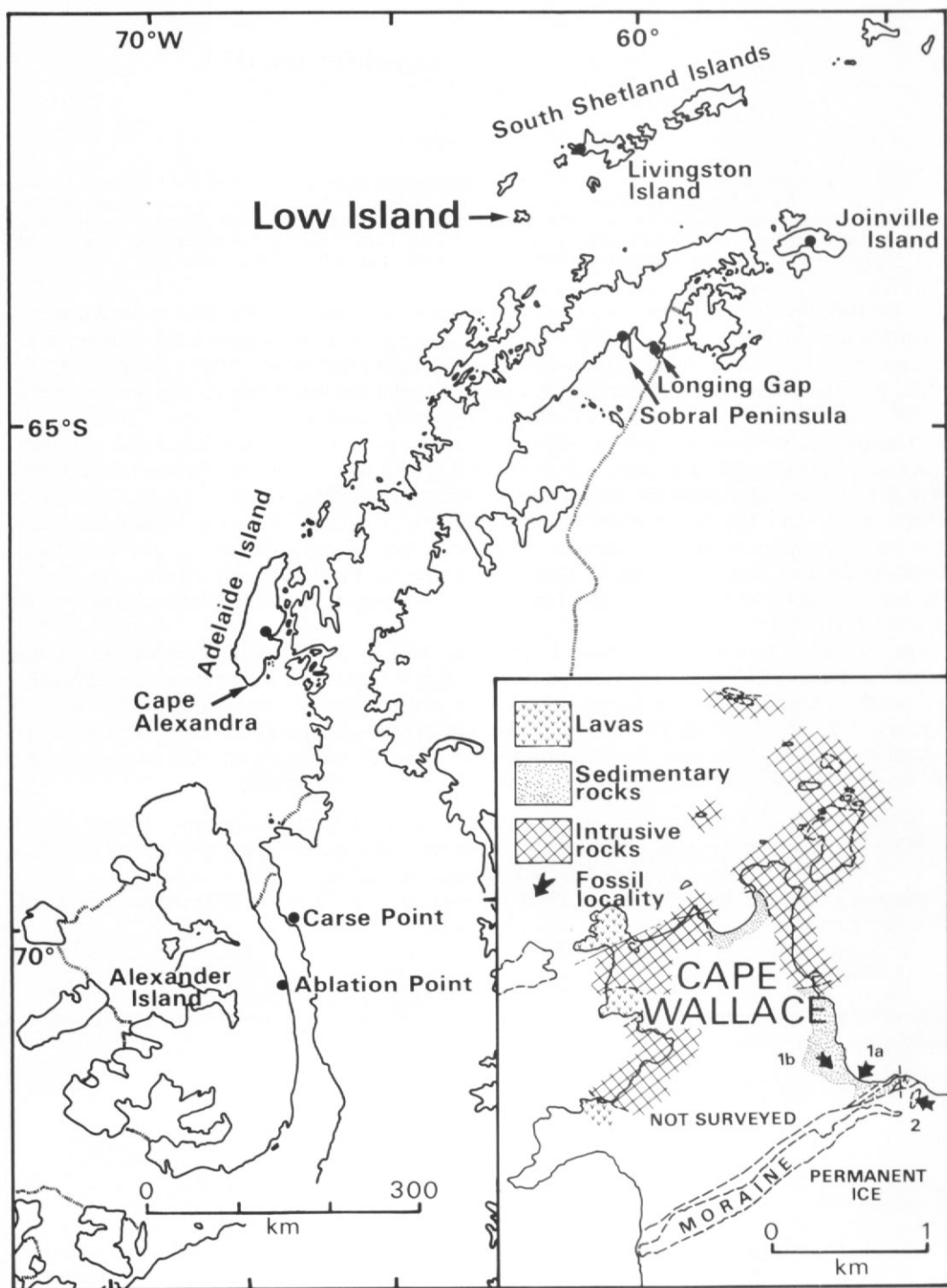


Fig. 1. Sketch map of the Antarctic Peninsula, showing the location of Low Island and other localities at which late Jurassic marine faunas have been found in association with volcanic successions (solid circles). The present fossils came from Cape Wallace, north-western Low Island (inset).

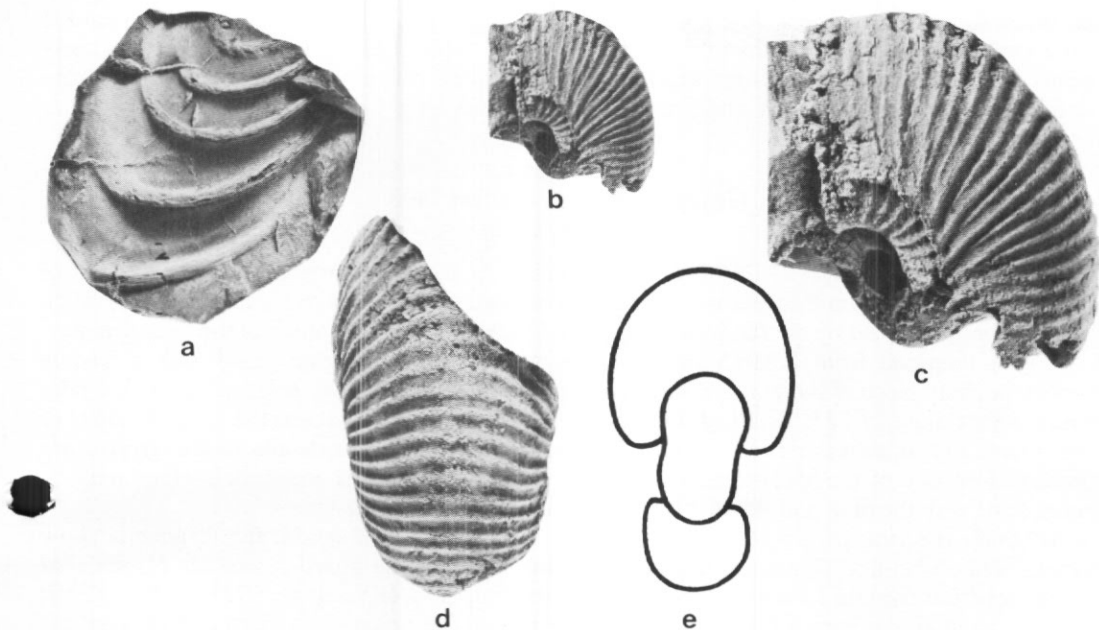


Fig. 2. The in-situ fauna of locality 1a

- a. *Retroceramus* sp. ex gr. *haasti* (Hochstetter); latex cast of a (?) right valve, $\times 1$, coated (P.216.6).
- b. *Epimayites* aff. *transiens* (Waagen); latex cast, lateral view, $\times 1$, coated (P.216.5).
- c. *E.* aff. *transiens*; latex cast lateral view, $\times 2$, coated (P.216.5).
- d. *E.* aff. *transiens*; latex cast, ventral view showing feebly projected ribbing, $\times 2$, coated (P.216.5).
- e. *E.* aff. *transiens*; whorl cross-sections, $\times 2$ (P.216.5).

A precise identification from such a small fragment is unwarranted but the ornament resembles that seen on a number of specimens which have been referred to *Retroceramus haasti* (Hochstetter) and the highly variable *R. subhaasti* (Wandel).

In addition to published illustrations, the present fragment was compared with specimens in the British Museum (Nat. Hist.), and plaster casts of inoceramids from New Zealand, kindly supplied by Dr I. G. Speden (New Zealand Geological Society). The extreme prominence of its concentric ribs is also seen on several specimens from Kawhia Harbour (New Zealand) assigned to '*Inoceramus haasti*', some of which also have relatively oblique shells. Illustrations of similar examples from New Zealand include those by Trechmann (1923, pl. 15, fig. 3) and Marwick (1953, pl. 12, fig. 1). An example from the late Jurassic of Alexander Island (Thomson and Willey, 1972, fig. 6) has widely spaced ribs which are, however, relatively less prominent than those of many of the New Zealand examples and the fragment figured here (Fig. 2a). The curvature of its ribs also suggests that it had a broader shell form.

Among the variants grouped by Wandel (1936) in his new species '*Inoceramus subhaasti*' are two Indonesian examples which have similar, although perhaps not as prominent ribbing as the present specimen: '*I.*' *subhaasti* forma *typica* (Wandel, 1936, pl. XVIII, fig. 2) and var. *lateplicata* (Wandel, 1936, p. 471, fig. 3). Some specimens identified with '*Inoceramus*' *galoi* Boehm (e.g. Boehm, 1907, pl. IX, fig. 14) have similar widely-spaced prominent ribbing but the typical *galoi* (Boehm, 1907, pl. X, fig. 1a-c) has more broadly rounded ribs, and the first specimen was transferred by Wandel (1936, p. 469) to '*I.*' *subhaasti*.

Inoceramids identified with the species *haasti*, *subhaasti* and *galoi* include a complex of forms with overlapping morphological characteristics, and they need careful interpretation. Probably

all three should be placed in the genus *Retroceramus* Koschelkina (personal communication from Dr J. A. Crame), rather than *Inoceramus* Sowerby, which has become something of a sack-genus. *Retroceramus* differs from *Inoceramus* in its more oblique equivalve shell form, sub-terminal umbones, prominent concentric ornament and long hinge line with large irregular ligament pits.

Belemnoidea

Genus *Hibolithes* Montfort 1808

Hibolithes (?) sp.

Four mudstone samples (P.216.2–5) from locality 1a contain poorly preserved examples of belemnite guards. Original calcite was present in only two of these (P.216.3 and 5) whereas much of it had been replaced by quartz, iron pyrites and (?) zeolite, masking much of the finer details.

A cast prepared from P.216.5 shows a moderately robust elongate guard with a hastate profile. A small piece of the phragmocone still preserved indicates an alveolar cavity with a relatively obtuse angle of 25°. Although this specimen has been somewhat eroded, cross-sections of the guard appear to have been circular or slightly depressed. No details of the groove are preserved on any of the specimens. P.216.6 is from a larger hastate individual, which may be conspecific with the first, and P.216.4 is a small, possibly juvenile example.

Although the lack of groove details prevents a positive identification, the fragments show general *Hibolithes*-like characteristics. The overall shape of the guard resembles *H. verbecki* Kruizinga from the late Jurassic of the Sula Islands, Indonesia (Kruizinga, 1921; p. 180, pl. VI, fig. 1a–c) and *H. catlinensis* (Hector) from the Teraikan (Bajocian–Callovian) of New Zealand (Marwick, 1953, p. 26 and 125, pl. 17, figs. 1 and 2; Stevens, 1965, p. 96, pl. 14, figs. 1, 2, 6–8, 12 and 16–18).

Ammonoidea

Genus *Epimayites* Spath 1928

Epimayites aff. *transiens* (Waagen, 1875)

Fig. 2b–e

Material. One external mould from the earlier septate part of a conch (P.216.5), incomplete but preserved uncrushed.

Description. A latex cast (Fig. 2b–e) shows that the specimen represents the earlier septate stages of a broken conch. In its present state it would have been about 30 mm in diameter but a low wall near the umbilical rim of the outer whorl, represents the vestiges of a further whorl no longer present. The conch is formed of inflated whorls (Fig. 2b–e) which are about as wide as high, and each of which envelops more than three-quarters of the preceding volution. The venter is well-rounded but the umbilical wall curves steeply into the deep, finely perforate umbilicus. On one side of the natural mould the umbilical 'plug' terminated in a needle-like spindle which projected deep into the umbilicus; this was partly broken in preparing the cast. Ornament consists of fine wiry prorsiradiate ribs which are initiated on the umbilical wall, recurved as they cross the umbilical rim and feebly projected on the venter (Fig. 2d). The earlier ribs preserved are simple with long intercalated ribs, but later they all bifurcate low on the flank.

One septum is preserved at the rear end of the outer whorl section. The preservation is not good enough to show the fine details of the suture but, between the ventral lobe and the umbilical seam, there are four saddles and three lobes. A notable feature is that the whole septum and the general course of the suture line lean backwards in relation to the more radial course of the ribbing.

Remarks. The highly involute, almost globose shell form and the simple ornament of this ammonite are reminiscent of the 'macrocephalitids'. Within this generalized terminology may be

included not only the Macrocephalitidae proper, but also the Mayitidae (Oxfordian), some genera of which are 'indistinguishable from the Callovian Macrocephalitidae' (Arkell, in Moore, 1957, p. L297). However, according to Arkell, the two groups are separated by a short stratigraphical interval from which both are missing.

Although the present specimen is superficially similar to many true macrocephalitids, its slightly sinuous ribbing and the projection of the ribs on the venter are more typical of the Oxfordian genus *Epimayites* Spath, as outlined by Arkell (in Moore, 1957) and described in a detailed review of the Mayitidae by Basse and Perrodon (1952). Many described 'macrocephalitids' are large specimens and it is difficult to make close comparisons with the small fragment illustrated here (Fig. 2b). However, there are general similarities with a number of specimens identified with Waagen's (1875) *Stephanoceras transiens*, type-species of *Epimayites*. A small individual of *E.* aff. *transiens* from Cutch (Spath, 1928, pl. XXVIII, fig. 3) differs in lateral aspect by its more pronounced primary ribs and denser secondaries, and the same is true of a young *E. transiens* (Spath, 1928, pl. XXXVI, fig. 11). The smaller of Waagen's (1875, pl. XXXVII, fig. 3a, b) two examples, also from Cutch, shows a more compressed whorl section than on the present specimens. Spath (1928) did not show cross-sections.

Kruizinga (1926, p. 53, pl. 9, figs. 3 and 4) illustrated a small specimen of '*Macrocephalites*' cf. *transiens* (Waagen) from the Sula Islands of Indonesia, which has thin wiry ribs that resemble the present ones closely except that they are not projected on the venter. Like most specimens assigned to *E. transiens* it is also a little more involute than the Antarctic example.

'*Macrocephalites*' *palmarum* var. *tenuicostata* Boehm (1907, p. 92, pl. XXIII, fig. 3), designated by Spath (1928, p. 223) as a new species *Epimayites tenuicostatus*, is interesting because like the present specimen, it has primary ribs which are apparently no more prominent than the secondaries as is frequently the case in *Epimayites*. It also has a reclined suture line. However, the ribbing is much denser than on the Low Island example.

The only macrocephalitids previously described from Antarctica are Quilty's (1970) *Megasphaeroceras* cf. *rotundum* Imlay, *Nothocephalites* (?) sp. and an indeterminate form from the southern Behrendt Mountains. Both his examples and others collected from the same area by the present author all have rectiradiate ribs which pass straight over the venter, a characteristic of the true macrocephalitids rather than the mayitids.

Trace fossils

Ichnogenus *Rhizocorallium* Zenker 1836

Rhizocorallium (?) sp.

Fig. 3

U-shaped traces, oriented parallel to the bedding, were observed in the outcrop at the back of the beach (locality 1b), where the only other fossil noticed was an inoceramid bivalve (not collected). These traces are slightly raised on upper bedding surfaces, suggesting that they represent flattened horizontal burrows, rather than surface trails. On a collected sample (Fig. 3) the burrow is about 10 mm wide and it is perfectly straight for a distance of 100 mm, after which it turns through 180° in a circle of radius 13 mm to trend back exactly parallel to the first length. More complete examples, observed in the field, extended for at least 200 mm but in these cases the burrows were slightly sinuous. It was noticeable that deviations in the direction of one burrow were followed precisely by the returning section of its parallel counterpart. There are faint irregular longitudinal marks on the burrow, particularly near the bend, and lateral iron-stained 'frills' suggest some disturbance of the sediment adjacent to the main burrow. Although marked parallelism of neighbouring traces is present in *Helminthoida* Schafhäutel, that form is far more complex, successive traces are closer together, and it is a furrow (trail) rather than a burrow. Perhaps the most likely affinities of the present trace fossil are with *Rhizocorallium* Zenker, a burrow form that is U-shaped, is typically horizontal to sub-horizontal in attitude and in which there is a close parallelism of the two limbs of the burrow (Fürsich, 1974). The principal

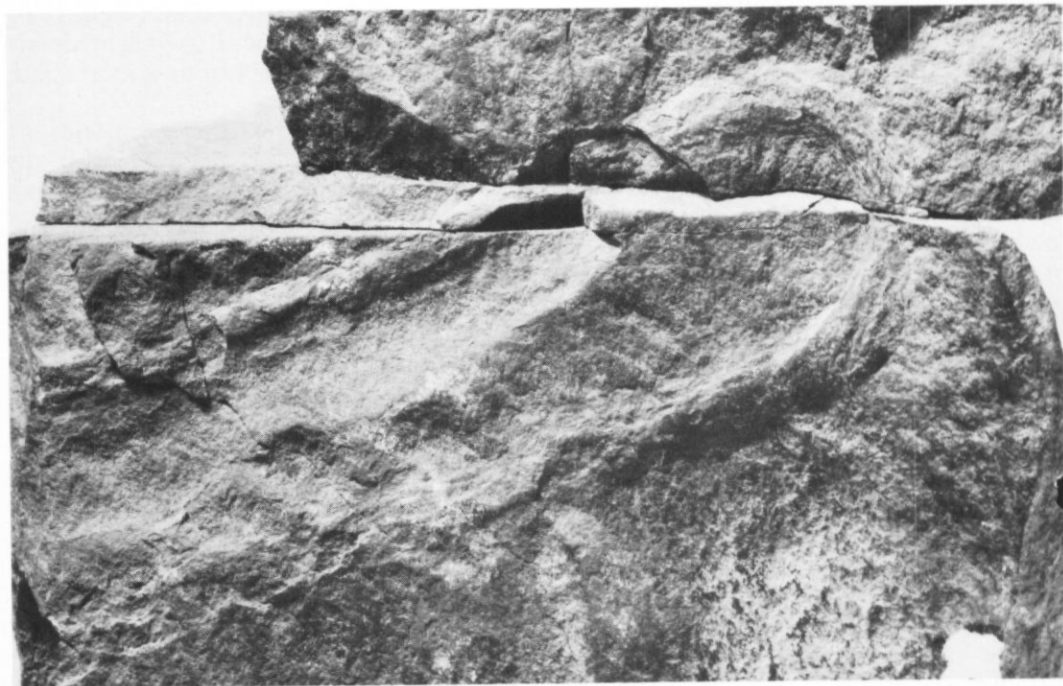


Fig. 3. *Rhizocorallium* (?) sp.; upper bedding surface from locality 1b, showing a U-form burrow oriented parallel to the bedding, $\times 1$ (P.216.9).

difference between the present specimen and *Rhizocorallium*, however, is that the latter typically has *Spreite* between the two limbs of the burrow. It is not known if the lack of these in the present specimen is due to non-preservation or original non-existence, but examples of *Rhizocorallium* in which the *Spreite* are not preserved have been described in earlier literature (Fürsich, 1974, p. 22).

Erratic fauna (locality 2)

Belemnnoidea
Genus *Hibolithes* Montfort 1808
Hibolithes sp.
Fig. 4a

Two belemnite guards (P.217.6 and 7) were found. The best (P.217.6, Fig. 4a) is relatively short (45 mm long) moderately robust and hastate, with a maximum transverse diameter of 10 mm. It has a deeply incised median ventral groove, which extends from the alveolar region almost to the mucronate apex. It has been slightly distorted by lateral compression but cross-sections appear to have been almost circular throughout. The phragmocone is relatively acute with an alveolar angle of about 18° .

This specimen has characteristics which appear to be intermediate between *Hibolithes arkelli* from the Puarooan (Lower Tithonian) of New Zealand, and *Hibolithes* sp. nov. (?) from the Berriasian of Alexander Island. In general shape and the possession of a long ventral groove it resembles many smaller specimens of *H. arkelli* (Stevens, 1965, pl. 15, figs 8–10, pl. 16, figs 1–6 and pl. 17, figs 4, 5 and 8) which, however, lack a mucronate termination to the guard.

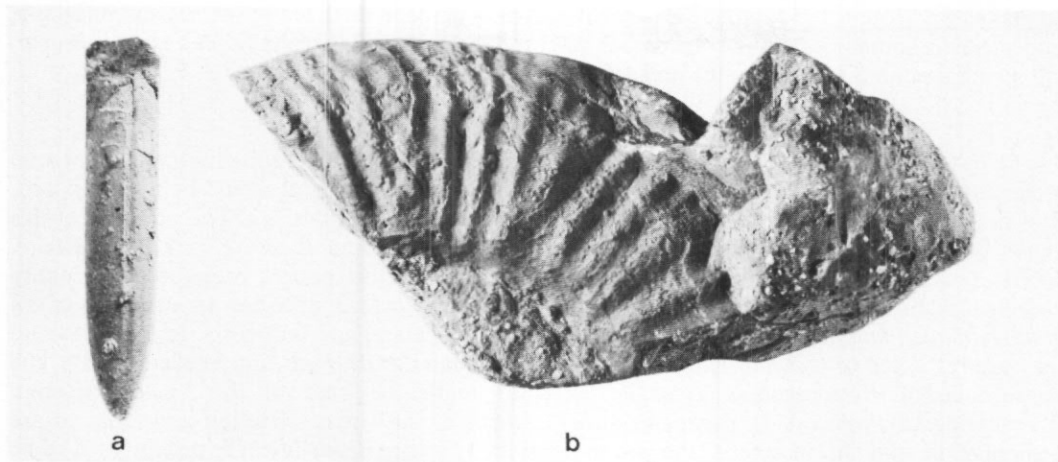


Fig. 4. Erratic fauna of locality 2

- a. *Hibolithes* sp.; silicone rubber cast, $\times 1$ (P.217.6).
 b. Indeterminate perisphinctid ammonite $\times 1$ (P.217.5).

Hibolithes sp. nov. (?) (Willey, 1973, fig. 6a–c) is closer in size and has a mucronate apex, but it has a shorter ventral groove that is restricted to the alveolar and upper stem region.

The second specimen is from a short, slender slightly hastate guard. Although generically indeterminate, it is of particular interest because it has been extensively invaded by acrothoracic cirripedes, similar to those described in early Cretaceous belemnite guards from Alexander Island (Taylor, 1965, fig. 3a–c).

Ammonoidea

Fig. 4b

Two fragmentary ammonite moulds, representing distinct species, occur in a highly calcareous tuffaceous (?) concretion. The first has a compressed oval cross-section and measures 29 mm high and 18 mm wide. Somewhat feeble, regularly spaced, radial ribs, extending from the umbilical seam, are little better marked on the external than on the internal mould, but most appear to bifurcate narrowly just below the ventral shoulder. The exact pattern of the secondary ribbing is difficult to discern but there may be occasional intercalated ribs, or else some primary ribs may branch virgatotomously.

The second specimen (Fig. 4b) differs from the first in having more inflated whorls which are almost as broad as high, and in its different ornamentation. Fragments of two whorls are present; the outer one (removed in the illustration) envelops the inner by about one quarter. The inner one is entirely septate and has stout radial ribs separated by spaces about twice as wide as themselves. Each primary rib bifurcates at the ventral shoulder into indistinct secondaries which pass straight across the venter where they appear to be somewhat fainter. Two pairs of primary ribs join at the umbilical rim. The umbilical wall is smooth. Only a fragment of the umbilical rim of the outer whorl is preserved; its surface is smooth apart from two widely spaced umbilical swellings, which probably represent the bases of stout primary ribs.

Neither of these two ammonite fragments has been identified, the first because its ribbing is too indistinct for comparison with known forms, and the second because no closely matching species is known to the author, despite the apparently characteristic pairing of some primary ribs. General perisphinctid affinities are apparent in the bifurcate ornament of both specimens. The second specimen (Fig. 4b) shows some similarities of ornament to species of the Upper Oxfordian–Lower Kimmeridgian genus *Idoceras* Burckhardt. The projected ribbing mentioned

by Arkell (in Moore, 1957, p. L323) is slight or barely perceptible in many species and pairing of major ribs is sometimes seen in the earlier stages, although this is normally the result of crowding by constrictions (absent on the present specimen).

AGE OF THE FAUNAS

The in-situ fauna of Low Island has a general late Jurassic aspect. Probably the most precise indication of age comes from the ammonite, although further material would be useful to confirm the identification of *Epimayites*, which is a new record for Antarctica. The presence of this genus favours a correlation with the upper part of the Oxfordian stage (cf. Arkell, in Moore, 1957, p. L298). The belemnites (*Hibolites* (?) sp.) are too poorly preserved to identify specifically and apparently only show broad middle to late Jurassic affinities. Inoceramids of the *galoi-subhaasti-haasti* complex are well known in New Zealand and Indonesia. In New Zealand they are restricted to rocks of Kimmeridgian to Tithonian age (Stevens and Speden, 1978). The appearance of *Retroceramus galoi* is taken to mark the base of the Lower Heterian (Kimmeridgian), whereas *R. subhaasti* and *R. haasti* of the Upper Heterian and Ohauan are Tithonian in age. In Indonesia the group appears to range from late Oxfordian to Middle Tithonian (Wandel, 1936; Stevens, 1965, table 13; Westermann and others, 1978); *galoi* and *subhaasti* (?) have been reported from the same stratigraphical unit as *Epimayites* (Sato and others, 1978, p. 17). However, much work remains to be done on the stratigraphical ranges of these species and, in view of the imprecise identification of the present fragment it would be unwise to interpret its stratigraphical significance closer than late Jurassic.

The erratic fauna may be a little younger. Although it was not possible to identify the ammonite fragments, the belemnite (*Hibolites* sp.) is related to Lower Tithonian–Berriasian species. The provenance of this fauna is unknown but it has presumably been transported from the interior of Low Island by ice. Faunas of Tithonian–Berriasian age are known from Byers Peninsula, Livingston Island 90 km to the north-east (Smellie and others, 1980) but comparable species are apparently absent there.

BIOGEOGRAPHICAL CONSIDERATIONS

The occurrence of the ammonite *Epimayites* is a new record for Antarctica and fills a gap in the known distribution pattern of the Mayitidae as discussed by Westermann and Riccardi (1975). They argued that the distribution of these ammonites (Fig. 5) could be accounted for by a circum-Gondwana migration or possibly by migration along a narrow trans-Gondwana epicontinental seaway passing between Antarctica and South Africa. Hallam (1973) previously proposed such a seaway to explain the distribution of the pectinid bivalve *Weyla* in the early Jurassic (Toarcian) and later he (Hallam, 1977) further suggested that this seaway remained open throughout the rest of Jurassic time. However, the palaeogeographical distribution of *Weyla* is open to other interpretations (Damborena and Manceñido, 1979), and physical evidence of the existence of this trans-Gondwana seaway before latest Jurassic or earliest Cretaceous times is inconclusive.

The most southerly marine Jurassic rocks known in East Africa are the Kimmeridgian occurrences of the Nacala area, Mozambique (14°S) (Henriques da Silva, 1966). From there southwards, there is a substantial geographical gap in their occurrence until the (?) Upper Jurassic rocks of the Mganza area (31.5°S) and the (?) Middle to Upper Jurassic Infanta Formation of the Algoa and offshore Outeniqua basins of South Africa (Dingle, 1978) are reached. Although a more continuous outcrop can be reconstructed by moving Madagascar south-westwards to a palaeoposition closer to southern Mozambique, rather than the more usual one adjacent to Kenya (Fig. 5), the above mentioned deposits are mainly late Jurassic in age, and this would do little to support an early Jurassic seaway. Known Lower Jurassic marine rocks are restricted to the horn of Africa and northern Madagascar (Kent, 1972), and they are apparently absent from southernmost Africa.

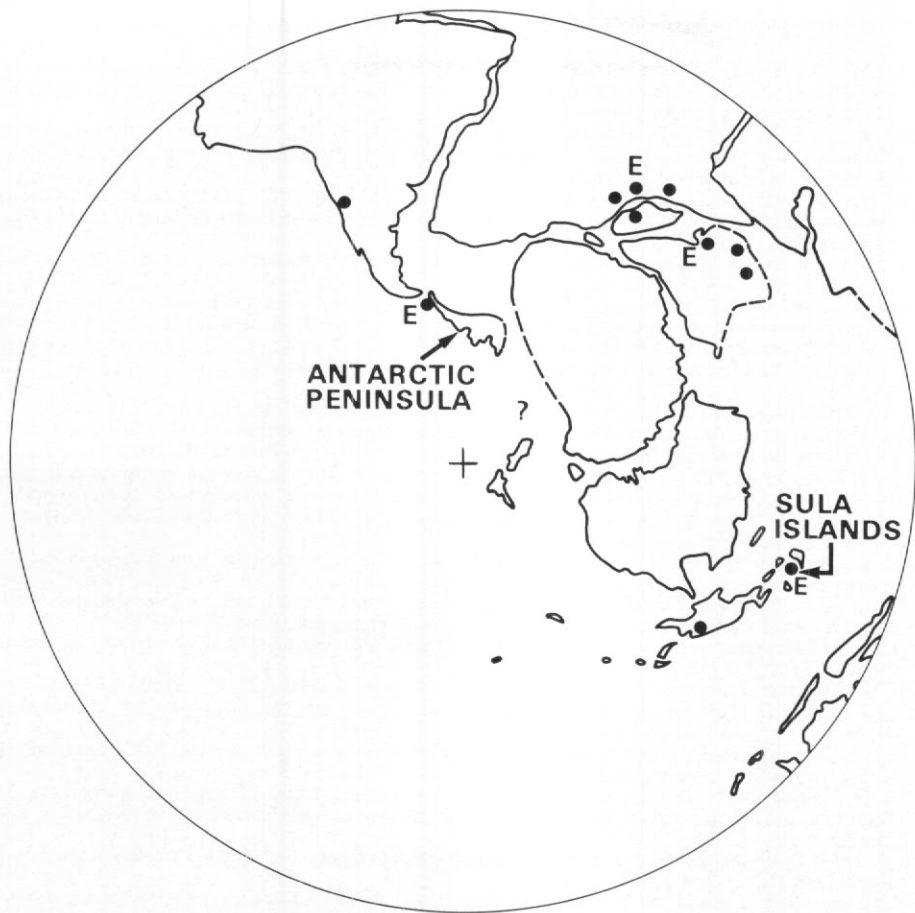


Fig. 5. Sketch reconstruction of Gondwana in the late Jurassic to show the distribution of the Mayitidae (solid circles) and *Epimayites* (E). The reconstruction is based on Smith and others (1981) but with the Antarctic Peninsula treated as a separate microcontinental fragment (Longshaw and Griffiths, in press). The status of other possible microcontinental fragments on the Pacific margin of Antarctica in the late Jurassic is uncertain. The Sula Islands and part of Timor and East Sulawesi are included with the Australasian region (Audley-Charles, 1978) and not with the main part of Indonesia to the north.

The discovery of *Epimayites* in the South Shetland Islands completes the chain in a distribution pattern for the Mayitidae, which includes South America, New Guinea, the Sula Islands, north-western India, Cutch, East Africa and Madagascar (Fig. 5). (Since the Oxfordian is apparently missing from the Jurassic succession of New Zealand (Stevens and Speden, 1978) the genus cannot be expected to be found there.) Their widespread occurrence in the patchy Jurassic record around the Indo-Pacific margin of Gondwanaland suggests that the Mayitidae achieved a geographically continuous distribution in that region. Although a trans-Gondwana seaway, along what is now the East African coast, would have considerably facilitated the interchange of faunas at the opposing limits of this distribution pattern, the latter can be satisfactorily explained in terms of a circum-Gondwana migration.

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