'INDIAN' BELEMNITES FROM THE ALBIAN (LOWER CRETACEOUS) OF JAMES ROSS ISLAND, ANTARCTICA

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ABSTRACT. Two belemnite species (*Parahibolites blanford* and *Tetrabelus seclusus*) are described for the first time outside southern India from the Albian of James Ross Island. The generic status of the controversial *Tetrabelus* Whitehouse is maintained. The palaeobiogeographic distribution of the Albian genera *Dimitobelus*, *Tetrabelus* and *Parahibolites* in southern Gondwana is discussed.

INTRODUCTION

Although two rostral fragments, tentatively assigned to *Belemnopsis* sp., had been recorded previously by Medina and others (1982), belemnites were first collected in some numbers from the Cretaceous sediments of James Ross Island by Dr J. A. Crame, J. R. Ineson and Dr M. R. A. Thomson during the Antarctic summer of 1981/82 and 1982/83. Most of the specimens are of late Lower Cretaceous age, although they were collected from strata previously thought to be Campanian (Bibby, 1966). The presence of Lower Cretaceous strata on James Ross Island was first identified by Crame (1981, 1983*a*, *b*) and Thomson (1981, 1984*a*, *b*) and the stratigraphy of this succession is currently being revised by Ineson and others (pers. comm.).

Examination of belemnites from the Albian of the Gin Cove region (Fig. 1) has revealed a close similarity with part of the Lower Uttattur Group (Albian to Lower Cenomanian) fauna, described from the Trichinopoly District of southern India by Blanford (1861) and Spengler (1910). The *Tetrabelus–Parahibolites–Neohibolites* association found in southern India is represented by a *Tetrabelus–Parahibolites–Dimitobelus* association on James Ross Island. The purpose of this paper is to record for the first time the presence of *Tetrabelus* and *Parahibolites* (and their 'Indian' species) on James Ross Island. Glaessner (1945) recorded *Tetrabelus* and *Parahibolites* from the Albian-Lower Cenomanian of New Guinea, but the author considers that these forms are more properly regarded as *Dimitobelus* and *Neohibolites*(?) (see below).

The family Dimitobelidae was first recognised in the Antarctic Peninsula region by Willey (1972), who described species of *Dimitobelus* and *Peratobelus* from south-eastern Alexander Island (71° 28′ S, 68° 15′ W); *Tetrabelus*, however, was not recognized at the time. The generic status of the dimitobelid *Tetrabelus* has been questioned by Glaessner (1957, 1958) and Stevens (1965) (see below). In the Antarctic Peninsula, however, the generic distinction is clear and several species of *Tetrabelus* occur with species of *Dimitobelus*. The Dimitobelidae will be the subject of a fuller revision to be published elsewhere. *Parahibolites*, a belemnopseid, is also present but has not previously been described from Antarctica.

The morphological terms used here are given in Doyle (1985) (see also Stevens, 1965). All specimens cited are housed in the collections of the British Antarctic Survey, Cambridge, except where otherwise stated. The following abbreviations have been used; BM, British Museum (Natural History); HM, Hunterian Museum, Glasgow; Dv, dorso-ventral diameter at the protoconch (= dsa of Stevens, 1965); Dvmax, maximum dorso-ventral diameter (= dsM); Dvmin, minimum dorso-ventral diameter (= dsm); Dlmax, maximum lateral diameter (= dtM). The symbols used in conjunction with synonymies are given in Matthews (1973).

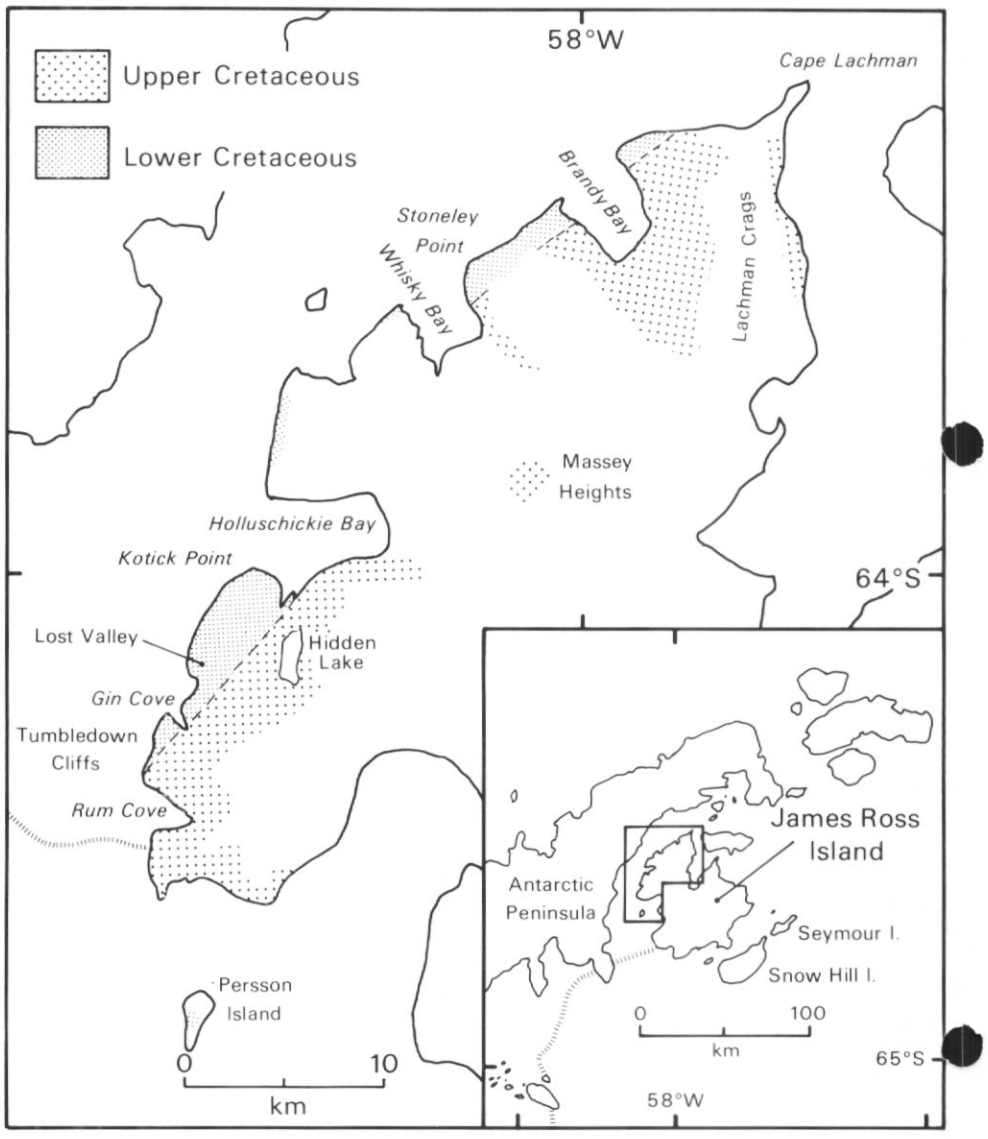

Fig. 1. Sketch maps to show the location of James Ross Island and the extent of Cretaceous strata on its western side.

Systematic Descriptions

FAMILY BELEMNOPSEIDAE Naef, 1922

Genus *Parahibolites* Stolley, 1915

Type species (by original designation). *Neohibolites duvalaeformis* Stolley, 1911.

Diagnosis. Small (30–60 mm approximate total length), slender, hastate to cylindriconical compressed Belemnopseidae. Outline symmetrical, cylindriconical to sub-

hastate. Apex acute. Profile asymmetrical, hastate to cylindriconical. Venter commonly inflated to very inflated. Transverse sections notably compressed, elliptical to subquadrate. A single ventral alveolar groove extends adapically one sixth to one fifth of the total length of the rostrum and is accompanied by a well defined splitting surface. Deeply incised lateral lines consist of a double line (*Doppellinien*) extending for the full length of each flank. Phragmocone penetrates one third to one half of the rostrum. Pseudalveous and *Nadelspitze* may be developed. Apical line (?) goniolineate.

Range. Albian–Cenomanian of Europe, USSR, South America, southern India and Antarctica.

Remarks. *Parahibolites* encompasses several *Hibolithes*-like forms that are markedly compressed and possess well-developed lateral lines. It is much smaller than *Hibolithes*, and has a much less hastate, compressed outline. *Mesohibolites* differs by being more conical with a depressed profile. *Neohibolites* resembles both *Parahibolites* and *Mesohibolites* by possessing a relatively short groove, but is neither markedly compressed nor depressed like these genera. *Pseudobelus* (a duvaliid) resembles *Parahibolites*, but may be distinguished by a dorsal alveolar groove and very incised lateral grooves.

Typical species include: *Parahibolites duvalaeformis* (Stolley), *P. pseudoduvalia* (Sinzow), *P. touritae* (Weigner), *P. blanfordi* (Spengler), *P. stoliczkai* (Spengler), and *P. fuegensis* Stolley.

Parahibolites blanfordi (Spengler, 1910)
Fig. 2a–d

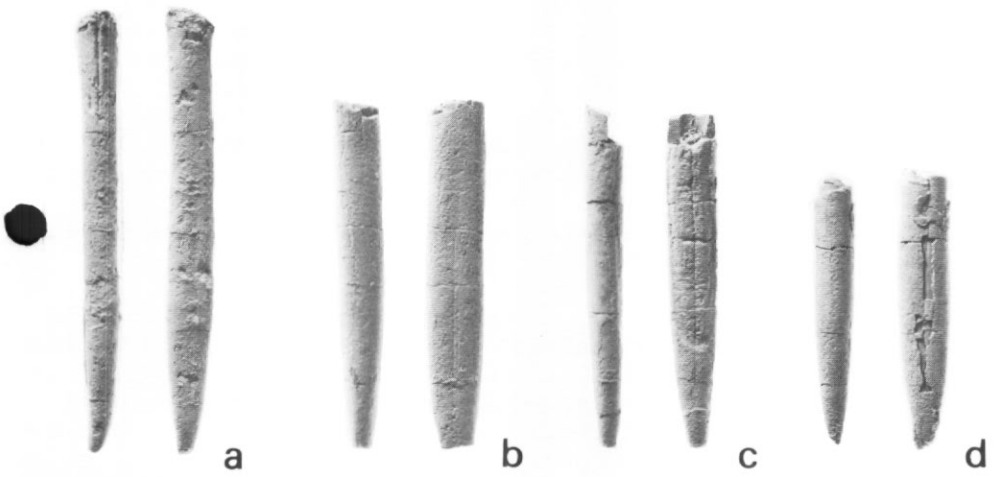

Fig. 2. *Parahibolites blanfordi* (Spengler) from Lost Valley, James Ross Island: a, ventral outline and left profile of specimen with ventral groove preserved, × 1 (D.8423.7); b, ventral outline and left profile of inflated specimen, × 1 (D.8423.13); c, ventral outline and left profile of specimen with ventral splitting surface, × 1 (D. 8423.5*a*); d, ventral outline and left profile of specimen with pseudalveolus, × 1 (D.8423.4).

v non 1845	*Belemnites? fibula* Forbes, p. 119, pl. 9, fig. 3.
p 1861	*Belemnites fibula* Forbes: Blanford, p. 3, pl. I, figs. 13, 16–20, 22–39; pl. II, figs. 5, 6.
1866	*Belemnites fibula* Forbes: Stoliczka p. 201.
*1910	*Belemnites* (*Pseudobelus*) *blanfordi* Spengler, p. 155, pl. 12, fig. 6; pl. 14, fig. 6.
1920	*Parahibolites blanfordi* (Spengler): Bülow-Trummer, p. 164.
non 1945	*Parahibolites blanfordi* (Spengler): Glaessner, p. 158, pl. VI, fig. 16.

Material. Twelve complete rostra (D.8423.4, 5b, d, 7, 8a, b, 9–11, 12a, b, 13), three fragmentary rostra (D. 8423.12c–e) and one natural external mould (D. 8423.6) from the Upper Albian, at 114 and 123 m in the Lost Valley section (locality D.8423: 64° 05′ S, 58° 26′ W), James Ross Island (see Crame, 1985, fig. 11).

Diagnosis. Small, slender subhastate to cylindriconical *Parahibolites*. Outline symmetrical, cylindriconical. Profile asymmetric, subhastate, venter weakly inflated to inflated. Transverse sections compressed, elliptical to subquadrate. Ventral alveolar groove short. Lateral lines form shallow depressions in the rostral flanks.

Type Specimens. No type specimen was designated by Spengler (1910), but measurements of three specimens were given, and these may be considered syntypes. One of these, from the Lower Uttattur Group of Uttattur, southern India figured by him as pl. XIV, fig. 16, is here designated lectotype.

Description. Small (40–60 mm approximate total length), slender, subhastate to cylindriconical rostra. Total length approximately six or seven times the dorso-ventral diameter at the protoconch (Dv).

The outline is symmetrical and cylindriconical to subhastate, with an acute apex. The profile is asymmetrical and subhastate, the venter being slightly more inflated than the dorsum. Transverse sections of the rostrum are compressed and generally elliptical becoming compressed subquadrate. The apical transverse section may be pyriform.

A short, deeply incised ventral groove is confined to the alveolar region. In many cases, the presence of this groove is detected only by a well-defined splitting surface (Fig. 2b, c), but well-preserved specimens clearly display the groove (Fig. 2a). The double lateral lines (*Doppellinien*) form depressions in the rostral flanks, but often it is difficult to differentiate the individual 'lines'.

The phragmocone is nearly central, penetrating a third of the rostrum. Pseudalveolus and *Nadelspitze* are commonly developed. The apical line is (?) goniolineate.

Remarks. Parahibolites blanfordi is easily distinguished from *P. duvalaeformis* (the genotype) which has a much more inflated venter (Stolley, 1911*a*, pl. III, fig. 1–4). *P. stoliczkai* (also from the Lower Uttattur Group of Uttattur; see Spengler, 1910, pl. XIV, fig. 8) possesses a more robust rostrum with inflated apical region in profile. *P. fuegensis* (described from South America; see Stolley *in* Richter, 1925, pl. 7, figs. 12–13) has a much more regularly cylindriconical profile than any of these species.

Blanford (1861) assigned a great number of specimens from Uttattur (Lower Uttattur Group) to *Belemnites fibula* Forbes, a species originally described from Pondicherry (Forbes, 1845, p. 118). The Pondicherry Cretaceous ranges from Santonian to Maastrichtian (see Bhalla, 1983), whereas the Lower Uttattur Group is Albian–Cenomanian (Bhalla, 1983). In addition, Kossmat (1897) considered Blanford's (1861) specimens distinct from the younger *B. fibula*, and Spengler (1910)

later reinforced this view by renaming most of these specimens *Belemnites* (*Pseudobelus*) *blanfordi* n.sp., while referring others to *B.* (*Pseudobelus*) *stoliczkai* n.sp. Examination of Forbes' (1845) types (BM. C.46367, C.46373–C.46374) showed that *B. fibula* is much more cylindrical in profile than *B. blanfordi* and that it also possesses broader lateral depressions.

A specimen from New Guinea, referred to *Parahibolites blanfordi* by Glaessner (1945), is considered by the author more properly assigned to *Neohibolites*(?) sp., because it is uncompressed, and lacks the incised *Doppellinien* characteristic of *Parahibolites*. Thus *P. blanfordi* has not before been recorded unequivocally from outside southern India (see below).

FAMILY DIMITOBELIDAE Whitehouse, 1924

Genus *Tetrabelus* Whitehouse, 1924

Type species (by original designation). *Belemnites seclusus* Blanford, 1861.

Diagnosis. Small (20–60 mm approximate total length), moderately robust to slender, hastate to cylindriconical, compressed Dimitobelidae. Outline symmetrical, subhastate to cylindriconical. Apex acute. Profile asymmetrical to nearly symmetrical, hastate to cylindriconical. Venter commonly inflated to very inflated. Transverse sections compressed to very compressed, subquadrate to pyriform. Two pronounced ventro-lateral alveolar grooves with splitting surfaces extend adapically for one third of the rostrum. Ventro-lateral grooves straight in alveolar region, becoming shallow and curving ventrally (a feature reduced in some species). Dorso-lateral depressions present. Lateral lines (*Doppellinien*) close to and parallel with the dorsum, extending adapically from the dorso-lateral depressions. Fine striae may be present on venter and dorsum. Phragmocone penetrates one quarter to a third of rostrum, ventrally deflected. Apical line (?) goniolineate to (?) cyrtolineate.

Range. (?) Upper Aptian to Albian of Antarctica and southern India.

Remarks. *Tetrabelus* was originally erected by Whitehouse (1924, p. 413) to encompass 'Clavate belemnites provided with dorso-lateral grooves and lateral lines, but having, in addition, independent ventro-lateral grooves.' Glaessner (1957, 1958) and Stevens (1965) argued that these characters were not generically diagnostic and considered *Tetrabelus* to be synonymous with *Dimitobelus*. However, examination of *Tetrabelus* from Antarctica by the author has revealed the true nature of the genus. What unites all species of *Tetrabelus* is their marked compression; whereas all other dimitobelids are either depressed (*Dimitobelus*) or uncompressed (*Peratobelus*) (Fig. 4). The 'independence' of ventro-lateral grooves, is, as was pointed out by Glaessner (1958) and Stevens (1965) an unreliable character. The form of these ventro-lateral grooves in *Tetrabelus* is, however, diagnostic; those of true species of this genus commonly display a marked ventral curvature posteriorly (see Fig. 5 and Whitehouse, 1924, fig. 4). The presence of this vental curvature was doubted by Stevens (1965, p. 61), but its existence is confirmed in the Antarctic specimens. In comparison, species of *Dimitobelus* commonly possess dorsally deflected ventro-lateral grooves, whereas those of *Peratobelus* possess straight grooves which are parallel to the venter (Fig. 4).

Belemnites kleini Gürich from the Upper Albian of White Cliffs, Australia (Gürich, 1901, p. 489, pl. XIX, figs. 2, 3), previously considered as a typical *Tetrabelus* (Whitehouse, 1924, p. 413), possesses an uncompressed section and dorsally deflected

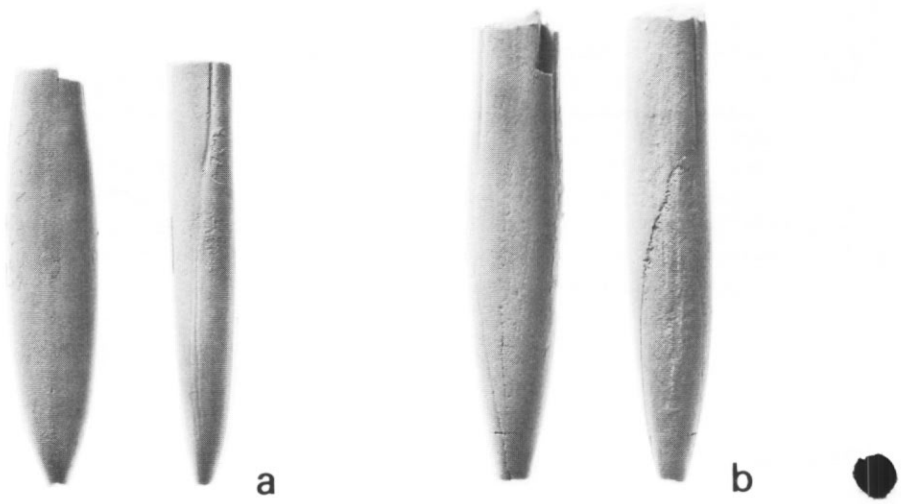

Fig. 3. a. *Dimitobelus diptychus* (McCoy); ventral outline and right profile of specimen from the Albian of Lake Eyre, South Australia; × 1 (HM. S5581). b, *Peratobelus* cf. *oxys* (Tenison-Woods); ventral outline and right profile of specimen from the Aptian of Alexander Island, × 1 (KG.10.61).

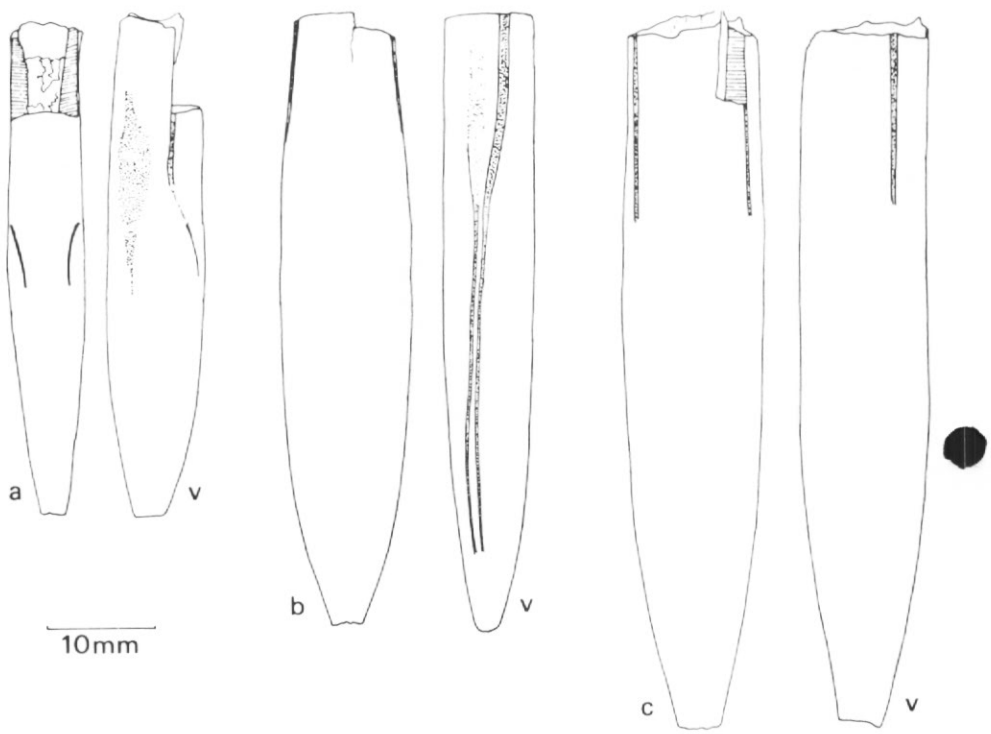

Fig. 4. Camera lucida drawings to illustrate differences between component genera of the Dimitobelidae; ventral outlines and right profiles. Fine stipple not outlined, shallow depressions; outlined stipple, incised grooves or lateral lines; horizontal shading, splitting surfaces; v, venter: a, *Tetrabelus seclusus* (Blanford), the ventral groove to the right of the outline is reconstructed as it is eroded in the original, × 1 (D.8420.37, Fig. 5a); b, *Dimitobelus diptychus* (McCoy, × 1 (HM. S5581, Fig. 3a); c, *Peratobelus* cf. *oxys* (Tenison-Woods), × 1 (KG 10.61, Fig. 3b).

ventro-lateral grooves (seen in (?) topotypes BM. C.12086 and C.20248) and is a species of *Dimitobelus*. Similarly the specimen figured by Etheridge (1902*b*, pl. IX, figs. 3, 4) which was also referred to *Tetrabelus* by Whitehouse (1924, p. 413), possesses the depressed section of a typical *Dimitobelus*. That specimen has affinities to *Tetrabelus macgregori* (Glaessner, 1945), a species subsequently referred to *Dimitobelus* for the same reason (see Glaessner, 1958).

Typical species of *Tetrabelus* are therefore restricted to the genotype *Tetrabelus seclusus* (Blanford), from southern India and James Ross Island, and two new species from Antarctica, to be formally described elsewhere. The first of these (*Tetrabelus* sp.nov. A; Fig. 5c), from the Aptian–Albian of south-eastern Alexander Island (71° 28′ S, 68° 15′ W) possesses a cylindriconical form with a compressed subquadrate section and clearly defined ventraly deflected ventro-lateral grooves. The second (*Tetrabelus* sp.nov. B; Fig. 5b), from the Albian of James Ross Island, also possesses a cylindriconical form, but has a very compressed section. Ventral deflection of the ventro-lateral grooves is restricted to their furthest posterior point, and is somewhat reduced in this species.

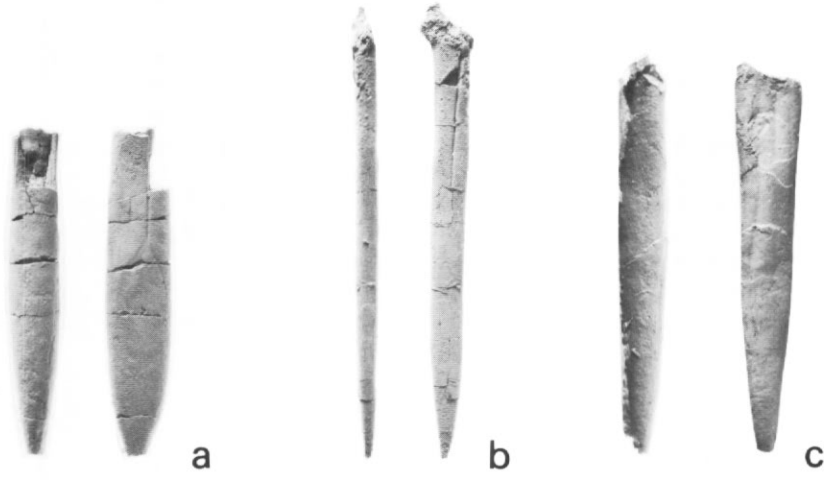

Fig. 5. a. *Tetrabelus seclusus* (Blanford); ventral outline and right profile of a specimen from the Gin Cove region, James Ross Island, × 1 (D.8420.37). b, *Tetrabelus* sp.nov. B; ventral outline and right profile of a specimen from the Gin Cove region, James Ross Island, × 1 (D.8412.98). c, *Tetrabelus* sp.nov. A; ventral outline and left profile of latex cast from natural mould, south-eastern Alexander Island, × 1 (KG.103.29).

Tetrabelus seclusus (Blanford, 1861)
Fig. 5a

*1861 *Belemnites seclusus* Blanford, p. 4, pl. I, figs. 43–51; pl. II, fig. 8.
1866 *Belemnites seclusus* Blanford; Stoliczka, p. 202.
1910 *Belemnites seclusus* Blanford; Spengler, p. 153, pl. XIV, fig. 7.
1920 *Parahibolites* (?) *seclusus* (Blanford); Bülow-Trummer, p. 166.
1924 *Tetrabelus seclusus* (Blanford); Whitehouse, p. 413, fig. 4.

Material. Two complete rostra (D.8420.37, D.8412.49) from the Albian of the Gin Cove region (localities D.8420; at 168.5 m in the section 2 km north of Gin Cove

(60° 01.5′ S, 58° 24′ W) and D.8412; at 64 m in the section at the northern end of Tumbledown Cliffs (64° 03.5′ S, 58° 26′ W), see Crame, 1985, fig. 11) James Ross Island.

Diagnosis. Small, hastate *Tetrabelus*. Outline symmetrical, subhastate. Profile asymmetric, subhastate to hastate. Venter inflated. Transverse sections compressed elliptical to rounded subquadrate, pyriform in alveolar region. Ventro-lateral alveolar grooves display sharp ventral curvature in stem region. Dorso-lateral depressions broad.

Type specimens. No type specimen was designated by Blanford (1861), but those figured in his pl. I, figs. 43–51 may be taken as syntypes. The original of his fig. 44, from the Lower Uttattur Group of Uttattur, southern India, is here designated lectotype.

Description. Small (30–45 mm approximate total length), relatively robust, compressed hastate rostrum. Total length approximately five times the dorso-ventral diameter at the protoconch.

The outline is symmetrical, subhastate (accentuated by the dorso-lateral alveolar 'pinching'), and the apex is acute. The profile is asymmetrical and hastate to subhastate depending on the ventral inflation of the rostrum. Transverse sections are compressed, more so in the apical region. The stem and apical sections are rounded subquadrate to elliptical, becoming pyriform in the alveolar region (at Dvmin).

Two deep, straight, ventro-lateral alveolar grooves with splitting surfaces are developed, reaching adapically for one third of the rostrum. The grooves become shallow, curving sharply onto the venter in the stem region. Dorso-lateral broad depressions occur (at Dvmin) as 'pinches'. Lateral lines (Doppellinien) extend adapically from these regions, remaining close to the dorsum.

The phragmocone commonly penetrates one third to a quarter of the rostrum, and is slightly ventrally displaced. A pseudalveolus may be developed. The apical line is (?) cyrtolineate.

Remarks. Belemnites seclusus was the first of the dimitobelids to be described (Blanford, 1861) and was designated genotype of *Tetrabelus* by Whitehouse (1924). It remains the only true *Tetrabelus* so far described ('*T.*' *kleini* and '*T.*' *macgregori* are excluded from the genus for the reasons outlined above), possessing a compressed section and ventrally curving ventro-lateral grooves, characters here considered diagnostic of the genus. Two further species of *Tetrabelus* from Antarctica (Alexander and James Ross islands) will be described elsewhere (see above).

Bülow-Trummer (1920) considered *B. seclusus* to be a species of *Parahibolites* (see also Stolley, 1919), presumably because of its close association with species of this genus, and its degree of compression. However, its paired ventro-lateral grooves clearly distinguish if from species of *Parahibolites* which possess only a single ventral groove.

Biogeographic Distribution of Albian *Dimitobelus*, *Tetrabelus* and *Parahibolites*

The palaeobiogeography of the Cretaceous belemnites has been discussed in some detail by Stevens (1965, 1973), who suggested that a distinct austral belemnite group, the Dimitobelidae, was initiated in the Aptian–Albian. He noted that dimitobelid belemnites were not found north of the 30° S palaeo-latitude for that time, being known only from Australia, New Zealand, New Guinea and southern India. Later,

dimitobelids were recognised in the Aptian–Albian of Antarctica (Willey, 1972). Although the belemnite faunas of central and southern Europe were characterised by an assemblage of *Neohibolites* and *Parahibolites* at that time (Stevens, 1965, 1973), both genera also occur as far south as South America, southern India and the Malagasy Republic (Stevens, 1965). The present work extends the range of *Parahibolites* to Antarctica, but the genus has not yet been recorded from Australasia (Stevens, 1973). *Neohibolites*, however, may be represented in Australia by *Belemnites liversidgei* Etheridge from the Rolling Downs Group (Albian).

A palaeogeographic reconstruction for the Albian is given in Fig. 6, with occurrences of the dominant belemnite genera plotted. *Dimitobelus s.s.* shows a wide distribution within the 30° S palaeolatitude, extending from New Guinea (Glaessner, 1945, 1958), eastern Australia (Etheridge, 1902*a*, *b*; Whitehouse, 1925; Skwarko, 1966), New Zealand (Stevens 1965) to Alexander Island, Antarctica (Willey, 1972). Specimens of *Dimitobelus* have now been identified by the author also from James Ross Island. The occurrence of *Dimitobelus* in South America is suggested by specimens recorded from South Georgia (Annenkov Island; Pettigrew and Willey, 1975, p. 36) and the reported presence of this genus in collections at La Plata, Argentina by Dr L. E. Willey (Pettigrew and Willey, 1975, p. 36). *Dimitobelus* has not been recorded from South Africa or the Malagasy Republic. Although Whitehouse (1924, p. 415) suggested the genus may occur in the Neocomian Uitenhage Formation of South Africa on the strength of fragments described by Kitchin (1908), those specimens are probably better referred to the depressed *Hibolithes pistilliformis* group, common in the lowermost Cretaceous of India and the Malagasy Republic (Stevens, 1965).

By contrast, *Tetrabelus s.s.* apparently possesses a more restricted geographic range than *Dimitobelus*, as it has so far only been recorded with certainty from southern India (Blanford, 1861; Spengler, 1910) and James Ross Island (this paper). A species of *Tetrabelus* has also been identified from Alexander Island (*T.* sp.nov. A; see above) and this will be described elsewhere. Other forms described from Australia and New Guinea as species of *Tetrabelus* (Glaessner, 1945; Whitehouse, 1924) are more properly assigned to *Dimitobelus* for the reasons outlined above. No examples of compressed dimitobelids (i.e. of *Tetrabelus*) have so far been recorded from the abundant fauna of the Rolling Downs Group, Australia. *Tetrabelus* may occur in the Malagasy Republic, but citations of *Belemnites* cf. *seclusus* without description or illustration (Lemoine, 1906, p. 195; Boule and others, 1906, p. 6) must be treated with some caution.

Parahibolites occurs in the Albian of central and eastern Europe (Stolley 1911*a*, *b*; Sinzow, 1913; Weigner, 1910), Argentina (Stolley *in* Richter, 1925) and southern India (Blanford, 1861; Spengler, 1910), and its distribution has been discussed in detail by Stevens (1973). *Parahibolites blanfordi* is here recorded for the first time outside southern India, in the Albian of Jame Ross Island. Lemoine (1906, p. 195) did however report the presence of *Belemnites* cf. *fibula* (? = *P. blanfordi*) in the Malagasy Republic.

Allowing for the inadequacies in the record, the following tentative conclusions can be drawn:

(1) *Dimitobelus* appears to have been restricted within the 30° S Aptian–Albian palaeolatitude, predominantly on the Pacific margin of Gondwana. Although it should be noted that few Albian localities exist on the Tethyan margin, *Dimitobelus* has not been recorded from the Uttattur Group of southern India (Fig. 6), possibly indicating a preference of this genus for the long-established, circum-Gondwana migratory route.

(2) *Tetrabelus*, a distinctive compressed dimitobelid, has so far only been recorded with certainty from the Albian of southern India and Antarctica. No occurrences of this genus have yet been reported from New Zealand or Australia (Fig. 6).

(3) *Parahibolites* is never abundant but it is more cosmopolitan, occurring in

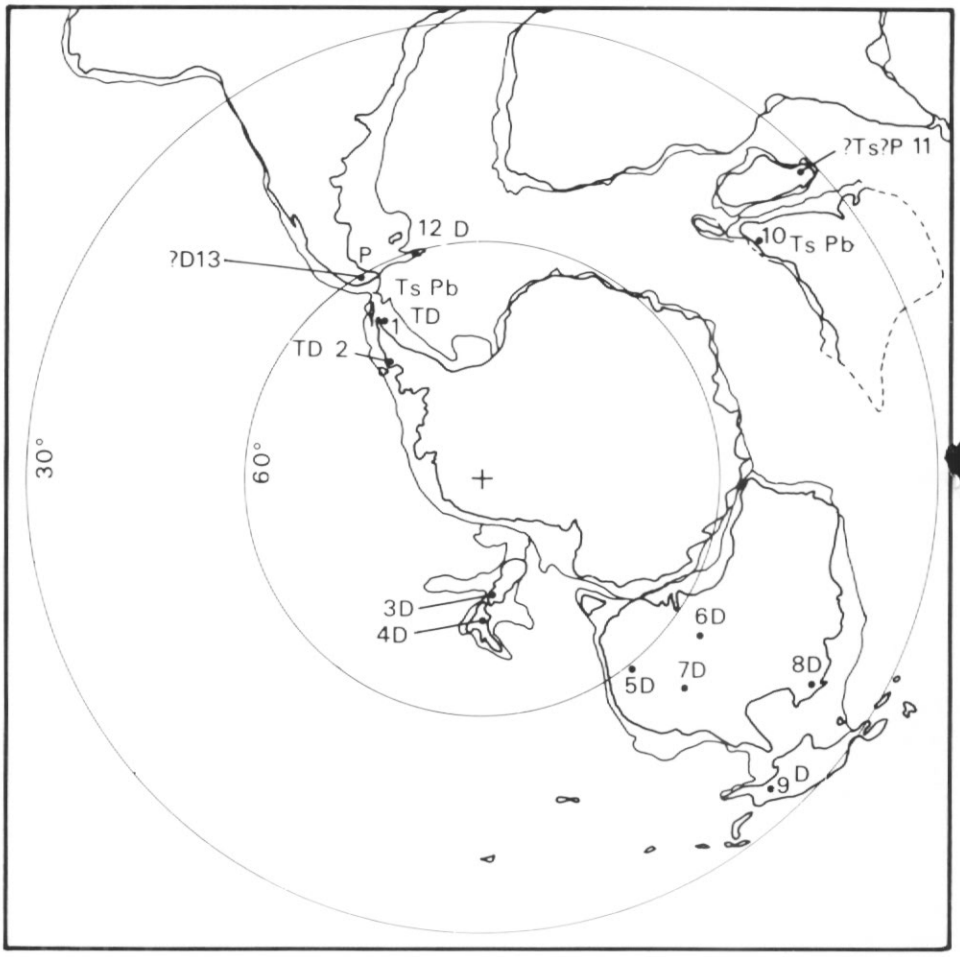

Fig. 6. Palaeogeographic reconstruction of southern Gondwana in the late Albian (100 ma), with the occurrences of dominant belemnite genera and some species plotted. T, *Tetrabelus*; Ts, *T. seclusus*; P, *Parahibolites*; Pb, *P. blanfordi*; D, *Dimitobelus*. Numbered localities are as follows: 1, James Ross Island; 2, Alexander Island (Willey, 1972); 3, South Island and, 4, North Island, New Zealand (Stevens, 1965); 5, New South Wales, Australia (Etheridge, 1902*b*); 6, South Australia (Etheridge, 1902*a*); 7, Queensland, Australia (Jack and Etheridge, 1892); 8, Northern Territories, Australia (Skwarko, 1966); 9, Papua (Glaessner, 1945); 10, Trichinopoly, India (Blanford, 1861); 11, Malagasy Republic (Lemoine, 1906); 12, Annenkov Island, South Georgia (Pettigrew and Willey, 1975); 13, Patagonia (Stolley *in* Richter, 1925, Pettigrew and Willey, 1975). Base map © Cambridge University Press 1981, taken from Smith, Hurley and Briden *Phanerozoic paleocontinental world maps*.

Europe, South America, southern India, Antarctica and doubtfully in the Malagasy Republic.

(4) There appear to be close links between the Albian belemnite fauna of James Ross Island, Antarctica and that of Uttattur, southern India, indicating free, trans-Gondwana belemnite migration for the first time. The *Dimitobelus* element of the Antarctic fauna is, however, replaced by *Neohibolites* in India (see conclusion 1 above).

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REFERENCES

BHALLA, S. N. 1983. India. (*In* MOULLADE, M. *and* NAIRN, A. E. M. *eds. The Phanerozoic Geology of the World, II. The Mesozoic, B.* Amsterdam, Elsevier, 305–52.)

BIBBY, J. S. 1966. The stratigraphy of part of north-east Graham Land and the James Ross Island group. *British Antarctic Survey Scientific Reports*, No. 53, 37 pp.

BLANFORD, H. F. 1861–65. The fossil Cephalopoda of the Cretaceous rocks of southern India: Belemnitidae–Nautilidae. *Memoirs of the Geological Survey of India. Palaeontologia Indica*, **1**, 1–400.

BOULE, M., LEMOINE, P. *and* THEVENIN, A. 1906. Céphalopodes crétaces des environs de Diégo-Suarez (Madagascar). *Annales de Paléontologie*, **1**, 173–92.

BÜLOW-TRUMMER, E. VON 1920. *Fossilium Catalogus 1: Animalia. Pars 11: Cephalopoda dibranchiata.* Berlin, Junk, 313 pp.

CRAME, J. A. 1981. Upper Cretaceous inoceramids (Bivalvia) from the James Ross Island group and their stratigraphical significance. *British Antarctic Survey Bulletin*, No. 53, 29–56.

CRAME, J. A. 1983*a*. Lower Cretaceous bivalve biostratigraphy of Antarctica. *Zitteliana*, **10**, 399–406.

CRAME, J. A. 1983*b*. Cretaceous inoceramid bivalves from Antarctica. (*In* OLIVER, R. L., JAMES, P. R. *and* JAGO, J. G. *eds. Antarctic Earth Science*. Canberra, Australian Academy of Science and Cambridge, Cambridge University Press, 298–302.)

CRAME, J. A. 1985. Lower Cretaceous inoceramid bivalves from the Antarctic Peninsula region. *Palaeontology*, **28**, 475–525.

DOYLE, P. 1985. Sexual dimorphism in the belemnite *Youngibelus* from the Toarcian (Lower Jurassic) of Yorkshire. *Palaeontology*, **28**, 133–46.

ETHERIDGE, R., *Jr.* 1902*a*. The Cretaceous Mollusca of South Australia and the Northern Territory. *Memoirs of the Royal Society of South Australia*, **2**, 1–54.

ETHERIDGE, R., *Jr.* 1902*b*. A monograph of the Cretaceous invertebrate fauna of New South Wales. *Memoirs of the Royal Society of New South Wales, Palaeontology*, No. 11, 98 pp.

FORBES, E. 1845. Report on the Cretaceous fossil invertebrates from south India, collected by Mr Kaye and Mr Cunliffe. *Transactions of the Geological Society, London*, **7**, 97–174.

GLAESSNER, M. F. 1945. Mesozoic fossils from the central highlands of New Guinea. *Proceedings of the Royal Society of Victoria, N.S.*, **56**, 151–68.

GLAESSNER, M. F. 1957. Cretaceous belemnites from Australia, New Zealand and New Guinea. *Australian Journal of Science*, **20**, 88–9.

GLAESSNER, M. F. 1958. New Cretaceous fossils from New Guinea. *Records of the South Australian Museum*, **13**, 199–226.

GÜRICH, G. 1901. Jura- und Devon-Fossilien von White Cliffs, Australien. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie Beilage Band*, **14**, 484–518.

JACK, R. L. *and* ETHERIDGE, R., *Jr.* 1892. The geology and palaeontology of Queensland and New Guinea. Brisbane, J.C. Beal, 768 pp.

KITCHIN, F. L. 1908. Invertebrate fauna and palaeontological relations of the Uitenhage Series. *Annals of the South African Museum*, **7**, 21–250.

KOSSMAT, F. 1897. The Cretaceous deposits of Pondicherry. *Records of the Geological Survey of India*, **30**, 51–110.

LEMOINE, P. 1906. *Etudes géologiques dans le Nord de Madagascar*. Paris, Hermann, 520 pp.

MATTHEWS, S. C. 1973. Notes on open nomenclature and on synonymy lists. *Palaeontology*, **16**, 713–9.

MEDINA, F. A., RINALDI, C. A., DEL VALLE, R. A. *and* BALDONI, A. M. 1982. Edad de la Formación Lower Kotick Point en la Isla James Ross, Antártida. *Ameghiniana*, **19**, 263–72.

PETTIGREW, T. H. *and* WILLEY, L. E. 1975. Belemnite fragments from Annenkov Island. *British Antarctic Survey Bulletin*, No. 40, 33–6.

RICHTER, M. 1925. Beiträge zur Kenntnis der Kreide in Feuerland. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie Beilage Band*, **52**, 524–68.

SINZOW, J. 1913. Beiträge zur Kenntis der unteren Kreideablagerungen des Nord Kaukasus. *Trudy geologicheskogo Museya Petra Velikago. Imperatorska Akademiya Nauk, Sanktpeterburg*, **7**, 93–117.

SKWARKO, S. K. 1966. Cretaceous stratigraphy and palaeontology of the North Territory. *Bulletin. Bureau of Mineral Resources, Geology and Geophysics, Melbourne*, **73**, 135 pp.

SPENGLER, E. 1910. Die Nautiliden und Belemniten des Trichinopolydistrikts. *Beiträge zur Paläontologie und Geologie Österreich-Ungarns und des Orients*, **23**, 125–57.

STEVENS, G. R. 1965. The Jurassic and Cretacous belemnites of New Zealand and a review of the Jurassic and Cretaceous belemnites of the Indo-Pacific region. *Palaeontological Bulletin of the Geological Survey of New Zealand*, No. 36, 283 pp.

STEVENS, G. R. 1973. Cretaceous belemnites. (*In* HALLAM, A., *ed. Atlas of Palaeobiogeography*. Amsterdam, Elsevier, 387–401.)

STOLLEY, E. 1911*a*. Beiträge zur Kenntnis der Cephalopoden der norddeutschen Unterenkreide. 1. Die Belemniten der norddeutschen unteren Kreide. *Geologische und paläontologische Abhandlungen. Neue Folge*, **10**, 201–72.

STOLLEY, E. 1911*b*. Studien an den belemniten der unteren Kreide Norddeutschlands. *Jahresbericht des niedersachsischen geologischen Vereins*, **11**, 174–91.

STOLLEY, E. 1919. Die Systematik der Belemniten. *Jahresbericht des niedersachsischen geologischen Vereins*, **11**, 1–59.

STOLICZKA, F. 1866. Cretaceous fauna of Southern India, Ammonitidae with a revision of the Nautilidae etc. *Memoirs of the Geological Survey of India. Palaeontologia Indica*, **3**, 1–216.

THOMSON, M. R. A. 1981. Antarctica. (*In* REYMENT, R. A. *and* BENGTSON, P. *eds. Aspects of Mid-Cretaceous regional geology*. London, Academic Press, 269–96.)

THOMSON, M. R. A. 1984*a*. 'European' ammonites in the Cretaceous of Antarctica. *Zitteliana*, **10**, 407–12.

THOMSON, M. R. A. 1984*b*. Report on Antarctic Field Work. Preliminary ammonite zonation of the mid-Cretaceous rocks of James Ross Island. *British Antarctic Survey Bulletin*, No. 64, 85–91.

WEIGNER, A. 1910. Studya nad cenomanem podolskim. 1. Fauna piaskow-nizniowskich. *Rozprawy Akademii Unjetnosci Wydzialu matematyczno-przynodnizego, Ser.* 3, **9B** (1909), 111–31.

WHITEHOUSE, F. W. 1924. Dimitobelidae – a new family of Cretaceous belemnites. *Geological Magazine*, **61**, 410–16.

WHITEHOUSE, F. W. 1925. On Rolling Downs fossils collected by Prof. J. W. Gregory. *Transactions of the Royal Society of South Australia*, **49**, 27–36.

WILLEY, L. E. 1972. Belemnites from south-eastern Alexander Island. 1. The occurrence of the family Dimitobelidae in the Lower Cretaceous. *British Antarctic Survey Bulletin*, No. 28, 29–42.