

SPECIAL PAPERS IN PALAEOLOGY · 41

**Late Jurassic – early
Cretaceous cephalopods of
eastern Alexander Island,
Antarctica**



THE PALAEOLOGICAL ASSOCIATION

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Simon R.A. Kelly

Hope this is useful!
With best wishes,

Phil

SPECIAL PAPERS IN PALAEOLOGY NO. 41

LATE JURASSIC-EARLY CRETACEOUS
CEPHALOPODS OF EASTERN
ALEXANDER ISLAND, ANTARCTICA

BY

P. J. HOWLETT

with 10 plates and 9 text-figures

THE PALAEOLOGICAL ASSOCIATION

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ABSTRACT. The Fossil Bluff Group of eastern Alexander Island was deposited in the fore-arc basin of an active magmatic arc, which formed the present-day Antarctic Peninsula. Cephalopods are common throughout the group. Ammonites and belemnites of several localities within the northern half of the outcrop are described, and previously described cephalopods are revised. Nine genera and seventeen species of ammonites (of which *Raimondiceras alexandrensis* and *Blanfordiceras weaveri* are new), and two genera and sixteen species of belemnites (including two new subgenera: *Belemnopsis (Parabelemnopsis)* and *B. (Telobelemnopsis)*), and four new species: *B. (Belemnopsis) launceloti*, *B. (T.) rymilli*, *B. (T.) bertrami* and *B. (T.) stephensoni* are described. This detailed study of the cephalopods indicates that the Fossil Bluff Group ranges in age from Kimmeridgian (late Jurassic) to at least Aptian (early Cretaceous), and enables seven ammonite biozones and three belemnite biozones (including two sub-biozones) to be erected within the group. By comparing this new biozonation with other Southern Hemisphere schemes, the positions of the stage boundaries within the succession can be recognized.

INTRODUCTION

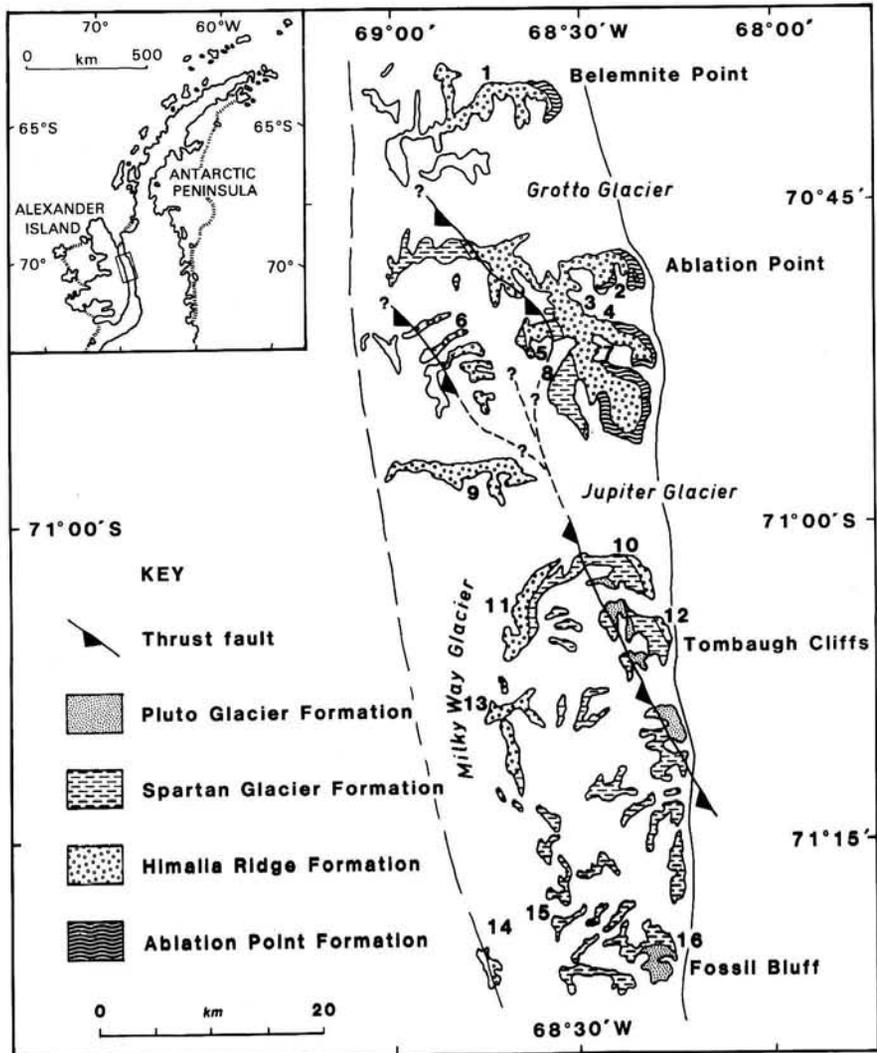
MESOZOIC CEPHALOPODS have been reported from a number of localities around the Antarctic Peninsula. The stratigraphically oldest occurrence is of an ammonite (provisionally assigned to the genus *Ephioceras*) and an indeterminate belemnite phragmocone collected from the Lully Foothills of central Alexander Island, which were dated as early Jurassic, possibly Sinemurian (Thomson and Tranter 1986). The youngest faunas are from the James Ross and Seymour islands region, where a rich Lower to Upper Cretaceous (?Aptian–Maastrichtian) ammonite and belemnite assemblage has been described (Thomson 1984; Doyle 1985*b*, 1987; Macellari 1986; see also Feldmann and Woodburne 1988). However, important Antarctic cephalopod localities of late Jurassic–early Cretaceous age are known. The most diverse and well-preserved cephalopod faunas of this age are to be found along the eastern coast of Alexander Island, and they are the subject of this paper.

PREVIOUS WORK

Fossils were first collected from Alexander Island during the initial exploration of the area by the British Graham Land Expedition of 1934–37. That expedition visited two localities along the eastern coast of the island: 'Fossil Camp', now known as Fossil Bluff, and 'Ablation Camp', now Ablation Point (text-fig. 1). No ammonites were found, but belemnites and a variety of other marine fossils were collected from both areas. These were tentatively dated as Middle Jurassic, largely on the basis of the associated flora (Stephenson and Fleming, 1940). Subsequent visits to the area by Sir Vivian Fuchs and R. J. Adie in 1948 and 1949 resulted in further collections of belemnites and the discovery of ammonites at a number of localities. The belemnites were examined by L. Bairstow and provisionally dated as late Jurassic (Adie 1958). The ammonites were described by M. K. Howarth, who identified an Upper Jurassic (late Oxfordian–Kimmeridgian) fauna from the north of the area and a Lower Cretaceous (Aptian) fauna from the south (Howarth 1958).

The first detailed study of the belemnites of the area was by L. E. Willey, who described the collections made by the British Graham Land Expedition and by Sir Vivian Fuchs and R. J. Adie, together with further material which he collected himself (Willey 1972, 1973). Willey identified five species of the family Dimitobelidae from the south of the area (Aptian–Albian), and sixteen species of Belemnopseidae from the north (late Oxfordian–Berriasian). Recently, the dimitobelids have been extensively revised and expanded (Doyle 1987), but no new work has been carried out on the belemnopseids.

Further collections of ammonites from the 'Lower Cretaceous fauna' of Howarth (1958), and of Upper Jurassic and lowermost Cretaceous ammonites from the Ablation Point area (including the 'Upper Jurassic fauna' of Howarth 1958) were described by M. R. A. Thomson (1974, 1979), but since then little work has been done on the ammonite faunas. The following descriptions are of new cephalopod material collected since 1970 at sixteen localities along the eastern side of Alexander Island, from Fossil Bluff northwards (see below; text-fig. 1), together with some revision of the previous work.



TEXT-FIG 1. Locality and geological map of the central east coast of Alexander Island (see inset). Fossil occurrences are numbered as in the text: 1. Belemnite Point; 2. Ablation Point; 3. Ablation Valley; 4. Himalia Ridge; 5. K.G. 3452-3; 6. Europa Cliffs; 7. Moutonnée Valley; 8. Leda Ridge; 9. Nonplus Crag; 10. Callisto Cliffs; 11. northern Planet Heights; 12. Tombaugh Cliffs; 13. Lunar Crag; 14. Vesta Nunataks; 15. Aeolus Ridge; 16. Fossil Bluff.

GEOLOGICAL SETTING

Exposed on the eastern coast of Alexander Island is the extensive Fossil Bluff Group (formerly the Fossil Bluff Formation; see Butterworth *et al.* 1988), which ranges in age from the Kimmeridgian to Aptian (Crame and Howlett 1988). This 4000 m thick sedimentary succession represents part of a fore-arc sequence situated to the west of an active magmatic arc (the present-day Antarctic Peninsula; Storey and Garrett 1985). The Fossil Bluff Group is envisaged as having been deposited within a deep, narrow, tectonically active basin (Storey and Nell 1988), and shows a general transition from deep to shallow marine environments throughout the uppermost Jurassic and

Lower Cretaceous (Butterworth and Macdonald 1989). The cephalopods described below occur in the first three formations of the group: the Ablation Point, Himalia Ridge and Spartan Glacier Formations, spanning the Kimmeridgian to Barremian stages. These correspond to the deep marine and slope environments described by Butterworth and Macdonald (1989).

LOCALITIES

The descriptions of some of the localities listed below, together with their fossil content, exist only as unpublished field reports. However, the majority of the sections have either been described or sedimentary logs have been published (see Elliott 1974; Taylor *et al.* 1979; Butterworth 1985; Butterworth *et al.* 1988; Crame and Howlett 1988). In Butterworth *et al.* (1988) general descriptions of the lithologies of the Fossil Bluff Group are given. It is hoped that the remaining localities will be described shortly.

1. *Belemnite Point* (70° 40' S, 68° 37' W). Large section measured largely on the ridge immediately west of Belemnite Point (figured in Butterworth *et al.* 1988, fig. 5).
2. *Ablation Point* (70° 48' S, 68° 25' W). Locality AB of Elliott (1974) on the west side of Erratic Valley, west of Ablation Point.
3. *Ablation Valley* (70° 49' S, 68° 31' W). Short section along the major stream in the western end of Ablation Valley (unpublished).
4. *Himalia Ridge* (70° 50' S, 68° 27' W). Very thick succession best exposed on the northern side and along the summit of the ridge. This locality is equivalent to localities AG, AH and AK of Elliott (1974), and forms one of the most important sections through the Fossil Bluff Group (Butterworth 1984; Butterworth *et al.* 1988; Crame and Howlett 1988).
5. *KG. 3452-KG. 3453* (70° 50' S, 68° 30' W). Short section up the eastern side of the unnamed hill at the extreme western end of Himalia Ridge, previously unvisited (unpublished).
6. *Europa Cliffs* (70° 51' S, 68° 47' W). Europa Cliffs consists of six ridges trending approximately north-east-south-west, the second ridge from the northern end being the most accessible. The short section at this previously unvisited locality was measured largely on the extreme eastern face of the ridge (unpublished).
7. *Moutonnée Valley* (70° 51' S, 68° 27' W). This previously unexamined section is in part equivalent to locality AS of Elliott (1974), and forms an eastward extension of Leda Ridge (unpublished).
8. *Leda Ridge* (70° 51' S, 68° 32' W). The section was measured largely along the summit of the ridge (Crame and Howlett 1988). This is the second major section through the Fossil Bluff Group, and though previously undescribed, it was visited by M. H. Elliott and C. M. Bell, and referred to by Elliott (1974) as locality AP.
9. *Nonplus Crag* (70° 56' S, 68° 45' W). Prominent east-west trending massif, lying on the west side of the Jupiter Glacier, between Europa Cliffs and Planet Heights. The locality visited lies at about the mid-point of the south side (unpublished).
10. *Callisto Cliffs* (71° 03' S, 68° 37' W). An extensive section extending up the northern side of Callisto Cliffs (Crame and Howlett 1988). This forms the third major section through the Fossil Bluff Group, and was previously undescribed.
11. *Northern Planet Heights* (71° 00' S, 68° 37' W). This previously unvisited section was measured eastwards up the second ridge (looking south) of Planet Heights (Crame and Howlett 1988).
12. *Tombaugh Cliffs* (71° 04' S, 68° 18' W). A short section at the northern end of Tombaugh Cliffs, equivalent to locality Z of Taylor *et al.* (1979).

13. *Lunar Crag* (71° 08' S, 68° 42' W). Short section largely along northern side of this previously unvisited locality (figured in Butterworth *et al.* 1988, fig. 5).

14. *Vesta Nunataks* (71° 18' S, 68° 43' W). One of a few scattered nunataks south-west of the Milky Way Glacier, previously unvisited (unpublished).

15. *Aeolus Ridge* (71° 19' S, 68° 34' W). Ridge trending north-east-south-west on the western side of the Milky Way Glacier, approximately level with Vesta Nunataks (unpublished).

16. *Fossil Bluff* (71° 20' S, 68° 18' W). A well-known section (see Taylor *et al.* 1979) recently remeasured and extended stratigraphically (figured in Butterworth *et al.* 1988, fig. 6).

SYSTEMATIC PALAEOONTOLOGY

The classification used for the ammonites is based on those proposed by Arkell *et al.* (1957), Donovan *et al.* (1981), Wright (1981) and House (1985). Glossaries of ammonite terminology can be found in Arkell *et al.* (1957) and Cope (1978). For the belemnites, the classification scheme proposed by Jeletzky (1965, 1966) is adopted. Glossaries of belemnite terminology are contained in Stevens (1965), Doyle (1985a, 1987) and Doyle and Kelly (1988). In the belemnite descriptions, where possible, the following measurements are recorded (see Doyle and Kelly 1988):

<i>L</i>	total length of rostrum preserved.
<i>l</i>	length from apex to protoconch.
<i>Dl</i>	lateral diameter at the protoconch.
<i>Dl</i> _{max}	maximum lateral diameter (in hastate forms).
<i>Dv</i>	dorso-ventral diameter at the protoconch
<i>Dv</i> _{max}	maximum dorso-ventral diameter (in hastate forms)

All measurements are in millimetres, and on incomplete specimens estimated values are marked by an asterisk (*). Approximate size (length, *l*) ranges are given by the terms small (*l* < 80 mm), medium (*l* = 80–110 mm) and large (*l* > 110 mm).

In all the descriptions, the synonymy lists have been annotated with the symbols suggested by Matthews (1973). As some of the specimens are fragmentary, a system of open nomenclature has been used for some species; this usage conforms with the proposals of Bengtson (1988). All the specimens (unless otherwise stated) are housed in the collections of the British Antarctic Survey, Cambridge, and are prefixed by KG (signifying Alexander Island). The following prefixes have been used to denote specimens housed in other collections: BM, British Museum (Natural History), London; FCB, Feruglio collection, Capellini Museum, Università di Bologna (Italy).

Class CEPHALOPODA Cuvier, 1797
 Subclass AMMONOIDEA Zittel, 1884
 Order PHYLLOCERATIDA Arkell, 1950
 Family PHYLLOCERATIDAE Zittel, 1884
 Subfamily PHYLLOCERATINAE Zittel, 1884
 Genus PHYLLOPACHYCERAS Spath, 1927

Type species. *Ammonites infundibulum* d'Orbigny, 1841, by original designation.

Diagnosis. Very involute, with very narrow to minute umbilicus; moderately inflated oxycone; rounded ribs which may divide are typically present on the outer part of the whorl flanks; intercalatory ribs are common; weak lirae sometimes preserved on external moulds.

Range and distribution. Cretaceous (the age range of *Phyllopachyceras* depends on the interpretation of the genus, but most occurrences are from the Cretaceous; see below); Europe, North Africa, India, Australia, Japan, New Zealand, Argentina and Alexander Island.

Remarks. Over the past twenty years, the Phylloceratidae have been extensively revised and discussed (see Wiedmann 1962a, 1964; Joly 1975; Kennedy and Klinger 1977; Henderson and McNamara 1985), but there is still confusion over the status of the many genera, including *Phyllopachyceras*. The genus was erected by Spath (1927) without a clear description and has since been widely regarded as including phylloceratids with very narrow umbilici and coarse ribs. However, Wiedmann (1964) considered that it was a junior subjective synonym of the Jurassic-Lower Cretaceous genus *Partschiceras* Fucini, which has both coarse ribs and frequent, prominent lirae, together with a wider umbilicus than *Phyllopachyceras*. Henderson and McNamara (1985) thought that though closely related, *Phyllopachyceras* was sufficiently distinct that it should be separated as a subgenus of *Partschiceras*. In contrast, Joly (1975) considered that *Partschiceras* should be a subgenus of *Phylloceras* Suess, and followed Collignon (1937) in placing *Phyllopachyceras* within a separate subfamily of Phylloceratidae, the Phyllopachyceratinae, on the basis of differences in the suture pattern. As the material described below is relatively poorly preserved, a full discussion of the status of *Phyllopachyceras* is beyond the scope of this work, but it is here provisionally retained as a full genus and is regarded as part of the subfamily Phylloceratinae.

Phyllopachyceras aureliae (Feruglio, 1936)

Plate 1, fig. 7

- v*.1936 *Phylloceras aureliae* Feruglio, p. 41, pl. 4, figs 1-5.
- v.1971 *Phyllopachyceras aureliae* (Feruglio); Thomson, p. 160, fig. 3g.
- v.1974 *Phyllopachyceras aureliae* (Feruglio); Thomson, p. 5, pl. 1, fig. e.

Type specimen. No type specimen was designated by Feruglio (1936). However, he stated that the specimen illustrated in pl. 4, fig. 1 (FCB 254) was the best preserved, and as most of the original description of this species is based on this specimen, it is here designated as the lectotype. Feruglio's specimens are from Cerro de los fósiles, Estancia del Quemado (Argentina).

Diagnosis. Moderately sized (shell diameter = 100 mm approx.), strongly involute, with very narrow umbilicus; stout, irregular, prorsiradiate ribs start near the umbilicus and extend across the venter without interruption; some ribs divide irregularly, and intercalatory ribs are common; weak lirae are sometimes visible on the ribs; rare constrictions parallel to ribbing may be present.

Material. Four fragments of internal moulds (KG. 3401.429, .441, .517 and .587) and four fragments of external moulds (KG. 3401.428, .508, .560 and .574) from Callisto Cliffs (text-fig. 1); two fragments of internal moulds (KG. 3457.66 and .70a) and two fragments of external moulds (KG. 3457.70b and .73) from Leda Ridge (text-fig. 1); Spartan Glacier Formation, ?Hauterivian-Barremian.

Description. All the specimens are fragmentary and crushed. They appear to be of a moderately large phylloceratid (shell diameter = 60-90 mm) which is strongly involute and with a very narrow umbilicus. The ornament consists of stout, irregular ribs which start near the umbilicus. These ribs are slightly flexuous and prorsiradiate. Some divide at irregular heights, though usually on the outer half of the whorl flank. Intercalatory ribs are common, and all the ribs cross the venter uninterrupted. On some specimens, fine lirae can be seen on the ribs. No constrictions are visible on the material. Neither the suture nor the aperture is preserved on any of the specimens.

Remarks. Despite the suture not being preserved on any of these specimens, it is considered that their similarity with examples of *P. aureliae* described and figured by Feruglio (1936) and Thomson

(1974) is sufficient to identify the new Antarctic material with this species. The specimen described by Thomson is identical in ribbing strength and pattern, and in overall size, and the discussion therein (Thomson 1974, p. 5) is equally applicable to these specimens.

P. aureliae is known only from Argentina (Feruglio 1936) and Alexander Island (Thomson 1974), and its age is problematical. Feruglio (1936, p. 43) compared this species with a European form of Hauterivian-Barremian age, and Leanza (1967), in his reassessment of the Feruglio collection, suggested that this species was of Aptian age. Recently, Riccardi (1984) stated that *P. aureliae* is of Berriasian or earliest Valanginian age. Thomson (1971) originally considered that the Antarctic specimen was of 'Upper Neocomian' (presumably Barremian) age. Later he revised the age to Albian (Thomson 1974), on the basis of the accompanying fauna, but also pointed out that his specimen was collected from immediately above a large, complex, slumped unit. Thus, though Thomson considered it unlikely, it is possible that the ammonite is out of sequence with the overlying sediments. The specimens described above are thought to be of Hauterivian-Barremian age as they occur above the known Valanginian (denoted by *Olcostephanus*) but below the Aptian (suggested by *Sanmartinoceras*) in the Fossil Bluff Group.

Occurrence. *P. aureliae* is recorded from the Lower Cretaceous of Argentina (Feruglio 1936) and Alexander Island (Thomson 1974).

Order LYTOCERATIDA Hyatt, 1889
Superfamily LYTOCERATAEAE Neumayr, 1875
Family LYTOCERATIDAE Neumayr, 1875
Genus PTEROLYTOCERAS Spath, 1927

Type species. *Ammonites exoticus* Opper, 1863, by original designation.

Diagnosis. Very evolute, whorls barely in contact; whorl section approximately circular or sub-circular; very many fine ribs (lirae) with frequently widely spaced, prominent, wavy flares; all the ribs and flares are convex or slightly sinuous.

Range and distribution. Tithonian; Himalayas, Pakistan, East Africa, Madagascar, Antarctica and possibly parts of southern Europe.

Remarks. *Pterolytoceras* is distinguished from other lytoceratids by the sinuous ribs, the frequent crinkled flares separated by many faint lirae, and the very evolute coiling of the shell.

Pterolytoceras cf. *exoticum* (Opper, 1863)

Plate 2, fig. 6

- cf. *.1863 *Ammonites exoticus* Opper, p. 278, pl. 76, fig. 5a-c.
- cf. 1903 *Lytoceras exoticum* Opper; Uhlig, p. 14, pl. 1, figs 3a-d and 4a-c.
- cf. 1960 *Pterolytoceras exoticum* Uhlig; Collignon, pl. 140, figs 532 and 533.
- cf. v. 1972 *Pterolytoceras exoticum* (Opper); Fatmi, p. 329, pl. 2, fig. 2a and b.
- cf. v. 1979 *Pterolytoceras exoticum* (Opper); Thomson, p. 9, pl. 2, figs 1 and m.

Material. One nearly complete, though weathered, external mould (KG. 1926.200) from Belemnite Point and one poorly preserved external and internal mould of a fragment of outer whorl (KG. 2912.18) from Himalia Ridge (text-fig. 1); Himalia Ridge Formation, Lower Tithonian.

Description. The fragments are quite small (estimated shell diameter = 50-60 mm; umbilicus = 40-45% of diameter) but very evolute, with the whorls apparently only just touching. Due to crushing and distortion, the

whorl section is now difficult to determine, but it appears to have been moderately rounded. The ornament consists of convex, irregularly spaced, crinkled flares which are sometimes also associated with a constriction. Between the flares, and parallel to them, are many (generally more than eight) faint, fine ribs (lirae). Neither the aperture nor the suture is preserved.

Remarks. Though the specimens are poorly preserved and only represent the earlier growth stages, on the basis of the ornament they can be assigned to the genus *Pterolytoceras*. Furthermore, they are comparable to most examples of *P. exoticum*, especially those of Collignon (1960), Fatmi (1972) and Thomson (1979). The specimens illustrated by Thomson (1979) are from Himalia Ridge and are similar to the material under discussion, though this new material is slightly better preserved. Verma and Westermann (1984, p. 33) tentatively included Collignon's examples of *P. exoticum* in the species *P. montanum* (Oppel, 1865). The latter species has closely spaced, coarsely crinkled flares, with only a few lirae between them, and lacks any flares on the innermost whorls (Uhlig 1903, p. 18). Whereas the larger of Collignon's specimens (Collignon 1960, pl. 140, fig. 532) could possibly belong to *P. montanum* (though the innermost whorls are missing), the smaller of the two (pl. 140, fig. 533) is clearly a *P. exoticum* and appears to be almost identical to the Antarctic specimens. However, both Collignon's Madagascan specimens resemble the *P. exoticum* of Fatmi (1972).

Occurrence. This species is recorded from the Tithonian of the Himalayas (Oppel 1863; Uhlig 1903; Helmstaedt 1969), Madagascar (Collignon 1960), Antarctica (Thomson 1979) and the Upper Tithonian of Pakistan (Fatmi 1972).

Order AMMONITIDA Hyatt, 1889
 Suborder AMMONITINA Hyatt, 1889
 Superfamily PERISPINCTACEAE Steinmann, 1890
 Family OLCOSTEPHANIDAE Pavlow, 1892
 Subfamily OLCOSTEPHANINAE Pavlow, 1892
 Genus OLCOSTEPHANUS Neumayr, 1875

Type species. *Ammonites asterianus* d'Orbigny, 1840, by subsequent designation (Lemoine 1906). Neumayr (1875) erected the genus *Olcostephanus* and designated the type species as '*Olcostephanus Astierianus*' without stating an author for the species. Lemoine (1906) clarified the situation by concluding that Neumayr meant *Ammonites asterianus* of d'Orbigny (1840, pl. 28).

Diagnosis. Strongly involute with deep, funnel-like umbilicus; typically inflated whorl section; stout primary ribs on umbilical wall, leading to peri-umbilical tubercles from which arise bundles of two or more secondary ribs; some intercalatory secondaries; occasional strong constrictions, typically oblique to ribbing.

Range and distribution. Valanginian-Hauterivian; Europe, North Africa, Pakistan, South East Asia, Japan, Madagascar, South Africa, western Antarctica, North, Central and South America.

Remarks. Some forms of *Olcostephanus* are very similar to species of *Spiticeras*, but generally the latter can be distinguished by a more prorsiradiate ribbing pattern, slight differences in the suture and the distinctive early growth stages. Juvenile stages can be recognized on the basis of the tubercles which move from a more lateral position, in the earliest stages, to an umbilical position in the adult (see Djanélidzé 1922). Much of the Antarctic material has been crushed, but they can still be assigned with some confidence to the genus *Olcostephanus*, in their overall morphology.

The first reported occurrence of *Olcostephanus* in Antarctica was by Weller (1903), who described a poorly preserved ammonite from Snow Hill Island as *O. antarctica* sp. nov. (see also Andersson 1906). However, Kilian and Reboul (1909) pointed out that this specimen belonged to the genus

Gunnarites and not *Olcostephanus*. Thomson (1981) figured and described a poorly-preserved fragment of an ammonite from Matthews Island, South Orkney Islands, which he suggested was very similar to *Olcostephanus*. The poor state of preservation precludes any further amendment of this identification. A nearly complete specimen of *Olcostephanus*, comparable with *O. guebhardi* (Kilian), and a further small fragment were recently described from Himalia Ridge (Howlett 1986).

Members of this genus are dimorphic, as shown by Riccardi *et al.* (1971) and Cooper (1981). However, large numbers of samples are needed to assess the morphology of the dimorphs, and unfortunately there are too few Antarctic specimens for this.

Subgenus LEMUROSTEPHANUS Thieuloy, 1977

Type species. *Holcostephanus madagascariensis* Lemoine, 1906, by original designation.

Diagnosis. Evolute form, with a large umbilicus (umbilicus = 40–45% of diameter). The ornament is similar to *Olcostephanus s. s.*, but the peri-umbilical tubercles are sharp and pointed. Strong constrictions, preceded by a prominent rib, are common.

Range and distribution. Valanginian-Hauterivian; southern Europe, Pakistan, Madagascar, South and Central America, and Alexander Island.

Remarks. Spath (1939, p. 12) considered that relatively evolute forms of *Olcostephanus*, such as *O. madagascariensis*, may belong to a natural subdivision of the genus. Thieuloy (1977, p. 432) erected the subgenus *Lemurostephanus* specifically to include all such forms, pointing out that they all had sharp, pointed tubercles, strong constrictions and very large umbilici (umbilicus = 40–45% of diameter). However, Cooper (1981, p. 169) thought that this subgenus was actually a heterogeneous assemblage of little taxonomic significance, and divided the species included by Thieuloy between *Olcostephanus s. s.* and *O. (Subastieria)*. Despite this, the distinct morphological differences between *Lemurostephanus* and *Olcostephanus s. s.* suggest that *Lemurostephanus* should be retained as a valid subgenus.

Olcostephanus (Lemurostephanus) madagascariensis Lemoine, 1906

Plate 1, fig. 5

- *.1906 *Holcostephanus madagascariensis* Lemoine, p. 182, pl. 1, fig. 3.
- .1939 *Olcostephanus* cf. *madagascariensis* Lemoine; Spath, p. 28, pl. 19, fig. 3a and b.
- .1962a *Holcostephanus madagascariensis* Lemoine; Collignon, pl. 182, fig. 825.
- v.1977 *Olcostephanus (Rogersites) madagascariensis* Lemoine; Fatmi, p. 271, pl. 5, figs 3 and (?)4.
- v.1986 *Olcostephanus* sp. Howlett, p. 75, fig. 2c and d.

Type specimen. Holotype: figured specimen of Lemoine (1906, pl. 1, fig. 3); Rodo Valley, Antseranana (= Diego-Suarez) (Madagascar); Lower Valanginian. The holotype was refigured by Collignon (1962a, pl. 182, fig. 825) and Cooper (1981, fig. 14).

EXPLANATION OF PLATE 1

- Fig. 1. *Virgatosphinctes* cf. *frequens* (Oppel). Lower Tithonian, Belemnite Point. KG. 1854.51, × 1.
- Fig. 2. *Virgatosphinctes denseplicatus* (Waagen). Lower Tithonian, Belemnite Point. KG. 1926.176, × 1.
- Fig. 3. *Blanfordiceras acuticosta* (Uhlig). Upper Tithonian, Himalia Ridge. Latex cast, KG. 2919.29, × 1.
- Fig. 4. *Virgatosphinctes* cf. *mexicanus* (Burckhardt). Lower Tithonian, Belemnite Point. KG. 1854.104, × 1.
- Fig. 5. *Olcostephanus (Lemurostephanus) madagascariensis* Lemoine. Valanginian, Leda Ridge. KG. 3461.106a, × 1.
- Fig. 6. *Virgatosphinctes falloti* Collignon. Lower Tithonian, Belemnite Point. Latex cast, KG. 1926.44, × 1.
- Fig. 7. *Phyllopachyceras aureliae* (Feruglio). ?Hauterivian-Barremian, Callisto Cliffs. Latex cast, KG. 3401.428, × 1.



HOWLETT: Antarctic ammonites

Diagnosis. Moderately small (shell diameter = 65 mm approx.) and evolute, with very wide umbilicus; strong primary ribs leading to sharp, pointed umbilical tubercles; bundles of two to four secondary ribs from each tubercle, with frequent intercalatory ribs; occasional strong constrictions.

Material. Two fragments of internal moulds (KG. 3461.105 and .106a) and an incomplete external mould (KG. 3461.106b) from Leda Ridge (text-fig. 1); Spartan Glacier Formation, Valanginian.

Description. The specimens are relatively evolute, with a broad umbilicus (approximately 40% of diameter). The shell diameter is approximately 70 mm, but the whorl section is impossible to determine. The ornament consists of stout, radial or gently rursiradiate primary ribs which cross the shallow umbilical wall to prominent, sharp peri-umbilical tubercles. From these tubercles, the ribs divide into bundles of usually four secondary ribs. Between the bundles are occasional intercalatory ribs. All the secondaries are slightly prorsiradiate and, on the inner whorls, they appear to cross the venter uninterrupted. On the outer whorl of KG. 3461.106b there is a prominent constriction which is parallel to the ribbing, and is marked by a prominent rib immediately preceding it.

Remarks. This material is very similar to the holotype of *O. madagascariensis* as illustrated by Lemoine (1906, pl. 1, fig. 3), Collignon (1962a, pl. 182, fig. 825) and Cooper (1981, fig. 14). However, the holotype has more primary ribs and tubercles on the last whorl, but slightly fewer secondaries, than the Antarctic examples. The constrictions are of similar strength, though KG. 3461.106b has a more prominent preceding rib. A specimen from Himalia Ridge, previously described as *Olcostephanus* sp. (Howlett 1986, p. 75), is included here as it bears a strong resemblance to the inner whorls of KG. 3461.106a and b.

The Antarctic specimens are comparable to *O. salinarius* Spath (1939, p. 13, pl. 1, fig. 1a and b; holotype), but this species differs in having a narrower umbilicus (less than 40% of diameter) and weaker, thinner, primary ribs. A more evolute example of *O. salinarius* figured by Fatmi (1977, pl. 1, fig. 6a and b; BM C. 79111) is almost identical to *O. madagascariensis* and illustrates the similarity of these two species.

There are further similarities with *O. rogersi* (Kitchin, 1908) and *O. baini* (Sharpe, 1856), (see Cooper 1981), but both these species have more umbilical tubercles per whorl than *O. (L.) madagascariensis*, and they also have smaller umbilici. *O. mitreanus* (d'Orbigny) (see Cottreau 1934) is comparable with *O. (L.) madagascariensis*, and Thieuloy included it within the subgenus *Lemurostephanus*. However, it is markedly depressed in cross-section and has very strong primary ribs.

Occurrence. *O. madagascariensis* is known from the Lower Valanginian of Madagascar (Lemoine 1906; Collignon 1962a) and the Upper Valanginian of Pakistan (Spath 1939; Fatmi 1977).

Family ATAXIOCERATIDAE Buckman, 1921
Subfamily VIRGATOSPHINCTINAE Spath, 1923
Genus VIRGATOSPHINCTES Uhlig, 1910b

Type species. *Perisphinctes (Virgatosphinctes) broilii* Uhlig, 1910b, by subsequent designation (Douvillé 1910a, p. 737).

EXPLANATION OF PLATE 2

- Figs 1 and 2. *Bochianites* aff. *versteeghi* Boehm. Berriasian-Valanginian. 1, Leda Ridge. KG. 3461.73. $\times 1$,
2, Himalia ridge. KG. 2934.67, $\times 1$.
Fig. 3. *Virgatosphinctes* cf. *mexicanus* (Burckhardt). Lower Tithonian, Belemnite Point. KG. 1854.117. $\times 1$.
Fig. 4. *Virgatosphinctes* cf. *kagbeniensis* Helmstaedt. Lower Tithonian, Himalia Ridge. Ventral view. KG.
712.101, $\times 1$ (see also Plate 3, fig. 1).
Figs 5 and 7. *Blanfordiceras weaveri* sp. nov. Upper Tithonian, Himalia Ridge. 5, ventral view. 7, lateral view.
Holotype KG. 2919.19, $\times 1$.
Fig. 6. *Pterolytoceras* cf. *exoticum* (Oppel). Lower Tithonian, Himalia Ridge. KG. 2912.18. $\times 1$.



1



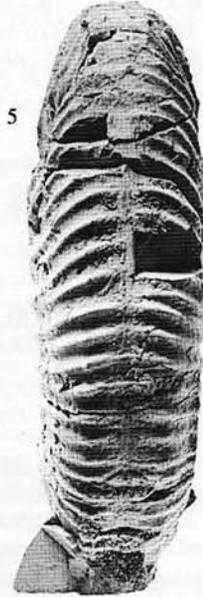
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6



7

Diagnosis. Large, moderately evolute shell. Whorls are typically rounded, slightly inflated and depressed. Ribs are dense and prominent, usually bifurcate on inner whorls, with polygyrate and virgatotomous ribs increasing in number on the last whorl. Constrictions are common, and are more noticeable on inner whorls.

Range and distribution. Tithonian; Europe, eastern and North Africa, Madagascar, Himalayas, India, Pakistan, Australia, western Antarctica, Central and South America.

Remarks. This genus was originally created by Uhlig (1910*b*) to include all ammonites with virgatotome ribbing, with the exception of *Virgatites* Pavlow and *Pseudovirgatites* Vetter, but as it is an extremely complex group it has since been subdivided. As Uhlig (1910*b*, p. 307) pointed out, hardly a single specimen resembles another in every detail, due to the great variability.

The genus *Subplanites* Spath is very similar to *Virgatosphinctes*, but can be distinguished by its compressed whorl-section, the sharp, distinct ribs, and its complex suture. The Antarctic material is typically crushed flat, and the sutures are rarely preserved, but on the basis of morphological similarities with existing species of *Virgatosphinctes* (see below), the specimens are provisionally assigned to this genus.

Virgatosphinctes cf. *kagbeniensis* Helmstaedt, 1969

Plate 2, fig. 4; Plate 3, fig. 1

- cf. *.1969 *Virgatosphinctes kagbeniensis* Helmstaedt, p. 74, pl. 4, fig. 1a-b.
v. 1979 *Spiticeras* sp. indet., Thomson, p. 25, pl. 6, fig. e.

Material. One large fragment of internal mould (KG. 712.101) from Himalia Ridge, and one small fragment of internal mould (KG. 722.21) from north of Ablation Valley (locality AB of Elliott 1974; text-fig. 1). Himalia Ridge Formation, Lower Tithonian.

Remarks. Thomson (1979) described these specimens in some detail, and as no new material has been found nothing can be added to the existing descriptions. Thomson (1979) provisionally assigned these specimens to the genus *Spiticeras* Uhlig. However, although they are poorly preserved and fragmentary, the larger fragment bears a striking resemblance to *V. kagbeniensis*. Helmstaedt, in possessing a smooth band along the venter on the inner whorls, a complex suture, and elongate primary ribs rather than tubercles. Furthermore, Helmstaedt's lateral view of the holotype (pl. 4, fig. 1) shows that the secondary ribs of this species commence high on the whorl flanks, above the mid-point. The better preserved Antarctic fragment similarly shows the secondary ribs starting well above the mid-point of the flanks (Thomson (1979) only illustrated the ventral view). In contrast, in *Spiticeras* the secondary ribs usually commence on the inner half, or at the mid-point of the whorl flanks.

Occurrence. *V. kagbeniensis* was originally known only from the Tithonian Spiti Shales of Nepal (Helmstaedt, 1969).

Virgatosphinctes cf. *mexicanus* (Burckhardt, 1906)

Plate 1, fig. 4; Plate 2, fig. 3

- cf. *.1906 *Virgatites mexicanus* Burckhardt, p. 115, pl. 31, figs 5-9.
cf. 1910*b* *Virgatites mexicanus* Burckhardt; Douvillé, p. 8, pl. 1, figs 1 and 2.
cf. 1954 *Virgatosphinctes* cf. *mexicanus* (Burckhardt); Indans, p. 113, pl. 18, fig. 1.
v. 1979 *Virgatosphinctes* aff. *mexicanus* (Burckhardt); Thomson, p. 20, pl. 4, fig. h.
cf. 1980 *Virgatosphinctes mexicanus* (Burckhardt); Leanza, p. 28, pl. 2, fig. 1a and b, text-fig. 7c.

Material. Seven fragments of internal moulds (KG. 1854.46, .97, .104, .106, .107, .117 and KG. 1926.1) and one incomplete external mould (KG. 1854.79) from Belemnite Point (text-fig. 1); Himalia Ridge Formation, Lower Tithonian.

Description. All the specimens are crushed and fragmentary, consequently the cross-section and degree of evoluteness are uncertain. However, they all appear to be part of a large, evolute form. The ribs are stout and distant, and start near the umbilical seam, where they are rursiradiate. On the flanks, the ribs become forward-facing and divide at about the mid-point. On the outer third they curve very gently backwards, producing a slightly flexuous appearance. On the inner whorls the ribs are bifurcate, and the point of division is just visible, whereas on the outer whorls the ribs are mostly either polygyrate or virgotomous, with some intercalatory ribs. Irregular constrictions are quite common. The simple and sinuous aperture is visible on two specimens (KG. 1854.97 and .117), but the suture is not preserved.

Remarks. Burckhardt (1906) figured two fragments, one of which (pl. 31, figs 8 and 9) he described as being the better preserved. This specimen strongly resembles the Antarctic material in rib strength and spacing, and in that the division of the ribs on the inner whorls is visible within the umbilicus. However, Burckhardt's specimen is slightly smaller, as is his other fragment, which also has closer and weaker ribs. The specimens subsequently assigned to this genus are all rather smaller than the Antarctic fragments, though in all other respects they are all very similar. The lack of inner whorls prevents a firm identification.

The specimen figured by Thomson (1979, pl. 4, fig. h) as *V. aff. mexicanus* is very like the material described above, though the secondary ribs curve more noticeably backwards on the outer third of the whorl.

Occurrence. *V. mexicanus* was originally described from the Lower Tithonian of Mexico (Burckhardt 1906). It has since also been recorded from the Lower Tithonian of Argentina (Douvill  1910b; Indans 1954; Leanza 1980).

Virgatosphinctes cf. andesensis (Douvill , 1910b)

Text-fig. 2C

- cf. *.1910b *Virgatites andesensis* Douvill , p. 7, pl. 1, figs 3a, b and 4a-f.
- cf. 1931 *Virgatosphinctes andesensis* (Douvill ); Weaver, p. 422, pl. 47, figs 313 and 314, pl. 48, figs 318-321.
- cf. 1954 *Virgatosphinctes andesensis* (Douvill ); Indans, p. 111, pl. 13, fig. 9, pl. 16, figs 1-5.
- cf. 1959 *Virgatosphinctes andesensis* (Douvill ); Corval n, p. 23, pl. 4, fig. 18, pl. 5, fig. 19.
- cf. v 1979 *Virgatosphinctes* sp. nov. aff. *andesensis* (Douvill ); Thomson, p. 18, pl. 4, figs e-g.
- cf. 1980 *Virgatosphinctes andesensis* (Douvill ); Leanza, p. 29, pl. 2, fig. 5a and b, text-figs 7d and 9.

Material. Three fragments of internal moulds (KG. 1854.48, .58 and .103) from Belemnite Point (text-fig. 1); Himalia Ridge Formation, Lower Tithonian.

Description. The fragments have been crushed and are poorly preserved. It appears that they were from a large, evolute ammonite. The ornament is of stout, distant ribs which are gently prorsiradiate, and divide in an irregular but characteristic manner producing three, or more commonly four secondaries; some divide virgotomously but others branch to produce polyploke ribs. The inner whorls bear bifurcate and polygyrate ribs in equal proportion, and at all growth stages intercalatory ribs occur, though they are not frequent. No constrictions are visible on any of the specimens. A sinuous aperture is present on one specimen (KG. 1854.48), but the suture is not preserved.

Remarks. Though the fragments described above are of a rather larger form than most specimens of *V. andesensis* (Douvill ), the pattern of ribbing is very similar both to Douvill 's illustrations (1910b, pl. 1, figs 3 and 4) and to other examples (e.g. Weaver 1931, pl. 47, figs 313 and 314, pl. 48, figs 318-321; Leanza 1980, pl. 2, fig. 5). However, as Thomson (1979, p. 19) pointed out, *V. andesensis* is a widely interpreted group and may well consist of more than one species. The characteristic ribbing of the true *V. andesensis*, as illustrated by the holotype, appears to be polyploke ribs produced by dichotomous branching. Such ribs are present on all three fragments described here.

V. sp. nov. aff. andesensis of Thomson (1979) from Himalia Ridge differs from the new material from Belemnite Point in that it is smaller, with finer ribs, and the division of ribs on the inner whorl

is visible. Furthermore, none of Thomson's specimens shows the typical *V. andesensis* style of ribbing. One specimen of Thomson (1979, pl. 4, fig. f) however, is almost identical in strength of ribs and spacing to the material described above (especially KG. 1854.48). The strength and spacing of the ribs of the specimens is also similar to that of *V. mexicanus* (Burckhardt) and *V. cf. mexicanus* from Alexander Island (described above), but these lack the characteristic polyplike ribs and typically have more intercalatory ribs than *V. cf. andesensis*, especially close to the aperture.

Occurrence. This species has been described from the Lower Tithonian of Argentina (Douville 1910b; Weaver 1931; Indans 1954; Leanza 1980) and Chile (Corvalán 1959). Tavera (1970) reported a possible example of *V. andesensis* from Livingston Island, South Shetland Islands (Antarctica), but as the fragment is very small and weathered, the identification is very tentative.

Virgatosphinctes cf. rotundidoma Uhlig, 1910b

Plate 3, fig. 2; Plate 4, fig. 4

cf. *.1910b *Perisphinctes (Virgatosphinctes) rotundidoma* Uhlig, p. 318, pl. 52, fig. 1a-c, pl. 53, fig. 1.
v. 1979 *Virgatosphinctes acuticostus* Thomson, p. 17, pl. 4, fig. 6.

Material. Two nearly complete internal moulds (KG. 1854.75 and KG. 1926.203A), six fragments of internal moulds (KG. 1854.50, .74, .81, KG. 1926.182, .191 and .203B) and one incomplete external mould (KG. 1854.108) from Belemnite Point; one nearly complete internal and external mould (KG. 2912.17a and b) and one incomplete internal and external mould (KG. 2913.3a and b) from Himalia Ridge (text-fig. 1); all are from the Himalia Ridge Formation, Lower Tithonian.

Description. The specimens are all evolute, with a moderately wide umbilicus (approx. shell diameter = 100 mm; umbilicus = 35-40% of diameter). All the fragments have been crushed, but one specimen (KG. 1854.81; Pl. 3, fig. 2) still gives some impression of the inflated whorl section. The ornament consists of prominent, dense ribs which are very slightly flexuous and gently prorsiradiate. On the inner whorls, the majority of the ribs are dichotomous, but on the outer whorl there is an increase in the number of polygyrate ribs. Also on the outer whorl are a few, rare, intercalatory ribs. Constrictions are present at all growth stages. The aperture is clearly visible on KG. 2912.17a (Pl. 4, fig. 4), and is sinuous and simple. The suture is incompletely preserved on three specimens (KG. 1926.203A, .203B and KG. 2912.17a).

Remarks. The material described above closely resembles Uhlig's illustration of *Perisphinctes (Virgatosphinctes) rotundidoma* (Uhlig 1910b, pl. 52, fig. 1a-c). However, they differ slightly in that Uhlig's specimen has simple ribs, whereas these are absent on the Antarctic material, when not associated with constrictions. Furthermore, the body chamber of *V. cf. rotundidoma* occupies approximately three-quarters of the last whorl, whereas that of *V. rotundidoma* is less than half the last whorl. This last character was suggested by Uhlig (1910b) to be perhaps of some importance in identifying *V. rotundidoma*.

These new specimens are very similar to *V. acuticostus* Thomson (1979), who stated that his species differed from *V. rotundidoma* in lacking simple ribs and in possessing a larger body chamber. However, these differences are not regarded as being sufficiently great to merit a new species, and it is preferred here to include *V. acuticostus* within *V. cf. rotundidoma*.

There are further similarities with *Subplanites malarguensis* Spath (1931) from Argentina (= *Perisphinctes* aff. *pseudolictor* in Burckhardt 1903), though this species has more distant and

EXPLANATION OF PLATE 3

Fig. 1. *Virgatosphinctes cf. kagbeniensis* Helmstaedt. Lower Tithonian, Himalia Ridge. KG. 712.101, $\times 1$ (see also Plate 2, fig. 4).

Fig. 2. *Virgatosphinctes cf. rotundidoma* Uhlig. Lower Tithonian, Belemnite Point. KG. 1854.81, $\times 1$.

Fig. 3. *Virgatosphinctes denseplicatus* (Waagen). Lower Tithonian, Belemnite Point. KG. 1854.116, $\times 1$.



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sharper ribs than the Antarctic specimens. Furthermore, intercalatory and simple ribs occur at all the growth stages of *S. malarguensis*, especially on the body chamber, unlike *V. cf. rotundidoma*.

Occurrence. *V. rotundidoma* is only recorded from the Middle Spiti Shales (Lower Tithonian) in India (Uhlig 1910b).

Virgatosphinctes cf. frequens (Oppel, 1865)

Plate 1, fig. 1

- cf. *.1865 *Ammonites frequens* Oppel, p. 295, pl. 87.
 cf. 1910b *Perisphinctes (Virgatosphinctes) frequens* (Oppel); Uhlig, p. 325, pl. 63, figs 1a-c and 3a-c, pl. 65, fig. 1a-c, pl. 65A, fig. 1a-c.
 cf. 1960 *Virgatosphinctes frequens* Collignon, pl. 154, figs 619 and 620.
 cf. v 1972 *Virgatosphinctes frequens* (Oppel); Fatmi, p. 346, pl. 9, fig. 1a and b.
 v.1979 *Virgatosphinctes cf. frequens* (Oppel); Thomson, p. 20, pl. 1, fig. c, pl. 5, figs a-d.

Material. Two nearly complete external moulds of inner whorls (KG. 1926.31 and .32), two fragments of external moulds of later growth stages (KG. 1854.7 and .63) and two fragments of internal moulds of later growth stages (KG. 1854.51 and .56). All are from Belemnite Point (text-fig. 1); Himalia Ridge Formation, Lower Tithonian.

Description. The fragments are of a large, evolute form. As with most of the fossils from Alexander Island, these specimens have been crushed, and therefore their whorl sections are unknown. The inner whorls are covered in very dense, sharp radial ribs, all of which bifurcate at about the mid-point of the flanks. No simple ribs are visible. At a more mature growth stage (Pl. 1, fig. 1), polygyrate and virgatotomous ribs appear and increase in number. Similarly, the primary ribs become stouter and more widely spaced. On the probable body chamber they are very stout and distant, and each primary rib divides virgatotomously into three or four, closely spaced secondaries. Between each rib bundle are some intercalatory ribs, producing a very dense ribbing pattern on the outer half of the whorl. Some constrictions can be seen on the inner whorls. Neither the aperture nor the suture is preserved on any of the specimens.

Remarks. The inner whorls (KG. 1926.31 and .32) are both very similar to *V. denseplicatus* in the sharp, very dense ribbing. However, as Collignon (1960) stated, *V. denseplicatus* has simple, as well as bifurcate, ribs on the inner whorls, whereas *V. frequens*, though very like *V. denseplicatus* in appearance, does not have any simple ribs. As Uhlig (1910b, p. 325) described, with increasing size the ribs become polygyrate and the primaries become stouter and more widely spaced (as on KG. 1926.31). Uhlig (1910b) further stated that on the body chamber, the primary ribs were stout and distant, and divided into many secondaries, frequently with intercalatory ribs between the bundles of secondaries. All the specimens described above are comparable with examples of *V. frequens* illustrated by Uhlig (1910b), Collignon (1960) and Fatmi (1972), though Collignon's Madagascan specimens are more densely ribbed, and Fatmi's Pakistani specimen appears to have weaker ribs. Thomson (1979) described some specimens from the Ablation Valley area which he referred to as *V. cf. frequens* which are very similar to the material from Belemnite Point.

The *Perisphinctes frequens* of Waagen (1875) is the basis of the species *V. oppeli* (Spath 1931, p. 536) which differs from the true *V. frequens* in having finer and denser ribs. Furthermore, polygyrate ribs tend to appear later in this species than in *V. frequens*. Spath (1931, p. 537) noted that such ribs appeared only after the diameter reached 60-70 mm.

Occurrence. This species has been described from the Tithonian of the Himalayas (Oppel 1865; Uhlig 1910b), and the Lower Tithonian of Madagascar (Collignon 1960) and Pakistan (Fatmi 1972).

Virgatosphinctes cf. *haydeni* Uhlig, 1910b

Text-fig. 2G

cf. *.1910b *Perisphinctes* (*Virgatosphinctes*) *haydeni* Uhlig, p. 334, pl. 61, fig. 2a-d.

Material. One nearly complete internal mould (KG. 1929.4) and three fragments of internal moulds (KG. 1854.99, KH. 1855.5 and .19) from Belemnite Point; one nearly complete internal mould (KG. 2910.32) from Himalia Ridge (text-fig. 1). All are from the Himalia Ridge Formation, Lower Tithonian.

Description. The shell is evolute, with a wide umbilicus (approx. shell diameter = 120 mm; umbilicus = 45-50% of diameter). All the specimens have been crushed, consequently the cross-section is unknown. The ornament consists of prominent ribs which are radial or slightly prorsiradiate, though where they start on the umbilical wall, they are markedly rursiradiate. On the inner whorls the majority of the ribs are bifurcate, whereas on the body chamber the majority are polygyrate. Intercalary ribs do occur but are rare. Occasional constrictions are present. The aperture is poorly preserved on one specimen (KG. 2910.32; text-fig. 2G) and shows the development of a possible lappet. The suture is just visible on two specimens (KG. 1855.19 and KG. 2910.32), but is incomplete.

Remarks. The material above is comparable to *Perisphinctes* (*Virgatosphinctes*) *haydeni* of Uhlig (1910b) on the basis of the ornamentation and the evolute nature of the shell. Uhlig's figured specimen shows moderately dense, prorsiradiate ribs, though they are rursiradiate on the umbilical wall. Like the Antarctic specimens, these ribs divide at about the mid-point of the whorl (or slightly above) into alternate two and three secondaries, with rare intercalary ribs between the rib bundles. The umbilicus of the holotype accounts for approximately 44% of the total diameter, whereas the specimens described above appear to have wider umbilici. *V. rousseli* described by Collignon (1960) has a very wide umbilicus (umbilicus = 49% of diameter), but the ribs divide in the outer third of the whorl, unlike the Antarctic material. In other respects there is little to distinguish between *V. haydeni*, *V. rousseli* and *V. cf. haydeni*. Hemstaedt (1969, p. 74) considered that *V. haydeni* was not a true *Virgatosphinctes*, but that it belonged to the genus *Subplanites*. There are some similarities between *V. haydeni* and *Subplanites*, but the more rounded ribs and, in the Antarctic material, the simple suture suggest closer affinities with *Virgatosphinctes*. The specimens described above are also similar to *V. evolutus* Leanza (1980) from Argentina, but they are more evolute and have fewer intercalary ribs than the South American species.

Occurrence. The species *V. haydeni* is only known from the Lower Tithonian of India (Uhlig 1910b).

Virgatosphinctes denseplicatus (Waagen, 1875)

Plate 1, fig. 2; Plate 3, fig. 3

- *.1875 *Perisphinctes denseplicatus* Waagen, p. 201, pl. 46, fig. 3a and b, pl. 55, fig. 1a and b.
- .1910b *Perisphinctes* (*Virgatosphinctes*) *denseplicatus* Waagen; Uhlig, p. 313, pl. 53, fig. 3a-d, pl. 54, fig. 1a-c, pl. 55, figs 1a-d, 2a-d and 3a-d, pl. 56, fig. 1a-c.
- v.1931 *Virgatosphinctes denseplicatus* (Waagen); Spath, p. 532, pl. 77, fig. 3a-c, pl. 90, fig. 1a-c, pl. 96, fig. 3a and b, pl. 102, fig. 4.
- .1960 *Virgatosphinctes denseplicatus* Waagen; Collignon, pl. 154, figs 617 and 618, pl. 155, fig. 621.
- v.1972 *Virgatosphinctes denseplicatus* (Waagen); Fatmi, p. 346, pl. 8, fig. 5a and b.
- v.1979 *Virgatosphinctes denseplicatus* (Waagen); Thomson, p. 15, pl. 3, fig. h.

Type specimen. Lectotype: specimen figured by Waagen (1875, pl. 55, fig. 1a and b; designated by Spath 1931, p. 532); Oomia Group, north of Moondan, Kachchh, Gujarat (India), Tithonian.

Diagnosis. Moderately involute and inflated *Virgatosphinctes*. Ribs are very densely spaced, with only bifurcate and simple ribs on inner whorls; ribs with more secondaries appear only in the last growth stages of large forms. Constrictions are common on inner whorls.

Material. Four nearly complete external moulds (KG. 1854.116, KG. 1855.15, KG. 1926.93 and .174) and one nearly complete internal mould (KG. 1926.176) from Belemnite Point (text-fig. 1); Himalia Ridge Formation, Lower Tithonian.

Description. The specimens are quite small (shell diameter = 55–60 mm; umbilicus = approx. 35% of diameter) and involute, the outer whorl enclosing about half or two-thirds of the preceding whorl. The shell appears to have been inflated, with a deep umbilicus, but only one specimen (KG. 1926.176; Pl. 1, fig. 2) now gives any idea of the original overall morphology, as all the fragments have been crushed and distorted. The ribs are very closely spaced, and the majority bifurcate at about the mid-point of the flank. Simple ribs are present and on some specimens they are quite common; polygyrate ribs are very rare. The ribs appear to have been fine and sharp, and are slightly prorsiradiate. Constrictions are common at all growth stages. The aperture is not preserved, and the suture cannot be clearly distinguished, though it is partially visible on specimen KG. 1926.176.

Remarks. Waagen (1875, p. 201) stated that *V. denseplicatus* resembled *V. frequens* (Oppel), even though, as Spath (1931, p. 536) later pointed out, Waagen had misinterpreted the latter. As has already been shown, the major difference between *V. frequens* and *V. denseplicatus* is that the latter has both simple and bifurcate ribs on the inner whorls, whereas *V. frequens* does not have any simple ribs. At later growth stages, *V. frequens* develops stout, distant primary ribs which divide into many secondaries, but this does not occur in *V. denseplicatus*.

V. falloti of Collignon (1960) from Madagascar is similar to *V. denseplicatus*, but it differs in the absence of simple ribs, the lower point of division of ribs and a smaller umbilicus (see below). The species *V. saharaensis* Spath (1931) also resembles *V. denseplicatus*, but it can be distinguished by its larger umbilicus. Also, the division of the ribs on the inner whorls of *V. saharaensis* is just visible as it is more evolute.

Occurrence. *V. denseplicatus* is known from the Lower Tithonian of India (Waagen 1875; Uhlig 1910b; Spath 1931), Pakistan (Fatmi 1972), Madagascar (Collignon 1960), western Antarctica (Thomson 1979, 1983) and Argentina (Leanza 1981; Riccardi 1984).

Virgatosphinctes falloti Collignon, 1960

Plate 1, fig. 6

- *.1960 *Virgatosphinctes falloti* Collignon, pl. 157, fig. 626, pl. 158, fig. 627.
- vp .1979 *Virgatosphinctes* aff. *denseplicatus* (Waagen); Thomson, p. 16, pl. 4, fig. a [non pl. 3, figs j and k = *V.* aff. *denseplicatus* (Waagen)].

Type specimen. Holotype: figured specimen of Collignon (1960, pl. 157, fig. 626); locality 549, the source of the Mandarana River, Manera, Toliara Province (Madagascar); Lower Tithonian (*Hildoglochiceras kobelli* Zone).

Diagnosis. Moderately large and involute *Virgatosphinctes*, with small umbilicus. Ribs are regular and densely spaced; most are bifurcate, though polygyrate and intercalatory ribs are not unknown; no simple ribs. Constrictions may be present.

Material. Two incomplete external moulds (KG. 1855.13 and KG. 1926.20) and one nearly complete external and internal mould (KG. 1926.44) from Belemnite Point (text-fig. 1); Himalia Ridge Formation, Lower Tithonian.

Description. The specimens are large (approx. shell diameter = 90 mm; umbilicus = about 30% of diameter), moderately evolute and have a small umbilicus. They have all been crushed and therefore the whorl-section is unknown. The ornamentation is of dense, sharp, fine ribs which are radial or very gently prorsiradiate. The ribs are mostly bifurcate and divide near, or just below the mid-point of the flanks. Towards the end of the whorls polygyrate ribs appear and become common. There are no simple ribs, though some intercalatory ribs are present, together with a few constrictions. The aperture is not preserved. Though the suture is present on specimen KG. 1926.44b, it has been distorted and fractured, and therefore its detail cannot be discerned.

Remarks. Collignon (1960, pl. 158, fig. 627) described a variety of this species called *V. falloti* var. *perangustumbilicata*, and it is with this variety that the specimens described above are most comparable. Collignon stated that its ornamentation consists of regular, dense ribs, the majority of which divide just below the mid-line of the whorl flank. This variety differs from the type in that intercalatory ribs are rare and polygyrate ribs become the norm towards the aperture. Furthermore, Collignon remarked that the variety *perangustumbilicata* has a small umbilicus (32% of shell diameter), and that it seemed to have the smallest umbilicus of all the *Virgatosphinctes*. Though there are strong similarities, the Antarctic material is too poorly preserved to permit assignment to this variety.

The specimens are similar to *V. denseplicatus*, in their dense, regular, sharp ribbing. However, they lack simple ribs, and the ribs divide lower on the whorl flanks. The large size but small umbilicus of these specimens is a further difference from *V. denseplicatus*.

Occurrence. *V. falloti* has so far only been described from the Lower Tithonian of Madagascar.

Family NEOCOMITIDAE Salfeld, 1921
Subfamily BERRIASSELLINAE Spath, 1922
Genus LYTOHOPLITES Spath, 1925

Type species. *Hoplites burckhardti* Mayer-Eymar (in Burckhardt, 1900), by original designation.

Diagnosis. Evolute, moderately inflated, subquadrate whorls. The ribs are distant, prominent and either single or biplicate, with the anterior secondary rib being less strong than the posterior. At the point of division, weak tubercles may be present, and on either side of the venter are more prominent tubercles. Feeble intermediate ribs may be present.

Range and distribution. Tithonian-Berriasian; Argentina, Cuba, North Africa, Madagascar and Alexander Island.

Remarks. The genus *Lytiohoplites* has been placed in the Berriasellinae on account of its similarities to other members of the subfamily: e.g. some swelling may be present at the point of division of the ribs, and a tubercle formed at the end of a rib on either side of a smooth venter (cf. *Raimondiceras* and *Blanfordiceras*).

Lytiohoplites cf. *burckhardti* (Mayer-Eymar, in Burckhardt, 1900)

Plate 4, fig. 3

cf. *.1900 *Hoplites burckhardti* Mayer-Eymar, in Burckhardt, p. 17, pl. 26, figs 1 and 2.

cf. 1903 *Hoplites burckhardti* Mayer-Eymar; Burckhardt, p. 61, pl. 10, figs 17-20.

v. 1936 *Berriasella alternans* Gerth; Feruglio, p. 70, pl. 8, fig. 6.

Material. One incomplete internal and external mould (KG. 3404.138) from northern Planet Heights (text-fig. 1); Himalia Ridge Formation, Upper Tithonian.

Description. Though the specimen is incomplete and apparently distorted, it is clear that it was moderately evolute, with a wide umbilicus (estimated diameter = 26 mm; umbilicus = 40% of diameter). The whorl section appears to have been compressed. The ornament on the outer whorl consists of distant, prominent, slightly sinuous and prorsiradiate ribs which start on the steep umbilical wall. All, apart from the anterior three ribs, divide at about the mid-point of the flank. The anterior branch is less strong than the posterior one, especially at first. The posterior branches terminate on either side of the smooth venter in prominent tubercles, whereas the anterior ones do not, though they sometimes cross the venter, in which case they are greatly reduced in strength. At the point of division of the ribs, small swellings are sometimes present. The anterior three ribs are all simple, but also have ventro-lateral tubercles. Between the prominent ribs are occasional, faint intercalatory ribs. The inner whorls are very poorly preserved, and though ribs can be seen, the ornament cannot be determined. The aperture appears to be sinuous, but simple.

Remarks. The fragment resembles the illustrated specimen of *Hoplites burckhardti* (Mayer-Eymar, in Burckhardt 1900), but the latter is larger, has less prominent ventro-lateral tubercles and more densely packed, faint, intercalatory ribs than the Antarctic specimen. Furthermore, Mayer-Eymar's illustrated *H. burckhardti* has a more inflated whorl section than the specimen described above, though this could be accounted for by deformation of the specimen. An ammonite originally described by Feruglio (1936, p. 70) as *Berriasella alternans* Gerth, is almost identical to the Antarctic fragment. Leanza (1967, p. 146), in his revision of the Feruglio collection, considered that Feruglio's specimen was in fact a *Lyttohoplites*, and stated that it compared almost perfectly with *L. burckhardti*. Collignon (1960) described six species of *Lyttohoplites* from the Tithonian and Berriasian of Madagascar, but they are all quite different from *L. burckhardti* and the Antarctic specimen.

Occurrence. *L. burckhardti* was originally known only from the Upper Tithonian of Argentina (Burckhardt 1900; Leanza 1967; Leanza 1981).

Genus RAIMONDICERAS Spath, 1924

Type species. '*Hoplites* juv. *raimondii* Gabb' of Lisson (1907), by original designation. It appears that Spath (1924) considered the immature forms of *H. raimondii* Gabb described by Lisson (1907) as representing a distinct species, *Raimondiceras raimondianum* (Gabb) [sic], and that this species was the type species of the new genus.

Diagnosis. Evolute; strong, distant ribs, every second or third of which is prominent and bituberculate; at the ventro-lateral tubercle the prominent ribs divide into two secondaries which are strongly projected on the venter; ventral sulcus on phragmocone, but ribs cross venter uninterrupted on body chamber.

Range and distribution. Berriasian-Valanginian; South America, Pakistan and Antarctica.

Remarks. Leanza (1972) created a new genus *Acantholissonia* and included several specimens formerly included in *Raimondiceras*. The differences between the two genera are slight: *Acantholissonia* usually has three secondary ribs from each ventro-lateral tubercle and the ventral sulcus persists throughout the phragmocone and body chamber, whereas *Raimondiceras* has two secondary ribs and loses the ventral sulcus on the body chamber. *Raimondiceras* is similar to both *Acanthodiscus* and *Distoloceras* but can easily be distinguished by the characteristic ribbing pattern. Furthermore *Distoloceras* is uncoiled, and *Acanthodiscus* has no ventral sulcus.

Raimondiceras alexandrensis sp. nov.

Plate 4, figs 1 and 2; Plate 5, fig. 1

v.1979 *Raimondiceras* sp., Thomson, p. 29, pl. 7, figs d, f and h.

Type material. Holotype: KG. 3461.13 (nearly complete internal mould from Leda Ridge). Paratypes: KG.

EXPLANATION OF PLATE 4

Figs 1 and 2. *Raimondiceras alexandrensis* sp. nov. Berriasian, Himalia Ridge. 1, lateral view. 2, ventral view. Paratype, KG. 2934.29, $\times 1$.

Fig. 3. *Lyttohoplites* cf. *burckhardti* (Mayer-Eymar). Upper Tithonian, northern Planet Heights. KG. 3404.138, $\times 1$.

Fig. 4. *Virgatosphinctes* cf. *rotundidoma* Uhlig. Lower Tithonian, Himalia Ridge. Silicone rubber cast, KG. 2912.17a, $\times 1$.



HOWLETT: Antarctic ammonites

720.40 (incomplete internal mould from Himalia ridge), KG. 2934.29 (incomplete internal mould from Himalia Ridge), KG. 3461.25 (fragment of external mould from Leda Ridge) and .27 (incomplete internal mould from Leda Ridge) (text-fig. 1). All are from the top of the Himalia Ridge Formation; Berriasian.

Derivation of name. From its occurrence on Alexander Island.

Diagnosis. Evolute, large *Raimondiceras* (approx. diameter = 240 mm); strong ribs, with every second or third rib bituberculate, prominent and dividing into two projected secondaries at the ventro-lateral tubercle; ribs terminate on the venter of phragmocone, producing a smooth sulcus; on body chamber, ribs cross venter uninterrupted but are slightly reduced.

Description. All the fragments show the shell to have been large (estimated shell diameter = 240 mm; KG. 3461.13) and evolute. The whorl section is rectangular and moderately compressed (whorl width = 35 mm, whorl height = 50 mm; KG. 2934.29), with weakly convex flanks and angular ventro-lateral shoulders. The ribbing pattern comprises strong, fairly distant ribs, every second or third of which is tuberculate with prominent ventro-lateral tubercles and less prominent dorso-lateral tubercles. These tuberculate ribs are usually stouter than the intervening simple ribs and divide into two secondaries at the ventro-lateral tubercle. On the inner whorls, the division of ribs is less regular, with some dividing at the dorso-lateral tubercle and some tuberculate ribs remaining simple. The simple ribs appear to commence near, or just beyond, the umbilical rim, whereas the tuberculate ribs start almost at the umbilical seam. All the ribs are markedly prorsiradiate, and terminate on the phragmocone in slight swellings on either side of the venter, forming a shallow, broad ventral sulcus. However, on the body chamber, the ribs pass uninterrupted over the venter, though they are reduced in strength. The aperture is not preserved, and the suture incomplete.

Remarks. The specimen described by Thomson (1979, p. 29, pl. 7, figs d, f and h; KH. 720.40) belongs to this new species, and was collected from the same locality as KG.2934.29. Thomson (1979, p. 29) thought that his specimen resembled a fragment figured by Spath (1939, pl. 16, fig. 7a and b) from Colombia as *Raimondiceras* sp. ind. (BM C. 4268), which was designated the holotype of *Acantholissonia colombiana* by Leanza (1972, p. 69). However, the Antarctic material is larger than *A. colombiana* and the ribs are less closely spaced and projected.

Only three species have been described for the genus so far. *R. raimondi* (Gabb) (see Spath 1924) is the type species and is smaller, and appears to have closer, weaker ribs, than *R. alexandrensis*, and has up to three simple ribs between the tuberculate ones. *R. salinarium* (Spath, 1939) is similar to *R. raimondi*, but has only two simple ribs between tuberculate ones, as in *R. alexandrensis*. *R. pfuckeri* (Lisson, 1904) (see Etayo-Serna 1985) is also smaller than *R. alexandrensis* and, like *R. salinarium*, has only two simple ribs per tuberculate one. However, the ribs are moderately, though irregularly, distant and the tuberculate ribs appear to divide into three secondaries.

Occurrence. *R. alexandrensis* is considered to be of Berriasian age (Howlett 1986; Crame and Howlett 1988), and appears to be restricted to Alexander Island.

GENUS BLANFORDICERAS Cossmann, 1907

Type species. *Ammonites wallichi* Gray, 1832, by original designation (Uhlrig 1905; see Thomson 1979, p. 25, for an outline of the complex nomenclatural history).

Emended diagnosis. Large, evolute shell, with moderately inflated subquadrate whorls. The ribs are

EXPLANATION OF PLATE 5

Fig. 1. *Raimondiceras alexandrensis* sp. nov. Berriasian, Leda Ridge. Holotype, KG. 3461.13, $\times 1$.

Fig. 2. *Blanfordiceras weaveri* sp. nov. Upper Tithonian, northern Planet Heights. Paratype, latex cast, KG. 3406.25, $\times 1$.



HOWLETT: *Raimondiceras* and *Blanfordiceras*

typically quite stout, distant and irregularly spaced; the majority bifurcate at about the mid-point of the flank, though sometimes the point of division is near to, or at the umbilical edge; simple and intercalatory ribs are common. The venter commonly has a shallow sulcus at which the ribs terminate with slight swellings. Small tubercles or swellings are also frequently associated with the point of division of the ribs.

Range and distribution. Tithonian-Berriasian; Himalayas, Indonesia, Madagascar, western Antarctica and South America.

Remarks. While examining the Antarctic specimens of *Blanfordiceras*, it became increasingly clear that the distinction between *Blanfordiceras* and the related genus *Berriasella* Uhlig was not sufficiently precise. Consequently, an emended diagnosis for *Blanfordiceras* is presented in an attempt to clarify the situation.

Blanfordiceras may be distinguished from *Berriasella* by its more inflated whorl section and its stouter, more distant and projected ribs. Intercalatory ribs are very rare in *Berriasella*, though quite common in *Blanfordiceras*. Similarly, the irregular divisions of ribs and polygyrate ribs occur in *Blanfordiceras*, but are absent in *Berriasella*.

Blanfordiceras acuticosta (Uhlig, 1910a)

Plate 1, fig. 3

- p.1863 *Ammonites Wallichi* Gray; Blanford, p. 127, pl. 1, fig. 4, [non pl. 3, fig. 2 and 3 = *B. wallichi* (Gray)].
- *.1910a *Blanfordia acuticostum* Uhlig, p. 201, pl. 37, fig. 2a-c.
- cf. 1939 *Blanfordiceras* cf. *acuticosta* (Uhlig); Spath, p. 45, pl. 6, figs 10, 13 and 14.
- .1960 *Blanfordiceras acuticosta* (Uhlig); Collignon, pl. 166, figs 682 and 683.
- .1969 *Blanfordiceras acuticosta* (Uhlig); Helmstaedt, p. 69.

Type specimen. Holotype: figured specimen of Blanford (1864, pl. 1, fig. 4); Spiti Valley (India); Tithonian. The holotype was refigured by Uhlig (1910a, pl. 37, fig. 2).

Diagnosis. Small, evolute *Blanfordiceras*, with moderately distant ribs. The whorl section is compressed with the greatest width occurring level with, or slightly above, the umbilicus. The radial, stout, primary ribs divide into two secondaries of reduced strength, with the point of division usually swollen and sometimes a small tubercle (especially on the inner whorls). A prominent ventral sulcus, at which the ribs terminate with slight swellings, is usually present.

Material. Three incomplete external moulds (KG. 2919.20, .24 and .29) and three incomplete internal moulds (KG. 2919.27, .30 and KG. 2922.5) from Himalia Ridge; one incomplete internal mould from Lunar Crag (KG. 3669.36) (text-fig. 1). All are from the Himalia Ridge Formation, Upper Tithonian.

Description. All the fragments are of small (approx. shell diameter = 50 mm), evolute forms with compressed whorls, which are trapezoidal in cross-section with the widest part near the umbilicus. The ribs are distant, though irregularly spaced, and approximately radial. The majority bifurcate at about the mid-point of the whorls, though some simple ribs also occur. On the inner whorls the point of division of ribs is just visible, and this is frequently emphasized by a small tubercle. On the other whorls, the primary ribs swell slightly prior to division. The secondaries show a marked reduction in strength, and the ribs are still further reduced across the venter where a prominent sulcus is developed. On either side of the sulcus the ribs are slightly swollen. The aperture is not preserved, but the suture is partly visible on one specimen (KG. 2919.30).

Remarks. The material described above is very similar to a specimen described by Blanford (1863) as *Ammonites wallichi* (Gray) and which Uhlig (1910a) refigured, placing it into a new species, *B. acuticosta*, on the basis of its small size and distinctive ribs. As both Uhlig (1910a) and Helmstaedt (1969) pointed out, this species has radial ribs, as opposed to sinuous ribs which are more usual for

the genus *Blanfordiceras*. Furthermore, the compressed cross-section and prominent ventral sulcus of *B. acuticosta* are also characteristic. Helmstaedt (1969) did not figure any of his specimens of *B. acuticosta*, but his description agrees well with the material described here. The Antarctic specimens are identical to two specimens of *B. acuticosta* (Uhlig) figured by Collignon (1960), which are of the same size, cross-section, style of ribbing and type of venter.

Spath (1939, pl. 6, figs 10, 13 and 14) illustrated three specimens which he referred to *B. cf. acuticosta*. Two of his fragments (figs 10 and 13) have the typical radial ribs, but the venter of fig. 13 lacks a sulcus (the ventral view of fig. 10 is not illustrated). The third specimen (figured in fig. 14), has a ventral groove which is similar to *B. acuticosta*, but has sinuous ribs.

There are some similarities between *B. acuticosta* and some specimens described as *B. aff. wallichi* by Thomson (1979, pl. 7, figs a and b). However, in Thomson's material the ribs are slightly sinuous and the whorl section more inflated and rounded than in *B. acuticosta*.

Occurrence. *B. acuticosta* has been recorded from the Himalayas (Uhlig 1910a; Helmstaedt 1969), Pakistan (Spath 1939) and Madagascar (Collignon 1960), where they are all considered to be of late Tithonian age.

Blanfordiceras weaveri sp. nov.

Plate 2, figs 5 and 7; Plate 5, fig. 2

- .1931 *Berriasella subprivasensis* Krantz; Weaver, p. 443, pl. 56, figs 356 and 357.
 v.1979 '*Berriasella*' *subprivasensis* Krantz; Thomson, p. 28, pl. 7, fig. i.
 v?1979 *Blanfordiceras aff. wallichi* Gray; Thomson, p. 27, pl. 7, figs a-c; text-fig. 6b.

Type material. Holotype: KG. 2919.19 (incomplete internal mould from Himalia Ridge). Paratypes: two incomplete internal moulds (KG. 2919.11 and .18) and two incomplete external moulds (KG. 2919.14 and .16) from Himalia Ridge; one incomplete internal and external mould (KG. 2802.79) from Callisto Cliffs; one nearly complete external mould (KG. 3406.25) from northern Planet Heights; three incomplete internal moulds (KG. 3669.31, .37a and .38) and one incomplete external mould (KG. 3669.37b) from Lunar Crag (text-fig. 1). All are from the Himalia Ridge Formation, Upper Tithonian.

Derivation of name. After C. E. Weaver, who was the first to describe specimens of this species (as *Berriasella subprivasensis*) in 1931.

Diagnosis. Moderately large and evolute *Blanfordiceras*. Sub-quadrate, inflated whorl section. Ribs are strong, flexuous and prorsiradiate, irregularly spaced, and most are bifurcate. Ribs cross the venter, but are greatly reduced, with slight swellings on either side of the venter.

Description. The specimens appear to be moderately large (estimated shell diameter = 100 mm) and moderately evolute (umbilicus = approx. 35% of diameter). The whorl section is only preserved on one specimen (KG. 2919.19; Pl. 2, figs 5 and 7) where it is inflated, sub-quadrate and approximately equidimensional. The ribs are strong, flexuous and prorsiradiate, and are quite widely, though irregularly spaced. Most ribs bifurcate near the middle of the flank, but there are also some simple, polygyrate and rare intercalatory ribs present. Some ribs divide at, or near, the umbilical edge but these are rare. The majority of the ribs continue across the venter, though strongly reduced, with slight swellings on either side of the venter. The aperture is not preserved, nor is the suture in any detail.

Remarks. The specimens, despite being incomplete, are identical to *Berriasella subprivasensis* of Weaver (1931) and Thomson (1979) in their strength and style of ribbing (e.g. ribs dividing low on the whorl flanks), and in their degree of evoluteness. This style of ornamentation is considered here to be more like that of the genus *Blanfordiceras* than of *Berriasella* (see emended diagnosis above). The figured specimen of *Berriasella subprivasensis* in Krantz (1928, pl. 3, fig. 4) does not show any ribs dividing low on the flanks, but high on the outer third of the whorls. The Antarctic specimens differ further from Krantz's illustration in having a narrower umbilicus. Both Feruglio (1936, p. 63)

and Thomson (1979) considered that *B. subprivasensis*, as interpreted by them, was closer to *Blanfordiceras* than *Berriasella*.

Blanfordiceras delgai Collignon (1960, pl. 166, figs 680 and 681) is comparable to the material described above, but differs in having a much greater number of single ribs and a wider umbilicus. There are further similarities with *Blanfordiceras wallichi* (Gray), but this species, though widely interpreted, appears to have more distant ribs and a sulcus, unlike the Antarctic specimens. The examples of *B. aff. wallichi* of Thomson (1979) appear to be closer to *B. weaveri* than to *B. wallichi*, especially one figured specimen (Thomson 1979, pl. 7, fig. 3), and they are tentatively included within this new species.

Occurrence. *B. weaveri* is regarded as being present in the Upper Tithonian of Argentina (Weaver 1931) and Alexander Island (Thomson 1979).

Suborder ANCYLOCERATINA Wiedmann, 1966
Superfamily ANCYLOCERATAEAE Meek, 1876
Family BOCHIANITIDAE Spath, 1922
Subfamily BOCHIANITINAE Spath, 1922
Genus BOCHIANITES Lory, 1898

Type species. *Baculites neocomiensis* d'Orbigny, 1842, by original designation.

Diagnosis. Uncoiled, straight, tapering shell, typically with an ornament of oblique, rounded ribs. Irregular constrictions are sometimes present.

Range and distribution. Berriasian–Hauterivian; Europe, North Africa, Himalayas, Indonesia, Madagascar, South Africa, western Antarctica, North, South and Central America.

Remarks. *Bochianites* is a very distinct, straight, ammonite genus. Within the subfamily Bochianitinae, Arkell *et al.* (1957, p. L207) list three other genera besides *Bochianites*: *Janenschites* Durand Delga, *Kabylites* Durand Delga, and *Baculina* d'Orbigny. Arkell *et al.* (1957) considered *Janenschites* to be doubtfully distinct from *Bochianites*, and Wiedman (1962b) has since included it in the synonymy of *Bochianites*. Both *Kabylites* and *Baculina* differ from *Bochianites* in having much simpler suture patterns and also a weaker ornamentation. Klinger and Kennedy (1979) described a further genus, *Umgazanicerias*, from South Africa. This genus differs from *Bochianites* in having small, distinct tubercles on either side of both the dorsum and venter.

Some members of the largely Upper Cretaceous family Baculitidae are similar to *Bochianites*. However, generally they lack ribs and have a more oval cross-section, with the venter sometimes emphasized by being raised into a small ridge (see Arkell *et al.* 1957, fig. 245). The sutures of the Baculitidae are frequently more complex than those of the Bochianitinae.

The specimens described below, though poorly preserved, appear to belong to the genus *Bochianites* rather than *Umgazanicerias*, as they lack tubercles on the dorsum and venter. Despite the suture not being preserved, the strength of the ornament also suggests *Bochianites* rather than any other genus.

Bochianites aff. versteeghi Boehm, 1904

Plate 2, figs 1 and 2

aff. *.1904 *Bochianites versteeghi* Boehm, p. 27, pl. 2, fig. 6a–c.

v .1979 *Bochianites aff. versteeghi* Boehm; Thomson, p. 10, pl. 2, figs n–p.

Material. One fragment from Callisto Cliffs (KG. 2802.439); seventeen fragments (KG. 2934.57, .67, .68, .69, .73, .76, .84, .85, .98, .116, KG. 2935.5, KG. 2939.11, .13, KG. 2942.5, .6, .10 and .11) from Himalia

Ridge; six fragments (KG. 3461.11, .38, .48, .51, .64 and .73) from Leda Ridge (text-fig. 1). All are from the Spartan Glacier Formation, Berriasian-Valanginian.

Description. All the specimens are fragmentary and crushed, and many are weathered. The shell is straight, gently tapering, and has a prominent ornamentation of oblique ribs which cross the venter uninterrupted, but are reduced on the dorsum. The ribs are quite closely spaced and quite stout, and there are occasional well defined constrictions which are parallel to the ribbing. The total length of the shell is impossible to determine, but the largest specimen (KG. 3461.51) is approximately 80 mm long.

Remarks. All the fragments are similar to those described by Thomson (1979, p. 10), which are from the Himalia Ridge area. Unfortunately, comparison with other material is difficult due to the poor preservation of all the Antarctic specimens. However, the distinct ribs and periodic constrictions are very similar to *B. versteeghi* Boehm (1904). Other similarities with the Antarctic material can be found in Thomson (1979, pp. 10 and 11), whose discussion is also applicable to the specimens described above.

Occurrence. *B. versteeghi* was originally described from the Jurassic-Cretaceous boundary beds of Taliabu, Indonesia (Boehm 1904).

Subclass COLEOIDEA Bather, 1888
Order BELEMNITIDA Zittel, 1895
Suborder BELEMNOPSEINA Jeletzky, 1965
Family BELEMNOPSEIDAE Naef, 1922
Genus BELEMNOPSIS Bayle, 1878

Type species. *Belemnites sulcatus* Miller, 1823, by subsequent designation (Douvillé 1879).

Diagnosis. Rostrum elongate, cylindrical to hastate, typically asymmetrical in profile, and with an acute apex. Transverse sections are usually depressed throughout most of the rostrum. Prominent ventral alveolar groove usually extending to near the apex. No dorsal or lateral grooves. Lateral lines rarely preserved, but when present, usually weakly developed as a broad flattening along the flank of the rostrum.

Range and distribution. Bajocian (Middle Jurassic) to lowermost Hauterivian (Lower Cretaceous), Europe, Africa, Madagascar, Pakistan, India, Tibet, South East Asia, Australia, New Zealand, western Antarctica and South America. *Belemnopsis* is restricted to the Middle Jurassic in Europe and to the Upper Jurassic and Lower Cretaceous in other areas.

Remarks. Bayle (1878) erected several new genera and species without designating any types. Douvillé (1879, p. 91) listed the same genera and clearly indicated a suitable type species for each one, designating *B. sulcatus* Miller as the type species of *Belemnopsis*. It is worth noting that Miller (1823, pl. 8, figs 1-3) illustrated two specimens of *B. sulcatus*, only one of which (figs 1 and 2) appears to be a true *Belemnopsis*. The second specimen (fig. 3) seems to belong to the genus *Aulacoteuthis* Stolley (see below). Several authors (e.g. Naef 1922; Riegraf 1980; Combémoré 1988) regard the type species of *Belemnopsis* as *Belemnites bessinus* d'Orbigny, subsequently designated by Fischer (1887). However, Fischer (1887, p. 363) gave only a list of the new generic names erected by Bayle (1878), with two or three species of each, and did not designate any of them types.

Belemnopsis is distinctive with its prominent ventral alveolar groove. However, it could be confused with *Aulacoteuthis*, which differs in that its ventral groove is an apical groove which does not extend fully into the alveolar region. Some of the more hastate forms of *Belemnopsis* can be very like *Hibolites* Montfort, but species of the latter are generally regularly hastate and usually have

shorter (typically not reaching the mid-point of the rostrum), narrower grooves. *Hibolites* are also usually less robust than *Belemnopsis*.

Riegraf (1980) subdivided *Belemnopsis* into four new subgenera, *B. (Pachybelemnopsis)*, *B. (Conobelemnopsis)*, *B. (Longibelemnopsis)* and *B. (Belemnopsis)*, using specimens from the Middle Jurassic of southern Germany. *B. (Pachybelemnopsis)* has a long, wide ventral groove, is moderately robust and weakly hastate, and has a depressed apical region with an acute apex. *B. (Conobelemnopsis)* is rather variable, but generally is short and robust, and frequently conical in shape. The ventral groove is long and narrow, extending almost to the acute apex. *B. (Longibelemnopsis)* is rather like the genus *Hibolites* in that it is typically slender, hastate and has a short, narrow groove which only reaches to the mid-point of the rostrum. *B. (Belemnopsis)* is usually slender and hastate, with a long, wide ventral groove which extends almost to the acute apex, and is markedly depressed throughout the length of the rostrum. Most of the Indo-Pacific *Belemnopsis* can be assigned to the nominal subgenus (see below for discussion), but some of the species described below cannot be included in any of the existing subgenera, and therefore two new ones (*B. (Parabelemnopsis)* and *B. (Telobelemnopsis)*) have been erected to accommodate them.

Subgenus BELEMNOPSIS Bayle, 1878

Type species. As for genus.

Diagnosis. Typically moderately elongate rostrum, with an acute apex. In outline, cylindrical or hastate; in profile, usually non-hastate and asymmetrical. Transverse sections are commonly depressed in the apical and stem regions. Prominent, typically broad, ventral alveolar groove, usually extending to near the apex.

Range and distribution. Bajocian to Valanginian; Europe, Africa, Madagascar, Pakistan, India, Tibet, South East Asia, Australia, New Zealand, Antarctica and South America.

Remarks. This subgenus is typified by the European forms of *Belemnopsis* (e.g. *B. sulcatus* (Miller)) with very acute apices, quite slender hastate shapes and pronounced depressed cross-sections throughout the length of the rostra. The Indo-Pacific forms differ slightly in that they are often robust with obtuse apices, and their transverse sections are slightly or moderately depressed in the apical and stem regions. In some species, the cross-sections are circular in the stem, and depressed in the apex. The unifying feature is the ventral groove which is prominent, long and usually broad in both groups.

The subgenus *B. (Pachybelemnopsis)* Riegraf (1980) is very similar to *B. (Belemnopsis)* except that the rostrum of the former is moderately robust and depressed in the apical region. Furthermore, *B. (Pachybelemnopsis)* is, as far as is known, restricted to the Bajocian-Bathonian (Middle Jurassic). However, further work on European *Belemnopsis*, may unite these two subgenera as there is little to distinguish between them.

Belemnopsis (Belemnopsis) cf. alfurica (Boehm, 1907)

Plate 6, figs 8, 9, 11, 12

- cf. *1907 *Belemnites alfuricus* Boehm, p. 56, pl. 8, figs 4, 5 and 7-11.
 cf. 1910b *Belemnites (Belemnopsis) alfuricus* Boehm; Uhlig, p. 388, pl. 93, figs 3, 4 and 6.
 .1921 *Belemnopsis alfoericus* [sic] Boehm; Kruizinga, p. 166, pl. 2, figs 1-3.
 cf. 1940 *Belemnopsis cf. alfurica* (Boehm); Teichert, p. 114, pl. 1, figs 14-21.
 cf. 1963b *Belemnopsis alfurica* (Boehm); Stevens, p. 101, pl. 1, figs 14-21.
 .1964 *Belemnopsis alfuricus* (Boehm); Yang and Wu, p. 202, pl. 1, figs 8-12.
 cf. ?1965 *Belemnopsis alfurica* (Boehm); Stevens, p. 78, pl. 4, figs 5-7; pl. 5, figs 10-12 and 16-18; pl. 6, figs 7-9.

- cf. v 1973 *Belemnopsis* cf. *alfurica* (Boehm); Willey, p. 41, fig. 4c.
 cf. 1982 *Belemnopsis alfurica* (Boehm); Challinor and Skwarko, p. 19, pl. 7, figs 5-8; pl. 8, figs 1-14;
 pl. 9, figs 1-10.
 cf. v 1988 *Belemnopsis alfuricus* (Boehm); Combémorrel, p. 82, pl. 11, figs 1-4.

Material. One nearly complete rostrum (KG. 1925.18b) and two fragments (KG. 1925.18a and c) from Belemnite Point; two fragments (KG. 2905.5 and KG. 2910.42) from Himalia Ridge; one fragment (KG. 1919.1) from Nonplus Crag (text-fig. 1). All are from the Himalia Ridge Formation, Kimmeridgian-Lower Tithonian.

Dimensions	L	l	Dlmax	Dvmax
KG. 1925.18b	79	80*	8.7	8.5

Description. Slender rostrum of medium length (*l* is approximately nine times *Dlmax*). The outline is hastate, with *Dlmax* at about the mid-point of the rostrum. The profile is slightly hastate and asymmetrical (due to inflation of the venter). The rostrum tapers from *Dlmax* gradually to an acute apex. The cross-sections are slightly depressed in the apical region and circular in the stem. The alveolar region is not preserved in any of the specimens. A prominent ventral groove extends from the anterior margin, and in the upper stem it is characteristically steep-sided and has a broadly rounded shape. Near the apex, the groove shallows rapidly and finally disappears approximately 10 mm from the apex. No lateral lines can be seen on the material. The apical line is ortholineate.

Remarks. Although the material is very poorly preserved, and only one specimen (KG. 1925.18b) gives any real indication of the overall morphology, similarities can be seen between these specimens and *B. alfurica* (Boehm, 1907). As Boehm's figured material (pl. 8, figs 4, 5 and 7-11) was destroyed in the 1939-45 war, Stevens (1963b) designated a lectotype from topotypes collected by Boehm. The lectotype (Stevens 1963b, pl. 1, figs 1-4), together with examples of *B. alfurica* illustrated by Kruizinga (1921, pl. 2, figs 1-3) and Yang and Wu (1964, pl. 1, figs 8-12), is very similar to the Antarctic rostra, though those of Kruizinga are larger. Challinor (1979, p. 121) considered that the lectotype designated by Stevens was a juvenile, and that the original of Boehm's (1907) pl. 8, fig. 11 was a more typical example, on the basis of recently collected Indonesian material (Challinor and Skwarko 1982). Challinor also concluded that the New Zealand examples of *B. alfurica* (see Stevens 1965) were wrongly identified, and that they are in fact *B. keari* Stevens, implying that *B. alfurica* does not occur in New Zealand (Challinor 1979, p. 121; Challinor and Skwarko 1982, p. 22). However, as Stevens (1965, p. 77) stated, *B. keari* can be distinguished by its greater degree of hastation and more depressed cross-section than *B. alfurica*, and hence Stevens's specimens of *B. alfurica* from New Zealand are considered typical of the species.

The Antarctic material described above differs from *B. alfurica* by being less robust, hastate in profile, circular in cross-section throughout the stem region, and in having a narrower ventral groove. The material can also readily be distinguished from *B. keari* which is markedly hastate, moderately robust and depressed in both apical and stem regions. The Antarctic specimens described by Willey (1973), from the same areas as those under discussion, are larger and appear to have more rounded margins to the ventral groove, but otherwise are of similar appearance.

B. tangansensis (Futterer) is comparable with *B. cf. alfurica*, though the former is depressed throughout the apical and stem regions. Furthermore, the ventral groove of *B. tangansensis* remains deep and broad almost to the apex (see Stevens 1963c, pl. 1, figs 1 and 4), whereas this does not occur in the Antarctic specimens. A further comparison is with *B. taliabutica* (Boehm), but this is robust, depressed throughout, and cylindrical in both outline and profile.

Occurrence. *B. (B.) alfurica* was originally described from the Oxfordian of Indonesia (Boehm 1907; Kruizinga 1921), though it is now known to occur in the Kimmeridgian of Indonesia (Stevens 1965, p. 139; Challinor and Skwarko 1982) and India (Uhlig 1910b; Stevens 1965, p. 149), the Ohauan (Kimmeridgian) of New Zealand (Stevens 1965), the Oxfordian-Lower Tithonian? of Tibet (Yang and Wu 1964; Chen 1982) and the Oxfordian-Kimmeridgian of Madagascar (Combémorrel 1988).

Belemnopsis (Belemnopsis) cf. aucklandica (Hochstetter, 1963)

Plate 7, figs 1, 2, 5, 6

- cf. *.1863 *Belemnites aucklandicus* Hochstetter, p. 129, text-fig. (on p. 129).
 cf. 1864 *Belemnites aucklandicus* Hauer in Zittel, p. 29, pl. 8, figs 2a-c.
 cf. 1878 *Belemnites aucklandicus* Hauer; Hector, p. 486, figs 2a and b.
 .1921 *Belemnopsis cf. aucklandica* Hauer; Kruizinga, p. 172, pl. 4, figs 1-4.
 cf. 1953 *Belemnopsis cf. aucklandica* (Hochstetter); Avias, p. 161, pl. 14, figs 1-3, pl. 16, figs 2, 15 and 16.
 cf. 1965 *Belemnopsis aucklandica aucklandica* (Hochstetter); Stevens, p. 82, pl. 6, figs 1-6, 10-15; pl. 7, figs 1-7, 11-13; pl. 8, figs 1-8; text-figs 22f, 24b and c.
 cf. 1970 *Belemnopsis aucklandica aucklandica* (Hochstetter); Challinor, p. 70, figs 2-4a-h.
 .1982 *Belemnopsis aucklandica aucklandica* (Hochstetter); Chen, p. 299, pl. 5, figs 10-14; pl. 8, figs 1-5; pl. 13, figs 1-3.

Material. One undeformed and complete rostrum (KG. 2910.27), three deformed complete rostra (KG. 2923.25, .35 and .42) and four fragments (KG. 2905.1 .19, KG. 2907.19 and KG. 2923.39) from Himalia Ridge; one nearly complete rostrum (KG. 1926.36) and four fragments (KG. 1926.14, .151, .152a and .152b) from Belemnite Point; three fragments (KG. 2802.108, .115 and .126) from Callisto Cliffs; one fragment (KG. 3464.3) from Moutonée Valley; one fragment (KG. 1915.1) from Vesta Nunataks (text-fig. 1). All are from the Himalia Ridge Formation, Kimmeridgian-Tithonian.

Dimensions	<i>L</i>	<i>l</i>	<i>D</i> /max	<i>D</i> _v
KG. 1926.36	121	66	15.8	14.5
KG. 2910.27	85	68	15.5	14.8

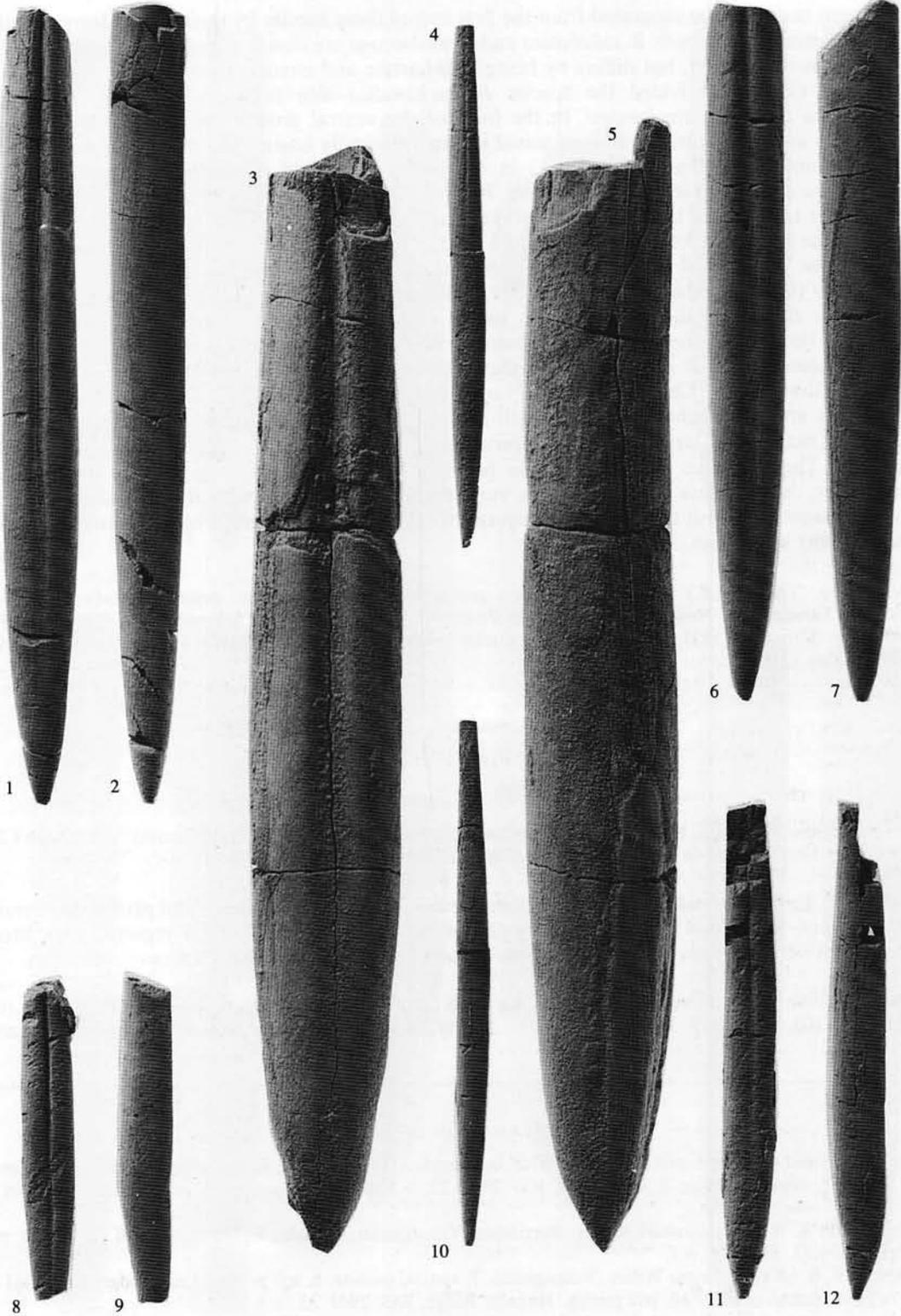
Description. Small, robust rostrum (*l* is approximately four times *D*/max). Slightly hastate in outline, with the maximum lateral diameter occurring slightly anterior of the mid-point. The profile is typically non-hastate or very slightly hastate, and asymmetrical with the ventral surface inflated and the maximum dorsoventral diameter occurring at the protoconch. Transverse sections are depressed at the apex and stem, but compressed in the alveolar region. A prominent, deep, ventral groove extends from the alveolar region until approximately 15-25 mm from the apex. Some of the specimens are mucronate (e.g. KG. 2923.25 and .35). Lateral lines are not preserved on any of the specimens. The apical line is weakly cyrtolineate.

Remarks. The Antarctic specimens described above are all poorly preserved and therefore any identification must be tentative. However, they are comparable to Hochstetter's holotype of *B. aucklandica* (re-figured in Stevens 1965, pl. 6, figs 4-6), though generally they are slightly more elongate and robust, and less hastate than the holotype. One of the fragments (KG. 2905.19) is very similar to a specimen illustrated as *B. cf. aucklandica* by Kruizinga (1921, pl. 4, fig. 3), from the Sula Islands, Indonesia. Some of the Antarctic fragments also appear to be close to some other examples of this species figured by Stevens (e.g. KG. 2910.27 and Stevens 1965, pl. 6, figs 1-3).

There are further similarities between the material described here and other *Belemnopsis* species, such as *B. taliabutica* (Boehm 1907, p. 74, pl. 11, figs 5a-c and 6a-c), *B. moluccana* (Boehm 1907, p. 76, pl. 11, fig. 12) and *B. uhligi* Stevens (1963a, p. 694, pl. 99, figs 1-9). However, the Antarctic

EXPLANATION OF PLATE 6

- Figs 1, 2, 6 and 7. *Belemnopsis (Belemnopsis) launceloti* sp. nov. Valanginian-?Hauterivian, Leda Ridge. 1, ventral outline. 2, right profile. Holotype, KG. 3455.64, $\times 1$. 6, ventral outline. 7, right profile. Paratype, KG. 3455.19, $\times 1$.
 Figs 3 and 5. *B. (B.) alexandri* Willey. Berriasian-Valanginian, Leda Ridge. 3, ventral outline. 5, left profile. KG. 3461.71, $\times 1$.
 Figs 4 and 10. *Hibolithes argentinus* (Feruglio). Upper Tithonian, Ablation Valley. 4, ventral outline. 10, right profile. KG. 2909.18, $\times 1$.
 Figs 8, 9, 11 and 12. *B. (B.) cf. ahfurica* (Boehm). Kimmeridgian-Lower Tithonian, Belemnite Point. 8, ventral outline. 9, right profile. KG. 1925.18a, $\times 1$. 11, ventral outline. 12, right profile. KG. 1925.18b, $\times 1$.



HOWLETT: *Belemnopsis* and *Hibolithes*

specimens can easily be separated from the first two of these species by their robust form and their shorter rostral length: both *B. taliabutica* and *B. moluccana* are elongate and more slender. *B. uhligi* is closer, as it is robust, but differs by being non-hastate and circular in cross-section.

Stevens (1965) subdivided the species *B. aucklandica* into two subspecies: *B. aucklandica aucklandica* and *B. a. trechmanni*. In the form of the ventral groove and cross-section, the two subspecies are similar, but *B. a. trechmanni* is more markedly hastate in outline and has the point of maximum lateral diameter (D_{lmax}) in the posterior half of the rostrum, whereas in *B. a. aucklandica* D_{lmax} lies in the anterior half. Furthermore, the groove of *B. a. trechmanni* frequently ends closer to the apex than on *B. a. aucklandica*.

Challinor and Skwarko (1982) described a further two subspecies from Indonesia, *B. a. galoi* and *B. a. similis*. The first of these is based on *Belemnopsis galoi* (Boehm), *B. taliabutica* (Boehm) and *B. sularum* (Boehm), which nominal species Challinor and Skwarko (1982, p. 28) considered were synonyms. *B. a. galoi* differs from *B. a. similis* in being slightly less hastate and more strongly depressed throughout the length of the rostrum. Both *B. a. galoi* and *B. a. similis* are distinct from *B. a. aucklandica* and *B. a. trechmanni* in their lesser degree of hastation and in their wider ventral groove. However, as Challinor and Skwarko (1982, p. 40) state, the differences between the subspecies are very slight and gradational, and are best shown by numerical techniques. As the Antarctic material is largely poorly preserved and incomplete, detailed statistical tests are not possible. There are no clear similarities between the material described above and any one subspecies, though there do appear to be more features in common with *B. a. aucklandica* and *B. a. trechmanni* than with the Indonesian subspecies. However, no attempt has been made to assign them to any subspecies.

Occurrence. The *B. (B.) aucklandica* species group has previously been described from the Kimmeridgian-Tithonian of New Zealand (Ohauan-Puaroan; Hochstetter 1863; Stevens 1965; Challinor 1970), Indonesia (Kruizinga 1921; Challinor and Skwarko 1982), New Caledonia (Avias 1953), Tibet (Chen 1982) and possibly Chile (see Stevens 1965, p. 158).

Belemnopsis (Belemnopsis) alexandri Willey, 1973

Plate 6, figs 3 and 5; Plate 7, figs 3 and 4

v *.1973 *Belemnopsis alexandri* Willey, p. 37, fig. 3a-e.

Type specimen. Holotype: KG. 402.55a and b (two adjacent fragments of the same species); Tombaugh Cliffs, Alexander Island; Spartan Glacier Formation, Berriasian-Valanginian.

Diagnosis. Large (typical $l = 125$ mm), robust *Belemnopsis*. Hastate outline and profile. Moderately obtuse apex. Depressed in apical region, compressed in stem and alveolar regions. Very broad, prominent ventral groove which is deep in the alveolar region and does not reach the apex.

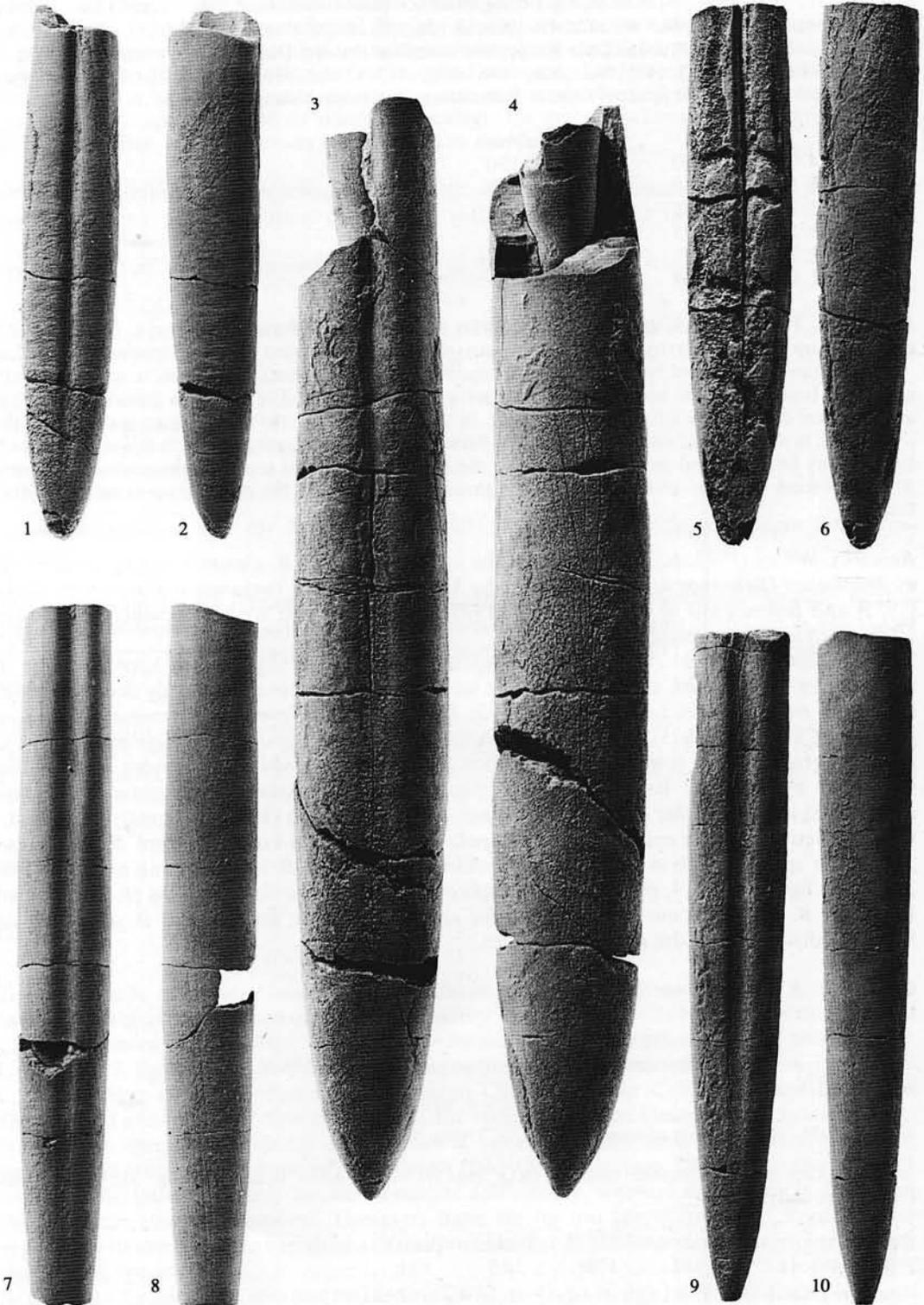
Material. Five complete rostra (KG. 2934.93, .105, KG. 2942.18, .28 and .41), eight fragments (KG. 2934.95, .103, .109, .123, KG. 2942.24, .37, .39 and .42) and one natural mould (with mould of attached

EXPLANATION OF PLATE 7

Figs 1, 2, 5 and 6. *Belemnopsis (Belemnopsis) cf. aucklandica* (Hochstetter). Kimmeridgian-Tithonian, Himalia Ridge. 1, ventral outline. 2, left profile. KG. 2910.27, $\times 1$. 5, ventral outline. 6, left profile. KG. 2905.19, $\times 1$.

Figs 3 and 4. *B. (B.) alexandri* Willey. Berriasian-Valanginian, Himalia Ridge. 3, ventral outline. 4, right profile. KG. 2942.18, $\times 1$.

Figs 7-10. *B. (B.) gladiatoris* Willey. Valanginian. 7, ventral outline. 8, left profile. Leda Ridge, KG. 3461.43, $\times 1$. 9, ventral outline. 10, left profile. Himalia Ridge, KG. 2942.33, $\times 1$.



HOWLETT: *Belemnopsis*

phragmocone; KG. 2934.59) from Himalia Ridge; two complete rostra (KG. 3461.71 and .146) and twenty-two fragments (KG. 3461.44, .46, .47, .49, .52, .55, .56, .57, .61, .63, .66, .69, .70, .72, .74, .92, .96, .97, .101, .102, .103 and .104) from Leda Ridge; one complete rostrum (KG. 3453.15) from KG. 3452—KG. 3453; seven fragments (KG. 3401.50a, .50b, .50c, .50d, .51, .52 and .53) from Callisto Cliffs (text-fig. 1). All the specimens are from the Spartan Glacier Formation, Berriasian-Valanginian.

Dimensions	L	l	Dlmax	Dvmax
KG. 2934.93	163	131	23.0	22.6
KG. 2934.105	130	118	23.0	22.3
KG. 2942.18	172	128	24.3	25.1
KG. 2942.23	125	102	21.8	21.5
KG. 3461.71	178	137	24.2	24.7
KG. 3461.146	169	136	21.6	20.3

Description. The description given by Willey (1973, p. 37) fits the material listed above, but many of these specimens are better preserved than the type material as they are the first complete specimens to be found.

The rostrum is large and robust (l is approximately five times Dl_{max}). In outline, it is hastate, with the maximum lateral diameter occurring just anterior of the mid-point. The profile is hastate and frequently asymmetrical due to some inflation of the venter. In transverse section, the apical region is depressed, though compressed in the stem and alveolar regions. The flanks of the rostrum taper posteriorly to a moderately obtuse apex. A very broad ventral groove extends from the alveolar end (where it is at its deepest) to approximately 30–40 mm from the apex, gradually shallowing throughout its length. No dorsal grooves or lateral lines are visible.

Remarks. Willey (1973, p. 37) included in the synonymy list of *B. alexandri* the specimens figured as *Belemnites (Belemnopsis) gerardi* Opper by Uhlig (1910b), *B. tangensis* Futterer by Stefanini (1925) and *Belemnopsis* sp. ind. by Spath (1939). However, these are not considered to be typical of *B. alexandri* in the present work.

Belemnites (Belemnopsis) gerardi Opper as interpreted by Uhlig (1910b) appears to be much shorter than *B. alexandri*, and is non-hastate with the ventral groove apparently deeper throughout its length, ending closer to the apex than in *B. alexandri*. *Belemnites (Belemnopsis) tangensis* Futterer of Stefanini (1925) is more like the Antarctic material, though the specimen in fig. 9a–c has a ventral groove which is much narrower than that of *B. alexandri*. Furthermore, both specimens illustrated by Stefanini have circular, or slightly depressed sections, whereas *B. alexandri* is compressed in the alveolar region. *Belemnopsis* sp. ind. in Spath (1939) is strongly depressed, and the deep ventral groove ends close to the apex. This favours its exclusion from *B. alexandri*.

Another species which is similar to the Antarctic material is *B. sinensis* Yang and Wu (1964, p. 204, pl. 1, figs. 13 and 14, pl. 2, figs 1–5), especially the paratype illustrated on pl. 2, fig. 1a and b. However, *B. sinensis* is not hastate in profile and has a deeper groove than *B. alexandri*, and is therefore distinct from the Antarctic species.

Occurrence. *B. (B.) alexandri* is apparently restricted to the Berriasian-Valanginian of eastern Alexander Island.

Belemnopsis (Belemnopsis) aff. alexandri Willey, 1973

Plate 8, figs 3 and 4

aff. v 1973 *Belemnopsis alexandri* Willey, p. 37, fig. 3a–e.

Material. One nearly complete rostrum (KG. 3461.41) from Leda Ridge (text-fig. 1); Spartan Glacier Formation, Valanginian.

Dimensions	L	l	Dlmax	Dvmax
KG. 3461.41	167	130*	18.5	17.1

Description. Large and moderately robust rostrum (the length being approximately seven times D_{lmax}). In outline it is hastate, with the maximum lateral diameter situated at about the mid-point of the rostrum. The profile is slightly hastate and asymmetrical, with the maximum dorso-ventral diameter also at about the mid-point of the rostrum. The transverse sections are depressed in the apical and stem regions, but compressed in the alveolar region. A broad, prominent ventral groove extends from the alveolar end to approximately 35 mm from the mucronate apex (much of the mucron is missing). The groove shallows gradually throughout its length. No lateral lines or other grooves are preserved on the specimen.

Remarks. This specimen, though possessing a similar outline to *B. alexandri* is far more slender and mucronate than is typical. It is more comparable with *B. gladiatoris* in robustness.

Occurrence. *B. (B.)* aff. *alexandri* appears to be unique to the Valanginian of Alexander Island.

Belemnopsis (Belemnopsis) gladiatoris Willey, 1973

Plate 7, figs 7-10

- .1932 *Belemnites africanus* Tate; Besairie, p. 45, pl. 6, figs 1 and 2.
 v ? 1939 *Belemnopsis africana* (Tate); Spath, p. 138, pl. 24, fig. 15a and b.
 ? 1964 *Belemnopsis* cf. *africana* (Tate); Yang and Wu, p. 203, pl. 2, fig. 4.
 v * .1973 *Belemnopsis gladiatoris* Willey, p. 33, fig. 2a-e.
 .1981 *Belemnopsis africana* (Tate); Cooper, p. 355, fig. 204.

Type specimen. Holotype: KG. 401.702; Tombaugh Cliffs, Alexander Island; Spartan Glacier Formation, Valanginian.

Diagnosis. Medium length (typical $l = 95$ mm), moderately robust *Belemnopsis*. Outline weakly hastate. Profile non-hastate, asymmetrical. Acute apex. Transverse sections depressed in apical and stem regions, compressed in alveolar region. Prominent, ventral groove extends from anterior end almost to apex.

Material. Seven nearly complete rostra (KG. 2934.117, KG. 2939.7, .9, KG. 2942.21, .22, .43 and .44) and ten fragments (KG. 2934.60, .96, .108, .124, KG. 2939.8, KG. 2942.20, .25, .30 and .33) from Himalia Ridge; eight fragments (KG. 3455.21, .33, .47, KG. 3461.36, .43, .114, .124 and .140) from Leda Ridge (text-fig. 1). All are from the Spartan Glacier Formation, Valanginian.

Dimensions	L	l	D_{lmax}	D_v
KG. 2934.117	100	91	12.9	12.2
KG. 2942.21	120	101	14.5	13.9
KG. 2942.43	138	101	19.8	19.5
KG. 3455.21	105	83	14.6	13.5
KG. 3455.33	104	102	14.1	13.0
KG. 3455.47	107	93	13.7	12.9

Remarks. The original description of the species (Willey 1973, p. 36) covers fully the specimens listed here, and little more can be added, except that indistinct lateral lines are sometimes present (KG. 3461.43; Plate 7, fig. 8). Most of Willey's specimens (including the holotype) are from Tombaugh Cliffs, with further samples collected from Callisto Cliffs, Georgian Cliff and Fossil Bluff. The specimens listed above are the first examples of the species from the Ganymede Heights massif.

Many of the specimens formerly assigned to *B. africana* (Tate) seem to be examples of *B. gladiatoris*. However, the holotype of *B. africana* (BM C. 26890; Tate 1867) is distinct from *B. gladiatoris* as the latter is slightly hastate in outline and slender, whereas *B. africana* is depressed, non-hastate and rather more robust. However, there are far too few examples of *B. africana* to assess properly its intra-specific variation and it is possible that *B. gladiatoris* is a morphological end-member of this species.

The specimen figured as *B. africana* by Besairie (1932, p. 45, pl. 6, figs 1 and 2) is almost identical

to Willey's paratype (KG. 402.33), though the Antarctic specimen is slightly smaller. Similarly, the specimen referred to as *B. africana* by Spath (1939) is also comparable with *B. gladiatoris*, though the groove is much more deeply incised. *B. cf. africana* illustrated by Yang and Wu (1964) is too slender to be typical of *B. africana*, but it is very like the Antarctic species. The example of *B. africana* figured by Cooper (1981) is identical to the holotype of the Antarctic species and is considered to be conspecific with it.

Willey (1973) considered that *B. patagoniensis* (Favre) of Feruglio (1936), though not well preserved, was very similar to the holotype of *B. gladiatoris*. However, Feruglio's specimens are, in general, smaller and the ventral groove is shorter and narrower than *B. gladiatoris*.

Occurrence. This species, as defined here, is known to occur in the Valanginian of South Africa (Cooper 1981), Madagascar (Besairie 1932; Spath 1939) and Tibet (Yang and Wu 1964).

Belemnopsis (Belemnopsis) launceloti sp. nov.

Plate 6, figs 1, 2, 6, 7; Plate 8, figs 5 and 6

- p.1936 *Belemnopsis africanus* Tate; Besairie (*partim*), p. 147, pl. 23, figs 6 and 7 [*non* figs 20 and 21 = *Belemnopsis* sp.].
 vp.1936 *Belemnites (Belemnopsis) patagoniensis* Favre; Feruglio, p. 81, pl. 10, figs 3 and 4 [*non* figs 1 and 2 = *Belemnopsis* sp.].

Type material. Holotype: KG. 3455.64. Paratypes: KG. 3455.19 (complete), KG. 3455.1, .4, .16, .25, .28, .40, .44, .46, .53, .74, .117, .167, .171, .181, .191, KG. 3461.65, .87 and .138 (all fragmentary) from Leda Ridge, and KG. 3401.100 (fragment) from Callisto Cliffs (text-fig. 1). All are from the Spartan Glacier Formation, Valanginian-?Hauterivian.

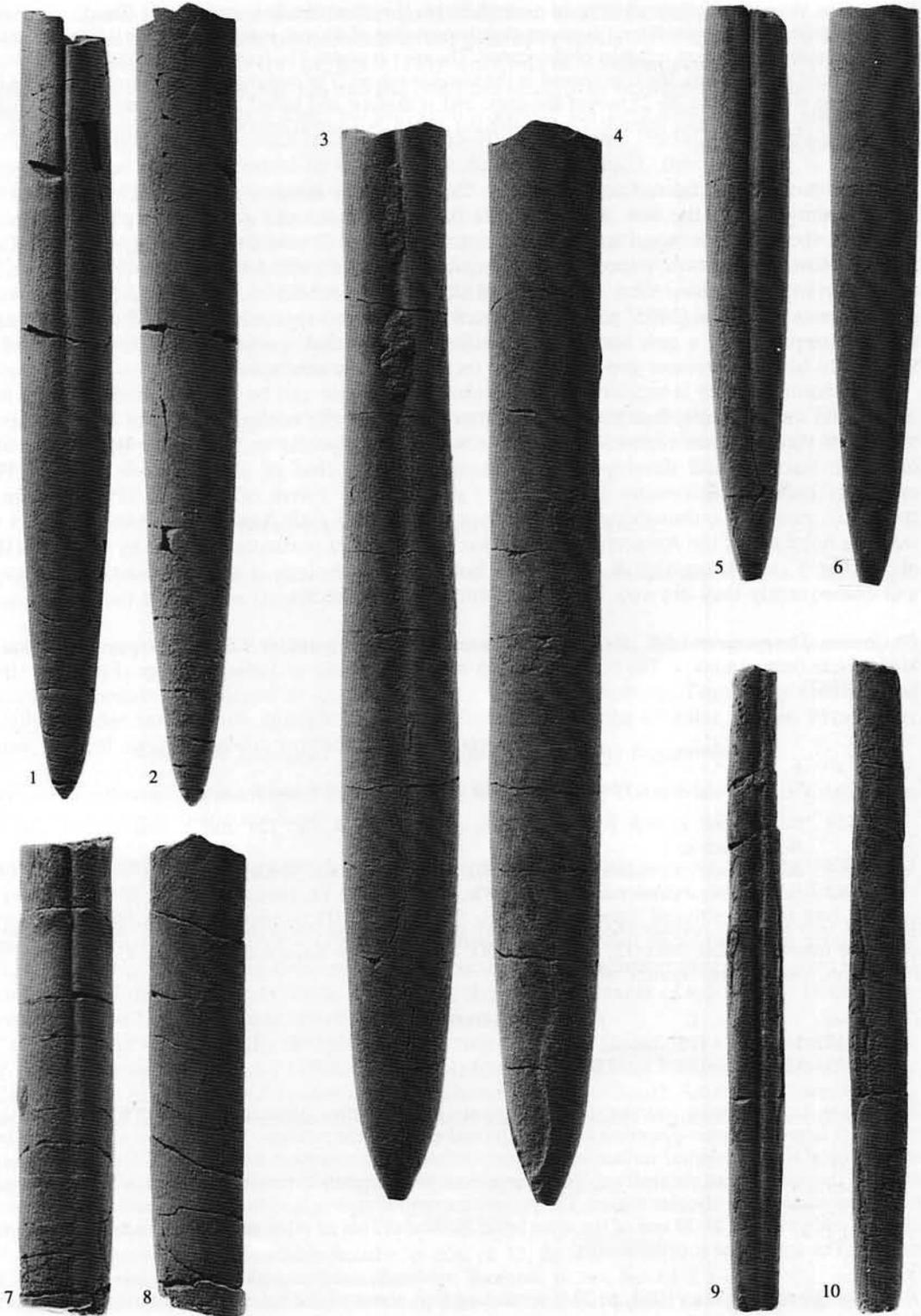
Derivation of name. In recognition of the Rt. Rev. Launcelot Fleming of the British Graham Land Expedition (1934-37), who was the first geologist to visit Alexander Island.

Diagnosis. Medium length (typical $l = 85-90$ mm), moderately robust *Belemnopsis*. Outline hastate, profile asymmetrical and non-hastate. Apex acute. Cross-sections depressed in apical and stem regions, compressed in alveolar region. Prominent ventral groove extending from alveolar end to within 20-25 mm of apex; groove shallow and broad in stem region, but becomes slightly narrower in anterior portion.

<i>Dimensions</i>	<i>L</i>	<i>l</i>	<i>Dl</i> max	<i>Dv</i>
KG. 3401.100	102	80*	12.2	12.1
KG. 3455.4	86	85*	11.8	10.7
KG. 3455.16	97	84	11.4	10.8
KG. 3455.19	111	82	12.7	12.5
KG. 3455.28	110	100*	12.3	12.0
KG. 3455.64 (Holotype)	125	91	12.3	11.4

EXPLANATION OF PLATE 8

- Figs 1, 2, 7 and 8. *Belemnopsis (Telobelelemnopsis) rymilli* sp. nov. Valanginian-?Hauterivian, Leda Ridge. 1, ventral outline. 2, right profile. Holotype, KG. 3455.195, $\times 1$. 7, ventral outline. 8, left profile. Paratype, KG. 3455.179, $\times 1$.
 Figs 3 and 4. *B. (Belemnopsis) aff. alexandri* Willey. Valanginian, Leda Ridge. 3, ventral outline. 4, left profile. KG. 3461.41, $\times 1$.
 Figs 5 and 6. *B. (B.) launceloti* sp. nov. Valanginian-?Hauterivian, Leda Ridge. 5, ventral outline. 6, right profile. Paratype, KG. 3455.40, $\times 1$.
 Figs 9 and 10. *B. (B.) cf. extenuatus* Yang and Wu. Valanginian-?Hauterivian, Leda Ridge. 9, ventral outline. 10, left profile. KG. 3455.45, $\times 1$.



HOWLETT: *Belemnopsis*

Description. Moderately robust rostrum of medium length (l = approximately seven times D_{\max}). The outline is hastate, with the maximum lateral diameter slightly posterior of the mid-point. The profile is non-hastate and weakly asymmetrical due to inflation of the venter. The apex is acute. The transverse sections are depressed in the apical and stem regions, but compressed in the alveolar region. The prominent ventral groove extends from the anterior end to within 20–25 mm of the apex, and is shallow and broad in the stem region, but narrows slightly and develops steeper shoulders in the alveolar region. No lateral lines or other grooves are visible. The apical line is ortholineate.

Remarks. A specimen figured as *B. africanus* Tate (1867) by Besairie (1936, pl. 23, figs 6 and 7) is considered typical of the new species on the basis of its size and general morphology. Besairie described the specimen (together with another, pl. 23, figs 20 and 21) as a thin variety of Tate's species. However, Besairie's specimen is elongate, moderately slender and hastate in outline, and more akin to *B. launzeloti* than *B. africana*, which is short, robust and cylindrical (see remarks for *B. gladiatoris*). Stevens (1965, p. 165) suggested that the two specimens of *B. africana* of Besairie probably represented a new species, but as Besairie's second specimen (pl. 23, figs 20 and 21) appears to have a narrower groove it is not included in the new species.

B. gladiatoris Willey is similar to *B. launzeloti* sp. nov. but can be distinguished by being more robust and less markedly hastate than the latter. Although the ventral grooves of both species are similar in the mid-stem region, they differ towards the alveolar region where the groove of *B. launzeloti* narrows and develops steeper shoulders, than that of *B. gladiatoris*. Willey (1973) originally included *Belemnites (Belemnopsis) patagoniensis* Favre of Feruglio (1936) within his species *B. gladiatoris*, though none of the four illustrated South American specimens agrees well with the holotype of the Antarctic species. Two specimens, in particular, figured by Feruglio (1936, pl. 10, figs 3 and 4) resemble *B. gladiatoris*, but their morphology is much closer to *B. launzeloti*, and consequently they are now included within this new species.

Occurrence. The specimen of *B. (B.) launzeloti* illustrated by Besairie (1936) is from the Upper Valanginian of Madagascar (near Ambiky). The South American examples are also of Valanginian age (Feruglio 1936; cf. Leanza 1967).

Belemnopsis (Belemnopsis) cf. extenuatus, Yang and Wu, 1964

Plate 8, figs 9 and 10; Plate 9, figs 5 and 6

p?1939 *Belemnopsis gerardi* (Oppel); Spath, p. 110, pl. 24, fig. 12a and b [non figs 11 and 13 = *Belemnopsis* sp.].

cf. *1964 *Belemnopsis extenuatus* Yang and Wu, p. 203, pl. 4, fig. 5a and b.

cf. 1982 *Belemnopsis extenuatus* Yang and Wu; Chen, p. 302, pl. 15, figs 10–12.

Material. One complete rostrum (KG. 3455.7), two nearly complete rostra (KG. 3461.133 and KG. 3455.45) and three fragments (KG. 3461.127, .145 and KG. 3455.17) from Leda Ridge (text-fig. 1); Spartan Glacier Formation, Valanginian–Hauterivian.

<i>Dimensions</i>	<i>L</i>	<i>l</i>	<i>D</i> _{max}	<i>D</i> _v max
KG. 3455.7	126	113	8.5	8.1
KG. 3455.45	102	130*	9.5	9.3

Description. Large, slender rostrum (l is approximately fifteen times D_{\max}). The outline is hastate, with the maximum lateral diameter occurring at about the mid-point of the rostrum. The profile is also hastate, but is asymmetrical with the ventral surface being slightly inflated. The maximum dorso-ventral diameter also occurs at about the mid-point of the rostrum. Transverse sections are slightly depressed in the apical and stem regions, but compressed in the alveolar region. The prominent ventral groove is wide and deep, and extends from the alveolar end to within 20–30 mm of the acute apex. No lateral lines or other grooves are visible on the material studied. The apical line is ortholineate.

Remarks. Yang and Wu (1964, p. 204) remarked that some of the belemnites described as *B. gerardi*

(Oppel) by Spath (1939) from the Salt Range in Pakistan, should be included in the species *B. extenuatus*, although they made no reference to any particular specimen or figure. Spath illustrated three specimens of *B. gerardi* (pl. 24, figs 11–13), only one of which appears to be similar to *B. extenuatus* (Spath 1939, pl. 24, fig. 12a and b). There are similarities between this specimen and true *B. gerardi*, but *B. gerardi* has a long, narrow ventral groove reaching almost to the apex, and a typical length from the protoconch to the apex of 65–70 mm (Stevens 1963a). As Spath's pl. 24, fig. 12 appears to be almost identical to some of the Antarctic material, this specimen is therefore tentatively included in *B. extenuatus*. This specimen was considered to be of Cretaceous age by Spath (1939, p. 111). However, Stevens (1965, p. 150) thought that it, and the other belemnites from the Salt Range, were all derived from the underlying Upper Jurassic horizons as *B. gerardi* (Oppel 1865, p. 296, pl. 88, figs 1–3) is a typical Kimmeridgian–Lower Tithonian belemnite elsewhere in the Indo-Pacific region (Teichert 1940; Glaessner 1945; Stevens 1963a). Despite this, Fatmi (1972, p. 363) agreed with Spath that the age of the locality was Berriasian or Valanginian, but thought that the belemnites found there were not derived. He therefore suggested that a long age range for *B. gerardi* was the only logical conclusion.

Occurrence. *B. (B.) extenuatus* Yang and Wu has been described from the Valanginian of southern Tibet (Yang and Wu 1964; Chen 1982) and is now thought also to occur in the Berriasian or Valanginian of the Salt Range in Pakistan.

Subgenus PARABELEMNOPSIS subgen. nov.

Type species. *Belemnites madagascariensis* Besairie 1930; Andrafiavelo (Madagascar); Tithonian (Upper Jurassic) to ?Lower Hauterivian (Lower Cretaceous).

Derivation of name. *Para* (Greek) meaning near; *Belemnopsis*, the genus that this new group resembles.

Diagnosis. Elongate, cylindrical or conical rostrum, frequently robust. Transverse sections are typically circular throughout, though sometimes compressed in the alveolar region. Prominent, narrow, ventral alveolar groove extends almost to apex.

Range and distribution. Kimmeridgian (Upper Jurassic) to Valanginian–Hauterivian (Lower Cretaceous); Madagascar, Alexander Island and South America.

Remarks. This subgenus is characterized by the tapering, non-hastate rostrum, and by the form of the narrow, deep, ventral groove. Three species show these characters, namely: *Belemnopsis (Parabelemnopsis) madagascariensis* (Besairie 1930), *B. (P.) casterasi* Besairie (1936) and *B. (P.) patagoniensis* (Favre 1908). Stevens (1965, p. 160) first suggested that these formed a group quite distinct from other Indo-Pacific *Belemnopsis*, and speculated as to whether they represented isolated developments of the Indo-Pacific stock, or whether they were remnants of a Southern Hemisphere equivalent of the Upper Jurassic 'Boreal' assemblage.

B. (P.) casterasi was originally thought to be restricted to Madagascar, but a specimen figured as *B. cf. stolleyi* Stevens by Jeletzky (1983, pl. 2, fig. 4) from the Falkland Plateau appears to be very similar to *B. (P.) casterasi*. *B. (P.) patagoniensis* is known only from South America, whereas *B. (P.) madagascariensis* occurs in Madagascar, South America and possibly Antarctica (see below).

Belemnopsis (Parabelemnopsis) cf. madagascariensis (Besairie, 1930)

Plate 9, figs 3 and 4

- cf. *.1930 *Belemnites madagascariensis* Besairie, p. 208, pl. 13, fig. 4
- cf. 1977 *Belemnopsis cf. madagascariensis* (Besairie); Riccardi, p. 244, figs 6d–f, j–i.
- cf. 1985 *Belemnopsis madagascariensis* (Besairie); Aguire-Urreta and Suárez, p. 1–9, pl. 1, figs a–y.

Material. One complete rostrum (KG. 3455.87) and one distorted, but nearly complete rostrum (KG. 3455.86) from Leda Ridge (text-fig. 1); Spartan Glacier Formation, Valanginian-Hauterivian.

<i>Dimensions</i>	<i>L</i>	<i>l</i>	<i>DI</i>	<i>Dv</i>
KG. 3455.87	136	115	16.6	16.9

Description. Large, robust rostrum, the length of which is about seven times the lateral diameter at the protoconch (*DI*). Both outline and profile are conical, but the profile is slightly asymmetrical due to slight inflation of the venter. The apex, though partially missing, appears to be very acute. Transverse sections are compressed in the alveolar region, but circular throughout the remainder of the rostrum. A prominent, narrow ventral groove extends from the anterior end to about 20 mm from the apex. No lateral lines are visible. The apical line is ortholineate.

Remarks. The specimens differ from the original description and illustration of *B. (P.) madagascariensis* (Besairie 1930, p. 208) in that the apical region is less inflated and the specimens are slightly smaller. However, strong similarities exist, in general shape, and morphology of the ventral groove. The South American specimens described by Aguirre-Urreta and Suárez (1985), though poorly preserved, appear to be closer to the lectotype than the two rostra described above.

A strong similarity exists between the Antarctic specimens *B. (P.) madagascariensis* s.s. and *B. (P.) patagoniensis* (Favre), though the latter has a more narrow, shallow ventral groove (see Stevens 1965, p. 160). *B. (P.) casterasi* Besairie is also similar but this species is more slender and also has a narrower groove than the Antarctic material.

Occurrence. *B. (P.) madagascariensis* has been reported from the Tithonian-?Lower Hauterivian of Madagascar (Besairie 1930; Besairie and Collignon 1956), the Tithonian-Valanginian of southernmost Chile (Aguirre-Urreta and Suárez 1985) and the ?Berriasian of Argentina (Riccardi 1977).

Subgenus *TELOBELEMNOPSIS* subgen. nov.

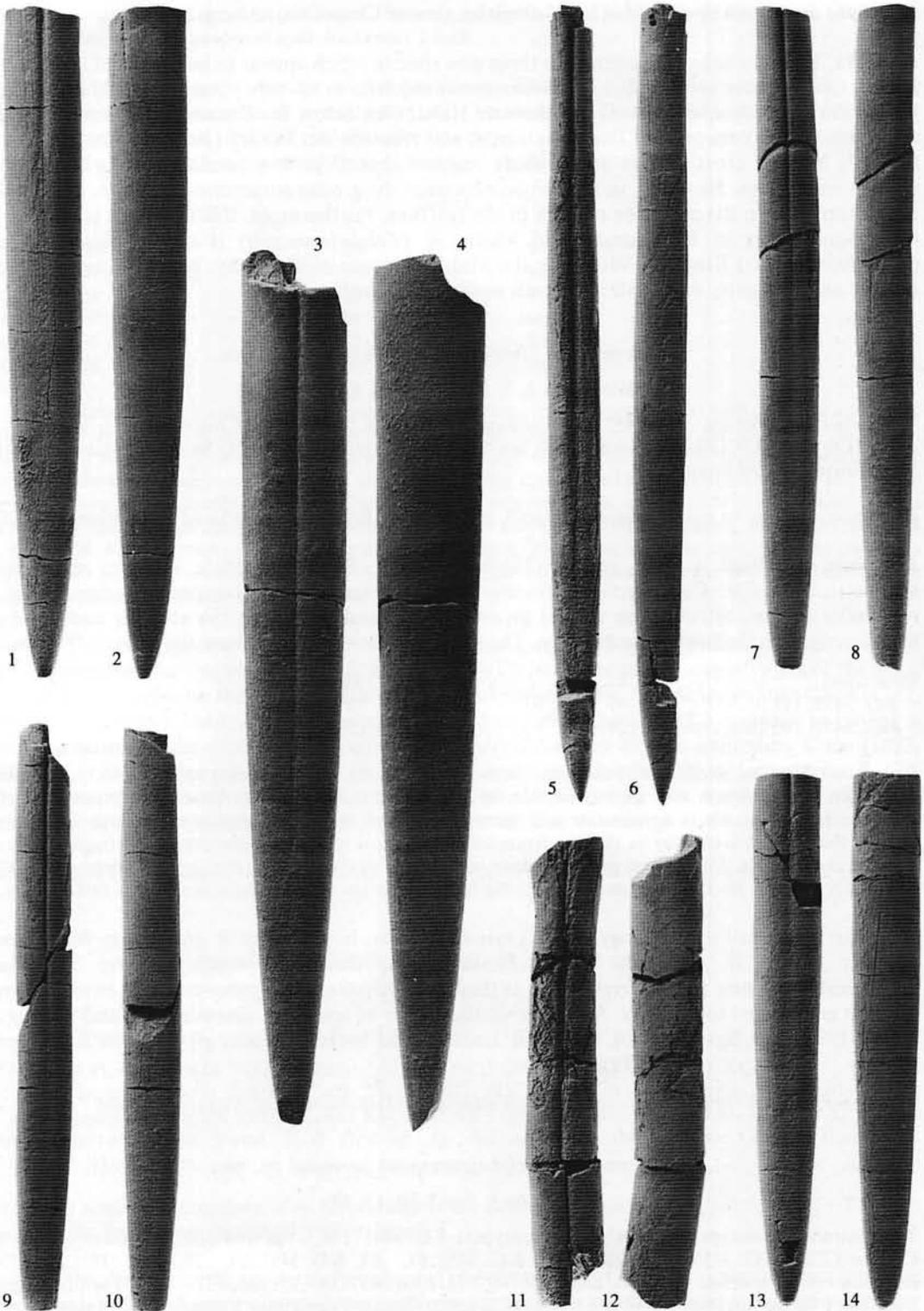
Type species. *Belemnopsis (Telobelelemnopsis) bertrami* sp. nov.; Leda Ridge, Ganymede Heights, Alexander Island (Antarctica); Spartan Glacier Formation, ?Hauterivian.

Derivation of name. *Telo* (Greek) meaning 'end'; *Belemnopsis*, the genus which this new group resembles.

Diagnosis. Medium length, slender to robust, cylindrical or sub-hastate *Belemnopsis*. Transverse sections are usually circular, but may be depressed at the apex and compressed in the alveolar region. A prominent, narrow, ventral alveolar groove extends into the upper stem, beyond which it may continue as a broad furrow some way past the mid-point of the rostrum, or shallow away completely. On some species, the venter in the lower stem is slightly flattened.

EXPLANATION OF PLATE 9

- Figs 1 and 2. *Belemnopsis (Telobelelemnopsis) stephensoni* sp. nov. Valanginian-?Hauterivian, Leda Ridge. 1, ventral outline. 2, right profile. Holotype, KG. 3457.38, $\times 1$.
 Figs 3 and 4. *B. (Parabelemnopsis) cf. madagascariensis* (Besairie). Valanginian-?Hauterivian, Leda Ridge. 3, ventral outline. 4, right profile. KG. 3455.87, $\times 1$.
 Figs 5 and 6. *B. (Belemnopsis) cf. extenuatus* Yang and Wu. Valanginian-?Hauterivian, Leda Ridge. 5, ventral outline. 6, right profile. KG. 3455.7, $\times 1$.
 Figs 7-10, 13 and 14. *B. (T.) bertrami* sp. nov. Valanginian-?Hauterivian, Leda Ridge. 7, ventral outline. 8, right profile. Holotype, KG. 3456.47, $\times 1$. 9, ventral outline. 10, right profile. Paratype, KG. 3457.31, $\times 1$. 13, ventral outline. 14, right profile. Paratype, KG. 3455.151, $\times 1$.
 Figs 11 and 12. *Hibolithes belligerundi* Willey. Upper Tithonian, Himalia Ridge. 11, ventral outline. 12, right profile. KG. 2922.11b, $\times 1$.



HOWLETT: *Belemnopsis* and *Hibolithes*

Range and distribution. Valanginian to ?Hauterivian (Lower Cretaceous); Alexander Island.

Remarks. This new subgenus comprises three new species which appear to be restricted to Alexander Island. One of these species (*B. (Telobelelemnopsis) stephensoni* sp. nov.) was originally described by Willey (1973) as *Neohibolites* cf. *miyakoensis* Hanai (see below for discussion). There are indeed some similarities between *B. (Telobelelemnopsis)* and *Neohibolites* Stolley (1911), in that both have a typically circular cross-section and a short, narrow ventral groove confined to the alveolar and upper stem regions. However, in *B. (Telobelelemnopsis)* the groove sometimes continues as a shallow, broad furrow into the posterior portion of the rostrum. Furthermore, this subgenus is much larger than *Neohibolites* in both length and width. *B. (Telobelelemnopsis)* is also comparable to *B. (Longibelelemnopsis)* Riegraf (1980) from the Middle Jurassic of Germany, but the latter is typically slender and elongate, and hastate in both outline and profile.

Belemnopsis (Telobelelemnopsis) rymilli sp. nov.

Plate 8, figs 1, 2, 7, 8; Plate 10, figs 11 and 12

Type material. Holotype: KG. 3455.195. Paratypes: KG. 3455.111 (complete rostrum), KG. 3455.91, .172, .174, .178 and .179 (all fragmentary). All are from Leda Ridge (text-fig. 1); Spartan Glacier Formation, Valanginian-?Hauterivian.

Derivation of name. In recognition of J. Rymill, leader of the British Graham Land Expedition (1934-37).

Diagnosis. Medium length, robust *Telobelelemnopsis*. Slightly hastate outline; non-hastate, symmetrical profile. Cross-sections circular in the apical region, compressed throughout the remainder of the rostrum. The ventral groove is deep and narrow at the alveolar end, gradually broadening and shallowing posteriorly. The groove ends some way from the apex.

<i>Dimensions</i>	<i>L</i>	<i>l</i>	<i>Dlmax</i>	<i>Dv</i>
KG. 3455.111	99	91	13.2	13.3
KG. 3455.195 (holotype)	124	89	14.8	15.5

Description. Medium sized, robust rostrum, the maximum lateral diameter being approximately six times the length (*l*). The outline is very slightly hastate, with the maximum lateral diameter slightly posterior of the protoconch. The profile is non-hastate and symmetrical, and the apex is moderately acute. In transverse section, the rostrum is circular or slightly depressed in the apical region, but compressed throughout the stem and alveolar regions. The ventral groove is deep and narrow at the alveolar end, but broadens and shallows posteriorly, ending 30-35 mm from the apex. No lateral lines are visible. The apical line is ortholineate.

Remarks. In overall morphology, *B. (T.) rymilli* sp. nov. is similar to *B. gladiatoris* Willey and to a lesser extent, *B. alexandri* Willey. However, the distinctive ventral groove immediately distinguishes the new species from them, as they both possess broad grooves which extend from the alveolar end almost to the apex. A further similarity can be seen in *B. sinensis* Yang and Wu (figured by Wu 1982, pl. 2, figs 9 and 10), though *B. sinensis* has a longer, broader groove than *B. (T.) rymilli* sp. nov.

Occurrence. *B. (T.) rymilli* is restricted to the Valanginian-?Hauterivian of Alexander Island.

Belemnopsis (Telobelelemnopsis) bertrami sp. nov.

Plate 9, figs 7-10, 13, 14

Type material. Holotype: KG. 3456.47. Paratypes: KG. 3401.134, .169 and .307 (all fragmentary) from Callisto Cliffs; KG. 3455.151, .205, .207, KG. 3456.61, .67, KG. 3457.24, .28, .31, .32, .34, .53 (all complete rostra) and KG. 3455.51, KG. 3456.30, .78, KG. 3457.14, .27, .35, .37, .44, .51 (all fragmentary) from Leda Ridge (text-fig. 1). All are from the Spartan Glacier Formation, Valanginian-?Hauterivian.

Derivation of name. In recognition of G. C. L. Bertram of the British Graham Land Expedition (1934-37), who was among the first people to visit Alexander Island.

Diagnosis. Medium length, slender *Telobelelemnopsis*. Outline slightly hastate, profile slightly asymmetrical and non-hastate or weakly hastate. Acute apex. Transverse sections depressed in apical and stem regions, circular in the alveolar region. Ventral groove narrow extending to approximately mid-point, after which it is broad and shallow.

<i>Dimensions</i>	<i>L</i>	<i>l</i>	<i>Dlmax</i>	<i>Dv</i>
KG. 3455.151	83	80	10.9	10.7
KG. 3455.207	106	105*	10.4	9.4
KG. 3456.47 (holotype)	104	100*	9.7	9.3
KG. 3456.61	89	85*	10.8	9.8
KG. 3456.67	98	86	10.3	10.1
KG. 3457.31	102	83	8.9	8.8
KG. 3457.34	115	100*	9.5	9.0

Description. Slender rostrum of medium length (*l* is approximately ten times *Dlmax*) with an acute apex. The outline is slightly hastate, with the maximum lateral diameter occurring anterior of the mid-point. In profile, the rostrum is slightly asymmetrical and non-hastate or very weakly hastate. The transverse sections are depressed in the apical and stem regions, but circular or slightly compressed in the alveolar region. The ventral groove is narrow and relatively deep in the alveolar and upper stem region, and extends from the anterior end to at least the mid-point of the rostrum or further, gradually shallowing and broadening. On some specimens (e.g. KG. 3456.47) the groove finally disappears approximately 20-30 mm from the apex, whereas on others (e.g. KG. 3456.67) the groove is indistinct at the mid-point, apart from flattening of the venter. No lateral lines are visible, and the apical line is ortholineate.

Remarks. This new species is similar to three existing species from the Tithonian-Berriasian of Tibet. *Belemnopsis muricatus* Chen (1982, pl. 18, figs 7-17) has a ventral groove which is of the same length as *B. (T.) bertrami*, though it is rather wider, and non-hastate. *Hibolites gracilis* Chen (1982, pl. 19, figs 1-6) has a long, narrow, ventral groove, but differs from *B. (T.) bertrami* in having a longer and more slender rostrum. The third species, *H. jiabulensis* Yin, as figured by Chen (1982, pl. 16, figs 5-14), is also similar to *B. (T.) bertrami* but has a shorter and wider groove. *B. (T.) bertrami* also resembles *H. joleaudi* Besairie (1936, pl. 22, figs 5-8), but the latter is markedly depressed and, like *H. jiabulensis*, it has only a short, slit-like ventral groove.

Occurrence. *B. (T.) bertrami* is restricted to the Valanginian-?Hauterivian of Alexander Island.

Belemnopsis (Telobelelemnopsis) stephensoni sp. nov.

Plate 9, figs 1 and 2; Plate 10, figs 1-4

v. 1973 *Neohibolites* cf. *miyakoensis* Hanai; Willey, p. 51, fig. 7c-e.

Type material. Holotype: KG. 3457.38. Paratypes: KG. 3455.200, .209, KG. 3456.73, KG. 3457.11, .17, .22 and .33 (all complete rostra), and KG. 3456.28, .58, KG. 3457.3 and .30 (all fragments) from Leda Ridge; KG. 3676.16 (nearly complete rostrum), and KG. 3685.1a-f (all fragments) from Aeolus Ridge; KG. 3151.2 (complete rostrum) from Fossil Bluff (text-fig. 1). All are from the Spartan Glacier Formation, Valanginian-?Hauterivian.

Derivation of name. In recognition of A. Stephenson of the British Graham Land Expedition (1934-37), who was among the first people to visit Alexander Island.

Diagnosis. Medium length, moderately robust *Telobelelemnopsis*. Cylindrical outline and conical, asymmetrical profile. Apex moderately acute. Cross-sections slightly depressed at the apex, circular

in the stem and compressed in the alveolar region. Narrow ventral groove extends from alveolar end to mid-point of rostrum. Venter slightly flattened in posterior half.

Dimensions	<i>L</i>	<i>l</i>	<i>DI</i>	<i>Dv</i>
KG. 3455.200	127	87	13.8	13.6
KG. 3455.209	131	77	15.7	15.8
KG. 3456.73	130	84	14.5	14.5
KG. 3457.11	102	66	12.8	13.7
KG. 3457.22	127	81	12.9	13.1
KG. 3457.33	115	94	13.3	13.9
KG. 3457.38 (holotype)	104	99	12.2	12.2

Description. Moderately robust rostrum of medium length (*l* is approximately six times *DI*). In outline, the rostrum is cylindrical, and in profile it is asymmetrical and conical, with the ventral surface slightly inflated. The apex is moderately acute. The cross-sections are typically slightly depressed in the apical region, circular or sub-circular in the stem and compressed in the alveolar region. A narrow ventral groove extends from the alveolar end to approximately the mid-point of the rostrum, after which the venter is slightly flattened. The groove is at its deepest in the alveolar region, but shallows rapidly throughout its length. No lateral lines or other grooves are visible. The apical line is ortholineate.

Remarks. Specimens of this new species were originally compared by Willey (1973) with *Neohibolites myakoensis* Hanai from the Aptian of Japan (Hanai 1953). However, *B. (T.) stephensoni* is non-hastate, much larger and more robust than *N. miyakoensis*. *B. (T.) stephensoni* most closely resembles *B. (T.) rymilli* which is noticeably compressed with a long, prominent groove. Some similarities exist between *B. (T.) stephensoni* and *B. (P.) madagascariensis* (Besairie 1930), but the Madagascan species possesses a much longer and more prominent ventral groove, as well as being typically more robust than *B. (T.) stephensoni*.

Occurrence. This species is restricted to the Valanginian-?Hauterivian of Alexander Island.

Belemnopsis (Telobelelemnopsis) cf. stephensoni sp. nov.

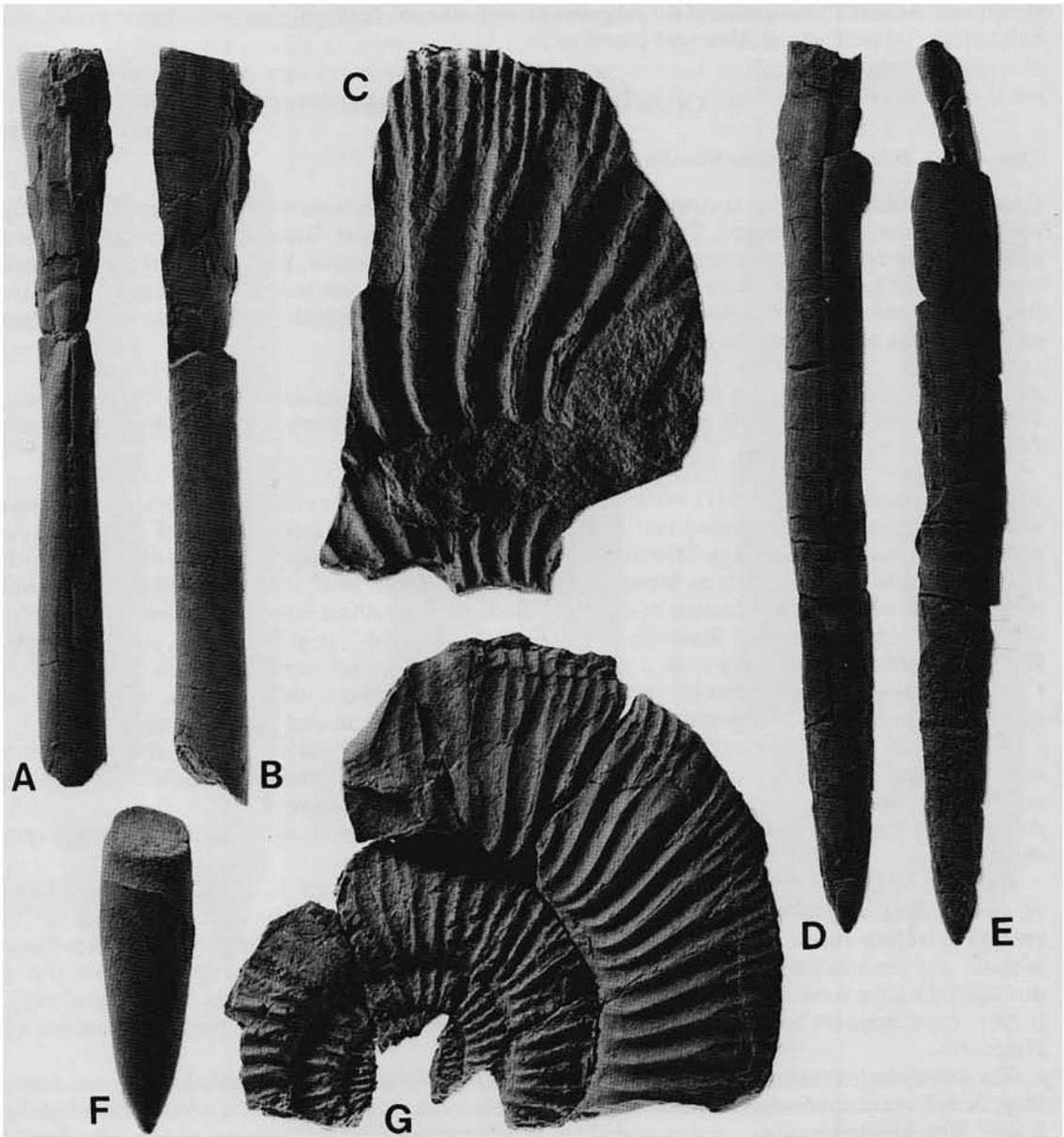
Text-fig. 2D, E

Material. One nearly complete rostrum (KG. 3455.149) and eight fragments (KG. 3455.144, KG. 3456.2, .34, .36, .45, .70, .74 and .101) from Leda Ridge (text-fig. 1); Spartan Glacier Formation, Valanginian-?Hauterivian.

Dimensions	<i>L</i>	<i>l</i>	<i>DI</i> max	<i>Dv</i> max
KG. 3455.144	113	95*	11.8	11.9
KG. 3455.149	129	77	—	—
KG. 3456.45	98	80*	13.3	14.3

Description. Moderately robust rostrum of medium length, *l* being approximately seven times the maximum lateral diameter (*DI*max). The outline is hastate, with *DI*max situated slightly anterior of the mid-point. The profile is symmetrical and weakly hastate. In transverse section, the rostrum is circular near the acute apex, but compressed throughout the rest of the length. A narrow ventral groove extends from the alveolar end to the upper stem or mid-point of the rostrum, shallowing rapidly throughout its length. Lateral lines are not visible on any of the specimens and the apical line is ortholineate.

Remarks. These specimens are, in general, similar to *B. (T.) stephensoni* sp. nov. (see above). However, they differ in being more slender, and hastate in both outline a profile. Also, unlike *B. (T.) stephensoni*, after the mid-point of the rostrum on *B. (T.) cf. stephensoni*, there is no visible flattening of the venter.



TEXT-FIG. 2. A, B and F. *Hibolites* aff. *windhoweri* Stolley. Upper Tithonian-Berriasian, Callisto Cliffs. A, ventral outline. B, right profile. KG. 2802.250, $\times 1$. F, ventral outline of apical region KG. 2803.137, $\times 1$. C. *Virgatosphinctes* cf. *andesensis* (Douvillé). Lower Tithonian, Belemnite Point. KG. 1854.103, $\times 1$. D and E. *Belemnopsis* (*Telobelemnopsis*) cf. *stephensoni* sp. nov. Valanginian-?Hauterivian, Leda Ridge. D, ventral outline. E, right profile. KG. 3455.149, $\times 1$. G. *Virgatosphinctes* cf. *haydeni* Uhlig. Lower Tithonian, Himalia Ridge. KG. 2910.32, $\times 1$.

Occurrence. As with all the species of the subgenus *Telobolemnopsis*, *B. (T.) cf. stephensoni* is restricted to the Valanginian-?Hauterivian of Alexander Island.

Genus *HIBOLITHES* Montfort, 1808

Type species. *Hibolites hastatus* Montfort, 1808, by monotypy.

Diagnosis. Slender to robust rostrum. Symmetrical and hastate in both outline and profile, typically with an attenuated stem region. Transverse sections usually circular, though sometimes compressed in the alveolar region. Apex commonly acute. Shallow, ventral groove, typically short and confined to the anterior half of the rostrum. No dorsal or lateral grooves, but lateral lines (*Doppellinien*) are frequently preserved, being closely paired and parallel, in the apical and lower to middle stem regions. In the upper stem they slowly diverge and disappear.

Range and distribution. Bajocian (Middle Jurassic) to Aptian (Lower Cretaceous); Europe, Pakistan, India, Tibet, Africa, Madagascar, South East Asia, New Zealand, Australia, western Antarctica, South and North America.

Remarks. Fischer (1887, p. 363) considered that the name *Hibolites* was invalid because the genus was poorly defined and suggested that Montfort had in fact illustrated a species of *Duvalia* Bayle as *Hibolites hastatus*. Although Montfort's illustration is rather mis-shaped, it is hard to agree with Fischer's conclusion, especially as Montfort's description, albeit brief, does not indicate any lateral compression, which is a key feature of most duvaliids. Some authors have interpreted the genus by using '*Belemnites hastatus*' of Blainville (1827, pl. 2, figs 4 and 4a), (e.g. Naef 1922, p. 249) as type. However, without designating it as a neotype, this usage does not conform to the International Code of Zoological Nomenclature (Ride *et al.* 1985). Furthermore, this specimen would also be inadequate as Blainville's illustration is of a fragment (upper stem and alveolar region only).

Hibolites is very similar to three other genera. *Mesohibolites* Stolley is shorter and has a more robust, conical shaped and depressed rostrum, with a long ventral groove. *Parahibolites* Stolley is much smaller and less hastate than *Hibolites*, and is markedly compressed throughout its length. *Neohibolites* Stolley is small, moderately robust, with a circular cross-section and typically a very short groove.

Riegraf (1981) described three subgenera of *Hibolites*: *Hibolites s. s.*, *H. (Rhopaloteuthis)* and *H. (Acutibelus)*. *H. (Rhopaloteuthis)* is based on the genus *Rhopaloteuthis* which Lissajous (1915) created to include rostra which were similar to *Hibolites* in that they were hastate, club-shaped and without any pronounced compression or depression, but which possessed a dorsal groove (i.e. a duvaliid). Despite some dispute concerning the type species (see Jeletzky 1972, p. 159; Riegraf 1981, p. 90), there appears to be little reason to consider this widely accepted genus a subgenus of *Hibolites*.

H. (Acutibelus) represents a long, slender form of *Hibolites* which is barely hastate and has a long, broad ventral groove. Riegraf (1981, p. 92) considered that this subgenus was restricted to the Lower Kimmeridgian *sensu anglico*, and there is no evidence that it is present in the Indo-Pacific province. All the *Hibolites* described below are *Hibolites s. s.*

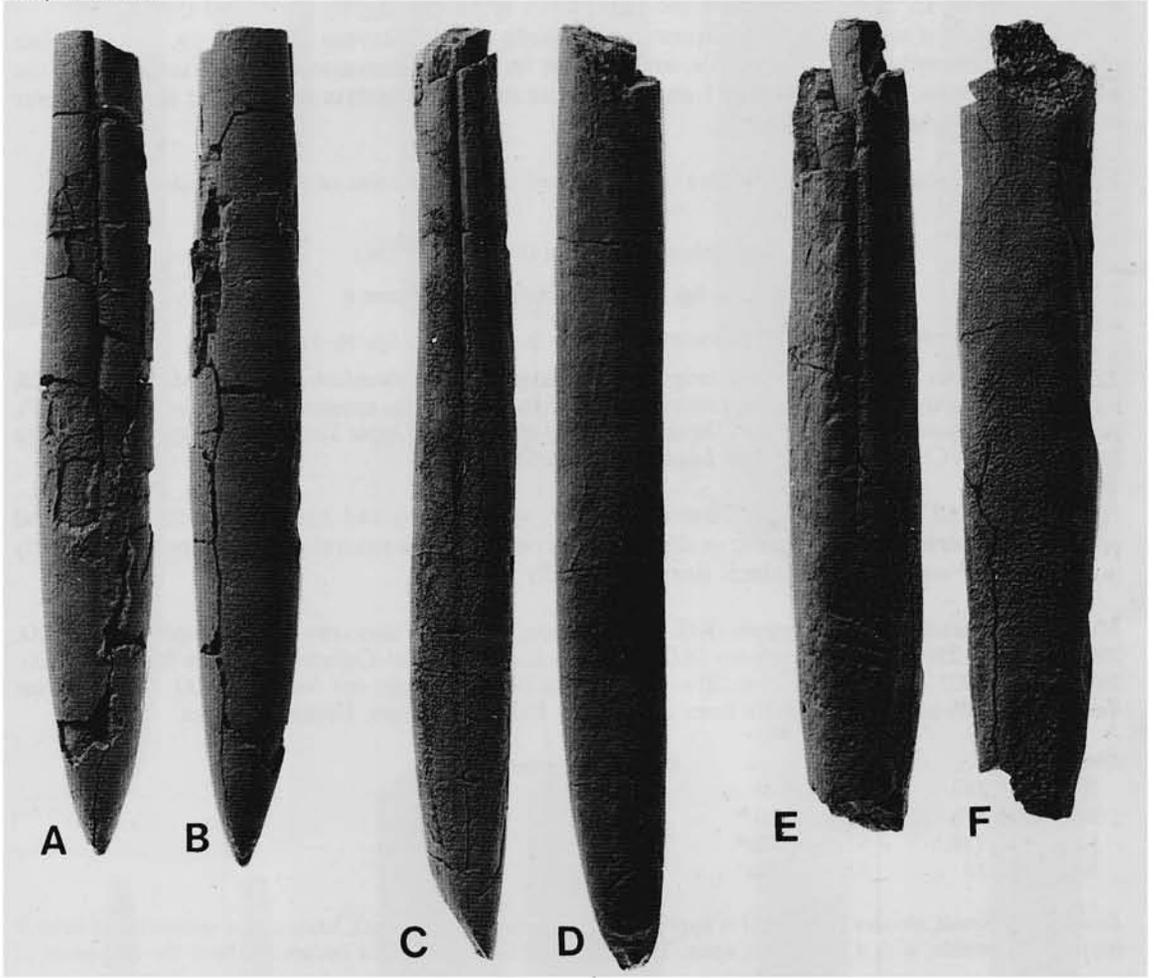
Hibolites belligerundi Willey, 1973

Plate 9, figs 11 and 12; text-fig. 3A-D

v *.1973 *Hibolites belligerundi* Willey, p. 43, fig. 5c and d.

Type specimen. Holotype: KG. 712.63a; Himalia Ridge, Alexander Island; Himalia Ridge Formation, Tithonian. The holotype is refigured here (text-fig. 3A and B), as the original illustration (Willey 1973, fig. 5c and d) is incomplete.

Diagnosis. Medium length (typical $l = 100$ mm), moderately robust rostrum. Outline is markedly hastate, whereas the profile is asymmetrical and only slightly hastate. Transverse sections are depressed in the apical and lower stem regions, but compressed in the upper stem and alveolar regions. Moderately deep ventral groove extending from alveolar region almost to apex. No lateral lines preserved.



TEXT-FIG. 3. A-D. *Hibolithes belligerundi* Willey. Upper Tithonian. A, ventral outline. B, right profile. Himalia Ridge. Holotype, KG. 712.63a, $\times 1$. C, ventral outline. D, left profile. Belemnite Point. KG. 1926.A, $\times 1$. E and F. *H. antarctica* Willey. Berriasian, Europa Cliffs. E, ventral outline. F, left profile. KG. 3235.5, $\times 1$.

Material. Four incomplete specimens (KG. 2910.14, KG. 2922.1, .11b and .18) from Himalia Ridge; one fragment (KG. 2802.49) from Callisto Cliffs; two nearly complete rostra (KG. 1926.A and .B) from Belemnite Point (text-fig. 1). All are from the Himalia Ridge Formation, Tithonian.

Dimensions	L	l	D_{\max}	D_{\min}
KG. 1926.A	127	105*	14.2	14.6
KG. 2922.11b	110	—	11.5	11.1

Remarks. Nothing further can be added to the definition of the species (see Willey 1973), as all the specimens are incomplete and poorly preserved.

Willey (1973, p. 45) compared this species with *H. verbeeki* Kruizinga (1921, pl. 6, figs 1 and 1a-c), from the Upper Jurassic of Taliabu Island, Indonesia, and *H. catlinensis* (Hector) from the Teraikan (Middle Jurassic) of New Zealand (Hector 1878, p. 486, pl. 22, figs 3a and b; Marwick 1953, p. 26, pl. 17, figs 1 and 2; Stevens 1965, p. 96, pl. 14, figs 1, 2, 6-8 and 16-18). *H. verbeeki* differs from *H. belligerundi* by its short, wide ventral groove and its more elongate upper stem and alveolar region. In transverse section the Indonesian species is slightly depressed throughout.

H. catlinensis is similar to *H. belligerundi* (especially that of Stevens 1965, pl. 14, figs 6-8), but differs by being symmetrical in profile, and circular in apical transverse section. Furthermore, the lectotype (Stevens 1965, pl. 14, figs 1 and 2) is more markedly hastate and slender in the alveolar region than the Antarctic species.

Occurrence. *H. belligerundi* Willey appears to be restricted to the Tithonian of Alexander Island.

Hibolithes argentinus (Feruglio, 1936)

Plate 6, figs 4 and 10; Plate 10, figs 7 and 8

v *.1936 *Belemnites* (*Hibolites*?) *argentinus* Feruglio, p. 85, pl. 10, figs 16-19.

Type specimen. No type specimen was designated by Feruglio (1936), therefore those figured by him (pl. 10, figs 16-19) are syntypes. Complete measurements are given for only one specimen (pl. 10, fig. 17; FCB 448), and this is designated as the lectotype. The specimens are all from the Upper Tithonian of Argentina (Laguna Anita-l'Estancia Cristina area north of Lago Argentina, Santa Cruz).

Diagnosis. Small (approx. $l = 65-70$ mm), slender, symmetrical and hastate in both outline and profile. Transverse sections circular or slightly depressed. Shallow ventral groove extends posteriorly into the upper stem region. Lateral lines not usually seen.

Material. One nearly complete rostrum (KG. 2909.18) from Ablation Valley; two nearly complete rostra (KG. 2809.175 and .259) and two fragments (KG. 2082.160 and .195) from Callisto Cliffs; five fragments (KG. 2918.4, KG. 2923.3a, .3b, KG. 2940.20 and .41) from Himalia Ridge; one fragment (KG. 2803.84) from Tombaugh Cliffs (text-fig. 1). All are from the Himalia Ridge Formation, Upper Tithonian.

<i>Dimensions</i>	<i>L</i>	<i>l</i>	<i>Dlmax</i>	<i>Dvmax</i>
KG. 2802.160	46	—	5.0	4.8
KG. 2802.175	53	50*	4.6	4.7
KG. 2802.259	67	70*	5.8	5.8
KG. 2909.18	83	80*	5.7	5.5

Description. Small, slender rostrum (l is approximately eleven times $Dlmax$), hastate and symmetrical in both outline and profile, with a very acute apex. The maximum lateral diameter occurs at about the mid-point of

EXPLANATION OF PLATE 10

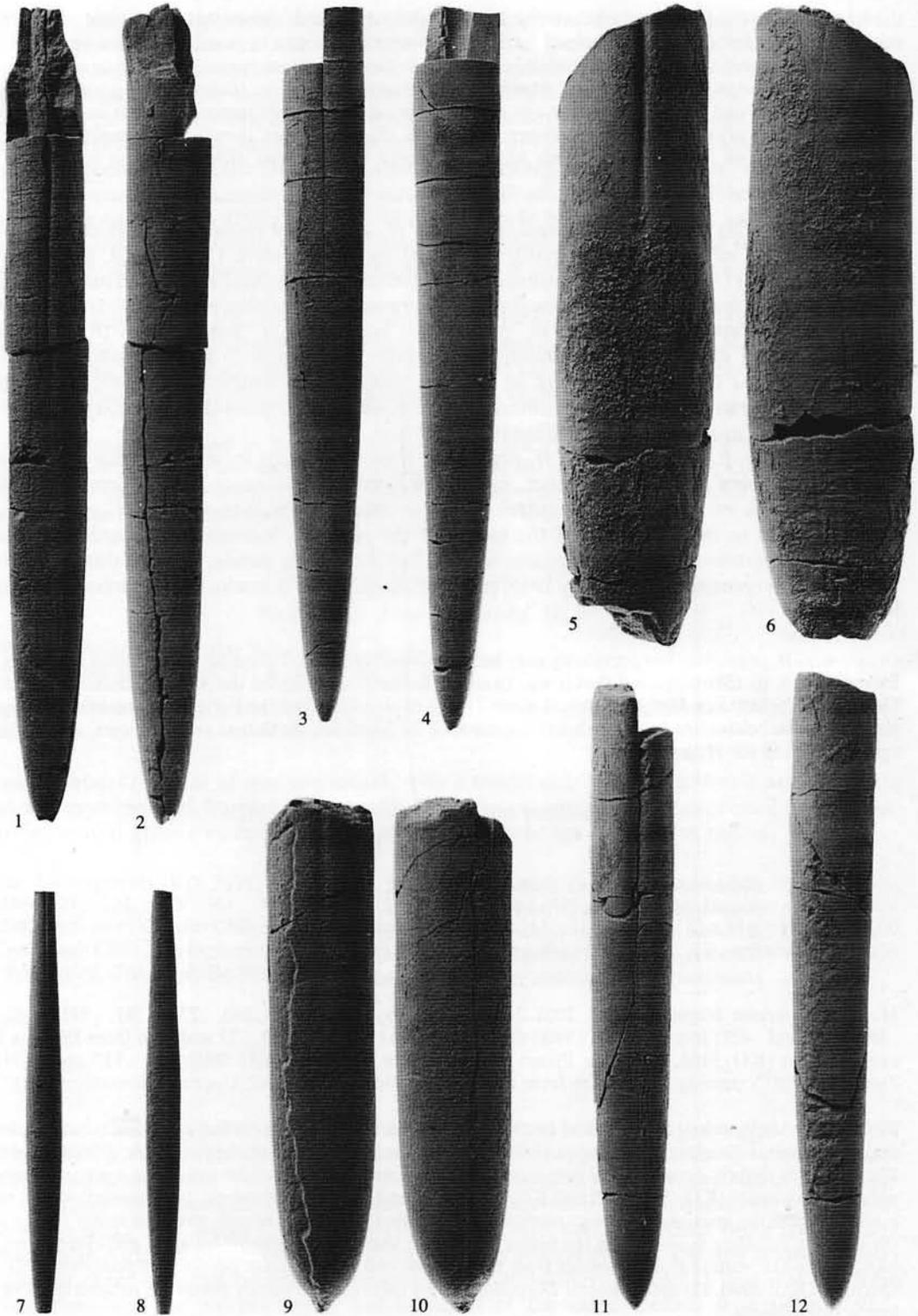
Figs 1-4. *Belemnopsis* (*Telobelelemnopsis*) *stephensoni* sp. nov. Valanginian-?Hauterivian, Leda Ridge. 1, ventral outline. 2, right profile. Paratype, KG. 3457.22, $\times 1$. 3, ventral outline. 4, right profile. Paratype, KG. 3457.33, $\times 1$.

Figs 5 and 6. *Hibolithes* cf. *antarctica* Willey. Berriasian, Callisto Cliffs. 5, ventral outline. 6, left profile. KG. 2802.609, $\times 1$.

Figs 7 and 8. *H. argentinus* (Feruglio). Upper Tithonian, Callisto Cliffs. 7, ventral outline. 8, right profile. KG. 2802.259, $\times 1$.

Figs 9 and 10. *H. antarctica* Willey. Berriasian, Europa Cliffs. 9, ventral outline. 10, left profile. KG. 3235.4, $\times 1$.

Figs 11 and 12. *B. (T.) rymilli* sp. nov. Valanginian-?Hauterivian, Leda Ridge. 11, ventral outline. 12, right profile. Paratype, KG. 3455.111, $\times 1$.



the rostrum. The transverse sections are circular or slightly depressed, especially in the apical region, though some specimens are slightly compressed in the upper stem or alveolar regions. A shallow, narrow ventral groove extends from the anterior end of the rostrum into the upper stem region, reaching in some specimens almost to the point of maximum lateral diameter. Faint double lateral lines (*Doppellinien*) are present on parts of KG. 2802.254 and KG. 2940.41, but not on the other rostra. The phragmocone is not usually preserved. The apical line is ortholineate. One specimen (KG. 2909.18) has a short, dorsal apical groove, but as this is not seen on any of the other specimens and is unknown in the genus *Hibolithes*, it is considered to be pathological.

Remarks. Feruglio (1936, p. 85) considered that *H. argentinus* resembled most closely juvenile examples of *H. subfusiformis* (Raspail), illustrated by Duval-Jouve (1841, pl. 9, fig. 2), and *H. jaculum* (Phillips) (= *H. jaculoides* Swinnerton). However, in both these species the maximum lateral diameter occurs much nearer the apex than in *H. argentinus*, resulting in a more hastate shape and a more obtuse apex. Feruglio (1936, p. 86) also compared *H. argentinus* with ?*Belemnopsis carpaticus* Uhlig and *Oxyteuthis hibolitiformis* Stolley. *B. carpaticus* is more fusiform, with the maximum lateral diameter occurring at the mid-point of the rostrum, *O. hibolitiformis* has its maximum diameter occurring in the anterior portion, and furthermore the genus *Oxyteuthis* Stolley has no alveolar grooves and a cyrtolineate apical line.

Stevens (1965, p. 159) compared *H. argentinus* with the slender forms of *H. marwicki marwicki* Stevens from New Zealand; however, even these forms are more robust. Moreover, in all the specimens of *H. m. marwicki* the ventral groove is much longer than that of *H. argentinus*, as it extends for up to three-quarters of the length of the rostrum. Stevens also recorded a similarity between *H. argentinus* and *H. compressus* Stolley, but though the slender form of this species is very similar to *H. argentinus* (e.g. Stolley 1935, pl. 4, fig. 5a and b), it is markedly compressed throughout its length.

Occurrence. *H. argentinus* has previously only been described from the Tithonian of Argentina (Feruglio 1936). Stevens (1965, p. 159) suggested that it was from the Lower Tithonian on the basis of similarities with other Indo-Pacific belemnites. Unfortunately, Leanza (1967) in his revision of the Feruglio collection in Bologna did not include the belemnites, but from his re-appraisal of the localities, the faunas and their ages, a late Tithonian age is indicated for *H. argentinus*.

Hibolithes aff. *windhouweri* Stolley, 1929

Text-fig. 2A, B, F

- aff. 1907 *Belemnites* cf. *lagoicus* Boehm, p. 57, pl. 8, figs 14–16.
- aff. 1907 *Belemnites* aff. *lagoicus* Boehm, p. 58, pl. 8, figs 17–19.
- aff. *.1929 *Hibolites windhouweri* Stolley, p. 204, pl. 256, figs 1–5.
- aff. 1929 *Hibolites* cf. *Boehmi* Stolley, p. 206, pl. 256, figs 6, 8–11.
- v ?1986 *Hibolithes* sp., Mutterlose, p. 10, figs 5e and f.

Material. Fourteen fragments (KG. 2802.214, .215, .216, .232, .247, .250, .276, .281, .311, .362, .366, .369, .393 and .421) from Callisto Cliffs; three fragments (KG. 2940.29, .32 and .39) from Himalia Ridge; one fragment (KG. 3404.363) from Planet Heights; three fragments (KG. 2803.135, .137 and .139) from Tombaugh Cliffs (text-fig. 1). All are from the Himalia Ridge Formation, Upper Tithonian.

Description. Medium length (estimated $l = 90$ mm), slender rostrum. The outline is markedly hastate, with the maximum lateral diameter occurring at about the mid-point of the rostrum (approximate $D_{lmax} = 11.5$ mm). The profile is slightly asymmetrical and hastate (approximate $D_{vmax} = 12.0$ mm). The apex is preserved on only two specimens (KG. 2802.215 and KG. 3404.363) and is moderately acute. In cross-section, the rostrum is circular near the apex, and becomes markedly compressed anteriorly, usually with the venter narrower than the dorsum, resulting in an almost triangular (pyriform) shape in the uppermost stem and alveolar region. A narrow, slit-like ventral groove extends from the anterior end to 10–20 mm beyond the protoconch. Only one specimen (KG. 2940.32) shows lateral *Doppellinien*, but these are too poorly preserved to describe. The apical line is ortholineate.

Remarks. The description is based on twenty specimens, of which only two (KG. 2802.215 and KG. 3404.363) give any indication of the overall morphology of the rostrum. The remaining eighteen fragments are nearly all of upper stem and/or alveolar regions only.

The rostra resemble *Belemnites* cf. *lagoicus* (Boehm 1907, pl. 8, figs 14–16), *B.* aff. *lagoicus* (Boehm 1907, pl. 8, figs 17–19), *Hibolites windhouweri* Stolley (1929, pl. 256, figs 1–5) and *H.* cf. *boehmi* Stolley (1929, pl. 256, figs 6, 8–11) as they all appear to be elongate and have short, narrow ventral grooves confined to the alveolar and anterior stem regions. However, *H. windhouweri* and *B.* cf. *lagoicus* are typically circular in cross-section, and *B.* aff. *lagoicus*, though compressed in the alveolar region (see Boehm 1907, pl. 8, fig. 18a), appears to be more elongate and have a longer ventral groove than the Antarctic material. *Belemnites lagoicus* (Boehm 1907, pl. 8, figs 12 and 13) differs from *H.* aff. *windhouweri* in its prominent hastate outline and apparently wider ventral groove.

Two rostra described as *Hibolithes* sp. by Mutterlose (1968, p. 10, figs 5e and f) are comparable with the material described above. The pyriform cross-section in the uppermost stem is almost identical to some of the Alexander Island specimens, and the degree of robustness is very similar too. They are therefore tentatively included with *H.* aff. *windhouweri*.

Occurrence. The material figured by Boehm (1907) and Stolley (1929) is from Upper Wai Lagoi, Taliabu, in the Sula Islands of Indonesia, and both authors considered that the rostra were of early Oxfordian age. The specimens described by Mutterlose (1986) are from the Kimmeridgian–Lower Tithonian of the Latady Formation, on the Orville Coast, Antarctica.

Hibolithes antarctica Willey, 1973

Plate 10, figs 9 and 10; text-fig. 3E, F

v*.1973 *Hibolithes antarctica* Willey, p. 43, fig. 5a and b.

v.1973 *Hibolithes* sp. nov. (?) Willey, p. 43, fig. 6a–c.

Type specimen. Holotype: KG. 401.211; Tombaugh Cliffs, Alexander Island; Himalia Ridge Formation; Berriasian.

Diagnosis. Robust rostrum of medium length, with a moderately acute, mucronate apex. Hastate outline, and asymmetrical, barely hastate profile. Cross-section is markedly compressed throughout. A narrow, ventral groove extends from the alveolar end into the upper stem region.

Material. Six fragments (KG. 3235.1a, .3a, .4, .5, KG. 3468.4 and .7) from Europa Cliffs; ten fragments (KG. 3404.321, .322, .343, .361, .366, .369, .371, .386, .390 and .419) from Planet Heights; one fragment (KG. 2802.365) from Callisto Cliffs; seven fragments (KG. 2803.115, .116, .122, .133, .134, .136 and .145) from Tombaugh Cliffs; one fragment (KG. 3680.6) from Vesta Nunataks (text-fig. 1). All are from the Himalia Ridge Formation, Tithonian–Berriasian.

<i>Dimensions</i>	<i>L</i>	<i>l</i>	<i>D</i> max	<i>D</i> vmax
KG. 3235.4	83	—	17.3	18.9
KG. 3235.5	110	80*	18.2	18.9
KG. 3404.321	74	—	14.6	15.8

Remarks. All the material is fragmentary and therefore little can be added to the original description by Willey (1973, p. 43). However, with these new specimens it is apparent that the apex is mucronate and that *Hibolithes* sp. nov.(?) of Willey (1973) should be included within *H. antarctica*. For Willey (1973), the major differences between the holotype of *H. antarctica* and the illustrated specimen of *Hibolithes* sp. nov.(?) of Willey (1973, fig. 6a and b) were size, with the former being larger, more robust and with a greater degree of hastation, and a longer ventral groove. The new material shows a continuous range of forms between *H. antarctica* and *Hibolithes* sp. nov.(?), and it is therefore suggested that they are morphological end-members of the same species. It is possible that

Hibolithes sp. nov.(?) is only a juvenile, whereas the holotype of *H. antarctica* represents the adult stage.

H. antarctica is similar to *H. aff. windhouweri* Stolley (see above), but they may be distinguished as *H. aff. windhouweri* is more slender and more hastate in both outline and profile. Moreover, *H. antarctica* lacks the distinctive pyriform cross-section in the upper stem and alveolar regions. The morphology and length of the ventral groove are comparable in both species. Though the details of the apex of *H. aff. windhouweri* are uncertain, it appears that the tip of *H. antarctica* is relatively more obtuse. The only other belemnite which is similar to *H. antarctica* is *H. arkelli* Stevens (1965, p. 99) from the Puroan (Lower Tithonian) of New Zealand. However, as Willey (1973, p. 43) pointed out, *H. arkelli* has a prominent ventral groove which extends along almost the entire length of the rostrum. Furthermore, the maximum lateral diameter (D_{lmax}) of *H. arkelli* is in the posterior half of the rostrum, unlike *H. antarctica* where D_{lmax} occurs at about the mid-point.

Occurrence. This species is apparently restricted to the Tithonian-Berriasian of Alexander Island.

Hibolithes cf. *antarctica* Willey, 1973

Plate 10, figs 5 and 6

cf. v * .1973 *Hibolithes antarctica* Willey, p. 43, fig. 5a and b.

Material. One nearly complete rostrum (KG. 2802.609) from Callisto Cliffs (text-fig. 1); HIMALIA Ridge Formation, Berriasian.

<i>Dimensions</i>	<i>L</i>	<i>l</i>	D_{lmax}	D_{vmax}
KG. 2802.609	100	90*	25.0	26.8

Description. Medium length (l is approximately four times D_{lmax}), very robust rostrum. In outline, the rostrum is hastate, with the maximum lateral diameter lying slightly anterior to the mid-point. The profile is also hastate but asymmetrical, as the ventral surface is inflated. In transverse section the rostrum is compressed throughout its length. A prominent, narrow, ventral groove extends from the alveolar end to approximately the mid-point. In the alveolar region, the groove is deeply incised. Lateral lines are not preserved and no other grooves are present.

Remarks. The specimen differs from *H. antarctica* only in its shortness and extreme robustness. The outline, cross-section and morphology of the groove are similar in both. *H. antarctica* has been compared with *H. arkelli* Stevens, but the similarity is even less apparent with *H. cf. antarctica*.

Occurrence. *H. cf. antarctica* is only known from Callisto Cliffs (Berriasian).

BIOZONATION

The sedimentary succession of the northern Fossil Bluff Group was originally thought to range in age from the late Oxfordian (Upper Jurassic) to Aptian (Lower Cretaceous), although the presence of the Valanginian-Barremian stages could not be proved (Taylor *et al.* 1979). Recent work shows that the succession ranges in age from Kimmeridgian to Aptian, and further demonstrates that the Valanginian is present (Howlett 1986; Crame and Howlett 1988). It is also suggested that the Hauterivian and Barremian stages are represented though there are no diagnostic fossils (Crame and Howlett 1988). Throughout the succession the stage boundaries are, in general, poorly defined due to the inadequacies of the fossil collections.

Little work has been done on the biozonation of the Fossil Bluff Group, despite distinct stratigraphic changes in the faunas having been recognized and quoted for some time. Thomson (1971), while describing the Lower Cretaceous ammonites of the Fossil Bluff Formation, identified five ammonite faunas based on several localities around Ablation Point in the north, and Keystone

	HOWARTH, 1958	THOMSON, 1971c	THOMSON, 1974	THOMSON, 1979	THIS WORK
ALBIAN			FAUNA 3 Lower Albian		
APTIAN	Lower Cretaceous Fauna	FAUNA 5 uppermost Aptian	FAUNA 5 uppermost Aptian-earliest Albian		
		FAUNA 4 Lower Aptian	FAUNA 4 Lower Aptian		<i>Sanmartinoceras</i> Biozone
BARREMIAN		FAUNA 3 Upper Neocomian			<i>Phyllopacchyceras</i> Interval Biozone
HAUTERIVIAN					
VALANGINIAN					
BERRIASIAN		FAUNA 2 Upper Tithonian-Berriasian	FAUNA 2 Berriasian	<i>Haplophylloceras-Bochianites</i> fauna	<i>Haplophylloceras</i> Interval Biozone
TITHONIAN				<i>Blanfordiceras</i> fauna	<i>Blanfordiceras</i> Biozone
				<i>Virgatosphinctes-Aulacosphinctoides</i> fauna	BARREN INTERZONE <i>Virgatosphinctes</i> Biozone
KIMMERIDGIAN	Upper Jurassic fauna	FAUNA 1 Upper Oxfordian-Kimmeridgian			
OXFORDIAN					

TEXT-FIG. 4. Comparison of ammonite faunas and biozones of eastern Alexander Island.

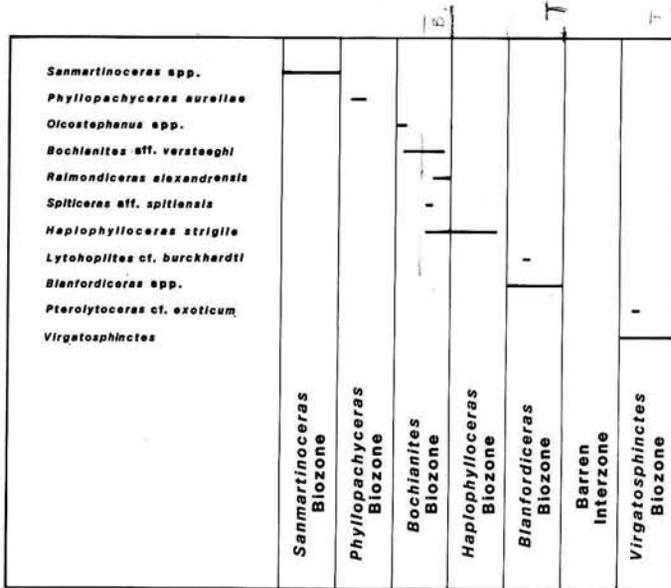
Cliffs in the south (text-fig. 4). These faunas were thought to range in age from the late Oxfordian to Aptian. Fauna 1 was broadly equivalent to the Upper Jurassic fauna of Howarth (1958) and faunas 4 and 5 were equivalent to Howarth's Lower Cretaceous fauna (text-fig. 4). The Lower Cretaceous ammonite sequence was later refined by Thomson (1974). He placed the 'Upper Tithonian-Berriasian fauna' (fauna 2) entirely within the Berriasian, extended the 'uppermost Aptian fauna' (fauna 5) into the earliest Albian, and concluded that the 'Upper Neocomian fauna' (fauna 3) was in fact of Lower Albian age (see text-fig. 4). In a paper on the Upper Jurassic and Lower Cretaceous ammonite faunas of the Ablation Point area, Thomson (1979) defined a further three ammonite faunas ranging in age from early Tithonian to Berriasian (text-fig. 4). The uppermost fauna (the *Haplophylloceras-Bochianites* fauna) is partly equivalent stratigraphically to the 'Upper Tithonian-Berriasian fauna' (fauna 2) of Thomson (1971, 1974), though there are only a few species and genera in common. These ammonite faunas have sometimes been quoted as 'zones' (e.g. Crame 1982), and are used here, together with new material, to create an ammonite biozonation scheme for the Tithonian (Upper Jurassic) to Aptian (Lower Cretaceous) interval which can be applied throughout the Fossil Bluff Group. No previous attempt has been made to create a belemnite biozonation for the Fossil Bluff Group.

The principal reference sections are Himalia Ridge, Leda Ridge and Callisto Cliffs, as these offer the largest continuous successions through the group, and the precise ranges of the fossils through

these successions are known (Crame and Howlett 1988; Howlett 1988). The types of biozones used are stated in the name of each zone (e.g. *Virgatospinctes* Assemblage Biozone), and are defined in Hedberg (1976) and Holland *et al.* (1978).

Ammonite biozonation

Virgatospinctes Assemblage Biozone. This biozone is characterized by *Virgatospinctes*, which is the most abundant and widespread taxon in the biozone. The first occurrence of the genus defines the base of the biozone (text-fig. 5). Other fossils present include: *Pterolytoceras* cf. *exoticum*



TEXT-FIG. 5. Ammonite range-chart for the Fossil Bluff Group.

(Oppel), *Aulacosphinctoides* spp. (see Thomson 1979) and indeterminate phylloceratids. This biozone corresponds to the *Virgatospinctes*-*Aulacosphinctoides* fauna of Thomson (1979). Type locality: Himalia ridge (340-400 m).

Age: Lower Tithonian.

Other localities: Belemnite Point, Ablation Point, Moutonnée Valley.

Barren Interzone. The interval between the *Virgatospinctes* Assemblage Biozone and *Blanfordiceras* Local-range Biozone is devoid of any ammonites and is therefore referred to as a barren interzone. The base of the interzone is at the last appearance of the *Virgatospinctes* (text-fig. 5).

Age: Lower Tithonian.

Localities: Himalia Ridge, Moutonnée Valley.

Blanfordiceras Local-range Biozone. The characteristic genus is *Blanfordiceras*, and its first appearance marks the start of the biozone (text-fig. 5). Other fossils within the zone include *Lytohoplites* cf. *burckhardti* (Mayer-Eymar) and indeterminate berriasellids. This biozone is equivalent to the *Blanfordiceras* fauna of Thomson (1979). Type locality: Himalia Ridge (720-900 m).

Age: Upper Tithonian.

Other localities: Callisto Cliffs, northern Planet Heights, Lunar Crag.

Haplophylloceras Interval Biozone. This interval biozone is characterized by poorly preserved, indeterminate examples of the genus *Haplophylloceras* (see Thomson 1979). No other ammonites

	MEXICO Arkell, 1956; Verma & Westermann, 1973	CHILE BASIN Biró-Bagóczy, 1980	ANDEAN BASIN Riccardi, 1984	MAGALLANES BASIN Riccardi, 1984
APTIAN				TROPAEUM/ AUSTRALICERAS
				COLCHIDITES
BARREMIAN				HATCHICERAS PATAGONENSE
HAUTERIVIAN		PARACRIO CERAS ANDINUM		FAVRELLA WILCKENSI
				FAVRELLA AMERICANA
VALANGINIAN		FAVRELLA cf, ANGULATIFERUM	OLCOSTEPHANUS CURACOENSIS	<i>Olcostephanus</i>
			NEOCOMITES WICHMANNI	
BERRIASIAN	<i>Spiticeras</i>	CUYANICERAS TRANSGREDIENSIS	SPITICERAS DAMESI	JABRONELLA
		ARGENTINICERAS BITUBERCULATUM	ARGENTINICERAS NODULIFERUM	
TITHONIAN	U	SUBSTEUEROCEROS KOENENI	SUBSTEUEROCEROS KOENENI	SUBSTEUEROCEROS KOENENI
		CORONGOCERAS ALTERNANS	CORONGOCERAS ALTERNANS	CORONGOCERAS ALTERNANS
			WINDHAUSENICERAS HUMPHREYI	WINDHAUSENICERAS INTERSPINOSUM
	L		ZONA NO. 1	AULACOSPHINCTES PROXIMUS
				PSEUDOLISSOCERAS ZITTELI
				VIRGATOSPHINCTES MENDOZANUS
KIMMERIDGIAN				Fauna del Kimmeridgiano

TEXT-FIG. 6. Correlation table of Southern Hemisphere ammonite biozones and faunas (biozones are shown in upper case, faunas in lower case).

Mexico (Verma and Westermann 1973) and Indonesia (Sato *et al.* 1978), though there are no species in common with Alexander Island. The 'Zona No. 1' of Biró-Bagóczy (1980) in Chile also contains *Virgatosphinctes*, including *V. andesensis* (Douvillé), which occurs in the *Virgatosphinctes* Assemblage Biozone of Alexander Island. Though no *Virgatosphinctes* are known from New Zealand, the related genus *Aulacosphinctoides* is present (*A. brownei* Biozone; Fleming and Kear 1960; Stevens 1978), and is also found in Alexander Island (*Virgatosphinctes* Biozone). This genus

ALEXANDER ISLAND This work	SOUTH AFRICA Kennedy & Klinger, 1975	MADAGASCAR Collignon, 1959 1960, 1962a, b; Verma & Westermann, 1984	INDONESIA Sato et al., 1978	NEW ZEALAND Fleming & Kear, 1960
	Aptian IV	ACANTHOHOPLITES BIGOURETI		
	Aptian III	ACONECERAS NISUS		
SANMARTINOCERAS	Aptian II	KUNTZIELLA KUNTZI		
	Aptian I	—		
	Barremian II			
PHYLLOPACHYCERAS	Barremian I	SAYNELLA BESAIRIE		
		LEOPOLDIA LEOPOLDIA		
		OLCOSTEPHANUS SCHENKI		
BOCHIANITES		NEOCOMITES TESCHENSIS		
		BERRIASELLA BOISSIERI		
HAPLOPHYLLOCERAS				
BLANFORDICERAS		AULACOSPHINCTES HOLLANDI	<i>Blanfordiceras</i> & <i>Haplophylloceras</i>	
—		HILDOGLOCHICERAS KOBELLI		AULACOSPHINCTOIDES BROWNEI
VIRGATOSPHINCTES		HYBONOTICERAS HYBONOTUM		
		ASPIDOCETRAS LONGISPINOSUM		

TEXT-FIG. 6. (continued).

is also recorded from the Lower Tithonian of Madagascar (*H. hybonotum*/*A. acanthicum* Biozone–*H. kobelli* Biozone) and the Lower Tithonian of Mexico (*Virgatosphinctes* fauna) and Indonesia (Sato et al. 1978). Enay (1973) and Sato et al. (1978) regarded *Virgatosphinctes* as being of late Tithonian age, but there is little evidence to support this.

Berriasellid ammonites are common in the Upper Tithonian allowing inter-regional comparison between Alexander Island, South America and Madagascar. Thus, for example, *Blanfordiceras acuticosta* (Uhlig) occurs in Alexander Island (*Blanfordiceras* Biozone) and Madagascar

(*Aulacosphinctes hollandi* Biozone); *B. weaveri* sp. nov. is known in Alexander Island and the Andean Basin (*Corongoceras alternans* Biozone); *Lytohoplites* cf. *burckhardti* (Mayer-Eymer) is recorded from the Andean Basin (*C. alternans* Biozone), the Magallanes Basin (Fauna del Tithoniano) and Alexander Island (*Blanfordiceras* Biozone); while the genus *Lytohoplites* also occurs in Madagascar (*A. hollandi* Biozone). The *C. alternans* Biozone is also recorded in Mexico and Chile, but in both these localities neither *Blanfordiceras* nor *Lytohoplites* are known (see Verma and Westermann 1973; Biró-Bagóczy 1980). *Blanfordiceras* and *Haplophylloceras* are recorded from the Upper Tithonian of Indonesia (Sato *et al.* 1978), equating with both the *Blanfordiceras* and *Haplophylloceras* biozones of Alexander Island. The marine Upper Tithonian is not represented in New Zealand.

The Berriasian biozones cannot be correlated accurately though some genera are comparable, e.g. *Spiticeras* in the *Bochianites* Assemblage Biozone of Alexander Island, the *Spiticeras* fauna of Mexico, the *Cuyanicerias transgrediens* Biozone of Chile, the *S. damesi* Biozone of the Andean Basin and the *Berriasella boissieri* Biozone of Madagascar. The Valanginian shows a better comparison, with *Olcostephanus (Lemurostephanus) madagascariensis* Lemoine occurring in both the *Bochianites* Biozone of Alexander Island and the *Hibolites joleaudi/Neocomites teschenensis* Biozone of Madagascar. The subgenus *Lemurostephanus* also occurs in the *Olcostephanus curacoensis* Biozone of the Andean Basin, but with different species.

The Hauterivian and Barremian are poorly defined in all the areas, and there are no species and very few genera in common. Aconeceratid ammonites occur in all the areas from the uppermost Barremian onwards except in the Andean Basin where the sedimentary succession stops in the Upper Barremian. Genera such as *Aconeceras* and *Sanmartinoceras* occur in the Magallanes Basin (*Colchidites* Biozone), Alexander Island (*Sanmartinoceras* Biozone), Madagascar (*Aconeceras nesus/Melchiorites melchioris* Biozone) and South Africa (Barremian I–Aptian I, and Aptian III and IV; Kennedy and Klinger 1975). Some species are common to more than one area, e.g. *S. patagonicum* Bonarelli in Alexander Island and South America (though some authors regard this species as occurring in the Lower Albian of the Magallanes Basin, see Waterhouse and Riccardi 1970; Thomson 1974; Riccardi 1984; Riccardi *et al.* 1987).

Belemnite biozonation

Belemnopsis cf. *aucklandica* *Concurrent-range Biozone*. The base of this biozone is marked by the first occurrence of *B. cf. alfurica* (Boehm) (text-fig. 7). This species occurs concurrently with *B. cf. aucklandica* (Hochstetter), which has been chosen as the index fossil as it is the more common belemnite.

Type locality: Himalia Ridge (190–330 m).

Age: Kimmeridgian.

Other localities: Belemnite Point, Moutonnée Valley, ?Nonplus Crag.

Hibolites belligerundi *Assemblage Biozone*. The start of this biozone is marked by the first occurrence of *H. belligerundi* Willey (text-fig. 7), and the fauna within it consists of several species of *Hibolites*, e.g. *H. argentinus* (Feruglio), *H. antarctica* Willey, *H. cf. antarctica* Willey and *H. aff. windhouweri* Stolley, together with rare *Belemnopsis*: in the first 50 m, *Belemnopsis* cf. *alfurica* (Boehm) is also present, and at around 230 m on Callisto Cliffs and at about 770 m on Himalia Ridge, *B. cf. aucklandica* (Hochstetter) also occurs. *H. belligerundi* was chosen as the index fossil on account of its relatively large range and distinctive appearance.

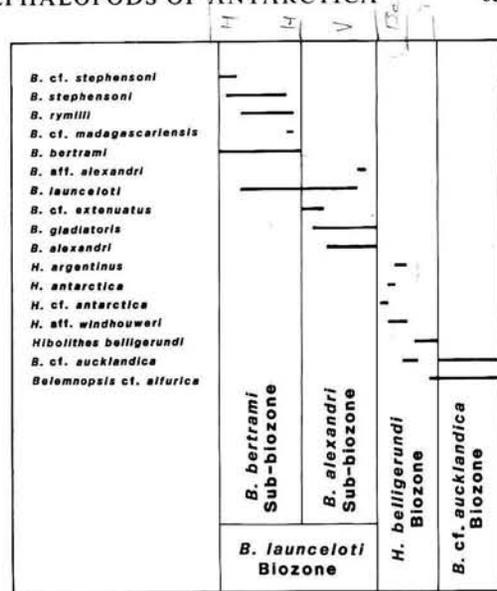
Type locality: Callisto Cliffs (100–1090 m).

Age: Tithonian–Berriasian.

Other localities: Belemnite Point, Ablation Valley, Himalia Ridge, Europa Cliffs, Planet Heights, Tombaugh Cliffs, Vesta Nunataks.

Belemnopsis launceloti *Assemblage Biozone*. The base of this biozone is defined by the first occurrence of *B. (Belemnopsis) alexandri* Willey, but as *B. (B.) launceloti* sp. nov. occurs through

TEXT-FIG. 7. Belemnite range-chart for the Fossil Bluff Group.



almost the entire thickness of the biozone, it has been chosen as the index fossil. This biozone contains an abundant and diverse *Belemnopsis* fauna which is only fully represented on Leda Ridge, where it can be subdivided into two sub-biozones:

(a) *Belemnopsis alexandri* Assemblage Sub-biozone. *B. (B.) alexandri* is the most abundant and distinctive taxon, and the start of the subzone is defined by the first appearance of this species (text-fig. 7). Other fossils present include *B. (B.) gladiatoris* Willey, *B. (B.) cf. extenuatus* Yang and Wu, *B. (B.) launzeloti* sp. nov. and *Belemnopsis (B.) aff. alexandri*.

Type locality: Leda Ridge (50–230 m).

Age: Valanginian.

Other localities: Himalia Ridge, KG. 3452–KG. 3453, Callisto Cliffs.

(b) *Belemnopsis bertrami* Total-range Sub-biozone. The species *B. (Telobelelemnopsis) bertrami* sp. nov. occurs throughout the whole subzone and therefore marks the base of this total-range subzone (text-fig. 7). Also occurring within the subzone are *B. (B.) launzeloti* sp. nov., *B. (Parabelemnopsis) cf. madagascariensis* (Besairie), *B. (T.) rymilli* sp. nov., *B. (T.) stephensoni* sp. nov. and *B. (T.) cf. stephensoni*.

Type locality: Leda Ridge (230–555 m).

Age: ?Hauterivian.

Other locality: Callisto Cliffs, Aeolus Ridge, Fossil Bluff.

No formal Upper Jurassic and Lower Cretaceous belemnite biozonations have yet been published anywhere in the Southern Hemisphere, though an informal scheme was presented by Stevens (1965). His biozonation is based on ranges of the New Zealand belemnites (see text-fig. 8), and he identified a *Conodicoelites* zone (lower Heterian), *Belemnopsis keari* zone (Heterian), *B. alfurica* (Heterian), first *uhligi*-complex zone (*B. aucklandica aucklandica*) (Ohauan), *Hibolites* zone (lower Puarooan) and a second *uhligi*-complex zone (*B. a. trechmanni*) (upper Puarooan). This broadly parallels the belemnite succession in Antarctica, i.e. *Conodicoelites*, earliest Kimmeridgian (seen at Lyons Nunataks; Stevens 1967); *B. alfurica* (Boehm), Kimmeridgian; *B. aucklandica* (Hochstetter, latest Kimmeridgian; *H. belligerundi* Willey, Lower Tithonian; *B. aucklandica* (Hochstetter), Upper Tithonian (occurring within the *H. belligerundi* biozone). Stevens (1965, p. 138) re-examined some

Indonesian material and revised the stratigraphical column for the Jurassic of Misool of Stolley (1934). Stevens remarked upon the similarity of the succession of belemnites from both New Zealand and Misool, and in the latter, he recognized a *Dicoelites* fauna, which he considered to be equivalent to the *Conodicoelites* zone of New Zealand. This was followed by a *B. alfurica* fauna, *uhligi*-complex, *Hibolithes* fauna, a second *uhligi*-complex, succeeded by a *Duvalia* and *Hibolithes* assemblage, which was considered to be of late Tithonian or lowermost Cretaceous age (Stevens 1965, p. 139; see text-fig. 8).

	FALKLAND PLATEAU Jeletzky, 1983	ALEXANDER ISLAND Willey, 1973, This work	NEW ZEALAND Stevens, 1965	INDONESIA	
				MISOOL Stolley, 1935	SULA Sato <i>et al.</i> 1978
HAUTERIVIAN		B. LAUNCELOTI BIOZONE			
VALANGINIAN					
BERRIASIAN					
TITHONIAN		H. BELLIGERUNDI BIOZONE		<i>Hibolithes</i> & <i>Duvalia</i>	
	<i>Hibolithes</i>		<i>B. uhligi</i> 2	<i>B. uhligi</i> 2	
			<i>Hibolithes</i>	<i>Hibolithes</i>	<i>Hibolithes</i>
KIMMERIDGIAN	<i>B. uhligi</i>	B. cf. AUCKLANDIGA BIOZONE	<i>B. uhligi</i> 1	<i>B. uhligi</i> 1	<i>B. uhligi</i>
	? <i>B. alfurica</i> - <i>keari</i>	<i>B. alfurica</i> - <i>keari</i>	<i>B. alfurica</i> - <i>keari</i>	<i>B. alfurica</i> - <i>keari</i>	<i>B. alfurica</i> - <i>keari</i>
			<i>Conodicoelites</i>		
OXFORDIAN				<i>Dicoelites</i>	<i>Dicoelites</i>

TEXT-FIG. 8. Correlation table of Southern Hemisphere belemnite faunas and biozones (biozones are shown in upper case, faunas in lower case).

Further Indonesian material from the Sula Islands, has recently been described by Challinor and Skwarko (1982). The ages of their faunas appear to be based on the preliminary stratigraphy of Sato *et al.* (1978), which is now in need of some revision. When the cephalopod ages are revised in comparison with Alexander Island, a further similarity between these faunas and those of Misool and New Zealand can be seen (text-fig. 8), though the *Hibolithes* assemblage is less well defined, and a second occurrence of the *uhligi*-complex is not seen.

Jeletzky (1983) has examined material from the Falkland Plateau and has also identified a similar succession, with a *B. alfurica-keari* assemblage (referred to as *B. cf. keari* Beds by Jeletzky 1983, p. 959), followed by an *uhligi*-complex fauna, and finally a *Hibolithes*-dominant horizon (text-fig. 8).

The material from the Orville Coast, described by Mutterlose (1986), is poorly located stratigraphically, and is therefore excluded from this comparison. However, Mutterlose (1986, fig. 7) considered that the succession of belemnites from the Orville Coast did conform with the rest of the Indo-Pacific region.

The sequence in Madagascar differs from this succession, as the Kimmeridgian-Valanginian belemnites are dominated by *Hibolithes*. However, there are some similarities, e.g. *B. alfurica* (Boehm) has been identified from the Middle Oxfordian-Kimmeridgian (Combémoré 1988); *B.*

gladiatoris Willey and *B. launzeloti* sp. nov. are both known from the Valanginian of Madagascar, together with *B. (P.) madagascariensis* (Besairie), which may even be of early Hauterivian age (Besairie and Collignon 1956).

Though belemnites are also known from a number of other localities (e.g. South America, South Africa, Tibet, etc.), too little is known about their stratigraphical successions, and consequently no comparisons can be drawn.

CONCLUSIONS

The sedimentary succession of the Fossil Bluff Group ranges in age from the Kimmeridgian, in the chaotically slumped units below Belemnite Point and Himalia Ridge, to the Aptian, at the top of Spartan Glacier and Leda Ridge (Crame and Howlett 1988; Butterworth *et al.* 1988). There do not appear to be any significant breaks, though the Hauterivian and Barremian stages cannot be proved clearly. The two biozonations presented above are compared and correlated with the lithostratigraphy in text-fig. 9. The stages of the uppermost Jurassic and Lower Cretaceous cannot be strictly recognized in Antarctica owing to the lack of diagnostic fossils. However, stage boundaries can be broadly linked to the biozones on the basis of the similar schemes for Madagascar and South America (discussed), and their comparisons with the standard Tethyan succession (see Harland *et al.* 1982; Rawson 1983; Birkelund *et al.* 1984):

		AMMONITE BIOZONES	BELEMNITE BIOZONES		LITHOSTRATIGRAPHY
APTIAN		<i>Sanmartinoceras</i> Biozone			Pluto Glacier Formation
BARREMIAN		<i>Phyllophyceras</i> Interval Biozone			Spartan Glacier Formation
HAUTERIVIAN			<i>B. launzeloti</i> Biozone	<i>B. bertrami</i> Sub-biozone	
VALANGINIAN				<i>B. alexandri</i> Sub-biozone	
BERRIASIAN		<i>Bochianites</i> Biozone			Himalia Ridge Formation
TITHONIAN	U	<i>Haplophylloceras</i> Interval Biozone	<i>H. belligerundi</i> Biozone		
		<i>Blanfordiceras</i> Biozone			
	L	Barren Interzone			
		<i>Virgatosphinctes</i> Biozone			
KIMMERIDGIAN			<i>B. cf. aucklandica</i> Biozone	Ablation Point Formation	

TEXT-FIG. 9. Correlation of ages, cephalopod biozones and formations of the Fossil Bluff Group.

1. Kimmeridgian-Tithonian boundary coincides with the base of the *H. belligerundi* Biozone.
2. Lower and Upper Tithonian boundary is placed at the base of the *Blanfordiceras* Biozone.
3. The Jurassic-Cretaceous boundary lies within the *Haplophylloceras* and *H. belligerundi* biozones.
4. Berriasian-Valanginian boundary is placed at the base of the *B. launzeloti* Biozone (*B. alexandri* Sub-biozone).
5. Valanginian-Hauterivian boundary provisionally lies at the base of the *B. bertrami* Sub-biozone (*B. launzeloti* Biozone).

6. Barremian-Aptian boundary is taken as being at the base of the *Sanmartinoceras* Biozone.

With further work on the Aptian-Albian cephalopod faunas (e.g. Doyle 1987), together with more detailed stratigraphical studies of the respective localities, it is anticipated that these biozonation schemes could be extended throughout the entire Lower Cretaceous and possibly some way into the Upper Cretaceous.

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