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AMMONOIDEA FROM THE MATA SERIES (SANTONIAN-MAASTRICHTIAN) OF NEW ZEALAND

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ABSTRACT. A complete taxonomic revision of ammonites from the Mata Series (Santonian–Maastrichtian) of New Zealand is presented. Two genera and twelve species previously established for New Zealand ammonites of this age are considered to be junior synonyms. The new diplomoceratid genera, *Astreptoceras* and *Masonites*, and sixteen new species, *Anagaudryceras tennenti*, *Masonites biannulatus*, *Pseudoxybeloceras compressum*, *P. bicostatum*, *Kossmaticeras* (*Natalites*) *bensoni*, *Jacobites* (*Jacobites*) *flexicostatus*, *J.* (*J.*) *maximus*, *J.* (*J.*) *stevensi*, *J.* (*J.*) *quadratus*, *J.* (*J.*) *marwicki*, *Maorites angulocostatus*, *M. multiconstrictus*, *Gunnarites spathi*, *G. varicostatus*, *Neograhamites transitorius*, and *Eupachydiscus depressus*, are proposed. Representatives of *Neograhamites*, *Eupachydiscus*, and *Anapachydiscus* are recorded from New Zealand for the first time. Biostratigraphy of Mata ammonite taxa is reviewed in terms of New Zealand stage divisions. It is thought that two stratigraphically and faunally distinct assemblages can be differentiated, one characteristic of the lower Piripauan Stage and the other characteristic of the upper Piripauan and Haumurian Stages. Correlation with faunas of other countries shows the lower Piripauan assemblage to be of Santonian age while the upper Piripauan and Haumurian assemblage is of Campanian age and may range into the Maastrichtian. Biogeographic relationships of the fauna are discussed in terms of the marked faunal provincialism evident from the global distributions of ammonite taxa for Santonian–Maastrichtian time.

INTRODUCTION

THE MATA SERIES is the youngest of four series comprising the Cretaceous System in New Zealand and is a correlative of the Santonian, Campanian, and Maastrichtian Stages of Europe. Its ammonite fauna is among the most prolific and best preserved of this date and is complementary to that known from Graham Land in being dominated by members of the Kossmaticeratidae. This family underwent a spectacular evolutionary radiation, mainly in the southern Indo-Pacific region, during late Senonian time with the inception of ten new generic or subgeneric stocks. Six of these are represented in the Mata fauna, the affinities of which are largely with the southern Indo-Pacific region. Other genera of the Mata fauna are more widely distributed, being represented in the northern Indo-Pacific and northern Atlantic regions. Since 1950 late Cretaceous ammonites from the margins of the Indo-Pacific have been subjected to considerable attention with important contributions arising from the work of Collignon (Madagascar), Howarth (Graham Land), Jones (Alaska), Matsumoto (Japan and California), Spath (Graham Land), and Usher (British Columbia). Better knowledge of these related faunas has made a review of Marshall's (1926) monograph of the New Zealand Mata fauna desirable, both in updating its systematics, and in reinterpreting its age and affinities.

Small collections of ammonites, some of which have never been duplicated, were made last century mainly by the notable New Zealand geologist Alexander McKay; a few of these were described by Hector (1886) and Woods (1917) and most are of Mata age. Trechmann (1917) recorded two species of this age from Selwyn Rapids, North Canterbury. The collection of three ammonite species by Marshall from two new localities during a geological investigation of the country surrounding Kaipara Harbour, North Auckland, the results of which were published in 1917, evoked his interest in New Zealand members of the group. Marshall made extensive collections from the Kaipara ammonite localities he had discovered and from Waitapu Bay, Whangaroa Harbour which was recorded as an ammonite locality by Bell and Clarke (1909). A large fauna resulted and Marshall's study was culminated by his 1926 monograph of the North Auckland Mata assemblage. In a small additional paper, Marshall (1927) revised the generic placing of two species and established a new genus. References by overseas workers of the same period to the New Zealand fauna include Spath (1921, p. 299) and Kilian (1922). Marwick (1950) redescribed the single specimen of *Ammonites mckayi* Hector which had formerly been thought lost. Spath (1953) made extensive reference to New Zealand Mata ammonites in his revision of the Graham Land fauna. Wright (1957*b*) described a number of New Zealand Cretaceous ammonites, some of which are of Mata age. Wellman's definitive work on the divisions of the New Zealand Cretaceous published in total in 1959 allowed New Zealand ammonites to be satisfactorily related to the Cretaceous stratigraphic succession of this country for the first time.

Since the time of Marshall's investigation, many additional collections have been made so that the total number of Mata ammonite specimens in existing collections exceeds 1700. Many of these provide better material than that studied by Marshall allowing a re-evaluation of the taxa he created and some represent new taxa. Most of the material so far collected is curated in New Zealand and all the New Zealand collections were examined during the present study. Part of the collection of New Zealand Mata ammonites of Messrs. C. W. and E. V. Wright (London) and all the New Zealand ammonite specimens in the palaeontological collections of Kyushu University (Japan) have also been examined. The only important specimens not studied are those recorded by Trechmann (1917), which are in the collection of the British Museum (Natural History). Most of the previously known localities have been recollected and a few new localities have come to light.

Types. The personal collection on which Marshall based his studies is now fragmented, parts of the collection being curated by the Geology Department, Auckland University, The New Zealand Geological Survey, and Otago Museum. Several specimens, including figured specimens, have been lost. No specimens in any of the collections were labelled as types by Marshall himself. Figured specimens had been mixed with others in the collection and have only recently been recognized and separated. Marshall did not systematically designate holotypes in his papers but makes casual references to type specimens in some descriptions. Only figured specimens that are recorded by Marshall as the single representatives of species he created and specimens which are referred to by Marshall as types and which can be unequivocally recognized from his statements can be regarded as holotypes. It has been necessary to designate lectotypes for several species and wherever possible the specimen figured by Marshall as representative of a species has been selected as the lectotype of that species. In two species, *Tetragonites marshalli* (Collignon) (= *Tetragonites epigonus* Marshall, *non* Kossmat), and *Kitchinites* (*Kitchinites*) *angustus*, the type series referred to by Marshall cannot be found or recognized with certainty. Since all ammonites curated in New Zealand institutions have been examined in the present survey, there is no doubt that Marshall's figured examples of these two species have been lost. *Kitchinites* (*K.*) *angustus* is a senior synonym while *Tetragonite marshalli* is of disputed generic placing so that the designation of neotypes is desirable in both cases for taxonomic stability.

Abbreviations. The following abbreviations are used in the systematic descriptions:

- *D* shell diameter.
- *B* breadth of last whorl.
- *H* height of last whorl.
- *B/H* ratio of whorl breadth to whorl height.
- *U* umbilical diameter.
- % umbilical diameter expressed as a percentage of the shell diameter.
- *Dist.* distance between measurements.

The repository collections of type and other specimens are indicated by the following prefixes to their catalogue numbers:

- VC. Victoria University of Wellington, cephalopod collection.
- C. Auckland University, cephalopod collection.
- OU. Otago University, palaeontological collection.
- OM. Otago Museum.
- AM. Auckland Museum and Institute, collection of geological specimens.
- AMT. Auckland Institute and Museum, type collection.
- CE. New Zealand Geological Survey, cephalopod collection.
- M. Mr. A. P. Mason (private collection).
- GK.H. Kyushu University (Japan), palaeontological collection.
- W.N.Z. Messrs. C. W. and E. V. Wright (London) (private collection).

The prefixes AM; AMT; OU; OM; and M have no meaning outside of this report; the others are actual prefixes appearing in the catalogue numbers of the institutions to which they pertain. Where two or more catalogue numbers are bracketed, the numbers refer to pieces of a single specimen.

Localities are referred to in terms of the Sheet Fossil Numbers (e.g. N28/626) assigned to them in the New Zealand Fossil Record System.

Measurements given in the systematic section are in millimetres.

SYSTEMATIC DESCRIPTIONS

Superfamily PHYLLOCERATACEAE Zittel 1884
Family PHYLLOCERATIDAE Zittel 1884
Subfamily PHYLLOCERATINAE Zittel 1884
Genus NEOPHYLLOCERAS Shimizu 1934

1934 *Neophylloceras* Shimizu, in Shimizu and Obata, p. 61.
1947 *Hyporbulites* Breistroffer, p. 82.

Type species: *Ammonites* (*Scaphites?*) *ramosus* Meek 1857, p. 45. Wright (1957*a*, p. 189) and Wiedmann (1962, p. 139) regarded *Neophylloceras* as a junior synonym of *Hypophylloceras* Salfeld but Matsumoto (1959*a*, p. 55) and Packard (1960, p. 426) treated *Neophylloceras* as distinct. Both Matsumoto and Packard illustrated the suture of *H. onoense* (Stanton), the type species of *Hypophylloceras*, which is less finely incised than that of *Neophylloceras* and has much better developed phylloid terminations. Birkelund (1965, p. 21) regards *Neophylloceras* as a subgenus of *Hypophylloceras*. The sutural distinction between these two genera demonstrated by Matsumoto and Packard is here considered sufficient to warrant their separation at the generic level.

Neophylloceras marshalli (Shimizu)

Plate 1, fig. 1

1926 *Phylloceras nera* Marshall (*non* Forbes); Marshall, p. 134, pl. 19, fig. 4; pl. 26, figs. 1, 2.
1935 *Paraphylloceras marshalli*; Shimizu, p. 180.

Material. Holotype: C.997, N28/626 (figured by Marshall 1926, pl. 26, figs. 1, 2).

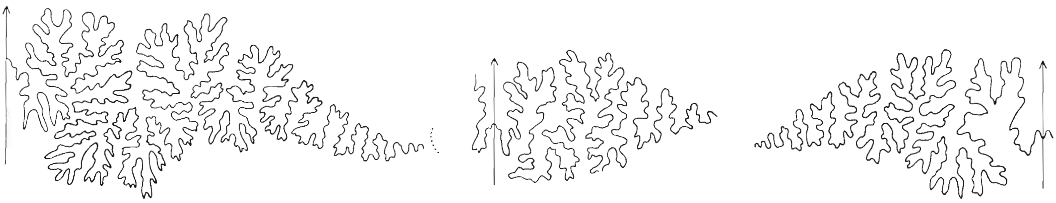
Diagnosis. Involute forms with compressed whorls and an umbilicus which is unusually wide for the genus. The test is ornamented with fine, closely spaced ribs which are slightly prorsiradiate on the dorsal flanks, straighten at the mid-flank and are rectiradiate across the venter; the dorsal flanks bear six conspicuous folds in a half whorl. The suture is of the *Neophylloceras* type, deeply and finely incised with a shallow ventral lobe.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
C.997	42·0	22·0	12·0	0·55	5·5	13

Remarks. The following Indo-Pacific species are closely related to *N. marshalli*: *N. nera* (Forbes) (Forbes 1846, p. 106, pl. 8, fig. 7) from India; *N. hetonaiense* Matsumoto (1942, p. 675, text-figs. $1a_3$, b_3) from Japan, Graham Land, Alaska, and California; *N. lambertense* Usher (1952, p. 50, pl. 1, figs. 1–3) from British Columbia and Chile; and *N. woodsi* (van Hoepen) (1921, p. 3, pl. 2, figs. 1–6, text-fig. 1) from South Africa. All are characterized by a narrow umbilicus, compressed whorls, slightly convex flanks, a narrowly arched venter, fine, weakly flexiradiate ribs which are rectiradiate across the venter, radial ridges on the dorsal flanks, and a complex suture of the *Neophylloceras* style. The strength of the radial ridges varies not only between different species but, in the case of *N. hetonaiense*, between different examples of the same species (Matsumoto 1959*c*, p. 6).

According to Usher, *N. lambertense* is distinguished from *N. hetonaiense* by having less flexuous ribs and more flattened flanks, but Jones (1963, p. 23) considers that the two forms may be conspecific. The only distinguishing characters between *N. hetonaiense*, *N. nera*, and *N. woodsi* are differences in their suspensive lobes. *N. hetonaiense* has the elements of its suspensive lobe arranged in an adorally concave arc, *N. nera* has a straight, rectiradiate suspensive lobe and this portion of the suture is straight and slightly



a b c

TEXT-FIG. 1. Sutures of *Neophylloceras*. *a*, *N. hetonaiense* Matsumoto (after Jones 1963, text-fig. 8); ×3. *b*, *N. nera* (Forbes) (after Forbes 1846, pl. 8, fig. 4*c*); scale unknown. *c*, *N. woodsi* (van Hoepen) (after van Hoepen 1921, text-fig. 1); approximately ×4.

retracted in *N. woodsi* (text-fig. 1). However, Matsumoto (1959*c*, p. 5) considers that the shape of the suspensive lobe may be of little importance in the specific classification of *Neophylloceras*.

N. marshalli is distinguished by pronounced radial ridges and a relatively wider umbilicus, but is at present known from only one specimen. The example mentioned by Marshall as having an umbilicus measuring 17% of the shell diameter cannot be located in the present New Zealand collections. A juvenile specimen, VC.9, collected from N14/655 (Ngamahanga Point, Hokianga Harbour) may belong in *N. marshalli*; it has a diameter of 12 mm. and an umbilicus measuring 12% of the shell diameter.

For the present *N. marshalli* is retained, but further study may show that it is synonymous with one or more of the species mentioned above.

EXPLANATION OF PLATE 1

Fig. 1. *Neophylloceras marshalli* (Shimizu); holotype, C.997. N28/626. Lateral view; ×1.

Figs. 2, 4, 5. *Phyllopachyceras forbesianum* (d'Orbigny). 2, C.1015. N28/626. *a*, Lateral, *b*, ventral view; ×1. 4, C.1017. N28/626. *a*, Lateral, *b*, ventral view; ×3. 5, C.1016. N28/626. *a*, Ventral, *b*, lateral view; ×1.

Fig. 3. *Neophylloceras ramosum* (Meek); CE.2136. N28/636. *a*, Apertural, *b*, lateral view; ×1.

Fig. 6. *Tetragonites simplex* Marshall; VC.21. N14/655. *a*, Lateral, *b*, ventral view; ×2.

Fig. 7. *T. margaritatus* Marshall; C.1019. N28/639. *a*, Lateral, *b*, apertural view; ×1·5.

Figs. 8, 9. *T. marshalli* (Collignon). 8, C.847. Locality unknown. Lateral view, ×1·5. 9, neotype, CE.2137 N28/626. *a*, Lateral, *b*, apertural view; ×1·5.

Fig. 10. *Pseudophyllites latus* (Marshall); VC.267. S36/1301. *a*, Apertural, *b*, lateral view; ×1.

Neophylloceras ramosum (Meek)

Plate 1, fig. 3; text-fig. 2*a*

1857 *Ammonites* (*Scaphites?*) *ramosus* Meek, p. 45.
1876 *Phylloceras ramosum* (Meek); Meek, p. 371, pl. 5, figs. 1, 1*a*, 1*b*.
1895 *Phylloceras ramosum* (Meek); Steinmann, p. 80, pl. 5, figs. 4*a*, *b*.
1903 *Phylloceras ramosum* (Meek); Whiteaves, p. 327.
?1906 *Phylloceras nera* (Forbes); Paulcke, p. 3, pl. 14, figs. 5, 5*a–c*.
1909 *Phylloceras* (*Schlueteria?*) *ramosum* (Meek); Kilian and Reboul, p. 9, pl. 1, figs. 3*a*, *b*, text-fig. 1.
?1928 *Phylloceras* aff. *ramosum* (Meek); Collignon, p. 7, pl. 1, figs. 2–4.
1934 *Neophylloceras ramosum* (Meek); Shimizu, in Shimizu and Obata, p. 62.
1942 *Neophylloceras ramosum* (Meek); Matsumoto, p. 674.
1942 *Neophylloceras compressum* Matsumoto, p. 175, text-figs. 1a_2, 1b_2.
1952 *Neophylloceras ramosum* (Meek); Usher, p. 49, pl. 1, figs. 4, 5.
1958 *Phylloceras ramosum* (Meek); Anderson, p. 181, pl. 40, figs. 4, 4*a*.
1958 *Phylloceras vaculae* Anderson, p. 181, pl. 40, figs. 3, 3*a*, 3*b*.
?1958 *Phylloceras pachecoensis* Anderson, p. 182, pl. 53, figs. 1, 1*a*.
1959*c* *Neophylloceras ramosum* (Meek); Matsumoto, p. 1, pl. 1, figs. 1*a–d*; pl. 2, fig. 2; pl. 8, figs. 1*a–c*.
1963 *Neophylloceras ramosum* (Meek); Jones, p. 22, pl. 6, figs. 1–8, text-fig. 7.

Material. VC.105a–c, N14/656; C.883, M.579, N28/636; GK.H9303, N28/639.

Diagnosis. Highly involute forms with compressed whorls, narrowly arched venter, weakly convex flanks, and a narrow umbilicus. Closely spaced, fine, flexiradiate ribs ornament the thin test; these are prorsiradiate on the dorsal flanks and venter but rectiradiate on the mid-flanks. Weak radial ridges may be present on the dorsal flanks. The suture is finely and deeply incised with some small phylloid terminations.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
GK.H9303	25·5	14·5	8·0	0·55	2·5	10
CE.2136	51·2	29·0	13·5	0·47	5·5	11

Remarks. Radial ridges are weakly developed on VC105a but are absent from the other three New Zealand specimens. The elements of the suspensive lobe of CE.2136 lie in a straight rectiradiate line rather than an adorally concave arc as in the Alaskan examples (Jones 1963, p. 23). This supports the suggestion of Matsumoto (1959*c*, p. 5) that the shape of the suspensive lobe may not be significant in the specific classification of *Neophylloceras*. Distinct phylloid terminations are present on the first and second lateral saddles of CE.2136 where the suture can be observed through the semi-transparent inner layers of the test (text-fig. 2*a*), but these structures are lost when the margins of the septa are slightly eroded.

N. ramosum is a widely distributed Indo-Pacific species closely related to the *N. nera* plexus discussed above but is distinguished by the prorsiradiate inclination of its ribs on the venter. The ventral projection of ribs ornamenting the specimen figured as *Phylloceras nera* (Forbes) by Paulcke (1906, p. 3, pl. 1, figs. 5, 5*a–c*) suggest that it belongs in the present species.

Neophylloceras radiatum (Marshall)

Text-fig. 2*b*

1926 *Phylloceras radiatum* Marshall, p. 135, pl. 19, fig. 7; pl. 26, figs. 3, 4.

Diagnosis. Highly involute and narrowly umbilicate. Whorls less compressed than is typical of the genus and ornamented with coarse, well-spaced fine ribs which are slightly

a b

TEXT-FIG. 2. *a*. Second and third lateral saddles of *Neophylloceras ramosum* (Meek); CE.2136, whorl height 29 mm., ×4. *b*, *Neophylloceras radiatum* (Marshall) (after Marshall 1926, pl. 26, fig. 3); approximately ×1·2.

prorsiradiate on the dorsal flanks but straighten by mid-flank and are rectiradiate across the venter. The flanks bear twelve radial, ventrally widening folds in a half revolution. Suture similar in complexity to that of other *Neophylloceras*.

Dimensions (after Marshall).

D	*H*	*B*	*B/H*	*U*	%
43·0	25·0	18·0	0·72	2·0	5

Remarks. *N. radiatum* has doubtful status because the good specimen and the three fragments used by Marshall in establishing this species cannot be found in the existing New Zealand collections and no further specimens have been collected. Marshall's illustration of the whorl cross-section is probably inaccurate, for the whorls are depicted as considerably more compressed than suggested by his table of dimensions. Although the ornamentation of both *N. surya* (Forbes) (1846, p. 106, pl. 7, figs. 10*a*, *b*) and *N. mikobokense* Collignon (1956, p. 24, pl. 2, figs. 3, 3*a*; pl. 4, figs. 5, 5*a*, 5*b*) is very similar, Marshall's table of dimensions suggests that *N. radiatum* is less compressed than either of these species.

Genus PHYLLOPACHYCERAS Spath 1925

Phyllopachyceras forbesianum (d'Orbigny)

Plate 1, figs. 2, 4, 5

1846 *Ammonites rouyanus* d'Orbigny; Forbes, p. 108, pl. 8, fig. 6.
1850 *Ammonites forbesianum* d'Orbigny, p. 213.
1865 *Ammonites rouyanus* d'Orbigny; Stoliczka, p. 117, pl. 59, figs 5–7.
1890 *Phylloceras ezoënsis* Yokoyama, p. 178, pl. 19, figs. 2*a–c*.
1895 *Phylloceras forbesianum* (d'Orbigny); Kossmat, p. 109, pl. 15, figs. 1*a–c*.
1903 *Phylloceras forbesianum* (d'Orbigny); Whiteaves, p. 328.
1921 *Phylloceras ezoense* (Yokoyama); Yabe and Shimizu, p. 54, pl. 8, fig. 2.
1926 *Phylloceras forbesianum* (d'Orbigny); Marshall, p. 136, pl. 19, fig. 6; pl. 27, figs. 3, 4.
1926 *Phylloceras minimum* Marshall, p. 137, pl. 19, fig. 8; pl. 26, figs. 5, 6.
1926 *Phylloceras bistriatum* Marshall, p. 138, pl. 19, fig. 5; pl. 27, figs. 1, 2.
1926 *Schluteria rarawa* Marshall, p. 192, pl. 19, fig. 10; pl. 32, figs. 7, 8.
1935 *Phyllopachyceras inflatum* Shimizu, p. 178.
1935 *Phyllopachyceras forbesianum* (d'Orbigny); Shimizu, p. 178.
1935 *Phyllopachyceras ezoense* (Yokoyama); Shimizu, p. 172.
1937 *Phyllopachyceras marshalli* Collignon, p. 26.
1941 *Phyllopachyceras forbesianum* (d'Orbigny); Spath, p. 42.
1942 *Phyllopachyceras ezoense* (Yokoyama); Matsumoto, p. 674.
1952 *Phyllopachyceras forbesianum* (d'Orbigny); Usher, p. 52, pl. 2, figs. 1–5; pl. 31, figs. 11, 12.
1953 *Phyllopachyceras forbesianum* (d'Orbigny); Spath, p. 6, pl. 1, figs. 3–5.
1956 *Phyllopachyceras forbesi* (d'Orbigny); Collignon, p. 26.
1956 *Phyllopachyceras zelandicum* Collignon, p. 31.
1962 *Phyllopachyceras forbesianum* (d'Orbigny); Wiedmann, p. 145, text-fig. 10.
1963 *Phyllopachyceras forbesianum* (d'Orbigny); Jones, p. 24, pl. 41, figs. 2, 4–6, text-fig. 9.

Material. C.467 (figured by Marshall 1926, pl. 27, figs. 3, 4). N28/626. 134 additional specimens.

Diagnosis. Involute, inflated forms with whorls increasing rapidly in size and with almost closed umbilicus. Test thin with fine, closely spaced lirae which are rursiradiate on the umbilical shoulder, swing forward on the dorsal flank and straighten on the mid-flank to be rectiradiate across the venter. After every seventh or eighth lira there is a distinct groove on the flanks of juvenile shells; these are the precursors of interspaces between the broad, weak, ridges that appear at late growth stages. The suture is of the *Phyllopachyceras* type with tetraphylloid terminations to the first and second lateral saddles.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
VC.214	7·5	4·0	4·5	1·13	0·2	3
M.382	8·5	4·5	5·0	1·11	0·2	2
M.116	10·0	6·0	6·5	1·08	0·2	2
C.722	11·0	6·0	6·0	1·00	0·2	2
C.475	12·0	7·2	7·0	0·97	0·2	2
C.474	12·0	7·0	7·0	1·00	0·2	2
C.470	13·0	7·5	7·0	0·93	0·2	2
M.775	15·0	9·5	9·5	1·00	0·5	3
MC.198	15·0	8·8	9·2	1·05	0·5	3
M.164	15·0	9·0	9·5	1·06	0·5	3
VC.197	20·0	11·8	12·5	1·06	0·5	3
VC.467	28·0	18·0	17·0	0·94	0·8	3
C.1016	36·0	19·0	19·5	1·03	0·8	2

Remarks. Most of the New Zealand specimens are immature but the broad, weak, ribbing described from late growth stages of overseas specimens is present on those which exceed 30 mm. in shell diameter. For initial growth stages, up to a shell diameter of 10 mm., whorls are wider than high but at later growth stages they are approximately equidimensional. As suggested by Spath (1953, p. 7), *P. minimum* (Marshall) is a junior synonym of *P. forbesianum*. The specimen (C.470) figured by Marshall as *P. minimum* is indistinguishable from *P. forbesianum* of the same growth stage. The high degree of sutural complexity at an early growth stage listed by Marshall as the main distinguishing character of *P. minimum* is shared by *P. forbesianum* and by other *Phyllopachyceras*. *P. bistriatum* (Marshall) was described from a single specimen, CE.580, which has a shell diameter of approximately 55 mm. Marshall's measurements and description suggest that it is slightly narrower whorled than *P. forbesianum* with a distinct angle at the umbilical shoulder but both these features are due to deformation. The other distinction listed by Marshall is that its last quarter whorl has well-developed coarse ribs. Coarse ribs appear at a shell diameter of some 27 mm. and coarsen towards the aperture as on specimens of *P. forbesianum*. The single specimen representing *P. bistriatum* (CE.580) is the largest *Phyllopachyceras* from New Zealand and its well-developed coarse ribs at late growth stages are consistent with the ontogenic strengthening of ribs observed on smaller specimens of *P. forbesianum*. The two species are synonymous.

Schluteria rarawa Marshall is also synonymous with *P. forbesianum*. Specimens of *S. rarawa* including C.722, which was Marshall's figured representative, are identical with juvenile *P. forbesianum* in all characters except that they bear up to six broad, weak, rectiradiate ridges per whorl (see Pl. 1, fig. 4). The ridges are not associated with constrictions as recorded by Marshall, and are largely formed by local thickening of the test so that they are poorly marked on internal moulds. All the ridged shells are juvenile with shell diameters less than 15 mm. and the ridges vary in strength between different specimens. They are interpreted here as ecotypes of *P. forbesianum*. It is proposed that fluctuating ecological conditions such as changing temperatures or periodic food shortages caused some juveniles of *P. forbesianum* to lay down periodic calluses during early ontogeny. At late growth stages *P. forbesianum* develops broad, weak ribs; these structures are easily distinguished from calluses as they are separated by much narrower interspaces and appear at a much later stage of ontogeny. No adult specimens of *P. forbesianum* exhibit callus ridges and it seems likely that callused juveniles achieved a more uniform rate of calcium carbonate secretion at later growth stages. Contrary to Marshall's view, these callused shells are unrelated to *Schluteria* Grossouvre (junior synonym of *Desmophyllites* Spath) which has complex sutures lacking phylloid terminations and collared constrictions that are strongly projected on the venter. A specimen (CE.1022) collected by McKay from Cenomanian rocks at Port Awanui, Gisborne district (N72/485) was compared to the present form by Marshall, but is a juvenile desmoceratid.

Shimizu (1935, p. 178) remarked that the form described by Marshall as *P. forbesianum* was more depressed than *P. forbesianum* (s.s.) and proposed a new species, *P. inflatum* for the New Zealand material. Collignon (1937, p. 26) proposed *P. marshalli* for the same reason but later (1956, p. 31) proposed a substitute name, *P. zelandicum*, for *P. marshalli* to avoid confusion with *Paraphylloceras marshalli* Shimizu. Thus both *P. marshalli* and its substitute, *P. zelandicum*, are junior synonyms of *P. inflatum* Shimizu.

P. inflatum and *P. forbesianum* are here considered synonymous. The New Zealand specimens have similar dimensions to those of the original of *P. forbesianum* figured by Forbes. Further, Spath (1953, p. 6) examined both New Zealand material and the Indian originals (Kaye and Cunliffe collection in the British Museum) when dealing with the Graham Land members of *P. forbesianum* and considered the three groups to be conspecific.

The status of *P. forbesianum* in Japan is not clear; Shimizu (1935, p. 178) recorded the species from Saghalien but Matsumoto (1942, p. 674), did not include it in his list of Japanese Phylloceratidae or in his later list (1954, table 1) of Cretaceous Cephalopoda from Hokkaido and Saghalien. The variation in whorl breadth/height ratios of the New Zealand material supports the suggestion of Spath (1953, p. 6) that *P. forbesianum* and *P. ezoense*, are indistinguishable in whorl dimensions. A well-developed coarse ribbing, appearing at a shell diameter of some 30 mm. on *P. ezoense*, is the other reputed distinction between the two species (Matsumoto 1942, p. 674). The type of *P. forbesianum* (BM no. R.10476) with a shell diameter of 31 mm. is barren of coarse ribs as are *P. ezoense* of the same growth stage but a larger specimen of *P. forbesianum* from the Kaye and Cunliffe collection, with a shell diameter of 48 mm., exhibits the mature ribbing (Spath 1953, p. 6). Also a specimen (VC.315) collected from Kawakami district, Saghalien by S. Shimizu and identified by him as *P. ezoense*, is indistinguishable from New Zealand *P. forbesianum*. Like Spath (1941, p. 43), I consider the two species to be synonymous.

The Alaskan and British Columbian specimens of *P. forbesianum* measured by Jones (1963) and Usher (1952) are consistently more slender whorled than those of other countries and may represent a separate subspecies.

Superfamily LYTOCERATACEAE Neumayr 1875
Family TETRAGONITIDAE Hyatt 1900

Wright (1957*a*, p. 200) ranked the Tetragonitidae as a family of Superfamily Lytoceratacea Neumayr 1875 and considered the Gaudryceratinae Spath 1927 and the Tetragonitinae Hyatt 1900 as subfamilies. This classification is used here rather than that proposed by Wiedmann (1962, p. 147) which ranks Hyatt's Family Tetragonitidae as a superfamily and recognizes the Gaudryceratidae and Tetragonitidae as families. Wiedmann has demonstrated a sutural distinction between the Lytoceratacean family Protetragonitidae Spath, proposed as the ancestral stock of Family Tetragonitidae by Spath (1927, p. 67) and Wright (1957, p. 200), and Family Tetragonitidae. Until the ancestry of the Tetragonitidae is known, its systematic position with respect to the Lytoceratacеae is uncertain but the general similarity in shell form and sculpture between members of the two groups suggests a phylogenetic connection between them. The range of variation of the Lytoceratacеae (inclusive of the Tetragonitidae), Tetragonitidae, Tetragonitinae, and Gaudryceratinae is akin to that of other taxa of Cretaceous ammonites of equivalent rankings. Thus there seems little point in upgrading Family Tetragonitidae and its two subfamilies at present.

Subfamily TETRAGONITINAE Hyatt 1900
Genus TETRAGONITES Kossmat 1895

1895 *Tetragonites* Kossmat, p. 131.
1925 *Epigoniceras* Spath, p. 29.

Type species. Tetragonites timotheanus (Pictet 1847, p. 295, pl. 2, figs. 6*a*, *b*; pl. 3, figs. 1*a–c*).

Epigoniceras was proposed to separate members of *Tetragonites* with retracted suspensive lobes from *Tetragonites* (s.s.). Howarth examined the sutures of *Tetragonites* and *Epigoniceras* in the British Museum collection as well as all the published figures and concluded (1958, p. 9) that the two genera are synonymous.

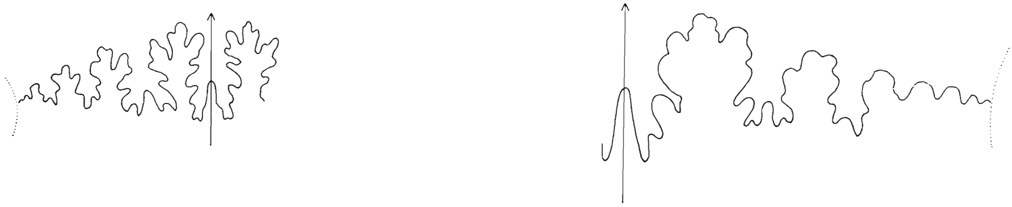
Tetragonites margaritatus Marshall

Plate 1, fig. 7; text-fig. 3*a*

1926 *Tetragonites margaritatus* Marshall, p. 151, pl. 20, fig. 5; pl. 30, figs. 5, 6.

Material. Lectotype here designated: C.1001 (figured by Marshall 1926, pl. 30, figs. 5, 6). N28/636. 26 additional specimens.

Diagnosis. Shell small with gently tapering depressed volutions and a narrow umbilicus. All whorls are subquadrate in cross-section with a low steep umbilical wall, weakly



TEXT-FIG. 3. *a*, Suture of *Tetragonites margaritatus* Marshall; C.1018, whorl height 2·8 mm., ×7. *b*, Suture of *Tetragonites simplex* Marshall; C.1020, whorl height 5·5 mm., ×7.

convex flanks, and a broadly arched, slightly flattened venter. Fine lirae are rectiradiate on the umbilical wall, then swing forward and become progressively weaker on the umbilical shoulder and dorsal flanks. The ventral flanks and venter have no radial sculpture. Some specimens bear 2 or 4 spiral ribs on the venter. Weak infrequent constrictions with the same inclination as the lirae and rectiradiate across the venter are distinct on the internal moulds of some specimens but obscure on others. Sutures have well-developed auxiliary elements.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
M.14	8·5	3·5	4·5	1·29	3·0	35
C.1018	12·0	4·8	6·0	1·25	4·0	33
VC.170	13·5	5·5	6·8	1·24	4·5	33
C.500	14·0	6·0	7·0	1·17	4·2	30
M.716	15·0	6·0	7·0	1·17	4·5	30
M.11	15·0	6·0	7·5	1·25	5·0	33
C.1001	15·5	6·5	7·5	1·15	5·0	32
M.398	22·8	8·2	10·5	1·28	7·0	31

Remarks. Tetragonites superstes van Hoepen (1921, p. 10, pl. 2, figs. 17–20, text-fig. 6) is closely related to *T. margaritatus* but only its mature whorls are subquadrate.

T. popetensis Yabe (1903, p. 48, pl. 7, figs. 4*a*, *b*, 6) is also close but has less depressed whorls than *T. margaritatus*.

Tetragonites simplex Marshall

Plate 1, fig. 6; text-fig. 3*b*

1926 *Tetragonites simplex* Marshall, p. 160, pl. 20, figs. 11, 11*a*; pl. 32, figs. 3, 4.

Material. Lectotype here designated: CE.652, N28/626. 35 additional specimens.

Diagnosis. Small with gently tapering, depressed volutions and a moderately wide umbilicus. Whorls are subquadrate in cross-section, the umbilical wall low and steep, the flanks weakly convex and the venter broad and slightly flattened. Infrequent, weak constrictions may be present, being rectiradiate on the umbilical wall and venter but prorsiradiate on the umbilical shoulder and dorsal flanks. Very fine lirae with the same inclination as the constrictions ornament the umbilical wall, umbilical shoulder, and dorsal flanks but are absent from the venter. Two or four weak spiral ridges are usually present on the venter. Suture unusually simple with poorly developed auxiliary elements.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
CE.666	10·5	4·0	5·0	1·25	3·5	33
M.414	11·5	4·2	5·0	1·19	4·0	35
M.764	12·0	4·5	5·0	1·11	4·0	33
M.656	12·0	4·5	5·0	1·11	4·0	33
M.585	14·0	5·0	5·8	1·16	5·0	36
C.795	16·0	5·5	7·0	1·27	5·8	36
M.137	17·0	5·8	7·0	1·21	6·2	36
CE.650	17·0	6·0	7·0	1·17	5·8	34
CE.647	18·0	6·5	7·5	1·15	6·5	36
C.514	18·5	7·0	8·5	1·21	6·5	35
VC.21	19·0	7·0	8·2	1·17	7·0	37

Remarks. The specimen figured by Marshall cannot be found in the existing New Zealand collections. CE.652, here selected as the lectotype, is labelled as *Tetragonites simplex* in Marshall's handwriting and is undoubtedly one of his original syntypes. *T. simplex* is very closely related to *T. margaritatus* Marshall. It usually has a slightly wider umbilicus and more strongly subquadrate whorls than *T. margaritatus*, but the range of variation of these characters overlaps in the two species. They are best distinguished by their sutures; that of *T. margaritatus* has well-developed auxiliary elements while that of *T. simplex* is unusually simple (text-fig. 3). Where the suture of *T. margaritatus* has been simplified by erosion of the septal margins, the two species may be confused.

Tetragonites marshalli (Collignon)

Plate 1, figs. 8, 9

1926 *Tetragonites epigonus* Kossmat; Marshall, p. 149, pl. 21, fig. 10; pl. 29, figs. 6, 7.
1956 *Pseudophyllites marshalli* Collignon, p. 86.

Material. Neotype here designated: CE.2137, N28/626. 8 additional specimens.

Diagnosis. Whorls weakly subquadrate, slightly wider than high, increasing rapidly in size and strongly embracing to produce a narrow umbilicus. Umbilical wall steep, flanks weakly convex and usually convergent, venter forming a broad low arch. Test thin, ornamented with fine lirae which are rectiradiate on the umbilical wall, prorsiradiate on the flanks and weakly rursiradiate across the venter. Broad, weak ribs, separated by interspaces as wide as themselves appear on the flanks of late growth stages and have the same inclination as the lirae. Constrictions also with the same inclination are variable in number and development, incised on the umbilical wall and dorsal flanks but weak on the venter. Sutures have well-developed auxiliary elements.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
VC.171	22·0	10·0	11·2	1·12	6·2	28
CE.2137	24·0	11·2	12·8	1·14	6·0	25

Remarks. Broad, weak ribs are present only on the two largest specimens, appearing at shell diameters of 23 mm. and approximately 24 mm. on CE.2137 and CE.847 respectively. They are unusual features for *Tetragonites.*

Tetragonites marshalli (Collignon) was proposed for *Tetragonites epigonus* Marshall (*non* Kossmat) without reference to Marshall's original specimens. In his description, Marshall referred to two specimens figuring one of them. His figured specimen cannot be found in the present New Zealand collections but three specimens of *T. marshalli* are present in the collection he donated to Auckland University. Unfortunately there is no way of deciding which of these specimens is the other syntype. Since none of the specimens meet the requirements of a lectotype, the best-preserved specimen available, CE.2137, is here designated as a neotype; it is from Bull's Point (N28/626), the same locality as Marshall's measured specimen. Because of the divergence of opinion in the generic placing of *T. marshalli*, the designation of a neotype is thought to be desirable for nomenclatural stability.

Collignon correctly recognized that the New Zealand specimens referred to *T. epigonus* Kossmat (1895, p. 135, pl. 17, figs 4*a–c*, 5*a*, *b*, 10) by Marshall comprise a separate species but his inclusion of this species in *Pseudophyllites* is invalid. *Pseudophyllites* is restricted to forms without constrictions (Wright 1957*a*, p. 203). A weakly subquadrate whorl shape as well as the presence of constrictions suggests that *P. marshalli* Collignon is a member of *Tetragonites.*

T. marshalli differs from the widely distributed *T. epigonus* in having a much less quadrate whorl shape. According to Kossmat (1895, pl. 17, fig. 5*b*) and Usher (1953, pl. 3, fig. 1) *T. epigonus* has a distinctly angular whorl shape at an early stage of ontogeny so that juveniles of the two species are easily differentiated. Juveniles of *T. glabrus* (Jimbo) (1894, p. 34, pl. 6, figs. 2, 2*a*) and *T. marshalli* are indistinguishable but the appearance of coarse ribbing at late growth stages of the latter allows the two species to be separated.

Genus PSEUDOPHYLLITES Kossmat 1895

Pseudophyllites latus (Marshall)

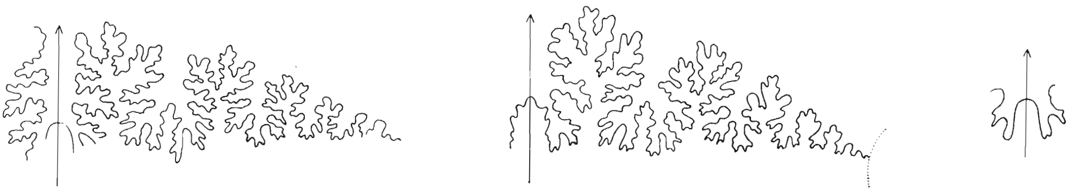
Plate 1, fig. 10; Plate 2, fig. 3; text-fig. 4*a*, *c*

?1909 *Pseudophyllites indra* (Forbes); Kilian and Reboul, p. 14.
1926 *Pseudophyllites indra* (Forbes); Marshall, p. 152, pl. 20, fig. 1; pl. 29, figs. 3–5.
1926 *Tetragonites latus* Marshall, p. 149, pl. 20, figs. 6, 6*a*; pl. 32, figs. 1, 2.

1926 *Pseudophyllites whangaroaensis* Marshall, p. 153, pl. 20, fig. 2; pl. 21, fig. 11; pl. 32, figs. 5, 6.
1953 *Pseudophyllites peregrinus* Spath, p. 7, pl. 1, figs. 6, 7*a*, *b*, 8*a*, *b*, 9*a–c*.
1956 *Pseudophyllites peregrinus* Spath; Collignon, p. 92, text-fig. 12.
1965 *Pseudophyllites skoui* Birkelund, p. 37, pl. 3, figs. 2–6, text-figs. 26–33.

Material. Lectotype here designated: C.494 (figured by Marshall 1926, pl. 32, fig. 1), N28/636. 100 additional specimens.

Diagnosis. Rapidly tapering, volutions initially depressed and weakly subquadrate but become higher than wide and rounded at late growth stages. All growth stages narrowly umbilicate due to strong involution. Umbilical wall steep but not vertical, flanks convex



a b c

TEXT-FIG. 4. Sutures of *Pseudophyllites latus* (Marshall). *a*, VC.267, whorl height 10·2 mm., ×3. *b*, *P. skoui* Birkelund = *P. latus* (Marshall) (after Birkelund 1965, text-fig. 32); whorl height 10·7 mm., ×3. *c*, Ventral saddle of VC.13, N14/655; whorl height 6 mm., ×5.

and subparallel and the venter broadly arched. Test smooth apart from growth lines up to a shell diameter of 22–40 mm.; thereafter broad, weak radial ribs appear. Indistinct spiral ridges may be present from an early growth stage. Where both are well developed a recticulate pattern results. Suture similar to *P. indra* (Forbes) but has a ventral saddle with a broad front.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
M.558	10·0	4·5	5·5	1·22	2·5	25
M.167	11·5	5·5	6·5	1·18	2·5	22
M.765	13·5	6·0	7·0	1·17	3·5	26
M.648	16·0	6·8	8·0	1·18	4·0	25
C.516	18·0	8·5	9·8	1·15	4·5	25
C.494	18·0	8·5	10·0	1·18	4·5	25
C.495	19·0	8·0	9·5	1·19	4·5	24
C.584	22·0	11·0	12·5	1·14	5·5	25
C.517	24·5	11·5	12·5	1·09	6·0	25
VC.267	28·0	14·0	15·2	1·09	7·0	25
M.128	29·0	14·0	15·0	1·07	7·0	24
M.558	31·0	15·0	15·5	1·03	7·5	24
C.593	35·0	17·0	16·0	1·06	8·0	23
CE.670	37·5	19·0	20·0	1·05	9·0	24
C.871	41·0	20·5	21·0	1·02	10·8	26
C.1021		35·0	33·0	0·94		

Remarks. Although *P. latus* is abundant in New Zealand, few specimens are mature, and these are invariably crushed because the test is thin. The New Zealand examples, like

P. indra (Forbes) (1846, p. 105, pl. 11, figs. 7*a–c*) are variable in ornamentation. Radial ribs develop at a shell diameter of 22 mm. on CE.670 but are absent from C.593 which has a shell diameter of 35·0 mm. Two large crushed specimens, C.1021 and VC.250 have very well-developed radial ribs like those on a specimen of *P. indra* figured by Usher (1952, pl. 3, figs. 11, 12). Weak spiral ridges are usually present on juvenile shells of *P. latus*. Two mature specimens, C.998 and C.1021 have both spiral and radial ornament well developed; these intersect in a reticulate pattern. Ribs are closely spaced on C.998 and a fine reticulation results (Pl. 2, fig. 3) but those of C.1021 are well spaced to produce a coarse reticulation. Similar reticulate ornament is present on specimens of *P. indra* figured by Kossmat (1895, pl. 16, fig. 9*a*) and Jones (1963, pl. 9, fig. 6).

Three species recognized by Marshall, *Tetragonites latus*, *Pseudophyllites indra*, and *Pseudophyllites peregrinus* are here synonymized. Marshall based *Tetragonites latus* on a juvenile specimen (now numbered C.494) but the measurements he gave (1926, p. 149, dimensions for specimen A) are incorrect. The revised measurements given above show the specimen to belong to an ontogenetic series of forms which comprise a single species. The absence of constrictions and the smoothly rounded whorl cross-section show the species to belong in *Pseudophyllites*. The specimen figured by Marshall (now numbered CE.670) as *Pseudophyllites indra* is indistinguishable from *P. latus* of the same growth stage; it differs from *P. indra* (Forbes) (1846, p. 105, pl. 11, figs. 7*a–c*) in possessing a broader venter and a broader termination to the ventral saddle of the suture. Marshall differentiated *P. whangaroaensis* (represented by a single specimen, C.871) on the basis of fine reticulate ornament at late growth stages. However, as discussed above, reticulate ornament may be developed at late growth stages in specimens otherwise indistinguishable from *P. latus*; it is a variable character and cannot be used for specific distinction.

Pseudophyllites latus is taken as the name of the present species in spite of its lectotype being an immature specimen. The holotype of *P. whangaroaensis* is atypical in that its reticulate mature ornamentation is near the extreme for the species.

P. peregrinus Spath, described from Graham Land and Madagascar, is indistinguishable from *P. latus*; both species agree very closely in whorl cross-section and sutural characteristics. The single specimen measured by Spath is a little more narrowly umbilicate (20% of the shell diameter) than the measured New Zealand specimens but the difference is small and not worthy of specific distinction. *P. skoui* Birkelund (1965, p. 37, pl. 3, figs. 2–6, text-figs. 26–33) is also synonymous with *P. latus*. This Greenland species is given by Birkelund as differing from *P. peregrinus* in its smaller size, its less incised suture and in lacking distinct ribs. The suggested large size of *P. peregrinus* is based on three very large, isolated camerae recorded by Spath (1953, p. 8) but the best preserved of these was only doubtfully referred to *P. peregrinus*. The single mature specimen of *P. skoui*, with a shell diameter of about 60 mm. is of similar size to mature *P. latus* from New Zealand. The suture of *P. latus* is of similar complexity to that of *P. skoui* (text-fig. 4). Ribs appear at a shell diameter of 22 mm. on a small specimen of *P. skoui* figured by Birkelund (1965, pl. 3, fig. 3*a*) yet apparently are absent from larger specimens. Similar variation in rib development is shown by New Zealand *P. latus*.

P. latus is very closely related to *P. indra* (Forbes). The New Zealand examples exhibit identical ontogenetic changes in whorl dimensions to *P. indra*, measurements for which are summarized by Jones (1963, p. 26, text-fig. 11). The Graham Land and Madagascan examples of *P. latus* differ slightly from those of New Zealand in possessing whorls that are wider than high at very large shell diameters. New Zealand and Madagascan specimens of *P. latus* are almost identical to *P. indra* in ornamentation. Spath emphasized the differences in the ventral saddles of the two species, that of *P. indra* being lanceolate while that of *P. latus* is spatulate. Collignon (1956, p. 93) has described a specimen which is identical to *P. latus* in all characters except the suture which has a ventral saddle of the *P. indra* type. The most consistent distinguishing character is that *P. latus* has a broader venter than *P. indra*, but the distinction may be of subspecific rather than specific importance.

Subfamily GAUDRYCERATINAE Spath 1927
Genus GAUDRYCERAS Grossouvre 1894

Gaudryceras propemite Marshall

Plate 2, fig. 1

1926 *Gaudryceras propemite* Marshall, p. 142, pl. 20, fig. 4; pl. 28, figs. 3, 4.

Material. Holotype: CE.596 (figured by Marshall, pl. 20, fig. 4; pl. 28, figs. 3, 4), N28/626. 2 additional specimens.

Diagnosis. Whorls depressed and rounded at all known growth stages (up to a shell diameter of 65 mm.); umbilicus of moderate size for the genus. Juvenile whorls ornamented with fine primary ribs which split on the mid-flank into numerous closely spaced lirae; the ribs are rectiradiate on the umbilical wall, prorsiradiate on the umbilical shoulder, rectiradiate at the mid-flank and cross the venter with a slight adapertural projection. On mature whorls, primary ribs have the same sinuosity but continue across the venter without dividing but a number of intercalatory ribs appear on the flanks. Each whorl has four sinuous constrictions preceded by weak collars. The suture has a retracted suspensive lobe.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
M.384	28·0	8·5	10·8	1·27	13·0	46
CE.596	65·0	28·0	35·0	1·25	23·0	35

Remarks. At early and middle growth stages, the whorls of *C. propemite* become more depressed with increasing shell diameter but at late growth stages the reverse is true. Successive whorls become more embracing so that the umbilical diameter expands at a slower rate than the shell diameter.

There are a number of Indo-Pacific species which closely resemble *G. propemite*. They can be divided into two groups; some develop coarse ribbing at late growth stages and some do not. Species with coarse mature ribs include *G. tenuiliratum* Yabe (1903, p. 19, pl. 3, figs. 3, 4), *G. densiplicatum* (Jimbo) (1894, p. 182, pl. 23, figs.1, 1*a*), *G. denmanense* Whiteaves (redescribed by Usher, 1952, p. 59, pl. 4, figs. 1, 1*a*, 1*b*) and *G. lauteli* Collignon (1956, p. 57, pl. 57, figs. 1, 1*a*, 1*b*). *G. densiplicatum* and *G. tenuiliratum* are both characterized by two orders of ribs when mature and are poorly differentiated to the degree that *G. tenuiliratum* var. *intermedium* of Yabe is classified as a subspecies of *G. densiplicatum* by Matsumoto (1959*c*, p. 143). *G. denmanense* is differentiated from these two species in that it has coarse ribs alone when mature; however, the Alaskan specimen figured by Jones (1963, pl. 9) as *G. tenuiliratum* appears to be of intermediate character. *G. lauteli* seems to be indistinguishable from the *G. tenuiliratum–G. densiplicatum* group except that its adult ribbing appears at a later stage of ontogeny and is perhaps a little more widely spaced. All four species warrant study with regard to variation in adult ornamentation to see if there is a basis for their separation.

The group lacking coarse adult ribbing includes *G. varagurense* Kossmat (1895, p. 122, pl. 17, fig. 9; pl. 18, figs. 2*a–c*), *G. cinctum* Spath (1922, p. 118, pl. 9, figs. 3*a, b*), *G. analabense* Collignon (1956, p. 54, pl. 6, figs. 1, 1*a, b*, 2, 2*a, b*, 3, 3*a, b*), *G. beantalyense* Collignon (1956, p. 53, pl. 5, figs. 1, 1*a*, 2, 2*a, b*, 3, 3*a, b*). Judging from Collignon's more recent figure of *G. beantalyense* (1966, fig. 1713) it is indistinguishable from *G. analabense*. Both species have fine dense ribbing like that of *G. varagurense*. *G. cinctum* is more coarsely ribbed.

G. propemite probably belongs to the group lacking coarse adult ribbing because the lectotypes of *G. densicostatum*, *G. tenuiliratum*, and *G. denmanense* all have the mature costation at the diameter of the largest New Zealand specimen. It is affiliated with *G. cinctum* rather than to the more finely ribbed *G. varagurense–analabense–beantalyense* group. It seems to differ from this and from all the species discussed in having distinctly depressed whorls at a shell diameter of 60 mm. For the present *G. propemite* is retained but when the other species are revised and clarified, it is likely to pass into synonymy.

Gaudryceras sp.

1917 *Gaudryceras* sp. aff. *jukesii* (Whiteaves) (*non* Sharp); Woods, p. 35, pl. 10, fig. 2.

Material. CE.886, S56/25.

Description. The specimen is a fragment showing parts of three whorls. The umbilical wall is steep, the umbilical shoulder sharp, and the flanks weakly convex. Dense, sharp primary ribs begin from the umbilical seam. At first they are prorsiradiate but become rectiradiate at the mid-flank. Intercalatories, as numerous as the primary ribs are inserted on the dorsal flanks. Constrictions are not present on the portions of whorl preserved.

Remarks. The specimen superficially resembles several species of *Gaudryceras*, including *G. denmanense* Whiteaves (1901, p. 31) (= *Anmonites jukesii* Whiteaves *non* Sharpe), but is too incomplete to be specifically identified. However, it appears to be distinct from *G. propemite*.

EXPLANATION OF PLATE 2

Fig. 1. *Gaudryceras propemite* Marshall; holotype, CE.596. N28/626. Lateral view; ×1.

Figs. 2, 9. *Anagaudryceras particostatum* (Marshall). 2, lectotype, CE.604. N28/626. *a*, Apertural, *b*, lateral view; ×1. 9, C.588b. N28/626. *a*, Apertural, *b*, lateral view; ×1.

Fig. 3. *Pseudophyllites latus* (Marshall); C.1021. N28/639. Lateral view; ×1.

Figs. 4, 7. *A. tennenti* sp. nov. 4, holotype, VC.284. N150/1137. *a*, Apertural, *b*, lateral view; ×1. 7, paratype, C.477. N28/626. *a*, Lateral, *b*, apertural view; ×1.

Figs. 5, 6. *A. subsacya* (Marshall). 5, C.771. N28/626. Lateral view, ×1. 6, AM.5765. N28/626. *a*, Apertural, *b*, lateral view; ×1·5.

Fig. 8. *Zelandites kaiparaensis* Marshall; C.1022. N28/639. *a*, Lateral, *b*, apertural view; ×1.

Genus ANAGAUDRYCERAS Shimizu 1934

Anagaudryceras particostatum (Marshall)

Plate 2, figs. 2, 9

1926 *Gaudryceras particostatum* Marshall, p. 143, pl. 20, fig. 7; pl. 30, figs, 3, 4.
1926 *Gaudryceras crenatum* Marshall, p. 146, pl. 20, fig. 10; pl. 31, figs. 3, 3*a*.
1926 *Gaudryceras politissimum* Kossmat; Marshall, p. 145, pl. 20, fig. 3; pl. 28, figs. 1, 2.
1935 *Saghalinites zealandicus* Shimizu, p. 181.

Material. Lectotype here designated: CE.604 (figured by Marshall 1926, pl. 30, figs. 3, 4), N28/626. 32 additional specimens.

Diagnosis. Shell of moderate size and widely umbilicate. Initial volutions depressed with rounded flanks and a broad venter but later volutions compressed with convergent flanks and a narrowly arched venter. On initial volutions, ornament consists of fine, closely spaced lirae, which break down into extremely fine secondaries on the umbilical shoulder; the primaries, when well preserved, are finely crenulate on their adapertural faces. At a shell diameter of 12–14 mm. the primaries suddenly become finer, more closely spaced, and less regular; at a shell diameter of approximately 30 mm. the *Vertebrites* style of ornamentation characteristic of inner whorls becomes obscure and the lirae are not crenulate. Suture with strongly retracted suspensive lobe.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
CE.601	15·0	4·5	5·5	1·22	7·0	47
M.658	18·0	5·5	6·5	1·18	8·5	47
CE.604	25·0	8·0	8·5	1·06	10·8	43
C.476	26·5	8·5	8·5	1·00	11·5	43
M.721	27·8	9·2	9·0	0·98	12·2	44
C.873	27·0	9·5	9·5	1·00	11·5	43
M.122	28·0	10·0	9·5	0·95	12·0	43
C.767a	30·5	10·8	10·5	0·97	11·8	39
C.587	38·0	13·5	12·0	0·89	16·0	42
CE.993	38·0	14·0	12·2	0·87	14·5	38
C.588b	41·0	14·5	13·0	0·90	16·2	40
C.739a	43·0	16·0	14·5	0·91	17·0	40
M.548	16·0	16·5	15·0	0·91	20·0	43

Remarks. Marshall based *G. crenatum* on a single specimen, C.873, his criteria for distinguishing it being incorrectly measured dimensions and its finely crenulate lirae. The correct dimensions given above agree with those of *A. particostatum* and crenulate lirae are preserved on C.439a, 767a, CE.993, M.667, and 721 which are undoubted examples of *A. particostatum*. Although the *Vertebrites* style of ornamentation disappears at a smaller shell diameter on C.873 than typical of *A. particostatum*, the two species are here synonymized. Crenulate lirae may be a consistent specific character of *A. particostatum* and its absence from some specimens attributable to slight erosion. The specimen figured by Marshall as *G. politissimum* Kossmat, CE.627, was renamed *Saghalinites zealandicus* by Shimizu because of its narrower umbilicus and high whorls. This specimen is severely crushed and Marshall's dimensions (on which *S. zealandicus* is based) are valueless. Its ornament and other characters agree closely with those of *A. particostatum*.

Two crushed specimens collected from southern Hawke's Bay Province, VC.287a–c (N150/1135) and CE.980 (N146/440) are *Anagaudryceras* of the *particostatum* type but are too poorly preserved to be accurately identified.

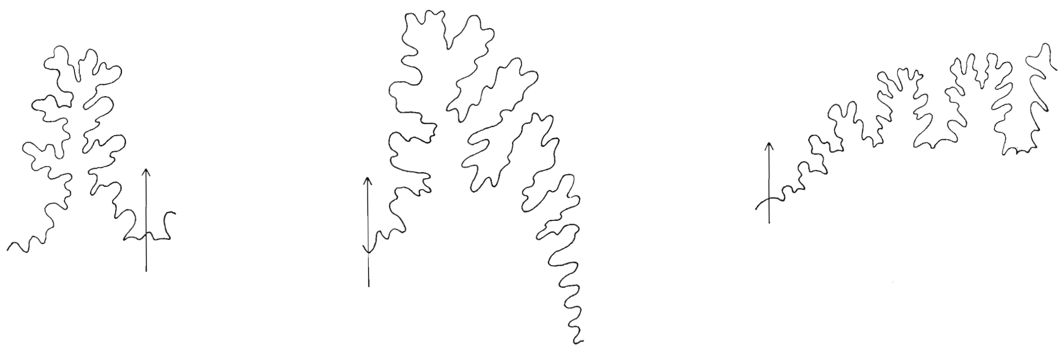
A. mikobokense Collignon (1956, p. 59, pl. 8, figs. 1, 1*a*, 1*b*) closely resembles *A. particostatum* but, judging from Collignon's figures, its whorls do not become higher than wide until a shell diameter of approximately 60 mm., and its suspensive lobe is not as strongly retracted. The two forms figured as *G. politissimum* Kossmat by Kilian and Reboul (1909, pl. 1, figs. 7, 8) and synonymized with *A. mikobokense* by Collignon appear to be a distinct species. Unless they are crushed, they are too narrowly umbilicate and their whorls are too high for them to belong to either of the two species to which they have been referred, or to *A. particostatum*.

Anaguadryceras subsacya (Marshall)

Plate 2, figs. 5, 6; text-fig. 5*a*

1917 *Lytoceras* sp.; Marshall, p. 445, pl. 33, fig. 3, text-fig. 4.
1926 *Gaudryceras subsacya* Marshall, p. 144, pl. 20, figs. 8, 8*a*; pl. 29, figs. 1, 2.

Material. Lectotype here designated: CE.611 (figured by Marshall, pl. 29, figs. 1, 2), N28/626. 30 additional specimens.



a b c

TEXT-FIG. 5. *a*, Internal suture of *Anagaudryceras subsacya* (Marshall) (after Marshall 1926, pl. 20, fig. 8*a*); whorl height 7 mm., ×7·5. *b*, Internal suture of *Anagaudryceras tennenti* sp. nov.; holotype VC.284, whorl height 6·5 mm., ×7·5. *c*. Internal suture of *Vertebrites murdochi* Marshall (after Marshall 1926, pl. 20, fig. 9*a*); ×7·5.

Diagnosis. Early whorls depressed, rounded, and gently tapering but mature whorls almost equidimensional, subquadrate, and expand rapidly in size so that adult shells are narrowly umbilicate. Fine, closely spaced primary lirae swing forward from the umbilical seam; at the umbilical shoulder they are joined by intercalatories which are as numerous as the primaries themselves. Lirae are weakly convex towards the aperture on the flanks and are slightly projected across the venter. At a shell diameter of 40–50 mm. a prominent ribbing replaces the liration. Ribs are relatively narrow, separated by interspaces as wide as themselves and have the same inclination as the lirae. The five constrictions per whorl are preceded by a prominent collar. Suture more finely divided than is typical of the genus.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
M.657	11·5	4·5	6·0	1·33	5·0	44
C.479	15·0	5·0	6·8	1·36	6·8	45
CE.626	16·0	6·0	7·5	1·25	7·0	44
M.52	17·0	6·5	8·0	1·23	7·0	41
CE.611	22·8	8·5	10·0	1·18	9·5	42
CE.618	24·0	9·0	10·5	1·17	9·0	38
C.478	24·0	9·5	11·0	1·16	9·5	40
CE.625	30·0	11·0	12·5	1·14	11·5	38
CE.994	31·0	11·5	13·0	1·13	12·5	40
C.532	32·0	12·0	12·8	1·07	12·2	38
C.585	51·0	22·0	22·5	1·02	16·0	31

Remarks. At the time of Marshall's account, no mature specimens of *A. subsacya* had been collected and the change in ornamentation and whorl shape at late growth stages is not listed in the original description. The mature ribbing is variable both in stage of appearance and degree of development. On C.532 it appears at a shell diameter of approximately 40 mm. but is poorly developed; on C.771a a well-developed ribbing appears at a shell diameter of approximately 52 mm.; and on C. 800a strong ribs appear at a shell diameter of approximately 43 mm.

Several species of *Anagaudryceras* described from other countries are morphologically similar to *A. subsacya*. *A. sacya* (Forbes) (1846, p. 113, pl. 14, figs. 10*a–c*) has rounded mature whorls bearing very broad ribs separated by narrow interspaces, and from a direct comparison of a specimen of *A. subsacya* with Forbes's type Marshall concluded that lirae of the New Zealand species are a little finer and more closely spaced than in *A. sacya*. *A. limatum* (Yabe) (1903, p. 34, pl. 4, fig. 2; pl. 5, fig. 2; pl. 6, figs. 3*a*, 3*b*) has similar ornament to that of *A. subsacya* but its mature whorls are rounded and constrictions, if present, have much weaker collars. *A. subtililineatum* (Kossmat) (1895, p. 129, pl. 19, figs. 1*a–c*) is very similar to *A. subsacya* but its early growth stages are more widely umbilicate. *A. salinarium* (Douville) (1931, p. 42, pl. 1, fig. 3, text-fig. 5) is also close but here the lirae are stronger and the ribs weaker than in *A. subsacya*. Two of these species, *A. sacya* and *A. salinarium*, are of Cenomanian age while the others are Senonian. The close resemblance between species of widely divergent ages suggests that *Anagaudryceras* was a slowly evolving group.

The specimen collected from Cenomanian strata at Coverham, Marlborough and described by Woods (1917, p. 11, pl. 5, figs. 4*a*, 4*b*) as *A. sacya* was tentatively included in *A. subsacya* by Marshall. Several more specimens now available show it to be a new species. It is indistinguishable from *A. subsacya* when immature but late growth stages are more widely umbilicate and the largest specimen as yet collected, with a shell diameter of 65 mm., has no ribs and maintains a rounded whorl profile throughout ontogeny.

Anagaudryceras tennenti sp. nov.

Plate 2, figs. 4, 7; text-fig. 5*b*

Material. Holotype: VC.284, N150/1157. Paratypes: C.477, N28/626; CE.112, 129, N159/738.

Description. The shell is small and widely umbilicate with gently tapering volutions which are strongly depressed at early growth stages but become progressively less so with increasing shell diameter. At early and middle stages of growth, whorls have a low, steep umbilical wall, rounded flanks, and a broadly arched venter. In contrast, mature whorls (appearing at a shell diameter of about 37 mm. on VC.284) develop convergent flanks and a narrowly arched venter. Ornamentation is of the *Vertebrites* style. Fine primary lirae are rectiradiate on the umbilical wall and strongly prorsiradiate on the umbilical shoulder and on the dorsal flanks break down into numerous, closely spaced, fine lirae which cannot be distinguished with the naked eye. As the lirae cross the flanks they become progressively less inclined and eventually rectiradiate, but are projected on the venter. The primary lirae become progressively more widely spaced as the shell diameter increases up to approximately 18 mm. Thereafter they are more closely spaced and distinctly finer. The five constrictions per whorl have the same inclination as the ribs and are preceded by collars. The suspensive lobe of the suture is strongly retracted. The internal suture consists of a single asymmetrical internal saddle and a deep dorsal lobe; the internal saddle is composed of six accessory saddles which decrease regularly in size towards the umbilical seam.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
CE.129	18·0	4·2	5·8	1·38	10·0	56
C.477	33·8	9·0	10·5	1·17	17·5	52
VC.284	19·5	5·0	6·8	1·36	11·0	56
	29·5	7·8	10·0	1·28	15·5	53
	48·0	15·0	16·5	1·10	22·5	47

Remarks. Anagaudryceras tennenti is morphologically intermediate between *Vertebrites* and *Anagaudryceras*. Its ornamentation is of the *Vertebrites* type as are its strongly depressed, widely umbilicate juvenile growth stages. But at late growth stages the whorl cross-section, with convergent flanks, and a narrowly arched venter, is unlike *Vertebrites* and resembles some members of *Anagaudryceras*.

Marshall (1926, p. 138) in the type description of *Vertebrites* emphasized the difference in internal suture between *Vertebrites* and *Gaudryceras*. Later Shimizu (in Shimizu and Obata, 1934, p. 67) split *Anagaudryceras* from *Gaudryceras* (s.s.) but both these genera have a single internal saddle with several weak accessory saddles. The internal suture of *V. murdochi*, the type species of *Vertebrites*, has six internal saddles. Although *A. tennenti* has a single major internal saddle the accessory saddles are much more pronounced than in *Gaudryceras* or *Anagaudryceras*. The accessory saddles of *Gaudryceras* and *Anagaudryceras* are the precursors of the six internal saddles of *Vertebrites* and the internal suture of *Anagaudryceras tennenti* is intermediate between the two (text-fig. 5). *A. varicostatum* (van Hoepen) (1921, p. 7, pl. 2, figs. 10–12, text-figs. 3, 4) is also intermediate in shell form and internal suture between these two groups.

Mature growth stages are here used to classify *A. tennenti*; these are distinct from *Vertebrites* in whorl cross-section. According to Wright (1957*a*, p. 200), *Gaudryceras* is distinguished from *Anagaudryceras* by its coarser lirae. This character varies widely in both genera and the exact point of distinction between them is not well defined. The extremely fine secondary liration of the present species, like that of *A. varicostatum*, suggests reference to *Anagaudryceras*. The origin of *Vertebrites* is in doubt. *A. tennenti* and *A. varicostatum* suggest derivation from *Anagaudryceras* but Matsumoto (1959*c*, p. 141) has noted that juveniles of *Gaudryceras tenuiliratum* Yabe resemble *Vertebrites* in shell form and ornamentation.

A. tennenti is closely related to *A. varicostatum* but at corresponding growth stages its whorls are more depressed and it is more widely umbilicate.

Genus ZELANDITES Marshall 1926

Zelandites kaiparaensis Marshall

Plate 2, fig. 8

1926 *Zelandites kaiparaensis* Marshall, p. 147, pl. 19, figs. 9, 9*a*; pl. 31, figs. 1, 2.
1959*c* *Zelandites* sp.; Matsumoto, p. 148, text-fig. 71.

Material. Lectotype here designated: CE.631, N28/626. 16 additional specimens.

Diagnosis. Shell small, involute, with compressed volutions and a narrow umbilicus. Volutions become more compressed and embracing with increasing shell diameter. Umbilical wall, which is low and steep, curves rapidly into slightly convex, convergent flanks; venter narrowly arched. Very fine, closely spaced lirae are rectiradiate on the umbilical wall, prorsiradiate on the dorsal flanks but straighten on the ventral flanks to be rectiradiate across the venter. Each whorl bears 10–12 constrictions which have the same inclination as the lirae. Constrictions are deeply incised on the umbilical wall and dorsal flanks but become increasingly less so as the venter is approached. The suture has a retracted suspensive lobe.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
VC.5a	15·5	6·8	5·2	0·76	5·2	34
M.412	16·0	7·0	5·5	0·79	5·0	31
VC.239a	20·0	8·5	6·8	0·80	5·8	29
M.763	23·5	11·5	8·0	0·70	6·2	26
C.1022	26·0	12·5	8·5	0·68	7·0	27

Remarks. The specimen figured by Marshall cannot be found. The specimen (CE.631) designated as the lectotype is poorly preserved but is the only specimen which can be regarded as part of Marshall's original type series. Marshall's illustration of the suture shows the first lateral lobe to be divided by an unusually small median auxiliary saddle and he drew attention to this feature in his description. The sutures of specimens examined in the present survey are essentially identical to those illustrated for members of *Gaudryceras* and *Anagaudryceras*. *Z. kaiparaensis* is very similar to *Z. inflatus* Matsumoto (1959*a*, p. 74, pl. 23, figs. 2*a–d*, 3*a–c*, 4*a–c*, 5*a–d*; pl. 24, figs. 1*a–c*, text-fig. 14). Although *Z. inflatus* is of Cenomanian age, the shells of the two species are identical in form. The only distinction between them is that the constrictions of *Z. inflatus* are projected across the venter while those of *Z. kaiparaensis* are rectiradiate. The contemporary *Z. varuna* (Forbes) (1846, p. 107, pl. 8, figs. 5*a–c*) is also similar to *Z. kaiparaensis* but has distinctly flattened flanks and is more compressed and more narrowly umbilicate.

Matsumoto argued that the umbilicus of the single Californian example of *Zelandites* (24% of the shell diameter when the latter is 22·3 mm.) is wider than that of *Z. kaiparaensis* but the dimensions above show that it is indistinguishable from *Z. kaiparaensis* of this shell diameter. CE.1023, collected by A. McKay from Port Awanui, Gisborne district (N72/485) and tentatively included in *Z. kaiparaensis* by Marshall is a juvenile phylloceratid.

Genus VERTEBRITES Marshall 1926

Type species. Vertebrites murdochi Marshall (1926, p. 139, pl. 20, figs. 9, 9*a*, pl. 30, figs. 1, 2, pl. 40, fig. 3).

Wiedmann (1962, p. 49) proposed Subfamily Vertebritinae to separate *Vertebrites* from members of the Gaudryceratinae (s.s.). According to Wiedmann, members of the Vertebritinae possess a greater number of umbilical lobes than Gaudryceratinae (s.s.). However, *Anagaudryceras tennenti* sp. nov. discussed above and *A. varicostatum* (van Hoepen) (1921, p. 7, pl. 2, figs. 10–12, text-figs. 3, 4) are transitional to *Vertebrites* in proliferation of umbilical lobes and shell form. Matsumoto (1959*c*, p. 141) noted that juveniles of *Gaudryceras tenuiliratum* Yabe resemble *Vertebrites* in shell form and sculpture and suggested that *Vertebrites* is best ranked as a subgenus of *Gaudryceras*. The close relationship between *Vertebrites* and these gaudryceratids suggests that Subfamily Vertebritinae is unnecessary.

Vertebrites murdochi Marshall

Plate 3, fig. 1; text-fig. 5*c*

1909 *Desmoceras* sp.; Bell and Clarke, p. 56, pl. 12, figs. 3*a*, *b*.
1926 *Vertebrites murdochi* Marshall, p. 139, pl. 20, figs. 9, 9*a*; pl. 30, figs. 1, 2; pl. 40, fig. 3.

Material. Lectotype here designated: CE.582 (figured by Marshall 1926, pl. 30, figs. 1, 2), N11/499. 68 additional specimens.

Diagnosis. Numerous, strongly depressed, gently tapering whorls with low umbilical walls, rounded flanks, and very broad venters. The umbilicus is unusually wide and deep. Fine, closely-spaced ribs are prorsiradiate on the umbilical wall, and swing forward on the umbilical shoulder and the dorsal flanks where they break down into numerous minute lirae. Lirae are prorsiradiate on the ventral flanks and projected across the venter. Each whorl bears four constrictions which have the same inclination as the ribs and are preceded by weak constrictions. The internal suture consists of a shallow dorsal lobe and six saddles which decrease regularly in size towards the umbilical seam.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
CE.595	10·0	2·0	4·5	2·25	6·2	62
AMC.4350.2	14·5	3·2	6·5	2·03	8·5	59
C.590	17·0	4·0	7·5	1·88	10·0	59
C.661a	19·5	4·5	8·0	1·78	11·0	56
M.566	26·0	6·0	10·5	1·75	15·0	58
CE.584	28·0	6·5	11·0	1·69	18·5	62
C.489	42·0	9·5	16·0	1·69	24·0	57
C.1023	45·0	11·0	16·0	1·45	26·0	58

Remarks. V. murdochi is distinguished from its closest relative, *V. kayei* (Forbes) (1846, p. 101, pl. 8, figs. 3*a–c*) by possessing more depressed whorls at corresponding growth stages. A specimen of *V. murdochi* (VC.339) has been collected by Mr. G. Grindley from the Dumbea Basin, New Caledonia.

Superfamily TURRILITACEAE Meek 1876
Family BACULITIDAE Meek 1876
Genus BACULITES Lamarck 1799

Type species. Birkelund (1965, p. 44) reports that the type species is *Baculites vertebralis* Lamarck 1801 rather than *B. vertebralis* Defrance 1830 which is recorded as the type species by Wright (1957*a*, p. 218).

Baculites rectus Marshall

Plate 3, figs. 2, 3; text-fig. 6

1926 *Baculites rectus* Marshall, p. 154, pl. 19, fig. 1; pl. 32, figs. 9, 10.
1953 *Baculites* aff. *rectus* Marshall; Spath, p. 19, pl. 7, figs. 2*a–c*.
?1960 *Baculites* cf. *rectus* Marshall; Obata, in Freneix, p. 47.
?1963 *Baculites* cf. *rectus* Marshall; Matsumoto and Obata, p. 98.

Material. Lectotype here designated: CE.722 (figured by Marshall, 1926, pl. 32, figs. 9, 10), N28/636. 117 additional specimens.

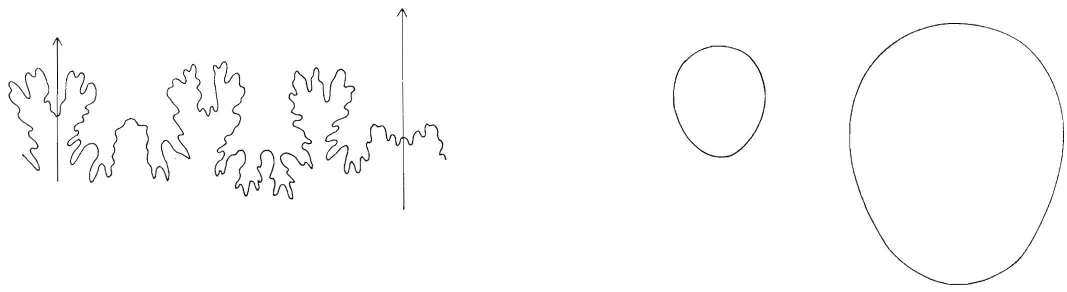
Diagnosis. Gently tapering forms, oval in cross-section, with the venter more narrowly rounded than the dorsum. Ornament consists of broad, weak ribs which are strongly projected on the venter. The suture is complex with sub-trigonal elements, and unusually slender saddles.

Dimensions.

	H	*B*	*B/H*	*Dist.*
VC.193	4·2	3·8	0·90	12
	2·2	2·0	0·91	
VC.191	4·0	3·5	0·88	10
	3·0	2·7	0·90	
VC.210	6·0	5·0	0·83	28
	3·0	3·0	1·0	
C.646	8·0	6·2	0·78	25
	5·8	4·5	0·78	
C.679	8·0	6·0	0·75	27
	6·2	5·0	0·81	
C.664	11·2	9·5	0·85	44
	9·0	7·8	0·87	
C.682	10·5	8·0	0·76	27
	9·0	7·0	0·78	
C.672	11·0	9·0	0·82	29
	10·9	8·0	0·73	
CE.741	13·5	10·5	0·78	45
	11·0	8·5	0·77	
CE.733	19·0	14·8	0·78	47
	16·2	12·0	0·74	
VC.96	27·0	22·0	0·81	200
	16·0	13·0	0·81	
VC.107a	25·5	21·0	0·84	116
	19·0	16·0	0·84	

Remarks. The cross-sectional shape and the rate of taper change during ontogeny. Early growth stages, up to a dorso-ventral diameter from 2 mm. to about 3 mm. are cylindrical or very slightly compressed. At a dorso-ventral diameter of 5–6 mm. the cross-section is distinctly oval and remains so for all later growth stages. The shell expands slowly. Initial growth stages, up to a dorso-ventral diameter of 2 mm. are not exhibited by any specimen yet collected.

Marshall's statement that the shell is smooth apart from growth-lines is incorrect. Well-preserved specimens bear weak, irregularly spaced but distinct ribs on their ventro-lateral and ventral surfaces; the ribs are strongly projected on the ventral flanks (making an angle of about 30 degrees with the long axis of the shell) and on the venter. On the few specimens where the ornament can be traced over all surfaces of the shell, the ribs become recurved just dorsal of mid-flank and are slightly projected on the dorsum. The



a b c

TEXT-FIG. 6. *Baculites rectus* Marshall. *a*, Suture of VC.86b; whorl height 16 mm., ×2. *b*, Cross-section, VC.210; ×5. *c*, Cross-section of VC.107b; ×2.

distance of the dorso-ventral diameter spans from 3 to 8 ribs on the venter. Periodically the interspace between two adjacent ribs incised on the venter and ventral flanks to form a discontinuous constriction.

Many specimens of *B. rectus* carry an epifauna of *Ostrea lapillicola* Marwick. The epifauna is commonly present on the dorsum, venter, and one flank of the shell, but never on all four surfaces; it is probable that the epizoans established themselves after the *Baculites* was dead and lying on the sea-floor, for then only three surfaces of the shell would be available for colonization.

A specimen of Piripauan age from Amuri Bluff, CE.887, referred to *B. anceps* (Lamarck) by Hector (1886, p. 64, fig. 28, 6), described as *B.* cf. *vagina* Forbes by Woods (1917, p. 36, pl. 20, figs. 5*a–d*) and tentatively included in *B. rectus* Marshall by Marshall (1926, p. 155) and by Matsumoto and Obata (1963, p. 97), is too poorly

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EXPLANATION OF PLATE 3

Fig. 1. *Vertebrites murdochi* (Marshall); C.1023. N11/499. *a*, Lateral, *b*, apertural view; ×1.

Figs. 2, 3. *Baculites rectus* (Marshall). 2, CE.733. N28/626. *a*, Dorsal, *b*, lateral, *c*, ventral view; ×1. 3, VC.210. N28/636. *a*, Dorsal, *b*, lateral, *c*, ventral view; ×1·5.

Fig. 4. *Astreptoceras zelandicum* (Marshall); VC.67. N14/655. *a*, Dorsal, *b*, lateral, *c*, ventral view; ×2.

Fig. 5. *Diplomoceras* sp. nov.?; CE.997. N146/441. Lateral view; ×0·67.

Fig. 6. *Glyptoxoceras* sp.?; C.1024. N28/626. Lateral view; ×1.

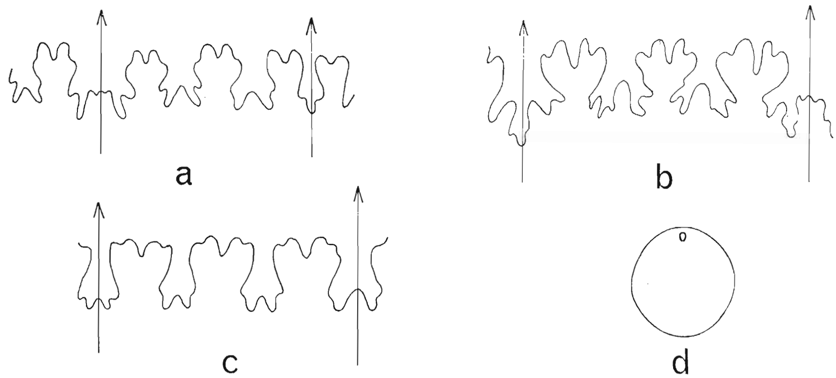
Fig. 7. *G. wakanenei* (Marshall); VC.262a. S36/1301. Lateral view; ×0·67.

Fig. 8. *Glyptoxoceras* sp. nov.?; CE.2139. N28/626. Lateral view; ×1.

Fig. 9. *Masonites biannulatus* gen. et sp. nov.; holotype, VC.35a. N14/655. *a*, Lateral view, *b*, ventral view; ×2.

preserved to permit specific identification. A fragment of *Baculites* (CE.1134) collected from the same general locality prior to 1903 and not referred to by any of these authors is a definite *B. rectus*.

The fragments from Graham Land referred to as *B.* aff. *rectus* by Spath agree closely with *B. rectus*. Specimens close to *B. rectus* have been reported from New Caledonia by Matsumoto and Obata (1963, p. 98) and by Obata (in Freneix, 1960). Marshall suggested that the present species is closely related to *B. chicoensis* Trask (1856, p. 92, pl. 2, fig. 2, 2*a*) but as both Spath (1953, p. 19) and Matsumoto (1959*b*, p. 149) have pointed out,



TEXT-FIG. 7. *a*, *b*: Sutures of *Phylloptychoceras*. *a*, *P.* sp. nov.? (after Spath 1953, pl. 11, fig. 8); ×7·5. *b*, *P. sipho* (Forbes) (after Spath 1953, pl. 11, fig. 7); ×3. *c*, *d*: *Astreptoceras zelandicum* (Marshall). *c*, Suture; VC.46, whorl height 3·5 mm., ×5. *d*, Cross-section; VC.66, ×5.

B. rectus does not, at any growth stage, exhibit the ventral keel characteristic of *B. chicoensis*.

B. rex Anderson (redescribed by Matsumoto, 1959*b*, p. 136, pl. 31, figs. 5*a–d*, pl. 34, fig. 5, pl. 39, pl. 40, text-figs. 46–52) is perhaps the closest relative of *B. rectus*; it differs in that it is more compressed, has a more narrowly arched venter and has a more complex suture.

Family DIPLOMOCERATIDAE Spath 1926
Genus GLYPTOXOCERAS Spath 1926

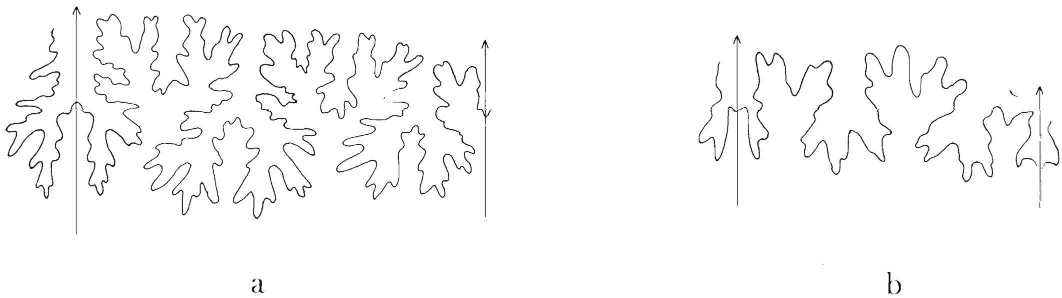
Glyptoxoceras wakanenei (Marshall)

Plate 3, fig. 7; text-fig. 8*a*

1926 *Diplomoceras wakanene* Marshall, p. 155, pl. 19, fig. 3, pl. 31, figs. 8, 9.
1953 *Glyptoxoceras wakanene* (Marshall); Spath, p. 15.

Material. Holotype: CE.746 (figured by Marshall 1926, pl. 31, figs. 8, 9). N28/626. 21 additional specimens.

Description. The shell consists of just over two slightly compressed whorls which are coiled in an open planispire. The outer whorl at any growth stage is separated from the adjacent inner whorl by a gap measuring one-fifth of the former's dorso-ventral diameter. Whorls are oval in cross-section with breadth/height ratios ranging from 0·82 to 0·86. Thin, closely spaced ribs, which are prominent on the venter and weak on the dorsum, ornament all volutions; they are slightly concave on the dorsum, slightly prorsiradiate on the flanks and rectiradiate on the venter. As volutions increase in size, the ribs become widely spaced but at a slower rate; the distance of the dorso-ventral diameter spans seven ribs on the venter of initial growth stages but the ratio gradually changes until, at mature growth stages, the span of the dorso-ventral diameter encompasses twelve ribs at the periphery. The suture is deeply incised with trigonal elements; the ventral, lateral, and umbilical lobes and the corresponding saddles are trifid. The most complete specimen, VC.262a, b, measures 95 mm. in diameter and its body chamber, although incomplete, occupies half the last whorl.



TEXT-FIG. 8. Sutures of *Glyptoxoceras*. *a*, *G. wakanenei* (Marshall); VC. 262a, whorl height 9 mm., ×5. *b*, *G.* sp. nov.?; CE.2128, whorl height 3·5 mm., ×7·5.

Remarks. Better-preserved material, collected since the original description, confirms that the present species belongs in *Glyptoxoceras* as suggested by Spath (1953, p. 15). *G. indicum* (Forbes) (1846, p. 116, pl. 11, figs. 4*a–c*) resembles *G. wakanenei* but is distinguished by its initial helicoidal spire, its almost circular cross-section and its coarser, more widely spaced ribs. The ontogeny of other described members of *Glyptoxoceras* invariably includes an early helicoidal stage but *G. wakanenei* is bilaterally symmetrical throughout its life history. The species was named after the Maori chief Wakanene so that the specific name, when latinized, takes the genitive singular case ending.

Glyptoxoceras sp. nov.?

Plate 3, fig. 8; text-fig. 8*b*

Material. CE.2128, 2139, M.925, 926, 928–36, N28/626.

Description. The shell forms an open elliptical planispire with its whorls separated from each other by a gap. Whorls are oval in cross-section with a height to breadth ratio of 0·80. Well-spaced ribs which are prominent on the venter and weak on the dorsum, ornament all whorls; they are concave towards the aperture on the dorsum, rectiradiate on the flanks and weakly projected on the venter. The distance of the dorso-ventral diameter spans five to six ribs on the venter. The suture is preserved on a small fragment, CE.2128 which has a dorso-ventral diameter of 4 mm., and is almost identical with that of *G. wakanenei* at a comparable stage of growth.

Remarks. Nearly all specimens are badly crushed and most are juveniles but some specimens are sufficiently complete to show the open elliptical mode of coiling. All growth stages seem to be planispiral but early growth stages may have been helicoidal and their present bilateral symmetry may be due to deformation. From shell form and ornamentation the present species could be referred to *Diplomoceras* Hyatt, but the suture (text-fig. 8*b*) has a prominent dorsal lobe margined by umbilical saddles which coalesce in a wide base and is typical of *Glyptoxoceras*. The suture of *Diplomoceras* is characterized by a small dorsal lobe margined by umbilical saddles which coalesce in a narrow base (Spath 1953, p. 15).

Several poorly preserved fragments (VC.174, 178, 179, from N11/606 and VC.103, 117–19 from N14/656) probably belong in this species also. In addition, C.1024 (N28/626, pl. 3, fig. 6), a fragment of body whorl, may represent a late growth stage of the present species. This specimen may be interpreted as a fragment of an elliptical whorl; it has a breadth/height ratio of 0·78 and its ribs are initially well spaced and regular but become more widely and irregularly spaced adaperturally. In the absence of intermediate growth stages, C.1024 cannot be referred with certainty to the present species.

The present species is easily distinguished from *G. wakanenei* in that its ribs are coarser and more widely spaced. It may be conspecific with *G. subcompressum* (Forbes) (1846, p. 116, pl. 11, figs. 6*a*–*c*) which it closely resembles in ornamentation. However, *G. subcompressum* appears to have slightly more compressed whorls with a breadth/height ratio of 0·7 compared to 0·8 for the present species. Until the range of variation of this character is known for both taxa, the present species cannot be assigned a name.

Genus DIPLOMOCERAS Hyatt, 1900

Diplomoceras sp. nov.?

Plate 3, fig. 5

1935 *Diplomoceras* cf. *cylindraceum* Defrance; Spath in Marwick, p. 11.

Material. CE.979, N146/441.

Description. The specimen consists of a straight, crushed fragment of body chamber 105 mm. in length with a maximum width of approximately 15 mm. Although it is too badly crushed to allow its cross-sectional dimensions to be accurately measured, it was strongly compressed before deformation with flattened flanks and a narrowly arched dorsum and venter. Its fine ribs are straight and prorsiradiate, making an angle of about 80° with the long axis of the shell, and are separated by interspaces as wide as the ribs themselves.

Remarks. Diplomoceras cylindraceus (Defrance) (in d'Orbigny 1842, p. 551, pl. 86, figs. 1–4) is subcircular in cross-section, and of other described *Diplomoceras*, only *D. ellipticus* (Anderson) (1902, p. 87, pl. 3, figs. 102, 103; pl. 10, fig. 191) is as strongly compressed as CE.979. Since the interspaces between ribs are twice as wide as the ribs themselves on the Californian species, CE.979 probably represents a new local species, but better preserved material is required before it can be adequately described.

Diplomoceras sp.

1957 *Diplomoceras* sp.; Wright, p. 806.

Material. CE.1381, S36/502.

Description. The specimen is a fragment of the body chamber recurvature of a very large shell. It is almost equidimensional in cross-sectional dimensions and has closely spaced, straight rectiradiate ribs.

Remarks. This specimen closely resembles *D. lambi*, Spath (1953, p. 17, pl. 2, figs. 1–3, pl. 3, fig. 1) but is insufficiently complete to be placed with certainty in this species.

ASTREPTOCERAS gen. nov.

Type species. *Ptychoceras zelandicum* Marshall, 1926, p. 157, pl. 19, fig. 2, pl. 32, figs. 11, 12.

Diagnosis. Small forms with a straight shell that is subcircular in cross-section and ornamented with periodic, well-defined constrictions. The suture is simple with all its elements of equal height; it has six bifid lobes and six bifid saddles.

Remarks. Spath (1953, p. 16) established *Phylloptychoceras* to include the Indian *Ptychoceras sipho* Forbes (1846, p. 118, p. 11, figs. 5*a*–*g*) and *P. zelandicum* Marshall. Spath designated *P. sipho* as the type species and his generic diagnosis is based entirely on this species. The revision of *P. zelandicum* in this survey shows it to be distinct from *P. sipho* in shell form, ornamentation and sutural characteristics; the Indian species consists of at least three straight shafts connected by tight recurvatures, it has well-developed annular ridges but lacks distinct constrictions, and its suture has a trifid dorsal lobe. *P. sipho* is more closely allied to members of *Polyptychoceras*, such as *P. vancouverensis* (Whiteaves) (refigured by Usher, 1952, p. 101, pl. 26, figs. 5, 6), with which it agrees in shell form and ornamentation, than to *P. zelandicum*. Howarth (1965, p. 368) regards *Phylloptychoceras* as a subgenus of *Polyptychoceras* and the distinction between them rests largely on the nature of the dorsal lobe which is much larger in *Phylloptychoceras* than in *Polyptychoceras* (s.s.).

P. zelandicum cannot be grouped with *P. sipho*, nor can it be placed in any existing diplomoceratid genus; it is therefore segregated in a new genus, *Astreptoceras*, which is at present monotypic. *Astreptoceras* is most closely allied to *Ryugasella* Wright and Matsumoto (1954, p. 122) which approaches straightness in shell form and has well-developed constrictions but the two are readily distinguished in that *Ryugasella* is conspicuously ribbed from an early growth stage and has a more complex suture with a small dorsal lobe.

Astreptoceras zelandicum (Marshall)

Plate 3, fig. 4; text-figs. 7*c*, *d*

1926 *Ptychoceras zelandicum* Marshall, p. 157, pl. 19, fig. 2, pl. 32, figs. 11, 12.
1953 *Phyllopychoceras zelandicum* Marshall; Spath, p. 16.

Material. Lectotype here designated: C.803 (figured by Marshall 1926, pl. 32, figs. 11, 12), N28/626. 62 additional specimens.

Diagnosis. Small, straight, gently tapering forms, circular in cross-section; most of the shell ornamented with well-spaced, oblique constrictions which are strongly projected on the dorsum. Weak ribs appear at late growth stages. Suture is simple with bifid dorsal and ventral lobes and three bifid lateral saddles separated by bifid lobes.

Remarks. Members of this species are almost circular in cross-section as illustrated in text-fig. 7*d*. Constrictions are absent from initial growth stages and appear at a cross-sectional diameter of about 2 mm.; they are well marked on the internal cast but obscure on the outer surface of the test. Each constriction is concave towards the aperture on the venter, rursiradiate on the flanks and projected on the dorsum; the distance between successive constrictions is two to three times greater than the cross-sectional diameter at any growth stage. At late growth stages, constrictions may be preceded by a collar, and shallow, discontinuous, irregularly spaced, secondary constrictions may appear. In addition, thin weak ribs separated by narrow interspaces and with the same inclination as the constrictions, appear at late growth stages.

No complete specimens of *A. zelandicum* are known, but many fragments representing almost all growth stages, have been collected and none of these exhibit a curvature. It is concluded that its shell consists of a simple straight shaft. The largest fragment in the present New Zealand collections has a diameter of 6 mm. The fragment of body chamber mentioned by Marshall as being 16 mm. in diameter and 72 mm. in length cannot be traced; as it is much larger than other specimens and apparently devoid of ribs, it must be regarded as a doubtful member of *A. zelandicum*. Spath (1953, p. 18, pl. 11, fig. 8) identified a small fragment from Graham Land as *A. zelandicum*, and suggested that Marshall's drawing of the suture line was incorrect. He stated that the internal lobe, unlike the lateral and umbilical lobes, is not bifid, but distinctly trifid. Spath was mistaken; *A. zelandicum* has a bifid dorsal lobe as illustrated by Marshall (pl. 19, fig. 2) and the Graham Land fragment is a different species which, judging by its suture (text-fig. 7*b*) is a true *Phylloptychoceras*.

MASONITES gen. nov.

Type species. Masonites biannulatus sp. nov.

Diagnosis. Shell comprised of an initial straight portion followed by an open, elliptical planispire. Whorls are circular or slightly elliptical in cross-section and taper gently; they bear annular ribs and periodic constrictions margined by collars. The suture consists of simple bifid elements of equal height.

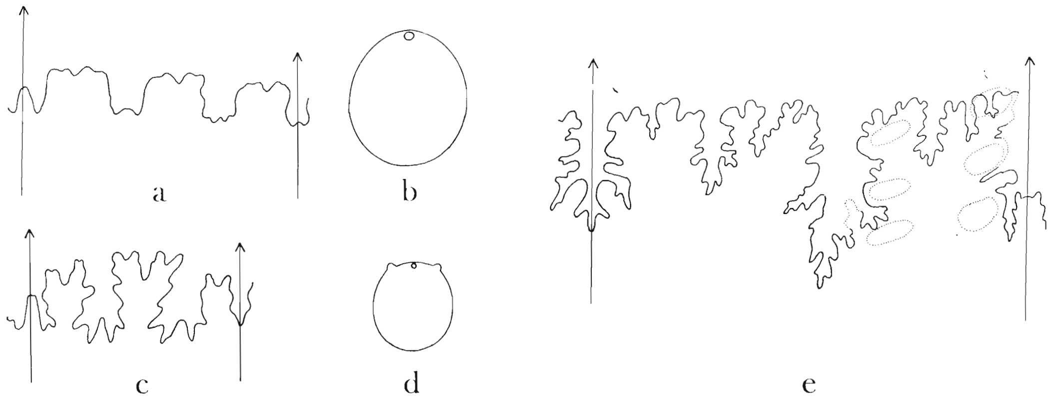
Remarks. The mode of coiling, annular ribs, periodic constrictions, and simple suture suggests that *Masonites* should be classified in Family Diplomoceratidae. In shell form, *Masonites* resembles *Glyptoxoceras* Spath and *Scalarites* Wright and Matsumoto, but its simple suture is analogous to those of *Polyptychoceras*, *Ryugasella*, *Phylloptychoceras*, and *Astreptoceras* nov. Its resemblance to *Glyptoxoceras* and *Scalarites* may be due to homeomorphy rather than a close phylogenetic affiliation.

Masonites biannulatus sp. nov.

Plate 3, fig. 9; text-figs. 9*a*, *b*

Material. Holotype: VC.35a, b, N14/655. Paratypes: VC.22–34, N14/655; CE.2134, M.790–4, 799, 801, 803, 805, 806, 808, 810, 812–18, 820–3, N28/639; CE.876, locality unknown.

Description. The shell consists of slender, gently tapering volutions; an initial straight shaft is followed by an open elliptical planispire. The initial straight shaft is smooth and its axis is oblique to the plane of later coiling. The whorl cross-section is circular or slightly compressed. Ribbing, on the elliptical whorls is of two orders; fine, irregularly spaced lirae are superimposed on broad weak ribs of variable width which are separated by narrow interspaces. The distance of the dorso-ventral diameter spans 7–12 lirae and 2 broad ribs on the venter at any growth stage. Prominent constrictions bordered on both sides by collars are spaced at irregular intervals. The collars bear lirae and are of the same width as, but slightly higher than, the adjacent broad ribs. Both orders of ribs, the constrictions, and their collars are rectiradiate on the flanks and venter and slightly concave towards the apertures on the dorsum; they are weakly developed on the dorsum and strongest on the venter. The suture is simple and without ternary incisions; the ventral saddle is low and weakly bifid, the three lateral saddles are weakly bifid and separated by narrow bifid lobes. The dorsal saddle is narrow and also bifid.



TEXT-FIG. 9. *a*, *b*: *Masonites biannulatus* gen. and sp. nov.: paratype CE.2134. *a*, Suture; whorl height 3·7 mm., ×7. *b*, Cross-section; ×5. *c*, *d*: *Pseudoxybeloceras bicostatum* sp. nov.; paratype CE.889. *c*, Suture; whorl height 4·0 mm., ×5. *d*, Cross-section; ×3. *e*, Suture of *Pseudoxybeloceras* sp.; CE.1062, whorl height 20·5 mm., ×2.

Dimensions.

	H	*B*	*B/H*	*Dist.*
M.812	3·5	3·2	0·91	14
	4·0	4·0	1·00	
CE.2134	3·5	3·0	0·86	20
	4·5	4·0	0·89	
VC.35a	2·8	2·8	1·00	40
	4·5	4·5	1·00	
M.814	3·8	3·5	0·92	22
	5·0	4·5	0·90	
M.810	5·0	5·0	1·00	16
	5·2	5·2	1·00	

Remarks. The initial straight portion is variable in length measuring 4 mm. and more than 9 mm. on VC.35a and M.799 respectively. Constrictions are more marked on internal moulds than on the shell surface.

Family NOSTOCERATIDAE Hyatt 1894
Genus PSEUDOXYBELOCERAS Wright and Matsumoto 1954.

Type species. Pseudoxybeloceras quadrinodosum (Jimbo) (1894, p. 37, pl. 7, figs. 3, 3*a*, 4, 4*a*).

Wright (1957*a*, p. 228) classified *Pseudoxybeloceras* in Family Diplomoceratidae Spath. As it is probably a descendant of *Neocrioceras* Spath, an undisputed member of the Nostoceratidae, Matsumoto (1959*c*, p. 162) suggested that *Pseudoxybeloceras* is best classified in this family.

Pseudoxbeloceras compressum sp. nov.

Plate 4, fig. 4

1926 *Oxybeloceras* sp.; Marshall, p. 156, pl. 33.

Material. Holotype: AMT.1301, N14/741.

Description. The specimen is a large, straight fragment of body chamber measuring 292 mm. in length and approximately 40 mm. in maximum whorl height. It is slightly deformed and eroded on one side. The whorl cross-section is strongly compressed with a breadth/height ratio of approximately 0·5. The dorsum is narrowly arched, the flanks weakly convex and the venter broadly arched and comprised of two flattened surfaces which meet at an angle on the median line. The venter meets the flanks in a distinct angle. Thin ribs separated by wide, regular interspaces are straight and prorsiradiate on the flanks and rectiradiate across the venter. The change in inclination occurs abruptly at the ventro-lateral angle and is marked by a small, radially elongate tubercle on each rib. The distance of the dorso-ventral diameter spans ten ribs on the venter.

Remarks. Although it is incomplete and slightly deformed, the specimen is sufficiently distinct from other described members of *Pseudoxybeloceras* to be regarded as a new species. The type species, *P. quadrinodorsum* (Jimbo) (1894, p. 37, pl. 7, figs. 3, 3*a*, 4, 4*a*) exhibits an upper and a lower row of ventro-lateral tubercles at late growth stages. *P. lineatum* (Gabb) (1869, p. 139, pl. 23, figs. 18, 18*a–c*) and *P. amapodensis* (van Hoepen) (1921, p. 15, pl. 3, figs. 5, 6, text-fig. 9) resembles the present species in bearing a single row of ventro-lateral tubercles at late growth but are distinguished by their much less compressed whorl cross-sections. *Solenoceras biconstrictum* (Anderson) (1958, p. 202, pl. 31, fig. 2) closely resembles *P. compressum* in whorl dimensions and ribbing but differs in bearing constrictions.

Pseudoxbeloceras bicostatum sp. nov.

Plate 4, fig. 2; text-figs. 9*c*, *d*

1917 *Hamites* (*Anisoceras*?) sp.; Woods, p. 35, pl. 20, figs. 3*a–c*, 4.

Material. Holotype: CE.888, S56/25. Paratypes: CE.855, N14/655; M.1044, 1046, 1048, 1049, 1053–5, 1058, 1059, N28/639; CE.889, S56/25.

Description. No complete shell has been collected but since all the fragments known are coiled in one plane, the complete shell probably is also. Initial growth stages are arcuate, but later growth stages form straight shafts connected by recurvatures. Whorls are elliptical in cross-section with a breadth/height ratio of about 0·9. All whorls bear closely spaced primary ribs which are weakly convex on the dorsum, straight and weakly prorsiradiate across the flanks and rectiradiate across the venter. At the margin of the venter, each primary rib bears a small rounded tubercle. On straight shafts, intercalatories separate adjacent primaries; they are continuous across the flanks and dorsum and absent from the venter. Intercalatories are not present on curved segments of shell. The suture, with florid, bifid lateral lobes and a small, trifid dorsal lobe, is typical of the genus.

Remarks. The two specimens from Amuri Bluff are of Santonian age for they were collected from the same horizon (Lower Piripauan Stage of Wellman 1959) as true *Kossmaticeras* (*Kossmaticeras*). The North Auckland specimens were collected in association with a fauna of Campanian–Maastrichtian age. The species ranges at least from Santonian to Campanian and it may extend into the Maastrichtian.

A fragment of a large *Pseudoxybeleceras* (CE.2127) also collected from Amuri Bluff (S56/529) probably represents a late growth stage of *P. bicostatum*. The fragment measures 50 mm. in length with a whorl height of 20 mm. and has a breadth/height ratio of 0·78; it has the *P. bicostatum* style of ornament. The ornamentation of *P. bicostatum*, with straight segments of shell bearing as many intercalatories as primary ribs, distinguishes it from other described members of *Pseudoxybeloceras*.

Pseudoxybeloceras sp.

Plate 4, fig. 1; text-fig. 9*e*

1957 *Pseudoxybeloceras* sp. aff. *quadrinodosum* (Jimbo); Wright, p. 306, pl. 54, fig. 1, 1*a*.

Material. CE.1062, S42/534.

Description. The specimen is a slightly distorted, gently curved fragment of shell some 60 mm. in length with a maximum dorso-ventral diameter of 28 mm.; it consists of the last few camerae and the beginning of the body chamber. The whorl cross-section is compressed with a height to breadth ratio of about 0·7. Ornamentation consists of sharp, well-spaced simple ribs which are prorsiradiate across the flanks; each bears small lower and prominent upper ventro-lateral tubercles.

Remarks. The specimen closely resembles *P. quadrinodosum* (Jimbo) (1894, p. 39, pl. 7, figs. 3*a*, 3*b*, 4, 4*a*); both are distinguished from other described members of *Pseudoxybeloceras* by possessing four rows of ventro-lateral tubercles at late growth stages. It appears to differ from *P. quadrinodosum* in possessing more widely spaced ribs and may well represent a new local species. The specimen was found in Muzzle River, Marlborough and was considered by the collector, H. W. Wellman (1959, p. 121) to be associated with Clarentian rocks (Aptian?–Cenomanian) but since the known range of *Pseudoxybeloceras* is from Coniacian to Maastrichtian the specimen was probably derived from younger rocks which outcrop in the watershed of the river.

Superfamily DESMOCERATACEAE Zittel 1895
Family DESMOCERATIDEA Zittel 1895
Subfamily PUZOSIINAE Spath 1922
Genus KITCHINITES Spath 1922

Kitchinites (*Kitchinites*) *brevicostatus* (Marshall)

Plate 13, fig. 4; text-fig. 10*b*

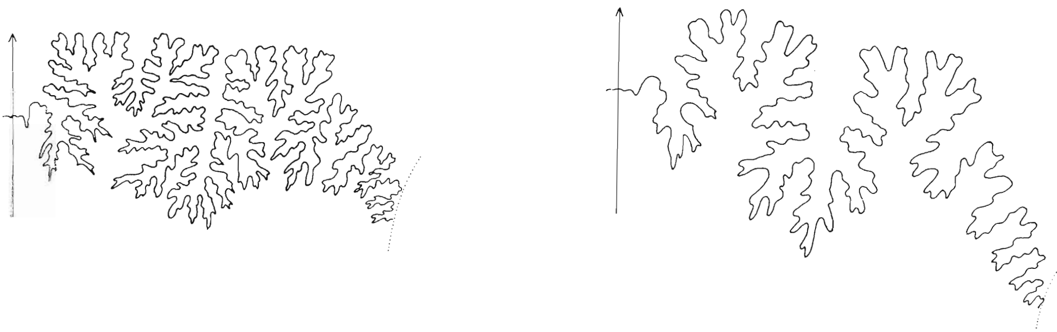
1926 *Parapuzosia brevicostata* Marshall, p. 183, pl. 24, fig. 3; pl. 43, fig. 2; p. 45, fig. 6.

EXPLANATION OF PLATE 4

Fig. 1. *Pseudoxybeloceras* sp.; CE.1062. S142/534. *a*, Lateral, *b*, ventral view; ×1.
Fig. 2. *P. bicostatum* sp. nov.; holotype; CE.888. S55/25. *a*, Dorsal, *b*. lateral, *c*, ventral view; ×1·5.
Fig. 3. *Kossmaticeras* (*Natalites*) *bensoni* sp. nov.; holotype, OU.4679. S163/511. Lateral view, ×0·5.
Fig. 4. *Pseudoxybeloceras compressum* sp. nov.; holotype, AMT.1302. N14/741. *a*, Lateral, *b*, ventral view; ×0·5.
Figs. 5, 6. *K.* (*K.*) *haumuriensis* (Hector). 5, lectotype, CE.890. S55/25. *a*, Apertural, *b*, lateral view; ×1·25. 6, CE.1021. S55/25. Lateral view; ×1·25.

Material. Holotype: CE. 828 (figured by Marshall, 1926, pl. 24, fig. 3; pl. 43, fig. 2; pl. 45, fig. 6), N11/499. 5 additional specimens.

Diagnosis. Shell large and moderately umbilicate. Whorls compressed with a low, steep umbilical wall, flattened sub-parallel flanks and a narrowly arched venter. Closely spaced primary ribs beginning from the umbilical wall are rectiradiate on the dorsal flanks, prorsiradiate on the ventral flanks and projected across the venter. On the umbilical shoulder each primary is thickened slightly to form a weak umbilical tubercle and on



a b

TEXT-FIG. 10. Sutures of *Kitchinites* (*Kitchinites*). *a*, *K.* (*K.*) *angustus* (Marshall); C. 608, whorl height 27·5 mm., ×2. *b*, *K.* (*K.*) *brevicostatus* (Marshall); CE.829, whorl height 21·5 mm., ×2.

the ventral flanks, an intercalatory appears after each primary. Five constrictions per whorl, margined on both sides by collars, swing gently forward across the flanks and are strongly projected across the venter so that each truncates one or two ribs. Suture with subquadrate lateral saddles, and lateral lobes with narrow axial regions.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
CE.828	55·5	24·0	12·5	0·52	17·1	31
CE.829	84·0	34·0	16·0	0·47	27·5	33

Remarks. Ribs appear at a shell diameter of 12–35 mm. The body chamber of the largest specimen, CE.829, begins at a shell diameter of 85·0 mm.; the last camerate half whorl bears 40 ribs and the small section of body chamber present shows that the ribs enlarge and become more widely spaced at this growth stage. The suture was not accurately drawn by Marshall. It is unusual in having lateral lobes and saddles which are pachydiscid in form but the suspensive lobe, unlike those of members of Family Pachydiscidae, is quite strongly retracted as in other members of the genus.

Three crushed, fragmentary specimens (CE.885–7) collected from the Mangatu River, Raukumara Peninsula (N79/599), were previously described by Wright (1957*b*, p. 808) as *Kitchinites*? sp. They have fine, well-spaced primary ribs which are rectiradiate on the dorsal and mid-flanks and projected across the venter, a few intercalatories arising on the ventral flanks and prominent prorsiradiate constrictions each of which truncates three ribs. These characters suggest reference to *K. brevicostatus* but as noted by Wright, the poor preservation of the specimens precludes their accurate classification.

The type species *Kitchinites* (*K.*) *pondicherryanus* (Kossmat) (1898, p. 40, pl. 6, figs. 6*a–c*) is closely related to *K.* (*K.*) *brevicostatus* but is slightly less compressed, and its ribs are more widely spaced and less strongly projected across the venter. *K.* (*K.*) *hearni* (Anderson) (1958, p. 238, pl. 38, figs. 1, 1*a*, 1*b*) is also closely related; its ornamentation is almost identical to that of *K.* (*K.*) *brevicostatus* but it is considerably less compressed.

Kitchinites (*Kitchinites*) *angustus* (Marshall)

Plate 14, fig. 1; text-fig. 10*a*

1926 *Puzosia angusta* Marshall, p. 182, pl. 22, fig. 5; pl. 41, figs. 1, 2.
1926 *Parapuzosia ordinaria* Marshall, p. 184, pl. 24, fig. 4; pl. 31, figs. 6, 7.
1926 *Hauericeras ngapuhi* Marshall, p. 190, pl. 24, fig. 5; pl. 43, fig. 3; pl. 45, fig. 3.

Material. Neotype here designated: C.608, N28/626. 18 additional specimens.

Diagnosis. Shell large and moderately umbilicate. Whorls compressed with a low, vertical umbilical wall, weakly convex, convergent flanks and a narrowly arched venter. Ribs, appearing at a shell diameter of approximately 45 mm. are rectiradiate on the ventral flanks and strongly projected across the venter. On camerate whorls of mature specimens they are fine and closely spaced but strengthen and become more widely spaced on the body chamber. The fine conspicuous constrictions per whorl are almost straight and prorsiradiate across the flanks but strongly projected across the venter; each is bordered on both sides by collars and truncates up to two ribs. Lateral lobes of the suture have wide axial regions.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
C.867	20·0	8·8	5·8	0·66	5·2	26
VC.4	26·0	10·2	7·0	0·69	7·5	29
C.721	28·2	12·2	9·0	0·74	8·8	31
M.720	42·0	16·5	12·0	0·73	13·8	33
C.610	43·5	18·5	12·0	0·65	13·0	30
C.608	74·0	30·0	19·0	0·63	27·0	36
M.51	82·0	34·0	17·5	0·51	25·0	30
M.643	84·0	35·0	15·0	0·43	26·5	32

Remarks. Both C.608 and M.51 exceed 120 mm. in diameter but their body chambers are crushed. The measurements given above suggest that the species is somewhat variable in dimensions but less compressed than suggested by Marshall. The breadth/height ratio decreases with increasing shell diameter. Ribs are broadest on the ventral flanks and become thinner as the venter is approached. Closely spaced, irregular lirae ornament the dorsal two-thirds of mature whorls but either disappear on the dorsal flanks or are obliterated by the ribs on the dorsal flanks. The last half camerate whorl of C.608 bears approximately 50 ribs while the half whorl of body chamber bears 38.

The specimen figured by Marshall cannot be found in the existing New Zealand collections. Of the specimens available, only two juvenile shells, C.610 and C.867, were members of the Marshall collection. Marshall in his description, refers to his material as three fragmentary specimens collected from Bull's Point, Kapara Harbour. C.610 and C.867 are almost complete specimens collected from Waitapu Bay, Whangaroa. Although they are members of the Marshall collection, they cannot be regarded as members of his type series. C.608, here designated as a neotype, is a well-preserved specimen which is a little less densely ribbed than the fragment figured by Marshall. It is from Bull's Point (N28/626), the same locality as Marshall's figured specimen. Since *K.* (*K.*) *angustus* is a senior synonym, the establishment of a neotype is desirable.

The specimen figured by Marshall as *Hauericeras ngapuhi* also cannot be found in the existing New Zealand collections but appears to be identical to growth stages of *K.* (*K.*) *angustus* preceding the appearance of ribs. The juvenile whorls of *K.* (*K.*) *angustus* were apparently unknown to Marshall; his figured specimen is a fragment of adult whorl. C.721, figured and described by Marshall as *Parapuzosia ordinaria* is also indistinguishable from juvenile growth stages of *K.* (*K.*) *angustus*. The three species are here synonymized. Growth stages of *K.* (*K.*) *brevicostatus* (Marshall) and *K.* (*K.*) *angustus* preceding the development of ribs can be differentiated by their sutures.

K. (*K.*) *angustus* is related to *K.* (*K.*) *darwini* (Steinmann) (1895, p. 73, pl. 5, figs. 3*a*, *b*) and *K.* (*K.*) *angolaensis* Howarth (1965, p. 386, pl. 11, figs. 4–6). These three species can be regarded as specialized members of *K.* (*Kitchinites*) characterized by the restriction of ribs to the ventral flanks and venter for at least a part of ontogeny. The New Zealand species is distinguished from *K.* (*K.*) *darwini* by the prorsiradiate inclination of the constrictions as they cross the dorsal flanks, by its possession of umbilical tubercles, and by having more compressed whorls at corresponding stages of growth. It differs from *K.* (*K.*) *angolaensis* in having more distinct constrictions and its ribs are more strongly projected across the venter.

Family KOSSMATICERATIDAE Spath 1922
Genus KOSSMATICERAS Grossouvre 1901

1901 *Kossmaticeras* Grossouvre, p. 719.
1909 *Madrasites* Kilian and Reboul, p. 28.
1909 *Pseudoholcodiscus* Kilian and Reboul, p. 19.

Type species. *K. theobaldianum* (Stoliczka) (1865, p. 161, pl. 78, figs. 1, 2).

The genus *Kossmaticeras* was established by Grossouvre to separate Indian species of Senonian age of the group of *K. theobaldianum* (Stoliczka) from the Barremian genus *Holcodiscus* to which they had been previously referred. As stated by Hass (1948) there is no doubt that Grossouvre intended *K. theobaldianum* as the type species and this became so by subsequent designation (Diener 1925, p. 96). Kilian and Reboul (1909) subdivided *Kossmaticeras* into six new subgenera. Of these, *Madrasites* was illegally used for *Kossmaticeras* (s.s.) inclusive of *K. theobaldianum* and is thus a still-born synonym (Hass 1948). *Jacobites*, *Gunnarites*, and *Grossouvrites* have subsequently been raised to full genera. The remaining two, *Grahamites* (junior synonym of *Stephanoceras* Waagen) and *Seymourites* are Jurassic taxa and have no connection with *Kossmaticeras*. At the same time Kilian and Reboul (1909) unwittingly introduced *Pseudoholcodiscus* as a still-born synonym of *Kossmaticeras* (s.l).

Collignon (1954, p. 6) split *Kossmaticeras* with the introduction of *Natalites* and *Karapadites*, both of which he ranked as full genera. *Natalites* (type species *Madrasites natalense* Spath 1922, p. 34, pl. 5, fig. 3) differs from *Kossmaticeras* (s.s.) in possessing prominent umbilical tubercles throughout most of ontogeny. *Karapadites* (type species *Holcodiscus karapadensis* Kossmat 1897, p. 148, pl. 19, figs. 2*a*, *b*, 4*a–c*) differs from

Kossmaticeras (s.s.) in that its ribs are restricted to the ventral flanks and venter for most of ontogeny. Matsumoto (1955), working independently of Collignon, proposed duplicate names for these two genera. Thus *Karapadites* Matsumoto 1955 is equal to *Karapadites* Collignon 1954 and *Kaiparaites* Matsumoto 1955 is a junior synonym of *Natalites* Collignon 1954.

Following Wright (1957*a*, p. 374), *Natalites*, *Karapadites*, and *Kossmaticeras* (s.s.) are here considered as subgenera of *Kossmaticeras* (s.l). All three taxa are analogous in characters other than ornamentation and at certain stages of ontogeny the ornament of one resembles that of another. Thus the body chamber ornamentation of some species of *Karapadites* such as *K. besairiei* Collignon and *K. hourqi* Collignon, is of the *Kossmaticeras* (s.s.) style with ribs extending to the umbilicus. Further, some examples of *Kossmaticeras* (s.s.) such as the specimen of *K. theobaldianum* (Stoliczka) figured by Collignon (1954, pl. 2, figs. 1, 1*a*, 1*b*) have umbilical tubercles at late growth stages and thus resemble *Natalites*. The close relationships of the three taxa are best expressed by treating them as subgenera of *Kossmaticeras* (s.l.) from whence they were split.

Subgenus KOSSMATICERAS

Kossmaticeras (*Kossmaticeras*) *haumuriensis* (Hector)

Plate 4, figs. 5, 6

1886 *Ammonites haumuriensis* Hector, p. 58, fig. 20, no. 7.
1917 *Kossmaticeras* (*Madrasites*) *haumuriensis* (Hector); Woods, p. 34, pl. 19, figs. 5*a–c*; pl. 20, fig. 1.

Material. Lectotype here designated: CE.890 (figured by Woods, pl. 19, figs. 5*a–c*), S56/25. Also CE.1021 (figured by Woods, pl. 20, fig. 1), S56/25.

Diagnosis. Shell small and narrowly umbilicate. Umbilical wall steep, flanks subparallel, gently convex, and the venter broadly arched. Regularly spaced primary ribs appear on the umbilical shoulder where they may be slightly thickened. Umbilical tubercles are absent. On the dorsal or mid-flank an intercalatory appears after each primary so that the number of ribs is doubled. Ribs are prorsiradiate on the dorsal flanks, rectiradiate on the mid-flank and quite strongly projected across the venter. They number some 45 per half whorl. Wide, incised constrictions, margined on both sides by collars, appear at a shell diameter of 15–20 mm. and number some 3 or 4 per half whorl; they are prorsiradiate and sinuous in the same sense as the ribs and each truncates one or two ribs. The suture is typical of the genus.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
CE.1021	15·0	6·5	7·5	1·15	3·2	21
CE.890	31·0	15·2	14·2	0·93	6·5	21

Remarks. In some cases primary ribs split on the dorsal flanks to form two secondaries rather than being separated by intercalatories. Occasionally two intercalatories, rather than one, separate adjacent primaries. *K.* (*K.*) *haumuriensis* resembles *K.* (*K.*) *sacondryense* Collignon (1954, p. 30, pl. 5, figs. 2–5) but is more narrowly umbilicate, has less compressed whorls, more distinct constrictions and its intercalatories arise from a more dorsal position on the flanks. *K.* (*K.*) *bhavani* (Stoliczka) (1865, p. 138, pl. 69, figs. 4–7) also resembles the present species but is more widely umbilicate, has much more compressed whorls and has less flexuous ribs.

Subgenus NATALITES Collignon, 1954

Kossmaticeras (*Natalites*) *sulcatum* (Marshall)

Plate 5, fig. 1

1926 *Madrasites sulcatus* Marshall, p. 164, pl. 38, figs. 1, 2.
1926 *Jacobites anderssoni* Marshall, Kiiian, and Reboul; p. 168, pl. 21, figs. 3, 3*a*, pl. 37, figs. 3, 4.

Material. Holotype: C. 538 (figured by Marshall 1926, pl. 38, figs. 1, 2), N28/636. 24 additional specimens.

Diagnosis. Shell small with compressed whorls and a narrow umbilicus. The umbilical wall is almost vertical, the umbilical shoulder abrupt, the flanks flattened and the venter broadly arched. In each half whorl there are 9–11 prominent, radially elongate umbilical tubercles from each of which arise one or two primary ribs with one or two interstitial primaries arising from the umbilical shoulder between adjacent umbilical tubercles. At mid-flank an intercalatory appears after each primary so that the number of ribs is doubled. Ribs are prorsiradiate on the dorsal flanks but rectiradiate on the ventral flanks and venter. Each whorl bears 4–5 constrictions which are almost straight and prorsiradiate so that each truncates four ribs.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
C.651b	22·5	8·5	8·0	0·94	7·5	33
M.714	25·2	10·5	9·0	0·86	7·2	29
M.50	27·2	11·5	11·2	0·97	8·0	29
M.715	28·0	12·0	10·2	0·85	8·0	29
C.611	28·0	11·5	10·5	0·91	9·0	32
C.1025	41·8	16·5	14·0	0·85	13·5	32

Remarks. Some specimens have two intercalatories separating adjacent primary pairs for short periods of growth but usually the pattern of ribbing is extremely regular. The whorls become less densely ribbed with increasing shell diameter; the last half whorl of C.1025 has 50 ribs while that preceding it has 62. This feature is not shown by the single specimen described by Marshall because its inner whorls are not exposed. As a result, Marshall described a small, incomplete, more densely ribbed specimen (C.1005) as a distinct species, *Jacobites anderssoni* Kilian and Reboul, when it is indistinguishable from juveniles of *K.* (*N.*) *sulcatum*. One specimen (M.50) has intercalatories arising at the margins of the venter and is slightly less compressed than is typical of the species. An incomplete specimen, CE.130 collected from a stream boulder in Makirikiri Stream, Tinui district, Wairarapa (N159/738) by M. Ongley may belong in *K.* (*N.*) *sulcatum* but cannot be identified with certainty.

The compressed whorls with flattened flanks, the narrow umbilicus and the details of ornamentation distinguish *K.* (*N.*) *sulcatum* from the other New Zealand members of the subgenus. *K.* (*N.*) *natalensis* (Spath) (1922, p. 34, pl. 5, fig. 3) has some affinities with the present species but is distinguished by its depressed whorls and by its ribs which are prorsiradiate throughout their length. The Australian specimen described by Spath

(1941, p. 44, pl. 1, fig. 2) as *Kossmaticeras* sp. is also closely related but the ribs of its outer whorl are more closely spaced than in *K.* (*N.*) *sulcatum*.

Kossmaticeras (*Natalites*) *regularis* (*Marshall*)

Plate 5, fig. 3

1926 *Madrasites regularis* Marshall, p. 165, pl. 21, fig. 7, pl. 35, figs. 3, 4.

Material. Lectotype here designated: C.788, N28/626. 9 additional specimens.

Diagnosis. Shell small, with depressed whorls and a wide umbilicus. Umbilical wall almost vertical, umbilical shoulder abrupt, flanks weakly convex and venter broadly arched. 9–14 regularly spaced umbilical tubercles in a half whorl. Regularly spaced ribs with interspaces as wide as themselves are weakly convex towards the aperture on the dorsal flanks and recurved on the ventral flanks to be weakly projected across the venter. Three constrictions per whorl margined on both sides by collars; they are prorsiradiate and weakly flexuous so that each truncates two ribs. Suture with a strongly retracted suspensive lobe.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
C.1006	19·5	7·0	8·8	1·26	7·5	39
C.801a	23·0	8·0	9·5	1·19	8·5	37
CE.788	25·0	8·5	10·0	1·18	9·5	38
AM.8306.1	31·0	11·0	12·5	1·14	12·0	39
C.999	35·0	13·0	14·5	1·12	13·0	37
C.1026	38·0	13·2	14·5	1·10	15·2	40

Remarks. The whorls become less densely ribbed with increasing shell diameter. On mature whorls, three ribs originate from the umbilical shoulder between the apicies of two adjacent umbilical tubercles but on juvenile whorls the number is increased to four. The specimen figured by Marshall cannot be found in the existing New Zealand collections. CE.788, here designated as the lectotype, is from the Marshall collection and is almost certainly a specimen referred to by Marshall in his table of dimensions (p. 165, table of dimensions, specimen B).

K. (*N.*) *africanus* (van Hoepen) (1920, p. 146, pl. 14, figs. 3–5) resembles *K.* (*N.*) *regularis* but its outer whorls are compressed, it is more narrowly umbilicate and has fewer umbilical tubercles. The single specimen representing *K.* (*N.*) *acuticostatus* (Spath) (1922, p. 134, pl. 8, fig. 2) was incorrectly measured by Spath who states its umbilical diameter as being 28% of the shell diameter while his figure suggests a value of approximately 42%. This species closely resembles *K.* (*N.*) *regularis* in shell dimensions but its ribs are prorsiradiate throughout their length and less regularly spaced. A small

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EXPLANATION OF PLATE 5

Fig. 1. *Kossmaticeras* (*Natalites*) *sulcatum* (Marshall); C.1025. N28/626. *a*, Lateral, *b*, apertural view; ×1·5.
Fig. 2. *K.* (*N.*) *multicostatum* (Marshall); lectotype, C.737. N28/626. *a*, Lateral, *b*, apertural view; ×1·5.
Fig. 3. *K.* (*N.*) *regularis* (Marshall); C.1026. N28/639. *a*, Lateral, *b*, apertural view; ×1·5.
Figs. 4, 5. *Jacobites* (*Jacobites*) *nodulosus* (Marshall). 4, C.1029. N28/626. Lateral view, ×1. 5, C.1031. N28/626. *a*, Lateral, *b*, ventral view; ×1·5.

fragment of *Kossmaticeras* recorded from Kii, south-west Japan, by Yabe (1915, p. 22, pl. 1, fig. 8) was compared to *K.* (*N.*) *regularis* by Matsumoto (1955, p. 142) but its ribs are more widely spaced than those of the New Zealand species.

Kossmaticeras (*Natalites*) *multicostatum* (Marshall)

Plate 5, fig. 2

1926 *Madrasites multicostatus* Marshall, p. 164, pl. 21, fig. 6, pl. 35, figs. 1, 2.

Material. Lectotype here designated C.737 (figured by Marshall, 1926, pl. 35, figs. 1, 2), N28/626. 2 additional specimens.

Diagnosis. Small, widely umbilicate forms with depressed whorls. Umbilical wall almost vertical, umbilical shoulder abrupt, flanks weakly convex and the venter broadly arched. 9 or 10 umbilical tubercles of variable size per half whorl. 4 or 5 weak ribs originate either from the umbilical shoulder or dorsal flanks, between two adjacent umbilical tubercles. Ribs are variable in size and spacing and may be replaced by lirae for a short period of growth during middle age; they are convex towards the aperture on the dorsal flanks but recurved on the ventral flanks to be weakly flexuous constrictions per whorl margined on each side by collars; each truncates two ribs. Suture with a strongly retracted suspensive lobe.

Dimensions.

	D	*H*	*B*	*B*/*H*	*U*	%
C.738	24·0	9·2	10·2	1·11	9·0	38
C.737	35·0	13·8	14·2	1·03	13·0	37

Remarks. Mature whorls have a weaker ribbing and a more narrowly arched venter than other members of the subgenus. In addition, the irregular ribbing of middle and late growth stages distinguishes it from its closest relative, *K.* (*N.*) *regularis.* The ornament of juvenile growth stages may be quite regular and juvenile specimens of *K.* (*N.*) *multicostatum* and *K.* (*N.*) *regularis* cannot always be distinguished. *K.* (*N.*) *multicostatus* may prove, with the collection of further specimens, to be an extreme variant of *K.* (*N.*) *regularis.* However, as the two populations at present available are not connected by intermediaries, it is thought best to retain the two species as distinct.

Kossmaticeras (*Natalites*) *bensoni* sp. nov.

Plate 4, fig. 3

Material. Holotype: OU.4679, S163/511. Paratypes: OU.4678, CE.1670, S163/511.

Description. The shell is large with depressed mature volutions. The umbilical wall is steep but not vertical, the flanks weakly rounded and the venter broadly arched. Each mature half whorl bears 11–13 small radially elongate, twisted umbilical tubercles and some 35 thin primary ribs. The primary ribs swing forward from the umbilical shoulder, become rectiradiate at the mid-flank and are strongly projected across the venter. Intercalatories appear after each primary on the ventral flanks so that there are approximately 70 ribs in a half whorl. Four constrictions ornament the last half whorl of the holotype, each has the same inclination as the ribs and is preceded by an unusually thick collar.

Dimensions.

	H	*B*	*B/H*
CE.1670	29·5	36·0	1·22

Remarks. Specimens OU.5458, 7131, 7167, 7170, 8468, 8469, 8471, and 8472 probably also belong in *K.* (*N.*) *bensoni*, but are too poorly preserved or too incomplete to be identified with certainty. All the material, with the exception of CE.1670, is badly crushed so that representative dimensions apart from whorl height and whorl breadth are unavailable. Unfortunately, the inner whorls of the two most complete specimens have been obliterated by deformation and cannot be described; the sutural details are also unavailable. In spite of the limitations imposed by the material, this species is quite distinctive. Some of the specimens were examined by Spath (1953, p. 31) who classified them as new forms of the group of *Gunnarites zelandicus* Marshall. None of the specimens have retained the test but careful examination of the external moulds has failed to show rib denticulation. Lack of this feature suggests that the present species should be classified in *Kossmaticeras* (*Natalites*) and the nature of its ribbing supports this designation. *K.* (*N.*) *sulcatum* (Marshall), and *K.* (*N.*) *faku* (van Hoepen) (1920, p. 144, pl. 25, figs. 3, 4) have an intercalatory appearing after each primary rib while all the ribs on members of *Gunnarites* arise from close to the umbilical shoulder. *K.* (*N.*) *bensoni* is distinguished from the other members of the subgenus by its closely spaced ribbing which is strongly projected across the venter.

Genus JACOBITES Kilian and Reboul 1909

1926 *Neomadrasites* Marshall, p. 171.
1927 *Aucklandites* Marshall, p. 358.

Type species. Jacobites anderssoni Kilian and Reboul (1909, p. 35, pl. 7, figs. 1–5; pl. 8, figs. 3, 5; pl. 12, figs. 1, 2; pl. 16, fig. 3).

Jacobites is restricted to Graham Land and New Zealand with eleven of the thirteen species indigenous to New Zealand. Study of the New Zealand material has shown this genus to be highly variable and not easily subdivided. Marshall (1926, pp. 171, 186, and 1927, p. 358) proposed three monotypic genera, *Neomadrasites* (type species *N. nodulosus* Marshall), *Tainuia* (type species *T. aucklandica* Marshall), and *Aucklandites* (type species *Acanthoceras ultimum* Marshall) for three New Zealand forms which are closely related to *Jacobites*. Wright (1957*a*, p. 376) synonymized *Aucklandites* with *Neomadrasites* and recognized the latter, along with *Tainuia* and *Jacobites* (s.s.) as subgenera of *Jacobites* (s.l.).

The subgenera *Jacobites* and *Tainuia* are easily recognized as their patterns of ornamentation are quite different. The two species comprising *Neomadrasites*, *J.* (*N.*) *nodulosus* and *J.* (*N.*) *ultimus*, are discussed in the specific descriptions below and it is demonstrated that they are as closely related to some members of *Jacobites* (s.s.) as they are to each other. *Neomadrasites* is here synonymized with *Jacobites* (s.s.).

Subgenus JACOBITES

Jacobites (*Jacobites*) *minimus* Marshall

Plate 6, fig. 2

1926 *Jacobites minimum* Marshall, p. 169, pl. 21, fig. 5; pl. 38, figs. 3, 4.

Material. Holotype: C.1003 (figured by Marshall 1926, pl. 21, fig. 5; pl. 38, figs. 3, 4), N28/626 or N28/636. 14 additional specimens.

Diagnosis. Shell minute with compressed volutions and a narrow umbilicus. Umbilical wall steep and curving gently into weakly convex, convergent flanks, which are separated by a distinct angle from the venter. Venter composed of two flattened surfaces which meet in an angle at the median line. Umbilical tubercles, large and variable in size and spacing, appear at a shell diameter of 4–5 mm. and number 10–11 per whorl. Lirae are present up to a shell diameter of 5·5–6 mm. but are thereafter replaced by coarser ribs which number 4–6 between the apices of two adjacent umbilical tubercles. The ribs are slightly flexuous on the flanks and weakly projected across the venter; each bears a ventro-lateral tubercle and another at the middle of the venter. Constrictions are absent.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
M.981	6·5	3·0	3·0	1·00	1·5	23
C.1003	9·0	4·0	3·5	0·88	2·0	22
VC.220	9·0	4·0	3·5	0·88	2·2	24
M.979	9·8	4·2	3·8	0·90	2·5	26
C.1027	10·5	4·5	4·0	0·89	2·5	24
CE.856	15·0	6·5	5·5	0·85	4·0	27

Remarks. Marshall established the species on a single specimen, C.1003. He noted the small size of the specimen but remarked that it was probably immature. With fifteen specimens now available, it is clear that minute size is a distinctive specific character. The minute size, pronounced development of tubercles at a very small shell diameter and the details of ornamentation distinguish *J.* (*J.*) *minimus* from other described members of the subgenus. The suture, although simple, resembles those of other members of the subgenus at the same shell diameter, suggesting that the species may have been derived by neotony. The type locality is in doubt as Marshall recorded it as both Batley and Bull's Point in different parts of the text.

Jacobites (*Jacobites*) *nodulosus* (Marshall)

Plate 5, figs. 4, 5; Plate 6, fig. 1

1926 *Neomadrasites nodulosus* Marshall, p. 171, pl. 21, figs. 4, 4*a*; pl. 36, figs. 1–3.
1926 *Brahamites rotundus* Marshall, p. 173, pl. 21, fig. 9; pl. 31, figs. 4, 5.

Material. Lectotype here designated: C.559a, b, N28/626. 60 additional specimens.

Diagnosis. Shell of moderate size with early whorls strongly depressed and mature whorls less so. Umbilicus broad with steep walls; flanks rounded and venter broadly arched. Each mature half whorl bears seven umbilical tubercles high on the umbilical shoulder; 6–7 ribs arise from the umbilical shoulder between the apices of two adjacent umbilical tubercles. Ribs curve gently forward from the umbilical shoulder to the edge of the venter, where two of every three coalesce to form a ventro-lateral tubercle and the third separates adjacent tubercles. The two ribs which form a ventro-lateral tubercle reappear on the venter and together with the intercalatory are quite strongly projected across the venter. All ribs bear weak median ventral tubercles. Weakly flexuous, prorsiradiate constrictions are margined on both sides by collars; each truncates one rib. Suture with a strongly retracted suspensive lobe.

Dimensions.

	D	H	B	B/H	U	%
VC.138	7·5	3·5	5·5	1·57	3·5	47
C.562	12·5	4·0	6·0	1·50	5·0	40
CE.798	15·0	5·2	8·0	1·54	5·5	37
CE.796	18·0	6·5	9·0	1·38	7·0	39
C.1028	20·0	7·0	9·5	1·36	7·5	38
M.496	20·5	7·5	10·0	1·33	8·0	39
M.900	26·0	9·5	12·0	1·26	10·0	38
C.763a	28·0	10·0	12·2	1·22	10·5	38
C.559a	30·0	10·5	12·5	1·19	12·0	40
M.898	50·0	18·0	21·0	1·17	18·0	36

Remarks. Umbilical tubercles are present at very early growth stages but ventro-lateral tubercles do not appear until the shell diameter is 13–15 mm. and for a short period of growth may be present on every rib, shared by two ribs without an intercalatory, or as described above for more mature whorls. Median ventral tubercles appear at a shell diameter of approximately 20 mm. and are weaker than the ventro-lateral tubercles throughout ontogeny. On M.898, the largest specimen, a change in ornamentation develops at a shell diameter of approximately 40 mm. Ribs become more widely spaced and umbilical tubercles, represented by local swellings in height of some ribs as they cross the umbilical shoulder, become weaker. Constrictions increase in number to four on the last quarter whorl. Throughout ontogeny constrictions are preceded by a strong collar and followed by one which is weaker. Marshall's dimensions show the umbilicus as wider than is actually the case.

The specimen figured by Marshall cannot be found in the existing New Zealand collections. C.559a, b, here selected as the lectotype is a specimen from the portion of the Marshall collection presented to Auckland University and is almost certainly a member of Marshall's type series.

The specimen described and figured by Marshall as *Brahamites rotundus*, C.562, has a shell diameter of 12·5 mm. and represents a growth stage of *J.* (*J.*) *nodulosus* which just precedes the development of ventro-lateral tubercles. Slightly larger specimens show that *B. rotundus* and *J.* (*J.*) *nodulosus* are synonymous. Marshall defined the genus *Neomadrasites* as forms with umbilical and median ventral tubercles, and a suture resembling that of *Madrasites* Kilian and Reboul (junior synonym of *Kossmaticeras* Grossouvre). *Neomadrasites* was retained as a genus by Collignon (1954, p. 48) and by Matsumoto (1955, p. 145) in their reviews of Family Kossmaticeridae. Wright (1957*a*, p. 376) recognized *Neomadrasites* as a subgenus of *Jacobites* and synonymized it with *Aucklandites* Marshall. The maximum shell diameter known for a member of *J.* (*J.*) *nodulosus* is 50 mm. and its ornament up to this growth stage agrees well with some *J.*

EXPLANATION OF PLATE 6

Fig. 1. *Jacobites* (*Jacobites*) *nodulosus* (Marshall); C.1028. N28/626. *a*, Lateral, *b*, apertural view; ×1·5.

Fig. 2. *J.* (*J.*) *minimus* Marshall; C.1027. N28/639. *a*, Lateral, *b*, ventral view; ×3.

Figs. 3, 4. *J.* (*J.*) *angularis* Marshall. 3, C.622. N28/626. *a*, Lateral, *b*, ventral view; ×1. 4, lectotype, CE.795. N28/626. *a*, Lateral, *b*, apertural view; ×1.

Fig. 5. *J.* (*J.*) *stevensi* sp. nov.; holotype, CE.870. Unlocalized, Hokianga Harbour. *a*, Lateral, *b*, ventral view; ×1.

(*Jacobites*) of similar diameters and is very close to that of *J.* (*J.*) *stevensi* sp. nov. Its suture cannot be adequately distinguished from other members of *J.* (*Jacobites*).

The strongly depressed initial whorls and the details of ornamentation distinguish *J.* (*J.*) *nodulosus* from other described members of the subgenus.

Jacobites (*Jacobites*) *ultimus* (Marshall)

Plate 7, figs. 1, 2

1926 *Acanthoceros ultimum* Marshall, p. 158, pl. 25, figs. 1, 1*a*; pl. 34, figs. 1, 2.
1927 *Aucklandites ultimum* (Marshall); Marshall, p. 358.

Material. Lectotype here designated: CE.764 (figured by Marshall 1926, pl. 34, figs. 1, 2), N28/626. 8 additional specimens.

Diagnosis. Shell of moderate size with nearly equidimensional whorls and an umbilicus of moderate width. Juvenile whorls densely ribbed with flattened flanks and a rounded venter; six umbilical tubercles in a half whorl but ventro-lateral and median ventral tubercles absent. At later growth stages ribs become very strong and greatly reduced in number; prominent ventro-lateral and median ventral tubercles develop on all ribs. Flattened flanks are separated by a distinct angle from the venter; the venter consists of two flattened surfaces which meet in an angle at the median line. Three or four constrictions per whorl are margined by collars and intersect one or two ribs; on mature whorls the collars may bear weak ventro-lateral and median ventral tubercles. Suture with relatively undissected elements.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
M.738	14·0	6·0	6·0	1·00	4·0	29
C.1031	24·2	10·5	10·5	1·00	7·2	30
C.653	27·0	11·2	11·8	1·05	8·0	30
C.654	37·0	16·0	16·0	1·00	12·5	34
C.623	93·0	39·0	40·0	1·03	30·0	32
M.19	94·0	38·8	39·5	1·02	30·5	32
CE.764	96·0	41·0	41·0	1·00	28·0	29

Remarks. Juveniles bear 45–50 ribs in a half whorl while adults bear 17–20 in a half whorl. The change in whorl shape and ornamentation begins at a shell diameter of about 30 mm. The lectotype, CE.764, has one ventro-lateral spine some 10 mm. long preserved at a shell diameter of 94 mm. Juveniles resemble early growth stages of *Maorites tenuicostatus* but are less compressed and have stronger umbilical tubercles. The species is easily distinguished from other New Zealand members of the subgenus by its marked ontogenetic changes and its very coarse mature ornamentation. Marked ontogenetic changes are also typical of *J.* (*J.*) *anderssoni* Kilian and Reboul (1909, p. 35, pl. 7, figs. 1–5; pl. 8, figs. 3, 5; pl. 12, figs. 1, 2; pl. 16, fig. 3) which has densely ribbed initial volutions and develops coarse ribs, ventro-lateral tubercles and median ventral tubercles at later growth stages. Although *J.* (*J.*) *ultimus* is readily distinguished from *J.* (*J.*) *anderssoni* by its equidimensional whorls and by more numerous ventro-lateral and median ventral tubercles, the two forms are closely related and must be grouped in the same subgenus.

Jacobites (*Jacobites*) *whangaroaensis* Marshall

Plate 8, figs. 1, 4

1926 *Jacobites whangaroaensis* Marshall, p. 170, pl. 21, fig. 1; pl. 37, figs. 1, 2.
1926 *Jacobites waitapuensis* Marshall, p. 170, pl. 23, fig. 2; pl. 44, fig. 1; pl. 45, fig. 2.

Material. Holotype: C.995a, b (figured by Marshall, 1926, pl. 21, fig. 1; pl. 37, figs. 1, 2), N11/499. Also C.996, N11/499.

Diagnosis. Shell large, with a steep umbilical wall, flattened convergent flanks, and well-rounded venter. Ten prominent, radially elongate umbilical tubercles in a half whorl. Inner whorls, up to a shell diameter of 100 mm. are densely ribbed; primary ribs begin from umbilical tubercles and from the umbilical seam with numerous intercalatories appearing at the mid-flanks to make a total of some 90 ribs per half whorl. Prominent ventro-lateral tubercles and a pair of median ventral tubercles occur on every fourth rib but the two series are out of phase. Five flexuous, prorsiradiate constrictions per whorl each truncating two or three ribs and margined on both sides by prominent collars. Mature whorls have a coarser, more widely spaced ribbing. A few primary ribs bifurcate at the periphery to make a total of some 65 ribs per half whorl at the periphery. Constrictions are absent from mature whorls. Suture with a strongly retracted suspensive lobe.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
C.996	89·0	35·0	31·0	0·89	31·0	35
C.995a	152·0	62·0	*c.* 54·0	0·87	45·0	30

Remarks. J. (*J.*) *whangaroaensis* Marshall and *J.* (*J.*) *waitapuensis* Marshall are here considered to be synonymous. The single specimen (C.996) used by Marshall to establish *J.* (*J.*) *waitapuensis* shows good agreement in all characters with the inner whorls of the holotype of the present species. The ribbing of C.996 is slightly coarser but this difference is too small to warrant specific differentiation. The lectotype was more complete when figured by Marshall and the missing piece cannot be traced. Ventro-lateral and median ventral tubercles are missing from mature whorls of the lectotype but it is uncertain whether this is natural or due to poor preservation. Ventro-lateral tubercles appear at a shell diameter of some 60 mm. and persist at least until a shell diameter of 100 mm. *J.* (*J.*) *whangaroaensis* resembles *J.* (*J.*) *stevensi* sp. nov. but is less compressed, more densely ribbed, and its ventro-lateral tubercles appear at a later growth stage.

Jacobites (*Jacobites*) *angularis* Marshall

Plate 6, figs. 3, 4

1926 *Jacobites angularis* Marshall, p. 169, pl. 21, fig. 2; pl. 36, figs. 4, 5.

Material. Lectotype here designated: CE.795 (figured by Marshall 1926, pl. 36, figs. 3, 4), N28/626. 14 additional specimens.

EXPLANATION OF PLATE 7

Figs. 1, 2. *Jacobites* (*Jacobites*) *ultimus* (Marshall). 1, C.623. N28/638. *a*, Ventral, *b*, lateral view; ×1. 2, C.1031. N28/626. *a*, Ventral, *b*, lateral view; ×1·5.
Fig. 3. *J.* (*J.*) *maximus* sp. nov.; holotype, CE.2130. N11/605. Lateral view, ×0·5.
Fig. 4. *J.* (*J.*) sp. nov.?; C.564. N28/626. *a*, Ventral, *b*, lateral view; ×2.

Diagnosis. Shell large with almost equidimensional whorls and a narrow umbilicus. Umbilical wall steep and flanks weakly convex; on mature whorls the venter is differentiated from the flanks by a distinct angle and the venter is composed of two flattened surfaces which meet in an angle at the median line. 11–14 large umbilical tubercles in a half whorl. Inner whorls densely ribbed; mature whorls with fewer, larger ribs. Ribs swing forward from the umbilical wall, straighten by mid-flank and are rectiradiate across the venter; on mature whorls each bears a ventro-lateral tubercle. Four weakly flexuous, prorsiradiate constrictions per whorl, each bordered on both sides by collars and intersecting one or two ribs.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
M.44	25·5	12·0	12·0	1·00	8·0	31
CE.795	38·0	16·0	17·2	1·08	11·8	31
	53·0	22·0	25·0	1·14	17·0	32
C.622	88·0	38·5	41·0	1·06	27·0	31

Remarks. C.619, with a shell diameter of approximately 90 mm., has 28 ribs on its last half whorl while that preceding it has 37. Umbilical tubercles are already present at a shell diameter of 13 mm. but ventro-lateral tubercles do not appear until a shell diameter of approximately 65 mm. Very weak median ventral tubercles may be present on mature whorls but are not a conspicuous feature. The angles of the whorl profile are not distinct until a shell diameter of approximately 40 mm.

Of other described species of subgenus *Jacobites* only *flexicostatus* sp. nov., and *minimus* Marshall possess ventro-lateral tubercles on every rib at late growth stages but both these species have compressed whorls and their ventro-lateral tubercles appear at an earlier stage of ontogeny than in *J.* (*J.*) *angularis*. Juveniles of *J.* (*J.*) *anderssoni* Kilian and Reboul (1909, p. 35, pl. 7, figs. 1–5; pl. 8, figs. 3, 5; pl. 12, figs. 1, 2; pl. 16, fig. 3) are very similar to juveniles of *J.* (*J.*) *angularis* but have compressed whorls.

Jacobites (*Jacobites*) *flexicostatus* sp. nov.

Plate 8, fig. 2

1926 *Madrasites* sp.; Marshall, p. 167, pl. 41, fig. 4.

Material. Holotype: C.1010, N11/499.

Description. The shell is small and narrowly umbilicate. Whorls are compressed with a steep umbilical wall, a narrowly rounded umbilical shoulder and convex flanks. The venter, differentiated from the flanks by a distinct angle, is broad and formed of two flattened surfaces which meet in an angle at the median line. Eight umbilical tubercles in a half whorl are radially elongate and irregular in size, spacing, and shape. Fine, closely spaced primary ribs arise from the umbilical tubercles and from the intervening parts of umbilical shoulder; a few intercalatories appear on the ventral flanks. Altogether there are about 50 ribs in a half whorl; they are prorsiradiate on the dorsal flanks, rectiradiate on the mid-flank, and quite strongly projected on the venter. Five constrictions per whorl are margined on both sides by collars, have the same flexuosity as the ribs, and are prorsiradiate so that each truncates one rib. The suture was not observed.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
C.1010	23·0	10·2	9·0	0·88	6·0	26

Remarks. Although C.1010 was compared by Marshall to '*Madrasites*' *cumshewaensis* (Whiteaves) (1884, p. 208, pl. 24, fig. 1), the presence of ventro-lateral tubercles show it to be a member of *Jacobites* differing from other described species in the details of its ornamentation. It closely resembles *J.* (*J.*) *minimus* Marshall in dimensions and whorl shape but its ribs are more flexuous and its ventro-lateral tubercles appear at a later growth stage.

Jacobites (*Jacobites*) *maximus* sp. nov.

Plate 7, fig, 3

Material. Holotype: CE.2130, N11/605.

Description. The specimen has a shell diameter of approximately 200 mm. but is badly crushed so that its true proportions cannot be determined. The umbilicus is of moderate size. Whorls are wider than high with an umbilical wall which is steep but not vertical, a narrowly rounded umbilical shoulder, parallel, weakly convex flanks, and a broadly arched venter. There are some twenty poorly developed umbilical tubercles in a half whorl; numerous fine, closely spaced ribs arise from these and from the intervening parts of umbilical shoulder. Ribs number some 90 per half whorl on the inner whorls but coarsen on the last half whorl where they number 60. They are prorsiradiate on the dorsal flanks, rectiradiate at the mid-flank, and weakly projected across the venter. Prominent, rounded ventro-lateral tubercles, each interrupting three or four ribs appear at a shell diameter of approximately 110 mm.; they number seven in a half whorl and become progressively larger with increasing shell diameter. Small median ventral tubercles form a single row at the mid-line and are twice as numerous as the ventro-lateral tubercles. Infrequent constrictions have the same flexuosity as the ribs, are bordered on both sides by collars and are prorsiradiate; each intersects one or two ribs. The suture was not observed.

Remarks. Although the specimen is poorly preserved, it is clearly representative of a new species. It is related to *J.* (*J.*) *whangaroaensis* Marshall, but distinguished by its poorly developed umbilical tubercles, its fewer ventro-lateral tubercles, and its finer adult ribbing.

Jacobites (*Jacobites*) *stevensi* sp. nov.

Plate 6, fig. 5

Material. Holotype: CE.870, Hokianaga Harbour (? mouth of the Wairua River).

Description. The shell is large and very narrowly umbilicate. Whorls are strongly compressed with a steep umbilical wall, high, weakly convex flanks which meet the rounded venter in a distinct angle. Fine, well-spaced ribs swing forward from the umbilical wall

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EXPLANATION OF PLATE 8

Figs. 1, 4. *Jacobites* (*Jacobites*) *whangaroaensis* Marshall. 1, holotype, C.995a. N11/499, lateral view, ×0·67. 4, C.996. N11/499. *a*, Ventral, *b*, lateral view; ×0·67.

Fig. 2. *J.* (*J.*) *flexicostatus* sp. nov.; holotype, CE.1010. N11/499. *a*, Lateral, *b*, ventral view; ×1·5.

Fig. 3. *J.* (*J.*) *quadratus* sp. nov.; holotype, CE.2131. N28/639. *a*, Lateral, *b*, ventral view; ×1·5.

Fig. 5. *J.* (*J.*) *marwicki* sp. nov.; holotype, CE.2138. N28/639. *a*, Ventral, *b*, lateral view; ×2.

and split into two secondaries at the mid-flank. The secondaries are straight, slightly rursiradiate and strong across the ventral flanks but projected and very weak across the venter. Every third or fourth secondary is slightly stronger than its neighbours and bears a small, radially elongate ventro-lateral tubercle on the angle between the flanks and venter. Every rib is swollen into a weak tubercle at the periphery. Constrictions, if present, are not well developed. The suture, as far as can be seen, is typical of the genus.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
CE.870	46·0	26·5	16·8	0·63	6·0	13

Remarks. The holotype is slightly eroded and still septate at its maximum shell diameter (46·0 mm.). The umbilicus is filled with rock and the umbilical shoulder slightly eroded where it is exposed. In consequence, umbilical tubercles were not observed. Erosion had largely obliterated ornamentation on the dorsal flanks. Even though the specimen is poorly preserved it represents a distinctive new species.

The locality of the specimen is recorded as Hokianga Harbour and it was collected at a time when very few ammonites had been collected from Hokianga Harbour. Marshall (1926, p. 167), in his discussion of *Jacobites*, recorded that a representative of this genus had been collected by J. A. Bartrum from the mouth of the Wairua River, Hokianga. This specimen is not referred to in his specific descriptions and is highly likely to be CE.870.

J. (*J.*) *whangaroaensis* Marshall is perhaps closest to *J.* (*J.*) *stevensi* but is easily distinguished by its less compressed whorls, its wider umbilicus, and by details of ornamentation.

Jacobites (*Jacobites*) *quadratus* sp. nov.

Plate 8, fig. 3

Material. Holotype: CE.2131, N28/639. Paratypes: M.1114. 1–4, N28/626; M.1031, 1033–7, 1064, 1065, N28/639.

Description. The shell is of moderate size and widely umbilicate. Early whorls (up to a shell diameter of about 20 mm.) are rounded with convex flanks passing in a smooth curve to a broadly arched venter. For the remainder of ontogeny, whorls are sub-quadrate; they have a steep umbilical wall and flattened, sub-parallel flanks which meet the venter in a distinct angle. The venter is composed of two flattened surfaces which meet in a weak angle at the median line. Weak, radially elongate umbilical tubercles number 8–10 in a half whorl; from each arise two primary ribs with one or two additional primaries arising from the umbilical shoulder between adjacent umbilical tubercles. Primary ribs swing gently forward from the umbilical shoulder, straighten to be recti-radiate dorsal of the mid-flank, and are strongly projected across the venter. At the margin of the venter a few primaries may bifurcate and a variable number of inter-calatories appear making a total of some 38 ribs in a half whorl. Up to a shell diameter of approximately 30 mm. there are 6 subcircular ventro-lateral tubercles of variable size in a half whorl; 2–4 ribs pass into each and reappear on the other side. Thereafter ventro-lateral tubercles may be developed as elongate local thickenings on all ribs at the margin of the venter, or may be absent. Median ventral tubercles are absent. Each whorl, up to a shell diameter of 30–40 mm., bears 5 constrictions which are bordered on both sides by collars, flexuous in the same manner as the ribs and prorsiradiate so that each truncates one rib. Thereafter constrictions cannot be recognized with certainty except for a collared constriction which margins the aperture. The suture is very similar to that illustrated for other members of the genus.

Dimensions

	D	*H*	*B*	*B/H*	*U*	%
M.1034	14·5	5·0	6·2	1·24	4·8	33
M.1035	17·5	6·2	7·0	1·13	7·0	40
M.1036	18·5	6·2	7·5	1·21	6·8	37
CE.2131	34·0	12·0	12·0	1·00	12·8	38

Remarks. The holotype, CE.2131, is immature but three fragmentary specimens (M.1034, 1064, 1065) show the nature of late growth stages. Although *J.* (*J.*) *quadratus* is variable in shell dimensions and ornamentation its flattened flanks when mature, wide umbilicus and the ontogenetic change in ventro-lateral tuberculation distinguish it from other described *Jacobites*. *J.* (*J.*) *nodulosus* is perhaps closest but has a rounded whorl profile and regular ventro-lateral tuberculation throughout ontogeny.

Jacobites (*Jacobites*) *marwicki* sp. nov.

Plate 8, fig. 5

Material. Holotype: CE.2138, N28/639, Te Opu, Kaipara Harbour.

Description. The shell is small and narrowly umbilicate. The whorls are compressed, with a low, steep umbilical wall and convex, weakly convergent flanks which are separated from the venter by an angle. The venter is composed of two flattened surfaces which meet in an angle at the median line. Weak, radially elongate, irregularly spaced umbilical tubercles number 11–15 per whorl. From each arise one or two weak primary ribs with additional primaries arising from the top of the umbilical wall between adjacent umbilical tubercles. Intercalatories which are variable in number, spacing, and length appear on the flanks. Ribs are prorsiradiate on the dorsal flanks, rectiradiate on the ventral flanks, and weakly projected across the venter. The total number of ribs in a half whorl is about 42. Each rib bears a small ventro-lateral tubercle on the angles between the flanks and the venter, and a small median ventral tubercle. Constrictions are absent. The suture is similar to those of other members of the genus.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
CE.2138	14·0	7·0	5·0	0·71	3·8	27
	19·0	8·2	6·0	0·73	4·5	24

Remarks. Although the last quarter whorl of CE.2138 is not septate, the specimen may be immature. In spite of being represented by a single specimen which is possibly immature, *J.* (*J.*) *marwicki* is a separate species. Its closest relative is *J.* (*J.*) *minimus* from which it differs in being more compressed and in possessing intercalatory ribs. In addition, all the elements of ornamentation of *J.* (*J.*) *minimus* are stronger than those of *J.* (*J.*) *marwicki*.

Jacobites (*Jacobites*) sp. nov.?

Plate 7, fig. 4

Material. C.564, N28/626 or N28/636; VC.212, N28/636.

Description. The shell is small, with depressed whorls and an umbilicus of moderate size. The umbilical wall is steep and the weakly convex flanks meet the venter in a distinct angle. The venter is comprised of two flattened surfaces which meet in an angle at the median line. Each half whorl bears 5 large umbilical tubercles and 18–20 fine, well-spaced ribs which swing forward from the umbilical wall, straighten on the mid-flank and are rectiradiate across the venter. At a shell diameter of approximately 21 mm. ventro-lateral tubercles develop on every rib at a slightly smaller shell diameter. Each whorl has five prominent prorsiradiate constrictions margined on both sides by collars and each intersects one rib. The suture is typical of the genus.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
C.564	14·0	5·5	6·5	1·18	5·0	36

Remarks. Since the largest specimen, VC.212, is entirely septate, both specimens are immature. They superficially resemble juveniles of *J.* (*J.*) *angularis* but are less densely ribbed, bear median ventral tubercles, and develop ventro-lateral tubercles at an earlier stage of ontogeny. The morphology of *J.* (*Tainuia*) *aucklandicus* Marshall during early ontogeny is not known, but adults, with the exception of their tuberculate flanks and prorsiradiate ribs, resemble the two specimens here discussed. They may be juveniles of *J.* (*T.*) *aucklandicus* or may represent a new species.

Subgenus TAINUIA Marshall

Jacobites (*Tainuia*) *aucklandicus* Marshall

Plate 9, fig. 1

1926 *Tainuia aucklandica* Marshall, p. 186, pl. 24, fig. 2, pl. 34, fig. 3; pl. 46, figs. 1–3.

Material. Holotype: AMT.752 (figured by Marshall 1926, pl. 24, fig. 2; pl. 34, fig. 3; pl. 46, figs. 1–3), N11/499. 3 additional specimens.

Diagnosis. Shell large with compressed whorls and a wide umbilicus. Umbilical wall steep, flanks weakly convex and meet the venter in a distinct angle. Venter comprised of two flattened surfaces which meet in an angle at the median line. 7–10 prominent umbilical tubercles in a half whorl. 16–18 strong, well-spaced ribs arise from the umbilical shoulder in a half whorl and are straight and prorsiradiate throughout their length; each bears prominent ventro-lateral and median ventral tubercles and up to four smaller additional tubercles on the flanks. Five prorsiradiate constrictions in a whorl, margined on both sides by collars, each truncating one rib.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
AMT.752	121·0	42·0	35·0	0·83	42·0	35
C.629a	135·0	54·0	41·0	0·76	48·0	36
C.561	188·0	67·0	55·0	0·82	73·0	39

Remarks. The development of flank tubercles is more regular on the holotype than on the other specimens. A whorl fragment (CE.2004) collected from a pebble in the basal conglomerate of the Mangatu Formation near Ruatoria, Raukumara Peninsula (N72/494), has the ornament characteristics of *Tainuia* and probably represents *J. (T.) aucklandicus*.

Genus MAORITES Marshall 1926

Maorites tenuicostatus (Marshall)

Plate 9, figs. 3, 4; Plate 10, fig. 2

1917 *Kossmaticeras tenuicostatum* Marshall, p. 445, text-fig. 3 (misprinted as text-fig. 2), pl. 33, fig. 1.
1926 *Maorites tenuicostatus* (Marshall); Marshall, p. 177, pl. 23, figs. 1, 1*a*; pl. 42, figs. 1, 2; pl. 45, fig. 1.
1926 *Maorites densicostatus* (Kilian and Reboul); Marshall, p. 178, pl. 24, fig. 1; pl. 44, fig. 2; pl. 45, fig. 4.
1926 *Maorites suturalis* Marshall, p. 179, pl. 23, fig. 3; pl. 43, fig. 1; pl. 45, fig. 5.
1955 *Maorites suturalis* Marshall; Matsumoto, text-fig. 5.
1955 *Maorites tenuicostatus* Marshall; Matsumoto, text-fig. 6.

Material. Holotype: OM.16.47 (figured by Marshall 1917, text-fig. 3, pl. 33, fig. 1), N28/636. 48 additional specimens.

Diagnosis. Shell large, narrowly umbilicate; volutions compressed with flattened, convergent flanks and a narrowly arched venter. Early whorls bear very weak umbilical tubercles and fine, closely spaced primary ribs arising from the umbilical shoulder and numerous intercalatories arising on the flanks; ribs swing forward on the dorsal flanks, straighten on the mid-flanks and are weakly projected across the venter. Whorls of middle age bear similar ribs but may lack umbilical tubercles. Thin, prorsiradiate constrictions margined on both sides by weak collars ornament whorls of early and middle age; each truncates several ribs. Mature whorls bear radial folds which initially (at shell diameters of approximately 150 mm.) are broad, weak, and separated by narrow interspaces, but later (at shell diameters of 165–200 mm.) become stronger and may be broad and separated by narrow interspaces (as on M.56) or narrow and separated by broad interspaces (as on M.545). The strength of ribs and the width of their interspaces varies greatly between different specimens, and occasionally between different growth stages of the same specimen. Suture extremely florid.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
M.659	20·2	9·5	6·8	0·72	4·5	22
M.787	29·0	14·0	9·2	0·66	6·8	24
M.760	54·0	26·8	17·0	0·63	11·5	21
C.1034	57·0	28·0	17·0	0·61	12·2	21
M.580	62·0	30·5	18·8	0·62	14·0	23
M.641	81·2	38·0	26·0	0·68	20·5	25
OM.16.47	142·0	61·0	43·0	0·71	36·0	25

EXPLANATION OF PLATE 9

Fig. 1. *Jacobites* (*Tainuia*) *aucklandicus* Marshall; holotype, AMT.752. N11/499. *a*, Lateral, *b*, apertural view; ×0·67.
Fig. 2. *Maorites multiconstrictus* sp. nov.; holotype, CE.793. N28/639. Lateral view, ×1.
Figs. 3, 4. *M. tenuicostatus* Marshall; 3, C.1032a–c. N28/626. *a*, Ventral, *b*, lateral view; ×1. 4, C.1034. N28/639. Lateral view; ×1.

Remarks. Marshall had only four reasonably large specimens of *Maorites* at his disposal and subdivided them into three species largely on the size of the ribs and their interspaces. Many more specimens are now available showing a continuous gradation from the elegant, fine ribbing of the specimen figured by Marshall as *M. tenuicostatus* (OM.16.47) to the much coarser ribbing of the specimen figured by Marshall as *M. suturalis* (CE.816). Some specimens (for example, C.1034 figured in Pl. 9, fig. 4) exhibit a similar range of variation between different growth stages. On others, for example CE.815 (the specimen figured by Marshall as *M. densicostatus*), several ribs immediately preceding a constriction may be much more widely spaced than the others. It is clear that the size and spacing of the ribs cannot be regarded as a significant taxonomic character and Marshall's three species are here regarded as synonymous.

Marshall's illustrations of the sutures are deceptive and his three species cannot be distinguished by sutural complexity. The suture of intermediate complexity illustrated for *M. suturalis* was taken at a much smaller shell diameter than the suture of maximum complexity illustrated for *M. tenuicostatus*. The apparent sutural simplicity of *M. densicostatus* was due to the severe grinding of the surface used by Marshall to clarify the sutural pattern. On other specimens of *Maorites*, slight natural erosion of the septal surfaces has greatly reduced the complexity of the suture.

Whorls become more compressed with increasing shell diameter and there is some variation in the whorl breadth/height ratio. The juvenile specimens figured by Marshall as *M. densicostatus* and *M. suturalis* (Pl. 42, fig. 3 and fig. 4 respectively) cannot be found but fig. 3 probably represents a juvenile *Jacobites* (*Jacobites*) *ultimus*, and fig. 4 may be a juvenile *Maorites* although its umbilical tubercles appear earlier and are stronger than those on available specimens of *M. tenuicostatus*. Several badly deformed specimens collected from Isolated Hill Creek, Marlborough (S36/1301), are included in this species but they have more prominent constrictions and slightly less regular ribs than the North Auckland material. The locality from which the specimen figured by Marshall as *M. densicostatus* (CE.815) was collected is uncertain. It is given as Batley (N28/638) in the text but as Bull's Point (N28/626) in the plate caption.

Maorites densicostatus (Kilian and Reboul) is closely related to *Maorites tenuicostatus*, and, judging from Spath's illustrations (1953, pl. 2, figs. 7–9), is also variable in the spacing of its ribbing. Mature examples of the two species are easily distinguished, because *M. tenuicostatus* retains a delicate, fine ribbing up to very large shell diameters (200 mm.) while *M. densicostatus* develops a much more widely spaced ribbing at shell diameters as small as 65 mm. Initial growth stages of both species cannot be distinguished, and it is possible that some of the small examples here referred to the present species are in fact juvenile *M. densicostatus*.

Maorites multiconstrictus sp. nov.

Plate 9, fig. 2

Material. Holotype: CE.793, N28/639.

Description. The shell is small with compressed volutions and a narrow umbilicus. The umbilical wall is steep, the flattened flanks sub-parallel and the venter rather narrowly arched. Approximately twelve small, radially elongate umbilical tubercles ornament each half whorl; from each arise two or three thin ribs, separated by interspaces which are wide for the genus. The ribs are strongly flexuous being prorsiradiate on the dorsal flanks, rursiradiate on the mid-flanks and strongly projected across the venter. Occasionally a rib bifurcates at the margin of the venter and the secondary may be continuous across the venter or rejoin the primary on the venter. At a shell diameter of approximately 50 mm. there is a sudden change in ornamentation. The ribs and umbilical tubercles at first become progressively weaker and later, at a shell diameter of approximately 52 mm., are replaced by a very fine, closely spaced liration. Numerous, regularly spaced constrictions, numbering five on the last quarter whorl are prorsiradiate and flexuous. Each is margined on both sides by collars and each truncates two ribs. The suture is known only at a very small shell diameter but its major elements are typical of the genus.

Dimensions.

	H	*B*	*B/H*
CE.793	20·5	17·0	0·83

Remarks. This species, although represented by a single, poorly preserved specimen, is highly distinctive. None of the other described members of *Maorites* exhibit the highly flexuous ribbing or the change in ornamentation at late growth stages of *Maorites multiconstrictus.*

Maorites angulocostatus sp. nov.

Plate 10, fig. 1

Material. Holotype: CE.2133, N28/2133, N28/626.

Description. The shell is of moderate size with whorls initially strongly compressed and becoming still more compressed with increasing shell diameter, and a wide umbilicus. The umbilical wall is steep but not vertical, the flattened flanks weakly convergent and the venter narrowly arched. There are twelve prominent, radially elongate umbilical tubercles in a half whorl. The ribbing is highly distinctive; fine, well-spaced primaries are directed strongly forward from the umbilical wall and strongly recurved dorsal of the mid-flank to be straight and rectiradiate across the venter; at the recurvature, an intercalatory usually appears after each primary. The inner whorls, up to a shell diameter of approximately 60 mm. are finely and densely ribbed but at later growth stages ribs strengthen and become more widely spaced. The last half whorl bears approximately 65 ribs while that preceding it bears approximately 75. Each whorl has four slightly flexuous, prorsiradiate constrictions, each margined on both sides by collars and intersecting three or four ribs on the ventral flanks. On the dorsal side of their recurvature, ribs are more strongly prorsiradiate than the constrictions. The suture is similar to that of *Maorites tenuicostatus* at a comparable stage of growth.

Dimensions. The last whorl is slightly deformed so that the dimensions for the maximum shell diameter are approximate.

EXPLANATION OF PLATE 10

Fig. 1. *Maorites angulocostatus* sp. nov.; holotype, CE.2133. N28/626. *a*, Apertural, *b*, lateral view; ×1.
Fig. 2. *M. tenuicostatus* Marshall; C.1033. N28/637. Lateral view, ×0·5.
Fig. 3. *M. mackayi* (Hector); holotype, CE.794. N141/481. Lateral view; ×1.

	D	H	B	B/H	U	%
CE.2133	32·2	13·2	9·5	0·72	10·0	31
	73·0	33·5	21·0	0·63	20·5	28

Remarks. M. angulocostatus is easily distinguished from *M. tenuicostatus* Marshall by its wide umbilicus, more widely spaced mature ribs, stronger recurvature of the ribs, and more prominent umbilical tubercles. It is closer to *M. seymourianus* (Kilian and Reboul) (1909, p. 29, pl. 19, fig. 1) but is much more compressed and has more strongly recurved ribs.

Maorites mackayi (Hector)

Plate 10, fig. 3

1886 *Ammonites mckayi*, Hector, p. 57, fig. 19A, no. 4.
1950 *Madrasites mckayi* (Hector); Marwick, p. 482, pl. 59.

Material. Holotype: CE.794 (figured by Hector, fig. 19A, no. 4), N141/481.

Diagnosis. Shell of moderate size, compressed and moderately umbilicate. Accurate dimensions and whorl shape are unavailable because the specimen is badly crushed; the shell diameter is approximately 95 mm. of which the umbilical diameter comprises approximately 25%. Up to a shell diameter of approximately 65 mm. whorls bear fine ribs separated by interspaces as wide as the ribs themselves. Here primary ribs arise from numerous, radially elongate umbilical tubercles and an intercalatory appears on the flanks between adjacent primaries; ribs are rectiradiate at the mid-flank and projected across the venter. After a shell diameter of approximately 65 mm. ribs gradually become more widely spaced so that eventually the interspaces are three times as wide as the ribs themselves. Infrequent constrictions, margined before and behind by collars are flexuous and prorsiradiate so that each truncates 4 ribs. The suture is not preserved.

Remarks. Marwick (1950) recorded the history of CE.794 and established that it is the specimen collected by McKay from the Waipawa Gorge. *M. mackayi* is poorly defined being represented by a single, poorly preserved specimen, but appears to be distinct from other described *Maorites*. *M. seymourianus* (Kilian and Reboul) (1909, p. 29, pl. 19, fig. 1) is related but has stronger umbilical tubercles and its shell is probably more inflated. *M. densicostatus* (Kilian and Reboul) (1909, p. 30, pl. 18, fig. 1) is also related but its ribs at late growth stages are stronger and separated by narrower interspaces.

Genus GUNNARITES Kilian and Reboul 1909

Type species. Gunnarites antarcticus (Weller) (1903, p. 417, pl. 11, figs. 1, 2).

Gunnarites is most abundantly represented in Graham Land where it is highly variable and poorly speciated. Spath (1953) recognized seven endemic Graham Land species together with *G. kalika* (Stoliczka) which is shared with India. Most of these species are poorly differentiated as they are variable and connected to one and other by transitional forms. The variability led Spath to recognize numerous varieties. The transitional forms are suggestive of interbreeding and cast doubt on the validity of the species.

According to Howarth (1966) there is a complete gradation in the Graham Land *Gunnarites* from a coarsely ribbed inflated form (*G. pachys* Spath) to a delicately ribbed, compressed form (*G. kalika*). Howarth reduced the seven endemic species to three.

They are: *G. antarcticus* (Weller) (= *G. gunnari* Kilian and Reboul, *G. paucinodatus* Spath, *G. rotundus* Spath and *G. flexuosus* var. *transitorius* Spath), *G. bhavaniformis* Kilian and Reboul (= *G. flexuosus* Spath), and *G. pachys* Spath. However, the remaining species are connected to each other and to *G. kalika* by intermediaries. It may be that there is but a single species of *Gunnarites*, with spectacular variation, represented in Graham Land. There are no such transitions between the four New Zealand species of *Gunnarites*.

Gunnarites zelandicus (Marshall)

Plate 11, fig. 1

1917 *Kossmaticeras zelandicum* Marshall, p. 444, text-fig. 2, pl. 23, fig. 2.
1926 *Gunnarites zelandicum* (Marshall); Marshall, p. 161, pl. 22, fig. 2, pl. 39, figs. 1, 2.

Material. Holotype: OM.16.50 (figured by Marshall 1917, text-fig. 2, pl. 23, fig. 2), N28/636. 8 additional specimens.

Diagnosis. Shell large, moderately umbilicate; juvenile whorls almost equidimensional, middle-aged and adult whorls weakly compressed. Umbilical wall steep but not vertical, flanks flattened and sub-parallel and the venter broadly arched. Ribs are regular in spacing throughout the flanks. The eight regularly spaced umbilical tubercles per half whorl are small for most of ontogeny but enlarge after a shell diameter of approximately 100 mm. 35–40 thin, finely denticulate ribs per half whorl arising in twos or threes from the umbilical tubercles with one or two intercalatories arising from the umbilical shoulder between adjacent umbilical tubercles. Ribs are rectiradiate or weakly prorsiradiate on the dorsal flanks, rectiradiate on the mid-flanks and quite strongly projected across the venter. Constrictions, numbering 4 per whorl, are restricted to juvenile and middle-aged growth stages; they are weakly flexuous and prorsiradiate so that each truncates one rib.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
VC.270a	57·0	23·5	23·0	0·98	18·0	32
OM.16.50	76·0	31·0	28·2	0·91	23·0	30
C.614a	81·0	33·5	32·0	0·96	25·0	31
	36·8	25·0	24·8	0·99	12·2	33
C.1035	128·0	58·2	52·8	0·91	36·0	28

Remarks. There is some variation in the width of ribs; interspaces on the venter are as wide as the ribs themselves on OM.16.50 and C.1035 but twice as wide as the ribs on C.614a. Rib denticulation is variable in size and appears at a shell diameter of approximately 24 mm. At shell diameters of 25 mm., ribs are weaker on the venter than on the flanks. Mature whorls of *G. zelandicus* closely resemble those of the flexuous ribbed variants of *G. bhavaniformis* figured by Spath (1953, p. 35, pl. 3, figs. 3, 4; pl. 9, figs. 4, 5) as *G. flexuosus* Spath but their juvenile and middle-aged whorls are different, those of the Graham Land species being more densely ribbed and more compressed.

EXPLANATION OF PLATE 11

Fig. 1. *Gunnarites zelandicus* (Marshall); C.1035. N28/640. *a*, Lateral, *b*, ventral, *c*, apertural view; ×0·67.
Fig. 2. *G. denticulatus* (Marshall); C.615. N28/626. *a*, Lateral, *b*, apertural view; ×0·5.

Gunnarites denticulatus (Marshall)

Plate 11, fig. 2; Plate 12, fig. 2

1926 *Nowakites denticulatus* Marshall, p. 189, pl. 25, fig. 3; pl. 38, figs. 5, 6.
1927 *Grossouvrites denticulatus* (Marshall); Marshall, p. 357, pl. 36, pl. 37, figs. *a*, *b*.
1953 *Gunnarites denticulatus* (Marshall); Spath, p. 29.
1957 *Grossouvrites* sp.; Wright, p. 809.

Material. Holotype: CE.833 (figured by Marshall 1926, p. 25, fig. 3; pl. 38, figs, 5, 6), N28/626. 5 additional specimens.

Diagnosis. Shell large and moderately umbilicate; early whorls depressed but mature whorls compressed. Umbilical wall steep but not vertical, flanks flattened and subparallel, and the venter broadly arched. Juvenile and middle-aged whorls bear thin, closely spaced, very finely denticulate ribs, separated by interspaces on the venter that are three times as wide as themselves, and small, regularly spaced umbilical tubercles. Mature whorls have similar, but more closely spaced ribs and umbilical tubercles. Ribs arise in groups of three and four from the umbilical tubercles with occasional intercalatories arising from the umbilical shoulder between adjacent umbilical tubercles; they are rectiradiate across the flanks and weakly projected across the venter. Infrequent, prorsiradiate, almost straight constrictions bordered on both sides by collars are present on juveniles and middle-aged whorls but absent from mature whorls; each constriction truncates one or two ribs.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
C.540	50·8	20·0	21·2	1·06	17·8	35
CE.774	79·0	35·5	32·0	0·90	25·0	32
C.615	134·0	59·0	54·0	0·92	41·0	31

Remarks. The last half whorl of C.615 (up to a maximum shell diameter of approximately 165 mm.) bears 15 umbilical tubercles and approximately 70 ribs; the last half whorl of CE.774 (up to a maximum shell diameter of 79 mm.) bears 11 umbilical tubercles and 45 ribs. The denticulation is extremely delicate and is lost with even slight decortication of the ribs. CE.1077 was classified as *Grossouvrites* by Wright (1957*b*, p. 809). Although this specimen is not denticulate, all its ribs are partially or entirely decorticated and its other characteristics are identical to *G. denticulatus*. Judging from the description and figure of the specimen collected from Selwyn Rapids and classified by Trechmann (1917, p. 338, pl. 21, fig. 6) as *Grossouvrites gemmatus* (Huppé), it may also be a decorticated *G. denticulatus*. Marshall (1926) classified this species in *Nowakite*s and later (1927) as a member of *Grossouvrites* although here the figure is labelled *Gunnarites denticulatus*, apparently by mistake. As suggested by Spath (1953, p. 29), rib denticulation shows the species to be a member of *Gunnarites*. The mature whorls of *G. denticulatus* and *G. zelandicus* (Marshall) are easily distinguished for the former has a broadly arched venter, and finer, more closely spaced and more finely denticulate ribs than the latter. Middle-aged growth stages of the two species are less easily distinguished although *G. denticulatus* has weaker, more closely spaced ribs than *G. zelandicus*. Juvenile growth stages of the two species, up to a shell diameter of 25 mm., cannot be distinguished with confidence. Some finely ribbed variants of *G. antarcticus* (Weller) such as those figured by Spath (1953, p. 36, pl. 12, figs. 1–3) as *G. rotundus* Spath are similar to *G. denticulatus* but their mature whorls are more compressed, less densely ribbed and possess constrictions. *Grossouvrites gemmatus* (Huppé) is closely analogous to the present species in ornament but is distinguished by its lack of denticulations and its more compressed whorl profile.

Gunnarites spathi sp. nov.

Plate 12, figs. 1, 4

1926 *Gunnarites inflatus* Kilian and Reboul; Marshall, p. 160, pl. 22, figs. 1, 1*a*, 1*b*; pl. 40, figs. 1, 2.
1926 *Gunnarites antarcticus* (Weller); Marshall, p. 162, pl. 22, fig. 3; pl. 39, figs. 3, 4.
?1926 *Madrasites fortior* Marshall, p. 166, pl. 21, fig. 12; pl. 41, fig. 3.
1953. *Gunnarites* sp. juv. (cf. *inflatus* Marshall, *non* Kilian and Reboul); Spath, p. 31, pl. 9, fig. 6.

Material. Holotype: CE.2129, N28/639. Paratypes: C.700a–c, 791, N28/626; CE.769, 773, M.138, 591 N28/636; CE.2135, N28/639; CE.(765–8), N28/640.

Description. The shell is large with an umbilicus of moderate size. Mature whorls are weakly compressed with a steep but not vertical umbilical wall, an abrupt umbilical shoulder, flattened sub-parallel flanks, and a broadly arched venter. Ornamentation is the same for all growth stages. Strong, thin, regularly spaced ribs numbering 20–25 in a half whorl are separated on the venter by interspaces three times as wide as themselves. They arise in pairs from regularly spaced, prominent umbilical tubercles, usually with one intercalatory arising from the umbilical wall between adjacent umbilical tubercles. Ribs are rectiradiate on the flanks and weakly projected across the venter; they are finely denticulate after a shell diameter of approximately 12 mm. The three constrictions per whorl are weakly flexuous, prorsiradiate, thinner than the interspaces between ribs, margined on both sides by denticulate collars and each usually truncates one rib. The aperture is preceded by a constriction. The suture is of the kossmaticeratid type but less dissected than those illustrated for other members of the genus.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
C.791a	15·0	5·5	7·0	1·27	5·8	39
C.769	22·0	9·0	10·0	1·11	7·5	34
CE.2135	24·5	10·0	10·8	1·08	8·0	33
CE.785	85·0	35·0	32·0	0·91	27·0	32
CE.2129	111·0	43·5	42·0	0·97	37·0	33

Remarks. None of the specimens referred to *Gunnarites inflatus* (Kilian and Reboul) by Marshall are present in the existing New Zealand collections but there is no doubt that his figured specimen is identical with mature *G. spathi.* As noted by Spath, the New Zealand species is quite distinct from *G. antarcticus* var. *inflata* (Kilian and Reboul)

EXPLANATION OF PLATE 12

Figs. 1, 4. *Gunnarites spathi*, sp. nov. 1, holotype, CE.2129. N28/639. *a*, Apertural, *b*, lateral, *c*, ventral view; ×0·67. 4, paratype, CE.2135. N28/639. *a*, Ventral, *b*, lateral view; ×1·5.
Fig. 2. *G. denticulatus* (Marshall); CE.774. Locality unknown. *a*, Ventral, *b*, lateral view; ×0·67.
Fig. 3. *G.* sp. nov. ?; CE.2132. N28/636. *a*, Lateral, *b*, ventral view; ×1.

(1909, p. 35, pl. 9, fig. 1; pl. 10, fig. 1; pl. 16, fig. 1) as the latter is more densely ribbed. The juvenile *Gunnarites* (W.N.Z. 94) figured by Spath as a doubtful member of *G. inflatus* Marshall (*non* Kilian and Reboul) is identical with other small examples in the New Zealand collections and can be placed with confidence in *G. spathi*. CE.769, figured by Marshall as *G. antarcticus* (Weller) is also a juvenile *G. spathi*; it is slightly atypical in possessing distinctly flexuous ribs but is not inconsistent with the variation of this character exhibited by the other juveniles examined. The juvenile specimen (C.1004) described and figured by Marshall as *Madrasites fortior* Marshall is probably a juvenile *G. spathi*. This specimen is an internal mould and does not show the denticulate ribs characteristic of specimens that retain the test.

Juveniles of *G. spathi* resemble juveniles of *G. zelandicus* but ribs are continuous across the venter of the former at a shell diameter of 9 mm. while they do not reach this stage of development until a shell diameter of 20–25 mm. on the latter. At shell diameters greater than 25 mm., the difference in rib density distinguishes the two species. Juveniles of *G. varicostatus* are similar to juveniles of *G. spathi* in rib density but are compressed and do not develop denticulations until a later growth stage. The sparsely ribbed variant of *Gunnarites antarcticus* (Weller) figured by Spath (1953, p. 31, pl. 6, fig. 3) is very similar to the present species but has more conspicuous crenulations. All other figured specimens of *G. antarcticus* are more densely ribbed than *G. spathi*.

Gunnarites varicostatus sp. nov.

Plate 13, figs. 1, 3

1955 *Neograhamites* sp. Matsumoto; p. 144.

Material. Holotype: VC.45a, b, N14/655. Paratypes: M.167, 169, 170, 827, W.N.Z.99, 100, N11/604; VC.43, 44, 55–9; N14/655; M.560, 784, N28/639.

Description. The shell is of moderate size with a shallow umbilicus of moderate width. Whorls are compressed with a steep, low umbilical wall, an abrupt umbilical shoulder, flattened, sub-parallel flanks and a narrowly arched venter. Juvenile whorls, up to a shell diameter of 30 mm. bear fine, regularly spaced ribs separated by interspaces slightly wider than themselves; ribs arise in twos or threes from small, regularly spaced umbilical tubercles and there is usually one rib arising from the umbilical wall between adjacent umbilical tubercles. Each half whorl of VC.45a, beyond a shell diameter of 30 mm., bears 26 ribs and 8 umbilical tubercles. Ribs strengthen and become more widely spaced on the body chamber where they arise in pairs from the umbilical tubercles with one rib usually arising from the umbilical wall between adjacent tubercles; the ribs and the umbilical tubercles are irregular in spacing and the three ribs before the aperture are more closely spaced than those preceding them. The last half whorl of VC.45a is composed of body chamber and bears 20 ribs and 7 umbilical tubercles. After a shell diameter of 30 mm. ribs are finely denticulate, prorsiradiate and strongly flexuous being more strongly inclined on the dorsal flanks and venter than on the mid-flank. Each whorl has five flexuous constrictions, bordered on each side by denticulate collars, that are more strongly prorsiradiate than the ribs, one of which is usually truncated. A constriction lies immediately between the aperture. The suture is complex and similar to those illustrated for other members of the genus.

Dimensions. VC.45a is slightly crushed; its measurements are approximate and not taken at the maximum shell diameter which is approximately 70 mm.

	D	*H*	*B*	*B/H*	*U*	%
M.784	23·0	8·5	7·5	0·88	8·5	37
VC.43	25·0	9·0	8·5	0·94	9·5	38
M.827	25·5	9·0	8·5	0·94	10·0	39
VC.45a	64·0	24·0	20·0	0·83	22·0	34

Remarks. All the paratypes are juveniles, the largest being M.827. They are slightly more widely umbilicate and less compressed than the mature shell. Early growth stages, up to a shell diameter of some 30 mm. are not denticulate and are more sparsely ribbed than the whorls of middle growth stages; they bear 7 umbilical tubercles and approximately 20 ribs per half whorl which are not as flexuous or as prorsiradiate as those of later growth stages.

The two New Zealand specimens from the C. W. and E. V. Wright collection (NZ.99 and 100) which were classified as *Neograhamites* sp. by Matsumoto (1955, p. 144) were kindly loaned to me by Mr. C. W. Wright. They are juvenile *G. varicostatus. G. varicostatus* is closely related to the variant of *G. bhavaniformis* described by Spath (1953, p. 33, pl. 5, fig. 3) as variety *vegaensis*. Both forms have similar flexuous ribbing, more widely spaced on the mature body chamber than on the preceding whorls but showing a secondary return to close spacing as the aperture is approached, together with the compressed whorl cross-section and flattened flanks. However, *G. varicostatus* is less densely ribbed and its ribs have a distinct prorsiradiate inclination. Its camerate whorls closely resemble those of *G. kalika* (Stoliczka) (1865, p. 140, pl. 70, figs. 5, 5*a*) but are less densely ribbed.

Gunnarites sp.

Plate 12, fig. 3

Material. CE.2132, N28/636.

Description. The shell is small and its umbilicus is of moderate width. Early whorls are almost equidimensional, mature whorls compressed and rapidly tapering. The umbilical wall is steep but not vertical, the flanks flattened and weakly convergent and the venter rather narrowly arched. Each half whorl bears some 10 strong, pointed, radially elongate umbilical tubercles and some 28 thin, finely denticulate ribs which are separated on the venter by interspaces that are three times as wide as the ribs themselves. Ribs arise in twos and threes from umbilical tubercles with an occasional intercalatory arising from the umbilical shoulder between two adjacent umbilical tubercles; they are weakly flexuous being prorsiradiate on the dorsal flanks, rectiradiate on the mid-flanks and projected across the venter. Constrictions appear to be absent from mature whorls. The suture was not observed.

EXPLANATION OF PLATE 13

Figs. 1, 3. *Gunnarites varicostatus* sp. nov.; holotype, VC.45a. N14/655. Lateral view; ×1. 3, paratype, VC.48. N14/655. *a*, Ventral, *b*, lateral view; ×1·5.

Fig. 2. *Neograhamites transitorius* sp. nov.; holotype, VC.163a. N11/606. *a*, Lateral, *b*, ventral view; ×1.

Fig. 4. *Kitchinites* (*K.*) *brevicostatus* (Marshall); CE.829. N11/604. Lateral view, ×1.

Dimensions.

H	*B*	*B/H*
29·8	28·0	0·94
13·0	13·8	1·06

Remarks. The specimen, although incomplete, appears to lie within the range of variation of *G. antarcticus* Weller (redescribed by Spath 1953, p. 29, pl. 3, fig. 5; pl. 4, fig. 9; pl. 6, figs. 1–5; pl. 7, fig. 1; pl. 8, fig. 8; pl. 11, fig. 1) which is considered by Howarth (1966) to be conspecific with *G. gunnari* (Kilian and Reboul), *G. flexuosus* var. *transitorius* Spath, *G. paucinodatus* Spath, and *G. rotundus* Spath. However, more complete material is needed to classify this New Zealand species with certainty.

Kossmaticeratidae sp. juv. indet.

A number of juvenile kossmaticeratids in the New Zealand collections are too small to be generically or specifically classified. Included here is the specimen (C.875) described by Marshall (1926, p. 162, pl. 21, fig. 8; pl. 36, fig. 6) as *Gunnarites antarcticus* var. *nordenskjoldi* (Kilian and Reboul).

Genus NEOGRAHAMITES Spath 1953

Neograhamites transitorius sp. nov.

Plate 13, fig. 2

Material. Holotype: VC.163a, b, N11/606. Paratypes: VC.95, N14/655; VC.106a, b, N14/656; C.625, M.24, N28/638.

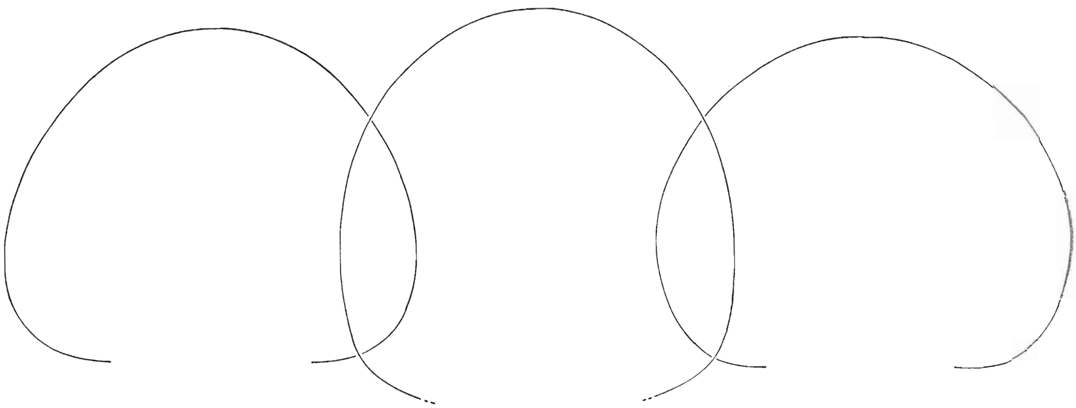
Description. The shell is of moderate size and moderately umbilicate. Whorls are slightly wider than high throughout ontogeny with the umbilical wall steep but not vertical, the weakly convex flanks sub-parallel and the venter broadly arched. Camerate whorls of adult specimens are ornamented with fine, equispaced ribs which arise in twos or threes from small, regularly spaced umbilical tubercles with one or two intercalatories. The last camerate whorl of VC. 163a bears some 80 ribs and 19 umbilical tubercles. The body chamber of mature specimens occupies the last half whorl; here the ribs abruptly strengthen and become more widely spaced and umbilical tubercles become stronger. Two ribs arise from each umbilical tubercle and there is usually one intercalatory. The body chamber of VC.163a bears 19 ribs and seven umbilical tubercles. Ribs swing gently forward from the umbilical shoulder but straighten when slightly dorsal of mid-flank to be straight and rectiradiate across the ventral flanks and venter. Throughout ontogeny, each whorl bears four almost straight, prorsiradiate constrictions; each is slightly narrower than the interspaces between adjacent ribs, bordered on both sides by collars and each truncates one or two ribs. The aperture is bordered by a constriction with a double collar on its adapertural margin. A median ventral groove is present on camerate whorls simulating the position of the siphuncle. The suture is complex and has the basic kossmaticeratid structure.

Dimensions.

	D	*H*	*B*	*B/H*	*U*	%
VC.163a	72·0	28·0	25·0	0·89	22·0	31
VC.95a	79·0	30·5	28·0	0·92	27·2	34
C.625	100·0	40·0	35·0	0·88	33·0	33
	37·0	26·0	24·0	0·92	12·2	33

Remarks. Coarsening of ornament during late ontogeny is typical of many members of Family Kossmaticeratidae including some species of *Gunnarites*. *N. transitorius* is very similar to *Gunnarites* in all features except rib denticulation. It seems likely that *Neograhamites* was derived from *Gunnarites*, rather than from *Kossmaticeras* as suggested by Matsumoto (1955, p. 158).

N. taylori Spath (1953, p. 28, pl. 11, figs. 5*a–d*) has a similar pattern of mature body whorl ribbing but its umbilical tubercles are much stronger and less numerous that those of *N. transitorius*. *N. kiliani* Spath (1953, p. 27, pl. 4, figs. 4*a*, *b*, 5*a*, *b*) is also similar but is more widely umbilicate.



a b c

TEXT-FIG. 11. *a*, Reconstructed whorl cross-section of *Eupachydiscus depressus* sp. nov.; holotype AMT.1302, ×0·25. *b*, Reconstructed whorl cross-section of *Pachydiscus* (*Pachydiscus*) *rogeri* Marshall; lectotype CE.1020, ×0·25. *c*, Reconstructed whorl cross-section of *Anapachydiscus* sp. nov.?; CE.2140, ×0·25.

Family PACHYDISCIDAE Spath 1922
Genus EUPACHYDISCUS Spath 1922

Eupachydiscus depressus sp. nov.

Plate 15, fig. 1

Material. Holotype: AMT.1302, N142/555.

Description. The shell is very large with strongly depressed outer whorls and a narrow umbilicus. Its exact dimensions and the nature of the inner whorls are not known because the specimen is a fragment of an outer whorl; it is still septate at a shell diameter

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EXPLANATION OF PLATE 14

Fig. 1. *Kitchinites* (*Kitchinites*) *angustus* (Marshall); neotype, C.608. Bull's Point, N28/626. *a*, Lateral, *b*, apertural view; ×0·67.

Figs. 2, 3. *Pachydiscus* (*Pachydiscus*) *rogeri* (Marshall). 2, lectotype, CE.1020. N28/626. Lateral view; ×0·25. 3, C.1009. N28/626. Lateral view; ×0·33.

of approximately 390 mm. so that the entire shell probably exceeded 600 mm. in diameter. The umbilical wall is vertical and low, the umbilical shoulder gently rounded, the flanks convex and convergent and the venter broadly arched. Ornamentation consists of fine, rounded ribs which number approximately 35 in a half whorl. Primary ribs appear on the umbilical shoulder and are rectiradiate across the flanks; on the ventral flanks, an intercalatory appears between adjacent primaries. Both sets of ribs are weakly projected across the venter where they are separated by interspaces as wide as the ribs themselves. The suture is basically similar to those illustrated for other members of the genus but has unusually wide lateral lobes.

Approximate dimensions.

	D	*H*	*B*	*B/H*	*U*	%
AMT.1302	390·0	175·0	216·0	1·23	100·0	26

Remarks. Eupachydiscus pseudogrossouvrei Collignon (1955, p. 42, pl. 8, figs. 1, 1*a*, 1*b*, 2, 2*a*, 2*b*) is perhaps the closest relative of *E. depressus* but like other described members of *Eupachydiscus*, it is less depressed, and has fewer ribs per whorl.

Genus PACHYDISCUS Zittel 1884

Pachydiscus (*Pachydiscus*) *rogeri* (Marshall)

Plate 14, figs. 2, 3

1926 *Parapachydiscus rogeri* Marshall, p. 188, pl. 25, fig. 2, pl. 47, figs. 1, 2.

Material. Lectotype here designated: CE.1020 (figured by Marshall 1926, pl. 25, fig. 2; pl. 47, fig. 1), N28/626. Also C.1009 (figured by Marshall 1926, pl. 47, fig. 2), N28/626.

Diagnosis. Shell large, narrowly umbilicate and with a very thick test. Whorls are almost equidimensional with a steep but not vertical umbilical wall, weakly convex, sub-parallel flanks and a broadly arched venter. Ornamentation consists of approximately 12 coarse, distant, rounded ribs in a half whorl; they are rursiradiate on the umbilical wall and rectiradiate across the flanks, and increase in size ventrally. The inclination of ribs across the venter is not known. Umbilical tubercles are absent. As far as can be seen, the suture is characteristic of the genus.

Approximate dimensions.

	D	*H*	*B*	*B/H*	*U*	%
CE.1020	480·0	235·0	230·0	0·98	125·0	26

Remarks. Pachydiscus rogeri is based on two poor specimens and is not well known. The lectotype is the most complete but is badly eroded so that most of its ornamentation has been removed. C.1009 is a well preserved but small fragment of dorsal flank and umbilical wall from what was originally a large shell. As far as can be seen the two specimens agree fairly well in ornamentation and whorl profile. An additional badly eroded specimen, C.631, also collected from Bull's Point (N28/626) may belong in *P. rogeri*.

P. legouxi Collignon (1955, p. 67, pl. 22, figs. 1, 1*a*, 1*b*) closely resembles *P. rogeri* in mature ornamentation but is much more compressed.

Genus ANAPACHYDISCUS Yabe and Shimizu 1926

Anapachydiscus sp. nov.?

Plate 15, fig. 2

Material. CE.2140, N28/801.

Description. The specimen consists of a whorl fragment and the umbilicus. The complete shell was large with strongly depressed whorls and a narrow umbilicus. The umbilical wall is steep, the umbilical shoulder abrupt, the flanks convex and convergent and the venter well rounded. The shell surface is poorly preserved and apparently devoid of ornament except for traces of umbilical tubercles which are preserved only on the inner whorls. The suture is complex, and as far as can be seen, typical of the genus. The fragment is still septate at its maximum diameter so that the complete shell must have measured at least 450 mm. in diameter.

Approximate dimensions.

	D	*H*	*B*	*B/H*	*U*	%
CE.2140	340	175	214	1·23	57	17

Remarks. Only the shell dimensions of the maximum growth stage can be estimated. The specimen appears to differ from all existing species of *Anapachydiscus* in having a narrower umbilicus and in being completely devoid of ornament on the last preserved whorl. However, many species of *Anapachydiscus* are known from specimens of smaller shell diameters and tend to become more narrowly umbilicate and undergo a reduction in ornament with increasing shell diameter. Hence the present specimen may represent an adult growth stage of a species already described and its juvenile growth stages need to be examined before it can be considered as a new species.

LOCALITIES

Ammonite localities of Mata age referred to in the systematic descriptions and discussion of stratigraphy are listed below; an eight figure grid reference, in terms of the New Zealand National Yard Grid, is given for each when known.

N11/499, N11/604. 12678778 to 12698777. West shore of Waitapu Bay, Whangaroa Harbour, North Auckland.
N11/605. 12068772. 100 yards downstream from the Kahoe Bridge, Whangaroa Harbour, North Auckland.
N11/606. 12218760 to 12208765. Ferguson Point, Whangaroa Harbour, North Auckland.
N14/654. 08968266. Waitapu Native School, Hokianga Harbour.
N14/655. 08978273 to 08948276. Ngamahanga Point, Hokianga Harbour, North Auckland.
N14/656. 09988354. Matawhera Point, Hokianga Harbour, North Auckland.
N14/741. Mangamuka River, Hokianga Harbour, North Auckland.
N15/491. Waitangi River, opposite Waimate township, North Auckland.

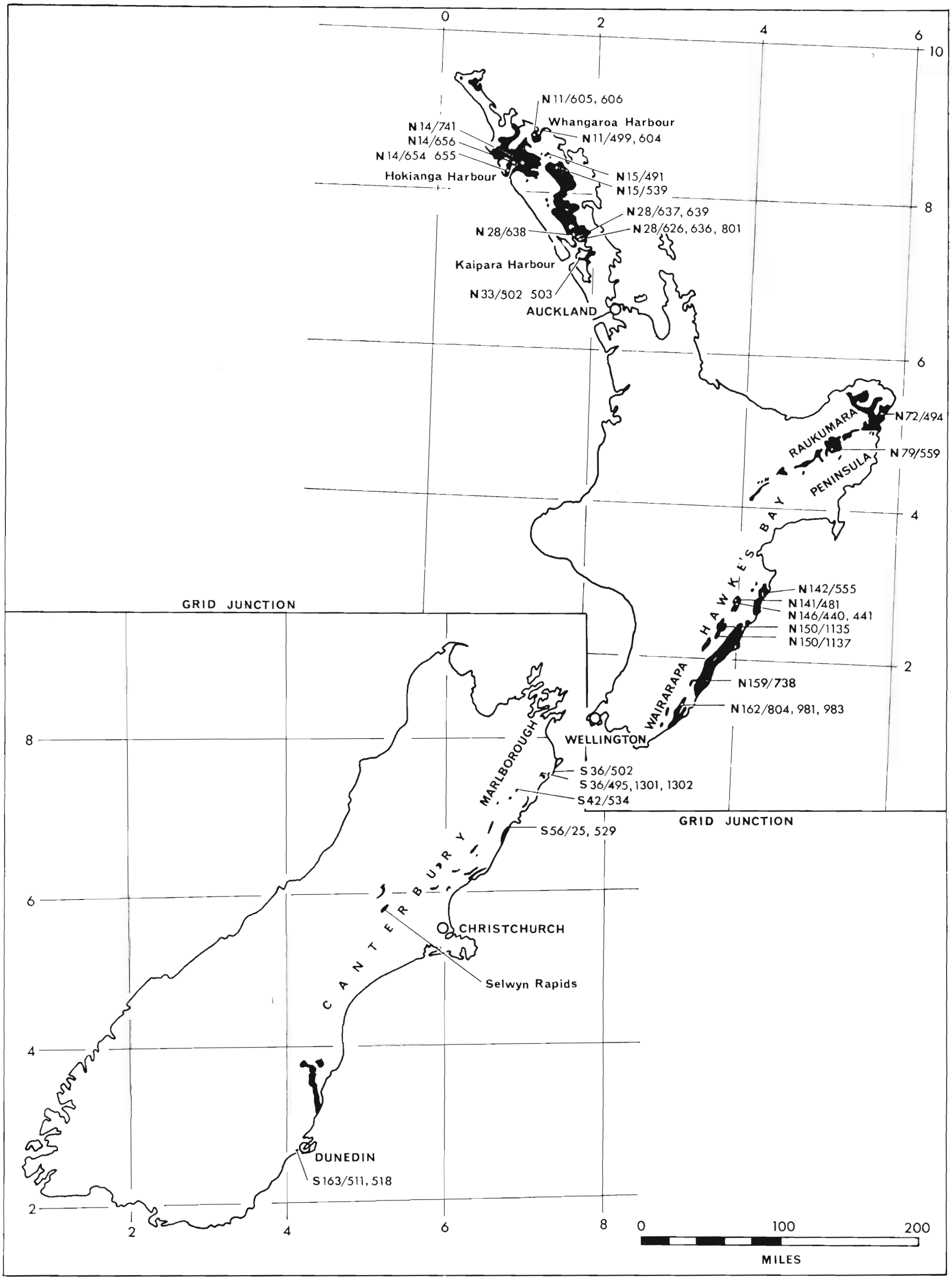
EXPLANATION OF PLATE 15

Fig. 1. *Eupachydiscus depressus* sp. nov.; holotype, AMT.1302. N142/555. *a*, Ventral, *b*, lateral view; ×0·33.
Fig. 2. *Anapachydiscus* sp. nov. ?; CE.2140. N28/801. Lateral view, ×0·33.

N28/626. 18117387 to 18087393. Bull's Point, Kaipara Harbour, North Auckland.
N28/636. 18487374. Batley, Kaipara Harbour, North Auckland.
N28/637. 18137414. Whakapirau Creek, Kaipara Harbour, North Auckland.
N28/638. 17247471. Mouth of Matakohe River, Kaipara Harbour, North Auckland.
N28/639. 18067426. Between the mouths of Opu and Whakapirau Creeks, Kaipara Harbour, North Auckland.
N28/640. 18037413. Whakapirau Creek, Kaipara Harbour, North Auckland.
N28/801. 19057302. Puketotara Peninsula, Kaipara Harbour, North Auckland.
N33/502. 19127287. Gittos Point, Kaipara Harbour, North Auckland.
N33/503. 19117288. Gittos Point, Kaipara Harbour, North Auckland.
N72/494. Half a mile north of the bridge over the Waiapu River, Raukumara Peninsula.
N79/599. Mangatu River, Arowhana Survey District, Raukumara Peninsula.
N141/481. South side of Waipawa Gorge, Hawke's Bay.
N142/555. 44052978. Waimarama Beach, Hawke's Bay.
N146/440. Section 85, Block 4, Motuotaria Survey District, Hawke's Bay.
N146/441. Section 41, Block 4, Motuotaria Survey District, Hawke's Bay.
N150/1135. Tangaruhe Stream, Porangahau district, Hawke's Bay.
N150/1137. Paddock in Northcott farm, Weber district, Hawke's Bay.
N159/738. 34641823. North branch of Makirikiri Stream, Tinui district, Wairarapa.
N162/804. 33791408. Stream flowing past Ngahape School, Wairarapa.
N162/981. 34131457. Totara Creek, Ngahape district, Wairarapa.
N162/983. Kaiwhata Stream, Ngahape district, Wairarapa.
S36/495. Isolated Hill Creek, Kekerengu district, Marlborough.
S36/502. Mouth of Mirza Creek, Ward district, Marlborough.
S36/1301. 72607520. Isolated Hill Creek, Kekerengu district, Marlborough.
S36/1302. 72607518. Isolated Hill Creek, Kekerengu district, Marlborough.
S42/534. 69307284. Muzzle River, Clarence Valley, Marlborough.
S56/25. Calcareous conglomerate, east wing of Amuri Bluff, Kaikoura district, Marlborough.
S56/529. 68006737. North face of Amuri Bluff, Kaikoura district, Marlborough.
S163/511. 40712691. Fairfield Quarry, Fairfield, Dunedin district, Otago.
S163/518. 40202651. Barron's Hill, Fairfield, Dunedin district, Otago.

STRATIGRAPHY

In New Zealand, the uppermost Cretaceous rocks comprise the Mata Series, in which two stages are recognized, the Haumurian (upper) and the Piripauan (lower) (Wellman 1959). The Mata Series is conformably underlain by rocks of the Raukumara Series and is conformably overlain by rocks of the Teurian Stage that is of early Tertiary (Danian) age (Hornibrook and Harrington 1957). The Mata Series crops out in eastern districts of both the North and South Islands and is well represented in North Auckland (text-fig. 12). In the South Island to the south of the Clarence River (southern Marlborough), the Mata Series is largely composed of concretionary siltstone, concretionary jarositic sandstone, and concretionary glauconitic sandstone (shelf facies of Wellman 1959). Here it is thought to have been deposited in shallow water during an Upper Cretaceous transgression and conformably overlies non-marine beds that are separated from the more indurated, complexly folded pre-Cretaceous basement by an angular unconformity (Wellman 1959 and Wilson 1963). At several localities, it contains a fairly rich macrofossil fauna. To the north of the Clarence River in the South Island, and in the North Island, the Mata Series is composed largely of concretionary jarositic siliceous shale (the Whangai or transitional facies of Wellman 1959) and concretionary massive sandstone, concretionary graded sandstone and mudstone rhythms and



TEXT-FIG. 12. Map of New Zealand showing the distribution of the Mata ammonite localities listed above and the distribution of Mata rocks (shown in black). The grid is the New Zealand National Yard Grid and has been drawn at intervals of 200 000 yards.

intraformational conglomerates (Tapuwaeroa or redeposited facies of Wellman 1959). Here it is considered to have been deposited in deep water in the geosynclinal trough (the 'Eastern Geosyncline' of Macpherson 1946; see also Wellman 1959) that extended continuously from the Raukumara Peninsula to Marlborough during late Cretaceous time and in a second geosyncline that occupied the present site of western North Auckland; with the exception of some rocks in North Auckland and some in the Raukumara Peninsula, it is sparsely fossiliferous.

The most important index macrofossils for the Mata Series are *Inoceramus matotorus* Wellman, *Ostrea lapillicola* Marwick, and *Dimetobelus hectori* Stevens (Haumurian) and *Inoceramus pacificus pacificus* Woods, *Inocermus australis* Woods, and *Dimetobelus lindsayi* (Hector) (Piripauan). All are present in the type section of the Mata Series at Amuri Bluff on the Marlborough coast (Wellman 1959). As in the underlying Cretaceous stages, *Inoceramus* is the most useful age indicator in the Piripauan. In the Haumurian, *I. matotorus* is poorly known and recorded from few localities so that *Ostrea lapillicola* and *Dimetobelus hectori* are the most useful key macrofossils. However, macrofossils are rare or lacking in the Haumurian rocks of many areas and foraminifera are more useful for dating purposes.

NORTH AUCKLAND

The great majority of ammonites of Mata age have been collected from loose concretions lying on the shore platforms of the Kaipara, Hokianga, and Whangaroa Harbours, North Auckland. In North Auckland, the oldest definite Cretaceous rocks are of Middle Cretaceous (Clarence Series) age (Wellman 1959, Hay 1960) and deposition was probably continuous, in at least some areas, for the remainder of Cretaceous time with rocks of the Mata Series being particularly well represented. The presence of Cretaceous rocks in North Auckland has been known since late last century but in spite of several detailed investigations (Bell and Clarke 1909, Marshall 1917; Ferrar *et al.* 1925, Ferrar 1934, Mason 1953, and Hay 1960), the details of the regional Cretaceous lithological succession are poorly known and the structure of Cretaceous rocks obscure.

Lithologies and facies. The common Mata lithologies in North Auckland are concretionary siltstones some of which are jarositic and resemble the Whangai facies, concretionary claystones, concretionary graded bedded sandstones with interbedded shales and conglomerates, and massive concretionary sandstones. The claystones and siltstones probably represent the transitional facies of Wellman and the graded bedded sandstones with interbedded shales and conglomerate represent the redeposited facies. The massive concretionary sandstones (Otamatea beds of Ferrar 1924) are commonly interbedded with graded sandstone and shale rhythms and resemble the fluxoturbidite deposits of Dzułyński *et al.* (1959) that are thought to result from redeposition by submarine slumps. They are best considered as deep water deposits and included in the redeposited facies. Rocks representing the shelf facies have not been recognized from outcrops. Well-exposed sections are rare and few macrofossils have been found in place.

Marshall (1926) gave the name 'Batley Series' to the source rocks of the loose ammonite-bearing concretions that at that time were known mainly from Bull's Point (N28/626) and Batley (N28/636) on the shores of Kaipara Harbour and Waitapu Bay (or Nedler's Point, N11/499) on the shores of Whangaroa Harbour. The lithology of the 'Batley Series' has never been adequately described from outcrops and its stratigraphical relationship to other rock units is obscure. It is doubtful if Marshall observed any reliable outcrops of the 'Batley Series' whatsoever. Since Marshall's study, many other localities consisting of loose concretions have been discovered in North Auckland. At all except one, poor exposures and widespread present-day slumping preclude satisfactory examination of the source rocks of the ammonite-bearing concretions. Rocks with olistrome structure (Onerahi Chaos Breccia) ranging from Mata age to Oligocene are known from several localities in North Auckland (Kear and Waterhouse, 1967) and much of the rock previously mapped as Upper Cretaceous may prove to be Onerahi Chaos Breccia. It seems very likely that ammonite-bearing concretions at some of the localities at least have been derived from the chaos breccia. The 'Batley Series' of Marshall may well be in part a junior synonym of the Onerahi Formation (now known as the Onerahi Chaos Breccia) that dates from Ferrar (1920), and is valueless as an Upper Cretaceous stratigraphic unit.

At several localities in North Auckland concretionary, ammonite-bearing pebbles have been collected from conglomerate boulders (Mason 1953) and at three localities (N14/654, N33/502, N33/503) from conglomerate outcrops. Similar conglomerates of Mata age are interbedded with graded sandstone and shale rhythms on the south shore of Hokianga Harbour and all the North Auckland conglomerates are likely to be redeposited and thus analogous to conglomerates of the Tapuwaeroa facies described from the Raukumara Peninsula by Ongley and Macpherson (1928) and Wellman (1959). Since the North Auckland Mata conglomerates were probably produced by redeposition and are not basal conglomerates, they are probably of little value as a marker horizon in the lithostratigraphic framework. It is unlikely that the ammonite-bearing conglomerates were produced by submarine erosion from the underlying strata as suggested by Mason (1953). A more probable explanation is that they were formed in shelf sediments that underwent periodic redeposition of the turbidity current style such that concretions from a large volume of shelf sediment were concentrated to form a single conglomerate bed. Since concretion formation is known to be an early diagenetic process (Pantin 1958), the concretions and the fossils they contain may not be significantly older than the conglomerate itself. Mata redeposited conglomerates at Port Awanui (Raukumara Peninsula) and the Kaiwhata River (Wairarapa) contain pre-Mata fossils but none of the Mata conglomerates in North Auckland are known to contain pre-Mata fossils.

Ferguson Point, Whangaroa Harbour (N11/606) is the only North Auckland locality where the source rocks of ammonite-bearing concretions is known. Here, a grey, jarositic, concretionary, siliceous shale is well exposed. Ammonite-bearing concretions are scattered on the shore platform and are undoubtedly derived from the nearby shale outcrops although no ammonites have actually been collected in place.

Stratigraphic position of ammonite localities. It is impossible satisfactorily to relate the ammonite faunas of most of the North Auckland localities to the stratigraphy of the localities themselves, let alone to a regional lithostratigraphic framework for North Auckland that itself is poorly understood. However, at some localities ammonites occur in the same concretions as index fossils of the Haumurian and Piripauan Stages. Three ammonite-bearing concretions contained belemnites that were studied in thin section by Dr. G. R. Stevens of the New Zealand Geological Survey and reported to be indistinguishable from *Dimetobelus hectori*. The ammonites are *Phyllopachyceras forbesianum*, *Pseudophyllites latus*, *Kossmaticeras* (*Natalites*) *sulcatum*, *Astreptoceras zelandicum*, and ?*Gunnarites varicostatus*. At Ferguson Point, *Inoceramus pacificus* occurs in the shale from which the ammonite-bearing concretions were derived, so that the fauna is of Piripauan age. The fauna includes *Phyllopachyceras forbesianum*, *Tetragonites margaritatus*, *Tetragonites marshalli*, *Pseudophyllites latus*, ?*Gaudryceras propemite*, *Baculites rectus*, ?*Glyptoxoceras* sp. nov.?, *Kossmaticeras* (*Natalites*) *sulcatum*, ?*Jacobites* (*Jacobites*) *whangaroaensis*, *Jacobites* (*Jacobites*) *nodulosus*, ?*Maorites* sp., and *Neograhamites transitorius*. Several specimens of *Baculites rectus* from a number of localities carry an epifauna of *Ostrea lapillicola*, which is of Haumurian age. At Te Opu (N28/639), a specimen of *Dimetobelus*, which is indistinguishable from *D. hectori* in cross-sectional features, was collected from a loose concretion but was not associated with ammonites. The holotype of *D. hectori* was collected from a boulder in the Waitangi River (N15/491) but whether or not it was associated with the single ammonite known from this locality is not recorded. A single juvenile specimen of *I. bicorrigatus* Marwick (AM.7600) that is restricted to the Mangaotanean Stage of the Raukumara Series is recorded as having been collected from Bull's Point, Kaipara Harbour. It may represent the only fossil known to be of pre-Mata age that has been collected from any of the North Auckland ammonite localities but it is uncertain if it was collected from that part of the shore platform at Bull's Point to which ammonite-bearing concretions are restricted. Apart from concretions from Ferguson Point (N11/606) discussed above and a concretion from Waimarama, Hawke's Bay (N142/555) that contained *Eupachydiscus depressus*, no fragments of *Inoceramus* have been observed in ammonite-bearing concretions of Mata age either in North Auckland or elsewhere in New Zealand. As *Inoceramus* is by far the most common fossil throughout the New Zealand Cretaceous this mutual exclusion is unusual. The upper limit of *Inoceramus matotorus* in the Haumurian is not well known but there is some evidence to suggest that it is restricted to the lower part of the stage. Thus it is possible that many of the Mata ammonites are derived from horizons higher than that reached by *Inoceramus* in New Zealand. An alternative explanation is that *Inoceramus* and ammonites inhabited different environments.

EASTERN DISTRICTS OF THE NORTH AND SOUTH ISLANDS

In eastern districts of the North and South Islands, Upper Cretaceous stratigraphy is much better known but ammonites are rare and generally not well preserved. In Marlborough north of the Clarence River, and to the north Mata ammonites have been collected mainly from concretions in the Whangai facies, which is considered to be of Haumurian age in most areas on microfaunal evidence and which is of far greater aerial extent and usually of different lithology than rocks known to be Piripauan in age. Ammonites that have been collected from Whangai facies in the North Island include *Kitchinites* (*Kitchinites*) sp. (N79/599) from the Raukumara Peninsula and *Anagaudryceras subsacya* (N150/1135), *Anagaudryceras tennenti* (N150/1137), *Anagaudryceras* sp. indet. (N146/440, N150/1135), *Diplomoceras* sp. nov.? (N146/441), and *Maorites mackayi* (N141/481) from southern Hawke's Bay. Three loose concretions derived from the Whangai facies cropping out in Isolated Hill Creek, Kekerengu district, Marlborough, contained the following: *Gunnarites denticulatus* (S36/495); *Pseudophyllites latus*, *Anagaudryceras subsacya*, *Glyptococeras wakanenei*, *Maorites tenuicostatus* and

Gunnarites denticulatus (S36/1301); and *Tetragonites margaritatus*, *Pseudophyllites latus*, *Anagaudryceras subsacya*, *Kossmaticeras* (*Natalites*) sp., and *Maorites tenuicostatus* (S36/1302). The ammonites from S36/1301 are associated with *Dimetobelus*, which was studied in cross-section by Dr. G. R. Stevens and reported to be indistinguishable from *D. hectori*. Since all the available fossil evidence suggests that the Whangai facies in the Raukumara Peninsula, southern Hawke's Bay and the Kekerengu district of Marlborough is no older than Haumurian in age, the composite ammonite fauna of the Whangai facies must be regarded as Haumurian in age also. *Pseudoxybeloceras* sp. from the Muzzle River, Marlborough (S42/534), and *Diplomoceras* sp. from Mirza Creek, Marlborough (S36/502), may be derived from rocks of the Whangai facies that outcrops in both water-sheds but cannot be included in the composite Whangai fauna with certainty.

A loose concretion from the north branch of Makirikiri Stream (N159/738), Tinui area, Wairarapa district contained *Anagaudryceras tennenti* and ?*Kossmaticeras* (*Natalites*) *sulcatum*. Most of the Cretaceous rocks known from the watershed of Makirikiri Stream are of Middle Cretaceous (Clarence Series) age and older but according to M. R. Johnston (pers. comm.) a small infaulted strip of Upper Cretaceous rock crops out immediately upstream from the point in the stream where the ammonites were found.

Four loose ammonite-bearing concretions of Mata age have been collected from streams in the Ngahape area, Wairarapa district. One of the concretions was collected from near the mouth of Totara Creek (N162/981) and contained *Phyllopachyceras forbesianum*, *Tetragonites simplex*, and *Kossmaticeras* (*Natalites*) *sulcatum*. Its lithology, a distinctive, richly fossiliferous, highly calcareous sandstone is similar to other boulders in the stream bed and probably a shelf facies. The boulders can be traced upstream to a small area of sandstone with unexposed contracts. The sandstone is not represented by any further outcrops along the strike and is surrounded by siltstone with interbedded graded sandstone and mudstone rhythms that suggest deep water deposition. The discrepancy in facies between the sandstone and the surrounding strata, and its restriction to a small area of outcrop suggest that it is an exotic black that may be significantly older than the surrounding strata. Thus the ammonites cannot be tied to the stratigraphy of the area. Three concretions, two of which contain *Baculites rectus* while the other contained *Phyllopachyceras forbesianum* have been collected from the bed of a small unnamed stream near Ngahape School (N162/804). Strata in the stream valley overlie rocks containing *Inoceramus pacificus* and are known to be the source rocks of a concretion containing *Ostrea lapillicola* (N162/899). The ammonites therefore are probably of Haumurian age. The fourth concretion contained *Neograhamites transitorius* and was collected from the Kaiwhata Stream (N162/983), which cuts through Cretaceous rocks representing a variety of ages so that the provenance of the concretion is not known.

A specimen which is doubtfully referable to *Jacobites* (*Tainuia*) *aucklandicus* was collected from a concretionary pebble in a conglomerate close to the base of the Mangatu Group, near Ruatoria, Raukumara Peninsula (N72/494). The basal horizons of the Mangatu Formation are considered to be Haumurian in age (Wellman, *in* Fleming, 1959) but since the ammonite is derived, its age is in doubt. The single specimen representing *Eupachydiscus depressus* was collected from Waimarama Beach, Hawke's Bay (N142/555), where rocks representing both the Raukumara and Mata Series crop out.

It is uncertain if the specimen was collected in place and since present-day slumping is widespread at the locality the source beds of the concretion are uncertain and its age cannot be determined. The inclusion of *Eupachydiscus depressus* in the Mata fauna is based on the known range of *Eupachydiscus* overseas.

Seven ammonite species are known from the shelf facies of the Mata Series in eastern districts of the South Island, south of the Clarence River, Marlborough. *Kossmaticeras* (*Natalites*) *bensoni* was collected from a greensand horizon near Fairfield, Dunedin district (S163/511), which is considered to be Haumurian in age on both macrofaunal (S163/489) and microfaunal (S163/537) evidence. A specimen doubtfully referable to *K.* (*K.*) *bensoni* was collected from Barron's Hill, Dunedin district (S163/518), is associated with *Dimetobelus hectori*, and is of Haumurian age. The form described as *Grossouvreites gemmatus* (Huppé) by Trechmann (1917) from Selwyn Rapids, North Canterbury, now thought to be *Gunnarites denticulatus*, is probably of Haumurian age as *Dimetobelus hectori* is known from the same general locality. A second specimen, recorded from the same locality by Trechmann but not named or described, was referred to *Pseudophyllites* by Spath (1921, p. 299).

Eight ammonites representing four species are known from Amuri Bluff, Marlborough. McKay collected six of the specimens in 1876 and gave the first detailed geological description of Amuri Bluff in 1877. He showed that the younger rocks formed an anticline and referred to the two limbs as the east and west wings. The east wing corresponds to what is now the type section of the Mata Series at Amuri Bluff. The west wing is exposed near Mikonui Stream about $1\frac{1}{2}$ miles to the north of Amuri Bluff and is separated from the type section of the Mata Series by a pre-Cretaceous greywacke core. Wellman (1959, p. 140) erroneously referred to the section near Mikonui Stream as the east wing of Amuri Bluff in the sense of McKay. Six specimens representing *Gaudryceras* sp., *Baculites* sp., *Pseudoxybeloceras bicostatum*, and *Kossmaticeras* (*Kossmaticeras*) *haumuriensis* are recorded by McKay as having been collected from the 'calcareous conglomerate' of the east wing, Amuri Bluff, which is now the type section of the Mata Series. According to Wellman (1959) strata representing the Piripauan Stage lie between the base of a black grit horizon and the pre-Cretaceous basement. McKay recognized two stratigraphic units within what is now the Piripauan stage. These are 215–315 ft. of grey sands (upper) and 180–240 ft. of 'calcareous conglomerate' (lower). It is concluded that ammonites from the 'calcareous conglomerate' were collected from the lower Piripauan stage in the sense of Wellman. Of the remaining specimens, one represents *Baculites rectus* and is recorded from the calcareous conglomerate, Amuri Bluff. It is probably also from the lower Piripauan strata of the east wing, but could be from the west wing where the stratigraphy, in terms of the current Cretaceous stage divisions, is not well known and most of the fossils have been collected from loose boulders at the mouth of Mikonui Stream. The other is a specifically indeterminable *Pseudoxybeloceras* and was collected from lower Piripauan strata of the east wing some 75 ft. stratigraphically above the base of the Cretaceous section.

AMMONITE ZONES

Two stratigraphically and faunally distinct assemblages are recognized in the Mata series. Although they are not sufficiently widespread or sufficiently well known stratigraphically to constitute true zones, they are informally referred to as zones for convenience.

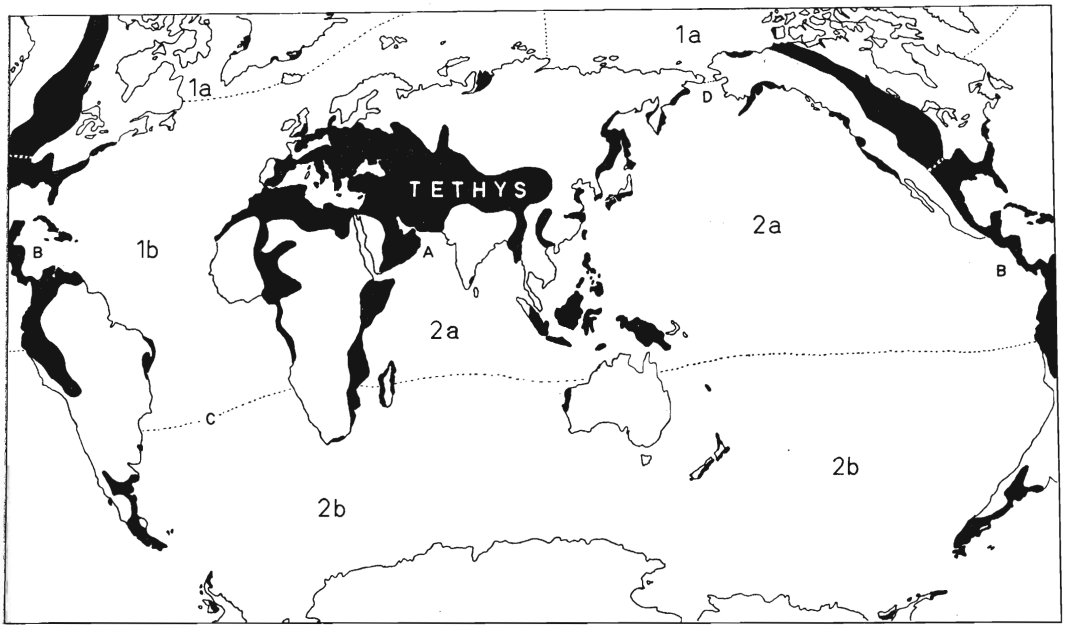
The Kossmaticeras (Natalites) '*zone*'. Faunas of all the North Auckland localities are closely akin; almost all the species represented at one locality are represented at several others as well, and a few species, including *Phyllopachyceras forbesianum*, *Pseudophyllites latus*, *Baculites rectus*, and *Kossmaticeras* (*Natalites*) *sulcatum* have been collected from almost all localities where a large number of specimens are known. The ammonites at the different localities were derived from strata of much the same age and since many ammonite species are short-ranging in overseas countries, it is likely that the ammonite-bearing strata represent a relatively short span of time. The small fauna of the Whangai facies of eastern districts of the North and South Islands has all but two of its nine determinable species and all but one of its nine genera in common with the composite North Auckland fauna. Because of the strong affinities between the two faunas, this entire assemblage is considered to comprise a single 'zone'. Some elements of this assemblage, those associated with *Dimetobelus* cf. *hectori* and those known from the Whangai facies, are probably of Haumurian age while those associated with *Inoceramus pacificus* are of Piripauan age. However, the entire assemblage lacks *Kossmaticeras* (*Kossmaticeras*) known from the Lower Piripauan of Amuri Bluff. Therefore the range of the 'zone' is probably Upper Piripauan–Haumurian although some of the individual species may range lower than this. *Kossmaticeras* (*Natalites*) *bensoni* is known to be of Haumurian age and must be included in this 'zone' also. Taxa attributed to the 'zone' are as follows: *Neophylloceras marshalli*, *N. ramosum*, *N. radiatum*, *Phyllopachyceras forbesianum*, *Tetragonites margaritatus*, *T. simplex*, *T. marshalli*, *Pseudophyllites latus*, *Gaudryceras propemite*, *Anagaudryceras particostatum*, *A. subscaya*, *A. tennenti*, *Zelandites kaiparaensis*, *Vertebrites murdochi*, *Baculites rectus*, *Astreptoceras zelandicum*, *Glyptoxoceras wakanenei*, *G.* sp. nov.?, *Diplomoceras* sp. nov.?, *Masonites biannulatus*, *Kossmaticeras* (*Natalites*) *sulcatus*, *K.* (*N.*) *regularis*, *K* .(*N.*) *multicostatum*, *K.* (*N.*) *bensoni*, *Jacobites* (*Jacobites*) *minimus*, *J.* (*J.*) *nodulosus*, *J.* (*J.*) *ultimus*, *J.* (*J.*) *whangaroaensis*, *J.* (*J.*) *angularis*, *J.* (*J.*) *flexicostatum*, *J.* (*J.*) *quadratus*, *J.* (*J.*) *marwicki*, *J.* (*J.*) sp. nov.?, *J.* (*Tainuia*) *aucklandicus*, *Maorites tenuicostatus*, *M. multiconstrictus*, *M. angulocostatus*, *M. mackayi*, *Gunnarites zelandicus*, *G. denticulatus*, *G. spathi*, *G, varicostatus*, *Neograhamites transitorius*, *Kitchenites* (*Kitchinites*) *brevicostatus*, *K.* (*K.*) *angustus*, *Pachydiscus* (*Pachydiscus*) *rogeri*, and *Anapachydiscus* sp. nov.?

The Kossmaticeras (Kossmaticeras) '*zone*'. The small fauna from the east wing of Amuri Bluff is characterized by *Kossmaticeras* (*Kossmaticeras*) *haumuriensis*. The *Gaudryceras* sp. although poorly known appears to be distinct from *G. propemite* of the *Kossmaticeras* (*Natalites*) 'zone'. Since the only known occurrence of this 'zone' is in the Lower Piripauan of Amuri Bluff it is considered to be of Lower Piripauan age although it may well range lower than this.

Jacobites (*Jacobites*) *maximus*, *J.* (*J.*) *stevensi*, *Pseudoxybeloceras compressum*, and *Eupachydiscus depressus* are all known from single localities which have yielded no other ammonites and cannot be assigned to either 'zone'. *Pseudoxybeloceras bicostatum* ranges through both 'zones' and *Baculites rectus* probably does so as well.

FAUNAL RELATIONS

The major transgression of late Cretaceous time inundated the margins of most land masses of the world in existence at that time and spread extensively across the interiors of North America, Eurasia, and Africa (text-fig. 13). Deposits of the transgression were largely formed in shallow water, are often richly fossiliferous and crop out widely on all the major land masses. As a result, the world distribution of late Cretaceous marine taxa, including ammonites, is fairly well known, the record of distribution being particularly complete for the Campanian and Maastrichtian Ages.



TEXT-FIG. 13. Palaeogeographic map of the world for Santonian–Maastrichtian time; former sea areas shown in black. Data mainly from Weeks (1947), Birkelund (1965), and Gerasimov, *et al.* (1964). Also shown are ammonite faunal realms and provinces for Santonian–Maastrichtian time, and areas of faunal interchange. 1, Atlantic realm; 2, Indo-Pacific realm; 1*a*, north-western Atlantic province; 1*b*, median Atlantic province; 2*a*, northern Indo-Pacific province; 2*b*, southern Indo-Pacific province; A, Tethyan, B, central American, C, southern Atlantic, D, Bering Strait areas of faunal interchange.

Approximately 115 genera of ammonites are known from Santonian to Maastrichtian time and analysis of their distributions suggests the existence of marked faunal provincialism. To appreciate the faunal relations of the New Zealand ammonite taxa described in this paper, it is necessary to outline the major world faunal provinces as indicated by ammonites. Most of the genera discussed below are restricted in range to within Santonian to Maastrichtian time but where genera occur lower in the column, only their distributions for Santonian to Maastrichtian time is considered. The genera and families discussed are those recognized by Wright (1957*a*) except where revised in the preceding taxonomic section of this paper or where separately referenced. Most of the data on generic distributions are presented by Wright (1957*a*) with important contributions from the following more recent publications: Besairie and Collignon (1956), Birkelund (1965), Howarth (1965), Jones (1963), Katz (1963), Matsumoto (1959), Wiedmann (1962), and Young (1963).

FAUNAL REALMS

Only *Baculites* and *Texanites* are truly cosmopolitan, although *Pachydiscus* has a world-wide distribution with the exception of the western interior of the United States of America and Canada, and Greenland. The remaining genera conform basically to two main faunal realms. One is comprised of ammonites from the borderlands of the Atlantic Ocean (including Europe, North Africa, and the former site of the epicontinental sea that traversed the interior of North America) and is here termed the Atlantic realm. The other is comprised of ammonites from the borderlands of the Pacific and Indian Oceans (including Graham Land and Patagonia) and is here termed the Indo-Pacific realm.

Genera typical of the Atlantic realm, being represented on both the east and west sides of the Atlantic Ocean are as follows: *Nostoceras*, *Axonoceras*, *Solenoceras*, *Cirroceras*, *Scaphites*, *Hoploscaphites*, *Discoscaphites*, *Trachyscaphites* Cobban and Scott (1964), *Parapuzosia*, *Placenticeras*, *Stantoniceras*, *Hoplitoplacenticeras*, *Menabites*, *Eulophoceras*, *Coahuilites*, and *Sphenodiscus*. Genera typical of the Indo-Pacific realm are as follows: *Neophylloceras*, *Phyllopachyceras*, *Vertebrites*, *Eubaculites*, *Pseudophyllites*, *Gaudryceras*, *Anagaudryceras*, *Tetragonites*, *Glyptoxoceras*, *Diplomoceras*, *Polyptychoceras*, *Pseudoxybeloceras*, *Mesopuzosia*, *Kitchinites*, *Damesites*, *Desmophyllites*, *Hauericeras*, *Kossmaticeras*, *Grossouvrites*, *Gunnarites*, *Jacobites*, *Maorites*, *Neograhamites*, *Canadoceras*, and *Metaplacenticeras*. At the family level, Nostoceratidae, Placenticeratidae, Scaphitidae, and Sphenodiscidae are dominantly Atlantic in distribution for Santonian to Maastrichtian time while the Kossmaticeridae, Diplomoceratidae, Tetragonitidae, and Desmoceratidae are dominantly Indo-Pacific.

While these realms remained distinct in a broad sense, interchange of genera between them was permitted by interconnecting seaways existing at the time. The areas of interconnection are shown in text-fig. 13 and faunal interchange across them is discussed below.

The Tethyan seaway. The Tethyan Sea ran as a continuous body of water from the Mediterranean Sea to western China. Between India and Africa and east of India, it merged with the Indian Ocean providing a migration route for faunal interchange between the Indo-Pacific and Atlantic realms. Some Atlantic genera migrated along the Tethys to colonize the region of peninsular India. These include *Placenticeras* and *Sphenodiscus*. *Indoscaphites* may have been derived in the same way or may have evolved from a relict stock of scaphitids isolated in the Indian region during the late Cretaceous withdrawal of this group to the Atlantic realm following its widespread distribution in the Indo-Pacific region during Albian and Cenomanian time. A stronger representation of Atlantic elements reached south-east Africa and Madagascar. Two faunas are known from south-eastern continental Africa. The Pondoland fauna is the most southern and includes the Atlantic genera *Hoploscaphites* and *Parapuzosia* as well as thirteen Indo-Pacific genera. The Zululand fauna includes the Atlantic genera *Menabites*, *Nostoceras*, *Parapuzosia*, and *Placenticeras* as well as the genera *Glyptoxoceras* and *Gaudryceras* of Indo-Pacific affinities. The Atlantic dominance of the more northern (Zululand) fauna compared to the Indo-Pacific dominance of the more southern (Pondoland) fauna suggests that migration of Atlantic elements was from north to south via the Tethyan seaway rather than from south to north following derivation via the Cape of Good Hope. The

Madagascan fauna is the richest so far described and includes the Atlantic genera *Nostoceras*, *Solenoceras*, *Scaphites*, *Hoploscaphites*, *Parapuzosia*, *Placenticeras*, *Hoplitoplacenticeras*, *Menabites*, *Eulophoceras*, and *Sphenodiscus*. Some twenty-one species shared between Europe and Madagascar emphasize the ease of migration. Several Indo-Pacific genera are represented in Europe. These include *Phyllopachyceras*, *Tetragonites*, *Glyptoxoceras*, *Diplomoceras*, *Polyptychoceras*, *Desmophyllites*, and *Hauericeras*. European *Gaudryceras* and *Tetragonites* may be relicts of a more widespread distribution of these genera in mid-Cretaceous time.

Certain genera that are more or less restricted to the area formerly occupied by the Tethys or that have distributions centred on the Tethyan 'area' suggest the existence of a separate Tethyan faunal province. These are *Bostrychoceras*, *Pseudokossmaticeras*, *Brahmaites*, *Nowakites*, *Menuites*, *Pseudomenuites*, *Bayleites*, *Manambolites*, *Pseudoschloenbachia*, and *Indoceras*. Some of these genera reached as far as Japan on one hand (*Bostrychoceras*, *Brahmaites*, *Menuites*, *Bayleites*), and eastern North America (*Bostrychoceras*, *Pseudoschloenbachia*) and eastern South America (*Pseudokossmaticeras*) on the other.

The Central American seaway. Central America was inundated at this time allowing interchange between the Indo-Pacific and Atlantic realms. Atlantic nostoceratids spread northwards up the west coast of North America reaching California (*Nostoceras*, *Solenoceras*, *Cirroceras*), British Columbia (*Cirroceras*), and Alaska (*Cirroceras*). *Hoplitoplacenticeras* reached British Columbia as did *Pseudoschloenbachia* of Tethyan affinities. Indo-Pacific elements migrating into the Atlantic realm include *Glyptoxoceras* that reached north-east Brazil and Texas, and *Pseudophyllites* and *Canadoceras* that reached north-east Brazil. For the most part, the two realms remained remarkably distinct at this area of contact as evidenced by the strong disparity between the fauna of California and those of Columbia, north Mexico, and Texas.

The South Atlantic contact area. The two realms were in contact in the South Atlantic Ocean and some faunal interchange took place between them. The Angola fauna is dominantly Atlantic in aspect but includes the Indo-Pacific genera *Anagaudryceras* and *Gaudryceras* (both represented by species occurring in the Indo-Pacific region), *Polyptychoceras*, *Kitchinites*, *Neophylloceras*, and *Desmoceras*. The south Patagonian fauna includes a strong Indo-Pacific representation (*Eubaculites*, *Gaudryceras*, *Glyptoxoceras*, *Grossouvrites*, *Gunnarites*, *Maorites*, *Neograhamites*, *Polyptychoceras*, *Pseudophyllites*, *Tetragonites*, *Vertebrites*, and *Zelandites* but also includes representatives of the Atlantic genera *Hoplitoplacenticeras* and *Parapuzosia*, and *Pseudokossmaticeras* of Tethyan affinities. The small Conception Bay fauna, Chile, is dominantly Indo-Pacific in aspect but includes the Atlantic genus *Hoploscaphites*. Atlantic representatives in the Graham Land fauna are *Solenoceras* and *Discoscaphites*. *Oiophyllites* is at present known only from Graham Land and Angola.

The Arctic seaway. Some Indo-Pacific taxa reached Greenland via the Bering Strait and the Arctic Ocean (Birkelund 1965, p. 168). These are *Tetragonites* (*Saghalinites*), *Pseudophyllites*, and *Neophylloceras*. *Diplomoceras* is also recorded from Greenland but resembles the European *D. cylindraceum* (Defrance) and was probably derived via the North Atlantic and ultimately the Tethyan seaway. Migration in the reverse direction apparently did not take place.

FAUNAL PROVINCES

The Atlantic realm may be divided into two faunal provinces. One of these was outlined by Birkelund (1965) and includes the Western interior of the United States of America and Canada, and West Greenland. It is here termed the north-western Atlantic province and is characterized by the dominance of scaphitid forms with *Clioscaphites*, *Desmoscaphites*, and *Haresiceras* endemic to the region, and the absence of *Pachydiscus* that is otherwise cosmopolitan. The eastern and western boundaries of this province are problematical. A second, more loosely knit faunal province encompasses land bordering on the remainder of the Atlantic Ocean (including central and eastern Europe and North Africa) down to a latitude of some 25° S. This province is here termed the median Atlantic province and is characterized by *Nostoceras*, *Cirroceras*, *Solenoceras*, *Scaphites*, *Hoplitoplacenticeras*, *Sphenodiscus*, and *Placenticeras*.

The Indo-Pacific realm can also be divided into two regions of faunal contrast, here termed the northern and southern Indo-Pacific provinces. The northern Indo-Pacific province is characterized by *Mesopuzosia*, *Kitchinites* (*Neopuzosia*), *Damesites*, *Desmophyllites*, *Hauericeras*, *Kossmaticeras* (*Karapadites*), *Brahmaites*, *Canadoceras*, *Pachydiscus* (*Neodesmoceras*), and *Metaplacenticeras* faunas within the province being known from the western seaboard of North America, Japan, Saghalien, and India. The southern Indo-Pacific province is characterized by *Kitchinites* (*Kitchinites*), *Kossmaticeras* (*Natalites*), *Grossouvrites*, *Gunnarites*, *Maorites*, *Jacobites*, and *Neograhamites*. It is represented at Conception Bay, Chile, south Patagonia, Graham Land, New Zealand, western Australia, and New Caledonia. Considerable interchange occurred between the two provinces. Madagascar and south-east Africa lie within the region of overlap; here elements of both provinces are completely intermixed. Several southern genera reached south India (*Vertebrites*, *Phylloptychoceras*, *Maorites*, and *Kitchinites* (*Kitchinites*), and two are represented in California (*Vertebrites* and *Maorites*). Of the northern genera, *Hauericeras* reached Victoria, Australia. Several genera are widely distributed and occur in both faunal provinces. These are *Anagaudryceras*, *Gaudryceras*, *Zelandites*, *Tetragonites*, *Pseudophyllites*, *Diplomoceras*, *Glyptoxoceras*, *Neophylloceras*, and *Phyllopachyceras*.

AFFINITES OF THE NEW ZEALAND FAUNA

New Zealand occupies a central position in the southern Indo-Pacific province, well away from the areas of faunal interchange. Atlantic, Tethyan, and northern Indo-Pacific elements are absent from the New Zealand fauna. Its affinities are strongest with the Graham Land fauna, both assemblages being dominated by southern Indo-Pacific kossmaticeratids. Similarities are also close with south Patagonia, Conception Bay, Chile, New Caledonia, Australia, and areas where the northern and southern Indo-Pacific provinces overlap (Madagascar, south-east Africa, India, and California). Forty-three of the forty-nine species occurring in New Zealand appear to be endemic. Species represented elsewhere in the world are as follows: *Neophylloceras ramosum* (western seaboard of North America, Conception Bay, Chile, south Patagonia, Graham Land, and Japan); *Phyllopachyceras forbesianum* (India, Japan, British Columbia, Graham Land, Spain, Australia, Madagascar); *Pseudophyllites latus* (Graham Land, Madagascar, Greenland); *Vertebrites murdochi* (New Caledonia); *Zelandites kaiparaensis* (California), and *Baculites rectus* (Graham Land and possibly New Caledonia).

CORRELATION

The Senonian and Maastrichtian strata of Europe are characterized by a number of widely distributed belemnite species which, with the more numerous but less widely distributed ammonite taxa, have been used to produce a fine zonal succession that can be recognized over most of the subcontinent. The zonal succession is poorly tied to the type sequences. The type sequence of the Maastrichtian has never been adequately designated (Thiadens 1959). According to Jeletzky (1951), the uppermost zone of the 'Maastrichtian' is missing or not exposed in the type area but this is disputed by Voigt (1956); in any case, if the zone exists, it has no distinctive ammonites. Although most workers agree on the positions of the Santonian–Campanian and Coniacian–Santonian boundaries, four interpretations have been put forward for the position of the Campanian–Maastrichtian boundary (Voigt 1956). Many of the ammonite taxa are in need of revision. Several North American species have been reported from Europe and incorporated into the European zonation but Young (1963) has cast doubt on some of the European specific identifications. In addition, the ranges of many European species are reported differently by different authors. The lack of agreement and definitive work in Europe, quite apart from difficulties of correlation, fully substantiates the erection of local stages as has been practised in New Zealand and other countries. Jeletzky (1951, 1958) has given the most complete modern summary of European Santonian–Maastrichtian biostratigraphy and his interpretation of the Campanian–Maastrichtian boundary, taken as between the *Bostrychoceras polyplocum* and *Haploscaphites constrictus* zones, is generally accepted and is followed in this paper.

Because of faunal provincialism, correlation of most of the Indo-Pacific realm with Europe during Santonian–Maastrichtian time is not easy. Faunal interchange between Europe and the Indo-Pacific realm via the Tethyan seaway provided a notable exception for Madagascar and to a lesser extent, for India. No short-ranging species are shared between Europe and most of the Indo-Pacific realm. In Europe few widely distributed genera are known to be restricted to any of the Maastrichtian, Campanian, and Santonian. Exceptions include *Sphenodiscus* (Maastrichtian) and *Trachyscaphites* (Campanian). The shortage of widely distributed reliable international stage indicators of generic rank in the Indo-Pacific realm is even more acute. The ranges of single species in different countries are known to differ (Matsumoto 1959*d*, p. 61), probably reflecting ecologic factors, and this also impedes correlation.

New Zealand has no direct faunal ties with the European Cretaceous succession and correlation must be effected indirectly. Madagascar and India form the most useful intermediaries; faunal interchange via the Tethys allows both to be correlated with Europe, and the numerous Indo-Pacific elements shared between both countries and New Zealand allow mutual correlation between all three. Unfortunately most of the faunas as yet described from the southern Indo-Pacific province are not related to a stratigraphic framework and consequently the ranges of many southern Indo-Pacific genera are poorly known. Some stratigraphic control is available in south Patagonia, which can also be correlated with New Zealand, and to some extent, with Europe. Because correlation of the New Zealand faunas with the standard European succession is indirect, it is desirable to review the biostratigraphy and European correlations of India, Madagascar, and south Patagonia.

Madagascan assemblages are the richest in the world and have been subjected to intense palaeontological examination. In addition, the stratigraphy is well known, allowing a fine biostratigraphic zonation. Many species are shared with Europe, allowing accurate correlation with the standard Cretaceous succession. A complete synopsis of the Madagascan Cretaceous succession and correlation is given by Besairie and Collignon (1956, 1960). The geographic location of Madagascar in the region of overlap between the northern and southern Indo-Pacific provinces, coupled with its accurate correlation with the European standard, make it the practical standard for correlation within the Indo-Pacific realm.

The main areas of fossiliferous Senonian and Maastrichtian rock in Peninsula India outcrop on the south-east coast near the towns of Pondicherry and Trichinopoly. The ammonite faunas of both areas have been intensively studied (Forbes 1846, Stoliczka 1864–6, Kossmat 1895–8, 1897). The lithostratigraphic sequence at Pondicherry was described in detail by Warth (1895) and biostratigraphic units established by Kossmat (1897) long after most of the palaeontological work had been completed. Fortunately careful recollection by Warth allowed Kossmat to fit most of the described species into the stratigraphic framework. According to Kossmat, the sequence consists of three biostratigraphic units: *Nerinea* beds lacking ammonites and of probable Danian age (youngest), *Trigonarca* beds, and Valudavur beds (oldest). The lower two units contain a rich ammonite fauna and are probably of Maastrichtian age. The Trichinopoly succession, although not studied in such detail, has been taken as the basis of three local stages. These are the Niniyur Stage that is a correlative of the *Nerinea* beds, the Ariyalur Stage that is partially equivalent to the *Trigonarca* and Valudavur beds and probably of Maastrichtian and Campanian age, and the Trichinopoly Stage that is probably Coniacian to Santonian in age. The Ariyalur and Trichinopoly Stages are separated by an unconformity. The fauna of the Valudavur beds includes *Pachydiscus egertoni* (Forbes) that occurs in the European Maastrichtian and *Sphenodiscus* and *Brahmaites* that are the only genera restricted to the Maastrichtian in Europe and elsewhere. Nine species are shared with Madagascar where the ranges of six of them include or are restricted to the Maastrichtian. The remaining three, *Tetragonites garuda* (Forbes), *Pachydiscus ganesa* (Forbes), and *Neophylloceras decipiens* (Kossmat) taken collectively range in age from Santonian to Campanian in Madagascar and are probably longer ranging than their Indian occurrences suggest. Since the Valudavur beds are probably Maastrichtian in age, the overlying *Trigonarca* beds must be also. The fauna of the Ariyalur Stage includes *Pachydiscus egertoni* as well as five species known from the Maastrichtian of Madagascar. In addition four species are shared with the Lower Campanian of Madagascar. The Ariyalur Stage is therefore probably of Campanian and Maastrichtian age. The fauna of the Trichinopoly Stage has no links with Europe at the specific level but shares ten species with Madagascar. Five of these are from the Madagascan Coniacian and three are from the Santonian. The remaining two, *Anagaudryceras politissimum* (Kossmat) and *Mesopuzonia indopacifica* (Kossmat) are known from the Maastrichtian and Campanian of Madagascar respectively. Since part of the Ariyalur Stage is probably Lower Campanian in age and the two stages are separated by an unconformity, it seems that both these species are longer ranging than their Madagascan occurrences suggest. The Trichinopoly Stage is therefore best correlated with the Coniacian and Santonian. The inclusion of three Indian taxa as zonal index species in the elaborate scheme of subdivision of the Upper Cretaceous proposed by Spath (1926) and perpetuated by Muller and Schenck (1943) is without basis. Correlation of the Indian biostratigraphic units with the European standard is accurate only to a stage at best. As pointed out by Matsumoto (1959*c*), the *Kossmaticeras theobaldi* horizon of Spath is reputed to lie in the Campanian whereas *K. theobaldi* occurs in the Trichinopoly Stage in India and is known from the Middle Coniacian of Madagascar.

Since the early palaeontological description of a South Patagonian fauna by Paulcke (1906) knowledge of the local stratigraphy has improved considerably and several new collections have been made. Katz (1963) has presented a summary of the faunas and a revision of the stratigraphy. Katz recognizes three divisions of the thick Senonian and ?Maastrichtian succession: the Dorotea Formation (youngest), the Tres Pasos Formation, and the Cerro Torro Formation (oldest). *Texanites*, which ranges from Coniacian to Lower Campanian (Young 1963) is known from the lower Cerro Terro Formation. *Vertebrites kayei* (Forbes) is also reported from this horizon but since it is indicative of the Maastrichtian in Madagascar and this is in agreement with its occurrence in the Valudavur beds of India, it may have been misidentified. *Leopoldia paynensis* Favre of Lower Cretaceous age was also reported to occur in this horizon but has subsequently been interpreted as a representative of a new genus, *Parabinneyites*, by Leanza (1964). *Hoplitoplacenticeras*, which is no older than Upper Campanian and ranges into the lower Maastrichtian (Howarth 1965, p. 391), occurs in the Tres Pasos and Dorotea Formations. *Pachydiscus* cf. *gollevillensis* (d'Orbigny) is reported from the Dorotea Formation. *P. gollevillensis* itself is a reliable indicator of the Lower Maastrichtian in Europe and the closely related *P. compressus* Spath from the *Trigonarca* beds of India is almost certainly of Maastrichtian age also. However, *P. sharpei* Spath from the *Mucronata* Zone (Campanian) of Ireland is closely related to *P. gollevillensis* suggesting that *Pachydiscus* of the *gollevillensis* type is not restricted to the Maastrichtian. The south Patagonian succession can thus be considered as being largely of Campanian age although it may extend into the Maastrichtian. The successions in the three countries reviewed above form a basis for correlation of the ammonite faunas of the two New Zealand ammonite 'zones' here discussed.

Age of the Kossmaticeras (Natalites) *'zone'*. *Phyllopachyceras*, *Neophylloceras*, *Gaudryceras*, *Anagaudryceras*, *Tetragonites*, and *Zelandites* are all known to be very long ranging and are useless for correlation at the generic level. *Neophylloceras ramosum* (Meek) occurs stratigraphically above *Hoplitoplacenticeras* at Vancouver Island if the local correlations of Usher (1952) are accepted, and is known from the middle Cerro Torro Formation of south Patagonia. Thus, it spans much of the Campanian and may extend into the Maastrichtian. *Phyllopachyceras forbesianum* (d'Orbigny) is known from the same horizon as *N. ramosum* at Vancouver Island, from Spain where it is doubtfully referred to the Lower Campanian (Wiedmann 1962), from the Santonian of Madagascar (Collignon 1956, p. 26), and from the Valudavur beds of India. Its range, therefore, is probably Santonian to Maastrichtian. *Pseudophyllites latus* (Marshall) ranges from Upper Santonian to Lower Campanian in Madagascar and is known from the Campanian of Greenland (Birkelund 1965). *Vertebrites* occurs in the Maastrichtian of Madagascar and the Valudavur beds of India but has also been reported from the middle Cerro Torro Formation of south Patagonia. Although the Patagonian material has never been described and may be misidentified, the range of *Vertebrites* must be considered as Campanian–Maastrichtian at present. *Glyptoxoceras* is abundant in the Valudavur beds of India and represented in the Maastrichtian of Europe and Madagascar, the Campanian of England and Ireland, and the middle Cerro Torro Formation of south Patagonia giving a range of Campanian–Maastrichtian. *Diplomoceras* occurs in the Maastrichtian of Europe and Madagascar but is nowhere well dated as Campanian. *Pseudoxybeloceras* is recorded from the Coniacian in Madagascar and is long ranging in Japan where it reaches as high as the Maastrichtian (Matsumoto 1954). *Jacobites* is nowhere well dated but forms part of the Graham Land assemblage that is no older than Campanian. *Neograhamites*, *Gunnarites*, and *Maorites* all occur with and range higher than *Hoplitoplacenticeras* in south Patagonia. *Gunnarites* and *Maorites* are known from the Ariyalur Stage in India and *Maorites* is restricted to the Lower Campanian in Madagascar. All these genera are thus in part Campanian and may range into the Maastrichtian. *Kossmaticeras* (*Natalites*) is known from the Campanian in Madagascar (Collignon 1955). The range of *Kitchinites* (*Kitchinites*) is probably Campanian–Maastrichtian; it is restricted to the Lower Campanian in Madagascar, represented in the Valudavur beds of India and associated with *Hoplitoplacenticeras* in Angola (Howarth, 1965). *Pachydiscus* ranges from Santonian to Maastrichtian in Europe and *Anapachydiscus* is accredited the same range in Madagascar.

It is concluded that there are no elements in the fauna of the *Kossmaticeras* (*Natalites*) 'zone' which are not consistent with a Campanian–Maastrichtian age, although the presence of the latter cannot be proved. Spath (1953) considered the very similar Graham Land fauna to be largely of Upper Campanian age in the sense of Haug (1908) (approximately equal to the *Hoplitoplacenticeras vari* Zone that is the lower of two zones placed in the Upper Campanian by Jeletzky 1958). Howarth (1966) gave a faunal analysis of the various Graham Land localities and concluded that most were of similar age and correlative with the upper Lower Campanian or Middle Campanian. Some localities on Seymour Island containing only *Pachydiscus* aff. *gollevillensis* (d'Orbigny) and *Maorites tuberculatus* Howarth were considered to be of probably Upper Campanian age. However, the occurrence of three Graham Land kossmaticeratids, *Maorites densicostatus* (Kilian and Reboul), *Gunnarites bhaviformis* (Kilian and Reboul) (= *G. flexuosus* Spath), and *Neograhamites taylori* Spath above *Hoplitoplacenticeras* suggest that the Graham Land fauna may be in part uppermost Campanian or possibly basal Maastrichtian.

Age of the Kossmaticeras (Kossmaticeras) *'zone'*. *Kossmaticeras* (*Kossmaticeras*) ranges no higher than Santonian in Madagascar and is restricted to the Trichinopoly Stage in India. *Gaudryceras* and *Pseudoxybeloceras* are both long ranging. Since the overlying *Kossmaticeras* (*Natalites*) 'zone' is no older than Campanian, it is concluded that the *Kossmaticeras* (*Kossmaticeras*) 'zone' is of Santonian age.

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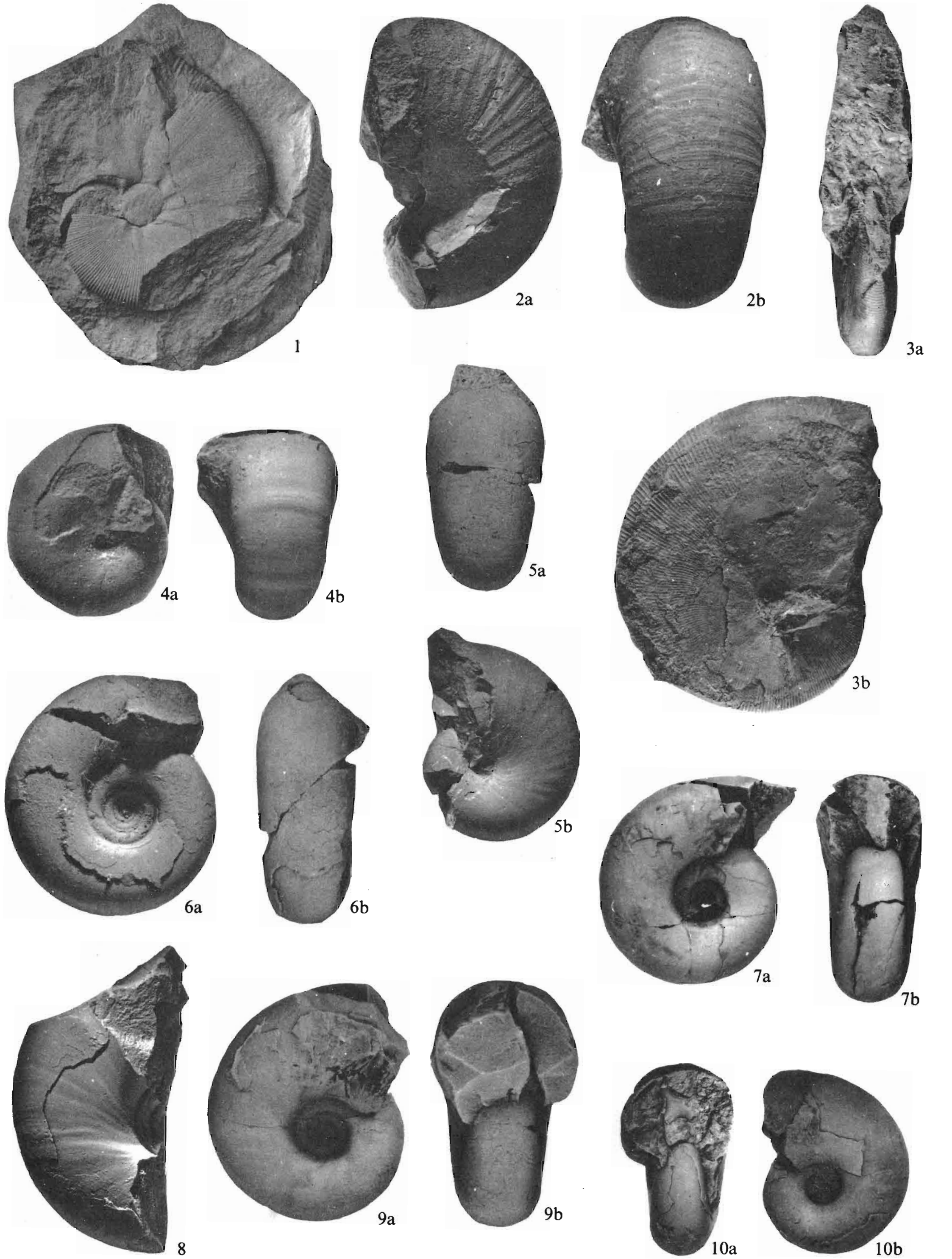

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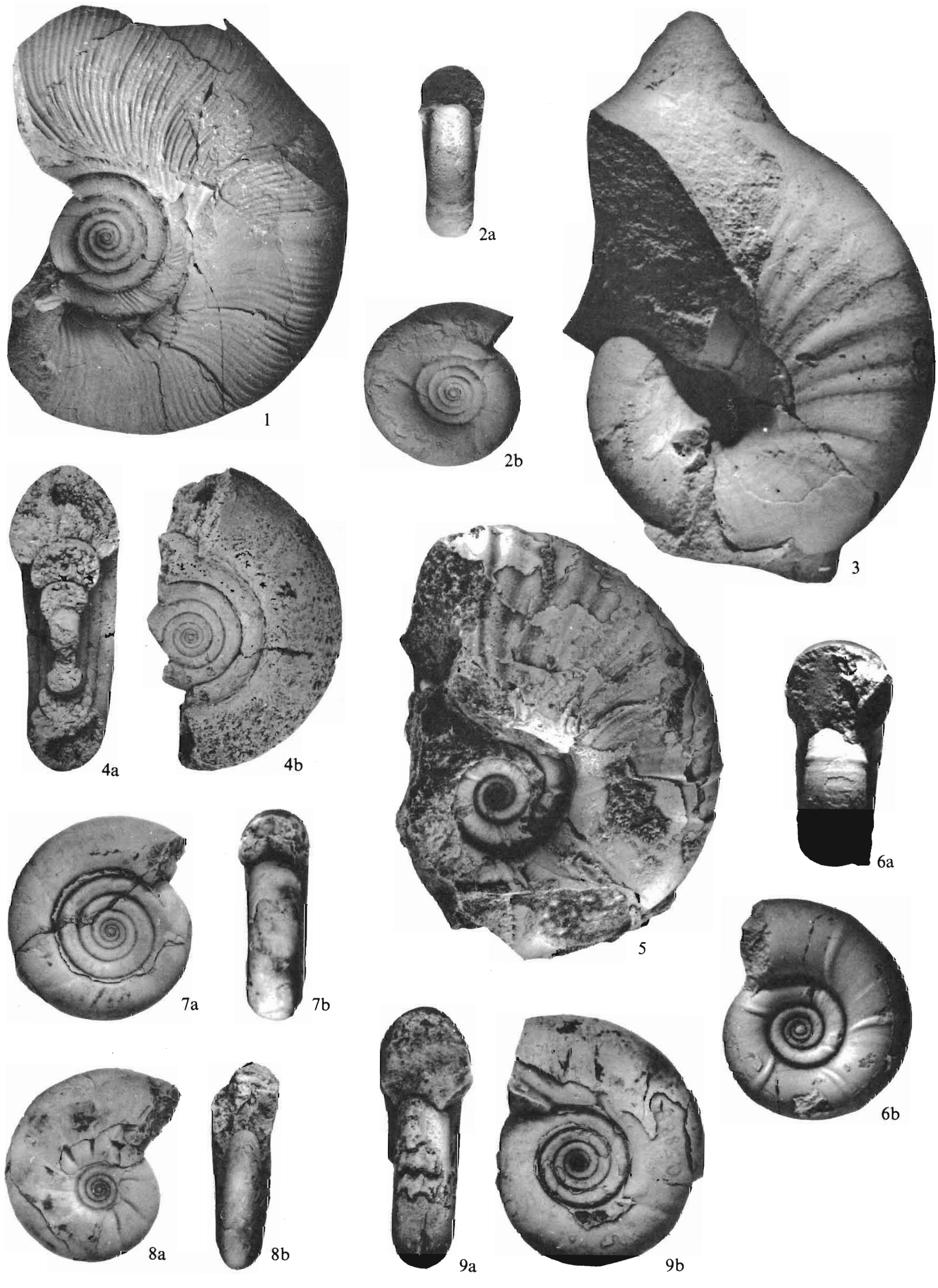

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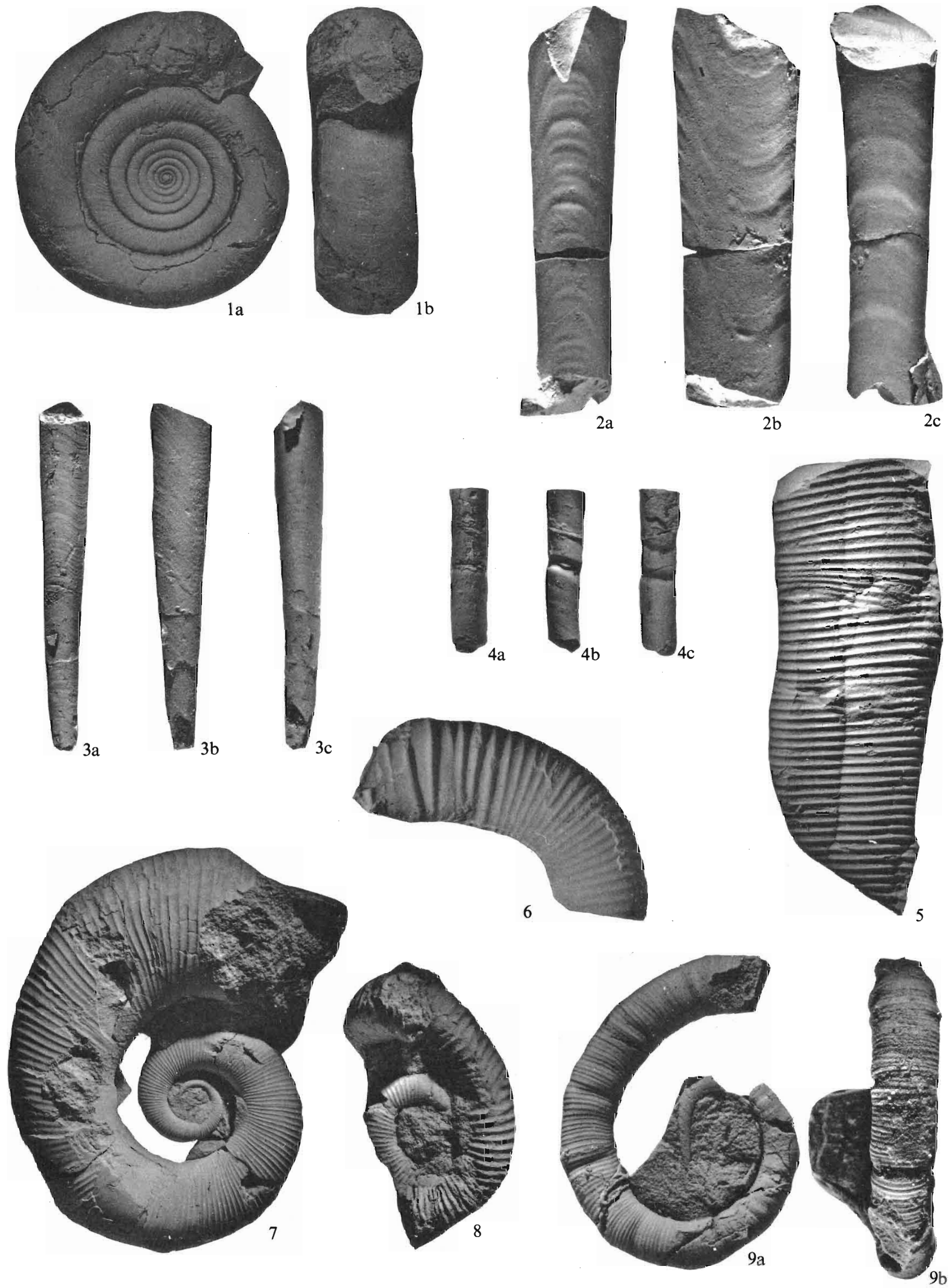

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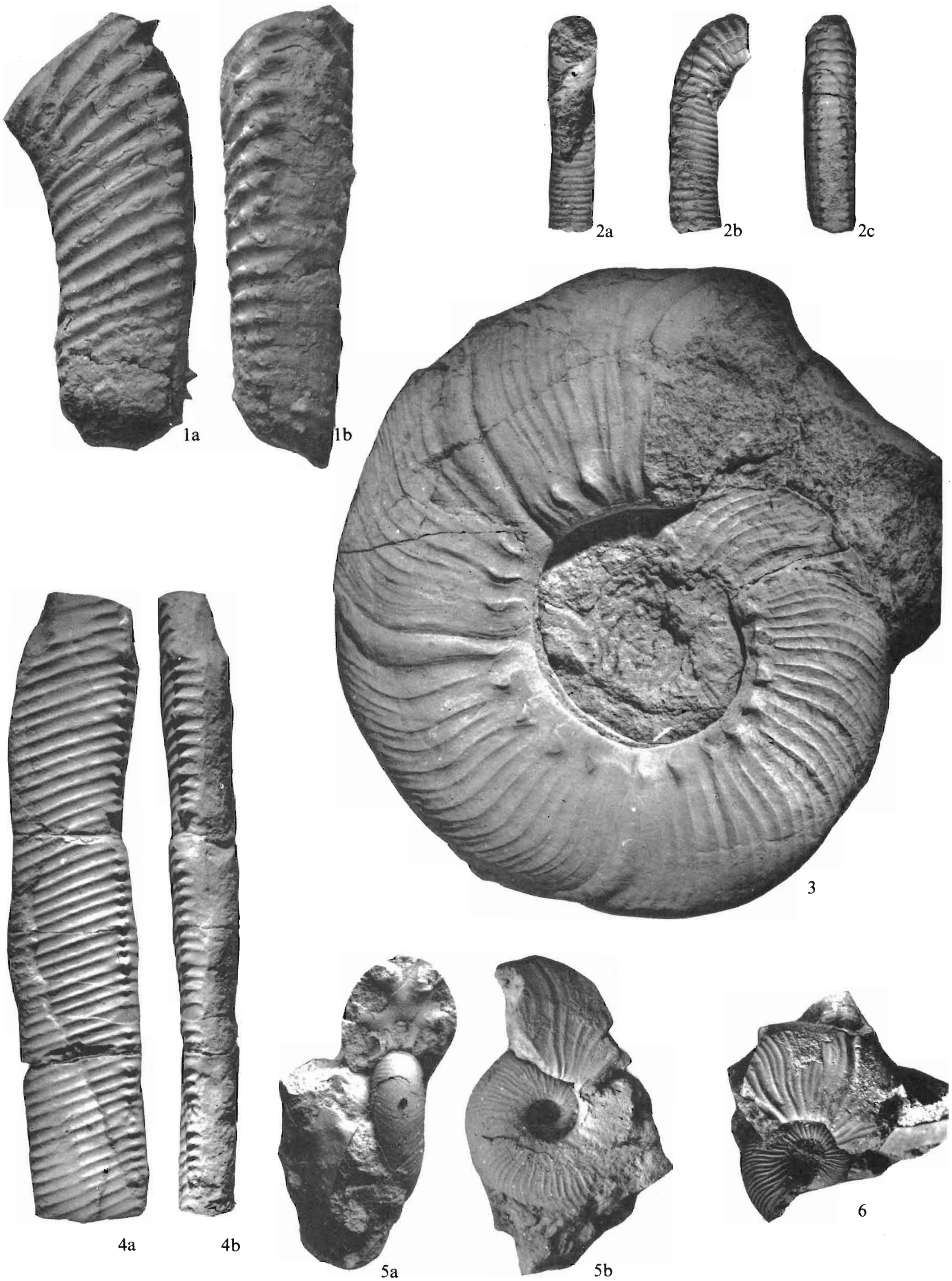

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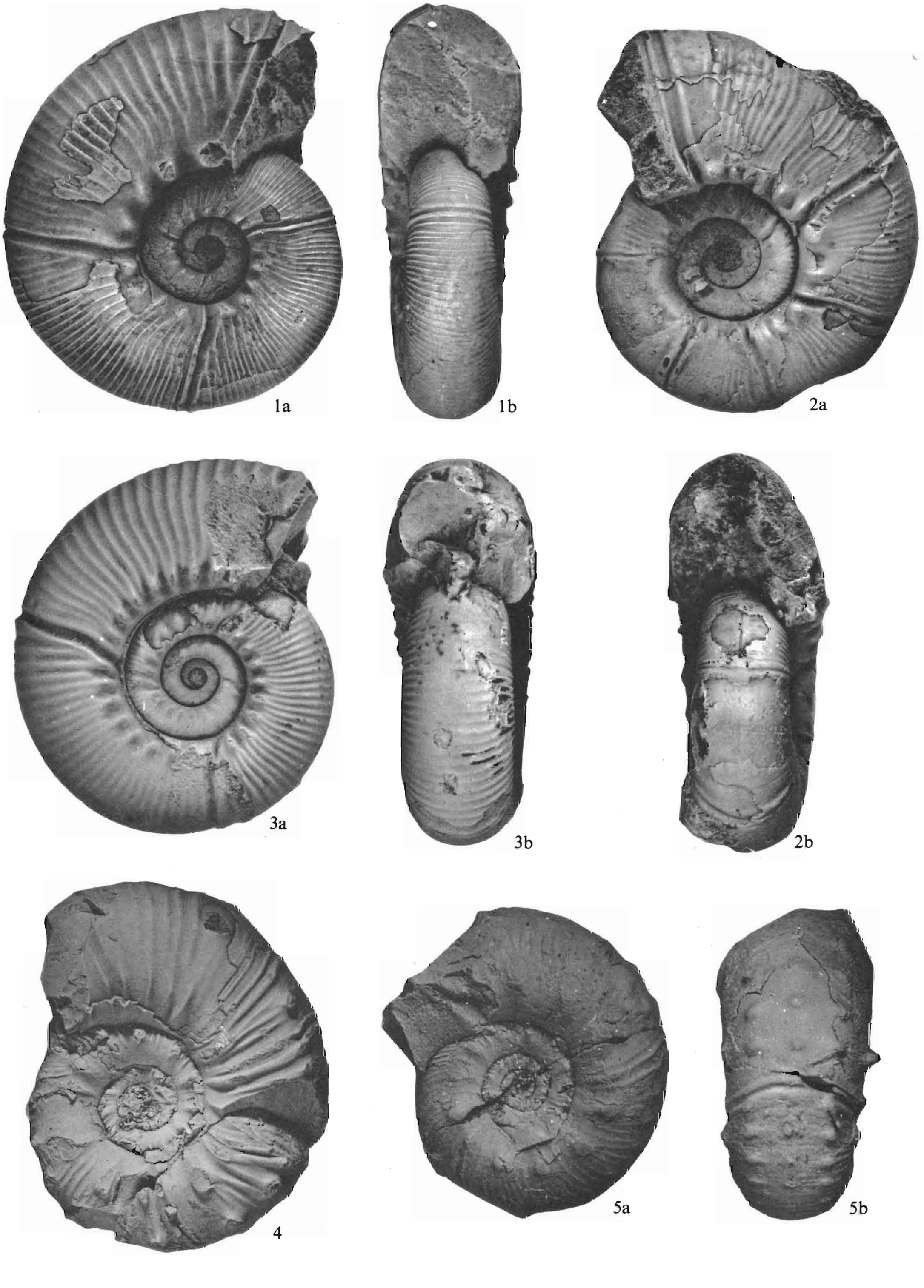

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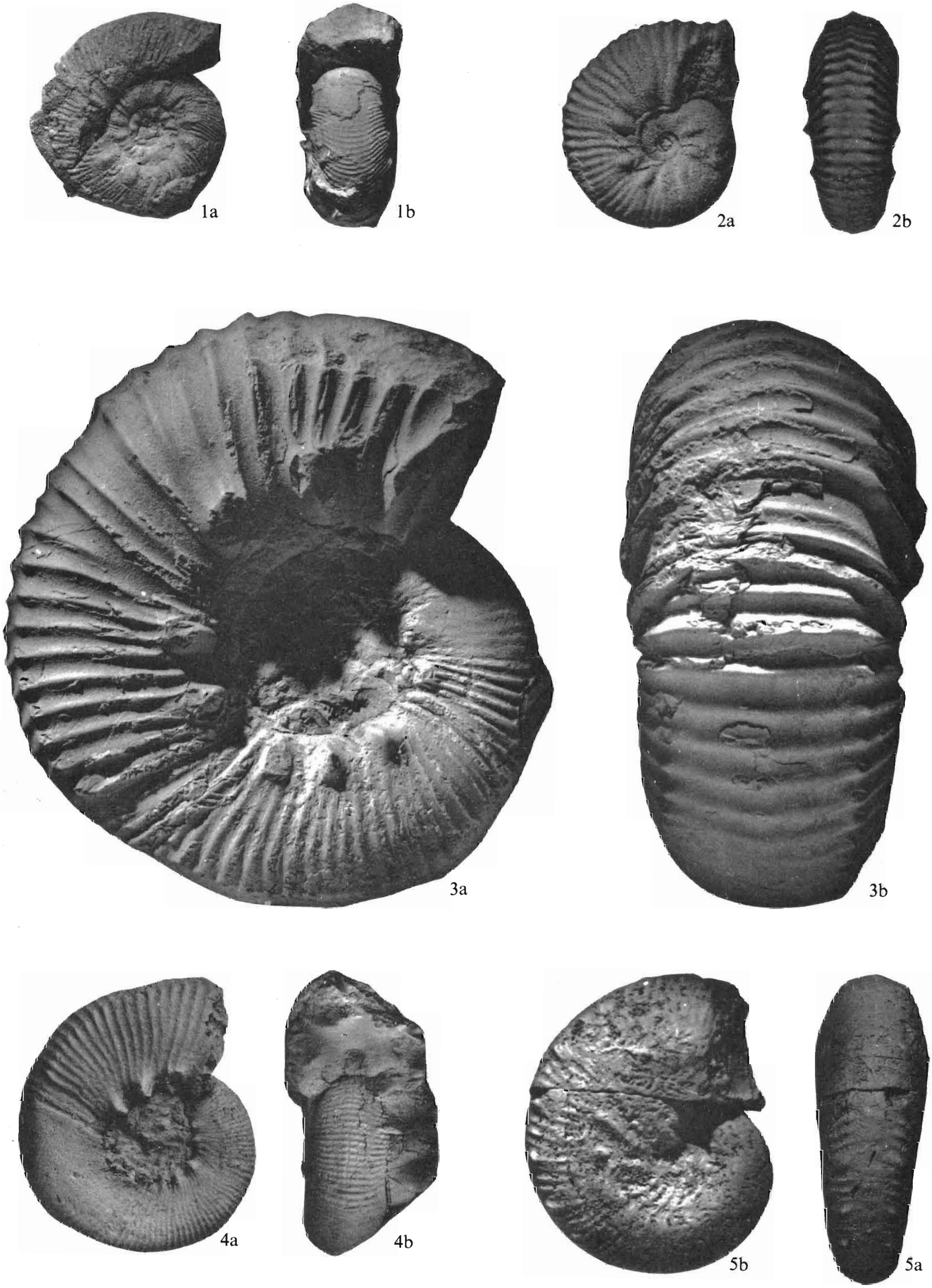

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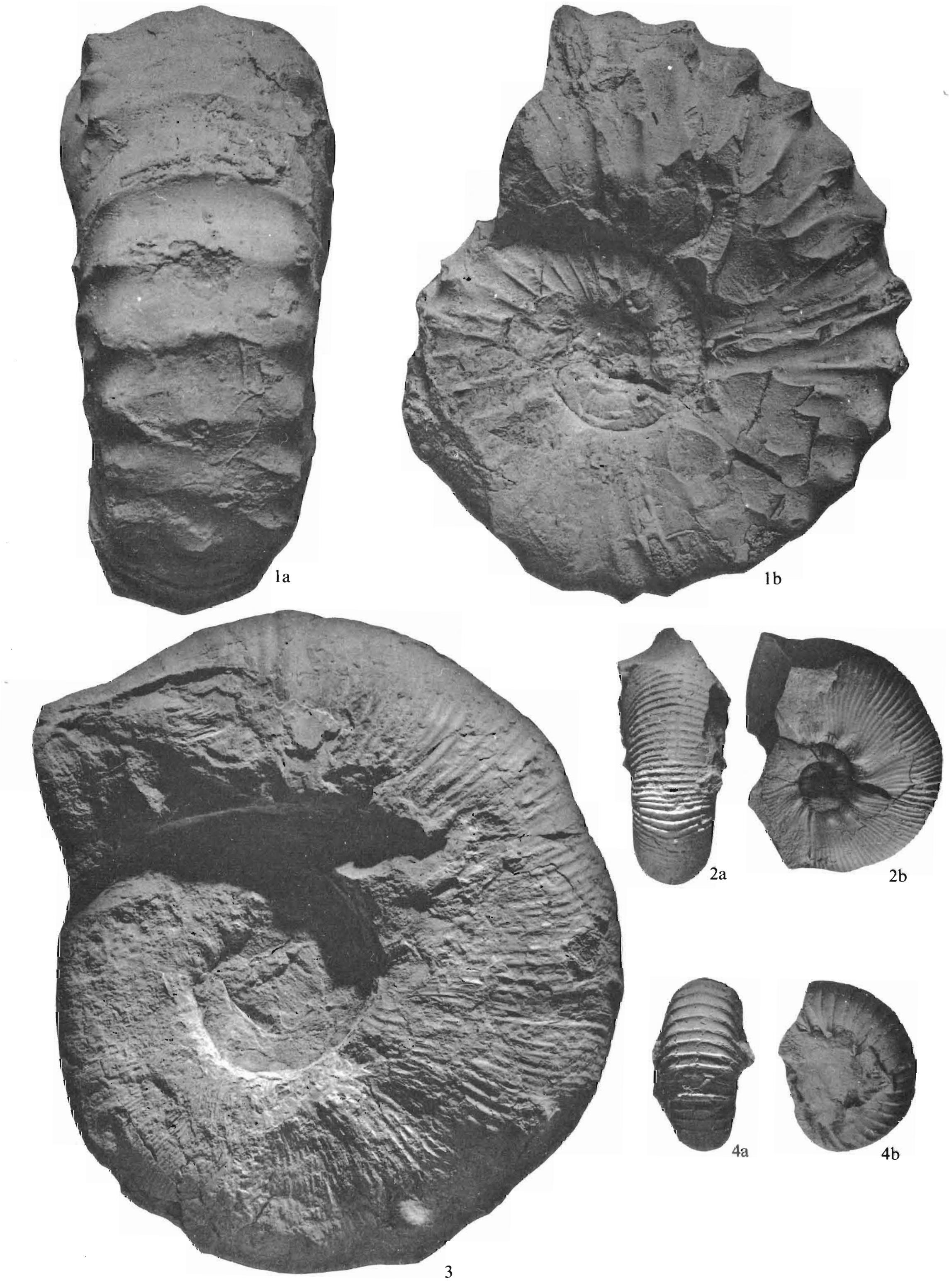

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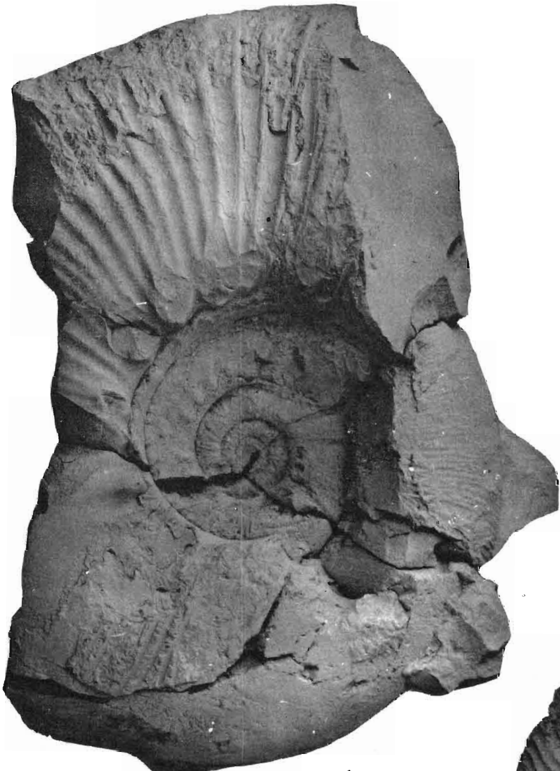

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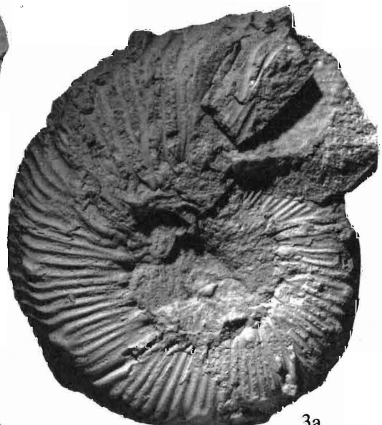

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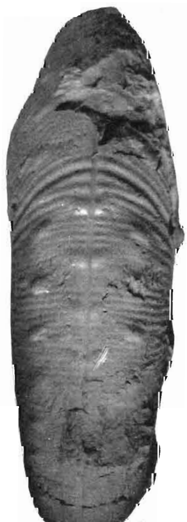

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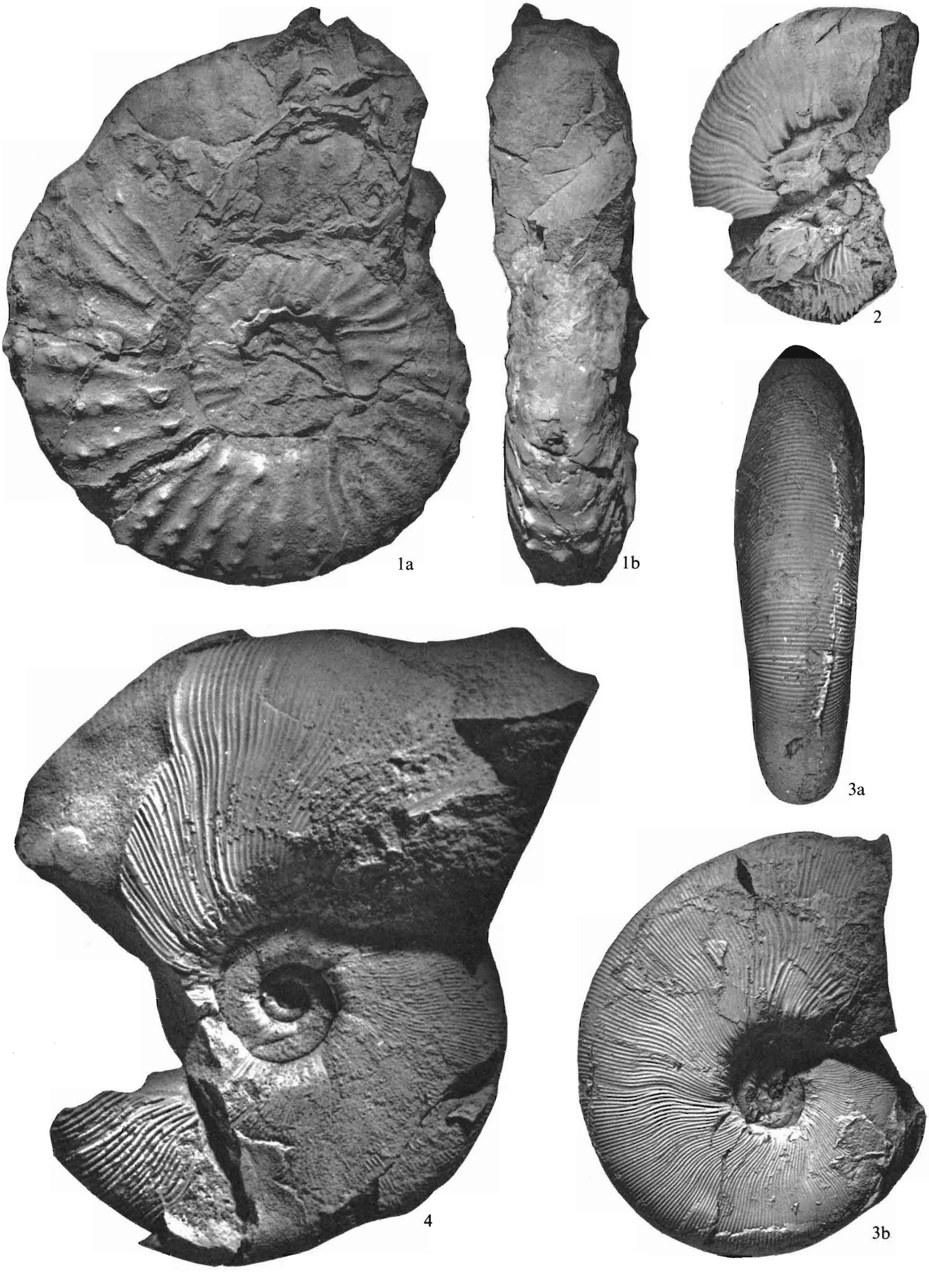

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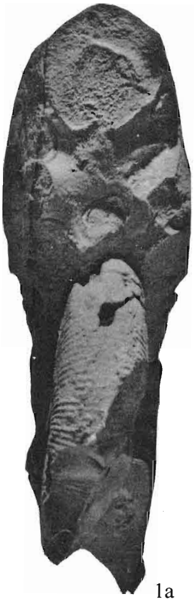

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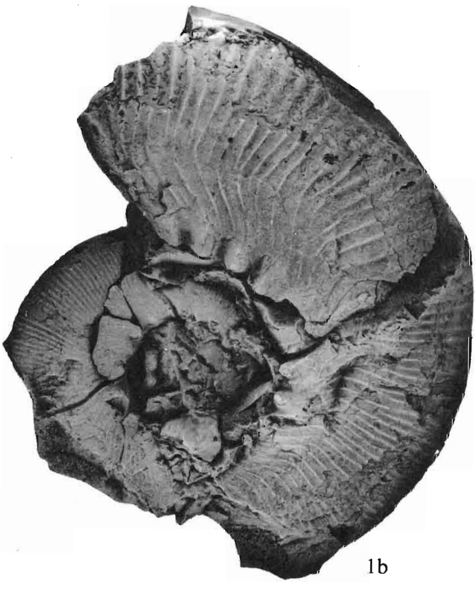

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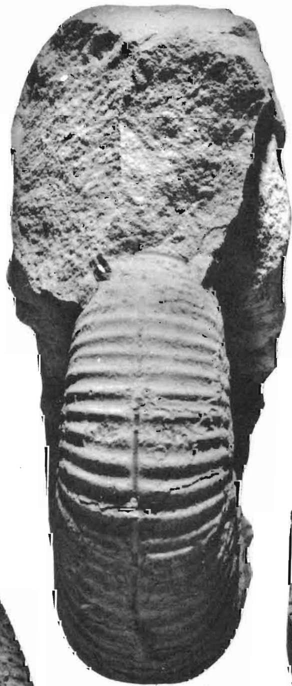

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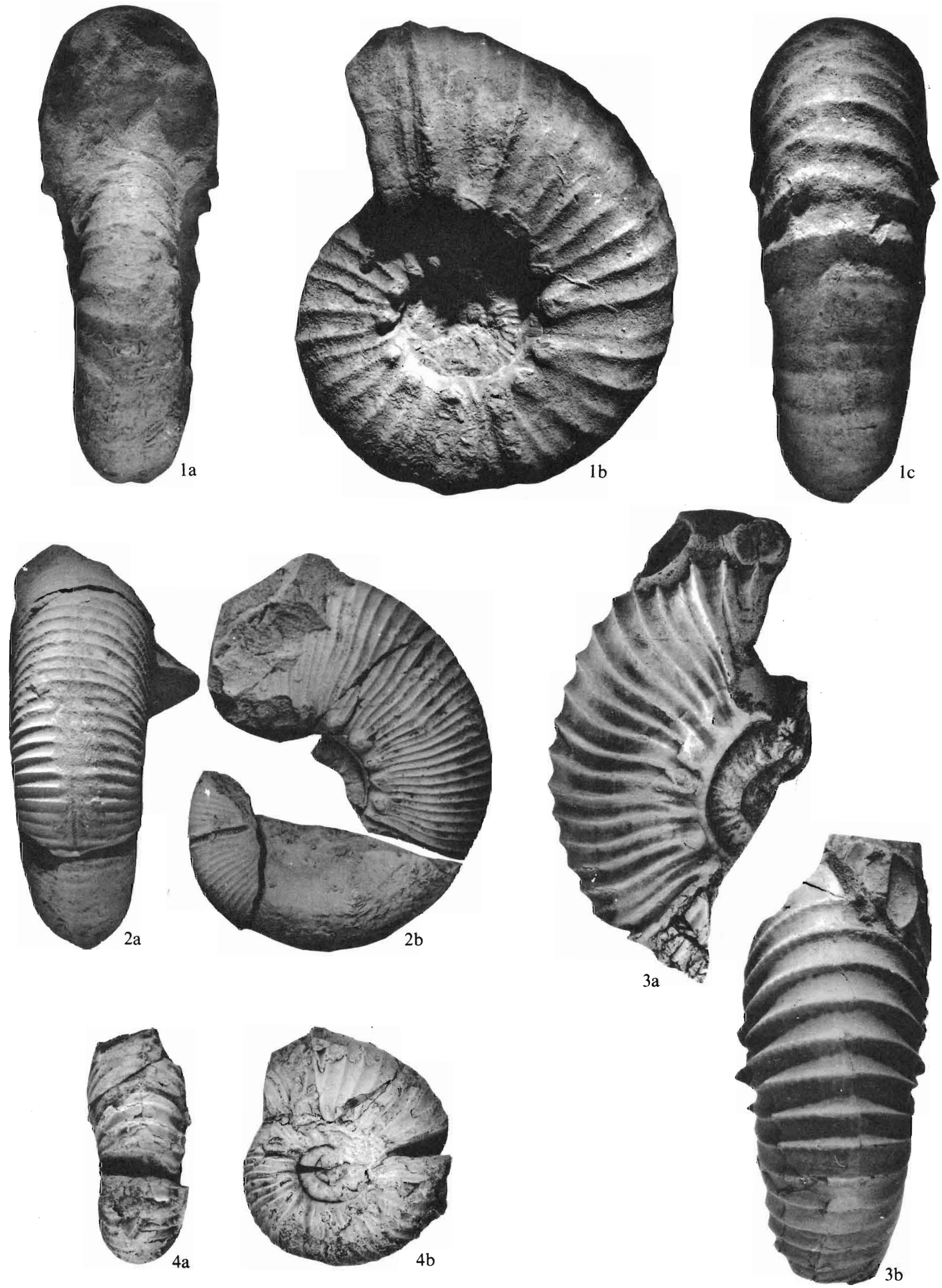

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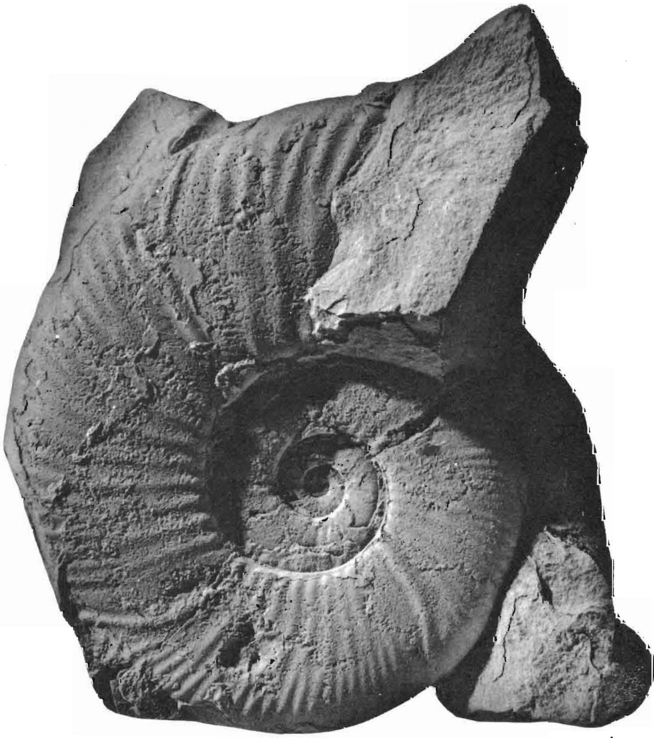
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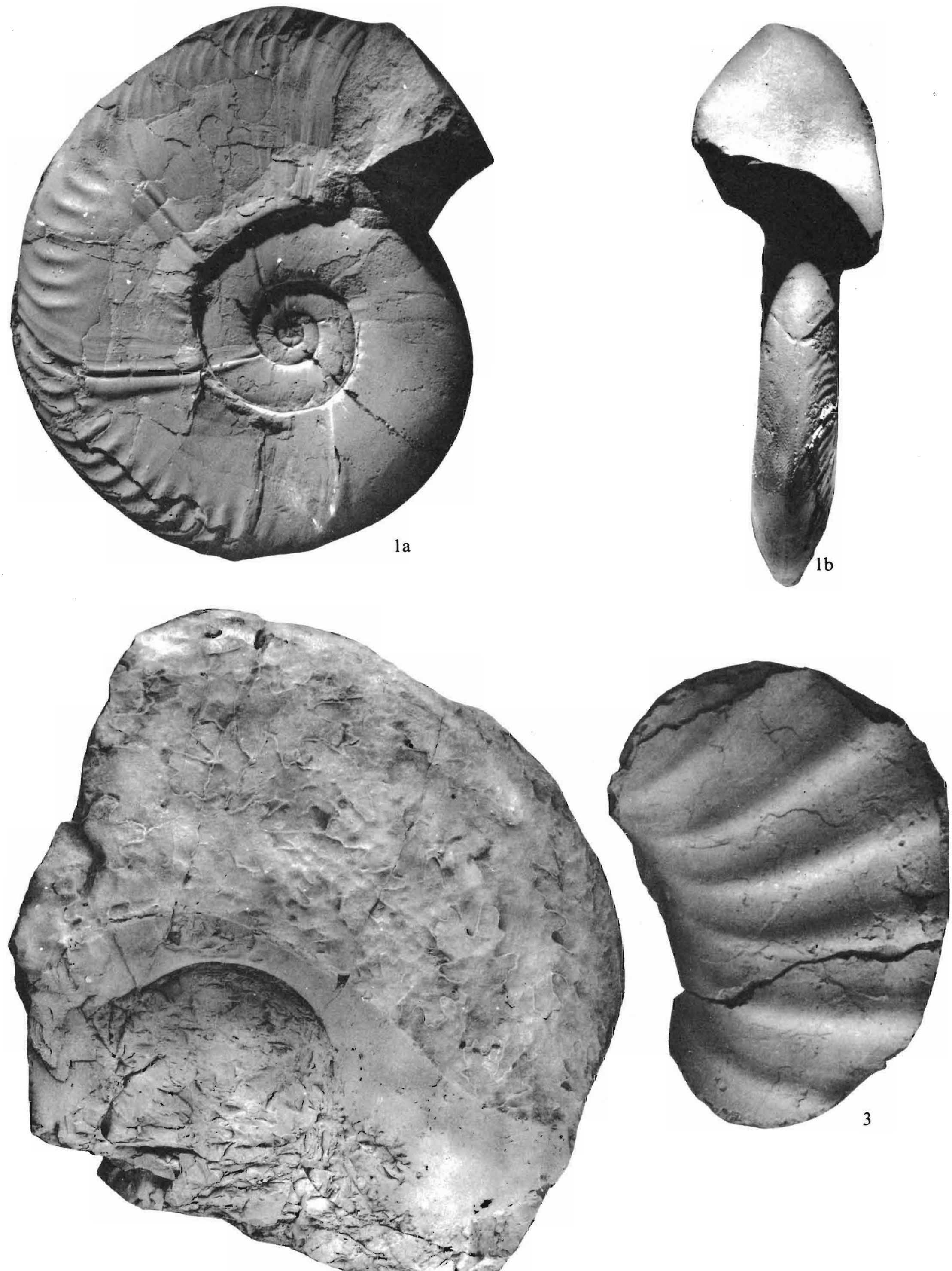

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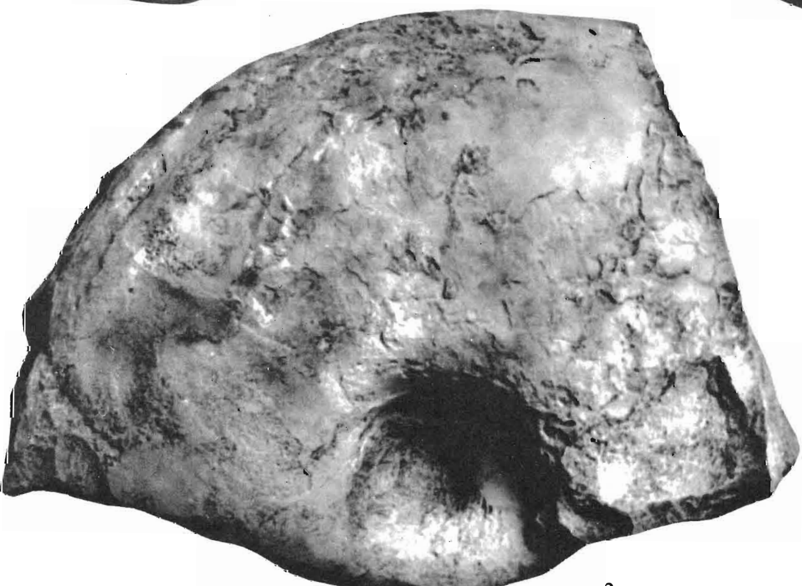

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