AGSO Journal of Australian Geology & Geophysics, 14/4 , 411–433

Cretaceous ammonites from south–central Papua New Guinea

Tatsuro Matsumoto[1] & Stanislaw K. Skwarko[2]

Eleven ammonite species, including one new taxon, are described from eleven localities in the south–central Papua New Guinea. One of them, *Fauriella boissieri* (Pictet), is a member of the Berriasian Tethyan fauna extended to peri-Gondwana. Three large, but fragmentary, ammonites are identified as *Puzosia* aff. *mayoriana* (d'Orbigny) and *Pachydesmoceras* sp. B and C, suggesting a Cenomanian age. *Acanthoceras rhotomagense* (Brongniart), *Calycoceras (Newboldiceras) asiaticum* (Jimbo), and *Cunningtoniceras cunningtoni* (Sharpe) indicate more distinctly the Cenomanian age. *C. cunningtoni* is associated with *Desmoceras (Pseudouhligella)* aff. *ezoanum* Matsumoto, both occurring in generally the same area as the type locality of *Chimbuites sinuosocostatus* (Casey & Glaessner). From another locality a new species, *Chimbuites giganteus* is described. *Chimbuites* is regarded as an offshoot of *Eopachydiscus*, and therefore a member of Pachydiscidae rather than Hoplitidae. A well-preserved specimen of *Romaniceras deverianum* (d'Orbigny) indicates a Turonian age.

Introduction

Eleven taxa of Cretaceous ammonites are described from south-central Papua New Guinea. The specimens were collected during a number of geological reconnaissances conducted by the Australian Petroleum Company (A.P.C.) between 1954 and 1969. They were collected at eleven localities scattered between 6° 0′ and 7° 30′ and between 143° 0′ and 145° 30′ in the Central Highlands and the adjacent foothills in the south. This same general area has previously yielded other Cretaceous fossils (Erni, 1944; Glaessner, 1958), but there is little duplication of species between the present and the previously described faunas.

Stratigraphy

The source area of the ammonites described below (Fig. 1) is large, and its geology complicated. The detailed locality records are presented individually in the systematic descriptions and are limited to the actual collecting sites (Fig. 2). The numbers in Figures 1 and 2 were originally the actual specimen numbers, but on the transfer of the collection to the Bureau of Mineral Resources, they were alloted the Commonwealth Palaeontological Collection (C.P.C.) numbers, and consequently the original specimen numbers are herewith used as those marking the collecting sites.

The problem that we have encountered is the inconsistency in the terminology and definition of stratigraphic units between old ones supplied to us from the A. P. C. (1961) and those of later papers. Even in the latter there is some discrepancy between authors. In the current paper, we depend much on the terminology in the Kutubu Sheet area explained in tabular form by Brown & Robinson (1982) and we also cite the newer scheme proposed by Welsh (1990). The stratigraphic results of the present study are discussed under the headings of the international stages below.

1. **Berriasian.** A well-preserved ammonite *Fauriella boissieri* (Pictet) from the "Tubu Shale" (i.e. Maril Shale in the current usage) in the Kereru Range suggests strongly a Berriasian age that corresponds to the upper part of the Sequence J/K of Welsh (1990). *F. boissieri*, under the genus *Subthurmannia*, has been reported previously from the Kereru Range (Spath, 1952, p. 23). Moreover, *Haplophylloceras strigile* (Blanford) and *?Parandiceras* sp. were identified and dated as basal Cretaceous (Berriasian) or transitional Jurassic by Glaessner (A.P.C., 1961, withou description).

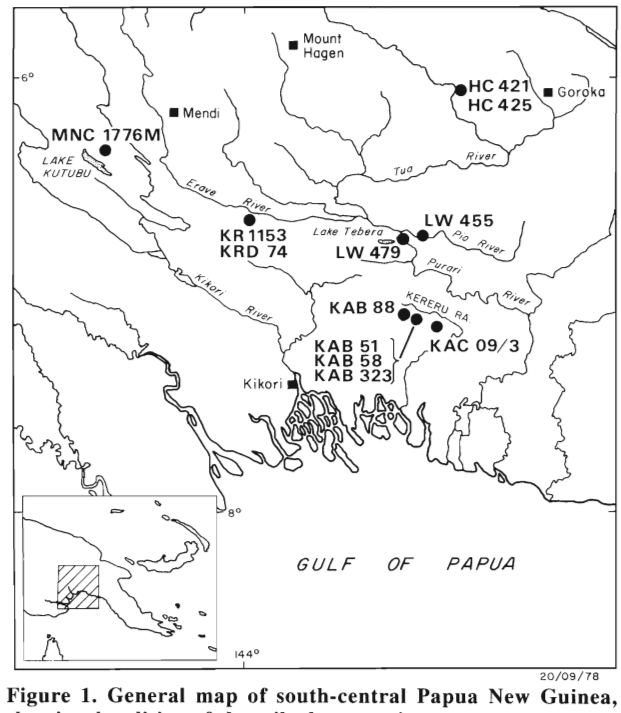


Figure 1. General map of south-central Papua New Guinea, showing localities of described ammonites.

2. **Valanginian–Barremian.** No ammonites indicating this time span are to be found among the currently discussed material. The absence of well-dated faunas of this age may be due to the lack of suitable facies rather than to a depositional hiatus (Glaessner, 1958, p. 200). A record of *Heteroceras* cf. *astieri* d'Orbigny from the Pio Gorge (A.P.C., 1961, p. 30) suggests a Barremian age, but it is unwise — particularly with heteromorph ammonites — to accept unquestionably an identification devoid of an adequate description and illustration.

3. **Aptian** and **Albian**. No ammonite of an undoubted Aptian age has been ever reported from Papua New

[1] Department of Earth & Planetary Sciences, Kyushu University 33, Hakozaki, Fukuoka, 812 Japan.
[2] Geological Research & Development Centre, Jl. Diponegoro 59, Bandung, Indonesia.

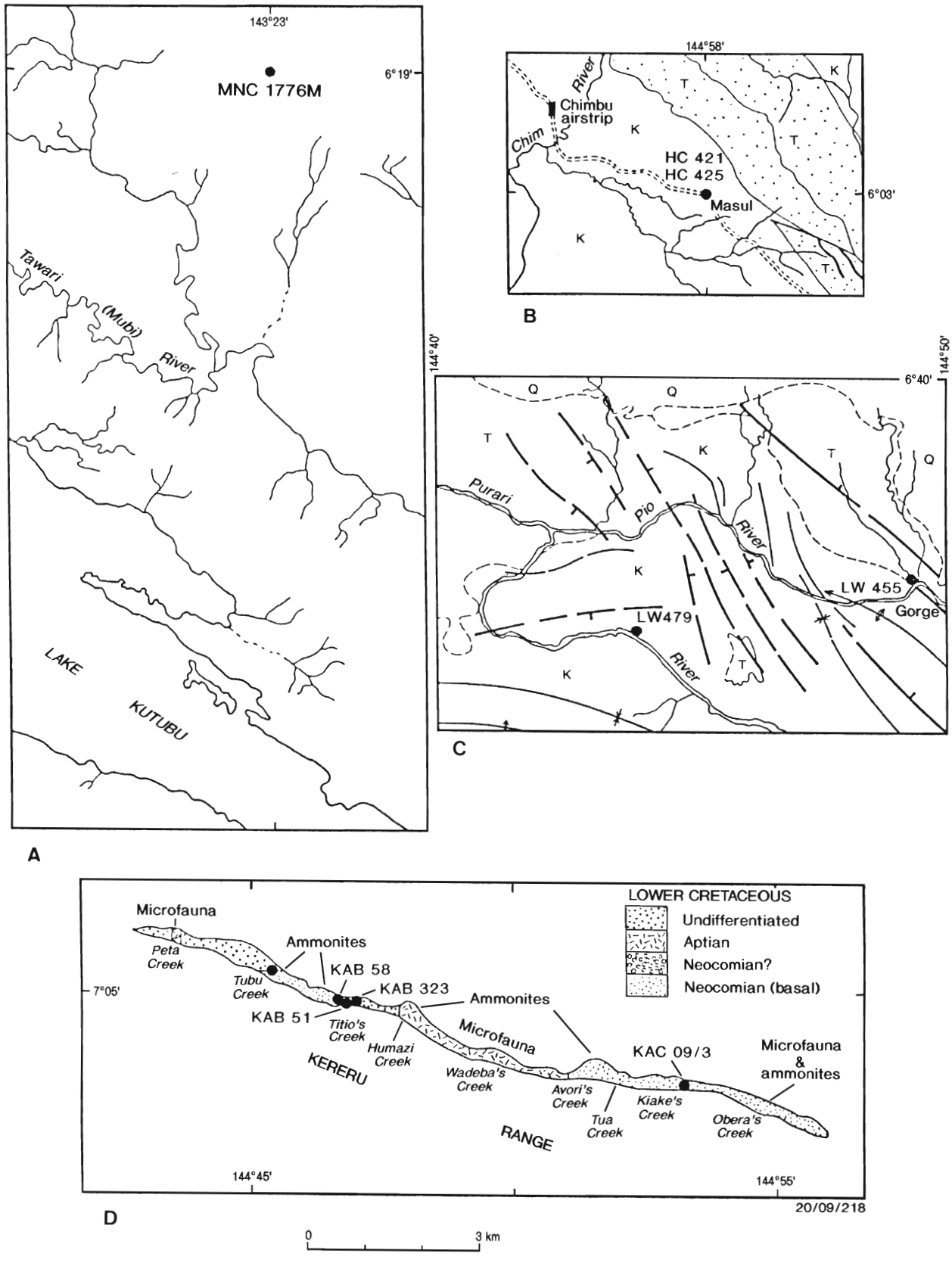


Figure 2. Individual fossil-collecting sites, with geographical data and, where available, geological information. (A) Northeast of Lake Kutubu. (B) Masul, southeast of Chimbu airstrip; K Cretaceous, T Tertiary. (C) Junction of the Purari and Pio Rivers; K, T as for Fig. B; Q Quarternary; thick line fault; moderate line with parting or facing arrows anticline or syncline. (D) Kereru Range. Information provided by courtesy of Australian Petroleum Company.

Guinea. Furthermore, neither the bivalve *Maccoyella* nor the belemnite *Peratobelus* — several species of which are both abundant and widespread in the Aptian strata in Australia — have been found in Papua New Guinea.

The Albian stage, however, is well represented by several species of heteromorph ammonites *Myloceras* and *Labeceras* from the Lake Toba area and from the middle Purari Valley, as well as by other molluscs — all described and illustrated by Glaessner (1958), who recognised the close faunal affinities with the Australian Albian. The above ammonites are absent from the collection described below which, however, includes *Puzosia* aff. *mayoriana* (d'Orbigny) and *Pachydesmoceras* spp. regarded as probably Cenomanian but possibly late Albian in age. It should be noted that there were in one of the A.P.C. collections several ammonites referrable to *Mortoniceras (Durnovarites)* sp., *Spathiceras* sp. and *Bhimaites (?)* sp., which together suggest a late Albian age. Regrettably, these ammonites could not be made available for this study, but their photographs remain in a copied plate with a caption in which the CPC numbers are left blank. They were all collected at locality KRE 527M which is not shown on the maps in Figures 1 and 2, but inferred as somewhere on the Erave River in the Kutubu Trough.

There is a lack of data on the Albian–Cenomanian stratigraphy for the area under discussion. Glaessner (1958) noted that his Albian and Cenomanian fossils came from a greensand and calcareous shale which were probably an eastward extention of the Feing Group in the Upper Fly River area. The Feing Group consists of the latest Jurassic to earliest Cretaceous Toro Sandstone and Early to Late Cretaceous Ieru Formation in the northwest Papua New Guinea. Eleven Late Cretaceous ammonites have been recently described from the Ieru Formation (Matsumoto & Skwarko, 1991).

4. **Cenomanian.** Undoubted Cenomanian ammonites in the collection at hand are the *Acanthoceras rhotomagense* (Brongniart) from locality KRD 74 on the Erave River, and *Calycoceras (Newboldiceras) asiaticum* (Jimbo) from the same locality (KR 1153 = KRD 74), and from locality LW 479 on the Purari River. They are recorded as float shed from the Kerabi Formation, an assumption supported by the greenish–dark grey silty sandstone matrix. In the Kutubu Trough, the upper Mesozoic strata are placed in the Wahgi Group, which consists of the Middle to Late Jurassic Maril Shale, the mainly Early to Late Cretaceous Kerabi Formation (siltstone–sandstone) and the Late Cretaceous Chim Formation (shale) (Brown & Robinson, 1982). As *A. rhotomagense* and *C. (N.) asiaticum* are limited to the Middle Cenomanian strata in many parts of the world, the occurrence of these ammonites from the Kerabi Formation is quite natural.

Farther north in the Central Highlands there occurs another Middle Cenomanian guide fossil, *Cunningtoniceras cunningtoni* (Sharpe). It is represented in the collection under discussion by several specimens from locality F2148, Mingenda Dome, Chimbu–Mt. Hagen area, as well as by a specimen described previously as *C. holtkeri*, a synonym of *C. cunningtoni*, by Erni (1944, p. 470, pl. 11 figs A–C). Erni's specimen came from the Wahgi Valley between Hagen and Bismarck Mountains. The type locality of *Chimbuites sinuosocostatus* Casey & Glaessner is in the same area — if not the same collecting site — as that of *C. cunningtoni*, and was collected from shale or mudstone which should be referred to the Chim Formation of the Wahgi Group. The boundary between Kerabi and Chim Formations is thus diachronous within the basin of sedimentation. In other words, the Chim Formation is at least partly a distal equivalent of the Kerabi Formation.

The zonal allocation of *Chimbuites sinuosocostatus* has yet to be worked out. It is, however, probably Middle Cenomanian in age, as the closely allied *Ch. mirindowensis* Wright occurs in Bathurst Island Middle Cenomanian with *C. cunningtoni* and *C. lonsdalei* (Adkins) (Wright, 1963).

A new species, *Chimbuites giganteus,* was collected at locality LW 455 at the Pio Gorge. The occurrence is somewhat isolated. It consists of a well-bedded calcareous sandstone with a bivalve–rich layer which may be referrable to the Kerabi Formation. Future study of the associated fossils may indicate whether *Ch. giganteus* is also of Middle Cenomanian age.

Farther south in the Kereru Range fragmentary whorls of large *Puzosia* aff. *mayoriana* (d'Orbigny) and *Pachydes-moceras* sp. B and C have been found as floats shedding possibly from the "Tubu Shale". They are regarded as Cenomanian on evidence from allied species (see systematic descriptions below). Further detailed field studies are needed to ascertain whether they came from the shaly part of the Ieru–Chim Formations, or Welsh's units K4–K5.

5. **Turonian**. There is little information available on the Cenomanian–Turonian transitional part in the local sequence. Among the ammonites in the collection there are no indicators of the Late Cenomanian (in the recently revised sense: Cobban, 1984; Kennedy, 1984; 1986, etc.) or Early Turonian. *Romaniceras deverianum* (d'Orbigny) is an undoubted Turonian representative. It was collected from a coquina limestone bed in a siltstone formation at locality MNC 1776M in the Kutubu Trough. The bed was said to belong to the Kerabi Formation, but the ammonite is a good Middle Turonian species. Whether the Kerabi Formation extends up into the Middle Turonian, or whether the ammonite bed represented is part of the Chim Formation can only be determined with more detailed work in the area. In addition to *Romaniceras deverianum*, several specimens referable to *Ammonites bravaisianus* d'Orbigny were obtained at locality MNC 1763 in the Mubi Anticline, and at localities KRE 521 and KRE 1311 in the Erave Valley. *Am. bravaisianus* was referred to *Subprionocyclus* by some authors and even considered as synonymous with *S. neptuni* (Geinitz). It is, however, regarded as a distinct species of *Collignoniceras* by Futakami (1990, p. 238) on a large number of fairly well preserved specimens from the late Middle and early Upper Turonian strata in Japan. The specimens from the Papua New Guinea collections, which can be called *C.* cf. *bravaisianum*, have not been located in the C.P.C. collections, but their photographs remain in a copy of an unpublished plate. Their collecting sites are not marked on any map at our disposal. Although their stratigraphic data are not very precise this record may be useful in future studies on Turonian ammonites.

The age-span Coniacian–Maastrichtian is not represented by the ammonites on hand.

Systematic descriptions

Morphological terms and abbreviations used below follow those in a recent paper by Matsumoto & Skwarko (1991; see also Table 1 below). The suture terminology is the same as that used by Wright & Kennedy (1984, p. 17).

Superfamily **Perisphinctacea** Steinmann 1890

Family **Neocomitidae** Salfeld 1921

Subfamily **Berriasellinae** Spath 1939

Genus ***Fauriella*** Nikolov 1966

Type species: *Berriasella gallica* Mazenot 1939 (by original designation).

Remarks. For the generic diagnosis see Le Hégarat, 1973, p. 146.

Fauriella boissieri (Pictet 1867)

(Figs 3, 4; Fig. 19 A–D)

1867 *Ammonites Boissieri* Pictet, p. 79, pl. 15 figs 1–3

1910 *Hoplites (Thurmannia) Boissieri* (Pictet); Uhlig, p. 233, pl. 80, figs 1a, b

1939 *Berriasella Boissieri* (Pictet); Mazenot, p. 106, pl. 15, figs 2a, b; pl. 16 figs 1a, b, 3, 4a, b

1939 *Subthurmannia boissieri* (Pictet); Spath, p. 51, pl. 9, figs 4a, b

1973 *Fauriella boissieri* (Pictet); Le Hégarat, p. 149, pl. 21 figs 1–3; pl. 48 fig. 1 (with synonyms)

Material and locality. A single fairly well preserved specimen, CPC 16088, from Tubu Shale collected at locality KAB 88 in the Kereru Range during the 1955 Abede Survey.

Description. The shell is fairly large. Assuming the body chamber of a little over half a whorl, the diameter of the original shell would have been nearly 200 mm. The whorl expands with a low ratio and is rather evolute, showing a degree of overlap betwen 1/3 and 1/4; the umbilicus is hence fairly wide (U/D = 0.38 to 0.40). The whorl is somewhat higher than broad and suboval or rounded oblong in cross-section. The body chamber has an arched venter, gently convex flank, tightly rounded umbilical edges, and steeply inclined umbilical walls. The septate whorl has flat siphonal zone on the arched venter, almost flat flanks, subangular umbilical edges and low but nearly vertical umbilical walls.

The ornament consists of numerous ribs of moderate intensity, and bullate tubercles at the umbilical edge on some ribs. The ribs are more or less gently sigmoidal on the main part of the flank, becoming more uniformly curved forward on the ventrolateral part. On the venter of the phragmocone, the ribs terminate on either side of the flat siphonal zone with or without tubercle-like thickening. On the venter of the body chamber, some ribs have feeble remnants of tubercle-like thickening on either side of the mid-ventral zone, which is crossed, however, by weak ribs; other ribs do not show such remnants and run across the venter with a forward convexity. The ribs

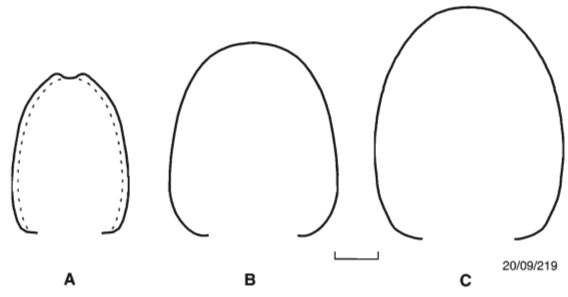


Figure 3. ***Subthurmannia boissieri*** **(Pictet).**
Whorl-section of CPC 16088 at the beginning of outer whorl (A), site of last septum (B) and midst of body chamber (C); x 3/5. Scale-bar 10 mm.

of the former kind occur frequently in the earlier part of the body chamber, where the generally arched venter looks rather flat at its top.

On the phragmocone, ribs are crowded — some arising in pairs from the umbilical bullae of moderate intensity and others occurring singly with or without weak umbilical bullae. Bifurcation may occur farther at about the mid-flank and/or still farther out on the ventrolateral part. In the last part of the septate whorl, intercalated shorter ribs occasionally appear instead of bifurcated ones.

On the body chamber, the bifurcation tends to become irregular, with some of the long ribs arising in pairs from the umbilical bullae, and single long ribs with or almost without narrow umbilical bullae occurring frequently. Many, if not all, shorter ribs are of unequal length and intercalated between longer ribs; some of them arise slighty outside the umbilical edge on the inner flank, some others at about the mid-flank, and a few others on the ventrolateral part of the flank.

The suture is fairly deeply and finely ramified. L is deeper than E and trifid, but its stem is not much narrowed; E/L saddle is broad and bifid; L/U2 saddle narrow and asymmetrically bifid.

The rib in front of the last suture is strongly convex at about the mid-flank. It may be a remnant trace of the basal part of a lappet.

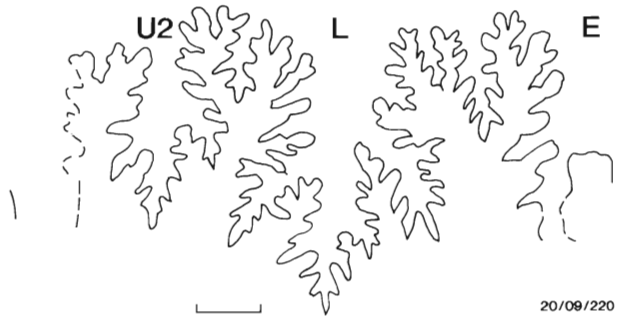


Figure 4. ***Subthurmannia boissieri*** **(Pictet).**
Last suture of CPC 16088; x 3/5. Scale-bar 10 mm.

Table 1. Measurements of *Fauriella boissieri*.

Specimen and position	*D*	*U*	*U/D*	*H*	*H/D*	*B*	*B/D*	*B/H*	*H/h*	*R (180°)*
CPC 16088 LS	123	47	.38	43	.35	35	.28	.81	1.28	21/54
CPC 16088 LS+45°	134	53	.40	48	.36	40	.30	.84	—	—
CPC 16088 LS+180°	175	73	.42	—	—	—	—	—	—	—
LT(Mazenot, 1939)	150	58	.38	53	.35	39	.26	.73	—	—
Uhlig, 1910	224	89	.40	82	.37	66	.29	.80	—	19/56

D diameter, *U* umbilicus, *H* whorl-height, *B* whorl-breadth, h whorl-height at the point a half whorl adapical from *H*, *R*(180°) number of primary ribs/ that of all ribs in a half whorl, Inv involution. Position means the measured point, where LS at last septum, LS+90° at a point a quarter whorl adoral from LS, E preserved end, E-90° at a point a quarter whorl adapical from E, (c) costal, (ic) intercostal. HT holotype, LT lectotype. Linear dimension is measured in mm.

Dimensions. See Table 1.

Comparison and discussion. The specimen described above resembles the lectotype (see Mazenot, 1939, pl. 46 figs 4a, b) and other figured specimens of *Fauriella boissieri* from Europe, the Salt Range, and the Himalayas. Some of the French specimens are much compressed, but this compression may be partly secondary.

The body chamber of our specimen is generally similar to that of the one from the Himalayas described by Uhlig (1910, pl. 80 figs 1a, b). The difference between the two is seen in the earlier and more frequent irregularity in bifurcated ribbing in our specimen.

In the four specimens from France illustrated by Mazenot (1939) and Le Hégarat (1973), the characters mentioned above vary considerably. In the lectotype, the break-up of bifurcation to intercalation occur fairly frequently on the preserved outer whorl. Even in our specimen an intercalated short rib on one side extends to a long rib on the other side. On the unillustrated left side of the body chamber in our specimen, bifurcation of the ribs at or somewhat outside the umbilical bullae occurs more frequently than those on the right side.

In the immature stage, we see no significant difference between the specimens from the three separate provinces (for the Salt Range, see Spath, 1939, pl. 9 figs 4a, b).

Occurrence. See "Material and locality" above. In southeastern France *F. boissieri* is the late Berriasian zonal index (Le Hégarat, 1973).

Superfamily **Desmoceratacea**e Zittel 1895

Family **Puzosiidae** Spath 1922

Genus ***Puzosia*** Bayle 1878

Type species. *Ammonites planulatus* Sowerby 1827 (non Schlotheim 1820) = *Ammonites mayorianus* d'Orbigny 1841 (see Wright & Kennedy, 1984, p. 54).

Remarks. See Matsumoto (1988, p. 8) for the generic diagnosis, relation with other genera, and occurrence.

Puzosia aff. ***mayoriana*** (d'Orbigny 1841)

(Fig. 5; Fig. 16 A–D)

Material and locality. A single specimen, CPC 16089, slightly more than a quarter of a whorl of a huge ammonite, septate throughout; collected as a float shed from the "Tubu Shale" at locality KAB 323 during the 1955 Abede Survey.

Description. Although only a fragment of a whorl, the specimen is wholly septate; it is 120 mm high at the preserved end. The original shell must have been huge, at least 60 cm in diameter, probably evolute and with a wide umbilicus.

The whorl is somewhat higher than broad, with B/H from 0.80 to 0.85 adorally, suboval in cross-section, with a moderately arched venter, very gently convex converging flanks, well-rounded umbilical margin, and nearly vertical or even overhanging umbilical wall. It is broadest slightly outside the umbilical shoulders, i.e. considerably below the mid-height.

The surface looks almost smooth when an inner shell-layer alone is preserved as well as on the internal mould. On a part of the right side, where the outer shell-layer is preserved, faint ribs are discernible on the outer flank and venter, showing a moderately forward curve. Some of them may extend to, but fade away on, the inner flank. Periodic constrictions are shallow and broad running outward nearly radially or with a slight flexuosity on the inner flank and curving gradually forward on the outer flank in parallel with the ribs. They may be moderately frequent, as at least two are discernible on this fragmentary quarter whorl, but equally they may fade away in later growth-stages as they are already very shallow and the associated flares very weak.

The suture is typical of *Puzosia*: finely and deeply incised, with asymmetrically tripartite large L and retracted suspensive lobes.

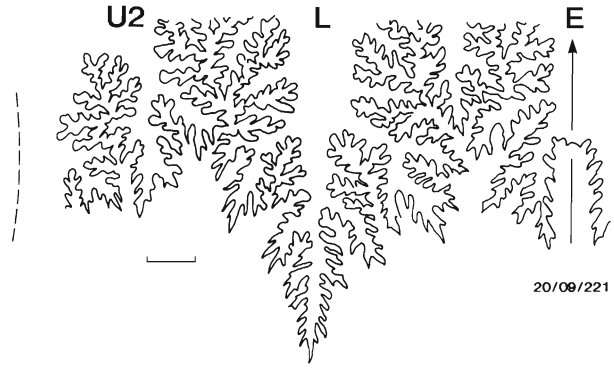


Figure 5. *Puzosia* aff. *mayoriana* (d'Orbigny). Suture of CPC 16089 at whorl-height about 105 (± 5) mm; x 3/5. Scale-bar 10 mm.

Dimensions. See Table 2.

Comparison and discussion. This specimen, although a fragment, resembles southern Indian *Puzosia planulata* var. *odiensis* Kossmat (1898, p. 112, pl. 16 figs 4, 5; pl. 18 fig. 1), which is a synonym of *Puzosia mayoriana* (d'Orbigny 1841) (see Wright & Kennedy, 1984, p. 55). The only difference is the apparently evolute, broadly curved shape which encircles a wide umbilicus. Whether this is an original character or an effect of a secondary deformation is difficult to judge. The Papua New Guinea specimen shows a probable trace of the umbilical seam of an outer whorl, which indicates 0.37 involution — a ratio close to that of Kossmat's medium-sized figured specimen.

Past literature contains little data on large examples of *P. mayoriana*. However, Kossmat (1899, p. 115) reported large specimens of *"P. planulata* var. *odiensis*, among which one of the fragmentary whorls measured by Kossmat shows B/H–152/170 = 0.89, which reasonably compares with the Papua New Guinea specimen, if the gradual increase of the ratio from 0. 80 to 0. 85 with growth in the outer whorl is considered.

It is not certain whether the huge *Ammonites planulatus* from southern India illustrated by Stoliczka (1865, pl. 68), can be referred to *P. mayoriana*. The specimen is indeed peculiar in having an unusually fat main part of the body chamber and a thick flare in front of a concave contriction at its peristome. Its entire shell diameter is 832 mm and its dimension at the thickened part, about a quarter whorl adapically from the aperture, are shown in Table 2 below. Its specific identification is uncertain as it is recorded from the Trichinopoly Group at Anapadyr, but its septate part is not much different from, if not indentical with, *P. mayoriana*. Many of the smaller specimens of *P. mayoriana* illustrated by Wright & Kennedy (1984) show geniculated ribs, suggesting basal traces of previous lappets. They are probably microconchs. Undoubted macroconchs should be described to define clearly *P. mayoriana*.

Jacob's (1908, pl. 6 fig. 2) large specimen is not the named species but a *Hyperpuzosia* (see Matsumoto, 1988, p. 27).

In summary, the specimen from Papua New Guinea is best tentatively referred to as *Puzosia* aff. *mayoriana*.

Occurrence. In Europe *P. mayoriana* occurs in the Cenomanian, although its true stratigraphic range has yet to be resolved.

Genus ***Pachydesmoceras*** Spath 1922

Type species. *Ammonites denisonianus* Stoliczka 1865 (by original designation).

Remarks. As discussed by Matsumoto (1988, pp. 22, 23), *Pachydesmoceras* is represented not only by a group of typical species, such as *P. denisonianum* (redefined by Matsumoto, 1987, p. 5), *P. kossmati* Matsumoto 1987, *P. linderi* (de Grossourve 1894) and *P. pachydiscoides* Matsumoto 1954, but also by the atypical ones, such as the Cenomanian *P. rarecostatum* Collignon 1961, Turonian *P. hourcqui* Collignon 1961, etc. Some of the latter species appear similar in lateral view to *Parapuzosia* Nowak 1913 (with type species *Sonneratia daubreei* de Grossouvre 1894), but because of their thick whorls are hardly phylogenetically linked with any known species of *P. (Parapuzosia)* or *P. (Austiniceras)* Spath 1922.

Pachydesmoceras sp. nov., described by Matsumoto & Skwarko (1991, p. 246, pl. 1 fig. 4; text fig. 2) from the Cenomanian of western Papua New Guinea, is an example of an atypical(?) subgroup. For the sake of convenience it is called here *Pachydesmoceras* sp. A. The two incomplete specimens described below as *Pachydesmoceras* sp. B and *Pachydesmoceras* sp. C are referred to the same subgroup.

Pachydesmoceras ranges stratigraphically from Upper Albian to Santonian, and *Parapuzosia* — including the two subgenera — from Lower Cenomanian to Upper Campanian.

Pachydesmoceras sp. B

(Fig. 6; Fig. 16, E, F)

Material and locality. Specimen CPC 18119, a fragment of a whorl collected at locality KAB 58, Kereru Range, during the 1955 Abede Survey; it is a float probably derived from the "Tubu Shale".

Description. The fragment of a whorl — part of the body chamber — is about 250 mm long along the mid-ventral curve, and from 75 to 105 mm in height between both ends. The whorl section is thickly cordate, with a moderately arched venter, convex flanks, well-rounded umbilical shoulders, and steep umbilical walls. The whorl is broadest between the inner flanks at about one third of its height. H is slighty greater than B in the intercostal part, and nearly equidimensional in the costal section (see Table 3). The involution is slight and the umbilicus seems wide.

The ornament consists of primary and secondary ribs. The primary ribs are regularly spaced on the main part of the flank; they are strong and nearly rectiradiate, with bullate tubercle-like elevations at the umbilical and the ventrolateral shoulders. The primary ribs give rise to two or three secondary ribs at about the ventrolateral shoulder. In addition there are four or three secondary ribs on each interspace of the outer extensions of primaries. The secondary ribs are thus 6 times as numerous as the

Table 2. Measurements of *Puzosia* aff. *mayoriana* (above) and allied species (below).

Specimen and position	*D*	*U*	*U/D*	*H*	*B*	*B/H*	*Inv*
CPC 16089 E	—	—	—	120	102	.85	—
CPC 16089 E–100°	—	—	—	97	78	.80	—
CPC 16089 restored	650	325	.50	190	—	—	.37
Kossmat, 1898, p. 115, fragmentary whorl				170	152	.89	
Kossmat, pl. 16, fig. 5	116	38	.33	48	40	.83	.39
Stoliczka, 1865 E-90°	690	225	.33	260	255	.98	—

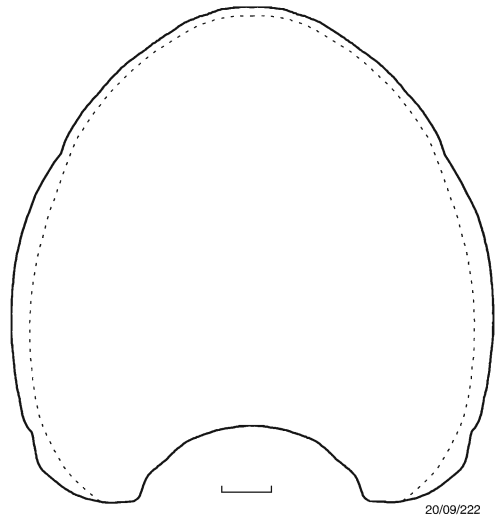


Figure 6. ***Pachydesmoeras*** **sp. B**
Diagrammatic cross-section of CPC 18119 at about the middle of the fragmentary body whorl, where H = 98.0 mm, B(c) = 92.5 mm; x 2/3. Scale-bar 10 mm.

primaries. They are somewhat prorsiradiate on the ventrolateral part, crossing the venter with a moderate convexity. Where shell layers are preserved on the venter, they are crowded and of moderate intensity. The secondaries are thus developed mainly on the outer part of the whorl, but some of them may extend inward to the middle part of the flank.

Comparison and discussion. The ornament of the Papua New Guinea specimen is similar to that of the lectotype (designated by Matsumoto, 1988, p. 19) of *Parapuzosia daubreei* (de Grossourve, 1894, p. 154, pl. 28), from the Santonian of France, although the primary ribs are more widely interspaced in the Papua New Guinea specimen. The large lectotype is somewhat compressed secondarily, but is never as thick-whorled as the Papua New Guinea specimen. This and other specimens of *P. daubreei* in Paris (e.g. the one shown by Matsumoto, 1966, p. 284, pl. 31 fig. 2) indeed do have the generally compressed whorl and tightly bent or nearly subangular umbilical edge.

The Papua New Guinea specimen has no affinity with any of other well-defind species of *Parapuzosia.* On the other hand, it is most closely allied to CPC 18126, here called *Pachydesmoceras* sp. A (an unnamed n. sp. by Matsumoto & Skwarko, 1991, p. 246, pl. 1 fig. 4; text-fig. 2) from locality 187, Cenomanian part of the Ieru

Table 3. Measurements of ***Pachydesmoceras*** **spp.**

Specimen and position	*H*	*B*	*B/H*
CPC 18119 at 5th rib (c)	98	92	0.94
CPC 18119 behind 5th rib (ic)	95	81	0.85
CPC 18120 at 3rd rib (c)	92	84	0.90
CPC 18120 adapical end (ic)	88	76	0.86

For comparison see Matsumoto & Skwarko, 1991, table 1.

Formation. The latter is somewhat larger and has thicker and more widely interspaced primary ribs and less numerous and coarser secondaries — differences which could merely represent changes with growth or variations of one and the same species.

Occurrence. As for "Material and locality" above. The above-mentioned similarity to CPC 18126 suggests Cenomanian age of CPC 18119.

Pachydesmoceras sp. C

(Fig. 7; Fig. 16G)

Material and locality. A large but incomplete specimen CPC 18120 collected during the 1957 Kereru–Purari Survey at locality KAC 09/3, Kereru Range. It is a float thought to have been shed from the "Tubu Shale".

Description. This specimen consists of a quarter of an outer whorl, which represents a part of the body chamber and the next inner whorl with earlier whorls obscured by matrix. It must have been originally over 30 cm in diameter. It is secondarily compressed, with its right side severely squashed.

The whorl section, restored from the less deformed left half, is subrounded–trapezoid, with a broadly rounded venter, very gently convex flanks, rounded umbilical shoulder, and nearly vertical umbilical walls. Its maximum breadth is slightly outside the umbilical shoulder. The whorl height is a little greater than the whorl breadth, but B/H may have been originally somewhat larger as the left half itself has been secondarily flattened: the original whorl section was probably more rounded. The involution is slight and the umbilicus seems to be fairly wide.

The ornament consists of primary and secondary ribs somewhat irregularly disposed. On the outer whorl there are numerous long ribs, but some of them are weaker and less elevated than the undoubted major primaries. They are gently prorsiradiate, some gently flexuous. At about the ventrolateral shoulder, most become bipartite and occasionally tripartite. There are also two or three secondary ribs on each interspace. Some of the secondaries are fairly long, extending inward to or beyond the mid-flank and a few close to the umbilical edge. The long ribs are indistinctly bullate at the umbilical edge. On the venter, numerous secondary ribs are disposed regularly, showing a gently forward convex curve. They seem to weaken on the mid-ventral zone, but this may be due to abrasion.

On the flank of the next somewhat weathered inner whorl, there are also ribs of unequal length and strength. Long and strong primaries occur at frequent but irregular intervals and indistinctly tuberculate at the umbilical edge. On the interspaces there are secondaries of unequal length. All ribs are slightly prorsiradiate, and some gently concave.

Where discernible on the inner whorl, the sutures are of *Puzosia* type.

Comparison and discussion. This specimen probably represents a species which is distinct from the preceding one, because of the dissimilar outline of the whorl section and difference in ornament as described above. Both are,

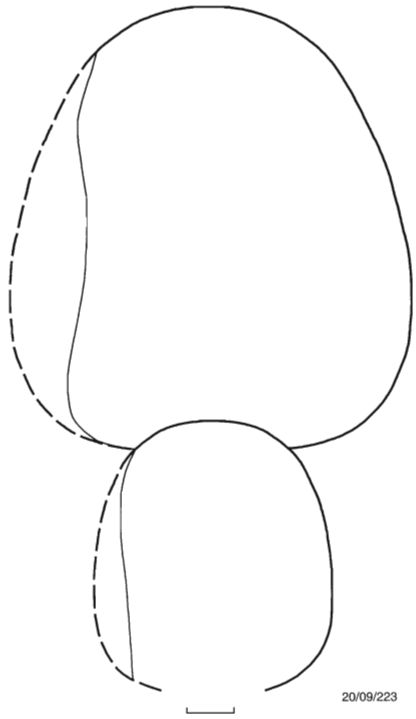


Figure 7. ***Pachydesmoceras*** **sp. C.**
Cross-section of CPC 18120 on its adapical side; thick broken line restored outline; x 2/3. Scale-bar 10 mm.

however, referrable to the same subgroup of *Pachydesmoceras,* because of broad whorls and *Parapuzosia*-like ribbing in the late growth stage. The ornament of the next inner whorl resembles that of the middle-aged whorls of the typical species of *Pachydesmoceras,* e.g. *P. denisonianum* described by Matsumoto & others (in Matsumoto, 1988, pp. 109–116, figs 48, 49).

Occurrence. Locality KAC 09/3 of CPC 18120 is separate from locality KAB 58 of CPC 18119, but the two specimens occur in nodules of similar lithology collected as float shed from a formation containing shale in the Kereru Range. A Cenomanian age may be suggested by this fact, but the true age of this species has yet to be worked out.

Family **Desmoceratidae** Zittel 1895

Genus ***Desmoceras*** Zittel 1884

Subgenus ***Desmoceras (Pseudouhligella)*** Matsumoto 1938

Type species. *Desmoceras (Psedouhligella) japonicum* Yabe 1904 (by original designation).

Remarks. This subgenus was establised in an English palaeontological note included as an appendix to a paper written mainly in Japanese (Matsumoto, 1938, pp. 1–46, of which pp. 13–24, pl. 1, 2, tables 2–6 are in English).

Desmoceras (Pseudouhligella) aff. ***ezoanum*** Matsumoto 1941

(Fig. 20A)

1941 *Desmoceras (Pseudouhligella) ezoana (sic)* Matsumoto, p. 26, fig. 4d

1942 *Desmoceras (Pseudouhligella) ezoana (sic)* Matsumoto; Matsumoto, p. 26, fig. 1b

1954 *Desmoceras (Pseudouhligella) ezoanum* Matsumoto; Matsumoto, p. 260, pl. 3 (19) figs 1–6

Material and locality. CPC 16084, an incomplete specimen consisting of the body chamber for half a whorl with destroyed last part and the last portion of the phragmocone, from locality 79, Mingenda Dome, Chimbu–Mt.Hagen area.

Remarks. *D. (P.) ezoanum* was established in a short paper (Matsumoto, 1941; repeated in 1942 in English), with a concise but clear diagnosis and distinction from other species. The species was based on a number of specimens, which are syntypes. More detailed description was given later when specimen GT. I–3030 [= UMUT. MM 6705] was chosen as the holotype (Matsumoto, 1954, p. 26, pl. 3 [19], fig. 1a–c); this specimen should now be considered as the lectotype.

Description and comparison. The specimen may be referrable to *D. (P.) ezoanum* in its fairly compressed whorl (B/H–32/42 = 0.76) with very gently convex — instead of flat and parallel — flanks, frequent constrictions which are gently flexiradiate in the main part of flank and markedly projected on venter, and the suture with a number of regularly aligned lobes and saddles whose stems are rather narrow.

The lectotype from Japan is mainly a phragmocone with few constrictions. On the body chamber, the constrictions are numerous as seen in the specimens from a subsequent collection. Very faint subcostae or lirae are discernible in some well-preserved specimens from Japan; they generally parallel the constrictions, except for the portion near the apertural margin. Similar lirae are observable on some part of CPC 16084.

As the Papua New Guinea specimen has a somewhat wider umbilicus than *D. (P.) ezoanum,* and because of the absence of additional material, it is referred to *D. (P). ezoanum* with a qualification. It is Cenomanian because it is associated with *Cunningtonicers cunningtoni* (Sharpe).

Family **Pachydiscidae** Spath 1922

Genus ***Chimbuites*** Casey & Glaessner 1958

Type species. *C. sinuosocostatus* Casey & Glaessner 1958 (in Glaessner, 1958) (by original designation).

Diagnosis. Shell medium-sized to large, fairly involute and rather narrowly umbilicate in typical forms. Whorls in middle to late growth stages higher than broad, suboval or subelliptical or subtrapezoid in section, with steep umbilical walls, subrounded umbilical edges, very gently convex flanks, and narrowly or broadly arched venter which may be flat-topped in some cases.

Distant major ribs on inner half of flank with bullate tubercles at umbilical edge, lowered and broadened outward. Minor ribs superimposed on major ribs in addition to those on interspaces: sinuous, and some of them branch

from major ribs. On ventrolateral part ribs all curved forward, crossing (typically) venter with projection, but rarely fading away toward mid-venter. Some interspaces between minor ribs deeper than others and look like incomplete constrictions. In late growth-stage major ribs become less sinuous, and at the end of shell ornament tends to weaken.

Suture of general desmoceratacean type, with tripartite L and U2, bipartite E/L, L/U2 saddles and gently descending auxiliaries. In late growth stages, major elements (E, L, U2; E/L. L/U2) broadened and minutely fringed.

Affinities. Casey & Glaessner (in Glaessner, 1958) ascribed *Chimbuites* to the family Hoplitidae in a broad sense. However, on the general shell-form, the ornament, and in particular the sutural pattern, as well as its stratigraphic and biogeographic occurrences, this genus is best regarded as a descendant of *Eopachydiscus* Wright 1955 (p. 570) — a pachydiscid — which is represented by *E. marcianus* (Shumard 1854), a senior synonym of *Pachydiscus laevicanicutatus* (ex Roemer MS) Lasswitz (1904, p. 236 [16], pl. 27 [3] fig. 2; text-fig. 3) (see Wright, 1955; Kennedy & others, 1983).

As Kennedy & others (1983) have demonstrated, in certain immature stages of *E.marcianus,* the major ribs have distinct umbilical bullae and cross the venter with a marked forward sinus; also in some immature stages minor ribs appear on the interspaces, showing a forward sweep on the ventrolateral part; occasionally some ribs branch from the umbilical bulla. These features seem to imply a high potential to give rise to the diagnostic ornament of *Chimbuites.* The only distinction is the sinuosity of the ribs on the flanks of *Chimbuites* in the early to middle growth stage. The absence of complete constrictions in the latter may be another difference.

The suture of *Chimbuites sinuosocstatus* on an immature shell is shown by Casey & Glaessner (in Glaessner, 1958, pl. 25, fig. 1), and that on a mature shell below (Fig. 8). They are similar to those of *Eopachydiscus* and *Lewesiceras* (see Kennedy & others, 1983, text-fig. 1B, C, D). The suture of a large new species *(C. giganteus)* described below (Fig. 10) is precisely like that of a similarly large specimen of *"Pachydiscus laevicaniculatus"* of Lasswitz (1904, pl. 27 [3] fig. 2).

Lewesiceras Spath 1939 from the Cenomanian and Turonian is closely allied to *Eopachydiscus* from the Upper Albian, with retention of tuberculate ribs into later growth stages. It is regarded as linking the ancestral *Eopachydiscus* with later developments of the Pachydiscidae (Kennedy & others, 1983). *Chimbuites,* which has some peculiar features of its own, is not on this main evolutionatry stock but probably an offshoot from *Eopachydiscus.*

Whether this offshoot died out or evolved into another group is not known, but some surprising similarity in the suture pattern between *Chimbuites* species and such species of *Tragodesmoceras* as *T. carlilense* Cobban (1971, pp. 8–10, pls. 3–5; text-figs 6–8) might be significant. In the latter, however, the venter is fastigiate and the ribs form chevrons and may be tuberculate at their top. The bullae at the umbilical margin of the long ribs are very faint in *T. carlilense,* but they are fairly distinct in another *Tragodesmoceras* species, *T. ashlandicum* (Anderson 1902) (described under *Pachydiscus* by Anderson, 1958, p. 221, pl. 27 figs 3, 4) (see Matsumoto, 1959, pp. 26–29, pl. 5 fig. 1; text-figs 8–10). The suture of *T. ashlandicum* is more finely and deeply incised. In any case, *T. carlilense* and *T. ashlandicum* occur in the Middle Turonian. There is so far no species which could link *Chimbuites* successively with *Tragodesmoceras* either morphologically or stratigraphically.

Wright (in litt., 4 March 1992) seems right in thinking that *Eopachydiscus* is derived from *Uhligella* Jacob 1908, and presumably from one of the coarsely ribbed species such as *U. balmensis* (Jacob 1908). The numerous sigmoidal ribs in young to middle-aged *Chimbuites* may be a hereditary character from that desmoceratid member.

Chimbuites sinuosocostatus Casey & Glaessner 1958

(Fig. 8; Fig. 17 A, B)

1953 *Deshayesites* n. sp. Edward & Glaessner, p. 98

1958 *Chimbuites sinuosocostatus* Casey & Glaessner, *in* Glaessner, p. 214, pl. 24 figs 3a, 3b; pl. 25 figs 1a, b, 2; text-fig. 4

Material and locality. Specimen CPC 16081 and two other specimens of different size from locality HC 421 [= HC 425] regarded as the type locality, near Masul Village, about 4.5 km ESE of Chimbu Airstrip, Karimui 1:250 000 Sheet area; obtained from the local people during the Central Highlands Reconnaissance Survey. The locality is in the area of the Middle Cenomanian shale and mudstone 1980 m thick in the Wahgi Group.

Dimensions. See Table 4.

Descriptive remarks. Only one specimen, CPC 16081, out of three is available. It is nearly as large as one of the paratypes (Casey & Glaessner, *in* Glaessner, 1958, pl. 25 fig. 2), which shows similiar measurement ratios and similar ornament in lateral view.

This specimen has suboval to subelliptical whorl sections, once the squashed left side of the phragmocone is restored. The venter on the body chamber is more broadly rounded than that on the phragmocone, although the roundness of the specimen is not quite identical with that of the paratype illustrated by Casey & Glaessner (op. cit., text-fig. 4). The character must vary with growth and also individually.

The ornament is quite similar to that of the holotype and

Table 4. Measurements of *Chimbuites sinuosocostatus*.

Specimen and position	*D*	*U*	*U/D*	*H*	*H/D*	*B*	*B/D*	*B/H*	*H/h*	*Inv*	*R (180°)*
CPC 16081 E (ic)	126	28	.22	57	.45	45	.36	.79	1.39	2/3	6/24
HT*	87	17.5	.20	43	.49	36.5	.41	.85	—	—	6/30
PT*	130	23	.17	60	.46	46	.35	77	1.34	—	—

* Cited from Casey & Glaessener (1958, p. 215) for comparison.

the larger paratype. Its primary ribs arise from the bullate umbilical tubercles and are more or less prorsiradiate on the inner flank, becoming sinuous and broadening outward on the main part of the flank. They show the same frequency (12 per whorl) as those of the types. The secondaries are numerous but of unequal lenght and superimposed on the outward-broadening primaries, some in a branched fashion from the primaries and others intercalated. On the outer part of the phragmocone, they are of moderate intensity and equally curved forward, crossing the venter with projection. Incomplete constrictions may run along some of the primary ribs.

On the body chamber, the ornament becomes weaker or blunter. Some ribs and shallow constrictions extend across the venter with a forward convexity, but other ribs seem to terminate with or without slight thickening on either side of the mid-venter. Such details are not recorded in the original description and are in fact partly obscured in the present specimen by surface abrasion.

Sutures are clearly exposed on the flank of the early part of the preserved outer whorl (with H = 30 to 35 mm). Their pattern is fundamentay similar to that shown on a smaller paratype (op. cit., pl. 25, figs 1a, 1b), but the stems of E/L, L and L/U2 are broader in the former. The difference is attributed to change with growth.

Comparison and discussion. *Chimbuites mirindowensis* Wright (1963, p. 603, pl. 82 figs 1, 2), from the Cenomanian of Bathurst Island, northern Australia, is closely allied to this species and distinguished mainly by its much-lesser differentiation between primary and secondary ribs.

C. aff. *mirindowensis* of Matsumoto & Skwarko (1991, p. 348, pl. 1 figs 1, 2), from the Cenomanian part of the Ieru Formation, is larger and more evolute.

Occurrence. See "Material and locality" above. As Wright (1963, p. 604) suggested, this species is probably Cenomanian in age.

Chibuites giganteus sp. nov.

(Figs. 9, 10; Fig. 17 C–F)

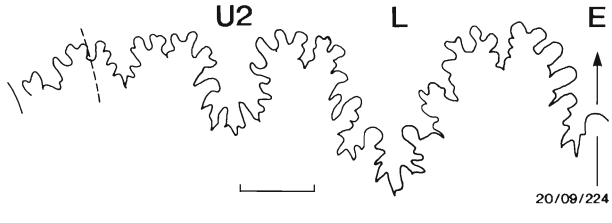


Figure 8. ***Chimbuites sinuosocostatus*** **Casey & Glaessner.** Suture of CPC 16081, slighty over a quarter whorl adapical from the last suture; x 4/5. Scale-bar 10 mm.

Material and locality. A single specimen, holotype CPC 16082, from locality LW 455 at Pio Gorge, 6.5 km east from the junction with the Purari River, in a well-bedded calcareous sandstone containing a bivalve-rich layer. Collected during the 1954 Pio–Purari Survey.

Description. The shell is very large, its original diameter being estimated at about 320 mm, if the incomplete ventral part of the outer whorl is restored. Whorls are fairly higher than broad, with B/H = 0.65 in a measurable part of the middle-aged whorl, and compressed suboval in cross-section; broadest at about the umbilical shoulder, with gently convex and outward converging flanks which show blunt ventrolateral shoulders passing to a subrounded venter. There is a narrow and nearly flat zone at the top of venter in the middle-aged whorl.

The whorl is fairly involute, overlapping nearly two-thirds in height of the preceding inner whorl. The umbilicus is fairly narrow, showing U/D = 0.17 in the middle growth-stage. The umbilical wall inclines steeply from the subangular (costal) or subrounded (intercostal) umbilical edge.

Primary ribs are widely separated, numbering six in half-whorl of the middle stage; each rib arising from a bullate tubercle at the umbilical edge, prosiradiate in an inner third of the flank with gradual broadening and obscure branching, curving backwards at about the mid-flank and again swinging forward at the ventolateral shoulder. Secondary ribs of irregular length and strength are superimposed on the broadened outer part of the primary ribs. Some are extended from the branched primaries. Four or five secondaries are present for each primary rib. Ribs are all projected on the outer part of the flank. The interspaces between the primary ribs are gently concave and may form constriction-like grooves on the outer part of the flank. The nearly flat and narrow zone at the mid-venter of the middle-aged whorl is scarcely crossed by the secondaries.

On the outer whorl, which consists of the last part of the phragmocone and the body chamber, the primary ribs are coarser, arising from more or less thick and strong tubercles at the umbilical edge, and are nearly rectiradiate or slightly prorsiradiate with outward-broadening and lowering. The secondaries become faint and finally disappear, for the preserved longest primary (the fifth from the beginning of the body chamber shown on the right side) has no secondaries on its broad and low outer part.

The sutures exposed on the middle-aged whorl, have tripartite L and U2, bipartite E/L and L/U2, and nearly straightly aligned auxiliaries. E/L, L/U2 and L itself are broadly stemmed and minutely fringed.

Dimensions. See Table 5.

Table 5. Measurements of *Chimbuites giganteus*.

Specimen and position	*D*	*U*	*U/D*	*H*	*H/D*	*B*	*B/D*	*B/H*	*H/h*	*Inv*	*R (60°)*
CPC 16082 Em (c)	157	27	.17	78	.50	51	.32	.65	1.37	2/3	2/10
CPC 16082 Em–180° (ic)	102	17	.17	53	.52	32	.31	.60	—	2/3	—
CPC 16082 Em+180° (c)	235	47	.20	106	.45	80	.34	.75	—	—	—

Em: preserved end of middle-aged whorl; CPC 16082 Em+180° are based on a tentative restoration as shown by Fig. 9

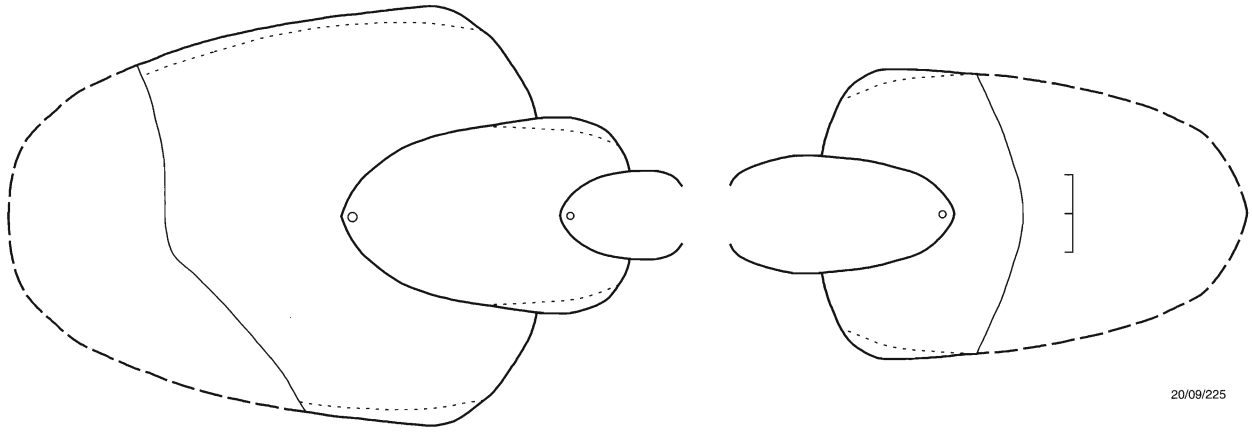


Figure 9. ***Chimbuites giganteus*** **sp. nov.**
Diagrammatic cross-section of CPC 16082; thick broken line restored outline; x 8/15. Scale-bar 20 mm.

Comparison and discussion. With respect to the ornament and sutural pattern of the middle-aged shell, the holotype of this species is fundamentally similar to the holotype and paratypes of *C. sinuosocostatum*, but it has more compressed whorls with narrower venter in its young to middle-aged stages. Its adult shell is much larger and has coarser primary ribs with stronger umbilical tubercles, while the secondaries fading away.

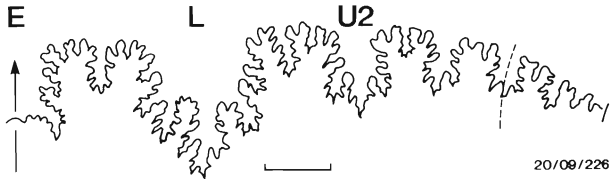


Figure 10. ***Chimbuites giganteus*** **sp. nov.**
Suture of CPC 16082 at H = 77 mm; x 1. Scale-bar 10 mm.

Although only a single somewhat incomplete specimen is available, it certainly does represent a distinct species of *Chimbuites*.

Occurrence. As for "Material and locality" above. The suggested age is Cenomanian, with confirmation to be sought among the associated fossils.

Superfamily **Acanthoceratacea**e de Grossouvre 1894

Family **Acanthoceratidae** de Grossouvre 1894

Genus ***Acanthoceras*** Neumayr 1875

Type species. *Ammonites rhotomagensis* Brongniart 1822 (by subsequent designation of de Grossouvre, 1894)

Acanthoceras rhotomagense (Brongniart 1822)

(Fig. 11; Fig. 18 B–D)

Synonymy. See Wright & Kennedy, 1987, pp. 156–158.

Material and locality. A single specimen, CPC 16085, a float shed from the Kerabi Formation, obtained at locality KRD 74, some 3 km north of Kerabi Village and south of the Erave Valley, Karimui 1:250 000 Sheet area. Collected during the 1955 Erave Survey.

Description. The specimen is medium sized. The body chamber which begins at D = 95 mm (see Fig. 18C) is incomplete, but when restored the shell would be about 150 mm in diameter.

The whorl expands moderately, overlapping considerably the previous inner whorl. The umbilical ratio (U/D) is slightly less than 30%. The whorl is a little broader than high and subquadrate in cross-section, with sloping ventrolateral shoulders.

The ribs are mostly rectiradiate, separated by broader interspaces, and alternately long and short on the septate whorls, with the longer ones becoming predominent on the body chamber. The long primary ribs have strong tubercles which are sharply pointed at the umbilical edge, and bullate inward and also outward. The short secondary ribs arise from some point on the inner flank. On the early part of the body chamber, some of the intercalated ribs become long but free from umbilical tubercles. All the ribs have inner and outer ventrolateral tubercles; the former are conical to obliquely clavate and the latter distinctly and sharply clavate. The siphonal tubercles are clavate but weak, becoming fainter or almost obsolete in the mature shell.

The suture is of *Acanthoceras* pattern, with deep and

Table 6. Measurements of ***Acanthoceras rhotomagense*****.**

Specimen and position	*D*	*U*	*U/D*	*H*	*H/D*	*B*	*B/D*	*B/H*	*H/h*	*Inv*	*R (360°)*
CPC 16085 near E (c)	113	32	.28	48	.42	51	.45	1.06	1.45	.50	12/22
CPC 16085 near E (ic)	106	31	.29	44	.42	47	.44	1.07	1.42	.45	—
CPC 16085 E–180° (c)	71	20	.28	32	.45	35	.49	1.09	1.52	—	9/17

For comparison see Matsumoto & Skwarko, 1991, table 8.

roughly rectangular E, massive and bipartite E/L saddle, L and L/U2 saddle of moderate bradth and depth or height, and small U2.

Dimensions. See Table 6.

Comparison and discussion. This specimen is identified with *A. rhotomagense,* which shows a high morphological variability as demonstrated by Wright & Kennedy (1987). It is, however, noted that the hitherto described specimens from Papua New Guinea and adjacent areas (Wright, 1963; Matsumoto & Skwarko, 1991; the current paper) are commonly characterized by prominent outer ventrolateral clavi and much weakening siphonal ones. If populations from this province commonly showed these

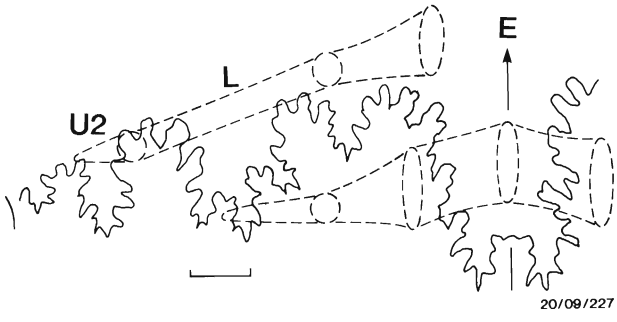


Figure 11. ***Acanthoceras rhotomagense*** **(Brongniart).** Suture of CPC 16085 at H = 34 mm; x 1. Scale-bar 5 mm.

characters, they would result in the naming of a subspecies, such as *Acanthoceras rhotomagense mirialampiense* Wright 1963. Further careful comparison is, however, needed in view of certain species from South Africa, the Gulf Coast, and Western Interior of North America which appear similar to but are not identified with *A. rhotomagense* (see Wright & Kennedy 1987, pp. 189–190).

Occurrence. As for "Material" above. In Europe and other regions *A. rhotomagense* occurs abundantly in the Middle Cenomanian.

Genus ***Cunningtonicers*** Collignon 1937

Type species. *Ammonites cunningtoni* Sharpe 1855 (by absolute tautonymy).

Remarks. Cobban (1987, p. 19) and Krikland & Cobban (1986, p. 2) give the generic diagnosis of *Cunningtoniceras* and its distinction from *Euomphaloceras* Spath 1923. The phylogenetic origin of this genus is probably in *Acanthoceras* as discussed by Wright & Kennedy (1987, p. 193). Well-known species have a world-wide distribution in the Middle Cenomanian; but some species occur in the Late Cenomanian. There is a single record from the Turonian of Japan (Matsumoto & others, 1987, p. 37), but this may be either a relict or a derived fossil.

Cunningtoniceras cunningtoni (Sharpe 1855)

(Fig. 20 B–J)

Synonymy. See Wright & Kennedy (1987, p. 196).

Material and locality. Two adult specimens, CPC 16079 and CPC 16080, and one juvenile, CPC 16075, from loc. 79 (F2148), Mingenda Dome, Chimbu–MT. Hagen area, Central Highlands.

Description. The specimens from the Mingenda Dome, both mature and juvenile, are characterised by a depressed squarish whorl-section, widely separated primary ribs with prominent umbilical and ventrolateral tubercles, and numerous secondary riblets with smaller tubercles on the venter. The umbilicus is fairly deep and of medium width. The involution is slight; the outer whorl overlaps the ventral part of the inner one whose inner ventrolateral tubercles stretch along the umbilical wall of the former.

The umbilical tubercles are prominent at some distance outward from the umbilical edge and bullate on the umbilical wall. On the septate whorl, the inner ventrolateral tubercles are rather clavate; the ribs are normally divided at the outer ventrolateral tubercles, and there are often additional intercalated riblets which may or may not be looped at the base of the inner ventrolateral tubercles. Some of the riblets are associated with constriction-like grooves which may be extended onto the flank as somewhat deeper interspaces without forming distinct constrictions. Ventral riblets mostly run perpendicular to the siphonal line, but some of them are curved gently forward or form obtuse chevrons.

On the adult body chamber, the primary ribs are widely interspaced and strengthened; the inner and outer ventrolateral tubercles are united into prominent horns stretching upwards and sideways. The summit of each horn is obscurely doubled with a remnant of the outer ventrolateral tubercle on the siphonal side. The mid-ventral zone is concave between the paired horns. Short riblets remain on that concave part, and long and blunt ones are traced on the broad venter of the interspaces of horned ribs, whereas siphonal tubercles become obsolete and disappear.

The suture is of typical *Acanthoceras* type as seen clearly in CPC 16079.

Dimensions. See Table 7.

Comparison and discussion. On the basis of the characters described above, the three specimens from the Central Highlands of Papua New Guinea are certainly identifiable with *Cunningtoniceras cunningtoni* (Sharpe) as re-defined recently by Wright & Kennedy (1987), who pointed out the great variability of the species, and the difficulty in separating taxa of subspecific category under previously proposed names.

Our above described specimens share characters most similar, among others, to those in *Acanthoceras cunningtoni* var. *cornuta* Kossmat (1897, p. 18, pl. 5 figs 1a–c). This also holds true for another specimen from the Wahgi Valley described as *C. höltkeri* Erni 1944 (p. 470, pl. 11 figs A–C), and also probably to the one from Bathurst Island, Northern Territory of Australia, described as *"Euomphaloceras cunningtoni"* by Wright (1963, p. 607, pl. 88 fig. 2). Kossmat's (1897) specimen came from southern India which in mid Cretaceous times was intimately palaeogeographically related with both northern Australia and Papua New Guinea. This may suggest that *cornutum* could be used as a geographical subspecies of *cunningtoni*, but further study of various forms from different areas is desirable before a definite conclusion

Table 7. Measurements of *Cunningtoniceras cunningtoni*.

Specimen and position	*D*	*U*	*U/D*	*H*	*H/D*	*B*	*B/D*	*B/H*	*H/h*	*R (180°)*
CPC 16075 near E (ic)	56	17	30	25	.45	32	.57	1.28	1.38	7/17
CPC 16079 near E (ic)	108	38	35	44	.41	60	55	1.36	1.35	6/20
CPC 16080 near E (ic)	129	41	32	57	.44	—	—	—	—	7/21
CPC 16080 E–70° (c)	—	35	—	58	—	75	—	1.29	—	—

is to be reached. In any case, Wright (1963, p. 196) was correct in regarding *C. hoeltkeri* Erni 1944 as a synonym of *C. cunningtoni* (Sharpe, 1855).

Occurrence. See "Material and locality". *C. cunningtoni* occurs in various parts of the world, and where well-dated it is Middle Cenomanian in age (Wright & Kennedy, 1987, p. 205).

Genus ***Calycoceras*** Hyatt 1900

Type species. *Ammonites navicularis* Mantell 1822 (by designation under the Plenary Powers, ICZN Opinion No. 557).

Subgenus ***Calycoceras (Newboldiceras)*** Thomel 1972

Type species. *Acanthoceras newboldi* Kossmat 1897 (by original designation of Thomel, 1972, p. 105), which is a junior synonym of *Acanthoceras rhotomagense* var. *asiatica* Jimbo 1894, as pointed out by Wright & Kennedy (1990, p. 238).

Calycoceras (Newboldiceras) asiaticum (Jimbo 1894)

(Figs 12, 13; Fig. 18 A, E, F)

Synonymy. See Wright & Kennedy (1990, pp. 239–240) under *Calycoceras (Newboldiceras) asiaticum asiaticum* (Jimbo 1894).

1991 *Calycoceras (Newboldiceras) newboldi* (Kossmat 1897); Matsumoto & Skwarko, 1991, p. 252, pl. 4 fig. 4

Material and locality. Two specimens, CPC 16074, fairly large and wholly septate shell, from loc. LW 479, Gurimatu on the Purari River, downstream from its junction with the Pio River, collected during the Pio–Purari Survey of 1954; and CPC 18121, nearly as large as CPC 16074, float from loc. KR 1153 collected in the Erave Valley during Erave–Kutubu Survey conducted by R.C. Herrera and A.L. Findley. The rock matrix of the specimens consists of dark grey sandstone. Karimui 1: 250 000 Sheet area.

Description. Both specimens are about 200 mm in diameter. If the preserved end is assumed to be the last septum, and the body chamber as half a whorl, the entire shell diameter would be about 320 mm. The whorl expands with a moderate ratio (H/h = 1.4 to 1.5), overlapping about 1/3H of the preceeding inner whorl. The umbilicus is of moderate width, with U/D from 28 to 33% in measured parts.

The whorl is somewhat broader than high, and broadest between inner flanks. Its intercostal section is subrounded, with abruptly rounded umbilical shoulders and a more or less broadly arched venter; the flanks are nearly flat in early growth stages and gently convex later. In the costal section, the ventral zone between a pair of outer ventrolateral tubercles is nearly flat, whereas the zone between the rows of outer and inner ventrolateral forms a sloping facet.

Ribs are rather crowded and as a rule alternately long and short. The long or primary ribs arise from the umbilical seam and are slightly rurusiradiate on the wall and at the umblical shoulder provided with prominent tubercles which are bullate inward and outward. Secondaries arise on the inner flank, in some cases from the point close to the umbilical shoulder, and may approach the umbilical tubercle of the preceding primary rib.

On the main part of the flank ribs are mostly rectiradiate in CPC 16074. Gently flexuous ribs occur rarely in CPC 16074 but more frequently in CPC 18121. In both specimens some ribs are slightly elevated but not tuberculate at about the mid-flank. The inner ventrolateral tubercles are conical, whereas the outer ventolaterals are clavate. Between them the ribs broaden gradually and are lowered and weakly projected; on the ventral zone the ribs are broad but low, running across the venter at right angles with the siphonal line. The siphonal clavi on the outer whorl are faint, becoming almost obsolete later.

In CPC 16074, a long rib with umbilical tubercle on one side of the outer whorl extends to a short rib on the other

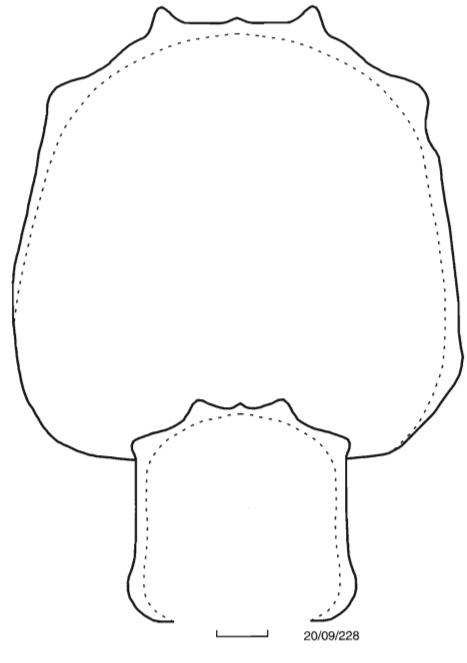


Figure 12. ***Calycoceras (Newboldiceras) asiaticum*** **(Jimbo)** Whorl-section of CPC 16074 near the preserved end at H(c) = 83 mm; x 2/3. Scale-bar 10 mm.

Table 8. Measurements of *Calycoceras (Newboldiceras) asiaticum*.

Specimen and position	*D*	*U*	*U/D*	*H*	*H/D*	*B*	*B/D*	*B/H*	*H/h*	*Inv*	*R (60°)*
CPC 16074 E (c)	206	69	.33	83	.40	95	.46	1.14	1.48	.32	17/36
CPC 16074 E–90° (ic)	160	51	.32	65	.40	72	.45	1.11	1.44	—	16/33
CPC 18121 near E (c)	199	64	.32	82	.41	88	.44	1.07	1.49	.33	19/36
CPC 18121 E–120° (c)*	151	43	.28	64	.42	64	.42	1.0 *	1.42	—	15/30

* May be secondarily compressed.
For comparison see Matsumoto & Skwarko, 1991, table 4.

side. Such a feature is not seen in CPC 18121

The suture is of typical *Acanthoceras* pattern.

Dimensions. See Table 8.

Comparison and discussion. *Calycoceras (Newboldiceras) asiaticum* (Jimbo 1894) has been recently redefined by Wright & Kennedy (1991, p. 239) to include *C. (N.) newboldi* (Kossmat 1897) of previous authors as a synonym. Whether to rank *Acanthoceras newboldi* var. *spinosa* Kossmat 1897 as a subspecies of *C. (N.) asiaticum* or an independent (but closely allied) species is a problem still to be resolved.

The holotype from the Mikasa Formation in Hokkaido, and a number of specimens from the type and contiguous localities as well as from the correlatable zone in other parts of Japan, are now under investigation by Matsumoto and his colleagues. It has been already observed that the *newboldi*-type shell-form with rather flat and subparallel

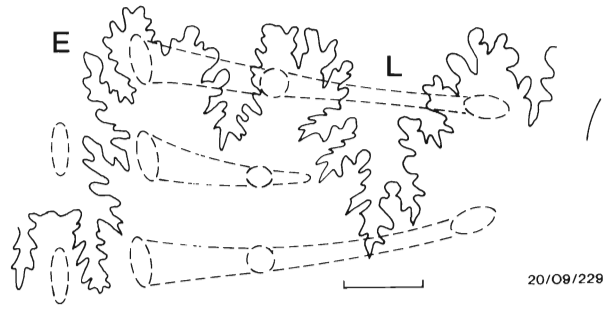


Figure 13. ***Calycoceras (Newboldiceras) asiaticum* (Jimbo).** Suture of CPC 16074 at H = 45 mm in the early part of the preserved outer whorl; x 1. Scale-bar 10 mm.

flanks occurs frequently in early to middle growth-stages, whereas fairly to very large outer whorls of late growth-stages show subrounded inter-costel sections with the maximum breadth between the inner parts of flanks or between the umbilical tubercles in costal section. In some cases, the *newboldi*-type form may persist to a late growth-stage, and as a matter of course there are gradations between the above two forms ontogenetically and also individually.

There is also some variation in ornament; the weakness of siphomal clavi can be attributed to such variation.

In summary, the Papua New Guinea specimens described above are identified as *C. (N.) asiaticum*. Another specimen, CPC 16073, from the Ieru Formation, western Papua New Guinea, earlier described as *C. (N.) newboldi* (Matsumoto & Skwarko, 1991, p. 252, pl. 4 fig. 4) is now also identified as *C. (N.) asiaticum*.

Occurrence. See "Material and locality" above. From its occurence in Japan, southern India and Europe *C. (N.) asiaticum* indicates the Middle Cenomanian age.

Genus ***Romaniceras*** Spath 1923

Type species. *Ammonites deverianus* d'Orbigny 1841 (by original designation).

Romaniceras deverianum (d'Orbigny 1841)

(Figs 14, 15: Fig. 19 E, F)

1841 *Ammonites deverianus* d'Orbigny, p. 346, pl. 110 figs 1–2

1980 *Romaniceras (Romaniceras) deverianum* (d'Orbigny); Kennedy & others, p. 332, pl. 39 figs 7–10; pl. 41 figs 1–6; pl. 42 figs 1–7; text-figs 1, 3D, 4, 5 (with full synonymy, except for those discussed bellow).

Material and locality. Specimen CPC 16086, which shows fine detail on the right side and the major part of the venter but is much abraded on the left side; collected from locality MNC 1776M, northwest end of the core of Mubi anticline, where up to 214 m of the Late Cretaceous Chim(?) Formation (siltstone with occasional coquina limestone) is exposed. This ammonite was taken from one of these limestones, a 90 cm thick band, 22 m below the top of the formation. Lake Kutubu 1:250 000 Sheet area.

Description. The specimen is fairly large, with diameter 175 mm at the last septum and probably about 250 mm when body-chamber was complete. Its outer whorl consists of the late part of the phragmocone and the body-chamber on halves. A restored whorl is nearly as high as broad at about the beginning of the body chamber, and shows a subrounded intercostal section.

The whorl expands with a fairly high ratio, overlapping one third of the previous inner whorl. The umbilicus is of moderate width, showing the umbilical ratio (U/D) of nearly 30%.

On the outer whorl ribs are all long; on the previous inner whorl long ribs predominate but occasionally short ribs are branched or intercalated. The ribs are nearly rectiradiate and rather crowded on the inner whorl, but on the outer whorl they are prorsiradite or gently concave, broadening outward, but somewhat widely interspaced. The long ribs number 12 per half whorl.

Tubercles are in nine rows; those at the umbilical edge are small and bullate; the laterals are somewhat thick and bullate at the base and fairly prominent on the summit; the inner ventrolaterals are conical and the strongest; the outer ventrolaterals subconical to obliquely clavate and of moderate intensity; the siphonal ones clavate and distinct. The distance between the umbilical and lateral tubercles is slightly shorter than that between the lateral and inner ventrolateral ones.

Suture is of *Acanthoceras* type, showing broad and bipartite saddles of E/L and L/U2. The illustrated last suture is somewhat reduced in the depth of lobes and minor incisions.

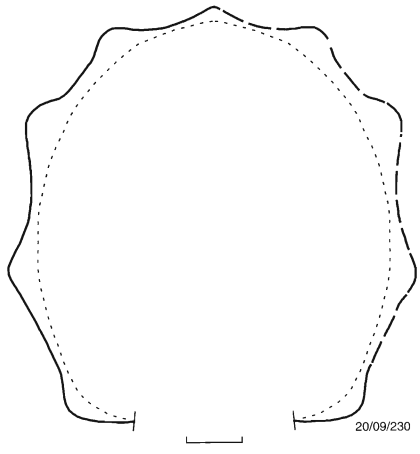


Figure 14. ***Romaniceras deverianum*** **(d'Orbigny).**
Whorl-section of CPC 16086 at the last septum; x 2/3. Scale-bar 10 mm.

Dimensions. See Table 9.

Comparison and discussion. Kennedy & others (1980) have revised *Romaniceras deverianum* (d'Orbigny), showing a great extent of variation in its shell form and ornament. It is difficult to decide whether to regard *R. pseudodeverianum* (Jimbo 1894) as a synonymy of *R. deverianum* (see Matsumoto & others, 1985, pp. 165–167; pl. 8, fig. 3).

The described specimen from Papua New Guinea is somewhat peculiar in having equally long ribs on the outer whorl, whilst on the inner whorl a few of the long ribs are nodeless at the umbilical margin and branched or intercalated shorter ribs do occur, though infrequently. In the figured examples of *R. deverianum* (in the sense of Kennedy & others, 1980) from Europe, the frequency of intercalated secondaries seems to vary with growth and between individuals. In the holotype of *R. uchauxiense*

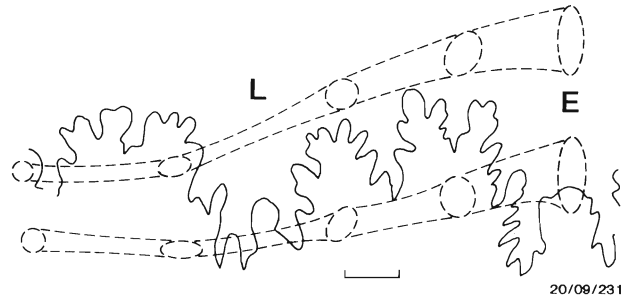


Figure 15. ***Romaniceras deverianum*** **(d'Orbigny).**
Last suture of CPC 16086; x 2/3. Scale-bar 10 mm.

Collignon (1939, p. 38) (= Roman & Mazeran, 1913, pl. 3, figs 1, 1a), synonym of *R. deverianum* as Kennedy & others stated, the primaries are predominant over secondaries on its wholly septate whorl.

The lectotype of *Ammonites medlicottianus* Stoliczka (1864, pl. 43 figs 1, 1a, 1b), GSI 181, is nearly as large as the present pecimen (see Table 8) and has a similar mode of ribbing and tuberculation. In view of the great variability in the European material (Kennedy & others 1980), these minor differences can be attributed to intraspecific variation.

The specimen from Papua New Guinea is thus referred to *R. deverianum* despite some individual peculiarities.

A specimen illustrated by Noda (1969, pl. 3) as *Romaniceras* sp., from the middle part of the Zone of *Inoceramus hobetsensis* in Kyushu, is a distorted internal mould. It is very similar to the Papua New Guinea specimen in size, the presence of equally long and gently concave ribs on the outer whorl, and the configuration of tubercles. It is now identified with *R. deverianum.*

Occurrence. See "Material and locality" above. *R deverianum* is widespread and limited to occurrence to the upper part of Middle Turonian wherever it is found.

Conclusions

Among the Papua New Guinea ammonites described in this paper: one is a member of the Berriasian Tethyan fauna extended to peri-Gondwana; those of Albian age suggest a palaeogeographic connection with the Australian fauna; others, of Cenomanian age, are well-represented both by well-known widespread species and by *Chimbuites*

Table 9. Measurements of ***Romaniceras deverianum.***

Specimen and position	*D*	*U*	*U/D*	*H*	*H/D*	*B*	*B/D*	*B/H*	*H/h*	*Inv*	*R (180°)*
CPC 16086 LS+85° (ic)	206	61	.30	91	.44	75	.36	82	1.62	—	12/12
CPC 16086 LS+80° (c)	208	61	29	93	.45	90	.43	97	1.63	—	12/12
CPC 16086 LS (c)	173	52	30	78	.45	79	.46	1.01	—	.33	12/13
GSI 181* LS+130° (c)	210	67	.32	87	.41	95	.45	1.09	1.50	.31	9/11

* Measured by T. M. (at the preserved last 3rd rib).
For comparison see Kennedy & others, 1980, p. 336.

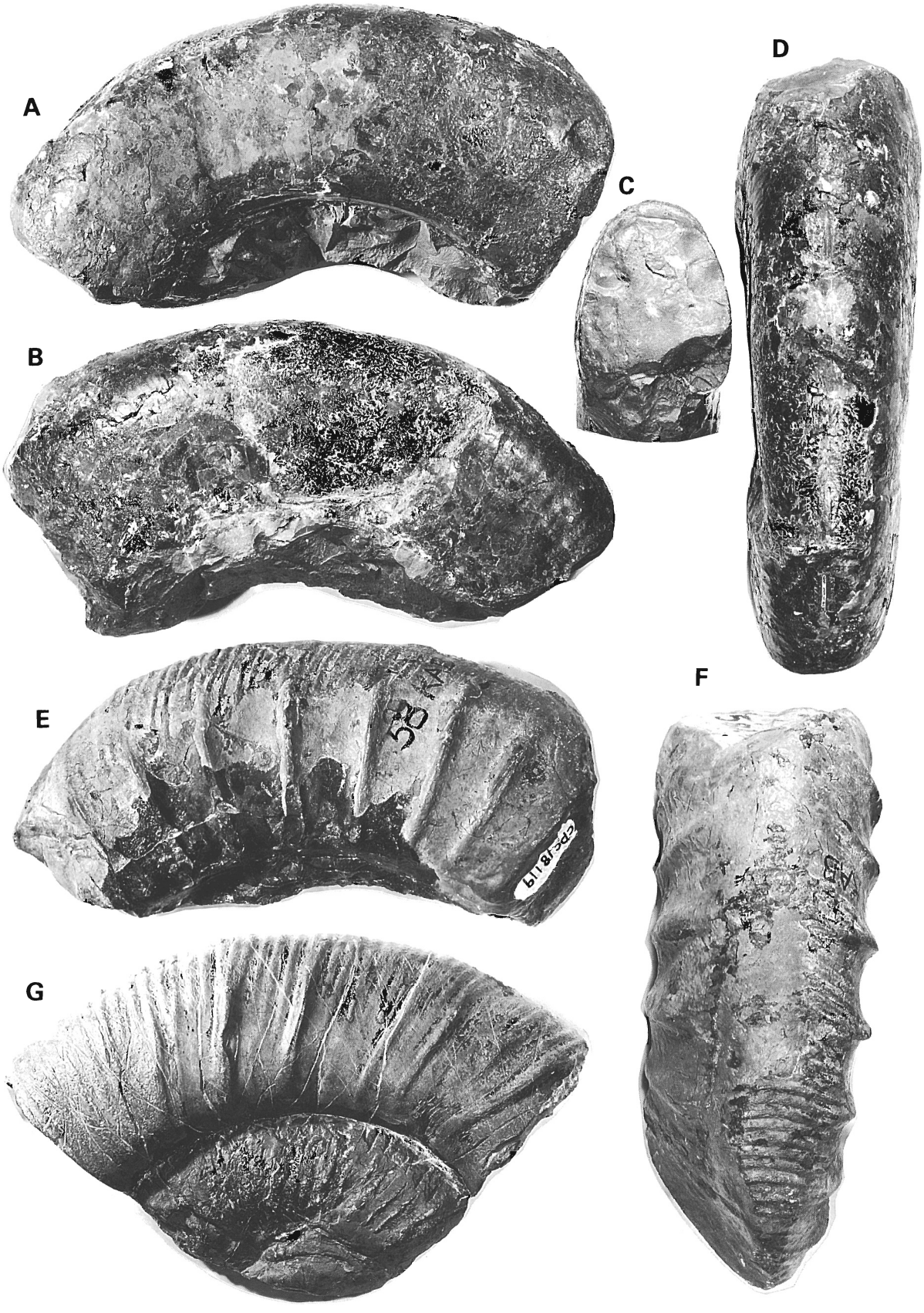


Figure 16. A–D. *Puzosia* aff. *mayoriana* (d'Orbigny 1841).
CPC 16089; locality KAB 323, Kereru Range, Cenomanian (?). Left and right lateral views, adapical section, and ventral view; x 1/3. **E, F. *Pachydesmoceras* sp. B.**
CPC 18119; locality KAB 58, Kereru Range, Cenomanian. Lateral and ventral views; x 2/5.
G. *Pachydesmoceras* sp. C.
CPC 18120; locality KAC 09/3, Kereru Range, Cenomanian; lateral view; x 1/3.

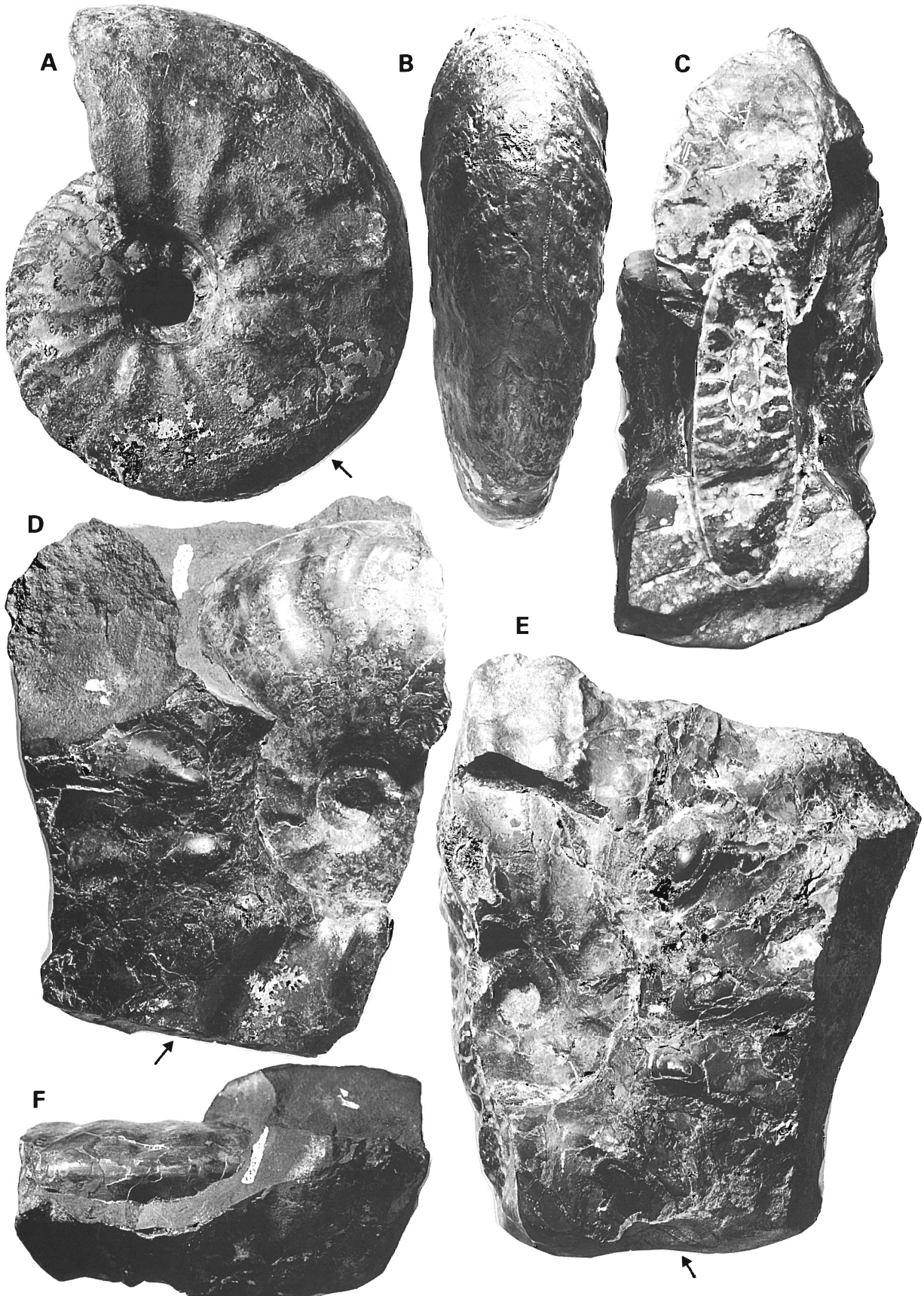
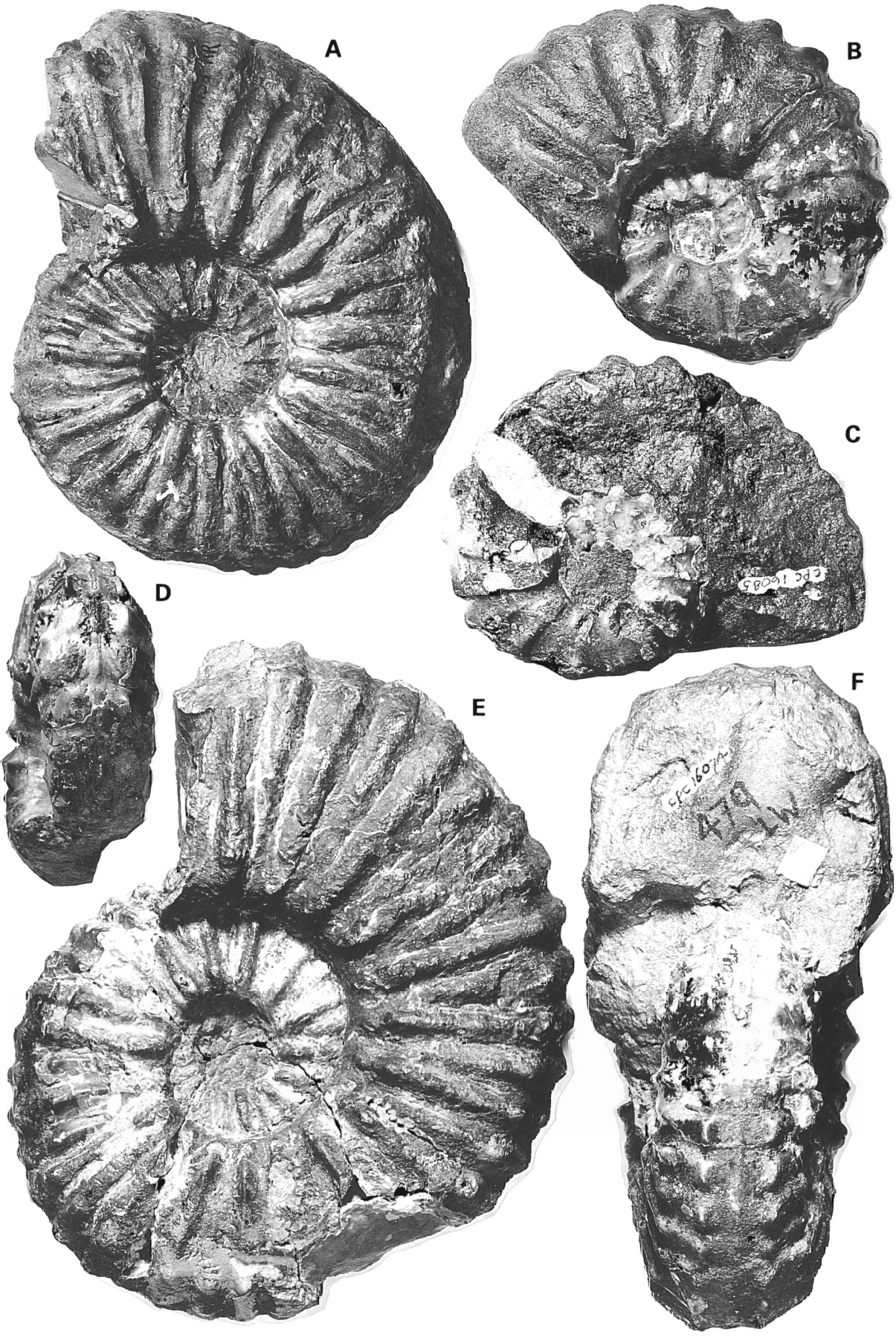


Figure 17. A,B. *Chimbuites sinuosocostatus* Casey & Glaessner 1958.
CPC 16081; locality HC 425, 4.5 km ESE of Chimbu Airstrip in the Central Highlands, Cenomanian. Lateral and ventral views; x 7/10.
C-F. *Chimbuites giganteus* sp. nov.
CPC 16082; locality LW 455 at Pio Gorge, Central Highlands, Cenomanian. Natural section, left and right lateral views, ventral view of inner whorl cropping out through the broken part of the body chamber; x 3/5. Arrow: beginning of body chamber.


A
B
C
D
E
F

— now regarded as an offshoot of *Eopachydiscus* which is in turn ancestral to main members of Pachydiscidae — which so far seem endemic to Papua New Guinea and the northern Australian margin; *Romaniceras* is a cosmopolitan representative of the ammonites of Turonian age.

It is worthy of note that no Valanginian–Aptian ammonites are present in the collection; that in contrast to the extensive retreat of the sea from the main part of Australia, Papua New Guinea was well inundated during at least part of Cenomanian and Turonian times; and that the age-span Coniacian–Maastrichtian is not clearly indicated by the ammonites studied.

Acknowledgements

We thank the Director, Bureau of Mineral Resources (now Australian Geological Survey Organisation), and the Director, Australian Petroleum Company, for the permission to publish on the old A.P.C. collection. We also thank Dr. C. W. Wright, for kindly reading a part of the manuscript and for his many valuable suggestions. Thanks are extended to Dr. D. L. Strusz, the B.M.R. curator, and Professor Juichi Yanagida, Kyushu University curator for the loan of specimens; Professor Hugh Davies of the University of Papua New Guinea for his kind comments on the stratigraphy, and to Dr. Masayuki Noda and the B.M.R. staff for photography. Finally, we are much obliged to Dr. Karl H. Wolf, Senior Editor of the AGSO Journal, Dr. K.J. McNamara, Senior Curator of the Western Australian Museum, and Professor Jost Wiedman of Tuebingen, Germany, for their kind suggestions to improve our manuscript.

References

Anderson, F. M., 1958, Upper Cretaceous of the Pacific Coast. *Geological Society of America, Memoir,* 71, 178 pp. 75 pls.

Australian Petroleum Company, 1961, Geological results of petroleum exploration in western Papua 1937–1961. *Journal of Geological Society of Australia,* 8 (1), p. 1–133.

Brown, C. M. & Robinson, G. P., 1982, Kutubu 1:250 000 Geologicial Series. *Geological Survey of Papua New Guinea Explanatory Notes* SB/54–12.

Cobban, W. A., 1971, New and little known ammonites from the Upper Cretaceous (Cenomanian and Turonian) of the Western Interior of the United States. *U.S. Geological Survey Professional Paper,* 645, 1–108, pls 1–39.

Cobban, W. A., 1984, Mid-Cretaceous ammonite zones, Western Interior, United States. *Bulletin of the Geological Society of Denmark*, 33, 71–89.

Cobban, W. A., 1987, Some Middle Cenomanian (Upper Cretaceous) acanthoceratid ammonites from the Western Interior of the United States. *U.S. Geological Survey Professional Paper,* 1445, 1–28, pls 1–13.

Collignon, M., 1937, Ammonites Cenomaniennes du sud-ouest de Madagascar. *Annales Géologiques du Services des Mines, Madagascar*, 8, 31–72, pls 1–11.

Collignon, M., 1939, Fossiles Cénomaniennes et Turoniens du Menabe. *Annales Géologiques Services des Mines, Madagascar*, 10, 1–49, pls 1–11.

Collignon, M., 1961, Ammonites néocretacees du Menabe (Madagascar). VII. Les Desmoceratidae. *Annales Géologiques du Services des Mines, Madagascar,* 31, 1–115, pls 1–32.

Edwards, A. B. & Glaessner, M. F., 1953, Mesozoic and Tertiary sediments from the Wahgi Valley, New Guinea. *Proceedings of the Royal Society of Victoria,* 64, 93–112.

Erni, A., 1944, Ein Cenoman–Ammonit, Cunningtoniceras Höltkeri nov. spec., aus Neuguinea, nebst Bemerkungen über einige andere Fossilien von dieser Insel. *Eclogae Geologicae Helvetiae,* 37, 468–475, pl. 11.

Futakani, M., 1990, Turonian collignoniceratid ammonites from Hokkaido, Japan. *The Journal of Kawamura Gakuen Woman's University,* 1, 235–280, pls 1–10.

Glaessner, M. F., 1945, Mesozoic fossils from the Central Highlands of New Guinea. *Proceedings of the Royal Society of Victoria,* 56, 151–168.

Glaessner, M. F., 1958, New Cretaceous fossils from New Guinea, with a contribution on a new ammonite genus by R. Casey. *Records of the South Australian Museum,* 13, 199–226, pls 24–26.

Grossouvre, A. de, 1894 (for 1893), Recherches sur la craie superieure. 2, Paléontologie. Les ammonites de la craie superieure. *Memoir Service Carte Geologique France,* 264 pp., 39 pls.

Jacob, C., 1908, Etudes sur quelques ammonites du Cretace moyen. *Memories de la Societe Géologique de France, Paléontologie,* 15, *Memoire No. 38 (for 1907),* 61 pp., 19 pls.

Jimbo, K., 1894, Beiträge zur Kenntniss der Fauna der Kreideformation von Hokkaido. *Geologische und Palaeontologische Abhandlungen, Neue Folge,* 2, 149–194, pls 17–25.

Kennedy, W. J., 1984, Ammonite faunas and the standard zones of the Cenomanian to Maastrichtian Stages in their type areas, with some proposals for the definition of the stage boundaries by ammonites. *Bulletin of the Geological Society of Denmark,* 33, 147–161.

Kennedy,W.J., 1986, Ammonite biostratigraphy of the Albian to basal Santonian. *In* Reyment, R.A. & Bengtson, P. (compilers) — Events of the Mid-Cretaceous. *Pergamon Press, Oxford, Appendix* 1, 129–144, 155–182.

Kennedy, W. J., Wright, C. W. & Chancellor, G. R., 1983, The Cretaceous ammonite Eopachydiscus and the origin of the Pachydiscidae. *Palaeontology,* 26 (3), 655–662, pls 67–68.

Kennedy, W. J., Wright, C. W. & Hancock, J. M., 1980, The European species of the Cretaceus ammonite Romoniceras with a revision of the genus. *Palaeontology,* 23 (2), 325–362, pls 39–50.

Kirkland, J. I. & Cobban, W. A., 1986, Cunningtoniceras arizonense n.sp. a large acanthoceratid ammonite from the Upper Cenomanian (Cretaceous) of eastern central Arizona. *Hunteria,* 1 (1), 1–14.

Kossmat, F., 1895–98, Untersuchungen über die Südindische Kreideformation. *Beiträge zur Palaontology und Geologie/ron Oesterreich — Ungarns und des Orients* 9 (1895), 97–203(1–107), pls 15–25 (1–11); 11 (1897), 1–46 (108–153), pls 1–8 (12–19); 12 (1898), 89–152 (154–217), pls 14–19 (20–25).

Figure 18. A, E, F. *Calycoceras (Newboldiceras) asiaticum* (Jimbo 1894). (A) CPC 18121; locality KR 1153, Erave Valley, Cenomanian; lateral view; x 1/2. E, F. CPC 16074; locality LW 479, Guimatu on the Purari River, Cenomanian; lateral and frontal views; x 4/7.

B–D. *Acanthoceras rhotomagense* (Brongniart 1822).

CPC 16085; locality KRD 74, Erave Valley, Cenomanian; right and left lateral and rear views; x 2/3. The preserved last half whorl in Fig. C exhibits a natural longitudinal section in which the last 6 septa at dotted positions and posterior half of the body chamber are observable.

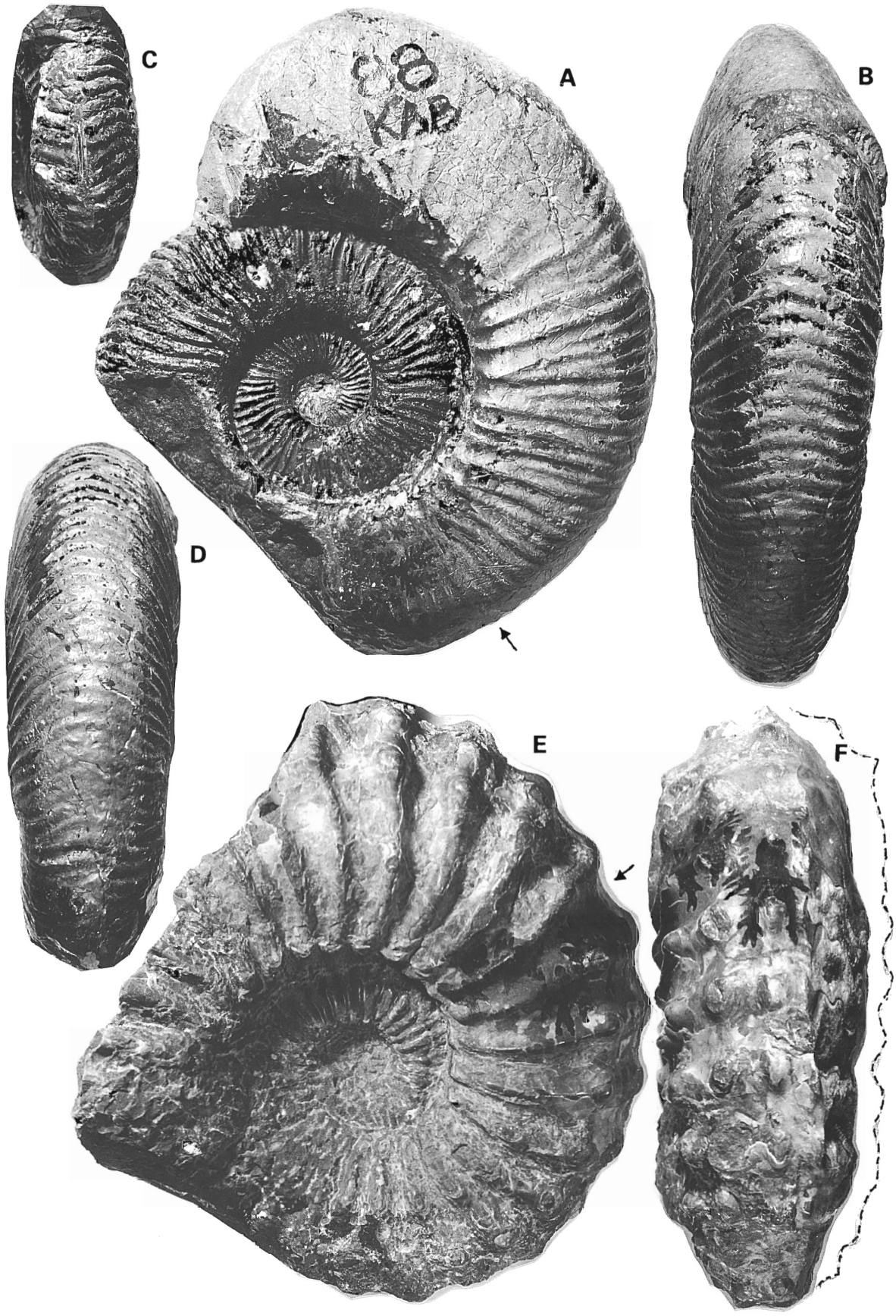


Figure 19. A–D. *Fauriella boissieri* (Pictet 1867).
CPC 16088; locality KAB 88, Kereru Range, Berriasian. Lateral and three ventral views; x 7/10. Fig. C shows the venter of the early part of the outer whorl.
E, F. *Romaniceras deverianum* (d'Orbigny 1841).
CPC 16080; locality MCN 1776 M, about 8 km northeast from the northeastern coast of Lake Kutubu; Turonian. Lateral and ventral views; x 1/2.

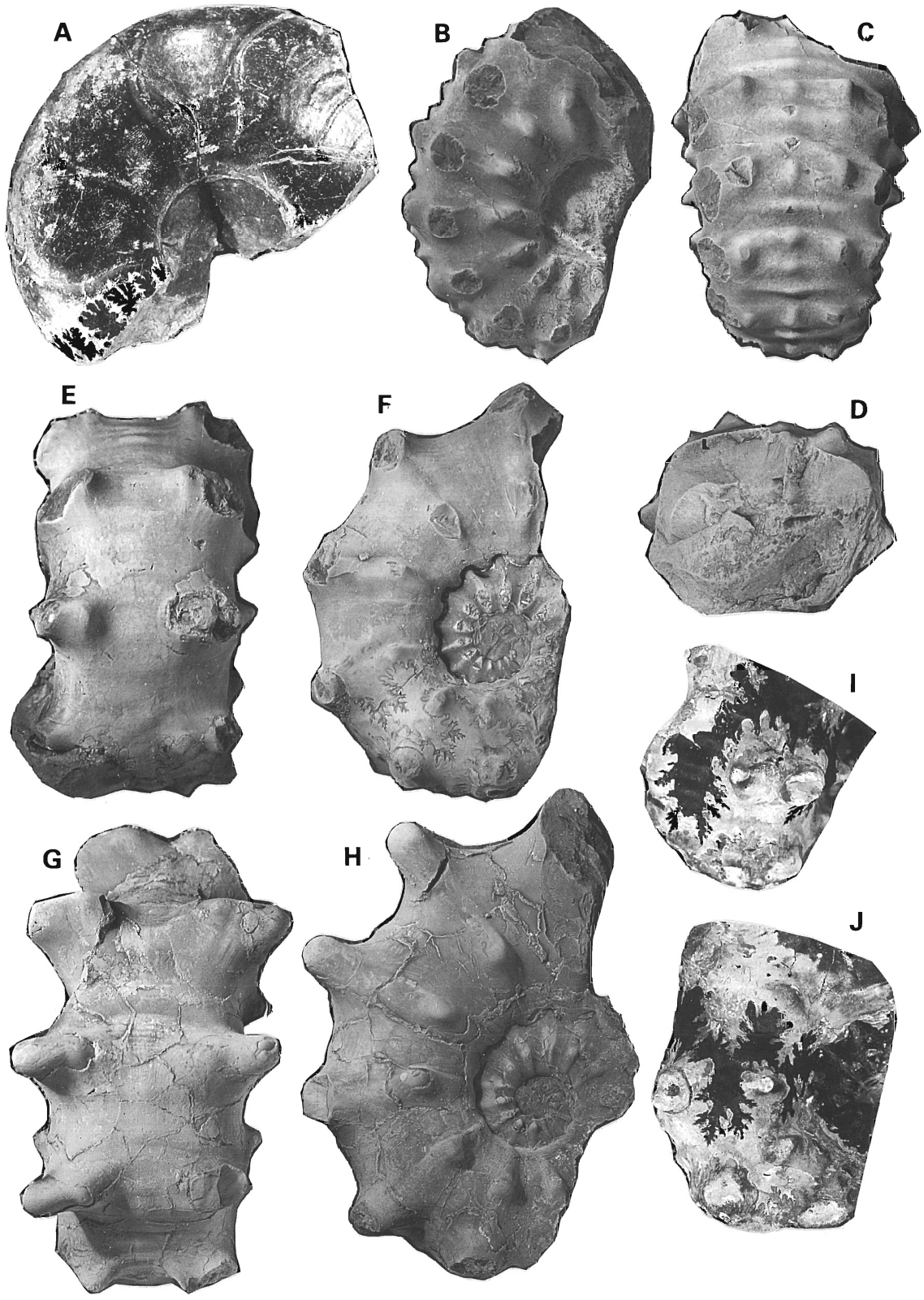


Figure 20. A. ***Desmoceras (Pseudouhligella)*** **aff.** ***ezoanum*** **Matsumoto** ***1941.***
CPC 16084; Lateral view; x 7/10.
B–J. ***Cunningtoniceras cunningtoni*** **(Sharpe 1856).**
(B–D) CPC 16075, juvenile; lateral, ventral, and end-on views; x 1.
E, F. CPC 16079, adult; ventral and lateral views; x 7/10.
G, H. CPC 16080,adult; ventral and lateral views; x 0.55.
I, J. CPC 16079, showing the last second suture with black and white: external lobe E and E/L saddle in I; lateral lobes L, U2 and auxiliary in J. All from locality 79 [= F 2148], Mingenda Dome, Chimbu — Mount Hagen area, Cenomanian.
B–H. coated with ammonium chloride.
A, I, J. not coated.

Lasswitz, R., 1904, — Die Kreide-Ammoniten von Texas (Collection F. Roemer). *Geologische und Palaeontologische Abhandlungen, Neue Folge,* 6, 223–359 (3–40), pls 13–20 [25–32] (1–8).

Le Hégarat, G., 1973 (for 1971), Le Berriasien de sud-est de la France. *Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon,* 43 (1), 1–308, pls 1–53.

Matsumoto, T., 1938, Preliminary notes on some of the more important fossils among the Gosyonoura fauna. Appendix in Matsumoto, T., 1938 — The geology of Gosyonoura islands, Amakusa. *Journal of the Geological Society of Japan,* 45, 13–24, pls 1, 2.

Matsumoto,T., 1941, A study of the inter-specific relationships, with special reference to the range of a fossil species. *Journal of the Geological Society of Japan,* 48, 17–37 (in Japanese, with table 1 and caption of fig. 4 in English).

Matsumoto, T., 1942, A note on the Japanese Cretaceous ammonites belonging to the subfamily Desmoceratinae. *Proceedings of the Imperial Academy (Tokyo)* 18 (1), 24–29.

Matsumoto, T., 1954a, Selected Cretaceous leading ammonites in Hokkaido and Saghalien. *In* Matsumoto, T. (compiler), 1954. The Cretaceous System in the Japanese Islands, Appendix 243–313, pls 1 (17) 20 (36). *Japan Society for the Advancement of Sciences, Tokyo.*

Matsumoto, T., 1954b, Family Puzosiidae from Hokkaido and Saghalien. *Memoirs of the Faculty of Science, Kyushu University, ser. D,* 5 (2), 69–118, pls 9–23.

Matsumoto, T., 1959, Upper Cretaceous ammonites of California Part II. *Memoirs of the Faculty of Science, Kyushu University, ser. D, Special volume* 1, 1–172, pls 1–41.

Matsumoto, T., 1966, A Cretaceous ammonite from the island Curasao, Netherlands Antilles. *Memoirs of the Faculty of Science, Kyushu University, ser. D,* 17 (3), 277–294, pl. 31.

Matsumoto, T., 1987, Note on Pachydesmoceras, a Cretaceous ammonite genus. *Proceedings of the Japan Academy ser. B,* 63 (1), 5–8.

Matsumoto, T., 1988, A monograph of the Puzosiidae (Ammonoidea) from the Cretaceous of Hokkaido. *Palaeontological Society of Japan Special Papers,* 30, 179 pp.

Matsumoto, T., 1991, On some acanthoceratid ammonites from the Turonian of Hokkaido. *Transactions and Proceedings of the Palaeontological Society of Japan, New series No.* 164, 910–927.

Matsumoto, T., Obata, I. & Kawashita, Y., 1985, Notes on some acanthoceratid ammonites from the Oyubari area, Hokkaido. *Bulletin of the National Science Museum, Series C (Geology & Paleontology),* 11 (4), 155–174. pls 1–8.

Matsumoto, T. & Skwarko, S. K., 1991, Ammonites of the Cretaceous Ieru Formation, western Papua New Guinea. *BMR Journal of Australian Geology & Geophysics,* 12 (3), 245–262.

Mazenot, G., 1939, Les Palaeohoplitidae tithoniques et berriasiens du sud-est de la France. *Mémoires de la Societe Géologiques de France, Nouvelle Serie* 18, *Memoire No.* 41, 303 pp., 34 pls.

Noda, M., 1969, Biostratigraphic study of the Onogawa Group, Kyushu. *Science Report of the Department of Geology, Kyushu University,* 10 (1), 1–10, pls 1–3 *(in Japanese with English abstract and caption of figures).*

Orbigny, A.d', 1840–1842, Paléontologie francaise; Terrains crétacés, 1, Cephalopodes, 1–120 (1840); 121–143 (1841); 431–662 (1842), 151 pls. *Paris.*

Pictet, F. J., 1867, Mélange paléontologiques, 2, *Geneve.*

Roman, F. & Mazeran, P., 1913, Monographie paléontologique de la faune du Turonien du bassin d'Uchaux et de ses dépendances. *Archives du Museum d'histoire naturelle de Lyon,* 12, 1–137, pls 1–11.

Sharpe, D., 1853–57, Description of the fossil remains of Mollusca found in the Chalk of England. I. Cephalopoda. *Palaeographical Society Monograph,* 68 pp., 27 pls. 1–27, pls 1–10 (1853); 27–36, pls 11–16 (1855); 37–68, pls 17–27 (1857).

Spath, L. F., 1922, On the Senonian ammonite fauna of Pondoland. *Transaction of the Royal Society of South Africa* 10 (3), 113–147, pls 5–9.

Spath, L. F., 1939, The Cephalopoda of the Neocomian Belemnite Beds of the Salt Range. *Memoir of the Geological Survey of India, Palaeontologia Indica, New Series* 25 (1), 1–154, pls 1–25.

Spath, L. F., 1952, Additional obsevations on the invertebrates (chiefly ammonites) of the Jurassic and Cretaceous of east Greenland II. *Meddelelser om Grønland* 133 (4), pls 1–4.

Stoliczka, F., 1863– 1866, The fossil Cephalopoda of the Cretaceous rocks of southern India. Ammonoidea with revision of the Nautildae. *Memoirs of the Geological Survey of India, Palaeontologia Indica, ser. I.* 3 (1), 41–56, pls 26–31 (1863); (2–5), 57–106, pls 32–54 (1864); (6–9) 107–154, pls 55–80 (1865); (10–13), 155–216, pls 81–94 (1866).

Thomel, G., 1972, Les Acanthoceratidae des chaines subalpines meridionales. *Mémoire Societe Géologique du France, Nouvelle Serie,* 116, 204 pp., 88 pls.

Uhlig, V., 1903–1910, Himalayan fossils. The fauna of the Spiti Shales. *Memoirs of the Geological Survey of India. Palaeontologia Indica, ser.* 15, 4 (1–3), 511 pp., 94 pls.

Welsh, A., 1990, Applied Mesozoic biostratigraphy in the Western Papua Basin. *In* Carman, G & Carman, Z. (editors): *Petroleum Exploration in Papua New Guinea. Papua New Guinea Chamber of Mines and Petroleum, Port Moresby*, 369–379.

Whitehouse, F. W., 1926, The Creataceous Ammonoides of eastern Australia. *Memoir of the Queensland Museum* 8 (3), 195–242, pls 34–41.

Wright, C. W., 1955, Notes on Cretaceous ammonites. — 1II. The phylogeny of the Desmoceratacеae and the Hoplitaceae. *Annals and Magazine of Natural History, ser.* 12, 8, 561–575.

Wright, C. W., 1963, Cretaceous ammonites from Bathurst Island, northern Australia. *Palaeontology,* 6 (4), 579–614, pls 81–89.

Wright, C. W. & Kennedy, W. J., 1984, The Ammonoidea of the Lower Chalk. Part 1. *Palaeontographical Society, London, Monograph* 1–126, pls 1–40 (Publ. No. 567, part of vol. 137 for 1983).

Wright, C. W. & Kennedy, W. J., 1987, The Ammonoidea of the Lower Chalk. Part 2. *Palaeontographical Society, London, Monograph* 127–218, pls 41–55 (Publ. No. 573, part of vol. 139 for 1985).

Wright, C. W. & Kennedy, W. J., 1990, The Ammonoidea of the Lower Chalk, Part 3. *Palaeontographical Society, London, Monograph* 219–294, *Pls.* 56–86 (Publ. No. 5858, part of vol. 144 for 1990).

Appendix

Stratigraphic terminology

For the readers who may not be acquainted with local formation names, the stratigraphic terminology of the Cretaceous Papuan Basin is concisely shown in Table 10 below, with some additional remarks.

Remarks. Correlation in the table below is approximate. The **Maril Fm** is mainly black shale. **Kondaku** is volcanogenic and is Early Cretaceous. **Kerabi** is part-volcanic-derived, sandy, and is Early to Late Cretaceous (including Cenomanian) and in part distal equivalent of Kondaku. **Chim** is mainly mudstone and is Late Cretaceous and may be in part distal equivalent of Kerabi. "Tubu Shale" was once used by field geologists but it was not defined clearly; hence it has not survived. Presumably it may have included a part of Maril or Chim or otherwise. The ages of units in Welsh's framework are based on a palynological zonation; J/K: Kimmeridgian–earliest Valanginian. K1: Valanginian–Early Aptian, K2: Late Aptian–Early Albian, K3: Middle Albian–Late Albian, K4: Early Cenomanian–Middle Cenomanian, and K5: Late Cenomanian–Turonian.

Table 10. Stratigraphic terminology of the Papuan Basin.

Formation name				*Sequence*	*Age*
S. Central P.N.G.		*Northwestern P.N.G.*		*(Welsh, 1990)*	
Wahgi Group	Chim	Feing Group	Ieru	K5	Late Cretaceous
	Kerabi			|	
	Kondaku		Toro	K1	Early Cretaceous
	Maril		Imburu	J/K	Late Jurassic