

## TRIASSIC AND JURASSIC GASTROPODS FROM THE MISOOL ARCHIPELAGO, EASTERN INDONESIA

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### ABSTRACT

The known gastropod fauna of Triassic and Jurassic ages from the Misool Archipelago is reviewed, based on collections made during a 1981 expedition jointly by personnel from the then-Geological Research and Development Centre, Bandung, and the Australian Bureau of Mineral Resources. The new material includes one new species, *Bathrotomaria foronica*, from the Yefbie Formation (Aalenian), and two undescribed but probably new species, a Rhaetian ?*Angularia* from the Lios Member of the Bogal Formation and a *Purpurina* of Aalenian or Bajocian age from the Yefbie Formation. In addition, other material from the Rhaetian Lios Member, too poorly preserved for generic identification, is allotted to the Subfamily Neritinae. Some forms recorded by earlier workers were not recollected but have been listed for completeness, giving a total of five described species and a further five in open nomenclature. Most taxa are unique to this area, but one, *Eucyclus orbignyianus* (Hudleston), is known also from Europe.

Ke words: gastropod, Triassic, Jurassic, Misool Archipelago, Yefbie Formation, Lios Member, Bogal Formation

### SARI

*Fauna gastropoda yang diketahui berumur Trias sampai Jura dibahas, berdasarkan koleksi-koleksi yang dikumpulkan tahun 1981 pada ekspedisi gabungan para ahli dari Pusat Survei Geologi (dahulu Pusat Penelitian dan Pengembangan Geologi), Bandung dan the Australian Geological Survey Organization/AGSO (dahulu Australian Bureau of Mineral Resources/BMR). Spesimen-spesimen jenis baru, Bathrotomaria foronica, dari Formasi Yefbie (Aalenian), dan dua jenis yang tidak terdeskripsi tetapi kemungkinan termasuk jenis baru, yaitu ?Angularia yang berumur Rhaetian dari Anggota Lios, Formasi Bogal dan Purpurina yang berumur Bajocian dari Formasi Yefbie. Sebagai tambahan, beberapa materi dari Anggota Lios yang berumur Rhaetian, pengawetannya sangat buruk untuk diidentifikasi sampai tingkat genus, dimasukkan ke dalam Subfamili Neritinae. Materi lainnya yang dikumpulkan oleh peneliti-peneliti terdahulu tidak terkumpulkan, tetapi didaftar untuk kelengkapan, menghasilkan jumlah keseluruhannya menjadi lima jenis yang dideskripsi dan lima jenis lainnya masih terbuka untuk dibahas. Hampir semua jenis yang ditemukan merupakan fauna khas untuk daerah ini, tetapi dua jenis di antaranya dikenali juga di Eropa.*

*Kata kunci: gastropoda, Trias, Jura, Kepulauan Misool, Formasi Yefbie, Anggota Lios, Formasi Bogal*

### INTRODUCTION

The archipelago of Misool lies in eastern Indonesia about 80 km west of the "Bird's Head" of Papua. Mesozoic strata occupy the southern region of Misool and adjacent islands, lying unconformably on a metamorphic basement complex and passing up into a marine Tertiary sequence. Since Mesozoic fossils were first reported from the area (Verbeek, 1900) many studies have sought to document the fauna, date the strata, and correlate them with others in the region and further afield.

The Mesozoic macrofauna has been found to be quite diverse and dominated by molluscs, especially bivalves and cephalopods, with subsidiary

brachiopods, corals, annelid worms and crinoids. The contemporary microbiota has been largely untouched although a few studies have been undertaken. As structural studies have progressed, particularly in the present era of the concept of plate tectonics, paleontologic and stratigraphic data have taken on even greater correlative and interpretative significance and Misool has been found to play a pivotal role in the interpretations.

It was in this climate that a re-examination of the Misool Mesozoic was undertaken in 1981 by a joint party from the Indonesian Geological Research and Development Centre (now the Geological Survey Institute - GSI), Bandung, and the Australian Bureau of Mineral Resources, Geology and Geophysics (now

Geology Australia), Canberra, including the senior author, who later studied the macrofossils from the expedition (except the coleoid cephalopods), which, despite the large number of earlier studies, included many forms not previously recorded from Misool.

The only macrofossil group to have been so far intensively documented since this field study has been the belemnites (Challinor, 1991), with the Brachiopoda presently under examination (MacFarlan *et al.*, in prep.). In addition, preliminary studies on some of the microbiota have been undertaken (dinoflagellate floras by Helby & Hasibuan, 1988, and Triassic ostracodes by Kristan-Tolmann & Hasibuan, 1990).

The present work represents the first of a series dealing with the Mesozoic gastropods and bivalves collected during the 1981 field visit, and covers the Late Triassic to Middle Jurassic gastropods; the 1981 expedition collected none of other ages. One Jurassic species of gastropod was reported by Soergel (1913) and again by Wandel (1936), and five Late Triassic species by Jaworski (1915); here we add a further four. No Cretaceous species is yet known from Misool.

The collection, including type specimens, is held in the GSI. Fossil localities are referred to by the field number allotted at the time of collection (a running number prefixed by 81FH), and individual specimens are listed in the GSI macrofossil catalogue (a running number prefixed by IMC).

## REGIONAL GEOLOGY

The geological mapping of Misool Archipelago was carried out by a joint party from Geological Survey Institute (formerly Geological Research and Development Centre/GRDC), Indonesia and Australian Geological Survey Organization/AGSO (formerly Australian Bureau of Mineral Resources), Australia and they have produced a geological map (Rusmana & Hartono, 1983). The results of this study will contribute to a better understanding of the lithology and their faunas and geological history of this part of Indonesia which bears most complete sequences of Mesozoic strata and will be useful as a reference section for adjacent areas. The area studied and distribution of localities yielding the molluscs reported in here are shown in Figure 1. A geological map of the studied area is shown in Figure 2 and the horizons of the localities yielding the present species are shown in Figure 3. Gastropods in these formations are rare and difficult to extract.

Formations cited herein are part of the lithostratigraphic scheme proposed for the Misool Mesozoic by Pigram *et al.* (1982a, b) and by Simbolon *et al.* (1984). Although Mesozoic strata on Misool cover the interval from Middle Triassic to end-Cretaceous, lacking only Lower Jurassic rocks, gastropods have come from only two units, the Late Triassic Bogal Formation, mostly carbonates, and the mid Jurassic Yefbie Formation, of shales and fine sandstones.

The oldest rocks (basement) of the Misool Archipelago is metamorphic rocks Kemum Formation (Siluro-Devonian) which overlain unconformably by a turbiditic origin the Keskain Formation (Anisian to Ladinian), and in turn overlain unconformably by limestone of the Bogal Formation (Carnian to Late Norian) and its Lios Member (Late Norian). The Jurassic rocks are grouped into Fageo Group consists of Yefbie Formation (Late Toarcian to Late Callovian), Demu Formation (Late Callovian to Late Oxfordian), and Lelinta Formation (Late Oxfordian to Late Tithonian). This study dealt only with Lios Member of the Keskain Formation (Triassic) and Yefbie Formation (Jurassic) where the gastropod fauna were collected. Gastropods in these formations are rare and difficult to extract.

## METHOD

The morphologic terms used here are largely those of the appropriate volumes of the Treatise on Invertebrate Paleontology (Cox, 1964), whilst classification of the Gastropoda follows that of Bouchet & Rocroi (2005), in which all traditional classificatory levels below Class and above Superfamily are replaced by the single level "Clade" without citation of any authority.

Full lists of the macrofauna of each formation are still to be provided. Age allocations will also be argued in detail later. It should be noted that the Rhaetian Stage is used as the youngest division of the Triassic following the decision of the Subcommittee on Triassic Stratigraphy (Krystyn, 1990).

All linear measurements are given in millimetres (mm); D = maximum diameter of the body whorl and H = overall anteroposterior length of the shell. Abbreviations used throughout for type species designation are OD (by original designation) and SD (by subsequent designation), In keeping with the ruling of most journal editors, references are not given for publication citations for the various levels in the classificatory hierarchy.

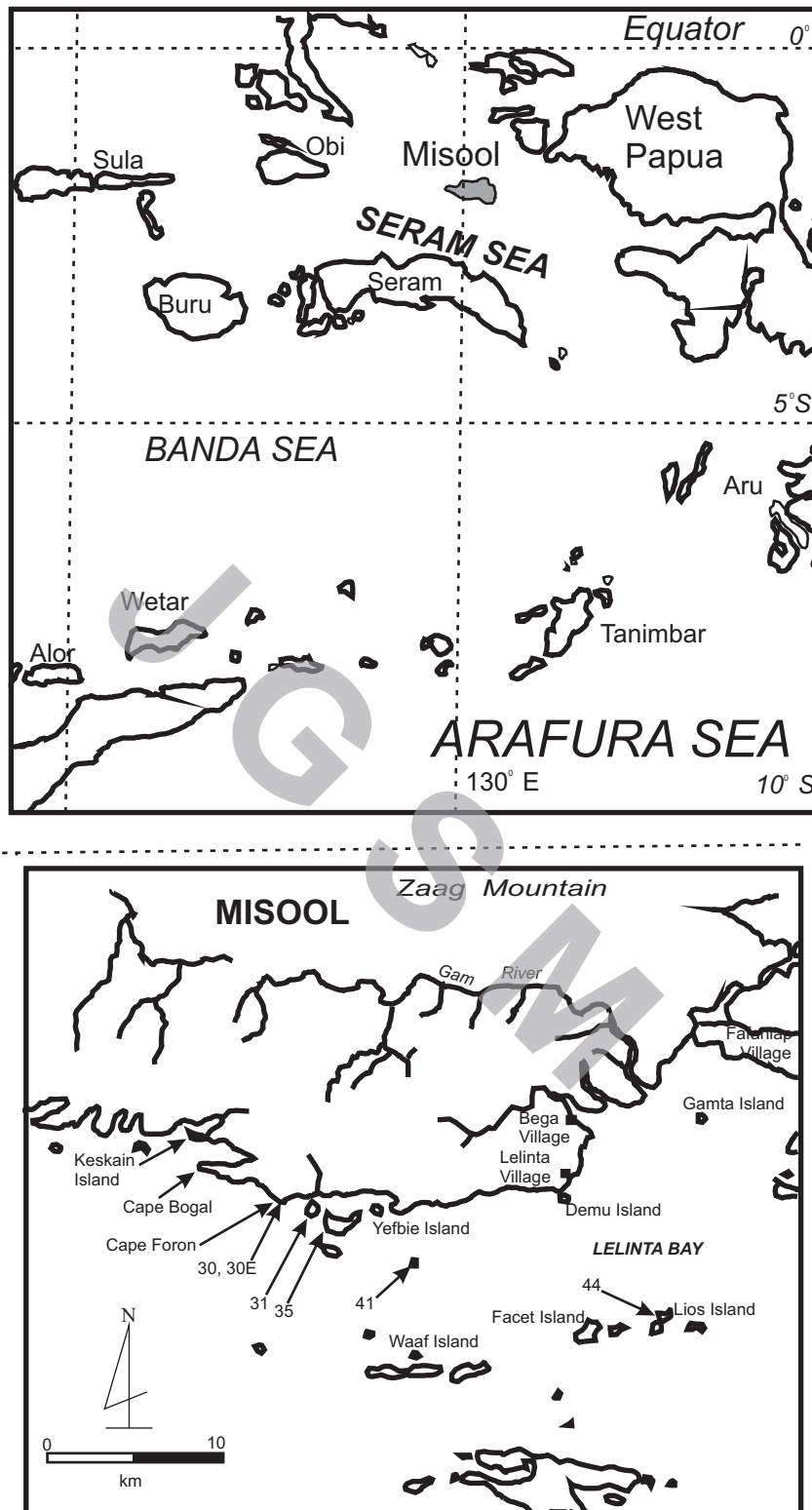


Figure 1. Locality maps for the Misool Archipelago and for collection sites which have yielded the specimens discussed herein.

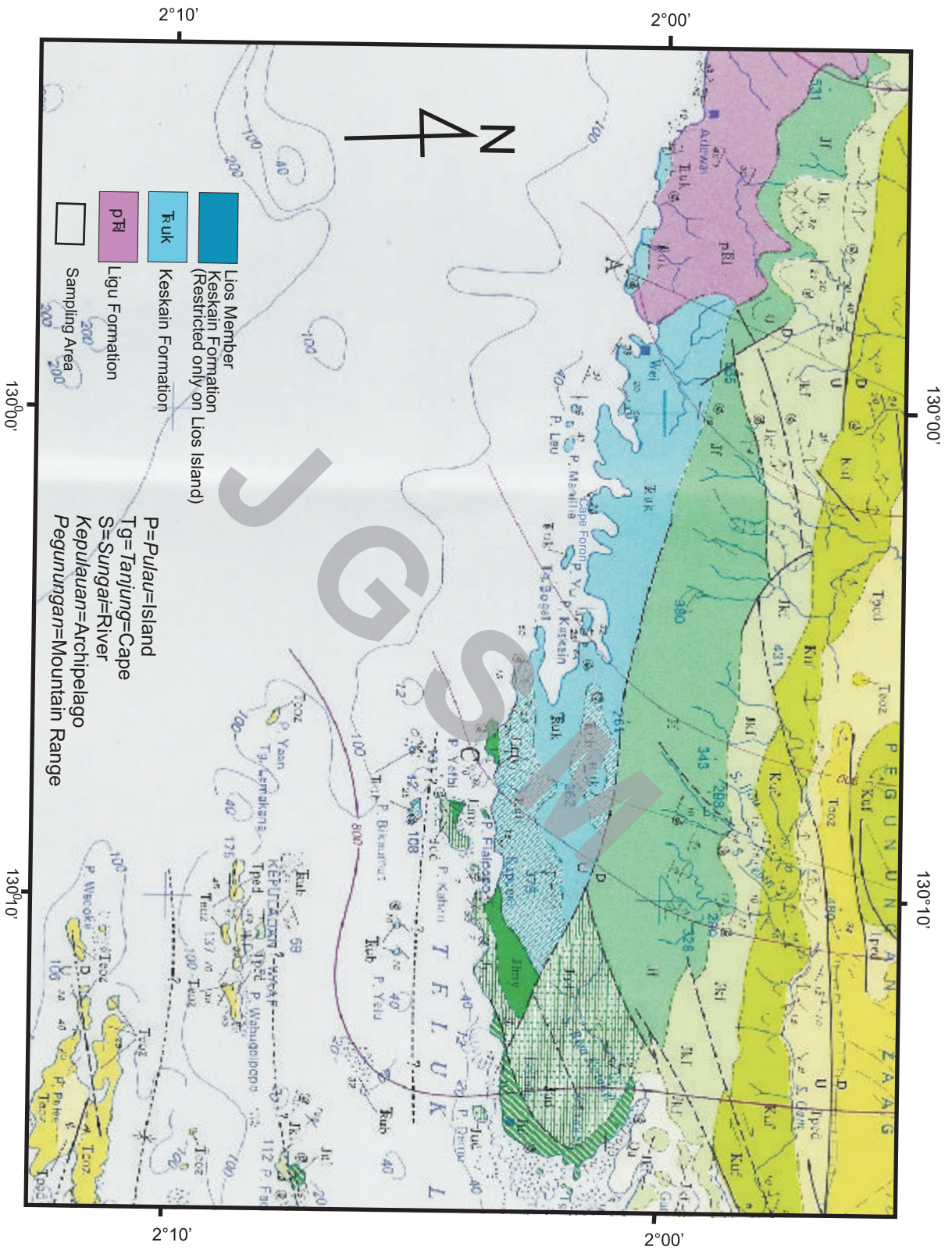


Figure 2. Geological map of Misool Archipelago. (after Rusmana et al., 1989, 1:250,000 scale).

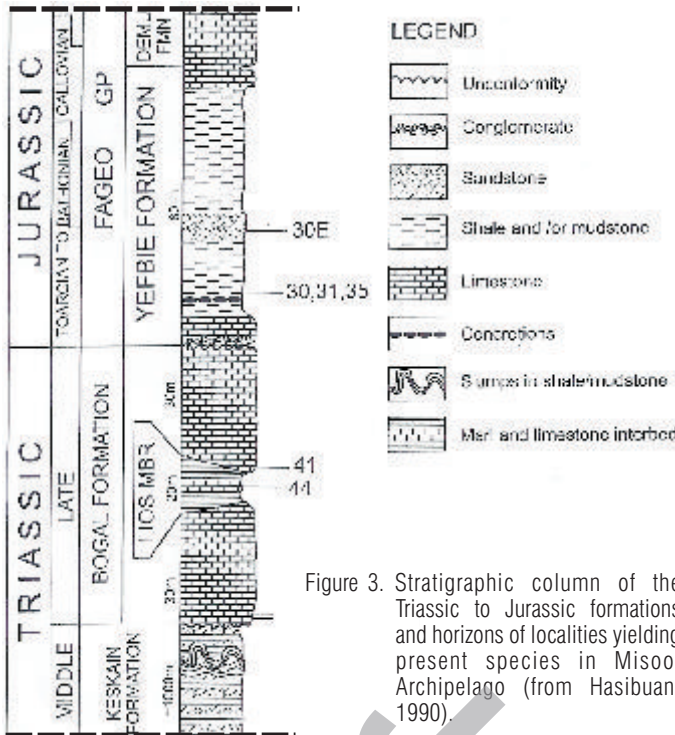


Figure 3. Stratigraphic column of the Triassic to Jurassic formations and horizons of localities yielding present species in Misool Archipelago (from Hasibuan, 1990).

**DISCUSSION**

**Systematic Paleontology**

- Phylum Mollusca
- Class Gastropoda Cuvier, 1797
- Clade Vetigastropoda
- Superfamily Pleurotomarioidea Swainson, 1840
- Family Pleurotomariidae Swainson, 1840
- Genus *Bathrotomaria* Cox, 1956
- Type species: *Trochus reticulatus* J. Sowerby, 1821;  
OD. Kimmeridgian, England
- Bathrotomaria foronica* n.sp.**

**Pl. 1, Fig. 1 - 5.**

**Etymology:** Named for Cape Foron, Misool Island, where this specimen was collected.

**Material:** Holotype: IMC 1057, a moderately well preserved conch lacking the apex and having suffered slight lateral compression.

**Dimensions:** (mainly estimates, in an attempt to eliminate effects of damage and distortion): D ~ 48; H ~ 32; height of aperture: 12; width of aperture: 23; spire angle (normal to direction of compression, and thus least deformed): 110°.

**Description:** Shell of moderate size, depressed trochiform, with gradate spire and rounded body whorl; spire whorls angled below middle to produce broad sloping ramp and low flat whorl face,

angulation fading (on this specimen) approximately one full volution before aperture by rounding of ramp, whorl face and angle between; no indication on body whorl of second angulation but flattened form of spire whorls implies possible presence in subadult condition and if present is overlapped by each succeeding whorl. Base rounded, moderately phaneromphalous. Selenizone clearly apparent only on body whorl near aperture, as narrow convex zone bordered by raised confluent growth lines and occupying periphery of whorl; on spire whorls appears that upper (posterior) ridge or thread bordering selenizone forms angulation of whorls. Sculpture of spiral chords of two orders, 4 - 5 primaries on spire ramp with intercalated much finer secondaries, 2-3 primaries on whorl face (presence of secondaries not demonstrated); on base c. 20 stronger primaries of slightly varying strength spaced about own width apart with fine secondaries in

at least some interspaces; umbilicus seems free of spirals; axial sculpture on spire consists of colabral rows of gemmules on spiral threads, larger on primary spirals than on secondaries, c. 50 - 60 rows on penultimate whorl, with strength and spacing rather variable; on body whorl gemmules broaden and fade and not discernable on final half whorl; base shows no axial sculpture, only irregular colabral growth lines. Aperture oval, broader than high, probably with short excavated columella.

**Remarks:** Even though a highly diverse group, Pleurotomarias are seldom common members of individual Mesozoic faunules. Consequently there is greater justification for formally naming a taxon based on a solitary specimen in this group, so long as that specimen is adequately preserved. We believe that this is the case here and choose to erect a new taxon rather than await the unlikely collection of a significantly larger population.

Location in *Bathrotomaria* is indicated by the gradate early shell form with a broad ramp, ornament of dominant spiral type, and location of the selenizone at the whorl angulation. An alternative of placement in *Pleurotomaria* is less comfortable because of the narrow selenizone and lack of shoulder tubercles. The type species, English Kimmeridgian *B. reticulata* (Cox, 1964) is higher spired, with a more sloping ramp and flattened periphery.

*Pleurotomaria barrottei* Cossmann (1907) from the Callovian of Haute-Marne, France, closely resembles the Misool specimen both in ornamentation and coiling but differs slightly by having stronger nodes in the apical region. The present specimen differs from *P. montreuilensis* Heb (Thiery & Cossmann, 1907), also from the French Callovian, by having a rounded basal edge.

*Bathrotomaria jurensis* (Hartmann) of the European Upper Jurassic (e.g. Janicke, 1966) has the form of our species but lacks its heavier gemmules and may have a deeper umbilicus. *B. aitkeni* of the Tanzanian Kimmeridgian (Cox, 1965) has comparable basal ornamentation but a more angled periphery and more conical, less gradate spire profile.

None of the pleurotomarias recorded by Krumbeck (1924) from the Triassic of Timor show any close similarity to *B. foronica* and, in fact, of the six forms illustrated, only "*Pleurotomaria (Wortheria) escheri* var. *timorensis*" Krumbeck may possibly be referable to *Bathrotomaria*.

Occurrence and Age: This specimen was found in the lower part of the Yefbie Formation at Cape Foron, locality 81FH30, in the *Bredyia* horizon, and is thus Aalenian.

Superfamily Seguenzioidea Verrill, 1884

Family Eucyclidae Koken, 1896

There has been considerable recent discussion concerning the classification of the Eucyclidae, with Szabo (1995) and Conti & Monari (2001) placing it in a Superfamily Eucycloidea, which they had accepted as being validly separable from the Trochoidea, whereas Bouchet & Rocroi (2005) relate it more closely to the vetigastropod Family Chilodontidae. We here follow the latter decision.

Genus *Eucyclus* Eudes-Deslongchamps, 1860

Type species: *E. obeliscus* Eudes-Deslongchamps, 1860; OD. Middle Liassic, France

***Eucyclus orbignyana* (Hudleston, 1892).**

**Pl. 1, Fig. 6 - 9.**

1892. *Amberleya orbignyana* Hudleston: 285, pl. 22, fig. 7-8  
 1909. *Eucyclus orbignyana*, Brösamlen: 262, pl. 20, fig. 16  
 1913. *Amberleya* aff. *orbignyana*, Soergel: 607, pl. 23, fig. 2a-c

1915. *Eucyclus orbignyana*, Cossmann, 54  
 1936. *Eucyclus* aff. *orbignyana*, Wandel, 499  
 1946. *Amberleya orbignyana*, Gardet & Gerard: 36, pl. 3, fig. 16-18

Material: There are 2 specimens from locality 81FH30, 11 specimens from locality 81FH31 (including IMC1058), and 14 specimens from locality 81FH35 (including IMC1059). Most exteriors are covered by a hard matrix of calcareous shale, and most specimens are a little flattened.

Dimensions: Most apices and apertures are broken, making it difficult to obtain precise measurements. Table 1, however, covers the best preserved members of the collection.

Table 1. Measurements (in mm) for Specimens of *Eucyclus orbignyana* (Hudleston, 1847) from Misool.

Specimen No.	D.	H	Apertura Height	Apertural Width
35.1	23	40	16	c. 10
35.2	23	c. 40	-	-
35.3	21	c. 37	16	11
35.4	16	37	14	-
35.5	17	c. 30	-	-
IMC1059	c. 20	c. 37	c. 15	c. 10
35.7	c. 17	c. 31	-	-
35.9	16	31	12	c. 7
35.10	16	c. 27	c. 10	c. 8
35.11	15	c. 28	c. 10	c. 7
35.12	14	25	9	c. 6
35.13	c. 15	26	-	-

Description: Shell of medium size, biconic, anomphalous, with moderately thick shell material; of at least six inflated whorls (apex not preserved); in some specimens whorls increase rather more rapidly in size than in others, so that some appear more attenuate than others. Columella lip more or less straight and vertical, its margin commonly meets basal lip in angle or spout-like protrusion. Penultimate whorl carries 2-3 spiral ridges, uppermost situated at about mid-whorl (slightly above in some, slightly below in others), lowest short distance above and overhanging inconspicuous suture and rather less prominent than the other one or two.

Final whorl bears 6 - 7 sharp, narrow, spaced spiral ridges which gradually decrease in size anteriorly on base, upper two are being equally prominent or with

lower sometimes slightly stronger. Posterior ridge occurs rather more than third of distance from suture and ramp slightly concave in some specimens, flat in others.

Coarser growth lines regular and sharp, somewhat foliaceous, producing series of sharp tuberculations on spirals in some specimens; on others growth lines smooth, possibly due to abrasion; on others seen as crowded lirae in interspaces between spirals. Growth lines and lirae smoothly concave adaperturally on ramp and between spirals with slight forward (prosocline) inclination overall. Aperture not always seen, but in specimens with outline (cast) preserved, seen to be oval to pyriform, higher than wide, with blunt posterior angulation, outer lip smoothly rounded.

Remarks: These specimens seem to fall all into the one species. It is better placed in the genus *Eucyclus*, which possesses ornament of spiral carinae. The species was originally described from the Middle Jurassic of England by Hudleston (1892) and recorded as *E. aff. orbignyanus* by Soergel (1913) and Wandel (1936) from Misool. Specimens from the Bajocian of the Moroccan Atlas, identified as Hudleston's species by Gardet & Gérard (1946), are very similar to ours except that there are one or two fewer spirals on the base, but unfortunately the authors do not describe precise details of the ornament. The British material figured by Hudleston (1892) shows some of the same morphological variation seen in the Misool collection, such as the spire-whorl profile below the peripheral spiral being parallel in one (Hudleston's pl. 22, Fig. 7; our Pl. 1, Fig. 6) and anteriorly converging in another (Hudleston's pl. 22, Fig. 8 - 10; our Pl. 1, Fig. 7, 8). Our specimens (e. g., Pl. 1, Fig. 8, 9) may be a little more elongate than those figured by Hudleston (1892), and their spirals have less prominent nodulation, but the number of these spirals, their strength variation on the base of the shell, and the fine but obvious axial lirae over the shell are the same in both sets of specimens.

Our material is very close to *E. pacificus* Jaworski (1922) from the Triassic of South America. *E. subtiliscostatus* Gründel (2001a), from the Andean Hettangian, has the same axial sculpture as this species, but spirals on the spire whorls are more spaced and the base more flattened. *Amberleya zealandica* Trechmann (1923) from the Callovian-Oxfordian of New Zealand resembles the Misool

specimens, but the ramp is perhaps more steeply inclined to the shell axis and the basal region is less inflated; in addition, Trechmann's type specimen and those in the collection of the University of Auckland Geology Programme are but half the size of the Misool specimens.

Occurrence and Age: *E. orbignyanus* comes from the lower part of the Yefbie Formation, with an Aalenian fauna including the *Fontannesia* ammonite assemblage. It has a similar age in Europe and Morocco (Gardet & Gérard, 1946).

Clade Cycloneritimorpha

Superfamily Neritoidea Rafinesque, 1815

Family Neritidae Rafinesque, 1815

Subfamily Neritinae Rafinesque, 1815

**Neritinae gen. et sp. indet.**

**Pl. 2, Fig. 1, 2**

Material and Remarks: Three poorly preserved specimens, largely steinkerns, have dimensions of H > 18, D = 21.3 (IMC 1060); H = 25, D = 27; and H = 25, D = 24. Shell material is thick and shells are globular, with spire about one third of the total height, unsculptured, apparently non-umbilicate, with a channelled suture, and an oblique 'D'-shaped aperture. The outer lip is slightly prosocline. Protoconch and columellar are not seen.

These features invite allocation to the Nerinidae, although the presence or absence of inner lip callus or denticulations on the columella cannot be determined. The spire is rather more protuberant than is found in the Neritopsidae. Within the Neritinae these shells could fit in *Neritaria* Koken or one of a small number of other smaller genera. No member of this group has previously been reported from the Misool Triassic.

Age and Location: These shells come from locality 81FH41, on Yellu Island, within the Bogal Formation immediately above the Lios Member, and are judged to be of Rhaetian age from their position above the *Rhabdoceras/Cochloceras*-bearing Lios Member and below the unconformity at the base of the Jurassic sequence.

Clade Hypsogastropoda

Superfamily uncertain

Family Coelostylinidae Cossmann, 1908

Bouchet & Rocroi (2005) state that the placement of this family is uncertain and could be either Cerithioidea or Littorinoidea.

Genus *Coelostylina* Kittl, 1894

Type species: *Melania conica* Münster, 1841; OD;  
Carnian, St Cassian, Italy

***Coelostylina* sp. cf. *C. similis* Münster, 1841**

cf. 1841. Münster, in Goldfuss

cf. 1915. *Coelostylina similis*, Jaworski, 125, pl. 45,  
fig. 6-8 (and references therein).

non 1978. *Oonia similis*, Zardini, 46, pl. 30, fig. 10.

Material and Remarks: We have five specimens ranging from 16 mm to 28 mm high (lacking the apical ~2 mm), the body whorl occupying half that amount, and with 3 - 4 gently rounded spire whorls and an obliquely oval slightly angled aperture. No specimen shows any indication of ornament or umbilicus. The fossils are rolled and decorticated, but retain enough detail to enable us to relate them with some confidence to the above species. Jaworski (1915) recorded three species within *Coelostylina* from the Misool 'Nucula-Mergel': *C. wanneri* is more attenuate than our specimens and has a relatively shorter body whorl, and *Coelostylina* n. sp. is more squat and with a much more inflated body whorl. Our specimens have the proportions of *C. similis*. Those which are more fully decorticated show the same shell remnants at the suture as shown by Jaworski (1915, pl. 45, fig. 7).

The type of this genus, *C. conica*, is significantly less attenuate than *C. similis* (see, e.g., Bandel, 1992) but shows the same lack of ornament, impressed sutures that make the shell slightly gradate, and an oval aperture slightly angled posteriorly, but unfortunately our material does not show protoconch or narrow umbilicus. Nützel & Senowbari-Daryan (1999) point out that although the generic diagnosis for *Coelostylina* includes its members being phaneromphalous, for many species the presence of an umbilicus has not been demonstrated. These authors also comment that one feature apparently typical of the genus is the presence of incised sutures with shouldered whorls. Our material certainly appears to have the incised sutures, but the state of preservation does not show clearly if the whorls are shouldered or not (and figures of *C. conica*, including in Nützel & Senowbari-Daryan 1999, show the shoulder to be very narrow). At this stage we see no basis for altering the generic placement of this species.

Jaworski's (1915) synonymy list for the species shows that some earlier workers have included it in the genus *Oonia* Gemmelaro. Zardini (1978) figured

a shell from the Ladinian-Carnian St Cassian Formation, Italy, under the name *Oonia similis*, but it is rather more gradate in spire outline, with less inflated whorls, with a clear inner lip callus, and is not believed to be conspecific with the Misool material.

Location and Age: Specimens come from locality 81FH44 in the Lios Member of the Bogal Formation, Lios Island, with a Rhaetian age indicated by the presence of the ammonoids *Rhabdoceras* and *Cochloceras*.

Clade Littorinimorpha

Superfamily Littorinoidea Children, 1834

Family Purpurinidae Zittel, 1895

Genus *Purpurina* d'Orbigny, 1853

Type species: *Purpurina bellona* d'Orbigny, 1853 (OD);  
Bathonian, France

***Purpurina* sp. (?n. Sp.)**

**Pl. 2, Fig. 3, 4.**

Material: One well preserved but incompletely exposed specimen (IMC1061) from locality 81FH35, in the Yefbie Formation at the western end of Yefbie Island.

Description: Of small to medium size; at 22.8 mm high and 15.5 mm maximum diameter, it is probably adult, or nearly so, but lacks the protoconch. The spire, 12 mm high, with an apical angle of 45°, consists of 3 + gently inflated whorls, each whorl with a very narrow posterior ramp and shoulder nodulated by 13 prominent, rounded, upright axials with wider interspaces. Axials are crossed by weaker narrow spirals, 9 on spire whorls up to the shoulder, with angled crests and interspaces of the same width. Axials and spirals continue onto the bodywhorl, with at least 5 spirals on the base. The shoulder is too poorly exposed to see spirals, but axials appear to reach the suture; anteriorly the axials rapidly weaken on the base and fade out before reaching the anterior. The aperture is obliquely oval, slightly angled posteriorly and rounded anteriorly, without sign of an anterior canal.

Remarks: This genus has not previously been reported from the Misool Mesozoic, nor elsewhere in the Triassic-Jurassic of the Indonesian archipelago or southwest Pacific. Even without the confirmation of the protoconch and the absence of spirals on the ramp, this shell is, however, confidently placed in *Purpurina*. The modest size, angled shoulder, and combination of rounded axial ornament and



subsidiary finer spirals which overtop the axials attests to this placement. The genus, which ranges from the Ladinian to Tithonian, has many representatives in Middle Jurassic strata, especially in the western Tethys.

This specimen differs from most others in the extreme narrowness of the ramp, so that the shoulder is more posteriorly placed, and the spire profile is not gradate as, for instance, in the Callovian *P. coronata* of Europe or *P. formosa* of Russia and Poland (v. Kaim, 2004). The axials begin to weaken at about the level of the suture, as also in these two species and in *P. formosiformis* from the Callovian of the Russian platform (Gründel, 2005). One species that does have a similarly narrow ramp is *P. cancellata* Hudleston, from the English and French Bajocian (v. Cossmann, 1913), which is also of similar size to our specimen, but has a wider spire angle, more axials, which are prosocline. Another is *P. rotunda* from the British Middle Jurassic (Hudleston 1888) which, however, has a larger more inflated body whorl and more closely spaced axials.

Our specimen has fewer axials folds than other known Jurassic species; there are, for instance, 15 axials in *P. formosa*, *P. formosiformis*, and in the north German Callovian *P. condensata* (v. Gründel, 2001b), and more in other species. The number of spirals on the body whorl of the Misool shell is about the same as on most species, but it shows 7 or 8 on spire whorls, whereas all other Jurassic species but *P. inflata* (Callovian of northeast Germany) have 6 or fewer; in *P. inflata* there are 6 or 7 (Gründel, 1997b), but this species also has 19 axials that fade on spire whorls before reaching the anterior suture.

This shell does not compare closely with any other known species and appears to be new. It differs from species of the related genus *Angularia* Koken by its significantly lower spire.

Occurrence and Age: The specimen came from locality 81FH35, in the Yefbie Formation at the western end of Yefbie Island. The presence of members of the *Fontannesia* association and *Chondroceras* and of *Bredya* at localities along strike from this site indicates an Aalenian or Early Bajocian age.

Genus *Angularia* Koken, 1892

Type species: *Turbo subpleurotomaria* Münster, 1841 (OD); Carnian, Italy

?*Angularia* (n.) sp.

Pl. 2, Fig. 5 - 7

Material: Three shells (IMC1062 - 1064, largest to smallest); the two larger are slightly compressed in the plane of the aperture, well preserved but incompletely exposed. All have epifaunal annelid worm tubes (*'Serpula' segmentata* Dumortier) attached to body and spire whorls; two have in addition small cemented right valves of the plicatulid *Atreta* Étallon on the body whorl, 12 on the larger shell, one on the smaller. They come from the Lios Member of the Bogal Formation on Lios Island.

Description: Shell of medium size, to H ~ 53, D ~ 35, apical angle ~ 65°, almost biconic. Spire and body whorl of about equal height, spire of 5+ whorls (on largest specimen), slightly stepped but not gradate, spire whorls gently rounded, suture unseen; protoconch not preserved. Aperture pyriform, higher than wide, broadly rounded anteriorly, angled posteriorly, outer lip and growth lines slightly prosocline, columella slightly excavate. Base rounded, anomphalous, merging smoothly with the whorl flank. Anterior suture and posterior zone of whorls hidden by hard matix, so that form of the suture and the nature of any ornament anterior to it are not visible; however, there does seem to be an indistinct shoulder close to that suture. Ornament of dominant spiral ribs of varying strength made gemmate where they are crossed by subordinate low, broadly rounded axials spaced their own width apart; 30 - 35 axials/whorl, beginning at or near the posterior suture and fading out over the base; 8 - 9 spirals between shoulder and anterior suture on spire whorls and apparently a similar number on the base.

Remarks: *Angularia* Koken is characterised by a biconic profile, subsutural ramp, pyriform aperture, and spiral and/or axial ornament. The type species, *A. subpleurotomaria* (Münster) from the Italian Carnian (v., e.g., Zardini, 1978; Bandel, 1994), has a wider excavated ramp, opisthocline axials, and weaker spirals than the Misool specimens, and has an umbilical chink, but other species are anomphalous and possess orthocline axials (*A. rectecostata* Nutzel & Erwin, 2004). *A. pleurotomaria* (Münster) has both spiral and axial sculpture, but axials are not nodulated where crossed by spirals. No other species has the very narrow subsutural ramp apparent on our specimens which thus take on a much more rounded rather than angulated outline. Lack of the protoconch prevents their closer comparison with this genus, but they can be tentatively accommodated here more readily than elsewhere.

Gründel's (1998) genus *Tripartella* (type: *T. compacta* Gründel, German Callovian), in the purpurinoid family Tripartellidae, is characterised by a similar outline and apertural features to those of our material, and has a comparable combination of sculptural elements. The images presented by Gründel (1998) show the 15 - 16 axials to be very nearly orthocone, whereas he later (2001b) figures under the same name a shell with 18 markedly opisthocline axials; in this paper he also describes a second species, *T. procera*, from the north German Bajocian, which is rather more attenuate and has ~ 13 axials that are only gently opisthocline. In both species the axials on spire whorls are more prominent than the spiral elements, thus differing from our material, but on the body whorl of *T. compacta* (Gründel, 1998, pl. 8, fig. 1, 2) spirals become dominant. Despite some close similarities the Misool specimens cannot readily be included in *Tripartella* because they are more than an order of magnitude larger.

Other genera with similar ornament are the *Eucycloscala* Cossmann (1895) (type: *Trochus binodosus* Münster, Carnian, Italy) and *Maturifusus* Szabo (1983) (type: *M. densicostatus* Szabo, Middle Jurassic, Hungary), but our material is excluded on the basis of its lack of an anterior canal which is short in *Eucycloscala* but longer in *Maturifusus* (v. Gründel, 1998, 2000, 2001b).

This taxon is also newly recorded from Misool.

Location and age: Locality 81FH44, in the Lios Member of the Bogal Formation at the western end of Lios Island; Rhaetian, from the ammonoid fauna (see earlier).

Clade Heterobranchia

Informal Group Lower Heterobranchia

Superfamily Mathildoidea Dall, 1889

Family Mathildidae Dall, 1889

Genus *Promathilda* Andreae, 1887

Type species: *Cerithium bisertum* von Münster, 1841, SD (Nützel & Erwin, 2004). Late Triassic, Italy

***Promathilda* sp. cf. *P. pacifica* Jaworski, 1915**

cf. 1915. *Promathilda pacifica* Jaworski, 130, pl. 45(3), fig. 11.

Material and Remarks: One poorly preserved adult shell of ~8 whorls lacking apex and much of the shell material of the whorls; for this specimen H = 32, D = 14, and it has an apical angle of 30°. There is also a juvenile shell of five whorls with H = 16.6, also

lacking the protoconch but with more of the shell material preserved. The shells are turreted, with evenly and shallowly rounded whorl faces and prominent sutures, a subquadrate aperture and gently swollen base. No sculpture is seen on whorls or base, but the overall features show a close similarity to Jaworski's (1915) species.

We follow Schröder (1995) in accepting that the correct spelling of the generic name is "*Promathilda*", although a few authors continue to use the alternative (e.g., Kaim, 2004). The genus has been subjected to considerable revision in recent years, with various species split off into new genera (e.g., Gründel 1973, 1997a; Schröder 1995; Bandel, 1995), especially based on differences in protoconch and sculpture, with *Promathilda* characterised by an immersed heterostrophic low helical protoconch, as in *Mathilda* Semper. *P. biserta*, the type species, has one or two dominant spiral ribs on the early teleoconch whorls, crossed by minor axial elements (e.g., Bandel, 1995); axials may be very faint or quite prominent (e.g., Gründel, 1997a; Kaim, 2004); in *Mathilda* axial ornament is very weak and not nodular. The aperture in *Promathilda* is angled posteriorly, whereas it is rounded in *Mathilda* (see discussion by Nützel & Erwin, 2004).

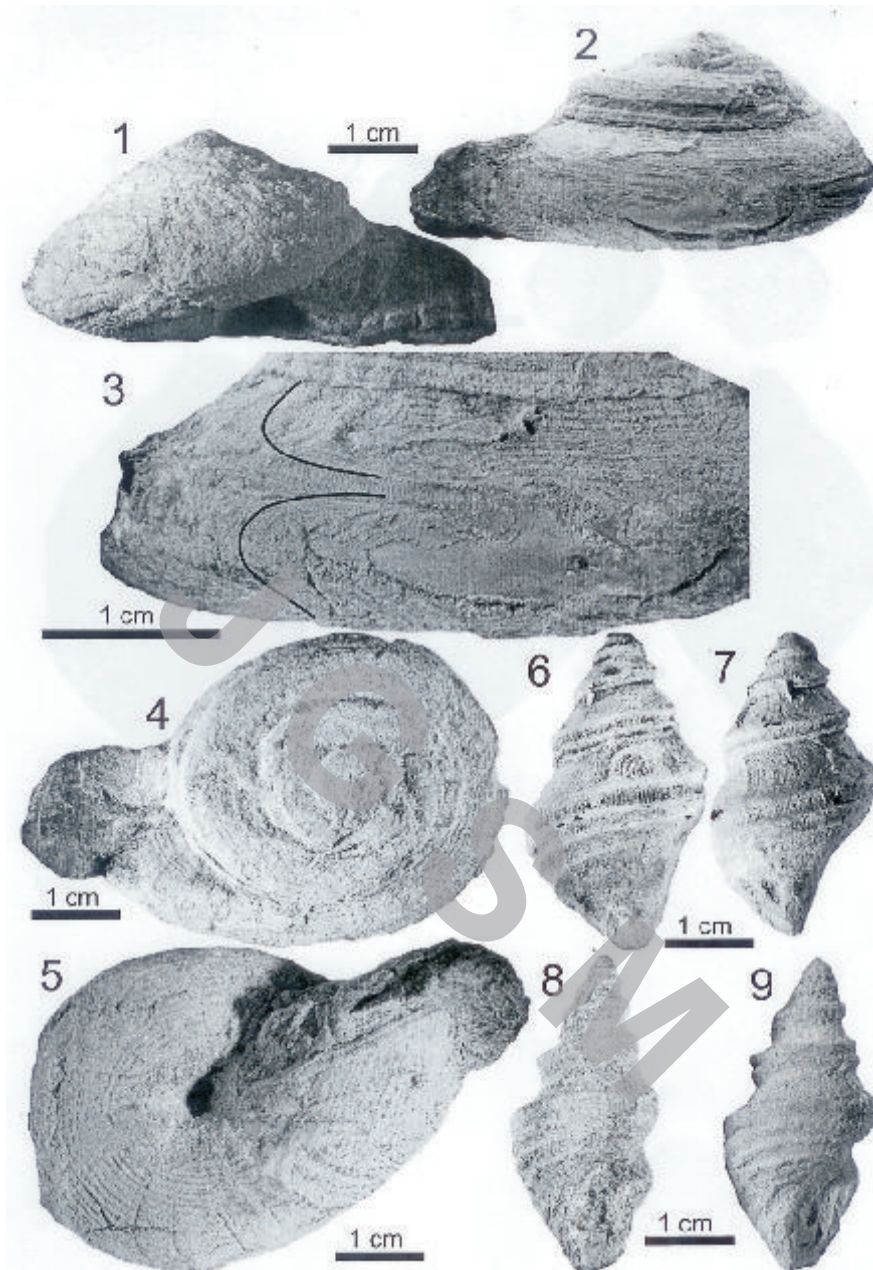
This is a large genus, with some 60 Triassic species currently included. Jaworski's (1915) species has not been mentioned in association with any of the new genera, so it would appear that authors have either ignored it or have accepted its allocation to *Promathilda* in its modern narrower sense.

Jaworski's figures (1915) are of better preserved shells than those to hand and, whilst they do not show protoconch features, they do show sculptural details that allow retention in *Promathilda*, with a strong single spiral carina on each whorl and an additional weaker one or two on the base, but without indication of axials.

Location and Age: These shells come from locality 81FH44, in the Lios Member of the Bogal Formation on Lios Island, from which Jaworski's type material also came. Association with *Rhabdoceras* and *Cochloceras* indicates a Rhaetian age.

In addition to the above taxa, earlier workers have reported a few not recollected by the 1981 expedition. Jaworski (1915) described *Coelostylina wanneri* n. sp. and an undescribed species in addition to *C. similis* (see above), and a single specimen he identified as *Worthenia* cf. *munsteri* Klippstein, all from the Rhaetian Lios Member ("Nucula-Mergel").

# Plate 1



## Explanation

### Plate 1

Fig. 1 - 5: *Bathrotomaria foronica* n. sp., IMC 1057, from 81FH30, Yefbie Formation, Aalenian; Fig. 1, in apertural view, Fig. 2, in lateral view, Fig. 3, an enlarged part of Fig. 2, to show selenizone and trend of growth lines, Fig. 4, in posterior view, Fig. 5, viewed anteriorly.

Fig. 6 - 9: *Eucyclus orbignyana* (Hudleston), Yefbie Formation, Aalenian or Early Bajocian; Fig. 6, 7, IMC 1058, from 81FH31, in apertural and lateral views; Fig. 8, 9, IMC 1059, a more attenuate specimen, from 81FH35, in apertural and lateral views. All figures at c. X 1.5 magnification, except Fig. 3, at c. X 3.5.

## Plate 2



### Explanation

#### Plate 2

Fig. 1, 2: Neritinae gen et sp. indet., IMC 1060, from Lios Member, Bogal Formation, Rhaetian, in lateral and posterior views; essentially a steinkern.

Fig. 3, 4: *Purpurina* (n.?) sp., IMC 1061, from 81FH35, Yefbie Formation, Aalenian or Early Bajocian, in lateral and apertural views.

Fig. 5-7: *Angularia* (n.) sp., from 81FH44, Lios Member of Bogal Formation, Rhaetian; Fig. 5, IMC 1062, in apertural view, showing epifauna of serpulid tubes and, on the inner lip, cemented specimens of *Atreta* sp.; Fig. 6, 7, IMC 1063, in two lateral views, with the aperture facing left in Fig. 6 and showing the serpulid epifauna, and right in Fig. 7, showing spiral ornament exaggerated by adhering sediment. All figures at c. X 1.5.

Triassic *worthenias*, possessing planispiral early teleoconch whorls as opposed to the trochispiral form of some Palaeozoic species of *Worthenia*, may be separated into *Wortheniella* Schwardt (1992), and although there is some doubt about this procedure (*vide* discussion in Nützel & Senobari-Daryan, 1999) this terminology is followed here. In many Triassic species the nature of the early whorls is not known, but re-allocation is justified in the case of *W. muensteri* because Zardini (1985) has figured its planispiral earliest whorls. The Misool *Wortheniella* cf. *muensteri* differs from the St Cassian (Carnian, north Italy) *W. muensteri* by its lower less gradate spire, less angled periphery, and straight, non-excavate sub-peripheral whorl-face, and minor sculptural details. We suggest that these differences are enough to warrant further separation of the Misool shell and propose its characterisation as *W. sp. aff. muensteri*. This taxon shows no close similarity with any of the other *worthenias* from the St Cassian fauna figured by Zardini (1978), which are generally too high-spined and/or with rounded whorl outlines, and it differs significantly from *W. escheri timorensis* (Krumbeck, 1924), from the Timor Triassic, which is umbilicate and has a gradate spire and quite weak ornament.

A full listing of presently-known Triassic and Jurassic gastropod taxa from the Misool archipelago follows. It should be noted that the Cretaceous strata have not yet yielded any members of this group.

*Bathrotomaria foronica* Hasibuan & Grant-Mackie, n. sp.; Yefbie Formation, Aalenian.

*Wortheniella* cf. *muensteri* (Klippstein); Lios Member, Bogal Formation, Rhaetian.

*Eucyclus orbignyanus* (Hudleston); Yefbie Formation, Aalenian or Early Bajocian.

*Neritinae* gen. et sp. indet.; Bogal Formation, Rhaetian.

*Coelostylina* cf. *similis* (Münster); Lios Member, Bogal Formation, Rhaetian.

*Coelostylina wanneri* Jaworski; Lios Member, Bogal Formation, Rhaetian.

*Coelostylina* sp.; Lios Member, Bogal Formation, Rhaetian.

*Purpurina* (?n.) sp.; Yefbie Formation, Aalenian or Early Bajocian.

?*Angularia* (n.) sp.; Lios Member, Bogal Formation, Rhaetian.

*Promathilda pacifica* (Jaworski); Lios Member, Bogal Formation, Rhaetian.

These ten species are thus found exclusively in the

latest Triassic Bogal Formation, or the Middle Jurassic Yefbie Formation. None is common, and some are represented by single specimens. Affinities lie primarily with north Tethyan faunas, especially the Ladinian-Carnian St. Cassian fauna of northern Italy, and in the case of *Eucyclus orbignyanus* there are also weak links suggested with the Andean region and New Zealand. There is no close link shown with other contemporary Asian faunas.

## CONCLUSIONS

Molluscan fauna of Misool Archipelago is quite diverse, especially bivalves, gastropods, with the subsidiary brachiopods, corals, annelid worms and crinoid.

Gastropod *Bathrotomaria foronica* is found in Yefbie Formation of Aalenian age is a new species in this area. *Eucyclus orbignyanus* from from Yefbie Formation is Early Bajocian in age. *Neritinae* and *Angularia* sp from the Lios Member of Bogal Formation is difficult to describe up to species level due to badly preserved and also *Purpurina* sp. from Yefbie Formation (Early Bajocian).

*Coelostylina* sp. cf. *C. similis* Münster (1841) also from the Lios Member of Bogal Formation, Rhaetian in age has the proportion of *C. similis*, but our material does not show protoconch or narrow umbilicus, however we can relate them with confidence to the *Coelostylina similis*.

*Promathilda* sp. cf. *P. pacifica* Jaworski (19915) Is poorly preserved lacking apex and no sculpture on whorls or base, but the overall features show a close similarity to Jaworski's (1915) species.

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