Early Late Jurassic radiolarians from the clastic unit in Busuanga Island, North Palawan, Philippines

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Abstract

Abundant occurrence of radiolarians has been observed from the siliceous mudstone of the Tulbuan Plain, Busuanga Island, Palawan Province, Philippines. There are at least 60 species encountered with generally moderate to good preservation. The faunal assemblage is dominated by 2-to 4-segmented smaller nassellarians such as *Stichocapsa robusta* Matsuoka, *Stylocapsa*(?) *spiralis* Matsuoka, *Stylocapsa tecta* Matsuoka, *Tricolocapsa conexa* Matsuoka, *Dicolocapsa conoformis* Matsuoka, *Zhamoidellum mikamense* Aita. *Zhamoidellum ventricosum* Dumitrica, *Protunuma*(?) *ochiensis* Matsuoka and *Sethocapsa funatoensis* Aita. Other forms that occur abundantly include *Hsuum maxwelli* Pessagno gr. *Parvicingula dhimenaensis* Baumgartner and *Orbiculiforma*(?) spp. The high occurrence of *Stylocapsa*(?) *spiralis* indicates that the assemblage belongs to the *S.*(?) *spiralis* Zone or JR6 of Matsuoka (1995). Associated occurrence of *Stylocapsa tecta, Dicolocapsa conoformis, Guexella nudata* (Kocher) and *G.* sp. aff. *G. nudata* narrows down the represented age to the lower part of the *S.*(?) *spiralis* Zone which is assignable to late Callovian or early Oxfordian.

Key words: Busuanga Island, chert-clastics sequence, Jurassic, North Palawan Block, paleoenvironment, radiolaria, siliceous mudstone, *Stylocapsa*(?) *spiralis* Zone.

Introduction

The thick chert and clastic sequence in Busuanga Island, Palawan Province provides extensive geologic records from the Late Paleozoic to Middle Mesozoic uncommon in the largely island arc system of the Philippines. As the number of studies gradually increased, more complexities were uncovered that only deepens the challenges to understand its geology. Previous works brought in a wide spectrum of views, which model to follow can only be answered by further investigations.

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The generally high occurrence of radiolarians in Busuanga Island has been an invitation to micropaleontologists as nowhere else in the Philippines so far have such abundant radiolarian occurrence, not even in the northern Palawan Island where extensive chert deposits are also found. Since the late 1980's, the number of radiolarian reports from Busuanga has substantially increased. The important studies include Isozaki et al. (1988), Cheng (1989), Tumanda (1991), Cheng (1992), Yeh (1992), Tumanda (1994), Yeh and Cheng (1996), Tumanda-Mateer et al. (1996) and Yeh and Cheng (1998). These works which have established landmarks are highly valuable for subsequent radiolarian researchers in this region. The comprehensive work of Tumanda (1991), in particular, which established 13 radiolarian interval zones from the late Early Permian up to early Early Jurassic has become an essential reference for present and future biostratigraphic works.

This report is part of an ongoing research on Paleozoic-Mesozoic radiolarians in Busuanga Island. During our geologic survey in 1999, a number of sampled outcrops proved to be Permian, Triassic and Jurassic based on quick look through processed slides. In this early stage of our research, we focus on the early Late Jurassic radiolarian assemblage (*Stylocapsa*(?) *spiralis* Zone) of the siliceous mudstone from the Tulbuan Plain, central part of Busuanga Island. Its abundant radiolarian content with relatively good preservation provides us a good material for analysis.

It is noteworthy that the clastic portion of the chert-clastic sequence has been given little emphasis in previous works, contrary to the continuously increasing number of radiolarian reports based on the chert portion. Its poorly defined nature of occurrence in the absence of favorable exposures illustrating a clear stratigraphic relationship with the chert portion probably gave rise to inconsistent interpretation by many workers. Characterizing this clastic unit and defining its role in the Permian, Triassic and Jurassic chert complex are among the challenges in this ongoing research in Busuanga Island.

Geologic setting

The North Palawan Block (Fig. 1) is considered as one continental fragment by Hashimoto and Sato (1973) and Hamilton (1979). It is a crustal unit which integrates northern half of Palawan Island, the Calamian Island Group where Busuanga Island belongs, the Reed Bank, western Mindoro, northwest Panay and Tablas Islands. Distinguished by its different stratigraphic sequence from the Philippine island arc system, its origin has been considered as a result of crustal fragmentation from southeast margin of mainland Asia. The thick sequence of Late Paleozoic to Middle Mesozoic chert sequence shows its distinctive character against the predominantly Cretaceous to Cenozoic sedimentary deposits in the island arc system of the Philippines. The emplacement process of the North Palawan Block had been closely analyzed starting in the late 1970's. Through the analysis of magnetic anomaly data from the South China Sea, Taylor and Hayes (1980) were able to define systematic pattern of sea-floor

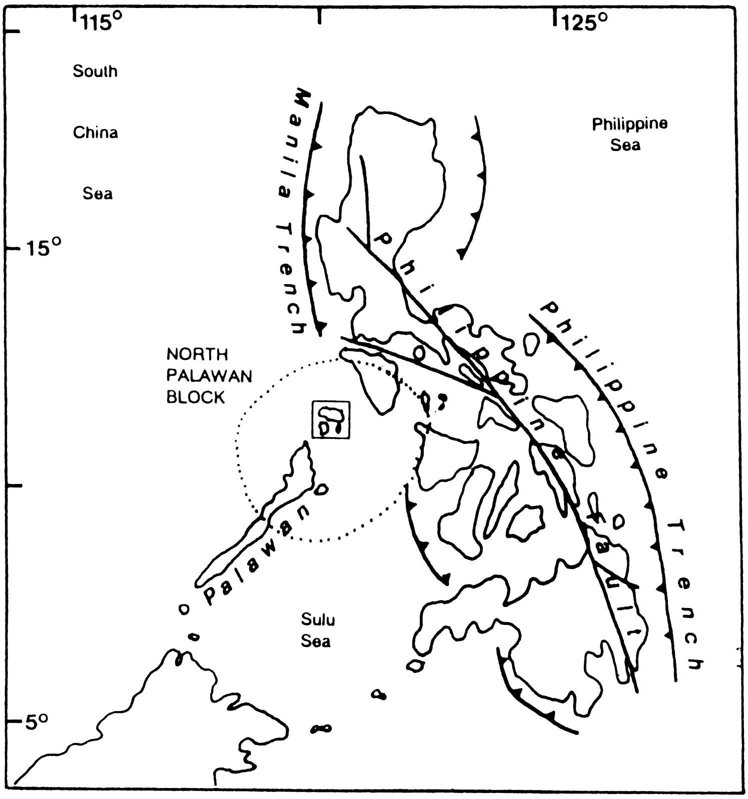

Fig. 1. General tectonic map of the Philippines and the North Palawan Block (after Taylor andHayes, 1980).

spreading based on east-west trending magnetic lineations. Such discovery provided useful evidence essential to formulating the post-depositional or tectonic history of the North Palawan Block. This spreading center was dated as active from mid-Oligocene to early Miocene (32-17 Ma). Holloway (1982) furthermore analyzed the evolution of the South China Sea, hence separation process of the North Palawan Block, using palinspastic reconstruction of tectonic plate movements from Late Triassic to Pliocene, based on stratigraphic data, structural analysis and magnetic anomaly data. This work illustrates the migration stages of the North Palawan Block from the incipient spreading center to its present position. The Jurassic-Cretaceous stage of Holloway (1982) is later supported by the Jurassic-Cretaceous accretionary complex theory for East Asia, which extends to southeast Asia, of Mizutani (1995). Furthermore, Isozaki et al. (1988) considered the North Palawan Block as a subduction accretion complex which is closely related to the Mesozoic subduction-accretion complex in southwest Japan. Faure and Ishida (1990) interpreted the chaotic strata in North Palawan Block as a Mesozoic olistostrome and correlated with the coeval olistostromal sequences along the eastern Eurasian margin.

Stratigraphy

Three rock types generally constitute Busuanga Island namely, chert, limestone and the clastics group. The chert, generally characterized as bedded and highly folded, is the most predominant rock type. The Philippine Bureau of Mines and Geosciences (BMG, 1984) and Wolfart et al. (1986), considered this as part of Middle Triassic Liminangcong Formation earlier proposed by Hashimoto and Sato (1973), based on an extensive chert exposure in Liminangcong coast, northeastern Palawan Island. Isozaki et al. (1988) considered the chert-clastics sequence including the limestone units as subduction-related and named as the North Palawan Complex. The clastics group consisting of shale / siliceous mudstone, sandstone and conglomerate has been poorly defined or established by previous studies. It has been referred to as the Guinlo Formation with inconsistent age assignments; Early Jurassic (Hashimoto and Sato, 1973), Middle Jurassic (BMG, 1981), Early to Middle Jurassic (Wolfart et al., 1986), Middle to Late Jurassic (Faure and Ishida, 1990), and Late Cretaceous (JICA-MMAJ, 1990). Other works consider it as Middle to Late Jurassic King Ranch Formation (BMG, 1984); some exposures as interbeds of the Liminangcong Formation (BMG, 1984); and olistostrome (Faure and Ishida, 1990).

The limestone units occur in several different places such as in Coron Island, Sangat Island and in several smaller islands west of Busuanga Island. Their ages range from Mid-Permian to Late Jurassic based on foraminifers, algae, conodonts, porifera and cnidaria (Fontaine, 1979; Wolfart et al., 1986).

Material studied and procedures

The rock sample processed for radiolarian assemblage analysis is Sample No. 990303-02. It is characterized as bedded with thickness ranging from 3 to 12 cm, gray-colored, siliceous mudstone, and exposed along a thickly vegetated small stream east of the Busuanga Airport (Fig. 2). This lithology either represents the Guinlo Formation (Hashimoto and Sato, 1973; BMG, 1981; Wolfart et al., 1986) or the King Ranch Formation (BMG, 1984). Thick vegetation with predominantly soil-covered stream sides hardly provides information on its contacts with chert, 500 meters southeast, and the highly indurated arkosic sandstone about 300 meters north.

The sample was cut perpendicular to the bedding plane to observe clearer sedimentary features. Half of the sample was treated with 5% HF for 12 hours. Residue extraction followed with #35 and #200 sieves. Preliminary observation of the radiolarian content was done by glass slide, which was later followed by SEM detailed examination.

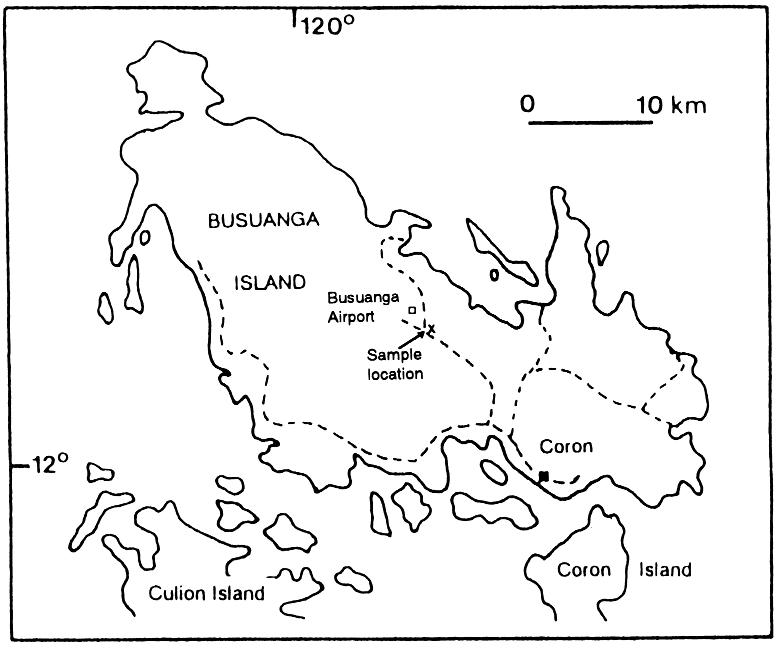

Fig. 2. Map of Busuanga Island and the location of the siliceous mudstone sample.

Faunal assemblage

The radiolarian assemblage, as shown in Table 1 and Plates 1-3, is dominated by 2- to 4-segmented closed smaller nassellarians namely, *Stichocapsa robusta* Matsuoka, *Stylocapsa*(?) *spiralis* Matsuoka, *Stylocapsa tecta* Matsuoka, *Tricolocapsa conexa* Matsuoka, *Dicolocapsa conoformis* Matsuoka and *Zhamoidellum mikamense* Aita, *Zhamoidellum ventricosum* Dumitrica. In similar degree of abundance, only two open-ended coned nassellarian species were noted: *Hsuum maxwelli* Pessagno group and *Parvicingula dhimenaensis* Baumgartner. Other common species include *Williriedellum*(?) *marcuccii* Cortese, *Sethocapsa funatoensis* Aita, *Obesacapsula magniglobosa* Aita, *Gongylothorax favosus* Dumitrica, *Archaeodictyomitra suzukii* Aita, *Amphipyndax tsunoensis* Aita and *Guexella* sp. aff. *G. nudata* (Kocher). Representatives of the spumellarian group have been often disregarded due to poor preservation and prevalent fragmentation. The most common spumellarians in the fauna are *Cenosphaera* spp., *Triactoma* spp., *Phaseliforma* sp. and *Orbiculiforma*(?) spp. Their imperfect forms, particularly the missing spines, have caused difficulties for more accurate taxonomic identification.

Table 1. List of radiolarian species from Tulbuan Plain sample (990303-02).

Species	Abundance	Figures
Amphipyndax tsunoensis Aita	***	pl. 3, fig. 9
Angulobracchia sp.	**	
Archaeodictyomitra(?) *amabilis* Aita	**	pl. 2, fig. 10
Archaeodictyomitra apiarium (Rüst)	*	
Archaeodictyomitra suzukii Aita	***	pl. 3, fig. 7
Archaeospongoprunum sp.	**	pl. 1, fig. 13
Canelonus sp. cf. *C. conus* Hull	*	pl. 2, fig. 14
Cenosphaera spp.	***	
Cinguloturris carpatica Dumitrica	*	pl. 2, fig. 11
Crucella theokaftensis Baumgartner	**	pl. 3, fig. 6
Dicolocapsa conoformis Matsuoka	****	pl. 3, fig. 8
Dictyomitrella(?) *kamoensis* Mizutani and Kido	**	pl. 2, fig. 8
Eucyrtidiellum nodosum Wakita	*	pl. 2, fig. 6
Eucyrtidiellum ptyctum (Riedel and Sanfilippo)	*	pl. 3, fig. 4
Eucyrtidiellum unumaense (Yao)	*	pl. 2, fig. 12
Eucyrtidiellum spp.	**	
Gongylothorax favosus Dumitrica	**	pl. 2, fig. 15
Guexella nudata (Kocher)	**	pl. 3, fig. 10
Guexella sp. aff. *G. nudata* (Kocher)	***	pl. 3, fig. 13
Guexella sp.	*	pl. 3, fig. 14
Haliodictya(?) *hojnosi* Riedel and Sanfilippo	*	pl. 1, fig. 8
Hsuum brevicostatum (Ozvoldova) gr.	**	pl. 2, fig. 2
Hsuum maxwelli Pessagno gr.	****	pl. 2, fig. 1
Hsuum sp. aff. *H. cuestaense* Pessagno	***	pl. 2, fig. 7
Leugeo sp. cf. *L. hexacubicus* (Baumgartner)	**	pl. 3, fig. 5
Napora sp.	*	pl. 1, fig. 7
Obesacapsula magniglobosa Aita	***	pl. 1, fig. 14
Orbiculiforma(?) spp.	****	pl. 1, fig. 12
Parahsuum spp.	***	
Parvicingula dhimenaensis Baumgartner	****	pl. 2, fig. 4
Parvicingula sp.	**	pl. 2, fig. 9
Phaseliforma sp.	****	
Praeconosphaera sp.	**	pl. 3, fig. 2
Protunuma(?) *ochiensis* Matsuoka	***	pl. 3, fig. 16
Protunuma japonicus Matsuoka and Yao	**	pl. 3, fig. 15
Sethocapsa funatoensis Aita	****	pl. 3, fig. 11
Stichocapsa cephalospinosa (Kozur)	*	pl. 1, fig. 16
Stichocapsa decora Rüst	*	pl. 1, fig. 15
Stichocapsa robusta Matsuoka	****	pl. 1, figs. 3-4
Stichocapsa sp.	**	
Stichomitra(?) *takanoensis* Aita	*	pl. 2, fig. 3
Stylocapsa(?) *spiralis* Matsuoka	****	pl. 1, figs. 1, 5
Stylocapsa tecta Matsuoka	****	pl. 1, figs. 2, 6
Triactoma spp.	***	
Tricolocapsa conexa Matsuoka	****	pl. 1, fig. 10; pl. 3, fig. 3
Tricolocapsa plicarum Yao	**	
Tricolocapsa sp.	***	pl. 1, fig. 9
Unuma gorda Hull	**	pl. 3, fig. 12
Williriedellum(?) *marcuccii* Cortese	***	pl. 1, fig. 11
Xitus sp.	**	pl. 2, fig. 13
Zhamoidellum mikamense Aita	**	pl. 3, fig. 1
Zhamoidellum ventricosum Dumitrica	***	pl. 2, fig. 16
Theoperidae gen. et sp. indet. (in Aita, 1987)	***	pl. 2, fig. 5

* rare (1) *** common(5-10)
**few (2-4) ****abundant (11+)

Age analysis and correlation

Based on the Jurassic-Cretaceous zonal scheme for Japan and western Pacific of Matsuoka (1995), this assemblage with high occurrence of *Stylocapsa*(?) *spiralis* should belong to JR6 - the *S*.(?) *spiralis* Zone. In this zone, associated occurrences of *T. conexa, P*.(?) *ochiensis* and *W*.(?) *marcuccii* are expected, wherein they simultaneously disappear with *S*.(?) *spiralis* at the upper boundary of the zone (Matsuoka, 1983). The presence of *S. tecta, D. conoformis, G. nudata* and *G.* sp. aff. *G. nudata* furthermore narrows down the represented age of this fauna to lower *S*.(?) *spiralis* Zone since these species disappear in the lower part of the JR6 Interval Zone (Matsuoka, 1983). This is also supported by the presence of Theoperidae gen. et sp. indet. in Aita (1987) which also disappears in similar period (Aita, 1987). Since the *S*.(?) *spiralis* Zone ranges from the late Callovian through the end of Oxfordian (Matsuoka, 1995), then probably this lower *S*.(?) *spiralis* Zone assemblage represents either the late Callovian or early Oxfordian, which generally falls in the boundary between Middle and Late Jurassic. The assumed absence of *Gongylothorax sakawaensis* Matsuoka furthermore suggests that this fauna belongs to the biohorizon below the first appearance of *G. sakawaensis* (Aita, 1987; Matsuoka, 1995). This is quite consistent with the apparent biostratigraphic gap specifically between the group of *Guexella nudata, G.* aff. *nudata, S. tecta, D. conoformis* and Theoperidae gen. et sp. indet., with the first appearance of *G. sakawaensis* (Matsuoka, 1983; Aita, 1987)

The *S*.(?) *spiralis* assemblage representative of Tumanda (1991) and Tumanda-Mateer et al. (1996) was taken from the San Nicolas section, about 10 km southeast of the studied exposure. Although the reported species were rather few, some key species such as *D. conoformis, G. nudata, Dictyomitrella*(?) *kamoensis* Mizutani and Kido and *A. suzukii* are relevant to the present study. The presence of *D. conoformis* and *G. nudata* in the San Nicolas section, particularly indicates rather close if not the same sublevel within the *S*.(?) *spiralis* Zone of the Tulbuan section. However, the same absence of *G. sakawaensis* in the fauna of the San Nicolas sample likewise signifies the lower part of *S*.(?) *spiralis* (Matsuoka, 1983) and below the *G. sakawaensis* Zone of Aita (1987).

The sample's faunal assemblage shows a remarkable affinity with those from the Southern Chichibu Terrane, particularly, Sakawa area (Matsuoka, 1983) and Mt. Irazu area (Aita, 1987) in Shikoku, southwest Japan. Among the common to abundant species in both areas include *S. robusta, S*.(?) *spiralis, S. tecta, T. conexa, A. suzukii, H. maxwelli, P. dhimenaensis* and *S. funatoensis*. The few to commonly occurring radiolarian group in the Tulbuan sample consisting of *Amphipyndax tsunoensis* Aita, *Archaeodictyomitra*(?) *amabilis* Aita, *D*.(?) *kamoensis, Eucyrtidiellum ptyctum* (Riedel and Sanfilippo), *Eucyrtidiellum unumaense* (Yao), *G. nudata, G.* sp. aff. *G. nudata, Obesacapsula magniglobosa* Aita, *P*.(?) *ochiensis, W*.(?) *marcuccii* and Theoperidae gen. et sp. indet. also shows corresponding similar degree of occurrence in Mt.

Irazu, Shikoku of Aita (1987). Furthermore, some species like *Stichocapsa cephalospinosum* (Kozur), *Stichocapsa decora* Rüst and *Cingulutorris carpatica* Dumitrica appear rather rare to few in both compared areas.

This faunal similarity as well as degree of occurrence apparently suggests some linkage between Busuanga and Shikoku sections generally during the Middle to Late Jurassic Period. In the work of Aita (1987), the Mt. Irazu sections in Shikoku are correlated with the Lombardy Basin sections in southern Europe using radiolarians and calcareous nannofossils. Remarkable similarity of Middle Jurassic to Early Cretaceous radiolarian faunas between both regions is observed, leading to a concluded good oceanographic connection in the Circum-Pacific, Tethyan and Atlantic regions (Aita, 1987). This oceanographic connection between Shikoku and Lombardy Basin areas thereby associates Busuanga as one of the areas in between.

Besides Japan and the Philippines, *S.*(?) *spiralis* has been reported from the Western Pacific (Matsuoka, 1992), California (Hull, 1997), Tibet (Matsuoka et al., 1999), Pakistan (Kojima et al., 1994), the Alps (Aita, 1987; Gorican, 1994) and in the Northern Atlantic (Baumgartner and Matsuoka, 1995). Its spatially wider and temporally shorter distribution provides an essential basis for worldwide correlation and other biostratigraphic works. Comparison of chronologically well-controlled radiolarian faunas taken from different regions makes it possible to produce a paleobiogeographic framework for a specific time-slice. That will be our future work.

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Appendix

List of genus and species names cited

The following is a list of all taxa represented in this paper. Original and recent publications of each species are also cited below.

Amphipyndax tsunoensis Aita

Amphipyndax tsunoensis Aita - Aita 1987, p. 69, pl. 1, figs. 11-12; pl. 9, fig. 4-5.

Amphipyndax tsunoensis Aita - Baumgartner et al. 1995, p. 84, pl. 2025, figs. 1-3.

Archaeodictyomitra(?) *amabilis* Aita

Archaeodictyomitra(?) *amabilis* Aita - Aita 1987, fig. 6.6.

Archaeodictyomitra(?) *amabilis* Aita - Matsuoka and Baumgartner 1997, pl. 2, fig. 6.

Archaeodictyomitra apiarium (Rüst)

Lithocampe apiarium Rüst - Rüst 1885, p. 314, pl. 39(14), fig. 8.

Archaeodictyomitra apiarium (Rüst)- Baumgartner et al. 1995, p. 98, pl. 3263, figs. 1-7.

Archaeodictyomitrella suzukii Aita

Archaeodictyomitrella suzukii Aita - Aita 1987, p. 71, pl. 2, figs. 1a-2b; pl. 9, fig. 9.

Canelonus sp. cf. *C. conus* Hull

cf. *Canelonus conus* Hull- Hull 1997, p. 146, pl. 47, figs. 15, 16, 19; pl. 48, fig. 17.

Cinguloturris carpatica Dumitrica

Cinguloturris carpatica Dumitrica - Dumitrica and Mello 1982, p. 23, pl. 4, figs. 7-11.

Cinguloturris carpatica Dumitrica - Baumgartner et al. 1995, p. 142, pl. 3193, figs. 1-6.

Crucella theokaftensis Baumgartner

Crucella theokaftensis Baumgartner - Baumgartner 1980, p. 308, pl. 8, figs. 19-22; pl. 12, fig. 1.

Crucella theokaftensis Baumgartner - Baumgartner et al. 1995, p. 158, pl. 3131, figs. 1-3.

Dicolocapsa conoformis Matsuoka

Dicolocapsa(?) *conoformis* Matsuoka - Matsuoka, 1983, p. 3, pl. 1, figs. 1-3b; pl. 5, figs. 1-6b;

Dicolocapsa conoformis Matsuoka - Baumgartner et al. 1995, p. 182, pl. 4013, figs. 1-3.

Dictyomitrella(?) *kamoensis* Mizutani and Kido

Dictyomitrella(?) *kamoensis* Mizutani and Kido - Kido, et al. 1982, pl. 2, figs. 9-11.

Dictyomitrella(?) *kamoensis* Mizutani and Kido - Baumgartner et al. 1995, p. 188, pl. 4014, figs. 1-4.

Eucyrtidiellum nodosum Wakita

Eucyrtidiellum nodosum Wakita - Wakita 1988, p.408, pl. 4, fig. 29; pl. 5, fig. 16.

Eucyrtidiellum nodosum Wakita - Baumgartner et al. 1995, p. 213, pl. 3014, figs. 1-3.

Eucyrtidiellum ptyctum (Riedel and Sanfilippo)

Eucyrtidium ptyctum Riedel and Sanfilippo - Riedel and Sanfilippo 1974, p. 778, pl. 5, fig. 7; pl. 12, fig. 14

Eucyrtidiellum ptyctum (Riedel and Sanfilippo) - Zyabrev and Matsuoka 1999, pl. 2, fig. 1.

Eucyrtidiellum unumaense (Yao)

Eucyrtidium(?) *unumaensis* Yao - Yao 1979, p. 39, pl. 9, figs. 1-11.

Eucyrtidiellum unumaensis (Yao) - Baumgartner 1984, p. 765, pl. 4, fig. 6.

Eucyrtidiellum unumaense (Yao) - Nagai 1987, pl. 2, figs. 1a-c.

Gongylothorax favosus Dumitrica

Gongylothorax favosus Dumitrica - Dumitrica 1970, p. 56, pl. 1, figs. 1a-c, 2.

Gongylothorax favosus Dumitrica - Baumgartner et al. 1995, p. 230, pl. 6131, figs. 1-7.

Guexella nudata (Kocher)

Lithocampe nudata Kocher - Baumgartner et al. 1980, p. 55, pl. 6, fig. 3.

Guexella nudata (Kocher) - Baumgartner et al. 1995, p. 238, pl. 3061, figs. 1-4.

Haliodictya(?) *hojnosi* Riedel and Sanfilippo

Haliodictya(?) *hojnosi* Riedel and Sanfilippo - Riedel and Sanfilippo 1974, p. 779, pl. 2, fig. 6; pl. 12, fig. 2.

Haliodictya(?) *hojnosi* Riedel and Sanfilippo - Matsuoka 1992, pl. 3, fig. 11.

Hsuum brevicostatum Ozvoldova gr.

Lithostrobus brevicostatus Ozvoldova - Ozvoldova 1975, p. 84, pl. 102, fig. 1.

Hsuum brevicostatum (Ozvoldova)

- Baumgartner 1984, p. 769, pl. 5, figs. 1-2.

Transhsuum brevicostatum (Ozvoldova) gr. - Baumgartner et al. 1995, p. 578, pl. 3181, figs. 1-5.

Hsuum maxwelli Pessagno gr.

Hsuum maxwelli Pessagno - Pessagno 1977 , p. 81, pl. 7, figs. 14-16.

Transhsuum maxwelli (Pessagno) gr. - Baumgartner et al. 1995, p. 582, pl. 3180, fig. 1-6.

Hsuum sp. aff. *H. cuestaense* Pessagno

aff. *Hsuum cuestaensis* Pessagno - Pessagno 1977, p. 81, pl. 7, figs. 12-13.

aff. *Hsuum cuestaensis* Pessagno - Baumgartner et al. 1995, p. 282, pl. 3182, figs. 1-3.

Leugeo sp. cf. *L. hexacubicus* (Baumgartner)

Praeconocaryomma(?) *hexacubica* Baumgartner - Baumgartner 1984, p. 780, pl. 7, figs.

11-14.

cf. *Leugeo hexacubicus* (Baumgartner) - Baumgartner et al. 1995, p. 296, pl. 3244, figs. 1-4.

Obesacapsula magniglobosa Aita

Obesacapsula magniglobosa Aita - Aita 1987, p. 71, pl. 2, figs. 4a-b; pl. 9, figs. 10-11.

Parvicingula dhimenaensis Baumgartner

Parvicingula dhimenaensis Baumgartner - Baumgartner 1984, p. 778, pl. 7, figs. 2-3, not fig. 4.

Parvicingula dhimenaensis s.l. Baumgartner - Matsuoka and Baumgartner 1997, pl. 2, figs. 2-3.

Protunuma japonicus Matsuoka and Yao

Protunuma japonicus Matsuoka and Yao - Matsuoka and Yao 1985, p. 130-131, pl. 1, figs. 11-15; pl. 3, figs. 6-9.

Protunuma(?) *ochiensis* Matsuoka

Protunuma(?) *ochiensis* Matsuoka - Matsuoka 1983, p. 26, pl. 4, figs. 8-11; pl. 9, figs. 3-7.

Protunuma(?) *ochiensis* Matsuoka - Baumgartner et al. 1995, p. 436, pl. 3290, figs. 1-2.

Sethocapsa funatoensis Aita

Sethocapsa funatoensis Aita - Aita 1987, p. 73, pl. 2, figs. 6a-7b; pl. 9, figs. 14-15.

Sethocapsa funatoensis Aita - Baumgartner et al. 1995, p. 494, 3070, figs. 1-5.

Zhamoidellum funatoensis (Aita) - Hull 1997, p. 132, pl. 38, figs. 13, 15.

Stichocapsa cephalospinosa (Kozur)

Praewilliriedellum cephalospinosum Kozur 1984, p. 51, pl. 2, figs. 1a-c.

Stichocapsa decora Rüst

Stichocapsa decora Rüst - Rüst, 1885, p. 319, pl. 42(17), fig. 3.

Stichocapsa decora Rüst - Baumgartner et al. 1995, p. 520, pl. 3269, figs. 1-4.

Stichocapsa robusta Matsuoka

Stichocapsa robusta Matsuoka - Matsuoka 1984, p. 146, pl. 1, figs. 6-13; pl. 2, figs. 7-12.

Stichocapsa robusta Matsuoka - Baumgartner et al. 1995, p. 524, pl. 3298, figs. 1-7.

Hiscocapsa robusta (Matsuoka) - Hull 1997, pl. 39, fig. 7, 8, 22.

Stichomitra(?) *takanoensis* Aita

Stichomitra(?) *takanoensis* Aita - Aita 1987, p. 73, pl. 3, figs. 10a-12; pl. 10, figs. 6-7.

Stylocapsa(?) *spiralis* Matsuoka

Stylocapsa(?) *spiralis* Matsuoka - Matsuoka 1982, pl. 3, figs. 8-9.

Stylocapsa(?) *spiralis* Matsuoka - Baumgartner et al. 1995, p. 534, pl. 3046, figs. 1-5.

Kilinora spiralis gr. (Matsuoka) - Hull 1997, p. 93, pl. 37, figs. 4, 5, 12, 23.

Stylocapsa tecta Matsuoka

Stylocapsa tecta Matsuoka - Matsuoka 1983, pl. 14, pl. 1, figs. 5-11, pl. 5, figs. 8-14.

Stylocapsa tecta Matsuoka - Baumgartner et al. 1995, p. 534, pl. 4047, figs. 1-3

Tricolocapsa conexa Matsuoka

Tricolocapsa conexa Matsuoka - Matsuoka 1983, p. 20, pl. 3, figs. 3-7; pl. 7, figs. 11-14.

Tricolocapsa conexa Matsuoka - Baumgartner et al. 1995, p. 594, pl. 3297, figs. 1-5

Striatojaponicapsa conexa (Matsuoka) - Hull 1997, p. 166, pl. 37, fig. 20.

Tricolocapsa plicarum Yao

Tricolocapsa plicarum Yao - Yao 1979, p. 32, pl. 4, figs. 1-11.

Tricolocapsa plicarum ssp. A Yao - Baumgartner et al. 1995, p. 598, pl. 4052, figs. 1-5.

Unuma gorda Hull

Unuma gorda Hull – Hull 1997, p. 172, pl. 43, figs. 9, 11, 12.

Williriedellum(?) *marcuccii* Cortese

Williriedellum(?) sp. A gr. – Matsuoka 1983, p. 23, pl. 4, figs. 1-3; pl. 8, figs. 11-15.

Williriedellum(?) *marcuccii* Cortese - Cortese 1993, p. 180, pl. 7, figs. 6-7.

Zhamoidellum mikamense Aita

Zhamoidellum mikamense Aita - Aita 1987, p. 74, pl. 4, figs. 9a-b; pl. 10, figs. 10-11.

Zhamoidellum ventricosum Dumitrica

Zhamoidellum ventricosum Dumitrica - Dumitrica 1970, p. 79, pl. 9, figs. 55a-b.

Zhamoidellum ventricosum Dumitrica - Baumgartner et al. 1995, p. 660, pl. 3308, figs. 1-5.

Explanation of Plates

Plate 1

1. *Stylocapsa*(?) *spiralis* Matsuoka (x250)
2. *Stylocapsa tecta* Matsuoka (x250)
3. *Stichocapsa robusta* Matsuoka (x250)
4. *Stichocapsa robusta* Matsuoka (x250)
5. *Stylocapsa*(?) *spiralis* Matsuoka (x250)
6. *Stylocapsa tecta* Matsuoka (x250)
7. *Napora* sp. (x375)
8. *Haliodictya*(?) *hojnosi* Riedel and Sanfilippo (x250)
9. *Tricolocapsa* sp. (x500)
10. *Tricolocapsa conexa* Matsuoka (x250)
11. *Williriedellum*(?) *marcuccii* Cortese (x375)
12. *Orbiculiforma*(?) sp. (x250)
13. *Archaeospongoprunum* sp. (x375)
14. *Obesacapsula magniglobosa* Aita (x375)
15. *Stichocapsa decora* Rüst (x250)
16. *Stichocapsa cephalospinosa* (Kozur) (x250)

Plate 1

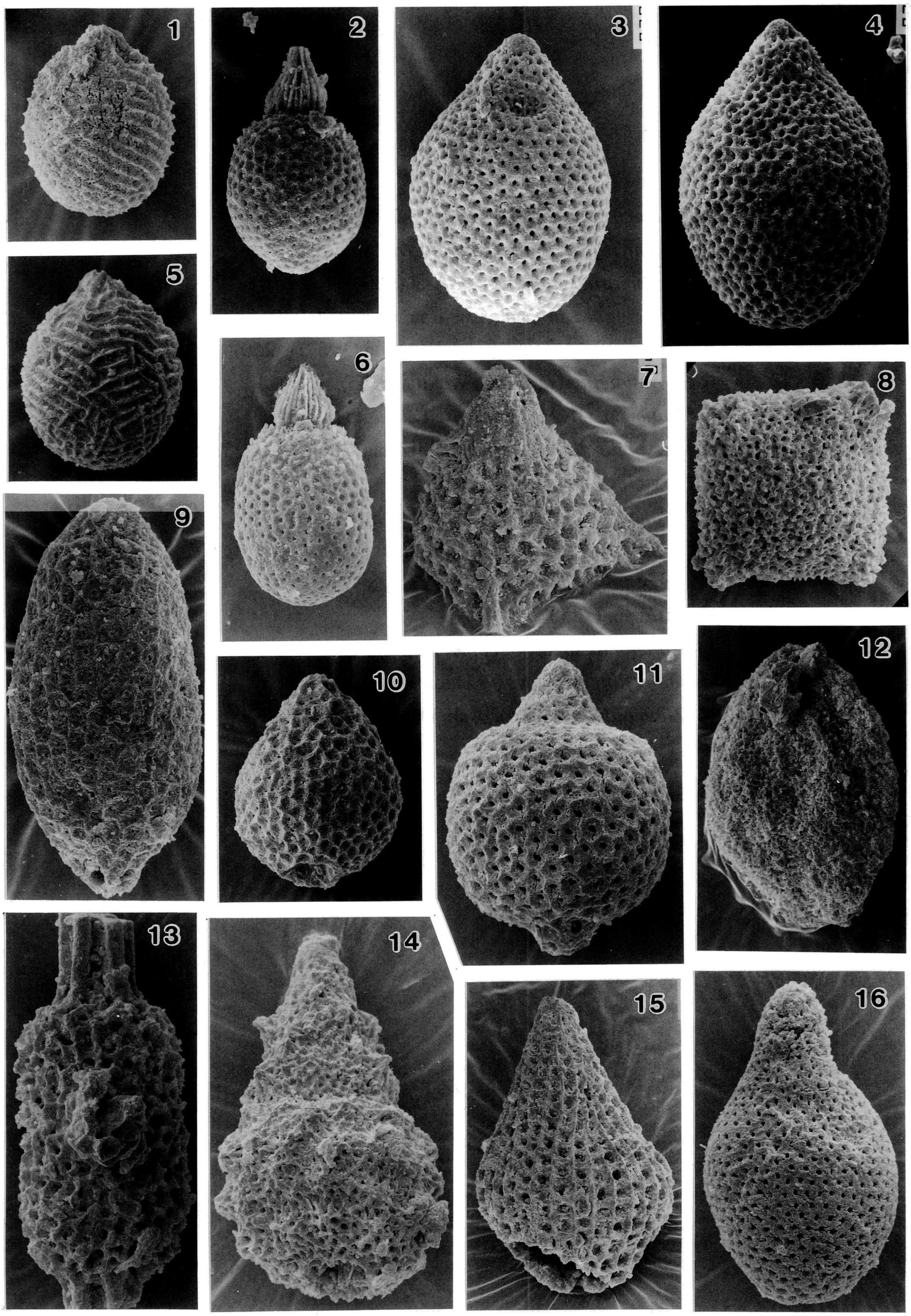

Plate 2

1. *Hsuum maxwelli* Pessagno gr. (x250)
2. *Hsuum brevicostatum* (Ozvoldova) gr. (x375)
3. *Stichomitra(?) takanoensis* Aita (x250)
4. *Parvicingula dhimenaensis* Baumgartner (x250)
5. Theoperidae gen. et sp. indet. in Aita (1987) (x250)
6. *Eucyrtidiellum nodosum* Wakita (x375)
7. *Hsuum* sp. aff. *H. cuestaense* Pessagno (x250)
8. *Dictyomitrella(?) kamoensis* Mizutani and Kido (x375)
9. *Parvicingula* sp. (x250)
10. *Archaeodictyomitra(?) amabilis* Aita (x375)
11. *Cinguloturris carpatica* Dumitrica (x250)
12. *Eucyrtidiellum unumaense* (Yao) (x375)
13. *Xitus* sp. (x250)
14. *Canelonus* sp. cf. *C. conus* Hull (x250)
15. *Gongylothorax favosus* Dumitrica (x250)
16. *Zhamoidellum ventricosum* Dumitrica (x250)

Plate 2

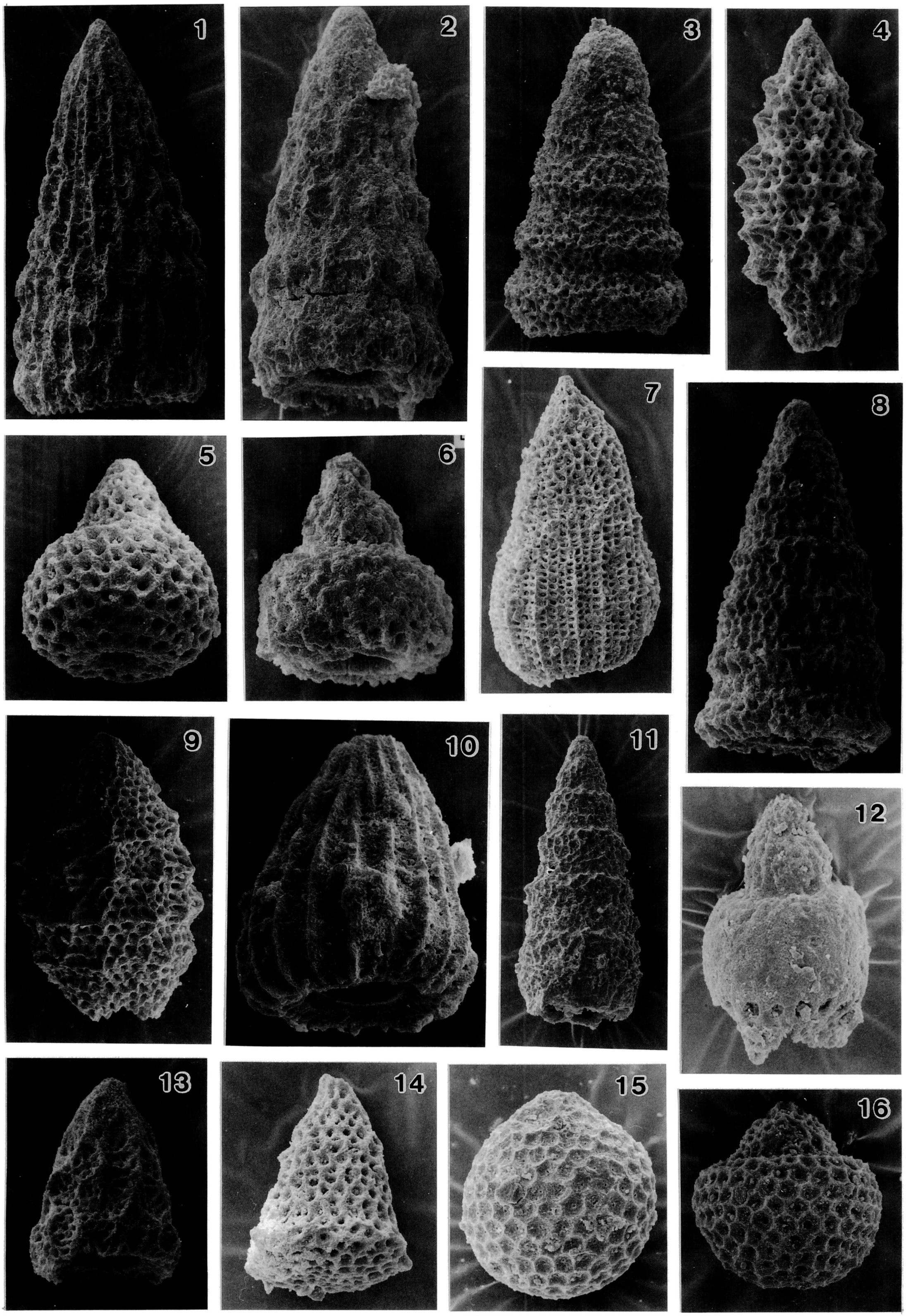

Plate 3

1. *Zhamoidellum mikamense* Aita (x250)
2. *Praeconosphaera* sp. (x175)
3. *Tricolocapsa conexa* Matsuoka (x250)
4. *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo) (x250)
5. *Leugeo* sp. cf. *L. hexacubicus* (Baumgartner) (x250)
6. *Crucella theokaftensis* Baumgartner (x250)
7. *Archaeodictyomitra suzukii* Aita (x250)
8. *Dicolocapsa conoformis* Matsuoka (x375)
9. *Amphipyndax tsunoensis* Aita (x250)
10. *Guexella nudata* (Kocher) (x250)
11. *Sethocapsa funatoensis* Aita (x250)
12. *Unuma gorda* Hull (x375)
13. *Guexella* sp. aff. *G. nudata* (Kocher) (x250)
14. *Guexella* sp. (x250)
15. *Protunuma japonicus* Matsuoka and Yao (x375)
16. *Protunuma*(?) *ochiensis* Matsuoka (x375)

Plate 3