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Discovery of Triassic microfossils from the Buruanga Peninsula, Panai Island, North Palawan Block, Philippines

Keisuke Ishida *[1], Shigeyuki Suzuki [2], Carla B. Dimalanta [3], Graciano P. Yumul Jr. [4, 5], Lawrence R. Zamoras [5], Michel Faure [6], Francis Hirsch [7], Ali Murat Kiliç [8], Pablo Placencia [9]

[1] *Laboratory of Geology, Institute of SAS, University of Tokushima, 770-8502, Tokushima, Japan*

[2] *Department of Earth Sciences, Okayama University, Okayama, 700-8530, Japan*

[3] *Rushurgent Working Group, National Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City, 1101, Philippines*

[4] *Apex Mining Company, Inc., Ortigas Center, Pasig City, Metro Manila, Philippines*

[5] *Monte Oro Resouces and Energy Inc., Makati City, Philippines*

[6] *Department of Earth Sciences, Orleans University, 45067 Orleans, France*

[7] *Laboratory of Geology, Naruto University of Education, Naruto 772-8502, Japan*

[8] *Department of Geological Engineering, Balıkesir University 10145, Balıkesir, Turkey*

[9] *Department of Geology and ICBIBE, University of Valencia, Dr. Moliner 50. 46100, Burjassot, Spain*

** Corresponding author: ishidak@tokushima-u.ac.jp*

Abstract

We found Middle and Late Triassic conodonts and radiolarians from the pelagic carbonates and successive siliceous sediments of the Buruanga Peninsula in Panai Island, North Palawan Block. The carbonate units, long estimated to be Jurassic, revealed late Anisian and late Norian. The pelagic limestone carapace of basalt was constrained within the conodont *Gladigondolella tethydis* – *Paragondolella excelsa* Zone (late Illyrian/early Fassanian). The successive bedded-chert unit starts from Fassanian (lower Ladinian) radiolarian *Triassocampe* spp. – *Yeharaia* spp. Zone. The early to late Norian conodont mixed faunas (from *Ancyrogondolella quadrata* Zone to *Mockina bidentata* Zone and *Misikella hernsteini* Zone) were extracted from the turbiditic clastic-carbonate unit that intertongues with the pelagic limestone/chert unit of latest Norian age (conodont *Misikella hernsteini* Zone).

Keywords: *Triassic, carbonates, conodont, radiolaria, Buruanga Peninsula, Panai Island, North Palawan Block.*

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1. Introduction

The North Palawan Block (NPB) between South China Sea and Sulu Sea encompasses islands of the northern part of Palawan, Calamian, Cuyo, Reed Bank, Spratly, Dangerous Grounds, western Mindoro, Tablas and the northwestern part of Panai (Fig. 1). Rifted apart from the Asian continent during Late Cretaceous – Paleogene times (Hamilton, 1979; Metcalfe, 2013), the NPB, drifted southwards and collided with the volcanic arc of the Philippine Mobile Belt (PMB: Gervasio, 1966) in the Miocene

(Holloway, 1982; Suzuki et al., 2000). Both tectonic units are bounded by the Manila Trench (Karig, 1982, 1983; Yumul et al., 2001, 2003; Maruyama et al., 1997).

The NPB consists of Permian and Jurassic accretionary complexes (PAC and JAC) of the Panthalassan Izanagi plate origin, and the plate was accreted to the southwestern side of the Yangtze Continental Margin (Isozaki et al., 1988; Faure and Ishida, 1990; Tumanda, 1991, 1994; Maruyama et al., 1997; Zamoras, L.R. and Matsuoka, A., 2001; Zhou et al, 2008; Metcalfe, 2010).

Hashimoto and Sato (1973) and Hashimoto et. al. (1980) investigating the Calamian Island, were the first to report Triassic conodonts (Early Norian). Occurrences of Permian and Trisaaic limestone blocks have been known sporadically from the NPB (Wolfart et al., 1986; Amiscaray, 1987). The OPS of JAC in NPB has been regarded basically composed of chert-clastic successions. The Upper Permian to Middle Jurassic chert facies in JAC of the NPB (ex. Liminangcong Formation) was interpreted to deposit below the CCD, except for some foraminiferal horizons (Marquez et al., 2006).

Newly found Triassic conodonts and radiolarians revealed the wide distribution of Middle and Late Triassic pelagic carbonates with basalts and cherts in the Buruanga Peninsula, western part of the Panai Island (Fig. 1). The OPS in Buruanga and its conodont-radiolarian faunas are correlative with those in the Sambosan-Hisaidani JAC Zone in Southwest Japan (Ishida et al., 2015). Both the Sambosan-Hisaidani and the herein newly defined Triassic pelagic carbonates in the Buruanga of NPB originated from the Panthalassan Izanagi Plate, and derived from the Izanami Seamount Swarm (Hirsch and Ishida, 2002).

2. Stratigraphic Outline

Zamoras et al. (2008) subdivided the lithostratigraphy of the Buruanga Peninsula into the Unidos (Jurassic chert sequence), Saboncogon (Jurassic siliceous mudstone –terrigenous mudstone and quartz-rich sandstone), and Gibon (Jurassic (?) bedded pelagic limestone) formations (Fig. 2). The three lithostratigraphic units were interpreted to construct oceanic plate stratigraphy (OPS).

Our findings of Upper Triassic microfaunas reveal the limestone unit of Gibon Formation that do not juxtapose with the chert unit of the Jurassic Unidos Formation. The chert units of the Unidos Formation belong to Middle Triassic (Ladinian) and upper Lower to upper Middle Jurassic (*Zartus* sp. - *Hsuum matsuokai* Zone to *Kilinora spiralis* Zone). Thus, the "Unidos Formation" consists of two parts, with the newly revealed Upper Triassic (Norian) carbonates of the "Gibon Formation" in between.

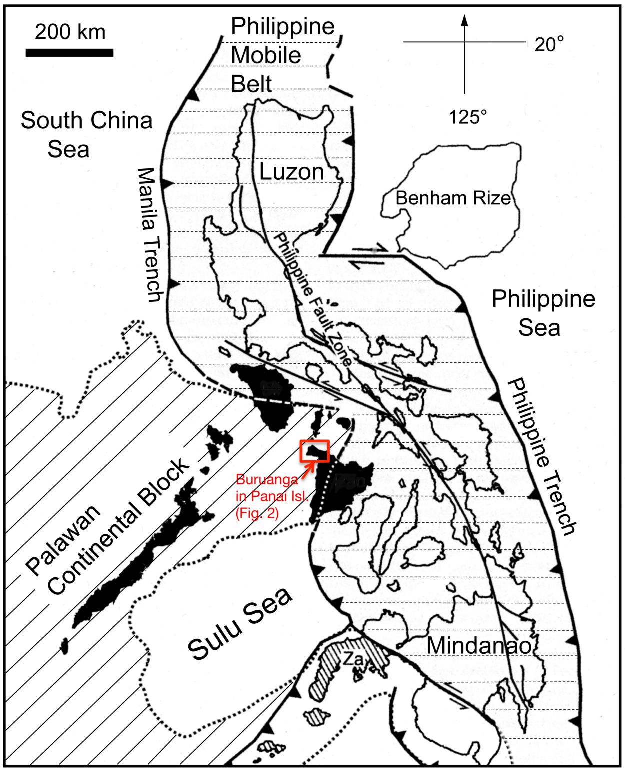


Fig. 1. Index map showing the tectonic outline of the Philippines with study area.

3. Occurrence of microfossils

3.1. Loc 1

At the Saboncogon Point (Fig. 2, Loc 1: 11°54'30"N, 121°59'56.4"E), basal siliceous mudstones of the Saboncogon Formation yield radiolarian faunas of upper Middle - lower Late Jurassic *Kilinora spiralis* Zone (Zamoras et al., 2008). The Saboncogon basal siliceous mudstone beds conformably overlies on the pelagic bedded-chert of the Unidos Formation.

3.2. Loc 2

The locality exposes along the Nabas–Caticlan Road (Fig. 2, Loc 2: 11°52'16. 2"N, 121°59'33"E). The section consists of basalt, pelagic limestone bed (St 2- horizon A), and reddish bedded-chert unit (20 m +; St2- horizons B and C) in ascending order. The beds gently dip northwest.

St 2- horizon A:
Laminated limestone bed (8 cm thick) between basalt and bedded chert unit.
Illyrian – lower Fassanian (uppermost Anisian – lower Ladinian).
Paragondolella excelsa Mosher group P1 (Plate 1, fig. 1),
Gladigondolella tethydis (Huckriede) P1 (Plate 1, figs. 2, 3).

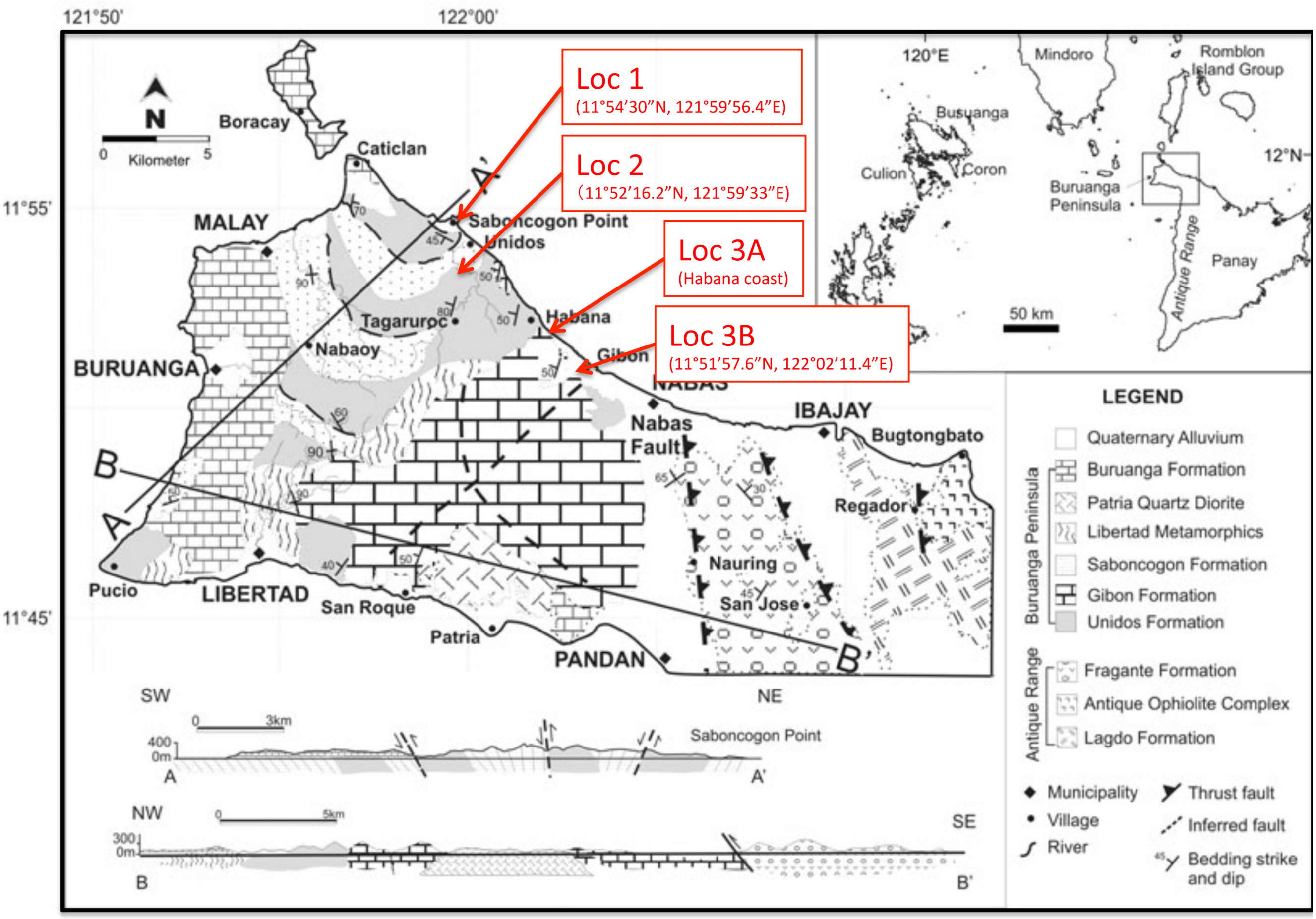


Fig. 2. Microfossil localities filled in the geological map of Buruanga Peninsula, Panai Island (after Zamoras et al., 2008: longitude and latitude of the localities are also followed).

St 2- horizon B:
Base of the bedded chert unit just above the horizon A limestone.
Illyrian - Fassanian (uppermost Anisian – lower Ladinian).
Triassocampe sp. 1 (Plate 3, fig. 5).

St 2- horizon C:
About 20 m above the base of the bedded chert unit (St 2- horizon B).
Fassanian (Lower Ladinian).
Triassocampe sp. 1 (Plate 3, fig. 6),
Triassocampe sp. 2 (Plate 3, figs. 7-11),
Triassocampe sp. 3 (Plate 3, figs. 12),
Triassocampe sp. 4 (Plate 3, figs. 13),
Yeharaia elegans Nakaseko and Nishimura (Plate 3, figs. 14),
Yeharaia aff. *japonica* Nakaseko and Nishimura (Plate 3, fig. 15),
Yeharaia transita Kozur and Mostler (Plate 3, fig. 16)

The bedded chert in this section has been attributed to the Unidos Formation (Zamoras et al., 2008), named after this type locality along the Unidos River at Tagaruroc (11°52′16.2″N, 121°59′33″E). The bedded cherts of the Unidos Formation contain the radiolarians *Zartus* sp. and *Hsuum matsuokai* (radiolarian zone JR3) of early Middle Jurassic ages (Zamoras et al., 2008).

3.3. Loc 3A

Along the coast at Habana, cliff is composed of folded limestone beds with intercalated cherts. The section at this locality has been regarded as "lower stratigraphic sections" of the Gibbon Formation (Zamoras et al., 2008), presumably to be the Lower Jurassic pelagic carbonatic formation. Even the outcrop is too weathered and eroded for sampling of carbonates, we could recognised two types of carbonate units based on huge amount of boulders under the cliff. The one is interbedded micrite/chert unit (pelagic carbonate: ex. Sample Ls/ch 1). The other is bedded lime-mudstones with thinner intercalations of lime-sandstones (distal turbidite of clastic carbonates: ex. Sample Ls 3). They yield the following Late Triassic (late Norian) conodont faunas:

		LITHOSTRATIGRAPHY	AGE	BIOSTRATIGRAPHY
JURASSIC	LATE	turbidite sst/mst	Late Jurassic –	RAD: post-*K. spiralis* Zone
JURASSIC	LATE	siliceous mudstone/ch	Mid/Late Jurassic	RAD: *Kilinora spiralis* Zone
JURASSIC	MIDDLE	upper bedded chert	early Mid Jurassic	RAD: *Zartus* sp. - *Hsuum matsuokai* Zone
JURASSIC	E			
TRIASSIC	LATE	upper pelagic ls/ch	latest Norian	CON: *Misikella hernsteini* Zone
TRIASSIC	LATE	clastic limestone beds (turbidites)	late – latest Norian	CON: mixed fauna (early to late Norian) *Ancyrogondolella quadrata* to *Misikella hernsteini* zones
TRIASSIC	LATE	(carbonate deposition)	early to latest Norian	CON: *Ancyrogondolella quadrata* Zone to *Misikella hernsteini* Zone
TRIASSIC	MIDDLE	lower bedded chert	early Ladinian –	RAD: *Triassocampe* spp. – *Yeharaia* spp. Zone
TRIASSIC	MIDDLE	pelagic limestone bed	late Anisian	CON: *Gladigondolella tethydis* – *Paragondolella excelsa* Zone
TRIASSIC	MIDDLE	basalt		

Fig. 3. Revised litho- and biostratigraphy of the Buruanga Peninsula in Panai Island, North Palawan Block.

Sample Ls/ch 1:
Interbedded micrite limestone and chert.
Upper Norian.
Misikella hernsteini (Mostler) P1 (Plate 1, fig. 4).

Sample Ls 3:
Lime mudstone beds with intercalations of wackestone bands.
Sevatian (upper Norian).
Mockina sp. P1 juvenile-intermediate stages (Plate 1, figs. 5, 6, 8),
Norigondolella sp. P1 Juvenile stage (Plate 1, fig. 7),
Misikella hernsteini (Mostler) P1 intermediate stage (Plate 1, fig. 9).

3.4. Loc 3B

According to Zamoras et al., (2008), locality along the Nabas–Caticlan Road (11°51'57.6"N, 122°02'11.4"E) near Gibbon was regarded as "upper stratigraphic section" of the Gibbon Formation.

The formation consists mainly of bedded lime-mudstone and wackestone alternations. Each bed ranges in thickness from 1 to 30 cm, dipping 45° northwest. Well-bedded limestone, exposed here, extends 15 km over almost half of the Buruanga Peninsula (Fig. 2). It consists of approximately 1000 m thick stratigraphic units.

We have recognized that the section comprises interbedded turbiditic clastic carbonates and lime-mudstones. The graded bedding from granule to mud is well observable on the slab. Rock samples from three meters in vertical distance St 3B-horizons A (lower) and B (upper) of the bedded limestone unit yield the following Late Triassic mixed conodont faunas (from earliest to latest Norian):

St 3B- horizon A:
The graded clastic carbonate bed contains thin and small bivalve shells. A mixed fauna of late Norian age (form Lacian Quadrata Zone to Sevatian Bidentata Zone) was found.
Ancyrogondolella quadrata (Orchard) P1 mature stages (Plate 1, figs. 10, 11),

Ancyrogondolella spatulata (Hayashi) P1 mature stage (Plate 1, fig. 12),
Ancyrogondolella uniformis (Orchard) P1 mature stage (Plate 1, fig. 13),
Mockina postera (Kozur and Mostler) P1 intermediate stages (Plate 2, fig. 5; Plate 3, figs. 1, 4),
Mockina bidentata (Mosher) P1 intermediate stage (Plate 2, fig. 1).

St 3B- horizon B:
Clastic carbonate (wackestone) bed with closed bivalve shells (3 m above the horizon A).
Late Norian mixed fauna from Lacian Quadrata Zone to Alaunian Postera Zone:
Ancyrogondolella quadrata (Orchard) P1 intermediate stages (Plate 2, figs. 3, 4),
Ancyrogondolella spatulata (Hayashi) P1 intermediate stages (Plate 2, figs. 2, 7, 8),
Mockina multidentata (Mosher) P1 mature stages (Plate 2, fig. 6; Plate 3, fig. 3),
Mockina postera (Mosher) P1 intermediate stage (Plate 3, fig. 2).

4. Conclusions

Newly found Triassic conodont and radiolarian faunas from the Bruanga Peninsula in Panai Island were described. The finding of Triassic microfossils from the pelagic carbonates adds the litho- and biostratigraphic constraints for the OPS of Buruanga Unit in North Palawan Block as followings (Fig. 3).

1) The lower pelagic limestone unit covers basalt and yields conodonts of the *Gladigondolella tethydis – Paragondolella excelsa* group Zone (Illyrian/Fassanian). It is overlain by the lower bedded-chert unit of the radiolarian *Triassocampe* spp. - *Yeharaia* spp. Zone (lower Fassanian).

2) Thick turbidite unit of inter-bedded clastic carbonates and lime-mudstones yields late Norian mixed conodont faunas from the Lacian Quadrata Zone to the Sevatian Bidentata Zone.

3) The lime-mudstone dominated alternations of the distal turbidite unit intertongues with the unit of micrites and ribbon-cherts. Both units yield upper Sevatian conodont *Misikella hernsteini* Zone (upper Norian).

4) The micrites and ribbon-cherts unit suggests the late Norian CCD oscillations in the pelagic deep-sea environment.

5) The revised litho- and biostratigraphy of the Buruanga Peninsula in NPB shows typical OPS with Late Triassic Pelagic carbonates (Fig. 3).

6) The revised OPS in Buruanga and its conodont-radiolarian faunas are correlative with those in the Sambosan-Hisaidani JAC Zone in Southwest Japan (Ishida et al., 2015).

5. Paleontological note

The P1 elements of conodonts were discussed as multielement taxonomy. SEM photographs of the described specimens were shown in Plates 1-3. The terminology of a particular part on the oral surface of P1 element is consistent with the notaion of Purnell et al. (2000): anterior (= "ventral"), posterior (= "dosal") by the biological orientation, surrounded by quotation marks proposed in Sanz-Lopez et al. (2004: Figure 3).

Repository: All the specimens are housed in the Tokushima University, SAS collection, Japan, under the numbers TKUCON- for conodonts, and TKURAD- for radiolarians.

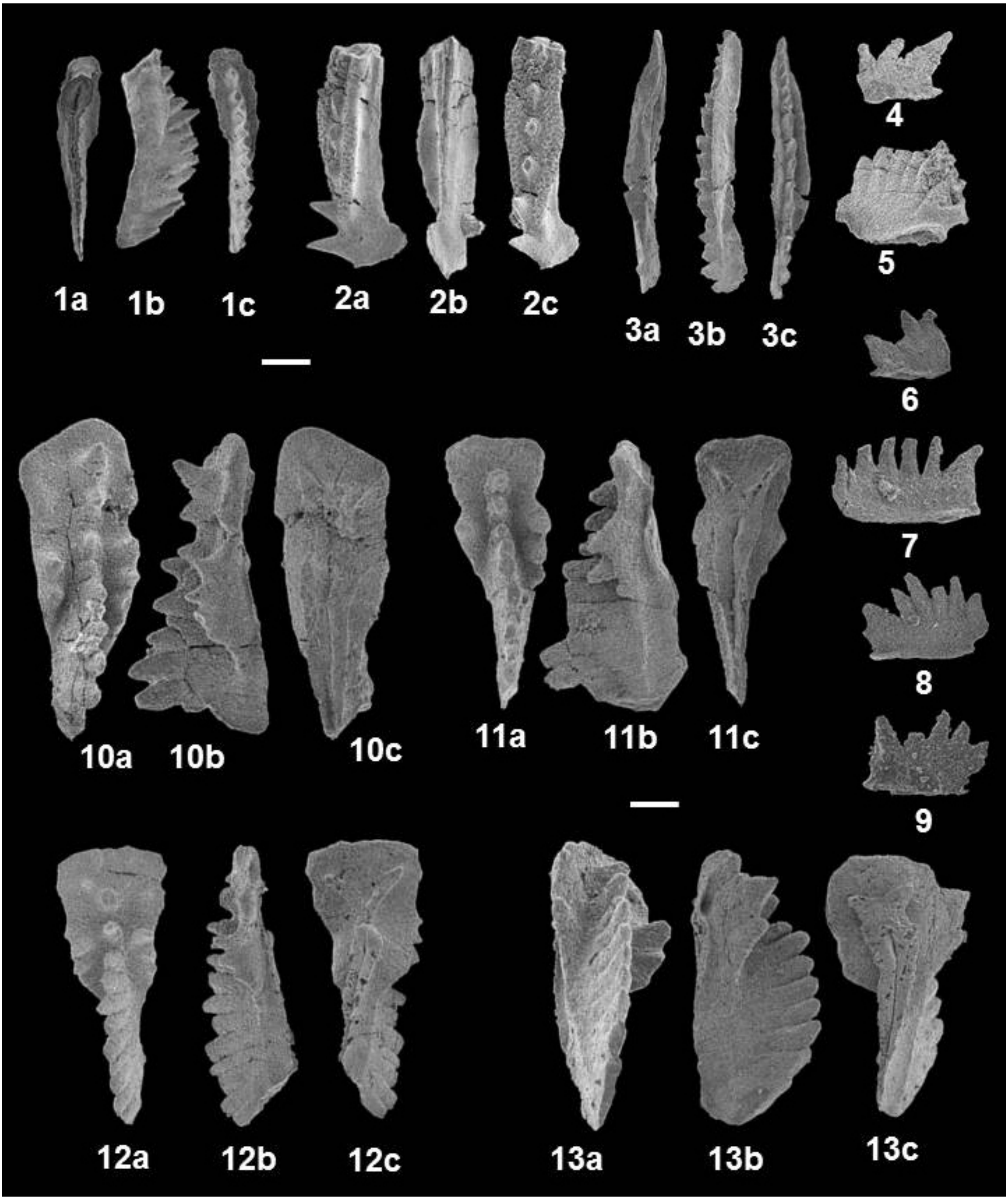
Phylum **CONODONTA**
Order PRIONIODINIDA (Sweet, 1988)
Family Gondolellidae (Lindstroem, 1970)
Subfamily Neogondolellinae (Hirsch, 1994)

Genus *Paragondolella* (Mosher, 1968) p. 938
Type species: *Paragondolella excelsa* Mosher, 1968

Paragondolella excelsa Mosher, 1968 group
Plate 1, figures 1a-c
Paragondolella excelsa n. sp. – Mosher, 1968, p. 938-939, pl. 118, figs. 1-8.
Neogondolella aff. *excelsa* (Mosher) – Ishida, 1981, p. 126-127, Plate 2, fig. 5.
Neogondolella excelsa (Mosher) – Ishida, 1984, p. 28, Plate 2, figs. 5-7.
Specimen: TKUCON002334: P1 intermediate stage.
Remarks: Carina of 11 inclined denticles is highest in mid-anterior portion, decreasing to the posterior end. Outer platform occupies 3/4 and the inner platform occupies less than half of total length. Platform, widening posteriorly, surrounds the posterior node. A narrow seam tapers away anteriorly, ending slightly behind anterior edge, leaving two or three denticles of blade free. At the present growth stage, the platform is initiated at four to seven denticles of the carina. Keel is fairly narrow and arched, ending in flaring loop.
Occurrence: Buruanga 20131106 Loc.2 horizon-A Ls.
Age: latest Illyrian/earliest Fassanian; middle Anisian to early Carnian (Mosher, 1968).

Genus *Norigondolella* Kozur, 1990
Norigondolella Kozur, 1990, p. 127-131.
Type species: *Paragondolella navicula steinbergensis* Mosher, 1968, p. 939, pl. 117, figs. 13-22.

***Norigondolella* sp.**
Plate 1, figures 7a-c
Specimens: TKUCON002272: P1 Juvenile stage.
Remarks: In juvenile, six high-stand denticles in carina are isolated. Cusp inclined posteriorly at the posterior end of the carina. Bulge is observable for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11a
11b
11c
12a
12b
12c
13a
13b
13c

Plate 1

Explanation of Plate 1

SEM-photographs of conodonts from the Buruanga Peninsula. All the specimens are housed in SAS Earth Science Laboratory of Tokushima University, Japan, under the numbers TKUCON- for conodonts. Scale bar: 200 micron-meters for all figures.

Fig. 1. *Paragondolella excelsa* Mosher group P1 intermediate stage
a: aboral, b: lateral, c: oral views. Buruanga 20131106 Loc.2 horizon-A Ls. TKUCON002334.
Fig. 2. *Gladigondolella tethydis* (Huckriede) P1 anterior half of mature stage
a: lateral, b: aboral, c: oral views. Buruanga 20131106 Loc.2 horizon-A Ls. TKUCON002365
Fig. 3. *Gladigondolella tethydis* (Huckriede) P1 intermediate stage
a: aboral, b: lateral, c: oral views. Buruanga 20131106 Loc.2 horizon-A Ls. TKUCON002333
Fig. 4. *Misikella hernsteini* (Mostler) P1 intermediate stage
lateral view. Panai Buruanga 20131106 Loc.3A Coast Ls/ch-1, TKUCON002266
Fig. 5. *Mockina* sp. P1 juvenile-intermediate stage
lateral view. Panai Buruanga 20131106 Loc.3A Coast Ls-3, TKUCON002285
Fig. 6. *Mockina* sp. P1 juvenile stage
lateral view. 20131106 Loc.3A Coast Ls-3, TKUCON002267
Fig. 7. *Norigondolella* sp. P1 juvenile stage
lateral view. 20131106 Loc.3A Coast Ls-3, TKUCON002272
Fig. 8. *Mockina* sp. P1 juvenile stage
lateral view. 20131106 Loc.3A Coast Ls-3, TKUCON002269
Fig. 9. *Misikella hernsteini* (Mostler) P1 intermediate stage
lateral view. 20131106 Loc.3A Coast Ls-3, TKUCON002268
Fig. 10. *Ancyrogondolella quadrata* (Orchard) P1 mature stage
a: oral, b: lateral, c: aboral views. Panai Buruanga 20131106 Loc.3B horizon-A Ls, TKUCON002295
Fig. 11. *Ancyrogondolella quadrata* (Orchard) P1 mature stage
a: oral, b: lateral, c: aboral views. Panai Buruanga 20131106 Loc.3B horizon-A Ls, TKUCON002287
Fig. 12. *Ancyrogondolella spatulata* (Hayashi) P1 mature stage
a: oral, b: lateral, c. aboral views. Panai Buruanga 20131106 Loc.3B horizon-A Ls, TKUCON002288
Fig. 13. *Ancyrogondolella uniformis* (Orchard) P1 mature stage
a: oral lateral, b: lateral, c: aboral views. Panai Buruanga 20131106 Loc.3B horizon-A Ls. TKUCON002294

platform initiation at the mid-lateral position of the terminal cusp.
Occurrence: Buruanga 20131106 Loc.3A Coast Ls-3.
Age: Norian.

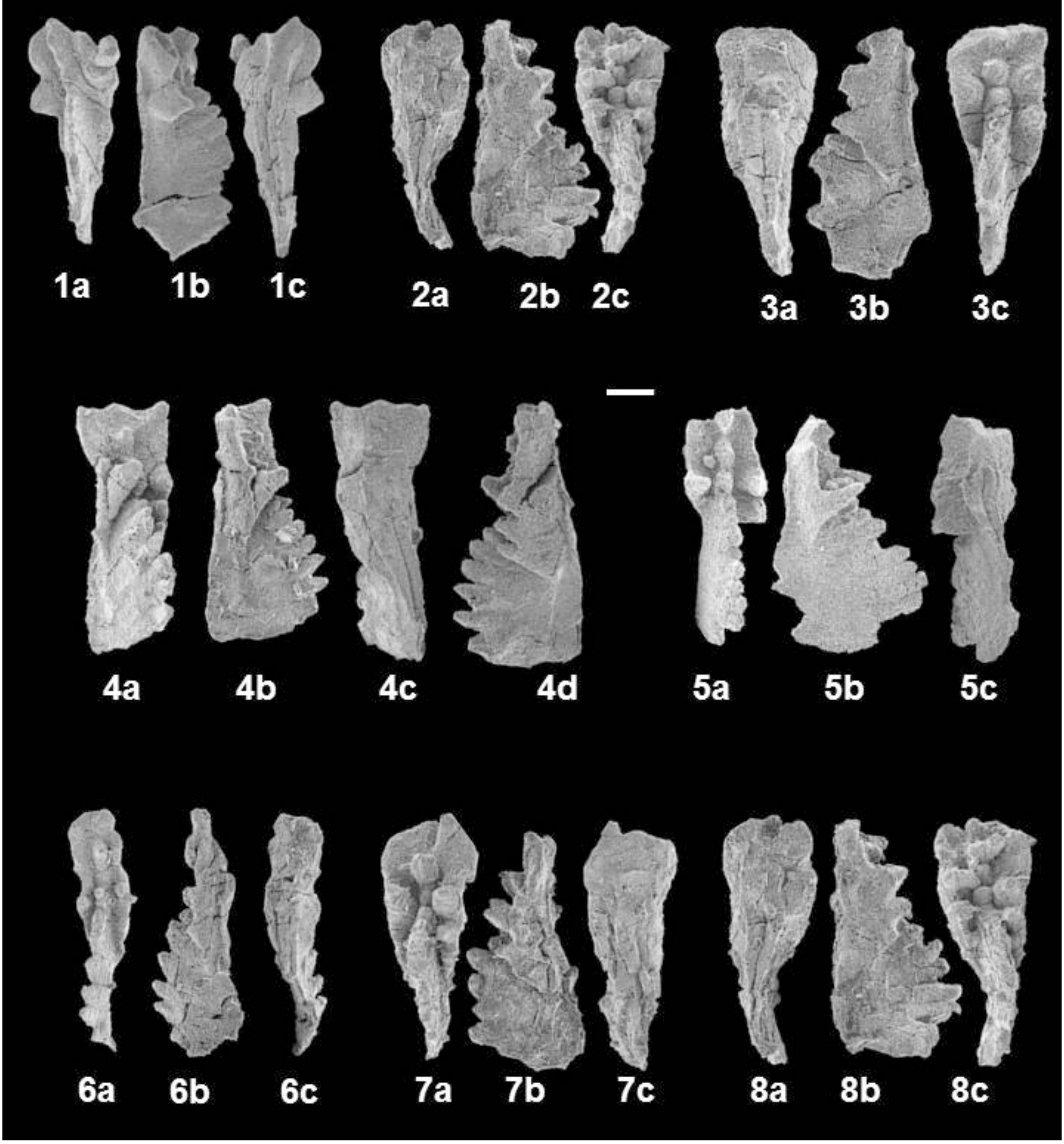
Genus *Ancyrogondolella* Budurov, 1972
Type species: *Ancyrogondolella triangularis* Budurov, 1972, p. 855, pl. 1, figs. 3-6.

Ancyrogondolella quadrata (Orchard, 1991)
Plate 1, figures 10a-c, 11a-c; Plate 2, figures 3a-c, 4a-d

Epigondolella quadrata Orchard, 1991, p. 311, pl. 2, figs, 1-3, 7-9, 10, 12.
Ancyrogondolella quadrata (Orchard). – Ishida and Hirsch, 2001, p. 236, pl. 2, figs. 4a-c, 5a-c, 6a-c, 7a-c, 8a-c; – Ishida et al., 2006, fig. 11, 1a-c. – Mikami et al., 2008, p. 171, pl. 2, figs. 1a-c, 2a-c, 3a-c, 4a-c, 5a-c, 6a-c; pl. 3, figs. 4a-c, 5a-c.
Specimens: TKUCON002295: P1 mature stage; TKUCON002287: P1 mature stage; TKUCON002303: P1 intermediate stage; TKUCON002297: P1 intermediate stage.
Remarks: Rectangular to linguid posterior platform is flat and un-ornamented. A few discrete denticles situate on both sides of anterior platform margins. Posterior end of keel has rectangular cavity.
Occurrence: Panai Buruanga 20131106 Loc.3B horizon-A Ls; horizon-B Ls.
Age: early Lacian (earliest Norian), Quadulata Zone (Orchard, 1991).

Ancyrogondolella spatulata (Hayashi, 1968)
Plate 1, figure 12a-c;
Plate 2, figures 2a-c, 7a-c, 8a-c

Gladigondolella abneptis var. *spatulata* n. subsp. – Hayashi, 1968, p. 69, pl. 2, figs. 5a-c.
Epigondolella spatulata (Hayashi). – Orchard, 1991, p. 312, pl. 2, figs. 4-6, 11.
Ancyrogondolella spatulata (Hayashi). – Ishida and Hirsch, 2001, pl. 3, figs. 5a-c, 6a-c, 7a-c; pl. 4, figs. 1a-c, 3a-c, 5a-c; – Ishida et al., 2006, fig. 12: 4a-c, 5a-c, 6a-d, 7a-d; – Mikami et al., 2008, p. 171, plate 2, figs. 7, 8a-c, 9a-c, 10a-c, 12; plate 3, figs. 6a-c, 7a-c, 8a-c.
Specimens: TKUCON002288: P1 mature stage; TKUCON002304: P1 intermediate stage; TKUCON002300: P1 intermediate stage.
Remarks: Platform short, circular in oral view; spatula- or spoon-shaped; surface more or less radially ridged. Posterior end of keel is wedge-shaped (Pl. 2, figs. 2a, 7c, 8a) primary or bifurcated (Pl. 1, fig. 12) after secondary growth. The species is characterized by an expanded posterior platform with a pair of transversely elongate nodes on anterior platform margins. The posterior part of the keel is triangular or bifurcated. Two types of the posterior platform margin are regarded. One is languid without nodes (Pl. 1, fig. 12a), the other has a marginal denticle in the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6a
6b
6c
7a
7b
7c
8a
8b
8c

Plate 2

Explanation of Plate 2

SEM-photographs of conodonts from the Buruanga Peninsula. All the specimens are housed in SAS Earth Science Laboratory of Tokushima University, Japan, under the numbers TKUCON- for conodonts. Scale bar: 200 micron-meters for all figures.

Fig. 1. *Mockina bidentata* (Mosher) P1 intermediate stage
a: oral, b: lateral, c: aboral views. Panai Buruanga 20131106 Loc.3B horizon-A Ls. TKUCON002290
Fig. 2. *Ancyrogondolella spatulata* (Hayashi) P1 intermediate stage
a: aboral, b: lateral, c: oral views. Panai Buruanga 20131106 Loc.3B horizon-B Ls. TKUCON002304
Fig. 3. *Ancyrogondolella quadrata* (Orchard) P1 intermediate stage
a: aboral, b: lateral, c: oral views. Panai Buruanga 20131106 Loc.3B horizon-B Ls. TKUCON002303
Fig. 4. *Ancyrogondolella quadrata* (Orchard) P1 intermediate stage
a: oral, b: lateral, c: aboral, d: lateral views. Panai Buruanga 20131106 Loc.3B horizon-B Ls. TKUCON002297
Fig. 5. *Mockina postera* (Kozur and Mostler) P1 intermediate stage
a: oral, b: lateral, c: aboral views. Panai Buruanga 20131106 Loc.3B horizon-A Ls. TKUCON002446
Fig. 6. *Mockina multidentata* (Mosher) P1 mature stage
a: oral, b: lateral, c: aboral views. Panai Buruanga 20131106 Loc.3B horizon-B Ls. TKUCON002305
Fig. 7. *Ancyrogondolella spatulata* (Hayashi) P1 intermediate stage
a: oral, b: lateral, c: aboral views. Panai Buruanga 20131106 Loc.3B horizon-B Ls. TKUCON002300
Fig. 8. *Ancyrogondolella spatulata* (Hayashi) P1 intermediate stage
a: aboral, b: lateral, c: oral views. Panai Buruanga 20131106 Loc.3B horizon-B Ls. TKUCON002304 (Specimen is same as in Fig. 2.)

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center of its posterior margin (i.e. extended position of carina: Pl. 2, figs. 2c, 7a, 8c). The latter form has a similarity with *A. triangularis*.
Occurrence: Panai Buruanga 20131106 Loc.3B horizon-A Ls; horizon-B Ls.
Age: late Lacian (early Norian Triangularis Zone: Orchard, 1991).

Ancyrogondolella uniformis (Orchard, 1991)
Plate 1, figures 13a-c
Epigondolella triangularis uniformis Orchard, 1991, p. 315, pl. 3, figs. 1-3.
Ancyrogondolella uniformis (Orchard, 1991). – Ishida and Hirsch, 2001, p. 236, pl. 3, figs. 1a-c, 2a-c, 3a-c, 4a-c.
Specimens: TKUCON002294: P1 mature stage.
Remarks: The aboral side is triangular to round, sometimes quadrate, always bilobal or bifid. Oral side varies from quadrate to triangular or round. The carina has up to 11 denticles. The platform has up to 14 denticles.
Occurrence: Panai Buruanga 20131106 Loc.3B horizon-A Ls.
Age: Early Norian (middle Lacian, lower Triangularis Zone: Orchard, 1991).

Genus *Mockina* Kozur, 1989
Type species: *Tardogondolella abneptis postera* Kozur and Mostler, 1971, p. 14-15, pl. 2, figs. 4-6.

Mockina bidentata (Mosher, 1968)
Plate 2, figures 1a-c
Epigondolella bidentata n. sp. – Mosher, 1968, p. 936, pl.118, fig. 31-35; non pl. 118, fig. 36 = holotype of *E. mosheri* (Kozur and Mostler, 1971); – Orchard, 1991, p. 307, pl. 4, fig. 12.
Specimens: TKUCON002290: P1 intermediate stage.
Remarks: A single pair of lateral denticles situates on each side of narrow platforms that reduced as lateral swelling. Cusp and basal pit situate anteriorly as same as the single pair of lateral denticles. Carina and keel reach to the posterior end.
Occurrence: Panai Buruanga 20131106 Loc.3B horizon-A Ls.
Age: Sevatian (late Norian), Bidentata Zone (Orchard, 1991).

Mockina postera (Kozur and Mostler, 1971)
Plate 2, figures 5a-c;
Plate 3, figures 1a-c, 2a-c, 4a-c
Tardogondolella abneptis postera Kozur and Mostler, 1971, p. 14-15, pl. 2, figs. 4-6.
Epigondolella abneptis (Huckriede). – Mosher, 1968, (partim), pl. 118, figs. 20, 21.
Metapolygnathus posterus posterus (Kozur and Mostler). –Kozur, 1972, p. 3, pl. 6, figs. 23-25.
Epigondolella postera (Kozur and Mostler). – Orchard, 1983, p. 186-188, figs. 15 P-R; – Orchard, 1991, p. 310-311, pl. 4, figs. 16-19.

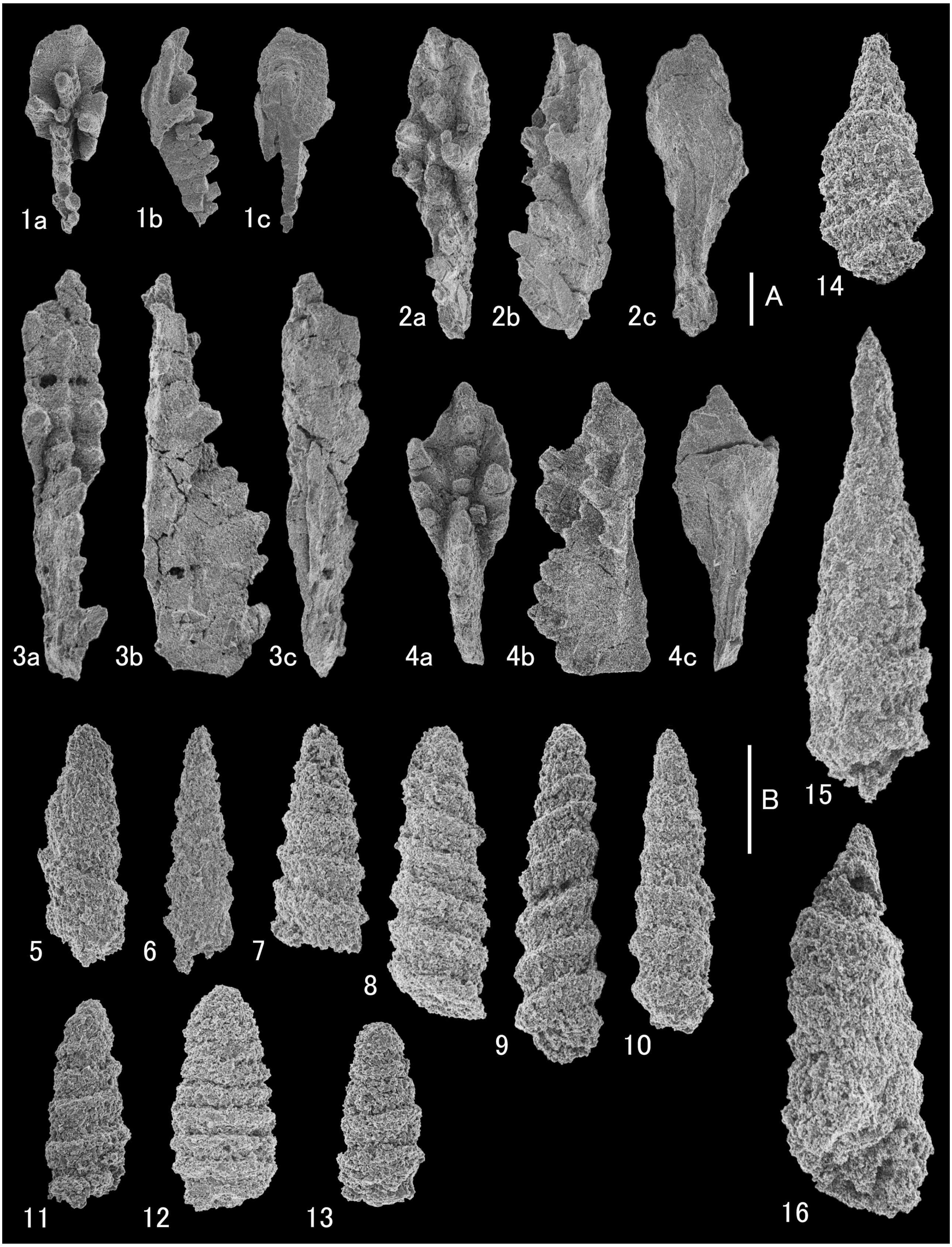

Plate 3

Explanation of Plate 3

SEM-photographs of conodonts (figs. 1-4) and radiolarians (figs. 5-16) from the Buruanga Peninsula. All the specimens are housed in SAS Earth Science Laboratory of Tokushima University, Japan, under the numbers TKUCON- for conodonts, and TKURAD- for radiolarians. Scale bars: A: 200 micron-meters for all conodonts in figs. 1-4; B: 100 micron-meters for all radiolarians in figs. 5-16.

Fig. 1. *Mockina postera* (Kozur and Mostler) P1 intermediate stage
a: oral, b: lateral, c: aboral views. Panai Buruanga 20131106 Loc.3B horizon-A Ls. TKUCON002296
Fig. 2. *Mockina postera* (Kozur and Mostler) P1 mature stage
a: oral, b: lateral, c: aboral views. Panai Buruanga 20131106 Loc.3B horizon-B Ls. TKUCON002298
Fig. 3. *Mockina multidentata* (Mosher) P1 mature stage
a: oral, b: lateral, c: aboral views. Panai Buruanga 20131106 Loc.3B horizon-B Ls. TKUCON002301
Fig. 4. *Mockina postera* (Kozur and Mostler) P1 mature stage
a: oral, b: lateral-oral, c: aboral views. Panai Buruanga 20131106 Loc.3B horizon-A Ls. TKUCON002296
Figs. 5, 6. *Triassocampe* sp. 1
5: Panai Buruanga 20131106 Loc. 2 horizon-B Ch (base of the bedded chert unit), TKURAD002548; 6: Panai Buruanga 20131106 Loc. 2 horizon-C Ch, TKURAD002498
Figs. 7-11. *Triassocampe* sp. 2
Panai Buruanga 20131106 Loc. 2 horizon-C Ch, 7: TKURAD002508; 8: TKURAD002510; 9: TKURAD002482; 10: TKURAD002530; 11: TKURAD002472
Figs. 12. *Triassocampe* sp. 3
Panai Buruanga 20131106 Loc. 2 horizon-C Ch, TKURAD002526
Figs. 13. *Triassocampe* sp. 4
Panai Buruanga 20131106 Loc. 2 horizon-C Ch, TKURAD002542
Fig. 14. *Yeharaia elegans* Nakaseko and Nishimura
Panai Buruanga 20131106 Loc. 2 horizon-C Ch, TKURAD002532
Fig. 15. *Yeharaia* aff. *japonica* Nakaseko and Nishimura
Panai Buruanga 20131106 Loc. 2 horizon-C Ch, TKURAD002501
Fig. 16. *Yeharaia transita* Kozur and Mostler, 1994
Panai Buruanga 20131106 Loc. 2 horizon-C Ch, TKURAD002474

Mockina postera (Kozur and Mostler). – Ishida and Hirsch, 2001, p. 218, pl. 4, figs. 2a-c, 4a-c, 6a-c.
Specimens: TKUCON002446: P1 intermediate stage; TKUCON002296: P1 intermediate stage; TKUCON002298: P1 mature stage; TKUCON002296: P1 mature stage.
Remarks: Nearly half unit length of shorter platform becomes either smaller or nearly the same width, the posterior end is nearly always pointed (acuminate) with terminal denticle of the carina. Generally one lateral denticle situated near each anterior end of the platform, one side can bear a second shorter denticle(s). Basal pit is situated in the central part of the platform. Posterior end of the basal keel bifurcates after the secondary growth.
Occurrence: Panai Buruanga 20131106 Loc.3B horizon-A Ls.; horizon-B Ls.
Age: Alaunian (later middle Norian), Postera Zone (Orchard, 1991).

Mockina multidentata (Mosher, 1970)
Plate 2, figures 6a-c; Plate 3, figures 3a-c
Epigondolella multidentata Mosher, 1970, p.739, pl. 110, figs. 19, 22-26; – Orchard, 1991, p. 310, pl. 4, figs. 1-3, 7.
Specimens: TKUCON002305, TKUCON002301: P1 mature stages.
Remarks: Platform posteriorly tapering, posterior portion is smooth (or gently and regularly crenelated) and free of denticles. Antero-lateral margins of platform bear two to three spike-like denticles.
Occurrence: Panai Buruanga 20131106 Loc.3B horizon-B Ls.
Age: early Alaunian (earliest middle Norian), Multidentata Zone (Orchard, 1991).

***Mockina* sp.**
Plate 1, figures 5, 6, 8
Specimens: fig. 5: TKUCON002285: P1 Juvenile-intermediate stage; fig. 6: TKUCON002267: P1 Juvenile stage; fig. 8: TKUCON002269: P1 Juvenile stage.
Remarks: Even in the juvenile-intermediate stage (Pl. 1, fig. 5), a pair of lateral denticles is recognized on each anterior end of small platform. Posterior part of platform is narrow square and flat. In case of juvenile (Pl. 1, figs. 6, 8), platform is recognized as bulge at the posterior end similar to mid-lateral rib.
Occurrence: Panai Buruanga 20131106 Loc.3A Coast Ls-3.
Age: Alaunian – Sevatian (middle – late Norian).

Genus *Misikella* Kozur and Mock, 1974
(Emend. Ishida and Hirsch, 2001)
Misikella Kozur and Mock, 1974, p. 135-136.
Axiothea Faraeus and Ryley, 1989, p. 1258.
Type species: *Misikella longidentata* Kozur and Mock, 1974, p. 136-137, pl. 1, figs. 4-5.

Misikella hernsteini (Mostler, 1967)
Plate 1, figures 4, 9

Spathognathodus hernsteini Mostler, 1967, p. 182, fig. 1a-c.
Misikella hernsteini (Mostler). – Kozur and Mock, 1974, p. 135-136, pl. 1, figs. 6-7; – Ishida and Hirsch, 2001, p. 246, pl. 7, figs. 5-10.
Axiothea hernsteini (Mostler). – Fahraeus and Ryley, 1989, p. 1258, pl. 1, figs. 4-6.
Specimens: TKUCON002266, TKUCON002268: P1 intermediate stages.
Remarks: Drop shaped basal cavity, carina-blade with four to six fused denticles.
Occurrence: Panai Buruanga 20131106 Loc. 3A Coast Ls/ch 1.
Age: Sevatian (late Norian) – Rhaetian.

Family Gladigondolellidae Ishida and Hirsch, 2011, p. 29-31
Genus *Gladigondolella* (Mueller, 1962) emend. (Ishida and Hirsch, 2011) p. 29-31
Type species: *Polygnathus tethydis* Huckriede, 1958, p. 157-158, pl.11, figs. 39, 40; pl. 12, figs. 1, 38a, b; pl. 13, figs. 2-5

Gladigondolella tethydis (Huckriede, 1958)
Plate 1, figures 2a-c, 3a-c

Polygnathus tethydis Huckriede, 1958, p. 157-158, pl.11, figs. 39, 40; pl. 12, figs. 1, 38a, b; pl. 13, figs. 2-5.
Gladigondolella tethydis (Huckriede). – Mueller, 1962, p.116; – Mosher, 1968, p. 937, pl. 116, figs. 1, 2, 5, 8.
Specimens: TKUCON002365: P1 intermediate stage; TKUCON002333: anterior half of P1 mature stage.
Remarks: Posterior part of platform after the basal pit is slightly twisted both downward and laterally. A short and high free blade indicates anterior-most part of the unit. Carina on narrow and longer platform is characterized by isolated low node-like denticles in mature form (Pl. 1, figs. 2a, 2c), whereas fused blade-like row of platform denticles that represents a fixed blade (Pl. 1, figs. 3b, c) in the intermediate growth stage. Carina-blade is composed of nearly twenty denticles in the intermediate stage. Narrow amygdaloidal basal cavity situates in the posterior one-third to the central position.
Occurrence: Buruanga 20131106 Loc.2 horizon-A Ls.
Age: Aegean – Julian (early Anisian – early Carnian).

Subphylum **RADIOLARIA**
Class POLYCYSTINEA
Order NASSELLARIA Ehrenberg, 1875
Family Triassocampidae Kozur and Mostler, 1981
Genus *Triassocampe* Dumitrica, Kozur and Mostler, 1980
Type species: *Triassocampe scalaris* Dumitrica, Kozur and Mostler, 1980, p. 26, pl. 9, figs. 5,6, 11; pl. 14, fig. 2

Age and Range: middle Anisian – early Ladinian (Ishida, 1984); rarely in late Anisian (only *T. deweveri* group) and are most frequent in early Ladinian (Kozur and Mostler, 1994).

***Triassocampe* sp. 1**
Plate 3, figures 5, 6

Triassocampe aff. *scalaris* Dumitrica, Kozur and Mostler. – Ishida, 1984, p. 26, pl. 1, figs. 1-4.
Specimens: TKURAD002548; TKURAD002498.
Remarks: Slender outline with less developed transverse ridges on post-abdominal segments.
Occurrence: Panai Buruanga 20131106 Loc. 2 horizon-B Ch (base of the bedded chert unit); horizon-C Ch (20 m above the base of the bedded chert unit).
Age: late Bithynian – early Fassanian (middle anisian – early Ladinian: Ishida, 1984).

***Triassocampe* sp. 2**
Plate 3, figures 7 – 11

Triassocampe sp. a. – Mizutani and Koike, 1982, p. 128, pl. 4, fig. 3; – Ishida, 1984, p. 26, pl. 1, figs. 5-9.
Triassocampe deweveri Kozur and Mostler, 1994, pp. 140-141, pl. 42, fig. 1; pl. 44, fig. 14; pl. 45, fig. 6.
Triassocampe postdeweveri Kozur and Mostler, 1994, pp. 144-145, pl. 42, fig. 2.
Specimens: TKURAD002508; TKURAD002510; TKURAD002482;TKURAD002530;TKURAD002472.
Remarks: Well-developed brim on the proximal part of each post-abdominal segment. Cephalis is round and smooth without apical horn. In relatively well-preserved specimens (figs. 7, 9), two rows of transversely arranged pores remain on the distal side of the brim and the proximal part of the post-abdominal segments. This species differs from *Triassocampe deweveri* (Nakaseko and Nishimura, 1979) nor *T. scalaris* by Dumitrica et al. (1980), without having nodose ornamentations on the post-abdominal chambers.
Occurrence: Panai Buruanga 20131106 Loc. 2 horizon-C Ch (20 m above the base of the bedded chert unit).
Age: Illyrian – Fassanian (late Anisian – early Ladinian).

***Triassocampe* sp. 3**
Plate 3, figure 12

Specimens: TKURAD002526.
Remarks: Relatively low post-abdominal segments with well-developed transverse brim (ridges).

Occurrence: Panai Buruanga 20131106 Loc. 2 horizon-C Ch (20 m above the base of the bedded chert unit).
Age: Illyrian – Fassanian (late Anisian – early Ladinian, estimated).

***Triassocampe* sp. 4**
Plate3, figure 13
cf. *Dictyomitrella deweveri* n. sp. – Nakaseko and Nishimura 1979. p. 77, pl. 10, figs. 8, 9.
cf. *Triassocampe deweveri* (Nakaseko and Nishimura). – Ishida, 1984, p. 26-27, Pl. 1, figs. 10-12.
Specimens: TKURAD002542.
Remarks: This specimen is comparable to *Triassocampe deweveri* with dome-shaped large round cephalis. Each of high post-abdominal segments are ornamented by a row of granular small knobs.
Occurrence: Panai Buruanga 20131106 Loc. 2 horizon-C Ch (20 m above the base of the bedded chert unit).
Age: late Illyrian – early Fassanian (estimated by generic range: Ishida, 1984; Kozur and Mostler, 1994). (not late Carnian nor Norian).

Genus *Yeharaia* Nakaseko and Nishimura, 1979
Type species: *Yeharaia elegans* Nakaseko and Nishimura, 1979, p. 82.
Remarks: Multi-segmented *Yeharaia* is distinguished from *Triassocampe* by having large apical horn. A deep stricture separates gourd-shaped cephalo-thorax from the distal segments.
Age and Range: Genus *Yeharaia* is a worldwide distributed very good guide form of the Fassanian (Kozur and Mostler, 1994).

Yeharaia elegans Nakaseko and Nishimura, 1979
Plate 3, figure 14
Yeharaia elegans Nakaseko and Nishimura, 1979, p. 82, pl. 10, figs. 2-5, pl. 12, figs 2, 6; – Ishida, 1981, p.26, pl. 1, fig. 16.
Specimens: TKURAD002532.
Remarks: The deep stricture separates gourd-like expanded spherical cephalis-thorax with three-edged stout apical horn from the distal segments.
Occurrence: Panai Buruanga 20131106 Loc. 2 horizon-C Ch (20 m above the base of the bedded chert unit).
Age: latest Illyrian – early Fassanian (Ishida, 1984).

Yeharaia* aff. *japonica Nakaseko and Nishimura, 1979
Plate 3, figure 15
aff. *Yeharaia japonica* n. sp. – Nakaseko and Nishimura, 1979, p. 83, Pl. 10, figs. 6, 10; Pl. 12, fig. 9; – Ishida, 1984, p. 26-27, pl. 1, figs. 17-19.
Specimens: TKURAD002501.
Remarks: This species has projection of stout three-edged apical horn that is larger than original.
Occurrence: Panai Buruanga 20131106 Loc. 2 horizon-C Ch (20 m above the base of the bedded chert unit).
Age: early Fassanian (estimated).

Yeharaia transita Kozur and Mostler, 1994
Plate 3, figure 16
Yeharaia transita Kozur and Mostler, 1994, p. 148, pl. 46, figs. 1-4, 12.
Specimens: TKURAD002474.
Remarks: Kozur and Mostler (1994) regarded this species as the transitional from *Triassocampe* to *Yeharaia* with short horn and proximal rings on the post-abdominal segments.
Occurrence: Panai Buruanga 20131106 Loc. 2 horizon-C Ch (20 m above the base of the bedded chert unit).
Age: Lower – middle Fassanian (Kozur and Mostler, 1994).

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