A comparative study on Upper Jurassic radiolarian biostratigraphy of the Taman Formation, east-central Mexico and the ODP Site 801B Section, west Pacific

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Abstract

This study reveals that the following zonal marker taxa occur both in the Taman Formation and at the ODP Site 801B section: *Acanthocircus dicranacanthos* (Squinabol), *Hsuum maxwelli* Pessagno, *Mirifusus guadalupensis* Pessagno, Genus *Perispyridium* Dumitrica, *Pseudodictyomitra carpatica* (Lozyniak), and *Vallupus hopsoni* Pessagno and Blome. Six bio-events, such as the first occurrence biohorizon (FOB), the last occurrence biohorizon (LOB) and the evolutionary first appearance biohorizon (EFAB), are commonly identified in the Taman Formation and in the ODP Site 801B section: (1) LOB of *Mirifusus guadalupensis* Pessagno, (2) LOB of the *Hsuum maxwelli* Pessagno group, (3) FOB of *Vallupus hopsoni* Pessagno and Blome, (4) LOB of Genus *Perispyridium* Dumitrica, (5) EFAB of *Pseudodictyomatra carpatica* (Lozyniak), and (6) FOB of *Acanthocircus dicranacanthos* (Squinabol). By using these bio-events, the North American and Japan-Pacific radiolarian zones are correlated with each other. North American Zone 3/Zone 4 and Zone 4/Zone 5 boundaries are situated within the Japan-Pacific *Loopus primitivus* Zone and *Pseudodictyomitra carpatica* Zone, respectively. Conversely, the Japan-Pacific *Hsuum maxwelli*/*Loopus primitivus* and *Loopus primitivus*/*Pseudodictyomitra carpatica* zonal boundaries are situated within North American Zone 3 (Subzone 3 α) and Zone 4 (around Subzone 4 β /Subzone 4 α boundary), respectively.

Key words : radiolarian biostratigraphy, Upper Jurassic, Taman Formation, east-central Mexico, ODP Site 801, west Pacific, North American zonation, Japan-Pacific zonation, zonal correlation

Introduction

Parallel radiolarian biostratigraphic zones for the Jurassic have been independently developed in North America (Pessagno *et al.*, 1984, 1987b, 1989, 1993) and in Japan-Pacific regions (Matsuoka and Yao, 1986; Matsuoka, 1992, 1995a). Although zonal correlation has been attempted (Pessagno

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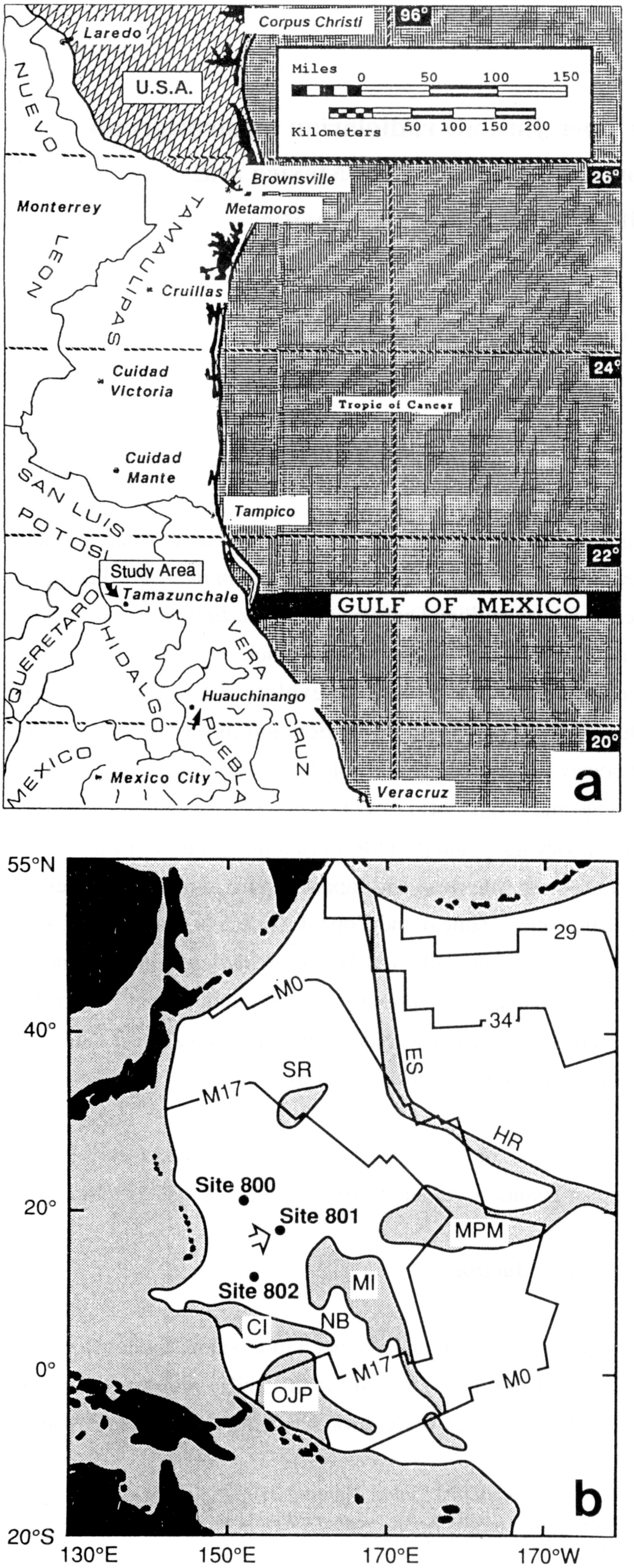

Fig. 1. Index maps showing the study areas. Arrows point to sample localities. a: east-central Mexico (adapted from Pessagno *et al.*, 1987a); b: ODP Site 801, west Pacific (from Lancelot *et al.*, 1990). Abbreviations: CI = Caroline Islands, ES = Emperor Seamounts, HR = Hawaiian Ridge, MI = Marshall Islands, MPM = Mid-Pacific Mountains, NB = Nauru Basin, OJP = Ontong Java Plateau, SR = Shatsky Rise.

and Mizutani, 1992; Matsuoka, 1995b; Pessagno and Hull, 1996), the results are still controversial. In an attempt to resolve this problem, this study presents two sets of data; one obtained from the Upper Jurassic Taman Formation of east-central Mexico (Fig. 1a), and the other from the Upper Jurassic section at Ocean Drilling Program (ODP) Site 801B, west Pacific (Fig. 1b).

The east-central Mexico section (Taman Formation) and the west Pacific section (ODP Site 801B) are probably the best sections available for studying Upper Jurassic (Tithonian) radiolarian biostratigraphy in the Pacific and circum-Pacific regions because of the abundance and preservational status of Radiolaria recovered, the stratigraphic continuity, and the degree of taxonomic studies conducted. The Taman Formation has been intensively studied for its biostratigraphy, including Radiolaria (Pessagno *et al.*, 1984, 1986, 1987a, 1989), bivalves and ammonites (Cantu Chapa, 1971, 1976; Imlay, 1980), and calpionellids (Pessagno *et al.*, 1984), whereas the ODP Site 801B section is especially significant for its continuous nature of lithological succession.

The Taman Formation is primarily composed of micritic limestones and shales, representing an outer neritic to bathyal sedimentary environment above the CCD, while the ODP strata mainly comprise a sequence of radiolarites and claystone, deposited in a pelagic and deep ocean environment below the CCD. Although these lithologies and depositional environments differ, both sections were located within the *Vallupus* territory (Matsuoka, 1995b) which was a tropical biogeographic realm during late Jurassic time. We compare radiolarian faunas and bio-events in these Mexican and Pacific sections and present a correlation chart of Upper Jurassic radiolarian zonations for North America and Japan-Pacific.

Oceanographic setting and stratigraphic summary

The Taman Formation, east-central Mexico

Middle and Upper Jurassic strata in east Mexico are part of a transgressive sequence that occurs above Middle Jurassic continental deposits and below Cretaceous limestone platform strata (Longoria, 1984). This sequence begins with the Tepexic Calcarenite (upper Bathonian to lower Callovian), and is overlain successively by the "Sandiago Formation" (Callovian to Oxfordian), the Taman Formation (Kimmeridgian to Tithonian), the Pimienta Formation (Berriasian), and the Chapulhuacan Formation (Berriasian to Aptian). The whole sequence typically consists of black clayey limestone, shale, and nodular limestone. Longoria (1985) suggested that this transgressive sequence represents a period of sea-floor spreading that led to the opening of the Gulf of Mexico.

The Taman Formation is composed of interbedded dark gray shale and limestone. It is divided into two informal members: the lower member consists of massively-bedded limestone intercalated with a minor amount of shale; the upper member is thin-bedded limestone with thick intervals of shale (Fig. 2). Dark micritic limestone nodules (ca. 7 to 90 cm in diameter) commonly occur in the upper member and in the upper part of the lower member. Both the bedded micritic limestone and the limestone nodules contain abundant Radiolaria. The thickness of the Taman Formation is estimated to range from 200 m to 500 m (Erben, 1956) or greater. At the type locality (Taman-Tamanzunchale area, San Luis Potosi, Fig. 1a), the upper thin-bedded member is about 150 m (Yang, 1993).

Ammonites are present in the Taman Formation, the underlying "Santiago Formation", and the

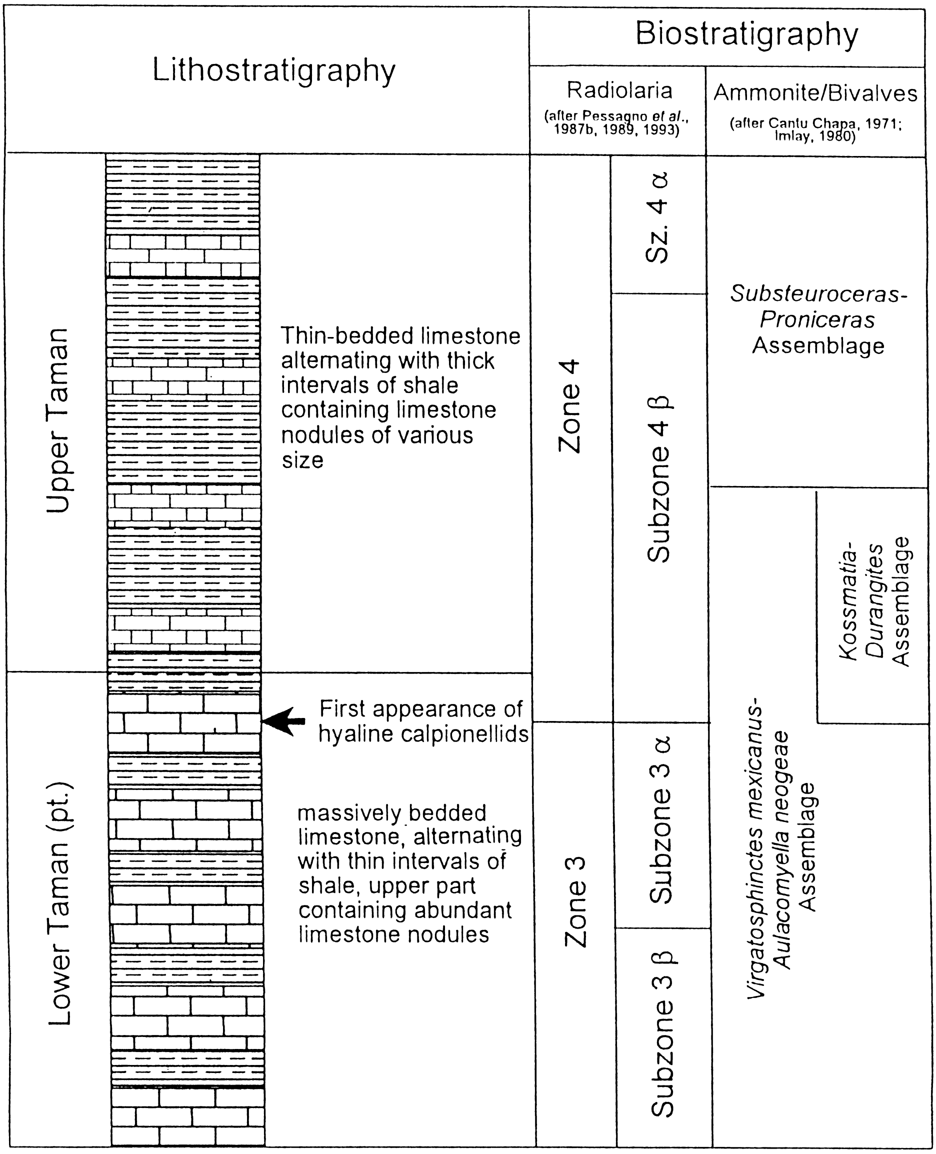

Fig. 2. Schematic diagram showing lithostratigraphy and biostratigraphy of the Taman Formation, east-central Mexico.

overlying Pimienta Formation. In the Taman-Tamazunchale area (Fig. 1a), the lower, massively-bedded member of the Taman Formation includes the *Ataxioceras* Zone (lower Kimmeridgian), the *Idoceras* Zone (uppermost lower Kimmeridgian), the *Glochiceras* gp. *fialar* Zone (upper Kimmeridgian), and the *Virgatosphinctes mexicanus-Aulacomyella neogeae* Zone (lower to upper Tithonian) (Cantu Chapa, 1971; Imlay, 1980)(Fig. 2). The calpionellid *Crassicollaria intermedia* (Durand Delga) was reported by Pessagno *et al.* (1984, 1987a) in the uppermost 6 m of the lower, massively-bedded member of the Taman Formation (Fig. 2).

Radiolarian studies of the Taman Formation were first initiated by Pessagno *et al.* (1984, 1986, 1987a, 1989). Hull (1991) and Yang (1993) presented detailed taxonomic and biostratigraphic analy-

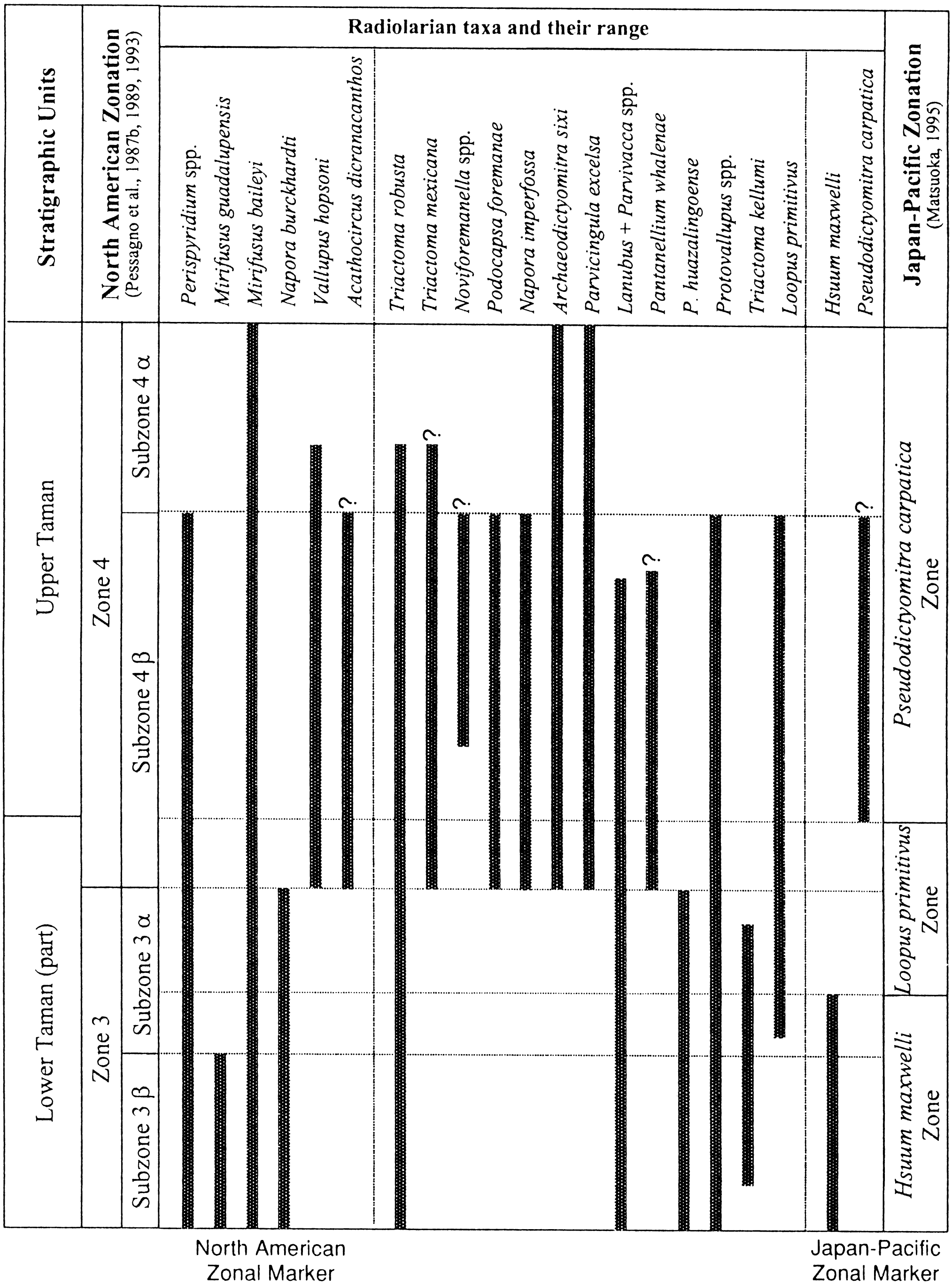

Fig. 3. Range of selected radiolarian taxa in the Taman Formation, east-central Mexico. Original data from Pessagno *et al.* (1987a, 1989), Hull (1991), and Yang (1993).

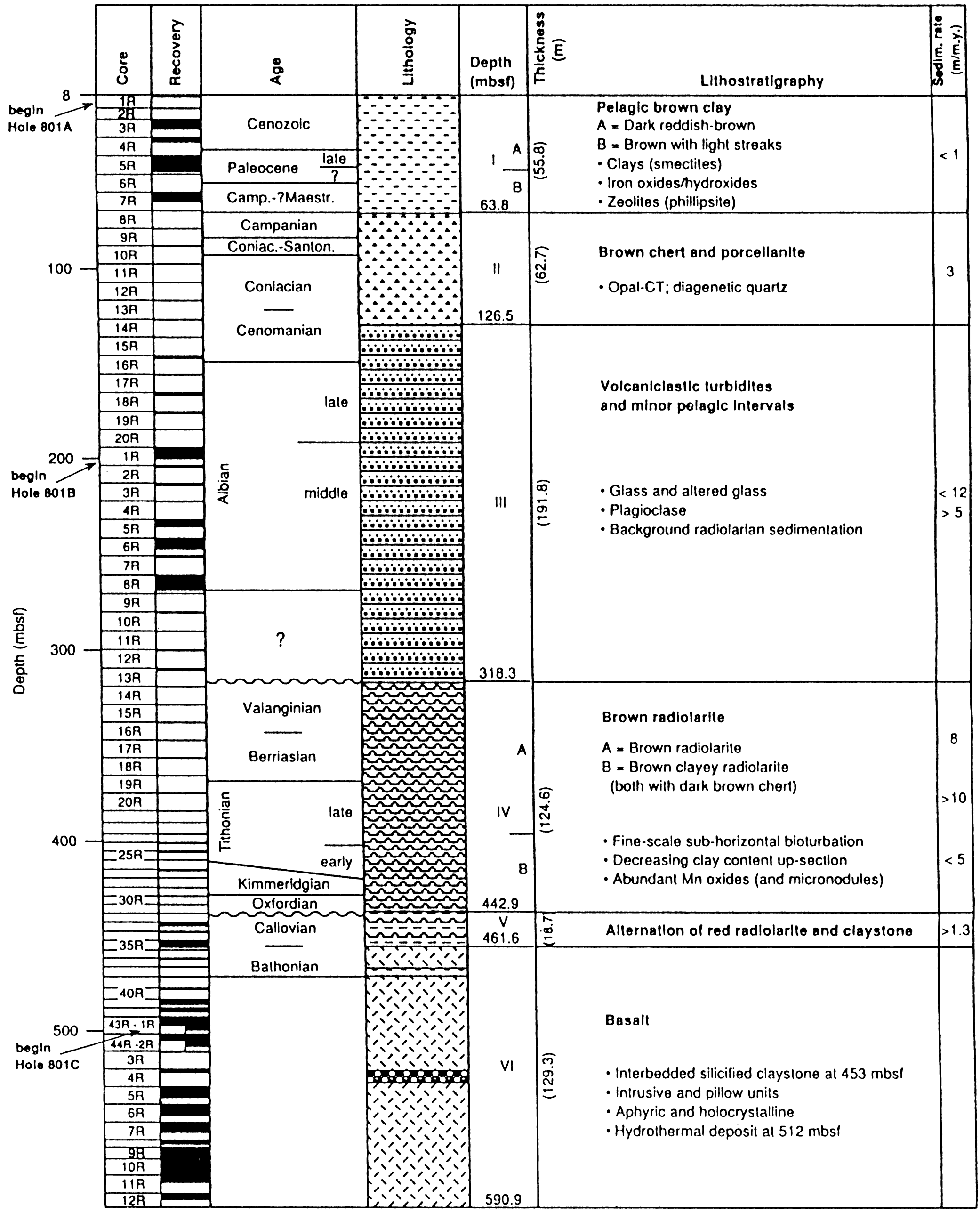

Fig. 4. Schematic diagram showing lithostratigraphy at ODP Site 801, west Pacific (from Lancelot *et al.*, 1990).

ses of Radiolaria from the Taman Formation. The studied interval of the Taman Formation is assigned to North American Zone 3 (Subzones 3 β and 3 α) and Zone 4 (Subzones 4 β and 4 α) in ascending order (Figs. 2 and 3) (Pessagno *et al.*, 1987a; Hull, 1991; Yang, 1993). North American Zone 3 and Zone 4 are dated as lower Tithonian and upper Tithonian, respectively on the basis of co-occurring ammonites and calpionellids (Pessagno *et al.*, 1987a, 1987b, 1989, 1993). The ranges of some biostratigraphically important radiolarian taxa are presented in Fig. 3.

ODP Site 801B Section

ODP Site 801 is located in the central Pigafetta Basin (18°38.54'N, 156°21.58'E) at a water depth of 5,682m. It is situated in a magnetic quiete zone southwest of the M25-M37 magnetic lineation sequence. According to Lancelot *et al.* (1990), strata at this site are divided into six lithostratigraphic units (Fig. 4). The radiolarian samples under study are from Unit IV (Core 14R to 32R). The base of Unit IV is in uncomformable contact with alternating beds of red radiolarite and claystone of Unit V; the top of Unit IV is overlain by Albian volcano-clastic turbidites of Unit III. Unit IV represents a continuous sedimentary section consisting of 124.6 m of brown radiolarites and clayey radiolarites with scattered dark brown porcellanite bands and nodules. The porcellanite bands and nodules are more abundant in the upper 82 m interval than in lower part of the unit. Radiolarians are abundant and fairly well-preserved in this interval. With the exception of rare nannofossils of Tithonian age in Cores 801B-25R and -26R (Erba and Covington, 1992), the studied section is barren of age-diagnostic fossils other than radiolarians. The scarcity of calcareous elements suggests that the radiolarites were deposited below the calcium carbonate compensation depth (CCD). Paleomagnetic data indicate that ODP Site 801 was located in the vicinity of the paleo-equator during latest Jurassic (Tithonian) time (Steiner and Wallick, 1992).

Radiolarian biostratigraphic research at ODP Site 801 was carried out by Matsuoka (1992). In his research on Jurassic-Cretaceous radiolarian zonation applicable to Japan-Pacific regions, Matsuoka (1995a) recognized several stratigraphically important biohorizons in this section. He designated it the type section for the last occurrence biohorizon of the *Hsuum maxwelli* group and the evolutionary first appearance biohorizon of *Pseudodictyomitra carpatica* (Lozyniak). In addition, ODP Site 801B is regarded as one of reference sections for the evolutionary first appearance biohorizon of *Cecrops septemporatus* (Parona). According to the Japan-Pacific zonation of Matsuoka (1995a), the studied interval in the ODP Site 801B section includes from the base up the *Hsuum maxwelli*, *Loopus primitivus*, *Pseudodictyomitra carpatica*, and *Cecrops septemporatus* zones (Fig. 5). The above-mentioned Tithonian nannofossil-bearing horizons are included in the *Loopus primitivus* Zone. The ranges of some biostratigraphically important radiolarian taxa are presented in Fig. 5.

Comparative analysis on radiolarian faunas and bio-events

Radiolarian faunas

Among zonal maker taxa for Upper Jurassic North American and Japan-Pacific radiolarian zona-

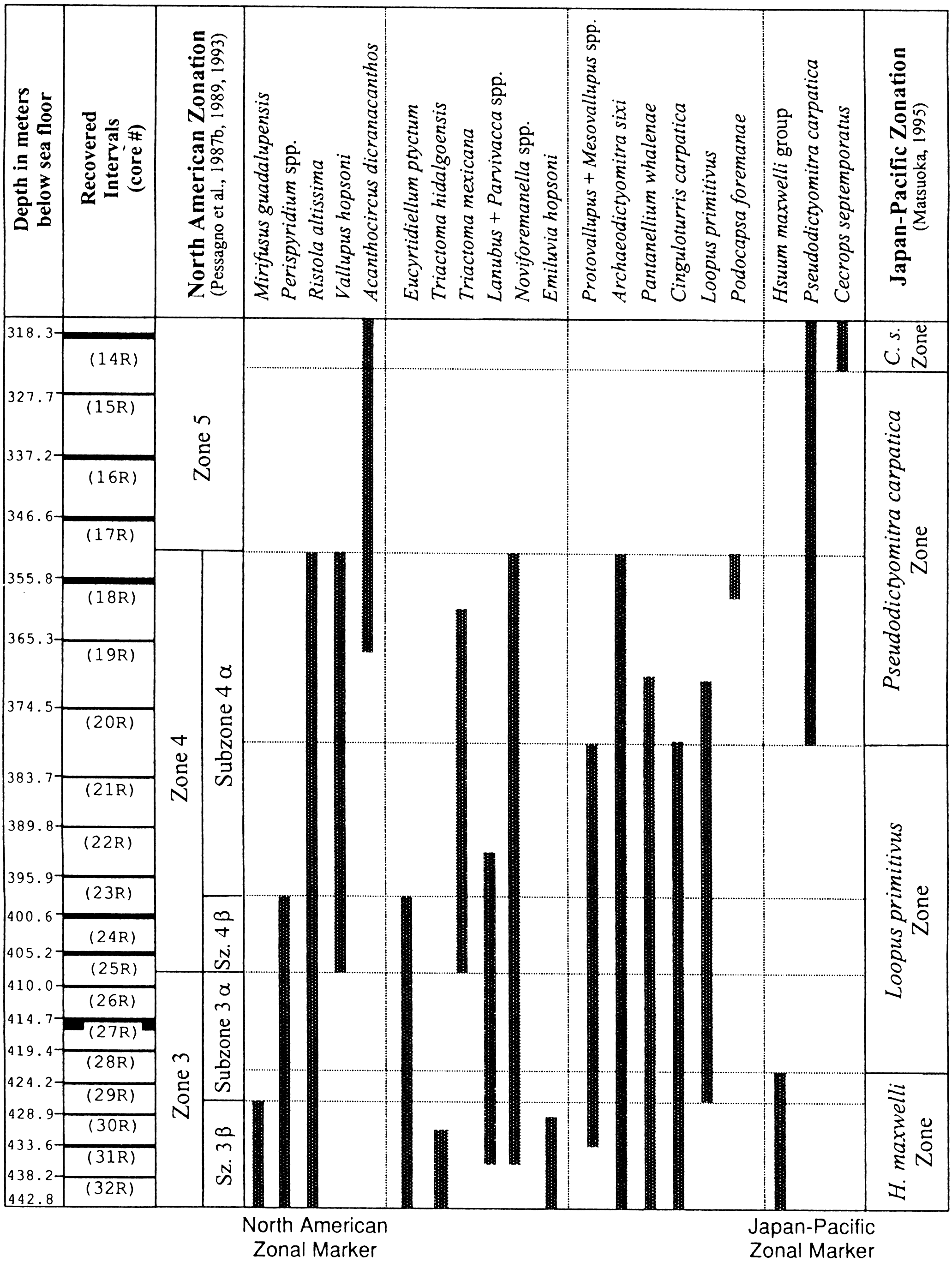

Fig. 5. Range of selected radiolarian taxa in the Upper Jurassic-Lower Cretaceous section at ODP Site 801B, west Pacific. Data based on Matsuoka (1992) and present research.

tions, the following species and genera commonly occur from the Taman Formation and the ODP Site 801B section: *Acanthocircus dicranacanthos* (Squinabol), *Hsuum maxwelli* Pessagno, *Mirifusus guadalupensis* Pessagno, Genus *Perispyridium* Dumitrica, *Pseudodictyomitra carpatica* (Lozyniak), and *Vallupus hopsoni* Pessagno and Blome. Additional important taxa for zonal correlation include *Archaeodictyomitra sixi* Yang, Genus *Lanubus* Pessango and Yang, *Loopus primitivus* (Matsuoka and Yao), Genus *Mesovallupus* Pessagno and MacLeod, Genus *Noviforemanella* Pessagno and Hull, *Pantanellium whalenae* Pessagno and Yang, Genus *Parvivacca* Pessagno and Yang, *Podocapsa amphitreptera* (Foreman), *Podocapsa foremanae* Yang, Genus *Protovallupus* Pessagno and MacLeod, *Triactoma robusta* Yang, and *Triactoma mexicana* Pessagno and Yang. Plates 1-3 illustrate selected radiolarians from the Taman Formation and ODP Site 801B.

The zonal marker taxa *Eucrytidium ptyctum* (Riedel and Sanfilippo), *Ristola altissima* (Rüst), and *Ristola procera* (Pessagno) are not found in the Taman Formation and the genus *Mirifusus* is rare in the Taman Formation. On the other hand, *Hsuum mclaughlini* Pessagno and Blome, *Napora burckhardti* Pessagno, Whalen and Yeh, *Orbiculiforma lowreyensis* Pessagno, *Parvicingula colemani* Pessagno and Blome, and Genus *Turanta* Pessagno and Blome are not found in the ODP Site 801B section.

Bio-events

The following bio-events are commonly identified in the Taman Formation and in the ODP Site 801B section.

(1) Last occurrence biohorizon (LOB) of *Mirifusus guadalupensis* Pessagno.

The LOB of *Mirifusus guadalupensis* Pessagno defines the boundary between North American Zone 3 β and Zone 3 α This bio-event is recognized in the Lower Taman Formation (Fig. 3) and Core 801-30R of the ODP section (Fig. 5).

(2) Last occurrence biohorizon (LOB) of the *Hsuum maxwelli* Pessagno group.

The LOB of the *Hsuum maxwelli* Pessagno group defines the boundary between the Japan-Pacific *Hsuum maxwelli* and *Loopus primitivus* zones. *Hsuum maxwelli* Pessagno is a secondary marker taxon whose last occurrence is located within North American Zone 3 α. This bio-event is recognized in the Lower Taman Formation (Fig. 3) and in Core 801B-29R of the ODP section (Fig. 5).

(3) First occurrence biohorizon (FOB) of *Vallupus hopsoni* Pessagno and Blome.

The FOB of *Vallupus hopsoni* Pessagno and Blome defines the boundary between North American Zone 3 and Zone 4. This bio-event is recognized in the Lower Taman Formation (Fig. 3) and in Core 801B-25R of the ODP section (Fig. 5).

(4) Last occurrence biohorizon (LOB) of Genus *Perispyridium* Dumitrica.

The LOB of Genus *Perispyridium* Dumitrica defines the boundary between North American Zone 4 β and Zone 4 α. This bio-event is recognized in the Upper Taman Formation (Fig. 3) and in Core 801-24R of the ODP section (Fig. 5).

(5) Evolutionary first appearance biohorizon (EFAB) of *Pseudodictyomatra carpatica* (Lozyniak).

Pseudodictyomatra carpatica (Lozyniak) evolved from *Loopus primitivus* (Matsuoka and

CHRONO-STRATIGRAPHY	RADIOLARIAN ZONATION		
	NORTH AMERICA Pessagno et al., 1987b,1989,1993		JAPAN-PACIFIC Matsuoka, 1995
LOWER CRETA.	Zone 5		*Pseudodictyomitra carpatica* Zone
UPPER JURASSIC	Zone 4	Subzone 4 α	
		Subzone 4 β	*Loopus primitivus* Zone
	Zone 3	Subzone 3 α	
		Subzone 3 β	*Hsuum maxwelli* Zone

Fig. 6. Correlation chart of uppermost Jurassic-lowest Cretaceous radiolarian zonation between North America and Japan-Pacific.

Yao)(Matsuoka, 1992). The EFAB of *Pseudodictyomatra carpatica* (Lozyniak) defines the boundary between the Japan-Pacific *Loopus primitivus* and *Pseudodictyomitra carpatica* zones. This bio-event is recognized around the boundary between the Lower and Upper Taman Formation (Fig. 3) and in Core 801B-20R of the ODP section (Fig. 5).

(6) First occurrence biohorizon (FOB) of *Acanthocircus dicranacanthos* (Squinabol).

The FOB of *Acanthocircus dicranacanthos* (Squinabol) defines the boundary between North American Zone 3 and Zone 4. This bio-event is recognized in the Lower Taman Formation (Fig. 3) and in Core 801B-19R of the ODP section (Fig. 5).

Zonation and zonal correlation

The Taman Formation includes Zone 3 (Subzones 3β and 3α) and Zone 4 (Subzones 4β and 4α) of the North American radiolarian zonation (Hull, 1991; Yang, 1993)(Fig. 3). By using the LOB of the *Hsuum maxwelli* group and the EFAB of *Pseudodictyomitra carpatica* of Japan-Pacific zonal markers (Matsuoka, 1995a), the Taman Formation can also be assigned to the *Hsuum maxwelli* Zone, *Loopus primitivus* Zone, and *Pseudodictyomitra carpatica* Zone (Fig. 3).

The ODP Site 801B section (Cores 14R-32R) includes the Japan-Pacific *Hsuum maxwelli* Zone, *Loopus primitivus* Zone, and *Pseudodictyomitra carpatica* Zone, and *Cecrops septemporatus* Zone (Fig. 5). In applying the North American zonation of Pessagno *et al.* (1993), there are conflicts regarding the range of zonal marker taxa. According to the North American zonal scheme, the FOBs of *Acanthocircus dicranacanthos* and *Vallupus hopsoni* are regarded to be contemporaneous and define the Zone 3/Zone 4 boundary. In the ODP 801B section, the FOB of the former is located about

40 m higher than that of the latter. Furthermore, the LOB of Genus *Perispyridium*, which defines Subzone 4 β /Subzone 4 α boundary, is higher than the FOB of *Acanthocircus dicranacanthos* in North American zonal definition. No overlapping interval of these two taxa is recognized in the ODP 801B section. It seems that only partial ranges of both Genus *Perispyridium* and *Acanthocircus dicranacanthos* are represented in the ODP section. We take the FOB of *Vallupus hopsoni* as the base of Zone 4. By using the LOB of *Mirifusus guadalupensis*, FOB of *Vallupus hopsoni*, LOB of Genus *Perispyridium*, and LOB of *Ristola altissima*, the investigated portion of the ODP Site 801B section are assigned to North American Zone 3 (Subzone 3 β and Subzone 3 α), Zone 4 (Subzone 4 β and Subzone 4 α), and Zone 5 (Fig. 5).

Correlation chart between North American and Japan-Pacific zonations based on the present research is shown in Fig. 6. The North American Zone 3/Zone 4 and Zone 4/Zone 5 boundaries are situated within the Japan-Pacific *Loopus primitivus* Zone and *Pseudodictyomitra carpatica* Zone, respectively. Conversely, the Japan-Pacific *Hsuum maxwelli*/*Loopus primitivus* and *Loopus primitivus*/*Pseudodictyomitra carpatica* zonal boundaries are situated within North American Zone 3 (Subzone 3 α) and Zone 4, respectively. The Japan-Pacific *Loopus primitivus*/*Pseudodictyomitra carpatica* zonal boundary and North American Subzone 4 β /Subzone 4 α boundary can be roughly correlated. Further research is needed for a more precise correlation of these zonal boundaries.

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Appendix

List of genus and species names cited

All taxa included in the text, Figures, and Plates are listed with a few references of the original and the recent publications.

Acanthocircus dicranacanthos (Squinabol)
Saturnalis dicranacanthos Squinabol 1914, p. 289, pl. 22, figs. 4, 6, 7.
Acanthocirus dicranacanthos (Squinabol), Yang 1993, p. 80, pl. 13, figs. 3, 5, 7, 19.
Acastea acer Yang
Acastea acer Yang 1993, p. 94, pl. 15, figs. 1, 2, 13, 15, 16; pl. 16, figs. 3, 8, 14.
Acastea bipes Yang
Acastea bipes Yang 1993, p. 95, pl. 16, figs. 9, 10, 13, 16; pl. 17, figs. 5, 15.
Archaeodictyomitra sixi Yang
Archaeodictyomitra sixi Yang 1993, p. 112, pl. 19, figs. 3, 19; pl. 20, figs. 9, 10, 19.
Cecrops septemporatus (Parona)
Staurosphaera septemporata Parona 1890, p. 151, pl. 2, figs. 4, 5.
Cecrops septemporatus (Parona), Pessagno 1977b, p. 33, pl. 3, fig. 11; Matsuoka 1992, pl. 1, fig. 1.
Cinguloturris carpatica Dumitrica
Cinguloturris carpatica Dumitrica, Dumitrica and Melo 1982, p. 23, pl. 4, figs. 7-11.
Emiluvia hopsoni Pessagno
Emiluvia hopsoni Pessagno 1977a, p. 76, pl. 4, figs. 14-16; pl. 5, figs. 1-7; pl. 12, figs. 15, 16; Matsuoka 1992, pl. 4, fig. 11.
Eucyrtidiellum ptyctum (Riedel and Sanfilippo)
Eucyrtidium ptyctum Riedel and Sanfilippo 1974, p. 778, pl. 5, fig. 7, pl. 12, fig. 13.
Eucyrtidiellum ptyctum (Riedel and Sanfilippo), Baumgartner 1984, p. 764, pl. 4, figs. 1-3; Matsuoka 1992, pl. 4, fig. 9.
Hsuum maxwelli Pessagno
Hsuum maxwelli Pessagno 1977a, p. 81, pl. 7, figs. 12, 13; Pessagno *et al.* 1984, p. 25, pl. 1, fig. 6; Matsuoka 1992, pl. 4, fig. 4.
Genus *Lanubus* Pessagno and Yang 1989
Type species: *Lanubus holdsworthi* Pessagno and Yang, Pessagno *et al.* 1989, p. 243, pl. 4, figs. 15, 25.
Loopus primitivus (Matsuoka and Yao)
Pseudodictyomitra primitiva Matsuoka and Yao 1985, p.131, pl. 1, figs. 1-6; pl. 3, figs. 1-4; Matsuoka 1992, pl. 3, fig. 1.
Loopus primitivus (Matsuoka and Yao), Yang 1993, p.125, pl. 23, figs. 5, 6, 13, 21.
Mesovallupus guadalupensis Pessagno and MacLeod
Mesovallupus guadalupensis Pessagno and MacLeod, Pessagno *et al.* 1987a, p. 28, pl. 3, figs. 6,7, pl. 7, fig. 12.
Mirifusus baileyi Pessagno
Mirifusus baileyi Pessagno 1977a, p. 83, pl. 10, figs. 6-8; pl. 11, figs. 9-11; Pessagno *et al.* 1984, p. 26, pl. 2, figs. 1-3, 10, 13, 17, 21-23.
Mirifusus guadalupensis Pessagno
Mirifusus guadalupensis Pessagno 1977a, p. 83, pl. 10, figs. 9-14; Pessagno *et al.* 1993, p. 140, pl. 6, fig. 9.
Napora burckhardti Pessagno, Whalen and Yeh
Napora burckhardti Pessagno, Whalen and Yeh 1986, p. 37, pl. 10, figs. 2-5, 15, 16, 21-23.
Napora imperfossa Yang
Napora imperfossa Yang 1993, p. 138, pl. 24, figs. 9, 10, 18, 19.
Genus *Noviforemanella* Pessagno, Blome and Hull 1993
Type species: *Paronaella*(?) *hipposiderica* Foreman, 1975, p. 612, pl. 2E, figs. 1, 2; pl. 5, figs.

3, 7, 10.

Neovallupus dumtricai Yang and Pessagno

Neovallupus dumtricai Yang and Pessagno 1989, p. 129, pl. 1, figs. 1-3, 8, 13, 17, 19.

Pantanellium heimi Pessagno and MacLeod

Pantanellium heimi Pessagno and MacLeod, Pessagno *et al.* 1987a, p. 20, pl. 1, figs. 5, 6, 17-21, 24.

Pantanellium huazalingoense Pessagno and MacLeod

Pantanellium huazalingoense Pessagno and MacLeod, Pessagno *et al.* 1987a, p. 21, pl. 4, figs. 8, 9, 17, 29, 30.

Pantanellium ranchitoense Pessagno and MacLeod

Pantanellium ranchitoense Pessagno and MacLeod, Pessagno *et al.* 1987a, p. 23, pl. 1, figs. 1, 25; pl. 5, figs. 4, 8, 22; pl. 7, fig. 6; Yang 1993, p. 16, pl. 1, fig. 6; pl. 2, fig. 3.

Pantanellium whalenae Pessagno and MacLeod

Pantanellium whalenae Pessagno and MacLeod, Pessagno *et al.* 1987a, p. 25, pl. 2, figs. 1-3, 10-13, 18, 24; Yang 1993, p. 19, pl. 1, figs. 1, 9, 14, 25.

Parvicingula excelsa Pessagno and Blome

Parvicingula excelsa Pessagno and Blome, Pessagno *et al.* 1984, p. 27, pl. 3, figs. 1-4, 11-13, 17, 22; pl. 5, figs. 4, 5; Yang 1993, p. 119, pl. 18, figs. 5, 6, 10; pl. 19, figs. 1, 16.

Genus *Parvivacca* Pessagno and Yang

Type species: *Parvivacca blomei* Pessagno and Yang, Pessagno *et al.* 1989, p. 244, pl. 10, figs. 13, 14, 16, 18, 28.

Perispyridium ordinarium (Pessagno)

Trilonche(?) *ordinaria* Pessagno 1977a, p. 79, pl. 6, fig. 14.

Perispyridium ordinarium (Pessagno), Dumitrica 1978, p. 35, pl.3, figs. 1, 2, 5; pl. 4, fig. 9.

Podocapsa amphitreptera Foreman

Podocapsa amphitreptera Foreman 1973, p. 267, pl. 13, fig. 11; Baumgartner 1984, p. 780, pl. 7, figs. 9, 10.

Podocapsa foremanae Yang

Podocapsa foremanae Yang 1993, p. 129, pl. 24, figs. 6, 12; pl. 26, figs. 9, 10, 18.

Protovallupus excellens Yang and Pessagno

Protovallupus excellens Yang and Pessagno 1989, p. 131, pl. 3, figs. 2-4, 9, 10, 14, 19.

Pseudodictyomitra carpatica (Lozyniak)

Dictyomitra carpatica Lozyniak 1969, p. 38, pl. 2, figs. 11-13.

Pseudodictyomitra carpatica (Lozyniak), Matsuoka 1992, pl. 2, figs. 2, 3.

Loopus(?) *campbelli* Yang 1993, p. 123, pl. 23, figs. 2, 3, 17, 19.

Ristola altissima (Rüst)

Lithocampe altissima Rüst 1885, p. 315(45), pl. 40(15), fig. 2.

Ristola altissima (Rüst), Pessagno *et al.* 1984, p. 28, pl. 3, fig.10; Matsuoka 1992, pl. 5, fig. 6.

Triactoma hidalgoensis Pessagno and Yang

Triactoma hidalgoensis Pessagno and Yang, Pessagno *et al.* 1989, p. 206, pl. 1, figs. 2, 8; pl. 7, figs. 7, 12, 14, 16, 18, 23.

Triactoma kellumi Pessagno and Yang

Triactoma kellumi Pessagno and Yang, Pessagno *et al.* 1989, p. 208, pl. 8, figs. 12, 13, 15, 21, 22.

Triactoma mexicana Pessagno and Yang

Triactoma mexicana Pessagno and Yang, Pessagno *et al.* 1989, p. 210, pl. 1, fig. 5, pl. 9, figs. 9, 16, 20; Yang 1993, p. 64, pl. 11, figs. 6, 21; pl. 12, fig. 9.

Triactoma robusta Yang

Triactoma robusta Yang 1993, p.65, pl. 8, figs. 12, 13, 15, 19; pl. 11, figs. 10, 11, 19.

Vallupus hopsoni Pessagno and Blome

Vallupus hopsoni Pessagno and Blome, Pessagno *et al.* 1984, p. 23, pl. 1, figs. 18, 19, 21; Pessagno *et al.* 1987a, pl. 3, figs. 1, 5.

Vallupus laxus Yang and Pessagno

Vallupus laxus Yang and Pessagno 1989, p. 132, pl. 3, fig. 12; pl. 4, figs. 8, 10, 15, 20.

Plate 1

All specimens come from the Taman Formation, east-central Mexico.

1. *Acastea bipes* Yang, x 225, MX-85-25
2. *Acastea acer* Yang, x 125, MX-84-8
3. *Emiluvia hopsoni* Pessagno, x 130, MX-85-26
4. *Triactoma robusta* Yang, x 125, MX-84-8
5. *Triactoma mexicana* Pessagno and Yang, x 130, MX-85-26
6. *Acanthocircus dicranacanthos* (Squinabol), x 225, MX-85-22
7. *Pantanellium ranchitoense* Pessagno and MacLeod, x 450, MX-84-8
8. *Pantanellium heimi* Pessagno and MacLeod, x 225, MX-85-23
9. *Pantanellium whalenae* Pessagno and MacLeod, x 215, MX-84-8

Plate 1

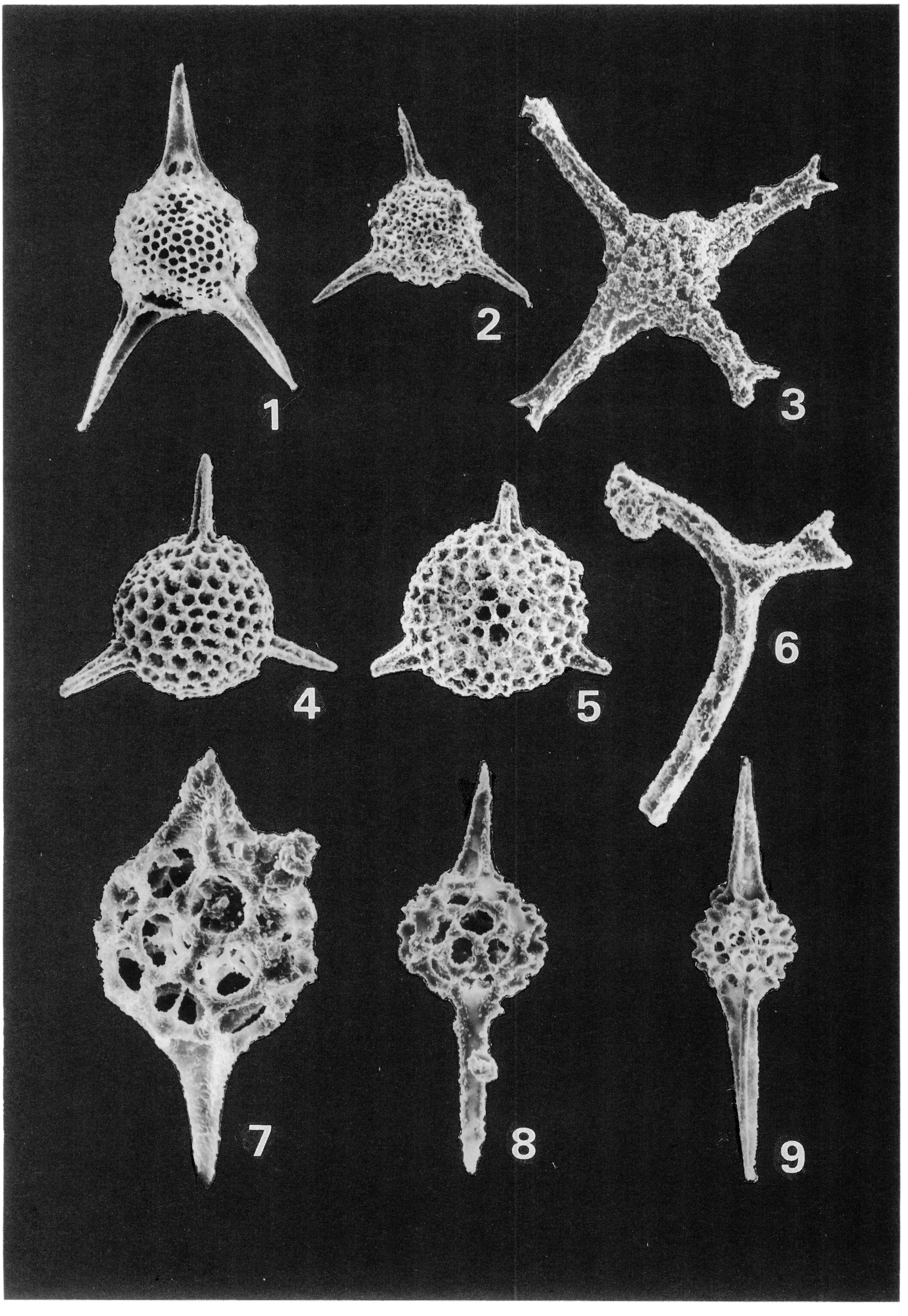

Plate 2

All specimens come from the Taman Formation, east-central Mexico.

1. *Protovallupus* sp., x 320, MX-85-23
2. *Vallupus laxas* Yang and Pessagno, x 320, MX-85-24
3. *Neovallupus dumtricai*, x 305, MX-85-12
4. *Parvivacca* sp., x 130, MX-85-25
5. *Podocapsa foremanae* Yang, x 225, MX-85-4
6. *Mirifusus* sp., x 120, MX-84-26
7. *Parvicingula excelsa* Pessagno and Blome, x 130, MX-85-23
8. *Loopus primitivus* (Matsuoka and Yao), x225, MX-85-25

Plate 2

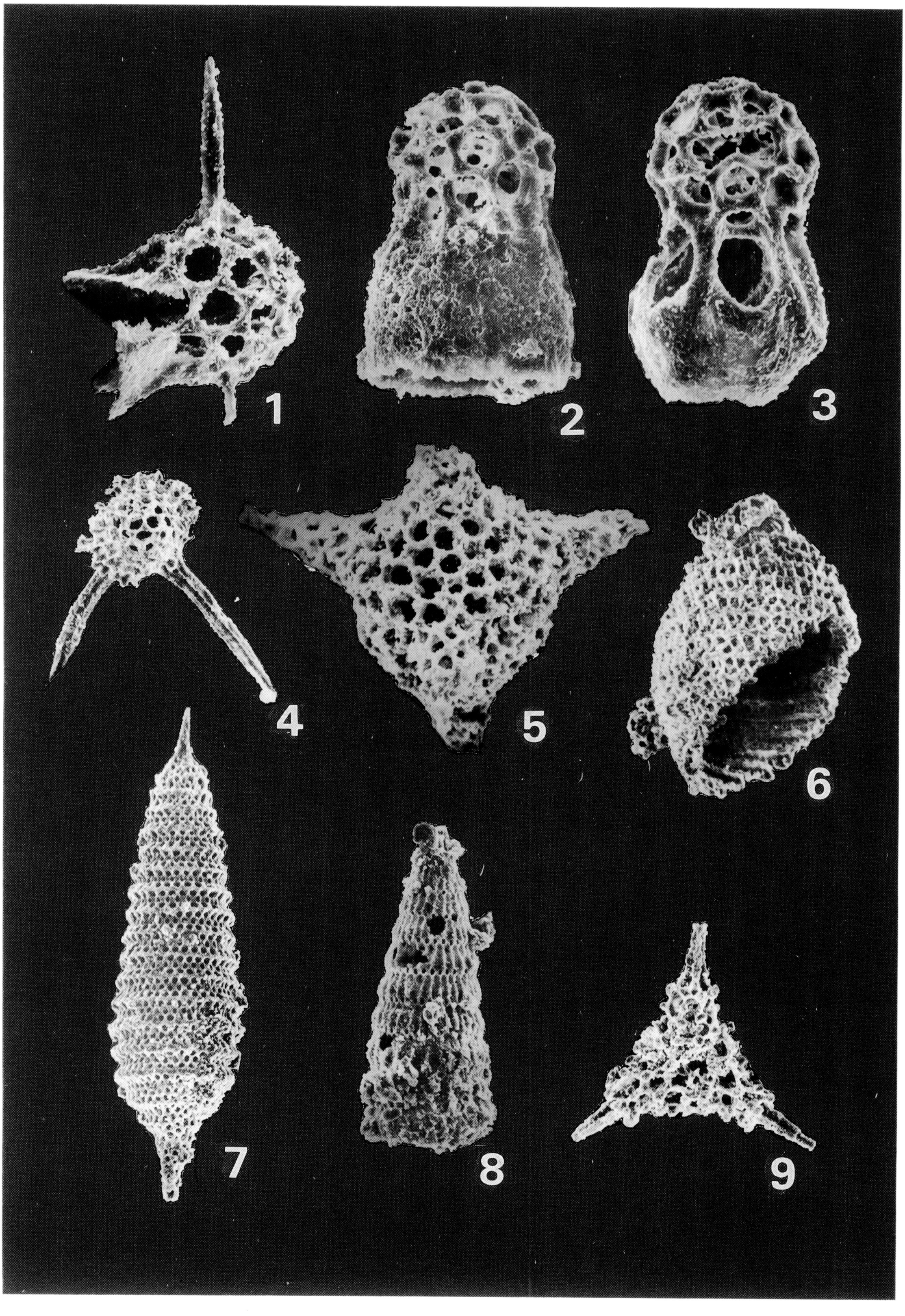

Plate 3

All specimens come from the ODP Site 801B section, west Pacific.

1. Triactoma robusta Yang, x 180, 801B-22R-1, 0-2 cm
2. Emiluvia hopsoni Pessagno, x 100, 801B-32R-CC
3. Cecrops septemporatus (Parona), x 180, 801B-14R-CC
4. Protovallupus excellens Yang and Pessagno, x 250, 801B-25R-1, 32-35 cm
5. Mesovallupus guadalupensis Pessagno and MacLeod, x 250, 801B-25R-1, 32-35 cm
6. Vallupus hopsoni Pessagno and Blome, x 250, 801B-25R-1, 32-35 cm
7. Vallupus laxas Yang and Pessagno, x 250, 801B-25R-1, 32-35 cm
8. Pantanellium whalenae Pessagno and MacLeod, x 180, 801B-28R-CC
9. Cinguloturris carpatica Dumitrica, x 250, 801B-32R-CC
10. Hsuum maxwelli Pessagno, x 180, 801B-32R-CC
11. Mirifusus guadalupensis Pessagno, x100, 801B-32R-CC
12. Podocapsa amphitreptera Foreman, x 100, 801B-32R-CC
13. Pseudodictyomitra carpatica (Lozyniak), x 180, 801B-18R-CC,
14. Loopus primitivus (Matsuoka and Yao), x 380, 801B-22R-1, 0-2 cm

Plate 3