

Jurassic Radiolaria from the Josephine ophiolite and overlying strata, Smith River subterrane (Klamath Mountains), northwestern California and southwestern Oregon

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ABSTRACT: This report deals with the radiolarian assemblage occurring within the Josephine ophiolite and in overlying sedimentary strata in the Western Klamath terrane, Smith River subterrane, northwestern California. Twenty-seven new species, eight new genera, and one new family (Bernoulliidae, n. fam.) are described from this succession. An emended definition is given for *Parvicingula* Pessagno and a new name is given for *Andromeda* Baumgartner. In addition, a revised radiolarian zonation is presented for the Middle and Upper Jurassic. This new zonal scheme can be linked to both zonal schemes in Japan and Europe via first or last occurrence biohorizons of diagnostic taxa. Radiolarian biostratigraphic data from the Smith River and Rogue Valley subterrane is related to co-occurring megafossil chronostratigraphic data and to U/Pb geochronometry. Range, occurrence, and relative abundance of the more important taxa are shown in the text-figures. This investigation also establishes that well-preserved Radiolaria can be extracted from strata exposed to prehnite-pumpellyite facies metamorphism. Moreover, paleobiogeographic data are presented to substantiate tectonic transport of the Western Klamath terrane from low latitudes to high latitudes during the course of the Middle and Late Jurassic (Oxfordian-Callovian).

INTRODUCTION

Radiolaria are the most abundant fossils in Mesozoic eugeoclinal terranes along the Circum-Pacific margin. They are often present and, in fact, well-preserved where most other fossils are absent.

During the last 15 years radiolarian biostratigraphy has had a great impact on unraveling the stratigraphy and in turn the structure of many eugeoclinal terranes in Western North America and, indeed, elsewhere in the world. In addition, it is now apparent from our investigations in North America (e.g. Pessagno and Blome 1986) that Radiolaria can be utilized in paleobiogeographic reconstructions and to document the presence of Mesozoic displaced terranes.

The purpose of this report is to document the radiolarian assemblage occurring in strata both *within* and *above* the Josephine ophiolite in the Western Klamath terrane, Smith River subterrane (Blake et al. 1985; Silberling et al. 1984; text-fig. 1 herein). This radiolarian assemblage is important for the following reasons:

- 1) It contains numerous faunal elements in common with those in radiolarian-bearing strata within the Mino Complex of Japan and thus can be related to the radiolarian zonation of Matsuoka and Yao (1986) and Matsuoka (1988).
- 2) The first and final occurrences of a number of diagnostic radiolarian taxa can be related to the radiolarian zonation of Baumgartner (1987) and the tentative new unitary associations of Baumgartner et al. (1991).
- 3) The radiolarian assemblage occurring within the volcanic member of the Josephine ophiolite can be *directly* related to a concordant U/Pb age of 162 ± 1 Ma (zircon in plagiogranite) obtained by Saleeby (1987) on the ophiolite.

4) Radiolaria occurring in strata immediately above the ophiolite can be related *indirectly* to geochronometric ages on dikes and sills that intrude the sedimentary succession. Harper et al. (1986) obtained an $^{40}\text{Ar}/^{39}\text{Ar}$ age of 148 ± 1 Ma on a calc-alkalic sill that intruded the succession and a 150 ± 1 Ma age on a small calc-alkalic pluton that intrudes the Josephine ophiolite.

5) The radiolarian assemblage can be related directly at some horizons to megafossils (e.g. *Buchia concentrica* (Sowerby) occurring at nearby localities and at localities in the adjacent Rogue Valley subterrane which are not known from strata older than middle Oxfordian.

6) Radiolaria occurring in strata both within and above the Josephine ophiolite indicate tectonic transport of the Smith River subterrane from Central Tethyan paleolatitudes to Southern Boreal paleolatitudes during the Middle and Late Jurassic.

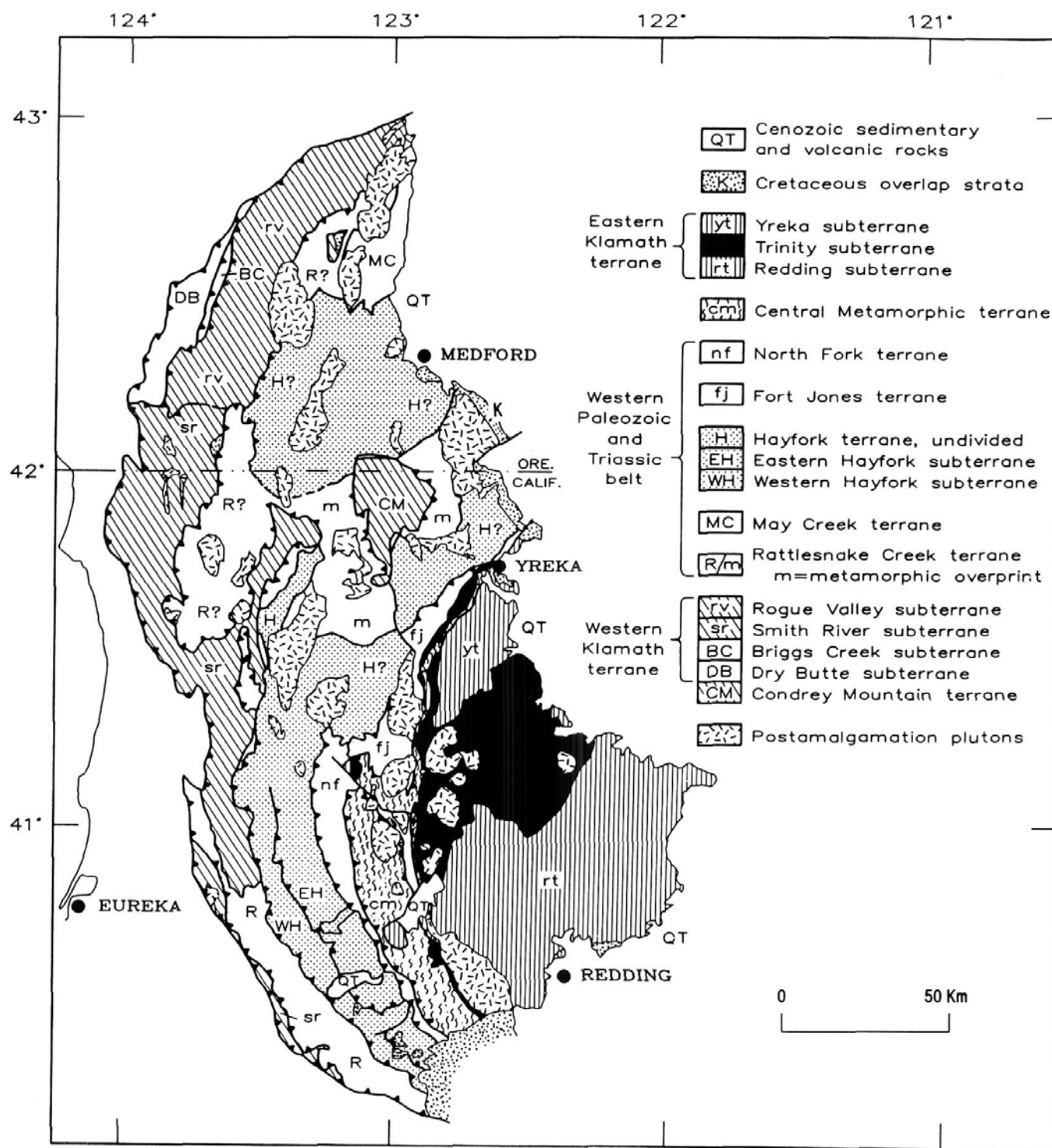
7) Radiolaria are present and in fact relatively well-preserved in strata which have been exposed to prehnite-pumpellyite facies metamorphism (Harper 1983, 1984; personal communication, 1992).

Our investigations during the course of this study have focused primarily on the area mapped by Harper (1983, 1984) in northwestern California and in an adjacent area bridging the Oregon-California border (Turner-Albright Mine; text-figs. 1, 2). Additional investigations were directed toward a study of the Jurassic stratigraphic succession in the Rogue Valley terrane (text-figs. 1, 10).

BIOSTRATIGRAPHY AND CHRONOSTRATIGRAPHY

Definition of Middle and Upper Jurassic Radiolarian Biozones

Pessagno et al. (1984, 1987b, 1989) revised the Upper Jurassic radiolarian zonation presented by Pessagno (1977a). A more updated version of this zonal scheme modified from that of

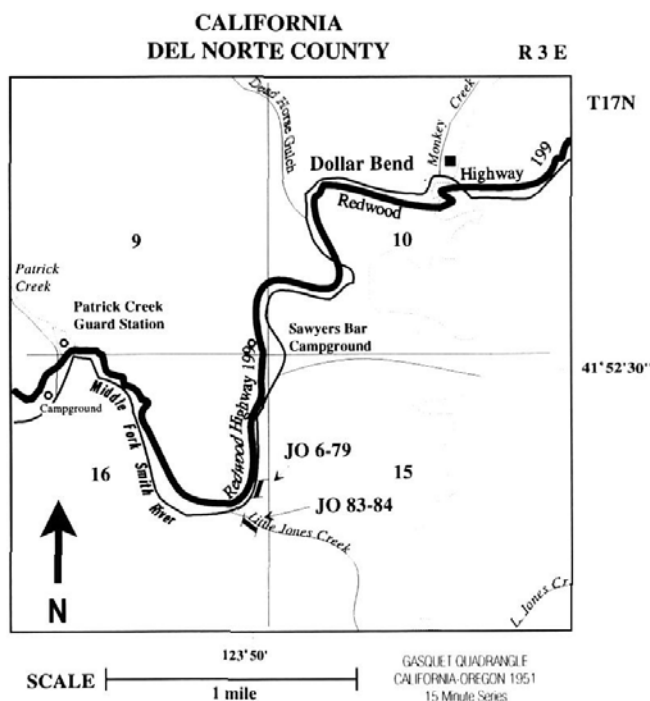


TEXT-FIGURE 1

Map showing terranes, post-amalgamation plutons and overlap assemblages of the Klamath Mountains (from Irwin 1989).

Pessagno et al. (1989) is shown in text-figure 4. The revised zonation shown in text-figure 4 differs from that of Pessagno et al. (1987b, 1989) through the introduction of several new biozones in the upper part of Superzone 1 and the subdivision of Zone 2 into additional Subzones. In addition, it should be noted that the definition of Subzone 2 gamma of Pessagno et al. (1989) has been emended. The formal definition of new or emended biozones is given below.

Following the terminology of Pessagno et al. (1984), taxa which are used as the primary means of defining a biozone are termed "primary marker taxa." Primary marker taxa are selected because they are distinctive in character, because they have sturdy tests capable of being preserved in a variety of rock types and, where possible, because they bridge faunal and floral realm boundaries. Taxa used as a secondary means of delimiting a biozone are referred to as "supplementary marker taxa." In the



TEXT-FIGURE 2

Index map for sample localities along the Middle Fork of the Smith River, northwestern California. Volcanopelagic strata overlying Josephine ophiolite and Galice Formation s.l.

absence of primary marker taxa, they may be used to define a biozone with a lower level of confidence. Additional taxa that make their first or last appearance within the body of a biozone are referred to as "corporeal taxa." It should be stressed that the formal definition of a zonal unit is based on the primary marker taxa.

Zone 2, Subzone 2 Alpha (emended herein): Parvicnigula s.s. - Mirifusus baileyi Interval Subzone. Text-figure 4.

Top: Occurs immediately below first occurrence of *Mirifusus baileyi*.

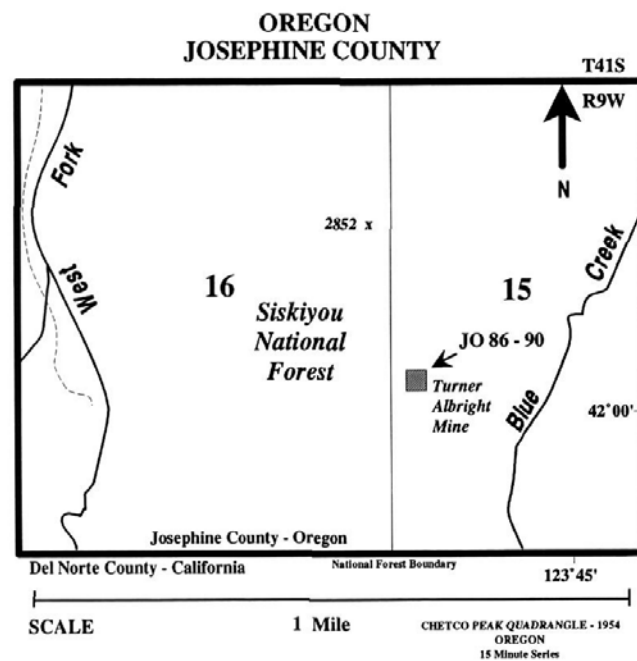
Base: Occurs immediately above the first occurrence of *Parvicnigula s.s.* and *Caneta s.s.* (Both parvicnigulid taxa developing elongate tubes on final postabdominal chamber).

Corporeal taxa: none.

Type of biozone: Interval Zone sensu International Stratigraphic Guide (International Subcommittee on Stratigraphic Classification, 1976, p. 50).

Occurrence: Northern Tethyan Province, Southern Boreal Province in California Coast Ranges; Northern Tethyan Province in East-Central Mexico. Central Tethyan Province in Franciscan Complex, California Coast Ranges and San Juan Islands, and so forth.

Zone 2, Subzone 2 Beta (emended herein): Xiphostylus-Parvicnigula s.s. Interval Subzone (new formal name). Text-figure 4.



TEXT-FIGURE 3

Index map for sample localities in the volcanic member of the Josephine ophiolite at the Turner Albright Mine, northwestern California and southwestern Oregon.

Top: Occurs immediately below the first occurrence of primary marker taxa *Caneta s.s.* and *Parvicnigula s.s.* which define the base of Subzone 2 alpha.

Base: Occurs immediately above the final appearance of primary marker taxon *Xiphostylus* Haeckel (sensu Pessagno and Yang [in Pessagno et al. 1989]) which marks the top of underlying Subzone 2 gamma.

Corporeal taxa: *Praeconocaryomma immodica* Pessagno and Poisson makes its final appearance in the lower part of this subzone whereas *Hsuum cuestaense* Pessagno makes its first appearance near the base of this subzone.

Type of biozone: Interval Zone sensu International Stratigraphic Guide (Internat. Subcom. on Strat. Classif. 1976, p. 50).

Occurrence: Central Tethyan, Northern Boreal strata in the California Coast Ranges. Northern Tethyan strata in east-central Mexico.

Subzone 2 Gamma (emended herein): Eucyrtidiellum ptyctum-Xiphostylus Subzone. Concurrent Range Subzone (with new formal name). Text-figure 4

Top: Defined by final appearance of primary marker taxon *Xiphostylus* Haeckel. Secondary marker taxa making their final appearance at the top of this subzone include *Emiluvia premyogii* Baumgartner and members of the *Unuma echinatus* group (data from Hull 1991).

Base: Defined by first appearance of primary marker taxon *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo).

Chronostrat.		Biostratigraphic		PRIMARY MARKER TAXA	Selected Secondary
Units		Units		Taxa used to define a given biostratigraphic unit (i.e., Subzone, Zone, Superzone).	Marker Taxa & Corporeal Taxa.
MID. JURASSIC	BATHON.	lower	SUPERZONE 1	<i>Praeparvicingula profunda</i> <i>Praecaneta turpicula</i>	<i>Praeparvicingula schoolhousensis</i> <i>Turanta capsensis</i>
	CALLOVIAN	lower	ZONE 1F	<i>Perispyridium nitidum</i>	<i>Praecaneta prisca</i> <i>Perispy. determani</i> <i>Perispy. alinchakense</i>
	OXFORDIAN	middle	ZONE 1H	<i>Perispyridium gujohachimanense</i>	<i>Pantanellium foveatum</i>
	KIMMERIDGIAN	upper	ZONE 2	<i>Mirifusus spp.</i>	<i>Praeconocaryomma immodica</i> Group
UPPER JURASSIC	TITHONIAN	lower	ZONE 3	<i>Mirifusus baileyi</i> <i>Mirifusus guadalupensis</i>	<i>Caneta hsui</i> <i>Parvicingula blowi</i>
	TITHONIAN	upper	ZONE 4	<i>Vallupus hopsoni</i> <i>Perispyridium</i> <i>Acanth. dicranocanthos</i>	<i>Parv. colemani</i> <i>Hsuum mclaughlini</i>

TEXT-FIGURE 4
Revised radiolarian zonation for the Middle and Upper Jurassic.

Corporeal taxa: Biohorizon 1 (upper Subzone 2 gamma) marks the first evolutionary appearance of species of *Mirifusus* with two rows of pores between the circumferential ridges of post-abdominal chambers/segments (e.g. *Mirifusus mediodilatatus* (Rüst) group). In addition, members of the *Podobursa spinosa* Ozvoldová group and *Stylocapsa(?) spiralis* Matsuoka first appear at or near biohorizon 1. See text-figure 4.

Type of biozone: Concurrent range zone sensu International Stratigraphic Guide (Internat. Subcom. on Strat. Classif. 1976, pp. 55-56).

Occurrence: Central Tethyan strata in the California Coast Ranges. Southern Boreal strata in the Klamath Mountains, northwestern California. Central Tethyan strata in the Mino Complex of Japan.

Subzone 2 Delta: *Mirifusus* spp.-*Eucyrtidiellum ptyctum* Interval Subzone (new subzone). Text-figure 4.

Top: Occurs immediately below the first occurrence of *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo).

Base: Defined by the first occurrence of *Mirifusus* Pessagno. This biohorizon also marks the first evolutionary appearance of species of *Mirifusus* with three rows of pores.

Corporeal taxa: *Pachyoncus kamiasoensis* Mizutani and Kido makes its final appearance in the lowermost part of this subzone. Text-figure 4

Type of Biozone: Interval Zone sensu International Stratigraphic Guide (Internat. Subcom. on Strat. Classif. 1976, p. 50).

Occurrence: Central Tethyan strata above Josephine ophiolite, Smith River Subterranean, northwest California and in Mino Complex of Japan.

Zone II (Superzone 1): *Perispyridium gujohachimanense-Mirifusus* spp. Interval Zone (new interval zone).

Top: Occurs immediately below the first occurrence of *Mirifusus* spp. which marks the base of overlying Zone 2, Subzone 2 delta.

Base: Defined by first occurrence of primary marker taxon *Perispyridium gujohachimanense*. Secondary marker taxon *Acanthocircus suboblongus* Yao makes its first occurrence at the base of this subzone. See text-figure 4.

Corporeal taxa: Distinctive taxa that make their first appearance in the lower part of Zone II include *Pantanellium darlingtoniaense*, n. sp., *P. josephinense*, n. sp., and *Emiluvia hopsoni* Pessagno.

Occurrence: Central Tethyan strata occurring above Josephine ophiolite, Smith River subterranean, northwestern California.

Zone 1H (Superzone 1): *Perispyridium nitidum-Perispyridium gujohachimanense* Interval Zone. Text-figure 4.

Top: Occurs immediately below the first occurrence of *Perispyridium gujohachimanense* Takemura.

Base: Occurs immediately above the final appearance of *Perispyridium nitidum* Pessagno and Blome.

UNIT NOMENCLATURE	UNIT THICKNESS (Meters)	LITHOSTRATIGRAPHIC UNITS	DESCRIPTIONS
GREAT VALLEY SUPERGROUP <i>sensu stricto</i>	15+		UNIT 6: Massive graywacke
	100		UNIT 5: Interbedded black shale and mudstone with thin beds of graywacke and limestone
	9		UNIT 4: Interbedded shale/graywacke
	6		UNIT 3: Interbedded black chert and graywacke, transitional
VOLCANOPELAGIC SEQUENCE	68		UNIT 2: Predominantly red chert, darker at top; thin-bedded gray, manganiferous limestone
	62		UNIT 1: Interbedded black/green/red chert, tuff breccia, and thin beds of limestone
CRO	?		UNIT 0: Weathered pillow basalts

TEXT-FIGURE 5

Sedimentary succession above Coast Range ophiolite along Alamo Creek, San Luis Obispo County, California. Stanley Mountain remnant of Coast Range ophiolite.

Corporeal taxa: *Pantanellium foveatum* Mizutani and Kido first appears in the lower part of this zonal unit.

Type of biozone: Interval Zone sensu International Stratigraphic Guide (International Subcommittee on Stratigraphic Classification, 1976, p. 50).

Occurrence: Central Tethyan strata occurring above Josephine ophiolite, Smith River subterranean, northwestern California.

Chronostratigraphic Calibration of Important Radiolarian Biohorizons

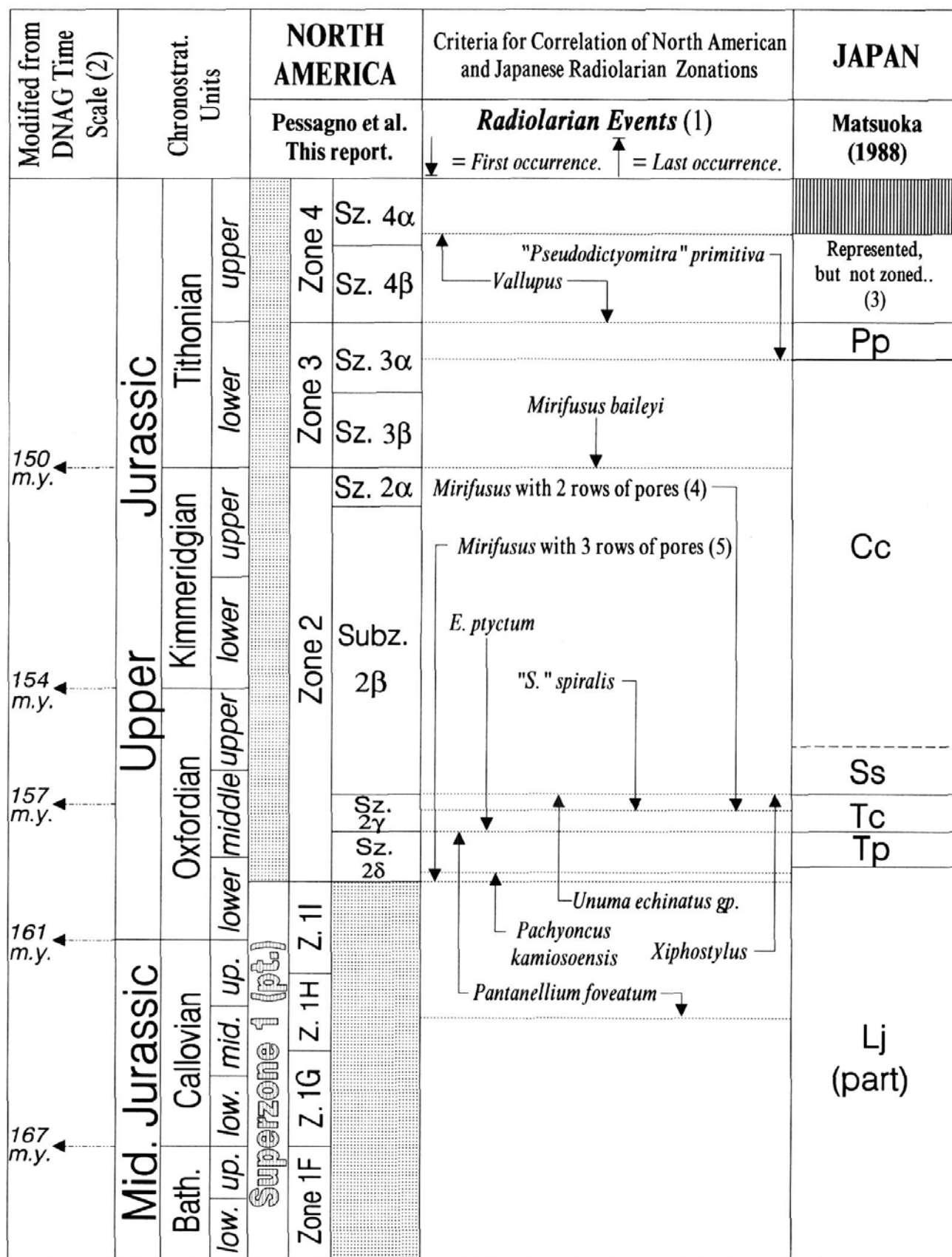
Of particular importance in the discussion to follow are the following biohorizons:

- 1) The base of Zone 4, defined by the first occurrence of *Vallupus hopsoni* Pessagno and Blome or *Acanthocircus dicranocanthos* (Squinabol);
- 2) The base of Zone 3, defined by the first occurrence of *Mirifusus baileyi* Pessagno;
- 3) The base of Subzone 2 alpha, defined by the first occurrence of *Caneta* s.s. (n. gen.) and *Parvicingula* Pessagno s.s. (= forms with long, slender, relatively sturdy tubes on final post-abdominal chamber);
- 4) The top of Subzone 2 gamma (emend.), defined by the last occurrence of *Xiphostylus* Haeckel, and the base of biohorizon 1 defined by the first occurrence of *Mirifusus* with two rows of

Mid. Jurassic					Upper Jurassic					Chronostrat. units
Bath.	Callovian			Oxfordian	Kimmeridgian		Tithonian			
low. up.	low.	mid.	up.	lower	middle	upper	lower	upper	lower	upper
Superzone 1 (pt.)										
Zone 1F	Z.1G	Z.1H	Z.1I	Zone 2			Zone 3		Zone 4	
				Sz. 2 γ			Sz. 2 α		Sz. 4 α	
				Sz. 2 δ					Sz. 4 β	
							Subz. 2 β		Sz. 3 α	
									Sz. 3 β	
									Sz. 2 α	
Differences in ammonite based chronostratigraphic correlations between competitive zonations.										
Baumgartner et al. (1991)										
Tentative New U. A.'s										
Baumgartner (1987)										
Zone D										
Zone C2										
Zone C1										
Zone B										
Zone A2										
Zone A1										
Zone A0										
Aal.	Bajocian	Bathonian			Callovian	Oxfordian	Kimmer.	Tithonian	Jurassic	
Middle Jurassic								Upper Jurassic		

TEXT-FIGURE 7

Differences in chronostratigraphic assignment of zonal units between radiolarian zonations of Pessagno et al. (herein) and Baumgartner et al. (1991).



TEXT-FIGURE 8

Correlation of North American and Japanese radiolarian zonation (Pessagno et al. herein versus Matsuoka 1988).

pores between circumferential ridges (*M. mediodilatatus* group);

5) The base of Subzone 2 gamma, defined by the first occurrence of *Eucyrtidiellum ptyctum*;

6) The base of Zone 2 (Subzone 2 delta), defined by the first occurrence of *Mirifusus* Pessagno; and

7) The base of Zone II (Superzone 1), defined by the first occurrence of *Perispyridium gujohachimanense*;

1) Base of Zone 4 (Subzone 4 beta)

The base of Zone 4 can be recognized in both the Tethyan strata of east-central Mexico and the Boreal strata of the California Coast Ranges. In the Taman Formation (San Luis Potosí, east-central Mexico), the base of Zone 4 corresponds closely to the first occurrence of *Crassicollaria intermedia* (Durand Delga) as well as the first occurrence of upper Tithonian ammonites; it is regarded herein as the base of the upper Tithonian (Pessagno et al. 1984, 1987a, 1987b). Pessagno et al. (ibid.) demonstrated that the lower part of Subzone 4 beta is correlative with the *Kossmatia-Durangites* assemblage of Imlay (1980). They correlated the remainder of Subzone 4 beta and Subzone 4 alpha with all but the uppermost part of the *Substeuroceras-Pronicerias* assemblage of Imlay (1980). In the California Coast Ranges the base of Zone 4 (Subzone 4 beta) can be recognized in the upper part of the VP succession between 84m (227ft) and 90m (264ft) above the contact with the Stanley Mountain remnant of the CRO (Alamo Creek; text-fig. 5 herein; see Pessagno et al. 1984).

2) Base of Zone 3

In east-central Mexico (San Luis Potosí) the base of Zone 3 can be observed in the type area of the Taman Formation near Tamazunchale (Pessagno et al. 1987a, 1987b). Here, it occurs about 40m (131ft) below the first occurrence of the calpionellid *Crassicollaria intermedia* (see above). Furthermore, it occurs either within the uppermost part of the *Glochiceras* gp. *fialar* Zone (uppermost upper Kimmeridgian sensu gallico) or the lowermost part of the *Virgatospinches mexicanus-Aulacommyella neogae* Zone (lowermost Tithonian; Cantú Chapa, 1971). The base of Zone 3 is arbitrarily placed at the Kimmeridgian-Tithonian boundary in this report. In the California Coast Ranges the base of Zone 3 occurs in the VP succession in the interval between 11.5m (38ft) and 13.4m (44ft) above the contact with the CRO at Point Sal (text-fig. 5 herein; Pessagno et al. 1984, p. 31).

3) Base of Subzone 2 alpha

The Subzone 2 alpha-Subzone 2 beta boundary can be recognized in the California Coast Ranges and in east-central Mexico. At Point Sal it occurs in the VP succession between 10.6m (35ft) and 11.5m (38ft) above the contact with the CRO. At Paskenta (Tehama Co., Loc. 22 of Hopson et al., 1981), Subzone 2 alpha radiolarian faunas are directly associated with *Buchia rugosa* (Fischer) and specimens transitional between *B. rugosa* and *B. concentrica* (Sowerby) (Jones, 1975, p. 330). Both Jones (ibid.) and Imlay (1980) favored assigning this *Buchia* assemblage to the upper Kimmeridgian (sensu gallico). However, Imlay (ibid. p. 63) indicated that it might also be representative of the lower Tithonian.

ROGUE VALLEY SUBTERRANE		
UPPER JURASSIC	GALICE FORMATION SENSU STRICTO	Syntectonic flysch succession consisting predominantly of black, slaty, siliceous mudstone and metagraywacke. Minor black chert, conglomerate, and sparse limestone. 3000-4500 m?
	<i>Buchia concentrica</i> + <i>Dichotomosphinctes</i> spp.	
	Concordant U/Pb age (zircon) of 157 ± 1.5 m.y.	
	ROGUE FORMATION SENSU STRICTO	Calc-alkaline succession consisting of dacitic tuff, tuff breccia, andesitic to basaltic flows, tuffaceous chert, and volcanic wacke. 4500 m +. Base of Rogue = structural contact. Rogue rests on garnet-bearing amphibolite of Briggs Creek subterrane (Western Klamath terrane).

TEXT-FIGURE 9

Jurassic lithostratigraphic units in Rogue Valley subterrane.

In east-central Mexico (San Luis Potosí) the Subzone 2 alpha-Subzone 2 beta boundary can be recognized in the upper part of the lower, more massively bedded member of the type Taman Formation (Pessagno et al. 1987a). As in the case of the base of Zone 3 (see above), the base of Subzone 2 alpha may either occur in the upper part of the *Glochiceras* gp. *fialar* Zone (uppermost upper Kimmeridgian) or the lowermost part of the *Virgatospinches mexicanus-Aulacommyella neogae* Zone (lowermost lower Tithonian).

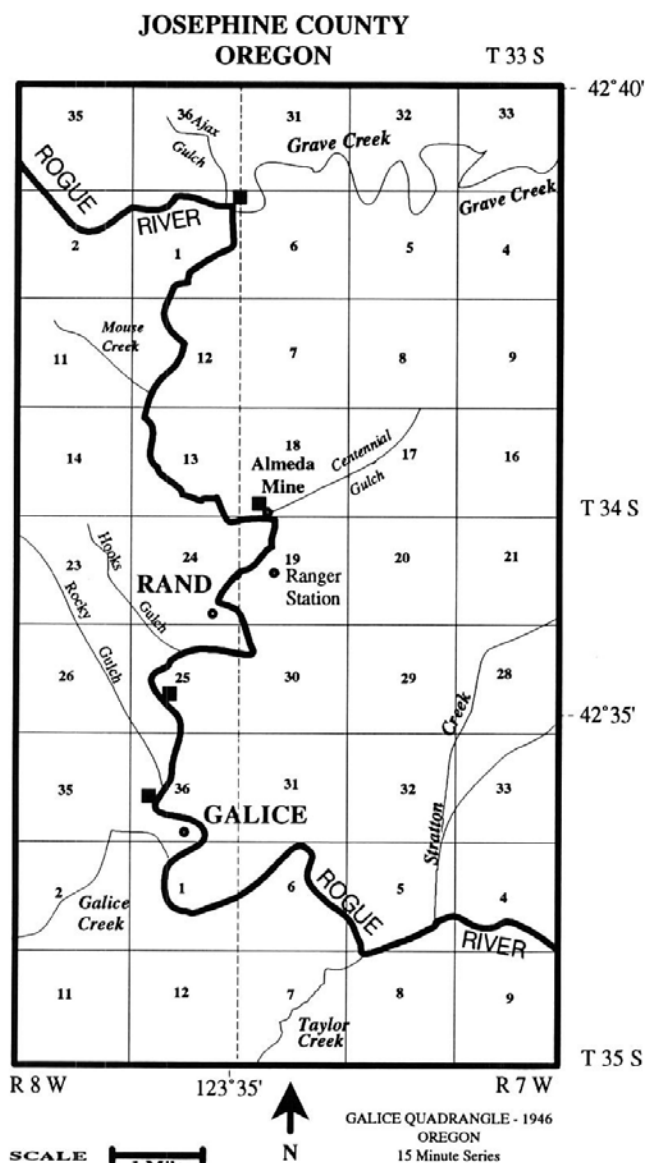
4) Top of Subzone 2 gamma and 5) base of Subzone 2 gamma (emended herein).

Subzone 2 gamma (emend.) occurs in the lower part of the volcanopelagic sequence (Stanley Mountain terrane, Stanley Mountain remnant of the Coast Range ophiolite) from 3.8m to 27.0m above its contact with the CRO. The Stanley Mountain remnant of the CRO has been dated by Mattinson (in Pessagno et al. in prep.) at 166 ± 1 Ma (= concordant U/Pb date, sphene [titanite], plus feldspar and amphibole from a quartz-bearing hornblende gabbro). In addition, biohorizon 1 (see above) can be recognized in Subzone 2 gamma VP strata 27m above the contact with the CRO.

Although Subzone 2 gamma (emend.) has been recognized neither in radiolarian cherts within the Josephine ophiolite nor in VP strata above the JO (Smith River subterrane, Klamath Mountains, Calif.; see Subzone 2 delta below), its subset, biohorizon 1, can be recognized in the overlying Galice Formation s.l. (JO-17: 60.2m above the contact with the JO). The presence of *Buchia concentrica* (Sowerby) in the lower part of the Galice s.l. at nearby localities (e.g. Shelly Creek; see Harper 1983) indicates that these strata are no older than mid middle Oxfordian. Moreover, the presence of this taxon together with the ammonite *Dichotomosphinctes* in the Galice Formation s.s. (Rogue River subterrane, Alameda Mine; text-fig. 10) indicates that the interval from the base of biohorizon 1 to the top of Subzone 2 gamma (emend.) is mid middle Oxfordian (Pessagno et al. 1986; Pessagno and Blome 1988).

6) Base of Zone 2 (Subzone 2 delta, new subzone) and 7) Top of Zone II (new zone).

Along the Middle Fork of the Smith River at Harper's (1983) locality 1 (text-fig. 2), *Mirifusus* first appears in volcanopelagic strata 17.6m (58.0ft) above the contact with the Josephine ophiolite (Pessagno and Blome 1990); these strata, which lack *E. ptyctum*, but contain the first *Mirifusus* spp., are assigned to Subzone 2 delta (new interval subzone). In the adjacent Rogue



TEXT-FIGURE 10

Index map showing the location of Almeda Mine along the Rogue River.

Valley subterranean *Mirifusus* occurs at the base of the type Galice Formation (Almeda Mine) in strata that also contain *Buchia concentrica* (Sowerby) and *Perisphinctes* (*Dichotomosphinctes*). The concurrence in range of *B. concentrica* with that of *Dichotomosphinctes* indicates that the basal Galice is assignable to the middle part of the middle Oxfordian (Pessagno et al. 1986; Pessagno and Blome 1990). Significantly, Saleeby et al. (1982) obtained a date of $157 \text{ Ma} \pm 1 \text{ m.y.}$ (concordant U/Pb date; zircon) from tuff breccia occurring in the Rogue Formation several hundred meters below its contact with the Galice Formation. Hence, the combined biostratigraphic, chronostratigraphic and geochronometric data from the Rogue Valley and Smith River subterranean (western Klamath terrane) constrain the *Mirifusus* first-occurrence event to being younger than 162 m.y. (late Callovian); i.e., 157 m.y. (mid-middle Oxfordian) or somewhat older. Because biohorizon 1 (Subzone 2 gamma) occurs in the mid middle Oxfordian, we place the Subzone 2 gamma-Subzone 2 delta boundary in the middle Oxfordian and

Galice Formation <i>sensu lato</i> . Syntectonic flysch consisting of 56 m of massive metagraywacke interbedded with thick intervals of dark-gray to black siliceous mudstone ("argillite"). Common interbedded layers of light to medium-gray, thin-bedded pelagic limestone and black, thin-bedded chert. Abundant, well-preserved Radiolaria occurring in limestone. Boreal Realm, Southern Boreal Province.	Zone 2 (part)	Subzone 2γ	lower & middle Oxfordian
		Subzone 2δ	
Volcanopelagic succession (VP). 44.9 m of black, thin-bedded, tuffaceous, siliceous mudstone and tuff interbedded with lesser amounts of black, thin-bedded chert and thin-bedded lenticular masses of medium-gray pelagic limestone. Well-preserved Radiolaria occurring in pelagic limestone. Radiolaria indicative of Tethyan Realm.	Superzone 1 (part)	Zone 11	upper Callovian
Josephine ophiolite, volcanic member (upper part). Pillow basalt with light-green to gray, tuffaceous interpillow chert. Saleeby (1987) obtained a concordant U/Pb date of $162 \pm 1 \text{ m.y.}$ (zircon in plagiogranite) from ophiolite. Radiolaria occurring in chert well-preserved. Radiolaria indicative of Tethyan Realm: Central Tethyan Province.		Zone 1H	

TEXT-FIGURE 11

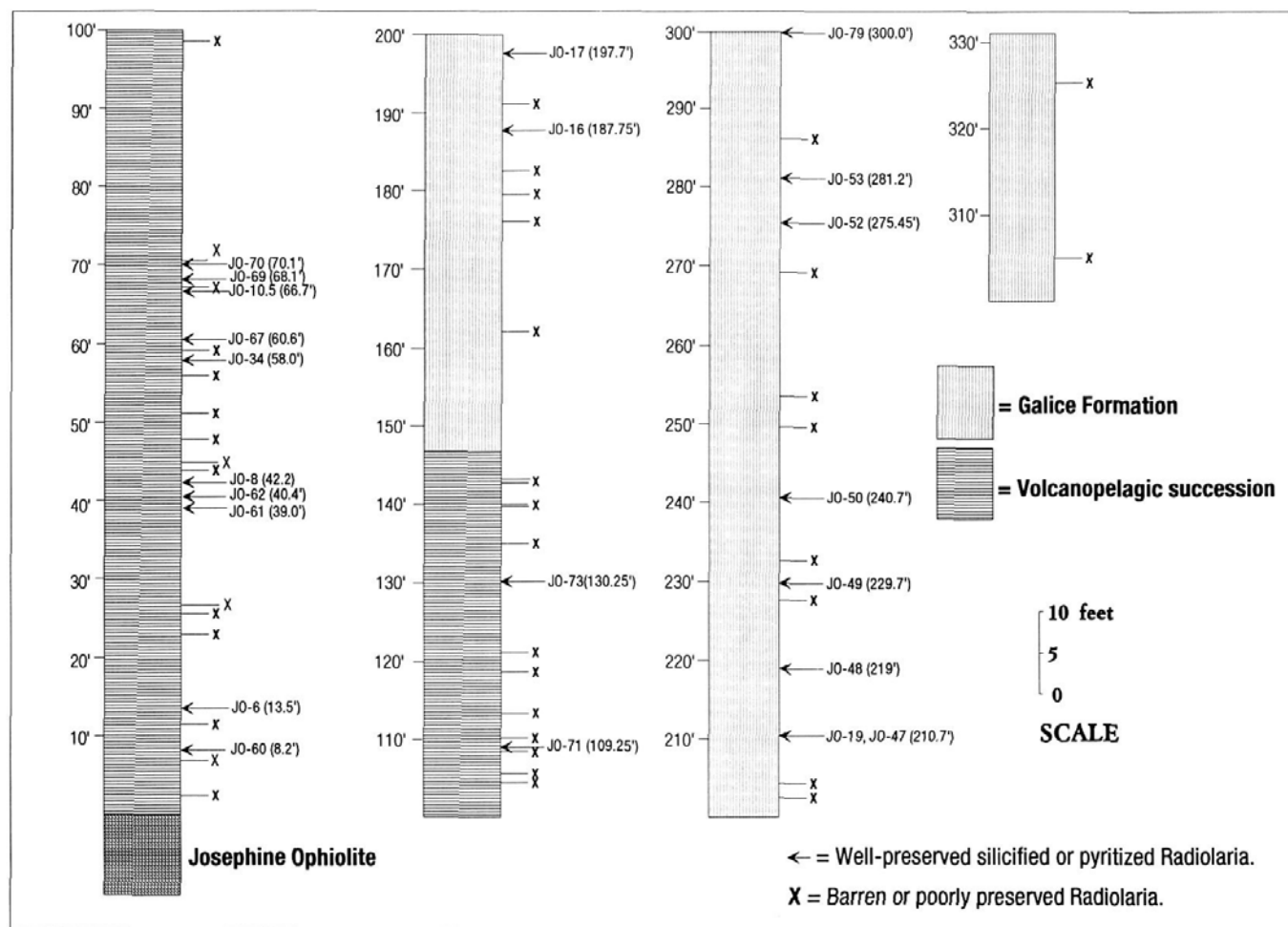
Jurassic lithostratigraphic units in Smith River subterranean.

arbitrarily place the Zone 2 (Subzone 2 delta)-Superzone 1 boundary in the lower Oxfordian in text-figure 4.

Below this horizon (i.e. base, Zone 2) the radiolarian assemblage in strata overlying the ophiolite is characterized by lacking *Mirifusus* and by containing *Xiphostylus* Haeckel in association with *Perispyridium gujohachimaense*. These strata are assigned to Zone 11 (new zone) which is formally defined as including the interval above the first occurrence of *Perispyridium gujohachimaense* and below the first occurrence of *Mirifusus*. It can be determined that Zone 11 is younger than 162 m.y. (late Callovian) and older than 157 m.y. (middle Oxfordian).

Pessagno, Blome and Longoria (1984, p. 12) noted that *Mirifusus* Pessagno first appeared 4.5m (15ft) above the contact with the Coast Range ophiolite at Point Sal (Santa Barbara Co., Calif.). Consequently, they tentatively assigned strata below this horizon and above the contact with the Coast Range ophiolite (CRO) to the upper part of Superzone 1. This interpretation is no longer justifiable. Evidence from east-central Mexico suggests that *Mirifusus* is a stenobathic abyssal taxon. The absence of *Mirifusus* in the lower 4.5m of the Point Sal succession may be due to the elevation of the sea floor to shallower abyssal or bathyal depths at the site of an oceanic spreading center. We assign the lower 4.4m of the volcanopelagic succession to Subzone 2 beta or, possibly, Subzone 2 gamma (text-fig. 4). Although this interval lacks *Mirifusus*, it contains *Eucyrtidium prytum* in samples collected 0.9m (3.0ft) above the contact with the CRO. Moreover, while it appears to lack *Xiphostylus* which is present in Subzone 2 gamma strata at Stanley Mountain and in the upper part of the *Unuma echinatus* Zone (top Zone Tc, text-fig. 8) in Japan, it is possible that this taxon could be missing due to the sparse nature of the radiolarian assemblage.

All samples previously assigned by Pessagno, Blome and Longoria (1984) and Pessagno et al. (1987a) to Superzone 1 in the Taman Formation of east-central Mexico were re-assigned by Pessagno et al. (1989) to Subzone 2 beta. Although these lower Kimmeridgian s.g. samples lack *Mirifusus*, its absence is likely due to the depth of the Taman basin of deposition (see above). *Xiphostylus* (primary marker taxon, top Subzone 2



TEXT-FIGURE 12

Columnar section showing position of samples in measured section along Middle Fork of Smith River. See also text-figure 1.

gamma) appears to be absent in the lower Kimmeridgian Taman samples that have been analyzed to date. Moreover, it appears to be missing in lower Kimmeridgian samples dated by ammonites that we have examined from San Pedro del Gallo (Durango, Mexico). We tentatively place the Subzone 2 beta-Subzone 2 delta boundary in the middle Oxfordian.

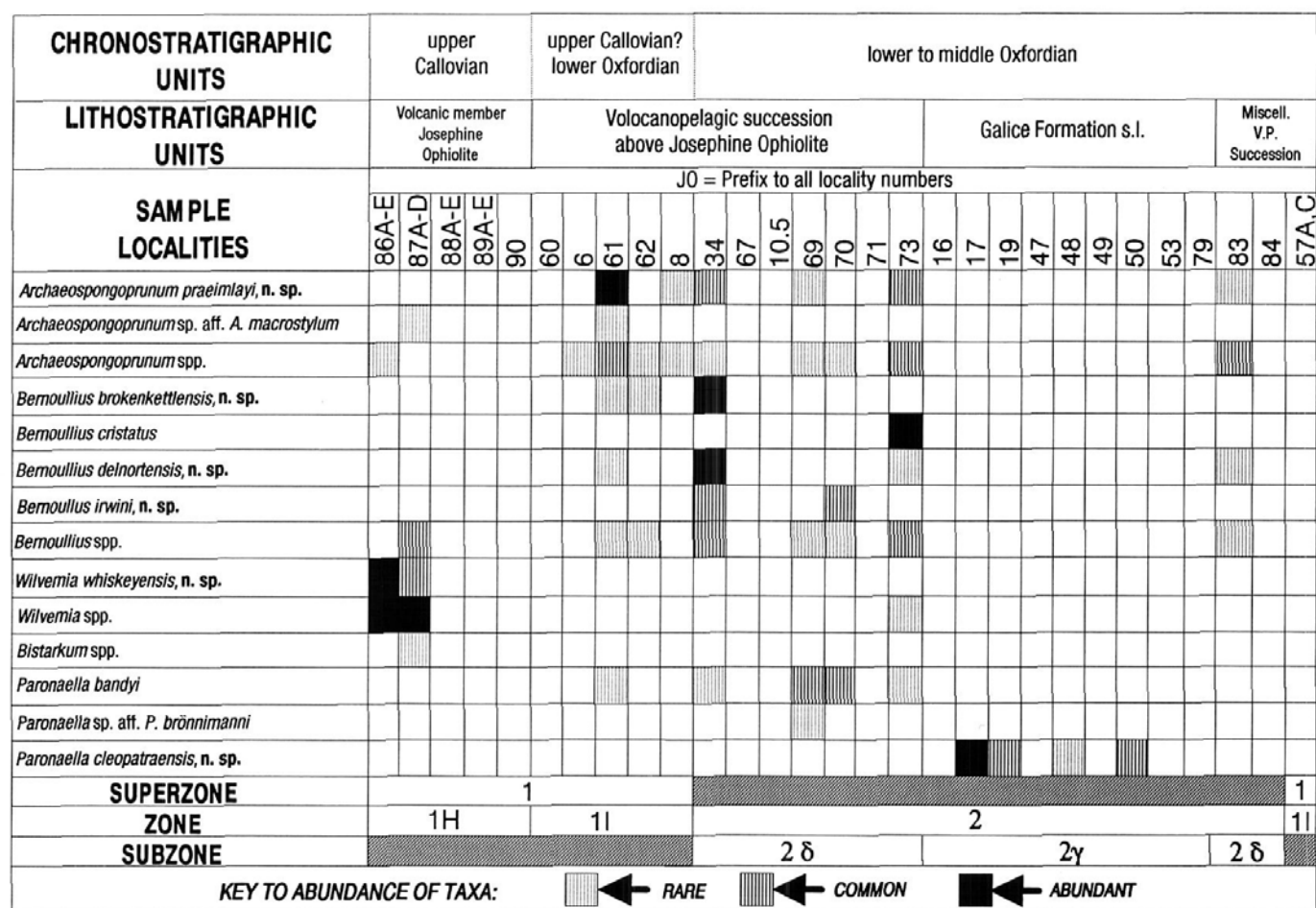
8) Zone 1H (Superzone 1) (See text-figure 4)

This new interval zone includes the interval immediately above the final appearance of *Perispyridium nitidum* and immediately below the first appearance of *Perispyridium gujohachimanense* (base Zone 1I). In so far as can be determined, *Pantanellium foveatum* Mizutani and Kido makes its first appearance in the lower part of this zonal unit. Radiolaria assignable to Zone 1H are well represented in chert within the volcanic member of the Josephine ophiolite (Pessagno and Blome 1990 and herein). Hence, much of Zone 1H can be related directly to the 162 Ma \pm 1 m.y.; late Callovian) date obtained by Saleeby (1987). The base of Zone 1H is late early or middle Callovian or younger. This conclusion is based on the age of the top of underlying Zone 1G (see text-fig. 4, Imlay 1981 and Pessagno et al. 1987b).

CORRELATION WITH JURASSIC RADIOLARIAN ZONATION OF BAUMGARTNER (1987) AND BAUMGARTNER ET AL. (1991)

Biostratigraphic Considerations

The correlation of the Jurassic radiolarian biozones utilized herein with those of Baumgartner et al. (1980) and Baumgartner (1984, 1987) was discussed in detail by Pessagno et al. (1984) and Pessagno et al. (1987a, 1987b). Although in the past major taxonomic and biostratigraphic differences have prevented accurate correlations of Baumgartner's biozones with those utilized herein, it is now possible to link the two competitive zonal schemes at a number of "tie points." New data resulting from studies by Pessagno et al. (1989), Hull (1991, in prep.), Matsuoka and Yao (1986), Matsuoka (1988), O'Dogherty et al. (1991) and Baumgartner et al. (1991) indicate that there is close correspondence in the sequence of radiolarian first and last occurrence events between Europe, Japan and North America. Text-figure 6 shows the correlation of North American zonal units with radiolarian first and last occurrence events that can in turn be related to the Baumgartner (1987) zonal scheme and to the tentative new Unitary Associations of Baumgartner et al. (1991).



TEXT-FIGURE 13

Occurrence chart showing *Archaeospongoprimum praeimlayi*, n. sp. to *Paronaella cleopatraensis*, n. sp. See Locality Descriptions herein. Samples JO-60 to JO-79 from measured section on Middle Fork of Smith River (see text-figures 2 and 12).

Differences in Chronostratigraphic Assignment

Twenty years ago Jurassic Radiolaria remained practically unstudied; most taxa were undescribed and little was known about the stratigraphic distribution of existing taxa. It soon became apparent that to develop a detailed radiolarian zonation for the Jurassic it would first be necessary to ignore chert successions lacking fossils other than Radiolaria and to examine well-known successions containing ammonites and other chronostratigraphically significant fossil groups (e.g. in Snowshoe Formation, east-central Oregon; Taman Formation, east-central Mexico; Kunga and Maude formations, Queen Charlotte Islands, B.C.). Utilizing this methodology, Pessagno et al. (1987b) introduced the first comprehensive radiolarian zonation for the entire Jurassic.

Text-figure 7 illustrates differences in the chronostratigraphic calibration of the Pessagno et al. (herein) and Baumgartner et al. (in prep.) zonal schemes. These differences are, at the moment, difficult to reconcile. The Pessagno et al. zonal scheme is linked to abundant ammonite-based chronostratigraphic data from the Lower, Middle and Upper Jurassic of North America (see Pessagno et al. 1987a, 1987b). The Baumgartner et al. (1991) zonation is linked to less abundant, but seemingly

reliable ammonite-based chronostratigraphic data from southern Europe (Subbetic; Spain, Italy; see Baumgartner 1990).

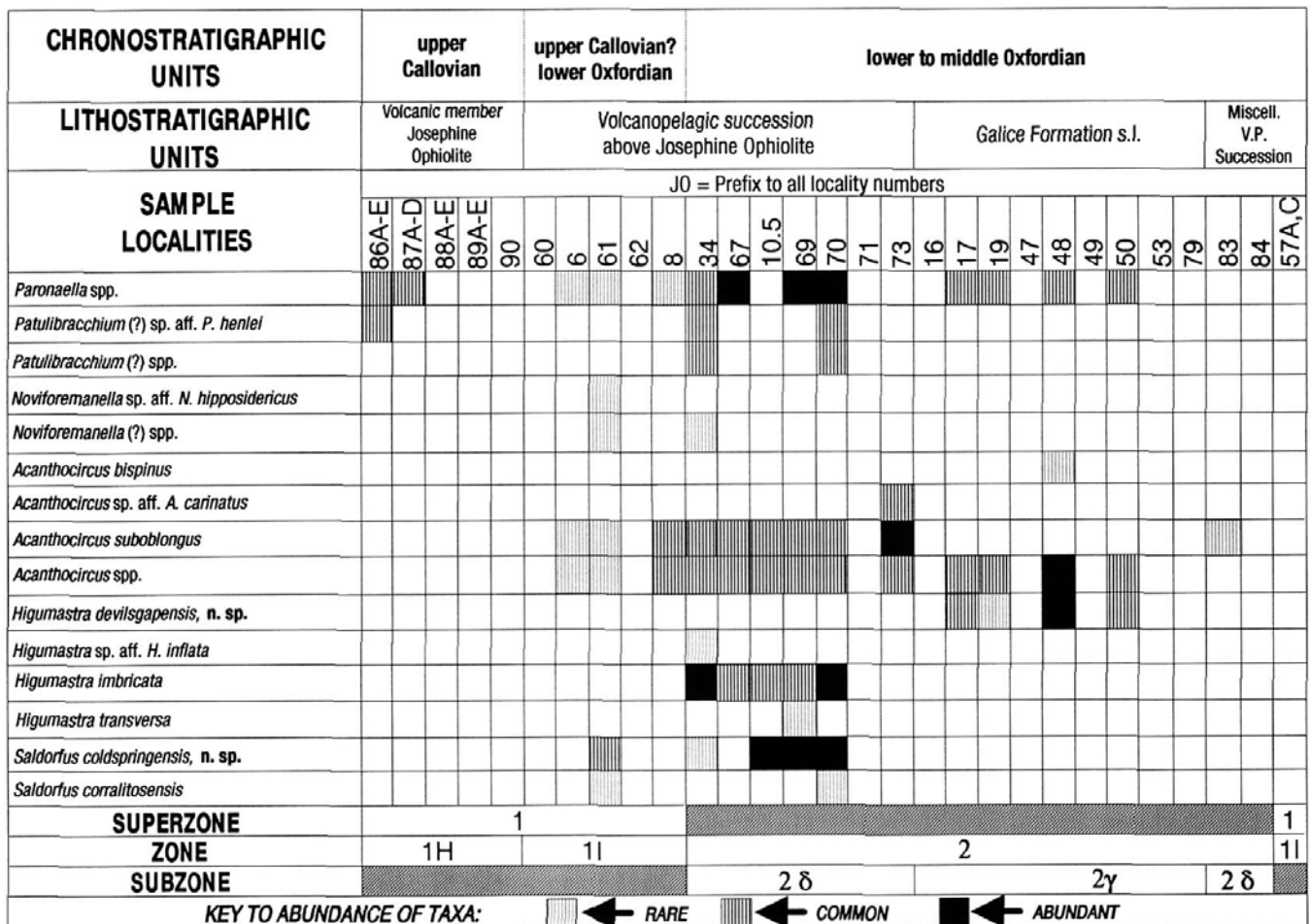
Several rationales are offered below to explain the diachronous chronostratigraphic correlations between southern Europe and North America:

1) Ammonite biozones are diachronous between Southern Europe and North America.

The synchronicity of ammonite biozones defining stages has never been tested. Most ammonite workers assume that their so-called "standard zones" are, in fact, chronozones. In that Jurassic stage boundaries have been defined by ammonite standard zones, the whole fabric of the Jurassic System would be obliterated if such zones are, in fact, diachronous.

2) Radiolarian biozones are diachronous between southern Europe and North America.

Initial studies involving the integration of radiolarian biostratigraphic data with ammonite-based chronostratigraphic data between North America and South America show little indication of radiolarian biozones being diachronous (Pessagno



TEXT-FIGURE 14

Occurrence chart showing *Paronaella* sp. to *Saldorfus corralitosensis*. See Locality Descriptions herein. Samples JO-60 to JO-79 from measured section on Middle Fork of Smith River (see text-figures 2 and 12).

et al. 1991) and offer an independent cross-check on chronostratigraphic correlations.

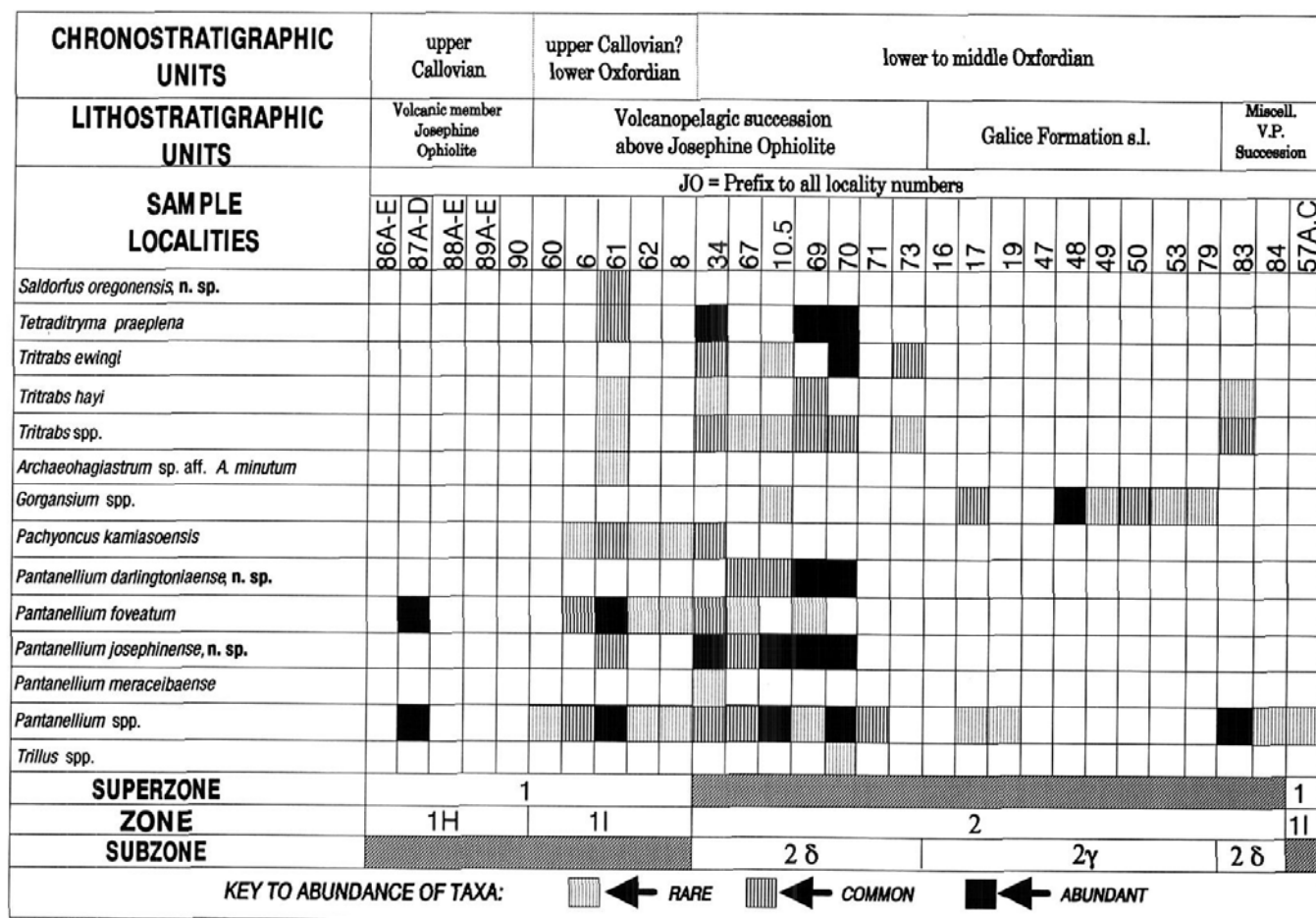
Because radiolarian-bearing strata commonly occur both within and above ophiolite complexes in eugeoclinal terranes, it is often possible to relate radiolarian biostratigraphic biozones both directly or indirectly to concordant U/Pb geochronometric dates (Pessagno and Blome 1990). Obviously, the linkage of radiolarian biozones with geochronometry offers a totally independent cross-check on their synchronicity. The integration of radiolarian biostratigraphic and geochronometric data indicates that the North American radiolarian biozones are relatively synchronous.

3) Radiolarian biozones have been imprecisely related to ammonite-based chronostratigraphy in North America and southern Europe.

The majority of North American radiolarian biozones can frequently be related directly to ammonite biostratigraphic and chronostratigraphic data; that is, our radiolarian-bearing samples were collected from the same strata containing ammonites (see Pessagno et al. 1987a, 1987b, 1989; Yang and Pessagno 1989).

Our greatest difference with Baumgartner et al. (1991) chronostratigraphically is their assignment of Zone A0 to the Aalenian and Bajocian. Apparently, the Bajocian chronostratigraphic assignment is based on data from Umbria in Italy and from the Subbetic in Spain. In Umbria Baumgartner (1990) recorded A0 Radiolaria from Valdorbis and Fiume Bosso. The Valdorbis section lacks ammonites. However, in the Fiume Bosso section A0 Radiolaria occur above strata bearing ammonites assignable to the lower Bajocian *Humphresianum* Standard Zone. In that there is no one to one relationship between the ammonite-bearing strata and those bearing A0 Radiolaria, it can only be established that these strata are early Bajocian or younger. We, in fact, interpret Baumgartner's A0 sample BO 230.8 as being Oxfordian in age. Because this sample contains *Mirifusus fragilis* we correlate it with our Zone 2, Subzone 2 delta (text-figs. 4, 7). Moreover, we suggest that a paraconformity accompanied by a hiatus of considerable magnitude occurs somewhere in the interval above the ammonite-bearing horizon and below the first radiolarian-bearing strata.

In the Subbetic region of Spain Baumgartner originally placed Zone A0 in the Bathonian. However, this chronostratigraphic assignment was based on ammonites from limestone olistoliths



TEXT-FIGURE 15

Occurrence chart showing *Saldorfus oregonensis* n. sp. to *Trillus* sp. See Locality Descriptions herein. Samples JO-60 to JO-79 from measured section on Middle Fork of Smith River (see text-figures 2 and 12).

occurring in radiolarian-bearing strata (Sierra de Ricote, Murcia Province, Spain) and is, hence, suspect. Subsequently, however, both Baumgartner (personal communication, 1991) and O'Dogherty (personal communication, 1991) indicated that A0 Radiolaria have been found to be associated with lower Bajocian ammonites elsewhere in the Subbetic.

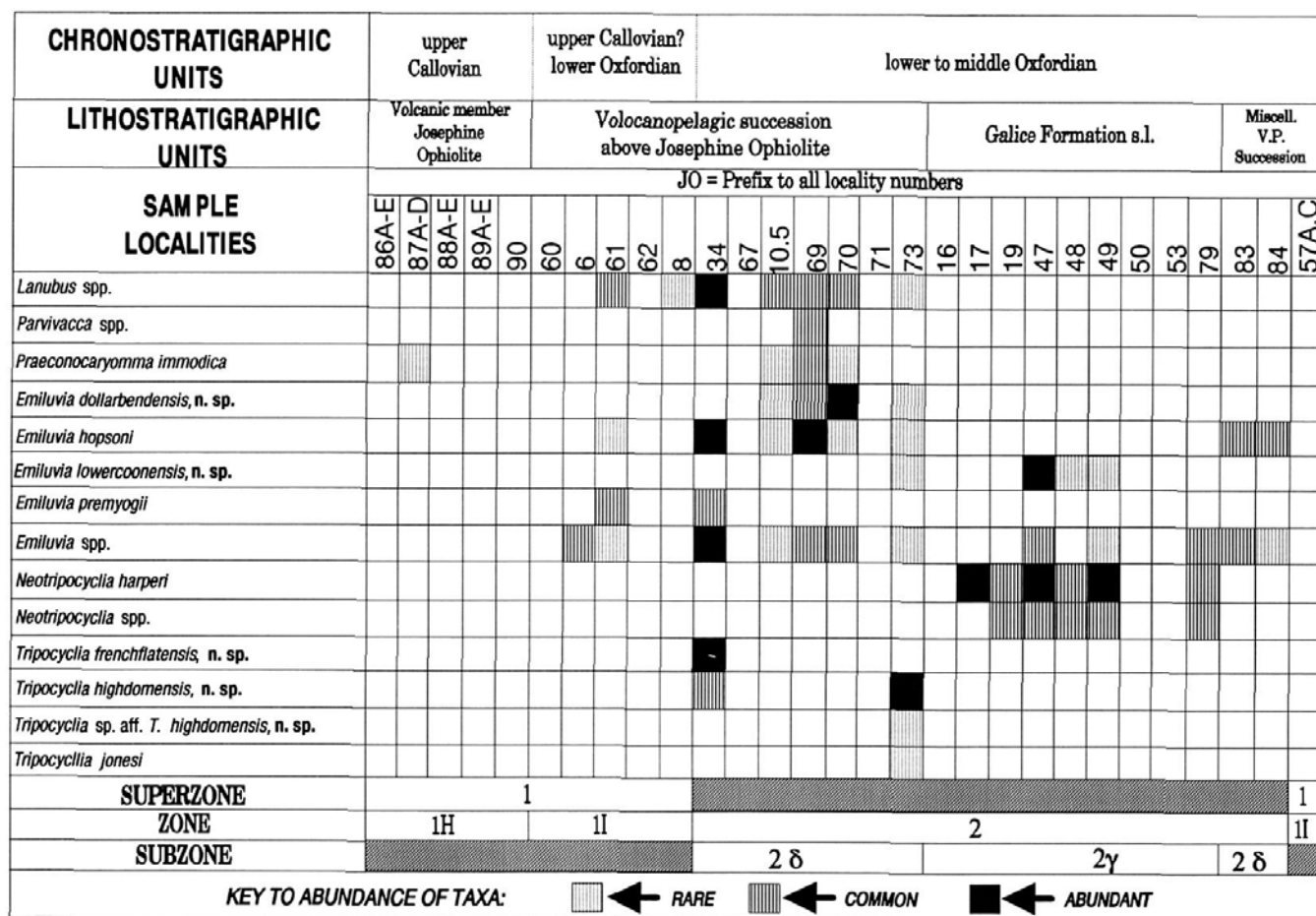
The Aalenian-early Bajocian age endorsed by Baumgartner et al. (1991) for Zone A0 has great impact on plate tectonic models involving the opening of the Gulf of Mexico and the North Atlantic. The oldest strata known from the North Atlantic occur in the Blake-Bahama (e.g. DSDP Site 534) and contain a radiolarian assemblage assignable to Zone A0. As indicated in text-figure 7, we equate Zone A0 with our Zone 1I, Subzone 2 delta (Z. 2), and the lower part of Subzone 2 gamma (Z. 2). Moreover, we assign this interval to the upper Callovian and lower and middle Oxfordian. Our correlations are in fact rather close to those of other micropaleontologists who studied samples from Site 534 (Roth 1983; Roth et al. 1983; Habib and Drugg 1983). In addition, a Callovian or possibly late Bathonian age for the opening of the Gulf of Mexico is suggested by the oldest Middle Jurassic marine strata in the deep water segment (Huayacocotla Segment; Longoria 1985) of the Sierra Madre Oriental (east-central Mexico). In the Huayacocotla Segment the continental strata of the Cahuasas Formation are overlain by

the marine strata of the Palo Blanco Formation. Imlay (1980, p. 50) indicated that Cantú Chapa recovered *Keplerites* in association with small ammonites resembling *Wagnericeras* from the Palo Blanco Formation. The onset of marine sedimentation in the Huayacocotla Segment as well as the rapid deepening of the basin of deposition in this area from shallow neritic to bathyal depths clearly reflects the beginning of a marine transgression which was coupled to the opening of the Gulf of Mexico (Longoria 1984; Pessagno et al. 1984). This transgressive cycle began in the Callovian or possibly the late Bathonian and continued into the Late Jurassic and Early Cretaceous.

4) The physical stratigraphy of strata containing both ammonites and Radiolaria has been improperly interpreted in both areas.

CORRELATION WITH THE RADIOLARIAN ZONES OF MATSUOKA (1988)

The Japanese Jurassic radiolarian zonation is totally uncalibrated by ammonite-based chronostratigraphic data. Most of the Japanese radiolarian biostratigraphic data come from the study of masses of radiolarian chert emplaced in tectonic melange (Mino Complex). Unfortunately, no megafossils are associated with the radiolarian cherts of the Mino Complex.



TEXT-FIGURE 16

Occurrence chart showing *Lanubus* sp. to *Tripocyclia jonesi* See Locality Descriptions herein. Samples JO-60 to JO-79 from measured section on Middle Fork of Smith River (see text-figures 2 and 12).

Text-figure 8 shows criteria for correlating the North American and Japanese radiolarian zonations using diagnostic radiolarian first and last occurrence events which can be recognized in both Japan and North America.

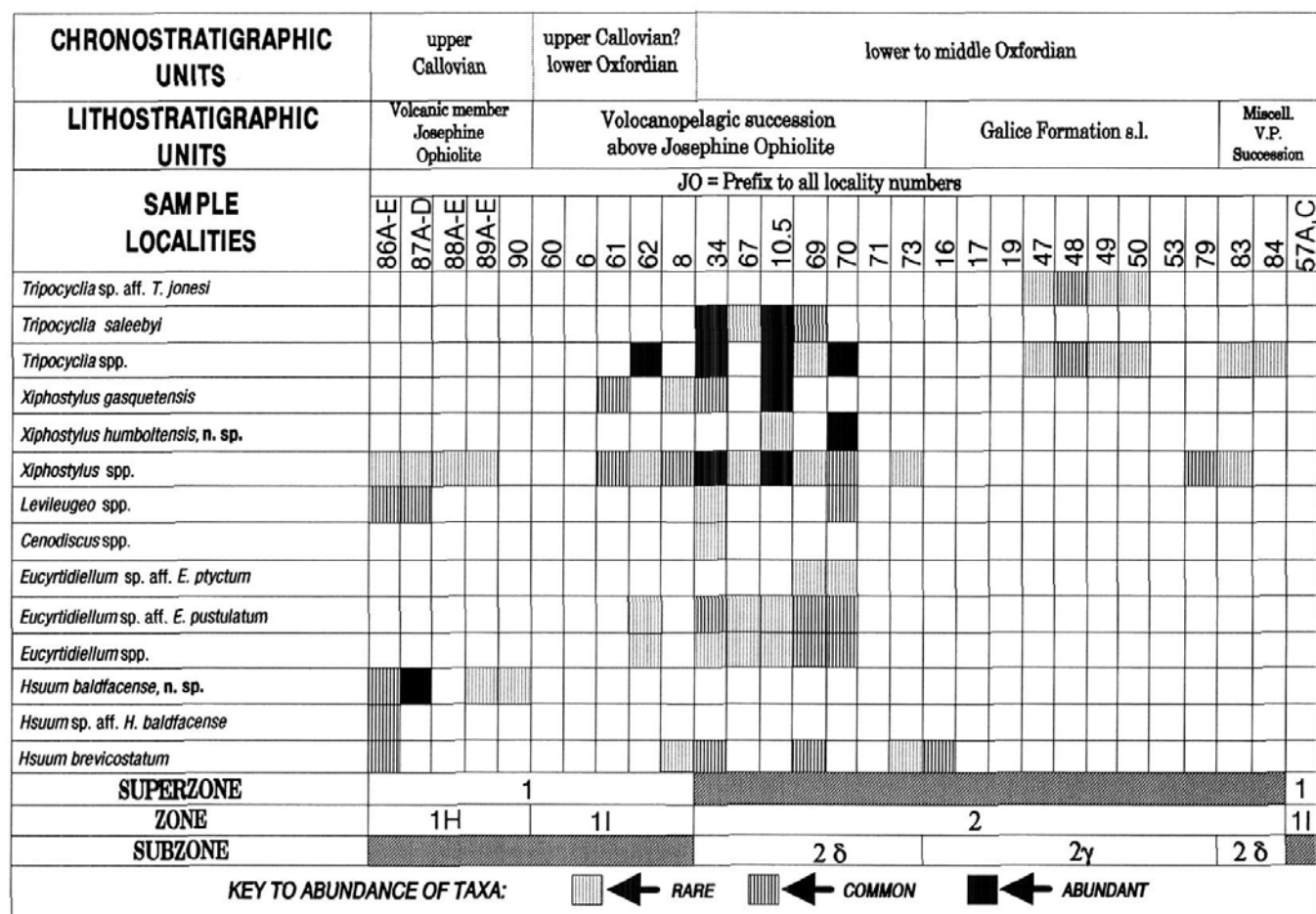
Until recently, no definite upper Tithonian Radiolaria were known from Japan. The highest Tithonian in the Japanese succession was assigned to the *Pseudodictyomitra primitiva* Zone of Matsuoka (1988). However, the recent discovery of *Vallupus hopsoni* and other species of *Vallupus* in Japanese strata by Kawabata (1988) indicates the presence of upper Tithonian Zone 4 (Subzone 4 beta to lower Subzone 4 alpha) equivalents in the Western Pacific.

The "*Pseudodictyomitra*" *primitiva* Zone (Pp, text-fig. 8) (Matsuoka and Yao 1986; Matsuoka 1988) is correlated with the upper part of Zone 3 Subzone 3 alpha (upper-most lower Tithonian). Pessagno and Mizutani (1992) stated that "In North America, '*Pseudodictyomitra*' *primitiva* Matsuoka and Yao has been found in upper Tithonian strata in east-central Mexico assignable to Zone 4, Subzone 4 beta (Yang 1988). The Mexican strata ('upper thin-bedded member' of the Taman Formation) contain a rich radiolarian assemblage which can be related to co-occurring ammonites and calpionellids (Pessagno et al. 1987a, 1987b). In Japan, no Zone 4, Subzone 4 beta marker taxa have been found in Zone Pp. Nevertheless, '*Pseudodictyomitra*'

primitiva appears to occur above the last appearance of both *Hsuum maxwelli* Pessagno and *Turanta* Pessagno and Blome which make their final appearance within North American Subzone 3 alpha. The last taxon is regarded as a more reliable marker than *Hsuum maxwelli* simply because it is easy for all workers to identify correctly. In summary, our analysis of both the North American and Japanese data indicates that the base of Zone Pp and, for that matter, all of Zone Pp (Matsuoka and Yao 1986) are correlative with the upper part of Subzone 3 alpha and occur in the lower Tithonian."

We correlate Subzone 2 gamma (text-figs. 4, 8) with all of the Japanese *Tricolocapsa conexa* Zone (Tc) and with the lower part of the overlying *Strylocapsa*(?) *spiralis* Zone (Ss). Biohorizon 1 (Subzone 2 gamma) occurs in the lower part of the *Stylocapsa*(?) *spiralis* Zone (Ss) (see Matsuoka 1988, p. 26).

We correlate Zone 2, Subzone 2 delta (text-figs. 4, 8) with the *Tricolocapsa plicarum* Zone (Tp) and the upper part of the *Lactorum*(?) *jurassicum* (Lj) Zone of Japan (Matsuoka and Yao 1986; Matsuoka 1988). It is significant to note that Subzone 2 delta, Zone 1I and Zone 1H all contain *Pantanellium foveatum* Mizutani and Kido. This taxon, which occurs as high as the lower part of the *Tricolocapsa conexa* Zone in Japan, is missing in North American Subzone 2 gamma strata.



TEXT-FIGURE 17

Occurrence chart showing *Tripocyclus* sp. to *Hsuum brevicostatum*. See Locality Descriptions herein. Samples JO-60 to JO-79 from measured section on Middle Fork of Smith River (see text-figures 2 and 12).

STRATIGRAPHIC SUMMARY

Western Klamath Terrane

The Western Klamath terrane of Blake et al. (1985) (= Western Jurassic terrane of Irwin 1985) includes Middle and Upper Jurassic rocks that crop out along the western margin of the Klamath Mountains and in a large outlier along the coast (northwestern California; southwestern Oregon). Blake et al. subdivided the Western Klamath terrane into five distinct subterrane which were each characterized by a different substrate. Our investigations are intimately related to two of these subterrane: the Rogue Valley subterrane and the Smith River subterrane (text-fig. 1).

Rogue Valley subterrane

The Rogue Valley subterrane (text-fig. 1) structurally overlies the Briggs Creek subterrane (Blake et al. 1985). It includes the type Rogue Formation (Wells and Walker 1953) and the overlying type Galice Formation (Diller 1907). The lithostratigraphic characteristics of these two formations are summarized in text-figure 9.

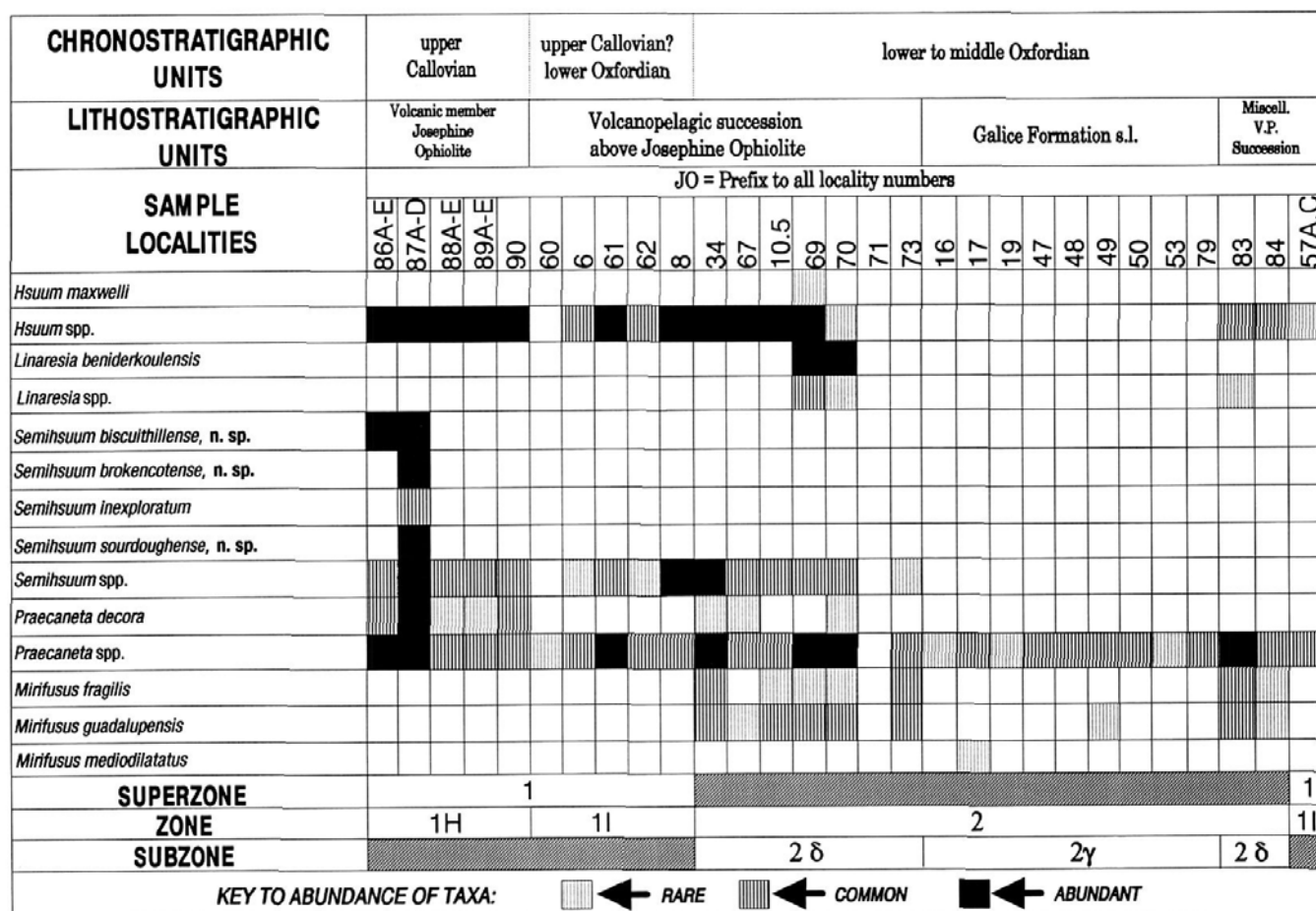
Rogue Formation

The Rogue Formation (Wells and Walker 1953) consists of a thick succession (4500m+) of calc-alkaline rocks which include

dacitic tuff and tuff breccia, andesitic to basaltic flows, tuffaceous chert and volcanic wacke. Harper (personal communication, 1992) suggests that the thickness cited above represents only an apparent thickness in that the Rogue is tightly folded. Blake et al. (1985) indicated that the Rogue was deposited on ophiolite basement. We suggest that this ophiolite basement, although now badly dismembered, represents an extension of the Josephine ophiolite (see Smith River subterrane below).

The Rogue Formation in its type area along the Rogue River valley is conformably overlain by the Galice Formation (text-fig. 9). No megafossils are known from the Rogue. However, we observed poorly preserved Central Tethyan Radiolaria in fine-grained tuff and tuffaceous chert samples just below the contact with the Galice Formation (loc. RR-89-8: entrance to shaft of Alameda Mine; see text-fig. 10).

The geochronologic assignment of the Rogue Formation can only be determined by superposition; i.e., the top of the Rogue Formation is middle middle Oxfordian or older (see Galice Formation s.s. below). If unequivocal field evidence can be offered that proves that the Rogue Formation rests in sedimentary contact above the Josephine ophiolite, the age of the base of the Rogue Formation must be no older than 164 Ma (Callovian; = oldest reliable age on JO; cf. Wright and Wyld 1986).



TEXT-FIGURE 18

Occurrence chart showing *Hsuum maxwelli* to *Mirifusus mediodilatatus*. See Locality Descriptions herein. Samples JO-60 to JO-79 from measured section on Middle Fork of Smith River (see text-figures 2 and 12).

Saleeby (1984) obtained a concordant U/Pb age of $157 \text{ Ma} \pm 1.5 \text{ m.y.}$ from zircon in dacitic tuff breccia in the type Rogue Formation. The dated tuff breccia horizon occurs a few hundred meters below the contact with the overlying Galice Formation (*sensu stricto*) and is, given the rapid rate of deposition of tuff breccia, only slightly older than the base of the Galice.

Galice Formation

The Galice Formation was originally named and described by Diller (1907, pp. 403-407) for exposures along Galice Creek, a tributary of the Rogue River (text-figs. 9, 10). In its type area, the Galice Formation includes a thick syntectonic flysch succession consisting predominantly of black, slaty, siliceous mudstone ("argillite") and medium gray, often calcareous meta-graywacke together with minor amounts of black chert, conglomerate and limestone (very rare). The thickness of the Galice Formation is difficult to estimate because of the structural complexity of the area and because the top of the unit is generally obscured by faulting. However, estimates of thickness generally range from 3000 to 4500m. Harper (personal communication, 1962) states that like the Rogue, the Galice is structurally thickened by large tight folds.

At the Alameda Mine along the Rogue River (text-figs. 9, 10), *B. concentrica* was found together with the ammonite *Peri-*

sphinctes (*Dichotomosphinctes*) in the basal Galice adjacent to its conformable contact with the underlying Rogue Formation (Diller 1907; Imlay 1961, 1980). As noted in Biostratigraphy and Chronostratigraphy above (p. 93), the concurrence of these two taxa is indicative of the middle part of the middle Oxfordian (see also Pessagno et al. 1986, in prep.; Pessagno and Blome 1988, 1990). *Buchia concentrica* occurs sporadically throughout the Galice in its type area (Diller 1907; Imlay 1961). However, because of the structural complexity of the Rogue Valley subterranean, it is not clear whether this taxon ranges to the top of the Galice. Nevertheless, because *Buchia concentrica* ranges as high as the late Kimmeridgian elsewhere in North America (see Imlay 1980), it is possible that the top of the Galice is this young.

Radiolaria occur in finer grained clastic strata, thin-bedded chert and sparse limestone. Well-preserved calcified Radiolaria (incl. *Mirifusus* spp. and *Praeparvicungula* spp.) occur in small lenticular masses of dark gray, micritic pelagic limestone interbedded with dark gray siliceous mudstone near the base of the unit at the Alameda Mine (text-figs. 9, 10).

The presence of *Buchia concentrica* together with *Praeparvicungula* and *Perisphinctes* (*Dichotomosphinctes*) in the lower Galice is indicative of Southern Boreal paleolatitudes (see Tectonostratigraphic Implications below).

CHRONOSTRATIGRAPHIC UNITS	upper Callovian		upper Callovian? lower Oxfordian		lower to middle Oxfordian																									
LITHOSTRATIGRAPHIC UNITS	Volcanic member Josephine Ophiolite				Volcanopelagic succession above Josephine Ophiolite												Galice Formation s.l.										Miscell. V.P. Succession			
SAMPLE LOCALITIES	JO = Prefix to all locality numbers																													
	86A-E	87A-D	88A-E	89A-E	90	60	6	61	62	8	34	67	10.5	69	70	71	73	16	17	19	47	48	49	50	53	79	83	84	57A,C	
<i>Mirifusus</i> spp.																														
<i>Praeparvicingula deadhorsensis</i> , n. sp.																														
<i>Praeparvicingula hurdygurdyensis</i> , n. sp.																														
<i>Praeparvicingula packsaddlensis</i> , n. sp.																														
<i>Praeparvicingula siskiyouensis</i> , n. sp.																														
<i>Praeparvicingula</i> spp.																														
<i>Ristola procera</i>																														
<i>Ristola</i> sp. aff. <i>R. procera</i>																														
<i>Ristola</i> spp.																														
<i>Perispyridium dangerpointense</i> , n. sp.																														
<i>Perispyridium gujohachimanense</i>																														
<i>Perispyridium</i> spp.																														
<i>Spongocapsula palmerae</i>																														
<i>Spongocapsula yehae</i> , n. sp.																														
SUPERZONE	1																												1	
ZONE	1H					1I					2																		II	
SUBZONE											2δ								2γ										2δ	
KEY TO ABUNDANCE OF TAXA:																														
<div><div></div> RARE</div> <div><div></div> COMMON</div> <div><div></div> ABUNDANT</div>																														

TEXT-FIGURE 19

Occurrence chart showing *Mirifusus* spp. to *Spongocapsula yehae* n. sp. See Locality Descriptions herein. Samples JO-60 to JO-79 from measured section on Middle Fork of Smith River (see text-figures 2 and 12).

Smith River Subterrane

The Smith River subterrane (southwestern Oregon; northwestern California) structurally overlies the Rogue Valley subterrane and the Dry Butte subterrane along the Madstone Cabin thrust (Blake et al. 1985). Our studies of the Smith River subterrane have focused primarily on the area mapped by Harper (1983, 1984) in northwestern California and in an adjacent area bridging the Oregon-California border (Turner-Albright Mine; text-fig. 3). According to Harper (1983, 1984) the rocks of the Smith River subterrane were exposed to prehnite-pumpellyite to lower greenschist facies metamorphism. The radiolarian-bearing rocks, however, were exposed to only prehnite-pumpellyite facies metamorphism.

Volcanic Member of the Josephine Ophiolite

The volcanic member of the Josephine ophiolite was most accessible at the Turner Albright Mine along the Oregon-California border (text-fig. 3). At this locality we observed common masses of light green to gray tuffaceous radiolarian chert interbedded with the pillow lavas of the volcanic member of the Josephine ophiolite. Along the Middle Fork of the Smith River (along strike and 10-20 km to west-southwest of Harper 1983: Loc. 1; text-fig. 2 herein) Saleeby (1987) obtained a concordant

U/Pb age of $162 \text{ Ma} \pm 1 \text{ m.y.}$ (zircon in plagiogranite) from the ophiolite.

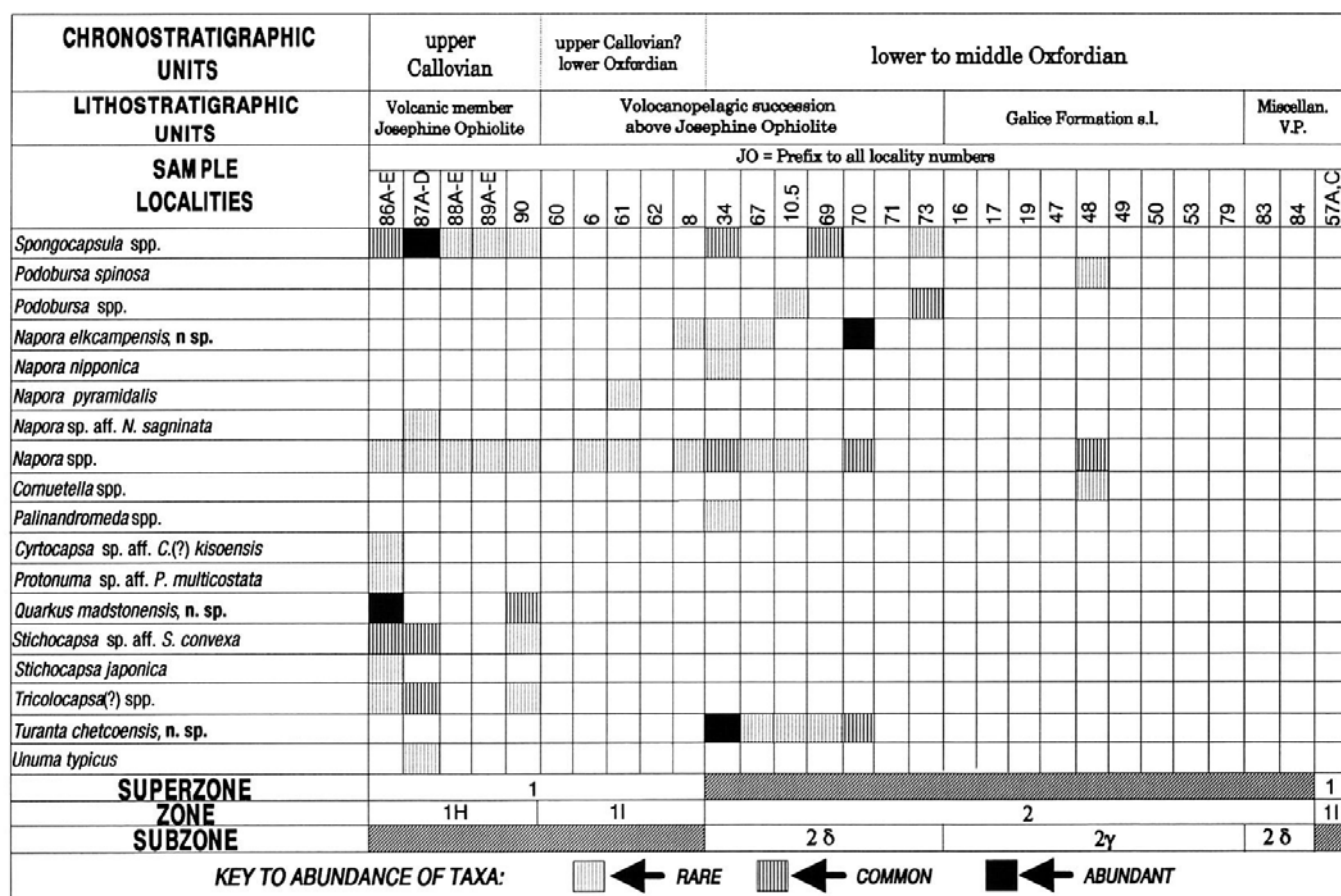
The depositional contact between the volcanic member of the JO and overlying sedimentary strata is well-exposed along the Middle Fork of the Smith River just upstream from the mouth of Little Jones Creek (text-fig. 2). Here, the sedimentary succession (100.9m) consists of two units (text-fig. 11): 1) a lower volcanopelagic succession (VP) and 2) an upper syntectonic flysch succession (Galice sensu lato).

Volcanopelagic Succession (VP)

The VP succession includes 44.9m of black, thin-bedded, phyllitic, tuffaceous, siliceous mudstone (tuffaceous "argillite") and tuffs which are interbedded with lesser amounts of black, thin-bedded chert and thin-bedded, lenticular masses of phyllitic, medium gray pelagic limestone. Radiolaria occur throughout the VP succession, but are best preserved in the pelagic limestone. No megafossils are known to date from the VP succession at this locality or, for that matter, at any other locality in the Smith River subterrane.

Galice Formation s.l.

The Galice s.l. consists of 56m of massive metagraywacke with interbedded, often thick intervals of black, phyllitic, siliceous



TEXT-FIGURE 20

Occurrence chart showing *Spongocapsula* spp. to *Unuma typicus*. See Locality Descriptions herein. Samples JO-60 to JO-79 from measured section on Middle Fork of Smith River (see text-figures 2 and 12).

mudstone and minor amounts of light gray, phyllitic, thin-bedded pelagic limestone and thin-bedded black chert. The siliceous mudstone beds in the upper 15.2m of the syntectonic flysch succession contain common, small rip up clasts of light gray pelagic limestone. Radiolaria occur in all of the finer grained strata. However, they are best preserved in the pelagic limestone. *Buchia concentrica* (middle Oxfordian to upper Kimmeridgian) was noted from Galice s.l. strata by Diller (1907) and Harper (1983) at nearby localities along Shelly Creek and Monkey Creek to the north.

Correlation with the Type Galice Formation and Type Rogue Formation in the Rogue Valley Subterrane

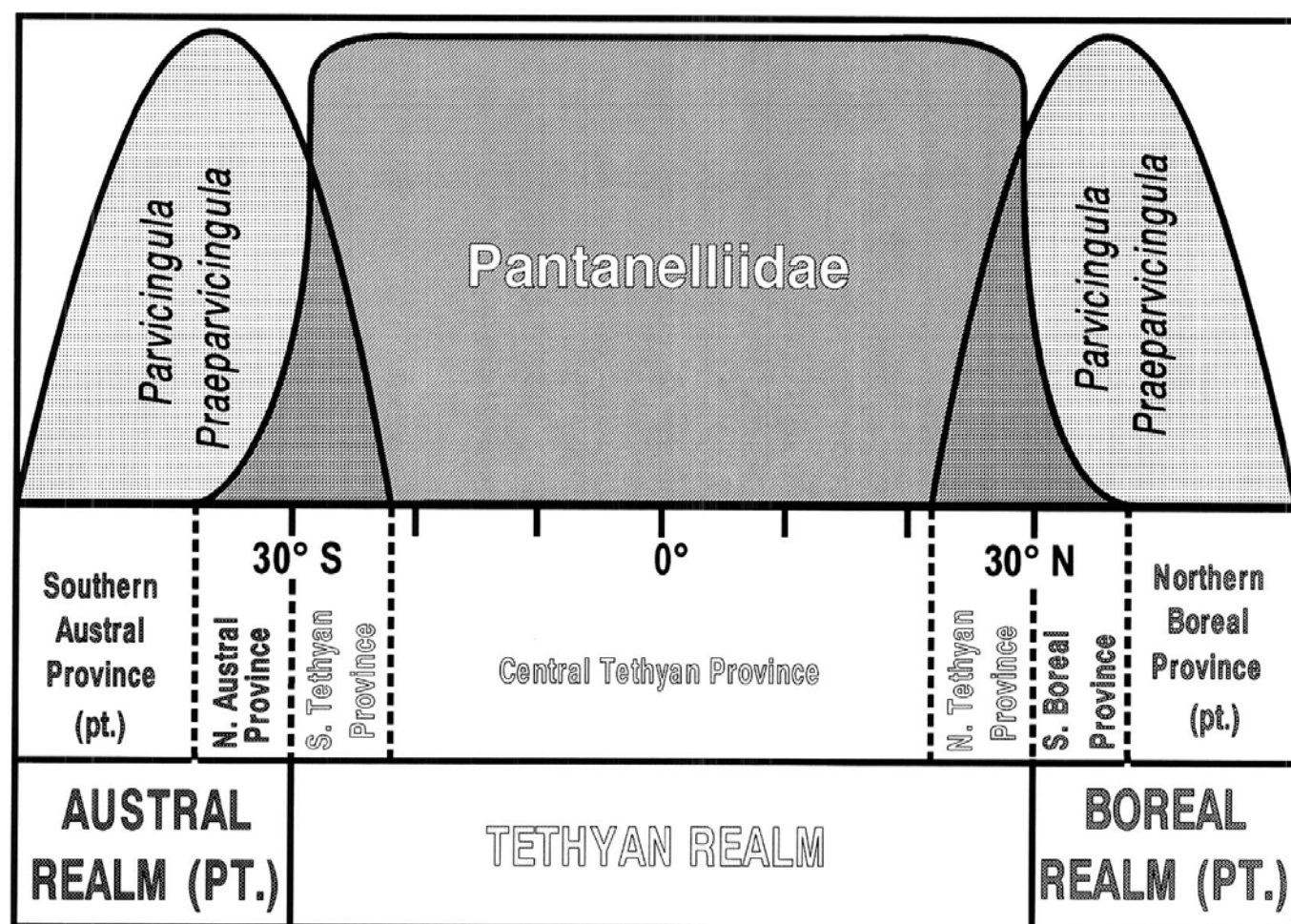
Harper (1983, 1984) included both the volcanopelagic succession (VP) and the Galice Formation s.l. in the Galice. We totally exclude the VP succession from the Galice in that it is neither lithologically nor genetically related to the type Galice Formation. The VP succession was formed from an admixture of radiolarian ooze and fine pyroclastics which were deposited in relative proximity to the Rogue Island arc. We suggest, in fact, that the VP succession represents the distal equivalent of the Rogue Formation. In this report we restrict the term *Galice* along the Middle Fork of the Smith River to the Galice Formation s.l. The Galice Formation s.s. and Galice Formation s.l. consist of syntectonic flysch and are lithologically distinct from the VP succession.

Both the VP succession and the overlying Galice s.l. contain common thin-bedded layers or lenticular masses of pelagic limestone, which though present in the type Galice, are rare and are only present in the lower part of the unit near its contact with the Rogue Formation. It should be noted that the Galice s.l. along the Middle Fork of the Smith River and Little Jones Creek is identical to some horizons within the lower part of the Monte del Oro Formation at its type area near Oroville, California (Foothills terrane; Sierra Nevada; Pessagno, Blome and Hull, unpublished field data).

Regionally, there appears to be a genetic relationship between the Galice Formation s.s. and the Galice s.l. (Western Klamath terrane) and the Monte del Oro and Mariposa formations (Foothills terrane; Sierra Nevada). All of these lithostratigraphic units are of middle Oxfordian to early Kimmeridgian age and consist of probable syntectonic flysch formed during an orogenic event which could conceivably represent an earlier pulse of the Nevadan Orogeny.

Biostratigraphic and Chronostratigraphic Assignment of Radiolarian-bearing Strata

Over the past 9 years we collected 92 samples from 65 horizons in the succession above the Josephine ophiolite along the Middle Fork of the Smith River and along adjoining Little Jones Creek (text-fig. 2). Twenty samples were collected from tuffa-



TEXT-FIGURE 21

Paleolatitudinal Model. Modified from Pessagno and Blome (1986) and Pessagno et al. (1986, 1987a.) Boundary between Central and Northern Tethyan Provinces placed at approximately 22°N based on existing paleomagnetic data; boundary between Tethyan and Boreal Realms placed at approximately 30°N. Boundary between Southern Boreal and Northern Boreal Provinces not established from paleomagnetic data.

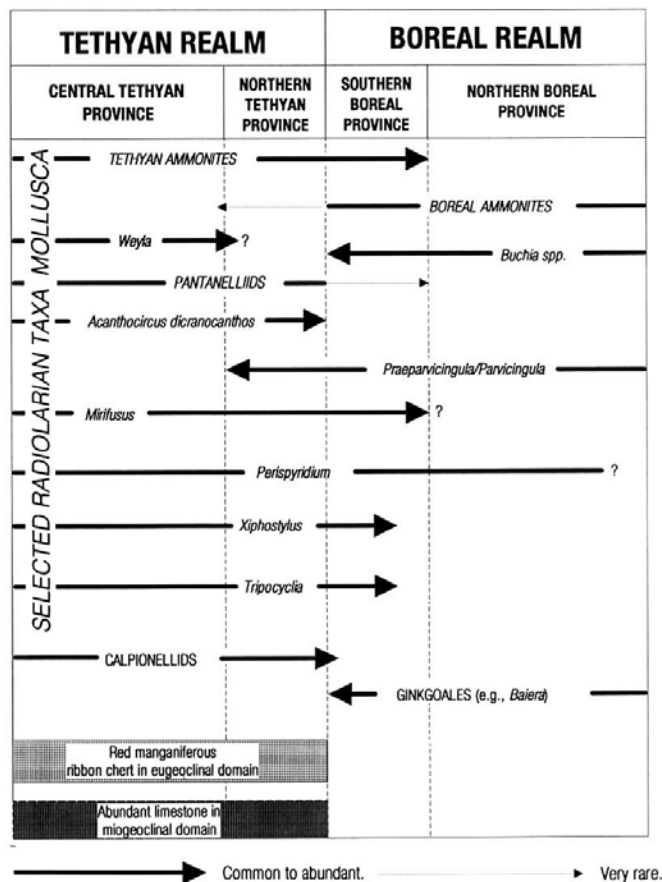
ceous chert within the volcanic member of the Josephine ophiolite at the Turner Albright Mine along the Oregon-California border (Del Norte Co., Calif.; Josephine Co., Ore.; text-fig. 3).

Text-figure 12 shows radiolarian-bearing samples collected in a measured section of the volcanopelagic succession and the overlying Galice Formation s.l. along the Middle Fork of the Smith River and along adjacent Little Jones Creek (text-fig. 2). Text-figures 13-20 show the occurrence and relative abundance of Radiolaria occurring in samples from strata overlying the Josephine ophiolite at this locality and at other localities in the area. Moreover, these same text-figures also show the occurrence and relative abundance of Radiolaria occurring within the volcanic member of the Josephine ophiolite. Also shown in these same text-figures are the biostratigraphic and chronostratigraphic assignments of radiolarian-bearing samples.

The radiolarian biostratigraphic data presented in text-figures 13-20 (samples JO-86A-E; JO-87A-D; JO-88A-E; JO-89A-E; JO-90) indicate that the volcanic member of the Josephine ophiolite is assignable to the upper Callovian portion of Superzone 1, Zone 1H. Our analysis of samples occurring above the Josephine ophiolite along the Middle Fork of the Smith River (see text-figs. 13-20) indicates that strata from 8.2 ft (2.5m:

JO-60) to 42.2 ft (12.8m: JO-8) above the contact with the Josephine ophiolite are assignable to Superzone 1, Zone 2 (upper Callovian to lower Oxfordian). No Radiolaria were recovered from VP strata lower than 8.2 ft above the contact with volcanic member of the Josephine ophiolite. The first Zone 2, Subzone 2 delta Radiolaria were recovered from VP strata 58 ft (17.6m: JO-34) above the contact with the JO. Hence, the Zone 2-Superzone 1, Zone 1 boundary must be situated somewhere in the interval between JO-8 at 42.2 ft and JO-34 at 58.0 ft (text-fig. 12). Zone 2, Subzone 2 delta (lower to middle Oxfordian) Radiolaria were recovered from VP strata from 58 ft (JO-34) to 130.25 ft (39.7m: JO-73) above the contact with the ophiolite.

In the overlying Galice Formation s.l. Radiolaria assignable to Zone 2, Subzone 2 gamma (upper part: mid middle Oxfordian) were recovered from the interval 187.7 ft (57.2m: JO-16) to 300 ft (91.4m: JO-79) above the contact with the Josephine ophiolite. The Subzone 2 delta-Subzone 2 gamma boundary must lie somewhere in the barren zone between 130.25 ft (39.7m) and 187.7 ft (57.2m). It is conceivable that the upper 17.0 ft (5.18m) of the VP succession at this locality are assignable to Subzone 2 gamma. The presence of *Eucyrtidellum* sp. aff. *E. ptyctum* (see Systematic Paleontology) at JO-69 (68.1ft) would



TEXT-FIGURE 22
Definition of realms and provinces using multiple criteria.

tend to support this conclusion. However, it is also possible, but not probable that the lower 40.3 ft (12.3m) are of the Galice s.l. is assignable to Subzone 2 delta (see Tectonostratigraphic Implications below). We arbitrarily place the Subzone 2 delta-2 gamma boundary at the contact between the VP succession and the Galice s.l. in the text-figures included with this report.

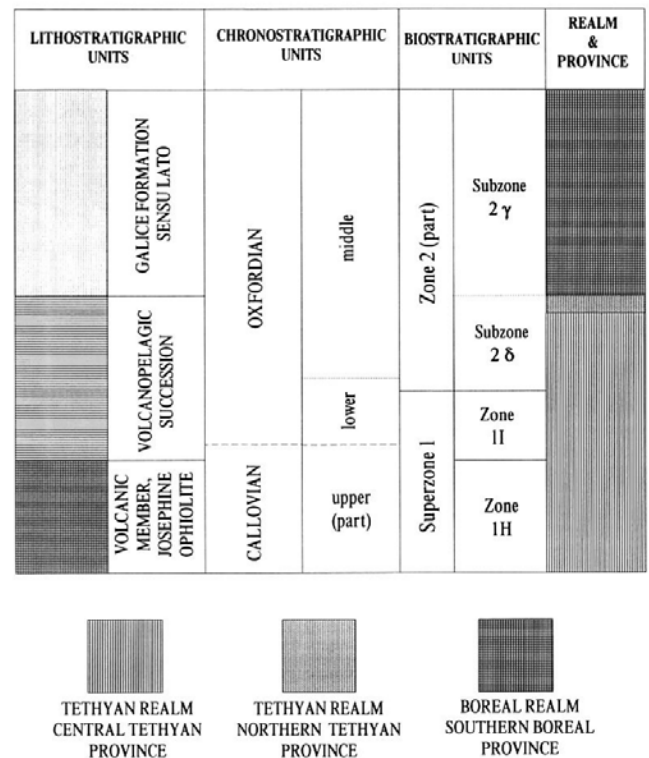
TECTONOSTRATIGRAPHIC IMPLICATIONS

Reconstructing the Circum-Pacific Collage

Much of the Circum-Pacific margin is comprised of a collage of tectonostratigraphic terranes. Many of these terranes have been displaced paleolatitudinally for hundreds or, in some cases, possibly thousands of kilometers. Circum-Pacific Jurassic paleogeography, as a result, is difficult to discuss in simplistic terms and must be viewed through this complex mosaic.

Recognition of displaced tectonostratigraphic terranes depends primarily on paleolatitudinal data derived from paleomagnetism and paleontology. Faunal and floral data can be used to constrain existing paleomagnetic data and help determine whether tectonostratigraphic terranes originated in the Northern or Southern Hemisphere or in the eastern or western Pacific (Pessagno and Blome 1986; Pessagno et al. 1986, 1987a).

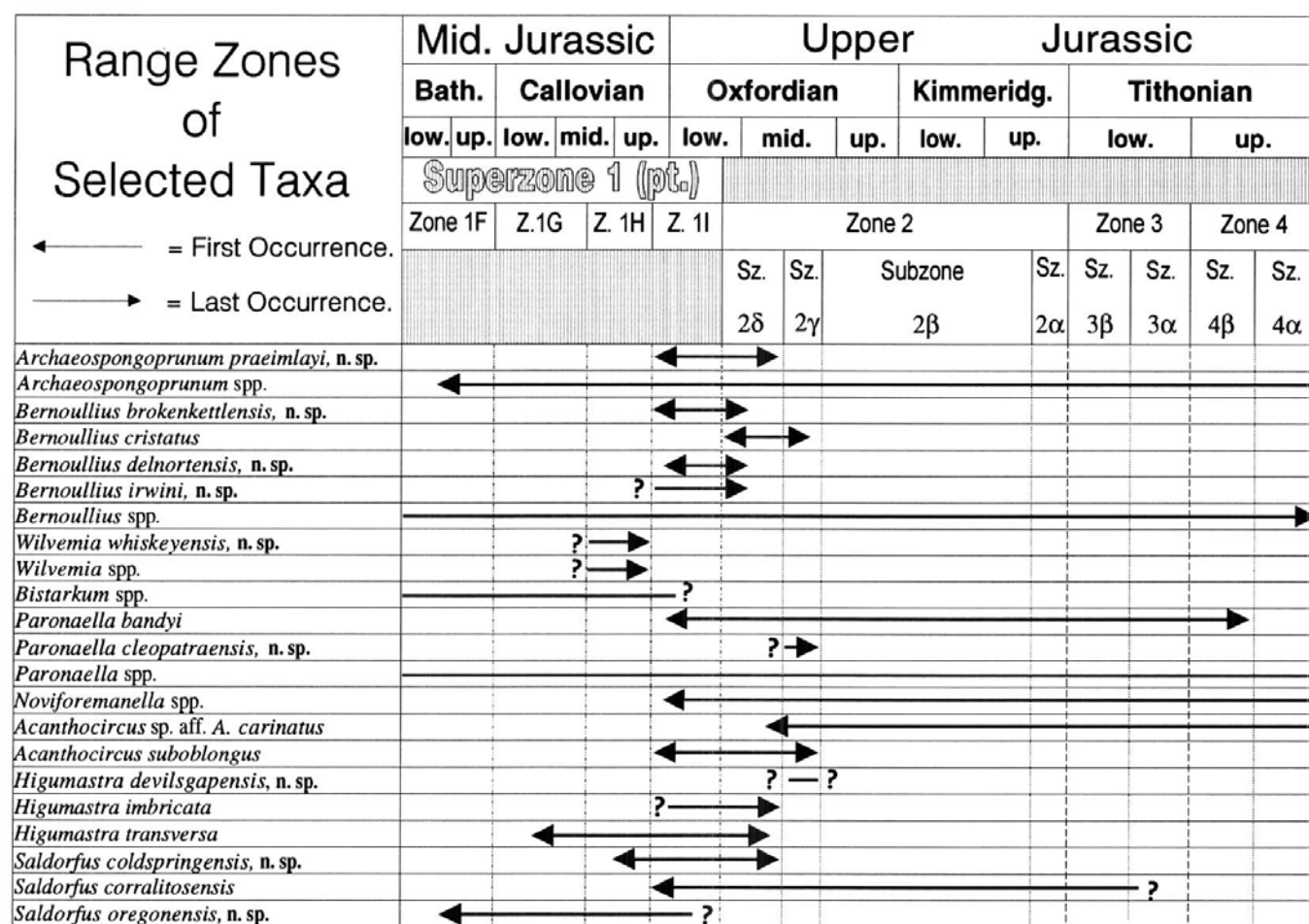
In the Northern Hemisphere Pessagno and Blome (1986) and Pessagno et al. (1986, 1987a) divided the Tethyan Realm into a Central Tethyan Province characterized by a radiolarian



TEXT-FIGURE 23
Paleolatitudinal change in Smith River subterrane during Middle and Upper Jurassic.

assemblage with high pantanelliid abundance and diversity and no *Parvicingula* and into a Northern Tethyan Province with high pantanelliid abundance and diversity and common *Parvicingula*. The Boreal Realm was subdivided into a Southern Boreal Province and a Northern Boreal Province. The Southern Boreal Province is characterized by a sharp decline in pantanelliid abundance and diversity and by the abundance and diversity of species of *Parvicingula*; the Northern Boreal radiolarian assemblage is distinguished by abundant *Parvicingula* and by its total lack of pantanelliids. Changes in the definition of *Parvicingula* (see Systematic Paleontology herein) have made minor cosmetic changes in the model presented above; that is, *Parvicingula* in the sense of Pessagno and Blome (1986) and Pessagno et al. (1986, 1987a) includes both *Praeparvicingula* and *Parvicingula* herein. This minor change is reflected in text-figure 21. In this text-figure the boundary between the Tethyan Realm and Boreal Realm is placed at approximately 30°N, the boundary between the Central Tethyan Province and the Northern Tethyan Province is placed at approximately 22°N, whereas the boundary between the Southern Boreal Province and Northern Boreal Province is not firmly established. It is likely, however, that the Southern Boreal Province is quite narrow paleolatitudinally.

Pessagno and Blome (1986) originally proposed that the model for the Southern Hemisphere is the mirror image of that in the Northern Hemisphere (see text-fig. 21). Subsequently, new data from the Southern Hemisphere have substantiated this hypothesis at least in part. Pujana (in progress) has found *Praeparvicingula* in association with common pantanelliids and Tethyan ammonites in the Callovian of Patagonia (Argentina);



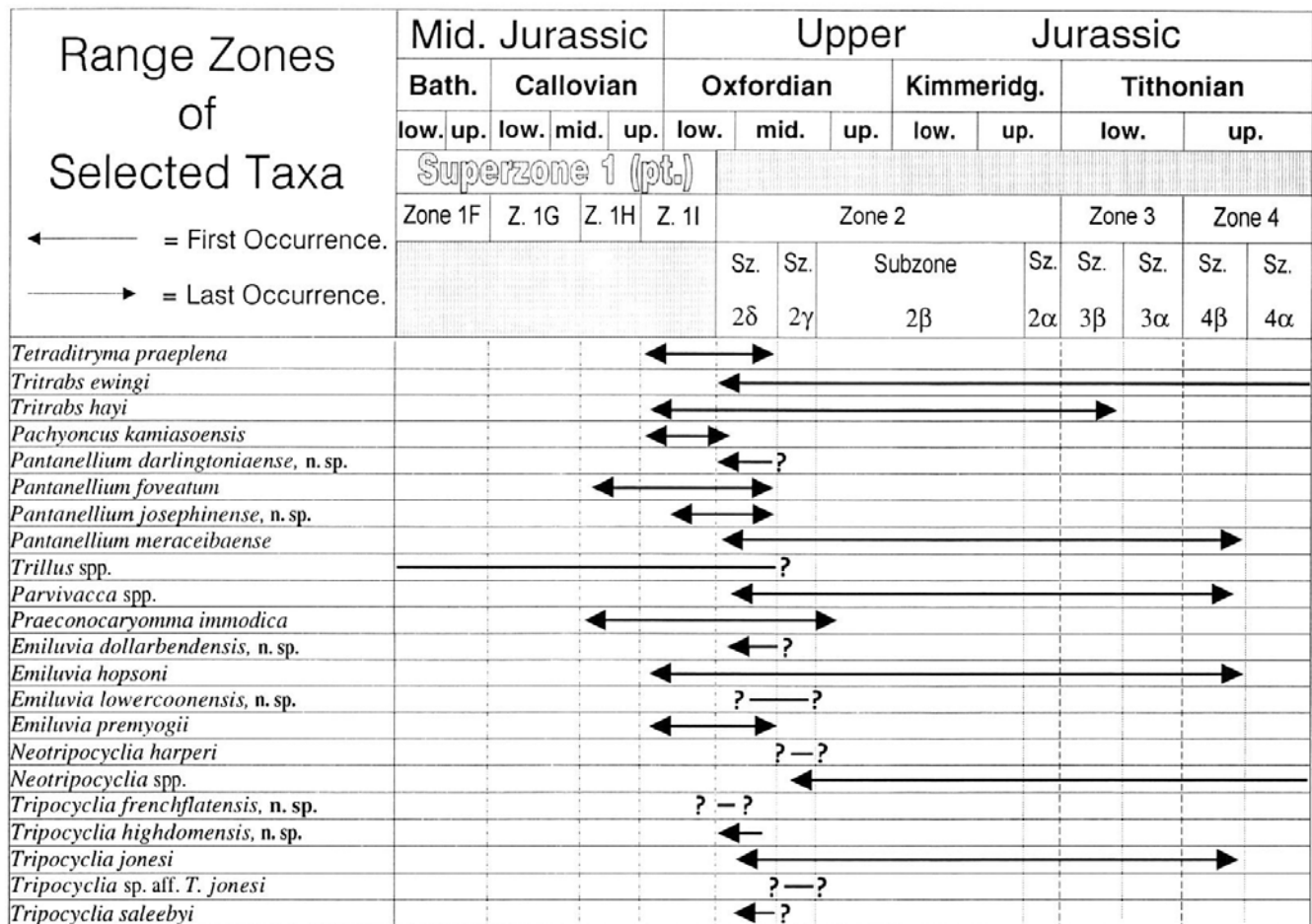
TEXT-FIGURE 24

Range zones of selected taxa. *Archaeospongoprimum praeimlayi*, n. sp. to *Saldorfus oregonensis*, n. sp.

this assemblage appears to be assignable to the Southern Tethyan Province (cf. text-fig. 21). Pessagno and Hull (in progress) and Aita and Grant-Mackie (1992) have recovered well-preserved radiolarian assemblages from Gondwanaland terranes in the Sula Islands (East Indies) and New Zealand (respectively). These radiolarian assemblages, though frequently well-preserved, are characterized by their low diversity. Abundant specimens of *Praeparvicungula* in association with very rare pantanelliids and Tethyan and Austral ammonites suggest an assignment of Sula Islands and New Zealand assemblages to the Austral Realm, Northern Austral Province. The middle Oxfordian Sula Island radiolarian assemblage is quite analogous to the Southern Boreal radiolarian assemblage figured herein from the Galice Formation.

Although radiolarian paleobiogeographic reconstructions are useful and can stand alone, they are far more useful when combined with information derived from paleomagnetism, analysis of the total faunal and floral assemblage and other criteria having paleolatitudinal or paleolongitudinal significance. The tenet stressed herein is that paleogeographic reconstructions should use all criteria available and should not focus on any one facet (e.g. analysis of the ammonite assemblage). This tenet has, in part, been fostered by necessity. Until 20 years ago little was known about Jurassic Radiolaria; few radiolarian taxa had been

described and virtually nothing was known about either their stratigraphic or paleobiogeographic distribution. In the process of constructing a radiolarian zonation for the Jurassic of North America, it has been necessary to describe numerous taxa and relate their stratigraphic distribution to that of the ammonites, *Buchia*, calpionellids and other well-studied fossil groups (Pessagno et al. 1987b). The paleobiogeographic model presented in text-figure 22 for the Jurassic is in essence a by-product of such an integrated approach to radiolarian biostratigraphy. This model is applicable worldwide to strata in the Northern Hemisphere and now to strata in the Southern Hemisphere as well (Pujana 1991, in progress; Aita and Grant-Mackie 1992). The approach used here as well as by Pessagno and Blome (1986) and Pessagno et al. (1986, 1987a) differs from that of Taylor et al. (1984) by being more generalized and by utilizing all available faunal and floral data. Whereas Taylor et al. focused on the Jurassic molluscan assemblage alone, we try to utilize data (when available) from Radiolaria, calpionellids, Mollusca, land plants and other fossil groups (text-fig. 23). The use of this multitaxial approach, together with existing paleomagnetic data, the paleogeographic maps of Smith, Hurley and Briden (1981) and the paleo-oceanographic reconstructions of Gordon (1974), allowed Pessagno and Blome (1986) and Pessagno et al. (1986) to calibrate the paleolatitudinal distribution of Triassic and Jurassic Radiolaria. Hence, even in eu-



TEXT-FIGURE 25

Range zones of selected taxa. *Tetradietyma praeplena* to *Tripocyclia saleebyi* n. sp.

geoclinal terranes where other fossils are absent, it is often possible to determine the relative paleolatitudinal position of a given terrane from the study of the radiolarian assemblage alone. Conversely, in successions where megafossils are present and the Radiolaria remain unstudied, it is possible to predict the character of the radiolarian assemblage from that of the megafossil assemblage.

Tectonic Transport of the Rogue Valley and Smith River Subterrane

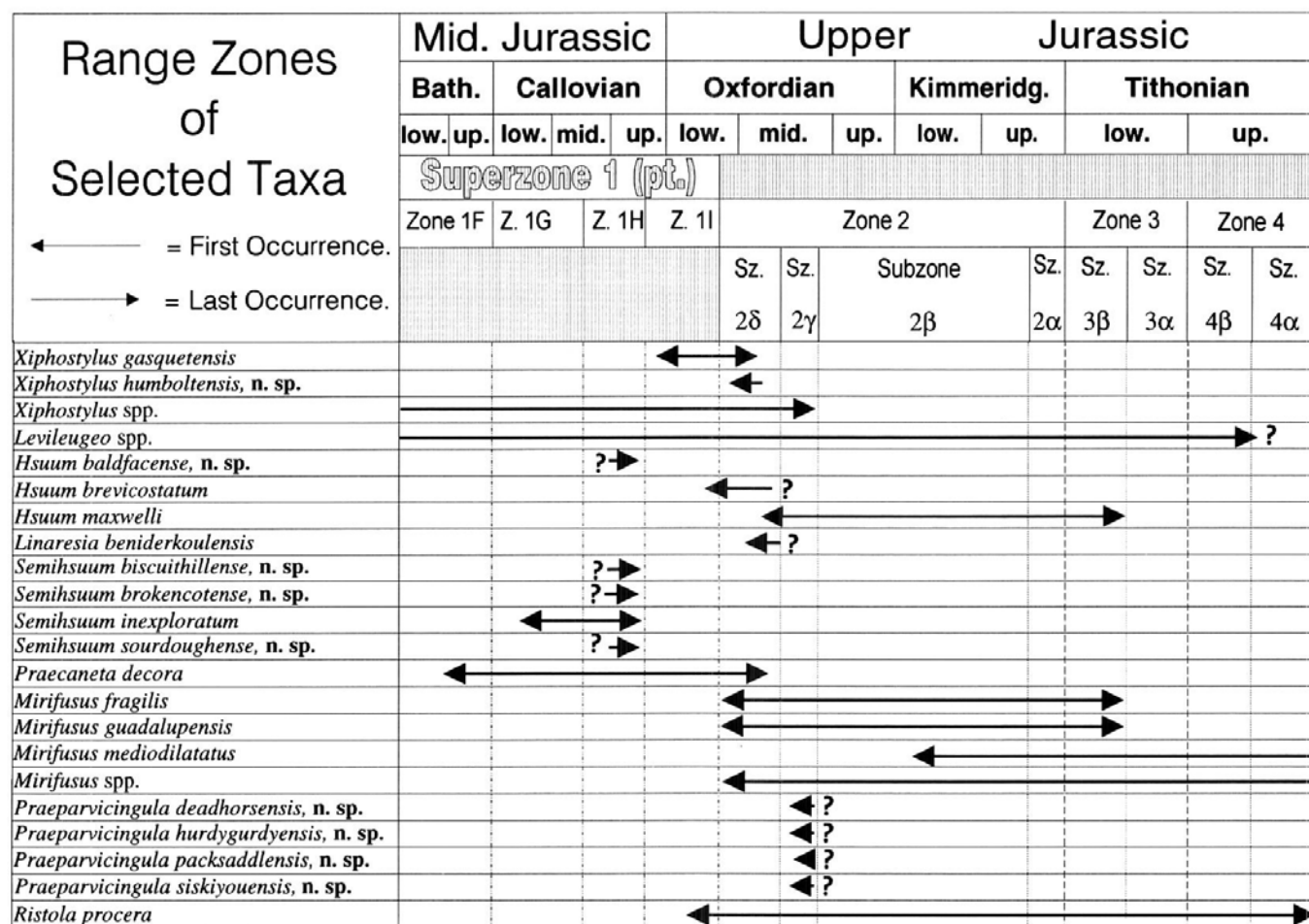
Rogue Valley Subterrane

Paleontological data are at best meager from the Rogue Valley subterrane. We observed Central Tethyan Radiolaria at the top of the Rogue Formation. The presence of *Buchia* in association with *Persisphinctes* (*Dichotomosphinctes*) in the basal Galice together with abundant specimens of *Praeparvicungula* indicates that these strata were deposited in the Southern Boreal Province. The remainder of the type Galice contains *Buchia*, but lacks Radiolaria and other megafossils. The data at hand suggest that the Rogue Valley subterrane was subjected to northward tectonic transport similar to that displayed by the Smith River subterrane (see below).

Smith River Subterrane

The volcanic member of the Josephine ophiolite (Turner Albright Mine) and the lower 39m of the VP succession (Middle Fork of the Smith River near Little Jones Creek) contain a radiolarian assemblage characteristic of the Tethyan Realm, Central Tethyan Province; the upper 5m of the VP succession contain a Northern Tethyan Radiolarian assemblage. All of the overlying strata of the Galice Formation s.l. contain a Southern Boreal radiolarian assemblage with abundant *Praeparvicungula* and a common to rare, poorly diversified pantanelliid assemblage characterized by the presence of *Gorgansium* Pessagno and Blome. In addition, *Buchia concentrica* was reported in Galice s.l. strata by both Diller (1907) and Harper (1983) at localities along Shelly Creek and Monkey Creek to the north of the site we investigated along the Middle Fork of the Smith River (text-fig. 2). No paleomagnetic data are presently available from this succession.

In summary, faunal data from strata within the volcanic member of the Josephine ophiolite and above the Josephine ophiolite indicate that the ophiolite originated at Central Tethyan paleolatitudes during the latest Callovian (162 Ma) and was carried northward to Northern Tethyan and Southern Boreal paleolatitudes during the early and middle Oxfordian (text-fig. 23).



TEXT-FIGURE 26

Range zones of selected taxa. *Xiphostylus gasquetensis* to *Ristola procera*.

If the Josephine ophiolite formed at a back-arc spreading center as suggested by Saleeby et al. (1982), it is likely that the rate of movement northward was not much greater than that of the continent. It is conceivable that the ophiolite originated near the boundary between the Central and Northern Tethyan provinces. The presence of similar tuffaceous cherts both within the volcanic member of the ophiolite and within the volcanopelagic succession tends to support a back-arc origin for the JO.

Evidence for Two Metamorphic Events in Smith River Subterrane

A dramatic difference in preservation occurs between radiolarian specimens extracted from pelagic limestone within the VP succession and the overlying Galice s.l. Radiolaria from the VP succession tend to be considerably more recrystallized and deformed whereas those from the overlying Galice are not recrystallized and less deformed. These easily observable differences in the preservation of the Radiolaria (see pls. 1-8 herein) may suggest that the Josephine ophiolite and the VP succession had been exposed to a period of metamorphism prior to the deposition of the Galice. As noted above, the interface between the VP succession and the Galice marks the onset of the deposition of flysch both in the Klamath Mountains and in the Sierra Nevada and may mark an early pulse of the Nevadan Orogeny.

SYSTEMATIC PALEONTOLOGY

Class ACTINOPODA

Subclass RADIOLARIA

Order POLYCYSTIDA Ehrenberg 1838

Suborder SPUMELLARIINA Ehrenberg 1838

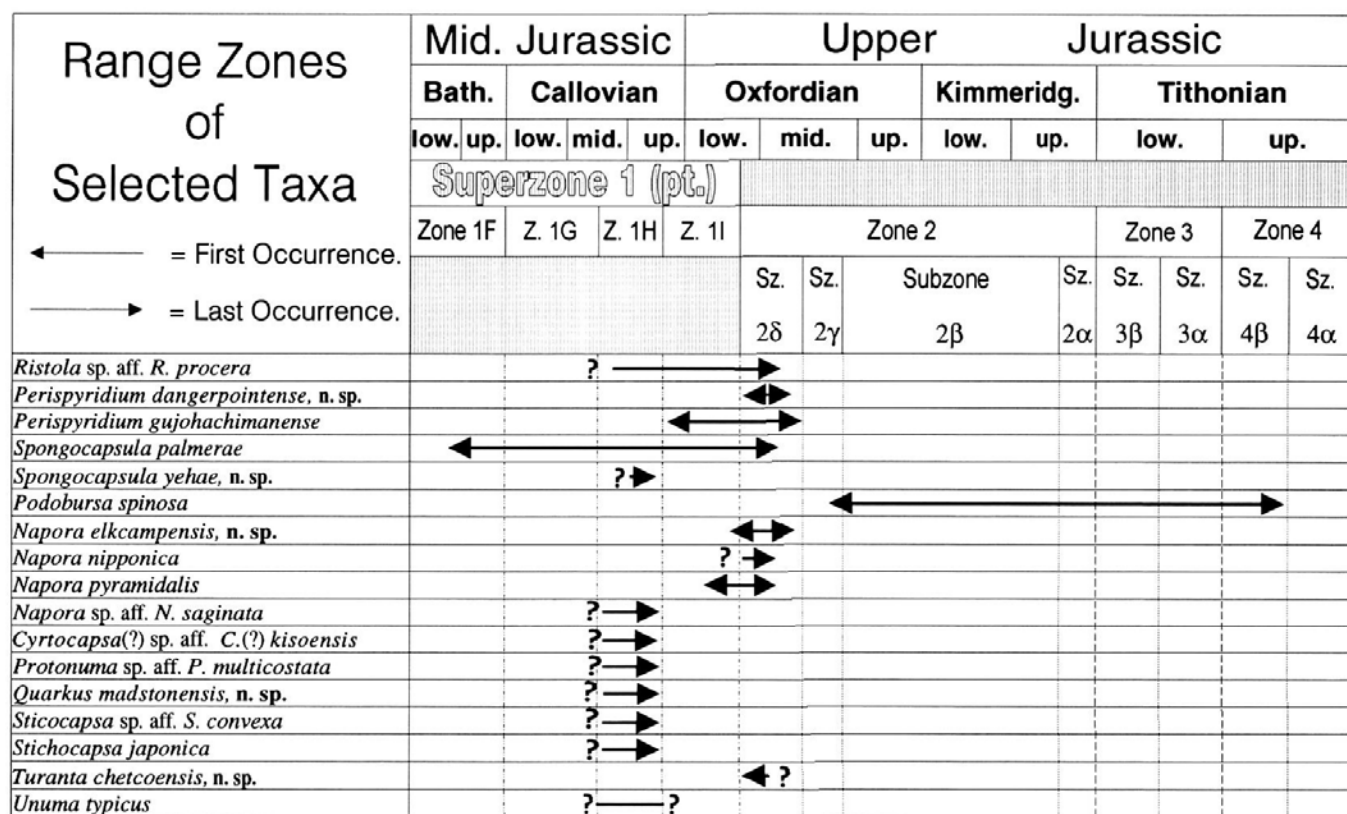
Superfamily SPONGODISCEACEA Haeckel 1881; emend. Pessagno 1971, 1973

Subsuperfamily PSEUDOAULOPHACILAE Riedel 1967; emend. Pessagno 1971

Family **ARCHAEOSPONGOPRUNIDAE** Pessagno 1973*Type species: Archaeospongoprunum venadoense* Pessagno 1973 (= nomen correctum).*Range:* Middle Jurassic (Bathonian) to Lower Tertiary (Middle Eocene) so far as known. See text-figure 24 herein.*Occurrence:* Worldwide in Tethyan and Boreal Realms.*Archaeospongoprunum praeimlayi* Pessagno, Blome and Hull, n. sp.

Plate 1, figures 8, 9, 20, 22, 25, 29

Description: Spongy cortical shell ellipsoidal to subcylindrical with tetragonal and pentagonal pore frames. Bipolar spines nearly equal in length; elongate, slender, triradiate with three



TEXT-FIGURE 27

Range zones of selected taxa. *Ristola* sp. aff. to *Unuma typicus* n. sp.

longitudinal ridges alternating with three longitudinal grooves; ridges about same width as grooves. Ridges developing subsidiary grooves.

Remarks: *Archaeospongoprunum praeimlayi*, n. sp., differs from *A. imlayi* Pessagno (1977a) by having longer, much more slender spines. It is likely that the two species are phylogenetically related.

Etymology: *Prae* (Latin, prefix) + *imlayi* (Pessagno 1977a).

Measurements: (μm) Holotype + 4 paratypes. See text-figure 28 for explanation of measurements.

	AA'	A'	S'	AS	BB'	cc'
Holotype	80	124	120	78	36	20
Mean	68	76	78	63.6	24.4	63.6
SD	16.4	40.4	38.9	14.6	8.2	1.7
Max.	80	124	120	80	36	80
Min.	40	40	40	50	16	16

Co-type localities: Holotype from JO-61. Paratypes from JO-61 and JO-73. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458954. Paratypes = USNM 458955 and Pessagno Collection.

Range: Superzone 1, Zone 1I to Zone 2, Subzone 2 delta; uppermost Callovian?; Oxfordian. See text-figure 24.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, northwestern California; Tethyan Realm, Central Tethyan Province. See text-figure 13.

Archaeospongoprunum sp. aff. *A. macrostylum* (Rüst)
Plate 1, figure 19

Spongolonche macrostyla RÜST 1898, p. 34, pl. 11, fig. 12.

Remarks: The form figured herein differs from that of Rüst (1898) by having longer spines and a proportionately shorter cortical shell.

Range: Superzone 1, Zone 1H; uppermost Callovian?.

Occurrence: Volcanic member of Josephine ophiolite, Smith River subterranean, Klamath Mountains, southwestern Oregon. Tethyan Realm, Central Tethyan Province. See text-figure 13.

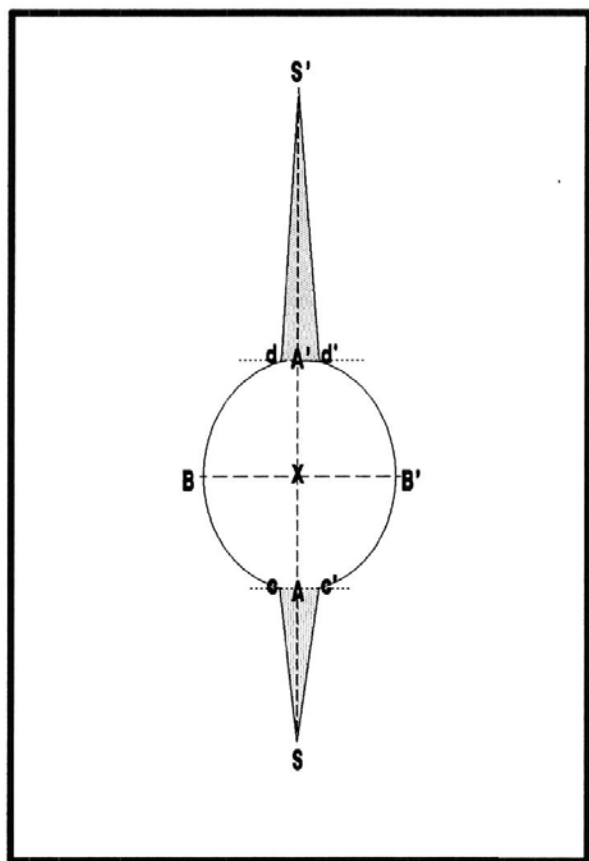
Archaeospongoprunum sp. A
Plate 1, figures 3, 17, 21

Range and occurrence: Zone 2, Subzone 2 delta; Oxfordian. Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California. Tethyan Realm: Central Tethyan Province. JO-34; rare.

Archaeospongoprunum sp. B
Plate 1, figures 11, 16, 23

Remarks: This form is similar to *A. praeimlayi*, n. sp., but differs from the latter form by having considerably broader and more massive polar spines.

Range and occurrence: Zone 2, Subzone 2 delta; Oxfordian. JO-73; rare. Volcanopelagic strata above Josephine ophiolite,



TEXT-FIGURE 28

System of measurements for species of *Archaeospongoprunum*, *Wilvemina*, *Pantanellium* and *Xiphostylus*.

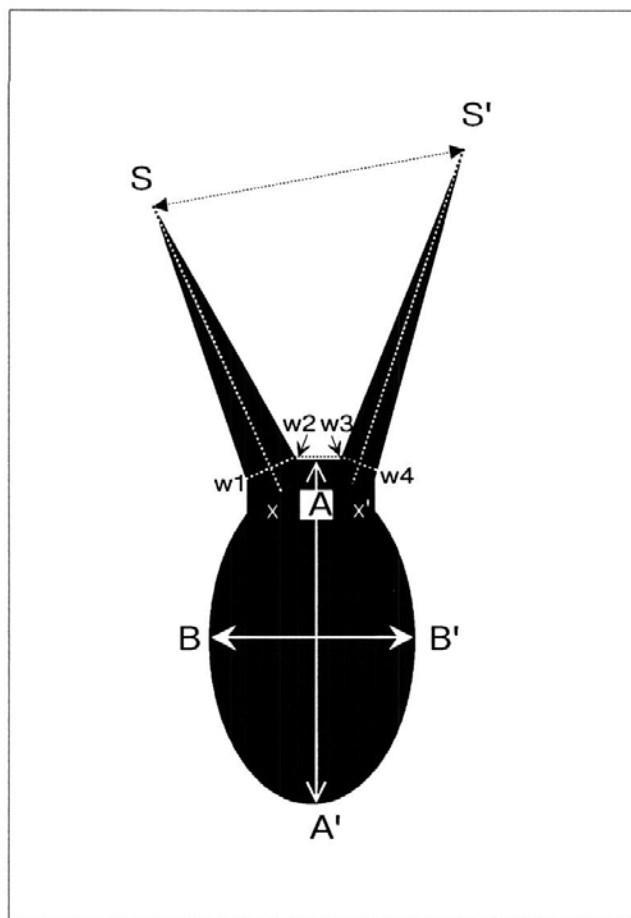
Smith River subterranean, northwestern California; Tethyan Realm, Central Tethyan Province.

Family **BERNOULLIIDAE** Pessagno, Blome and Hull, n. fam.
Type genus: *Bernoullius* Baumgartner 1984.

Description: Test flattened to slightly inflated, circular to elliptical in shape with pore frames of spongy meshwork arranged in concentric rings. Two triradiate spines occurring in one plane either adjacent to each other on one side of test (e.g. *Bernoullius*) or opposed to each other on opposite sides of the test (e.g. *Wilvemina*); spines with three longitudinal ridges alternating with three longitudinal grooves. Some specimens of type genus with central spine placed between two lateral spines (fide Baumgartner 1984).

Remarks: The Bernoulliidae, n. fam., differ from the Archeospongoprunidae Pessagno (1973) by having a test that is compressed in the plane of the primary spines rather than an inflated test. Moreover, the primary spines of the Bernoulliidae are sometimes, as in the case of the type genus *Bernoullius*, not opposed.

Range: Uppermost Superzone 1, Zone 1A to Zone 4, Subzone 4 alpha; upper middle Toarcian (LJ) to uppermost Tithonian (UJ).



TEXT-FIGURE 29

System of measurements for species of *Bernoullius*.

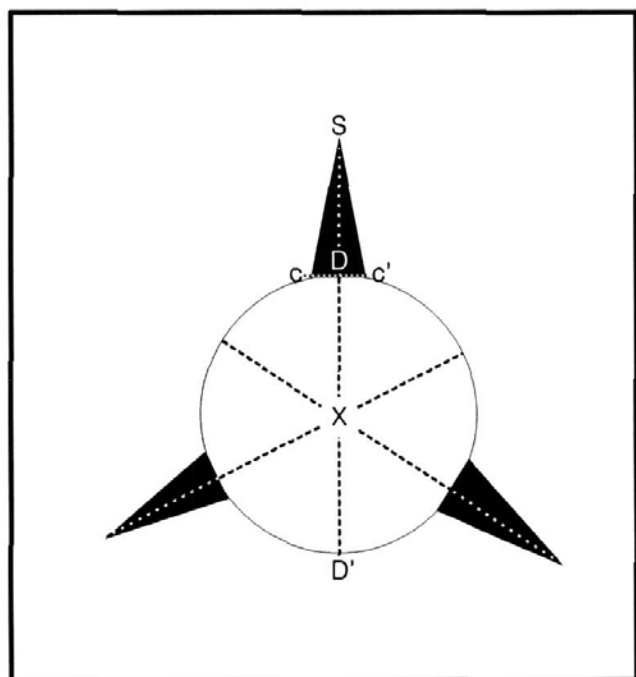
Occurrence: Worldwide in Tethyan Realm and Boreal Realm. Rare in Boreal Realm.

Genus *Bernoullius* Baumgartner 1984
Type species: *Eucyrtis(?) dicera* Baumgartner 1980b.

Spongiostroma Carter 1988, p. 46 (type sp. = *S. saccideon* Carter 1988, pp. 46-47, pl. 12, figs. 4, 7, 10).

Remarks: Note that some species of *Bernoullius* such as *B. irwini*, n. sp., have tests which are circular in outline. Forms of this sort were included by Carter (1988) in *Spongiostroma* Carter, but are included under *Bernoullius* herein. It also should be noted that *Bernoullius* possesses primary spines that are usually subequal in length. The specimen shown on plate 1, figure 1 shows the concentric arrangement of the spongy meshwork. This feature was also documented by Carter (1988) in her illustrations of *Spongiostoma saccideon*.

There appear to be two lineage groups of *Bernoullius* in the Jurassic herein referred to as the *Bernoullius irwini* Group and the *B. cristatus* Group. The *Bernoullius irwini* group is characteristic of the Toarcian (LJ) to Oxfordian (UJ) interval. Members of this lineage group have adjacent primary spines which are straight and possess deeply incised, subparallel, narrow longitudinal grooves. The *Bernoullius cristatus* Group is characteristic of the Oxfordian, Kimmeridgian, and Tithonian. Members



TEXT-FIGURE 30
System of measurements for species of *Tripocyclia*.

of the latter group possess adjacent primary spines which are curved often with markedly curved tips.

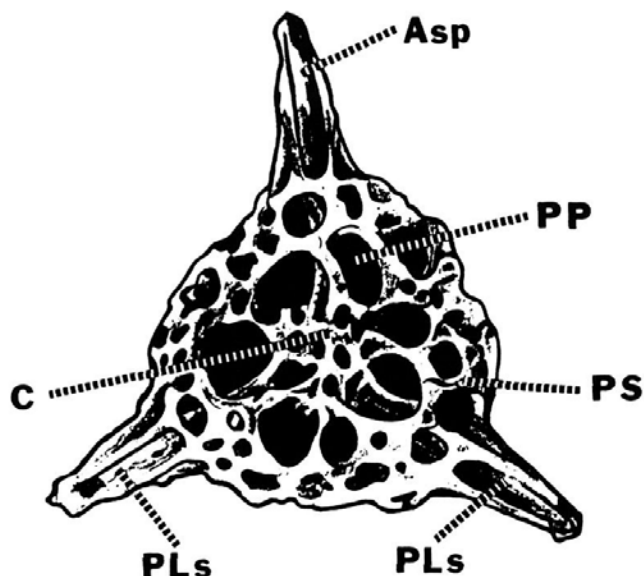
Range: Superzone 1, Zone 1A to Zone 4, Subzone 4 alpha; upper middle Toarcian to uppermost Tithonian. See text-figure 24 herein.

Occurrence: Worldwide in Tethyan Realm: California, Queen Charlotte Islands, B.C., Japan, France, Greece, Yugoslavia, Cape Verde Basin (DSDP Leg 41) and Boreal Realm: California. Boreal Realm, Southern Boreal Province in volcanopelagic strata above Coast Range ophiolite (Stanley Mountain remnant). It should be noted that *Bernoullius* is rare in Southern Boreal strata.

Bernoullius brokenkettlensis Pessagno, Blome and Hull, n. sp.
Plate 1, figures 5-7, 24, 28

Description: Test broad, elliptical in outline with two straight, pointed, subequal primary spines which are triradiate in axial section. Spinal bases close together. Spines with three longitudinal ridges alternating with three longitudinal grooves. Longitudinal ridges lacking subsidiary grooves; wide proximally, very gradually decreasing in width in a distal direction. Longitudinal grooves narrow, deeply incised, gradually decreasing in width in a distal direction. Spinal tips circular in axial section, lacking longitudinal ridges and grooves.

Remarks: *Bernoullius brokenkettlensis*, n. sp., differs from *B. irwini*, n. sp., by having a test which is broadly elliptical in outline rather than circular in outline and by having spines whose bases originate close together on the spongy cortical shell. *B. brokenkettlensis* differs from *B. delnortensis*, n. sp., by having a test which is broadly elliptical in outline.



TEXT-FIGURE 31
System of measurements for species of *Perispyridium*.

Etymology: This species is named for Broken Kettle Creek to the northeast of its type locality.

Measurements: (μm) Holotype + 6 paratypes. See text-figure 29 for explanation of measurements.

	AA'	Sx	S'x'	BB'	w1w2	w3w4	w2w3	SS'
Holotype	240	—	150	195	60	30	30	—
Mean	218.5	157.5	160	177	60	40.7	31.6	—
SD	35.5	19.3	8.6	32.6	0	7.3	4	—
Max.	270	180	165	210	60	45	40	—
Min.	165	135	150	135	60	30	30	—

Co-type localities: Holotype from JO-34. Paratypes from JO-34 and JO-61. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458956. Paratypes = USNM 458957 and Pessagno Collection.

Range: Superzone 1, Zone 1I to Zone 2, Subzone 2 delta; uppermost Callovian?; lower to middle Oxfordian. See text-figure 24.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province. See text-figure 13.

Bernoullius cristatus Baumgartner
Plate 1, figure 14

Eucyrtis(?) dicera BAUMGARTNER 1980b in Baumgartner et al. 1980, pl. 6, fig. 6.

Eucyrtis(?) sp. A KOCHER 1981, p. 68, pl. 13, figs. 19-20.

Bernoullius cristatus BAUMGARTNER 1984, p. 760, pl. 2, figs. 14-15.

Range: Zone 2, Subzone 2 delta; Oxfordian to upper part of Subzone 2 gamma. Baumgartner et al. (1991) indicated that this species ranges from new U.A. 19 to new U.A. 33 (= base of Zone

A1 to bottom of Zone A2 of Baumgartner 1987). See text-figure 24.

Occurrence: Volcanopelagic strata above the Josephine ophiolite, Klamath Mountains, northwestern California; Tethyan Realm, Northern Tethyan Province. Blake Bahama Basin at DSDP Site 534 (Baumgartner 1984); Tethyan Realm, Central Tethyan Province. Italy; Tethyan Realm, Central Tethyan Province. See text-figure 13.

Bernoullius delnortensis Pessagno, Blome and Hull, n. sp.

Plate 1, figures 4, 15, 26

?*Bernoullius* sp. A, GORICAN 1987, p. 181, pl. 1, fig. 17.

Description: Test relatively slender, flaring slightly laterally away from spines. Primary spines straight, rather short and massive, triradiate in axial section with three longitudinal ridges alternating with three longitudinal grooves. Longitudinal grooves, narrow, deeply incised, gradually decreasing in width in a distal direction. Ridges wide proximally, becoming progressively narrower in a distal direction.

Remarks: This form greatly resembles *Bernoullius* sp. A of Goric (1987). It possesses straight, short, subequal spines with parallel sided, deeply incised grooves separating wide, longitudinal ridges which wedge out distally. *Bernoullius* sp. A of Goric, however, possesses short spines which are nearly equal in length and are somewhat shorter than those of *B. delnortensis*. *B. delnortensis* differs from *B. sp. A* (herein) by having considerably shorter, wider, and more massive primary spines. *B. delnortensis* differs from *B. cristatus* Baumgartner (1984) by having spines which are straight and lack curved tips.

Etymology: This species is named for Del Norte County, California.

Measurements: (μm) Holotype + 3 paratypes. See text-figure 29 for explanation of measurements.

	AA'	Sx	S'x'	BB'	w1w2	w3w4	w2w3	SS'
Holotype	210	165	—	135	45	30	30	—
Mean	206	130	136.5	135	37.5	27.3	41.2	187.5
SD	14.3	31.2	19	32.4	8.6	3.5	7.5	10.6
Max.	225	165	150	180	45	30	45	195
Min.	195	105	123	105	30	22.5	30	180

Co-type localities: Holotype from JO-70. Paratypes from JO-34 and JO-70. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458958. Paratypes = USNM 458959 and Pessagno Collection.

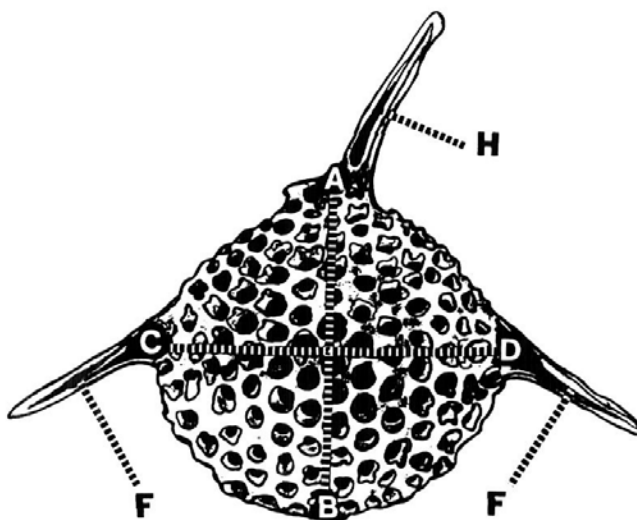
Range: Superzone 1, Zone II to Zone 2, Subzone 2 delta; uppermost Callovian?; Oxfordian. See text-figure 24.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province. See text-figure 13.

Bernoullius irwini Pessagno, Blome and Hull, n. sp.

Plate 1, figures 1, 10, 13, 27

Bernoullius sp. B GORICAN, 1987, pp. 181-182, pl. 1, fig. 18.



TEXT-FIGURE 32

System of measurements for species of *Turanta*.

Description: Test more or less circular in outline with two adjacent, straight spines on one side which tend to be more widely separated than those of other species figured herein. Spines wide, relatively massive, triradiate in axial section with three longitudinal grooves alternating with three longitudinal ridges; ridges developing narrow subsidiary grooves proximally. One spine slightly shorter than other.

Remarks: *Bernoullius irwini*, n. sp., was first figured by Goric (1987) as *Bernoullius* sp. B. *Bernoullius irwini* is also closely related to *Bernoullius rectispinus* Kito et al. (1990, pp. 347-348, pl. 2, figs. 5, 7, 9, 10 = holotype; not pl. 2, fig. 4 = paratype). *B. irwini* differs from *B. rectispinus* by having primary spines with narrow, deeply incised, parallel-sided longitudinal grooves. The primary spines of *B. rectispinus* possess wide, flaring longitudinal grooves; moreover, subsidiary grooves tend to be developed on the proximal part of its longitudinal ridges. Although the test of the holotype of *B. rectispinus* is broken, it seems to be circular in outline like that of *B. irwini*. In addition, the angle between the primary spines of both species appears to be similar. We suggest that *B. rectispinus* represents a somewhat more advanced form of *Bernoullius* than *B. irwini*. *B. rectispinus* has been figured [under *Cuniculiformis* sp. aff. *C. diceris* (Baumgartner) and *Cuniculiformis* sp. by El Kadiri (1984, pl. 4, figs. 3, 7)] from the Jurassic of Morocco.

Etymology: This species is named for Dr. William P. Irwin in honor of his many valuable contributions to the study of the geology of the Klamath Mountains.

Measurements: (μm) Holotype + 3 paratypes. See text-figure 29 for explanation of measurements.

	AA'	Sx	S'x'	BB'	w1w2	w3w4	w2w3	SS'
Holotype	180	180	190	180	40	37	60	340
Mean	176	143	175	179.5	35	30	55	280
SD	7.5	35	21	1	10	9.4	10	72
Max.	180	180	190	180	40	37	60	340
Min.	165	110	160	178	20	17	40	200

Type locality: JO-70. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458960. Paratypes = USNM 458961 and Pessagno Collection.

Range: Superzone 1, Zone 1I to Zone 2, Subzone 2 delta; uppermost Callovian?; Oxfordian. See text-figure 24.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, northwestern California; Tethyan Realm: Central Tethyan Province. Uppermost Superzone 1 strata in Yugoslavia (Gorican 1987); Tethyan Realm, Central Tethyan Province. See text-figure 13 herein.

Genus *Wilvemina* Pessagno, Blome and Hull, n. gen.

Type species: *Wilvemina whiskeyensis* Pessagno, Blome and Hull, n. sp.

Description: Spongy cortical shell circular to elliptical in outline, flattened to slightly inflated with two opposed triradiate polar spines and rounded sides. Spines subequal in length with three longitudinal ridges alternating with three longitudinal grooves.

Remarks: *Wilvemina*, n. gen., differs from *Bernoullius* Baumgartner by having a test with two opposed primary spines and a cortical shell which is more inflated in the plane of the spines. It is possible that *Wilvemina* evolved from *Protopsisium* Pessagno and Poisson via flattening of the spongy cortical shell. Moreover, it is likely that *Wilvemina* in turn gave rise to *Bernoullius* via further flattening of the cortical shell and the shift of the primary spines to a position adjacent to each other on the same side of the test.

Etymology: *Wilvemina* (f.) is a name formed by an arbitrary combination of letters (ICZN 1985, p. 21, Art. 11b).

Range: Superzone 1, Zone 1H so far as known; Callovian. See text-figure 24.

Occurrence: Volcanic member of Josephine ophiolite; Tethyan Realm, Central Tethyan Province.

Wilvemina whiskeyensis Pessagno, Blome and Hull, n. sp.
Plate 1, figure 12

Description: Cortical shell compressed, disk-like, subcircular in outline with surfaces of opposing sides being convex. Spongy meshwork of cortical shell comprised predominantly of small tetragonal and pentagonal pore frames; nodes occurring at pore frame vertices. Bipolar primary spines massive, sharply terminating distally with three longitudinal ridges alternating with three longitudinal grooves. Ridges and grooves about equal in width; often wider medially; and decreasing in width both proximally and distally. Ridges developing deeply incised narrow grooves on their proximal nine-tenths.

Remarks: *Wilvemina whiskeyensis*, n. sp., differs from *Wilvemina* sp. A by having a subcircular rather than an elliptical test and by having longer, more massive and pointed bipolar spines.

Etymology: This species is named for Whiskey Creek near its type locality.

Measurements: (μm) Holotype + 4 paratypes. See text-figure 28 for explanation of measurements.

	AA'	A'S'	AS	BB'	cc'	dd'
Holotype	80	116	124	80	28	28
Mean	79.6	105.2	107.5	85.2	25.6	29.6
SD	0.89	12.4	17.7	8.67	3.84	0.89
Max.	80	120	124	100	30	30
Min.	78	90	86	80	20	28

Type locality: JO-86D. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458962. Paratypes = USNM 458963 and Pessagno Collection.

Range: Superzone 1, Zone 1H so far as known; Callovian. See text-figure 24.

Occurrence: Volcanic member of Josephine ophiolite, Smith River terrane, northwestern California and southwestern Oregon Tethyan Realm, Central Tethyan Province. See text-figure 13 herein.

Wilvemina sp. A
Plate 1, figure 2

Range: Superzone 1, Zone 1H so far as known; upper Callovian?.

Occurrence: Volcanic member of Josephine ophiolite, Smith River terrane, northwestern California and southwestern Oregon; Tethyan Realm, Central Tethyan Province.

Family **PATULIBRACCHIIDAE** Pessagno 1971

Type genus: *Patulibracchium* Pessagno 1971.

Range: Upper Paleozoic?; Triassic to Upper Cretaceous.

Occurrence: Worldwide in Tethyan and Boreal Realms.

Bistarkum Yeh 1987

Type species: *Bistarkum rigidum* Yeh 1987

Remarks: Yeh (1987, pp. 42-43) regarded *Amphibracchium* Haeckel (1881) and its type species, *Amphibracchium diminutum* Rüst (1885) as nomina dubia. This practice is followed herein.

Range: Zone 01, Subzone 01A to Superzone 1, Zone 1H so far as known; Lower Jurassic, upper Pliensbachian to Middle Jurassic, upper Callovian so far as known. See text-figure 24.

Occurrence: Worldwide in Tethyan Realm so far as known.

Bistarkum sp. A

Plate 1, figure 18

Range and occurrence: Superzone 1, Zone 1H; upper Callovian. Volcanic member of Josephine ophiolite. JO-87A, rare.

Genus *Paronaella* Pessagno 1971; emend. Baumgartner 1980a.

Type species: *Paronaella solanoensis* Pessagno 1971.

Paronaella PESSAGNO 1971, pp. 46-47. – BAUMGARTNER 1980a, p. 300.

Sontonaella YEH 1987, p. 44.

Remarks: We follow Baumgartner (1980a) in including three rayed forms lacking a brachchiopyle and having bulbous ray tips in *Paronaella* Pessagno. Forms with bulbous ray tips and forms lacking bulbous ray tips appear to be completely gradational. Hence, we include *Sontonaella* Yeh under *Paronaella*.

Range: ?Paleozoic; Triassic to Upper Cretaceous. Text-figure 24.

Occurrence: Worldwide in Tethyan and Boreal Realms.

Paronaella bandyi Pessagno s.l.

Plate 2, figure 1

Paronaella bandyi PESSAGNO 1977a, p. 68, pl. 1, figs. 1-3. — BAUMGARTNER 1980a, p. 300, pl. 9, fig. 4.

Range: Superzone 1, Zone 1I to Zone 4, Subzone 4 beta; uppermost Callovian/lower Oxfordian to upper Tithonian. Text-figure 24.

Occurrence: Volcanopelagic strata above Coast Range ophiolite at Point Sal, Santa Barbara Co., California and Stanley Mountain, San Luis Obispo Co., California; Jurassic of Greece, Japan (fide Baumgartner 1980a); Tethyan Realm: Central Tethyan Province to Boreal Realm: Southern Boreal Province. See text-figure 13 herein.

Paronaella* sp. aff. *P. brönnimanni Pessagno

Plate 2, figures 2, 26

?*Paronaella brönnimanni* Pessagno. — BAUMGARTNER 1984, p. 777, pl. 6, fig. 17.

Remarks: This form differs from the type specimens of *P. brönnimanni* by having slender, somewhat more elongate rays with a more pronounced linear arrangement of pore frames. Both forms, however, share parallel-sided rays with similar ray tips. It is conceivable that this form is ancestral to *P. brönnimanni*. The form figured herein appears to be very similar to that figured by Baumgartner (1984, pl. 6, fig. 17).

Range and occurrence: Zone 2, Subzone 2 delta; Oxfordian. Volcanopelagic strata overlying Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California. See text-figures 13 and 25 herein.

Paronaella cleopatraensis Pessagno, Blome and Hull, n. sp.

Plate 2, figures 3, 25

Description: Test comprised of irregularly sized and shaped tetragonal, pentagonal and hexagonal (predominantly pentagonal) pore frames with poorly developed nodes at the pore frame vertices. Three rays short, wide with wide wedge-shaped tips. Ray tips terminating in seven or more wide, closely spaced, blade-like spines lacking ridges and grooves. Blade-like spines merging proximally near juncture with each spongy ray.

Remarks: *Paronaella cleopatraensis*, n. sp., appears to be closely related to *P. pessagno* Blome and *P. pristidentata* Baumgartner. It differs from *P. pessagno* by having pore frames which lack prominent nodes at their vertices, by lacking abundant triangular pore frames and by possessing spines at the ray tips which all tend to merge proximally. *P. cleopatraensis* differs from *P. pristidentata* Baumgartner by having rays which have wide, wedge-shaped tips, by having more numerous spines at ray tips, and by lacking any sort of linear arrangement of pore frames.

Etymology: This species is named for the Cleopatra Mine to the northwest of its type locality.

Measurements: (µm) Holotype + 10 paratypes.

	Length of ray	Width of ray proximally	Width of ray tips
Holotype	195	67.5	150
Mean	195	67.5	137.7
SD	56.5	15	41.25
Max.	285	105	240
Min.	120	45	90

Co-type localities: Holotype from JO-17. Paratypes from JO-17 and JO-50. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458964. Paratypes = USNM 458965 and Pessagno Collection.

Range: Zone 2, Subzone 2 gamma so far as known; middle Oxfordian so far as known. Text-figure 24.

Occurrence: Galice Formation s.l., Smith River subterranean, Klamath Mountains, northwestern California; Boreal Realm, Southern Boreal Province. Middle Oxfordian of Sula Islands, East Indies; Austral Realm, Northern Austral Province; occurs in direct association with the ammonite *Epimayaites*. See text-figure 13 herein.

***Paronaella* sp. A**

Plate 2, figure 4

Remarks: This form is characterized by having short rays with very wide ray tips, coarse meshwork, and a massive centrally placed spine at the center of each ray tip.

Range and occurrence: Superzone 1, Zone 1H; upper Callovian so far as known. Volcanic member of Josephine ophiolite, Smith River subterranean, Klamath Mountains, southwestern Oregon. JO-87C; rare.

***Paronaella* sp. B**

Plate 2, figures 6, 24

Range and occurrence: Zone 2, Subzone 2 delta; Oxfordian. Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California. JO-34; rare.

Genus *Patulibracchium* Pessagno 1971

Type species: *Patulibracchium davisi* Pessagno 1971.

Range: Lower Jurassic, lower Pliensbachian to Upper Cretaceous, Maestrichtian.

Occurrence: Worldwide in Tethyan and Boreal Realms.

Patulibracchium*(?) sp. aff. *P. henlei (Rüst)

Plate 2, figure 5

Rhopalastrum henlei RÜST 1898, p. 26, pl. 8, fig. 10.

Remarks: Spines are missing on the specimen figured herein as well as on the form figured by Rüst (1898). In addition, both forms have asymmetrically arranged rays with one ray being longer and widely separated from the two remaining rays. The unequal length of the rays together with their asymmetrical arrangement suggest that this form is assignable to *Patulibracchium*.

Range and occurrence: Superzone 1, Zone 1H to Zone 2, Subzone 2 delta; uppermost Callovian to middle Oxfordian so far as known. Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern Cal-

ifornia; Tethyan Realm, Central Tethyan Province. See text-figure 13 herein.

Superfamily PSEUDOAULOPHACILAE Riedel, Family Incertae Sedis.

Genus *Noviforemanella* Pessagno, Blome and Hull, **n. gen.**

Type species: *Paronaella*(?) *hipposiderica* Foreman 1975 (= nomen correctum)

Foremanella Muzavor 1977, p. 67 = nomen nudum.

Description: Test consisting of three rays. Two rays not in same plane as third ray and assuming a horseshoe-like configuration due to asymmetrical accretion of pore frames on inner portions of ray tips. Rays with spinose tips and linear to sublinear arrangement of pore frames. Patagium not observed.

Remarks: Baumgartner (1984) incorrectly applied the name *Foremanella* Muzavor (1977) to these forms. Unfortunately, Muzavor's name is a nomen nudum in that it was presented in an unpublished doctoral dissertation [ICZN 1985, p. 17, Article 9 (11)]. *Noviforemanella* differs from *Paronaella* by having two asymmetrical rays which are not situated in the same plane and assume a horse-shoe-shaped configuration.

Etymology: *Novus-a-um* (Latin, adj. = new, fresh, young) + Foreman + -ella (= diminutive Latin suffix). This genus is named for the late Dr. Helen Foreman, Department of Geology, Oberlin College, in honor of her pioneering contributions to the study of Mesozoic Radiolaria.

Range and occurrence: Superzone 1, Zone II to Zone 5 uppermost Callovian?; Oxfordian to Lower Cretaceous: upper Valanginian/Hauterivian. See Baumgartner (1984). Tethyan Realm, Central Tethyan Province. Text-figure 24.

Noviforemanella sp. aff. *N. hipposiderica* (Foreman)
Plate 2, figures 8, 9, 22, 23

Paronaella(?) *hipposiderica* FOREMAN 1975, p. 612, pl. 2E, figs. 1-2; pl. 5, figs. 3, 7, 10. – BAUMGARTNER et al. 1980, pl. 2, fig. 4.
Foremanella hipposidericus (Foreman). BAUMGARTNER 1984, p. 765, pl. 6, fig. 19.

Remarks: The specimens figured herein appear to be closely related to *Noviforemanella hipposiderica* (Foreman). However, their fragmentary nature makes definite identification difficult.

Range and occurrence: Superzone 1, Zone II; uppermost Callovian?; Oxfordian. Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province. Text-figure 24.

Noviforemanella(?) sp. A
Plate 2, figures 10, 16

Remarks: This form differs from the typical *Noviforemanella* by possessing four rather than three rays. One ray has a spinal tip with two closely separated spines.

Range and occurrence: Zone 2, Subzone 2 delta; Oxfordian so far as known. Volcanopelagic strata overlying the Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California. JO-34; rare. Tethyan Realm, Central Tethyan province.

Subsuperfamily SPONGODRUPILAE Haeckel 1887; emend. Pessagno 1973

Family PARASATURNALIDAE Kozur and Mostler 1972; emend. Pessagno 1979

Type genus: *Parasaturnalis* Kozur and Mostler 1972.

Range: Upper Triassic (Karnian?; Norian) to Upper Cretaceous (Maastrichtian).

Occurrence: Worldwide.

Subfamily PARASATURNALINAE Kozur and Mostler 1972

Type genus: *Parasaturnalis* Kozur and Mostler 1972; emend. Pessagno 1979

Range and occurrence: Same as for family.

Genus *Acanthocircus* Squinabol 1903; **emend.** Pessagno 1979

Type species: *Acanthocircus irregularis* Squinabol 1903.

Range and occurrence: Same as for family.

Acanthocircus bispinus (Yao)

Plate 2, figure 7

Spongosaturnalis bispinus YAO 1972, p. 28, pl. 2, figs. 1, 2, 3, 4, 5; not figs. 6-9.

Range: Zone 2, Subzone 2 delta; middle Oxfordian so far as known. Range not fully established. However, in Japan Yao (1972, p. 24, table 1) demonstrated that this species was closely associated with *Acanthocircus suboblongus* (Yao).

Occurrence: Galice Formation s.l., Smith River subterranean, Klamath Mountains, northwestern California; Boreal Realm, Southern Boreal Province. Mino Complex of Japan; Tethyan Realm, Central Tethyan Province. See text-figure 14 herein.

Acanthocircus carinatus Foreman
(Not illustrated herein)

Acanthocircus carinatus FOREMAN 1973, p. 260, pl. 5, figs. 1, 2.

?*Acanthocircus suboblongus* (Yao). – BAUMGARTNER 1984, p. 755, pl. 1, fig. 6. – AITA 1987, pl. 8, fig. 9. – OZVOLDOVÁ and PETERČÁKOVÁ 1987, p. 118, pl. 31, fig. 3.

?*Acanthocircus variabilis* (Squinabol). – PESSAGNO 1977a, p. 74, pl. 3, fig. 6.
Spongosaturnalis variabilis (Squinabol). – MOORE 1973 (part), p. 824, pl. 6, figs. 1, 3; not pl. 6, fig. 2.

Remarks: *Acanthocircus carinatus* differs from *A. variabilis* by possessing a ring with opposed pairs of peripheral spines which are more massive, less widely separated and interconnected by ridges. *A. carinatus* differs from *A. suboblongus* by having a broad elliptical ring rather than a subrectangular ring and by having opposed pairs of peripheral spines on the ring which are considerably narrower and whose tips are directed outwards rather than inwards. The forms assigned to *A. variabilis* by Pessagno (1977a) and to *A. suboblongus* by Baumgartner (1984), Aita (1987) and Ozvoldová and Peterčáková (1987) are questionably assigned to *A. carinatus* because of the unequal development of spine pairs at opposing ends of their rings and because their rings are much more constricted medially along the axis of the polar spines.

Range: Zone 2, Subzone 2 delta; Oxfordian to Zone 4, Subzone 4 alpha; upper Tithonian or higher.

Occurrence: Volcanopelagic strata above the Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province. DSDP Sites 194, 195 and 195 in the northwest Pacific (Foreman 1973); Tethyan Realm, Central Tethyan Province. DSDP Site 303-307, North Pacific (Foreman 1975); Tethyan Realm, Central Tethyan Province. Lagonegro Basin, Lucany, Southern Italy; Tethyan Realm, Central Tethyan Province. Volcanopelagic strata above Coast Range ophiolite at Point Sal, Santa Barbara County, California and at Stanley Mountain (Alamo Creek), San Luis Obispo County, California; Tethyan Realm, Central Tethyan Province to Boreal Realm, Southern Boreal Province. Pacific Rim Complex, west coast of Vancouver Island, British Columbia; Tethyan Realm, Central Tethyan Province.

Acanthocircus sp. aff. *A. carinatus* Foreman

Plate 2, figure 11

Remarks: The figured specimen appears to possess peripheral spines resembling those of *A. carinatus* Foreman. However, it is too fragmentary to make identification certain.

Range and occurrence: Zone 2, Subzone 2 delta; Oxfordian. Volcanopelagic strata above the Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California. See text-figures 14, 25 herein.

Acanthocircus suboblongus (Yao)

Plate 2, figure 12

Spongosaturialis? *suboblongus* YAO 1972, p. 29, pl. 3, figs. 1-6; pl. 10, figs. 3a-c.

?*Acanthocircus carinatus* Foreman 1973. – DEWEVER and MICONNET 1985, p. 383, pl. 7, figs. 7-8.

Acanthocircus suboblongus (Yao). – WAKITA 1982, pl. 4, fig. 10. – GORICAN 1987, p. 180, pl. 3, figs. 2, 3. – MURCHEY 1984, pl. 2, fig. 12. Not *Acanthocircus suboblongus* (Yao). – BAUMGARTNER 1984, p. 755, pl. 1, fig. 6. – AITA 1987, pl. 8, fig. 9. – OZVOLDOVÁ and PETERČÁKOVÁ 1987, p. 118, pl. 31, fig. 3.

Acanthocircus sp. cf. *Spongosaturialis(?) suboblongus* Yao. – FOREMAN 1978, p. 744, pl. 1, fig. 9.

Remarks: *Acanthocircus suboblongus* (Yao) s.s. is characterized by having a subrectangular ring paired flattened peripheral spines at opposing ends of the ring, and spinal tips which curve inwards. A well-developed ridge occurs along the ring and extends outwards onto the peripheral spines. The ridges on the peripheral spines display the same curvature as the spinal tips (see Yao 1972).

The forms figured by Baumgartner (1984, pl. 1, fig. 6) and Ozvoldová and Peterčáková (1987) are excluded from *Acanthocircus suboblongus* (Yao). These forms differ from *A. suboblongus* by possessing a considerably broader ring which is much more constricted medially, and by having opposed pairs of peripheral spines on the ring which are considerably narrower, somewhat more widely separated and which have spinal tips that curve outwards rather than inwards. To include the morphotype figured by Baumgartner under *A. suboblongus* obscures its possible phylogenetic relationships as well as its stratigraphic range. Together with *Acanthocircus dicranocanthos* (Squinabol), *A. suboblongus* is one of the most distinctive species of *Acanthocircus* in the Mesozoic. The form figured by Foreman (1978) from the Cape Verde Basin, though fragmentary, is referable to *A. suboblongus*. The specimens figured by De Wever and Miconnet (1985, pl. 2, figs. 7-8) as *A. carinatus*

possesses peripheral spines which are much broader and flatter than those of *A. carinatus* and, hence, resemble those of *A. suboblongus*. Moreover, these specimens display spinal tips which are more like those of *A. suboblongus*. It should be noted, however, that the De Wever and Miconnet specimens also possess rings which are tending to become broadly elliptical like that of *A. carinatus*. Such a combination morphological features may suggest that the De Wever and Miconnet specimens are transitional between the two species.

Range: Superzone 1, Zone 11 to Zone 2, Subzone 2 gamma; uppermost Callovian or lower Oxfordian to middle Oxfordian. In the California Coast Ranges, this species occurs in strata assignable to Subzone 2 gamma (Hull 1991). See text-figure 24. Baumgartner et al. (1991) indicate that this species first appears at the bottom of their tentative new U.A. 3 (Zone A0, Baumgartner 1987) and makes its final appearance at the top of new U.A. 14 (upper Zone A0, Baumgartner 1987). See text-figure 24 herein.

Occurrence: Volcanogenic strata above Josephine ophiolite, Smith River subterrane, northwestern California; Tethyan Realm, Central Tethyan Province to Northern Tethyan Province (see text-fig. 14). Volcanopelagic strata above Coast Range Ophiolite, Stanley Mountain terrane (San Luis Obispo County, California; Hull 1991) in Central Tethyan strata. Mino Complex of Japan; Central Tethyan Province. Jurassic of Yugoslavia; Central Tethyan Province. Cape Verde Basin (DSDP Site 367, Core 37, Section 1: 147-149cm); Central Tethyan Province.

Acanthocircus sp. A

Plate 2, figure 14

Range: Subzone 2 gamma so far as known; middle Oxfordian so far as known.

Occurrence: Galice Formation s.l.; Smith River subterrane, Klamath Mountains, northwestern California; Boreal Realm, southern Boreal Province. JO-79; common.

Acanthocircus sp. B

Plate 2, figure 15

Range: Subzone 2 delta so far as known; middle Oxfordian so far as known.

Occurrence: Galice Formation s.l.; Smith River subterrane, Klamath Mountains, northwestern California; Boreal Realm, southern Boreal Province. JO-79; rare.

Acanthocircus sp. C

Plate 2, figure 18

Range: Subzone 2 gamma so far as known; middle Oxfordian so far as known.

Occurrence: Galice Formation s.l.; Smith River subterrane, Klamath Mountains, northwestern California; Boreal Realm, southern Boreal Province. JO-79; rare.

Acanthocircus sp. D

Plate 2, figure 19

Range: Subzone 2 gamma so far as known; middle Oxfordian so far as known.

Occurrence: Galice Formation s.l.; Smith River subterranean, Klamath Mountains, northwestern California; Boreal Realm, southern Boreal Province. JO-79; rare.

Acanthocircus sp. E

Plate 2, figure 20

Range and occurrence: Zone 2, Subzone 2 gamma; middle Oxfordian so far as known. Galice Formation s.l., Smith River subterranean, Klamath Mountains, northwestern California; Boreal Realm, Southern Boreal Province. JO-48; rare.

Acanthocircus sp. F

Plate 2, figure 21

Range and occurrence: Zone 2, Subzone 2 gamma; middle Oxfordian so far as known. Galice Formation s.l., Smith River subterranean, Klamath Mountains, northwestern California; Boreal Realm, Southern Boreal Province. JO-48; rare.

Superfamily LIOSPHAERACEA Haeckel 1881; sensu Pessagno and Blome 1980

Subsuperfamily LIOSPHAERILAE Haeckel 1881; sensu Pessagno and Blome 1980

Family **HAGIASTRIDAE** Riedel 1971; emend. Baumgartner 1980a.

Type genus: *Hagiastrum* Haeckel 1881.

Subfamily **HIGUMASTRINAE** Baumgartner 1980a;

Type genus: *Higumastra*.

Higumastriinae BAUMGARTNER 1980, p. 290.

Tetraditrymae BAUMGARTNER 1980a, p. 296 = subjective synonym.

Remarks: Yang (1988) emended the Higumastriinae to include the Tetraditrymae of Baumgartner (1980, p. 296). This usage is followed herein.

Range: Lower Jurassic, Sinemurian to Lower Cretaceous: Albian.

Occurrence: Worldwide in Tethyan and Boreal Realms.

Genus *Higumastra* Baumgartner 1980a

Type species: *Higumastra inflata* Baumgartner 1980a.

Range: Zone 01, Subzone 01A to Zone 6; Lower Jurassic, upper Pliensbachian to Lower Cretaceous, Barremian.

Occurrence: Worldwide in Tethyan and Boreal Realms.

Higumastra devilsgapensis Pessagno, Blome and Hull, n. sp.

Plate 2, figures 13, 17

Description: Test as with genus. Rays short, broad proximally, tapered in a distal direction, elliptical in cross-section, and sloping away from central area. Rays terminating in short spines which are smooth and completely circular in axial section. Meshwork of rays consisting of two layers of pentagonal and hexagonal pore frames together with minor triangular and tetragonal pore frames; pore frames with small nodes at vertices. Four to five rows of pore frames visible on upper and lower ray surfaces. Central area usually a large circular lacuna (sensu Pessagno 1971, p. 16) through which medullary shell can be seen. First medullary shell with fragile, thin pentagonal and hexagonal pore frames. Remnants of patagium visible on most specimens.

Remarks: *Higumastra devilsgapensis*, n. sp., differs from *Higumastra imbricata* Baumgartner by having tapered rays which terminate in spines which are smooth and circular in axial section, by possessing pore frames with small nodes at the vertices and by having a large, circular lacuna.

Etymology: This species is named for Devil's Gap to the south of its type locality.

Measurements: (μm) Holotype + 2 paratypes.

	Length of rays	Width of rays	Width of central area	Length of spines	Width of lacuna
Holotype	100	60	140	36	66
Mean	84	68.66	120	34	—
SD	21.16	8	34.6	2.8	—
Max.	100	76	140	36	—
Min.	60	70	80	32	—

Co-type localities: Holotype from JO-48. Paratypes from JO-48 and JO-17. Galice Formation. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458966. Paratypes = USNM 458967 and Pessagno Collection.

Range: Zone 2, Subzone 2 gamma so far as known; Oxfordian so far as known. See text-figure 24.

Occurrence: Galice Formation s.l., Smith River subterranean, Klamath Mountains, northwestern California; Boreal Realm, Southern Boreal Province. See text-figure 14.

Higumastra imbricata (Ozsvoldová)

Plate 3, figures 23, 24

Crucella(?) *imbricata* OZVOLDOVÁ 1979, p. 254, pl. 3, figs. 1, 4.

Higumastra imbricata (Ozsvoldová). — KOCHER 1981, p. 71, pl. 1, fig. 10. — BAUMGARTNER 1984, p. 767, pl. 4, fig. 13.

Range: Superzone 1, Zone 11 to Zone 2, Subzone 2 delta; uppermost Callovian?; lower to middle Oxfordian. Baumgartner et al. (1991) indicate that this species first appears at the bottom of their new U.A. 13 (Zone A0, Baumgartner 1987) and makes its final appearance at the top of new U.A. 40 (Zone B, Baumgartner 1987). See text-figure 24 herein.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province (text-fig. 14). Blake Bahama Basin at DSDP Site 534A; Tethyan Realm, Central Tethyan Province. Greece; Tethyan Realm, Central Tethyan Province. Czechoslovakia; Tethyan Realm. Lagonegro Basin, Lucany, Southern Italy; Tethyan Realm, Central Tethyan Province.

Higumastra sp. aff. *H. inflata* Baumgartner

Plate 3, figure 9

Higumastra inflata BAUMGARTNER 1980a, p. 290, pl. 3, figs. 1, 2, 5-9, 11.

Remarks: This form is very similar to *H. inflata*, but possesses shorter rays. It also similar to the specimen figured by Baumgartner (1980, p. 290, pl. 3, fig. 4) as *H. sp. aff. H. inflata*. It differs from Baumgartner's form by possessing pointed rather than rounded ray tips.

Range: Zone 2, Subzone 2 delta; Oxfordian.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province. See text-figure 14.

***Higumastra transversa* Blome**

Plate 3, figure 22

Higumastra transversa BLOME 1984, pp. 350-351, pl. 1, figs. 3-5, 8-13, 16-19; pl. 15, fig. 4.

Range: Superzone 1, Zone 1G to Zone 2, Subzone 2 delta; middle Callovian to middle Oxfordian. See text-figure 24.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province (text-fig. 14). Lonesome Formation, Izee terrane, east-central Oregon; Boreal Realm, Southern Boreal Province. Shelikof Formation, southern Alaska; Boreal Realm, northern Boreal Province.

Genus *Saldorffus* Pessagno, Blome and Hull, n. gen.

Type species: *Crucella(?) corralitosensis* Pessagno 1977a.

Description: Like *Tetraditryma*, but possessing pointed or rounded rather than bulbous or wedge-shaped ray tips. Rays with centrally placed primary spines which occasionally bifurcate; lateral spines lacking. Primary, secondary and tertiary canals of equal size. Secondary and tertiary canals present with more advanced forms such as *Saldorffus corralitosensis* (Pessagno), but absent in more primitive, older forms from the Bajocian.

Remarks: *Saldorffus*, n. gen., differs from *Tetraditryma* Baumgartner (1980) by possessing four rays with rounded or pointed tips rather than bulbous or wedge-shaped tips. Moreover, the ray tips of *Saldorffus* possess a centrally placed primary spine and lack lateral spines. In addition, *Saldorffus* possesses primary, secondary and tertiary canals of equal size which are often less regularly arranged and lacks cortical apertures (see Baumgartner 1980a, text-fig. 4, diagrams F and G).

Etymology: *Saldorffus* (m.) is a name formed by an arbitrary combination of letters (ICZN 1985, p. 21, Art. 11b).

Range: Superzone 1, Zone 1A, Subzone 1A₁ to Zone 4; Middle Jurassic, Aalenian to Upper Jurassic, upper Tithonian so far as known.

Occurrence: Volcanopelagic pelagic strata above Coast Range ophiolite, Stanley Mountain terrane at Point Sal, Santa Barbara County, California, and at Stanley Mountain (Alamo Creek), San Luis Obispo County, California; Tethyan Realm, Central Tethyan Province to Boreal Realm, Southern Boreal Province. Volcanopelagic strata above Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province to Northern Tethyan Province. Snowshoe and Lonesome formations, Izee terrane, east-central Oregon; Tethyan Realm, Northern Tethyan Province to Boreal Realm, Southern Boreal Province. DSDP Site 534 (Baumgartner 1984); Tethyan Realm, Central Tethyan Province. Greece, Mino Complex of Japan (Baumgartner 1980a).

***Saldorffus coldspringensis* Pessagno, Blome and Hull, n. sp.**

Plate 3, figures 1, 4, 7

Tetraditryma corralitosensis (Pessagno). – AITA 1987, pl. 9, fig. 1.

Description: Test as for genus. Rays long, parallel-sided, very narrow, about four times as wide as width of central area; central area square, quite small relative to length of rays. Central spines at ray tips triradiate in axial section. Top and bottom ray surfaces nearly parallel to near tip of spine, converging rapidly distally. Sides and tops of rays flanked by two lateral ridges; lateral ridges with well-developed nodes. Median ridges lacking on top and bottom surfaces of rays. Rays divided on tops and bottom surfaces into two rows of small, square pores. Sides of rays with three rows of polygonal pore frames. Central area with mixture of somewhat larger, nodose triangular and tetragonal pore frames.

Remarks: *Saldorffus coldspringensis*, n. sp., differs from *S. oregonensis*, n. sp., by having narrower, longer rays which are four times longer than the width of the central area and which are parallel sided, by having a smaller central area, by having spines that are triradiate in axial section and by having rays with parallel top and bottom surfaces.

Etymology: This species is named for Cold Spring Mountain to the west, northwest of its type locality.

Measurements: (μm) Holotype + 5 paratypes.

	Length of rays	Width of rays	Width of central area	Length of spines
Holotype	140	30	40	60
Mean	138	32	52	56
SD	9.83	3.66	9.46	8.64
Max.	150	38	60	66
Min.	120	30	40	42.2

Co-type localities: JO-69 and JO-70. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458968. Paratypes = USNM 458969 and Pessagno Collection.

Range: Superzone 1, Zone 1 to Zone 2, Subzone 2 delta; uppermost Callovian?; lower to middle Oxfordian. See text-figure 24.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; See Text-figure 14.

***Saldorffus corralitosensis* (Pessagno)**

Plate 3, figure 13

Crucella(?) corralitosensis PESSAGNO 1977a, p. 72, pl. 2, figs. 10-11; ?figs. 12-13.

Not *Tetraditryma corralitosensis* (Pessagno). – BAUMGARTNER 1980a, pp. 296-297, pl. 7, figs. 12-15; ?pl. 11, fig. 13. – BAUMGARTNER 1984, p. 787, pl. 9, figs. 6-7. – DEWEVER and MICONNET 1985, p. 390, pl. 1, fig. 9. – AITA 1987, pl. 9, fig. 1.

Remarks: The forms figured by Baumgartner (1980, 1984) are excluded from *Saldorffus corralitosensis* (Pessagno) because they have a smaller central area with more irregular pore frames, longer rays, pore frames that lack well-developed nodes and spines on ray tips which are circular in axial section. The paratype figured by Pessagno (1977a, pl. 2, figs. 12-13) is excluded from *S. corralitosensis* because it possesses longer, more slender rays, a proportionately smaller central area and less nodose pore frames. The specimen figured by Aita (1987,

pl. 9, fig. 1) as "*T. corralitosensis*" is excluded from this species because it possesses very long, narrow, parallel-sided rays, a very small central area and pore frames which are weakly nodose.

Range: Superzone 1, Zone II to Zone 3 so far as known; uppermost Callovian?; Oxfordian to Tithonian. See text-figure 24.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; Tethyan Realm, Northern Tethyan Province (text-fig. 14). Volcanopelagic strata above Coast Range ophiolite at Point Sal, Santa Barbara County, California, and at Stanley Mountain (Alamo Creek), San Luis Obispo County, California; Boreal Realm, Southern Boreal Province.

Saldorfus oregonensis Pessagno, Blome and Hull, n. sp.
Plate 3, figures 11, 12, 18

Description: Test as for genus. Rays about three times as long as the width of the central area; central spines at terminations of four rays predominantly circular in axial section. Central area square, small relative to length of the rays. Ray surfaces sloping progressively away from central area towards tips and lending a wedge-shaped appearance to the rays in side view. Sides and tops of rays flanked by two lateral ridges; lateral ridges with small nodes. Weakly developed, variably nodose median ridge often present between two lateral ridges on each ray. Rays on top and bottom surfaces divided into two rows of square pore frames with circular pores. Sides of rays with somewhat larger tetragonal, pentagonal and hexagonal pore frames arranged in three rows above and below lateral ridges. Central area with a mixture of medium sized triangular, tetragonal, pentagonal and hexagonal (predominantly tetragonal and hexagonal) pore frames with small nodes at the pore frame vertices.

Remarks: *Saldorfus oregonensis*, n. sp., differs from *Saldorfus corralitosensis* (Pessagno) by having rays that are three rather than two times longer than the width of the central area, by having three rows of larger tetragonal, pentagonal and hexagonal pore frames on the sides of rays, by having a smaller central area, and by having rays that slope progressively away from the central area toward the tips and that terminate in spines that are predominantly circular in axial section.

Etymology: This species is named for the state of Oregon.

Measurements: (μm) Holotype + 5 paratypes.

	Length of rays	Width of rays	Width of central area	Length of spines
Holotype	140	40	60	56
Mean	127	62	62	55
SD	10.4	4.1	5.1	10.2
Max.	140	42	76	76
Min.	116	26	56	40

Type locality: OR-501-B. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458970. Paratypes = USNM 458971 and Pessagno Collection.

Range: Superzone 1, Zone 1F to Zone 1I; upper Bathonian to upper Callovian. See text-figure 24.

Occurrence: Snowshoe Formation, Izee terrane, east-central Oregon; Boreal Realm, Southern Boreal Province. Volcanopelagic strata above Josephine ophiolite; Tethyan Realm, Central Tethyan Province. See text-figure 15.

Genus *Tetraditryma* Baumgartner 1980a, emend.

Type species: *Tetraditryma pseudoplena* Baumgartner 1980a.

Emended definition: As in Baumgartner (1980), but restricted to forms with wedge-shaped or bulbous ray tips (top and bottom surfaces) with central and lateral spines. Lateral spines oriented at variable angles with respect to ray axis, varying with a given species. Rays with cortical apertures (see Baumgartner 1980a, text-fig. 4, diagram F).

Range: Middle Jurassic (Bajocian) to Lower Cretaceous (Berriasian).

Occurrence: Worldwide in Tethyan and Boreal Realms.

Tetraditryma praeplena Baumgartner
Plate 3, figures 6, 19

Tetraditryma praeplena BAUMGARTNER 1984, p. 787, pl. 9, figs. 8-9, 13-13a.

?*Tetraditryma pseudoplena* Baumgartner. – GORICAN 1987, p. 187, pl. 1, fig. 10.

Remarks: The specimen figured by Goricani (1987) appears to show characteristics in common between *Tetraditryma pseudoplena* and *T. praeplena*. The rays of this specimen display triradial lateral spines which are situated both at right angles and at 60-70° degrees with respect to the ray axes. The length of the rays relative to the central area is more similar to that of *T. pseudoplena*. It would appear that Goricani's specimen is transitional between *Tetraditryma pseudoplena* and *T. praeplena*.

Range: Superzone 1, Zone II to Zone 2, Subzone 2 delta; uppermost Callovian?; lower to middle Oxfordian (text-fig. 25). According to Baumgartner et al. (1991) this species ranges from new U.A. 7 to new U.A. 26 (new unitary associations tentative).

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; Tethyan Real, Central Tethyan Province. See text-figure 15.

Subfamily **TRITRABINAE** Baumgartner 1980a
Type genus: *Tritrabs* Baumgartner 1980a.

Range: Lower Jurassic, lower Toarcian to Lower Cretaceous, Hauterivian.

Occurrence: Worldwide in Tethyan and Boreal Realms.

Genus *Tritrabs* Baumgartner 1980a

Type species: *Paronaella(?) casmaliaensis* Pessagno 1977a.

Range: Superzone 1, Zone 1A, Subzone 1A₁ to Zone 6 (lower part); Middle Jurassic, Aalenian to Lower Cretaceous, Hauterivian.

Occurrence: Tethyan and Boreal Realms, Worldwide.

Tritrabs ewingi (Pessagno) s.l.
Plate 3, figure 8

Paronaella(?) ewingi PESSAGNO 1971, pp. 47-48, pl. 19, figs. 2-5. – PESSAGNO 1977a, p. 70, pl. 1, figs. 14-15. – ?FOREMAN 1973, p. 262, pl. 8, fig. 1.

Tritrabs ewingi Pessagno. – BAUMGARTNER 1980a, pp. 292-294, pl. 4, figs. 5, 7, 17, 18. – BAUMGARTNER 1984, p. 791, pl. 10, fig. 10.

Remarks: The form figured by Pessagno (1977a, pl. 1, figs. 14-15) as well as that figured herein fall within the variation originally allowed by Pessagno (1971) for this species. However, it should be noted that these morphotypes possess shorter, broader rays and possibly should be assigned to a new species. These forms are referred to as *T. ewingi* s.l. herein.

Range: Zone 2, Subzone 2 delta to Zone 5, Subzone 5A; Oxfordian to Berriasian. See text-figure 25.

Occurrence: Volcanopelagic strata above Coast Range ophiolite, Stanley Mountain terrane, California Coast Ranges at Point Sal, Santa Barbara County, California and Stanley Mountain, San Luis Obispo County, California; Tethyan Realm, Central Tethyan Province to Boreal Realm, Southern Boreal Province. Volcanopelagic strata above Josephine ophiolite, Smith River terrane, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province (text-fig. 15). Blake Bahama Basin at Site 5A, Romania, Greece, Sicily, Mino Complex of Japan, etc.; Tethyan Realm, Central Tethyan Province. Taman Formation, east-central Mexico; Tethyan Realm, Northern Tethyan Province.

Tritrabs hayi (Pessagno)
Plate 3, figure 5

Paronaella(?) hayi PESSAGNO 1977a, pp. 70-71, pl. 1, fig. 16; pl. 2, fig. 1. *Tritrabs hayi* (Pessagno). – BAUMGARTNER 1980a, p. 294, pl. 4, figs. 10, 21, 22. – BAUMGARTNER 1984, p. 791, pl. 10, fig. 12.

Range: Superzone 1, Zone II to Zone 3, Subzone 3 beta so far as known in North America; upper Callovian?; Oxfordian to lower Tithonian. See text-figure 25.

Occurrence: Volcanopelagic strata above Coast Range ophiolite at Point Sal, Santa Barbara County, California and at Stanley Mountain, San Luis Obispo County, California; Tethyan Realm, Central Tethyan province to Boreal Realm, Southern Boreal Province. Volcanopelagic strata above Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province to Northern Tethyan Province (text-fig. 15).

Tritrabs sp. A
Plate 3, figure 10

Remarks: This form may be related to *Tritrabs hayi* (Pessagno). It differs by having three very short rays.

Range and occurrence: Zone 2, Subzone 2 delta; lower to middle Oxfordian. Volcanopelagic strata above Josephine, Smith River subterrane, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province.

Family HAGIASTRIDAE, Subfamily Incertae Sedis

Genus *Archaeohagiasium* Baumgartner 1984
Type species: *Archaeohagiasium munitum* Baumgartner 1984.

Range: Sinemurian to Callovian fide Baumgartner (1984).

Occurrence: Worldwide in Tethyan and Boreal Realms.

Archaeohagiasium sp. aff. *A. munitum* Baumgartner
Plate 3, figure 21

Archaeohagiasium munitum BAUMGARTNER 1984, p. 759, pl. 2, figs. 9-13.

Remarks: The form figured here differs from Baumgartner's holotype (pl. 2, fig. 9) by lacking highly raised nodes in the central area and by having wider, somewhat less nodose rays.

Range and occurrence: Superzone 1, Zone II; uppermost Callovian?; lower Oxfordian. Volcanopelagic strata overlying the Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; See text-figure 15.

Family PANTANELLIIDAE Pessagno 1977a
Type genus: *Pantanellium* Pessagno 1977a sensu Pessagno and Blome 1980.

Remarks: Pessagno and MacLeod (1987; in Pessagno et al. 1987a) further subdivided this family to include the Vallupinae. All members of this latter subfamily possess peculiar broad, tubular structures known as cortical collars.

Range: Upper Triassic (Karnian) to Lower Cretaceous (upper Aptian; ?lower Albian).

Occurrence: Tethyan Realm, Central Tethyan Province and Northern Tethyan Province (Jurassic). Boreal Realm, Southern Boreal Province (Jurassic). Also reported from Tethyan deposits in Southern Hemisphere (Pujana 1991).

Subfamily PANTANELLIINAE Pessagno 1977a sensu Pessagno and Blome 1980
Type genus: *Pantanellium* Pessagno 1977a sensu Pessagno and MacLeod 1987 (in Pessagno et al. 1987a).

Range and occurrence: Same as for family.

Genus *Gorgansium* Pessagno and Blome 1980
Type species: *Gorgansium silviesense* Pessagno and Blome 1980.

Range: Upper Triassic (Norian) to Upper Jurassic (Oxfordian) so far as known.

Occurrence: Worldwide in Tethyan and Boreal Realms.

Gorgansium sp. A
Plate 3, figure 16

Range and occurrence: Zone 2, Subzone 2 gamma; middle Oxfordian. Galice Formation, s.l., Smith River subterrane, Klamath Mountains, northwestern California; Boreal Realm, Southern Boreal Province. JO-48; rare.

Gorgansium sp. B
Plate 3, figure 20

Remarks: This form differs from *Gorgansium* sp. A by having longer, more eccentric spines.

Range and occurrence: Zone 2, Subzone 2 gamma; middle Oxfordian. Galice Formation, s.l., Smith River subterrane, Klamath Mountains, northwestern California; Boreal Realm, Southern Boreal Province. JO-48; rare.

Gorgansium sp. C
Plate 3, figure 17

Remarks: *Gorgansium* sp. C differs from *Gorgansium* sp. A and *Gorgansium* sp. B by having longer, more massive spines.

Range and occurrence: Zone 2, Subzone 2 gamma; middle Oxfordian. Galice Formation, s.l., Smith River subterranean, Klamath Mountains, northwestern California; Boreal Realm, Southern Boreal Province. JO-48; rare.

Genus *Pachyoncus* Pessagno and Blome 1980

Type species: *Pachyoncus tumidus* Pessagno and Blome 1980

Range: Superzone 1, Zone 1E to Zone 2, Subzone 2 delta; upper Bajocian to Oxfordian.

Occurrence: Tethyan Realm, Central Tethyan Province and Northern Tethyan Province. Klamath Mountains, northwestern California, Smith River subterranean; east-central Oregon, Izee terrane; Japan, Mino Complex.

Pachyoncus kamiassoensis Mizutani and Kido
Plate 3, figures 14, 26

Pachyoncus kamiassoensis MIZUTANI and KIDO 1983, pp. 257-258, pl. 52, figs. 4a-d; pl. 53, figs. 1a-c.

Range: Superzone 1, Zone 1I to Zone 2, Subzone 2 delta so far as known; uppermost Callovian to middle Oxfordian. See text-figure 25.

Occurrence: Tethyan Realm, Central Tethyan Province, Mino Complex of Japan and volcanopelagic strata above the Josephine ophiolite, Smith River subterranean, northwestern California and southwestern Oregon. See text-figure 15.

Genus *Pantanellium* Pessagno 1977a sensu Pessagno and Blome 1980

Type species: *Pantanellium riedeli* Pessagno 1977a.

Range and occurrence: Same as for subfamily.

Pantanellium darlingtoniaense Pessagno, Blome and Hull, n. sp.
Plate 3, figures 2, 3, 15, 25, 27

Description: Cortical shell small, ellipsoidal with a mixture of medium-sized pentagonal and hexagonal pore frames with small nodes at their vertices. Five pore frames visible along AA'; four pore frames visible along BB'. Two polar spines long, pointed apically, subequal in length, triradial in axial section with three longitudinal ridges alternating with three longitudinal grooves. Longitudinal grooves parallel sided, about equal in width to longitudinal ridges proximally; about twice the width of longitudinal ridges on distal part of a given spine. Longitudinal ridges developing subsidiary grooves on proximal half of a spine; distal half with narrower ridges lacking subsidiary grooves.

Remarks: *Pantanellium darlingtoniaense*, n. sp., differs from *P. josephinense*, n. sp., by having an ellipsoidal cortical shell with considerably smaller nodes at pore frame vertices. Moreover, whereas the spines of *P. darlingtoniaense* possess wide longitudinal grooves, those of *P. josephinense* possess narrow, deeply incised longitudinal grooves. Both species share long spines and small cortical shells.

Etymology: This species is named for Darlingtonia, a settlement to the west of its type locality.

Measurements: (μ m) Holotype + 7 paratypes. See text-figure 28 for explanation of system of measurements.

	AA'	A'S'	AS	BB'	cc'	dd'
Holotype	70	116	—	76	24	36
Mean	79.75	109	125	74.25	27.5	22.5
SD	11.97	12.47	10	11.53	4.37	5.63
Max.	100	130	260	96	34	36
Min.	60	100	60	60	20	20

Co-type localities: Holotype from JO-70. Paratypes from JO-70 and JO-69. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458972. Paratypes = USNM 458973 and Pessagno Collection.

Range: Zone 2, Subzone 2 delta; lower to middle Oxfordian so far as known. See text-figure 25.

Occurrence: Volcanopelagic strata above the Josephine ophiolite, Klamath Mountains, northwestern California, Smith River subterranean; Tethyan Realm, Central Tethyan Province so far as known. See text-figure 15 herein.

Pantanellium foveatum Mizutani and Kido
Plate 4, figures 11, 19, 22

Pantanellium sp. A MIZUTANI et al. 1981, p. 197, fig. 2b.

Pantanellium sp. alpha MIZUTANI and KOIKE 1982, p. 122, pl. 1, fig. 2.

Pantanellium foveatum KIDO, KAWAGUCHI, ADACHI and MIZUTANI 1982, p. 204, pl. 1, figs. 1-2 (= nomen nudum).

Pantanellium foveatum MIZUTANI and KIDO 1983, pp. 256-257, pl. 51, figs. 1a-d, 2a-c; pl. 52, figs. 1-3.

Remarks: The circular pits at pore frame vertices on the cortical shell figured by Mizutani and Kido (1983, pl. 51, figs. 1-2) are certainly the most distinctive feature of this species. On many of our specimens the preservation of the cortical shell often inhibits the recognition of these pits. However, the shape of the cortical shell as well as the structure of the bipolar spines are other diagnostic features that can be utilized in recognizing *P. foveatum*.

Range: Superzone 1, Zone 1H to Zone 2, Subzone 2 delta; uppermost Callovian to middle Oxfordian. See text-figure 25. The range of this *P. foveatum* in the Smith River terrane is quite similar to that in the Mino Complex of Japan (Mizutani and Koike 1982; Kido et al. 1982; Mizutani and Kido 1983).

Occurrence: Mino Complex of Japan; Tethyan Realm, Central Tethyan Province. Volcanopelagic strata within volcanic member of Josephine ophiolite and above Josephine ophiolite. Tethyan Realm, Central Tethyan Province to Northern Tethyan Province. See text-figure 15

Pantanellium josephinense Pessagno, Blome and Hull, n. sp.
Plate 3, figures 1, 2, 4, 5, 13, 18, 24, 31, 32

Trillus(?) sp. cf. *T. seidersi* Pessagno and Blome. — MURCHEY 1984, p. 55, pl. 2, fig. 15.

Description: Cortical shell small, spherical with a mixture of medium-sized pentagonal and hexagonal pore frames. Pore frames with prominent nodes at vertices. Bars of pore frames four or five times thicker in Z direction than in Y direction

(sensu Pessagno and Blome 1980); four pore frames visible along AA' and five pore frames visible along BB'. Two polar spines quite long; one spine slightly shorter than other. Both spines with three deeply incised, parallel-sided longitudinal grooves alternating with three rounded, parallel-sided ridges. Grooves slightly wider than ridges; both maintaining the same width until spinal tip. Some specimens with noticeable flaring of grooves distally.

Remarks: *Pantanellium josephinense* is clearly an early member of the *Pantanellium meraceibaense* group of Pessagno and MacLeod (in Pessagno et al. 1987a) in that it possesses a highly nodose cortical shell and polar spines with parallel-sided ridges and grooves. *P. josephinense* Pessagno, Blome and Hull differs from *P. meraceibaense* by possessing considerably longer polar spines which are subequal in length and a smaller more spherical cortical shell.

The form figured by Murchey (1984) as *Trillus*(?) sp. cf. *T. seidersi* Pessagno and Blome (1980) from the Franciscan Complex of northern California is assignable to this species.

Etymology: This species is named for Josephine County, Oregon.

Measurements: (µm) Holotype + 7 paratypes. See text-figure 30 for explanation of system of measurements.

	AA'	A'S'	AS	BB'	cc'	dd'
Holotype	80	120	140	80	30	20
Mean	76.75	118.75	135	77	29.5	24
SD	4.65	13.3	13.9	7.01	6.9	5.01
Max.	120	136	160	80	40	34
Min.	70	100	120	60	20	20

Type locality: JO-69. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458974. Paratypes = USNM 458975 and Pessagno Collection.

Range: Zone 2, Subzone 2 delta; lower to middle Oxfordian so far as known.

Occurrence: Volcanopelagic strata above the Josephine ophiolite, Klamath Mountains, northwestern California, Smith River subterrane; Tethyan Realm, Central Tethyan Province so far as known. See text-figure 15 herein.

Pantanellium meraceibaense Pessagno and MacLeod
Plate 4, figure 17

Pantanellium meraceibaense PESSAGNO and MACLEOD 1987, p. 22, pl. 5, figs. 5, 6, 18, 19; pl. 7, fig. 4.

Range: Zone 2, Subzone 2 delta to Zone 4, Subzone 4 beta (lower part). Oxfordian to lower part of upper Tithonian. See text-figure 25.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterrane, northwestern California (text-fig. 15 herein); Tethyan Realm, Central Tethyan Province. Taman Formation, east-central Mexico; Tethyan Realm, Northern Tethyan Province. Also occurs in Baumgartner's sample POB 899 (upper Kimmeridgian), Argolis Peninsula, Peloponnesus, Greece (see Baumgartner et al. 1980); Central Tethyan Province.

***Pantanellium* sp. A**
Plate 4, figure 20

Range and occurrence: Volcanopelagic strata above Josephine ophiolite; Smith River subterrane, northwestern California; Tethyan Realm, Central Tethyan Province. JO-34, rare. See Locality Descriptions herein.

Genus *Trillus* Pessagno and Blome 1980

Type species: *Trillus seidersi* Pessagno and Blome 1980.

Range: Zone 01 to Zone 2; upper Pliensbachian to upper Kimmeridgian.

Occurrence: Tethyan Realm, Central Tethyan Province to Boreal Realm, Southern Boreal Province. Worldwide.

***Trillus* sp. A**
Plate 4, figures 23, 26

Remarks: This form possesses an extremely wide peripheral band which comprises most of the cortical shell. We see no evidence of spine bases present. Hence, it seems certain that *Trillus* sp. A is assignable to *Trillus* rather than *Zartus* Pessagno and Blome.

Range: Zone 2, Subzone 2 delta; Oxfordian so far as known. See text-figure 25.

Occurrence: Volcanopelagic strata above the Josephine ophiolite, Smith River subterrane, northwestern California; Northern Tethyan Province. JO-73; rare.

Family **PARVIVACCIDAE** Pessagno and Yang 1989
Type genus: *Parvivacca* Pessagno and Yang 1989.

Range: Superzone 1, Zone 1A, Subzone 1A₁ to Zone 4, Subzone 4 beta; Middle Jurassic (Aalenian) to Upper Jurassic (upper Tithonian).

Occurrence: Tethyan Realm, Central Tethyan Province to Boreal Realm, Southern Boreal Province.

Genus *Lanubus* Pessagno and Yang 1989

Type species: *Lanubus holdsworthi* Pessagno and Yang 1989.

Range and occurrence: Same as for family.

***Lanubus* sp. A**
Plate 4, figure 25

Range and occurrence: Superzone 1, Zone 1I. Volcanopelagic strata overlying the Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province. JO-61; rare.

***Lanubus* sp. B**
Plate 4, figure 6

Range and occurrence: Zone 2, Subzone 2 delta. Volcanopelagic strata overlying the Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; JO-10.5; rare.

***Lanubus* sp. C**
Plate 4, figure 9

Range and occurrence: Zone 2, Subzone 2 delta. Volcanopelagic strata overlying the Josephine ophiolite, Smith River

subterranean, Klamath Mountains, northwestern California; JO-34; rare.

Genus *Parvivacca* Pessagno and Yang 1989

Type species: *Parvivacca blomei* Pessagno and Yang 1989.

Range: Zone 2, Subzone 2 delta to Zone 4, Subzone 4 beta; Oxfordian to upper Tithonian.

Occurrence: Volcanopelagic strata overlying the Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California; Taman Formation, east-central Mexico. Tethyan Realm, Central Tethyan Province to Northern Tethyan Province.

Parvivacca sp. A

Plate 4, figures 15, 27

Range and occurrence: Zone 2, Subzone 2 delta. Volcanopelagic strata overlying the Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California; JO-69; very rare.

Family **PRAECONOCARYOMMIDAE** Pessagno 1976

Type genus: *Praeconocaryomma* Pessagno 1976.

Range: Zone 01, Subzone 01A to Zone 14, Subzone 14B; Lower Jurassic, upper Pliensbachian to Upper Cretaceous, middle Campanian.

Occurrence: Worldwide in Tethyan and Boreal Realms.

Genus *Praeconocaryomma* Pessagno 1976

Type species: *Praeconocaryomma universa* Pessagno 1976.

Range and occurrence: Same as for family.

Praeconocaryomma immodica Pessagno and Poisson

Plate 4, figure 30

Praeconocaryomma immodica PESSAGNO and POISSON 1981, p. 57, pl. 7, figs. 2-9.

Range: Superzone 1, Zone 1H to Zone 2, Subzone 2 beta; uppermost Callovian?; Oxfordian-lower Kimmeridgian. See text-figure 25.

Occurrence: California Coast Ranges: volcanopelagic strata above Coast Range ophiolite at Stanley Mountain, San Luis Obispo County, California and Franciscan Complex, various localities. Volcanopelagic strata above and within Josephine ophiolite, Smith River Subterranean, Klamath Mountains, northwestern California; See text-figure 16 herein. Chert from North Fork terrane, Klamath Mountains, northwestern California.

Family **STAUROLONCHIDAE** Haeckel 1881; emend. Pessagno 1977a

Type genus: *Staurolonche* Haeckel 1881; emend. Pessagno 1977a

Range and occurrence: Jurassic to Lower Cretaceous. Worldwide in Tethyan and Boreal Realms.

Genus *Emiluvia* Foreman 1973; emend. Pessagno 1977a

Type species: *Emiluvia chica* Foreman 1973.

Range: Superzone 1, Zone 1A (pt.), Subzone 1A₂ to Zone 5. Lower Jurassic (Toarcian) to Lower Cretaceous (upper Valanginian/lower Huaterian).

Occurrence: Worldwide in Tethyan Realm and in Southern Boreal Province, Boreal Realm.

Emiluvia dollarbendensis Pessagno, Blome and Hull, n. sp.

Plate 4, figures 10, 28, 33

Description: Cortical shell with outer layer consisting of medium-sized (for genus) nodes and interconnecting bars; bars and nodes forming irregular polygonal pore frames; nodes often merging. Inner latticed layer with a mixture of tetragonal, pentagonal and hexagonal pore frames. Four primary spines short, pointed, tapering rapidly distally, triradial in axial section; three longitudinal grooves alternating with three longitudinal ridges; grooves, relatively shallow, slightly wider than ridges; both ridges and grooves decreasing rapidly in width in a distal direction.

Remarks: *Emiluvia dollarbendensis*, n. sp., differs from *Emiluvia chica* Foreman by having shorter, considerably more tapered primary spines with shallow, wedge-shaped grooves and by having fewer and less massive nodes in the outer latticed layer. It should be noted that the grooves of *E. chica* are parallel sided, narrow and very deeply incised.

Etymology: *Emiluvia dollarbendensis*, n. sp., is named for Dollar Bend along the Middle Fork of the Smith River.

Measurements: (μm) Holotype + 10 paratypes.

	Width: cortical shell	Length: primary spines	Width: primary spines proximally
Holotype	135	90	45
Mean	128.1	100	35.4
SD	13.2	15.9	5.4
Max.	135	120	45
Min.	105	75	30

Type locality: JO-70. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458976. Paratypes = USNM 458977 and Pessagno Collection.

Range: Zone 2, Subzone 2 delta; Oxfordian. See text-figure 25.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, northwestern California; Tethyan Realm, Central Tethyan Province (text-fig. 16).

Emiluvia hopsoni Pessagno

Plate 4, figure 21

Remarks: The forms figured herein appear to fall within the variation displayed by Pessagno's (1977a) type specimens from Point Sal, Santa Barbara Co., California.

Range: Superzone 1, Zone 1I to Zone 4, Subzone 4 beta; Oxfordian to upper Tithonian. See text-figure 25. Baumgartner et al. (1991) indicate that the range of the *E. hopsoni* Group extends from new U.A. 35 (between Zones A1 and A2 of Baumgartner 1987) to new U.A. 67 (Zone D, Baumgartner 1987).

Occurrence: Volcanopelagic strata above the Coast Range ophiolite (see Pessagno 1977a); Central Tethyan Province to Southern Boreal Province (text-fig. 16).

Emiluvia lowercoonensis Pessagno, Blome and Hull, n. sp.

Plate 4, figures 3, 14, 29

Description: Cortical shell with outer layer consisting of small nodes and thin interconnecting bars; bars and nodes forming triangular and irregularly sized and shaped tetragonal pore frames. Inner latticed layer with more massive irregular tetragonal and pentagonal pore frames. Four primary spines long, sharply pointed; proximal two-thirds of spines triradiate in axial section with three narrow, deeply incised longitudinal grooves alternating with three wider longitudinal ridges. Longitudinal grooves gradually decreasing in width distally. Longitudinal ridges developing narrow, often weakly developed subsidiary grooves. Distal one-third of primary spines circular in axial section; rapidly decreasing in width initially.

Remarks: *Emiluvia lowercoonsensis*, n. sp., differs from other species of *Emiluvia* by virtue of the construction of its spinal tips.

Etymology: This species is named for Lower Coon Ridge to the southwest of its type locality.

Measurements: (µm) Holotype + 6 paratypes.

	Width: cortical shell	Length: primary spines	Width: primary spines proximally
Holotype	142.5	225	30
Mean	154.6	198.2	34.5
SD	23	19.2	6.2
Max.	195	225	42
Min.	135	180	30

Type locality: JO-48. Galice Formation. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458978. Paratypes = USNM 458979 and Pessagno Collection.

Range: Zone 2, Subzone 2 delta so far as known; Oxfordian so far as known. See text-figure 25.

Occurrence: Galice Formation s.l., Smith River subterranean, Klamath Mountains, north-western California; Boreal Realm, Southern Boreal Province (text-fig. 16).

***Emiluvia premyogii* Baumgartner**
Plate 4, figures 7, 12

Emiluvia premyogii BAUMGARTNER 1984, pp. 762-763, pl. 3, figs. 6, 8-9, 11-12. - DEWEVER and MICONNET 1985, p. 386, pl. 1, fig. 6; ?figs. 3-4; Not fig. 5. - GORICAN 1987, p. 182, pl. 3, fig. 8.

Range: Superzone 1, Zone 1I to Zone 2, Subzone 2 delta; Oxfordian. See text-figure 25. Baumgartner et al. (1991) indicate that this species first appears in new U.A. 6 (Zone A0, Baumgartner 1987) and makes its final appearance in new U.A. 47 (between Zones C1 and B, Baumgartner 1987).

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, northwestern California; Tethyan Realm, Central Tethyan Province (text-fig. 16).

***Emiluvia* sp. A**
Plate 4, figures 8, 16

Remarks: Note the distinctive spinal tips.

Range and occurrence: Zone 2, Subzone 2 delta; Oxfordian. JO-34; rare. Tethyan Realm, Central Tethyan province. See Locality Descriptions herein.

Family **LEUGEONIDAE** Yang and Wang 1990
Type genus: *Leugeo* Yang and Wang 1990.

Range: Superzone 1, Zone 1D to Zone 4; upper Bajocian to Tithonian.

Occurrence: Volcanic member of Josephine ophiolite and volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California and southwestern Oregon; Tethyan Realm, Central Tethyan Province to Northern Tethyan Province. Volcanopelagic strata above Coast Range ophiolite at Point Sal, Santa Barbara County, California, and at Stanley Mountain (Alamo Creek), San Luis Obispo County, California; Tethyan Realm, Central Tethyan Province to Boreal Realm, Southern Boreal Province. Snowshoe and Lonesome formations, Izee terrane, east-central Oregon; Tethyan Realm, Northern Tethyan Province to Boreal Realm, Southern Boreal Province. Blake Bahama Basin, Site 534 (Baumgartner 1984); Tethyan Realm, Central Tethyan Province (our interpretation). Bermeja Complex of Puerto Rico; Tethyan Realm, Central Tethyan Province. Tibet; Tethyan Realm, Central Tethyan Province.

Genus ***Levilleugeo*** Yang and Wang 1990
Type species: *Levilleugeo ordinarius* Yang and Wang 1990.

Range and occurrence: Same as for family.

***Levilleugeo* sp. A**
Plate 5, figure 23

Remarks: This form differs from the type species by having pore frames with more massive bars.

Range and occurrence: Volcanic member of the Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California and southwestern Oregon; Tethyan Realm, Central Tethyan Province.

***Levilleugeo* sp. B**
Plate 5, figure 24

Range and occurrence: Snowshoe Formation and Lonesome Formation, Izee terrane, east-central Oregon; Tethyan Realm; Northern Tethyan Province to Boreal Realm, Southern Boreal Province. Superzone 1, Zone 1D to Zone 1G; upper Bajocian to middle Callovian.

Family **XIPHOSTYLIDAE** Haeckel 1881; emend. Pessagno and Yang 1989
Type genus: *Xiphostylus* Haeckel 1881, emend. Pessagno and Yang 1989.

Range: Mesozoic: Triassic to Cretaceous.

Occurrence: Worldwide in the Tethyan Realm and the southern part of the Boreal Realm (sensu Pessagno and Blome 1986; Pessagno et al. 1986, 1987a).

Genus ***Neotripocyclia*** Pessagno and Yang
Type species: *Neotripocyclia harperi* Pessagno and Yang 1989, p. 204, pl. 6, figs. 9, 11, 14, 17-20, 26-27; pl. 7, fig. 22.

Range: Zone 2, Subzone 2 delta to Zone 5, Subzone 5C; Upper Jurassic, middle Oxfordian to Lower Cretaceous, upper Valanginian/lower Hauterivian. The range of *Neotripocyclia* was

erroneously stated by Pessagno and Yang (1989, p. 204) to be Zone 2, Subzone 2 beta to Zone 5, Subzone 5C.

Occurrence: Tethyan Realm, Central Tethyan Province to Boreal Realm, Southern Boreal Province sensu Pessagno and Blome (1986) and Pessagno et al. (1986, 1987a).

Neotripocyclia harperi Pessagno and Yang
Plate 5, figures 8, 14

Neotripocyclia harperi PESSAGNO and YANG 1989, pp. 204-205, pl. 6, figs. 9, 11, 14, 17-20, 26-27; pl. 7, fig. 22.

Range: Zone 2, Subzone 2 delta to Zone 5, Subzone 5C; Upper Jurassic, middle Oxfordian to Lower Cretaceous, upper Valanginian. See text-figure 25.

Occurrence: Galice Formation s.l., Smith River subterranean, (Klamath Mountains, northwestern California); Boreal Realm: Southern Boreal Province sensu Pessagno and Blome (1986) and Pessagno et al. (1986, 1987a) (text-fig. 16).

Genus *Tripocyclia* Haeckel 1881; emend. Pessagno and Yang 1989
Type species: *Tripocyclia trigonum* Rüst 1885 (subsequent designation by Campbell 1954, p. D-82).

Range: Lower Jurassic (lower Toarcian) to Lower Cretaceous so far as known.

Occurrence: Tethyan Realm, Central Tethyan Province to Northern Tethyan Province. Boreal Realm, Southern Boreal Province (sensu Pessagno et al. 1986, 1987a).

Tripocyclia frenchflatensis Pessagno, Blome and Hull, n. sp.
Plate 5, figures 6, 20, 22

Description: Cortical shell subcircular in outline, elliptical in cross-section. Outer latticed layer (sensu Pessagno, Six and Yang 1989) thick, consisting of a mixture of medium sized pentagonal and hexagonal pore frames. Nineteen to twenty pore frames visible along DD' (see text-figure 30). Three secondary spines somewhat longer than DD', sharply terminating, triradiate in axial section with three longitudinal grooves alternating with three longitudinal ridges. Longitudinal grooves narrow, deeply incised, decreasing gradually in width distally. Longitudinal ridges equal in width to longitudinal grooves; developing subsidiary grooves proximally.

Remarks: *Tripocyclia frenchflatensis*, n. sp., differs from *T. highdomensis*, n. sp., by having sharply terminating spines rather than spines that terminate in crown-like tips. Moreover, its spines are narrower than those of *T. highdomensis*.

Etymology: This species is named for French Flat to the west of its type locality.

Measurements: (μm) Holotype + 8 paratypes. See text-figure 30 for explanation of measurements.

	DD'	DS	cc'
Holotype	135	108	30
Mean	146.6	124.35	34.5
SD	19.5	27.32	7.8
Max.	180	165	52.5
Min.	135	75	30

Type locality: JO-34. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458980. Paratypes = USNM 458981 and Pessagno Collection.

Range: Zone 2, Subzone 2 delta; Oxfordian so far as known. See text-figure 25.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California; See text-figure 16.

Tripocyclia highdomensis Pessagno, Blome and Hull, n. sp.
Plate 5, figures 15, 16, 18

Description: Cortical shell elliptical in outline and in cross-section. Outer latticed layer (sensu Pessagno, Six and Yang 1989) thick, consisting of a mixture of larger hexagonal pore frames and smaller pentagonal pore frames having small nodes at vertices. Thirteen to fifteen pore frames visible along DD' (see text-fig. 30). Three secondary spines wide, medium length, length equaling diameter (DD') of cortical shell; proximal three quarters of each spine nearly parallel sided; distal one-quarter decreasing somewhat in width. Secondary spines with three wide, deeply incised longitudinal grooves alternating with three wide longitudinal ridges. Longitudinal ridges developing deeply incised subsidiary grooves which terminate at a point near distal three-quarters of spine (see above); distal one-quarter of each longitudinal ridge lacking subsidiary grooves and being somewhat narrower. All secondary spines terminating in distinctive, outwardly projecting crown-like tips which are formed from extensions of longitudinal ridges. Cortical buttresses very prominent.

Remarks: This form is similar to *T. jonesi*, but differs from the latter form by possessing well-developed cortical buttresses and wider, somewhat shorter spines with distinctive crown-like tips.

Etymology: This species is named for High Dome located to the north-northwest of its type locality.

Measurements: (μm) Holotype + 6 paratypes. See text-figure 30 for explanation of measurements.

	DD'	DS	cc'
Holotype	150	187.5	67.5
Mean	150	168.7	65.3
SD	0	45.4	7.1
Max.	150	225	75
Min.	150	90	60

Type locality: JO-73. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458982. Paratypes = USNM 458983 and Pessagno Collection.

Range: Zone 2, Subzone 2 delta; middle Oxfordian. See text-figure 25 herein.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California; See text-figure 16 herein.

Tripocyclia* sp. aff. *Tripocyclia highdomensis Pessagno, Blome and Hull, n. sp.
Plate 5, figure 2

Remarks: This form differs from *T. highdomensis*, n. sp., by having shorter secondary spines and a proportionately larger

cortical shell with smaller pore frames. Like *T. highdomensis* this form possesses spines with peculiar crown-like tips.

Range and occurrence: Zone 2, Subzone 2 delta; middle Oxfordian. Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California.

Tripocyclia jonesi Pessagno 1977a, emend. Pessagno and Yang 1989 Plate 5, figures 3, 21

Tripocyclia jonesi PESSAGNO 1977a, p. 80, pl. 7, figs. 1-3; not figs. 4-6. — PESSAGNO and YANG 1989, pp. 222-223, pl. 7, figs. 5, 11, 21. Not *Triactoma jonesi* (Pessagno). — FOREMAN 1978, p. 743, pl. 1, figs. 13-14; Not *Triactoma jonesi* (Pessagno). — BAUMGARTNER 1984, p. 790, pl. 10, fig. 4.

Remarks: The specimens figured herein appear to fall within the variation displayed by *Tripocyclia jonesi* Pessagno in that they show similar spine structure and cortical shell structure.

Range: Zone 2, Subzone 2 delta to Zone 4, Subzone 4 beta; Upper Jurassic, middle Oxfordian to upper Tithonian (text-fig. 25). Pessagno, Six and Yang (1989) chose this taxon as a supplementary marker taxon to mark the base of their Subzone 2 alpha (uppermost Kimmeridgian/lowermost Tithonian). It is now apparent that *Tripocyclia jonesi* also is present in Subzone 2 delta (middle Oxfordian). Hence, the definition of Subzone 2 alpha is emended herein to exclude *Tripocyclia jonesi* as a supplementary marker taxon (see Biostratigraphy and Chronostratigraphy herein).

Occurrence: Volcanopelagic strata above Josephine ophiolite; Tethyan Realm, Central Tethyan Province (text-fig. 16). California Coast Ranges in volcanopelagic strata above Coast Range ophiolite at Point Sal (Santa Barbara Co.) and Alamo Creek (San Luis Obispo Co.); Boreal Realm, Southern Boreal Province (see Pessagno, Six and Yang 1989). Taman Formation, east-central Mexico; Tethyan Realm, Northern Tethyan Province.

Tripocyclia* sp. aff. *T. jonesi Pessagno Plate 5, figure 11

Remarks: This form differs from *Tripocyclia jonesi* Pessagno by having very pronounced cortical buttresses.

Range and occurrence: Zone 2, Subzone 2 delta; Upper Jurassic; middle Oxfordian so far as known. Galice Formation s.l., Smith River Subterranean, Klamath Mountains, northwestern California; Boreal Realm, Southern Boreal Province. See text-figures 17 and 25.

Tripocyclia saleebyi Pessagno and Yang Plate 5, figure 1

Tripocyclia saleebyi PESSAGNO and YANG 1989, p. 223, pl. 6, figs. 5, 6, 24.

Range: Zone 2, Subzone 2 delta; Oxfordian. See text-figure 25.

Occurrence: Tethyan Realm: Central Tethyan Province to Northern Tethyan Province. Boreal Realm: Southern Boreal Province.

Genus *Xiphostylus* Haeckel 1881; emend. Pessagno and Yang 1989. **Type species:** *Xiphostylus attenuatus* Rüst 1885 (subsequent designation by Campbell 1954, p. D54).

Range: Zone 01, Subzone 01A to top of Zone 2, Subzone 2 gamma; Lower Jurassic, upper Pliensbachian to Upper Jurassic, middle Oxfordian. See Pessagno et al. (1987b) and text-figure 4 herein.

Xiphostylus gasquetensis Pessagno and Yang Plate 5, figures 10, 25

Xiphostylus gasquetensis PESSAGNO and YANG 1989, pp. 236-238, pl. 6, figs. 7, 8, 22, 23.

Range: Superzone 1, Zone 11; Zone 2, Subzone 2 delta; upper Callovian? to middle Oxfordian. See text-figure 26.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, northwestern California (text-fig. 17). Tethyan Realm, Central Tethyan Province (sense of Pessagno and Blome 1986; Pessagno et al. 1986, 1987a).

Xiphostylus humboldtensis Pessagno, Blome and Hull, n. sp. Plate 5, figures 7, 13, 19

Description: Cortical shell diamond-shaped in outline, small relative to size of broad, long secondary spines. Cortical shell with well-developed cortical buttresses at base of spines and with a mixture of common hexagonal and rare pentagonal pore frames comprising latticed layer. Secondary spines long, wide, subequal in length with wide rounded tips and with three longitudinal ridges alternating with three longitudinal grooves. Longitudinal ridges relatively narrow; developing subsidiary grooves which extend in a distal direction nearly two-thirds of the length of the spine. Longitudinal grooves extremely broad for genus; flaring out more distally than proximally; closed off by longitudinal ridges at both proximal and distal ends.

Remarks: *Xiphostylus humboldtensis*, n. sp., differs from *X. gasquetensis* Pessagno and Yang by having considerably broader polar spines with extremely wide grooves and broad, rounded rather than sharply pointed spinal tips. Moreover, the spinal tips of *X. gasquetensis* are circular in axial section.

Etymology: This species is named for Humboldt Flat to the west of its type locality.

Measurements: (μm). Holotype + 2 paratypes. See text-figure 28 for explanation of system of measurements.

	AA'	A'S'	AS	BB'	cc'	dd'
Holotype	97.5	240	210	135	60	45
Mean	92.5	240	240	135	60	45
SD	15.6	—	30	15	0	0
Max.	105	240	270	150	60	45
Min.	75	240	210	120	60	45

Type locality: JO-70. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458984. Paratypes = USNM 458985 and Pessagno Collection.

Range: Zone 2, Subzone 2 delta; Oxfordian. See text-figure 26.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern Cal-

ifornia; Tethyan Realm, Central Tethyan Province. See text-figure 17.

Xiphostylus sp. A

Plate 5, figures 12, 17

Range and occurrence: Zone 2, Subzone 2 gamma so far as known; Oxfordian so far as known. JO-69: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province.

Subsuperfamily LIOSPHAERILAE, Family/Genus Incertae Sedis

Genus **Cenodiscus** Haeckel 1887.

Range and occurrence: Indeterminate at present. There appears to be no direct phylogenetic link between the Mesozoic and Cenozoic forms. Hence, the form shown below should probably be assigned to a new genus.

Cenodiscus(?) sp.

Plate 5, figure 5

Range: Zone 2, Subzone 2 delta to Subzone 2 beta so far as known.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province to Northern Tethyan Province. Volcanopelagic strata above Coast Range ophiolite at Stanley Mountain (Alamo Creek) San Luis Obispo County, California; Tethyan Realm, Central Tethyan Province.

Suborder NASSELLARIINA Ehrenberg 1875

Family **EUCYRTIDIELLIDAE** Takemura 1986

Type genus: *Eucyrtidiellum* Baumgartner 1984.

Remarks: Some forms such as *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo) show a cephalopyle at the base of the cephalis (see Pessagno and Blome 1984, p. 30).

Range and occurrence: Jurassic; not fully established. Occurrence worldwide in Boreal and Tethyan Realms.

Genus **Eucyrtidiellum** Baumgartner 1984

Type species: *Eucyrtidium*(?) *unumaensis* Yao 1979.

Remarks: Some forms such as *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo) show a cephalopyle at the base of the cephalis (see Pessagno and Blome 1984, p. 30).

Range and occurrence: Jurassic; not fully established. Occurrence worldwide in Boreal and Tethyan Realms.

Eucyrtidiellum sp. aff. *E. ptyctum* (Riedel and Sanfilippo)

Plate 5, figure 9

Eucyrtidium ptyctum RIEDEL and SANFILIPPO 1974, p. 778, pl. 5, fig. 7; pl. 12, fig. 14, not fig. 15.

Remarks: *E. sp. aff. E. ptyctum* is intermediate between *E. ptyctum* and *E. semifactum* Nagai and Mizutani (1990). Whereas *E. ptyctum* possesses a short, needle-like horn, *E. sp. aff. E. ptyctum* possesses a horn which is rather large and massive like that of *E. semifactum*. On the other hand, the costae

of *E. sp. aff. E. ptyctum* tend to extend in a distal direction over the entire surface of the abdomen like those of *E. ptyctum*.

Range and occurrence: Zone 2, Subzone 2 delta; Oxfordian. Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province (text-fig. 17).

Eucyrtidiellum sp. aff. *E. pustulatum* Baumgartner

Plate 5, figure 4

Eucyrtidiellum pustulatum BAUMGARTNER 1984, p. 765, pl. 4, figs. 4-5.

Remarks: The preservation of the specimen figured herein is too poor to determine whether it is definitely assignable to Baumgartner's species. Nevertheless, it would appear that the figured specimen is a non-costate form similar to *Eucyrtidiellum pustulatum*.

Range and occurrence: Superzone 1, Zone II to Zone 2, Subzone 2 delta; upper Callovian?; Oxfordian. Volcanopelagic strata above the Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province (text-fig. 17).

Family **HSUIDAE** Pessagno and Whalen 1982

Type genus: *Hsuum* Pessagno 1977a.

Range: Zone 01A to Zone 5, Subzone 5C. Lower Jurassic: lower Pliensbachian to Lower Cretaceous: upper Valanginian/lower Hauterivian.

Occurrence: Worldwide in Tethyan and Boreal Realms.

Genus *Hsuum* Pessagno 1977a

Type species: *Hsuum cuestaense* Pessagno 1977a (= nomen correctum).

Hsuum PESSAGNO 1977a, p. 81.

Transhsuum TAKEMURA 1986, p. 51.

Remarks: The genus *Transhsuum* Takemura (1986, p. 51) is treated herein as a junior synonym of *Hsuum* Pessagno (1977a). Takemura's holotype (pl. 6, fig. 1) of *Transhsuum medium* (= type species of *Transhsuum*) possesses a horn and discontinuous costae. He utilized the possession of discontinuous costae as the primary criterion for separating *Hsuum* from *Transhsuum*. However, we regard this criterion to have no phylogenetic significance at the generic level.

Range and occurrence: Same as for family.

Hsuum baldface Pessagno, Blome and Hull, n. sp.

Plate 6, figures 2, 5

Description: Test conical, pointed apically and terminating in a short, stout horn. Apical portion of test (cephalis and thorax) covered by a layer of microgranular silica, smooth, lacking costae. Horn with small subsidiary spine at base. Costae of outer latticed layer aligned in longitudinal rows tending to be both continuous over several postabdominal chambers or discontinuous and restricted to a single chamber; two adjacent costae occasionally interconnected by lateral branches. Eleven to nineteen costae visible on final postabdominal chambers. Postabdominal chambers eight to nine in number, separated by strictures. Pore frames small and rectangular. Cephalis hemispherical in shape. Thorax, abdomen and all subsequent post-

abdominal chambers trapezoidal in outline. Postabdominal chambers increasing slightly in length and more rapidly in width as added.

Remarks: *Hsuum baldfacense*, n. sp., appears to be closely related to *H. brevicostatum* (Ozoldová) and *H. maxwelli* Pessagno. It differs from both of these species by developing an subsidiary spine at the base of its horn. Moreover, it differs from *H. brevicostatum* by having longer, more continuous and more numerous costae on its postabdominal chambers, and by having postabdominal chambers that increase less rapidly in length as added. Furthermore, *H. baldfacense* differs from *H. maxwelli* by having more continuous and more numerous costae, and a more prominent horn.

Etymology: *Hsuum baldfacense*, n. sp., is named for Baldface Creek to the west-northwest of its type locality.

Measurements: (µm) Holotype + 8 paratypes.

	Max test width	Max. test length	Length of horn	Width of horn proximally	Number of postabdom. chambers
Holotype	112.5	240	15	12	8
Mean	110.5	240.8	16.5	12.9	7.8
SD	10.17	31.9	1.7	1.5	1.1
Max.	120	300	18	15	10
Min.	90	187.5	15	12	7

Co-type localities: Holotype from JO-87B. Paratypes from JO-87B and JO-87C. Volcanic member of the Josephine ophiolite. Turner Albright Mine. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458986. Paratypes = USNM 458987 and Pessagno Collection.

Range: Superzone 1, Zone 1H; upper Callovian? See text-figure 26.

Occurrence: Volcanic member of Josephine ophiolite, Smith River subterranean, southwestern Oregon (text-fig. 17).

Hsuum* sp. aff. *H. baldfacense Pessagno, Blome and Hull
Plate 6, figure 8

Remarks: This form differs from *Hsuum baldfacense*, n. sp., by having a broader test and by having a wider apical portion.

Range: Superzone 1, Zone 1H; uppermost Callovian?

Occurrence: Volcanic member of Josephine ophiolite, Smith River subterranean, southwestern Oregon. Text-figure 17.

Hsuum brevicostatum (Ozoldová)
Plate 6, figures 3, 4, 21, 23

Lithostrobus brevicostatus OZOLDOVÁ 1975, p. 84, pl. CII, fig. 1.
Hsuum brevicostatum (Ozoldová). – ?BAUMGARTNER 1984, p. 769, pl. 5, figs. 1-2. – Not DEWEVER, GEYSSANT, AZÉMA, DEVOS, DUÉE, MANIVIT and VRIELYNCK 1986, pl. 11, fig. 2. – Not OZOLDOVÁ and PETERČÁKOVÁ 1987, p. 119, pl. XXXIII, fig. 3.

Remarks: The specimen figured by Baumgartner as *Hsuum brevicostatum* (Ozoldová) lacks a horn although it is possible that the horn was not preserved. This specimen is questionably assigned to *H. brevicostatum* herein. The form figured by DeWever et al. (1986) as *H. brevicostatum* is assignable to neither the family Hsuidae, the genus *Hsuum*, or the species *H. brevicostatum*. This specimen lacks the square to rectangular

pore frames characteristic of all members of the Hsuidae. Instead, it possesses irregular polygonal pore frames. In 1987, Ozoldová and Peterčáková figured a specimen which they referred to *H. brevicostatum*. This form (pl. XXXIII, fig. 3) differs from Ozoldová's (1975) holotype both by lacking a horn and by possessing a test which is somewhat broader and rounded apically.

Range: Superzone 1, Zone 11 to Zone 2, Subzone 2 delta; upper Callovian to Oxfordian so far as known. See text-figure 26.

Occurrence: Volcanic member, Josephine ophiolite; volcanopelagic strata overlying Josephine ophiolite, Smith River subterranean, Klamath Mountains, southwestern Oregon and northwestern California; Tethyan Realm, Central Tethyan Province. Jurassic of Czechoslovakia; Tethyan Realm, Central Tethyan Province (text-fig. 17).

Hsuum maxwelli Pessagno s.l.

Plate 6, figure 1

Hsuum maxwelli PESSAGNO 1977a, pp. 81-82, pl. 7, figs. 14-16. – Not MATSUOKA and YAO 1986, pl. 2, fig. 16.

Not *Hsuum maxwelli* Pessagno group BAUMGARTNER 1984, p. 769, pl. 5, figs. 3, 4.

Remarks: This form differs from the typical *Hsuum maxwelli* by having a somewhat longer, more massive horn and by being slightly more pointed apically.

Range: Zone 2, Subzone 2 delta to Zone 3, Subzone 3 alpha. See text-figure 26.

Occurrence: Volcanopelagic strata overlying Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California (text-fig. 18). Volcanopelagic strata overlying Coast Range ophiolite at Point Sal, Santa Barbara County, California and at Stanley Mountain, San Luis Obispo County, California; Tethyan Realm, Central Tethyan Province to Boreal Realm, Southern Boreal Province. Baja California Sur; Boreal Realm, Southern Boreal Province.

Genus *Linaresia* El Kadiri, **emend.** Pessagno et al.

Type species: *Linaresia beniderkoulensis* El Kadiri 1992.

Eucyrtid gen. et sp. indet. BAUMGARTNER 1984, p. 763, pl. 3, figs. 13-16.
?GORICAN 1987, p. 182, pl. 2, fig. 9.

Canutus spp. DEWEVER, DUÉE and EL KADIRI 1985, p. 370, pl. 1, ?fig. 8, figs. 9-11.

Linaresia EL KADIRI 1992, p. 42.

Ogivus EL KADIRI 1992, p. 43.

Emended definition: Test multicyrtyd, spindle-shaped, often quite pointed apically. Apical portion of test usually smooth, non costate, covered by layer of microgranular silica; remainder of test with well-developed continuous costae which converge apically and to some degree distally. Costae comprising outer latticed layer aligned longitudinally between the linearly arranged rows of square to rectangular pore frames of inner latticed layer; costae with poorly developed lateral extensions or lacking lateral extensions. Square to rectangular pore frames of inner latticed layer increasing in size on all but last several postabdominal chambers; pore frames of last final postabdominal chambers decreasing in size. Cephalis small, conical; often with a short, stout horn. Thorax, abdomen and all postabdominal chambers trapezoidal in outline, increasing very rapidly in width and gradually in length as added; distal two-thirds of test

quite inflated. Type species with six to eight postabdominal chambers. Postabdominal chambers separated by circular partitions each having a circular aperture. Aperture flanked by prominent rim.

Remarks: *Linaresia* El Kadiri differs from *Hsuum* Pessagno and *Semihsuum*, n. gen., by having a test which rapidly expands in width and is quite inflated distally.

Ogivus El Kadiri (1992) is included under *Linaresia* El Kadiri (1992) herein. We see no significant differences in test structure to warrant the separation of these two genera.

Range: Superzone 1, Zone 1C (base) to Zone 2, Subzone 2 delta so far as known; Middle Jurassic: lower Bajocian to Upper Jurassic; Oxfordian so far as known in North America. In Morocco El Kadiri (1992) indicated that this genus ranges into the Lower Jurassic (Toarcian). We see no evidence of this from our North American studies. It is worth noting that the strata bearing radiolaria in Morocco (i.e. "radiolarites roses") occur above Toarcian limestone bearing ammonites. This is analogous to Baumgartner's data from Umbria in Italy (see p. 100 above).

Occurrence: Volcanopelagic strata overlying Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province to Northern Tethyan Province. Snowshoe Formation, Izee terrane, Blue Mountains Province, east-central Oregon; Tethyan Realm, Northern Tethyan Province. Donja-Gornja Lastva section, Yugoslavia (Gorican 1987); Tethyan Realm, Central Tethyan Province. Jurassic of Chrafate klippe, Northern Rif, Morocco; Tethyan Realm, Central Tethyan Province.

Linaresia beniderkoulensis El Kadiri, **emend.** Pessagno et al. Plate 6, figure 18; ?figures 6, 27; Plate 8, figure 6

Emended definition: Proximal one-third of test pointed; cephalis with short horn. Distal two-thirds of test quite inflated. Last several postabdominal chambers decreasing in width. Square to rectangular pore frames suddenly increasing in size between pointed proximal one-third of test and distal two-thirds. Pore frames of distal two-thirds large, maintaining more or less a constant size throughout. Costae usually continuous, blade-like in aspect, high in relief on distal two-thirds of test, maintaining same width, converging slightly on final postabdominal chambers. Costae decreasing dramatically in width and rapidly converging between proximal one-third and distal two-thirds of test. Costae often developing lateral branches transversely. One to three rows of pore frames visible between costal elements. Ten to eleven costae visible in lateral view.

Remarks: *Linaresia beniderkoulensis* El Kadiri is compared to *L. mizutanii*, n. sp., under the latter species.

Range: Zone 2, Subzone 2 delta so far as known. Oxfordian so far as known from our North American studies. However, note comments above under range of genus. See text-figure 26.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province. Jurassic of Chrafate klippe, Northern Rif, Morocco; Tethyan Realm, Central Tethyan Province. See text-figure 18.

Linaresia mizutanii Pessagno, Blome and Hull, **n. sp.** Plate 6, figures 12, 19, 25, 26

Description: Test quite pointed apically, increasing rapidly in width in a distal direction and with six to eight postabdominal chambers. Cephalis very small with a stout horn. Last several postabdominal chambers decreasing in width. Pore frames becoming progressively larger in a distal direction; quite large on final several postabdominal chambers. One to four rows of pore frames present between costal elements. Costae continuous; converging and closely spaced apically; widely spaced on all but last several postabdominal chambers; costae converging slightly on last several postabdominal chambers. Costae wide on inflated part of test; suddenly decreasing dramatically on proximal pointed part of test.

Remarks: *Linaresia mizutanii*, n. sp., differs from *L. beniderkoulensis* El Kadiri (1992) by having an test which is more elongate and more pointed apically, by having a longer horn, by lacking well-developed lateral extensions between costal elements and by having costae which are more convergent on the last several postabdominal chambers.

Etymology: This species is named for Dr. Shinjiro Mizutani (Department of Earth Sciences, Nagoya University, Nagoya, Japan) in honor of his contributions to the study of the Jurassic Radiolaria of Japan.

Measurements: (μ m) Holotype + 5 paratypes.

	Max test width	Max. test length	Length of horn	Number of postabdom. chambers
Holotype	157.5	322.5	22.5	6
Mean	171.25	313.75	321.25	7
SD	9.96	29	7.37	0.63
Max.	180	345	45	8
Min.	157.5	262.5	22.5	6

Co-type localities: Holotype from OR-554. Paratypes from OR-554 and OR-595. Warm Springs Member, Snowshoe Formation. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458994. Paratypes = USNM 458995 and Pessagno Collection.

Range and occurrence: Superzone 1, Subzone 1C (base); upper lower Bajocian so far as known. Warm Springs Member of Snowshoe Formation, Izee terrane, east-central Oregon. Tethyan Realm, Northern Tethyan Province. Abundant.

***Linaresia* sp. A**
Plate 6, figure 14

Remarks: This form differs from *Linaresia beniderkoulensis* El Kadiri (1992) by having a test which is broader and more rounded apically, by having four rows of pore frames between costae, and by eight or nine rather than ten or eleven costae visible in lateral view.

Range and occurrence: Zone 2, Subzone 2 delta; Oxfordian. Volcanopelagic strata above Josephine ophiolite. JO-69; rare.

Genus *Semihsuum* Pessagno, Blome and Hull, **n. gen.**
Type species: *Hsuum*(?) *inexploratum* Blome 1984.

Description: Test like that of *Hsuum* Pessagno, but lacking a horn. Costae continuous to discontinuous, often staggered.

Remarks: *Semihsuum* differs from *Hsuum* Pessagno by lacking a horn. *Hsuum*(?) sp. A of Pessagno and Whalen (1982, p. 134,

pl. 5, figs. 7, 12) is assignable to *Semihsum*, n. gen. This form was recorded by Pessagno and Whalen from the lower Pliensbachian portion of the Maude Formation, Queen Charlotte Islands. In addition, *Hsuum*(?) sp. F of Pessagno and Whalen (1982, p. 135, pl. 8, figs. 2, 9; pl. 10, fig. 8) should be assigned to *Semihsum*. The latter form was figured by Pessagno and Whalen from the lower Bajocian and upper Bathonian portions of the Snowshoe Formation, Izeé terrane, east-central Oregon. The form figured by Baumgartner (1984, pl. 5, figs. 1-2) as *Hsuum brevicostatum* (Ozoldová) is assigned to *Semihsum* herein.

Etymology: *Semi* (Latin, prefix) = half, somewhat + *Hsuum*.

Range: Zone 01A to Zone 4 or higher. Lower Jurassic, lower Pliensbachian to Lower Cretaceous, upper Valanginian/lower Hauterivian.

Occurrence: Worldwide in Tethyan Realm and in Boreal Realm.

Semihsum biscuithillense Pessagno, Blome and Hull, n. sp.
Plate 6, figure 22

Description: Test very broad, subcylindrical with broad, rounded apical portion. Apical portion of test (cephalis + thorax) lacking costae, covered by veneer of microgranular silica. Costae both continuous and discontinuous; continuous costae sometimes covering all but cephalis and thorax. Costae fluted, high in relief sometimes with lateral extensions. Nine to eleven costae visible on postabdominal chambers laterally. Pore frames of postabdominal chambers large, massive, square to rectangular. Cephalis hemispherical. Thorax, abdomen and all subsequent post abdominal chambers trapezoidal in outline. Six to seven postabdominal chambers present.

Remarks: *Semihsum biscuithillense*, n. sp., differs from *Semihsum brokencotense* n. sp. by having a broader, more rounded test apically which lacks a knob-like protrusion and by having costae which are less numerous, fluted and higher in relief.

Etymology: This species is named for Biscuit Hill to the west of its type locality.

Measurements:(μ m) Holotype + 7 paratypes.

	Max. test width	Max. test length	Number of postabdom. chambers
Holotype	105	195	5
Mean	108.75	184.6	6.25
SD	6.27	14.4	0.46
Max.	120	210	7
Min.	105	165	6

Type locality: JO-87D. Volcanic member of the Josephine ophiolite. Turner Albright Mine. See Locality Descriptions herein. Text-figure 3.

Deposition of types: Holotype = USNM 458988. Paratypes = USNM 458989 and Pessagno Collection.

Range: Superzone 1, Zone 1H so far as known; upper Callovian so far as known. See text-figure 26.

Occurrence: Volcanic member of Josephine ophiolite, Smith River subterranean, Klamath Mountains, southwestern California. See text-figure 18.

Semihsum brokencotense Pessagno, Blome and Six, n. sp.
Plate 6, figures 10, 17, 20

Hsuum maxwelli Pessagno group. – BAUMGARTNER 1984, p. 769, pl. 5, fig. 3; not pl. 5, fig. 4.

Hsuum maxwelli Pessagno. MATSUOKA and YAO 1986, pl. 2, fig. 16.

Description: Test broad, subcylindrical with a knob-like early portion (cephalis and thorax). Costae of outer latticed layer largely continuous with 12-13 visible laterally on each chamber; two adjacent costae frequently interconnected by well-developed lateral branches. Apical knob-like portion of test lacking costae; pore frames obscured by layer of microgranular silica. Pore frames square to rectangular, large and massive. Thorax and postabdominal chambers trapezoidal in outline. Postabdominal chambers seven to eight in number; increasing slightly in length and more rapidly in width as added.

Remarks: *Semihsum brokencotense*, n. sp., differs from *S. inexploratum* (Blome) by having a subcylindrical test with more numerous and closely spaced costae. The specimen from Greece figured by Baumgartner (1984, pl. 5, fig. 3) as "*Hsuum maxwelli* Pessagno group" is assignable to *S. brokencotense*. Moreover, the specimen figured by Matsuoka and Yao (1986) as *Hsuum maxwelli* Pessagno is referable to *S. brokencotense*, n. sp. This form like that figured by Baumgartner lacks a horn, possesses a test with a knob-like protrusion apically, larger and more massive pore frames and more closely spaced, more continuous costae.

Etymology: This species is named for Brokencot Creek to the northwest of its type locality.

Measurements: (μ m) Holotype + 10 paratypes.

	Max. test width	Max. test length	Number of postabdom. chambers
Holotype	105	225	8
Mean	113.4	217.5	7.63
SD	12.3	11.1	0.5
Max.	135	240	8
Min.	97.5	202.5	7

Type locality: JO-87B. Volcanic member of the Josephine ophiolite. Turner Albright Mine. See Locality Descriptions herein. Text-figure 3.

Deposition of types: Holotype = USNM 458990. Paratypes = USNM 458991 and Pessagno Collection.

Range: Superzone 1, Zone 1H; uppermost Callovian? See text-figure 26.

Occurrence: Volcanic member of Josephine ophiolite, Smith River subterranean, southwestern Oregon (text-fig. 18). Jurassic of Greece; Tethyan Realm, Central Tethyan Province. Mino Complex of Japan; Tethyan Realm, Central Tethyan Province.

Semihsum inexploratum (Blome)
Plate 6, figure 11

Hsuum(?) *inexploratum* BLOME 1984, p. 356, pl. 9, figs. 7, 17, 18; pl. 10, figs. 2, 7, 9, 13.

Remarks: This form differs from *Semihsuum inexploratum* s.s. by having a test which is broader and less constricted apically.

Range: Superzone 1, Zone H to Zone I; upper middle Callovian to upper Callovian. See text-figure 26.

Occurrence: Volcanic member of Josephine ophiolite, Smith River subterranean, southwestern Oregon; Tethyan Realm, Central Tethyan Province. Shelikof Formation, southern Alaska.

Semihsuum sourdoughense Pessagno, Blome and Hull, n. sp.
Plate 6, figures 7, 13

Transhsuum medium TAKEMURA 1986, p. 51, pl. 5, ?fig. 25; not pl. 5, fig. 26; pl. 6, fig. 1 (= holotype).

Description: Test elongate subcylindrical, broad, dome-like apically. Dome-like apical portion of test (cephalis + thorax) lacking costae; pore frames covered by layer of microgranular silica. Abdomen subtrapezoidal in shape lacking well-developed costae. Postabdominal chambers seven to nine in number and with well-developed costae. Costae on postabdominal chambers discontinuous, staggered; located between rows of square pore frames.

Remarks: *Semihsuum sourdoughense*, n. sp., differs from *S. inexploratum* (Blome) by having a test which is much more slender and is nearly cylindrical in shape. Moreover, the apical portion of the test of *S. sourdoughense* is much broader and tends to be more rounded. The form figured by Takemura (1986, pl. 5, fig. 25) as *Transhsuum medium* Takemura closely resembles *S. sourdoughense*. Like *S. sourdoughense* it is broadly rounded apically and is subcylindrical in shape. However, the Japanese specimen tends to show strictures between its postabdominal chambers and somewhat more numerous costae. Curiously, Takemura included three totally different morphotypes under his *Transhsuum medium*. The genus *Transhsuum* is treated a junior synonym of *Hsuum* Pessagno herein.

Etymology: This species is named for Sourdough Camp to the west of its type locality.

Measurements: (μm) Holotype +5 paratypes.

	Max. test width	Max. test length	Number of postabdom. chambers
Holotype	109.5	300	8
Mean	105.5	230.5	8
SD	4.03	35.7	0.47
Max.	112.5	300	9
Min.	97.5	180	7

Type locality: JO-87D. Volcanic member of Josephine ophiolite. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 458992. Paratypes = USNM 458993 and Pessagno Collection.

Range: Superzone 1, Zone 1H so far as known; upper Callovian. See text-figure 26.

Occurrence: Volcanic member of Josephine ophiolite, Smith River subterranean, Klamath Mountains, southwestern Oregon. See text-figure 18.

Semihsuum sp. A
Plate 6, figure 24

Remarks: *Semihsuum* sp. A closely resembles *Semihsuum biscuithillense*, n. sp. It differs from the latter form by having a test which is dome-shaped rather than a knob-like proximally. Both forms show costae which are similar in arrangement and structure.

Range and occurrence: Volcanic member of Josephine ophiolite, Smith River subterranean, Klamath Mountains, southwestern Oregon. JO-87D; Rare.

Family **PARVICINGULIDAE** Pessagno 1977a; emend. Pessagno and Whalen 1982

Type genus: *Parvicingula* Pessagno 1977a.

Range and occurrence: Lower Jurassic (Toarcian: base of Superzone 1) to Lower Cretaceous (lower Hauterivian). Worldwide.

Genus **Caneta** Pessagno, Blome and Hull, n. gen.

Type species: *Parvicingula hsui* Pessagno 1977a.

Description: Test multicystid, conical to cylindrical, without apical horn. Postabdominal chambers with three rows of symmetrical pore frames separated by markedly nodose ridges. Center row of pore frames consisting of much smaller, usually elliptical pores that are usually aligned directly below massive nodes of H-linked circumferential ridges. Flanking rows of pore frames with larger circular pores aligned adjacent to and opposite the massive bars of the "H-linked" circumferential ridges. Narrow tubular extension observed on final postabdominal chamber of type species.

Remarks: *Caneta*, n. gen., differs from both *Parvicingula* Pessagno and *Ristola* Pessagno and Whalen by possessing massive "H-linked" circumferential ridges (See Pessagno 1977a, pl. 8, figs. 1-2) and by having a consistently smaller middle row of pore frames which are usually aligned with the nodes of the circumferential ridges. Such forms were included in *Ristola* Pessagno and Whalen (1982, p. 136). *Caneta* differs also from *Risotola* and *Praecaneta*, n. gen., by possessing a narrow tube on the final postabdominal chamber and from *Parvicingula* s.s. by lacking a horn.

Caneta is believed to have been derived from *Praecaneta*, n. gen., through the acquisition of a narrow terminal tube on the final postabdominal chamber and a middle row of pore frames with circular pores that are smaller and are usually consistently aligned with the massive nodes of the circumferential ridges.

No specimens of *Caneta* are figured herein. The reader is referred to illustrations of the type species, *Parvicingula hsui* Pessagno (1977a, pl. 7, figs. 15-16; pl. 8, figs. 1-5).

Etymology: *Caneta* is a name formed by an arbitrary combination of letters (ICZN 1985, Appendix D, Pt. VI, Recommendation 40, p. 113).

Range: Zone 2, Subzone 2 alpha (base) to Zone 4, Subzone 4 beta. Upper Jurassic: upper Kimmeridgian sensu gallico to upper Tithonian.

Occurrence: Volcanopelagic strata overlying the Coast Range Ophiolite, Stanley Mt., Cuesta Ridge and Point Sal, California; upper member of the Taman Formation, east-central Mexico. Eugenia Formation, Baja California Sur. San Pedro del Gallo, Durango.

Genus *Mirifusus* Pessagno 1977a

Type species: *Mirifusus guadalupensis* Pessagno 1977a.

Remarks: The form illustrated by Takemura (1986, pl. 6, figs. 6-7) as *Mirifusus* sp. is excluded from this genus. This specimen lacks discrete circumferential ridges. Instead of circumferential ridges there are rows of spines which are loosely interconnected.

Range: Zone 2, Subzone 2 delta (base) to Zone 5, Subzone 5C (top); Upper Jurassic, middle Oxfordian to Lower Cretaceous, upper Valanginian/lower Hauterivian.

Occurrence: Tethyan Realm, Central Tethyan Province to Northern Tethyan Province; Boreal Realm, Southern Boreal Province. Worldwide.

Mirifusus fragilis Baumgartner

Plate 6, figure 16; Plate 7, figure 11

Mirifusus fragilis BAUMGARTNER 1984, pp. 770-771, pl. 5, figs. 12, 17, 20; not pl. 5, figs. 16, ?21.

Remarks: Curiously, Baumgartner selected a holotype (pl. 5, figs. 12, 17, 20) for *M. fragilis* from near Unuma in the Mino Complex of Japan. The figured paratype (pl. 5, fig. 16 = *M. guadalupensis* Pessagno) comes from the Blake-Bahama Basin.

Range: Zone 2, Subzone 2 delta to Zone 3, Subzone 3 beta; middle Oxfordian to lower Tithonian. See text-figure 26. Baumgartner et al. (1991) indicate that this species first appears

in their new U.A. 6 (Zone A0, Baumgartner 1987) and makes its final appearance in new U.A. 33 (base Zone A2, Baumgartner 1987). See text-figure 6 herein.

Occurrence: Japan, Blake-Bajama Basin, volcanopelagic strata above Coast Range ophiolite at Point Sal and Stanley Mountain, California Coast Ranges, volcanopelagic strata above Josephine ophiolite, Smith River Subterranean, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province to Boreal Realm, Southern Boreal Province (see text-figure 18).

Mirifusus guadalupensis Pessagno

Plate 6, figure 9

Mirifusus guadalupensis PESSAGNO 1977a, pp. 83-84, pl. 10, figs. 9-14.

Mirifusus fragilis BAUMGARTNER 1984, pp. 770-771, pl. 5, figs. 16, ?21; not pl. 5, figs. 12, 17, 20.

Remarks: Baumgartner (1984) regarded *Mirifusus fragilis* Baumgartner to be the immediate ancestor to *M. guadalupensis* Pessagno. Although this may well be the case, it is also possible that *M. fragilis* represents an early stage in the ontogenetic development of *M. guadalupensis*—lacking an outer layer of triangular pore frames. The similarity in the ranges of both forms (i.e., Zone 2, Subzone 2 delta to Zone 3, Subzone 3 beta; see text-fig. 26) may support the latter hypothesis.

The paratype figured by Baumgartner (1984, pl. 5, fig. 16) from the Blake-Bahama Basin possesses a well-developed outer layer of meshwork and appears to fall within the variation of *M.*

PLATE 1

All illustrations are scanning electron micrographs of Middle and Upper Jurassic Radiolaria from the Western Klamath terrane, Smith River subterranean (northwestern California and southwestern Oregon). Scale in upper right = number of μm cited for each illustration.

1, 10, 13, 27 *Bernoullius irwini* Pessagno, Blome and Hull, n. sp. JO-70: Volcanopelagic strata above Josephine ophiolite. 1 = Holotype (USNM 458962). Scale = 200 μm . 10, 13, 27 = Paratypes (USNM 458963). Scale = 150, 150, 88.23 μm .

2 *Wilvemina* sp. A. JO-86B: Volcanic member, Josephine ophiolite. Scale = 60 μm .

3, 17, 21 *Archaeospongoprunum* sp. A. JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 150, 60, 69 μm respectively.

4, 15, 26 *Bernoullius delnortensis* Pessagno, Blome and Hull, n. sp. JO-34: Volcanopelagic strata above Josephine ophiolite. Holotype (USNM 458958). Scale = 157.9, 60, 60 μm . respectively.

5, 6, 24, 28 *Bernoullius brokenkettlensis* Pessagno, Blome and Hull, n. sp. JO-34: Volcanopelagic strata above Josephine ophiolite. 5, 24, 28 = Holotype (USNM 458956). Scales = 150, 60, 88.23 μm . 6 = Paratype (Pessagno Collection). Scale = 150 μm .

7 *Bernoullius brokenkettlensis* Pessagno, Blome and Hull, n. sp. JO-61: Volcanopelagic strata above Josephine ophiolite. Paratype (USNM 458957). Scale = 150 μm .

8, 9, 20, 22, 25, 29 *Archaeospongoprunum praeimlayi* Pessagno, Blome and Hull, n. sp. JO-61: Volcanopelagic strata above Josephine ophiolite. 8, 20, 25 = Holotype (USNM 458954). Scales = 150, 60, 60 μm , respectively. 9, 22, 29 = Paratype (Pessagno Collection). Scales = 150, 60, 37.5 μm , respectively.

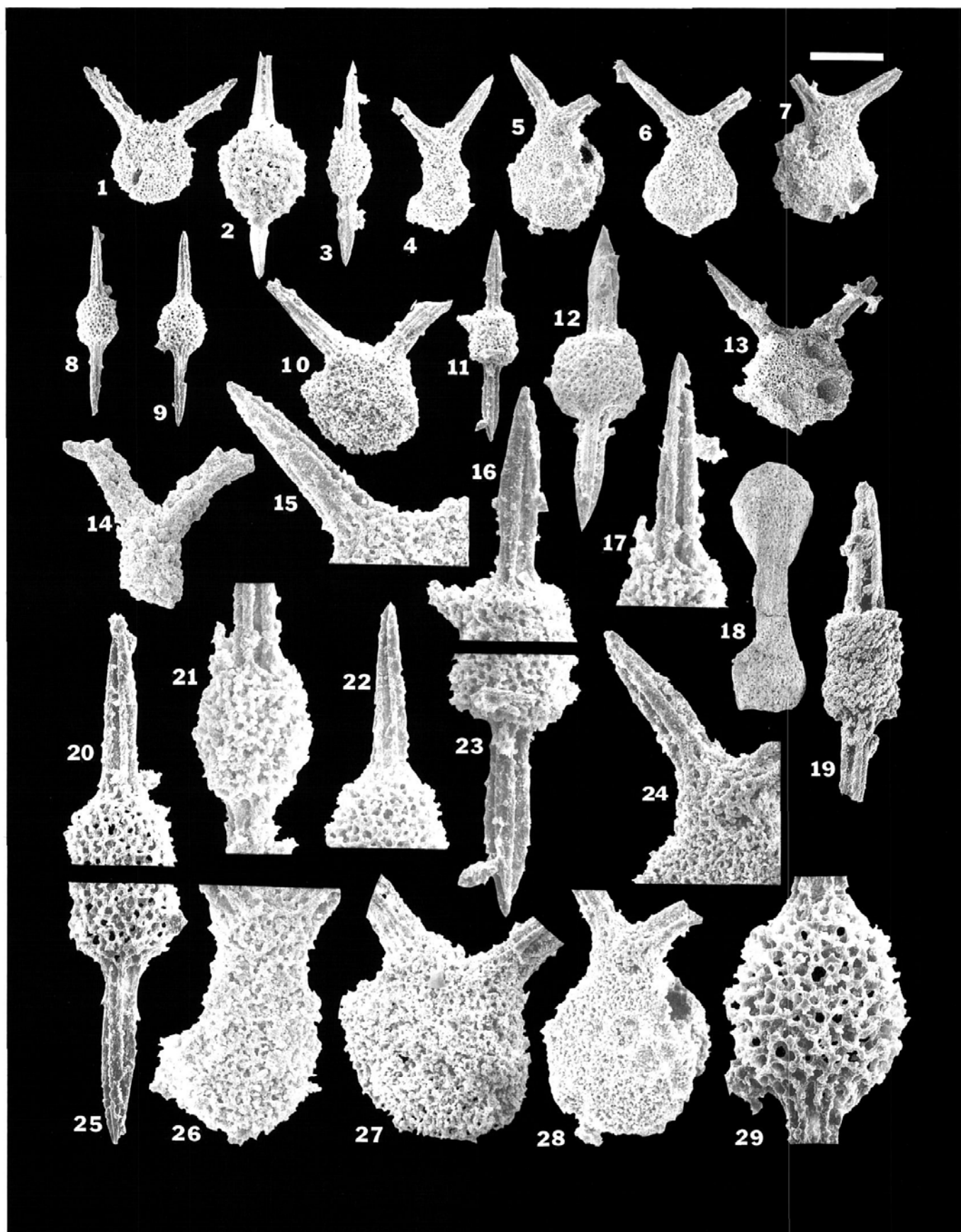
11, 16, 23 *Archaeospongoprunum* sp. B. JO-73: Volcanopelagic strata above Josephine ophiolite. Scales = 150, 60, 60 μm , respectively.

12 *Wilvemina whiskeyensis* Pessagno, Blome and Hull, n. sp. JO-86-D: Volcanic member, Josephine ophiolite. Scale = 88.2 μm .

14 *Bernoullius cristatus* Baumgartner. JO-73: Volcanopelagic strata above Josephine ophiolite. Scale = 88.2 μm .

18 *Bistarkum* sp. A. JO-87A: Volcanic member, Josephine ophiolite. Scale = 150 μm .

19 *Archaeospongoprunum* sp. aff. *A. macrostylum* Rüst. JO-87B. Volcanic member, Josephine ophiolite. Scale = 88.2 μm .



guadalupensis. This also appears to be true of the fragmented specimen figured by Baumgartner (1984) in plate 5, figure 21. In the latter case, however, the outer layer of meshwork is not as well-developed. See *Mirifusus fragilis* Baumgartner herein.

Range: Zone 2, Subzone 2 delta to Zone 3, Subzone 3 beta; middle Oxfordian to lower Tithonian. See text-figure 26.

Occurrence: Same as for genus.

Mirifusus mediodilatatus (Rüst)

Plate 7, figure 13

Lithocampe mediodilatata RÜST 1885, p. 316, pl. 40 (15), fig. 9.

Remarks: *Mirifusus mediodilatata* Rüst first occurs near the top of the succession above the Josephine ophiolite. The first occurrence of all forms of *Mirifusus* with two rather than three rows of pore frames between circumferential ridges is an extremely useful biohorizon in the Upper Jurassic

Range and occurrence: Upper Jurassic, Middle Oxfordian; Zone 2, Subzone 2 gamma. Galice Formation s.l.; Smith River Subterranean, Klamath Mountains, Northwestern California; Boreal Realm, Southern Boreal Province. See text-figures 18, 26 herein.

Genus *Praecaneta* Pessagno, Blome and Hull, n. gen.

Type species: *Ristola decora* Pessagno and Whalen 1982.

Description: Test conical to subcylindrical, lacking horn with massive "H-linked" circumferential ridges. Ridges flanking three rows of predominantly equal-sized symmetrical pore frames. Final post-abdominal chambers increasing in width or remaining same width, never decreasing in width. Central row of pore frames often with pores covered by microgranular silica.

Remarks: *Praecaneta*, n. gen., is compared to *Caneta*, n. gen., above. It is likely that *Praecaneta* was derived from either a *Paracanoptum* Yeh or *Wrangellium* Pessagno and Whalen stock. Both of the latter genera possess massive "H-linked" ridges and pore frames covered either entirely or in part by an outer layer of microgranular silica.

Etymology: *Prae* (Latin, prefix = before) + *Caneta* (see above).

Range: Superzone 1, Zone 1A₂ to Zone 4/Zone 5; Middle Jurassic (Aalenian) to Upper Jurassic (Tithonian) or Lower Cretaceous (lower Hauterivian).

Occurrence: Worldwide in Tethyan Realm and Southern Boreal Province, Boreal Realm.

Praecaneta decora (Pessagno and Whalen)

Plate 6, figure 15

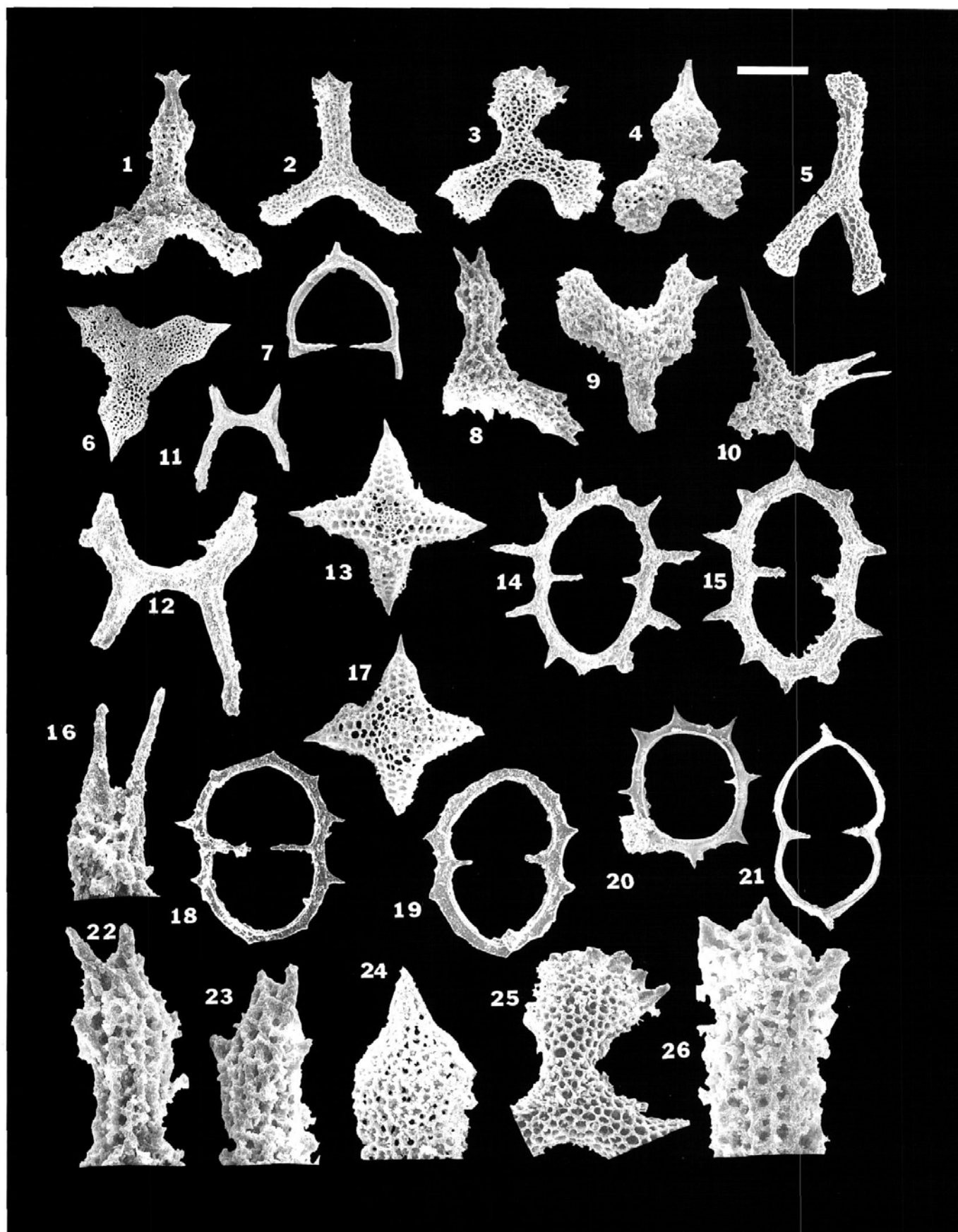
Ristola decora PESSAGNO and WHALEN 1982, p. 148, pl. 11, figs. 7, 10, 21; pl. 13, figs. 12-13.

Ristola sp. B MURCHEY 1984, pl. 1, fig. 10.

PLATE 2

All illustrations are scanning electron micrographs of Middle and Upper Jurassic Radiolaria from the Western Klamath terrane, Smith River subterranean (northwestern California and southwestern Oregon). Scale in upper right = number of μm cited for each illustration.

- | | | | |
|--------|---|--------|---|
| 1 | <i>Paronaella bandyi</i> Pessagno. JO-73: Volcanopelagic strata above Josephine ophiolite. Scale = 88.2 μm . | 11 | <i>Acanthocircus</i> sp. aff. <i>A. carinatus</i> Foreman. JO-73: Volcanopelagic strata above Josephine ophiolite. Scale = 88.2 μm . |
| 2, 26 | <i>Paronaella</i> sp. aff. <i>P. brönnimanni</i> Pessagno. JO-69: Volcanopelagic strata above Josephine ophiolite. Scales = 157.8, 42.9 μm . | 12 | <i>Acanthocircus suboblongus</i> (Yao). JO-73: Volcanopelagic strata above Josephine ophiolite. Scale = 88.2 μm . |
| 3, 25 | <i>Paronaella cleopatraensis</i> Pessagno, Blome and Hull, n. sp. JO-48: Galice Formation s.l. Holotype (USNM 458964). Scales = 103.4, 88.2 μm . | 13, 17 | <i>Higumastra devilsgapensis</i> Pessagno, Blome and Hull, n. sp. JO-48: Galice Formation s.l. 13 = Holotype (USNM 458966). 17 = Paratype (Pessagno Collection). Scales = 157.9 μm . |
| 4 | <i>Paronaella</i> sp. A. JO-87C: Volcanic member, Josephine ophiolite. Scale = 88.2 μm . | 14 | <i>Acanthocircus</i> sp. A. JO-79: Galice Formation s.l. Scale = 157.9 μm . |
| 5 | <i>Patulibracchium</i> (?) sp. aff. <i>P. henlei</i> (Rüst). JO-70: Volcanopelagic strata above Josephine ophiolite. Scale = 103.4 μm . | 15 | <i>Acanthocircus</i> sp. B. JO-79: Galice Formation s.l. Scale = 157.9 μm . |
| 6, 24 | <i>Paronaella</i> sp. B. JO-34: Volcanopelagic strata above Josephine ophiolite. Scales = 103.4, 61.2 μm . | 18 | <i>Acanthocircus</i> sp. C. JO-79: Galice Formation s.l. Scale = 157.9 μm . |
| 7 | <i>Acanthocircus bispinus</i> (Yao). JO-48: Galice Formation s.l. Scale = 88.2 μm . | 19 | <i>Acanthocircus</i> sp. D. JO-79: Galice Formation s.l. Scale = 157.9 μm . |
| 8, 9, | <i>Noviforemanella</i> sp. aff. <i>N. hipposidericus</i> (Foreman). | 20 | <i>Acanthocircus</i> sp. E. JO-48. Galice Formation s.l. Scale = 157.9 μm . |
| 22, 23 | JO-61: Volcanopelagic strata above 22, Josephine ophiolite. Scales = 88.2, 88.2, 42.9, 42.9 μm , respectively. | 21 | <i>Acanthocircus</i> sp. F. JO-48: Galice Formation s.l. Scale = 157.9 μm . |
| 10, 16 | <i>Noviforemanella</i> (?) sp. A. JO-34: Volcanopelagic strata above Josephine ophiolite. Scales = 103.44, 61.2 μm . | | |



Range: Superzone 1, Zone 1F to Zone 2, Subzone 2 delta so far as known. See text-figure 26.

Occurrence: Volcanic member of Josephine ophiolite and volcanopelagic strata overlying JO, Smith River subterrane, Klamath Mountains, southwestern Oregon (See text-fig. 18). Izee terrane, east-central Oregon.

Genus *Parvicingula* Pessagno 1977a

Type species: *Parvicingula santabarbarensis* Pessagno 1977a.

Emended definition: Test with variably sized horn, spindle-shaped to subcylindrical; final postabdominal chamber always terminating in narrow tube which may be open or end with a spinose projection. Length of tube on final postabdominal chamber may often equal Length of horn. Final postabdominal chamber(s) always decreasing rapidly in width.

Remarks: Pessagno et al. (1987a, 1987b, 1989) referred to this form as *Parvicingula* s.s. Forms that these workers formerly referred to *Parvicingula* s.l. are now included in *Praeparvicingula*, n. gen. *Parvicingula* is compared to *Praeparvicingula*, n. gen., under the latter genus.

No specimens of *Parvicingula* s.s. are figured herein. The reader is referred to illustrations of the type species or those presented by Hull (1991).

Range: Zone 2, Subzone 2 alpha to Zone 5, Subzone 5C. Upper Jurassic (uppermost Kimmeridgian/lowermost Tithonian) to Lower Cretaceous (upper Valanginian/lower Hauterivian).

Occurrence: Worldwide in Tethyan Realm, Northern Tethyan Province and in the Boreal Realm, Southern Boreal Province.

Genus *Praeparvicingula* Pessagno, Blome and Hull, n. gen.

Type species: *Parvicingula profunda* Pessagno and Whalen 1982.

Description: Test conical to subcylindrical (never spindle-shaped) with horn. Final postabdominal chamber(s) either increasing in width or maintaining same width. Final chamber lacking narrow terminal tube as with *Parvicingula* s.s.

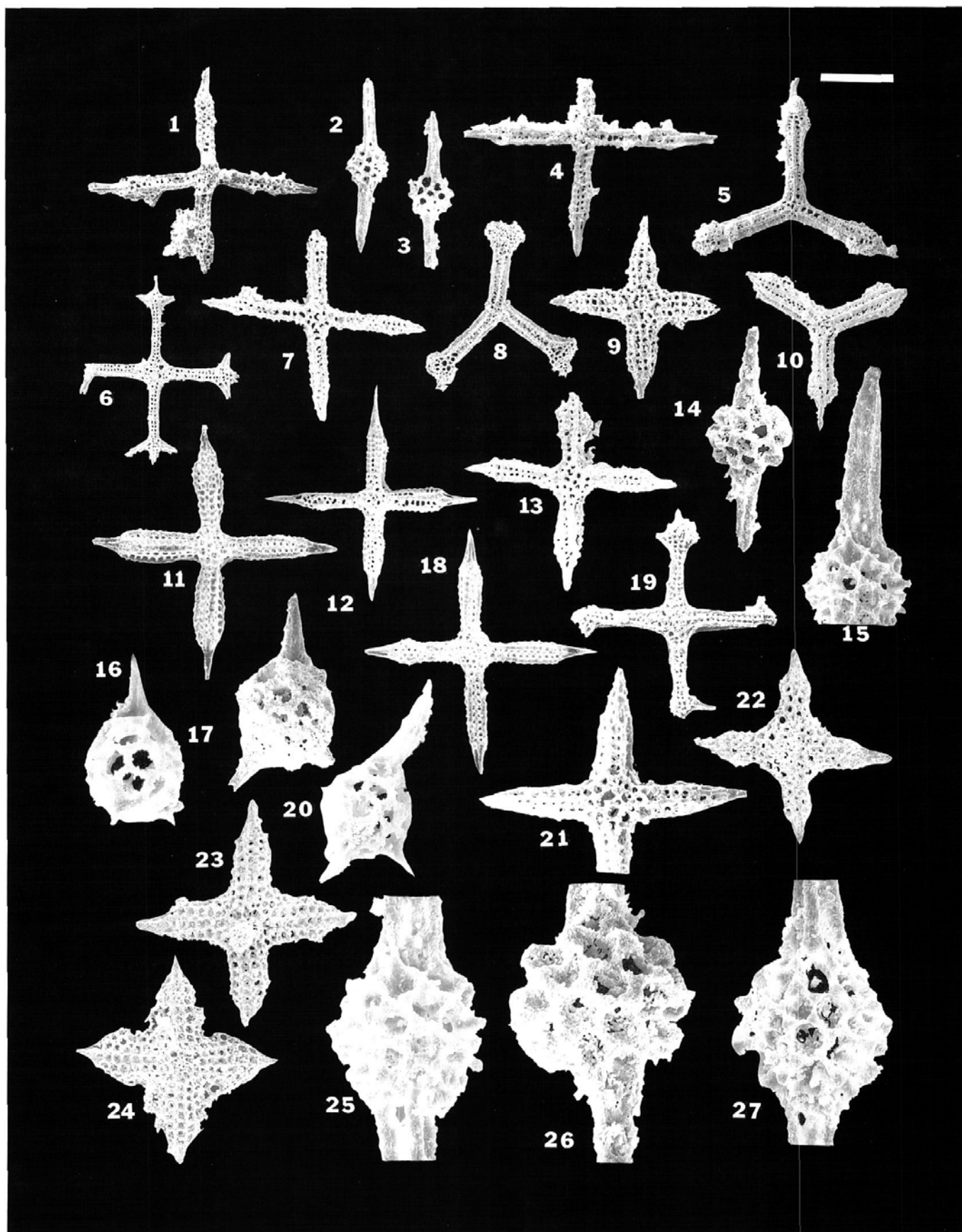
Remarks: *Praeparvicingula* was originally referred to by Pessagno et al. (1987a, 1987b, 1989) as *Parvicingula* s.l. *Praeparvicingula* differs from *Parvicingula* s.s. by lacking a narrow tube on the final postabdominal chamber. Moreover, the final postabdominal chamber/chambers of *Praeparvicingula* continue to increase in width, either rapidly or slowly, as added.

PLATE 3

All illustrations are scanning electron micrographs of Middle and Upper Jurassic Radiolaria from the 549 Western Klamath terrane, Smith River subterrane (northwestern California and southwestern Oregon) and Izee Terrane (east-central Oregon).

Scale in upper right = number of μm cited for each illustration.

- | | | |
|------------------|---|---|
| 1, 4, 7 | <i>Saldorfus coldspringensis</i> Pessagno, Blome and Hull, n. sp. JO-69: Volcanopelagic strata above Josephine ophiolite. 1 = Holotype (USNM 458968). Scale = 157.9 μm . 4, 7 = Paratypes (Pessagno Collection). Scales = 157.9, 157.9 μm , respectively. | ber, Snowshoe Formation, Izee Terrane, east-central Oregon. Scales = 150, 157.9, 150 μm . |
| 2, 3, 15, 25, 27 | <i>Pantanellium darlingtoniaense</i> Pessagno, Blome and Hull, n. sp. JO-70: Volcanopelagic strata above Josephine ophiolite. 3, 15, 25 = Holotype (USNM 458972). Scales = 103.4, 6.1, 6.1 μm . 3, 27 = Paratypes (Pessagno Collection). Scales = 103.4, 6.1 μm . | 13 <i>Saldorfus corralitosensis</i> (Pessagno). JO-70: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9 μm . |
| 5 | <i>Tritrabs hayi</i> (Pessagno). JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9 μm . | 14, 26 <i>Pachyoncus kamiasoensis</i> Mizutani and Kido. JO-34: Volcanopelagic strata above Josephine ophiolite. Scales = 61.2, 42.8 μm . |
| 6, 19 | <i>Tetraditryma praeplena</i> (Baumgartner). Figured specimens from JO-34 and JO-61, respectively: Volcanopelagic strata above Josephine ophiolite. Scales = 157.9 μm . | 16 <i>Gorgansium</i> sp. A. JO-48: Galice Formation s.l. Scale = 61.2 μm . |
| 8 | <i>Tritrabs ewingi</i> (Pessagno) s.l. JO-70: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9 μm . | 17 <i>Gorgansium</i> sp. C. JO-48. Galice Formation s.l. Scale = 61.2 μm . |
| 9 | <i>Higumastra</i> sp. aff. <i>H. inflata</i> Baumgartner. JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9 μm . | 20 <i>Gorgansium</i> sp. B. JO-48. Galice Formation s.l. Scale = 61.2 μm . |
| 10 | <i>Tritrabs</i> sp. A. JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9 μm . | 21 <i>Archaeohagiastrium</i> sp. aff. <i>A. munitum</i> Baumgartner. JO-61: Volcanopelagic strata above Josephine ophiolite. Scale = 88.2 μm . |
| 11, 12, 18 | <i>Saldorfus oregonensis</i> Pessagno, Blome and Hull, n. sp. 11 = Holotype (USNM 458970). 12, 18 = Paratypes (Pessagno Collection). OR-501B. Top South Fork Mem- | 22 <i>Higumastra transversa</i> Blome. JO-69: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9 μm . |
| | | 23, 24 <i>Higumastra imbricata</i> (Ozoldová). JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9 μm . |



Etymology: *Prae* (Latin, prefix = before) + *Parvicingula* Pessagno.

Range: Superzone 1, Zone A₂ to Zone 5, Subzone 5C; Lower Jurassic (Toarcian) to Lower Cretaceous (upper Valanginian/lower Hauterivian).

Occurrence: Worldwide in Tethyan Realm, Northern Tethyan Province and in the Boreal Realm, Southern Boreal Province.

Praeparvicingula deadhorsensis Pessagno, Blome and Hull, n. sp. Plate 7, figures 1, 2, 25, 27

Description: Test short, broadly conical with eight postabdominal chambers. Cephalis broad, hemispherical with short horn; horn circular in axial section except for extreme proximal portion which tends to be triradiate in axial section with three large pores inserted in grooves between three ridges. First postabdominal chamber separated from abdomen and subsequent postabdominal chambers separated from each other by thin, nodose circumferential ridges. Thorax, abdomen and postabdominal chambers subtrapezoidal in shape; postabdominal chambers increasing very slowly in height and more rapidly in width as added; chambers in proximal one-half of test increasing in width more rapidly than those of distal half. Cephalis, thorax and abdomen with irregular polygonal pore frames. Pore frames of first five postabdominal chambers

tending to be irregular, polygonal, usually arranged in two rows. Final three postabdominal chambers less irregular with pentagonal and hexagonal pore frames arranged in three rows between flanking circumferential ridges.

Remarks: *Praeparvicingula deadhorsensis*, n. sp., differs from *P. siskiyouensis*, n. sp., by having a test which is less broad, by having more irregular, smaller pore frames, and by having nodose, more strongly developed circumferential ridges.

Etymology: This species is named for Dead Horse Gulch near its type locality.

Measurements: (μm) Length excludes horn. Holotype + 10 paratypes.

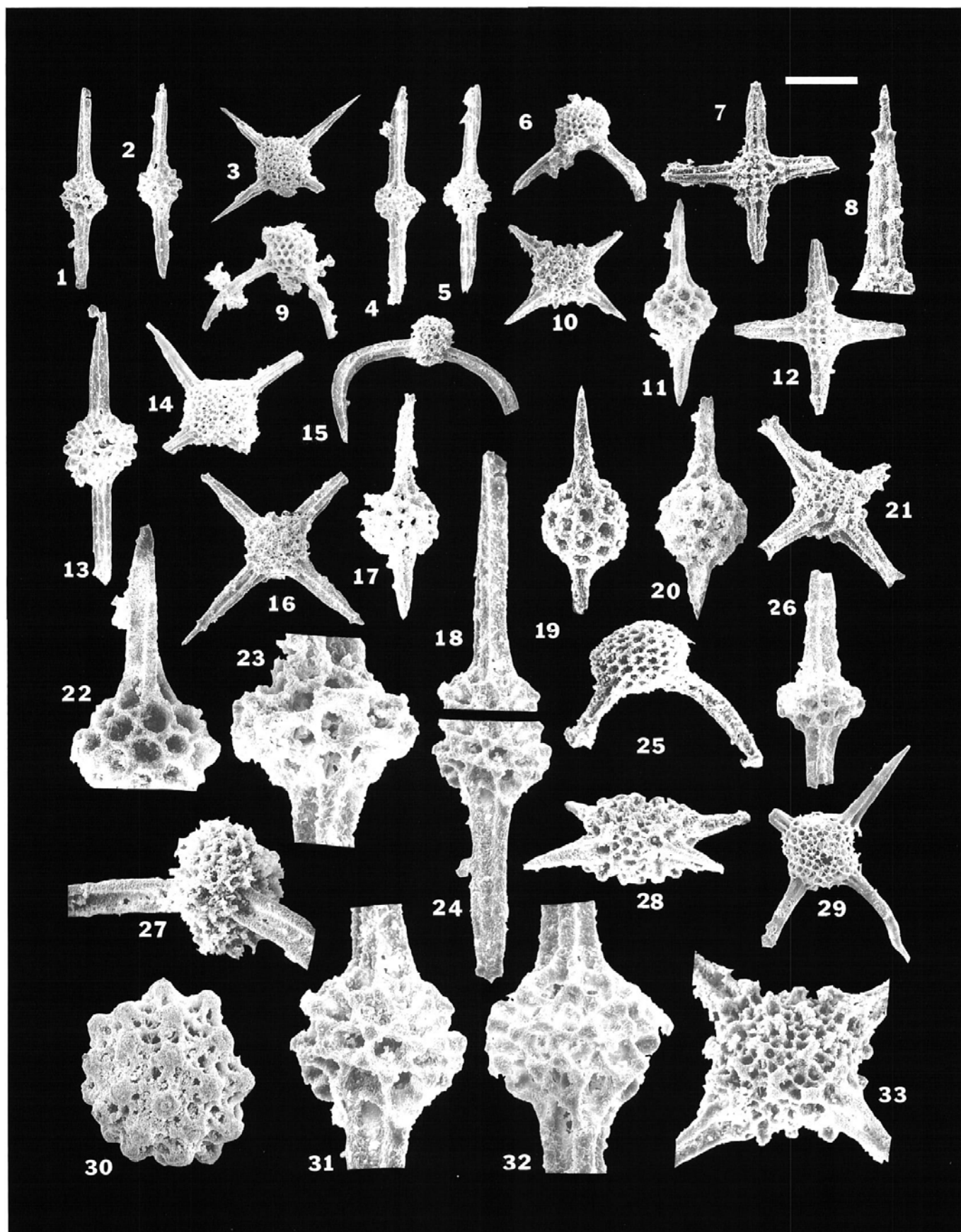
	Max. test width	Max. test length	Length of horn	Number of postabdom. chambers
Holotype	150	270	30	9
Mean	125	223.6	18.75	7.5
SD	21.8	61.6	5.7	1.21
Max.	150	315	30	9
Min.	93	135	15	6

Type locality: JO-48. See Locality Descriptions.

PLATE 4

All illustrations are scanning electron micrographs of Middle and Upper Jurassic Radiolaria from the Western Klamath terrane, Smith River subterrane (northwestern California and southwestern Oregon). Scale in upper right = number of μm cited for each illustration.

- | | | |
|---------|---|---|
| 1, 2, | <i>Pantanellium josephinense</i> Pessagno, Blome and Hull, n. sp. 1, 18, 24, 31 = Holotype (USNM 458974). JO-69: Volcanopelagic strata above Josephine ophiolite. Scales = 157.9, 61.2, 61.2, 15.8 μm. 2 = Topotype from JO-69. Scale = 157.9 μm. 4, 32 = Paratype (Pessagno Collection). Scales = 157.9, 15.8 μm. 5, 13 = Specimens (non-types) from JO-70. Scales = 157.9, 88.2 μm. | strata above Josephine ophiolite. Scales = 157.9, 88.2, 61.2 μm. |
| 4, 5, | | |
| 13, 18, | | |
| 24, | | |
| 31, 32 | | |
| 3, 14, | <i>Emiluvia lowercoonensis</i> Pessagno, Blome and Hull, n. sp. JO-48. Galice Formation s.l. 3 = Holotype (USNM 458978). Scale = 214.3 μm. 14, 29 = Paratypes (Pessagno Collection). Scales = 214.3, 157.9 μm. | 11, 22 from tuffaceous radiolarian cherts interbedded with pillow basalt in volcanic member of Josephine ophiolite at JO-86D. Scales = 88.2, 176.5 μm. 19 from JO-61: Volcanopelagic strata above Josephine ophiolite. Scale = 88.2 μm. |
| 29 | | |
| 6 | <i>Lanubus</i> sp. B. JO-10.5: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9 μm. | 15, 27 <i>Parvivacca</i> sp. A. JO-69: Volcanopelagic strata above Josephine ophiolite. Scales = 157.9, 61.2 μm. |
| 7, 12 | <i>Emiluvia premyogii</i> Baumgartner. JO-34: Volcanopelagic strata above Josephine ophiolite. Note that specimen in figure 7 has more massive nodes than is typical for species. Scales = 157.9 μm. | 17 <i>Pantanellium meraceibaense</i> Pessagno and MacLeod. JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 88.2 μm. |
| 8, 16 | <i>Emiluvia</i> sp. A. JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 88.2, 157.9 μm. | 20 <i>Pantanellium</i> sp. A. JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 61.2 μm. |
| 9 | <i>Lanubus</i> sp. C. JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9 μm. | 21 <i>Emiluvia hopsoni</i> Pessagno. JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9 μm. |
| 10, | <i>Emiluvia dollarbendensis</i> Pessagno, Blome and Hull, n. sp. Holotype (USNM 458976). JO-70: Volcanopelagic | 23, 26 <i>Trillus</i> sp. A. JO-73: Volcanopelagic strata above Josephine ophiolite. Scales = 428.6, 88.2 μm. |
| 28, 33 | | 25 <i>Lanubus</i> sp. A. JO-61: Volcanopelagic strata above Josephine ophiolite. Scale = 88.2 μm. |
| | | 30 <i>Praeconocaryomma immodica</i> Pessagno and Poisson. JO-86D: Tuffaceous radiolarian chert interbedded with volcanic member of Josephine ophiolite. Scale = 88.2 μm. |



Deposition of types: Holotype = USNM 458998. Paratypes = USNM 458999 and Pessagno Collection.

Range: Zone 2, Subzone 2 gamma so far as known. Upper Jurassic: middle Oxfordian. See text-figure 26.

Occurrence: Galice Formation s.l., Klamath Mountains, northwestern California; Boreal Realm, Southern Boreal Province. "Capas de San Pedro" (Burckhardt 1910). Middle Oxfordian of Sula Islands; Austral Real, Northern Austral Province. In the Sula Islands this species is directly associated with the ammonite *Epimayaites* spp. See text-figure 19.

Praeparvicingula hurdygurdyensis Pessagno, Blome and Hull, n. sp. Plate 7, figures 22, 23

Description: Apical one-quarter of test conical; remainder subcylindrical. Test with eight or nine postabdominal chambers. Cephalis hemispherical with large polygonal pore frames and with short, slender horn apically; horn circular in axial section. Thorax and abdomen subtrapezoidal in outline with large polygonal pore frames. Rims of pore frames cephalis, thorax and abdomen accentuated by overgrowth of microgranular silica; microgranular silica obscuring pores of some specimens. Postabdominal chambers subtrapezoidal, separated by narrow, weakly developed circumferential ridges and with three rows of hexagonal pore frames; center row of pore frames of each postabdominal chamber usually somewhat smaller in size than

those of two flanking rows. Pore frames of first several postabdominal chambers often partially covered by and sometimes accentuated by veneer of microgranular silica.

Remarks: *Praeparvicingula hurdygurdyensis*, n. sp., differs from *Praeparvicingula deadhorsensis*, n. sp., by having a test which is larger, more elongate and conical with more symmetrical pore frames.

Etymology: This species is named for Hurdygurdy Butte to the southeast of its type locality.

Measurements: (μm) Length excludes horn. Holotype + 9 paratypes.

	Max. test width	Max. test length	Length of horn	Number of postabdom. chambers
Holotype	120	277.5	15	10
Mean	112.8	232.5	15	10
SD	18.6	31.2	19.33	8.4
Max.	150	277.5	30	10
Min.	90	180	15	7

Type locality: JO-48. See Locality Descriptions.

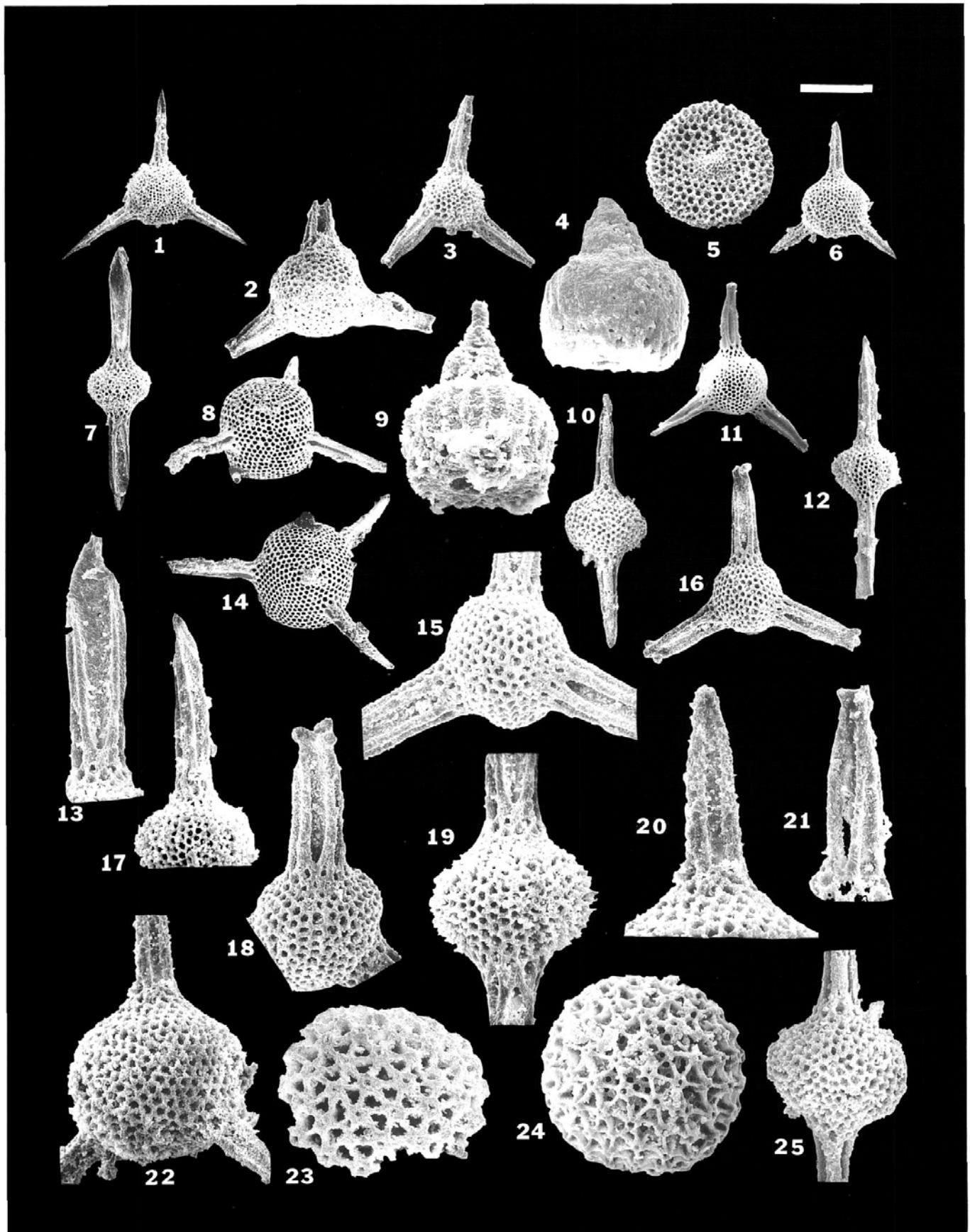
Deposition of types: Holotype = USNM 459000. Paratypes = USNM 459001 and Pessagno Collection.

Plate 5

All illustrations are scanning electron micrographs of Middle and Upper Jurassic Radiolaria from the Western Klamath terrane, Smith River subterranean (northwestern California and southwestern Oregon) and Izee terrane (east-central Oregon).

Scale in upper right = number of μm cited for each illustration.

- 1 *Tripocyclus saleebii* Pessagno and Yang. JO-34. Volcanopelagic strata above Josephine ophiolite. Scale = 157.9μm.
- 2 *Tripocyclus* sp. aff. *T. highdomensis* Pessagno, Blome and Hull, n. sp. JO-70. Volcanopelagic strata above Josephine ophiolite. Scale = 157.9μm.
- 3, 21 *Tripocyclus jonesi* Pessagno. JO-73. Volcanopelagic strata above Josephine ophiolite. Scales = 157.9, 61.2μm.
- 4 *Eucyrtidiellum* sp. aff. *E. pustulatum* Baumgartner. JO-61: Volcanopelagic strata above Josephine ophiolite. Scale = 428.6μm.
- 5 *Cenodiscus*(?) sp. A. JO-34. Volcanopelagic strata above Josephine ophiolite. Scale = 157.9μm.
- 6, 20, 22 *Tripocyclus frenchflatensis* Pessagno, Blome and Hull, n. sp. Holotype (USNM 458980). JO-34. Volcanopelagic strata above Josephine ophiolite. Scales = 157.9, 42.8, 61.2μm.
- 7, 13, 19 *Xiphostylus humboldtensis* Pessagno, Blome and Hull, n. sp. Holotype (USNM 458984). JO-70: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9, 61.2, 61.2μm.
- 9 *Eucyrtidiellum* sp. aff. *E. ptyctum* (Riedel and Sanfilippo). Volcanopelagic strata above Josephine ophiolite. Scale = 42.8μm.
- 8, 14 *Neotripocyclus harperi* Pessagno and Yang. JO-48: Galice Formation s.l. 8 = Paratype Pessagno Collection. 9 = Holotype (USNM 424138). Scale = 157.9μm.
- 10, 25 *Xiphostylus gasquetensis* Pessagno and Yang. Topotype. JO-34: Volcanopelagic strata above Josephine ophiolite. Scales = 157.9, 88.2μm.
- 11 *Tripocyclus* sp. aff. *Tripocyclus jonesi* (Pessagno). JO-48: Galice Formation s.l. Scale = 157.9μm.
- 12, 17 *Xiphostylus* sp. A. JO-69: Volcanopelagic strata above Josephine ophiolite. Scales = 157.9, 82.2μm.
- 15, 16, 18 *Tripocyclus highdomensis* Pessagno, Blome and Hull, n. sp. Holotype (USNM 458982). JO-73: Volcanopelagic strata above Josephine ophiolite. Scales = 82.2, 157.9, 82.2μm.
- 23 *Levilleugeo* sp. A. JO-87D. Volcanic member of Josephine ophiolite. Scale = 61.2μm.
- 24 *Levilleugeo* sp. B. OR-501C. South Fork Member of Snowshoe Formation, Izee terrane, east central Oregon; uppermost Bathonian. Scale = 75μm.



Range: Zone 2, Subzone 2 gamma so far as known. Upper Jurassic, middle Oxfordian. See text-figure 26.

Occurrence: Galice Formation s.l., Klamath Mountains, northwestern California; Boreal Real, Southern Boreal Province. See text-figure 19 herein.

Praeparvicingula packsaddlensis Pessagno, Blome and Hull, n. sp. Plate 7, figures 12, 17, 19

Parvicingula sp. AITA and GRANT-MACKIE 1992, pp. 380-381, fig. 6: 2, 7.

Description: Test conical with short horn which is circular in axial section; thin, blade-like ridges projecting downwards from base of horn to surface of cephalis and thorax. Cephalis wide, hemispherical with flattened proximal surface and relatively large, irregular polygonal pore frames. Thorax and abdomen with large polygonal pore frames; pore frames often arranged in two rows on abdomen. Postabdominal chambers subtrapezoidal, separated by well-developed circumferential ridges and increasing gradually in height, but more rapidly in width as added. Postabdominal chambers generally with three rows of relatively large hexagonal pore frames. Center row of pore

frames smaller, somewhat staggered with respect to flanking rows.

Remarks: *Praeparvicingula packsaddlensis*, n. sp., differs from *P. hurdygurdyensis*, n. sp., by possessing well-developed circumferential ridges, blade-like ridges that project downwards from the base of the horn, and somewhat larger pore frames.

The form figured by Aita and Grant-Mackie (1992, fig. 6: 2, 7) from the Jurassic of New Zealand is assignable to this species.

Etymology: This species is named for Packsaddle Creek near its type locality.

Measurements: (µm) Length excludes horn. Holotype + 9 paratypes.

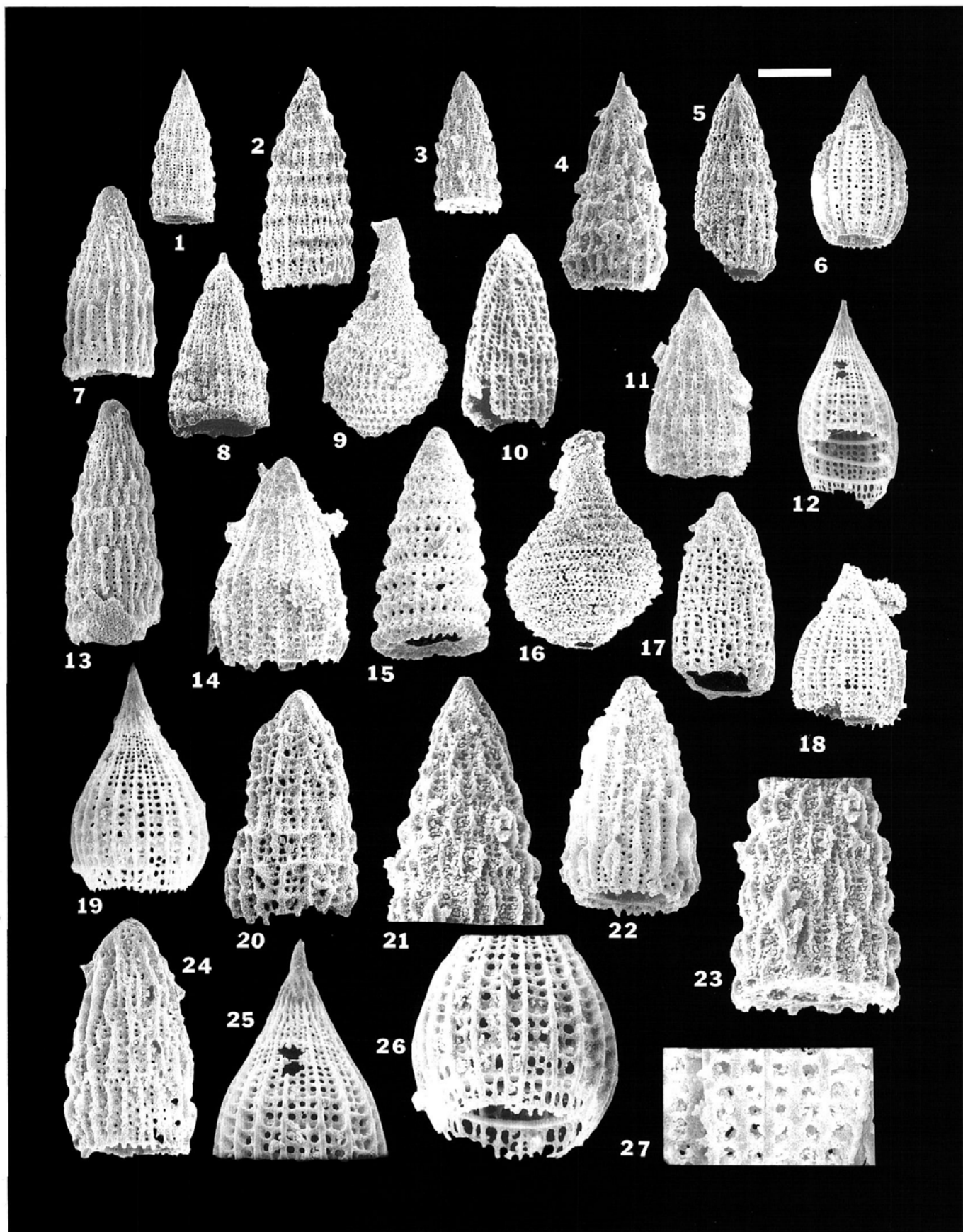
	Max. test width	Max. test length	Length of horn	Number of postabdom. chambers
Holotype	120	240	30	10
Mean	114.3	252	29.31	8.5
SD	17.17	55.2	5.6	0.97
Max.	135	375	37.5	10
Min.	90	180	17	7

Plate 6

All illustrations are scanning electron micrographs of Middle and Upper Jurassic Radiolaria from the Western Klamath terrane, Smith River subterrane (northwestern California and southwestern Oregon) and Izee terrane (east-central Oregon).

Scale in upper right = number of µm cited for each illustration.

- 1 *Hsuum maxwelli* Pessagno s.l. JO-69: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9µm.
- 2, 5 *Hsuum baldfacense* Pessagno, Blome and Hull, n. sp. 2 = Holotype (USNM 458986). 5 = Paratype (Pessagno Collection). JO-87B: Volcanic member, Josephine ophiolite. Scales = 88.2µm.
- 3, 4, 21, 23 *Hsuum brevicostatum* (Ozoldová). Specimen in figures 3 and 21 with a broken horn, JO-70: Volcanopelagic strata above Josephine ophiolite. 4, 23 from JO-87C: Volcanic member, Josephine ophiolite. Scales = 157.9, 82.2, 61.2, 61.2µm, respectively.
- 18 *Linaresia beniderkoulensis* El Kadiri. 18 = JO-70: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9µm.
- 6, 27 *Linaresia beniderkoulensis* El Kadiri? JO-70: Volcanopelagic strata above Josephine ophiolite 157.9, 42.9µm.
- 7, 13 *Semihsuum sourdoughense* Pessagno, Blome and Hull, n. sp. 7 = Paratype (Pessagno Collection). 13 = Holotype (USNM 458992). Volcanic member, Josephine ophiolite. Scales = 88.2µm.
- 8 *Hsuum* sp. aff. *H. baldfacense* Pessagno, Blome and Hull, n. sp. JO-87B. Volcanic member, Josephine ophiolite. Scale = 88.2µm.
- 9 *Mirifusus guadalupensis* Pessagno. JO-70: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9µm.
- 10, 17, 20 *Semihsuum brokencotense* Pessagno, Blome and Hull, n. sp. 10 = Holotype (USNM 458990). 17, 20 = Paratypes (Pessagno Collection). JO-87B: Volcanic member, Josephine ophiolite. Scale = 88.2, 88.2, 61.2µm, respectively.
- 11 *Semihsuum inexploratum* (Blome). JO-87A: Volcanic member, Josephine ophiolite. Scale = 88.2µm.
- 12, 19, 25, 26 *Linaresia mizutanii* Pessagno, Blome and Hull, n. sp. 12, 25 = Holotype (USNM 458994). 19, 26 = Paratypes (Pessagno Collection). OR-554: Warm Springs Member of Snowshoe Formation, Izee Terrane, east-central Oregon. Scales = 120, 99, 66, 66µm, respectively.
- 14 *Linaresia* sp. A. JO-69. Volcanopelagic strata overlying Josephine ophiolite. Scale = 88.2µm.
- 15 *Praecaneta decora* (Pessagno and Whalen). JO-87B: Volcanic member, Josephine ophiolite. Scale = 61.2µm.
- 16 *Mirifusus fragilis* Baumgartner. JO-70: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9µm.
- 22 *Semihsuum biscuithillense* Pessagno, Blome and Hull, n. sp. Holotype (USNM 458988). JO-87D: Volcanic member, Josephine ophiolite. Scale = 61.2µm.
- 24 *Semihsuum* sp. A. JO-87D: Volcanic member, Josephine ophiolite. Scale = 61.2µm.



Type locality: JO-48. See Locality Descriptions.

Deposition of types: Holotype = USNM 459002. Paratypes = USNM 459003 and Pessagno Collection.

Range: Zone 2, Subzone 2 gamma so far as known. Upper Jurassic, middle Oxfordian. See text-figure 26.

Occurrence: Galice Formation s.l., Klamath Mountains, northwestern California: Boreal Realm, Southern Boreal Province. Kowhai Point Siltstone, Murihku terrane, North Island, New Zealand; Austral Realm, Northern Austral Province. See text-figure 19 herein.

Praeparvicingula siskiyouensis Pessagno, Blome and Hull, n. sp. Plate 7, figure 24

Description: Test broad, distal two-thirds subcylindrical; proximal one-third broadly conical. Cephalis wide, hemispherical with short horn. Thorax and abdomen wide, subtrapezoidal with large, massive pentagonal and hexagonal pore frames. Thin,

weakly developed circumferential ridges separate first abdominal chamber from thorax and subsequent postabdominal chambers. Postabdominal chambers subtrapezoidal in shape with three rows of pentagonal and hexagonal pore frames set between two given flanking circumferential ridges. Pore frames increasing slightly in size in a distal direction. Test with six or seven postabdominal chambers.

Remarks: This species differs from *Praeparvicingula hurdygurdyensis*, n. sp., by having a shorter horn and a broader, shorter test with fewer postabdominal chambers and proportionately larger pore frames that tend to increase in size in a distal direction. *Praeparvicingula siskiyouensis* is compared to *P. deadhorsensis*, n. sp., under the latter species.

Etymology: *Praeparvicingula siskiyouensis*, n. sp., is named for the Siskiyou National Forest in its type area.

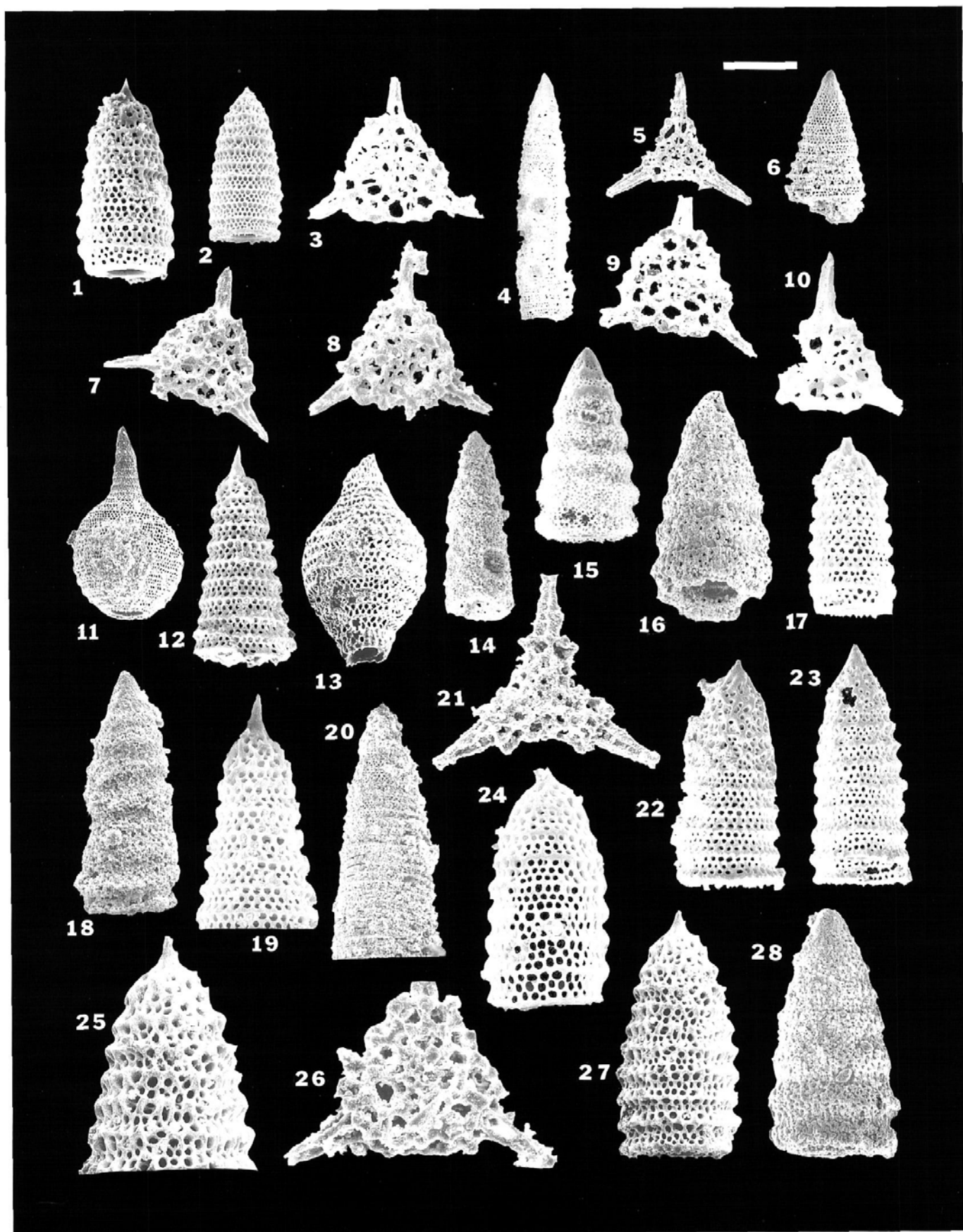
Measurements: (μm) Length excludes horn. Holotype + 9 paratypes.

Plate 7

All illustrations are scanning electron micrographs of Middle and Upper Jurassic Radiolaria from the Western Klamath terrane, Smith River subterrane (northwestern California and southwestern Oregon) and Izee terrane (east-central Oregon).

Scale in upper right = number of μm cited for each illustration.

- | | | | |
|----------------------|--|---------------|--|
| 1, 2,
25, 27 | <i>Praeparvicingula deadhorsensis</i> Pessagno, Blome and Hull, n. sp. 1, 2 = Paratypes (Pessagno Collection). 25, 27 = Holotype (USNM 458998). JO-48: Galice Formation s.l. Scales = 85.7, 157.9, 60, 85.7 μm . | 12,
17, 19 | <i>Praeparvicingula packsaddlensis</i> Pessagno, Blome and Hull, n. sp. 12, 19 = Holotype (USNM 459002). Scales = 88.2, 61.2 μm . 17 = Paratype (Pessagno Collection). JO-48: Galice Formation, s.l. Scale = 85.7 μm . |
| 3, 7,
8, 9,
26 | <i>Perispyridium dangerpointense</i> Pessagno, Blome and Hull, n. sp. 3 = Topotype. Specimen accidentally destroyed. 7 = Holotype (USNM 459006). 8, 26 = Paratype (Pessagno Collection). 9 = Paratype (Pessagno Collection). Specimens in figures 3 and 7 from locality JO-69. Other specimens from locality JO-70. Volcanopelagic strata above Josephine ophiolite. Scales = 88.2, 88.2, 88.2, 61.2 μm . | 13 | <i>Mirifusus mediodilatatus</i> (Rüst) s.l. JO-17: Galice Formation s.l. Scale = 200 μm . |
| 4 | <i>Ristola procera</i> (Pessagno). JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9 μm . | 14 | <i>Spongocapsula</i> sp. A. JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9 μm . |
| 5, 21 | <i>Perispyridium gujohachimanense</i> Takemura. Specimens in figures 5 and 21 from localities JO-34 and 70, respectively: Volcanopelagic strata above Josephine ophiolite. Scales = 150, 88.2 μm . | 15,
16, 28 | <i>Spongocapsula yehae</i> Pessagno, Blome and Hull, n. sp. 15 = specimen (non-type) from OR-501B: South Fork Member, Snowshoe Formation (east-central Oregon); Scale = 99 μm . 16 = Paratype (Pessagno Collection). JO-87B: Volcanic member, Josephine ophiolite. Scale = 61.2 μm . 28 = Holotype (USNM 459008). JO-87B: Volcanic member, Josephine ophiolite. Scale = 61.2 μm . |
| 6 | <i>Ristola</i> sp. A. JO-86D: Volcanic member, Josephine ophiolite. Scale = 157.9 μm . | 18 | <i>Spongocapsula palmerae</i> Pessagno s.l. JO-69: Volcanopelagic strata above Josephine ophiolite. Scale = 88.2 μm . |
| 10 | <i>Perispyridium</i> sp. A. JO-87D: Volcanic member, Josephine ophiolite. Scale = 88.2 μm . | 20 | <i>Ristola</i> sp. aff. <i>R. procera</i> (Pessagno). JO-69: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9 μm . |
| 11 | <i>Mirifusus fragilis</i> Baumgartner. NSF-907: Volcanopelagic strata above Coast Range ophiolite. Well-preserved specimen. Compare to specimen on plate 6, figure 16. Scale = 198 μm . | 24 | <i>Praeparvicingula siskiyouensis</i> Pessagno, Blome and Hull, n. sp. Holotype (USNM 459004). JO-48: Galice Formation s.l. Scale = 61.2 μm . |
| | | 22, 23 | <i>Praeparvicingula hurdygurdyensis</i> Pessagno, Blome and Hull, n. sp. JO-48: Galice Formation s.l. 22 = Paratype (Pessagno Collection). 23 = Holotype (USNM 459000). Scales = 85.7 μm . |



	Max. test width	Max. test length	Length of horn	Number of postabdom. chambers
Holotype	105	180	15	6
Mean	103.2	165	15	5.4
SD	13.1	36	0	1.07
Max.	135	240	15	7
Min.	90	120	15	4

Type locality: JO-48. See Locality Descriptions.

Deposition of types: Holotype = USNM459004. Paratypes = USNM 459005 and Pessagno Collection.

Range: Zone 2, Subzone 2 gamma so far as known. Upper Jurassic, middle Oxfordian. See text-figure 26.

Occurrence: Galice Formation s.l., Klamath Mountains, northwestern California; Boreal Realm, Southern Boreal Province. See text-figure 19 herein.

Genus *Ristola* Pessagno and Whalen 1982

Type species: *Parvicingula procera* Pessagno 1977a.

Remarks: Forms with nodose H-linked circumferential ridges and larger pore frames (e.g. *Ristola decora* Pessagno and Whalen 1982) are now included in *Caneta* Pessagno, Blome and Hull, n. gen.

Range: Superzone 1, Zone II to Zone 5, Subzone 5A so far as known; Middle Jurassic, uppermost Callovian?; lower Oxfordian to Lower Cretaceous: Berriasian.

Occurrence: Baja California, California, Oregon, Alaska, Japan, Greece, Italy, Oman, Puerto Rico, Mexico, DSDP Leg 17 (Moore 1973), DSDP Leg 76, Site 534A, Blake-Bahama Basin (Baumgartner 1984). Worldwide in Tethyan Realm and Boreal Realm, Southern Boreal Province.

Ristola procera (Pessagno)

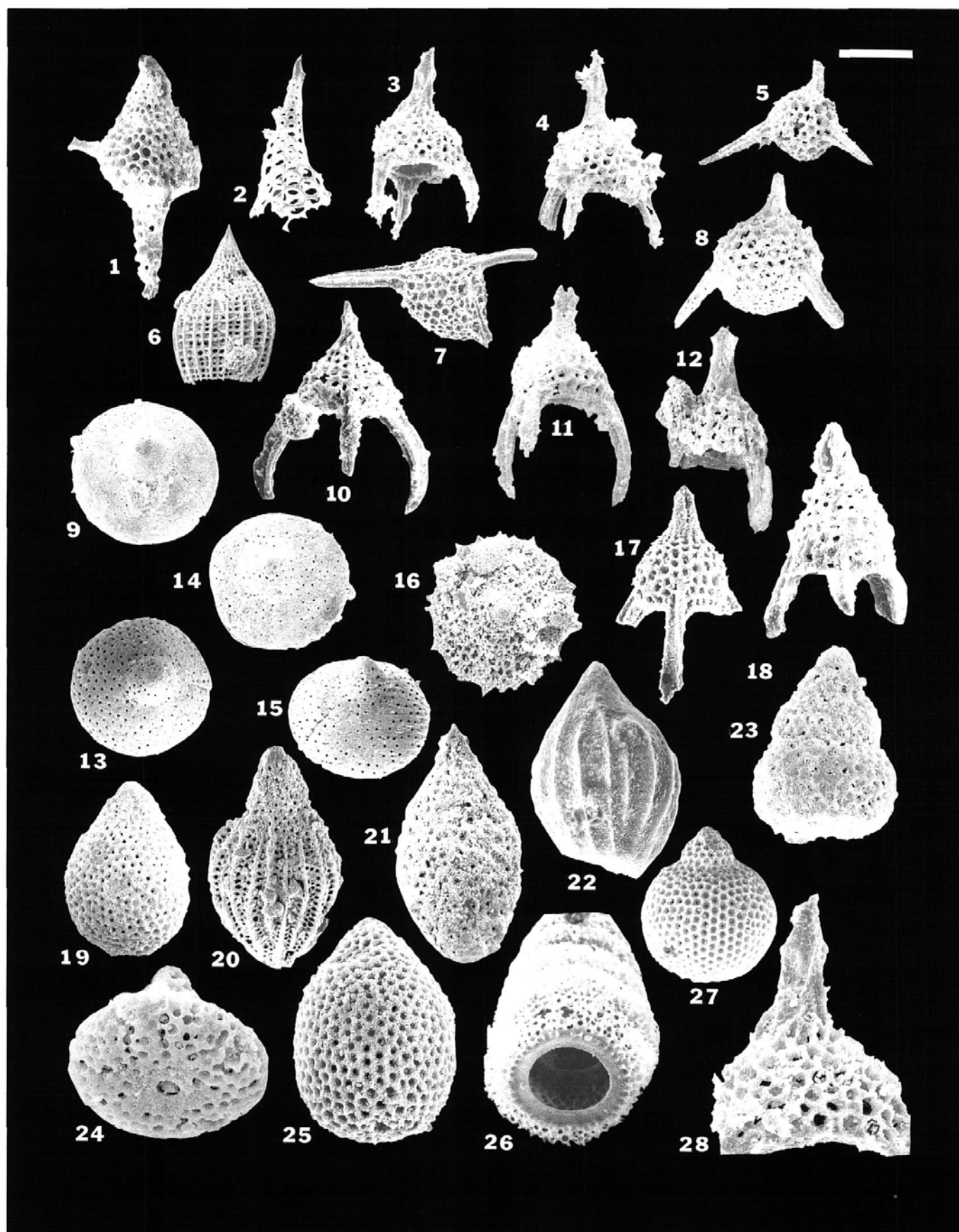
Plate 7, figure 4

Plate 8

All illustrations are scanning electron micrographs of Middle and Upper Jurassic Radiolaria from the Western Klamath terrane, Smith River subterrane (northwestern California) and the Izee terrane (east-central Oregon).

Scale in upper right = number of μm cited for each illustration.

- 1 *Podobursa spinosa* Ozvoldová s.l. JO-48: Galice Formation s.l. Scale = 85.7 μm .
- 2 *Cornutella* sp. JO-48: Galice Formation s.l. Scale = 85.7 μm .
- 3, 4, 28 *Napora elkcampensis* Pessagno, Blome and Hull, n. sp. 3, 28 = Holotype (USNM459010). Scales = 87.5, 400 μm . 4 = Paratype (Pessagno Collection). Scale = 87.7 μm . JO-70: Volcanopelagic strata above Josephine ophiolite.
- 5, 7 *Turanta chetcoensis* Pessagno, Blome and Hull, n. sp. 5 = Holotype (USNM 459014). 7 = Paratype (Pessagno Collection). JO-34: Volcanopelagic strata above Josephine ophiolite. Scales = 157.9 μm .
- 6 *Linaresia beniderkoulensis* El Kadiri. JO 70: Volcanopelagic strata above Josephine ophiolite. Scale = 157.9 μm .
- 8 *Turanta chetcoensis* Pessagno, Blome and Hull, n. sp. Specimen (non-type) from JO-10.5: Volcanopelagic strata above Josephine ophiolite. Scale = 150 μm .
- 9, 13, 14, 15, 24 *Quarkus madstonensis* Pessagno, Blome and Hull, n. sp. 13, 15 = Holotype (USNM459012). Scales = 61.2 μm . 9, 14, 24 = Paratypes (Pessagno Collection). Scales = 61.2, 61.2, 42.8 μm . JO-86D: Volcanic member, Josephine ophiolite.
- 10 *Napora nipponica* Takemura. JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 88.2 μm .
- 11 *Napora* sp. B. JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 88.2 μm .
- 12 *Napora* sp. aff. *N. saginata* Takemura. JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 88.2 μm .
- 16 *Palinandromeda* sp. A. JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 150 μm .
- 17 *Napora* sp. A. JO-34: Volcanopelagic strata above Josephine ophiolite. Scale = 88.2 μm .
- 18 *Napora pyramidalis* Baumgartner. JO-61: Volcanopelagic strata above Josephine ophiolite. Scale = 42.8 μm .
- 19 *Stichocapsa* sp. aff. *S. convexa* Yao. JO-87A: Volcanic member, Josephine ophiolite. Scale = 61.2 μm .
- 20 *Unuma typicus* Ichikawa and Yao. JO-87B: Volcanic member, Josephine ophiolite. Scale = 61.2 μm .
- 21 *Cyrtocapsa* sp. aff. *C. (?) kisoensis* Yao. JO-86D: Volcanic member, Josephine ophiolite. Scale = 61.2 μm .
- 22 *Protonuma* sp. aff. *P. multicostata* Heitzer. Three rows of pores occur between costae, but now covered by glue on figured specimen. JO-86D: Volcanic member, Josephine ophiolite. Scale = 61.2 μm .
- 23 *Stichocapsa japonica* Yao. JO-86-D: Volcanic member, Josephine ophiolite. Scale = 42.8 μm .
- 25 *Tricolocapsa* sp. B. JO-87-D: Volcanic member, Josephine ophiolite. Scale = 42.8 μm .
- 26 *Spongocapsula yehae* Pessagno, Blome and Hull, n. sp. OR-501B: South Fork Member, Snowshoe Formation, Izee Terrane, east-central Oregon. Scale = 60 μm .
- 27 *Tricolocapsa (?)* sp A. JO-87D: Volcanic member, Josephine ophiolite. Scale = 61.2 μm .



Parvicingula(?) procera PESSAGNO 1977a, p. 86, pl. 9, figs. 6-9.

Range: Superzone 1, Zone I to Zone 4, Subzone 4 alpha; upper Callovian?; Oxfordian to uppermost Tithonian. See text-figure 26. Baumgartner et al. (1991) indicate that this taxon first appears in their new U.A. 30 (between Zones A1 and A2, Baumgartner 1987) and makes its final appearance in new U.A. 47 (between Zones B and C, Baumgartner 1987). See text-figure 19 herein.

Occurrence: Same as for genus.

Ristola sp. aff. *R. procera* (Pessagno)
Plate 7, figure 20

Range and occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province.

Ristola sp. A
Plate 7, figure 6

Remarks: This form differs from *Ristola* sp. aff. *R. procera* by being narrower apically and broader distally. It is probable that *Mirifusus fragilis* and *M. guadalupensis* evolved from a form similar to this.

Range and occurrence: Superzone 1, Zone H; uppermost Callovian. Volcanic member of Josephine ophiolite, Smith River subterrane, Klamath Mountains, southwestern California; Tethyan Realm, Central Tethyan Province.

Family **PERISPYRIDIIDAE** Takemura 1986
Type genus: *Perispyridium* Dumitrica 1978.

Range: Superzone 1, Zone 1A, Subzone 1A₂ (base) to Zone 4, Subzone 4 beta (top); Lower Jurassic (middle Toarcian) to Upper Jurassic (upper Tithonian).

Occurrence: Worldwide.

Genus ***Perispyridium*** Dumitrica 1978
Type species: *Trilonche(?) ordinaria* Pessagno 1977a.

Range: Same as for family.

Occurrence: Japan, Argentina, Alaska, California Coast Ranges, Klamath Mountains (Ore. and Calif.), east-central Oregon, Baja California Sur, east-central Mexico, Romania, Greece, Blake-Bahama Basin (DSDP Site 534A), Tibet; Tethyan Realm, Central Tethyan Province to Northern Tethyan Province; Boreal Realm; Southern Boreal Province to Northern Boreal Province; Austral Realm, Southern Austral Province.

Perispyridium dangerpointense Pessagno, Blome and Hull, n. sp.
Plate 7, figures 3, 7, 8, 9, 26

Description: Cephalis medium-sized (for genus), ellipsoidal with a predominance of pentagonal pore frames having poorly developed nodes at vertices. Cephalis oriented with its long axis at right angles to axis of apical spine. Outline of peripheral shell in frontal plane rounded, subtriangular. Peripheral shell of medium thickness (for genus) at right angles to frontal plane and with rounded sides. Apical and two primary lateral spines of medium length, triradiate in axial section with three longitudinal grooves alternating with three longitudinal ridges; grooves and ridges about equal in width, both tapering rapidly toward pointed spinal tips. Peripheral shell narrow; comprised of

medium-sized tetragonal and pentagonal pore frames with massive nodes at their vertices. Peripheral shell connected to cephalis by four or five bars which separate four or five large, rounded pericephalic pores. Peripheral shell shoulder (sense of MacLeod 1988, pp. 294-295) poorly developed.

Remarks: *Perispyridium dangerpointense*, n. sp., differs from *P. gujohachimanense* Takemura by having a more rounded, less triangular peripheral shell, more poorly developed peripheral shell shoulders and somewhat shorter spines.

Etymology: This species is named for Danger Point a few miles to the southwest of its type locality along U.S. Route 199.

Measurements: (μm) Holotype + 8 paratypes. See text-figure 31 for explanation of system of measurements.

	Width of test along axis of axial spine	Length of axial spine
Holotype	180	60
Mean	128	55.5
SD	20.1	6.7
Max.	180	6.7
Min.	120	45

Type locality: JO-69. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 459006. Paratypes = USNM 459007 and Pessagno Collection.

Range: Zone 2, Subzone 2 delta; middle Oxfordian. See text-figure 27.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterrane, northwestern California; Tethyan Realm, Central Tethyan Province sensu Pessagno and Blome (1986) and Pessagno et al. (1986, 1987a). See text-figure 19 herein.

Perispyridium gujohachimanense Takemura
Plate 7, figures 5, 21

Perispyridium gujohachimanense TAKEMURA 1986, p. 42, pl. 1, figs. 15-20.

Remarks: For the most part, the North American specimens compare favorably with those figured by Takemura (1986). The spines of the North American specimens are sometimes slightly longer and slender.

Range: Superzone 1; Zone 1I to Zone 2, Subzone 2 delta; uppermost Callovian/lower Oxfordian to middle Oxfordian. See text-figure 27.

Occurrence: Volcanopelagic strata above Josephine ophiolite; Smith River subterrane, northwestern California; Tethyan Realm, Central Tethyan Province to Northern Tethyan Province (See text-fig. 19). Mino Complex of Japan; Tethyan Realm, Central Tethyan Province.

***Perispyridium* sp. A**
Plate 7, figure 10

Range: Superzone 1, Zone 1H; uppermost Callovian? so far as known.

Occurrence: Volcanic member of Josephine ophiolite, Smith River subterranean, southwestern Oregon; Tethyan Realm, Central Tethyan Province.

Family **SPONGOCAPSULIDAE** Pessagno 1977a

Type genus: *Spongocapsula* Pessagno 1977a.

Range: Superzone 1, Zone 1 F to Zone 10, Subzone 10A; Middle Jurassic, Bathonian to Upper Cretaceous, lower Cenomanian.

Occurrence: Worldwide in Tethyan and Boreal Realms.

Genus *Spongocapsula* Pessagno 1977a

Type species: *Spongocapsula palmerae* Pessagno 1977a.

Emended definition: Defined as with Pessagno (1977a), but restricted to forms having strictures developed at the joints between postabdominal chambers.

Range: Superzone 1, Zone 1F to Zone 4 or higher. Middle Jurassic, upper Bathonian to Upper Jurassic, upper Tithonian or higher.

Occurrence: Worldwide in Tethyan and Boreal Realms.

Spongocapsula palmerae Pessagno s.l.

Plate 7, figure 18

Spongocapsula palmerae PESSAGNO 1977a, pp. 88-90, pl. 11, figs. 12-14, 16.

Range: Zone 2, Subzone 2 delta to Zone 3; Oxfordian to lower Tithonian.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province. California Coast Ranges, volcanopelagic strata above Coast Range ophiolite: Point Sal (Santa Barbara Co.), Alamo Creek (Stanley Mountain; San Luis Obispo Co.), and so forth; Tethyan Realm, Central Tethyan Province to Boreal Realm, Southern Boreal Province.

Spongocapsula yehae Pessagno, Blome and Hull, n. sp.

Plate 7, figures 15, 16, 28; plate 8, figure 26

Description: Test broad apically, rounded with six to eight postabdominal chambers separated by weakly developed strictures. Apical portion of test (cephalis, thorax, abdomen) often covered by a veneer of microgranular silica. Spongy meshwork consisting of small tetragonal, pentagonal, and hexagonal pore frames. Cephalis very broad, hemispherical; thorax, abdomen, and subsequent postabdominal chambers trapezoidal in outline. Postabdominal chambers increasing rapidly in width and more slowly in length as added.

Remarks: *Spongocapsula yehae*, n. sp., differs from *S. palmerae* Pessagno by having a test which is broader and which is more rounded apically.

Etymology: This species is named for Dr. Kuei-Yu Yeh (National Museum of Natural Science, Taichung, Taiwan) in honor of her contributions to the study of Lower Jurassic Radiolaria.

Measurements: (μm) Holotype + 6 paratypes.

	Max. test width	Max. test length	Number of postabdom. chambers
Holotype	105	135	6
Mean	109	171.4	5.3
SD	14.3	40.2	0.48
Max.	135	250	6
Min.	90	112.5	5

Type locality: OR-501-B. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 459008. Paratypes = USNM 459009 and Pessagno Collection.

Range: Superzone 1, Zone 1F to Zone 1H; upper Bathonian to upper Callovian so far as known. See text-figure 27.

Occurrence: South Fork Member, Snowshoe Formation, Ize terrane, east-central Oregon; Boreal Realm, Southern Boreal Province. Volcanic Member of Josephine ophiolite, Smith River subterranean, Klamath Mountains, southwestern Oregon; Tethyan Realm, Central Tethyan Province. See text-figure 19 for occurrence in Smith River subterranean.

Spongocapsula sp. A

Plate 7, figure 14

Range: Zone 2, Subzone 2 delta; middle Oxfordian.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, southwestern Oregon; Tethyan Realm, Central Tethyan Province.

Family **SYRINGOCAPSIDAE** Foreman 1973

Type genus: *Syringocapsa* Neviani 1900.

Range and occurrence: Triassic to Cretaceous; worldwide.

Genus *Podobursa* Wisniewski 1889; emend. Foreman 1973

Type species: *Podobursa dunikowskii* Wisniewski 1889.

Podobursa spinosa Ozvoldová

Plate 8, figure 1

Podobursa pantanellii (Parona). – RIEDEL and SANFILIPPO 1974, p. 779, pl. 8, fig. 5; pl. 13, fig. 6.

Heitzeria spinosa OZVOLDOVÁ 1975, p. 78, pl. 101, fig. 2.

Podobursa berggreni PESSAGNO 1977a, p. 90, pl. 12, figs. 1-5.

Podobursa spinosa (Ozvoldová). – OZVOLDOVÁ 1979, p. 256, pl. 2, fig. 4. – BAUMGARTNER in Baumgartner et al. 1980, p. 60, pl. 3, fig. 10. – BAUMGARTNER 1984, p. 779, pl. 7, fig. 8. – DEWEVER et al. 1986, pl. 10, figs. 5-8, 10. – OZVOLDOVÁ 1990, p. 305, pl. 2, fig. 6.

Remarks: The form figured herein, though missing two of its spines, is assignable to *P. spinosa*.

Range: Zone 2, Subzone 2 gamma to Zone 4, Subzone 4 beta (see text-figure 27). Baumgartner et al. (1991) indicate that this species first appears in their new U.A. 35 (Zone A2, Baumgartner 1987) and makes its final appearance in new U.A. 56 (Zone C2, Baumgartner 1987).

Occurrence: Galice Formation s.l., Smith River subterranean, Klamath Mountains, northwestern California; Boreal Realm, Southern Boreal Province (see text-fig. 20). Volcanopelagic strata overlying the Point Sal remnant of the Coast Range ophiolite (Santa Barbara Co., Calif.) and the Stanley Mountain remnant of the Coast Range ophiolite (San Luis Obispo Co., Calif.); Boreal Realm, Southern Boreal Province. Eugenia

Formation, Vizcaino Peninsula, Baja California Sur, Boreal Realm Southern Boreal Province (Davila 1986). DSDP Site 167 (Magellan Rise; see Riedel and Sanfilippo 1974); Tethyan Realm, Central Tethyan Province. Santa Ana, Sicily (De Wever et al. 1986); Tethyan Realm, Central Tethyan Province. For other Tethyan occurrences see Baumgartner (1984).

Family **ULTRANAPORIDAE** Pessagno 1977b; emend. Pessagno, Whalen and Yeh 1986.

Type genus: *Ultranapora* Pessagno 1977b (= *Napora* Pessagno 1977a).

Range: Lower Jurassic, ?upper Sinemurian; lower Pliensbachian to Upper Cretaceous.

Occurrence: Worldwide in Tethyan and Boreal Realms.

Genus *Napora* Pessagno 1977b; emend. Pessagno, Whalen and Yeh 1986.

Napora PESSAGNO 1977a, p. 94.

Ultranapora PESSAGNO 1977b, p. 38.

Type species: *Napora bukryi* Pessagno 1977a.

Range and occurrence: Same as for family.

Napora elkcampensis Pessagno, Blome and Hull, n. sp.
Plate 8, figures 3, 4, 28

Description: Cephalis small, hemispherical with medium length horn. Horn completely triradiate in axial section with three longitudinal ridges alternating with three longitudinal grooves. Proximal two-thirds of horn parallel-sided. Distal one-third with sides rapidly converging toward tip. Grooves widening medially. Ridges decreasing rapidly in width on proximal one-third of horn; maintaining about same width on distal one-third. Thorax hemispherical with a mixture of slightly nodose pentagonal and hexagonal pore frames. Feet slender, short, curved, triradiate in axial section with three longitudinal ridges alternating with three longitudinal grooves. Grooves and ridges relatively narrow, decreasing in width distally.

Remarks: *Napora elkcampensis*, n. sp., appears to be closely related and possibly ancestral to *Napora bukryi* Pessagno. It differs from the latter species by having larger pore frames with much thinner bars, larger pores, and a horn which possesses well-developed longitudinal grooves on its distal one-third and lacking subsidiary spines on its longitudinal ridges. Both species share tests which possess a hemispherical thorax and similar feet.

Etymology: This species is named for Elk Camp Ridge to the west of its type locality.

Measurements: (μm) Holotype + 6 paratypes.

	Length of cephalis	Length of thorax	Width of thorax	Length of horn	Width of horn proximally	Length of foot	Width of foot proximally
Holotype	37.5	45	105	45	30	75	22.5
Mean	30.6	68.5	117.8	57.8	27.2	72	20.5
SD	3.2	11.8	13.4	10.3	2.7	6.7	3.2
Max.	37.5	75	135	75	30	75	22.5
Min.	27	45	105	45	22.5	60	15

Type locality: JO-70. Volcanopelagic strata overlying the Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 459010. Paratypes = USNM 459011 and Pessagno Collection.

Range: Zone 2, Subzone 2 delta; Oxfordian so far as known. See text-figure 27.

Occurrence: Volcanopelagic strata overlying Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province. See text-figure 20.

Napora nipponica Takemura 1986
Plate 8, figure 10

Napora nipponica TAKEMURA 1986, p. 44, pl. 2, figs. 16-21.

Range: Zone 2, Subzone 2 delta. See text-figure 27.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province. Mino Complex of Japan; Tethyan Realm, Central Tethyan Province.

Napora pyramidalis Baumgartner
Plate 8, figure 18

Napora pyramidalis BAUMGARTNER 1984, p. 775, pl. 6, figs. 11-12.
YAMAMOTO, MIZUTANI and KAGAMI 1985, pp. 36, 42, pl. 5, fig. 7.

Remarks: The specimen figured herein, though not as well preserved, compares well with those figured from the Blake-Bahama Basin by Baumgartner (1984) and Yamamoto, Mizutani, and Kagami (1985).

Range and occurrence: Superzone 1, Zone II; uppermost Callovian/lowermost Oxfordian to middle Oxfordian. Volcanopelagic deposits above Josephine ophiolite, Smith River subterrane, Klamath Mountains, northwestern California; Blake-Bahama Basin at Site 534; Tethyan Realm, Central Tethyan Province. See text-figures 20 and 27 herein.

Napora sp. aff. *N. saginata* Takemura
Plate 8, figure 12

Napora saginata TAKEMURA 1986, p. 44, pl. 2, figs. 12-15.

Remarks: The specimen figured herein, though not complete, greatly resembles *Napora saginata* Takemura. It possesses essentially the same short horn with a small V-shaped notch at its top as well as wide feet with extremely wide longitudinal grooves. This specimen differs from those figured by Takemura having larger, less numerous pore frames.

Range and occurrence: Superzone 1, Zone 1H; upper Callovian. Volcanic member of Josephine ophiolite, Smith River subterrane, Klamath Mountains, southwestern Oregon. See text-figures 20 and 27 herein.

Napora sp. A
Plate 8, figure 17

Range and occurrence: Zone 2, Subzone 2 delta; Oxfordian. JO-34; rare. Volcanopelagic strata above Josephine ophiolite; Tethyan Realm, Central Tethyan Province.

Napora sp. B
Plate 8, figure 11

Remarks: Note the V-shaped notch at top of horn and alignment of pores transversely in rows on thorax.

Range and occurrence: Zone 2, Subzone 2 delta; Oxfordian. JO-34; rare. Volcanopelagic strata above Josephine ophiolite; Tethyan Realm, Central Tethyan Province.

NASSELLARIINA incertae sedis

Genus *Cornutella* Ehrenberg 1838

Type species: *Cornutella clathrata* Ehrenberg 1838.

Range and occurrence: Jurassic to Recent; worldwide.

Cornutella sp.

Plate 8, figure 2

Range and occurrence: Zone 2, Subzone 2 gamma; middle Oxfordian so far as known. Galice Formation s.l., Smith River subterranean, Klamath Mountains, northwestern California; Boreal Realm, Southern Boreal Province. JO-48; rare.

Genus *Palinandromeda* Pessagno, Blome and Hull, nomen novum for *Andromeda* Baumgartner 1980b.

Type species: *Andromeda crassa* Baumgartner 1980b.

Andromeda BAUMGARTNER 1980b in Baumgartner et al. 1980, pp. 49-50. (= junior homonym of *Andromeda* Gistl 1834 (Insecta).)

Definition: Same as that for *Andromeda* Baumgartner 1980.

Remarks: The name *Palinandromeda* Pessagno, Blome and Hull is introduced as a replacement name for *Andromeda* Baumgartner. *Andromeda* Baumgartner (1980b) is a junior homonym of *Andromeda* Gistl 1834 (Coeloptera, Insecta).

Etymology: *Pali(n)* (= Greek prefix) meaning back, again, once more + *Andromeda*.

Range: Lower Jurassic to Cretaceous; not fully established.

Occurrence: Worldwide in Tethyan and Boreal Realms.

Palinandromeda sp. A

Plate 8, figure 16

Range and occurrence: Zone 2, Zone 2 delta; Oxfordian. Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, Klamath Mountains, northwestern California; Tethyan Realm, Central Tethyan Province.

Genus *Cyrtocapsa* Haeckel 1881

Type species: *Cyrtocapsa ovalis* Rüst 1885 (Inadvertent subsequent designation by Campbell 1954, p. D143).

Remarks: Rüst's (1885, p. 50, pl. 17, fig. 11) illustration of the type specimen is too generalized to allow any precise definition of the genus *Cyrtocapsa*. Moreover, the figured type is fragmentary. If the name *Cyrtocapsa* is to be used with any degree of precision, it is advisable that a neotype will have to be erected for *Cyrtocapsa ovalis* Rüst.

Range and occurrence: Mesozoic and Cenozoic; worldwide.

Cyrtocapsa sp. aff. *C. (?) kisoensis* Yao

Plate 8, figure 21

Cyrtocapsa (?) kisoensis YAO 1979, pp. 37-39, pl. 8, figs. 9-16.

Range and occurrence: Superzone 1, Zone 1H; uppermost Callovian? Volcanic member of Josephine ophiolite, Smith River subterranean, Klamath Mountains, southwestern Oregon.

Genus *Protonuma* Ichikawa and Yao 1976

Type species: *Protonuma fusiformis* Ichikawa and Yao 1976.

Range and occurrence: Middle and Upper Jurassic. Tethyan Realm, Central Tethyan Province to Boreal Realm, Southern Boreal Province, worldwide.

Protonuma sp. aff. *P. multicostata* Heitzer

Plate 8, figure 22

Cenellipsis multicostata HEITZER 1930, p. 388, pl. 27, fig. 13.

Remarks: This form is characterized by having two to four rows of linearly arranged, square pore frames between costal ridges. Ten or eleven costae are visible in side view; these are relatively massive and high in relief. The costae seem to be superimposed between linear rows of square pore frames. This may indicate that *Protonuma* should be assigned to the Hsuidae Pessagno and Whalen.

The shape of the test apically is quite similar to that of *Protonuma multicostata* Heitzer. Heitzer's illustrated type specimen shows two rows of pore frames between nine costal elements.

Range and occurrence: Superzone 1, Zone 1H; upper Callovian? Volcanic member of Josephine ophiolite, Smith River subterranean, Klamath Mountains, southwestern Oregon. See text-figures 20, 27 herein.

Genus *Quarkus* Pessagno, Blome and Hull, n. gen.

Type species: *Quarkus madstonensis* Pessagno, Blome and Hull, n. sp.

Description: Test pyramid-like, multicystid; consisting of four chambers. Cephalis lacking a horn, hemispherical; thorax and subsequent chambers subtrapezoidal in outline. Proximal one-quarter of test conical, relatively narrow; distal three-quarters of test very broad and hemispherical. Final postabdominal chamber with small, circular aperture at its base; base of test flattened. Test wall thick, microgranular, pierced by relatively large circular pores; pores at base of final postabdominal chamber tending to be larger and more polygonal in nature.

Remarks: *Quarkus*, n. gen., differs from *Tricolocampe* Haeckel (1881; type species = *T. clypsidra* Rüst 1885; subsequent designation by Campbell 1954, p. D134) by having a test with a greatly inflated, hemispherical final chamber with a small, circular aperture situated in the center of its flattened base. The form described by Rüst (1885) as *Tricolocampe pyramidea* may be assignable to *Quarkus*. Rüst's illustration of the type specimen is too generalized to allow an accurate comparison with the type species of *Quarkus*, *Q. madstonensis*.

Etymology: *Quarkus* (m.) is a name formed by an arbitrary combination of letters (ICZN 1985, p. 21, Art. 11b).

Range and occurrence: Superzone 1, Zone 1H so far as known. Middle Jurassic, uppermost Callovian? so far as known. See text-figures 20 and 27 herein.

Quarkus madstonensis Pessagno, Blome and Hull, n. sp.

Plate 8, figures 9, 13, 14, 15, 24

Description: Test lacking a horn, pyramid-like, quite broad with centrally placed circular aperture at the flattened base of the final chamber (segment). Pores circular in outline on most of test surface except on flattened base of final chamber; pores polygonal in outline on flattened surface of final chamber.

Remarks: See remarks for genus above.

Etymology: *Quarkus madstonensis*, n., sp., is named for Madstone Cabin to the northwest of its type locality.

Measurements: (μm) Holotype + 9 paratypes.

	Diameter: Final postabdominal chamber	Diameter: conical
Holotype	120	30
Mean	113.7	34.5
SD	6.8	6.48
Max.	120	45
Min.	105	30

Type locality: JO-86D. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 459012. Paratypes = USNM 459013 and Pessagno Collection.

Range: Superzone 1, Zone 1H so far as known; uppermost Callovian? so far as known. See text-figure 27 herein.

Occurrence: Volcanic member of Josephine ophiolite, Smith River subterranean, Klamath Mountains, southwestern Oregon; Tethyan Realm, Central Tethyan Province.

Genus *Stichocapsa* Haeckel 1881

Type species: *Stichocapsa jaspidea* Rüst (inadvertent subsequent designation by Campbell 1954, p. D143).

Range and occurrence: Mesozoic and Cenozoic.

Stichocapsa sp. aff. *S. convexa* Yao
Plate 8, figure 19

Stichocapsa convexa YAO 1979, pp. 35-36, pl. 5, figs. 14-16, pl. 6, figs. 1-7.

Remarks: The scanning electron micrographs of the forms figured by Yao show forms lacking discrete polygonal pore frames on the test surface. Yao's light photomicrographs (e.g. pl. 6, figs. 1a, 1b = holotype) reveal polygonal pore frames on the interior of the first and second postabdominal chambers (segments). It would appear, therefore, the exterior of the test of well-preserved specimens may be covered by a veneer of microgranular silica. We interpret the specimen figured herein as a form in which the outer layer of microgranular silica has been stripped away.

Range and occurrence: Volcanic member of Josephine ophiolite, Smith River subterranean, Klamath Mountains, southwestern Oregon; Tethyan Realm, Central Tethyan Province. See text-figures 20 and 27 herein.

Stichocapsa japonica Yao
Plate 8, figure 23

Stichocapsa japonica YAO 1979, p. 36, pl. 6, figs. 8-12; pl. 7, figs. 1-14.

Range and occurrence: Superzone 1, Zone 1H so far as known; uppermost Callovian? so far as known. Volcanic member of Josephine ophiolite, Smith River subterranean, Klamath Moun-

tains, southwestern Oregon; Tethyan Realm, Central Tethyan Province. See text-figures 20 and 27 herein.

Genus *Tricolocapsa* Haeckel 1887

Type species: *Tricolocapsa theophrasti* Haeckel (subsequent designation by Campbell 1954, p. D136).

Range and occurrence: Mesozoic and Cenozoic worldwide.

Tricolocapsa(?) sp. A
Plate 8, figure 27

Remarks: It should be noted that the type species of *Tricolocapsa* is a Cenozoic taxon. The thorax and abdomen of the type species are nearly equal in size. It is questionable whether *Tricolocapsa* sp. A or, for that matter, most Mesozoic forms figured by various workers as *Tricolocapsa* are assignable to this genus.

Range and occurrence: Volcanic member of the Josephine ophiolite at JO-87D; rare. Smith River subterranean, Klamath Mountains, northwestern California.

Tricolocapsa(?) sp. B
Plate 8, figure 25

Range and occurrence: Volcanic member of the Josephine ophiolite at JO-87D; rare. Smith River subterranean, Klamath Mountains, northwestern California.

Genus *Turanta* Pessagno and Blome 1982

Type species: *Turanta capsensis* Pessagno and Blome.

Remarks: Pessagno and Blome (1982, p. 296) originally stated that *Turanta* was a dicyrtid genus in which the cephalis was very fragile and only partially preserved. They illustrated a specimen that had the sides of the cephalis preserved and the roof of the cephalis missing. Subsequently, Takemura (1986) and Yeh (1987) considered *Turanta* to be monocyrtid. We still believe that the morphological evidence cited above is sufficiently strong to support the dicyrtid hypothesis favored by Pessagno and Blome.

Range: Zone 01, Subzone 01B (base) to Zone 3, Subzone 3 beta; Lower Jurassic, Toarcian to Upper Jurassic, lower Tithonian.

Occurrence: Tethyan Realm, Central Tethyan Province to Northern Tethyan Province. Boreal Realm, Southern Boreal Province.

Turanta chetcoensis Pessagno, Blome and Hull, n. sp.
Plate 8, figures 5, 7, 8

Description: Cephalis as with genus. Thorax subelliptical tending to be more elongate along CD (text-fig. 32) with mixture of relatively massive, nodose pentagonal and hexagonal pore frames. Horn and feet slender and of medium length with three longitudinal ridges alternating with three narrow ridges of equal width. Ridges and grooves gradually wedging out in a distal direction. Ventral and dorsal feet straight, widely separated; horn curved, somewhat shorter.

Remarks: *Turanta chetcoensis*, n. sp., differs from *Turanta officierense* Pessagno and Blome (1982) by having a thorax which is elongate along axis CD and by having a shorter horn and shorter feet.

Etymology: This species is named for Chetco Peak to the north of its type locality.

Measurements: (μm) Holotype + 2 paratypes and 4 topotypes. See text-figure 32 for explanation of measurements.

	AB	CD	LF	LH
Holotype	139.5	135	120	90
Mean	155.6	150.4	155	120
SD	18.4	38.3	44.1	20.3
Max.	180	195	225	132.5
Min.	130	97.5	120	90

Type locality: JO-34. See Locality Descriptions herein.

Deposition of types: Holotype = USNM 459014. Paratypes = USNM 459015 and Pessagno Collection.

Range: Zone 2, Subzone 2 delta so far as known; Oxfordian so far as known. See text-figure 27 herein.

Occurrence: Volcanopelagic strata above Josephine ophiolite, Smith River subterranean, northwestern California; Tethyan Realm, Central Tethyan Province.

Genus *Unuma* Ichikawa and Yao 1976

Type species: *Unuma typicus* Ichikawa and Yao 1976

Range: Middle Jurassic.

Occurrence: Worldwide in Tethyan Realm, Central Tethyan Province.

Unuma typicus Ichikawa and Yao

Plate 8, figure 20

Unuma typicus ICHIKAWA and YAO 1976, p. 112, pl. 1, figs. 1-3. — HATTORI 1989, p. 129, pl. 40, fig. D.

Range: Superzone 1, Zone 1H to Zone 2, Subzone 2 delta; upper Callovian to Oxfordian so far as known (see text-fig. 27). In Japan Mizutani and Koike (1982, p. 122) record *Unuma typicus* in strata that we correlate with Zone 2, Subzone 2 delta. To date, we have not recovered this taxon from Subzone 2 delta strata in the Smith River subterranean.

Occurrence: Mino Complex of Japan. Volcanic member of Josephine ophiolite, Smith River subterranean, Klamath Mountains, southwestern Oregon.

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REFERENCES

- AITA, Y., 1987. Middle Jurassic to Lower Cretaceous radiolarian biostratigraphy of Shikoku with reference to selected sections in Lombardy Basin and Sicily. Tohoku University, Science Reports, 2nd ser. (Geology), 58(1):1-91, 37 figs., 1 table, 14 pls.
- AITA, Y. and GRANT-MACKIE, J. A., 1992. Late Jurassic Radiolaria from Kowhai Point siltstone, Murihiku terrane, North Island, New Zealand. In: K. Ishizaki and T. Saito, eds., Centenary of Japanese Micropaleontology. Terra Scientific Publishing Co., Tokyo, pp. 375-382.
- BAUMGARTNER, P. O., 1980a. Late Jurassic Hagiastriidae and Patulibracchiidae (Radiolaria) from the Argolis Peninsula (Peloponnese, Greece). Micropaleontology, 26(3):274-322.
- , 1980b. Systematic paleontology. In: Baumgartner, P. O., DeWever, P., and Kocher, R., Correlation of Tethyan Late Jurassic-Early Cretaceous radiolarian events. Cahiers de Micropaleontology, 2:23-73. (New taxa authored by Baumgartner.)
- , 1984. A Middle Jurassic-Early Cretaceous low latitude radiolarian zonation based on unitary association and age of Tethyan radiolarites. Eclogae Geologicae Helveticae, 77(3):729-837, 12 pls.
- , 1987. Age and genesis of Tethyan Jurassic radiolarites. Eclogae Geologicae Helveticae, 80:831-879.
- , 1990. Genesis of Jurassic Tethyan radiolarites. The example of Monte Nerone (Umbria-Marche Apennines). Atti Conv. Int. F.E.A. Pergola, 87, Pallini et al. cur., pp. 19-32.
- BAUMGARTNER, P. O., DEWEVER, P., and KOCHER, R., 1980. Correlation of Tethyan Late Jurassic-Early Cretaceous radiolarian events. Cahiers de Micropaleontology, 2:23-73, 6 pls.
- BAUMGARTNER, P. O., GORICAN, S., JUD, R., O'DOHERTY, L., CONTI, M., DANIELIAN, T., DEWEVER, P., DUMITRICA, P., KITO, N., MARCUCCI, M., MATSUOKA, A., STEIGER, T. and URGUAT, E., 1991. A new Middle Jurassic - Early Cretaceous radiolarian biochronology of Tethys. 3rd International Symposium on Jurassic Stratigraphy, Poitiers, France, September 22-29, 1991. Abstracts, p. 16 and poster display.
- BLAKE, M. C., JR., ENGBRETSON, D. C., JAYKO, A. S. and JONES, D. L., 1985. Tectonostratigraphic terranes in southwest Oregon. In: Howell, G. D., Ed., Tectonostratigraphic terranes of Circum-Pacific Region. Circum-Pacific Council for Energy and Mineral Resources Earth Sciences Series, Volume 1:147-157.
- BLOME, C. D., 1984. Middle Jurassic (Callovian) Radiolaria from southern Alaska and eastern Oregon. Micropaleontology, 30(4):343-389, pls. 1-16.
- BURCKHARDT, C., 1910. Estudio Geologico de la Region de San Pedro del Gallo (Durango). Instituto Geol. de Mexico, Parergones tomo III, no. 6, pp. 307-357, 1 chart, 1 plate, 1 geologic map.
- CAMPBELL, A. S., 1954. Protozoa (chiefly Radiolaria and Tintinnia), Part D. In: Moore, R. C., Ed., Treatise on Invertebrate Paleontology, Protista 3. Lawrence, Kansas: Geological Society of America and University of Kansas Press, 92 pp.
- CANTUCHAPA, A., 1971. Le serie Huasteca (Jurassico medio-superior) del centro este de Mexico. Instituto Mexicano del Petroleo Revista, 3(2):17-40.
- CARTER, E. S., 1988. Part 2, Systematic Paleontology. In: Cameron, B., and Smith, P. L., Lower and Middle Jurassic Radiolarian Biostratigraphy and Systematic Paleontology, Queen Charlotte Islands, British Columbia. Geological Society of Canada Bulletin 236:110.

- DAVILA, V., 1986. Upper Jurassic and Cretaceous radiolarian biostratigraphy of the Eugenia and Asuncion formations, Vizcaino Peninsula, Baja California Sur, Mexico. Unpublished Master's thesis, Programs in Geosciences, University of Texas at Dallas, 129 p.
- DEWEVER, P., DUÉE, G. and EL KADIRI, K., 1985. Les séries stratigraphiques des klippes de Chrafate (Rif septentrional, Maroc) témoins d'une marge continentale subsidente au cours du Jurassique-Crétacé, pp. 363-379, pl. 1.
- DEWEVER, P., GEYSSANT, J. R., AZÉMA, J., DEVOS, I., DUÉE, G., MANVIT, H. and VRIELYNCK, B., 1986. La coupe de Santa Anna (Zone de Sciacca, Sicile): Une synthèse biostratigraphique des apports des macro-, micro-, et nannofossiles du Jurassique Supérieur et Crétacé Inférieur. *Revue de Micropaléontologie*, 29(3):141-186, 5 figs., 13 pls.
- DEWEVER, P. and MICONNET, P., 1985. Datations directes des radiolarites du Bassin du Lagonegro (Lucanie, Italie Meridionale) implications et conséquences. *Revista Española de Micropaleontología*, XVII(3):373-402.
- DILLER, J. S., 1907. The Mesozoic sediments of southwestern Oregon. *American Journal of Science*, 3:401-421.
- DUMITRICA, P., 1978. Family Eptingiidae, n. fam., extinct Nassellaria (Radiolaria) with sagittal ring. *Dari Seama Sedintelor Institutul si Géologie Geofizica*, 64(3):27-38.
- EHRENBERG, C. G., 1838. Über die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbare Organismen. *Königlich Akademie Wissenschaften Berlin, Abhandlung Jahrbuch 1838*: 59-147, pls. 1-4.
- , 1875. Fortsetzung, der microgeologische Studien als Gesamt-Übersicht Gebirgsarten der Erde, mit specieller Rücksicht auf den Polycystinen-Mergel von Barbados. *Königlich Akademie Wissenschaften Berlin*: 1-226, pls. 1-30.
- EL KADIRI, K., 1984. Les radiolarites jurassiques des Klippes de Chrafate (Rif septentrional, Maroc): Stratigraphie, taxonomie. Thèse 3ème Cycle, PAU (France), 2 vols., 460 pp., 30 figs., 26 pls.
- , 1992. Description de nouvelles espèces de radiolaires Jurassiques de La Dorsale Calcaire Externe (Rif, Maroc). *Revista Española de Paleontología, Extra*, 37-48.
- FOREMAN, H. P., 1973. Radiolaria from DSDP Leg 20. In: Heezen et al., Eds., *Initial Reports of the Deep Sea Drilling Project*: Washington, D.C.: U.S. Government Printing Office, 20:249-305, pls. 1-16.
- , 1975. Radiolaria from the North Pacific, Deep Sea Drilling Project, Leg 32. In: Larson, R. L. et al., *Initial Reports of the Deep Sea Drilling Project, covering Leg 32 of the cruises of the Drilling Vessel Glomar Challenger*, Volume 32:579-676. Washington, D.C.: U.S. Government Printing Office.
- , 1978. Mesozoic Radiolaria in the Atlantic Ocean off the Northwest coast of Africa, DSDP, Leg 41. In: Lancelot, Y., Seibold, E., et al., Eds., *Initial reports of the Deep Sea Drilling Project*, Volume 41:739-761. Washington, D.C.: U.S. Government Printing Office.
- GISTLE, A., 1834. Ins. -Doubletten Walworth, 19 [n.n.], 1848 Nat. Thierr., 127.
- GORDON, W. A., 1974. Physical controls on marine biotic distribution in the Jurassic Period. In: Ross, C. A., Ed., *Paleogeographic provinces and provinciality*. S.E.P.M. Special Publication, 21:136-147, 4 figs.
- GORICAN, S., 1987. Jurassic and Cretaceous radiolarians from the Budva Zone (Montenegro, Yugoslavia). *Revue de Micropaléontologie*, 30(3):177-196, pls. 1-3.
- HABIB, D. and DRUGG, W. S., 1983. Dinoflagellate age of Middle Jurassic-Early Cretaceous sediments in the Blake-Bahama Basin. In: Orlofsky, S., Ed., *Initial Reports of the Deep Sea Drilling Project*, Volume 76:623-628. Washington, D.C.: U.S. Government Printing Office.
- HAECKEL, E., 1881. Entwurf eines Radiolarien - Systems auf Grund von Studien der Challenger - Radiolarien. *Jenaische Zeitschrift Naturwissenschaft*, 15(8):418-472.
- , 1887. Report on the Radiolaria collected by H.M.S. Challenger during the years 1873-76. Reports of the Voyage of the Challenger, 1873-1876. *Zoology*, 18(1-2):1-1803, pls. 1-140.
- HARPER, G. D., 1983. A depositional contact between the Galice Formation and a Late Jurassic ophiolite in northwestern California and southwestern Oregon. *Oregon Geology*, 45(1):3-9.
- , 1984. Josephine ophiolite, northwestern California. *Geological Society of America Bulletin*, 95(9):1009-1026.
- HARPER, G. D., SALEEBY, J. B., CASHMAN, S. and NORMAN, E. A. S., 1986. Isotopic age of the Nevadan Orogeny in the western Klamath Mountains, California-Oregon, Cordilleran Section, *Geological Society of America, Abstracts with Programs*, 18(2):114.
- HATTORI, I., 1989. Jurassic radiolarians from manganese nodules at three sites in the western Nanjo Massif, Fukui Prefecture, central Japan (DATA). *Journal Faculty Education, Fukui Univ., Pt. II (Natural Science)*, 36:47-134, pls. 1-45.
- HEITZER, I., 1930. Die Radiolarienfauna der mittelljurassischen Kieselmergel im Sonwendgebirge. *Jahrbuch Geologisch Bundesanstalt*, 80:381-406.
- HOPSON, C. A., MATTINSON, J. M. and PESSAGNO, E. A., JR., 1981. Coast Range ophiolite, western California. In: Ernst, W. G., Ed., *The Geotectonic Development of California*, Rubey Volume I. Englewood Cliffs, New Jersey: Prentice-Hall, pp. 419-510.
- HULL, D., 1991. Upper Jurassic Radiolarian biostratigraphy of the lower member of the Taman Formation, east-central Mexico and of volcanopelagic strata overlying the Coast Range ophiolite, Stanley Mountain, Southern California Coast Ranges. Ph.D. dissertation, Univ. Texas at Dallas, 696 pp., 62 pl.
- ICHIKAWA, K. and YAO, A., 1976. Two new genera of Mesozoic cyrtoid radiolarians from Japan. *Progress in Micropaleontology, Micropaleontology Press Special Publication*. New York: American Museum of Natural History, pp. 110-117.
- ICZN [International Code of Zoological Nomenclature], 1985. Adopted by the 20th General Assembly of the International Union of Biological Sciences. 338 pp.
- IMLAY, R. W., 1961. Late Jurassic ammonites from the western Sierra Nevada, California. U.S. Geological Survey Professional Paper 374-D: D-1-D-30, 6 pls.
- , 1980. Jurassic paleobiogeography of conterminous United States in its continental setting. U.S. Geological Survey Professional Paper 1062: 134 pp.
- , 1981. Jurassic (Bathonian and Callovian) ammonites in eastern Oregon and western Idaho. U.S. Geological Survey Professional Paper 1142, 24 p.
- INTERNATIONAL SUBCOMMISSION ON STRATIGRAPHIC CLASSIFICATION, 1976. International stratigraphic guide. In: Hedberg, H. D., Ed., *A guide to stratigraphic classification, terminology, and procedure*. New York: John Wiley and Sons, 200 pp.
- IRWIN, W. P., 1985. Age and tectonics of plutonic belts in accreted terranes of the Klamath Mountains, California and Oregon. In: Howell, G. D., Ed.,

- Tectonostratigraphic terranes of Circum-Pacific Region. Circum-Pacific Council for Energy and Mineral Resources Earth Sciences Series, Volume 1:187-199.
- , 1989. Terranes of the Klamath Mountains, California, and Oregon. International Geological Congress Guidebook, Field Trip T108, Tectonic Evolution of Northern California.
- JONES, D. L., 1975. Discovery of *Buchia rugosa* Kimmeridgian age from the base of the Great Valley sequence. Geological Society of America, Abstracts with Programs, Cordilleran Section, 7(3):330.
- KAWABATA, K., 1988. New species of latest Jurassic and earliest Cretaceous radiolarians from the Sorachi Group in Hokkaido, Japan. Bulletin of the Osaka Museum of Natural History, 43:1-13, 3 pls.
- KIDO, S., KAWAGUCHI, I., ADACHI, M. and MIZUTANI, S., 1982. On the *Dictyonitella* (?) *kamoensis* – *Pantanelium foveatum* assemblage in the Minor area, central Japan. Japanese Academy, 57-B(8):194-199.
- KITO, N., DE WEVER, P., DANELIAN, T. and CORDEY, F., 1990. Middle to Late Jurassic Radiolarians from Sicily (Italy). Marine Micropaleontology, 15:329-349.
- KOCHER, R. N., 1981. Biostratigraphische Untersuchungen oberjurassischer radiolarienführender Gesteine insbesondere der Südalpen. Mitteilungen Geologisch Institut ETH und Zürich. [N.F.] 234:1-184.
- KOZUR, H. and MOSTLER, H., 1972. Beiträge zur erforschung der Mesozoische Radiolarien. Teil 1: Revision der Oberfamilie Coccodiscacea Haeckel, 1862 und Beschreibung ihrer Triassischen Vertreter. Geologisch Paläontologisch Mitteilungen Innsbruck, 2:1-60.
- LONGORIA, J. F., 1984. Mesozoic tectonostratigraphic domains in east-central Mexico. In: Westermann, G. E. G., Ed., Jurassic-Cretaceous Biochronology and Paleogeography of North America. Geological Association of Canada Special Paper 27:6576.
- , 1985. Tectonic Transpression in the Sierra Madre Oriental, North-eastern Mexico: An Alternative Model. Geology, 453-456.
- MACLEOD, N., 1988. Lower and Middle Jurassic *Perispyridium* (Radiolaria) from the Snowshoe Formation, east-central Oregon. Micropaleontology, 34(4):289-315, pls. 1-5.
- MATSUOKA, A., 1988. Jurassic radiolarian succession in Japan. Conference Book, First International Conference on Radiolaria (EuroRad V), Abstracts, pp. 25-26.
- MATSUOKA, A. and YAO, A., 1986. A newly proposed radiolarian zonation for the Jurassic of Japan. Marine Micropaleontology, 11:95-105.
- MIZUTANI, S., HATTORI, I., ADACHI, M., WAKITA, K., OKAMURA, Y., KIDO, S., KAWAGUCHI, I. and KOJIMA, S., 1981. Jurassic formations in the Mino area, central Japan. Proceedings of the Japan Academy, 57(B):194-199.
- MIZUTANI, S. and KIDO, S., 1983. Radiolarians in Middle Jurassic siliceous shale from Kamaizao, Gifu Prefecture, central Japan. Transactions and Proceedings of the Palaeontological Society of Japan, N.S., 132:253-262, pls. 51-53.
- MIZUTANI, S. and KOIKE, T., 1982. Radiolarians in the Jurassic siliceous shale and in the Triassic bedded chert of Unuma, Kagamigahara City, Gifu Prefecture, Japan. In: Proceedings of the First Japanese Radiolarian Symposium. News of Osaka Micropaleontologists Special Vol. No. 5:117-134.
- MOORE, T. C., 1973. Radiolaria from Leg 17 of the Deep Sea Drilling Project. In: Winterer, E. L., et al., Initial Reports of the Deep Sea Drilling Project, Volume 17:797-869. Washington, D.C.: U.S. Government Printing Office.
- MURCHEY, B., 1984. Biostratigraphy and lithostratigraphy of chert in the Franciscan Complex, Marin Headlands, California. In: Blake, M. C. Ed., Franciscan Geology of Northern California. Pacific Section S.E.P.M., 43: 51-70.
- MUZAVOR, S. N. X., 1977. Die Oberjurassische Radiolarien fauna von Oberaudorf am Inn. Dis. Fachber. Geowiss. Ludwig-Maximilians-Univ., München, pp. 1-163.
- NAGAI, H. and MIZUTANI, S., 1990. Jurassic *Eucyrtidellum* (Radiolaria) in the Mino terrane. Transactions and Proceedings of the Palaeontological Society of Japan, N.S., 159:587-602.
- NEVIANI, A., 1900. Supplemento alla fauna a Radiolari delle rocce mesozoiche del Bolognese. Bolletino Società Geologica Italiana, 19:645-671, pls. 9-10.
- O'DOHERTY, L., BAUMGARTNER, P. O., MARTINALGARRA, A. and SANDOVAL, J., 1991. Paleogeography and biostratigraphy of Middle and Late Jurassic radiolarites in the Betic Cordillera. 3rd International Symposium on Jurassic Stratigraphy, Poitiers, France, September 22-29, 1991. Abstracts, p. 88.
- OZVOLDOVÁ, L., 1975. Upper Jurassic radiolarians from the Kysuca Series in the Klippen Belt. Západné Karpaty, Séria Paleontológia 1:73-86.
- , 1979. Radiolarian assemblage of radiolarian cherts at Podbiel locality (Slovakia). Cas. Mineralógia Geológia, 24(3):249-266.
- , 1990. Radiolarian microfauna from radiolarites of the Varín part of the West Carpathian Klippen Belt. Geologicky Zborník-Geologica Carpathica, 41:295-310.
- OZVOLDOVÁ, L. and PETERČÁKOVÁ, M., 1987. Biostratigraphic research of Upper Jurassic limestones of the Cachtice Carpathians (locality Bzince pod Javorinou). Západné Karpaty, Séria Paleontológia 12. Geologicky Ústav D. Stúra, Bratislava, pp. 115-124.
- PESSAGNO, E. A., JR., 1971. Jurassic and Cretaceous Hagiastriidae from the Blake-Bahama Basin (Site 5A, JOIDES Leg 1) and the Great Valley sequence, California Coast Ranges. Bulletins of American Paleontology, 63(264):1-83, pls. 1-19, text-figs. 1-5.
- , 1973. Upper Cretaceous Spumellariina from the Great Valley sequence, California Coast Ranges. Bulletins of American Paleontology, 63(276):49-102, pls. 9-21.
- , 1976. Radiolarian zonation and stratigraphy of the Upper Cretaceous portion of the Great Valley Sequence, California Coast Ranges. Micropaleontology Special Publication 2. New York: American Museum of Natural History, pp. 1-95, 14 pls.
- , 1977a. Upper Jurassic Radiolaria and radiolarian biostratigraphy of the California Coast Ranges. Micropaleontology, 23(1):117-134.
- , 1977b. Lower Cretaceous radiolarian biostratigraphy of the Great Valley sequence and Franciscan Complex, California Coast Ranges. Cushman Foundation for Foraminiferal Research Special Publication No. 15:1-87.
- , 1979. Systematic Paleontology. In: Pessagno, E. A., Jr., Finch, W. and Abbott, P. L., Upper Triassic Radiolaria from the San Hipólito Formation, Baja California. Micropaleontology, 25(2):160-197, pls. 1-9.
- , 1984. Systematic Paleontology. In: Pessagno, E. A., Jr., Blome, C. D. and Longoria, J. F. A revised radiolarian zonation for the Upper Jurassic of western North America. Bulletins of American Paleontology, 87(320):1-51, pls. 1-5.
- , 1986. Faunal affinities and tectonogenesis of Mesozoic rocks in the Blue Mountains Province of Eastern Oregon and Western Idaho. In: Vallier, T. C. and Brooks, H., Eds., Geology of the Blue Mountains region

- of Oregon, Idaho, and Washington. Geologic implications of Paleozoic and Mesozoic paleontology and biostratigraphy, Blue Mountains Province, Oregon and Idaho. USGS Prof. Paper 1435: 65-78.
- , 1988. Biostratigraphic, chronostratigraphic, and U/Pb geochronometric data from the Rogue and Galice formations, Western Klamath terrane (Oregon and California): their bearing on the age of the Oxfordian–Kimmeridgian boundary and the *Mirifusus* first occurrence event. 2nd International Symposium on Jurassic Stratigraphy, Lisbon, Portugal, 1:477-490.
- , 1990. Implications of new Jurassic stratigraphic, geochronometric, and paleolatitudinal data from the Western Klamath terrane (Smith River and Rogue Valley subterrane). *Geology*, 18:665-668.
- PESSAGNO, E. A., JR. and BLOME, C. D., 1980. Upper Triassic and Jurassic Pantanelliinae from California, Oregon and British Columbia. *Micropaleontology*, 26(3):225-273, pls 1-11.
- , 1982. Bizarre Nasselleriina (Radiolaria) from the Middle and Upper Jurassic of North America. *Micropaleontology*, 28(3):289-318.
- PESSAGNO, E. A., JR., BLOME, C. D., CARTER, E. S., MACLEOD, N., WHALEN, P. A. and YEH, K.-Y., 1987b. Studies of North American Jurassic Radiolaria. Part II, Preliminary Radiolarian Zonation for the Jurassic of North America. Cushman Foundation for Foraminiferal Research Special Publication, 23(II):1-18, figs. 1-7.
- PESSAGNO, E. A., JR., BLOME, C. D. and LONGORIA, J. F., 1984. A revised radiolarian zonation for the Upper Jurassic of western North America. *Bulletins of American Paleontology*, 87(320):1-51, pls. 1-5.
- PESSAGNO, E. A., JR., HOPSON, C. A., MATTINSON, J. M., BLOME, C. D., LUYENDYK, B. P., HULL, D. and BEEBE, W., in prep. Coast Range Ophiolite and its sedimentary cover (California Coast Ranges): Jurassic stratigraphy and northward tectonic transport. 45 p. ms.
- PESSAGNO, E. A., JR., HULL, D. M. and PUJANA, I., 1991. Correlation of Circum-Pacific upper Tithonian Boreal and Tethyan strata in Northern and Southern Hemispheres: Synthesis of radiolarian and ammonite biostratigraphic and chronostratigraphic data. 3rd International Symposium on Jurassic Stratigraphy. Poitiers, France: Abstract Volume, p. 97.
- PESSAGNO, E. A., JR., LONGORIA, J. F., MACLEOD, N. and SIX, W. M., 1987a. Studies of North American Jurassic Radiolaria. Part I, Upper Jurassic (Kimmeridgian-upper Tithonian) Pantanelliidae from the Taman Formation, east-central Mexico: tectonostratigraphic, chronostratigraphic, and phylogenetic implications. Cushman Foundation for Foraminiferal Research Special Publication, 23(I):1-51, pls. 1-7, figs. 1-9.
- PESSAGNO, E. A., JR. and MACLEOD, N., 1987. Systematic Paleontology. In: Pessagno, E. A., Jr., Longoria, J. F., MacLeod, N. and Six, W. M., Studies of North American Jurassic Radiolaria. Part I, Upper Jurassic (Kimmeridgian-upper Tithonian) Pantanelliidae from the Taman Formation, east-central Mexico: tectonostratigraphic, chronostratigraphic, and phylogenetic implications. Cushman Foundation for Foraminiferal Research Special Publication, 23(I):19-49.
- PESSAGNO, E. A., JR. and MIZUTANI, S., 1992. Radiolarian biozones of North America and Japan. In: Westermann, G. E. G., Ed., *The Jurassic of the Circum-Pacific*. Cambridge, England: Cambridge University Press, pp. 293-295.
- PESSAGNO, E. A., JR. and POISSON, A., 1981. Lower Jurassic Radiolaria and Gümlüslü Allochthon of Southwestern Turkey (Taurides Occidentales). *Bulletin of Mineral Research and Exploration Institute of Turkey* 92: 47-69, 15 pls.
- PESSAGNO, E. A., JR., SIX, W. M. and YANG, Q., 1989. The Xiphostylidae Haeckel and Parvivaccidae, n. fam. (Radiolaria), from the North American Jurassic. *Micropaleontology*, 35(3):193-255, pls. 1-10, text-figs. 1-11.
- PESSAGNO, E. A., JR. and WHALEN, P. A., 1982. Lower and Middle Jurassic Radiolaria from California, east-central Oregon, and the Queen Charlotte Islands, British Columbia. *Micropaleontology*, 28(2):111-169.
- PESSAGNO, E. A., JR., WHALEN, P. A. and YEH, K., 1986. Jurassic Nasselleriina (Radiolaria) from North American geological terranes. *Bulletins of American Paleontology*, 91(326):68 pp.
- PESSAGNO, E. A., JR. and YANG, Q., 1989. Systematic Paleontology. In: Pessagno, E. A., Jr., Six, W. M. and Yang, Q., *The Xiphostylidae Haeckel and Parvivaccidae, n. fam. (Radiolaria), from the North American Jurassic*. *Micropaleontology*, 35(3):202-245.
- PUJANA, I., 1991. Pantanelliidae (Radiolaria) from the Tithonian of the Vaca Muerta Formation, Neuquén, Argentina. *Neues Jahrbuch Geologie und Paläontologie Abhandlungen*, 180(3):391-408.
- RIEDEL, W. R., 1967. A symposium with documentation. Chapter 8 (Protozoa), The fossil record. Geological Society of London, pp. 291-332.
- , 1971. Systematic classification of polycystine Radiolaria. In: Funnel, B. and Riedel, W. R., Eds., *The micropaleontology of the oceans*. Cambridge: Cambridge University Press, pp. 649-661.
- RIEDEL, W. R. and SANFILIPPO, A., 1974. Radiolaria from the southern Indian Ocean, DSDP Leg 26. In: Davies, T. A., Luyendyk, B. P. et al., *Initial Reports of the Deep Sea Drilling Project, Volume 26:771-814*, pls. 1-15. Washington, D.C.: U.S. Government Printing Office.
- ROTH, P. H., 1983. Jurassic and Lower Cretaceous calcareous nannofossils in the western Atlantic (Site 534): Biostratigraphy, preservation, and some observations on biogeography and paleoceanography. In: Orlofsky, S., Ed., *Initial Reports of the Deep Sea Drilling Project, Volume 76:587-615*. Washington, D.C.: U.S. Government Printing Office.
- ROTH, P. H., MEED, A. W. and WATKINS, D. K., 1983. Jurassic calcareous nannofossil zonation, an overview with new evidence from the Deep Sea Drilling Project Site 534. In: Orlofsky, S., Ed., *Initial Reports of the Deep Sea Drilling Project Volume 76:573-579*. Washington, D.C.: U.S. Government Printing Office.
- RÜST, D., 1885. Beiträge zur kenntniss der fossilen Radiolarien aus Gesteinen des Jura. *Palaeontographica*, 31(ser. 3):269-321, pls. 26-45.
- , 1898. Neue Beiträge zur Kenntniss fossilen Radiolarien aus Gesteinen des Jura und der Kreide. *Paleontographica*, 45:1-67, pls. 1-19.
- SALEEBY, J. B., 1984. Pb/U zircon ages from the Rogue River area, Western Jurassic belt, Klamath Mountains, Oregon, Geological Society of America, Abstracts with Program, 16(5):331.
- , 1987. Discordance patterns in Pb/U zircon ages of the Sierra Nevada and Klamath Mountains. *EOS*, 68(44):1514-1515.
- SALEEBY, J. B., HARPER, G. D., SNOKE, A. W. and SHARP, W. D., 1982. Time relations and structural-stratigraphic patterns in ophiolite accretion, west-central Klamath Mountains, California. *Journal of Geophysical Research*, 87(B5):3831-3848.
- SILBERLING, N. J., JONES, D. L., BLAKE, M. C., JR. and HOWELL, D. G., 1984. Part C - Lithotectonic terrane map of the western conterminous United States. In: Silberling, N. J. and Jones, D. L., Eds., *Lithotectonic terrane maps of the North American Cordillera*. U.S. Geological Survey Open-File Report 84-523, C-1-C43.
- SMITH, A. G., HURLEY M. and BRIDEN, J. C., 1981. Phanerozoic paleocontinental world maps. Cambridge: Cambridge University Press, pp. 1-102.
- SQUINABOL, S., 1903. Le Radiolarie dei noduli selciosi nella scaglia degli Euganei. *Rivista Italiana Paleontologia*, 9(4):105-150.

- TAKEMURA, A., 1986. Classification of Jurassic nassellarians (Radiolaria). *Palaeontographica*, Abt. A, 195:29-74.
- TAYLOR, D. G., CALLOMON, J. H., HALL, R., SMITH, P. L., TIPPER, H. W. and WESTERMANN, G. E. G., 1984. Jurassic ammonite biogeography of western North America: The tectonic implications. In: Westermann, G. E. G., Ed., *Jurassic-Cretaceous biochronology and paleogeography of North America*. Geological Association of Canada Special Paper 27, 121-141.
- WAKITA, K., 1982. Jurassic radiolarians from Kuzuryu-ko-Gujohachiman area. In: *Proceedings of the First Japanese radiolarian symposium*. News of Osaka Micropaleontologists Special Vol. No. 5:153-172.
- WELLS, F. G. and WALKER, G. W., 1953. Geology of the Galice Quadrangle, Oregon. U.S. Geological Survey Geologic Quadrangle Map GQ-25, scale 1:62,500.
- WISNIOWSKI, T., 1889. Beitrag zur Kenntniss der Mikrofauna aus den oberjurassischen Feuersteinknollen der Umgegend von Krakau. *Jahrbuch Kaaiserl. Königlich Geologisch Reichsanstalt*, Wien, 38(3) (1888):657-702, pls. 12-13.
- WRIGHT, J. E. and WYLD, S. J., 1986. Significance of xenocrystic Pre-Cambrian zircon contained within the southern continuation of the Josephine ophiolite: Devils Elbow ophiolite remnant, Klamath Mountains, northern California. *Geology*, 14:671-674.
- YAMAMOTO, H., MIZUTANI, S. and KAGAMI, H., 1985. Middle Jurassic radiolarians from the Blake-Bahama Basin, West Atlantic Ocean. *Bulletin Nagoya University Museum*, 1:25-49.
- YANG, Q., 1988. Upper Jurassic (upper Tithonian) Radiolaria from the Taman Formation, east-central Mexico. Ph. D. dissertation, University of Texas at Dallas, 228 pp., 35 pls.
- , in press. Upper Jurassic (upper Tithonian) Radiolaria from the Taman Formation, east-central Mexico. *Palaeontologia Cathayana*, no. 7.
- YANG, Q. and PESSAGNO, E. A., JR., 1989. Upper Tithonian Vallupinae (Radiolaria) from the Taman Formation, east-central Mexico. *Micropaleontology*, 35(2):114-134.
- YANG, Q. and WANG, Y., 1990. A taxonomic study of Upper Jurassic Radiolaria from Rutog Country, Xizang (Tibet). *Acta Micropaleontologica Sinica*, 7(3):195-218, pls. 1-4.
- YAO, A., 1972. Radiolarian fauna from the Mino Belt in the northern part of the Inuyama area, central Japan. Part I. Spongosaturnalids. *Osaka City University, Journal of Geoscience*, 15(2):21-64.
- , 1979. Radiolarian fauna from the Mino Belt in the northern part of the Inuyama area, central Japan. *Journal of Geoscience*, Osaka City University, 22(2):21-72.
- YEH, K., 1987. Taxonomic studies of Lower Jurassic Radiolaria from east-central Oregon. Special Publications Number 2, National Museum of Natural Science, Taichung, Taiwan, R.O.C., pp. 1-169, 30 pls.

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APPENDIX 1

Locality Descriptions

Western Klamath Terrane

Smith River Subterrane

Volcanic member, Josephine ophiolite

JO-86—JO-90: Tuffaceous cherts within upper basalt member of Josephine Ophiolite. Samples collected at Turner Albright Mine. Text-figure 3.

JO-86A-E. Medium to dark gray tuffaceous chert/siliceous mudstone weathering light green to buff. Sedimentary strata occurring within basalt.

JO-87A-D. Same lithology as JO-86. Along strike with JO-86.

JO-88A-E. Same lithology except that JO-88E consists of red tuffaceous mudstone.

JO-89A-E. Adjacent samples. Pockets of green weathering tuffaceous chert in pillow basalt.

JO-90. Light gray to bleached tuffaceous chert.

Volcanopelagic succession (VP)

Samples are listed both biostratigraphically and chronostratigraphically in ascending order except where otherwise indicated. Middle Fork of Smith River. See text-figures 2 and 12.

JO-60. 2.5m (8.2ft) above contact with Josephine ophiolite (JO). Thin stringer of medium gray, micritic pelagic limestone interbedded with black tuffaceous chert.

JO-6. 4.1m (13.5ft) above contact with Josephine ophiolite (JO). Black, laminated tuffaceous chert or cherty tuff.

JO-61. 11.8m (39.0ft) above contact with JO. Thin stringer of medium gray, micritic pelagic limestone interbedded with dark gray tuffaceous chert and mudstone.

JO-62. 12.1m (40.4ft) above contact with JO. Same as JO-61.

JO-8. 12.8m (42.2ft) above contact with JO. Lenticular mass of medium gray, micritic, pelagic limestone 62 x 15cm (24 x 6 in) interbedded with dark gray tuffaceous chert and mudstone.

JO-34. 17.68m (58ft) above contact with JO. Lenticular mass of medium gray, micritic, pelagic limestone 62 x 15cm (24 x 6 in) interbedded with dark gray tuffaceous chert and mudstone.

JO-67. 18.4m (60.6ft) above contact with JO. Lens of medium gray pelagic limestone about 5 x 15cm (2 x 6 in) in dimension.

JO-10.5 20.3m (66.7ft) above contact with JO. Lens of medium gray pelagic limestone about 5 x 15cm (2 x 6 in) in dimension interbedded with dark gray tuffaceous chert and mudstone.

JO-69. 20.7m (68.1ft) above contact with JO. Lens of medium gray pelagic limestone about 5 x 15cm (2 x 6 in) in dimension interbedded with dark gray tuffaceous chert and mudstone.

JO-70. 21.3m (70.1ft) above contact with JO. Lens of medium gray pelagic limestone about 5 x 6.8cm (2 x 3 in) in dimension interbedded with dark gray tuffaceous chert and mudstone.

JO-71. 33.3m (109.25ft) above contact with JO. Thin bed of medium gray pelagic limestone interbedded with dark gray tuffaceous mudstone and chert.

JO-73. 39.7m (130.25ft) above contact with JO. Lens of medium gray pelagic limestone about 10 x 20cm (4 x 8 in) interbedded with dark gray tuffaceous chert and mudstone.

Galice Formation s.l.

JO-16. 57.2m (187.7ft) above contact with JO. Light gray pelagic limestone interbedded with dark gray siliceous mudstone, black chert and graywacke.

JO-17. 60.2m (197.7ft) above contact with JO. Thin-bed of light gray pelagic limestone interbedded with dark gray siliceous mudstone, black chert and graywacke.

JO-19, JO-47. 64.2m (210.7ft) above contact with JO. Stringer of light gray pelagic limestone interbedded with dark gray siliceous mudstone, black chert and graywacke.

JO-48. 66.7m (219.0ft) above contact with JO. Thin bed of light gray pelagic limestone interbedded with dark gray siliceous mudstone, black chert and graywacke.

JO-49. 70m (229.7ft) above contact with JO. Thin bed of light gray pelagic limestone interbedded with dark gray siliceous mudstone, black chert and graywacke.

JO-50. 73.3m (240.7ft) above contact with JO. Thin bed of light gray pelagic limestone interbedded with dark gray siliceous mudstone, black chert and graywacke.

JO-53. 85.7m (281.2ft) above contact with JO. Thin bed of light gray pelagic limestone interbedded with dark gray siliceous mudstone, black chert and graywacke.

JO-79. 91.4m (300ft) above contact with JO. Thin bed of light gray pelagic limestone interbedded with dark gray siliceous mudstone, black chert and graywacke.

Miscellaneous samples from the volcanopelagic succession at other localities

JO-83. 12.5m (41ft) below contact with Galice Formation. Little Jones Creek* near its junction with Middle Fork of Smith River. See text-figure 2. *Note: Little Jones Creek is referred to as Jones Creek on the U.S.G.S. Gasquet Quadrangle (15'). Harper (1984) refers to the same creek as Little Jones Creek.

JO-84. 8.1m (26.6ft) below contact with Galice Formation. Little Jones Creek near its junction with Middle Fork of Smith River. See text-figure 2.

JO-57A, C. U.S.G.S. Gasquet Quadrangle (15'): T18N; R9W; NE section 15. Black, manganiferous radiolarian chert near contact between VP succession and JO. Harper Locality 4. U.S.N.F.S road 316 along Shelly Creek.

Rogue Valley subterranean

RR-89-8A-D: Entrance to mine shaft of Alameda Mine. See text-figure 10. Green to gray, Thin bedded vitric tuff from entrance to mine shaft. Tuff containing abundant Radiolaria.

Galice Formation s.s.

RR-2A, 2B, RR-89-11. 3.0m (10ft) above the contact with the Rogue Formation. Shoreline of Rogue River below the Alameda Mine. See text-figure 10. Medium gray pelagic limestone in lenticular masses interfingering with medium beds of graywacke. Calcified and pyritized radiolaria.