*Journal of Paleontology*, 87(5), 2013, p. 909–921

0022-3360/13/0087-909$03.00
DOI: 10.1666/12-138

# MIXED TETHYAN AND McCLOUD BELT RUGOSE CORALS AND FUSULINIDS IN AN UPPER TRIASSIC CONGLOMERATE, CENTRAL OREGON

MERLYND K. NESTELL[1] AND CALVIN H. STEVENS[2]
[1]Department of Earth and Environmental Sciences, The University of Texas at Arlington, Arlington, Texas 76019, USA,<nestell@uta.edu>; and [2]Department of Geology, San Jose State University, San Jose, California 95192-0102, USA, <calvin.stevens@sjsu.edu>

ABSTRACT—Colonial rugose corals ranging in age from Carboniferous to Late Triassic and Early Permian (Cisuralian) fusulinids have been recovered from cobbles in a conglomerate in the Upper Triassic Brisbois Member of the Vester Formation in the Izee terrane in central Oregon. Early Permian (late Sakmarian or early Artinskian) fusulinids typical of those present in the Coyote Butte Limestone in the nearby Grindstone terrane (part of the allochthonous McCloud Belt) include *Eoparafusulina*, *Pseudofusulinella*, *Chalaroschwagerina, and Schwagerina*. The presence of these fusulinid genera and the Pennsylvanian coral *Heritschioides*?, which is mostly restricted to the McCloud Belt, suggest these particular cobbles were derived from limestone in that belt. The Early Permian fusulinids *Changmeia bostwicki* new species and *Changmeia bigflatensis* new species, and the Early Permian corals *Yokoyamaella*? *oregonensis* new species and *Yokoyamaella*? sp. 1, all of which have Tethyan affinities, occur rarely in other cobbles. The presence of definitive fossils from the two different realms in a conglomerate associated with beds containing Late Triassic ammonoids indicates that by Late Triassic time a fragment of a Tethyan terrane was close to or had been amalgamated with a terrane belonging to the McCloud Belt.

## INTRODUCTION

THE BLUE MOUNTAINS province of central and eastern Oregon comprises a complex mosaic of accreted terranes composed of Paleozoic and Mesozoic rocks exposed as inliers (Fig. 1) interspersed with and surrounded by Cenozoic sedimentary and volcanic rocks. The Izee and Grindstone terranes (Fig. 1) contain some of the best exposures of relatively unmetamorphosed Paleozoic and Mesozoic rocks in this region. The Izee terrane, which contains the cobbles bearing the fossils described here, also contains in situ faunas dominated by ammonites and radiolarians of Mesozoic age (Dickinson and Vigrass, 1964; Dickinson and Thayer, 1978; Blome, 1984). The Grindstone terrane, part of the McCloud Belt of Miller (1987), all of which is considered to have formed on volcanic arcs located off of the coast of Paleo North America (e.g., Belasky and Stevens, 2006), ranges in age from Devonian to Late Permian (Merriam, 1942; Dickinson and Vigrass, 1965; Skinner and Wilde, 1966; Blome and Nestell, 1991; Blome and Reed, 1992) based on several groups of fossils including corals, fusulinaceans and radiolarians. Fusulinacean-bearing cobbles of Middle Permian age are very rare in the material collected in the Big Flat area. In particular, no verbeekinids or neoschwagerinids have ever been found in rocks of the Grindstone or Izee terranes although these forms are known from several localities in the mélange of the Baker terrane (Nestell, 1998).

In recent years, the distribution and postulated emplacement of the various exotic terranes of central and eastern Oregon have been extensively studied and revised by a number of workers (Dorsey and LaMaskin, 2007; Schwartz et al., 2009; LaMaskin et al., 2011), but this paper is not the place to debate the correct assignment of the various terranes. Briefly, in the newer terminology introduced for these terranes, the Late Triassic and Early Jurassic age rocks of the Izee terrane would be referred to as belonging to Megasequence 1 (MS-1) as interpreted by Dorsey and LaMaskin (2008).

This paper documents several new and interesting corals and fusulinaceans which occur in cobbles from a conglomerate in the Upper Triassic Brisbois Member of the Vester Formation located in the Big Flat area (Fig. 2) in the southernmost part of the Izee terrane that were collected by Nestell during a number of visits to the area over many years. This conglomerate crops out in many parts of the Big Flat area and, with careful searching, has yielded many rounded to subangular fossil-bearing carbonate clasts that range from pebble size up to 25 cm (Fig. 3). The associated siltstone and the matrix of the coarse conglomerate contain scarce, poorly preserved ammonoids of Carnian age (one specimen was identified as *Discotropites* sp. by N. Silberling, personal commun., 1998). A specimen identified as *Discotropites sengeli* (Mojsisovics, 1893) and deposited in the University of Oregon Museum of Natural and Cultural History, is known from strata of the Brisbois Member of the Vester Formation near Suplee not far to the northwest of the conglomerate locality. Fusulinacean species of *Chalaroschwagerina* Skinner and Wilde, 1965, *Pseudofusulinella* Thompson, 1951, and *Schwagerina* von Möller, 1877, as described by Skinner and Wilde (1966) from the Coyote Butte Limestone in the Grindstone terrane located adjacent to and to the west of the Izee terrane, are common in the cobbles of this conglomerate, whereas corals characteristic of the McCloud Belt, including the genus *Heritschioides*?, are scarce. Tethyan corals and fusulinaceans are very rare.

This conglomerate, which bears the corals and fusulinids described here, also has yielded a large cobble bearing *Polydiexodina oregonensis* Bostwick and Nestell, 1965. The unique occurrence of a true central tunnel-bearing *Polydiexodina* Dunbar and Skinner, 1931 in east-central Oregon is unusual as true central tunnel-bearing *Polydiexodina* are only known elsewhere in North America in Late Guadalupian (Middle Permian) age strata in West Texas and Mexico. As Skinner (1971, p. 5) stated, large, later Middle Permian fusulinaceans "can be divided into three major groups". His

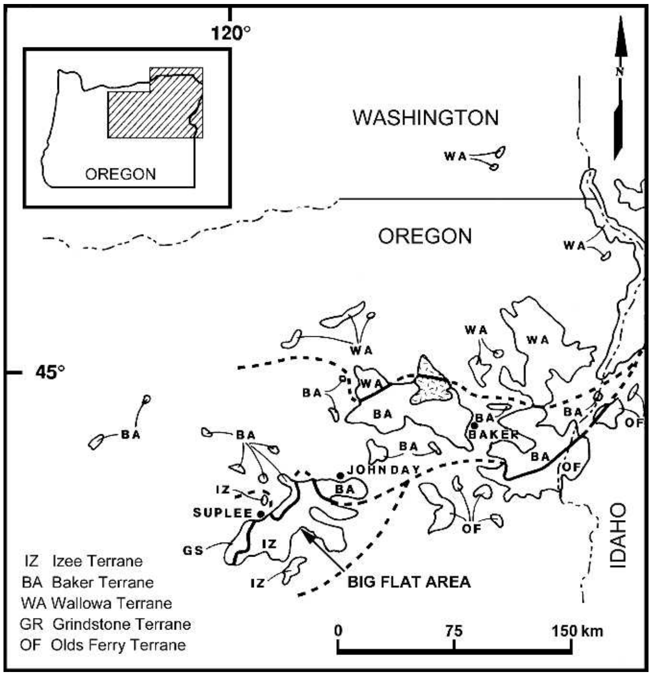



FIGURE 1 —Pre-Tertiary terranes in the Blue Mountain province, east central and northeastern Oregon.

first group consisted of true *Polydiexodina*, represented by *P. capitanensis* Dunbar and Skinner, 1931, *P. shumardi* Dunbar and Skinner, 1931, *P. mexicana* Dunbar, 1944, and *P. oregonensis* Bostwick and Nestell, 1965, which are large and elongate subcylindrical in shape. Species of this group possess a well-defined median tunnel and persistent, more or less regularly arranged supplementary tunnels. The second group contains *Skinnerina* Ross, 1964*,* and the third group consists of forms later referred to as *Eopolydiexodina* Wilde, 1975. This latter form, which is common in Middle Permian (Roadian–Wordian) Tethyan fusulinacean faunas extending from the Mediterranean to middle and eastern Asia (Kobayashi, 1997; Leven, 1997), has no well-defined median tunnel and its supplementary tunnels are sporadic and discontinuous.

## SYSTEMATIC PALEONTOLOGY

*Locality and repository data*.—All of the corals were assigned a SJS number referring to the locality followed by a letter designating the particular specimen described. All figured specimens also were assigned the letter C followed by the number of that slide. Slides of all holotypes are housed in the collections of the U.S. National Museum and bear a USNM number as well as a C number. Slides of other figured specimens, as well as all samples including the holotypes, are retained in the University of California Museum of Paleontology at Berkeley. Fusulinaceans are deposited in the University of Kansas Museum of Invertebrate Paleontology (KUMIP) because this museum houses the fusulinaceans from other exotic terranes of the Pacific Northwest described by Skinner and Wilde in several publications. Measurements for the fusulinaceans are presented in Table 1.

### FUSULINACEANS

Superorder FUSULINOIDA Fursenko, 1958
Order SCHWAGERINIDA Solovieva, 1985
Family SCHWAGERINIDAE Dunbar and Henbest, 1930

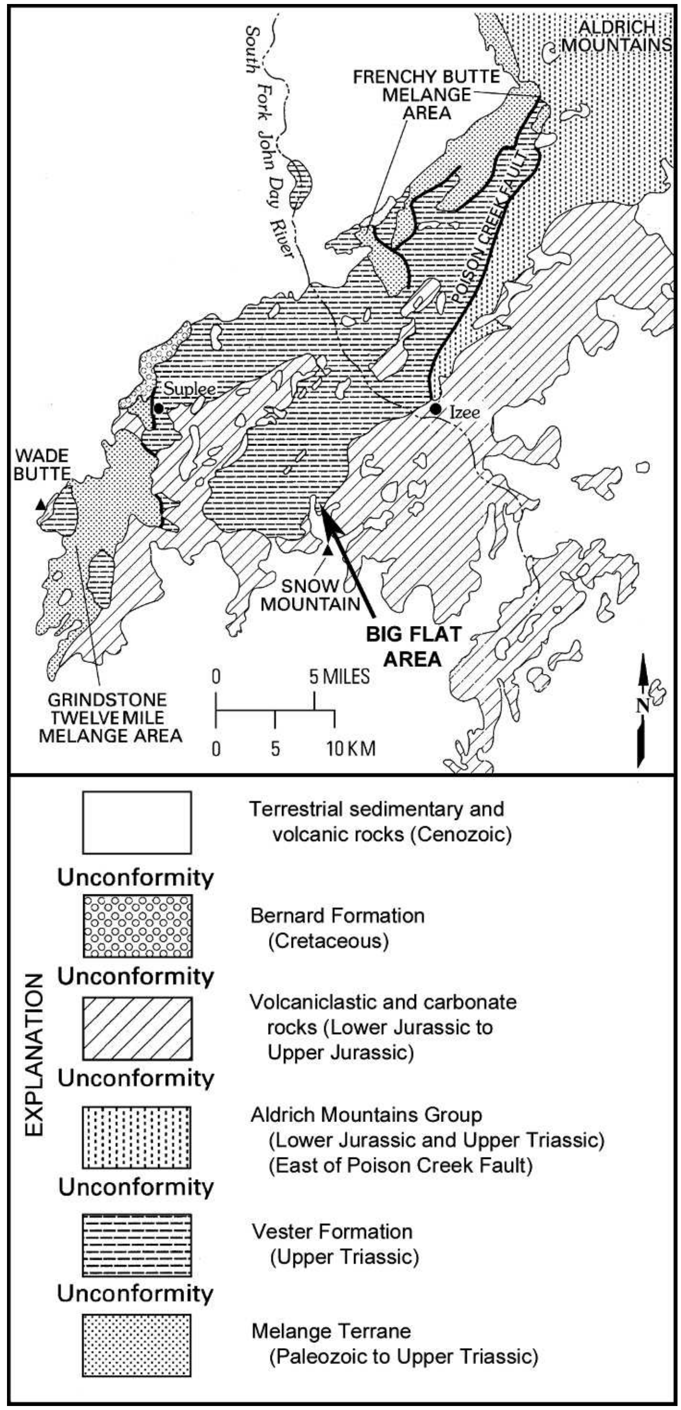



FIGURE 2 —Generalized geologic map of the Izee and Grindstone terranes showing the surrounding mélange areas (modified from Dickinson and Thayer, 1978). The Frenchy Butte mélange area is included within the Baker terrane, the Grindstone-Twelvemile mélange area is considered as part of the Grindstone terrane, and other rocks between Suplee and John Day are placed within the Izee terrane according to Silberling et al. (1984, 1987). Terminology after Silberling et al. (1984, 1987); map modified from Blome and Nestell (1991). The outcrop of the clastic unit in the Brisbois Member (upper part of the Vester Formation) bearing limestone cobbles with corals and fusulinids is approximately 15 km (9.3 mi) southeast of Suplee on private property near a local land mark called "Fort Rock" (at approximately N 44°01′06″ and W 119°30′11″) just a few hundred meters southeast of Grant County Road 69 that traverses the Big Flat area (Dickinson and Vigrass, 1965, p. 26, locality D6). Location of area collected is noted by an arrow.

Subfamily SCHWAGERININAE Dunbar and Henbest, 1930
Genus CHANGMEIA Zhou and Luo, 1998

*Type species*.—*Changmeia compacta* Zhou and Luo, 1998.

*Other species*.—Changmeia longlinensis Zhou and Luo, 1998.

*Diagnosis*.—As for the subgenus *Paraschwagerina* (*Changmeia*) Zhou and Luo, 1998, p. 270.

*Remarks*.—The genus *Changmeia* Zhou and Luo, 1998 (herein elevated to generic status) was first described from the Lower Permian Changmo Formation in Longlin County in the province of Guangxi in southeastern China with its age considered as Early Permian. At the time of its description, it was assigned as a subgenus of *Paraschwagerina* Dunbar and Skinner, 1936, and two species were described: *P. (C.) compacta* Zhou and Luo, 1998 and *P. (C.) longlinensis* Zhou and Luo, 1998. These two species are associated with species of *Pamirina* Leven, 1970, *Biwaella* Morikawa and Isomi, 1960, *Schubertella* Staff and Wedekind, 1910, *Pseudofusulina* Dunbar and Skinner, 1931, and *Staffella* Ozawa, 1925, an assemblage considered Cisuralian (Yakhtashian in the Tethyan Scheme proposed by Leven (2009)) or, in general terms, of Artinskian age in the standard Permian scale. *Changmeia* is closely related to *Paraschwagerina,* but differs in its very large size and its much less inflated and more elongate fusiform shape. Fluting also is more intense, especially in the polar regions. The juvenarium is tightly coiled with a very tiny proloculus and elongate axial filling. The test of *Changmeia* expands rapidly and elongates after the first five or six volutions to a maximum of about 10 or 11 volutions. In addition, *Changmeia* has cuniculi (Fig. 5.5) whereas *Paraschwagerina* does not. *Changmeia* is similar in general structure to the genus *Acervoschwagerina* Hanzawa, 1949, but differs in its more elongate shape, the nature and intensity of the fluting, and the sudden shift in expansion of coiling. The species *A. maclayi* Davydov et al., 1996 is somewhat similar to the Oregon species of *Changmeia*, but it is much more fusiform, the shape of folds and chamber height are different, and the juvenarium is more elongate. *Acervoschwagerina* is only known in North America from one locality near John Day, Oregon in Baker terrane mélange from which a very fractured but complete specimen was illustrated by Blome and Nestell (1992).

CHANGMEIA BOSTWICKI new species
Figures 4.2–4.6, 5.3–5.5

*Diagnosis*.—Species of *Changmeia* characterized by its very large size, elongate shape and presence of intense fluting in polar regions.

*Description*.—Test very large, thin and elongate fusiform, one side of median portion commonly slightly concave; other side slightly convex, poles bluntly pointed. Mature tests have 9–11 volutions and range from about 9–11 mm in half length and from 1.5–2.1 mm in half width, with a form ratio of about 5.6–7.6. Inner six volutions tightly coiled, pointed fusiform, chamber heights abruptly and regularly increase in the outer volutions. Septa fluted in juvenarium, but lower and wider in interior part of the test and strongly and rather regularly fluted in the outer volutions**.** Septal folds nearly parallel-sided, reaching almost to the tops of chambers, pointed to flattened at the top. Fluting very intense in polar regions of later volutions. Spirotheca very thin, composed of a tectum and a rather coarsely alveolar keriotheca, structure not easily seen in inner volutions. Thickness of the spirotheca in 1–9 volutions ranges from less than 0.01 mm in early volutions to between 0.08–0.1 mm in last volutions. Chomata only slightly developed in the juvenarium. Tunnel poorly developed, high and narrow. Axial filling only developed in early volutions. Very low cuniculi can be seen on slopes of outer volutions (Fig. 5.5). Proloculus very small, round, 0.032–0.065 mm in outer diameter.

FIGURE *3* —Large piece of conglomerate with fusulinacean-bearing clast. Several small limestone clasts are also in the picture. Pocket watch for scale.

*Etymology*.—Named for David Bostwick, former Oregon State University paleontologist and fusulinid worker who pioneered the study of Permian outcrops in the exotic terranes of east-central Oregon.

*Material*.—Five specimens from cobble 35S1-26. One specimen from cobble, 35S1-25-1, is also referred to this species and appears to be a transitional form between the two species of *Changmeia* described herein.

*Types*.—Holotype KUMIP 321620 (Fig. 4.3); paratypes KUMIP 321619 (Fig. 4.2), KUMIP 321621 (Fig. 4.4), KUMIP 321622 (Fig. 4.5), KUMIP 321623 (Fig. 4.6).

*Remarks*.—Associated with *Changmeia bostwicki* n. sp. in cobble 35S1-26 are scarce specimens of *Eoparafusulina* Coogan, 1960 and a species of *Schwagerina* von Möller, 1877 represented by one specimen.

Some of our specimens of *Changmeia* are more than twice the size of the genotypical species, but other characters such as a very tight juvenarium, paraschwagerinid coiling and fluting support the assignment of our species to this genus. Our two new species differ from the two Chinese species by their size, general type of fluting, especially in the polar regions, and more elongate shape. The genus *Changmeia* is a true Tethyan fusulinacean which occurs with the fusulinacean *Pamirina* in China. Its presence in Oregon also demonstrates that a Tethyan Early Permian counterpart exists for the Middle Permian Tethyan fusulinaceans such as *Yabeina* Deprat, 1914, *Pseudodoliolina* Yabe and Hanzawa, 1932, and *Misellina* Schenck and Thompson, 1940, previously described or reported from Oregon (Thompson and Wheeler, 1942; Blome and Nestell, 1992; Nestell, 1983, 1998). An interesting contrast is that fusulinids found in rocks of the Grindstone terrane and in the Triassic conglomerate of the Vester Formation in the Izee terrane do not contain Middle Permian genera of the Neoschwagerinidae Staff and Wedekind, 1910 or Verbeekinidae Dunbar and Condra, 1928 that dominate the faunas found in Middle Permian exotic limestone blocks of the nearby Baker terrane.

Two strongly aberrant specimens of *Changmeia bostwicki* new species from cobble 35S1-26 that exhibit damage of the test with subsequent healing and growth are also illustrated. In one specimen (Fig. 5.3) one end of the test was broken off early in the ontogeny, and then growth on that end was accommodated by the abnormal addition of partial chambers while chambers were added on the other end in their normal order. The other specimen

TABLE 1—Data table for the fusulinacean species. Numbers 1–10 on the left side refer to the individual specimens (1, 4, 5, 6, 9 are *Changmeia bostwicki* new species; 2, 3 are *Changmeia bigflatensis* new species; 7, 8 are *Eoparafusulina* sp.). Measurement data of specimen 10 (35S1-26-11) are given but the specimen is not illustrated.

| | Figure | Specimen num. | Length (mm) | Half length | Width (mm) | Half width | Form ratio | Diameter of proloculus (mm) | Number of volutions | Width of volutions (mm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | 4.5 | 35S1-25-1 | | 11.32 | | 1.695 | 7.3 | 0.032 | 12 | 0.02 | 0.044 | 0.078 | 0.125 | 0.17 | 0.242 | 0.375 | 0.585 | 0.818 | 1.15 | 1.445 | 1.695 |
| 2 | 5.2 | 35S1-25-3 | 17.48 | | 2.3 | | 7.6 | 0.035 | 10 | 0.045 | 0.073 | 0.095 | 0.142 | 0.22 | 0.295 | 0.41 | 0.585 | 0.86 | 1.18 | | |
| 3 | 5.1 | 35S1-25-7 | | 8.735 | | 1.48 | 5.9 | 0.033 | 10 | 0.031 | 0.059 | 0.084 | 0.141 | 0.23 | 0.367 | 0.584 | 0.91 | 1.194 | 1.48 | | |
| 4 | 4.2 | 35S1-26-1 | | 11 | | 1.98 | 5.6 | 0.044 | 10 | 0.042 | 0.07 | 0.115 | 0.172 | 0.28 | 0.495 | 0.745 | 1.125 | 1.56 | 1.98 | | |
| 5 | 4.3 | 35S1-26-3 | | 10.56 | | 2.02 | 5.2 | ?? | 11 | 0.04 | 0.07 | 0.09 | 0.116 | 0.23 | 0.37 | 0.54 | 0.97 | 1.23 | 1.6 | 2.02 | |
| 6 | 4.4 | 35S1-26-7 | | 9.3 | | 1.82 | 5.1 | 0.065 | 10 | 0.045 | 0.075 | 0.11 | 0.165 | 0.255 | 0.32 | 0.56 | 0.98 | 1.37 | 1.82 | | |
| 7 | 5.6 | 35S1-26-8 | 4.788 | | 1.775 | | 2.7 | 0.09 | 7 | 0.07 | 0.11 | 0.175 | 0.255 | 0.415 | 0.645 | 0.925 | | | | | |
| 8 | 5.7 | 35S1-26-9 | 5.233 | | 1.574 | | 3.3 | 0.058 | 7 | 0.045 | 0.088 | 0.135 | 0.215 | 0.345 | 0.568 | 1.07 | | | | | |
| 9 | 4.6 | 35S1-26-10 | | | | 2.1 | | ?? | 11 | ?? | 0.06 | 0.09 | 0.16 | 0.255 | 0.49 | 0.74 | 1.12 | 1.41 | 1.805 | 2.1 | |
| 10 | | 35S1-26-11 | | 11.22 | | 1.866 | 6 | 0.052 | 11 | 0.033 | 0.068 | 0.11 | 0.152 | 0.235 | 0.345 | 0.64 | 0.935 | 1.2 | 1.533 | 1.866 | |

| | Figure | Specimen num. | Length (mm) | Half length | Width (mm) | Half width | Form ratio | Diameter of proloculus (mm) | Number of volutions | Half length of volutions (mm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | 4.5 | 35S1-25-1 | | 11.32 | | 1.695 | 7.3 | 0.032 | 12 | 0.055 | 0.098 | 0.142 | 0.345 | 0.568 | 0.775 | 1.76 | 2.755 | 5.095 | 6.805 | 9.21 | 11.32 |
| 2 | 5.2 | 35S1-25-3 | 17.48 | | 2.3 | | 7.6 | 0.035 | 10 | 0.035 | 0.105 | 0.225 | 0.43 | 0.625 | 0.945 | 1.71 | 3.605 | 5.56 | 8.05 | | |
| 3 | 5.1 | 35S1-25-7 | | 8.735 | | 1.48 | 5.9 | 0.033 | 10 | 0.041 | 0.105 | 0.223 | 0.444 | 0.785 | 1.6 | 3.66 | 4.575 | 5.99 | 8.735 | | |
| 4 | 4.2 | 35S1-26-1 | | 11 | | 1.98 | 5.6 | 0.044 | 10 | 0.03 | 0.212 | 0.322 | 0.865 | 2.05 | 3.305 | 3.71 | 6.095 | 7.78 | 11 | | |
| 5 | 4.3 | 35S1-26-3 | | 10.56 | | 2.02 | 5.2 | ?? | 11 | 0.088 | 0.182 | 0.391 | 0.72 | 0.968 | 1.403 | 2.42 | 4.086 | 5.225 | 7.594 | 10.56 | |
| 6 | 4.4 | 35S1-26-7 | | 9.3 | | 1.82 | 5.1 | 0.065 | 10 | 0.045 | 0.115 | 0.355 | 0.545 | 0.835 | 1.265 | 2.17 | 3.58 | 5.32 | 9.3 | | |
| 7 | 5.6 | 35S1-26-8 | 4.788 | | 1.775 | | 2.7 | 0.09 | 7 | 0.055 | 0.13 | 0.275 | 0.465 | 0.875 | 1.54 | 2.33 | | | | | |
| 8 | 5.7 | 35S1-26-9 | 5.233 | | 1.574 | | 3.3 | 0.058 | 7 | 0.035 | 0.115 | 0.24 | 0.495 | 0.995 | 1.74 | 2.68 | | | | | |
| 9 | 4.6 | 35S1-26-10 | | | | 2.1 | | ?? | 11 | | | | | | | | | | | | |
| 10 | | 35S1-26-11 | | 11.22 | | 1.866 | 6 | 0.052 | 11 | 0.045 | 0.135 | 0.34 | 0.575 | 0.915 | 1.275 | 2.485 | 4.595 | 5.845 | 8.29 | 11.22 | |

| | Figure | Specimen num. | Length (mm) | Half length | Width (mm) | Half width | Form ratio | Diameter of proloculus (mm) | Number of volutions | Thickness of spirotheca (mm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | 4.5 | 35S1-25-1 | | 11.32 | | 1.695 | 7.3 | 0.032 | 12 | 0.006 | 0.007 | 0.009 | 0.017 | 0.019 | 0.022 | 0.032 | 0.048 | 0.06 | 0.078 | 0.08 | 0.082 |
| 2 | 5.2 | 35S1-25-3 | 17.48 | | 2.3 | | 7.6 | 0.035 | 10 | 0.006 | 0.008 | 0.01 | 0.015 | 0.02 | 0.025 | 0.033 | 0.052 | 0.08 | 0.085 | | |
| 3 | 5.1 | 35S1-25-7 | | 8.735 | | 1.48 | 5.9 | 0.033 | 10 | 0.007 | 0.009 | 0.013 | 0.027 | 0.033 | 0.044 | 0.055 | 0.065 | 0.091 | 0.11 | | |
| 4 | 4.2 | 35S1-26-1 | | 11 | | 1.98 | 5.6 | 0.044 | 10 | 0.007 | 0.008 | 0.01 | 0.015 | 0.18 | 0.023 | 0.03 | 0.046 | 0.068 | 0.075 | | |
| 5 | 4.3 | 35S1-26-3 | | 10.56 | | 2.02 | 5.2 | ?? | 11 | | 0.012 | 0.018 | 0.024 | 0.03 | 0.041 | 0.055 | 0.076 | 0.102 | 0.115 | 1.4 | |
| 6 | 4.4 | 35S1-26-7 | | 9.3 | | 1.82 | 5.1 | 0.065 | 10 | 0.008 | 0.01 | 0.013 | 0.022 | 0.033 | 0.045 | 0.055 | 0.065 | 0.095 | 0.115 | | |
| 7 | 5.6 | 35S1-26-8 | 4.788 | | 1.775 | | 2.7 | 0.09 | 7 | 0.009 | 0.015 | 0.017 | 0.03 | 0.05 | 0.07 | 0.062 | | | | | |
| 8 | 5.7 | 35S1-26-9 | 5.233 | | 1.574 | | 3.3 | 0.058 | 7 | 0.008 | 0.011 | 0.015 | 0.023 | 0.052 | 0.06 | 0.068 | | | | | |
| 9 | 4.6 | 35S1-26-10 | | | | 2.1 | | ?? | 11 | ?? | ?? | 0.013 | 0.018 | 0.024 | 0.03 | 0.042 | 0.058 | 0.075 | 0.095 | 0.065 | |
| 10 | | 35S1-26-11 | | 11.22 | | 1.866 | 6 | 0.052 | 11 | 0.006 | 0.009 | 0.016 | 0.02 | 0.032 | 0.036 | 0.055 | 0.062 | 0.08 | 0.085 | 0.135 | |

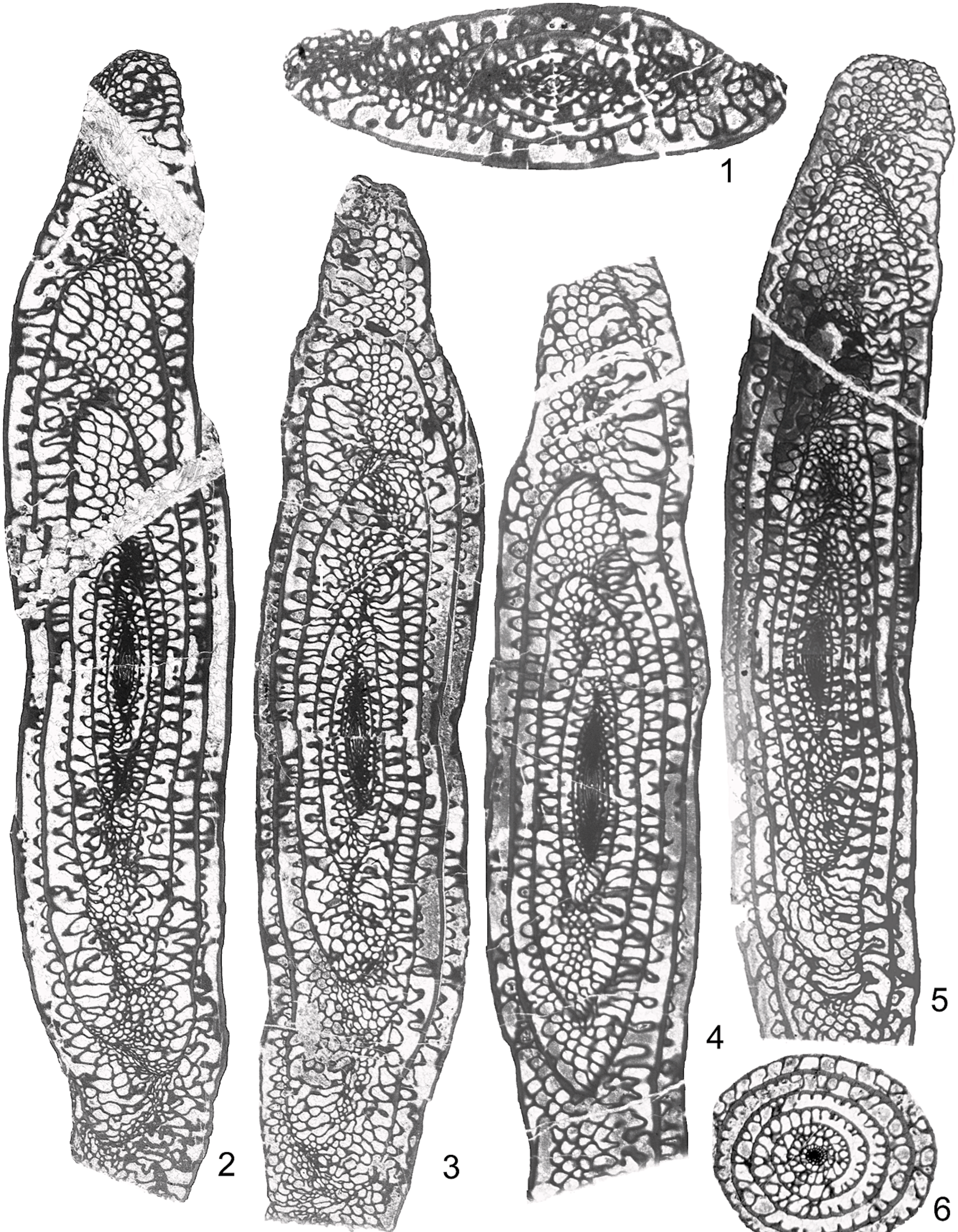
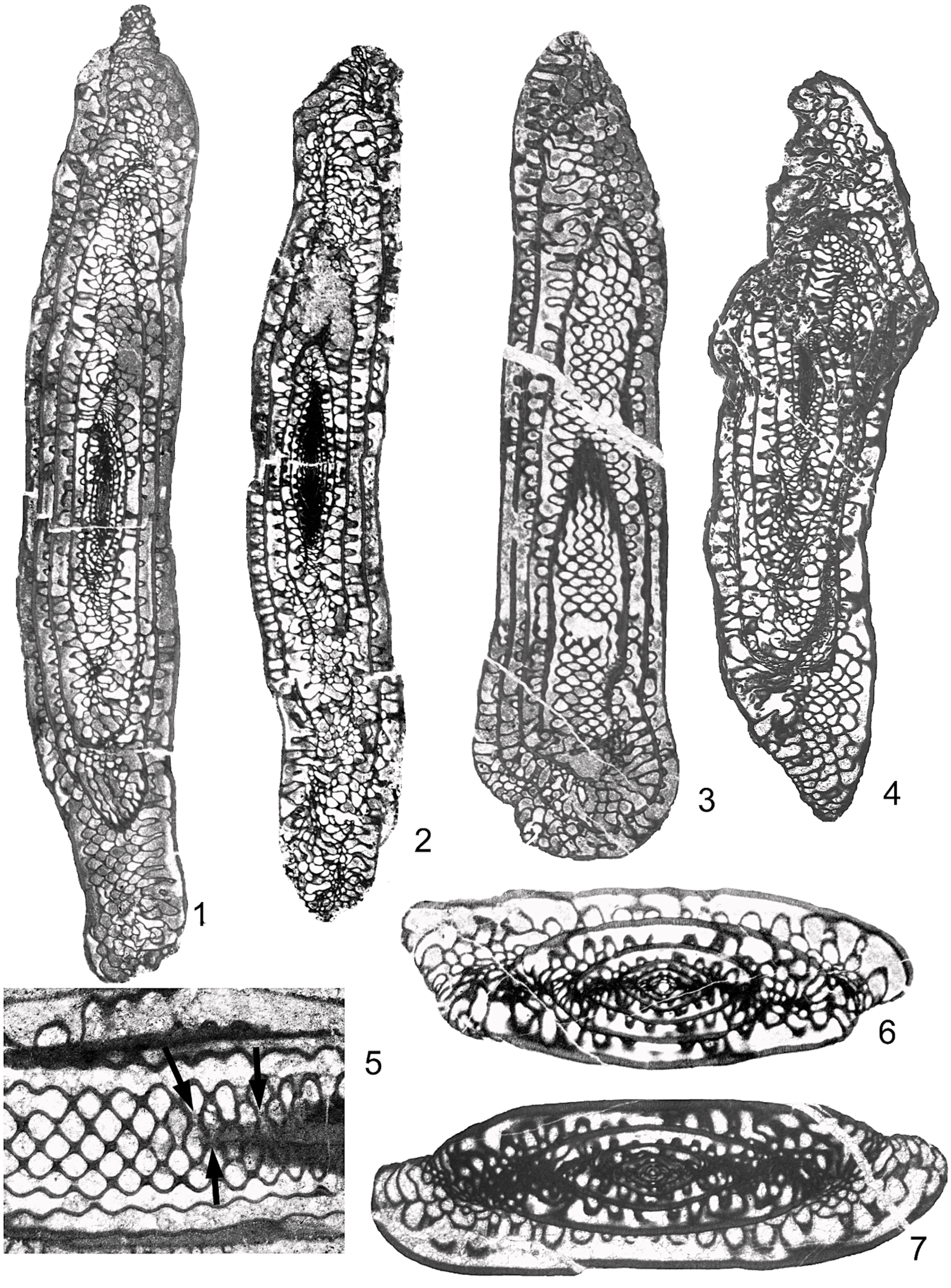



FIGURE *4* —*1, Schwagerina* sp., slide 35S1-26-6, KUMIP 321631; *2–6*, *Changmeia bostwicki* new species: *2*, paratype slide 35S1-26-1, KUMIP 321619; *3*, holotype slide 35S1-26-3, KUMIP 321620; *4*, paratype slide 35S1-26-7, KUMIP 321621; *5*, paratype slide 35S1-25-1, KUMIP 321622; *6*, paratype slide 35S1-26-10, KUMIP 321623. All figures ×10 except *1* (×20).

https://doi.org/10.1666/12-138 Published online by Cambridge University Press




https://doi.org/10.1666/12-138 Published online by Cambridge University Press

(Fig. 5.4) shows a major offset and abnormal growth of one side of the test.

CHANGMEIA BIGFLATENSIS new species
Figure 5.1, 5.2

*Diagnosis*.—Species of *Changmeia* characterized by its large size, elongate shape, low chambers in midportion of the test, and only moderately intense fluting in polar regions.

*Description*.—Test large, very thin and elongate fusiform, one side slightly convex, the other slightly concave, poles bluntly pointed. Mature tests have 10 volutions and range from about 16.0–17.9 mm long and 2.3–2.6 mm wide, with a form ratio of about 6.8–6.9. Inner six volutions tightly coiled, pointed fusiform, chamber heights abruptly and regularly increase in outer volutions. Septa fluted in juvenarium; fluting lower and wider in interior part of the test, and strong and regular in the outer volutions. Septal folds nearly parallel-sided, reaching almost to tops of chambers, pointed to flattened at top. Somewhat more intense fluting is in polar regions in later volutions. Spirotheca very thin, composed of a tectum and a rather coarsely alveolar keriotheca, a structure not easily seen in inner volutions. Thickness of spirotheca in 1–9 volutions ranges from less than 0.01 mm in early volutions to between 0.08–0.1 mm in last volutions. Chomata only slightly developed in the juvenarium. Tunnel poorly developed, high and narrow. Axial filling only developed in early volutions. Proloculus very small, round, 0.032–0.035 mm in outer diameter.

*Etymology*.—Named for the area of the locality.

*Material*.—Four specimens from one small cobble 35S1-25.

*Types*.—Holotype KUMIP 321624 (Fig. 5.1); paratype KUMIP 321625 (Fig. 5.2).

*Remarks*.—*Changmeia bigflatensis* new species differs from *C. bostwicki* new species in the general size and shape, with the latter being much larger and thicker with more inflated chambers in the midportion of the test. Major difference between the two new species is the presence of very intense fluting in the polar regions of *C. bostwicki* n. sp. and a distinct difference in form ratio.

Genus SCHWAGERINA von Mőller, 1877
SCHWAGERINA sp.
Figure 4.1

*Description*.—Test small, fusiform, with slightly convex lateral slopes and bluntly rounded polar regions. Single specimen of seven volutions has a length of 4.72 mm and width of 1.58 mm; form ratio 3. Spirotheca composed of a tectum and fine keriotheca, ranges in thickness in regular increments from 0.012 mm in first whorl to 0.66 mm in the seventh. Septa strongly and regularly fluted from pole to pole with looped folds more than half of the height of chambers. Small proloculus not complete because of a break in the specimen. Tunnel low with chomata difficult to distinguish.

*Material*.—One specimens from cobble 35S1-26.

*Remarks*.—The single specimen is not well oriented and is difficult to assign to a species.

Family PSEUDOFUSULINIDAE Dutkevich, 1934
A. D. Miklukho-Maklay, 1959 emend.
Genus EOPARAFUSULINA Coogan, 1960
Skinner and Wilde, 1965 emend.
EOPARAFUSULINA sp.
Figure 5.6, 5.7

*Description*.—Test small, subcylindrical, with bluntly rounded poles and seven volutions. Two specimens available measure 4.788 mm and 5.233 mm in length and 1.775 mm and 1.574 mm in width with form ratios of 2.7 and 3.3, respectively. Spirotheca composed of tectum and coarsely alveolar keriotheca, from thickness less than 0.01 mm to 2.68 mm in seventh volution. Septa strongly and regularly fluted from pole to pole, more so in polar areas. Septal folds about half as high as chambers, leaving upper part of each septum only broadly wavy or nearly planar. No cuniculi seen. Proloculus is very small in one specimen and larger in the other one; outside diameter of 0.05 mm and 0.09 mm, respectively. Tunnel apparent but not well developed in some volutions with narrow bounding pseudochomata.

*Material*.—Two specimens from cobble 35S1-26.

*Remarks*.—As only two specimens of this form were found in one of the samples bearing *Changmeia*, one with a tiny proloculus and one with a larger proloculus, it is not described as a new species.

CORALS

Order STAURIIDA Verrill, 1865
Family KEPINGOPHYLLIDAE Wu and Zhou, 1982
Genus YOKOYAMAELLA Minato and Kato, 1965
YOKOYAMAELLA? OREGONENSIS new species
Figure 6.4, 6.5, 6.7–6.10

*Diagnosis*.—Corallum cerioid, composed of small polygonal corallites about 2.0 mm in diameter. Septa of two orders, about 10 of each at diameter of 2.0 mm; major septa long with one generally continuous with median lamella. Axial structure consists of median lamella, few septal lamellae in some corallites, and generally one row of axial tabellae.

*Description*.—Partitions moderately thick. Septa thick; major septa long, taper slightly axially, approach axial structure; one septum commonly continuous with axial lamella with another one or two commonly extending to margin of axial structure; minor septa well developed, short, about two-thirds length of major septa, confined to dissepimentarium. Axial structure composed of median plate, several septal lamellae in some corallites, and generally one row of axial tabellae. Dissepimentarium variable, generally consisting of one or two ranks of globose and very elongate, steeply declined, interseptal dissepiments; lonsdaleoid dissepiments not noted. Clinotabulae steeply declined adaxially. Transverse tabulae also declined adaxially, rather evenly spaced, about five per mm.

*Etymology*.—The new species is named for the State of Oregon where the specimen was collected.

*Material*.—One corallum with three transverse and five longitudinal sections. Sample SJS 1309k.

*Holotype*.—USNM 531317, SJS 1309k.

*Remarks*.—Two species, *Yokoyamaella*? *oregonensis* new species and *Y.*? sp. 1, are assigned to the Family Kepingophyllidae Wu and Zhou, 1982 following the suggestion of X. Wang (personal commun., 2011) rather than the Family Waagenophyllidae Wang, 1950 on the basis of their partitions which appear to be of the mural septal type. Preservation is such that the structure

←
FIGURE 5 —*1, Changmeia bigflatensis* new species, holotype slide 35S1-25-7, KUMIP 321624; *2*, paratype slide 35S1-25-3, KUMIP 321625; *3–5*, *Changmeia bostwicki* new species: *3,* aberrant specimen, slide 35S1-26-2, KUMIP 321626; *4*, aberrant specimen, slide 35S1-26-4, KUMIP 321627; *5*, arrows denote low cuniculi, slide 35S1-25-9, KUMIP 321628; *6, 7*, *Eoparafusulina* sp.: *6,* slide 35S1-26-8, KUMIP 321629; *7,* slide 35S1-26-9, KUMIP 321630. All figures ×10 except *5–7* (×20).

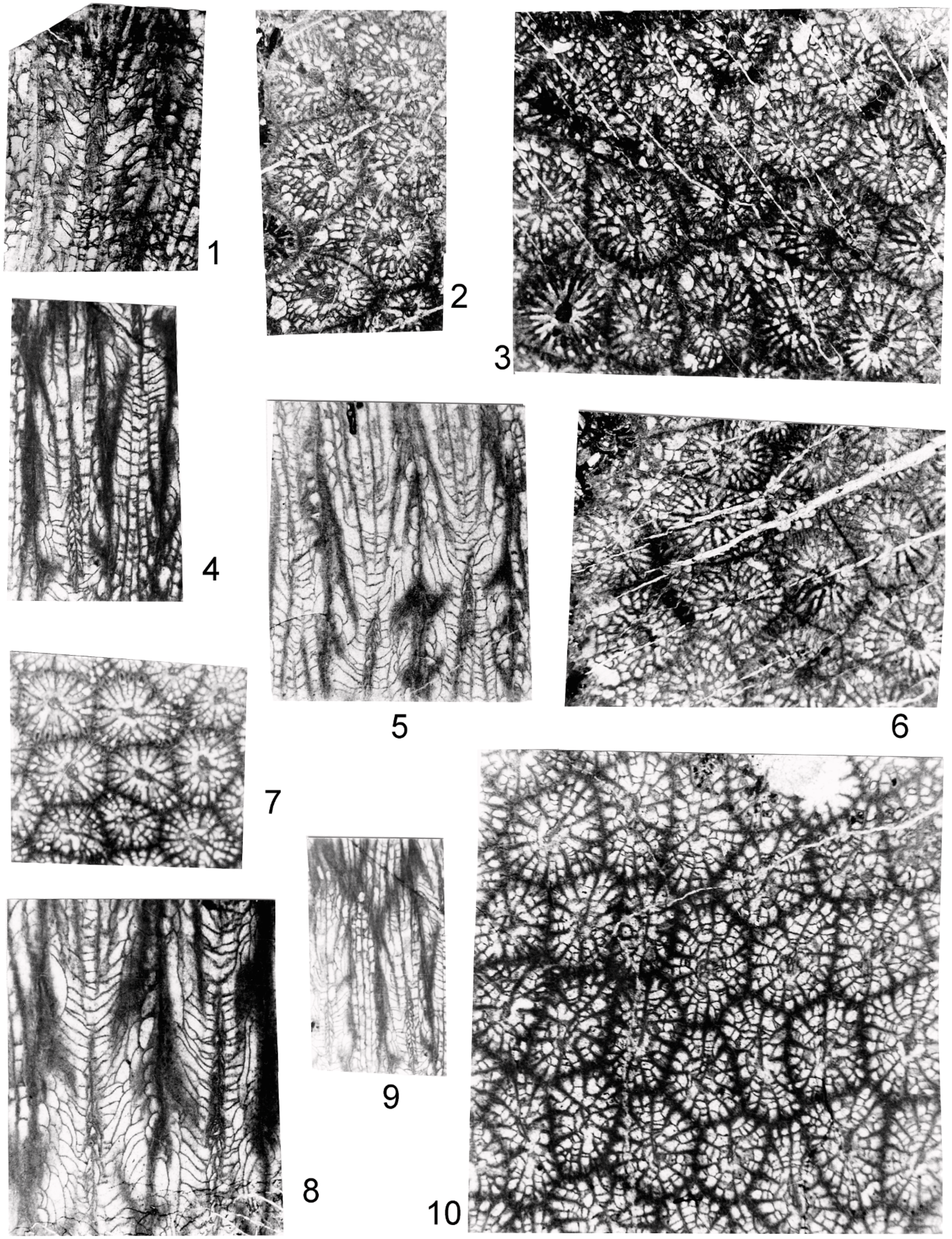



FIGURE 6—*1–3, 6*, *Yokoyamaella*? sp. 1, slides C182, 183, 185 from specimen SJS 1309c; *4, 5, 7–10*, *Yokoyamaella*? *oregonensis* new species, holotype slides C184, 186–189 from specimen USNM 531317 (SJS 1309k). All figures ×6 except *4* (×9), *5* (×10), *7* (×7), *8* (×11), *9* (×5), *10* (×9).

of the partitions, however, cannot be proven. The generic assignment is also uncertain. The general characteristics of these two species from Oregon (e.g., cerioid form, relatively thick walls, and septa of two orders) suggest a relationship to the genus *Yokoyamaella*. The size of the corallites and the simplicity of their structures, however, are unlike that in any other species assigned to that genus, and the partitions are thinner. In transverse sections the partitions in *Y. oregonensis* appear much thinner than in typical *Yokoyamaella,* but in longitudinal section they appear to be thickened as is typical of *Yokoyamaella*. In transverse sections the partitions in *Y.*? sp. 1 appear to be of the mural septal type and similar to that in the genotype of *Yokoyamaella* as illustrated by Minato and Kato (1965). The present species superficially resembles some species assigned to *Ipsiphyllum* Hudson, 1958, but that genus is characterized by a thin wall.

Photographs of this species and the form described here as *Yokoyamaella*? sp. 1 were examined by Y. Ezaki, T. Kawamura, and X. Wang. None could place these specimens in an existing genus. The material available for study, however, is too meager for erection of a new genus.

The genus *Yokoyamaella* occurs in the *Pseudoschwagerina* Dunbar and Skinner, 1936 and *Pseudofusulina* Dunbar and Skinner, 1931 fusulinid zones (Early Permian) in the Tethyan Realm. No species remotely resembling this one has ever been recorded outside of the Tethyan Realm.

YOKOYAMAELLA? sp. 1
Figure 6.1–6.3, 6.6

*Description*.—Corallum cerioid, composed of polygonal corallites 3 to 4 mm in diameter. Walls thickened with stereozone. Septa moderately thick, taper axially; major septa about 12 at corallite diameter of 3.5–4.0 mm, slightly withdrawn from axial column, one septum commonly extends into axial structure. Minor septa well developed, penetrate outer tabularium, commonly two-thirds length of major septa. Axial structure generally formed by obscure median lamella, commonly several septal lamellae, and apparently one row of axial tabellae. Dissepimentarium variable, up to one-third corallite radius and generally consisting of one or two ranks of globose dissepiments, in places absent. Lonsdaleoid dissepiments common, especially in corners. Few clinotabulae noted. Transverse tabulae well developed and moderately steeply declined adaxially.

*Material*.—One corallum with four transverse and five longitudinal sections. Sample SJS l309c.

*Remarks*.—The species described herein is similar to *Yokoyamaella*? *oregonensis* new species and similarly can be assigned to that genus only questionably because the detail of the wall structure is uncertain and the complexity of structures is much less than in other species previously assigned to that genus. This species differs from *Yokoyamaella*? *oregonensis* new species in having lonsdaleoid dissepiments, greater corallite diameters, a more highly developed axial structure, and a thicker wall.

A fusulinacean, possibly a species of *Monodiexodina* Sosnina, 1956 of Early Permian age, occurs in the same sample.

Family AULOPHYLLIDAE Dybowski, 1873
Genus CORWENIA Smith and Ryder, 1926
CORWENIA? ASHWILLENSIS new species
Figure 7.4, 7.5, 7.7–7.9

*Diagnosis*.—Corallum fasciculate, composed of corallites mostly 9–14 mm in diameter. Major septa 22–24, commonly reach axial structure. Axial structure continuous with long series of linked axial tabellae.

*Description*.—Corallites closely grouped and commonly touching, up to 14 mm in diameter with 22–24 major septa. Major septa thin in dissepimentarium, slightly thickened in tabularium, taper axially, long, with several extending into axial area in some immature specimens; in larger specimens most major septa retreat from axial structure; in few specimens counter septum continuous with median lamella. Axial structure formed by obscure median lamella, generally numerous septal lamellae, and up to three ranks of axial tabellae. Dissepimentarium one-third to one-half corallite width, contains up to six ranks of small, globose, interseptal dissepiments. Tabulae incomplete, moderately inclined adaxially.

*Etymology*.—Named for Mel Ashwill, an amateur paleontologist from central Oregon.

*Material*.—One corallum with six transverse and two longitudinal sections.

*Holotype*.—USNM 531334, SJS 1309h.

*Remarks*.—The described species, although somewhat different from the genotype, probably belongs in the genus *Corwenia*. This species possesses several features similar to those in paratypes USNM 161037 and USNM 161039 of *Corwenia*? *jagoensis* of Armstrong (1972) including the ratio of number of major septa to corallite diameter. It differs in having a generally significantly narrower axial structure.

Genus HERITSCHIOIDES Yabe, 1950
HERITSCHIOIDES? sp.
Figure 7.1–7.3, 7.6

*Description*.—Corallum apparently phaceloid although this cannot be proven from material available; corallites 15–27 mm in diameter. Septa of two orders, generally 32–34 of each at diameters of 20–27 mm; major septa thin in dissepimentarium, thickened in tabularium, taper axially, generally withdrawn from axial structure, rarely continuous with some septal lamellae; cardinal septum shortened about 1.0 mm; counter septum may extend into axial structure. Minor septa short, do not penetrate tabularium. Axial structure up to 4.0 mm wide, formed by median lamella, numerous septal lamellae, some representing crests of minor septa, and up to eight ranks of axial tabellae. Dissepimentarium up to one-third corallite radius, contains up to eight ranks of mostly small, globose, moderately adaxially declined dissepiments, outer part complicated with some small lonsdaleoid dissepiments. Tabulae incomplete, moderately adaxially inclined, closely spaced, about 15 per cm. Axial tabellae very elongate, forming a continuous axial column.

*Material*.—One corallum with five transverse and four longitudinal sections. Sample SJS 1309j.

*Remarks*.—Assignment of this species to the genus *Heritschioides* is questioned because it is uncertain that the corallum is phacelloid. However, this species has a n:d ratio similar to that of *H. columbicum* (Smith, 1935) and in longitudinal section appears very similar to that in some specimens of that species from the Quesnel terrane (part of the McCloud Belt). The present species differs from *H. columbicum* primarily in the presence of a more narrow axial structure. This species also resembles *Heritschioides* sp. 2 of Kawamura and Stevens (2012) from the Eastern Klamath terrane, part of the McCloud Belt, but the former has many more septa.

Family KLEOPATRINIDAE Fedorowski, Bamber, and Stevens, 2007
Genus KLEOPATRINA McCutcheon and Wilson, 1963
KLEOPATRINA sp. cf. K. MAGNIFICA (Porfiriev, 1941)
Figure 8.5, 8.6, 8.8–8.10

*Description*.—Corallum cerioid, composed of polygonal corallites 14–15 mm in diameter. Septa slightly thickened in tabularium; major septa 15–21 in corallites 14 mm in diameter, mostly withdrawn from axial structure; cardinal septum slightly shortened; minor septa short, slightly penetrate tabularium. Axial structure formed of prominent median lamella with few axial tabellae and rarely septal laminae. Dissepimentarium up to one-

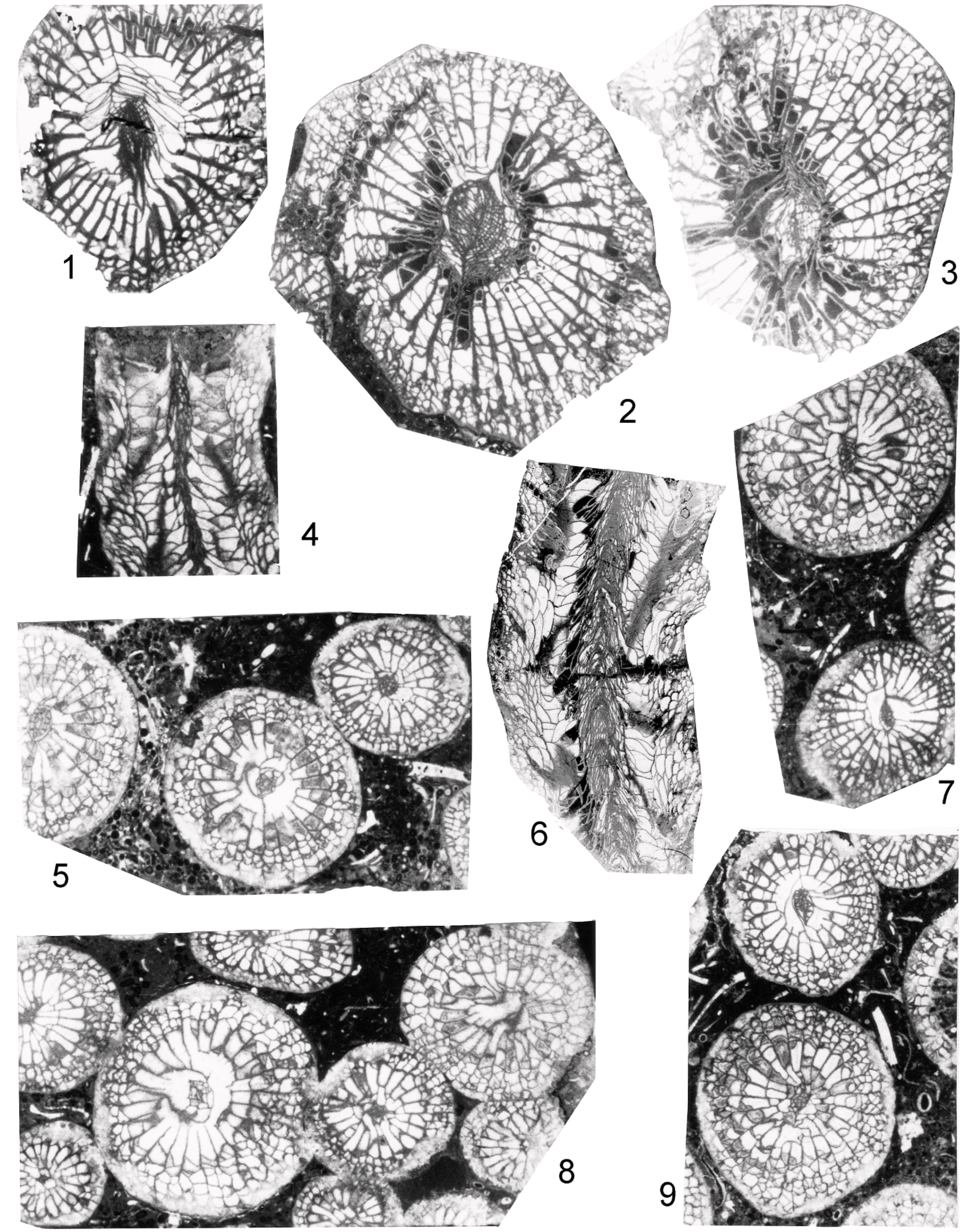



FIGURE 7—*1–3, 6, Heritschioides*? sp., slides C190–193 from specimen SJS 1309j; *4, 5, 7–9, Corwenia*? *ashwillensis* new species, holotype slides C194–198 from specimen USNM 531334 (SJS 1309h). All figures ×3.

https://doi.org/10.1666/12-138 Published online by Cambridge University Press

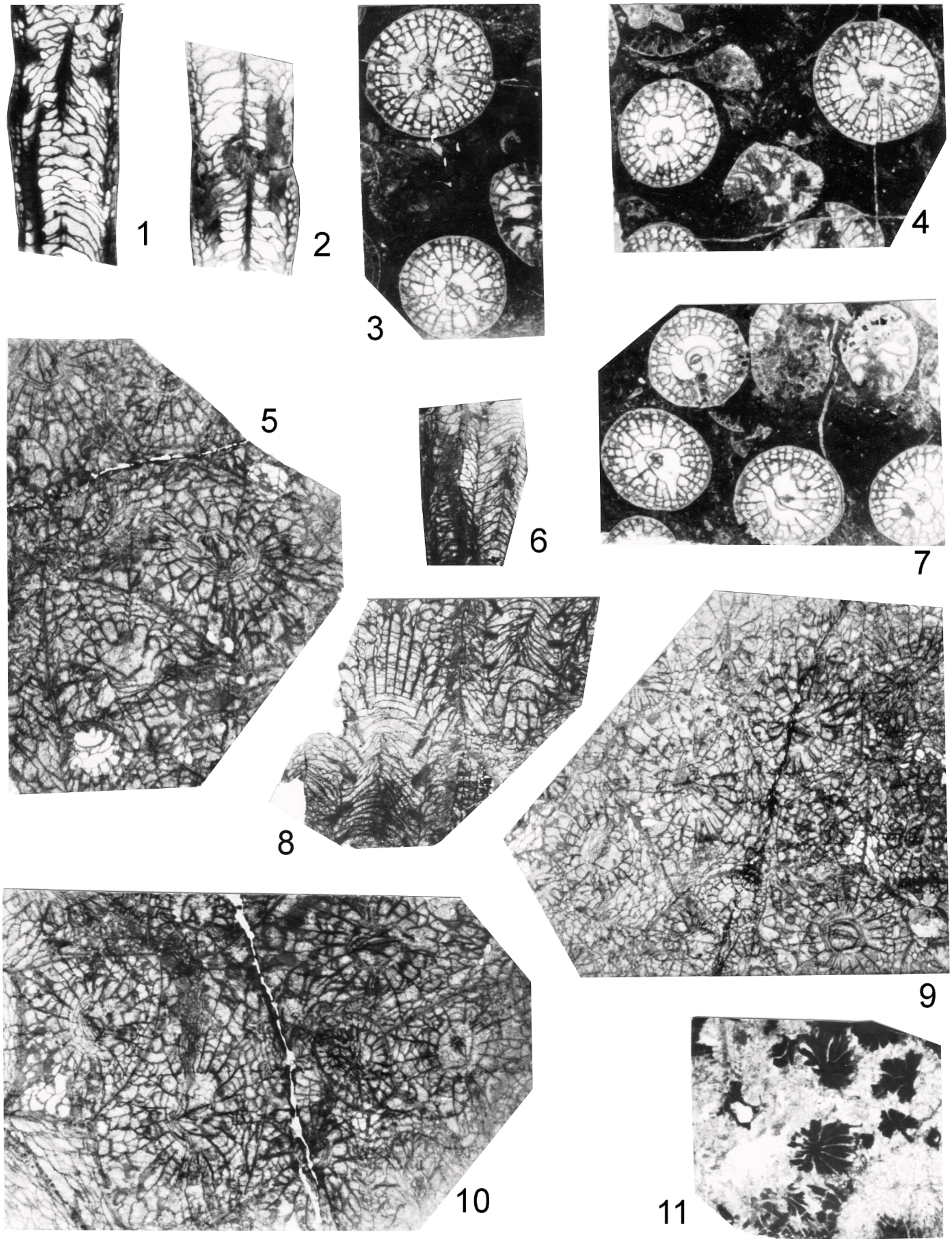


FIGURE 8 —*1–4, 7*, *Siphonodendron*? sp., slides C199–203 from specimen SJS 1309g; *5, 6, 8–10*, *Kleopatrina* sp. cf. *K. magnifica* (Porfiriev, 1941, slides C204–208 from sample SJS 1309f; *11*, possibly *Kuhnastraea* or *Gablonzeria*, slide C209 from sample SJS 1309e. All figures ×3 except *6* (×2.5).

https://doi.org/10.1666/12-138 Published online by Cambridge University Press

half corallite radius, contains up to five ranks of interseptal globose to fairly steeply-dipping elongate dissepiments. Lonsdaleoid dissepiments commonly developed in corners. Tabulae most commonly complete, moderately inclined adaxially, closely spaced, about 18–30 per cm; axial tabellae rare.

*Material*.—One corallum with five transverse and three longitudinal sections. Sample SJS 1309f.

*Remarks*.—The described specimen closely resembles *K. magnifica*, a widespread species in the Early Permian of the Cordilleran-Arctic-Uralian (CAU) Realm which includes the McCloud Belt (Fedorowski et al., 2007), differing only in the greater development of lonsdaleoid dissepiments.

Family Lithostrotionidae d'Orbigny, 1852
Subfamily Lithostrontioninae d'Orbigny, 1852
Genus Siphonodendron McCoy, 1849
Siphonodendron? sp.
Figure 8.1–8.4, 8.7

*Description*.—Corallum phaceloid, composed of corallites 6.0–8.0 mm in diameter. Septa moderately thick in both dissepimentarium and tabularium, major septa moderately long, withdrawn from axial structure, cardinal septum slightly shortened; counter septum commonly elongated, may be continuous with median lamella; minor septa short. Axial structure formed by median lamella, commonly few septal lamellae and one or two rows of axial tabellae. Dissepimentarium about one-third corallite width, contains one to three ranks of small, globose dissepiments. Tabulae complete and incomplete, closely spaced, 12–15 per cm; complete tabulae inclined adaxially at the periphery and then flattened to produce a distinct shoulder. Axial tabellae occur in discontinuous linked series.

*Material*.—One colony with three transverse and four longitudinal sections. Specimen SJS 1309g.

*Remarks*.—The generic placement of this coral is uncertain. It resembles *Siphonodendron* McCoy, 1849 in some respects, but differs in the presence of sporadic axial tabellae, a wide dissepimentarium, some cystose tabulae, and a shortened cardinal? septum in some corallites. In these respects it resembles a much larger species referred to as *Acrocyathus proliferus* (Hall, 1858) by Sando (1983). That species, however probably should not be placed in the genus *Acrocyathus* d'Orbigny, 1849 because of its fasciculate nature. Here, both Hall's species and the present species are questionably placed in *Siphonodendron*. The present species is provisionally considered Early Carboniferous in age.

Order Scleractinia Bourne, 1900
Genus Kuhnastraea Cuif, 1976 or Gablonzeria Cuif, 1976
Kuhnastraea? sp. or Gablonzeria? sp.
Figure 8.11

*Description*.—Very poorly preserved, contains few septa of two or three cycles.

*Material*.—One corallum with two transverse sections. Specimen SJS 1309e.

*Remarks*.—The specimen is unidentifiable, but probably Late Triassic in age. It possibly belongs in *Kuhnastraea* or *Gablonzeria* and resembles a coral in the exotic Alaska Peninsula terrane (G. Stanley, personal commun., 2004).

## CONCLUSIONS

Different cobbles in the Late Triassic Brisbois Member of the Vester Formation in the Izee terrane in central Oregon contain Carboniferous and Early Permian colonial corals and Early–Middle Permian fusulinaceans characteristic of the McCloud Belt, and Early Permian colonial corals and fusulinaceans representing the Tethyan Realm. These fossils indicate that by Late Triassic time a fragment of a Tethyan terrane was located adjacent to or had been amalgamated to one of the terranes belonging to the McCloud Belt.

## ACKNOWLEDGMENTS

We are grateful to Y. Ezaki, T. Kawamura, and X. Wang for their evaluations of the affinities of the Tethyan corals and G. Stanley for his comments on the Triassic coral. We also are very grateful to J. Fedorowski for his insight into relationships among the corals and acknowledge comments made by E.W. Bamber on the initial draft of the part of the manuscript dealing with corals. We also thank V. Davydov and G. Nestell for their comments about the fusulinaceans and the general geological setting.

## REFERENCES

Armstrong, A. K. 1972. Pennsylvanian carbonates, paleoecology, and rugose colonial corals, north flank, eastern Brooks Range, arctic Alaska. U.S. Geological Survey Professional Paper 747, 19 p.

Belasky, P. and C. H. Stevens. 2006. Permian faunas of westernmost North America: Paleobiogeographic constraints on the Permian positions of Cordilleran terranes, p. 71–80. *In* J. W. Haggart, R. J. Enkin, and J. W. H. Monger (eds.), Paleogeography of the North American Cordillera: Evidence For and Against Large-Scale Displacements. Geological Association of Canada, Special Paper 46:71–80.

Blome, C. D. 1984. Upper Triassic Radiolarians and radiolarian zonation from western North America. Bulletins of American Paleontology, 85(318):1–88.

Blome, C. D. and M. K. Nestell. 1991. Paleontologic and tectonic significance of the Grindstone terrane, east-central Oregon. Geological Society of America Bulletin, 103:1280–1296.

Blome, C. D. and M. K. Nestell. 1992. Field guide to the geology and paleontology of pre-Tertiary volcanic arc and mélange rocks, Grindstone, Izee, and Baker terranes, east-central Oregon. Oregon Geology, 54:123–141.

Blome, C. D and K. M. Reed. 1992. Permian and Early(?) Triassic radiolarian faunas from the Grindstone terrane, central Oregon. Journal of Paleontology, 66:351–383.

Bostwick, D. A. and M. K. Nestell. 1965. A new species of *Polydiexodina* from Oregon. Journal of Paleontology, 39:611–614.

Bourne, G. C. 1900. The Anthozoa. *In* R. Lankester (ed.), Treatise on Zoology, II, Chapter VI, 84 p.

Coogan, A. H. 1960. Stratigraphy and paleontology of the Permian Nosoni and Dekkas Formations (Bollibokka Group). University of California, Publications in Geological Sciences, 36(5):243–316.

Cuif, J. P. 1976. Recherches sur les Madréporaires du Trias IV. Formes cériomeandroides et thamnastérioides du Trias des Alpes et du Taurus sud-anatolien. Bulletin du Muséum National d'Histoire Naturelle, Paris, serie 3, no. 381, Sciences de la Terre, 53:65–194.

Davydov, V. I., P. Belasky, and N. I. Karavayeva. 1996. Permian fusulinids from the Koryak terrane, northeastern Russia, and their paleobiogeographic affinity. Journal of Foraminiferal Research, 26:213–243.

Deprat, J. 1914. Étude des fusulinidés de Chine et d'Indochine. Étude comparative des fusulinidés d'Akasaka (Japon) et des fusulinidés de Chine et d'Indochine. Mémories du Service Géologique de l'Indochine 3:1–45.

Dickinson, W. R. and T. P. Thayer. 1978. Paleogeographic and paleotectonic implications of Mesozoic stratigraphy and structure in the John Day inlier of central Oregon, p. 147–161. *In* D. G. Howell and K. A. McDougall (eds.), Mesozoic Paleogeography of the Western United States (Pacific Coast Paleogeography Symposium 2). Society of Economic Paleontologists and Mineralogists, Pacific Section, Publication 8.

Dickinson, W. R. and L. W. Vigrass. 1964. Pre-Cenozoic history of the Suplee-Izee district, Oregon: implications for geosynclinal theory. Geological Society of America Bulletin, 75:1037–1044.

Dickinson, W. R. and L. W. Vigrass. 1965. Geology of the Suplee-Izee area, Crook, Grant, and Harney Counties, Oregon. Oregon Department of Geology and Mineral Industries, Bulletin 58, 109 p.

Dorsey, R. J. and T. A. Lamaskin. 2007. Stratigraphic record of Triassic–Jurassic collisional tectonics in the Blue Mountains province, northeastern Oregon. American Journal of Science, 307:1167–1193.

Dorsey, R. J. and T. A. Lamaskin. 2008. Mesozoic collision and accretion of oceanic terranes in the Blue Mountains province of northeastern Oregon: new insights from the stratigraphic record, p. 325–332. *In* J. E. Spencer and S. R. Titley (eds.), Ores and Orogenesis: Circum-Pacific tectonics, Geologic Evolution, and Ore Deposits. Arizona Geological Society Digest 22:325–332.

Dunbar, C. O. 1944. Permian and Pennsylvanian(?) fusulines, p. 35–48. *In* R. E. King, C. O. Dunbar, P. E. Cloud, Jr., and A. K. Miller (eds.), Geology and Paleontology of the Permian Area Northwest of Las Delecias, Southwestern Coahuila, Mexico, Part II. Geological Society of America Special Paper 52.

DUNBAR, C. O. AND G. E. CONDRA. 1928. The Fusulinidae of the Pennsylvanian system in Nebraska. Bulletin of the Nebraska Geological Survey, series 2, 2:1–135.

DUNBAR, C. O. AND L. G. HENBESTH. 1930. The fusulinid genera *Fusulina, Fusulinella*, and *Wedekindellina*. American Journal of Science, series 5, 20: 357–364.

DUNBAR, C. O. AND J. W. SKINNER. 1931. New fusulinid genera from the Permian of west Texas, American Journal of Science, series 5, 22:252–268.

DUNBAR, C. O. AND J. W. SKINNER. 1936. *Schwagerina* versus *Pseudoschwagerina* and *Paraschwagerina*. Journal of Paleontology, 10:83–91.

DUTKEVICH, G. A. 1934. O nekotorykh novykh vidakh fusulinid iz verkhnego i srednego karbona Verkhne-Chusovskikh Gorodkov na r. Chusovoy (zapadnyy sklon Srednego Urala. Trudy Neftyanogo geologo-razvedochnogo institute, Series A, 36:3–98. (In Russian)

DYBOWSKI, W. H. 1873. Monographie der Zoantharia Sclerodermata Rugosa aus der Silurformation Estlands, Nord-Livlands und der Insel Gotland: Archiv Naturkunde, Liv-Ehst-Kurlands, series 1, 5:257–414.

FEDOROWSKI, J., E. W. BAMBER, AND C. H. STEVENS. 2007. Lower Permian colonial rugose corals, western and northwestern Pangaea: Taxonomy and distribution. NRC Research Press, Ottawa, Ontario, Canada, 231 p.

FURSENKO, A. V. 1958. Osnovnye etapy razvitiya faun foraminifer v geologicheskom proshlom. Trudy Instituta Geologicheskikh Nauk Akademii Nauk Belorusskoy SSR, 1:10–29. (In Russian)

HALL, J. 1858. *In* J. Hall and J. D. Whitney. 1858. Report on the geological survey of the State of Iowa, Paleontology, 1(2):473–724.

HANZAWA, S. 1949. A new type of fusulinid foraminifera from central Japan. Journal of Paleontology, 23:205–209.

HUDSON, R. G. S. 1958. Permian corals from northern Iraq. Palaeontology, 1: 174–192.

KAWAMURA, T. AND C. H. STEVENS. 2012. Middle Pennsylvanian rugose corals from the Baird Formation, Klamath Mountains, northwestern California. Journal of Paleontology, 86:513–520.

KOBAYASHI, F. 1997. Middle Permian fusulinacean faunas and paleogeography of exotic terranes in the Circum-Pacific, p. 77–80. *In* C. A. Ross, J. R. P. Ross, and P. L. Brenckle (eds.), Late Paleozoic Foraminifera, their Biostratigraphy, Evolution, and Paleoecology, and the Mid-Carboniferous Boundary. Cushman Foundation for Foraminiferal Research, Special Publication 36.

LAMASKIN, T. A., J. D VERVOOT, R. J. DORSEY, AND J. E. WRIGHT. 2011. Early Mesozoic paleogeography and tectonic evolution of the western United States: insights from detrital zircon U-Pb geochronology, Blue Mountains Province, northeastern Oregon. Geological Society of America Bulletin, 123:1939–1965.

LEVEN, E. YA. 1970. O proiskhozhdenii vysshikh fusulinid. Paleontologicheskii Zhurnal, 3:18–25. (In Russian)

LEVEN, E. YA. 1997. *In* C. H. Stevens and D. Baars (eds.), Permian stratigraphy and Fusulinida of Afghanistan with their paleogeographic and paleotectonic implications. Geological Society of America Special Paper 316, 144 p.

LEVEN, E. YA. 2009. Systematic description of fusulinids, in Section of Permian deposits and fusulinids in the Halvan Mountains, Yazd Province, central Iran. Stratigraphy and Geological Correlation, 17:155–172.

MCCOY, F. 1849. On some new genera and species of Palaeozoic corals and Foraminifera. Annals and Magazine of Natural History, 2(3):119–136.

MCCUTCHEON, V. A. AND E. C. WILSON. 1963. *Kleopatrina*, new name for *Ptolemaia* McCutcheon and Wilson. Journal of Paleontology, 37:299.

MERRIAM, C. W. 1942. Carboniferous and Permian corals from central Oregon. Journal of Paleontology, 16:372–381.

MIKLUKHO-MAKLAY, A. D. 1959. Novye fusulinidy verkhnego paleozoya SSSR. Materialy k osnovam paleontologii, 3:3–6. (In Russian)

MILLER, M. M. 1987. Dispersed remnants of a northeast Pacific fringing arc: upper Paleozoic terranes of Permian McCloud faunal affinity, western U.S. Tectonics, 6:807–830.

MINATO, M. AND M. KATO. 1965. Waagenophyllidae. Journal of the Faculty of Science, Hokkaido University, Series 4, Geology and Mineralogy, 12(3–4): 1–241.

MOJSISOVICS, E. VON. 1893. Die Cephalopodan der Hallstatter Kalde. Abhandlungen der Geologischen Reichanstalt 6, 835 p.

MÖLLER, V. VON. 1877. Ueber Fusulinen und ähnliche Foraminiferen-Formen des russischen Kohlenkalkes. Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, 1877:139–146.

MORIKAWA, R. AND H. ISOMI. 1960. A new genus *Biwaella. Schwagerina*-like *Schubertella*. Science reports of the Saitama University, Urawa, Japan, series B (Biology and Earth Sciences) 3:301–305.

NESTELL, M. K. 1983. Permian foraminiferal faunas of Central and Eastern Oregon. Symposium: Pre-Tertiary Evolution of northeast Oregon and Western Idaho, Cordilleran-Rocky Mountain Section Meeting, Geological Society of America, Salt Lake City. Abstracts with Programs, 15:371.

NESTELL, M. K. 1998. Correlation of Middle and Upper Permian Tethyan-related fusulinaceans in the United States. International Symposium: Upper Permian Stratotypes of the Volga Region, Kazan State University, Kazan, Tartarstan, Russia, Abstracts Volume, p. 129–143.

ORBIGNY, D'. A. 1849. Note sur des polypiers fossils. Victor Masson, Paris, 12 p.

ORBIGNY, D'. A. 1852. Cours élémentaire de paléontology et de géologie stratigraphique Victor Masson, Paris, 2:1–382.

OZAWA, Y. 1925. On the classification of Fusulinidae. Journal of the College of Science, Imperial University of Tokyo 45(4):1–26.

PORFIRIEV, G. S. 1941. *In* E. D. Soshkina, T. A. Dobrolyubova, and G. S. Porfiriev, Permskie Rugosa evropeyskoy chasti SSSR: Paleontologiya SSSR. Monograph 5, 3(1):1–304. (In Russian)

ROSS, C. A. 1964. Two significant fusulinid genera from the Word Formation (Permian) Texas. Journal of Paleontology, 38:311–315.

SANDO, W. J. 1983. Revision of *Lithostrotionella* (Coelenterata, Rugosa) from the Carboniferous and Permian. U.S. Geological Survey Professional Paper 1247:1–52.

SCHWARTZ, J. J., A. W. SNOKE, C. D. FROST, C. G. BARNES, L. P. GROMET, AND K. JOHNSON. 2009. Analysis of the Wallowa-Baker terrane boundary: implications for tectonic accretion in the Blue Mountains province, northeastern Oregon. Geological Society of America Bulletin, 123:2083–2111.

SCHENCK, H. G. AND M. L. THOMPSON. 1940. *Misellina* and *Brevaxina*, new Permian fusulinid foraminifera. Journal of Paleontology, 14:584–589.

SILBERLING, N. J., D. L. JONES, M. C. BLAKE JR., AND D. G. HOWELL. 1984. Lithotectonic terrane map of the western conterminous United States. U.S. Geological Survey, Open File Report 84–0523:C1–C43.

SILBERLING, N. J., D. L. JONES, M. C. BLAKE JR., AND D. G. HOWELL. 1987. USGS Miscellaneous Field Studies Map MF-1874-C, scale 1:2,500,000.

SKINNER, J. W. 1971. The fusulinid genera *Polydiexodina* and *Skinnerina*. University of Kansas Paleontological Contributions, 57:1–10.

SKINNER, J. W. AND G. L. WILDE. 1965. Permian biostratigraphy and fusulinid faunas of the Shasta Lake area, northern California. University of Kansas Paleontological Contributions, Special Paper 6:1–98.

SKINNER, J. W. AND G. L. WILDE. 1966. Permian fusulinids from Suplee area, east-central Oregon, p. 11–16. *In* Permian fusulinids from Pacific Northwest and Alaska. The University of Kansas Paleontological Institute, Paleontological Contributions, Special Paper 4(2):11–16.

SMITH, S. 1935. Two anthracolithic corals from British Columbia and related species from the Tethys. Journal of Paleontology, 9:30–42.

SMITH, D. AND T. A. RYDER. 1926. The genus *Corwenia*, gen. nov. Annals and Magazine of Natural History, series 9, 17:149–159.

SOLOVIEVA, M. N. 1985. *In* Epshteyn, O. G., Terekhova, T. P., and Solovieva, M. N. Paleozoy Koryakskogo nagor'ya (fauna foraminifer, biostratigrafiya). Voprosy Mikropaleontologii, 27:47–77. (In Russian)

SOSNIN, M. I. 1956. *In* L. D. Kiparisova, B. P. Markovsky, and G. P. Radchenko (eds.), Materialy po paleontologii, novye semeystva i rody. Vsesoyuznuy Nauchno-issledovatelskiy Geologicheskiy Institut (VSEGEI), 354 p. (In Russian)

STAFF, H. AND R. WEDEKIND. 1910. Der Oberkarbone Foraminiferensapropelit Spitzbergens Bulletin of the Geological Institution of the University of Uppsala, 10:81–123.

THOMPSON, M. L. 1951. New genera of fusulinid Foraminifera. Foraminiferal Research, Contributions, 2(4):115–119.

THOMPSON, M. L. AND H. E. WHEELER. 1942. Permian fusulinids from British Columbia, Washington, and Oregon. Journal of Paleontology, 16:700–711.

VERRILL, A. E. 1865. Classification of polyps (extract condensed from a synopsis of the polyps of the North Pacific Exploring Expedition, under captains Ringgold and Rodgers, U.S.N.). Essex Institute Proceedings, 4: 145–149.

WANG, H. C. 1950. A revision of the Zoantharia Rugosa in the light of their minute skeletal structures. Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences, 611:175–264.

WILDE, G. L. 1975. Fusulinid-defined Permian stages, p. 67–83. *In* Permian Exploration, Boundaries, and Stratigraphy: West Texas Geological Society and Permian Basin Section SEPM, Publication 75–65.

WU, W. S. AND K. J. ZHOU. 1982. Upper Carboniferous corals from Kalping and Aksu, Xinjiang. Bulletin of Nanjing Institute of Geology and Palaeontology, Academia Sinica, 4:213–239. (In Chinese)

YABE, H. 1950. Permian corals resembling *Waagenophyllum* and *Corwenia*. Japan Academy Proceedings, 26:74–79.

YABE, H. AND S. HANZAWA. 1932. Tentative classification of the foraminifera of the Fusulinidae. Proceedings of the Imperial Academy of Japan, 8:40–43.

ZHOU, J. AND H. LUO. 1998. *Changmeia*, a new fusulinid subgenus of *Paraschwagerina*. Acta Micropaleontologica Sinica, 15:267–271.

ACCEPTED 25 MARCH 2013