

Late Early Permian (late Leonardian; Kungurian) algae, microproblematica, and smaller foraminifers from the Yeso Group and San Andres Formation (New Mexico; USA)

Daniel Vachard, Karl Krainer, and Spencer G. Lucas

ABSTRACT

Six new species of algae and microproblematica, three new genera and nine new species of smaller foraminifers are described in the late Early Permian (= late Cisuralian = Kungurian = late Leonardian) strata of the Yeso Group and San Andres Formation in New Mexico (USA). These are four algae *Boueina? tubulata* n. sp., *B.? crassundia* n. sp., *Gymnocodium? johnsonii* n. sp., *G.? bacillum* n. sp.; two microproblematica *Ellesmerella rara* n. sp., and *Tubiphytes epimonellaeformis* n. sp.; four globivalvulinoid foraminifers *Globivalvulina parapiciformis* n. sp., *G. retroseptata* n. sp., *G. novamexicana* n. sp., and *G. praegraeca* n. sp.; and five miliolate foraminifers *Orthovertellopsis proteaeformis* n. gen. n. sp., *O. calcitornellaeformis* n. gen. n. sp., *Olgaorlovella davydovi* n. gen. n. sp., *Glomomidiella infrapermica* n. sp., and *Praeoneodiscus convexus* n. gen. n. sp. The Yeso Group and San Andres Formation are subdivided into six Kungurian/late Leonardian biozones. This accurate biozonation permits a better correlation of the Leonardian regional stage of Northern America, especially in New Mexico, and its comparison with the international Kungurian stage. Furthermore, the new taxa are important for reconstructing the phylogeny of Miliolata, and for correlating more accurately the series of North America, the Ural Ocean and Tethys.

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| TETHYS | | GLOBAL STAGES | URALS | CHINA | CARNIC ALPS | TEXAS | NEW MEXICO | | | |
|----------------------------------|------------------------------------|---------------|--|---------------|----------------------------|--------------------------------|------------|---------------------|----------------------|---------------|
| KUB. | <i>Cancellina</i> | ROADIAN | ?UFIMIAN | XIANGBOAN | TARVIS BRECCIA | CUTOFF FORMATION (part.) | ? | | | |
| | <i>Armenina</i> | 272.3 | | | BOLORIAN | | (part.) | LEONARDIAN | SAN ANDRES FORMATION | |
| BOLORIAN | <i>Misellina parvicostata</i> | KUNGURIAN | IRENIAN | GOGGAU MEMBER | | CATHEDRALIAN (LATE LEONARDIAN) | | | | GLORIETA SST. |
| | <i>Brevaxina dyhrenfurthi</i> | | | | | | | | | |
| | <i>Pamirina darvasica</i> | | SARANIAN | | ZOTTACKOPF FM. | | YESO GROUP | | | |
| YAKHTASHIAN | <i>Robustoschwagerina tumida</i> | | | ARTINSKIAN | | SARGINIAN | LUODIANIAN | ZWEIKOFEL FORMATION | APACHE DAM FORMATION | |
| | <i>Chalaroschwagerina vulgaris</i> | | IRGINIAN | | HESSIAN (EARLY LEONARDIAN) | | | | | |
| | <i>Darvasella</i> spp. | | | BURTSEVIAN | | ROBLEDO MOUNTAINS FORMATION | | | | |
| | <i>Darvasites contractus</i> | | COMMUNITY PIT FORMATION (uppermost part) | | | | | | | |
| <i>Chalaroschwagerina solita</i> | | | | | | | | | | |
| ? | | | | | | | | | | |
| <i>Zellia colanii</i> | | | | | | | | | | |
| <i>Minojapanella</i> sp. | | | | | | | | | | |
| | | 290.1 | | | | | | | | |

FIGURE 1. Stratigraphical nomenclature and correlations of the Artinskian, Kungurian, and Roadian (partim) interval (based on Ross and Ross, 1995; Henderson et al., 2012; Davydov et al., 2013; Lucas et al., 2015 modified). Abbreviations: KUB = Kubergandian; part. = partim (partially; in Latin); SST. = Sandstone; sp. = undetermined species; spp. = several undetermined species. Numbers 272.3, 279.3, and 290.1 represent radiometric ages in million years according to Henderson et al. (2012).

INTRODUCTION

Although the Late Pennsylvanian-Early Permian (i.e., Virgilian-Wolfcampian) fusulinids are well known in New Mexico (e.g., Thompson, 1948, 1964; Wilde, 1990, 2006; Vachard et al., 2012, 2013a with references therein), the late Early Permian (= Leonardian) assemblages of smaller foraminifers and algae remain poorly investigated (Krainer et al., 2009; Brose et al., 2013; Lucas et al., 2013a, 2013b, 2013c, 2015; Vachard et al., 2013b). In general, the Leonardian regional stage is less known than the other Permian stages in the USA (Dunbar et al., 1960; Ross, 1960, 1962, 1986, 1995; Magginetti et al., 1988; Fichten et al., 1995; Davydov, 1996; Davydov et al., 1997; Ross and Ross, 2003; Stevens and Stone, 2007); and in all of the Americas (Johnson and Kaska, 1965; Pérez-Ramos, 1992; Vachard et al., 1997; 2000a, 2000b, 2000c; Groves, 2000; Pérez-Ramos and Nestell, 2002). The equivalents of the Leonardian are the Artinskian and Kungurian of the Ural Mountains in Russia (e.g., Chuvashov et al., 1990; Anfimov et al., 1991); two stages which are now the international references in chronostratigraphy. The Tethyan equivalents are Yakhtashian and Bolorian (Leven, 1992, 1993, 2003); the Chinese regional names are Luodianian and Xiangboan (= early Chi-

hsian = early Qixaian) (Tong and Shi, 2000; Wang and Jin, 2000; Zhang et al., 2003; Yang et al., 2004) (Figure 1). This paper intends to: 1) describe a rich microflora of calcareous algae and microfauna of smaller foraminifers with interesting transitional forms, recently recovered from the late Early Permian Yeso and San Andres strata in central New Mexico; 2) document a rich microflora of codiaceans and gymnocodiaceans, as well as rare carbonate microproblematica, the zoological or botanical affinities (and consequently, the taxonomy) of which continue to be discussed: tuberitids (or tuberitinaceans), tubiphytidids (or tubiphytaceans), and ellesmellerids (or ellesmeraceans); 3) document various species of globivalvulinid, miliolate and nodosariate smaller foraminifers; and 4) try to provide biostratigraphic and palaeobiogeographic inferences.

HISTORICAL BACKGROUND

The Leonardian of the USA was divided into three fusulinid biozones by Wilde (1990), from bottom to top: 1) PL1: zone of *Schwagerina* (now *Praeskinnerella*) *crassitectoria* (Dunbar and Skinner, 1937); 2) PL2: zone of transitional *Parafusulina*; 3) PL3: middle zone of *Parafusulina*. According to Wilde (1990), PL1 is well represented

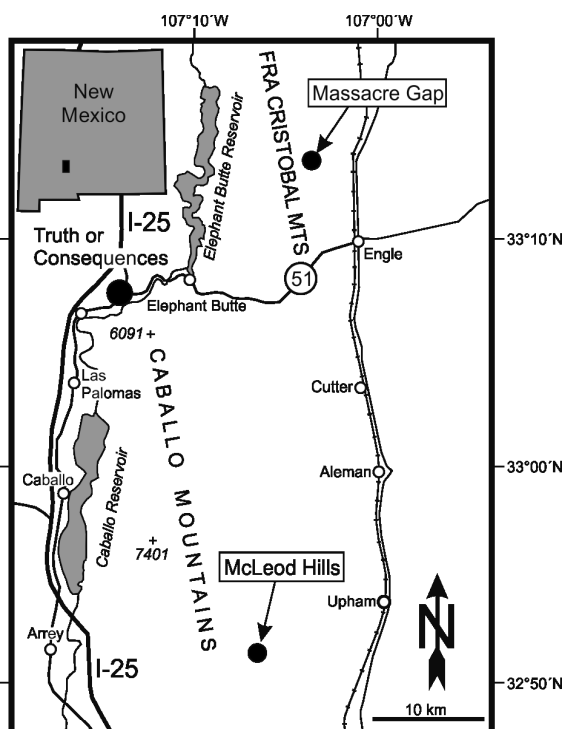


FIGURE 2. Location map of the Yeso Group sections at Massacre Gap and in the McLeod Hills, Sierra County (New Mexico) (after Lucas and Krainer, 2012 and Krainer et al., 2012, slightly modified).

by the lower Bone Spring Formation in the Delaware Basin, whereas its upper part corresponds to the lower part of the Yeso Group. The biozone PL2 is represented by the middle Bone Spring Formation and the middle Yeso shales and carbonates. The biozone PL3 corresponds to the upper Bone Spring Formation and the upper part of the Yeso Group. Moreover, PL3 contains the first *Boultonia* (now *Ogbinella*) *guadalupensis* Skinner and Wilde, 1954, which were encountered in the subsurface in the San Andres Formation (Wilde, 1990). These three biozones are considered to be either Artinskian and Kungurian (Ross and Ross, 1987, 1995; Vachard et al., 1997, 2000c) or parts of both stages (i.e., late Artinskian to early late Kungurian according to Davydov et al., 2013); the first two parts correspond to the Hessian regional substage and the last one to the Cathedralian substage. A zone of *Chalartoschwagerina hawkinsi* (Dunbar and Skinner, 1937) is occasionally added at the base of the Leonardian.

No biozonations with smaller foraminifers have been established in the Leonardian beds, and, in general, the knowledge of these groups is very poor in the Americas. References are more

numerous in the Urals (Morozova, 1949; Grozdilova, 1956; Zolotova and Baryshnikov, 1980; Baryshnikov et al., 1982; Chuvashov et al., 1990) and other regions of the former USSR (Filimonova, 2008, 2010), as well as in the Arctic islands of Norway and Canada (Sosipatrova, 1972; Groves and Wahlman, 1997; Pinard and Mamet, 1998; Blazejowski, 2009).

MATERIAL AND METHODS

Yeso Group

We studied the Yeso Group in the southern Fra Cristobal Mountains where a complete section is exposed at Massacre Gap and in the McLeod Hills of the southern Caballo Mountains, where a complete section is present but poorly-exposed, both in Sierra County, New Mexico (Figure 2).

In southern New Mexico, the Lower Permian Yeso Group is divided into the Arroyo de Alamillo Formation and the overlying Los Vallos Formation. The Los Vallos Formation is further divided into the (ascending order) Torres, Cañas and Joyita members (Lucas et al., 2005, 2013b; Lucas and Krainer, 2012). The Yeso Group (Figure 3) is underlain by nonmarine redbeds of the Abo Formation and overlain by strata of the eolian and shallow marine Glorieta Sandstone or the marine San Andres Formation (Figures 4, 5, 6).

At Massacre Gap in the Fra Cristobal Mountains (Figure 2), the Torres Member is approximately 134 m thick and composed of dolomite, gypsiferous siltstone, gypsum and siltstone to fine-grained sandstone (see details in Lucas and Krainer, 2012). The succession is composed of six transgressive-regressive cycles marked by six intervals of dolomite separated by thicker intervals composed of siltstone, gypsiferous siltstone, gypsum and minor carbonate and sandstone beds. Dolomite is present as bedded to massive, and is locally indistinctly laminated. Calcareous algae and foraminifers were recognized in dolomite horizons 2 and 4. In dolomite horizon 2, algae and foraminifers occur in an oncoidal floatstone to rudstone, composed of oncoids up to 6 mm in diameter, coated grains and fossil fragments including skeletons of bivalves and brachiopods, gastropods, foraminifers, ostracods, crinoids and calcareous algae (sample MG 10). In dolomite horizon 4, an intercalated dolomitized wackestone is composed of peloidal matrix with bivalves, gastropods, ostracods, crinoids, foraminifers and calcareous algae. In dolomite horizon 4, there are also thin intercalated rudstone layers (coquina) composed of abun-

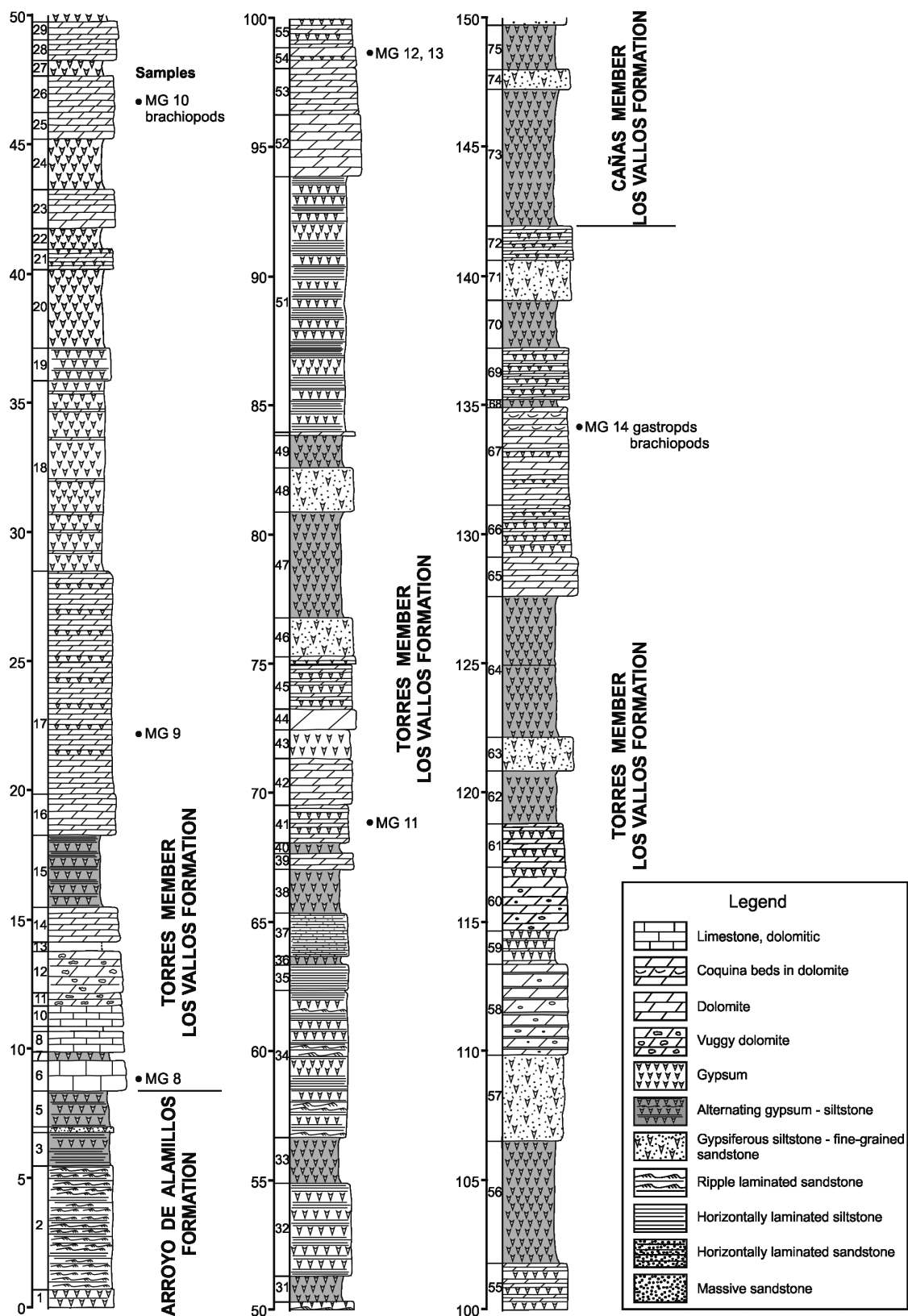


FIGURE 3. Lithostratigraphic columns of the Group at Massacre Gap with ticknesses (in m) and sample MG locations (after Lucas and Krainer, 2012 and Krainer et al., 2012, slightly modified).

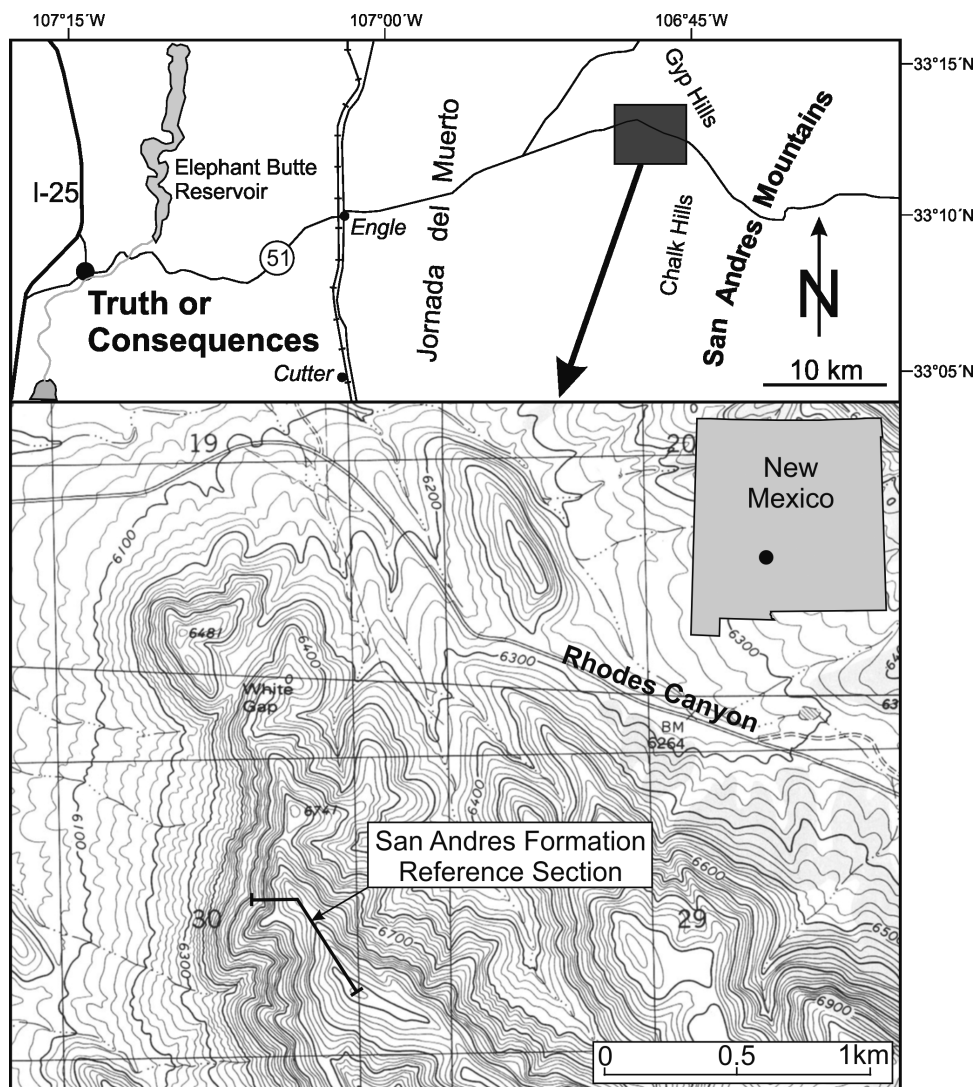


FIGURE 4. Location map of San Andres Formation at the reference section in the San Andres Mountains. After Krainer et al. (2012) (slightly modified).

dant bivalve and brachiopod fragments, minor amounts of gastropods and ostracods, and rare fragments of crinoids and calcareous algae (samples MG 12-13).

The dolomite horizon in the middle of the Torres Member in the McLeod Hills of the southern Caballo Mountains contains mudstone to wackestone composed of peloidal micrite and a poorly diversified fossil assemblage of locally abundant ostracods, crinoids and a few smaller foraminifers (Lucas and Krainer, 2012) (samples MLY 1-2). Dolomite of the Torres Member was deposited in a shallow marine, mostly restricted environment indicated by the low-diversity fossil assemblage. In this probable coastal sabkha, partly evaporitic conditions prevailed. Rare normal marine incursions into

the sabkha provide diversified fossil assemblages, whereas some coquina layers may represent storm layers (tempestites) (for details, see Lucas and Krainer, 2012).

San Andres Formation

The San Andres Formation was studied at the reference section in the northern San Andres Mountains, approximately 1.6 km west of the type section near Rhodes Canyon, Sierra County, and in the McLeod Hills of the southern Caballo Mountains New Mexico (Figures 2, 4).

The reference section of the San Andres Formation, exposed in the northern San Andres Mountains, is approximately 130 m thick (Figure 5).

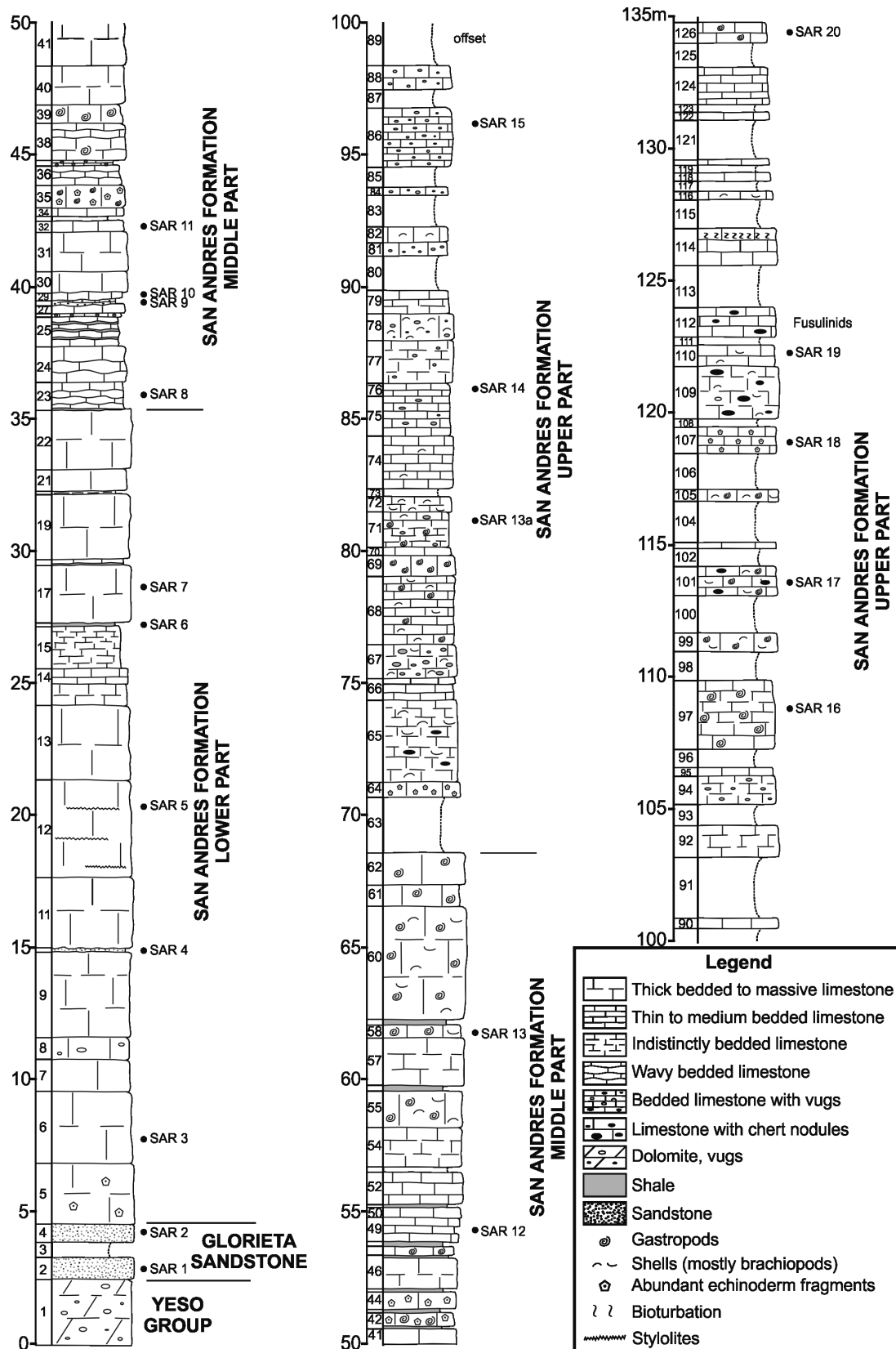


FIGURE 5. Stratigraphic columns of the San Andres Formation with thicknesses and sample SAR locations.

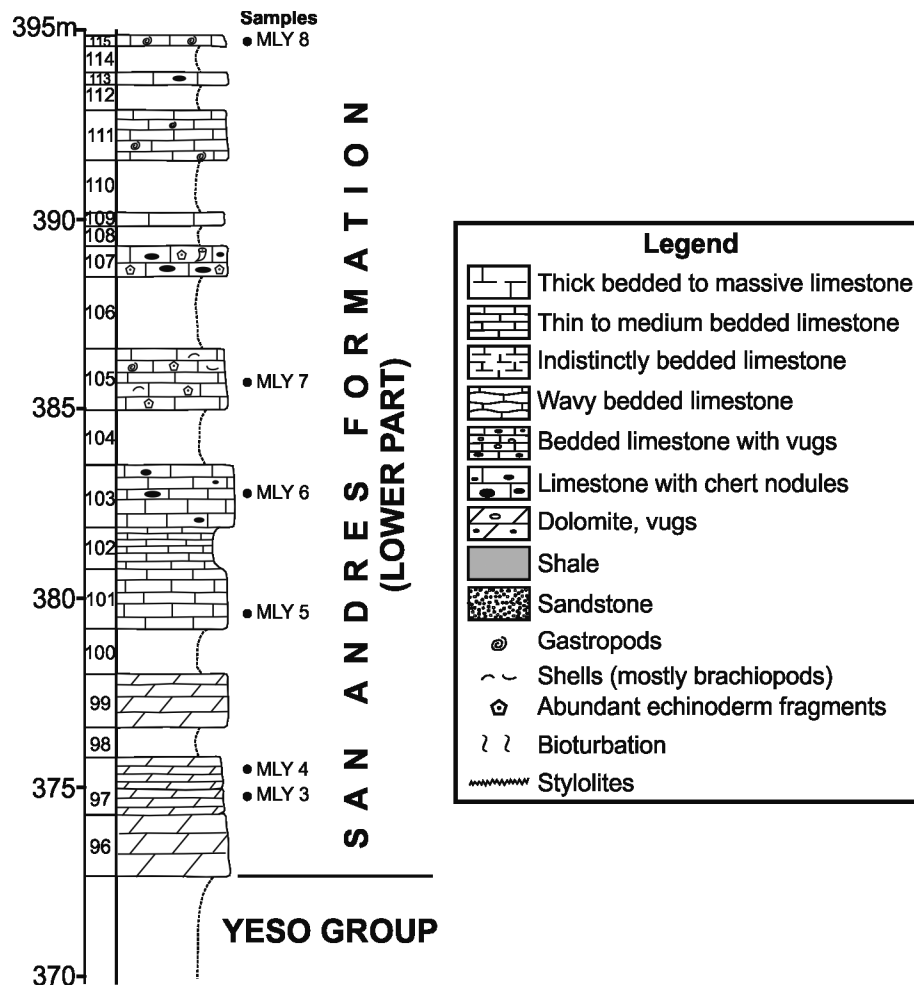


FIGURE 6. Detailed stratigraphic column of the lower part of San Andres Formation, in the McLeod Hills (southern Caballo Mountain), with thicknesses and sample MLY locations.

The succession rests on a very thin Glorieta Formation (= Glorieta Sandstone). The San Andres Formation section, which has an eroded top (and is probably incomplete), can be divided into lower, middle and upper parts (Krainer et al., 2012). The lower part (30 m thick) is composed of thick-bedded to massive, rare thin-bedded, gray to dark gray, bituminous, muddy limestone. The middle part (33 m thick) consists of thin- to thick-bedded limestone and massive limestone beds up to 4.3 m thick. Limestone is gray to dark gray and of muddy texture. The upper part is 67 m thick and composed of medium- to thick-bedded, partly indistinctly bedded, light to dark gray limestone, which rarely contain chert nodules. Richly bioclastic wackestone is the dominant microfacies, whereas subordinate microfacies are rudstone, floatstone and in the upper part grainstone (see details in Krainer et al., 2012). Smaller foraminifers and cal-

careous algae are present throughout the section; particularly, in its top (samples SAR 8, 11, 13 and 20).

The succession, approximately 22 m thick, overlying the Yeso Group in the McLeod Hills, southern Caballo Mountains (Figure 6), has been assigned to the San Andres Formation by Lucas and Krainer (2012). It is composed of massive to bedded dolomite, and bedded (mostly 20-40 cm) dolomitic limestone and limestone. Individual pure limestone intervals are up to 1.6 m thick; they contain echinoderm fragments (mainly crinoids), bryozoans, brachiopods, gastropods and rare corals. A few limestone beds contain chert nodules and silicified fossils; they are composed of wackestone with a high diversity fossil assemblage (including algal wackestone) and bioclastic mudstone with a low diversity fossil assemblage (samples MLY 3-8; Figure 6). The wackestone indicates deposition in

| YESO GROUP | | | GLORIETA SST. | SAN ANDRES FORMATION | | LITHOSTRATIGRAPHY |
|-----------------------------|---------|----------|---------------|----------------------|----------------|---|
| 1 | 2 | 3 | 4 | 5 | 6 | ZONES |
| MG 10 | MLY 1-2 | MG 12-13 | - | MLY 3-8 | SAR 8,11,13,20 | SAMPLES |
| | | | | | | 1 - <i>Boueina? tubulata</i> |
| | | | | | | 2 - <i>Boueina? crassundia</i> |
| | | | | | | 3 - <i>Gymnocodium? johnsonii</i> |
| | | | | | | 4 - <i>Gymnocodium? bacillum</i> |
| | | | | | | 5 - Chlorophyta indet. |
| | | | | | | 6 - <i>Tubiphytes epimonellaeformis</i> |
| | | | | | | 7 - <i>Eotuberitina reitlingeræ</i> |
| | | ● | | | | 8 - <i>Ellesmerella rara</i> |
| Saranian? | | | Filipovian? | | Irenian? | CHRONOSTRATIGRAPHY |
| K U N G U R I A N | | | | | | |
| L A T E L E O N A R D I A N | | | | | | |

FIGURE 7. Distribution of the studied algae, and microproblematica, and their biozonation and proposed chronstratigraphy, in the Yeso Group and San Andres Formation (New Mexico, USA).

an open marine, shallow shelf environment of dominantly low to moderate water turbulence; whereas the mudstone, containing vugs filled with calcite pseudomorphs of gypsum or other evaporite minerals, and a less diverse fossil assemblage indicates deposition in a restricted environment with increased salinity (Krainer et al., 2012). Nautiloids and ammonoids indicate a late Leonardian age (Kottlowski et al., 1956).

BIOSTRATIGRAPHIC SUBDIVISIONS

Two parallel biostratigraphic scales for the Yeso Group and San Andres Formation, are presented in this paper (Figures 7, 8, 9). These biozones are proposed, following the definitions of Salvador (1994), in order to: 1) propose a first consistent biozonation of the different lithostratigraphical units; 2) try to correlate the lithological units across New Mexico; 3) permit correlations in North America and eventually with the type Kungurian in Russia.

The Yeso Group is subdivided into three zones of calcareous algae and microproblematica (Figure 7):

Zone 1 with *Boueina? crassundia* n. gen. n. sp. and *Gymnocodium? johnsonii* lowest-occurrence zone;

Zone 2 with *Gymnocodium? johnsonii* n. sp. interval zone;

Zone 3 with *Ellesmerella rara* n. sp. and *Gymnocodium? johnsonii* n. sp. assemblage zone.

The Glorieta Formation is barren of microfossils and corresponds to an informal fourth zone.

The San Andres Formation is subdivided into two zones (Figure 7):

Zone 5 with *Boueina? tubulata* n. sp. taxon-range zone;

Zone 6 with *Tubiphytes epimonellaeformis* n. sp. taxon-range zone;

Similarly, the Yeso Group and San Andres Formation are subdivided here into six zones of smaller foraminifers (Figures 8, 9), which are probably exactly in correlation with the six biozones of calcareous algae and microproblematica which have just been proposed:

Zone 1 with *Glomomidiella infrapermica* n. sp. and *Orthovertellopsis protaeformis* n. sp. lowest-occurrence zone;

Zone 2 with *G. parapiciformis* n. sp. and *Nestellorella? sp.* assemblage zone;

| YESO GROUP | | | GLORIETA SST. | SAN ANDRES FORMATION | | LITHOSTRATIGRAPHY |
|------------------------------------|---------|----------|---------------|----------------------|----------------|---|
| 1 | 2 | 3 | 4 | 5 | 6 | ZONES |
| MG 10 | MLY 1-2 | MG 12-13 | - | MLY 3-8 | SAR 8,11,13,20 | SAMPLES |
| | — | | | | | 1 - <i>Globivalvulina parapacificiformis</i> |
| | | | | | | 2 - <i>Globivalvulina retroseptata</i> |
| | — | | | | | 3 - <i>Globivalvulina novamexicana</i> |
| | | | | | | 4 - <i>Globivalvulina praegraeca</i> |
| | | | | | | 5 - <i>Orthovertellopsis proteaeformis</i> |
| | | | | — | | 6 - <i>Orthovertellopsis calcitornellaeformis</i> |
| | | | | | — | 7 - <i>Olgaorlovella davydovi</i> |
| | | | | | | 8 - <i>Glomomidiella infrapermica</i> |
| | | | | | | 9 - <i>Praeoneodiscus convexus</i> |
| | | | | | — | 10 - <i>Ammovertella</i> sp. |
| | | | | | | 11 - <i>Palaeonubecularia</i> sp. |
| | | | | — | | 12 - <i>Calcitornella elongata</i> |
| | | | | | | 13 - <i>Hemigordiellina</i> cf. <i>elegans</i> |
| | | | | | — | 14 - <i>Hemigordiellina</i> aff. <i>elegans</i> |
| | | | | — | | 15 - <i>Hemigordiellina</i> ? cf. <i>simplex</i> |
| Saranian? | | | Filipovian? | | Irenian? | CHRONOSTRATIGRAPHY |
| K U N G U R I A N | | | | | | |
| L A T E L E O N A R D I A N | | | | | | |

FIGURE 8. Distribution of the smaller foraminifers (taxa 1 to 15), and their biozonation and proposed chronstratigraphy, in the Yeso Group and San Andres Formation (New Mexico, USA).

Zone 3 with "*Fronidularia*" aff. *turrae* taxon-range zone;

Zone 4 with the Glorieta Formation barren of microfossils;

Zone 5 with *Praeoneodiscus convexus* n. gen. n. sp. and *Orthovertellopsis calcitornellaeformis* n. gen. n. sp. assemblage zone;

Zone 6 with *Olgaorlovella davydovi* n. gen. n. sp. taxon-range zone.

Ammovertella, *Calcitornella*, *Palaeonubecularia*, *Orthovertellopsis*, *Hemigordiellina*, *Pseudospira*, *Olgaorlovella*, *Hemigordius*, *Glomomidiella*, *Praeoneodiscus*, *Protonodosaria*?, *Nodosinelloides*, *Nestellorella*?, *Geinitzina*, "*Fronidularia*", and Gen. indet. (Figures 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36); and 3) some microproblematica including species of *Tubiphytes*, *Ellesmerella*, and *Eotuberitina* (Figures 10, 11, 12, 13, 14, 19, 22, 24).

FORAMINIFERAL AND CALCAREOUS ALGAL ASSEMBLAGES

The regional Kungurian assemblages from the Yeso Group and San Andres Formation are composed of: 1) common codiacean and gymnocodiacean algae including species of *Boueina*?, *Gymnocodium*? and undetermined Chlorophyta (Figure 10, Figure 11, Figure 12, Figure 13, Figure 14, Figure 15, Figure 16, Figure 17, Figure 18, Figure 19, Figure 20); 2) relatively common smaller foraminifers including species of *Globivalvulina*,

ABBREVIATIONS AND REPOSITORY

In the systematic part below, we used the following abbreviations for the algae: L = length, D = outer diameter, d = inner diameter, s = thickness of wall, p = diameter of pores (= diameter of laterals), and ip = interval between two pores (i.e., between two laterals). For the foraminifers, the abbreviations are as follows: L = length, H = height, D = outer diameter, d = inner diameter, s = wall thickness, w = width, w/D = ratio width to outer diameter, p = proloculus diameter, n = number of whorls,

| YESO GROUP | | | GLORIETA SST. | SAN ANDRES FORMATION | | LITHOSTRATIGRAPHY |
|------------------------------------|---------|----------|---------------|----------------------|----------------|--|
| 1 | 2 | 3 | 4 | 5 | 6 | ZONES |
| MG 10 | MLY 1-2 | MG 12-13 | - | MLY 3-8 | SAR 8,11,13,20 | SAMPLES |
| | | | | — | — | 16 - <i>Hemigordiellina?</i> aff. <i>simplex</i> |
| | | | | — | | 17 - <i>Hemigordiellina?</i> aff. <i>pseudopusilla</i> |
| | | | | — | | 18 - <i>Pseudospira</i> aff. <i>ishimica</i> |
| | | | | — | | 19 - <i>Hemigordius</i> aff. <i>saranensis</i> |
| | | | | — | | 20 - <i>Protonodosaria?</i> sp. |
| | | | | — | | 21 - <i>Nodosinelloides longa</i> |
| | | | | — | | 22 - <i>Nodosinelloides netjaschewi</i> |
| | — | | | | — | 23 - Gen. indet. |
| | | — | | | | 24 - <i>Nestellorella?</i> sp. |
| | | | | | | 25 - <i>Fronicularia</i> aff. <i>turæ</i> |
| | | | | | | 26 - <i>Geinitzina indepressa</i> |
| Saranian? | | | Filipovian? | | Irenian? | |
| K U N G U R I A N | | | | | | CHRONOSTRATIGRAPHY |
| L A T E L E O N A R D I A N | | | | | | |

FIGURE 9. Distribution of the studied smaller foraminifers (taxa 16 to 26), and their biozonation and proposed chronostratigraphy, in the Yeso Group and San Andres Formation (New Mexico, USA).

and h = height of last whorl or height of last chamber.

All type specimens (holotypes and paratypes) of algae and foraminifers are housed in the collection of the New Mexico Museum of Natural History and Science and have NMMNH catalogue numbers.

SYSTEMATIC PALAEONTOLOGY

Phylum CHLOROPHYCOPHYTA Papenfuss, 1955
 Class BRYOPSIDOPHYCEAE Bessey, 1907
 Order BRYOPSIDALES Schaffner, 1922

Description. See e.g., Chuvashov, Luchinina, Shuysky, Shaikin, Berchenko, Ishchenko, Saltovskaya and Shirshova, 1987.

Remarks. The bryopsidales (codiales or caulerpales auctorum) appeared in the Ordovician and were abundant and diverse in back-reef environments during the Late Silurian and Early to Middle Devonian (Rothpletz, 1908; Poncet, 1982, 1990; Roux, 1985; Chuvashov et al., 1987; Mamet and Pr eat, 1994; Vachard, 1993). However, unquestionable bryopsidalean genera are very rare during Carboniferous and Permian times (e.g., Vachard et al., 1989b, 2001; Parvizi et al., 2013), whereas many Middle-Late Permian taxa belong to Gym-

nocodiaceae or “phylloid algae”, the botanical assignment of which is discussed. These questionable genera are *Succodium* Konishi, 1955; *Aphroditicodium* Elliott, 1970; *Tauridium* G ven c, 1966; *Tibeticodium* Mu, 1982; *Nanjinophycus* Mu and Riding, 1983; and *Thaiporella* Endo, 1969, which, although described as codiaceans, instead belong to gymnocodiaceans. Pia (1937), Elliott (1955) and Kochansky-Devid  and Sliskovic (1969) interpreted the gymnocodiaceans as galaxauracean red algae, based on the shape and subcortical location of the conceptacles, and the intraskeletal tubular elements identified as long files of cells. More recently, the gymnocodiaceans have been transferred to the green algae (Mu and Riding, 1983; Chuvashov et al., 1987; Bucur, 1994; Radoicic, 2004; and Schlagintweit and Sanders, 2007). Morphologically, it is evident that the files of cells are rarely visible (except for *Tauridium*, perhaps) and that the deltoid terminations of many genera are similar to the utricles of the codiaceans.

Phylogenetically, the assignment to the galaxauraceans leads to many problems with a very problematical and puzzling history: 1) unquestionable pre-Middle Permian ancestors are unknown; the Devonian “*Gymnocodium*” *devonicum* Mamet et al., 1993, is most probably a fossil ulotrachale

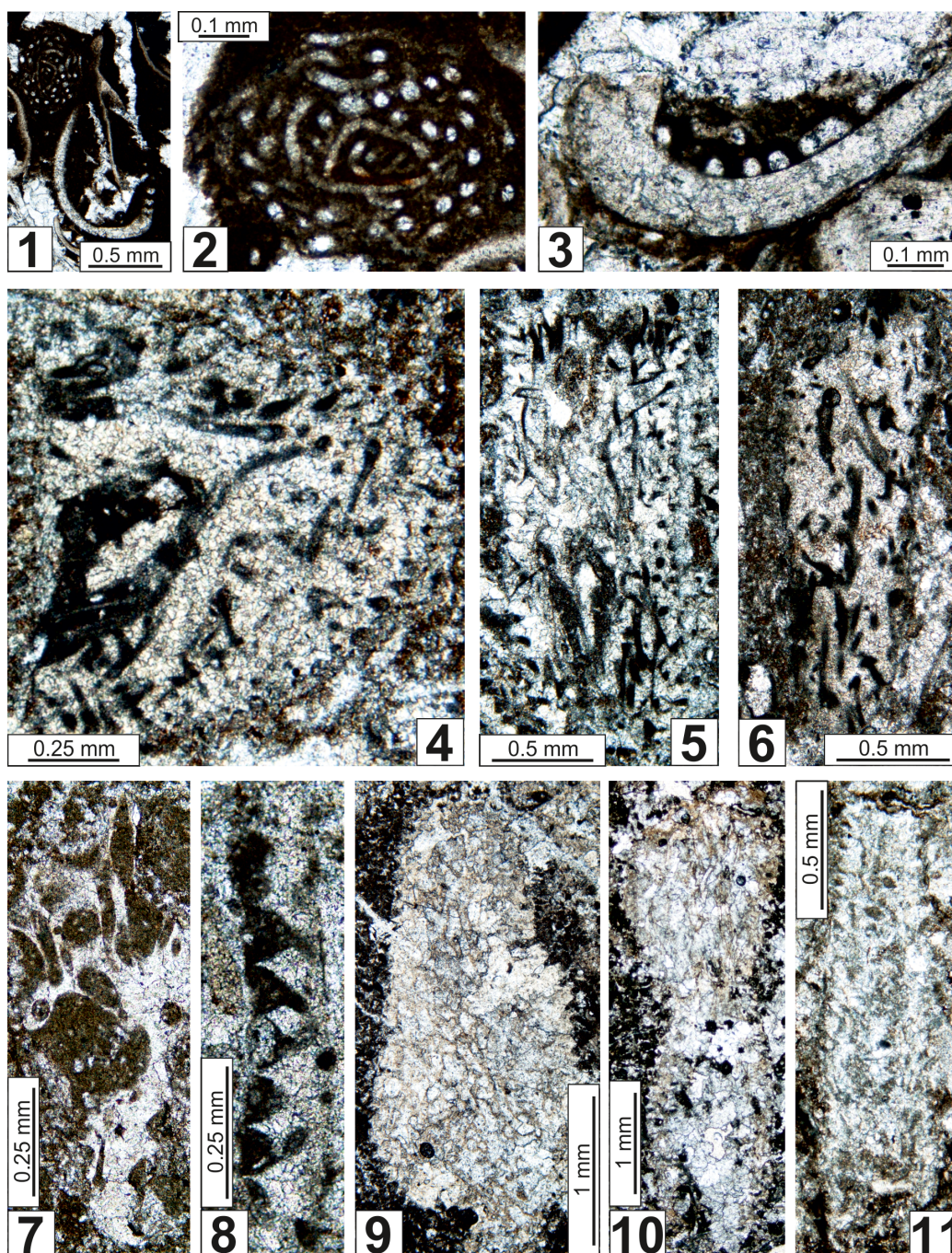


FIGURE 10. 1-3. *Ellesmerella rara* n. sp. 1. NMMNH P-67501, holotype and microfacies. Yeso Group. Sample MG 13c. 2. NMMNH P-67501, detail of holotype. Yeso Group. Sample MG 13d. 3. NMMNH P-67502, paratype encrusting the concavity of a bivalve shell. Yeso Group. Sample MG 13i. 4-6. *Boueina? tubulata* n. sp. 4. NMMNH P-67504, paratype. Oblique section with two medullar siphons (left) and numerous cortical siphons. San Andres Fm. Sample MLY(2) 5-17. 5. NMMNH P-67503, holotype. Axial section. San Andres Fm. Sample MLY(2) 6-12. 6. NMMNH P-67505, paratype. Axial section. San Andres Fm. Sample MLY(2) 6-19b. 7-8. Undetermined Chlorophyta. 7. NMMNH P-67514, subaxial section with possible connections between two orders of siphons or of laterals L1 and L2 (top, right). Yeso Group. Sample MG(2) 12-1. 8. Oblique section with distal parts of siphons or laterals. San Andres Fm. Sample MLY(2) 6-9. 9-10. *Gymnocodium? johnsonii* n. sp. 9. NMMNH P-67509, holotype. Longitudinal section. Yeso Group. Sample MG(2) 12-4. 10. NMMNH P-67510, paratype. Compressed longitudinal section. Yeso Group. Sample MG(2) 12-12. 11. *Gymnocodium? bacillum* n. sp. NMMNH P-67513, holotype. Longitudinal section. San Andres Fm. Sample SAR 8a-4.

(according to the criteria proposed by Kozłowski and Kazmierczak, 1968); 2) productivity was huge in Middle-Late Permian times followed by an almost total absence during the Triassic and the Early and Middle Jurassic; 3) a Lazarus effect occurs from Late Jurassic to Palaeocene; 4) a second Lazarus effect occurs in the Recent. Several derivations from one or several stocks of bryopsidales are most easy to imagine.

We speculate here that the phylogeny codiaceans-gymnocodiaceans really exists, and that our late Early Permian material has been particularly interesting for confirming this relationship with possible transitional forms similar to and/or ancestral to *Boueina*? described from our material.

Similarly, the “phylloid algae” are questionable codiacean algae. According to Schlagintweit (2010) and Granier (2012), the phylloid algae *sensu lato* can be considered as an informal botanical group. Indeed, the group defined by Pray and Wray (1963) is heterogenous, since it encompassed codiaceans (see Roux, 1985; Mamet et al., 1987; Forsythe et al., 2002; Torres, 2003), ancestral corallinales (see Wray, 1971; Vachard et al., 1989a; Corrochano et al., 2013), and algospongia (see Vachard et al., 1989a, 1989b, 2001, 2012; Vachard and C  zar 2010; Granier 2012; Parvizi et al., 2013). Furthermore, some representatives are probably the result of complex taphonomic interactions on algal thalli (Vachard et al., 1989a, 1989b, 2001). According to our published and unpublished data, the phylloid algae are to interpret as follows: 1) *Eugonophyllum* Konishi and Wray, 1961; *Ivanovia* Khvorova, 1946; *Anchicodium* Johnson, 1946; *Neoanchicodium* Endo in Endo and Kanuma, 1954; *Kansaphyllum* Baars, 1992; *Calcipatera* Torres, West and Sawin, 1992; and *Iranicodium* Senowbari-Daryan and Rashidi, 2010 most probably belong to the codiaceans (moreover, there are many generic synonymies; see discussion in Parvizi et al. (2013)); 2) *Archaeolithophyllum* Johnson, 1956 is typically a red alga; and perhaps, the unique unquestionable Palaeozoic calcareous red alga (Vachard et al., 1989a, 2001; Kirkland et al., 1991, 1993; Dawson, 1992; Moshier and Kirkland, 1993; Pintigore, 1994; Corrochano et al., 2013); 3) *Calcifolium* Maslov, 1956 and the calcifoliids differ totally and belong to the incertae sedis algosponges (Vachard and C  zar, 2010).

Occurrence. Ordovician to Recent; cosmopolitan in subtropical seas.

Family CODIACEAE K  tzing, 1843

Synonyms. Dimorphosiphonaceae (Shuysky in Chuvashov, Luchinina, Shuysky, Shaikin, Berchenko,

enko, Ishchenko, Saltovskaya and Shirshova, 1987) Vachard, 1993; Codiaceae K  tzing, 1843 (partim); Praecodiaceae Dragastan, 2008 (partim); Scribroporellaceae (Rietschel, 1966) Vachard, 1993 emend. Vachard, Haig and Mory, 2014 (partim).

Description. Large thalli not segmented, probably cylindrical or club-shaped. Broad medullar zone poorly preserved. Subcortical zone with subvertical siphons, acrophore, slightly phloiophore or perhaps vesiculifer, more or less euspondyl. Cortical zone with fine siphons linked in tuft-like groups and showing several ramifications with constant diameter up to the outer surface, and terminated by circular pores (deltoid terminations corresponding to utricles are inconspicuous). Reproductive structures unknown (the occasionally mentioned subcortical conceptacles are in fact misinterpreted and correspond to lithophagous perforations). Wall whitish, microspartitized, probably originally aragonitic.

Composition. Six Palaeozoic tribes (plus eventually two tribes of “phylloid algae” to emend): Ivanoviae Shuysky in Chuvashov et al. (1987) and Paradeliae Maslov, 1956; Lanciculeae Shuysky, 1985; Palaeoporellae Shuysky in Chuvashov et al. (1987); Abacelleae Shuysky in Chuvashov et al. (1987); Ampulliporeae Shuysky in Chuvashov et al. (1987); Botryelleae Shuysky in Chuvashov et al. (1987); and the first Boueineae Shuysky in Chuvashov et al. (1987) (orth. mut.; sic: Boueneae).

Remarks. The name Codiaceae has priority over Scribroporellaceae as well as Dimorphosiphonaceae and encompasses the majority of the Praecodiaceae. The Palaeozoic members of this family constitute a group that shares morphological and possible phylogenetic affinities with various fossil ulotrichales (Kozłowski and Kazmierczak, 1968), gymnocodiales, dasycladales, and siphonales.

Occurrence. Ordovician-Holocene; widespread on Palaeotethys and Urals Ocean shelves during the Late Palaeozoic.

Tribe BOUEINEAE Shuysky in Chuvashov, Luchinina, Shuysky, Shaikin, Berchenko, Ishchenko, Saltovskaya and Shirshova, 1987

Description. Codiaceae with a medullar zone well to poorly preserved. Cylindrical thalli (or segments). Medullar zone with coarse, tangled siphons. Subcortical zone with subvertical siphons, acrophore to slightly phloiophore, more or less euspondyl. Cortical zone with perpendicular, thin, acrophore, finer, ramified siphons first parallel and then linked in tuft-like groups and showing several

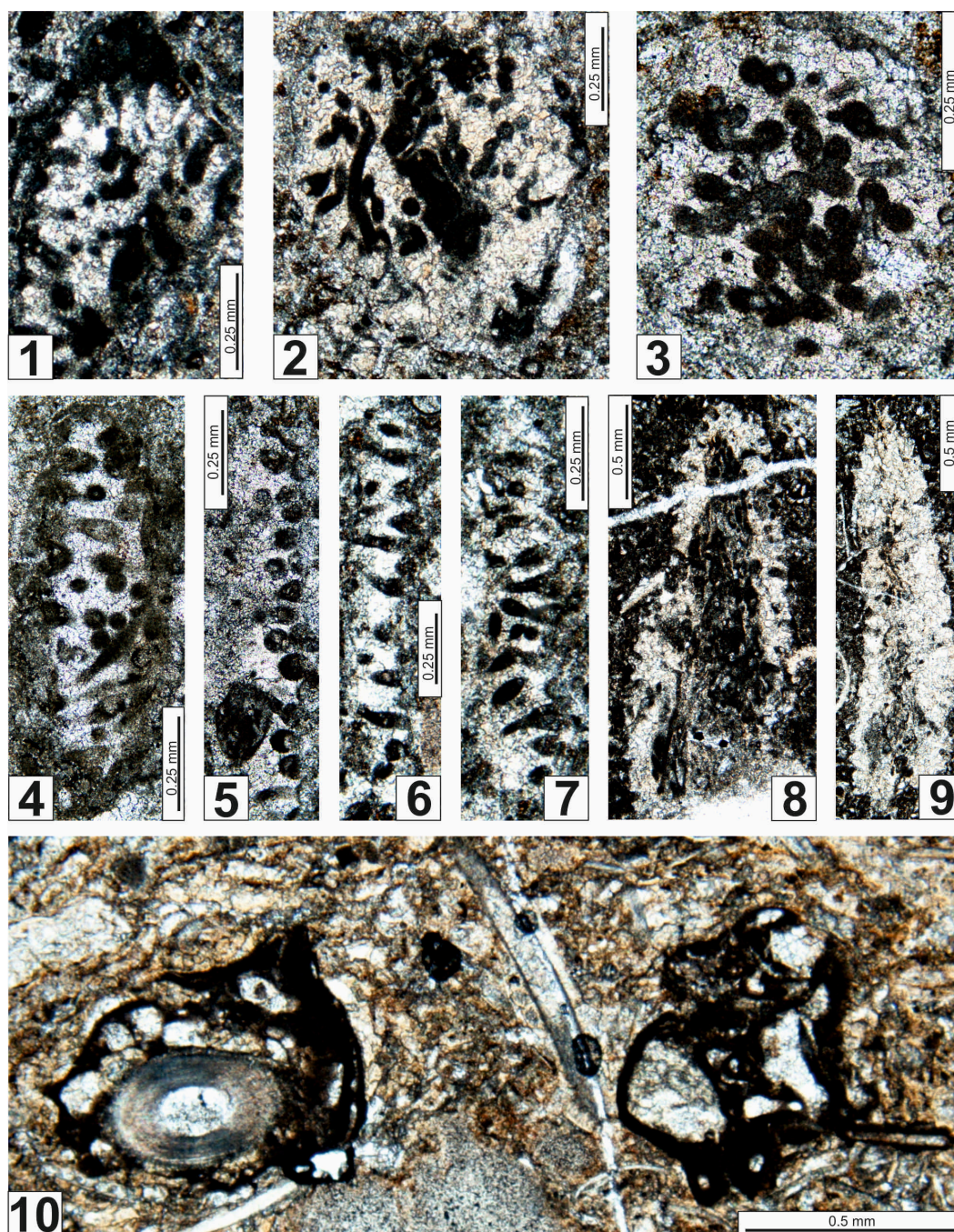


FIGURE 11. 1-4, 6-7. *Boueina? crassundia* n. sp. 1. NMMNH P-67506, holotype. Oblique section showing all the types of siphons. San Andres Fm. Sample MLY(2) 6-7a. 2. NMMNH P-67494, paratype. Axial section. San Andres Fm. Sample MLY(2) 5a-13. 3. NMMNH P-67495, paratype. Axial section with medullar siphons. San Andres Fm. Sample MLY(2) 5a-11. 4. NMMNH P-67507, paratype. Oblique section with cortical siphons. San Andres Fm. Sample MLY(2) 6-27. 6. NMMNH P-67507, paratype. Oblique sections with cortical siphons (already illustrated in Brose et al., 2013, figure 6.8). San Andres Fm. Sample MLY(2) 5-9. 7. NMMNH P-67496, paratype. Oblique section with cortical siphons. San Andres Fm. Sample MLY(2) 6-28. 5. Undetermined Chlorophyta. NMMNH P-67516, oblique sections with siphons or L2 and L1 laterals (bottom, left). San Andres Fm. Sample MLY(2) 6-10. 8-9. *Gymnocodium? johnsonii* n. sp. 8. NMMNH P-67511, paratype. Axial section with well preserved medullar zone. Yeso Group. Sample MG(2) 12-3. 9. NMMNH P-67512, paratype. Axial section more recrystallized than Figure 11.8. Specimen already illustrated in Lucas et al. (2013b, figure 8J). Yeso Group. Sample MG(2) 12-5. 10. *Tubiphytes epimonellaeformis* n. sp. NMMNH P-67518, a paratype encrusting a productoid spine (left); another paratype (right); and an isolated brachiopod spine (centre). San Andres Fm. Sample SAR 12-3.

ramifications with constant diameter up to the outer surface.

Composition. *Boueina* Toulou, 1884; *Boueina?* (this study); *Maslovina* Obrhel, 1968; *Pseudolitanaia* Mamet and Pr eat, 1994; *Bijagodella* Chuvashov, Yuferev and Liuchinina, 1985; *Poncetellina* Mamet and Roux, 1984; *Palaeoporella?* sp. sensu Vachard, 1988; *Funiculus* Shuysky and Shirshova in Chuvashov et al. (1987); *Arabicodium* Elliott, 1957.

Remarks. *Boueinae?* differs from the other tribes of Palaeozoic Codiaceae listed above, and especially from *Litanaia* Shuysky in Chuvashov et al. (1987), by the weak development or absence of inflated parts in the siphons and/or deltoid terminations (utricles). Some Devonian taxa have more affinities with *Boueinae* than *Litanaia* or *Palaeoporellae* Shuysky in Chuvashov et al. (1987), such as *Maslovina meyenii* Obrhel, 1968; *M. australensis* Mamet and Pohler, 2002; *Pseudolitanaia graecensis* [sic; to correct in *graeca*] (Hubmann, 1990) Mamet and Pr eat, 1994; *Paralitanaia baileuxensis* Mamet and Pr eat, 1985; *Praelitanaia anirica* (Maslov, 1956) Shuysky in Chuvashov et al. (1987); *Bijagodella bijagodensis* (Chuvashov, 1973) Chuvashov et al. (1985); etc. (the diagnoses of these taxa are compiled, for example, in Bassoullet et al. (1983)). *Arabicodium* seems to be morphologically transitional between *Boueina* and *Halimeda* Lamouroux, 1812 (see Elliott, 1982; Bassoullet et al., 1983).

Occurrence. FAD in the Late Silurian with *Maslovina*. First acme in the Middle Devonian with *Funiculus*. The tribe is present with *Palaeoporella?* sp. at the Devonian-Carboniferous boundary (Vachard, 1988, plate 1, figure 7). *Boueina* is known from the Late Triassic of Thailand (Fl ugel, 1988) to Early Cretaceous (Toulou, 1884). LAD in early Eocene with *Arabicodium* (Bassoullet et al., 1983).

Genus BOUEINA?

Description. Cylindrical *Boueinae* with medium, tangled, longitudinal medullary threads with long segments of tubes; and fine, oblique, and one time branching, radial or oblique cortical threads. The subdermal zone shows fine terminal branchlets (and very rarely very small deltoid terminations). No reproductive organs obvious.

Composition. *Boueina? tubulata* n. sp.; *B.? crassundia* n. sp.; *Boueina* sp. sensu Maslov (1973, plate 12, figure 4).

Remarks. *Boueina?* differs from true *Boueina* by having less ramification orders in the cortical zone,

less difference in filament diameters between the cortical and medullar zones, and shorter and more rectilinear medullar siphons (see Elliott, 1970, table 2). These differences are presently insufficient to permit the description of a new genus. The coeval genus *Nanjinophycus* Mu and Riding, 1983 (from the late Bolorian = latest Kungurian = *Misellina claudiae* Deprat fusulinid zone of the Nanjing area in China), differs fundamentally by the cortex of typically gymnocodiacean deltoid terminations. Moreover, incomplete and/or abraded fragments may be relatively identical, due to relatively similar cortical and medullar siphons.

Occurrence. Kungurian (late Leonardian) of New Mexico. Middle Permian of Armenia (Maslov, 1973).

Boueina? tubulata n. sp.

Figures 10.4-10.6, 13.3, 13.6, 13.7, 18.1-18.5

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v. 2013b *Boueina?* sp. 1; Vachard, Krainer and Lucas, p. 348 (no illustration).

Etymology. Latin *tubulatus*: bearing small tubes.

Holotype. NMMNH P-67503; Figure 10.5; sample MLY(2) 6-12.

Paratypes. NMMNH P-67504, 67505; Figure 10.4, 10.6.

Material. 52 specimens.

Locus Typicus. NMMNH locality 8892, San Andres Formation, McLeod Hills (New Mexico).

Stratum Typicum. Middle? Kungurian (late Leonardian).

Diagnosis. *Boueina?* with thin siphons in both medullar and cortical zones.

Description. The thallus is cylindrical and measures: L = 0.86-1.86 mm and w = (rarely 0.34-0.47) 0.72-1.25 mm. Medullar zone with medium-sized, tangled, longitudinal threads exhibiting long segments of tubes with a diameter of (rarely 0.01 mm) 0.02-0.04 mm. Cortical zone with fine (0.01 mm), oblique, and one time branching, radial or oblique threads. The subdermal zone shows some small deltoid terminations, 0.03 mm wide.

Occurrence. Middle? Kungurian (late Leonardian) of New Mexico (San Andres Formation, McLeod Hills (lower part): samples MLY 5-8, MLY 5-10, MLY 5-14, MLY(2) 5-17, MLY(2) 5-19, MLY(2) 5a-2, MLY(2) 5a-9, MLY(2) 5a-20, MLY(2) 5a-26, MLY(2) 6-4, MLY(2) 6-8, MLY(2) 6-12, MLY(2) 6-19a, MLY(2) 6-19b, MLY 6-20)).

Boueina? crassundia n. sp.

Figures 11.1-11.4, 11.6, 11.7, 13.1, 13.2, 13.4, 13.5, 13.8, 13.10, 14.1-14.4, 14.10, 15.1, 15.2,

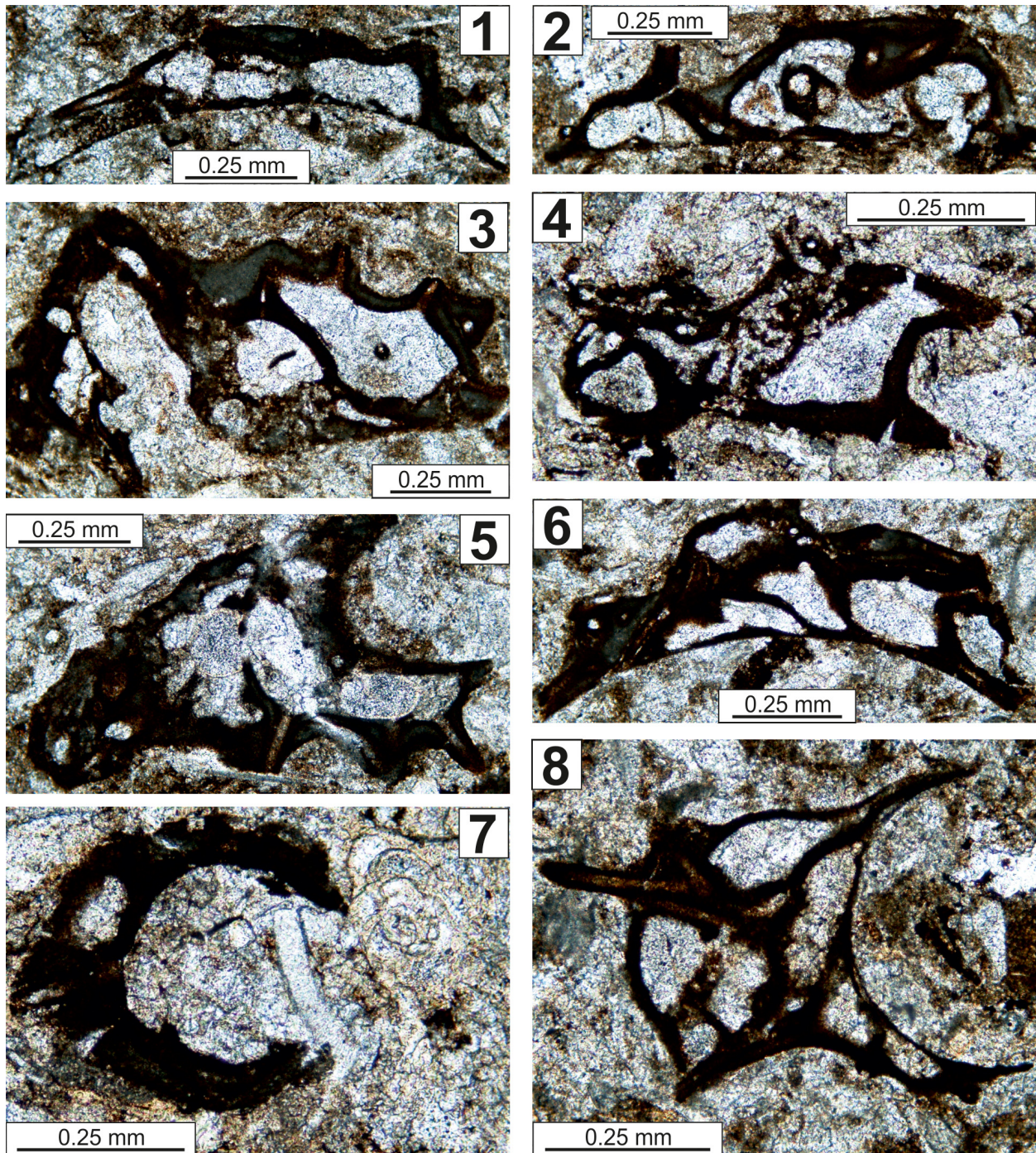


FIGURE 12. 1-8. *Tubiphytes epimonellaeformis* n. sp. 1. NMMNH P-67517, holotype. San Andres Fm. Sample SAR(2) 12-2. 2. NMMNH P-67518, paratype. San Andres Fm. Sample SAR(2) 12-3a. 3. NMMNH P-67519, paratype. San Andres Fm. Sample SAR(2) 12-3. 4. NMMNH P-67520, paratype. San Andres Fm. Sample SAR(2) 11-9. 5. NMMNH P-67521, paratype. San Andres Fm. Sample SAR(2) 12-12. 6. NMMNH P-67522, paratype. San Andres Fm. Sample SAR(2) 12-8. 7. NMMNH P-67523, paratype with *Olgaorlovella davydovi* n. gen. n. sp. (paratype; top right). San Andres Fm. Sample SAR(2) 11-8. 8. NMMNH P-67524, paratype. San Andres Fm. Sample SAR(2) 12-13.

15.4, 15.7, 15.9, 16.1, 16.2, 16.6, 16.8, 18.6-18.11,
20.13, 20.15

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v. 2013 *Paraboueina*; Brose, Lucas and Krainer, fig. 6.8.

v. 2013b *Boueina*? sp. 2; Vachard, Krainer and Lucas, p. 348 (no illustration).

Etymology. Latin *crassundia*: large intestine; because of the broad medullar siphons.

Holotype. NMMNH P-67506; Figure 11.1; sample MLY(2) 6-7a.

Paratypes. NMMNH P-67494, 67495, 67496, 67507, 67508; Figure 11.2-4, 11.6-7.

Material. 200 specimens.

Locus Typicus. NMMNH locality 8892; San Andres Formation, McLeod Hills (New Mexico).

Stratum Typicum. Middle? Kungurian (late Leonardian).

Diagnosis. *Boueina*? with broad siphons in both medullar and cortical zones.

Description. The thallus is cylindrical (L = 1.00-1.75 mm; w = 0.45-0.75 mm). Medullar zone with medium-sized, tangled, longitudinal threads exhibiting long segments of tubes with a diameter of 0.05-0.09 mm. Cortical zone with relatively wide (0.03-0.04 mm), oblique, and one time branching, radial or oblique threads. The subdermal zone shows some small deltoid terminations (0.03-0.05 mm).

Comparison. *Boueina*? *crassundia* n. sp. differs from *B. tubulata* n. sp. by broader siphons, even where the other dimensions are the same. This character is not diagenetic because there are no transitional measurements.

Occurrence. Early?-middle? Kungurian (late Leonardian) of New Mexico (Yeso Group, Los Vallos Formation, Torres Member: samples MG 10-1, MG 10-10, MG(2) 12-6, MG(2) 12-11, MG(2) 12-15; San Andres Formation, McLeod Hills (lower part); samples MLY 5-1, MLY 5-2, MLY 5-6, MLY(2) 5-6, MLY 5-7b, MLY(2) 5-9, MLY(2) 5-11, MLY(2) 5-14, MLY(2) 5-16, MLY 5-18, MLY(2) 5-18, MLY(2) 5-19, MLY(2) 5-19d, MLY 5-20, MLY 5-26, MLY 5-27, MLY 5-28, MLY(2) 5a-1, MLY(2) 5a-3, MLY(2) 5a-4, MLY(2) 5a-10, MLY(2) 5a-11, MLY(2) 5a-12, MLY(2) 5a-13, MLY(2) 5a-19, MLY(2) 5a-19a, MLY(2) 5a-21, MLY(2) 5a-23, MLY(2) 5a-25, MLY(2) 6-7, MLY(2) 6-7a, MLY 6-8, MLY(2) 6-8, MLY(2) 6-8a, MLY 6-10, MLY(2) 6-11, MLY 6-13, MLY 6-14, MLY(2) 6-15, MLY(2) 6-16, MLY(2) 6-17, MLY(2) 6-21, MLY(2) 6-27, MLY(2) 6-28, MLY(2) 6-30, MLY 8-3)).

Incerti ordinis

Family GYMNOCODIACEAE Elliott, 1955

Genus GYMNOCODIUM Pia, 1920 emend. Elliott, 1955

Type Species. *Gyroporella bellerophontis* Rothpletz, 1894.

Description. Gymnocodiaceae characterised by thallus rarely hollow and/or bifurcated; elongate cone shaped to pinching and swelling, circular in cross section. Medullar siphons oblique, numerous, preserved in the form of short segments; cortical siphons not ramified and with relatively wide deltoid terminations.

Occurrence. FAD poorly known; LAD at the Permian-Triassic Boundary. Common and cosmopolitan in the Late Permian (Carnic Alps, Southern Alps, Croatia, Montenegro, Serbia, Hungary, Greece, Tunisia, Turkey, Armenia, North Caucasus, Iran, Iraq, Saudi Arabia, Oman, Afghanistan, Pakistan, Ladakh, Tibet, South China, Thailand, Malaysia, Laos, Cambodia, Viet Nam, Japan, New Zealand, New Mexico, Guatemala).

Genus GYMNOCODIUM?

Description. The regional representatives differ from true *Gymnocodium* by the absence of conceptacles, the thallus less regularly cylindrical and not bifurcated, the occasionally well preserved medullary zone, the smaller deltoids, and the cortical siphons better preserved; however, these characters seem to be insufficient to create a distinct genus or subgenus. *Gymnocodium*? differs also from *Permocalculus* Elliott, 1955 in the thallus less regularly segmented, the wider deltoids, the lesser number of ramifications of the cortical siphons, and the absence of conceptacles.

Composition. *Gymnocodium*? *johnsonii* n. sp., *G. bacillum* n. sp. (and their possible synonyms indicated below).

Occurrence. Kungurian (= late Leonardian) of New Mexico; Artinskian-Kungurian (early-late Leonardian) of Guatemala. Possibly present in the Early Permian of South China (Li and Mamet, 1993) and North China (Mamet and Zhu, 2005).

Gymnocodium? *johnsonii* n. sp.

Figures 10.9, 10.10, 11.8, 11.9, 14.6, 14.7, 14.11, 15.3, 15.5, 15.6-15.8, 15.10, 15.11, 16.3-16.5, 16.7, 16.9, 17.5, 17.8, 17.9, 18.11, 19.1, 19.2, 19.4-19.6, 19.9, 20.17, 20.19

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? 1965 *Gymnocodium bellerophontis* (Rothpletz); Johnson and Kaska, p. 64, pl. 1, figs. 1, 2, 3, 4.

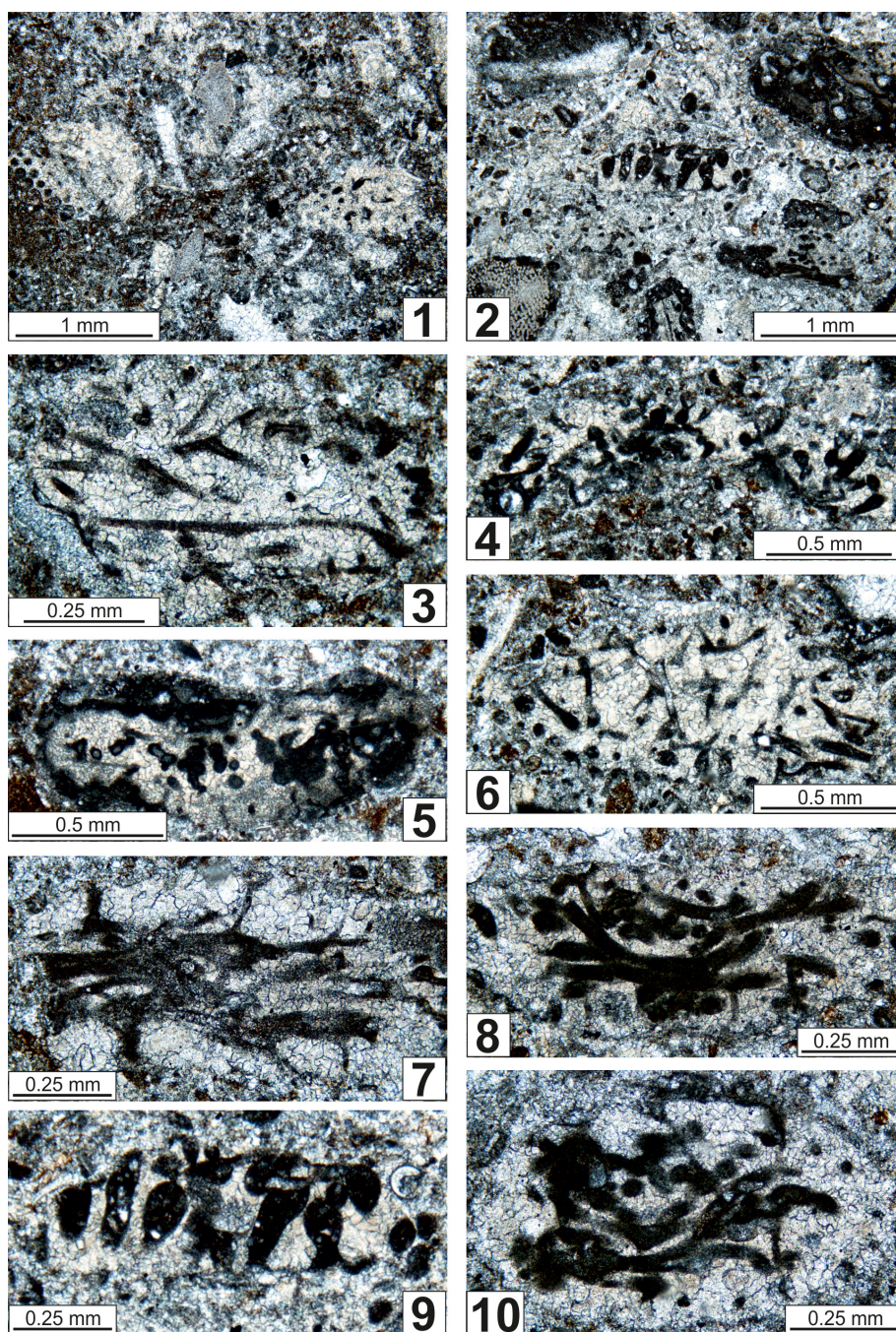


FIGURE 13. 1, 4-5, 8, 10. *Boueina? crassundia* n. sp. 1. Tangential section (right) with *Gymnocodium? johnsonii* n. sp. (left) and crinoids (centre top and bottom). San Andres Fm. Sample MLY 5-26. 4. Oblique subaxial section showing the siphons of the medullar zone. San Andres Fm. Sample MLY 5-6. 5. Oblique section showing the siphons of the medullar zone. San Andres Fm. Sample MLY 5-18. 8. Axial section with cortical and medullar zones. San Andres Fm. Sample MLY 5-8. 10. Axial section with a well-developed medullar zone but a poorly preserved cortical zone. San Andres Fm. Sample MLY 5-20. 2, 9. Undetermined Chlorophyta. 2. Fragment of a longitudinal section and microfacies (bivalve, top left; *Palaeonubecularia* sp. (top right); *Eotuberitina reitlingerae* Miklukho-Maklay, 1958 (right, centre); crinoid (bottom left); *Boueina? crassundia* n. sp. (bottom right)). San Andres Fm. Sample MLY 5-2a. 9. Detail of Figure 13.2; with *Eotuberitina reitlingerae* Miklukho-Maklay, 1958 (top right). San Andres Fm. Sample MLY 5-2a. 3, 6-7. *Boueina? tubulata* n. sp. 3. Subaxial section showing the ramified siphons of the medullar zone. San Andres Fm. Sample MLY 5-14. 6. Oblique subaxial section showing some ramifications of the siphons of the medullar zone. San Andres Fm. Sample MLY 5-7b. 7. Axial section with typical cortical and medullar siphons. San Andres Fm. Sample MLY 5-10.

- ? 1965 *Permocalculus* cf. *tenellus* Pia; Johnson and Kaska, p. 64-65, pl. 2, fig. 1.
 ? 1993 *Gymnocodium*; Li and Mamet, fig. 4F.
 ? 2005 *Gymnocodium*; Mamet and Zhu, fig. 6H.
 v. 2013b *Gymnocodium*; Lucas, Krainer and Voigt, fig. 8H, J.
 v. 2013 Gymnodiacean algae; Brose, Lucas and Krainer, fig. 6.1, 6.3.
 v. 2013 *Gymnocodium*; Brose, Lucas and Krainer, fig. 6.9.
 v. 2013b *Gymnocodium* sp. 1; Vachard, Krainer and Lucas, p. 348 (no illustration).

Etymology. In memory of J.H. Johnson for his fundamental work on the North American algae.

Holotype. NMMNH P-67509; Figure 10.9; sample MG(2) 12-12.

Paratypes. NMMNH P-67510, 67511, 67512; Figures 10.10, 11.8-9.

Material. 275 specimens.

Locus Typicus. NMMNH locality 8893; Yeso Group, Los Vallos Formation, Torres Member, Massacre Gap in the southern Fra Cristobal Mountains (New Mexico).

Stratum Typicum. Early? Kungurian (late Leonardian).

Diagnosis. A *Gymnocodium?* characterised by some constrictions of the thallus, a poorly individualized medullar zone, and curved cortical siphons with large deltoid terminations.

Description. Thallus moderately large (L = 1.13-4.50 mm, w = 0.45-3.00 mm), and periodically but asymmetrically compressed. Medullar zone generally sparitized and poorly individualized from the cortical zone. This cortical zone is relatively wide and crossed by euspondyl, curved, thin siphons, with terminal deltoids equilaterally triangular and relatively wide (0.05-0.07 (0.09) mm). Conceptacles not observed.

Comparisons. *Gymnocodium? johnsonii* n. sp. differs from the typical *Gymnocodium* by the characters indicated above. From the rare moniliform *Gymnocodium* as such as *G. nodosum* (Ogilvie-Gordon, 1927) Bilgütay, 1959, it differs by larger dimensions (w = 1.27-2.40 mm in this latter species; see Roux, 1991), irregular swelling (against regular barrel-like segments), and less deep deltoid terminations. It differs from *Siamporidium elongatum* Endo, 1969 by a less elongate test and less ramified cortical siphons.

The new taxon *Gymnocodium? johnsonii* n. sp., as one of the oldest representatives of the Gymnodiaceae, may represent a missing link between an ancestral *Boueina*-like codiacean or

Nanjinophycus-like gymnodiaceans and the true gymnodiaceans; i.e., *Gymnocodium* and *Permocalculus*. Nevertheless, *Permocalculus* Elliott, 1955 might correspond to another branch of this lineage, because its FAD is possibly located as early as the Sakmarian (see, Homann, 1972, plate 1, figure 8; identified as *Gymnocodium* cf. *gracile* Kordé) or the early Wolfcampian (Buitrón-Sánchez et al., 2012); i.e., prior to the first occurrence of *Gymnocodium? johnsonii* n. sp.

Occurrence. Kungurian (late Leonardian) of New Mexico (Yeso Group, Torres Member: samples MG 10-13, MG(2) 10-15, MG(2) 12-3, MG(2) 12-4, MG 12-4a, MG(2) 12-5, MG(2) 12-8, MG 12-9, MG(2) 12-12, MG(2) 12-13, MG(2) 12-14, MG 13e; San Andres Formation, McLeod Hills, lower part (MLY) and reference sections (SAR): samples MLY 5-26, MLY(2) 5a-12, MLY(2) 5-13, MLY(2) 6-5, MLY 6-6, MLY(2) 6-6, MLY 6-7, MLY 6-11, MLY 6-12, MLY(2) 6-14, MLY(2) 6-15, MLY(2) 6-17, MLY(2) 6-18, MLY(2) 6-19, MLY(2) 6-20, MLY(2) 6-22, MLY 6-25, MLY 6-27, MLY 6-32, MLY 8-5, SAR 2-1, SAR 2-2, SAR 2-3, SAR 2-4, SAR 7-8, SAR 7-9, SAR(2) 8-7/8-17, SAR(2) 8-11, SAR 8-15, SAR 8a-15, SAR 8a-16, SAR 8a-25)). Possibly present in the Artinskian-Kungurian (Leonardian) of Guatemala and in the Lower Permian of South China (Li and Mamet, 1993) and North China (Mamet and Zhu, 2005).

Gymnocodium? bacillum n. sp.

Figures 10.11, 14.5, 14.8, 14.9, 19.3, 19.7, 19.8, 19.10-19.16, 20.16

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- v. 1997 *Gymnocodium bellerophontis* (Rothpletz); Vachard et al., figs. 12.2-9.
 v. 2013b *Gymnocodium* sp. 2; Vachard, Krainer and Lucas, p. 348 (no illustration).
 v. 2013b Dasycladacean algae; Lucas, Krainer and Voigt, fig. 8D.

Etymology. Latin *bacillus*, small stick.

Holotype. NMMNH P-67513; Figure 10.11; sample SAR 8a-4.

Material. 42 sections.

Locus Typicus. NMMNH locality 8894; San Andres Formation, reference section near Rhodes Canyon in the San Andres Mountains (New Mexico).

Stratum Typicum. Late? Kungurian (latest Leonardian).

Diagnosis. A *Gymnocodium?* characterised by small, stick-shaped segments, relatively well-preserved medullar zone, and moderately wide deltoid terminations.

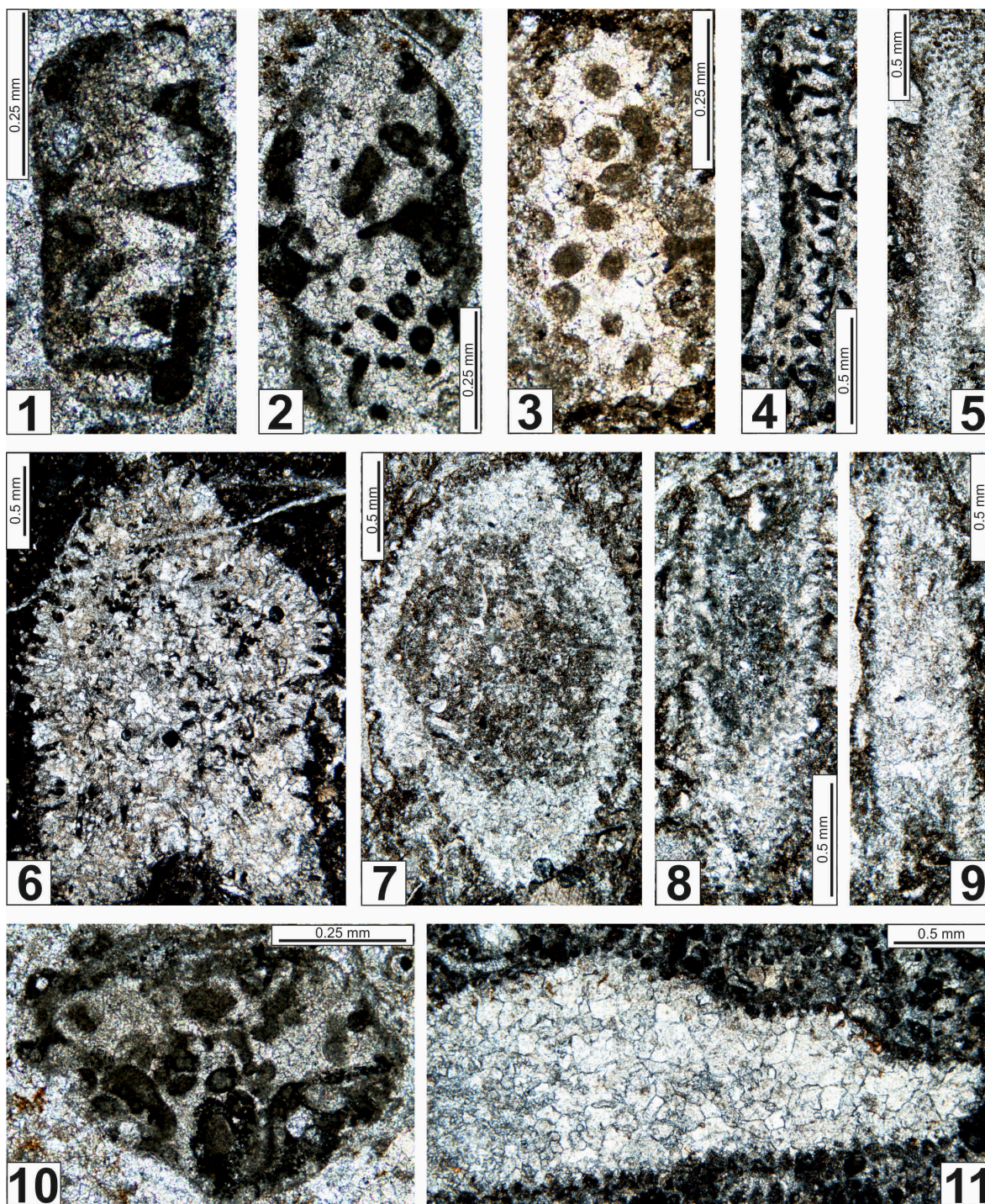


FIGURE 14. 1-4, 10. *Boueina? crassundia* n. sp. 1. Axial section through dilated deltoid terminations. San Andres Fm. Sample MLY(2) 6-16. 2. Oblique section through the siphons. San Andres Fm. Sample MLY(2) 5a-25. 3. Tangential sections of the siphons. Yeso Group. Sample MG(2) 12-5. 4. Subaxial sections of cortical siphons. San Andres Fm. Sample MLY(2) 6-7. 10. Subaxial section showing medullar and cortical siphons. San Andres Fm. Sample MLY(2) 5a-19a. 5, 8-9. *Gymnocodium? bacillum* n. sp. 5. Tangential section. San Andres Fm. Sample SAR(2) 8-9. 8. Axial section. San Andres Fm. Sample SAR(2) 8-20. 9. Axial section. San Andres Fm. Sample SAR(2) 8-14. 6-7, 11. *Gymnocodium? johnsonii* n. sp. 6. Axial section. Yeso Group. Sample MG(2) 12-13. 7. Subaxial section without calcified medullar zone; the internal sediment contains an *Eotuberitina reitlingerae* Miklukho-Maklay, 1958. San Andres Fm. Sample SAR(2) 8-17. 11. Axial section completely recrystallized. San Andres Fm. Sample MLY(2) 6-14.

Description. The thallus is small (L = 1.75-3.00 mm, w = 0.50-0.90 mm), segmented, and our material is composed of individualized stick-shaped segments. They are tapering to subcylindrical. Numerous tangled, thin medullar tubes are often preserved. Oblique cortical simple siphons with terminal deltoids (= utricles) (p = 0.01-0.02 mm). Conceptacles not observed.

Remarks. In our material, some specimens of this species are relatively similar to *Gymnocodium? johnsonii* n. sp. (e.g., compare the Figures 19.7 and 19.9), but differ by their smaller deltoids, other are relatively similar to true *Gymnocodium* (Figure 19.8-19.11) but more tapering. On the other hand, *G.? bacillum* n. sp. differs from a true *Gymnocodium* like *G. bellerophontis* by its smaller dimensions and well-preserved medullar zones, and from *Siamporidium minum* (sic; probably *minimum*) Endo, 1969 by a less lanceolate test, well preserved medullar zone, and less ramified cortical siphons.

Occurrence. Artinskian/Kungurian of Guatemala. Kungurian of New Mexico (Yeso Group, Los Vallos Formation, Torres Member: samples MG 10-11, MG(2) 12-2; San Andres Formation: samples SAR 2-5, SAR 7-8, SAR 8-8, SAR(2) 8-9, SAR 8-14, SAR(2) 8-20, SAR 8a-3, SAR 8a-4, SAR 8a-15, SAR 8a-16, SAR 8a-23, SAR 8a-26, SAR 13-6).

Undetermined Chlorophyta

Figures 10.7, 10.8, 11.5, 13.2, 13.9, 16.3-16.5, 17.1-17.4, 17.7, 20.18

v. 2013b Undetermined mastoporean? dasyclads; Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. The fragments measure: L = 0.50-1.43 mm; w = (0.09)-0.17-0.38 mm; they display the classical aspect of large, spherical, broken epimastoporean thalli. The shapes of the laterals are variable in sections (Figure 16.3-16.4). The siphons or laterals are ovoid and measure 0.03-0.04 mm in diameter and up to 0.20 mm long. The L2 are cup-shaped (proximal diameter = 0.03-0.04 mm; distal diameter = 0.05-0.10 mm).

Material. 37 specimens; illustrated are NMMNH P 67514, 67515, 67516.

Remarks. Some sections are relatively similar to those of *Wagonella* Mamet and Pr at, 1992 from the Middle Devonian of Belgium (compare Figure 13.9 with the holotype of *Wagonella*). They differ from *Wagonella* by the shape of the laterals (cylindrical and not acrophore); and on the other hand, that might correspond to a peculiar and extreme

taphonomic transformation of *Boueina? crassius-dia* (Figures 10.8, 11.5, 16.4).

Occurrence. Early? and middle? Kungurian of New Mexico (Yeso Group, Los Vallos Formation, Torres Member: samples MG(2) 10-11a, MG 10-19, MG 10-27, MG(2) 12-1, MG 12-2, MG 12-3, MG 12-3a; San Andres Formation, McLeod Hills (lower part): samples MLY 5-2, MLY 5-2a, MLY(2) 5-18, MLY(2) 5a-6a, MLY(2) 6-9, MLY(2) 6-9a, MLY(2) 6-10, MLY 6-20, MLY(2) 6-24, MLY(2) 6-26).

Kingdom indet.

Phylum indet.

Incertae sedis

Order TUBERITINIDA Miklukho-Maklay, 1958
nom. transl. herein

Family TUBERITINIDAE Miklukho-Maklay, 1958

Description. See Vachard (1994).

Remarks. Despite their resemblances to foraminifers, tuberitinids cannot belong to this group because of: 1) some microstructures of their wall; 2) common mutual attachment; and 3) existence of a double way of life, either free or attached (Conil and Lys in Conil et al., 1977). This latter character might indicate a relationship with the Euglenophyta but this group is not calcified, and the remarkable biological tolerance of the tuberitinids is not compatible with a protophytral ecology. As indicated by Vachard (1994), some links might exist with the calcitarcha calcisphaeraceae, but this group is also incertae sedis. Appearing in the Silurian, the tuberitinids are still common up to the Permian-Triassic Boundary (PTB) (Vachard, 1994), Very rare forms cross through the PTB, given that Song et al. (2011; and personal commun., November 2014) have identified *Diplosphaerina* Derville 1952 (the free stage of *Eotuberitina*) in the lowermost Triassic beds of South China.

Occurrence. Silurian-Permian, cosmopolitan.

Genus EOTUBERITINA

Miklukho-Maklay, 1958

Type Species. *Eotuberitina reitlingerae* Miklukho-Maklay, 1958.

Description. Ampulliform test often showing an attachment disk. Wall thin, dark, microgranular, with very fine radial microperforations inconspicuous to obvious.

Remark. This genus has its first acme in the Middle Devonian but appears in the Early Silurian of Tajikistan (Gissar Range: Saltovskaya, 1981).

Occurrence. Early Silurian-Late Permian, cosmopolitan.

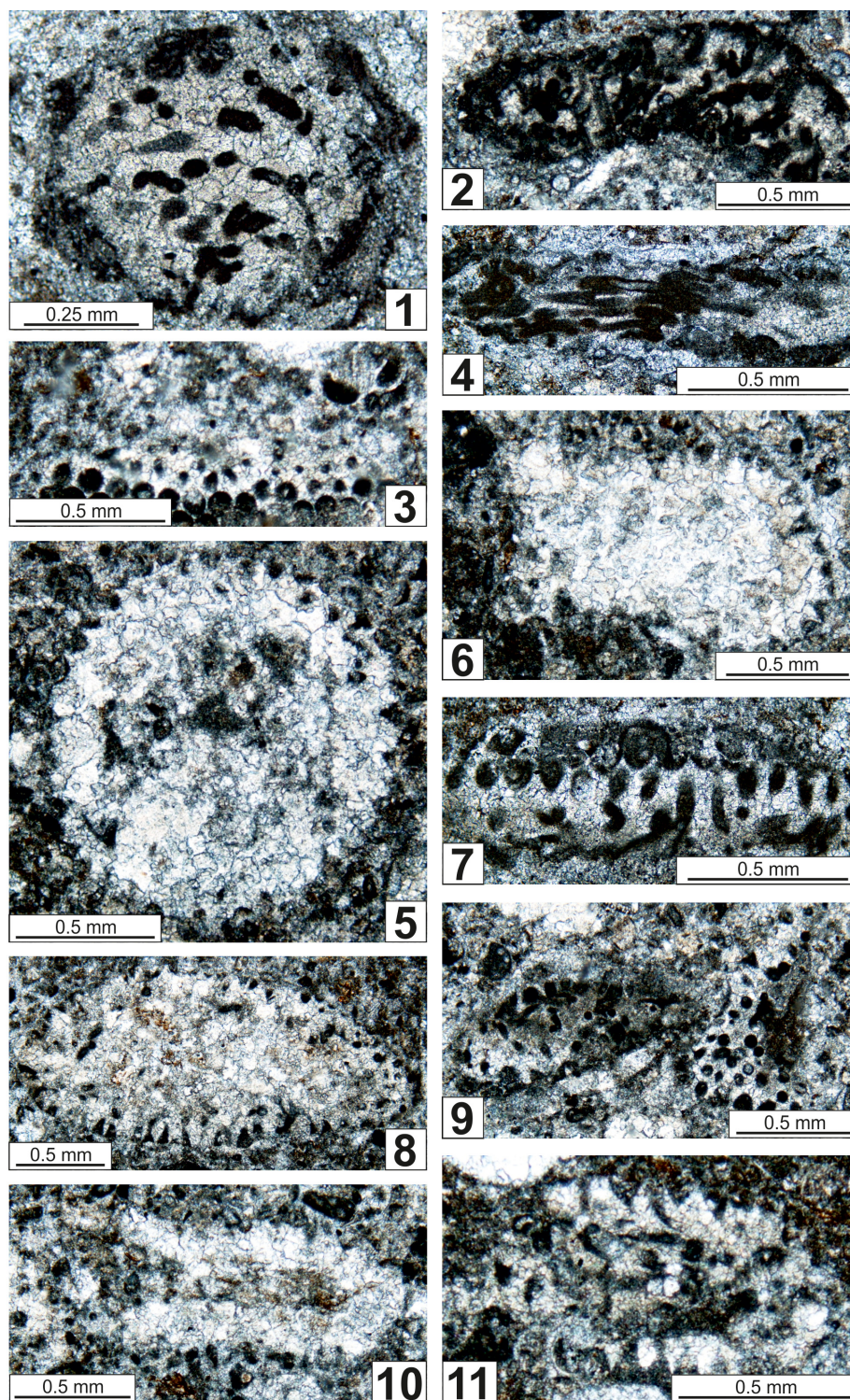


FIGURE 15. 1-2, 4, 7, 9. *Boueina? crassundia* n. sp. 1. Oblique subaxial section. San Andres Fm. Sample MLY 5-1. 2. Oblique section. San Andres Fm. Sample MLY 5-27. 4. Axial section. San Andres Fm. Sample MLY 5-28. 7. Atypical axial section with excessively dilated siphons of medullar zones. San Andres Fm. Sample MLY 6-8. 9. Two oblique sections with typical dilated siphons of medullar zones. San Andres Fm. Sample MLY 6-10. 3, 5-8, 10-11. *Gymnocodium? johnsonii* n. sp. 3. Tangential section. San Andres Fm. Sample MLY 6-6. 5. Transverse section. San Andres Fm. Sample MLY 6-11. 6. Subaxial section. San Andres Fm. Sample MLY 6-7. 7. Oblique section. San Andres Fm. Sample MLY 6-8. 8. Oblique subaxial section. San Andres Fm. Sample MLY 6-15. 10. Axial section. San Andres Fm. Sample MLY 6-12. 11. Axial section. San Andres Fm. Sample MLY 6-25.

Eotuberitina reitlingerae Miklukho-Maklay, 1958
 Figures 13.2, 13.9, 14.7, 20.9, 22.15

1950 *Tuberitina maljavkini* Mikhailov; Reitlinger, p. 88, pl. 19, figs. 2, 3 (non Mikhailov, 1939).

1958 *Eotuberitina reitlingerae* Miklukho-Maklay, p. 134 (nomen novum).

v. 2013b *Eotuberitina reitlingerae* Miklukho-Maklay; Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. *Eotuberitina reitlingerae* is relatively rare in our material but typical with the following parameters: H = 0.05-0.15 mm; w = 0.13-0.17 mm; and s = 0.005-0.007 mm.

Occurrence. Kungurian (late Leonardian) of New Mexico (Yeso Group, Los Vallos Formation, Torres Member: sample MG 12-12a; San Andres Formation; samples MLY 4-5, MLY 4-7, SAR(2) 8.7, SAR 11a-1, SAR(2) 12-15).

Kingdom indeterminate

Phylum indeterminate

Incertae sedis

Family TUBIPHYTIDAE Vachard, Krainer and Lucas, 2012

Description. Microproblematica probably constituted by the weakly to strongly transformed consortial association of cyanobacterial algae and Miliolata foraminifers. Proloculus and juvenarium are very poorly known but occasionally illustrated. Poorly transformed chambered tubes of *Tubiphytes* are called *Cordiformis* Güvenç, 1965 (nomen nudum; see Vachard and Montenat, 1981 and Vachard and Ferrière, 1991) and *Nodophthalmidium* Macfadyen, 1939. Typical *Tubiphytes* appear as masses of a rounded, thick-walled taxon with a small rounded cavity (e.g., Razgallah and Vachard, 1991; Senowbari-Daryan and Flügel, 1993); atypical *Tubiphytes* exhibit large cavities, integrated small tubes and other transformations of the initial foraminifer for which the specimen illustrated by Riding and Guo (1992, plate 1, figure 4) is the best example.

Composition. *Tubiphytes* Maslov, 1956 (= *Nigriporella* Rigby, 1958 = *Tubiella* sensu Rauzer-Chernousova, 1949 (or 1951 fide Roux, 1985, p. 620) preoccupied = *Shamovella* in the sense of Rauzer-Chernousova, 1950 nomen dubium); *Plexoramea* Mello, 1977; *Crescentiella* Senowbari-Daryan et al., 2008; *Latitubiphytes* Vachard et al., 2012; *Cordiformis* Güvenç, 1965 (nomen nudum; = *Incertae sedis* 5 in the sense of Nguyen Duc Tien, 1979 = Foraminifer gen. et sp. indet. in the sense of Senowbari-Daryan and Flügel, 1993); one of the *Vervilleina bradyi* (Spandel, 1901) illustrated by

Filimonova (2010, plate 5, figure 11); *Porferitubus* Senowbari-Daryan, 1984; *Nodophthalmidium* Macfadyen, 1939; *Ramovsia* Kochansky-Devidé, 1973 (= *Dorudia* Jenny and Jenny-Deshusses, 1978 = *Apterinella* in the sense of Berczi-Makk and Kochansky-Devidé, 1981 non Cushman and Waters, 1928b); ?*Nubeculinella* Cushman, 1930.

Remarks. As indicated by many authors (Elias, 1959; Riding and Guo, 1992), the genera *Shamovella* and *Tubiphytes* share the same stratigraphic level and type area, in the pre-Kungurian of the Urals in the Ishimbajevo oil-field, near the town of Sterlitamak, probably in the bioconstruction (shikhan) of Nizhni-Irginsk re-studied by Vennin et al. (1997). An origin in the Sylvinsk reefs, near the town of Kungur, where *Tubiphytes* is very common (Chuvashov, 1983), is also possible. Furthermore, the type material of *Tubiphytes* was collected by Maslov and Rauzer-Chernousova together (Riding, 1993). During this joint field-trip, Rauzer-Chernousova, who had created *Shamovella* a few years before had a valuable opportunity to promote it to Maslov. However, in his diagnosis of *Tubiphytes*, Maslov did not refer to *Shamovella*, but instead to *Tubiella* Rauzer-Chernousova as a preoccupied name which specifically must be replaced by *Tubiphytes*. After that, Rauzer-Chernousova has never contested *Tubiphytes* and proposed its replacement by *Shamovella*. We can deduce that, as soon as 1956, a consensus about *Tubiphytes* existed among the Russian micropalaeontologists, and, ipso facto, the unique argument of Riding (1993) and Riding and Barkham (1999) to replace *Tubiphytes* by *Shamovella* is irrelevant.

On the other hand, our studies in New Mexico confirm the synonymy of *Nigriporella magna* Rigby, 1958, defined in the lower Leonard Formation, with *Tubiphytes obscurus* (synonymy first suggested by Elliott, 1962).

The external surface of the wall of *Tubiphytes* is probably relatively soft (or firm, at the maximum) because, as mentioned by Vachard (1980) and Vennin et al. (1997), *Tubiphytes* is rarely encrusted and only by *Tubiphytes*, *Archaeolithoporella* Endo, 1959, tuberitinid microproblematica, and/or fistuliporid bryozoans. For this reason, the soft/firm wall of *Tubiphytes* was probably able to integrate some elements of the sea bottom: generally, sponge spicules but also some fragments of bryozoans, rare foraminifers and fragments of ungdarellacean algae (Maslov, 1956; Homann, 1972; Vachard, 1980; Vachard and Montenat, 1981; Vennin et al., 1997). Due to this character, the foraminifer included in *Tubiphytes* and illustrated by Krainer et

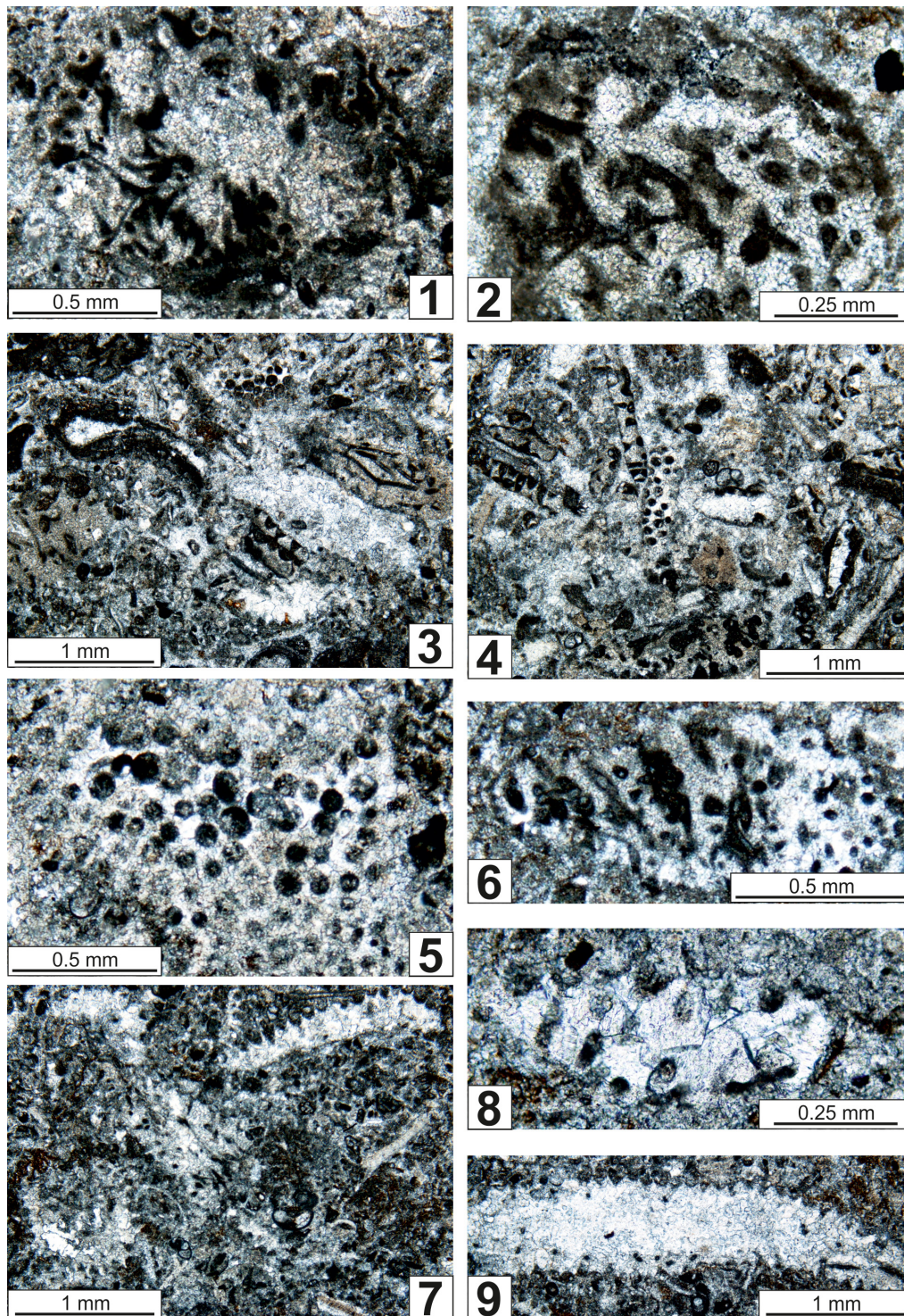


FIGURE 16. 1-2, 6, 8. *Boueina? crassundia* n. sp. 1. Oblique section. San Andres Fm. Sample MLY 6-13. 2. Subaxial section. San Andres Fm. Sample MLY 6-14. 3. Tangential section. San Andres Fm. Sample MLY 6-30. 8. Atypical oblique section. San Andres Fm. Sample MLY 8-3. 3-5. Undetermined Chlorophyta. 3. Two sections (centre) with *Gymnocodium? johnsonii* n. sp. (centre bottom and top) and *Boueina? tubulata* n. sp. (top right). San Andres Fm. Sample MLY 6-20. 4. At least six fragments. San Andres Fm. Sample MLY 6-21. 5. Tangential section. San Andres Fm. Sample MLY 8-5. 7, 9. *Gymnocodium? johnsonii* n. gen. n. sp. 7. Various sections associated with *Globivalulina parapiciformis* n. sp. (bottom, left) and *G. novamexicana* n. sp. (centre). San Andres Fm. Sample MLY 6-32. 9. Subaxial section. San Andres Fm. Sample MLY 6-27.

al. (2009, plate 3, figure 2), which is probably a *Nodosinelloides netschajewi* (compare with plate 5, figures 1, 2, 3, 4 in the same article), is not a boring foraminifer as suggested by Schlagintweit et al. (2013), but an included foraminifer. Another nodosariate incorporated in *Tubiphytes* has been illustrated by Razgallah and Vachard (1991, plate 2, figures 7, 8). After this soft/firm stage with the possibility of inclusion, *Tubiphytes* rapidly becomes strongly hard and lithified because many fragments of *Tubiphytes* can be reworked near the colonies in situ (Sano et al., 1990), and because these fragments can be covered by early diagenetic fibrous cements (Vennin et al., 1997).

No new data can be provided here concerning the assignment of *Tubiphytes*. The interpretation of Bernier (1984), Vachard et al. (2001), and Vachard and Krainer (2001b) is fundamentally different from that of Maslov (1956) and Senowbari-Daryan and Flügel (1993), because the former authors consider the internal cavity as an important part of the organism; i.e., inherited from an ancestral Miliolata foraminifer. During evolution in the late Moscovian, this ancestor (probably a species of *Palaeonubecularia* Reitlinger, 1950) becomes intimately associated with a cyanobacterium (in a narrow assemblage similar to a lichen, for example). During this evolution, the shape of the foraminiferal cavity trends to disappear; for example, from *Latitubiphytes* in the Late Pennsylvanian (Kasimovian-Gzhelian) to true *Tubiphytes* in the Early Permian (Asselian-Kungurian), but it can reappear in the Late Permian with the “stages” of *Tubiphytes obscurus* illustrated by Senowbari-Daryan and Flügel, 1993 (text-figure 10 A-D, plate 3, figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16; plate 4, figures 1, 2, 5, 6) and Vachard et al., 2003 (plate 27, figures 1, 4, 5), and called *Cordiformis* (nomen nudum) by Güvenç (1965). Similarly, the resemblance of the cavity of *Tubiphytes* (now *Crescentiella*) *morroneensis* Crescenti, 1969 with that of nubecularioid foraminifers has often been stressed (Bernier, 1984; Senowbari-Daryan et al., 2008).

Occurrence. Questionable references to tubiphytids in Bashkirian and early Moscovian deposits seem more related to “tolypamminid” (in fact, porcelaneous homeomorphs of these latter) foraminifers (Vachard et al., 2012). The family truly appears in the late or latest Moscovian (Chuvashov et al., 1993; Vachard et al., 2012), during which *Palaeonubecularia rustica* Reitlinger, 1950, true primitive tubiphytids (*Latitubiphytes*), and transitional forms between both genera can be found together. The typical tubiphytids are present from the Late Penn-

sylvanian (Kasimovian) to Early Cretaceous (for the Mesozoic forms see Senowbari-Daryan et al., 2008).

Genus TUBIPHYTES Maslov, 1956

Type Species. *Tubiphytes obscurus* Maslov, 1956.

Tubiphytes epimonellaeformis n. sp.

Figures 11.10, 12.1-12.8, 18.12, 24.8, 24.12

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? v. 2009 *Tubiphytes* (“*Rigidicaulis*”) sp.; Krainer, Lucas and Vachard, pl. 3, fig. 7.

v. 2013b *Tubiphytes* sp. 1; Vachard, Krainer and Lucas, p. 348 (no illustration).

Etymology. Relatively similar to *Epimonella* Vachard in Kolodka, Vennin, Vachard, Trocmé and Goodarzi, 2012.

Holotype. NMMNH P-67517; Figure 12.1; sample SAR 12-2.

Paratypes. NMMNH P-67518-67524; Figures 11.10, 12.2-8.

Material. 32 specimens.

Locus Typicus. NMMNH locality 8896; San Andres Formation, reference section near Rhodes Canyon in the San Andres Mountains (New Mexico).

Stratum Typicum. Late? Kungurian (latest Leonardian).

Diagnosis. *Tubiphytes* with large subquadratic cavities and some prominent, small, cylindrical tubes.

Description. Test elongate rarely subquadratic (Figure 12.8) encrusting a curved to cylindrical substrate, not preserved. Test surface very irregular. Lateral sides inflated. Peripheral margin rounded. Large subquadratic cavities as well as typical tubiphytid small cavities are present within the test (Figure 24.8). Some cylindrical, small tubes are prominent and evidently permit a communication with the exterior. L = (0.50)-0.81-1.45 mm; H = 0.30-0.70 mm; width of large cavities = (0.10-0.12)-0.20-0.63 mm; height of large cavities = (0.05)-0.14-0.34 mm; width of small tubes = 0.04-0.08-(0.10) mm; maximal length of small tubes = 0.22 mm; large cavities wall thickness = 0.03-0.10 mm; small tube wall thickness = 0.01-0.02 mm.

Remarks. To the typical forms with irregular broad cavities and prominent tubes, we can add some representatives relatively difficult to distinguish from *Latitubiphytes* and that also show the typical porcelaneous recrystallization “en dents de peigne” (fine-tooth comb-shaped) of Gargouri and Vachard (1988). This observation provides further evidence of a more or less direct relationship with the Miliolata (see also *Tubiphytes* sp. sensu Krainer et al.

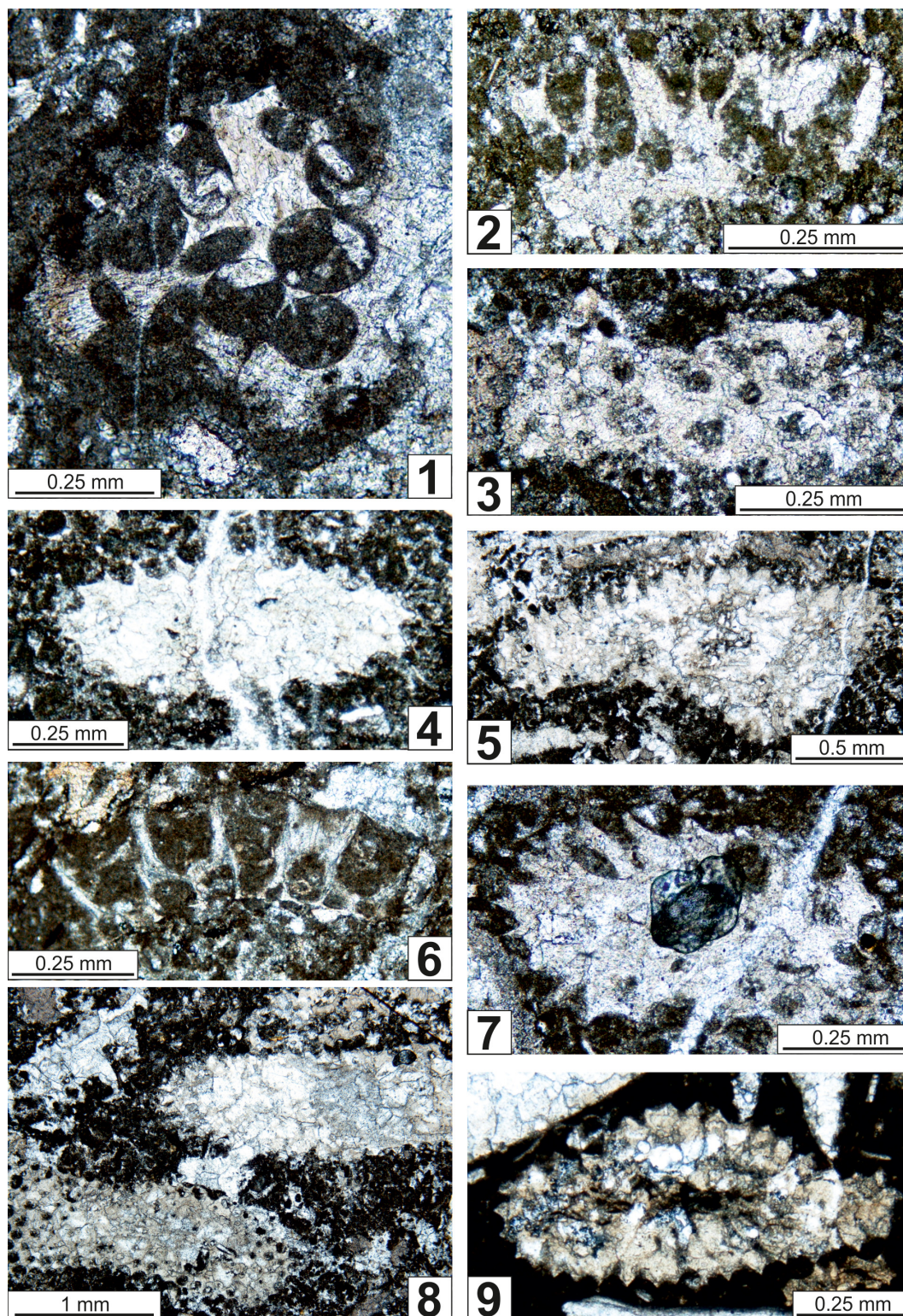


FIGURE 17. 1-4, 7. Undetermined Chlorophyta. 1. Tangential section. Yeso Group. Sample MG 10-27. 2. Subaxial section. Yeso Group. Sample MG 12-2. 3. Tangential section. Yeso Group. Sample MG 12-3. 4. Subaxial section. Yeso Group. Sample MG 12-8. 7. Oblique subaxial section. Yeso Group. Sample MG 12-3a. 6. Bryozoa. Subaxial section. Yeso Group. Sample MG 12-10. 5, 8-9. *Gymnocodium? johnsonii* n. sp. 5. Subaxial section. Yeso Group. Sample MG 12-5. 8. Two specimens in subaxial and tangential sections. Yeso Group. Sample MG 12-9 (already illustrated in Lucas et al., 2013b, figure 8H). 9. Subaxial section. Yeso Group. Sample MG 13e.

(2003, plate 60, figure 4)); and with these tubiphytids, probably *Latitubiphytes*, illustrated under the name *Vermiporella nipponica* by Flügel (1966, plate 8, figure 3).

The taxon has also possibly been illustrated as *Galaenella?* sp. by Kobayashi (2001, plate 2, figure 13) from the earliest Middle Permian of S-W Japan; but this specimen may also correspond to a non-skeletal aggregate grain in the sense of Flügel (2004).

No inclusions in the wall (as described above for typical *Tubiphytes*) have been observed in *Tubiphytes epimonellaeformis* n. sp. With all these particularities, *T. epimonellaeformis* n. sp. constitutes a very atypical trend among the tubiphytids, and it is suggested here as the ancestor of the genus *Epimonella* Kolodka et al., 2012, which is another unusual tubiphytid.

The cavities of *Tubiphytes epimonellaeformis* can be explained by comparison with some marine species of *Rivularia* Agardh ex Bornet and Flahault, 1886, or by an incomplete distribution of the calcium carbonate, where the older thalli are hollow and occupied by gas (Fritsch, 1945, p. 840), or by an incomplete distribution of the calcium carbonate precipitated in vivo in the cyanobacterial part of the wall (compare with Altermann et al., 2006, figure 3A-D).

Numerous small cylindrical tubes without apparent connections with *Tubiphytes* have been illustrated by Flügel et al. (1984, plate 31, figure 6, plate 42, figures 8, 9, 10) and Noé (2003, plate 18, figures 7, 8; plate 19, figures 1, 2, 3, 4, 5). Senowbari Daryan and Flügel (1993, plate 2, figure 3) illustrated an “extended tube passing through younger segments.” The connected small tubes are present in several reconstructions of *Tubiphytes* provided by Wang et al. (1994, figure 7.3-4, 9). The figure 7.9 of these authors is externally very similar to *T. epimonellaeformis*; nevertheless, the internal aspect of this specimen is not given, and the other illustrated sections (figures 8.1-11, 11.1-8) more likely correspond to *T. obscurus* or *T. carinthiacus*.

Comparison. This form appears to be transitional between true *Tubiphytes* and *Epimonella* because of the tubular expansions of the hemispherical masses.

Some parts are similar to *Tubiphytes obscurus*, and the other ones show large cavities totally unknown in the latter species.

The new species appears relatively similar to *Palaeonubeculata* (sic) *fluxiformis* Igonin, 1998 in the dimensions of the larger cavities and the strati-

graphic occurrence (*P. fluxiformis* is known from the Kungurian of the Northern Pre-Urals and Pechora Basin), but apparently the small open tubes are not present in this species.

The new species is relatively similar to *Tubiphytes* (“*Rigidicaulis*”) sensu Krainer et al. (2009, plate 3, figure 7), which is older.

Occurrence. Late? Kungurian (latest Leonardian) of New Mexico (San Andres Formation, reference section: samples SAR 3-3, SAR 8a-22, SAR(2) 11-6, SAR(2) 11-8, SAR(2) 11-9, SAR(2) 11-12, SAR(2) 12-1, SAR 12-3, SAR(2) 12-3, SAR(2) 12-3a, SAR(2) 12-5, SAR(2) 12-7, SAR(2) 12-8, SAR(2) 12-9, SAR(2)12-10, SAR(2) 12-12, SAR(2) 12-13).

Kingdom indeterminate

Class, Order and Family incertae sedis

Genus ELLESMERELLA Mamet and Roux in

Mamet, Roux and Nassichuk, 1987 emend.

Vachard and Krainer, 2001b

Type Species. *Girvanella permica* Pia, 1937.

Description. Encrusting groups of tubular chambers, forming flat nodules or oncoids. These elongate cylindrical undivided chambers are arranged parallel to each other in subhorizontal or roughly concentric layers. Their diameter varies due to the presence of pseudoconstrictions. The basal part of the tubular chambers is flatter than the upper part, which is more rounded.

Remarks. *Ellesmerella* has been interpreted as an atypical foraminifer by Vachard and Krainer (2001b). Further unpublished observations of the same authors, on specimens of the Grenzland Fm of the Carnic Alps, provide evidence of a porcelaneous wall in the well-preserved specimens. The girvanellacean nature of this taxon thus might be definitely abandoned, because the wall of this cyanobacterial group is dark-microgranular, but never porcelaneous; a type of wall apparently only known among the miliolate foraminifers. *Ellesmerella* is therefore more similar to nubeculariid foraminifers than girvanellacean trichomes. *Ellesmerella* is probably present in the literature under several names: *Girvanella* auctorum (partim), Nubecularioidea (partim), *Osagia* (partim), *Otonosia* (partim), and *Clinortonella* Vachard and Moix, 2013. If *Ellesmerella* was easily confused with cyanobacteria (*Girvanella*, *Clinortonella*, etc.), that is probably because porcelaneous walls are very rarely preserved (as in the Zweikofel Formation of the Carnic Alps; Vachard and Krainer, unpublished data), and because, almost always, it diagenetically becomes microgranular and similar to an ontogenic girvanellacean wall.

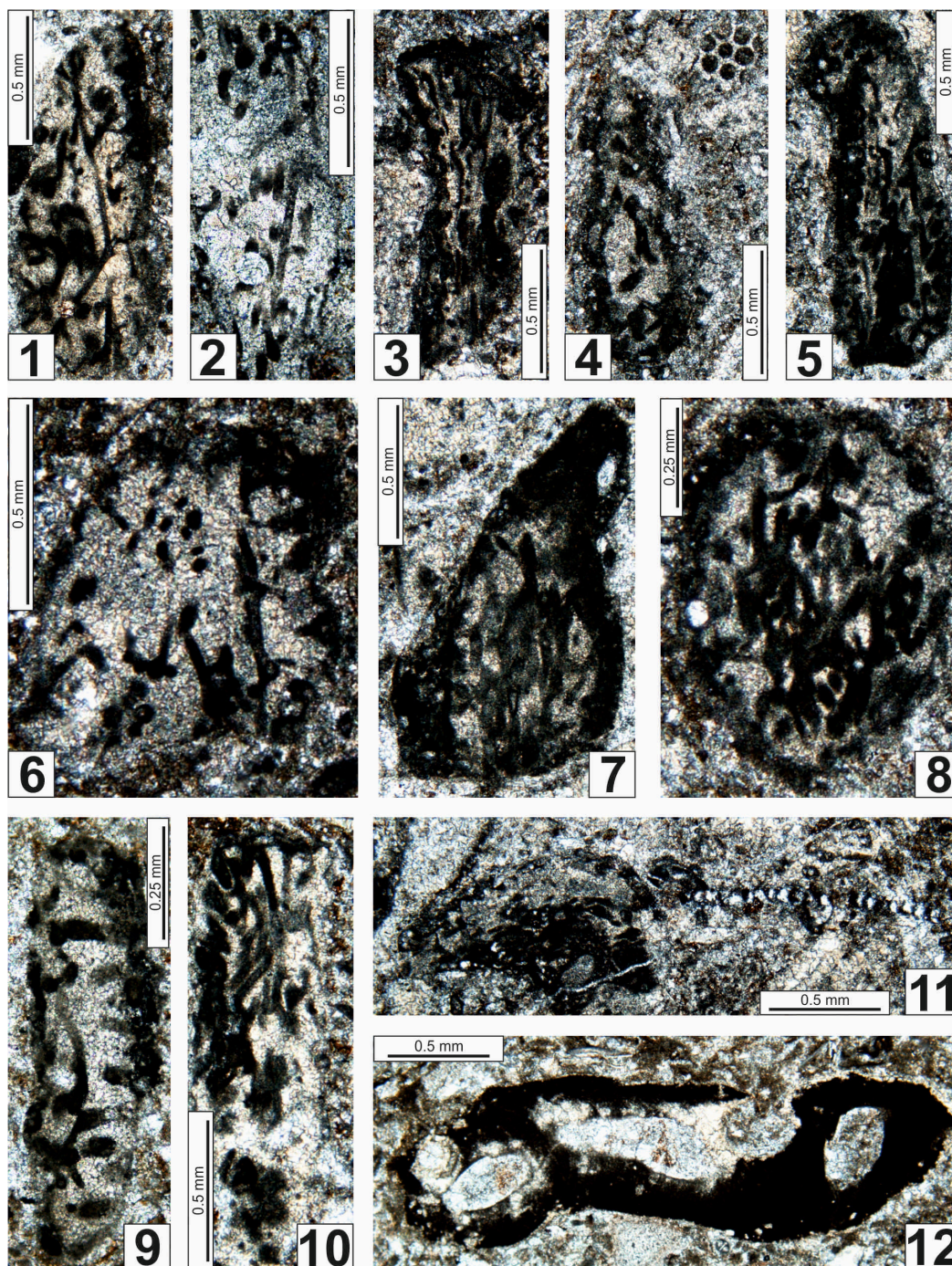


FIGURE 18. 1-5. *Boueina? tubulata* n. sp. 1. Axial section. San Andres Fm. Sample MLY(2) 5a-26. 2. Axial section. San Andres Fm. Sample MLY(2) 5a-9. 3. Subaxial section. San Andres Fm. Sample MLY(2) 5a-2. 4. Oblique section. San Andres Fm. Sample MLY 5-18. 5. Subaxial section. San Andres Fm. Sample MLY(2) 5-19. 6-11. *Boueina? crassundia* n. sp. 6. Axial section. San Andres Fm. Sample MLY(2) 5-9. 7. Axial section. San Andres Fm. Sample MLY(2) 5-19d. 8. Oblique section. San Andres Fm. Sample MLY(2) 5-11. 9. Oblique subaxial section. San Andres Fm. Sample MLY(2) 5-16. 10. Longitudinal section. San Andres Fm. Sample MLY(2) 5-14. 11. Oblique section (left). San Andres Fm. Sample MLY(2) 5a-12. 11. *Gymnocodium? johnsonii* n. sp. An axial section through the cortical zone (right). San Andres Fm. Sample MLY(2) 5a-12. 12. *Tubiphytes epimonellaeformis* n. sp. Specimen similar to *Latitubiphytes* Vachard, Krainer and Lucas, 2012 exhibiting a neosparitization of Miliolata, especially *Hemigordiopsis*, *Baisalina* or *Pseudobaisalina* (see Gargouri and Vachard, 1988; Vdovenko et al., 1993). San Andres Fm. Sample SAR(2) 12-15.

Finally, it is interesting to notice that three groups of Permian Miliolata are very transformed and exhibit some resemblances with algae or cyanobacteria: ellesmerellids, tubiphytids, and pseudovermiporellids. These three groups, although abundant, are difficult to palaeobiologically interpret because their descendents (or at least homeomorphs) are absent from the modern seas.

Occurrence. Early Permian, cosmopolitan (see Vachard and Krainer, 2001b, p. 190).

Ellesmerella rara n. sp.
Figure 10.1-10.3

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v. 2013b *Ellesmerella* sp. 1; Vachard, Krainer and Lucas, p. 348 (no illustration).

Etymology. Latin *rarus*, rare.

Holotype. NMMNH P-67501; Figure 10.1-2; sample MG 13c-d.

Paratypes. NMMNH P-67502; Figure 10.3.

Material. 3 specimens (samples MG 13 c-d, i).

Locus Typicus. NMMNH locality 8891; Yeso Group, Los Vallos Formation, Torres Member, Massacre Gap in the southern Fra Cristobal Mountains (New Mexico).

Stratum Typicum. Early? Kungurian (late Leonardian).

Diagnosis. An *Ellesmerella* constituting some small ovoid sets of attached trichomes without encrustation of an exotic nucleus.

Description. The whole colony is elongate to ovoid (L = 0.47-0.50 mm; w = 0.10-0.65 mm); it is composed of 4-5 whorls of roughly concentric rows of very low, undivided pseudochambers measuring D = 0.04-0.05 mm; d = 0.03 mm; l = 0.16-0.33 mm; and s = 0.01-0.02 mm.

Remarks. *Ellesmerella permica* is distinct in constituting large oncoids around elongate nuclei (e.g., bivalve or brachiopod shell fragments or *Anchicodium* phylloid algae), which are common from the Carnic Alps (Austria-Italy) to Alborz (Iran); moreover, its pseudochambers are shorter and smaller (l = 0.30-0.40 mm (rarely 0.11 mm) and d = 0.01-0.02 mm according to Flügel, 1966).

Occurrence. Early? Kungurian (late early Leonardian) of New Mexico (Yeso Group, Torres Member).

Phylum RHIZARIA Cavalier-Smith, 2002
Subphylum FORAMINIFERA d'Orbigny, 1826 nom. transl. Cavalier-Smith, 2003
Class FUSULINATA Möller, 1878 nom. transl. Gaillot and Vachard, 2007
Subclass FUSULININA Möller, 1878 nom. transl.

Vachard, Pille and Gaillot, 2010
Order ENDOTHYRIDA Brady, 1884 nom. transl. Fursenko, 1958
Superfamily GLOBIVALVULINOIDEA Reitlinger, 1950 nom. transl.
Hance, Hou and Vachard, 2011
Family GLOBIVALVULINIDAE Reitlinger, 1950 nom. transl. Gaillot and Vachard, 2007
Subfamily GLOBIVALVULININAE Reitlinger, 1950 orth. mut. Pokorny, 1958
Genus GLOBIVALVULINA Schubert, 1921

Type Species. *Valvulina bulloides* Brady, 1876.

Description. Test planispirally and biserially coiled; occasionally initially trochospiral. Coiling entirely involute, rarely semi-involute to evolute. Test subspherical to nautiloid, rarely ovoid. The ventral side is flattened to concave; the dorsal side is strongly convex to slightly curved. Proloculus spherical, more or less large and more or less inserted in the inner whorls. Few whorls (1-3) and relatively few chambers (6-10). Chambers inflated to triangular. Diameter small to medium, rarely large in Middle and Late Permian species (0.25-1.00 mm). Septa complete and well-curved. Umbilicus slightly depressed to absent. A diversely developed oral valvula (or valvular projection) is present in the last chamber. Wall unilayered (microgranular or microgranular with a calcareous agglutinate) or bilayered (with a pseudofibrous inner layer discontinuously present). The described "diaphanotheca" seems only to correspond to a luminotheca-like wall or even a diagenetic differentiation of the medium to thick microgranular walls. Aperture low, arched, central or peripheral at the extremity of a funnel diversely developed.

Remarks. For the phylogeny of this genus, see Vachard et al. (2006), Gaillot and Vachard (2007), and Cózar and Somerville (2012).

Although repetitively revised, the type species *Globivalvulina bulloides* remains under discussion, especially, its true aspects in transverse and axial sections. These types of section are perhaps more accurately known in *G. moderata* Reitlinger, 1949, which has been synonymized with *G. bulloides* by Groves (1988) or Harris et al. (1997). *Globivalvulina moderata* sensu stricto differs by its smaller dimensions, and a microgranular wall that is never differentiated, but *G. bulloides* sensu Potievskaya, 1962 (p. 65-66, plate 4, figures 7, 8, 10, 11) is truly a *G. ex gr. moderata*. Geometrically, the best and most complete illustrations of *G. bulloides* have probably been provided by Kulagina et al. (1992, plate 4, figures 3, 4, 8; plate 8, figures 4, 5; plate 9, figure 28; plate 13, figures 23, 24, 25). Among the

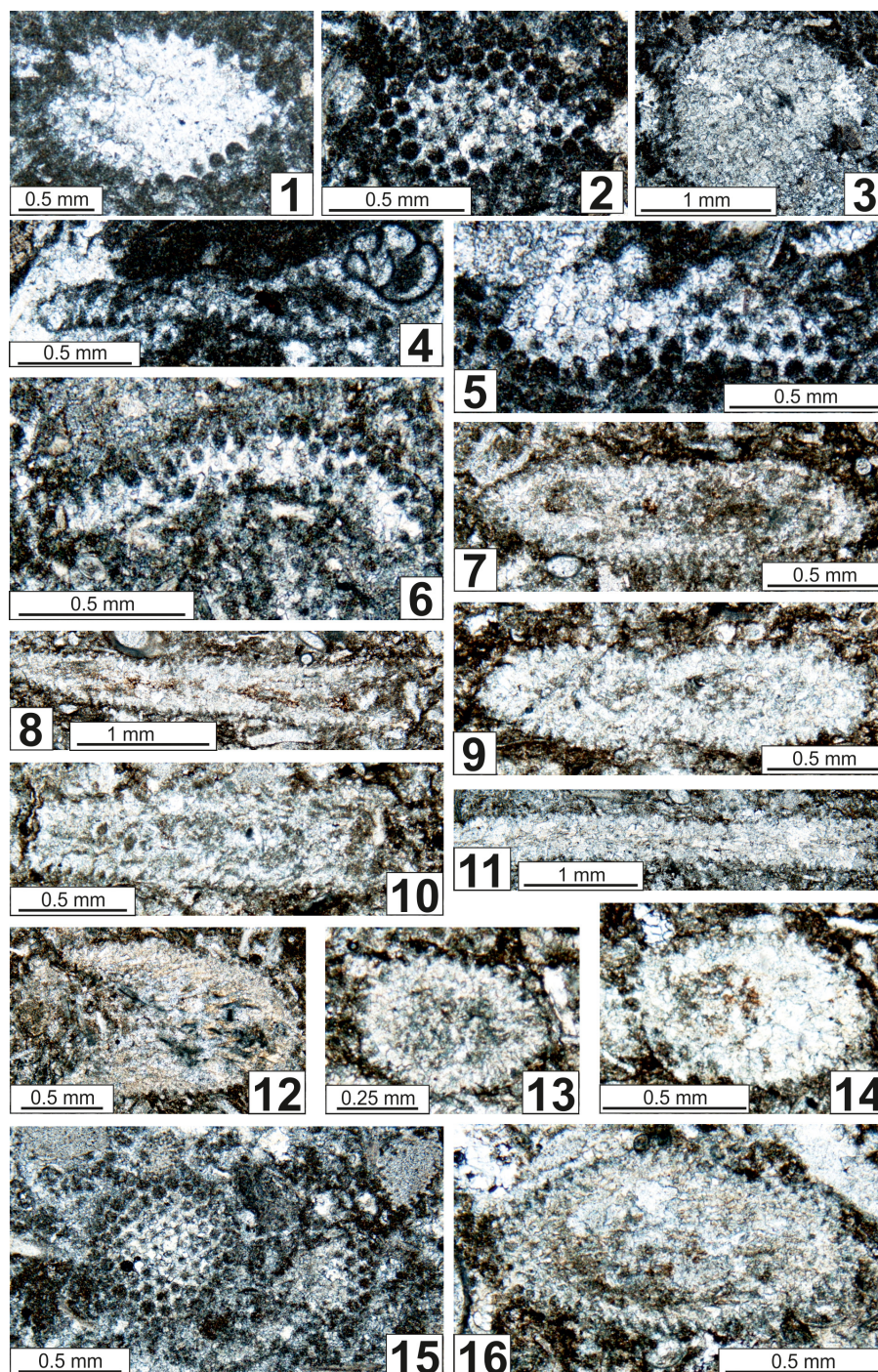


FIGURE 19. 1-2, 4-6, 9. *Gymnocodium? johnsonii* n. sp. 1. Subaxial section. San Andres Fm. Sample SAR 2-1. 2. Tangential section. San Andres Fm. Sample SAR 2-2. 4. Subaxial section. San Andres Fm. Sample SAR 2-3. 5. Tangential section. San Andres Fm. Sample SAR 2-4. 6. Subaxial section. San Andres Fm. Sample SAR 7-9. 9. Subaxial section. San Andres Fm. Sample SAR 8a-25 (already illustrated in Brose et al., 2013, figure 6.9). 3, 7-8, 10-16. *Gymnocodium? bacillum* n. sp. 3. Oblique subaxial section. San Andres Fm. Sample SAR 2-5. 7. Subaxial section. San Andres Fm. Sample SAR 8a-3. 8. Axial section. San Andres Fm. Sample SAR 8a-26. 10. Axial section. Yeso. Sample MG(2) 12-2 (already illustrated in Lucas et al., 2013b, figure 8D). 11. Axial section. San Andres. Sample SAR 8-8. 12. Axial section. San Andres Fm. Sample SAR 13-6. 13. Subaxial section. San Andres Fm. Sample SAR 8a-16. 14. Subaxial section. San Andres Fm. Sample SAR 8a-15. 15. Two tangential sections. San Andres Fm. Sample SAR 7-8. 16. Subaxial section. San Andres Fm. Sample SAR 8a-23.

Pennsylvanian species of North America, *G. gap-tankensis* Harlton, 1928 (p. 308-309, plate 53, figure. 3a-c) might be a synonym of *G. bulloides*, because *G. bulloides*, based on our collection materials can be described as follows: test subhemispherical ("similar to *Globigerina*" according to the diagnosis of Brady, 1876) with a trochospirally coiled axis of biseriality; dorsal size moderately convex; round peripheral margin; lateral sides strongly convex to slightly compressed to the flanks; umbilicus absent; proloculus spherical medium-sized (0.04 mm); D = (0.17)-0.30-0.50 mm; w = (0.19-0.21)-0.25-0.42-(0.47) mm; w/D = 0.96-1.17; 1.5 whorl; 4-7 (8) chambers at last whorl, very inflated, almost spherical, and with h = (0.07-0.09)-0.10-0.14-(0.20) mm; sutures curved, moderately deep; septa thin, typically globivalvulinid; ventral side flattened; aperture elongate, oblique, at the base and center of apertural face; oral valvula small in each chamber of last whorl or "heavy, strongly overlapping" (Armstrong and Mamet, 1977); funnel short or absent; wall microgranular (eventually diagenetized with diaphanoteca-like median layer; Armstrong and Mamet, 1977; Brenckle et al., 1997); s = 0.01-0.02 mm.

Occurrence. Late Mississippian (Serpukhovian)-latest Permian (Changhsingian); cosmopolitan.

Globivalvulina parapiciformis n. sp.

Figures. 22.6, 25.3, 26.1, 26.4-26.7, 26.9, 26.11-26.14, 26.16-26.19, 26.21, 26.23, 26.25, 27.10, 27.11, 28.13, 30.5

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- v. 2003 *Globivalvulina* spp.; Krainer, Vachard and Lucas, pl. 6, figs. 18, 22, 23, 28, 29, 32.
- v. 2003 *Globivalvulina bulloides* Brady; Krainer, Vachard and Lucas, pl. 7, figs. 3, 9, 15, 16, 17, 18, 19, 32.
- v. 2009 *Globivalvulina* cf. *apiciformis* Zolotova and Baryshnikov; Krainer, Lucas and Vachard, pl. 5, figs. 17, 18, 19, 20.
- v. p. 2013 *Globivalvulina*; Brose, Lucas and Krainer, fig. 6.6 (only, non fig. 6.7 = *G. retroseptata* n. sp.).
- v. 2013b *Globivalvulina* cf. *apiciformis* Zolotova and Baryshnikov; Vachard, Krainer and Lucas, p. 348 (no illustration).

Etymology. Relatively similar to *G. apiciformis* Zolotova in Zolotova and Baryshnikov, 1980.

Holotype. NMMNH P-67551; Figure 22.6; sample MLY 4-3.

Paratype. NMMNH P-67552; Figure 25.3.

Material. 50 sections.

Locus Typicus. NMMNH locality 8897; San Andres Formation, McLeod Hills, southern Caballo Mountains (New Mexico).

Stratum Typicum. Middle? Kungurian (late Leonardian).

Diagnosis. Small *Globivalvulina* with an unilayered wall, early planispirally coiled axis of biseriality, hemispherical to trapezoidal chambers and basal aperture with long funnel.

Description. Test small, subnautiloid; D = (0.17)-0.22-0.53 mm; w = 0.18-0.43 mm; w/D = 0.91-1.08. Subplanispirally coiled axis of biseriality. Proloculus spherical, small to large-sized (0.02-0.03 up to 0.06-0.08 mm), not inserted, not prominent. Dorsal side moderately convex. Sutures poorly- to moderately marked. Whorls: 1-1.5. Peripheral margin rounded. Lateral sides of spire inflated. Umbilicus absent. Chambers: 5-6 (rarely 7-8) pairs, hemispherical to trapezoidal; relatively irregular in shape; h = (rarely 0.06)-0.10-0.13 (rarely 0.17-0.22) mm. Septa complete, well curved, in the continuity of the wall. Ventral side concave. Aperture basal with a long funnel. Oral valvula often well developed. Wall microgranular, moderately thick; s = 0.01-0.02 mm.

Comparison. Differs from *G. apiciformis*, a coeval species from the Kungurian (Filipovsky horizon) of the Urals (Russia), by less chambers for a similar diameter, a smaller proloculus, higher chambers, and a more compressed axial section. It differs from *G. sossipatrovae* Baryshnikov in Zolotova and Baryshnikov, 1980 by a longer funnel, and from *G. uncinata* Zolotova in Zolotova and Baryshnikov, 1980 by larger dimensions and thinner walls. It is probable that these three latter Kungurian species and *G. parapiciformis* n. sp. constitute a morphological and phylogenetic group of species or a plexus.

Occurrence. Kungurian (late Leonardian) of New Mexico (San Andres Formation, McLeod Hills (MLY) and reference section in the San Andres Mountains (SAR): samples MLY 2-1, MLY 3-4, MLY 3-7, MLY 3-9, MLY 4-3, MLY 4-4, MLY 4-10, MLY(2) 4-11, MLY 4-14, MLY 5-7c, MLY 5-7d, MLY 5-11, MLY 5-11a, MLY 5-20a, MLY 5-24a, MLY(2) 5a-6a, MLY 6-2, MLY 6-3, MLY 6-4, MLY 6-9, MLY 6-11a, MLY 6-12a, MLY 6-16, MLY(2) 6-17, MLY 6-24, MLY 6-31, MLY 8-2, SAR 7-6, SAR(2) 8-1, SAR 8a-8a, SAR(2) 12-18, SAR 13-9, SAR(2) 13a-4a, SAR(2) 13a-5, SAR 13a-6, SAR 13a-7, SAR 20-3, SAR 20-4).

Globivalvulina retroseptata n. sp.

Figures 21.1-21.8, 27.1, 27.4, 27.9, 27.20, 28.1-

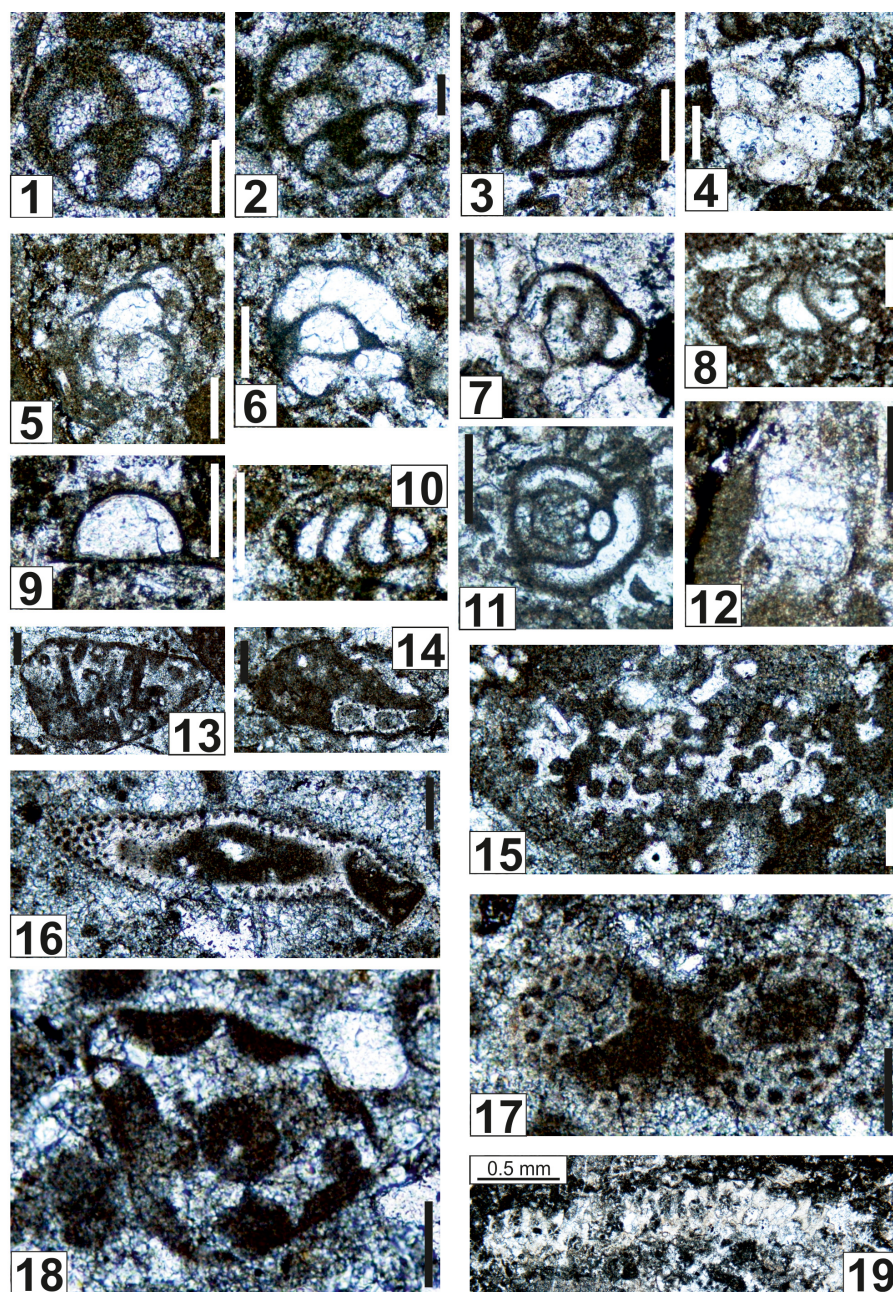


FIGURE 20. 1-4. *Globivalvulina novamexicana* n. sp. 1. Subaxial section. Yeso Group. Sample MG 10-18. 2. Subaxial section. Yeso Group. Sample MG 10-19a. 3. Oblique section. Yeso Group. Sample MG 12-1. 4. Recrystallized subaxial section. Yeso Group. Sample MG 12-4. 5-8, 10-11. *Hemigordiellina* aff. *simplex* (Harlton, 1928). 5. Random section. Yeso Group. Sample MG 10-23. 6. Random section. Yeso Group. Sample MG 12-7. 7. Random section. Yeso Group. Sample MG 12-11. 8. Random section. Yeso Group. Sample MG 12-12. 10. Random section. Yeso Group. Sample MG 12-13. 11. Random section. Yeso Group. Sample MG 12-14. 9. *Eotuberitina reitlingerae* Miklukho-Maklay, 1958. Axial section with basal disk. Yeso Group. Sample MG 12-12a. 12. *Geinitzina indepressa* Cherdyntsev, 1914. Subaxial section. Yeso Group. Sample MG 12-13a. 13, 15. *Boueina? crassundia* n. gen. n. sp. 13. Oblique section. Yeso Group. Sample MG 10-1. 15. Tangential section. Yeso Group. Sample MG 10-10. 14. *Palaeonubecularia* sp. Subaxial section. Yeso Group. Sample MG 10-5. 16. *Gymnocodium? bacillum* n. sp. Axial section. Yeso Group. Sample MG 10-11. 17, 19. *Gymnocodium? johnsonii* n. sp. 17. Two transverse sections. Yeso Group. Sample MG 10-13. 19. Subaxial section. Yeso Group. Sample MG 12-4a. 18. Undetermined Chlorophyta. Subtransverse section through the laterals. Yeso Group. Sample MG 10-19. Scale bars 1-12 equal 0.10 mm; 13-19 equal 0.50 mm.

28.3, 28.7, 29.1-29.4, 29.7, 30.2, 30.3, 30.11,
30.13, 30.16, 31.9-31.12, 32.1-32.3, 32.6

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- v. 2003 *Globivalvulina* spp. (partim); Krainer, Vachard and Lucas, pl. 8, figs. 2, 12.
- v. p. 2013 *Globivalvulina*; Brose, Lucas and Krainer, fig. 6.7 (only, non fig. 6.6 = *G. parapiciformis* n. sp.).
- v. 2013b *Globivalvulina* aff. *kamensis* Reitlinger; Vachard, Krainer and Lucas, p. 348 (no illustration).

Etymology. With septa turned backwards (relatively similar to those of the genus *Retroseptellina* Gaillot and Vachard, 2007).

Holotype. NMMNH P-67553; Figure 21.4; sample SAR 13-2.

Paratypes. NMMNH P-67554-67560; Figure 21.1-3, 21.5-8.

Material. 35 sections.

Locus Typicus. NMMNH locality 8898; San Andres Formation, reference section, San Andres Mountains near Rhodes Canyon (New Mexico).

Stratum Typicum. Late? Kungurian (latest Leonardian).

Diagnosis. Test medium-sized, often ovoid, with septa curved backward, funnel wide and shallow, and thin microgranular wall.

Description. Test ovoid to rounded trapezoidal; $D = (0.23)\text{-}0.30\text{-}0.60$ mm; $w = 0.28\text{-}0.55$ mm; $w/D = 0.63\text{-}1.25$. Planispiral to trochospiral axis of biseriality. Proloculus spherical, small to medium-sized (0.03-0.08 mm; mainly 0.06-0.07 mm), moderately large, centred. Dorsal side gently curved, strongly convex with weak sutures, to irregular and humped. Sutures moderately deep to deep. Whorl: 1-1.5. Peripheral margin semicircular to crescentic. Lateral sides of spire relatively flat. Umbilicus absent. Chambers: (4)-5-6-(rarely 8) pairs, semicircular to rounded, eventually deformed; the two last chambers are disproportionate with a strong increase in height as in *Globivalvulina graeca* Reichel, 1946 ($h = (\text{rarely } 0.11)\text{-}0.13\text{-}0.30$ mm). Septa thin and curved backwards at their distal extremity. Ventral side flat to slightly concave. Aperture is a basal slit. Funnel wide and shallow. Oral valvula variously developed, from faint to developed, as in *G. kamensis* Reitlinger, 1950. Wall thin, dark, undifferentiated, unilayered, and microgranular ($s = 0.01\text{-}0.02$ mm).

Remarks. The new species differs from all other species of *Globivalvulina* (except for those assigned to *Retroseptellina*) by the curvature of septa. Some transverse sections are difficult to dis-

tinguish from *G. kamensis* (nevertheless, the axial sections of this species are poorly known), generally smaller with a diameter of 0.43-0.50 mm for Reitlinger (1950) and 0.43 mm according to Bogush (1963, p. 60). Although synonymized with *Globivalvulina bulloides* by Groves (1988), *G. kamensis* differs by its smaller dimensions, stronger valvular projections, and a microgranular wall that is never differentiated.

Occurrence. Kungurian (late Leonardian) of New Mexico (Yeso Group, Los Vallos Formation, Torres Member, Massacre Gap (MG): samples MG 10-9, MG(2) 10-12; and San Andres Formation, McLeod Hills (MLY) and reference section in the San Andres Mountains (SAR): samples MLY 5-3, MLY 5-23, MLY(2) 5a-5a, MLY(2) 6-13, MLY(2) 6-31, MLY 8-2a, SAR 3-1, SAR 3-4, SAR 8a-19, SAR 10-3, SAR(2) 12-6, SAR 13-2, SAR 13-5b, SAR 13-5c, SAR 13-7, SAR 13-10, SAR(2) 13a-1, SAR(2) 13a-2, SAR 13a-7, SAR 13a-8, SAR 13a-9, SAR 13a-10, SAR 13a-11, SAR 19-2, SAR 19-3, SAR 19-4, SAR 20-1, SAR 20-6, SAR (A-1§)).

Globivalvulina novamexicana n. sp.

Figures 20.1-20.4, 27.2, 27.5-27.8, 27.12-27.19, 28.1-28.3, 28.7, 29.6, 29.9, 30.7, 31.1, 32.4, 32.5

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- 1972 *Globivalvulina bulloides* (Brady); Toomey, p. 295, pl. 2, figs. 19, 20, 21, 22, 23.
- v. 1993 *Globivalvulina* ex gr. *bulloides* (Brady); Vachard, Oviedo, Flores de Dios, Malpica, Brunner, Guerrero and Buitrón, pl. 6, fig. 8; pl. 8, figs. 7, 8, 9.
- 2000 *Globivalvulina* ex gr. *bulloides* (Brady); Groves, pl. 2, figs. 25, 26, 27, 28, 29, 30, 31, 32.
- v. 2003 *Globivalvulina* spp. (partim); Krainer, Vachard and Lucas, pl. 8, figs. 1, 11, 15, 16?
- v. 2009 *Globivalvulina* ex gr. *mosquensis* Reitlinger; Krainer, Lucas and Vachard, pl. 4, figs. 6, 7.
- v. 2013b *Globivalvulina* cf. *G. mosquensis* Reitlinger; Lucas, Krainer and Voigt, fig. 8G.
- v. 2013b *Globivalvulina* cf. *donbassica* Potievskaya; Vachard, Krainer and Lucas, p. 348 (no illustration).

Etymology. Latinized name indicating a New Mexican origin.

Holotype. NMMNH P-67561; Figure 25.1; sample MLY 6-17.

Paratypes. NMMNH P-67562, 67563; Figures 21.15, 22.2.

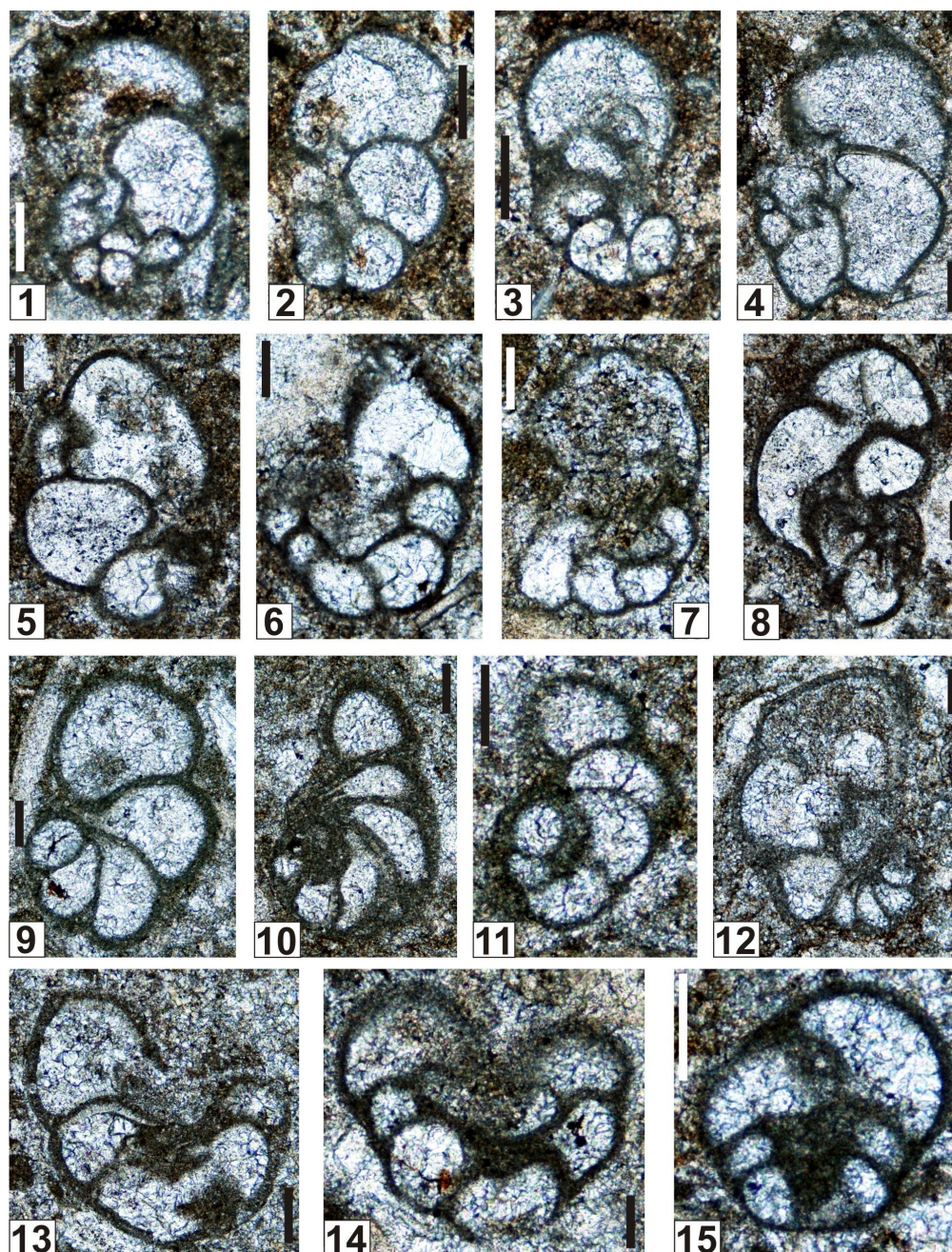


FIGURE 21. 1-8. *Globivalvulina retroseptata* n. sp. 1. NMMNH P-67554, paratype. Axial section showing the siphon formed by a curved backwards septum and an oral valvula. San Andres Fm. Sample SAR 10-3. 2. NMMNH P-67555, paratype. Transverse section. San Andres Fm. Sample SAR 12-6. 3. NMMNH P-67556, paratype. Subtransverse section. San Andres Fm. Sample SAR 12-7. 4. NMMNH P-67553, holotype. Transverse section. San Andres Fm. Sample SAR 13-2. 5. NMMNH P-67557, paratype. Subtransverse section. San Andres Fm. Sample SAR 13a-3a. 6. NMMNH P-67558, paratype. Oblique section. San Andres Fm. Sample SAR 13a-4. 7. NMMNH P-67559, paratype. Subtransverse section. San Andres Fm. Sample SAR 13a-6. 8. NMMNH P-67560, paratype. Oblique subtransverse section. San Andres Fm. Sample SAR 13a-3. 9-14. *Globivalvulina praegraeca* n. sp. 9. NMMNH P-67565, paratype. Subtransverse section. San Andres Fm. Sample SAR 7-1. 10. NMMNH P-67566, paratype. Subtransverse section. San Andres Fm. Sample SAR 7-2. 11. NMMNH P-67567, paratype. Oblique subtransverse section. San Andres Fm. Sample SAR 7-6. 12. NMMNH P-67564, holotype. Subtransverse section. San Andres Fm. Sample SAR 7-7. 13. NMMNH P-67568, paratype. Subaxial section. San Andres Fm. Sample MLY 3-3. 14. NMMNH P-67569, paratype. Axial section. San Andres Fm. Sample MLY 6-18. 15. *Globivalvulina novamexicana* n. sp., NMMNH P-67562, paratype. Oblique subaxial section. San Andres Fm. Sample MLY 5-22. Scale bars equal 0.10 mm.

Material. 70 specimens.

Locus Typicus. NMMNH locality 8899; San Andres Formation, McLeod Hills in the southern Caballo Mountains (New Mexico).

Stratum Typicum. Middle? Kungurian (late Leonardian).

Diagnosis. Test medium-sized, often ovoid, with septa curved backward, funnel wide and shallow, and thin microgranular wall.

Description. Test subspherical to nautiloid, moderate in size ($D =$ (rarely 0.23)-0.28-0.55 mm; $w =$ (rarely 0.24-0.25)-0.30-0.62 mm; $w/D = 0.89-1.20$). Slightly trochospiral axis of biseriality. Dorsal side convex. Sutures absent or very weak. Lateral sides strongly convex to a few compressed on the flanks. Proloculus medium to large (0.05-0.06 mm), spherical. Whorl: 1-1.5. Peripheral margin round. Lateral sides of spire inflated. Umbilicus absent. Chambers: 6-7 (rarely 8) pairs, subtriangular, and with $h =$ (rarely 0.07-0.09) 0.11-0.20 mm. Septa almost perpendicular to the wall. Ventral side flattened to slightly depressed. Aperture in basal slit. Oral valvula weakly developed to absent. Wall bilayered, with an inner layer relatively developed, especially on the septa; $s = 0.02-0.04$ mm with a maximum of 0.01 mm for the inner layer.

Comparisons. This taxon is similar to *G. donbassica* Potievskaya, 1962 but differs by slightly larger dimensions, chambers less rounded in transverse section, and a basal part more planar in axial section. This species also resembles *Globivalvulina biserialis* Cushman and Waters 1928b sensu St Jean, 1957 (p. 36-37, plate 3, figures 3a-c, 4-5) but differs in the shape of the axial section. It also resembles *G. mosquensis* Reitlinger, 1950 but differs in its larger dimensions (D , w , h) for the same number of chambers and in the great difference of age (*G. mosquensis* is initially a Moscovian species). The morphology is relatively similar to that of *Globivalvulina bulloides*; the main difference is the wall microstructure (a possible but controversial generic character; see Brenckle, 2005; Vachard et al., 2006).

Occurrence. Kungurian (late Leonardian) of New Mexico (Yeso Group, Los Vallos Formation, Torres Member, Massacre Gap in the southern Fra Cristobal Mountains: samples MG(2) 10-1, MG 10-3, MG 10-6, MG 10-6a, MG 10-7, MG 10-8, MG 10-14, MG 10-17, MG 10-17a, MG 10-18, MG 10-19a, MG 12-1, MG 12-4; San Andres: samples MLY 3-2, MLY 3-6, MLY 3-7a, MLY 3-8, MLY 3-10, MLY 4-1, MLY 4-2, MLY 4-4, MLY 4-6, MLY 4-9, MLY 4-13, MLY 4-17, MLY(2) 5-2, MLY(2) 5-2a, MLY 5-7c, MLY 5-20a, MLY(2) 5-21, MLY 5-22, MLY(2) 5-23,

MLY 6-1, MLY(2) 6-1, MLY(2) 6-2, MLY 6-16, MLY 6-17, MLY(2) 6-23, MLY(2) 6-25, MLY 6-29a, MLY 8-8, SAR 7-3, SAR(2) 8-4, SAR 8-5, SAR 8a-5a, SAR 8a-9, SAR 8a-12, SAR 8a-20, SAR 8a-21, SAR 8a-24, SAR 12-2, SAR(2) 12-4, SAR(2) 13-3, SAR(2) 13-4, SAR(2) 13-5, SAR(2) 13-8, SAR(2) 13-11, SAR 13-12, SAR(2) 13a-3/3a, SAR 20-8).

Globivalvulina praegraeca n. sp.

Figures 21.9-21.14, 28.4-28.6, 28.8-28.12, 28.14-28.16, 29.5, 29.8, 29.10-29.13, 30.1, 30.4-30.6, 30.8-30.10, 30.12, 30.14, 30.15, 31.2-31.8

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1970 *Globivalvulina graeca* Reichel; Kochansky-Devidé, p. 185, pl. 9, fig. 6; pl. 18, figs. 1, 2.

1972 *Globivalvulina* aff. *donbassica* Potievskaya; Sosipatrova, pl. 10, figs. 14, 15.

1974 *Globivalvulina graeca* Reichel; Akopian, p. 101, pl. 39, fig. 4.

2009 *Globivalvulina syzranica* Reitlinger; Blazejowski, fig. 10.3.

2009 *Globivalvulina graeca* Reichel; Blazejowski, figs. 10.4-5.

2009 *Globivalvulina* cf. *graeca* Reichel; Blazejowski, fig. 10.6-9.

v. 2013b *Globivalvulina* cf. *graeca* Reichel; Vachard, Krainer and Lucas, p. 348 (no illustration).

Etymology. Probable ancestor of *G. graeca* Reichel, 1946.

Holotype. NMMNH P- 67564; Figure 21.12; sample SAR 7-7.

Paratypes. NMMNH P- 67565-67569; Figure 21.9-11, 21.13-14.

Material. 40 specimens.

Locus Typicus. NMMNH locality 8900; San Andres Formation, reference section in the San Andres Mountains (New Mexico).

Stratum Typicum. Late? Kungurian (latest Leonardian).

Diagnosis. Test large, with a wide aperture, a deep and relatively wide funnel, no oral valvula, and a bilayered wall, but with an inner pseudofibrous layer that is very thin and discontinuous.

Description. Test nautiloid, involute, and large: $D = (0.45)-0.50-0.73-(0.83)$ mm, $w = 0.50-0.72$ mm, $w/D = 0.71-1.0$. Planispirally coiled axis of biseriality. Proloculus spherical, small (0.02) to large (0.06-0.13 mm), and subprominent. Dorsal side convex, curved to semicircular. Sutures weak to absent. Whorls: 1-1.5. Peripheral margin rounded to slightly angular; lateral sides of spire slightly

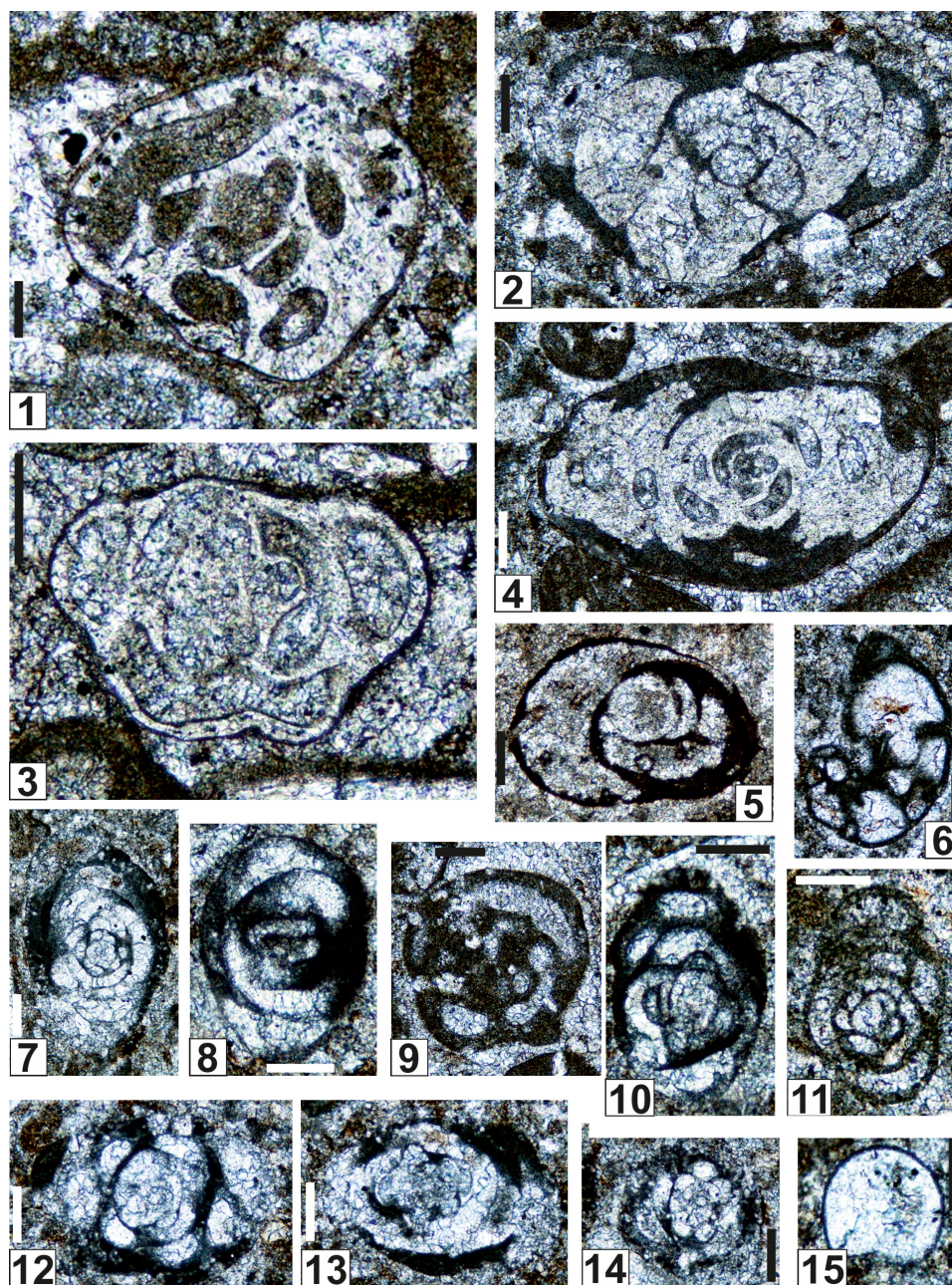


FIGURE 22. 1, 3. *Glomomidiella infrapermica* n. sp. 1. NMMNH P-67600, holotype. Subtransverse section. Yeso Group. Sample MG 10-22. 3. NMMNH P-67601, paratype. Subtransverse section. Yeso Group. Sample MG 10-25. 2. *Orthovertellopsis proteaeformis* n. gen. n. sp., NMMNH P-67570, holotype. Axial section with relatively well-preserved wall. Yeso Group. Sample MG 10-21. 4, 7-8, 10, 12-14. *Praeneodiscus convexus* n. gen. n. sp. 4. NMMNH P-67606, holotype. Axial section. Yeso Group. Sample MG 10-24. 7. NMMNH P-67607, paratype. Axial section. San Andres Fm. Sample MLY 5-13 (already illustrated in Brose et al., 2013, figure 6. 11). 8. NMMNH P-67608, paratype. Axial section. San Andres Fm. Sample MLY 5-4. 10. NMMNH P-67609, paratype. Axial section with a relatively preserved wall. San Andres Fm. Sample MLY 5-7. 12. NMMNH P-67610, paratype. Axial section. San Andres Fm. Sample MLY 5-7a. 13. NMMNH P-67611, paratype. Axial section. San Andres Fm. Sample MLY 5-30. 14. NMMNH P-67612, paratype. Axial section. San Andres Fm. Sample MLY 5-21. 5. *Tubiphytes epimonellaeformis* n.sp. Subtransverse section. San Andres Fm. Sample SAR 8a-22. 6. *Globivalvulina parapiciformis* n. sp. NMMNH P-67551, holotype. Transverse section. San Andres Fm. Sample MLY 4-3. 9. *Pseudospira* aff. *ishimbaica* (Lipina, 1949). Subtransverse section. Yeso Group. Sample MG 10-26. 11. *Hemigordiellina?* cf. *simplex* (Harlton, 1928). Axial section. San Andres Fm. Sample MLY 6-28. 15. *Eotuberitina reitlingeræ* Miklukho-Maklay, 1958. Axial section. San Andres Fm. Sample MLY 4-5. Scale bars equal 0.10 mm.

inflated; umbilicus absent. Chambers rectangular; the last one is rounded trapezoidal; $n = 5-7$ (rarely 8); $h =$ (rarely 0.13-0.20)-0.20-0.43 mm. Septa regular, sigmoid, typical of the genus. Ventral side concave to flattened. Aperture broad with a deep and relatively wide funnel. Oral valvula not obvious. Wall bilayered ($s = 0.03-0.05$ mm) and relatively thick, microgranular with calcareous agglutinate, locally bilayered with an inner pseudo-fibrous clear layer that is very thin and not obviously continuous.

Comparisons. The new species differs from *G. graeca* by smaller dimensions (mean diameter of *G. graeca* = 0.70 mm), less chambers, wider aperture and less developed funnel, larger proloculus, absence of lamella, and thinner and discontinuously located inner pseudofibrous layer. It differs from *G. syzranica* Reitlinger, 1950 by the shape of the chambers and the deeper funnel; from *G. donbassica* Potievskaya, 1962 by larger dimensions (in this latter species, $D = 0.31-0.42$ mm; $w = 0.26-0.39$ mm), and higher chambers (maximum 0.22 mm, mainly 0.11-0.15 mm in *G. donbassica*), and from *G. granulosa* Reitlinger, 1950 by the stronger development of the pseudofibrous inner layer, less thick wall (up to 0.06 mm-thick in *G. granulosa*), less coarse calcareous agglutinate, and the deep funnel. Furthermore, contrary to Pinard and Mamet (1998), we do not assign *G. granulosa* to the group *G. bulloides*, because of the difference of wall microstructure.

Occurrence. Early Permian of Croatia and Armenia. Early Artinskian of Spitsbergen. Middle?-late? Kungurian (late Leonardian) of New Mexico (San Andres Formation, McLeod Hills (MLY) and reference section in the San Andres Mountains (SAR): samples MLY 3-3, MLY(2) 4-9, MLY 6-18, samples SAR 3-4, SAR 7-1, SAR 7-2, SAR 7-4, SAR 7-5, SAR 7-6, SAR 7-7, SAR 8-1, SAR(2) 8-1a, SAR 8-2, SAR(2) 8-3, SAR(2) 8-4, SAR(2) 8-6, SAR 8-7, SAR 8-7a, SAR(2) 8-8, SAR(2) 8-10, SAR(2) 8-18, SAR(2) 8-21, SAR 8a-2, SAR 8a-5, SAR 8a-10, SAR 8a-10a, SAR 8a-12, SAR 8a-13a, SAR 8a-20, SAR 8a-21, SAR 8a-24, SAR 9-1, SAR 12-7, SAR 13-1, SAR(2) 13-2, SAR(2) 13-6, SAR(2) 13-9, SAR(2) 13a-4).

Class MILIOLATA Lankester, 1885 nom. transl.
Saidova, 1981

Order MILIOLIDA Lankester, 1885

Remarks. The principal character of the class Miliolata is the porcelaneous wall. This wall, composed of high magnesian calcite, is often unstable, and the typical extant aspect amber-coloured or tan-skinned (Scholle and Ulmer-Scholle, 2003, p.

41) becomes rapidly and eodiagenetically black, and then, whitish if it is meso- or telodiagenetized in neosparite and/or silica and/or anhydrite (Vachard et al., 2005, plate. 4, figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17).

When the wall is black, it is strictly identical in optical as well as in electronic microscopy to the originally microgranular wall of a Fusulinata. For instance, our unpublished material of Palaeozoic Miliolata, SEM-observed, is similar in wall aspect to the Fusulinida *Eostaffella* illustrated by Vachard et al. (2004, plate 1, figure 2). The argument of Pronina (1994) that "Late Permian cornuspirids [which] have microgranular wall structure (...) are considered to belong to genus *Pseudoammodiscus*" is therefore irrelevant.

Because it is originally purely calcitic, a microgranular wall remains more stable than a porcelaneous one. Consequently, the difference between some taxa of Miliolata and Fusulinata are not purely dialectic and diagenetic, and cannot be indicated only by arguments of formal logic. That is particularly true for the genus *Cornuspira* Schultze, 1854 in opposition to the genus *Pseudoammodiscus* Conil and Lys in Conil and Pirlet, 1970; as well as *Hemigordiellina* Marie in Deleau and Marie, 1961 sensu Vachard and Beckary, 1991 versus "*Pseudoglomospira*" auctorum (non Bykova in Bykova and Polenova, 1955) or *Pseudospira* Reitlinger in Vdovenko et al., 1993; or *Hoyenella* Rettori, 1994 emend. Gaillot and Vachard, 2007 versus *Glomospirella* Plummer, 1945 auctorum; *Brunsiella* Reitlinger, 1950 versus *Brunsia* Mikhailov, 1935; *Palaeonubecularia* Reitlinger, 1950 versus *Tolypammia* Rhumbler, 1895, etc. Despite the homeomorphy existing between the free bilocular Late Mississippian (Serpukhovian) *Pseudoammodiscus* and *Cornuspira* (underlined for example by Tappan and Loeblich, 1988), Gaillot and Vachard (2007) supposed that the phylogenetic change from a microgranular to a porcelaneous wall occurred in a group of attached forms because of: 1) the older appearance of these porcelaneous forms (at the beginning of the Serpukhovian; whereas the FAD of *Cornuspira* would be late Serpukhovian in age); 2) the great morphological similarity between attached genera like *Scalebrina* Conil and Longestaey in Conil et al., 1980 and *Palaeonubecularia*; 3) the dominance of the attached porcelaneous forms during the Bashkirian; 4) the rarity of *Cornuspira* and *Hemigordiellina* during the Bashkirian-Moscovian; 5) the FAD of the first genus universally accepted as porcel-

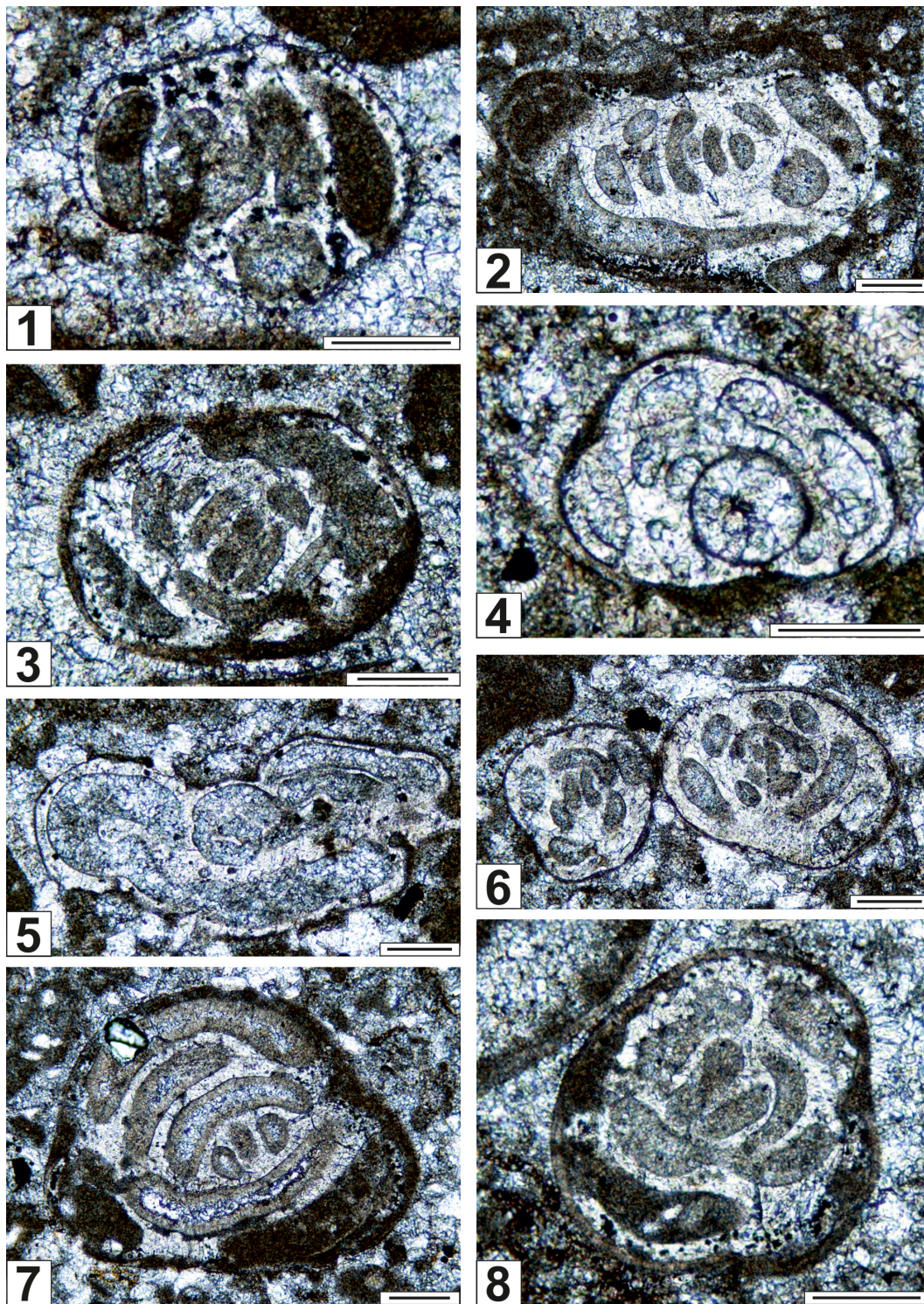


FIGURE 23. 1, 3, 7-8. *Glomomidiella infrapermica* n. sp. 1. NMMNH P-67602, paratype. Subtransverse section. Yeso Group. Sample MG 10-12. 3. NMMNH P-67603, paratype. Oblique subaxial section. Yeso Group. Sample MG 10-15. 7. NMMNH P-67604, paratype. Two subtransverse sections. Yeso Group. Sample MG 10-2. 8. NMMNH P-67605, paratype. Subtransverse section. Yeso Group. Sample MG 10-16. 2, 4, 6. *Orthovertellopsis proteaeformis* n. gen. n. sp. 2. NMMNH P-67571, paratype. Subaxial section. Yeso Group. Sample MG 10-23. 4. NMMNH P-67572, paratype. Subaxial section. Yeso Group. Sample MG 10-13a. 6. NMMNH P-67573, two paratypes. Subtransverse section. Yeso Group. Sample MG 10-20. 5. *Calcitornella* cf. *elongata* Cushman and Waters, 1928a. Subaxial section. Yeso Group. Sample MG 10-20a. Scale bars equal 0.10 mm.

aneous, i.e., *Hemigordius* Schubert, 1908, is during the late Moscovian.

Superfamily ?NUBECULARIOIDEA Jones in Griffith and Henfrey, 1875
nom. transl. Mikhalevich, 1988

Family ?CALCIVERTELLIDAE Loeblich and Tappan, 1964 nom. transl. Reitlinger in Vdovenko, Rauzer-Chernousova, Reitlinger and Sabirov, 1993 emend. Gaillot and Vachard, 2007

Description. Attached bilocular, undivided, tubular genera separated by the type of coiling and/or the thickness of the wall. Porcelaneous wall often neosparitized. Aperture terminal, simple.

Occurrence. Serpukhovian-Recent, cosmopolitan.

Genus AMMOVERTELLA Cushman, 1928

Type Species. *Psammophis inversus* Schellwien, 1898.

Description. Calcivertellid characterised by a zig-zagging initial coiled stage followed by an erect last stage.

Remarks. For Henbest (1963), *Ammovertella* is the Textulariata homeomorph of the Miliolata *Calcivertella* Cushman and Waters, 1928a. Inversely, Vachard and Krainer, (2001a, p. 157) have indicated that *Ammovertella* has a porcelaneous wall and not an agglutinated wall and consequently belongs to the family Calcivertellidae and not to the Ammodiscidae. According to Gaillot and Vachard (2007), a part of the atypical species of this genus belongs to *Calcivertella* or *Palaeonubecularia*.

We suggest here that *Calcivertella*, *Ammovertella*, and *Trepeilopsis* Cushman and Waters, 1928a are related but distinct genera due to their microhabitats and types of attachment. If the three genera are synonymous, *Calcivertella* has priority to designate the taxon.

Occurrence. Pennsylvanian-Permian, cosmopolitan.

Ammovertella sp.

Figure 34.13

? 1984 "*Ammodiscella*" sp.; Flügel, Kochansky-Devidé and Ramovs, pl. 32, fig. 2.

v. 2013b *Ammovertella* sp.; Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. Planispiral initial stage followed by an uncoiled tubular last part. D = 0.26 mm; whorls: 4; p = 0.05 mm; h = 0.04 mm; s = 0.01 mm. Proloculus spherical, moderately large, larger than the first whorl, with a short flexostyle channel. No umbilicus. Four whorls. Lateral sides of spire slightly

inflated. Peripheral margin rounded. Uncoiling in the form of a tubular chamber in which the diameter is equal to the height of the last planispiral whorl, erect, vertical, tubular, perpendicular with the axis of coiling. No secondary incrustation of lateral walls. Wall porcelaneous, dark transformed in microgranular calcite.

Occurrence. Late? Kungurian (latest Leonardian) of New Mexico (San Andres Fm; sample SAR 13-9a).

Genus PALAEONUBECULARIA Reitlinger, 1950

Type Species. *Palaeonubecularia rustica* Reitlinger, 1950.

Description. Attached, uncoiled tubular, serpentine-form, gregarious test. Proloculus and early stage poorly known. Wall porcelaneous, often transformed in microgranular calcite or poorly silicified (and consequently, they are often misinterpreted as Fusulinata pseudolituotubids and Textulariata tolypamminids).

Remarks. The gregarious tubes of this genus are generally few around the substrate; nevertheless, some reefs of *Palaeonubecularia* have been described, in particular in the Artinskian of the Pre-Urals, Russia (Khvorova, 1951).

Occurrence. Late Mississippian (Serpukhovian)-Late Permian (Wuchiapingian), cosmopolitan.

Palaeonubecularia sp.

Figures 13.2, 20.14, 33.25, 34.7, 34.8

v. 2013b *Palaeonubecularia* sp.; Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. No initial glomospiral stage known; the tube is immediately serpentine-form. Sutures absent but tube limits very visible. Whorls relatively numerous but difficult to estimate exactly. Lateral sides of spire inflated. Peripheral margin round. Aperture not observed. L = 1.25-2.50 mm; H = 0.68-0.75 mm; h = 0.08-0.25 mm; s = 0.03/0.05 mm.

Remark. Similar in its dimensions to *P. rustica*, this taxon differs by the thinner wall and the less elongate lumen.

Occurrence. Early?-late? Kungurian (Leonardian) of New Mexico (Yeso Group: samples MG 10-26a, MG 10-28, MG 10-29, MG 10-5, MG 12 7a, MG(2) 12 10. San Andres Fm: samples MLY(2) 5-19, MLY(2) 5-22, MLY 5-29, MLY 6-24, SAR 20).

Genus CALCITORNELLA Cushman and Waters, 1928a

Type Species. *Calcitornella elongata* Cushman and Waters, 1928a.

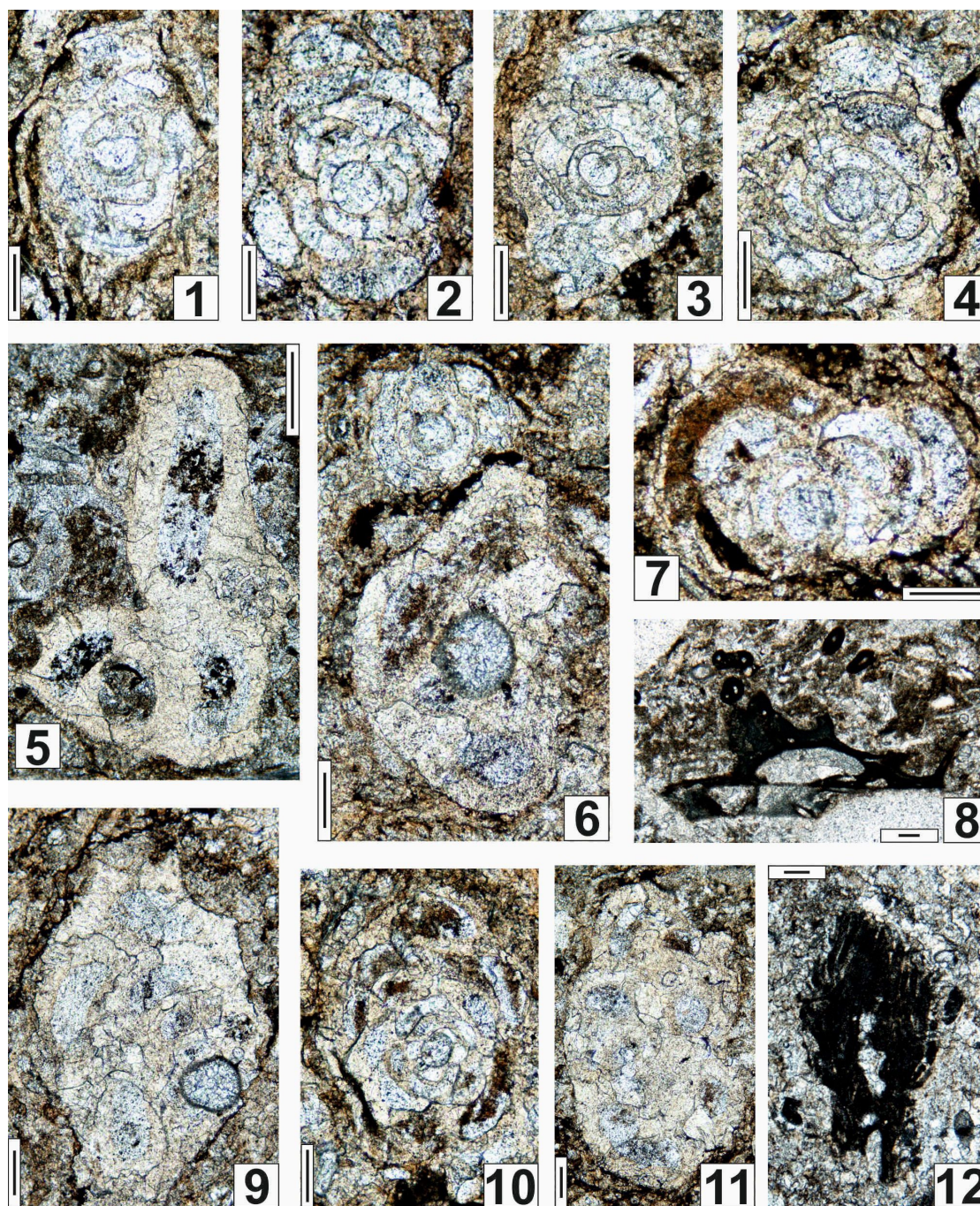


FIGURE 24. 1-4, 7, 10. *Olgaorlovella davydovi* n. gen. n. sp. 1. NMMNH P-67595, paratype. Axial section. San Andres Fm. Sample SAR 11-15. 2. NMMNH P-67596, paratype. Axial section. San Andres Fm. Sample SAR 11a-7. 3. NMMNH P-67597, paratype. Axial section. San Andres Fm. Sample SAR 11-8. 4. NMMNH P-67598, paratype. Axial section. San Andres Fm. Sample SAR 11-12. 7. NMMNH P-67599, paratype. Subaxial section. San Andres Fm. Sample SAR 11-6b. 10. NMMNH P-67594, holotype. Axial section. San Andres Fm. Sample SAR 11-2. 5-6, 9, 11. *Orthovertellopsis calcitornellaeformis* n. gen. n. sp. 5. NMMNH P-67575, paratype. Oblique section showing the costae. San Andres Fm. Sample SAR 12-8. 6. NMMNH P-67574, holotype. Transverse section with *Olgaorlovella davydovi* n. gen. n. sp. San Andres Fm. Sample SAR 11-10. 9. NMMNH P-67592, paratype. Oblique section. San Andres Fm. Sample SAR 11a-13. 11. NMMNH P-67593, paratype. Subaxial section. San Andres Fm. Sample SAR 11-7a. 8, 12. *Tubiphytes epimonellaeformis* n. sp. 8. Subaxial section. San Andres Fm. Sample SAR 12-1. 12. Subaxial section difficult to distinguish from *T. obscurus* Maslov, 1956. San Andres Fm. Sample SAR 3-3. Scale bars equal 0.10 mm.

Description. Calcivertellid characterised by a nearly planispirally coiled initial stage followed by a serpentine last stage.

Remarks. According to Henbest (1963), *Apterinella* Cushman and Waters, 1928b and *Calcitornella* are two synonyms among the Miliolata. However, *Calcitornella* is priority over *Apterinella*, because these genera have been described on p. 45-47 and p. 64, respectively, of the same publication. On the other hand, *Apterinella* was too poorly defined to be preferred to *Calcitornella*. That was first suggested by Browne and Pohl (1973), even if these latter authors have erroneously considered *Calcitornella* as a representative of the Fusulinata Pseudoammodiscidae.

Occurrence. Pennsylvanian-Permian; cosmopolitan.

Calcitornella cf. *elongata* Cushman and Waters,
1928a
Figures 23.5, 34.19

? 1928a *Calcitornella elongata* Cushman and Waters, p. 47-48, pl. 6, fig. 5.

? 1985 *Calcitornella elongata* Cushman and Waters; Palmieri in Foster, Palmieri and Fleming., p. 80, pl. 5, figs. 11, 12, 13.

v. 2013b *Calcitornella* cf. *elongata* Cushman and Waters; Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. Poorly developed glomospiral initial stage followed by an uncoiled tubular last part arranged symmetrically around the initial coiling (D = 0.67 mm; w = 0.29 mm). No umbilicus. Four whorls. Lateral sides of spire flat to slightly inflated. Peripheral margin rounded. Uncoiling in form of a tubular chamber in which the diameter is equal to the height of the last planispiral whorl (h = 0.10 mm), erect, vertical, tubular, aligned with the axis of coiling. No secondary incrustation of lateral walls. Wall originally porcelaneous, currently neosparitized (s = 0.01 mm).

Occurrence. Late Pennsylvanian of Texas and Ecuador. Early Permian of Australia. Middle Permian of Cambodia. Early?-middle? Kungurian of New Mexico (Yeso Group: sample MG 10-20a. San Andres Fm: sample MLY(2) 5a-24).

Genus ORTHOVERTELLOPSIS n. gen.

zoobank.org/DA607E3F-F49B-47CC-A605-E821FC00F3ED

Etymology. Similar to *Orthovertella* Cushman and Waters, 1928a.

Synonym. *Orthovertella* (pars).

Type Species. *Orthovertellopsis proteaeformis* n. gen. n. sp.

Diagnosis. Free Calcivertellidae? characterised by a large coiled initial coiled stage followed by a very short uncoiled, rectilinear last stage.

Composition. *Orthovertellopsis proteaeformis* n. gen. n. sp.; *O. calcitornellaeformis* n. gen. n. sp.; *Orthovertella? simplicissima* Miklukho-Maklay, 1968; *Midiella glomospiroidalis* (Sosipatrova, 1972) sensu Blazejowski, 2009, figure 16.12; *Hemigordius hyrnefjelleti* Blazejowski, 2009; *H.* sp. sensu Blazejowski, 2009, figures 15.8-12, 16.13-14; *H.?* sp. sensu Blazejowski, 2009, figure 15.7; Hemigordiopsida indet. sensu Blazejowski, 2009, figure 15.13-15; *Orthovertella protea* sensu Crespini, 1958; *O. protea* sensu Foster, Palmieri and Fleming, 1985, ?*Orthovertella* sp. 1 sensu Lambert et al. (2002, plate 7, figure 28); ?*Graecodiscus praecursor* Nestell and Nestell, 2006; and ?*G.* sp. 2 sensu Nestell and Nestell, 2006.

Comparison. *Orthovertellopsis* n. gen. differs from *Orthovertella* by a terminal stage less developed, a more regular coiling, and differs from *Calcitornella* by a more regular coiling and a free habitat indicated by the absence of an attachment plane face.

Occurrence. Kungurian (late Leonardian) of New Mexico. Early Permian of Australia (Carnarvon Basin, Canning Basin, Tasmania, and perhaps Sydney Basin). Permian of South China. Early Kazanian (Middle Permian) of the Urals. ?Latest Guadalupian of Texas.

Orthovertellopsis proteaeformis n. gen. n. sp.
Figures 22.2, 23.2, 23.4, 23.6, 33.19, 33.20, 35.10,
35.12

zoobank.org/47A263E8-C536-4705-B36C-7CEF5B7CA43D

? 1958 *Orthovertella protea* Cushman and Waters; Crespini, p. 82, pl. 18, figs. 7-9.

1985 *Orthovertella protea* Cushman and Waters; Foster, Palmieri and Fleming, p. 81, pl. 5, figs. 5-7.

? 1993 *Neodiscus* cf. *permicus* (Grozdilova); Ueno and Sakagami, fig. 3.14.

? 2006 *Hemigordius* sp. 1; Nestell, Nestell, Wardlaw and Sweatt, pl. 1, fig. 21 (only).

v. 2013b *Orthovertella?* sp. 1 (part.); Vachard, Krainer and Lucas, p. 348 (no illustration).

v. 2013b *Orthovertella?* sp. 2; Vachard, Krainer and Lucas, p. 348 (no illustration).

Etymology. Similar to some *O. protea* Cushman and Waters, 1928a of the authors.

Holotype. NMMNH P-67570; Figure 22.2; sample MG 10-21.

Paratypes. NMMNH P-67571-67573; Figure 23.2, 23.4, 23.6.

Material. 10 specimens.

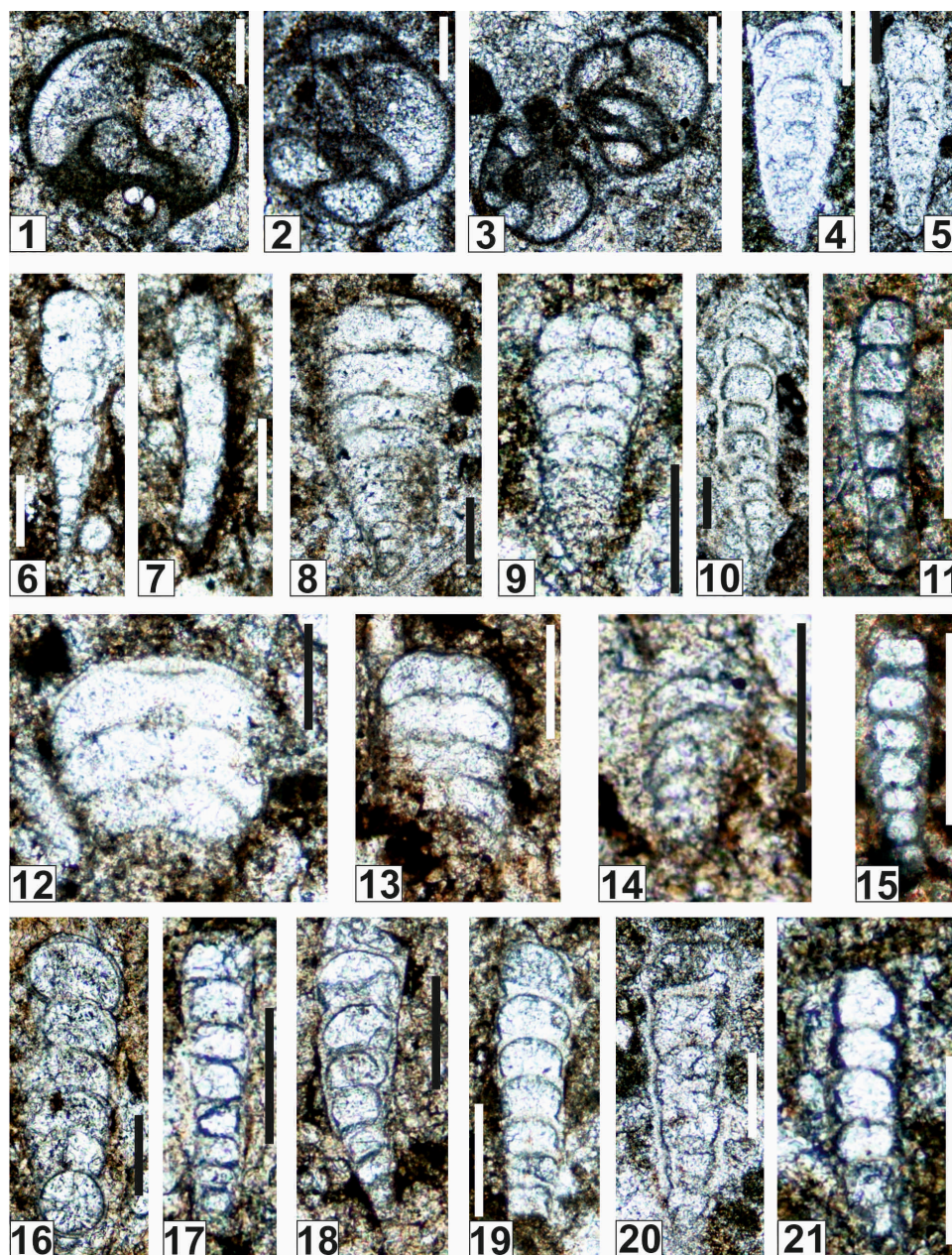


FIGURE 25. 1-2. *Globivalvulina novamexicana* n. sp. 1. NMMNH P-67561, holotype. Subaxial section. San Andres Fm. Sample MLY 6-17. 2. NMMNH P-67563, paratype. Subaxial section. San Andres Fm. Sample MLY 6-29a. 3. *Globivalvulina parapacificiformis* n. sp. NMMNH P-67552, two paratypes. Two oblique sections. San Andres Fm. Sample MLY 6-11a. 4. *Nestellorella?* sp. Subaxial section. San Andres Fm. Sample MLY 1-1. 5. *Protonodosaria?* sp. Subaxial section. San Andres Fm. Sample MLY 3-5. 6-7, 10, 17-19. *Nodosinelloides longa* (Lipina, 1949). 6. Axial section. San Andres Fm. Sample SAR 8a-4a. 7. Subaxial section. San Andres Fm. Sample SAR 8a-8. 10. Axial section. San Andres Fm. Sample SAR 8a-17 (already illustrated by Brose et al., 2013, figure 6.5). 17. Axial section. San Andres Fm. Sample SAR 11a-6. 18. Axial section. San Andres Fm. Sample SAR 11a-9. 19. Axial section. San Andres Fm. Sample SAR 12-4. 8-9, 12-14. *Geinitzina indepressa* Cherdyntsev, 1914. 8. Axial section. San Andres Fm. Sample SAR 8a-11. 9. Axial section. San Andres Fm. Sample SAR 8a-14. 12. Subaxial section. San Andres Fm. Sample SAR 8a-7. 13. Subaxial section. San Andres Fm. Sample SAR 11-13. 14. Oblique subaxial section. San Andres Fm. Sample SAR 11a-10. 11, 15, 20?, 21. *Nodosinelloides netjaschewi* (Cherdyntsev, 1914). 11. Axial section. San Andres Fm. Sample SAR 11-17. 15. Axial section. San Andres Fm. Sample SAR 11-19/19a. 20. Axial section. San Andres Fm. Sample SAR 20.2. 21. Axial section. San Andres Fm. Sample SAR 13a-2. 16. *Nodosariata* indet. cf. *Dentalina* cf. *ninae* Grozdilova sensu Chuvashov et al., 1990. Axial section. San Andres Fm. Sample SAR 11a-4. Scale bars equal 0.10 mm.

Locus Typicus. NMMNH locality 8901; Yeso Group, Los Vallos Formation, Torres Member, Mas-sacre Gap in the southern Fra Cristobal Mountains (New Mexico).

Stratum Typicum. Early? Kungurian (late Leon-ardian).

Diagnosis. Large and elongate species of *Ortho-vertellopsis* with a large or huge proloculus and a test, inflated in the central part, entirely streptospiral or with the last or semi-last whorl semi-evolute. Wall relatively thick and lumen approximately three times wider than the wall.

Description. The test is large and elongate; $D = 0.60-0.85$ mm; $w =$ (rarely 0.20)- $0.34-0.41$ mm; $w/D =$ (rarely $0.33-0.41$)- $0.51-0.58$. The spherical proloculus is large to huge (up to 0.09 mm). The coiling, initially weakly streptospiral, becomes oscillating and forms a thin-walled glomus, and is then sigmoidal with all the whorls thick-walled, evolute, and with deep sutures. Asymmetrical umbilici are present. Whorls: 4-5-(6), involute at the beginning, then semi-involute and finally evolute. Sutures marked between the different whorls of coiling. Lateral sides of spire irregular. Peripheral margin round. Tube walls relatively thick ($0.02-0.03$ mm). Lumina semi-circular ($h = 0.09-0.13$ mm). Uncoiling inconspicuous. Some basal lateral thickenings in the wall are obvious.

Remarks. Our sections are very similar to those of Foster et al. (1985) due to the evolute last whorls and the deep sutures that evoke the concavo-angulatus stage of the archaediscoids (Pille et al., 2007; Pille, 2008). The uncoiled last stage of coiling is inconspicuous in our thin sections. The new species differs from *O. protea* sensu stricto by the regular elongate test, larger dimensions, less conspicuous uncoiled last part, and different ages (early Late Carboniferous against late Early Permian). It differs from *O. protea* sensu Crespin, 1958 or Foster et al., 1985 by the elongate test and smaller dimensions.

Occurrence. Early Permian Australia (Carnarvon Basin, Canning Basin, Tasmania, and perhaps Sydney Basin). Early?-middle? Kungurian (Leonardian) of New Mexico (Yeso Group, Los Vallos Formation, Torres Member: samples MG(2) 10-6, MG 10-13a, MG(2) 10-14, MG 10-20, MG 10-21, MG 10-23. San Andres Formation, McLeod Hills: samples MLY 6-5, MLY 6-5a). ?Early Murgabian (= Rodian) of NE Thailand.

Orthovertellopsis calcitornellaeformis n. gen. n. sp.
Figures 24.5, 24.6, 24.9, 24.11, 34.6, 34.10, 34.17,
35.6, 35.7, 35.13

zoobank.org/C5D1A3E1-902B-466E-B8EF-E648998A901E

v. 2013b *Calcitornella?* sp. 1; Vachard, Krainer and Lucas, p. 348 (no illustration).

Etymology. Similar to *Calcitornella* Cushman and Waters, 1928a.

Holotype. NMMNH P-67574; Figure 24.6; sample SAR 11-10.

Paratypes. NMMNH P-67576, 67592-67593; Figure 24.5, 24.9, 24.11.

Material. 15 specimens.

Locus Typicus. NMMNH locality 8902; San Andres Formation reference section in the San Andres Mountains near Rhodes Canyon (New Mexico).

Stratum Typicum. Late? Kungurian (latest Leonardian).

Diagnosis. Attached porcelaneous, undivided, tubular, thick walled, with internal surface smooth and external surface displaying some acute costae (i.e., apparently transitional between the genera *Calcitornella* and *Hedraites* Henbest, 1963).

Description. No transverse growth lines but some small, narrow, equilateral costae are sparsely arranged. The irregular initial spiral is followed by an uncoiled tubular last part. Umbilicus not observed. Sutures relatively well marked. Whorls partially involute in some specimens. Lateral sides of spire flat to slightly inflated. Peripheral margin round to slightly angular. Chamber walls relatively thick. Uncoiling in form of a tubular chamber that has a diameter equal to the height of the last planispiral whorl, erected, vertical, tubular, and perpendicular to the axis of coiling. Measurements: $D =$ (rarely $0.35-0.40$)- $0.52-1.00$ mm; $w =$ (rarely 0.15)- $0.34-0.66$ mm; $p = 0.08-0.17$ mm; whorls: 1-3 (rarely 4); $h = 0.06-0.17$ mm; $s = 0.02-0.04$ -(rarely 0.06) mm.

Remark. This new species differs from *O. proteaeformis* n. gen. n. sp. by a more irregular test, some costae and thicker walls.

Occurrence. Middle?-late? Kungurian (late Leonardian) of New Mexico (San Andres Formation, McLeod Hills (MLY) and reference section in the San Andres Mountains (SAR): samples MLY 8-6, SAR 11-7a, SAR(2) 11-10, SAR(2)11-11, SAR 11-16, SAR 11a-5, SAR 11a-12a, SAR 11a-13, SAR 11a-16, SAR 12-8, SAR 19-1).

Superfamily CORNUSPIROIDEA Schulze 1854
nom. translat. Mikhalevich, 1988

Family CORNUSPIRIDAE Schulze, 1854

Genus HEMIGORDIELLINA Marie in Deleau and Marie, 1961 emend. Vachard in Vachard and Beckary, 1991

Type Species. *Glomospira diversa* Cushman and Waters, 1930.

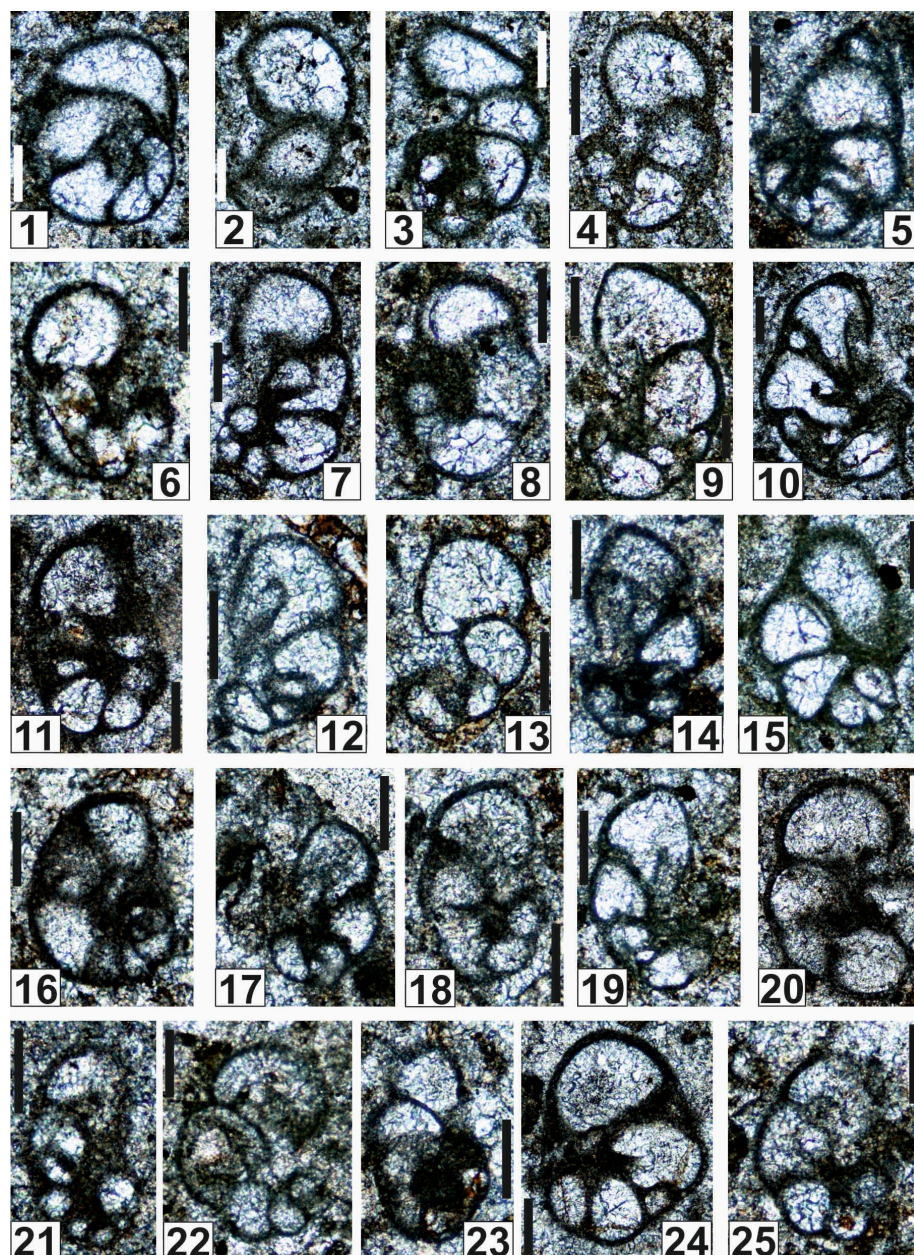


FIGURE 26. 1, 4-7, 9, 11-14, 16-19, 21, 23, 25. *Globivalvulina parapiciformis* n. sp. 1. Subtransverse section. San Andres Fm. Sample MLY 4-14. 4. Subtransverse section. San Andres Fm. Sample MLY 3-4. 5. Subtransverse section. San Andres Fm. Sample MLY 3-7. 6. Subtransverse section. San Andres Fm. Sample MLY 6-12a. 7. Transverse megalospheric? section. San Andres Fm. Sample MLY 3-9 (already illustrated by Brose et al., 2013, figure 6.6). 9. Subtransverse section. San Andres Fm. Sample MLY(2) 4-11. 11. Subtransverse section. San Andres Fm. Sample MLY 6-31. 12. Subtransverse section. San Andres Fm. Sample MLY 5-11. 13. Subtransverse section. San Andres Fm. Sample MLY 5-11a. 14. Transverse section. San Andres Fm. Sample MLY 5-24a. 16. Transverse section. San Andres Fm. Sample MLY 8-2. 17. Subtransverse section. San Andres Fm. Sample MLY 6-4. 18. Subtransverse section. San Andres Fm. Sample MLY 6-3. 19. Transverse section. San Andres Fm. Sample MLY 6-2. 21. Transverse megalospheric section. San Andres Fm. Sample MLY 2-1. 23. Subtransverse section. San Andres Fm. Sample MLY 5-7d. 25. Subtransverse section. San Andres Fm. Sample MLY 6-9. 2-3, 8, 10, 15, 20, 22, 24. *Globivalvulina novamexicana* n. sp. 2. Oblique subtransverse section. San Andres Fm. Sample MLY 3-2. 3. Transverse section. San Andres Fm. Sample MLY 3-6. 8. Subaxial section. San Andres Fm. Sample MLY 3-10. 10. Oblique subtransverse section. San Andres Fm. Sample MLY 4-4. 15. Transverse section. San Andres Fm. Sample MLY 3-7a. 20. Subtransverse section. San Andres Fm. Sample MLY 6-1. 22. Subtransverse section. San Andres Fm. Sample MLY 8-8. 24. Subtransverse section. San Andres Fm. Sample MLY 5-19. Scale bars equal 0.10 mm.

Synonyms. *Pseudoglomospira* auctorum non Bykova in Bykova and Polenova, 1955; *Glomospira* auctorum non Rzehak, 1885; *Tansillites* Nestell and Nestell, 2006.

Description. Small glomospiroid, bilocular, tubular, undivided tests. Wall porcelaneous. Aperture terminal simple.

Occurrence. Early Pennsylvanian-Late Permian, cosmopolitan.

Hemigordiellina cf. *elegans* (Lipina, 1949)
 Figures 34.11, 34.12

? 1949 *Glomospira elegans* Lipina, p. 206-207, pl. 2, figs. 11, 12, 16; pl. 7, fig. 5.

v. 2013b *Hemigordiellina* cf. *elegans* (Lipina) - Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. Short glomospire. Lateral sides of spire slightly inflated. Peripheral margin rounded to slightly angular. Whorls involute. Whorl sutures weak to moderate. Chamber walls thin. Measurements: D = 0.07-0.22 mm; whorls: 4-5; p = 0.01 mm; h = 0.01-0.03 mm; s = 0.01-0.02 mm.

Occurrence. Middle?-late? Kungurian (=late Leonardian) of New Mexico (San Andres Fm: samples MLY(2) 4-5, MLY(2) 4-8a, MLY(2) 4-10a, MLY(2) 4-12, MLY(2) 5-15, SAR 18-3, SAR 18-3a).

Hemigordiellina aff. *elegans*
 Figure 34.16

v. 2013b *Hemigordiellina* aff. *elegans* (Lipina); Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. Only one section. Test ovoid, relatively elongate. Peripheral margin rounded to slightly angular. Whorls involute, partially evolute in last whorls. Whorl sutures relatively marked for the genus. Tube wall moderately thick. Lumen bean-shaped and relatively large. Measurements: D = 0.22 mm; whorls: 4; p = 0.05 mm; h = 0.05 mm; s = 0.01 mm.

Occurrence. Late? Kungurian (latest Leonardian) of New Mexico (San Andres Fm: sample SAR 14).

Hemigordiellina? cf. *simplex* (Harlton, 1928)
 Figures 22.11, 33.1-33.14, 33.16, 33.18

? 1928 *Glomospira simplex* Harlton, p. 305, pl. 52, fig. 2a-c.

v. 2013b *Hemigordiellina?* cf. *simplex* (Harlton); Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. This taxon is characterised by a large proloculus, a thin wall, high lumina and an evolute last whorl. D = 0.14-0.43 mm; whorls: 3-4; p = 0.01-0.04 mm; h = 0.03-0.06 mm; s = 0.01 mm.

Comparison. Due to the evolute, plane last whorl, this taxon is transitional with *Hoyenella* Rettori, 1994 (if this Triassic genus possesses a porcelaneous wall, as we suppose). It differs from true *H. simplex* and from *Hemigordiellina nanzhangensis* (Zhang and Lin in Lin, 1978) n. comb. by its larger size.

Occurrence. Middle? Kungurian (late Leonardian) of New Mexico (San Andres Fm: samples MLY 3-1, MLY 3-11, MLY(2) 4-1, MLY(2) 4-2, MLY 4-8, MLY 4-11, MLY 4-12, MLY(2) 4-13, MLY 4-15, MLY 4-16, MLY 4-18, MLY 4-19, MLY 4-20, MLY 4-21, MLY(2) 5-1, MLY(2) 5-3, MLY(2) 5-4, MLY 5-5, MLY 5-12, MLY 5-15, MLY 5-16a, MLY 5-17, MLY 5-21, MLY(2) 5a-8, MLY 6-25a, MLY 8-7).

Hemigordiellina? aff. *simplex*
 Figures 20.5-20.8, 20.10, 20.11, 34.15, 34.18

v. 2013b *Hemigordiellina?* aff. *simplex* (Harlton) - Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. Whorls involute. Lateral sides of spire flat to slightly inflated. Peripheral margin rounded. Chamber walls thin. Measurements: D = 0.16 mm; h = 0.03-0.05 (rarely 0.07) mm; s = 0.01 mm.

Occurrence. Middle?-late? Kungurian (late Leonardian) of New Mexico (San Andres Fm: samples MLY(2) 4-2 and SAR 18-2).

Hemigordiellina? aff. *pseudopusilla* (Baryshnikov in Zolotova and Baryshnikov, 1980)
 Figure 33.23-33.24

? 1980 *Glomospira?* *pseudopusilla* Baryshnikov in Zolotova and Baryshnikov, p. 76-77, pl. 1, figs. 1, 2.

? 1986 *Glomospira?* *pseudopusilla* Baryshnikov; Gorsky and Kalmykova, pl. 20, fig. 19.

v. 2013b *Hemigordiellina?* aff. *pseudopusilla* (Baryshnikov in Zolotova and Baryshnikov) - Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. Whorls involute. Lateral sides inflated. Peripheral margin rounded. No umbilicus. No sutures. Chamber walls thin. Measurements: D = 0.30-0.40 mm; whorls: 5; p = 0.02-0.05 mm; h = 0.05-0.06 mm; s = 0.02-0.03 mm.

Remarks. The generic assignment of this taxon is questionable. It appears transitional between the entirely glomospiral *Hemigordiellina*, and *Hoyenella* which exhibits a second planispiral stage. Moreover, *Hoyenella* itself is a questionable genus. It was described with a porcelaneous wall, but this character is not really demonstrated; and, if it is porcelaneous, *Hoyenella* appears very similar to several porcelaneous genera: *Brunsiella* Reitlinger,

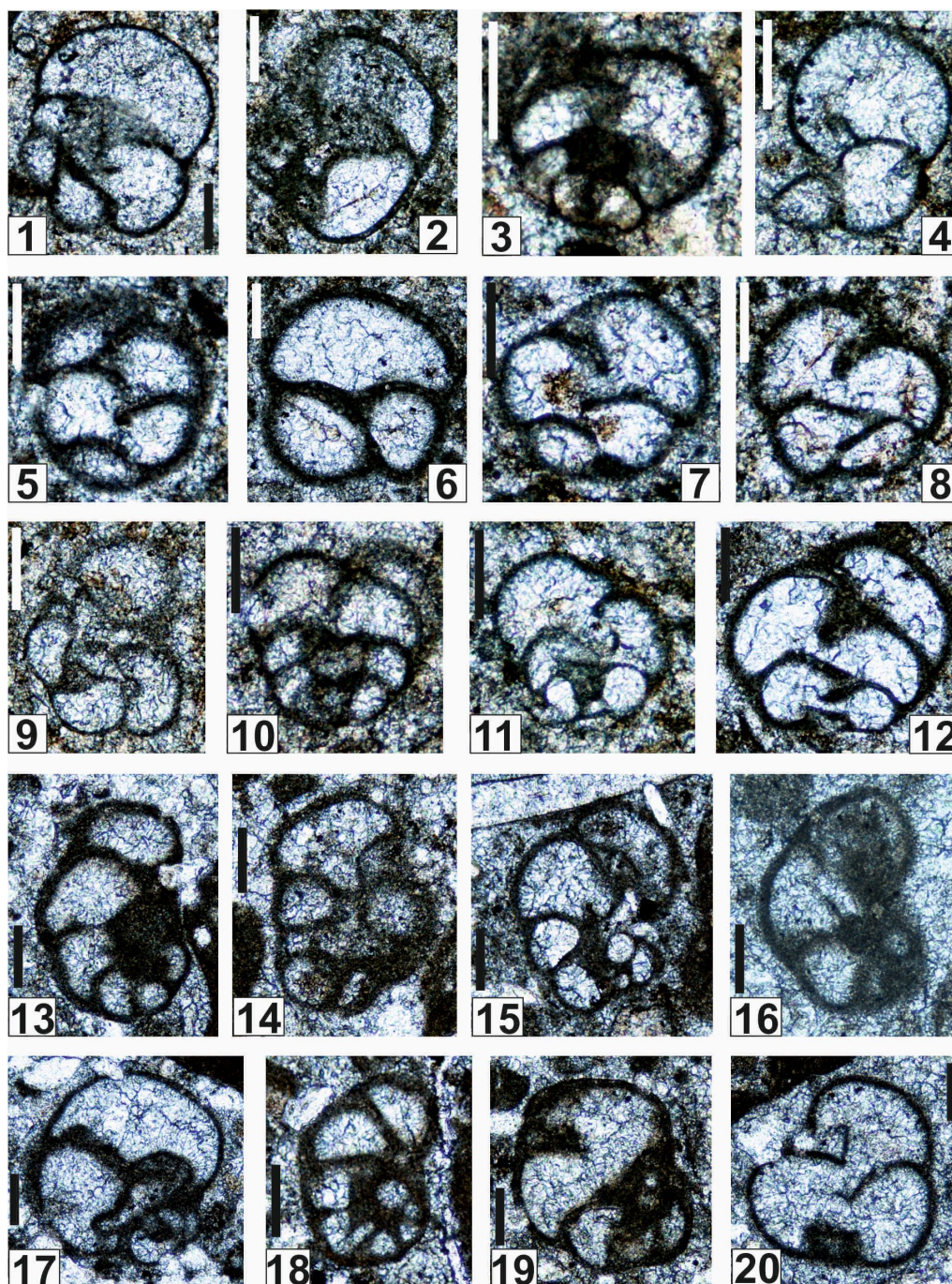


FIGURE 27. 1, 4, 9, 20. *Globivalvulina retroseptata* n. sp. 1. Subaxial section. San Andres Fm. Sample MLY 8-2a. 4. Subtransverse section. San Andres Fm. Sample MLY 5-23. 9. Subaxial section. San Andres Fm. Sample MLY 5-3. 20. Transverse section. Yeso Group. Sample MG 10-9. 2, 5-8, 12-19. *Globivalvulina novamexicana* n. sp. 2. Subtransverse section. San Andres Fm. Sample MLY 4-13. 5. Oblique subaxial section. San Andres Fm. Sample MLY 4-9. 6. Oblique section. San Andres Fm. Sample MLY4-1. 7. Axial section. San Andres Fm. Sample MLY 4-2. 8. Subaxial section. San Andres Fm. Sample MLY 4-6. 12. Axial section. San Andres Fm. Sample MLY 3-8. 13. Subtransverse section. Yeso Group. Sample MG 10-8 (already illustrated in Lucas et al., 2013b, figure 8G). 14. Subaxial section. Yeso Group. Sample MG 10-14. 15. Oblique subtransverse section. Yeso Group. Sample MG 10-17a. 16. Subtransverse section. Yeso Group. Sample MG 10-17. 17. Subaxial section. Yeso Group. Sample MG 10-7. 18. Subtransverse section. Yeso Group. Sample MG10 6. 19. Subaxial section. Yeso Group. Sample MG 10-6a. 3, 10-11. *Globivalvulina parapiciformis* n. sp. 3. Axial section. San Andres Fm. Sample MLY 6-16. 10. Axial section. San Andres. Sample MLY 5-20a. 11. Axial section. San Andres Fm. Sample MLY 5-7c. Scale bars equal 0.10 mm.

1950; some *Hemigordius* Schubert, 1908 and *Brunsiella* Vachard et al., 2005. Similarly, if its wall is dark-walled microgranular, it might be a synonym of the Fusulinata *Brunsia* Mikhailov, 1935; if agglutinated, it corresponds exactly to some taxa assigned to the agglutinated Textulariata *Glomospirella* Plummer, 1945. In fact, the type species of *Glomospirella* differs a lot from these small forms because it is a very large foraminifer, which can therefore be a synonym of *Palaeonubecularia* (= ?*Minammodytes* Henbest, 1963; = ?“*Tolypamina*” auct.), but, differs totally from the small *Brunsia*, *Brunsiella*, and *Hoyenella*.

The type species of *Glomospirella* (*Glomospira umbilicata* Cushman and Waters, 1927) is a very large taxon, with a diameter of up to 1.00 mm. Its age is Middle/Late Pennsylvanian. However, the other species described in *Glomospirella* are small to very small (because they measure generally 0.25-0.40 mm) with a second part of coiling markedly planispiral and evolute (consistent with the definition of Loeblich and Tappan, 1964, for example). *Glomospirella* sensu stricto is a particularly large genus with either: 1) a siliceously agglutinated test; or 2) a recrystallized porcelaneous test (similar to many taxa in the North American Pennsylvanian; e.g., Henbest, 1963; Vachard and Krainer, 2001a, 2001b); or, finally, 3) an agglutinated and porcelaneous test as in *Pseudospira* or *Palaeonubecularia* (and, in general, many false tolypamminid forms of the Pennsylvanian). Furthermore, *Glomospirella* sensu Loeblich and Tappan, 1964 non Plummer, 1945 has at least two homeomorphs: 1) the Fusulinata *Brunsia*; and 2) the Miliolata *Brunsiella* and some *Hemigordius* sensu lato. Another homeomorph is *Hoyenella* sensu stricto (i.e., the Triassic representatives of “*Glomospirella*” of the authors), the range of which has been extended to the Permian by Gaillot and Vachard (2007). The Permian glomospirellids evidently have a porcelaneous wall, whereas the true microstructure of Triassic *Hoyenella* is not well established (porcelaneous, calcitic microgranular, aragonitic microgranular, or an uncharacteristic and unknown wall?).

Gu et al. (2007) used *Glomospirella* with a question mark, but did not explain why. Moreover, they compared for example *G.?* *mamilla* Gu, Feng and He, 2005 (*G.?*: with a question mark) to *G. robusta* Scherp, 1962 (*G.*: without a question mark); whereas *G.?* *curva* Gu, Feng and He, 2005 is probably a *Postcladella* Krainer and Vachard, 2011.

Groves and Boardman (1999, p. 249) admitted a perfect homeomorphy of *Brunsiella* and *Brunsia*, as well as the same wall microstructure (i.e., dark-microgranular). Therefore, they require two successive derivations from the common ancestor *Pseudoammodiscus*; i.e., the first one in the Early-Middle Mississippian (for *Brunsia*), and the second one in the Middle Pennsylvanian-Early Permian (for *Brunsiella*). A lineage *Pseudoammodiscus-Brunsiella-Hemigordius* is also suggested by Groves and Boardman (1999). With such reasoning, *Hoyenella* will be a third derivation, in the Triassic. Similarly, we can admit a lot of derivations from “*Pseudoammodiscus*” auctorum and/or “*Pseudoglomospira*” auctorum, giving all the successive forms of the Lower Palaeozoic (previously called “*Ammodiscus*”, “*Cornuspira*”, “*Rectocornuspira*”, and now *Pseudoammodiscus*, *Pseudospira*, *Postcladella*, etc.). As indicated by Tappan and Loeblich (1988), *Pseudoammodiscus* might give rise to all the Triassic order Involutinida, and subsequently all the modern Miliolata. Finally, the descendants of *Pseudoammodiscus* may appear too prolific and too diverse.

An alternative hypothesis was presented by Vachard et al. (2005), Gaillot and Vachard (2007) and Vachard et al. (2010), based on the particular aspect and exceptional preservation of the porcelaneous wall; i.e., amber-colored or tan-skin. This aspect is relatively common among the well-preserved *Hemigordius* (for example in the Early Permian microfacies from Iran illustrated by Alipour et al., 2013). We admit that *Brunsiella* is also porcelaneous and constitutes the ancestor of *Hemigordius*. The first specimens with a porcelaneous test are more difficult to characterise. Vachard et al. (2010) suggested that the first ones belong to the calcivertellids (e.g., *Calcivertella*, *Ammovevertella*), and cornuspirids (either planispiral evolute: *Cornuspira*; or streptospiral: *Hemigordielina* sensu Vachard and Beckary, 1991).

The status of *Warnantella* Conil and Lys in Conil et al., 1977, whose FAD is poorly known, is uncertain and it corresponds either to a Miliolata or a Fusulinata (for example, to “*Pseudoglomospira*” sensu lato, according to Reitlinger in Vdovenko et al., 1993, p. 55, plate 10, figures 8, 9). Apparently, all authors admit the porcelaneous nature of the calcivertellid wall (Loeblich and Tappan, 1964, 1987; Gaillot and Vachard, 2007; Vachard et al., 2010); nevertheless, Pronina (1994, figure 1, p. 22) proposed a phylogenetic tree, where calcivertellids are related to pseudoammodiscids as well as *Hemigordius* and *Hemigordiopsis* Reichel, 1945

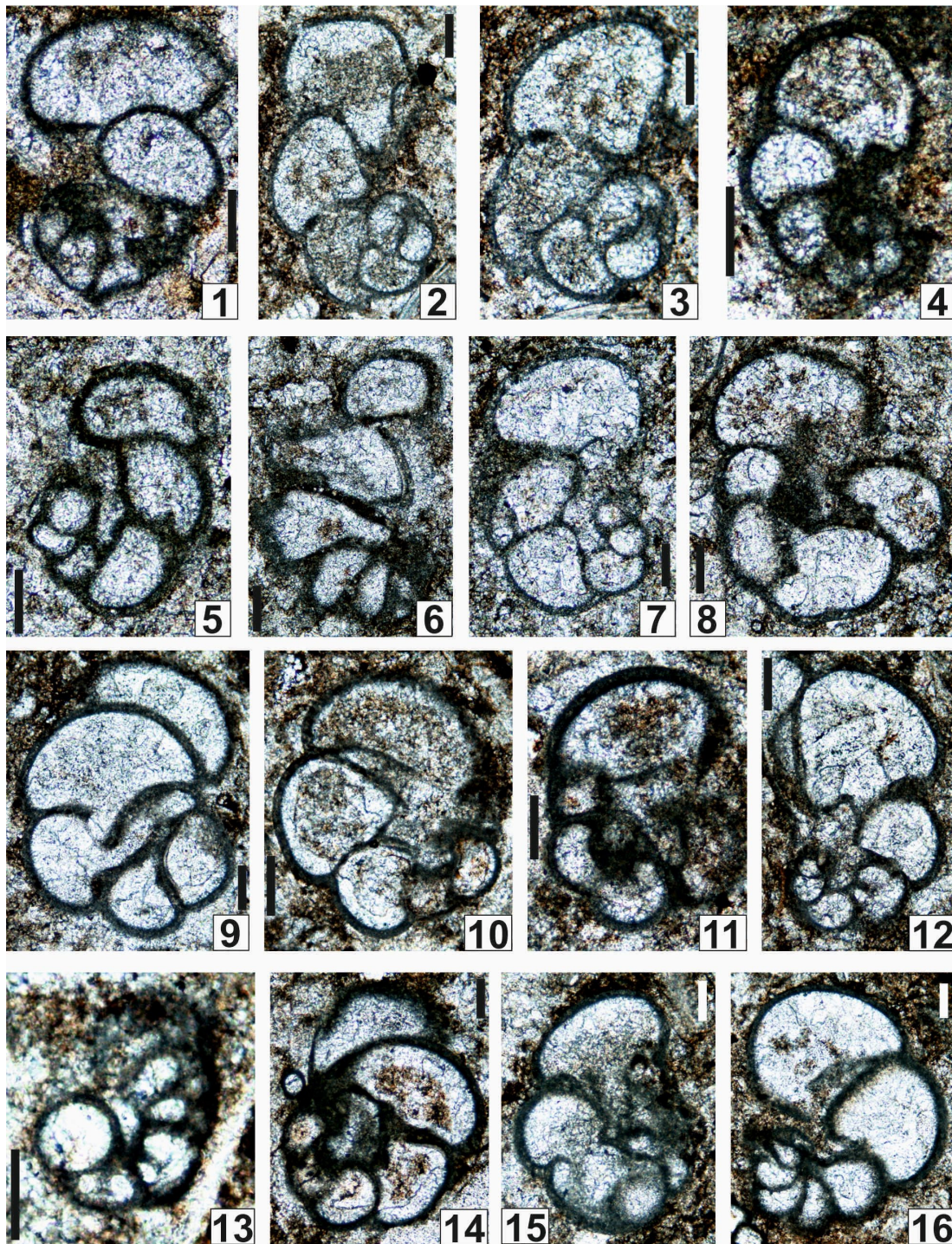


FIGURE 28. 1-3, 7. *Globivalvulina retroseptata* n. sp. 1. Transverse section. San Andres Fm. Sample SAR 13-5. 2. Transverse section. San Andres Fm. Sample SAR 13-5b. 3. Transverse section. San Andres Fm. Sample SAR 13-5c. 7. Transverse section. San Andres Fm. Sample SAR 8-5. 4-6, 8-12, 14-16. *Globivalvulina praegraeca* n. sp. 4. Transverse section. San Andres Fm. Sample SAR 13-7. 5. Transverse section. San Andres Fm. Sample SAR 8-2. 6. Subtransverse section. San Andres Fm. Sample SAR 8-3. 8. Subaxial section. San Andres Fm. Sample SAR 8-7a. 9. Subaxial section. San Andres Fm. Sample SAR 8a-2. 10. Subaxial section. San Andres Fm. Sample SAR 8a-5. 11. Axial section. San Andres Fm. Sample SAR 8a-5a. 12. Transverse section. San Andres Fm. Sample SAR 8a-18. 14. Subtransverse section. San Andres Fm. Sample SAR 8a-9. 15. Oblique subtransverse section. San Andres Fm. Sample SAR 8a-10. 16. Subtransverse section. San Andres Fm. Sample SAR 8a-12. 13. *Globivalvulina parapicipiformis* n. sp. Transverse section. San Andres Fm. Sample SAR 8a-8a. Scale bars equal 0.10 mm.

(two genera for which a porcelaneous wall is also unanimously admitted). Inversely, if we admit the repetitive derivations from *Pseudoammodiscus*, the same reasoning leads to thinking that the derivations previously occurred in the Lower Palaeozoic, from the *Ammodiscus* of the literature. Consequently, in terms of wall microstructure, these primitive homeomorphs are not Fusulinata, but are Textulariata. Inversely, the Lower Palaeozoic forms are already Fusulinata, so, all the first forms of foraminifers are recrystallized Fusulinata and not Textulariata. Consequently, the megaevolution of the foraminifers during the Palaeozoic remains poorly known, but the schemes of Tappan and Loeblich (1988) or Pronina (1994) cannot be applied, either because there are misinterpretations of the Palaeozoic genera, or because of the lack of knowledge of the wall microstructures, respectively.

Occurrence. Early?-middle? Kungurian (late Leonardian) of New Mexico (Yeso Group: sample MG(2) 10-2. San Andres Fm: samples MLY 5-24, MLY 5-25, MLY(2) 5-10).

Genus PSEUDOSPIRA Reitlinger in Vdovenko, Rauzer-Chernousova. Reitlinger and Sabirov, 1993 nom. transl. herein

Type Species. *Glomospira mikhailovi* Reitlinger, 1950.

Description. Test attached, tubular, bilocular, undivided, with a coiling initially glomospiral and then elongated on the substrate, and serpentiform or oscillating. Wall porcelaneous mixed with a calcareous agglutinate.

Remarks. Some extant and fossil Miliolata exhibit a porcelaneous wall mixed with a siliceous agglutinate (*Agglutinella* El-Nakhal, 1983 and other Siphonapertinae Saidova, 1975; see Loeblich and Tappan, 1987; Tappan and Loeblich, 1988). Based on this microstructural similarity, *Pseudospira* is interpreted here as a Miliolata.

Pseudospira was introduced as a subgenus of *Pseudolituotuba* Vdovenko, 1971; however, the former has a porcelaneous agglutinated wall, whereas the latter has a microgranular agglutinated wall; consequently, they belong to two different classes, Miliolata and Fusulinata, respectively.

Pseudospira differs from *Hemigordiellina* by the attached habitat, terminal uncoiling and wall microstructure. From the other calcivertellids (and especially *Palaeonubecularia*), it differs in its agglutinated porcelaneous wall. From *Tolypamina* Rhumbler, 1895, it differs in a calcareous and not siliceous agglutinate; however, like the type

species, many false Palaeozoic "*Tolypamina*" might belong to *Palaeonubecularia*, *Pseudospira*, *Quasilituotuba* Brazhnikova in Aizenverg et al., 1983, or *Baryshnikovia* Reitlinger in Vdovenko et al., 1993.

Occurrence. Middle Pennsylvanian-Early Permian, Donbass, Uzbekistan, New Mexico.

Pseudospira aff. *ishimbaica* (Lipina, 1949)
Figures 22.9, 33.15, 33.21, 34.9

? 1949 *Glomospira ishimbaica* Lipina, p. 207-208, pl. 2, figs. 14, 15.

? 1980 *Pseudoglomospira ishimbaica* (Lipina); Rich, p. 45 (no illustration).

v. 2003 "*Glomospira*" or young *Palaeonubecularia* sp.; Krainer, Vachard and Lucas, pl. 3, fig. 22.

v. 2013b *Pseudospira* aff. *ishimbaica* (Lipina); Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. Large glomospiroid part followed by an uncoiled or serpentiform tubular last part. Whorls: 3-4; involute, partially evolute in some specimens. Peripheral margin rounded. Wall porcelaneous including a calcareous agglutinate. D = 0.20-0.55 mm; h = 0.04-0.15 mm; s = 0.01-0.04 mm.

Occurrence. Asselian (Nealian) of New Mexico (Krainer et al., 2003); middle? Kungurian (late Leonardian) of New Mexico (San Andres Fm: samples MLY 5-17, MLY 6-22, MLY 6-23).

Superfamily ?CORNUSPIROIDEA Schulze 1854
nom. transl. Mikhalevich, 1988

Family ?CORNUSPIRIDAE Schultze, 1854
Genus OLGAORLOVELLA n. gen.

zoobank.org/53210326-7BDC-4903-9232-C36ECA757A6D

Etymology. Dedicated to Dr Olga Orlov-Labkovsky, Tel-Aviv University, for her contributions to Carboniferous and Permian biostratigraphy.

Synonyms. *Pseudoagathammina* (part.); *Glomospira* (part.).

Type Species. *Olgaorlovella davydovi*, n. gen. n. sp.

Diagnosis. Rounded to ovoid test, moderately large in diameter, with relatively numerous volutions. No pseudosepta. Proloculus spherical with flexostyle canal. Wall particularly thin and often recrystallized (light gray to whitish color).

Composition. *Olgaorlovella davydovi* n. gen. n. sp.; *Glomospira regularis* Lipina, 1949 (sensu stricto); *G. regularis* sensu Wang, 1982 (plate 4, figure 24; another species); *G. regularis* sensu

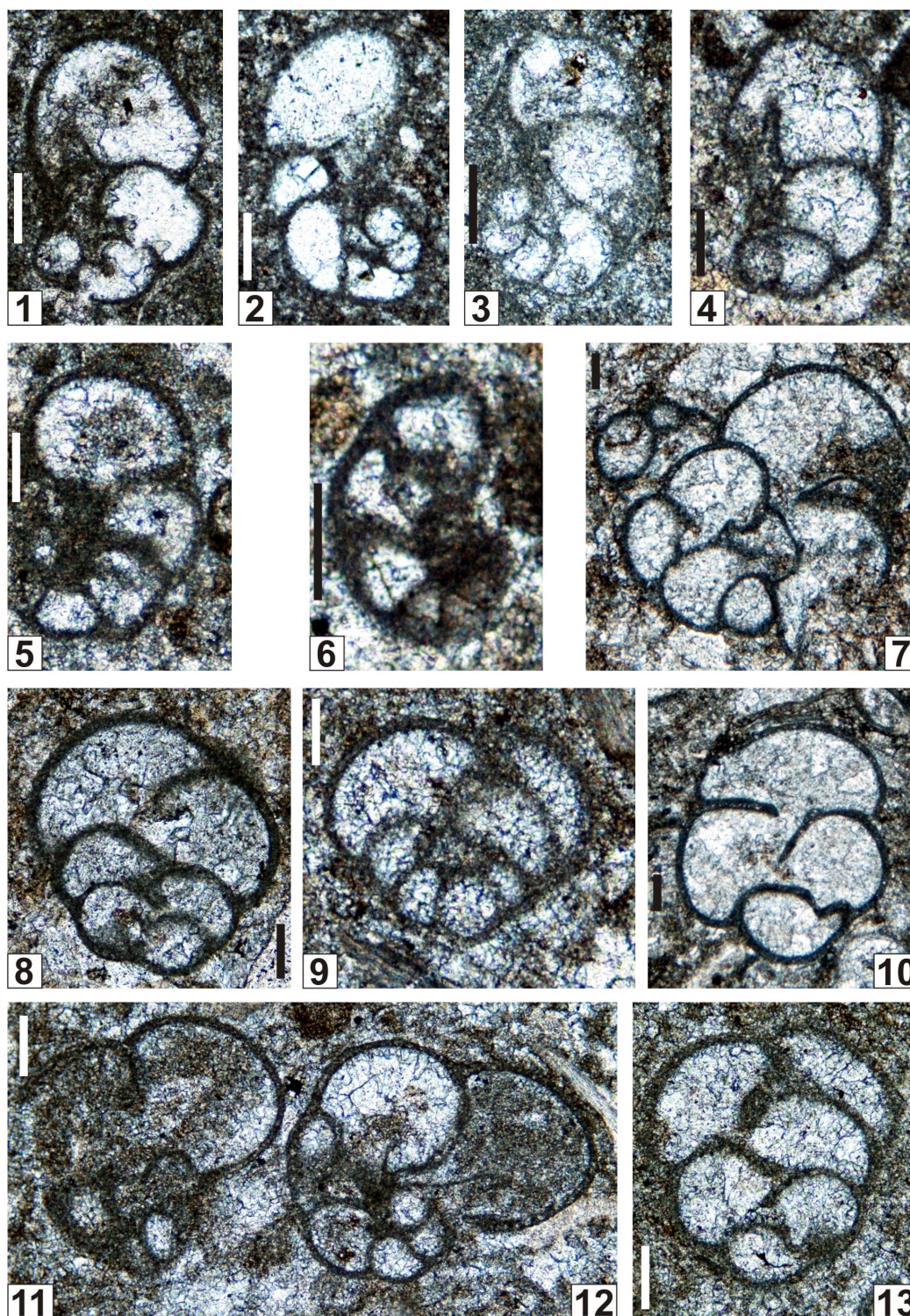


FIGURE 29. 1-4, 7. *Globivalvulina retroseptata* n. sp. 1. Transverse section. San Andres Fm. Sample SAR 19-2. 2. Transverse section. San Andres Fm. Sample SAR 19-3. 3. Transverse section. San Andres Fm. Sample SAR 19-4. 4. Subtransverse section with developed oral valvula. San Andres Fm. Sample SAR 20-1. 7. Teratogenic specimen. San Andres Fm. Sample SAR 3-1. 5, 8, 10-13. *Globivalvulina praegraeca* n. sp. 5. Transverse section. San Andres Fm. Sample SAR 20-3. 8. Axial section. San Andres Fm. Sample SAR 3-4. 10. Subaxial section. San Andres Fm. Sample SAR 8-1. 11-12. Two transverse sections. San Andres Fm. Sample SAR 7-4. 13. Subaxial section. San Andres Fm. Sample SAR 7-5. 6, 9. *Globivalvulina novamexicana* n. sp. 6. Subtransverse section. San Andres Fm. Sample SAR 20-4. 9. Axial section. San Andres Fm. Sample SAR 7-3. Scale bars equal 0.10 mm.

Vachard and Krainer, 2001b (plate 4, figures 16, 17, 19 (only); a third different species); *Pseudoagathammina regularis* sensu Filimonova, 2008 (plate 2, figure 21; a fourth species); *G. dublicata* Lipina, 1949 non Reitlinger, 1950; non Filimonova, 2008 = ?*O. davydovi*, see below; nec 2010 = another species; *G. dublicata turajevica* Baryshnikov in Baryshnikov et al., 1982; *G. tenuifistula* sensu Lin et al., 1990 (plate 2, figures 1, 2, 3); *Pseudoagathammina orbicularia* Lin, Li and Sun, 1990 (plate 27, figures 2, 3, 4, 5?, 6?); *P. retroseptata* sensu Filimonova, 2008 (plate 2, figure 23) and 2010 (plate 2, figure 10); *Streblospira australae* sensu Mamet (1996, plate 1, figure 35).

Remarks. *Olgaorlovella* n. gen. differs from the Permian (and Triassic?) "*Glomospira*" and *Pseudoospira* by the type of wall, larger size, the proportionally very thin wall that is often recrystallized, and the flexostyle canal of the proloculus. *Olgaorlovella* n. gen. differs from *Pseudoagathammina* sensu stricto by the more regular coiling and the absence of agathamminid stage; nevertheless, some *Pseudoagathammina* described by Lin et al. (1990) and Filimonova (2010) probably correspond to our new genus.

The flexostyle canal of the proloculus of *Olgaorlovella davydovi* n. gen. n. sp. is conspicuous in Figure 24.3. Similarly, the holotype of *Olgaorlovella regularis* (Lipina) n. comb. and a specimen of Vachard and Krainer (2001b, plate 14, figure 17) show a flexostyle canal.

Occurrence. Early Permian of Bashkortostan (Russia), South China and the Carnic Alps. Artinskian of South America (Yaurichambi, Bolivia). Late? Kungurian (latest Leonardian) of New Mexico. Bolorian (late Kungurian) of Darvaz (Tajikistan) and Armenia. Lazarus effect or parallel evolution with the group *Glomospira tenuifistula* Ho, 1959 during the Triassic.

Olgaorlovella davydovi n. gen. n. sp.

Figures 12.7, 24.1-24.4, 24.7, 24. 10, 35.1-35.5, 35. 8, 36.13

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? 2008 *Pseudoagathammina dublicata* (Lipina); Filimonova, pl. 2, fig. 19.

? 2010 *Pseudoagathammina regularis*; Filimonova, pl. 2, fig. 21.

v. 2013 *Orthovertellopsis*; Brose, Lucas and Krainer, fig. 6.12.

v. 2013b *Neodiscus?* sp. 2; Vachard, Krainer and Lucas, p. 348 (no illustration).

Etymology. For Dr. V. Davydov, Boise State University, to honor his knowledge of the International Code of Zoological Nomenclature.

Holotype. NMMNH P67954; Figure 24.10; sample SAR 11-2.

Paratypes. NMMNH P-67595-67599; Figure 24.1-4, 24.6-7.

Material. 45 specimens.

Locus Typicus. NMMNH locality 8903; San Andres Formation reference section in the San Andres Mountains near Rhodes Canyon (New Mexico).

Stratum Typicum. Late? Kungurian (latest Leonardian).

Diagnosis. Ovoid to subspherical test with a coiling transitional from streptospiral to oscillating to planispiral.

Description. Ovoid to subspherical test. Umbilicus absent. Sutures absent. Whorls involute. Lateral sides strongly inflated. Peripheral margin rounded. $D = (0.35-0.400)-0.43-0.58$ mm; $w = 0.25-0.46$ mm; $w/D = 0.60-0.87 (0.95)$; whorls: (rarely 3.5)-4-6; $p = (0.06)-0.08-0.09$ mm; $h = (0.05-0.06)-0.07-0.11$ mm; $s = 0.001$ mm.

Comparisons. *O. davydovi* differs from *O. regularis* by the more ovoid test, higher lumen and more whorls. A related taxon might be *Agathammina* sp. sensu Flügel et al. (1984, plate 32, figure 7; plate 34, figures 1, 2, 3). It is similarly morphologically transitional between *Glomomidiella* and *Praeneodiscus* and/or *Neodiscus*, but devoid of a relationship with true *Agathammina*, as well as late Midian (latest Middle Permian) in age.

Occurrence. Late? Kungurian (latest Leonardian) of New Mexico (San Andres Formation, reference section: samples SAR 8a-27, SAR(2) 11-1, SAR 11-2, SAR 11-3, SAR(2) 11-3, SAR(2) 11-3a, SAR(2) 11-4, SAR(2) 11-5, SAR 11-6, SAR 11-6b, SAR(2) 11-7, SAR(2) 11-8, SAR 11-9, SAR 11-10, SAR 11-11, SAR 11-12, SAR(2) 11-13, SAR(2) 11-14, SAR(2) 11-15, SAR(2) 11-16, SAR(2) 11-7, SAR 11-18, SAR 11a-2, SAR 11a-3, SAR 11a-7, SAR 11a-8, SAR 11a-11, SAR 11a-14, SAR 11a-15, SAR 13-4).

Family HEMIGORDIIDAE Reitlinger in Vdovenko, Rauzer-Chernousova, Reitlinger and Sabirov, 1993
Genus HEMIGORDIUS Schubert, 1908

Type Species. *Cornuspira schumbergeri* Howchin, 1895.

Description. Test free. Proloculus followed by a tubular, undivided chamber. Coiling initially streptospiral, more or less protuberant in the central part of the test, followed by a discoid planispiral involute part to occasionally semi-evolute or evolute in the

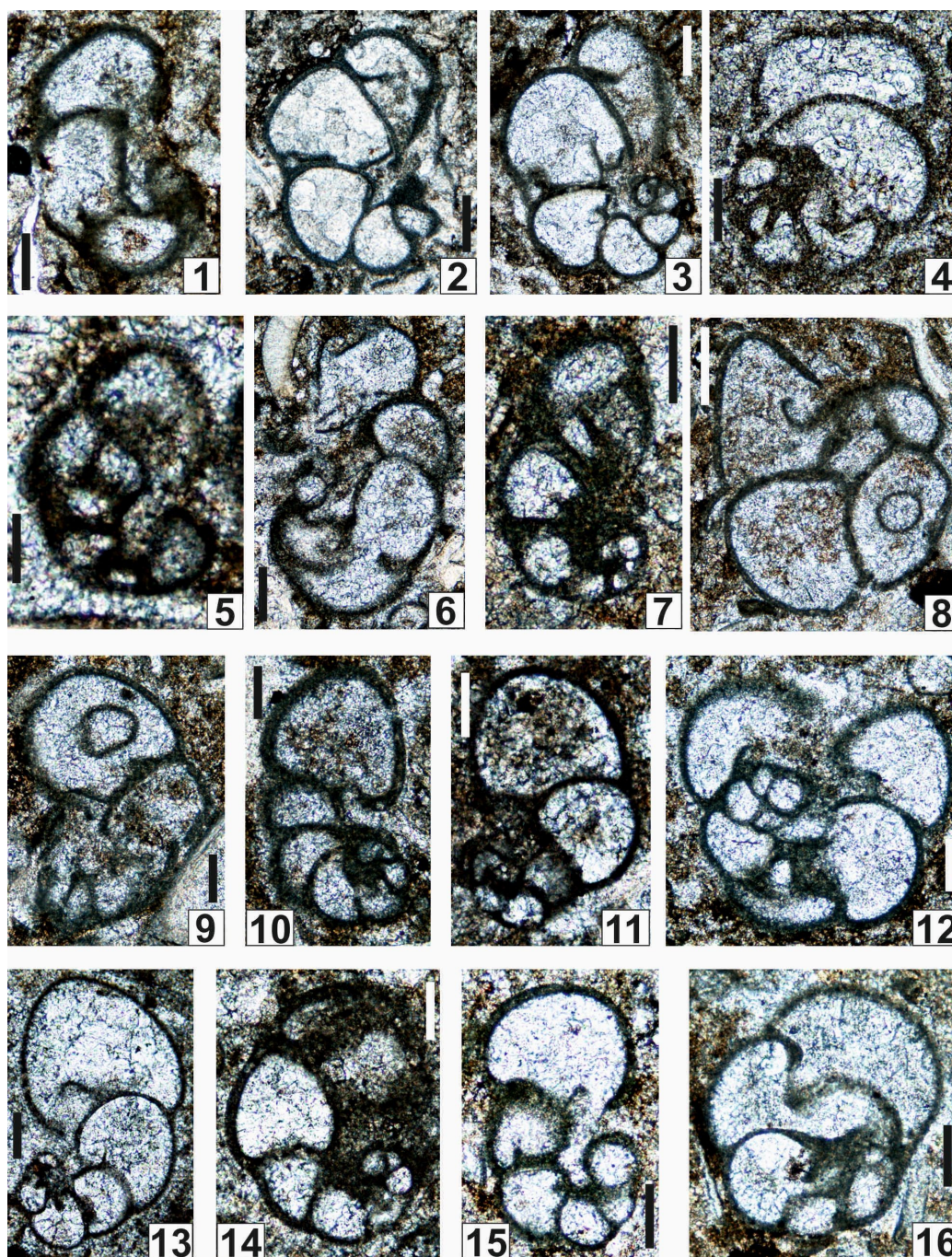


FIGURE 30. 1, 4-6, 8-10, 12, 14-15. *Globivalvulina praegraeca* n. sp. 1. Subtransverse section. San Andres Fm. Sample SAR 8a-13a. 4. Transverse section. San Andres Fm. Sample SAR 9-1. 6. Transverse section. San Andres Fm. Sample SAR 13-10. 8. Subaxial section. San Andres Fm. Sample SAR(2) 13-2. 9. Subtransverse section. San Andres Fm. Sample SAR(2) 13-6. 10. Transverse section. San Andres Fm. SAR 13-9. 12. Axial section showing the proloculus and the first whorl. San Andres Fm. Sample SAR(2) 8-21. 14. Transverse section. San Andres Fm. Sample MLY(2) 4-9. 15. Transverse section. San Andres Fm. Sample SAR 8-18. 2-3, 11, 13, 16. *Globivalvulina retroseptata* n. sp. 2. Subtransverse section. San Andres Fm. Sample SAR 8a-19. 3. Transverse section. San Andres Fm. Sample SAR 8a-24. 11. Transverse section. San Andres Fm. Sample SAR 13a-7. 13. Transverse section. San Andres Fm. Sample MLY(2) 6-13 (already illustrated by Brose et al., 2013, figure 6.7). 16. Axial section. San Andres Fm. Sample SAR(2) 12-6. 5. *Globivalvulina parapiciformis* n. sp. Subtransverse section. San Andres Fm. Sample SAR 13-9. 7. *Globivalvulina novamexicana* n. sp. Transverse section. San Andres Fm. Sample SAR 13-12. Scale bars equal 0.10 mm.

last whorl. Lumen at the concavus stage. Wall porcelaneous, generally recrystallized as a dark microgranular one. Aperture at the end of the tubular chamber.

Remarks. There are probably five lineages of *Hemigordius* sensu lato. The first one has its FAD in North America (Groves, 1984) with *H. harltoni* Cushman and Waters, 1928a and then migrates at the end of the Moscovian into the Urals and Tethys with *H. discoideus* (Brazhnikova and Potievskaya, 1948) and *H. simplex* (Reitlinger, 1950). These primitive forms gave rise to the type species of the genus, *H. schlumbergeri* (Howchin, 1895), which is Late Pennsylvanian-Early Permian in age. This species generated a plexus of hemigordiids with an important marker *Rectogordius* Alipour and Vachard in Alipour et al., 2013 (= false *Neohemigordius* of the authors). Then, another lineage started with *H. schlumbergeri* sensu Foster et al. (1985; to rename) where the chamber lumina became concavus-angulatus to angulatus in shape (see below for the discussion of these terms); this latter taxon generated various Neodiscidae Lin, 1984 nom. transl. Gaillot and Vachard, 2007, especially in this study *Glomomidiella* and *Prae-neodiscus* n. gen. (or *Uralogordius* in the Urals).

The fifth lineage during the Middle Permian is more poorly known, but it displays diversified small forms showing: 1) a long, semi-evolute to evolute secondary stage (*Okimuraites* Reitlinger in Vdovenko et al., 1993 = *Discospirella* Okimura and Ishii, 1981 homonym of *Discospirella* Loeblich and Tappan, 1961 = ?*Brunsispirella*, according to Nestell et al., 2009); 2) entirely planispiral forms (*Arenovidalina* sensu Sosnina, 1977 (non? Ho, 1959); see also some unnamed taxa in Berczi-Makk et al., 1995 from the Wuchiapingian of Hungary); 3) sigmoidal to planispiral rhombic forms (*Midiella* Pronina, 1988 sensu stricto not auctorum); or 4) distally irregularly coiled forms (*Pseudohemigordius* Nestell and Nestell, 2006). Various forms with pseudosepta are probably related to these different lineages but difficult to link with them: *Septagordius* Gaillot and Vachard, 2007; *Nikitinella* Sosnina, 1983; *Pseudomidiella* Pronina-Nestell in Pronina-Nestell and Nestell, 2001, and several atypical *Baisalina* (non Reitlinger, 1965).

Occurrence. Bashkirian of North America. Cosmopolitan from late Moscovian to latest Permian.

Hemigordius aff. *saranensis* Baryshnikov in Baryshnikov, Zolotova and Kosheleva, 1982
Figure 34.1-34.5

? 1982 *Hemigordius saranensis* Baryshnikov in Baryshnikov, Zolotova and Kosheleva, p. 24-25, pl. 7, fig. 13.

v. 2013b *Hemigordius* aff. *saranensis* Baryshnikov in Baryshnikov, Zolotova and Kosheleva; Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. Short glomospiroid initial stage followed by a proportionally long planispiral part. Proloculus spherical, relatively large. Lumina slit-shaped or low-crescentic. Wall surface smooth. No umbilici. Whorls involute, partially evolute in some specimens. Lateral sides of spire flat. Peripheral margin rounded. Wall black porcelaneous or often whitish neosparitized. D = 0.15-0.30 mm; w = 0.05-0.07 mm; w/D = 0.21-0.28; whorls: 5-6; p = 0.01-0.02-(0.04) mm; h = 0.02-0.04 mm; s = 0.01 mm.

Remark. The observed taxon differs from true *H. saranensis* by the smaller proloculus and the smaller dimensions for the same number of whorls.

Occurrence. Early Kungurian of Preurals (Russia). Late? Kungurian (latest Leonardian) of New Mexico (San Andres Fm: samples SAR 11-5a, SAR 11a-12, SAR 11a-12a, SAR(2) 12-11, SAR 13-5a, SAR 13-5d, SAR 13-8, SAR 13-11, SAR 20-5).

Hemigordius? sp.
Figure 32.7-32.10

Description. Umbilicus comprises all whorls. Sutures absent. Whorls evolute, partially involute in some specimens. Lateral sides flat to slightly inflated. Peripheral margin round to slightly angular. Chamber walls thin. Measurements: D = 0.55 mm; w = 0.15 mm; whorls: 4; p = 0.05 mm; h = 0.07 mm; s = 0.01 mm.

Occurrence. Kungurian (late Leonardian) of New Mexico.

Family ?NEODISCIDAE Lin, 1984 nom. transl.
Gaillot and Vachard, 2007
Genus GLOMOMIDIELLA Vachard, Rettori,
Angiolini and Checconi, 2008

Type Species. *Glomomidiella nestellorum* Vachard, Rettori, Angiolini and Checconi, 2008.

Description. Test ovoid, circular or triangular, bilocular, undivided. The coiling is almost entirely streptospiral, but becomes planispiral and perhaps a little uncoiled at the end of the tube growth. Sutures weakly marked. Tubular chamber initially undivided, but rapidly showing some pseudosepta.

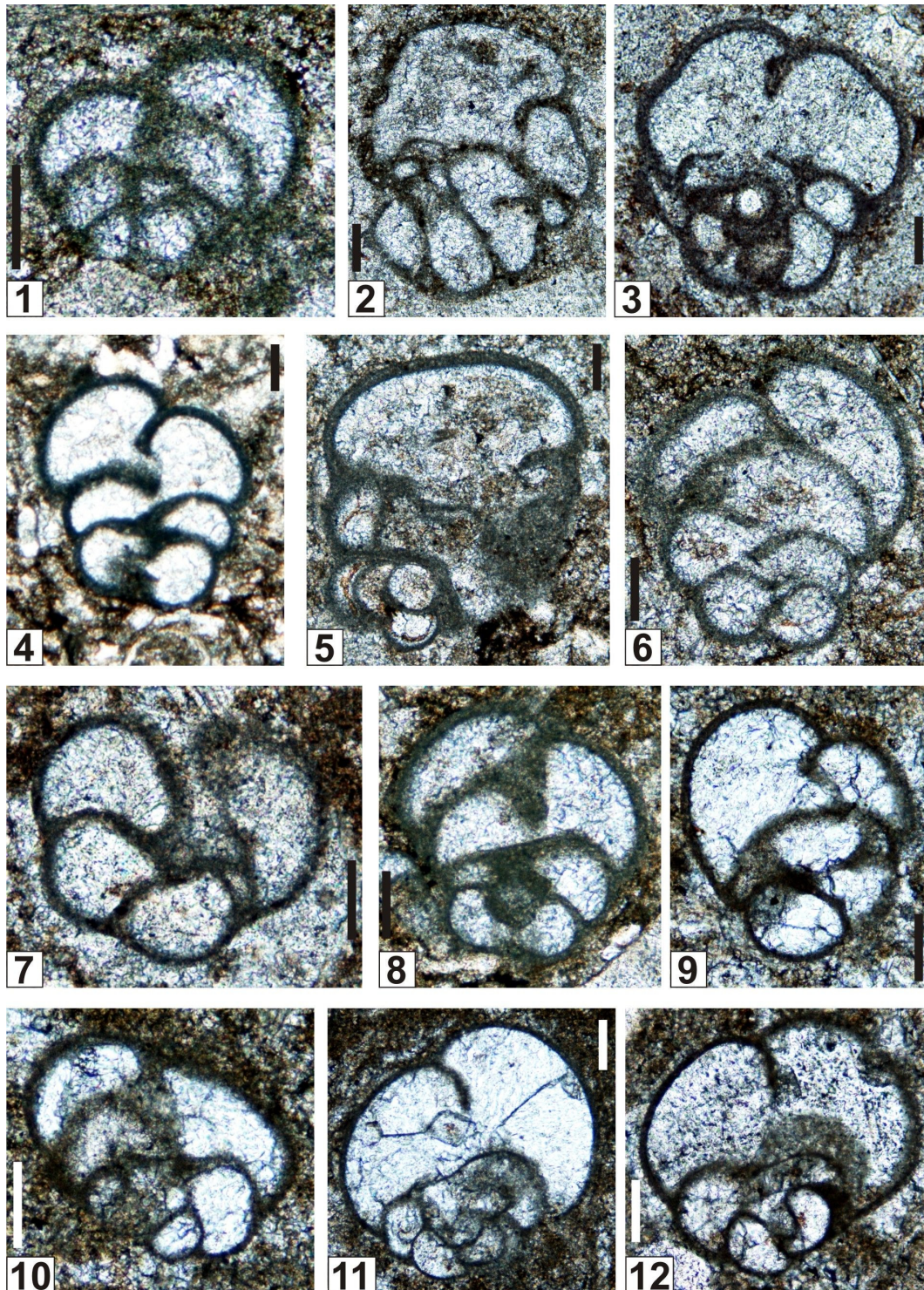


FIGURE 31. 1. *Globivalvulina novamexicana* n. sp. Axial section. San Andres Fm. Sample SAR 8-4. 2-8. *Globivalvulina praegraeca* n. sp. 2. Subtransverse section. San Andres Fm. Sample SAR 8-6. 3. Axial section. San Andres Fm. Sample SAR 8-7. 4. Subaxial section. San Andres Fm. Sample SAR 8a-10a. 5. Paratype. Oblique section. San Andres Fm. Sample SAR 8a-20. 6. Subaxial section. San Andres Fm. Sample SAR 8a-21. 7. Subaxial section. San Andres Fm. Sample SAR 12-2. 8. Subaxial section. San Andres Fm. Sample SAR 13-1. 9-12. *Globivalvulina retroseptata* n. sp. 9. Oblique subaxial section. San Andres Fm. Sample SAR 13a-7. 10. Subaxial section. San Andres Fm. Sample SAR 13a-1. 11. Oblique subaxial section. San Andres Fm. Sample SAR 13a-8. 12. Axial section. San Andres Fm. Sample SAR 13a-9. Scale bars equal 0.10 mm.

Lumina crescentic to semicircular. Wall porcellaneous, often neosparitized. Aperture terminal.

Composition. See Vachard et al. (2008, p. 354) and add: *Agathammina pusilla* sensu Berczi-Makk, 1978 (plate 1, figure 1); *Archaediscus* cf. *milliolides* (sic) sensu Berczi-Makk, 1978 (plate 3, figure. 4); *A. milliolides* (sic) sensu Berczi-Makk, 1978 (plate 3, figure 5); *Orthovertella* sp. sensu Wang, 1982 (plate 4, figure 2); *Baisalina* sp. of *B. pulchra* group sensu Okimura et al. (1985, plate 1, figure 9); *Glomospira compressiformis* Igonin, 1998; *Hemigordius* sp. sensu Panzanelli-Fratoni et al. (1987, plate 9, figure 18; only); *Neodiscus grandis* Lin, Li and Sun, 1990; *Glomospira ishimbaica* sensu Lin, Li and Sun, 1990 (part.: plate 1, figure 28 only); *Hemigordius* sp. sensu Kobayashi, 1997 (plate 4, figures 20, 21, 22, 23, 24); ?*Agathammina* sp. B sensu Kobayashi, 2001 (plate 2, figures 7, 8, 9); *Neodiscus* sp. A sensu Kobayashi, 2004 (figure 7.24-33); *Hemigordius guangdongensis* Gu, Feng and He, 2005 (plate 1, figure 8); *Neodiscus* aff. *qinglongensis* sensu Vachard et al. (2005, plate 5, figures 3, 7, 8, 9, 10); *Hemigordiscus baoqingensis* sensu Vachard et al. (2005, plate 5, figures 4, 5, 6, 11); *Baisalina miscella* Nestell and Nestell in Nestell et al. (2006, plate 1, figures 35-38, plate 2, figures 1, 2, 3, 4, 5, 6); *B. americana* Nestell and Nestell, 2006 (plate 2, figures 28, 29, 30, 31, 32, 33, 34, 35, 36); *Neodiscopsis ambiguus* Gaillot and Vachard, 2007; *Hemigordius* sp. B sensu Kobayashi, 2007 (figure 3.18-19); *Glomospira darvasica* Filimonova, 2008 (plate 2, figure 24); *Glomomidiella nestellorum* sensu Song et al. (2009, figure 8.33-34 = another species); *Glomospira* ex gr. *aquilonaris* sensu Filimonova, 2010 (plate 2, figure 20) non Konovalova, 1962; *Glomomidiella* sp. sensu Song et al. (2011, figure 6.46); *Glomomidiella* sp. A sensu Kobayashi, 2012 (figures 7.10-13, 7.16-17, 9.1-8); G. sp. A sensu Kobayashi, 2012 (figure 7.18-19).

Comparison. *Glomomidiella* differs from *Neodiscopsis* Gaillot and Vachard, 2007 by a spherical test, streptospiral coiling and less developed pseudo-septa. *Neodiscopsis* sensu stricto; i.e., as typified by *Hemigordius specialis* Lin, Li and Sun, 1990, is probably a junior synonym of *Pseudomidiella* Pronina-Nestell in Pronina-Nestell and Nestell, 2001 and/or *Baisalina* Reitlinger, 1965. However, *Neodiscopsis ambiguus* differs from this group and is probably more closely related to *Glomomidiella* ex gr. *infrapermica* n. sp.

Occurrence. Artinskian-Changhsinghian, Tethys and Ural Ocean carbonate platforms.

Glomomidiella infrapermica n. sp.

Figures 22.1, 22.3, 23.1, 23.3, 23.7, 23.8, 35.9, 35.11, 35.14, 36.1-36.12, 36.16

zoobank.org/D88B37EB-ED93-4EAA-899C-6C338B784706

? 1982 *Orthovertella* sp.; Wang, p. 19, pl. 4, fig. 2.

v. 2013b *Orthovertellopsis*; Lucas, Krainer and Voigt, fig. 8l.

v. 2013b *Orthovertella?* sp. 1 (partim); Vachard, Krainer and Lucas, p. 348 (no illustration).

Etymology. Latin *infrapermicus*, from the Lower Permian strata.

Holotype. NMMNH P-67600; Figure 22.1; sample MG 10-22.

Paratypes. NMMNH P-67601-67605; Figures 22.3, 23.1, 23.3, 23.7-8.

Material. 35 specimens.

Locus Typicus. NMMNH locality 8904; Yeso Group, Los Vallos Formation, Torres Member, Massacre Gap in the southern Fra Cristobal Mountains (New Mexico).

Stratum Typicum. Early? Kungurian (late Leonardian).

Diagnosis. Large *Glomomidiella* with weak pseudosepta, numerous whorls and last whorls semi-evolute to evolute.

Description. Test ovoid to circular or triangular ($D =$ (rarely 0.24)-0.35-0.69 mm). The spherical proloculus is proportionally very large (up to 0.09 mm). The coiling is almost entirely streptospiral, but becomes planispiral and perhaps a little uncoiled at the end of the tube growth. There are (rarely 3.5)-4-5 involute whorls. Sutures weakly marked between the different whorls of coiling. Lateral sides of spire irregular. Peripheral margin rounded. No umbilicus. The tube is undivided at the beginning but can show some pseudosepta in the two last whorls (Figures 22.1, 22.3, 23.1, 23.3, 23.7-8). Tube walls moderately thick to thick (0.02-0.05 mm), always and entirely neosparitized. Lumina crescentic ($h = 0.06$ -0.13 mm).

Remarks. *Orthovertella* sp. sensu Wang, 1982 is remarkably similar but larger ($D = 1.25$ mm). The new species differs from *G. nestellorum* by lower lumina, more numerous whorls and occasionally a semi-evolute last whorl. It differs from *Glomomidiella americana* (Nestell and Nestell, 2006) n. comb. by less developed pseudosepta and higher lumina; from *Glomomidiella miscella* (Nestell and Nestell in Nestell et al., 2006) n. comb., which is very similar and probably the direct descendent of *G. infrapermica* n. sp.; the latter species differs by smaller dimensions of the test and the proloculus and especially by lower chambers ($h = 0.10$ -0.18

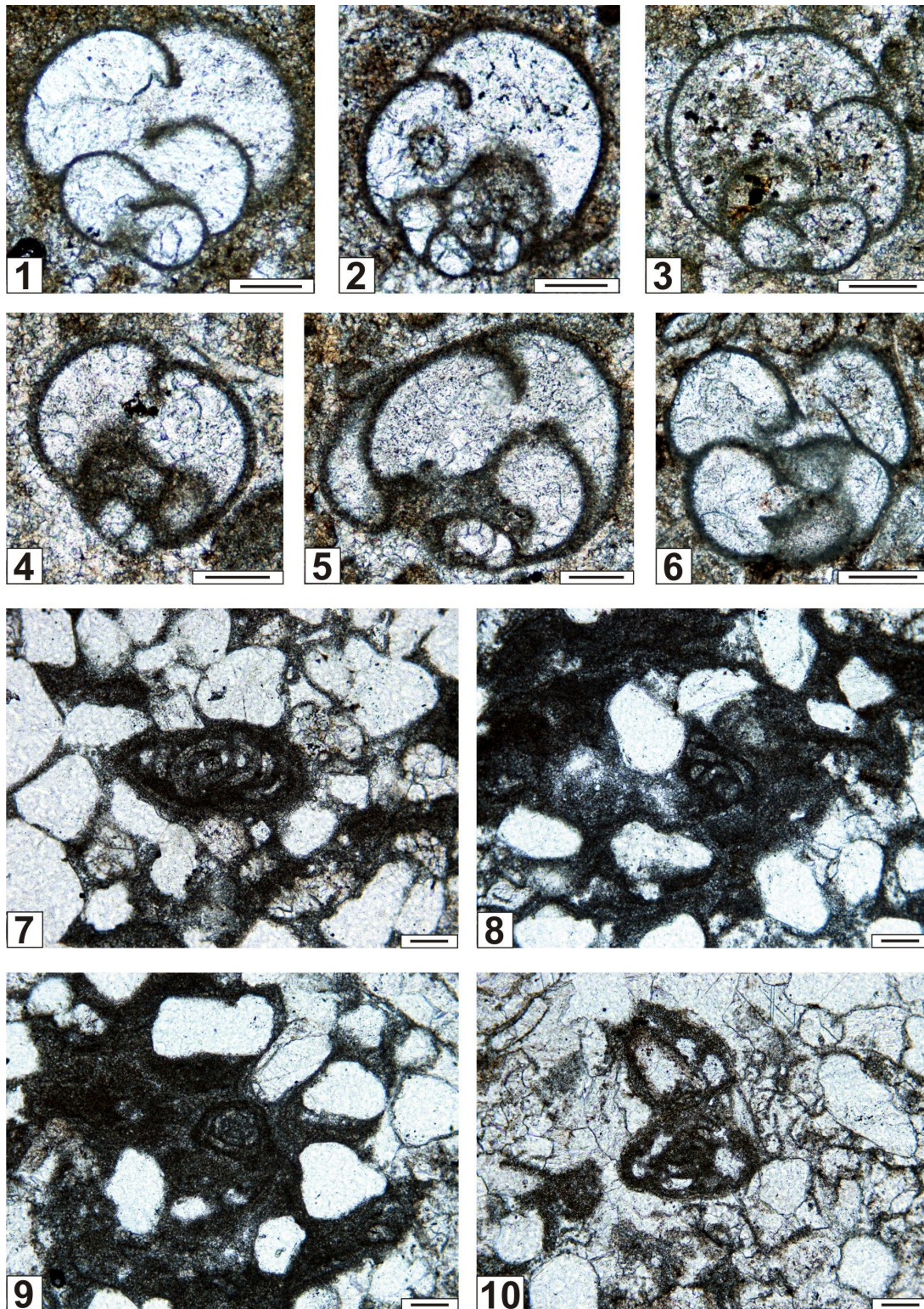


FIGURE 32. 1-3, 6. *Globivalvulina retroseptata* n. sp. 1. Subaxial section. San Andres Fm. Sample SAR 13a-10. 2. Oblique subaxial section. San Andres Fm. Sample SAR 13a-11. 3. Subaxial section. San Andres Fm. Sample SAR 20-6. 6. Axial section. San Andres Fm. Sample SAR (A-1§). 4-5. *Globivalvulina novamexicana* n. sp. 4. Oblique subaxial section. San Andres Fm. Sample SAR 20-8. 5. Subaxial section. San Andres Fm. Sample SAR 20-9. 7-10. *Hemigordius?* sp. Four sections. San Andres Fm Sample SAR 1. Scale bars equal 0.10 mm.

mm); and from *Glomomidiella darvasica* n. comb., another similar species, by larger dimensions, a smaller proloculus, and more whorls (5-7).

Neodiscus grandis Lin, Li and Sun, 1990 is relatively similar to *G. infrapermica* n. sp., although much larger (D = 1.09-1.51 mm), but it is also related to some species of Iran and Armenia that exhibit sporadic pseudosepta and even rare true septa (materials of Mobin Ebrahim Nejad and Gevorg Grigoryan), and consequently are apparently convergent with *Baisalina*.

Occurrence. Kungurian (late Leonardian) of New Mexico (Yeso Group, Los Vallos Formation, Torres Member, Massacre Gap: samples MG 10-2, MG(2) 10-3, MG(2) 10-4, MG(2) 10-5, MG(2) 10-7b, MG(2) 10-7c, MG(2) 10-8, MG(2) 10-9, MG(2) 10-10, MG(2) 10-11, MG 10-12, MG(2) 10-13, MG 10-15, MG 10-16, MG 10-22, MG 10-25, MG(2) 12-7). San Andres Formation, McLeod Hills: samples MLY 6-26, MLY(2) 5-12, MLY(2) 5-19a, MLY(2) 5-19c, MLY(2) 5-20, MLY(2) 5-24, MLY(2) 5a-5, MLY(2) 5a-6, MLY(2) 5a-7, MLY(2) 5a-15, MLY(2) 5a-22, MLY(2) 6-18, SAR 11-14). Permian of South China.

Genus PRAENEODISCUS n. gen.

zoobank.org/AABE7958-7961-4CFD-90FB-4FD54D6E34B1

Type Species. *Praeneodiscus convexus* n. gen. n. sp.

Etymology. Before (= prae) *Neodiscus*, similar genus.

Synonyms. *Hemigordius* sensu Grozdilova, 1956; *Hemigordius* (partim) sensu Filimonova, 2008, 2010; *Midiella* (partim) sensu Blajezowski, 2009.

Diagnosis. Test ovoid. Oscillating, involute coiling. Proloculus spherical followed by a tubular chamber in which lumina are initially semicircular and then ogival.

Composition. *Praeneodiscus convexus* n. gen. n. sp.; *P. transitus* n. gen. n. sp.; *P. lipinae* (Lipina, 1949) (= *Glomospira? compressa* Lipina, 1949 (plate 3, figures 1, 2; plate 7, figure 1) preoccupied by *G. compressa* Waters, 1928 as indicated by Rich, 1980); *Glomospira? miranda* Lipina, 1949; *Hemigordius ovatus* Grozdilova, 1956; *H. longus* Grozdilova, 1956; *H. permicus* Grozdilova, 1956; *H. sp.* sensu Zolotova and Baryshnikov, 1980; *H. guandongensis* sensu Lin et al., 1990; *Neodiscus* sp. A sensu Kobayashi, 1997 (plate 4, figure 10); *Agathammina* sp. A sensu Kobayashi, 2001 (plate 2, figure 2); *?Hemigordius* sp. 4 sensu Krainer et al. (2003, plate 6, figure 34); *?Agathammina?* sp. A sensu Kobayashi, 2004 (figure 7. 21); *Neodiscus orbicus* sensu Gu et al. (2005, plate 1, figure 9); *Pseudoagathammina regularis* sensu Filimonova,

2008 non Lipina, 1949 nec auctorum; *P. duplicata* sensu Filimonova, 2008 non Lipina, 1949 nec auctorum; *Midiella?* n. sp. sensu Krainer et al. (2009, plate 4, figures 1, 2, 3); *Neodiscus plectogyraeformis* sensu Song et al. (2009, figure 8.35-37).

Comparison. The new genus differs from *Neodiscus* Miklukho-Maklay, 1953 by less ogival lumina, smaller dimensions and less whorls and the difference of age (*Neodiscus* is Midian-Lopingian in age). In fact, after the work of Miklukho-Maklay (1953), little unquestionable material of this genus has been published, and many misinterpretations have been made. The best re-illustrated material is that of Kobayashi (2006, figure 4.1-13, 4.21) under the name of *Neodiscus padangensis* (Lange). It is relatively similar to our new genus; compare in particular the holotype of *Praeneodiscus convexus* n. sp. (Figure 19.4) with the specimen of Kobayashi (2006, figure 4.5).

The new genus differs from *Glomomidiella* in the more ovoid to lenticular test, and coiling oscillating to terminally planispiral and not streptospiral. It differs from *Uralogordius* Gaillot and Vachard, 2007 which possesses the same shape of lumen, because this latter is entirely planispiral. It differs from *Pseudoagathammina* Lin, Li and Sun, 1990 by a more regular test and the absence of miliolid coiling. It differs from *Hemigordius* Schubert, 1908 by the type of coiling, the larger dimensions and the ogival lumen (semicircular in *Hemigordius* sensu stricto). All the subspecies of *Hemigordius quinglongensis* (Wang, 1976) orth. mut. (i.e., with "qu" more consistent with the Latin spelling) -*qinglongensis*, *forma* (sic), *laxa* and *minima*- belong to either *Praeneodiscus* or *Neodiscus*.

Among the specimens of Lin, Li and Sun (1990), *Neodiscus ovatus* (Grozdilova) more resembles *Neodiscus milliloides* Miklukho-Maklay, 1953, whereas *Neodiscus paraovatus* Lin, Li and Sun, 1990 is more similar to true *Praeneodiscus ovatus*.

Occurrence. Rare in Kungurian (late Leonardian) beds of New Mexico. Early Permian of Japan. Late Early Permian of Bashkortostan (Russia). Middle-Late Permian of Tethys and Japan.

Praeneodiscus convexus n. gen. n. sp.

Figures 22.4, 22.7, 22.8, 22.10, 22.12-22.14, 33.17, 33.22, 33.26, 34.14

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? v. 2009 *Midiella?* n. sp.; Krainer, Lucas and Vachard, pl. 4, figs. 1, 2, 3.

v. 2013 *Midiella*; Brose, Lucas and Krainer, fig. 6.11.

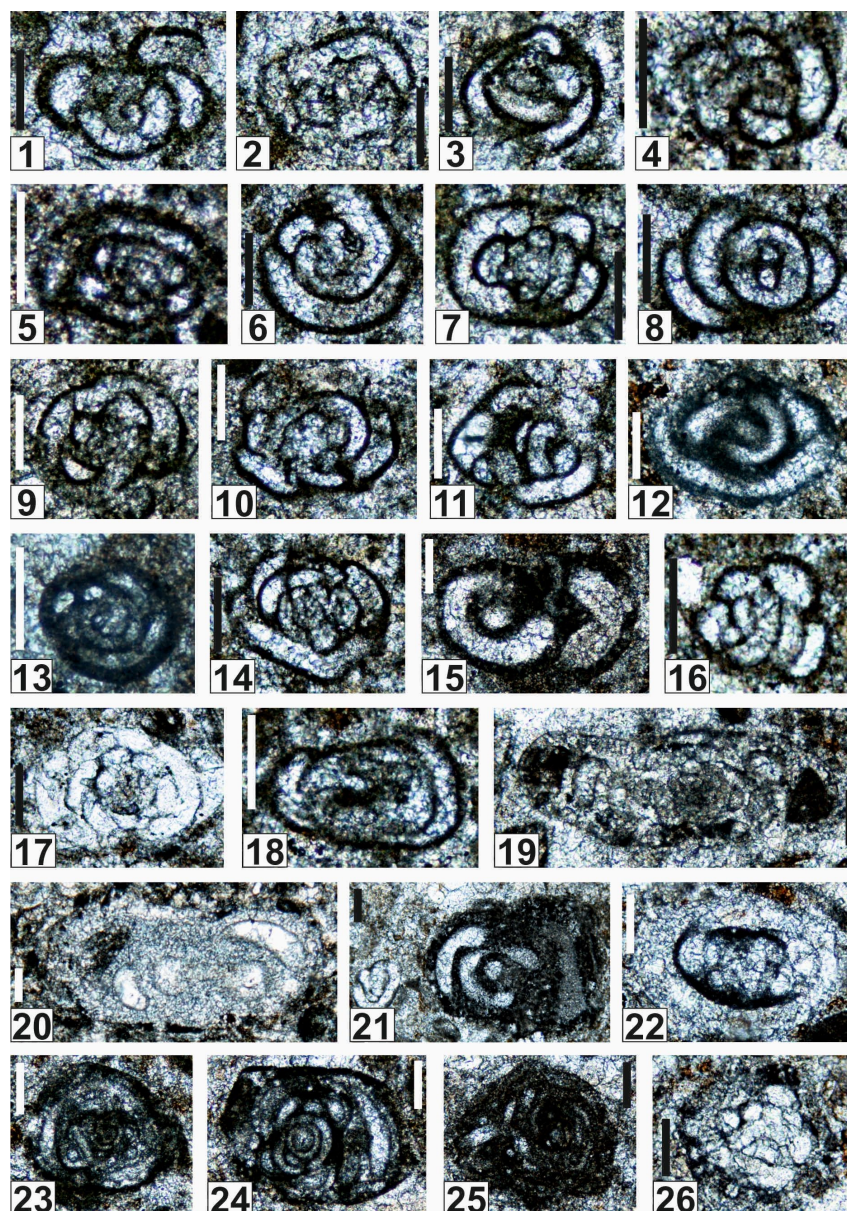


FIGURE 33. 1-14, 16, 18. *Hemigordiellina?* cf. *simplex* (Harlton, 1928). 1. Oblique subtransverse section. San Andres Fm. Sample MLY 3-1. 2. Oblique subaxial section. San Andres Fm. Sample MLY 3-11. 3. Subtransverse section. San Andres Fm. Sample MLY 4-8. 4. Subaxial section. San Andres Fm. Sample MLY 4-11. 5. Transverse section. San Andres Fm. Sample MLY 4-15. 6. Subtransverse section. San Andres Fm. Sample MLY 4-16. 7. Transverse section. San Andres Fm. Sample MLY 4-18. 8. Subaxial section. San Andres Fm. Sample MLY 4-19. 9. Subtransverse section. San Andres Fm. Sample MLY 8-7. 10. Subtransverse section. San Andres Fm. Sample MLY 4-20. 11. Subtransverse section. San Andres Fm. Sample MLY 5-15. 12. Subaxial section. San Andres Fm. Sample MLY 5-16a. 13. Transverse section. San Andres Fm. Sample MLY 5-5. 14. Subtransverse section. San Andres Fm. Sample MLY 4-12. 16. Oblique section. San Andres Fm. Sample MLY 6-25a. 18. Transverse section. San Andres Fm. Sample MLY 4-21. 19, 21. *Pseudospira* aff. *ishimbaica* (Lipina, 1949). 15. Subaxial section. San Andres Fm. Sample MLY 6-22. 21. Axial section with *Hemigordiellina?* cf. *simplex* (left). San Andres Fm. Sample MLY 5-17. 17, 22, 26. *Praeneodiscus convexus* n. gen. n. sp. 17. Oblique section. San Andres Fm. Sample MLY 5-16. 22. Transverse section. San Andres Fm. Sample MLY 5-8a. 26. Subaxial section. San Andres Fm. Sample MLY 5-9. 19-20. *Orthovertellopsis protaeformis* n. gen. n. sp. 19. Subaxial section. San Andres Fm. Sample MLY 6-5. 20. Oblique subaxial section. San Andres Fm. Sample MLY 6-5a. 23-24. *Hemigordiellina?* aff. *pseudopusilla* (Baryshnikov in Zolotova and Baryshnikov, 1980). 23. Oblique section. San Andres Fm. Sample MLY 5-25. 24. Axial section. San Andres Fm. Sample MLY 5-24. 25. *Palaeonubecularia?* sp. Axial section. Perhaps also related with *Ellesmerella* (see Vachard et al., 2013b). San Andres Fm. Sample MLY 5-29. Scale bars equal 0.10 mm.

v. 2013b *Neodiscus?* ex gr. *ovatus* (Grozdilova); Vachard, Krainer and Lucas, p. 348 (no illustration).

Etymology. A species with regularly convex flanks.

Holotype. NMMNH P-67606; Figure 22.4; sample MG 10-24.

Paratypes. NMMNH P-67607-67612; Figure 22.7-8, 22.10, 22.12-14.

Material. 40 specimens.

Locus Typicus. NMMNH locality 8905; Yeso Group, Los Vallos Formation, Torres Member, Massacre Gap, southern Fra Cristobal Mountains (New Mexico).

Stratum Typicum. Early? Kungurian (late Leonardian).

Diagnosis. *Praeneodiscus* characterised by an ovoid test, medium to large in diameter, with oscillating coiling and an ogival lumen of the tubular chamber.

Description. Test ovoid. Oscillating involute coiling. No umbilici. No sutures. Wall surface smooth. Lateral sides of spire strongly inflated. Peripheral margin rounded. Proloculus spherical and small to moderate in size, followed by a tubular chamber with a diameter that is equal to the height of the third volution. $D = 0.35-0.50-(0.70)$ mm; $w = (0.14)-0.22-0.35$ mm; $w/D = 0.50-0.70$; whorls: (4)-5-6; $p = 0.01-0.02-(0.05-0.06)$ mm; $h = 0.05-0.10$ mm; $s = 0.01-0.02$ mm.

Remarks. The new species differs from *Praeneodiscus arcticus* n. comb. (formerly *Midiella arctica*) by a less sigmoidal coiling and a less inflated test (probably 0.66-0.71 in this latter species; although the ratio D/w indicated by Blazejowski, 2009 is 2.4-2.5; a probable lapsus calami for 1.4-1.5). It differs from *P. compressus* (Lipina, 1949) n. comb. by more whorls and more aligned last whorls. In contrast to *P. ovatus* (Grozdilova, 1956) n. comb. which is relatively similar in the shape of the tube lumina (i.e., crescentic, very wide, and well-developed in the lateral sides), the lumina of *P. convexus* n. gen. n. sp. are smaller, semicircular and limited to the central part of the test; the test, itself, of *P. ovatus* is much larger with $D = 0.490-0.990$ mm; $w = 0.340-0.480$ mm (for the same number of whorls: 5-6); $h = 0.076-0.150$ mm; $s = 0.026-0.038$ mm. *Praeneodiscus darvasica* n. comb. is similar to *P. ovatus*; it differs from *P. convexus* n. gen. n. sp. by a shorter lumen of the chambers and a glomus more developed by the internal and external whorls. The holotype of *P. convexus* n. gen. n. sp. (Figure 19.4) is similar to *Neodiscus padangensis* sensu Kobayashi (2006, figures 4, 5), but differs by

its smaller size (1.00 mm for the Kobayashi's specimen), its smaller proloculus, and the total similarity of all lumina, whereas Kobayashi's specimen seems to exhibit a juvenarium, as does the holotype of *N. milliloides* Miklukho-Maklay, 1953 or *Neodiscus* cf. *N. milliloides* sensu Nestell et al., 2009 (plate 1, figures 30, 31). *Praeneodiscus convexus* n. gen. n. sp. differs from *P. longus* n. comb. and *P. permicus* n. comb. by the more inflated test and therefore a larger width; from *Midiella zaninetiae* (Altiner, 1978) by larger dimensions and a more oscillating coiling; from *Neodiscus quinqlongensis* Wang, 1976 by a test less inflated test with more volutions for a similar diameter; and from *Neohemigordius zulumartensis* Filimonova, 2010 by larger dimensions.

Occurrence. Early?-middle? Kungurian (late Leonardian) of New Mexico (Yeso Group, Los Vallos Formation, Torres Member: sample MG 10-24; San Andres Formation, McLeod Hills: samples MLY 5-4, MLY(2) 5-5, MLY 5-7, MLY 5-7a, MLY(2) 5-8, MLY 5-8a, MLY(2) 5-8a, MLY 5-9, MLY 5-13, MLY(2) 5-19b, MLY 5-21, MLY 5-30, MLY 5-31, MLY 5-32, MLY(2) 5a-14, MLY(2) 5a-16, MLY(2) 5a-17, MLY(2) 5a-18, MLY 8-1).

Class NODOSARIATA Mikhalevich, 1993

Subclass NODOSARIANA Mikhalevich, 1993 nom. correct. Mikhalevich, 1998

Order NODOSARIIDA Calkins, 1926

Superfamily ROBULOIDOIDEA Reiss, 1963 nom. transl. Loeblich and Tappan, 1964 emend. Gaillot and Vachard, 2007

Description. See Gaillot and Vachard, 2007.

Remarks. The study of the Nodosariata is particularly difficult and requires many biometric studies (Sellier de Civrieux and Dessauvage, 1965; Gerke, 1967; Ruget, 1976; Hohenegger, 1997; Karavaeva and Nestell, 2007). Gaillot and Vachard (2007) proposed to subdivide the Palaeozoic Nodosariata into two superfamilies: 1) Robuloidoidea, with a primitive aperture (generally round, areal and simple), and; 2) Nodosarioidea Ehrenberg, 1838 nom. transl. Loeblich and Tappan, 1961, with the typical stellate radial aperture of the post-Palaeozoic Nodosariata. The exact period of appearance of this type of aperture during the Permian is not yet precisely known, but it probably occurs during the evolution of *Protonodosaria* and/or *Nodosinelloides* to *Nodosaria* sensu stricto (the two types of apertures are present together in the *Nodosaria* of Woszczyńska's paper (1987): for example, *N. candida* Woszczyńska, 1987, is really a *Nodosaria* "with a neck and radiate aperture", whereas *N. polonica* Woszczyńska, 1987 belongs

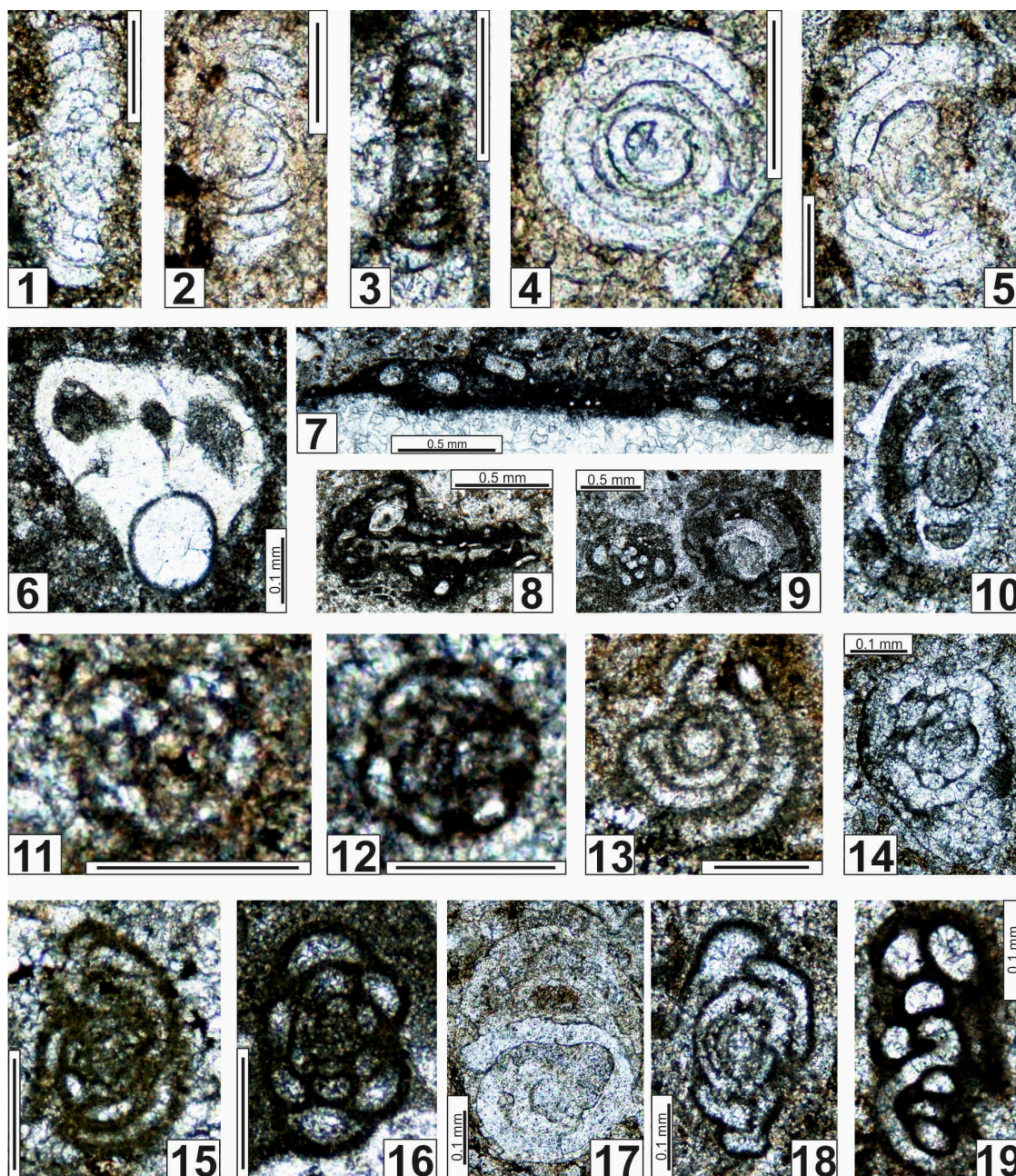


FIGURE 34. 1-5. *Hemigordius* aff. *saranensis* Baryshnikov in Baryshnikov, Zolotova and Kosheleva, 1982. 1. Subaxial section. San Andres Fm. Sample SAR 13-5d. 2. Subaxial section. San Andres Fm. Sample SAR 11-5a. 3. Axial section. San Andres Fm. Sample SAR 20-5. 4. Transverse section. San Andres Fm. Sample SAR 11a-12. 5. Subtransverse section. San Andres Fm. Sample SAR 13-11. 6, 10, 17. *Orthovertellopsis calcitornellaeformis* n. gen. n. sp. 6. Subtransverse section. San Andres Fm. Sample SAR 19-1. 10. Oblique section. San Andres Fm. Sample MLY 8-6. 17. Transverse section. San Andres Fm. Sample SAR(2) 11-10. 7-8. *Palaeonubecularia* sp. 7. Subtransverse section. San Andres Fm. Sample MLY 5-19. 8. Subtransverse section encrusting a *Boueina? crassundia* n. sp. San Andres Fm. Sample MLY(2) 5a-19. 9. *Pseudospira* aff. *ishimbaica* (Lipina, 1949). Two random sections. San Andres Fm. Sample MLY 6- 23. 11-12. *Hemigordellina* cf. *elegans* (Lipina, 1949). 11. Random section. San Andres Fm. Sample SAR 18-3a. 12. Random section. San Andres Fm. Sample SAR 18-3. 13. *Ammovertella* sp. Transverse section. San Andres Fm. Sample SAR 13-9a. 14. *Prae neodiscus convexus* n. gen. n. sp. Subaxial section. San Andres Fm. Sample MLY 5-32. 15, 18. *Hemigordiellina?* aff. *simplex* (Harlton, 1928). 15. Random section. San Andres Fm. Sample SAR 18-2. 18. Transverse section. San Andres Fm. Sample MLY(2) 4-2. 16. *Hemigordellina* aff. *elegans* (Lipina, 1949). Random section. San Andres Fm. Sample SAR 14. 19. *Calcitornella* cf. *elongata* Cushman and Waters, 1928a. Subtransverse section. San Andres Fm. Sample MLY(2) 5a-24. Scale bars 1-6, 10-19 equal 0.10 mm.

to another genus because of its “aperture terminal rounded”).

Family PROTONODOSARIIDAE Mamet and Pinard, 1992 emend. Gaillot and Vachard, 2007
Genus PROTONODOSARIA Gerke, 1959

Type Species. *Nodosaria proceraeformis* Gerke, 1952 (orth. mut. Gaillot and Vachard, 2007 for *proceraeformis*).

Remarks. As noted here, and apparently in agreement with the redefinition of Groves (2000), *Protonodosaria* differs from *Nodosinelloides*, by the monolayered hyaline wall and the round, areal aperture. However, due to numerous other definitions, the name of the taxon described hereafter is followed by a question mark.

Protonodosaria? sp.
Figure 25.5

v. 2013b *Protonodosaria?* sp.; Vachard, Krainer and Lucas., p. 348 (no illustration).

Description. Test cuneate to tongue-shaped, moderately elongate (H = 0.50 mm; w = 0.12 mm; w/H = 0.24). Proloculus terminal, not prominent, spherical (0.03 mm in diameter). Six chambers from small crescentiform to high spear-shaped crescentiform (h = 0.11 mm). Wall thin (s = 0.01 mm).

Remark. *Nodosaria polonica* Wozsyczynska, 1987 is relatively similar in shape although smaller (H = 0.36 mm and w = 0.08-0.11 mm) for 6-8 chambers.
Occurrence. Middle? Kungurian (late Leonardian) of New Mexico (San Andres Fm: sample MLY 3-5).

Genus NODOSINELLOIDES Mamet and Pinard, 1992

Type Species. *Nodosinelloides potievskayae* Mamet and Pinard, 1996 (nom. nov. pro *Nodosaria gracilis* Potievskaya, 1962 pre-occupied).

Nodosinelloides longa (Lipina, 1949)
Figure 25.6-25.7, 25.10, 25.17-25.19

1949 *Nodosaria longa* Lipina, p. 216-217, pl. 4, fig. 6.

v. 2009 *Nodosinelloides longa* (Lipina); Krainer, Lucas and Vachard, pl. 5, figs. 2, 5, 6; pl. 6, fig. 23.

2010 *Nodosinelloides longa* (Lipina); Filimonova, p. 784, 786, pl. 5, fig. 19 (with synonymy).

v. 2013 *Geinitzina*; Brose, Lucas and Krainer, fig. 6.5.

v. 2013b *Nodosinelloides longa* (Lipina); Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. Test cuneate, rectilinear, slightly curved to curved, very strongly elongate. Chambers subrectangular, fabiform to semicircular. Wall

thin, bilayered, with small inner layer. H = 0.24-0.38-(0.60) mm; w = 0.05-0.09-(0.13) mm; w/H = 0.22-0.50; chambers: 7-12; p = 0.01-0.02-(0.03) mm; h = 0.05-0.09 mm; s = 0.01 mm.

Remarks. *Nodosinelloides longa* might be characteristic of the early Kungurian according to Sosipatrova (1972) and Pronina (1999). However, it may be present as early as the earliest Permian (Vachard and Krainer, 2001a, 2001b; Krainer et al., 2009; Filimonova, 2010).

Occurrence. Late? Kungurian (latest Leonardian) of New Mexico (San Andres Fm: samples SAR 8a-4a, SAR 8a-8, SAR 8a-17, SAR 11a-6, SAR 11a-9, SAR 12-4, SAR(2) 12-17).

Nodosinelloides netjaschewi (Cherdyntsev, 1914)
Figure 25.11, 25.15, 25.20, 25.21

1914 *Nodosaria netjaschewi* Cherdyntsev, p. 38, pl. 2, figs. 3, 4.

2000 *Nodosinelloides netjaschewi* (Cherdyntsev); Groves, p. 298 pl. 4, figs. 31, 32, 33, 34, 35, 36, 37, 38, 39, 40 (with synonymy).

v. 2009 *Nodosinelloides netjaschewi* (Cherdyntsev); Krainer, Lucas and Vachard, pl. 5, figs. 1, 4; pl. 65, fig. 25.

v. 2013b *Nodosinelloides netjaschewi* (Cherdyntsev); Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. Test cylindrical and strongly elongate. Chambers angular. Measurements: H = 0.13-0.15-(0.39) mm; w = 0.03-0.04-(0.10) mm; w/H = 0.25-0.27; chambers: 6-7; p = 0.01-0.03 mm; h = 0.02-0.03 (0.07) mm; s = 0.01 mm.

Occurrence. Late? Kungurian (latest Kungurian) of New Mexico (San Andres Fm: samples SAR 11-17, SAR 11-19/19a, SAR(2) 12-6, SAR 13a-2, SAR 20.2).

Genus NESTELLORELLA Gaillot and Vachard, 2007

Type Species. *Pseudolangella pulchra* Pronina in Kotlyar, Zakharov, Kropacheva, Pronina, Chediya and Burago, 1989.

Nestellorella? sp.
Figure 25.4

v. 2013b *Nestellorella?* sp. - Vachard, Krainer and Lucas, p. 348 (no illustration).

Description. Test wide cuneate, moderately elongate, with chambers fabiform (i.e., semi-circular) or trapezoidal internally, and subpentagonal externally. Wall thick. Aperture simple, depressed. H = 0.32 mm; w = 0.12 mm; w/H = 0.38; chambers: 6; p = 0.02 mm; h = 0.06 mm; s = 0.02 mm. As our

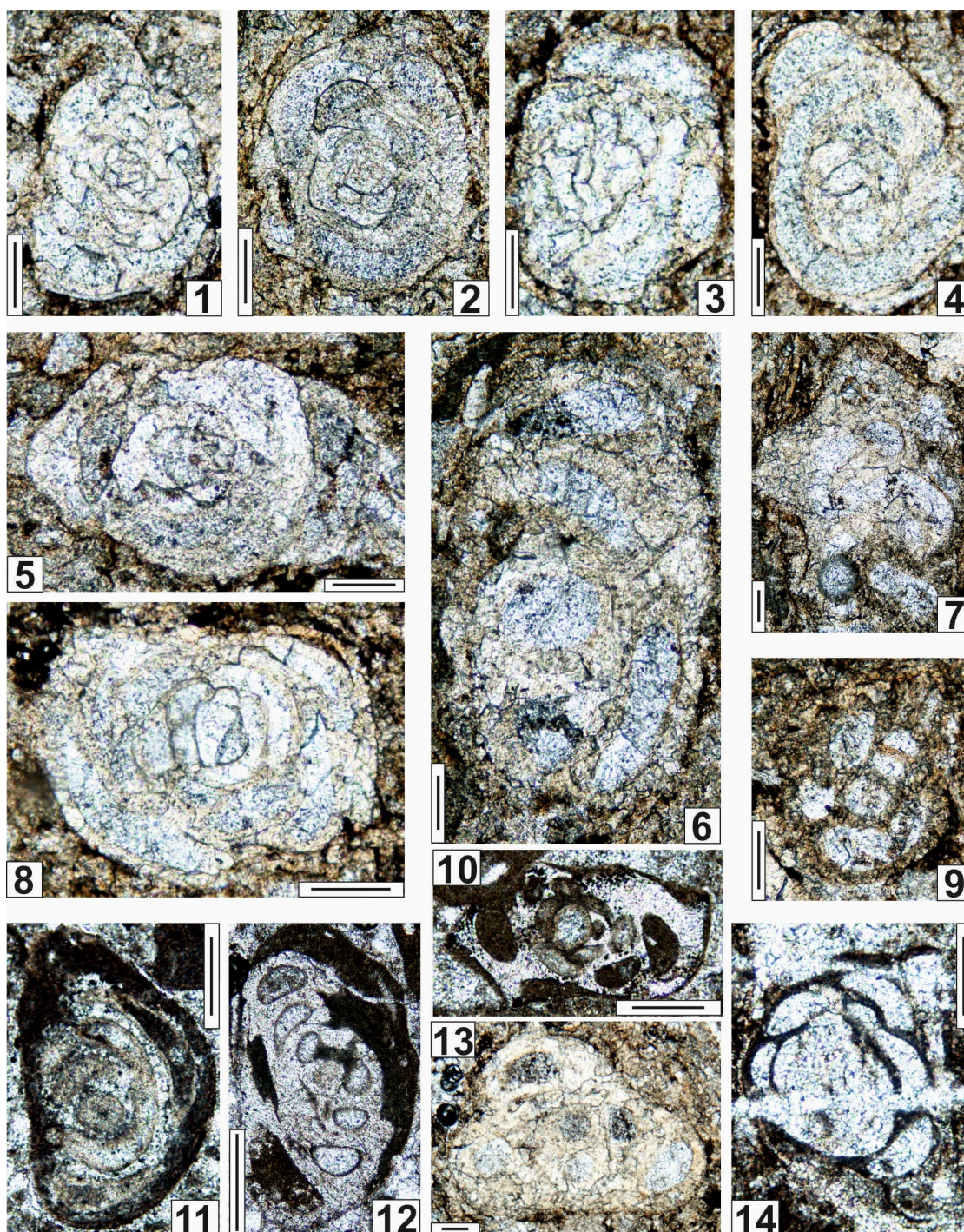


FIGURE 35. 1-5, 8. *Olgaortovella davydovi* n. gen. n. sp. 1. Axial section. San Andres Fm. Sample SAR 11a-11. 2. Axial section. San Andres Fm. Sample SAR 11a-8 (already illustrated in Brose et al., 2013, figure 6. 12). 3. Subaxial section. San Andres Fm. Sample SAR 11a-15. 4. Axial section. San Andres Fm. Sample SAR 11a-14. 5. Axial section. San Andres Fm. Sample SAR 11a-3. 8. Axial section. San Andres Fm. Sample SAR 11-6. 6-7, 13. *Orthovertellopsis calcitornellaeformis* n. gen. n. sp. 6. Subtransverse section. San Andres Fm. Sample SAR 11a-16. 7. Transverse section. San Andres Fm. Sample SAR 11-16. 13. Oblique section. San Andres Fm. Sample SAR 11a-5. 9, 11, 14. *Glomomidiella infrapermica* n. sp. 9. Axial section showing the proloculus. San Andres Fm. Sample SAR 11-14. 11. Subtransverse section. Yeso Group. Sample MG(2) 10-7b. 14. Axial section relatively well preserved (dark wall). Yeso Group. Sample MG(2) 12-7. 10, 12. *Orthovertellopsis protaeformis* n. gen. n. sp. 10. Axial section. Yeso Group. Sample MG(2) 10-14. 12. Subaxial section. Yeso Group. Sample MG(2) 10-6. Scale bars equal 0.10 mm.

specimen is unique and the genus is still under discussion, a question mark is added to the name.

Occurrence. Early? Kungurian (late Leonardian) of New Mexico (San Andres Fm: sample MLY 1-1).

Nodosariata indet. cf. *Dentalina* cf. *ninae*
Grozdilova
sensu Chuvashov, Dyupina, Mizeis and Chernykh,
1990
Figure 25.16

? 1990 *Dentalina* cf. *ninae* Grozdilova; Chuvashov,
Dyupina, Mizeis and Chernykh, pl. 30, fig.
8.

v. 2013b Gen. indet.; Vachard, Krainer and Lucas,
p. 348 (no illustration).

Description. Test ribbon-shaped to strongly elongate, with two rounded extremities. Very broad proloculus. Chambers semicircular. Measurements: H = 0.40 mm; w = 0.14 mm; w/H = 0.34; chambers: 5; p = 0.08 mm; h = 0.08 mm; s = 0.01 mm.

Occurrence. Late? Kungurian (latest Leonardian) of New Mexico (San Andres: sample SAR 11a-4).

Genus FRONDICULARIA Defrance in d'Orbigny,
1826 emend. Sellier de Civrieux and Dessauvage,
1965

Type Species. *Renulina complanata* Defrance in de Blainville, 1824.

"*Frondicularia*" aff. *turæ* Baryshnikov in
Baryshnikov, Zolotova, and Kosheleva, 1982
Figure 36.17

? 1982 *Frondicularia turæ* Baryshnikov in Baryshnikov,
Zolotova and Kosheleva, p. 33-34,
pl. 9, figs. 2, 3.

? v. 2009 *Frondicularia* cf. *turæ* Baryshnikov;
Krainer, Lucas and Vachard, pl. 5, fig. 7, pl.
6, fig. 28.

v. 2013b *Frondicularia* aff. *turæ* Baryshnikov;
Vachard, Krainer and Lucas, p. 348 (no
illustration).

Description. Measurements: H = 0.42 mm; w = 0.17 mm; w/H = 0.40; chambers: 4; h = 0.12 mm; s = 0.01 mm.

Remark. All the parameters of the species are a little smaller than those of our material.

Occurrence. Late Artinskian (Sarginian) of the Pre-Urals (Russia). Early? Kungurian (late Leonardian) of New Mexico (Yeso Group: sample MG 13f).

Family GEINITZINIDAE Bozorgnia, 1973
Genus GEINITZINA Spandel, 1901

Type Species. *Geinitzina postcarbonica* Spandel, 1901.

Occurrence. Latest Pennsylvanian or earliest Permian-latest Permian; cosmopolitan.

Geinitzina indepressa Cherdyntsev, 1914
Figure 25.8-25.9, 25.12-25.14

1914 *Geinitzina indepressa* Cherdyntsev, p. 26-27,
pl. 1, fig. 9.

2000 *Geinitzina indepressa* Cherdyntsev; Groves,
p. 300-301, pl. 5, figs. 1, 2, 3, 4, 5, 6 (with
synonymy).

v. 2013b *Geinitzina* ex gr. *postcarbonica* Spandel -
Vachard, Krainer and Lucas, p. 348 (no
illustration).

Description. Test straight triangular, moderately elongate. Chambers semisinushaped. H = (0.14)-0.16-0.45 mm; w = (0.07)-0.10-0.22 mm; h = (0.02)-0.03-0.06 mm; s = 0.01 mm. Proloculus spherical, a little prominent, 0.02-0.03 mm in diameter. Up to nine chambers, relatively short and high for the genus; moreover, the central depression is absent or very faint. Aperture terminal, central, simple, a little depressed.

Remarks. This species differs from *G. postcarbonica* in the shape of the chambers with a convex roof and not a centrally depressed one, and from *G. spandeli plana* Lipina, 1949, which is relatively similar, by more chambers and a smaller proloculus.

The material of Groves (2000) is remarkably similar to ours and proves the importance of this species for the stratigraphic and geographic correlations in North America.

Occurrence. Early Permian (sensu lato) of Russian Platform, Urals, and Xizang (China). Artinskian (early Leonardian) of Oklahoma (USA). Late? Kungurian (late Leonardian) of New Mexico (San Andres Fm: samples SAR 8a-7, SAR 8a-11, SAR 8a-14, SAR(2) 11-2, SAR 11-13, SAR 11a-10, SAR(2) 13-7, SAR(2) 13-10, SAR 18-1, SAR(2) 19-11).

CONCLUSIONS

1. The algal microfloras described in this paper are poorly known in North and Central America. Therefore, the comparisons are difficult at the genus and/or species levels.
2. Hypothetically, a biostratigraphic zonation is proposed with six informal zones: 1) *Boueina? crassundia* and *Gymnocodium? johnsonii* Zone; 2) *Gymnocodium? johnsonii* Zone; 3) *Ellesmerella rara* and *Gymnocodium? johnsonii* Zone; 4) intercalation of the Glorieta sandstones barren of microfossils; 5) *Boueina? tubulata* Zone; and 6) *Tubiphytes epim-*

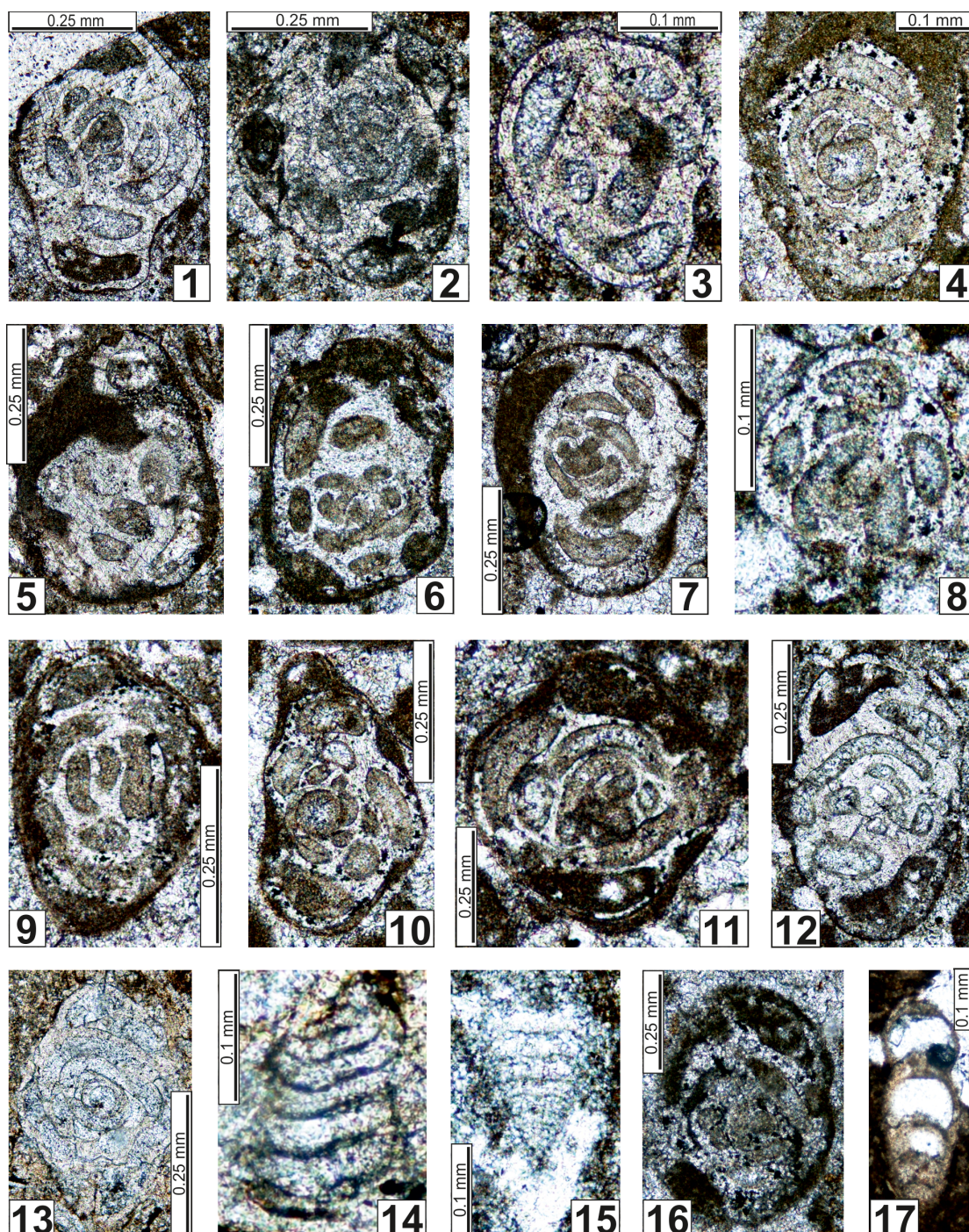


FIGURE 36. 1-12, 16. *Glomomidiella infrapermica* n. sp. 1. Axial section. Yeso Group. Sample MG(2) 10-9. 2. Subaxial section. San Andres Fm. Sample MLY(2) 5a-15. 3. Oblique subaxial section. Yeso Group. Sample MG(2) 10-8. 4. Subtransverse section. Yeso Group. Sample MG 10-7. 5. Broken subaxial section. Yeso Group. Sample MG(2) 10-10. 6. Subaxial section. Yeso Group. Sample MG(2) 10-4. 7. Axial section. Yeso Group. Sample MG(2) 10-5. 8. Oblique subaxial section. Yeso Group. Sample MG(2) 10-3. 9. Subaxial section. Yeso Group. Sample MG(2) 10-11. 10. Axial section. Yeso Group. Sample MG 10-7a. 11. Subtransverse section. Yeso Group. Sample MG(2) 10-7c. 12. Subaxial section. Yeso Group. Sample MG(2) 10-13 (already illustrated in Lucas et al., 2013b, figure 8I). 16. Poorly preserved subaxial section. San Andres Fm. Sample MLY 6-26. 13. *Olgaorlovella davydovi* n. gen. n. sp. Axial section. San Andres Fm. Sample SAR(2) 11-7. 14-15. *Geinitzina indepressa* Cherdyntsev, 1914. 14. Oblique subaxial section. San Andres Fm. Sample SAR(2) 11-2. 15. Subaxial section. San Andres Fm. Sample SAR(2) 19-1. 17. "*Fronicularia*" aff. *turae* Baryshnikov in Baryshnikov, Zolotova and Kosheleva, 1982. Axial section. Yeso Group. Sample MG 13f.

onellaeformis Zone.

3. Biostratigraphically, the most characteristic taxa seem to be *Ellesmerella rara* n. sp. for the early? Kungurian; *Boueina? tubulata* n. sp. for the middle? Kungurian; and *Gymnocodium? bacillum* n. sp. and *Tubiphytes epimonellaeformis* n. sp. for the late? Kungurian.
4. This microflora is interesting for the knowledge of some palaeobotanical orders and classes: codiaceans, gymnocodiaceans; as well as for the discussion of these possible cyanobacterial/foraminiferal consortia, the Tubiphytidae. The codiaceans, always rare in the Carboniferous-Permian, are exceptionally abundant in the Kungurian deposits of New Mexico with a relatively abundant *Boueina?*, which permits adjustment of the phylogeny of this group during the late Early Permian. *Boueina?*, even if it is not exactly the ancestor of the gymnocodiaceans, probably provides a good image of this ancestor. Eventually, *Boueina?* might be the ancestor of *Gymnocodium?*, whereas *Permocalculus* evolved earlier from another branch of this lineage; also appeared in North America and not in Tethys.
5. The gymnocodiaceans are well represented in our material with two new primitive species; relatively difficult to classify, because their conceptacles have not been observed.
6. The dasycladales are very rare in the Kungurian of New Mexico, and consequently, less well represented than in Tethys. In particular, the epimastoporaceans have disappeared from North America, but remained common during the same epoch in the Tethyan shelves, in particular in the Carnic Alps. Only an undetermined Chlorophyta has been found which may have some affinities with the dasycladales, but might also be an atypical taphonomic stage of codiacean algae.
7. There are rare specimens of a new species of *Ellesmerella*. The ellesmerellids are very rare in the Kungurian of New Mexico; especially, the complex biopisoliths of the Late Pennsylvanian-earliest Permian disappeared. This point is apparently unrelated to the supposed Artinskian-Kungurian warming of the seas.
8. The Tubiphytidae present locally a diversification, which is apparently absent in Tethys; that will give rise to *Epimonella*, present in both parts of the world. They are represented by a new species *Tubiphytes epimonellaeformis* n. sp., which confirms the double affinity, botanical and animal, but does not permit us to formulate a new explanatory hypothesis about this very puzzling group. It would be useful to restudy the affinities between *Palaeonubeculata* (sic) *fluxiformis* and *Tubiphytes epimonellaeformis* n. sp. and the value of both taxa as Kungurian biomarkers.
9. The Tuberitinidae are present everywhere, but not very diversified.
10. These microfloras are endemic and do not provide data for palaeobiogeographic correlations.
11. The foraminiferal microfaunas described in this paper are poorly known in North and Central America. Therefore, the comparisons are difficult at the generic and/or specific levels.
12. Two new species of dark-microgranular walled *Globivalvulina* are described: *G. parapiciformis* n. sp. and *G. retroseptata* n. sp.
13. Two new species of atypical *Globivalvulina* (i.e. with a sporadic inner pseudofibrous layer in the wall) are also created: *G. novamexicana* n. sp. and *G. praegraeca* n. sp.
14. The Miliolata are primitive taxa: *Hemigordielina*, *Ammovertella*, *Pseudospira*, *Palaeonubecularia*, and *Hemigordius*, as well as some taxa newly appeared: *Glomomidiella* already described, and *Olgaorlovella* n. gen., *Orthovertellopsis* n. gen., and *Praeneodiscus* n. gen.
15. These new taxa are important for understanding the beginning of the differentiation of various lineages of Permian Miliolata.
16. These new taxa might permit a more accurate biozonation of the Leonardian regional stage of Northern America, especially of the Yeso Group and San Andres Formation in New Mexico.
17. The principal biomarkers seem to be the four new species of *Globivalvulina*, *Olgaorlovella davydovi* n. gen. et sp., *Glomomidiella infrapermica* n. sp., *Praeneodiscus convexus* n. gen. et sp., *Nodosariata* gen. indet., *Nestellorella?* sp., and "*Fronicularia*" aff. *turrae*.
18. The assemblages are characteristic of the Artinskian-Kungurian, but each stage of this period is difficult to characterise separately.
19. Despite their general endemism, some foraminifers might be used for accurate correlations with the stratotypes of the Urals (Russia): *Globivalvulina apiciformis*; *G. donbassica*; *Hemigordius saranensis*; *Nodosinella*

loides longa; and *Geinitzina indepressa*.

20. A biostratigraphic zonation by means of smaller foraminifers is proposed with six zones: 1) *Glomomidiella infrapermica* n. sp. and *Orthovertellopsis protaeformis* n. sp. Zone; 2) *Globivalvulina parapiciformis* n. sp. and *Nestellorella?* sp. Zone; 3) "*Frondicularia*" aff. *turae* Zone; 4) intercalation of the Glorieta sandstones barren of microfossils; 5) *Prae-neodiscus convexus* n. gen. et sp and *Orthovertellopsis calcitornellaeformis* n. gen. et sp. Zone; and 6) *Olgaorlovella davydovi* n. gen. et sp. Zone.

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