

The last Permian deep-water fauna: Latest Changhsingian small foraminifers from southwestern Guangxi, South China

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ABSTRACT: Free specimens of small foraminifers are not commonly reported from Permian strata. A foraminiferal fauna with free tests accompanied by abundant radiolarians has been discovered from uppermost Permian, upper Changhsingian strata in the Liuqiao Section, southwestern Guangxi Zhuang Autonomous Region, South China. SEM microphotography and thin sections of free specimens were both used for the study of external and internal morphological features. In most cases the wall structure is not preserved because of recrystallization, however, most species could be identified based on test morphology. Twenty species (six new) of fourteen genera (one new) have been identified. The new genus and new species are: *Dalongella* n. gen., *Dalongella fusiformis* n. gen. n. sp., *Glomospirella? mamilla* n. sp., *Glomospirella? curva* n. sp., *Hemigordius? yini* n. sp., *Geinitzinita changhsingensis* n. sp. and *Pseudolangella costata* n. sp. The composition of this fauna is quite different from similar age small foraminiferal faunas reported from South China. Furthermore, the presence of radiolarians and cool-water brachiopods probably implies that the fauna is from a deep-water environment.

INTRODUCTION

The mass extinction in the Paleozoic/Mesozoic transitional interval resulted in the greatest reduction of biodiversity in geological history (e.g. Sepkoski 1982, 1984; Erwin 1993, 1994; Hallam and Wignall 1997; Jin et al. 2000). As with other benthic organisms, small foraminifers experienced a catastrophic biodiversity reduction at the end of the Permian, when 91% of calcareous foraminiferal genera became extinct (Groves and Altiner 2005). However, few foraminiferal faunas have been reported from latest Permian strata that contain a Permo-Triassic boundary section (e.g. Shang et al. 2003; Groves and Altiner 2005). Questions concerning the faunal composition and extinction process of latest Permian small foraminifers are not well answered: 1) What types of small foraminifers lived before the mass extinction and how did they diversify? 2) How did the small foraminifers disappear? Did they disappear gradually or suddenly? 3) How did different small foraminiferal groups disappear and which group disappeared first or which last, and why? Among these questions, the first one, to document as much as possible the foraminiferal faunas from various environment of latest Permian, would be crucial for answering the other two. Therefore, the study of small foraminifers from the uppermost Permian strata that recorded the end-Permian mass extinction deserves more attention.

Late Permian small foraminifers are nearly exclusively found in strata from the Tethyan region, such as South China (e.g., Wang G. 1966; Wang K. 1976; Lin 1978, 1984; Lin et al. 1990), Primorye (Sosnina and Nikitina 1977; Vuks and Chediya 1986), Japan (Kobayashi 1997, 2001, 2002, 2004), North Vietnam (Liem 1971; Hung 1981), North Thailand (Sakagami and Hatta 1982; Fontaine and Nguyen 1989; Fontaine et al. 1993; Ueno and Igo 1997; Ishibashi et al. 1998), Peninsular Malaysia (Fontaine et al. 1994), Sumatra (Lange 1925; Fontaine and Vachard 1984, 1986; Nguyen 1986; Pringgoprawiro et al. 1998), northwestern Caucasus (Miklukho-Maklay 1954, Pronina-Nestell and Nestell 2001), Transcaucasia (Reitlinger 1965; Pronina 1988, 1989, 1999), Iran (Mohtat-Aghai and Vachard 2005), Turkey (Sellier de Civrieux and Dessauvagie

1965; Altiner 1978, 1984, 1988, 1999; Altiner and Zaninetti 1977; Altiner and Brönnimann 1980; Altiner et al. 1980; Altiner and Özgül 2001; Altiner and Özkan-Altiner 2001; Leven and Okay 1996; Ünal et al. 2003; Groves et al. 2005), Greece (Reichel 1946), Crimea (Pronina and Nestell 1997; Kotlyar et al. 1999), Germany (Scherp 1962), South Alps (e.g. Broglio-Loriga et al. 1988, Jenny-Deshusses 1991, Broglio-Loriga and Cassinis 1992), Poland (Woszczyńska 1987), and the Himalaya of India (Lys et al. 1980). In South China, the Lin et al. monograph (1990) is possibly the most comprehensive study of Paleozoic small foraminifers. These foraminiferal faunas have expanded our knowledge of the Late Permian oceanic life, but some species have been described based on poorly oriented thin sections that led to incorrect identification and limited their stratigraphic importance. Therefore, free specimens are the most useful in the study of Late Permian small foraminifers because both internal and external features can be studied. When free specimens are not available, at least well-oriented thin sections should be used.

Free specimens of small foraminifers are not commonly reported from Permian strata because of the difficulties of extraction of specimens from limestone. Some Permian assemblages from clastic rocks that can be disaggregated are well known, for example: Sellier de Civrieux and Dessauvagie (1965), Miklukho-Maklay and Ukharskaya (1975), Woszczyńska (1987) and Wang K. (1976). Recently, Shang et al. (2003) reported free foraminiferal specimens co-occurring with radiolarians from two sections of uppermost Permian strata in the Bandong and Liuqiao areas, southwestern Guangxi, South China and discussed their implication for diversity loss differentiation during the Permo-Triassic mass extinction. However, perhaps because of lack of enough specimens, no thin sections were illustrated showing the internal structure of the tests. Therefore, it is difficult to identify some of the forms. For example, some uniserial, rectilinear tests with strong longitudinal costae were identified as *Austrocolomia* (?) sp. (Shang et al. 2003, p. 381, pl. 1, figs. 4, 7; pl. 2, fig. 10). These forms are re-identified as *Pseudolangella costata* n. sp. herein (Pl. 5, figs.

1-5; Pl. 7, fig. 2), because after the study of thin sections made from free specimens, we found that the tests have a hyaline atelo-monolamellar wall and have gradually enlarging high fabiform chambers, which is totally different from the tests of *Austrocolomia*.

We revisited the Liugiao section in a comprehensive study of the paleontology and stratigraphy of the Permo-Triassic boundary and found many interesting free specimens of foraminifers in addition to those forms noted in Shang et al. (2003). We used SEM photomicrography for the study of external morphological features and prepared thin sections for the study of internal structures, which allows reconstruction of internal features.

Fourteen genera of foraminifers, including one new, and 20 species, including six new, have been identified from the uppermost Permian strata of the Liugiao section, southwestern Guangxi, South China. The aim of this paper is to illustrate and describe the small foraminiferal fauna discovered from the upper Changhsingian Dalong Formation and to present and interpret the composition of the fauna.

LOCALITY AND GEOLOGICAL SETTING

The area studied is located to the south of Nanning, the capital city of the Guangxi Zhuang Autonomous Region, China. The studied section is by the national highway N322 from Nanning to Pingxiang (text-fig. 1.1). Its geographic location is 22°6.196'N, 107°1.505'E.

The strata in this area are mainly Upper Permian (the Heshan, Changhsing, and Dalong Formations) and Lower Triassic (the Luolou Formation) (text-fig. 1.2). The Liugiao section comprises the Dalong Formation of late Changhsingian age, and the Luolou Formation of Induan age. Lithologically, the Dalong Formation from the Liugiao section can be divided into two parts. The lower part (from Bed 2 to Bed 6) is mainly composed of muddy and bedded chert with some intercalations of claystone and limestone, and yields abundant and diversified foraminifers, radiolarians, ostracods and brachiopods. The upper part (from Bed 7 to Bed 12) consists of siliceous mud rock with some thin intercalations of claystone, and yields a few ammonoids and bivalves.

The ammonoid data (Bu et al. 2006) show that strata from Bed 2 to Bed 12 contain the Changhsingian ammonoids *Pernodoceras robustum*, *Dushanoceras* cf. *D. rotarium*, *Huananoceras* cf. *H. perornatum*, and *Qianjiangoceras* sp. A few Triassic ammonoids such as *Lytphiceras* cf. *L. chamunda*, and *Ophiceras tingi* were obtained from the base of Bed 13. According to these data, the Permo-Triassic boundary in this section is possibly located between Bed 12 and Bed 13.

CHARACTERISTICS OF THE FORAMINIFERAL FAUNA

An abundant, relatively well-preserved and diverse small foraminiferal fauna including 20 species (six new) belonging to 14 genera (one new) has been obtained from the bedded chert and siliceous mud rocks of the Dalong Formation of the Liugiao section after dissolving the rock samples with HF. The foraminiferal taxa present include *Lasiodiscus*? sp., *Glomospirella*? *mamilla* n. sp., *Glomospirella*? *curva* n. sp., *Hemigordius*? *yini* n. sp., *Nodosaria*? sp., *Nodosariida* indet., *Nodoinvolutaria* sp., *Pseudolangella costata* n. sp., *Dalongella fusiformis* n. gen. and sp., *Geinitzina ichnouse* Sellier de Civrieux and Dessauvage 1965, *G.*? sp., *Geinitzina changhsingensis* n. sp., *G. kongdongshanensis* (Zhang and

Hong 2004), *Howchinella*? sp. A, *H.*? sp. B, *Pachyphloides inflatus* (Miklukho-Maklay 1954), *Ichthyolaria* sp., *Ichthyofrondina*? sp., *Frondinodosaria* sp., *Neoendothyra*? *reicheli* Reitlinger 1965, and *N.*? sp. Taxa found in this fauna and their stratigraphic distribution are shown in Figure 2.

This small foraminiferal fauna is characterized by the presence of diverse nodosariids that constitute over 70% of the species. Only two species of endothyrids (*Neoendothyra*? *reicheli* and *N.*? sp.) were found. No Colaniellas or fusulinaceans were found in the chert from the Liugiao section, although, they are found in the limestone intercalations (Gu et al. 2005), and some forms of Colaniellas were found at the adjacent Bandong section according to Shang et al. (2003). Significant loss of small foraminifers is noted in the Liugiao section between Bed 5 and Bed 6, where the specific diversity of foraminiferal species drops by 65%. Radiolarian data from this section also exhibit a clear extinction level between Bed 5 and Bed 6. According to Feng (personal communication, 2005), the specific extinction rate of radiolarian species at this level is 95%.

The composition of the small foraminiferal fauna in Bed 2 to Bed 7 of the Liugiao section is different from that in Bed 8 to Bed 10 and is characterized by abundant and diverse nodosariids, among which 15 species were found. In contrast, the small foraminiferal fauna in Bed 8 to Bed 10 consists of only four species, with *Geinitzina changhsingensis* n. sp. in Bed 8 being the sole nodosariid.

The recovered taxa are interpreted as a relatively deep-water fauna. Firstly, this fauna is extracted from siliceous rocks with abundant radiolarians. Although radiolarite can also indicate a shallow water environment (e.g. Folk and McBride 1978; McBride and Folk 1979), we still believe that the chert from the Dalong Formation is of deep-water origin because independent sedimentologic evidence reported by Meng et al. (2005) suggests that the Dalong Formation at the Liugiao section represents a relatively deep-water environment. Secondly, the recovered fauna occurs with abundant latentifistularian radiolarians (Feng et al. 2006), which are considered to live in a water column deeper than 200 meters (He et al. 2005a). Thirdly, the fauna is largely different from most of the contemporaneous ones of South China that are mostly from relatively shallow-water sequences (e.g. Lin et al. 1990). Six new species and even one new genus such as *Dalongella* are found in the assemblage that constitutes 30% of this fauna in specific diversity, even though there are only two taxa in common with those from the Upper Permian of the Tethyan region, such as *Geinitzina ichnouse* Sellier de Civrieux and Dessauvage, and *Pachyphloides inflatus* (Miklukho-Maklay). Finally and most interestingly, some brachiopods found in the Dalong Formation of the Liugiao section (He et al. 2005b) are from an antitropical environment indicating a water temperature neither cold nor warm, such as the genus *Costatumulus* Waterhouse, implying possible occurrence of cool-water in this area. In our opinion, because South China was in the tropics during the Late Permian (e.g. Golonka et al. 1994; Yin et al. 1999), if the environment is shallow, the temperature would be warm rather than cool. Of course, there are some other interpretations for cool-water in the tropics, such as upwellings in shallow tropical seas (e.g. Samankassou 2002). However, some paleogeographic evidence shows that during the Permo-Triassic transitional stage the Liugiao area was located to the west of Panthalassa (Golonka et al. 1994) where upwellings were less likely to occur because most upwellings occur at the eastern sides of modern oceans

(e.g. Summerhayes 1992). Therefore, the cool-water could probably be interpreted as representing a deep-water environment.

SYSTEMATIC PALEONTOLOGY

Considering that test morphology is of higher priority in foraminiferal classification, the authors use the system of higher taxa proposed by Mikhalevich (2001), Vdovenko et al. (1993) and Rauser-Chernousova et al. (1996), with some comments of G. Nestell (personal communication, 2006) for order and family level. Descriptions follow the methods of description and terminology proposed by Gerke (1967) for the bisymmetrical nodosariids. All specimens described in this paper are deposited in the Museum of China University of Geosciences, Wuhan, Hubei, China under number X0302.

Phylum Foraminifera d'Orbigny 1826

Class SPIRILLINATA Maslakova 1990; emend. Mikhalevich 1998

Order LASIODISCIDA Mikhalevich 1993

Family LASIODISCIDAE Reitlinger 1956

Genus *Lasiodiscus* Reichel 1946

Lasiodiscus? sp.

Plate 1, figures 1-5; plate 4, figure 1

Description: External features: Test free, very small, discoid, evolute. Test consists of proloculus and undivided pseudo-tubular second chamber. Second chamber forms six to seven volutions coiled planispirally. Tubular pillars fill one side of the test (Pl. 1, fig. 4). On the other side, some outgrowths are weakly developed (Pl. 1, fig. 2). Aperture is simple and terminal. Internal features: Second chamber increases slowly in height. Wall structure is unknown. Diameter of the test varies from 0.12mm to 0.22mm. Thickness of the test is 0.025mm.

Material: Seven free specimens were examined, of which two were prepared as thin sections.

Discussion: The present specimens are similar to representatives of the genus *Ammodiscus* Reuss based in their planispiral coiling. Some specimens, however, showed tubular pillars (Pl. 1, fig. 4) or outgrowths (Pl. 1, fig. 2), suggesting that this form should be assigned to the genus *Lasiodiscus* Reichel. The presence of the tubular pillar fillings, on the other hand, may be due to recrystallization. Therefore, the generic assignment is still questionable.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.

Order AMMODISCIDA Fursenko 1958

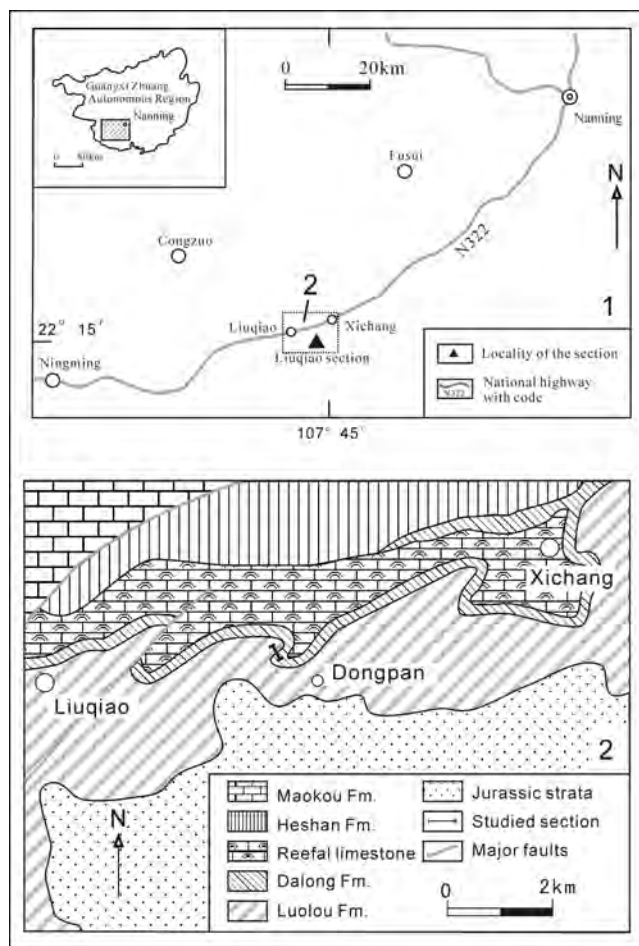
Family AMMODISCIDAE Reuss 1862

Genus *Glomospirella* Plummer 1945

Glomospirella? mamilla Gu, Feng and He n. sp.

Plate 1, figures 6-15; plate 4, figures 2, 3

Description: External features: Test free, bichambered, discoid, planoconvex. Peripheries in axial view are round, one side slightly concave, and the other slightly convex. The undivided tubular second chamber forms six to seven volutions. Initial one to three volutions streptospirally enrolled; terminal three to four planispiral volutions with axis of coiling perpendicular to the initial volutions. The coiling plane deviates progressively. Heights of the volutions increase gradually. Internal features: Proloculus is spherical, with diameter 0.02mm. Second cham-



TEXT-FIGURE 1

Location map and the regional geological map of the studied area. 1, Geographic locality of the studied area. 2, Regional geological map of the studied area. Locality of the Liuqiao section is shown, and distribution of the Maokou, Heshan, Dalong and Luolou formations is presented.

ber is tubular, slowly increasing in height and width. Height of the last volution is 0.02mm. Aperture is simple and terminal. Wall structure is unknown because of recrystallization. Thickness of the wall in the last volution is 0.01mm. Diameter of the test is 0.26-0.33mm, thickness 0.07mm, in the holotype, respectively, 0.26mm and 0.07mm.

Designation of types: The specimen illustrated in plate 4, figure 3 (X0302-48/DP-2) is designated as the holotype. It is from Bed 2, Liuqiao section, Dalong Formation, upper Changhsingian, Upper Permian.

Etymology: From the Latin *mamilla* nipple.

Material: 21 specimens were examined, of which eight were prepared as thin sections.

Discussion: *Glomospirella? mamilla* n. sp. is similar to *Glomospirella robusta* Scherp (1962, p. 292, pl. 4, figs. 18-21) from the Zechstein of northwestern Germany in its size and shape, but differs in having relatively slower chamber growth. The new species resembles one described by Ho (1959, p. 398, pl. 4, figs. 14-23) under the name *Glomospirella irregularis*

(Moeller) from the Early Triassic Jialingjiang (Chialingkiang) Formation of Sichuan, South China, in its type of coiling and test shape in axial section, but differs in its relatively higher volutions. The new species also resembles *Glomospirella vulgaris* Ho (1959, p. 399, pl. 6, figs. 1-7) in its coiling, but differs in having the asymmetrically prominent central part. Because the wall structure is unknown, the generic assignment is equivocal.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.

Glomospirella? curva Gu, Feng and He **n. sp.**

Plate 2, figures 1-7; plate 4, figures 4, 5

Description: External features: Test free, bichambered, small, discoid, and evolute. Lateral sides in axial view are flush or slightly concave. The terminal stage is uncoiled, extending along the coiling plane at a varied angle from the periphery of the discoid part or curving irregularly on and adhering to one side of the test. Internal features: Proloculus is spherical, with diameter 0.01mm. Initial two or three volutions are streptospirally coiled, following four to five planispiral volutions with slight displacement. Terminal stage is as described in the External features part. The second chamber increases gradually in height. Wall structure is unknown. Diameter of the test is 0.20-0.33mm, width 0.05-0.07mm, in the holotype, respectively, 0.21mm and 0.06mm.

Designation of types: The specimen illustrated in plate 4, figure 5 (X0302-50/DP-3) is designated as the holotype. It is from Bed 3, Liugiao section, Dalong Formation, upper Changhsingian, Upper Permian.

Etymology: From the Latin *curvus* curved.

Material: 15 specimens were examined, of which three were prepared as thin sections.

Discussion: *Glomospirella? curva* n. sp. is similar to the representatives of the genus *Rectocornuspira* Warthin, but differs in its streptospirally coiled initial part. The new species differs from other species of *Glomospirella* in its irregularly uncoiled terminal part. Because the wall structure is unknown, the authors assign the new species to *Glomospirella* with question.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.

Order HEMIGORDIOPSIDA Mikhalevich 1987 [nom. transl. Pronina 1990 ex Hemigordiopsina Mikhalevich 1987] Family HEMIGORDIIDAE Reitlinger in Vdovenko et al. 1993 Genus *Hemigordius* Schubert 1908

Hemigordius? yini Gu, Feng and He **n. sp.**

Plate 2, figures 8, 12, 13; plate 4, figures 6, 7

Description: External features: Test free, small, bichambered, pseudoinvolute, lenticular in side views. In axial view, peripheries are rounded; lateral sides are slightly convex, sometimes slightly concave in the umbilical area. Internal features: Test consists of two chambers. Proloculus is spherical, with diameter of 0.02mm. Second pseudotubular chamber makes six to seven volutions, coiling is planispiral with insignificant displacement of the initial two volutions. Chamber lumen is semicircular. The height of the second chamber increases rapidly. Height of the last volution is 0.015mm. Wall structure is un-

known. Umbilical area has thick secondary lateral thickenings. Test diameter (D) 0.21-0.31mm, width (W) 0.07-0.08mm. The D/W ratio is 0.30-0.34.

Designation of types: The specimen illustrated in plate 4, figure 7 (X0302-52/DP-2) is designated as the holotype. It is from Bed 2, Liugiao section, Dalong Formation, upper Changhsingian, Upper Permian.

Etymology: After Professor Yin Hongfu, from China University of Geosciences.

Material: Six specimens were examined, of which three were prepared as thin sections.

Discussion: The new species resemble *Hemigordius discoides* Lin, Li and Sun (Lin et al. 1990, pl. 24, fig. 6) non Miklukho-Maklay 1968, described from the Changhsing Formation of Shanglin County, Guangxi, South China, in the coiling of the initial two volutions, but differs in having a semicircular chamber lumen and lenticular test shape. Because the wall structure is unknown, the generic assignment is equivocal.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.

Class NODOSARIATA Mikhalevich 1992

Order NODOSARIIDA Calkins 1926 [=Nodosariida Guvenç 1967]

Family NODOSARIIDAE Ehrenberg 1838

Genus *Nodoinvolutaria* Lin 1978

Nodoinvolutaria sp.

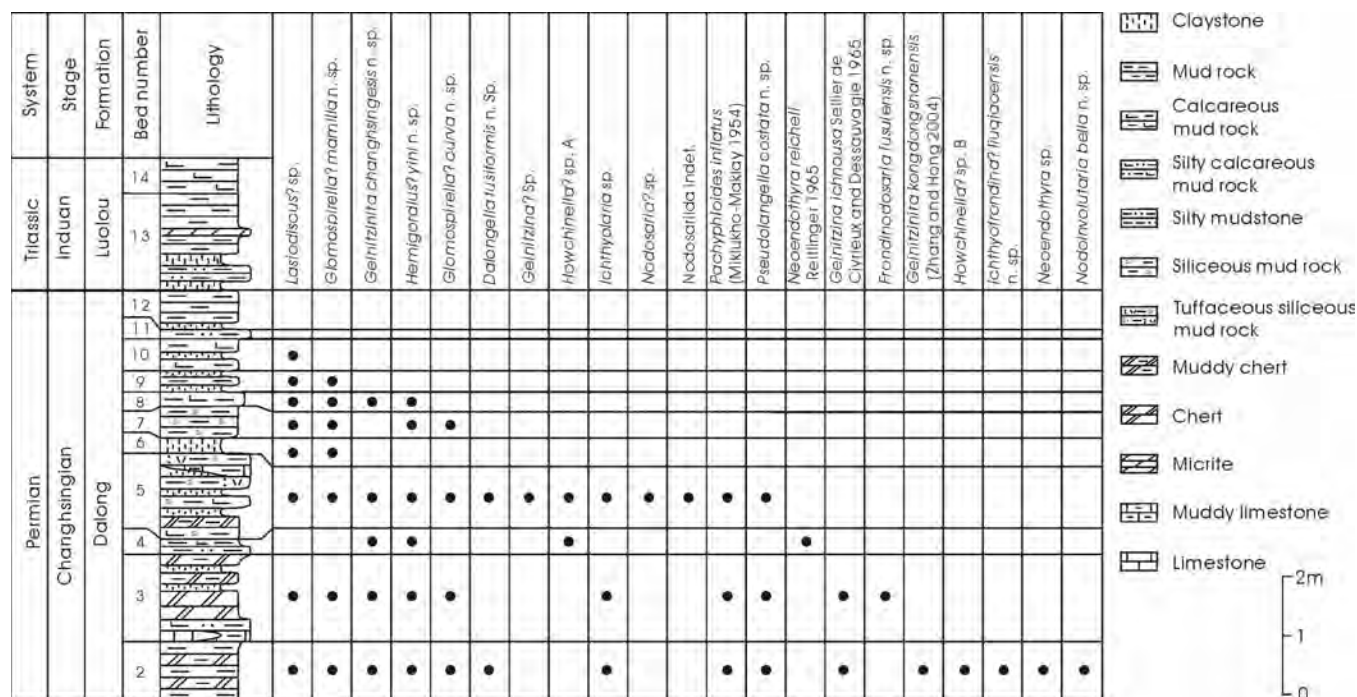
Plate 3, figure 6; plate 5, figure 6.

Description: External features: Test free, small, multi-chambered, tongue-shaped or rectangular oval, moderately to strongly elongate, weakly flattened. In axial view, the apertural and initial periphery is parabola-shaped. The lateral sides are wavy. Internal features: Test consists of six uniserial chambers. Proloculus is spherical, with diameter 0.04mm. Proloculus is one third overlapped by the second chamber. The third chamber completely envelopes the initial two ones and this allows only four chambers to be observed externally. The following chambers are crescentiform. Chambers grow rapidly in the initial part, but very slowly in the terminal part. The initial two chambers are low to moderately high and the last three ones are high. Axial height of the second chamber is 0.025mm; third 0.03mm; fourth 0.06mm; fifth 0.05mm; sixth 0.06mm. Width of the second chamber is 0.05mm; third 0.07mm; fourth, fifth and sixth 0.09mm. Aperture is terminal, central, and probably oval. Wall structure is unknown because of recrystallization. Test length L 0.29-0.34mm, width W 0.10mm. Ratio L/W is 2.90-3.40.

Material: Two specimens are found, of which one was prepared as a thin section.

Discussion: The present form differs from *N. hunanica* Lin (1978, p. 14, pl. 1, figs. 22-23) described from the Maokou Formation, Lower Permian (now Middle Permian), Hunan, South China, by smaller size of the test, relatively regularly arranged initial chambers, and higher last chambers. More specimens are needed to establish a reasonable new species.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.



TEXT-FIGURE 2

Stratigraphic distribution of the foraminiferal species from the Liugiao section.

Genus *Pseudolangella* Sellier de Civrieux and Dessauvage 1965

Pseudolangella costata Gu, Feng and He **n. sp.**

Plate 3, Figures 1-5; Plate 5, Figure 2

Austrocolomia (?) sp. SHANG et al. 2003, p. 381, pl. 1, figs. 4, 7; pl. 2, fig. 10.

Description: External features: Test free, multichambered, uniserial, triangular, moderately elongate, rounded in transverse section. In axial view, the initial periphery is arcuate, the terminal periphery rounded, and the lateral sides wavy. Surface of the test ornamented by strong longitudinal costae through out, vanishing at the apertural surface. Sutures are moderately distinctive, and horizontal. Aperture is terminal, central, rounded with low and rounded projection. Internal features: Test consists of six chambers. Proloculus is spherical, with internal diameter 0.01mm, one third enveloped by the second chamber. The following chambers are moderately high to high fabiform, gradually enlarging as added. Axial height of the second chamber is 0.015; third 0.02; fourth 0.025; fifth 0.04; sixth 0.04. Axial width of the second chamber is 0.03; third 0.035; fourth 0.05; fifth 0.07; sixth 0.08. Aperture is simple, with apertural projections. Wall is atelo-monolamellar, and radial. Test length (L) is 0.15-0.23mm, width (W) 0.07-0.11mm, in the holotype, respectively, 0.21mm and 0.09mm. Ratio L/W is 2.14-2.09

Designation of types: The specimen illustrated in plate 5, figure 2 (X0302-61/DP-2) is designated as the holotype. It is from Bed

2 of the Dalong Formation from the Liugiao section, upper Changhsingian, Upper Permian.

Etymology: From the Latin *costa* bib.

Material: Five specimens are examined, of which one was prepared as a thin section.

Discussion: The new species is similar to *Pseudolangella acus* Pronina (1989, p. 33, pl. 2, fig. 36) described from the *Paratirolites kittli* Zone of the Dorashanian (or Changhsingian) of Transcaucasia based on test shape, size and chamber shape, but differs in its slightly produced aperture and wavy lateral sides.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.

Genus *Dalongella* Gu, Feng and He **n. gen.**

Type species: *Dalongella fusiformis* n. gen., n. sp.

Description: Test free, multichambered, uniserial, rhombic or fusiform oval, moderately elongate, rounded in transverse section. Chambers strongly curved, high to very high, narrow crescentiform. Chambers increase rapidly in size, strongly overlapped. Sutures are not excavated. Aperture is terminal, central, rounded with radial grooves. Wall is atelo-monolamellar, and radial.

Etymology: After Dalong Formation, Changhsingian, Upper Permian, South China.

Discussion: The new genus is very similar to the genus *Involutaria* Gerke in chamber shape and test shape, but differs by the atelo-monolamellar test wall and rounded aperture with radial grooves.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.

***Dalongella fusiformis* Gu, Feng and He n. sp.**

Plate 3, figure 8; plate 5, figures 3, 4

Description: External features: Test free, multichambered, uniserial, rhombic or fusiform oval, moderately elongate, rounded in transverse section. In axial view, the apertural and initial peripheries are sharp-angled, the lateral sides even. Aperture is terminal, central, rounded, with radial grooves. Sutures are not excavated. Internal features: Test consists of five chambers. Proloculus is spherical, with diameter 0.025mm, about one third enveloped by the second chamber. The following chambers are uniserial, rectilinear, high, narrow crescentiform in shape. Chambers increase rapidly in size, and are strongly overlapping. Axial height of the last chamber is 0.10mm. Width of the last chamber is 0.11mm. Aperture is simple with developed thickening. Wall is atelo-monolamellar, radial, with thickness 0.005mm in the last chamber. Test length (L) is 0.31-0.36mm, width (W) 0.12-0.13mm, in the holotype 0.34mm and 0.13mm, respectively. Ratio L/W is 2.58-2.76.

Designation of types: The specimen illustrated in Plate 5, figure 4 (X0302-63/DP-2) is designated as the holotype. It is from Bed 2 of the Dalong Formation from the Liuqiao Section, upper Changhsingian, Upper Permian.

Etymology: From the Latin *fusiformis* fusiform.

Material: Three specimens were found and illustrated.

Discussion: See description and discussion of the genus.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.

Family GEINITZINIDAE Bozorgnia 1973

Genus *Geinitzina* Spandel 1901 [= *Neogeinitzina* K. Miklukho-Maklay 1954]

***Geinitzina ichnouse* Sellier de Civrieux and Dessauvage**
Plate 2, Figure 14; Plate 4, Figures 9, 10

Geinitzina ichnouse SELLIER DE CIVRIEUX and DESSAUVAGIE 1965, p. 35, pl. 3, fig. 5. – PRONINA, 1989, pl. 2, figs 3-5.

Description: External features: Test free, multichambered, very small, triangular, very weakly elongate, and strongly flattened, bilobed in transverse section. Median depression weakly developed. In axial view, apertural periphery is sinuate; initial periphery is rounded. Sutures are indistinctive. Aperture is terminal, central, and probably oval. Internal features: Test consists of eight to nine uniserial and rectilinear chambers. Proloculus is spherical, with diameter 0.010-0.015mm. The second chamber strongly overlaps the proloculus. The following chambers are low, very weakly curved, and sinus-shaped. Chambers increase rapidly in width, very slowly in height, and strongly overlapped. Axial height of the seventh chamber is 0.015mm, the eighth 0.020mm and the last 0.030mm; the width of the seventh chamber is 0.105mm, the eighth 0.125mm and the last 0.155mm. Wall structure is unknown. Test length is (L)

0.17-0.23mm, width (W) 0.16-0.21mm. Ratio L/W is 1.06-1.09.

Material: Three specimens were examined, of which two were prepared as thin sections.

Discussion: The specimens resemble the holotype of *Geinitzina ichnouse* Sellier de Civrieux and Dessauvage (1965, p. 35, pl. 3, fig. 5) in size and shape of the test, and chamber shape. They differ from *Geinitzina araxensis* (Pronina 1989, p. 34, pl. 2, figs. 1, 2) from the Dorashamian of Transcaucasia in their relatively more overlapping chambers and more rounded initial end.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.; upper Bellerophon Formation, Turkey; *Paratirolites kittli* zone, Transcaucasia.

Genus *Geinitzina* Sellier de Civrieux and Dessauvage 1965

***Geinitzina changhsingensis* Gu, Feng and He n. sp.**

Plate 2, figures 9-11; plate 4, figures 8, 14

Description: External features: Test free, multichambered, small, triangular, moderately to weakly elongate and moderately compressed. Transverse section is oval biconcave. Longitudinal median depression well developed. Sutures are insignificant. Apertural periphery is truncate, lateral sides even. Aperture is terminal, centered and slit-like. Internal features: Test consists of seven uniserial and rectilinear chambers. Proloculus is spherical, with internal diameter 0.03mm. The second chamber moderately envelopes the proloculus. The following chambers are low, semi-sinus shaped, weakly overlapping. Axial height of the fourth chamber is 0.25mm; fifth 0.028mm; sixth 0.03mm and seventh 0.035mm. Axial width of the fourth chamber is 0.09mm; fifth 0.11; sixth 0.12; seventh 0.13. Aperture is with very thin annular fold. Although the test wall is recrystallized, part of it still preserves radial structure and the wall structure can be assumed as radial. Wall thickness is 0.01mm. Test length 0.21-0.34mm, test width 0.15-0.20mm. In the holotype, the test length (L) is 0.21mm and width (W) is 0.15mm. Ratio L/W is 1.40-1.70.

Designation of types: The specimen illustrated in Figure 6.14 (X0302-54/DP-3) is designated as the holotype. It is from Bed 3, Liuqiao section, Dalong Formation, upper Changhsingian, Upper Permian.

Etymology: After the Changhsingian Stage, Upper Permian.

Material: Five specimens were studied, of which two were prepared as thin sections.

Discussion: The new species differs from *Geinitzina sosninae* Vuks (1984, p. 56, pl. 2, fig. 9) described from the Dzhulfian (or Wuchiapingian) *Araxoceras* beds of Transcaucasia, in its smaller test, less elongate test, and truncated apertural surface.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.

***Geinitzina kongdongshanensis* (Zhang and Hong)**

Plate 4, Figure 11

Neogeinitzina kongdongshanensis ZHANG and HONG 2004, p. 74, pl. 2, fig. 41.

Description: Test free, multichambered, large, bi-triangular in shape, strongly elongate. Transverse section is oval biconcave. In axial view, apertural periphery is truncate and lateral sides are slightly convex, initial periphery rounded arcuate. Test consists of 10 uniserial and rectilinear chambers. Proloculus is spherical, with diameter 0.04mm, enveloped weakly by the second chamber. The following chambers are low, box-shaped, and very weakly curved, and very weakly to weakly overlapping. Axial height of the fourth chamber is 0.015; the fifth 0.025; the sixth 0.03. Axial width of the fourth chamber is 0.11; fifth 0.13; sixth 0.16. Aperture is terminal, central, and silt-like, with a very thin annular fold. Wall is atelo-monolamellar and radial. Wall thickness is 0.020-0.025mm. Test length is 0.45-0.50mm, width 0.30-0.33mm. Ratio L/W is 1.5.

Materials: Five specimens were examined, of which one was prepared as a thin section.

Discussion: Zhang and Hong (2004) described species *Neogeinitzina kongdongshanensis* from the Changhsing Formation of the Datian area, Fujian Province, South China. Our specimen resembles Zhang and Hong's (2004, pl. 2, fig. 41) specimen in shape and size of the test and chamber shape. However, the genus *Neogeinitzina* Miklukho-Maklay has been considered by Pronina-Nestell and Nestell (2001) as a synonym of the genus *Geinitzina* Spandel because the apertural tube throughout the test is due to tangential section being to the margin of the test (Pronina-Nestell and Nestell 2001, p. 206). In our opinion, the chamber shape of our form is weakly curved and box-shaped, which makes it different from that of the genus *Geinitzina*. Therefore, we assign our species to the genus *Geinitzina*. The species *Geinitzina kongdongshanensis* (Zhang and Hong) differs from *Geinitzina changhsingensis* sp. n. in its larger number of chambers, larger test size, thicker wall and relatively lower chambers.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, Guangxi; Changhsing Formation, Fujian, South China.

Genus *Howchinella* Palmieri 1985 in Foster et al. 1985

Howchinella? sp. A

Plate 3, figure 9; plate 4, figure 13

Description: External features: Test free, multichambered, uniserial, tongue-shaped, strongly elongate and flattened. In axial view, the initial periphery is rounded, lateral sides are slightly wavy, apertural periphery is angular. Aperture is terminal, central, and probably rounded. Internal features: Initial chambers are not well preserved; the following chambers are arcuate, low to very low. Chamber growth is very slow in height and width. Septa slightly curved, with weakly developed thickening in the apertural border of the septa. Wall structure is probably hyaline radial. Test length is 0.45mm, width 0.11mm.

Material: Two specimens were studied and illustrated, of which one was prepared as a thin section.

Discussion: The present specimens are similar to unquestioned representatives of the genus *Howchinella* in test shape and there is some clue of typical apertural thickenings (showed by an arrow in pl. 4, fig. 13a) of *Howchinella*. However, because we have no more specimens, this assignment is not confidently, we assign it into *Howchinella* with question mark.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.

Howchinella? sp. B

Plate 4, figure 12

Description: Test free, multichambered, uniserial, tongue-shaped, strongly elongate and flattened. In axial view, the initial periphery is rounded, the lateral sides are strongly wavy, and the apertural periphery is angular. Internal features: Test consists of eight chambers. Proloculus is spherical, with internal diameter 0.04mm. The following chambers are arcuate, low to very low. Chambers increase very slowly in height and width. Axial height of the second and third chamber is 0.020mm; fourth and fifth 0.025mm; sixth 0.030mm; seventh 0.035mm; eighth 0.040mm. Width of the second chamber is 0.060mm; third 0.075mm; fourth 0.085mm; fifth 0.100mm; sixth 0.120mm; seventh 0.130mm; eighth 0.140mm. Septa are slightly curved, with prominent apertural thickenings. Aperture is terminal, central, and probably oval, with moderately apertural thickening and a nipple-shaped projection. Wall structure is probably hyaline radial. Test length is 0.45mm, width 0.11mm. Ratio L/W is 4.09.

Material: Only one specimen was studied and illustrated.

Discussion: The development of the apertural thickenings would make this form a *Howchinella*. However, more specimens are needed for confident generic or even specific assignment.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.

Family PACHYPHLOIDAE Loeblich and Tappan 1984

Genus *Pachyphloides* Sellier de Civrieux and Dessauvage 1965

Pachyphloides inflatus (Miklukho-Maklay)

Plate 5, Figure 7

Geinitzina inflata MIKLUKHO-MAKLAY 1954, p.31, pl. 3, fig. 4.
Frondicularia inflata (Miklukho-Maklay 1954) WANG, K. 1976, p. 189, pl. 1, fig. 3a-c.

Pachyphloides inflatus (Miklukho-Maklay 1954) PRONINA-NESTELL and NESTELL 2001, p. 210, pl. 2, fig. 28.

Description: Test free, multichambered, small, egg-diamond-shaped, very weakly elongate, strongly flattened, and lens-shaped in transverse section. In axial view, apertural periphery is curved; initial periphery is rounded-angular. Test consists of seven chambers. Proloculus is spherical, with internal diameter 0.01mm, about half enveloped by the second chamber. The following chambers are low and arcuate, strongly overlapping and grow slowly in height and width. Axial height (h) of the fourth chamber is 0.020mm, the fifth 0.025mm, the sixth 0.030mm, the last 0.035mm; the width (w) of the fourth chamber 0.06mm, the fifth 0.08mm, the sixth 0.10mm, the last 0.12mm. The h/w ratio varies from 0.28-0.33, average 0.30. Septa are strongly curved. Aperture is terminal, central, and rounded. Wall structure is unknown. Test length (L) is 0.15mm, width (W) 0.13mm. Ratio L/W is 1.15.

Materials: Only one specimen was examined and illustrated.

Discussion: The specimen resembles the holotype of *Pachyphloides inflatus* (Miklukho-Maklay) [= *Geinitzina inflata*] described from the northwestern Caucasus, Russia (Miklukho-Maklay 1954, p.31,

pl. 3, fig. 4) in all morphological features such as test shape, chamber shape, chamber growth and overlapping. However, our specimen is smaller. Since it is from chert, the smaller size of the test may be due to the lilliputian effect under stressed environment. Therefore, the authors assign this form to *Pachyphloides inflatus* (Miklukho-Maklay 1954).

Occurrence: Upper Permian, upper Changhsingian; Dalong Formation, South China; algal-foraminiferal limestone of the Nikitian lithofacies and reefal limestone of the Urushtenian lithofacies of the Belalabinskaya Group, northwestern Caucasus, Russia.

Family ICHTHYOLARIIDAE Loeblich and Tappan 1986
Genus *Ichthyolaria* Wedekind 1937; emend. Norling 1972

***Ichthyolaria* sp.**

Plate 2, figures 15-17

Description: Test free, multichambered, uniserial, fusiform oval, strongly elongate, strongly flattened, and compressed hexagonal in transverse section. Initial and apertural peripheries are rounded, or rounded-angular; lateral sides straight. Three strong longitudinal costae flare from the initial part and congregate to the terminal of both front and back sides of the test. Shape and size of proloculus is unknown. The following chambers are chevron-shaped, probably high. Aperture is terminal, central, and probably slit-like. Wall structure is unknown. Length (L) of the test is 0.34-0.40mm, width (W) 0.17-0.19mm, thickness 0.04-0.05mm. Ratio L/W is 2.00-2.11.

Material: Three specimens were studied and illustrated.

Discussion: The specimen illustrated on plate 2, figure 15b shows that the chambers are chevron-shaped and strongly curved, which together with very strongly flattened and elongated test make it assignable to *Ichthyolaria*. The present speci-

mens differ from *Ichthyolaria bicostata* (d'Orbigny) in the presence of three strong costae on each side of the test and indistinctive sutures. Additional specimens are necessary for sectioning in order to determine internal features of the test.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.

Genus *Ichthyofrondina* Vachard 1991 in Vachard and Ferrière 1991

***Ichthyofrondina?* sp.**

Plate 5, figure 1

Description: Test free, multichambered, lanceolate, moderately elongate and strongly flattened, oval in transverse section. In axial view, initial periphery strongly angular, apertural periphery is parabola-shaped and lateral sides are sinuate. Test consists of six or seven chambers. Proloculus is probably spherical, with diameter 0.02mm. The following chambers are moderate to high chevron-shaped. Second, third and fourth chambers are very strongly overlapped. The last two chambers moderately overlapping. Chamber growth in height is moderate. The initial few chambers increase in width rapidly, the following ones slowly. Axial height (h) of the fourth chamber is 0.35mm, the fifth 0.04mm, the last 0.06mm; width (w) of the fourth chamber is 0.60mm, the fifth 0.80mm, and the last 0.105mm. The h/w ratio of the chambers varies from 0.50-0.58, average 0.56. Septa are strongly curved, with small thickenings in the apertural border. Aperture is terminal, central, and probably oval. Wall structure is unknown. Length (L) of the test is 0.32mm, width (W) 0.13mm, thickness not measured. Ratio L/W is 2.38.

Material: Only one specimen was found and prepared as a thin section.

PLATE 1

All SEM microphotography. All scale bars 100µm, except 2-4—10µm; 5, 12—50µm.

The collection number and sample number are given in order for each specimen and separated by a virgule.

1-5 *Lasiodiscus?* sp. All side views except 5—lateral view of a broken test.

1 X0302-1/DP-7;

2 X0302-2/DP-8, note the possible outgrowth (arrow);

3 X0302-3/DP-8;

4 X0302-4/DP5, showing possible tubular pillars (arrow);

5 X0302-5/DP-7.

6-15 *Glomospirella?* *mamilla* Gu, n. sp. All side views except 12 lateral view.

6 X0302-6/DP-8;

7 X0302-7/DP-8;

8 X0302-8/DP-8;

9 X0302-9/DP-8;

10 X0302-10/DP-7;

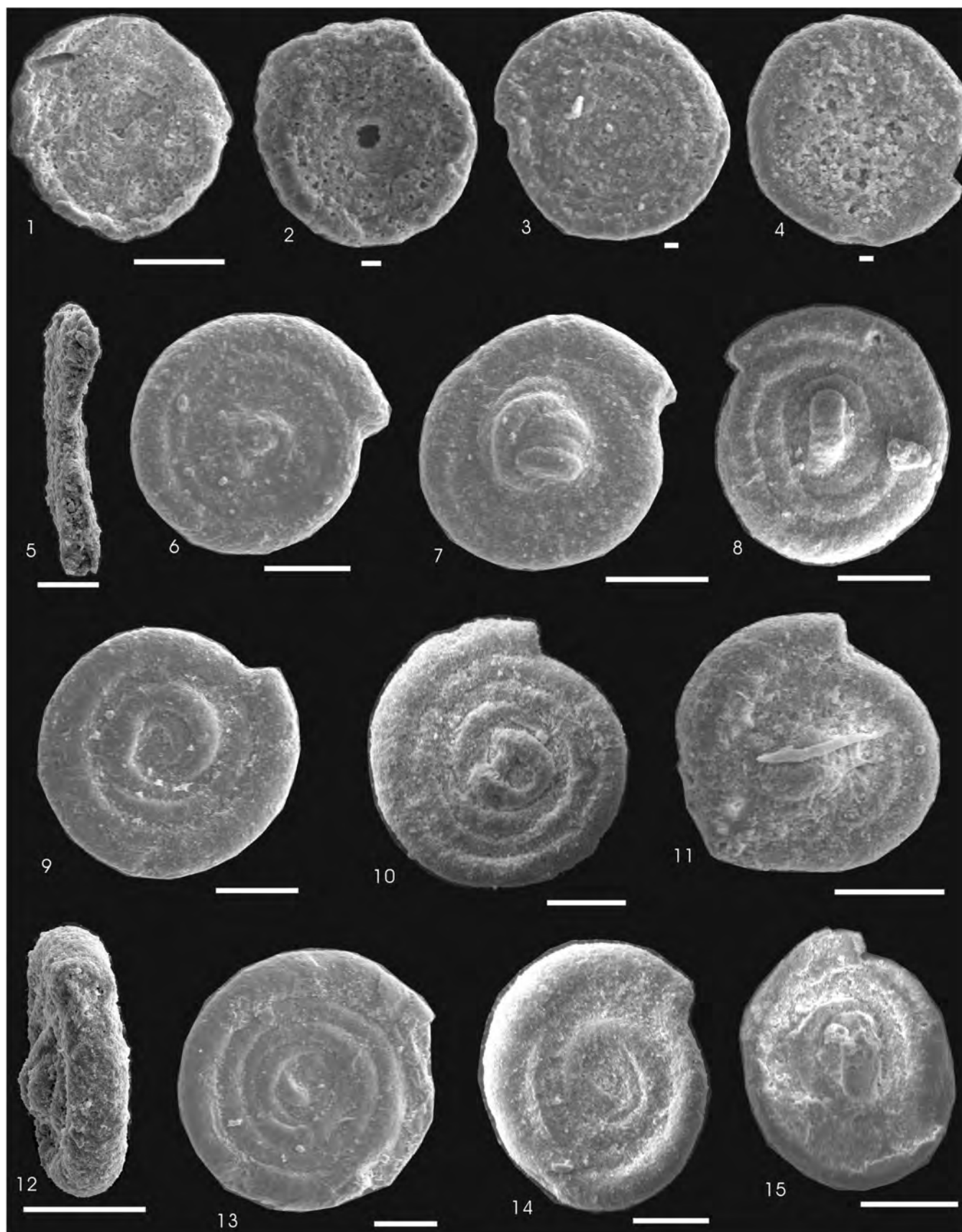
11 X0302-11/DP-7;

12 X0302-12/DP-5, showing that the mamilla-like initial chambers protruding out of one side of the test (arrow);

13 X0302-13/DP-8;

14 X0302-14/DP-8;

15 X0302-15/DP-10.



Discussion: The present form differs from *Ichthyofrondina latilimbata* (Sellier de Civrieux and Dessauvague) (Sellier de Civrieux and Dessauvague, 1965, pl. 75, pl. 5, fig. 41, pl. 14, fig. 11) in its much more elongate test. Because the inner apertural structure is not observed, we assign this species to *Ichthyofrondina* with question mark.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.

Family LINGULINIDAE Loeblich and Tappan 1961
Genus *Frondinodosaria* Sellier de Civrieux and Dessauvague 1965

***Frondinodosaria* sp.**

Plate 5, figure 5

Description: Test free, multichambered, uniserial, oval ribbon-shaped, very strongly elongate, very weakly flattened, and oval in transverse section. In axial section, the lateral sides are straight in the initial part and become slightly wavy in the terminal part, the initial periphery is rounded, and the apertural periphery angular. Test consists of nine uniserial rectilinear chambers. Proloculus is elongate oval in shape, with internal height 0.06mm, and diameter 0.04mm. Second chamber envelopes one fourth of the proloculus. The following three chambers are moderately high, crescentiform, weakly enveloping. The last four chambers are moderately high to high, rectangular, very weakly overlapped. Chambers grow very slowly in height and width, but the last chamber decreases in size. Axial height of the second, third, fourth and fifth chamber is 0.030mm; sixth 0.040mm; seventh 0.045mm; eighth 0.050mm;

ninth 0.040mm. Width of the second and third chamber is 0.055mm; fourth and fifth 0.060mm; sixth and seventh 0.070mm; eighth 0.080mm; ninth 0.050mm. Septa in the initial four or five chambers are curved, but become horizontal in the remaining chambers. Thickness of the septa between the last two chambers is 0.005mm. Aperture is terminal, central, and oval, with a moderately developed external neck. Wall structure is unknown because of recrystallization. Test length 0.430mm, width 0.085mm. Ratio L/W is 5.05.

Material: Only one specimen was found and prepared as a thin section.

Discussion: This form is similar to a form identified as *Frondinodosaria nodosaria* (Reuss) by Sellier de Civrieux and Dessauvague (1965, p. 64, pl. 13, fig. 8) in overall shape, but it differs by smaller size of the test and the last chamber decreasing in size. More specimens are needed to establish a new species.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China.

Class ROTALIATA Mikhalevich 1980
Order ENDOTHYRIDA Fursenko 1958
Family ENDOTHYRANOPSIDAE Reitlinger 1958
Genus *Neoendothyra* Reitlinger 1965

Neoendothyra? reicheli Reitlinger
Plate 3, Figures 10, 11; Plate 5, Figure 8

PLATE 2

All SEM microphotography. All scale bars 100µm, except 15b—50µm.

The collection number and sample number are given in order for each specimen and separated by a virgule.

1-7 *Glomospirella? curva* Gu, n. sp. All side views except 7—lateral view of a broken test.

1 X0302-16/DP-5;

2 X0302-17/DP-5;

3 X0302-18/DP-3;

4 X0302-19/DP-5;

5 X0302-20/DP-5;

6 X0302-21/DP-5;

7 X0302-22/DP-3, showing the formation of the second chamber.

8, 12-13 *Hemigordius? yini* Gu, n. sp.

8 X0302-23/DP-5, periphery view, showing the aperture and slightly convex sides;

12 X0302-24/DP-5, note weakly concaved umbilical area; side view

13 X0302-25/DP-4; side view

9-11 *Geinitzinita changhsingensis* Gu, n. sp.

9 X0302-26/DP-5, apertural view, showing the slit-like aperture and bi-lobed transverse section of the test;

10 X0302-27/DP-4; axial view

11 X0302-28/DP-5, axial view.

14 *Geinitzina ichnousea* Sellier de Civrieux and Dessauvague. X0302-29/DP-2, axial view.

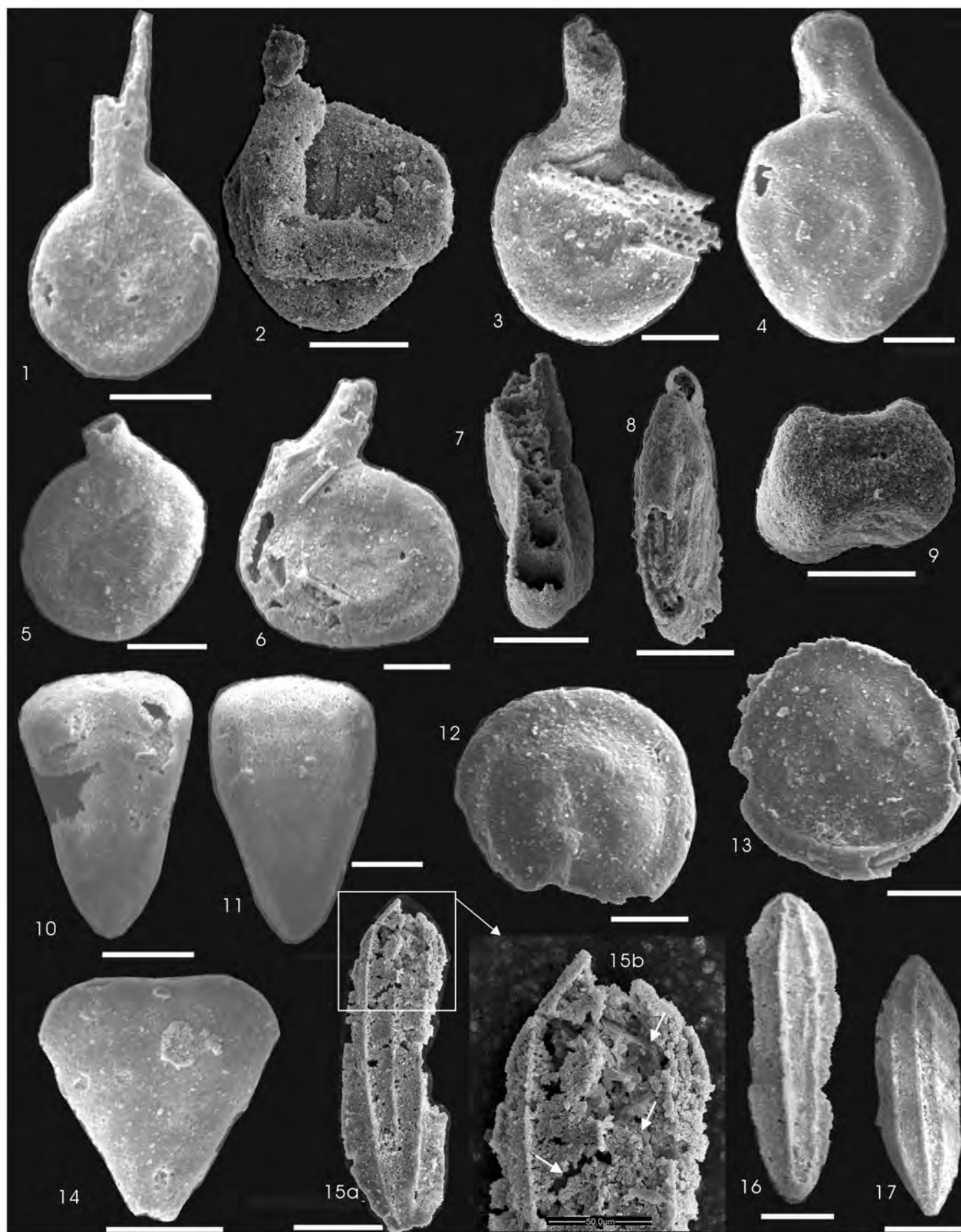
15-17 *Ichthyolaria* sp.

15 X0302-30/DP-5; axial view

15b enlargement of 15a, chevron shaped chamber shown by dissolved septa (arrows);

16 X0302-31/DP-3; axial view

17 X0302-32/DP-2; axial view.



Neoendothyra reicheli REITLINGER 1965, p. 61, pl. 1, figs. 6-9. – LYS 1980, p. 93, pl. 6, fig. 1. – HUNG 1981, p. 30, pl. 3, figs. 4, 6, 18, 19. – MOHTAT-AGHAI and VARCHARD 2005, pl. 1, figs. 9-12.

Description: External features: Test free, multichambered, involute, planispiral, lenticular or oval rhombic in axial section. The periphery is rounded acute in axial section. In transverse view, the periphery is wavy. Aperture is basal, oval. Sutures are slightly concave. Internal features: Test consists of about three planispiral volutions. Proloculus shape and size is unknown. Height of the volutions increases gradually. Chambers are sub-rectangular, and gradually increase in height. There are eight to nine chambers in the last volution. Wall structure is unknown because of recrystallization. Test diameter 0.39-0.46mm, axial width 0.18mm.

Material: Two free specimens were found in the Liuiqiao section. In order to show the internal structures, we illustrate another specimen from Bed 22 of adjacent Liuiqiao section (Pl. 5, fig. 8).

Discussion: Correct generic assignment of specimens is made difficult by recrystallization of the wall. Therefore, this form could be assigned to either *Robuloides* (hyaline radial wall) or *Neoendothyra* (microgranular wall). The authors tends to regard the wall of this form originally microgranular in that there is no clue of hyaline radial wall noted in this form, but in the same sample (LQ-22), there are many other foraminifers exhibit possibly a hyaline radial wall. Because it would be more likely that one sample would show a uniform degree of diagenesis or recrystallization, and a hyaline wall structure would be more likely to be preserved, the wall structure of the present form would not be hyaline radial. Anyway, more specimens are needed for confident identification of this form, therefore, we put a question mark on the generic name. Although the specimens present are recrystallized and initial part is not well preserved, they are similar to the forms of Reitlinger (1965, p. 61, pl. 1, figs. 6-9) in the oval shape of the test in the axial section, type of coiling and chamber growth.

Occurrence: Upper Permian, upper Changhsingian, Dalong Formation, South China; the *Palaeofusulina* zone, North Viet-

nam; Upper Dorashamian, Transcaucasia; Lamayuru block, Himalaya, Indus suture Zone; Hambast Formation, Central Iran.

CONCLUSIONS

The Upper Permian Dalong Formation from Guangxi, southwestern China, contains abundant small foraminifers including 20 species (six new) belonging to 14 genera (one new). The new genus is *Dalongella*, and the recovered species are *Lasiodiscus*? sp., *Glomospirella*? *mamilla* n. sp., *Glomospirella*? *curva* n. sp., *Hemigordius*? *yini* n. sp., *Nodosaria*? sp., *Nodosariida* indet., *Nodoinvolutaria* sp., *Pseudolangella costata* n. sp., *Dalongella fusiformis* n. sp., *Geinitzina ichnousea* Sellier de Civrieux and Dessauvage 1965, *G.*? sp., *Geinitzina changhsingensis* n. sp., *G. kongdongshanensis* (Zhang and Hong 2004), *Pachyphloides inflatus* (Miklukho-Maklay 1954), *Ichthyofrondina*? sp., *Ichthyolaria* sp., *Howchinella*? sp. A, *H.*? sp. B, *Fronidinodosaria* sp., *Neoendothyra*? *reicheli* Reitlinger 1965, and *N.*? sp. This small foraminiferal fauna is characterized by the presence of diverse nodosariids that constitute over 70% of the species. In Bed 2 to Bed 7 of the Liuiqiao section 15 species were found, whereas in Bed 8 to Bed 10 only four species extracted. This small foraminiferal fauna is interpreted as a relatively deep-water fauna in the following four aspects. Firstly, independent sedimentologic evidence suggests that the Dalong Formation at the Liuiqiao section represents a relatively deep-water environment. Secondly, the co-occurring abundant latentifistularian radiolarians would also support the deep-water model. Thirdly, the fauna is largely different from most of the contemporaneous ones of South China that are mostly from relatively shallow-water sequences. Finally, indicating possible occurrence of cool water in this area, paleoecological data of brachiopods from the Dalong Formation of the Liuiqiao section could probably be another supporting evidence of the deep-water model because of the impossibility of upwelling occurrence in this area.

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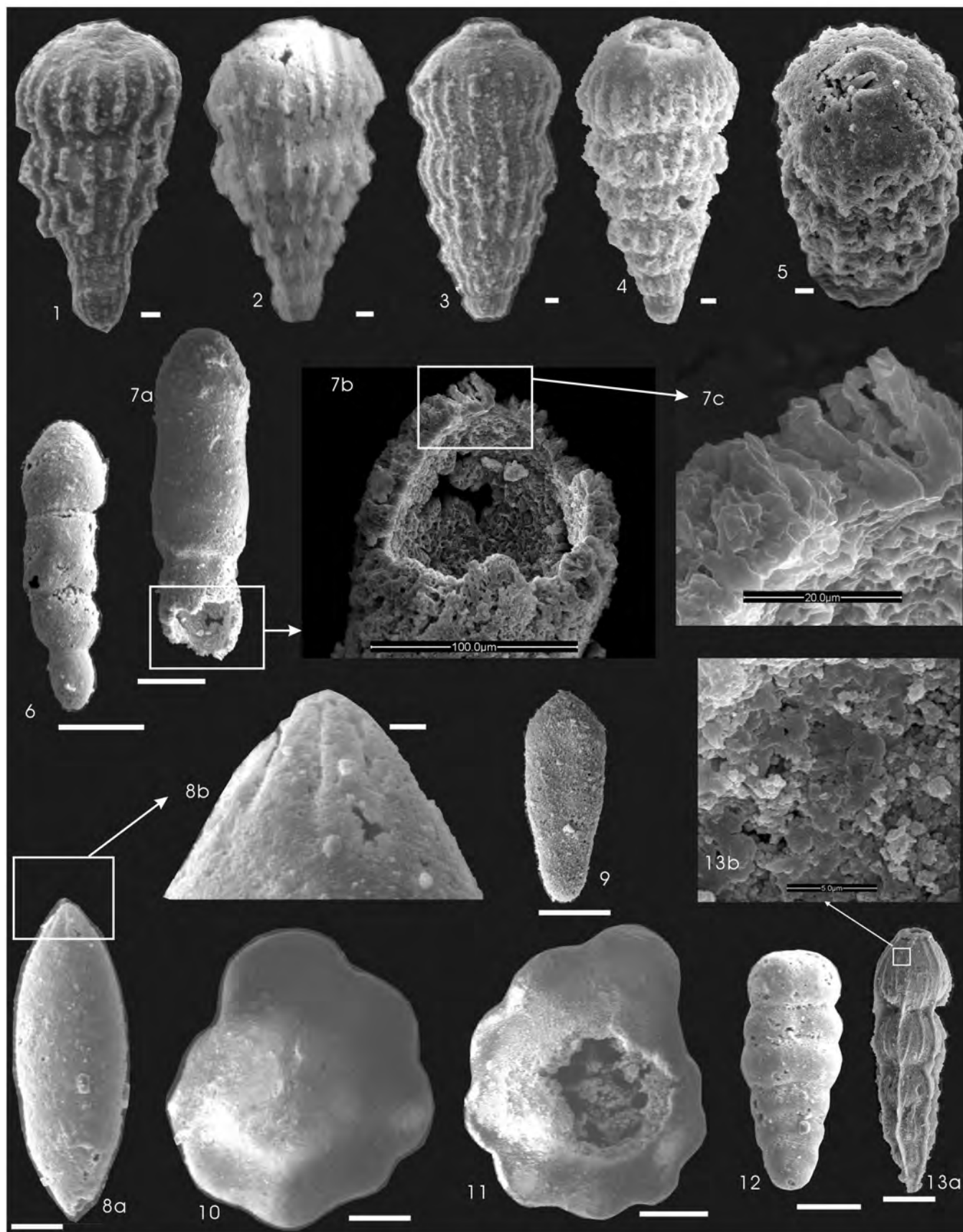
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PLATE 3

All SEM microphotography. All scale bars 100µm except 1-5—10µm; 8b—10µm; 8c—20µm; 13b—5µm. The collection number and sample number are given in order for each specimen and separated by a virgule.

- 1-5 *Pseudolangella costata* Gu, n. sp. 1, X0302-33/DP-5; 2, X0302-34/DP-5; 3, X0302-35/DP-5; 4, X0302-36/DP-5; 5, X0302-37/DP-2, all axial views except 5 pertural view.
- 6 *Nodoinvolutaria* sp. X0302-38/DP-2, axial view.
- 7 *Nodosariidae* indet. 7a, X0302-39/DP-5, axial view; 7b, enlargement of 7a; 7c, enlargement of 7b, showing radial wall structure.

- 8 *Dalongella fusiformis* Gu, n. gen. and n. sp. 8a, X0302-40/DP-5, axial view; 8b, enlargement of 8a, showing the radial groove structure of the aperture.
- 9 *Howchinella*? sp. A. X0302-41/DP-4, axial view.
- 10, 11 *Neoendothyra*? *reicheli* Reitlinger. 10, X0302-42/DP-4; 11, X0302-43/DP-4, axial views..
- 12 *Geinitzina*? sp. X0302-44/DP-5, axial view.
- 13 *Nodosaria*? sp. 13a, X0302-45/DP-5, axial view; 13b, enlargement of 13a, showing wall structure.



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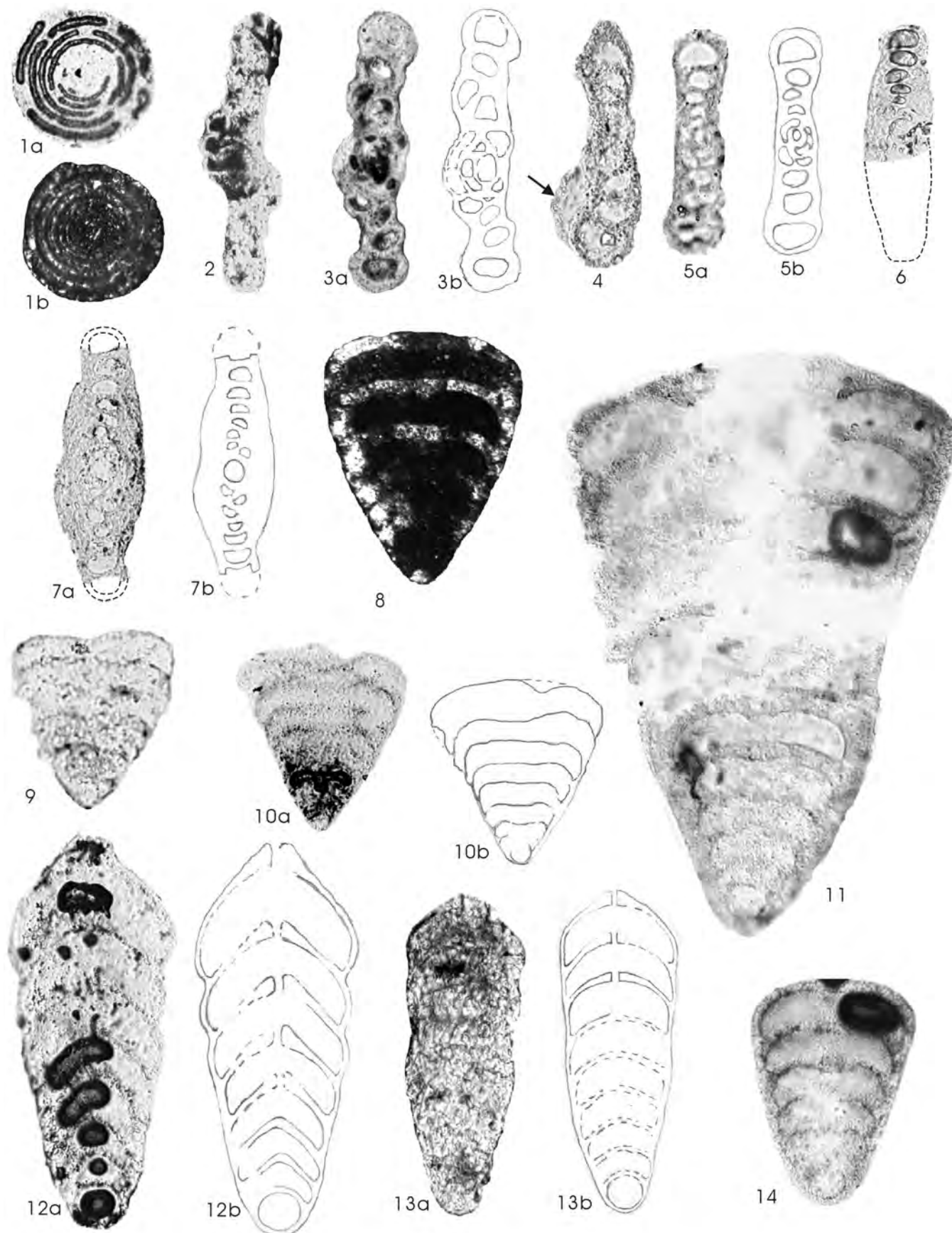
PLATE 4

Thin section microphotography (Figs. 1, 2, 3a, 4, 5a, 6, 7a, 8, 9, 10a, 11, 12a, 13a, 14) with hand drawings (Figs. 3b, 5b, 7b, 10b, 12b, 13b) illustrating important features. All under transmitted light except 1b and 8 under cross polarized light.

All axial sections, except 1 transverse section. Magnification is $\times 200$.

The collection number and sample number are given in order for each specimen and separated by a virgule.

- | | | | |
|------|--|------|---|
| 1 | <i>Lasiodiscus</i> ? sp. X0302-46/DP-5. | 9,10 | <i>Geinitzina ichnousa</i> Sellier de Civrieux and Dessauvage. 9, X0302-56/DP-2; 10, X0302-57/DP-3. |
| 2,3 | <i>Glomospirella</i> ? <i>mamilla</i> Gu, n. sp. 2, X0302-47/DP-9; 3a, X0302-48/DP-2, holotype. | 11 | <i>Geinitzina kongdongshanensis</i> (Zhang and Hong). X0302-55/DP-2. |
| 4,5 | <i>Glomospirella</i> ? <i>curva</i> Gu, n. sp. 4, X0302-49/DP-3, note the last volution adhering at on side of the test (arrow); 5, X0302-50/DP-3, 5a, holotype. | 12 | <i>Howchinella</i> ? sp.B. X0302-58/DP-2. |
| 6,7 | <i>Hemigordius</i> ? <i>yini</i> Gu, n. sp. 6, X0302-51/DP-9; 7a, X0302-52/DP-2, holotype. | 13 | <i>Howchinella</i> ? sp.A. X0302-59/DP-5, note the apertural thickening (arrow). |
| 8,14 | <i>Geinitzina changhsingensis</i> Gu, n. sp. 8, X0302-53/DP-3; 14, X0302-54/DP-3, holotype. | | |



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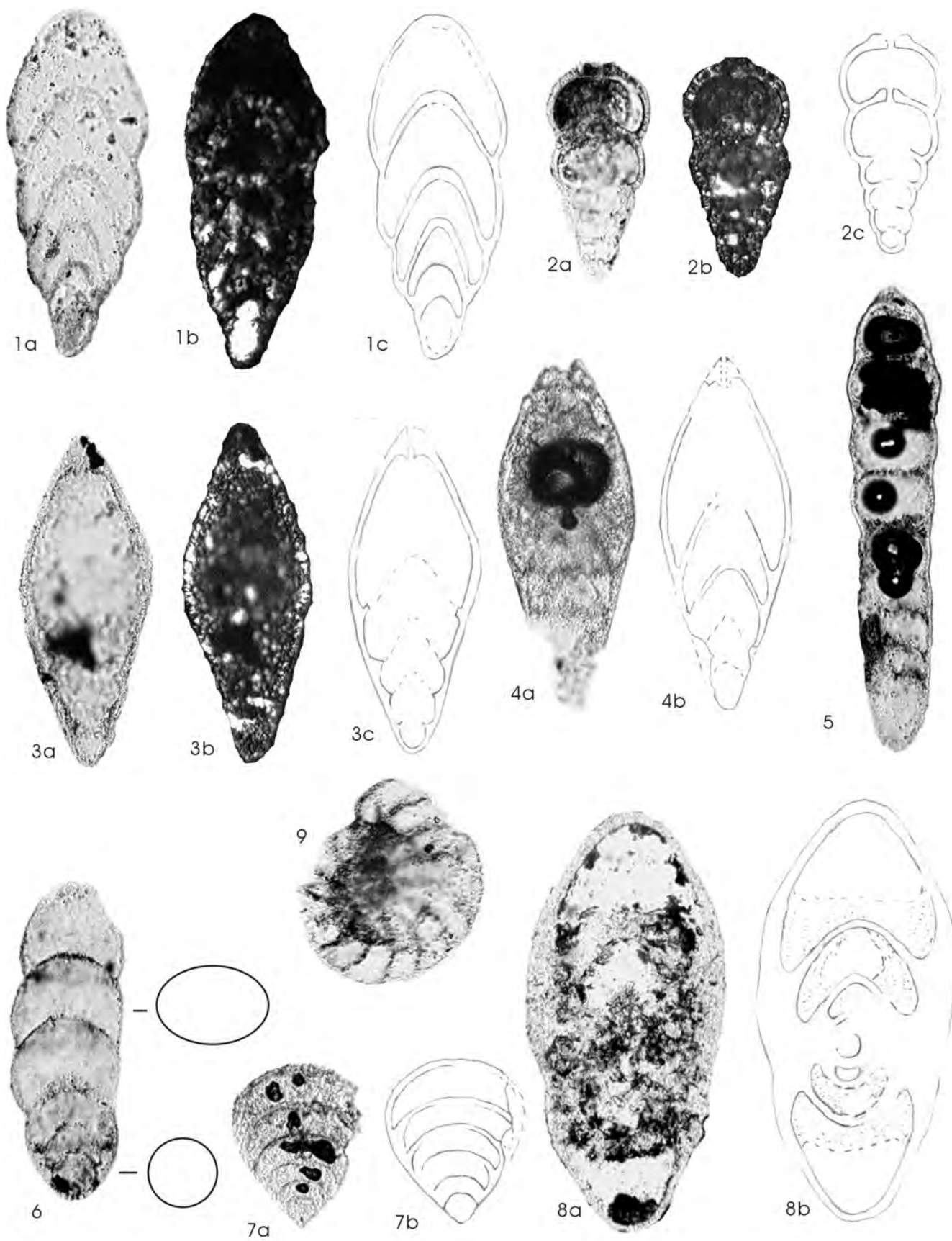
PLATE 5

Thin section microphotography (Figs. 1a, 1b, 2a, 2b, 3a, 3b, 4a, 5, 6, 7a, 8a, 9) with hand drawings (Figs. 1c, 2c, 3c, 4b, 7b, 8b) illustrating important features. All axial sections, except 9 - transverse section. Magnification is $\times 200$.

All under transmitted light except 1b, 2b, 3b - under cross polarized light.

The collection number and sample number are given in order for each specimen and separated by a virgule.

- 1 *Ichthyofrondina?* sp. X0302-60/DP-2.
- 2 *Pseudolangella costata* Gu, n. sp. X0302-61/DP-2, 2a, holotype.
- 3,4 *Dalongella fusiformis* Gu, n. gen. and n. sp. 3, X0302-62/DP-2; 4, X0302-63/DP-2, 4a, holotype.
- 5 *Frondinodosaria* sp. X0302-64/DP-3.
- 6 *Nodoinvolutaria* sp. X0302-65/DP-2.
- 7 *Pachyphloides inflatus* (Miklukho-Maklay). X0302-66/DP-2.
- 8 *Neoendothyra? reicheli* Reitlinger. X0302-67/LQ-22.
- 9 *Neoendothyra?* sp. X0302-68/DP-2.



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