

Late Campanian to early Maastrichtian planktonic foraminiferal assemblages from Cretaceous oceanic red beds (CORBs) in the Yongla section, Gyangze, southern Tibet

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ABSTRACT: Well-preserved and abundant planktonic foraminifera have been recovered from limestones of the Cretaceous oceanic red beds (CORBs) from the Yongla section in Gyangze, southern Tibet. This foraminiferal assemblage is dominated by species of *Contusotruncana*, *Globotruncana*, and *Globotruncanita*. The assemblage contains 21 species belonging to 7 genera and suggests a late Campanian to early Maastrichtian age, which permits a more precise age constraint for CORBs in the Gyangze area. This planktonic assemblage provides an important biostratigraphic datum for the correlations of the CORBs in the Himalayan region of the northern Tethys. The interval yielding foraminifera in the Yongla section may be the youngest known CORB in the Gyangze area.

KEYWORDS: Planktonic foraminifera; late Campanian to early Maastrichtian; CORBs; Gyangze; southern Tibet.

INTRODUCTION

In southern Tibet, reddish lithofacies ranging from the late Santonian to early Maastrichtian (Wan et al. 2005a, 2005b; Li et al. 2011a, 2011b) are developed extensively in the northern Tethyan Himalaya. These sediments, which present a colorful contrast to the black-dominated strata of the subjacent black shales, were considered as CORBs (Cretaceous oceanic red beds) and were assigned to the Chuangde Formation (Li et al. 1999; Wang et al. 2000; Hu 2002). The term CORBs as used in this paper represents reddish sedimentary rocks (generally limestones, marls, shales, and cherts) usually containing abundant planktonic foraminifera and indicating deposition in a pelagic marine environment (Hu et al. 2005). Occurrences of CORBs have been documented for more than 150 years since Štúr (1860) and Gümbel (1861) first described them from the Púchov beds in the Carpathians and the Nierental beds in the Eastern Alps. Since then CORBs were found to occur globally in outcrops within New Zealand, Asia, Africa, Europe, Caribbean and in DSDP (Deep Sea Drilling Project) and ODP (Ocean Drilling Program) cores from the Indian, Tethyan Atlantic, and Pacific oceans (Widder 1988; Premoli Silva et al. 1992; Wonders 1992; Balla and Bodrogi 1993; Mitchell 1995; Premoli Silva and Sliter 1995; Robertson and Sharp 1998; Erba et al. 1999; Robertson and Shalloo 2000; Strasser et al. 2001; Tur et al. 2001; Bak 2002; Michalik et al. 2002; Wägreich 2002; Zhao and Wan 2003; Hu et al. 2005; Wägreich and Krenmayr 2005; Wan et al. 2005a, 2005b; Melinte and Jipa 2005; Hu et al. 2006a; Hu et al. 2006b; Li et al. 2007; Hikuroa et al. 2009; Melinte-Dobrinescu et al. 2009; Skupien et al. 2009; Wägreich et al. 2009; Wang et al. 2009; Wendler et al. 2009; Wiese 2009; Li et al. 2011a, 2011b; Coccioni et al. 2012; Hu et al. 2012; Setoyama and Kaminski, 2015) (text-fig. 1 B). They have a

wide stratigraphic range spanning from the Aptian of the Lower Cretaceous to the end of the Cretaceous (Wägreich 1995; Bak 2002; Hu et al. 2005; Melinte and Jipa 2005; Wägreich and Krenmayr 2005; Wägreich et al. 2009; Wang et al. 2009; Coccioni et al. 2012; Wägreich et al. 2012; Wolfgring et al. 2016; Wolfgring and Wägreich 2016; Wolfgring et al. 2018). The study of CORBs provides new insight into the global climate and oceanic changes during the warm Cretaceous (Hu et al. 2012).

CORBs in the Gyangze area are located within the Subduction Mélange Belt (Chen et al. 1984), near the Yarlung-Zangbo Suture Zone, which marks where the Tethys Ocean was consumed during the approach and collision of India with Eurasia (Aitchison et al. 2000). Therefore a better understanding of CORBs in the Gyangze region could provide new insight into the evolutionary history of the Neo-Tethys in this region. Previous studies of CORBs in Gyangze mainly focus on the Chuangde section (e.g., Li et al. 2005; Wan et al. 2005a, 2005b; Wang et al. 2005; Hu et al. 2006b), while CORBs in the Yongla section, which is easily accessible and not far from the Chuangde section, is little known. CORB sediments are well exposed and enriched with microfossils in the Yongla section (text-fig. 2A, Unit 4, text-fig. 2E).

Planktonic foraminifera play a critical role providing age constraints for the CORBs and, to date, most planktonic foraminiferal studies from CORBs in the Tethys were made mainly in Italy (Premoli Silva 1977; Coccioni et al. 1991, 1992, 1995, 2012; Premoli Silva and Sliter 1995; Hu et al. 2005; Hu et al. 2006a; Petrizzo et al. 2011; Coccioni and Premoli Silva 2015), Austrian Alps (Wägreich et al. 2006, 2012; Wolfgring et al. 2016, 2018; Wolfgring and Wägreich 2016), Slovakia, West-

ern Carpathians (Salaj and Gasparikova 1983), southeast Hungary (Balla and Bodrogi 1993), Romania, East Carpathians (Ion and Szasz 1994), north Caucasasia (Tur et al. 2001), Turkey (Oz et al. 2016) and southern Tibet (Zhao and Wan 2003; Wan et al. 2005a, 2005b; Li et al. 2007, 2011). Four planktonic foraminiferal zones, the *Dicarinella asymetrica*, *Globotruncanita elevata*, *Globotruncana ventricosa* and (*Globotruncanita*) *Radotruncana calcarata* Zones, were proposed by Wan et al. (2005a, 2005b) with an age ranging from the late Santonian to early late Campanian. However, no or few planktonic foraminiferal images were provided in these studies and, therefore detailed biostratigraphic and microfossil evidence for the CORBs in Gyangze are still lacking.

In this paper, we report a new planktonic foraminiferal assemblage from CORBs in the Yongla section of Gyangze, southern Tibet. This well-preserved planktonic assemblage provides a more precise biostratigraphic framework for the CORBs. On the basis of our new findings, we discuss the regional correlations of the CORBs in the northern Tethyan Himalaya.

GEOLOGICAL SETTING

Cretaceous marine sediments are exposed extensively in the Tethyan Himalayan region of southern Tibet and are located between the Greater Himalayan and the Indus-Yarlung Zangbo Suture Zone (IYZS) (Gansser 1964; Wang et al. 1996; Yin and Harrison 2000) (text-fig. 1A). The Tethyan Himalaya belongs to the northern Greater India continental margin (text-fig. 1B), and this region could be further subdivided into northern and southern subzones by the E-W running Tingri-Gamba Thrust (TGT) (Hu et al. 2008). The CORBs are only widespread in the northern subzone (Hu et al. 2005; Wan et al. 2005a, 2005b). Except the Chuangde section, the Yongla section in Gyangze studied in this paper is another typical outcrop of the CORBs in the northern subzone, which may belong to the Yamdrok mélange (Aitchison et al. 2000; Hu et al. 2006b).

The Yongla section, which was first discussed by Hu (2002), is located about 20 km to the east of Gyangze, southern Tibet (28°58'54.1" N, 89°48'11.4" E, Alt 4464 m) (text-fig. 1C–D). Based on lithological differences, this section was separated into four units (text-fig. 2A). The lower 10.7 m of the section, unit 1, consists of gray to black shales with a whitish-gray weathering color and a few siliceous concretions at the top (text-fig. 2B). The second interval, 10.7 m to 19.3 m, is composed of dark-colored chert that contains abundant radiolaria (text-fig. 2C). Unit 3, ranging from 19.3 m to 22.9 m, is characterized by gray and greenish-gray shales (text-fig. 2D). Strata overlying the shales of unit 3 are a sequence of red-colored beds (CORBs), classified as unit 4 (text-fig. 2E). This interval has sharp contact with the underlying shales and consists of medium-bedded, red limestones and marly limestones. The CORBs (Unit 4) and lower chert (Unit 2) in this section are exotic blocks, and the black shales (Units 1 and 3) are matrix of the mélange. The studied interval belongs to the lower part of the CORBs in the Yongla section.

MATERIALS AND METHODS

A total of 10 samples of red limestones spanning ~18 m of the CORBs were collected during a field trip in 2017 (text-fig. 2A, Unit 4, text-fig. 2E, text-fig. 3). Samples studied for planktonic foraminifera were both thin sectioned and wet-sieved. Laboratory procedures for retrieving isolated foraminiferal tests mainly followed the method by Tur et al. (2001) and Green

(2013). Each sample was chipped into pieces approximately 1 cm in diameter and then immersed in concentrated acetic acid in a well-labeled beaker. The beakers were placed in a fume hood for 1–2 days. The residue was washed through two stainless steel sieves (550 µm and 120 µm for each) under a continuous flow of water. The residue was dried at room temperature. All the illustrated specimens were photographed with a Hitachi TM3030 Scanning Electron Microscope (SEM) at the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (NIGPAS). All the studied material is deposited at the NIGPAS.

RESULTS AND DISCUSSION

Age assignment for the planktonic foraminiferal assemblage in Yongla section

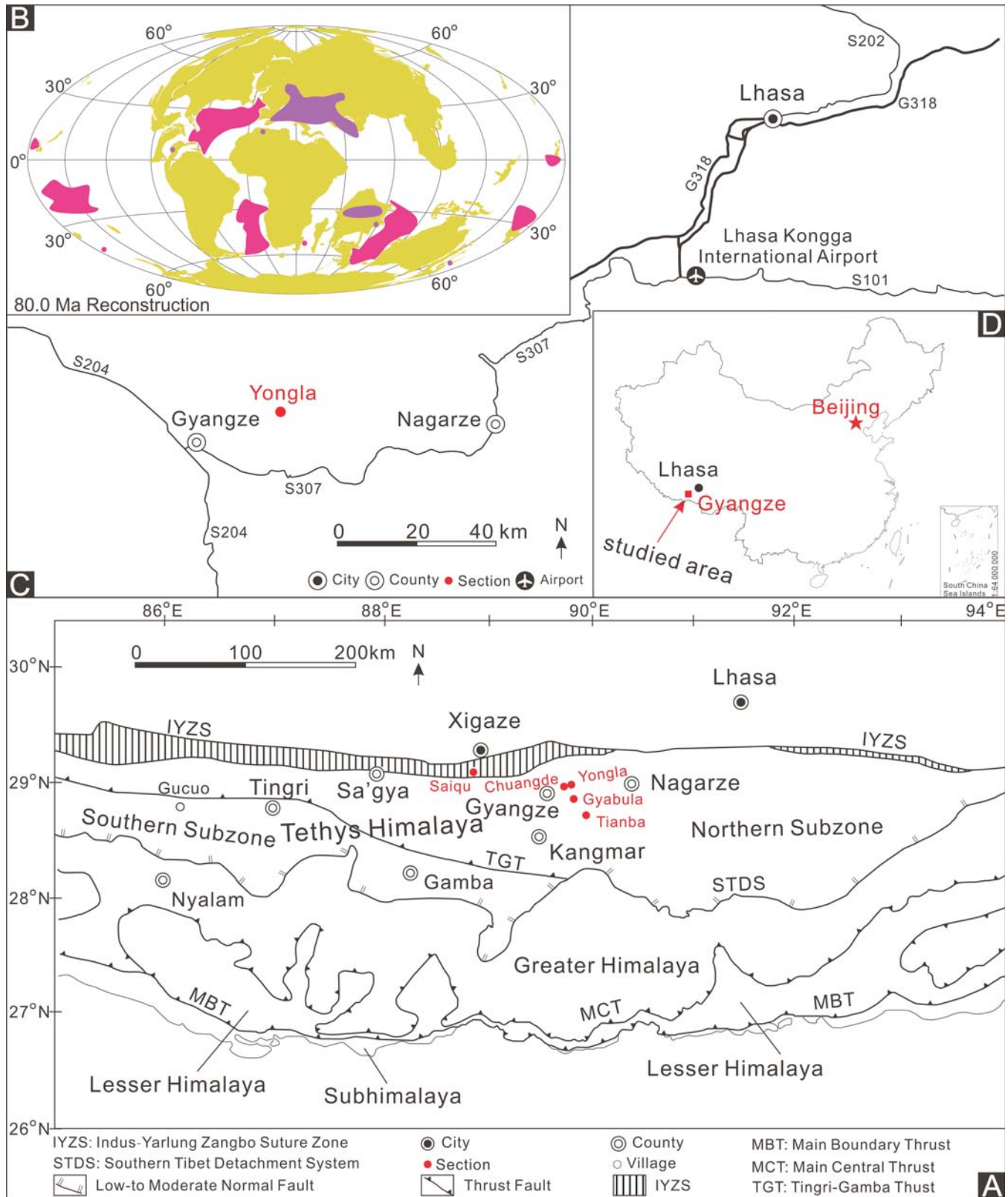
A relatively diverse and well-preserved planktonic foraminiferal assemblage was found in the Yongla section. The assemblage contains 21 species from 7 genera and is dominated by species of *Contusotruncana*, *Globotruncana*, and *Globotruncanita*. The distribution of these planktonic foraminifera in the Yongla section is shown in text-fig. 3, and all the significant species identified in this paper are illustrated in Plates 1–5.

Among all the species, *Globotruncanita stuarti* was observed from two samples, one from near the base and the other from the top of the studied interval. The *Gl. stuarti* Interval Zone was established in Trinidad by Bolli (1957, 1966). Subsequently, a revised definition of this zone was proposed in the Tingri section, southern Tibet by Willems et al. (1996), defined as the interval from the highest occurrence of *Radotruncana calcarata* (= *Globotruncanita calcarata* of Willems et al. 1996) to the lowest occurrence of *Gansserina gansseri*. The *Gl. stuarti* Zone was applied in sections from Iran, but the zonal definitions were different. A *Gl. stuarti* Partial Range Zone, defined from the HO of *R. calcarata* to the LO of *Ga. gansseri*, was used by Mogaddam (2002) and was dated as early Maastrichtian. Esmailbeig (2018) defined the upper limit of the *Gl. stuarti* Zone by the LO of *Globotruncanella havanensis* instead of the LO of *Ga. gansseri*, and considered the zone to indicate a late Campanian age. This is consistent with the age assignment for this zone in the latest version of the Geological Time Scale (Ogg et al. 2016). The planktonic foraminiferal assemblage recovered from the studied CORBs in Yongla section correlates with part of the zones mentioned above from Iran.

Petrizzo et al. (2011) observed that *Globotruncanita atlantica* could be a potential marker for global correlation since it is restricted to the Campanian in the Bottaccione section, the Caribbean Sea, Shatsky Rise, Tanzania, Exmouth Plateau (Petrizzo et al. 2011) and Tunisia (Robaszynski et al. 2000). This species was detected only in one sample from the lower part of the studied stratigraphic interval of the CORBs in the Yongla section. Considering the absence of *G. havanensis*, *Ga. gansseri* and younger biozonal markers, the planktonic foraminiferal assemblages recovered from CORBs in the Yongla section, Gyangze southern Tibet suggest a late Campanian to early Maastrichtian age.

Regional correlation

Outcrops of CORBs are found extensively in the northern Tethys Himalaya. Planktonic foraminifera from CORBs in Gyangze were reported in the Jiabula section (= Gyabula section in Wan et al. 2005a, Zhao and Wan 2003) and the Chuangde



TEXT-FIGURE 1

Sketch map showing the tectonic setting and location of the studied area and section. A. Sketch geological map of the studied area and section (after Hu et al. 2008); B. Paleogeographic reconstruction for 80 Ma (modified from <http://www.odsn.de/odsn/index.html>) showing the distribution of CORBs both on continents (in purple) and in oceans (in red) (after Wang et al. 2009); C–D. Location of the studied stratigraphic area and section.

section (Wan et al. 2005a, 2005b) (text-fig. 1A). Three planktonic foraminiferal zones from red beds in the Jiabula section were identified, including the *Globotruncanita elevata*, *Globotruncana ventricosa* and *Globotruncanita stuartiformis* Zones (Zhao and Wan 2003), and correlated with part of the Chuangde section. A more detailed biostratigraphic elaboration from CORBs of the Chuangde section was recorded by Wan et al. (2005a, 2005b) and four planktonic zones, the *Dicarinella asymetrica*, *Globotruncanita elevata*, *Globotruncana ventricosa*, and *Radotruncana (Globotruncanita) calcarata* were recognized, pointing to an age from late Santonian to early late Campanian. The interval in the Yongla section dated as late Campanian to early Maastrichtian is the youngest known CORB in Gyangze.

Li et al. (2007) reported a planktonic foraminiferal assemblage from CORBs in the Saiqu section of Sa'gya, west of Gyangze, and assigned them to the late Campanian. The CORBs in the Yongla section can be correlated with their counterpart in the Saiqu section, while the poorly preserved biozonal markers from thin sections of the Saiqu section hampered further correlations.

Detailed planktonic foraminiferal data from the CORBs in the Tianba section of Kangmar, south of Gyangze, were provided by Li et al. (2011b). Six planktonic foraminiferal zones were recognized by that author, the *Globotruncanita elevata*, *Globotruncana ventricosa*, *Radotruncana calcarata*, *Globotruncanella havanensis*, *Globotruncana aegyptiaca* and *Gansserina gansseri* Zones, indicating an early Campanian to early Maastrichtian age. The CORBs in the Yongla section may be correlated with the upper part of the Tianba section. An attempt to correlate the CORBs in the northern Tethys Himalaya subzone is shown in text-fig. 4.

CONCLUSIONS

By using concentrated acetic acid, a rich planktonic foraminiferal assemblage has been recovered for the first time from the limestones of CORBs in the Yongla section of the Gyangze area, southern Tibet. This foraminiferal assemblage contains 21 taxa from 7 genera and suggests a late Campanian to early Maastrichtian age. The interval in the Yongla section is the youngest known CORB in the Gyangze area and could correlate with the upper part of the Tianba section of Kangmar.

TAXONOMIC NOTES

Taxonomic concepts applied in this study for the identified planktonic foraminiferal species mainly follow Robaszynski et al. (1984), Petrizzo et al. (2011) and the online Mesozoic Planktonic Foraminifera Database located at www.mikrotax.org/pforams (Huber et al. 2016). Comments and distinguishing features are included for some species to clarify the taxonomic concepts adopted in this study.

Genus *Contusotruncana* Korchagin 1982

Contusotruncana fornicata (Plummer 1931)

Plate 1, Figures 1–4

Globotruncana fornicata PLUMMER 1931, p. 130, pl. 13, figs. 4–6.
Rosita fornicata (Plummer).– ROBASZYNSKI et al. 1984, p. 250, 301, pl. 38, figs. 1–5.

Contusotruncana fornicata (Plummer).– HUBER et al. 2017, p. 174, pl. 2, figs. 9–10.

Remarks: *Contusotruncana fornicata* is distinguished from other species of the genus *Contusotruncana* by its long, narrow and strongly arched chambers on the spiral side. *Contusotruncana fornicata* usually has 4–5 rather than the 6–7 chambers of *C. morozovae* in the final whorl, and the former does not have the trend of reducing the size of the last chamber as in *C. morozovae*. In the Yongla section, some specimens with 6 chambers in the last whorl (e.g., plate 1, fig. 1a–c), while without the smaller ultimate chamber, are also classified as *C. fornicata*.

Stratigraphic range: *Contusotruncana fornicata* is recorded in the upper Turonian in Tanzania (TDP 31) and at ODP Site 762 (Huber et al. 2017) and up to upper Maastrichtian in the Gubbio section, Italy (Coccioni and Premoli Silva 2015).

Contusotruncana morozovae (Vasilenko 1961)

Plate 1, Figure 5

Globotruncana morozovae VASILENKO 1961, p. 161, pl. 2, figs. 2–4.
Globotruncana? morozovae Vasilenko.– PETRIZZO 2000, p. 496–497, Figure 17. 4–6.

Contusotruncana morozovae (Vasilenko).– ION and ODIN 2001, p. 376–377, pl. , figs. 150–159.

Remarks: *Contusotruncana morozovae* differs from *C. fornicata* by having more chambers in the last whorl (6–7 rather than 4–5), and by the reduced size of the last chamber, which is often smaller than the two preceding ones. In the Yongla section, the smaller final chamber in the ultimate whorl is the main character that distinguishes *morozovae* from *fornicata*.

Stratigraphic range: *Contusotruncana morozovae* is recorded in the uppermost Santonian at Exmouth Plateau, NW Australia (Petrizzo 2000) and ranges to the upper Maastrichtian in Landes, France (Ion and Odin 2001).

Contusotruncana patelliformis (Gandolfi 1955)

Plate 1, Figures 6–7

Globotruncana (Globotruncana) contusa (Cushman) subsp. *patelliformis* GANDOLFI 1955, p. 54, pl. 4, fig. 2 a–c.

Rosita patelliformis (Gandolfi).– ROBASZYNSKI et al. 1984, pp. 250, 301, pl. 38, fig. 1–5.

Stratigraphic range: Upper lower Campanian to upper Maastrichtian in the Gubbio section, Italy (Coccioni and Premoli Silva 2015).

Contusotruncana cf. C. plummerae

Plate 1, Figures 8–12

Remarks: *Contusotruncana plummerae* differs from *C. fornicata* by having inflated chambers on the spiral side and occasionally on the umbilical side; *C. plummerae* differs from *Globotruncana bulloides* by having elongated rather than petaloid chambers on the spiral side. Usually, *Contusotruncana plummerae* has 4–5 chambers in the last whorl, as described in Gandolfi (1955) and Petrizzo et al. (2011), while specimens in the Yongla section show variation in the number of chambers in the final whorl (5–6 rather than 4–5).

Genus *Globotruncana* Cushman 1927

Globotruncana arca (Cushman 1926)

Plate 2, Figures 1–4

Pulvinulina arca CUSHMAN 1926, p. 23, pl. 3, fig. 1 a–c.



TEXT-FIGURE 2
Field photographs of the Yongla section. A. Overall view of the Yongla section; B–E. Close-up of each unit.

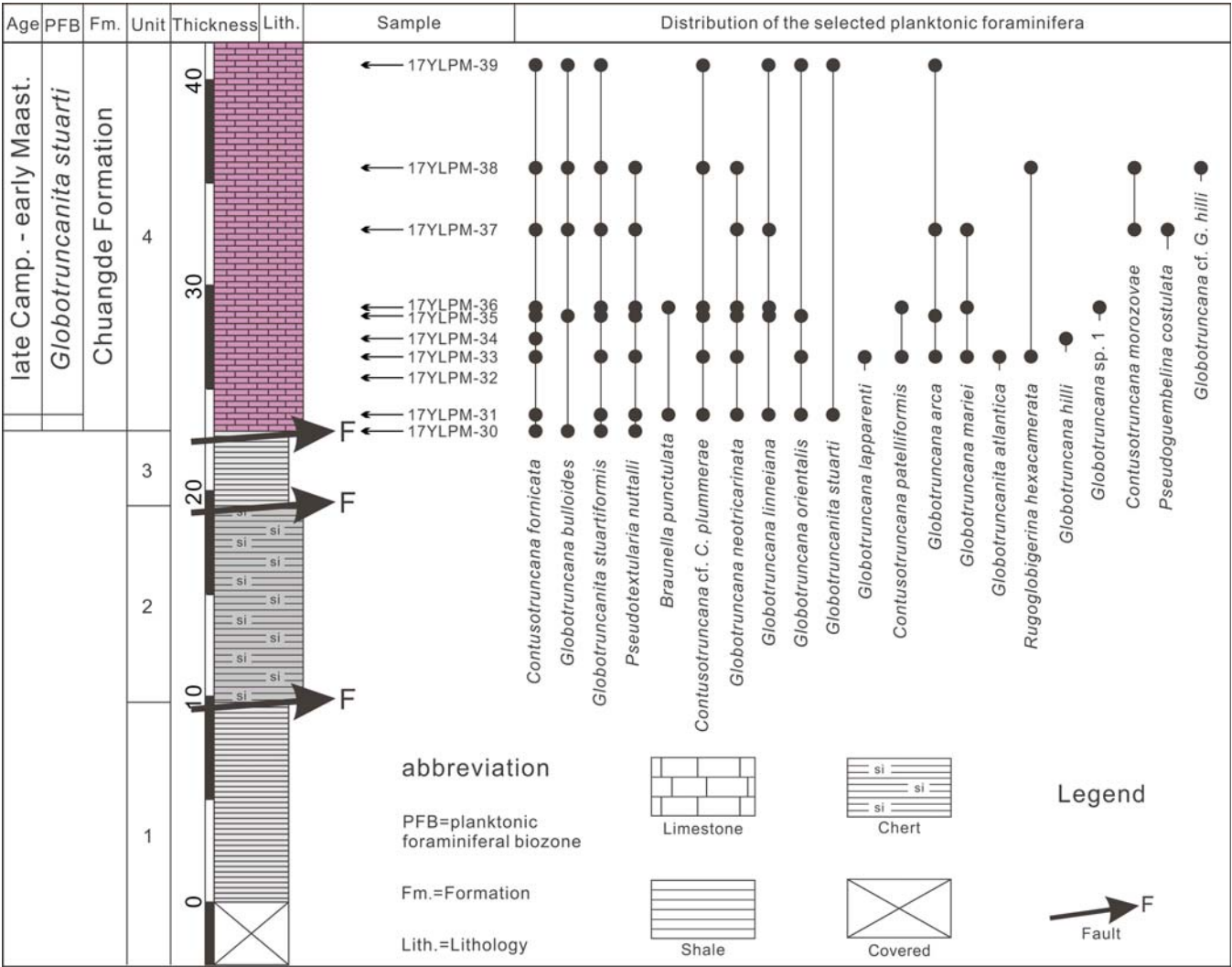
Globotruncana arca (Cushman).—BANDY 1951, p. 509, pl. 75, fig. 1 a–c.—ROBASZYNSKI et al., 1984, pp. 182–184, pl. 4, figs. 1–3.—PETRIZZO et al. 2017, fig. 12 (1a–c).

Stratigraphic range: *Globotruncana arca* is first recorded in the Santonian at Tanzania Drilling Project Site 39 (Petrizzo et al. 2017) and the Gubbio section, Italy (Coccioni and Premoli Silva 2015), and it ranges to the upper Maastrichtian (Robaszynski et al. 1984).

Globotruncana bulloides Vogler 1941
Plate 2, Figures 5–7

Globotruncana linnei bulloides VOGLER 1941, p. 287, pl. 23, figs. 32–39.

Globotruncana bulloides Vogler.—PESSAGNO 1967, p. 325, fig. 33 of Vogler, 1941. —ROBASZYNSKI et al. 1984, pp. 186, 300, pl. 6, figs. 1–4.



TEXT-FIGURE 3
Stratigraphic column of the Yongla section and distribution of the selected planktonic foraminifera.

Stratigraphic range: Lower Santonian to upper Maastrichtian in the Gubbio section, Italy (Coccioni and Premoli Silva 2015).

***Globotruncana hilli* Pessagno 1967**

Plate 2, Figure 8

Globotruncana hilli PESSAGNO 1967, p. 343, pl. 64, figs. 9–14.–
PREMOLI SILVA and SLITER 1995, pl. 16, 10, figs. 2–4.–
PETRIZZO, 2000, p. 496, fig. 18.3a–c.

Stratigraphic range: *Globotruncana hilli* occurs in middle Santonian to Maastrichtian deposits in the Gubbio section, Italy (Premoli Silva and Sliter 1995; Coccioni and Premoli Silva 2015).

Globotruncana* cf. *G. hilli

Plate 2, Figure 9

Remarks: The specimen labeled as *Globotruncana* cf. *G. hilli* differs from *G. hilli* by the absence of the double keels in the final chambers of the ultimate whorl.

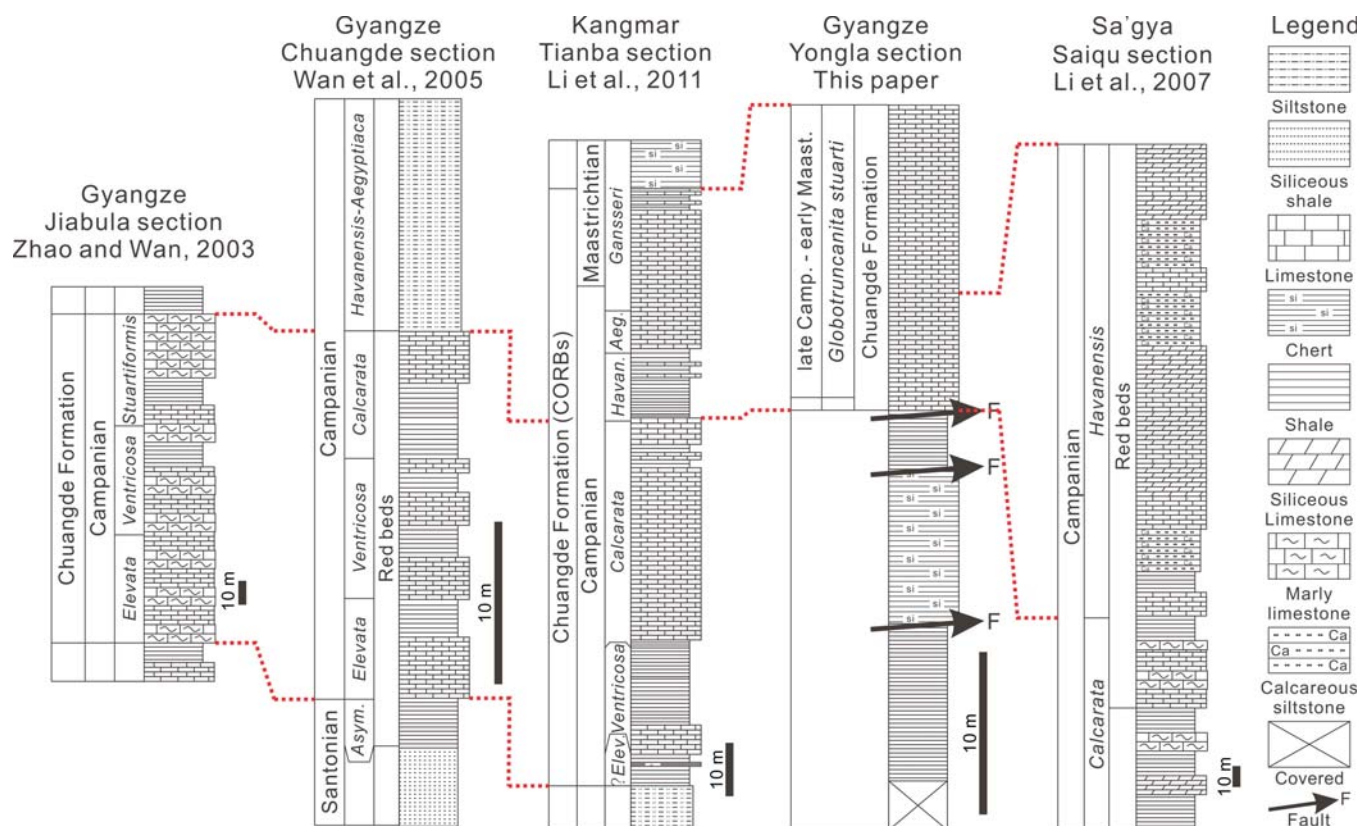
***Globotruncana lapparenti* Brotzen 1936**

Plate 2, Figure 10

Globotruncana lapparenti BROTZEN 1936, pp. 175–176, pl. 5, fig. 2 (a, d, m, n); n was selected as a lectotype by Pessagno (1967) and m was selected as a paralectotype by Pessagno (1967).– PESSAGNO 1967, pp. 344–346, pl. 71, figs. 6–13, pl. 97, figs. 8–9.

Remarks: *Globotruncana lapparenti* differs from *G. linneiana* by having a narrower peripheral band and less developed keels. *Globotruncana lapparenti* was considered as a junior synonym of *G. linneiana* by Robaszynski et al. (1984). In this paper, the emended definition of this species given by Pessagno (1967) is followed, and *G. lapparenti* is considered as a separate species. *Globotruncana lapparenti* occurs only in the lower part of the CORBs in the Yongla section.

Stratigraphic range: Upper Coniacian (Lamolda et al. 2007; Coccioni and Premoli Silva 2015) to upper Maastrichtian (Premoli Silva and Sliter 1995).



TEXT-FIGURE 4
Correlations of the CORBs in the northern Tethys Himalaya subzone.

Globotruncana linneiana (d'Orbigny 1839)
Plate 2, Figures 11–12; Plate 3, Figures 1–5

Rosalina linneiana D'ORBIGNY 1839, p. 101, pl. 15, figs. 10–12.
Globotruncana linneiana (d'Orbigny).— BRÖNNIMANN and BROWN, 1956, pp. 540–542, pl. 20, figs. 13–17, pl. 21, figs. 16–18.— ROBASZYNski et al. 1984, pp. 200–202, pl. 13, figs. 1a–c, 2a–c, 4a–c, pl. 14, figs. 1a–d, 2a–d, 4a–c.— LAMOLDA et al., 2007, p. 29, fig. 6B1–2, C1–2.

Stratigraphic range: *Globotruncana linneiana* is recorded at the base of the Santonian at Olazagutia, Navarra province, Spain (Lamolda et al. 2007) up to the lower Maastrichtian (Robaszynski et al. 1984).

Globotruncana mariei Banner & Blow 1960
Plate 3, Figures 6–7

Globotruncana mariei BANNER and BLOW 1960, pl. 11, fig. 6a–c.— ROBASZYNski et al., 1984, p. 204, pl. 15, figs. 1–6.

Stratigraphic range: Uppermost Santonian to Maastrichtian (Robaszynski et al. 1984).

Globotruncana neotricarinata Petrizzo et al. 2011
Plate 3, Figures 8–12

Globotruncana neotricarinata PETRIZZO et al. 2011, p. 404, figs. 3 (1–2, 4–10) and 2 (5).

Stratigraphic range: Uppermost Coniacian to lower Maastrichtian (Petrizzo et al. 2011).

Globotruncana orientalis El Naggari 1966
Plate 4, Figures 1–6

Globotruncana orientalis EL NAGGAR 1966, p. 125, pl. 12, fig. 4a–d.— ROBASZYNski et al. 1984, pp. 206–208, pl. 17, figs. 1–4.— PETRIZZO 2000, fig. 17.3a–c.

Stratigraphic range: Lower Campanian to lower Maastrichtian (Robaszynski et al. 1984).

***Globotruncana* sp. 1**
Plate 4, Figure 7

Remarks: The specimen labeled as *Globotruncana* sp. 1 looks similar to *G. linneiana* and *G. lapparenti*, but it doesn't have petaloid chambers on the spiral side, and it has relatively evolute coiling with a wide keel band. It was not identified at the species level because it is intermediate within the morphological range of *linneiana* and *lapparenti*.

Genus *Globotruncanita* Reiss 1957

Globotruncanita atlantica (Caron 1972)
Plate 4, Figures 8–9

Globotruncanita atlantica CARON 1972, p. 553, pl. 1, fig. 5, text-figs. 1–2.— ROBASZYNski et al. 1984, p. 222, pl. 24, figs. 1–4.—

PETRIZZO et al. 2011, pp. 404–405, Fig. 4(3a–c), (4a–c), (5)–(7), (8a–c), (9a–c), (10a–c).

Stratigraphic range: Lower Campanian in the Bottaccione section, Italy (Petrizzo et al. 2011; Coccioni and Premoli Silva 2015) to lower upper Campanian (Robaszynski et al. 1984).

Globotruncanita stuarti (de Lapparent 1918)

Plate 4, Figures 10–11

Rosalina stuarti DE LAPPARENT 1918, p. 11, pl. 12, fig. 7; pl. 13, fig. 5.

Globotruncanita stuarti (de Lapparent).– ROBASZYNSKI et al. 1984, pp. 234–236, pl. 30, figs. 1–3; pl. 31, figs. 1–2.– LONGORIA and VONFELDT 1991, pp. 218–219, pl. 2, figs. 7–12, pl. 9, figs. 8–11.

Stratigraphic range: Upper Campanian to upper Maastrichtian in the Gubbio section, Italy (Premoli Silva and Sliter 1995; Coccioni and Premoli Silva 2015).

Globotruncanita stuartiformis (Dalbiez 1955)

Plate 4, Figure 12; Plate 5, Figures 1–5

Globotruncana (*Globotruncana*) *elevata stuartiformis* DALBIEZ 1955, p. 169, text-figs. 10a–c.

Globotruncanita stuartiformis (Dalbiez).– ROBASZYNSKI et al. 1984, p. 238, pl. 32, figs. 1–4.– LONGORIA and VONFELDT, 1991, pp. 219–222, pl. 6, figs. 1–12, pl. 9, figs. 1–5.

Stratigraphic range: Upper Santonian to upper Maastrichtian (Robaszynski et al. 1984).

Genus *Rugoglobigerina* Brönnimann 1952

Rugoglobigerina hexacamerata Brönnimann 1952

Plate 5, Figure 6

Rugoglobigerina reicheli hexacamerata BRÖNNIMANN 1952, p. 23, pl. 2, fig. 10–12.

Rugoglobigerina hexacamerata Brönnimann.– ROBASZYNSKI et al. 1984, p. 282, pl. 49, fig. 8a–c.– OMIDVAR et al. 2018, fig. 8D.

Stratigraphic range: Middle-upper Campanian (Omidvar et al. 2018) to upper Maastrichtian (Robaszynski et al. 1984).

Genus *Braunella* Georgescu 2007

Braunella punctulata (Cushman 1938)

Plate 5, Figures 7–8

Gümbelina punctulata CUSHMAN 1938, p. 13, pl. 2, figs. 15–16.

Braunella punctulata (Cushman).– GEORGESCU 2007, p. 158, pl. 1, figs. 1–5, pl. 3, figs. 1, 3–4.

Stratigraphic range: Upper Campanian to upper Maastrichtian (Georgescu 2007).

Genus *Pseudoguembelina* Brönnimann and Brown 1953

Pseudoguembelina costulata (Cushman 1938)

Plate 5, Figure 9

Guembelina costulata CUSHMAN 1938, pp. 16–17, pl. 3, figs. 7–9. *Pseudoguembelina costulata* (Cushman).– NEDERBRAGT, 1991, pp. 358–360, pl. 8, figs. 3–4b.– PREMOLI SILVA and SLITER 1995, pl. 25, figs. 8–12.

Stratigraphic range: Middle Campanian to upper Maastrichtian (Premoli Silva and Sliter 1995).

Genus *Pseudotextularia* Rzehak 1891

Pseudotextularia nuttalli (Voorwijk 1937)

Plate 5, Figures 10–12

Guembelina nuttalli VOORWIJK 1937, p. 192, pl. 2, figs. 1–9.

Pseudotextularia nuttalli (Voorwijk).– NEDERBRAGT 1989, p. 204, text-fig. 9, pl. 8, figs. 2–3.– LAMOLDA et al. 2007, p. 29, fig. 4 N1–2, O1–2.– PETRIZZO et al. 2017, fig. 9. 11a–b.

Stratigraphic range: Lower Coniacian (Lamolda et al. 2007; Petrizzo et al. 2017) to upper Maastrichtian (Nederbragt 1989).

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PLATE 1

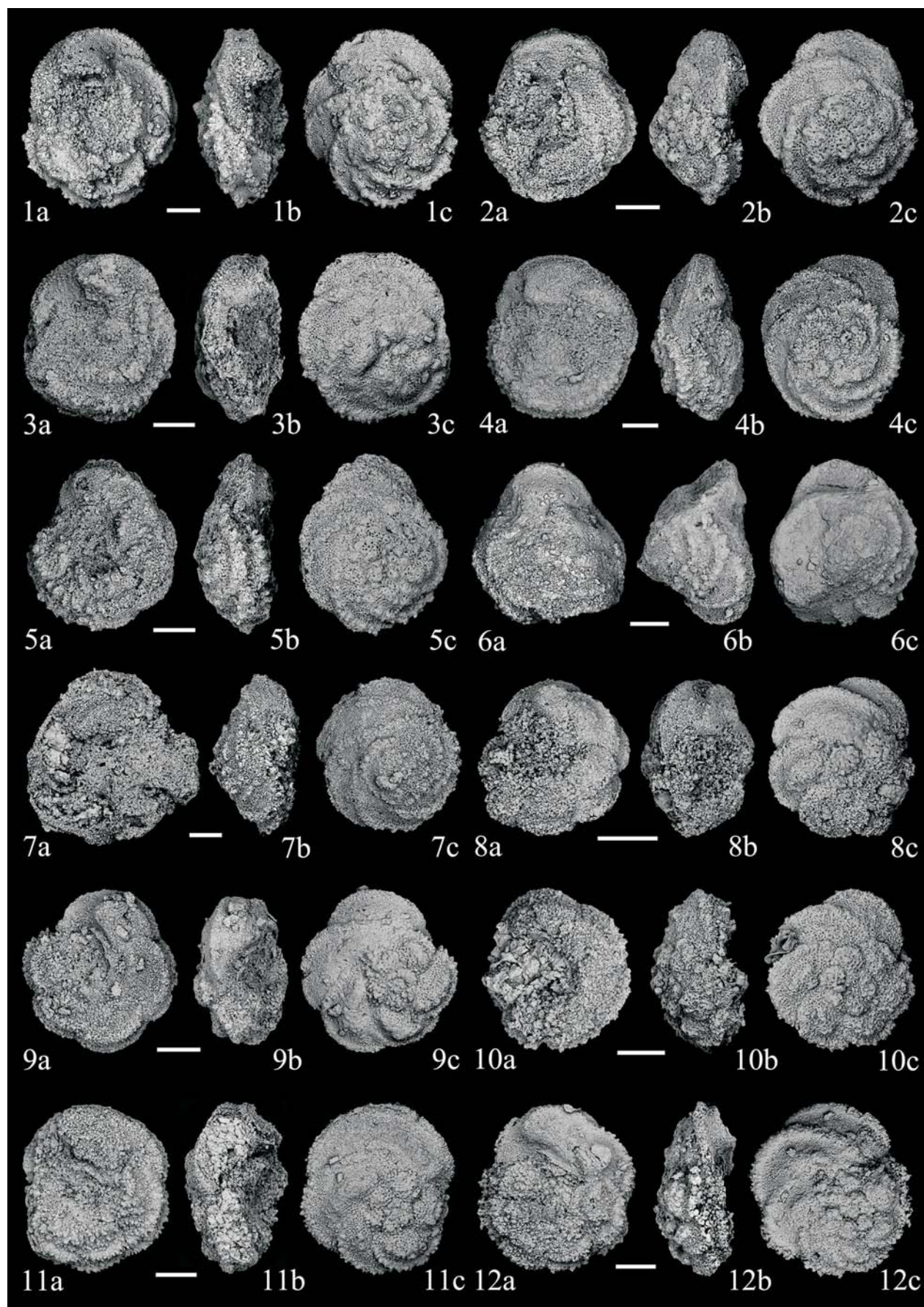
a, umbilical view; b, lateral view; c, spiral view. Scale bar = 100 µm.

1–4 *Contusotruncana fornicata*, 1, Sample 17YLPM–36; 2, Sample 17YLPM–37; 3, Sample 17YLPM–38; 4, Sample 17YLPM–31.

5 *Contusotruncana morozovae*, Sample 17YLPM–37.

6–7 *Contusotruncana patelliformis*, 6, Sample 17YLPM–33; 7, Sample 17YLPM–36.

8–12 *Contusotruncana plummerae*, 8, Sample 17YLPM–31; 9, Sample 17YLPM–33; 10, Sample 17YLPM–36; 11, Sample 17YLPM–38; 12, Sample 17YLPM–39.



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PLATE 2

a, umbilical view; b, lateral view; c, spiral view. Scale bar = 100 µm.

1–4 *Globotruncana arca*, 1–2, Sample 17YLPM–33; 3, Sample 17YLPM–37; 4, Sample 17YLPM–39.

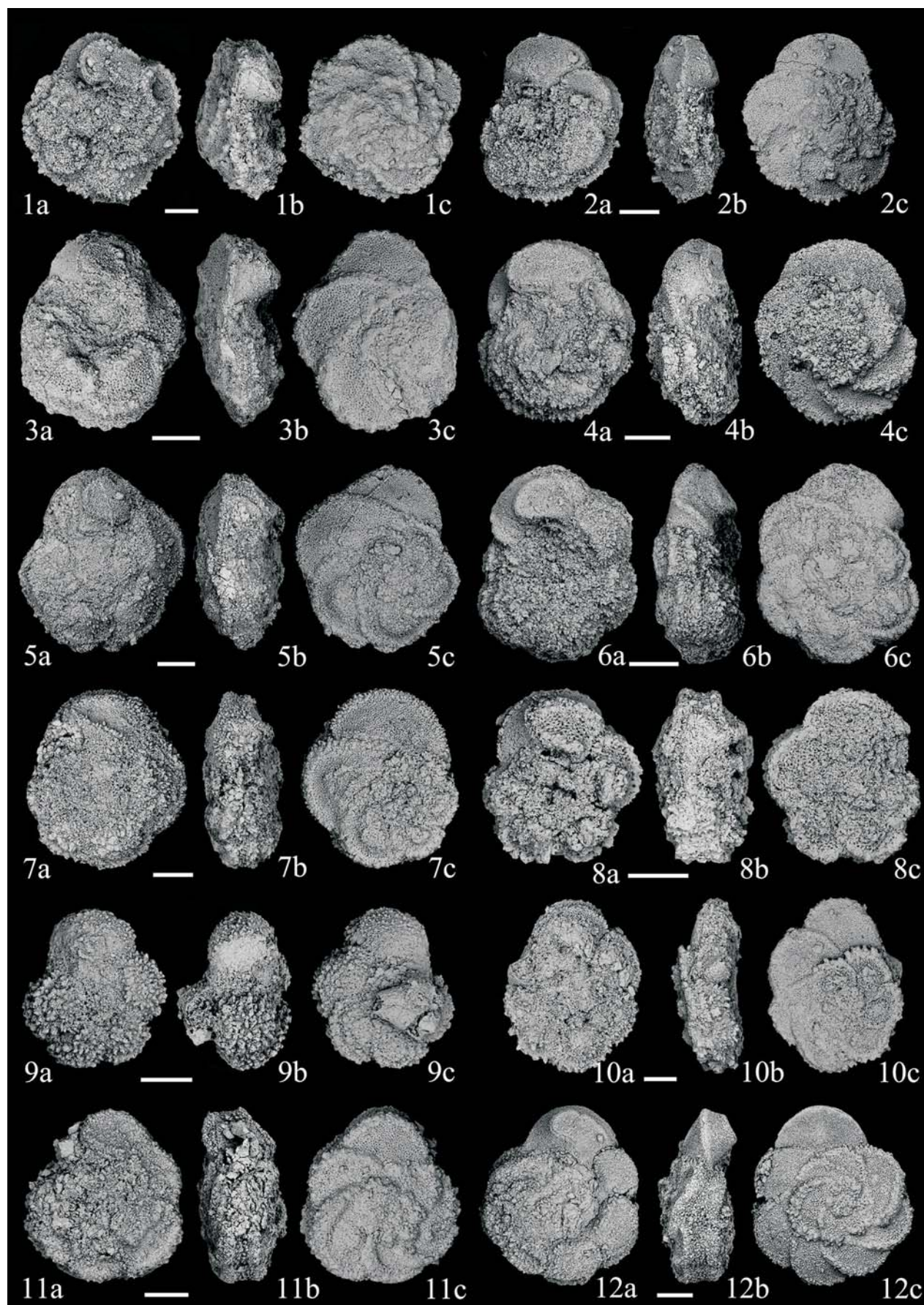
5–7 *Globotruncana bulloides*, 5, Sample 17YLPM–35; 6, Sample 17YLPM–37; 7, Sample 17YLPM–38.

8 *Globotruncana hilli*, Sample 17YLPM–34.

9 *Globotruncana* cf. *G. hilli*, Sample 17YLPM–38.

10 *Globotruncana lapparenti*, Sample 17YLPM–33.

11–12 *Globotruncana linneiana*, 11, Sample 17YLPM–31; 12, Sample 17YLPM–36.



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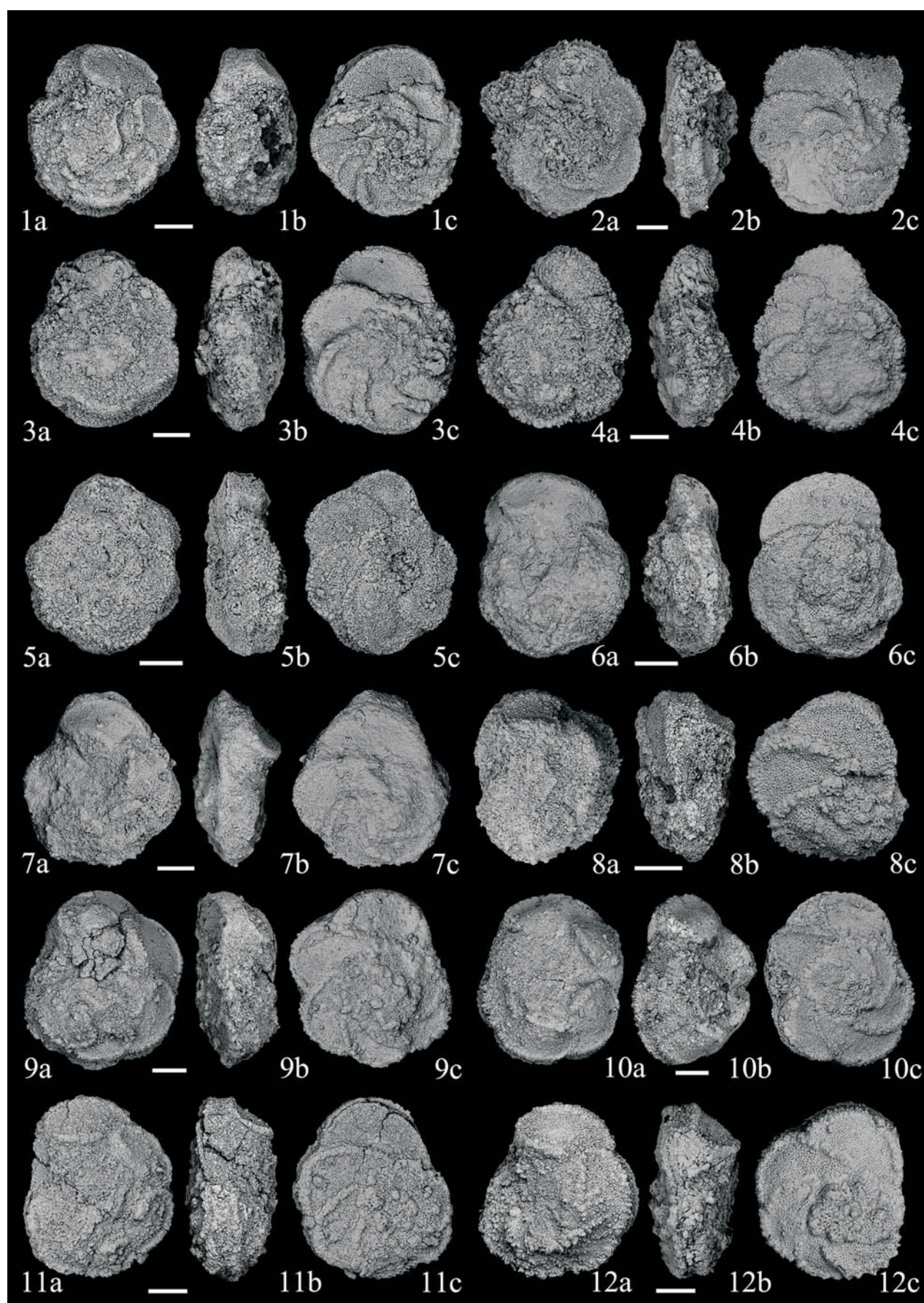
PLATE 3

a, umbilical view; b, lateral view; c, spiral view. Scale bar = 100 µm.

1–5 *Globotruncana linneiana*, 1–4: Sample 17YLP–31; 5: Sample 17YLP–36. Figs.

6–7 *Globotruncana mariei*, 6: Sample 17YLP–33; 7: Sample 17YLP–37. Figs.

8–12 *Globotruncana neotricarinata*, 8, Sample 17YLP–37; 9–10, Sample 17YLP–33; 11, Sample 17YLP–36; 12, Sample 17YLP–38.



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PLATE 4

a, umbilical view; b, lateral view; c, spiral view. Scale bar = 100 µm.

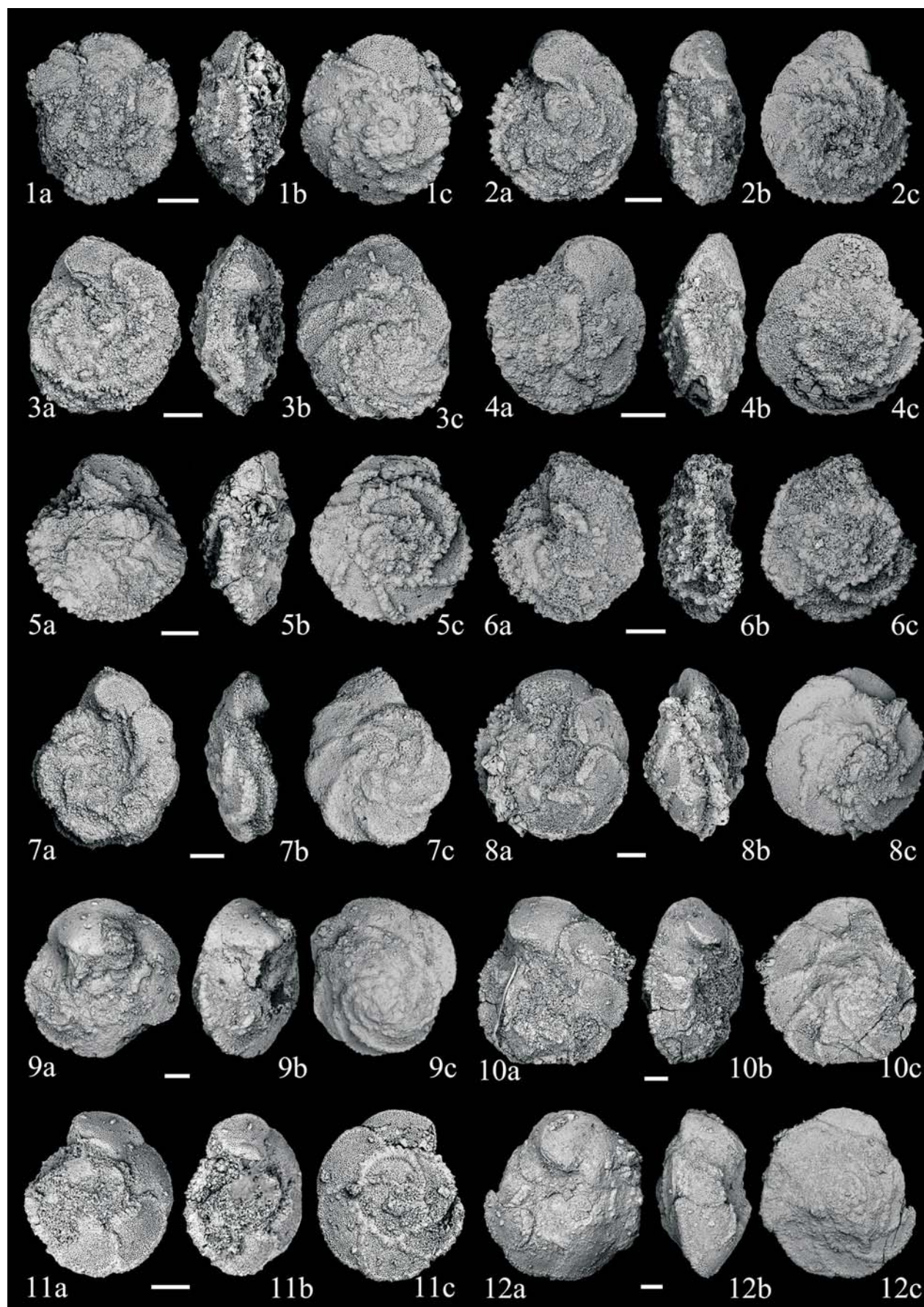
1–6 *Globotruncana orientalis*, 1, Sample 17YLP–31. 2, Sample 17YLP–33. 3, Sample 17YLP–35; 4–6, Sample 17YLP–39.

7 *Globotruncana* sp. 1, Sample 17YLP–36.

8–9 *Globotruncanita atlantica*, 8–9, Sample 17YLP–33. Figs.

10–11 *Globotruncanita stuarti* 10, Sample 17YLP–31; 11, Sample 17YLP–39.

12 *Globotruncanita stuartiformis*, Sample 17YLP–35.



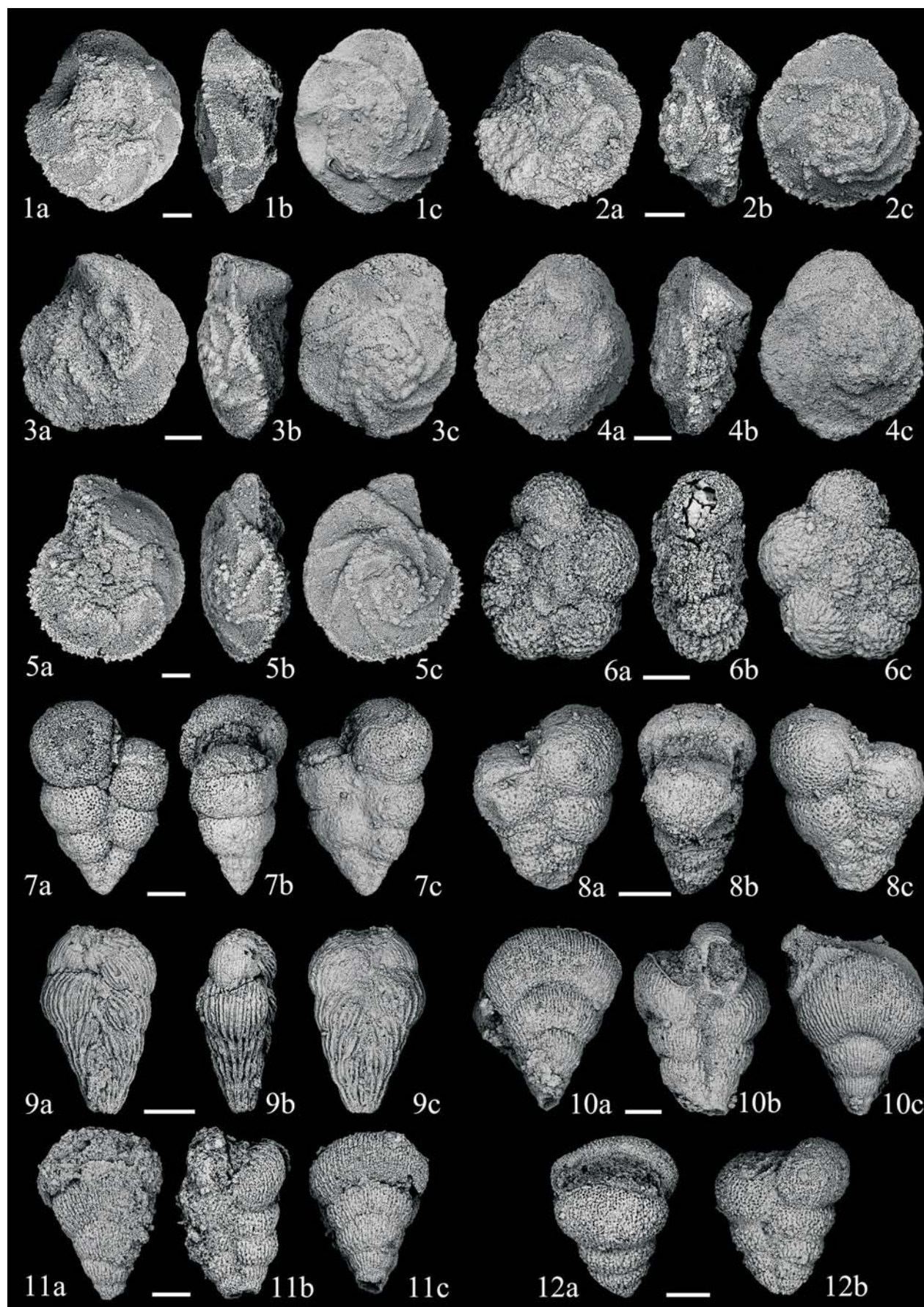
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PLATE 5

Scale bar = 100 µm.

- 1–5 *Globotruncanita stuartiformis*, 1–2, Sample 17YLPM–36; 3, 5, Sample 17YLPM–37; 4, Sample 17YLPM–38. a, umbilical view; b, lateral view; c, spiral view.
- 6 *Rugoglobigerina hexacamerata*, Sample 17YLPM–33. a, umbilical view; b, lateral view; c, spiral view.

- 7–8 *Braunella punctulata*, 7, Sample 17YLPM–31; 8, Sample 17YLPM–36. a, c, side view; b, edge view.
- 9 *Pseudoguembelina costulata*, Sample 17YLPM–37. a, c, side view; b, edge view.
- 10–12 *Pseudotextularia nuttalli*, 10, Sample 17YLPM–33; 11, Sample 17YLPM–37; 12: Sample 17YLPM–38. 10–12: a, c, edge view.



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