

Late Cretaceous Foraminiferal Faunas from the Saiqu “mélange” in Southern Tibet

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Abstract: As one of the mélanges in the southern side of the Yarlung-Zangbo suture zone, the Saiqu mélange in southern Tibet is important for understanding the evolution of the Neo-Tethys ocean. The age of the Saiqu mélange, however, has been debated due to the lack of reliable fossil evidence in matrix strata. Based on lithological similarities with platform strata in southern Tibet and limited fossils from exotic blocks, previous studies variously ascribed the Saiqu mélange to be Triassic in general, Late Triassic, or Late Cretaceous. Here we reported planktonic foraminiferal faunas from the matrix strata of the Saiqu mélange. The new fossils yield a Late Cretaceous age, which is so far the best age constraint for the mélange. Regional stratigraphic correlation indicates that the Cretaceous Oceanic Red Beds (CORBs) in Saiqu may be time equivalent to the CORBs of the Zongzhuo Formation in neighboring regions. Thus the Saiqu mélange should be correlated to the Upper Cretaceous Zongzhuo Formation rather than the Triassic Xiukang Group, as previously suggested.

Key words: Saiqu Mélange, Planktonic Foraminifera, Late Cretaceous, Red Beds, Zongzhuo Formation, Tibet

1 Introduction

A series of mélange complexes occur along the southern side of the Yarlung-Zangbo suture zone (Fig. 1). The age of these mélanges and their regional correlation are important for understanding the evolution of the Neo-Tethys ocean in southern Tibet. As one of the mélanges, the Saiqu mélange in Sa'gya, southern Tibet consists of matrix strata and exotic blocks. In the lack of reliable fossils from both matrix strata and exotic blocks, the age and stratigraphic correlation of this mélange have been debated (Gansser, 1974; Chen, 1980; Qian, 1982; TBGMR, 1983, 1993; Wang et al., 1983). Based a general stratigraphic comparison, it has been considered as equivalent to the upper Cretaceous Zongzhuo Formation (TBGMR, 1983). In contrast, on the basis of a few fossils from the exotic blocks within the mélange, it has been assigned as Triassic

in general (TBGMR, 1983) or Late Triassic (TBGMR, 1993). In this later suggestion, the Saiqu mélange was correlated to the upper Triassic “Xiukang Group” in the neighboring regions.

Away from the age of Saiqu mélange itself, two general problems existed regarding the age and regional correlation of the mélanges in southern Tibet. First, the lack of fossils in general has led to uncertainties on the age of mélanges and their correlation, resulting in arbitrary age assignments on the basis of lithological similarities. Second, many previous studies used fossils from exotic blocks as the formation age of mélanges, leading to different age assignments even for the same mélange. This has caused serious problems for the regional correlation of mélanges in orogenic belts in general (Guo et al., 2006). Particularly, the great differences regarding the ages of the mélanges along the southern side of the Yarlung-Zangbo suture zone prevent a better understanding of the history of the Neo-Tethys ocean in this region.

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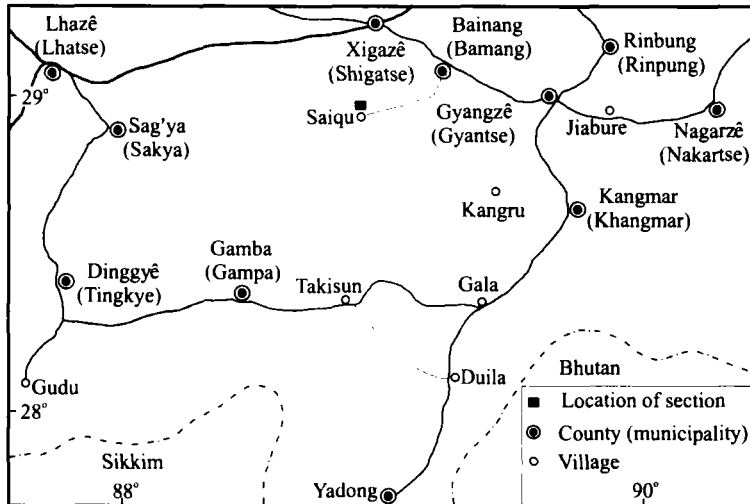


Fig. 1. Schematic map showing the location of the section.

For the purpose of better defining the age of the Saiqu mélange and its regional correlation, in this paper we report the foraminiferal fossils collected from the matrix strata of the mélange. The fossils reveal a Late Cretaceous age, different from those of the exotic blocks. The new data highlight the need to distinguish the fossils from exotic blocks and matrix strata and support the view that the age of the Saiqu mélange and other mélanges should be determined by fossils from the matrix strata rather than those from the exotic blocks.

2 Material and Methods

Samples for this study were collected from the mélange at the Saiqu section (88°53'28"E, 28°52'56"N) in Sa'gya, southern Tibet (Fig.1). A total of twenty-two limestone and shale samples were collected from the section.

The foraminifera were processed and determined at the Fossil Identification Center of China University of Geosciences in Beijing. For shale samples, 200 grams of sample were crushed into pieces of 2 mm dimensions or less. Crushed samples were disaggregated by repeated soaking and drying in 10% Na₂SO₄ solution and then wet-sieved through a 0.5 μm mesh. Residues were dried, weighed, and sieved using a series of sieves of 0.5, 0.25 and 0.16 μm mesh. Residues comprising particles greater than 0.5 μm in diameter were regarded as unprocessed. Specimens from the fraction of 0.5–0.16 μm were picked. For harder samples such as limestone, multiple oriented thin-sections were prepared for each sample. A total of 17 limestone samples were analyzed.

All foraminiferal specimens are deposited in the Fossil Identification Center of China University of Geosciences in Beijing.

3 The Age of Foraminiferal Assemblage

3.1 Foraminiferal assemblage

Planktonic foraminifera are the only, or the dominating, element of the foraminiferal assemblages examined in this work. The state of preservation is relatively good, but examination of specimens under a scanning electron microscope revealed considerable recrystallisation and traces of corrosion.

The assemblages are dominated by the following genera: *Globotruncana*, *Globotruncanella*, *Globotruncanita*, *Heterhelix* and *Rosita*, with *Globotruncana bulloides*, *G. lapparenti*, *G. linneiana*, *G. ventricosa*, *Globotruncanella havanensis*, *Globotruncanita calcarata*, *G. elevata*, *G. stuarti*, *G. stuartiformis*. *Heterhelix globulosa* and *Rosita fornicata* being the important and represented species (Fig.2). Most of them are the common elements of the Late Cretaceous planktonic foraminifera *Globotruncana* fauna widespread in the Tethyan Ocean.

3.2 Age assignment

G. bulloides is restricted to the latest Santonian to Middle Maastrichtian, i.e., from top *D. asymmetric* Zone to middle *A. mayaroensis* Zone in Caron's planktonic foraminiferal zonation (Caron, 1985). *G. lapparenti* ranges from the latest Santonian to Middle Maastrichtian, i.e., from the top of *D. asymmetric* Zone to the middle of *G. aegyptiaca* Zone. *G. linneiana* ranges from the latest Santonian to middle Maastrichtian, i.e., from the top of *D. asymmetric* Zone to the bottom of *G. gansseri* Zone. *G. ventricosa* defines the *G. ventricosa* Zone, which is Campanian to Maastrichtian in age. *G. havanensis* defines the *G. havanensis* Zone, which is the latest Campanian to the end of Maastrichtian in age. *G. calcarata* defines the *G. calcarata* Zone, which is limited to late Campanian in age. *G. elevata* defines the *G. elevata* Zone, which is the latest Santonian to the late Maastrichtian in age, i.e., from the top of *D. asymmetric* Zone to the middle of *G. calcarata* Zone. *G. stuarti* ranges from the latest Campanian to the end of Maastrichtian in age, i.e., from the middle of *G. havanensis* Zone to the top of *A. mayaroensis* Zone. *G. stuartiformis* is restricted to the latest Santonian to Late Maastrichtian, i.e., from top *D. asymmetric* Zone to lower *A. mayaroensis* Zone. *H. globulosa* ranges from the earliest Campanian to Middle Maastrichtian and *R. fornicata* ranges from Middle Santonian to middle Maastrichtian.

Based on the above-mentioned characteristics of the planktonic foraminiferal assemblage, this assemblage is

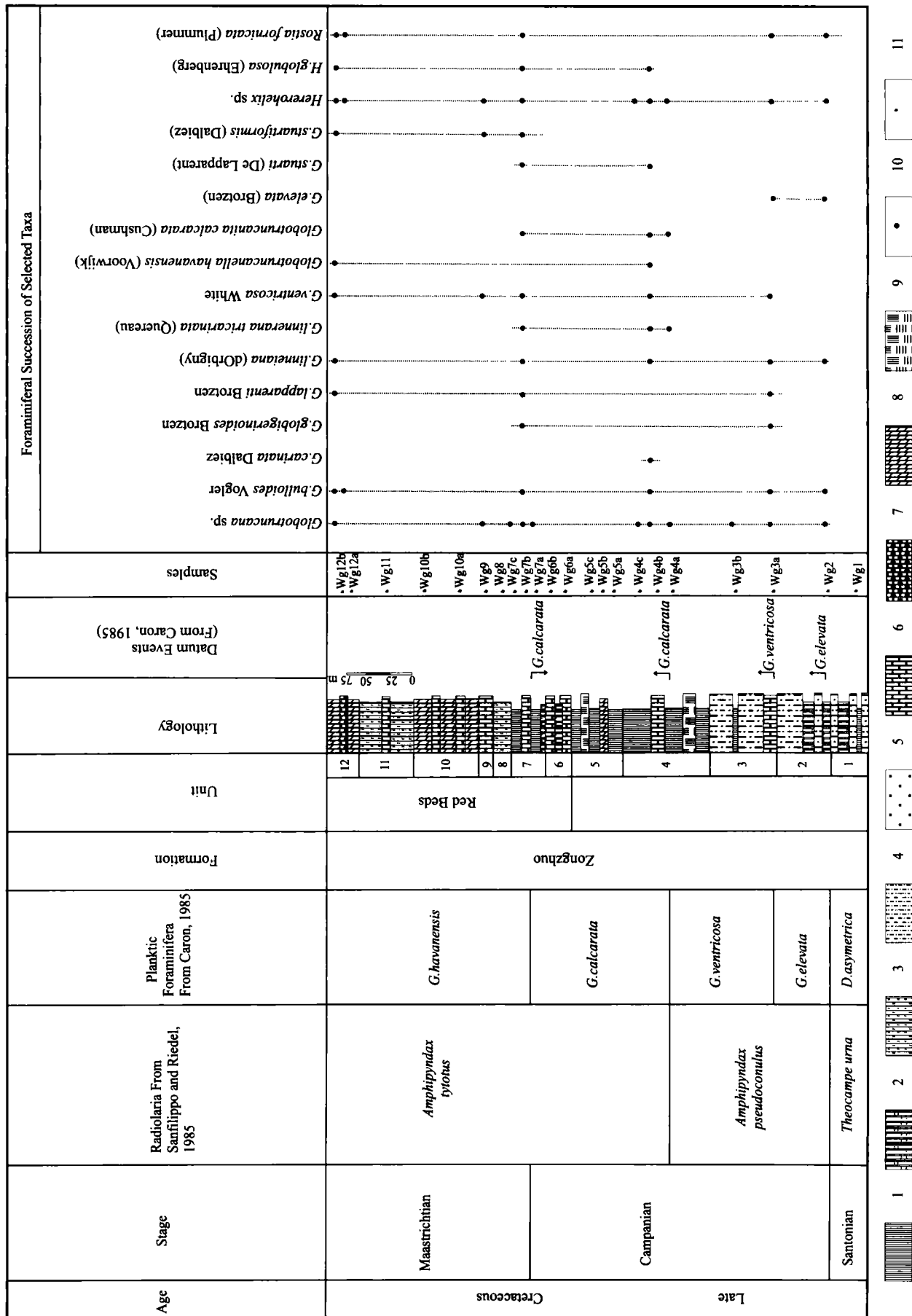


Fig. 2. Foraminiferal species ranges and datum events of the Saiqu section. 1. Shale; 2. Silty Shale; 3. Calcareous Siltstone; 4. Siltstone; 5. Sandstone; 6. Limestone; 7. Siliceous Limestone; 8. Marlite; 9. Silicoflites; 10. Fossils from Single Sample; 11. Location of Collection.

considered to be Campanian-early Maastrichtian in age.

4 Planktonic Foraminiferal Stratigraphy

Based on the compilation of Caron (1985), several planktonic foraminiferal zones have been determined in this paper in the Saiqu section. In an upward biostratigraphic order they are the *Globotruncanita elevata*, *Globotruncana ventricosa*, *Globotruncanita calcarata* and *Globotruncanella havanensis* zones (Fig.2).

4.1 *Globotruncanita elevata* Zone

Globotruncanita elevata Zone is a Partial Range Zone (PRZ) of Early Campanian named by Postuma (1971). It is characterized by the appearance of *Globotruncanita elevata* and encompasses the interval from last occurrence of *Dicarinella asymetrica* to the first occurrence of *Globotruncana ventricosa*. In the Saiqu section, this zone is represented by the Unit 2. The *Globotruncanita elevata* and four other species of planktonic foraminifera (*Globotruncana bulloides*, *G. linneiana*, *Rosita fornicata* and *Heterohelix* sp.) were preserved in this Unit. The top of this zone is delineated by the first occurrence of *Globotruncana ventricosa*. The age of this zone is early Campanian of Late Cretaceous.

4.2 *Globotruncana ventricosa* Zone

Globotruncana ventricosa Zone is an Interval Zone (IZ) named by Dalbiez (1955) and encompasses the interval from first occurrence of *G. ventricosa* to first occurrence of *Globotruncanella calcarata*. In the Saiqu section, this zone encompasses the interval from the Unit 3 to the lower part of Unit 4. The first occurrence of *G. ventricosa* marks the base of this zone. The top of this zone is delineated by the first occurrence of *G. calcarata*. Except for *G. ventricosa*, the presented elements occurring in this zone also include: *Globotruncana bulloides*, *G. globigerinoides*, *G. cf. lapparenti*, *G. linneiana*, *G. ventricosa*, *G. elevata*, *Heterohelix* sp., *Textularia* sp. and *Rostia fornicata*. The age of this zone is upper part of Early Campanian to Late Campanian.

4.3 *Globotruncanita calcarata* Zone

Globotruncanita calcarata Zone is Total Range Zone (TRZ) named by Herm (1962) and encompasses the interval of total range of *Globotruncanita calcarata*. In the Saiqu section, this zone spans the interval from the upper part of the Unit 4 to the lower part of Unit 7. The first appearance of *G. calcarata* marks the base of this zone. The top of this zone is delineated by the last occurrence of *G. calcarata*. Apart from *G. calcarata*, the presented elements occurring in this zone also include: *Globotruncana*

bulloides, *G. globigerinoides*, *G. lapparenti*, *G. linneiana*, *G. linneiana tricarinata*, *G. ventricosa*, *Globotruncanella calcarata*, *G. stuarti*, *G. stuartiformis*, *Heterohelix globulosa*, *Heterohelix* sp. and *Rosita fornicata*. The age of this zone is upper part of Late Campanian.

4.4 *Globotruncanella havanensis* Zone

Globotruncanella havanensis Zone is Partial Range Zone (PRZ) named by Caron (1978) and spans the interval from last occurrence of *G. calcarata* to first occurrence of *Globotruncana aegyptiaca*. This zone is characterized by the appearance and bloom of the nominated species (*G. havanensis*). In the Saiqu section, this zone spans the interval from the upper part of the Unit 7 to the Unit 12. The base of this zone is delineated by last occurrence of *G. calcarata*. Apart from the nominated species, the presented elements occurring in this zone also include: *Globotruncana bulloides*, *G. lapparenti*, *G. linneiana*, *G. ventricosa*, *Globotruncanella stuartiformis*, *Heterohelix globulosa*, *H. sp.*, *Nodosaria* sp. and *Rosita fornicata*. The age of this zone should be lower part of Early Maastrichtian.

5 Discussion

Abundant planktonic foraminifera were discovered from the matrix of the Saiqu mélange, which indicates a Late Cretaceous age for the mélange. The Red Member of this mélange can be correlated with the "Upper Cretaceous Ocean Red Beds (CORBs)", the Chuangde Formation (Li et al., 1999), by their lithologic similarities. Based on the age of the planktonic foraminifera and the lithological sequences, the matrix strata of the mélange should be part of the Late Cretaceous Zongzhuo Formation, in contrast to previous interpretations in which the mélange was considered as either broadly Triassic or equivalent to the Triassic Xiukang Group.

The "Red Member" of the Zongzhuo Formation, which has been raised to the formation status — the Chuangde Formation (Li et al., 1999; Wang et al., 2005), has been used as a marker to recognise the Zongzhuo Formation during our mapping in southern Tibet. This unit is widespread in southern Tibet and its time-equivalent units were reported globally (e.g., Schlanger and Jenkyns, 1976; Görür et al., 1993; Bak 1998; Eren and Kadir, 1999; Wan et al., 2005a; Wan et al., 2005b; Wang and Hu 2005; Wang et al., 2005; Hu et al., 2005). This unit and its equivalents were possibly deposited in response to a global oxygenation event. The Chuangde Formation consists of red marine mudstones intercalated with pelagic marlstones, limestones and radiolarian cherts (Wang et al., 2005) and should be part of the Zongzhuo Formation. The red

mudstones reflect deposition below the carbonate compensation depth (CCD) in a deep oceanic basin. The intercalated, thin-bedded marlstones represent fine-grained turbidites that were derived from the upper slope and transported into the adjacent deep basin. The red beds of the Chuangde Formation were deposited in a highly oxygenated deep-sea environment. Their deposition coincided with a Santonian–early Campanian diversity peak of planktonic foraminifera. The deposition of the Chuangde Formation is similar to that of the Upper Cretaceous oceanic red beds (CORBs) in Western Europe such as the Scaglia Rossa in Italy (Lehner et al., 1987) and Austrian Alps (Wagreich, 1995), Western Asia such as Eastern Pontides in Turkey (Görür et al., 1993), and Ladakh-Zaskar Himalayas (Robertson and Degnan, 1993; Robertson and Sharp, 1998).

Studies of the planktonic foraminiferal fauna of the Zongzhuo Formation in the Gyangtze area revealed five planktonic foraminiferal assemblages (Wan et al. 2005a, b). In an ascending order these include: (1) *Dicarinella asymetrica* Zone; (2) *Globotruncanita elevata* Zone; (3) *Globotruncana ventricosa* Zone; (4) *Globotruncanita calcarata* Zone; and (5) *Globotruncanella havanensis-Globotruncanita aegyptica* assemblage. The first four zones are present in the oceanic red beds and indicate an age from Late Santonian to Middle Campanian. The fifth zone occurs above the red beds in the Changde section, which may indicate a Maastrichtian age. The planktonic foraminifera from the Saiqu mélange are quite similar to those of the Zongzhuo Formation in Gyangtze area, except that the representative elements of *Dicarinella asymetrica* Zone were not found in Saiqu. The red beds in the Gyirong-Saga region also contain abundant planktonic foraminifera of late Campanian-Maastrichtian age, including species of four genera: *Globotruncana aegyptica*, *G. arca*, *G. bulloides*, *G. ventricosa*, *Globotruncanella stuarti*, *Gansserina gansseri* and *Abathomphalus mayaroensis* (Wan et al. 2005a, b).

Upper Cretaceous multi-coloured pelagic marly limestones (grey, red, green) of the Fatu La Formation cropped out widely in the Zaskar Himalaya (Gaetani et al., 1985; Garzanti, 1993) are also rich in planktonic foraminifera. Premoli Silva et al. (1991) dated the Fatu La Formation as early Turonian–early Campanian on the basis of planktonic foraminiferal fossils and considered it to have been deposited in a deep, opened shelf/slope environment under oxygenated conditions.

6 Conclusions

The planktonic foraminifera retrieved from the matrix strata of the Saiqu mélange at the Saiqu section in southern

Tibet indicate that this mélange is late Cretaceous in age. The red beds of the Saiqu mélange are of Campanian–Middle Maastrichtian age, as indicated by the presence of abundant planktonic foraminifera including *Globotruncana bulloides*, *G. lapparenti*, *G. linneiana*, *G. ventricosa*, *Globotruncanella havanensis*, *Globotruncanita elevata*, *G. stuarti*, *G. stuartiformis*, *Heterohelix globulosa* and *Rostia fornicata*.

A lithological and microfaunal comparison of the Saiqu mélange with formations in neighbouring regions in southern Tibet indicates that the matrix strata of the Saiqu mélange should be part of the Cretaceous Zongzhuo Formation rather than the Triassic Xiukang Group, as previously concluded. The red beds in the mélange are widespread in southern Tibet and globally, likely recording deposition in response to a global Late Cretaceous oxygenation event.

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Appendix.

List of species

Abathomphalus mayaroensis (Bolli, 1951)
Dicarinella asymetrica (Sigal, 1952)
Gansserina gansseri (Bolli, 1951)
Globotruncana aegyptica Nakkady, 1950
G. arca (Cushman, 1926)
G. bulloides Vogler, 1941
G. lapparenti Brotzen, 1936
G. linneiana (d'Orbigny, 1839)
G. ventricosa White, 1928
Globotruncanella havanensis (Voorwijk, 1937)
Globotruncanita calcarata (Cushman, 1927)
G. elevata (Brotzen, 1934)
G. stuarti (de Lapparent, 1918)
G. stuartiformis (Dalbiez, 1955)
Heterohelix globulosa (Ehrenberg, 1840)
Rostia fornicata (Plummer, 1931)

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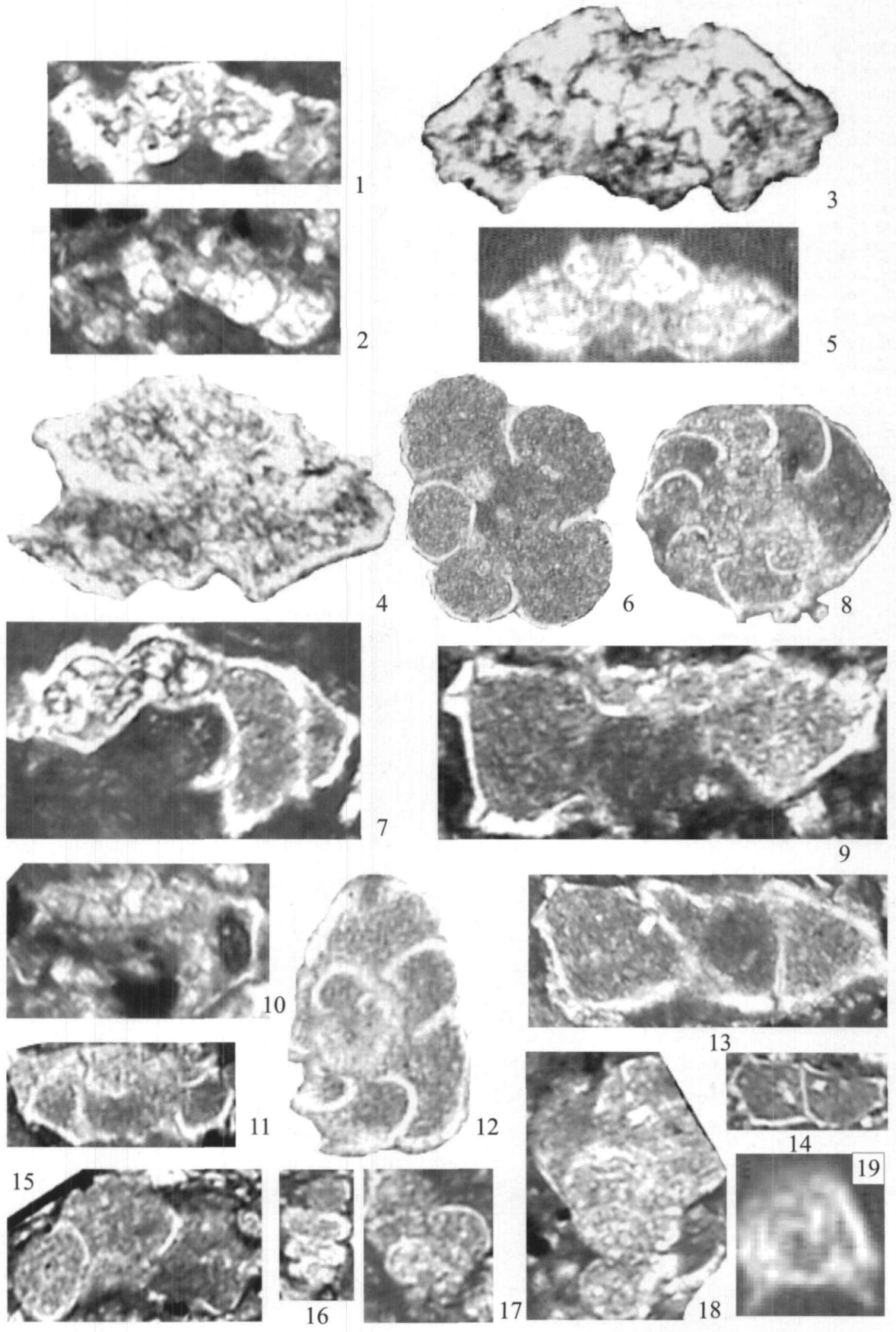
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Plate I



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- Figs. 1–3. *Globotruncanita stuarti* (De Lapparent).
 1. Axial section. Collection no.: Twg4. Catalogue no: Ts1.
 2. Axial section. Collection no.: Twg4. Catalogue no: Ts2.
 3. Axial section. Collection no.: Twg7. Catalogue no: Ts3.
- Fig. 4. *Rostia fornicata* (Plummer).
 4. Axial section. Collection no.: Twg3. Catalogue no: Ts4
- Fig. 5. *Globotruncanella havanensis* (Voorwijk).
 Axial section. Collection no.: Twg4. Catalogue no: Catalogue no: Ts5.
- Fig. 6. *Globotruncana bulloides* Vogler.
 Axial section. Collection no.: Twg4. Catalogue no: Catalogue no: Ts6.
- Fig. 7. *Globotruncana cf. ventricosa* White.
 Collection no.: Twg3 (P18-47-4). Catalogue no: Ts7.
- Figs. 8–10. *Globotruncana linneiana* (d'Orbigny)
 8. Collection no.: Twg4. Catalogue no: Ts8.
 9. Collection no.: Twg4. Catalogue no: Ts9.
 10. Collection no.: Twg4. Catalogue no: Ts10.
- Figs. 11–12. *Globotruncana linneiana tricarinata* (Quereau).
 11. Collection no.: Twg4. Catalogue no: Ts11.
 12. Collection no.: Twg4. Catalogue no: Ts12.
- Figs. 13–14. *Globotruncana carinata* Dalbiez.
 13. Collection no.: Twg4. Catalogue no: Ts13.
 14. Collection no.: Twg4. Catalogue no: Ts14.
- Fig. 15. *Globotruncana cf. ventricosa* White.
 Collection no.: Twg4. Catalogue no: Ts15.
- Fig. 16. *Heterohelix globulosa* (Ehrenberg)
 Collection no.: Twg4. Catalogue no: Ts16.
- Figs. 17–18. *Heterohelix* sp.
 17. Collection no.: Twg4. Catalogue no: Ts17.
 18. Collection no.: Twg4. Catalogue no: Ts18.
- Fig. 19. *Globotruncanita calcarata* (Cushman)
 19. Collection no.: Twg4. Catalogue no: Ts19.

Plate explanation

Plate I