Giornale di Geologia, ser. 3ª, vol. 58/1-2, 1996, pp. 151-155, Bologna

Paragloborotalia kugleri (Bolli). An index fossil for the Paleogene/Neogene Boundary

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In search for the Paleogene/Neogene boundary, *Paragloborotalia kugleri* (Bolli) was the only species of planktonic foraminifera applicable as a boundary marker. The biostratigraphic value of *«Globorotalia» kugleri* was demonstrated by Bolli (1957) in Trinidad. A *Globorotalia kugleri* total range zone was defined for the part of the Cipero Formation around the Oligocene/Miocene boundary. Blow (1969) did not accept this concept and extended the base of his zone N4 to the FAD of *Globigerinoides primordius*. Stainforth *et al.* (1975) modified the definition of the *G. kugleri* Zone according to Blow with the *Globigerinoides* datum, aware of the problem of diachroneity in the appearance of this genus. This was corrected later (Lamb and Stainforth, 1976), and the *G. kugleri* Zone re-defined by the total range of the nominate species *s.s.* To add to the confusion, Bolli and Saunders (1985) emended the definition of the *G. kugleri* Zone from the first occurrence of the zonal marker to the first occurrence of frequent *Globigerinoides primordius* and/or *G. trilobus s.l.* But the base of the zone was defined by the FAD of *G. kugleri s.s.* Here, we follow the definition of Berggren *et al.* (1983, 1985, 1995) where the FAD of «G*loborotalia» kugleri* was selected for the Oligocene/Miocene boundary, including the Aquitanian in the *G. kugleri* Zone, and the total range of *G. kugleri* for the definition of zone M1.

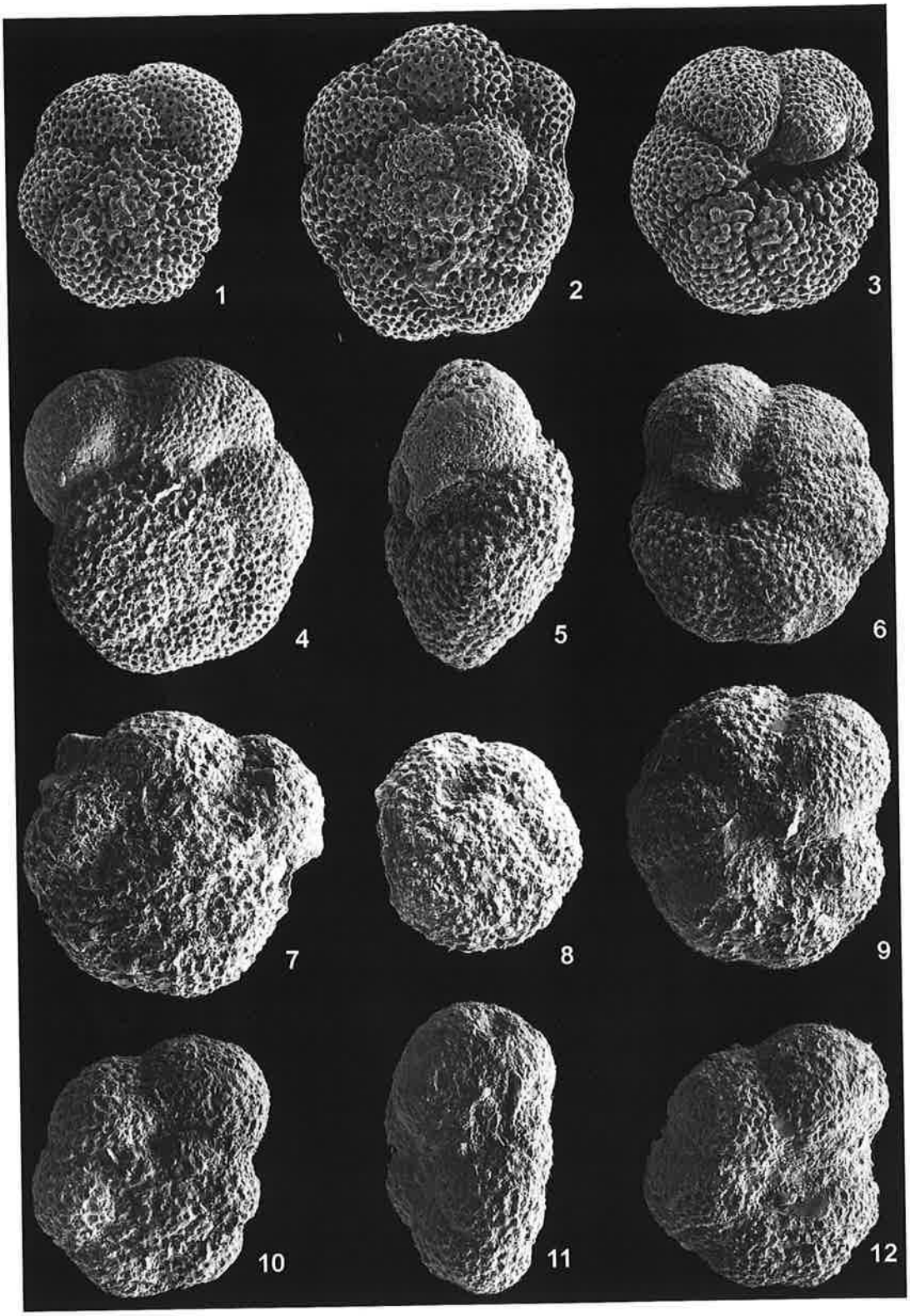
The second important index fossil in the critical time span, *Globoquadrina dehiscens* (Chapman, Parr and Collins), has its first occurrence in stratigraphically younger levels, above the base of nannoplankton zone NN1, in the upper part of the range of *G. kugleri* (Srinivasan and Kennett, 1983).

The use of *Paragloborotalia kugleri* as a marker for the Paleogene/Neogene boundary is limited by its palecological restriction to the tropical-subtropical belt. A further restriction is given by the common inaccurate usage of the species definition. The species concept of «*Globorotalia*» *kugleri* s.l. includes some ancestral forms such as «*Globorotalia*» *pseudokugleri* Blow and «*Globorotalia*» *mendacis* Blow. In such a broad concept (Stainforth *et al.*, 1975; Kennett and Srinivasan, 1983) the stratigraphic range of the *«Globorotalia» kugleri* group is extended for zones P21 to N4 of Blow (1969).

A detailed study of these different types is given by Spezzaferri (1991, 1992) and is summarized here. The purpose of this contribution is also to verify the results of Spezzaferri concerning the generic position of *Globorotalia kugleri* in *Paragloborotalia*, and to compare the forms from Trinidad, the Piedmont Basin, and the Appennine Basin.

1) *Paragloborotalia kugleri* (Bolli, 1957), Pl. 1, Figs. 1-3, is flat biconvex, with two and a half whorls; 6-8 strongly appressed chambers in the final whorl; the circumference is circular; the periphery is rounded to subacute and perforate without a keel; the aperture is a low umbilical-extraumbilical arch bordered by a lip; coiling is random, the holotype left coiling with 8 chambers in the final whorl. The most distinctive feature is the strongly backward curved intercameral sutures of the spiral side. The wall is cancellate, with spine holes und spines (Pl. 2, Figs. 4-7), commonly covered by secondary lamination (Pl. 2, Fig. 8). Therefore the species belongs to *Paragloborotalia*.

2) *Paragloborotalia pseudokugleri* (Blow, 1969), Pl. 2, Fig. 3, in contrast to *P. kugleri*, has 6-7 subovate inflated chambers in the final whorl, and the circumference is lobate;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the periphery is broadly rounded, and the intercameral sutures are radial on both sides. Blow has selected for a holotype the paratype of *Globorotalia kugleri* Bolli (1957, Pl. 28, Figs. 7a-c) from the *G. kugleri* Zone in Trinidad. It is right coiling with 7 chambers in the final whorl. Specimens from the Lemme section are figured (Pl. 1, Figs. 10-12).

3) *Paragloborotalia? mendacis* (Blow, 1969) is small, flattened biconvex, with 6-7 chambers in the final whorl; the periphery is sub-acute; the spiral intercameral sutures are slightly curved backwards, the umbilical ones radial; the umbilicus is closed; the wall is coarsely cancellate; the spinosity is not proven. According to Blow it is the ancestral form of *pseudokugleri*, differing in the compressed test and less inflated chambers. To differentiate this form as an independant species is questioned by many authors (e.g. Bolli and Saunders, 1985). In the case of a congruent definition of the Paleogene/Neogene boundary these forms as well as *P. pseudokugleri* have to be excluded from *Paragloborotalia kugleri* s.s.

In a comparison of different populations, the Trinidad specimens of *Paragloborotalia kugleri* and *P. pseudokugleri* are well developed and rather large. The forms in the Appennine Basin are similar (Pl. 1, Figs. 4-6), as big as in Trinidad and frequent. *Paragloborotalia kugleri* from the Lemme-Carrosio section (Pl. 1, Figs. 7-9) is generally poorly preserved, scarce and somewhat smaller. In bigger specimens from the Lemme-Carrosio section the circumference tends to be lobate in the younger chambers, and the spire is commonly vaulted.

Acknowledgement

For providing comparative material from Trinidad I wish to thank H.M. Bolli and J.-P. Beckmann (Zürich), and for the opportunity to study the type material I acknowledge the financial support by the Smithsonian Institution (Washington).

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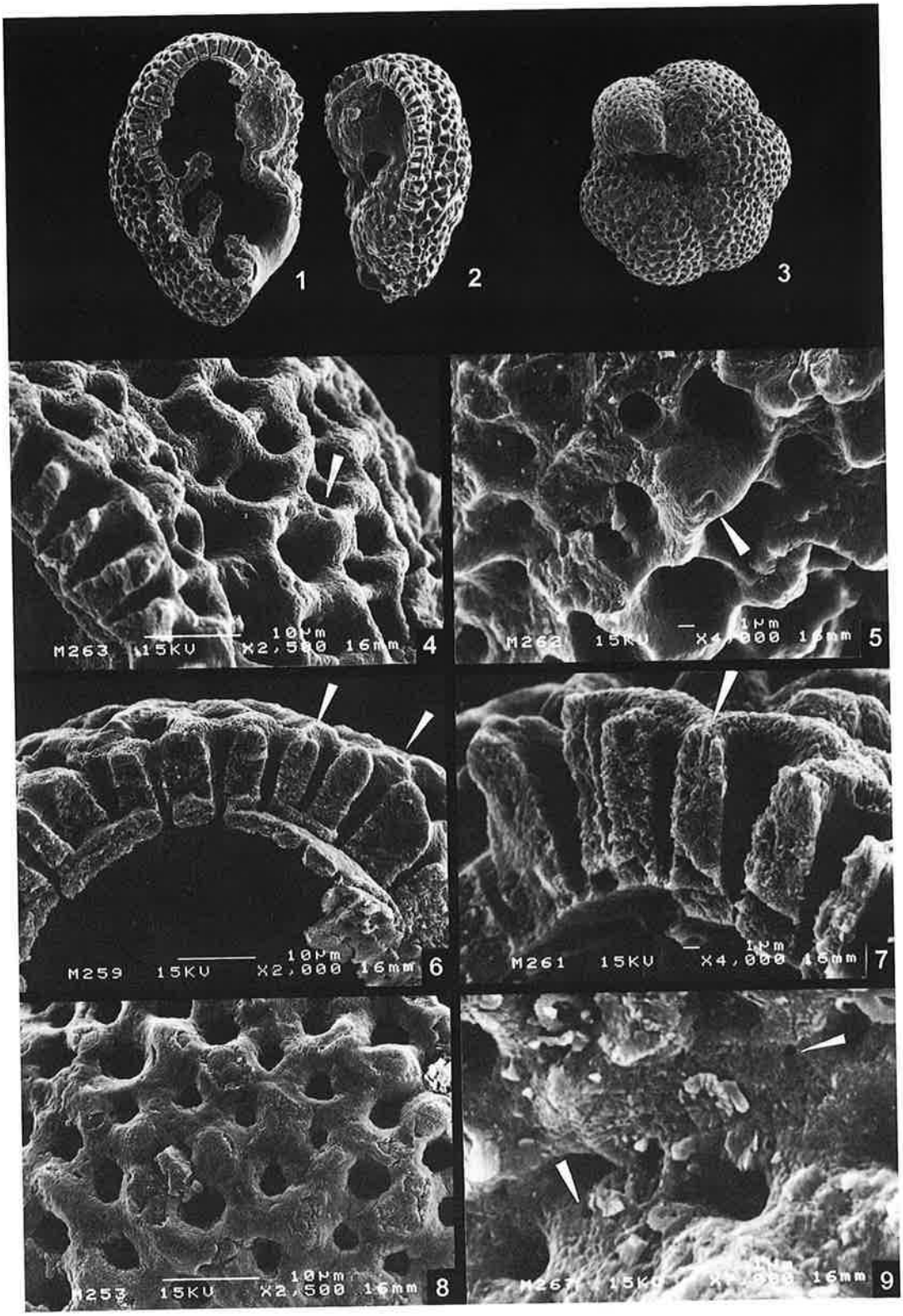
Pl. 1 - **1-3**, *Paragloborotalia kugleri* (Bolli, 1957). **1**, spiral view, right coiling. Trinidad, near San Fernando, Cipero Formation; coll. J.-P. Beckmann, no. 217.996; **2**, spiral view, right coiling; **3**, umbilical view, left coiling. Trinidad, La Romaine, N of Mosquito Creek, Cipero Formation; coll. H.M. Bolli, no. HMB 407.
4-6, *Paragloborotalia kugleri* (Bolli, 1957). **4**, spiral view, left coiling; **5**, lateral view, left coiling; **6**, umbilical view, right coiling. Italy, Marche region, Ca'Fusconi, section CF-II, 10 cm below Livello Raffaello, Scaglia Cinerea Formation.
7-9, *Paragloborotalia kugleri* (Bolli, 1957). Italy, Piedmont Basin, Carrosio, Rigoroso Formation. **7**, spiral view, right coiling; section LE-III, 27 m; **8**, spiral view, left coiling, section LE-III, 32 m; **9** umbilical view, left coiling, section LE-III, 26 m.
10-12, *Paragloborotalia pseudokugleri* (Blow, 1969). **10**, spiral view, right coiling; **11**, lateral view, left coiling; **12**, umbilical view, left coiling. Italy, Piedmont Basin, Carrosio, Rigoroso Formation, *Paragloborotalia kugleri* Zone, section LE-III, 32 m.
All figures × 200.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Pl. 2 - **1-2**, *Paragloborotalia kugleri* (Bolli, 1957). Trinidad, La Romaine, N of Mosquito Creek, Cipero Formation; coll. H.M. Bolli, no. HMB 407. Two parts of the same specimen exhibiting spines and spine holes (see Figs. 4-7). × 200.

3, *Paragloborotalia pseudokugleri* (Blow, 1969). Trinidad, near San Fernando, Cipero Formation «G*loborotalia» kugleri* Zone; coll. J.-P. Beckmann, no. 217.996. Spine holes are observed in the suture between first and second chamber of the final whorl (see Fig. 9). × 200.

4-5, *Paragloborotalia kugleri* (Bolli, 1957). Spineholes in the wall surface of specimen Pl. 2, Fig. 2; **6**, *Paragloborotalia kugleri* (Bolli, 1957). Spinholes in the wall section and surface of specimen Pl. 2, Fig. 1; **7**, *Paragloborotalia kugleri* (Bolli, 1957). Spines sitting in the sectioned wall between the pores; specimen Pl. 2, Fig. 2; **8**, *Paragloborotalia kugleri* (Bolli, 1957). Cover of the surface by secondary lamination, specimen Pl. 1, Fig. 2.

9, *Paragloborotalia pseudokugleri* (Blow, 1969). Spine holes piercing a suture of specimen Pl. 2, Fig. 3.