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PALAEOECOLOGICAL STUDIES OF BENTHIC FORAMINIFERA FROM THE ZOGELSDORF FORMATION (EGGENBURGIAN, EARLY MIOCENE) IN THE EGGENBURG AREA (AUSTRIA)

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The Early Miocene transgression which inundated the rugged crystalline morphology of the Bohemian Massif led to the formation of the Zogelsdorf Formation, which is characterised by a complex distribution of foraminiferal assemblages. Generally, preservation of the foraminiferal tests is poor; however, it was possible to distinguish six different foraminiferal assemblages using statistical methods (Q-mode cluster analysis and information index as a measure of diversity) applied to quantified species or genera counts, in addition to state of preservation. This method of analysis has allowed to differentiate between shallow-water assemblages, in part associated with sea grass meadows (*Ammonia* Assemblage and *Cibicides-Elphidium* Assemblage), in part with sandy bottom and a higher energy conditions (*Elphidium* Assemblage), and deeper water assemblages (>30m) (*Hanzawaia* Assemblage, *Cibicides pseudoungerianus* Assemblage and *Cassidulina* Assemblage).

Key words — Benthic foraminifera, Neogene (Eggenburgian, Miocene), Austria, palaeoecology, faunal analyses.

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INTRODUCTION

The Zogelsdorf Formation (Nebelsick, 1989a) comprises sediments formerly referred to in the literature as 'Eggenburger Schichten' (Suess, 1866), and consists mainly of well-indurated, bioclastic limestones, their facies having been interpreted by Nebelsick (1989a, b).

The object of the present paper is a systematic treatment and a palaeoecological analysis of the foraminiferal faunas from the unconsolidated levels within the Zogelsdorf Formation. The study area is the Eggenburg area in Lower Austria, at the eastern margin of the Waldviertel, *c* 60 km northwest of Vienna. Figures 1 and 2 illustrate the geography of the area, and indicated is the provenance of the samples studied. A few of these localities are of importance as facies stratotypes of the Eggenburgian (Early Miocene), a regional stratigraphic stage of the Paratethys (Steininger, 1971). The Eggenburgian corresponds to the Early Burdigalian of the Mediterranean chronostratigraphic zonation, as well as to the Early Sakarulian of the eastern Paratethys (Steininger & Seneš , 1971; Steininger, 1975; Rögl & Steininger, 1983).

The Cenozoic sediments deposited on top of the crystalline units (Moldanubikum and Moravikum) of the eastern margin of the Bohemian Massif in Lower Austria belong to the tectonic unit of the so-called 'autochthone Molassezone'. These terrestrial to marine sediments of the Eggenburg and Horn areas are erosional remnants of a formerly complete sediment cover, which was deposited on top of a partially presedimentarily formed crystalline basement. Subsequently, syn- and postsedimentary tectonics affected these deposits, which were partially eroded through uplift of the crystalline basement. This history provides an explanation for the gener-

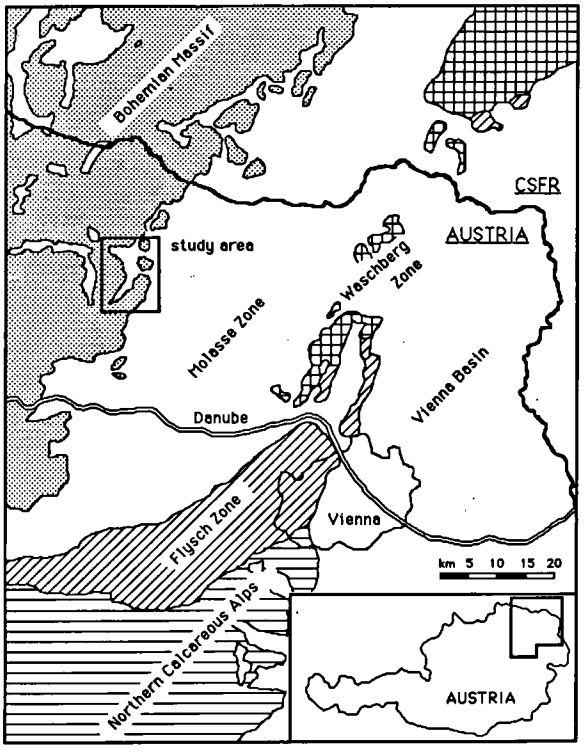

Fig. 1. Location of study area (after Nebelsick, 1992).

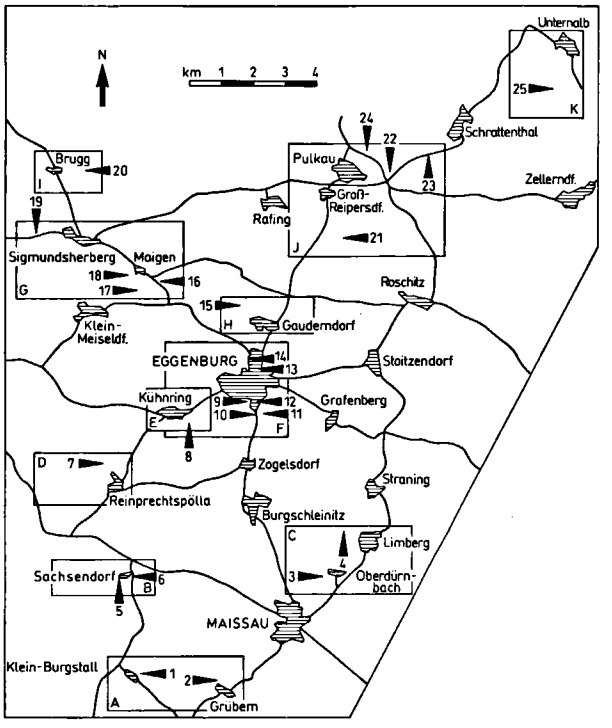

Fig. 2. Sampling localities in the study area.

ally discontinuous occurrence of Cenozoic sediments, which are separated by numerous interposing crystalline rocks and, in addition, are often covered with Quaternary deposits (Steininger, 1991).

The Paratethys came into existence through plate tectonic processes during the Late Oligocene and originated from the Tethys (compare Báldi, 1982; Rögl & Steininger, 1983; Seneš & Steininger, 1985). The marine Cenozoic sediments of the Eggenburg area are part of the sedimentation area of the central Paratethys (Fig. 3) and temporarily stood in faunal exchange with the adjoining bioprovinces of the Mediterranean, Atlantic/Boreal, and Indo-Pacific oceans. The geodynamic activity expressed itself in this sedimentation area as a sequence of transgressions and regressions, which locally led to the development of very different facies types.

During the Early Miocene, the molasse zone along the Alpine margins was connected with the south German bay, with the Rhône Graben and also with the Mediterranean Tethys. Towards the east, a connection existed over the Outer Carpathian Fore Depression (Moravia, east Silesia, Galicia and Romania), extending to the present-day Aral Sea. Over the 'Rheingraben' temporarily a connection existed with the North Sea (compare Steininger, 1979; Rögl & Steininger, 1983).

At the start of the Eggenburgian, a marine transgression approaching from the east/southeast reached the Eggenburg bay and the Horn Basin, which remained under this marine influence until the Middle Ottnangian. The Zogelsdorf Formation transgresses unconformably over the marine nearshore sediments of the Burgschleinitz and Gauderndorf formations, or rests directly on top of the crystalline basement, thus marking the start of the Late Eggenburgian transgression (Fig. 4). On top of the Zogelsdorf Formation rest fully marine, poorly fossiliferous pelites of the Zellerndorf Formation, which on the basis of planktonic foraminifers and fish remains should still be assigned to the latest Eggenburgian to Ottnangian (Steininger, 1991).

Preservation

The in part extremely poor preservation of the foraminiferal faunas posed a serious problem. Below only the preservation of benthic species is discussed, as planktonic foraminifers are rare in the samples studied.

Remarkable is the rare occurrence of miliolid foraminifers; these are absent or occur in fragments only with eroded surfaces (Pl. 1, Fig. 11). Of agglutinated forms often the first chambers are missing,

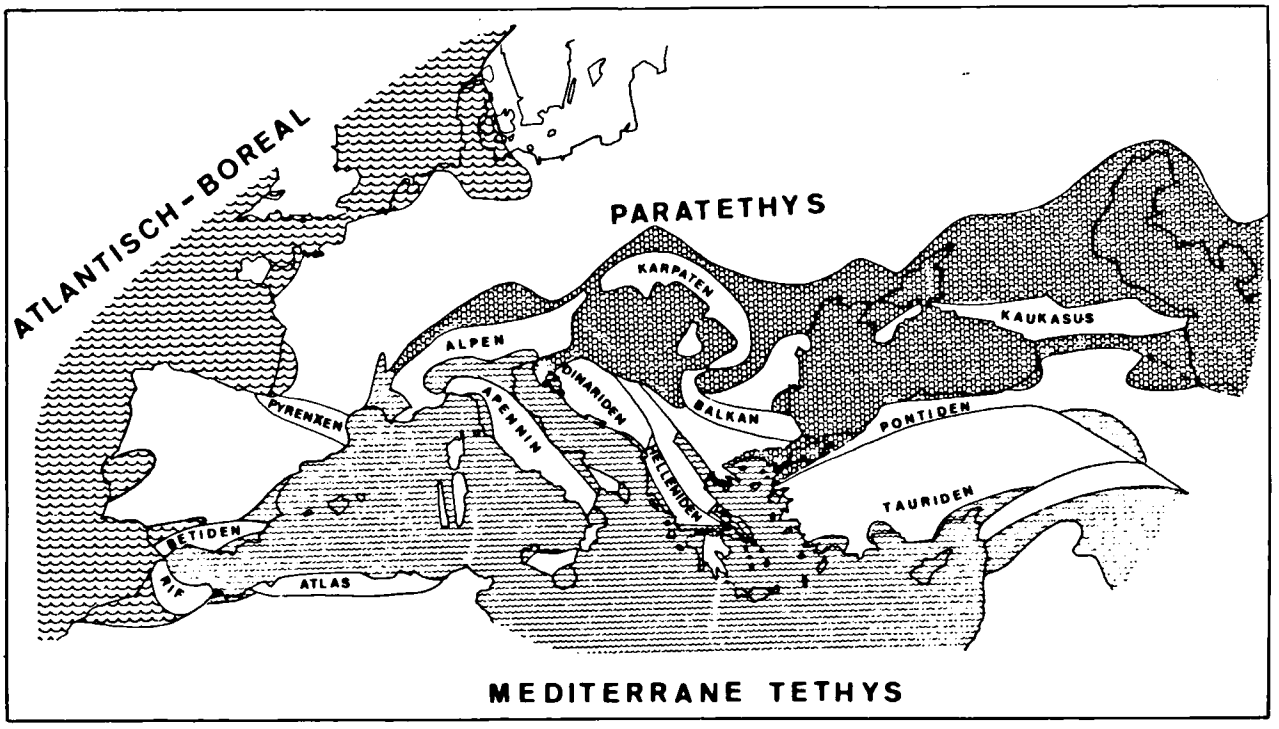

Fig. 3. Palaeogeography and distribution of bioprovinces, seas and landmasses for the period 23 to 15 my (after Steininger, 1991).

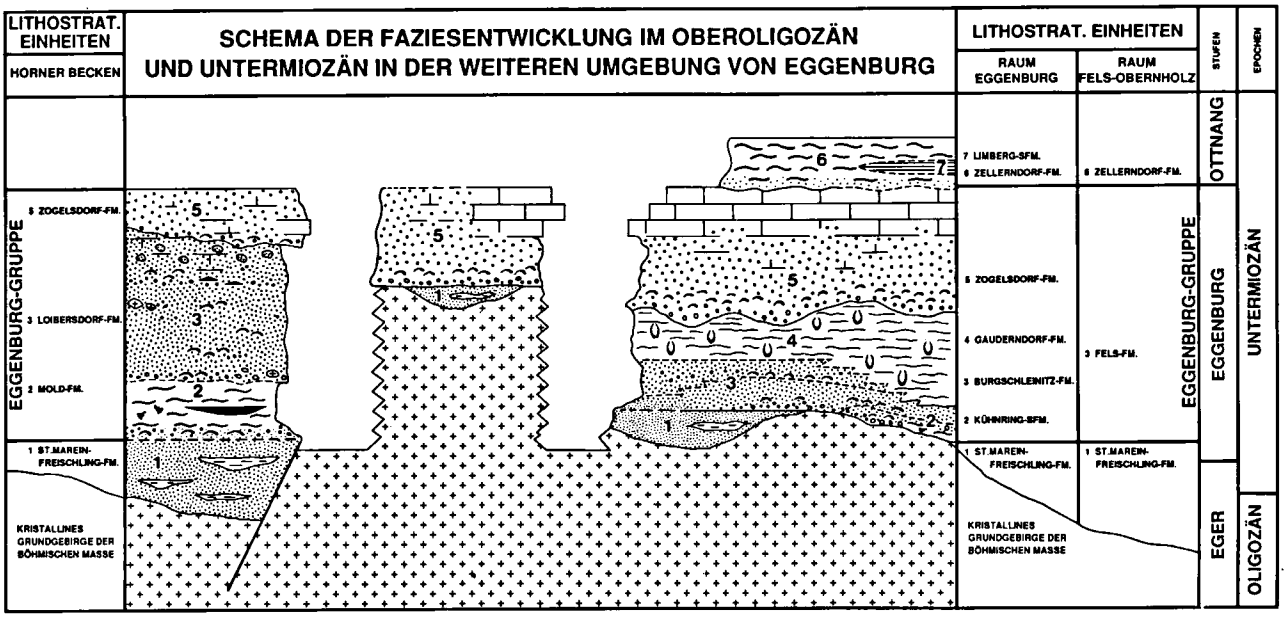

Fig. 4. Lithological classification of Cenozoic strata in the Eggenburg area (after Roetzl & Steininger, 1991).

which explains why it was often impossible to identify specimens to generic or specific levels (Pl. 1, Fig. 12).

Typical preservational states are the following:

— corrosion/abrasion, as in *Globulina gibba* (d'Orbigny, 1826) (Pl. 1, Figs 1-3);

— variably strong crystal overgrowths, as in *Asterigerinata planorbis* (d'Orbigny, 1846): well-preserved

(Pl. 1, Figs 4, 5); or strong crystal overgrowth (Pl. 1, Figs 6, 7);
— broken and abraded individuals, such as *Elphidium* sp. (Pl. 1, Fig. 8) and *Lenticulina inornata* (d'Orbigny, 1846) (Pl. 1, Fig. 9);
— porous and cracked specimens, often with cemented organic and anorganic particles (Pl. 1, Fig. 10).

In part, these preservational modes change the surface details of foraminiferal tests to such an extent that identification becomes impossible.

Various processes may lead to post-mortem alterations of surface details: mechanical abrasion through sediment particles, chemical corrosion by surrounding waters of calcareous tests (Murray & Wright, 1970), boring organisms, as well as calcite recrystallisation during diagenesis (Collen & Burgess, 1979). Dissolution of foraminiferal tests is a result of carbonate-undersaturated circulating pore waters. Etching or partial dissolution of test surfaces of various calcareous foraminifers was described by Murray (1967) and Murray & Wright (1970). During diagenesis, with changing chemico-physical conditions, specimens may show evidence of initial dissolution of test surface followed by later calcite overgrowth (Collen & Burgess, 1979).

Methods

The samples were processed using diluted hydrogen superoxide and wet-sieved on a 0.063 mm mesh, dried and then split. In order to gain an idea of faunal assemblages, the planktonic and benthic foraminifers were identified to species and numbers of specimens noted on lists. After this, the quantitative distribution of the preserved foraminifers was used as data matrix in Lotus 1-2-3. This matrix served as a basis for the use of multivariate statistical analyses.

A - Sample cluster ('Q-mode' analysis)

The sample cluster analysis was carried out in order to assign the samples on the basis of their faunal content. In this way, samples are compared to each other using occurrence and frequency of its features (= species). The SPSS-X programme groups similar measurements on a distance scale, from 0 to 25 (referred to in Fig. 5 as 'rescaled distance'). A small value indicates a close resemblance, a higher value indiates a lesser resemblance between samples. In accepting that comparable faunas are an expression of similar ecological conditions, the resulting sample clusters represent sample groupings with comparable faunal content. Despite the observed diagenetic overprinting in faunal assemblages, this method was used, as all samples processed were characterised by similarly poor preservation.

— Sample cluster analysis of benthic foraminifers only (Fig. 5, Table 1):

Cluster 1: The fauna is characterised by dominance of *Cibicides pseudoungerianus* (Cushman, 1922) (Pl. 8, Figs 4-6) and low numbers of elphidiids. Attached planoconvex forms such as discorbid and asterigerinatid species are rare. In contrast, *Spiroplectammina pectinata* (Reuss, 1850) (Pl. 1, Fig. 12; Pl. 2, Figs 1, 2), *Hanzawaia boueana* (d'Orbigny, 1846) (Pl. 8, Figs 10, 11) and bolivinids occur in larger numbers. Samples: EG 1, 2, 4, 5, 6, 7, 12, 36, 37, 40, 42, 46.

Sample number	Locality
EG 1	borehole Pulkau 1 (sample 11)
EG 2	borehole Pulkau 1 (sample 10)
EG 3	borehole Pulkau 2 (sample 13)
EG 4	Maigen, Metzger sandpit (sample 3/11E)
EG 5	Maigen, Wagerer sandpit (sample 1/9)
EG 6	Maigen, Metzger sandpit (sample 3/10E)
EG 7	Maigen, Stranzl sandpit (sample 2/32)
EG 8	Limberg (sample 15)
EG 9	Limberg (sample 14)
EG 10	Brugg
EG 11	Sigmundsherberg
EG 12	Klein Burgstall
EG 13	Pulkau-Weitersfeld
EG 14	Eggenburg-Bahnhof
EG 15	Eggenburg-Krankenhaus (sample 27)
EG 16	Eggenburg-Krankenhaus (sample 26)
EG 17	Eggenburg-Lagerhaus
EG 18	Eggenburg-Krankenhaus (sample 20)
EG 19	Eggenburg-Felberstraße
EG 20	Unternalb (upper sample)
EG 21	Unternalb (lower sample)
EG 22	Grübern (sample 129)
EG 23	Grübern (sample 128)
EG 24	Groß-Reipersdorf
EG 25	Unternalb (sample 2)
EG 26	Unternalb (sample 3)
EG 27	Eggenburg-Brunnstube (sample 3)
EG 28	Eggenburg-Brunnstube (sample 1)
EG 29	Eggenburg-Brunnstube (sample 5)
EG 30	Eggenburg-Brunnstube (sample 4)
EG 31	Eggenburg-Krankenhaus (sample 13)
EG 32	Eggenburg-Krankenhaus (sample 21)
EG 33	Eggenburg-Tankstelle
EG 34	Sachsendorf-Süd
EG 35	Reinprechtspölla
EG 36	Kühnring
EG 37	Unternalb (sample 1)
EG 38	Eggenburg-Krankenhaus (sample 1 NW)
EG 39	Oberdürnbach
EG 40	Eggenburg-Straßenmeisterei
EG 41	borehole Sachsendorf (sample 5)
EG 42	Eggenburg-Zwingergraben
EG 43	Grübern sandpit (sample 2)
EG 44	Grübern sandpit (sample 4)
EG 45	Grübern sandpit (sample 5)
EG 46	borehole Pulkau 2 (sample 11)

Table 1. Sample numbers.

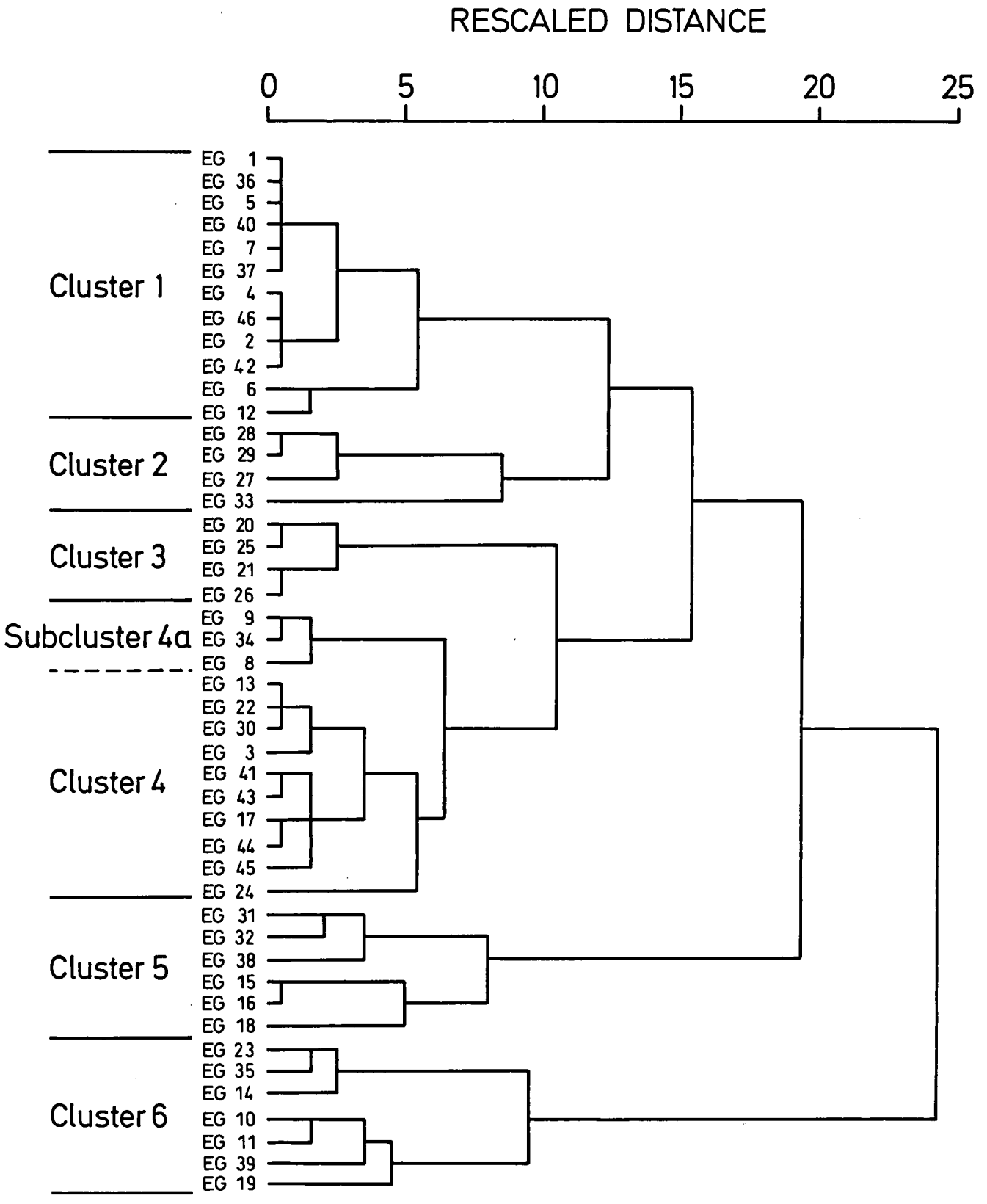

Fig. 5. Q-mode cluster analyses of benthic foraminiferal assemblages studied herein.

Cluster 2: This is characterised by large numbers of *Hanzawaia boueana*. The samples exclusively come from Eggenburg-Brunnstube and Eggenburg-Tankstelle, and this cluster represents a distinct local development. Samples: EG 27, 28, 29, 33.

Cluster 3: The fauna is characterised by high percentages of *Ammonia parkinsonia* (d'Orbigny, 1839) (Pl. 9, Figs 3, 6). Important additional elements are *Asterigerinata planorbis*, *Cibicides lobatulus* (Walker & Jacob, 1798) (Pl. 8, Figs 1-3), *C. pseudoungerianus*, *Elphidium* gr. *crispum/macellum* (Pl. 9, Figs 7-9, 12), and *Nonion commune* (d'Orbigny, 1846) (Pl. 10, Figs 4, 5). This cluster also represents a local development. Samples: EG 20, 21, 25, 26.

Cluster 4: planoconvex forms such as *Cibicides pseudoungerianus*, *C. lobatulus*, *Asterigerinata planorbis* and discorbid species characterise this cluster. Comparatively common also is the genus *Elphidium* de Montfort, 1808. Samples: EG 3, 13, 17, 22, 24, 30, 41, 43, 44, 45.

Subcluster 4a: This cluster is closely related to cluster 4. Planoconvex forms and elphidiids are less well represented, while *Hanzawaia boueana* is commoner. Samples: EG 8, 9, 34.

Cluster 5: The most important elements of this cluster are *Cassidulina laevigata* d'Orbigny, 1826 (Pl. 11, Fig. 7) and *Globocassidulina subglobosa* (Brady, 1881) (Pl. 11, Fig. 8). Additional forms are *Pullenia bulloides* (d'Orbigny, 1826) (Pl. 10, Figs 9, 10), *Lenticulina vortex* (Fichtel & Moll, 1798) (Pl. 3, Figs 7-9) and *Sphaeroidina bulloides* d'Orbigny, 1826 (Pl. 11, Figs 9, 10). Samples: EG 15, 16, 18, 31, 32, 38.

Cluster 6: The fauna is characterised by the dominance of the genus *Elphidium*. Also occurring more commonly is *Cibicides lobatulus*. Samples: EG 10, 11, 14, 19, 23, 35, 39.

B - Diversity

To analyse better the foraminiferal faunas, diversity was determined by means of the information index (Shannon & Weaver, 1963).

$$\text{Formula: } H = -\sum \frac{Ni}{N} \ln \frac{Ni}{N}$$

in which Ni represents the number of individuals of the i-species (i = 1 to S) and N the number of all individuals.

This index relates to sample size, species distribution and species number, and varies between 0 (a single species present) and infinite.

C - Benthic/planktonic ratio

To determine this ratio, percentages of benthic and planktonic foraminifers were calculated, which are here given in Table 2.

Localities and faunas

The location of the consecutively numbered sampled localities may be found in Fig. 2.

1 - Klein Burgstall, ÖK 50/sheet 21-Horn: situated at the forest margin in Raanfeld, *c* 300 m north of the Klein Burgstall-Freischling road, *c* 3.5 km NNW of the church of Klein Burgstall. Exposed are *c* 0.5 m of extremely poorly sorted, gravelly, sandy silts.
- Sample: EG 12.

Fauna: amongst the benthic species, *C. lobatulus* and *C. pseudoungerianus* are common. Bolivinids as

Locality	Sample number	P/B ratio
Klein Burgstall	EG 12	47.9
Grübern (road cut)	EG 23	0.2
Grübern (road cut)	EG 22	0
Grübern (sandpit)	EG 43	0
Grübern (sandpit)	EG 44	0.6
Grübern (sandpit)	EG 45	3.4
Oberdürnbach	EG 39	1.1
Limberg	EG 9	21.5
Limberg	EG 8	29.0
Sachsendorf (borehole)	EG 41	11.2
Sachsendorf-Süd	EG 34	18.9
Reinprechtspölla	EG 35	0.4
Eggenburg-Lagerhaus	EG 17	0.8
Eggenburg-Brunnstube	EG 27	28.9
Eggenburg-Brunnstube	EG 28	31.5
Eggenburg-Brunnstube	EG 29	2.0
Eggenburg-Brunnstube	EG 30	1.7
Eggenburg-Zwingergraben	EG 42	56.8
Eggenburg-Felberstraße	EG 19	24.1
Eggenb.-Straßenmeist.	EG 40	7.3
Eggenb.-Getreidegasse	EG 38	7.8
Eggenburg-Krankenhaus	EG 31	6.8
	EG 18	12.0
	EG 32	3.0
	EG 16	8.1
	EG 15	4.0
Gauderndorf	EG 47	2.0
Maigen-Stranzl sandpit	EG 7	4.9
Maigen-Wagerer sandpit	EG 5	12.9
Maigen-Metzger sandpit	EG 6	41.7
Maigen-Metzger sandpit	EG 4	10.3
Sigmundsherberg	EG 11	2.5
Brugg	EG 10	0.8
Kühnring	EG 36	6.6
Eggenburg-Bahnhof	EG 14	0
Eggenburg-Tankstelle	EG 33	3.9
Groß-Reipersdorf	EG 24	0.6
borehole Pulkau 1	EG 2	1.2
borehole Pulkau 1	EG 1	2.6
borehole Pulkau 2	EG 46	7.2
borehole Pulkau 2	EG 3	3.7
Pulkau-Weitersfeld	EG 13	0.1
Unternalb	EG 37	10.5
	EG 25	1.0
	EG 26	0.4
	EG 21	0
	EG 20	0

Table 2. Planktonic/benthic foraminifer ratio per locality/sample.

well as agglutinated forms are relatively common. Other benthics occur in low numbers only. Plankton: 47.9 %, mainly *Cassigerinella globulosa* (Egger, 1857) (Pl. 12, Figs 1, 2), while *Globigerina praebulloides praebulloides* Blow, 1959 (Pl. 12, Figs 6, 7) and *G. ciperoensis ottnangiensis* Rögl, 1969 (Pl. 12, Figs 4, 5) are rare.

Diversity index: 2.39. Preservation: good. Cluster: 1.

2a - Grübern, road cut, ÖK 50/sheet 21-Horn: situated *c* 200 m northwest of the church of Grübern, between wine cellars along the road to Gumping, on the northern side of the Tiefenbach valley. Exposed are 2.80 m of sediment. This section comprises a variable alternation of a coarse-grained, biogenic, poorly sorted gravelly sand, unconsolidated, as well as indurated calcarenite layers. Two samples, as follows:

- Sample: EG 23 (at 2.20 m).

Fauna: the fauna is dominated by *Elphidium* gr. *crispum/macellum* and *C. pseudoungerianus*. Other species, however, are rare. Plankton: 0.2%.

Diversity index: 1.82. Preservation: moderate; especially abraded and fragmentary test were observed. Cluster: 6.

- Sample: EG 22 (at 2.50 m).

Fauna: species of *Cibicides* are numerous. Common also are elphidiids, *A. planorbis*, *Discorbis patella* (Reuss, 1850) (Pl. 6, Figs 11, 12), *S. pectinata*, *Pararotalia rimosa* (Reuss, 1869) (Pl. 9, Figs 4, 5), *Cassidulina laevigata*. Plankton: absent.

Diversity index: 2.4. Preservation: moderate. Cluster: 4.

2b - sandpit Grübern, ÖK 50/sheet 21-Horn: this disused sandpit is situated *c* 350 m northwest of the church, and exposes a sequence of coarse-grained, biogenic, poorly sorted gravelly sand, unconsolidated, as well as indurated calcarenite layers. A maximum of 4 m is exposed.

- Sample: EG 43 (at 2.10 m).

Fauna: the commonest species is *C. pseudoungerianus*. Other typical species are *Elphidium macellum* (Fichtel & Moll, 1803), *E. fichtellianum* (d'Orbigny, 1846) (Pl. 9, Figs 10, 11), *A. planorbis*, *D. patella*, *Glabratella hagni* Wenger, 1987, *P. rimosa*, *Sphaerogypsina globulus* (Reuss, 1848) (Pl. 9, Figs 1, 2) and *S. pectinata*. Remains of miliolid foraminifers were observed. Plankton: only few specimens of *G. ciperoensis ottnangiensis*.

Diversity index: 2. Preservation: good; common also are ostracod shells. Cluster: 4.

- Sample: EG 44 (at 3.10 m).

Fauna: similar to that of sample EG 43; higher numbers of *S. pectinata* have been observed. Plankton: 0.6 %.

Diversity index: 2. Preservation: good. Cluster: 4.

- Sample: EG 45 (at 3.60 m).

Fauna: in addition to the genera *Elphidium* and *Cibicides* de Montfort, 1808, common are *A. planorbis*, various bolivinids, *Escornebovina cuvillieri* (Poignant, 1965) (Pl. 7, Figs 7, 8), *P. rimosa*, remains of miliolids and discorbids. Plankton: 3.4 %.

Diversity index: 2.6. Preservation: good. Cluster: 4.

3 - Oberdürnbach-Kellergasse, ÖK 50/sheet 22-Hollabrunn: this exposure is situated in the southern Kellergasse, south of the church, next to the entrance to a wine cellar. 210 cm of a poorly sorted silty sand are exposed, the base disappearing under the asphalt cover, the top passing smoothly into recent soil.

- Sample: EG 39 (at 1.70 m).

Fauna: the fauna is dominated by *C. lobatulus* and *E.* gr. *crispum/macellum* as well as *S. pectinata*. Plankton: 1.1 %. Diversity index: 1.83. Preservation: poor. Cluster: 6.

4 - Limberg, ÖK 50/sheet 22-Hollabrunn: the Hengl quarry is situated in the Gänsegraben, *c* 3.5 km northeast of Maissau, and *c* 500 m west of Limberg. Here the Zogelsdorf Formation (thickness *c* 7 m) is exposed as a transgressive unit covering the crystalline Bohemian Massif (here reaching a thickness of *c* 35 m), and comprising poorly lithified, poorly sorted sand with two pebble horizons.

- Sample: EG 9 (at 4.80 m).

Fauna: the dominant species is *C. pseudoungerianus*, *C. lobatulus* also occurs more commonly. Elphidiids are present but not common. Of infaunal species, *Bulimina* gr. *echinata/elongata*, as well as *Bolivina* spp. and agglutinated forms occur. Other elements are *A. planorbis*, *Eponides repandus* (Fichtel & Moll, 1798) (Pl. 7, Figs 4, 5), *E. cuvillieri*, glabratellids, *H. boueana*, *P. rimosa*, *N. commune*, *L. inornata* and *Cancris auriculus* (Fichtel & Moll, 1798) (Pl. 7, Figs 1, 2). Plankton: 21.5 %, *G. praebulloides praebulloides* is commoner, *G. ciperoensis ottnangiensis* rare and *Globigerinoides trilobus* (Reuss, 1850) (Pl. 12, Figs 8, 9) very rare.

Diversity index: 2.57. Preservation: good. Cluster: 4a.

- Sample: EG 8 (at 5.60 m).

Fauna: similar to that of sample EG 9. Planoconvex forms are rarer. Plankton: 29.0 %.

Diversity index: 2.49. Preservation: good. Cluster: 4a.

5 - borehole Sachsendorf, ÖK 50/sheet 21-Horn: this cored borehole of 4.20 m was drilled outside the moat in the northern part of the wall of Sachsendorf ruin. The sediment of sample EG 41 (at a depth of 4.00-4.20 m) consists of an extremely poorly sorted, clayey, silty sand.

Fauna: the commonest genera are *Cibicides* and *Elphidium*. Additional typical elements are *Bolivina* spp., *Bulimina* gr. *elongata/echinata* (Pl. 4, Fig. 12), agglutinated forms, *H. boueana*, *L. inornata* and *L. vortex*. Plankton: 11.2%.

Diversity index: 1.89. Preservation: good. Cluster: 4.

6 - Sachsendorf-Süd, ÖK 50/sheet 21-Horn: the samples were taken at the south entry to the village from a construction pit for the foundation of a house. An extremely poorly sorted, silty sand was exposed.

- Sample: EG 34.

Fauna: typical elements are *C. pseudoungerianus*, *C. lobatulus*, *E.* gr. *crispum/macellum*, agglutinated forms, *E. repandus*, *L. inornata*, and discorbids. Rare elements such as *Trifarina* cf. *globosa* (Stolz, 1925), *Pappina* cf. *parkeri* (Karrer, 1877) (Pl. 5, Figs 8, 9) and *Pullenia bulloides* are also observed. Plankton: *G. praebulloides praebulloides* and *G. ciperoensis ottnangiensis* occur, and make up 18.9% of total fauna.

Diversity index: 2.46. Preservation: good. Cluster: 4a.

7 - Reinprechtspölla, ÖK 50/sheet 21-Horn: the former exposure was situated at the forest margin, north of Kohläcker and could be reached via the road leading to Reinprechtspölla-Maria-Dreieichen, *c* 1.5 km NNW of Reinprechtspölla church. An extremely poorly sorted sand was exposed.

- Sample: EG 35.

Fauna: this assemblage is typified by elphidiids. Additional important elements are *C. pseudoungerianus*, *C. lobatulus*, *A. parkinsonia* and *N. commune*. Other species are rare and are found in few specimens. Plankton: 0.4%.

Diversity index: 1.38. Preservation: moderate with clear corrosion traces. Ostracods were also observed. Cluster: 6.

8 - Kühnring-Gemeindesandgrube, ÖK 50/sheet 21-Horn: the municipal sandpit of Kühnring is situated *c* 1 km southeast of Kühnring, *c* 3.5 km southwest of Eggenburg. This sandpit is situated in a narrow, almost W-E oriented trough, delimited in the north and south by crystalline rocks, and exposes marine sediments of the Burgschleinitz, Gauderndorf, and Zogelsdorf formations, the last-named reaching a thickness of *c* 1.2 m. It comprises an extremely poorly sorted, gravelly, sandy silt.

- Sample: EG 36.

Fauna: dominant is *C. pseudoungerianus*. Rare elements are *P. bulloides*, fragments of *Stilostomella danuviensis* Wenger, 1987 (Pl. 6, Fig. 7), *L. inornata*, *H. boueana*, *Discorbis* spp., *Bolivina* spp. and few specimens of elphidiids. Plankton: 6.6 %.

Diversity index: 1.78. Preservation: moderate. Cluster: 1.

9 - Eggenburg-Bahnhof, ÖK 50/sheet 21-Horn: the exposure is situated opposite the railway station, in the Florianibründlstraße no. 6. Sample EG 14 was collected during construction of a house; a poorly sorted sand was exposed.

Fauna: elphidiids are dominant. Common also are planoconvex forms. Fragments of miliolid tests are also observed. Plankton: none.

Diversity index: 1.51. Preservation: moderate; ostracods were also observed. Cluster: 6.

10 - Eggenburg-Tankstelle, south village entry, ÖK 50/sheet 21-Horn: situated west of the Brunnstubengraben, at the SSE entry to Eggenburg; sampled during construction of a filling station. A poorly sorted silty sand was exposed.

- Sample: EG 33.

Fauna: especially common is *H. boueana*. Common also is *L. inornata*. *Cibicides pseudoungerianus*, elphidiids, *N. commune* and *A. parkinsonia* occur in about equal numbers. Other taxa are rare. Plankton: 3.9%.

Diversity index: 2.1. Preservation: well-preserved ostracod shells were also observed. Cluster: 2.

11 - Eggenburg-Lagerhaus, ÖK 50/sheet 21-Horn: situated at the SSE entry to Eggenburg, east of the Brunnstubengraben. Exposed was a poorly sorted silty sand.

- Sample: EG 17.

Fauna: *C. pseudoungerianus*, *Elphidium* gr. *crispum/macellum*, *C. lobatulus*, *S. pectinata*, *A. planorbis*, *H. boueana* und glabratellids are common. Other species occur as single specimens. Plankton: 0.8%.

Diversity index: 1.69. Preservation: good. Cluster: 4.

12 - Eggenburg-Brunnstube, ÖK 50/sheet 21-Horn: the exposure is situated in the Brunn-

stubengraben at the SSE entry, on the Bundesstraße 35 leading to Maissau. Four samples (EG 27 to 30) from the 7 m thick section were analysed. Sample EG 27 (at 0.15 m), directly overlying the Gauderndorf Formation, comprises a fossiliferous, very poorly sorted biogenic hash horizon with ill-preserved aragonitic bivalves and gastropods. Sample EG 28 (at 1.80 m) is a reddish fine-grained, well-sorted sand with few fragments of bivalve shells. Samples EG 29 (at 4 m) and EG 30 (at 5.70 m) come from an alternation of unconsolidated and indurated sediments. The indurated parts follow more or less bedding planes and occur in the form of concretions.

- Sample: EG 27.

Fauna: *C. pseudoungerianus*, *L. inornata*, *N. commune*, *H. boueana*, *S. pectinata*, *Bolivina* spp. and *A. parkinsonia* are typical. Plankton: 28.9%, mainly *C. globulosa*. Preservation: good. Diversity index: 1.9. Cluster: 2.

- Sample: EG 28.

Fauna: similar to that of sample EG 27. Commoner occurrence of *H. boueana*, *N. commune* and *E. cuvillieri* is observed. Rarer are *L. inornata*, *A. parkinsonia* and *Bolivina* spp. Of agglutinated forms only textulariids occur. Plankton: 31.5%.

Diversity index: 2.2. Preservation: good. Cluster: 2.

- Sample: EG 29.

Fauna: the dominant species is *C. pseudoungerianus*, common also are *H. boueana* and *E.* gr. *crispum/macellum*. Plankton: 2%.

Diversity index: 1.63. Preservation: moderate. Cluster: 2.

- Sample: EG 30.

Fauna: commoner is in addition to *C. pseudoungerianus* also *C. lobatulus*. Occurring more commonly are elphidiids, *A. planorbis*, and *H. boueana*. Plankton: 1.7 %.

Diversity index: 1.8. Preservation: moderate. Cluster: 4.

Remark: Papp (*in* Steininger, 1971) described the foraminifers of Eggenburgian strata from Eggenburg-Brunnstube. By using the sieve fraction 0,063 mm, the faunal list could be enlarged. Also observed was a change in faunal assemblages from the base to the top.

13a - Eggenburg-Zwingergraben, ÖK 50/sheet 21-Horn: the exposure is situated east of the mediaeval Zwingergraben, which is part of the eastern defence works of Eggenburg. Sample EG 42 was taken from the lower part of this ditch, near the gate from between slightly dipping limestone beds. The maximum thickness of the Zogelsdorf Formation exposed amounted to 1.5 m: a poorly sorted, clayey, silty sand.

- Sample: EG 42 (at 0.30 m).

Fauna: the commonest species is *C. pseudoungerianus*. Additional important taxa are *Bolivina* spp., *C. laevigata*, *G. globulosa*, *H. boueana* and *Fissurina* sp. Remains of miliolids were also observed. Plankton: 56.8%, commonest are *G. praebulloides praebulloides* and *G. ciperoensis ottnangiensis*. Diversity index: 1.74. Preservation: poor. Cluster: 1.

13b - Eggenburg-Felberstraße, ÖK 50/sheet 21-Horn: the sample was taken from an open ditch in the Felberstraße north of the entrance to the Lindenhof.

- Sample: EG 19.

Fauna: *C. lobatulus* and *E.* gr. *crispum/macellum* occur in about equal numbers; slightly rarer is *C. pseudoungerianus*. Typical is the common occurrence of *G. subglobosa* and agglutinated forms. Plankton: 24.1 %, mainly *G. praebulloides praebulloides* and *G. ciperoensis ottnangiensis*.

Diversity index: 2.2. Preservation: moderate. Cluster: 6.

13c - Eggenburg-Straßenmeisterei, ÖK 50/sheet 21-Horn: the exposure is in the Pulkauer Straße, north of the KFZ Mechaniker-Landesberufsschule, on the grounds of the Straßenmeisterei. Exposed was a poorly sorted, silty gravelly sand.

- Sample: EG 40.

Fauna: characteristic species are *C. pseudoungerianus*, *C. lobatulus*, *E.* gr. *crispum/macellum*. Other taxa occur in few specimens only. Plankton: 7.3%.

Diversity index: 1.98. Preservation: moderate. Cluster: 1.

13d - Eggenburg-Getreidegasse, ÖK 50/sheet 21-Horn: the sample was collected from the northwestern corner of the Rechtberger-Getreidegasse at Eggenburg. Exposed was an extremely poorly sorted, clayey, silty sand.

- Sample: EG 38.

Fauna: identical to that found at locality 14 (see below).

14 - Eggenburg-Krankenhaus and environs, ÖK 50/sheet 21-Horn: sampling spots corner Engelsdorfer-Pulkauer Straße (Bryozoenmergel-EG 31), Krankenhaus (EG 32, 18), Krankenhaus-Kesselbau (EG 16, 15), are all situated directly adjacent

to the hospital. All samples were taken during construction of and additions to houses. The samples did not consist of original sediment, but comprised already sieved sediment.

- Samples: EG 15, 16, 18, 31, 32.

Fauna: *C. laevigata*, *G. subglobosa*, *P. bulloides*, *Astrononion perfossum* (Clodius, 1922) (Pl. 10, Figs 3, 6), *L. inornata*, *L. vortex*, *Astacolus crepidulus* (Fichtel & Moll, 1798) (Pl. 3, Fig. 3), *Fissurina* spp., *Sph. bulloides* and various agglutinated forms dominate the assemblages. *Cibicides pseudoungerianus*, *C. lobatulus* and *E.* gr. *crispum/macellum* occur in varying numbers, but do not contribute substantially to the characterisation of this fauna. Plankton: 4.0 to 12.0%.

Diversity index: 2.2 to 2.5. Preservation: very good. Cluster: 5.

15 - Gauderndorf, ÖK 50/sheet 21-Horn: the exposure is situated at Seefeld on the Himmelreich Straße, *c* 700 m north of Gauderndorf and can only be reached via a country road.

- Sample: EG 47.

Fauna: the dominant species is *C. pseudoungerianus*. Characteristic elements are elphidiids, *S. pectinata*, *A. planorbis*, *C. lobatulus* and *Discorbis* spp. Plankton: 2 %. Diversity index: 2. Preservation: moderate. Ostracods were also observed.

16 - Maigen, Stranzl sandpit, ÖK 50/sheet 21-Horn: this disused sandpit is situated along the road leading to Eggenburg-Maigen-Sigmundsherberg, *c* 700 m southeast of Maigen. A maximum of 4.20 m of Zogelsdorf Formation is exposed. Common macrofossils are pectinid bivalves. The sediment consists of an extremely poorly sorted, silty, gravelly sand.

- Sample: EG 7.

Fauna: *C. pseudoungerianus* is the dominant species. Common elements are *S. pectinata*, *Bolivina* spp. and *H. boueana*. Plankton: 4.9%.

Diversity index: 2. Preservation: good. Cluster: 1.

17 - Maigen, Wagerer sandpit, ÖK 50/sheet 21-Horn: this sandpit, which is only worked temporarily, is situated *c* 1 km southeast of Maigen, and exposes *c* 1-1.5 m of an extremely poorly sorted, silty sand of the Zogelsdorf Formation.

- Sample: EG 5.

Fauna: the most important species are *C. pseudoungerianus*, *E.* gr. *crispum/macellum*, bolivinids and *S. pectinata*. Plankton: 12.9%, mainly *G. praebulloides praebulloides* and *G. ciperoensis ottnangiensis*. Much rarer is *Cassigerinella globulosa*.

Diversity index: 2.1. Preservation: good. Cluster: 1.

18 - Maigen, Metzger sandpit, ÖK 50/sheet 21-Horn: this disused sandpit is situated *c* 400 m southwest of Maigen. The Zogelsdorf Formation comprises a maximum of 3 m and consists of a poorly sorted, silty sand.

- Sample: EG 6.

Fauna: in the lower sample EG 6, *C. pseudoungerianus Bolivina* spp., *H. boueana*, *Discorbis* spp., *S. pectinata* and *C. laevigata* are the most important species. Plankton: 41.7%, mainly *Cassigerinella globulosa*.

Diversity index: 2.38. Preservation: good. Cluster: 1.

- Sample: EG 4.

Fauna: important species are *C. pseudoungerianus*, *A. planorbis*, *Bolivina* spp., *S. pectinata* and *H. boueana*. Plankton: 10%, mainly *G. praebulloides praebulloides*.

Diversity index: 2.18. Preservation: good, in both samples ostracods were observed. Cluster: 1.

19 - Sigmundsherberg, ÖK 50/sheet 21-Horn: this sample was taken from the northwestern part of the hamlet of Sigmundsherberg, southwest of the Lagerhaus, during new construction of the Alpenlandsiedlung.

- Sample: EG 11.

Fauna: *C. pseudoungerianus*, *C. lobatulus* and elphidiids dominate, *S. pectinata*, *G. hagni*, asterigerinatids and discorbids, *H. boueana* and cassidulinids occur. Plankton: 2.5%.

Diversity index: 1.72. Preservation: poor. Cluster: 6.

20 - Brugg-Quellschutzgebiet, ÖK 50/sheet 21-Horn: sample EG 10 was taken north of the Bruggfeld, *c* 2 m from the entry to the Quellstube below a pectinid-rich layer. Exposed were *c* 30 cm of a poorly sorted, gravelly sand with high biogenic content.

- Sample: EG 10.

Fauna: *C. pseudoungerianus* and *C. lobatulus* are very common, and elphidiids are well represented. Characteristic elements are *A. planorbis*, *D. patella*, *G. hagni*, *H. boueana*. Other taxa occur in small numbers only. Plankton: 0.8%.

Diversity index: 1.39. Preservation: very poor. Cluster: 6.

21 - Groß-Reipersdorf, ÖK 50/sheet 22-Hollabrunn: disused quarry at the northern flank of the Feldberg, *c* 1.6 km SSE of Groß-Reipersdorf, *c* 350 m NNE of the Feldberg, *c* 50 m south of the railway Zellerndorf-Sigmundsherberg, directly after the

crossing of the road from Groß-Reipersdorf. The *c* 3 m of Zogelsdorf Formation consist of generally massive, fining upward, biogenic-rich limestones. From this upper part sample EG 24 was taken. In this exposure also the transition of the Zogelsdorf Formation (Late Eggenburgian) to the Zellerndorf Formation (Ottnangian) can be seen.

- Sample: EG 24.

Fauna: in addition to cibicids and elphidiids extraordinarily strong glabratelliid forms occur. Plankton: 0.6%.

Diversity index: 1.69. Preservation: very poor. Cluster: 4.

22 - borehole Pulkau 1, ÖK 50/sheet 22-Hollabrunn: this borehole was drilled directly south of the Bundesstraße between Pulkau and Schrattental, *c* 70 m WSW of the Gerichtsmarterls. The final depth was 32.60 m. The sediments were poorly sorted, silty sands, rich in molluscan remains.

- Sample: EG 1 (at 27 m).

Fauna: the assemblages of samples EG 1 and EG 2 are similar. Occurring more commonly are in sample EG 1 *S. pectinata* and stilostomellids. Plankton: 2.6 %.

Diversity index: 1.59. Preservation: good. Cluster: 1.

- Sample: EG 2 (at 29.27 m).

Fauna: characterised by high numbers of *C. pseudoungerianus*. Taxa such as *Bolivina* spp., *B.* gr. *elongata/echinata*, *S. pectinata*, *N. commune*, *E. cuvillieri* and discorbids are also commoner, as are fragments and whole specimens of *S. danuviensis*. Plankton: 1.2%.

Diversity index: 1.82. Preservation: good. Cluster: 1.

23 - borehole Pulkau 2, ÖK 50/sheet 2-Hollabrunn: this borehole was drilled 1 km WSW of borehole Pulkau 1, in the northwest corner of the Pulkauer Ziegelei, situated 1 km east of Pulkau and north of the Retzer Bundesstraße. End depth was 27 m.

- Sample: EG 46 (at 22.75 m), comprising an extremely poorly sorted, silty sand.

Fauna: dominant is *C. pseudoungerianus*. Rarer but still common elements are elphidiids, *H. boueana*, *S. pectinata* (with clearer keel) as well as discorbids. Plankton: 7.2%.

Diversity index: 1.6. Preservation: good. Cluster: 1.

- Sample: EG 3 (at 26.5 m), consisting of a poorly sorted calcareous sandstone, moderately lithified.

Fauna: elphidiids and cibicids are comparatively common. In higher numbers occur also *A. planorbis*, *Bolivina* spp. and glabratellid forms. Plankton: 3.7%.

Diversity index: 1.89. Preservation: good. Cluster: 4.

24 - Pulkau-Weitersfeld, ÖK 50/sheet 22-Hollabrunn: this road cut is situated along the road between Pulkau and Weitersfeld. The composite section comprises five sections with a total length of *c* 8 m. These are biogenic sands with a varying degree of lithification.

- Sample: EG 13.

Fauna: *C. pseudoungerianus* and *E.* gr. *crispum/macellum* are common, occurring in lesser numbers are *C. lobatulus*, *A. planorbis*, *Bolivina* spp., *E. cuvillieri*, *S. pectinata* and discorbids. Plankton: 0.1%.

Diversity index: 1.6. Preservation: moderate. Cluster: 4.

25 - Unternalb, ÖK 50/sheet 2-Hollabrunn: this disused sandpit is situated in the Hungerfeld, *c* 1.3 km south of Unternalb. Exposed are *c* 2.20-3.20 m of alternating poorly sorted gravelly sand with indurated layers.

- Sample: EG 37 (at 40 cm).

Fauna: *C. pseudoungerianus* is the dominant species; relatively common are *S. pectinata*, *C. laevigata*, *G. subglobosa*, *L. inornata*, *N. commune*, *H. boueana*, *E. cuvillieri* and discorbid taxa. Plankton: 10.5%.

Diversity index: 2. Preservation: good. Cluster: 1.

- Samples: EG 25 (at 2.10 m) and EG 26 (at 2.50 m).

Fauna: characterised by the common occurrence of *A. parkinsonia*. Common species also are *C. lobatulus*, *A. planorbis*, *E.* gr. *crispum/macellum*, *S. pectinata* and *N. commune*. Plankton: 1%.

Diversity index: 2. Preservation: good. Cluster: 3.

From the same locality two additional, previously taken samples were analysed. These samples had already been processed, and lacked precise indication of provenance in the section.

- Sample: EG 21.

Fauna: important taxa are *C. pseudoungerianus*, *C. lobatulus*, elphidiids spp., *A. planorbis*, *A. parkinsonia* and *N. commune*. Plankton: none.

Diversity index: 1.75. Preservation: moderate. Cluster: 3.

- Sample: EG 20.

Fauna: as sample EG 21. Plankton: none.

Diversity index: 1.58. Preservation: good. Cluster: 3.

Interpretation of foraminiferal assemblages

The benthic foraminiferal assemblages may be grouped by means of cluster analysis, counting results, diversity index and state of preservation. Planktonic foraminifers were not taken into consideration, as often only few specimens occur in the samples. The low plankton content may be explained by the marginal setting and the sheltered character of the sedimentation area. However, in a number of samples a mass occurrence of *Cassigerinella globulosa* should be noted. These small-sized forms have possibly been swept in from the open molasse sea. Despite the fact that the state of preservation of foraminifers is partly very poor, it has proved possible to distinguish six faunal assemblages (Table 3):

1 - *Ammonia* Assemblage
2 - *Cibicides-Elphidium* Assemblage
3 - *Elphidium* Assemblage
4 - *Hanzawaia* Assemblage
5 - *Cibicides pseudoungerianus* Assemblage
6 - *Cassidulina* Assemblage

CLUSTER	BENTHNIC FORAMINIFERA-ASSOC.		
3 4 6	AMMONIA CIBICIDES-ELPHIDIUM ELPHIDIUM	DEPTH < 30m	NERITIC
2 1 5	HANZAWAIA CIBICIDES PSEUDOUNGERIANUS CASSIDULINA	DEPTH > 30m	

Table 3. Cluster number, benthic foraminiferal assemblages and their depth distribution.

- *Description of assemblages*

1 - *Ammonia* Assemblage: this assemblage is characterised by *Ammonia parkinsonia*, which makes up 10 % of the total foraminiferal fauna, and is assigned to cluster 3. Phleger (1960) characterised *A. parkinsonia* as a shallow-water species, occurring in higher numbers especially in estuaries and reaching down to the middle neritic. Also common are *Asterigerinata planorbis*, *Cibicides lobatulus*, elphidiids and *Nonion commune*. The diversity in this assemblage amounts to 1.3 and the plankton percentage is at an average of 0.35 %. Faunas such as this are found in sea grass meadows.
Sampling localities: this assemblage is local only as it has been recognised exclusively at Unternalb (samples EG 20, 21, 25, 26).

2 - *Cibicides-Elphidium* Assemblage: this assemblage, in which *C. pseudoungerianus*, *C. lobatulus* and *Elphidium* gr. *crispum/macellum* occur in about equal numbers, also yields common *Asterigerinata planorbis* and glabratellid forms, and is assigned to cluster 4. In general, the relatively high number of species is typical. The diversity index amounts to 2.3 on average. The localities Limberg, Grübern and Sachsendorf-Süd, temporarily directly connected with the open molasse sea, have the highest diversities. Taxa characterising these diverse faunal assemblages will be treated below.

Glabratella Dorreen, 1948: Boltovskoy & Wright (1976) interpreted this genus as a typical representative of the shallow neritic; Murray (1973) recorded as lower limit of distribution for this genus a depth of 50 m.

Cancris auriculus is according to Hageman (1979) and Murray (1971) a typical shelf species, able to tolerate also weakly hyposaline conditions and preferring moderate water energy and higher sedimentation rates. Van Voorthuysen (1973) interpreted this species to indicate shelf seas with connections to the open sea. This species has a very large bathymetric distribution, the upper limit of which was recorded at 30 m by Haake (1980).

Pararotalia rimosa occurs in shallow neritic environments (Wenger, 1987), as does *Cibicides lobatulus*, which according to Phleger (1960) prefers nearshore sandy facies, but may also attach itself to sea grass leaves. Evidence for such a sessile habit on leaves has been found at Grübern (EG 22) and Limberg.

Other forms preferring an epiphytal or epibenthic mode of life are asterigerinatid and discorbid species. The genus *Discorbis* Lamarck, 1804 occurs mainly, according to Murray (1973), in shallow water (down to 50 m). Large specimens of the genus *Eponides* de Montfort, 1808 (0.5-1.5 mm), as found at Grübern and Limberg, are interpreted by Bandy (1964) to be typical of the central and outer shelf; small forms (generally <2 mm) would be found in bathyal settings.

For these diverse benthic fauna associations of the *Cibicides-Elphidium* Assemblage a shallow-water, neritic setting with connection to sea grass meadows may be assumed. Interesting is also the plankton distribution. Limberg (samples EG 9: 21.5%, EG 8: 29%) and borehole Sachsendorf (sample EG 41: 11,2%), as well as nearby Sachsendorf-Süd (EG 34: 18,9%) are the only localities to display a high plankton percentage. Other samples that should be

assigned here, on account of the similar faunal associations of benthic foraminifers, show a very small plankton percentage, on average 0.9%.
Sampling localities: Sachsendorf (samples EG 34, 41), Limberg (samples EG 8, 9), Grübern (samples EG 22, 43, 44, 45), Pulkau-Weitersfeld (sample EG 13), Groß-Reipersdorf (sample EG 24), upper part of Eggenburg-Brunnstube (sample EG 30) and Eggenburg-Lagerhaus (sample EG 17), borehole Pulkau 2 (sample EG 3).

3 - *Elphidium* Assemblage: in this assemblage, elphidiids may account for more than 50% of the fauna. Also commonly occurring is *Cibicides lobatulus*. This assemblage is defined by cluster 6. Elphidiids generally are interpreted as certain indicators of the shallow neritic (Wright, 1977). They are well adapted to near-shore turbulent waters and are commonest just below the littoral (Boltovskoy & Wright, 1976; Sen Gupta, 1982). According to Murray (1973), optimum conditions are at 50 m water depth. Hageman (1979) pointed out that elphidiids do not have a special preference of lithologic conditions. Van der Zwaan (1982), however, indicated that elphidiids display a wide tolerance for rising salinity. *Cibicides lobatulus* is also a typical member of the shallow neritic and prefers, according to Phleger (1960), near-shore sandy facies. This species is able to attach itself to sea grass leaves, shells and tests of other organisms, sand grains, pebbles and lithic substrates, and thus occurs in all facies (compare Murray, 1973; Sen Gupta, 1982).

The *Elphidium* Assemblage indicates a high-energy, sandy environment as based on its faunal composition. According to Murray (1973) typical members of high-energy environments are elphidiids, ammoniids, rosalinids and cibicids. An important factor is the destruction of tests through abrasion, which leads to loss of smaller forms and over-representation of larger, more thick-shelled and more resistant forms. The diversity is strongly reduced and in part foraminifers are absent from beach sands.

In samples yielding this assemblage traces of abrasion of tests, especially amongst elphidiids (sample EG 23) may be observed. Also noted was the virtual absence of smaller, thin-shelled forms. In general, the diversity index in samples of the *Elphidium* Assemblage reaches a maximum of 1.83 and the average state of preservation of the tests is relatively poor. The plankton percentage is at an average of 1%.
Sampling localities: Brugg (sample EG 10), Sigmundsherberg (sample EG 11), Oberdürnbach (sample EG 39), Reinprechtspölla (sample EG 35), Grübern (sample EG 23) and Eggenburg-Bahnhof (sample EG 14), Eggenburg-Felberstraße (sample EG 19).

4 - *Hanzawaia* Assemblage: this assemblage is characterised by the comparatively high percentage of *Hanzawaia boueana*, and is defined by cluster 2. Poag (1981) and Walton (1964) recorded the main occurrence of the genus *Hanzawaia* to be in the middle to outer shelf. A further important element is *Lenticulina inornata*. The genus *Lenticulina* Lamarck, 1804 shows a wide bathymetric distribution, reaching an acme between 800 and 1000 m according to Phleger (1960). Murray (1973) recorded a water depth in excess of 100 m for this genus. Elphidiids and *Cibicides lobatulus* show decreasing numbers of specimens in this association.

The diversity amounts to 1.9 and the plankton percentage is 16.45%. This again relates to a mass occurrence of *Cassigerinella globulosa* in sediments of the Brunnstuben sandstone. The faunal spectrum of the *Hanzawaia* Assemblage indicates deeper depositional environments. It differs from the *Cibicides pseudoungerianus* Assemblage mainly by the high numbers of *Hanzawaia boueana*, and should therefore be considered but a local variant of that assemblage.
Sampling localities: The samples come from the lower part of Eggenburg-Brunnstube (samples EG 27, 28, 29) and the nearby locality of Eggenburg-Tankstelle (sample EG 33).

5 - *Cibicides pseudoungerianus* Assemblage: In this assemblage, defined by cluster 1, *C. pseudoungerianus* is very common. Poag (1981) and Lutze (1980) recorded its abundance maximum in the deeper neritic. Co-occurring with *C. pseudoungerianus* is *Spiroplectammina pectinata* in higher numbers, which is found in decreasing numbers in shallow settings or disappears altogether there (Wenger, 1987). The marginal keel in this form is mostly sediment-related (Wenger, 1987). Indeed, also in the samples studied, a connection between finer-grained sediments and a more clearly developed keel was noted. In addition to the above-mentioned species, a few representatives of the genus *Stilostomella* Guppy, 1894 occur, which show a wide bathymetric distribution, but avoid shallow-water settings (Wenger, 1987). Low numbers of elphidiids are found in this facies. The diversity amounts to an average of 1.97. The plankton rate is at 16.67% and may be

described as comparatively high for the study area. It may be related to a mass occurrence of *Cassigerinella globulosa* in the samples from Klein Burgstall (sample EG 12: 47.9%) and Maigen (Metzger sandpit, sample EG 6: 41.7%). The sample Eggenburg-Zwingergraben (EG 42) also shows a high plankton rate of more than 50%, yielding mainly *Globigerina praebulloides praebulloides* and *G. ciperoensis ottnangiensis*. This sample's fauna shows influences of the *Hanzawaia* as well as of the *Cassidulina* Assemblage, and is thus a mixed fauna of two distinct faunal associations. The *Cibicides pseudoungerianus* Assemblage is, based on its faunal composition, indicative of a deeper depositional setting; typical shallow-water forms are virtually absent. In general, in this assemblage the plankton percentage is slightly higher than in other assemblages which are indicative of shallow marine settings, even when the mass occurrence of *Cassigerinella globulosa* is not considered. A water depth in excess of 30 m may be assumed for this fauna. The *Cibicides pseudoungerianus* Assemblage is represented in the greater part of the Eggenburg bay.

Sampling localities: borehole Pulkau 1 (samples EG 1, 2), borehole Pulkau 2 (sample EG 46), Maigen (samples EG 4-7), Kühnring-Gemeindesandgrube (sample EG 36), Eggenburg-Straßenmeisterei (sample EG 40), Eggenburg- Zwingergraben (sample EG 42), Unternalb (sample EG 37), Klein Burgstall (sample EG 12).

6 - *Cassidulina* Assemblage: In this assemblage, *Cassidulina laevigata* and *Globocassidulina subglobosa* make up *c* 20% of the fauna, and are defined by cluster 5. Murray (1973) pointed out that cassidulinids occur in cool to temperate regions and are found in shelf as well as in bathyal settings. Walton (1964) indicated depths between 30-100 m. Additional characteristic elements are *Astrononion perfossum*, *Melonis pompilioides* (Fichtel & Moll, 1798) (Pl. 10, Figs 7, 8), *Pullenia bulloides* and *Lenticulina vortex*. *Melonis pompilioides* is considered to indicate greater water depths. Phleger (1960) gave values from 1000 to 3000 m. *Pullenia bulloides* has a large bathymetric distribution, its upper limit according to Berggren & Haq (1976) and Phleger (1960) being at 50 m depth. For *Lenticulina vortex* too, an upper limit of 50 m was postulated by Drooger & Kaasschieter (1958). *Sphaeroidina bulloides* prefers, according to Hageman (1979), open marine conditions and has a large bathymetric distribution. All above-mentioned forms prefer, on the basis of studies of Recent faunas, deeper water settings. Taxa such as *C. laevigata*, *G. subglobosa*, *Bolivina concinna* (Knipscheer & Martin, 1955) (Pl. 5, Fig. 10) and *Uvigerina* cf. *posthantkeni* Papp, 1971 (Pl. 5, Figs 6, 7) indicate open marine conditions with predominantly clayey sedimentation (Murray, 1973; Hageman, 1979). The limited occurrence of epiphytal forms is indicative of deeper depositional settings. The diversity index averages between 2.2 and 2.5. The plankton percentage varies between 4 and 12% in the samples studied. The characteristic elements mentioned here have only been recorded from localities in the immediate vicinity of Eggenburg hospital and represent a local phenomenon only. The morphology of the crystalline basement on top of which the sediments were laid down, may be compared with a deep canal in which deeper water settings prevailed, with connections to the open sea. In these samples, *B. concinna* was found for the first time, a species which, according to Wenger (1987; compare Hofmann, 1967) is an important index taxon for the Late Eggenburgian.

Sampling localities: All are situated in the immediate vicinity of Eggenburg hospital (samples EG 15, 16, 18, 31, 32, 38).

Areal distribution of foraminiferal assemblages

The areal distribution of the assemblages will be discussed only briefly, as an exact reconstruction for this strongly structured area is impossible (Fig. 6). To indicate a coastal morphology *s. lat.* is not possible either, as formerly more extensive areas were inundated than are now found covered with sediment. Through synsedimentary faults and faults still active today, former topographical conditions have been further complicated.

Nebelsick (1989a, b; 1992) was able to distinguish eight different facies on the basis of microfacies analysis, three of which are dominant: a carbonate-rich bryozoan- and corallinacean algal facies as well as a bivalve-balanid facies rich in terrigenous material. Of lesser importance are an echinoderm-foraminiferal, a coralline algal-bryozoan, a calcareous sandstone, an oyster- and a conglomerate facies. The facies distribution (Fig. 7) in the Eggenburg area is characterised by a rough subdivision into an inner, protected area and an outer, exposed margin. The carbonate-rich facies types dominated by corallinacean algae and bryozoans are confined to the inner margin. The bivalve-balanid facies rich in

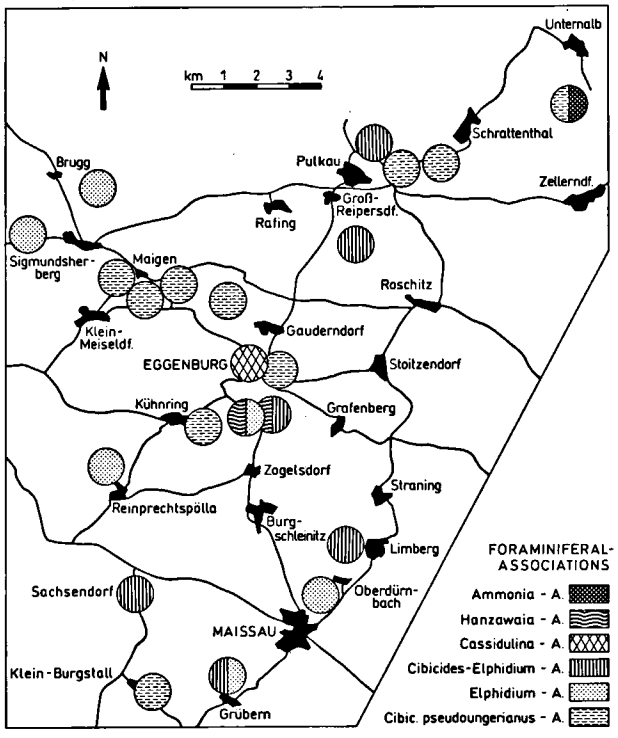

Fig. 6. Areal distribution of foraminiferal assemblages.

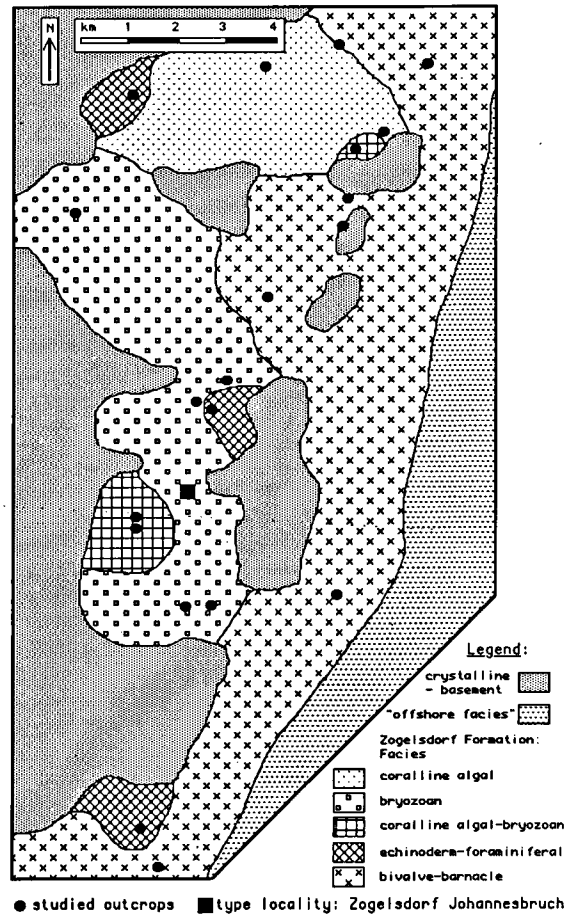

Fig. 7. Facies map for the Zogelsdorf Formation (after Nebelsick, 1989a, b, 1992).

terrigenous material occurs at the outer margin. A subdivision of the depositional area was not possible on the basis of foraminiferal assemblages. Only shallow neritic areas, with or without sea grass meadows, could be distinguished from slightly deeper settings.

Discussion

Benthic foraminifers occur in various ecological settings, from marshes to deep sea bottoms. Their distribution is controlled by complex biotic and abiotic factors.

The nature of the substrate is of prime importance in the composition of faunal assemblages. Factors such as nutrition, light, temperature, salinity and current activities shape the various faunal associations. All these factors are rarely recognisable in fossil associations.

It should also be noted that the samples studied do not come from a strict time interval and, even within a single exposure, may belong to different associations. For instance, at Grübern the lower sample (EG 23) represents the *Elphidium* Assemblage and thus a high-energy shallow littoral sandy facies, in which abrasion of tests may be seen. Sample EG 22, which was collected *c* 40 m higher, is assigned to the *Cibicides-Elphidium* Assemblage, which indicates a former setting of sea grass meadows. At the Unternalb section, the lower sample (EG 37) is referred to the *Cibicides pseudoungerianus* Assemblage, which is replaced by the shallow neritic *Ammonia* Assemblage higher up section (samples EG 25, 26), which is possibly tidally influenced.

The diversity of different settings is especially apparent in the samples from the Eggenburg city area, where over short distances various associations were recognised. Samples from the Brunnstube section show a decrease of water depth going up section. During deposition of the Zogelsdorf Formation, occasional reworking of the underlying Gauderndorf Formation occurred. The boundary between this formation and the Zogelsdorf Formation is characterised by a shell hash layer. The problem of remanié foraminifers is especially poignant at this locality. The foraminiferal fauna of the Zogelsdorf Formation in the Brunnstuben is indicative of deeper water settings, in which occurs a very

high plankton percentage (in excess of 20%), mainly *Cassigerinella globulosa*. Resting on these layers is a unit consisting of an alternation of unconsolidated and indurated sediment. Here the faunal composition changes and deposition of shallow neritic foraminiferal associations starts, with an abrupt decrease in plankton rate to 2%. However, in the upper part of the Zogelsdorf Formation occur typical molluscan faunas of the Eggenburgian with *Pecten hornensis* Deperet & Roman, 1902 and *P. pseudobeudanti* Deperet & Roman, 1902 (see Steininger, 1971). It may be assumed that the Brunnstuben strata consist largely of reworked deposits of the Gauderndorf Formation, especially of the shell hash unit. This problem cannot be solved on the basis of foraminiferal faunas, as criteria such as different modes of preservation cannot be applied. Furthermore, faunal elements that are either undoubtedly non-contemporary or typical of other biotopes are missing.

The nearby locality of Eggenburg-Bahnhof (EG 14) is assigned to the *Elphidium* Assemblage. The *Cassidulina* Assemblage has been encountered only in the vicinity of Eggenburg hospital. The morphology of the crystalline basement is comparable to a deep canal. From Eggenburg-Zwingergraben (EG 42) a fauna is available which displays influences of the *Hanzawaia* as well as of the *Cassidulina* Assemblage, and which thus represents a mixed fauna.

Subsequent to Nebelsick's (1989a, b) microfacies analysis of the Zogelsdorf Formation limestones, the sediments are assigned to the group of 'temperate-water-carbonates'. The biogenic content was referred to the 'Foramol' (foraminifers-molluscs) group by Nebelsick (1989a, b) with reference to Lees & Buller (1972) and Murray (1987). Foramol sands of Recent shelf seas may be distinguished on the basis of their climatic zonation and of the foraminiferal associations.

Subtropical faunas are characterised by miliolid forms (>40%) and by various larger foraminifers. The cool-temperate region is typified by the absence of larger foraminifers and the occurrence of *Clavulina angularis* d'Orbigny, 1826 or *C. pacifica* Cushman, 1954. In general, miliolid foraminifers make up less than 20% and cibicids more than 20% of the faunas. The warm-temperate region occupies a position in between these two extremes (Fig. 8; see also Murray, 1987).

An unambiguous assignment only on the basis of foraminifers was impossible as miliolid species are absent. However, in combination with Nebelsick's

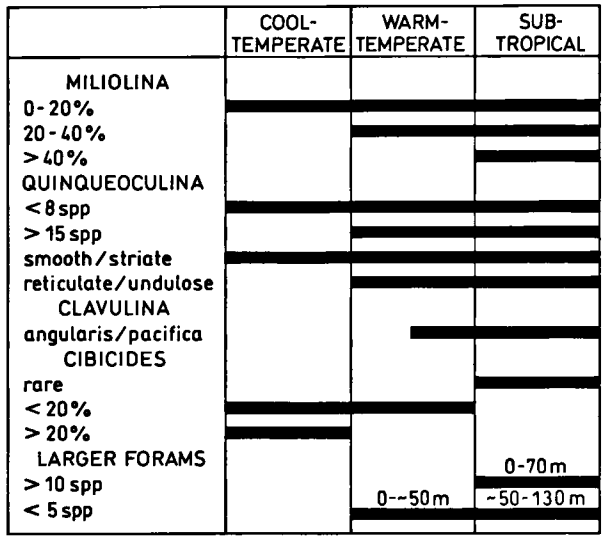

Fig. 8. Summary of criteria employed to divide foraminiferal assemblages of various climatic belts (after Murray, 1987).

work (1989a) and the occurrence of two species of larger foraminifers (*Amphistegina lessonii* d'Orbigny, 1826 (Pl. 7, Fig. 10) and *Sphaerogypsina globulosa*), an assignment to the warm-temperate region has proved possible.

These rare larger species occur within the Zogelsdorf Formation in the shallow neritic associations. According to Larsen (1976), the distribution of the genus *Amphistegina* d'Orbigny, 1826 is governed by a winter isotherm of 14 °C. Boltovskoy & Wright (1976) considered *A. lessonii* to be a typical indicator of warm-water and shallow neritic settings.

The sedimentation area of the Zogelsdorf Formation in the Eggenburg bay represents a sheltered environment. The depositional area of the foraminiferal associations corresponds especially with a shallow neritic setting. It should be noted that only part of the original associations, overprinted by diagenetic processes, is available for study. This is illustrated in particular by the loss of miliolid forms, whose aragonitic-granular tests have been subject to dissolution.

On the basis of the microfauna, analysed by Wenger (1987), the exposures of the Prien and in the Kaltenbachgraben of the Bavarian molasse, may be compared with those of the Zogelsdorf Formation. This Late Eggenburgian fauna association are also indicative of shallow neritic deposition.

The Ortenburg marine sands with their shallow-

water fauna, which in contrast to the Zogelsdorf Formation yield a more diverse microfauna, display a close resemblance to the localities Loibersdorf and Fels am Wagram. Tollmann (1957) already noted this resemblance. Hagn (1960, 1961) preferred an assignment of these sands to the Late Burdigalian. The strata exposed at Loibersdorf and Fels am Wagram in the Eggenburg area were assigned to the Late Burdigalian by Tollmann (1957), to the middle part of the Eggenburgian (M_{1b}) by Steininger (1971) or the younger part (M_{1c-d}). Wenger (1987) referred the Ortenburg marine sands to the Middle Eggenburgian.

Cicha *et al.* (1971) already noted that faunas are reduced in the higher part of the Eggenburg Group. A comparison of the microfaunas of the Late Eggenburgian Zogelsdorf Formation and the Early Eggenburgian Burgschleinitz and Gauderndorf formations has also demonstrated this.

In summarising the available data of foraminiferal associations of the Zogelsdorf Formation, it may be noted again that the sediments are typical of the shallow neritic deposited over a strongly structured area. This strongly structured region with its different ecological conditions resulted in the origination of various foraminiferal assemblages over very short distances.

Acknowledgements

For loan of material, suggestions, use of SEM facilities and assistance in many other ways, I wish to thank Drs F. Steininger, W. Piller, J. Hohenegger, and Th. Haunold of the Institut für Paläontologie (Universität Wien). The assistance of Drs Ch. Rupp, R. Roetzl (both Geologische Bundesanstalt, Wien) and J. Nebelsick (Institut für Geologie und Paläontologie, Tübingen) is gratefully acknowledged. All samples studied herein are deposited at the Institute of Palaeontology of Vienna University (Jenke Collection).

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PLATE 1

Examples illustrating the preservational state of foraminifer tests from the Zogelsdorf Formation. All specimens are in the Jenke Collection at the Institute of Palaeontology (University of Vienna).

Figs 1, 2. *Globulina gibba* (d'Orbigny, 1826), corrosion of the test wall.
Fig. 3. Close-up of test wall of *Globulina gibba* (d'Orbigny, 1826) (scale bar equals 10 µm).
Figs 4, 5. Well-preserved *Asterigerinata planorbis* (d'Orbigny, 1846).
Figs 6, 7. Crystal-overgrown specimen of *Asterigerinata planorbis* (d'Orbigny, 1846).
Figs 8, 9. Broken and abraded specimens of *Elphidium* sp. (8) and *Lenticulina inornata* (d'Orbigny, 1846) (9).
Fig. 10. Porous and cracked tests with cemented organic and anorganic particles.
Fig. 11. Fragment of a miliolid foraminifer.
Fig. 12. Broken specimen of an agglutinated foraminifer, *Spiroplectammina pectinata* (Reuss, 1850).

Unless indicated otherwise, the scale bar equals 100 µm.

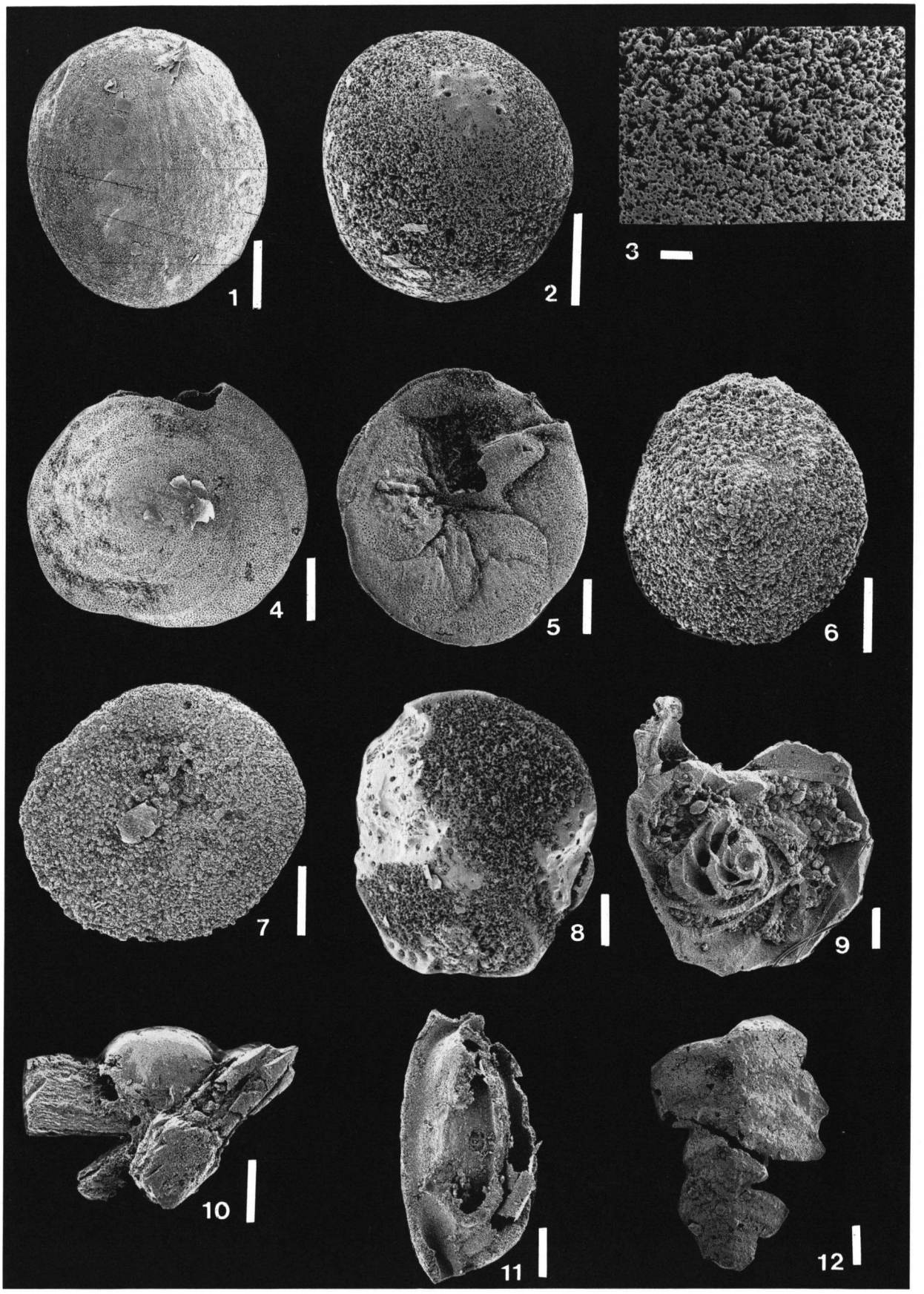
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PLATE 2

Benthic foraminifera from the Zogelsdorf Formation, Eggenburg area (Austria). All specimens are in the Jenke Collection at the Institute of Palaeontology (University of Vienna).

Figs 1, 2. *Spiroplectammina pectinata* (Reuss, 1850).

Figs 3-5. *Siphotextularia concava* (Karrer, 1868).

Figs 6, 9. *Textularia* cf. *nussdorfensis* d'Orbigny, 1846; this specimen differs from *T. nussdorfensis* by being broader and having a weaker keel.

Figs 7, 8. *Textularia pala* Czjzek, 1848.

Figs 10-12. *Gaudryina* sp., test with a three-chambered initial part. In the juvenile stage the chambers are very narrow, broaden very rapidly, leading to a quadrate cross section.

Unless indicated otherwise, the scale bar equals 100 μm.

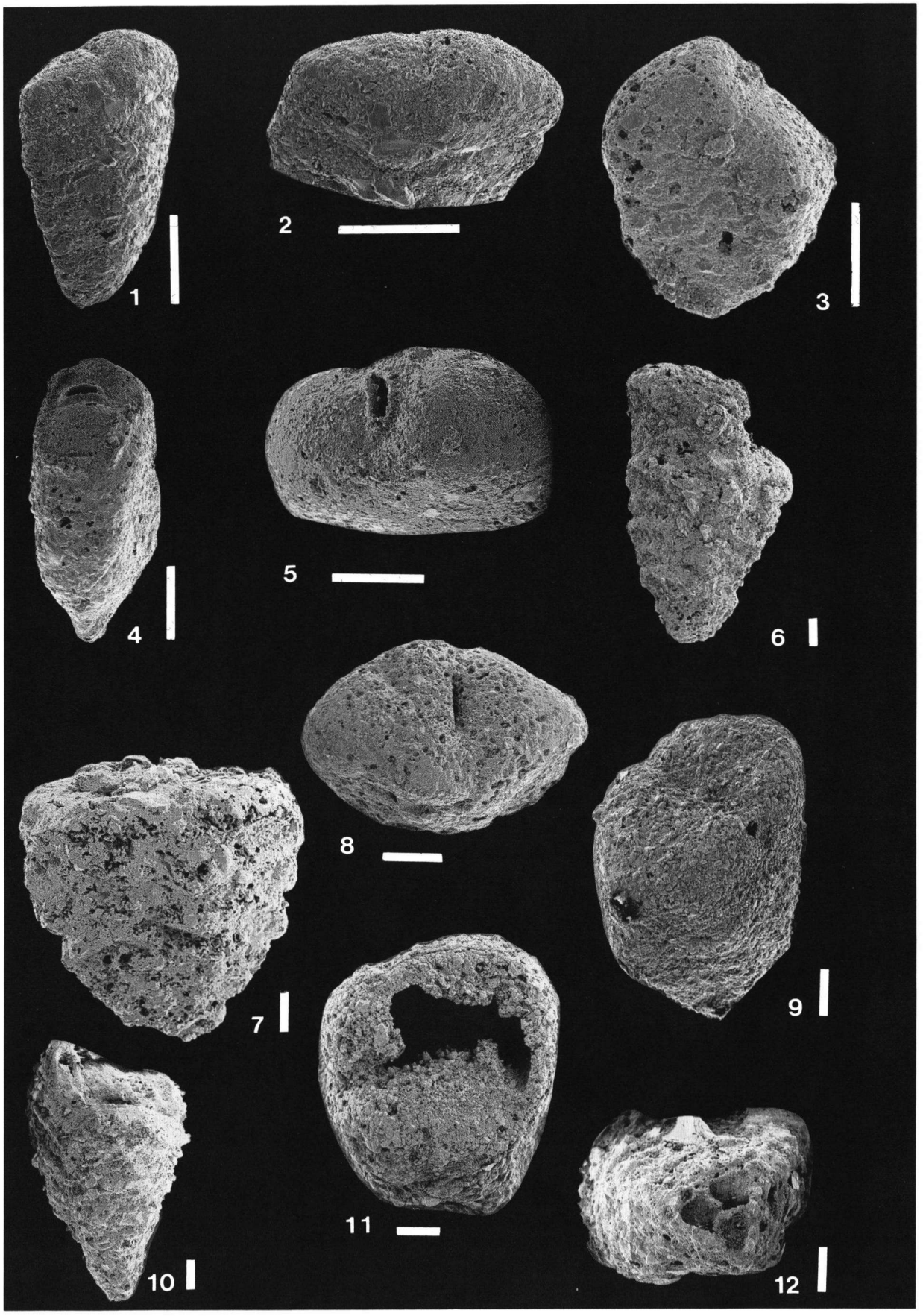
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PLATE 3

Benthic foraminifera from the Zogelsdorf Formation, Eggenburg area (Austria). All specimens are in the Jenke Collection at the Institute of Palaeontology (University of Vienna).

Figs 1, 2. *Bolivinella* sp., this rare species, exclusively found at Grübern, differs from *B. margaritacea* (Cushman, 1929) by its broad, triangular outline. The periphery is denticulate und shows clear spine attachment traces. The median line is poorly developed, and a strong ornament of the test surface is visible.
Fig. 3. *Astacolus crepidulus* (Fichtel & Moll, 1798), x 5.
Figs 4-6. *Lenticulina inornata* (d'Orbigny, 1846), x 10.
Figs 7-9. *Lenticulina vortex* (Fichtel & Moll, 1798), x 10.
Figs 10, 11. *Robulus pauperculus* (Reuss, 1866).

Unless indicated otherwise, the scale bar equals 100 µm.

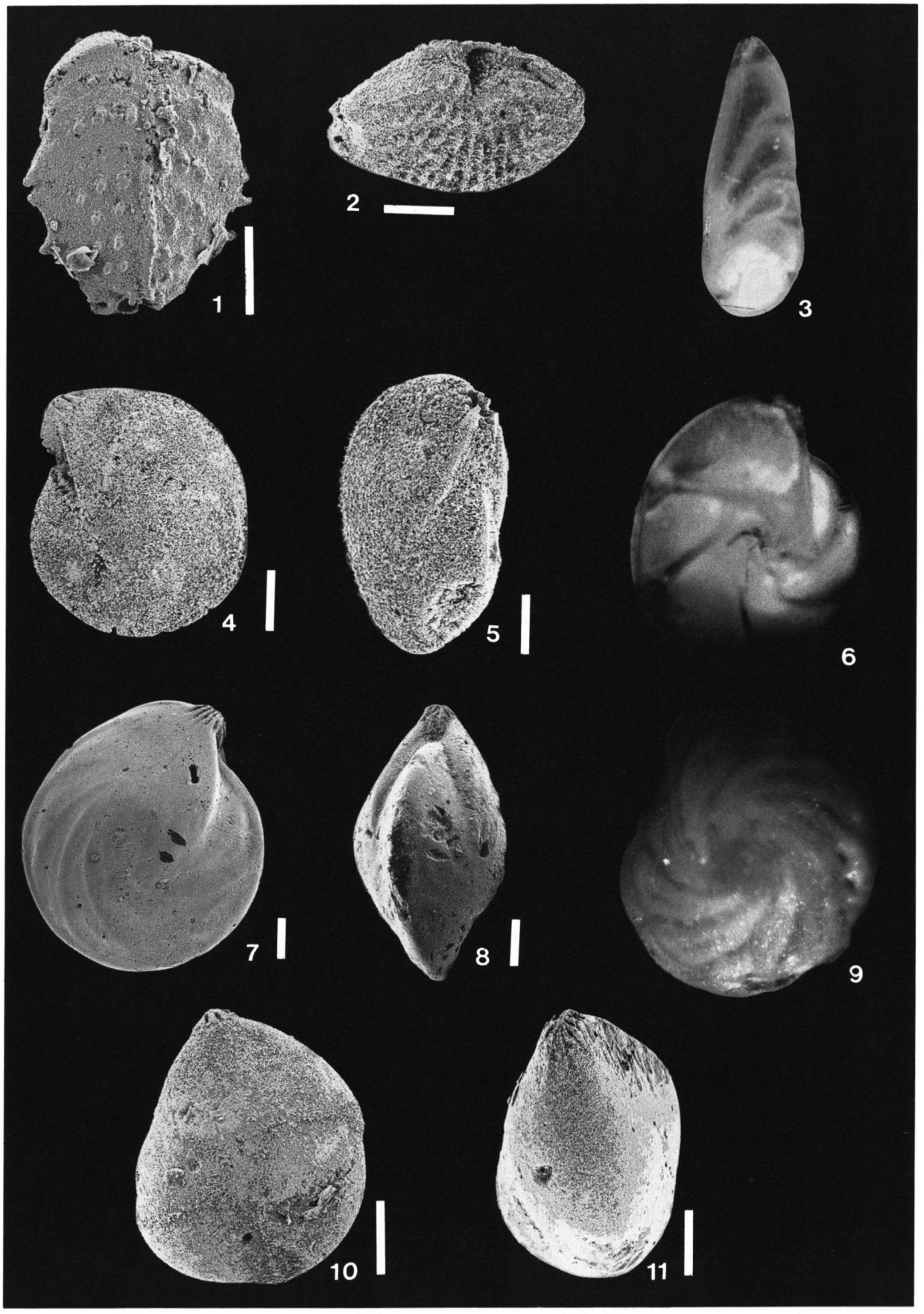
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PLATE 4

Benthic foraminifera from the Zogelsdorf Formation, Eggenburg area (Austria). All specimens are in the Jenke Collection at the Institute of Palaeontology (University of Vienna).

Figs 1, 2. *Globulina granulosa* (Egger, 1857).
Figs 3, 6. *Globulina striata* (Egger, 1857).
Figs 4, 5. *Guttulina austriaca* d'Orbigny, 1846.
Figs 7-9. *Guttulina communis* d'Orbigny, 1846.
Figs 10, 11. *Fissurina orbignyana* Seguenza, 1862.
Fig. 12. *Bulimina* gr. *elongata/echinata*. Rupp (1986) united *B. elongata* and *B. echinata* on account of their chamber form, size and outline in one group. Because of the similarity of the present material this assignment was adopted.

Unless indicated otherwise, the scale bar equals 100 µm.

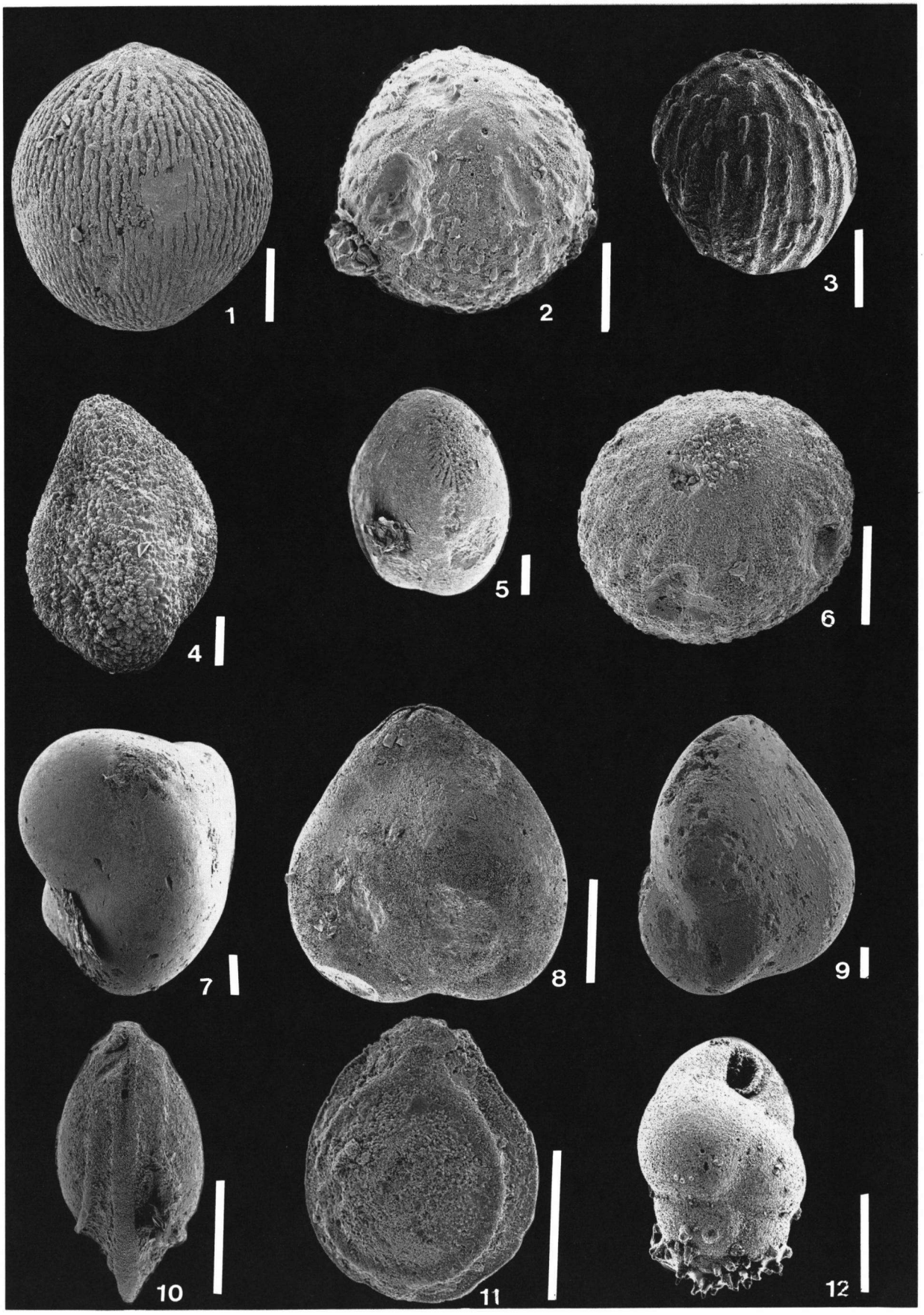
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PLATE 5

Benthic foraminifera from the Zogelsdorf Formation, Eggenburg area (Austria). All specimens are in the Jenke Collection at the Institute of Palaeontology (University of Vienna).

Fig. 1. *Virgulopsis tuberculata* (Egger, 1857).
Figs 2, 3. *Reussella spinulosa* (Reuss, 1850).
Figs 4, 5. *Trifarina* cf. *globosa* (Stoltz, 1925) (scale bar in 5 equals 10 µm).
Figs 6, 7. *Uvigerina posthantkeni* Papp, 1971.
Figs 8, 9. *Pappina* cf. *parkeri* (Karrer, 1877).
Fig. 10. *Bolivina concinna* (Knipscheer & Martin, 1955).
Fig. 11. *Bolivina crenulata trunensis* Hofmann, 1967 (10 µm).
Figs 12, 13. *Bolivina dilatata* (Reuss, 1850).

Unless indicated otherwise, the scale bar equals 100 µm.

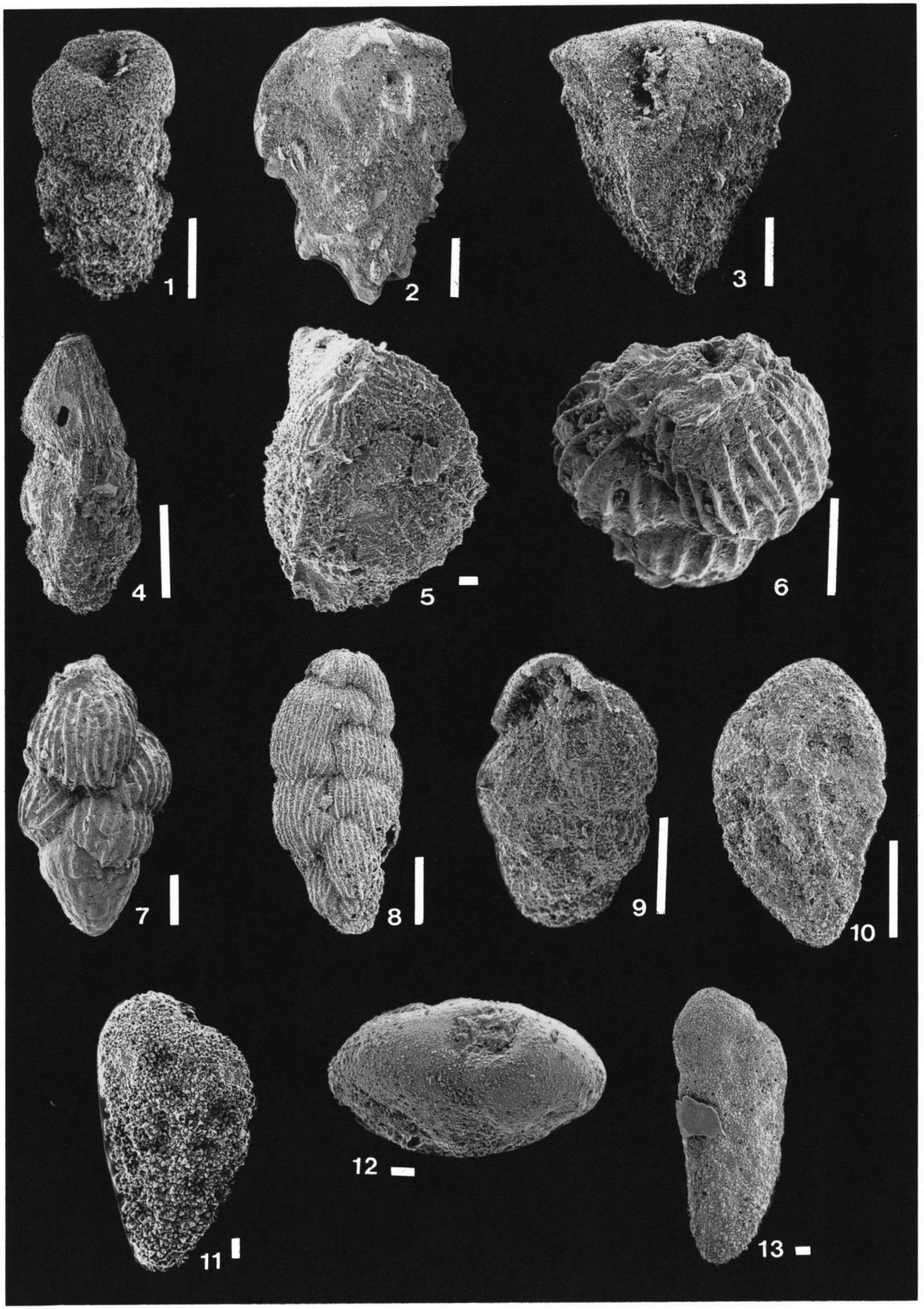
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PLATE 6

Benthic foraminifera from the Zogelsdorf Formation, Eggenburg area (Austria). All specimens are in the Jenke Collection at the Institute of Palaeontology (University of Vienna).

Figs 1, 2. *Bolivina fastigia* Cushman, 1936 (10 µm).
Figs 3, 4. *Bolivina hebes* MacFayden, 1930.
Figs 5, 6. *Bolivina* cf. *matejkai* Cicha & Zapletalova, 1963; the specimens collected are poorly preserved, so that the fine perforation is hardly visible. Typical however is the broad, relatively thick-set, plump test (10 µm).
Fig. 7. *Stilostomella danuviensis* Wenger, 1987.
Fig. 8. *Stilostomella* sp., uniserial, long, slender, lightly curved form. The chambers are inflated and broader than high; ornamented at the base with a ring of thorns. In all samples only three such specimens were encountered.
Figs 9, 10. *Discorbis biaperturatus* (Pokorny, 1956).
Figs 11, 12. *Discorbis patella* (Reuss, 1850).
Figs 13, 14. *Epistominella molassica* (Hagn, 1952) (10 µm).

Unless indicated otherwise, the scale bar equals 100 µm.

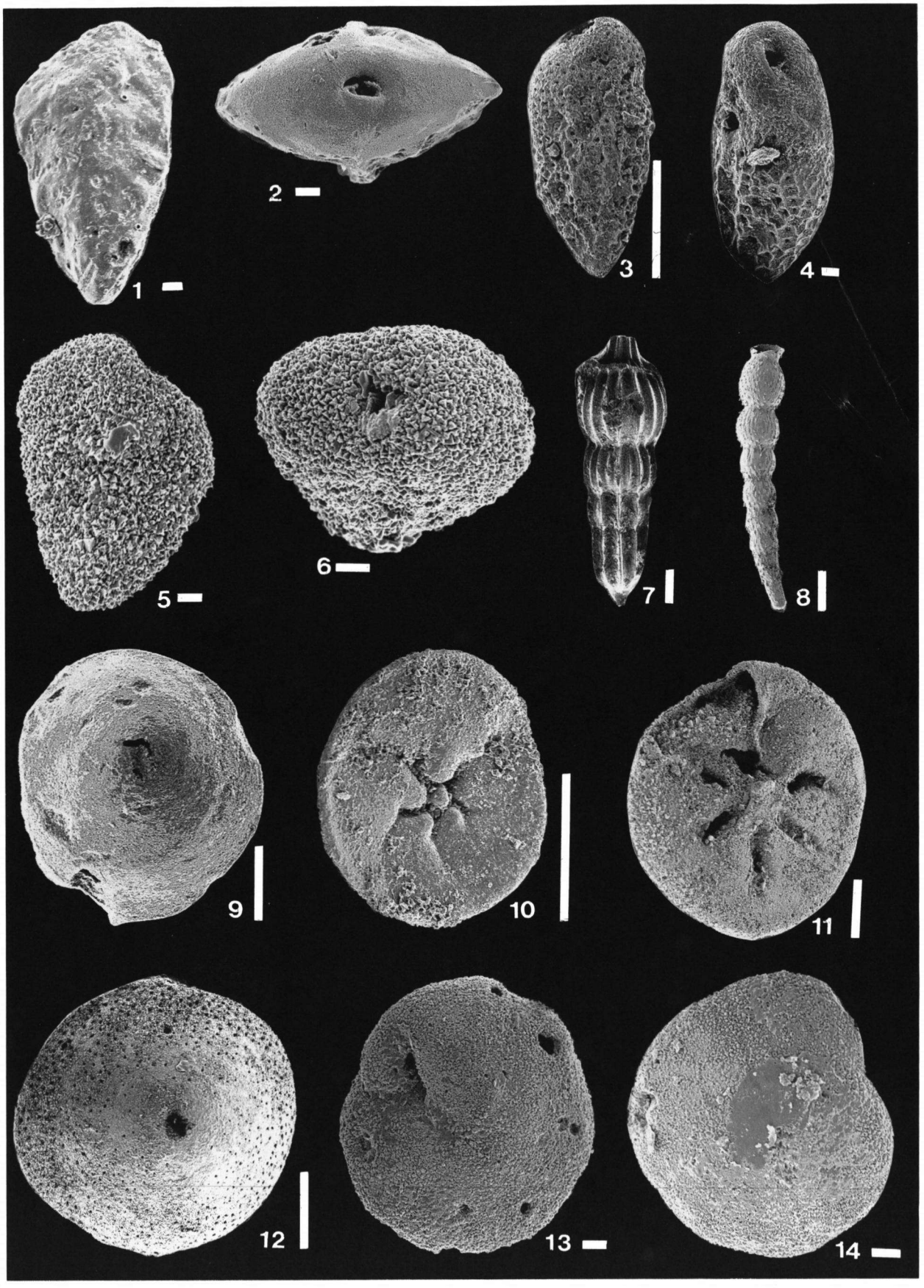
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PLATE 7

Benthic foraminifera from the Zogelsdorf Formation, Eggenburg area (Austria). All specimens are in the Jenke Collection at the Institute of Palaeontology (University of Vienna).

Figs 1, 2. *Cancris auriculus* (Fichtel & Moll, 1798).
Figs 3, 6. *Rosalina obtusa* d'Orbigny, 1846. In the statistical analyses *D. biaperturatus*, *D. uhligi austriacus* (Tollmann, 1957) and *R. obtusa* were grouped together under Discorbaceae and counted. The preservation in most cases was so poor that assignment to species was impossible.
Figs 4, 5. *Eponides repandus* (Fichtel & Moll, 1798).
Figs 7, 8. *Escornebovina cuvillieri* (Poignant, 1965).
Figs 9, 11. *Glabratella* cf. *aurantista* Seiglie & Bermudez, 1965.
Fig. 10. *Amphistegina lessonii* d'Orbigny, 1826.

Unless indicated otherwise, the scale bar equals 100 µm.

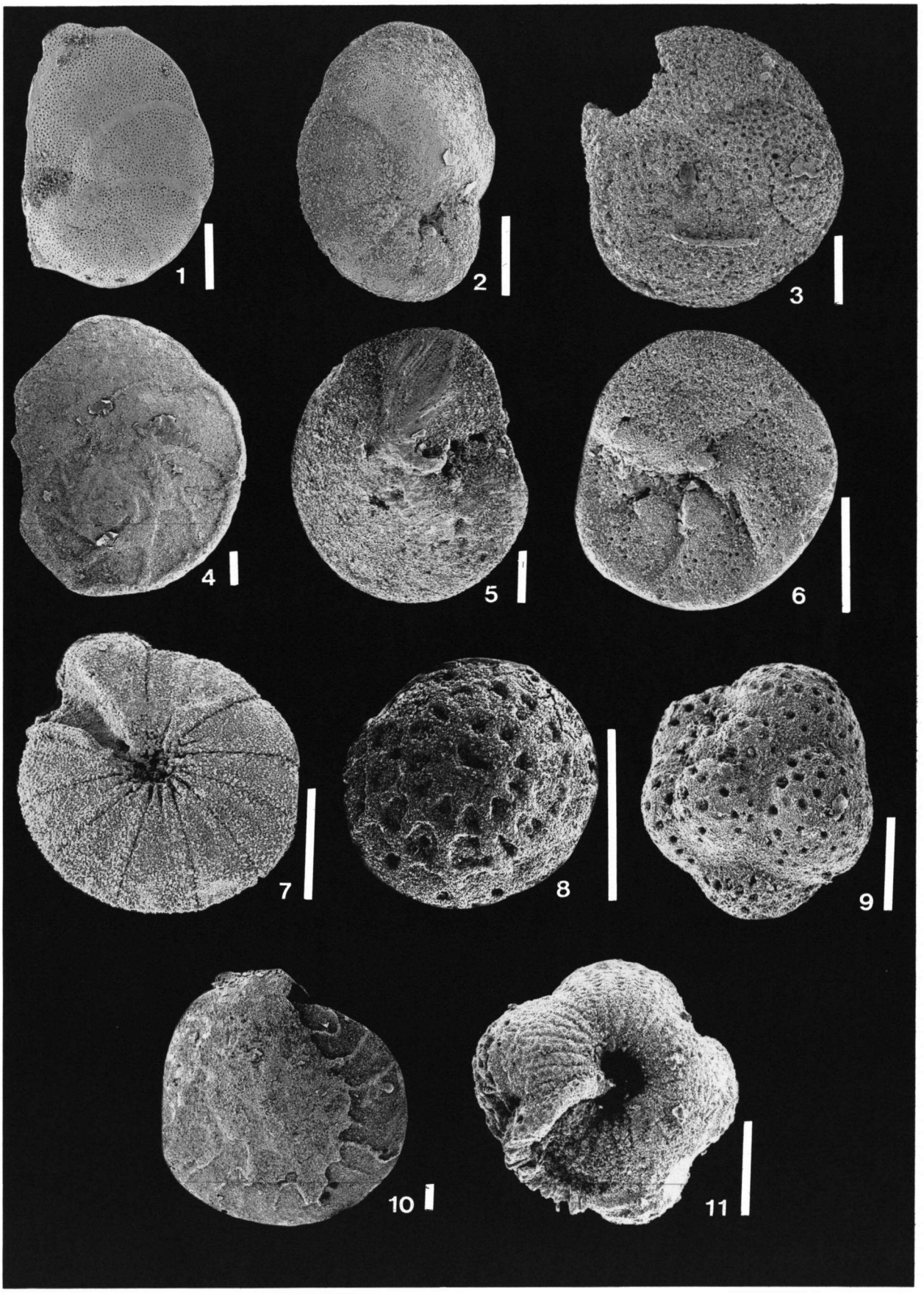
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PLATE 8

Benthic foraminifera from the Zogelsdorf Formation, Eggenburg area (Austria). All specimens are in the Jenke Collection at the Institute of Palaeontology (University of Vienna).

Figs 1-3. *Cibicides lobatulus* (Walker & Jacob, 1798).
Figs 4-6. *Cibicides pseudoungerianus* (Cushman, 1922).
Figs 7-9. *Heterolepa dutemplei* (d'Orbigny, 1846).
Figs 10, 11. *Hanzawaia boueana* (d'Orbigny, 1846).

Unless indicated otherwise, the scale bar equals 100 µm.

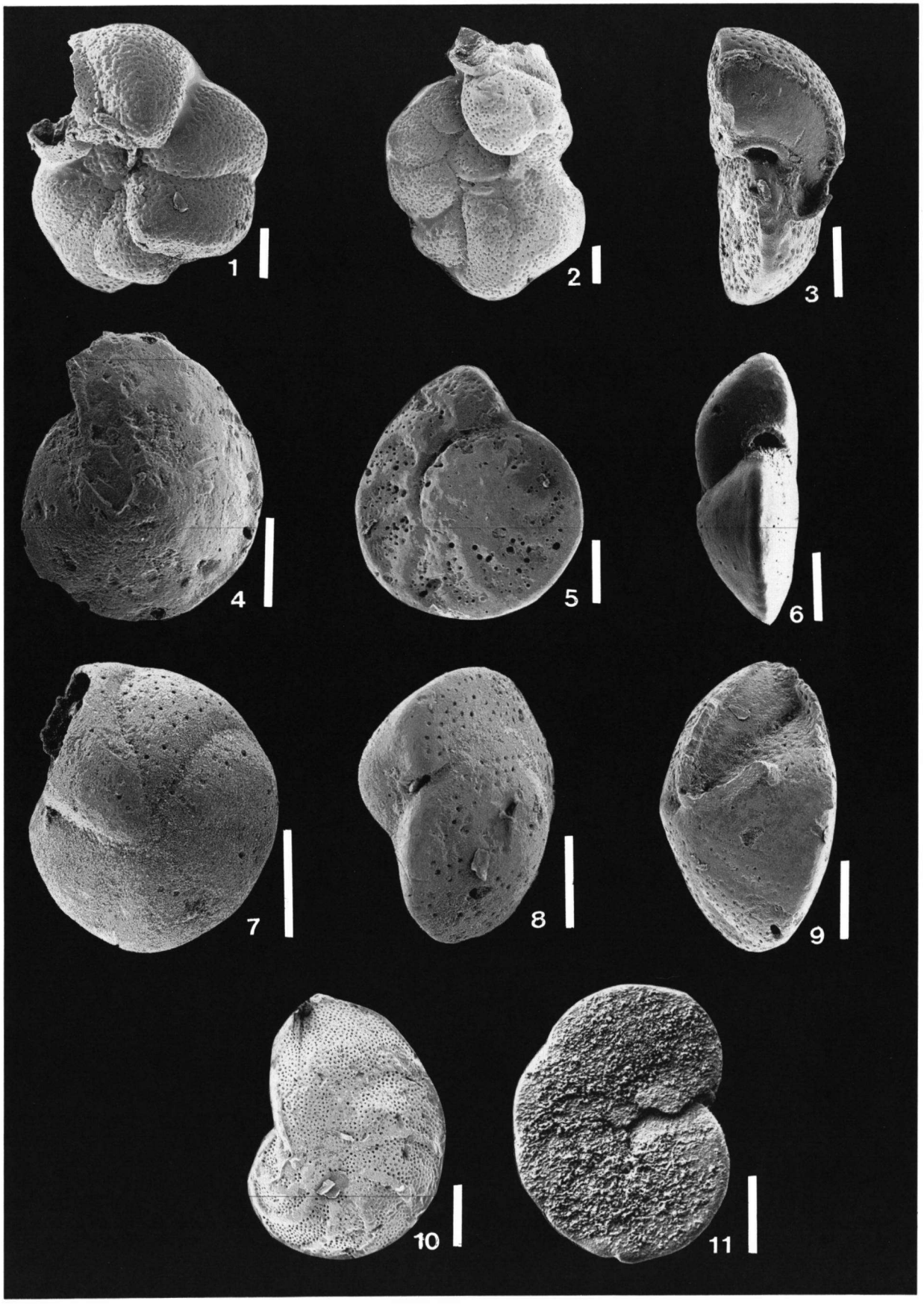
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PLATE 9

Benthic foraminifera from the Zogelsdorf Formation, Eggenburg area (Austria). All specimens are in the Jenke Collection at the Institute of Palaeontology (University of Vienna).

Figs 1, 2. *Sphaerogypsina globulus* (Reuss, 1848).

Figs 3, 6. *Ammonia parkinsonia* (d'Orbigny, 1839).

Figs 4, 5. *Pararotalia rimosa* (Reuss, 1869).

Figs 7-9, 12. *Elphidium* gr. *crispum/macellum*, 7, 8 - *E. macellum* (Fichtel & Moll, 1803), 9, 12 - *E. crispum* (Linné, 1758). *E. macellum* can be distinguished from *E. crispum* by lacking an umbonal boss and in having a more compressed shape (Hansen & Lykke-Andersen, 1976).
According to Wenger (1987), *E. macellum* typically shows a wide, shallowly sunken and granular umbilicus. Papp & Schmid (1985) illustrated as *E. crispum* a specimen which, in Wenger's (1987) definition, is reminiscent of *E. macellum*. Murray (1971) pointed out the wide range of variation of both species and grouped them together under *E. crispum*. For the present study, the original material of Papp & Schmid (1985) was available for study and comparison. The wide range of variation of the genus *Elphidium*, as noted by Murray (1971) could be demonstrated for this material as well. In addition, transitional forms between *E. macellum* and *E. crispum* were observed, which is why a definite assignment to either species was impossible and specimens were grouped together in *E.* gr. *macellum/crispum*. Changes in test surface ornament related to diagenetic processes also made assignment to species difficult.
Elphidiid species from the Zogelsdorf Formation are amongst the commonest foraminifers, and forms without a keel are extremely rare. Because of the wide range of variation of the genus *Elphidium* and the problems of specific assignment associated with this, it is difficult to use them as index fossils. In how far species are related has not yet been determined, and a thorough revision of all known species would certainly be rewarding.

Figs 10, 11. *Elphidium fichtellianum* (d'Orbigny, 1846).

Unless indicated otherwise, the scale bar equals 100 µm.

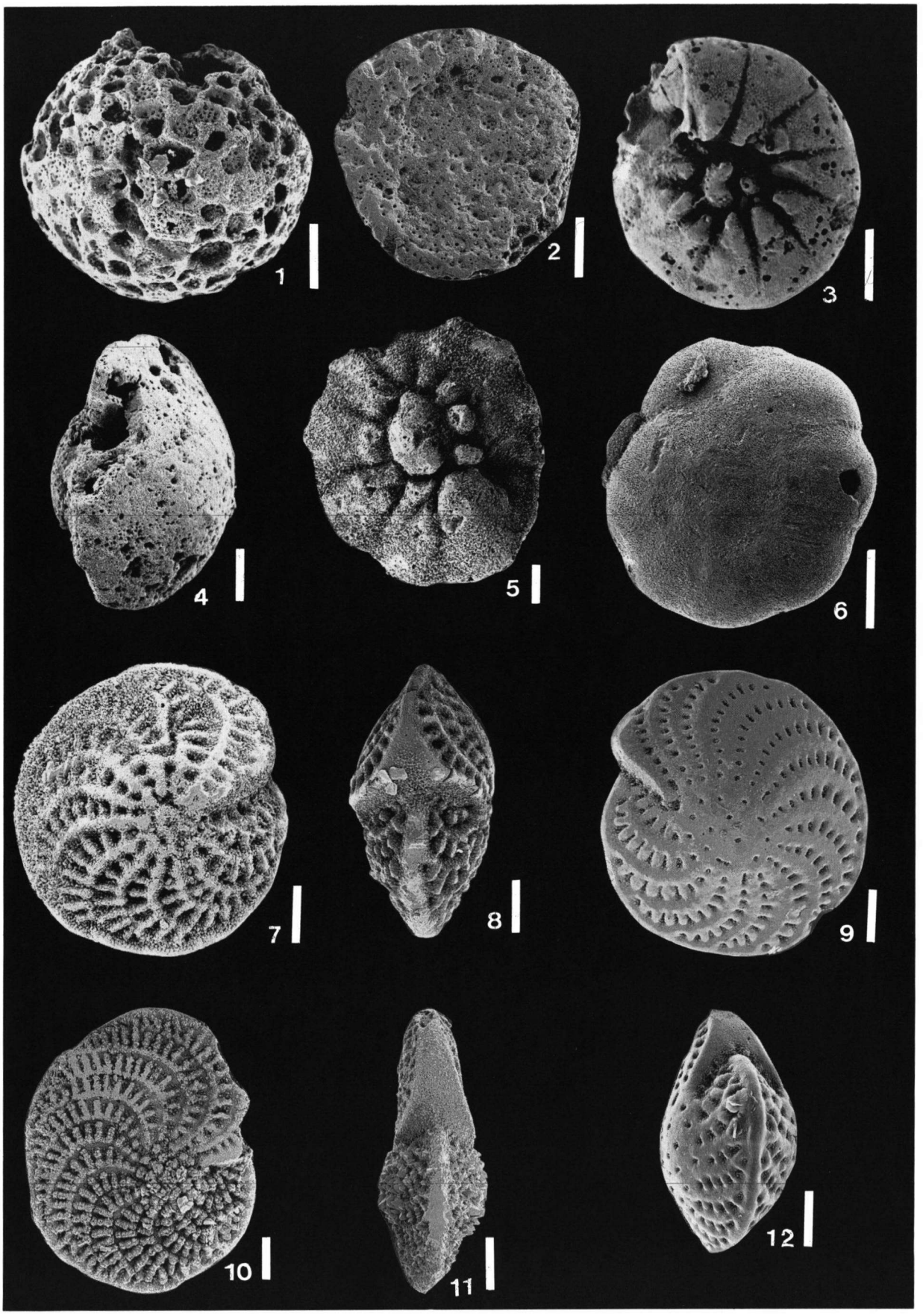
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PLATE 10

Benthic foraminifera from the Zogelsdorf Formation, Eggenburg area (Austria). All specimens are in the Jenke Collection at the Institute of Palaeontology (University of Vienna).

Figs 1, 2. *Elphidium* sp., planospiral-involute test with round periphery, the dorsal surface being broadly rounded, the periphery weakly and shallowly denticulate. Umbilical region with varyingly strong granulation. Because of the strong crystal overgrowth, a clear view of the apertural structure could not be gained, the retral processes were at best only difficult and indistinctly visible.

Figs 3, 6. *Astrononion perfossum* (Clodius, 1922).

Figs 4, 5. *Nonion commune* (d'Orbigny, 1798).

Figs 7, 8. *Melonis pompilioides* (Fichtel & Moll, 1798).

Figs 9, 10. *Pullenia bulloides* (d'Orbigny, 1826).

Unless indicated otherwise, the scale bar equals 100 µm.

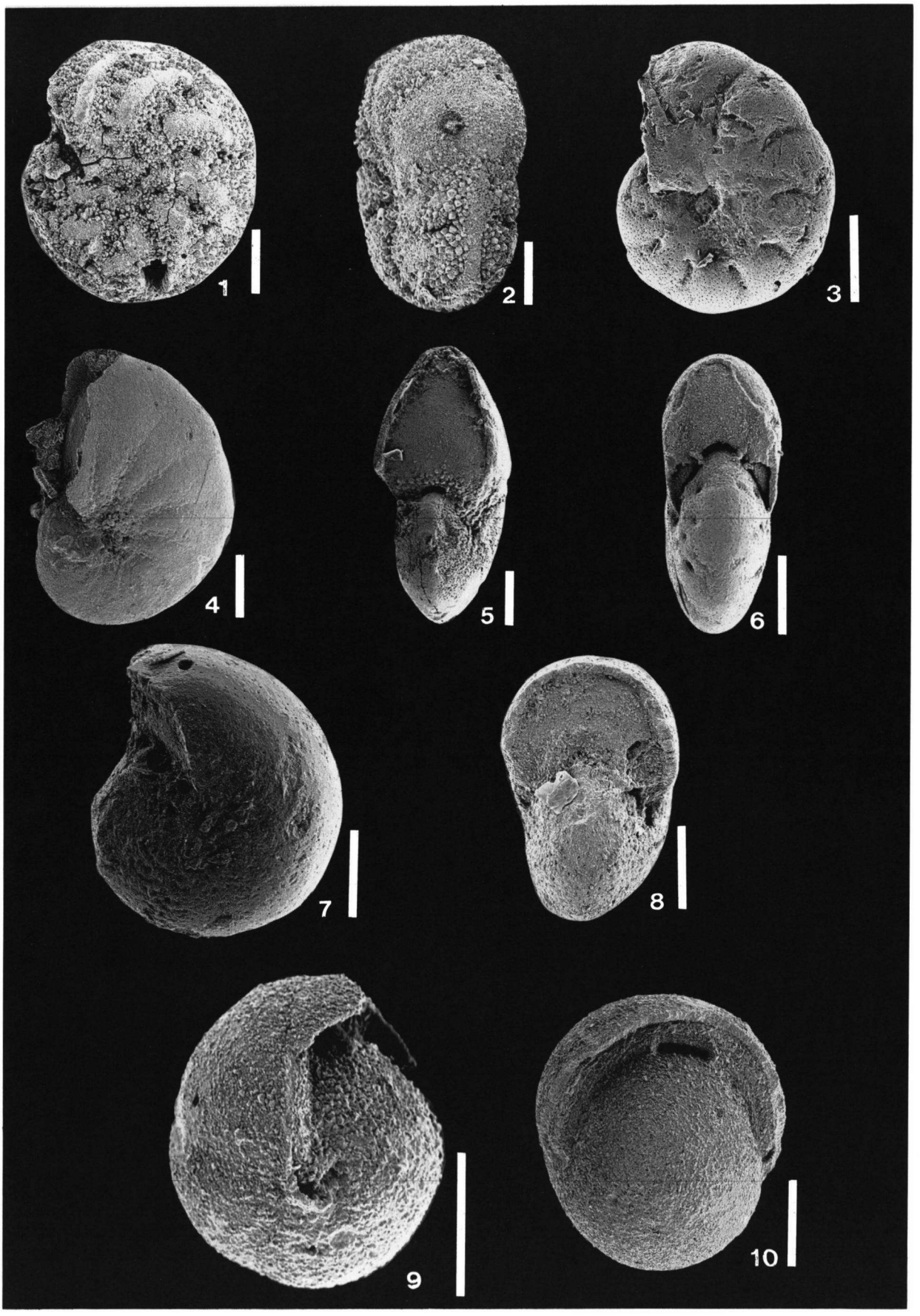
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PLATE 11

Benthic foraminifera from the Zogelsdorf Formation, Eggenburg area (Austria). All specimens are in the Jenke Collection at the Institute of Palaeontology (University of Vienna).

Figs 1-3. *Alabamina tangentialis* (Clodius, 1922).
Figs 4-6. *Gyroidina parva* Cushman & Renz, 1941.
Fig. 7. *Cassidulina laevigata* d'Orbigny, 1826.
Fig. 8. *Globocassidulina subglobosa* (Brady, 1881).
Figs 9, 10. *Sphaeroidina bulloides* (d'Orbigny, 1826).

Spirillina sp.: a specific assignment of rare, fragmentary specimens of spirillinacean forms was not attempted, and no specimens were selected for illustration.

Unless indicated otherwise, the scale bar equals 100 µm.

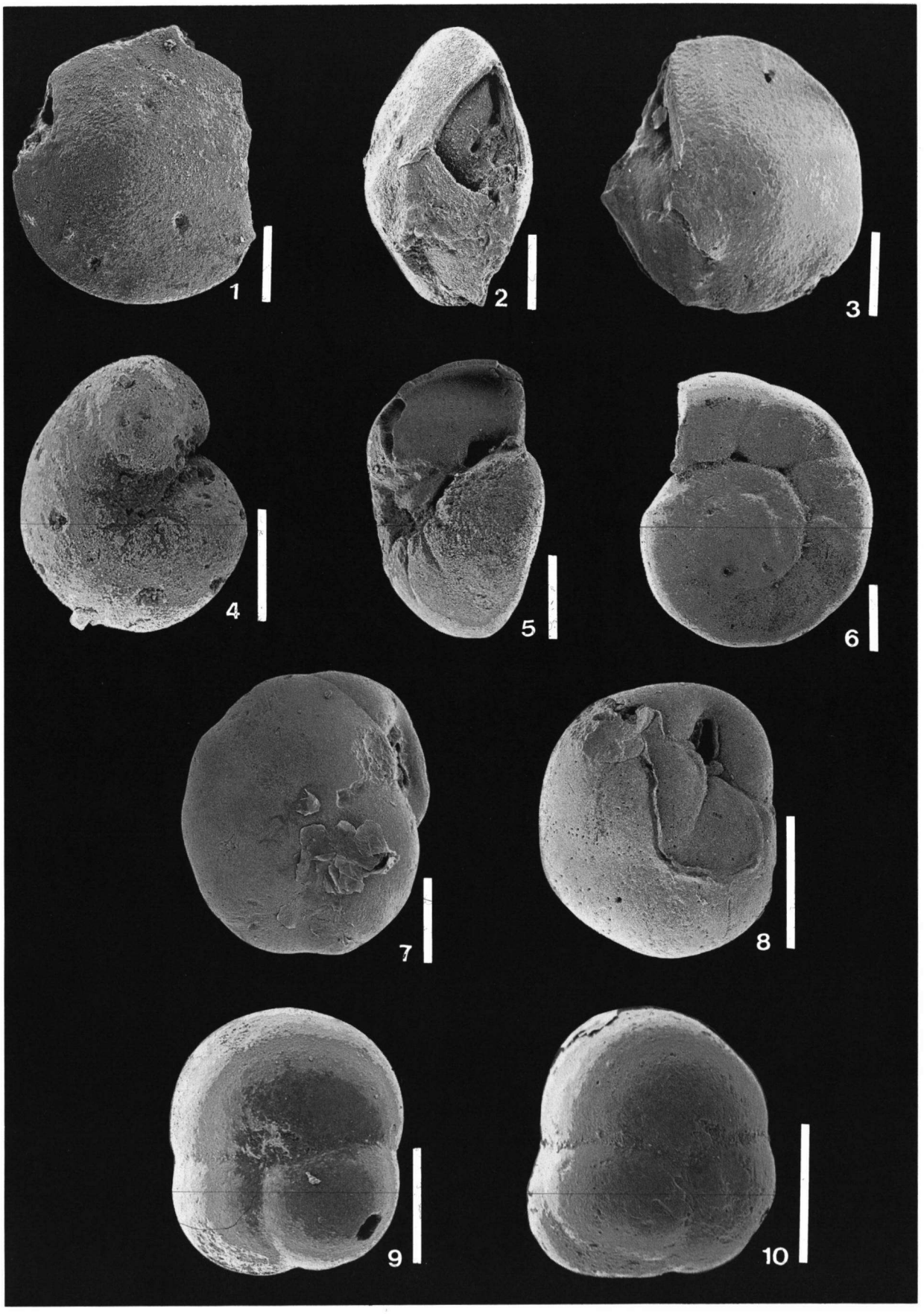
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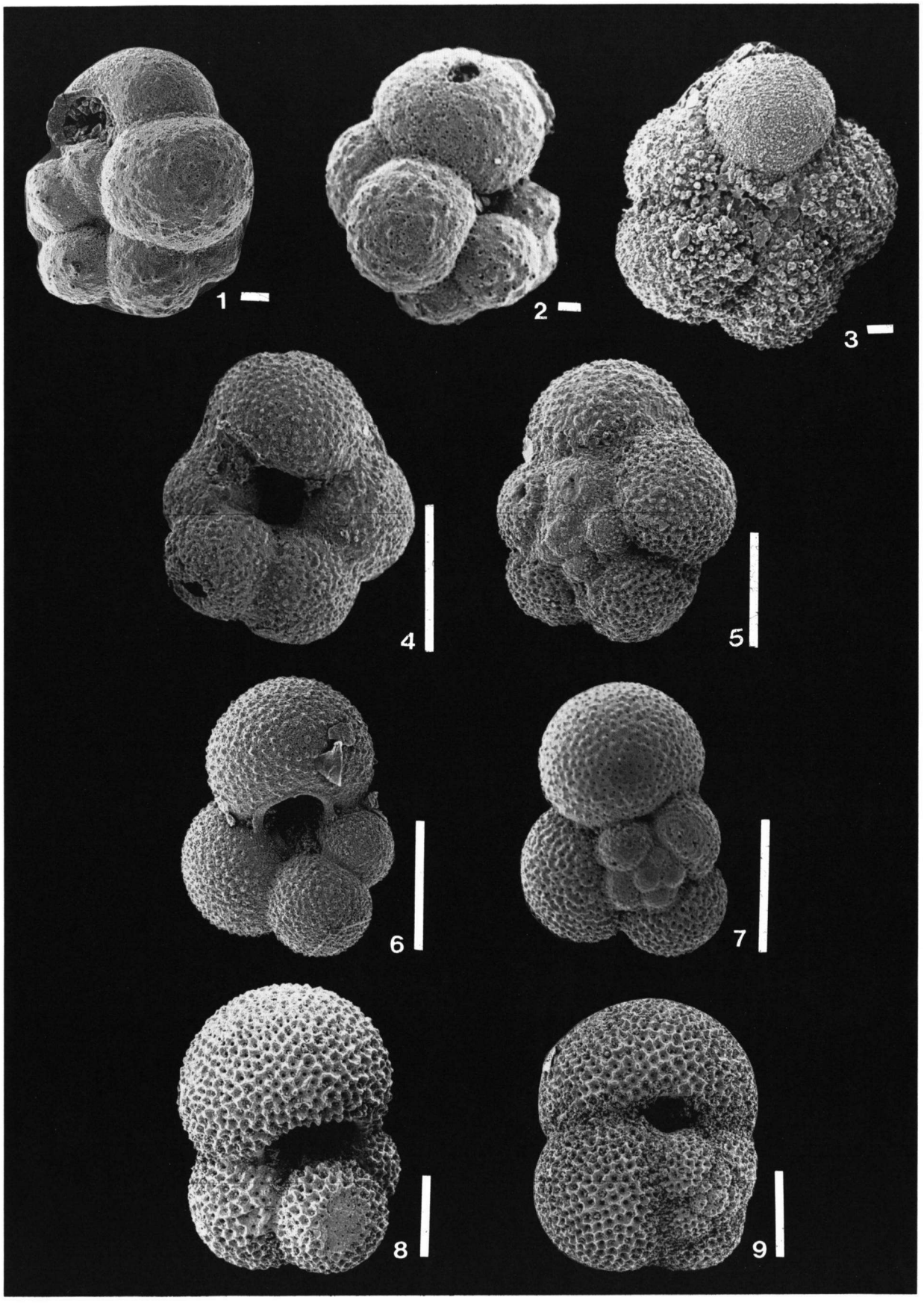
PLATE 12

Planktonic foraminifera from the Zogelsdorf Formation, Eggenburg area (Austria). All specimens are in the Jenke Collection at the Institute of Palaeontology (University of Vienna).

Figs 1, 2. *Cassigerinella globulosa* (Egger, 1857) (10 µm).
Fig. 3. *Globigerina angustiumbilicata* Bolli, 1957 (10 µm).
Figs 4, 5. *Globigerina ciperoensis ottnangiensis* Rögl, 1969.
Figs 6, 7. *Globigerina praebulloides praebulloides* Blow, 1959.
Figs 8, 9. *Globigerinoides trilobus* (Reuss, 1850).

Unless indicated otherwise, the scale bar equals 100 µm.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