THE FORAMINIFERAL FAUNA

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When visiting the temporary outcrop at Särdal, the author collected three samples in the basal beds of conglomeratic limestone (division A), and five samples in the overlying calcareous sandstone (division B). All but one of these samples were found to be rich in microfossils, including foraminifera, ostracods, and coccoliths. However, within the scope of the present article, it is not possible to give the microfauna and nannoflora a comprehensive treatment.

In the following, the composition and stratigraphical evidence of the foraminiferal fauna are discussed, a preliminary check-list given, and selected species described.

With the exception of disconnected remarks on, and some few descriptions of Cretaceous foraminifera (Nilsson, 1827; Lundgren, 1865, 1882, 1883, 1888; Moberg, 1882, 1884, 1888, 1895; Hägg, 1930, 1935; and Voigt, 1931), almost nothing was written on the foraminiferal fauna of the Swedish Cretaceous until 1936. In that year, the late Dr. F. Brotzen published his excellent work on the Senonian foraminifera of Eriksdal, SE Scania. This work, which will be referred to below, was followed by a great number of important publications on Cretaceous stratigraphy and foraminifera written by Brotzen in the period 1936–66 (see bibliography in Norling, 1970, pp. 211–213.).

Unfortunately, though Brotzen obviously studied the foraminiferal faunas obtained from Cretaceous deposits on the Swedish west coast (Bexell, 1938, p. 345), nothing but some general remarks on the faunas, and a few descriptions resulted (Brotzen, 1942, 1945).

Though mainly represented by a rather thin and incomplete Cretaceous sequence, several west coast localities have yielded fairly rich foraminiferal assemblages still awaiting investigation. This is especially true of deposits of the abandoned limestone quarry at Malen, Båstad, and of material from several wire line borings in the vicinity of Båstad, about 50 km south of Särdal.

In his comprehensive account on the Senonian foraminifera of Eriksdal, Brotzen (1936) described 141 species, 57 of which were new, but due attention was not paid to the planktic foraminifera at that time. Forms at present referred to genera such as *Hedbergella, Whiteinella* and *Archaeoglobigerina* were all placed in the genus *Globigerina,* and comparatively few species were described.

Many of the benthic foraminiferal species obtained from the Eriksdal Marl also occur in the Särdal beds. Brotzen is the author of eighteen species recorded from the Särdal beds; that is more than one third of the total number of species identified.

Brotzen referred the Eriksdal Marl to the boundary between the "Emscher" and the "Granulatensenon", which in modern terms corresponds to the boundary between the lower and the upper part of the Middle Santonian. This dating has recently been verified by Christensen (1971). As will be demonstrated in the following account, the Särdal beds appear to be somewhat older than the Eriksdal Marl.

The Bavnodde Greensand on the Island of Bornholm in the southern Baltic is of about the same age as the Särdal beds. The foraminiferal fauna of the Bavnodde Greensand was recently studied by Douglas & Rankin (1969); however, only the planktic foraminifera, including 13 species, were described. The Särdal foraminiferal assemblage includes at least eight species in common with the Bavnodde Greensand fauna.

Characteristics of the fauna

The foraminiferal fauna obtained hitherto from the Särdal beds includes the superfamilies listed below (following the classification by Loeblich & Tappan, 1964):

AGGLUTINATE FORAMINIFERA	% of the total fauna	
Lituolacea De Blainville, 1825	10.2	
		10.2
CALCAREOUS FORAMINIFERA		
Miliolacea Ehrenberg, 1839	0.1	
Nodosariacea Ehrenberg, 1838	74.8	
Buliminacea Jones, 1875	0.6	
Discorbacea Ehrenberg, 1838	5.4	
Spirillinacea Reuss, 1862	0.6	
Rotaliacea Ehrenberg, 1839	0.1	
Globigerinacea Carpenter, Parker & Jones, 1862	3.6	
Orbitoidacea Schwager, 1876	2.6	
Cassidulinacea D'Orbigny, 1839	2.6	
		90.4

The relative frequencies are based on counts of about 2000 specimens from sample fractions larger than 125 μ in size.

FORAMINIFERAL GENERA OF THE SÄRDAL CRETACEOUS	PRE–CRETACEOUS	LOWER CRETACEOUS	UPPER CRETACEOUS	POST–CRETACEOUS
Textularia DE FRANCE, 1824	—	—	—	—
Arenobulimina CUSHMAN, 1927		—	—	
Dorothia PLUMMER, 1931		—	—	—
Valvulina D'ORBIGNY, 1826	—	—	—	—
Ataxophragmium REUSS, 1860			—	
Quinqueloculina D'ORBIGNY, 1826	—	—	—	—
Nodosaria LAMARCK, 1812	—	—	—	—
Astacolus DE MONTFORT, 1808	—	—	—	—
Dentalina RISSO, 1826	—	—	—	—
Frondicularia DE FRANCE, 1826	—	—	—	—
Lagena WALKER & JACOB, 1798	—	—	—	—
Lenticulina LAMARCK, 1804	—	—	—	—
Neoflabellina BARTENSTEIN, 1948			—	
Vaginulina D'ORBIGNY, 1826	—	—	—	—
Guttulina D'ORBIGNY, 1839	—	—	—	—
Praebulimina HOFKER, 1953		—	—	
Conorbina BROTZEN, 1936		—	—	
Spirillina EHRENBERG, 1843	—	—	—	—
Daviesina SMOUT, 1954			—	
Heterohelix EHRENBERG, 1843		—	—	
Hedbergella BRÖNNIMANN & BROWN 1958		—	—	
Whiteinella PESSAGNO, 1967			—	
Globotruncana CUSHMAN, 1927			—	
Archaeoglobigerina PESSAGNO, 1967			—	
Planulina D'ORBIGNY, 1826			—	—
Cibicides DE MONTFORT, 1808		—	—	—
Cymbalopora VON HAGENOW, 1851			—	
Osangularia BROTZEN, 1940		—	—	—
Globorotalites BROTZEN, 1942		—	—	
Gyroidinoides BROTZEN, 1942		—	—	—
Anomalinoides BROTZEN, 1942			—	—
Gavelinella BROTZEN, 1942		—	—	—

Table 1.

The fauna includes at least 32 genera (Table 1), nine of which are restricted to the conglomeratic limestone (division A), and five to the calcareous sandstone (division B); eighteen genera occur in both the divisions. From a biostratigraphical point of view, however, no distinction can be made between the two different lithological units.

In numerous studies on Recent foraminifera (Loeblich & Tappan, 1953; Tappan, 1962; and others), it has been stated that the character of the bottom is an important factor in the distribution of foraminifera. The narrow beach area (sandy) is sparsely populated. Also the mud zone farther out from the shore has relatively few species, possibly because of the lack of oxygen due to its consumption by decaying organic matter. Within the offshore gravel zone, where gravel and cobbles are mixed with mud, the heterogenous bottom allows a better supply of oxygen and favours a larger and more varied population of benthic foraminifera.

The littoral zone, in a limited sense, includes the area of tidal pools and brackish water, which usually contains a microfauna of very few species of arenaceous foraminifera. The offshore facies may be given a threefold division: 1) inner sublittoral environment, 2) outer sublittoral environment, and 3) open sea environment. The inner sublittoral environment very often contains a microfauna of turbidity controlled, large arenaceous foraminifera, which may be accompanied by some calcareous forms. In the outer sublittoral environment, where turbulence and turbidity exert less control, the foraminiferal assemblage is mixed, containing a fauna of calcareous, as well as arenaceous foraminifera with a much greater number of species. In the open sea environment, the foraminiferal assemblage may be similar to that of the outer sublittoral environment, with the exception of planktic foraminifera, which also have entered the region. It must be pointed out, however, that although planktic assemblages generally indicate an open sea connection, it is possible that they may be excluded from an area by offshore currents. Faunal facies closely related to the lithological facies are also recognizable for certain fossil depositional environments.

Some idea of the environments forming the Cretaceous deposits at Särdal is given by their lithology as well as their microfauna and macrofauna. The discontinuity surfaces within the lower division (A) (herein called the conglomeratic limestone) indicate breaks in sedimentation. The middle part of the division contains portions of pure limestone (whitish calcarenite), in which was found the highest content of planktic foraminifera (10.1 %), represented by species of the genera *Hedbergella, Whiteinella, Archaeoglobigerina,* and *Globotruncana* (Table 2). In the matrix of the basal conglomerate (samples Nos. 7 and 8), planktic foraminifera constitute less than one per cent of the fauna. In the upper division (B) (composed of loose calcareous sandstone), the relative frequency of planktic foraminifera is also very low. Based on these data (see also p. 149), it may be fair to assume that the limestone and fauna in the middle part of division A reflect a closer connection to an open sea environment than any other part of the Särdal beds.

	Division A		Division B				
Sample No.:	7+8	6	1	2	3	4	5
BENTHIC ARENACEOUS FORAMINIFERA	8.9	11.9	9.8	6.0	10.4	0	18.9
BENTHIC CALCAREOUS FORAMINIFERA	90.2	78.0	85.9	92.7	87.9	100.0	79.0
PLANKTIC FORAMINIFERA	0.9	10.1	4.3	1.3	1.7	0	2.1

Table 2. Relative frequencies of benthic arenaceous, benthic calcareous, and planktic foraminifera in the Särdal beds.

As seen in p. 98 and table 2, the foraminiferal fauna is characterised by a strong predominance of benthic forms, including a varied calcareous fauna as well as several arenaceous forms. The predominance of benthic calcareous forms is due mainly to the prolific nodosariid fauna, which in its quantitative superiority (nearly 75 % of the total fauna) is reminiscent of Jurassic rather than Cretaceous conditions.

The predominance of a varied fauna of benthic calcareous foraminifera, accompanied by a low and rather constant frequency of arenaceous forms, very likely indicates that this fauna lived in a sublittoral, possibly outer sublittoral environment. Probably, the beds were formed not very distant from the shore.

To a certain extent empty tests of dead foraminifera, once living under sublittoral and even open sea conditions, might have been brought to the shore by currents and waves. This impression is strengthened by a study of the preservation of particularly large foraminifera ($\geqslant$ 1000 μ), but also by the composition of the fauna (neritic forms together with open sea forms). The fraction of large forms is mainly characterised by nodosariid species, such as *Lenticulina comptoni, L. secans, Neoflabellina praerugosa, N. deltoidea, N. ovalis,* and to some degree also by species of the discorbid genus *Conorbina,* the rotaliid species *Daviesina minuscula* (rare), and arenaceous forms. A great number of these larger foraminifera, including unidentified forms, were found to be badly corroded, possibly by wave action before their final burial. However, the composition of the fauna does not indicate repeated redepositions within a long interval of time.

The arenaceous foraminifera in the Särdal beds are represented by forms referred to the genera *Textularia, Arenobulimina, Dorothia, Valvulina,* and *Ataxophragmium.* This fauna, dominated by *Dorothia* forms, comprises about

10 % of the total foraminiferal fauna. Identified species of these genera have little bearing on the stratigraphical classification of the Särdal beds.

The only miliolid genus found is *Quinqueloculina*, represented by *Q. stolleyi* Brotzen, 1936, a species originally described from the Middle Santonian Eriksdal Marl, and reported by Brotzen (1936) to range from the Turonian to Maastrichtian in NW Europe.

Apart from *Lenticulina* and *Neoflabellina* commented on above, the nodosariacean foraminifera obtained from the Särdal beds include several other genera such as *Nodosaria, Astacolus, Dentalina, Frondicularia, Lagena, Vaginulina,* and the polymorphinid genus *Guttulina*. As mentioned previously, many of the benthic foraminifera, including the nodosariacean forms were originally described by Brotzen (1936) from the Middle Santonian Eriksdal Marl.

The only buliminacean genus obtained is *Praebulimina*, represented by the species *P. ventricosa*, characteristic of the lower Upper Cretaceous. The superfamily Discorbacea is represented by the species *Conorbina marginata* and *C. martini*. The former species constitutes a notable element of the foraminiferal assemblage at Särdal. *Conorbina martini* is said to be characteristic of neritic sediments in the Santonian of NW Germany ("Leitfossilien", 1962, pp. 303, 328). Another coastal foraminifer is *Daviesina minuscula* which has been recorded from Santonian and Campanian strata. In the Särdal material, this species is very rare. Only a few specimens were obtained from the matrix of the basal conglomerate in division A (sample No. 8). In material from the uppermost section exposed in the Malen limestone quarry at Båstad (SE corner of the quarry), *Daviesina minuscula* occurs in abundance, accompanied by species such as *Bolivinoides decoratus decoratus* (L. Campanian-L. Maastrichtian), and, at certain horizons, *Stensioeina exculpta* (Santonian-Campanian).

At Särdal, the planktic superfamily Globigerinacea is represented by the genera *Heterohelix, Hedbergella, Whiteinella, Globotruncana,* and *Archaeoglobigerina,* all with species recorded from the lower Middle Santonian Bavnodde Greensand of the Island of Bornholm (Douglas & Rankin, 1969). As remarked above, this group of planktic foraminifera (indicator of open sea environments) plays a subordinate role in the Särdal fauna. However, as will be demonstrated, this group includes some species of biostratigraphical importance.

Three genera obtained from the Särdal beds are included in the superfamily Orbitoidacea, viz. *Cibicides, Cymbalopora,* and *Planulina*. Identified species of these genera, including *Cibicides ribbingi, C. eriksdalensis,* and *Planulina lundegreni,* were originally described by Brotzen (1936) from the Eriksdal Marl. The *Cymbalopora* species has not yet been identified. However, it seems to be closely related to the type-species, *Cymbalopora*

A PRELIMINARY CHECK LIST OF FORAMINIFERA FROM THE SANTONIAN OF SÄRDAL, HALLAND, SW SWEDEN	CONGLOMERATIC LIMESTONE			CALCAREOUS SANDSTONE					EUROPEAN STRATIGRAPHIC DISTRIBUTION
SPECIES — SAMPLE No.:	6	7	8	1	2	3	4	5	
Arenobulimina d'orbignyi (REUSS, 1846)	—								L.-U. Cretaceous
Arenobulimina preslii (REUSS, 1845)	—								Cenomanian–Maastr.
Dorothia oxycona (REUSS, 1860)	—	—	—	—	—	—		—	Senonian
Valvulina bullata BROTZEN, 1936						—			Santonian
Ataxophragmium compactum BROTZEN, 1936	—		—						Cenomanian–Maastr.
Quinqueloculina stolleyi BROTZEN, 1936	—								Coniacian–Maastr.
Nodosaria obscura REUSS, 1845	—	—	—						L.Cret.–Campanian
Astacolus harpa (REUSS, 1860)			—						Coniacian–Maastr.
Astacolus jarvisi BROTZEN, 1936	—								Turonian–Campanian
Astacolus liebusi (BROTZEN, 1936)	—				—	—			Cenoman.–M.Santon.
Astacolus richteri (BROTZEN, 1936)	—			—	—	—			Senonian
Dentalina wimani BROTZEN, 1936						—			M.Santonian
Frondicularia aclis MORROW, 1934	—								Coniacian–Santonian
Frondicularia frankei CUSHMAN, 1936	—								Turonian–Maastr.
Frondicularia cuspidata CUSHMAN, 1931	—								Coniacian–Campan.
Lagena d'orbignyana SEQUENZA, 1862		—							Cretaceous–Recent
Lagena isabella D'ORBIGNY, 1839							—	—	Cretaceous–Recent
Lenticulina ex gr. comptoni (SOWERBY, 1818)	—	—	—	—	—	—	—	—	L.–U. Cretaceous
Lenticulina secans (REUSS, 1860)	—		—	—		—			L.Cret.–Santonian
Neoflabellina deltoidea (WEDEKIND, 1940)		—	—	—	—	—			Coniacian–L.Camp.
Neoflabellina ovalis (WEDEKIND, 1940)	—		—	—					Coniacian–Santon.
Neoflabellina praerugosa HILTERM., 1952			—						Coniacian–L.Santon.
Vaginulina bicostulata (REUSS, 1860)				—					Albian–Campanian
Guttulina trigonula (REUSS, 1846)	—		—	—		—			L.–U. Cretaceous
Praebulimina ventricosa (BROTZEN, 1936)				—	—	—			Turonian–Santonian
Conorbina marginata BROTZEN, 1936	—	—	—	—	—	—			Santonian
Conorbina martini BROTZEN, 1936			—	—	—	—			Santonian
Daviesina minuscula (HOFKER, 1957)			—						M.Santonian–Camp.
Heterohelix pulchra (BROTZEN, 1936)							—	—	Coniacian–Santonian
Hedbergella amabilis LOEBLICH & TAPPAN, 1961	—			—					Cenoman.–L.Santon.
Hedbergella bornholmensis DOUGLAS & RANKIN, 1969	—	—							Coniacian–L.Santon.
Hedbergella planispira (TAPPAN, 1940)	—								L.Cretac.–L.Campan.
Whiteinella baltica DOUGLAS & RANKIN, 1969	—								Turonian–L.Santon.
Globotruncana coronata BOLLI, 1945	—								Turonian–Santonian
Globotruncana cretacea (D'ORBIGNY 1840)	—			—					Coniacian–Maastr.
Globotruncana marginata (REUSS, 1845)	—		—						Turonian–Santonian
Archaeoglobigerina bosquensis PESSAGNO, 1967	—		—	—	—				Coniacian–Santon.
Planulina lundegreni BROTZEN, 1936		—	—		—	—		—	Santonian
Cibicides eriksdalensis BROTZEN, 1936		—							Santonian–Danian
Cibicides ribbingi BROTZEN, 1936		—							M.Santonian–Maastr.
Cibicides sandidgei BROTZEN, 1936	—		—	—					Santonian–Maastr.
Osangularia cordieriana (D'ORBIGNY, 1840)			—					—	Upper Cretaceous
Osangularia whitei (BROTZEN, 1936)			—	—				—	Upper Cretaceous
Globorotalites ex gr. multisepta BROTZEN, 1936	—			—		—			Turonian–Santonian
Gyroidinoides nitida (REUSS, 1846)	—	—				—			L.–U. Cretaceous
Gavelinella tumida BROTZEN, 1936	—		—		—	—			L.–U. Cretaceous

Table 3.

radiata von Hagenow, originally described from the Maastrichtian of Holland.

Finally, the superfamily Cassidulinacea is represented by the genera *Osangularia, Globorotalites, Gyroidinoides, Anomalinoides,* and *Gavelinella,* all with species known from the Eriksdal Marl also.

Table 3 is a preliminary check-list of foraminiferal species obtained from the Särdal beds. The list will most certainly include several other species after a more comprehensive treatment of the material.

Foraminiferal evidence of the age

All species obtained from the Särdal beds have been recorded from Santonian strata in Europe. However, very few of them are restricted to this

STRATIGRAPHIC RANGE OF SELECTED FORAMINIFERA FROM THE SANTONIAN OF SÄRDAL, HALLAND, SW SWEDEN	LOWER CRETACEOUS	CENOMANIAN	TURONIAN	CONIACIAN	L. SANTONIAN	M. SANTONIAN	U. SANTONIAN	CAMPANIAN	MAASTRICHTIAN	DANIAN
Astacolus liebusi (BROTZEN)		—	—	—	—	—				
Hedbergella amabilis LOEBLICH & TAPPAN		—	—	—	—					
Whiteinella baltica DOUGLAS & RANKIN		—	—	—	—					
Globotruncana coronata BOLLI			—	—	—	—	—			
Globotruncana marginata (REUSS)			—	—	—	—	—			
Neoflabellina praerugosa HILTERMANN				—	—					
Hedbergella bornholmensis DOUGLAS & RANKIN				—	—					
Heterohelix pulchra (BROTZEN)				—	—	—	—			
Archaeoglobigerina bosquensis PESSAGNO				—	—	—	—			
Frondicularia aclis MORROW				—	—	—	—			
Neoflabellina ovalis (WEDEKIND)				—	—	—	—			
Neoflabellina deltoidea (WEDEKIND)				—	—	—	—	—		
Conorbina marginata BROTZEN					—	—	—			
Conorbina martini BROTZEN					—	—	—			
Planulina lundegreni BROTZEN					—	—	—			
Dentalina wimani BROTZEN						—				
Daviesina minuscula (HOFKER)						—	—	—		
Cibicides ribbingi BROTZEN						—	—	—	—	
Gavelinella sandidgei (BROTZEN)					—	—	—	—	—	
Cibicides eriksdalensis BROTZEN					—	—	—	—	—	—
Number of species:		3	5	12	17	16	14	5	3	1

Table 4.

stage. Still, the varying stratigraphical range of the species found allows a fairly good age delimitation of the Särdal beds.

Twenty species selected from the known fauna have been listed in Table 4. They are arranged in stratigraphical order according to records on their vertical range taken mainly from western Europe. As seen, the Lower and Middle Santonian have the highest frequencies of the species listed. The full number of species occurs on the Lower/Middle Santonian boundary only.

The foraminiferal fauna of the Särdal beds includes many benthic forms in common with the Eriksdal Marl, but seems to be somewhat older. All species found in the planktic fauna also occur in the Bavnodde Greensand on the Island of Bornholm, which has been referred to the Lower/Middle Santonian by Christensen (1971). The foraminiferal faunas of the Särdal beds and the Bavnodde Greensand differ widely in the planktic/benthic ratio. In the Särdal beds, this ratio is about 1:10 or even smaller (Table 2, p. 101); in the Bavnodde Greensand the planktic/benthic ratio is 3:1 (Douglas & Rankin, 1969, p. 189). Still the two faunas seem to be more or less contemporary.

Systematic descriptions

Nodosariacea Ehrenberg, 1838
Nodosariidae Ehrenberg, 1838

Astacolus De Montfort, 1808
Astacolus jarvisi Brotzen, 1936

Pl. 3, fig. 3.

1891 *Cristellaria triangularis* D'Orbigny, 1840. – Beissel, p. 53, pl. 10, figs. 1–9.
1925 *Cristellaria navicula* D'Orbigny, 1840. – Franke, p. 72, pl. 5, fig. 28.
1928b *Cristellaria navicula* D'Orbigny, 1840. – Franke, p. 104, pl. 9, fig. 25 a, b.
1928 *Cristellaria nuda* Reuss, 1862. – Cushman & Jarvis, p. 96, pl. 14, fig. 2.
1932 *Cristellaria nuda* Reuss, 1862. – Cushman & Jarvis, p. 25, pl. 7, fig. 6 a, b.
1934b *Cristellaria navicula* D'Orbigny, 1840. – Brotzen, p. 49.
1936 *Astacolus jarvisi* Brotzen. – p. 56, pl. 3, fig. 5 a, b; text-fig. 17: 1–5.

Material: Three specimens from division A, conglomeratic limestone, sample No. 6.

Short description: This species exhibits a wide range of variation in shape and morphology of the test. Brotzen (1936), described two extremes united by transitional forms. Type 1, to which the specimen in pl. 3, fig. 3 is referred, has a low, broad and thick, rather closely coiled test with a narrow, keeled lower margin. The aperture (broken in the figured specimen) is radiate and rather small, situated at the peripheral angle. The distal part of the test is triangular or sub-triangular in transverse section. Ventral margins are usually keeled. The test may be smooth or ornamented with indistinct, discontinuous striae or costae. Type 2 has a more slender form with a pronounced tendency to uncoiling. The transverse section is triangular.

Geographical distribution: *Astacolus jarvisi* was originally described from the Eriksdal Marl (Middle Santonian) in the Vomb Basin, SE Scania. It has also been obtained from Campanian beds in the Köpingsberg No. 1 core SE of Eriksdal in the same basin (Norling herein). Outside Sweden, the species is reported from several European countries including France, Holland, and Germany (Brotzen, 1936). Similar forms have also been obtained from Upper Cretaceous strata of Trinidad (Cushman & Jarvis, 1928, 1932; Brotzen, 1936).

Stratigraphical distribution: Recorded from Turonian to Campanian strata.

Lenticulina Lamarck, 1804
Lenticulina secans (Reuss, 1860)

Pl. 3, fig. 1 A–B.

1860 *Cristellaria secans* Reuss. – p. 214, pl. 9, fig. 7.
1875 *Cristellaria secans* Reuss. – p. 105.
1892 *Cristellaria umbilicata* Perner. – p. 63, pl. 5, figs. 5, 6, 11.
1896 *Cristellaria secans* Reuss var. *angulosa* Chapman. – Chapman, p. 3, pl. 1, fig. 4 a, b.
1899 *Cristellaria secans* Reuss. – Bagg, p. 54.
1936 *Lenticulina secans* (Reuss). – Brotzen, p. 54, pl. 3, figs. 10 a, b; 11 a, b; text-fig. 16.

Material: Eleven specimens from division A, conglomeratic limestone, sample No. 6; one specimen from sample No. 1, and three specimens from sample No. 3, division B, calcareous sandstone.

Short description: *Lenticulina secans* has a discoid, lenticular shape and a series of 8–14 closely coiled, flat and broad chambers. Each side of the test is radially ornamented with curved sutural ribs, often united to form a circular umbilical boss. The peripheral margin is keeled, the ventral area triangular, often with an elevated margin. The radiate aperture is situated at the peripheral angle.

Remarks: The great number of unidentified, badly corroded specimens of *Lenticulina,* especially those obtained from sample fractions larger than 1000 μ, probably includes many specimens of this species.

Geographical distribution: *Lenticulina secans* is widely distributed in western Europe. In Sweden it has been found previously in the Eriksdal Marl (Middle Santonian) and in the Köpingsberg No. 1 core, 154.96–474.03 m (Campanian and Santonian strata).

Stratigraphical distribution: In Lower Cretaceous to Santonian strata of western Europe. Also obtained from Lower Campanian strata.

Neoflabellina Bartenstein, 1948
Neoflabellina deltoidea (Wedekind, 1940)

Pl. 3, fig. 2.

1940 *Flabellina deltoidea* Wedekind. – pp. 186, 190; text-fig. 6 a–c.
1956 *Neoflabellina deltoidea* (Wedekind). – Hiltermann & Koch, p. 37, text-fig. 4: 1–5, pls. 1, 2, fig. 2.
1962 *Neoflabellina "deltoidea"* (Wedekind). – "Leitfossilien", p. 308, tbl. 19; pl. 48, fig. 12.

Material: Nine specimens from division A, conglomeratic limestone, samples Nos. 7, 8; six specimens from division B, calcareous sandstone, samples Nos. 1–3.

Short description: *Neoflabellina deltoidea* has a large, broad, palmate (sub-rhomboidal) test with flattened, parallel sides. The early portion of the test is plani-spirally coiled, later becoming uncoiled and rectilinear. The later chambers are low, broad, arched and equitant as in *Frondicularia.* The sutures are thickened and elevated. The chamber wall has a rough, punctate surface. The radiate aperture is terminal.

Stratigraphical distribution: European records from Coniacian to Lower Campanian strata.

Discorbacea Ehrenberg, 1838
Discorbidae Ehrenberg, 1838

Conorbina Brotzen, 1936
Conorbina marginata Brotzen, 1936

Pl. 4, figs 1–4.

1936 *Conorbina marginata* Brotzen. – pp. 141–143; pl. 10, fig. 5 a–e; text-fig. 50.
1964 *Conorbina marginata* Brotzen. – Loeblich & Tappan, p. 575, fig. 453, 1.

Material: About fifty specimens from division A, conglomeratic limestone, samples Nos. 6–8; about fifty specimens from division B, calcareous sandstone, samples Nos. 1–3.

Short description: This species has a plano-convex, trochospiral test, crescentic chambers, gradually increasing in breadth. The final whorl has relatively few chambers. The chamber sutures are oblique on the spiral side, nearly radial on the umbilical side. The aperture is a low slit at the base of the final chamber.

Remarks: The Särdal material exhibits a wide range of variation in the height/breadth ratio, and in the development of the aperture. Some specimens are distinctly conical, other are rather flat, plano-convex. The apertural slit may be invisible, long and narrow, or short and crescentic.

Stratigraphical distribution: Recorded from Santonian strata in Europe.

Rotaliacea Ehrenberg, 1839
Rotaliidae Ehrenberg, 1839

Daviesina Smout, 1954
Daviesina minuscula (Hofker, 1957)

Pl. 4, figs 5–6.

1957 *Lockhartia minuscula* Hofker. – p. 427; p. 428, text-figs. 481 a–d, 482, 483 (2 figs.); p. 429, text-figs. 484 (2 figs.), 485 (2 figs.).
1958 *Daviesina voigti* Hofker. – p. 69, text-figs. 1–3.
1962 *Daviesina minuscula* (Hofker). – "Leitfossilien", p. 335, tbl. 19; pl. 46, figs. 2–4.
1968 *"Lockhartia" minuscula* Hofker. – Bang (in Larsen and others). p. 66.

Material: Three specimens (plus one questionable, corroded) from division A, conglomeratic limestone, sample No. 8.

Short description: *Daviesina minuscula* has an operculine, biconvex, but slightly asymmetrical test. The umbilical region on both sides of the test has many pillars, which in some specimens may be radially arranged along the inner part of the chamber sutures. The peripheral part of the sutures is sometimes thickened and elevated, but not as arched and distinct as in the Maastrichtian species *Daviesina fleurausi* (D'Orbigny, 1850). The aperture is a short slit at the base of the septal wall of the last chamber. The size of *Daviesina minuscula* varies from 0.2 to 2 mm.

Geographical distribution: This species is recorded from Holland, NW Germany, Denmark, and other countries (Hofker, 1957, 1958; "Leitfossilien", 1962; Bang in Larsen et al., 1968). In Sweden it has been found in the Malen quarry at Båstad (Campanian), apart from the Särdal finds.

Stratigraphical distribution: In neritic facies from the Lower/Middle Santonian to the Campanian.

Globigerinacea Carpenter, Parker & Jones, 1862
Rotaliporidae Sigal, 1958

Hedbergella Brönnimann & Brown, 1958
Hedbergella bornholmensis Douglas & Rankin, 1969

Pl. 5, fig. 1 A–C.

1969 *Hedbergella bornholmensis* Douglas & Rankin. – p. 193, fig. 6; p. 188, fig. 3; p. 189, tbl. 1.

Material: Four specimens from division A, conglomeratic limestone, samples Nos. 6 and 7.

Short description: The test has a low trochospiral coil, a lobulate equatorial periphery, and a rounded axial periphery. The chambers are subglobular; the final whorl has three and a half to four chambers. Initial chambers are small, increasing gradually in size. The final three to four chambers increase more rapidly. Chamber sutures are radial, depressed, distinct, and the wall is distinctly perforate. The surface is covered with small spines. Umbilical cavity is deep.

Remarks: According to Douglas & Rankin (1969), *Hedbergella bornholmensis* is similar to *Whiteinella baltica* Douglas & Rankin, but may be differentiated by the trilobate shape of the test, the rapid rate of whorl expansion in the final volution, and the more extra-umbilical position of the primary aperture.

Geographical distribution: Apart from the finds on the Island of Bornholm and at Särdal, this species has been recorded from northern Germany and probably occurs in other parts of the southern Baltic area (Douglas & Rankin, 1969).

Stratigraphical distribution: Coniacian to L./M. Santonian.

Globotruncanidae Brotzen, 1942

Archaeoglobigerina Pessagno, 1967
Archaeoglobigerina bosquensis Pessagno, 1967

Pl. 6, figs 1–2.

1967 *Archaeoglobigerina bosquensis* Pessagno. – p. 316, pl. 60, figs. 7–12.
1969 *Archaeoglobigerina bosquensis* Pessagno. – Douglas & Rankin, p. 199, fig. 10 a–c; p. 200, fig. 11 a–c; p. 188, fig. 3; p. 189, tbl. 1; pp. 211–213.

Material: Ten specimens from division A, conglomeratic limestone, samples Nos. 6 and 8; two specimens from division B, calcareous sandstone, samples Nos. 1 and 2.

Short description: Adult specimens of *Archaeoglobigerina bosquensis* are relatively large, about 0.30–0.40 mm in diameter. The chambers are subspherical, four to six per whorl, arranged in a medium to high trochospiral coil. Early chambers increase rapidly in size, later chambers gradually, and the last two chambers are of about the same size. The umbilicus is open, moderately deep, and becomes deeper with increasing spiroconvexity. The species has umbilical cover plates (tegilla), which commonly are broken. Usually, the broken base of a tegillum is visible on the last chamber only. The ornamentation of the test consists of frequent short spines, which are best developed on the early chambers. The sutures are fairly distinct and radially arranged on both sides of the test.

Geographical distribution: The species has been recorded from the American Gulf Coast, and from the Island of Bornholm in the southern Baltic. Forms resembling *Archaeoglobigerina bosquensis* have been reported from Alaska, Australia, and Russia.

Stratigraphical distribution: Restricted to the Coniacian and the Santonian.

Globotruncana Cushman, 1927
Globotruncana marginata (Reuss, 1845)

Pl. 8, fig. 1 A–C.

1845 *Rosalina marginata* Reuss. – p. 36, pl. 8, figs. 54, 74; pl. 13, fig. 68.
1956 *Globotruncana marginata* (Reuss).. – Jirova, p. 241, pl. 1, fig. 1 (neotype).
1969 *Globotruncana marginata* (Reuss). – Douglas & Rankin, p. 203, figs. 14, 15; p. 188, fig. 3; p. 189, tbl. 1; pp. 211–214.

Material: Numerous specimens from division A, conglomeratic limestone, samples Nos. 6 and 8.

Remarks: Nothing can be added to previous descriptions of this well-known species.

Geographical distribution: Reported from Europe, North and Central America, North Africa, Australia, and Russia.

Stratigraphical distribution: In older publications, this species has been reported mainly from Turonian strata. In recent years, it has also been recorded from the Coniacian and Santonian.

Cassidulinacea D'Orbigny, 1839
Anomalinidae Cushman, 1927

Gavelinella Brotzen, 1942
Gavelinella sandidgei (Brotzen, 1936)

P1.7, fig. 1 A–C.

1936 *Cibicides sandidgei* Brotzen. – p. 191, pl. 14, figs. 2–4.
1957 *Gavelinella sandidgei* (Brotzen). – Hofker, p. 315, text-fig. 358.

Material: Six specimens from division A, conglomeratic limestone, samples Nos. 6 and 8; one specimen from division B, calcareous sandstone, sample No. 1.

Remarks: Hofker correctly assigned this species to the genus *Gavelinella* Brotzen, 1942 on the basis of its aperture, which is a narrow interiomarginal slit extending from periphery to umbilicus. As demonstrated by Brotzen (1936), *Gavelinella sandidgei* exhibits a wide range in variation. The long, narrow apertural spiral and the distinctly concave umbilical side seem to be characteristic of this species.

Stratigraphical distribution: Recorded from Santonian to Lower Maastrichtian strata in Europe.

Gavelinella tumida Brotzen, 1942

Pl. 8, figs. 2–3.

1936 *Anomalina lorneiana* (D'Orbigny, 1840). – Brotzen, p. 178, pl. 12, figs. 1 a–c, 2 a–c; text-fig. 64.
1942 *Gavelinella tumida* Brotzen. – p. 47, text-fig. 15; p. 57.
1945 *Gavelinella tumida* Brotzen. – Thalmann, vol. 19, p. 405 (synonymy only).

Material: Ten specimens from division A, conglomeratic limestone, samples Nos. 6 and 8, and from division B, calcareous sandstone, samples Nos. 2 and 3.

Short description: *Gavelinella tumida* is a trochospiral, biconvex foraminifer with a broad, rounded periphery. The aperture is a low interiomarginal slit extending from periphery to umbilicus, which may be partially closed by subtriangular flaps projecting from umbilical margin of each chamber. The test surface is penetrated by large pores.

Stratigraphical distribution: Recorded from Turonian to Lower Campanian strata in Europe.

Plate 3

Fig. 1 *Lenticulina secans* (Reuss, 1860). EN SEM 121:1. Särdal, division A, conglomeratic limestone, sample No. 8. A: Side view; X 100. B: Ventral view; X100.

Fig. 2. *Neoflabellina deltoidea* (Wedekind, 1940). EN SEM 108:3. Särdal, division B, calcareous sandstone, sample No. 1; X 50.

Fig. 3. *Astacolus jarvisi* Brotzen, 1936. EN SEM 108:2. Särdal, division A, conglomeratic limestone, sample No. 6; X 100.

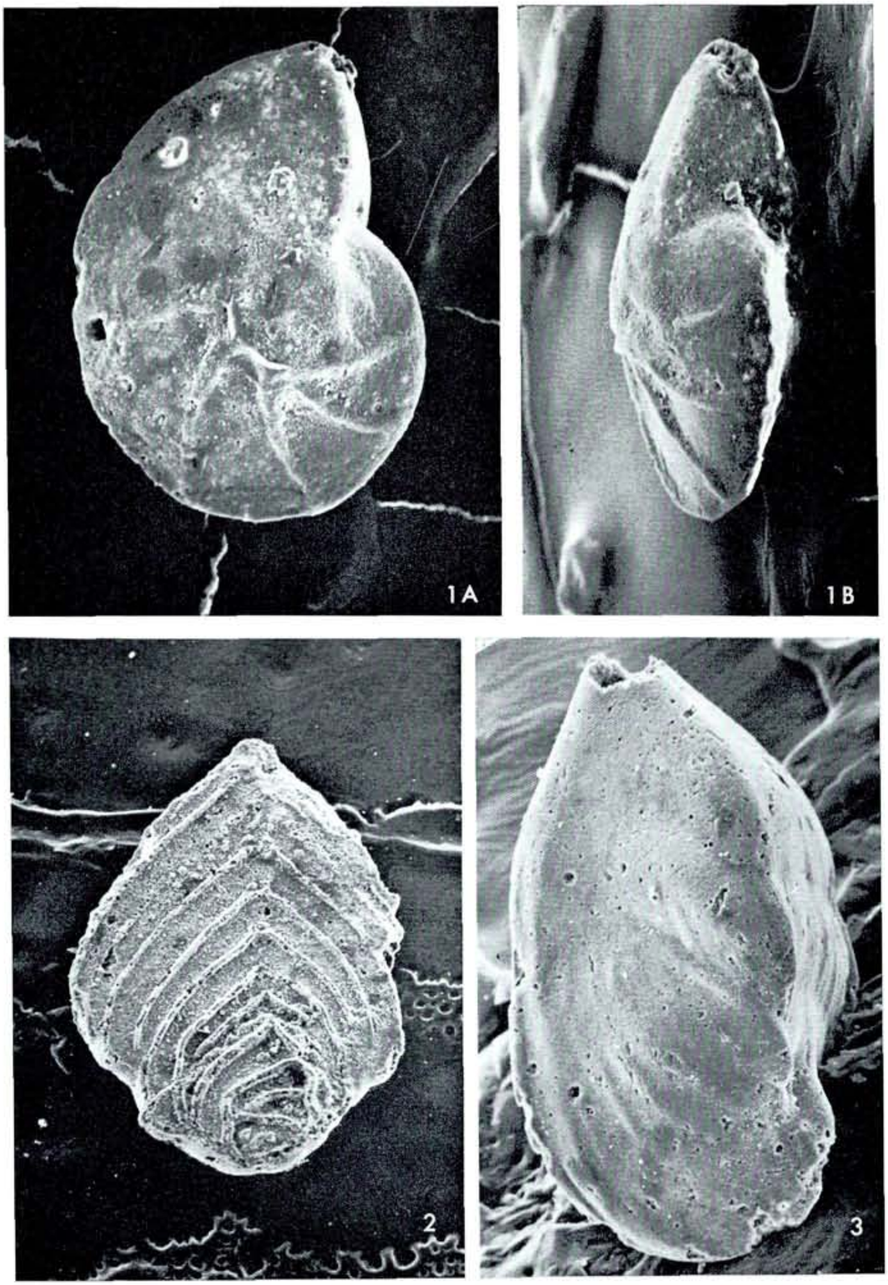

1A
1B
2
3

Plate 4

Figs. 1–4. *Conorbina marginata* Brotzen, 1936. Särdal, division B, calcareous sandstone.

1: Side view of specimen EN SEM 124:1; Sample No. 1; × 100. 2: Oblique umbilical view of specimen EN SEM 107:1; Sample No. 3; × 100. Note the crescentic aperture at the base of last chamber. 3: Oblique spiral view of specimen EN SEM 108:1; Sample No. 2; × 100. 4: Oblique umbilical view of specimen EN SEM 109:2; Sample No. 1; × 92. Note the radial sutures and the lack of a visible aperture.

Figs. 5–6. *Daviesina minuscula* (Hofker, 1957).

5: Side view of specimen EN SEM 120:1; Särdal, division A, conglomeratic limestone, sample No. 8; × 50. 6: Specimen EN SEM 120:2; Malen Quarry, Båstad; Campanian. A: Edge view; × 55. B: Side view. Note umbilical pillars and the septal slit at the left margin; × 60.

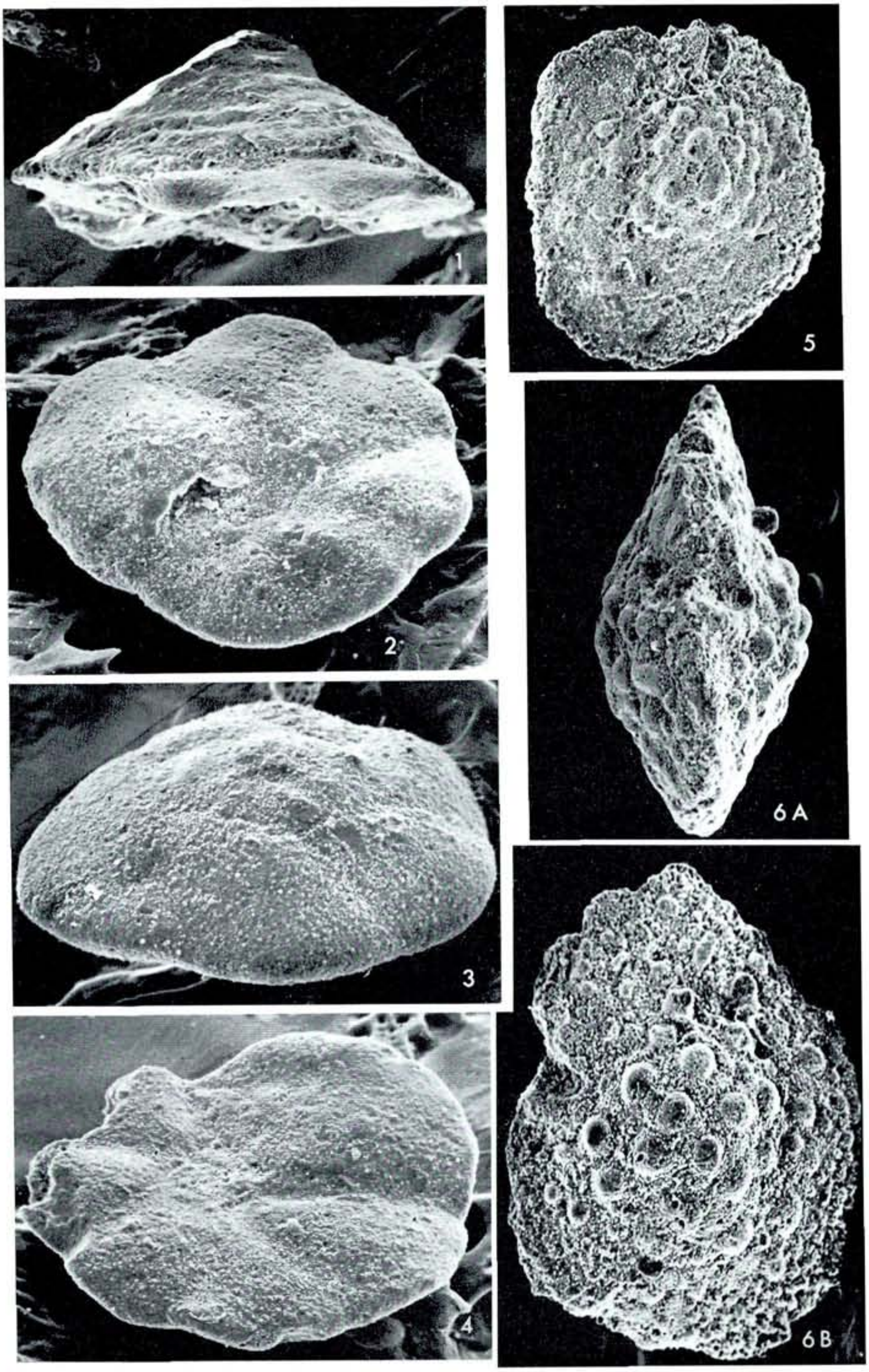

1
2
3
4
5
6A
6B

Plate 5

Fig. 1. *Hedbergella bornholmensis* Douglas & Rankin, 1969, Specimen EN SEM 110:1. Särdal, division A, conglomeratic limestone, sample No. 6. A: Slightly oblique umbilical view; X 200. B: Edge view, X 200 C: Detail showing umbilical cavity and spinose and perforate chamber wall; X 500.

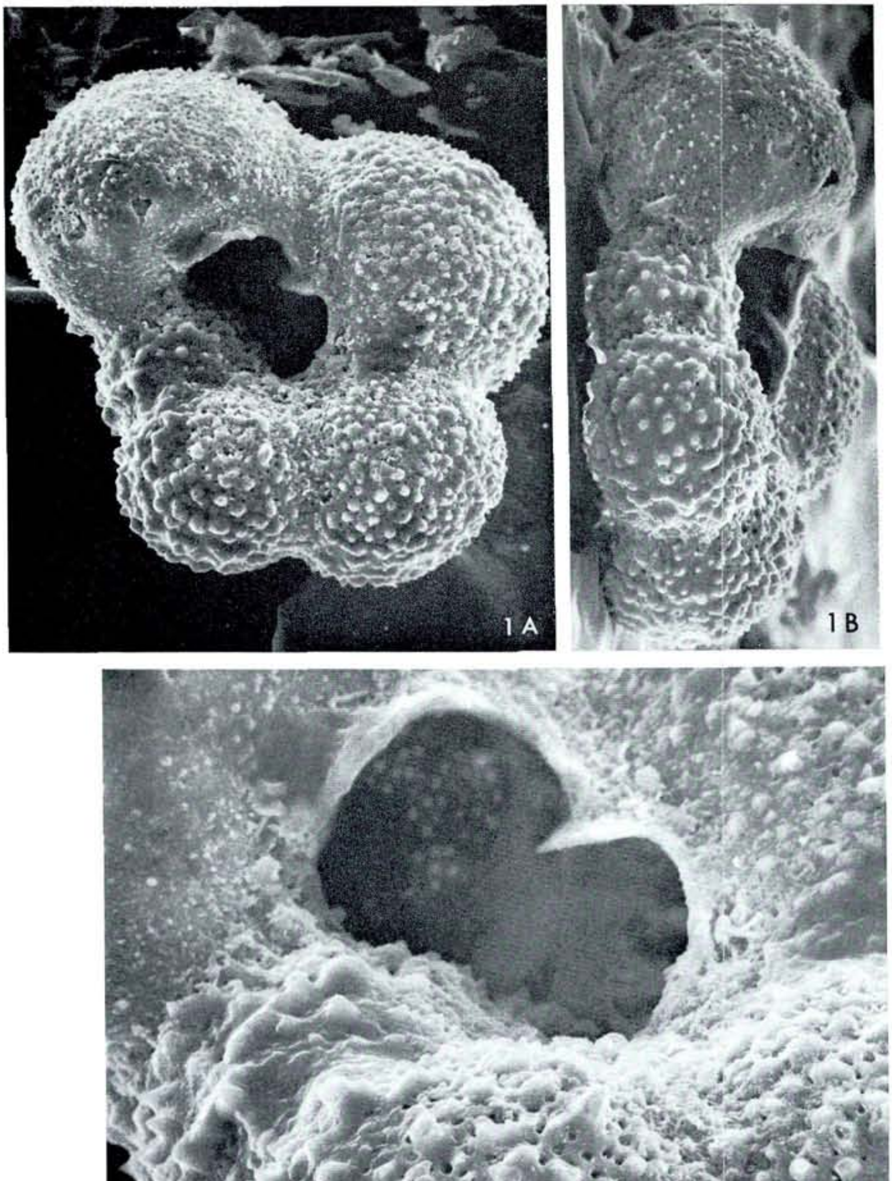

1 A
1 B
1C

Plate 6

Figs. 1–2. *Archaeoglobigerina bosquensis* Pessagno, 1967, Särdal, division A, conglomeratic limestone.

1: A: Umbilical view of specimen EN SEM 121:3; Sample No. 8; × 180. B: Edge view of the same specimen; × 180. 2: Specimen EN SEM 109:4; Sample No. 6. A: Umbilical view; × 210. B: Edge view, × 190.

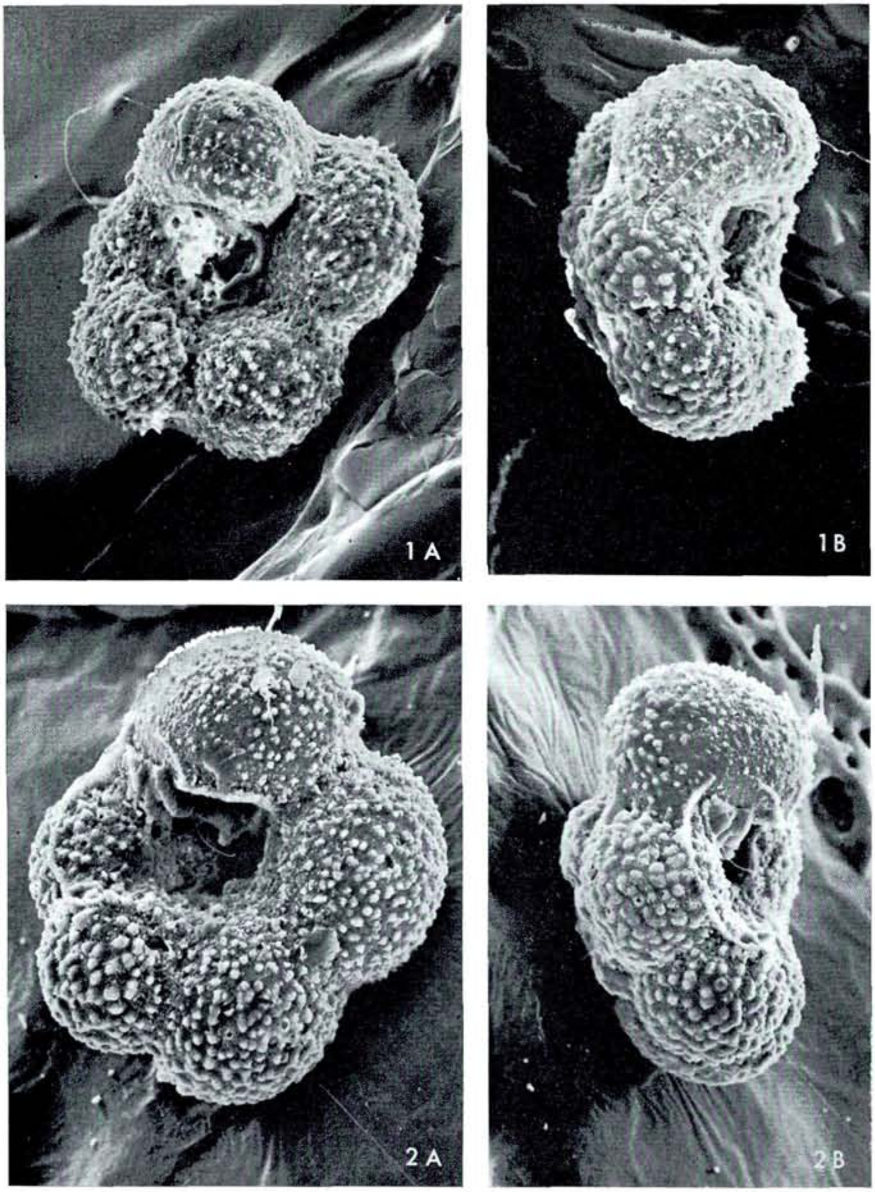

1 A
1 B
2 A
2 B

Plate 7

Fig. 1. *Gavelinella sandidgei* (Brotzen, 1936). Specimen EN SEM 109:3. Särdal, division B, calcareous sandstone, sample No. 1. A: Umbilical view; X 190. Note the interiomarginal, spirally coiled apertural slit. B: Edge view; X 190. C: Oblique umbilical view; X 190.

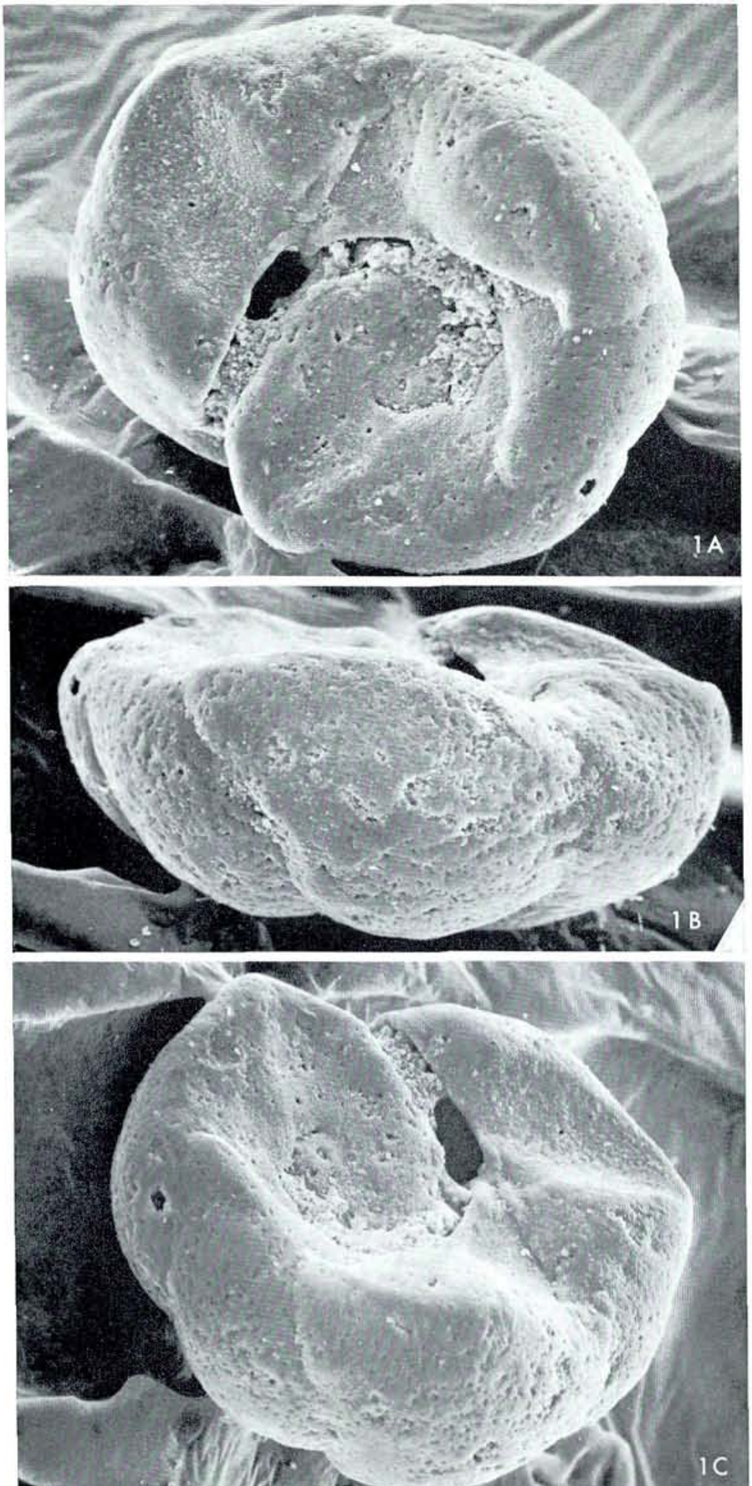
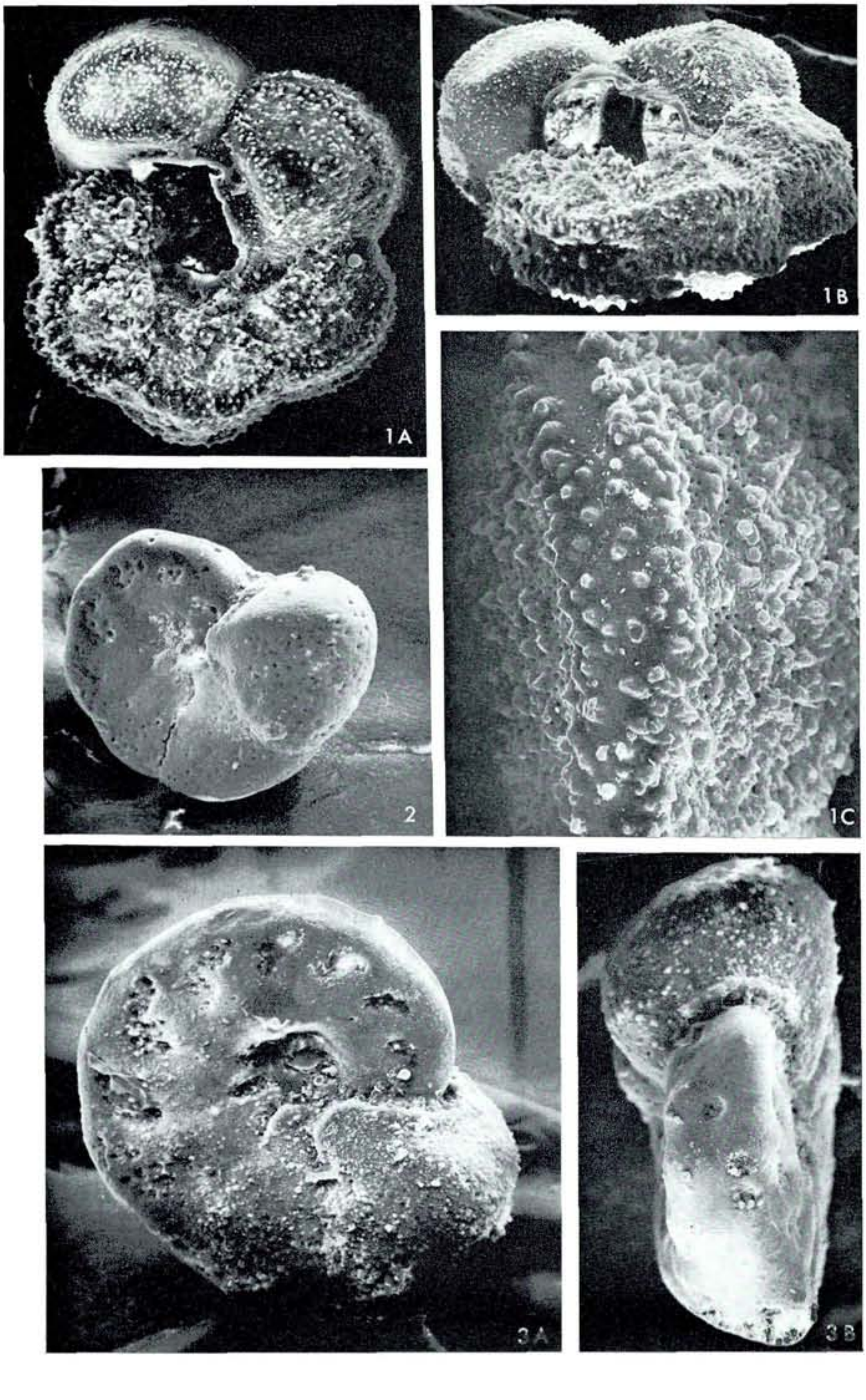

1A
1B
1C

Plate 8

Fig. 1. *Globotruncana marginata* (Reuss, 1845). Särdal, division A, conglomeratic limestone. A: Umbilical view of specimen EN SEM 121:2. Sample No. 8; X 133 approx. B: Oblique edge view of same specimen; X 127 approx. C: Detail of specimen EN SEM 109:5, sample No. 6, showing spinose ornamentation, imperforate margin, and perforate chamber wall; X 333 approx.

Figs. 2–3. *Gavelinella tumida* Brotzen, 1942.

2: Umbilical view of specimen EN SEM 115:2; Särdal, division A, conglomeratic limestone, sample No. 8. Note the coarse perforation; × 127 approx. 3: Specimen EN SEM 116:4. Särdal, division A, conglomeratic limestone, sample No. 6. A: Umbilical view; × 173 approx. B: Edge view showing the apertural slit at the base of the last chamber; × 180 approx.


1A
1B
1C
2
3A
3B