

## FORAMINIFERA FROM THE CRETACEOUS OF SOUTHERN LIMBURG, NETHERLANDS. XXI.

## THE SPECIES OF THE GENERA GAVELINELLA AND GAVELINOPSIS IN THE CRETACEOUS ABOVE THE HERVIAN IN GERMANY, HOLLAND AND BELGIUM, AND THE INCREASE OF THE DIAMETERS OF THEIR PORES AS INDICATION FOR STRATIGRAPHIC LEVELS (INCLUDING THE DEVELOPMENT OF THE PORES OF SOME STENSIONIA-SPECIES).

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## THE GENERA GAVELINELLA AND GAVELINOPSIS (Figs. 1—18).

Both genera belong to the *Gavelinellidae*. In *Gavelinella* the umbilicus of the ventral side is open, whereas in *Gavelinopsis* it is filled up by a chalk knob, protuding from the initial part of the test.

In both genera the aperture consists of two parts, a sutural slitlike opening at the ventral suture, becoming more or less marginal in highly developed forms, and an umbilical opening which is connected with the sutural one and is covered by short lips which many cases fuse together at the ventral side around the umbilical area into a spirally ridge.

In both genera in the older forms only the ventral side shows pores, whereas the dorsal side is poreless; but in highly advanced species pores may appear also at the dorsal side, at least in the later formed chambers.

In both genera the septal walls are double.

Primitive forms show slight difference between ventral and dorsal sides, since the ventral side and the dorsal side show all chambers, arranged into a spiral which is trochoidal. But in advanced species the chambers on the dorsal side may become involute up to reaching the centre of the test.

A very striking fact is the increase of the size of the pores during the evolution of each species, always beginning with pores of about  $1-2 \mu$  diameter, and increasing up to  $8 \mu$  diameter. When that size is reached, the species disappears. In most species the increase of pores is relatively rapid, since the whole development takes about a single period of the Upper Cretaceous; but in some species the increase is

rather slow, for instance in *Gavelinopsis bembix*, so that in that species the increase is of no stratigraphic significance.

Short description of the species.

GAVELINOPSIS PERTUSA (Marsson).  
Fig. 3.

*Truncatulina pertusa* Marsson, 1878, p. 166, pl. 4, fig. 35.

Test rounded to slightly oblong. At the ventral side only the chambers of the last formed whorl clearly visible, the distinct somewhat curved sutures, depressed between the last formed chambers and thickened to limbate between the older chambers. Umbilicus wide open and hollow, with very narrow lips. Pores distinct in all chambers. Margin rounded, periphery only slightly lobulate at the last formed chambers, else smooth. At the dorsal side all chambers visible, with slightly backward curved sutures which especially between the last formed chambers are distinct and limbate. Pores not developed on the dorsal side in the forms of the beginning of the development of the species, but at the end of the development also found in the walls of the last formed chambers of the test. Number of chambers 10—11 in the last whorl.

In South Limburg the diameter of the tests is comparatively small, about 0.7 mm in the largest specimens, thickness then 0.2 mm.

The species occurs, never common, from the Cr 3 a up into the Cr 4; it may be found very rarely in the Mb, but not higher up. Though Visser mentions it from the uppermost Md, this must be an error.

GAVELINELLA CLEMENTIANA  
(d'Orbigny). Fig. 2.

*Discorbis clementiana* d'Orbigny, 1840, p. 37, pl. 3, figs. 23—25.

Ventral side with a rather narrow umbilical hollow. The chambers of the last formed whorl only visible at the ventral side. Sutures distinct, depressed in the last formed chambers, but strongly limbate in the former chambers by a secondary thickening of the chalk substance. Umbilical lips strongly protruding over the umbilical hollow, forming a star-like figure. Last

formed chambers inflated, and thus the margin lobulated here. Ventral or marginal aperture often with a slight lip. Pores at the ventral side distinct. Margin strongly rounded. Dorsal side always without pores, with all chambers visible, but the initial part often covered by irregular bosses of chalk. Sutures strongly curving backwards, limbate by irregular bosses of chalk.

Number of chambers in most cases 7.

Diameter 0,9 to 1 mm. Thickness 0,37—0,4 mm.

The species occurs only in the Cr 3 a, where it is common, and in the Hervian, in the lower part of it.

*GAVELINELLA PERTUSA*  
*MAESTRICHTIENSIS* (Hofker). Fig. 4.

*Gavelinella pertusa maestrichtiensis* Hofker, Pal. Zeit., 30, 1956, p. 73, fig. 60.

This variety develops in the Lower Maestrichtian from the typical species. It must be a variation, since the pores do not decrease. Test rather small for the species; ventral side with slightly curved sutures between the chambers, sutures thickened between older chambers. Umbilical lips fusing together forming a narrow border over the large umbilicus. Pores at ventral side in all chamberwalls, distinct. Chambers, especially the later ones, strongly inflated, forming a lobulate periphery. Margin strongly rounded. Chambers at the dorsal side not reaching the centre, but more involute than in the real species. At the dorsal side pores in the younger chambers. Diameter of tests 0,55 mm, thickness 0,25 mm.

This variety is found from the Cr 3 c upwards into the Cr 4 and rarely in the lower Mb.

*GAVELINELLA UMBILICATIFORMIS*  
Hofker. Figs. 10—13.

*Gavelinella umbiliciformis* Hofker, 1955, Natuurhist. Maandblad Limburg, 44, p. 120, figs. p. 122.

Test small, dorsal side with chambers leaving a narrow umbilicus free, which in most cases is surrounded by a spirally formed rim, formed by the fusing umbilical lips of the chambers. Sutures slightly depressed at the ventral side but often becoming limbate by thickening be-

tween later chambers, slightly curving backwards. Ventral side somewhat flattened. Pores at ventral side small but distinct. At the dorsal side the chambers reach towards the centre of the test, leaving in some cases a small clear central part free. Here the sutures are slightly depressed, narrow, and slightly curved. Periphery very slightly lobulate or smooth. Margin rounded. The typical somewhat spiral umbilicus at the ventral side is the most striking feature. Number of chambers high, about 10—11 in the last formed whorl.

Diameter of test about 0.40—0.50 mm, thickness about 0,20 mm.

The species begins its development in the Upper Maestrichtian, the Cr 4, and develops during the whole M up into the Upper Md.

*GAVELINOPSIS COMPLANATA*  
(Reuss). Figs. 7, 8.

*Anomalina complanata* Reuss, 1851, p. 20, pl. 3, fig. 3.

Test rounded. Ventral side somewhat flattened, with slightly curved sutures directed backwards. Sutures filled up with chalk but not limbate. Umbilical lips forming a spiral thickened rim around the flatly filled umbilicus. Only the chambers of the last  $1\frac{1}{2}$  whorl visible on the ventral side. Pores in all chamberwalls, often distinct. Periphery smooth or very slightly lobulate at the last few chambers. Margin rounded to slightly compressed. Dorsal side with depressed strongly curved sutures.

No pores at the dorsal side.

Number of chambers in the last formed whorl 9.

Diameter about 0,65 mm, thickness about 0,35 mm. The ventral and dorsal sides equally convex.

This species is found in South-Limburg in the Cr 3 a, Cr 3 b et Cr 3 c.

*GAVELINOPSIS BARTENSTEINI*  
Hofker. Fig. 9.

*Gavelinopsis bartensteini* Hofker, Pal. Zeit., 30, 1956, p. 74, fig. 64.

Test differing from *G. complanata* in the higher inflated chambers, and the not so curving sutures. At the ventral side the umbilical



filling is in most cases not spirally, the periphery is strongly lobulated, the sutures not so oblique as in *G. complanata*. Pores in all chambers at the ventral side. At the dorsal side the sutures are depressed, the sutures nearly straight or very slightly curved, and pores are visible also at the dorsal side in most of the chambers.

Number of chambers 8—9.

Diameter about 0,60 mm, thickness 0,35 mm. Both sides are equally convex.

This species develops in South-Limburg in the upper part of the Cr 3 b, the lower part of the Cr 3 c and ends its development in the upper Cr 4 or Ma. It is typical for the whole Maestrichtian period, but does not occur in the M, or K.

*GAVELINOPSIS PLANA* (Schijfsma).  
Fig. 1.

*Cibicides voltziana* (d'Orbigny) var. *plana*  
Schijfsma, 1946, p. 104, pl. 7, fig. 11.

Test circular and flattened. At the ventral side the chambers surround a large chalk knob in the umbilical area, and the slightly depressed sutures are narrow and curved backwards. The pores are distinct here, and the chalk knob is surrounded by a small thickened area not forming a real spiral. The periphery is smooth, and the margin rounded. At the dorsal side most of the chambers are visible in transmittant light, but the central part is covered by the protruding smoothly finished chalk budd. At the dorsal side no pores are found in the chamber walls.

Number of chambers in the last formed whorl 12—13. Diameter about 0,80 mm or even larger. Thickness 0,30 mm.

This species occurs in some samples of the Cr 3 c in South-Limburg, where it is rather common.

*GAVELINOPSIS VOLTZIANA*  
(d'Orbigny). Fig. 5.

*Rosalina voltziana* d'Orbigny, 1840, p. 31  
pl. 2, figs. 32—34.

Test large and strongly built. Dorsal side flattened or slightly convex, ventral side strongly convex. Dorsal side with a large umbilical knob, not or only very slightly protruding and smoothly finished, surrounded by chambers

with nearly radiant sutures which may be slightly curved. Umbilical apertures visible as a narrow canal between the chambers and the knob. Pores very distinct. At the dorsal side no pores are found, and the sutures of the chambers are indistinct, covered mostly by a very large and bulging central chalk knob which is smoothly finished with the surface. Margin rounded to nearly keeled, periphery smooth.

Diameter of tests up to 1 mm or even slightly more, thickness about 0,50 mm.

Number of chambers about 10.

This species is found in the Cr 3 a and Cr 3 b, at the top of which it extinguishes; never common.

*GAVELINOPSIS INVOLUTA* (Reuss).  
Figs. 17, 48.

*Rotalia involuta* Reuss var. of Maestricht,  
1861, pl. 2, fig. 4.

Test large, rounded or slightly oval. Last chambers inflated on both sides. Ventral side flat or slightly convex, dorsal side slightly more convex. At the ventral side a large boss of chalk is found in the umbilical area, and the chambers of the last formed whorl are distinctly separated from it by a canal running spirally. The sutures at the ventral side are depressed, nearly radial or slightly curving backwards. Periphery strongly lobulate, especially at the last formed chambers. Pores distinct in all chamber walls of the ventral side. Margin rounded to slightly compressed. At the dorsal side the chambers reach the centre which may be covered by a small and inconspicuous knob, but this knob may be lacking totally. At the dorsal side nearly all chamber walls show the pores.

Number of chambers in the last formed whorl 9—12.

Diameter 1,10 mm, thickness about 0,50 mm. From the Cr 4 up to the highest Md.

*GAVELINOPSIS BEMBIX* (Marsson).  
Fig. 15.

*Discorbina bembix* Marsson, 1878, p. 167,  
pl. 5, fig. 37.

Test round, with very smooth periphery. At ventral side very flat, only with slightly protruding central knob, dorsally very strongly

convex with strongly developed hyaline central knob.

At the ventral side the central large chalk knob is surrounded by numerous chambers with very strongly oblique and slightly curved sutures which are not depressed and distinct. Margin compressed, at the ventral side the sutures are scarcely seen, strongly bent backwards. No pores at the dorsal side.

Number of chambers of last formed whorl 9—10.

Diameter 0,50—0,60 mm; thickness 0,25—0,35 mm.

This species is found in most gatherings of the whole Cretaceous of South-Limburg, never common. It may be that some young tests of other species are confused with the species also.

#### *GAVELINELLA DANICA* (Brotzen).

Fig. 16.

*Cibicides danica* Brotzen, Sver. geol. Unders., 1940, p. 61, figs. 7, 2.

This species has been fully described by the author in Natuurhist. Maandblad Limburg, 44, p. 49—53, figs. 1, 2. So no description is given here. It ranges from the Cr 3 b, upper part, into the Paleocene and Montian.

#### *GAVELINOPSIS ACUTA* (Plummer).

Fig. 14.

*Anomalina ammonoides* Reuss var. *acuta* Plummer, Univ. Texas Bull. no 2644, 1926, p. 149, pl. 10, fig. 2.

This species may be a descendant from *G. bembix*; it is found only in the Md and the Paleocene, and is characterised by a distinct mostly hyaline knob in the centre of the dorsal side. While *G. bembix* from the Maestrichtian does not change its pores, this form, which may be distinguished from *G. succedens* (Brotzen) in the Paleocene by its much more rough structure, increases the size of its pores in a rather spectacular way. It may be *G. bembix* in its later development.

### THE INCREASE OF PORE-DIAMETER OF THE *GAVELINELLIDAE* DURING DEVELOPMENT OF THE SPECIES.

#### WITH RANGE-CHART.

Abbreviations of locality-names used in the range-chart:

#### Belgium.

Hal 208; a large series of samples was gathered in the large Quarry at Hallenbaye, North Eastern Belgium; a single sample was taken 10 m down in the Hervian of that quarry, Hal GB 198.

Glons 69; At the bottom of a quarry near Glons, North Eastern Belgium, a drilling was made 69 m down; at the top of the quarry a sample is called Glons C top.

Nouv.; several samples were taken in quarries in the Hainaut, Southern Belgium, near Mons, in the Craie de Nouvelles.

North; a quarry in the North Eastern part of Belgium.

Esp; a large ancient quarry in North Eastern Belgium is called Bonne Espérance.

Spïen; several samples taken in quarries in the Hainaut, near Mons, in the Craie de Spiennes. Cr. phos; several samples taken in quarries in Southern Belgium near Mons, in the Craie phosphatée de Ciply.

Orp; a sample taken just above the hard ground at the top of the ancient quarry at Orp-le-Petit in Northern Belgium.

Lan 167; several samples along the hill-side near Lanaye, in North Eastern Belgium.

Serp; along a serpentine way near Lanay in North Eastern Belgium.

Gr-D holes; holes in the hard ground in the caves at Grez-Doiceau, North Belgium.

AlbC.; Series B, C, D, taken in the Tranché du Canal Albert, South-Western part of Petersberg; one sample was from the Paleocene near Vroenhoven (Alb. Vroen.).

#### Holland.

Beut; a quarry near Beutenaken in the Cr 3 a in South-Limburg.

7 W 445; in a hill-side at the locality "De Zeven Wegen" in South-Limburg.

OBos K 607; many samples in an outcrop called Onderste Bos in South-Limburg.

BBos 99; many samples in an outcrop called Bovenste Bos in South-Limburg.

Slen 458; samples taken in a small outcrop West of Slenaken (Kerkdel) in South-Limburg.

Mech top; a sample in chalk covering the Hervian in a hollow way near Mechelen (Overgeul) in South-Limburg.

Wahlw; outcrops North of Wahlwylre where the so-called Cr 3 gamma may be seen.

Mesch; two small outcrops near Mesch, in the South Western part of South-Limburg.

Vijlen; a large ancient quarry in the village of Vijlen, South-Limburg.



Moer; outcrop near Moerslag with tigre-chalk, Western South-Limburg.

Gulp; hollow way at the Gulper Berg, South-Limburg.

Enci K465, ET 40; samples in the large quarry of the ENCI near Maastricht, South-Limburg. Western part. A large set of samples was taken at this outcrop, given here as Enci, 4, 33 m; the level in m above the bottom of the quarry at that locality.

B 2203; a boring.

Tombe; ancient quarry in the Jekerdal, St. Pietersberg, called quarry of the Tombe.

Biebos; ancient quarry near Sibbe.

Neercanne; quarries in the Jekerdal, opposite St. Pietersberg.

Zwaan; large quarry in the Northern part of the Jekerdal, St. Pietersberg, proprietor v. d. Zwaan.

Putsberg; outcrop in the Eastern part of Limburg, South of Heerlen.

Kund; large quarry in the Kunderberg, near Kunrade.

Schunck; quarry South of Kunrade, proprietor Schunck.

Welt; outcrop in the Welterberg, South of Heerlen.

OB 194; drilling in the Pietersberg, Western part. ON I, Md; shaft of the mine Oranje Nassau, part of the Md.

Curfs; large quarry near Houthem, Southern Limburg.

Maurits; shaft III of the mine Maurits, in the Northern part of South-Limburg.

Beatrix; drilling in the Peel, West of Limburg.

#### Germany.

Mis; large quarry in the Campanian near Misburg near Hannover.

Lun; several samples taken at the large quarry near Lüneburg, am Zeltberg, North of Hannover.

Old; drilling near Oldenburg, North Western Germany.

Gr-H; drilling near Gross-Hehlen, No. 1016, North of Hannover.

Sieg; drilling near Siegelsum, Germany.

Hem; quarry near Hemmoor, North Western Germany.

Basbeck; quarry near Basbeck, North Western Germany.

Brun; drilling Brunhilde I, near Hannover.

Maasb; drilling Maasbühl I. about 554 m depth.

#### Denmark.

Stevns B; outcrop at Stevns Klint, berrhjetig-ketshusene.

Stevns Ps; outcrop at Stevns Klint, Pseudotextularia-zone.

Kjölby; outcrop at Kjölby Gaard, Pseudotextularia-zone.

Bögelund; outcrop at Bögelund, base of Danian.

Klagstrup-Albigaard; two outcrops with Danian.

Hjerm; outcrop near Hjerm, with Danian.

Helligkilde; Helligkilde I, outcrop with Danian.

Hyttehusvej; outcrop near Copenhagen.

Hvallose; outcrop with Danian.

Sweden.

Höllviken; two drillings near Höllviken, Schonen, Southern Sweden.

### GAVELINELLA DANICA.

This remarkable species was not observed in Germany in the neighbourhood of Hannover; in Denmark it is found in the Pseudotextularia-zone with pores of  $4\ \mu$ , and in the Danian with pores of  $5\ \mu$ . In Holland it begins in the Lower Maestrichtian, pores of  $3,5-4\ \mu$ , in the Upper Maestrichtian also the pores are  $4\ \mu$ , and during the Maestrichtian Tuff period the pores increase up to  $6\ \mu$ ; in the Paleocene the largest pores are found in the highest levels (Montian) with  $7,5\ \mu$ . In Belgium also the species begins in the Lower Maestrichtian,  $3\ \mu$ , is found in some outcrops during the Craie grise, attaining a diameter of  $4-4,5\ \mu$  in the Craie tuffoide and the Tuffeau of St. Symphorien, and is refound in the Tuffeau de Cibly (Paleocene) with  $7\ \mu$ .

### GAVELINELLA UMBILICATIFORMIS.

This small species in Denmark begins in the Pseudotextularia-zone with  $2\ \mu$ ; in the Danian it attains  $2,5\ \mu$ . In Holland it begins in the Cr 4, with  $1-1,5\ \mu$ , and during the M-period the pores increase gradually up to  $6\ \mu$ . It was also found in many samples of the Kunrade Chalk with  $3,5-4,5\ \mu$  indicating that this chalk must be of Lower Md age. In Belgium it was found in the Craie tuffoide and the Tuffeau de St. Symphorien, with pores of  $2\ \mu$ , indicating that both are of Cr 4- or Lower Mb age.

### GAVELINOPSIS ACUTA.

This species was found only in the highest levels studied; in Holland it begins in the Lower Md, with  $2\ \mu$ ; the increase of pores is very clear. In Belgium it was found in the Tuffeau de Cibly, pores  $3,5-4\ \mu$ , as in Holland in that level.

### GAVELINOPSIS VOLTZIANA.

The species begins in Germany in the Lower Campanian; in the lowest parts of the Upper Campanian (or Middle Campanian) pores show a diameter of  $2,5\ \mu$ . In the Upper Campanian pores are increasing to  $6\ \mu$ , and in the lowest

Maestrichtian pores up to  $8\ \mu$  are found. In Holland the species is not common, was found with pores  $4\ \mu$  in the Cr 3 a, which thus must be Upper Campanian, in the lowest Maestrichtian several localities show pores of  $5,5\text{--}6\ \mu$ , just like in Germany, and in the upper parts specimens with  $8\ \mu$  were found (Upper Lower Maestrichtian). In Belgium in the caves at Folx-les-Caves specimens were found with pores  $3,5\ \mu$ , so that these layers must belong to the lowest Upper Campanian or the Middle Campanian; in the Craie blanche pores measured  $5,5\text{--}6\ \mu$  (Upper Campanian); at few localities above the hard grounds pores also measured  $6\ \mu$ , as in Germany in the Lowest Maestrichtian, and just above the hard grounds in Holland.

#### *GAVELINOPSIS BARTENSTEINI.*

This species begins its development in Germany and Denmark in the lowest Upper Maestrichtian, already with pores  $4\ \mu$ , and in the Pseudotext. zone attains pores with diameter  $6\ \mu$ . In Holland it begins in the upper parts of the Cr 3 b or the lower Cr 3 c with  $2\ \mu$ , indicating that these layers must be uppermost Lower Maestrichtian, and increases its pores during the Cr 3 c up to  $5\ \mu$ ; then, suddenly a saltation is made and in the Cr 4 pores show a diameter of  $6\text{--}6,5\ \mu$ ; this also is the diameter in the Pseudotextularia-zone in Denmark. In Belgium the species is found for the first time in the Craie phosphatée and lowest Craie grise; here pores are found of  $3,5\text{--}4,5\ \mu$ ; in the Craie de Spiennes pores have a diameter of  $3\ \mu$ . So those Craies of Southern-Belgium must belong to the Lower Maestrichtian. In the Craie Tuffoide the pores reach a diameter of  $6\text{--}6,5\ \mu$ , as in the Cr 4 and the Pseudotextularia-zone.

#### *GAVELINOPSIS INVOLUTA.*

*G. involuta* begins its development in the Pseudotextularia-zone in Germany and Denmark, with pores  $3,5\ \mu$ , and ends here in the highest Danian with  $4,5\ \mu$ . In Holland it is found first in the Cr 4, also with pores  $3\ \mu$ , attains in the Mb  $4\ \mu$  and  $4,5\ \mu$ , as in the Danian. But then the development in Holland continues during the Mc and Md, gradually increasing its pores till in the highest Md a

diameter of  $6,5\ \mu$  is reached. In the Paleocene it is not refound. In Belgium the species was found only in the Craie tuffoide ( $3,5\ \mu$ ) and may reach in the boundary with the lowest Mb a diameter of  $4\ \mu$ . Here also it continues its development in the southern parts of the St. Pietersberg (Tranchée du Canal Albert). Here also it reaches  $6,5\ \mu$  in the uppermost Md. In the Kunrade Chalk many specimens of the typical species were found, with pores  $5,5\text{--}6\ \mu$ , indicating the age of the Lower Md for this chalk.

#### *GAVELINELLA CLEMENTIANA.*

In Germany it is found in the whole sequence of the Misburg quarry, with pores of  $4,5\text{--}5\ \mu$  diameter in the Middle Campanian and up to  $7\ \mu$  in the highest Upper Campanian. It could not be found in Luneburg, so that there is an indication that in Luneburg only the highest part of the Upper Campanian is traced, where the species is already extinguished. In Holland in the Hervian pores of  $4\text{--}5\ \mu$  are found, and in the uppermost part of the Cr 3 a it once again reaches  $7\ \mu$ . In Belgium specimens of the Hervian had pores of  $3\ \mu$ , and in the Craie de Nouvelles and Craie blanche pores increase gradually up to  $7\ \mu$ . In the Craie phosphatée specimens were found with pores  $7,5\ \mu$ , thus indicating that this craie may be of Lower Maestrichtian age.

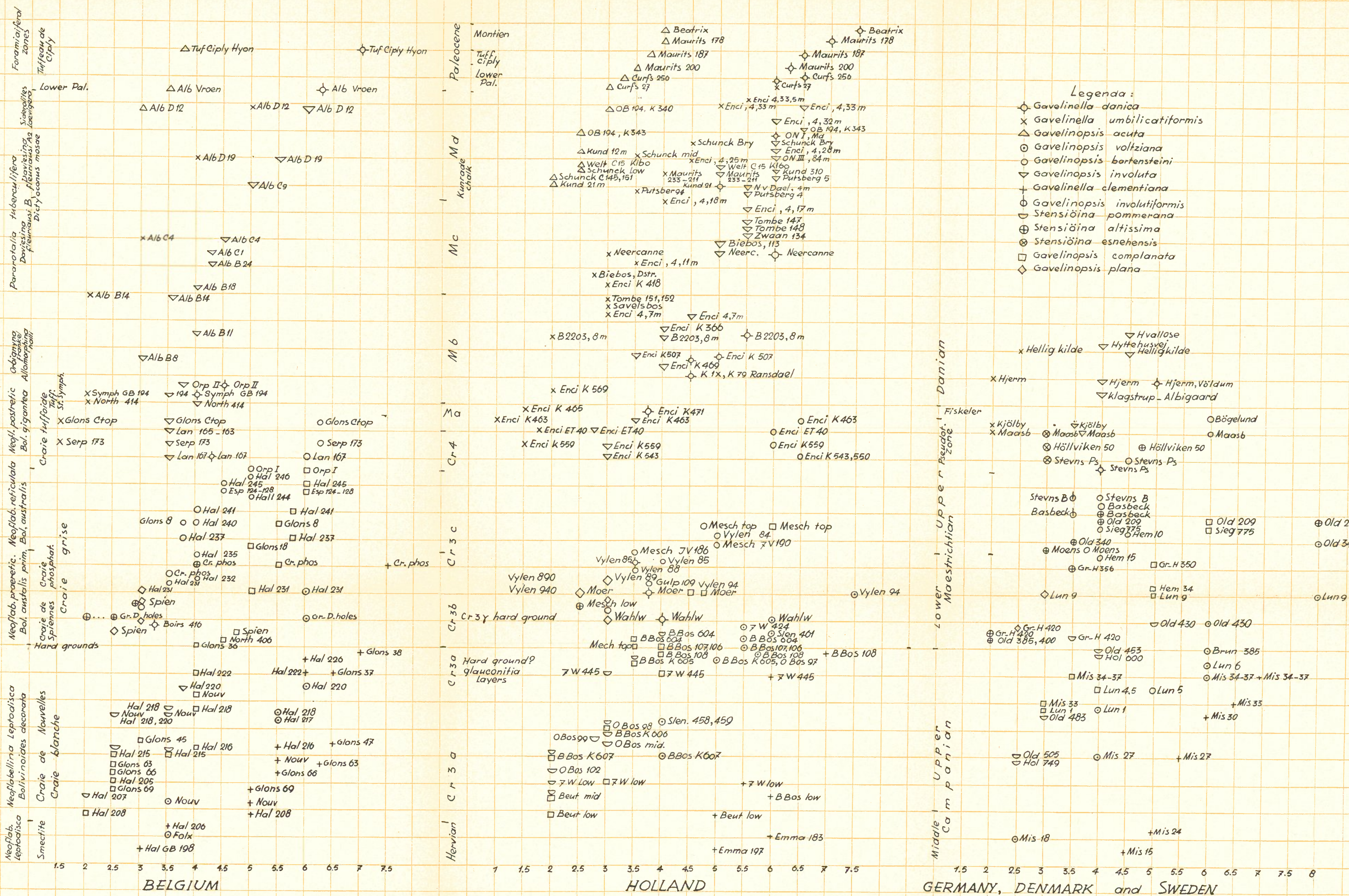
#### *GAVELINOPSIS INVOLUTIFORMIS.*

This mutant of *G. vultziana* was found only in Germany, in the Schreiekreide at Basbeck and in Denmark at Stevns Klint, both Upper Maestrichtian. Pores  $3,5\ \mu$ .

#### *STENSIOINA POMMERANA.*

In Germany and Sweden during the Upper Campanian pores increase from  $2,5$  to  $4\ \mu$ ; in the Lower Maestrichtian pores up to  $5\ \mu$  are found; then the species extinguishes. In Holland the increase of pores during the Cr 3 a, the only level in which the species is found, run from  $2$  to  $4\ \mu$ , indicating the Upper Campanian. In Belgium the development is quite similar in the Craie de Nouvelles and Craie blanche.





Pore-diameters of Gavelinellidae as indicators of stratigraphic age



*STENSIOINA ALTISSIMA.*

In Germany this species was found in the Lower and Upper Maestrichtian only, pores developping from 2 to 4  $\mu$ . In Holland the species is very rare, only in Mesch it was observed with 2,5  $\mu$ , so hat the lowest part of that quarry seems to be Lower Maestrichtian. In Belgium it was found in the fillings of the holes in the hard ground at Grez-Doiceau, and in the Craie de Spiennes and the Craie phosphatée, pores from 2—4  $\mu$ . Some samples of the Craie phosphatée thus seem already near to the Upper Maestrichtian.

*STENSIOINA ESNEHENSIS.*

This species in Germany and Denmark and in Höllviken, 50 m, only occurs in the Pseudotextularia-zone. It was not refound in Holland and Belgium.

*GAVELINOPSIS COMPLANATA.*

In Germany beginning with pores of diameter 3  $\mu$  in the Upper Campanian; in the Lower Maestrichtian pores increase to 5  $\mu$ , and in the Upper Maestrichtian they reach 6  $\mu$ ; in the highest parts of the Maestrichtian it is not found any more. In Holland the species is found in the lowest Cr 3 a with pores 2  $\mu$ , thus indicating that the Cr 3 a is older than the upper part of Misburg; at the highest levels of the Cr 3 a it reaches 4  $\mu$ , as in Germany in the highest Upper Campanian, but in Holland only in those layers which form the hard grounds at the boundary Camp. Maestr. Largest pores attain 6  $\mu$ , as in Germany. In Belgium the development is quite similar: 2—4  $\mu$  in the Craie de Nouvelles and the Craie blanche; 4,5—5,5  $\mu$  in the Craie de Spiennes and the Craie phosphatée, and also in the lowest parts of the Craie grise at Hallenbaye. In the typical craie grise 6  $\mu$  are attained, as in Germany in the Upper Maestrichtian. As in the Pseudotextularia-zone in Germany and the Cr 4 in Holland, also in the Craie tuffoide in Belgium no *G. complanata* are found.

*GAVELINOPSIS PLANA.*

This species seems to occur only in the lowest Maestrichtian, always with pores 2,5—3  $\mu$ . It seems to have had a very short invasional

period, in Germany, in Holland and in Belgium, and the occurrence in all these localities with the same diameter of pores indicates strongly that all these localities belong to the same stratigraphical level (Gross-Hehlen 1016, Luneburg 9; Moerslag; Cr 3 gamma Wahlwylre, lower parts Vijlen; Craie de Spiennes, Hallem-baye 231, just above the hard ground; fillings in the hard ground at North. They all are Lower Maestrichtian.

In the range-chart all these data about the pores of the *Gavelinellidae* are gathered together; they give a very strong indication for parallelisation of the different levels in the different regions studied. Moreover, all these parallelisations are in tune with the other faunal elements indicating the stratigraphical level of the studied localities. The most striking fact is that the Mc-Md period must be younger than the danish Danian and the Tuffeau de St. Symphorien, and also, that the Kunrade Chalk is of the same age as the Lower Md. Moreover, the Craie de Spiennes seems to be, in its fauna and in the pore-diameters, of Lowest Maestrichtian age, as was already suggested by L e r i c h e. It may be, as indicates the fauna as well as the diameter of pores, that the Cr 4, the Craie tuffoide of Belgium and the Pseudotextularia-zone of Germany, Denmark and Sweden, are of the same age also; only, in Belgium and Holland the facies of this chalk is different, and planktonic forms are rather rare. Yet some occur, and are identical with those found in the Pseudotextularia-zone.

The Range-chart gives us following data of stratigraphical importance:

*Gavelinella danica:*

- 3,5—5.....Lower Maestr. to Mb and Danian.
- 5—6.....Mb—Md.
- 6—7,5.....Paleocene.

*Gavelinella umbilicatifformis:*

- 1—2,5.....Pseudotext.-zone or Cr 4 to Mb.
- 2,5—4,5.....Mc and Lower Md.
- 5—6.....Upper Md.

*Gavelinopsis acuta:*

- 2—3.....Md.
- 3—4.....Paleocene.



*Gavelinopsis veltziana*:

- 4—6.....Upper Campanian.  
6—8.....Lower Maestrichtian.

*Gavelinopsis bartensteini*:

- 2,5—4.....Upper part of Lower Maestrichtian.  
4—5.....Lower part of Upper Maestrichtian.  
5—6,5.....Pseudotextularia-zone.

*Gavelinopsis involuta*:

- 3—3,5.....Pseudotextularia-zone, Cr 4.  
3,5—4,5.....Danian and Mb.  
4,5—5,5.....Mc.  
5—6,5.....Md and Kunrade Chalk.

*Gavelinella clementiana*:

- 3—4,5.....Middle Campanian.  
5—7.....Upper Campanian.

*Gavelinopsis involutiformis*:

- 3,5.....Upper Maestrichtian.

*Stensiöina pommerana*:

- 2—4.....Upper Campanian.

*Stensiöina altissima*:

- 2—3,5.....Lower Maestrichtian  
3,5—4.....Upper Maestrichtian.

*Stensiöina esnehensis*:

- 3.....Pseudotextularia-zone.

*Gavelinopsis complanata*:

- 2—4.....Upper Campanian.  
4—5.....Lower Maestrichtian.  
5,5—6.....Upper Maestrichtian.

*Gavelinopsis plana*:

- 2,5—3.....Lower Maestrichtian.

The Pseudotextularia-zone is characterised by: *Gavelinella umbilicatifformis* 1—2,5, *Gavelinopsis bartensteini* 5—6,5, *Gavelinopsis involuta* 3—3,5, *Stensiöina esnehensis* 3.

The Danian and the Mb are typified by: *Gavelinella danica* 4,5—5,5, *Gavelinella umbilicatifformis* 1,5—2,5, *Gavelinopsis involuta* 3,5—4,5.

The Mc—Md show the following indicators: *Gavelinella danica* 5—6, *Gavelinella umbilicatifformis* 2,5—6, *Gavelinopsis involuta* 4,5—6,5.

The Paleocene has the indicators: *Gavelinopsis acuta* 3—4 (in the Md 2—3), *Gavelinella danica* 6—7,5 (in some instances up to 8).

## Figures.

Fig. 1. *Gavelinopsis plana*. × 55. Mesch, old quarry, J.N. 186, lowest part. a, ventral side; b, dorsal side; c, apertural face. Cr 3 c.

Fig. 2. *Gavelinella clementiana*. × 55. Seven ways, on top. × 55. ventral side; b, dorsal side; c, apertural face. Cr. 3 a.

Fig. 3. *Gavelinella pertusa*. × 55. Seven ways, top. a, ventral side; b, dorsal side; c, apertural face. Cr. 3 a.

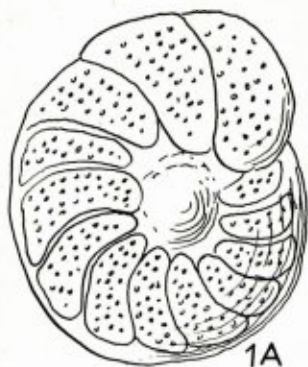
Fig. 4. *Gavelinella pertusa forma maestrichtiensis*. × 55. Cr 4, ENCI. a, ventral side; b, dorsal side; c, apertural face.

In this way the Upper Campanian is characterised by: *G. clementiana* 5—7, *Stensiöina pommerana* 2—4, *Gavelinopsis complanata* 2—4, *G. veltziana* 4—6.

The Lower Maestrichtian is typified by: *Gavelinella danica* 3,5—4, *Gavelinopsis veltziana* 6—8, *Gavelinopsis bartensteini* 2,5—4, *Stensiöina altissima* 2—3,5, *Gavelinopsis complanata* 4—5, *Gavelinopsis plana* 2,5—3.

The Upper Maestrichtian or zone of *Coleites* without *Stensiöina* of Wicher's: *Gavelinopsis bartensteini* 4—5; *Gavelinopsis involutiformis* 3,5, *Stensiöina altissima* 3,5—4, *Gavelinopsis complanata* 5,5—6.





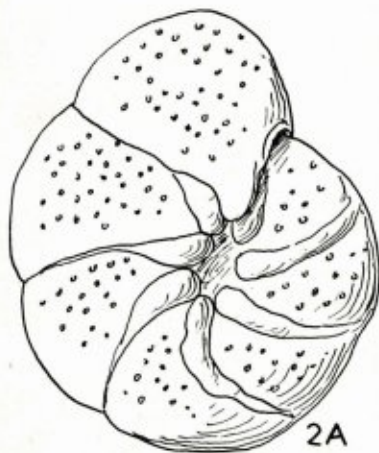
1A



1B



1C



2A



2B



2C



3A



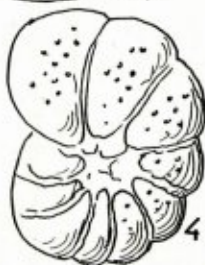
3B



3C



4A

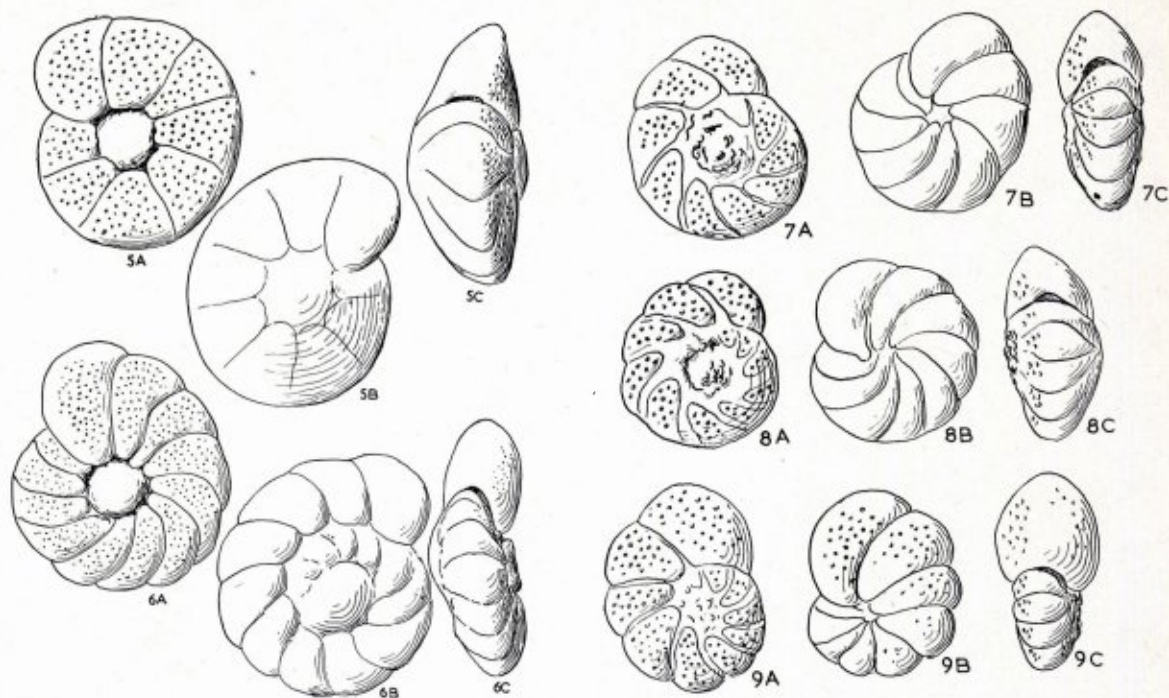


4B



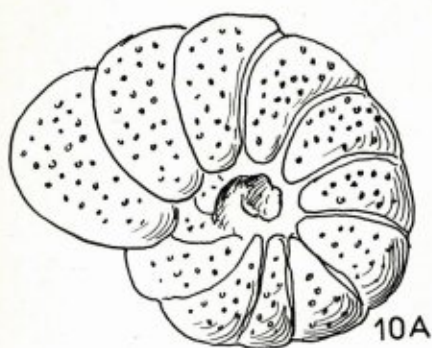
4C



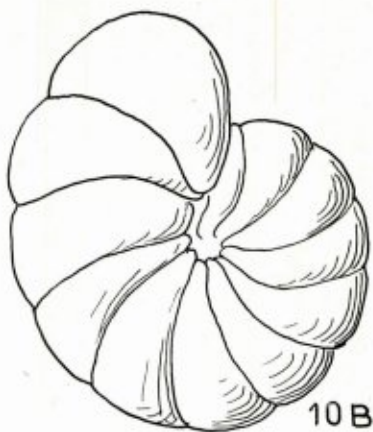


- Fig. 5. *Gavelinopsis voltziana*.  $\times 10$ . Quarren at Vijlen, sample 94. a, ventral side; b, dorsal side; c, apertural face. Cr 3 b.
- Fig. 6. *Gavelinopsis menneri*.  $\times 10$ . Outcrop at Noorbeek. a, ventral side; b, dorsal side; c, apertural face. Cr 3 a.
- Fig. 7. *Gavelinopsis complanata*.  $\times 20$ . Outcrop seven ways, top. a, ventral side; b, dorsal side; c, apertural face. Cr 3 a.
- Fig. 8. *Gavelinopsis complanata*.  $\times 20$ . Quarry at Vijlen, top of the Cr 3 b. a, ventral side; b, dorsal side; c, apertural face.
- Fig. 9. *Gavelinopsis bartensteini*.  $\times 20$ . Quarry ENCI, Cr 4. a, ventral side; b, ventral side; c, apertural face.
- Fig. 10. *Gavelinella umbilicatiformis*.  $\times 120$ . Neercanne, Mc. a, ventral side; b, dorsal side; c, apertural face.
- Fig. 11. *Gavelinella umbilicatiformis*.  $\times 120$ . Mine Oranje Nassau, 700 m W from main shaft. Kunrade Chalk. a, ventral face; b, dorsal side; c, apertural face.
- Fig. 12. *Gavelinella umbilicatiformis*.  $\times 120$ . Same locality. a, ventral side; b, dorsal side; c, apertural face.
- Fig. 13. *Gavelinella umbilicatiformis*.  $\times 50$ . Kunderberg, 4 m from top. a, ventral face; b, dorsal side.
- Fig. 14. *Gavelinopsis acuta*.  $\times 30$ . Mine Oranje Nassau, 700 m W from shaft. Kunrade Chalk. a, ventral side; b, dorsal side; c, apertural face.
- Fig. 15. *Gavelinopsis bembix*.  $\times 15$ . ENCI, Cr 4. a, ventral side; b, dorsal side; c, apertural face.
- Fig. 16. *Gavelinella danica*.  $\times 15$ . Mine Oranje Nassau, pillar 14, upbreak 114, 700 m W from shaft. Kunrade Chalk. a, ventral side; b, dorsal side; c, apertural face.
- Fig. 17. *Gavelinopsis involuta*.  $\times 40$ . ENCI, Coll. Kruit, 496, Lower Mb. a, ventral side; b, dorsal side; c, apertural face.
- Fig. 18. *Gavelinopsis involuta*.  $\times 40$ . ENCI, Upper Cr 4. a, ventral side; b, dorsal side; c, apertural face.





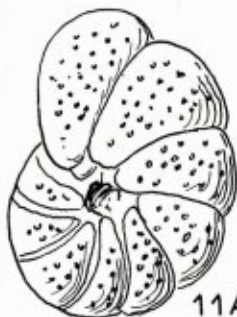
10A



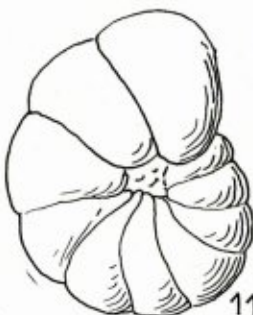
10B



10C



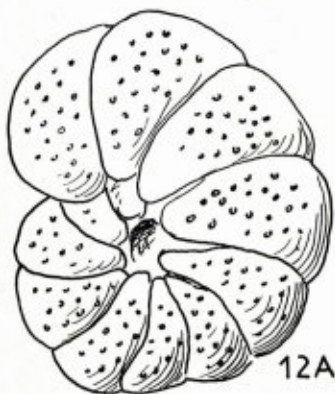
11A



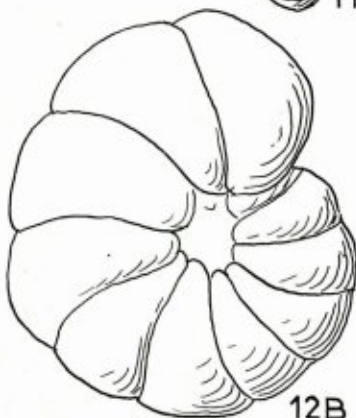
11B



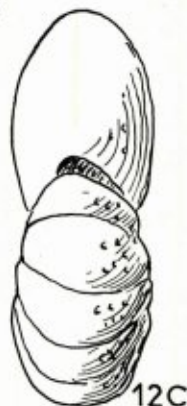
11C



12A



12B



12C



13A



13B



