Overlying the sand a discontinuous sandstone layer was found, of 1 to 5 cm thickness. The sandstones were soft, yellowish-white and medium-grained. A sample yielded many sponge spicules, shell fragments, fossil casts and limonite.

Above this level followed about 1 m of medium-grained quartz sand, of rusty-brown colour and rich in limonite. Overlying it another discontinuous sandstone with about the same features was observed.

Sample **WK 1145** of this sandstone yielded many sponge spicules, echinid spines, some foraminifera (with nummulites), shell fragments and bryozoan debris.

On top of this sand followed another metre of quartz sand with dispersed sandstone pieces.

WL Perwez, sandpit (250 m N and 800 m E of the church-tower of Perwez); also point 131 (W) 146 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

The sandpit showed alternating rusty-brown and yellow sands, with occasional some black seams, many of them some mm thick and of some m length. Sandstone pieces were not only found in very discontinuous layers, but also dispersed in the sand.

WM Nil-Saint-Vincent, hollow roadside (350 m S and 2.000 m W of the church-tower of Nil-Saint-Vincent).

Visited June 1954.

Sands of Brussels.

A poor exposure of rusty-brown, medium-grained, quartz sands.

The sample yielded echinid remains, sponge spicules, fish remains and scarce glauconite.

WN Mont-Saint-Guibert, sandpit (700 m N and 150 m E of the church-tower of Mont-Saint-Guibert); also point 130 (W) 224 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

Under a covering of 50 cm of Quaternary loess about 6 m of sands were exposed.

At the base these were yellowish-white, and medium-grained, with alternating horizontally stratified and current-bedded layers (with dips towards the north).

About 2 m above the bottom occurred a discontinuous 30 cm band of sandstone pieces that were sometimes fistulose.

Then followed another 1,30 m of distinctly current-bedded sands with again dips in northern direction, and with tubulations.

After another sandstone layer of 30 cm, the section ended with current-bedded rusty-brown sands and loess.

WO Mont-Saint-Guibert, abandoned sandpit (900 m N of the church-tower of Mont-Saint-Guibert); also point 130 (W) 198 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

Rusty-brown, medium-grained sands contained weathered, as well as unweathered, sandstone pieces, dispersed in the sand.

Sample **WO 1148** of some soft sandstone pieces yielded some foraminifera, sponge spicules, echinid spines, shell fragments, etc. The foraminifera were mostly siliceous casts.

WP Mont-Saint-Guibert, abandoned sandpit (300 m N and 400 m E of the church-tower of Mont-Saint-Guibert).

Visited June 1954.

Sands of Brussels.

Some poor exposures showed brownish-green to yellow, rather coarse-grained sands with some sandstone pieces.

WQ Hévillers, hollow roadside (400 m N and 700 m E of the church-tower of Hévillers); also point 130 (W) 223 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

A poor exposure of green, clayey, fine-grained, glauconitic sand, below a greyish-white sandstone bank of 5 cm thickness.

WR Tilly, sandpit (300 m N and 250 m W of the church-tower of Tilly); also points 130 (W) 5 and 6 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

About 5,50 m of sands were covered by 50 cm of Quaternary loess.

At the base the rather coarse-grained quartz sand was brownish-green, higher up it was of paler colour.

About 1,10 m above the base the remainder of a sandstone layer was found as whitish patches of about 7 cm height. A sample of this level appeared to be rich in sponge spicules,and also some echinid spines were encountered.

Upwards the sand was rich in ferruginous bands and dispersed sandstone pieces, often soft and weathered.

SHEET ATH

XB Frasnes-lez-Buissenal, hollow roadside (2.350 m N and 1.100 m E of the church-tower of Frasnes-lez-Buissenal); also point 113 (W) 108 of the archives of the Geological Survey.

Visited July 1954.

Sands of Mons-en-Pévèle.

A sample was taken from calcareous, sandy clay of yellowish-brown colour, possibly slightly contaminated with overlying Quaternary loess.

The wash residues contained scarce nummulites, shell fragments, glauconite, etc.

XC Frasnes-lez-Buissenal, hollow roadside (2.450 m N and 1.300 m E of the church-tower of Frasnes-lez-Buissenal); also point 113 (W) 111 of the archives of the Geological Survey.

Visited July 1954.

Sands of Mons-en-Pévèle.

A sample, **XC 1226**, was taken from brownish, sandy, calcareous clay, with nummulites and pieces of nummulitic sandstone.

The wash residues showed a fairly rich microfauna, shell fragments, sponge spicules, echinid spines, fish remains, bryozoan debris, etc.

SHEET IEPER

YA Ieper, claypit of the « Verenigde Steenbakkerijen van Ieperen » (1.650 m N and 400 m E of the church-tower of Ieper); also point 81 (E) 128 of the archives of the Geological Survey. See fig. 11.

Visited September 1953 and May 1954.

Clays of Ieper.

The lower part of this section was formed by dark grey to blue-grey, alternating sandy and slightly sandy, clay with gradual transitions between the beds.

About 4 m above the bottom of the pit an indistinct rusty-brown level separated oxidized from unoxidized clays. Above this brown band, grey-brown sandy clay was met with, up to the base of the Quaternary loess.

Out of the series of samples, only sample **YA 262** contained some foraminifera, associated with glauconite, quartz, silex fragments, and muscovite.

The wash residues of the other samples yielded some pyrite, fish remains, sponge spicules and gypsum.

YB Zonnebeke, claypit of the « Briqueterie Van Biervliet » (1.600 m W of the church-tower of Zonnebeke); also point 82 (W) 132 of the archives of the Geological Survey. See fig. 11.

Visited September 1953 and May 1954.

Possibly the section contained the contact of **Clays of Ieper** and **Sands of Mons-en-Pévèle** (partly developed as Clays of Roubaix). However, the possibility of a sandy lens in the higher part of the Clays of Ieper cannot be excluded.

The basal 50 cm of the section were formed by plastic, greenish-blue clay, sometimes slightly silty and with rusty-brown weathering colours. Higher up the clay gradually became siltier and greener.

Two samples of this lower clay yielded some shell fragments, fish remains, pyrite, etc.

About 80 cm above the base, a 50 cm of blue-grey, slightly clayey, sand was found, higher up more rusty-brown to grey. There were traces of current-bedding.

Overlying this sand we encountered a gravel bed, rich in silex, locally double with a maximal separation of 15 cm.

In the higher part of the section various clayey sands alternated. Greenish colours changed into rusty-brown ones. At some levels some current-bedding and also small tubulations appeared.

Two samples from the higher sands contained much glauconite, fish remains, muscovite, sponge spicules, shell fragments, etc.

YC Ledegem, claypit of the « Mekanieke Steenbakkerij Edouard Dumoulin » (4.700 m N and 1.500 m E of the church-tower of Ledegem); also point 82 (E) 53 of the archives of the Geological Survey. See fig. 11.

Visited September 1953.

Clays of Ieper.

The base of the section was formed by 5,50 m of silty clay, with a less silty lower part. Colours were blue-grey with some rusty-brown to grey, perhaps more sandy, patches. Pyritiferous spots were found.

Upwards the clay passed into sandy clay, the boundary being well visible by colour variations of the dry clay. This sandy clay was greyish-green, and it contained rather much muscovite in the basal parts. Furthermore, it showed some irregular sandy bands of some millimetres thickness.

On top of these 3 m of sandy clay followed 40 cm of whitish, silty deposits, with greener, more clayey levels; next we got an about 10 cm rusty-brown band, and finally oxidized, more or less sandy clay.

Two samples, **YC 293** and **295**, contained some foraminifera, in addition to fish remains, shell fragments, echinid spines, gypsum, muscovite, etc.

YD Kemmel, abandoned sandpit (700 m S and 500 m W of the church-tower of Kemmel); also point 95 (W) 30 of the archives of the Geological Survey.

Visited May 1954.

Perhaps **Sands of Vlierzele.**

Only some poor exposures directly below the Quaternary loess. These showed rusty-brown to green, rather coarse-grained, sand with glauconite in variable quantities.

YE Kemmel, hollow roadside (450 m S and 600 m W of the church-tower of Kemmel).

Visited May 1954.

Clays of Asse.

Greyish-green, slightly silty and glauconitic clay from a freshly-cut roadside was found to contain limonite, some silex fragments, some indeterminable foraminifera and shell fragments.

YF Voormezele, hollow roadside (900 m W of the church-tower of Voormezele).

Visited May 1954.

Clays of Ieper or Clays of Roubaix.

A sample of glauconitic, micaceous, greyish-green, sandy clay yielded muscovite, glauconite, etc.

SHEET GENT

ZA Gent, University Library and Geological Institute, Rozierstraat.

Visited September 1953 and June 1954.

Sands of Lede and **Clays of Asse.**

During a visit to the garden of the University Library Dr. D.A.J. BATJES took some samples from freshly-made pits.

One sample (**ZA 583**) was taken from fine-grained, yellowish-grey sands, with glauconite, nummulites and shell fragments (*Ostrea*, *Solarium*). In the wash residues we found many foraminifera and ostracods in addition to shell fragments, *Ditrupa*, fish remains, bryozoan debris, echinid spines, radiolarians, etc.

Another sample of greyish-brown plastic clay was taken in the south-western part of the garden. In the wash residues there were some glauconite and silex fragments.

Excavations near the Geological Institute exposed glauconitic, yellowish-green, sandy clay, which yielded glauconite, muscovite and some calcareous fragments.

Through the courtesy of Ir. R. MARÉCHAL, of the University of Gent, some samples from the Clays of Asse were obtained, which had been recovered during the construction of the Geological Institute.

These samples (**ZA 1242-1244**) came from the basal beds (with numerous shells) of the Clays of Asse. All contained rich foraminiferal faunae, with ostracods, shell fragments (as *Pecten corneus*), bryozoan debris, echinid spines and fish remains, etc.

ZB Vlierzele, sandpit (800 m N and 150 m W of the church-tower of Vlierzele).

Visited September 1953, May and September 1954.

Sands of Vlierzele (type-locality) and **Sands of Lede.**

In the southern wall of the pit, the basal part of the section consisted of cross-bedded sands with dominating southern dips. The sands were rather medium-grained, brownish-green, with some muscovite. The bedding was visible through variations in the glauconite contents of the 1 to 10 mm laminae.

Above this sand followed 15 cm of indistinctly horizontally bedded, medium to coarse-grained, greyish-brown to green sands. About 5 cm above the base of these sands a 3 to 10 mm thick, discontinuous lignite band was present, variable in distance to the base.

Overlying these sands a second, more continuous, lignite band was met with.

Upwards current-bedded sands were found again, now with the inclinations mainly in northern directions. This layer of about 35 cm consisted of medium to coarse-grained, greyish-white sands, with lignite particles and brownish spots and bands. The bedding was again visible because of different glauconite contents of the various laminae.

Another 65 cm of cross-bedded sand with many lignite particles showed variable dips.

In the whole complex the bedding was furthermore apparent by the presence of small clay beds intercalated in the sand. A sample from the base of the exposure yielded glauconite, sponge spicules, limonite, etc.

Overlying the described complex, 1,20 m (with gradually decreasing thickness towards the north) of indistinctly bedded, brownish-green, medium--grained sand was observed, with glauconite and much muscovite.

Above the latter sands of the Sands of Vlierzele 6 cm of coarse quartz sand with dispersed pebbles was found containing many teeth of fishes (mainly of sharks).

This gravel was covered by about 5,70 m of fine-grained, slightly glauconitic sands, with much limonite. The sand was slightly micaceous, and contained some more or less decalcified specimens of *Solarium dumonti*.

Wash residues of some samples contained some shell fragments.

In the extreme southern corner of the pit, a very calcareous intercalation occurred near the base of the latter sands. The position relative to the gravel bed could not exactly be established, but possibly the samples were only a few decimetres from this bed.

The calcareous sands were indurated and greyish-white, rich in shell fragments and nummulites, glauconite and muscovite.

The wash residues of both samples, **ZB 1021a** and **1022**, contained a rather rich microfauna in addition to shell fragments, *Ditrupa*, echinid and fish remains, sponge spicules, etc. The foraminifera were strongly incrustated and hard to determine.

ZC Cordegem, sandpit (800 m S and 1.500 m E of the church-tower of Oordegem ; also point 71 E 185 of the archives of the Geological Survey.

Visited September 1953.

Sands of Lede.

About 3 m of yellowish-green to grey, fine-grained sands were exposed, containing some irregular rusty-brown bands. Near the base of the pit the presence of some shell fragments was observed.

Half way the section occurred about 10 to 30 cm of coarse-grained sands, with hyaline, well-rounded, coarse quartz grains. The bedding was somewhat irregular.

The samples yielded no foraminifera, but a sample from below the coarse sand yielded some fragments of *Solarium*.

ZD Bambrugge, abandoned quarry « Steenberg » (300 m N and 1.100 m E of the church-tower of Bambrugge); also point 71 (E) 186 of the archives of the Geological Survey. See fig. 12.

Visited September 1953, May and September 1954.

Literature :

M. Leriche, 1926, Bull. Soc. belge Géol., vol. 36, pp. 129-137.
F. Dartevelle, 1941, Bull. Soc. belge Géol., vol. 50, pp. 148-149.

Sands of Lede.

During our visits the section, described by LERICHE, was found to be still partly intact. The bottom of the pit had been filled up, so that only the upper nummulitic limestone band (1) could be seen. The claybeds of the western part of the pit were covered and overgrown, but the «gully» was clearly visible.

The exposed sands were fine-grained, yellowish-green, and (except for the decalcified parts) rich in nummulites and shell fragments, associated with glauconite and muscovite.

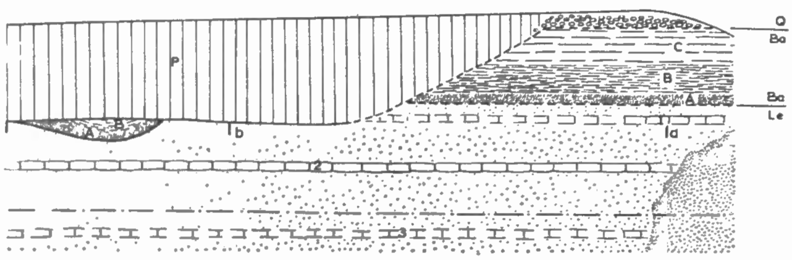

FIG. 12. — Schematic section of ZD, Bambrugge (after LERICHE, 1926). P : loess; C : grey clay; B : green-grey, glauconitic clay; A : fine-grained sand with clay strings; 1, 2 and 3 : layers of sandy limestone; a, b and c : sampled sections. Scale : vert. 1 : 200; hor. 1 : 500.

The samples were taken at three places (see figure):

a) **ZD 1011-1015**, below the limestone bank.

The lowermost (ZD 1011) 1,70 m below the base of the bank, and the other samples following at mutual distances of 40, 50, 50 and 30 cm, respectively.

From bottom to top a gradual decrease was found in the amount of nummulites and shell fragments, while the grain-size gradually became finer and the colour changed from green-yellow to yellowish, possibly as a consequence of the diminishing glauconite contents. Only the uppermost sample, ZD 1015, directly below the limestone bank, was again very rich in nummulites, which were often concentrated in small pockets. However, this sample was poor in mollusc fragments, but rich in fragments of *Ditrupa*.

The wash residues of these samples were rich in foraminifera and ostracods, in addition to shell fragments, bryozoan debris, echinid remains, *Ditrupa*-tubes, etc.

The basal surface of the limestone bank was irregular, causing the thickness to vary between 30 and 35 cm. The limestone itself was formed by many nummulites and shell fragments (as *Ostrea*). The nummulites were mostly concentrated in small pockets and discontinuous layers, more or less parallel to the surface. The limestone contained many small cavities, usually formed by dissolution of the shell fragments. Furthermore, *Ditrupa*-tubes, bryozoan debris and gastropods.

Above the limestone followed sandy material, which was partly decalcified.

b) **ZD 342, 343, 1016, 1017.**

ZD 342 directly underlay the base of the Quaternary; ZD 343, between *a* and *b*, must be at about the level of the locally dissolved limestone; also the samples ZD 1016 and 1017 were taken slightly below the limestone level.

The wash residues of these samples yielded a fairly rich microfauna and many organic remains, such as shell fragments (as *Ostrea*, *Pecten*, *Solarium*, *Nautilus*), *Ditrupa*-tubes, echinid remains, coral fragments (*Turbinolia*), fish remains, bryozoan debris, sponge spicules, radiolarians, etc.

c) Some pieces of nummulitic limestone were found, probably the continuation of bank 1, which partly escaped from decalcification.

Sample **ZD 340** had about the same identical wash residues as the other samples.

Clays of Asse.

The deposits in the centre of the «gully» showed a sandy base, mainly consisting of glauconite. In the wash residues the glauconite was associated with quartz, silex fragments, pyrite, limonite, sandstone fragments and muscovite.

On this base, about 4 cm thick, followed 6 to 10 cm of ferruginous fine-grained, rusty-brown to yellow sand, with dominant quartz, some glauconite and limonite.

Upwards clay was found with silex gravel at the base. The clay was green, glauconitic and sandy. In the wash residues also sandstone pieces, some muscovite, limonite and quartz were found. Another gravel bed occurred 20 cm above the base of the clay.

The wall of the western gully side was of regular form, dipping about 11° to the center. Locally the section was covered. At the eastern side the walls were somewhat steeper, more irregular and some sand tongues were found. The sand of these tongues was apparently decalcified Sands of Lede.

ZE Lede, sandpit (600 m S and 400 m W of the church-tower of Lede); also point 71 (E) 72 of the archives of the Geological Survey.

Visited May 1954.

Sands of Lede and **Clays of Asse.**

The basal part of the exposed section was formed by 3 m of fine-grained, whitish sand, with some glauconite and muscovite.

Overlying these sands a band of some centimetres of very glauconitic, green to black, clayey sand was found. Upwards 20 cm of sand was present, rusty-brown and ferruginous, forming the base of sandy glauconitic clay. Of this clay about 1 to 2,50 m were exposed below the covering Quaternary loess.

ZF Balegem, sandpit (200 m S and 600 m E of the church-tower of Balegem).

Visited May 1954.

Sands of Vlierzele.

Under 60 cm of Quaternary loess, 4,10 m of current-bedded, glauconitic sands were exposed, with only near the base of the loess a zone with a very indistinct stratification or none at all. About 50 cm below the loess two bands with much limonite were noticed.

At some places the series of current-bedded sands were interrupted by thin clay beds. Towards the base of the pit the sands became slightly clayey and the bedding was indicated by some, small and flat clay lenses at the base of the beds, in addition to variations in the glauconite contents of the various layers. Near the base also some lignitic spots were found.

ZG Balegem, hollow roadside (350 m S and 750 m E of the church-tower of Balegem).

Visited May 1954.

Sands of Lede.

A poor exposure of very calcareous, fine-grained, greenish-white sands with some glauconite, nummulites and shell fragments.

The wash residues of sample **ZG 1025** yielded a rich microfauna, shell fragments, echinid remains, bryozoan debris, fish remains, sponge spicules, radiolarians, and coarse quartz grains, silex fragments, some glauconite and muscovite.

ZH Gijzenzele, sandpit (1.700 m N and 1.250 m E of the church-tower of Gijzenzele); also point 70 (E) 56 of the archives of the Geological Survey.

Visited May 1954.

Sands of Vlierzele.

Two metres of cross-bedded, rather coarse, glauconitic sand were exposed, mainly of greenish-white colour with rusty-brown spots. The bedding was visible from variations in the glauconite contents and also from some flat, indurated, clayey lenses. Horizontal rusty-brown bands became more distinct and thicker higher upwards.

ZJ **Munte,** sandpit (150 m S and 700 m W of the church-tower of Munte); also point 70 (W) 204 of the archives of the Geological Survey.

Visited June 1954.

Sands of Vlierzele.

The section showed about 4 m of current-bedded sand with main dips towards the NE.

The sand was medium-grained, brownish to yellowish-green, and with variable glauconite contents. Some clayey lenses and some indistinct tubulations (probably of worms) were encountered.

The bedding was visible by variations in the glauconite contents, intercalated clayey lenses, and discontinuous layers of blue-grey to yellowish-white, hard sandstone pieces with some remains of fossils.

The contact with the Quaternary loess was formed by the remnants of a weathered sandstone bed.

ZK **Gavere,** abandoned sandpit (300 m S and 300 m E of the church-tower of Gavere); also point 70 (W) 26 of the archives of the Geological Survey.

Visited June 1954.

Sands of Vlierzele.

The basal part of the wall was formed by about 20 cm of greenish-yellow sand, on which followed a complex of 1 to 3 m thickness of alternating irregular beds of glauconitic sands and greenish-yellow to brown, clayey sands.

On this complex 1,50 m of current-bedded sands were found, covered by Quaternary loess.

BORINGS AND OTHER MATERIAL OF THE COLLECTION OF THE GEOLOGICAL SURVEY OF BELGIUM

Aalter-Sainte-Marie, waterboring (August 1925); point 53 (E) 36 of the archives of the Geological Survey.

Sands of Mons-en-Pévèle.

Four foraminiferous samples, derived from the interval between +5 and +0,50 O.D. Oostende, have been taken from Sands of Mons-en-Pévèle, with a clayey intercalation.

No. **21** (+4 +3 O.D. Oostende) : fine-grained, grey sand with many shell fragments and nummulites (recorded as *Nummulites planulatus*). The wash residues yielded some other foraminifera, shell fragments (mainly *Ostrea*), *Ditrupa*, fish remains, bryozoan debris, coral remains (*Turbinolia*), echinid spines, etc.

No. **22** (+3/+2,50 O.D. Oostende) : as sample no. 21, but less frequent organic remains.

No. **24** (+2 +1 O.D. Oostende) : fine-grained, greenish-grey sand contained a small microfauna (with nummulites), shell fragments, echinid spines, sponge spicules, etc.

No. **25** (+1 +0,50 O.D. Oostende) : slightly clayey sand appeared rich in nummulites, with shell fragments, bryozoan debris, echinid spines, sponge spicules, etc.

Asse, waterboring (October 1934); point 87 (W) 89 of the archives of the Geological Survey. See fig. 13.

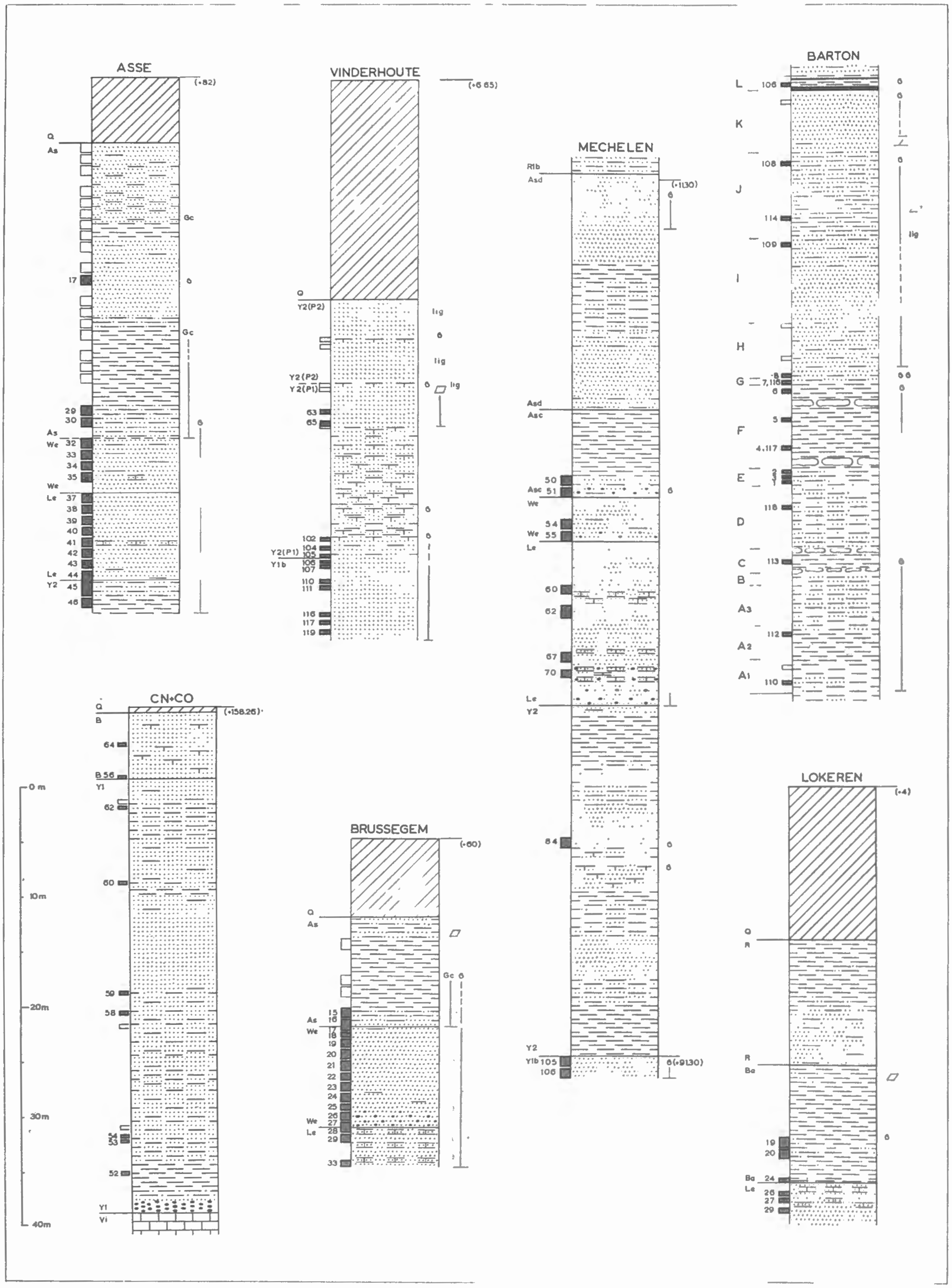
ASSE
VINDERHOUTE
MECHELEN
BARTON
CN+CO
BRUSSEGEM
LOKEREN
0 m
10m
20m
30m
40m

FIG. 13.

Sands of Vlierzele.

The deepest part of the section of this bore hole was formed by deposits, that possibly belonged to a clay member at the top of the Sands of Vlierzele.

No. **46** was from grey, plastic clay; sample no. **45** from grey, sandy clay. The wash residues of both samples contained some foraminifera (with nummulites), echinid remains, shell fragments, fish remains, some glauconite, etc.

Sands of Lede.

The grey sandy clay was covered by 8 m of grey, fine-grained, nummulitic, calcareous sand, slightly clayey in the basal part, and with some coarse quartz grains in 43 and 44, bone fragments in 44.

All the samples, **37-44**, were more or less foraminiferous and contained many other organic remains, such as shell fragments, *Ditrupa*-tubes, ostracods, and also pyrite, etc. Intercalated there was a sandy limestone, fragments of which were found in almost all the samples.

Sands of Wemmel.

The Sands of Lede were covered by 5 m of sands, in the lower part grey and with many sandstone fragments, upwards green-grey and more or less clayey. There was a gradual transition into the overlying sandy clays.

The base of the Sands of Wemmel was probably marked by sandstone fragments, coarse quartz grains and many (often worn) organic remains. No distinct gravel was found.

The two lower samples, **35** and **34**, were rich in elements that had probably been derived from older sediments (as worn foraminifera). Samples **33** and **32** dit not contain these worn elements. All samples were rich in nummulites, and contained, furthermore, ostracods, sponge spicules, shell fragments, bryozoan debris, etc.

Clays of Asse.

The overlying 10,50 m of clays graded into the Sands of Wemmel. The transitional beds were formed by sandy clays, rich in glauconite and shell fragments (as *Pecten corneus*), and with nummulites and other foraminifera in samples **30** and **29.**

At 30 m depth this sandy clay passed into grey clay with large, conspicuous glauconite grains, which diminished in quantity upwards. Half way the clay was plastic, and with rare glauconite.

Towards the top the clay again became sandy.

The wash residues yielded scarce shell fragments, glauconite, pyrite, etc., and in some samples fish remains, echinid spines, and at 27 m some ostracods (*Schizocythere appendiculata*).

Sands of Asse.

The sandy clay of the top passed into grey-green, medium-grained sands with some sandstone fragments and pyrite. Coarse, mainly black, silex fragments were present in all the samples from this sand. Only in **17** a small foraminiferal fauna was found. In this sample there were also some shell fragments and bryozoan debris; in all samples some glauconite and muscovite, etc.

This sand was covered by grey, plastic clay, with some glauconite, pyrite, muscovite and silex fragments in the wash residues of the investigated samples.

The top of the plastic clay was glauconitic and yielded some radiolarians.

The overlying clayey sand was also distinctly glauconitic. It formed the base of a complex of clayey sands and sandy clays.

All the investigated samples of these beds contained some glauconite, muscovite, some fish remains and radiolarians, etc.

The top of the section was formed by 6 m of Quaternary loess with some gravel at the base.

Brugge, waterboring at the firm De Laere, Fort Lapin 25, Brugge (March 1953); point 23 (W) 350 of the archives of the Geological Survey.

Sands of Mons-en-Pévèle.

The base of the column of the bore hole was formed by fine-grained, green, glauconitic and micaceous sands.

Sample **24** (−47/−56,50 O.D. Oostende) contained some foraminifera, shell fragments, sponge spicules, sandstone and lignite fragments, etc.

Clays of Roncq.

On top 5 m of grey, plastic clay with some shell fragments.

Sands of Vlierzele (?).

Higher up followed green, glauconitic, and micaceous sands with interstratified greenish sandstone beds.

The top part of the bore hole passed through Quaternary sands with *Cardium edule*, *Hydrobia*, *Tellina*, etc., with the base at about 14 m depth (- 8 O.D. Oostende).

Brussegem, waterboring at the brewery of Mr. Dekeersmaeker (September-October 1919); point 72 (E) 75 of the archives of the Geological Survey. See fig. 13.

Sands of Lede.

The basal part of the column was formed by fine-grained, grey-white sands with many nummulites and shell fragments (*Pecten*, *Ostrea*, etc.). Intercalated occurred three sandy limestone beds, the upper one of which close to the contact with the overlying Sands of Wemmel.

The investigated samples (**33**, **29** and **28**) yielded rich microfaunae, many shell fragments, echinid remains, sponge spicules, fragments of calcareous algae (*Uteria*). and mostly fine-grained glauconite, muscovite, pyrite and silex fragments.

Sands of Wemmel.

The overlying sands were at the base medium to coarse-grained (**27**), rich in worn nummulites, shell fragments (*Ostrea*, *Pecten*, etc.), *Ditrupa*, coral remains (*Turbinolia*), bryozoan debris, etc.

Upwards the sands were fine to medium-grained, sometimes slightly clayey, and with nummulites and shell fragments.

The basal samples (**25-27**) were very rich in foraminifera, probably partly derived from older sediments. The higher samples (**24-17**) also contained rich microfaunae. The wash residues of all these samples yielded also many other organic remains, glauconite in variable amounts, silex fragments and occasionally some muscovite and pyrite.

Clays of Asse.

The overlying sediments began with a clayey, glauconitic, nummulitic, green-grey sand (sample **16** : with foraminifera, shell and bone fragments, echinid spines, ostracods, much glauconite, etc.).

The overlying clay was sandy and glauconitic at the base (sample **15** with some foraminifera). Upwards it was plastic and grey, more or less glauconitic in the lower part. The samples above 15 were devoid of foraminifera, but the glauconitic lower part yielded some shell fragments.

At the top the clay became sandy and micaceous, passing into green, clayey sand (probably the transition into the Sands of Asse).

The top of the section was formed by Quaternary loess with sandy gravel at the base.

Gent, canal encircling Gent, near the level of the road to Kortrijk.

Sands of Mons-en-Pévèle.

Ir. M. GULINCK, of the Geological Survey of Belgium, kindly gave a sample from the Sands of Mons-en-Pévèle of this locality (indicated as sample **Gent**).

In the wash residues shell fragments, nummulites and a few other foraminifera, coral fragments (*Turbinolia*), ostracods, bryozoan debris, fish remains, etc.

Through the courtesy fo Dr. VAN VOORTHUYSEN, of the Geological Survey of the Netherlands, a sample was obtained probably from about the same level (sample **24912** of the collections of the Geol. Survey of the Netherlands).

Wash residues with nummulites and some other foraminifera, shell fragments, coral remains (as *Turbinolia*), *Ditrupa*-fragments, sponge spicules, bryozoan debris, ostracods, etc.

Heist-op-den-Berg, waterboring near the Rijksmiddelbare School (1951); point 59 (E) 140 of the archives of the Geological Survey, ground level at +26 O.D. Oostende.

At 120,50 m depth Oligocene (Boom Clay) overlay sandy deposits, which possibly belong to the Sands of Wemmel.

Sands of Wemmel (questionable for 129 and 129,50 m).

A continuous series of samples was studied from **121,50 m** down to **129,50 m** with regular intervals of 50 cm (except for sample H. 125 m which was lacking).

All the samples were formed by fine-grained, greenish-grey, glauconitic and more or less calcareous sand with nummulites. Especially the samples H. 129 m and H. 129,50 m were rich in organic remains (mainly nummulites). The wash residues of all samples contained more or less rich microfaunae, bryozoan debris, coral remains, bone fragments (probably fish remains), echinid spines, *Ditrupa* (especially at 121,50 m), some radiolarians, sponge spicules, and glauconite, muscovite and sometimes coarse quartz grains. The shell fragments partly belonged to *Pecten corneus* and *Ostrea.*

Hoboken, waterboring at the « Usine de désargentation » (1913); point 43 (W) 91 of the archives of the Geological Survey.

Possibly **Sands of Vlierzele.**

The bore hole ended at —151 O.D. Oostende, in slightly sandy, grey clay, overlain by 17,70 m of greenish-grey, clayey sands with greenish-grey sandstone at the top.

Sands of Lede.

The series continued with 14,95 m of fine-grained, grey sand with nummulites (numerous near the top) and shell fragments (*Ostrea inflata*, *Pecten*, etc.) with some pyrite concretions and sandstone.

Two samples were studied : no. **19** (−132,45/−121,00 O.D. Oostende) and no. **16** (−119,50/−117,50). The wash residues of both samples yielded a fairly rich microfauna in addition to shell fragments, echinid remains, *Ditrupa*, bryozoan debris, sponge spicules and radiolarians.

Sands of Wemmel.

Higher up followed grey plastic clay (3,75 m) and grey sand (4,70 m) with glauconitic sandstone.

Samples **15** (−117,50 −115,50 O.D. Oostende) and **14** (−115,50 −113,75) of the clay contained a fairly rich foraminiferal fauna, also shell fragments, ostracods, etc.

The sand above the clay (sample **13** : −113,75/−109,05 O.D. Oostende) showed a relatively rich microfauna with nummulites in addition to shell fragments, *Ditrupa*, sandstone fragments, etc.

Clays of Asse.

Upwards about 12 m of clay was found, very glauconitic and sandy at the base, with nummulites and shell fragments (mainly *Pecten corneus*).

Sample **12** (−109,05 −108,00 O.D. Oostende), of the glauconitic base, yielded a rich microfauna, shell fragments, bryozoan debris, bone fragments, echinid spines, etc.

Above this glauconitic, sandy clay, the clay was grey and plastic.

Sands of Asse.

Higher up the series continued with 6 m of grey sand with glauconite, then 4 m of grey, plastic clay, and 10 m of green sand.

The overlying deposits belonged to the Boom Clay.

Lede, small sandpit owned by Mr. Hartog (50 m S and 600 m E of the church-tower of Lede); also point 71 (E) 57 of the archives of the Geological Survey.

Sampled by M. Mourlon (1880).

Sands of Lede.

The sandpit showed 2 to 3 m of sand with interstratified sandy limestone beds, covered by 0,40 to 1,60 m of Quaternary loess.

The base of the section was formed by yellowish-white sand with gravel (mainly of worn nummulites, shell fragments, echinid remains, and also with perforated sandstone pieces and worn teeth of sharks).

On top came fine-grained sand with nummulites, over a height of 1,50 m, with above the base two sandy limestone beds of 10 to 15 cm thickness at 0,90 and 1,35 m, respectively.

The highest part of the sand was formed by yellow sand with some gravel.

Sample **2-V**, from the lower sands, directly above the gravelly sands yielded a rich microfauna and many other organic remains.

Lokeren, waterboring (July 1906); point 41 (E) 3 of the archives of the Geological Survey. See figure 13.

Sands of Lede.

The deepest part of the section was formed by about 3 m of pale-grey, fine-grained, nummulitic sands, with two interstratified sandy limestone beds.

The samples, **29**, **27**, **26**, contained many organic remains, such as a rich microfauna, shell fragments, bryozoan debris, etc.

Clays of Asse.

Upwards 5 cm of whitish clay, rich in shell fragments (as *Ostrea*) and nummulites formed the base of the Clays of Asse. Sample **24** appeared rich in foraminifera, associated with fish remains, shell fragments, and ostracods.

Upwards 50 cm of pale-grey, clayey sand, with nummulites, was observed, covered, by about 9 m of clay. The bulk of the complex was formed by grey, plastic clay, with slightly sandy clay with glauconite at the base.

The samples **20** and **19** were from this sandy base. Sample 20 was rich in shell fragments and nummulites. Both samples contained rich microfaunae, accompanied by bryozoan debris, echinid spines, some radiolarians, etc.

Upwards either Boom Clay or Sands of Asse, with a clayey intercalation were met with. On the figured section the notations of the archives of the Geological Survey were maintained.

Mechelen, waterboring at the New Barrack of the Artillery (August 1905); point 58 (E) 18 of the archives of the Geological Survey. See fig. 13.

Literature :

F. Halet, 1906, Bull. Soc. belge Géol., vol. 20, mem., pp. 61-69; 1910, ibid., vol. 24, mem., pp. 57-61.

Sands of Mons-en-Pévèle.

Upwelling water was encountered in the Sands of Mons-en-Pévèle at a depth of 98 m (—91,30 O.D. Oostende).

From this lithologic unit the samples **106** and **105** came from very fine-grained, green-grey sand with glauconite and nummulites. The wash residues yielded a fairly rich microfauna, shell fragments, echinid spines, sponge spicules, radiolarians, bone fragments, and muscovite, etc.

Clays of Roncq.

5 m of grey, plastic clays were found.

Sandy Clays of Anderlecht and **Sands of Vlierzele.**

Upwards followed a complex of 28 m of alternating sands (mostly fine-grained and with glauconite); clayey sands; sandy clays (grey, more or less glauconitic); grey, plastic clays; and some sandstone beds. Shell fragments were reported from some levels.

Sample **84** from a sandy clay with shell fragments yielded some foraminifera, shell fragments (such as *Ostrea*) and echinid spines.

The uppermost grey plastic clay had a top layer of green-grey, glauconitic, clayey sand.

Sands of Lede.

The base of the overlying sands was formed by a greyish, glauconitic sand with worn remains of fossils (nummulites, etc.) and coarse, hyaline quartz grains. Upwards coarse, worn elements were absent, but they returned in a sandy limestone, about 3,30 m above the base, which showed many worn nummulites, shell fragments (*Terebratula kickxi*, *Ostrea*), *Ditrupa*, and some coarse, hyaline quartz grains.

The sands were fine-grained, grey, with nummulites and glauconite, and with interstratified sandy limestone beds.

Samples **70**, **67**, **62** and **60**, of these sands, were all foraminiferous (and rich in nummulites), and contained many other organic remains, such as shell fragments, bryozoan debris, echinid spines, *Ditrupa*, ostracods, sponge spicules, etc.

Sands of Wemmel.

The overlying fine-grained, glauconitic sands, with at the base some coarse elements (**55**) were slightly clayey, and rich in nummulites and shell fragments (*Ostrea*) (**54**). The wash residues of both samples were foraminiferous, associated with ostracods, echinid spines, shell fragments, fish remains, bryozoan debris, radiolarians, etc.

Clays of Asse.

Upwards a grey, slightly clayey, glauconitic sand was found, with worn nummulites and coarse silex fragments (**51** , and also a small microfauna, shell fragments, echinid spines and pyrite.

Then followed grey, clayey sand (sample **50**) with some foraminifera (and nummulites), bone fragments, glauconite, pyrite, etc.

Higher up we observed plastic, grey clay with some scattered glauconite grains. The upper metre of the clay was reported to be micaceous.

Sands of Asse.

The Clays of Asse were overlain by sands to clayey sands, both glauconitic and green-grey. The overlying clay beds were more or less sandy and micaceous, in the lower part plastic and at the top very micaceous.

The upper sands (perhaps Sands of Berg) were very micacous in the lower part, glauconitic near the top, of grey to grey-brown colour, medium to fine-grained, and with shell fragments (reported as *Cytherea*).

Overlying, sandy, micaceous clays of the base of the Boom Clay were found.

Oostende, waterboring at the « Palais des Thermes » (1931); point 21 . 122 of the archives of the Geological Survey.

Sands of Oostende.

Five samples of the deposits underlying the Clays of Ieper were studied.

These samples came from depths between 174 and 186 m (—165 and —177 O.D. Oostende).

The upper three samples (between 174 and 177,72 m) were formed by grey, slightly clayey sands with pyrite concretions and many shell remains (*Melania inquinata*, *Melanopsis buccinoides*, *Natica deshayesiana*, *N. consobrina*).

The two lowermost samples, of plastic, grey clay and grey sand, respectively, were also rich in shell remains (*Cyrena cuneiformis*, *Melanopsis*, *Corbicula*, *Mytilus*, *Turritella*).

The wash residues of all samples yielded many shell fragments, pyrite and mainly black silex. The sample from sands between 174,52 m and 175,00 m contained some ostracods (*Cyprideis* sp.).

Vinderhoute, waterboring no. I (January-April 1942); point 55 (W) 784 of the archives of the Geological Survey. See fig. 13.

Sands of Mons-en-Pévèle.

The lowermost sands were formed by fine-grained material, with nummulites and shell fragments.

All samples (**119**, **117**, **116**, **111**, **110**, **107** and **106**) of this unit yielded some foraminifera (with nummulites), associated with *Ditrupa*, ostracods, fish remains, echinid spines, bryozoan debris, sponge spicules, coral remains (*Turbinolia*), shell fragments (*Ostrea*, etc), radiolarians, *Chara* remains (in 116), and glauconite, muscovite, etc.

Clays of Roncq (?), **Sandy Clays of Anderlecht** and **Sands of Vlierzele.**

The overlying grey, sandy clays possibly belonged to the Clays of Roncq. No data about the boring method were available, so that the variable clay contents of the samples may be of questionable origin.

Both samples (**105**, **104**) from these sands contained some foraminifera (with nummulites in 105) and ostracods, shell fragments, sponge spicules, bryozoan debris, echinid spines, radiolarians, *Ditrupa*, fish remains, etc.

Upwards more or less clayey sands with intercalated sandstone beds were found. The lower sandstones were recorded to have shell and nummulite fragments. The clay contents diminished higher up.

Sample **102** from one of the lower sandstone beds yielded some nummulites and other foraminifera, associated with shell fragments, sponge spicules, ostracods, etc.

There was no distinct boundary between the Sandy Clays of Anderlecht and the Sands of Vlierzele. We placed the boundary at about sample 65.

These sands were fine-grained, grey and micaceous. Near the transition into the Sands of Aalter grey, glauconitic sands were found, with soft sandstones and some shell fragments (*Turritella*).

Two foraminiferous samples (**65**, **63**) yielded shell fragments, lignite (partly pyritised), sponge spicules, radiolarians, echinid spines, etc.

The samples directly below the Sands of Aalter did not contain any foraminifera, but shell fragments, sponge spicules, lignite and some ostracods were present.

Sands of Aalter.

The overlying sediments were formed by fine-grained, glauconitic, grey sands, with more or less lignite and sandstone concretions. At the level of the highest sample occurred shell fragments of *Venericardia planicosta*.

All samples contained some scarce shell fragments, sponge spicules, lignite (partly pyritised), etc.

The top of the column was formed by 20 m of Quaternary deposits.

Wemmel.

Through the courtesy of Ir. GULINCK, of the Geological Survey of Belgium, a series of samples was obtained from a number of borings near Wemmel. These borings were made during the first exploration for the construction of a new road around Brussels.

Boring no. 10 (Zellik) (June 1955) (400 m N and 2.300 m E of the church-tower of Zellik); point 87 (E) 579 of the archives of the Geological Survey.

Sands of Wemmel.

The lower part of the section was formed by calcareous, glauconitic, brownish sand with many fossils. These sands were present between 12,50 and 15 m (+48,35 and +50,85 O.D. Oostende), and were studied with samples of **12,50, 13, 14, 14,50** and **15 m.**

The wash residues of all these samples yielded a fairly rich microfauna and many other organic remains, such as shell fragments (*Pecten corneus*, etc.), bryozoan debris, *Ditrupa*-tubes, coral remains, echinid spines, sponge spicules, radiolarians, etc.

Boring no. 14 (Wemmel) (June 1955) (1.900 m S and 150 m E of the church-tower of Wemmel); point 87 (E) 583 of the archives of the Geological Survey.

Sands of Wemmel.

Under the covering Quaternary loess (base at 4,50 m depth or +58,80 O.D. Oostende) a series of fine-grained, calcareous sand was found. The sands were rich in remains of fossils, as *Pecten corneus* and nummulites. A rather continuous series of samples of 5 to 11 m depth was investigated.

The samples of **5, 5,50, 6, 6,50, 7, 9,50, 10, 10,50** and **11 m** appeared rich in foraminifera (with nummulites) and ostracods, associated with shell fragments (*Pecten*, *Ostrea*, *Dentalium*, etc.), fish remains, bryozoan debris, echinid spines, radiolarians, *Ditrupa*-tubes, sponge spicules.

Boring no. 16 (Wemmel) (June 1955) (1.750 m S and 500 m E of the church-tower of Wemmel); point 87 (E) 585 of the archives of the Geological Survey.

Sands of Wemmel.

The lower part of the section was formed by fine-grained, calcareous sand, rich in remains of fossils. These sands were found between 6 and 10 m depth (+60,37 and +56,36 O.D. Oostende).

The samples of **6, 7** and **9 m** contained a fairly rich microfauna (with nummulites), associated with many other organic remains, such as shell fragments, bryozoan debris, etc.

Boring no. 48 (Strombeek-Bever) (July 1955) (150 m N and 900 m W of the church-tower of Strombeek-Bever); point 88 (W) 1387 of the archives of the Geological Survey.

Sands of Wemmel.

Between 19,50 and 25 m depth (+39,45 and +33,95 O.D. Oostende) fine-grained, slightly calcareous sands with some nummulites were met with.

The samples of **22** and **23,50 m** were investigated and yielded rich microfaunae with many other organic remains; about the same components as in the samples of the other borings of these series.

ENGLAND

Alum Bay (Isle of Wight).

The samples were collected during a field trip of a group of students under the direction of Prof. Dr. G. H. R. von Koenigswald in 1949, a field trip of Dr. C. W. Drooger in 1956, and a visit to this locality by the author, in 1957.

Mainly two parts of the section were sampled:

a) London Clay,
b) Barton beds.

London Clay.

The London Clay covered the so-called Reading beds (near the contact developed as yellow sands and clays with lignite remains). Upwards about 40 m of mostly dark-brown clay, with several layers of septaria were found; sandy at the base and with rounded silex pebbles. Shell fragments were irregularly distributed in the clay, but, in general, the amounts increased upwards.

The covering of the London Clay was formed by sulphur-yellow to grey sand (Bagshot Sands) with seams of dark-grey clay.

In the basal part the samples **EG 8** and **EG 101** were taken about 10 m above the base. The latter sample contained *Pholadomya margaritacea*. Three m above EG 101 sample **EG 102** was taken from a rusty-brown to grey sandy lens with many shell fragments.

All three samples showed a fairly rich microfauna, associated with shell fragments, ostracods, fish remains, glauconite, muscovite, gypsum; the wash residues of EG 102 also contained some echinid spines and *Ditrupa*-remains.

Sample **EG 9**, from about the middle part of the 40 m clay, appeared slightly foraminiferous, with fish remains, shell fragments, pyrite, glauconite, etc.

Near the top the samples **EG 104** and **105** were taken about 10 m below the overlying Bagshot Sands. Sample EG 104 was from a bed rich in *Venericardia planicosta*, and EG 105 from a lens with much *Turritella*. Sample **EG 10** represented the top of the London Clay.

In addition to shell fragments, all three samples contained some foraminifera and ostracods; and EG 103 and 104 also some *Ditrupa*-tubes and sponge spicules.

Barton beds.

In the literature a three-fold division of the Barton beds of Alum Bay is given with the Lower, Middle and Upper Barton beds.

The Lower Barton beds were at the contact with the Upper Bracklesham beds formed by 30 cm of dark bluish-green clay with nummulites. Upwards followed 17 m of dark bluish-green clay with sand patches and 2,75 m of grey, clayey sand at the top.

Sample **P 1** was taken near the base; **P 2**, **P 3** and **P 4** from the higher parts, at distances from P 1 of about 9, 11 and 17 m, respectively. **PQR 2** was from about the same level as P 4.

The wash residues of all these samples contained a fairly rich microfauna, shell fragments, fish remains, echinid spines, sponge spicules, coral remains (*Turbinolia*), bryozoan debris, etc.

The Middle Barton beds contained at the base 18 m of brownish clays (**P 4**, **PQR 1**) with two septaria layers near the top. Then followed 8,50 m of grey and brown sandy clay (**PQR 3**), with numerous fossil casts; covered by 3 m of green clays with septaria and 21 m of ferruginous, sandy clays (**P 6**, **PQR 4**, **EG 14**), pale yellow near the base, green in the upper part.

The wash residues of all the samples contained microfaunae, with shell fragments, and, in the lower samples, nummulites and coral fragments. Furthermore occasional bryozoan debris, echinid fragments, teeth of sharks and other fish remains.

The Upper Barton beds contained, near the base, 7,50 m of dark blue, fossiliferous clay (**PQR 5**, **EG 15**), followed by 27 m of white sand, clayey and yellow near the base.

Sample EG 15 had a small microfauna, shell fragments, fish remains, etc.; sample PQR 5 contained no foraminifera, but some ostracods were found (Keij, 1957).

Whitecliff Bay.

The section of the cliffs of Whitecliff Bay, Isle of Wight, was studied during a trip to Wight in 1957. A foraminiferous sample was also taken by Dr. DROOGER during a visit to this locality in September 1956.

Sample **EG 1**, from the Upper Bracklesham beds, zone with *Nummulites variolarius*, yielded a rich microfauna, and shell fragments, coral remains, fish remains, *Ditrupa*-tubes, etc.

Sample **EG 100**, from the Middle Headon beds, was taken from brown, sandy fossiliferous clay, and yielded a small microfauna, shell fragments, radiolarians, sponge spicules, etc.

Barton Cliff (see fig. 13).

Sampled during a trip in May 1957; some other samples of the collections of the Geological Institute of Utrecht had been taken during an excursion under the direction of Prof. Dr. G.H.R. VON KOENIGSWALD in 1949.

Literature :

J. S. GARDNER, H. KEEPING and H. W. MONKTON, 1888, Quart. Journ. Geol. Soc., vol. 44, pp. 578-635.
E. J. BURTON, 1929, Quart. Journ. Geol. Soc., vol. 85, pp. 223-241.
C. P. CHATWIN, 1948, The Hampshire Basin and adjoining areas, Geol. Surv. and Museum, Brit. Reg. Geol., 2d ed.

GARDNER, KEEPING and MONKTON made a detailed section of the Barton Cliff (coast section of Christchurch Bay over a length of about 5 km), mainly based on lithologic features. The same subdivision is maintained in our studies and reproduced in the figured section, with the addition of our field data.

The **Barton beds** cover green, sandy clay of the Bracklesham beds.

A 1. - Overlying the sandy clay, there must be an ironstone bed of about 30 cm, which could not be observed during our trip.

Only some poor exposures were visible of the following dark greenish-grey, sandy clay with shell fragments. Sample **EG 110** was taken from one of these exposures. It contained some nummulites and other foraminifera, shell fragments, fish remains,*Ditrupa*-tubes, echinid spines, ostracods, etc.

A 2. - Sample **EG 112** probably represented this dark greenish-grey clay with rusty-brown sand patches. It contained some foraminifera (with some nummulites), shell fragments, fish remains, lignite, echinid remains, etc.

A 3. - No good exposures could be found of these «Highcliff Sands» (GARDNER, KEEPING and MONKTON): grey sandy clay with shell fragments.

B. The same was true of this sandy clay with *Pholadomya* (= *Pholadomya*-bed), with at the top a septaria layer.

C. Greenish-grey clay with numerous shell fragments (*Voluta suspensa*, *Fusus*, etc.), sandy towards the top (= *Voluta suspensa*-bed).

Sample **EG 113** yielded a fairly rich microfauna, shell fragments, fish remains, coral fragments, echinid debris, *Ditrupa*, etc.

D. — Dark green-grey, sandy clays with rusty-brown patches and stripes, which were numerous in the lower, brown-grey part.

Sample **EG 118**, about 2 m below the top, contained some foraminifera, shell fragments, lignite, fish remains, etc.

E. In this slightly sandy, grey clay, the numerous remains of fossils were partly concentrated in indistinct lenses. At the top occurred a septaria layer; and near the base the clay was slightly more sandy and somewhat darker.

All three samples (**D 1**, **D 2** and **D 3**) yielded a fairly rich microfauna, shell fragments, *Ditrupa*-remains, fish remains, echinid spines, sponge spicules, etc.

F. — This more or less laminated, grey clay was again rich in shell fragments, that were mostly concentrated in lenses or discontinuous layers of some cm thickness (« drifts » of BURTON); lined by two layers of septaria.

In the lower part the samples **D 4** and **EG 117** were taken, about 1 m above the lower septaria layer from a lens, rich in shell material. They contained some foraminifera, ostracods, many shell fragments, *Ditrupa*, fish remains, radiolarians, etc.

Above the second septaria layer **D 6**, and below **D 5**, were taken, both with a fairly rich microfauna, shell fragments, *Ditrupa*, bryozoan debris, fish remains, echinid fragments, etc.

G. — Differentiated from F by the colour change to greyish-olive green, this unit had a layer of about 10 cm thickness, rich in shell fragments (mainly *Turritella*). This shell layer was locally indurated.

Samples **D 7** and **EG 116** both had fairly rich microfaunae, and shell fragments (*Ostrea*, *Turritella*), fish remains, echinid spines, etc.

H. — This so-called *Chama*-bed (*C. squamosa*) consisted of medium-grained, very clayey to clayey sands. In the lower part there were also other molluscs, such as *Turritella*, towards the base the amount of *Chama* decreased.

Only **D 8** yielded some foraminifera, in addition to fish remains, coral debris, etc.

I. — The lower part of this unit was formed by grey, well-bedded, fine-grained, sands with increasing clay content towards the base, gradually passing into H. Towards the top the sand passed (locally numerous worm tubes) into greenish, clayey sand, rich in shell fragments, and with bands with lignite.

EG 109, from the top, yielded some foraminifera, shell fragments, pyritised lignite, fish remains, etc.

J. — The lower part was formed by greenish-grey, sandy clay, with shell fragments.

Sample **EG 114** contained some foraminifera, lignite, shell fragments, etc.

From the higher, dark green to grey, more or less sandy, clay with numerous shell fragments, sample **EG 108** also had some foraminifera, shell fragments, echinid spines, and muscovite.

K. — This so-called «Long Mead End bed» consisted in the lower part (5 m according to CHATWIN) of fine-grained, whitish sands, at the base rich in limonite. At the contact with J distinct current-bedding was visible by the occurrence of some clayey beds in the sand. The current-bedding fainted out higher up.

The upper part was formed by fossiliferous and ferruginous sands of rusty-brown colour, with *Batillaria pleurotomoides*.

L. — This unit consisted of lignite bands with clay in between.

Sample **EG 106** from the intercalated clay contained some foraminifera, lignite, shell fragments, fish remains, etc.

Overlying this upper member of the Barton beds, followed the sands and sandy clays of the Headon beds.

FRANCE

CAA Cassel, sandpit in the western side of the mont des Récollets (sandpit owned by Mr. Masson), (100 m N and 800 m E of the church-tower of Cassel). See figs. 11 and 14.

Visited September 1953.

Literature :

M. LERICHE, 1937, Ann. Soc. Géol. Nord, vol. 62, pp. 80-85.

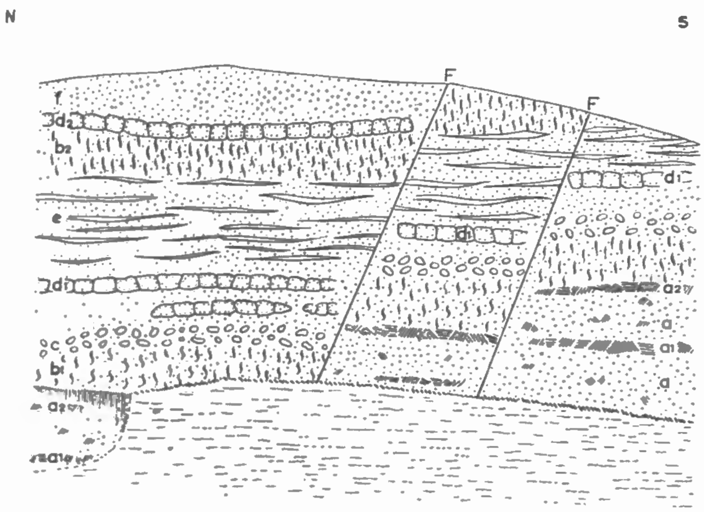

FIG. 14. — Schematic section of CAA, mont des Récollets (after LERICHE, 1937). a : glauconitic sand, with concentrations of glauconite (a 1 and a 2) and a distinct cross-bedding; b : glauconitic sand with tubulations; c : shell bed; d : sandy limestone; e : glauconitic sand with clay beds; f : glauconitic clayey sand; F : fault.

Scale : 16 mm = approximately 1 m.

Sands of Vlierzele passing into **Sands of Aalter**, and possibly with **Sands of Brussels** in the highest part.

The wall of this sandpit of a height of about 14,50 m had already been figured by LERICHE, which figure is reproduced as a text figure.

The faults present in the wall were quite distinct in 1953 during our visit.

LERICHE only figured the upper part of our 1953-section.

The lower part of the wall was formed by glauconitic, clayey sand of brownish to yellow--green colour, with indistinct bedding and more or less regular rusty-brown stripes. Upwards the glauconite was concentrated in thin stripes, which often indicated a more or less distinct cross-bedding. Also concentrations of more indistinct pattern occurred. The clay content of the lower part was rather variable, but upwards, generally, decreased.

The wash residues of this lower part yielded shell fragments, bryozoan debris, fish remains, muscovite, etc.

Higher on the sand became more calcareous and variable quantities of shell fragments were found, in addition to coral fragments (*Turbinolia*), bryozoan debris, echinid spines, etc.

Sample **CAA 273** yielded a small microfauna, shell fragments, echinid spines, sponge spicules, etc.

Upwards the quantity of shell fragments increased (mainly *Ostrea*); also tubes of *Ditrupa* were found. The sands became slightly clayey.

The samples **CAA 274** and **CAA 275** yielded small microfaunae, in addition to shell fragments, fish remains, bryozoan debris, echinid spines, sponge spicules (only in 275), etc.

The wash residues of **CAA 276** were rich in *Ostrea cymbula*, associated with a small microfauna, sponge spicules, bryozoan debris, coarse silex fragments, muscovite, etc.

Sample **CAA 277** contained no shell fragments; some foraminifera, sponge spicules, ostracods, etc., were found.

Between CAA 276 and 277 a sharp decrease in the quantities of shell fragments was met with, corresponding with a change into rusty-brown to green, glauconitic sand, with current-bedding, and clayey at the base. The top of these 2,70 m of sands was formed by fine-grained glauconitic, slightly micaceous sands with some tubulations (probably worms).

A sample of these higher sands yielded some shell fragments, sponge spicules, etc.

Overlying the level with tubulations, medium-grained, yellow-white, slightly micaceous sands, rather clayey and calcareous, were found.

Sample **CAA 279** from this clayey zone yielded many *Ostrea cymbula*, bryozoan debris, echinid spines, some foraminifera and ostracods.

Higher up 40 cm of sandy limestone was found, of yellowish white colour, and with some coarse glauconite grains and some, greenish, horizontal, sandy stripes.

The limestone was overlain by rusty-brown, medium-grained sand, with many shells and small, flat, green, clayey lenses.

The samples **CAA 280** and **281**, from this sand, were rich in *Ostrea cymbula*, with some coral remains (*Turbinolia*), bryozoan debris, echinid remains, sponge spicules, in addition to a small microfauna.

The top of this fossiliferous sand showed some tubulations.

Near the surface level another sandy limestone bank was found, of about the same texture and thickness, followed by fine-grained sands.

CAB Grignon, sandpit.

Visited April and December 1954.

Literature :

A. F. de Lapparent, 1942, Exc. Géol. Bassin Paris, vol. 1, p. 68.

Through the courtesy of the Director of the «Ecole d'Agriculture de Grignon» some samples could be taken from the very fossiliferous sands, exposed in the sandpit of this School.

The lowermost part of the 7 m wall consisted of glauconitic, very calcareous and fossiliferous sands, which possibly belong to the top of the zone III of the Lutetian, and from which sample **CAB 1000** was taken.

Higher up there was a gradual passage into whitish, calcareous sand from which the samples **CAB 1001**, **1002** and **1261** were taken. These belong to the zone IV of the Lutetian.

All samples appeared very rich in microfauna and other fossils.

CAG Mons-en-Pévèle, excavation (SSW of the church-tower, at about +97 O.D. Oostende).

Visited September 1954.

Sands of Mons-en-Pévèle.

Excavation in border of a meadow along the road to La Joncquière.

A poor exposure of very fine-grained, dark grey-green, calcareous sands with shell fragments, nummulites, coarse silex and sandstone fragments.

Two samples, **CAG 1249** and **1250** (the latter contaminated with overlying Quaternary loess), yielded wash residues with rich microfaunae (with nummulites), shell fragments, echinid spines, bone fragments (probably fish remains), radiolarians, fragments of calcareous algae, limonite, glauconite, muscovite and rather well-rounded, mostly hyaline, quartz grains.

Sample **CAG 1252** was taken from sand with nummulites along the roadside near the exposure.

CAH Cuise-Lamotte, sandpit (W of the village, near Le Ménil).

Visited December 1954.

Literature :

A. F. DE LAPPARENT, 1946, Exc. Géol. Bassin Paris, vol. 3, pp. 23, 24.

Sands of Cuise.

A sample, **CAH 1262**, from about 17 m below the grass, formed by yellowish-green, medium-grained sand, with nummulites and many remains of other fossils (mainly molluscs). The wash residues yielded a rather rich microfauna.

Daméry.

Literature :

A. J. KEIJ, 1958, Proc. Kon. Ned. Ak. Wetensch., ser. B, vol. 61, no. 1, pp. 63-73.
A. F. DE LAPPARENT, 1946, Exc. Géol. Bassin Paris, vol. 3, p. 46 (point 4 on fig. 11).

The samples were collected during an excursion under the direction of Prof. Dr. G.H.R. VON KOENIGSWALD in 1955.

Two samples were taken, marked as **Daméry** and as **Daméry-serratum.**

The first sample was taken from a quarry along the road from Arty to Fleury, 1,6 km NNW of the church-tower of Daméry.

It was composed of organic debris with large, rounded quartz grains, and it contained a rich mollusc fauna, accompanied by abundant remains of calcareous algae, foraminifera and ostracods.

It belongs to zone IV of the Lutetian of the Paris basin.

The second sample was taken from an outcrop at some 150 m ENE of the previous one.

Again an organic breccia, rich in molluscs, calcareous algae, ostracods and foraminifera.

It was taken from beds containing *Cerithium serratum*, indicative of zone V of the Lutetian of the Paris basin.

NETHERLANDS

Woensdrecht, diepboring no. 17 of the Rijks Opsporing voor Delfstoffen (1912); surface at +1,76 O.D. Amsterdam. See fig. 15.

Literature :

P. TESCH, 1912, Jaarverslag der Rijksopsporing voor delfstoffen over 1912, p. 11-22.
W. VAN WATERSCHOOT VAN DER GRACHT, P. TESCH and F. HALET, 1919, Bull. Soc. belge Géol., vol. 27, mem., pp. 169-176.

Through the courtesy of Dr. THIADENS, Director of the State Geological Survey of the Netherlands, and Dr. VAN VOORTHUYSEN, micropaleontologist of this Survey, a series of the core-samples was obtained, which are stored in the collections of the Geologische Stichting at Haarlem, Netherlands.

For the drawing of the section, the descriptions of the cited authors were combined with our own lithologic observations.

Sands of Landen (?).

Underlying the Eocene series sediments were found that possibly belonged to the Sands of Landen.

From 624 m depth upwards the investigated samples began with marly fossiliferous clay, which was followed by marly clay at a depth of 619 m.

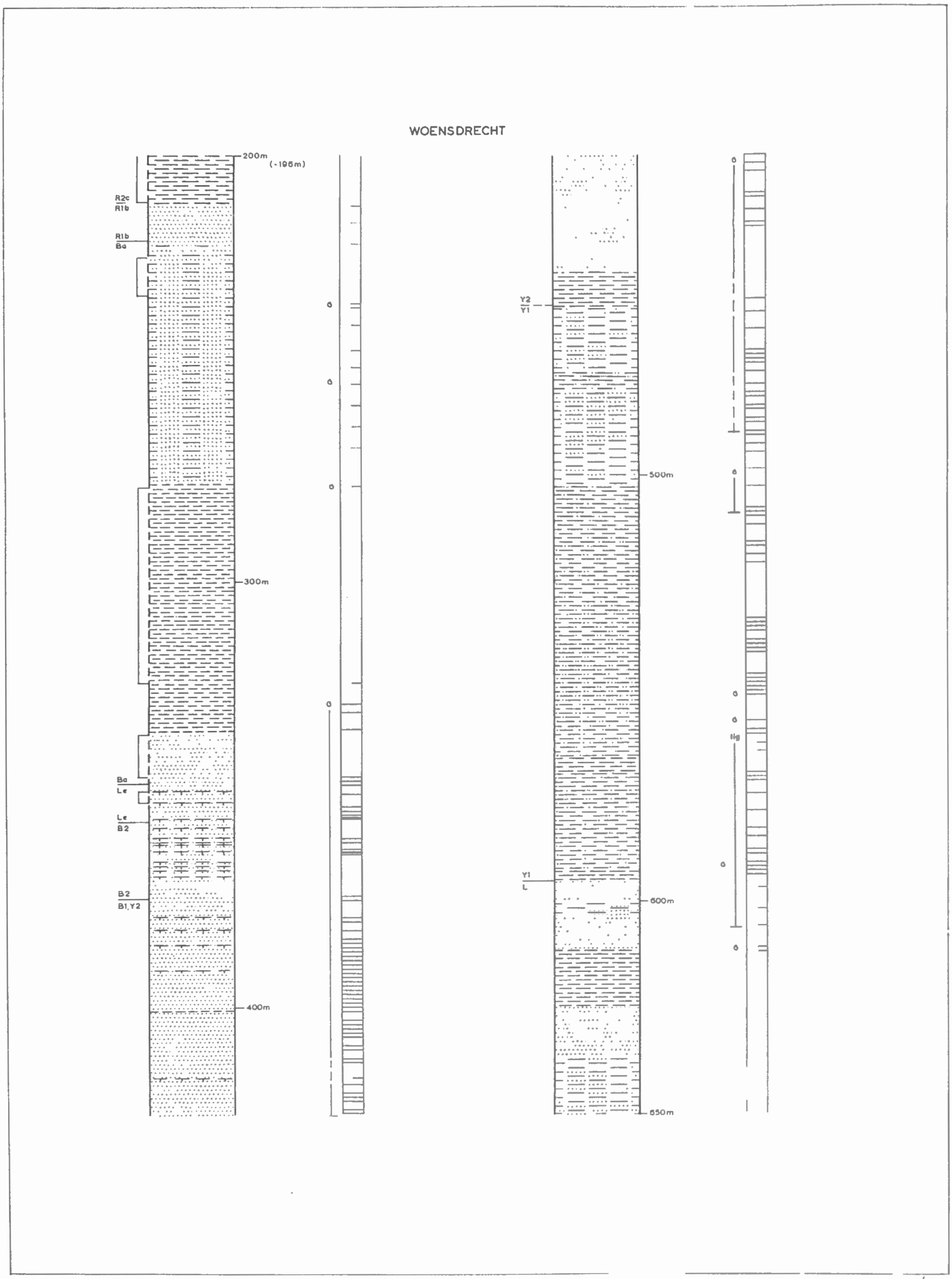
WOENSDRECHT
200m
(-196m)
R2c
R1b
R1b
Ba
300m
Ba
Le
Le
B2
B2
B1,Y2
400m
Y2
Y1
500m
Y1
L
600m
650m

FIG. 15.

From 612 m up to 604 m fine-grained sands were observed, sometimes with lignite, and clayey at the top, which marked the passing into lignitic sandy clay, which occurred up to 600 m.

Upwards, to 598 m, pale brown-grey, fine-grained sand was found.

A number of samples of the described sediments did not contain any microfauna; shell fragments, bone remains, lignite (often pyritised) were present.

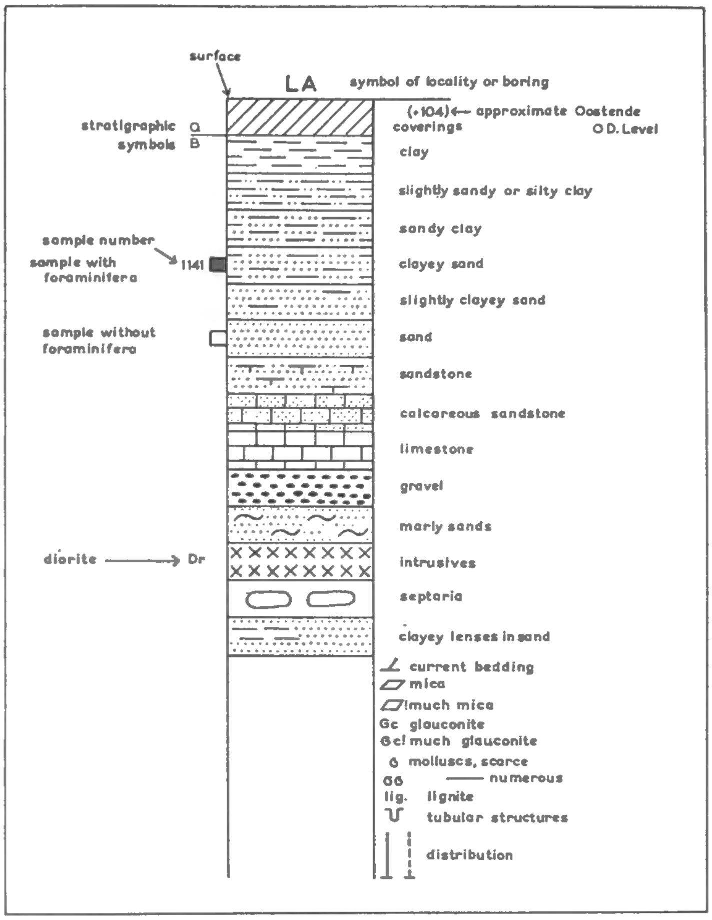

FIG. 16. — Legend for figures 6-15.

Clays of Ieper.

Higher up greenish-grey clay was found, with thin bands of silty clay and silt of the same colour. Locally some pyrite concretions and some fossil remains, as shell fragments, were found.

The contents of the following samples were investigated : **597, 594, 593, 592, 591, 589, 588, 585, 583, 579, 575, 572, 571, 570, 565, 563, 561, 560, 558, 552, 551, 550, 549, 548, 547, 542, 541, 540, 539, 537, 536, 535, 534, 521, 519, 517, 516, 512, 510, 509, 508, 503, 499, 495, 493, 491, 490, 488, 487, 485, 484, 482, 481, 479, 476 m.**

Most of these samples yielded variable quantities of foraminifera and ostracods. The basal samples contained some lignite (often more or less pyritised). Shell fragments were regularly present, but especially in the samples with many foraminifera. Sponge spicules and fish remains were also regularly distributed, as did some glauconite and muscovite.

Sands of Mons-en-Pévèle.

The overlying sands were recorded as slightly clayey, fine-grained, greyish-green.

The various samples showed a variable clay content, up to sandy clays.

Samples : **474, 473, 472, 471, 466, 462 m.**

They all yielded wash residues with foraminifera (with nummulites) and ostracods. Furthermore the presence of fish remains, shell fragments, sponge spicules, radiolarians, *Ditrupa* (only in the upper two samples), glauconite, muscovite, etc.

Clays of Roncq.

Higher up followed greenish-grey clays, silty at the top, plastic lower down and with a silty base.

Sample : **459 m.**

The wash residues contained some foraminifera, shell fragments, fish remains, sponge spicules, glauconite, muscovite, etc.

Sandy Clays of Anderlecht + Sands of Vlierzele.

From 385,05 m to 452,60 m fine-grained sands with interstratified sandstone layers were found. The sand was, in general, greenish-grey to grey-green. Locally occurred some shell fragments, and muscovite. The deposits were glauconitic.

Samples : **442, 441, 438, 435, 434, 429, 427, 425, 424, 422, 421, 420, 418, 416, 413, 412, 410, 409, 407, 406, 405, 404, 403, 401, 400, 399, 398, 397, 396, 395, 394, 393, 392, 391, 390, 389, 388, 387, 386 m.**

The wash residues mostly contained small microfaunae, in addition to shell fragments, echinid spines, fish remains, radiolarians, *Ditrupa*-fragments, etc.

The upper samples yielded some lignite.

Possibly these upper samples belonged to the equivalents of the Sands of Aalterbrug, which were marked in western Belgium by lignitic sands.

(?) **Sands of Aalter,** passing near the top into Sands of Brussels.

The latter lignitic sands were also found in our samples of 385 and 384 m. Higher up from 382 to 374 m were found medium to fine-grained sands of greenish-grey colours, slightly glauconitic, with more glauconitic and slightly clayey sands below. The sands were rich in shell fragments, which probably belong to *Venericardia planicosta.*

Samples : **384, 382, 380, 379, 375, 374 m.**

The wash residues contained small microfaunae, shell fragments, echinid spines, fish remains, radiolarians, etc. Some nummulites at 382 m.

The overlying deposits from 374 to 365 m were unknown, since the cores were lacking. In this part probably the transition of both lithologic units is to be found.

Sands of Brussels.

Higher upward occurred fine-grained, slightly micaceous, grey sands, locally with many nummulites. Intercalated in the sand there were a number of hard, and grey sandstones, sometimes rich in nummulites.

Samples : **365, 364, 363,50, 363,43 - 363, 362, 361, 360,50 m.**

They had rather rich microfaunae, associated with shell fragments, bryozoan debris, echinid spines, radiolarians, sponge spicules, etc. Sometimes there were many *Ditrupa*-fragments.

These sediments belonged evidently to the Sands of Brussels, but the sands resemble the Sands of Vlierzele, except for the greater lime content and the nummulites.

Sands of Lede.

The following greenish-grey, fine-grained sands, with nummulites, shell fragments, and *Ditrupa*, had interstratified calcareous sandstones, which were sometimes rich in organic remains, and resembled the sandy limestones of the Sands of Lede of Belgian localities.

Samples : **355,75, 355,50, 355, 354, 353, 350, 348, 347 m.**

The wash residues showed rich microfaunae, shell fragments, echinid remains, *Ditrupa*-tubes, bryozoan debris, fish remains, radiolarians, etc.

Sands of Wemmel.

Higher up we met with fine-grained sands with shell fragments (*Pecten corneus*, etc.).
Samples : **346, 335 m.**
They contained foraminifera, ostracods, shell fragments, bryozoan debris, fish remains, echinid spines, etc.

Clays of Asse.

These sands were overlain by grey, plastic clay with some shell fragments (decreasing amounts upwards).
Samples : **331, 329, 324 m.**
The first two yielded some foraminifera. The wash residues contained furthermore pyrite, gypsum, scarce glauconite, bone fragments, etc.
Higher up a great part of the cores were lacking. At 278 m again clay was found, but it was dubious whether this clay belonged to the Clays of Asse or to the clay bed which is often intercalated in the Sands of Asse.

Sands of Asse.

Overlying the clay of 278 m about 57 m of greenish-grey, slightly clayey sands were found. The sands did not contain any fossils, except for many shells in two levels (at 236 and 254 m) with many *Ostrea* (reported as *O. ventilabrum*). Sometimes pyrite concretions occurred in the sand.
Samples : **278, 269, 264, 259, 254, 250, 246, 240, 236, 235, 221, 216 m.**
No foraminifera were found.

Sands of Berg (Oligocene).

Upwards medium to fine-grained sands were found, with glauconite and lignite, grey colour, except for the lower 7 m, which were brownish and contained muscovite.
Sample : **211 m.**
The wash residues yielded glauconite, muscovite and bone fragments, but no foraminifera.
These sands were overlain by distinct Boom Clay (grey clay with *Leda deshayesiana*).

CHAPTER IV

REVIEW OF THE FORAMINIFERAL ASSOCIATIONS

INTRODUCTION

In our samples of the Eocene of Belgium, England, France and the Netherlands over 225 species and varieties of Foraminifera (excluding Nummulitidae) were recognized. Their distribution in the samples is shown in eight tables.

The quantitative indications in these tables were gained by counting the number of specimens of each species on a tray of 12 cm² spread for about one quarter of the surface with particles of the wash residue. The frequencies of the species in a single counting are expressed as follows:

r (rare)	1-3 specimens.
f (few)	4-6 specimens.
C (common)	7-20 specimens.
A (abundant)	21-60 specimens.
V (very abundant)	61 and more specimens.

In the discussion of the faunae of the various rock units, special attention will be paid to their possible environments. Our conclusions are partly based on considerations published by BETTENSTAEDT (1949) for the German Eocene. Comparison with recent faunae, such as those from the Gulf of Mexico-Caribbean, and the Californian coast, appeared difficult. Nearly all our species are extinct, so that only general resemblances of species, genera and associations could be used.

THE CLAYS OF IEPER

(Tables 1, 2 and 8)

Some seventy-five samples, fifty-two of which from the Woensdrecht boring, yielded altogether over seventy species and varieties of foraminifera.

The assemblages in the Woensdrecht boring enable us to distinguish three successive zones. In most of the Belgian samples the assemblages are too small for a recognition of the zonal associations. Only the samples of NT (Ecaussines-Lalaing) and RA (Kortemark) yielded fairly rich faunae which justify their parallelization with the Upper Woensdrecht zone. For the distribution chart (no. 2) the other Belgian samples have been classified in accordance with their probable relative position in the Ieper Clays series.

FEUGUEUR and Y. LE CALVEZ (1954) recorded a similar subdivision of the Ieper Clays of the boring Mouscron, but details about the characteristics of their faunae were not published.

1. THE LOWER WOENSDRECHT ZONE

In the lowermost samples of the Woensdrecht boring we found assemblages with many species of arenaceous foraminifera, associated with a few calcareous species. Upwards the faunae impoverished by disappearance of the arenaceous elements, except for *Karreriella* and *Ammodiscus*. The upper limit of the zone is directly below 552 m, where we find the abrupt start of the middle Woensdrecht faunal type.

The samples of Woensdrecht yielded nineteen species, eight of which were not found in other sediments of our Eocene, viz.

Ammobaculites sp. cf. *A. americanus*,
Anomalina sp. cf. *A. danica*,
Cibicides sp. cf. *C. dutemplei*,
Cribrostomoides sp.,
Haplophragmoides sp.,
Rhizammina sp.,
Spiroplectammina mexiaensis, and
Trochammina sp. cf. *T. inflata*.

The most common arenaceous species belong to the Rhizamminidae, Haplophragmiidae and Ammodiscidae, furthermore representatives were found of the Textulariidae, Trochamminidae and Verneuilinidae. The calcareous types mainly belong to the Anomalinidae, with minor contributions of other families.

Our fauna resembles the recent *Haplophragmoides-Trochammina* associations, as found by LOWMAN (1949), in North America, in the near-shore areas of lakes and bays and in quiet places in the bayous. In brackish marsh pools it was even found to be the only foraminiferal faunule present. However, such faunal elements may be transported to the bordering more marine areas. In such a shallow open water environment, with a sandy mud bottom, LOWMAN found another association of arenaceous foraminifera with *Ammobaculites*.

When we apply these facts it is possible that the sediments of the lower Woensdrecht zone were deposited in or near an area with more or less brackish, lagoonal environment, in the latter case with transport from the marsh or lagoon to the open water of a shallow marine environment.

WICK (1947) and BETTENSTAEDT (1949) recorded similar, but mostly entirely arenaceous faunae from the Paleocene to Lower Eocene of Germany. According to these authors the assemblages indicate low temperatures. Assemblages of arenaceous foraminifera only, were not found in Belgium.

2. THE MIDDLE WOENSDRECHT ZONE

In the boring the samples of this zone of 552 m and higher yielded rich assemblages, dominated by Lagenidae. From a depth of 521 m a decrease was noted in the number of individuals and of species, and at 516 to 512 m a slight change in the faunal type is taken as indicative for the gradual transition of the middle into the upper zone. This change mainly involves a relative decrease in number of the Lagenidae and a similar increase of the Anomalinidae.

The faunae of the middle Woensdrecht zone consist of forty-four species and varieties. The limit between the lower and middle zones is sharp. Only eleven of the nineteen species of the lower zone cross the boundary, and as many as thirty-four out of forty-four of the middle zone make their first appearance.

Only *Nodosaria* types are completely confined to this middle zone, viz.

Nodosaria elegantissima,
Nodosaria natchitochensis,
and some others referred to as *Nodosaria* spp.

Some other species are only known from our zone and the London Clay of Wight, viz.

Alabamina obtusa, and
Gyroidina angustiumbilicata.

The most frequent families and species are the Lagenidae [*Lenticulina* spp., *Lenticulina* (*Astacolus*) sp. cf. *L. decorata, Lenticulina* (*Marginulinopsis*) sp. cf. *L. enbornensis, Nodosaria latejugata*], Anomalinidae (*Anomalina acuta, Anomalina acuta* var. *ypresiensis, Cibicides proprius, Cibicides sulzensis*), Textulariidae (*Spiroplectammina adamsi, Textularia smithvillensis*), Nonionidae (*Nonion affine*) and Verneuilinidae (*Karreriella danica*). These families are commonly associated with representatives of the Epistominidae, Chilostomellidae, and Globigerinidae.

Assemblages with many lagenids are often regarded to be typical for a fairly deep marine environment of about 200 m and deeper, but the investigations of DROOGER and KAASSCHIETER (1958) showed that some relation with a muddy bottom is possible also at depths of less than 200 m.

The faunae of the middle Woensdrecht zone closely resemble those of the German Lower Eocene 3 (STAESCHE and HILTERMANN, 1940; HILTERMANN, 1949). BETTENSTAEDT (1949) concluded for the latter an environment of oxygenous water of relatively low temperature.

Concluding it is reasonable to assume an open marine environment, with unknown depths, but probably not much exceeding that of 200 m.

3. THE UPPER WOENSDRECHT ZONE

The transition from the middle into the upper Woensdrecht zone is gradual. From 512 m up to the overlying Sands of Mons-en-Pévèle the samples have a third, but less distinct faunal type.

Altogether twenty-seven species and varieties were met with. Five appear for the first time in our column. Not a single one appeared to be confined to this part of the Ieper Clays. *Turrilina brevispira* and *Asterigerina* sp. cf. *A. guerrai* were also met with in the Clays of Roubaix and in the Sands of Mons-en-Pévèle. *Alabamina wilcoxensis* is known from the upper Woensdrecht zone and the London Clay of Wight. All others have a still wider distribution.

In general, the faunae of the upper Woensdrecht zone (and corresponding localities in Belgium) show close affinities to those of the overlying members of the Ieper formation. This resemblance may be partly due to similar environmental conditions.

There is a distinct dominance of Anomalinidae (*Anomalina acuta, Cibicides lobatulus, Cibicides proprius, Cibicides proprius* var. *acutimargo, Cibicides sulzensis*) with as frequent associates species of the Nonionidae (*Nonion affine*). Less frequent, but not rare, are some representatives of the Lagenidae and Globigerinidae.

The slight impoverishment of the fauna in respect to that of the middle Woensdrecht zone is probably due to a shallowing of the water. This may be concluded from the decrease in Lagenidae, and the increase in Anomalinidae (mainly *Cibicides*). In comparison with the known recent American faunae there is a general resemblance with those of the neritic areas of 100 m depth and less (PHLEGER and PARKER, 1951; WALTON, 1955; DROOGER and KAASSCHIETER, 1958).

Summarizing the data of the Ieper Clays in the Woensdrecht boring there is a succession of three zones. Their faunal associations seem to be most closely connected with changing depths of deposition. The sediment type was fairly constant throughout, but other factors, such as temperature, may have been important.

The data from the other localities of the Ieper Clays do not add substantially to our picture. Most assemblages are too poor for a recognition of one of the Woensdrecht zones.

Of the total number of seventy-three species and varieties fourteen are restricted to the Ieper Clays as a whole :

Ammobaculites sp. cf. *A. americanus*,
Anomalina sp. cf. *A. danica*,
Cibicides sp. cf. *C. dutemplei*,
Cribrostomoides sp.,
Eponides plummerae,
Haplophragmoides sp.,
Marginulina pediformis,
Nodosaria elegantissima,
Nodosaria natchitochensis,
Nodosaria spp.,
Pseudoclavulina anglica,
Rhizammina sp.,
Spiroplectammina mexiaensis, and
Trochammina sp. cf. *T. inflata*.

If the London Clay of the Isle of Wight is included there are seventeen out of seventy-five.

THE LONDON CLAY

(Tables 1 and 7)

In our seven samples of the London Clay of Alum Bay, Hampshire, we found a total number of twenty-four species and varieties. *Cibicides proprius* and *Anomalina acuta* var. *ypresiensis* are the most common to frequent types. With the exception of *Quinqueloculina seminula*, all species were also met with in the Ieper Clays of Belgium. The following are confined to the London and Ieper Clays:

Alabamina obtusa,
Alabamina wilcoxensis, and
Gyroidina angustiumbilicata.

Representatives of the Anomalinidae are most common. Furthermore species of the Epistominidae, Textulariidae, and Elphidiidae are more or less frequent.

This type of association resembles those of the Ieper Clays, especially those of the middle and upper Woensdrecht zones. No equivalent of the lower Woensdrecht zone was found, which may be due to the small number of our samples.

THE CLAYS OF ROUBAIX

(Tables 1 and 2)

Eight samples from the Roubaix Clays yielded a total of about thirty-five species and varieties, of which only *Cibicides sulzensis* and *Nonion affine* are fairly common. Of the minor constituents of the fauna three (*Globotruncana* sp., *Gümbelina* sp. and *Planulina stelligera*) have probably been reworked from Cretaceous rocks.

No species was found to be restricted to the Roubaix Clays. These Clays share *Bolivina pulchra* with the Sands of Mons-en-Pévèle, commonly regarded as their lateral equivalent.

Notwithstanding the fairly gradual transition from the Ieper Clays into the Roubaix Clays the latter are distinct by the appearance of seven species. With the exception of *Bolivina pulchra* these types have also been found in younger strata. Nearly all thirty-five species and varieties are also known from the Sands of Mons-en-Pévèle. Most common are species of the Anomalinidae and Nonionidae, with less frequent to rare representatives of the Buliminidae, Globigerinidae, Discorbidae, Textulariidae, Epistominidae, Lagenidae, Verneuilinidae and Polymorphinidae.

The environment may have again been open sea of less than a 100 m depth, possibly somewhat deeper than it was in the areas of the Sands of Mons-en-Pévèle. But lithology is probably more important than depth for the differences of the faunae of both rock units.

THE SANDS OF MONS-EN-PÉVÈLE

(Tables 1, 2 and 8)

Altogether forty-four foraminiferous samples, thirty-eight from Belgium, six from Woensdrecht, yielded eighty species and varieties. Only *Bolivina pulchra* is characteristic for the Clays of Roubaix and the Sands of Mons-en-Pévèle together. All others have a longer range. Twenty-five make their first appearance. This great number may be connected with the mainly sandy character of the sediments. Such sedimentation had been absent in the area since the Paleocene.

Most frequent are representatives of the Nummulitidae (probably *Nummulites planulatus*), Epistominidae (*Asterigerina bartoniana, Karreria fallax*), Anomalinidae (*Cibicides proprius, Cibicides sulzensis*) and Discorbidae (*Cancris subconicus*). Furthermore there are common representatives of the Nonionidae, Lagenidae, Buliminidae, Globigerinidae, Elphidiidae. Striking is the very frequent association of *Nummulites* with *Asterigerina bartoniana* and *Asterigerina* sp. cf. *A. guerrai*.

The environment was probably not much different from that of the German Upper Eocene, described by Bettenstaedt (1949) : oxygenous, warm, shallow water. His arguments are also valid for our Sands : reticulate ostracoda, nummulites, rather high lime content, presence of *Ostrea*, glauconite, and some pyrite. The almost complete absence of Miliolidae in such an environment is thought to be one of aberration.

Towards the area of the Roubaix Clays the nummulites decrease in number, together with the decrease in grain size. Whether the disappearance of the Nummulitidae was caused by increasing depth in this direction or by the change in lithology is not clear.

THE SANDS OF CUISE

(Table 1)

Our sample, CAH 1262, from Cuise-Lamotte, yielded fourteen species in addition to those of *Nummulites*. *Anomalina acuta* and *Cibicides lobatulus* occur in somewhat greater numbers than the others.

Of the fourteen species *Karreriella danica* is in Belgium restricted to the Ieper formation; *Siphonina lamarckana* and *Eponides polygonus* are known from younger deposits in our material.

These scarce data neither confirm nor contradict Feugeur's time-correlation of the Cuise Sands and the Sands of Mons-en-Pévèle, which are lithologically very similar (1951).

THE CLAYS OF RONCQ

(Tables 1, 3 and 8)

Seven samples, six from Belgium, one from Woensdrecht, altogether yielded fourteen species and varieties. Only *Cancris subconicus* and *Cibicides lobatulus* are somewhat more numerous than the others. No species appeared to be restricted to the Roncq Clays.

The faunae do not give any clue about the Roncq Clays belonging in age either to the underlying Ieper formation or to the overlying members of the Panisel formation, because they are composed of the most consistent species of both formations.

Only *Anomalina acuta* var. *ypresiensis* was met with in the Ieper formation and not in the other members of the Panisel formation.

The Anomalinidae are the most common family. Furthermore we encountered in minor quantities : Discorbidae, Elphidiidae, Epistominidae, Rotaliidae, Miliolidae, and Ceratobuliminidae. These small faunae may indicate very shallow, marine water during deposition of the clays. Some lithologic data, such as nests of worn fossil remains, may also point to such an environment.

THE SANDY CLAYS OF ANDERLECHT and THE SANDS OF VLIERZELE

(Tables 1, 3 and 8)

Faunae of these two members are mainly known from the Woensdrecht boring. At this locality there is no distinct limit between both units, because of the sandy development of the Anderlecht member.

Thirty-nine samples of Woensdrecht and nine from Belgium yielded fifty-five species and varieties. No one is restricted to these members of the Panisel formation. Frequent are *Cibicides lobatulus*, *Cibicides proprius* and *Textularia agglutinans*.

Of our species and varieties seven are only known from the Ieper formation and the lower Panisel beds, viz.

Anomalina acuta var. *ypresiensis*,
Cibicides proprius,
Globigerina triloculinoides,
Globigerina sp. cf. *G. varianta*,
Globigerinoides sp. cf. *G. daubjergensis*,
Nodosaria minor, and
Spiroplectammina adamsi.

Twelve are only known from the Anderlecht and Vlierzele members, Aalter Sands, and Brussels formation or younger strata:

Bolivina brabantica,
Discorbis sp. cf. *D. ferganensis*,
Elphidium hiltermanni,
Globulina gravida,
Guttulina lactea,
Hastigerina micra,
Miliola saxorum,
Pyrulina thouini,
Quinqueloculina carinata,
Planulina burlingtonensis var. *tendami*,
Rotalia sp. cf. *R. calvezae*, and
Sigmomorphina semitecta.

In the interval of 442 to 387 m of Woensdrecht there is a gradual disappearance of species of the Ieper formation, whereas there is a gradual appearance of those of the Brussels formation. As a consequence the upper parts of the Anderlecht - Vlierzele series of Woensdrecht show associations characteristic of the Brussels formation. As the Brussels formation is commonly regarded as the Belgian representative of the Lutetian the limit between deposits of the Ypresian and those of the Lutetian is somewhere in this part of the Woensdrecht section, probably between 413 and 390 m.

In the Anderlecht and Vlierzele members the families of the Anomalinidae and Textulariidae are frequent, commonly associated by species of the Nonionidae, Polymorphinidae, Elphidiidae, and the Discorbidae.

Probably the water during the sedimentation was always shallow, at least as far as comparison with recent representatives of the encountered genera is admissible. Living species of *Hanzawaia, Textularia, Elphidium, Epistominella,* and *Planulina* are mainly found in water with a depth of less than 50 m (Phleger and Parker, 1951).

THE SANDS OF AALTER

(Tables 1, 3 and 8)

Fifteen foraminiferous samples, seven from Woensdrecht, eight from Cassel (CAA), yielded some thirty species and varieties, none of which was found only in the Aalter Sands. Even no species restricted to the Aalter Sands, Brussels formation and/or younger strata were met with. *Planulina burlingtonensis* var. *tendami* from the Aalter Sands and underlying Anderlecht-Vlierzele series is the only form unknown from the Brussels formation or younger beds. This latter variety and *Textularia agglutinans* are the most numerous forms.

Generally, the faunae of the Aalter Sands resemble closely those of the Vlierzele member and those of the Brussels formation.

Most frequent are species of the Textulariidae and the Anomalinidae, with as common associates members of the Polymorphinidae and Elphidiidae.

At Woensdrecht and at Cassel these faunae indicate a continuation of the depositional circumstances of the Anderlecht-Vlierzele sea. At Aalter (without foraminifera in our samples) more near-shore circumstances seem to have prevailed, with the deposition of a bed with *Venericardia planicosta* (Gardner, 1933, p. 90 : « coarse, heavy-shelled species of *Venericardia* suggesting in-shore waters ») and a layer with worn *Turritella* specimens. If any foraminifera were present, they have probably disappeared by decalcification.

THE SANDS OF BRUSSELS

(Tables 1, 4 and 8)

Some eighty foraminiferous samples, seven of which from Woensdrecht, yielded ninety-four species and varieties. One sample (CO 1240) from the base contained reworked foraminifera of the Ieper formation (*Siphonina prima*). Especially abundant, and as a group more or less characterizing the Brussels Sands, are *Anomalina grosserugosa*, *Cibicides proprius* var. *acutimargo*, *Cibicides lobatulus*, *Cibicides westi*, and *Elphidium laeve*.

Five species are restricted to the Brussels Sands:

Angulogerina sp. cf. *A. ovata*,
Cibicides sp. cf. *C. tallahatensis*,
Discorbis humilis,
Gyroidinella magna, and
Patellina nitida.

Furthermore *Bolivina brabantica* and *Discorbis* sp. cf. *D. ferganensis* are known from the Panisel and Brussels formations only. Seven species of older strata end their range in the Brussels formation, fifteen others begin in these Sands.

The Brussels formation is generally regarded to belong to the Lutetian. Therefore it is remarkable that only forty-nine of the ninety-four Brussels species and varieties were also encountered in our material from the type-region of the Lutetian. On the other hand, fifty out of ninety-nine species and varieties of the French Lutetian deposits are unknown from the Brussels Sands. However, in these comparisons differences of environment may strongly influence the relative numbers.

The Anomalinidae (*Anomalina grosserugosa*, *Cibicides lobatulus*, *Cibicides proprius* var. *acutimargo*, *Cibicides westi*, *Hanzawaia producta*), Nonionidae (*Nonion affine*), Elphidiidae (*Elphidium laeve*) and Epistominidae (*Asterigerina bartoniana*) are especially abundant in the Sands of Brussels. Less numerous to common are species of the Polymorphinidae, Ceratobuliminidae, Discorbidae, Rotaliidae, and Buliminidae.

The faunae point to warm and very shallow water. Some resemblance may exist with recent faunae, found by Lowman (1951), in the Gulf of Mexico off the Rio Grande River, on sandy bottoms with a maximal depth of about 30 m. These associations are dominated by species of *Hanzawaia* and *Elphidium*.

Much of the Brussels formation consists of quartz sands, with relatively poor faunae, but without special features. Mainly in the northern parts of the area the higher sands are calcareous and they contain rich faunae with relatively great numbers of Buliminidae and Rotaliidae, *Cibicides carinatus* and *Cibicides* sp. cf. *C. ungerianus*.

The faunae of Spy (NNA) and Nalinnes (THB) clearly belong to the latter type, but both show some species and varieties unknown from the other samples, as there are *Cibicides* sp. cf. *C. tallahatensis*, *Buliminella striatopunctata* and *Buliminella* sp. cf. *B. pulchra* in Spy, and *Textularia agglutinans* var. *nalinnesensis* and *Gyroidinella magna* in Nalinnes. The sediments of the latter locality are very rich in bryozoan debris, which probably were formed in a coastal part with bryozoan reef patches, somewhat removed from the area with the main sediment supply from the hinterland.

THE LUTETIAN OF THE PARIS BASIN

(Table 1)

In our samples from Grignon and Daméry we found more than ninety species and varieties. They enabled us to compare our Belgian material with topotypes of several species described by Lamarck, d'Orbigny, Terquem, Y. le Calvez, and others. No countings were made, but a conspicuous feature is the abundance of Miliolidae, Elphidiidae, and Anomalinidae.

As noted already the faunae of the French Lutetian material have forty-nine species in common with the Brussels formation. However, a much closer resemblance is found to be present with the associations of the Lede formation, with seventy-three species and varieties in common. In the latter we also have the abundance of Miliolidae and Anomalinidae. Nevertheless we consider the Lede formation to be younger than the French Lutetian deposits, since they also share many species (25) with the still younger Asse formation. Environmental influences are evidently a prevailing factor in these comparisons.

THE SANDS OF LEDE

(Tables 1, 5 and 8)

Our fifty-four foraminiferous samples (eight from Woensdrecht) altogether yielded one hundred and forty-two species and varieties, with predominance of the Nummulitidae (commonly determined as *Nummulites variolarius*), several species of the Miliolidae, Anomalinidae, Rotaliidae, and Polymorphinidae.

Three samples, representing the basal strata of the Lede formation, contained about seventy species, some of which are only known from underlying strata, as, for instance, *Discorbis* sp. cf. *D. ferganensis*.

Species confined to the Lede Sands were not found, but one occurs in these Sands and the basal strata of the Asse formation : *Articulina pseudosulcata*. Seven species and varieties, all miliolids, are restricted to the Sands of Lede and the Lutetian deposits of the Paris basin :

Miliola birostris,
Quinqueloculina crassa,
Quinqueloculina striata,
Renulina opercularis,
Spiroloculina costigera var. *carinata*,
Triloculina propingua, and
Vertebralina laevigata.

Another seven species and varieties of the Lutetian deposits of the Paris basin and the Lede formation were also met with in the basal strata of the Asse formation, which are locally rich in reworked elements of the Lede Sands. These forms are :

Alveolina sp.,
Articulina ornaticollis,
Dendritina depressa,
Globulina gibba var. *myristiformis*,
Spiroloculina costigera,
Spiroloculina tricarinata var. *angulifera*, and
Orbitolites complanatus.

A considerable faunal break is apparent between the Brussels and the Lede formations, with fifteen of the types of the Brussels formation not crossing the boundary, and sixty-nine beginning their range in the Lede Sands.

Most frequent are the Miliolidae (with thirty-nine species and varieties of the genera *Quinqueloculina, Spiroloculina, Articulina, Triloculina, Miliola, Miliolinella, Fabularia* and *Sigmoilina*), the Anomalinidae (*Cibicides carinatus, Cibicides lobatulus, Planulina burlingtonensis*), Rotaliidae (*Rotalia audouini*), the Polymorphinidae (*Globulina gibba*), the Ceratobuliminidae (*Asterigerina bartoniana*), and the Textulariidae (*Textularia agglutinans*). Commonly associated there are species of the Nonionidae, Buliminidae, Elphidiidae, Discorbidae, and Globigerinidae (*Globigerina* sp. cf. *G. angustiumbilicata, Hastigerina micra*).

These very rich faunae seem to indicate a shallow and warm, well-aerated, very calcareous environment, probably reef-like with many bryozoan patches. A reef-like environment is indicated by the presence of *Fabularia* (recent representatives are only known from the Great Barrier Reef of Australia, Collins, 1954), Peneroplidae and many Miliolidae, associated with numerous Anomalinidae and *Rotalia*. The environment probably did not differ much from that of the shallow coastal part of the shelf east of Trinidad (Drooger and Kaasschieter, 1958, p. 15) with its discontinuous reef pattern.

These rich assemblages are especially met with in the region of Gent, Balegem, Asse, Mechelen. Towards the north the samples of Lokeren and Woensdrecht suggest a position outside the « reef » area, because of the poorer faunae and the general increase of the number of Globigerinidae.

THE UPPER BRACKLESHAM BEDS

(Tables 1 and 7)

Our only sample (EG 1) from Whitecliff Bay, Isle of Wight, yielded many nummulites (probably *Nummulites variolarius*) associated with twenty-two species of smaller foraminifera with *Cibicides pygmeus* and *Bifarina selseyensis* as the most abundant types.

Of these species twenty were also found in the Lede formation. The remaining two, *Cibicides pygmeus* and *Cibicides vialovi*, are the most frequent species of the overlying Barton beds of Hampshire. The latter have fourteen species in common with our fauna of EG 1.

Most common are representatives of the Anomalinidae (*Cibicides pygmeus, Cibicides vialovi, Cibicides* sp. cf. *C. tenellus*), Buliminidae (*Bifarina selseyensis*) and Rotaliidae (*Rotalia audouini*).

THE BARTON BEDS

(Tables 1 and 7)

Thirty samples with foraminifera of the English Barton beds altogether yielded some thirty-five species and varieties. *Cibicides pygmeus* and *Cibicides vialovi* are the most common forms.

Of these species fourteen were also met with in the Upper Bracklesham beds. There is much resemblance with the faunae of the Lede and Asse formations. One of the species is confined in Belgium to the Lede formation and the base of the Asse formation: *Quinqueloculina costata*. Two others are in Belgium only known from the Asse formation:

Quinqueloculina bicarinata, and
Cibicides pygmeus.

Only one species, *Cibicides vialovi*, was not met with in Belgium.

Frequent are the Anomalinidae (*Cibicides pygmeus, Cibicides vialovi*) with as common associates members of the Miliolidae, Nonionidae, Rotaliidae, Polymorphinidae, and Elphidiidae.

Probably the Barton beds were deposited in relatively shallow water, with maximal depths of the sea during the sedimentation of the Barton Clays. Afterwards a gradual shallowing finally resulted in the littoral to brackish Headon beds.

THE SANDS OF WEMMEL

(Tables 1, 6 and 8)

Sixty-four foraminiferous samples, two of which from Woensdrecht, yielded altogether one hundred and thirty-nine species and varieties with dominance of *Asterigerina bartoniana* and *Nummulites* (commonly determined as *N. orbignyi* = *N. wemmelensis*).

Eight samples from the basal strata of the Wemmel Sands already contained one hundred and ten species, twelve of which are unknown from the higher Wemmel Sands. They are considered to have been reworked from older strata. None of our species is restricted to the Wemmel Sands, but together with the Asse Clays seven forms are confined to the Asse formaton :

Bolivina cookei,
Bulimina ovata,
Dentalina sp. cf. *D. baltica*,
Globulina gravida var. *lineata*,
Pseudoclavulina sp. cf. *P. cocoaensis*,
Loxostomum teretum, and
Uvigerina spinicostata.

Furthermore one species is known from the Wemmel Sands as well as from the English Barton beds: *Cibicides pygmeus*.

Four species make their appearance in the Wemmel Sands, and continue into the Belgian Rupel formation:

Epistomina elegans,
Eponides umbonatus,
Karreriella siphonella, and
Nodosaria ludwigi.

Most frequent are the families Anomalinidae (*Cibicides dutemplei, Planulina burlingtonensis*), Ceratobuliminidae (*Asterigerina bartoniana*), Miliolidae (*Miliola saxorum, Quinqueloculina carinata*) and the Polymorphinidae (*Globulina gibba*). Representatives of the Nonionidae, Rotaliidae, Textulariidae, Epistominidae and Discorbidae are common.

In general, the circumstances of sedimentation during the deposition of the Lede Sands seem to continue, but probably with a somewhat greater sediment supply from the hinterland. The Miliolidae are less frequent and the Peneroplidae are absent. However, these features may also be the consequence of a greater depth. These conclusions are mainly based on data from the Asse-Wemmel area and from the boring Heist-op-den-Berg. Regarding the variable lithology of the Wemmel Sands they have as yet only a restricted value.

THE CLAYS OF ASSE

(Tables 1, 6 and 8)

Our twenty-three foraminiferous samples of the Asse Clays, among which one from Woensdrecht, yielded ninety-three species and varieties. Only *Gyroidina* sp. cf. *G. soldanii* is confined to the Asse Clays.

One sample (BW 1273) was from the basal beds of the Asse Clays. It contains two species unknown from the other Asse Clays samples. As recorded already the Asse Clays and the Wemmel Sands have seven species in common not known from other Belgian rock units.

Not withstanding the change from sand to clay only three species of the Asse Clays are not known from the Wemmel Sands. But the Clays contain much less individuals of nearly all the species.

Most frequent are species of the Anomalinidae (*Cibicides dutemplei*) and the Ceratobuliminidae (*Asterigerina bartoniana*), commonly associated with representatives of the Nonionidae, Rotaliidae, Globigerinidae, Miliolidae, and Buliminidae.

In comparison with the recent associations of the Gulf of Mexico a maximal depth of 50 to 60 m, but probably less, seems to be reasonable (LOWMAN, 1949; PHLEGER and PARKER, 1951). The environment will have resembled that of the Wemmel Sands, with again warm, well-aerated water, but probably in a more offshore part of the sea.

These conclusions are valid only for the lower part of the Asse Clays, the higher parts containing no or very poor microfaunae.

THE LOWER TONGEREN BEDS

(Table 1)

In 1958 BATJES described some twenty species derived from the Lower Tongeren beds of Dutch South Limburg. The faunae, dominated by *Asterigerina bartoniana, Cibicides dutemplei* and *Nummulites* (probably *N. orbignyi*) show a closer resemblance to our Wemmel and Asse assemblages than to those of the Rupel formation. This was also concluded by BATJES.

Only four of BATJES' species are not present in our faunae of the Asse formation :

Glandulina aequalis,
Gyroidina soldanii,
Pyrulina fusiformis, and
Pullenia quinqueloba.

For the species of the Polymorphinidae this is due to difference of determination. So only *Pullenia quinqueloba* and *Gyroidina soldanii* were not met with in the Asse deposits, but these general forms cannot be given much weight.

On the other hand four of the species of these Lower Tongeren beds were not found in the Rupel formation:

Textularia agglutinans,
Alabamina wolterstorffi,
Asterigerina bartoniana, and
Nummulites germanicus.

The species of the Lower Tongeren beds which are also known from the Rupel formation occur as well in our Lede and/or Asse formations.

CHAPTER V

TIME-STRATIGRAPHIC INTERPRETATION

INTRODUCTION

In the previous chapters it was tried to stress the importance of formations and members as the fundamental units of the stratigraphy of the Belgian Eocene. In current European usage the word « formation » is given a rock-stratigraphic as well as a time-stratigraphic interpretation, such as in GIGNOUX's handbook « Géologie Stratigraphique » (1950, 4th ed., pp. 15-28) in which « étage » and « formation » are regarded as synonyms without a sharp distinction.

In this chapter a time-stratigraphic interpretation will be attempted of the available rock-stratigraphic data. However, this interpretation must be tentative, because of the lack of a reliable picture of the Belgian subsoil and because of the insufficient paleontological knowledge of many of the rock units. Further study of species or species groups will be needed to find evolutionary series which are independent of the sedimentary environment. Such series have not yet been described and neither were they obvious during our survey of the microfauna. For the moment the time relations of the major rock units have to be inferred from the faunal associations, combined with all other data on sediment, etc.

In the commonly accepted chronology of the Belgian Eocene, the rock units are placed in four stages: Ypresian, Lutetian, Ledian and Bartonian. However, in our opinion, it is preferable to unite the Ledian and Bartonian to one stage: the Bartonian.

As has been pointed out already in Chapter II, RUTOT (1883*a*) recognized a number of cycles of sedimentation during the Eocene, and he made each stage correspond with the time of a complete cycle. Each complete cycle should begin with a marine transgression, ushering into a marine phase, and followed by a regression and an increased spreading of continental conditions into the Belgian basin. However, the cycles are usually not complete. During the Eocene the sea probably abandoned the entire basin only once, namely, at the end of the Lutetian.

In the next paragraphs the history will be described of each stage of the Eocene in connection with the concept of the cycle of sedimentation. This is not done because the cycle is thought to be such a good basis for chronologic units, but in order to avoid unnecessary deviations from the traditional stratigraphy, especially since we cannot place at the moment the chronology on a sound paleontological basis alone.

PALEOGEOGRAPHY

The northern and northeastern parts of the basin have always had the most rapidly descending parts of the Paleozoic-Cretaceous basement. A maximal depth of −739 m O. D. Oostende is known at Turnhout.

Another important descending part is found in the E-W depression of the Haine basin, with the Cretaceous basement deeper than −100 m O.D. Oostende. Towards the east the depression ends in the region of La Louvière, towards the west it continues in northern France, running parallel to the Axis of Artois and probably shallowing gradually.

In between the Haine basin and the northern subsiding area the Swell of Namur-Oostende (Fourmarier, 1934) paralleled the Axis of Artois. Most Cretaceous strata, originally covering this swell, have been removed by early Tertiary erosion, and from the area of Tielt towards the southeast, Paleozoic rocks are at the base of the Tertiary strata. Differential movements of the swell were important during the Eocene, especially in the western part near Oostende.

In the southeast and south the area is bordered by the Ardennes and their western continuation into the Axis of Artois, which to-day is still a prominent geomorphologic feature of northern France. The available data point to relative movements of the Axis during the Eocene, since Eocene strata on the Axis are almost completely unknown. However, reworked elements of Eocene rocks reveal that one or more times during the Eocene the Axis was, at least partly, covered by the sea (Leriche, 1909).

LANDENIAN

Our discussion of the Eocene stages necessitates some remarks on the preceding Landenian.

During the Landenian two successive marine members were deposited in western Belgium: the Clays of Louvil and the Sands of Grandglise. The Sands, which are very glauconitic in their basal strata, show an upward diminishing of the content of this mineral, accompanied by an increasing number of tubulations, probably worm tubes, and more frequent irregular bedding. These features are often used as arguments for the assumption of deposition during the regressional period of the Landenian cycle (Gulinck, 1948).

The diminishing of the glauconite content is not a convincing argument, since the origin of autochthonic glauconite is thought by most authors to be closely related with a low rate of sedimentation (Cloud, 1955). Its diminishing in the Sands of Grandglise rather indicates an increase of sediment supply, which of course is possible if the regression lowered the erosion base of the rivers and thus caused a greater transport.

The shallowing depth during the deposition of the Sands of Grandglise is logically followed by the spreading of the lagoonal and continental conditions as they are found in the Sands of Oostende and the Sands of Erquelinnes and of Landen.

The Oostende Sands are known from the area of the Swell of Namur-Oostende and vicinity. The area of these sands more or less coincides with that of low thicknesses of the entire Landen formation (see map 7). The fauna of the Oostende Sands, with *Cyrena cuneiformis*, *Melania inquinata*, and the ostracode *Cyprideis*, is distinctly brackish. Many lignitic intercalations may point to a lagoonal origin of the Sands. The same type of deposits, also with lignitic intercalations, is known from the Woolwich beds of the London basin.

In the boring Oostende the Oostende Sands cover the Clays of Louvil, in the other occurrences the Grandglise Sands (see map 8). As far as the subsoil data are reliable the thickness diminishes in eastern and southern directions. The nothern and western extension is unknown.

In Hainaut and in northern France, in between the area of the Oostende Sands and the Sands of Erquelinnes, the Clays of Ieper directly cover the Grandglise Sands. This absence of either Oostende Sands or Erquelinnes Sands was explained by Stevens (1914) and Leriche (1928) by pre-Ypresian erosion. Such an assumption cannot be proved or disproved. In the basal layers of the Ieper Clays indications of an erosion period and a transgression are absent or very rare. A gradual passage between both members is fairly common. In this area there might as well have been continuous sedimentation from the Grandglise Sands into the Ieper Clays.

Alongside the Landen Sands of the Hesbaye there is another strip with Ieper Clays directly covering Grandglise Sands. This area furnishes no reliable data about the base of the Ieper Clays, but a continuous marine sedimentation may be suspected. Anyhow, if we assume erosion also for this strip, the erosion would have resulted in a very peculiar pattern.

These facts may also be explained by an arm of the Landenian sea in northern France and southern Flanders during the regressional period of the Landenian cycle, as it was assumed by Feugeur (1955). However, in such an explanation it is somewhat difficult to understand the brackish environment of the Oostende Sands in the seaward part.

In our opinion a third line of argumentation can be followed.

It is likely that during the time of maximal transgression of the Landenian sea the Louvil Clays were deposited in almost the whole basin with sedimentation of the Sands of Grandglise along the coasts. The following regression was accompanied by a lowering of the erosion base of the rivers and an increased rate of sedimentation, which caused the spreading of the Grandglise Sands over a greater part of the basin. During the deposition of the Sands the sea gradually shallowed, and it may be assumed that the upper parts of the Sands were deposited near sea level in some kind of a sandy « Wadden »-environment.

In the offshore area near Oostende the shallowing of the sea resulted in the passing of the Louvil Clays into the brackish Oostende Sands, which were deposited in a fringe along the sandy area of the Grandglise Sands. Possibly the fresh water was supplied through some shallow channels across tidal flats.

Along the borders of the basin continental conditions prevailed, and the Sands of Landen and of Erquelinnes were deposited. From research of Rutot (1884, 1887, 1903), Stevens (1914), Leriche (1928) and Gulinck (1948) a three-fold division of the Sands of Landen and of Erquelinnes became apparent. Such a division was also found by Briquet (1906) in the Upper Landen beds of northern France:

1. At the base there are fine-grained sands, with a gradual transition into the underlying Grandglise Sands.

2. These deposits were ravinated. Briquet (1906) and Gulinck (1948) assumed that a lower erosion base of the rivers during the regression caused the incision of channels, especially found in northern France, but also in the Hesbaye. Their greatest depth was reached at the moment of maximal regression of the Landenian sea.

A new transgression caused the filling of the channels, first with coarse sediments which gradually passed into finer grained deposits with increasing regularity of the bedding, thus changing into the third type.

3. This type is again formed by fine-grained sands with intercalated marls, lignites and lignitic clays.

Especially in the Hesbaye the sediments of the second type are often absent, and sediments of the first and third type pass into each other.

Summarizing the following correlation may be put forward. During the time of maximal regression the sea still covered parts of Belgium. The brackish deposits of the Oostende Sands are thought to correspond with about the erosion period of the Landen and Erquelinnes Sands. In between there was a strip with tidal flats where sedimentation of the Grandglise Sands continued. During the new transgression the channels were filled, and the Upper Sands of Landen and Erquelinnes were deposited.

In the meantime marine conditions gradually entered the basin, resulting in the deposition of the Ieper Clays, which successively covered the Oostende Sands, Grandglise Sands, and the seaward parts of the Sands of Landen and of Erquelinnes.

In Hainaut STEVENS found the Sands of Erquelinnes to pass upwards into the basal beds of the Sands of Péissant, which according to their fossils belong to the Ieper formation, and probably represent littoral sediments of the Ypresian.

Nearly identical relations exist between the members of the Landenian cycle in the London basin. In this basin the Thanet Sands form the lower marine part of the Landenian. They thin out along the borders of the basin, where they are overlain by the Woolwich and Reading beds (see fig. 3).

The bulk of the Woolwich beds show the same lithology and fossils as the Oostende Sands, and they are explained by a deposition in shallow lagoons on the seaward side of the delta's of the Reading beds. The delta's were traversed by several distributaries, as appeared from several shingle-filled channels. In the meantime glauconitic sands were accumulating in the sea of the centre of the basin, the northeastern part of Kent.

YPRESIAN

It has been shown already that the lower part of the marine Ieper Clays is thought to be contemporaneous with the upper part of the continental to lagoonal Upper Landen beds. The Ypresian cycle started with the relative rise of the sea, which caused the filling of the erosion channels in the Upper Landen beds and the shifting of lagoonal conditions towards the borders of the basin.

The marine sediments of the Ypresian cycle begin with the Ieper Clays, which may have a sandy base, sometimes with silex pebbles. Mostly, however, such coarse basal beds are absent, and there are no indications of an emersion period before the deposition of the clays.

On the base of foraminiferal associations a threefold division of the Ieper Clays was possible at Woensdrecht. Future research has to reveal whether this subdivision can really be applied over a greater area, but it certainly reflects a logical cycle during the deposition of the clays.

At Woensdrecht as well as at Mouscron (FEUGUEUR and Y. LE CALVEZ, 1951) the foraminiferal associations indicate shallow marine to lagoonal conditions for the lower part of the Ieper

Clays. Rutot (1893) also concluded to such conditions for this lower part from the presence of lignite remains. It may be expected that the sediments of this lagoonal phase of the early Ypresian occupy a wide area in Belgium. They would logically correspond to the advancing transgression.

The rich foraminiferal assemblages of the middle part of the Ieper Clays at Woensdrecht correspond with a period of maximal depths of deposition during the Ypresian cycle. It may be concluded from the fauna that the water depth gradually diminished during the deposition of the upper Woensdrecht Clays. The bulk of the Belgian Ieper Clays has been found to correspond with that of the middle and upper Woensdrecht zones.

The Ieper Clays occur over most of the basin, with greatest thicknesses in northwestern Belgium (see map 10). During their deposition, there was no activity of the Swell of Namur-Oostende, except for the southeastern part near the border of the basin. The irregularities of the isopach lines in the region of Gent, with northwestern to southeastern anomalies cannot be accounted for.

No continental of lagoonal deposits contemporaneous with the higher parts of the Ieper Clays can be pointed out. Probably, they were deposited outside our present area and have been removed by later erosion.

It appears from the faunae that shallow conditions prevailed over the entire basin after the deposition of the Ieper Clays. They resulted in the Clays of Roubaix and the fine-grained Sands of Mons-en-Pévèle. These two members pass laterally into each other, as was demonstrated in the region north of Mons-en-Pévèle (Hérent, 1895).

Fourmarier (1934) thought that thicknesses of the Sands of Mons-en-Pévèle generally increased towards the southeastern part of the Belgian basin, but map 12 reveals that the greatest thicknesses occur in northeastern Belgium and in the region of Mons-en-Pévèle. In the area in between the isopachs are irregular and there are, for instance, fairly great thicknesses near Renaix and around Brussels. In western Belgium the Swell of Namur-Oostende also shows relatively great thicknesses. Another expression of the activity of the Swell in this area of Torhout and Tielt is found in the increasing grain-size of the top beds of the Sands of Mons-en-Pévèle, which gradually pass upwards into coarse deposits of the base of the Panisel formation.

From this thickness pattern it may be concluded that the material came partly from northeastern directions, partly from the region of the Axis of Artois. The irregular distribution in between may be the result of currents and wave action in the shallow sea. Probably there were shoals, where winnowing out of the smaller particles resulted in coarser sands.

Furthermore there was an area in the sea where clay sedimentation persisted with the deposition of the Roubaix Clays. Possibly the water was somewhat deeper and was certain to be quieter than it was assumed for the Sands of Mons-en-Pévèle. However, the faunae of the Roubaix Clays do not clearly indicate such a greater depth of deposition.

There are but a few indications for a further general regression of the sea during the deposition of the Sands of Mons-en-Pévèle. For instance, the coarse sands of the Namur-Oostende Swell point to a local shallowing.

The connection of our Belgian sea with that of the Paris basin is sought for in the region of Mons-en-Pévèle and Douai. Many reworked elements of the Sands of Mons-en-Pévèle are present in the Quaternary of this low part of the Axis of Artois. There are also some exposures.

Feugueur (1951) supposed a close connection between the Sands of Mons-en-Pévèle and the Sands of Cuise, even with contemporaneity over this long distance for a level of limestone with nummulites. However, some doubt may be expressed about this correlation because of the restricted environment of such larger foraminifera.

Shoreward deposits of the entire Ieper formation are generally thought to be represented by the Morlanwelz member of eastern Hainaut and similar deposits in the Kempen. Unfortunately they are faunistically indefinite, foraminifera being nearly entirely lacking. The Sands of Péissant may be remnants of a still more coastal type of the Ieper formation.

In western Belgium the Ieper formation is overlain by the various members of the Panisel formation. The basal Roncq Clays are absent in the area of Torhout and Tielt, where the base of the Panisel formation is formed by coarse-grained deposits, underlying Sandy Clays of Anderlecht. The Roncq Clays are furthermore absent near Mons and in the Kempen.

It is not clear whether this irregular distribution of the Roncq Clays is due to local non-deposition or to environmental differences in the shallow sea during this time.

The Roncq Clays are often supposed to be of lagoonal origin (Rutot, 1885), but the regular thickness in the greater part of the basin as well as the presence of pockets with marine fossils do not support this supposition. These pockets of worn fossils are considered to point to an origin in very shallow water, as was also concluded from the fairly poor foraminiferal faunae. Possibly the Roncq Clays even correspond with the time of maximal regression of the Ypresian sea.

Overlying the Roncq Clays the Sandy Clays of Anderlecht gradually pass upwards into the Sands of Vlierzele. Both the Anderlecht and the Vlierzele member have a larger distribution than the Roncq Clays.

The Sandy Clays of Anderlecht are mostly clayey in the northwestern part of the Belgian basin (as near Pittem), with gradually and irregularly decreasing clay content towards the southern and eastern borders of the basin. At the mont Panisel the clayey character of the Anderlecht member is still distinct, but in the Woensdrecht boring and near Cassel the Clays of Roncq are directly overlain by sandy beds.

Gulinck (1952) assumed a « Wadden » facies for all these Panisel sediments, especially because of the erosion channels, intrastratal crumpling structures, clay lenses and pebbles, many tubulations in the sandy beds, and the fact that the bedding has always been disturbed by organic action.

Gulinck supposed during the sedimentation of the Panisel formation an initial period with mainly clay supply (Clays of Roncq). Later the sand supply increased intermittently, but constantly, resulting in the Sandy Clays of Anderlecht and finally in the Vlierzele Sands.

Probably the continuous sandy deposits of the Anderlecht and Vlierzele members in the Woensdrecht boring were formed in a fully marine environment, and somewhat deeper than the deposits of western Belgium, as far as may be concluded from the foraminiferal faunae.

This boring is the only place in our records with distinct continuous marine sedimentation from the Ypresian into the Lutetian. The composition of the microfaunae shows a gradual change of an Ypresian assocation into a Lutetian one.

Also Gulinck and Hacquaert (1954) stressed the fact that the Vlierzele Sands and the Brussels Sands must have been deposited under comparable circumstances, which resulted in a nearly identical lithology. In exposures glauconitic sands are often determined on the basis of presence or absence of lime, as Brussels or as Vlierzele Sands, respectively. This close resemblance also favours the idea of time equivalence of the Brussels Sands with at least part of the Vlierzele member.

Originally Belgian geologists, as Rutot and others, supposed that the « Paniselian » (our Panisel formation) represented a sedimentary cycle in between the Ypresian and the Lutetian. Later research, however, disproved that idea and so the Lower Panisel beds were classified as part of the Ypresian cycle (Leriche, 1937), and the Upper Panisel beds as the lowermost strata of the Lutetian cycle. This classification, also adopted for the legend of the Geological Map (1931), does not answer all questions. Especially the relations between the Aalter Sands and the Vlierzele Sands are a matter of conjecture. Sediments of the Aalter Sands facies are of restricted horizontal distribution. Possibly they are without time-stratigraphic meaning.

The same is true for the Sands of Aalterbrug in the region of Aalter, which are said to mark the boundary between the Lutetian and the Ypresian, corresponding to the moment of maximal regression between both cycles (HACQUAERT, 1939). They might as well be interpreted as a deposit of again local importance, and without any indication for the general movements of the sea level.

Summarizing it may be concluded that after the deposition of the Sands of Mons-en-Pévèle the regressive period continued, but that the sea did not abandon the Belgian area. In the open sea a fauna with close affinities to the Ypresian one gradually changed into a Lutetian one. In most of the Belgian area various deposits were formed in a very shallow sea of « Wadden » type, in which the sand supply increased with time. Minor fluctuations of the environment caused special deposits, such as the Sands of Aalterbrug, or the shell-rich levels of the Aalter Sands.

LUTETIAN

As has already been explained the beginning of the Belgian Lutetian has to be looked for in the Vlierzele Sands.

LERICHE (1937) concluded that the Aalter Sands belong to the Lutetian cycle on account of the presence of dubious *Nummulites lucasi*. He regarded the Aalter Sands as the lowermost part of the Lutetian succession with unknown equivalent in the Paris basin. The fish fauna of CASIER (1949) supported the opinion of LERICHE.

In the subdivision of LERICHE (1950) for the strata of Lutetian age, the Aalter Sands are followed by the Brussels Sands. In our opinion these units might as well be lateral equivalents. Furthermore LERICHE considered the western Brussels Sands, without nummulites, to be older than the eastern Sands with *Nummulites laevigatus*. But here again the explanation of lithologic variations of synchronous deposits cannot be dismissed.

The coarse-grained deposits along the eastern border of the Brussels Sands area seem to represent a coastal strip with much sediment supply, probably from southeastern directions. Towards the west and also in upward direction there is a change into fine-grained calcareous sands. Evidently transport diminished in later time.

This concept offers no explanation for the coarse sands near Wauthier-Braine, unless a second directon of sand supply is supposed from the southwest.

The northern contacts of Brussels Sands and Panisel formation without indications of a basal gravel of the former again point to close connections between both units.

Higher parts of the Brussels formation have evidently been removed by erosion. At Cassel as well as at Woensdrecht sandy and calcareous banks with nummulites were met with near the top of the supposed Brussels Sands. The basal beds of the Lede formation in about their whole area contain many reworked elements of such banks, as for instance nummulites, sandstone pieces, etc., which prove the existence of an important erosion period before the deposition of the Lede formation. GULINCK and HACQUAERT (1954) supposed that the lower part of the Brussels Sands had been present in western Belgium. LERICHE (1922) even assumed that the whole series comparable to the Lutetian sequence of the Paris basin had originally been deposited all over Belgium, and that afterwards it had been eroded, with preservation of only the lowermost member, the Brussels Sands, in the eastern area. Data about the lowermost zones of the French Lutetian are very scarce, however, and they do not justify at the moment a close correlation of the Brussels Sands with any part of the Lutetian series. LERICHE justified his correlation on features of the evolution pattern of the group of *Nummulites laevigatus*, but as long as no revision of this group is available this basis is considered to be very poor.

Our microfaunae show no close resemblance with those of the Lutetian of the Paris basin, which rather resemble our Lede associations. As a matter of fact the environment of the microfauna of the Brussels Sands must have been a very special one, of which we have no distinct recent equivalent (see also KEIJ, 1957, p. 21).

BARTONIAN

The Ledian and Bartonian are united to one stage because of the incomplete regression in between, and especially because of the great resemblances of the faunae.

The base of the Lede formation (map 15) is fairly regular, but in minor details there seems to be some ravination of the Brussel Sands. The coastline of this time was probably roughly east-west.

An interesting feature in the distribution of the Lede Sands is the area in western Belgium with absence of these sands. Possibly there was an island, or a shoal without deposition at this place. Along this structure glauconitic sands, the Sands of Strymees, have been deposited.

Deposition of the Lede Sands occurred on a more or less flat sea bottom, in shallow water, in which there was a very rich life connected with more or less distinct reef-like structures with many bryozoans. Our rich foraminiferal faunae were especially met with in the south between Balegem and Mechelen. Towards the north the fauna impoverished, probably because of increasing depths of the water.

It is not unlikely that the Sands of Rocourt form an eastern equivalent of the Lede Sands (VELGE, 1897; BATJES, 1958). This would mean that originally the Lede Sands covered a much greater area than it is currently assumed. In this way they get the same distribution as the combined Asse formation and Lower Tongeren beds.

LERICHE (1943) supposed that the sea of the Lede Sands regreded, but only partly left the Belgian area; after a short time a fresh transgression started and the sea again covered the whole area. Often a basal gravel, underlying the Wemmel Sands, suggests that some ravination took place before deposition. However, at other places such a gravel is absent and the sedimentation from Lede into Wemmel Sands appeared to be continuous (LERICHE, 1943).

In the Netherlands as well as in Germany these movements of the sea are not reflected in the sediments, and the deposits are often referred to as the Bartonian s.l.

A separate area of northwestern occurrences of the Wemmel Sands is found in the region with absence of the Lede Sands (see maps 15-18). This again suggests the presence of an island or a shoal.

Most data about the Wemmel Sands, however, come from the Asse-Brussels area. In the vicinity of Wemmel they form a homogeneous mass of sand with very rich faunae, but southeast of Brussels they are current-bedded sands with variable grain-size and intercalated gravel beds. The latter type of sands is also known from the region of Asse where they contain many worm tubes and clayey intercalations.

These deposits of Brussels and Asse have probably been deposited near the coast of the transgreding Wemmel sea. Those of Wemmel were deposited somewhat farther offshore.

Generally, the Wemmel Sands seem to form the near-shore deposits of the later Bartonian sea. At greater distance from the land, the Asse Clays were deposited. They cover the Lede Sands without Wemmel Sands in between.

In a later period the sand transport diminished and the clay sedimentation spread over the sandy areas towards the south and east. In the southern and eastern part the entire section of the clays is glauconitic. No indications for an allochtonous origin of the glauconite were found in our samples, so a low rate of sedimentation for this glauconitic parts must be suspected (Cloud, 1955). Towards the centre of the basin the middle part of the clays is devoid of glauconite, which middle part decreases in thickness in the direction towards the supposed coast.

The deposition of the Asse Clays was followed by a period of sandy sedimentation, but an important clayey intercalation in the lower part of these Asse Sands suggests an again decreased sand supply during part of the time.

A similar clayey intercalation was observed by Mourlon (1905) as far southeast as the area between Tervuren and Leuven. It was considered by this author to belong to the Lower Tongeren beds. Lithologically this clay of Tervuren and that of the Asse Sands are identical, except for a more sandy character near Tervuren.

West of the Hageland the Asse Sands are covered by the Rupel formation. The occurrences of Lower Tongeren beds reported from this area were fully discussed by Batjes (1958), who concluded that their presence could not be proved.

Only in the area east of Leuven and as far as western Germany have distinct Lower Tongeren beds been found. Generally a bipartite division of these beds is present, with the slightly clayey Sands of Grimmertingen below, covered by the Sands of Neerrepen. The Sands of Grimmertingen seem to be more clayey in the western part of the area (see Batjes' localities LN and LO). The lithology of the sandy clay at the locality LN even corresponds with that described by Mourlon of the clays west of Leuven. Lithologic parallelization of the lower Asse Sands and the Grimmertingen Sands is considered likely.

Moreover Batjes' faunae of the Lower Tongeren beds of Dutch South Limburg have so many affinities with the faunae of the Asse formation, that they are probably contemporaneous.

Batjes supposed the time-stratigraphic equivalence of the Asse and Lower Tongeren deposits; the enumerated paleontological and lithological data may be regarded as supporting his ideas.

It is therefore reasonable to suppose that the Bartonian sea also covered parts of eastern Belgium. After the deposition of the Asse and Lower Tongeren beds a more or less distinct regression occurred, the sea leaving the eastern area. Afterwards followed the deposition of the continental to lagoonal Upper Tongeren beds, which Batjes supposed to represent the coastal equivalents of the Rupel formation.

Possibly the sea did not leave the more northern and western parts of the basin, which may explain the rare occurrences of a basal gravel of the Rupel formation.

CHAPTER VI

SYSTEMATIC DESCRIPTION OF THE FORAMINIFERA

The species and higher taxonomic units have been arranged according to the classification of SIGAL (1952, in PIVETEAU, Traité de Paléontologie, vol. 1), which is considered to be more up to date than that of CUSHMAN (1950, Foraminifera, their classification and economic use, 4th rev. ed.).

Altogether some two hundred and twenty-five species and varieties were recognized. The following are considered to be new:

Textularia agglutinans (D'ORBIGNY) var. *nalinnensis*,
Spiroloculina tricarinata TERQUEM var. *belgica*,
Spiroloculina costigera TERQUEM var. *nuda*,
Articulina pseudosulcata,
Articulina flandrica,
Miliola prisca (D'ORBIGNY) var. *terquemi*,
Fabularia bella,
Globulina gravida (TERQUEM) var. *lineata*,
Bolivina brabantica,
Uvigerina batjesi,
Angulogerina abbreviata (TERQUEM) var. *tubulifera*,
Nonionella wemmelensis,
Planulina burlingtonensis (JENNINGS) var. *tendami*.

Furthermore two existing species had to be renamed, for which the following names are proposed:

Triloculina lecalvezae,
Bulimina parisiensis.

The greater part of the material is stored in the paleontological collections of the Mineralogisch-Geologisch Instituut of the State University at Utrecht (S 6.369-12.158). The specimens and samples of the boring Woensdrecht have been deposited in the collections of the Geological Survey of the Netherlands at Haarlem. Furthermore a collection of most of the recognized types will be stored in the Institut Royal des Sciences Naturelles de Belgique at Brussels.

FAMILY RHIZAMMINIDAE

Genus RHIZAMMINA H. B. BRADY, 1879

Type species RHIZAMMINA ALGAEFORMIS H. B. BRADY, 1879

Rhizammina sp.

6

Remarks. — Two groups of individuals were found, different from one another in the grain-size of the agglutinated material. The coarser ones resemble the specimen of *Bathysiphon* cf. *eocaenica* CUSHMAN and HANNA, figured by STAESCHE and HILTERMANN (1940, Mikrofaunen aus dem Tertiär Nordwestdeutschlands, pl. 37, f. 4); the more finely arenaceous ones the specimen of this species of pl. 37, f. 5 of the same authors.

No trace of sponge spicules, characteristic for the genus *Bathysiphon*, could be found.

TEN DAM (1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, pp. 72, 73) described *Rhizammina* as well as *Bathysiphon* from both the Paleocene and the lower part of the Ieper Clays of the Netherlands.

Distribution. — Netherlands (Woensdrecht): Ieper Clays.

FAMILY AMMODISCIDAE

Genus AMMODISCUS REUSS, 1862

Type species OPERCULINA INCERTA D'ORBIGNY, 1839

Ammodiscus incertus (D'ORBIGNY)

Pl. I, fig. 1; *16*

Operculina incerta D'ORBIGNY, 1839, in DE LA SAGRA, Hist. Phys. Nat. Cuba, Foraminifères, p. 49; vol. 8, pl. 6, f. 16, 17 (recent; Cuba, Martinique).

Ammodiscus incertus (D'ORBIGNY), H. B. Brady, 1884, Rep. Voy. Challenger, vol. 9, p. 330, pl. 38, f. 1-3; CUSHMAN, 1918, U. S. Nat. Mus., Bull. 104, pt. 1, p. 95, pl. 39, f. 1-7; TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 76, pl. 1, f. 10.

Remarks. — The specimens were especially found in the lower part of the Ieper Clays of the boring Woensdrecht. They are mostly more or less compressed. Regularly coiled forms have been deformed to somewhat angular specimens. Some individuals resemble those of *Glomospira* species.

TEN DAM (1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 77) described *Glomospira charoides* (JONES and PARKER) from the Ieper formation of the Netherlands.

Distribution. — Belgium : Ieper Clays, Sands of Mons-en-Pévèle, Sands of Aalter, Sands of Lede;
Netherlands (Woensdrecht) : Ieper Clays, Lower Panisel beds.

FAMILY CORNUSPIRIDAE

Genus CORNUSPIRA SCHULTZE, 1854

Type species CORNUSPIRA PLANORBIS SCHULTZE, 1854

Cornuspira bornemanni REUSS

Pl. I, fig. 2; *203*

Cornuspira bornemanni REUSS, 1863, Sitz. ber. K. Ak. Wiss. Wien, vol. 48, pt. 1, p. 39, pl. 1, f. 3 (Oligocene; Germany).

Remarks. — The species differs from *Cornuspira carinata* (COSTA) (*Operculina carinata* COSTA, 1856, Atti Accad. Fontaniana Napoli, vol. 7, pt. 2, p. 209, pl. 17, f. 15; *Cornuspira carinata* (COSTA), H.B. BRADY, 1884, Rep. Voy. Challenger, vol. 9, p. 201, pl. 11, f. 4) by the presence of growth lines and by the higher tube. Some of our specimens lack the carina.

Distribution. — Belgium: Sands of Lede, Sands of Wemmel.

Cornuspira involvens (Reuss)

Pl. I, fig. 3; *191*

Operculina involvens Reuss,1850, Denkschr. K. Akad. Wiss. Wien, Math.-Nat. Cl., vol. 1, p. 370, pl. 46, f. 20 (Miocene; Vienna basin).

Cornuspira involvens (Reuss), H. B. Brady, 1884, Rep. Voy. Challenger, vol. 9, p. 200, pl. 11, f. 1-3.

Remarks. — Our specimens are variable in their slight degree of compression.

Distribution. — Belgium: Lede Sands, Wemmel Sands.

Family SPIRILLINIDAE

Genus SPIRILLINA Ehrenberg, 1843

Type species SPIRILLINA VIVIPARA Ehrenberg, 1843

Spirillina spp.

140

Remarks. — Our ill-preserved specimens of *Spirillina* possibly belong to *S. striato-granulosa* Terquem (1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 33, pl. 1, f. 30; Y. le Calvez, 1949, Mém. Carte Géol. dét. France, pt. 2, p. 11, pl. 1, f. 3, 4) and to *S. simplex* Y. le Calvez (1949, Mém. Carte Géol. dét. France, pt. 2, p. 13, pl. 1, f. 1, 2). Specimens of the first group were only found in the Sands of Brussels. Both species were originally described from the Lutetian deposits of the Paris basin, France.

Distribution. — Belgium: Sands of Brussels, Sands of Lede, Sands of Wemmel; France: Lutetian.

Family HAPLOPHRAGMIIDAE

Genus CRIBROSTOMOIDES Cushman, 1910

Type species CRIBROSTOMOIDES BRADYI Cushman, 1910

Cribrostomoides sp.

Pl. I, fig. 4, 5; *4*

Remarks. — A number of specimens from the lowermost Ieper Clays of the boring Woensdrecht probably belong to this genus. They are all more or less distorted and ill-preserved. The apertural features are so indistinct that our specimens might as well belong to the genus *Barkerina*.

In the terminology of the apertures (Frizzell and Schwartz, 1950, Bull. Missouri School Mines, Techn. Ser., no. 76, pp. 1-12) our specimens belong to the « Multiple Apertured forms »

Distribution. — Netherlands (Woensdrecht): Clays of Ieper.

Genus HAPLOPHRAGMOIDES CUSHMAN, 1910

Type species HAPLOPHRAGMIUM CANARIENSE D'ORBIGNY, 1839

Haplophragmoides sp.

Pl. I, fig. 6; *5*

R e m a r k s . — In some samples of the lower Clays of Ieper of the boring Woensdrecht a number of ill-preserved, mostly distorted specimens of *Haplophragmoides* were found. Some individuals more or less resemble *H. eggeri* CUSHMAN (1926, Bull. A. A. P. G., vol. 10, p. 583, pl. 15, f. 1; TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 79) but they are bigger than the original specimens.

D i s t r i b u t i o n . — Netherlands (Woensdrecht): Clays of Ieper.

Genus AMMOBACULITES CUSHMAN, 1910

Type species SPIROLINA AGGLUTINANS D'ORBIGNY, 1846

Ammobaculites sp. cf. **A. americanus** CUSHMAN

Pl. I, fig. 7; *1*

cf. *Ammobaculites americanus* CUSHMAN, 1910, U. S. Nat. Mus., Bull. 71, pt. 1, p. 117, f. 184, 185 (recent; W coast of Mexico); CUSHMAN, 1920, U. S. Nat. Mus., Bull. 104, pt. 2, p. 64, pl. 12, f. 6, 7.

cf. *Haplophragmium fontinense* H. B. BRADY (not TERQUEM), 1884, Rep. Voy. Challenger, vol. 9, p. 305, pl. 34, f. 1-4.

R e m a r k s . — Some specimens, resembling *Trochamminoides* by the evolute character of the test, were found in the lowermost Ieper Clays of the Woensdrecht boring. However, the aperture is not at the base of the last formed chamber, but it is a more or less rounded opening in the apertural face. The last chambers mostly being broken off, the form of the aperture is unknown.

Our specimens more or less resemble A. *americanus*. In the latter species the evolute character of the test is still more distinct, and the aperture is an elongate slit.

No specimens were found with an uncoiling, straight adult part.

D i s t r i b u t i o n . — Netherlands (Woensdrecht): Clays of Ieper.

FAMILY TEXTULARIIDAE

Genus SPIROPLECTAMMINA CUSHMAN, 1937

Type species TEXTULARIA AGGLUTINANS D'ORBIGNY var. BIFORMIS PARKER and JONES, 1865

Spiroplectammina mexiaensis LALICKER

Pl. I, fig. 8; *7*

Spiroplectammina mexiaensis LALICKER, 1935, Contr. Cushm. Lab. Foram. Res., vol. 11, p. 43, pl. 6, f. 5, 6 (Eocene; Texas).

Remarks. — Our specimens from the lowermost part of the Ieper Clays of the boring Woensdrecht differ from the similar *S. spectabilis* (GRZYBOVSKI) (*Spiroplecta spectabilis* GRZYBOVSKI, 1898, Rozpr. Ak. Um. Krakov, ser. 2, vol. 13, p. 293, pl. 12, f. 12) by the ridge-like axial portion of the test and the usually somewhat limbate sutures.

Distribution. — Netherlands (Woensdrecht): Clays of Ieper.

Spiroplectammina adamsi LALICKER

Pl. I, fig. 9-11; *14*

Spiroplectammina adamsi LALICKER, 1935, Contr. Cushm. Lab. Foram. Res., vol. 11, p. 39, pl. 6, f. 1, 2 (Eocene; California).

Remarks. — The shape of the test of the Belgian specimens is variable. Mostly it is broad and compressed, and always subrhomboidal in apertural view. Some specimens show a distinctly planispiral beginning, others possess a biserial arrangement of the visible early chambers. The sutures are mostly slightly depressed; their thickening is variable and it depends on the degree of depression of the chamber walls. In some specimens the sutures are indistinct. They are usually straight and oblique, but curved sutures were found as well. LALICKER described the aperture to be found in a distinct reentrant of the apertural face. In our specimens this characteristic is not always present.

Our *Spiroplectammina adamsi* is not clearly separable from our *S. carinata* and *S. carinata* var. *deperdita*. Specimens with a slight carina resemble *S. carinata*, which is flatter. *S. carinata* var. *deperdita* is more elongate.

Distribution. — Belgium: Clays of Ieper, Clays of Roubaix, Sands of Mons-en-Pévèle;

Netherlands (Woensdrecht): Clays of Ieper, Sands of Mons-en-Pévèle, Lower Panisel beds;

England: London Clay.

Spiroplectammina carinata (D'ORBIGNY)

Pl. I, fig. 12; *103*

Textularia carinata D'ORBIGNY, 1846, Foram. foss. Vienne, p. 247, pl. 14, f. 32-34 (Miocene; Vienna basin).
Spiroplectammina carinata (D'ORBIGNY), TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 81; MARKS, 1951, Contr. Cushm. Found. Foram.Res., vol. 2, p. 35, pl. 6, f. 2; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 99, pl. 1, f. 2.

R e m a r k s . — Characteristic *Spiroplectammina carinata* individuals with a more or less wide, dentate to spinose carina, are rather scarce in the material of the Belgian Eocene. BATJES found a complete gradation between this type and *S. carinata* (D'ORBIGNY) var. *deperdita* (D'ORBIGNY). The variety is far more numerous in our Eocene material.

D i s t r i b u t i o n . — *Spiroplectammina carinata* is only dominant in some samples of the Clays of Asse. In the other deposits *S. carinata* var. *deperdita* outnumbers the species or it is the only representative (Sands of Brussels and of Lede).

Belgium: Sands of Mons-en-Pévèle, Sands of Wemmel, Clays of Asse;

Netherlands (Woensdrecht): Wemmel Sands.

Spiroplectammina carinata (D'ORBIGNY) var. **deperdita** (D'ORBIGNY)

Pl. I, fig. 13; *104*

Textularia deperdita D'ORBIGNY, 1846, Foram. foss. Vienne, p. 224, pl. 14, f. 23-25 (Miocene; Vienna basin .
Spiroplectammina deperdita (D'ORBIGNY), MARKS, 1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 36.
Spiroplectammina carinata (D'ORBIGNY) var. *deperdita* (D'ORBIGNY), BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 99, pl. 1, f.3.

R e m a r k s . — In the Oligocene material of Belgium and of Germany BATJES found a complete gradation between typical *Spiroplectammina carinata* with a more or less distinct, dentate to spinose carina, and forms without a carina and with more or less straight sutures. The latter he found to be identical with *S. deperdita* of the Miocene of the Vienna basin. In our Eocene material this intergradation is only present in some samples of the Asse Clays.

The specimens of the Clays of Asse, the Sands of Wemmel and the Sands of Lede resemble best the forms described by BATJES. They show a similar variation in the median ridge from broad and granulated to narrow and smooth.

The few specimens we found in the Sands of Brussels have low chambers and not-limbate, depressed sutures. They resemble *Spiroplectammina alabamensis* (CUSHMAN) var. *diminutiva* BANDY (1949, Bull. Am. Pal., no. 131, p. 33, pl. 4, f. 8).

The individuals from the Sands of Vlierzele and the Sandy Clays of Anderlecht in the Woensdrecht boring are sometimes hardly different from *Spiroplectammina adamsi*. This is especially true for young specimens. In these individuals the median ridge is ill-developed, and the sutures are mostly depressed and not or slightly limbate.

D i s t r i b u t i o n . — Belgium : Sands of Mons-en-Pévèle, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse;

Netherlands: Lower Panisel beds, Sands of Lede, Sands of Wemmel.

Genus TEXTULARIA DEFRANCE, 1824

Type species TEXTULARIA SAGITTULA DEFRANCE, 1824

Textularia agglutinans D'ORBIGNY

Pl. I, fig. 14-16; *100*

Textularia agglutinans D'ORBIGNY, 1839, in DE LA SAGRA, Hist. Phys. Nat. Cuba, p. 144, pl. 1, f. 17, 18, 32-34 (recent; West Indies); CUSHMAN, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 7, pl. 1, f. 4, 5; KEYZER, 1935, « On variability in East Indian Foraminifera », thesis Leiden, p. 128, tf. 25; TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 82.

R e m a r k s . — This specific name is applied to a large, variable group of our *Textularia* individuals. *T. agglutinans* was originally described for elongate specimens with straight, horizontal sutures and slightly inflated chambers. We found such specimens intergrading with shorter, more compressed forms which resemble *T. gramen* D'ORBIGNY (1846, Foram. foss. Vienne, p. 248, pl. 15, f. 4-6). The type of the latter species shows a relatively short form with oblique sutures. In the short specimens of *T. agglutinans* of the Belgian Eocene the sutures are more horizontal.

Elongate specimens of *Textularia agglutinans* are the most numerous in our Eocene material. The test is more or less compressed, with a rounded to subangular periphery. The wall is mostly finely arenaceous, but coarsely arenaceous specimens have been found as well. The aperture is often in a distinct reentrant of the apertural face.

The first three chambers of the test were found to be arranged triserially, the following ones biserially. This is the same arrangement as that found by HÖGLUND for *Textularia bocki* (1947, Uppsala Univ. Zool. Bidrag, vol. 26, p. 171, tf.152, 153, pl. 12, f. 5-7), a recent species off the western Swedish coast.

D i s t r i b u t i o n . — Belgium : Sands of Mons-en-Pévèle, Sands of Brussels, Sands of Lede, Sands of Wemmel and Clays of Asse;

Netherlands (Woensdrecht): Panisel formation, Sands of Lede, Sands of Wemmel.

Textularia agglutinans D'ORBIGNY var. nalinnesensis nov. var.

Pl. I, fig. 17, 18; *134*

E t y m o l o g y . — Named after the type locality Nalinnes (THB) in Hainaut, Belgium.

D e s c r i p t i o n . — Variety differing from the typical *Textularia agglutinans* by its greater size, more coarsely arenaceous wall, and less compressed test.

Length of holotype, 0,90 mm.; breadth of apertural end, 0,47 mm.; thickness, 0,35 mm.

R e m a r k s . — *Textularia agglutinans* var. *nalinnesensis* resembles *T. minuta* (TERQUEM) (*Textilaria minuta* TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 147, pl. 15, f. 15) which has a compressed initial part and is finely arenaceous. It differs from *T. midwayana* LALICKER (1935, Contr. Cushm. Lab. Foram. Res., vol. 11, p. 49, pl. 6, f. 7-9) in the aperture which is a low slit instead of a small, high arched opening.

The specimens of this new variety grade into our *Textularia agglutinans*; they furthermore have the same variation of the relative length of the test. Some specimens also show the triserial arrangement of the first three chambers.

Type locality. — The abandoned sandpit ESE of Nalinnes: our sample THB 1192.

Type level. — The Sands of Brussels. The age of these deposits is generally regarded to be Middle Eocene.

Distribution. — Belgium: Brussels Sands, only at Nalinnes (THB).

Depository. — The holotype and paratypoids are stored in the collections of the Geological Institute of Utrecht (S 6378, 6379).

Textularia smithvillensis Cushman and Ellisor

Pl. I, fig. 19; *32*

Textularia smithvillensis Cushman and Ellisor, 1933, Contr. Cushm. Lab. Foram. Res., vol. 9, p. 95, pl. 10, f. 11 (Eocene; Texas).

Remarks. — A number of specimens with the characteristics of this species was found. They usually have the initial portion broken off. Most of them show oblique, straight and slightly depressed sutures. A characteristic feature is the slight bulging of the lower part of the chambers.

Textularia gertrudeana Davis (1941, Journ. Pal., vol. 15, p. 148, pl. 24, f. 8), also from the Claiborne Eocene of Texas, is a similar, more slender form without the bulging chambers.

Distribution. — Belgium: Clays of Roubaix;
Netherlands (Woensdrecht): Clays of Ieper;
England: London Clay of Alum Bay.

Family **TROCHAMMINIDAE**

Subfamily **TROCHAMMININAE**

Genus TROCHAMMINA Parker and Jones, 1859

Type species NAUTILUS INFLATUS Montagu, 1808

Trochammina sp. cf. **T. inflata** (Montagu)

Pl. I, fig. 20; *8*

cf. *Nautilus inflatus* Montagu, 1808, Test. Britt., Suppl., p. 81, pl. 18, f. 3 (recent; England).

cf. *Trochammina inflata* (Montagu), H. B. Brady, 1884, Rep. Voy. Challenger, vol. 9, p. 338, pl. 41, f. 4; Cushman, 1920, U. S. Nat. Mus., Bull. 104, pt. 2, p. 73; ten Dam, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 87, pl. 2, f. 5.

Remarks. — Several *Trochammina* individuals resemble the figures given for *T. inflata*. The bad state of preservation, most specimens being distorted, hampers a correct determination.

Some specimens of *Haplophragmoides* may have been included. Their deformation probably caused a secondary trochoid character of the test.

Distribution. — Netherlands (Woensdrecht): Clays of Ieper.

Family VERNEUILINIDAE

Subfamily EGGERELLINAE

Genus KARRERIELLA Cushman, 1933

Type species GAUDRYINA SIPHONELLA Reuss, 1851

Karreriella siphonella (Reuss)

Pl. I, fig. 21-23; *222*

Gaudryina siphonella Reuss, 1851, Zschr. Deu. Geol. Ges., vol. 3, p. 78, pl. 5, f. 40-42 (Oligocene; Germany).
Karreriella siphonella (Reuss), Cushman, 1937, Cushm. Lab. Foram. Res., Spec. Publ. no. 8, p. 125, pl. 14, f. 17-19; Batjes, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 100, pl. 1, f. 6-8.
Textularia chilostoma Reuss, 1852, Zschr. Deu. Geol. Ges., vol. 4, p. 18, tf. a, b (Oligocene; Germany).
Karreriella chilostoma (Reuss), Cushman, 1937, Cushm. Lab. Foram. Res., Spec. Publ. no. 8, p. 126, pl. 15, f. 1-8.

Remarks. — Almost all our individuals belong to the *chilostoma* variety, in which nearly the entire test is biserial (see Batjes, 1958). The *siphonella* type with a more prominent multi-triserial part, and with the biserial chambers in a looser biserial arrangement, was found in but two samples.

The early chambers of our *chilostoma* variants are arranged in an indistinct triserial spiral. The often suggest a planispiral beginning of the test, which would be typical for the genus *Valvotextularia* Hofker.

Specimens from the Miocene of Belgium described by Batjes as *Siphotextularia labiata* (Reuss) (*Textilaria labiata* Reuss, 1861, Sitz. ber. K. Ak. Wiss. Wien, vol. 42, p. 362, pl. 2, f. 17; *Siphotextularia labiata* (Reuss), Batjes, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 100, pl. 1, f. 5) show the same arrangement of the early chambers: indistinctly triserial to planispiral. Possibly they belong to the same species as our specimens.

Distribution. — Belgium: Sands of Wemmel and Clays of Asse.

Karreriella danica Cushman

Pl. I, fig. 24, 25; *11*

Karreriella danica Cushman, 1937, Cushm. Lab. Foram. Res., Spec. Publ. no. 8, p. 122, pl. 14, f. 20-22 (Eocene; England).
(not *Gaudryina danica* Franke, 1927, Danmarks Geol. Unders., R. II, no. 46, p. 10, pl. 1, f. 4).

Remarks. — According to Brotzen (1948, Sver. Geol. Unders., Arsbok 42, no. 2. p. 36) *Gaudryina danica* Franke with triserial beginning belongs to *Bermudezina* because of the presence of an apertural neck. *Karreriella danica* Cushman has a multi- to triserial beginning, and the elongate aperture with indistinct neck lies near the inner margin of the final chamber.

In the Belgian specimens the neck is sometimes absent. In those cases the aperture is at the base of the last chamber. These specimens strongly resemble *Dorothia fallax* Hagn (1954, Contr. Cushm. Found. Foram. Res., vol. 5, p. 16, pl. 4, f. 10, 11; = *D. subglabra* Cusman (not Gümbel), 1937, Cushm. Lab. Foram. Res., Spec. Publ. no. 8, p. 86, pl. 9, f. 13, 14).

Considerable variation was found in the development of the multi- to triserial part of the specimens. In some individuals the beginning is nearly biserial. Young specimens with only the multi- to triserial beginning resemble *Trochamminella*.

Distribution. — Belgum : Clays of Roubaix, Sands of Mons-en-Pévèle;
Netherlands (Woensdrecht) : Clays of Ieper;
England: London Clay;
France: Sands of Cuise.

Subfamily VALVULININAE

Genus VALVULINA d'Orbigny, 1826

Type species VALVULINA TRIANGULARIS d'Orbigny, 1826

Valvulina spp.

Pl. I, fig. 26, *135*

Remarks. — In the Belgian Eocene, especially in the Lede Sands, a number of scattered *Valvulina* specimens were found. They are too few and too ill-preserved for a correct determination.

Most frequent are forms that resemble *Valvulina limbata* Terquem (1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 102, pl. 11, f. 7). In the Sands of Lede at Lede specimens were found resembling *V. terquemi* Y. le Calvez (1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 14, pl. 1, f. 6). An individual of the latter is figured.

Distribution. — Belgium : Sands of Brussels, Sands of Lede;
France : Lutetian.

Genus CLAVULINA d'Orbigny, 1826

Type species CLAVULINA PARISIENSIS d'Orbigny, 1826

Clavulina parisiensis d'Orbigny

Pl. I, fig. 27, 28; *173*

Clavulina parisiensis d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 268, no. 3, modèle no. 66 (Lutetian; Paris basin); Terquem, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 121, pl. 12, f. 34; Cushman, 1937, Cushm. Lab. Foram.Res., Spec. Publ. no. 8, p. 18, pl. 2, f. 22-26; Y. le Calvez, 1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 15.

Remarks. — Some variation was met with in the relative size of the triserial part of the test.

Most of our specimens show an abrupt transition from the triserial to the uniserial arrangement of the chambers. However, in some specimens the triserial part is followed by an irregularly biserial to uniserial arrangement. They resemble *Clavulina corrugata* Deshayes (1833, in Lyell, Princ. Geol., vol. 3, p. 251, pl. 4, f. 12-14; = *C. columnatortilis* d'Orbigny, Y. le Calvez, 1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 15).

Distribution. — Belgium : Sands of Lede, Sands of Wemmel;
France : Lutetian.

SUBFAMILY **VERNEUILININAE**

Genus PSEUDOCLAVULINA CUSHMAN, 1936

Type species CLAVULINA CLAVATA CUSHMAN, 1926

Pseudoclavulina anglica CUSHMAN

Pl. I, fig. 29; *29*

Pseudoclavulina anglica CUSHMAN, 1936, Cushm. Lab. Foram. Res., Spec. Publ. no. 6, p. 18, pl. 3, f. 5 (Lower Eocene; England); CUSHMAN, 1937, Cushm. Lab. Foram. Res., Spec. Publ. no. 7, p. 111, pl. 15, f. 26, 27; TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 84; BROTZEN, 1948, Sver. Geol. Unders., ser. C, Arsbok 42, no. 2, p. 37, pl. 5, f. 1, 2; BOWEN, 1954, Proc. Geol. Ass., vol. 65, p. 169, pl. D, f. 6, 7.

Remarks. — Some specimens from the Ieper Clays of the Woensdrecht boring are considered to belong to this species. The early part of the test is variable, from distinctly triangular to rounded. The latter specimens more or less resemble those found in the Sands of Wemmel and the Clays of Asse, and referred to as *Pseudoclavulina* sp. *P. cocoaensis* CUSHMAN.

Distribution. — Netherlands (Woensdrecht): Ieper Clays.

Pseudoclavulina sp. cf. **P. cocoaensis** CUSHMAN

Pl. I, fig. 30; *220*

cf. *Pseudoclavulina cocoaensis* CUSHMAN, 1936, Cushm. Lab. Foram. Res., pec. Publ. no. 6, p. 18, pl. 3, f. 6 (Eocene; Alabama); CUSHMAN, 1937, Cushm. Lab. Foram. Res., Spec. Publ. no. 7, p. 114, pl. 15, f. 29-31.

Remarks. — The fragmentary state of our specimens did not allow a more certain determination. Most individuals are damaged. They resemble *Pseudoclavulina cocoaensis* in the more or less rounded triserial portion of the test, in which the early chambers are not very clear. Also the slight apertural neck is similar. The uniserial chambers are less inflated and somewhat more elongate.

Distribution. — Belgium: Sands of Wemmel, Clays of Asse.

Family OPHTHALMIDIIDAE

Subfamily NODOPHTHALMIDIINAE

Genus VERTEBRALINA d'Orbigny, 1826

Type species VERTEBRALINA STRIATA d'Orbigny, 1826

Vertebralina laevigata Terquem

Pl. II, fig. 1-3; *164*

Vertebralina laevigata Terquem, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 44, pl. 2, f. 15-18 (Lutetian; Paris basin); Y. le Calvez, 1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 31, pl. 3, f. 33, 34.

Remarks. — Because of the general resemblance with this species many specimens in the material of Grignon (CAB) and Daméry (Paris basin), as well as in the Lede Sands of Belgium, are thought to be conspecific with *Vertebralina laevigata*. Although no specimens were encountered with visible sutures, they are in all other respects identical with the forms figured by Terquem and Y. le Calvez. Specimens with rectilinear series of chambers have not been found.

In some samples of the Wemmel Sands we found specimens resembling *Vertebralina laevigata*, but different by the presence of an elongate grooved tooth in the aperture.

These specimens, which are extremely rare, are possibly related to *Nummuloculina*.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel;
France : Lutetian;

Subfamily OPHTHALMIDIINAE

Genus SPIROPHTHALMIDIUM Cushman, 1927

Type species SPIROLOCULINA ACUTIMARGO H. B. Brady, 1884

Spirophthalmidium alata (Terquem)

Pl. II, fig. 4; *179*

Spiroloculina alata Terquem, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 158, pl. 16, f. 17, 18 (Lutetian; Paris basin).

Spirophthalmidium alata (Terquem), Cushman and Todd, 1944, Cushm. Lab. Foram. Res., Spec. Publ. no. 11, p. 74; Y. le Calvez, 1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 29, pl. 3, f. 31, 32.

Remarks. — Specimens from the Lutetian deposits of the Paris basin are characterized by a distinct planispiral beginning surrounded by elongate chambers, two in a coil. There is some variation in the borders of the chambers. Mostly the periphery is truncated, but specimens with one keel are present as well. The latter resemble our *Spiroloculina costigera*

(TERQUEM) var. *nuda*, of which they differ by the narrower chambers and the evolute character of the test with the exposed planispiral beginning. Y. LE CALVEZ described a small tooth in the aperture; in our specimens it was not found.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel; France : Lutetian.

Spirophthalmidium pertusa (TERQUEM)

156

Spiroloculina pertusa TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 160, pl. 16, f. 27 (Lutetian; Paris basin); CUSHMAN and TODD, 1944, Cushm. Lab. Foram. Res., Spec. Publ. no. 11, p. 12, pl. 2, f. 32-37; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 24.

Remarks. — A few specimens that clearly show a planispiral beginning typical for the genus *Spirophthalmidium*.

Distribution. — France: Lutetian.

FAMILY MILIOLIDAE

Genus QUINQUELOCULINA D'ORBIGNY, 1826

Type species SERPULA SEMINULUM LINNÉ, 1758

Quinqueloculina seminula (LINNÉ)

Pl. II, fig. 5, 6; *74*

Serpula seminulum LINNÉ, 1758, Syst. Nat., ed. 10, vol. 1, p. 786 (recent; Adriatic).

Quinqueloculina seminula (LINNÉ), BHATIA, 1955, Jour. Pal., vol. 29, p. 674, pl. 67, f. 8; KAASSCHIETER, 1955, Verh. Kon. Ned. Ak. Wet., Nat., ser. 1, vol. 21, no. 2, p. 56, pl. 2, f. 3; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 102, pl. 1, f. 15.

Quinqueloculina akneriana D'ORBIGNY, 1846, Foram. foss. Vienne, p. 290, pl. 18, f. 16-21 (Miocene; Vienna basin); MARKS, 1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 38.

Quinqueloculina laevigata D'ORBIGNY (not DESHAYES, 1831), 1839, Foram. Iles Canaries, in BARKER, WEBB and BERTHELOT, vol. 2, pt. 2, p. 143, pl. 3, f. 31-33 (Eocene; Paris basin; and recent; Atlantic Ocean, off Canary Islands); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 173, pl. 18, f. 14, 15; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 11.

Remarks. — In our material a lot of *Quinqueloculina* specimens were found which fairly well resemble the figures of *Q. seminula*, *Q. akneriana* and *Q. laevigata* of the cited authors. Mostly the test is distinctly longer than broad, but specimens with length equal to breadth were encountered as well. The latter individuals resemble *Q. vulgaris* D'ORBIGNY as figured by CUSHMAN (1929, U. S. Nat. Mus., Bull. 104, pt. 6, pl. 2, f. 3).

It sometimes appeared difficult to distinguish *Quinqueloculina seminula* from *Q. carinata* D'ORBIGNY, but *Q. seminula* is regarded to have a rounded periphery and *Q. carinata* a subacute to acute one.

The specimens of the Lutetian material of the Paris basin are often more elongate than the Belgian ones, but all intermediates are present. Such longer specimens have been described by Y. LE CALVEZ as *Quinqueloculina laevigata* D'ORBIGNY. However, this name was preoccupied by DESHAYES for a form which probably belongs to *Miliola*.

Some variation is found in the length of the apertural neck. Specimens with a distinct neck are assigned to *Quinqueloculina ludwigi*, but it appeared not always easy to separate this species from *Q. seminula* without a neck.

Distribution. — Belgium: Sands of Mons-en-Pévèle, Clays of Roncq, Sands of Lede, Sands of Wemmel, Clays of Asse;

England: London Clay, Upper Bracklesham beds, Barton beds;

France : Lutetian;

Netherlands (Woensdrecht): Lower Panisel beds.

Quinqueloculina ludwigi REUSS

Pl. II, fig. 7, 8: *187*

Quinqueloculina ludwigi REUSS, 1866, Denkschr. K. Akad. Wiss. Wien., vol. 25, p. 126, pl. 1, f. 12 (Oligocene; Germany); BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 103, pl. 1, f. 6.

Remarks. — BATJES united all *seminula*-like individuals with a more or less elongate apertural neck under *Quinqueloculina ludwigi*. However, there is no sharp boundary with *Q. seminula*.

Some specimens resemble *Quinqueloculina lippa* Y. LE CALVEZ (1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 15, pl. 1, f. 7-9), but they lack the angular periphery.

Distribution. — Specimens of *Quinqueloculina ludwigi* are especially abundant in the material of the Barton beds of Barton. BOWEN (1957, Micropal., vol. 3, p. 56) probably referred to them as *Q. akneriana* D'ORBIGNY.

Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse;

England : Barton beds;

France : Lutetian.

Quinqueloculina carinata D'ORBIGNY

Pl. II, fig. 9-11

Quinqueloculina carinata D'ORBIGNY, 1850, Prodrome Pal. Strat. Univ. Anim. Mollusques Ray., vol. 2, p. 410 (Eocene; Paris basin); FORNASINI, 1905, Mem. R. Accad. Sci. Ist. Bologna, ser. 6, vol. 2, p. 67, pl. 4, f. 2; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 9.

(not *Quinqueloculina carinata* TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 173, pl. 18, f. 16, 17).

Remarks. — Most specimens correspond well to the original figures of this species as given by FORNASINI.

A number of specimens was found with fairly acute angles, thus resembling *Quinqueloculina lamarckiana* D'ORBIGNY (1839, in DE LA SAGRA, Hist. Phys. Nat. Cuba, p. 189, pl. 11, f. 4, 5). They occur dispersed throughout the material of *Q. carinata* with all intermediates abundantly present.

Also some resemblance was found with *Quinqueloculina vulgaris* d'ORBIGNY (in FORNASINI, 1902, Accad. Sci. Ist. Bologna, ser. 5, vol. 10, p. 23, f. 13). CUSHMAN (1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 25, pl. 2, f. 3) described the latter species as close to *Q. seminula*, but being shorter and stouter. However, from the figures of d'ORBIGNY given by FORNASINI, *Q. vulgaris* appears to be more or less angular.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse;
England : Barton beds;
France : Lutetian;
Netherlands (Woensdrecht) : Lower Panisel beds.

Quinqueloculina bicarinata d'ORBIGNY

Pl. II, fig. 12, 13; *217*

Quinqueloculina bicarinata d'ORBIGNY, 1878, in TERQUEM, Mém. Soc. Géol. France, ser. 3, vol. 1, p. 68, pl. 7, f. 10 (recent; Rimini, Italy); FORNASINI, 1902, Mem. R. Accad. Sci. Ist. Bologna, ser. 5, vol. 10, p. 22, tf. 16; CUSHMAN, 1945, Cushm. Lab. Foram. Res., Spec. Publ. no. 13, p. 16, pl. 2, f. 9, pl. 4, f. 2; BHATIA, 1955, Jour. Pal., vol. 29, p. 671, pl. 67, f. 12; BOWEN, 1957, Micropal., vol. 3, p. 56.

Remarks. — Distinct specimens were found only in the Barton beds of the Hampshire basin, where they are generally somewhat more elongate than the topotypes figured by CUSHMAN. Young specimens do not show the bicarinate periphery. Some forms with unicarinate periphery were found. Others lack carinae and merge into *Quinqueloculina seminula* and *Q. ludwigi*. Some variants show distinctly striated walls with striae like those of *Q. striata*.

Specimen with a bicarinate periphery are rare in the Belgian material. In the Sands of Wemmel a number of individuals was found which fairly well resemble young specimens of the English representatives of the species.

The English and Belgian specimens are often vaguely quinqueloculine or even triloculine. The latter forms are a good resemblance to the Miocene *Triloculina consobrina* d'ORBIGNY (1846, Foram. foss. Vienne, p. 277, pl. 18, f. 10-12), as interpreted by MARKS (1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 40) and KAASSCHIETER (1955, Verh. Kon. Ned. Akad. Wetensch., Nat., ser. 1, vol. 21, no. 2, p. 60, pl. 4, f. 6).

Distribution. — Belgium : Sands of Wemmel;
England : Barton beds.

Quinqueloculina juleana d'ORBIGNY

Pl. II, fig. 14, 15; *200*

Quinqueloculina juleana d'ORBIGNY, 1846, Foram. foss. Vienne, p. 298, pl. 20, f. 1-3; (Miocene; Vienna basin); BHATIA, 1955, Jour. Pal., vol. 29, p. 672, pl. 66, f. 9, tf. 3; BOWEN, 1957, Micropal., vol. 3, p. 57, pl. 1, f. 18, 19; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 103, pl. 1, f. 16.

Remarks. — The variation of this species, as found by BHATIA in the Oligocene of Wight, was also observed in our Eocene material.

The difference from *Quinqueloculina bicarinata* is somewhat vague, as it is from *Q. ludwigi* for specimens with more rounded angles.

Specimens usually have a roughened exterior, typical of the *rugosa* variety (*Quinqueloculina rugosa* D'ORBIGNY, 1850, Prodrome Pal. Strat. Univ. Anim. Mollusques Ray., vol. 3, p. 195; FORNASINI, 1905, Mem. Accad. Sci. Ist. Bologna, ser. 6, vol. 2, p. 66, pl. 3, f. 13; MARKS, 1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 39).

A number of specimens, also with a roughened exterior, resemble *Quinqueloculina mauricensis* HOWE (1939, Louisiana Dept. Conserv., Geol. Bull. no. 14, p. 35, pl. 4, f. 8-10) from the Eocene of Louisiana. They are more or less unicarinate. We found them mostly among the younger individuals, but adult ones were encountered as well.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse; England : Upper Bracklesham beds, Barton beds.

Quinqueloculina sp. cf. Q. aspera D'ORBIGNY

Pl. II, fig. 16; *154*

cf. *Quinqueloculina aspera* D'ORBIGNY, in PARKER, JONES and BRADY, 1871, Ann. Mag. Nat. Hist., ser. 4, vol. 8, pl. 8, f. 11 (recent; Mediterranean); FORNASINI, 1905, Mem. R. Accad. Sci. Ist. Bologna, ser. 4, vol. 2, p. 65, pl. 3, f. 1; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 8.

Remarks. — In the Lutetian material of the Paris basin we found a number of *Quinqueloculina* specimens, tentatively referred to as *Q. aspera*.

Most of them are characterized by finely arenaceous walls, sometimes ornamented by rather obscure small pits. They have a strong apertural neck with a distinct lip and a small, bifid tooth. The test is about twice as long as broad.

They resemble the figures given by Y. LE CALVEZ (pl. 1, f. 16-18) for *Quinqueloculina pertusa* TERQUEM (1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 183, pl. 20, f. 5), but regularly arranged pits were not encountered. They also resemble the figures of *Miliola rostrata* (TERQUEM) (*Quinqueloculina rostrata* TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 174, pl. 18, f. 18), but the cribrate aperture was not met with in our material. However, the cribrate plate originally present may have been broken away, thus giving the impression of *Quinqueloculina*.

Distribution. — France : Lutetian.

Quinqueloculina costata KARRER

Pl. II, fig. 17-19

Quinqueloculina costata KARRER, 1867, Sitz. ber. K. Akad. Wiss. Wien, Math. Naturw. Cl., vol. 55, pt. 1, p. 362, pl. 3, f. 4 (Neogene; Rumania).

Quinqueloculina costata D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 135 (nom. nud.); TERQUEM, 1878, Mém. Soc. Géol. France, ser. 3, vol. 1, no. 3, p. 63, pl. 6, f. 3-5 (Pliocene; Rhodes); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 183, pl. 20, f. 8, 9; Y. LE CALYEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 9.

Remarks. — Specimens from the deposits of Lutetian age of the Paris basin have a more or less rounded periphery. Such types were found also in the Upper Eocene deposits of Belgium, but others might be costate variants of *Quinqueloculina juleana*. It appeared impossible to make a distinction between these two types, and so they are united here in *Q. costata*.

Some variation was found in the number of costae on each chamber; some specimens have variable parts of their chambers without costae.

According to the Catalogue of BROOKS ELLIS and MESSINA the first valid description of D'ORBIGNY's species was given by TERQUEM in 1878. KARRER's older description and figures are independent of D'ORBIGNY's « planches inédites », but they happen to refer to the same species.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse;
England : Barton beds;
France : Lutetian.

Quinqueloculina striata D'ORBIGNY

Pl. III, fig. 1, 2; *160*

Quinqueloculina striata D'ORBIGNY, in GUÉRIN-MÉNEVILLE, 1843, Iconographie Règne Animal Cuvier, Moll., p. 10, pl. 3, f. 10 (Lutetian; Paris basin); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 184, pl. 20, f. 10-12; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 14.

Remarks. — It is a generally neglected fact that *Quinqueloculina striata* DESHAYES, described by LYELL in 1833 (Princ. Geol., vol. 3, p. 28, 251, pl. 4, f. 5-8), is older than the first valid description of D'ORBIGNY's species by GUÉRIN-MÉNEVILLE in 1843. Possibly both species are conspecific. Although probably not correct, we retain D'ORBIGNY's species, which is certainly identical with our material.

The species differs from *Quinqueloculina costata* by the less elongate test with more and finer costae. Many references of authors to *Q. striata* possibly belong to *Q. costata*.

Distribution. — Belgium : Sands of Lede;
France : Lutetian.

Quinqueloculina crassa D'ORBIGNY

Pl. III, fig. 3; *159*

Quinqueloculina crassa D'ORBIGNY, 1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 409 (Lutetian; Paris basin); FORNASINI, 1905, Mem. Accad. Sci. Ist. Bologna, ser. 6, vol. 2, p. 65, pl. 3, f. 5; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 9.

Remarks. — It appeared impossible to make a distinction between *Quinqueloculina crassa* and *Q. grignonensis* Y. LE CALVEZ (1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 14, pl. 1, f. 1-3) in our material from Grignon.

Distribution. — Belgium : Sands of Lede;
France : Lutetian.

Quinqueloculina impressa REUSS

Pl. III, fig. 4-6; *21*

Quinqueloculina impressa REUSS, 1851, Zschr. Deu. Geol. Ges., vol. 3, p. 87, pl. 7, f. 59 (Oligocene; Germany); BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 103, pl. 1, f. 13.

Quinqueloculina cognata BORNEMANN, 1855, Zschr. Deu. Geol. Ges., vol. 7, p. 349, pl. 19, f. 7 (Oligocene; Germany).

Quinqueloculina impressa REUSS var. *cognata* BORNEMANN, BHATIA, 1955, Jour. Pal., vol. 29, p. 671, pl. 67, f. 10; BOWEN, 1957, Micropal., vol. 3, p. 56.

Remarks. — The test often has a more or less triloculine aspect, but generally all five chambers are visible. The wall is mostly covered by small clear quartz grains. *Quinqueloculina impressa* differs from *Q. agglutinans* D'ORBIGNY (1839, in DE LA SAGRA, Hist. Phys. Nat. Cuba, p. 195, pl. 12, f. 11-13) and from *Q. agglutinata* CUSHMAN (1917, U. S. Nat. Mus., Bull. 71, p. 43, pl. 9, f. 2) by the uniform, very small size of the grains, which are all quartz grains.

Our more or less arenaceous specimens differ from *Quinqueloculina constans* BANDY (1949, Bull. Am. Pal., vol. 32, p. 18, pl. 1, f. 4) by the absence of a distinct apertural neck with strong lip and by the less elongated test.

The *cognata* variety with more rounded periphery is predominant in our material. There is some variation in the relative length of the test. More elongate specimens are most common in the Lutetian deposits of the Paris basin.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse;
England : London Clay, Barton beds;
France : Lutetian;
Netherlands (Woensdrecht): Ieper Clays.

Genus MILIOLINELLA WIESNER, 1931

Type species VERMICULUM SUBROTUNDUM MONTAGU, 1803

Miliolinella oblonga (MONTAGU)

Pl. III, fig. 7, 8; *199*

Vermiculum oblongum MONTAGU, 1803, Test. Brit., p. 522, pl. 14, f. 9 (recent; England).
Miliolinella oblonga (MONTAGU), BHATIA, 1955, Jour. Pal., vol. 29, p. 671, pl. 67, f. 17.
Scutuloris oblongus (MONTAGU), BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 105, pl. 2, f. 1.

Remarks. — Our specimens from the Barton beds of Barton, Hampshire, are in good accordance with the figures given by BHATIA. The Belgian individuals are usually more elongate.

Most of the specimens show a quinqueloculine arrangement of the chambers and thus should belong to the genus *Scutuloris* LOEBLICH and TAPPAN. However, triloculine specimens were met with as well, and some intermediates between both types are present. BHATIA remarked that there is no fundamental difference between these two types. Consequently the genus *Miliolinella* is valid for both and there is some doubt as to the validity of the genus *Scutuloris*.

Distribution. — Belgium : Lede Sands, Wemmel Sands;
England : Barton beds.

Genus SPIROLOCULINA D'ORBIGNY, 1826

Type species SPIROLOCULINA DEPRESSA D'ORBIGNY, 1826

Spiroloculina tricarinata TERQUEM

Pl. III, fig. 9-11; *185*

Spiroloculina tricarinata TERQUEM (part) (not D'ORBIGNY), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 158, pl. 16, f. 19, 20 (not 21) (Lutetian; Paris basin); CUSHMAN and TODD, 1944, Cushm. Lab. Foram. Res., Spec. Publ. no. 11, p. 10, pl. 2, f. 19, 20 (not 21, 22); Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét . France, pt. 1, p. 24, pl. 2, f. 30, 31.

Remarks. — Our Belgian Eocene specimens are in good accordance with the individuals from the Lutetian deposits of the Paris basin. The number of carinae per chamber is variable; some specimens have 5 or 6 on the last chambers, but the distinct tricarinate form is the most common. Especially young specimens may have as few as two carinae.

There is a continuous gradation from the carinate type to that of the *belgica* variety, characterized by the rounded periphery.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse; France : Lutetian.

Spiroloculina tricarinata TERQUEM var. **belgica** nov. var.

Pl. III, fig. 12-14; *196*

Etymology. — Named after Belgium.

Description. — Variety differing from typical *Spiroloculina tricarinata* by the rounded periphery instead of the tricarinate one.

Length of holotype, 0,50 mm; breadth, 0,32 mm; thickness, 0,18 mm.

Remarks. — A large number of specimens are intermediate between typical *tricarinata* form and this new variety. They mostly possess carinae on the penultimate chamber and not or only slightly developed carinae on the last one.

The form of the aperture varies with the presence or absence of carinae, since the lateral sides of the aperture are generally formed by the carinae. In the *tricarinata* forms the aperture is mostly quadrangular, in the *belgica* individuals it is rounded. Both types show the bifid tooth.

This new variety somewhat resembles *Spiroloculina parisiensis* Y. LE CALVEZ (1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 28, pl. 2, f. 42, 43), but the latter species has a broad tooth and a test twice as long as broad, while the central portion of the test is more or less excavated. The general shape of *S. inflata* TERQUEM [1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 156, pl. 16, f. 8 (not f. 7)] resembles that of our variety,but this species is different in the bulging shape of the last chamber and by the absence of a tooth.

Type locality. — Jette, hollow roadside of the Rue du Marathon near the Stadium of Heizel (BS), our sample BS 1260.

Type level. — The Sands of Wemmel. The age of these Sands is generally regarded to be Late Eocene.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse.

Depository. — The holotype and paratypoids are stored in the collections of the Geological Institute of Utrecht (S 7530, 7534).

Spiroloculina tricarinata TERQUEM var. angulifera TERQUEM

Pl. III, fig. 15, 16; *171*

Spiroloculina angulifera TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 156, pl. 16, f. 9 (Lutetian; Paris basin); CUSHMAN and TODD, 1944, Cushman Lab. Foram. Res., Spec. Publ. no. 11, p. 9, pl. 2, f. 17, 18; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 27.

Remarks. — Many of our Belgian specimens resemble the figures of *Spiroloculina angulifera*, but others are intermediate between this form and *S. tricarinata*.

Because of these intermediate forms *Spiroloculina angulifera* is regarded to be an elongated variant of *S. tricarinata*.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel;
France : Lutetian.

Spiroloculina bicarinata D'ORBIGNY

Pl. III, fig. 17-19; *177*

Spiroloculina bicarinata D'ORBIGNY, 1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 409 (Lutetian; Paris basin); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 155, pl. 16, f. 5; FORNASINI, 1904, Mem. Accad. Sci. Ist. Bologna, vol. 1, p. 4, pl. 1, f. 5; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 25, pl. 2, f. 34, 35.

Spiroloculina tricarinata TERQUEM (part), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 158, pl. 16, f. 21 (not 19, 20); CUSHMAN and TODD, 1944, Cushm. Lab. Foram. Res., Spec. Publ. no. 11, p. 10, pl. 1, f. 10, pl. 2, f. 21, 22 (not 19, 20).

Remarks. — In our French material no sharp distinction could be made between *Spiroloculina bicarinata* and *S. obscura* CUSHMAN and TODD (1944, Cushm. Lab. Foram. Res., Spec. Publ. no. 11, p. 20), as figured by the latter authors from the Lutetian deposits of the Paris basin (1944, ibid., pl. 3, f. 22, 24, 25). *S. obscura* is different by the less thickened angles of the chambers. All intermediates between both types are present.

In the Belgian material the *obscura* type is predominant.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel;
France : Lutetian.

Spiroloculina canaliculata D'ORBIGNY

Pl. III, fig. 20-23; *189*

Spiroloculina canaliculata D'ORBIGNY, 1846, Foram. foss. Vienne, p. 269, pl. 16, f. 10-12 (Miocene; Vienna basin); CUSHMAN and TODD, 1944, Cushm. Lab. Foram. Res., Spec. Publ. no. 11, p. 22, pl. 4, f. 1-11; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 106, pl. 2, f. 3.

Spiroloculina limbata BORNEMANN (not D'ORBIGNY), 1855, Zschr. Deu. Geol. Ges., vol. 7, p. 348, pl. 19, f. 1 (Oligocene; Germany); STAESCHE and HILTERMANN, 1940, Mikrofaunen Tert. Nordwestdeutschland, pl. 43, f. 6.

Remarks. — Not all Belgian specimens show distinctly raised edges of the chambers, but they form an intergrading series to typical forms, which are abundantly present in our material. They closely resemble the specimens described by BATJES from the Oligocene of Belgium and Germany.

Sometimes the chambers are flatter and somewhat more rapidly increasing in size than they are in typical specimens.

In the specimens of Lede Sands the periphery is often more concave than it is in the specimens of younger strata, and the edges of the last-formed chambers are often more thickened. These individuals resemble *Spiroloculina contorta* Y. LE CALVEZ (1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 29, pl. 2, f. 38, 39) in peripheral characters, but they are different by the more evolute coiling.

Some resemblance was found with *Spiroloculina obscura* CUSHMAN and TODD (1944, Cushm. Lab. Foram. Res., Spec. Publ. no. 11, p. 20, pl. 3, f. 22-25). However, comparison with material from the Aquitaine basin showed that in typical specimens of *S. obscura* the sutures are indistinct and the chambers more rapidly increasing in size.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse;
England : Barton beds;
France : Lutetian.

Spiroloculina perforata D'ORBIGNY

Pl. IV, fig. 1; *155*

Spiroloculina perforata D'ORBIGNY in GUÉRIN-MÉNEVILLE, 1843, Iconographie Règne Anim. Cuvier, Moll., p. 10, pl. 3, f. 6 (Lutetian; Paris basin); D'ORBIGNY, 1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 409; TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 154, pl. 16, f. 3, 4; CUSHMAN and TODD, 1944, Cushm. Lab. Foram. Res., Spec. Publ. no. 11, p. 4, pl. 1, f. 7, pl. 2, f. 5-9; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 22.

Distribution. — France : Lutetian.

Spiroloculina costigera TERQUEM

Pl. IV, fig. 2, 3; *170*

Spiroloculina costigera TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 159, pl. 16, f. 24 (Lutetian; Paris basin); CUSHMAN and TODD, 1944, Cushm. Lab. Foram. Res., Spec. Publ. no. 11, p. 11, pl. 2, f. 25-31; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 26, pl. 2, f. 36, 37.

Spiroloculina costata TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 160, pl. 16, f. 25 (Lutetian; Paris basin).

Remarks. — It appeared that *Spiroloculina costigera* and *S. carinata* (see below) are variants of one species, for which the older name *S. costigera* is maintained.

The ornamentation of *Spiroloculina costigera* is the same as that of *S. costigera* var. *carinata*, but the carina is broad and hyaline in the *carinata* type, narrow and often double in the *costigera* type. All intergradations between these two types are present.

Especially in the Belgian specimens the ornamentation is mostly absent. They are the *ubiqua* and *nuda* types.

This species and its varieties are retained in the genus *Spiroloculina*. A planispiral beginning, visible in some broken specimens, suggests relations with *Spirophthalmidium*. However, frequently observed teeth and the slightly evolute character of the test restrained us from making for this species a distinction between both dubious genera.

Distribution. — Belgium : Sands of Lede, Sands of Wemel;
France : Lutetian.

Spiroloculina costigera Terquem var. **carinata** Y. le Calvez

Pl. IV, fig. 4; *162*

Spiroloculina carinata Y. le Calvez, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 26, pl. 2, f. 32, 33 (Lutetian; Paris basin).
Spiroloculina ornata Terquem (not d'Orbigny), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 159, pl. 16, f. 23 (Lutetian; Paris basin).
Spiroloculina striata Terquem (not d'Orbigny), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 160, pl. 16, f. 26 (Lutetian; Paris basin).

Remarks. — This variety is different by the unicarinate periphery. The carina is of variable width and often hyaline. There is a complete gradation to the double-keeled *costigera* type.

Distribution. — Belgium : Sands of Lede;
France : Lutetian.

Spiroloculina costigera Terquem var. **ubiqua** Y. le Calvez

Pl. IV, fig. 5, 6; *92*

Spiroloculina ubiqua Y. le Calvez, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 27, pl. 2, f. 40, 41 (Lutetian; Paris basin).
Spiroloculina angulifera Terquem (part), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 156, pl. 16, f. 13 (not f. 9-12, 14, 15) (Lutetian; Paris basin).

Remarks. — This variety is identical with the *carinata* type, but without ornamentation. Intermediates to the striated types are present.
No sharp distinction between the varieties *ubiqua* and *nuda* appeared possible.

Distribution. — Belgium : Sands of Mons-en-Pévèle, Sands of Brussels, Sands of Lede, Sands of Wemmel;
France : Lutetian.

Spiroloculina costigera Terquem var. **nuda** nov. var.

Pl. IV, fig. 7, 8; *178*

Etymology. — From the Latin : *nudus* = naked, bare.

Description. — This variety differs from *Spiroloculina costigera* s. str. by the lack of ornamentation. The periphery is truncate to rounded.
Length of the holotype, 0,70 mm; breadth, 0,45 mm; thickness, 0,13 mm.

Remarks. — The test is somewhat thicker than that of the variety *ubiqua*.
Especially in the Belgian deposits there is complete gradation to the *costigera* and *ubiqua* types.

Type locality. — Bambrugge, abandoned quarry « Steenberg » (ZD), our sample ZD 1013.

Type level. — Sands of Lede. The age of these sands is generally regarded as Late Eocene.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel;
France : Lutetian.

Depository. — The holotype and paratypoids are stored in the collections of the Geological Institute of Utrecht (S. 6950, 6951).

Genus SIGMOILINA SCHLUMBERGER, 1887

Type species PLANISPIRA SIGMOIDEA H. B. BRADY, 1884

Sigmoilina tenuis (CZJZEK)

Pl. IV, fig. 9, 10; *201*

Quinqueloculina tenuis CZJZEK, 1848, Haid. Naturw. Abh., vol. 2, p. 149, pl. 13, f. 31-34 (Miocene; Vienna basin).

Sigmoilina tenuis (CZJZEK), CUSHMAN, 1946, Contr. Cushm. Lab. Foram. Res., vol. 22, p. 32, pl. 5, f. 13-15; MARKS, 1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 39, pl. 5, f. 7; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 106, pl. 2, f. 5.

Remarks. — Most of our specimens are small and quinqueloculine. Sometimes they occur together with individuals with sigmoiline later chambers. Adult specimens distinctly belong to *Sigmoilina tenuis*.

Some broader specimens, especially from the Sands of Lede, more or less resemble *Sigmoilina oligocenica* CUSHMAN (1946, Contr. Cushm. Lab. Foram. Res., vol. 22, p. 31, pl. 5, f. 6). These few specimens form an intergrading series with our distinct *S. tenuis*. They are regarded as mere variants of this species. The broader variants also resemble *S. inconspicua* HOWE (1939, Louisiana Geol. Surv., Geol. Bull. no. 14, p. 36, pl. 2, f. 16-18) from the Upper Eocene of Louisiana.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse; Netherlands (Woensdrecht) : Sands of Lede, Sands of Wemmel.

Genus ARTICULINA D'ORBIGNY, 1826

Type species ARTICULINA NITIDA D'ORBIGNY, 1865

Articulina nitida D'ORBIGNY

Pl. IV, fig. 11; *147*

Articulina nitida D'ORBIGNY, 1865, in PARKER, JONES and BRADY, Ann. Mag. Nat. Hist., vol. 16, ser. 3, pl. 1, f. 2 (Lutetian; Paris basin); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 150, pl. 15, f. 22-24; CUSHMAN, 1944, Cushm. Lab. Foram. Res., Spec. Publ. no. 10, p. 2, pl. 1, f. 1-5; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 35.

Remarks. — The specimens from the type locality, Grignon, as well those from other localities in the Paris basin, show considerable variation in the development of the costae. Specimens with fine and numerous costae approach the type of *Articulina canui* CUSHMAN (1944, Cushm. Lab. Foram. Res., Spec. Publ. no. 10, p. 6, pl. 1, f. 12-14), those with coarser and fewer costae resemble *A. terquemi* CUSHMAN.

The coarse type was found in the Belgian *Articulina* material in which it is fairly constant. Therefore we assigned these Belgian individuals to *A. terquemi* CUSHMAN.

D i s t r i b u t i o n . — France : Lutetian.

Articulina terquemi CUSHMAN

Pl. IV, fig. 12, 13; *208*

Articulina terquemi CUSHMAN, 1933, Contr. Cushm. Lab. Foram. Res., vol. 9, p. 3, pl. 1, f. 7 (Eocene; Mississippi); CUSHMAN, 1935, U. S. Geol. Survey, Prof. Paper no. 181, p. 14, pl. 4, f. 2, 3; CUSHMAN, 1944, Cushm. Lab. Foram. Res., Spec. Publ. no. 10, p. 6, pl. 1, f. 16, 17.

R e m a r k s . — In some samples of the Upper Eocene of Belgium and of England *Articulina terquemi* is a constant type that differs from *A. nitida* by the fewer, more prominent costae, and the more compressed test.

The specimens from the Asse Clays are most compressed. Sometimes they have no costae, thus resembling the types described as *Articulina laevigata* TERQUEM but differing by the clearly visible sutures and the compressed test.

Some specimens resemble *Articulina gibbulosa* D'ORBIGNY as figured by TERQUEM (1882, Mém.Soc. Géol. France, ser. 3, vol. 2, pl. 15, f. 26) from the Lutetian of the Paris basin.

In our material there are no individuals with uniserial chambers.

D i s t r i b u t i o n . — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse; England : Upper Bracklesham beds.

Articulina contracta (TERQUEM)

Pl. IV, fig. 14; *172*

Vertebralina contracta TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 45, pl. 2, f. 19, 20 (not 21, 22) (Lutetian; Paris basin).

Articulina contracta (TERQUEM), Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 37.

R e m a r k s . — In our material specimens with a quinqueloculine arrangement of the chambers are most frequent. The triloculine specimens are less compressed. No specimens with uniserial portion were found.

CUSHMAN (1944, Cushm. Lab. Foram. Res., Spec. Publ. no. 10, p. 2) considered *Articulina contracta* to be a synonym of *A. nitida* D'ORBIGNY, but *A. contracta* is different by the distinct compression of the test, the slit-like aperture and the ornamentation with very fine striae.

D i s t r i b u t i o n . — Belgium : Sands of Lede, Sands of Wemmel; France : Lutetian.

Articulina laevigata TERQUEM

Pl. IV, fig. 15, 16, 17; *182*

Articulina laevigata TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 151, pl. 15, f. 27-31 (Lutetian; Paris basin); CUSHMAN, 1944, Cushm. Lab. Foram. Res., Spec. Publ. no. 10, p. 3, pl. 1, f. 6-10; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 36.

Remarks. — Typical forms of this species were found only in the Lutetian material of the Paris basin. They are characterized by a smooth surface without visible sutures, and a rounded periphery. The aperture has a slight lip. These specimens seem to intergrade with individuals with distinct sutures and a thick lip, such as *Articulina incerta* (TERQUEM), as figured by Y. LE CALVEZ (1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 38, pl. 4, f. 89).

In the Belgian material the majority of the specimens belong to the *incerta* type, but a clear-cut boundary with the *laevigata* type is absent. The Belgian specimens are associated with individuals which are more compressed and resemble *Ariculina flandrica* nov. sp., which is characterized by a bicarinate periphery.

All these types never showed a uniserial part of the test.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse;
England : Upper Bracklesham beds;
France : Lutetian.

Articulina ornaticollis Y. LE CALVEZ

Pl. IV, fig. 18; *166*

Articulina ornaticollis Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 38, pl. 4, f. 88 (Lutetian; Paris basin).

Remarks. — This name was only applied to specimens with a uniserial part. They are all of relatively small size.

Specimens without uniserial chambers are inseparable from very young individuals of *Articulina laevigata* TERQUEM. They have probably been incorporated in that species.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel;
France : Lutetian.

Articulina pseudosulcata nov. sp.

Pl. IV, fig. 19, 20; *190*

Etymology. — From Greek : *pseudo-* = false, and from Latin : *sulcus* = furrow.

Description. — Test biloculine, slightly longer than broad, somewhat compressed; periphery broadly rounded; visible chambers broad; sutures slightly depressed, often indistinct; wall ornamented with longitudinal low costae; aperture large, irregularly oval to rounded, with a distinct lip.

Length of the holotype, 0,46 mm; breadth, 0,32 mm; thickness, 0,19 mm.

Remarks. — A number of young specimens show the chambers arranged in a triloculine series; they possess a small bifid tooth in the aperture. Such a tooth is also found in young specimens of other *Articulina* species. It is always absent in our adult specimens.

Sometimes the costae are absent or indistinct.

Articulina pseudosulcata resembles *A. sulcata* REUSS (1850, Denkschr. K. Akad. Wiss. Wien, Math.-Nat. Cl., vol. 1, p. 383, pl. 49, f. 13-17) with its variety *nuda* MARKS (1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 37, pl. 5, f. 8). The species of REUSS shows a triloculine arrangement of the chambers, and the previous lip remains visible between the two last-formed chambers.

The generic designation of our species is somewhat uncertain. No uniserial chambers have been obeserved, but especially the biloculine arrangement is unknown in the genus *Articulina*. The species resembles those of the genus *Cribropyrgo*, but a cribrate aperture was not found.

Type locality. — Heist-op-den-Berg, boring near the Rijksmiddelbare School (1951); our sample from 129,50 m. depth.

Type level. — Sands of Wemmel. These sands are generally regarded to be of Late Eocene age.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel.

Depository. — The holotype and paratypoids are stored in the collections of the Geological Institute of Utrecht (S. 11518, 11519).

Articulina flandrica nov. sp.

Pl. IV, fig. 21-24, *202*

Etymology. — Named after Flanders, the western part of Belgium.

Description. — Test about one and a half times as long as broad, distinctly compressed; periphery truncate, mostly slightly concave with blunt carinae; chambers fairly distinct, arranged in a triloculine series; sutures rather indistinct; wall smooth and polished; aperture circular, often at the end of a very short neck, with a distinct lip, the lip of the penultimate aperture externally visible.

Length of the holotype, 0,70 mm; breadth, 0,39 mm; thickness, 0,10 mm.

Remarks. — This species has been assigned to the genus *Articulina* because of its apertural features, though no uniserial series of chambers, characteristic for the genus, have been found.

Some variation is present in the development of the bicarinate periphery. Sometimes the carinae are very distinct, but also variants with a more or less rounded periphery were observed.

No similar species is known in the genus *Articulina*. The species resembles variants of *Spiroloculina bicarinata* d'Orbigny, but it distinctly differs by the apertural features and the triloculine arrangement of the chambers.

Type locality. — Bambrugge, the abandoned quarry « Steenberg » (ZD), our sample ZD 1016.

Type level. — The Sands of Lede. The age of these sands is generally regarded to be Late Eocene.

Distribution. — Belgium : Lede Sands, Wemmel Sands.

Depository. — The holotype and paratypoids are stored in the collections of the Geological Institute of Utrecht (S 11587, 11588).

Genus MILIOLA LAMARCK, 1804

Type species MILIOLITES SAXORUM LAMARCK, 1804

Miliola saxorum (LAMARCK)

Pl. IV, fig. 25-27, pl. V, fig. 1; *121*

Miliolites saxorum LAMARCK, 1804, Ann. Mus. Hist. Nat., vol. 5, p. 352; 1807, ibid., vol. 9, pl. 17, f. 2 (Eocene; Paris basin).

Quinqueloculina saxorum (LAMARCK), TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 181, pl. 19, f. 22.

Miliola saxorum (LAMARCK), Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 30.

Pentellina pseudosaxorum SCHLUMBERGER, 1905, Bull. Soc. Géol. France, ser. 4, vol. 5, p. 126, pl. 2, f. 36, pl. 3, f. 40, tf. 19-21 (Lutetian; Paris basin).

Miliola pseudosaxorum (SCHLUMBERGER), Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 30.

Miliola pseudoprisca GULLENTOPS, 1956, Mém. Inst. Géol. Louvain, vol. 20, pt. 1, p. 13, pl. 1, f. 8 (Oligocene; Belgium).

Quinqueloculina parisiensis BATJES (not D'ORBIGNY) (part), 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 104, pl. 2, f. 4.

Remarks. — Two closely related species of *Miliola* have been described from the Middle Eocene of the Paris basin : M. *saxorum* (LAMARCK) and *M. pseudosaxorum* (SCHLUMBERGER). According to SCHLUMBERGER *M. pseudosaxorum* is different by the possession of two longitudinal ridges on the inner wall of each chamber, and by the more angular form of the chambers. However, we found both types intergrading. There are specimens with partly or faintly developed ridges. The shape of the chambers is rather variable, without correlation with the degree of development of the internal ridges.

Consequently, it appeared imposible to separate *Miliola saxorum* and *M. pseudosaxorum*. This relationship between both variants is apparent in our material from the Paris basin as well as in the samples of the Belgian Upper Eocene.

Specimens of *Miliola* are furthermore characterized by a cribrate aperture, but in many specimens this structure is broken off. In these damaged specimens a tooth can be seen below the cribrate plate, and the specimens resemble *Quinqueloculina*. Fortunately there are often some slight remains of the cribrate covering along the border of the aperture.

In specimens described by BATJES (1958) as *Quinqueloculina parisiensis* the cribrate plate is usually entirely broken off, but these specimens form one series with the Eocene *Miliola* individuals. They mostly belong to *M. saxorum* and its variety *pseudosaxorum*, but some specimens of the Lower Tongeren beds of Belgium resemble *M. prisca* or *M. disticha*.

The original description of *Quinqueloculina parisiensis* D'ORBIGNY (1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 409; FORNASINI, 1905, Mem. R. Accad. Sci. Ist. Bologna, ser. 6, vol. 2, p. 63, pl. 2, f. 9) does not mention pits between the striae, as they were described by TERQUEM for this species (1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 181, pl. 19, f. 21). On TERQUEM's diagnosis we based our earlier determinations of *Miliola saxorum* as *Quinqueloculina parisiensis* (see BATJES, p. 104). It is now considered doubtful that any *Quinqueloculina* species with striae and pits occurs in the Eocene or Oligocene of France and Belgium.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse;
France : Lutetian.
Netherlands (Woensdrecht) : Lower Panisel beds.

Miliola birostris (LAMARCK)

Pl. V, fig. 2; *158*

Miliolites birostris LAMARCK, 1804, Ann. Mus. Hist. Nat., vol. 5, p. 353 (Eocene; Paris basin).
Quinqueloculina birostris (LAMARCK), TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 181, pl. 19, f. 23; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 8, pl. 1, f. 4-6.
Miliola birostris (LAMARCK), Y. LE CALVEZ, 1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 46.

Remarks. — Possibly this species is merely an elongated variant of *Miliola saxorum.* Our French specimens of this species show about the same variation as *M. saxorum* in the presence or absence of two longitudinal ridges along the inner wall of the chambers, and in the occasional presence of ridges between the longitudinal rows of pits.

In the material of the Upper Eocene of Belgium similar forms were found, but always in minor quantities.

Distribution. — Belgium : Sands of Lede;
France : Lutetian.

Miliola disticha (TERQUEM)

Pl. V, fig. 3; *152*

Quinqueloculina disticha TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 183, pl. 20, f. 7 (Lutetian; Paris basin); Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 10.
Quinqueloculina parisiensis TERQUEM (not D'ORBIGNY), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 181, pl. 19, f. 21 (Lutetian; Paris basin); BATJES (part), 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 104.

Remarks. — The ornamentation of this species is close to that of striated variants of *Miliola saxorum,* but typical specimens are more flattened. Y. LE CALVEZ assigned this species to *Quinqueloculina,* because of the absence of a cribrate aperture. However, our material showed some remnants of this structure, which is always broken.

Part of the individuals described by BATJES as *Quinqueloculina parisiensis* belong to this species. His specimens, as well as ours, have the distinct, thickened striae with one or two rows of small pits in between.

Massilina-like individuals are also present. These forms are probably identical with *Massilina bella* Y. LE CALVEZ (1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 29, pl. 2, f. 44, 45). In our material they are regarded as variants of *Miliola disticha.*

Distribution. — France : Lutetian.

Miliola prisca (D'ORBIGNY)

Pl. V, fig. 4, 5; *186*

Quinqueloculina prisca D'ORBIGNY, 1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray, vol. 2, p. 410 (Lutetian; Paris basin); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 182, pl. 20, f. 1-4; FORNASINI, 1905, Mém. R. Accad. Sci. Ist. Bologna, ser. 6, vol. 2, p. 68, pl. 4, f. 5.
Miliola prisca (D'ORBIGNY), Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 31.

Remarks. — *Miliola prisca* differs from *M. saxorum* by the less elongated shape of the test, and the less distinct and fewer pits, but there is no sharp boundary between both species.

Our specimens of *Miliola prisca* show wide variation, with the relatively short type with weakely visible pits and rounded periphery as the most frequent form.

One variant is very conspicuous. It is characterized by a sharply angled periphery in stead of more or less rounded edges. This form will be described as *Miliola prisca* var. *terquemi* nov. var.

Other variants have distinct striae between the longitudinal rows of pits. They are regarded as the variety *strigillata* (D'ORBIGNY). Among specimens of the latter variety triloculine individuals are preponderant, but in the material of *Miliola prisca* triloculine forms with all intergradations to distinct quinqueloculine specimens were found as well.

Just as *Miliola saxorum* the cribrate plate of the aperture covers a bifid tooth. In many specimens this plate is lost, which explains the *Quinqueloculina*-like appearance in the figures of FORNASINI and TERQUEM.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse; France : Lutetian.

Miliola prisca (D'ORBIGNY) var. **strigillata** (D'ORBIGNY)

Pl. V, fig. 6; *174*

Triloculina strigillata D'ORBIGNY, 1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 409 (Lutetian; Paris basin); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 169, pl. 17, f. 25; FORNASINI, 1905, Mem. R. Accad. Sci. Ist. Bologna, ser. 6, vol. 2, p. 60, pl. 1, f. 7.
Pentellina strigillata (D'ORBIGNY), SCHLUMBERGER, 1905, Bull. Soc. Géol. France, ser. 4, vol. 5, p. 124, pl. 2, f. 35.
Trillina strigillata (D'ORBIGNY), Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 33.
Miliola strigillata (D'ORBIGNY), Y. LE CALVEZ, 1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 46.

Remarks. — Typical specimens are ornamented with very fine striae, with small pits in longitudinal rows in between.

Some variants without striae are ornamented with coarser pits than it is usual for the variety and the species.

In 1947 Y. LE CALVEZ described the triloculine forms as *Trillina*, but the later discovery of quinqueloculine specimens made her range the entire group in *Miliola*.

There is some confusion in the literature about the type species of *Trillina*. MUNIER-CHALMAS (1882, Bull. Soc. Géol. France, ser. 3, vol. 10, p. 424) erected *Trillina*, with the type species *Triloculina strigillata* D'ORBIGNY, for species characterized by a triloculine arrangement of the chambers, a punctate appearance of the wall and a cribrate aperture. PARR (1942, Jour. Mining and Geol., Melbourne, vol. 2, p. 361) remarked that the descriptions of *T. strigillata* by TERQUEM and FORNASINI do not mention the punctate wall, nor the cribrate aperture. However, the redescription of TERQUEM's material by YOLANDE LE CALVEZ showed MUNIER-CHALMAS to be right in mentioning the above cited features for *T. strigillata*. But additionally the studies of Y. LE CALVEZ, as well as those of the present author, revealed that *T. strigillata* belongs to *Miliola*, so that the name *Trillina* is a synonym of *Miliola*.

SCHLUMBERGER (1893, Bull. Soc. Géol. France, ser. 3, vol. 21, p. 118) changed the character of *Trillina*, when describing *T. howchini* SCHLUMBERGER (1893, ibid., p. 119). This species has thick chamber walls that are alveolate in the portion on the outside of the chamber cavity.

REICHEL (1936, Ecl. Geol. Helv., vol. 29, p. 136), in discussing the above cited facts, preferred to make *Trillina howchini* the type of *Trillina*, but PARR (1942, op cit.) correctly established the new genus *Austrotrillina* for this species.

CUSHMAN (1950, Foraminifera, their Classification and Economic Use, 4th ed., p. 184) regarded *Trillina* MUNIER-CHALMAS as a synonym of *Triloculina*, but he must have neglected the cribrate nature of the aperture.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel; France : Lutetian.

Miliola prisca (D'ORBIGNY) var. **terquemi** nov. var.

Pl. V, fig. 7; *175*

Etymology. — Named after the famous French paleontologist TERQUEM.

Description. — This variety differs from typical *Miliola prisca* by its acute periphery in stead of a more or less rounded one.

Length of the holotype, 0,60 mm; breadth, 0,40 mm; thickness, 0,34 mm.

Remarks. — The general appearance of the test strongly resembles that of *Quinqueloculina lamarckiana* D'ORBIGNY (1839, in DE LA SAGRA, Hist. Phys. Nat. Cuba, Foraminifères, p. 189, pl. 1, f. 14, 15), but our specimens distinctly belong to *Miliola* because of its cribrate aperture. The cribate plate is broken, but often remnants of this structure are still visible along the bordures of the aperture.

Forms intermediate between *Miliola prisca* and this variety are not abundant, but whenever present, they distinctly show the passage of the acute type of the *terquemi* variety into the rounded forms of *M. prisca* by a series of individuals with a subacute to rounded periphery.

Type locality. — Brussegem, waterboring at the brewery of Mr. Dekeersmaker (1919); the sample Brussegem 27.

Type level. — Basal beds of the Sands of Wemmel. These sands are generally regarded to be of Late Eocene age.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel;
France : Lutetian.

Depository. — The holotype and paratypoids are stored in the collections of the Geological Institute of Utrecht (S 11475).

Genus TRILOCULINA D'ORBIGNY, 1826

Type species MILIOLITES TRIGONULA LAMARCK, 1804

In our *Triloculina* material of France and Belgium three types appeared to be the most common, viz. *Triloculina trigonula* (LAMARCK) (and its variety *inflata* D'ORBIGNY), *T. angularis* D'ORBIGNY, and *T. gibba* D'ORBIGNY. However, there is complete intergradation and the recognition of these species is the most convenient way to describe our highly variable *Triloculina* material.

Triloculina trigonula (LAMARCK)

Pl. V, fig. 8-10; *99*

Miliolites trigonula LAMARCK, 1804, Ann. Mus. Hist. Nat., vol. 5, p. 351; 1807, ibid., vol. 9, pl. 17, f. 4 (Lutetian; Paris basin).

Triloculina trigonula (LAMARCK), TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 165, pl. 17, f. 3; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 18.

Remarks. — Topotypes of this species, from Grignon, show a considerable range of variation; the same variation was found in the material from other localities in the Paris basin and in Belgium. Most common are specimens with distinctly bulbose chambers, as shown in the figures of LAMARCK, but specimens with a subangular border were found as well. The latter specimens resemble *Triloculina gibba* which has a still more angular periphery. MARKS (1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 41) placed *T. gibba* in the synonymy of *T. trigonula*, but comparison of topotypes of both species showed them to be different in this character of the periphery.

Triloculina crenulata Y. LE CALVEZ (1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 19, pl. 4, f. 67, 68) is probably a variant of *T. trigonula*, differing in the broad, crenulated tooth in the aperture.

Distribution. — Belgium : Sands of Mons-en-Pévèle, Sands of Lede, Sands of Wemmel, Clays of Asse;

England : Barton beds;

France : Lutetian.

Triloculina trigonula (LAMARCK) var. inflata D'ORBIGNY

Pl. V, fig. 11; *180*

Triloculina inflata D'ORBIGNY, 1846, Foram. foss. Vienne, p. 278, pl. 17, f. 13-15 (Miocene; Vienna basin); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 165, pl. 17, f. 4-6; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 18.

Remarks. — The specimens of this variety differ from *Triloculina trigonula* in the less inflated appearance of the test, but all intermediates between this type and the bulbose type of *T. trigonula* were found.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel;

England : Upper Bracklesham beds, Barton beds;

France : Lutetian.

Triloculina gibba D'ORBIGNY

Pl. V, fig. 12-14; *106*

Triloculina gibba D'ORBIGNY, 1846, Foram. foss. Vienne, p. 274, pl. 16, f. 22-24 (Miocene; Vienna basin); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 163, pl. 16, f. 31; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 17.

Remarks. — Most of our specimens resemble D'ORBIGNY's figures fairly well. They are characterized by a subangular periphery, and slightly bulbose to flattened chambers.

Specimens with more rounded periphery and more or less bulbose chambers mark the intergradation with *Triloculina trigonula*.

Distribution. — Belgium : Sands of Mons-en-Pévèle, Brussels Sands, Sands of Lede, Sands of Wemmel, Clays of Asse;

France : Lutetian.

Triloculina angularis D'ORBIGNY

Pl. V, fig. 15: *141*

Triloculina angularis D'ORBIGNY, 1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 409 (Lutetian; Paris basin); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 163, pl. 16, f. 34, 35; FORNASINI, 1905, Mem. Accad. Sci. Ist. Bologna, ser. 6, vol. 2, p. 59, pl. 1, f. 2; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 17, pl. 4, f. 72.

Remarks. — Originally *Triloculina angularis* was described as a species with sharp angular borders. FORNASINI remarked that it must be very close to *T. tricarinata* D'ORBIGNY (1865, in PARKER, JONES and BRADY, Ann. Mag. Nat. Hist., vol. 16, pl. 1, f. 8) from the Red Sea.

Several authors figured forms with subangular borders, which they assigned to the latter species, but such types are probably closer to *Triloculina trigonula*. Similar variants with less sharply angled peripheral borders, and difficult to separate from *T. trigonula*, were especially met with in the Lede Sands.

Distribution. — Belgium : Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse.

Triloculina lecalvezae nov. nom.

Pl. V, fig. 16; *157*

Triloculina laevigata D'ORBIGNY, in TERQUEM, 1878, Mém. Soc. Géol. France, ser. 3, vol. 1, p. 57, pl. 5, f. 20, 21 (Pliocene; Rhodes, Mediterranean); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 168, pl. 17, f. 22, 23; FORNASINI, 1905, Mem. Accad. Sci. Ist. Bologna, ser. 6, vol. 2, p. 5, pl. 1, f. 10; Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 17.

[not *Triloculina laevigata* BORNEMANN, 1855, Zschr. Deu. Geol. Ges., vol. 7, p. 350, pl. 19, f. 5 (Oligocene; Germany)].

Etymology. — Named in honour of the excellent micropaleontologist Mrs. YOLANDE LE CALVEZ (Paris).

Remarks. — D'ORBIGNY mentioned this species in 1826 (Ann. Sci. Nat., ser. 1, vol. 7, p. 300), but the first valid description is the one of TERQUEM (1878), who based his determination on the « Planches inédites ». As a consequence it is a homonym of *Triloculina laevigata* BORNEMANN, and a new name is necessary.

Distribution. — France : Lutetian.

Triloculina propinqua TERQUEM

Pl. V, fig. 17; *163*

Triloculina propinqua TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 168, pl. 17, f. 19 (Lutetian; Paris basin); Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 19, pl. 4, f. 80-82.

Triloculina varians TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 161, pl. 18, f. 1-6 (Lutetian; Paris basin).

Distribution. — Belgium : Sands of Lede;
France : Lutetian.

Genus PYRGO DEFRANCE, 1824

Type species PYRGO LAEVIS DEFRANCE, 1824

Pyrgo bulloides (D'ORBIGNY)

Pl. V, fig. 18; *133*

Biloculina bulloides D'ORBIGNY, 1826, Ann. Sci. Nat., ser. 1, vol. 7, p. 297, pl. 16, f. 1-4 (Eocene; Paris basin; Miocene; Aquitaine basin; recent; Adriatic, Italy); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 153, pl. 15, f. 37, 38.

Pyrgo bulloides (D'ORBIGNY), Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 21; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 107.

Remarks. — D'ORBIGNY figured a rather elongate form of the species, but following TERQUEM (1882) we considered *Pyrgo bulloides* to have a test about as long as broad, and *P. elongata* a test about one and a half times as long as broad. *P. bulloides* is furthermore distinguished by the extended borders of the chambers, which are subacute to rounded.

Distribution. Belgium : Sands of Brussels, Sands of Lede;
France : Lutetian.

Pyrgo elongata (D'ORBIGNY)

Pl. V, fig. 19; *176*

Biloculina elongata D'ORBIGNY, 1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 409 (Miocene; Aquitaine basin); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 154, pl. 16, f. 1.

Pyrgo elongata (D'ORBIGNY), Y. LE CALVEZ, 1947, Mém. Expl. Carte Géol. dét. France, pt. 1, p. 21.

Remarks. — This species is different from *Pyrgo bulloides* by the elongate form of the test, and the less extended borders of the chambers.

Distribution. — Belgium : Sands of Wemmel;
France : Lutetian.

Genus FABULARIA DEFRANCE, 1820

Type species FABULARIA DISCOLITES DEFRANCE, 1825

Fabularia bella nov. sp.

Pl. VI, fig. 1-6; *205*

Etymology. — From Latin *bellus* = pretty.

Description. — Test nearly circular to oval in front view, strongly compressed in side view, slightly longer than broad to one and a half times as long as broad; periphery narrowly rounded, later chambers in adult specimens biloculine, involute; sutures distinct, slightly depressed; wall ornamented with numerous, fine, longitudinal striae, which are the external counterparts of the plates that divide the chamber cavities into series of longitudinal chamberlets, in between the striae the wall has finely pitted zones; aperture a terminal opening, in well-preserved specimens with a distinct, cribrate border, possibly a remnant of the original cribrate plate that covered the opening.