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KONINKLIJK BELGISCH INSTITUUT VOOR NATUURWETENSCHAPPEN

VERHANDELINGEN

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FORAMINIFERA OF THE EOCENE OF BELGIUM

BY

JOHANNES PAULUS HEIMEN KAASSCHIETER

« BATAAFSE INTERNATIONALE PETROLEUM MAATSCHAPPIJ N.V. », THE HAGUE

(WITH 16 PLATES)

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INTRODUCTION

During the years 1953 to 1958 a team of the Paleontological Department of the Geological Institute of the State University of Utrecht studied the ostracoda and foraminifera of the Eocene and Oligocene of Belgium. The first paper by Dr. A. J. KEIJ, dealing with the ostracoda, was published in 1957. The second, by Dr. D. A. J. BATJES, on the results of his studies of the Oligocene foraminifera, followed in 1958. The present paper is the last of this series.

These studies were started because of the special importance of the Belgian Eocene-Oligocene for the general stratigraphic column. The type deposits of some, more or less commonly accepted, stratigraphic units of the Eocene are to be found in Belgium : Ypresian, Ledian and Wemmelian. Furthermore, there are the types of the Paniselian, Bruxellian, Laekenian and Assian of the Belgian geologists.

During four months, in 1953 and 1954, over four hundred and fifty samples were collected from a great number of pits and smaller outcrops. In addition, about one hundred and seventy samples from borings could be studied by the courtesy of the Directorate of the Geological Survey of Belgium. Furthermore, samples were available from classical localities of the Lower and Middle Eocene of the Paris basin, such as Cuise, Grignon and Daméry, and from some localities of the Hampshire basin, such as Barton Cliff, Alum Bay and Whitecliff Bay. Through the kindness of the Directorate of the Geological Survey of the Netherlands an important series of samples from the boring Woensdrecht, covering nearly the whole Eocene interval, could be investigated. They facilitated the detailed study of many of the lithologic units in the Belgian sequence.

While studying the foraminifera, it appeared desirable to enter into further detail on the stratigraphy of the Belgian Eocene. For this purpose several weeks were spent in Brussels studying the Archives of the Geological Survey of Belgium. The collected data enabled us to prepare a number of stratigraphic maps. For definite conclusions the number of reliable data appeared insufficient; only a number of suggestions can be given.

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He is especially indebted to Dr. C. W. DROOGER for suggesting the problem, and for his unflagging criticism and cooperation during the investigations and the preparing of the manuscript; to Dr. A. J. KEIJ and to Dr. D. A. J. BATJES for their continuous interest and helpful collaboration during many years.

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FORAMINIFERA OF THE EOCENE OF BELGIUM

CHAPTER I

STRATIGRAPHIC REVIEW

INTRODUCTION

In 1833 Lyell subdivided the Tertiary period into four groups : Eocene, Miocene, Older Pliocene and Newer Pliocene. He based his subdivisions on the percentages of living species of molluscs of the various known fossil faunas of northwestern Europe. For these percentages he adopted the countings given by Deshayes (1830). The percentage of the Eocene was mainly based on the rich faunas of the Paris basin.

Since Lyell's proposal, the Eocene suffered the separation of the Oligocene (Beyrich, 1854) and of the Paleocene (Schimper, 1874), but it still represents the central and main part of the Paleogene (Naumann, 1866) or Nummulitique (Renévier, 1873; Haug, 1911).

Paleogene strata appear at the surface in a large part of Belgium. They belong to a much larger area of former deposition which included southern England (London and Hampshire basins), northern France (Paris basin) and the southern Netherlands.

The relationship between this great anglo-franco-belgian basin and the depositional areas in the northern Netherlands, northern Germany, and Denmark is not quite clear. According to stratigraphic maps, published by Pannekoek (1956), the Belgian basin was separated from the Northern German-Danish basin by a SE-NW striking swell. During at least part of the Eocene there must have been some connection between the two basins.

Since Lyell's time the Eocene has been subdivided into a number of stages. These stages, such as those established by Dumont, were originally merely names for rock-units. Later on a more or less vague time-stratigraphic meaning was added. Furthermore, each stage had to correspond with a cycle of sedimentation. It should comprise a transgression at the beginning of a marine phase, which after some time was followed by a recurrence of continental conditions. The next cycle again started with a marine transgression.

This subdivision based on cyclic sedimentation was developed in Belgium (Rutot, 1883*a*; and others) and France, and later on was applied to the Tertiary strata of England (Stamp, 1920).

Two cycles were recognized in the Paleocene, four in the Eocene, and one in the Oligocene.

At the end of the nineteenth century it became a general rule to introduce a stage with every basal bed that corresponded to a (supposed) transgression. This certainly overemphasized the importance of local conditions in the shallow seas that covered these areas. As a consequence the stratigraphy of especially the Upper Eocene in the Franco-Belgian territory was burdened with a large number of stage-names.

We will try to clear up part of the involved confusion by making a sharp distinction between rock- and time-stratigraphic units, as was done by BATJES (1958) for the Oligocene.

The rock-stratigraphic units are named after the type-locality with the addition of general names, such as formation, member or bed(s), or otherwise of nouns that indicate the lithologic nature of the unit. The time-stratigraphic units will be given the ending -ian or -an, and in most cases they are derived from the name of a type-locality, as recommended by the International Geological Congress at Paris in 1900.

For the reader's orientation a short review will be given of the main Eocene stratigraphic units of northwestern Europe, and their correlation, as found in literature.

BELGIUM

The first important papers on the Eocene stratigraphy of Belgium are those by DUMONT (1839, 1849, 1851, etc.) and D'OMALIUS D'HALLOY (1842).

In 1839 DUMONT subdivided the Belgian Tertiary in the following « systèmes » : Landenian, Bruxellian, Tongrian, Diestian, Campanian, and Hesbayan. In 1849 he further subdivided the Landenian into Landenian and Ypresian. Two years later he added three more units, thus subdividing the Belgian Eocene into : Heersian, Landenian, Ypresian, Paniselian, Bruxellian, Laekenian, and Tongrian.

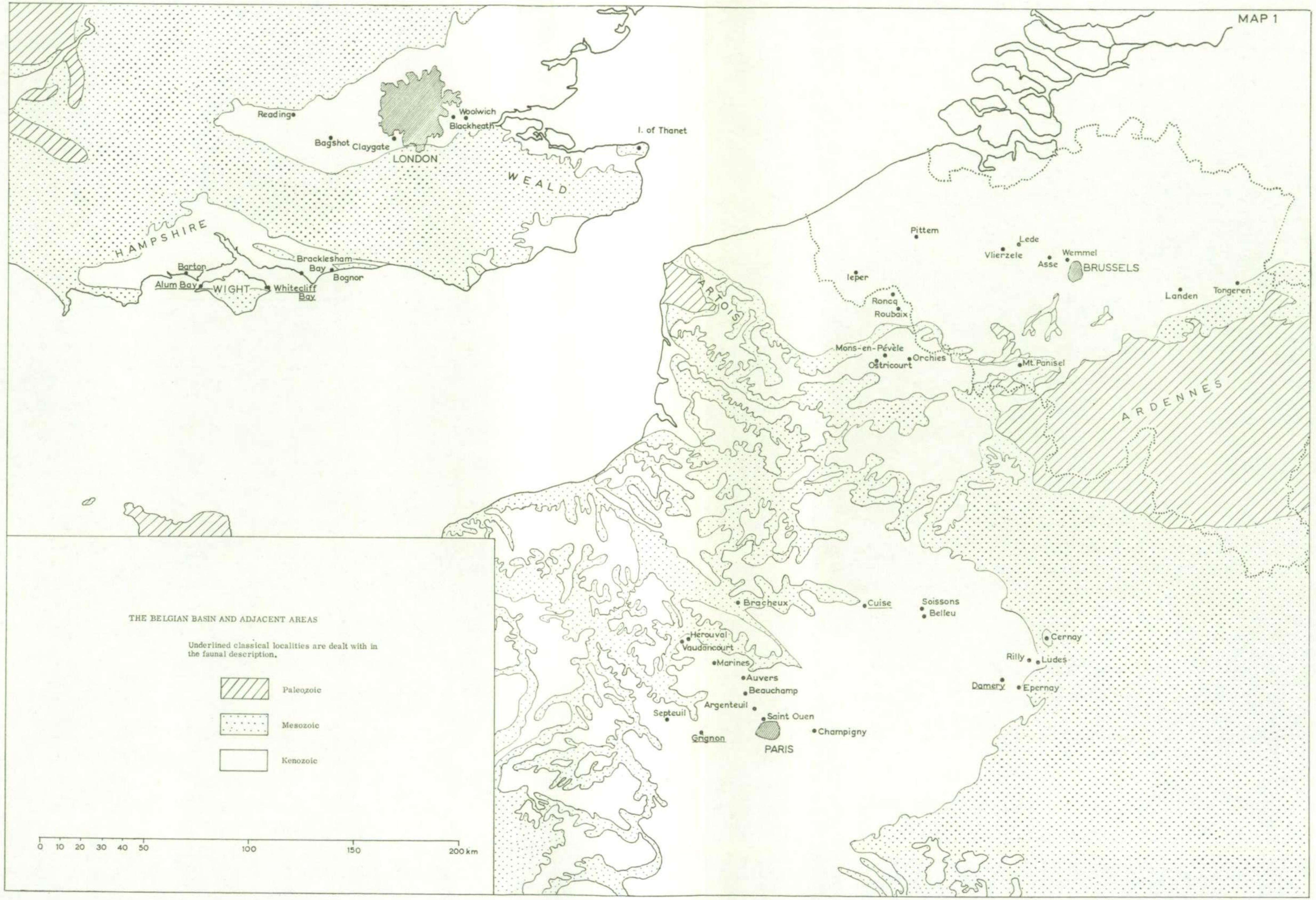
This classification still forms the foundation of Belgian Paleogene stratigraphy, though more or less completed and modified by later authors, especially by MOURLON, RUTOT and G. VINCENT during the second half of the 19th century. They based the stratigraphic subdivision on cycles of sedimentation, and in relation with this principle added some more stage-names : Ledian (MOURLON and E. VINCENT, 1887), Wemmelian (RUTOT and G. VINCENT, 1878) and Assian (RUTOT, 1882*b*), which were intended as parts of the Laekenian and the Tongrian of DUMONT.

The stratigraphic code, adopted for the geological maps of Belgium (1 : 40.000 and 1 : 160.000), was based for the greater part on this subdivision of the Eocene, with more additions by RUTOT.

Research of the Belgian Eocene and correlation with the deposits in surrounding countries were especially continued by LERICHE. His results were laid down in various publications from 1899 to 1951. He recognized the excessive subdivision into stages, and consequently he reduced the stratigraphic sequence to only four cycles of sedimentation during the Eocene, those of the Ypresian, Bruxellian (or Lutetian), Ledian and Bartonian. These correspond with the former Ypresian and part of the Paniselian, part of the Paniselian and the Bruxellian, the Laekenian and the Ledian, and the Wemmelian together with the Assian, respectively.

An extensive compilation of the more important data on the stratigraphy of the Belgian Eocene was published by GULINCK and HACQUAERT in the « Prodrome d'une description géologique de la Belgique » (1954).

In 1958 BATJES suggested that the Lower Tongeren beds, usually referred to as Lower Tongrian (Oligocene), probably belong to the Bartonian.


MAP 1
THE BELGIAN BASIN AND ADJACENT AREAS
Underlined classical localities are dealt with in the faunal description.
Paleozoic
Mesozoic
Kenozoic
0 10 20 30 40 50 100 150 200 km
Reading
Woolwich
Blackheath
Bagshot
Claygate
LONDON
I. of Thanet
WEALD
HAMPSHIRE
Barton
Bracklesham Bay
Bognor
Alum Bay
WIGHT
Whitecliff Bay
ARTOIS
Pittem
Lede
Vlierzele
Wemmel
Asse
BRUSSELS
Ieper
Landen
Tongeren
Roncq
Roubaix
Mons-en-Pévèle
Ostricourt
Orchies
Mt. Panisel
ARDENNES
Bracheux
Cuise
Soissons
Belleu
Cernay
Hérouval
Vaudancourt
Marines
Rilly
Ludes
Auvers
Beauchamp
Damery
Epernay
Argenteuil
Saint Ouen
Septeuil
Champigny
Grignon
PARIS

Hardly anything is known of Belgian Eocene foraminifera. GULLENTOPS (1956) published some remarks on smaller foraminifera of the Sands of Lede in a description of a foraminiferal fauna from a sample of Oligocene Oude Biezen Sands from Borgloon. Only the nummulites received more attention (DE LA HARPE, 1881, 1882; VAN DEN BROECK, 1896), but a revision of this group might be welcome.

FRANCE

PARIS BASIN

The Paris basin is separated from the Belgian area of deposition by the western continuation of the Ardennes into the so-called Axis of Artois (see map 1).

The Tertiary series of the Paris basin (see figs. 1 and 2) begin with deposits said to be of Montian (DEWALQUE, 1868) and of Landenian age, both considered to belong to the Paleocene.

The Landenian is represented by marine as well as by continental sediments, often distinguished as Thanetian (PRESTWICH, 1850) and Sparnacian (DOLLFUS, 1880; named after Epernay), respectively. They are more or less successive parts of the Landenian.

General time scale	ENGLAND Hampshire Basin	ENGLAND London Basin	FRANCE Paris Basin	BELGIUM	NETHERLANDS Northern German-Danish-Basin	GERMANY Northern German-Danish-Basin
Tongrian	Headon Beds		Marnes supragypseuses	Tongeren Beds		Latdorf
Bartonian	Upper / Middle / Lower Barton Beds		Gypse de Montmartre Marnes à Pholadomya ludensis	Sands of Asse Clays of Asse Sands of Wemmel	Bartonian s.l.	Upper Eocene
Ledian	Upper Bracklesham Beds		Sables de Marines Sables de Beauchamp Calcaires de St. Ouen	Sands of Lede		
Lutetian	Lower Bracklesham Beds	Bagshot Beds	Calcaire grossier	Sands of Brussels Panisel Beds	Lutetian	Lower Eocene 4
Ypresian	London clay	Claygate Beds London clay Blackheath Beds	Sables de Cuise Grès de Belleu	S. of Mons-en-Pévèle Clays of Ieper	Ypresian s.l.	Lower Eocene 3 Lower Eocene 2 Lower Eocene 1
Landenian	Reading Beds	Reading and Woolwich Beds	Argiles plastiques	Sands of Landen-Erquelinnes	Paleocene	Paleocene

FIG. 1. — General classification of the Paleocene and Eocene stratigraphic units of northwestern Europe.

The marine part of these strata is mainly represented by the Sands of Bracheux, which occur only in the northern part of the basin. LERICHE (1912) distinguished three paleontological zones, but FARCHAD (1936) remarked that the species of *Cyprina* and *Pholadomya*, which had been used for that purpose, are not of time-stratigraphic value over a greater distance, since they are only indicators of more or less littoral environments.

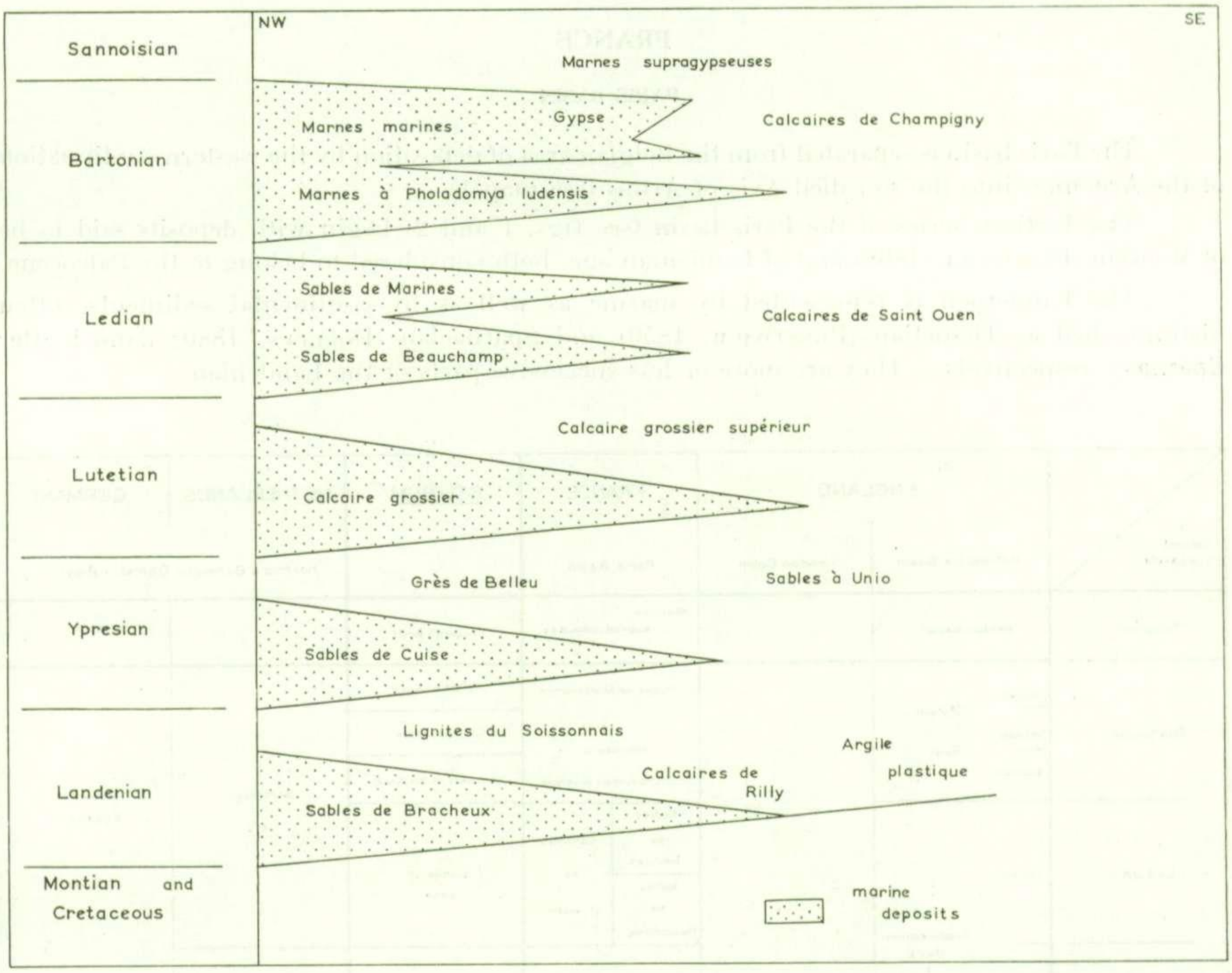


FIG. 2. — Paleocene and Eocene rock-units of the Paris basin (after LERICHE, 1912).

Along the borders of the area of these glauconitic Sands of Bracheux continental formations are to be found, the most important of which are the Limestones of Rilly with *Physa gigantea*, and the Conglomerate of Cernay with the oldest known mammalian fauna of the European Tertiary, but also with marine molluscs (TEILHARD DE CHARDIN, 1916-1921). Probably these deposits are lateral equivalents of the Sands of Bracheux, but they are often regarded as the lowermost part of the Sparnacian. This shows that the terms Thanetian and Sparnacian have often been used because of the facies of the sediments only. As time-stratigraphic units they had better to be neglected.

The « continental » part of the Landenian, often described as Sparnacian, includes various sediments, such as clays, lignites, limestones, and sands. Generally two groups of deposits are distinguished :

1. North and east of Paris, the mainly brackish sediments of the « Lignites du Soissonnais », consisting of clays, with lignites and some beds with marine to brackish molluscs : *Cyrena cuneiformis, Melania inquinata,* etc.

2. South of Paris, fully continental deposits, the « argile plastique », consisting of plastic clays with some irregular sandy intercalations.

There is some confusion as to whether these deposits belong to the cycle of sedimentation of the Landenian or to that of the Ypresian. In the last few years they have been regarded as continental variants of the Ypresian (FEUGUEUR, 1955).

In the northern part of the basin the overlying marine deposits, the Sands of Cuise, belong to the Ypresian cycle. These Sands of Cuise are often regarded as the type deposits of the Cuisian (DOLLFUS, 1880), but this Cuisian is no more than a synonym for the Ypresian.

The Sands of Cuise are characterized by *Nummulites planulatus.* At many places the base of the Sands is formed by a pebble bed, composed mainly of silex and fossil remains. These fossils, partly derived from the « Lignites du Soissonnais », are mixed up with those of the Sands of Cuise. This association is explained by the invasion of the Ypresian sea into the lagoons of the « Lignites du Soissonnais ».

The top part of the Sands of Cuise is formed by the Sands of Hérouval, in which a mixture is found of molluscs of the Sands of Cuise and of the « Calcaire grossier ».

Towards the end of Ypresian times continental conditions spread over the entire basin. One of the important members in the continental series, deposited after this marine period, is formed by the Sandstones of Belleu, with remains of *Lepidosteus* and of plants. Near Epernay, the « Sands with *Unio* », another member of these continental series, yielded mammalian remains of a fauna already related to that of the Lutetian (STEHLIN, 1941).

After the continental period of the Ypresian, another transgression brought back the sea into the Paris basin, this time with maximal extensions to the south beyond Paris. This transgression marks the beginning of the Lutetian (A. DE LAPPARENT, 1883; named after Lutetia = Paris), which corresponds to the formation referred to as the « Calcaire grossier ».

The marine part of the Lutetian deposits is mainly formed by soft limestones and/or calcareous sands. The basal coarse sand with quartz and glauconite as main components is called the « Glauconie grossière ».

In the sequence of the Lutetian LERICHE (1912) and ABRARD (1925) each distinguished four paleontological zones, sometimes with different names, but obviously with about the same meaning. They are from top to bottom :

4. Zone with *Cerithium giganteum* and *Orbitolites complanatus* (LERICHE) =
Zone with *Orbitolites complanatus* (ABRARD);

3. Zone with *Ditrupa strangulata* (LERICHE) =
Zone with *Echinolampas calvimontanus* and *Echinanthus issayvensis* (ABRARD);

2. Zone with *Nummulites laevigatus*;

1. Zone with *Marctia omaliusi* (LERICHE) =
Zone with two nummulites : *Nummulites laevigatus* and *N. lamarcki* (ABRARD).

These zones form by far the best way for a subdivision. The listed fossils appear to have a greater horizontal distribution than the numerous lithologic variations.

Overlying these four zones the topmost beds of the Lutetian are indicated as the « Calcaire grossier supérieur ». They consist mainly of crags with *Cerithium*, locally with some intercalated lignite horizons.

On top of these brackish and continental beds the Sands of Beauchamp belong to the sedimentary cycle of the Ledian.

Many variations of the marine environment resulted in several strictly local deposits. The Sands of Auvers are often taken as type for the Auversian (Dollfus, 1880). They belong to the lower part of the Ledian series of the Paris basin. Higher sands, such as the Sands of Marines, have been thought to represent the Bartonian, but they form parts of the younger Ledian deposits.

Encircling the area of the marine sands, several lacustrine limestones are found, such as the Limestones of Saint Ouen with *Planorbis pseudoammonius* and *Limnaea longiscata*.

The Ledian cycle ended with a continued deposition of lacustrine limestones, which spread over the greater part of the Paris basin.

The following cycle, the one during the Bartonian, started with the deposition of the transgressive « Marls with *Pholadomya ludensis* ». These are marly sands, marls or limestones, with their main outcrops near Ludes, in the vicinity of Reims. On top of this followed the deposition of the famous Gypsum beds of Montmartre, alternating with brackish or marine marls with molluscs.

South of the line Paris-Reims occur the Limestones of Champigny with scarce fresh-water molluscs (*Limnaea, Hydrobia, Nystia*, etc.).

In France this stage is often indicated as the Ludian (Munier-Chalmas and de Lapparent, 1893), an equivalent of the Bartonian.

The Oligocene is considered to begin with lagoonal deposits, the « Marnes supragypseuses », mostly supposed to be of Sannoisian (=Tongrian) age.

The important papers on smaller foraminifera by d'Orbigny (1826-1852) were partly based on material from the Eocene of the Paris basin, especially from Lutetian deposits. The same is true for earlier, but very important, notes of Lamarck and Defrance. Later on Terquem (1882) described foraminifera of the Lutetian deposits of Septeuil and Vaudancourt. The latter's collections, completed by material from several other localities of Lutetian deposits, were redescribed by Yolande le Calvez (1947-1952). She also described some foraminifera from the Sands of Hérouval.

Several papers and notes were published dealing with the nummulites of the Paris basin (Bruguière, 1792; Lamarck, 1804; Douvillé, 1919; Abrard, 1928; Schaub, 1951).

ENGLAND

In England the Paleogene strata are exposed in two areas, the London basin and the Hampshire basin.

LONDON BASIN

In the London basin (see fig. 3) the Tertiary system begins with the marine Thanet beds (Thanetian : Prestwich, 1850), typical in the Isle of Thanet. These Thanet beds are generally regarded as equivalents of the lower parts of the Landen beds of Belgium. They are poor in fossils, but they have yielded *Cyprina morrisi* and *Pholadomya konincki*.

Overlying these sandy beds follow the marine Bottom beds (of the Woolwich series), marked by the appearance of *Cyprina scutellaria*. They have been correlated with the upper part of the marine Landen beds of Belgium, approximately our Sands of Grandglise, or at least the upper part of these.

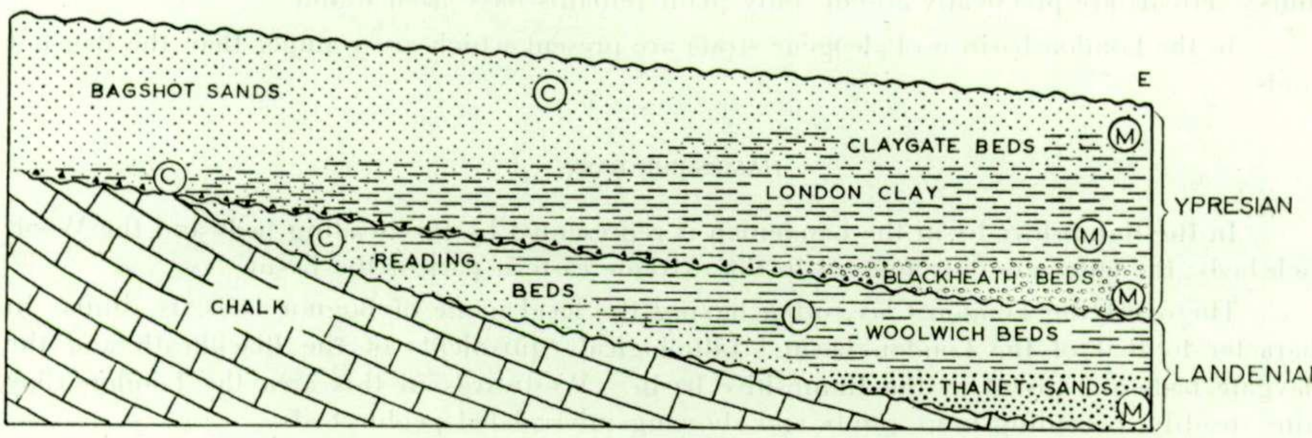


FIG. 3. — Generalized section through the Paleocene and Lower Eocene strata of the London basin (after WELLS, 1951). C : continental; L : lagoonal; M : marine.

The overlying Woolwich and Reading beds are lateral equivalents of different facies. The former are thought to be of estuarine or lagoonal origin; the second consist of freshwater deposits.

The Woolwich beds are found in the central area of the London basin. They contain a characteristic molluscan assemblage with *Cyrena cuneiformis, Melania inquinata* and *Potamides funatus*.

The area of the Reading beds forms a broad fringe along the western side of the Woolwich beds. They consist of current-bedded gravels and sands, and of clays and freshwater limestones.

This would be the end of the Landenian cycle.

The basal part of the overlying London Clay is formed by the Blackheath beds : pebble beds and sands with occasional pebbles. The fauna includes some brackish-water forms of the Woolwich beds and numerous marine species. In the western part of the London basin these beds are absent, and the London Clay directly overlies the Reading beds.

The London Clay is formed by a monotonous series of clays with layers of big septaria. Fossils are scarce. Subdivisions have not been made, except for one based on differences of the fauna :

Top beds,
Main mass,
Basement beds.

The fauna of the Basement beds suggests shallow water conditions; for the Main mass the water would have been deeper, and for the Top beds shallower conditions again recurred. Both the Bottom and the Top beds contain plant and animal remains, derived from the hinterland.

The Top beds pass upwards into the sandy Claygate beds, which, in the type area, consist of numerous alternations of sand and clay in thin layers. The Claygate beds are only known in the London area.

Upwards the London Clay or the Claygate beds pass into the Bagshot Sands, which, lithologically, closely resemble the Reading beds, again mainly consisting of current-bedded sands. Fossils are practically absent, only plant remains have been found.

In the London basin no Paleogene strata are present which are younger than the Bagshot Sands.

HAMPSHIRE BASIN

In the Hampshire basin the Landenian is represented by the Reading beds and the Woolwich beds; the latter are only present in the extreme eastern part of the basin.

The overlying London Clay, often having the local name of Bognor beds, is similar in character to that of the London basin. Lithological equivalents of the Blackheath and the Claygate beds are absent in the Hampshire basin. Westwards in this area the London Clay thins steadily, becoming more sandy and showing intercalated pebble beds.

Covering the London Clay, the Bagshot beds are found. They are marine deposits in the east, but have a fluviatile origin in the western part of the basin. In this fluviatile part pipeclay beds are found, which contain numerous leaves of plants, mainly of dicotyledonous angiosperms.

Overlying the Bagshot beds, the Bracklesham beds and the Barton beds represent the Lutetian, the Ledian and the Bartonian, as distinguished on the continent.

In the eastern part of the basin the Bracklesham beds consist of sandy clays with a rich fauna of marine molluscs and other fossils. The subdivision of these beds is based on species of *Nummulites*. The lower part contains *Nummulites laevigatus*, the upper part *N. variolarius*. The macrofauna of the Lower Bracklesham beds is said to differ more from the Upper Bracklesham assemblage than the latter does from the fauna of the Lower Barton beds. The Lower Bracklesham fauna contains, amongst others, *Turritella imbricataria, Venericardia planicosta*. The upper part with *Nummulites variolarius* is furthermore marked by the presence of *Cerithium giganteum*.

In western Hampshire, as well as at Alum Bay on the Isle of Wight, the entire series of the Bracklesham beds are formed by more or less continental sandy deposits. These beds are supposed to have been laid down on the seaward side of the deltas that extended from the west into the Lutetian and Ledian seas.

The lower limit of the overlying Barton beds in the type area has been defined by the appearance of *Nummulites orbignyi* (=*N. wemmelensis*). This species is confined to the lower part of the Barton beds. The threefold division of the Barton beds has been based on molluscan assemblages and on lithologic features.

The Lower Barton beds are green clays with sandy partings, and with a fauna of many species that range up from the Bracklesham beds, in addition to a number of new forms.

The Middle Barton beds are formed by the Barton Clay. The fauna consists for the greater part of molluscs, with but few characteristic species, however.

The Upper beds mainly consist of sands. The most fossiliferous horizon is the famous *Chama*-bed with abundant *Chama squamosa*. Towards the top the admixture of brackish-water fossils reflects the gradual shallowing and withdrawal of the Bartonian sea.

The topmost Barton beds and the lower strata of the overlying Headon beds form an almost continuous lithological unit. These beds and others, considered to belong to the Oligocene, are found only in the northern part of the Isle of Wight and in the adjacent parts of the mainland.

The Oligocene strata are represented by a thick series of freshwater and estuarine deposits, with occasional intercalated marine beds.

Burrows and Holland (1897) and Haynes (1956, 1957, 1958) described some of the foraminifera from the Thanet beds of the London basin; Bowen (1954, 1957) foraminiferal associations from the London Clay and the Barton beds. Smaller foraminifera from the Headon beds were described by Bhatia (1955), especially from Whitecliff Bay, Isle of Wight.

Nummulites have been described by Wrigley and Davis (1937), Wrigley (1934) and Curry (1937).

THE NETHERLANDS

Pannekoek (1956) published many data concerning the stratigraphy of the subsurface Eocene of the Netherlands, illustrated by several isopach maps and some sections.

In the Netherlands the main masses of the Eocene sediments occur in two areas. One is in the southwest, forming the northern part of the Belgian basin, the other is in the northeast, forming the western continuation of the Northern German-Danish basin. These two basins are separated by a swell without Eocene deposits, roughly from Nijmegen to The Hague. This structure is not distinct in the distribution of the Paleocene sediments, but it is found to be clear in the Eocene rocks, again fading out in those of the Upper Oligocene. These changing paleogeographic conditions are probably connected with the tectonic movements in the southeastern Netherlands, which resulted in the so-called « Horst and Graben structure » of that region.

In the southern basin the stratigraphic sequence is best known from the boring Woensdrecht. Our detailed investigation of this boring shows the distinct connection of its sedimentary series with those of the Belgian area.

In the northern basin the Eocene has been subdivided into three parts, indicated as Lower Eocene (Ypresian s.l.), Middle Eocene (Lutetian), and Upper Eocene (Bartonian s.l.).

The lower part of the sediments of the Lower Eocene consists of clays with intercalated sands, sandstones and numerous thin layers of bentonite. It corresponds to the more extensive deposits of this type in Denmark and Northern Germany. This lower part is thought to be mainly of lagoonal origin, which is in accordance with the type of the foraminiferal association. The clayey upper part of the Lower Eocene is distinctly marine.

The Middle Eocene deposits mainly consist of marine, marly and clayey deposits.

The lower part of the Upper Eocene series comprises sands, marls and limestones. *Nummulites orbignyi* (=*N. wemmelensis*) occurs throughout. The upper part is formed by sandy clays, with indications for a deposition in a shallowing sea, as was concluded from the presence of organic matter and wood fragments (Pannekoek).

Sediments of the Lower Oligocene have not been recorded. If present, they are very indistinct.

ten Dam (1944, 1945) studied the foraminifera of the Dutch Paleocene and Eocene. The faunae closely resemble those found in our Belgian material.

NORTHERN GERMANY

In Northern Germany the Eocene is again mainly known from borings.

Eocene deposits are found in a large area north of the line Münster-Hannover-Berlin. The subdivision of these beds is largely based on micropaleontological characteristics, which enabled the distinction of Lower Eocene 1, 2, 3 and 4, followed by Upper Eocene. BETTENSTAEDT (1949) emphasized the fact that the recognition of these units is for the greater part connected with differences of the facies of the sediments, but they show a remarkable horizontal continuity throughout the Northern German-Danish basin.

The correlation with the international stages is not quite clear. The lower three units and possibly part of the Lower Eocene 4 would correspond with the Ypresian. According to BETTENSTAEDT (1949) the Lutetian would be represented by the upper part of the Lower Eocene 4 and the lower part of the Upper Eocene. The top of the Upper Eocene would correspond to the Dutch Bartonian s.l. (e.g. the frequently adopted interpretation of the Bartonian, combining the Bartonian s.s. and the Ledian).

REUSS (1855, 1864) published some notes on foraminiferal assemblages of Eocene deposits of Germany. A general survey of the microfaunae of the German Tertiary was published by STAESCHE and HILTERMANN (1940) (with many illustrations of associations and of single specimens), and by HILTERMANN (1949). Also SCHUH (1952) published data on foraminifera, especially on those of the Upper Eocene; WICK (1946) on those of the Paleocene and Lower Eocene 1.

CHAPTER II

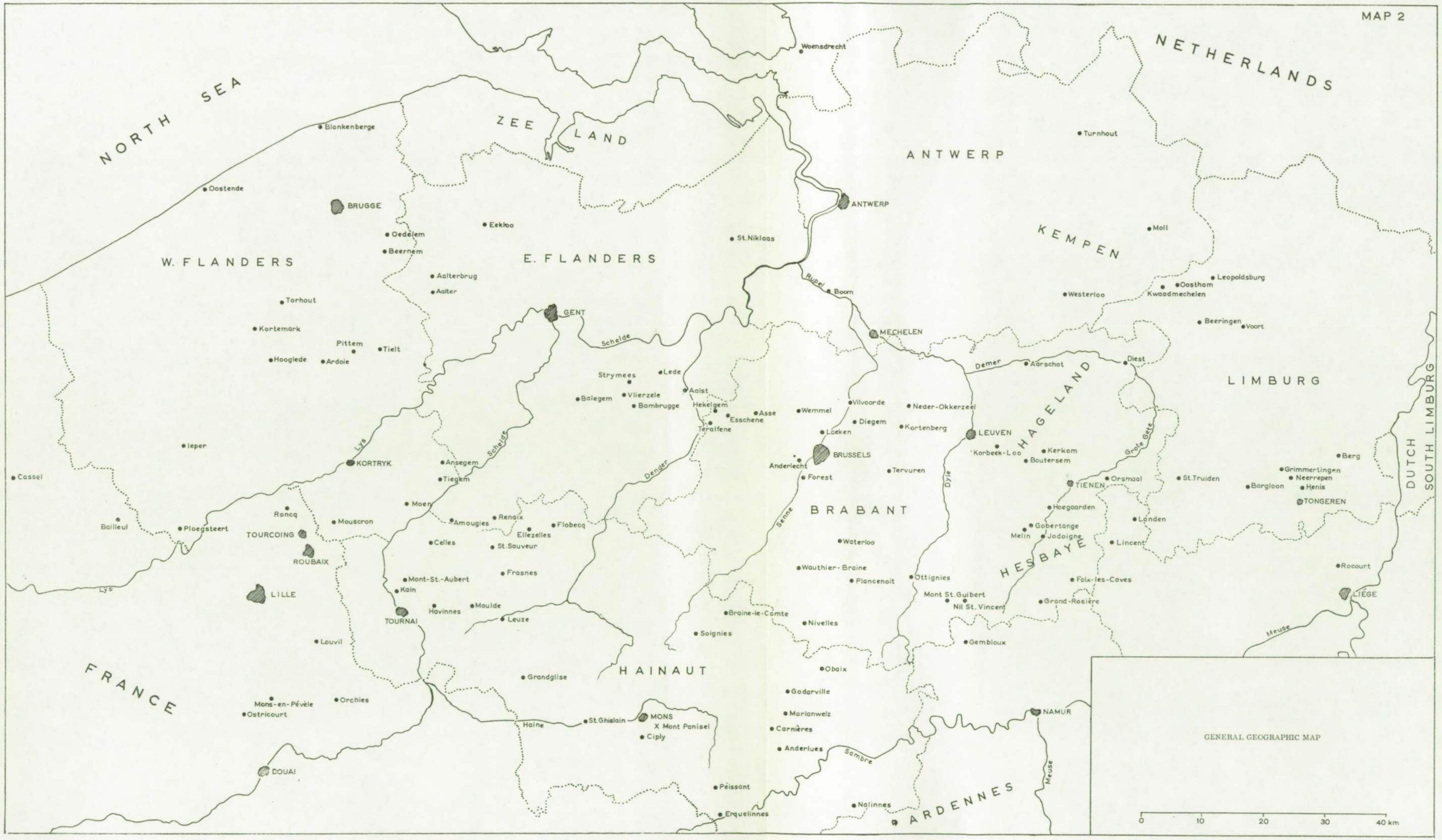
BELGIAN ROCK-UNITS

INTRODUCTION

In Belgian literature Paleocene and Eocene are often taken together as Eocene. In this paper the differentiation between Paleocene and Eocene is maintained, and the Eocene is considered to begin with the Ypresian, which in this northern region is characterized by the appearance of nummulites.

It has often been suggested that the area of sedimentation during Eocene time formed a single basin from Paris to the Netherlands, including the English basins. Isolated occurrences of deposits on the ridges in between the actual basins prove that during at least part of the Eocene, there must have been connections between the Paris and Belgian basins, as well as between the London and Hampshire basins. These deposits are partly of shallower water origin than their Belgian equivalents. This shows that the Axes of Artois and Weald, to-day mainly with outcrops of Paleozoic and Mesozoic rocks, must already have been an important geomorphologic feature during the Eocene.

In this paper the Axis of Artois is assumed to have formed the southern border of the Belgian basin. No distinct northern and eastern boundaries of the Eocene basin are known.



MAP 2

GENERAL GEOGRAPHIC MAP

Towards the east certain Eocene deposits have been found as far as the line Namur-Leopoldsburg. Towards the north the area of sedimentation continued in the southern Netherlands. In our investigations the boring of Woensdrecht is the most northern occurrence of Eocene rocks.

In the northern part of the Belgian area the Eocene sediments are covered by younger rocks, in the southern part they crop out south of the line Sint-Niklaas-Mechelen-Leuven-Tienen.

Most of the data, on which this chapter is based, were gathered during the field work. Data from the literature and from the Archives of the Geological Survey of Belgium have been added.

STRATIGRAPHIC MAPS

Three geological maps (no. 3-5) illustrate the distribution of the rock-units. They have been based on the Geological Maps of Belgium, namely the maps 1 : 40.000 published between 1890 and 1910, the map 1 : 160.000 of 1920, and the recent map 1 : 500.000 of DE BÉTHUNE, published in the Atlas of Belgium of 1954.

Thirteen maps (no. 6-18) further demonstrate the distribution and some other features of the various rock-units. These maps have been based on the geological maps, combined with our own observations and with data from the literature and the Archives of the Geological Survey at Brussels.

The data of only a few borings have been published, the greater part had to be collected from the Archives. Most are from water borings, many of which were flush borings and therefore less reliable. They had to be used by lack of sufficient data from dry or cored borings. In the northern part of the discussed area the water borings were not deep enough to reach the Eocene deposits. From this region only some widely spaced deep borings, nearly always flush borings, furnished some data. These data, when indicated, are considered to be very unreliable.

The description of borings and exposures in the Archives of the Geological Survey are not uniform. They have been made by several authors on samples that had usually been collected by the foremen of the borings, which fact often caused uncertainty in the interpretation of the reports.

These remarks must be taken into account when consulting the maps. However, the isopach maps and the contour maps may be considered to show the general features of the units.

LIST OF ROCK-UNITS

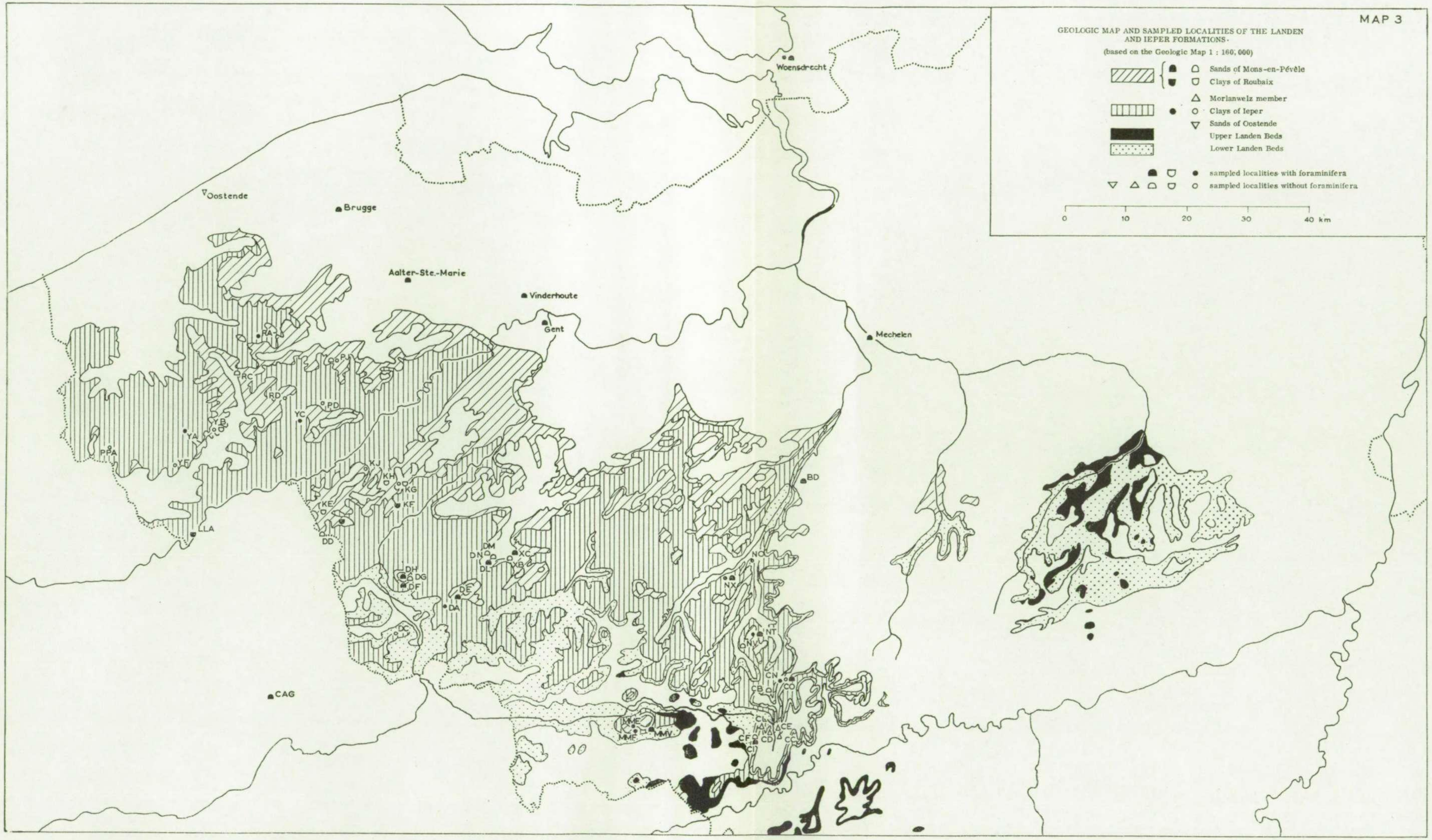
Our subdivision of the Eocene deposits is shown in the next table. The underlying and the covering units are also indicated.

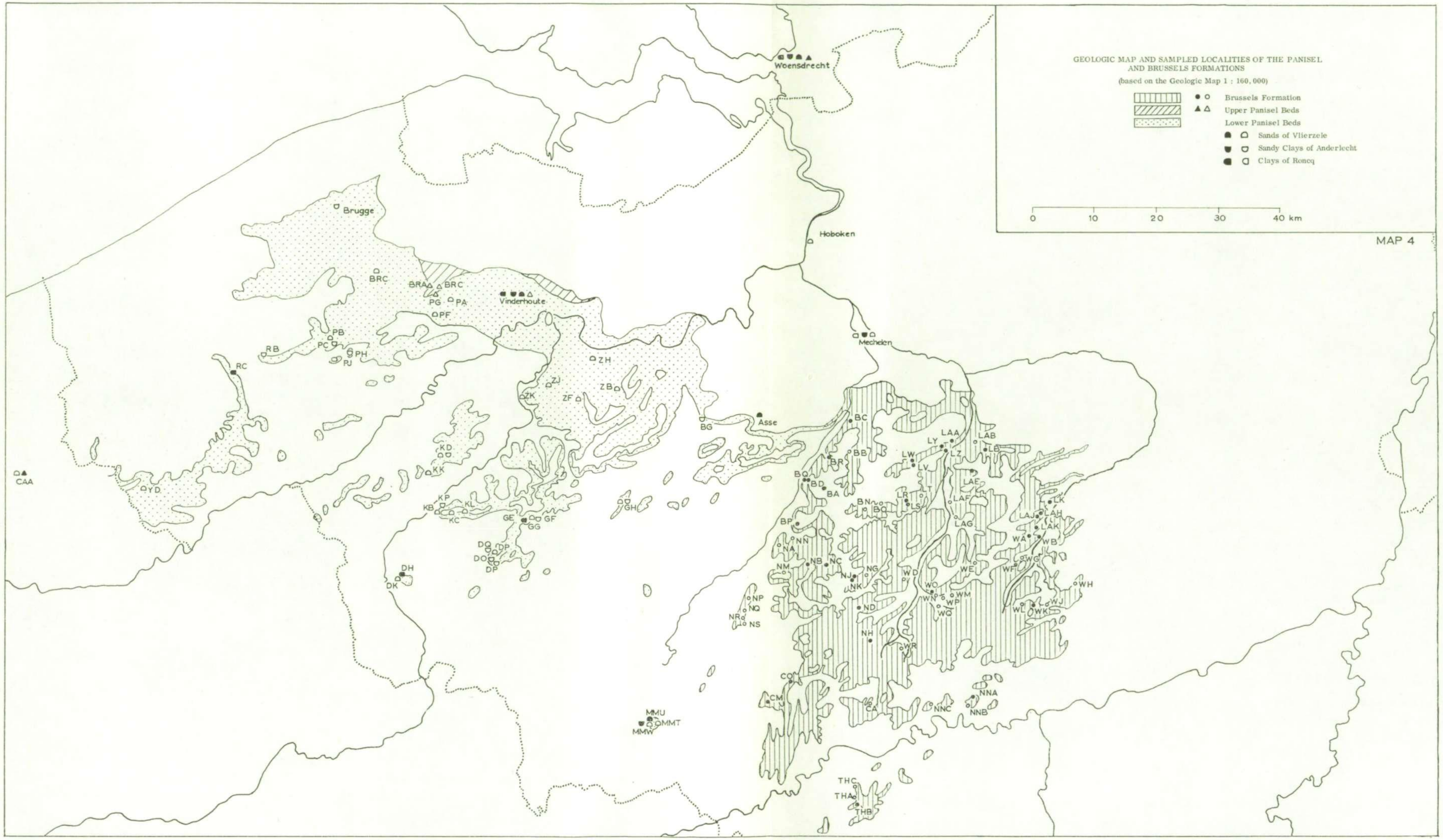
The succession in the list is not a time-stratigraphic one, only the most probable sequence of the discussed rock-units. Some of them have to be considered as lateral equivalents of one another (see Chapter V).

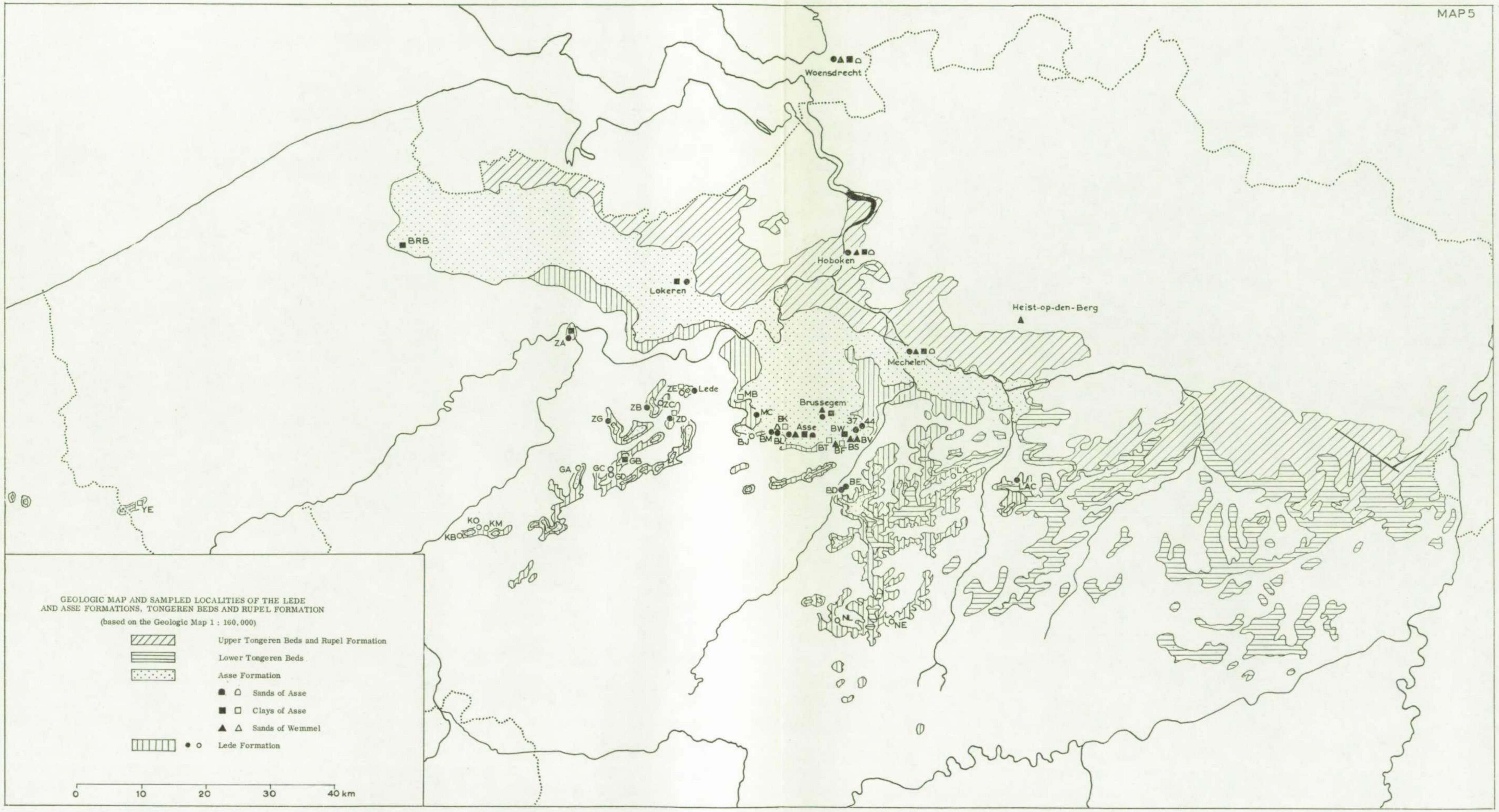
The notations between brackets are those of the geological map 1 : 160.000 or/and of the Stratigraphical Code adopted in 1932.

Rock-units introduced in this paper are : the Sands of Oostende, and the Sands of Vlierzele.

			Sands of Voort (V).	
OLIGOCENE (see BATJES, 1958).	Rupel formation (R)		Boom Clay (R2c).	
			Nucula-clay (R1c).	
			Sands of Berg (R1b).	
	Tongeren formation (Tg).	Upper Tongeren beds	Sands and marls of Oude-Biezen (Tg2c).	
			Clays of Henis (Tg2n).	
			Sands and marls of Boutersem (Tg2m).	
			Sands of Kerkom (Tg2k).	
		Lower Tongeren beds	Horizon of Hoogbutsel (Tg1m).	
			Sands of Neerrepen (Tg1d).	
			Sands of Grimmertingen (Tg1c).	
UPPER EOCENE.	Asse formation (Ba)		Sands of Asse (Asd)	(As).
			Clays of Asse (Asc)	(As).
			Sands of Wemmel (We).	
	Lede formation (Le)		Sands of Lede (Le).	
MIDDLE EOCENE.	Brussels formation (B)		Sands of Brussels (B).	
LOWER EOCENE.	Panisel formation (P)	Upper Panisel beds	Sands of Aalter (P2).	
		Lower Panisel beds	Sands of Vlierzele (P1d).	
			Sandy Clays of Anderlecht (P1c).	
			Clays of Roncq (P1m).	
	Ieper formation (Y)		Clays of Roubaix	(Y1b).
			Sands of Mons-en-Pévèle	(Y1b).
			Morlanwelz member.	
			Clays of Ieper (Y1a).	
PALEOCENE.	Landen formation (L).	Upper Landen beds	Sands of Oostende	(L2).
			Sands of Landen	(L2).
			Sands of Erquelinnes	(L2).
		Lower Landen beds	Sands of Grandglise (L1d).	
			Clays of Louvil (L1c).	
			Marls of Gelinden.	
			Sands of Orp.	


MAP 3
GEOLOGIC MAP AND SAMPLED LOCALITIES OF THE LANDEN AND IEPER FORMATIONS.
(based on the Geologic Map 1 : 160,000)
Sands of Mons-en-Pévèle
Clays of Roubaix
Morlanwelz member
Clays of Ieper
Sands of Oostende
Upper Landen Beds
Lower Landen Beds
sampled localities with foraminifera
sampled localities without foraminifera
0
10
20
30
40 km
Woensdrecht
Oostende
Brugge
Aalter-Ste.-Marie
Vinderhoute
Gent
Mechelen
CAG
RA
RC
RD
PD
YC
YB
YA
PPA
YF
LA
KE
KH
KG
KF
DD
DH
DG
DF
DE
DA
DC
DM
DN
DL
XC
XB
BD
NX
NT
NY
CN
CB
CO
MME
MMF
MMV
CF
CD
CE
CC
CI


GEOLOGIC MAP AND SAMPLED LOCALITIES OF THE PANISEL
AND BRUSSELS FORMATIONS
(based on the Geologic Map 1 : 160,000)
Brussels Formation
Upper Panisel Beds
Lower Panisel Beds
Sands of Vlierzele
Sandy Clays of Anderlecht
Clays of Roncq
0 10 20 30 40 km
Woensdrecht
Brugge
Hoboken
Vinderhoute
Mechelen
Asse
BRC
BRA
PG
PA
PF
PB
PC
PH
PJ
RB
RC
ZH
ZJ
ZK
ZF
ZB
BG
KD
KK
KP
KB
KL
KC
GE
GF
GG
GH
YD
CAA
DO
DP
DH
DK
MMU
MMT
MMW
BC
BB
BR
BQ
BD
BA
BP
BN
LW
LY
LAA
LAB
LB
LZ
LAE
LAF
LAG
LR
LS
LK
LAH
LAJ
LAK
WA
WB
WG
WF
WE
WD
WO
WN
WM
WP
WQ
WH
WJ
WK
WL
WR
NA
NB
NC
NG
NJ
NK
NM
ND
NH
NP
NQ
NR
NS
CO
CM
CA
NNA
NNB
NNC
THC
THA
THB
MAP 4


MAP 5
Woensdrecht
BRB
Hoboken
Lokeren
Heist-op-den-Berg
ZA
Mechelen
ZE
Lede
MB
ZB
ZC
ZD
ZG
MC
Brussegem
BK
Asse
BW
37
44
BM
BL
BJ
BT
BF
BS
BV
GB
GA
GC
GD
BE
BD
LAC
YE
KO
KM
KB
NL
NE
GEOLOGIC MAP AND SAMPLED LOCALITIES OF THE LEDE
AND ASSE FORMATIONS, TONGEREN BEDS AND RUPEL FORMATION
(based on the Geologic Map 1 : 160,000)
Upper Tongeren Beds and Rupel Formation
Lower Tongeren Beds
Asse Formation
Sands of Asse
Clays of Asse
Sands of Wemmel
Lede Formation
0
10
20
30
40 km

LANDEN FORMATION

named after Landen, in the Hesbaye

(Maps 3, 7 and 8)

The Landen formation overlies rocks of Paleozoic, Cretaceous, or Montian age; it is usually covered by the Clays of Ieper.

In the complicated series of rocks of different facies the Belgian geologists distinguish two greater units :

the Upper Landen beds, and
the Lower Landen beds.

The Upper Landen beds comprise sediments deposited in lagoonal to fluviatile environments. The Lower Landen beds are formed by deposits of marine origin; only their upper member will be dealt with.

SANDS OF GRANDGLISE (d'Omalius d'Halloy, 1842; Leriche, 1928)

named after Grandglise, in the western part of Hainaut

Exposures of the Grandglise Sands occur in part of the provinces Hainaut and Brabant, and in northern France. Furthermore these sands were encountered in borings in Flanders and the Kempen.

They usually cover the Louvil Clays, but in the southern part of Brabant and the eastern part of Hainaut they overlie rocks of Paleozoic or Cretaceous age.

The Sands of Grandglise mainly consist of fine-grained, glauconitic sands, often with clayey intercalations. In the upper part the bedding is irregular and often disturbed by tubulations (probably worm tubes), in the lower part bedding is more regular. In this lower part, near the transition into the Louvil Clays, the sands are rich in glauconite. The content of this mineral diminishes higher on, and locally the top beds are devoid of glauconite, and thus they may pass gradually into the Sands of Erquelinnes or of Landen.

Such a gradual passage occurs in the central part of the E-W directed depression of the Haine basin. Along the borders of this basin, as at Erquelinnes, the glauconitic Grandglise Sands have been ravinated before the deposition of the Upper Landen beds.

In the Hesbaye the transition zone shows distinct cross-bedding and intra-stratal crumpling features (Gulinck, 1948). At other places of this area the Sands of Grandglise have again been ravinated by the overlying Upper Landen beds.

Diminishing glauconite content and gradual passage into the Sands of Erquelinnes have been reported from many localities in northern France. In this area a distinction has been made between the « faciès flamand » and the « faciès cambrésien » of the Sands of Ostricourt (Gosselet, 1883). The first is equivalent with our Grandglise Sands, the second, formed by non-glauconitic, cross-bedded sands with many worm tubes, is partly the equivalent of our Upper Landen beds.

The Grandglise Sands are mostly overlain by the Ieper Clays. Wherever Oostende Sands are present, they are intercalated between the Sands of Grandglise and the Clays of Ieper. Along the southern and eastern border of the area the Grandglise Sands are covered by the Sands of Erquelinnes or of Landen.

In the greater parts of Flanders and Brabant a rather constant thickness of about 12 m has been found. In the Hesbaye thicknesses (up to 20 m) are more variable because of the erosion before the deposition of the Upper Landen beds.

The Grandglise Sands are devoid of fossils, except for small numbers at some localities, such as Nalinnes, Erquelinnes and Kortrijk. In northern France fossiliferous deposits are less rare.

The most frequent species are *Cyprina scutellaria, Venericardia pectuncularis, Crassatella bellovacina, Ostrea bellovacina, O. inaspecta.* From Erquelinnes also reptiles and fishes have been reported. They partly are of freshwater origin.

Leriche (1903) subdivided the Lower Landen beds into three paleontological zones; the upper one of which (the zone with *Cyprina scutellaria*) is about equivalent with our lithologic unit of the Grandglise Sands. In Belgium the threefold division is of little practical value because of the scarcity of fossils.

SANDS OF ERQUELINNES AND SANDS OF LANDEN (d'Omalius d'Halloy, 1842; Rutot, 1881)

named after Erquelinnes, in eastern Hainaut; and after Landen, in the Hesbaye

(Maps 3, 7 and 8)

We did not separate the Sands of Erquelinnes and the Sands of Landen because a good differential diagnosis cannot be given.

Their outcrops are found in two distinct areas : the southern and eastern part of Hainaut, and the Hesbaye, respectively (map 3). In between these two regions some dispersed small occurrences of lignitic clays are known. Their equivalence with the Upper Landen beds is questionable, however.

In the western part of the areas these units overlie the Grandglise Sands. More eastwards the Sands of Grandglise are absent and the Sands of Erquelinnes-Landen cover the Louvil Clays or older rocks.

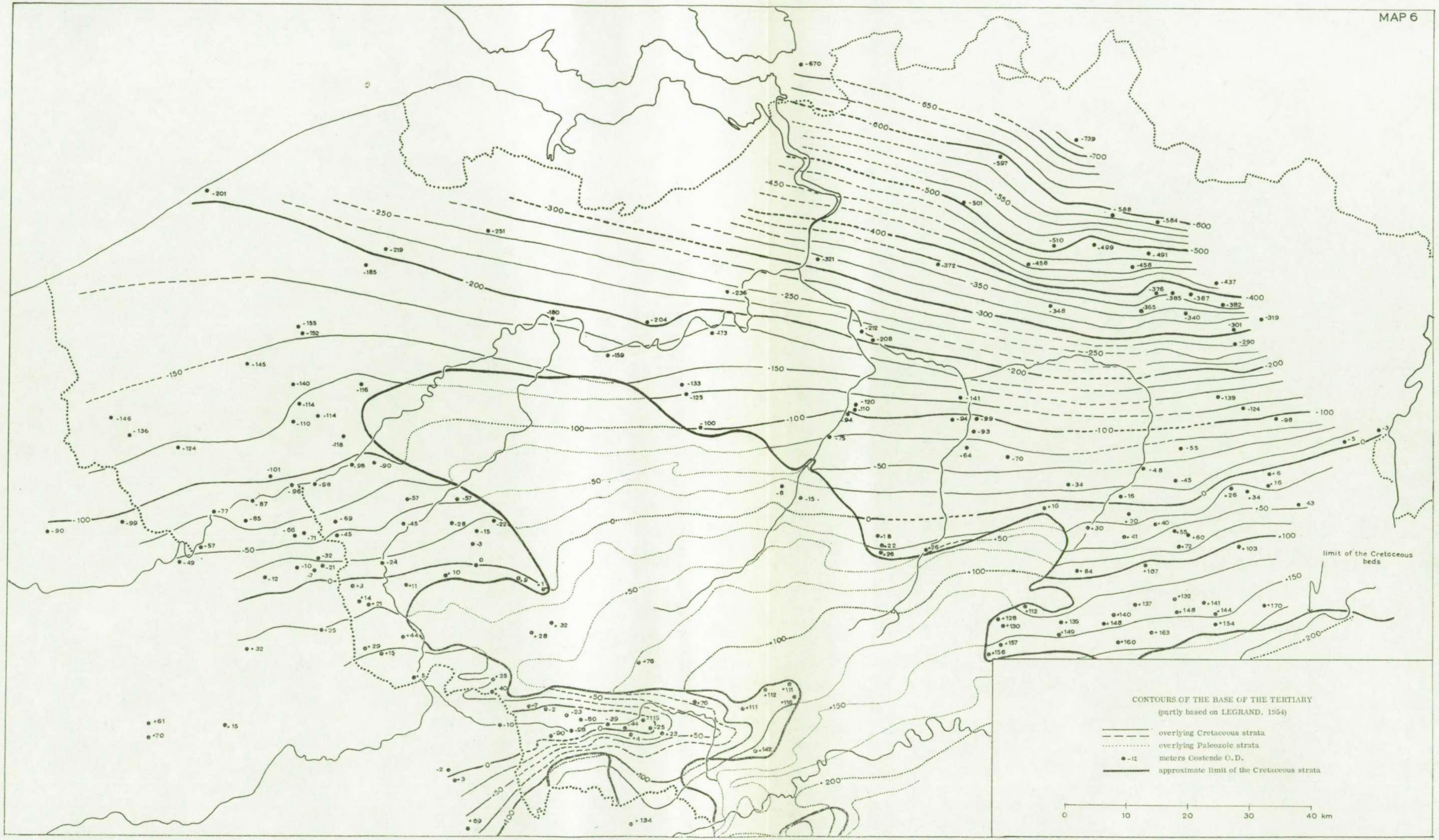
As has been described already the Grandglise Sands may gradually pass into the Sands of Erquelinnes-Landen. The lower part of the latter sands are of variable lithologic composition. They are mostly fine-grained sands, more or less lignitic, and often cross-bedded. Intercalations of clays, lignitic clays and marls may be of local importance, such as 5 m of lignitic clays at Havré.

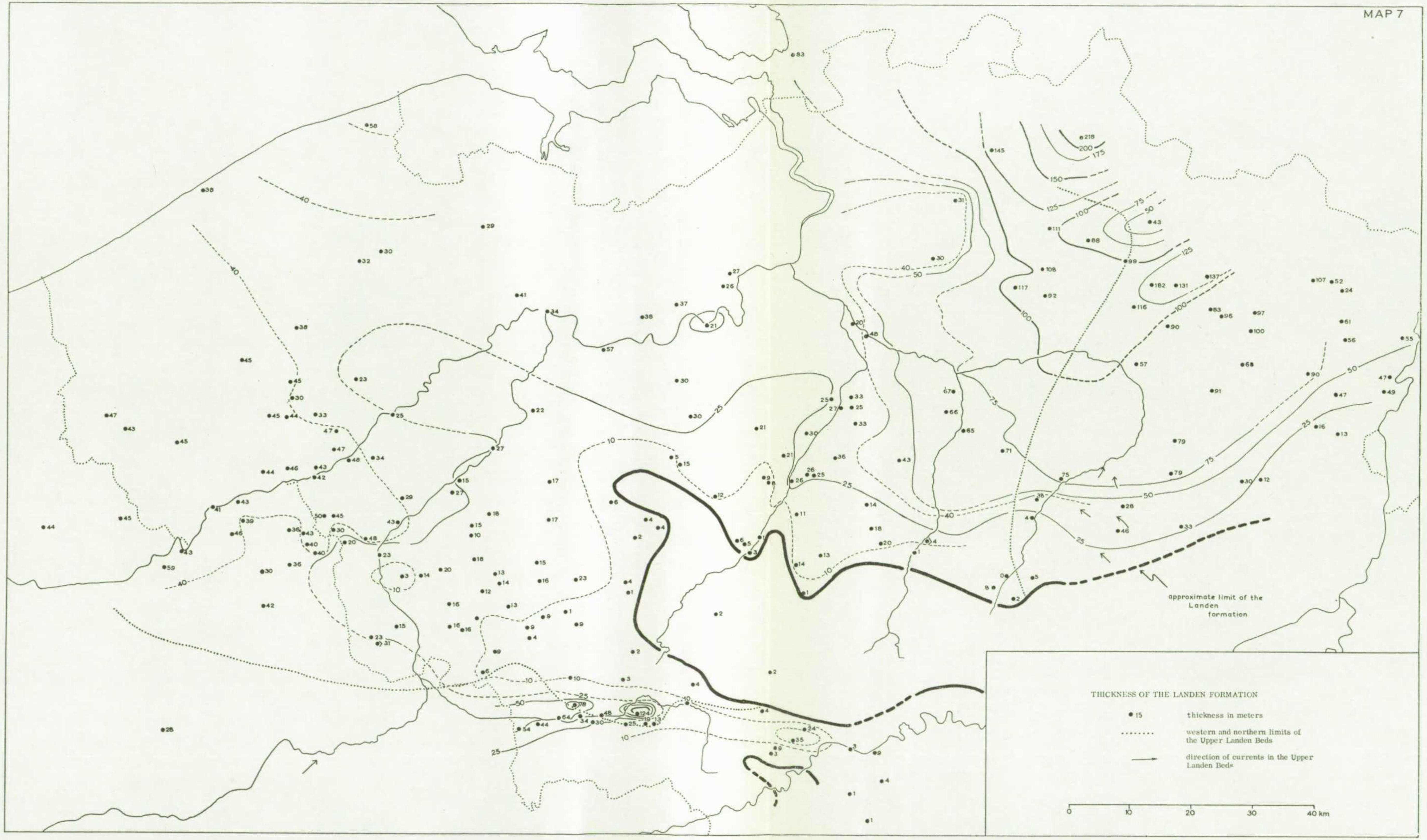
In northern France equivalent deposits contain brackish-water fossils, often accumulated at certain levels.

At other places the base of the Sands of Erquelinnes and of Landen contains many pebbles, which underlie coarse, current-bedded sands, deposited in more or less distinct erosion channels. From northern France such channels were described of 100 to 200 m wide and 50 m deep, incised as deep as in rocks of Cretaceous age. At a few places such coarse sediments were found in channels, incised in fine-grained Upper Landen beds only.

Both in the Hesbaye and in Hainaut the higher deposits become more fine-grained and pass into sands with frequent intercalations of clays and marls. These sediments resemble those already described from places where the coarser base is absent.

The upper sands often contain enormous sandstones pieces, the « grès mamelonnés », of about 1 to 2 m thickness (Ledoux, 1911), with frequent plant remains (partly roots of water-plants, Rutot, 1887*b*).


MAP 6
limit of the Cretaceous beds
CONTOURS OF THE BASE OF THE TERTIARY
(partly based on LEGRAND, 1954)
overlying Cretaceous strata
overlying Paleozoic strata
meters Oostende O.D.
approximate limit of the Cretaceous strata
0 10 20 30 40 km


MAP 7
approximate limit of the Landen formation
THICKNESS OF THE LANDEN FORMATION
15 thickness in meters
western and northern limits of the Upper Landen Beds
direction of currents in the Upper Landen Beds
0 10 20 30 40 km

The Sands of Erquelinnes and of Landen are well known for the mammalian faunae of Orsmaal and of Erquelinnes (TEILHARD DE CHARDIN, 1927) with, amongst others, *Phenacodus europaeus* and *Teilhardina belgica* at Orsmaal. From Erquelinnes *Coryphodon* cf. *eocaenus* (=*Coryphodon eocaenus* in DOLLO, 1909) and *Hyracotherium* sp. (=*Propachynolophus maldani* in RUTOT, 1881) should be mentioned.

LERICHE (1902) described the fish remains of the Sands of Erquelinnes and of Landen. Invertebrate fossils are very scarce, only *Unio* and *Helix* have been reported.

SANDS OF OOSTENDE (1)

named after Oostende, in western Flanders

(Map 8)

Because of the frequent fossils the Upper Landen beds in western Belgium differ so much from the Sands of Erquelinnes and of Landen that the new name, the Sands of Oostende, is proposed for them. They are furthermore distinct by the different areal distribution.

They consist of fine-grained, sometimes slightly glauconitic sands and lignitic clays, with several fossiliferous beds, such as limestones with numerous molluscs.

The Oostende Sands have been observed only in a number of borings. Their northern extension is unknown. In between the borings with Sands of Oostende others are present in which Ieper Clays directly overlie Grandglise Sands, so that the area of the Oostende Sands is probably not continuous.

At Oostende the Sands cover fossiliferous Clays of Louvil, but in other borings, especially near the borders of the area, they rest upon Grandglise Sands. Towards these borders the lithologic difference between Sands of Grandglise and Sands of Oostende is not very clear.

In the whole area the Sands of Oostende are overlain by the Ieper Clays.

At the type locality the unit appeared to consist of 26 m of sands and clays, often lignitic (GULINCK and HACQUAERT, 1954). This thickness of 26 m seems to be a maximum, other borings indicate 19,50 m (Gent) and 10 m (Beernem).

The most frequent fossil species are *Cyrena cuneiformis*, *C. forbesi*, *Ostrea bellovacina*, *Meretrix obliqua*, *Melania inquinata*, and *Otodus striatus* (LERICHE, 1899; GLIBERT in FEUGUEUR, 1955).

During the investigation of a number of samples of the Collections of the Geological Survey of Belgium, derived from the boring Oostende, no foraminifera were found. The samples yielded some *Cyprideis*, but no other ostracods.

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(1) Since completion of the manuscript Ir. GULINCK has kindly drawn my attention to the fact that the name « Assise d'Ostende » was already used as early as 1868 by DEWALQUE for a deposit that is characterized by *Corbicula fluminalis*. This deposit was regarded by TAVERNIER (1954, Prodrome d'une description géologique de la Belgique, p. 533) as belonging to the Riss-Würm interglacial.

Furthermore DUMONT (1839) has already used the name « Clay of Oostende ».

To avoid confusion we propose to alter the name of Sands of Oostende to Sands of Oostende-ter-Streep which name is derived from the old name (qth century) for Oostende.

IEPER FORMATION

(Maps 3, 8-12)

In the type area the Ieper formation is formed by the Clays of Ieper overlain by the Sands of Mons-en-Pévèle.

In northern France GOSSELET (1874) distinguished the Clays of Orchies, the Clays of Roubaix and the Clays of Roncq. This clay series is often referred to as the Clays of Flanders (« Argiles de Flandres », ORTLIEB and CHELLONEIX, 1874). The Clays of Orchies continue into our Clays of Ieper. The Clays of Roubaix are considered to be a lateral equivalent of the Sands of Mons-en-Pévèle. The Clays of Roncq belong to the Panisel formation. No distinct subdivision could be made in this French clay series by means of fossils (LERICHE, 1928).

CLAYS OF IEPER (D'OMALIUS D'HALLOY, 1842)

named after Ieper, in western Flanders

(Maps 3, 8, 9 and 10)

The base of the Ieper Clays consists of a layer of sand or sandy clay of some cm to three metres thickness. These basal sediments are absent in the greater part of Hainaut, Brabant and the eastern part of France du Nord.

If present these basal sands are usually coarse grained, especially near the contact with the underlying strata. Intercalated plastic clay beds have been found. The frequent occurrence of a basal gravel of small, mostly black silex pebbles has been reported. Associated with the silex, sandstone pieces, fragments of silicified wood, and occasional fish teeth (*Lamma elegans*) have been found (HALET, 1913). However, such pebbles or gravel may be entirely absent.

At a number of localities in France du Nord and Hainaut the transition from the Grandglise Sands into the Ieper Clays was observed to be gradual by the appearance of clayey intercalations in the upper part of the Grandglise Sands (DELVAUX, 1884; RUTOT, 1887; DEHÉE, 1927).

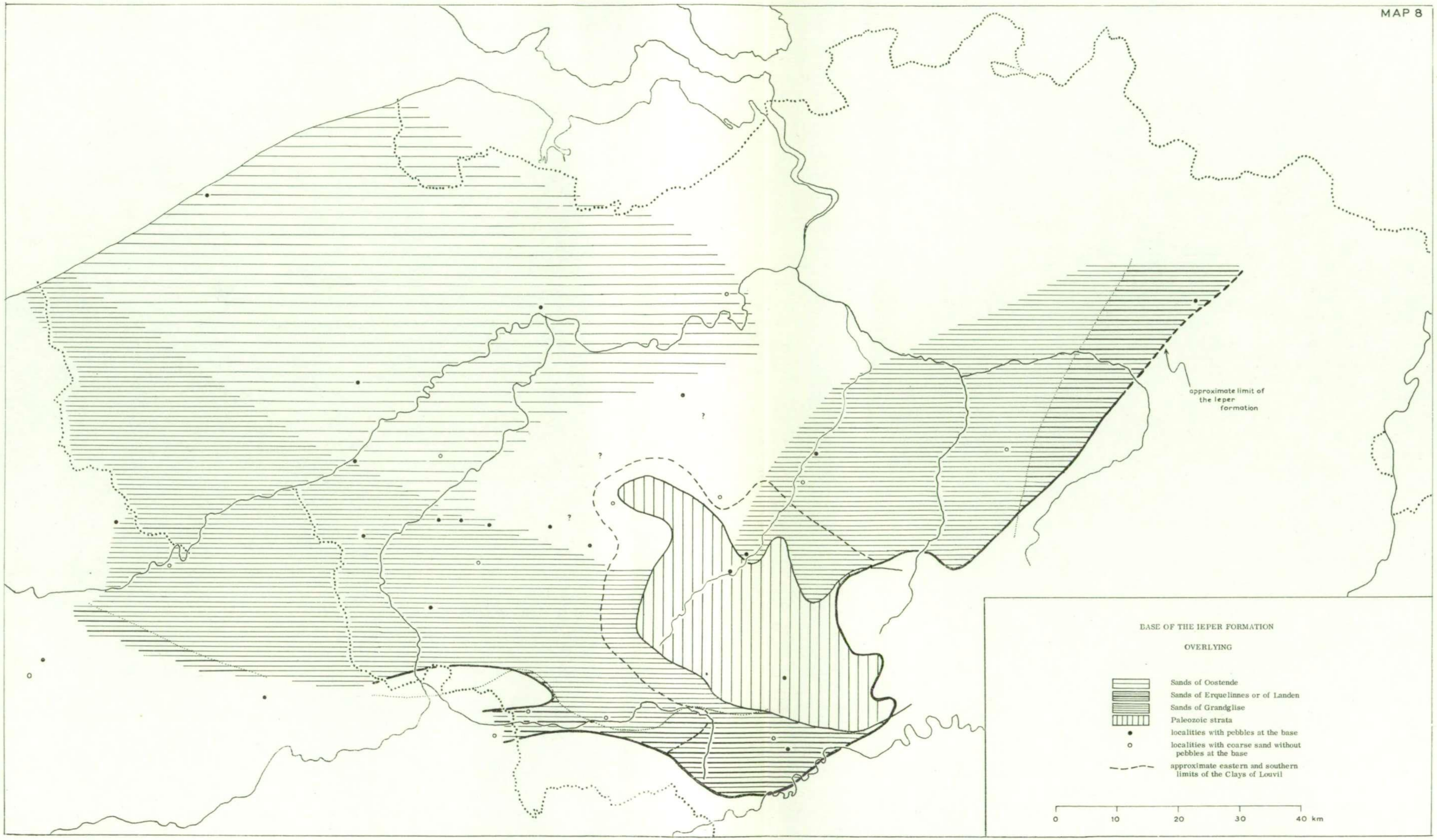
The bulk of the Ieper Clays consists of silty to plastic clays, mostly more or less blue to grey, fairly rich in pyrite, and with occasional small septaria. Furthermore muscovite, glauconite and gypsum are present.

The lower part of the clays often contains plant remains (RUTOT, 1904; Y. LE CALVEZ and FEUGUEUR, 1955). The higher part may show very silty beds, with a thickness of up to 3 m. Occasionally these beds are indurated. From the topmost part again more plant remains have been reported.

In the Kempen the Ieper Clays are represented by sandy and plastic clays, with intercalated sands and clayey sands. From the boring Kwaadmechelen plant remains have again been reported. Further eastwards, at Beeringen, no distinction is possible between Clays of Ieper and Sands of Mons-en-Pévèle; at this place sands predominate in the Ieper formation.

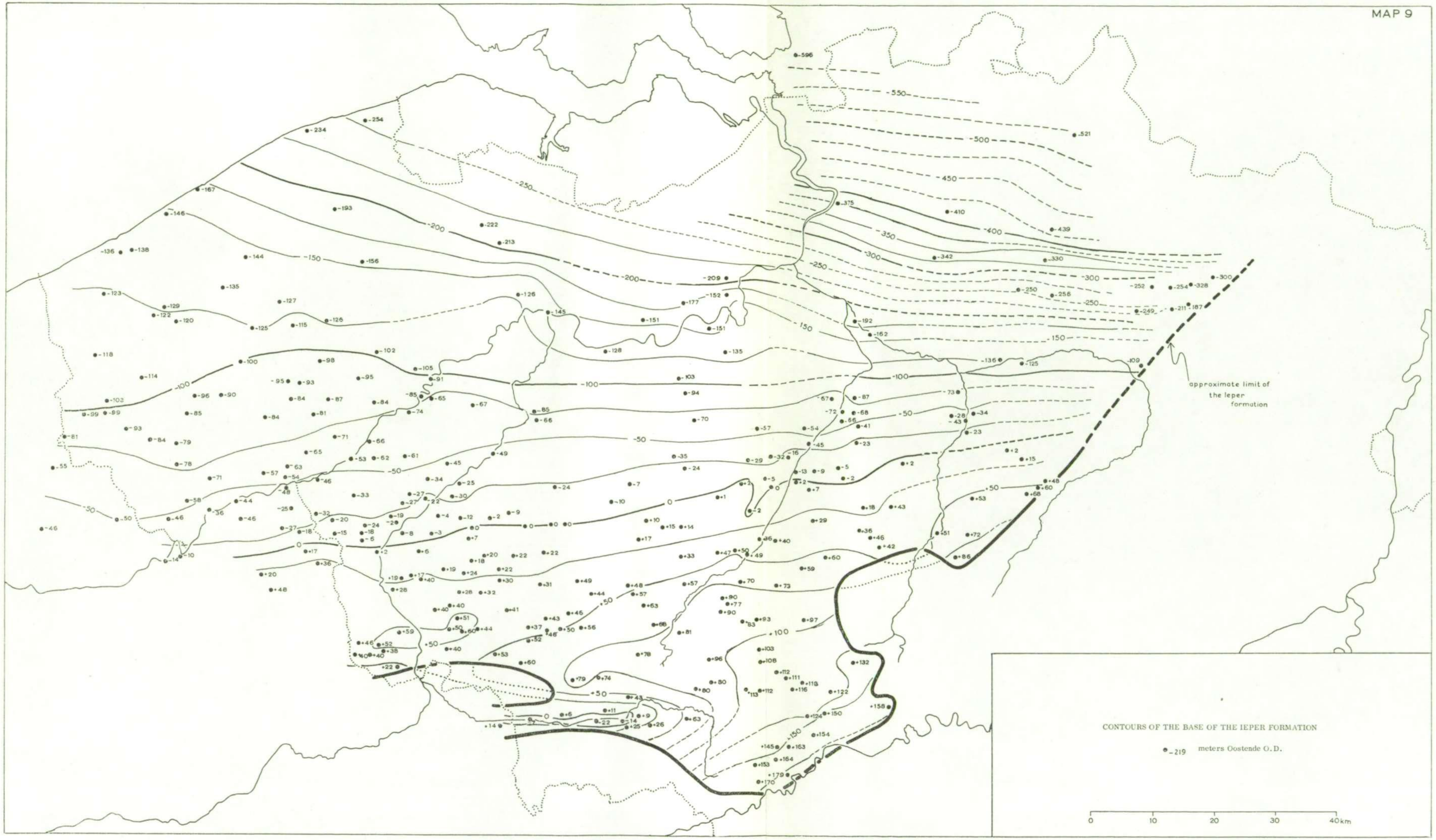
The Ieper Clays are mostly covered by the Sands of Mons-en-Pévèle, in the southwestern area by the Clays of Roubaix.

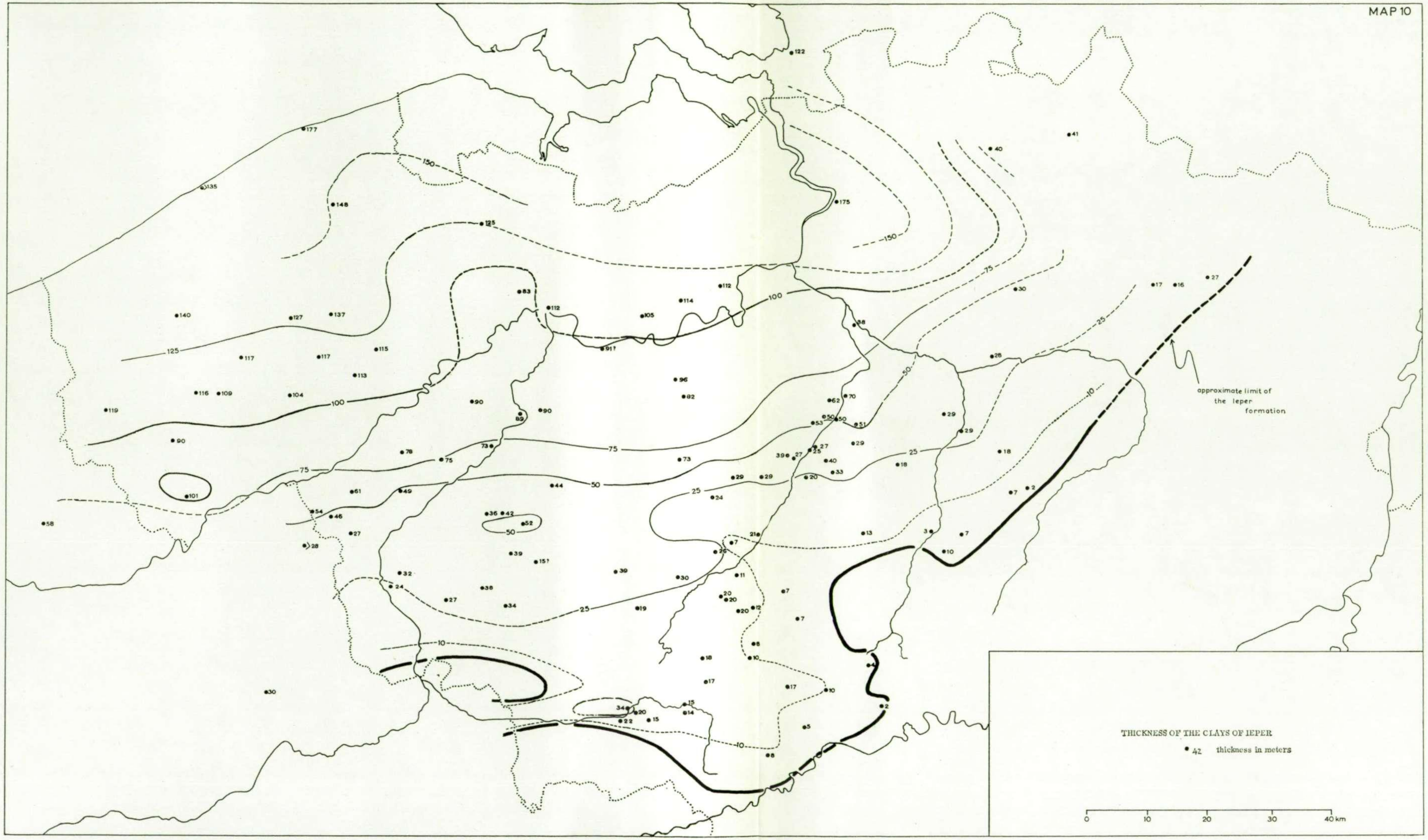
The fauna is poor. Locally some fossiliferous beds are met with, mostly with preponderance of *Turritella solanderi, Pecten corneolus, Lingula tenuis* and *Xanthopsis leachi*, species that are also present in the Sands of Mons-en-Pévèle. In a boring at Marck, near Calais, LERICHE (1909*b*, 1937*a*) found fossiliferous clays with *Pholadomya margaritacea* and a number of intercalated sandy beds with *Turritella hybrida, T. solanderi, T. carinifera* and *Nummulites planulatus*. This small fauna very much resembles that of the Sands of Mons-en-Pévèle.



MAP 8
approximate limit of the Ieper formation
BASE OF THE IEPER FORMATION
OVERLYING
Sands of Oostende
Sands of Erquelinnes or of Landen
Sands of Grandglise
Paleozoic strata
localities with pebbles at the base
localities with coarse sand without pebbles at the base
approximate eastern and southern limits of the Clays of Louvil
0
10
20
30
40 km

MAP 9


approximate limit of the Ieper formation
CONTOURS OF THE BASE OF THE IEPER FORMATION
-219 meters Oostende O.D.
0 10 20 30 40 km


MAP 10
THICKNESS OF THE CLAYS OF IEPER
42 thickness in meters
approximate limit of the Ieper formation
0 10 20 30 40 km

Important monographical studies about the fossil fishes have been published by LERICHE (1905*a*, 1951) and CASIER (1946). PASTIELS (1948) described some of the microfossils, such as radiolarians, pollen, hystrichosphaerids.

SANDS OF MONS-EN-PÉVÈLE (ORTLIEB and CHELLONEIX, 1874)

named after Mons-en-Pévèle, in France du Nord

(Maps 3, 11 and 12)

Except for the area of the Roubaix Clays the Clays of Ieper are nearly everywhere covered by the Sands of Mons-en-Pévèle.

LERICHE (1909*b*) recorded occurrences of sandstone pieces with *Nummulites planulatus* from the region of Artois, which fact gives an idea of the former extension of the Sands in southern direction.

Often there is no distinct limit with the underlying Ieper Clays. Generally there is an intermediate zone of silty, micaceous clay, or of alternating silty and clayey beds. Only near Renaix did DELVAUX (1887) find a bed with gravel and worn remains of fossils in between the Ieper Clays and the Sands of Mons-en-Pévèle.

In typical occurrences the sands are fine-grained, micaceous and glauconitic. They are thin-bedded with occasional cross-bedding, but bedding planes are often entirely absent. In western Belgium they are more clayey and hardly separable from the Clays of Ieper or from the Clays of Roubaix. From the region of Torhout and Tielt RUTOT (1886) described the uppermost beds as coarser grained, thus forming a gradual transition into the coarse sediments of the Lower Panisel beds of this region.

At Mons-en-Pévèle a series of about 50 m of sands, sandy clays and clays has been described (PARENT, 1894; HÉRENT, 1895). About twelve nummulite beds are intercalated.

In Belgium, and also at Mons-en-Pévèle, these nummulite beds often consist of sandy, glauconitic limestones, with numerous nummulites (LEDOUX, 1911). At Maulde (DE) we found a thickness of about 15 cm for one of these limestones, CASIER (1946) reported thicknesses of 2 to 10 cm at Forest. In Belgium these nummulite beds are less numerous than at Mons-en-Pévèle. Only one to three of them are present; mostly they are not indurated. In western Belgium the deposits of many localities have been reported to be devoid of nummulites.

The topmost Sands of Mons-en-Pévèle pass gradually into the Clays of Roncq. Especially in Brabant clayey intercalations in the sands mark the passage.

Fossils are mainly known from the nummulite beds. The most frequent molluscs are *Turritella solanderi, Lucina squamula, Pecten corneolus, Ostrea submissa* and *O. multicostata*. *Ditrupa plana*, one of the most common fossils of the Sands of Mons-en-Pévèle, is locally concentrated in distinct beds. Coral fragments of *Turbinolia sulcata* also occur. Among the fish remains, described by LERICHE (1905*a*, 1951) and CASIER (1946), mention should be made of those of *Odontaspis macrota, Lamna lerichei, Myliobatis toliapicus*.

CLAYS OF ROUBAIX (Gosselet, 1874)

named after Roubaix, in northern France

(Maps 3, 11 and 12)

The Clays of Roubaix cover the Ieper Clays, and they are in turn overlain by the Clays of Roncq, or especially along the borders of their area by the higher Sands of Mons-en-Pévèle.

They should be distinguishable from the Ieper Clays by the less compact appearance and a higher silt content (Leriche, 1928). When shell fragments are present the distinction is somewhat easier, because of the usual absence of such fossil remains in the Ieper Clays. If such remains are absent the distinction is difficult or impossible.

From Moen a thickness of 14 m has been reported, but the overlying 26 m of fine-grained sands, sandy clays and clays show a gradual passage into the Sands of Mons-en-Pévèle (also observed in DH), which fact renders the recorded thickness to a more or less arbitrary value.

Paleontologically the Clays of Roubaix resemble the Sands of Mons-en-Pévèle. Locally many nummulites are present, sometimes concentrated in distinct beds, such as near Moen (Halet, 1913).

MORLANWELZ MEMBER (Mourlon, 1880)

named after Morlanwelz, in eastern Hainaut

In the eastern part of Hainaut the Ieper formation consists of a series of alternating fine-grained sands, sandy clays, and silty and plastic clays (Leriche, 1936; Schellinck, 1937). They are most distinct around Morlanwelz and Carnières.

In Belgian literature this unit is incorrectly referred to as the « Argilites de Morlanwelz », but real « argilites » (clayey sandstones with coarse glauconite grains, sponge spicules, and a clayey to clayey-siliceous matrix; Schellinck, 1937) form only a minor part of the alternating series.

Some confusion exists about the horizontal and vertical extent of this member. For instance, Legrand and Tavernier (1948) concluded its absence at Godarville, because of the absence of typical argilites. However, the section of the Ieper formation at this locality strongly reminds of those of the Morlanwelz region.

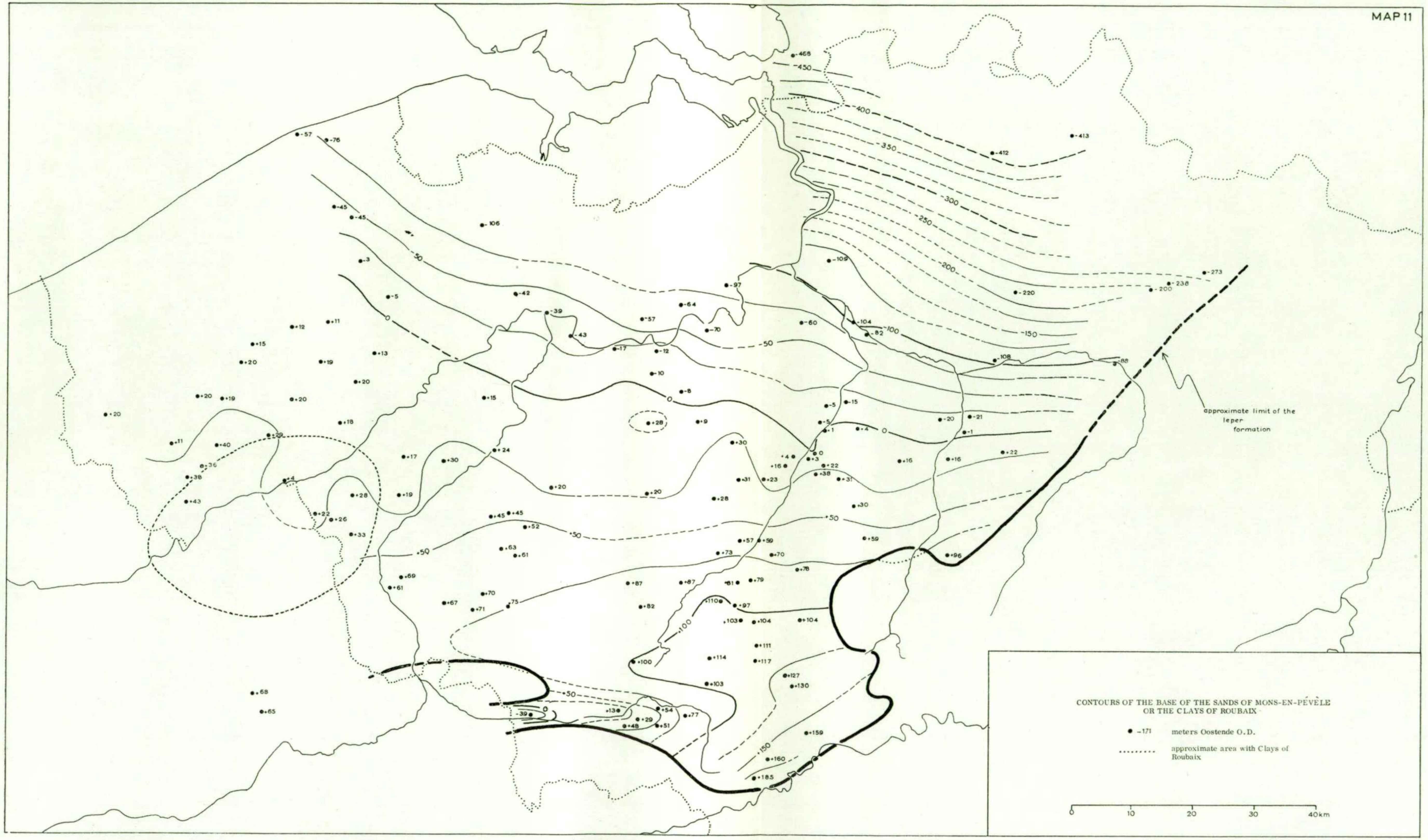
On the geological maps the distinction between Sands of Mons-en-Pévèle and Clays of Ieper is everywhere maintained. Evidently it was based on the correct supposition of a lower, more clayey and an upper, more sandy part of the series. However, in the area of the Morlanwelz member the boundary is arbitrary and the distinction of two units fairly artificial.

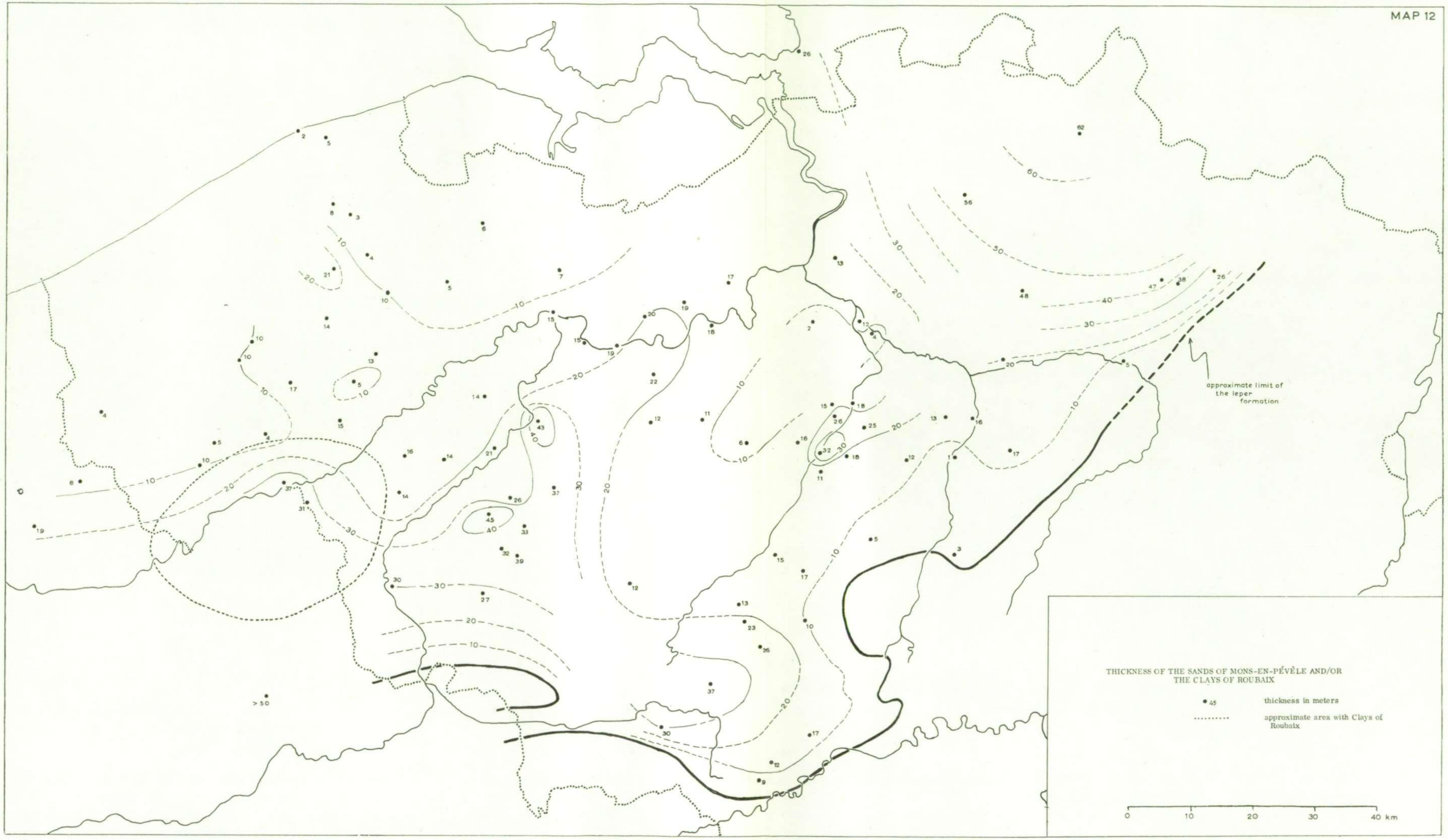
Especially from the sandstones a rich fauna has been collected with, amongst others, *Nummulites planulatus*, *Nucula fragilis*, *Leda corneta*, *Pecten corneolus*, *Voluta depressa*, *Turritella solanderi*, *T. hybrida*, and *Xanthopsis bispinosus*. Leriche (1905*a*, 1951) and Casier (1946) described the fish remains, Pastiels (1948) some of the microfossils.

In southwestern direction the described deposits of the Morlanwelz member pass into the local variant of the Sands of Péissant (Briart, 1882), which have a lesser clay content and a predominance of sands.

The Sands of Péissant, with a thickness of up to 40 m (Stevens, 1946), are medium to fine-grained, and slightly glauconitic. Thin intercalated clay beds are present. The basal part is said to be formed by lignitic clays with plant remains. The upper part contains sandstone pieces with many *Nucula fragilis*. It also contains pieces of wood, perforated by boring animals.

From Trélon, south of Péissant and near Avesnes, Leriche (1936) described the occurrence of the Sands of Trélon with about the same lithology as the Sands of Péissant, and with a fauna characteristic of the Ieper formation.


MAP 11
approximate limit of the Ieper formation
CONTOURS OF THE BASE OF THE SANDS OF MONS-EN-PÉVÈLE
OR THE CLAYS OF ROUBAIX
• -171 meters Oostende O.D.
approximate area with Clays of Roubaix
0 10 20 30 40km


MAP 12
THICKNESS OF THE SANDS OF MONS-EN-PÉVÈLE AND/OR THE CLAYS OF ROUBAIX
45 thickness in meters
approximate area with Clays of Roubaix
approximate limit of the Ieper formation
0 10 20 30 40 km

PANISEL FORMATION

named after the mont Panisel, near Mons

(Maps 4, 13 and 14)

Dumont based his « Paniselien » on the « Psammites du mont Panisel » (d'Omalius d'Halloy, 1842). Later research revealed the more complete series of the « Paniselian » in Flanders, those of the mont Panisel only being a far southeastern occurrence.

In Flanders the formation can be subdivised into four or five members.

CLAYS OF RONCQ (Gosselet, 1883)

named after Roncq, in northern France

The Clays of Roncq form the basal part of the Panisel formation both in France du Nord and in Flanders. In the region of Torhout and Tielt, in the Kempen, and at the mont Panisel the Clays of Roncq are absent.

They overlie the Sands of Mons-en-Pévèle or the Roubaix Clays, usually with a gradual transition.

The Roncq Clays consist of plastic, grey clays, with local sandy intercalations, in which there are often clay pebbles. Most occurrences of clay pebbles are in western Flanders near the area of Torhout and Tielt. At some places shell fragments have been found, mostly as worn remains occurring in pockets (Leriche, 1927). With the exception of these pockets, the clays are generally unfossiliferous.

Near the top the plastic clays become glauconitic and sandy, and gradually pass into the Sandy Clays of Anderlecht.

In the borings of Brabant and eastern Flanders thicknesses are remarkably constant, 4 to 8 m. In the central part of Flanders the thickness is more variable. In southern Flanders and in France du Nord up to 10 or 12 m have been found.

The Roncq Clays yielded, amongst others, *Turritella solanderi, Pinna margaritacea, Xanthopsis leachi, Lamna obliqua,* and *Nummulites planulatus.*

SANDY CLAYS OF ANDERLECHT (G. Vincent, 1874)

named after Anderlecht, near Brussels

This unit covers a wider area than the Roncq Clays, including the Kempen, the region of Torhout and Tielt, and the mont Panisel.

Mostly there is a gradual passage from the Roncq Clays into the Sandy Clays of Anderlecht. In the region of Torhout and Tielt there is coarse, gravelly sand with lignite remains and a few sandstone fragments at the base (P1a of the Geological Map) (Rutot, 1890*b*; Halet and Lejeune de Schiervel, 1905). Around this area the sand seems to fade out between the Roncq and Anderlecht members. Also in the Kempen there is a basal gravel, this time with fish remains, shell fragments and many, small *Nummulites planulatus.*

The greater part of the unit is formed by clayey sands and sandy clays, often in alternating layers of some centimetres thickness, and mostly with fairly regular bedding. The bedding planes have often been disturbed by organisms (Gulinck, 1952). Intercalations of plastic clay have been found, which lithologically resemble the Roncq Clays.

Sandstone pieces, mostly in discontinuous layers, form a characteristic feature of the Anderlecht member. Only in the lowermost part are they absent. The sandstone pieces, with thicknesses of up to 60 cm, have a variable degree of indurating. Generally, the pieces of the lower part are fossiliferous, higher up less fossil remains have been found, and the sandstones become quartzitic. They may be perforated by worm tubes.

In western Belgium the upper part of the Anderlecht member becomes very sandy and there is a more gradual transition into the Vlierzele Sands. The limit between these two units becomes artificial.

In the Kempen and in the boring Woensdrecht the Sandy Clays of Anderlecht are so sandy that they are inseparable from the Vlierzele Sands.

Because of the gradual passages thicknesses are unreliable. Near Vilvoorde 5 to 9 m are fairly certain.

The greater part of the fossils have been derived from the sandstone pieces, often as siliceous casts.

Very fossiliferous exposures are those of Teralfene (BG) and Scheutveld, near Anderlecht, with, amongst others, *Pinna margaritacea, Lucina squamula, Ostrea submissa, Nucula parisiensis, Leda striata, Rostellaria fissurella, Pleurotoma lajonkairei, Nummulites planulatus, Turbinolia sulcata*, some fish remains, pieces of silicified wood, and fructifications of *Nipadites*. The sandstone pieces are furthermore rich in diatoms, radiolarians and sponge spicules. *Nummulites planulatus* is also abundant at other localities, such as Grammont, Renaix, and Torhout.

SANDS OF VLIERZELE

named after Vlierzele, between Gent and Aalst

(Type locality : ZB)

The Vlierzele Sands occupy about the same area as the Anderlecht member. There is a gradual passage in between. They probably occur as far east as Oostham and Kwaadmechelen (Asselberghs, 1926).

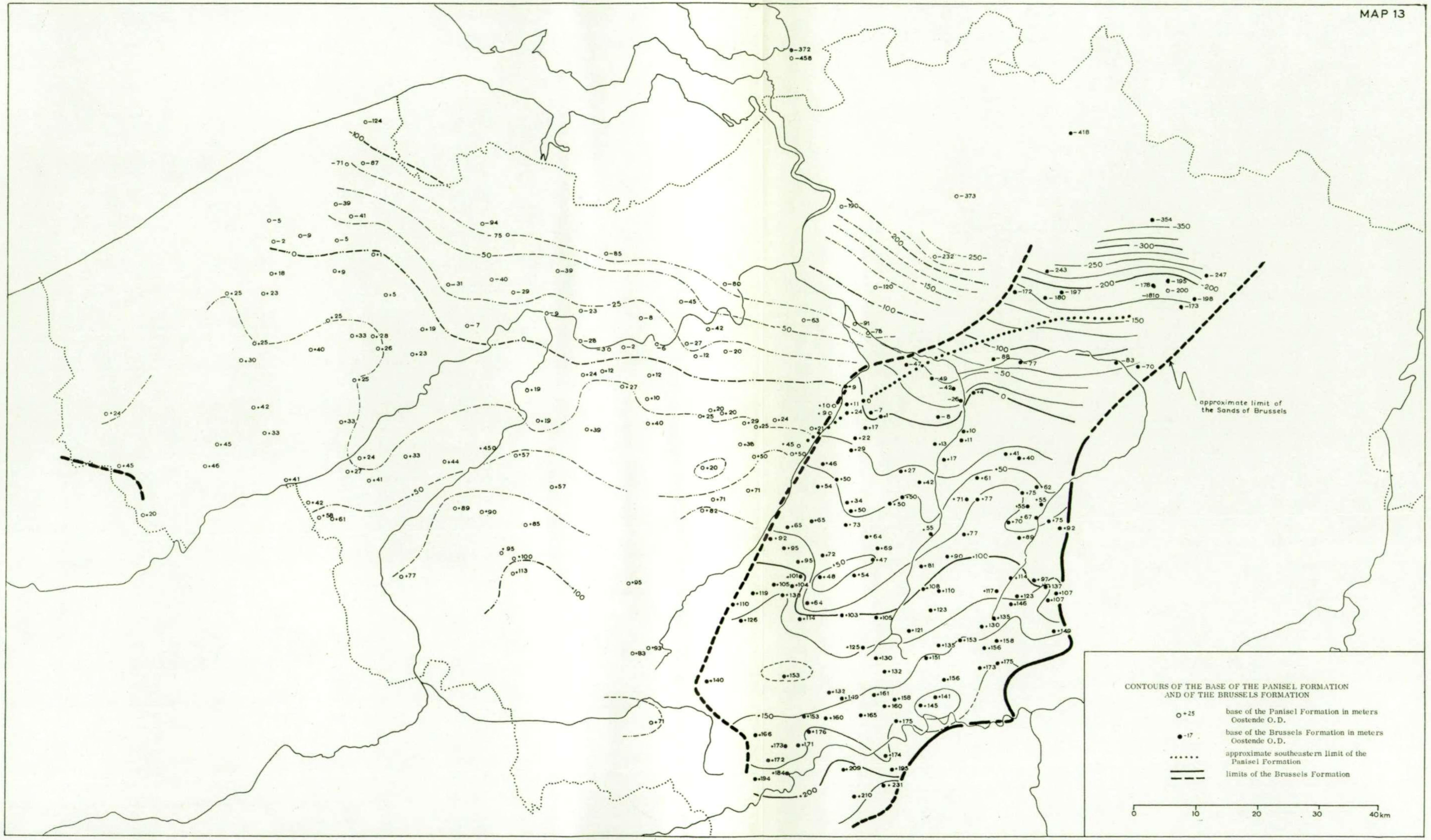
The member mainly consists of fine-grained, glauconitic, and rather well-sorted sands. Often distinct cross-bedding is found, which is usually absent in the lower part and more distinct higher upwards, such as at Vlierzele (ZB) and Balegem (ZF). Locally many tubulations, probably worm tubes, have been found. There are intercalated beds of plastic clay, which may be of considerable thickness towards the top of the unit (1 to 2 m at Mechelen; 50 cm in the hills of Esschene and Hekelgem).

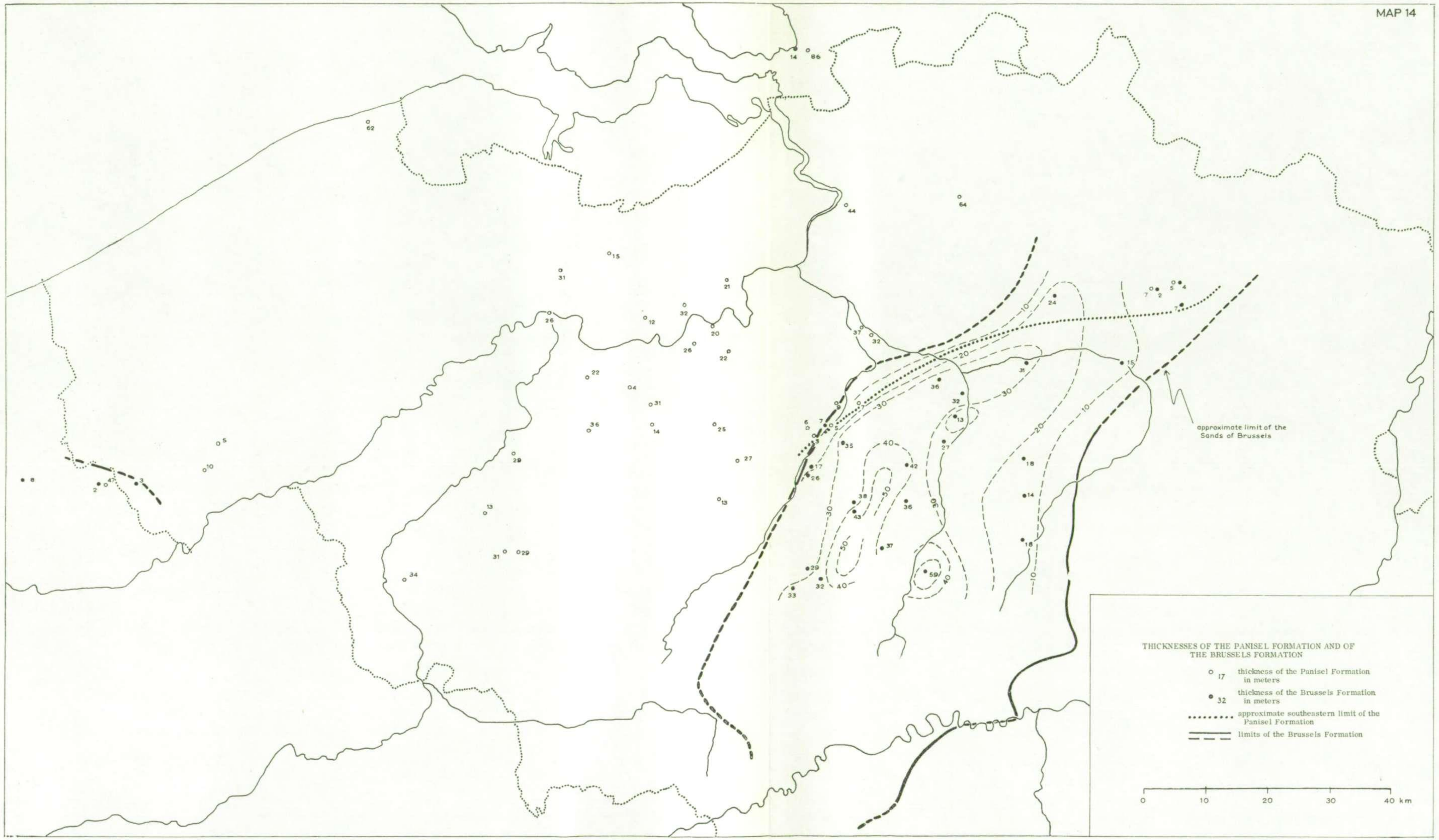
Associated with the fine-grained, glauconitic sands there occur coarser and less glauconitic sands, sometimes with lignite particles and silicified wood remains, the latter with perforations of boring animals. Some beds with clay pebbles have been reported as well.

Sandstone pieces are frequent, mostly flat pieces, but also with the shape of the « Grès fistuleux » of the Brussels Sands. All these pieces are quartzitic.

In the Kempen the Vlierzele member is partly overlain by the Sands of Brussels (maps 13 and 14). In Flanders, as well as in the boring Woensdrecht and in some hills of northern France, the Vlierzele Sands are covered by the Sands of Aalter, sometimes with the Sands of Aalterbrug in between.

Macar (1947) reported thicknesses of up to 10 or 20 m; others found 7 m at Gent and 5 m at Esschene.


MAP 13
approximate limit of the Sands of Brussels
CONTOURS OF THE BASE OF THE PANISEL FORMATION AND OF THE BRUSSELS FORMATION
+25 base of the Panisel Formation in meters Oostende O.D.
-17 base of the Brussels Formation in meters Oostende O.D.
approximate southeastern limit of the Panisel Formation
limits of the Brussels Formation
0 10 20 30 40 km


MAP 14
approximate limit of the Sands of Brussels
THICKNESSES OF THE PANISEL FORMATION AND OF THE BRUSSELS FORMATION
17 thickness of the Panisel Formation in meters
32 thickness of the Brussels Formation in meters
approximate southeastern limit of the Panisel Formation
limits of the Brussels Formation
0 10 20 30 40 km

Fossils are rare. Some ten species of plants have been recognized among the wood fragments (STOCKMANS and WILLIÈRE, 1943). Some localities with silicified fossils occur in the region of Torhout and Renaix. They contain, amongst others, *Nummulites planulatus.*

In the region of Gent and Brugge, the topmost beds of the Vlierzele Sands are known as the Sands of Aalterbrug (HACQUAERT and TAVERNIER, 1939; LERICHE, 1941). They are often referred to as « Panisélien ligniteux ».

At Aalterbrug these sands cover glauconitic Vlierzele Sands with perforated, silicified wood fragments. They are greenish to brownish, micaceous, fine-grained, glauconitic sands and clayey sands, with intercalations of clay lenses and of lignite beds. Further constituents are silicified, often perforated, wood fragments, flattened clay pebbles, and pieces of soft, lignitic sandstones. The whole series is strongly cross-bedded and is rich in tubulations, probably worm tubes.

From Gent these sands have been reported as lignitic sands of about 1,50 m thickness (STAINIER, 1930) overlying white sands, which pass downwards into glauconitic sands. At the top there is a gradual passage into the Aalter Sands.

At Woensdrecht the Aalter Sands directly overlie the Vlierzele Sands, without distinct Sands of Aalterbrug in between. However, the uppermost samples of the Vlierzele Sands of this boring contain some lignite fragments.

SANDS OF AALTER (LERICHE, 1937)

named after Aalter, between Brugge and Gent

(Map 4)

Outcrops of the Sands of Aalter are only known in the region of Aalter and Gent, and near Cassel. BAUDET (1941) reported a probable occurrence near Renaix. The occurrences of Gent and Aalter continue westward below younger deposits and are again cropping out on the bottom of the North Sea, off the Belgian coast. Along the coast, between Le-Coq-sur-Mer and Blankenberge, pieces of fossiliferous sandstone with *Venericardia planicosta* are quite common.

In the type region the transition into the Vlierzele Sands is formed by the intermediate Sands of Aalterbrug, which, however, are absent near Cassel (CAA) and inconspicuous in the Woensdrecht boring.

The Aalter Sands are glauconitic, slightly clayey sands. They are fossiliferous, except for their lower part. Mostly there are two very fossiliferous beds, that are locally indurated. The lower bed is rich in *Venericardia planicosta*, the upper one in *Turritella solanderi*. These two beds are separated by about one metre of fossiliferous, glauconitic sand, with many worn *Turritella* near the base.

In the boring Woensdrecht the Aalter Sands seem to be represented by sand rich in shell fragments (HALET, WATERSCHOOT VAN DER GRACHT and TESCH, 1913).

The contact with the Brussels Sands is only distinct in the hills near Cassel.

At Aalter thicknesses of about 8 m have been reported, at Cassel of 7 m.

The fossils are often more or less worn and somewhat decalcified. FEUGUEUR (1951) reported 106 species of molluscs, CASIER (1946) and LERICHE (1905*a*, 1951) a number of species of fishes. LERICHE's determination of *Nummulites lucasi* must be considered doubtful, since it was based on a few worn, unsectioned specimens (1937*b*).

BRUSSELS FORMATION

The Brussels formation contains only one unit, the Sands of Brussels.

SANDS OF BRUSSELS (D'OMALIUS D'HALLOY, 1842)

named after Brussels

(Maps 4, 13 and 14)

Northwest of the Belgian capital, the Brussels Sands gradually thin out between the Panisel formation and the Lede formation. Along the valley of the Senne the western border of the area is a puzzling straight line, which seems to be connected, for at least the greater part, with a difference of topography, with higher hills east of the valley. Possible deposits west of this line have been removed by erosion. However, other explanations are equally possible, such as that of SIMOENS (1904) with more or less complicated movements along a fault in the Senne valley.

In Flanders the Brussels Sands are absent, with the exception of some occurrences in the hills of Cassel, and probably near Amougies (BAUDET, 1941).

In part of Brabant the Brussels Sands overlie rocks of Paleozoic or Mesozoic age, at other places they cover the Landen or the Ieper formation. Near Vilvoorde and in the Kempen they overlie Lower Panisel beds, near Cassel and in the boring Woensdrecht Sands of Aalter.

When they are in contact with Paleozoic rocks the lower part mostly contains gravelly sands, often with cross-bedding, and sometimes with intercalated clay beds (LERICHE, 1943*a*). Elsewhere pebbles are usually absent at the base. Near Brussels the base locally contains reworked elements of the Ieper formation. At Godarville a gravel bed was found with derived *Nummulites planulatus*.

Lithologically the Sands of Brussels are variable in features such as grainsize, lime content, glauconite, etc. On the basis of the grainsize CLAEYS (published by DE HEINZELIN, 1947) made a regional subdivision of the Sands (fig. 4).

Generally, two types of sands are distinguishable :

a) quartz sands, and
b) calcareous sands.

Their areas roughly coincide with those of CLAEYS's coarse, and medium to fine-grained sands, respectively.

a) In the areas of coarse sands around Wauthier-Braine the whole section is formed by rather coarse, non-calcareous sands with some cross-bedding. Towards the north these non-calcareous sands continue with a gradually decreasing grainsize and an increasing degree of sorting. Near Brussels they form only the lower part of the series.

The Brussels Sands around Mont-Saint-Guibert and Ottignies resemble the quartz sands of Wauthier-Braine and Brussels. Towards the north these coarse sands continue as the lower part of the series, as, for instance, near Hoegaarden and Jodoigne. In these quartz sands, which are often strongly cross-bedded, there are thin and lenticular intercalations of marls, which are more or less silicified. DENAYER (1950) described them as « calcédonilithe ». The quartz sands of this region are rather glauconitic and, at some places, rich in tubulations. Still further north, in the borings of Diest, Aarschot and Westerloo, sands of about the same characters have been observed.

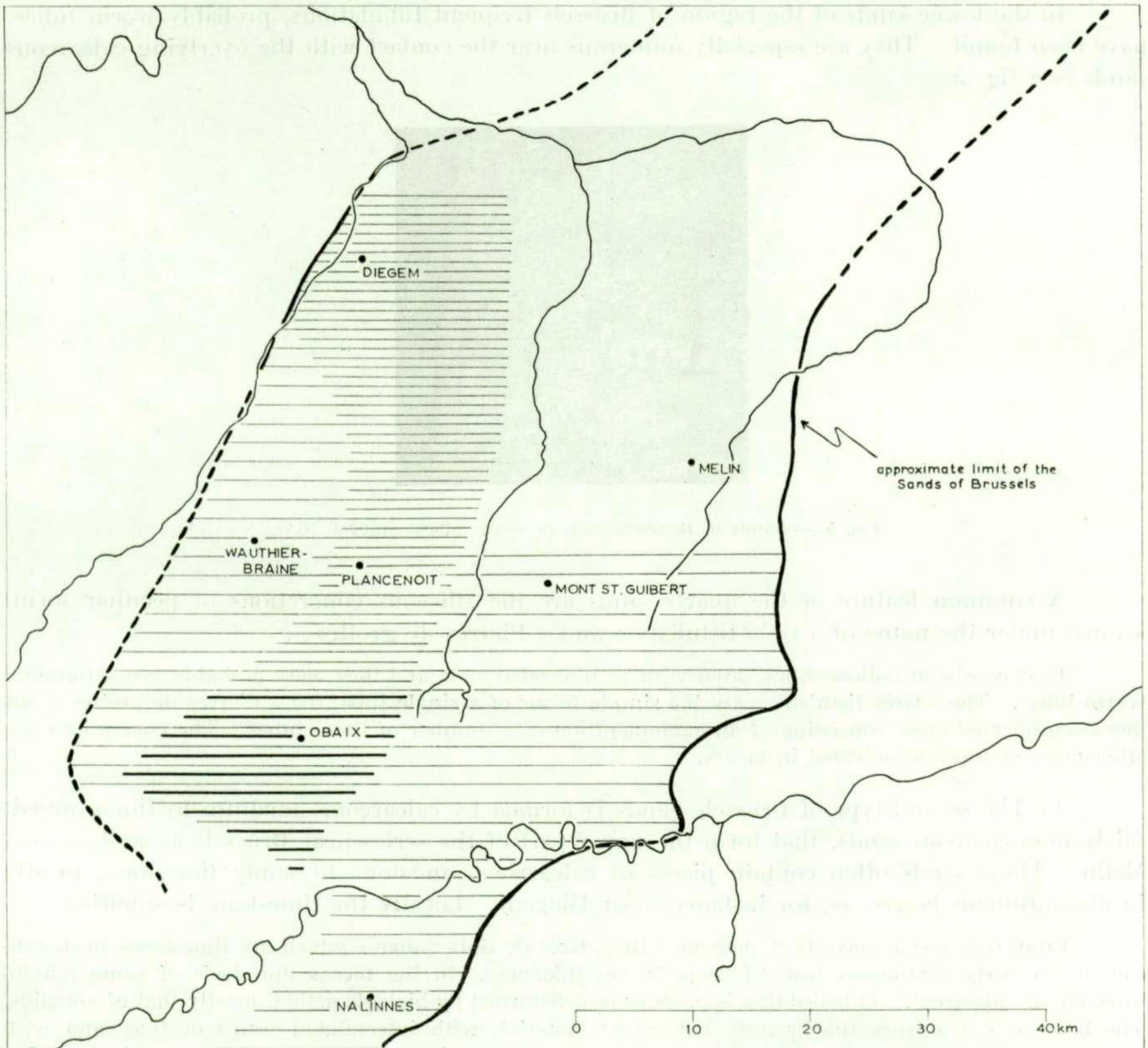
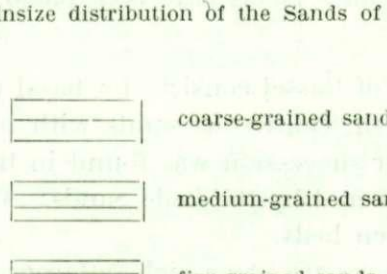


FIG. 4. — Grainsize distribution of the Sands of Brussels (after CLAEYS, 1947).



In the most eastern occurrences of Brabant, as at Grand-Rosières and Folx-les-Caves, the sands show rather frequent clayey intercalations, but they also contain pebbles in coarse sands.

In the lower sands of the region of Brussels frequent tubulations, probably worm tubes, have been found. They are especially numerous near the contact with the overlying calcareous sands (see fig. 5).

FIG. 5. — Sands of Brussels, rich in worm tubes, Sint-Job (BA).

A common feature of the quartz sands are the siliceous concretions of peculiar form, known under the name of « Grès fistuleux » and « Pierres de grottes ».

They consist of hollow tubes, often with an indurated core, and they were probably formed around worm tubes. The « Grès fistuleux » are the simple forms of a single tube, the « Pierres de grottes », the more complicated ones, consisting of an agglomeration of a number of these tubes. The concretions are often more or less concentrated in layers.

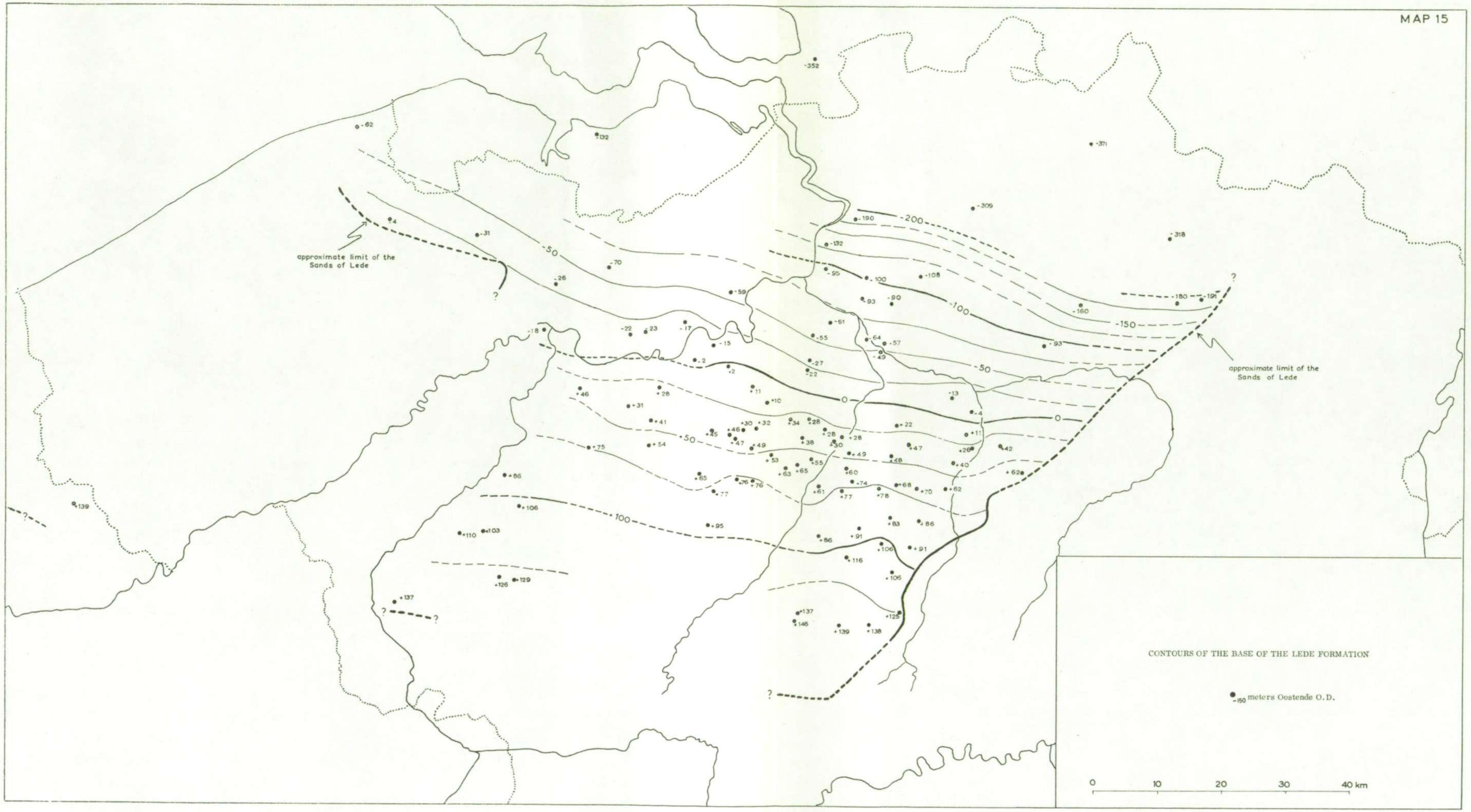
b) The second type of Brussels Sands is formed by calcareous, medium to fine-grained, fairly homogeneous sands, that form the upper part of the series near Brussels as well as near Melin. These sands often contain pieces of calcareous sandstone to sandy limestone, mostly in discontinuous layers, as, for instance, near Diegem. Locally the limestone is silicified.

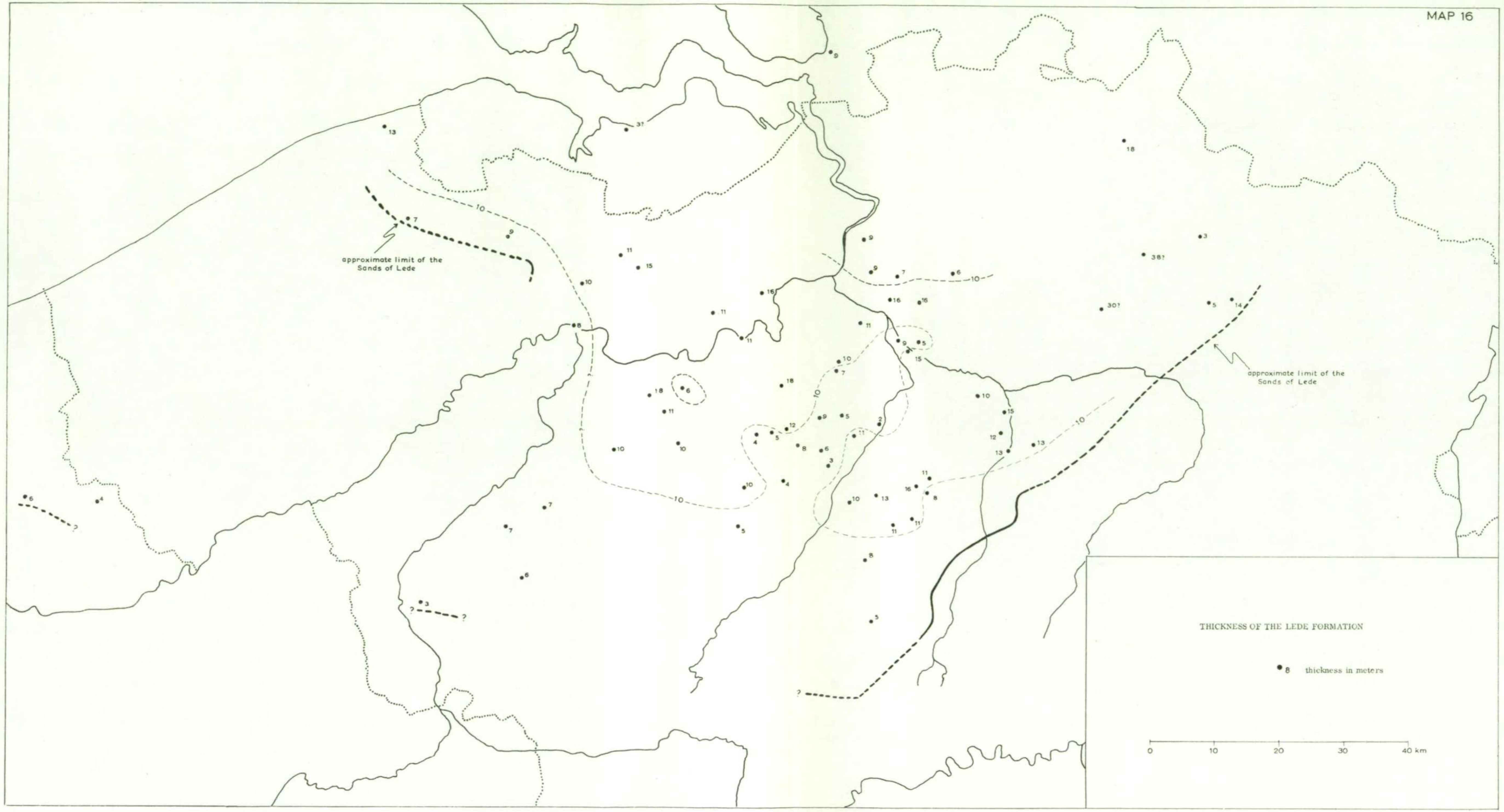
From Gobertange have been described the « Grès de Gobertange » which are limestones in discontinuous to fairly continuous beds of 20 to 40 cm thickness. In the pieces thin beds of some mm to three cm are apparent. This bedding is more or less disturbed by biologic action, mostly that of annelids. The beds consist of very fine-grained, calcareous material, with intercalated seams of fine sand with glauconite. The calcareous matter consists of debris of foraminifera, sponge spicules, echinid spines, bryozoan and shell fragments (*Lucina volderiana* is often found as casts), and calcite (LEDOUX, 1911). In the region of Gobertange about eight to ten of these banks have been found, in a series of about 10 m of very calcareous sands.

The Brussels Sands of the region of Cassel consist of a basal part of glauconitic and fine-grained quartz sands, overlain by whitish, calcareous sands with intercalated sandy limestones with *Nummulites laevigatus*. A similiar succession was found in the boring Woensdrecht.

The Brussels Sands are mostly covered by the Lede Sands. Outside the area of the latter unit they are overlain by Lower Tongeren beds.

Fossils are usually scarce, but there are some rich outcrops, such as those of Nil-Saint-Vincent, Neder-Okkerzeel, Nalinnes. GLIBERT (1933) described the molluscs of a number of localities around Brussels, CANU and BASSLER (1929) the bryozoans, LERICHE (1905*a*, 1951) a number of fish species, and STOCKMANS (1936) some plant remains.


MAP 15
approximate limit of the Sands of Lede
approximate limit of the Sands of Lede
CONTOURS OF THE BASE OF THE LEDE FORMATION
-150 meters Oostende O.D.
0 10 20 30 40 km


MAP 16
approximate limit of the
Sands of Lede
approximate limit of the
Sands of Lede
THICKNESS OF THE LEDE FORMATION
8 thickness in meters
0
10
20
30
40 km

One of the frequent species is *Ostrea cymbula*. It is associated with many others, such as *Gladius baylei, Rhinoclavis unisulcatus, Rostellaria fissurella, Natica labellata, Athleta cithara, Cassidaria coronata, Nautilus labellata, Lucina volderiana, Cardium porulosum, Meretrix proxima, M. laevigata, Corbula gallica, Maretia omaliusi, Lenita patellaris*, and species of *Turbinolia, Sphenotrochus, Paracyathus*, and *Amphibelia*. Furthermore there are frequent bryozoan debris, a fish fauna with *Odontaspis macrota*, especially in the basal beds and the limestones, remains of turtles (*Emys camperi*), and plant fragments, such as drift-wood, fructifications of *Nipadites burtini*.

Nummulites laevigatus is scarce to absent in the lower part of the Sands of Brussels, but it is abundant in the upper part, as at Cassel and Woensdrecht. Most of the other occurrences are found along the eastern and southern borders of the area, but also at some other places.

Leriche (1922*a*) used the nummulites for a subdivision of the Brussels Sands. He found a lower zone without nummulites and an upper one with *Nummulites laevigatus*. This subdivision was attacked by Halet (1939) as being too detailed for the scanty knowledge of the distribution of the nummulites. However, during our research we found the scheme of Leriche to be generally correct.

LEDE FORMATION

The Lede formation consists of only one member, the Sands of Lede.

SANDS OF LEDE (Mourlon, 1873)

named after Lede, between Aalst and Gent

(Maps 5, 15 and 16)

The Lede Sands cover the Sands of Vlierzele or those of Aalter in the western and central parts of the area. They overlie the Sands of Brussels in the farther occurrences of eastern Brabant, the borings Turnhout and Woensdrecht, and the hills of Cassel.

The basal part is formed by coarse sands with well-rounded, mostly hyaline quartz grains of 1 to 3 mm diameter. Sometimes these basal sands are indurated. Locally they overlie a ravinated surface of the older sediments. At these places, such as Forest and Vlierzele, they contain many worn fish remains, shell fragments (e.g. *Terebratula, Ostrea cymbula*), nummulites (recorded as *Nummulites laevigatus*), associated with small silex pebbles and fragments of calcareous sandstone, the latter often perforated. Near Brussels also mammalian remains have been found in these basal sands, such as *Lophiotherium cervulum, Lophiodon*, and *Chasmotherium minimum*.

At several places a second pebble bed has been found, higher up in the sands. This one is rich in *Nummulites variolarius* and shell fragments. It is especially developed around Brussels, where the underlying part of the sands may be as thick as 4 m.

On such lower sands Dumont (1851) based his Laekenian stage, named after Laeken, a northern municipality of Brussels. Further studies revealed the absence of the upper pebble bed and the consequent indistinctness of the Sands of Laeken at many localities. Furthermore no distinct paleontological characteristics could be found to distinguish them from the higher Sands of Lede.

The fine-grained sands on top of the basal gravel are mostly of remarkably uniform lithologic character. They are ill-sorted, and very rich in debris of fossils. Locally they contain slightly clayey beds (Waterloo, Glabais, Gent). The variable glauconite content is especially high in the western part of Flanders, from which region LERICHE (1913) described the Sands of Strymees. In the latter sands fossils are rare, and the basis contains fragments of wood and pebbles of clay, derived from the Panisel beds.

At the type locality Lede, the sandpits only showed decalcified sands. In his first description MOURLON already remarked this feature for the vicinity of Lede. However, at that time, some sandpits with incomplete decalcification of the sands occurred as well. A sample, taken by MOURLON, from one of the calcareous patches in these sands, could be investigated. It is indicated as « Lede ».

Commonly there are three discontinuous layers of sandy limestone. They are rather continuous in the area between Aalst and Balegem. They have local names after the villages near which they were formerly quarried, such as Balegem, Bambrugge.

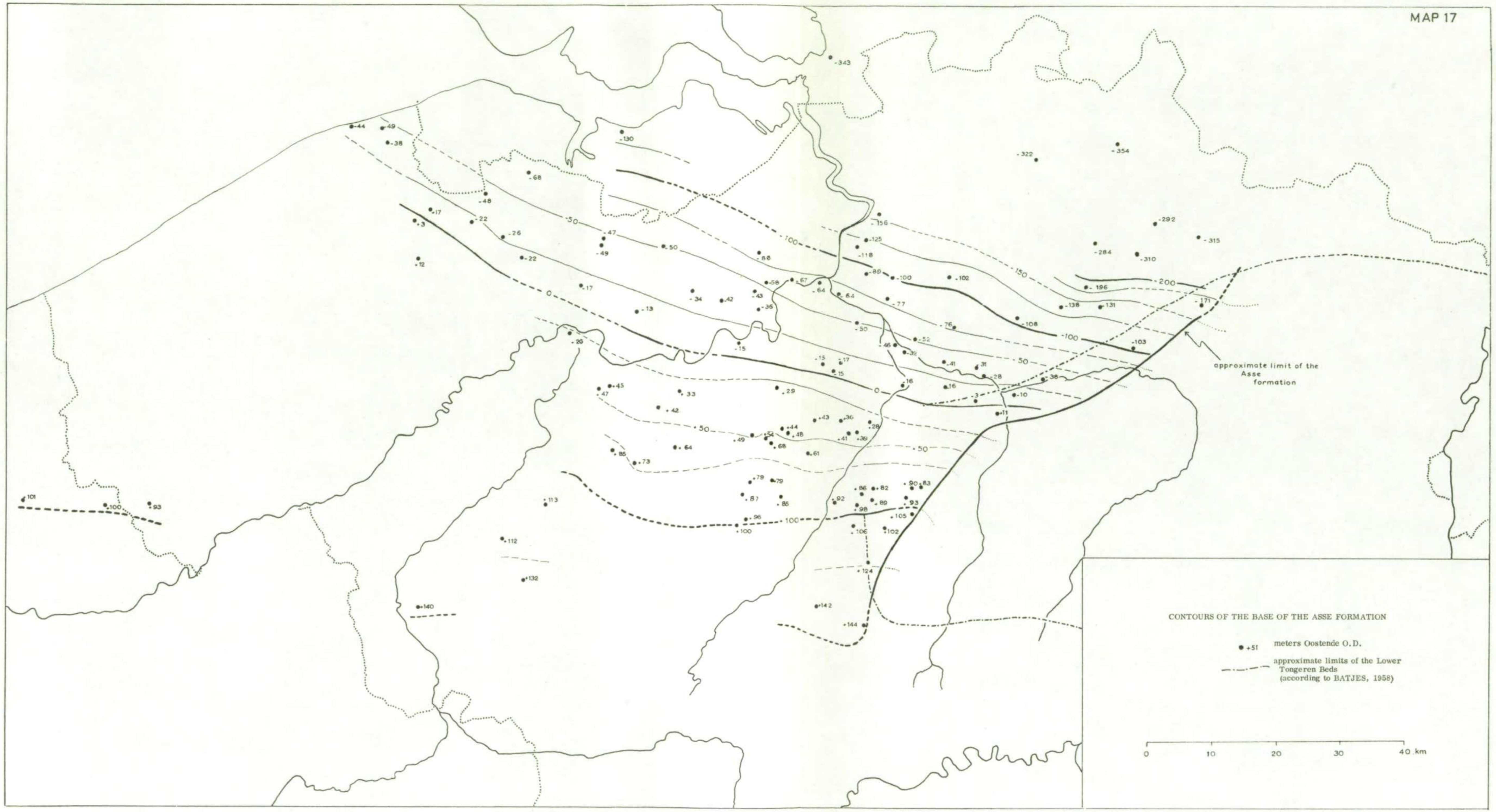
These limestones, with fairly high content of $CaCO_3$ (51 to 68 per cent), are formed by fine-grained quartz, foraminifera (especially nummulites), sponge spicules and calcite (LEDOUX, 1911). Also shell fragments and tubes of *Ditrupa* occur. Many casts and moulds give a vacuolar appearance.

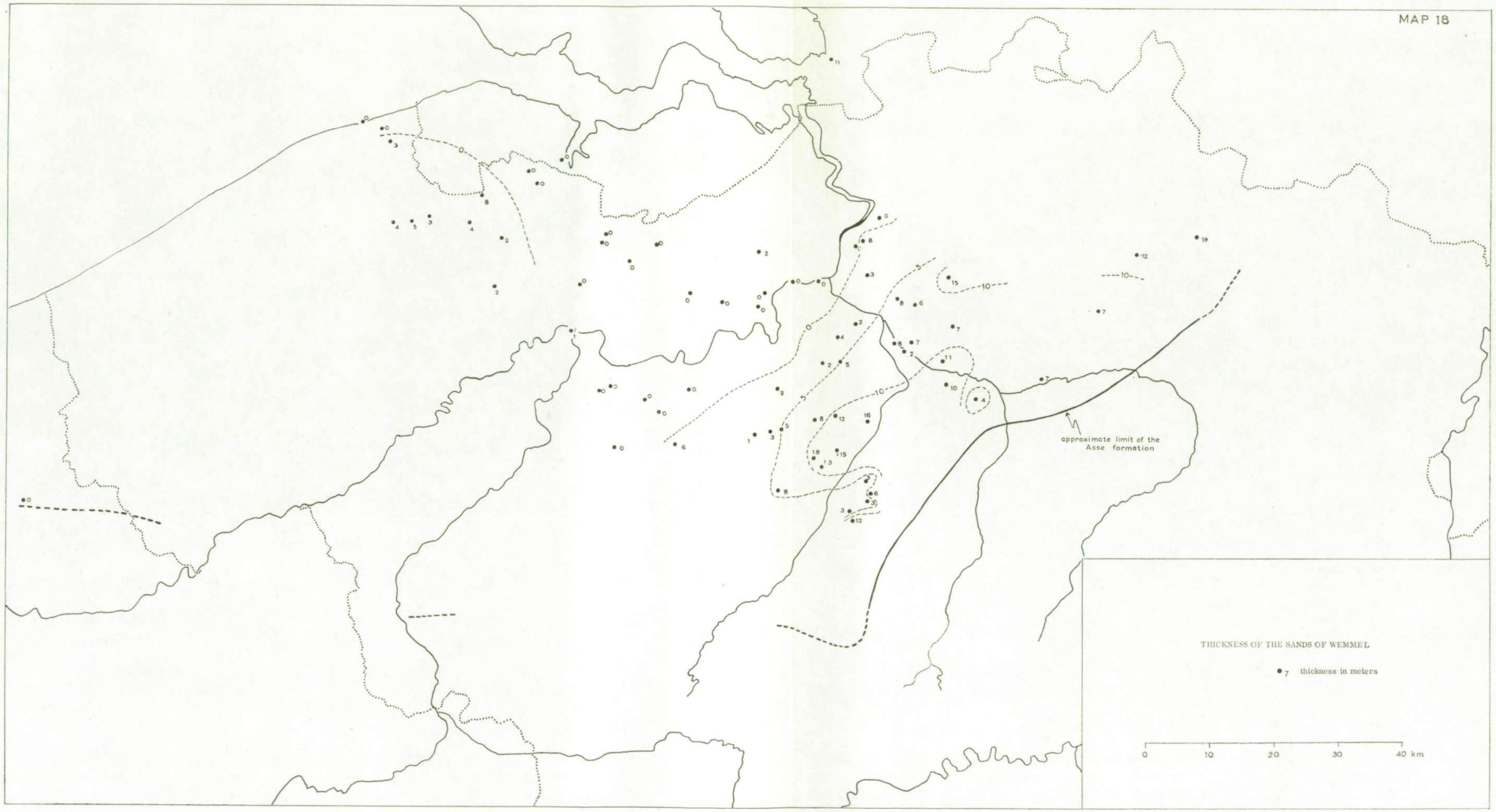
Except for the limestone banks, indications of bedding are usually absent. However, near Renaix, an abandoned sandpit was found, where the Lede Sands are distinctly current-bedded, with a general dip towards the south.

In almost the whole area the Lede Sands are overlain by the Asse formation. Only in the extreme eastern occurrences of the Kempen and in the southern occurrences of Brabant are they covered by Lower Tongeren beds.

The composition of the rich fauna appeared variable from one locality to the other. As main components may be listed *Nummulites variolarius, Turbinolia sulcata, Turritella imbricataria, Solarium nysti, Rostellaria fissurella, Ostrea gryphina, Pecten corneus, Nautilus lamarcki, Echinolampas affinis, Terebratula kickxi, Ditrupa strangulata,* fish remains (often more or less worn), such as *Lamna vincenti* and *Odontaspis macrota,* many bryozoan debris, as for instance of *Lunulites latera.*

CANU and BASSLER (1929) described the bryozoans of the Lede Sands; LERICHE (1905*a*, 1951) a number of fish species.


MAP 17
approximate limit of the Asse formation
CONTOURS OF THE BASE OF THE ASSE FORMATION
+51 meters Oostende O.D.
approximate limits of the Lower Tongeren Beds (according to BATJES, 1958)
0 10 20 30 40 km


MAP 18
approximate limit of the Asse formation
THICKNESS OF THE SANDS OF WEMMEL
7 thickness in meters
0 10 20 30 40 km

ASSE FORMATION

(Maps 5, 17 and 18)

Formerly Belgian geologists distinguished two stages : the Wemmelian and the Assian. Later research, especially that of LERICHE, revealed that the deposits of these two units had better be taken together as the Asse formation.

Three members can be distinguished.

SANDS OF WEMMEL (G. VINCENT, 1871)

named after Wemmel, a village northwest of Brussels

(Maps 17 and 18)

The Sands of Wemmel usually cover the Sands of Lede, but in the northwestern part of the area they overlie the Sands of Vlierzele or those of Aalter.

In the borings Asse and Brussegem and at some other places the Wemmel Sands are separated from the Lede Sands by a thin gravelly bed, of up to 30 cm, with *Nummulites variolarius*. At other localities no layer with pebbles was found, as, for instance, at Mechelen (HALET, 1910) and Forest (LERICHE, 1943*b*).

On top of the sandy bed with pebbles a clayey zone of about 10 cm, rich in glauconite, has been observed.

In the vicinity of Wemmel the Sands form a homogeneous mass of fine-grained, calcareous sands, rich in fossils. Towards the top alternating sandy and clayey beds were found, which mark the transition to the Asse Clays. Locally there is some coarse sand near the supposed limit (RUTOT, 1887*a*).

Near Asse other types of Wemmel Sands have been found. They are fine to coarse-grained and there are interstratified gravel beds. The sands of this region may contain tubulations, probably worm tubes, and they are more or less cross-bedded. Clayey intercalations have also been described. Towards the north this irregular series passes into more regularly bedded, glauconitic, clayey sands.

South of Brussels the Wemmel Sands were found to be non-calcareous, sometimes slightly clayey, and with intercalations of coarser sands. Near Solbosch they form a complex of about 10 m, with cross-bedded parts and intercalated gravel beds, which were interpreted by LERICHE (1943*b*) as recurrences of the basal gravel.

In the borings of northern Belgium the Sands have mostly been described as glauconitic and clayey, with *Nummulites orbignyi*.

The Wemmel Sands are covered by the Clays of Asse, or, in the extreme eastern part of the area, near Leuven, by the Lower Tongeren beds. A gradual passage from the Wemmel Sands into the Asse Clays has been found; at other places these two members are separated by the « bande noire » (LYELL, 1853), a very glauconitic bed of dark green to black.

The Sands of Wemmel are very rich in fossils, especially molluscs (GLIBERT, 1936 and 1938) with predominance of pelecypods. As the main components of the fauna should be mentioned : *Pecten corneus, Nuculella nysti, Ostrea cubita, Astarte nysti, Cardita sulcata, Crassatella cossmanni, Scala spirata*, scaphopods, coral remains (*Eupsammia burtinana*), bryozoans, and fish remains. The latter were described by LERICHE (1905*a*, 1951). Many nummulites have been found : *Nummulites orbignyi* (=*N. wemmelensis*) and possibly *N. variolarius*.

Outside the Wemmel region the Sands are poor in fossils. Mainly nummulites and *Pecten corneus* have been found.

CLAYS OF ASSE (G. VINCENT and A. RUTOT, 1878)

named after Asse, between Brussels and Aalst

The Clays of Asse overlie the Sands of Wemmel, but between Eekloo and Antwerp an area without Wemmel Sands is present, in which the Asse Clays directly cover the Sands of Lede.

A continuous passing from the Wemmel Sands into the Clays of Asse is often observed, by means of gradually increasing clay and glauconite contents. At other places the change is more abrupt, and the base of the Clays is formed by the « bande noire ». Often the « bande noire » is a thin band of coarse glauconitic sand, with many fossils, such as *Pecten corneus*, *Nummulites orbignyi* and *Eupsammia burtinana* (Wemmel, BW). Such a glauconitic layer may also be present when the Asse Clays overlie the Lede Sands.

Locally the « bande noire » may be present as a series of interfingering beds, as described by RUTOT (1882*b*) and LERICHE (1943) from the hills near Cassel and from Gent, at which locality this series may reach a thickness of about 1 m.

The Asse Clays are compact clays, that are partly sandy and glauconitic. In the type region and in Meetjesland, the region southeast of Brugge, the lower and upper parts are glauconitic, the middle part is devoid of this mineral and of lead-grey colour. This grey clay diminishes in thickness towards the south and the east, and near Brussels the entire mass of the clay is glauconitic.

At Cassel the Asse Clays consist of a lower part of glauconitic, sandy clays with fossils, and an upper part of grey, plastic clays without fossils.

The uppermost beds of the Clays become sandy and pass into clayey sands that form the base of the Sands of Asse.

The reported thicknesses of the Asse Clays, from borings, are highly variable, probably as a consequence of frequent incorporation of the clays of the lower part of the Asse Sands. HALET (1910) reported thicknesses of about 6 to 7 m at Mechelen. Northwest of Brussels thicknesses seem to vary between 3 and 10 m; at Cassel 13 to 16 m have been found.

Fossils are scarce in the Clays of Asse. Most of the described species have been derived from the lower glauconitic part, the fauna of which resembles that of the Sands of Wemmel. Dominant are *Pecten corneus* and *Nummulites orbignyi* (= *N. wemmelensis*).

SANDS OF ASSE (HENNEQUIN, 1880)

named after Asse, between Aalst and Brussels

In the northern and northwestern parts of Belgium the Asse Clays are overlain by the Sands of Asse, which, in turn, are covered by the basal beds of the Rupel formation.

Near Asse the Asse Clays become sandy near the top and pass into sands that are mostly ill-sorted and glauconitic. These sands, with a thickness of 9 m in our boring of Asse, become clayey again in the uppermost few metres and then pass into 1 to 2,50 m of plastic clay, which is often micaceous. VELGE (1896*a*) described this clay as the « argile gris supérieure d'Assche ». Upwards the clay is covered by more or less clayey, fine-grained sands that are again frequently micaceous.

Most facts of the Asse Sands are known from borings in northwestern Belgium, but it should be emphasized that the records of most of these borings are fairly unreliable, which may account for the frequent absence of reports of the threefold subdivision. Although MEUGY reported sands in between glauconitic clays and grey, plastic clays, as early as 1852, the presence of the Asse Sands in the hills of Cassel has not been verified.

The Asse Sands are locally fossiliferous. HENNEQUIN (1880) already reported the presence of fossiliferous, limonitic sandstones from sands that overlie the Asse Clays near Asse, at the « Camp romain ». RUTOT (1882*b*) described their fauna as consisting of a number of Eocene species associated with some Oligocene forms. VINCENT (1897) reported limonitic sandstone pieces with *Nummulites orbignyi*. HALET (1910) found some beds with nummulites in clayey sands of several borings near Mechelen.

The contact of Asse Sands and Berg Sands, the basal member of the Rupel formation in western Belgium, is usually not sharp. Only at some places there are dispersed pebbles at the contact of both units.

These Berg Sands are composed of fairly fine-grained sands with silex fragments and some glauconite (BATJES, 1958). Locally they are fossiliferous with *Pycnodonta callifera* as a characteristic species. Their thickness in western Belgium amounts to about 20 m.

LOWER TONGEREN BEDS

Distinct Lower Tongeren beds occur only in the Leuven-Tongeren-Dutch Limburg area. There are two members and sometimes a basal gravel.

The Sands of Grimmertingen are fine-grained, micaceous, clayey sands with, amongst others, *Ostrea ventilabrum* and *Turritella crenulata*. West of Leuven this unit is said to be more clayey (MOURLON, 1912).

The Sands of Neerrepen are fine-grained, micaceous sands, with small quantities of glauconite. They cover the Grimmertingen Sands. From the region of Leuven this unit is reported as yellowish sands that cover the sandy clays of the Grimmertingen member.

For more details about the Tongeren beds the reader may be referred to BATJES' study of the Oligocene of Belgium (1958).

BATJES (1958) discussed the few records of Lower Tongeren beds in a number of borings west of the Hageland, for which the occurrence of *Ostrea ventilabrum* and of mica in the sediments would be indicative. The value of *Ostrea ventilabrum* as an index fossil is considered doubtful by BATJES as long as no comparative study has been made with related species, such as *Ostrea wemmelensis* from the Asse formation. Furthermore, micaceous sediments occur both in the Asse formation and in the Lower Tongeren beds. Consequently the presence of mica can not be used as an argument. BATJES concluded that the presence of Lower Tongeren beds is very doubtful in the area west of the Hageland.

CHAPTER III

LOCALITY DETAILS

All sediments descriptions are based on field observations or data from the Archives of the Geological Survey of Belgium. No detailed account is given of the petrographic features of the sediments.

The legend of the figured sections of both outcrops and borings is to be found in figure 16.

The stratigraphic symbols marked on the left of the lithologic columns are given in Chapter II (p. 16).

BELGIUM

(Map 19)

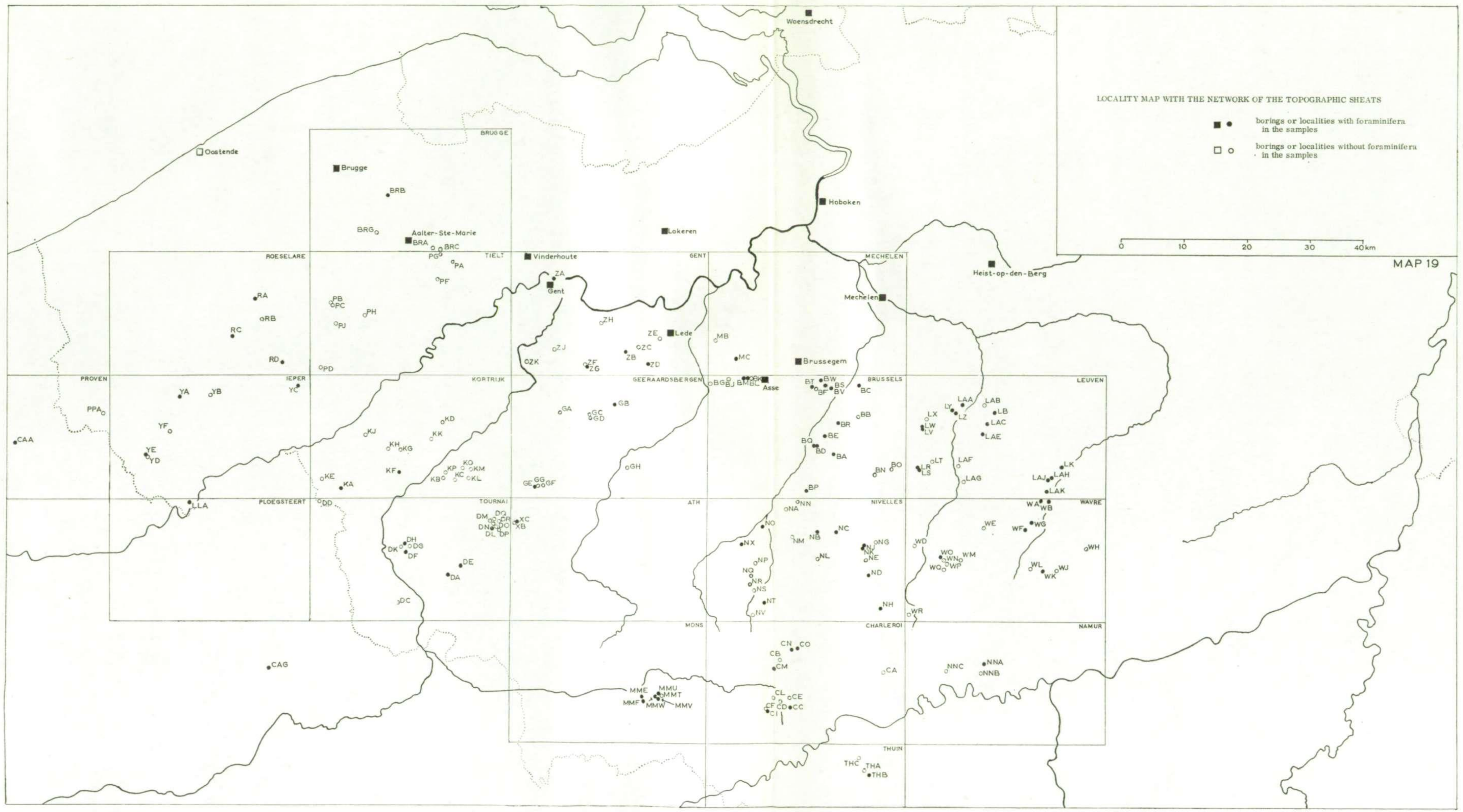
LIST OF LOCALITIES FOR EACH STRATIGRAPHIC UNIT

SANDS OF OOSTENDE

Boring Oostende.

CLAYS OF IEPER

CE	Carnières.	
CN	Godarville	samples CN 52-54.
CO	Godarville.	
DA	Havinnes	samples DA 311, 314.
DC	Saint-Maur.	
KG	Moen.	
KJ	Zwevegem.	
MME	Cuesmes	samples MME 27, 28.
MMF	Hyon	sample MMF 33.
NO	Tubize	samples NO 1170, 1173.
NT	Écaussines-Lalaing	samples NT 1181, 1182.
NX	Quenast	samples NX 89, 91, 92.
PD	Izegem.	
PJ	Ardoie.	
PPA	Poperinge.	
RA	Kortemark	samples RA 253, 254, 1071, 1072, 1079.
RD	Rumbeke	samples RD 1080, 1081.
YA	Ieper	sample YA 262.
YB	Zonnebeke.	
YC	Ledegem.	
YF	Voormezele.	
Boring Woensdrecht	....	samples W 476-597 m.


LOCALITY MAP WITH THE NETWORK OF THE TOPOGRAPHIC SHEATS
borings or localities with foraminifera in the samples
borings or localities without foraminifera in the samples
0 10 20 30 40 km
MAP 19
Oostende
Brugge
Woensdrecht
Hoboken
Lokeren
Aalter-Ste-Marie
Vinderhoute
Gent
Lede
Mechelen
Heist-op-den-Berg
Brussegem
Asse
BRUGGE
ROESELARE
TIELT
GENT
MECHELEN
PROVEN
IEPER
KORTRIJK
GEERAARDSBERGEN
BRUSSELS
LEUVEN
PLOEGSTEERT
TOURNAI
ATH
NIVELLES
WAVRE
MONS
CHARLEROI
NAMUR
THUIN

MORLANWELZ MEMBER

CD	Carnières.	
CF	Leval-Trahegnies.	
CI	Leval-Trahegnies	sample CI 41.
CL	Carnières.	

CLAYS OF ROUBAIX

KA	Luingne	samples KA 305, 306, 1092, 1093.
KE	Mouscron.	
KF	Moen	samples KF 1094-1096.
KG	Moen.	
KH	Knokke.	
LLA	Ploegsteert	sample LLA 1087.
YB	Zonnebeke.	

SANDS OF MONS-EN-PÉVÈLE

BD	Forest	sample BD 445.
CAG	Mons-en-Pévèle	samples CAG 1249, 1250, 1252.
CB	Manage.	
CO	Godarville	samples CO 58, 59, 60, 62, 1241.
DD	Mouscron.	
DE	Maulde	sample DE 1204.
DF	Mont-Saint-Aubert	samples DF 1205, 1206.
DG	Mont-Saint-Aubert.	
DH	Mont-Saint-Aubert	samples DH 1208-1212.
DL	Ellignies-lez-Frasnes	sample DL 1218.
DM	Saint-Sauveur.	
DN	Saint-Sauveur.	
KG	Moen.	
MMV	Hyon	samples MMV 79, 80, 1201.
NT	Écaussines-Lalaing	sample NT 1183.
NV	Écaussines-Lalaing.	
NX	Quenast	sample NX 95.
PJ	Ardoie.	
RC	Staden.	
XB	Frasnes-lez-Buissenal.	
XC	Frasnes-lez-Buissenal	sample XC 1226.
Boring Aalter-Sainte-Marie		samples Aalter-Sainte-Marie 21, 22, 24, 25.
Boring Brugge		sample Brugge 24.
Boring Gent		samples Gent; Gent 24912.
Boring Mechelen		samples Mechelen 105, 106.
Boring Vinderhoute		samples Vinderhoute 106, 107, 110, 111, 116, 117, 119.
Boring Woensdrecht		samples W 462-474 m.

CLAYS OF RONCQ

DH	Mont-Saint-Aubert	sample DH 1213.
GE	Ellezelles.	
PJ	Ardoie.	
RC	Staden	samples RC 1066-1068.
Boring Brugge.		
Boring Mechelen.		
Boring Vinderhoute		samples Vinderhoute 104, 105.
Boring Woensdrecht		sample W 459 m.

SANDY CLAYS OF ANDERLECHT

BG .... Teralfene.
DO .... Saint-Sauveur.
DP .... Saint-Sauveur.
DQ .... Saint-Sauveur.
GF .... Ellezelles.
GH .... Geeraardsbergen.
KD .... Ansegem.
KP .... Ruien.
MMT ..... Hyon.
MMW .... Hyon .... samples MMW 84, 85.
PB .... Eegem.
PC .... Eegem.
PH .... Pittem.
RB .... Hooglede.
Boring Vinderhoute .... sample Vinderhoute 102.

SANDY CLAYS OF ANDERLECHT + SANDS OF VLIERZELE

Boring Mechelen .... sample Mechelen 84.
Boring Woensdrecht .... samples W 386-442 m.

SANDS OF VLIERZELE

BRG ...... Beernem.
CAA ...... Cassel.
DK .... Mont-Saint-Aubert.
DR .... Saint-Sauveur.
GG .... Ellezelles.
GH .... Geeraardsbergen.
KB .... Orroir.
KC .... Amougies.
KD .... Ansegem.
KK .... Tiegem.
KL .... Russeignis.
MMT ..... Hyon.
MMU ..... Hyon .... sample MMU 78.
MMW ... Hyon.
PA .... Bellem.
PF .... Loo-ten-Hulle.
YD .... Kemmel.
ZB .... Vlierzele.
ZF .... Balegem.
ZH .... Gijzenzele.
ZJ .... Munte.
ZK .... Gavere.
Boring Asse .... samples Asse 45, 46.
Boring Brugge.
Boring Hoboken.
Boring Vinderhoute .... samples Vinderhoute 63, 65.

SANDS OF AALTER

BRA	Aalter.	
BRC	Aalter.	
CAA	Cassel	samples CAA 273-277, 279-281.
PG	Aalter.	
Boring Vinderhoute.		
Boring Woensdrecht	....	samples W 374-384 m.

SANDS OF BRUSSELS

BA	Sint-Job	samples BA 100-106.
BB	Woluwe-Saint-Lambert.	
BC	Diegem	samples BC 113-117.
BD	Forest	samples BD 388, 390-394, 1255.
BN	Hoeilaart.	
BO	Overijse.	
BP	Tourneppe	samples BP 1164-1167.
BQ	Forest	sample BQ 1168.
BR	Brussels	sample BR 1169.
CA	Heppignies.	
(?) CC	Carnières	sample CC 1197.
CM	La Hestre	sample CM 51.
CO	Godarville	samples CO 56, 64, 1241.
LAA	Bertem	sample LAA 1127.
LAB	Heverlee.	
LAE	Blanden	sample LAE 1130.
LAF	Pécrot.	
LAG	Archennes.	
LAH	Saint-Remy-Geest	sample LAH 1136.
LAJ	Saint-Remy-Geest	sample LAJ 1137.
LAK	Gobertange	sample LAK 1138.
LB	Korbeek-Loo	samples LB 124, 125.
LK	Hoegaarden	sample LK 163.
LR	Huldenberg	sample LR 1118.
LS	Huldenberg	sample LS 1119.
LT	Huldenberg.	
LW	Vossem	sample LW 1123.
LY	Bertem	sample LY 1125.
LZ	Bertem	sample LZ 1126.
NA	Esschenbeek.	
NB	Wauthier-Braine	samples NB 401, 403.
NC	Braine-l'Alleud	samples NC 405-407.
ND	Genappe	samples ND 410-412.
NG	Maransart.	
NH	Sart-Dame-Avelines	sample NH 1156.
NJ	Plancenoit	sample NJ 1158.
NK	Plancenoit	samples NK 1159, 1160.
NM	Braine-le-Château.	
NN	Tourneppe.	
NNA	Spy	samples NNA 1151, 1152.
NNB	Spy.	
NNC	Velaine.	
NP	Virginal-Samme.	
NQ	Hennuyères.	

NR	Henripont.	
NS	Henripont.	
THA	Nalinnes.	
THB	Nalinnes	samples THB 1189-1194.
THC	Jamioulx.	
WA	Lathuy	samples WA 164, 165, 166, 1139.
WB	Jodoigne	samples WB 169, 1141.
WD	Ottignies.	
WE	Chaumont-Gistoux.	
WF	Opprebais	sample WF 1134.
WG	Dongelberg	sample WG 1135.
WH	Folx-les-Caves.	
WJ	Grand-Rosière.	
WK	Perwez	sample WK 1145.
WL	Perwez.	
WM	Nil-Saint-Vincent.	
WN	Mont-Saint-Guibert.	
WO	Mont-Saint-Guibert	sample WO 1148.
WP	Mont-Saint-Guibert.	
WQ	Hévillers.	
WR	Tilly.	
Boring Woensdrecht		samples W 360,50-365 m.

SANDS OF LEDE

BD	Forest	samples BD 444, 1256-1258.
BE	Brussels	sample BE 446.
BJ	Esschene.	
BL	Asse	sample BL 1035.
BM	Asse	samples BM 1036, 1037.
GA	Roozebeke.	
GC	Erwetegem.	
GD	Erwetegem.	
KB	Orroir.	
KM	Kwaremont.	
KO	Kwaremont.	
LAC	Blanden	sample LAC 1128.
LV	Vossem	sample LV 1122.
LX	Leefdaal.	
MC	Meldert	sample MC 1040.
NE	Glabais.	
NL	Bois-Seigneur-Isaac.	
ZA	Gent	sample ZA 583.
ZB	Vlierzele	samples ZB 1021a, 1022.
ZC	Oordegem.	
ZD	Bambrugge	samples ZD 340, 342, 343, 1011-1017.
ZE	Lede.	
ZG	Balegem	sample ZG 1025.
Lede		sample Lede 2-V.
Boring Asse		samples Asse 37-44.
Boring Brussegem		samples Brussegem 28, 29, 33.
Boring Hoboken		samples Hoboken 16, 19.
Boring Lokeren		samples Lokeren 26, 27, 29.
Boring Mechelen		samples Mechelen 60, 62, 67, 70.
Boring Woensdrecht		samples W 347-355,75 m.

SANDS OF WEMMEL

BK	Asse.	
BS	Jette	samples BS 1259, 1260.
BT	Jette	sample BT 1266.
BV	Strombeek-Bever	samples BV 1269-1272.
Boring Asse	....	samples Asse 32-35.
Boring Brussegem	....	samples Brussegem 17-27.
Boring Heist-op-den-Berg	....	samples H 121,50-124,50 m, 125,50-129,50 m.
Boring Hoboken	....	samples Hoboken 13-15.
Boring Mechelen	....	samples Mechelen 54, 55.
Boring Wemmel	....	samples 10-12,50, 13, 14, 14,50, 15 m.
		14-5, 5,50, 6, 6,50, 7, 9,50, 10, 10,50, 11 m.
		16-6, 7, 9 m.
		48-22, 23,50 m.
Boring Woensdrecht	....	samples W 346 m, 335 m.

CLAYS OF ASSE

BF	Jette.	
BK	Asse.	
BT	Jette.	
BW	Wemmel	sample BW 1273.
BRB	Oedelem	samples BRB 237, 238, 241, 247, 1054-1057.
GB	Grootenberge	sample GB 1109.
MB	Moorsel.	
YE	Kemmel.	
ZA	Gent	samples ZA 1242, 1243, 1244.
ZD	Bambrugge.	
ZE	Lede.	
Boring Asse	....	samples Asse 29, 30.
Boring Brussegem	....	samples Brussegem 15, 16.
Boring Hoboken	....	sample Hoboken 12.
Boring Lokeren	....	samples Lokeren 19, 20, 24.
Boring Mechelen	....	samples Mechelen 50, 51.
Boring Woensdrecht	....	samples W 331-324 m.

SANDS OF ASSE

Boring Asse	....	sample Asse 17.
Boring Hoboken.		
Boring Mechelen.		
Boring Woensdrecht.		

SHEET BRUSSELS

(Map 20)

BA Sint-Job, sandpit « Ficerp » (250 m N of the church-tower of Sint-Job). See fig. 6.

Visited August 1953.

Sands of Brussels.

Quaternary loess covered about 13 m of sand. The lower part of the section was formed by 5,50 m of medium to fine-grained sand of greyish-green to yellow colour. The sand contained glauconite, some muscovite and many shell fragments (mainly *Ostrea cymbula*). No layers were apparent, except for an indistinct thin-bedded stratification, mostly cross-bedded, at some places. The upper part of this lower sand was rich in tubulations (probably wormtubes), which decreased in number downwards. At the top there was an indurated calcareous layer of variable thickness (max. 20 cm), rich in shell fragments and foraminifera.

Dispersed in the sand we found very hard concretions of the same material, rich in sponge spicules, cemented by SiO_2 (« Grès fistuleux » and « Pierres de grottes »).

Higher upwards the described sands gradually passed into more calcareous sand of yellowish-white colour, regularly stratified. In this part of the exposure, the upper 7,50 m under the Quaternary base, the sand was fine-grained, locally rich in shell fragments (mainly *Ostrea*), and it contained small, flat, more or less marly lenses (perhaps remains of slightly decalcified, more or less lenticular sandy limestones). Near the top the sand was coarser grained and slightly indurated.

The samples, **BA 100-106,** taken in the eastern part of the E-W striking wall, showed fairly rich foraminiferal faunae, increasing in abundance upwards. Associated were ostracodal remains, shell fragments, echinid debris, sponge spicules, bryozoan debris and some radiolarians. All the samples contained some muscovite (with green varieties) and glauconite (scarce in the upper samples).

BB Woluwe-Saint-Lambert, sandpit (1.250 m N and 250 m W of the church-tower of Woluwe-Saint-Lambert).

Visited August 1953.

Sands of Brussels.

Great excavation with about 14 m of decalcified sand, but locally with some very fragile shell remains (possibly mainly *Ostrea cymbula*). The sand was of whitish-yellow colour, and fine-grained. Sometimes stratification was visible by colour differences. There were irregular-shaped concretions of the same material, rich in sponge spicules and cemented by SiO_2 (partly « Grès fistuleux »). Towards the top the sands became coarser and greyish-brown (iron oxides), with a few scattered, small and flat clay lenses of some cm length.

The samples from the lowermost 5 m were taken at levels with shell fragments. They yielded also echinid remains and some ostracods. Muscovite was found, with increasing quantity higher upwards.

BC Diegem, sandpit (500 m W of the church-tower of Diegem); also point 88 (E) 207 of the archives of the Geological Survey. See fig. 6.

Visited August 1953.

Sands of Brussels.

Exposure of about 13 m height. Samples were taken in the southern part of the pit.

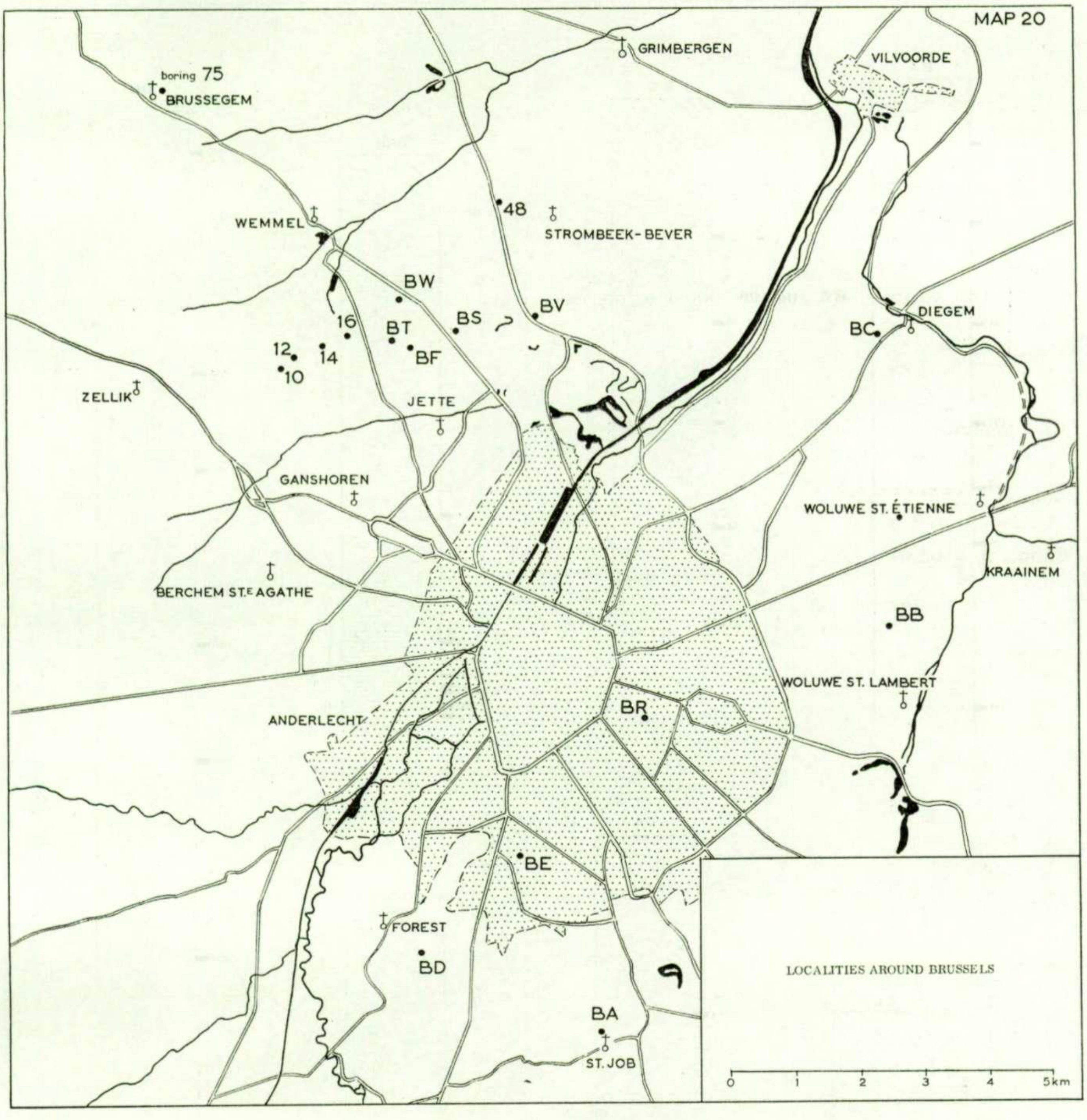
Under the Quaternary loess and the decalcified sands below followed a complex of about 8,50 m of very calcareous sands, whitish or yellowish, fine-grained, rich in organic remains. Interstratified occurred a number of discontinuous layers of sandy limestones, distances in between variable (5-130 cm). The pieces mostly had flat sides, but rounder ones were found as well (thickness 10-20 cm).

The uppermost part of the sand was distinctly decalcified. Decalcification sometimes showed a very irregular pattern (resembling organ pipes, etc.). This greenish layer, of variable thickness, was indistinctly overlain by Quaternary loess.

All samples (**BC 113-117**) are rich in foraminifera, associated with shell fragments, ostracods, echinid remains, fish remains, bryozoan debris, sponge spicules, radiolarians, etc. The wash residues showed no apparent variation of the grainsize of the sands.

BD Forest, exposures near the Stadium of the « Centre de Sports et de Santé »; also points 102 (W) 93 and 323 of the archives of the Geological Survey. See fig. 7.

Visited August 1953 and September 1955.



Literature :

M. Mourlon, 1905, Ann. Soc. Géol. Belg., vol. 32, mem., pp. 342-344; 1908, Bull. Soc. belge Géol., vol. 22, P.V., pp. 157-158; 1908, Ann. Soc. Géol. Belg., vol. 35, Bull., pp. 207-211.

A. Ledoux, 1911, Ann. Soc. Géol. Belg., vol. 38, mem., pp. 171-172.

M. Leriche, 1922, Congrès Géologique Internat., Livret-Guide Exc. A 4, Belgique, pp. 30-33.

M. Casier, 1946, Mém. Musée R. Hist. Nat. Belg., no. 104, pp. 22-30.

Two points were studied and sampled :

a) Abandoned sandpit « Jules Eggerickx », at present Stadium of C. S. Forestoise;

b) Exposure in hollow roadside, corner Avenue du Domaine-Avenue Minerve.

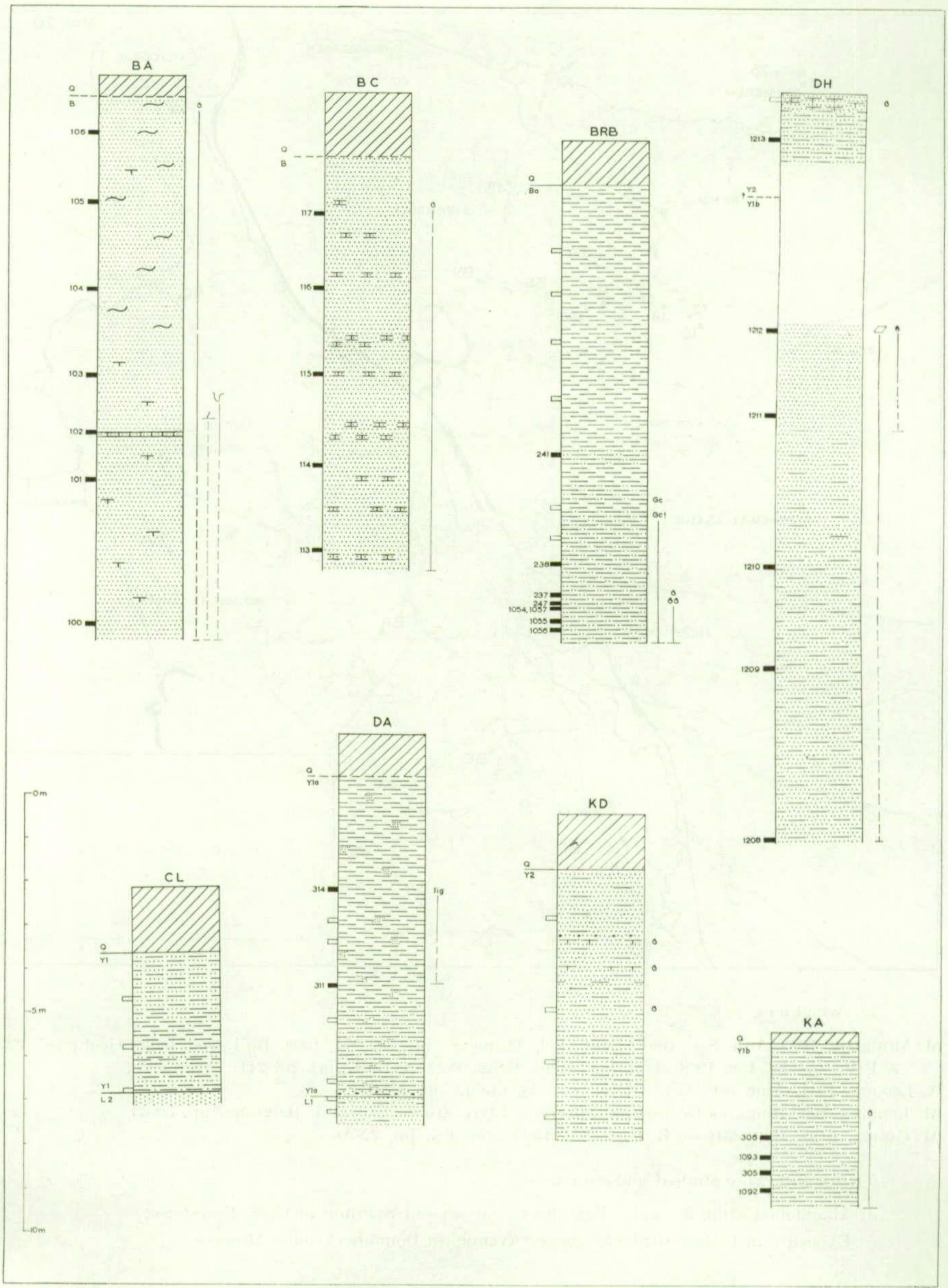


Fig. 6.

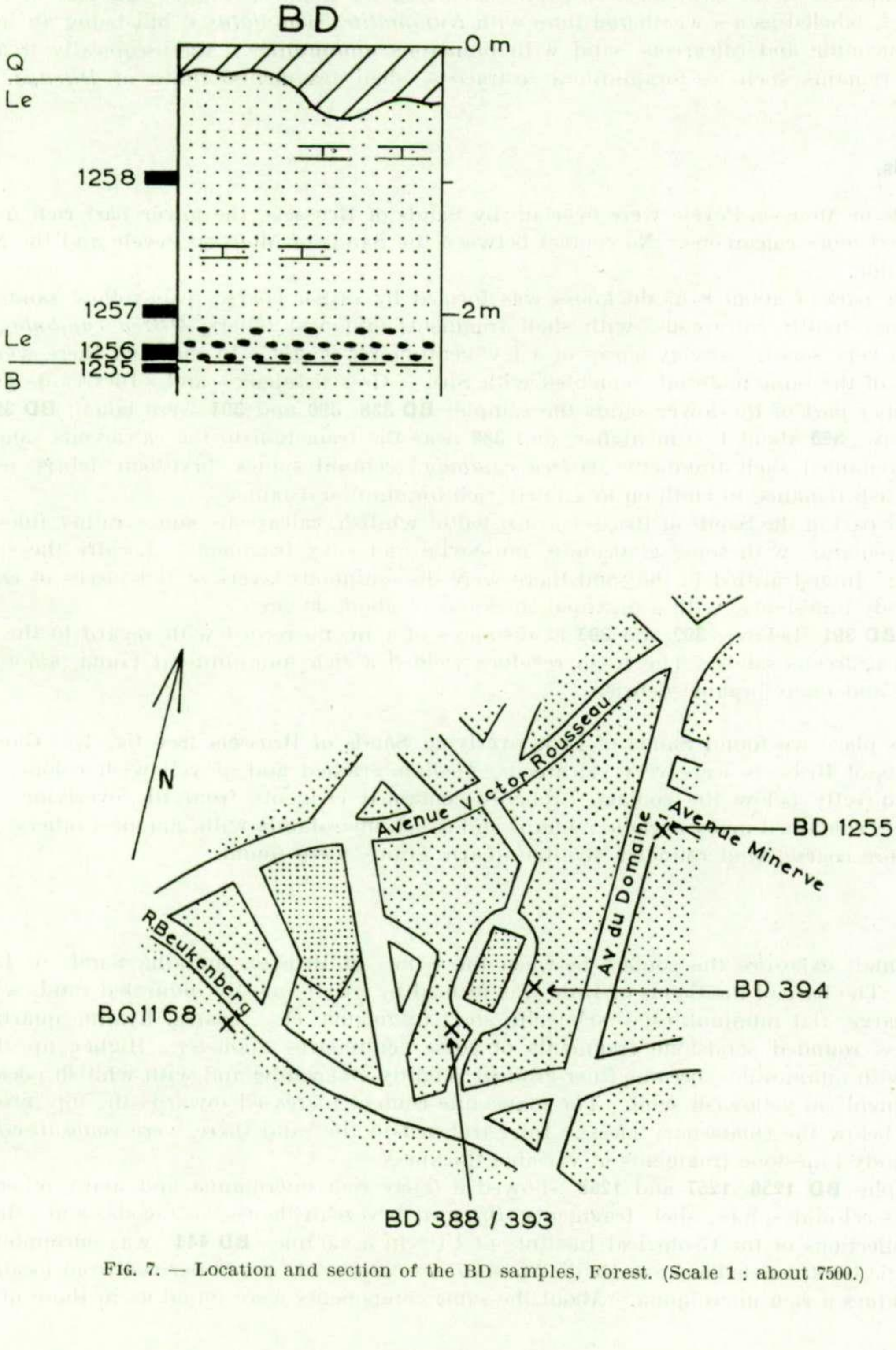


FIG. 7. — Location and section of the BD samples, Forest. (Scale 1 : about 7500.)

a) The exposed parts of the old wall of the pit did not allow a detailed stratigraphic survey. Exposed were Sands of Mons-en-Pévèle and Sands of Brussels.

Sands of Mons-en-Pévèle.

The base of the exposure was formed by fine-grained, clayey sands of green-grey colour, with calcareous remains, but without foraminifera.

In the collections of the Geological Institute of Utrecht we found a sample (**BD 445**) of the same stratigraphic level, labeled as a « weathered lime with *Nummulites planulatus* », but being an indurated fine-grained, glauconitic and calcareous sand with numerous nummulites. Microscopically it appeared rich in organic remains such as foraminifera, ostracods, shell fragments, tubes of *Ditrupa*, echinid spines, etc.

Sands of Brussels.

The Sands of Mons-en-Pévèle were overlain by Sands of Brussels, the lower part rich in quartz, and the upper part more calcareous. No contact between the Sands of Mons-en-Pévèle and the Sands of Brussels was visible.

The lower part of about 8 m thickness was formed by rather coarse, pale-yellow sands, which at the top became slightly calcareous, with shell fragments (amongst others, *Ostrea cymbula*), and at some places with very small, flat clay lenses of a few centimetres lenght. In the sand there were capricious concretions of the same material, cemented with SiO_2 (« Grès fistuleux » and « Pierres de grottes »).

In the upper part of the lower sands the samples **BD 388**, **390** and **394** were taken; **BD 394** about 4 m above the base, **390** about 1,50 m higher, and **388** near the transition to the calcareous sands. The wash residues contained shell fragments (*Ostrea cymbula*), echinid spines, bryozoan debris, ostracods, sponge spicules, fish remains, in addition to a fairly rich foraminiferal fauna.

The upper part of the Sands of Brussels consisted of whitish, calcareous sands, rather fine-grained, rich in organic remains, with some glauconite, muscovite and silex fragments. Locally the sand was somewhat marly. Interstratified in the sand there were discontinuous layers of flat pieces of calcareous sandstones to sandy limestones, with a maximal thickness of about 30 cm.

Samples **BD 391** (below), **392** and **393** at distances of 1 m; no record with regard to the top and the base of the calcareous sands. The wash residues yielded a rich foraminiferal fauna (among which are nummulites) and many organic debris.

b) At this place we found Sands of Lede overlying Sands of Brussels (see fig. 7). Close to the contact the Sands of Brussels were very calcareous, medium-grained and of yellowish colour. Sample **BD 1255**, taken directly below the contact, probably contained elements from the overlying material. The wash residues contained many organic remains and a rich microfauna with, amongst others, nummulites. Furthermore coarse, well rounded, hyaline quartz grains were found.

Sands of Lede.

In this small exposure the contact between the Sands of Brussels and the Sands of Lede was mostly obscure. The base of the Sands of Lede was formed by coarse, mostly indurated sand, with worn fossil remains (large, flat nummulites; shark-teeth; shell fragments, etc.), coarse, hyaline quartz grains, and more or less rounded sandstone fragments of some centimetres diameter. Higher up the sand, calcareous and with nummulites, became finer-grained, slightly glauconitic and with whitish pockets with small shell fragments in yellowish sand. The glauconite content increased towards the top (green-white colours directly below the Quaternary loess). Interstratified in the sand there were some discontinuous layers of flat, sandy limestone fragments of variable thickness.

The samples **BD 1256**, **1257** and **1258**, showed a fairly rich microfauna and many other organic remains, such as echinid spines, shell fragments, *Ditrupa*, bryozoan debris, ostracods, and others.

In the collections of the Geological Institute of Utrecht a sample (**BD 444**) was encountered from the same lithologic level, labeled as « sand with *Nummulites variolarius* », and derived from locality BD-a. In the wash residues a rich microfauna. About the same components were found as in those of samples BD 1256-1258.

BE Brussels, former exposure near the prison of Saint-Gilles.

Sands of Lede.

A sample (**BE 446**) in the collections of the Geological Institute of Utrecht was labeled as « base of the Ledian ».

It consisted of calcareous sand, rich in nummulites and shell fragments. The wash residues yielded a rich microfauna and many other organic remains.

BF Jette, small exposure in a foundation pit (1.300 m N and 450 m W of the church-tower of Jette).

Visited May 1954.

Clays of Asse (probably basal layers).

Exposure, at about +65 O.D. Oostende, with glauconitic clay covered by Quaternary loess. The clay was of green-grey colour and clearly showed the glauconite grains. In the wash residues of some samples we observed some shell fragments (*Pecten*), echinid spines, ostracodal fragments, fish remains, etc.

BG Teralfene, hollow roadside (600 m N and 850 m W of the church-tower of Teralfene); also point 87 (W) 213 of the archives of the Geological Survey.

Visited May 1954.

Literature:

G. VINCENT, 1889, Ann. Soc. Malac. Belg., vol. 24, Bull., pp. 156-162.

Sandy Clays of Anderlecht.

Small exposure, at about +37 O.D. Oostende, of about 1 m height, formed by Quaternary loess that covered clayey sand with an intercalated sandstone layer.

The sand was of brown-green colour, rather rich in glauconite, medium to fine-grained. The wash residues of a sample contained fragments of nummulites, ostracods, echinid spines and some indeterminable smaller foraminifera.

The sandstone was hard, medium to fine-grained, blue-grey, with casts of molluscs (mainly pelecypods), sometimes with silicified shell remains. Thickness variable (max. 60 cm). VINCENT recorded *Nummulites planulatus* from this sandstone.

BJ Esschene, abandoned sandpit (50 m N and 800 m W of the church-tower of Esschene); also point 87 (W) 148 of the archives of the Geological Survey.

Visited May 1954.

Possibly decalcified **Sands of Lede.**

Only small parts of the old wall were still visible. Sampled at about +60 O.D. Oostende.

Sample of fine-grained, yellow-green, slightly glauconitic and micaceous sand. Some more or less decalcified and undeterminable fragments of nummulites were found.

BK Asse, hollow roadside and abandoned claypit (50 m S and 1.350 m W of the church-tower of Asse); also point 87 (W) 66 of the archives of the Geological Survey.

Visited May 1954.

Sands of Wemmel (?) and **Clays of Asse.**

In the hollow roadside, directly E of the abandoned claypit, as well as in the wall of the pit glauconitic clay was exposed. In the pit it overlay sandy deposits.

The latter sands were medium to fine-grained, slightly glauconitic, of yellowish-brown to green colour. Exposed over 80 cm, at the top with interstratification of irregularly bedded sandy clay. Microscopically we found, amongst others, some tiny shell fragments (gastropods) and bone fragments (probably fish remains).

The stratigraphic position of the sands with regard to the base of the glauconitic clay could not be established.

The wall of the old pit was formed by about 13 m of clay with a variable degree of weathering, and consequently with variable colours (grey-green to brown-green). The clay contained variable quantities of glauconite, which decreased towards the top of the exposure. The mineral was sometimes concentrated in small spots of some millimetres diameter. Near the base the clay was fairly sandy, higher upwards the sand content decreased, but there were intercalated beds of very sandy clay to clayey sand.

Seven samples were taken. They show an increasing muscovite content towards the top of the exposure. Faunal elements were lacking.

BL Asse, hollow roadside (100 m S and 1.500 m W of the church-tower of Asse).

Visited May 1954.

Sands of Lede.

Some small exposures of sands, at about +50 O.D. Oostende. The sands were calcareous, pale green, fine-grained, rich in nummulites.

The wash residues of **BL 1035** contained many organic remains (such as a rich microfauna, shell fragments, echinid remains, *Ditrupa*, bryozoan debris), and some glauconite and muscovite.

BM Asse, hollow roadside (1.600 m W of the church-tower of Asse).

Visited May 1954.

Sands of Lede.

Small exposure, at +50 O.D. Oostende, with a height of 1,50 m.

Exposed we found fine-grained, calcareous sands, at some places slightly decalcified, at others more or less indurated.

At the base of the exposure sample **BM 1036** was taken from slightly decalcified sand with nummulites. The wash residues contained a rich microfauna and many organic remains as well as scarce glauconite and muscovite.

One meter higher sample **BM 1037** was taken from calcareous sand, again with many nummulites. In the wash residues some pyrite was found in addition to components identical to those of BM 1036.

BN Hoeilaart, abandoned sandpit (100 m S and 400 m W of the church-tower of Hoeilaart).

Visited June 1954.

Sands of Brussels.

About 6 m of sands covered by 0,50 m to 2 m of Quaternary loess. The bottom part of the wall was covered by sand from higher parts of the wall.

The base of the exposure was formed by horizontal, indistinctly bedded, coarse sand of yellowish colour, followed by obliquely bedded sands (dipping NW), with some tubulations (probably worms). In this part of the wall the bedding was visible by different contents of iron-oxides, and by small flat clayey particles of some mm length. On top of 35 cm of these current-bedded sands a more regulary bedded complex was found of about 80 cm thickness and formed by yellowish, medium-grained sand with intercalated irregular laminae of clayey composition.

Higher up the sand became fine-grained and contained irregularly shaped concretions of the same material, but richer in sponge spicules, cemented by SiO_2 (« Grès fistuleux » and « Pierres de grottes »). The bedding was irregular, but in general horizontal. Some cross-bedding was observed, with increasing importance towards the top of the exposure. Some clayey bands occurred near the top.

About 100 cm below the covering loess pockets with fine-grained gravel formed a discontinuous layer of about 10 cm thickness.

A sample at the base of the sands contained mainly quartz.

BO Overijse, sandpit « Van Billoen » near Zavelborre (150 m S and 2.300 m W of the church-tower of Overijse).

Visited June 1954.

Sands of Brussels.

Wall of about 20 m height with non-calcareous (possibly decalcified) sands. The steep wall did not allow for a detailed description of the succession, but in general the section resembled that of BN.

The basal part of the section was formed by pale-grey, medium-grained sands. Higher up the sands were coloured brownish by limonite. The sand was rich in « Grès fistuleux » and « Pierres de grottes », sometimes slightly calcareous.

A sample near the base of the pit yielded, amongst others, some ill-preserved fragments of bryozoa.

BP Tourneppe, hollow roadside at Bruineput (1.000-1.200 m N and 400 m W of the church-tower of Tourneppe).

Visited June 1954.

Sands of Brussels.

In an ascending road (Tourneppe - Bruineput) the sides showed calcareous sands over a total stratigraphic height of about 15 m (+75 to +90 O.D. Oostende).

Exposed were medium to fine-grained sands of whitish colours, with green-coloured, less calcareous parts in between. In the highest parts of the section calcareous patches occurred in rusty brown, decalcified sands. The sands were at some places more or less indurated.

Four samples were taken (**BP 1164** and **1165** at about +75, **BP 1166** at +81 and **BP 1167** at +88 O.D. Oostende). The wash residues of all these samples contained many organic remains, such as fairly rich microfaunae, echinid spines, shell fragments and some bryozoan debris.

BQ Forest, excavation at the Rue Beukenberg (small pit near newly-built houses). See fig. 7.

Visited June 1954.

Sands of Brussels.

A poor exposure, of about 1 m height, of very calcareous, white sands, irregularly bedded, medium-grained, covered by less calcareous, fine-grained, green-grey sands.

Sample **BQ 1168**, from the base of the exposure, yielded wash residues with a rich microfauna and many organic remains, especially shell fragments and echinid remains.

BR Brussels, station-junction of Leopoldswijk, tunnel-construction under the Rue Belliard; also point 88 (W) 637 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

Exposure at the eastern side of the works, at about +56 O.D. Oostende.

Exposed we found greenish, slightly calcareous sands. Some 2 m below the level of the street there were intercalated fine-grained, yellowish-white, occasionally indurated sands, rich in quartz and with some shell fragments.

Sample **BR 1169** was taken from these intercalated sands. The wash residues yielded some foraminifera, ostracods and other organic remains, such as echinid spines, bryozoan debris and sponge spicules. Some muscovite was present.

BS **Jette,** hollow roadside of the Rue du Marathon near the Stadium of Heizel (about 100 m S of the Stadium).

Visited September 1954.

Sands of Wemmel.

Exposure, of about 0,50 m height, of yellowish-green, fossiliferous and medium-grained sands, rich in shell fragments (amongst others, *Pecten corneus*, *Ostrea*), nummulites, *Ditrupa*-tubes, bryozoan debris and coral remains.

Two samples, **BS 1259** and **1260**, yielded wash residues with rich microfaunae and many other organic remains [amongst others, fish remains (otolithes), radiolarians, echinid spines].

BT **Jette,** excavation for the construction of a drainage system (1.450 m N and 700 m W of the church-tower of Jette).

Visited July 1956.

Sands of Wemmel and **Clays of Asse.**

A sample, **BT 1266**, from heaps of sand from a ditch dug out in fossiliferous sands, fine-grained and yellowish-green. The wash residues contained a small microfauna in association with other organic remains as shell fragments, bryozoan debris, echinid spines, *Ditrupa*.

Another sample from grey-green glauconitic clay, with some rare shell fragments contained no foraminifera.

BV **Strombeek-Bever,** excavation for tunnel-construction at the Meyselaan near Heizel, at « De dikke Linde »; also point 88 (W) 1402 of the archives of the Geological Survey.

Visited September 1956.

Sands of Wemmel.

Excavation, of about 7 m height, with homogeneous, green to yellow, medium-grained sands. The sands were fossiliferous in the lower part and passed higher up into a brownish-green, decalcified, slightly clayey sand.

The sands of the lower part were very rich in shell fragments (amongst others, *Pecten corneus*, *Ostrea wemmelensis*, *Nuculella nysti*, *Nemocardium*, *Aloides*, *Tellina rostralina*, *Nucula lunulata*, *Cardita*, *Turritella*, *Solarium*), nummulites and other foraminifera. The fossils were concentrated in indistinct layers or lenses of 20 to 30 cm thickness. Also glauconite, muscovite and, sometimes, some pyrite were found.

Four samples (**BV 1269-1272**) were taken from the fossiliferous lower sands :

BV 1269, about 7 m under streetlevel; **BV 1270** about 4 m higher; **BV 1271** about 4,50 m below streetlevel and **BV 1272** from material, rich in shell fragments, washed together by the rain.

The wash residues of all these samples yielded fairly rich microfaunae associated with many other organic debris, such as shell fragments, bryozoan debris, echinid spines, etc.

BW **Wemmel,** excavation near the crossing of the Avenue Limburg Stirum and the Chaussée Romaine.

Visited October 1956 by Dr. D.A.J. Batjes.

Clays of Asse.

During the construction of a new road W of the mentioned crossing, Clays of Asse were found exposed with very glauconite-rich basal layers, rich in nummulites.

Sample **BW 1273** [=sample 29362 of the Paleontological Department of the Geological Survey of the Netherlands (Haarlem)], taken from these basal beds, yielded wash residues with much glauconite and a rich microfauna associated with other organic remains.

SHEET BRUGGE

BRA Aalter, railwaycut at the station (1.000 m N and 100 m W of the church-tower of Aalter); also point 39 (W) 157 of the archives of the Geological Survey.

Visited September 1953.

Literature :

E. DELVAUX, 1886, Ann. Soc. Malac. Belg., vol. 21, pp. 275-276.

Sands of Aalter.

Along the northern side of the cut, at about +15 O.D. Oostende, large, slightly decalcified patches with many shells were present in completely decalcified, slightly glauconitic sands.

The exposure was of some 50 m length and of about 1,50 m height.

Some samples were taken from one of the mentioned patches, which was 60 cm broad, 80 cm high, and covered by 70 cm of decalcified sand and Quaternary coverings. The wash residues contained many shell fragments (amongst others, *Venericardia planicosta*, *Turritella solanderi*) in addition to bryozoan debris, bone fragments (probably fish remains), etc.

BRB Oedelem, claypit of the « N. V. Steenbakkerijen van Oedelem » (400 m E of the church-tower of Oedelem); also point 38 (E) 42 of the archives of the Geological Survey. See fig. 6.

Visited September 1953 and May 1954.

Clays of Asse.

The base of the section was formed by very glauconitic, silty clay (glauconite often as rather coarse grains). The clay was slightly micaceous and contained some pyrite, and some coarse, hyaline, well-rounded quartz grains. In connection with a slight diminishing of the glauconite contents the colour of the clay changed from blue-green at the base to blue-grey towards the top of this glauconitic part of the section. The basal part was rich in shell fragments (amongst others, *Pecten corneus*); upwards the number of which decreased to a complete absence in the highest part of the glauconitic clay.

Above this glauconitic clay a sharp decrease of the glauconite content marked the beginning of plastic clay, in the lower part of which some silty beds were still present. Near the base some glauconite occurred, but higher on this mineral was absent. Much pyrite and some gypsum were found.

About 4,50 m to 5 m below the grass (in the north-eastern part of the pit) a distinct, rusty-brown band was visible. Above it the clay was oxidized, and of yellowish-brown colours. From some non-oxidized patches the two uppermost samples were taken. In the upper one some muscovite was found.

The top of the section was formed by 0,50-1 m of Quaternary sand with cryoturbation phenomena and some gravel at the base.

All samples were taken in the eastern part of the pit; **BRB 237**, **238**, **241**, **247** and **1054** in the north-eastern corner, **BRB 1055-1057** in the south-eastern part.

The samples **BRB 237**, **238**, **247**, **1054-1057**, from the lower, glauconitic part of the wall, yielded wash residues with rich microfaunae (with nummulites in samples **247**, **1054-1057**), associated with bryozoan debris, shell fragments, fish remains (as otolithes and bone fragments), radiolarians, echinid spines, calcareous worms, sponge spicules, etc.

A sample, **BRB 241**, from one of the silty bands in the plastic clay, was found to contain a small microfauna.

BRC Aalter, hollow roadside (800 m N and 550 m E of the church-tower of Aalter).

Visited May 1954.

Sands of Aalter.

A poor exposure, at about +16 O.D. Oostende, near the bridge that crosses the railroad of Gent to Brugge, east of the station of Aalter.

The exposed sands were of yellowish-green colour, medium-grained, with some glauconite, slightly clayey and rich in shell fragments (many *Turritella*) that were often worn and showed traces of the holes of boring animals.

The wash residues of a sample yielded, amongst others, some bryozoan remains and muscovite.

BRG Beernem, small sandpit (3.400 m S and 1.600 m W of the church-tower of Beernem).

Visited May 1954.

Sands of Vlierzele.

A wall with about 70 cm of ferruginous sands with an intercalated discontinuous sandstone layer (up to 10 cm), formed by thin (maximally 1 cm) laminae that were also more or less discontinuous.

The sand was of brownish-green colour with many rusty-brown horizontal stripes; with small, flat clay-lenses. At the base of the exposure some cross-bedding was apparent.

The sands were covered by 60 cm of Quaternary loess with a silex-rich base.

SHEET CHARLEROI

CA Heppignies, sandpit of the « Société de Mont-Saint-Guibert » (1.300 m S and 400 m W of the church-tower of Heppignies); also point 142 (E) 146 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

Quaternary loess covered some 6 to 7 m of Sands of Brussels.

The sand was mostly yellowish-brown, and it contained a number of dispersed sandstone concretions (partly «Grès fistuleux»). The sand was rather coarse and with black grains, probably of Mn-oxide. Some dispersed rusty brown bands occurred.

CB Manage, abandoned sandpit north of « Les Mourettes » (900 m S and 1.100 m E of the church-tower of Manage); also point 141 (E) 208 of the archives of the Geological Survey.

Visited July 1954.

Probably **Sands of Mons-en-Pévèle.**

A poor exposure of fine-grained, yellowish-green sand, slightly glauconitic and with some nummulites.

The wash residues of a sample yielded, amongst others, shell fragments, a few nummulites (but there was no microfauna) and muscovite.

F. Halet (1920, archives of the Geol. Survey) recorded *Nummulites planulatus* from this locality.

CC Carnières, outcrop in the western side of a railroadcut (1.500 m S and 1.300 m E of the church-tower of Carnières); also point 152 (E) 107 of the archives of the Geological Survey.

Visited July 1954.

Probably **Morlanwelz member** contaminated with **Sands of Brussels.**

Again a poor exposure of contaminated, grey-green, silty clay or clayey silt.

Sample **CC 1197** contained, amongst others, organic remains, such as sponge spicules, echinid spines, shell fragments and a small microfauna.

The archives of the Geol. Survey recorded overlying fossiliferous Sands of Brussels, with silex gravel at the base. Perhaps our sample was contaminated with material from this overlying fossiliferous sand.

CD Carnières, exposure in railroadcut (900 m S and 400 m E of the church-tower of Carnières).

Visited July 1954.

Probably **Morlanwelz member.**

We took a sample of pale grey, silty clay. The wash residues contained rare glauconite and muscovite, in association with some organic remains as sponge spicules, echinid spines and ill-preserved foraminifera (indeterminable; partly nummulites).

CE Carnières, exposure in the northern side of the hollow road near the « Tranchée de Beauregard » (1.200 m E and 100 m N of the church-tower of Carnières); also point 152 (E) 265 of the archives of the Geological Survey.

Visited July 1954.

Possibly **Clays of Ieper.**

A sample from indurated, brown-green clay with some glauconite, muscovite, sponge spicules, lignite fragments, etc.

CF Leval-Trahegnies, exposure in northern side of a hollow road (700 m S and 300 m E of the church-tower of Leval-Trahegnies); also points 152 (E) 21 and 254 of the archives of the Geological Survey.

Visited July 1954.

Sands of Mons-en-Pévèle or Clays of Ieper (of the facies of the **Morlanwelz member**).

A poor exposure, at about +155 O.D. Oostende, of grey-green, slightly silty clay with flat, indurated parts of the same material («argilite»), which may be somewhat more sandy.

The wash residues of a sample contained, amongst others, glauconite, rare muscovite, some sponge spicules and lignite.

CI Leval-Trahegnies, excavation in a road (800 m S and 450 m E of the church-tower of Leval-Trahegnies); also point 152 (E) 20 of the archives of the Geological Survey.

Visited May 1953.

Probably Sands of Mons-en-Pévèle (of the facies of the **Morlanwelz member**).

An exposure, at about +165 O.D. Oostende, of yellowish-brown sandy clay, with some green, probably unweathered, patches.

Sample **CI 41**, taken from such a green patch, was slightly glauconitic and micaceous. The wash residues contained some foraminifera, in addition to sponge spicules, etc.

CL Carnières, sandpit « Dufonteny Frères » at « Saint-Eloy » (75 m N and 850 m W of the church-tower of Carnières); also point 152 (E) 283 of the archives of the Geological Survey. See fig. 6.

Visited May 1953.

Clays of Ieper (of the facies of the **Morlanwelz member**).

At the base of the section Sands of Grandglise were found, which were overlain by Sands of Erquelinnes. The latter were whitish coloured, at some places with rusty-brown spots. Some thin clayey beds were intercalated. No bedding planes were visible, except for the uppermost part, where they were distinctly horizontal.

The contact with the overlying Clays of Ieper was sharp and horizontal.

The basal part of the clays was formed by distinctly bedded, brown-green clay with thin sandy layers in betwee.n The clay was slightly glauconitic. The wash residues of a sample from this basal part contained some indeterminable fragments of foraminifera.

Higher upward the intercalated, sandy beds thickened and the clay was getting somewhat more sandy and glauconitic (the glauconite was more or less transformed in limonite).

This complex was covered by greenish, plastic clay which again passed into a sandy clay, more or less micaceous, and locally indurated, probably by siliceous cement («argilite»).

Covered by 1,50 m of Quaternary loess.

CM La Hestre, abandoned sandpit (750 m N and 150 m W of the church-tower of La Hestre).

Visited May 1953.

Sands of Brussels.

Small exposure (about 150 cm high) of green, medium-grained sand.

The wash-residues of a sample, **CM 51**, contained, amongst others, some foraminifera (partly indeterminable and incrustated with calcite).

CN+CO Godarville, canal-cut (see fig. 8 and 13).

Literature :

R. LEGRAND and R. TAVERNIER, 1948, Bull. Soc. belge Géol., vol. 57, pp. 249-276.

Between Godarville and Seneffe an elongated hill forms the watershed between the hydrographic basins of the Scheldt and the Meuse. Formerly the Canal of Brussels to Charleroi passed this hill through two tunnels. Nowadays this part of the canal is modernized and excavated.

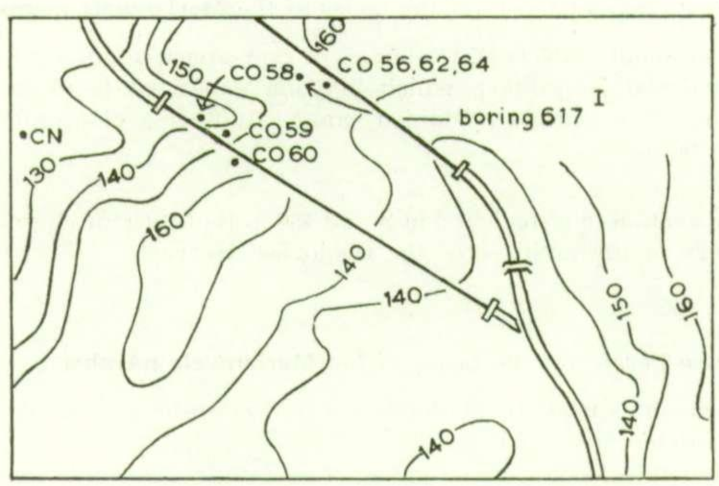


FIG. 8. — Location of the CN and CO samples, Godarville.
Scale : 1 : 40.000.

During our visit (May 1953) nearly complete series of Clays of Ieper, Sands of Mons-en-Pévèle and Sands of Brussels were exposed. However, it appeared impossible to sample a continuous stratigraphic section only remote parts of the canal sides being exposed, and often more or less covered by debris.

A number of reports of borings for the Geological Survey made during the first exploration (archives of the Geol. Survey) enabled us to make a fairly exact correlation between our own survey and the bore data.

One representative boring (no. 617-I) is figured with the supposed position of our samples.

CN Godarville, canal-cut east of the bridge near Long-Sart (1.250 m N and 900 m W of the church-tower of Godarville); also point 141 (E) 289 of the archives of the Geological Survey. See fig. 13.

Visited May 1953.

Clays of Ieper.

Some samples were taken in the walls of a new part of the canal.

Just above the camp-shot of the wall, at about +118 O.D. Oostende, a dark-grey, sandy clay was exposed. Higher up this clay was darker, locally even black; and 4 m above the camp-shot the clay passed rather abruptly into a slightly sandy, brownish clay. The contact was variable in position, and marked the boundary between two clay-complexes with a different degree of weathering. Above the contact the clay was indistinctly bedded.

Sample **CN 52**, taken at the height of the camp-shot, was rich in pyrite (possibly pyritised lignite). In the wash residues it contained some foraminifera, sponge spicules, muscovite, glauconite, etc.

Sample **CN 53**, directly below the contact with the brownish clay, contained less pyrite and more glauconite. Some foraminifera and radiolarians were encountered.

Sample **CN 54** contained some foraminifera (more or less covered by secondary $CACO_3$) and some bone fragments (probably fish remains). This sample is in the basal part of the brownish clay.

A sample taken somewhat higher contained the same components as the three others, but no foraminifera.

CO Godarville, construction of the canal-parts above the tunnels under the « Bois de Bomerée »; also points 141 (E) 292,299 of the archives of the Geological Survey. See fig. 13.

Visited May 1953.

Clays of Ieper and **Sands of Mons-en-Pévèle.**

On top of the clayey beds of the CN-series followed a complex of alternating clayey sands and sandy clays, with a thickness of about 10 m. Grey colours dominated; the sands were fine-grained.

The series continued with a sandy complex, clayey at the base, but with decreasing clay content towards the top. The base was formed by dark greenish, fine-grained, glauconitic, sandy clay with intercalated grey clay lenses of small dimensions (some centimetres). Higher up the colour became grey-green, and bedding was distinct. The sand was medium to fine-grained.

The samples (**CO 58** from the clayey base; **CO 59** near the transition to overlying sands) were rich in organic remains (foraminifera, such as fragments of nummulites; shell remains; bryozoan debris; sponge spicules; echinid spines; fish remains).

Above the level of CO 59 about 8,50 m of quartz sand was found. On top of this sand there were again clayey layers in the sand.

Sample **CO 60** was taken at the base of this clay and sand complex from a very clayey, fine-grained, brownish-green sand.

The complex, with a thickness of about 8 m, ended near the top with some layers of grey sandy clay, rich in foraminifera.

From one of these layers sample **CO 62** was taken; in the wash residues ostracodal fragments, sponge spicules, echinid spines, radiolarians, etc.

Sands of Brussels.

Sands of Brussels were found overlying the described complex of mainly sandy clays.

At the base well rounded pebbles (quartz, sandstone) were interbedded in coarse, greenish sands with shell fragments. Upwards rather coarse, greenish-brown sand was found, with shell fragments and nummulites. In this sand, about 2,50 m above the base, occurred some dispersed lenses of gravel, sometimes with bone fragments.

Sample **CO 56** was taken from the basal part with pebbles. The wash residues contained some foraminifera, shell fragments, sponge spicules, echinid spines, etc.

Sample **CO 64**, about 2 m above the base, yielded wash residues with many shell fragments (mainly *Ostrea*) and nummulites, a rather rich microfauna and bryozoan debris.

During a visit to the same constructional works in May 1954 Prof. dr. G. H. R. von KOENIGSWALD took two samples:

Sample **CO 1240** from fossiliferous Sands of Brussels. The wash residues yielded many shell fragments (*Ostrea*, *Solarium*, etc.), rich microfauna, echinid spines, bryozoan debris, sponge spicules, radiolarians, etc.

Sample **CO 1241** from a fossiliferous sandy clay from the Sands of Mons-en-Pévèle, possibly at the level of CO 62. Wash residues with a rich microfauna in addition to shell fragments, bryozoan debris, fish remains, radiolarians, echinid spines, sponge spicules, etc. Also nummulites were found.

SHEET TOURNAI

DA Havinnes, claypit of the « Nouvelles Tuileries de Havinnes, S. A. » (2.250 m E of the church-tower of Havinnes); also point 125 (W) 484 of the archives of the Geological Survey. See fig. 6.

Visited September 1953.

Literature :

J. BAUDET, 1939, Bull. Soc. belge Géol., vol. 49, pp. 307-308.

Sands of Grandglise and **Clays of Ieper.**

The base of the section was formed by more or less glauconitic, grey, clayey sand, pyritiferous (pyrite derived from the Clays of Ieper). Less glauconite was found in the upper part of the Sands of Grandglise.

The wash residues of some samples yielded, amongst others, sponge spicules and bone fragments (probably fish remains).

The base of the overlying clay contained dispersed, irregular pyritiferous concretions of black colour with a yellowish exterior; as well as some small, well rounded silex fragments of black colour. The silty clay furthermore contained sand of variable grain-size, and patches and discontinuous layers of plastic clay. This basal layer was about 30 cm thick.

Upwards the clay remained silty, with small sand-spots or strings. The samples yielded no microfauna; some bone fragments (probably fish remains) were found.

Some 2,50 m above the base the clay became lignitic. Some of the lignite occurred in bands with narrow, yellow, pyritiferous zones alongside them. At this level the clay was plastic with occasional small sand-patches; also gypsum was found.

Sample **DA 311** was taken at the base of this non-silty clay. The wash residues contained some foraminifera. .

Sample **DA 314** appeared to contain gypsum, pyrite, some foraminifera, etc.

On approaching this level the clay appeared to be oxidized and of brown-yellow colour.

DC Saint-Maur, claypit of the « Briqueterie de Wissempierre » (300 m S and 300 m W of the church-tower of St. Maur, municipality Ere); also point 124 (E) 402 of the archives of the Geological Survey.

Visited September 1953.

Clays of Ieper.

About 5,50 m of slightly silty, grey clay with scarce shell fragments. Five m below the surface there was a 10 cm bed of claystone.

The wash residues of the samples contained lignite, glauconite, muscovite, but no foraminifera.

DD Mouscron, railroadcut (2.000 m S and 900 m W of the church-tower of Mouscron); also point 119 (W) 112 of the archives of the Geological Survey.

Visited May 1954.

Perhaps **Sands of Mons-en-Pévèle.**

A poor exposure of clayey, rather coarse-grained, brownish-yellow to green sand. Contaminated samples without microfauna.

DE Maulde, hollow roadside in the « Bois des Houpes » (750 m N and 1.100 m W of the church-tower of Maulde); also point 125 (E) 120 of the archives of the Geological Survey.

Visited July 1954.

Sands of Mons-en-Pévèle.

The entrance of an old fox-hole showed a whitish-green bank of about 15 cm, with many nummulites and shell fragments (*Ostrea*), in grey-green, fine-grained, more or less glauconitic sand.

Sample **DE 1204**, from this band, yielded wash residues with a rich microfauna with many nummulites, also many shell fragments, echinid spines, bone fragments, sponge spicules and radiolarians.

DF Mont-Saint-Aubert, hollow roadside (350 m S and 400 m E of the church-tower of Mont-Saint-Aubert); also point 112 (W) 17 of the archives of the Geological Survey.

Visited July 1954.

Literature :

M. MOURLON, 1885, Ann. Soc. Géol. Belg., vol. 19, pp. 148-149.

Sands of Mons-en-Pévèle.

A small exposure, at about +90 O.D. Oostende, 1,50 m high.

The lower part of the exposure was formed by grey-green, very fine-grained micaceous sands, slightly glauconitic. Upwards the sands became brownish-green and clayey, up to a silty clay.

Sample **DF 1205**, taken from the basal part, yielded some foraminifera, sponge spicules and bone fragments.

Sample **DF 1206**, 1,30 m higher, from the brownish-green, clayey sand, contained some scarce foraminifera.

DG Mont-Saint-Aubert, hollow roadside (150 m S and 1.350 m E of the church-tower of Mont-Saint-Aubert); also point 112 (W) 155 of the archives of the Geological Survey.

Visited July 1954.

Possibly a clayey part of the **Sands of Mons-en-Pévèle.**

A poor exposure of green-grey, micaceous and silty clay, weathered and loamy.

The wash residues of a sample showed limonite, glauconite, muscovite, but no microfauna.

DH Mont-Saint-Aubert, hollow roadside (about 550 m N and 500 m E of the church-tower of Mont-Saint-Aubert); also points 112 (W) 71 and 111 (E) 528,529 of the archives of the Geological Survey. See fig. 6.

Visited July 1954.

The lower part of the exposure evidently belonged to the **Sands of Mons-en-Pévèle**. The boundary with the **Clays of Roncq** must be somewhere in the covered part of the section.

In the western side of the road, on the northern slope of the mont Saint-Aubert, clayey sands were exposed in the lower part of the exposure. These sands were fine-grained, brownish, and perhaps more or less contaminated with overlying Quaternary loess.

In the lowest part of the section no nummulites were observed, but higher up they were locally abundant, usually concentrated in small lenses and thin layers.

Upwards the clay content decreased; mostly the clay was restricted to thin bands. The colour changed to green-grey. These more or less micaceous sands were, in general, richer in nummulites than the underlying sediments. Also shell fragments occurred in this higher part.

Above these sands a part of the section was covered by Quaternary loess, after which followed greenish-brown sandy clay with some glauconite. In the upper part a lens (of about 10 cm thickness and 70 cm length) of indurated sandy clay, rich in fossil casts (mainly *Turritella solanderi*).

In the lower part of the section the samples **DH 1208-1210** were taken, all with a rather rich microfauna together with shell fragments (rare in 1208, increasing amount higher up), *Ditrupa*-fragments (possibly *D. plana*), remains of calcareous algae, echinid spines, bone fragments, sponge spicules and radiolarians.

The samples **DH 1211** and **1212** from the overlying sands yielded wash residues with rich microfaunae (with nummulites), associated with shell fragments, echinid spines, *Ditrupa*-fragments, etc. Furthermore sandstone fragments and rather much glauconite.

DH 1213 from the uppermost part contained a small microfauna and some echinid remains, etc.

A sample of the sandy claystone contained some foraminifera but too incrustated with calcite for a specific determination.

DK Mont-Saint-Aubert, hollow roadside (50 m N and 150 m W of the church-tower of Mont-Saint-Aubert); also points 111 (E) 523 and 543 of the archives of the Geological Survey.

Visited July 1954.

Possibly **Sands of Vlierzele.**

A poor exposure of yellowish-green sands, fine-grained, with glauconite and muscovite, and with flattened, siliceous sandstone pieces with the same lithological features.

The samples, without microfauna, contained some sponge spicules and radiolarians.

DL Ellignies-lez-Frasnes, hollow roadside (400 m N and 150 m E of the church-tower of Ellignies-lez-Frasnes); also point 112 (E) 150 of the archives of the Geological Survey.

Visited July 1954.

Sands of Mons-en-Pévèle.

The sides of the road yielded some scattered sandstone pieces with nummulites; at some places these were probably in situ and surrounded by clayey, yellowish-brown sand, which was fine-grained, calcareous and mostly weathered. Unweathered, greyish-green colours dominated.

Sample **DL 1218** contained a small microfauna in addition to many nummulites, some shell fragments, *Ditrupa*-tubes (possibly *D. plana*), echinid spines, sponge spicules, bone fragments and radiolarians.

DM Saint-Sauveur, hollow roadside (1.850 m S and 800 m W of the church-tower of Saint-Sauveur).

Visited July 1954.

Probably **Sands of Mons-en-Pévèle** (either clayey intercalation in the sands, or clayey equivalent of the sand, thus resembling the Clays of Roubaix).

A poor exposure of silty, greyish-green clay, with some glauconite.

The wash residues of a sample were without foraminifera.

DN Saint-Sauveur, hollow roadside (1.900 m S and 700 m W of the church-tower of Saint-Sauveur); also point 112 (E) 188 of the archives of the Geological Survey.

Visited July 1954.

Possibly **Sands of Mons-en-Pévèle.**

A poor exposure of fine-grained, greyish-green sand, slightly glauconitic and micaceous.

The wash residues of a taken sample contained some echinid spines and sponge spicules.

DO Saint-Sauveur, hollow roadside (1.900 m S and 600 m W of the church-tower of Saint-Sauveur); also point 112 (E) 226 of the archives of the Geological Survey.

Visited July 1954.

Possibly **Sandy Clays of Anderlecht.**

Small exposure of pale grey-green clay with some small sandstone pieces with fossil casts [DELVAUX, 1881, (archives of the Geol. Survey) reported *Nucula*]. The clay was slightly sandy and the wash residues of a sample contained some silex fragments and sponge spicules, but no foraminifera.

DP Saint-Sauveur, hollow roadside (2.050 m S and 350 m W of the church-tower of Saint-Sauveur); also point 112 (E) 227 of the archives of the Geological Survey.

Visited July 1954.

Perhaps **Sandy Clays of Anderlecht.**

A poor exposure of clayey sand with interbedded sandstone. Both were of grey-green colour, fine-grained, with quartz and glauconite.

The wash residues of a sample contained coarse silex fragments, lignite, etc.

DQ Saint-Sauveur, small excavation (1.150 m S and 450 m E of the church-tower of Saint-Sauveur); also point 112 (E) 246 of the archives of the Geological Survey.

Visited July 1954.

Sandy Clays of Anderlecht.

Exposure of silty, green-grey clay with intercalated sandstones of greyish-brown colour, with fossil casts (reported as *Nucula parisiensis* in the archives of the Geol. Survey).

The wash residues of a sample, with glauconite and much limonite, contained no foraminifera.

DR Saint-Sauveur, hollow roadside (1.350 m S and 600 m E of the church-tower of Saint-Sauveur); also point 112 (E) 248 of the archives of the Geological Survey.

Visited July 1954.

Sands of Vlierzele.

Sample of greenish-grey, clayey, glauconitic sand, with clayey patches and intercalated flat sandstone pieces with fossil casts.

Wash residues with sponge spicules, muscovite, silex fragments, etc.

SHEET GEERAARDSBERGEN

GA Roozebeeke, small excavation (300 m N and 700 m W of the church-tower of Roozebeeke); also point 85 (W) 540 of the archives of the Geological Survey.

Visited May 1954.

Probably **Sands of Lede.**

A poor exposure, at the bifurcation of the roads from Munkzwalm to Roozebeke and to Elst, with yellowish-brown, slightly clayey sand, that was fine-grained, with glauconite.

The sample contained no microfauna. Bone fragments, muscovite and much limonite were present.

GB Grootenberge, hollow roadside (50 m S and 1.350 m E of the church-tower of Grootenberge); also points 85 (W) 282 and 283 of the archives of the Geological Survey.

Visited May 1954.

Clays of Asse.

Exposure, at about +90 O.D. Oostende, of pale greyish-green, slightly silty clay. Present as unweathered patches in brownish, silty clay.

Sample **GB 1109** yielded wash residues with some foraminifera and ostracods.

GC Erwetegem, sandpit (1.100 m S of the church-tower of Erwetegem); also point 84 (E) 427 of the archives of the Geological Survey.

Visited June 1954.

Possibly decalcified **Sands of Lede.**

Under about 1 m of Quaternary loess, with an irregular base, some 3 m of sand were exposed. The sand was fine-grained and slightly clayey in the upper 2 m.

A sample from the basal part contained some shell fragments associated with limonite, pyrite and muscovite.

GD Erwetegem, sandpit (1.300 m S of the church-tower of Erwetegem); also point 85 (E) 426 of the archives of the Geological Survey.

Visited June 1954.

Probably **Sands of Lede.**

About 1 to 1,50 m was exposed. The sand was medium to fine-grained, green, with mica and glauconite, also some dispersed silex pebbles and clay lumps.

A sample yielded silex fragments, muscovite,pyrite, etc.

GE Ellezelles, railroadcut of the station (1.300 m N and 100 m W of the church-tower of Ellezelles); also point 99 (W) 7 of the archives of the Geological Survey.

Visited July 1954.

Clays of Roncq.

Exposure of greyish-brown to yellow, brittle clay with whitish, sandy spots (of some millimetres diameter), mainly consisting of hyaline quartz grains.

A sample contained some indeterminable foraminifera in addition to calcareous fragments, pyrite, etc.

GF Ellezelles, hollow roadside (1.250 m N and 850 m E of the church-tower of Ellezelles); also point 99 (W) 221 of the archives of the Geological Survey.

Visited July 1954.

Probably **Sandy Clays of Anderlecht.**

A poor exposure of yellowish-grey, sandy clay, with irregular, brownish bands, rich in limonite. A sample gave wash residues with some sponge spicules, etc.

GG Ellezelles, railroadcut (1.300 m N and 200 m E of the church-tower of Ellezelles); also point 99 (W) 37 of the archives of the Geological Survey.

Visited July 1954.

Possibly **Sands of Vlierzele.**

Alongside the railway some scattered sandstone pieces were found, mostly with a whitish and weathered surface, but unweathered of grey-green colour. Locally there were some ill-preserved fossil casts.

Some poor exposures of sand were found as well.

A sample yielded some sponge spicules, muscovite, glauconite, etc.

Possibly, pale-brown glauconitic clay was present under the sand.

GH Geeraardsbergen, abandoned sandpit (150 m N and 700 m E of the church-tower of Geeraardsbergen); also point 100 (W) 10 of the archives of the Geological Survey.

Visited July 1954.

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

The ancient wall of the pit was almost completely overgrown and covered by debris. Some small exposures were found, such as:

3,50 m below the top: yellowish-grey, sandy and glauconitic clay with irregular brownish bands, rich in limonite;

1,10 m below the top: grey-green, glauconitic, medium-grained sand, equally rich in limonite.

Samples, taken from both exposures, yielded no foraminifera; the highest exposure yielded some sponge spicules and muscovite.

SHEET KORTRIJK

KA Luingne, claypit of the « Briqueteries Modernes » (950 m E of the church-tower of Luingne); also point 97 (W) 201 of the archives of the Geological Survey. See fig. 6.

Visited September 1953 and May 1954.

Clays of Roubaix.

Wall of silty, brownish-grey, with more intense brown colours upwards (more oxidized). The lower part contained some shell fragments and other calcareous remains; upwards quantities decreased.

Four foraminiferous samples (**KA 1092, 305, 1093, 306**). The wash residues yielded shell fragments, remains of calcareous algae, ostracods, echinid spines, sponge spicules, fish remains, radiolarians, bryozoan debris, muscovite and glauconite.

All the samples, except for KA 306, contained some nummulites.

KB Orroir, sandpit (1.250 m N and 500 m E of the church-tower of Orroir); also points 98 (W) 24 and 772 of the archives of the Geological Survey.

Visited September 1953.

Sands of Vlierzele and possibly **Sands of Lede.**

A wall of about 4 m, with at the base medium-grained sands. These sands were micaceous and rather glauconitic (with the glauconite concentrated in thin laminae). Current-bedding frequently occurred.

Some 50 cm above the base of the pit, the sand contained thin clay seams over another 50 cm. This clay was of pale-green colour, and more or less silty. The beds were of variable thickness and sometimes discontinuous.

Upwards again medium-grained, micaceous, greenish-yellow sand was found, which showed a distinct bedding by alternating layers of different glauconite contents.

The whole complex was strongly disturbed.

About 4 m above the bottom of the pit, fine-grained, green-grey, glauconitic sand was found, possibly representing the Sands of Lede.

The whole wall showed many bands rich in limonite, sometimes indurated.

KC Amougies, sandpit (1.400 m N and 200 m E of the church-tower of Amougies); also points 98 (W) 55 and 59 of the archives of the Geological Survey.

Visited September 1953.

Possibly **Sands of Vlierzele.**

About 5 m of sand covered by Quaternary loess.

The base of the section was formed by clayey sand of brownish-yellow colour, slightly micaceous, and with some glauconite (often more or less weathered).

Upwards the clay content decreased. From about 2 m from the base of the section onwards pure sand was encountered. The grain size was fine; the colour brownish-grey with white spots.

The uppermost sands were yellowish-white, fine-grained and with many irregular rusty-brown bands and spots. The latter were rather numerous in the entire section; locally they were indurated.

Several samples, but no foraminifera.

KD Ansegem, claypit of the « Briqueterie du Borreberg » (150 m N and 50 m E of the church-tower of Ansegem); also point 84 (W) 1355 of the archives of the Geological Survey. See fig. 6.

Visited September 1953.

Sandy Clays of Anderlecht passing into **Sands of Vlierzele.**

At the base of the pit sandy, glauconitic and micaceous clay was found, of greyish-green colour with some rusty-brown spots, and rusty-brown to yellow, more sandy patches. Upwards the rusty-brown patches slightly increased in number, and also the glauconite contents of the clay increased. At about 1,50 m to 2 m above the base the colour gradually changed in olive-green, and 2,50 m from the base shell remains (mainly fossil casts) and pyrite were found.

Still higher the sandy clay passed into clayey sand, in which two whitish sandstone beds, of variable thickness (3-6 cm) were met with. They contained some fossil casts. Sometimes some gravel overlay the sandstone.

The uppermost sand was less clayey, thin-bedded and rather micaceous.

The samples contained no foraminifera.

Already GULINCK (1951, archives of the Geol. Survey) reported some indications of disturbed bedding planes, perhaps due to worm action. He found silicified wood remains at the levels of the sandstone beds.

KE Mouscron, claypit of the « Briqueterie Du Croisé » (500 m N and 650 m W of the church-tower of Mouscron).

Visited May 1954.

Clays of Roubaix.

The lower part of the 2,70 m wall showed brownish-grey, silty clay with shell fragments. Some 2 m from the top the clay got more brown and weathered.

Two samples were taken from the lower, unweathered clay. Both were rich in remains of calcareous algae, furthermore some fragments of nummulites, and shell debris. The fragments of nummulites were the only foraminiferal remains.

KF Moen, claypit of the « Briqueterie De Meester » (300 m S and 300 m W of the church-tower of Moen).

Visited May 1954.

Clays of Roubaix.

Some 8 m of silty clay to clayey sand, at the base dark-grey, higher upward paler. About 5,50 m from the top the clay became brown and oxidized. The clay was micaceous and of variable silt content.

Three samples were taken; all three had a rather small microfauna.

Sample **KF 1094**, taken at the base of the pit, from very silty clay, with bryozoan debris, shell fragments, sponge spicules, pyritised lignite particles, etc.

Sample **KF 1095**, about 7,20 m below the top, was taken from a silty clay with about the same components as 1094, but with less organic debris, though some fragments of nummulites.

Sample **KF 1096**, 6 m from the top, from very silty, pale-grey clay. The wash residues contained foraminifera (amongst others, some nummulites), some ostracods (*Cytherella* sp.), shell fragments, fish remains, echinid spines, sponge spicules, pyritised lignite, etc.

KG Moen, claypit of the « Briqueterie Moderne » (2.750 m N and 850 m W of the church-tower of Moen).

Visited May 1954.

Clays of Ieper with a gradual transition into **Sands of Mons-en-Pévèle** or **Clays of Roubaix.**

The lower part of the section was described from the southern part of the pit; the top from the northern part.

The basal part of the pit was formed by plastic clay; about 12 m below the grass. The clay was grey-green, pyritiferous, gypsiferous and slightly micaceous. Some small septaria (about 10 cm diameter) were found.

The wash residues of a sample from the base of the section yielded some shell fragments and bone remains.

Upwards the clay showed a very gradual increasing silt content. A sample from this silty clay (4,30 m above the previous one), yielded shell fragments and fish remains.

From 6 m below the top onwards the clay became more and more brownish (oxidation). The wash residues of a sample from this level yielded some sponge spicules, bone fragments, muscovite and scarce glauconite.

In the brownish clay a further increase of the silt content was found. At 4 m from the top it had changed into very clayey and very fine-grained sand.

These upper sands were sampled in the northern part of the pit, where they occurred unweathered. The wash residues were rich in glauconite and limonite, also muscovite, sponge spicules, radiolarians, etc., were found.

Whether these very clayey sands belong to the Sands of Mons-en-Pévèle or to the Clays of Roubaix is more or less uncertain.

KH Knokke, abandoned sandpit (1.600 m S and 1.750 m E of the church-tower of Zwevegem).

Visited May 1954.

Probably **Clays of Roubaix.**

The two uppermost metres of the old wall were still exposed. They showed very silty, laminated clay, with some current-bedding.

Two samples were taken; one at the base, and the other 1 m below the surface. The lower one showed fragments of *Lingula tenuis* and some fossil casts. The wash residues of both samples yielded shell fragments, bone remains, etc.

KJ Zwevegem, claypit of the « Briqueterie Ernest Dumoulin » (400 m N and 100 m W of the church-tower of Zwevegem).

Visited May 1954.

Clays of Ieper.

A wall of 3,30 m high, with the upper 1,50 m formed by Quaternary loess, and oxidized, weathered, brown, silty clay.

The lower part was formed by yellowish-grey to green clay, more or less silty near the contact with the weathered clay and a decreasing silt content lower down.

Two samples, one near the base of the exposure (3,10 m below the top), the other under the contact with the oxidized clay (1,70 m from the top) yielded wash residues with some glauconite and muscovite, etc.

KK Tiegem, sandpit (700 m N and 1.400 m W of the church-tower of Tiegem).

Visited May 1954.

Sands of Vlierzele.

Exposure of about 6 m, the lower 5,50 m formed by more or less glauconitic sands, covered by 0,50 m of Quaternary loess.

At the base of the section we observed medium-grained, brownish-yellow sand, with glauconite and muscovite. The quartz grains of this sand were mainly angular.

No bedding was visible in the lower part, upwards it was more apparent by laminations caused by variable glauconite content and by intercalated thin clayey beds.

Upwards the sand became coarser and greener (less limonite), also pyrite was found. In these upper 3,80 m the sands were distinctly cross-bedded (faintly at the base, more distinctly so higher up), with the dominant direction of the bedding planes towards the NE to E.

None of the taken samples yielded a microfauna.

KL Russeignies, sandpit (1.550 m N and 500 m E of the church-tower of Russeignies).

Visited July 1954.

Probably **Sands of Vlierzele.**

Under 30 cm of Quaternary loess with some scattered pebbles (mainly silex) at the base, 4,70 m of sand were exposed, with an intercalated clay lens of maximally 90 cm thickness.

The base of the exposure was formed by fine-grained, yellowish-brown to green sand, with mica and glauconite. Higher up it showed some clay lumps scattered at random. The upper part of this lower sand contained many rusty-brown bands.

At the top of the sand (1,70 m to 2,50 m from the base) there was a layer of pale-grey to green clay. This clay had an oblique base, with in the southern part of the pit the base 80 cm lower than it was in the northern part, with a distance between both points of about 50 m. The clay contained some greener, sandy parts and many brown, limonitic spots and irregular bands.

Overlying the clay (thickness of 10-90 cm) again sand was found. In the sand dispersed, discontinuous limonitic, brown claybeds of some cm thickness occurred. At its base this sand began with 15 cm of clayey sand of green-brown colour. Upwards it contained more glauconite, and less clay.

Probably we were dealing with the Sands of Vlierzele, which in this region contains clayey lenses at the transition towards the underlying, locally more sandy, Sandy Clays of Anderlecht.

KM Kwaremont, abandoned sandpit (1.150 m S and 950 m E of the church-tower of Kwaremont).

Visited July 1954.

Probably **Sands of Lede.**

The top of this old sandpit was formed by 30 cm of Quaternary loess, that covered 3,50 m of sand with many current-bedding features and some intercalated claybeds.

The current-bedding in the sand always had a southern direction with a maximal dip of 24°. The layers with the current-bedded laminae were rather variable in thickness, up to 55 cm.

The sands were often more or less salmon-coloured, with the bedding mostly visible by colour variations caused by variations of the glauconite or limonite contents. Perhaps there was also less conspicuous variation in the grainsize of the various layers.

Flat, clayey particles of some mm length occurred dispersed in the sand. Furthermore three claybeds, mostly brown, with a maximal thickness of 5 cm were horizontally intercalated. The lower 25 cm, and the upper 50 cm of sand were without current-bedding.

Some samples yielded wash residues with rather angular quartz grains in addition to muscovite, limonite, glauconite, sponge spicules, etc.

KO Kwaremont, hollow roadside (650 m S and 200 m E of the church-tower of Kwaremont); also point 98(E) 36 of the archives of the Geological Survey.

Visited July 1954.

Literature :

M. LERICHE, 1940, Bull. Soc. belge Géol., vol. 50, pp. 214-216.

Perhaps **Sands of Lede.**

A poor exposure, at the base with some 10 cm of green, sandy clay, locally enriched in lime (whitish parts of the clay). On top 3 m of salmon to green sand with current-bedding was found. This sand was fine-grained, with much limonite and glauconite.

A sample, from the basal clay, yielded sponge spicules, muscovite, etc., but no foraminifera.

KP Ruien, hollow roadside (1.250 m S and 150 m E of the church-tower of Ruien); also point 98 (W) 162 of the archives of the Geological Survey.

Visited July 1954.

Possibly belonging to the upper part of the **Sandy Clays of Anderlecht**, close to the transition into the Sands of Vlierzele.

In the roadside was exposed dark-green clayey sand, rich in glauconite. Downwards it passed into a sandy clay.

SHEET LEUVEN

LAA Bertem, hollow roadside (1.700 m N and 2.350 m E of the church-tower of Bertem); also point 89 (E) 28 of the archives of the Geological Survey.

Visited June 1954.

Probably **Sands of Brussels** or Sands of Lede (the poor fauna indicated either the Sands of Brussels or those of Lede).

A poor exposure, at about +47 O.D. Oostende, of more or less calcareous, fine-grained sands.

Sample **LAA 1127** was taken from a calcareous part in whitish, glauconitic sand, with some shell fragments (mainly *Ostrea*). The wash residues contained a poor microfauna and many organic remains, such as calcareous algal fragments and bryozoan debris.

LAB Heverlee, abandoned sandpit (250 m S and 1.300 m E of the church-tower of Heverlee).

Visited June 1954.

Sands of Brussels.

In the northern part of this old pit a section was exposed of some 2,50 m high, of strongly current-bedded sands. The sand was rather coarse-grained, glauconitic, and of greenish to brownish-green colour. It contained sometimes sandstone pieces of flat or capricious form, which were of grey-whitish colour.

The current-bedded sands were in layers of about 20 cm thickness, alternating with more or less horizontally bedded sands of about 10 cm. The overall inclination was towards the NE.

No samples were taken.

LAC Blanden, hollow roadside (1.350 m N of the church-tower of Blanden).

Visited June 1954.

Sands of Lede.

Poor exposure, at about +53 O.D. Oostende, of fine-grained, grey-white, calcareous sands with some soft, very sandy limestone pieces.

Sample **LAC 1128** yielded wash residues with a rich microfauna and many other organic remains (shell fragments, echinid spines, bryozoan debris, sponge spicules). The foraminifera were strongly incrustated with secondary $CaCO_3$.

LAE Blanden, hollow roadside (200 m S and 300 m W of the church-tower of Blanden); also point 89 (E) 69 of the archives of the Geological Survey.

Visited June 1954.

Probably **Sands of Brussels** or Sands of Lede.

A poor exposure, at about +65 O.D. Oostende, with fine-grained, calcareous, grey-white sands with some tiny shell fragments.

Sample **LAE 1130**, taken from this sand, yielded a fairly rich microfauna in addition to shell fragments, bryozoan debris, echinid spines, sponge spicules, etc.

LAF Pécrot, abandoned sandpit (600 m N and 150 m E of the church-tower of Pécrot, municipality of Bossut-Gottechain); also point 103 (W) 120 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

In the old sandpit there was a section of about 3,70 m of sands covered by about 80 cm of Quaternary loess.

The lowermost 2,30 m were formed by medium to fine-grained, brownish-yellow to green sands, more or less glauconitic, with sandstone concretions of capricious or flattened forms. These pieces were calcareous, occasionally they contained shell fragments. The bedding was indistinct. Interstratified there were five sandstone beds, more or less discontinuous. The basal ones were more or less calcareous, with shell fragments, and with some string-like marly parts.

The higher part, of about 1,40 m, showed irregular cross-bedding. Two fragmented and brittle sandstone layers occurred in the sand. Also a rusty-brown clayey bed of 15 - 20 cm was intercalated, at about 60 to 100 cm from the base of this part of the section. These upper sands were distinctly brown, with decreasing intensity of the colour lower down. There were concentrations in 2 to 5 cm rusty-brown bands.

LAG Archennes, sandpit (300 m N and 300 m W of the church-tower of Archennes); also point 103 (E) 74 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

A wall of about 6 m of grey-green sand, with much current-bedding, in which the dip was towards the NNE. Intercalated there were more horizontally bedded parts; some more or less horizontal, discontinuous sandstone layers, and some rusty-brown bands.

A sample from the base of the current-bedded sands (western wall) was taken in medium to coarse-grained sands, with silex fragments, scarce glauconite, muscovite, etc.

LAH Saint-Remy-Geest, old store of the so-called « Grès de Gobertange » (700 m N and 300 m W of the church-tower of St. Remy-Geest); also point 104 (W) 12 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

Some limestone pieces in this old store had a soft, weathered outer part. A sample was taken by scraping off some of the stones. The limestone itself was sandy, yellowish-white exteriorly and grey-white inside, and contained some casts of *Lucina volderiana*, and a number of dispersed glauconite grains.

The wash residues of sample **LAH 1136** contained a rather rich microfauna (among which some nummulites; covered by secondary $CaCO_3$), associated with echinid remains, bryozoan debris, sponge spicules, etc.

LAJ Saint-Remy-Geest, shallow ditch along road (650 m N and 400 m W of the church-tower of Saint-Remy-Geest); also point 104 (W) 12 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

Quaternary loess (50 cm) covered brittle sandy limestone of 20 cm, that overlay softer sandy limestone. The latter (sample **LAJ 1137**) was yellowish-white, with rare glauconite, and possibly mixed with some of the overlying loess.

The wash residues contained some foraminifera, shell remains, bryozoan debris and echinid spines, etc.

LAK Gobertange, old store of the so-called « Grès de Gobertange » (900 m S and 650 m W of the church-tower of Saint-Remy-Geest); also point 104 (W) 127 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

Sample **LAK 1138** consisted of some pieces of soft, weathered, sandy, yellowish-white limestone. It contained some casts of *Lucina volderiana*.

The wash residues contained a fairly rich microfauna, associated with many other organic remains.

LB Korbeek-Loo, hollow roadside (250 m S and 2.050 m W of the church-tower of Korbeek-Loo).

Visited August 1953.

Sands of Brussels.

Along the southern side of the road, at about +40 to +50 O.D. Oostende, some small and mostly poor exposures of calcareous sands were found, with intercalated discontinuous sandy limestone beds.

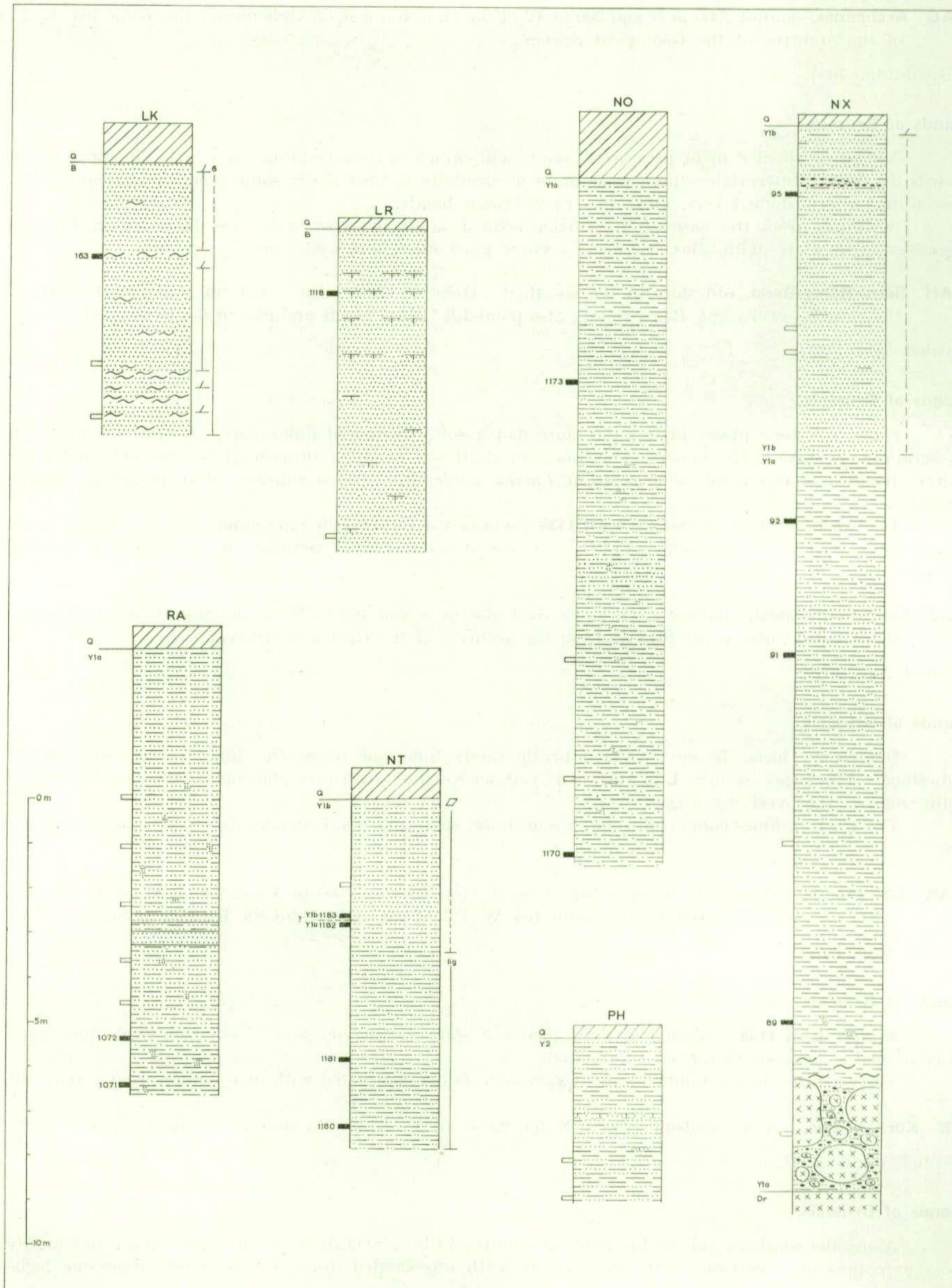


FIG. 9.

The limestones were of greyish-white colour and rich in shell fragments. Mostly they contained thin marly intercalations (of some millimetres thickness and some millimetres length).

From one of the exposures samples **LB 124** and **LB 125** were taken, at a mutual distance of 3,50 m and with LB 125 about 80 cm below the base of the Quaternary loess. Both samples consisted of rather fine-grained, calcareous, pale green-grey sands, more or less glauconitic and micaceous. The wash residues yielded many shell fragments (such as *Ostrea* and gastropods), echinid spines, bryozoan debris, sponge spicules, bone fragments (probably fish remains), some foraminifera and ostracods.

LK Hoegaarden, sandpit behind the brewery « Hoegardia » (600 m N and 50 m W of the church-tower of Hoegaarden). See fig. 9.

Visited August 1953.

Literature :

M. Leriche, 1922, Congrès Géol. Internat., Belgique, Livret-Guide, Exc. A 4, pp. 21,22.

Sands of Brussels.

The lower part (1,25 m) of the section was formed of alternating, medium to coarse-grained, glauconitic sands and marly beds. The sands were mostly more or less calcareous, with some shell fragments, and distinct cross-bedding (the bedding was partly apparent from thin marly lenses). Between these sandlayers more marly sands were intercalated. They were mostly yellowish, with interstratified non-marly, very thin sandy layers, which increased in number and thickness towards the top of these marly sands.

A sample near the base of the complex, from a marly glauconitic sand, yielded many coarse elements in the wash residues, such as well-rounded quartz grains, glauconite, silex fragments, sandstone-pieces, and some shell fragments.

On top followed some 4,50 m of glauconitic, sometimes marly, cross-bedded sands, with some interstratified marly lenses (of some centimetres thickness and some decimetres length). There were also more continuous, horizontal, sandy marls and marly limestones.

A sample from the base of these cross-bedded sands was taken from a marly, glauconitic sand with shell and coral fragments. The wash residues contained many coarse elements.

About 2,50 m above the base of this sand sample **LK 163** was derived from an interstratified yellowish-white marly bed of about 10 cm thickness. The wash residues yielded a rich microfauna, associated with remains of calcareous algae, sponge spicules, radiolarians, echinid spines, bryozoan debris, some shell fragments, and also coarse, well-rounded quartz grains.

LR Huldenberg, sandpit (1.100 m S and 1.700 m W of the church-tower of Huldenberg). See fig. 9.

Visited June 1954.

Sands of Brussels.

The lower part of the section was formed by medium-grained, yellowish-green sand with some scarce shell fragments. The latter were concentrated in small, whitish patches of 3 to 5 cm diameter. Many sandstone concretions of capricious form («Pierres de grottes» and «Grès fistuleux») and occasionally marly patches occurred dispersed in the sand.

The higher part consisted of more or less glauconitic, brownish-green sands with a number of discontinuous sandstone beds of variable thickness (max. 15 cm). No calcareous remains were found in this sand, but in the sandstones some calcareous places did occur.

Some samples of dispersed sandstone pieces from the lower part of the section appeared to be rich in sponge spicules. Some foraminifera occurred, but the specimens were too ill-preserved for specific determination.

Sample **LR 1118**, taken from some calcareous spots in one of the sandstone beds, yielded some foraminifera (mostly siliceous casts) and ostracods, also some shell fragments, bryozoan debris and many sponge spicules.

LS Huldenberg, hollow roadside (1.250 m S and 1.600 m W of the church-tower of Huldenberg); also point 103 (W) 25 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

A poor exposure of calcareous sand in between two sandy limestone banks of 5 to 10 cm thickness.

Sample **LS 1119** was taken from grey-white, slightly micaceous, fine-grained sand with sponge spicules. The wash residues delivered a fairly rich microfauna and many other organic remains, such as echinid spines, fish remains, bryozoan debris, radiolarians.

LT Huldenberg, abandoned sandpit (800 m S and 350 m E of the church-tower of Huldenberg); also point 103 (W) 19 of the archives of the Geological Survey.

Visited June 1954.

Probably **Sands of Brussels.**

A sample could be taken from rather coarse, rusty-brown to yellow sands with more or less altered glauconite and coarse silex fragments.

LV Vossem, hollow roadside (300 m S and 850 m E of the church-tower of Vossem); also point 89 (W) 26 of the archives of the Geological Survey.

Visited June 1954.

Probably **Sands of Lede.**

A poor exposure, in the western side of the road, at about +76 O.D. Oostende, showed fine-grained calcareous sand with some glauconite.

Sample **LV 1122** yielded a rather rich microfauna, shell fragments, bryozoan debris, sponge spicules and radiolarians.

LW Vossem, small sandpit (700 m E of the church-tower of Vossem).

Visited June 1954.

Sands of Brussels.

The wall of about 2,50 m was formed by about 50 cm of Quaternary loess over 2 m of medium-grained sands.

The sands were yellowish in the upper part with some calcareous spots of pale-grey colour. Downwards the latter increased in number and size. About 1,30 m below the loess, the sands appeared to be entirely calcareous. Throughout there were dispersed sandstone concretions of capricious form.

Sample **LW 1123**, taken at 2,30 m below the grass, yielded wash residues with a small microfauna as well as other organic remains, such as shell fragments, echinid spines, bryozoan debris, sponge spicules, radiolarians, etc.

LX Leefdaal, hollow roadside (200 m S and 1.200 m W of the church-tower of Leefdaal); also point 89 (W) 86 of the archives of the Geological Survey.

Visited June 1954.

Sands of Lede (MOURLON, 1890, archives of the Geol. Survey).

In both sides of this hollow road fine-grained, yellow-brown quartz sands were exposed.

A sample from the southern side of the road, at about +86 O.D. Oostende, yielded wash residues rich in limonite and muscovite.

LY Bertem, abandoned sandpit (150 m N and 650 m E of the church-tower of Bertem).

Visited June 1954.

Sands of Brussels.

Under a covering of 1 m of Quaternary loess, the lower 50 cm with much gravel, 1,75 m of sands were exposed.

The sand was medium-grained, glauconitic and green-grey, with some rusty-brown bands. Some whitish calcareous patches occurred.

From such a spot sample **LY 1125** was taken, about 25 cm below the base of the Quaternary. The wash residues yielded a small microfauna (the foraminifera were strongly incrustated by $CaCO_3$; frequent siliceous casts), some shell fragments, echinid spines, sponge spicules, etc.

LZ Bertem, hollow roadside (2.000 m E of the church-tower of Bertem); also points 89 (E) 27 and 27*a* of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

A poor exposure, at about +40 O.D. Oostende, of calcareous sands with capricious sandstone concretions («Pierres de grottes»).

Sample **LZ 1126** was from yellowish-white, medium-grained, calcareous sand with some shell fragments. The wash residues contained a rather rich microfauna and other organic debris.

SHEET PLOEGSTEERT

LLA Ploegsteert, claypit of the « Briqueterie La Lys » (950 m S and 3.050 m E of the church-tower of Ploegsteert); also point 110.12 of the archives of the Geological Survey.

Visited May 1954.

Clays of Roubaix.

About 3 m below the grass very silty clay of dark-grey colour was exposed, with some muscovite and shell fragments. Upwards the clay was less silty and of greener colour.

Sample **LLA 1087**, 3,20 m below the grass, yielded a rather rich microfauna, associated with shell fragments, nummulites, sponge spicules, radiolarians, etc.

SHEET MECHELEN

MB Moorsel, hollow roadside (1.100 m N and 150 m E of the church-tower of Moorsel).

Visited May 1954.

Clays of Asse.

Newly-constructed road with fresh sides.

Exposed was greenish, plastic clay with rusty-brown sand patches of some millimetres diameter, mainly quartz.

The wash residues of the sample yielded some glauconite, radiolarians, etc.

MC Meldert, abandoned sandpit (50 m S and 600 m E of the church-tower of Meldert).

Visited May 1954.

Sands of Lede.

The old wall was strongly overgrown and covered by debris. A small pit had to be dug for a fresh exposure.

Exposed was sandy limestone, of about 40 cm thickness, covered by Quaternary loess. The limestone bank was more or less discontinuously developed and overlay yellowish-white, fine-grained, calcareous sand, with nummulites and shell fragments, such as *Ostrea*, *Pecten*.

Sample **MC 1040**, of the sand, yielded a rather rich microfauna in addition to many other organic remains, such as bryozoan debris, echinid remains, *Ditrupa*, fish remains, sponge spicules, radiolarians, etc.

SHEET MONS

MME **Cuesmes,** abandoned sandpit on the western side of the Mont Eribus (900 m E of the church-tower of Cuesmes); also point 151 (W) 28 of the archives of the Geological Survey.

Visited May 1953.

Literature :

A. Rutot, 1903, Bull. Soc. belge Géol., vol. 17, mem., pp. 431-434.

Clays of Ieper.

In the northern part of the old pit, east of the railroad Mons-Ciply, some poor exposures of sandy clay were found. Two foraminiferous samples were taken in a small exposure of 1,50 m high, about 5 m above the bottom of the pit.

The base of the exposure was formed by sandy clay, higher up there was a gradual transition into clayey sand interstratified with some plastic clay seams of 2 to 5 mm thickness.

Sample **MME 27**, of green-grey clay with some patches of yellow-brown sand, contained some foraminifera. About 5 m above the bottom of the pit.

Sample **MME 28** was taken from green-grey, clayey, glauconitic sand, with some tubulations, of about 2 mm diameter, filled with greyish-white sand. The sand was fairly rich in limonite and contained some ill-preserved foraminifera and some bone fragments (probably fish remains). 1,50 m above MME 27.

MMF **Hyon,** sandpit « Malengrez » on the southern side of the Mont Eribus (1.500 m W and 1.100 m S of the church-tower of Hyon).

Visited May 1953.

Literature :

A. Rutot, 1903, Bull. Soc. belge Géol., vol. 17, mem., pp. 431-434.

Sands of Grandglise and **Clays of Ieper.**

Under Quaternary loess some 2,50 m of clays were exposed, covering about 7 m of sands.

The lowermost part of the sand was formed by grey-green, glauconitic, slightly clayey, fine-grained sand, with some tubulations (probably of annelids) filled with grey-white sand.

Upwards a decrease of the clay and glauconite was found, the colour became paler, and there was a gradual change into medium-grained sands. Also the number of tubulations increased. About 4 m below the contact with the overlying clay there was a layer of rusty-brown patches.

The contact of sand and clay was sharp, regular and horizontal. Directly above it brownish, weathered sandy clay was met with, containing some small spots of yellowish-brown sand. Higher upward the clay remained sandy, but it showed unweathered grey-green patches and spots of whitish sand, up to 5 mm diameter.

A sample, some centimetres above the contact, contained no microfauna, but it yielded many silex fragments.

Sample **MMF 33**, 1,80 m from the contact of sand and clay, contained some foraminifera.

MMT **Hyon,** hollow roadside (300 m N and 1.350 m E of the church-tower of Hyon); also point 151 (E) 231 of the archives of the Geological Survey.

Visited May 1953.

Probably the passage from **Sandy Clays of Anderlecht** into the **Sands of Vlierzele.**

Poor exposure, at about +85 O.D. Oostende, of greenish, slightly micaceous and glauconitic, clayey sand with sandstone pieces. The latter were hard and blue, weathered ones had a yellowish-white colour.

A sample near the level of the sandstone, 75 cm below the Quaternary coverings, yielded sponge spicules.

MMU **Hyon,** hollow roadside (400 m N and 750 m E of the church-tower of Hyon); also points 151 (E) 38 and 381 of the archives of the Geological Survey.

Visited May 1953 and July 1954.

Literature :

A. RUTOT, 1903, Bull. Soc. belge Géol., vol. 17, mem., pp. 461-462.
A. LEDOUX, 1911, Ann. Soc. Géol. Belg., vol. 38, mem., p. 163.

Sands of Vlierzele.

In the northern side of this road on the hill of the «Bois de la Haut» there was an exposure of grey-green sand with many irregular rusty-brown spots and stripes. The medium-grained sand was more or less clayey, with decreasing clay contents upwards.

A sandstone bed of about 20 cm thickness was found intercalated. It was of bluish-grey colour, and fairly rich in glauconite.

Sample **MMU 78** was taken just above the sandstone, about 3 m below the grass. The wash residues contained some ill-preserved foraminifera, radiolarians, etc.

Another sample, from about the same stratigraphic level, at some 60 m southward of the previous one, composed of weathered sandstone pieces, yielded only some bone fragments (probably fish remains) and sponge spicules.

MMV **Hyon,** hollow roadside (400 m S and 700 m E of the church-tower of Hyon); also points 151 (E) 37 and 382 of the archives of the Geological Survey.

Visited May 1953 and July 1954.

Literature :

A. RUTOT, 1903, Bull. Soc. belge Géol., vol. 17, mem., pp. 461-462.

Sands of Mons-en-Pévèle.

In the western side of this hollow road, in the southern part of the hill of the «Bois de la Haut», there was an exposure of about 1,50 m with fine-grained, grey-green sand. The basal sands were very clayey and contained many nummulites. The nummulites were often concentrated in pockets or small layers. Upwards the clay content decreased and less nummulites were found, the colour becoming yellowish-green.

From these sands the following samples were taken : **MMV 79**, of very clayey, greenish, fine-grained sand, with a rich microfauna with many nummulites, associated with fish remains, echinid spines, radiolarians, etc.

Sample **MMV 1201** from the same level as MMV 79; the wash residues also with a rich microfauna and many organic remains.

Sample **MMV 80** was taken from clayey sand with less nummulites, about 1 m above MMV 79. The wash residues contained a rich microfauna and the same other components as the previous two samples.

MMW Hyon, hollow roadside (500 m N and 650 m E of the church-tower of Hyon); also point 151 (E) 39 of the archives of the Geological Survey.

Visited May 1953.

Literature :

A. Rutot, 1903, Bull. Soc. belge Géol., vol. 17, mem., p. 462.
A. Ledoux, 1911, Ann. Soc. Géol. Belg., vol. 38, mem., p. 162.

Sandy Clays of Anderlecht passing into **Sands of Vlierzele.**

In the southern side of this hollow road, in the western part of the hill of the «Bois de la Haut», some samples were taken from sandy clays passing into clayey sands.

Sample **MMW 84** was taken at about +55 O. D. Oostende. It consisted of sandy, green-grey clay with rusty-brown spots and stripes, and contained sandstone pieces and shell fragments. The wash residues yielded some foraminifera, bryozoan debris, echinid spines, sponge spicules, etc.

Upwards this clay passed into clayey, glauconitic sand of greyish-green colour. Sandstone pieces with fossilcasts and shell fragments (as *Pinna margaritacea*) were visible as an indistinct layer of about 7 cm thickness.

Sample **MMW 85**, 1,30 m above MMW 84, contained some foraminifera, sponge spicules, echinid spines, etc.

Upwards the clay content decreased further and the grain-size of the sand became coarser.

At about +60 O.D. Oostende, we found slightly clayey sand with sandstone beds of a thickness of about 7 cm, again with fossilcasts and shell fragments.

SHEET NIVELLES

NA Esschenbeek, sandpits « Denayer » and « Louis Marcelis » (800 m S of the church-tower of Esschenbeek).

Visited September 1953.

Sands of Brussels.

The lower 8 m of this section were sampled in the sandpit « Denayer », the upper 9 m in that of «L. Marcelis».

The base of the section was formed by brownish-green, fine-grained, clayey sand, rich in limonite. A sample, from this level, contained some foraminifera, associated with some calcareous remains, etc.

This sand continued over about 2 m and was covered by fine-grained, sandy gravel, mainly consisting of silex.

Higher on the grainsize of the sand became coarser. It contained some sandstone pieces of capricious form.

Still higher upwards clay particles of some mm length were found. About 5,50 m above the mentioned sample began a series of alternating yellow, medium-grained sands and brown-yellow, fine-grained sands, which showed distinct current-bedding. The yellow sand contained some small clay lenses and irregular sandstone pieces.

This type of sands continued upwards, but with a more regular bedding.

About 8,50 m above the base of the pit a clayey band was observed, which again was covered by medium to coarse-grained sands with many sandstone concretions. The wash residues of some samples were very rich in hyaline, mostly angular quartz grains.

Higher on many limonite bands were found in this upper sandy complex of about 9 m with a fairly regular bedding. Towards the top of the section the colour became paler to whitish.

NB Wauthier-Braine, sandpit (250 m N and 1.900 m E of the church-tower of Wauthier-Braine); also point 116 (W) 132 of the archives of the Geological Survey.

Visited September 1953.

Sands of Brussels.

An excavation at the bottom of the pit yielded an additional section of some 3 m. At the bottom of this excavation we observed slightly clayey sand, brownish-green with some whitish, calcareous patches and larger, brownish spots.

Sample **NB 401** of this level yielded some foraminifera, sponge spicules, echinid spines, glauconite, muscovite, etc.

In the next metre upward the whitish spots gradually disappeared, also the brownish spots grew absent. The clay content slightly decreased.

The wash residues of sample **NB 403**, 2,40 m above NB 401, contained some foraminifera and ostracods, associated with other organic remains, such as shell fragments, sponge spicules, etc.

The upper part of the wall, of about 13 m, was formed by yellowish sands, mainly quartz with some glauconite.

NC Braine-l'Alleud, abandoned sandpit « Flamant » (500 m S and 250 m E of the church-tower of Braine-l'Alleud); also point 116 (W) 213 of the archives of the Geological Survey. See fig. 10.

Visited September 1953.

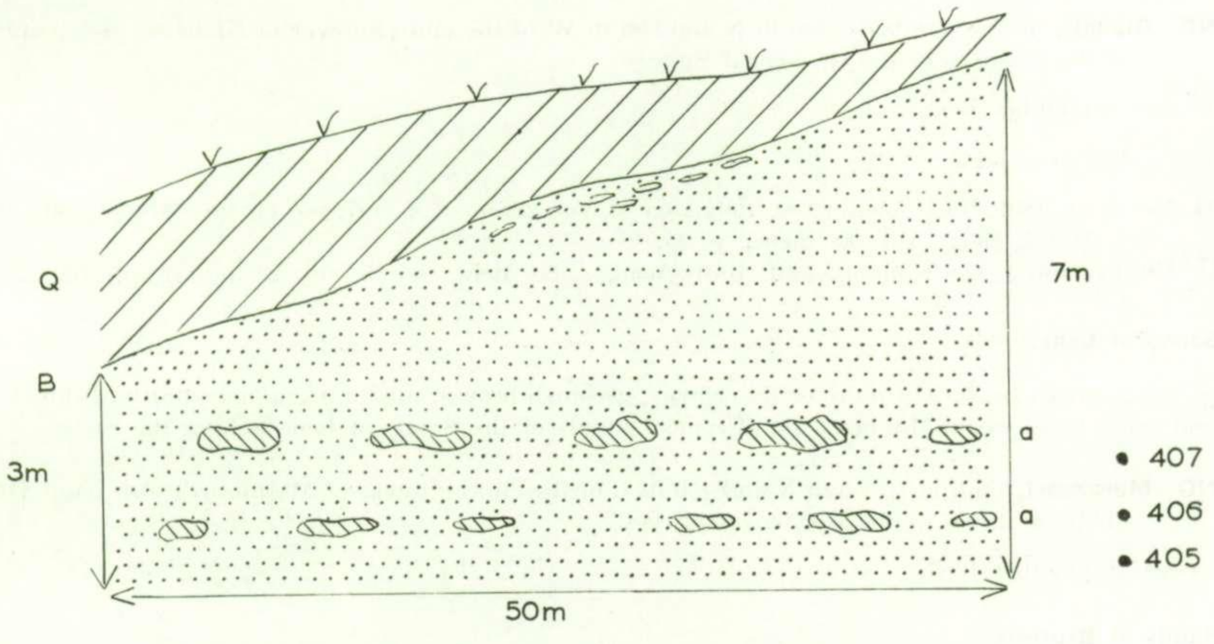


FIG. 10. — Schematic section of NC, Braine-l'Alleud
(after the archives of the Geological Survey of Belgium).

Sands of Brussels.

The more or less covered walls of the pit did not allow for an accurate section. For this reason the section in the archives of the Geological Survey (VERDIN) is figured with the supposed position of the foraminiferous samples (fig. 10).

The base of the section was formed by grey-green, fine-grained, calcareous sand with some glauconite. Upwards two discontinuous sandy limestone banks (a in the fig. 10) were found, each with a maximal thickness of 20 cm, and composed of the same material as the sand, but more calcareous. On top of the upper one the sand appeared decalcified, green, fine-grained, with some glauconite and muscovite.

The samples **NC 405**, **406** and **407** contained rich microfaunae, shell fragments (mainly *Ostrea*), echinid remains, bone fragments, many sponge spicules, bryozoan debris, radiolarians. The foraminifera of NC 406, of the level of the lower limestone, were strongly covered by secondary $CaCO_3$.

ND Genappe, hollow roadsides (650 m N and 50 m W of the church-tower of Genappe).

Visited September 1953.

Sands of Brussels.

There were two exposures along the road Charleroi-Brussels. In the southern one calcareous sands were exposed over about 3 m height; in the northern one the same sand was found, but here it appeared decalcified.

The calcareous sand was of pale-yellowish colour and fine-grained, with some more or less rusty-brown bands. In the sand also some pieces of limestone, possibly in a discontinuous layer. Also some «Grès fistuleux» were present.

Two samples (**ND 410** at the base of the exposure, **ND 411** about 2,80 m higher) appeared rich in incrustated foraminifera, associated with echinid remains, radiolarians, ostracods, sponge spicules, bryozoan debris, shell fragments, fish remains, some debris of calcareous algae, etc.

Sample **ND 412** was taken from the greyish-green, fine-grained, decalcified sands which contained more or less calcareous spots. The wash residues yielded some foraminifera and other organic remains.

NE Glabais, hollow roadside (800 m N and 500 m W of the church-tower of Glabais); also point 129 (E) 6 of the archives of the Geological Survey.

Visited September 1953.

L i t e r a t u r e :

M. MOURLON, 1891, Bull. Acad. r. Sc. Belg., ser. 3, vol. 22, no. 8, p. 107; no. 11, pp. 387-390; 1895, Ann. Soc. r. Malac. Belg., vol. 30, mem., p. 25.

G. VINCENT and J. COUTURIAUX, 1891, Bull. Acad. r. Sc. Belg., ser. 3, vol. 22, no. 12, pp. 521-528.

Sands of Lede.

A poor exposure of more or less clayey, greenish-brown, medium-grained sand with much limonite and some fossil casts (MOURLON found typical fossils of the Sands of Lede among the casts).

NG Maransart, sandpit (1.050 m N and 150 m E of the church-tower of Maransart); also point 116 (W) 127 of the archives of the Geological Survey.

Visited September 1953.

Sands of Brussels.

In this large sandpit we found a lower part of about 3 m of medium to coarse-grained sands, and a higher part of 7 m of finer grained, whitish to yellow sands. Many of the beds, especially the lower ones, showed current-bedding. « Grès fistuleux » with some fragments of *Ostrea cymbula* occurred throughout the section.

The higher sands were sometimes more or less clayey, and contained some small clay-lenses of some centimetres diameter.

NH Sart-Dame-Avelines, hollow roadside (300 m N and 900 m W of the church-tower of Sart-Dame-Avelines).

Visited July 1954.

Sands of Brussels.

A small exposure of about 1,20 m high, with fine-grained sands, more or less rich in limonite. Intercalated there were some clayey beds of about 5 cm. About 30 cm from the base we observed a layer of 20 cm of dispersed sandstone pieces of capricious form, rich in sponge spicules.

Sample **NH 1156**, taken about 50 cm from the base of the exposure, contained some foraminifera, echinid spines, sponge spicules, etc.

NJ Plancenoit, abandoned sandpit (250 m S and 800 m E of the church-tower of Plancenoit); also point 116 (E) 132 of the archives of the Geological Survey.

Visited July 1954.

Sands of Brussels.

Only some poor exposures remained. Exposed was fine-grained, calcareous, whitish sand with some pieces of slightly sandy limestone, and contaminated with overlying loess.

Sample **NJ 1158** contained a rich microfauna associated with many other organic remains, such as echinid remains, shell fragments, bryozoan debris, sponge spicules, remains of calcareous algae, radiolarians, etc.

NK Plancenoit, hollow roadside (350 m S and 800 m E of the church-tower of Plancenoit).

Visited July 1954.

Sands of Brussels.

Some poor exposures were found of whitish, calcareous, fine-grained sands with small pieces of sandy limestone.

Two samples were taken, **NK 1159** and **NK 1160**, with a vertical distance of 2 m. Lithologically they were identical with that of the nearby exposure of NJ.

The wash residues of both samples contained fairly rich microfaunae, associated with many other organic remains, with about the same components as NJ 1158.

NL Bois-Seigneur-Isaac, hollow roadside (300 m S and 550 m E of the church-tower of Bois-Seigneur-Isaac); also point 129 (W) 16 of the archives of the Geological Survey.

Visited July 1954.

Sands of Lede.

Exposure of fine-grained, brownish-yellow sands which were slightly glauconitic and contained limonite, sometimes concentrated in rusty-brown bands.

The sample contained some brown sandstone fragments, coarse quartz grains, radiolarians, etc.

NM Braine-le-Château, hollow roadsiide (650 m S and 550 m E of the church-tower of Braine-le-Château).

Visited July 1954.

Sands of Brussels.

A poor exposure of rusty-brown, medium-grained sands with some hard and cavernous sandstone pieces of capricious form.

The sample contained mainly angular quartz grains and sponge spicules.

NN Tourneppe, hollow roadside (1.350 m W of the church-tower of Tourneppe).

Visited July 1954.

Possibly **Sands of Brussels.**

Another poor exposure of rusty-brown, fine-grained sands with some sandstone pieces. The wash residues of the taken sample yielded, amongst others, sponge spicules.

NO Tubize, claypit of the « Tuileries et Briqueteries du Brabant » (400 m S and 150 m E of the church-tower of Tubize); also point 115 (E) 5 of the archives of the Geological Survey. See fig. 9.

Clays of Ieper.

Claypit with a section of about 16,75 m, the upper 1,50 m of which were formed by Quaternary loess with gravel in the lower 1,20 m.

Near the base of the section slightly silty clay was found, of olive-green colour, and with small strings of fine-grained quartz sand. This clay was found over 3,70 m, upwards greyer of colour, and with occasional rusty-brown bands.

The series continued with 1,80 m of grey silty clay with irregular, rusty-brown seams and spots, which usually showed a rusty-brown wall.

Upwards some 70 cm of silty clay with discontinuous, brownish and more silty beds occurred. At the base of this clay some beds (max. 10 cm) of fine-grained quartz sand were present.

The overlying 70 cm of very silty clay with thin sandstrings, gradually passed into 2,20 m of greyish-brown, less silty clay, with sand strings and some discontinuous clay seams (up to 10 cm).

Higher upwards 1 m of slightly silty clay was found, overlain by 2 m of silty clay (**NO 1173**), which gradually passed into 70 cm of dark-grey, plastic clay.

The clay series ended with 2,60 m of silty clay, rich in limonite.

Sample **NO 1170**, from the basal clays, contained some foraminifera (partly fragmentary nummulites) in addition to shell fragments, muscovite, etc.

Another sample of this clay contained no microfauna, except for some fragments of nummulites.

Sample **NO 1173** yielded some foraminifera, also muscovite, etc.

NP Virginal-Samme, sandpit (500 m S and 1.000 m W of the church-tower of Virginal-Samme).

Visited July 1954.

Sands of Brussels.

Some 20 m of coarse-grained, rusty-brown to yellowish sand were exposed. Sandstone pieces, mostly of capricious form, occurred either dispersed in the sand or in discontinuous layers.

In the lower part of the section much cross-bedding was found; upwards the bedding became more regular, and the sand finer grained.

A sample taken near the base of the section was almost completely formed by hyaline quartz grains.

NQ Hennuyères, sandpit (1.100 m S and 1.250 m E of the church-tower of Hennuyères); also point 128 (W) 207 of the archives of the Geological Survey.

Visited July 1954.

Literature :

M. Leriche, 1924, Bull. Soc. belge Géol., vol. 34, p. 49.

Sands of Brussels.

The pit had a wall of 19 m of coarse to medium-grained sands of yellowish to brownish colours, with much limonite in the higher parts.

«Grès fistuleux» occurred throughout, a discontinuous bed of «Pierres de grottes» was found about 5 to 7 m above the base. Cross-bedding of the sand was only faintly present.

The sand was covered by about 1 m of Quaternary loess.

NR Henripont, sandpit of the « Sablonnière Marouset » (1.300 m N and 500 m W of the church-tower of Henripont); also point 128 (W) 209 of the archives of the Geological Survey.

Visited July 1954.

Literature :

M. LERICHE, 1924, Bull. Soc. belge Géol., vol. 34, p. 50;
R. LEGRAND, 1945, ibid., vol. 54, pp. 91-103.

Sands of Brussels.

A wall of about 24 m; the upper 5 m were formed by Quaternary loess. The samples were taken in the southeastern part of the pit.

The lowermost part consisted of coarse-grained, pale rusty-brown sands with dispersed sandstone pieces (mostly «Grès fistuleux»). Discontinuous sandstone banks were found, formed by capricious, cavernous pieces. About 5 m above the bottom there were 2,50 m with indistinct current-bedding. On top coarse to medium-grained sands with discontinuous sandstone beds reappeared. In this part of the wall brown bands made their appearance, becoming more numerous and generally thicker upwards. Locally these bands were salmon coloured. These bands contained concretions of limonite that were often hollow and had thin, hard walls.

The upper 3 m of the sand were rich in limonite and of distinctly brownish colours, and again with concretions of limonite.

NS Henripont, abandoned sandpit (400 m E and 50 m N of the church-tower of Henripont); also point 128 (W) 232 of the archives of the Geological Survey.

Visited July 1954.

Sands of Brussels.

A wall of about 5 m, the upper 30 cm of which were formed by Quaternary loess.

The lower sands were of variable grain-size (mostly medium-grained) and with discontinuous sandstone levels, which consisted of flat pieces of maximally 30 cm length and some centimetres thickness. In the sand there were dispersed sandstone pieces of irregular form.

Altogether 5 sandstone levels were found at intervals of 60 to 80 cm, the first one near the base of the section.

The upper sands were medium to fine-grained, with green and salmon colours, and brownish, more or less irregular, bands.

Samples were taken from the first, third and fifth sandstone level. The foraminifera of these samples were mostly silicified and too ill-preserved for specific determination. Furthermore the wash residues contained echinid spines, sponge spicules, shell fragments, ostracods, bryozoan debris, etc.

NT Ecaussines-Lalaing, claypit (350 m N and 200 m E of the church-tower of Ecaussines-Lalaing); also point 128 (E) 18 of the archives of the Geological Survey. See fig. 9.

Visited July 1954.

Probably the passage of **Clays of Ieper** into **Sands of Mons-en-Pévèle.**

The base of the section was formed by dark grey, slightly silty clay, with increasing small quantities of lignite spots towards the top of the clay.

A sharp boundary marked the beginning of silty to very silty, yellowish-brown clay, with muscovite and glauconite. This sandy clay passed gradually into fine-grained, dark yellowish-green sand, with again glauconite and mica. This in turn was overlain by grey, silty clay; the lower part of which showed some tiny, rusty-brown spots. Upwards the limonite was more abundant and the colour was rusty-brownish to grey.

Samples **NT 1180** and **NT 1181** contained foraminifera, shell fragments, fish remains, muscovite, etc.
Sample **NT 1182** yielded the same components, and also sponge spicules.
Sample **NT 1183** contained foraminifera, shell fragments, much limonite, etc.

NV Ecaussines-Lalaing, quarry (1.400 m S and 400 m E of the church-tower of Ecaussines-Lalaing); also point 128 (W) 197 of the archives of the Geological Survey.

Visited July 1954.

Sands of Mons-en-Pévèle.

On top of the quarried Carboniferous limestone some sandy deposits were found. The sand was fine-grained and slightly clayey.

NX Quenast, quarry (about 950 m S and 250 m E of the church-tower of Quenast); also points 115 (W) 110 and 111 of the archives of the Geological Survey. See fig. 9.

Visited September 1953.

Clays of Ieper and **Sands of Mons-en-Pévèle.**

The greyish microdiorite (**Dr** in the section) was covered by its weathering products, which were green with yellowish spots, and of rather variable grain-size.

The base of the overlying clay was formed by a very coarse conglomerate of diorite boulders of 50 cm and more, in sandy and clayey materials of dark brownish to grey.

A sample yielded wash residues with coarse quartz grains, fish remains, diorite fragments, etc.

On top of the conglomerate thin-bedded, red to yellow, marly clay was found, followed by plastic, grey clay with some small sand patches. Upwards the silt content increased, and rusty-brown spots occurred at the level of NX 91. From the latter level upwards a rather sudden transition occurred into more sandy clay, followed again by pale clay. NX 92 was taken from slightly silty clay of green-grey colour.

Three samples (**NX 89**, **91** and **92**) contained foraminifera. The wash residues of NX 89 were rich in fish remains (bone fragments, teeth, etc.), in addition to diorite fragments, shell remains, echinid spines, etc. Fish remains were also found in the wash residues of NX 91.

Over the clay a sandy series was found, clayey at the base, with upwards diminishing clay content. At some places the sand showed cross-bedding. The grain-size was variable, but usually medium to fine-grained. From about 3 m above the base the sand was fine-grained, more or less clayey, and pyritiferous. The clay content gradually increased, and cross-bedding of thin laminae was present.

At some places lenses of gravel were very numerous, some 40 of them were counted in the southern part of the pit. In our section such a lens, mainly silex in coarse sand,figures above the level of NX 95. Upwards the sand became again fine-grained and clayey.

Only one sample, **NX 95**, contained some foraminifera, in association with glauconite, muscovite, etc.

SHEET NAMUR

NNA Spy, abandoned sandpit (850 m N and 1.000 m E of the church--tower of Spy).

Visited June 1954.

Sands of Brussels.

Only parts of the original section of the wall were exposed.

Near the bottom of the southern part of the pit an exposure of 80 cm of calcareous sand was found, interstratified with three sandy limestone banks of 8 to 20 cm. White colours dominated, except for some rusty-brown seams of about 2 cm.

Sample **NNA 1151** from this exposure yielded a rich microfauna (with nummulites), associated with shell fragments, echinid remains, bryozoan debris, sponge spicules, etc.

Higher upward decalcified sands were found, with at the base white calcareous sands with some green spots. In the decalcified sands occurred some discontinuous, whitish sandstone beds, with a thickness of 3 to 15 cm.

The northern part of the pit (distance about 7,50 m from the southern exposure) showed about the same type of sands as the first described exposure.

Sample **NNA 1152** was taken from these calcareous, fine-grained sands. The wash residues had about the same components as those of NNA 1151.

NNB Spy, abandoned sandpit (1.050 m S and 600 m E of the church-tower of Spy); also point 143 (E) 192 of the archives of the Geological Survey).

Visited June 1954.

Literature :

X. STAINIER, 1911, Ann. Soc. Géol. Belg., vol. 38, Bull., pp. 318-324.

Sands of Erquelinnes and **Sands of Brussels.**

The basal part of the section was formed by some 3 m of white sands, which STAINIER assigned to the Landenian, probably Sands of Erquelinnes.

The top of the sand was marked by a black zone with dispersed gravel at the base. The black grains (probably Mn-oxide) were concentrated in thin bands over about 40 cm.

Upwards 1 m of sand was found, with interstratified flat sandstone pieces of about 5 cm thickness, and rich in sponge spicules.

Quaternary loess (1 m) was forming the top, following another metre of rusty-brown sands.

NNC Velaine, old quarry (700 m N and 1.450 m E of the church-tower of Velaine); also point 143 (W) 191 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

Flat, greyish-white, medium-grained sandstone blocks of some metres diameter and about 30 cm thickness were formerly extracted from this quarry (« Grès de Fayat »). No fresh exposure was available.

From a heap of sand, without doubt coming from this sandpit, a sample was taken.

SHEET TIELT

PA Bellem, hollow roadside (2.150 m S and 100 m W of the church-tower of Bellem).

Visited September 1953.

Possibly **Sands of Vlierzele.**

Under the Quaternary coverings was exposed a medium-grained, yellow-white sand, which contained some sponge spicules.

PB + PC Eegem, sand and claypit of the « Steen- en Buizenbakkerij Gebr. Ampe » (600 m S and 2.100 m W of the church-tower of Eegem); also point 53 (W) 60 of the archives of the Geological Survey.

Visited September 1953.

Sandy Clays of Anderlecht.

PB The sandpit of these brick-works showed more or less medium-grained, green-brown sands in a wall of about 5 m, the upper metre formed by Quaternary loess.

The sand was more or less glauconitic and slightly micaceous. Wash residues yielded, amongst others, some fish remains and sponge spicules.

Two metres below the grass a 30 cm layer of sandstone of yellow to white colour, and rich in fossil casts.

PC At about the same topographical level a claypit was found, some 300 m to the west, with an exposure of about 5 m.

Visible was a sandy, brownish-green clay, rich in coarse glauconite grains. Half the way the section, a discontinuous sandstone layer of about 30 cm thickness was present, containing nummulites and fossil casts. Mostly the sandstone was weathered and of brownish-yellow colour; the unweathered interior was grey-brown, with coarse, green glauconite spots, muscovite and shell fragments (mostly pelecypods).

The stratigraphic relation between these two points was somewhat obscure. Either they were lateral facies of the same stratigraphic unit; or the clay was slightly below the level of the sand. Perhaps both exposures belonged to the passage beds of the Sandy Clays of Anderlecht into the Sands of Vlierzele.

PD Izegem, claypit of the « Briqueterie Van de Putte » (350 m S and 500 m W of the church-tower of Izegem); also point 68 (W) 489 of the archives of the Geological Survey.

Visited September 1953.

Clays of Ieper.

In the lower part of the exposed 7 m wall occurred blue grey, slightly silty clay with glauconite, muscovite and some fish remains in the wash residues.

Upwards the silt content of the clay increased and the colour became paler. Small brown, sandy spots with fine-grained sandy material were frequent. ,

Beneath the grass from about 3 m onwards the clay was weathered and oxidized to a rusty-brown clay.

PF Loo-ten-Hulle, sandpit (450 m S and 300 m E of the church-tower of Loo-ten-Hulle).

Visited May 1954.

Literature :

R. TAVERNIER, 1936, Natuurw. Tijdschr., Gent, jrg. 18, nr. 1, pp. 6-8.

Sands of Vlierzele.

Under 30 cm of Quaternary loess 2,70 m of sand were exposed.

In the lower part this glauconitic sand was rather coarse-grained; higher up the grain-size diminished.

Small, slightly calcareous tubulations (2 to 20 mm diameter) occurred, only the largest ones being hollow. Rare in the lower part, these tubes increased in number upwards, to just 1 m below the top of the section. Here a rather sharp boundary was found; below the sand was slightly indurated and full of tubulations. Above, the darker, grey-green sand contained very scarce tubulations.

The wash residues of the samples were rich in glauconite, with some calcareous remains, etc.

PG Aalter, railroadcut and sandpit (650 m N and 750 m E of the church-tower of Aalter); also point 64 (W) 8 of the archives of the Geological Survey.

Visited May 1954.

Sands of Aalter.

The main exposure of the Sands of Aalter was found along the southern side of the railroad, close to the small bridge that crosses the railroad east of the station of Aalter.

The base of this 1,50 m exposure was in slightly clayey, glauconitic, green sand, with many *Venericardia planicosta* and other shell remains, of mainly pelecypods. Furthermore it contained some bryozoan debris associated with glauconite and muscovite.

Upwards this sand with shell remains mainly contained *Turritella solanderi*. The fossils were worn and often perforated by boring animals. The samples from this level yielded scarce remains of the coral *Turbinolia* in addition to bryozoan debris, fish remains, etc.

Close to this exposure a small sandpit showed sands rich in *Venericardia planicosta*. The shells were mostly more or less decalcified. The sand was clayey and glauconitic, with decreasing glauconite content towards the top of this 1 m exposure.

PH Pittem, claypit of the « Steenbakkerij Claerhout » (150 m S and 1.850 m E of the church-tower of Pittem); also point 68 (E) 164 of the archives of the Geological Survey. See fig. 9.

Visited May 1954.

Sandy Clays of Anderlecht.

Quaternary loess (30 cm) covered about 3,60 m of sandy clay.

The base of the clayey series was formed by sandy to very silty, greyish-green clay with sand patches (some millimetres to 1 cm diameter), and dark brown spots. The rather fine-grained sand of the spots contained some glauconite and muscovite.

Upwards the same type of clay was found alternating with plastic claybeds of 6 to 20 cm. The latter clay was mostly brownish-green to grey, with rusty-brown spots. The thickness of the individual layers appeared rather variable.

Approaching the level of the upper sample the sand contents appeared slightly to increase; the wash residues of a sample contained some glauconite, muscovite, sponge spicules and radiolarians.

The sandy clay was again overlain by plastic clay of 5 cm thickness, followed by sandy clay with some flat sandstone pieces, of some decimetres diameter.

Alternating sandy and plastic clays continued higher up with again a discontinuous, intercalated sandstone layer. The layer was formed by flat, rounded pieces with a grey interior and shell fragments.

PJ Ardoie, claypit of the « Briqueterie Van de Vijvere » (200 m N and 2.700 m E of the church-tower of Ardoie); also point 68 (W) 58 of the archives of the Geological Survey.

Visited May 1954.

Possibly transitional beds from the **Clays of Ieper** into the **Sands of Mons-en-Pévèle**, and followed by the **Clays of Roncq.** In fact we may have to do with a sandy intercalation in the higher part of the Clays of Ieper.

About 3 m of clay with an interstratified sandlayer were exposed under a covering of Quaternary loess.

The lowermost 20 cm showed plastic, grey clay. Then followed 110 cm of silty to very silty, dark greyish-blue clay. The lower clays ended with 35 cm of alternating silty and plastic clay of dark greyish-blue colour.

The intercalated sandlayer of 60 cm was formed by greenish-yellow, fine-grained sand, with glauconite and muscovite. The contact with the overlying clays was somewhat irregular.

This overlying, green-grey clay, was slightly silty. A sample, close to its base, yielded glauconite, muscovite, etc.

SHEET PROVEN

PPA Poperinge, claypit of the « Mekanieke Steenbakkerij Sadi Schaballie » (850 m S and 700 m W of the church-tower of Poperinge); also point 80.72 of the archives of the Geological Survey.

Visited September 1953.

Probably **Clays of Ieper** with a sandy intercalation (with gravel). Possibly this gravel marks the base of the Clays of Roubaix, though in the Clays of Ieper sandy lenses have been entered in the legend of the geological map of this region.

The basal part of the section was formed by plastic clay (4,60 m), with in the upper 80 cm a slight silt content. The colour was in general dark bluish-grey, with occasional rusty-brown. The samples of this part of the section contained fish remains, shell fragments, etc.

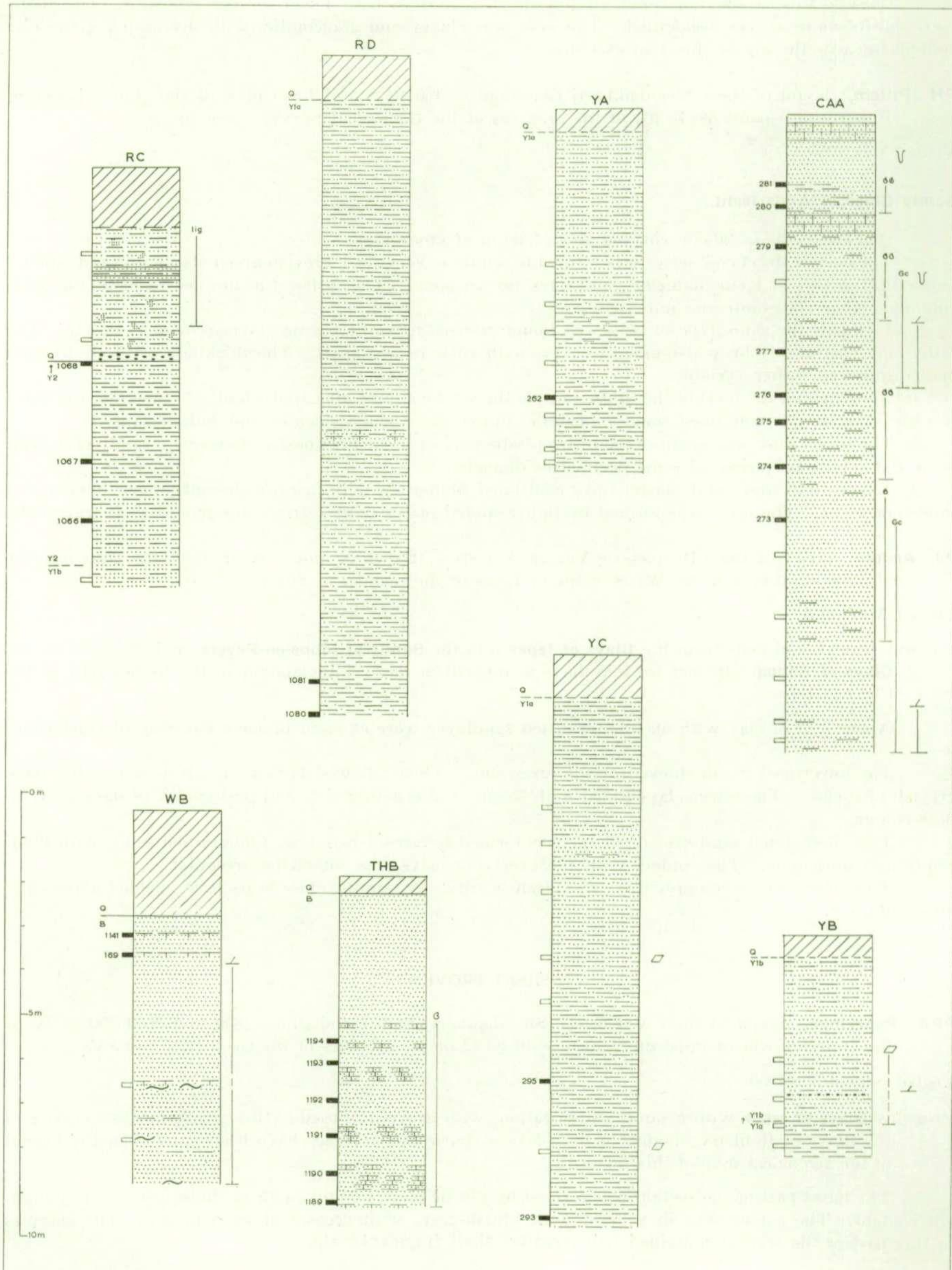


FIG. 11.

Upwards occurred a rusty-brown layer of 10 cm of clayey sand, with some gravel (mainly silex). With an irregular contact followed 4,40 m of green, glauconitic, very silty clay, with green-brown bands of 5 to 10 cm.

Higher upward this clay became more oxidized and rusty-brown, with some sandy patches.

The series was covered by 50 cm of Quaternary loess.

SHEET ROESELARE

RA Kortemark, claypit of the « Steenbakkerij Gebr. Desimpel » (1.150 m S of the church-tower of Kortemark); also point 52 (W) 150 of the archives of the Geological Survey. See fig. 9.

Visited September 1953 and May 1954.

Clays of Ieper.

The drawing corresponds to the eastern part of the pit.

The base was formed by calcareous, slightly silty, dark blue-grey clay, with small patches rich in silt or fine-grained sand and perhaps some lignite.

The samples showed tiny shell fragments, a fairly rich foraminiferal fauna (with some nummulites), echinid spines, fish remains, ostracods, glauconite and muscovite. From the eastern wall the samples **RA 1071** and **RA 1072** appeared to be foraminiferous; also some foraminiferous samples from the western wall were investigated, namely **RA 253** (on the same level as the sample above RA 1072), **RA 254** and **RA 1079** (somewhat above the level of RA 1072).

This calcareous clay continued over 2 m from the base of the pit. Upwards the clay became paler and richer in silt. Some yellow-grey layers were intercalated, chiefly composed of fine-grained, silty sand, with some rare, small shell fragments. These layers, with a thickness of 30 to 40 cm were discontinuous, sometimes indurated, forming grey-blue sandstone.

The higher clays were greenish-grey, more or less rich in silt, with the upper 3,50 m formed by weathered, brownish-grey clay and Quaternary coverings.

RB Hooglede, claypit of the « Briqueterie Lamsens » (400 m N and 1.350 m W of the church-tower of Hooglede); also point 67 (E) 61 of the archives of the Geological Survey.

Visited September 1953.

Sandy Clays of Anderlecht.

The base of the wall (3,50 to 4 m) was formed by grey, plastic clay.

Overlying it 1,50 m of grey-green, sandy clay were found, which were very sandy at the base, and contained fossil casts, abundant at the base, diminishing in number upwards.

Higher up followed another 60 cm of grey-green clay, again sandy in the lower part, and less sandy upwards, but with less numerous fossil casts.

This clayey complex was followed by glauconitic, grey-green sand with many dark-brown fossil casts at the base. Clayey, partly lenticular, intercalations of some centimetres got more numerous in upward direction, merging into a clayey sand, at about 70 cm above the base.

After 30 cm of this clayey sand there was a rather abrupt change into slightly sandy clay, mixed with the loamy Quaternary coverings.

RC Staden, claypit of the « Steenbakkerij Debeil-Bonte » (1.300 m S and 1.100 m W of the church-tower of Staden); also point 67 (W) 207 of the archives of the Geological Survey. See fig. 11.

Visited May 1954.

Sands of Mons-en-Pévèle and Clays of Roncq.

The base of this claypit was formed by green-grey, fine-grained, clayey sand, with glauconite, muscovite and some sponge spicules. Lower down pure sand was reported to be present. Upwards this clayey sand gradually passed into green-grey silty clay, which showed towards the top a continuous decrease of the silt contents, except for the last 50 cm (below the gravel bed) in which it again increased. The clay was slightly glauconitic and contained some muscovite.

The samples, **RC 1066**, **1067** and **1068**, showed rather poor microfaunae with some nummulites (RC 1068). Furthermore, shell fragments, echinid spines, fish remains, sponge spicules, radiolarians, etc.

A gravel bed of 10 to 20 cm, mainly composed of well-rounded quartz and silex, was found overlying this clay. These pebbles underlay greyish-brown, more or less silty clay.

According to C. CAMERMAN, (1951, archives of the Geol. Survey, unpublished) the gravel bed and the overlying deposits are of Quaternary age.

RD Rumbeke, claypit of the « Steenbakkerij Van de Putte » (600 m S and 2.600 m W of the church-tower of Rumbeke); also point 67 (E) 143 of the archives of the Geological Survey. See fig. 11.

Visited May 1954.

Clays of Ieper.

Under a covering of about 1 m of Quaternary loess about 14 m of more or less silty clay were exposed.

In the lower 6,50 m an exposure of slightly silty, grey-blue, gypsiferous clay. In the wash residues of **RD 1080** and **RD 1081** some foraminifera were found, also some shell fragments and fish remains.

In the upper part of this lower clay the silt content gradually increased. About 6,50 m above the base of the section a discontinuous layer of clayey sand was observed, 20 to 30 cm thickness, mostly indurated. The sand was very fine-grained and of green-grey colour.

Upwards again silty clay was noticed, with the upper 3 m weathered to a greyish-brown clay.

SHEET THUIN

THA Nalinnes, abandoned sandpit (400 m N and 300 m E of the church-tower of Nalinnes); also point 164 (E) 18 of the archives of the Geological Survey.

Visited July 1954.

Sands of Grandglise and **Sands of Brussels.**

The lowermost 20 cm of the partly covered wall were formed by rusty-brown to yellow, medium-grained sand, with glauconite and silex fragments. Upwards we found 10 cm of clayey, dark yellowish-brown sand.

On top followed 20 cm of gravel of mainly silex pebbles, coarse quartz grains, sandstone pieces and much glauconite.

Overlying this gravelly sand rested 1,75 m of rusty-brown to yellowish sand, in which BAYET (1884, archives of the Geol. Survey) observed some tubulations, probably of annelids.

The covering consisted of 70 cm of Quaternary loess.

THB Nalinnes, abandoned sandpit (100 m S and 650 m E of the church-tower of Nalinnes); also point 164 (E) 20 of the archives of the Geological Survey. See fig. 11.

Visited July and August 1954.

L i t e r a t u r e :

A. BRIART, 1888, Ann. Soc. Géol. Belg., vol. 15, mem., p. 35; 1890, ibid. vol. 17, mem., p. 259.

J. GOSSELET, 1892, Ann. Soc. Géol. Nord, vol. 19, p. 39.

Sands of Brussels.

Only the upper part of the former wall of the « Sablonnière des Monts » was still visible.

The basal part of our section was formed by very calcareous sand with intercalations of more or less discontinuous, sandy limestone banks, with, in general, a horizontal interval of 30 to 35 cm between the limestone pieces.

The sands were yellowish coloured, but upwards the colour changed into pale whitish-green, corresponding to the increasing glauconite content. Locally there were some rusty-brown spots. The sands were fine-grained and rich in organic remains, such as shell fragments (*Ostrea gigantea*, *Pecten subornatus*, and many others), echinid remains (*Crenaster*), bryozoan debris, fish remains, nummulites (probably *Nummulites laevigatus*), etc.

The limestones were commonly of yellowish-white colour, and also rich in organic remains. Great differences with the surrounding sand could not be found, except for the greater lime content of the limestone. Thicknesses of the pieces are rather variable (8 and 35 cm).

The samples, **THB 1189-1194**, all possessed rich microfaunae in addition to many organic remains of the above mentioned groups and sponge spicules, fragments of calcareous algae, etc.

Overlying these calcareous sands followed 2,95 m of decalcified sand of rusty-brown to green colour and with increasing limonite contents in upward direction. This complex of decalcified sands was thin in the northern part of the pit, and increased in thickness towards the south.

THC Jamioulx, sandpit (300 m S and 1.500 m E of the church-tower of Jamioulx); also point 164 (E) 812 of the archives of the Geological Survey.

Visited July 1954.

Sands of Brussels.

The basal part of the section consisted of brownish-yellow to white, fine-grained, micaceous sands, with some (?) lignitic bands of some mm thickness. Some 60 cm from the base of the pit, a band of 10 cm thickness contained grey-white patches. These patches were rich in sponge spicules, and probably were the remains of a discontinuous sandstone layer.

A sample from one of these pockets yielded some ill-preserved foraminifera (siliceous casts), in addition to shell fragments, echinid spines, bryozoan debris, etc.

From this level onwards 4 m of rusty-brown sand were found covered by 1 m of Quaternary loess.

SHEET WAVRE

WA Lathuy, quarry of « Grès de Gobertange » (950 m N and 1.000 m E of the church-tower of Lathuy).

Visited August 1953 and June 1954.

Sands of Brussels.

A small mine for the extraction of sandy limestone («Grès de Gobertange»). The limestones were found, at about 17 m below the surface level, in two layers with an interval of about 70 cm. Their thickness was variable, the basal one 15 to 20 cm, and the upper one 20 to 25 cm. Unweathered the limestone was hard and whitish, slightly sandy and with occasional cavities filled with soft, calcareous material. Locally they contained many casts of *Lucina volderiana*.

Samples **WA 164, 165** and **166** were taken during our first visit. The mine was closed at the time and only extracted pieces could be studied.

Sample **WA 1139** was taken in between the limestone levels, 30 cm above the lower limestone, from very calcareous, fine-grained, yellowish-white sand.

The wash residues of all samples showed rich microfaunae in addition to many other organic remains, such as shell fragments, echinid remains, bryozoan debris, sponge spicules, rests of calcareous worms, radiolarians, etc.

WB Jodoigne, sandpit of the « Briqueterie Lebegge » (50 m N and 850 m W of the church-tower of Jodoigne); also point 118 (W) 124 of the archives of the Geological Survey. See fig. 11.

Visited August 1953 and June 1954.

Sands of Brussels.

The basal part of the wall was formed by glauconitic, rather coarse-grained, yellow-green sands, with current-bedding, and occasional small clay-lenses and whitish marly patches. About 1 to 2 m were visible.

Upwards rather coarse-grained, glauconitic, brownish-green sand was met with, with a discontinuous sandstone level of about 6 cm thickness, of pale-grey colour, and locally more or less marly.

On top of this sandstone level 2,75 m of current-bedded sand was found, with dips towards the NE. The grain-size varied between medium and fine-grained. The bedding was visible by the concentrations of glauconite in thin layers, with diminishing quantities higher up. The thicknesses of the individual beds varied between 3 and 20 cm.

Overlying this sand 20 cm of calcareous sandstone were observed, in plates of about 2 m diameter, white with rusty-brown layers and spots. In between this bed and a higher one glauconitic coarse-grained sands were intercalated. The upper sandstone was about 10 cm thick, discontinuous and coarse-grained, with an irregular surface.

Upwards again coarse-grained, glauconitic, rusty-brown sands.

Only the two upper samples were foraminiferous. From both lower ones the residues yielded angular quartz grains, shell fragments, bryozoan debris, echinid spines, coarse silex fragments, and some nummulites.

Samples **WB 169** and **WB 1141** contained a small microfauna, associated with other organic remains.

WD Ottignies, abandoned sandpit (600 m S and 700 m W of the church-tower of Ottignies).

Visited August 1953.

Sands of Brussels.

On Palaeozoic rocks (quartzites and shales of the Revinian, according to the Geological Map) sands were found with gravel at the base. This gravel was rather fine-grained, of well-rounded quartz grains and Palaeozoic elements, bedded in rather glauconitic sand.

Higher up glauconitic quartz sand was noticed, mostly of green-grey colour, containing some capricious sandstone pieces, and some clay lenses of small diameter.

WE Chaumont-Gistoux, sandpit (850 m N and 650 m W of the church-tower of Chaumont-Gistoux); also point 117 (E) 89 of the Geological Survey.

Visited June 1954.

Sands of Brussels.

The wall had a length of about 250 m, about E-W directed, over a total height of sand of 25 to 30 m.

The sand showed some current-bedding and many capricious sandstone pieces, both dispersed and in discontinuous layers. The limonite contents increased towards the top.

WF Opprebais, abandoned quarry (400 m N and 750 m E of the church-tower of Opprebais); also point 118 (W) 231 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

The coverings of the Palaeozoic quartzites, formerly exploited in this quarry, were formed by sands and Quaternary loess. Only some small exposures of the sand could be found.

These showed brownish-green, medium-grained, quartz sand, with some more or less desintergrated sandstone pieces of whitish colour.

Sample **WF 1134** from one of the sandstone pieces yielded some foraminifera (mainly siliceous casts) and many sponge spicules, echinid remains, ostracods, bryozoan debris, etc.

WG Dongelberg, quarry (800 m S and 50 m W of the church-tower of Dongelberg); also point 118 (W) 39 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

The exploited Palaeozoic quartzites were covered by sands, at the base coarse-grained, glauconitic and dark-green, with coarse hyaline, well-rounded quartz grains and bryozoan debris, higher onward whitish and with current-bedding.

Sample **WG 1135**, just above the contact with the quartzites, yielded a small microfauna, bryozoan debris, shell fragments, sponge spicules, echinid spines, etc.

WH Folx-les-Caves, sandpit (200 m S and 100 m E of the church-tower of Folx-les-Caves); also point 118 (E) 55 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

About 4 m of quartz sands were found covered by 70 cm of Quaternary loess.

The basal 2 m were yellowish-white, showed current-bedding with southern dips, irregular, fistulose sandstone pieces, and some rusty brown bands and spots.

Upwards a 10 to 15 cm of discontinuous, weathered, yellowish-white sandstone bed, with some glauconite, was followed by 2 cm of greenish-brown silty clay and 4 cm of coarse-grained rusty brown sands with much limonite.

The overlying yellowish-white sands with rusty-brown bands showed towards the top a gradual increase of the limonite content.

WJ Grand-Rosière, sandpit (800 m S and 600 m E of the church-tower of Grand-Rosière); also point 131 (W) 131 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

Under 1 to 2 m of Quaternary loess ill-storted gravelly sand was visible over a height of about 8 m.

About 2 m below the surface a rather fine-grained gravel of 20 cm was present. Especially the gravel contained many silex fragments.

The grain-size of the sands was mostly coarse, but finer grained, mostly darker beds were found as well. Also lateral variation of grain-size was found. The sands were more or less greenish-grey, with some rusty-brown bands and spots.

WK Perwez, sandpit (50 m N and 2.350 m E of the church-tower of Perwez); also points 131 (W) 112 and 113 of the archives of the Geological Survey.

Visited June 1954.

Sands of Brussels.

The lower part of the 3,60 m high wall was formed by 1,10 m of green-grey sands, with brownish colours and irregular limonitic bands towards the top. Some small black spots (? Mn-oxide) increased in number and size in the same direction. The sand was fine-grained, glauconitic and with dispersed sandstone pieces.

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.

L i t e r a t u r e :

M. Leriche, 1926, Bull. Soc. belge Géol., vol. 36, pp. 129-137.
F. Darteville, 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.

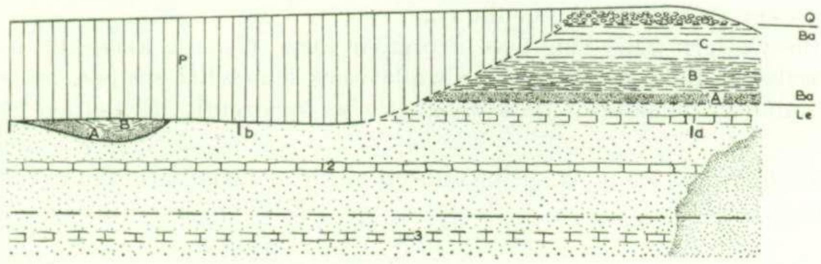


FIG. 12. — Schematic section of ZD, Bambrugge (after LERICHE, 1926). P : loess; C : grey clay; B : green-grey, glauconitic clay; A : fine-grained sand with clay strings; 1, 2 and 3 : layers of sandy limestone; a, b and c : sampled sections. Scale : vert. 1 : 200; hor. 1 : 500.

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.

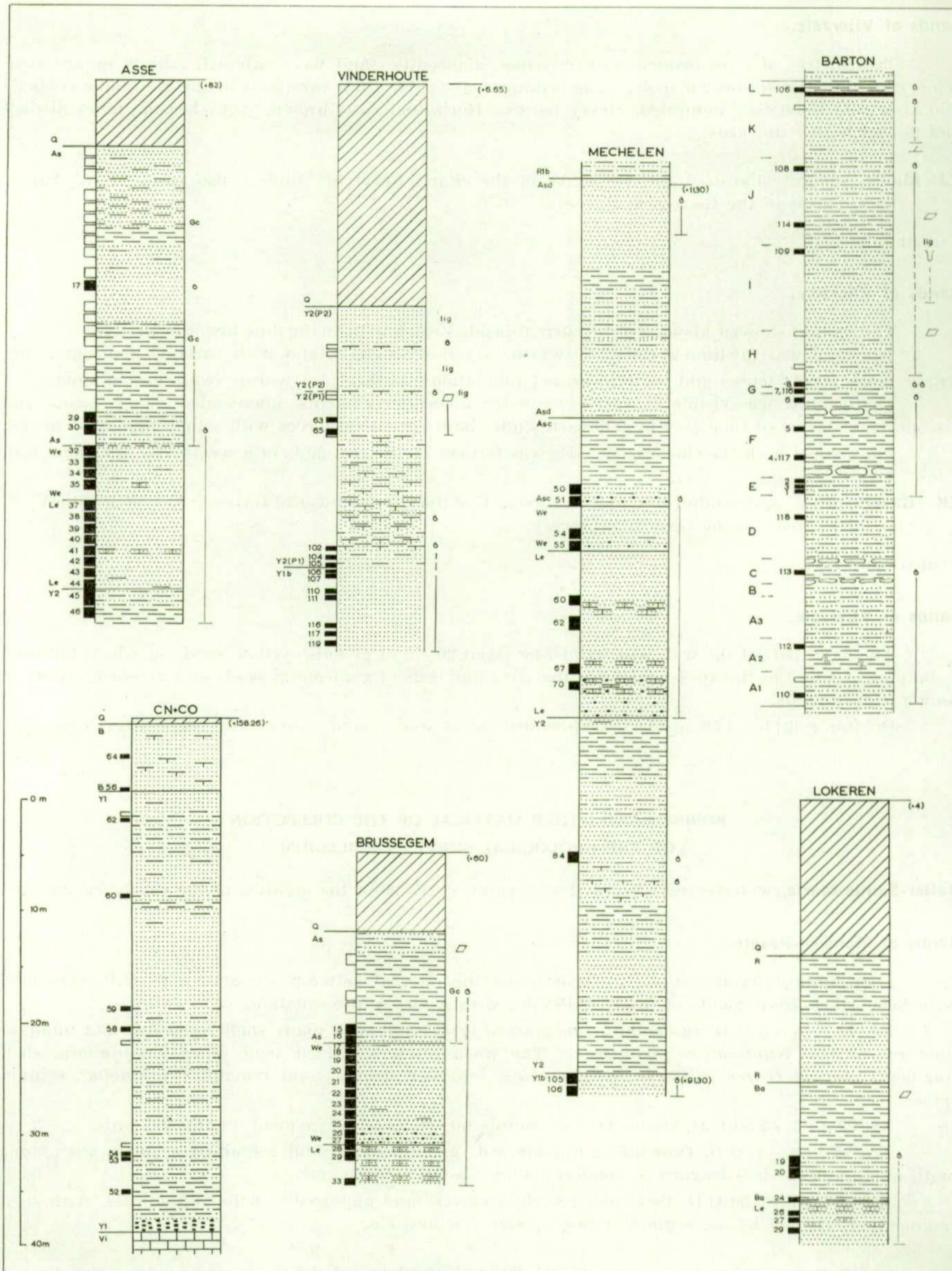

ASSE
VINDERHOUTE
MECHELEN
BARTON
CN·CO
BRUSSEGEM
LOKEREN
0 m
10m
20m
30m
40m

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.

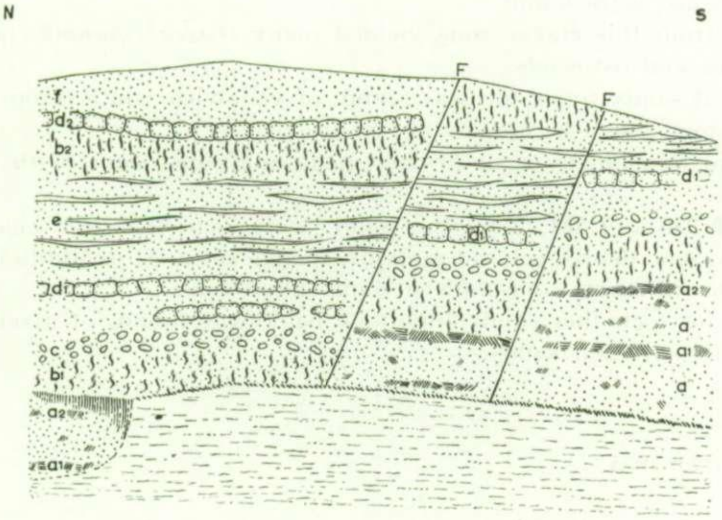


FIG. 14. — Schematic section of CAA, mont des Récollets (after LERICHE, 1937). a : glauconitic sand, with concentrations of glauconite (a 1 and a 2) and a distinct cross-bedding; b : glauconitic sand with tubulations; c : shell bed; d : sandy limestone; e : glauconitic sand with clay beds; f : glauconitic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

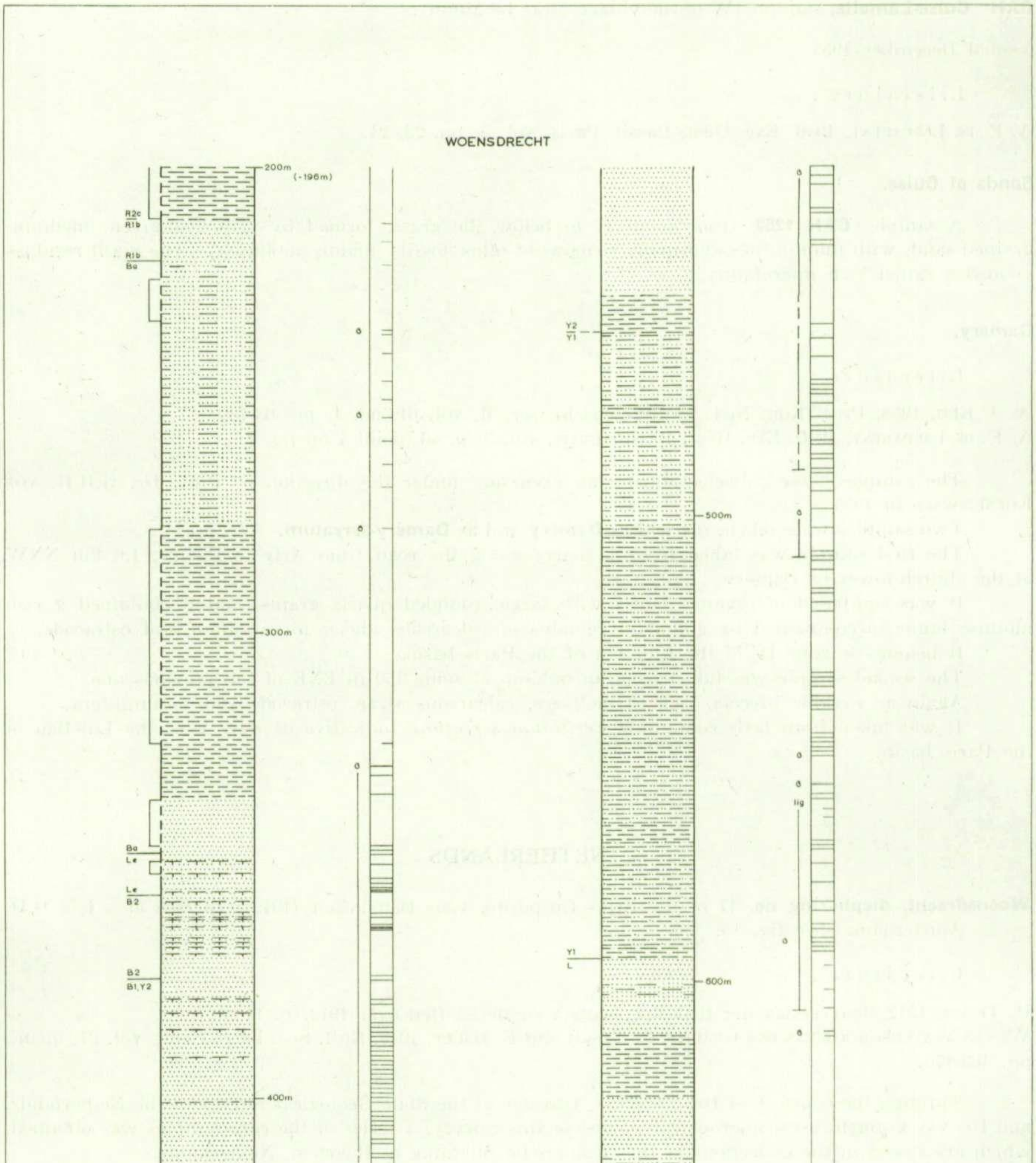

WOENSDRECHT
200m
(-196m)
300m
400m
500m
600m
650m
R2c
R1b
Be
Le
B2
B1,Y2
Y2
Y1
L

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.

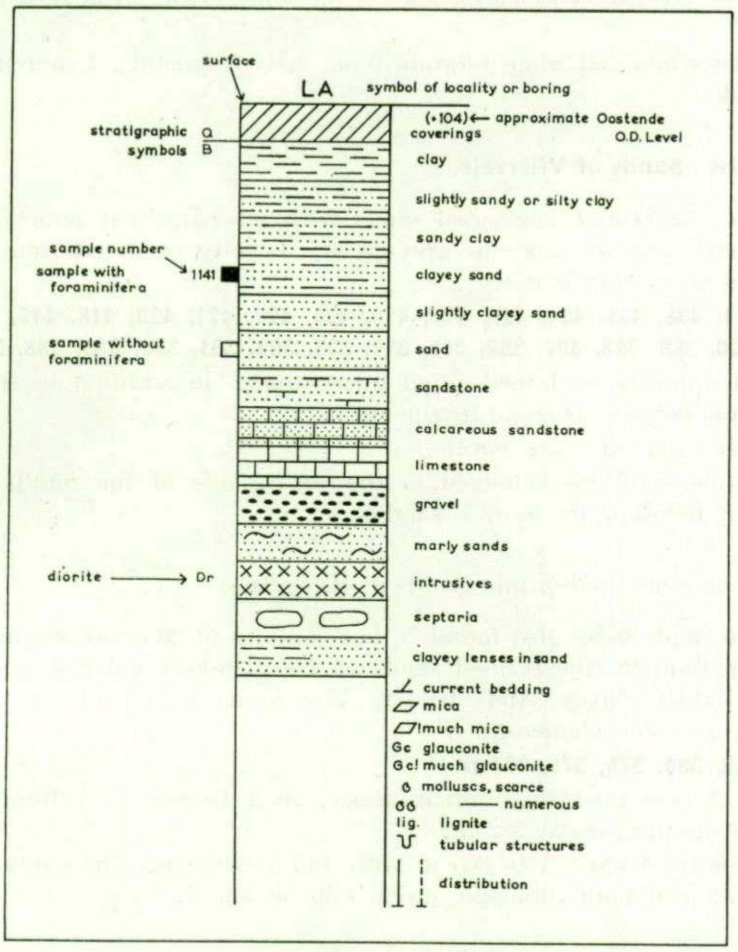


FIG. 16. — Legend for figures 6-15.

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.

Table 1.

GENERAL DISTRIBUTION CHART

RARE ×
COMMON =
FREQUENT ~

Species	Clays of Ieper (Lower)	Clays of Ieper (Middle)	Clays of Ieper (Upper)	London clay — Alum bay	Clays of Roubaix	Sands of Mons-en-Pévèle	Sands of Cuise	Clays of Roncq	Sandy clays of Anderlecht and sands of Vlierzele	Sands of Aalter	Sands of Brussels (basal strata)	Sands of Brussels	Lutetian — Paris basin	Sands of Lede (basal strata)	Sands of Lede	Upper Bracklesham beds — Whitecliff bay	Barton beds — Hampshire	Sands of Wemmel (basal strata)	Sands of Wemmel	Clays of Asse (basal strata)	Clays of Asse	Lower Tongeren beds (according to Batjes, 1958)	Upper Tongeren beds and Rupel formation (according to Batjes)
1. *Ammobaculites* sp. cf. *A. americanus*	×																						
2. *Anomalina* sp. cf. *A. danica*	×																						
3. *Cibicides* sp. cf. *C. dutemplei*	×																						
4. *Cribrostomoides* sp.	=																						
5. *Haplophragmoides* sp.	×																						
6. *Rhizammina* sp.	=																						
7. *Spiroplectammina mexiaensis*	×																						
8. *Trochammina* sp. cf. *T. inflata*	×																						
9. *Eponides plummerae*	×	×	×																				
10. *Dentalina megalopolitana*	×	×	×			×																	
11. *Karreriella danica*	×	~	×	×	×	×	×																
12. *Anomalina acuta* var. *ypresiensis*	×	~	×	=	×	×			×														
13. *Cibicides proprius*	×	~	~	=	×	~			~														
14. *Spiroplectammina adamsi*	×	~	×	×	×	×			×														
15. *Siphonina prima*	×	=	×	×	×	=					×												
16. *Ammodiscus incertus*	=		×			×			×	×					×								
17. *Eponides toulmini*	×	×				×	×					×	×		×						×		
18. *Hanzawaia producta*	×		×		×	×			=	×		=	×	×	×	×		×	×		×		
19. *Cibicides sulzensis*	×	~	~	×	×	~		×	×						×		×	×	×		×		~
20. *Dentalina* sp. cf. *D. ewaldi*	×	×																	×		×		×
21. *Quinqueloculina impressa*	×			×									×	×	~		×	×	×	×	×		×
22. *Lenticulina* spp.	×	~	=	×	×	=	×	×				×			×	×	×	×	×		×	×	=
23. *Nonion affine*	×	~	~	×	×	×			=	×	×	×	×		×		×	×	=	×	×	×	~
24. *Rotalia audouini*	×				×	×		×	×			~	×	×	~	×	×	×	×	×	×	×	×
25. *Nodosaria natchitochensis*		×																					
26. *Nodosaria* sp. cf. *N. elegantissima*		×																					
27. *Nodosaria* spp.		×																					
28. *Marginulina pediformis*		×	×																				
29. *Pseudoclavulina anglica*		×	×																				
30. *Alabamina obtusa*		=		×																			
31. *Gyroidina angustiumbilicata*		×		×																			
32. *Textularia smithvillensis*		~	×	×	×																		
33. *Asterigerina wilcoxensis*		×			×	×																	
34. *Lenticulina* (*Astacolus*) sp. cf. *L. decorata*		~	×	×		×																	
35. *Lenticulina* (*Marginulinopsis*) *enbornensis*		~				×																	
36. *Nodosaria latejugata*		~				×																	
37. *Uvigerina batjesi*		×			×	=																	
38. *Globigerina* sp. cf. *G. varianta*		=	=		×	×			×														
39. *Globigerina triloculinoides*		×	×		×	×			×														
40. *Globigerinoides* sp. cf. *G. daubjergensis*		×	×		×	=			×														
41. *Nodosaria minor*		=	×						×														
42. *Cibicides* sp. cf. *C. mauricensis*		×				×			×	×		=											
43. *Karreria fallax*		×				~									×								
44. *Cibicides westi*		×	×		×	=				×		~		×	×			×	×				
45. *Cibicides proprius* var. *acutimargo*		×	~	×	×	=			=	=	×	~		×	×			×	=	×			
46. *Angulogerina abbreviata*		×	×									×	×	×	×			×	×		×		
47. *Anomalina acuta*		~	~	×	×	×	~	×	×	×	~	×			×			×	=	×	×		
48. *Bolivina anglica*		×	×		×	×					×				×			×	×		×		
49. *Dentalina elegans*		×	×									×			×			×	×		×		
50. *Lagena globosa*		×				×						×		×	×				×				
51. *Rotalia* spp.		×				×			×		×	×	=	×					×		×		
52. *Asterigerina bartoniana*		×			×	~	×	×	×		~	=	×	×	~			~	~	~	~	=	
53. *Elphidium subnodosum*		×		×		×			×	×		×			×		×	×	×			×	
54. *Cibicides lobatulus*		×	~	×	×	~	×	×	~	×	×	~	×	~	=		×	=	=	×	×	×	
55. *Cibicides* sp. cf. *C. ungerianus*		×	×			×			×	×	=	=			×	×	×	×	×	×	×		=
56. *Globulina gibba*		×	×	×		×			=	=	×	×	×	×	~	×	×	~	~	×	×		×
57. *Guttulina irregularis*		×	×			×		×	=	=	×	×	×	×	=	×	×	×	×	×	×	×	×
58. *Guttulina problema*		×	×		×	×	×		×	=	=	×	×	=	×	×	×	×	×		×	×	×
59. *Pullenia quinqueloba*		=	×	×		×									×	×	×		×		×		×
60. *Alabamina wilcoxensis*			×	×																			
61. *Turrilina brevispira*			×		×	=																	
62. *Asterigerina* sp. cf. *A. guerrai*			×		×	~	×				=	×											
63. *Planulina burlingtonensis* var. *neelyi*			×		×	~			×	×	~	×											
64. *Anomalina auris*			×									×	×	×	×				×				
65. *Elphidium latidorsatum*			×	×	×	=		×	×			×		×	×		×	×	×				
66. *Bulimina parisiensis*			×		×	×				×			×		×			×	×		×		
67. *Dentalina inornata*			×			×			×			×		×	×			×	×		×		
68. *Elphidium laeve*			×	×		×	×	×	×	×	×	~	=	=	×		×	×	×		×		
69. *Guttulina pulchella*			×			×			×	×		×		×	×	×		×	×		×		
70. *Lagena striata*			×			×											×		×		×		
71. *Nonionella spissa*			×		×							×			×			×	×		×		
72. *Nonion graniferum*			×		×	×	×					×			×		×	×	×			×	×
73. *Nonion scaphum*			×	×		×			×		=	×		×	×			×	=		×	×	×
74. *Quinqueloculina seminula*				×		×	×	×	×				×	~	~	×	×	=	×		×		×
75. *Bolivina pulchra*					×	×																	
76. *Discorbis* spp.					×	×			×			×	×										
77. *Buliminella* sp. cf. *B. pulchra*					×							×	×	×	×				×				
78. *Bolivina crenulata*					×	×						×		×	×			×	×		×		
79. *Reussella elongata*					×	×						×	×	×	×	×		×	×		×		

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*,	*Haplophragmoides* sp.,
Anomalina sp. cf. *A. danica*,	*Rhizammina* sp.,
Cibicides sp. cf. *C. dutemplei*,	*Spiroplectammina mexiaensis*, and
Cribrostomoides sp.,	*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

TABLE 1 *(continued)*.

GENERAL DISTRIBUTION CHART

RARE ×
COMMON =
FREQUENT ~

Species	Clays of Ieper (Lower)	Clays of Ieper (Middle)	Clays of Ieper (Upper)	London clay — Alum bay	Clays of Roubaix	Sands of Mons-en-Pévèle	Sands of Cuise	Clays of Roncq	Sandy Clays of Anderlecht and Sands of Vlierzele	Sands of Aalter	Sands of Brussels (basal strata)	Sands of Brussels	Lutetian — Paris basin	Sands of Lede (basal strata)	Sands of Lede	Upper Bracklesham beds — Whitecliff bay	Barton beds — Hampshire	Sands of Wemmel (basal strata)	Sands of Wemmel	Clays of Asse (basal strata)	Clays of Asse	Lower Tongeren beds (according to Batjes, 1958)	Upper Tongeren beds and Rupel formation (according to Batjes)
80. *Gyroidina octocamerata*					×	=		×	×	×		=		×	×				×		×		
81. *Cancris subconicus*					×	~		=			~	×	×	×	×			×	×	×	×	×	
82. *Allomorphina* sp.						×						×											
83. *Pseudopolymorphina spatulata*						×						×											
84. *Reussella obtusa*						×							×										
85. *Globorotalia* spp.						×									×								
86. *Anomalina grosserugosa*						×		×	×	×	×	~	×	×	×								
87. *Discorbis perplexa*						×						×	×					×					
88. *Bolivina carinata*						×						×	×	×	×			×	×				
89. *Discorbis parisiensis*						×						×	×		×				×				
90. *Entosolenia orbignyana*						×						×			×			×	×				
91. *Pyrulina gutta*						×			×	×		×	×	×	×			×	×				
92. *Spiroloculina costigera* var. *ubiqua*						×						×	=	×	=			×	×				
93. *Angulogerina muralis*						×			×			×		×	×			×	×		×		
94. *Asterigerina* sp.						×									×	×	×	×	×		×		
95. *Cibicides carinatus*						×			×		×	×	=	~	~			×	×		×		
96. *Globulina gibba* var. *punctata*						×			×	×		×	×	×	×		×	×	×		×		
97. *Lamarckina cristellaroides*						×	×					×	×	×	=			×	×		×		
98. *Planulina burlingtonensis*						×			×	×	=				×			=	~		×		
99. *Triloculina trigonula*						×						×	×	×	~		×	×	×		×		
100. *Textularia agglutinans*						×			~	~		×		×	×			×	=		×	×	
101. *Epistominella oveyi*						×		×	×	×					×	×		×	×				×
102. *Glandulina laevigata*						×								×	×		×		×		×		×
103. *Spiroplectammina carinata*						×													×		×	×	~
104. *Spiroplectammina carinata* var. *deperdita*						×			×			×		×	×			×	×	=	=		
105. *Lagena isabella*						×						×	×	×	×						×		×
106. *Triloculina gibba*						×						×		×	~			×	×		×		×
107. *Eponides polygonus*							×		×			×	×	×	×			×	×				
108. *Siphonina lamarckana*							×					×	×		×			×	=		×		
109. *Planulina burlingtonensis* var. *tendami*									×	~													
110. *Bolivina brabantica*									×			×											
111. *Discorbis* sp. cf. *D. ferganensis*									×	×		×		~									
112. *Elphidium hiltermanni*									×			×			×	×		×	×				
113. *Guttulina lactea*									×			×	×		×				×		×		
114. *Rotalia* sp. cf. *R. calvezae*									×			×		×	×								
115. *Sigmomorphina semitecta*									×			×		×	×								
116. *Globulina gravida*									×	×		×		×	×			×	×				
117. *Hastigerina micra*									×	×				×	×			×	×		×		
118. *Lagena* spp.									×			×							×		×		
119. *Pyrulina thouini*									×	×		×		×	×		×		×		×		
120. *Quinqueloculina carinata*									×				×	~	~		×	~	~	×	×		
121. *Miliola saxorum*									×				=	=	~			~	=				×
122. *Discorbis quadrata*											×	×	×										
123. *Reussella terquemi*											×	=	×	×	×								
124. *Angulogerina* sp. cf. *A. ovata*												×											
125. *Cibicides* sp. cf. *C. tallahatensis*												×											
126. *Discorbis humilis*												×											
127. *Entosolenia* spp.												×											
128. *Globigerina* spp.												×											
129. *Gyroidinella magna*												×											
130. *Patellina nitida*												×											
131. *Buliminella striato-punctata*												×	×		×								
132. *Cycloloculina* sp. cf. *C. punctata*												×	=		×								
133. *Pyrgo bulloides*												×	×		×								
134. *Textularia agglutinans* var. *nalinnesensis*												×			×								
135. *Valvulina* spp.												×	×		×								
136. *Discorbis vesicularis*												×	=	×	×			×					
137. *Bulimina tenuistriata*												×	×					×	×				
138. *Discorbis limbata*												×	×		×				×				
139. *Sigmomorphina* sp. cf. *S. bornemanni*												×		×	×			×	×				
140. *Spirillina* spp.												×	×		×				×				
141. *Triloculina angularis*												×		=	~			×	×		×		
142. *Tubulogenerina tubulifera*												×	×						×				
143. *Alabamina wolterstorffi*												×			×				×		×	×	
144. *Trifarina wilcoxensis*												×	×	×	×			×	×		×		×
145. *Rotalia propingua*												×	×		×	×	×	×	×		×		×
146. *Anomalina claustrata*													×										
147. *Articulina nitida*													×										
148. *Baggina* sp. cf. *B. parisiensis*													×										
149. *Epistomaria semimarginata*													×										
150. *Epistominella gyrata*													×										
151. *Dendritina* spp.													×										
152. *Miliola disticha*													×										
153. *Neocribrella globigerinoides*													×										
154. *Quinqueloculina* sp. cf. *Q. aspera*													×										
155. *Spiroloculina perforata*													=										
156. *Spirophthalmidium pertusa*													×										
157. *Triloculina lecalvezae*													×										

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.

Table 1 (*continued*).

GENERAL DISTRIBUTION CHART

RARE ×
COMMON =
FREQUENT ~

	Clays of Ieper (Lower)	Clays of Ieper (Middle)	Clays of Ieper (Upper)	London clay — Alum bay	Clays of Roubaix	Sands of Mons-en-Pévèle	Sands of Cuise	Clays of Ronq	Sandy Clays of Anderlecht and Sands of Vlierzele	Sands of Aalter	Sands of Brussels (basal strata)	Sands of Brussels	Lutetian — Paris basin	Sands of Lede (basal strata)	Sands of Lede	Upper Bracklesham beds — Whitecliff bay	Barton beds — Hampshire	Sands of Wemmel (basal strata)	Sands of Wemmel	Clays of Asse (basal strata)	Clays of Asse	Lower Tongeren beds (according to Batjes, 1958)	Upper Tongeren beds and Rupel formation (according to Batjes)
158. *Miliola birostris*													× × × ×		× × × ×								
159. *Quinqueloculina crassa*													× × × ×		× × × ×								
160. *Quinqueloculina striata*													= = = =	× ×	= = = =								
161. *Renulina opercularis*													× × × ×		× × × ×								
162. *Spiroloculina costigera* var. *carinata*													× × × ×		× × × ×								
163. *Triloculina propingua*													× × × ×		× × × ×								
164. *Vertebralina laevigata*													× × × ×		× × × ×								
165. *Alveolina* spp.													× × × ×	× ×	× × × ×			× ×					
166. *Articulina ornaticollis*													× × × ×		× × × ×			× ×					
167. *Dendritina depressa*													× × × ×		× × × ×			× ×					
168. *Globulina gibba* var. *myristiformis*													× × × ×		× × × ×			× ×					
169. *Orbitolites complanatus*													× × × ×		× × × ×			× ×					
170. *Spiroloculina costigera*													× × × ×		× × × ×			× ×					
171. *Spiroloculina tricarinata* var. *angulifera*													× × × ×		× × × ×			× ×					
172. *Articulina contracta*													× × × ×		× × × ×				× × × ×				
173. *Clavulina parisiensis*													× × × ×	× ×	× × × ×			× ×	× × × ×				
174. *Millola prisca* var. *strigillata*													= = = =		= = = =			~ ~	× × × ×				
175. *Miliola prisca* var. *terquemi*													× × × ×		= = = =			~ ~	× × × ×				
176. *Pyrgo elongata*													× × × ×						× × × ×				
177. *Spiroloculina bicarinata*													= = = =	× ×	= = = =			× ×	× × × ×				
178. *Spiroloculina costigera* var. *nuda*													× × × ×		= = = =			× ×	× × × ×				
179. *Spirophthalmidium alata*													× × × ×		× × × ×				× × × ×				
180. *Triloculina trigonula* var. *inflata*													× × × ×	× ×	× × × ×	× × × ×	× × × ×	× ×	× × × ×				
181. *Entosolenia marginata*													× × × ×		× × × ×				× × × ×		× × × ×		
182. *Articulina laevigata*													× × × ×		× × × ×	× × × ×		× ×	× × × ×		× × × ×		
183. *Quinqueloculina costata*													= = = =	= =	~ ~ ~ ~		× × × ×	× ×	× × × ×		× × × ×		
184. *Reussella limbata*													× × × ×	× ×	× × × ×			× ×	× × × ×		× × × ×		
185. *Spiroloculina tricarinata*													× × × ×		× × × ×			× ×	× × × ×	× ×	× × × ×		
186. *Miliola prisca*													× × × ×		~ ~ ~ ~			~ ~	× × × ×		× × × ×		× × × ×
187. *Quinqueloculina ludwigi*													× × × ×	× ×	~ ~ ~ ~		= = = =	× ×	× × × ×		× × × ×		× × × ×
188. *Spirolina* spp.													× × × ×										× × × ×
189. *Spiroloculina canaliculata*													× × × ×		= = = =		× × × ×	× ×	= = = =	× ×	× × × ×		× × × ×
190. *Articulina pseudosulcata*														× ×	× × × ×			× ×					
191. *Cornuspira involvens*														× ×	× × × ×				× × × ×				
192. *Asterigerina* sp. cf. *A. glabra*														= =	= = = =			× ×	× × × ×	× ×			
193. *Bifarina selseyensis*														× ×	× × × ×	~ ~ ~ ~		× ×	× × × ×		× × × ×		
194. *Epistominella acutimargo*														× ×	× × × ×		× × × ×	× ×	× × × ×		× × × ×		
195. *Eponides schreibersi*														× ×	× × × ×			× ×	= = = =		× × × ×		
196. *Spiroloculina tricarinata* var. *belgica*														× ×	= = = =			= =	× × × ×	× ×	× × × ×		
197. *Cibicides* sp. cf. *C. tenellus*														× ×	× × × ×	= = = =	× × × ×	= =	= = = =	= =	× × × ×	× × × ×	
198. *Cibicides dutemplei*														= =	= = = =			= =	~ ~ ~ ~	= =	~ ~ ~ ~	= = = =	= = = =
199. *Miliolinella oblonga*														× ×	× × × ×		× × × ×	× ×					× × × ×
200. *Quinqueloculina juleana*														= =	~ ~ ~ ~		× × × ×	~ ~	× × × ×		× × × ×		× × × ×
201. *Sigmoilina tenuis*														× ×	× × × ×			× ×	× × × ×		× × × ×		× × × ×
202. *Articulina flandrica*															= = = =			× ×	× × × ×				
203. *Cornuspira bornemanni*															× × × ×			× ×	× × × ×				
204. *Dimorphina* sp.															× × × ×				× × × ×				
205. *Fabularia bella*															= = = =			~ ~	× × × ×				
206. *Nonionella wemmelensis*															× × × ×			× ×	× × × ×				
207. *Angulogerina abbreviata* var. *tubulifera*															× × × ×			× ×	× × × ×		× × × ×		
208. *Articulina terquemi*															× × × ×	× × × ×		× ×	× × × ×		× × × ×		
209. *Lenticulina (Astacolus) decorata*															× × × ×			× ×	× × × ×	× ×	× × × ×		
210. *Robertina germanica*															× × × ×		× × × ×	× ×	× × × ×		× × × ×		
211. *Seabrookia lagenoides*															× × × ×						× × × ×		
212. *Uvigerina farinosa*															× × × ×			× ×	× × × ×	× ×	× × × ×		
213. *Cancris auriculus* var. *primitivus*															× × × ×			= =	= = = =	× ×	× × × ×		
214. *Globigerina angustiumbilicata*															× × × ×		× × × ×	× ×	× × × ×	× ×	× × × ×		× × × ×
215. *Cibicides pygmeus*																~ ~ ~ ~	= = = =	× ×	× × × ×	× ×	× × × ×		× × × ×
216. *Cibicides vialovi*																= = = =	= = = =						
217. *Quinqueloculina bicarinata*																	× × × ×	× ×	× × × ×				
218. *Bolivina cookei*																		× ×	× × × ×		× × × ×		
219. *Globulina gravida* var. *lineata*																		× ×	× × × ×	× ×	× × × ×		
220. *Pseudoclavulina* sp. cf. *P. cocoaensis*																		× ×	× × × ×		× × × ×		
221. *Epistomina elegans*																		× ×	× × × ×				× × × ×
222. *Karreriella siphonella*																		× ×	× × × ×	× ×	× × × ×		= = = =
223. *Bulimina ovata*																			× × × ×	× ×	× × × ×		
224. *Dentalina* sp. cf. *D. baltica*																			× × × ×		× × × ×		
225. *Uvigerina spinicostata*																		× ×			× × × ×		
226. *Eponides umbonatus*																			× × × ×		× × × ×		= = = =
227. *Loxostomum teretum*																			× × × ×		× × × ×		
228. *Nodosaria ludwigi*																			× × × ×		× × × ×		× × × ×
229. *Gyroidina* sp. cf. *G. soldanii*																					× × × ×		
230. *Glandulina aequalis*																						× × × ×	× × × ×
231. *Gyroidina soldanii*																						× × × ×	~ ~ ~ ~
232. *Pyrulina fusiformis*																						× × × ×	× × × ×
233. *Pullenia bulloides*																						× × × ×	= = = =

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.

Table 2.

DISTRIBUTION CHART OF FORAMINIFERA OF THE IEPER FORMATION OF BELGIUM

	Ammodiscus incertus	Angulogerina abbreviata	Anomalina acuta	Anomalina acuta var. ypresiensis	Anomalina auris	Asterigerina sp. cf. A. guerrai	Bolivina anglica	Bulimina parisiensis	Cibicides lobatulus	Cibicides proprius	Cibicides proprius var. acutimargo	Cibicides sulzensis	Cibicides westi	Cibicides sp. cf. C. mauricensis	Elphidium laeve	Elphidium latidorsatum	Elphidium subnodosum	Eponides toulmini	Globigerina triloculinoides	Globigerina sp. cf. G. varianta	Globigerinoides sp. cf. G. daubjergensis	Globulina gibba	Guttulina irregularis	Guttulina problema	Guttulina pulchella	Hanzawaia producta	Lagena striata	Lenticulina (Astacolus) sp. cf. L. decorata	Lenticulina spp.	Marginulina pediformis
Lower Tongeren beds									×								×						×	×					×	
Asse formation		×	×		×		×	×	×		×	×	×		×	×	×					×	×	×	×	×	×		×	
Lede formation	×	×	×		×		×	×	×		×	×	×		×	×	×	×				×	×	×	×	×			×	
Brussels formation		×	×		×	×	×		×		×		×	×	×	×	×	×				×	×	×	×	×			×	
Panisel formation	×		×	×				×	×	×	×	×	×	×	×	×	×		×	×	×	×	×	×	×	×			×	
Morlanwelz member CI 41	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	.	.
Sands of Mons-en-Pévèle																														
CAG 1252	.	.	.	.	.	C	.	.	f	C	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
CAG 1250	.	.	r	.	.	C	.	.	A	A	.	.	.	.	.	.	.	.	r	.	r	.	.	.	.	r	.	.	.	.
CAG 1249	.	.	f	.	.	V	r	.	V	V	A	V	.	C	.	.	.	.	A	V	V	.	.	r	.	.	.	.	A	.
DH 1212	.	.	A	r	.	V	r	.	V	V	C	A	r	f	.	.	.	.	C	A	A	.	.	r	.	.	.	r	C	.
DH 1211	.	r	A	.	.	.	f	.	C	V	C	V	.	.	.	.	.	.	f	A	A	r	.	.	.	.	.	.	V	.
DH 1210	.	.	r	r	.	f	r	.	.	A	f	.	.	.	.	.	.	.	r	.	.	.	.	r	.	.	.	.	f	.
DH 1209	.	.	.	r	.	r	.	.	r	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.
DH 1208	r	.	.	.	.	r	.	.	r	.	.	.	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	f	.
DF 1206	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DF 1205	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DE 1204	.	.	r	r	.	C	r	.	f	A	f	A	.	.	.	.	.	.	r	r	r	.	.	.	.	.	.	.	f	.
DL 1218	.	.	r	.	.	.	.	.	r	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.
XC 1226	.	.	r	.	.	r	.	.	f	f	r	r	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.
MMV 80	.	.	A	.	.	A	.	.	A	.	.	C	.	.	.	.	.	.	r	r	.	r	f	f	.	.	.	.	.	.
MMV 1201	.	.	C	.	.	C	r	.	C	f	.	r	.	.	.	.	.	.	r	r	r	r	f	f	.	r	.	.	.	.
MMV 79	.	.	C	.	.	f	.	.	C	f	r	C	.	r	r	.	.	.	r	r	r	.	r	f	.	r	.	.	.	.
CO 1241	.	.	r	.	.	r	.	.	C	.	.	f	r	f	r	.	.	r	r	r	r	r	r	r	.	r	.	.	r	.
CO 62	.	r	r	.	.	.	.	r	C	.	.	f	.	f	.	.	.	.	r	r	r	.	.	r	.	.	r	.	r	.
CO 59	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CO 58	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NT 1183	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.
NX 95	.	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
BD 445	.	.	r	.	.	r	f	r	V	r	.	r	.	.	f	.	.	.	f	C	C	.	.	r	.	.	.	.	r	.
Brugge no. 24	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aalter Ste. Marie no. 25	.	.	.	.	.	.	.	.	f	r	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.
no. 24	.	r	.	.	.	.	.	.	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 22	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 21	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vinderhoute no. 119	.	.	.	.	.	.	.	.	r	r	r	.	.	.	.	.	r	.	.	.	.	r	r	r	.	.	.	.	.	.
no. 117	.	.	.	.	.	.	.	.	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.
no. 116	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 111	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 107	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 106	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Gent 24912	.	.	.	.	.	.	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mechelen no. 106	.	.	r	.	.	r	r	.	r	r	r	r	.	.	r	.	.	.	.	.	.	.	r	r	.	.	.	.	r	.
no. 105	.	.	.	.	.	r	r	.	f	f	.	A	.	.	r	r	r	.	r	r	.	r	.	.	.	r	.	.	r	.
Clays of Roubaix																														
LLA 1087	.	.	r	r	.	.	.	.	r	r	.	r	r	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	r	.
KA 1093	.	.	r	r	.	.	r	.	r	f	r	r	.	.	.	r	.	.	.	r	r	.	.	.	.	.	.	.	f	.
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KA 1092	.	.	r	.	.	r	.	.	.	f	r	r	.	.	.	.	.	.	.	r	r	.	.	r	.	.	.	.	r	.
KA 305	.	.	.	.	.	r	.	r	.	r	r	r	r	.	.	.	.	.	r	r	.	.	.	.	.	r	.	.	r	.
KF 1096	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.
KF 1095	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
KF 1094	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Clays of Ieper																														
YA 262	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.
RD 1081	.	.	C	.	.	.	.	.	.	V	.	V	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RD 1080	.	.	r	.	.	.	.	.	.	C	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RA 1079	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	.	.	.	r	.	r	r	.	.	.	r	.
RA 1072	.	.	f	.	.	.	.	.	V	V	A	V	.	.	.	C	.	.	r	f	r	.	r	r	.	.	.	.	r	.
RA 1071	.	.	.	.	.	.	.	r	V	V	A	V	.	.	r	r	.	.	C	C	r	.	C	r	r	f	r	.	f	.
RA 254	.	.	r	.	.	.	.	.	V	V	C	C	.	.	.	r	.	.	r	r	.	.	r	r	.	.	.	.	r	.
RA 253	.	.	r	.	r	.	r	.	A	V	V	V	.	.	r	r	.	.	r	C	.	.	r	r	.	f	.	.	r	.
MMF 33	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NX 92	.	.	r	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NT 1182	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NT 1181	.	r	.	r	.	r	r	.	r	.	r	r	.	.	.	.	.	.	r	r	.	.	.	r	.	.	.	r	r	r
MME 28	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MME 27	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	.	r	.	.	.	.	r	r	.	r	.	.	.	.
CN 54	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CN 52	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NO 1173	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NO 1170	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NX 91	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NX 89	.	.	r	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DA 314	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DA 311	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

	Nodosaria minor	Nonion affine	Nonion graniferum	Nonion scaphum	Nonionella spissa	Planulina burlingtonensis var. neelyi	Pullenia quinqueloba	Rotalia audouini	Rotalia spp.	Siphonina prima	Spiroplectammina adamsi	Turrilina brevispira	Uvigerina batjesi	Alabamina wolterstorffi	Asterigerina bartoniana	Asterigerina wilcoxensis	Bolivina crenulata	Bolivina pulchra	Buliminella sp. cf. B. pulchra	Cancris subconicus	Discorbis spp.	Globotruncana spp.	Gümbelina spp.	Gyroidina octocamerata	Karreriella danica	Planulina stelligera	Reussella elongata	Textularia smithvillensis	Allomorphina sp.	Angulogerina muralis
Lower Tongeren beds		×	×	×				×						×	×					×										
Asse formation		×	×	×	×		×	×	×					×	×		×		×	×		×		×			×			×
Lede formation		×	×	×	×		×	×	×					×	×		×		×	×		×		×			×			×
Brussels formation		×	×	×	×	×		×	×	×				×	×		×		×	×	×	×		×			×		×	×
Panisel formation	×	×		×		×		×	×		×				×					×	×			×						×
Morlanwelz member CI 41	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Mons-en-Pévèle																														
CAG 1252	.	r	.	.	.	.	.	.	.	r	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CAG 1250	.	r	.	.	.	.	.	.	.	C	.	.	C	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CAG 1249	.	f	.	f	.	r	.	r	.	V	.	.	A	r	C	.	.	.	.	C	.	.	.	.	r	.	.	.	.	r
DH 1212	.	A	.	r	.	.	.	.	.	A	.	.	C	.	V	f	.	r	.	C	.	.	.	.	.	.	.	.	.	.
DH 1211	.	C	.	r	.	.	.	.	.	V	[illegible]	r	r	A	C	.	r	C	.	.	.	.	.	r	.	.	.	.	.	.
DH 1210	.	f	.	r	.	.	.	.	.	C	[illegible]	.	C	.	C	.	r	r	.	.	r	r	.	r	r	.	.	.	.	.
DH 1209	.	r	.	.	.	.	.	.	.	r	[illegible]	.	r	.	r	.	.	r	.	.	.	r	.	r	r	r	.	.	r	.
DH 1208	.	.	.	r	.	.	r	.	.	.	.	.	.	r	r	.	.	.	.	.	r	C	r	C	.	C	f	.	.	.
DF 1206	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DF 1205	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DE 1204	.	r	.	.	r	C	.	.	.	r	.	.	r	r	V	.	.	.	.	r	.	.	.	r	.	r	.	.	.	.
DL 1218	.	r	.	.	.	r	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
XC 1226	.	r	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MMV 80	.	r	.	f	r	r	.	r	.	.	.	.	.	.	A	.	.	.	.	V	.	.	.	.	.	.	.	.	r	r
MMV 1201	.	.	.	C	.	f	.	C	r	r	.	.	.	.	A	.	r	.	.	C	.	.	.	.	.	.	r	.	.	C
MMV 79	.	r	.	f	.	f	r	r	.	r	.	.	.	.	A	.	.	r	.	f	.	.	.	.	.	r	.	.	.	r
CO 1241	.	r	.	r	.	C	.	.	.	.	.	.	.	r	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r
CO 62	.	.	r	r	.	r	.	.	.	r	.	.	.	.	r	.	.	r	.	r	.	.	r	.	r	.	.	.	.	.
CO 59	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CO 58	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NT 1183	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.
NX 95	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
BD 445	.	f	.	C	.	C	.	A	.	C	C	.	.	.	A	.	r	C	.	r	.	.	.	.	f	.	r	.	.	.
Brugge no. 24	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aalter Ste. Marie no. 25	.	r	.	r	.	.	.	.	.	.	[illegible]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 24	.	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 22	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 21	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vinderhoute no. 119	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 117	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 116	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 111	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 107	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 106	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gent 24912	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mechelen no. 106	.	r	.	.	.	A	.	.	.	f	.	.	.	.	r	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.
no. 105	.	f	.	.	.	r	.	r	.	.	.	.	r	.	C	.	.	f	.	f	r	.	.	.	.	.	.	.	.	.
Clays of Roubaix																														
LLA 1087	.	r	.	.	.	.	.	.	.	r	[illegible]	r	r	r	.	.	.	.	r	.	r	r	r	r	.	r	r	r	.	.
KA 1093	.	r	.	r	r	.	.	.	.	r	[illegible]	.	r	r	r	r	r	r	.	.	r	.	.	r	r	.	.	f	.	.
[illegible]	.	r	.	.	.	.	.	.	.	r	[illegible]	.	r	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.
KA 1092	.	r	.	.	.	r	.	r	.	f	[illegible]	.	r	r	r	.	.	r	.	r	.	.	.	r	.	.	.	r	.	.
KA 305	.	r	.	r	.	.	.	.	.	r	[illegible]	.	r	r	r	.	r	r	.	.	.	.	.	.	.	r	r	.	.	.
KF 1096	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	r	r	.	.
KF 1095	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
KF 1094	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Clays of Ieper																														
YA 262	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RD 1081	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RD 1080	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RA 1079	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RA 1072	.	V	.	r	r	.	.	.	.	C	[illegible]	r	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RA 1071	.	V	.	C	.	.	.	.	.	r	[illegible]	f	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RA 254	.	V	r	f	.	.	.	.	.	C	[illegible]	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RA 253	.	V	.	f	.	r	.	.	.	f	C	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MMF 33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NX 92	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NT 1182	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NT 1181	.	r	.	r	.	.	r	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MME 28	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MME 27	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CN 54	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CN 52	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NO 1173	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NO 1170	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NX 91	r	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NX 89	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DA 314	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DA 311	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

	Anomalina grosserugosa	Asterigerina sp.	Bolivina carinata	Buliminella sp.	Cibicides carinatus	Dentalina inornata	Discorbis parisiensis	Discorbis perplexa	Entosolenia orbignyana	Epistominella oveyi	Glandulina laevigata	Globorotalia sp.	Globulina gibba var. punctata	Karreria fallax	Lagena globosa	Lamarckina cristellaroides	Nodosaria latejugata	Planulina burlingtonensis	Pseudopolymorphina spatulata	Quinqueloculina seminula	Reussella obtusa	Spiroloculina costigera var. ubiqua	Spiroplectammina carinata	Spiroplectammina carinata var. deperdita	Triloculina gibba	Triloculina trigonula	Textularia agglutinans	Lagena isabella	Pyrulina gutta
Lower Tongeren beds																							×				×		
Asse formation		×	×		×	×	×	×	×	×	×		×		×	×		×		×		×	×	×	×	×	×	×	×
Lede formation	×	×	×		×	×	×		×	×	×	×	×	×	×	×		×		×		×		×	×	×	×	×	×
Brussels formation	×		×		×	×	×	×	×				×		×	×		×				×		×	×	×	×	×	×
Panisel formation	×				×	×				×			×					×		×				×			×		×
Morlanwelz member CI 41	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Mons-en-Pévèle																													
CAG 1252	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CAG 1250	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CAG 1249	.	.	.	.	.	.	.	.	r	.	r	.	.	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r
DH 1212	.	.	.	.	.	.	.	.	.	.	.	r	.	f	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
DH 1211	.	r	.	.	.	r	.	.	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
DH 1210	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.
DH 1209	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DH 1208	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	r	.	.
DF 1206	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DF 1205	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.
DE 1204	.	.	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DL 1218	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
XC 1226	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MMV 80	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	r	f	f	.	.	.	.	.	.	r	.	.
MMV 1201	.	.	r	.	f	.	.	.	.	.	.	.	.	.	.	.	.	f	r	C	r	r	.	.	r	r	.	.	.
MMV 79	r	r	.	.	.	.	r	.	.	.	.	r	.	r	.	.	.	f	.	.	.	.	.	.	.	.	.	.	.
CO 1241	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CO 62	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	r	.
CO 59	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.
CO 58	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.
NT 1183	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NX 95	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
BD 445	.	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	.	r	.	.	.	.	.	.	.	.	.
Brugge no. 24	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aalter Ste. Marie no. 25	.	.	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 22	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 21	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vinderhoute no. 119	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	r	.	.	.	r	.	.	r	.	.
no. 117	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
no. 116	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
no. 111	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 107	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
no. 106	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gent	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gent 24912	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mechelen no. 106	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.
no. 105	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
Clays of Roubaix																													
LLA 1087	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
KA 1093	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
[illegible]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
KA 1092	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
KA 305	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
KF 1096	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
KF 1095	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
KF 1094	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Clays of Ieper																													
YA 262	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RD 1081	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RD 1080	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RA 1079	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RA 1072	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RA 1071	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RA 254	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
RA 253	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MMF 33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NX 92	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NT 1182	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NT 1181	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MME 28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MME 27	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CN 54	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CN 52	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NO 1173	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NO 1170	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NX 91	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NX 89	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DA 314	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DA 311	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

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.

Table 3.

DISTRIBUTION CHART OF THE FORAMINIFERA OF THE PANISEL FORMATION OF BELGIUM

	Ieper formation	Clays of Roncq						Sandy Clays of Anderlecht + Sands of Vlierzele									Sands of Aalter								Brussels formation	Lede formation	Asse formation	Lower Tongeren beds
		DH 1213	RC 1066	RC 1067	RC 1068	no. 105	Vinderhoute no. 104	MMW 85	MMW 84	Vinderhoute no. 102	Mechelen no. 84	MMU 78	no. 46	Asse no. 45	no. 65	Vinderhoute no. 63	CAA 273	CAA 274	CAA 275	CAA 276	CAA 277	CAA 279	CAA 280	CAA 281				
Anomalina acuta	×	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	×	
Cibicides sulzensis	×	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		×	×	
Lenticulina spp.	×	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	×	×
Quinqueloculina seminula	×	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		×	×	
Asterigerina bartoniana	×	.	r	r	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	×	×
Elphidium latidorsatum	×	.	.	.	.	r	r	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	×	
Guttulina irregularis	×	r	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	×	
Rotalia audouini	×	.	.	.	.	.	r	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	×	×	×	×
Anomalina grosserugosa	×	r	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	r	×	×	×	
Cibicides lobatulus	×	r	.	.	.	.	f	.	.	r	r	.	r	r	r	.	.	r	r	C	.	.	r	r	×	×	×	×
Elphidium laeve	×	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	.	C	r	r	×	×	×	
Epistominella oveyi	×	.	.	.	.	.	r	.	.	r	.	.	.	.	.	r	.	.	.	.	.	f	.	.		×	×	
Gyroidina octocamerata	×	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	×	×	×	
Alabamina wolterstorffi	×	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	×	×
Angulogerina muralis	×	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	×	×	×	
Anomalina acuta var. *ypresiensis*	×	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Cibicides proprius	×	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.				
Eponides schreibersi		.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.		×	×	
Globulina gibba	×	.	.	.	.	.	.	.	.	r	.	.	r	r	.	.	.	.	.	.	.	.	.	.	×	×	×	×
Planulina burlingtonensis	×	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	×	×	×	
Planulina burlingtonensis var. *neelyi*	×	.	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	×			
Planulina burlingtonensis var. *tendami*		.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.				
Quinqueloculina carinata		.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	×	×	×	
Rotalia sp. cf. *R. calvezae*		.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×		
Rotalia spp.		.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	×	×		
Elphidium subnodosum	×	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	r	.	.	×	×	×	×
Hanzawaia producta	×	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	r	×	×	×	
Ammodiscus incertus	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.		×		
Cibicides sp. cf. *C. ungerianus*	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	r	.	.	.	×	×	×	
Cibicides westi	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	×	×	×	
Guttulina problema	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	×	×	×	×
Guttulina pulchella	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	×	×	×	
Nonion graniferum	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	×	×	×	×
Pyrulina gutta	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	×	×	×	

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.

Table 4.

DISTRIBUTION CHART OF THE FORAMINIFERA IN THE BRUSSELS FORMATION OF BELGIUM

Unit	Sample	*Bolivina anglica*	*Planulina burlingtonensis*	*Siphonina prima*	*Anomalina acuta*	*Anomalina grosserugosa*	*Asterigerina bartoniana*	*Asterigerina* sp. cf. *A. guerrai*	*Cancris subconicus*	*Cibicides carinatus*	*Cibicides lobatulus*	*Cibicides proprius* var. *acutimargo*	*Cibicides* sp. cf. *C. ungerianus*	*Discorbis quadrata*	*Elphidium laeve*	*Globigerina* spp.	*Globulina gibba*	*Guttulina irregularis*	*Guttulina problema*	*Nonion affine*	*Nonion scaphum*	*Planulina burlingtonensis* var. *neelyi*	*Reussella terquemi*	*Rotalia audouini*	*Rotalia* spp.
Lower Tongeren beds							×		×		×						×		×	×	×			×	
Asse formation		×	×		×	×	×		×	×	×	×	×		×		×	×	×	×	×			×	
Lede formation		×	×		×	×	×		×	×	×	×			×		×	×	×	×	×		×	×	×
? Sands of Lede	BD 1255	.	.	.	.	.	r	.	.	r	A	C	.	.	V	.	r	r	r	.	.	.	.	C	.
Sands of Brussels	THB 1194	.	.	.	.	C	.	.	.	.	C	.	.	.	r	.	.	r	f	.	.	.	.	C	.
Sands of Brussels	THB 1193	.	.	.	.	A	r	.	.	.	C	.	.	.	r	.	r	r	f	.	.	.	.	.	.
Sands of Brussels	THB 1192	.	.	.	.	C	f	.	.	r	V	.	r	.	f	.	r	r	.	.	.	.	r	V	.
Sands of Brussels	THB 1191	.	.	.	.	C	f	.	.	r	C	.	r	.	r	.	r	f	r	.	.	.	r	A	.
Sands of Brussels	THB 1190	.	.	.	.	C	f	.	.	f	C	.	.	.	r	.	r	r	r	.	.	.	r	C	.
Sands of Brussels	THB 1189	.	.	.	.	C	f	.	r	r	A	.	r	.	r	.	f	f	f	.	.	.	.	r	.
Sands of Brussels	NNA 1152	.	.	.	.	C	C	.	.	.	V	.	f	.	C	.	.	.	r	.	.	.	A	V	.
Sands of Brussels	NNA 1151	.	.	.	.	.	.	.	.	f	V	.	.	.	C	.	.	.	.	.	.	.	A	V	.
Sands of Brussels	CC 1197	.	.	.	.	r	.	.	.	.	C	.	.	.	C	.	.	r	.	.	.	.	.	.	.
Sands of Brussels	CM 51	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r
Sands of Brussels	CO 64	.	.	.	.	r	.	.	.	.	f	.	.	.	.	.	.	r	r	.	.	.	.	.	.
Sands of Brussels	CO 56	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	WK 1145	.	.	.	.	.	.	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	r	.
Sands of Brussels	WO 1148	.	.	.	.	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	r	.
Sands of Brussels	WF 1134	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	WG 1135	.	.	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	r	.	.	.	.	r	.
Sands of Brussels	WB 1141	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.
Sands of Brussels	WB 169	.	.	.	.	r	.	.	.	.	f	.	.	.	.	.	.	r	r	.	.	.	.	.	.
Sands of Brussels	WA 1139	.	.	.	.	C	V	.	r	r	V	V	r	.	A	r	f	f	f	r	r	.	.	r	.
Sands of Brussels	WA 166	.	.	.	.	f	V	.	r	C	V	C	C	.	r	.	.	.	.	.	r	.	C	C	.
Sands of Brussels	WA 165	.	.	.	.	f	V	.	.	r	V	A	f	.	C	.	.	.	.	r	.	.	f	C	.
Sands of Brussels	WA 164	.	.	.	.	r	V	.	.	C	V	C	C	.	C	.	.	r	.	r	.	.	C	V	.
Sands of Brussels	LAK 1138	.	.	.	.	f	C	.	r	r	C	.	f	.	f	.	.	.	.	.	.	.	r	r	.
Sands of Brussels	LAJ 1137	.	.	.	.	.	.	.	.	.	C	r	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	LAH 1136	.	.	.	.	C	V	.	.	.	V	C	.	.	C	.	r	r	.	.	.	.	A	V	.
Sands of Brussels	LK 163	.	.	.	.	r	f	.	r	C	A	r	C	.	r	r	.	r	r	r	.	.	r	r	.
Sands of Brussels	NH 1156	.	.	.	.	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	ND 412	.	.	.	.	r	.	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	ND 411	.	.	.	.	C	r	.	.	.	V	A	C	.	C	r	f	r	r	r	.	.	.	.	.
Sands of Brussels	ND 410	.	.	.	.	r	r	r	.	.	V	C	f	.	C	.	r	r	.	.	.	.	.	.	.
Sands of Brussels	NK 1159	.	.	.	r	C	.	.	r	r	A	A	C	.	A	r	r	r	r	r	.	.	.	.	.
Sands of Brussels	NK 1160	.	.	.	r	C	r	r	.	.	V	A	C	.	C	r	r	.	r	r	r	.	.	.	.
Sands of Brussels	NJ 1158	.	.	.	.	f	.	.	.	.	V	C	f	.	C	r	r	r	.	r	r	.	.	.	.
Sands of Brussels	NC 407	.	.	.	.	C	.	.	.	r	V	V	C	.	V	.	r	.	r	.	.	.	r	.	.
Sands of Brussels	NC 406	.	.	.	.	f	.	.	.	C	V	A	C	.	A	r	.	r	r	.	.	.	.	.	.
Sands of Brussels	NC 405	.	.	.	.	f	.	.	.	C	V	V	C	.	V	r	r	r	r	.	.	.	.	r	.
Sands of Brussels	NB 403	.	.	.	.	.	.	.	.	.	f	.	.	.	r	r	.	.	.	.	.	.	.	.	.
Sands of Brussels	NB 401	.	.	.	.	.	.	.	.	.	f	.	.	.	C	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	LS 1119	.	.	.	.	C	.	.	r	.	V	C	f	.	C	r	r	r	.	.	.	.	.	.	.
Sands of Brussels	LR 1118	.	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.	.	.	r	.	.	.	C	.
Sands of Brussels	LAE 1130	.	.	.	.	C	.	.	r	.	C	.	C	.	C	.	.	r	.	.	.	.	.	.	.
Sands of Brussels	LB 125	.	.	.	.	C	.	.	.	.	r	.	f	.	r	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	LB 124	.	.	.	.	r	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	LW 1123	.	.	.	.	r	r	.	r	.	V	r	r	.	r	r	r	.	r	.	.	.	.	.	.
Sands of Brussels	LZ 1126	.	.	.	.	C	r	.	.	f	V	A	r	.	A	r	r	r	.	r	.	r	r	.	.
Sands of Brussels	LY 1125	.	.	.	.	.	.	.	.	.	C	r	.	.	r	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	LAA 1127	.	.	.	.	A	.	.	.	.	A	A	.	.	V	.	r	.	.	.	.	.	.	.	.
Sands of Brussels	BP 1167	.	.	.	.	.	.	.	.	.	C	f	r	.	r	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BP 1166	.	.	.	.	V	r	.	.	.	V	A	C	.	V	r	r	r	r	.	.	.	.	.	.
Sands of Brussels	BP 1165	.	.	.	.	A	.	.	.	.	C	.	f	.	C	r	.	.	.	r	.	.	.	.	.
Sands of Brussels	BP 1164	.	.	.	.	f	.	.	.	.	C	C	.	.	C	r	.	r	r	.	.	.	.	.	.
Sands of Brussels	BA 106	.	.	.	.	.	r	.	.	.	V	V	.	.	V	.	r	r	r	.	.	.	.	.	.
Sands of Brussels	BA 105	.	.	.	.	.	.	r	.	r	V	V	r	.	V	.	r	f	r	.	.	.	.	.	.
Sands of Brussels	BA 104	.	.	.	.	.	r	.	r	.	V	A	r	.	C	r	r	f	.	.	.	.	.	r	.
Sands of Brussels	BA 103	.	.	.	.	.	.	.	.	.	r	.	.	.	f	.	.	r	r	.	.	.	.	.	.
Sands of Brussels	BA 102	.	.	.	.	r	r	.	.	.	A	C	r	.	A	r	.	r	.	r	.	.	r	.	.
Sands of Brussels	BA 101	.	.	.	.	.	.	.	.	r	C	.	.	.	V	.	.	f	.	.	.	.	.	.	.
Sands of Brussels	BA 100	.	.	.	.	.	.	.	.	.	r	.	r	.	f	.	r	r	.	.	.	r	.	.	.
Sands of Brussels	BD 394	.	.	.	.	r	.	.	.	.	r	.	r	.	r	.	.	.	r	.	.	.	.	.	.
Sands of Brussels	BD 393	.	.	.	.	V	r	r	.	.	C	C	f	.	C	r	r	r	.	.	.	.	.	.	.
Sands of Brussels	BD 392	.	.	.	.	V	r	.	r	r	V	r	.	.	A	r	C	C	.	.	.	.	.	.	.
Sands of Brussels	BD 391	.	.	.	.	V	r	.	.	r	V	C	f	.	A	.	f	f	C	.	.	.	.	.	.
Sands of Brussels	BD 390	.	.	.	.	f	.	.	.	r	r	.	.	.	r	.	r	.	r	.	.	.	.	.	.
Sands of Brussels	BD 388	.	.	.	.	.	.	.	.	.	A	.	.	.	C	.	f	f	r	.	.	.	.	.	.
Sands of Brussels	BQ 1168	.	.	.	.	V	r	.	.	.	V	A	f	.	A	r	r	r	.	.	.	.	.	.	.
Sands of Brussels	BR 1169	.	.	.	.	C	.	.	.	.	f	C	f	.	A	.	r	r	r	r	.	.	.	.	.
Sands of Brussels	BC 117	.	.	.	.	f	.	r	.	.	V	f	.	.	V	.	.	C	r	.	.	.	.	.	.
Sands of Brussels	BC 116	.	.	.	.	r	r	.	.	.	A	r	.	.	C	.	.	r	.	.	.	.	.	.	.
Sands of Brussels	BC 115	.	.	.	r	r	.	.	.	.	V	C	r	.	A	r	.	C	r	.	.	.	.	.	.
Sands of Brussels	BC 114	.	.	.	.	r	.	.	r	.	V	C	r	.	A	.	r	f	f	.	.	.	.	.	.
Sands of Brussels	BC 113	.	.	.	.	r	r	r	.	.	A	C	r	.	A	r	.	C	f	.	.	.	.	.	.
Basal strata	CO 1240	r	C	r	A	r	C	C	C	r	C	r	r	r	f	r	r	f	C	r	C	V	r	r	r
Panisel formation			×		×	×	×		×	×	×	×	×		×		×	×	×	×	×	×		×	×
Ieper formation		×	×	×	×	×	×	×	×	×	×	×	×		×		×	×	×	×	×	×		×	×

Unit	Sample	*Alabamina wolterstorffi*	*Angulogerina abbreviata*	*Angulogerina muralis*	*Angulogerina* sp. cf. *A. ovata*	*Anomalina auris*	*Bolivina brabantica*	*Bolivina carinata*	*Bolivina crenulata*	*Bulimina parisiensis*	*Bulimina tenuistriata*	*Buliminella striatopunctata*	*Buliminella* sp. cf. *B. pulchra*	*Cibicides westi*	*Cibicides* sp. cf. *C. mauricensis*	*Cibicides* sp. cf. *C. tallahatensis*	*Cycloloculina* sp. cf. *C. punctata*	*Dentalina elegans*	*Dentalina inornata*	*Discorbis humilis*	*Discorbis limbata*	*Discorbis parisiensis*	*Discorbis perplexa*	*Discorbis vesicularis*	*Discorbis* sp. cf. *D. ferganensis*	*Discorbis* spp.	*Elphidium hiltermanni*	*Elphidium latidorsatum*	*Elphidium subnodosum*	*Entosolenia orbignyana*	*Entosolenia* spp.	*Eponides polygonus*	*Eponides toulmini*	*Globotruncana* spp.	*Globulina gibba* var. *punctata*
Lower Tongeren beds		×																											×						
Asse formation		×	×	×		×		×	×	×	×		×	×				×	×		×	×	×	×			×	×	×	×		×	×	×	×
Lede formation		×	×	×		×		×	×	×	×	×	×	×	×		×	×	×		×	×		×	×		×	×	×	×		×	×	×	×
? Sands of Lede	BD 1255	.	.	.	.	.	.	.	r	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	C	.	.	.	f	.	.	.	.	.	.
Sands of Brussels	THB 1194	r	.	.	.	r	r	.	.	r	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.
Sands of Brussels	THB 1193	r	r	.	.	r	r	.	.	r	.	.	.	C	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	f	.	.	r
Sands of Brussels	THB 1192	r	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	r	r	.	.
Sands of Brussels	THB 1191	r	r	r	.	r	r	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	THB 1190	r	.	r	.	.	r	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	r	.	.	.
Sands of Brussels	THB 1189	r	.	r	r	r	.	.	.	r	.	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	r	r	.	r
Sands of Brussels	NNA 1152	.	.	.	.	.	.	.	r	.	.	r	f	.	.	V	.	.	.	.	r	.	.	r	.	.	.	.	.	.	.	r	.	.	.
Sands of Brussels	NNA 1151	.	.	C	.	r	r	r	r	.	f	r	.	A	f	V	.	.	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	.	.
Sands of Brussels	CC 1197	r	.	.	r	.	.	.	r	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.
Sands of Brussels	CM 51	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	CO 64	.	.	.	.	r	.	.	.	.	.	.	.	C	C	r	.	.	.	.	.	.	r	.	.	f	.	.	.	.	.	r	.	.	.
Sands of Brussels	CO 56	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	WK 1145	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	WO 1148	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	WF 1134	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	WG 1135	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	WB 1141	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	WB 169	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.
Sands of Brussels	WA 1139	r	r	.	.	.	f	r	r	r	.	.	.	V	C	.	r	r	r	.	r	.	r	.	.	.	.	r	.	r	.	r	r	.	.
Sands of Brussels	WA 166	.	r	.	r	.	r	.	.	.	.	.	.	f	.	.	.	.	.	.	r	.	.	r	.	.	.	.	r	.	.	.	.	.	.
Sands of Brussels	WA 165	r	r	r	r	.	r	r	r	.	.	.	.	C	.	.	.	.	.	.	r	.	.	.	.	r	.	.	f	r	.	r	r	.	.
Sands of Brussels	WA 164	.	.	.	f	.	.	.	.	r	.	.	.	f	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	r	r	.	.
Sands of Brussels	LAK 1138	r	r	.	.	.	r	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
Sands of Brussels	LAJ 1137	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
Sands of Brussels	LAH 1136	r	r	.	.	.	r	r	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r
Sands of Brussels	LK 163	.	.	r	.	.	.	f	.	r	.	.	.	.	.	.	.	.	.	.	r	.	r	r	.	.	.	.	.	.	r	r	.	.	.
Sands of Brussels	NH 1156	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	ND 412	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	ND 411	r	.	.	r	.	.	.	.	.	.	.	.	A	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	ND 410	r	.	.	r	.	r	.	.	.	.	.	.	A	.	.	.	r	.	r	.	.	r	.	.	.	.	.	.	.	.	r	r	.	.
Sands of Brussels	NK 1159	r	.	.	r	.	.	.	.	.	.	.	.	A	.	.	.	.	.	r	r	.	.	.	.	.	.	.	f	.	.	.	r	.	.
Sands of Brussels	NK 1160	r	.	.	.	.	.	r	.	.	.	.	.	A	.	.	.	.	.	.	r	.	.	.	.	.	.	r	f	.	.	r	.	.	.
Sands of Brussels	NJ 1158	.	.	r	r	.	r	.	.	.	r	.	.	A	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	NC 407	r	.	.	.	.	r	.	.	.	.	.	.	A	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.
Sands of Brussels	NC 406	r	.	.	r	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	NC 405	.	.	.	r	r	.	.	.	.	.	.	.	C	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.
Sands of Brussels	NB 403	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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Sands of Brussels	LZ 1126	.	r	.	.	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.
Sands of Brussels	LY 1125	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	LAA 1127	.	r	.	r	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
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Sands of Brussels	BP 1166	r	.	r	f	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	r	.	.	.	r	.	.	.	r	.	.
Sands of Brussels	BP 1165	r	.	.	.	.	r	.	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.
Sands of Brussels	BP 1164	r	.	.	r	.	r	.	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	r	.	.	.
Sands of Brussels	BA 106	r	.	.	r	.	.	r	.	.	.	.	.	A	C	.	.	r	.	.	r	.	.	.	.	.	.	.	r	.	.	.	.	.	r
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Sands of Brussels	BD 392	r	.	.	r	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BD 391	.	.	.	r	.	r	.	.	r	.	.	.	C	.	.	.	.	.	.	r	.	.	.	.	.	.	.	f	.	r	r	.	.	.
Sands of Brussels	BD 390	.	.	.	.	r	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BD 388	.	.	.	.	.	.	.	.	.	.	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BQ 1168	r	.	r	r	.	r	r	r	.	.	.	.	A	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BR 1169	r	.	.	r	.	r	.	.	.	.	.	.	A	.	.	.	.	r	.	.	.	.	.	f	.	.	.	r	.	.	.	.	.	.
Sands of Brussels	BC 117	r	.	.	r	.	.	.	r	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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Sands of Brussels	BC 114	.	.	.	r	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	r	.
Sands of Brussels	BC 113	r	.	.	.	.	.	.	.	.	.	.	.	C	r	.	.	.	.	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.
Basal strata	CO 1240	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Panisel formation		×		×										×					×						×	×	×	×	×			×			×
Ieper formation		×	×	×		×		×		×			×	×				×	×		×	×				×		×	×	×			×	×	×

Unit	Sample	*Globulina gravida*	*Guttulina lactea*	*Guttulina pulchella*	*Gyroidina octocamerata*	*Gyroidinella magna*	*Hanzawaia producta*	*Lagena globosa*	*Lagena isabella*	*Lagena* spp.	*Lamarckina cristellaroides*	*Lenticulina* spp.	*Nonion graniferum*	*Nonionella spissa*	*Patellina nitida*	*Pseudopolymorphina spatulata*	*Pyrgo bulloides*	*Pyrulina gutta*	*Pyrulina thouini*	*Rotalia propinqua*	*Rotalia* sp. cf. *R. calvezae*	*Sigmomorphina semitecta*	*Sigmomorphina* sp. cf. *S. bornemanni*	*Siphonina lamarckana*	*Spirillina* spp.	*Spiroloculina costigera* var. *ubiqua*	*Spiroplectammina carinata* var. *deperdita*	*Textularia agglutinans*	*Textularia agglutinans* var. *nalinnesensis*	*Triloculina angularis*	*Triloculina gibba*	*Triloculina trigonula*	*Valvulina* spp.	*Allomorphina* spp.	*Tubulogenerina tubulifera*
Lower Tongeren beds												×																×							
Asse formation		×	×	×	×		×	×	×	×	×	×	×	×				×	×	×			×	×	×	×	×	×		×	×	×			×
Lede formation		×	×	×	×		×	×	×		×	×	×	×			×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×		
? Sands of Lede	BD 1255	r	.	.	r	.	A	.	.	.	.	.	.	.	.	.	.	r	.	.	r	.	.	.	.	.	r	.	.	.	r	.	.	.	.
Sands of Brussels	THB 1194	.	.	r	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.
Sands of Brussels	THB 1193	r	r	r	r	.	f	.	.	.	.	r	.	.	.	.	.	r	.	.	.	.	r	r	r	.	.	.	r	.	.	.	.	.	.
Sands of Brussels	THB 1192	.	.	.	.	r	f	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	A	.	.	.	.	.	.
Sands of Brussels	THB 1191	.	.	r	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	.	.	.	V	.	.	.	.	.	.
Sands of Brussels	THB 1190	r	.	.	.	r	f	.	.	.	.	r	.	.	r	.	.	.	.	.	.	r	r	r	r	.	.	.	V	.	.	.	r	.	.
Sands of Brussels	THB 1189	r	r	r	r	r	r	r	.	.	.	r	.	.	.	r	.	.	r	.	.	.	f	r	.	.	.	.	f	.	.	.	.	.	.
Sands of Brussels	NNA 1152	.	.	.	.	.	V	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	NNA 1151	.	.	.	r	.	V	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	CC 1197	.	r	.	r	.	C	.	.	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	CM 51	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	CO 64	.	.	.	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.	.
Sands of Brussels	CO 56	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	WK 1145	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.
Sands of Brussels	WO 1148	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	WF 1134	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.
Sands of Brussels	WG 1135	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.
Sands of Brussels	WB 1141	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	WB 169	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	WA 1139	r	r	r	C	.	V	r	r	r	.	r	.	r	r	r	.	.	r	.	.	r	r	r	r	.	.	.	.	.	.	.	.	.	r
Sands of Brussels	WA 166	.	.	r	.	.	A	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r
Sands of Brussels	WA 165	.	r	r	r	.	A	.	.	.	.	.	.	.	.	.	.	r	r	.	r	.	.	r	.	.	.	.	.	.	.	.	.	.	r
Sands of Brussels	WA 164	.	r	.	r	.	A	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	r	.	.	.	.	.	.	.	.	.	.	r
Sands of Brussels	LAK 1138	.	r	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	LAJ 1137	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.
Sands of Brussels	LAH 1136	.	.	.	r	.	C	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r
Sands of Brussels	LK 163	.	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	f	.	.	.	r	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	NH 1156	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	ND 412	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	ND 411	r	r	r	r	.	C	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	ND 410	.	.	r	r	.	C	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	NK 1159	r	r	.	r	.	C	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	NK 1160	r	.	r	r	.	C	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	NJ 1158	r	r	.	r	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	NC 407	r	.	.	r	.	V	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	NC 406	r	r	.	r	.	V	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	NC 405	r	r	.	r	.	V	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	NB 403	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	NB 401	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.
Sands of Brussels	LS 1119	.	.	.	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	LR 1118	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	LAE 1130	r	.	.	r	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
Sands of Brussels	LB 125	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	LB 124	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	LW 1123	.	.	.	r	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.
Sands of Brussels	LZ 1126	r	r	.	.	.	C	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	LY 1125	.	.	.	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	LAA 1127	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BP 1167	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BP 1166	r	.	r	r	.	V	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BP 1165	r	.	r	r	.	r	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	r	.	.	.	.	.	.	.	.
Sands of Brussels	BP 1164	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BA 106	r	r	r	C	.	V	.	.	.	.	.	.	.	.	.	.	f	r	.	.	r	.	.	.	.	.	f	.	.	.	.	.	.	.
Sands of Brussels	BA 105	r	r	.	r	.	V	.	.	.	.	.	.	.	.	.	.	r	r	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BA 104	.	f	r	r	.	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BA 103	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BA 102	r	.	r	r	.	A	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Sands of Brussels	BA 101	.	r	.	r	.	V	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BA 100	.	r	.	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BD 394	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BD 393	r	.	.	r	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	r	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BD 392	r	r	r	f	.	r	.	.	.	.	.	r	.	.	.	r	r	r	.	.	.	.	r	.	.	r	.	.	.	.	.	.	.	.
Sands of Brussels	BD 391	r	r	r	f	.	C	.	.	.	.	.	.	.	.	.	.	f	r	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Sands of Brussels	BD 390	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BD 388	r	.	r	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BQ 1168	r	r	r	f	.	C	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BR 1169	.	.	.	r	.	V	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BC 117	.	r	.	r	.	V	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BC 116	.	r	.	r	.	C	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BC 115	.	C	.	r	.	V	.	.	r	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BC 114	.	f	.	r	.	V	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	BC 113	f	r	.	r	.	V	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Basal strata	CO 1240	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Panisel formation		×	×	×	×		×			×		×	×					×	×		×	×					×	×							
Ieper formation				×	×		×	×	×		×	×	×	×		×										×	×	×			×	×		×	

Unit	Sample	*Asterigerina* sp. cf. *A. glabra*	*Cibicides dutemplei*	*Cibicides* sp. cf. *C. tenellus*	*Quinqueloculina carinata*	*Quinqueloculina impressa*	*Quinqueloculina juleana*	*Reussella elongata*	*Reussella limbata*	*Trifarina wilcoxensis*
Lower Tongeren beds			×							
Asse formation		×	×	×	×	×	×	×	×	×
Lede formation		×	×	×	×	×	×	×	×	×
? Sands of Lede	BD 1255	C	C	f	r	r	r	r	r	r
Sands of Brussels	THB 1194	.	.	.	.	.	.	.	.	.
Sands of Brussels	THB 1193	.	.	.	.	.	.	.	.	.
Sands of Brussels	THB 1192	.	.	.	.	.	.	.	.	.
Sands of Brussels	THB 1191	.	.	.	.	.	.	.	.	.
Sands of Brussels	THB 1190	.	.	.	.	.	.	.	.	.
Sands of Brussels	THB 1189	.	.	.	.	.	.	.	.	.
Sands of Brussels	NNA 1152	.	.	.	.	.	.	.	.	.
Sands of Brussels	NNA 1151	.	.	.	.	.	.	.	.	.
Sands of Brussels	CC 1197	.	.	.	.	.	.	.	.	.
Sands of Brussels	CM 51	.	.	.	.	.	.	.	.	.
Sands of Brussels	CO 64	.	.	.	.	.	.	.	.	.
Sands of Brussels	CO 56	.	.	.	.	.	.	.	.	.
Sands of Brussels	WK 1145	.	.	.	.	.	.	.	.	.
Sands of Brussels	WO 1148	.	.	.	.	.	.	.	.	.
Sands of Brussels	WF 1134	.	.	.	.	.	.	.	.	.
Sands of Brussels	WG 1135	.	.	.	.	.	.	.	.	.
Sands of Brussels	WB 1141	.	.	.	.	.	.	.	.	.
Sands of Brussels	WB 169	.	.	.	.	.	.	.	.	.
Sands of Brussels	WA 1139	.	.	.	.	.	.	.	.	.
Sands of Brussels	WA 166	.	.	.	.	.	.	.	.	.
Sands of Brussels	WA 165	.	.	.	.	.	.	.	.	.
Sands of Brussels	WA 164	.	.	.	.	.	.	.	.	.
Sands of Brussels	LAK 1138	.	.	.	.	.	.	.	.	.
Sands of Brussels	LAJ 1137	.	.	.	.	.	.	.	.	.
Sands of Brussels	LAH 1136	.	.	.	.	.	.	.	.	.
Sands of Brussels	LK 163	.	.	.	.	.	.	.	.	.
Sands of Brussels	NH 1156	.	.	.	.	.	.	.	.	.
Sands of Brussels	ND 412	.	.	.	.	.	.	.	.	.
Sands of Brussels	ND 411	.	.	.	.	.	.	.	.	.
Sands of Brussels	ND 410	.	.	.	.	.	.	.	.	.
Sands of Brussels	NK 1159	.	.	.	.	.	.	.	.	.
Sands of Brussels	NK 1160	.	.	.	.	.	.	.	.	.
Sands of Brussels	NJ 1158	.	.	.	.	.	.	.	.	.
Sands of Brussels	NC 407	.	.	.	.	.	.	.	.	.
Sands of Brussels	NC 406	.	.	.	.	.	.	.	.	.
Sands of Brussels	NC 405	.	.	.	.	.	.	.	.	.
Sands of Brussels	NB 403	.	.	.	.	.	.	.	.	.
Sands of Brussels	NB 401	.	.	.	.	.	.	.	.	.
Sands of Brussels	LS 1119	.	.	.	.	.	.	.	.	.
Sands of Brussels	LR 1118	.	.	.	.	.	.	.	.	.
Sands of Brussels	LAE 1130	.	.	.	.	.	.	.	.	.
Sands of Brussels	LB 125	.	.	.	.	.	.	.	.	.
Sands of Brussels	LB 124	.	.	.	.	.	.	.	.	.
Sands of Brussels	LW 1123	.	.	.	.	.	.	.	.	.
Sands of Brussels	LZ 1126	.	.	.	.	.	.	.	.	.
Sands of Brussels	LY 1125	.	.	.	.	.	.	.	.	.
Sands of Brussels	LAA 1127	.	.	.	.	.	.	.	.	.
Sands of Brussels	BP 1167	.	.	.	.	.	.	.	.	.
Sands of Brussels	BP 1166	.	.	.	.	.	.	.	.	.
Sands of Brussels	BP 1165	.	.	.	.	.	.	.	.	.
Sands of Brussels	BP 1164	.	.	.	.	.	.	.	.	.
Sands of Brussels	BA 106	.	.	.	.	.	.	.	.	.
Sands of Brussels	BA 105	.	.	.	.	.	.	.	.	.
Sands of Brussels	BA 104	.	.	.	.	.	.	.	.	.
Sands of Brussels	BA 103	.	.	.	.	.	.	.	.	.
Sands of Brussels	BA 102	.	.	.	.	.	.	.	.	.
Sands of Brussels	BA 101	.	.	.	.	.	.	.	.	.
Sands of Brussels	BA 100	.	.	.	.	.	.	.	.	.
Sands of Brussels	BD 394	.	.	.	.	.	.	.	.	.
Sands of Brussels	BD 393	.	.	.	.	.	.	.	.	.
Sands of Brussels	BD 392	.	.	.	.	.	.	.	.	.
Sands of Brussels	BD 391	.	.	.	.	.	.	.	.	.
Sands of Brussels	BD 390	.	.	.	.	.	.	.	.	.
Sands of Brussels	BD 388	.	.	.	.	.	.	.	.	.
Sands of Brussels	BQ 1168	.	.	.	.	.	.	.	.	.
Sands of Brussels	BR 1169	.	.	.	.	.	.	.	.	.
Sands of Brussels	BC 117	.	.	.	.	.	.	.	.	.
Sands of Brussels	BC 116	.	.	.	.	.	.	.	.	.
Sands of Brussels	BC 115	.	.	.	.	.	.	.	.	.
Sands of Brussels	BC 114	.	.	.	.	.	.	.	.	.
Sands of Brussels	BC 113	.	.	.	.	.	.	.	.	.
Basal strata	CO 1240	.	.	.	.	.	.	.	.	.
Panisel formation					×					
Ieper formation						×		×		

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,	*Pyrulina fusiformis*, and
Gyroidina soldanii,	*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,	*Asterigerina bartoniana*, and
Alabamina wolterstorffi,	*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.

Table 5.

DISTRIBUTION CHART OF FORAMINIFERA IN THE LEDE FORMATION OF BELGIUM

Alveolina spp.; *Angulogerina abbreviata*; *Angulogerina muralis*; *Anomalina auris*; *Anomalina grosserugosa*; *Asterigerina bartoniana*; *Asterigerina* sp. cf. *A. glabra*; *Articulina pseudosulcata*; *Bifarina selseyensis*; *Bolivina carinata*; *Bolivina crenulata*; *Bulimina tenuistriata*; *Buliminella* sp. cf. *B. pulchra*; *Cancris subconicus*; *Cibicides carinatus*; *Cibicides dutemplei*; *Cibicides lobatulus*; *Cibicides propinquus* var. *acutimargo*; *Cibicides westi*; *Cibicides* sp. cf. *C. tenellus*; *Clavulina parisiensis*; *Cornuspira involvens*; *Dentalina inornata*; *Discorbis vesicularis*; *Discorbis* sp. cf. *D. fergusonensis*; *Elphidium laeve*; *Elphidium latidorsatum*; *Epistominella acutimargo*; *Eponides polygonus*; *Eponides schreibersi*; *Glandulina laevigata*; *Globulina gibba*; *Globulina gibba* var. *punctata*; *Globulina gravida*; *Guttulina irregularis*; *Guttulina problema*; *Guttulina pulchella*; *Gyroidina octocamerata*; *Hanzawaia producta*; *Hastigerina micra*; *Lagena globosa*; *Lagena isabella*; *Lamarckina cristellaroides*; *Miliola saxorum*; *Miliolinella oblonga*; *Nonion scaphum*; *Pyrulina gutta*; *Pyrulina thouini*; *Quinqueloculina carinata*; *Quinqueloculina costata*; *Quinqueloculina impressa*; *Quinqueloculina juleana*; *Quinqueloculina ludwigi*; *Quinqueloculina seminula*; *Quinqueloculina striata*; *Reussella elongata*; *Reussella limbata*; *Reussella terquemi*; *Rotalia audouini*; *Rotalia* sp. cf. *R. calcezae*; *Rotalia* spp.; *Sigmoilina tenuis*; *Sigmomorphina semitecta*; *Sigmomorphina* sp. cf. *S. bornemanni*; *Spiroloculina bicarinata*; *Spiroloculina costigera* var. *ubiqua*; *Spiroloculina tricarinata* var. *belgica*; *Spiroplectammina carinata* var. *deperdita*; *Textularia agglutinans*; *Trifarina wilcoxensis*; *Triloculina angularis*; *Triloculina gibba*; *Triloculina trigonula*; *Triloculina trigonula* var. *inflata*; *Alabamina wolterstorffi*; *Ammodiscus incertus*; *Angulogerina abbreviata* var. *tubulifera*; *Anomalina acuta*; *Articulina flandrica*; *Articulina laevigata*; *Articulina ornaticollis*; *Articulina contracta*; *Articulina terquemi*; *Asterigerina* sp.; *Bolivina anglica*; *Bulimina parisiensis*; *Buliminella striatopunctata*; *Cancris auriculus* var. *primitivus*; *Cibicides sulzensis*; *Cibicides* sp. cf. *C. ungerianus*; *Cornuspira bornemanni*; *Cycloloculina* sp. cf. *C. punctata*; *Dendritina depressa*; *Dentalina elegans*; *Elphidium hiltermanni*; *Entosolenia marginata*; *Entosolenia orbignyana*; *Epistominella oveyi*; *Eponides toulmini*; *Fabularia bella*; *Globigerina* sp. cf. *G. angustiumbilicata*; *Globorotalia* spp.; *Globotruncana* spp.; *Globulina gibba* var. *myristiformis*; *Guttulina lactea*; *Karreria fallax*; *Lenticulina* spp.; *Lenticulina (Astacolus) decorata*; *Miliola birostris*; *Miliola prisca*; *Miliola prisca* var. *strigillata*; *Miliola prisca* var. *terquemi*; *Nonion affine*; *Nonion graniferum*; *Nonionella spissa*; *Nonionella wemmelensis*; *Orbitolites complanatus*; *Planulina burlingtonensis*; *Pullenia quinqueloba*; *Pyrgo bulloides*; *Quinqueloculina crassa*; *Renulina opercularis*; *Robertina germanica*; *Rotalia propingua*; *Seabrookia lagenoides*; *Spiroloculina costigera*; *Spiroloculina costigera* var. *carinata*; *Spiroloculina costigera* var. *nuda*; *Spiroloculina tricarinata*; *Spiroloculina tricarinata* var. *angulifera*; *Spirillina* spp.; *Spirophthalmidium alata*; *Siphonina lamarckana*; *Textularia agglutinans* var. *nalinnensis*; *Triloculina propinqua*; *Uvigerina farinosa*; *Valvulina* spp.; *Vertebralina laevigata*; *Spiroloculina canaliculata*.

Lower Tongeren beds	[illegible]
Asse formation	[illegible]
Upper Bracklesham beds	[illegible]
Sand of Lede: Asse no. 37	[illegible]
no. 38	[illegible]
no. 39	[illegible]
no. 40	[illegible]
no. 41	[illegible]
no. 42	[illegible]
no. 43	[illegible]
no. 44	[illegible]
Brussegem no. 28	[illegible]
no. 29	[illegible]
no. 33	[illegible]
Hoboken no. 16	[illegible]
no. 19	[illegible]
Lokeren no. 26	[illegible]
no. 27	[illegible]
no. 29	[illegible]
Mechelen no. 60	[illegible]
no. 62	[illegible]
no. 67	[illegible]
no. 70	[illegible]
ZA 583	[illegible]
ZG 1025	[illegible]
ZB 1021*a*	[illegible]
ZB 1022	[illegible]
ZD 340	[illegible]
ZD 342	[illegible]
ZD 343	[illegible]
ZD 1011	[illegible]
ZD 1012	[illegible]
ZD 1013	[illegible]
ZD 1014	[illegible]
ZD 1015	[illegible]
ZD 1016	[illegible]
ZD 1017	[illegible]
Lede 2-V	[illegible]
MC 1040	[illegible]
BM 1036	[illegible]
BM 1037	[illegible]
BL 1035	[illegible]
BD 1258	[illegible]
LV 1122	[illegible]
LAC 1128	[illegible]
BD 444	[illegible]
(Basal strata) BD 1257	[illegible]
BD 1256	[illegible]
BE 446	[illegible]
Lutetian — Paris Basin	[illegible]
Brussels formation	[illegible]
Panisel formation	[illegible]
Ieper formation	[illegible]

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.

Table 6.

DISTRIBUTION CHART OF THE FORAMINIFERA OF THE ASSE FORMATION OF BELGIUM

Alveolina spp. — Articulina ornaticollis — Dendritina depressa — Discorbis perplexa — Discorbis vesicularis — Globulina gibba var. myristiformis — Miliolinella oblonga — Orbitolites complanatus — Spiroloculina costigera — Spiroloculina tricarinata var. angulifera

Articulina flandrica — Articulina pseudosulcata — Bolivina carinata — Bulimina tenuistriata — Cibicides westi — Clavulina parisiensis — Cornuspira bornemanni — Elphidium hiltermanni — Entosolenia orbignyana — Epistomina elegans — Epistominella oveyi — Miliola prisca var. strigillata — Miliola prisca var. terquemi — Nonion graniferum — Nonionella wemmelensis — Pyrulina gutta — Quinqueloculina bicarinata — Sigmomorphina sp. cf. S. bornemanni — Spiroloculina bicarinata — Spiroloculina costigera var. nuda — Spiroloculina costigera var. ubiqua — Triloculina trigonula var. inflata — (?) Vertebralina sp.

Angulogerina abbreviata — Angulogerina abbreviata var. tubulifera — Angulogerina muralis — Anomalina acuta — Articulina laevigata — Articulina terquemi — Asterigerina bartoniana — Asterigerina sp. cf. A. glabra — Asterigerina sp. — Bifarina selseyensis — Bolivina cookei — Bolivina crenulata — Bolivina anglica — Cancris auriculus var. primitivus — Cancris subconicus — Cibicides carinatus — Cibicides dutemplei — Cibicides lobatulus — Cibicides proprius var. acutimargo — Cibicides pygmeus — Cibicides sulzensis — Cibicides sp. cf. C. tenellus — Cibicides sp. cf. C. ungerianus — Dentalina elegans — Dentalina inornata — Elphidium laeve — Elphidium subnodosum — Epistominella acutimargo — Eponides polygonus — Eponides schreibersi — Fabularia bella — Globigerina sp. cf. G. angustiumbilicata — Globulina gibba — Globulina gibba var. punctata — Globulina gravida — Globulina gravida var. lineata — Guttulina irregularis — Guttulina problema — Guttulina pulchella — Hanzawaia producta — Hastigerina micra — Karreriella siphonella — Lamarckina cristellaroides — Lenticulina (Astacolus) decorata — Lenticulina spp. — Miliola prisca — Miliola saxorum — Nonion affine — Nonion scaphum — Planulina burlingtonensis — Pseudoclavulina sp. cf. P. cocoaensis — Pyrulina thouini — Quinqueloculina carinata — Quinqueloculina costata — Quinqueloculina impressa — Quinqueloculina juleana — Quinqueloculina ludwigi — Quinqueloculina seminula — Reussella elongata — Reussella limbata — Robertina germanica — [illegible] — Sigmoilina tenuis — Siphonina lamarckana — Spiroloculina canaliculata — Spiroloculina tricarinata — Spiroloculina tricarinata var. belgica — Spiroplectammina carinata var. deperdita — Textularia agglutinans — Trifarina wilcoxensis — Triloculina angularis — Triloculina gibba — Triloculina trigonula — Uvigerina farinosa — Uvigerina spinicostata

Anomalina auris — Articulina contracta — Buliminella sp. cf. B. pulchra — Cornuspira involvens — Dimorphina sp. — Discorbis limbata — Discorbis parisiensis — Elphidium latidorsatum — Pyrgo elongata — Spirillina spp. — Spirophthalmidium alata — Tubulogenerina tubulifera

Alabamina wolterstorffi — Bulimina ovata — Dentalina sp. cf. D. baltica — Dentalina sp. cf. D. ewaldi — Entosolenia marginata — Eponides umbonatus — Glandulina laevigata — Guttulina lactea — Gyroidina octocamerata — Lagena globosa — Lagena striata — Lagena spp. — Loxostomum teretum — Nodosaria ludwigi — Nonionella spissa — Pullenia quinqueloba — Spiroplectammina carinata

Eponides toulmini — Gyroidina sp. cf. G. soldanii — Lagena isabella — Seabrookia lagenoides

Lower Tongeren beds: × Nonion graniferum, Asterigerina bartoniana, Cancris subconicus, Cibicides dutemplei, Cibicides lobatulus, Elphidium subnodosum, Globulina gibba, Guttulina problema, Lenticulina spp., Nonion affine, Nonion scaphum, Textularia agglutinans, Alabamina wolterstorffi, Spiroplectammina carinata, Gyroidina sp. cf. G. soldanii

Barton beds: × Miliolinella oblonga, Nonion graniferum, Quinqueloculina bicarinata, Triloculina trigonula var. inflata, Asterigerina sp., Cibicides lobatulus, Cibicides pygmeus, Cibicides sulzensis, Cibicides sp. cf. C. tenellus, Cibicides sp. cf. C. ungerianus, Elphidium laeve, Elphidium subnodosum, Epistominella acutimargo, Globigerina sp. cf. G. angustiumbilicata, Globulina gibba, Globulina gibba var. punctata, Guttulina irregularis, Guttulina problema, Lenticulina spp., Nonion affine, Pyrulina thouini, Quinqueloculina carinata, Quinqueloculina costata, Quinqueloculina impressa, Quinqueloculina juleana, Quinqueloculina ludwigi, Quinqueloculina seminula, Robertina germanica, Spiroloculina canaliculata, Elphidium latidorsatum, Glandulina laevigata, Lagena striata, Pullenia quinqueloba

Rows (samples, top to bottom):

Lower Tongeren beds
Barton beds

Clays of Asse:
Asse no. 29 — no. 30 — Brussegem no. 15 — no. 16 — Hoboken no. 12 — Lokeren no. 19 — no. 20 — no. 24 — Mechelen no. 50 — no. 51 — BRB 237 — BRB 238 — BRB 241 — BRB 247 — BRB 1057 — BRB 1054 — BRB 1055 — BRB 1056 — ZA 1242 — ZA 1243 — ZA 1244 — (Basal strata) BW 1273

Sands of Wemmel:
Wemmel 10 — 12,50 m — 10 — 13,00 m — 10 — 14,00 m — 10 — 14,50 m — 10 — 15,00 m — 14 — 5,00 m — 14 — 5,50 m — 14 — 6,00 m — 14 — 6,50 m — 14 — 7,00 m — 14 — 9,50 m — 14 — 10,00 m — 14 — 10,50 m — 14 — 11,00 m — 16 — 6,00 m — 16 — 7,00 m — 16 — 9,00 m — 48 — 22,00 m — 48 — 23,50 m — Mechelen no. 54 — Hoboken no. 13 — no. 14 — no. 15 — Heist-op-den-Berg 121,50 m — 122,00 m — 122,50 m — 123,00 m — 123,50 m — 124,00 m — 124,50 m — 125,50 m — 126,00 m — 126,50 m — 127,00 m — 127,50 m — 128,00 m — 128,50 m — Brussegem no. 17 — no. 18 — no. 19 — no. 20 — no. 21 — no. 22 — no. 23 — no. 24 — Asse no. 32 — no. 33 — BV 1272 — BV 1271 — BV 1270 — BV 1269 — BT 1266 — BS 1260 — BS 1259

(Basal strata):
Mechelen no. 55 — Brussegem no. 25 — no. 26 — no. 27 — Asse no. 34 — no. 35 — Heist-op-den-Berg 129,00 m — 129,50 m

Lede formation
Brussels formation
Panisel formation
Ieper formation

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.

Table 7.

DISTRIBUTION CHART OF THE FORAMINIFERA OF THE LONDON CLAY, THE UPPER BRACKLESHAM BEDS AND THE BARTON BEDS, OF HAMPSHIRE, ENGLAND

			Alabamina obtusa	*Alabamina wilcoxensis*	*Anomalina acuta*	*Anomalina acuta* var. *ypresiensis*	*Cibicides proprius*	*Cibicides proprius* var. *acutimargo*	*Gyroidina angustiumbilicata*	*Karreriella danica*	*Lenticulina (Astacolus)* sp. cf. *L. decorata*	*Nonion scaphum*	*Siphonina prima*	*Spiroplectammina adamsi*	*Textularia smithvillensis*	*Cibicides sulzensis*	*Cibicides lobatulus*	*Elphidium laeve*	*Elphidium subnodosum*	*Globulina gibba*	*Lenticulina* spp.	*Nonion affine*	*Pullenia quinqueloba*	*Quinqueloculina impressa*	*Quinqueloculina seminula*	*Elphidium latidorsatum*	*Articulina laevigata*	*Articulina terquemi*	*Cibicides* sp. cf. *C. ungerianus*	*Asterigerina* sp.	*Bifarina selseyensis*	*Cibicides vialovi*	*Cibicides pygmeus*	*Cibicides* sp. cf. *C. tenellus*	*Elphidium hiltermanni*	*Epistominella oveyi*	*Guttulina irregularis*	*Guttulina problema*	*Guttulina pulchella*	*Hanzawaia producta*	*Reussella elongata*	*Rotalia audouini*	*Rotalia propingua*	*Triloculina trigonula* var. *inflata*	*Epistominella acutimargo*	*Glandulina laevigata*	*Globigerina* sp. cf. *G. angustiumbilicata*	*Globulina gibba* var. *punctata*	*Lagena striata*	*Miliolinella oblonga*	*Nonion graniferum*	*Pyrulina thouini*	*Quinqueloculina bicarinata*	*Quinqueloculina carinata*	*Quinqueloculina costata*	*Quinqueloculina juleana*	*Quinqueloculina ludwigi*	*Robertina germanica*	*Spiroloculina canaliculata*	*Triloculina trigonula*
Barton beds	Upper	EG 108	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Barton beds	Upper	EG 114	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Barton beds	Upper	D 8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	r	r	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	C	.	.	.	.	.	.	.	r	.	.	r	.	.	r	.	.	r	.
Barton beds	Upper	EG 116	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	f	.	C	.	.	.	.	.	.	.	r	.	.	.	r	.	.	r	r	.	.	.	.	.	.	r	.	.	.
Barton beds	Upper	D 7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	.	.	.	.	r	.	r	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.	r	r	r	.	.
Barton beds	Upper	EG 15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Barton beds	Middle	EG 14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Barton beds	Middle	PQR 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Barton beds	Middle	P 6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.	.	.	.	A	.	.	.	.	.	.	.	.	.	.	r	.	.	r	.	.	.	.	.	.	r	r	.	r	.	.	.	.
Barton beds	Middle	PQR 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Barton beds	Middle	PQR 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	.	.	.	.	.	.	.	.	.	.	r	r	r	.	.	.	r	.	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.
Barton beds	Middle	D 5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	r	.	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	f	.	.	.	r	.	.	.	r	.	.	r	.	.	.	r	r	.	.
Barton beds	Middle	D 6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	r	r	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	r	.	r	.	r	.	.	.	r	.	.	r	.	.	r	r	r	.	r
Barton beds	Middle	EG 117	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Barton beds	Middle	D 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	r	r	.	.	.	.	.	r	r	r	.	.	r	r	.	.	.	.	r	.	.	r	.	r	.	.	.	.	r	r	.	.	r	r	.	.
Barton beds	Middle	D 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	r	.	r	.	r	.	.	.	.	.	r	r	r	.	.	.	r	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.	r	.	.
Barton beds	Middle	D 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	r	r	.	.	.	.	.	.	r	.	r	.	.	.	r	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	r	r	r	.	.	.
Barton beds	Middle	D 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	r	.	r	.	.	.	.	.	r	.	r	.	r	.	.	.	r	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.	.	.	.
Barton beds	Lower	EG 118	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Barton beds	Lower	EG 113	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	r	.	f	.	.	.	r	f	f	.	.	r	.	.	C	V	.	.	.	r	.	.	.	.	r	f	.	.	.	r	.	.	.	r	r	.	r	.	.	r	C	.	.
Barton beds	Lower	EG 112	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Barton beds	Lower	EG 110	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
Barton beds	Lower	PQR 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
Barton beds	Lower	P 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Barton beds	Lower	P 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Barton beds	Lower	P 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Barton beds	Lower	P 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
U. Bracklesham beds		EG 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	r	.	f	.	f	r	r	r	A	C	A	C	r	r	r	f	r	r	r	f	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
London Clay		EG 10	.	.	.	f	A	.	r	.	.	.	.	.	.	C	C	.	r	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
London Clay		EG 104	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
London Clay		EG 9	r	r	.	r	C	r	r	.	r	r	f	r	r	f	r	.	.	r	f	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
London Clay		EG 102	.	.	r	f	.	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
London Clay		EG 101	.	.	r	C	.	.	.	r	.	.	r	C	.	.	.	r	r	.	.	.	.	C	r	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
London Clay		EG 8	.	.	.	f	r	.	.	.	.	.	r	r	.	.	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

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

TABLE 8.

DISTRIBUTION OF FORAMINIFERA IN THE EOCENE OF THE BORING WOENSDRECHT

(R. O. V. D. nº 17)

		Cribrostomoides sp.	Spiroplectammina mexiaensis	Haplophragmoides sp.	Trochammina sp. cf. T. inflata	Cibicides sp. cf. C. dutemplei	Karreriella danica	Ammodiscus incertus	Ammobaculites sp. cf. A. americanus	Lenticulina spp.	Eponides plummerae	Dentalina megalopolitana	Spiroplectammina adamsi	Rhizammina sp.	Nonion affine	Quinqueloculina impressa	Anomalina sp. cf. A. danica	Anomalina acuta var. ypresiensis	Siphonina prima	Cibicides proprius	Dentalina sp. cf. D. ewaldi	Nodosaria spp.	Alabamina obtusa	Lenticulina (Marginulinopsis) enbornensis	Lenticulina (Astacolus) sp. cf. L. decorata	Cibicides lobatulus	Guttulina problema	Anomalina acuta	Nodosaria minor	Dentalina elegans	Globulina gibba	Pullenia quinqueloba	Cibicides sulzensis	Nodosaria latejugata	Pseudoclavulina anglica	Textularia smithvillensis	Asterigerina bartoniana	Uvigerina batjesi	Nodosaria natchitochensis	Nodosaria sp. cf. N. elegantissima	Globigerina sp. cf. G. varianta	Globigerina triloculinoides	Angulogerina abbreviata	Bolivina anglica	Karreria fallax	Cibicides proprius var. acutimargo
Clays of Asse	329,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.
	331,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	.	.	.	r	.	.	.	.	.	.	.	.	.
Sands of Wemmel	335,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	f	f	.	.	f	.	.	.	.	.	V	.	.	.	.	.	.	.	.	.
	346,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
Sands of Lede	347,00 m	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	f	.	.	.	C	.	r	.	.	.	V	.	.	.	.	.	.	.	.	.
	348,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r	C	.	.	.	V	.	.	.	.	.	V	.	.	.	.	.	.	.	.	.
	350,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
	353,00 m	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	.	.	.	.	A	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
	354,00 m	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	A	.	.	.	.	A	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
	355,00 m	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	f
	355,50 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	f	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	355,75 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	360,50 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	C	.	.	.	.	.	C	.	.	.	.	.	.	.	.	C
	361,70 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	.	.	.	.	A	.	.	.	.	.	A	.	.	.	.	.	.	.	.	C
	362,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	363,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	A	.	.	.	.	.	.	.	.	C
	363,50 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	A	r	.	.	.	f	.	.	.	.	.	C	.	.	.	.	.	r	.	.	C
	364,00 m	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	A	f	.	.	.	f	.	.	.	.	.	C	.	.	.	.	.	.	.	.	A
	365,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	C
Sands of Aalter	374,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r
	375,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r
	379,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r	C	r	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C
	380,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	f	r	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r
	382,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	C	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r
	384,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	f	.	.	.	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	f
	385,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	f	f	.	.	.	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r
Sands of Vlierzele and Sandy Clays of Anderlecht	386,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	f	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r
	387,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	f	.	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	A
	388,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	A	f	r	.	.	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V
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	390,00 m	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	f	r	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V
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		Guttulina irregularis	Lagena globosa	Marginulina pediformis	Gyroidina angustiumbilicata	Asterigerina wilcoxensis	Globigerinoides sp. cf. G. daubjergensis	Cibicides sp. cf. C. ungerianus	Alabamina wilcoxensis	Dentalina inornata	Turrilina brevispira	Planulina burlingtonensis var. neelyi	Elphidium latidorsatum	Epistominella oveyi	Guttulina pulchella	Planulina burlingtonensis	Cancris subconicus	Rotalia audouini	Elphidium hiltermanni	Cibicides sp. cf. C. mauricensis	Textularia agglutinans	Spiroplectammina carinata var. deperdita	Elphidium laeve	Quinqueloculina carinata	Pyrulina gutta	Quinqueloculina seminula	Cibicides carinatus	Sigmomorphina semitecta	Discorbis sp. cf. D. ferganensis	Globulina gibba var. punctata	Elphidium subnodosum	Nonion scaphum	Miliola saxorum	Lagena spp.	Rotalia sp. cf. R. calvezae	Hanzawaia producta	Gyroidina octocamerata	Bolivina brabantica	Guttulina lactea	Planulina burlingtonensis var. tendami	Discorbis spp.	Eponides polygonus	Angulogerina muralis	Globulina gravida	Hastigerina micra	Pyrulina thouini
Clays of Asse	329,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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Sands of Wemmel	335,00 m	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.
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Sands of Brussels	360,50 m	C	.	.	.	.	.	V	.	.	.	.	.	.	r	.	.	V	.	.	.	.	r	.	r	.	f	.	.	.	f	.	.	.	.	f	.	.	r	.	.	.	.	r	.	.
	361,70 m	C	.	.	.	.	.	V	.	.	.	.	.	.	r	.	r	V	.	.	.	r	A	.	r	.	f	.	r	.	r	.	.	.	.	f	.	.	C	.	.	.	r	f	.	r
	362,00 m	.	.	.	.	.	.	A	.	.	.	.	.	.	.	.	.	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	f	.	.
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	363,50 m	f	.	.	.	.	.	C	.	.	.	.	.	.	r	.	r	V	.	r	.	.	C	.	.	.	r	.	.	.	.	.	.	.	.	C	.	.	r	.	.	r	r	r	.	r
	364,00 m	C	.	.	.	.	.	A	.	.	.	.	.	.	.	.	.	V	.	.	.	r	C	.	f	.	C	.	.	.	r	.	.	.	.	A	.	r	.	.	.	.	f	.	.	.
	365,00 m	r	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	C	.	.	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.	f	.	.	r	.	.	.	.	.	.	.
Sands of Aalter	374,00 m	r	.	.	.	.	.	.	.	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	.	V	.	.	.	.	.	.
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	379,00 m	C	.	.	.	.	.	.	.	.	.	f	.	f	r	.	.	.	.	r	C	.	f	.	.	.	.	.	.	.	r	.	.	.	.	r	.	.	.	C	.	.	.	r	.	r
	380,00 m	C	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	f	.	r	.	r	.	.	.	.	.	.	.	.	.	.	r	r	.	.	C	.	.	.	.	.	r
	382,00 m	C	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	A	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	.	.	.	.	r	r
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	385,00 m	C	.	.	.	.	.	.	.	.	.	r	.	r	.	r	.	.	.	.	C	.	r	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.	C	.	.	.	r	.	r
Sands of Vlierzele and Sandy Clays of Anderlecht	386,00 m	f	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	A	.	f	.	r	.	.	.	.	.	r	.	.	.	.	r	.	.	r	C	.	.	.	.	.	r
	387,00 m	f	.	.	.	.	.	.	.	.	.	.	.	f	r	.	r	.	.	.	C	.	f	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.
	388,00 m	C	.	.	.	.	.	.	.	.	.	.	.	A	r	.	.	.	.	.	V	.	r	.	.	.	.	.	r	r	r	.	.	.	.	f	.	.	.	f	.	.	.	.	r	r
	389,00 m	C	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	f	.	f	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.	f	.	r	.	.	r	.
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	391,00 m	r	.	.	.	.	.	.	.	.	.	.	.	f	.	.	.	.	.	.	A	.	.	.	r	.	.	.	r	.	.	.	.	.	.	f	.	.	.	.	.	f	r	.	.	.
	392,00 m	f	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	.	C	.	r	.	.	.	.	.	.	.	r	r	.	.	.	f	.	.	.	r	.	.	.	.	.	.
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	397,00 m	C	.	.	.	.	.	.	.	.	.	r	.	r	r	.	C	.	.	.	V	.	C	.	.	.	.	.	.	.	f	f	.	.	r	A	.	.	r	.	.	.	.	.	.	.
	398,00 m	f	.	.	.	.	r	.	.	.	.	f	.	r	r	.	C	.	.	.	C	.	C	.	.	.	r	.	.	.	f	r	.	.	.	A	.	.	r	.	.	.	.	.	.	.
	399,00 m	r	.	.	.	.	.	.	.	.	.	.	.	r	r	.	C	.	.	.	f	.	r	.	.	.	.	r	.	.	r	r	.	.	.	A	r	r	.	.	.	.	.	.	.	.
	400,00 m	.	.	.	.	.	.	.	.	.	.	.	.	C	r	.	C	.	.	.	f	.	.	.	.	.	.	.	.	.	.	f	.	.	.	A	.	.	.	.	.	.	.	.	.	.
	401,00 m	r	.	.	.	.	.	.	.	.	.	.	.	C	r	.	r	.	.	.	C	.	r	.	.	.	r	.	.	.	.	r	.	.	r	A	.	.	.	.	.	.	.	.	.	.
	403,00 m	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	f	r	.	r	C	.	.	.	.	.	.	.	.	.	r	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.
	404,00 m	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	405,00 m	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	A	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	406,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	C	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	407,00 m	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	.	.	.	A	.	.	.	.	.	.	.	r	.	.	f	r	.	.	.	.	.	.	.	.	.	.	.	.	.
	409,00 m	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	r	.	.	.	C	.	r	.	r	.	.	.	.	.	r	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	410,00 m	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	f	.	.	.	f	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	412,00 m	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	f	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	413,00 m	f	.	.	.	.	.	.	.	.	.	.	.	C	.	.	.	r	.	.	V	r	r	r	r	.	.	r	r	r	f	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	418,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	420,00 m	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	r	.	.	C	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	421,00 m	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	C	C	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	422,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	424,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	f	C	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	425,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	427,00 m	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r	.	.	r	.	.	.	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	429,00 m	r	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	r	r	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	434,00 m	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	435,00 m	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	438,00 m	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	C	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	441,00 m	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	442,00 m	C	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	r	r	C	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

		Cibicides westi	Bulimina parisiensis	Discorbis limbata	Reussella elongata	Rotalia spp.	Discorbis quadrata	Bulimina tenuistriata	Bolivina carinata	Bolivina crenulata	Rotalia propinqua	Anomalina auris	Sigmomorphina sp. cf. S. bornemanni	Discorbis parisiensis	Discorbis perplexa	Bifarina selseyensis	Reussella limbata	Cibicides sp. cf. C. tenellus	Cibicides dutemplei	Eponides schreibersi	Globigerina sp. cf. G. angustiumbilicata	Karreriella siphonella	Sigmoilina tenuis	Lenticulina (Astacolus) decorata	Angulogerina abbreviata var. tubulifera	Eponides umbonatus	Nodosaria ludwigi	Spiroplectammina carinata	Alabamina wolterstorffi
Clays of Asse	329,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	f	.	.	.	.	.	.	.	.	.	.
	331,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Wemmel	335,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V	.	.	.	r	r	r	f	r	r	r
	346,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Lede	347,00 m	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	r	.	A	C	r	r	r	r	.	.	.	.	.
	348,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	V	f	.	.	.	.	.	.	.	.	.
	350,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	353,00 m	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	r	r	A	.	.	.	.	.	.	.	.	.	.
	354,00 m	.	r	.	.	.	.	.	r	.	f	r	.	.	.	r	r	C	A	.	.	.	.	.	.	.	.	.	.
	355,00 m	.	.	.	.	.	.	.	.	.	f	r	.	.	.	r	r	r	C	.	.	.	.	.	.	.	.	.	.
	355,50 m	.	.	.	.	.	.	.	.	.	r	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.
	355,75 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Brussels	360,50 m	.	.	.	C	r	.	r	.	.	.	.	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	361,70 m	.	.	r	f	C	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	362,00 m	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	363,00 m	.	.	.	f	r	.	.	r	r	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	363,50 m	r	.	r	C	f	.	.	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	364,00 m	r	.	r	C	r	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	365,00 m	.	.	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Aalter	374,00 m	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	375,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	379,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	380,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	382,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	384,00 m	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	385,00 m	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Vlierzele and Sandy Clays of Anderlecht	386,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	387,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	388,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	389,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	390,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	391,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	392,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	393,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	394,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	395,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	396,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	397,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	398,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	399,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	400,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	401,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	403,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	404,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	405,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	406,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	407,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	409,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	410,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	412,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	413,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	418,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	420,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	421,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	422,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	424,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	425,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	427,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	429,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	434,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	435,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	438,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	441,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	442,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

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.

TABLE 8 *(continued)*.

DISTRIBUTION OF FORAMINIFERA IN THE EOCENE OF THE BORING WOENSDRECHT

(R. O. V. D. nº 17)

Unit	Depth	*Cribrostomoides* sp.	*Spiroplectammina mexiaensis*	*Haplophragmoides* sp.	*Trochammina* sp. cf. *T. inflata*	*Cibicides* sp. cf. *C. dutemplei*	*Karreriella danica*	*Ammodiscus incertus*	*Ammobaculites* sp. cf. *A. americanus*	*Lenticulina* spp.	*Eponides plummerae*	*Dentalina megalopolitana*	*Spiroplectammina adamsi*	*Rhizammina* sp.	*Nonion affine*	*Quinqueloculina impressa*	*Anomalina* sp. cf. *A. danica*	*Anomalina acuta* var. *ypresiensis*	*Siphonina prima*	*Cibicides proprius*	*Dentalina* sp. cf. *D. ewaldi*
Cl. of Roncq	459,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sands of Mons-en-Pévèle	462,00 m	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
	466,00 m	.	.	.	.	.	.	.	.	A	.	.	.	.	r	.	.	.	.	r	.
	471,00 m	.	.	.	.	.	.	.	.	r	.	.	r	.	r	.	.	.	.	V	.
	472,00 m	.	.	.	.	.	.	.	.	f	.	.	f	.	f	.	.	.	.	V	.
	473,00 m	.	.	.	.	.	.	.	.	f	.	r	r	.	r	.	.	.	.	V	.
	474,00 m	.	.	.	.	.	.	.	.	f	.	.	r	.	C	.	.	.	.	V	.
Clays of Ieper	476,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.
	479,00 m	.	.	.	.	.	.	.	.	f	.	r	.	.	.	.	.	.	.	C	.
	481,00 m	.	.	.	.	.	.	.	.	f	.	.	r	.	.	.	.	.	.	A	.
	484,00 m	.	.	.	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	C	.
	485,00 m	.	.	.	.	.	.	.	.	C	r	r	r	.	.	.	.	.	.	C	.
	487,00 m	.	.	.	.	.	.	.	.	C	r	r	.	.	.	.	.	.	.	A	.
	488,00 m	.	.	.	.	.	.	.	.	r	.	r	r	.	.	.	.	.	.	C	.
	490,00 m	.	.	.	.	.	.	.	.	f	r	r	.	.	.	.	.	.	.	f	.
	491,00 m	.	.	.	.	.	.	.	.	C	r	r	r	.	r	.	.	.	r	C	.
	493,00 m	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.
	495,00 m	.	.	.	.	.	.	.	.	f	r	.	.	.	.	.	.	.	.	V	.
	499,00 m	.	.	.	.	.	r	.	.	C	.	r	r	.	.	.	.	.	.	C	.
	503,00 m	.	.	.	.	.	.	.	.	r	.	r	r	.	.	.	.	.	.	C	.
	508,00 m	.	.	.	.	.	.	.	.	f	.	.	.	.	.	.	.	.	.	r	.
	509,00 m	.	.	.	.	.	.	.	.	f	r	r	.	.	.	.	.	r	.	A	.
	510,00 m	.	.	.	.	.	.	.	.	r	r	.	r	.	.	.	.	r	.	C	.
	512,00 m	.	.	.	.	.	r	.	.	f	.	.	.	.	.	.	.	r	.	C	.
	516,00 m	.	.	.	.	.	.	.	.	C	.	r	.	.	.	.	.	r	.	f	.
	517,00 m	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.
	519,00 m	.	.	.	.	.	.	.	.	A	.	f	.	.	.	.	.	r	.	f	.
	521,00 m	.	.	.	.	.	.	.	.	A	.	r	.	.	r	.	.	f	.	.	r
	534,00 m	.	.	.	.	.	A	.	.	A	.	r	C	.	f	.	.	f	r	.	r
	535,00 m	.	.	.	.	.	A	.	.	V	r	r	C	.	f	.	.	C	r	A	.
	536,00 m	.	.	.	.	.	A	.	.	V	.	r	A	.	A	.	.	V	C	V	.
	537,00 m	.	.	.	.	.	C	.	.	V	.	r	C	.	f	.	.	C	.	V	.
	539,00 m	.	.	.	.	.	A	.	.	V	r	.	A	.	r	.	.	f	f	A	r
	540,00 m	.	.	.	.	.	V	.	.	V	.	.	V	.	A	.	.	V	r	V	.
	541,00 m	.	.	.	.	.	A	.	.	V	.	.	A	.	C	.	.	A	r	V	.
	542,00 m	.	.	.	.	.	V	.	.	V	.	.	C	.	A	.	.	A	f	V	r
	547,00 m	.	.	.	.	.	r	.	.	A	.	f	.	.	r	.	.	r	r	C	.
	549,00 m	.	.	.	.	.	r	.	.	C	.	r	r	.	r	.	.	.	r	A	.
	550,00 m	.	.	.	.	.	r	.	.	C	.	r	r	.	r	.	.	.	r	f	.
	551,00 m	.	.	.	.	.	.	.	.	C	.	f	r	.	.	.	.	r	r	A	.
	552,00 m	.	.	.	.	.	.	.	.	C	.	r	r	.	r	.	.	r	r	C	r
	558,00 m	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r	.	f	r
	560,00 m	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	r	.
	561,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.
	570,00 m	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.
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	572,00 m	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.
	575,00 m	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	r	.
	583,00 m	.	.	.	.	C	.	r	.	.	.	.	.	.	.	.	C	.	.	.	.
	585,00 m	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	r	.	.	.	.
	588,00 m	.	.	.	r	.	.	r	r	.	.	.	.	f	.	.	.	.	.	.	.
	589,00 m	.	.	r	r	.	r	C	.	.	r	.	r	C	.	.	f	r	r	.	.
	591,00 m	r	r	r	r	r	r	r	.	r	.	.	.	r	r	r	.	.	.	.	.
	592,00 m	C	r	C	f	C	C	r	r	r	r	r	r	.	.	.	.	.	.	.	.
	593,00 m	C	.	f	f	.	r	r	r	r	.	.	.	.	.	.	.	.	.	.	.
	594,00 m	f	r	f	r	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.

Depth	*Nodosaria* spp.	*Alabamina obtusa*	*Lenticulina (Marginulinopsis) enbornensis*	*Lenticulina (Astacolus)* sp. cf. *L. decorata*	*Cibicides lobatulus*	*Guttulina problema*	*Anomalina acuta*	*Nodosaria minor*	*Dentalina elegans*	*Globulina gibba*	*Pullenia quinqueloba*	*Cibicides sulzensis*	*Nodosaria latejugata*	*Pseudoclavulina anglica*	*Textularia smithvillensis*	*Asterigerina bartoniana*	*Uvigerina batjesi*	*Nodosaria natchitochensis*	*Nodosaria* sp. cf. *N. elegantissima*	*Globigerina* sp. cf. *G. varianta*	*Globigerina triloculinoides*	*Angulogerina abbreviata*	*Bolivina anglica*	*Karreria fallax*	*Cibicides proprius* var. *acutimargo*	*Guttulina irregularis*	*Lagena globosa*	*Marginulina pediformis*	*Gyroidina angustiumbilicata*	*Asterigerina wilcoxensis*	*Globigerinoides* sp. cf. *G. daubjergensis*	*Cibicides* sp. cf. *C. ungerianus*
459,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
462,00 m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
466,00 m	.	.	.	.	f	r	.	.	.	.	.	A	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
471,00 m	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.	.	.	.	C	.	.	.	.	.	r	.
472,00 m	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	C	r	.	.	.	C	.	.	.	.	.	.	.
473,00 m	.	.	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.	.	.	.	C	.	.	.	.	.	.	.
474,00 m	.	.	r	r	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.	.	.	.	f	r	.	.	.	.	.	.
476,00 m	.	.	.	.	r	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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509,00 m	.	.	.	.	f	.	f	.	.	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C
510,00 m	.	.	.	.	.	.	f	.	r	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C
512,00 m	.	.	.	.	.	.	r	.	.	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C
516,00 m	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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521,00 m	.	r	r	r	.	.	.	.	r	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
534,00 m	.	C	r	f	.	.	A	r	.	.	r	A	C	.	.	.	.	.	.	r	.	.	.	.	f	.	.	.	r	.	.	.
535,00 m	r	A	C	C	.	.	V	C	r	.	r	A	C	.	.	.	.	.	.	f	r	.	.	r	.	.	.	.	C	r	.	.
536,00 m	r	f	A	A	r	r	V	A	r	r	C	V	A	.	C	.	.	.	r	C	C	.	.	.	.	r	.	.	C	r	r	r
537,00 m	.	.	r	A	.	r	V	C	r	.	f	A	A	.	r	.	.	r	r	r	.	.	.	r	f	r	.	r	f	.	.	.
539,00 m	r	.	r	A	.	.	A	C	.	r	f	C	C	.	V	.	r	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.
540,00 m	r	.	C	V	.	r	V	C	r	.	f	V	C	f	A	.	C	r	r	C	r	.	r	r	.	.	.	.	.	.	.	.
541,00 m	r	.	C	V	.	.	V	C	r	r	C	A	A	f	A	.	f	r	r	.	r	.	r	r	C	r	r	.	.	.	.	.
542,00 m	r	.	C	V	.	r	V	C	f	.	r	C	r	r	V	.	f	r	r	r	r	r	.	.	.	.	.	.	.	.	.	.
547,00 m	r	r	C	f	.	.	f	f	r	.	r	f	.	r	f	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
549,00 m	r	r	r	f	.	.	C	r	r	r	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
550,00 m	r	r	.	r	.	.	C	r	r	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
551,00 m	r	r	r	f	.	.	C	f	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
552,00 m	r	r	C	f	r	r	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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Depth	*Alabamina wilcoxensis*	*Dentalina inornata*	*Turrilina brevispira*	*Planulina burlingtonensis* var. *neelyi*	*Elphidium latidorsatum*	*Epistominella oveyi*	*Guttulina pulchella*	*Planulina burlingtonensis*	*Cancris subconicus*	*Rotalia audouini*
459,00 m	.	.	.	.	.	.	.	.	.	.
462,00 m	.	.	.	.	.	.	.	.	.	.
466,00 m	.	.	.	r	r	.	.	.	.	r
471,00 m	.	.	.	C	V	.	.	.	.	.
472,00 m	.	.	.	C	V	.	.	r	.	.
473,00 m	.	.	.	C	V	.	.	f	r	.
474,00 m	.	.	.	C	V	r	r	f	r	.
476,00 m	r	.	.	.	.	.	.	.	.	.
479,00 m	f	.	.	.	r	.	.	.	.	.
481,00 m	C	.	.	.	.	.	.	.	.	.
484,00 m	r	.	.	.	.	.	.	.	.	.
485,00 m	r	.	.	.	.	.	.	.	.	.
487,00 m	f	.	.	r	.	.	.	.	.	.
488,00 m	f	.	.	.	.	.	.	.	.	.
490,00 m	r	.	.	.	.	.	.	.	.	.
491,00 m	.	.	.	.	.	.	.	.	.	.
493,00 m	r	.	.	.	.	.	.	.	.	.
495,00 m	f	.	.	.	.	.	.	.	.	.
499,00 m	f	.	r	.	.	.	.	.	.	.
503,00 m	r	.	.	.	.	.	.	.	.	.
508,00 m	r	.	.	.	.	.	.	.	.	.
509,00 m	r	.	.	.	.	.	.	.	.	.
510,00 m	r	r	.	.	.	.	.	.	.	.
512,00 m	r	.	.	.	.	.	.	.	.	.
516,00 m	.	.	.	.	.	.	.	.	.	.
517,00 m	.	.	.	.	.	.	.	.	.	.
519,00 m	.	.	.	.	.	.	.	.	.	.
521,00 m	.	.	.	.	.	.	.	.	.	.
534,00 m	.	.	.	.	.	.	.	.	.	.
535,00 m	.	.	.	.	.	.	.	.	.	.
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Depth	*Elphidium hiltermanni*	*Cibicides* sp. cf. *C. mauricensis*	*Textularia agglutinans*	*Spiroplectammina carinata* var. *deperdita*	*Elphidium laeve*	*Quinqueloculina carinata*	*Pyrulina gutta*	*Quinqueloculina seminula*	*Cibicides carinatus*	*Sigmomorphina semitecta*	*Discorbis* sp. cf. *D. ferganensis*	*Globulina gibba* var. *punctata*	*Elphidium subnodosum*	*Nonion scaphum*	*Miliola saxorum*	*Lagena* spp.	*Rotalia* sp. cf. *R. calvezae*	*Hanzawaia producta*	*Gyroidina octocamerata*	*Bolivina brabantica*	*Guttulina lactea*	*Planulina burlingtonensis* var. *tendami*	*Discorbis* spp.	*Eponides polygonus*	*Angulogerina muralis*	*Globulina gravida*	*Hastigerina micra*	*Pyrulina thouini*
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Depth	*Cibicides westi*	*Bulimina parisiensis*	*Discorbis limbata*	*Reussella elongata*	*Rotalia* spp.	*Discorbis quadrata*	*Bulimina tenuistriata*	*Bolivina carinata*	*Bolivina crenulata*	*Rotalia propinqua*	*Anomalina auris*	*Sigmomorphina* sp. cf. *S. bornemanni*	*Discorbis parisiensis*	*Discorbis perplexa*	*Bifarina selseyensis*	*Reussella limbata*	*Cibicides* sp. cf. *C. tenellus*	*Cibicides dutemplei*	*Eponides schreibersi*	*Globigerina* sp. cf. *G. angustiumbilicata*	*Karreriella siphonella*	*Sigmoilina tenuis*	*Lenticulina (Astacolus) decorata*	*Angulogerina abbreviata* var. *tubulifera*	*Eponides umbonatus*	*Nodosaria ludwigi*	*Spiroplectammina carinata*	*Alabamina wolterstorffi*
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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. *nalinnesensis*,
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

Remarks. — 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.

Distribution. — 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.

Remarks. — 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.

Distribution. — 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.

Remarks. — 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.

Distribution. — *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.

Remarks. — 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.

Distribution. — 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.

Remarks. — 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.

Distribution. — 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*

Etymology. — Named after the type locality Nalinnes (THB) in Hainaut, Belgium.

Description. — 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.

Remarks. — *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.

R e m a r k s . — 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.

D i s t r i b u t i o n . — 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).

R e m a r k s . — 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 CALVEZ, 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.

D i s t r i b u t i o n . — 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.

R e m a r k s . — 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*.

D i s t r i b u t i o n . — 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.

R e m a r k s . — 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.

D i s t r i b u t i o n . — 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.

R e m a r k s . — 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.

D i s t r i b u t i o n. — 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.

R e m a r k s . — 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*.

D i s t r i b u t i o n . — 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.

T y p e l o c a l i t y . — Heist-op-den-Berg, boring near the Rijksmiddelbare School (1951); our sample from 129,50 m. depth.

T y p e l e v e l . — Sands of Wemmel. These sands are generally regarded to be of Late Eocene age.

D i s t r i b u t i o n . — Belgium : Sands of Lede, Sands of Wemmel.

D e p o s i t o r y . — 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*

E t y m o l o g y . — Named after Flanders, the western part of Belgium.

D e s c r i p t i o n . — 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.

R e m a r k s . — 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.

T y p e l o c a l i t y . — Bambrugge, the abandoned quarry « Steenberg » (ZD), our sample ZD 1016.

T y p e l e v e l . — The Sands of Lede. The age of these sands is generally regarded to be Late Eocene.

D i s t r i b u t i o n . — Belgium : Lede Sands, Wemmel Sands.

D e p o s i t o r y . — 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.

R e m a r k s . — 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.

D i s t r i b u t i o n . — 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.

R e m a r k s . — 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.

D i s t r i b u t i o n . — 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.

R e m a r k s . — 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*.

D i s t r i b u t i o n . — 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 CALYEZ, 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.

Transverse sections of mature individuals (fig. 4-6) showed a growth pattern that is quinqueloculine in the early stages, then triloculine, and finally biloculine. About 8 to 10 biloculine chambers maximally were found to be present, the final ones with 25 to 30 chamberlets.

Some specimens, probably the microspheric ones, begin with a proloculum of about 0,012 mm diameter, followed by a quinqueloculine and triloculine series of 15 to 16 chambers. Another group, probably the megalospheric individuals, have a proloculum of about 0,060 mm diameter, and a series of about 6 to 8 quinqueloculine and triloculine chambers.

Length of the holotype, 1,50 mm; breadth, 1,10 mm; thickness, 0,70 mm.

Remarks. — In external view this species reminds of *Fabularia howchini* SCHLUMBERGER (1891, Trans. Roy. South Australia, Proc., vol. 14, pp. 347-349, tf. 1-8) from the Lower Pliocene of Australia, which differs in the less developed quinqueloculine and triloculine series, and the fewer chamberlets per chamber.

Fabularia discolites DEFRANCE (1825, in BRONN, System Urwelt. Pflanzenthiere, Heidelberg, p. 43, pl. 7, f. 13), from the Lutetian of the Paris basin, differs by its more globular form. SCHLUMBERGER (1905, Bull. Soc. Géol. France, ser. 4, vol. 5, p. 139, pl. 3, f. 37, 38, tf. 22-25) published a number of transverse sections of *F. discolites*. There is a rather striking resemblance between the supposed microspheric forms of *F. discolites* and *F. bella*. However, the figures of the supposed megalospheric individuals of the French species show a distinct biloculine chamber arrangement throughout.

Type locality. — Bambrugge, the abandoned quarry « Steenberg » our sample ZD 1014.

Type level. — Sands of Lede. These Sands are generally regarded to be of Late Eocene age.

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 11643).

FAMILY PENEROPLIDAE

SUBFAMILY SPIROLININAE

Genus RENULINA LAMARCK, 1804

Type species RENULITES OPERCULARIA LAMARCK, 1804

Renulina opercularia (LAMARCK)

Pl. VI, fig. 7; *161*

Renulites opercularia LAMARCK, 1804, Ann. Mus. Hist. Nat., vol. 5, p. 354; 1807, ibid., vol. 9, pl. 17, f. 6 (Lutetian; Paris basin).

Peneroplis opercularis (LAMARCK), D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 286; TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 50, pl. 2, f. 29.

Renulina opercularia (LAMARCK), Y. LE CALVEZ, 1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 31, pl. 3, f. 38.

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

Genus SPIROLINA LAMARCK, 1804

Type species SPIROLINITES CYLINDRACEA LAMARCK, 1804

Spirolina spp.

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Remarks. — From the Lutetian of the Paris basin a number of *Spirolina* species were described by TERQUEM (1882) and Y. LE CALVEZ (1952).

Y. LE CALVEZ mentioned :

Spirolina cylindracea (LAMARCK) (1804, Ann. Mus. Hist. Nat., vol. 5, p. 243; 1806, vol. 8, pl. 62, f. 15),
Spirolina cylindracea (LAMARCK) var. *glabra* Y. LE CALVEZ (1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 22, pl. 2, f. 13, 14),
Spirolina laevigata D'ORBIGNY (1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 407; FORNASINI, 1904, Mem. R. Accad. Sci. Ist. Bologna, ser. 6, vol. 1, p. 8, pl. 2, f. 3),
Spirolina pedum D'ORBIGNY (1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 407; FORNASINI, 1904, Mem. R. Accad. Sci. Ist. Bologna, ser. 6, vol. 1, p. 8, pl. 2, f. 4, 5),
Spirolina striata D'ORBIGNY (1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 406; FORNASINI, 1904, Mem. R. Accad. Sci. Ist. Bologna, ser. 6, vol. 1, p. 8, pl. 2, f. 2), and
Spirolina mariei Y. LE CALVEZ (1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 25, pl. 2, f. 17, 18).

We found specimens of all these types in our material from Grignon. Regarding these specimens it is considered likely that the specific differences between *Spirolina mariei* and *S. striata* are not distinct. They possibly represent variants of a single species.

In the Eocene material of Belgium no specimens of *Spirolina* were found. GULLENTOPS (1956, Mém. Inst. Géol. Univ. Louvain, vol. 20, p. 16, pl. 1, f. 13) and BATJES (1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 107, pl. 2, f. 6) recorded *Spirolina*, possibly *S. cylindracea*, from the Lower Oligocene of Belgium.

Distribution. — France : Lutetian.

Genus DENDRITINA D'ORBIGNY, 1826

Type species DENDRITINA ARBUSCULA D'ORBIGNY, 1826

Dendritina depressa (LAMARCK)

151 and *167*

Spirolinites depressa LAMARCK, 1804, Ann. Mus. Hist. Nat., vol. 5, p. 245; 1806, ibid., vol. 8, pl. 62, f. 14 (Lutetian; Paris basin).
Spirolina depressa (LAMARCK), TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 53, pl. 3, f. 10.
Dendritina depressa (LAMARCK), Y. LE CALVEZ, 1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 25, pl. 3, f. 25-28.

Remarks. — Some small specimens from samples of the Upper Eocene of Belgium probably belong to this common species of the Lutetian of the Paris basin.

In our French material we found representatives of three more *Dendritina* species which had already been recorded from the Lutetian of the Paris basin. Figures and redescriptions of these species had been given by Y. LE CALVEZ (1952, Mém. Expl. Carte Géol. dét. France, pt. 4, pp. 25-28, pl. 2, f. 21-24, pl. 3, f. 25-30) :

Dendritina juleana D'ORBIGNY (1846, Foram. foss. Vienne, p. 134, pl. 7, f. 3, 4) was found in considerable numbers in our material from Grignon;

Dendritina laevigata TERQUEM (1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 51, pl. 3, f. 2, 3) and

Dendritina elegans D'ORBIGNY (1846, Foram. foss. Vienne, p. 135, pl. 7, f. 5, 6) were present as single specimens.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel (in both some scattered individuals of *Dendritina depressa*);

France : Lutetian.

SUBFAMILY **ORBITOLITINAE**

Genus ORBITOLITES LAMARCK, 1801

Type species ORBITOLITES COMPLANATUS LAMARCK, 1801

Orbitolites complanatus LAMARCK

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Orbitolites complanatus LAMARCK, 1801, Syst. Anim. sans Vert., p. 376 (Lutetian; Paris basin); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 125, pl. 13, f. 5; DOUVILLÉ, 1902, Bull. Soc. Géol. France, ser. 4, vol. 2, p. 296; HENSON, 1950, Middle Eastern Tert. Peneroplidae, thesis Leiden, p. 57; Y. LE CALVEZ, 1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 28.

Remarks. — In addition to the numerous individuals derived from the Lutetian of Grignon, we found the species rather scarcely represented in our Belgian Eocene material. Mostly fragments were encountered; well-preserved specimens are very rare.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel (one sample of the basal layers);

France : Lutetian.

FAMILY **ALVEOLINIDAE**

Genus ALVEOLINA D'ORBIGNY, 1826

Type species ORYZARIA BOSCII DEFRANCE, 1825

Alveolina spp.

Remarks. — A number of samples of the Belgian Upper Eocene contained fragments of *Alveolina*. Their state of preservation did not allow a definite determination. Possibly they belong to the same species as the specimens that occur in the Lutetian of the Paris basin, and which were reported by Y. LE CALVEZ (1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 41) as :

Alveolina boscii (DEFRANCE) (*Oryzaria boscii* DEFRANCE, 1825, in BRONN, System Urwelt. Pflanzenthiere, Heidelberg, p. 44, pl. 7, f. 17) and

Alveolina elongata D'ORBIGNY (1828, in DESHAYES, Ann. Sci. Nat., ser. 1, vol. 14, p. 234; FORNASINI, 1904, Mem. R. Accad. Sci. Ist. Bologna, ser. 6, vol. 1, p. 15, pl. 4, f. 14).

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

FAMILY LAGENIDAE

SUBFAMILY LENTICULININAE

Genus LENTICULINA LAMARCK, 1804

Type species LENTICULINA ROTULATA LAMARCK, 1804

Lenticulina spp.

Pl. VII, fig. 1-9; 22

Remarks. — Since BARTENSTEIN's paper (1948, Senckenbergiana, vol. 29, pp. 41-65) there has been a tendency to use *Lenticulina* as a generic name for all involute lagenids.

Several species may be present in the Belgian Eocene, but we failed to find constant distinctive characteristics. Only the species of *Lenticulina* (*Astacolus*) and *Lenticulina* (*Marginulinopsis*) could be separated.

The Ieper Clays and the Sands of Mons-en-Pévèle appeared fairly rich in *Lenticulina* specimens. Especially the samples of the boring Woensdrecht yielded many of them. Such types as our *Lenticulina* (*Darbyella*) sp. cf. *Darbyella wilcoxensis*, *L.* sp. cf. *L. umbonata* (REUSS), etc., appeared to be characteristic for these units.

The Roncq Clays, the Sandy Clays of Anderlecht and the Vlierzele Sands appeared to be devoid of *Lenticulina*. The genus is again represented in the Sands of Brussels, but in small numbers, and without distinctive species.

The Sands of Lede also had scarce, indistinct *Lenticulina* specimens. They became somewhat more numerous in the Wemmel Sands and the Asse Clays. The latter member had a slightly more diversified association than the Wemmel Sands. It contained, amongst others, *L.* sp. cf. *L. jugosa* (CUSHMAN and THOMAS) as a distinctive species (also in one sample of the Lede Sands of the Hoboken boring; contamination?).

The most important types are :

Lenticulina sp. cf. *L. alatolimbata* (GÜMBEL) (cf. *Robulina alato-limbata* GÜMBEL, 1868, Abh. K. Bayer. Akad. Wiss., Math.-Physik. Cl., vol. 10, pt. 2, p. 641, pl. 1, f. 70 — Eocene; Germany); pl. VII, fig. 1, 2.

Specimens resembling this species were found in the material of the Ieper Clays, Roubaix Clays and Mons-en-Pévèle Sands, but others with less numerous chambers (five to seven in stead of seven to nine) resemble *Lenticulina limbata* (BORNEMANN) (*Robulina limbata* BORNEMANN, 1855, Zschr. Deu. Geol. Ges., vol. 7, p. 335, pl. 15, f. 4-6) and *Lenticulina inornata* (D'ORBIGNY) (*Robulina inornata* D'ORBIGNY, 1846, Foram. foss. Vienne, p. 102, pl. 4, f. 25, 26). The latter types were found throughout our Eocene series.

Lenticulina sp. cf. *L. austriaca* (D'ORBIGNY) (cf. *Robulina austriaca* D'ORBIGNY, 1846, Foram. foss. Vienne, p. 103, pl. 15, f. 1, 2 — Miocene; Vienna basin).

A number of specimens of the Lede and Asse formations possibly belong to this species, which was also reported from the Lutetian of the Paris basin (Y. LE CALVEZ, 1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 40). This form with about ten chambers and a rather indistinct keel grades into that of our *Lenticulina* sp. cf. *alatolimbata*.

Lenticulina sp. cf. *L. limbosa* (REUSS) (cf. *Cristellaria limbosa* REUSS, 1863, Sitz. ber. K. Akad. Wiss. Wien, Math.-Naturw. Cl., vol. 48, pt. 1, p. 55, pl. 6, f. 69 — Oligocene; Germany).

Specimens that resemble this species were especially met with in the Ieper Clays and the Sands of Mons-en-Pévèle. Similar specimens occur in younger deposits; they were partly determined as *Lenticulina* sp. cf. *L. austriaca*.

Not all the specimens show the distinct keel as it was figured by REUSS. Occasional forms with more than nine to ten chambers resemble *Lenticulina clypeiformis* (D'ORBIGNY) (*Robulina clypeiformis* D'ORBIGNY, 1846, Foram. foss. Vienne, p. 101, pl. 4, f. 23, 24).

The specimens of the Wemmel Sands and the Asse Clays show the type described by many authors as *Lenticulina cultrata* (MONTFORT) (*Robulus cultratus* MONTFORT, 1808, Conch. Syst., vol. 1, p. 215, tf.), which type figure, however, is indistinct. These specimens have a distinct keel and lesser chambers than typical *L. limbosa*.

Lenticulina sp. cf. *L. costata* (D'ORBIGNY) (cf. *Robulina costata* D'ORBIGNY, 1902, in FORNASINI, Mem. R. Accad. Sci. Ist. Bologna, ser. 5, vol. 10, p. 43, tf. 44-recent; Adriatic, Italy), pl. VII, fig. 3.

The specimens of the Ieper formation resemble our *Lenticulina* sp. cf. *L. ellisori*, but they show the distinct limbate sutures of *L. costata*.

Lenticulina sp. cf. *L. ellisori* BOWEN (cf. *Lenticulina ellisori* BOWEN, 1954, Proc. Geol. Assoc., vol. 65, p. 146, pl. A, f. 12 — London Clay; England), pl. VII, fig. 4.

This type was only found in the Ieper Clays.

Some variation is found in the thickening of the sutures, especially in the specimens resembling *Lenticulina* sp. cf. *L. costata*.

Lenticulina sp. cf. *L. jugosa* (CUSHMAN and THOMAS) (cf. *Robulus jugosus* CUSHMAN and THOMAS, 1930, Jour. Pal., vol. 4, p. 36, pl. 3, f. 4 — Eocene; Texas), pl. VII, fig. 5.

Only specimens from the Asse Clays resemble this species. The earlier sutures are often nodose, the later ones raised. Our specimens also resemble *Lenticulina baconica* (HANTKEN) (*Robulina baconica* HANTKEN, 1875, Jahrb. K. Ungar. Géol. Anst., Mitt., vol. 4, pt. 1, p. 58, pl. 14, f. 9), but the latter species shows more chambers and less limbate sutures.

Lenticulina sp. cf. *L. pseudovortex* (COLE) (cf. *Robulus pseudovortex* COLE, 1927, Bull. Am. Pal., vol. 14, no. 51, p. 19, pl. 1, f. 12 — Eocene; Mexico), pl. VII, fig. 6.

Most specimens show a slight keel, which is nearly absent in the original specimen of COLE.

The individuals of the Lede Sands and the Wemmel Sands resemble our *Lenticulina* sp. cf. *L. yaguatensis*, which has more chambers and somewhat less curved sutures.

Lenticulina sp. cf. *L. umbonata* (REUSS) (cf. *Robulina umbonata* REUSS, 1851, Zschr. Deu. Geol. Ges., vol. 3, p. 68, pl. 4, f. 24 — Oligocene; Germany).

A number of small specimens, characterized by six chambers and the very large, thick umbo, were met with in some samples from the Ieper Clays of the Woensdrecht boring.

Lenticulina sp. cf. *L. yaguatensis* (BERMUDEZ) (cf. *Robulus yaguatensis* BERMUDEZ, 1949, Cushm. Lab. Foram. Res., Spec. Publ. no. 25, p. 132, pl. 7, f. 29, 30 — Oligocene; Dominican Republic), pl. VII, fig. 8, 9.

This is one of the most frequent species in the Lede and Asse formations. The individuals are characterized by about seven chambers with broadly curved sutures that are flush with the surface. The earlier chambers are often visible through the transparent umbo.

Lenticulina (*Darbyella*) sp. cf. *Lenticulina* (*Darbyella*) *wilcoxensis* (CUSHMAN and GARRETT) (cf. *Darbyella wilcoxensis* CUSHMAN and GARRETT, 1939, Contr. Cushm. Lab. Foram. Res., vol. 15, p. 79, pl. 13, f. 11, 12 — Eocene; Alabama), pl. VII, fig. 7.

A small number of specimens was found in the Ieper Clays and the Mons-en-Pévèle Sands.

Our individuals differ from *Lenticulina* (*Darbyella*) *wilcoxensis* by the less raised sutures and the usually lower number of chambers.

Subgenus ASTACOLUS MONTFORT, 1808

Type species NAUTILUS CREPIDULA FICHTEL and MOLL, 1798

Lenticulina (Astacolus) decorata (REUSS)

Pl. VII, fig. 10, 11; *209*

Cristellaria decorata REUSS, 1855, Zschr. Deu. Geol. Ges., vol. 7, p. 269, pl. 8, f. 16, pl. 9, f. 1, 2 (Upper Eocene; Germany).

Marginulina decorata (REUSS), STAESCHE and HILTERMANN, 1940, Abh. Reichst. f. Bodenf., New Series, vol. 201, p. 16, pl. 42, f. 4.

Vaginulinopsis decorata (REUSS), TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 101, pl. 2, f. 12, 13.

R e m a r k s . — Most of our variable specimens agree fairly well with the more or less schematic figures of REUSS. There may be some doubt about the subgeneric position of our specimens. The sutures of the last formed chambers often curve back to the spiral part of the test, thus fitting the diagnosis of *Astacolus*. Other specimens show the tendency to become distinctly uncoiling; they better resemble *Vaginulinopsis* or *Marginulinopsis*.

The ornamentation is variable. Most specimens show limbate, raised sutures, partly developed as a series of distinct tubercles of variable length. The test may further be ornamented by more or less longitudinal costae, which always become less apparent near the aperture. Granules may be present in between the costae.

D i s t r i b u t i o n . — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse; Netherlands (Woensdrecht): Sands of Lede, Sands of Wemmel.

Lenticulina (Astacolus) sp. cf. L. decorata (REUSS)

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cf. *Cristellaria decorata* REUSS, 1855, Zschr. Deu. Geol. Ges., vol. 7, p. 269, pl. 8, f. 16, pl. 9, f. 1, 2 (Upper Eocene; Germany).

R e m a r k s . — In a number of samples of the Ieper formation we found many specimens resembling our *Lenticulina decorata* of the Upper Eocene. However, most of them are more slender and some show a *Marginulinopsis*-like test. Perhaps some younger individuals of *Lenticulina* (*Marginulinopsis*) *enbornensis* without the typical ornamentation of that species have been included.

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

Subgenus MARGINULINOPSIS SILVESTRI, 1904

Type species MARGINULINOPSIS DENSICOSTATA THALMANN, 1937

Lenticulina (Marginulinopsis) enbornensis (BOWEN)

Pl. VII, fig. 12, 13; *35*

Marginulina enbornensis BOWEN, 1954, Proc. Geol. Ass., vol. 65, p. 149, pl. B, f. 1-4 (London Clay; England).

Remarks. — In the material of the Woensdrecht boring many specimens were found with the same variable ornamentation as described by BOWEN. The aperture is always eccentric on a stout neck. BOWEN figured specimens without a distinct spiral part. In our material types with and without such a spiral part are present.

Distribution. — Netherlands (Woensdrecht) : Clays of Ieper, Sands of Mons-en-Pévèle.

Genus MARGINULINA D'ORBIGNY, 1826

Type species MARGINULINA GLABRA D'ORBIGNY, 1826

Marginulina pediformis BORNEMANN

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Marginulina pediformis BORNEMANN, 1855, Zschr. Deu. Geol. Ges., vol. 7, p. 326, pl. 13, f. 13 (Oligocene; Germany); HAGN, 1956, Palaeontographica, vol. 107, pt. A, p. 132, pl. 11, f. 13.

Distribution. — Belgium : Clays of Ieper (one sample);
Netherlands (Woensdrecht) : Clays of Ieper (one sample).

Genus DENTALINA D'ORBIGNY, 1839

Type species NODOSARIA OBLIQUA D'ORBIGNY, 1826

Dentalina megalopolitana REUSS

Pl. VII, fig. 14; *10*

Dentalina megalopolitana REUSS, 1855, Zschr. Deu. Geol. Ges., vol. 7, pt. 1, p. 267, pl. 8, f. 10 (Upper Eocene; Germany).

Dentalina approximata TEN DAM (not REUSS), 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 91, pl. 2, f. 10 (Paleocene; Netherlands) .

R e m a r k s . — Our specimens lack the initial spine, but in the other features they closely resemble the species described by REUSS. They are somewhat variable in the relative height of the chambers and the thickness of the sutures.

Dentalina approximata (REUSS) (*Nodosaria approximata* REUSS, 1866, Denkschr. K. Akad. Wiss. Wien, Math.-Naturw. Cl., vol. 25, pt. 1, p. 134, pl. 2, f. 22) from the Oligocene of Germany is a more slender type with higher chambers.

Some resemblance is found with American types, such as those of *Dentalina colei* CUSHMAN and DUSENBURY (1943, Contr. Cushm. Lab. Foram. Res., vol. 19, p. 54, pl. 17, f. 10-12), *D. cooperensis* CUSHMAN var. *nonapicalis* BANDY (1949, Bull. Am. Pal., vol. 32, no. 131, p. 52, pl. 7, f. 1), *D. eocenica* CUSHMAN (1944, Contr. Cushm. Lab. Foram. Res., vol. 20, p. 36, pl. 6, f. 1) and *D. jarvisi* CUSHMAN and TODD (1945, Cushm. Lab. Foram. Res., Spec. Publ. no. 15, p. 22, pl. 3, f. 22).

D i s t r i b u t i o n . — Netherlands (Woensdrecht): Clays of Ieper, Sands of Mons-en-Pévèle.

Dentalina sp. cf. **D. ewaldi** (REUSS)

Pl. VII, fig. 15, 16; *20*

cf. *Nodosaria ewaldi* REUSS, 1851, Zschr. Deu. Geol. Ges., vol. 3, p. 58. pl. 2, f. 2 (Oligocene; Germany); BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 117.

R e m a r k s . — There are a number of fragments of *Dentalina*-like specimens with more or less elongate chambers.

The specimens of the Upper Eocene resemble *Dentalina ewaldi* as figured by REUSS, but individuals closer to *D. consobrina* D'ORBIGNY (1846, Foram. foss. Vienne, p. 46, pl. 2, f. 1-3) are present as well.

The fragments from the Lower Eocene, especially from the Clays of Ieper in the boring Woensdrecht, have about the same morphological range, but there are fragments with very elongate chambers. They resemble *Nodosaria longiscata* D'ORBIGNY (1846, Foram. foss. Vienne, p. 32, pl. 1, f. 10-12). They were recorded under this name by TEN DAM (1944, Meded. Geol. Stichting, ser. C., vol. 5, no. 3, p. 95) from the Ypresian of the Netherlands.

D i s t r i b u t i o n . — Belgium : Sands of Wemmel, Clays of Asse;
Netherlands (Woensdrecht) : Clays of Ieper.

Dentalina elegans D'ORBIGNY

Pl. VII, fig. 17; *49*

Dentalina elegans D'ORBIGNY, 1846, Foram. foss. Vienne, p. 45, pl. 1, f. 52-56 (Miocene; Vienna basin); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 36, pl. 1, f. 40; TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 92; Y. LE CALVEZ, 1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 39.

R e m a r k s . — Specimens resembling the typical ones from the Miocene of Austria are relatively scarce in our material, but they occur throughout.

The chambers are often less inflated; such specimens resemble *Dentalina pauperata* D'ORBIGNY (1846, Foram. foss. Vienne, p. 46, pl. 1, f. 57, 58). The sutures are generally straight and distinct, but specimens with slightly oblique sutures were found as well. They approach the indistinct boundary with *D. inornata* D'ORBIGNY, which shows distinctly oblique sutures. The specific difference between these two species is somewhat questionable.

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

Netherlands (Woensdrecht) : Clays of Ieper.

Dentalina inornata D'ORBIGNY

Pl. VII, fig. 18, 19; *67*

Dentalina inornata D'ORBIGNY, 1846, Foram. foss. Vienne, p. 44, pl. 1, f. 50, 51 (Miocene; Vienna basin); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 37, pl. 1, f. 41 (42 ?); Y. LE CALVEZ, 1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 39.

Remarks. — MARKS (1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 45) regarded *Dentalina inornata* as a synonym of *D. communis* (D'ORBIGNY) (*Nodosaria communis* D'ORBIGNY, 1840, Mém. Soc. Géol. France, vol. 4, no. 1, p. 13, pl. 1, f. 4), which had originally been described from the Adriatic, Italy. However, the type figures of the latter species are too bad to prove such an assumption.

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

Netherlands (Woensdrecht) : Clays of Ieper, Lower Panisel beds.

Dentalina sp. cf. **D. baltica** REUSS

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cf. *Dentalina baltica* REUSS, 1855, Zschr. Deu. Geol. Ges., vol. 7, p. 269, pl. 8, f. 15 (Upper Eocene; Germany).

Remarks. — Variation especially concerns the development of the costae, which are often distinct and heavy, and in other cases absent on the middle part of the chambers.

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

Genus NODOSARIA LAMARCK, 1812

Type species NAUTILUS RADICULUS LINNÉ, 1758

Nodosaria sp. cf. **N. elegantissima** HANTKEN

Pl. VII, fig. 20; *26*

cf. *Nodosaria elegantissima* HANTKEN, 1875, Jahrb. K. Ungar. Geol. Anst., Mitt., vol. 4, pt. 1, p. 24, pl. 12, f. 16 (Upper Eocene; Hungary).

cf. *Stilostomella* cf. *elegantissima* (HANTKEN), HAGN, 1956, Palaeontographica, vol. 107, pt. A, p. 155, pl. 13, f. 24.

Nodosaria spinulosa (MONTAGU), TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 95, pl. 2, f. 8; BOWEN, 1954, Proc. Geol. Ass., vol. 65, p. 155.

Remarks. — Our specimens, always fragmentary, fairly well resemble the figures given by HAGN. The apertural characters are indistinct, and our specimens are provisionally described as *Nodosaria*. In the original figures of HANTKEN the upper part of the chambers is smooth, which is unlike our specimens. Our Dutch individuals resemble the specimens figured by TEN DAM as *N. spinulosa*. However, *Nautilus spinulosus* MONTAGU (1808, Test. Brit., Suppl.,

p. 86, pl. 19, f. 5) shows a smooth upper part of the chambers and a spinose lower part. The longitudinal costae ending in spinose projections are absent in MONTAGU's figures.

Externally there is no difference from *Ellipsonodosaria midwayensis* CUSHMAN and TODD (1946, Contr. Cushm. Lab. Foram. Res., vol. 22, p. 61, pl. 10, f. 25) from the Paleocene of Arkansas and Texas. However, owing to lack of specimens with a preserved apertural part, the generic determination of our specimens remains uncertain.

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

Nodosaria minor HANTKEN

Pl. VII, fig. 21; *41*

Nodosaria bacillum DEFRANCE var. *minor* HANTKEN, 1875, Jahrb. K. Ungar. Geol. Anst., Mitt., vol. 4, pt. 1, p. 26, pl. 2, f. 7 (Upper Eocene; Hungary); STAESCHE and HILTERMANN, 1940, Abh. Reichstelle f. Bodenforschung, New Series, vol. 201, pl. 39, f. 3.

Remarks. — Specimens, such as those figured by HANTKEN and by STAESCHE and HILTERMANN, were rather frequently met with. They are always accompanied by *Nodosaria latejugata*. Possibly both types are only variants of one species, but *N. latejugata* differs by the more inflated chambers and the more strongly developed costae.

Distribution. — Belgium : Clays of Ieper, Lower Panisel beds;
Netherlands (Woensdrecht) : Clays of Ieper.

Nodosaria latejugata GÜMBEL

Pl. VII, fig. 22; *36*

Nodosaria latejugata GÜMBEL, 1870, Abh. Bayr. Ak. Wiss., vol. 10, p. 619, pl. 1, f. 32 (Eocene; Bavaria, Germany); TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 94; HAGN, 1956, Palaeontographica, vol. 107, pt. A, p. 137, pl. 12, f. 11, pl. 13, f. 1.

Remarks. — *Nodosaria latejugata* is considered to be different from *N. minor* by the distinctly inflated chambers and the heavier costae.

Distribution. — Belgium : Sands of Mons-en-Pévèle;
Netherlands (Woensdrecht) : Clays of Ieper.

Nodosaria ludwigi REUSS

Pl. VII, fig. 23; *228*

Nodosaria ludwigi REUSS, 1866, Denkschr. K. Akad. Wiss. Wien, vol. 25, p. 135, pl. 2, f. 23 (Oligocene; Germany); BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 116, pl. 3, f. 15, 16.

Remarks. — Our few specimens are in all features identical with the specimens described by BATJES from the Oligocene.

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

Nodosaria natchitochensis (Howe)

Pl. VII, fig. 24; *25*

Dentalina natchitochensis Howe, 1939, Louisiana Dept. Conserv., Geol. Surv., Bull. no. 14, p. 45, pl. 6, f. 6 (Eocene; Louisiana).

Nodosaria natchitochensis (Howe), Bowen, 1954, Proc. Geol. Ass., vol. 65, p. 154.

Remarks. — Like the specimens from the London Clay, recorded by Bowen, our individuals differ from the original one by the rectilinear in stead of the curvilinear shape of the test.

Some variation was found in the size of the first chamber. It is sometimes distinctly bigger than the second one, but mostly the chambers gradually increase in size as added.

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

Nodosaria spp.

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Remarks. — Indeterminable fragments of *Nodosaria* species were found in many samples of the Woensdrecht boring. Most frequent are fragments resembling *Nodosaria spinescens* Reuss (1851, Zschr. Deu. Geol. Ges., vol. 3, p. 62, pl. 3, f. 10).

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

Subfamily **LAGENINAE**

Genus LAGENA Walker and Jacob, 1798

Type species SERPULA SULCATA Walker and Jacob, 1798

Lagena isabella (d'Orbigny)

Pl. VII, fig. 25; *105*

Oolina isabella d'Orbigny, 1839, Voy. Amér. Mér., Foram., vol. 5, pt. 5, p. 20, pl. 5, f. 7, 8 (recent; Falkland Islands, Atlantic).

Lagena isabella (d'Orbigny), Batjes, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 119, pl. 3, f. 11.

Lagena elegantissima (Bornemann), Matthes, 1939, Palaeontographica, vol. 90, pt. A, p. 58, pl. 3, f. 13, 14.

Remarks. — Our specimens are completely within the range of variation found by Batjes in the Oligocene. We only encountered single individuals in a number of samples.

Specimens like ours, were often referred to as *Lagena acuticosta* Reuss (1862, Sitz. Ber. K. Akad. Wiss. Wien, vol. 44, pt. 1, p. 305, pl. 1, f. 4) and *L. sulcata* (Walker and Jacob) [*Serpula* (*Lagena*) *sulcata* Walker and Jacob, 1798, in Kanm., Adams 'Essays, p. 634, pl. 14, f. 5].

Distribution. — Belgium : Clays of Roubaix, Sands of Mons-en-Pévèle, Sands of Brussels, Sands of Lede, Clays of Asse.

Lagena striata (D'ORBIGNY)

Pl. VII, fig. 26; *70*

Oolina striata D'ORBIGNY, 1839, Voy. Amér. Mér., Foram., vol. 5, pt. 5, p. 21, pl. 5, f. 12 (recent; Falkland Islands, Atlantic).

Lagena striata (D'ORBIGNY), BOWEN, 1954, Proc. Geol. Ass., vol. 65, p. 143; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 119, pl. 3, f. 6.

Remarks. — All the individuals we assigned to this species are characterized by the presence of fine, longitudinal striae. The shape of the test ranges from globular to pear-shaped. Mostly there is a terminal neck, but never with a series of rings. When the neck is absent, the test is pear-shaped.

CUSHMAN and McCULLOCH (1950, Allan Hancock Pacific Exp., vol. 6, no. 6, p. 350, pl. 47, f. 1-4) seem to interpret the species as characterized by the rings on the elongate apertural neck. Forms without such rings they placed in *Lagena sulcata* (WALKER and JACOB) and varieties. However, the type of *L. sulcata* possesses fewer and heavier costae.

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

England : Barton beds.

Lagena globosa (MONTAGU)

Pl. VII, fig. 27; *50*

Vermiculum globosum MONTAGU, 1803, Test. Brit., p. 523 (recent; England).

Lagena globosa (MONTAGU), BOWEN, 1954, Proc. Geol. Ass., vol. 65, p. 142.

Lagena vulgaris TERQUEM (not WILLIAMSON), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 25, pl. 1, f. 3; Y. LE CALVEZ, 1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 39.

Remarks. — *Lagena vulgaris* was described by WILLIAMSON (1858, Rec. Foram. Great Brit., p. 4, pl. 1, f. 5) as a smooth, very elongate, pear-shaped species.

Our specimens, as well as the one figured by TERQUEM and redescribed by Y. LE CALVEZ, show globular tests, which resemble the original figures of *Lagena globosa* very well.

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

Netherlands (Woensdrecht) : Clays of Ieper.

Lagena spp.

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Remarks. — In addition to the three described species, scarce individuals of some others were found. The following names may be applied to them :

Lagena squamosa (MONTAGU) var. *hexagona* (WILLIAMSON) [*Entosolenia squamosa* (MONTAGU) var. *hexagona* WILLIAMSON, 1848, Ann. Mag. Nat. Hist., ser. 2, vol. 1, p. 20, pl. 2, f. 23 — recent; Great Britain].

Single specimens in Woensdrecht 403 m (Lower Panisel beds), WA 1139 and ND 411 (Sands of Brussels), and BRB 237 (Clays of Asse).

Lagena hispidula CUSHMAN (1913, U. S. Nat. Mus., Bull. 71, pt. 3, p. 14, pl. 5, f. 2, 3 — recent; Pacific).

A single specimen in BRB 237 (Clays of Asse).

Lagena striatopunctata PARKER and JONES (*Lagena sulcata* (WALKER and JACOB) var. *striatopunctata* PARKER and JONES, 1865, Philos. Trans., vol. 155, p. 350, pl. 13, f. 25-27 — recent; Atlantic and Indian Oceans; Lutetian, France).

Single specimens in BC 115 and WA 1139 (Sands of Brussels), and in Wemmel 14-10,50 m (Sands of Wemmel).

Genus ENTOSOLENIA EHRENBERG, 1848

Type species ENTOSOLENIA LINEATA WILLIAMSON, 1848

Entosolenia marginata (WALKER and BOYS)

Pl. VII, fig. 28; *181*

Serpula marginata WALKER and BOYS, 1784, Test. Min., p. 2, pl. 1, f. 7 (recent; Great Britain).
Lagena marginata (WALKER and BOYS), CUSHMAN, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 35, pl 6, f. 9.
Entosolenia marginata (WALKER and BOYS), Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 41.

R e m a r k s . — Our few specimens show some variation in the size of the carina.

D i s t r i b u t i o n . — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse; France : Lutetian.

Entosolenia orbignyana (SEGUENZA)

Pl. VII, fig. 29; *90*

Fissurina orbignyana SEGUENZA, 1862, Foram. Monothal. Mioc. Messina, p. 66, pl. 2, f. 25, 26 (Miocene; Italy).
Lagena (*Entosolenia*) *orbignyana* (SEGUENZA), BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 118.

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.

Entosolenia spp.

127

R e m a r k s . — In addition to the above two species we encountered a few specimens of some others. The following specific names could be applied for them :

Entosolenia laevigata (REUSS) (*Fissurina laevigata* REUSS, 1850, Denkschr. K. Ak. Wiss. Wien, vol. 1, p. 366, pl. 46, f. 1 — Miocene; Vienna basin).

LK 163 (Sands of Brussels).

Entosolenia bicarinata (TERQUEM) (*Fissurina bicarinata* TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 31, pl. 1, f. 24 — Lutetian; Paris basin).

BD 391 (Sands of Brussels).

FAMILY POLYMORPHINIDAE

Genus GUTTULINA D'ORBIGNY, 1839

Type species POLYMORPHINA PROBLEMA D'ORBIGNY, 1826

Guttulina problema (D'ORBIGNY)

Pl. VII, fig. 30, 31, 32, pl. VIII, fig. 1; *58*

Polymorphina (*Guttvlina*) *problema* D'ORBIGNY, 1846, Foram. foss. Vienne, p. 224, pl. 12, f. 26-28 (Pliocene; Italy).

Guttulina problema (D'ORBIGNY), CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 19, pl. 2, f. 1-6, pl. 3, f. 1; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 11, pl. 1, f. 7-9; BATJES (part), 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 121, pl. 4, f. 10, 11 (not 12).

Polymorphina communis D'ORBIGNY, 1826, Ann. Sci. Nat., ser. 1, vol. 7, p. 266, pl. 12, f. 1-4 (Eocene; Paris basin).

Guttulina communis (D'ORBIGNY), Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 13, pl. 1, f. 13-15.

Remarks. — *Guttulina problema* is one of the most common species of the Belgian Eocene with numerous representatives throughout the whole column.

It appeared impossible to separate *Guttulina problema, G. communis* and specimens similar to *G. austriaca* D'ORBIGNY (1846, Foram. foss. Vienne, p. 223, pl. 12, f. 23-25). Variants that resemble the latter species are scarce; most of them were found in samples from the Lede Sands, Wemmel Sands and Asse Clays.

The separation of young individuals of *Guttulina problema* and *G. irregularis* appeared to be difficult, and sometimes impossible. The same difficulty was encountered with young specimens of *G. lactea* and of *Pyrulina* species.

Among the numerous specimens of the Asse formation some may be assigned to *Guttulina frankei* CUSHMAN and OZAWA (1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 28, pl. 4, f. 1), but a clear distinction between the latter species and *G. problema* was not observed. All specimens were united under *G. problema,* as BATJES did for the Oligocene ones.

Distribution. — Belgium : Clays of Ieper, Sands of Mons-en-Pévèle, Clays of Roubaix, Sands of Aalter, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse;

England : Upper Bracklesham beds, Barton beds;

France : Lutetian;

Netherlands (Woensdrecht) : Clays of Ieper, Sands of Mons-en-Pévèle, Lower Panisel beds, Sands of Aalter, Sands of Brussels, Sands of Lede, Sands of Wemmel.

Guttulina irregularis (D'ORBIGNY)

Pl. VIII, fig. 2, 3; *57*

Globulina irregularis D'ORBIGNY, 1846, Foram. foss. Vienne, p. 226, pl. 13, f. 9, 10 (Miocene; Vienna basin).

Guttulina irregularis (D'ORBIGNY), CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 25, pl. 3, f. 4, 5, pl. 7, f. 1, 2; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 14; MARKS, 1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 47; BHATIA, 1955, Jour. Pal., vol. 29, no. 4, p. 676, pl. 67, f. 26.

Remarks. — Our specimens of *Guttulina irregularis* are rather variable in general appearance. They include forms as were figured by BHATIA as *G. bulloides* REUSS (BHATIA, 1955, op. cit., p. 676, pl. 67, f. 28). The type of *G. inaequalis* REUSS, as figured by BHATIA (1955, p. 676, pl. 67, f. 23) occurs among young specimens.

BATJES (1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 226, pl. 12, f. 12) included *Guttulina irregularis* as a variant of *G. problema*. The distinction between the two species is not always very clear, but in our Eocene material they are generally fairly well separable.

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

England : Upper Bracklesham beds, Barton beds;

France : Lutetian;

Netherlands (Woensdrecht) : Clays of Ieper, Sands of Mons-en-Pévèle, Lower Panisel beds, Sands of Aalter, Sands of Brussels, Sands of Lede, Sands of Wemmel.

Guttulina pulchella D'ORBIGNY

Pl. VIII, fig. 4; *69*

Guttulina pulchella D'ORBIGNY, 1839, in DE LA SAGRA, Hist. Phys. Nat. Cuba, p. 134, vol. 8, pl. 2, f. 4-6 (recent; West Indies); CUSHMAN, 1923, U. S. Nat. Mus., Bull. 104, p. 157, pl. 40, f. 6; CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 33, pl. 5, f. 7.

Guttulina spicaeformis (ROEMER) var. *parisiensis* Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 15, pl. 1, f. 10-12 (Lutetian; Paris basin).

Remarks. — The Belgian and French specimens resemble the figures of *Guttulina pulchella* very well. They are considered conspecific with this recent Caribean species. Most of our specimens are also in good accordance with the one figured by Y. LE CALVEZ as *G. spicaeformis* var. *parisiensis*. In our opinion this form is identical with *G. pulchella*.

A large number of variants in our material are smooth.

Distribution. — Belgium : Clays of Ieper, Sands of Aalter, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse;

England : Upper Bracklesham beds;

Netherlands (Woensdrecht): Sands of Mons-en-Pévèle, Lower Panisel beds, Sands of Aalter, Sands of Brussels.

Guttulina lactea (WALKER and JACOB)

Pl. VIII, fig. 5; *113*

Serpula lactea WALKER and JACOB, 1798, Adams' Essays, ed. 2, p. 634, pl. 14, f. 4 (recent; England).

Polymorphina lactea (WALKER and JACOB), CUSHMAN, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 146, pl. 39, f. 9 (not 11).

Guttulina lactea (WALKER and JACOB), CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 43, pl. 10, f. 1-4; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 14.

Remarks. — *Guttulina lactea* differs from *G. problema* by the elongate chambers and the slightly compressed test. In some specimens there is a tendency of the chambers to become arranged in a sigmoid series. This was noted earlier by CUSHMAN and OZAWA for recent specimens from the Atlantic.

Some specimens with shorter chambers hamper a clear separation from *Guttulina problema*.

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

Genus GLOBULINA D'ORBIGNY, 1839

Type species POLYMORPHINA GIBBA D'ORBIGNY, 1826

Globulina gibba (D'ORBIGNY)

Pl. VIII, fig. 6, 7; *56*

Polymorphina gibba D'ORBIGNY, 1846, Foram. foss. Vienne, p. 227, pl. 13, f. 13, 14 (Miocene; Vienna basin).
Globulina gibba (D'ORBIGNY), TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 130, pl. 13, f. 23-25 (not 22, 26, 27); CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 60, pl. 16, f. 1-4; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 17; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 121, pl. 4, f. 9.
Globulina inaequalis REUSS, 1850, Denkschr. K. Ak. Wiss. Wien, vol. 1, p. 377, pl. 48, f. 9 (Miocene; Vienna basin); CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 73, pl. 18, f. 2-4.

Remarks. — Compressed forms, distinctly belonging to *Globulina inaequalis*, appeared to be rare in our abundant Eocene *Globulina* material, but they are present throughout the entire column. Intermediates with the more globular *G. gibba* are much more abundant. In our material *G. inaequalis* was regarded as a compressed variant of *G. gibba*.

Distribution. — Belgium : Clays of Ieper, Sands of Mons-en-Pévèle, Sands of Aalter, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse;
England : Upper Bracklesham beds, Barton beds;
France : Sands of Cuise, Lutetian;
Netherlands (Woensdrecht) : Clays of Ieper, Sands of Mons-en-Pévèle, Lower Panisel beds, Sands of Aalter, Sands of Brussels, Sands of Lede, Sands of Wemmel.

Globulina gibba (D'ORBIGNY) var. punctata D'ORBIGNY

Pl. VIII, fig. 8, 9; *96*

Globulina punctata D'ORBIGNY, 1846, Foram. foss. Vienne, p. 229, pl. 13, f. 7, 8 (Miocene; Vienna basin).
Globulina gibba (D'ORBIGNY) var. *punctata* D'ORBIGNY, CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 69, pl. 17, f. 4, 5; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 20.
Globulina rugosa D'ORBIGNY, 1846, Foram. foss. Vienne, p. 229, pl. 13, f. 19, 20.

Remarks. — The specimens of this variety are distinct *Globulina gibba* with small granules of variable quantity. Sometimes the granules are coarser. Such variants resemble *G. gibba* (D'ORBIGNY) var. *tuberculata* D'ORBIGNY (1846, Foram. foss. Vienne, p. 230, pl. 13, f. 21, 22), but specimens with tubercles as coarse as those of the specimens figured by CUSHMAN and OZAWA (1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 68, pl. 17, f. 6, 7) are extremely rare in our material.

CUSHMAN and OZAWA recognized the identity of *Globulina punctata* D'ORBIGNY and *G. rugosa* D'ORBIGNY, both from the Miocene of the Vienna basin. In the latter the granules would have to be arranged in longitudinal rows, in which this form differs from *G. punctata* with haphazard dispersion. This variant is a minor constinuent in our *punctata* collection.

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

England : Barton beds;

France : Lutetian;

Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Lede.

Globulina gibba (d'Orbigny) var. myristiformis (Williamson)

Pl. VIII, fig. 10; *168*

Polymorphina myristiformis Williamson, 1858, Recent Foram. Gr. Britain, p. 73, pl. 6, f. 156, 157 (recent; Br. Isles); Brady, 1884, Rep. Voy. Challenger, Zoology, vol. 9, p. 571, pl. 73, f. 9, 10.

Globulina gibba (d'Orbigny) var. *myristiformis* (Williamson), Cushman and Ozawa, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 66, pl. 16, f. 8, pl. 20, f. 6; Y. le Calvez, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 18.

Lagena costata Terquem (not Williamson), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 27, pl. 1, f. 11 (Lutetian; Paris basin).

Polymorphina sulcata d'Orbigny, 1902, in Fornasini, Mem. R. Accad. Sci. Ist. Bologna, ser. 5, vol. 10, p. 50, tf. 52 (recent; France).

Globulina gibba (d'Orbigny) var. *sulcata* (d'Orbigny), Y. le Calvez, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 18, pl. 4, f. 54, 55.

Remarks. — Cushman and Ozawa noted that specimens from the Lutetian deposits of Grignon show heavier costae than typical specimens from the seas around Great Britain. The same applies to most of our Belgian specimens.

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

France : Lutetian.

Globulina gravida (Terquem)

Pl. VIII, fig. 11; *116*

Guttulina gravida Terquem, 1878, Mém. Soc. Géol. France, ser. 3, vol. 1, p. 47, pl. 4, f. 28-32 (Pliocene; Rhodes, Mediterranean); 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 135, pl. 14, f. 20-21.

Globulina gravida (Terquem), Y. le Calvez, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 20, pl. 1, f. 16-18.

Remarks. — Cushman and Ozawa (1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 61) regarded *Globulina gravida* as a synonym of *G. gibba*. However, this species is distinguished from *G. gibba* by the more elongate and flask-like shape and the thickened hyaline wall surrounding the distinct apertural tube.

Some broader variants resemble *Globulina ampulla* (Jones) (*Polymorphina ampulla* Jones, 1852, Quart. Journ. Geol. Soc., vol. 8, p. 267, pl. 16, f. 14).

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

Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Brussels, Sands of Lede.

Globulina gravida (TERQUEM) var. **lineata** nov. var.

Pl. VIII, fig. 12; *219*

E t y m o l o g y . — From Latin : *lineatio* = marking with lines.

D e s c r i p t i o n . — Variety differing from *Globulina gravida* (TERQUEM) in having the test ornamented by numerous, faint, longitudinal striae.

Length of the holotype 0,39 mm.

R e m a r k s . — The striae are sometimes interrupted at the sutures.

T y p e l o c a l i t y . — Boring at the New Barracks of the Artillery at Mechelen (1905) : our sample Mechelen 51.

T y p e l e v e l . — Basal layers of the Asse Clays. The age of these deposits is generally regarded to be Late Eocene.

D i s t r i b u t i o n . — Belgium : Sands of Wemmel, Clays of Asse.

D e p o s i t o r y . — The holotype and the paratypoids are stored in the collections of the Geological Institute of Utrecht (S 9609).

Genus PYRULINA D'ORBIGNY, 1839

Type species POLYMORPHINA GUTTA D'ORBIGNY, 1826

Pyrulina gutta (D'ORBIGNY)

91

Polymorphina gutta D'ORBIGNY, 1826, Ann. Sci. Nat., ser. 1, vol. 7, p. 267, pl. 12, f. 5, 6 (Pliocene; Italy).
Pyrulina gutta (D'ORBIGNY), CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 51, pl. 13, f. 1; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 16.

R e m a r k s . — Owing to the bad preservation the first chambers of most of our specimens are not clear. Many of the individuals are only young ones, in which the biserial part is not yet distinctly developed.

Some scarce specimens resembling *Pyrulina polita* (TERQUEM) (*Polymorphina polita* TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 139, pl. 14, f. 23-25) have been included.

D i s t r i b u t i o n . — Belgium : Sands of Aalter, Sands of Brussels, Sands of Lede, Sands of Wemmel;

France : Lutetian;

Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Brussels.

Pyrulina thouini (D'ORBIGNY)

Pl. VIII, fig. 13, 14; *119*

Polymorphina thouini D'ORBIGNY, 1865, in PARKER, JONES and BRADY, Ann. Mag. Nat. Hist., vol. 16, ser. 3, pl. 2, f. 49 (Eocene; Paris basin); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 142, pl. 14, f. 33.

Pyrulina thouini (D'ORBIGNY), CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 57, pl. 14, f. 6; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 17.

Remarks. — According to CUSHMAN and OZAWA *Pyrulina thouini* is one of the best defined species of *Pyrulina*. However, in our material distinct types of *P. thouini*, with the elongate chambers in the slender test, intergrade with shorter specimens assignable to *P. cylindroides* (ROEMER) (*Polymorphina cylindroides* ROEMER, 1839, N. Jahrb. Min., etc., p. 385, pl. 3, f. 26) with less elongate chambers. There is also intergradation with individuals resembling *P. fusiformis* (ROEMER) (*Polymorphina fusiformis* ROEMER, 1838, op. cit., p. 386, pl. 3, f. 37), as described by BATJES (1958, Mém. Inst. R. Sci. Nat. Belg., no. 143, p. 122, pl. 4, f. 3).

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

England : Barton beds;

Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Brussels, Sands of Lede.

Genus PSEUDOPOLYMORPHINA CUSHMAN and OZAWA, 1928

Type species PSEUDOPOLYMORPHINA HANZAWAI CUSHMAN and OZAWA, 1928

Pseudopolymorphina spatulata (TERQUEM)

83

Polymorphina spatulata TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 142, pl. 14, f. 32 (Lutetian; Paris basin).

Pseudopolymorphina spatulata (TERQUEM), CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 105, pl. 27, f. 4, 5; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 23.

Distribution. — Belgium : Sands of Mons-en-Pévèle, Sands of Brussels.

Genus SIGMOMORPHINA CUSHMAN and OZAWA, 1928

Type species SIGMOMORPHINA KAGAENSIS CUSHMAN and OZAWA, 1928

Sigmomorphina sp. cf. S. bornemanni CUSHMAN and OZAWA

Pl. VIII, fig. 15, 16; *139*

cf. *Sigmomorphina bornemanni* CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 134, pl. 36, f. 3 (Oligocene; Germany).

cf. *Polymorphina dilatata* REUSS (not D'ORBIGNY), 1851, Zeitschr. Deu. Geol. Ges., vol. 3, p. 83, pl. 6, f. 49 (Oligocene; Germany).

Remarks. — Most of our specimens are more slender than the typical, broad specimens of *Sigmomorphina bornemanni*. They also resemble *S. regularis* (ROEMER) (*Polymorphina regularis* ROEMER, 1839, N. Jahrb. Min., etc., p. 385, pl. 3, f. 21) as described by BATJES (1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 125, pl. 4, f. 2). They have a more produced initial end, which is often developed as a distinct spine, as it was figured by Y. LE CALVEZ for *S. apiculata* Y. LE CALVEZ (1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 24, pl. 4, f. 51-53).

Our specimens lack the ornamentation of the latter species, except for a few which did show very faint striae on the early part of the test.

Some specimens resemble *Sigmoidella,* in which each chamber embraces the previous ones. Especially *S. plummerae* CUSHMAN and OZAWA (1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 142, pl. 39, f. 3) is similar, but it has the chambers in a contraclockwise series.

Distribution. — Belgium : Sands of Brussels, Sands of Lede, Sands of Wemmel; Netherlands (Woensdrecht) : Sands of Brussels, Sands of Lede.

Sigmomorphina semitecta (REUSS)

115

Polymorphina semitecta REUSS, 1867, Sitz. Ber. K. Akad. Wiss. Wien, vol. 55, pt. 1, p. 91, pl. 3, f. 10 (Miocene; Poland).

Sigmorphina semitecta (REUSS), CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus, vol. 77, art. 6, p. 129, pl. 33, f. 6, 7.

Polymorphina amygdaloides TERQUEM (not REUSS), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 141, pl. 14, f. 30, 31 (Lutetian; Paris basin).

Sigmomorphina amygdaloides (TERQUEM), Y. LE CALVEZ 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 24.

Remarks. — In the Belgian material we found *Sigmomorphina semitecta* as well as its variant *terquemiana* (FORNASINI) (*Polymorphina amygdaloides* REUSS var. *terquemiana* FORNASINI, 1900, Boll. Soc. Geol. Ital., vol. 19, p. 136).

Our elongate variants are identical with the forms described as *Sigmomorphina amygdaloides* (TERQUEM) by Y. LE CALVEZ.

Distribution. — Belgium : Sands of Brussels, Sands of Lede;
Netherlands (Woensdrecht) : Lower Panisel beds.

Genus GLANDULINA D'ORBIGNY, 1839

Type species NODOSARIA (GLANDULINA) LAEVIGATA D'ORBIGNY, 1826

Glandulina laevigata (D'ORBIGNY)

Pl. VIII, fig. 17; *102*

Nodosaria (*Glandulina*) *laevigata* D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 252, pl. 10, f. 1-3 (recent; Adriatic, and Pliocene; Italy).

Glandulina laevigata (D'ORBIGNY), D'ORBIGNY, 1846, Foram. foss. Vienne, p. 29, pl. 1, f. 4, 5; CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 143, pl. 40, f. 1; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 123, pl. 4, f. 7, 8.

Remarks. — BATJES described the variability of the species by enumeration of a number of types of species of BORNEMANN and REUSS, which he had found in the Oligocene material. These types are also present in our material of the Eocene of Belgium and England. Furthermore we encountered individuals described by BANDY (1949, Bull. Am. Pal., vol. 32, no. 131) as *Glandulina elliptica* REUSS (p. 49, pl. 6, f. 12), *G. laevigata* (D'ORBIGNY) (p. 49, pl. 6, f. 13), *G. occidentalis* (CUSHMAN) (p. 49, pl. 6, f. 14) and *G. ovata* CUSHMAN (p. 50, pl. 6, f. 15), all from the Jackson Eocene of Alabama. It appeared impossible to make a specific distinction between these forms, which are all regarded as variants of *G. laevigata.*

Furthermore a number of single specimens was found, resembling *Glandulina aequalis* REUSS (1863, Sitz. ber. K. Akad. Wiss. Wien, vol. 48, p. 48, pl. 3, f. 28) as described by BATJES (1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 123, pl. 4, f. 5, 6). These forms occur together with those of *G. laevigata*. They may also be variants of our *G. laevigata*.

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

England : Barton beds.

Genus DIMORPHINA D'ORBIGNY, 1826

Type species DIMORPHINA TUBEROSA D'ORBIGNY, 1826

Dimorphina sp.

Pl. VIII, fig. 18; *204*

Remarks. — The microspheric specimens of this peculiar *Dimorphina* resemble *Dimorphina danvillensis* HOWE and WALLACE (1932, Louis. Dept. Cons., Geol. Bull., no. 2, p. 44, pl. 8, f. 1), but the initial end is more acuminate and the aperture is central, also in the uniserial stages, instead of eccentric as in the figure of HOWE and WALLACE.

The macrospheric specimens, however, lack the triserial stage and begin biserially like *Glandulina*. These specimens resemble *G. aequalis* REUSS, but the initial biserial part is much longer, and the chambers are mostly less high.

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

FAMILY **BULIMINIDAE**

SUBFAMILY **TURRILININAE**

Genus TURRILINA ANDREAE, 1884

Type species TURRILINA ALSATICA ANDREAE, 1884

Turrilina brevispira TEN DAM

Pl. IX, fig. 1; *61*

Turrilina brevispira TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 110, pl. 3, f. 4 (Eocene; the Netherlands).

Remarks. — The final coil of our specimens is less high than it is in the individual figured by TEN DAM. The aperture at the base of the chamber is separated from the margin by a slight lip.

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

Netherlands (Woensdrecht) : Clays of Ieper.

Genus BULIMINELLA CUSHMAN, 1911

Type species BULIMINA ELEGANTISSIMA D'ORBIGNY, 1839

Buliminella sp. cf. **B. pulchra** (TERQUEM)

Pl. IX, fig. 2; 77

cf. *Bulimina pulchra* TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 114, pl. 12, f. 9-12 (Lutetian; Paris basin).

cf. *Buliminella pulchra* (TERQUEM), CUSHMAN and PARKER, 1947, U. S. Geol. Survey, Prof. Paper 210-D, p. 61, pl. 16, f. 5, 6; Y. LE CALVEZ, 1950, Mém. Expl. Carte Geol. dét. France, pt. 3, p. 33, pl. 2, f. 21, 22.

Remarks. — It appeared difficult to separate our ill-preserved specimens between *Buliminella pulchra* and *B. elegantissima* (D'ORBIGNY) (*Bulimina elegantissima* D'ORBIGNY, 1839, Voy. Am. Mér., Foram., vol. 5, pt. 5, p. 51, pl. 7, f. 13, 14), the latter as figured by BOWEN (1957, Micropal., vol. 3, p. 54, pl. 1, f. 17) from the Upper Eocene of England, and by BHATIA (1955, Jour. Pal., vol. 29, p. 679, pl. 66, f. 11) from the Oligocene of Wight.

Only some of the specimens of the Lede Sands and of the Wemmel Sands show the great relative size of the last coil with long and narrow chambers, as it is typical for *Buliminella pulchra*.

Distribution. — Belgium : Clays of Roubaix, Sands of Brussels, Sands of Lede, Sands of Wemmel;

France : Lutetian.

Buliminella striatopunctata (TERQUEM)

131

Bulimina striato-punctata TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 116, pl. 12, f. 19 (Lutetian; Paris basin).

Buliminella striato-punctata (TERQUEM), Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 30, pl. 2, f. 29, 30.

Remarks. — This species is only represented by some young specimens.

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

France : Lutetian.

Buliminella sp.

Remarks. — In two samples from the Sands of Mons-en-Pévèle at Mont-Saint-Aubert a number of *Buliminella* specimens was found, which resemble Cretaceous species, such as *B. imbricata* (REUSS) (*Bulimina imbricata* REUSS, 1851, Haidinger's Naturw. Abh., vol. 4, p. 22, pl. 3, f. 7) and *B. cushmani* SANDIDGE (1932, Jour. Pal., vol. 6, p. 280, pl. 42, f. 18, 19).

An exact specific determination is impossible, because all specimens are damaged and are without the early whorls.

Probably they had been redeposited from the Cretaceous. Both samples also contained a number of *Globotruncana* specimens.

SUBFAMILY BULIMININAE

Genus BULIMINA D'ORBIGNY, 1826

Type species BULIMINA MARGINATA D'ORBIGNY, 1826

Bulimina parisiensis nov. nom.

Pl. VIII, fig. 19, pl. IX, fig. 3, 4; *66*

Bulimina trigona CUSHMAN and TODD (not TERQUEM), 1945, Contr. Cushm. Lab. Foram. Res., vol. 21, p. 17, pl. 4, f. 6 (Lutetian; Paris basin); CUSHMAN and PARKER, 1947, U. S. Geol. Survey, Prof. Paper 210-D, p. 91, pl. 21, f. 18; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 37, pl. 3, f. 35.

Etymology. — Named after Paris.

Remarks. — The type-specimens of *Bulimina trigona* TERQUEM (1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 110, pl. 11, f. 28, 29) were restudied by Y. LE CALVEZ. They appeared to belong to *Valvulina*. However, the name has also been used for a distinct *Bulimina* species.

This species is characterized by the great relative size of the last coil and by the rounded aperture.

In the Belgian Eocene material, however, there are some specimens with a less prominent last whorl, which are commonly also slightly more elongate. They resemble *Bulimina candida* TERQUEM (1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 111, pl. 11, f. 30, 31), as refigured by Y. LE CALVEZ (1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 35, pl. 3, f. 39). Complete intergradation between these two types was found. Unfortunately *B. candida* in TERQUEM's collections appears to be based on a single broken specimen (Y. LE CALVEZ, p. 35). For this reason a new name is given to the *trigona* type, which is more general.

Distribution. — Belgium : Clays of Ieper, Clays of Roubaix, Sands of Mons-en-Pévèle, sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse;

France : Lutetian;

Netherlands (Woensdrecht) : Sands of Aalter, Sands of Lede.

Bulimina tenuistriata TERQUEM

Pl. IX, fig. 5; *137*

Bulimina tenui-striata TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 118, pl. 12, f. 24, 25 (Lutetian; Paris basin); CUSHMAN and PARKER, 1947, U. S. Geol. Survey, Prof. Paper 210-D, p. 91, pl. 21, f. 17; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 36, pl. 3, f. 36, 37.

Remarks. — Generally, the specimens of the Belgian Eocene and the Lutetian of the Paris basin are in good accordance with those figured in the references above. However, some specimens are slightly more elongate.

The generic determination of this species may be doubted. CUSHMAN and PARKER already remarked that it is not advisable to place *Bulimina tenuistriata* in *Buliminella*, because of the lack of a distinct spiral suture. The ventral face resembles that of species of *Glabratella* DORREEN, but our species is much more elongate.

Distribution. — Belgium : Sands of Brussels, Sands of Lede, Sands of Wemmel;
France : Lutetian;
Netherlands (Woensdrecht) : Sands of Brussels.

Bulimina ovata D'ORBIGNY

Pl. IX, fig. 6; 223

Bulimina ovata D'ORBIGNY, 1846, Foram. foss. Vienne, p. 185, pl. 11, f. 13, 14 (Miocene; Vienna basin); TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 111, pl. 3, f. 10, 11; CUSHMAN and PARKER, 1947, U. S. Geol. Survey, Prof. Paper 210-D, p. 106, pl. 25, f. 8, 9; MARKS, 1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 57.

Remarks. — MARKS found that in most Austrian Miocene specimens of *Bulimina ovata* the last whorl forms about half of the test. In our Eocene material this is often a much greater part, but specimens identical with those from Austria are present as well.

The lips on either side of the apertural slit are distinct in our material; furthermore a tooth is often discernible.

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

SUBFAMILY REUSSELLINAE

Genus REUSSELLA GALLOWAY, 1933

Type species VERNEUILINA SPINULOSA REUSS, 1850

Reussella elongata (TERQUEM)

Pl. IX, fig. 7-9; 78

Verneuilina elongata TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 106, pl. 11, f. 13 (Lutetian; Paris basin).

Reussella elongata (TERQUEM), CUSHMAN, 1945, Contr. Cushm. Lab. Foram. Res., vol. 21, p. 27, pl. 5, f. 10, 11; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 46, pl. 3, f. 45, 46.

Remarks. — Most of the Belgian Eocene specimens are shorter than those figured previously. However, such shorter individuals appeared to be also the most frequent forms in the type deposits of the Lutetian of the Paris basin. They more or less resemble the form figured by CUSHMAN (1945, Contr. Cushm. Lab. Foram. Res., vol. 21, pl. 5, f. 7) as *Reussella oberburgensis* (FREYER) (*Verneuilina oberburgensis* FREYER, 1864, in REUSS, Denkschr. K. Akad. Wiss. Wien, vol. 23, p. 6, pl. 1, f. 2).

The test is rather variable, especially in the character of the borders. Typical individuals seem to be angular, but specimens with more obtuse angles occur as well.

The apertural area is formed by the inflated tops of the last three chambers, which are covered by striae, wich radiate from the apertural opening in the centre. Such striae occur also in *Reussella secans* Y. LE CALVEZ (1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 48, pl. 3, f. 47, 48), which is only a keeled variant of *R. elongata*.

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

England : Upper Bracklesham beds, Barton beds;
France : Lutetian;
Netherlands (Woensdrecht) : Sands of Brussels.

Reussella limbata (Terquem)

Pl. VIII, fig. 20, 21, pl. IX, fig. 10; *184*

Verneuilina limbata Terquem, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 105, pl. 11, f. 12 (Lutetian; Paris basin).
Reussella limbata (Terquem), Y. le Calvez, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 47, pl. 3, f. 49, 50.

Remarks. — The triserial arrangement of the chambers gets lost in the later part of the test, in which the more or less uniserial arrangement is less distinct than it is in *Chrysalidinella*.

The apertural face of adult specimens is formed by two or by one chamber(s). In the first case the aperture is a slit in between the perforated, flattened tops of the two chambers. When only one chamber forms the apertural face it is formed by the perforated top with the slit-like aperture alongside. The slit is sometimes bordered by a thickened rim. The thin, finely perforated top is often broken, leaving a large opening, as it was figured by Y. le Calvez.

The peripheral borders are mostly angular, and interrupted by downward projecting spines at the lower end of the chambers. Some specimens lack these interruptions, and the peripheral borders may be more or less rounded and thickened.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse;
France : Lutetian;
Netherlands (Woensdrecht) : Sands of Lede.

Reussella terquemi Cushman

Pl. IX, fig. 11; *123*

Verneuilina spinulosa Terquem (not Reuss), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 107, pl. 11, f. 16 (Lutetian; Paris basin).
Reussella terquemi Cushman, 1945, Contr. Cushm. Lab. Foram. Res., vol. 21, p. 28, pl. 5, f. 15, 16; Y. le Calvez, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 48.

Remarks. — The species differs from *Reussella spinulosa* by its shorter test, its smaller size, and the less developed spinose projections. As in *R. spinulosa* (Reuss) (*Verneuilina spinulosa* Reuss, 1850, Denkschr. K. Ak. Wiss. Wien, vol. 1, p. 374, pl. 47, f. 12) the species includes spinulose forms and smoother types.

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

Reussella obtusa (Terquem)

84

Verneuilina obtusa Terquem, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 106, pl. 11, f. 14, 15 (Lutetian; Paris basin).
Reussella obtusa (Terquem), Cushman, 1945, Contr. Cushm. Lab. Foram. Res., vol. 21, p. 27, pl. 5, f. 12-14; Y. le Calvez, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 48.

Distribution. — Belgium : Sands of Mons-en-Pévèle;
France : Lutetian.

SUBFAMILY BOLIVININAE

Genus BOLIVINA D'ORBIGNY, 1839

Type species BOLIVINA PLICATA D'ORBIGNY, 1839

Bolivina carinata TERQUEM

Pl. IX, fig. 12-14; *88*

Bolivina carinata TERQUEM, 1882 ,Mém. Soc. Géol. France, ser. 3, vol. 2, p. 149, pl. 15, f. 19 (Lutetian; Paris basin); CUSHMAN, 1937, Cushm. Lab. Foram. Res., Spec. Publ. no. 9. p. 46, pl. 6, f. 14-16; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 42.

Remarks. — Associated with relatively short individuals, as figured by TERQUEM and CUSHMAN, longer ones occur, with the greater breadth in the last part of the test. The slight median ridge, mentioned by CUSHMAN, was found in a number of specimens, but it appeared to be absent in most of our individuals, especially in younger ones. Usually the chambers fairly rapidly increase in size.

Distribution. — Belgium : Sands of Mons-en-Pévèle, Sands of Brussels, Sands of Lede, Sands of Wemmel;
France : Lutetian;
Netherlands (Woensdrecht) : Sands of Brussels.

Bolivina brabantica nov. sp.

Pl. VIII, fig. 22; *110*

Etymology. — Named after the Belgian province Brabant.

Description. — Test about two to three times as long as broad; periphery rounded; chambers comparatively few, slightly, if at all inflated, increasing rapidly in relative height as added, in the last formed chambers height and breadth about equal; sutures distinct, oblique, slightly curved; wall strongly perforated, the early portion ornamented with numerous, very fine, longitudinal striae; aperture an elongate narrow opening, with a slight lip.

Length of the holotype, 0,42 mm, breadth, 0,19 mm, thickness 0,11 mm.

Remarks. — This new species differs from *Bolivina budensis* (HANTKEN) (*Textilaria budensis* HANTKEN, 1857, Magy. kir. földt. int. évkönyve, vol. 4, p. 57, pl. 15, f. 1) by the thicker test, the rounded periphery, the coarser perforations, and the presence of striae on the early portion of the test.

Some variants resemble *Bolivina jacksonensis* CUSHMAN and APPLIN (1926, Bull. Am. Ass. Petr. Geol., vol. 10, p. 167, pl. 7, f. 3, 4) and its variety *striatella* CUSHMAN and APPLIN (1926, ibid., p. 167, pl. 7, f. 5, 6), which, however, both have a subacute periphery, numerous chambers, and a finely perforated wall.

Type locality. — Quarry of the so-called « Grès de Gobertange », NE of Lathuy, Brabant (our sample WA 1139).

Type level. — The Sands of Brussels. These deposits are generally regarded as to be of Middle Eocene age.

Distribution. — Belgium : Sands of Brussels; Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Brussels.

Depository. — The holotype and paratypoids are stored in the collections of the Geological Institute of Utrecht (S 10254, 10255).

Bolivina crenulata Cushman

Pl. IX, fig. 15-17; *78*

Bolivina crenulata Cushman, 1936, Cushm. Lab. Foram. Res., Spec. Publ. no. 6, p. 50, pl. 7, f. 13 (Eocene; Hungary); 1937, Cushm. Lab. Foram. Res., Spec. Publ. no. 9, p. 53, pl. 6, f. 33, 34.

Remarks. — Most of our specimens, considered to belong to this species, are more tapering than the individuals figured by Cushman.

The re-entrants are always arranged in longitudinal rows, the ridges in between are sometimes obscure. Our specimens also resemble *Bolivina plicatella* Cushman (1930, Florida State Geol. Survey, Bull. 4, p. 46, pl. 8, f. 10), and especially its variety *mera* Cushman and Ponton (1932, Florida State Geol. Survey, Bull. 9, p. 82, pl. 12, f. 4), with less pronounced crenulate sculpture of the test.

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

Netherlands (Woensdrecht) : Sands of Brussels.

Bolivina anglica Cushman

Pl. IX, fig. 18, 19; *48*

Bolivina anglica Cushman, 1936, Cushm. Lab. Foram. Res., Spec. Publ. no. 6, p. 50, pl. 7, f. 11 (Eocene; England); 1937, Cushm. Lab. Foram. Res., Spec. Publ. no. 9, p. 45, pl. 6, f. 10.

Bolivina punctata Sherborn and Chapman (not d'Orbigny), 1886, Journ. Roy. Micr. Soc., ser. 2, vol. 6, p. 743, pl. 14, f. 10 (Eocene; England); Bowen, 1954, Proc. Geol. Ass., vol. 65, p. 139.

Remarks. — Our Eocene individuals are characterized by oblique to strongly oblique sutures, an elongate, tapering test, and a loop-shaped aperture. They resemble *Bolivina anglica* especially if the description is taken into account. Bowen's *B. punctata* is considered to belong to *B. anglica*.

A number of our individuals described as *Bolivina pulchra* resemble *B. anglica*, but they have more or less crenulate and less oblique sutures.

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

Netherlands (Woensdrecht) : Clays of Ieper.

Bolivina pulchra (Terquem)

Pl. VIII, fig. 23, 24; *75*

Bulimina pulchra Terquem, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 114, pl. 12, f. 8 (Lutetian; Paris basin).

Bolivina pulchra (Terquem), Y. le Calvez, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 43, pl. 3, f. 43, 44.

Remarks. — *Bolivina pulchra* is characterized by slightly crenulate sutures near the central axis. The sutures are often nearly horizontal and straight.

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

Bolivina cookei CUSHMAN

Pl. VIII, fig. 25, 26; *218*

Bolivina cookei CUSHMAN, 1922, U. S. Geol. Survey, Prof. Paper 129-F, p. 126, pl. 29, f. 1 (Oligocene; Mississippi); 1937, Cushm. Lab. Foram. Res., Spec. Publ. no. 9, p. 68, pl. 8, f. 15.

Remarks. — Most of our specimens show slightly more curved sutures than is indicated by CUSHMAN, but in other features they closely resemble the original figures of the species.

Some variation was noted in the development of the costae. They may be thin, and only present on the earliest chambers. Mostly, however, they cover all chambers, with the exception of the last two. In a number of specimens, especially those from the Clays of Asse, they are very numerous and thus obscure the sutures. These variants are also somewhat more coarsely perforated and they show less curved sutures.

Bolivina cookei differs from *B. vaceki* SCHUBERT (1902, Beitr. Pal. Geol. Osterreich-Ungarns, etc., vol. 14, p. 25, pl. 1, f. 29) by the higher chambers, the less oblique sutures and the absence of a more strongly developed median ridge.

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

Genus LOXOSTOMUM EHRENBERG, 1854

Type species LOXOSTOMUM SUBROSTRATUM EHRENBERG, 1854

Loxostomum teretum CUSHMAN

Pl. IX, fig. 20; *227*

Loxostomum teretum CUSHMAN, 1936, Cushm. Lab. Foram. Res., Spec .Publ. no. 6, p. 60, pl. 8, f. 14 (Oligocene; France); 1937, Cushm. Lab. Foram. Res., Spec. Publ. no. 9, p. 179, pl. 21, f. 1, 2; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 133, pl. 5, f. 17.

Remarks. — It is probable that the types of *Loxostomum teretum* are juvenile specimens. In our larger individuals the test is about six times as long as broad, and often slightly twisted. They resemble *Bolivina semistriata* HANTKEN (1868, Magy. Földt. tars. munk., vol. 4, p. 95, pl. 2, f. 34), which is different by the horizontal sutures and the rapid increase in relative height of the chambers.

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

SUBFAMILY UVIGERININAE

Genus UVIGERINA D'ORBIGNY, 1826

Type species UVIGERINA PIGMEA D'ORBIGNY, 1826

Uvigerina farinosa HANTKEN

Pl. IX, fig. 21; *212*

Uvigerina farinosa HANTKEN, 1875, Jahrb. K. Ungar. Geol. Anstalt, Mitt., vol. 4, pt. 1, p. 62, pl. 7, f. 6 (Eocene; Hungary); CUSHMAN and EDWARDS, 1937, Contr. Cushm. Lab. Foram. Res., vol. 13, p. 58, pl. 8, f. 8, 9.

Remarks. — Our specimens show a hispid surface of the test, a relatively short apertural neck, and in adult specimens the tendency to become uniserial. Only some full-grown specimens of the Asse Clays show this last feature; in others the last-formed chambers are triserial or more or less biserial. Most specimens are distinctly hispid, but the granules may be arranged in more or less distinct, longitudinal rows, which resemble broken, longitudinal costae.

Smaller specimens are not distinctly different from *Uvigerina batjesi*, except for the wall which is less hispid in *U. batjesi*.

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

Uvigerina spinicostata CUSHMAN and JARVIS

Pl. IX, fig. 22; *225*

Uvigerina spinicostata CUSHMAN and JARVIS, 1929, Contr. Cushm. Lab. Foram. Res., vol. 5, p. 12, pl. 3, f. 9, 10 (Eocene; Trinidad); CUSHMAN and EDWARDS, 1937, Contr. Cushm. Lab. Foram. Res., vol. 13, p. 83, pl. 12, f. 11, 12.

Remarks. — Just as our *Uvigerina farinosa*, the individuals of this species show the tendency to become uniserial or biserial in the adult. The costae on the basal portions of the chambers are sometimes broken up, forming short spines. This is also known of the American representatives of this species. Sometimes the surface of the last chamber lacks costae, being smooth or hispid.

The surface of the apertural neck has an ornamentation of oblique costae, just as may be seen in the figures of CUSHMAN and EDWARDS.

Probably *Uvigerina seriata* CUSHMAN and JARVIS (1929, Contr. Cushm. Lab. Foram. Res., vol. 5, p. 13, pl. 3, f. 11, 12) is a variant of *U. spinicostata* with a greater tendency to become uniserial and with less plate-like costae. Such individuals were also found in our material.

The relation with our similar *Uvigerina farinosa* is not clear. There is no intergradation.

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

Uvigerine batjesi nov. sp.

Pl. VIII, fig. 27, 28, pl. IX, fig. 23; 37

Uvigerina rugosa TEN DAM (not TERQUEM), 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 115, pl 3, f. 13.

E t y m o l o g y . — Named after Dr. D. A. J. BATJES, author of the monograph on the Belgian Oligocene foraminifera.

D e s c r i p t i o n . — Test elongate, about three times as long as broad, initial end subacute to rounded, microspheric form tapering, macrospheric form quickly reaching its full breadth; periphery slightly lobulate; chambers numerous, inflated; sutures rather indistinct in the early portion, later distinct and depressed; wall smooth or finely hispid, very finely perforated; aperture with a short neck and a slight lip.

Dimensions of the holotype : length, 0,38 mm; breadth, 0,13 mm.

R e m a r k s . — TERQUEM (1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 120, pl. 12, f. 32) described *Uvigerina rugosa* as a species with a roughened surface and a short tubular neck. Y. LE CALVEZ (1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 49) restudied the types of the species and found them to be variants of *Angulogerina abbreviata* (TERQUEM), especially because of the terminal aperture without a neck.

The specimens of the Lower Eocene of Belgium show a looser arrangement of the more inflated chambers than *Angulogerina abbreviata.* They are more finely perforated and have a distinct apertural neck.

Uvigerina batjesi differs from *U. farinosa* HANTKEN by the absence of a more or less distinct longitudinal arrangement of the spinose projections. Young specimens of *U. farinosa* resemble *U. batjesi,* but differ in the rougher appearance of the wall.

Uvigerina batjesi differs from *U. minuta* CUSHMAN and STONE (1949, Contr. Cushm. Lab. Foram. Res., vol. 25, p. 54, pl. 10, f. 5, 6) by the more elongate test and the less coarsely hispid wall.

T y p e l o c a l i t y . — A hollow roadside NE of Mont-Saint-Aubert; our sample DH 1210.

T y p e l e v e l . — The Sands of Mons-en-Pévèle. These deposits are generally regarded as to be of Early Eocene age.

D i s t r i b u t i o n . — Belgium : Clays of Ieper, Clays of Roubaix, Sands of Mons-en-Pévèle;

Netherlands (Woensdrecht) : Clays of Ieper.

D e p o s i t o r y . — The holotype and the paratypoids are stored in the collections of the Geological Institute of Utrecht (S 10486-10488).

Genus ANGULOGERINA CUSHMAN, 1927

Type species UVIGERINA ANGULOSA WILLIAMSON, 1848

Angulogerina abbreviata (TERQUEM)

Pl. VIII, fig. 29, 30, pl. IX, fig. 24; *46*

Uvigerina abbreviata TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 120, pl. 12, f. 33 (Lutetian; Paris basin); CUSHMAN and EDWARDS, 1937, Contr. Cushm. Lab. Foram. Res., vol. 13, p. 56, pl. 8, f. 6, 7.

Angulogerina abbreviata (TERQUEM), Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 49.

Uvigerina rugosa TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 120, pl. 12, f. 32 (Lutetian; Paris basin).

Remarks. — The aperture is surrounded by a more or less flaring lip.

Some of our specimens resemble *Uvigerina farinosa*, which, however, shows much more inflated chambers and a more roughened aspect of the wall.

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

France : Lutetian;

Netherlands (Woensdrecht) : Clays of Ieper, Sands of Brussels.

Angulogerina abbreviata (TERQUEM) var. **tubulifera** nov. var.

Pl. X, fig. 1, 2; *207*

Etymology. — From Latin : *tubulus* = small tube.

Description. — Variety differing from the species by the more elongate test, the crenulate sutures, and the distinct apertural neck.

Dimensions of the holotype : length, 0,47 mm; breadth, 0,14 mm.

Remarks. — Our variety differs from *Uvigerina wilcoxensis* CUSHMAN and GARRETT (1939, Contr. Cushm. Lab. Foram. Res., vol. 15, p. 82, pl. 14, f. 17, 18) by the more elongate test, and the absence of slight ridges on the lower part of the chambers. *Uvigerina alabamensis* CUSHMAN and GARRETT (1939, op. cit., vol. 15, p. 83, pl. 14, f. 26, 27) does not show the crenulations, nor does *U. russelli* HOWE (Louisiana Dept. Cons., Geol. Bull., no. 14, p. 71, pl. 8, f. 21, 22).

Type locality. — Claypit of the « N. V. Steenbakkerijen van Oedelem » at Oedelem : our sample BRB 237.

Type level. — The Clays of Asse. The age of these deposits is commonly regarded as to be Late Eocene.

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

Netherlands (Woensdrecht) : Sands of Wemmel.

Depository. — The holotype and the paratypoids are stored in the collections of the Geological Institute at Utrecht (S 10412, 10413).

Angulogerina muralis (TERQUEM)

Pl. X, fig. 3, 4; *93*

Uvigerina muralis TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 119, pl. 12, f. 26-29 (Lutetian; Paris basin).

Angulogerina muralis (TERQUEM), CUSHMAN, 1937, Contr. Cushm. Lab. Foram. Res., vol. 13, p. 55, pl. 8, f. 3-5; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 49.

Remarks. — Some variation was found in the excavations at the base of the chambers. In most specimens they are not as deep as they are in TERQUEM's figures. The angles of the test are more or less rounded.

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

Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Brussels.

Angulogerina sp. cf. **A. ovata** (TERQUEM)

Pl. X, fig. 5; *124*

cf. *Tritaxia ovata* TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 105, pl. 11, f. 11 (Lutetian; Paris basin).

Remarks. — According to Y. LE CALVEZ (1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 18) the type of this species has been lost. Our specimens resemble both the description and the figures given by TERQUEM, and it seems very probable that TERQUEM's species is an *Angulogerina*.

Our individuals differ from the Upper Eocene *Trifarina* species by the lack of distinct uniserial chambers, although the tendency to become uniserial was noted among some elongate specimens. They furthermore lack the furrow along the peripheral angles, as well as the pores along the sutures.

The state of preservation of our specimens is too bad for a complete description.

Distribution. — Belgium : Sands of Brussels.

Genus TRIFARINA CUSHMAN, 1923

Type species TRIFARINA BRADYI CUSHMAN, 1923

Trifarina wilcoxensis (CUSHMAN and PONTON)

Pl. X, fig. 6, 7; *144*

Pseudouvigerina wilcoxensis CUSHMAN and PONTON, 1932, Contr. Cushm. Lab. Foram. Res., vol. 8, p. 66, pl. 8, f. 18 (Eocene; Alabama).

Angulogerina wilcoxensis (CUSHMAN and PONTON), CUSHMAN and GARRETT, 1939, Contr. Cushm. Lab. Foram. Res., vol. 15, p. 84, pl. 14, f. 24, 25.

Trifarina wilcoxensis (CUSHMAN and PONTON), BANDY, 1949, Bull. Am. Pal., vol. 32, no. 131, p. 145, pl. 27, f. 1.

Remarks. — In adult specimens the last two or three chambers are distinctly uniserial.

BANDY remarked that this species is different from *Trifarina bradyi* CUSHMAN (1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 99, pl. 22, f. 3-9) and its variety *advena* CUSHMAN (1926, Contr. Cushm. Lab. Foram. Res., vol. 1, p. 87) in the canaliculate character of the periphery. This feature is distinct in almost all Belgian specimens, but the furrow begins anew along each chamber, and it is sometimes absent along the first-formed chambers. Our specimens resemble furthermore those of BANDY because of its distinct rows of pores along the strongly curved sutures.

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

Genus TUBULOGENERINA CUSHMAN, 1927

Type species TEXTULARIA (BIGENERINA) TUBULIFERA PARKER and JONES, 1863

Tubulogenerina tubulifera (PARKER and JONES)

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Textularia (Bigenerina) tubulifera PARKER and JONES, 1863, Ann. Mag. Nat. Hist., ser. 3, vol. 11, p. 94, tf. 2 (Lutetian; Paris basin).
Tubulogenerina tubulifera (PARKER and JONES), CUSHMAN, 1937, Cushm. Lab. Foram. Res., Spec. Publ. no. 9, p. 215, pl. 24, f. 14-16; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 46.
Clavulina eocaenica TERQUEM (not GÜMBEL), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 121, pl. 12, f. 35 (Lutetian; Paris basin).

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

Genus BIFARINA PARKER and JONES, 1872

Type species DIMORPHINA SAXIPARA EHRENBERG, 1854

Bifarina selseyensis (HERON-ALLEN and EARLAND)

Pl. X, fig. 8, 9, 10; *193*

Bigenerina selseyensis HERON-ALLEN and EARLAND, 1909, Jour. Roy. Micr. Soc. London, p. 330, pl. 15, f. 15-17 (? Eocene; England).
Siphogenerina hexagona HALKYARD, 1918, Mem. Proc. Manchester Lit. Philos. Soc., vol. 62, pt. 2, p. 41, pl. 6, f. 5 (Eocene; Biarritz, France).

Remarks. — Most of our specimens of the Belgian and English Eocene show a very short triserial beginning of the test. In the English specimens the biserial part is followed by two or three irregularly uniserial chambers. In the Belgian material no specimens with a distinct uniserial part were found, but the last chambers of full-grown specimens show the tendency to become uniserial. In other respects the Belgian and English specimens are identical, and they resemble very well HERON-ALLEN and EARLAND's figures of *Bigenerina selseyensis*.

The aperture has a distinct collar-like lip, surrounding a very finely perforated plate, at the border of which a small slit is the only opening. The same type of aperture is indicated by CUSHMAN for *Bifarina reticulosa* CUSHMAN (1936, Cushm. Lab. Foram. Res., Spec. Publ. no. 6, p. 61, pl. 8, f. 17). The latter species also has about the same type of ornamentation as ours, but the reticulation of *B. reticulosa* is somewhat coarser than in our *B. selseyensis*.

BHATIA (1955, Jour. Pal., vol. 29, p. 680, pl. 66, f. 16) described specimens referable to our *Bifarina selseyensis* as *Bitubulogenerina reticulata* CUSHMAN (1936, Cushm. Lab. Foram. Res., Spec. Publ. no. 6, p. 62, pl. 8, f. 21). Probably both species are identical. Like *B. reticulata* our species sometimes shows a short and stout spine at the initial end, but mostly such a spine is absent.

The generally described differences between *Bifarina* and *Bitubulogenerina* seem to be more or less illusionary for our specimens.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse;
England : Upper Bracklesham beds;
Netherlands (Woensdrecht) : Sands of Lede.

SUBFAMILY ROBERTININAE

Genus ROBERTINA D'ORBIGNY, 1846

Type species ROBERTINA ARCTICA D'ORBIGNY, 1846

Robertina germanica CUSHMAN and PARKER

Pl. X, fig. 11, 12; *210*

Robertina germanica CUSHMAN and PARKER, 1938, Contr. Cushm. Lab. Foram. Res., vol. 14, p. 73, pl. 13, f. 2 (Oligocene; Germany); 1947, U. S. Geol. Survey, Prof. Paper 210-D, p. 73, pl. 18, f. 5.

Remarks. — Our specimens fairly well resemble the type figures, especially in the apertural characters.

The length of the test is variable. Some specimens are elongate like *Robertina mcguirti* HOWE (1939, Louisiana Dept. Cons., Geol. Bull. no. 14, p. 82, pl. 8, f. 23, 24). Just as in this species the earlier whorls of the test are hardly visible. In some specimens the narrow aperture lies in a groove.

Five to eight pairs of chambers are found in the final coil; the sutures are mostly slightly limbate and slightly, if at all, depressed. Specimens with more depressed sutures resemble *Robertina ovigera* CUSHMAN and PARKER (1936, Contr. Cushm. Lab. Foram. Res., vol. 12, p. 98, pl. 16, f. 15) from the Lutetian of the Paris basin, but they differ because of the flattened apertural face and the greater average number of chambers per coil.

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

FAMILY CHILOSTOMELLIDAE

Genus PULLENIA PARKER and JONES, 1862

Type species NONIONINA BULLOIDES D'ORBIGNY, 1846

Pullenia quinqueloba (REUSS)

Pl. XI, fig. 1, 2; *59*

Nonionina quinqueloba REUSS, 1851, Zschr. Deu. Geol. Ges., vol. 3, p. 71, pl. 5, f. 31 (Oligocene; Germany).
Pullenia quinqueloba (REUSS), CUSHMAN and TODD, 1943, Contr. Cushm. Lab. Foram. Res., vol. 19, p. 10, pl. 2, f. 5, pl. 3, f. 8; TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 128; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 139, pl. 6, f. 8.

Remarks. — Generally the periphery is slightly lobulate. Some specimens were noted with six chambers in the final coil.

A number of specimens have a slightly more compressed test than is typical for the species; they are perhaps referable to as *Pullenia quinqueloba* (REUSS) var. *angusta* CUSHMAN and TODD (1943, Contr. Cushm. Lab. Foram. Res., vol. 19, p. 10, pl. 2, f. 3, 4).

Distribution. — Belgium : Clays of Ieper, Sands of Mons-en-Pévèle, Sands of Lede, Sands of Wemmel, Clays of Asse;
England : London Clay, Upper Bracklesham beds, Barton beds;
Netherlands (Woensdrecht) : Clays of Ieper.

Genus SEABROOKIA H. B. BRADY

Type species SEABROOKIA PELLUCIDA H. B. BRADY, 1890

Seabrookia lagenoides TEN DAM

Pl. X, fig. 13; *211*

Seabrookia lagenoides TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 127, pl. 3, f. 18 (Eocene; Netherlands); CUSHMAN and TODD, 1949, Contr. Cushm. Lab. Foram. Res., vol. 25, p. 97, pl. 16, f. 21.

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

Genus ALLOMORPHINA REUSS, 1850

Type species ALLOMORPHINA TRIGONA REUSS, 1850

Allomorphina sp.

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Remarks. — A small number of *Allomorphina* moulds was found. Specific determination appeared impossible.

Distribution. — Belgium : Sands of Mons-en-Pévèle, Sands of Brussels.

Family NONIONIDAE

Genus NONION Montfort, 1808

Type species NAUTILUS INCRASSATUS Fichtel and Moll, 1798

Nonion affine (Reuss)

Pl. XI, fig. 3, 4; 23

Nonionina affinis Reuss, 1851, Zschr. Deu. Geol. Ges., vol. 3, p. 72, pl. 5, f. 32 (Oligocene; Germany).

Nonion affine (Reuss), Cushman, 1939, U. S. Geol. Survey, Prof. Paper no. 191, p. 9, pl. 2, f. 13; ten Dam, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 108; Batjes, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 140, pl. 6, f. 12.

Nonion umbilicatulum (Walker and Jacob), Bhatia, 1955, Jour. Pal., vol. 29, p. 678, pl. 66, f. 2.

Remarks. — In our material the predominant type is that of *Nonion affine*, but it merges into others with an indistinctly developed central boss of hyaline shell material, which is more or less formed by thickenings along the umbilical opening. Such specimens mostly show limbate sutures, which are absent in typical forms. They resemble *N. chapapotense* Cole (1928, Bull. Am. Pal., vol. 14, no. 53, p. 210, pl. 1, f. 18, 19). Cushman (1939, op. cit., p. 6) noticed the considerable variation of this species in the development of the central boss, which is present in typical forms, but completely absent in others.

Rather considerable variation we found in the degree of compression of the test. Forms resembling *Nonion soldanii* (d'Orbigny) (*Nonionina soldanii* d'Orbigny, 1846, Foram. foss. Vienne, p. 109, pl. 5, f. 15, 16) were met with, but their apertural face is not as broad as in typical specimens of that species from the Miocene of the Vienna basin. Y. le Calvez (1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 53) recorded *N. soldanii* from the Lutetian of the Paris basin, but our specimens from the Lutetian of Grignon distinctly belong to *N. affine*.

Specimens in our collections from the Eocene of Biarritz, probably conspecific with *Nonion halkyardi* Cushman (1936, Contr. Cushm. Lab. Foram. Res., vol. 12, p. 63. pl. 12, f. 1) from this locality, appeared to be broader and to have a lower apertural face than our *N. affine*. Some variants resembling *N. halkyardi* were found among our Lower and Middle Eocene material of Belgium. This proves that *N. halkyardi* may be another variant of the wide *N. affine* group.

Distribution. — Belgium : Clays of Ieper, Clays of Roubaix, Sand of Mons-en-Pévèle, Sands of Aalter, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse;

England : London Clay, Barton beds;

France : Lutetian;

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

Nonion scaphum (Fichtel and Moll)

Pl. X, fig. 14, pl. XI, fig. 5; 73

Nautilus scapha Fichtel and Moll, 1798, Test. Micr., p. 105, pl. 19, f. d-f (recent; Adriatic, Italy).

Nonionina scapha (Fichtel and Moll), H. B. Brady, 1884, Rep. Voy. Challenger, vol. 9, p. 730, pl. 109, f. 14, 15 (not 16).

Nonion scaphum (Fichtel and Moll), Cushman, 1939, U. S. Geol. Survey, Prof. Paper no. 191, p. 20, pl. 5, f. 18-21; Marks, 1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 49, pl. 5, f. 16.

Nonionina communis d'Orbigny, 1846, Foram. foss. Vienne, p. 106, pl. 5, f. 7 (Miocene; Vienna basin); Terquem, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 42, pl. 2, f. 6.

Nonion commune (d'Orbigny), Cushman, 1939, U. S. Geol. Survey, Prof. Paper no. 191, p. 10, pl. 3, f. 2; Y. le Calvez, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 52.

Nonion acutidorsatum ten Dam, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 108, pl. 3, f. 19 (Sands of Brussels, boring Woensdrecht, the Netherlands).

R e m a r k s . — As Marks pointed out it is very difficult to make any distinction between *Nonion commune* and *N. scaphum* in the material of the Vienna basin. He proposed to maintain the older name of Fichtel and Moll.

Nonion acutidorsatum lacks the granular filling of the umbilical region, but it is apparently only a variant of *N. scaphum*. Specimens with and without granules occur together throughout the Belgian material; the younger specimens mostly lack granules.

Some specimens, resembling *Nonion elongatum* (d'Orbigny) (*Nonionina elongata* d'Orbigny, 1852, Prodrome Pal. Strat. Univ. An. Moll. Ray., vol. 3, p. 155) have been included.

Specimens from the Belgian Oligocene deposits described by Batjes as *Nonion boueanum* (d'Orbigny) (1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 143, pl. 7, f. 6, 7) appeared to comprise both *N. boueanum* (f. 7) and *N. scaphum* (f. 6). In the Lower Tongeren beds of the mine shaft Hendrik IV, Dutch Limburg, only *N. scaphum* was encountered.

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

England : London Clay;

Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Lede.

Nonion graniferum (Terquem)

Pl. X, fig. 15; 72

Nonionina granifera Terquem, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 42, pl. 2, f. 8, 9 (Lutetian; Paris basin).

Nonion graniferum (Terquem), Cushman, 1939, U. S. Geol. Survey, Prof. Paper no. 191, p. 4, pl. 1, f. 9-11; Y. le Calvez, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 53, pl. 4, f. 58, 59.

R e m a r k s . — Sometimes the fine, granular umbilical filling extends more or less along the inner ends of the depressed sutures. Specimens with excessive development of these granules are sometimes inseparable from similar variants of *Elphidium laeve* (d'Orbigny).

Nonion graniferum resembles *N. granosum* (d'Orbigny) (*Nonionina granosa* d'Orbigny, 1846, Foram. foss. Vienne, p. 110, pl. 5, f. 19, 20), but it differs by the fine pores in the wall and the smaller granules in the umbilicus.

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

England : Barton beds;

France : Sands of Cuise.

Genus NONIONELLA CUSHMAN, 1926

Type species NONIONELLA MIOCENICA CUSHMAN, 1926

Nonionella spissa CUSHMAN

Pl. XI, fig. 7, 8; *71*

Nonionella hantkeni (CUSHMAN and APPLIN) var. *spissa* CUSHMAN, 1931, Contr. Cushm. Lab. Foram. Res., vol. 7, p. 58, pl. 7, f. 13 (Eocene; Carolina); CUSHMAN, 1939, U. S. Geol. Survey, Prof. Paper no. 191, p. 30, pl. 8, f. 5.

Nonionella spissa CUSHMAN, BANDY, 1949, Bull. Am. Pal., no. 131, p. 78, pl. 11, f. 2, 4.

Remarks. — The majority of our specimens agree fairly well with the figures given by BANDY. Thick variants, as figured by CUSHMAN, are scarce in our material. Some are still more compressed than those figured by BANDY.

Our specimens of the Lower Eocene are hardly distinguishable from *Nonion applinae* HOWE and WALLACE (1932, Louisiana Dept. Cons., Bull. no. 2, p. 51, pl. 9, f. 4). According to the figures this species is possibly a *Nonionella*.

Distribution. — Belgium : Clays of Ieper, Clays of Roubaix, Sands of Mons-en-Pévèle, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse.

Nonionella wemmelensis nov. sp.

Pl. XI, fig. 6; *206*

Etymology. — Named after Wemmel, the type locality of the Sands of Wemmel.

Description. — Test small, about twice as long as broad, sides nearly parallel, ventral side involute with some papillae in the umbilicus, dorsal side evolute; periphery smooth, rounded; chambers eight to ten in the last whorl, distinct, increasing rapidly in length as added, the umbilical lobes very slight; sutures distinct, slightly depressed, slightly curved towards the periphery; surface smooth; wall very finely perforate; aperture a very low arch at the base of the septal face of the last chamber, extending slightly towards the involute side.

Dimensions of the holotype : length, 0,31 mm; breadth, 0,19 mm; thickness, 0,10 mm.

Remarks. — This rather flat species is characterized by the parallel sides and the very elongate chambers. It differs from *Nonionella longicamerata* BANDY (1949, Bull. Am. Pal., no. 131, p. 77, pl. 11, f. 8) by the few umbilical papillae and the absence of a far overlapping final chamber.

Nonionella wemmelensis also reminds of *Nonion grateloupi* (D'ORBIGNY) (*Nonionina grateloupi* D'ORBIGNY, 1839, in DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foram., p. 46, pl. 6, f. 6, 7), especially in the form of the chambers, but it distinctly belongs to the genus *Nonionella*.

Type locality. — Boring 48 near Wemmel; our sample Wemmel 48-22 m.

Type level. — The Sands of Wemmel. These deposits are commonly regarded as to be of Late Eocene age.

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

Depository. — The holotype and the paratypoids of this species are stored in the collections of the Geological Institute at Utrecht (S 10813, 10814).

FAMILY DISCORBIDAE

SUBFAMILY PATELLININAE

Genus PATELLINA WILLIAMSON, 1858

Type species PATELLINA CORRUGATA WILLIAMSON, 1858

Patellina nitida TERQUEM

130

Patellina nitida TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 123, pl. 12, f. 38 (Lutetian; Paris basin); Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 14, pl. 1, f. 11.

Remarks. — Only some single specimens, mostly ill-preserved.

Distribution. — Belgium : Sands of Brussels.

SUBFAMILY DISCORBININAE

Genus DISCORBIS LAMARCK, 1804

Type species DISCORBITES VESICULARIS LAMARCK, 1804

Discorbis vesicularis (LAMARCK)

Pl. XI, fig. 11-13; *136*

Discorbites vesicularis LAMARCK, 1804, Ann. Mus. Hist. Nat., vol. 5, p. 183; vol. 8, pl. 62, f. 7 (Lutetian; Paris basin).

Discorbis vesicularis (LAMARCK), CUSHMAN, 1927, Contr. Cushm. Lab. Foram. Res., vol. 3, p. 123, pl. 24, f. 1; Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 16, pl. 3, f. 36-38.

Rotalina depressa TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 58, pl. 3, f. 17 (Lutetian; Paris basin).

Rotalina porosa TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 84, pl. 8, f. 15 (Lutetian; Paris basin).

Rosalina propinqua TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 99, pl. 10, f. 14 (Lutetian; Paris basin).

Discorbis propinqua (TERQUEM), Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 17, pl. 1, f. 12-14.

Rotalina coarctata TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 76, pl. 7, f. 8 (Lutetian; Paris basin).

Rotalina semipunctata TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 84, pl. 8, f. 15 (Lutetian; Paris basin).

Globigerina aequabilis TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 86, pl. 9, f. 5 (Lutetian; Paris basin).

Globigerina lamellosa TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 85, pl. 9, f. 1 (Lutetian; Paris basin).

Remarks. — YOLANDE LE CALVEZ concluded that several of TERQUEM's species are variants of *Discorbis vesicularis* and *D. propinqua*. On the basis of specimens from Grignon, the type locality of *D. vesicularis*, it appeared furthermore impossible to make a clear distinction between *D. vesicularis* and *D. propinqua*. The latter represents a younger stage of *D. vesi-*

cularis. Both types are characterized by narrow projections extending across the depressed central area of the ventral side, mostly fused together forming an imperforated calcareous plate that covers this central area. In young specimens this plate is star-like, as in *D. propinqua*, as it was figured by Y. LE CALVEZ. In bigger specimens more material is added to this structure which becomes less star-like, and forms a fairly irregular plate. Sometimes the extensions fuse incompletely. Such specimens are good in resemblance with the figures of *D. vesicularis* by Y. LE CALVEZ (pl. 3, f. 36-38).

Mostly there is a keeled periphery, but specimens without a keel and with a rounded periphery occur as well. The perforations of the dorsal sides are sometimes lacking, except along the sutures. Often the first formed chambers are not distinct.

The Belgian specimens all belong to the *Disorbis propinqua* group of young individuals. Keeled variants resemble *Discorbis dimidiata* (PARKER and JONES) (*Discorbina dimidiata* PARKER and JONES, 1862, in CARPENTER, Introduction Study Foram., p. 201, tf. 32), type species of the genus *Lamellodiscorbis* BERMUDEZ, 1952.

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

Discorbis limbata (TERQUEM)

Pl. X, fig. 16; *138*

Rotalina limbata TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 80, pl. 8, f. 6 (Lutetian; Paris basin).

Discorbis limbata (TERQUEM), Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 19, pl. 2, f. 30-32.

Remarks. — In the Belgian material some specimens with a stronger carina resemble the figures given by Y. LE CALVEZ for *Discorbis vitrea* (TERQUEM) (*Rotalina vitrea* TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 79, pl. 8, f. 3).

Some of our specimens show swollen inner ends of the chambers at the ventral side. They resemble *Discorbis huneri* HOWE (1939, Louisiana Dept. Cons., Geol. Bull. no. 14, p. 74, pl. 9, f. 26, 27) and *D. mauricensis* HOWE and ROBERTS (1939, ibid., p. 74, pl. 9, f. 28-30). They differ from *D. obvoluta* (TERQUEM) (*Rotalina obvoluta* TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 81, pl. 8, f. 7) by the less curved sutures of the dorsal side, and by the absence of visible pores.

Distribution. — Belgium : Sands of Brussels, Sands of Lede, Sands of Wemmel; France : Lutetian;
Netherlands (Woensdrecht) : Sands of Brussels.

Discorbis humilis Y. LE CALVEZ

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Discorbis humilis Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 24, pl. 3, f. 48-50 (Lutetian; Paris basin).

Remarks. — This species differs from *Discorbis limbata* (TERQUEM) in the more strongly curved sutures of both sides and the greater number of chambers in the final coil, six to seven instead of four to five. *D. obvoluta* (TERQUEM) also shows strongly curved sutures on the dorsal side, but ventrally this feature is less distinct.

Distribution. — Belgium : Sands of Brussels.

Discorbis parisiensis (d'Orbigny)

Pl. XI, fig. 9, 10; *89*

Rosalina parisiensis d'Orbigny, 1865, in Parker, Jones and Brady, Ann. Mag. Nat. Hist., vol. 16, ser. 3, pl. 2, f. 70 (Eocene; Paris basin); Terquem, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 99, pl. 10, f. 15-17.

Discorbis parisiensis (d'Orbigny), Cushman, 1927, Contr. Cushm. Lab. Foram. Res., vol. 3, p. 142; Y. le Calvez, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 16.

Remarks. — The dorsal as well as the ventral side are usually coarsely perforated.

Most specimens of the Lutetian of Grignon are characterized by the peculiar ornamentation of the ventral side which consists of costae, broken up in the earlier part and running at right angles to the strongly curved sutures. Generally thicker specimens are less ornamented than thinner ones.

In the Belgian Eocene only a small number, of young individuals, was found. They mostly show the ornamentation, but lack the pores. Only flat representatives were met with. The ornamentation distinguishes these young specimens from those of *Discorbis humilis* Y. le Calvez.

Distribution. — Belgium : Sands of Mons-en-Pévèle, Sands of Brussels, Sands of Lede, Sands of Wemmel;

France : Lutetian;

Netherlands (Woensdrecht) : Sands of Brussels.

Discorbis perplexa Y. le Calvez

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Discorbis perplexa Y. le Calvez, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 21, pl. 2, f. 18-20 (Lutetian; Paris basin).

Rotalina elegans Terquem (not d'Orbigny), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 75, pl. 7, f. 6 (Lutetian; Paris basin).

Rotalina elegans Terquem (not d'Orbigny), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 80, pl. 8, f. 5 (Lutetian; Paris basin).

Remarks. — Our specimens from the Paris basin very well resemble the figures of Y. le Calvez. Some ill-preserved, young specimens of the Belgian Eocene could be recognized by the characteristic umbilical knob.

Distribution. — Belgium : Sands of Mons-en-Pévèle, Sands of Brussels, Sands of Wemmel;

France : Lutetian.

Discorbis quadrata (Terquem)

Pl. X, fig. 17; *122*

Rosalina quadrata Terquem, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 98, pl. 10. f. 12 (Lutetian; Paris basin).

Discorbis quadrata (Terquem), Y. le Calvez, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 25, pl. 2, f. 21-23.

Remarks. — According to Y. le Calvez this species has a smooth wall with very fine pores. Associated with such types we found very coarsely perforated individuals which are otherwise identical with those described by Y. le Calvez. Mostly the ventral side is without pores, but some may be present along the periphery.

Possibly *Discorbis ubiqua* Y. LE CALVEZ (1949, op. cit., p. 23, pl. 2, f. 27-29) is a young stage of *D. quadrata*.

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

Discorbis sp. cf. **D. ferganensis** BYKOVA

Pl. X, fig. 18; *111*

cf. *Discorbis ferganensis* BYKOVA, 1939, Neft. Geol. - Razv. Inst. Trudy, ser. A, vol. 121, pp. 28, 36, pl. 3, f. 7-9 (Eocene; Uzbek S. S. R., U. S. S. R.).

Remarks. — A number of small specimens, mostly single ones, resemble this Russian species best. They are characterized by the flat ventral side of the test. The chambers, seven to nine in the last whorl, leave a faint depression in the center of the ventral side. The chamber ends are mostly slightly raised. The aperture is ventral. Our specimens are less conical than those figured by BYKOVA.

They also resemble *Eponides minima* CUSHMAN (1933, Contr. Cushm. Lab. Foram. Res., vol. 9, p. 17, pl. 2, f. 8), but the latter species has a biconvex test, a slightly keeled periphery, and papillae at the ventral side.

Eponides dorfi TOULMIN (1941, Jour. Pal., vol. 15. p. 601, pl. 81, f. 8, 9, tf. 4) has a more conical dorsal side, and the chambers are more inflated than in *Discorbis* sp. cf. *D. ferganensis*.

The generic place of our species is not clear. Secondary umbilical apertures seem to be present, which favours the assigning to *Discorbis*.

Distribution. — Belgium : Sands of Brussels, Sands of Lede;
Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Brussels.

Discorbis spp.

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Remarks. — In the samples of the French Lutetian a number of single individuals of some *Discorbis* species were found.

They belong to :

Discorbis turbinata (TERQUEM) (*Rotalina turbinata* TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 75, pl. 7, f. 5),
Discorbis rotata (TERQUEM) (*Rotalina rotata* TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 83, pl. 8, f. 13), and
Discorbis excavata (TERQUEM) (*Rosalina excavata* TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 98, pl. 10, f. 11).

Undeterminable specimens were found in a number of samples of the Belgian Eocene.

Distribution. — Belgium : Clays of Roubaix, Sands of Mons-en-Pévèle, Sands of Brussels;
France : Lutetian;
Netherlands (Woensdrecht) : Lower Panisel beds.

Genus EPONIDES MONTFORT, 1808

Type species NAUTILUS REPANDUS FICHTEL and MOLL, 1798

Eponides schreibersi (D'ORBIGNY)

Pl. XI, fig. 14, 15; *195*

Rotalina schreibersi D'ORBIGNY, 1846, Foram. foss. Vienne, p. 154, pl. 8, f. 4-6 (Miocene; Vienna basin).
Rotalina karsteni REUSS, 1855, Zschr. Deu. Geol. Ges., vol. 7, pt. 1, p. 273, pl. 9, f. 6 (Upper Eocene; Germany - see TRIEBEL, 1952, Notizbl. Hess. L. - Amt f. Bodenforschung, Wiesbaden, vol. 6, pt. 3, p. 29).

Remarks. — Our material showed that the illustration of *Eponides karsteni* (REUSS) represents a young individual of *E. schreibersi*.

The inner ends of the chambers of the ventral side are thickened to a number of hyaline knobs, which surround the narrow umbilical opening. Occasionally these knobs are absent (as in *Eponides karsteni*, as figured by REUSS). Sometimes the hyaline structures extend some way along the sutures. Those of adjoining chambers may have fused, forming limbate and raised instead of depressed sutures.

REUSS mentioned the absence of pores, but this seems to be due to the state of preservation. The walls are mostly finely perforated.

The aperture is a distinct slit at the base of the apertural face of the last chamber. Sometimes it continues into the umbilical depression.

Eponides scheibersi must be closely related to or conspecific with the American *E. mexicanus* (CUSHMAN) (*Pulvinulina mexicana* CUSHMAN, 1925, Bull. Am. Ass. Petr. Geol., vol. 9, p. 300, pl. 7, f. 7, 8) from the Eocene of Mexico.

Distribution. — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse;
Netherlands (Woensdrecht) : Sands of Lede.

Eponides polygonus Y. LE CALVEZ

Pl. XII, fig. 1; *107*

Eponides polygonus Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 28, pl. 5, f. 90-92 (Lutetian; Paris basin).

Remarks. — There is some varation in the distribution of the pores. Y. LE CALVEZ described the wall as finely perforate. In our Belgian specimens, as well as in individuals of the Lutetian of the Paris basin, the pores appeared to be rather coarse. They are distinctly absent on the apertural face of the last chamber. In very young individuals the pores are clearly fewer in number, and mostly only met with along the sutures.

Distribution. — Belgium : Sands of Brussels, Sands of Lede, Sands of Wemmel;
France : Sands of Cuise, Lutetian;
Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Brussels.

Eponides toulmini BROTZEN

Pl. XII, fig. 2; *17*

Eponides boueana TOULMIN (not *Rotalina boueana* D'ORBIGNY), 1941, Jour. Pal., vol. 15, p. 601, pl. 81, f. 6, 7 (Eocene; Alabama).

Eponides toulmini BROTZEN, 1948, Sver. Geol. Unders., Avh., ser. C, no. 493, p. 78, pl. 10, f. 16 (Paleocene; Sweden).

Remarks. — A number of small specimens closely resemble BROTZEN's species. Only the dorsal sutures are not raised or only faintly so.

Distribution. — Belgium : Clays of Ieper, Sands of Mons-en-Pévèle, Sands of Brussels, Sands of Lede, Clays of Asse;
France : Lutetian.

Eponides umbonatus (REUSS)

Pl. XIII, fig. 1; *226*

Rotalina umbonata REUSS, 1851, Zschr. Deu. Geol. Ges., vol. 3, p. 75, pl. 5, f. 35 (Oligocene; Germany).

Pulvinulina umbonata (REUSS), H. B. BRADY, 1884, Rep. Voy. Challenger, vol. 9, p. 695, pl. 105, f. 2.

Eponides umbonatus (REUSS), TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 120; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 146, pl. 7, f. 10.

Remarks. — The variable curvature of the ventral sutures near the closed umbilicus is never as strongly developed as it is in *Eponides umbonatus* (REUSS) var. *ecuadorensis* (GALLOWAY and MURRAY) (*Rotalia ecuadorensis* GALLOWAY and MURRAY, 1929, Bull. Am. Pal., vol. 15, p. 26, pl. 3, f. 13).

The sutures of the dorsal side are at right angles to the periphery, but oblique and slightly curved sutures were found as well.

The aperture mostly shows a distinct lip, but this structure may be absent.

Distribution. — Belgium : Sands of Wemmel, Clays of Asse;
Netherlands (Woensdrecht) : Sands of Wemmel.

Eponides plummerae CUSHMAN

Pl. XII, fig. 3; *9*

Truncatulina tenera PLUMMER (not *Pulvinulina tenera* H. B. BRADY), 1927, Univ. Texas Bull., no. 2644, p. 146, pl. 9, f. 5 (Paleocene; Texas).

Eponides plummerae CUSHMAN, 1948, Contr. Cushm. Lab. Foram. Res., vol. 24, p. 44, pl. 8, f. 9 (Paleocene; Texas).

Eponides midwayensis HARRIS and JOBE, 1951, Microfauna basal Midway outcrops near Hope, Arkansas; Transcr. Press, Norman, Okl., p. 47, pl. 9, f. 3, 6 (Paleocene; Arkansas).

Remarks. — The number of chambers in the final coil varies from five to seven. Near the umbilical center the sutures of the ventral side are sometimes obscured by secondary material.

Our specimens resemble *Eponides lunata* BROTZEN (1948, Sver. Geol.Unders., Avh., ser. C, no. 493, p. 77, pl. 10, f. 17, 18) from the Lower Paleocene of Sweden. They differ by the lower conical test, and the less acute peripheral margin. Furthermore our specimens are dorsally less distinctly perforated than those of BROTZEN's figures.

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

Genus GYROIDINA D'ORBIGNY, 1826

Type species GYROIDINA ORBICULARIS D'ORBIGNY, 1826

Gyroidina octocamerata CUSHMAN and G. D. HANNA

Pl. XIII, fig. 2; *80*

Gyroidina soldanii D'ORBIGNY var. *octocamerata* CUSHMAN and G. D. HANNA, 1927, California Acad. Sci. Proc., ser. 4, vol. 16, p. 223, pl. 14, f. 16-18 (Eocene; California); CUSHMAN, 1935, U. S. Geol. Survey, Prof. Paper 181, p. 45, pl. 18, f. 4; HOWE, 1939, Louisiana Dept. Conserv., Geol. Bull. no. 14, p. 75, pl. 9, f. 34-36; TOULMIN, 1941, Jour. Pal., vol. 15, p. 600, pl. 81, f. 3-5.

Gyroidinoides soldanii (D'ORBIGNY) var. *octocamerata* (CUSHMAN and G. D. HANNA), BROTZEN, 1948, Sver. Geol. Unders., Avh., ser. C, no. 493, p. 76, pl. 11, f. 3.

Valvulineria octocamerata (CUSHMAN and G. D. HANNA), BANDY, 1949, Bull. Am. Pal., vol. 32, no. 131, p. 84, pl. 13, f. 1.

Valvulineria scrobiculata CUSHMAN and PONTON, 1932, Contr. Cushm. Lab. Foram. Res., vol. 8, p. 70, pl. 9, f. 5 (Eocene; Alabama).

Rotalina orbicularis TERQUEM (not *Gyroidina orbicularis* D'ORBIGNY), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 60, pl. 4, f. 1-3 (Lutetian; Paris basin).

Gyroidina orbicularis Y. LE CALVEZ (not D'ORBIGNY), 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 27.

Gyroidina cf. orbicularis D'ORBIGNY, TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 118.

Remarks. — Our specimens from the Lutetian of Grignon, as well as the individuals from the Eocene of Belgium, resemble *Gyroidina octocamerata* much better than *G. orbicularis* D'ORBIGNY. The latter species seems to be characterized by an acute periphery, a closed umbilicus, and a more or less convex dorsal side with a distinctly protruding first part. Our specimens show a rounded periphery, an open umbilicus, and a flattened dorsal side. The elongate aperture extends from a point close to the periphery to the umbilicus, which is partly covered by a thin, valvular flap. This flap, which is mostly broken, is of variable size. Specimens with a flap as large as it is in the figures of TOULMIN are very scarce. Types, shown in the figures of BROTZEN and BANDY, are most common.

According to BANDY this flap, as well as the extending of the aperture into the umbilicus, are diagnostic features of *Valvulineria*. However, a definite statement about the generic position of the species is premature as long as no detailed description of *Gyroidina orbicularis*, the type species of *Gyroidina*, is available. The same holds true for the distinction between *Gyroidina* and *Gyroidinoides*, because the apertural features of *G. orbicularis* seem to be rather obscure. In material of our collections from Rimini, Italy, we failed to find distinct *G. orbicularis*.

Some variation is found in the depression of the sutures of both sides. Adult specimens mostly show a depressed spiral suture, as well as depressed ventral sutures near the umbilicus.

Distribution. — Belgium : Clays of Roubaix, Sands of Mons-en-Pévèle, Clays of Roncq, Sands of Aalter, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse;
Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Aalter.

Gyroidina angustiumbilicata TEN DAM

Pl. XII, fig. 4; *31*

Gyroidina angustiumbilicata TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 117, pl. 4, f. 7 (Lower Eocene; Netherlands).

Remarks. — Our individuals of *Gyroidina angustiumbilicata* differ from those of *G. octocamerata* by the less depressed umbilicus, closed or nearly closed, without flap and by the more evenly rounded periphery.

TEN DAM figured a specimen with seven chambers in the final coil, but in the description eight chambers are said to be typical. The last number appeared to be the most common among his paratypoids and also among our individuals.

Distribution. — England : London Clay;
Netherlands (Woensdrecht) : Clays of Ieper.

Gyroidina sp cf. G. soldanii (D'ORBIGNY)

Pl. XII, fig. 5; *229*

cf. *Rotalina soldanii* D'ORBIGNY, 1846, Foram. foss. Vienne, p. 155, pl. 8, f. 10-12 (Miocene; Vienna basin).
cf. *Gyroidina soldanii* (D'ORBIGNY), MARKS, 1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 64; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 147, pl. 7, f. 12-15.

Remarks. — Our specimens are characterized by the distinctly limbate and raised sutures, the very convex ventral and flat dorsal side, and the valvular flap that covers part of the small umbilical opening.

Gyroidina girardana (REUSS) (*Rotalina girardana* REUSS, 1851, Zschr. Deu. Geol. Ges., vol. 3, p. 73, pl. 5, f. 34), interpreted by BATJES as a variety of *G. soldanii*, greatly resembles our individuals, but it has no limbate sutures, and furthermore an umbilical flap seems to be absent.

Distribution. — Belgium : Clays of Asse (only known from some samples of Oedelem, BRB).

SUBFAMILY CANCRININAE

Genus CANCRIS CUSHMAN, 1926

Type species NAUTILUS AURICULUS FICHTEL and MOLL, 1803

Cancris subconicus (TERQUEM)

Pl. XII, fig. 6-8; *81*

Rotalina subconica TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 61, pl. 4, f. 5 (Lutetian; Paris basin).
Valvulineria subconica (TERQUEM), Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 26, pl. 5, f. 87-89.
Cancris turgidus CUSHMAN and TODD, 1942, Contr. Cushm. Lab. Foram. Res., vol. 18, p. 92, pl. 24, f. 3, 4 (Oligocene; Germany); BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 149, pl. 10, f. 5.
Valvulineria ovalis TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 103, pl. 11, f. 10 (Lutetian; Paris basin).

Remarks. — Our specimens of the Lutetian of Grignon and BATJES' individuals of the Oligocene of Kassel, the type area of *Cancris turgidus*, appeared to belong to the same species.

Most Lower Eocene specimens of Belgium are young individuals, with six or seven chambers in the last whorl, and a distinct *Valvulineria*-like lip. They always show the clear area in the wall of the last-formed chamber, typical for *Cancris*. Specimens of the Upper Eocene sometimes show the same number of chambers, but individuals with five chambers are also frequent.

Some variation is found in the curvature of the sutures of the dorsal side. Specimens with most curved sutures commonly have a slightly lobulate periphery.

The lobe at the inner end of the last-formed chamber is variously developed, and hence the small rounded bosses around the umbilicus. They are almost absent in most of our individuals. Generally the lobes are best developed in young specimens, and gradually disappear in more adult ones.

There is some confusion about the generic place of our species, either in *Cancris* or in *Valvulineria*. We had better assign all forms characterized by a clear area of the last-formed chamber to *Cancris*, since in the description of the genotype of *Valvulineria* (*V. californica* CUSHMAN, 1926, Contr. Cushm. Lab. Foram. Res., vol. 2, p. 60, pl. 9, f. 1) no hyaline area was described. Such an area is also present in *Baggina*, but this genus is dorsally involute and *Cancris* evolute.

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

France : Lutetian;

Netherlands (Woensdrecht) : Sands of Mons-en-Pévèle, Lower Panisel beds, Sands of Brussels.

Cancris auriculus (FICHTEL and MOLL) var. primitivus CUSHMAN and TODD

Pl. XII, fig. 9, 10; *213*

Cancris auriculus (FICHTEL and MOLL) var. *primitivus* CUSHMAN and TODD, 1942, Contr. Cushm. Lab. Foram. Res., vol. 18, p. 77, pl. 19, f. 1, 2 (Oligocene; Germany); BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 148.

R e m a r k s . — The variety differs from *Cancris auriculus* (FICHTEL and MOLL) (*Nautilus auricula* FICHTEL and MOLL, 1803, Test. Micr., var. α, p. 108, pl. 20, f. a-c; var. β, p. 110, pl. 2, f. d-f) by the narrower test, the more depressed sutures, and in being more umbilicate and more convex on the ventral side, and in having a less acute periphery. The clear area above the aperture is mostly situated more towards the periphery than it is in *Cancris auriculus* s. str.

Specimens strongly resembling this *Cancris auriculus* type were sometimes found, but they have the less acute periphery and the more convex side of the variety.

Individuals with a more rounded periphery resemble *Cancris subconicus*, and it occasionally appeared difficult to distinguish both species.

D i s t r i b u t i o n . — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse.

Genus BAGGINA CUSHMAN, 1926

Type species BAGGINA CALIFORNICA CUSHMAN, 1926

Baggina sp. cf. B. parisiensis (D'ORBIGNY)

Pl. XIII, fig. 3; *148*

cf. *Globigerina parisiensis* D'ORBIGNY, 1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 407 (Lutetian; Paris basin); FORNASINI, 1903, R. Accad. Sci. Ist. Bologna, vol. 7, p. 141, pl. 1, f. 5.

cf. *Baggina parisiensis* (D'ORBIGNY), CUSHMAN, 1944, Contr. Cushm. Lab. Foram. Res., vol. 20, p. 97, pl. 15, f. 1, 2.

R e m a r k s . — The original *Globigerina parisiensis* is possibly conspecific with *Cancris subconicus*. Therefore our distinct *Baggina* individuals are tentatively assigned to D'ORBIGNY's species.

D i s t r i b u t i o n . — France : Lutetian.

Genus NEOCRIBRELLA CUSHMAN, 1928

Type species DISCORBINA GLOBIGERINOIDES PARKER and JONES, 1864

Neocribrella globigerinoides (PARKER and JONES)

153

Discorbina globigerinoides PARKER and JONES, 1864, Phil. Trans. Roy. Soc. London, vol. 155, pt. 1, p. 325 (Lutetian; Paris basin).

Neocribrella globigerinoides (PARKER and JONES), CUSHMAN, 1928, Contr. Cushm. Lab. Foram. Res., vol. 4, p. 6, pl. 1, f. 6, 7.

Discorbina megasphaerica GÜMBEL, 1868, Abh. K. Bayer. Akad. Wiss., II Cl., vol. 10, pt. 2, p. 655, pl. 2, f. 96 (Eocene; Bavaria).

Rotalina megasphaerica (GÜMBEL), TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 59, pl. 3, f. 21.

Distribution. — France : Lutetian.

FAMILY ANOMALINIDAE

Representatives of the genera *Anomalina, Cibicides* and *Planulina* are very numerous throughout our material. Some types could always be distinguished as distinct species, but most of them show various ways of intergradation. For possible stratigraphic subdivision of the column many types have been given specific rank, notwithstanding the fact that morphologically they are not clearly distinguishable from others. The clusters are but partly illustrated by our figures.

Genus ANOMALINA D'ORBIGNY, 1826

Type species ANOMALINA PUNCTULATA D'ORBIGNY, 1826

Anomalina auris Y. LE CALVEZ

Pl. XII, fig. 11; *64*

Anomalina auris Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 43, pl. 4, f. 66-68 (Lutetian; Paris basin).

Remarks. — The species resembles *Anomalina bundensis* VAN BELLEN (1946, Meded. Geol. Stichting, ser. C, vol. 5, no. 4, p. 73, pl. 11, f. 1-3), from which it differs by the keeled periphery and the less depressed sutures.

Distribution. — Belgium : Clays of Ieper, Sands of Brussels, Sands of Lede, Sands of Wemmel;

France : Lutetian;

Netherlands (Woensdrecht) : Sands of Brussels, Sands of Lede.

Anomalina acuta PLUMMER

Pl. XII, fig. 12, 13, pl. XIII, fig. 4; *47* and *12*

Anomalina ammonoides (REUSS) var. *acuta* PLUMMER, 1926, Univ. Texas Bull., no. 2644, p. 149, pl. 10, f. 2 (Paleocene; Texas).

Anomalina acuta PLUMMER, TOULMIN, 1941, Jour. Pal., vol. 15, p. 608, pl. 82, f. 9, 10; TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 129.

Anomalinoides acuta (PLUMMER), BROTZEN, 1948, Avh. Sver. Geol. Unders., ser. C, no. 493, p. 87, pl. 14, f. 2.

Remarks. — TEN DAM reported *Anomalina acuta* from the Lower and Middle Eocene of the Netherlands, and *Cibicides anomalinoides* TEN DAM (1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 132, pl. 5, f. 7) from the Upper Eocene. However, the latter species seems to be only a larger, flatter variant of the other, with fainter dorsal and ventral knobs. This variant, frequent in the Belgian Upper Eocene, was also met with in samples from older strata.

The numerous specimens found in the Ieper Clays of the boring Woensdrecht (pl. XII, fig. 12, 13) are all small and less distinctly compressed than those of PLUMMER's figures. They belong to *Anomalina acuta* var. *ypresiensis* (TEN DAM) (*Cibicides ypresiensis* TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 136, pl. f. 2). Mostly the sutures are limbate but not raised; the bead-like umbilical ends of the sutures of the dorsal side, characteristic of *A. acuta*, are not present. Mostly the chambers of the last whorl form a rim around the central knob, which is slightly raised if at all. The individuals of this variety are smaller than those of *A. acuta* s. str.; perhaps this explains their lower number of chambers, eight to ten instead of ten to twelve.

Anomalina acuta var. *ypresiensis* resembles *A. nobilis* (BROTZEN) (*Anomalinoides nobilis* BROTZEN, 1948, Sver. Geol. Unders., Avh., ser. C, no. 493, p. 89, pl. 19, f. 5), but it differs by the smooth, apparently not perforated ventral side of the test, and the less broadly rounded periphery. However, the last two or three chambers of some of our specimens show umbilical lips. This feature occurs in *A. nobilis*, but it was not reported by TEN DAM for *Cibicides ypresiensis*.

Distribution. — *Anomalina acuta*. Belgium : Clays of Ieper, Clays of Roubaix, Sands of Mons-en-Pévèle, Clays of Roncq, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse;

England : London Clay;

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

Anomalina acuta var. *ypresiensis*. Belgium : Clays of Ieper, Clays of Roubaix, Sands of Mons-en-Pévèle;

England : London Clay;

Netherlands (Woensdrecht) : Clays of Ieper.

Anomalina sp. cf. **A. danica** (BROTZEN)

Pl. XIII, fig. 5; *2*

cf. *Cibicides danica* BROTZEN, 1940, Sver. Geol. Unders., Avh., ser. C, no. 42, p. 31, tf. 2 (Upper Cretaceous; Sweden).

cf. *Anomalinoides danica* (BROTZEN), BROTZEN, 1948, Avh. Sver. Geol. Unders., ser. C, no. 493, p. 87, pl. 14, f. 1, tf. 22.

Remarks. — Our few small specimens somewhat resemble the original figures of BROTZEN's species. They are more involute, and are furthermore different by the distinct coarse perforation of the dorsal side and the virtual absence of pores ventrally. The dorsal pores are accentuated by a thickened rim around them. Most specimens lack a distinct angle in the dorsal part of the broadly rounded periphery as is typical for *Anomalina danica*.

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

Anomalina grosserugosa (GÜMBEL)

Pl. XII, fig. 14; *86*

Truncatulina grosserugosa GÜMBEL, 1868, Abh. Bay. Ak. Wiss., vol. 10, p. 660, pl. 2, f. 104 (Eocene; Bavaria).

Anomalina grosserugosa (GÜMBEL), TEN DAM (part), 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 130.

Truncatulina granosa HANTKEN, 1875, Mitt. Jahrb. Ung. Geol. Anst., vol. 4, pt. 1, p. 74, pl. 10, f. 2 (Eocene; Hungary).

Anomalina granosa (HANTKEN), LEROY, 1953, Mem. Geol. Soc. Am., no. 54, p. 17, pl. 6, f. 1-3.

Remarks. — Specimens from material of the Bavarian Eocene showed this species to be characterized by its coarse perforations, inflated chambers, and broadly rounded, more or less lobulate periphery. Often only the last-formed chambers are inflated.

The aperture extends to the dorsal side, often but slightly, but specimens with the aperture along the last two chambers were met with as well. The aperture is usually bordered by a slight lip.

Sometimes the dorsal sutures are somewhat limbate, and the umbilical region shows a more or less rounded and irregular knob. In the samples of the lowermost Panisel beds in the Woensdrecht boring this knob is distinct and limbate sutures between the early chambers are common. These variants resemble *Anomalina grandis* LEROY (1953, op. cit., p. 18, pl. 9, f. 6-8). They form an intergrading series with the more frequent type of the accompanying *A. grosserugosa* s. str.

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

Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Aalter, Sands of Brussels.

Anomalina claustrata (TERQUEM)

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Rotalina claustrata TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 78, pl. 7, f. 15 (Lutetian; Paris basin).

Anomalina claustrata (TERQUEM), Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 43, pl. 4, f. 63-65.

Boldia claustrata (TERQUEM), Y. LE CALVEZ, 1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 50.

Remarks. — As long as the character of the genus *Boldia* is not clear (see our remarks concerning *Globotruncana*), it seems preferable to maintain this species in *Anomalina*.

Distribution. — France : Lutetian.

Genus CIBICIDES MONTFORT, 1808

Type species CIBICIDES REFULGENS MONTFORT, 1808

Cibicides westi HOWE

Pl. XIII, fig. 6, 7; *44*

Cibicides westi HOWE, 1939, Louisiana Dept. Cons., Geol. Bull. no. 14, p. 88, pl. 13, f. 20-22 (Eocene; Louisiana); BANDY, 1949, Bull. Am. Pal., vol. 32, no. 131, p. 112, pl. 20, f. 7.

Remarks. — The specimens of the Belgian Eocene appeared to be rather variable, including variants as those figured by HOWE and BANDY. A deep umbilicus, as in the figured type of HOWE, is absent in most of our specimens, but distinctly present in others. Lobulation of the periphery is mostly slight, but some very lobulate specimens were met with. The latter individuals resemble variants of *Cibicides lobatulus*, but they differ from the general type of this species by the more widely evolute character of the dorsal side. In the apertural face perforations are mostly absent.

Probably *Cibicides vortex* DORREEN (1948, Jour. Pal., vol. 22, p. 299, pl. 41, f. 5) from the Eocene of New Zealand is very close to our *C. westi*. Both species belong to the group of *C. refulgens*, but, unfortunately, MONTFORT's species has never been accurately described and figured.

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

Netherlands (Woensdrecht) : Sands of Aalter, Sands of Brussels.

Cibicides dutemplei (D'ORBIGNY)

Pl. XII, fig. 15; *198*

Rotalina dutemplei D'ORBIGNY, 1846, Foram. foss. Vienne, p. 157, pl. 8, f. 19-21 (Miocene; Vienna basin).

Cibicides dutemplei (D'ORBIGNY), MARKS, 1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 72; KAASSCHIETER, 1955, Verh. Kon. Ned. Ak. Wet., afd. Nat., ser. 1, vol. 21, no. 2, p. 94, pl. 11, f. 3; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 150, pl. 9, f. 9-11.

Cibicides pygmeus TEN DAM (not *Pulvinulina pygmea* HANTKEN), 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 135, pl. 5, f. 3.

Remarks. — Just as in the Belgian Oligocene, *Cibicides dutemplei* and its allies are very common in the Upper Eocene. They show about the same variation as BATJES described for the group in the Lower Tongeren beds.

Distinct *Cibicides dutemplei*, with a more or less biconvex test, coarsely perforated walls, and mostly eight to ten chambers, has the sutures ventrally slightly depressed and dorsally flush and limbate. It is most common in the Asse Clays. In these deposits there is a fairly sharp boundary between *C. dutemplei* and *C.* sp. cf. *C. tenellus* which is more finely perforated. The *praecinctus*-type (see BATJES), with limbate and raised dorsal sutures, is only represented by a few individuals.

In the Lede Sands and in the Wemmel Sands it appeared difficult to recognize any boundary in the group of *Cibicides dutemplei*, *C.* sp. cf. *C. tenellus*, *C. proprius* var. *acutimargo*, and *C. lobatulus*, especially because most individuals are young ones. The determination of intermediate specimens is a matter of personal opinion. The *C. dutemplei* type is the most distinct.

Cibicides dutemplei, as found in the Belgian and Dutch Upper Eocene, differs from *C. pygmeus* (HANTKEN) by the greater dimensions, the curved sutures of the ventral side instead of nearly straight ones and the more prominent spiral portion of the test.

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

Cibicides pygmeus (HANTKEN)

Pl. XIV, fig. 1; *215*

Pulvinulina pygmea HANTKEN, 1875, Mitt. Jahrb. K. Ungar. Geol. Anstalt, vol. 4, pt. 1, p. 78, pl. 10, f. 8 (Eocene; Hungary).
Eponides pygmeus (HANTKEN), BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 146, pl. 7, f. 11.
Eponides cf. *pygmeus* (HANTKEN), BHATIA, 1955, Jour. Pal., vol. 29, p. 683, pl. 67, f. 7.

Remarks. — In adult specimens of *Cibicides pygmeus* the aperture clearly extends to the dorsal side of the test, but most younger individuals show an *Eponides*-like aperture, situated completely ventrally and near the periphery.

Specimens from the Upper Bracklesham beds and Barton beds of Wight are more distinct than the Belgian ones.

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

Cibicides sp. cf. C. tenellus (REUSS)

Pl. XIV, fig. 2; *197*

cf. *Truncatulina tenellus* REUSS, 1865, Sitz. ber. K. Akad. Wiss. Wien, vol. 50, p. 477, pl. 5, f. 6 (Oligocene; Germany).
cf. *Cibicides tenellus* (REUSS), TEN DAM and REINHOLD, 1942, Meded. Geol. Stichting, ser. C, vol. 5, no. 2, p. 99, pl. 8, f. 6, pl. 10, f. 2; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 151, pl. 9, f. 3, 4.

Remarks. — According to BATJES *Cibicides tenellus* is characterized by the glassy knob that fills the umbilicus, the great number of chambers, and the curvation of the sutures near the periphery. The same author found in the Lower Tongeren beds of Dutch South Limburg a number of specimens closely resembling *C. tenellus*, except for the knob that is mostly wanting.

In the Asse formation such specimens were found in great numbers, accompanied by a few with a more or less distinct knob. The majority shows smooth ventral sides with a restricted number of pores (not in our figured full-grown specimen).

The number of chambers is variable, in general between seven and eleven. The form of the test varies also. There is not always a clear difference with *Cibicides lobatulus*. Small individuals are sometimes hard to distinguish from young individuals of *C.* sp. cf. *C. ungerianus*.

In the Lede Sands typical specimens of *Cibicides* sp. cf. *tenellus* are scarce. Possibly a number of this type was included in *C. lobatulus*.

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

Cibicides sp. cf. **C. ungerianus** (D'ORBIGNY)

Pl. XIV, fig. 3; *55*

cf. *Rotalina ungeriana* D'ORBIGNY, 1846, Foram. foss. Vienne, p. 157, pl. 8, f. 16-18 (Miocene; Vienna basin).

cf. *Cibicides ungerianus* (D'ORBIGNY), MARKS, 1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 73, pl. 8, f. 2; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 152, pl. 9, f. 6.

Remarks. — Typical *Cibicides ungerianus* has coarsely perforated walls, numerous chambers, strong curvature of the ventral sutures near the periphery, and a granular covering of the earlier whorls of the dorsal side. It is rare in our material. Especially specimens without coarse perforations and without dorsal granules form the majority of our group. These specimens, nearly all of them juvenile ones, differ from our *C.* sp. cf. *C. tenellus* by the greater number of chambers, and the more convex dorsal side, but a distinct boundary between both types is absent among these young individuals. Some specimens with dorsal granules, but without the characteristic perforation are intermediate to *C.* sp. cf. *C. tenellus*.

From the Ieper formation TEN DAM (1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 136) described a number of specimens as *C.* aff. *ungerianus*. In the Ieper Clays of the boring Woensdrecht individuals of the same group were found. They show the granular ornamentation of the dorsal umbilical region, but sometimes the granules seem to have fused and to form an irregular umbilical knob. Furthermore these individuals show fewer chambers than typical *C. ungerianus* and they lack the peculiarly curved sutures of the ventral side.

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

England : Upper Bracklesham beds, Barton beds;

Netherlands (Woensdrecht) : Clays of Ieper, Lower Panisel beds, Sands of Brussels.

Cibicides sp. cf. **C. dutemplei** (D'ORBIGNY)

Pl. XIV, fig. 4; *3*

cf. *Rotalina dutemplei* D'ORBIGNY, 1846, Foram. foss. Vienne, p. 157, pl. 8, f. 19-21 (Miocene; Vienna basin).

Remarks. — This type only occurs in the lower Ieper Clays of the boring Woensdrecht. Its dorsal side reminds of *Cibicides dutemplei*, but the specimens are smaller, ventrally without visible pores and mostly with a distinct glassy ventral knob.

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

Cibicides vialovi BYKOVA

Pl. XIII, fig. 8; *216*

Cibicides vialovi BYKOVA, 1939, Trudy Naft. Geol. - Razv. Inst., ser. A, vol. 121, pp. 31, 37, pl. 4, f. 13-15 (Eocene; Uzbek S. S. R.).

Remarks. — The characteristic ornamentation of the umbilical region of the dorsal side of *Cibicides vialovi* with the spirally situated small knobs of hyaline shell material is distinct in all our specimens. Most of them are slightly smaller than the type, and they show about eight to ten chambers in the final whorl. The periphery is mostly narrowly rounded, occasionally somewhat more acute.

Distribution. — England : Upper Bracklesham beds, Barton beds.

Cibicides lobatulus (WALKER and JACOB)

Pl. XIV, fig. 5; *54*

Nautilus lobatulus WALKER and JACOB, 1798, Adam's Essays, Kanm. Ed., p. 642, pl. 14, f. 36 (recent; England).

Truncatulina lobatula (WALKER and JACOB), CUSHMAN, 1918, U. S. Nat. Mus., Bull. 676, p. 16, pl. 1, f. 10, p. 60, pl. 17, f. 1-3.

Cibicides lobatulus (WALKER and JACOB), Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 46; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 153, pl. 9, f. 7, 8.

Remarks. — It is considered questionable whether all specimens united here as *Cibicides lobatulus*, form a single species. We included all individuals with a more or less distinctly lobulate periphery and flattened dorsal side.

Samples with only *Cibicides lobatulus* are very rare. Mostly the specimens occur together with individuals of other types, with intermediates in between. One of the adjoining distinct types is described here as *C. carinatus*, which is of stratigraphic importance for the Sands of Lede. All others have been included in *C. lobatulus*.

BATJES' remark that his *Cibicides lobatulus* grades into *C. dutemplei* is alo valid for our Upper Eocene specimens, but they are also sometimes hardly separable from *C. proprius*, *C.* sp. cf. *C. ungerianus*, and *C.* sp. cf. *C. tenellus*, especially in groups of smaller individuals.

Distribution. — Belgium : Clays of Ieper, Clays of Roubaix, Sands of Mons-en-Pévèle, Clays of Roncq, Sandy Clays of Anderlecht, Sands of Vlierzele, Sands of Aalter, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse;

England : London Clay, Barton beds;

France : Sands of Cuise, Lutetian;

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

Cibicides carinatus (TERQUEM)

Pl. XIV, fig. 6; *95*

Truncatulina carinata TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 94, pl. 10, f. 1, 2 (Lutetian; Paris basin).

Cibicides carinatus (TERQUEM), Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 45, pl. 4, f. 72-74.

Truncatulina disjunctis TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 95, pl. 10, f. 3 (Lutetian; Paris basin).

Truncatulina orbicularis TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 95, pl. 10, f. 4, 5 (Lutetian; Paris basin).

Cibicides orbicularis (TERQUEM), TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 134, pl. 5, f. 10.

Truncatulina boueana TERQUEM (not D'ORBIGNY), 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 94, pl. 9, f. 28 (Lutetian; Paris basin).

Remarks. — This *Cibicides* type is characterized by the planoconvex test, the wide keel, the low number of usually six chambers, and the coarsely perforated wall.

It differs from *Cibicides lobatulus* by the usually more flattened aspect of the test, and the hyaline carina. However, complete intergradation between both types was found. *C. carinatus* is considered to be a variant of our *C. lobatulus* group.

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

France : Lutetian;

Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Brussels, Sands of Lede.

Cibicides proprius (BROTZEN)

Pl. XIII, fig. 9, 10, pl. XIV, fig. 7; *13* and *45*

Cibicidoides proprius BROTZEN, 1948, Avh. Sver. Geol. Unders., ser. C, no. 493, p. 78, pl. 12, f. 3, 4 (Paleocene; Sweden).

Cibicides proprius (BROTZEN), HAYNES, 1957, Contr. Cushm. Found. Foram. Res., vol. 8, p. 46, pl. 5, f. 1, 2.

Cibicides praecursorius TOULMIN (not *Discorbina praecursoria* SCHWAGER), 1941, Jour. Pal., vol. 15, p. 610, pl. 81, f. 19, 20 (Eocene; Alabama).

Cibicides cryptomphalus TEN DAM (not *Rotalina cryptomphala* REUSS), 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 132, pl. 1, f. 4 (Eocene; Netherlands).

Remarks. — Our specimens agree fairly well with the type description of the species. Mostly the test is planoconvex with the dorsal side flat and the ventral side more or less elevated. Individuals with a convex spiral side occur as well. Young specimens have a rounded keel; in adult ones the periphery is more acute, and the keel of the younger stages remains visible as a distinct, thickened spiral suture. Some specimens lack the central filling of the ventral side. Coarse pores of the ventral side are restricted in number to absent.

Part of the specimens resemble *Cibicides crassus* TEN DAM (1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 133, pl. 6, f. 1).

Cibicides proprius differs from our *C. pygmeus* by the curved sutures, the greater number of chambers, and the not protruding early part.

Part of our material of *Cibicides proprius* is referable to the variety *acutimargo* TEN DAM [*Cibicides cryptomphalus* (REUSS) var. *acutimargo* TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 133, pl. 5, f. 4] from the Eocene of the Netherlands (see our pl. XIII, fig 10; pl. XIV, fig. 7). This variety differs from typical *C. proprius* by the more rounded periphery and the finer perforation of the dorsal side. The periphery of the last chambers of adult specimens is more or less lobulate, with considerable overlap of the chambers on the previous whorl. According to the description and the figures *C. pygmeus* (HANTKEN) var. *almaensis* SAMOILOVA (1947, Bull. Soc. Nat. Moscou, New Series, vol. 52, no. 4, pp. 94, 101, tf. 31-33) is probably identical with our variety *acutimargo*.

Distribution. — *Cibicides proprius*-Belgium : Clays of Ieper, Clays of Roubaix, Sands of Mons-en-Pévèle, Sandy Clays of Anderlecht;

England : London Clay;

France : Sands of Cuise;

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

Cibicides proprius var. *acutimargo*-Belgium : Clays of Ieper, Clays of Roubaix, Sands of Mons-en-Pévèle, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse;

England : London Clay;

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

Cibicides sulzensis (Herrmann)

Pl. XIII, fig. 11; *19*

Discorbina sulzensis Herrmann, 1917, Mitt. Geol. L. Anst. Els. - Loth., vol. 10, pt. 3, p. 290, pl. 3, f. 2 (Oligocene; Germany).

Cibicides sulzensis (Herrmann), Batjes, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 149, pl. 9, f. 5.

Cibicides baileyi Beck, 1943, Jour. Pal., vol. 17, p. 611, pl. 109, f. 7-9 (Eocene; State of Washington, U. S. A.).

Remarks. — *Cibicides sulzensis* has a compressed test, a more or less prominent keel, frequently a hyaline umbilical filling at the ventral side, a very evolute dorsal spiral, and five to nine, mostly seven or eight, chambers in the final coil.

Throughout the Eocene *Cibicides sulzensis* shows but little variation. The umbilical filling may be absent.

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

England : London Clay, Barton beds;

Netherlands (Woensdrecht) : Clays of Ieper, Lower Panisel beds, Sands of Lede, Sands of Wemmel, Clays of Asse.

Cibicides sp. cf. **C. mauricensis** Howe and Roberts

Pl. XIV, fig. 8; *42*

cf. *Cibicides mauricensis* Howe and Roberts, 1939, Louisiana Dept. Cons., Geol. Bull. no. 14, p. 87, pl. 13, f. 4, 5 (Eocene; Louisiana).

cf. *Cibicidina mauricensis* (Howe and Roberts), Bandy, 1949, Bull. Am. Pal., vol. 32, no. 131, p. 93, pl. 15, f. 3.

Remarks. — Our specimens belong to the group of species referred to by Bandy as *Cibicidina*. They are characterized by the involute dorsal side with a small umbo, surrounded by a furrow with reentrants between the chambers.

Our specimens differ from *Cibicides mauricensis*, as figured by Bandy, in the depressed dorsal sutures, and the absence of papillae. The figures of Howe and Roberts are still more different, also from those of Bandy.

The test of our individuals is variably convex ventrally, the periphery is subacute to rounded. Some specimens without a ventral umbilical filling were found.

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

France : Sands of Cuise;

Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Brussels, Sands of Lede.

Cibicides sp. cf. **C. tallahatensis** Bandy

Pl. XIII, fig. 12; *125*

cf. *Cibicides tallahatensis* Bandy, 1949, Bull. Am. Pal., vol. 32, no. 131, p. 110, pl. 20, f. 5 (Eocene; Alabama).

Remarks. — No better name could be found for a number of *Cibicides* individuals of the Brussels Sands. In general appearance they might be intermediate between *C. tallahatensis* and *C. mimulus* Bandy (1949, op. cit., p. 106, pl. 19, f. 1).

Adult specimens often show a more or less developed ventral umbo, but specimens without it, such as *Cibicides mimulus*, were found as well. Dorsally the wall of the earlier whorls is much thickened, mostly forming an umbilical knob.

Distribution. — Belgium : Sands of Brussels.

Genus PLANULINA D'ORBIGNY, 1826

Type species PLANULINA ARIMINENSIS D'ORBIGNY, 1826

Planulina burlingtonensis (JENNINGS)

Pl. XIV, fig. 9, 10; *98*

Cibicides burlingtonensis JENNINGS, 1936, Bull. Am. Pal., vol. 23, no. 78, p. 39, pl. 5, f. 5 (Eocene; New Jersey); TOULMIN, 1941, Jour. Pal., vol. 15, p. 609, pl. 82, f. 14, 15.

Anomalina grosserugosa TEN DAM (not GÜMBEL) (part), 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 130 (Eocene; the Netherlands).

Remarks. — Our specimens are in good accordance with JENNINGS' figures, but most of the adult specimens are ventrally distinctly evolute, which feature justifies our placing them in the genus *Planulina*. Often this species is assigned to *Anomalina*, but the aperture is a *Planulina*-like, arched slit at the periphery extending to the dorsal side along one or more chambers.

Considerable variation is found in the ventral side, with in part of our individuals a distinctly evolute chamber series. Dorsally the chambers are mostly completely embracing. The periphery is asymmetrically rounded.

Our species somewhat resembles *Cibicides robustus* Y. LE CALVEZ (1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 47, pl. 4, f. 57-59) from the Lutetian of the Paris basin, but the latter has about twelve chambers in the final convolution; in our species there are only five to seven.

Rosalina kochi REUSS (1855, Zschr. Deu. Geol. Ges., vol. 7, p. 274, pl. 9, f. 8) as described from the Upper Eocene of Mecklenburg, Germany, resembles our species in general outline, but it differs by the granular ornamentation of the central dorsal part. Perhaps REUSS' species is conspecific with our *Cibicides* sp. cf. *C. ungerianus*.

In the Lower Eocene of Belgium, the typical form was found to intergrade with *Planulina burlingtonensis* var. *neelyi*, which is characterized by a dorsal ornamentation of strongly limbate and raised sutures.

There is no intergradation with *Anomalina grosserugosa* (GÜMBEL) with which our species has often been confused.

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

Netherlands (Woensdrecht) : Sands of Mons-en-Pévèle, Lower Panisel beds, Sands of Lede.

Planulina burlingtonensis (JENNINGS) var. **neelyi** (JENNINGS)

Pl. XIV, fig. 11; *63*

Cibicides neelyi JENNINGS, 1936, Bull. Am. Pal., vol. 23, no. 78, p. 39, pl. 5, f. 4 (Eocene; New Jersey).

Remarks. — In samples of the Lower Eocene typical *Planulina burlingtonensis* appeared to intergrade with a more heavily ornamented type, which corresponds to JENNINGS' figures of *Cibicides neelyi*.

There is no distinct boundary with *Planulina burlingtonensis* var. *tendami*. The latter variety is different by a more compressed test, some more chambers, and a more evolute character of the test.

D i s t r i b u t i o n . — Belgium : Clays of Ieper, Clays of Roubaix, Sands of Mons-en-Pévèle, Sandy Clays of Anderlecht, Sands of Aalter, Sands of Brussels;

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

Planulina burlingtonensis (JENNINGS) var. **tendami** nov. var.

Pl. XIV, fig. 12; *109*

Planulina osnabrugensis TEN DAM (not ROEMER), 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 131, pl. 5, f. 3 (Eocene; the Netherlands).

E t y m o l o g y . — Named after the Dutch micropaleontologist Dr. A. TEN DAM, Turkey.

D e s c r i p t i o n . — Variety differing from the type of the species by the more compressed and more evolute test with about seven to nine chambers in the final whorl instead of five to seven, and by the raised and limbate sutures.

Dimensions of the holotype : length, 0,65 mm; breadth, 0,58 mm; thickness, 0,20 mm.

R e m a r k s . — As indicated already *Planulina burlingtonensis*, P. *burlingtonensis* var. *neelyi*, and *P. burlingtonensis* var. *tendami* form an intergrading series. The varieties differ in the limbate and raised character of the sutures, and in the greater compression of the test. Furthermore some variation is found in the number of chambers, with five to seven in the type of the species, six to eight in the variety *neelyi*, and seven to nine in the variety *tendami*.

In the material of the Panisel beds, for which this variety seems to be a characteristic form, a complete intergradation was found between the varieties *neelyi* and *tendami*, but in adult specimens the latter variety is distinct by its still more compressed test and the more evolute whorls.

Some variation is found in the limbation of the sutures; in some specimens it is almost absent, and these individuals differ from the type of the species only in the more compressed test with more chambers.

T y p e l o c a l i t y . — The boring Woensdrecht, in the Dutch province Noord Brabant; our sample Woensdrecht 385 m.

T y p e l e v e l . — Sands of Aalter; these deposits are probably of Middle Eocene age.

D i s t r i b u t i o n . — Belgium : Sandy Clays of Anderlecht;

Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Aalter.

D e p o s i t o r y . — The holotype and the paratypoids of this variety are stored in the collections of the Geological Institute of Utrecht (S 11769, 11770).

Planulina stelligera MARIE

Planulina stelligera MARIE, 1941, Mém. Mus. Nat. Hist. Nat. Paris, New Series, vol. 12, pt. 1, p. 245, pl. 37, f. 344 (Cretaceous; Paris basin).

R e m a r k s . — Many specimens assignable to this Cretaceous species were found in a number of samples of the Roubaix Clays and the Sands of Mons-en-Pévèle. These individuals occur together with a number of *Globotruncana* specimens. They are more or less worn. Probably they were derived from Cretaceous sediments of the area of the Axis of Artois in northern France.

Genus HANZAWAIA ASANO, 1944

Type species HANZAWAIA NIPPONICA ASANO, 1944

Hanzawaia producta (TERQUEM)

Pl. XIII, fig. 13; *18*

Truncatulina producta TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 92, pl. 9, f. 20, 21 (Lutetian; Paris basin).

Cibicides productus (TERQUEM), Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 47, pl. 4, f. 69-71.

Remarks. — Our specimens from the Lutetian of the Paris basin, as well as those from the Belgian Eocene, clearly belong to the *Hanzawaia boueana* group. They differ from *H. boueana* (D'ORBIGNY) (*Truncatulina boueana* D'ORBIGNY, 1846, Foram. foss. Vienne, p. 169, pl. 9, f. 24-26) in the number of chambers : six to eight instead of nine to eleven. A hyaline keel is usually absent, but especially specimens of the Upper Eocene show this feature distinctly. At both sides of the test, the sutures are mostly curved, depressed and not limbate. The pores are of variable size, but always medium to coarse. Usually there are dorsally hyaline areas above the aperture. Specimens with a fully perforated dorsal side, thus resembling the figures of YOLANDE LE CALVEZ, are extremely rare in our material. The dorsal, imperforate flaps covering the aperture, are often broken.

The specimens of *Hanzawaia producta* of the Upper Eocene resemble *H. boueana* better than do the stratigraphically older ones. However, only small individuals were found in the Upper Eocene, which fact hampers a reliable comparison. The specimens of the Upper Eocene generally have more chambers (up to eight) than those of the Lower or Middle Eocene (six to seven). The Eocene individuals probably form a completely intergrading series, which shows the development from *H. producta* towards *H. boueana*. The latter type is dominant in Upper Oligocene and younger strata.

Distribution. — Belgium : Clays of Ieper, Clays of Roubaix, Sands of Mons-en-Pévèle, Sandy Clays of Anderlecht, Sands of Aalter, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse;

England : Upper Bracklesham beds;

France : Lutetian;

Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Brussels, Sands of Lede.

FAMILY EPISTOMINIDAE

Genus EPISTOMINA TERQUEM, 1883

Type species EPISTOMINA REGULARIS TERQUEM, 1883

Epistomina elegans (D'ORBIGNY)

221

Rotalia elegans D'ORBIGNY, 1871, in PARKER, JONES and BRADY, Ann. Mag. Nat. Hist., ser. 4, vol. 8, pl. 12, f. 142 (Pliocene; Italy).

Epistomina elegans (D'ORBIGNY), MARKS, 1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 65; TROELSEN, 1954, Medd. Dansk Geol. For., vol. 12, p. 460; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 155, pl. 10, f. 2.

Distribution. — Belgium : Sands of Wemmel.

Genus ALABAMINA TOULMIN, 1941

Type species ALABAMINA WILCOXENSIS TOULMIN, 1941

Alabamina obtusa (BURROWS and HOLLAND)

Pl. XIII, fig. 15; *30*

Pulvinulina exigua (BRADY) var. *obtusa* BURROWS and HOLLAND, 1897, Proc. Geol. Assoc., vol. 15, p. 49, pl. 2, f. 25 (Paleocene; England); PLUMMER, 1926, Texas Univ. Bull., no. 2644, p. 151, pl. 11, fig. 2.

Alabamina obtusa (BURROWS and HOLLAND), HAYNES, 1956, Contr. Cushm. Found. Foram. Res., vol. 7, p. 89, pl. 17, f. 3-3 l.

Remarks. — Our specimens of *Alabamina obtusa* are characterized by a rounded periphery and five to six chambers in the last whorl. The test is mostly biconvex, ventrally more convex than dorsally.

In the redescription of the species, HAYNES mentioned the apertural face to be infolded into a deep « infundibulum » parallel to the periphery. This infolding, characteristic for the genus, is usually not as well developed in our material as it is in specimens from the Thanet Sands of England (according to HAYNES' descriptions).

A number of specimens were noted with a more narrowly rounded periphery.

BOWEN (1954, Proc. Geol. Assoc., vol. 65, p. 165) reported *Alabamina scitula* BANDY (1949, Bull. Am. Pal., vol. 32, no. 131, p. 89, pl. 14, f. 6) from the London Clay of the London basin and of Alum Bay. Our specimens from the latter locality are closer to *A. obtusa* than to *A. scitula*. They seem to form only variants of *A. obtusa*, different by the relatively greater height of the last two chambers.

Distribution. — England : London Clay;
Netherlands (Woensdrecht) : Clays of Ieper.

Alabamina wilcoxensis TOULMIN

Pl. XIII, fig. 14; *60*

Alabamina wilcoxensis TOULMIN, 1941, Jour. Pal., vol. 15, p. 603, pl. 81, f. 10-14, tf. 4 A-C (Eocene; Alabama).

Remarks. — Our specimens, mainly small, show some variation in the periphery. It is blunt in most specimens, but more acute in some others, which resemble *Alabamina amchitkaensis* TODD (1953, Contr. Cushm. Found. Foram. Res., vol. 4, p. 5, pl. 2, f. 7).

As noted by BROTZEN (1948, Sver. Geol. Unders., Avh., ser. C, no. 493, p. 99) it is difficult to distinguish these small, apparently young individuals of *Alabamina wilcoxensis* from his *A. midwayensis*. This latter species was established for forms intermediate between *A. wilcoxensis* and *A. obtusa*. However, HAYNES (1956, Contr. Cushm. Found. Foram. Res., vol. 7, p. 89) concluded that *A. midwayensis* is no more than a variety of *A. obtusa*, but, in between our *A. wilcoxensis* and *A. obtusa* there is no group referable to as *A. midwayensis*. This may be due to the small size of all our individuals, however.

Distribution. — England : London Clay;

Netherlands (Woensdrecht) : Clays of Ieper.

Alabamina wolterstorffi (FRANKE)

Pl. XIV, fig. 13; *143*

Rotalia wolterstorffi FRANKE, 1925, Abh. Ber. Mus. Nat. Heimatk. Naturw. Ver. Magdeburg, vol. 4, pt. 2, p. 186, pl. 6, f. 66 (Oligocene; Germany).

Alabamina wolterstorffi (FRANKE), BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 156, pl. 8, f. 11.

Remarks. — The ventral side of our specimens is of variable convexity. Some specimens resemble *Alabamina scitula* BANDY (1949, Bull. Am. Pal., vol. 32, no. 131, p. 89, pl. 14, f. 6), especially in the apertural features.

Specimens with a bluntly rounded periphery resemble *Alabamina obtusa*. In general, the dorsal side of *A. wolterstorffi* specimens is somewhat flatter, the periphery sharper, and the aperture is a slightly higher arched opening.

As BATJES has remarked already, the specimen from the Belgian coast, figured by CUSHMAN (1949, Mém. Inst. R. Sc. Nat. Belg., no. 111, p. 47, pl. 9, f. 3) probably belongs to *Alabamina wolterstorffi*, reworked from Eocene strata.

Distribution. — Belgium : Clays of Roubaix, Sands of Mons-en-Pévèle, Sandy Clays of Anderlecht, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse;

Netherlands (Woensdrecht) : Sands of Aalter.

Genus EPISTOMINELLA Husezima and Maruhasi, 1944

Type species EPISTOMINELLA PULCHELLA Husezima and Maruhasi, 1944

Epistominella oveyi (Bhatia)

Pl. XV, fig. 1; *101*

Pseudoparella oveyi Bhatia, 1955, Jour. Pal., vol. 29, p. 684, pl. 66, f. 29, tf. 7 (Oligocene; Wight); Batjes, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 158, pl. 8, f. 10.

Remarks. — As in the Oligocene material of Wight and Belgium considerable variation was met with in the convexity of the dorsal side. Distinctly conical specimens are scarce, most are more or less biconvex. A subacute periphery occurs frequently, but specimens with a more rounded periphery were encountered as well. As in the type material the conical specimens appeared to be microspheric with up to four visible whorls. The more numerous megalospheric specimens show about three whorls.

Distribution. — Belgium : Sands of Mons-en-Pévèle, Lower Panisel beds, Sands of Aalter, Sands of Lede, Sands of Wemmel;
England : Upper Bracklesham beds;
Netherlands (Woensdrecht) : Lower Panisel beds.

Epistominella acutimargo (Halkyard)

Pl. XIV, fig. 14; *194*

Pulvinulina acutimargo Halkyard, 1919, Mem. Proc. Manchester Lit. Philos. Soc., vol. 62, pt. 6, p. 120, pl. 7, f. 4, (Eocene; Biarritz, France).

Remarks. — Halkyard figured a specimen with five chambers in the last whorl, but both in our samples from the Upper Eocene of Biarritz and in those from the Belgian Eocene most specimens have five to six chambers in the final coil.

At the ventral side our specimens show a closed umbilicus, sometimes ornamented with knobs. The length of the aperture is variable, sometimes it is as long as the apertural face. Occasionally it is bordered by a slight lip.

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

Epistominella gyrata (Terquem)

150

Rotalina gyrata Terquem, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 70, pl. 6, f. 6 (Lutetian; Paris basin).

Pulvinulinella gyrata (Terquem), Y. le Calvez, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 38, pl. 6, f. 106-108.

Remarks. — As far as could be observed the aperture of *Epistominella gyrata* is ventral at the base of the last chamber, and extending over a short distance into the apertural face, parallel to the periphery.

Our observations are too few for a definite decision about the generic place of this species.

Distribution. — France : Lutetian.

Genus SIPHONINA Reuss, 1850

Type species SIPHONINA FIMBRIATA Reuss, 1850

Siphonina prima Plummer

Pl. XV, fig. 2; *15*

Siphonina prima Plummer, 1927, Bull. Texas Univ., no. 2644, p. 148, pl. 12, f. 4 (Paleocene; Texas); ten Dam, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 122.
Pulsiphonina prima (Plummer), Haynes, 1956, Contr. Cushm. Found. Form. Res., vol. 7, p. 96, pl. 17, f. 9-9*b*.

Remarks. — Most of our specimens show about four chambers instead of five as indicated by Plummer, but individuals with five chambers in the last whorl were found as well. The ventral perforations are very minute, with some scattered coarse ones. The pores of the keel are clearly visible.

The form of the test is mostly equally biconvex and strongly compressed, but some specimens have a flatter dorsal side.

The aperture, without a neck, is distinctly that of the subgenus *Pulsiphonina*. Brotzen suggested that a primitive neck might be seen in the peripheral keel combined with the lip below the apertural slit. This lip is more or less variable, but in our material it is somewhat more distinct in the stratigraphically younger individuals.

Distribution. — Belgium : Clays of Ieper, Clays of Roubaix, Sands of Mons-en-Pévèle, Sands of Brussels (basal strata);
England : London Clay;
Netherlands (Woensdrecht) : Clays of Ieper.

Siphonina lamarckana Cushman

Pl. XIV, fig. 15; *108*

Siphonina lamarckana Cushman, 1927, Proc. U. S. Nat. Mus., vol. 72, no. 2716, art. 20, p. 3, pl. 3, f. 3 (Lutetian; Paris basin); Y. le Calvez, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 34.

Remarks. — *Siphonina lamarckana* is an intermediate type between *S. prima* and younger, more typical *Siphonina* species, such as *S. reticulata* (Czjzek) (*Rotalina reticulata* Czjzek, 1848, Haidinger's Nat. Abh., vol. 2, p. 145, pl. 13, f. 7, 8).

The apertural slit is situated on a very short neck, which is formed by the peripheral margin and the lip below this slit. This lip and correspondingly the neck is somewhat variable in development. Further variability is as in our *Siphonina prima*. Pores are distinct on the dorsal side. The ventral wall is very finely perforate, with occasionally some coarse pores.

In the original description Cushman mentioned a number of four chambers in the last whorl. In our Belgian material four or five chambers are present, in the samples of the Upper Eocene there are mostly five.

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

Genus KARRERIA RHEZAK, 1891

Type species KARRERIA FALLAX RHEZAK, 1891

Karreria fallax RHEZAK

Pl. XIV, fig. 16; *43*

Karreria fallax RHEZAK, 1891, Ann. Naturh. Hofmus. Wien, vol. 6, p. 4; 1895, ibid., vol. 10, p. 40, pl. 7, f. 7, 8 (Eocene; Austria); BROTZEN, 1948, Sver. Geol. Unders., Avh., ser. C, no. 493, p. 115, pl. 18, f. 3, tf. 34-37.

Remarks. — Most of our specimens show spiral tests without a rectilinear series of chambers; specimens with such a rectilinear part show as many as three uniserial chambers.

The variable form of the test is clearly connected with the original attachment. The various positions of the aperture in spiral specimens, as indicated by BROTZEN (tf. 35), were also found in our material, but specimens with the aperture at the base of the apertural face of the last-formed chamber are relatively rare.

Some specimens show a position in between *Karreria fallax* and *K. cubensis* (CUSHMAN and BERMUDEZ) (*Stichocibicides cubensis* CUSHMAN and BERMUDEZ, 1936, Contr. Cushm. Lab. Foram. Res., vol. 12, p. 33, pl. 5, f. 19-21) in showing a more or less keeled periphery.

In our opininon *Ammocibicides pontoni* EARLAND (1935, Discovery Rep., Foraminifera, pt. 3, vol. 10, p. 107, pl. 4, f. 8-12) from the Wilcox Eocene of Alabama, is a synonym of *Karreria fallax*.

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

FAMILY CERATOBULIMINIDAE

Genus LAMARCKINA BERTHELIN, 1881

Type species PULVINULINA ERINACEA KARRER, 1868

Lamarckina cristellaroides (TERQUEM)

Pl. XV, fig. 3, 4; *97*

Rotalina cristellaroides TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 57, pl. 3, f. 15 (Lutetian; Paris basin).

Lamarckina cristellaroides (TERQUEM), CUSHMAN, 1926, Contr. Cushm. Lab. Foram. Res., vol. 2, pt. 1, p. 10; Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 25.

Remarks. — TERQUEM's figures of this species are either those of a young specimen, somewhat damaged near the aperture, or they give a simplified idea of the species. Specimens of the Lutetian of the Paris basin (see fig. 3) are characterized by limbate dorsal sutures, that are curved backward. The early part of the dorsal side is flattened, sometimes slightly concave. The periphery of the early stages is often slightly keeled, that of later chambers more rounded. Ventrally a large, semicircular plate covers the apertural area. About seven to eight chambers are found in the last coil.

Specimens with about the same features were found in the Belgian Upper Eocene. In these strata the tests of larger specimens are less elongate than those of the French Lutetian.

The surface of the dorsal part of the chambers is mostly smooth, but specimens with short, blunt spines near the periphery were found as well. The latter resemble *Lamarckina halkyardi* CUSHMAN (1926, Contr. Cushm. Lab. Foram. Res., vol. 2, p. 11), in which species the spines are coarser and cover the whole dorsal surface between the ridges of the sutures.

Lamarckina naheolensis CUSHMAN and TODD (1942, Contr. Cushm. Lab. Foram. Res., vol. 18, p. 39, pl. 7, f. 5-7) from the Midway formation of Alabama, resembles *L. cristellaroides* in the ventral aspect of the test, but differs by the more coarsely perforated dorsal side.

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;
France : Sands of Cuise, Lutetian.

Genus ASTERIGERINA D'ORBIGNY, 1839

Type species ASTERIGERINA CARINATA D'ORBIGNY, 1839

Asterigerina bartoniana (TEN DAM)

Pl. XVI, fig. 2, 3; 52

Rotalia granulosa TEN DAM (not *Rosalina granulosa* KARRER), 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 121, pl. 4, f. 2 (Eocene; the Netherlands).
Rotalia bartoniana TEN DAM, 1947, Jour. Pal., vol. 21, p. 186.
Asterigerina bartoniana (TEN DAM), BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 158, pl. 10, f. 1, 8.

R e m a r k s . — Our specimens of *Asterigerina bartoniana* show considerable variation, perhaps including *A. tatumi* HUSSEY (1951, Contr. Cushm. Found. Foram. Res., vol. 2, p. 19, pl. 3, f. 1-3).

The ventral side of the test varies between strongly convex to flat. The young stages mostly have a flat dorsal side, as it is also shown in TERQUEM's figures of *Asterigerina campanella* (GÜMBEL) [see *Rotalina campanella* (GÜMBEL), TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 74, pl. 7, f. 1-4]. Such young individuals are often the only representatives of the species in the Brussels Sands, in which strata adult specimens are very rare.

The peripheral keel is variably developed. Mostly it forms a broad rim around the test, while it varies but slightly in thickness. In the Upper Eocene, specimens with crenulations of the keel are rare, in the Lower Eocene deposits they occur more often. Specimens with the keel almost wanting, as figured by BATJES, were found as well, but always in low numbers. Sometimes there are distinct spines on the keel.

The papillae of the ventral side vary in coarseness. Specimens with a granulation as fine as indicated by BATJES occur together with individuals with papillae of somewhat greater size, as figured by TEN DAM. This granulation covers the whole test of the type specimen of the species, but often it is only found in front of the aperture.

The number of chambers varies between seven and twelve, the secondary chambers vary in relative size. In the Upper Eocene they mostly reach half way to the periphery. In the Lower Eocene specimens with smaller secondary chambers are more numerous. Usually the stellate pattern of these secondary chambers is distinct, but it may be obscured by a cover of papillae or shell material of the central boss. This central knob is not found in all specimens, especially in small individuals it may be absent.

Often the chambers are ventrally slightly inflated. The dorsal sutures are generally curved, sometimes they are oblique and straight. The ventral sutures are often more or less radial; curved sutures were largely found in younger specimens.

In the Barton beds of Barton, England, a number of small specimens was found resembling our *Asterigerina bartoniana*. They lack a distinct keel as it is present in most of the Belgian young individuals. Furthermore their papillae are restricted to the apertural area.

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

France : Sands of Cuise, Lutetian;

England : Barton beds;

Netherlands (Woensdrecht) : Clays of Ieper, Sands of Mons-en-Pévèle, Lower Panisel beds, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse.

Asterigerina wilcoxensis CUSHMAN and GARRETT

Pl. XVI, fig. 4; *33*

Asterigerina wilcoxensis CUSHMAN and GARRETT, 1939, Contr. Cushm. Lab. Foram. Res., vol. 15, p. 86, pl. 15, f. 10 (Eocene; Alabama).

Asterigerina lutetiana TEN DAM, 1947, Jour. Pal., vol. 21, p. 586, tfs. 1-4 (Middle Eocene; the Netherlands).

Remarks. — *Asterigerina wilcoxensis*, as well as *A. lutetiana*, are characterized by the large secondary chambers, which form almost the whole ventral surface, so that the chambers of the dorsal series are ventrally only visible as small triangles along the periphery. In some samples of the Ieper Clays there are specimens with smaller secondary chambers.

The dorsal side of the test as well as the supplementary chambers are coarsely perforated, the ventral parts of the dorsal chamber series are hyaline, and lack visible pores.

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

Netherlands (Woensdrecht) : Clays of Ieper.

Asterigerina sp. cf. **A. guerrai** (BERMUDEZ)

Pl. XVI, fig. 1; *62*

cf. *Asterigerinata guerrai* BERMUDEZ, 1952, Mem. Soc. Cien. Nat. La Salle, vol. 12, no. 32, p. 204, pl. 1, f. 4-6 (Eocene; Mexico).

Remarks. — Our specimens resemble the Mexican species fairly well. Generally, the small supplementary chambers are less inflated. In BERMUDEZ's figures the sutures of the dorsal side are more limbate than in our specimens. The apertural arch of our individuals often reaches the peripheral margin, instead of it being confined to the central portion of the inner margin of the final chamber.

Some similarity is apparent with *Asterigerina primaria* PLUMMER (1926, Univ. Texas Bull., no. 2644, p. 157, pl. 12, f. 8), which differs by the greater supplementary chambers, and the limbate and less curved sutures of the dorsal side.

Our specimens furthermore resemble *Asterigerina hadleyi* HOWE and ROBERTS (1939, Louis. Dept. Cons., Geol. Bull. no. 14, p. 79, pl. 10, f. 13, 14), which species differs by the coarsely perforated dorsal side, the limbate dorsal sutures, the not-inflated chambers, and the small apertural opening near the umbilicus.

Distribution. — Belgium : Clays of Ieper, Clays of Roubaix, Sands of Brussels; France : Sands of Cuise.

Asterigerina sp. cf. A. glabra (BERMUDEZ)

Pl. XV, fig. 5; *192*

cf. *Asterigerinata globulospinosa* (CUSHMAN) var. *glabra* BERMUDEZ, 1952, Mem. Soc. Cien. Nat. La Salle, vol. 12, no. 32, p. 209, pl. 3, f. 4-6 (Eocene; Mexico).

Remarks. — Most of our specimens show greater secondary chambers than BERMUDEZ's figures. Sometimes the apertures as well as the supplementary chambers reach the peripheral margin, but in general they are well removed from the periphery. The secondary chambers may be slightly inflated.

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

Asterigerina sp.

Pl. XV, fig. 6; *94*

Remarks. — Especially in the Upper Eocene we found a great number of single specimens of a small *Asterigerina* species. They are characterized by a more or less semiglobular test, a concave ventral side, a rounded periphery, three to five chambers in the last whorl, which are more or less inflated, and small and often indistinct supplementary chambers.

In general form they resemble *Discorbis lauriei* (HERON-ALLEN and EARLAND) (*Discorbina lauriei* HERON-ALLEN and EARLAND, 1924, Jour. Linn. Soc. London, Zool., vol. 35, p. 633, pl. 36, f. 50-52, pl. 37, f. 53-55).

Probably our specimens are variants of *Asterigerina* sp. cf. *A. glabra*, but intermediate types were not found.

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

Genus EPISTOMARIA GALLOWAY, 1933

Type species DISCORBINA RIMOSA PARKER and JONES, 1862

Epistomaria semimarginata (D'ORBIGNY)

149

Rotalia semi-marginata D'ORBIGNY, 1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 407 (Lutetian; Paris basin).

Rotalina semi-marginata (D'ORBIGNY), TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 56, pl. 3, f. 12-14.

Epistomaria semi-marginata (D'ORBIGNY), Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pl. 2, p. 33.

Distribution. — France : Lutetian.

FAMILY GLOBIGERINIDAE

Genus HASTIGERINA THOMSON, 1876

Type species HASTIGERINA MURRAYI THOMSON, 1876

Hastigerina micra (COLE)

Pl. XVI, fig. 5, 6; *117*

Nonion micrus COLE, 1927, Bull. Am. Pal., vol. 14, no. 51, p. 22, pl. 5, f. 12 (Eocene; Mexico).
Globigerinella (?) *micra* (COLE), GRIMSDALE, 1951, Proc. 3rd World Petrol. Congr., section 1, p. 468.
Globigerinella micra (COLE), SUBBOTINA, 1953, Trudy Vses. Neft. Naukno.-Issledov., Geol.-Razv. Inst., New Series, no. 76, pl. 13, f. 16, 17; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 162, pl. 11, f. 6.
Hastigerina micra (COLE), BOLLI, 1957, U. S. Nat. Mus., Bull. 215, p. 161, pl. 35, f. 2.
Globigerinella pseudovoluta BANDY, 1949, Bull. Am. Pal., vol. 32, no. 131, p. 123, pl. 24, f. 4 (Eocene; Alabama).

Remarks. — Most specimens show a high, arched basal opening. Others possess a lower aperture in which the septal face touches the previous whorl, thus dividing the aperture into two openings. The coarseness of the pores is somewhat variable, mostly they are fine.

GRIMSDALE recognized that *Globigerinella micra* and *G. pseudovoluta* belong to one species. Some variants in our material, identical with BANDY's species, show a slightly evolute test, but in others the previous whorls are hardly visible.

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

Genus GLOBIGERINA D'ORBIGNY, 1826

Type species GLOBIGERINA BULLOIDES D'ORBIGNY, 1826

Globigerina triloculinoides PLUMMER

Pl. XVI, fig. 7; *39*

Globigerina triloculinoides PLUMMER, 1926, Univ. Texas Bull., no. 2644, p. 134, pl. 8, f. 10 (Paleocene; Texas); SUBBOTINA, 1953, Trudy Vses. Neft. Naukno.-Issledov., Geol.-Razv. Inst., New Series, no. 76, pl. 11, f. 15, pl. 12, f. 1, 2; BOLLI, 1957, U. S. Nat. Mus., Bull. 215, p. 70, pl. 15, f. 18-20; TROELSEN, 1957, U. S. Nat. Mus., Bull. 215, p. 129, pl. 30, f. 4.

Remarks. — Our specimens of the Lower Eocene are all characterized by the reticulate surface, and the globular chambers. The fairly low apertural slit is often provided with a lip. In most specimens the chambers are rapidly enlarging, others show a more gradual increase in chamber size.

Distribution. — LOEBLICH and TAPPAN (1957, U. S. Nat. Mus., Bull. 215, p. 175) recorded this species from the whole Paleocene of the Gulf and Coastal Plains of the U. S. A. SUBBOTINA (1953) found *Globigerina triloculinoides* in deposits from Paleocene to Middle Eocene age, as did GRIMSDALE (1951, Proc. 3rd World Petrol. Congr., sect. 1, p. 466).

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.

Globigerina sp. cf. **G. angustiumbilicata** Bolli

Pl. XV, fig. 7, 8; *214*

cf. *Globigerina ciperoensis angustiumbilicata* Bolli, 1957, U. S. Nat. Mus., Bull. 215, p. 109, pl. 22, f. 12, 13, p. 164, pl. 36, f. 6 (Oligocene; Trinidad).

R e m a r k s . — Our specimens tentatively described as *Globigerina angustiumbilicata* more or less resemble Bolli's figures. Some individuals show more depressed ventral sutures than is indicated by Bolli, but these sutures never become as distinctly depressed and U-shaped as in *G. ciperoensis angulisuturalis* Bolli (1957, op. cit., p. 109, pl. 22, f. 11). Some specimens show a somewhat coarser perforation of the test than seems to be typical for *G. angustiumbilicata*.

The aperture is a low, arched slit, often bordered by a thin lip, and opening into the small umbilicus. A few individuals show a greater umbilicus. The aperture of these specimens is somewhat higher than is found in *Globigerina angustiumbilicata*. They better resemble the figures of *G. ciperoensis ciperoensis* Bolli (1957, op. cit., pl. 22, f. 10) (see our figure 7).

D i s t r i b u t i o n . — Belgium : Sands of Lede, Sands of Wemmel, Clays of Asse;
England : Barton beds;
Netherlands (Woensdrecht) : Sands of Lede.

Globigerina sp. cf. **G. varianta** Subbotina

Pl. XV, fig. 9, 10; *38*

cf. *Globigerina varianta* Subbotina, 1953, Trudy Vses. Neft. Naukno-Issledov., Geol.-Razv. Inst., New Series, vol. 76, pl. 3, f. 5-12, pl. 4, f. 1-3, pl. 15, f. 1-3 (Eocene; U. S. S. R.).

cf. *Globorotalia varianta* (Subbotina), Loeblich and Tappan, 1957, U. S. Nat. Mus., Bull. 215, p. 196, pl. 44, f. 1, 2, pl. 45, f. 4.

R e m a r k s . — Specimens of this species, the most numerous *Globigerina* type in the Belgian Lower Eocene, are in fairly good accordance with Subbotina's figures. The height of the coils is somewhat variable. Some specimens resemble *G. pseudobulloides* Plummer (1926, Univ. Texas Bull., no. 2644, p. 133, pl. 8, f. 9) in which species the spiral side is flattened and the initial whorl depressed to slightly convex. They differ from *G. pseudobulloides* by the spinose surface. The number of chambers varies between four and five, specimens with six chambers in the final coil are very scarce. Often the early chambers are somewhat more spinose than the later ones, which may be entirely smooth. The aperture is a high, arched opening, bordered by a distinct lip. In a number of specimens this lip has a more or less triangular form, widest in the middle.

Our specimens also resemble *Globigerina prolata* Bolli (1957, U. S. Nat. Mus., Bull. 215, p. 72, pl. 15, f. 24-26), but they differ by the more spinose surface.

D i s t r i b u t i o n . — 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.

Globigerina spp.

128

R e m a r k s . — The few ill-preserved Globigerinae of the Sands of Brussels could not be determined specifically.

D i s t r i b u t i o n . — Belgium : Sands of Brussels.

Genus GLOBIGERINOIDES CUSHMAN, 1927

Type species GLOBIGERINA RUBRA D'ORBIGNY, 1839

Globigerinoides sp. cf. **G. daubjergensis** (BRÖNNIMANN)

Pl. XV, fig. 11; *40*

cf. *Globigerina daubjergensis* BRÖNNIMANN, 1953, Eclog. Geol. Helv., vol. 45, no. 2, p. 340, f. 1 (Paleocene; Denmark); TROELSEN, 1957, U. S. Nat. Mus., Bull. 215, p. 128, pl. 30, f. 1, 2; BOLLI, 1957, U. S. Nat. Mus., Bull. 215, p. 70, pl. 16, f. 13-15.

cf. *Globigerinoides daubjergensis* (BRÖNNIMANN), LOEBLICH and TAPPAN, 1957, U. S. Nat. Mus., Bull. 215, p. 184, pl. 40, f. 1, 8, pl. 41, f. 9, pl. 42, f. 6, 7, pl. 43, f. 1, pl. 44, f. 7, 8.

R e m a r k s . — Our small specimens are always high-spired. Specimens with four chambers in the final coil are the most numerous, but individuals with five chambers occur as well. The low aperture opens into the small umbilicus. The finely perforated surface is usually spinose; some specimens with a smooth surface were noted. The latter resemble *Globigerina spiralis* BOLLI (1957, U. S. Nat. Mus., Bull. 215, p. 70, pl. 16, f. 16-18).

Secondary apertures, typical for *Globigerinoides*, could often not be observed, but this may be due to the state of preservation.

D i s t r i b u t i o n . — 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.

FAMILY **GLOBOROTALIIDAE**

Genus GLOBOROTALIA CUSHMAN, 1927

Type species PULVINULINA MENARDII (D'ORBIGNY) var. TUMIDA H. B. BRADY, 1877

Globorotalia spp.

85

R e m a r k s . — Some scattered young specimens of *Globorotalia* were found. The specimens of the Sands of Mons-en-Pévèle resemble *G. lensiformis* SUBBOTINA (1953, Trudy Vses. Neft. Naukno-Issledov., Geol.-Razv. Inst., New Series, vol. 76, pl. 18, f. 4, 5), but they may as well be young specimens of other similar *Globorotalia* species.

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

Genus CYCLOLOCULINA HERON-ALLEN and EARLAND, 1908

Type species CYCLOLOCULINA ANNULATA HERON-ALLEN and EARLAND, 1908

Cycloloculina sp. cf. **C. punctata** (TERQUEM)

132

cf. *Planorbulina punctata* TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 91, pl. 9, f. 18 (Lutetian; Paris basin).

cf. *Cycloloculina punctata* (TERQUEM), Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 41, pl. 6, f. 93, 94.

Remarks. — Some specimens were found resembling this Lutetian species. A single individual with bridges across the sutures of the last circular chambers, met with in the Brussels Sands, resembles the figure of Y. LE CALVEZ of *Cycloloculina eocenica* (TERQUEM) (*Planorbulina eocenica* TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 90, pl. 9, f. 15; *Cycloloculina eocenica* (TERQUEM), Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 42, pl. 6, f. 96).

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

Genus GLOBOTRUNCANA CUSHMAN, 1927

Type species PULVINULINA ARCA CUSHMAN, 1926

Globotruncana spp.

Remarks. — Reworked specimens of *Globotruncana* were found in a number of samples of the Belgian Eocene, often together with other Cretaceous foraminifera, such as *Buliminella* sp., *Planulina stelligera* and *Gümbelina* spp.

Especially in dorsal view, our specimens of the Lutetian of the Paris basin resemble the figures of TERQUEM of *Rotalina lobata* TERQUEM (1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 63, pl. 4, f. 11) redescribed by Y. LE CALVEZ (1952, Mém. Expl. Carte Géol. dét. France, pt. 4, p. 50, pl. 4, f. 40, 41) as *Boldia lobata*.

In 1946 VAN BELLEN described the genus *Boldia* with *Rotalina lobata* TERQUEM as type species. The value of this generic name may be doubted as long as the exact nature of the type specimen is not clarified. If the type specimen of *Rotalina lobata* does belong to *Globotruncana*, the name *Boldia* is a synonym.

FAMILY GÜMBELINIDAE

Genus GUMBELINA EGGER, 1899

Type species TEXTULARIA GLOBULOSA EHRENBERG, 1840

Gümbelina spp.

Pl. XV, fig. 12

Remarks. — In some samples a few, mostly broken and silicified specimens of *Gümbelina* were found. Probably they have been reworked from Cretaceous strata; they occur together with *Globotruncana* specimens.

FAMILY ELPHIDIIDAE

Genus ELPHIDIUM MONTFORT, 1808

Type species NAUTILUS MACELLUS FICHTEL and MOLL, 1798

Elphidium laeve (D'ORBIGNY)

Pl. XVI, fig. 15, 16; *68*

Nonionina laevis D'ORBIGNY, 1865, in PARKER, JONES, and BRADY, Ann. Mag. Nat. Hist., vol. 16, ser. 3, pl. 3, f. 97 (Eocene; Paris basin); TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 44, pl. 2, f. 12-14.

Nonion laeve (D'ORBIGNY), CUSHMAN, 1939, U. S. Geol. Survey, Prof. Paper no. 191, p. 3, pl. 1, f. 6, 7; TEN DAM, 1944, Meded. Geol. Stichting, ser. C, vol. 5, no. 3, p. 108; Y. LE CALVEZ, 1950, Mém. Expl. Carte Géol. dét. France, pt. 3, p. 52.

Remarks. — Some of our specimens of the Lutetian of the Paris basin as well as of those of the Belgian Eocene showed small sutural openings and hence, the distinct belonging of the species to *Elphidium*.

CUSHMAN (1939) described the aperture as a low opening at the base of the last chamber, but specimens from Grignon showed a row of pores at the inner margin of the last chamber.

The species resembles *Elphidium cryptostomum* (EGGER) (*Polystomella cryptostoma* EGGER, 1857, Neues Jahrb. Min., etc., p. 301, pl. 9, f. 19, 20) which is possibly identical.

Small specimens of *Elphidium laeve* and *E. subnodosum* are sometimes difficult to separate from each other. The umbilical knob is occasionally developed as a mass of granules, resembling the ornamentation of our *Nonion graniferum* (TERQUEM).

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

England : London Clay, Barton beds;

France : Sands of Cuise, Lutetian;

Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Brussels, Sands of Lede.

Elphidium subnodosum (ROEMER)

Pl. XVI, fig. 17, 18; *53*

Robulina subnodosa ROEMER, 1838, Neues Jahrb. Min., etc., p. 391, pl. 3, f. 61 (Miocene; Germany).

Elphidium subnodosum (ROEMER), CUSHMAN, 1939, U. S. Geol. Survey, Prof. Paper no. 191, p. 40, pl. 11, f. 2; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 163, pl. 8, f. 12, 13.

Remarks. — Our specimens, scattered throughout the whole column, are regarded to be conspecific with the forms described by BATJES from the Oligocene. Distinct specimens as figured by BATJES in figure 12 were not encountered in our material. Sometimes individuals resembling the one of his figure 13 were met with, but they have somewhat more indistinct sutural openings.

The majority of our material is formed by young specimens. They are identical with the small specimens, which in BATJES' material were found together with distinct larger individuals. They differ from our *Elphidium laeve* in having no depression around the umbo.

Distribution. — Belgium : Clays of Ieper, Sands of Mons-en-Pévèle, Sandy Clays of Anderlecht, Sands of Aalter, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse;

England : London Clay, Barton beds;

Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Aalter, Sands of Brussels, Sands of Lede.

Elphidium hiltermanni Hagn

112

Elphidium hiltermanni Hagn, 1952, Geol. Bav., no. 10, p. 163, pl. 1, f. 6, pl. 2, f. 14 (Miocene; Germany); Batjes, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 165, pl. 12, f. 4.

Remarks. — Our few specimens have more in common with those of Batjes than those of Hagn.

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

England : Upper Bracklesham beds;

Netherlands (Woensdrecht) : Lower Panisel beds.

Elphidium latidorsatum (Reuss)

Pl. XV, fig. 13, 14; *65*

Polystomella latidorsata Reuss, 1864, Denkschr. K. Akad. Wiss. Wien, vol. 23, p. 10, pl. 1, f. 6 (Oligocene; Germany).

Elphidium latidorsatum (Reuss), Cushman, 1939, U. S. Geol. Survey, Prof. Paper no. 191, p. 39, pl. 10, f. 16.

Remarks. —Small specimens referable to *Elphidium latidorsatum* occur throughout the Belgian Eocene. They have a rounded periphery, six to eight chambers, and small retral processes, up to twenty in the last formed chambers. The umbilicus is usually small and depressed, some specimens show an umbilical filling; the degree of compression of test is variable.

Specimens with inflated chambers resemble *Elphidium rischtanicum* Bykova var. *ferganensis* Bykova (1939, Trudy Neft. Geol.-Razv. Inst., ser. A, vol. 121, pp. 27, 36, pl. 3, f. 13, 14), which is different by an inflated umbo.

A number of specimens have fine, longitudinal striae on the early part of the last whorl. Often the striae are also present on the apertural face.

Elphidium minutum (Reuss) (*Polystomella minuta* Reuss, 1865, Sitz. Ber. K. Akad. Wiss. Wien, vol. 50, p. 478, pl. 4, f. 6) resembles our *E. latidorsatum*, but it has more chambers (ten to fourteen) in the last coil, and more distinct retral processes.

Distribution. — Belgium : Clays of Ieper, Clays of Roubaix, Sands of Mons-en-Pévèle, Lower Panisel beds, Sands of Brussels, Sands of Lede, Sands of Wemmel;

England : London Clay, Barton beds;

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

FAMILY ROTALIIDAE

Genus ROTALIA LAMARCK, 1804

Type species ROTALIA TROCHIDIFORMIS LAMARCK, 1804

Rotalia audouini D'ORBIGNY

Pl. XVI, fig. 8-10; 24

Rotalia audouini D'ORBIGNY, 1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 407 (Lutetian; Paris basin); FORNASINI, 1906, Mem. R. Accad. Sci. Ist. Bologna, ser. 6, vol. 3, p. 65, pl. 2, f. 9, 10; Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 29; KAASSCHIETER, 1955, Verh. Kon. Ned. Akad. Wetensch., afd. Nat., ser. 1, vol. 21, no. 2, p. 84, pl. 9, f. 3.

Rotalina audouini (D'ORBIGNY), TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 72, pl. 6, f. 11.

Rotalia armata D'ORBIGNY, 1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 3, p. 157 (Miocene; France and recent; West Indies); Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 29.

Rotalina armata (D'ORBIGNY), TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 67, pl. 5, f. 14, 15.

Pararotalia armata (D'ORBIGNY), LOEBLICH and TAPPAN, 1957, Smiths. Misc. Coll., vol. 135, no. 2, p. 9, pl. 5, f. 2.

Rotalina inermis TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 68, pl. 6, f. 1 (Lutetian; Paris basin).

Pararotalia inermis (TERQUEM), Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 32, pl. 3, f. 54-56; LOEBLICH and TAPPAN, 1957, Smiths. Misc. Coll., vol. 135, no. 2, p. 14, pl. 1, f. 2, 3.

Rosalina spinigera TERQUEM, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 97, pl. 10, f. 10 (Lutetian; Paris basin).

Globorotalia spinigera (TERQUEM), Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 39, pl. 6, f. 97-99.

Rotalia spinigera (TERQUEM), GULLENTOPS, 1956, Mém. Inst. Géol. Univ. Louvain, vol. 20, p. 17, pl. 1, f. 15, 16.

Pararotalia spinigera (TERQUEM), LOEBLICH and TAPPAN, 1957, Smiths. Misc. Coll., vol. 135, no. 2, p. 18, pl. 4, f. 1-3.

Rotalia canui CUSHMAN, 1928, Bull. Soc. Sci. Seine-et-Oise, ser. 2, vol. 8, p. 55, pl. 3, f. 2 (Oligocene; Paris basin); BHATIA, 1955, Jour. Pal., vol. 29, p. 684, pl. 66, f. 32; BATJES, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 168, pl. 12, f. 5-7.

Pararotalia subinermis BHATIA, Jour. Pal., vol. 29, p. 683, pl. 67, f. 3 (Oligocene; Wight).

Remarks. — *Rotalia audouini* s. str. is characterized by depressed sutures on the ventral side of the test, a more or less elevated plug surrounded by a distinct furrow, and a keeled, lobulate periphery, often ornamented with spines.

The *armata*-variant has a stellate outline, and around the umbo there is a series of nodes, which correspond to the inner parts of the chambers. Intermediates between the *audouini* and the *armata* types are much more numerous than the types themselves. They were referred to by LOEBLICH and TAPPAN as *Pararotalia inermis*, which is not exactly the same as the type of TERQUEM's species.

The *spinigera* type lacks the umbilical plug, and it has a *Globorotalia*-like aperture in the last-formed chamber. However, specimens with such an aperture in the last chamber and with a distinct umbilical plug are more common. The *spinigera* variant is furthermore connected with the *armata* type by a series of specimens with small umbilical knobs. Broken specimens of this *spinigera* variant showed that penultimate chambers never possess a *Globorotalia*-like aperture, which opens into the umbilicus.

Most variation is found among juvenile specimens. The adult specimens of a sample mostly belong to only one of the mentioned varieties. The presence of spines along the keel is common in young individuals, adult ones generally show a lobulate periphery. Commonly there is only one spine per chamber. A peripheral keel is nearly always present, but some specimens show a more or less rounded periphery. They resemble *Rotalia canui*. This type appeared to be common in the Oligocene (BATJES, 1958, p. 168).

The plug is variable. In distinct *armata* forms it is large, rounded and well elevated, in others it is frequently smaller, and it is completely absent in the *spinigera* variants.

The aperture varies between a large opening along the entire inner margin and a narrow, elliptical opening in the apertural face, more or less removed from the base, and provided with lips below and above the slit. This apertural type was considered typical for the genus *Pararotalia* by Y. LE CALVEZ and by LOEBLICH and TAPPAN. In our material it was found more often in penultimate chambers than in final ones. LOEBLICH and TAPPAN described this apertural type to be due to the development of a plate, which covers the umbilical portion of the aperture. Mostly this plate overlies the whole basal part of the aperture along the inner margin, leaving a slit-like opening roughly parallel to the base of the apertural face. Sometimes, however, the plate extends less far to the peripheral margin, and the slit still reaches the base of the chamber margin.

This *Pararotalia* type of aperture was also found in our *audouini* specimens, though LOEBLICH and TAPPAN described the aperture of *Rotalia audouini* to be always completely basal and without umbilical plate.

D i s t r i b u t i o n . — Belgium : Clays of Ieper, Clays of Roubaix, Sands of Mons-en-Pévèle, Sands of Brussels, Sands of Lede, Sands of Wemmel, Clays of Asse;
England : Upper Bracklesham beds, Barton beds;
France : Lutetian;
Netherlands (Woensdrecht) : Lower Panisel beds, Sands of Brussels.

Rotalia sp. cf. **R. calvezae** (LOEBLICH and TAPPAN)

Pl. XVI, fig. 11; *114*

cf. *Pararotalia calvezae* LOEBLICH and TAPPAN, 1957, Smithsonian Misc. Coll., vol. 135, no. 2, p. 12, pl. 2, f. 3-7 (Eocene; France).

R e m a r k s . — Some scattered, small and juvenile specimens resemble *Rotalia calvezae*. Spines on the periphery are but faint, a furrow around the plug is indistinct. The periphery is rounded, but some specimens with a slight keel were found as well. The aperture is commonly an arched opening at the inner margin of the last-formed chamber. A number of specimens showed the features of *Pararotalia* Y. LE CALVEZ with an aperture removed from the base of the chamber. Some specimens without an umbilical plug were noted.

The specimens are often ill-preserved. Thus a more certain determination is impossible.

D i s t r i b u t i o n . — Belgium : Sandy Clays of Anderlecht, Sands of Brussels, Sands of Lede;
Netherlands (Woensdrecht) : Lower Panisel beds.

Rotalia propingua Reuss

Pl. XVI, fig. 12; *145*

Rotalia propingua Reuss, 1856, Sitz. ber. K. Akad. Wiss. Wien, vol. 18, p. 241, pl. 4, f. 53 (Oligocene; Germany); Batjes, 1958, Mém. Inst. R. Sc. Nat. Belg., no. 143, p. 167, pl. 12, f. 11.

Remarks. — Our specimens better resemble Batjes' figures than those of Reuss. They often show deep grooves in the sutures near the umbilicus. This feature was also met with in Batjes' specimens from the German Upper Oligocene.

Some variation is found in the convexity of the dorsal and ventral sides. In typical specimens the dorsal side is convex and the ventral side nearly flat, but sometimes the test is about equally biconvex.

Rotalia papillosa d'Orbigny (1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 407; Fornasini, 1906, Mem. R. Accad. Sci. Ist. Bologna, ser. 6, vol. 3, p. 64, pl. 2, f. 6) has more chambers and a more distinctly granular umbilical filling. No indications of sutural grooves are to be found in Fornasini's figures.

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

England : Upper Bracklesham beds, Barton beds;

France : Lutetian;

Netherlands (Woensdrecht) : Sands of Lede.

Rotalia spp.

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Remarks. — In the Belgian Eocene, as well as in the Lutetian of the Paris Basin, some other *Rotalia* species were recognized. The Belgian material is rather ill-preserved, and the different species mostly occur in very low numbers.

Three types could be distinguished :

Rotalia thouini d'Orbigny (1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 407; Fornasini, 1906, Mem. R. Accad. Sci. Ist. Bologna, ser. 6, vol. 3, p. 64, pl. 2, f. 7) - plate XVI, fig. 13.

Singe specimens in MMV 1201 (Sands of Mons-en-Pévèle) and CO 1240 (basal strata of the Sands of Brussels).

Rotalia guerini d'Orbigny (1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 407; Fornasini, 1906, Mem. R. Accad. Sci. Ist. Bologna, ser. 6, vol. 3, p. 65, pl. 2, f. 8).

Some specimens in three samples of the Brussels Sands of the Woensdrecht boring.

Rotalia perovalis (Terquem) (*Rotalina perovalis* Terquem, 1882, Mém. Soc. Géol. France, ser. 3, vol. 2, p. 70, pl. 6, f. 5).

Single specimens in NX 91 and 95 (Clays of Ieper and Sands of Mons-en-Pévèle, respectively), in CM 51 and Woensdrecht 364 m (Sands of Brussels).

The individuals of other samples are too ill-preserved and fragmentary for specific determination.

In our samples of Grignon (CAB) we found in association with *Rotalia guerini* and *R. perovalis* some other species, such as :

Rotalia trochidiformis LAMARCK (1804, Ann. Mus., vol. 5, p. 184; vol. 8, pl. 14, f. 8),
Rotalia complanata D'ORBIGNY (1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 407; FORNASINI, 1906, Mem. R. Accad. Sci. Ist. Bologna, ser. 6, vol. 3, p. 67, pl. 3, f. 9), and
Rotalia suessonensis D'ORBIGNY (1850, Prodrome Pal. Strat. Univ. Anim. Moll. Ray., vol. 2, p. 336; FORNASINI, 1906, Mem. R. Accad. Sci. Ist. Bologna, ser. 6, vol. 3, p. 66, pl. 3, f. 2).

FAMILY **VICTORIELLIDAE**

Genus GYROIDINELLA Y. LE CALVEZ, 1949

Type species GYROIDINELLA MAGNA Y. LE CALVEZ, 1949

Gyroidinella magna Y. LE CALVEZ

Pl. XVI, fig. 14; *129*

Gyroidinella magna Y. LE CALVEZ, 1949, Mém. Expl. Carte Géol. dét. France, pt. 2, p. 27, pl. 6, f. 103-105 (Lutetian; Paris basin).

R e m a r k s . — Specimens of *Gyroidinella magna* were found only in section THB (Nalinnes) of the Belgian Eocene.

HAGN (1955, Pal. Zeitschr., vol. 29, pt. 1/2, p. 66) described the features of *Gyroidinella* and *Eorupertia*. Pillars, characterizing the chamber walls of *Eorupertia*, are completely absent in our specimens.

D i s t r i b u t i o n . — Belgium : Sands of Brussels.

SUMMARY

A systematic study of the foraminifera from the Belgian Eocene has been carried out. The examined material has been collected from more than 450 surface samples. For a more complete knowledge of the foramineral assemblages a number of well samples of the Geological Survey of Belgium were at our disposal. Furthermore the Eocene core samples from the Woensdrecht-well (the Netherlands) have been investigated. To compare the faunas of the Belgian and Dutch Eocene formations a number of samples from the type localities of the most important formations of the Paris and the Hampshire basins were available.

Altogether some 225 species and varieties were recognized, of wich 13 are new. Furthermore 2 existing species had to be renamed.

The ostracods of most of our samples have been described by Keij (1957).

Some remarks about the studied foraminiferal assemblages have been added, as well as some conclusions about the Belgian Eocene stratigraphy. It is suggested that the Brussels formation and part of the Lower Panisel beds are of the same age and both belong to the Lutetian. Serious doubt is expressed about the existence of Ledian and Bartonian as separate stages in the Late Eocene, and both may have to be united as Bartonian. Some more facts supporting a time-equivalence of the Late Bartonian and the Early Tongrian have been given.

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On the occasion of the writer taking his degree at the State University of Utrecht in April 1959, a summary of the present paper was published in dutch under the same title. Except for one note about the Sands of Oostende the manuscript of the present paper has not been modified since its presentation in April 1959.

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FIG. 19. — *Textularia smithvillensis* CUSHMAN and ELLISOR, a, side view, b, apertural view, Clays of Ieper, boring Woensdrecht 542 m, ×25

FIG. 20. — *Trochammina* sp. cf. *T. inflata* (MONTAGU), a, dorsal view, b, ventral view, c, peripheral view, Clays of Ieper, boring Woensdrecht 593 m, ×80

FIG. 21. — *Karreriella siphonella* (REUSS), a, side view, b, apertural view, Clays of Asse, Oedelem (BRB 247), ×55

FIG. 22. — *Karreriella siphonella* (REUSS), a, side view, b, apertural view, Clays of Asse, Wemmel (BW 1273), ×40

FIG. 23. — *Karreriella siphonella* (REUSS), a, side view, b, apertural view, Sands of Wemmel, Jette (BT 1266), ×50

FIG. 24. — *Karreriella danica* CUSHMAN, a, side view, b, apertural view, Clays of Ieper, boring Woensdrecht 534 m, ×25

FIG. 25. — *Karreriella danica* CUSHMAN, a, side view, b, apertural view, Clays of Ieper, boring Woensdrecht 542 m, ×50

FIG. 26. — *Valvulina* sp., Sands of Lede, Lede (2-V), ×35

FIG. 27. — *Clavulina parisiensis* D'ORBIGNY, a, side view, b, apertural view, Sands of Lede, Asse (BL 1035), ×40

FIG. 28. — *Clavulina parisiensis* D'ORBIGNY, a, side view, b, apertural view, Lutetian, Grignon (CAB 1261), ×40

FIG. 29. — *Pseudoclavulina anglica* CUSHMAN, a, side view, b, apertural view, Clays of Ieper, boring Woensdrecht 540 m, ×35

FIG. 30. — *Pseudoclavulina* sp. cf. *P. cocoaensis* CUSHMAN, a, b, side views, c, apertural view, Clays of Asse, Oedelem (BRB 237), ×35

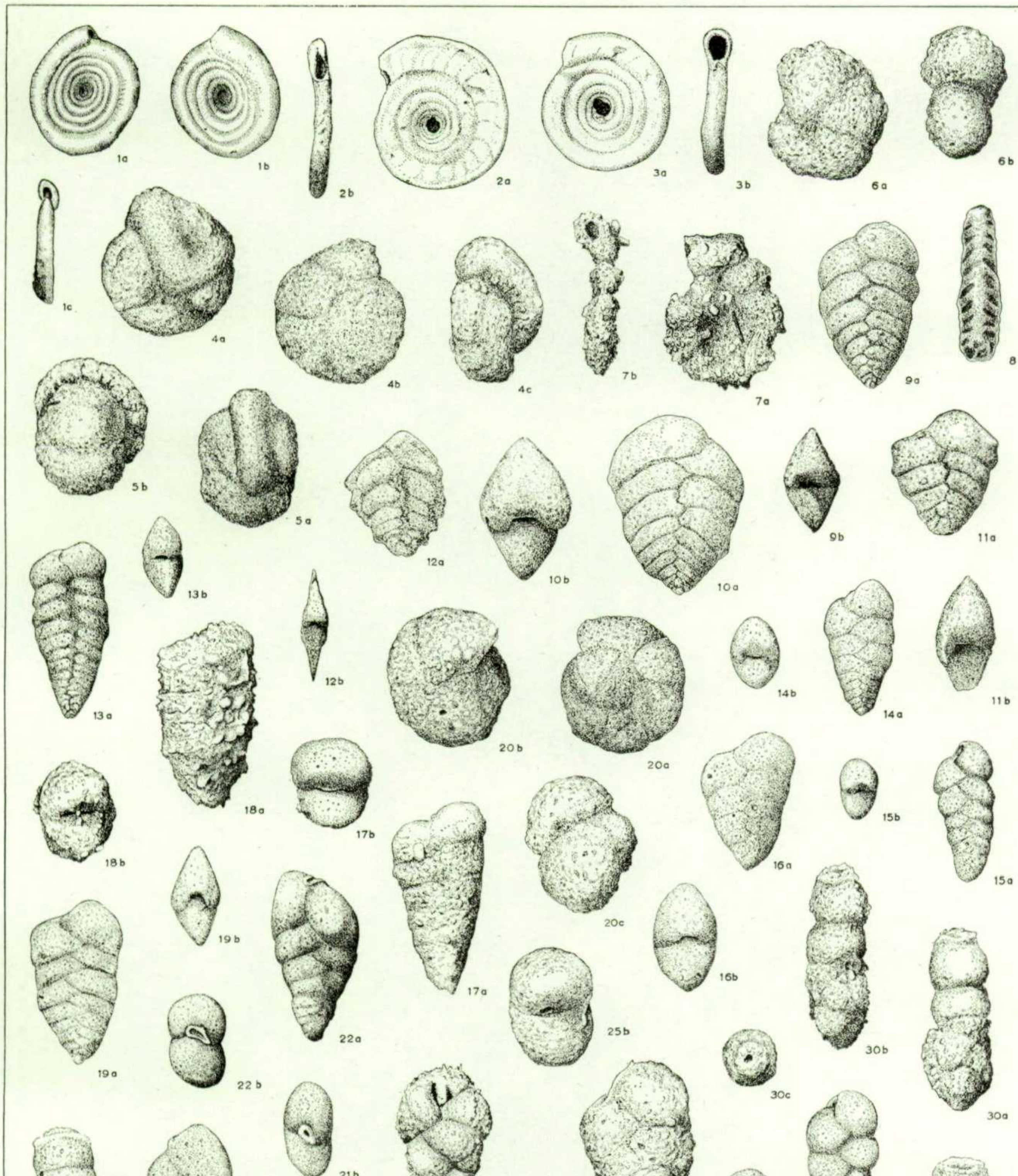

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PLATE II

EXPLANATION OF PLATE II

FIG. 1. — *Vertebralina laevigata* TERQUEM, a, side view, b, peripheral view, Sands of Lede, Bambrugge (ZD 1012), ×80

FIG. 2. — *Vertebralina laevigata* TERQUEM, a, side view, b, peripheral view, Lutetian, Grignon (CAB 1002), ×80

FIG. 3. — (?) *Vertebralina* sp., a, side view, b, peripheral view, Sands of Wemmel, boring Heist-op-den-Berg 129,50 m, ×55

FIG. 4. — *Spirophthalmidium alata* (TERQUEM), a, b, opposite sides, c, apertural view, Lutetian, Grignon (CAB 1261), ×40

FIG. 5. — *Quinqueloculina seminula* (LINNÉ), a, b, opposite sides, c, apertural view, Sands of Wemmel, boring Wemmel 48-22 m, ×55

FIG. 6. — *Quinqueloculina seminula* (LINNÉ), a, b, opposite sides, c, apertural view, Sands of Lede, Bambrugge (ZD 1011), ×35

FIG. 7. — *Quinqueloculina ludwigi* REUSS, a, b, opposite sides, c, apertural view, Sands of Lede, Bambrugge (ZD 1016), ×55

FIG. 8. — *Quinqueloculina ludwigi* REUSS, a, b, opposite sides, c, apertural view, Barton beds, Barton (D 2), ×55

FIG. 9. — *Quinqueloculina carinata* D'ORBIGNY, a, b, opposite sides, c, apertural view, Sands of Wemmel, Strombeek-Bever (BV 1272), ×35

FIG. 10. — *Quinqueloculina carinata* D'ORBIGNY, a, b, opposite sides ,c, apertural view, Sands of Wemmel, boring Wemmel 14-6,50 m, ×35

FIG. 11. — *Quinqueloculina carinata* D'ORBIGNY, a, b, opposite sides, c, apertural view, Sands of Lede, Bambrugge (ZD 1016), ×35

FIG. 12. — *Quinqueloculina bicarinata* D'ORBIGNY, a, b, opposite sides, c, apertural view, Barton beds, Barton (D 5), ×30

FIG. 13. — *Quinqueloculina bicarinata* D'ORBIGNY, a, b, opposite sides, c, apertural view, Sands of Wemmel, boring Brussegem no. 18, ×20

FIG. 14. — *Quinqueloculina juleana* D'ORBIGNY, a, b, opposite sides, c, apertural view, Sands of Lede, Bambrugge (ZD 1016), ×35

FIG. 15. — *Quinqueloculina juleana* D'ORBIGNY, a, b, opposite sides, c, apertural view, Sands of Lede, Bambrugge (ZD 1015), ×55

FIG. 16. — *Quinqueloculina* sp. cf. *Q. aspera* D'ORBIGNY, a, b, opposite sides, c, apertural view, Lutetian, Grignon (CAB 1261), ×55

FIG. 17. — *Quinqueloculina costata* KARRER, a, b, opposite sides, c, apertural view, Sands of Lede, Bambrugge (ZD 1014), ×35

FIG. 18. — *Quinqueloculina costata* KARRER, a, b, opposite sides, c, apertural view, Lutetian, Grignon (CAB 1261), ×40

FIG. 19. — *Quinqueloculina costata* KARRER, a, b, opposite sides, c, apertural view, Sands of Lede, Bambrugge (ZD 1011), ×40

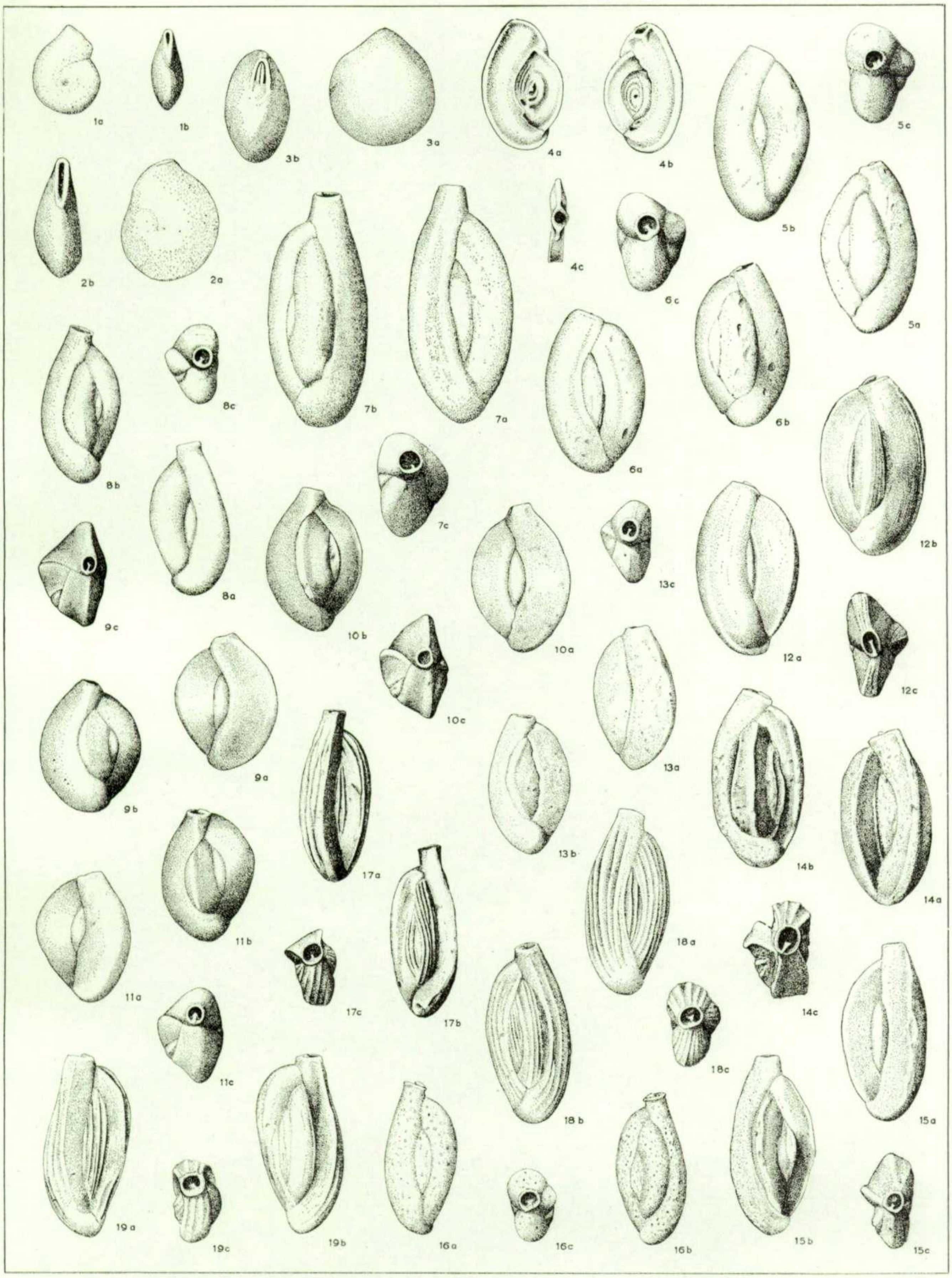

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PLATE III

EXPLANATION OF PLATE III

FIG. 1. — *Quinqueloculina striata* D'ORBIGNY, a, b, opposite sides, c, apertural view, Lutetian, Grignon (CAB 1002), ×30

FIG. 2. — *Quinqueloculina striata* D'ORBIGNY, a, b, opposite sides, c, apertural view, Sands of Lede, Bambrugge (ZD 1014), ×35

FIG. 3. — *Quinqueloculina crassa* D'ORBIGNY, a, b, opposite sides, c, apertural view, Lutetian, Grignon (CAB 1002), ×35

FIG. 4. — *Quinqueloculina impressa* REUSS, a, b, opposite sides, c, apertural view, Lutetian, Grignon (CAB 1261), ×40

FIG. 5. — *Quinqueloculina impressa* REUSS, a, b, opposite sides, c, apertural view, Barton beds, Barton (D 2), ×55

FIG. 6. — *Quinqueloculina impressa* REUSS, a, b, opposite sides, c, apertural view, Sands of Wemmel, boring Wemmel 14-10 m, ×55

FIG. 7. — *Miliolinella oblonga* (MONTAGU), a, b, opposite sides, c, apertural view, Barton beds, Barton (D 8), ×55

FIG. 8. — *Miliolinella oblonga* (MONTAGU), a, b, opposite sides, c, apertural view, Sands of Lede, Bambrugge (ZD 1016), ×55

FIG. 9. — *Spiroloculina tricarinata* TERQUEM, a, side view, b, apertural view, Sands of Wemmel, Jette (BS 1260), ×55

FIG. 10. — *Spiroloculina tricarinata* TERQUEM, a, side view, b, apertural view, Sands of Wemmel, Jette (BS 1260), ×40

FIG. 11. — *Spiroloculina tricarinata* TERQUEM, a, side view, b, apertural view, Lutetian, Grignon (CAB 1000), ×55

FIG. 12. — *Spiroloculina tricarinata* TERQUEM var. *belgica* nov. var., holotype, a, side view, b, apertural view, Sands of Wemmel, Jette (BS 1260), ×35

FIG. 13. — *Spiroloculina tricarinata* TERQUEM var. *belgica* nov. var., a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1014), ×50

FIG. 14. — *Spiroloculina tricarinata* TERQUEM var. *belgica* nov. var., a, side view, b, apertural view, Sands of Wemmel, boring Wemmel 16-6 m, ×35

FIG. 15. — *Spiroloculina tricarinata* TERQUEM var. *angulifera* TERQUEM, a, side view, b, apertural view, Lutetian , Grignon (CAB 1002), ×55

FIG. 16. — *Spiroloculina tricarinata* TERQUEM var. *angulifera* TERQUEM, a, side view, b, apertural view, Sands of Wemmel, boring Brussegem no. 27, ×40

FIG. 17. — *Spiroloculina bicarinata* D'ORBIGNY, a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1014), ×55

FIG. 18. — *Spiroloculina bicarinata* D'ORBIGNY, a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1014), ×55

FIG. 19. — *Spiroloculina bicarinata* D'ORBIGNY, a, side view, b, apertural view, Lutetian, Damery (Damery-serratum), ×80

FIG. 20. — *Spiroloculina canaliculata* D'ORBIGNY, a, side view, b, apertural view, Sands of Wemmel, boring Heist-op-den-Berg 129,50 m, ×30

FIG. 21. — *Spiroloculina canaliculata* D'ORBIGNY, a, side view, b, apertural view, Sands of Wemmel, boring Wemmel 48-22 m, ×55

FIG. 22. — *Spiroloculina canaliculata* D'ORBIGNY, a, side view, b, apertural view, Sands of Wemmel, boring Wemmel 14-10 m, ×25

FIG. 23. — *Spiroloculina canaliculata* D'ORBIGNY, a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1014), ×55

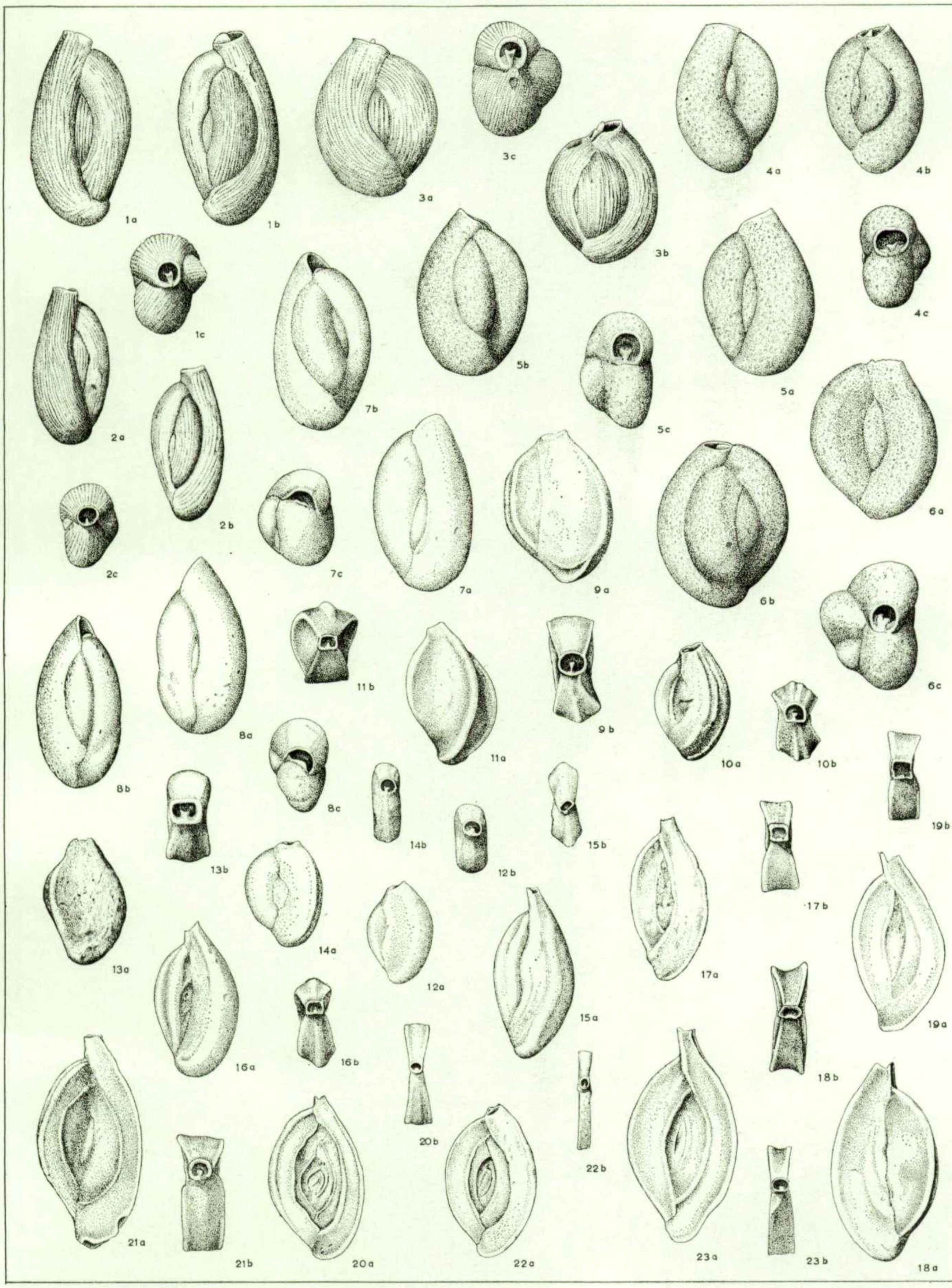

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PLATE IV

EXPLANATION OF PLATE IV

FIG. 1. — *Spiroloculina perforata* D'ORBIGNY, a, side view, b, apertural view, Lutetian, Grignon (CAB 1002), ×40

FIG. 2. — *Spiroloculina costigera* TERQUEM, a, side view, b, apertural view, Lutetian, Grignon (CAB 1261), ×40

FIG. 3. — *Spiroloculina costigera* TERQUEM, a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 340), ×55

FIG. 4. — *Spiroloculina costigera* TERQUEM var. *carinata* Y. LE CALVEZ, a, side view, b, apertural view, Lutetian, Grignon (CAB 1002), ×40

FIG. 5. — *Spiroloculina costigera* TERQUEM var. *ubiqua* Y. LE CALVEZ, a, side view, b, apertural view, Lutetian, Grignon (CAB 1002), ×35

FIG. 6. — *Spiroloculina costigera* TERQUEM var. *ubiqua* Y. LE CALVEZ, a, side view, b, apertural view, Sands of Lede, Meldert (MC 1040), ×35

FIG. 7. — *Spiroloculina costigera* TERQUEM var. *nuda* nov. var., holotype, a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1013), ×40

FIG. 8. — *Spiroloculina costigera* TERQUEM var. *nuda* nov. var., a, side view, b, apertural view, Sands of Wemmel, boring Brussegem no. 27, ×35

FIG. 9. — *Sigmoilina tenuis* (CZJZEK), a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 343), ×50

FIG. 10. — *Sigmoilina tenuis* (CZJZEK), a, side view, b, apertural view, Clays of Asse, Oedelem (BRB 1054), ×55

FIG. 11. — *Articulina nitida* D'ORBIGNY, Lutetian, Daméry (Daméry), ×50

FIG. 12. — *Articulina terquemi* CUSHMAN, a, side view, b, apertural view, Sands of Wemmel, boring Brussegem no. 27, ×75

FIG. 13. — *Articulina terquemi* CUSHMAN, a, side view, b, apertural view, Clays of Asse, Oedelem (BRB 1056), ×50

FIG. 14. — *Articulina contracta* (TERQUEM), a, side view, b, apertural view, Sands of Wemmel, boring Wemmel 14-10 m, ×75

FIG. 15. — *Articulina laevigata* TERQUEM, a, side view, b, apertural view, Sands of Lede, boring Brussegem no. 33, ×35

FIG. 16. — *Articulina laevigata* TERQUEM, a, side view, b, apertural view, Lutetian, Daméry (Daméry), ×50

FIG. 17. — *Articulina laevigata* TERQUEM, a, side view, b, apertural view, Lutetian, Grignon (CAB 1261), ×35

FIG. 18. — *Articulina ornaticollis* Y. LE CALVEZ, Lutetian, Daméry (Daméry), ×50

FIG. 19. — *Articulina pseudosulcata* nov. sp., holotype, a, side view, b, apertural view, Sands of Wemmel, boring Heist-op-den-Berg 129,50 m, ×50

FIG. 20. — *Articulina pseudosulcata* nov. sp., a, side view, b, apertural view, Sands of Lede, Meldert (MC 1040), ×50

FIG. 21. — *Articulina flandrica* nov. sp., holotype, a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1016), ×50

FIG. 22. — *Articulina flandrica* nov. sp., a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1011), ×50

FIG. 23. — *Articulina flandrica* nov. sp., a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1017), ×50

FIG. 24. — *Articulina flandrica* nov. sp., a, side view, b, apertural view, Sands of Wemmel, boring Heist-op-den-Berg 121,50 m, ×50

FIG. 25. — *Miliola saxorum* (LAMARCK), a, b, opposite sides, c, apertural view, Lutetian, Grignon (CAB 1261), ×25

FIG. 26. — *Miliola saxorum* (LAMARCK), a, b, opposite sides, c, apertural view, Sands of Wemmel, boring Brussegem no. 25, ×35

FIG. 27. — *Miliola saxorum* (LAMARCK), a, b, opposite sides, c, apertural view, Lutetian, Grignon (CAB 1261), ×35

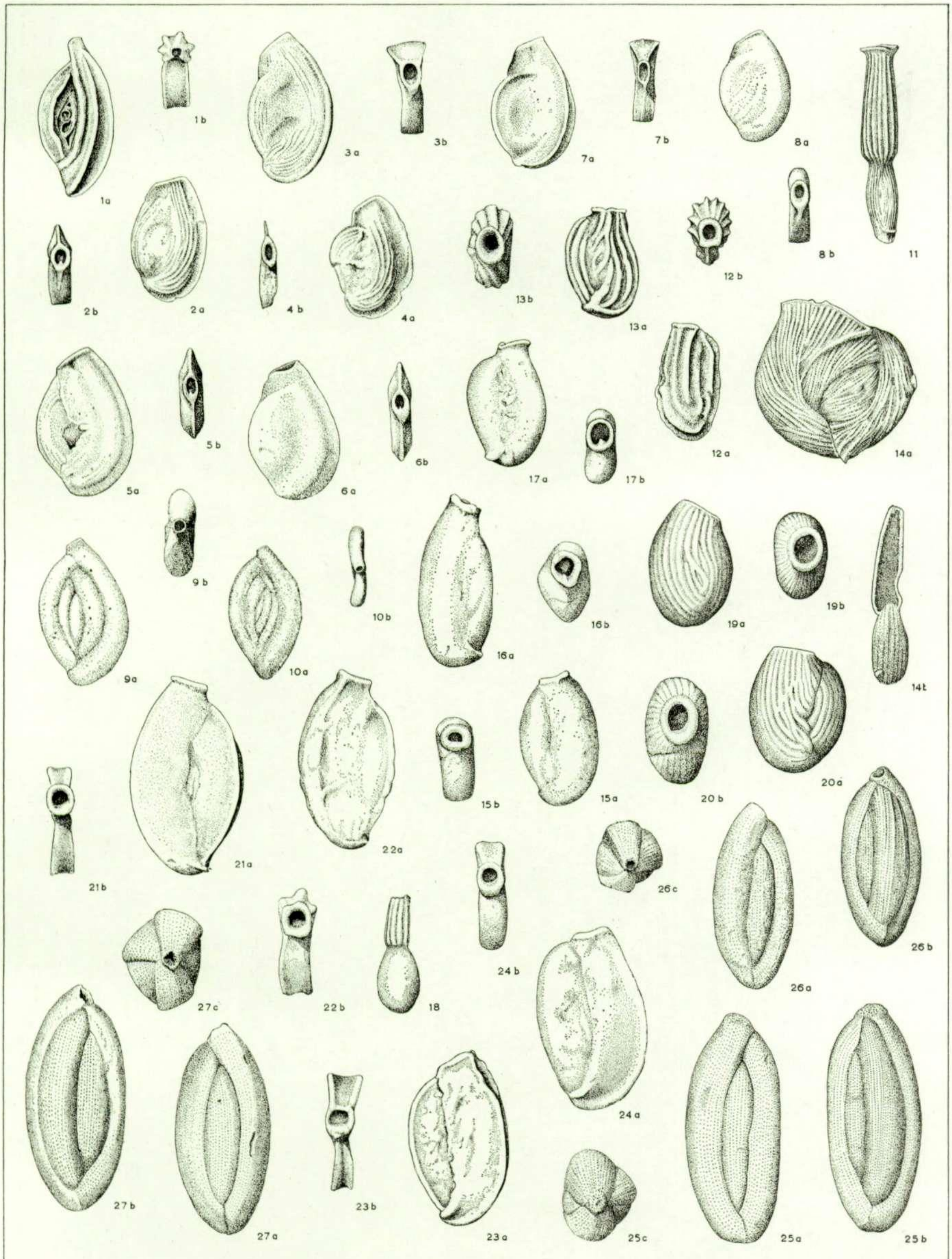

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PLATE V

EXPLANATION OF PLATE V

FIG. 1. — *Miliola saxorum* (LAMARCK), a, b, opposite sides, c, apertural view, Sands of Lede, Bambrugge (ZD 1016), ×40

FIG. 2. — *Miliola birostris* (LAMARCK), a, b, opposite sides, c, apertural view, Lutetian, Grignon (CAB 1000), ×50

FIG. 3. — *Miliola disticha* (TERQUEM), a, b, opposite sides, c, apertural view, Lutetian, Grignon (CAB 1002), ×50

FIG. 4. — *Miliola prisca* (D'ORBIGNY), a, b, opposite sides, c, apertural view, Lutetian, Grignon (CAB 1261), ×35

FIG. 5. — *Miliola prisca* (D'ORBIGNY), a, b, opposite sides, c, apertural view, Sands of Wemmel, boring Brussegem no. 26, ×50

FIG. 6. — *Miliola prisca* (D'ORBIGNY), var. *strigillata* (D'ORBIGNY), a, b, opposite sides, c, apertural view, Lutetian, Grignon (CAB 1261), ×55

FIG. 7. — *Miliola prisca* (D'ORBIGNY) var. *terquemi* nov. var., holotype, a, b, opposite views, c, apertural view, Sands of Wemmel, boring Brussegem no. 27, ×55

FIG. 8. — *Triloculina trigonula* (LAMARCK), a, b, side views, c, apertural view, Lutetian, Daméry (Daméry-serratum), ×50

FIG. 9. — *Triloculina trigonula* (LAMARCK), a, b, side views, c, apertural view, Sands of Lede, Bambrugge (ZD 1016), ×35

FIG. 10. — *Triloculina trigonula* (LAMARCK), a, side view, b, apertural view, Sands of Wemmel, boring Wemmel 14-9,50 m, ×35

FIG. 11. — *Triloculina trigonula* (LAMARCK) var. *inflata* D'ORBIGNY, a, b, side views, c, apertural view, Sands of Lede, Bambrugge (ZD 1013), ×50

FIG. 12. — *Triloculina gibba* D'ORBIGNY, a, b, side views, Sands of Lede, Bambrugge (ZD 1014), ×25

FIG. 13. — *Triloculina gibba* D'ORBIGNY, a, b, side views, c, apertural view, Lutetian, Grignon (CAB 1261), ×40

FIG. 14. — *Triloculina gibba* D'ORBIGNY, a, b, side views, c, apertural view, Sands of Lede, Meldert (MC 1040), ×35

FIG. 15. — *Triloculina angularis* D'ORBIGNY, a, b, side views, c, apertural view, Sands of Wemmel, Strombeek-Bever (BV 1272), ×55

FIG. 16. — *Triloculina lecalvezae* nov. nom., a, side view, b, apertural view, Lutetian, Daméry (Daméry-serratum), ×25

FIG. 17. — *Triloculina propinqua* TERQUEM, a, side view, b, apertural view, Lutetian, Grignon (CAB 1261), ×35

FIG. 18. — *Pyrgo bulloides* (D'ORBIGNY), a, front view, b, apertural view, Lutetian, Grignon (CAB 1002), ×25

FIG. 19. — *Pyrgo elongata* (D'ORBIGNY), a, front view, b, apertural view, Lutetian, Grignon (CAB 1261), ×30

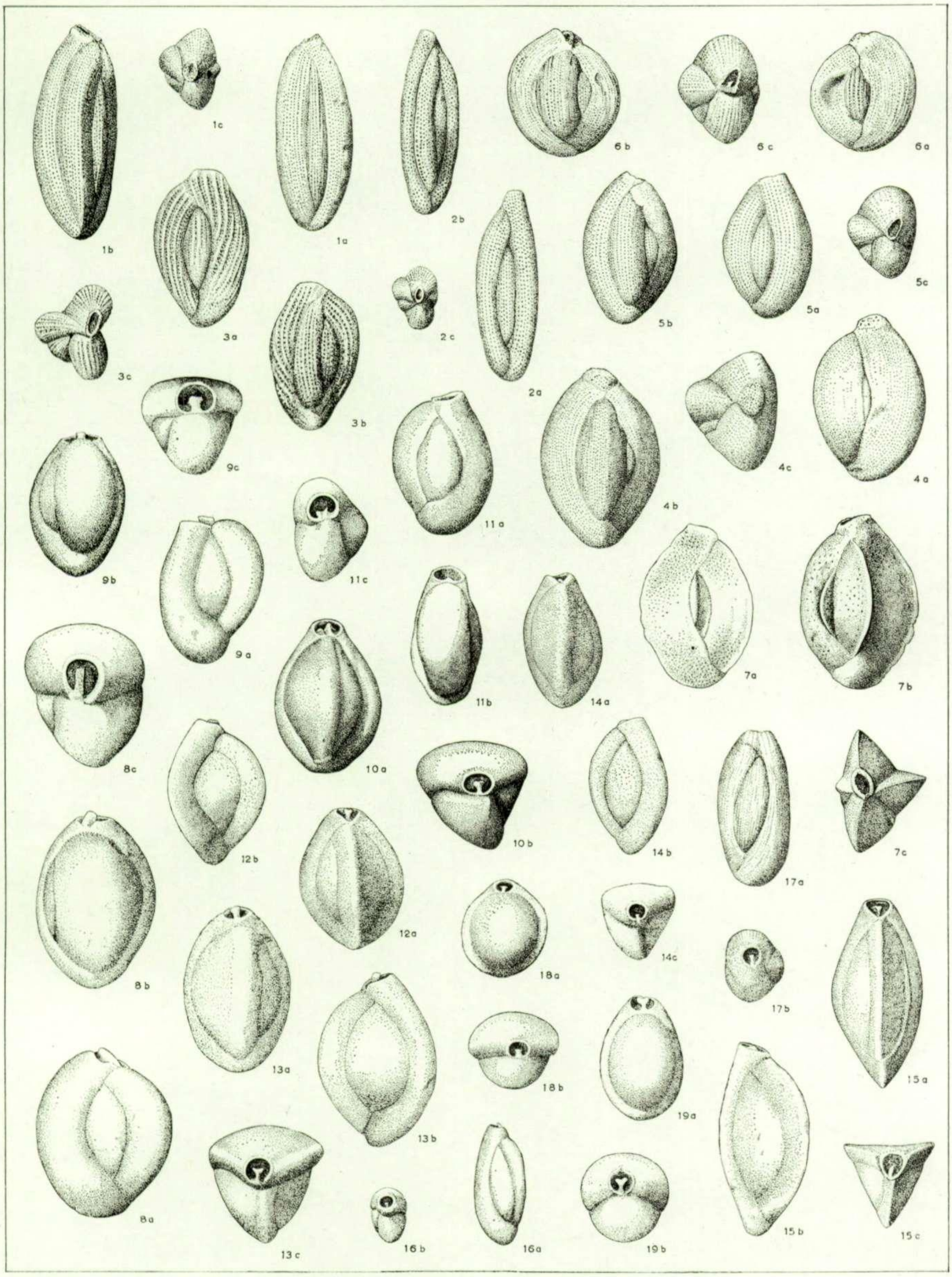

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PLATE VI

EXPLANATION OF PLATE VI

FIG. 1. — *Fabularia bella* nov. sp., holotype, a, front view, b, side view, Sands of Lede, Bambrugge (ZD 1014), ×30

FIG. 2. — *Fabularia bella* nov. sp., a, front view, b, side view, Sands of Lede, Bambrugge (ZD 1016), ×40

FIG. 3. — *Fabularia bella* nov. sp., a, front view, b, side view, Sands of Lede, Bambrugge (ZD 342), ×40

FIG. 4. — *Fabularia bella* nov. sp., median section of a probably microspheric specimen, Sands of Lede, Bambrugge (ZD 1016), ×80

FIG. 5. — *Fabularia bella* nov. sp., median section of a probably megalospheric specimen, Sands of Lede, Meldert (MC 1040), ×80

FIG. 6. — *Fabularia bella* nov. sp., median section through the central part of a probably microspheric specimen, Sands of Wemmel, boring Heist-op-den-Berg 129,50 m, ×120

FIG. 7. — *Renulina opercularia* (LAMARCK), a, dorsal view, b, ventral view, Lutetian, Daméry (Daméry-serratum), ×40

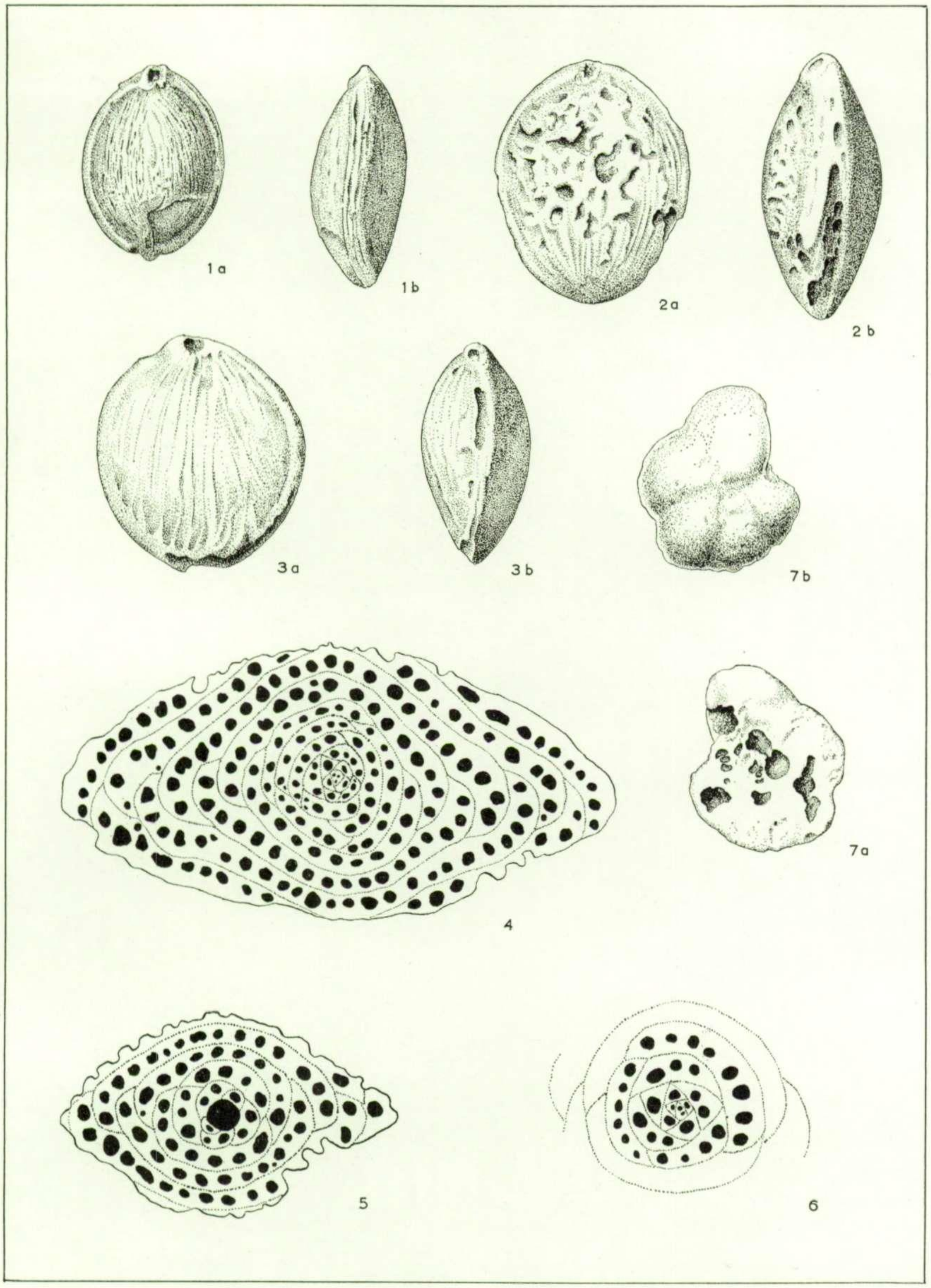

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PLATE VII

EXPLANATION OF PLATE VII

FIG. 1. — *Lenticulina* sp. cf. *L. alatolimbata* (GÜMBEL), a, side view, b, apertural view, Sands of Mons-en-Pévèle, Mont-Saint-Aubert (DH 1211), ×35

FIG. 2. — *Lenticulina* sp. cf. *L. alatolimbata* (GÜMBEL), a, side view, b, peripheral view, Clays of Roubaix, Luingne (KA 1093), ×25

FIG. 3. — *Lenticulina* sp. cf. *L. costata* (D'ORBIGNY), a, side view, b, peripheral view, Clays of Asse, Oedelem (BRB 1054), ×20

FIG. 4. — *Lenticulina* sp. cf. *L. ellisori* BOWEN, a, side view, b, apertural view, Clays of Ieper, boring Woensdrecht 550 m, ×40

FIG. 5. — *Lenticulina* sp. cf. *L. jugosa* (CUSHMAN and THOMAS), a, side view, b, apertural view, Clays of Asse, Oedelem (BRB 237), ×35

FIG. 6. — *Lenticulina* sp. cf. *L. pseudovortex* (COLE), a, side view, b, peripheral view, Clays of Ieper, boring Woensdrecht 536 m, ×35

FIG. 7. — *Lenticulina* (*Darbyella*) sp. cf. *Lenticulina* (*Darbyella*) *wilcoxensis* CUSHMAN and GARRETT, a, b, side views, c, apertural view, Clays of Ieper, boring Woensdrecht 547 m, ×25

FIG. 8. — *Lenticulina* sp. cf. *L. yaguatensis* (BERMUDEZ), a, side view, b, apertural view, Sands of Wemmel, Jette (BS 1260), ×55

FIG. 9. — *Lenticulina* sp. cf. *L. yaguatensis* (BERMUDEZ), a, side view, b, apertural view, Upper Bracklesham beds, Whitecliff Bay (EG 1), ×35

FIG. 10. — *Lenticulina* (*Astacolus*) *decorata* (REUSS), a, side view, b, apertural view, Sands of Wemmel, boring Wemmel 16-6 m, ×35

FIG. 11. — *Lenticulina* (*Astacolus*) *decorata* (REUSS), Clays of Asse, Oedelem (BRB 237), ×35

FIG. 12. — *Lenticulina* (*Marginulinopsis*) *enbornensis* (BOWEN), a, side view, b, apertural view, Clays of Ieper, boring Woensdrecht 542 m, ×20

FIG. 13. — *Lenticulina* (*Marginulinopsis*) *enbornensis* (BOWEN), a, side view, b, apertural view, Clays of Ieper, boring Woensdrecht 548 m, ×25

FIG. 14. — *Dentalina megalopolitana* REUSS, Clays of Ieper, boring Woensdrecht 547 m, ×35

FIG. 15. — *Dentalina* sp. cf. *D. ewaldi* (REUSS), Clays of Asse, Oedelem (BRB 247), ×35

FIG. 16. — *Dentalina* sp. cf. *D. ewaldi* (REUSS), Clays of Asse, Oedelem (BRB 1054), ×35

FIG. 17. — *Dentalina elegans* D'ORBIGNY, Sands of Wemmel, boring Brussegem no. 23, ×35

FIG. 18. — *Dentalina inornata* D'ORBIGNY, Sands of Wemmel, Strombeek-Bever (BV 1272), ×35

FIG. 19. — *Dentalina inornata* D'ORBIGNY, Clays of Asse, Oedelem (BRB 1055), ×35

FIG. 20. — *Nodosaria* sp. cf. *N. elegantissima* HANTKEN, Clays of Ieper, boring Woensdrecht 540 m, ×20

FIG. 21. — *Nodosaria minor* HANTKEN, Clays of Ieper, boring Woensdrecht 541 m, ×15

FIG. 22. — *Nodosaria latejugata* GÜMBEL, Clays of Ieper, boring Woensdrecht 537 m, ×20

FIG. 23. — *Nodosaria ludwigi* REUSS, Clays of Asse, Oedelem (BRB 237), ×20

FIG. 24. — *Nodosaria natchitochensis* (HOWE), Clays of Ieper, boring Woensdrecht 540 m, ×55

FIG. 25. — *Lagena isabella* (D'ORBIGNY), Clays of Asse, Oedelem (BRB 237), ×55

FIG. 26. — *Lagena striata* (D'ORBIGNY), Sands of Wemmel, Strombeek-Bever (BV 1272), ×55

FIG. 27. — *Lagena globosa* (MONTAGU), Sands of Wemmel, boring Woensdrecht 335 m, ×55

FIG. 28. — *Entosolenia marginata* (WALKER and BOYS), Sands of Lede, Bambrugge (ZD 1017), ×80

FIG. 29. — *Entosolenia orbignyana* (SEGUENZA), a, side view, b, peripheral view, Sands of Brussels, Lathuy (WA 1139), ×80

FIG. 30. — *Guttulina problema* (D'ORBIGNY), a, b, opposite views, Sands of Lede, Bambrugge (ZD 1011), ×35

FIG. 31. — *Guttulina problema* (D'ORBIGNY), a, b, opposite views, Sands of Wemmel, boring Wemmel 16-6 m, ×50

FIG. 32. — *Guttulina problema* (D'ORBIGNY), a, b, opposite views, Sands of Wemmel, boring Wemmel 16-7 m, ×50

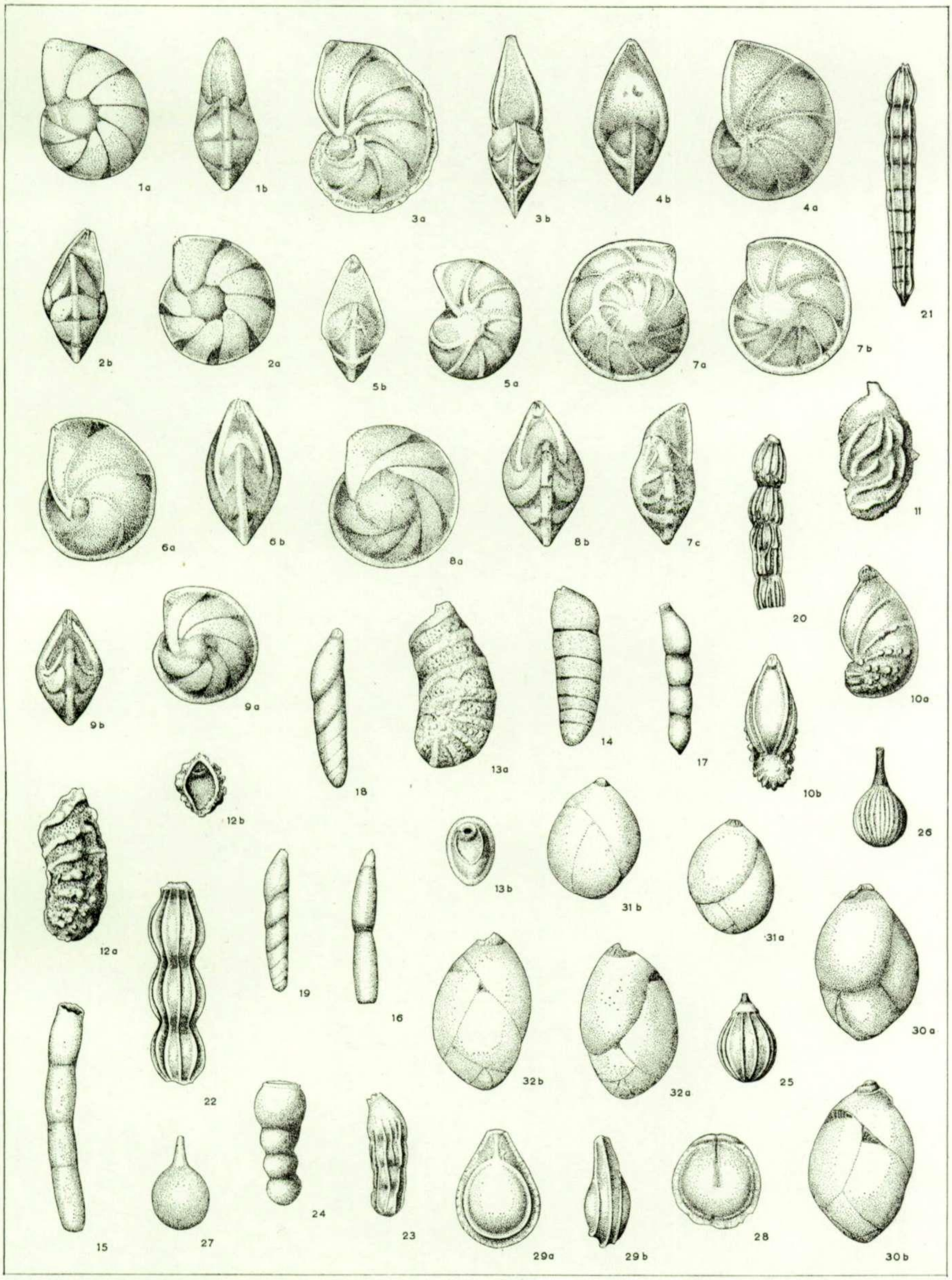

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PLATE VIII

EXPLANATION OF PLATE VIII

FIG. 1. — *Guttulina problema* (D'ORBIGNY), a, b, opposite views, Clays of Asse, Oedelem (BRB 237), ×55
FIG. 2. — *Gutttulina irregularis* (D'ORBIGNY), a, b, opposite views, Lower Panisel beds, boring Woensdrecht 434 m, ×35
FIG. 3. — *Guttulina irregularis* (D'ORBIGNY), a, b, opposite views, Sands of Wemmel, Strombeek-Bever (BV 1272), ×50
FIG. 4. — *Guttulina pulchella* D'ORBIGNY, a, b, opposite views, Sands of Brussels, Saint-Job (BA 102), ×50
FIG. 5. — *Guttulina lactea* (WALKER and JACOB), a, b, opposite views, Sands of Brussels, Diegem (BC 115), ×80
FIG. 6. — *Globulina gibba* (D'ORBIGNY), a, b, opposite views, Sands of Wemmel, boring Wemmel 14-10 m, ×50
FIG. 7. — *Globulina gibba* (D'ORBIGNY), a, b, opposite views, Sands of Wemmel, boring Heist-op-den-Berg 129,50 m, ×50
FIG. 8. — *Globulina gibba* (D'ORBIGNY) var. *punctata* D'ORBIGNY, Sands of Wemmel, boring Heist-op-den-Berg 129,50 m, ×50
FIG. 9. — *Globulina gibba* (D'ORBIGNY) var. *punctata* D'ORBIGNY, Barton beds, Alum Bay, Wight (PQR 1), ×50
FIG. 10. — *Globulina gibba* (D'ORBIGNY) var. *myristiformis* (WILLIAMSON), a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 340), ×35
FIG. 11. — *Globulina gravida* (TERQUEM), Sands of Wemmel, boring Heist-op-den-Berg 124,50 m, ×35
FIG. 12. — *Globulina gravida* (TERQUEM) var. *lineata* nov. var., holotype, Sands of Wemmel, boring Mechelen no. 51, ×55
FIG. 13. — *Pyrulina thouini* (D'ORBIGNY), a, b, opposite views, Sands of Lede, boring Brussegem no. 33, ×35
FIG. 14. — *Pyrulina thouini* (D'ORBIGNY), a, b, opposite views, Sands of Wemmel, boring Wemmel 14-10 m, ×20
FIG. 15. — *Sigmomorphina* sp. cf. *S. bornemanni* CUSHMAN and OZAWA, Sands of Lede, Asse (BL 1035), ×50
FIG. 16. — *Sigmomorphina* sp. cf. *S. bornemanni* CUSHMAN and OZAWA, a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1011), ×55
FIG. 17. — *Glandulina laevigata* (D'ORBIGNY), Barton beds, Barton (D 4), ×50
FIG. 18. — *Dimorphina* sp., Sands of Lede, Bambrugge (ZD 1016), ×50
FIG. 19. — *Bulimina parisiensis* nov. nom., a, b, opposite views, c, apertural view, Lutetian, Grignon (CAB 1261), ×75
FIG. 20. — *Reussella limbata* (TERQUEM), a, side view, b, apertural view, Sands of Lede, boring Brussegem no. 33, ×75
FIG. 21. — *Reussella limbata* (TERQUEM), a, side view, b, apertural view, Sands of Lede, Forest (BD 1258), ×75
FIG. 22. — *Bolivina brabantica* nov. sp., holotype, a, side view, b, apertural view, Sands of Brussels, Lathuy (WA 1139), ×80
FIG. 23. — *Bolivina pulchra* (TERQUEM), a, side view, b, apertural view, Sands of Mons-en-Pévèle, boring Mechelen no. 105, ×75
FIG. 24. — *Bolivina pulchra* (TERQUEM), a, side view, b, apertural view, Sands of Mons-en-Pévèle, Mont-Saint-Aubert (DH 1210), ×80
FIG. 25. — *Bolivina cookei* CUSHMAN, a, side view, b, apertural view, Clays of Asse, Oedelem (BRB 1054), ×65
FIG. 26. — *Bolivina cookei* CUSHMAN, a, side view, b, apertural view, Sands of Wemmel, boring Wemmel 14-9,50 m, ×80
FIG. 27. — *Uvigerina batjesi* nov. sp., holotype, a, side view, b, apertural view, Sands of Mons-en-Pévèle, Mont-Saint-Aubert (DH 1210), ×80
FIG. 28. — *Uvigerina batjesi* nov. sp., Clays of Roubaix, Luingne (KA 1093), ×80
FIG. 29. — *Angulogerina abbreviata* (TERQUEM), a, side view, b, apertural view, Sands of Lede, boring Brussegem no. 33, ×80
FIG. 30. — *Angulogerina abbreviata* (TERQUEM), a, b, side views, c, apertural view, Sands of Wemmel, boring Wemmel 14-10 m, ×75

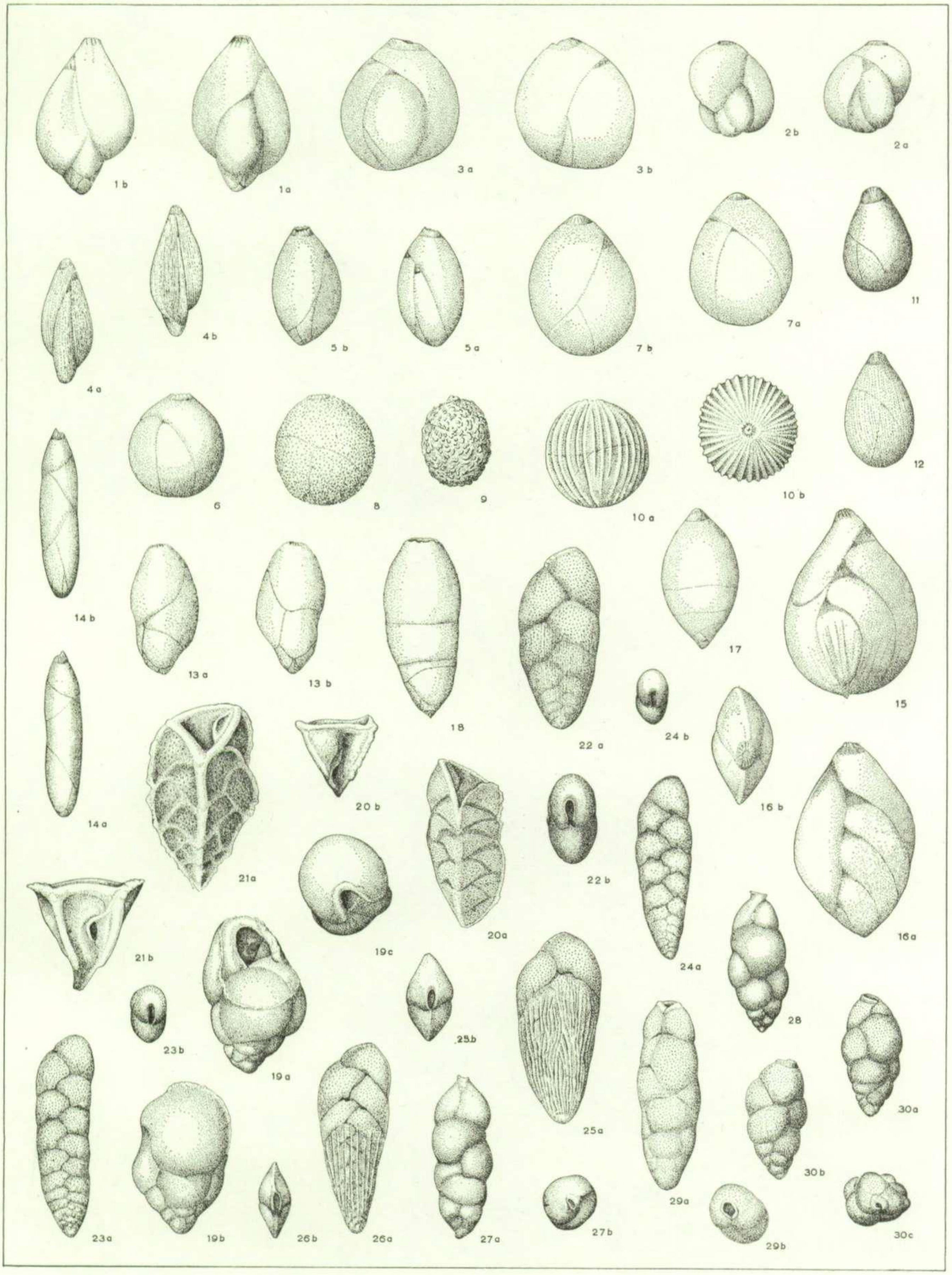

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PLATE IX

EXPLANATION OF PLATE IX

FIG. 1. — *Turrilina brevispira* TEN DAM, a, b, side views, Clays of Ieper, Kortemark (RA 253), ×100

FIG. 2. — *Buliminella* sp. cf. *B. pulchra* (TERQUEM), a, b, side views, Sands of Lede, Bambrugge (ZD 1016), ×70

FIG. 3. — *Bulimina parisiensis* nov. nom., a, side view, b, apertural view, Clays of Asse, Oedelem (BRB 247), ×105

FIG. 4. — *Bulimina parisiensis* nov. nom., a, side view, b, apertural view, Sands of Wemmel, boring Wemmel 14-10 m, ×100

FIG. 5. — *Bulimina tenuistriata* TERQUEM, a, side view, b, apertural view, Lutetian, Daméry (Daméry-serratum), ×100

FIG. 6. — *Bulimina ovata* D'ORBIGNY, a, side view, b, apertural view, Clays of Asse, Oedelem (BRB 247), ×75

FIG. 7. — *Reussella elongata* (TERQUEM), Sands of Wemmel, boring Wemmel 14-5,50 m, ×100

FIG. 8. — *Reussella elongata* (TERQUEM), a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 340), ×110

FIG. 9. — *Reussella elongata* (TERQUEM), a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1016), ×100

FIG. 10. — *Reussella limbata* (TERQUEM), a, side view, b, apertural view, Sands of Wemmel, boring Wemmel 14-7 m, ×105

FIG. 11. — *Reussella terquemi* CUSHMAN, a, side view, b, apertural view, Sands of Brussels, Lathuy (WA 165), ×100

FIG. 12. — *Bolivina carinata* TERQUEM, a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1014), ×105

FIG. 13. — *Bolivina carinata* TERQUEM, a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1016), ×105

FIG. 14. — *Bolivina carinata* TERQUEM, a, side view, b, apertural view, Sands of Wemmel, boring Wemmel 14-10 m, ×100

FIG. 15. — *Bolivina crenulata* CUSHMAN, a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1016), ×100

FIG. 16. — *Bolivina crenulata* CUSHMAN, a, side view, b, apertural view, Clays of Asse, Gent (ZA 1243), ×105

FIG. 17. — *Bolivina crenulata* CUSHMAN, a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1013), ×105

FIG. 18. — *Bolivina anglica* CUSHMAN, a, side view, b, peripheral view, Sands of Mons-en-Pévèle, Maulde (DE 1204), ×105

FIG. 19. — *Bolivina anglica* CUSHMAN, a, side view, b, apertural view, Sands of Wemmel, boring Wemmel 14-9,50 m, ×115

FIG. 20. — *Loxostomum teretum* CUSHMAN, a, side view, b, apertural view, Clays of Asse, Oedelem (BRB 247), ×75

FIG. 21. — *Uvigerina farinosa* HANTKEN, a, side view, b, apertural view, Clays of Asse, Oedelem (BRB 238), ×75

FIG. 22. — *Uvigerina spinicostata* CUSHMAN and JARVIS, Clays of Asse, Oedelem (BRB 247), ×75

FIG. 23. — *Uvigerina batjesi* nov. sp., Sands of Mons-en-Pévèle, Mont-Saint-Aubert (DH 1210), ×100

FIG. 24. — *Angulogerina abbreviata* (TERQUEM), a, side view, b, apertural view, Sands of Wemmel, Strombeek-Bever (BV 1272), ×100

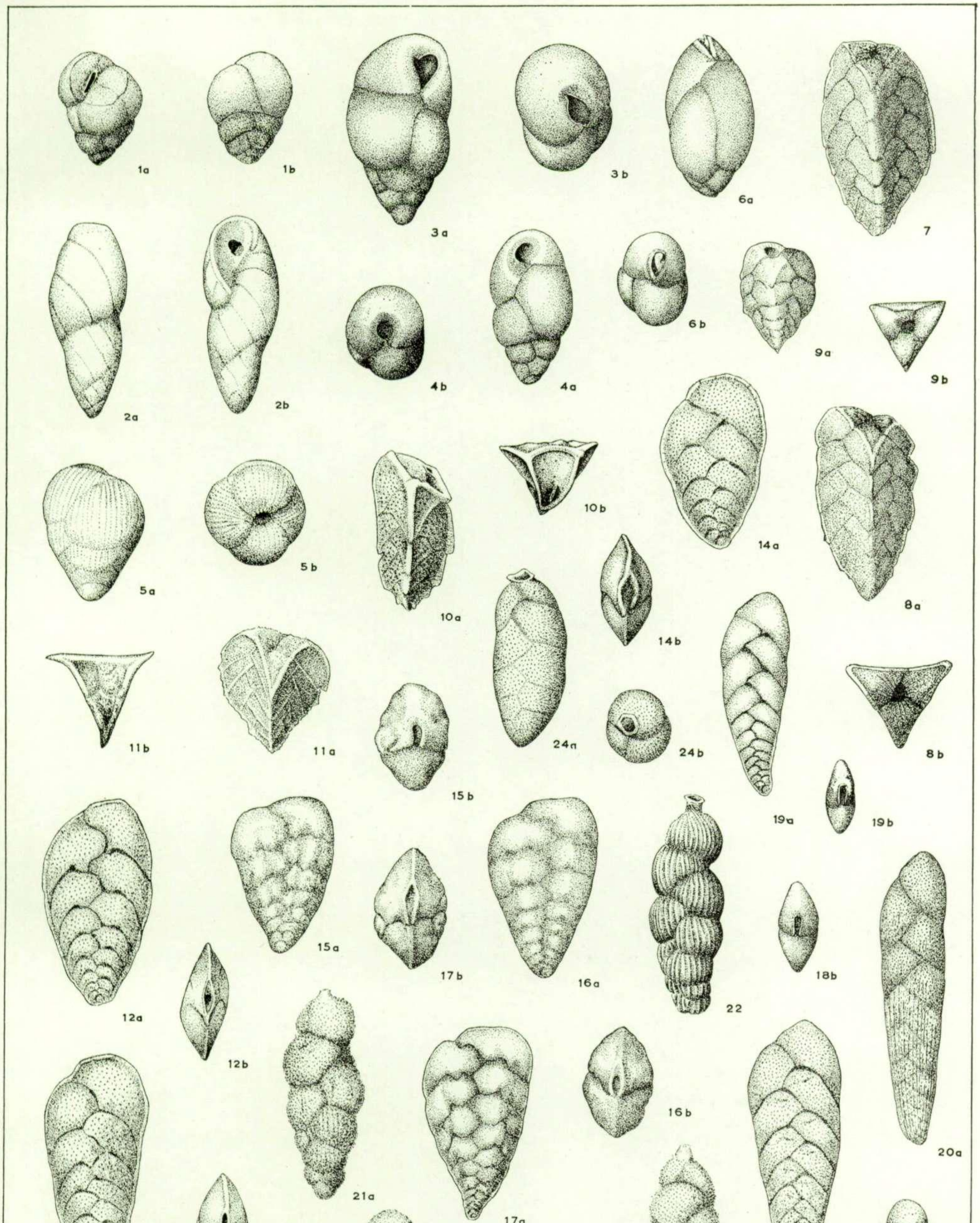

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PLATE X

EXPLANATION OF PLATE X

FIG. 1. — *Angulogerina abbreviata* (TERQUEM) var. *tubulifera* nov. var., holotype, a, side view, b, apertural view, Clays of Asse, Oedelem (BRB 237), ×100

FIG. 2. — *Angulogerina abbreviata* (TERQUEM) var. *tubulifera* nov. var., Clays of Asse, Oedelem (BRB 247), ×70

FIG. 3. — *Angulogerina muralis* (TERQUEM), a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1017), ×110

FIG. 4. — *Angulogerina muralis* (TERQUEM), a, b, side views, c, apertural view, Sands of Wemmel, Strombeek-Bever (BV 1272), ×110

FIG. 5. — *Angulogerina* sp. cf. *A. ovata* (TERQUEM), a, side view, b, apertural view, Sands of Brussels, Saint-Job (BA 106), ×100

FIG. 6. — *Trifarina wilcoxensis* (CUSHMAN and PONTON), a, b, side views, c, apertural view, Sands of Wemmel, Strombeek-Bever (BV 1272), ×75

FIG. 7. — *Trifarina wilcoxensis* (CUSHMAN and PONTON), a, b, side views, Sands of Wemmel, boring Brussegem no. 25, ×75

FIG. 8. — *Bifarina selseyensis* (HERON-ALLEN and EARLAND), a, side view, b, apertural view, Upper Bracklesham beds, Whitecliff Bay (EG 1), ×100

FIG. 9. — *Bifarina selseyensis* (HERON-ALLEN and EARLAND), a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 1013), ×100

FIG. 10. — *Bifarina selseyensis* (HERON-ALLEN and EARLAND), a, side view, b, apertural view, Sands of Lede, Bambrugge (ZD 340), ×100

FIG. 11. — *Robertina germanica* CUSHMAN and PARKER, a, b, opposite sides, Barton beds, Barton (EG 113), ×95

FIG. 12. — *Robertina germanica* CUSHMAN and PARKER, a, b, opposite sides, Clays of Asse, Oedelem (BRB 1056), ×70

FIG. 13. — *Seabrookia lagenoides* TEN DAM, Sands of Lede, boring Hoboken no. 19, ×100

FIG. 14. — *Nonion scaphum* (FICHTEL and MOLL), a, side view, b, apertural view, Sands of Mons-en-Pévèle, Mont-Saint-Aubert (DH 1212), ×85

FIG. 15. — *Nonion graniferum* (TERQUEM), a, side view, b, apertural view, Sands of Wemmel, boring Brussegem no. 26, ×120

FIG. 16. — *Discorbis limbata* (TERQUEM), a, dorsal view, b, ventral view, c, peripheral view, Sands of Wemmel, boring Wemmel 14-10 m, ×120

FIG. 17. — *Discorbis quadrata* (TERQUEM), a, dorsal view, b, ventral view, c, peripheral view, Lutetian, Grignon (CAB 1000), ×70

FIG. 18. — *Discorbis* sp. cf. *D. ferganensis* BYKOVA, a, dorsal view, b, ventral view, c, peripheral view, Sands of Brussels, Diegem (BC 115), ×120

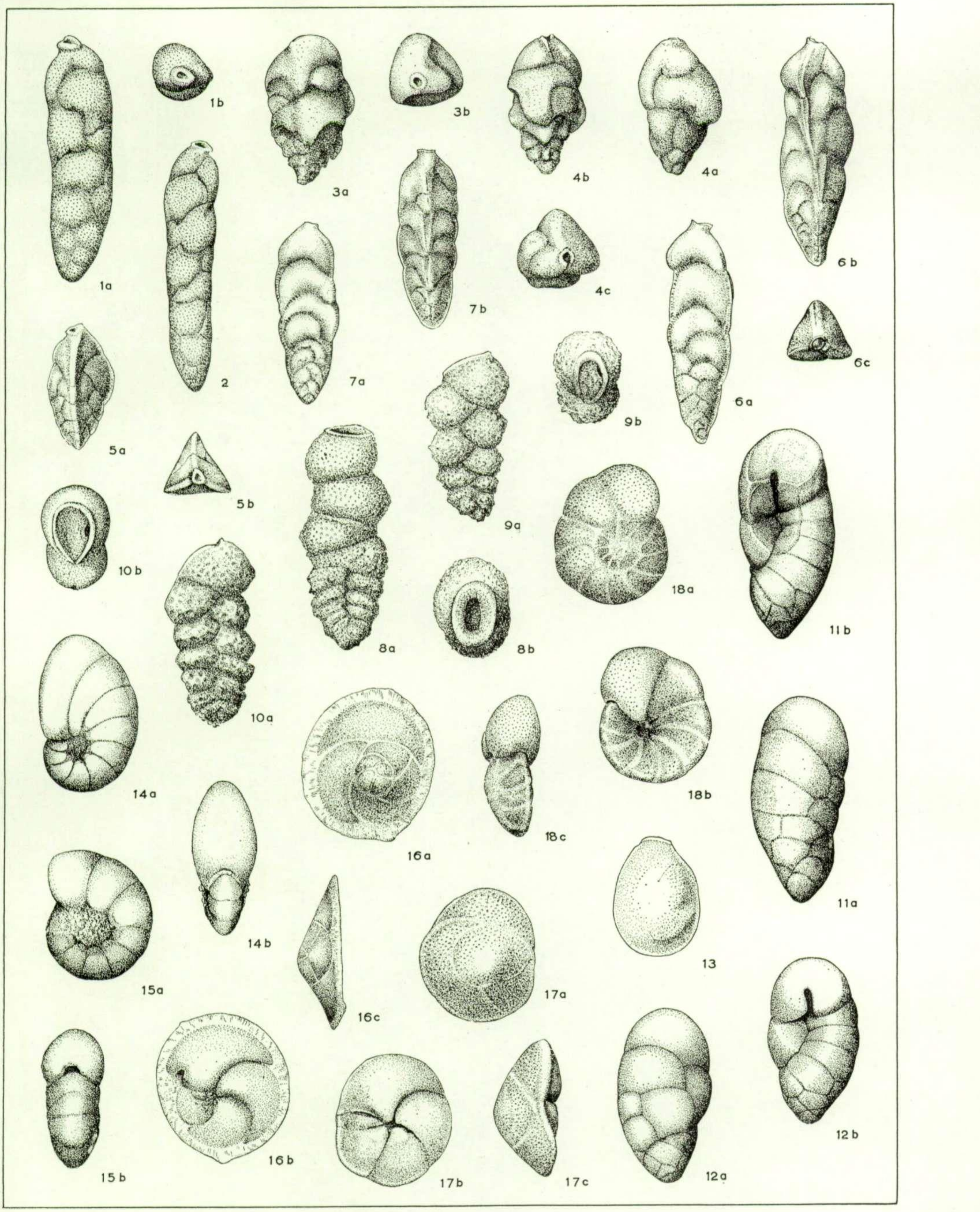

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PLATE XI

EXPLANATION OF PLATE XI

FIG. 1. — *Pullenia quinqueloba* (REUSS), a, side view, b, apertural view, Clays of Asse, Oedelem (BRB 1057), ×90

FIG. 2. — *Pullenia quinqueloba* (REUSS), a, side view, b, apertural view, Clays of Ieper, boring Woensdrecht 536 m, ×55

FIG. 3. — *Nonion affine* (REUSS), a, side view, b, apertural view, Clays of Asse, Oedelem (BRB 1057), ×55

FIG. 4. — *Nonion affine* (REUSS), a, side view, b, apertural view, Sands of Mons-en-Pévèle, Hyon (MMV 79), ×95

FIG. 5. — *Nonion scaphum* (FICHTEL and MOLL), a, side view, b, apertural view, Sands of Wemmel, Strombeek-Bever (BV 1272), ×50

FIG. 6. — *Nonionella wemmelensis* nov. sp., holotype, a, b, side views, c, apertural view, Sands of Wemmel, boring Wemmel 48-22 m, ×90

FIG. 7. — *Nonionella spissa* CUSHMAN, a, b, side views, c, apertural view, Sands of Brussels, Lathuy (WA 1139), ×90

FIG. 8. — *Nonionella spissa* CUSHMAN, a, b, side views, c, apertural view, Sands of Wemmel, boring Wemmel 14-5 m, ×90

FIG. 9. — *Discorbis parisiensis* (D'ORBIGNY), a, dorsal view, b, ventral view, c, peripheral view, Lutetian, Grignon (CAB 1002), ×55

FIG. 10. — *Discorbis parisiensis* (D'ORBIGNY), a, dorsal view, b, ventral view, c, peripheral view, Lutetian, Daméry-serratum, ×55

FIG. 11. — *Discorbis vesicularis* (LAMARCK), a, dorsal view, b, ventral view, c, peripheral view, Lutetian, Grignon (CAB 1261), ×45

FIG. 12. — *Discorbis vesicularis* (LAMARCK), a, dorsal view, b, ventral view, c, peripheral view, Lutetian, Grignon (CAB 1002), ×30

FIG. 13. — *Discorbis vesicularis* (LAMARCK), a, dorsal view, b, ventral view, c, peripheral view, Lutetian, Daméry-serratum, ×20

FIG. 14. — *Eponides schreibersi* (D'ORBIGNY), a, dorsal view, b, ventral view, c, peripheral view, Sands of Wemmel, Strombeek-Bever (BV 1272), ×30

FIG. 15. — *Eponides schreibersi* (D'ORBIGNY), a, dorsal view, b, ventral view, c, peripheral view, Sands of Wemmel, boring Wemmel 14-9,50 m, ×35

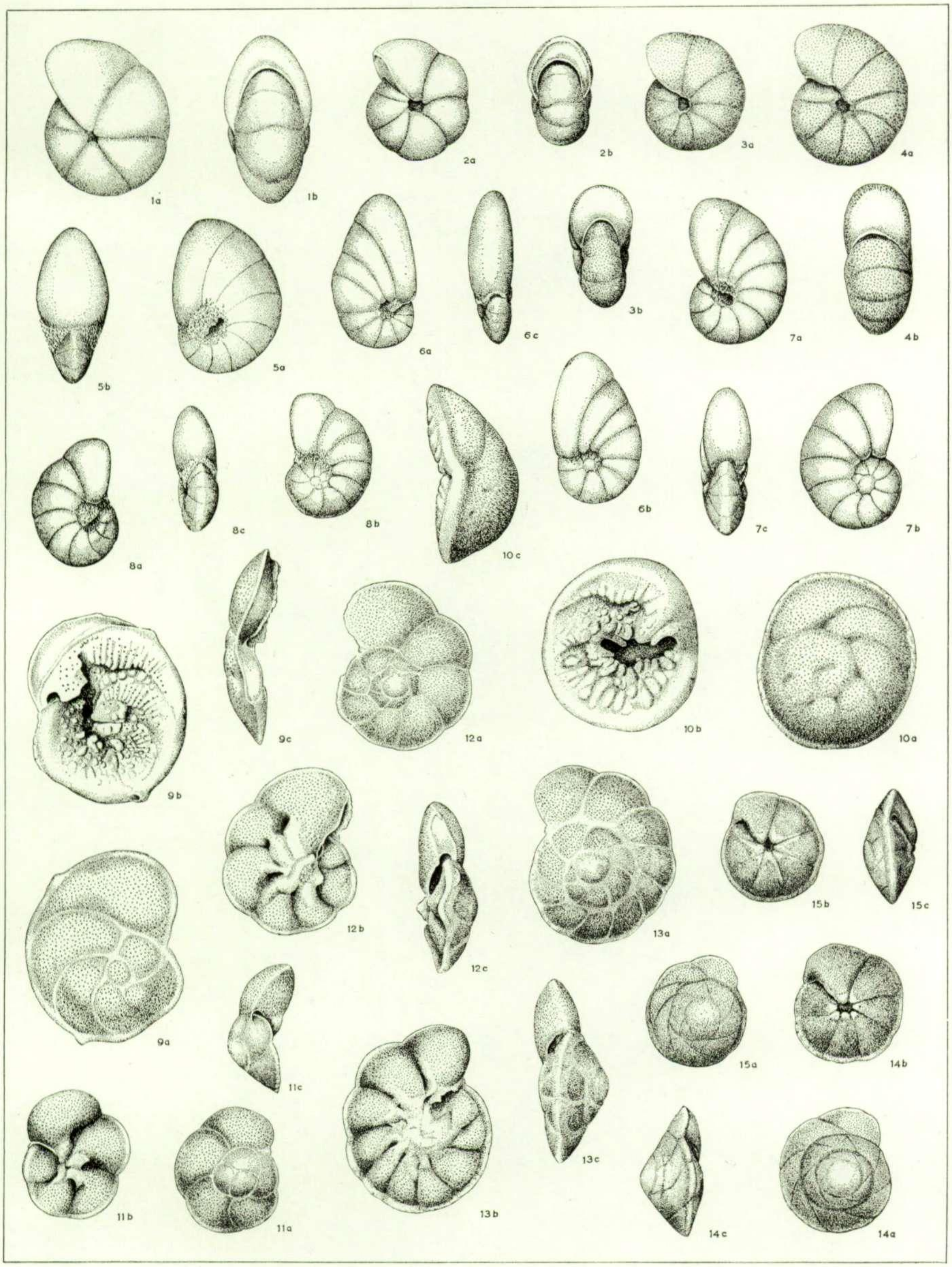

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PLATE XII

EXPLANATION OF PLATE XII

FIG. 1. — *Eponides polygonus* Y. LE CALVEZ, a, dorsal view, b, ventral view, c, peripheral view, Sands of Wemmel, boring Wemmel 48-23,50 m, ×60

FIG. 2. — *Eponides toulmini* BROTZEN, a, dorsal view, b, ventral view, c, peripheral view, Lutetian, Grignon (CAB 1000), ×80

FIG. 3. — *Eponides plummerae* CUSHMAN, a, dorsal view, b, ventral view, c, peripheral view, Clays of Ieper, boring Woensdrecht 485 m, ×80

FIG. 4. — *Gyroidina angustiumbilicata* TEN DAM, a, dorsal view, b, ventral view, c, peripheral view, Clays of Ieper, boring Woensdrecht 535 m, ×85

FIG. 5. — *Gyroidina* sp. cf. *G. soldanii* (D'ORBIGNY), a, dorsal view, b, ventral view, c, peripheral view, Clays of Asse, Oedelem (BRB 1054), ×45

FIG. 6. — *Cancris subconicus* (TERQUEM), a, dorsal view, b, ventral view, c, peripheral view, Sands of Lede, Bambrugge (ZD 1012), ×55

FIG. 7. — *Cancris subconicus* (TERQUEM), a, dorsal view, b, ventral view, c, peripheral view, Lower Panisel beds, boring Woensdrecht 398 m, ×55

FIG. 8. — *Cancris subconicus* (TERQUEM), a, dorsal view, b, ventral view, c, peripheral view, Sands of Mons-en-Pévèle, Hyon (MMV 79), ×55

FIG. 9. — *Cancris auriculus* (FICHTEL and MOLL) var. *primitivus* CUSHMAN and TODD, a, dorsal view, b, ventral view, c, peripheral view, Sands of Wemmel, boring Wemmel 48-22 m, ×55

FIG. 10. — *Cancris auriculus* (FICHTEL and MOLL) var. *primitivus* CUSHMAN and TODD, a, dorsal view, b, ventral view, c, peripheral view, Clays of Asse, Oedelem (BRB 1055), ×55

FIG. 11. — *Anomalina auris* Y. LE CALVEZ, a, dorsal view, b, ventral view, c, peripheral view, Sands of Lede, Bambrugge (ZD 340), ×55

FIG. 12. — *Anomalina acuta* PLUMMER, a, dorsal view, b, ventral view, c, peripheral view, Clays of Ieper, boring Woensdrecht 540 m, ×85

FIG. 13. — *Anomalina acuta* PLUMMER var. *ypresiensis* (TEN DAM), a, dorsal view, b, ventral view, c, peripheral view, Clays of Ieper, boring Woensdrecht 542 m, ×85

FIG. 14. — *Anomalina grosserugosa* (GÜMBEL), a, dorsal view, b, ventral view, c, peripheral view, Sands of Brussels, Nalinnes (THB 1190), ×55

FIG. 15. — *Cibicides dutemplei* (D'ORBIGNY), a, dorsal view, b, ventral view, c, peripheral view, Clays of Asse, Oedelem (BRB 247), ×45

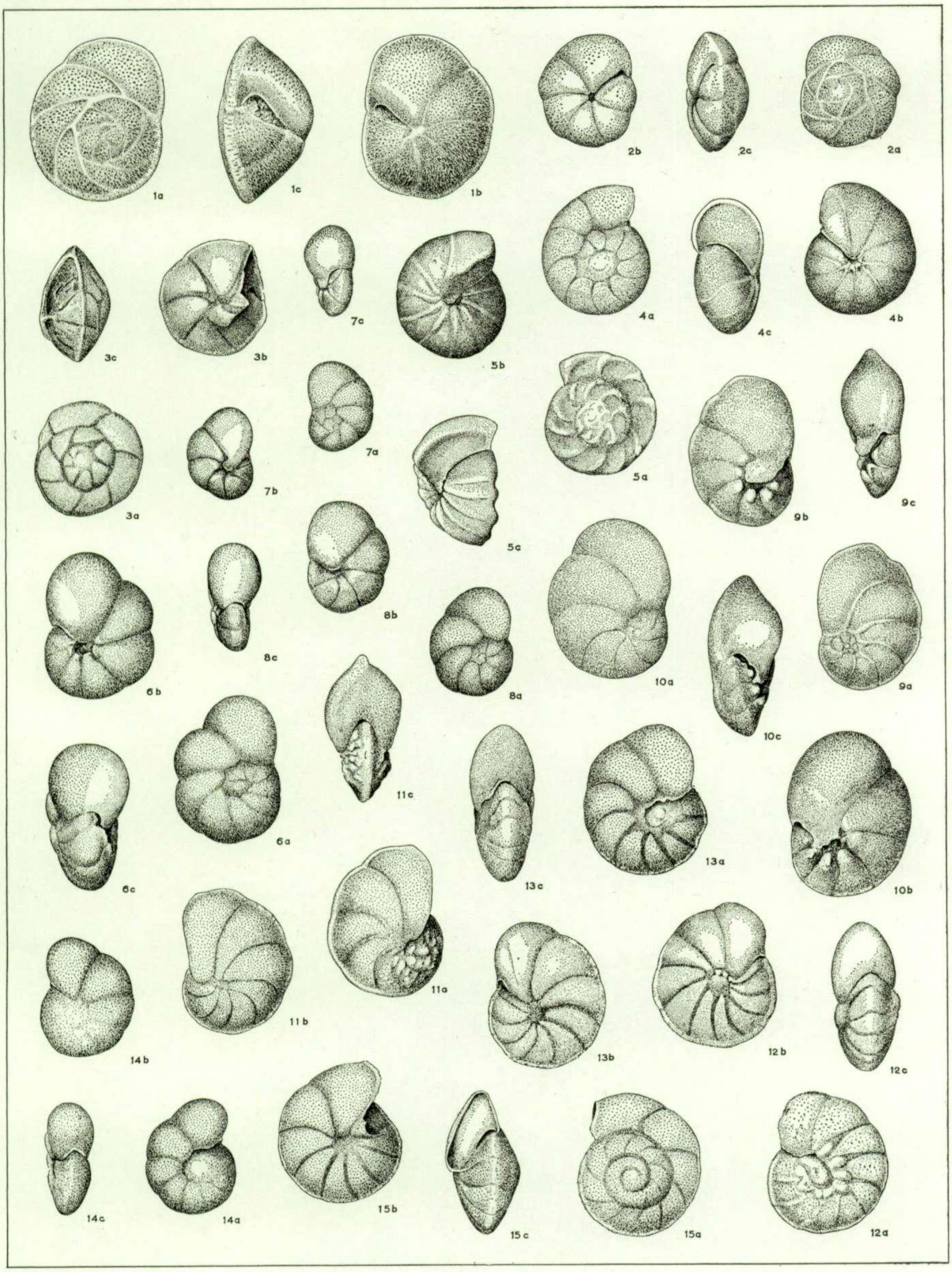

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PLATE XIII

EXPLANATION OF PLATE XIII

FIG. 1. — *Eponides umbonatus* (REUSS), a, dorsal view, b, ventral view, c, peripheral view, Clays of Asse, Oedelem (BRB 247), ×80

FIG. 2. — *Gyroidina octocamerata* CUSHMAN and HANNA, a, dorsal view, b, ventral view, c, peripheral view, Sands of Brussels, Forest (BD 393), ×110

FIG. 3. — *Baggina* sp. cf. *B. parisiensis* (D'ORBIGNY), a, dorsal view, b, ventral view, Lutetian, Grignon (CAB 1000), ×90

FIG. 4. — *Anomalina acuta* PLUMMER var. *anomalinoides* (TEN DAM), a, dorsal view, b, ventral view, c, peripheral view, Sands of Wemmel, Strombeek-Bever (BV 1272), ×70

FIG. 5. — *Anomalina* sp. cf. *A. danica* (BROTZEN), a, dorsal view, b, ventral view, c, peripheral view, Clays of Ieper, boring Woensdrecht 583 m, ×75

FIG. 6. — *Cibicides westi* HOWE, a, dorsal view, b, ventral view, c, peripheral view, Sands of Brussels, Saint-Job (BA 105), ×75

FIG. 7. — *Cibicides westi* HOWE, a, dorsal view, b, ventral view, c, peripheral view, Sands of Brussels, Plancenoit (NK 1159), ×75

FIG. 8. — *Cibicides vialovi* BYKOVA, a, dorsal view, b, ventral view, c, peripheral view, Barton beds, Alum Bay (D 4), ×75

FIG. 9. — *Cibicides proprius* (BROTZEN), a, side view, b, ventral view, c, peripheral view, Clays of Ieper, boring Woensdrecht 549 m, ×60

FIG. 10. — *Cibicides proprius* (BROTZEN) var. *acutimargo* TEN DAM, a, dorsal view, b, ventral view, c, peripheral view, Lower Panisel beds, boring Woensdrecht 391 m, ×60

FIG. 11. — *Cibicides sulzensis* (HERRMANN), a, dorsal view, b, ventral view, c, peripheral view, Sands of Wemmel, boring Woensdrecht 335 m, ×60

FIG. 12. — *Cibicides* sp. cf. *C. tallahatensis* BANDY, a, dorsal view, b, ventral view, c, peripheral view, Sands of Brussels, Spy (NNA 1151), ×30

FIG. 13. — *Hanzawaia producta* (TERQUEM), a, dorsal view, b, ventral view, c, peripheral view, Sands of Lede, Balegem (ZG 1025), ×60

FIG. 14. — *Alabamina wilcoxensis* TOULMIN, a, dorsal view, b, ventral view, c, peripheral view, Clays of Ieper, boring Woensdrecht 488 m, ×60

FIG. 15. — *Alabamina obtusa* (BURROWS and HOLLAND), a, dorsal view, b, ventral view, c, peripheral view, Clays of Ieper, boring Woensdrecht 535 m, ×60

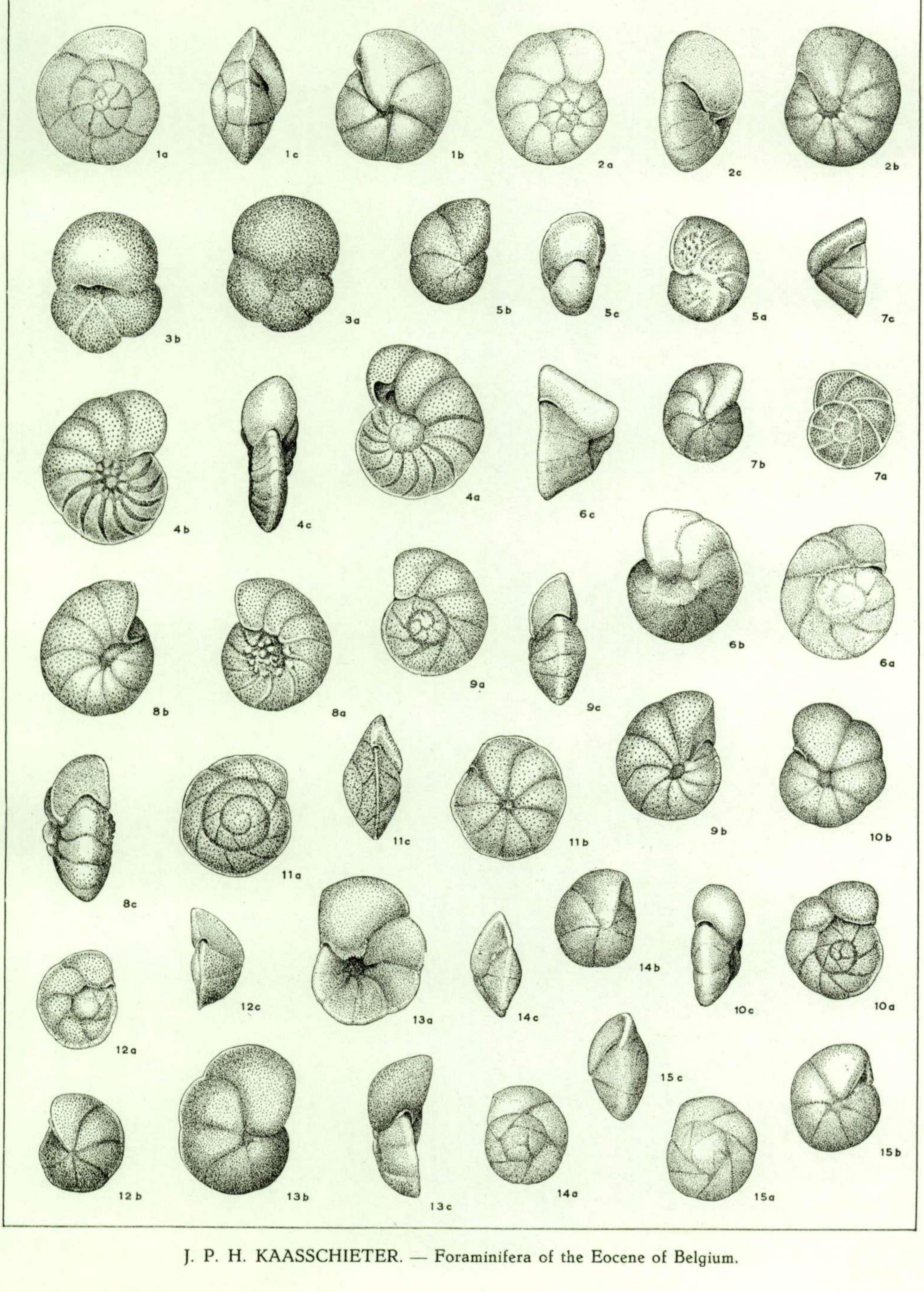

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PLATE XIV

EXPLANATION OF PLATE XIV

FIG. 1. — *Cibicides pygmeus* (HANTKEN), a, dorsal view, b, ventral view, c, peripheral view, Upper Bracklesham beds, Whitecliff Bay (EG 1), ×55

FIG. 2. — *Cibicides* sp. cf. *C. tenellus* (REUSS), a, dorsal view, b, ventral view, c, peripheral view, Sands of Wemmel, boring Wemmel 14-10 m, ×45

FIG. 3. — *Cibicides* sp. cf. *C. ungerianus* (D'ORBIGNY), a, dorsal view, b, ventral view, c, peripheral view, Sands of Wemmel, boring Asse no. 35, ×45

FIG. 4. — *Cibicides* sp. cf. *C. dutemplei* (D'ORBIGNY), a, dorsal view, b, ventral view, c, peripheral view, Clays of Ieper, boring Woensdrecht 592 m, ×70

FIG. 5. — *Cibicides lobatulus* (WALKER and JACOB), a, dorsal view, b, ventral view, c, peripheral view, Sands of Brussels, Saint-Job (BA 102), ×45

FIG. 6. — *Cibicides carinatus* (TERQUEM), a, dorsal view, b, ventral view, c, peripheral view, Sands of Lede, Bambrugge (ZD 1014), ×45

FIG. 7. — *Cibicides proprius* (BROTZEN) var. *acutimargo* TEN DAM, a, dorsal view, b, ventral view, c, peripheral view, Sands of Lede, Bambrugge (ZD 342), ×45

FIG. 8. — *Cibicides* sp. cf. *C. mauricensis* HOWE and ROBERTS, a, dorsal view, b, ventral view, c, peripheral view, Sands of Brussels, Saint-Job (BA 105), ×45

FIG. 9. — *Planulina burlingtonensis* (JENNINGS), a, dorsal view, b, ventral view, c, peripheral view, Sands of Wemmel, Strombeek-Bever (BV 1272), ×50

FIG. 10. — *Planulina burlingtonensis* (JENNINGS), a, dorsal view, b, ventral view, c, peripheral view, Sands of Wemmel, Strombeek-Bever (BV 1272), ×45

FIG. 11. — *Planulina burlingtonensis* (JENNINGS) var. *neelyi* (JENNINGS), a, dorsal view, b, ventral view, c, peripheral view, Sands of Mons-en-Pévèle, boring Woensdrecht 474 m, ×55

FIG. 12. — *Planulina burlingtonensis* (JENNINGS) var. *tendami* nov. var., holotype, a, dorsal view, b, ventral view, c, peripheral view, Lower Panisel beds, boring Woensdrecht 385 m, ×45

FIG. 13. — *Alabamina wolterstorffi* (FRANKE), a, dorsal view, b, ventral view, c, peripheral view, Sands of Brussels, Nalinnes (THB 1189), ×45

FIG. 14. — *Epistominella acutimargo* (HALKYARD), a, dorsal view, b, ventral view, c, peripheral view, Clays of Asse, Oedelem (BRB 1056), ×30

FIG. 15. — *Siphonina lamarckana* CUSHMAN, a, dorsal view, b, ventral view, c, peripheral view, Sands of Wemmel, boring Wemmel 14-7 m, ×75

FIG. 16. — *Karreria fallax* RHEZAK, a, dorsal view, b, ventral view, c, peripheral view, Sands of Mons-en-Pévèle, Mons-en-Pévèle (CAG 1249), ×45

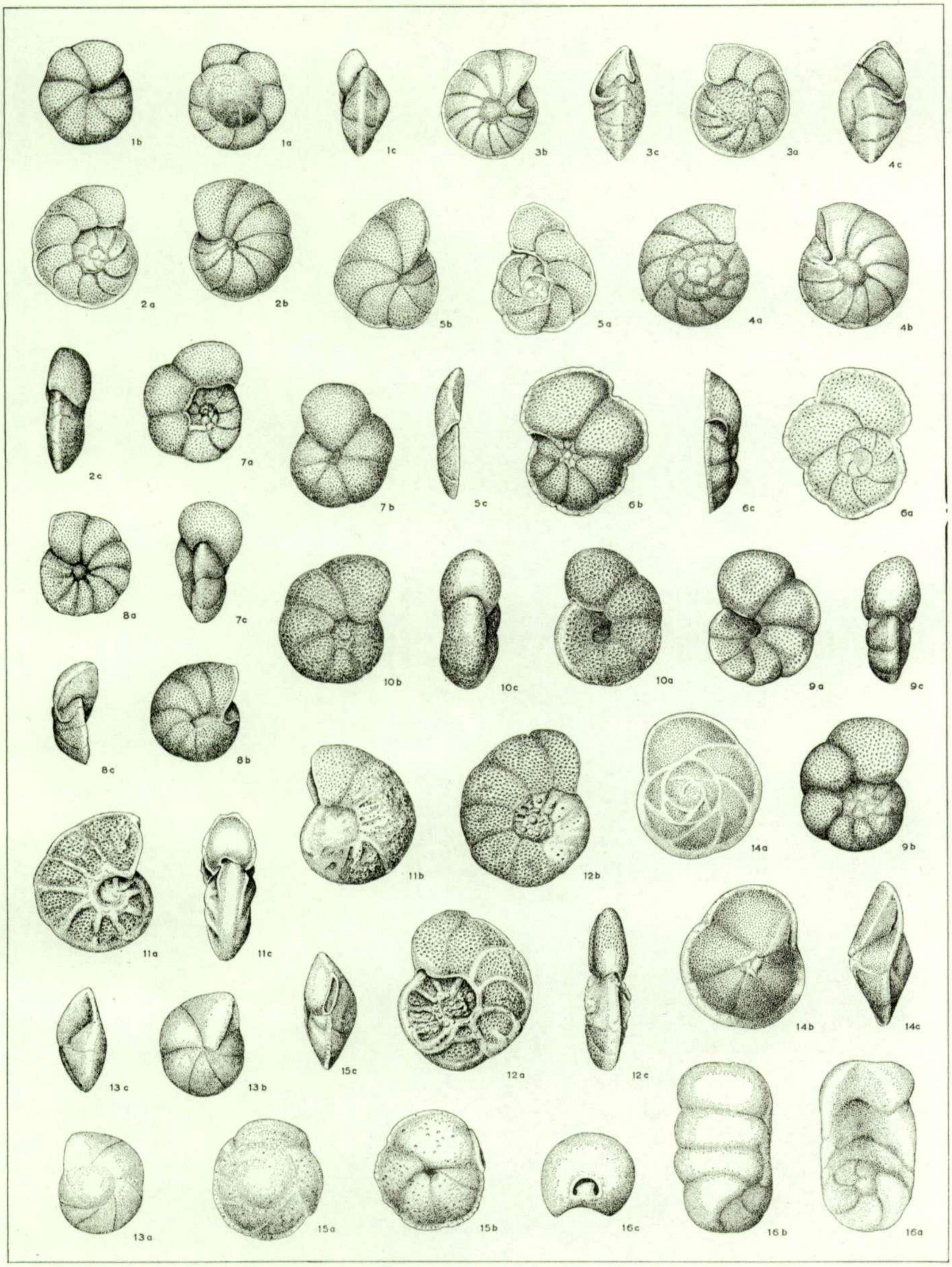

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PLATE XV

EXPLANATION OF PLATE XV

FIG. 1. — *Epistominella oveyi* (BHATIA), a, dorsal view, b, ventral view, c, peripheral view, Lower Panisel beds, boring Woensdrecht 391 m, ×60

FIG. 2. — *Siphonina prima* PLUMMER, a, dorsal view, b, ventral view, c, peripheral view, Clays of Ieper, boring Woensdrecht 550 m, ×75

FIG. 3. — *Lamarckina cristellaroides* TERQUEM, a, dorsal view, b, ventral view, c, peripheral view, Lutetian, Grignon (CAB 1261), ×75

FIG. 4. — *Lamarckina cristellaroides* TERQUEM, a, dorsal view, b, ventral view, c, peripheral view, Sands of Lede, Bambrugge (ZD 1013), ×60

FIG. 5. — *Asterigerina* sp. cf. *A. glabra* (BERMUDEZ), a, dorsal view, b, ventral view, c, peripheral view, Sands of Lede, Bambrugge (ZD 1017), ×115

FIG. 6. — *Asterigerina* sp., a, ventral view, b, dorsal view, c, peripheral view, Sands of Wemmel, boring Wemmel 14-10,50 m, ×110

FIG. 7. — *Globigerina* sp. cf. *G. angustiumbilicata* BOLLI, a, dorsal view, b, ventral view, c, peripheral view, Sands of Wemmel, boring Wemmel 14-9,50 m, ×75

FIG. 8. — *Globigerina* sp. cf. *G. angustiumbilicata* BOLLI, a, dorsal view, b, ventral view, c, peripheral view, Sands of Wemmel, boring Wemmel 48-23,50 m, ×75

FIG. 9. — *Globigerina* sp. cf. *G. varianta* SUBBOTINA, a, dorsal view, b, ventral view, c, peripheral view, Clays of Ieper, boring Woensdrecht 536 m, ×75

FIG. 10. — *Globigerina* sp. cf. *G. varianta* SUBBOTINA, a, dorsal view, b, ventral view, c, peripheral view, Clays of Ieper, boring Woensdrecht 536 m, ×110

FIG. 11. — *Globigerinoides* sp. cf. *G. daubjergensis* (BRONNIMANN), a, dorsal view, b, ventral view, c, peripheral view, Sands of Mons-en-Pévèle, Mons-en-Pévèle (CAG 1249), ×110

FIG. 12. — *Gümbelina* sp., a, side view, b, apertural view, Clays of Roubaix, Ploegsteert (LLA 1087), ×100

FIG. 13. — *Elphidium latidorsatum* (REUSS), a, side view, b, apertural view, Sands of Mons-en-Pévèle, boring Woensdrecht 473 m, ×45

FIG. 14. — *Elphidium latidorsatum* (REUSS), a, side view, b, apertural view, Barton beds, Alum Bay (D 5), ×45

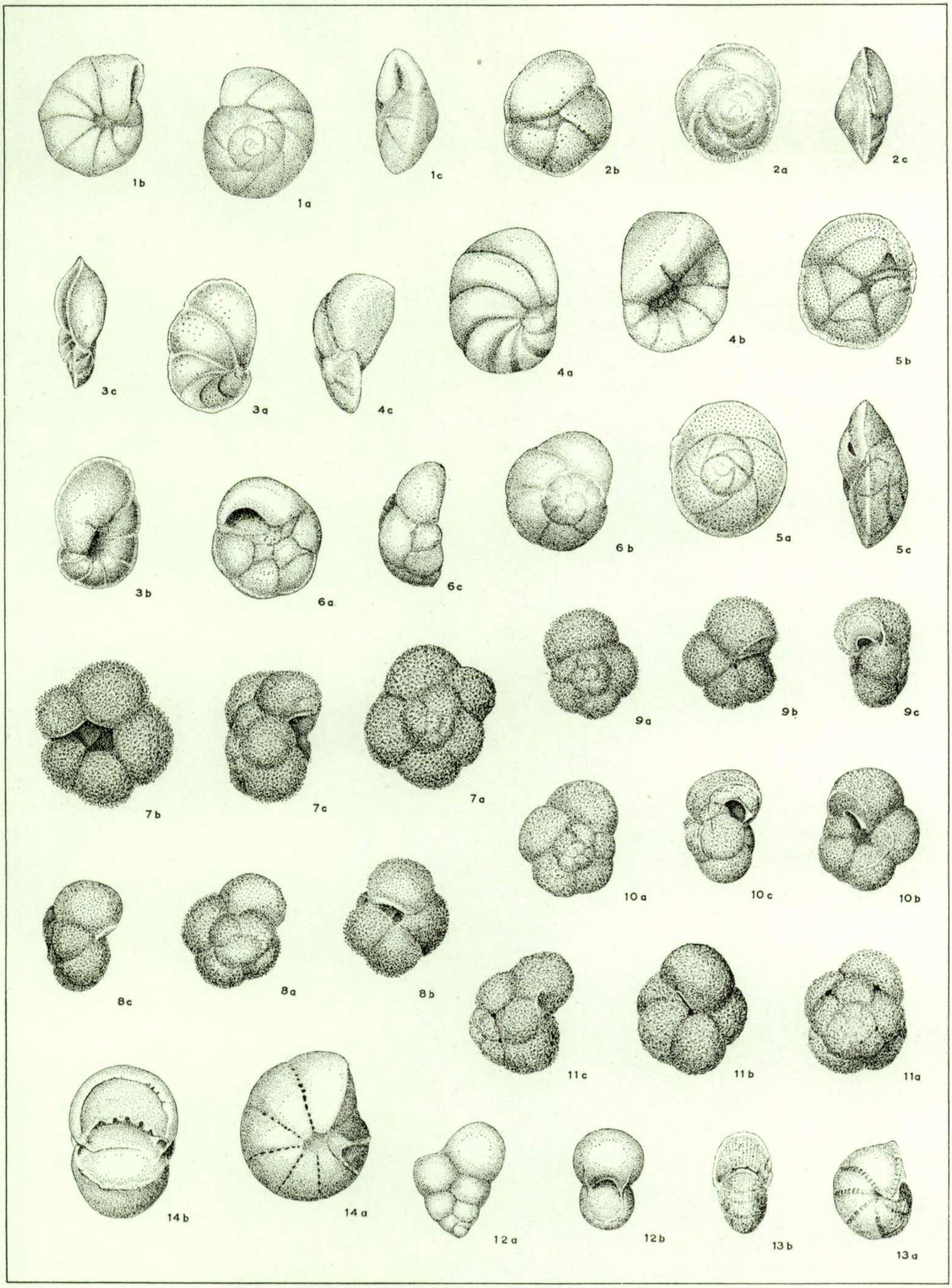

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PLATE XVI

EXPLANATION OF PLATE XVI

FIG. 1. — *Asterigerina* sp. cf. *A. guerrai* (BERMUDEZ), a, dorsal view, b, ventral view, c, peripheral view, Sands of Mons-en-Pévèle, Mont-Saint-Aubert (DH 1212), ×45

FIG. 2. — *Asterigerina bartoniana* (TEN DAM), a, dorsal view, b, ventral view, c, peripheral view, Clays of Roubaix, Luingne (KA 1093), ×30

FIG. 3. — *Asterigerina bartoniana* (TEN DAM), a, dorsal view, b, ventral view, c, peripheral view, Clays of Asse, Oedelem (BRB 237), ×30

FIG. 4. — *Asterigerina wilcoxensis* CUSHMAN and GARRETT, a, dorsal view, b, ventral view, c, peripheral view, Clays of Roubaix, Luingne (KA 1093), ×85

FIG. 5. — *Hastigerina micra* (COLE), a, side view, b, peripheral view, Clays of Asse, Oedelem (BRB 1055), ×130

FIG. 6. — *Hastigerina micra* (COLE), a, side view, b, peripheral view, Clays of Asse, Oedelem (BRB 247), ×130

FIG. 7. — *Globigerina triloculinoides* PLUMMER, a, dorsal view, b, ventral view, c, oblique peripheral view, Sands of Mons-en-Pévèle, Godarville (CO 62), ×85

FIG. 8. — *Rotalia audouini* D'ORBIGNY, a, dorsal view, b, ventral view, c, peripheral view, Sands of Lede, Bambrugge (ZD 1016), ×55

FIG. 9. — *Rotalia audouini* D'ORBIGNY, a, dorsal view, b, ventral view, c, peripheral view, Sands of Lede, Bambrugge (ZD 1017), ×35

FIG. 10. — *Rotalia audouini* D'ORBIGNY, a, dorsal view, b, ventral view, c, peripheral view, Sands of Lede, Bambrugge (ZD 1017), ×50

FIG. 11. — *Rotalia* sp. cf. *R. calvezae* (LOEBLICH and TAPPAN), a, dorsal view, b, ventral view, c, peripheral view, Lower Panisel beds, boring Woensdrecht 401 m, ×85

FIG. 12. — *Rotalia propingua* REUSS, a, dorsal view, b, ventral view, c, peripheral view, Sands of Lede, boring Woensdrecht 354 m, ×85

FIG. 13. — *Rotalia thouini* D'ORBIGNY, a, dorsal view, b, ventral view, c, peripheral view, Sands of Mons-en-Pévèle, Hyon (MMV 1201), ×30

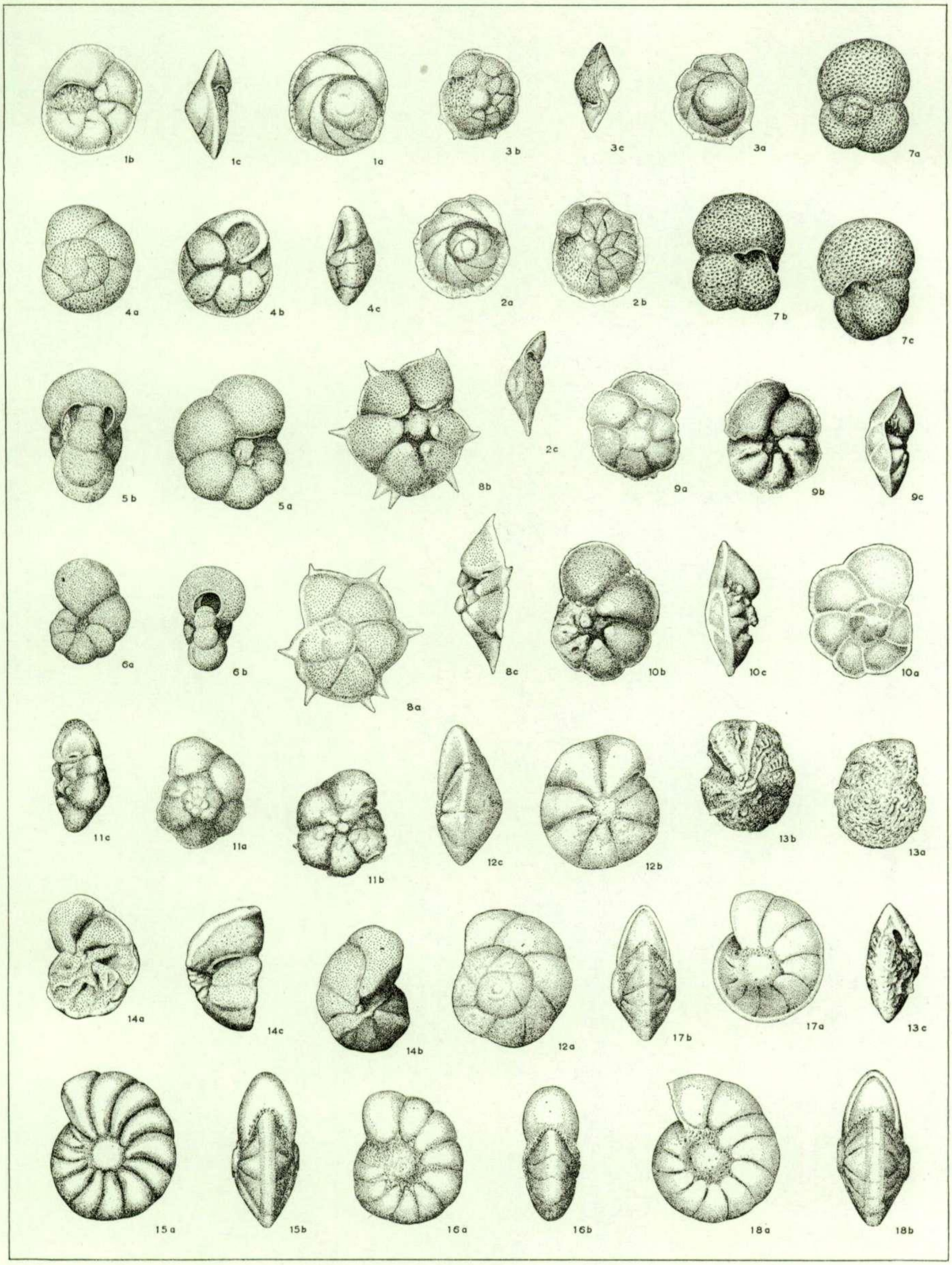
FIG. 14. — *Gyroidinella magna* Y. LE CALVEZ, a, dorsal view, b, ventral view, c, peripheral view, Sands of Brussels, Nalinnes (THB 1190), ×25

FIG. 15. — *Elphidium laeve* (D'ORBIGNY), a, side view, b, peripheral view, Lutetian, Grignon (CAB 1001), ×40

FIG. 16. — *Elphidium laeve* (D'ORBIGNY), a, side view, b, peripheral view, Sands of Brussels, Saint-Job (BA 105), ×65

FIG. 17. — *Elphidium subnodosum* (ROEMER), a, side view, b, peripheral view, Barton beds, Alum Bay (PQR 1), ×60

FIG. 18. — *Elphidium subnodosum* (ROEMER), a, side view, b, peripheral view, Barton beds, Barton (D 1), ×55



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