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STRATIGRAPHY OF THE IEPER FORMATION AND ARGILE DE FLANDRES (EARLY EOCENE) IN WESTERN BELGIUM AND NORTHERN FRANCE

by

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(with 14 figures)

ABSTRACT

The Ieper Formation (Early Eocene) in western Belgium and its equivalent in northern France (the Argile de Flandres) are divided into six lithostratigraphic units, of which three are newly defined here. Correlations within the middle of the Formation are established through the recognition of nine biostratigraphic events, based on planktonic and benthonic foraminiferids, ostracods and bivalve molluscs. Five thin glauconitic beds are identified within the middle of the Formation, which form lithostratigraphic marker-horizons and in most cases correspond to the biostratigraphic events. These probably mark minor stratigraphic discontinuities or condensed horizons.

The Mons-en-Pévèle Sands of southern Belgium and northern France are demonstrated to be unconnected with their supposed equivalents in northern Belgium, and to represent a shallow marine facies of the middle Ieper Formation. The "Panisel Formation" which overlies them is probably equivalent to the upper Ieper Formation of northern Belgium, implying the need for reclassification of these beds.

Detailed correlation between the lower and middle Ieper Formation and the London Clay Formation is established, and some tentative correlations with the Paris Basin are suggested. Generalised depth-controlled lithofacies belts are suggested for the middle Ieper Formation, giving an indication of basin-margin morphology in this area.

Key words: Ypresian, lithostratigraphy, biostratigraphic events, correlations.

SAMENVATTING

De Formatie van Ieper (Vroeg-Eoceen) in het westelijk deel van België en de overeenkomende afzettingen in het noorden van Frankrijk (de "Argile de Flandres") worden onderverdeeld in zes litostratigrafische eenheden waarvan er drie voor het eerst worden gedefinieerd. Op grond van negen herkenbare biostratigrafische "events" die gebaseerd zijn op planktonische en benthonische foraminiferen, op ostracoden en bivalven, werden korrelaties gemaakt tussen afzettingen die behoren tot het middendeel van de formatie. In dat middendeel zijn vijf glauconietniveau's waargenomen die litostratigrafische referentiehorizonten vormen en die in de meeste gevallen met de biostratigrafische "events" overeenstemmen. Deze niveau's wijzen wellicht op kleine stratigrafische onderbrekingen of op periodes van sterk vertraagde afzetting.

Wij tonen aan dat er geen verband bestaat tussen de Zanden van Mons-en-Pévèle uit het zuidelijk deel van België en Noord Frankrijk en hun veronderstelde equivalenten in Noord België, en dat deze zanden een ondiep marien facies vertegenwoordigen van het midden van de Formatie van Ieper. De "Panisel Formatie" (afzettingen van de Mont Panisel) die er in het centraal tot zuidelijk landsgedeelte op rust, komt waarschijnlijk overeen met het bovenste deel van de Formatie van Ieper in Noord België, wat impliceert dat men die Mont-Panisel afzettingen moet herklasseren.

Nauwkeurige korrelaties tussen het onder- en middendeel van de Formatie van Ieper en de London Clay Formatie worden vastgelegd, terwijl enkele mogelijke korrelaties met het Bekken van Parijs worden voorgesteld. Er zijn aanwijzingen van het voorkomen van litofacies-gordels in het middendeel van de Formatie van Ieper. Deze gordels worden bepaald door de afzettingsdiepte en geven indicaties over de morfologie van de rand van het bekken in dit gebied.

Sleutelwoorden: Ypresien, lithostratigrafie, biostratigrafische gebeurtenissen, korrelaties.

RESUME

La Formation d'Ypres (Eocène inférieur) dans l'ouest de la Belgique et son équivalent dans le nord de la France (L'Argile de Flandres) sont divisés en six unités lithostratigraphiques dont trois sont nouvellement décrites ici. Des corrélations au sein de la partie médiane de la Formation sont tracées en se basant sur la reconnaissance de neuf événements biostratigraphiques indiqués par les foraminifères planctoniques et benthoniques, les ostracodes et les mollusques bivalves. Cinq minces lits glauconieux y sont identifiés qui constituent des horizons marqueurs et qui, dans la plupart des cas, coïncident avec les événements biostratigraphiques. Ils soulignent probablement des discontinuités stratigraphiques mineures ou des horizons condensés.

Il est démontré que les sables de Mons-en-Pévèle du sud de la Belgique et du nord de la France, sont distincts de leurs équivalents supposés du nord de la Belgique et qu'ils représentent un facies marin peu profond de la partie moyenne de la Formation d'Ypres. La "Formation du Panisel" qui les recouvre est probablement l'équivalent de la partie supérieure de la Formation d'Ypres du nord de la Belgique, ce qui implique la nécessité d'une révision stratigraphique de ces couches.

Une corrélation détaillée est établie entre les parties inférieure et moyenne de la Formation d'Ypres d'une part, et l'Argile de Londres d'autre part. Quelques essais de corrélations avec le Bassin de Paris sont proposés. La disposition des zones isopiques contrôlées par la profondeur est suggérée pour la partie moyenne de la Formation d'Ypres; elle donne une indication sur la morphologie de la bordure du bassin dans cette région.

Mots-clés: Yprésien, lithostratigraphie, événements biostratigraphiques, corrélations.

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1. INTRODUCTION

The stratigraphy of the Ieper Formation in Belgium was for many years very imperfectly understood, due to the scarcity of good exposures and the general absence of well-preserved macrofossils. In recent years, studies based mainly on samples from deep cored boreholes have provided sufficient lithostratigraphic and biostratigraphic information to enable subdivision and correlation of these beds. The results obtained are summarised by Willems et *al.* 1981 and Willems 1982. However, the biostratigraphy, biofacies, lithostratigraphy and lithofacies of the Ieper Formation are still inadequately documented. In particular, the relationship between the argillaceous and sandy facies, and the stratigraphical significance of distinctive beds such as the "lit glauconifère de Tielt" (de Coninck 1976a), have not been fully elucidated.

The "Argile de Flandres" of northern France is lithostratigraphically a part of the Ieper Formation, separated from it only by the artificial boundary of the Franco-Belgian frontier. Its stratigraphy is also poorly documented. Although a number of sections were described in the nineteenth century and early twentieth century, few recent studies have been published, except for brief descriptions of several exposures by the present author (King, 1981). In the present study the term "Ieper Formation" is extended to include the Argile de Flandres and associated deposits in northern France.

The objective of this study is to establish a biostratigraphic and lithostratigraphic framework within the Ieper Formation of western Belgium and northern France, based on lithological, micropalaeontological and macropalaeontological analysis of boreholes and surface exposures. This study does not constitute a comprehensive biostratigraphic or lithostratigraphic analysis; in particular, only very brief details are given of the abundant and diverse microfaunas encountered. The stratigraphic scheme introduced here refers mainly to the area south of Kortemark, but some information from the Knokke and Kallo boreholes

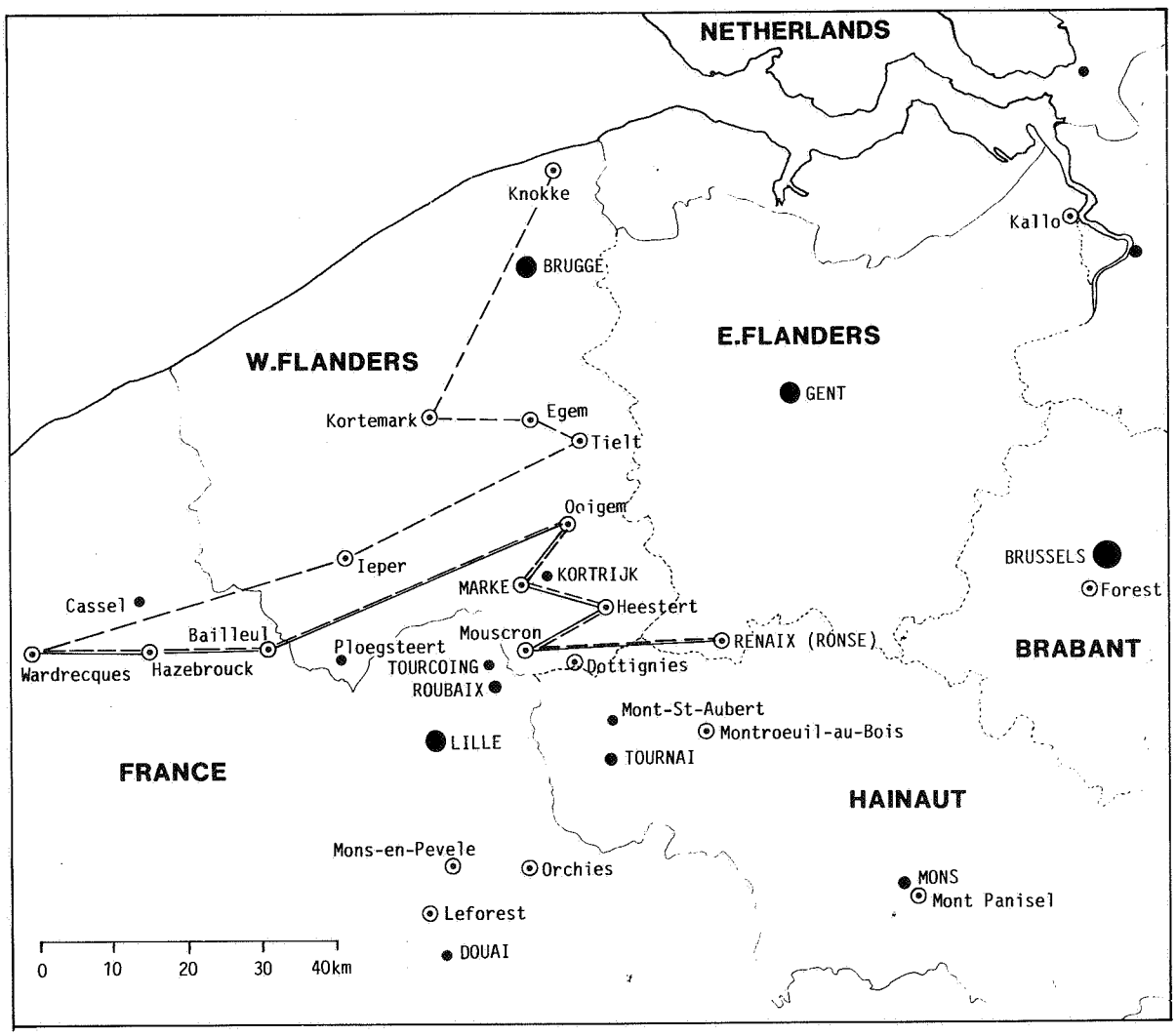


Fig. 1

Localities studied in western Belgium and northern France. The solid and interrupted lines indicate the position of the cross-sections (Figs 10 and 11 respectively).

is also included. Correlation with other sections in Belgium, France and southern England are also discussed. This study forms part of a continuing programme of research into the Early Eocene in the North Sea Basin.

2. TECHNIQUES

The field work for this study was carried out between 1968 and 1984. Sections in quarries and temporary exposures in road cuttings were logged and sampled. Collections of macrofossils were made, and samples for micropalaeontological analysis were collected where possible at 0.5 m intervals. Shallow hand-auger borings were made at several sites.

Core samples from the Knokke and Ooigem boreholes were made available by the Geological Survey of Belgium. Processed samples from the Kallo and Tielt boreholes were supplied by the late Willy Willems. Unpublished lithological logs of the Ooigem, Kallo and Tielt boreholes were also supplied by the Geological Survey of Belgium.

Micropalaeontological analysis was carried out by processing 500 g-1 kg samples on a 120 μm sieve. Semi-quantitative analysis of relative species abundance of foraminiferids and ostracods included the calculation of two ratios: "AG1 ratio" of King (in press), which is the percentage of non-calcareous agglutinating foraminiferids in the total benthonic foraminiferid population, and the "P ratio", the percentage of planktonic foraminiferids in the total foraminiferid population. These ratios, when plotted against a vertical section, enable major microfaunal trends and "faunal breaks" to be rapidly assessed, and are a valuable primary correlation tool.

3. BIOSTRATIGRAPHY

Introduction

The upper and lower parts of the Ieper Formation in western Belgium and northern France are partly or wholly decalcified, and therefore generally poorly fossiliferous with respect to microfauna and macrofauna, but the middle of the Formation contains well-preserved and diverse calcareous microfaunas. Analysis of the sections included in this study has established a sequence of biostratigraphic "events" within the middle of the Ieper Formation (Fig. 3). These events are numbered I1 to I9, in ascending order.

The events are defined by the first or last occurrence or abundance-levels of selected species of microfossils and macrofossils (foraminiferids, ostracods and bivalves) within the middle of the Ieper Formation, and by changes in the total foraminiferid assemblage reflected in the AG1 ratio or the P ratio.

These events are the basis for the biostratigraphic subdivision and correlation of the section, supplemented by the use of other selected short-ranging species. As they are to a large extent coincident with minor sedimentary discontinuities or levels of condensation, they are probably controlled partly by regional tectonic/eustatic events and can therefore be considered as effectively synchronous.

It must be emphasised that the vertical ranges of some of the species utilised in this scheme apply only in the specific stratigraphic context under study, and that some occur below or above the interval studied here, either in this area or elsewhere. The species utilised are listed below, with brief taxonomic notes where necessary.

Foraminiferids

***Textularia smithvillensis* (Cushman & Ellisor 1933)**

1961 *Textularia smithvillensis:* Kaasschieter, p. 142, pl. 1, fig. 19.
1980 *Textularia smithvillensis:* Willems, p. 25, pl. 2, fig. 16.

***Vaginulinopsis wetherellii* (Jones 1856)**

1961 *Lenticulina (Marginulinopis) enbornensis:* Kaasschieter, p. 174, pl. 7, fig. 12, 13.
1980a *Marginulinopsis enbornensis:* Willems, p. 68, pl. 5, fig. 15-16.

The complicated history of the nomenclature of this species is elucidated by Hughes (1957). The present author prefers to refer it to *Vaginulinopsis*, based on its shape and ornementation.

***Nodosaria latejugata* (Guembel 1868)**

1961 *Nodosaria latejugata:* Kaasschieter, p. 177, pl. 7, fig. 22.
1980a *Nodosaria latejugata:* Willems, p. 41, pl. 4, fig. 1.

Nodosaria minor Hantken, regarded as a separate species by most authors, probably falls within the limits of variation of this species.

***Karreria fallax* Rzehnak 1891**

1961 *Karreria fallax:* Kaasschieter, p. 23, pl. 14, fig. 16.
1980a *Karreria fallax:* Willems, p. 173, pl. 16, fig. 7a-d.

***Asterigerina bartoniana kaasschieteri* Zaneva 1972 emend. Willems**

1961 *Asterigerina bartoniana:* Kaasschieter, p. 232 (part), pl. 16, fig. 2 (non fig. 3).
1980a *Asterigerina bartoniana kaasschieteri:* Willems, p. 113, pl. 8, fig. 9a-b.

***Nummulites planulatus* (Lamarck 1804)**

***Subbotina gr. linaperta* (Finlay 1939)**

1961 *Globigerina triloculinoides:* Kaasschieter, p. 235, pl. 16, fig. 7.
1980a *Globigerina patagonica:* Willems, p. 136, pl. 12, fig. 3a-b.

Bivalves

Crassostrea multicostata (Deshayes)

Three species of pectind bivalves have proved to be important index fossils in the middle of the Ieper Formation. Their distinctive ornament often enables them to be identified when only fragments of shell are available.

"Pecten" duplicatus (J. de C. Sowerby 1827)

1861 *Pecten duplicatus* J. Sowerby: Wood, p. 41, pl. 8, fig. 10, pl. 10, fig. 3.

A species described originally from the middle of the London Clay Formation (see King 1981), characterised by numerous radial ribs with imbricate ornament. The correct generic name for this species remains to be determined.

"Pseudamussium" sp.

An apparently undescribed species, common at several localities; unribbed, but with well-marked concentric growth lines and faint divaricate ornament on the lateral margins of the valves. Similar species in the Paris Basin were formerly referred to *"Pseudamussium"* (Cossmann 1887), but this is apparently an invalid genus (Cox et al. 1969, p. 354), and the generic assignment is again uncertain.

Lentipecten corneum (J. Sowerby 1818)

1861 *Pecten corneus* J. Sowerby: Wood, p. 39, pl. 9, fig. 7.

Almost entirely smooth, with a "polished" surface: only faint growth-lines are visible.

Ostracods

Cytheretta decipiens Keij 1957

1973 *Cytheretta decipiens:* Willems, p. 514, pl. 2, fig. 5.

Cytheretta scrobiculoplicata (Jones 1857)

1973 *Cytheretta scrobiculoplicata:* Willems, p. 514, pl. 1, fig. 3.
1978 *Cytheretta scrobiculoplicata:* Keen, p. 412, pl. 7, figs. 8, 9.

Leguminocythereis striatopunctata (Roemer 1838)

1973 *Leguminocythereis striatopunctata:* Willems, p. 515, pl. 1, fig. 9.
1978 *Leguminocythereis striatopunctata:* Keen, p. 416, pl. 9, fig. 7.

Echinocythereis reticulatissima Eagar 1965

1973 *Echinocythereis reticulatissima:* Willems, p. 515,pl. 1, fig. 6.
1978 *Echinocythereis reticulatissima:* Keen, p. 422, pl. 12, figs. 7, 9.

Echinocythereis sp. A

1981 *Echinocythereis sp. A:* King 1981, p. 126.
1985 *Echinocythereis cf. reticulatissima:* Ducasse *et al.*, p. 288, pl. 80, fig. 4.

An unnamed species, similar to *E. reticulatissima*, but with discrete tubercles not connected by reticulation. It appears in the middle London Clay Formation, below the earliest occurrence of *E. reticulatissima* (see King 1981).

Biostratigraphic Events

Nine biostratigraphic events are identified within the middle of the Ieper Formation in the area between Wardrecques and Ooigem (Fig. 3). Some of these events are also identifiable in the Kallo and Tielt boreholes, and some can probably be traced also into the "Sands of Mons-en-Pévèle" of the Renaix, Tournai and Mons-en-Pévèle areas. They are defined by vertical changes in the total microfauna, or by the "tops" or "bases" of individual species.

Most of these biostratigraphic events also correspond to lithological events — mainly glauconitic horizons — indicating that they probably reflect regional or more widespread tectonic or eustatic events. Thus they are probably effectively synchronous throughout the area.

The lowest event (I1) is about 40m above the base of the Ieper Formation in the Kortrijk area, and the highest (I9) about 70m above the base. Some of these events correspond to the boundaries of microfaunal units identified by Willems (1980a, b, 1982) in the Kallo and Tielt boreholes, but due to lateral biofacies changes, the full sequence of benthonic foraminiferid assemblages (associations) established by Willems at Kallo and Tielt are only partially recognisable in the Kortrijk area.

Event I1: defined by a major faunal change, from a benthonic microfauna dominated by (or composed exclusively of) non-calcareous agglutinating foraminiferids (AG1 agglutinants of King *in press*) in the underlying beds, to one composed almost exclusively of calcareous foraminiferids and AG2 agglutinants. Among the species occurring for the first time in the Ieper Formation at (or just above) this level are *Vaginulinopsis wetherellii* and *Nodosaria latejugata.* This event corresponds to the base of Willems' benthonic foraminiferid association BFIV. It also marks the first significant appearance of planktonic foraminiferids in the Ieper Formation in this area, the "planktonic datum" (although planktonics occur in some localities at a lower level in the Formation).

Event I2: defined by the earliest occurrence of *Textularia smithvillensis. T. smithvillensis* occurs commonly through a thin interval (4m thick at Wardrecques, 5m at Ooigem), and its basal occurrence appears to be sharply defined. It is usually

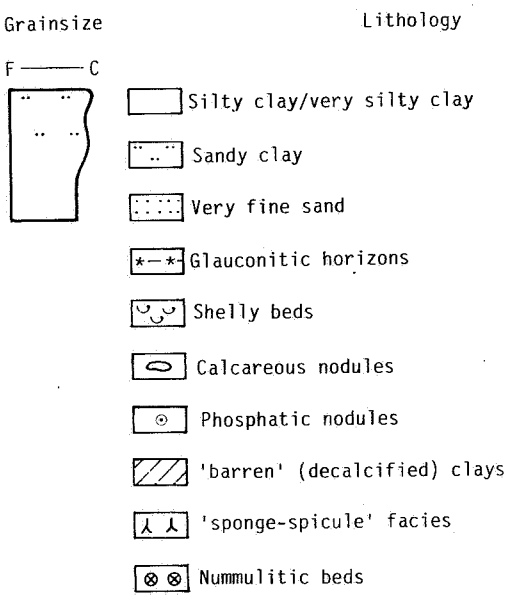


Fig. 2
Key to symbols used on Figures 3 to 11.

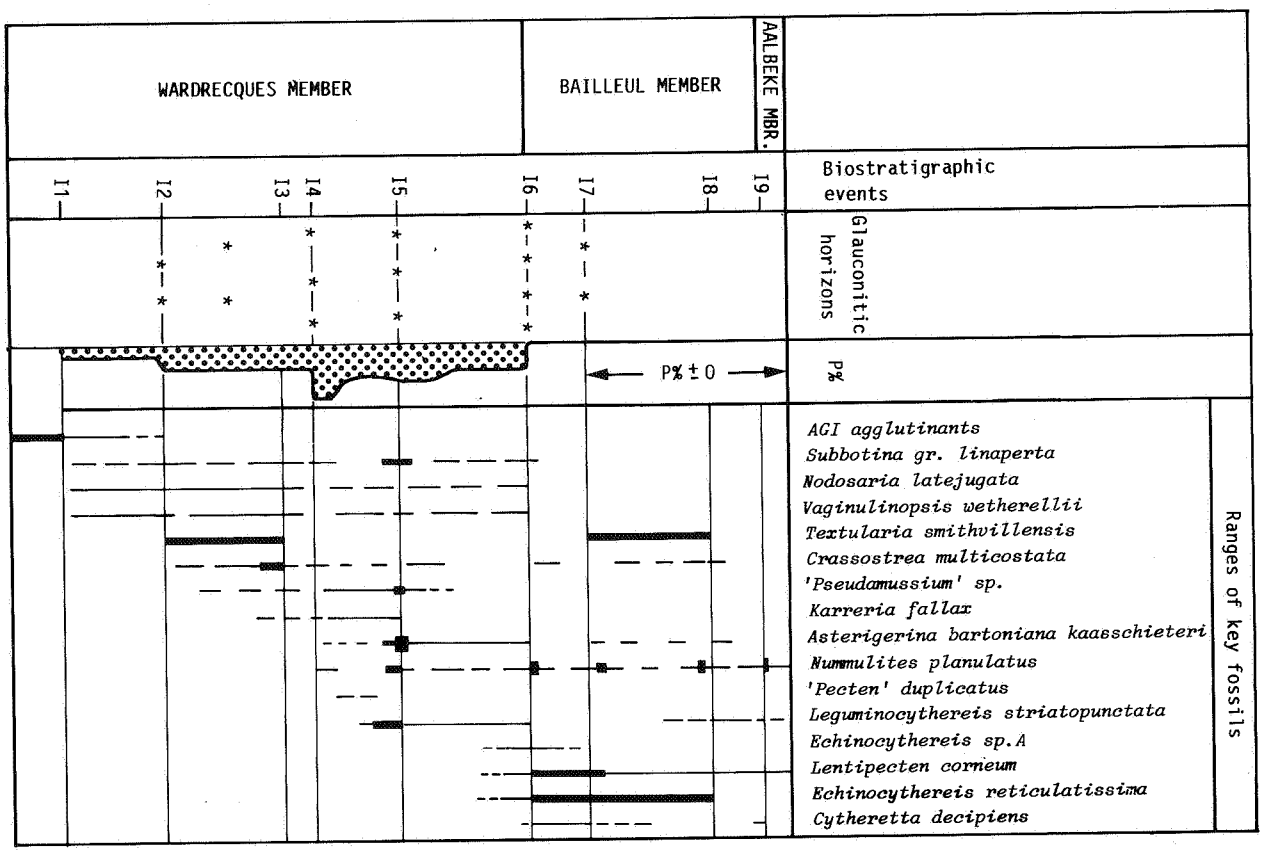
associated with frequent oysters (*Crassostrea multicostata*); a distinct "oyster bed" occurs near the top of its range at Wardrecques, and oysters are common at a similar level over a wide area (e.g. at Dottignies). This event also coincides with an increase in the proportion of planktonic foraminiferids, typically from 10 % to 20-30 % of the total foraminiferid assemblage. A thin glauconitic horizon is present at this level at Wardrecques, Ooigem and Dottignies.

Event I3: defined by the disappearance of *T. smithvillensis*. This event is probably not strictly synchronous, but is useful in correlation. *T. smithvillensis* reappears at a higher level in the middle Ieper Formation (Event I7, see below).

Event I4: defined by an abrupt increase in the percentage of planktonic foraminiferids (from 10 % to 50 % at Wardrecques; although a less dramatic rise is seen at localities further east). At Wardrecques this event occurs at a glauconite-rich horizon, and glauconite is also recorded at this level at Ooigem. *"Pecten" duplicatus* is retricted to the interval between Events I4 and I5; it is associated with *"Pseudamussium"* sp.

Event I5: the *"Asterigerina bartoniana kaasschieteri* acme zone" of Willems (1982). *A.b. kaasschieteri* ranges from slightly below this level, which is defined as its level of greatest abundance. It coincides approximately with the *"Globigerina patagonica* acme zone" of Willems. *G. patagonica* (*Subbotina* gr. *linaperta* of this paper) is not confined to this level, but is most common, and represented by rather large specimens, in a thin interval approximating to Event I5. These events

Fig. 3
Biostratigraphic events, ranges of key fossils and positions of glauconitic beds in the middle of the Ieper Formation of the area between Wardrecques and the Kortrijk area. P% = percentage of planktonic foraminiferids.



were first identified by Willems (1980a) in the Kallo and Tielt boreholes. He subsequently recognised them at Heestert (canal section) (Willems 1982). I5 can also be identified at Ooigem and Bailleul, but at Wardrecques it has become indistinct, as *A.b. kaasschieteri* becomes progressively rarer to the west.

At this level the ostracod *Leguminocythereis striatopunctata* also has its most abundant occurrence. *"Pseudamussium"* sp. and other bivalves are often common at this level, and there is often a distinct "shelly" bed with a macrofauna dominated by pectinids. This is the lowest level at which *Nummulites planulatus* occur commonly. At most localities Event I5 occurs within, or immediately below, a thin glauconitic horizon.

There is a change in the pectinid bivalve assemblage between Events I5 and I6. *"Pseudamussium" sp.* disappears, and is replaced by *Lentipecten corneum*. The exact level at which this occurs is difficult to define, as pectinids are not usually common in this interval, but *L. corneum* certainly appears below Event I6. The earliest specimens of *Echinocythereis sp. A* are recorded approximately at the same level as the earliest *L. corneum*, although it is not common below Event I6.

Event I6: defined by an abrupt fall in the percentage of planktonic foraminiferids, typically from 10%-20%, below this event to 2% above it. Between events I6 and I7, planktonics are very low in abundance, or completely absent. This event also marks the highest consistent occurrence of the foraminiferid *Asterigerina bartoniana kaasschieteri*, and the highest occurrence of *Nodosaria latejugata, Vaginulinopsis wetherellii* and *Cytheretta scrobiculoplicata. Leguminocythereis striatopunctata* has its highest consistent occurrence at this event, although it locally recurs at a higher level and probably has a longer range in the more sandy facies.

Event I6 corresponds approximately to the base of Willems' ostracod faunizone 3 at Kallo (Willems 1973). *Echinocythereis sp. A* is restricted to the section below and immediately above Event I6; this species is not present at Kallo, probably reflecting some condensation of this interval, or a minor hiatus. Between event I6 and event I7, *Echinocythereis reticulatissima*, the "index-species" of Willems' faunizone 3, becomes abundant, and *Lentipecten corneum* is common.

Event I6 occurs at a prominent glauconite-rich horizon, which in the Kortrijk-Ooigem area is the thickest and coarsest-grained glauconite level in the succession.

Event I7: defined by the reappearance of *Textularia smithvillensis*. At Bailleul (and probably also at other localities) this event also marks the highest occurrence of planktonic foraminiferids within the middle Ieper Formation. At Bailleul this event occurs at a glauconitic horizon. This may be true also at Ooigem. *T. smithvillensis* occurs commonly between Events I7 and I8, associated with common *Echinocythereis reticulatissima*.

Event I8: defined by the highest occurrence of *Echinocythereis reticulatissima*. This event coincides approximately with the highest occurrence of *Textularia smithvillensis*.

Event I9: defined by the disappearance (or abrupt decrease in abundance and diversity) of the calcareous microfauna. This event corresponds approximately to the top of Willems' benthonic foraminiferid association BF IV, and to the base of his "barren zone" (Willems, 1982).

This event occurs at a lithological change, marking the base of a sequence of largely decalcified silty clays (defined below as the Aalbeke Member).

Calcareous microfossils formerly existed in the "barren zone", as it contains pyrite casts and moulds of molluscs and calcareous foraminiferids and ostracods (see King, in press). The boundaries of the "barren zone" (especially the upper boundary) cross lithological and faunal boundaries, and it is probably largely controlled by post-depositional diagenetic carbonate dissolution. Calcareous fossils usually reappear at a higher level, in the upper part of the Ieper Formation (Willems 1982).

4. SECTIONS STUDIED

The location of these sites is shown on Fig. 1. Their biostratigraphy and lithostratigraphy is summarised in Figures 3 to 10. The symbols used in these figures are given in Figure 2. The new lithostratigraphic units referred to here are described in the following section of this paper.

Kallo borehole (No. 27E-148) (Fig. 4). Drilled for the Geological Survey of Belgium in 1964. The Ieper Formation was penetrated between 239 m and 377.4 m and was almost continuously cored. A brief description of the section is given by Gulinck (1967). The foraminiferids and ostracods are described by Willems (1973, 1980a,b). The processed samples used by Willems were made available to the author, and selected core samples held at the Rijksuniversiteit Gent were logged lithologically. The unpublished lithological log of the borehole was supplied by the Geological Survey of Belgium. The stratigraphy and index fossils of the middle part of the Ieper Formation are summarised here for comparison with Willems' work and with the other sections, although this borehole is outside the area studied here.

Knokke borehole (No. 11E-138) (Fig. 11). Drilled for the Geological Survey of Belgium in 1982. The Ieper Formation was penetrated between 132.0m and 288.0m, and is represented by a continuous series of cores. Samples were collected by the author at intervals of 1 metre.

A detailed study of the stratigraphy of the Ieper Formation in the Knokke borehole is soon to be published (King, in press), and information given here is taken from this forthcoming paper.

Kortemark (Desimpel clay Quarry) (Fig. 11). A large, deep quarry in which the upper part of the

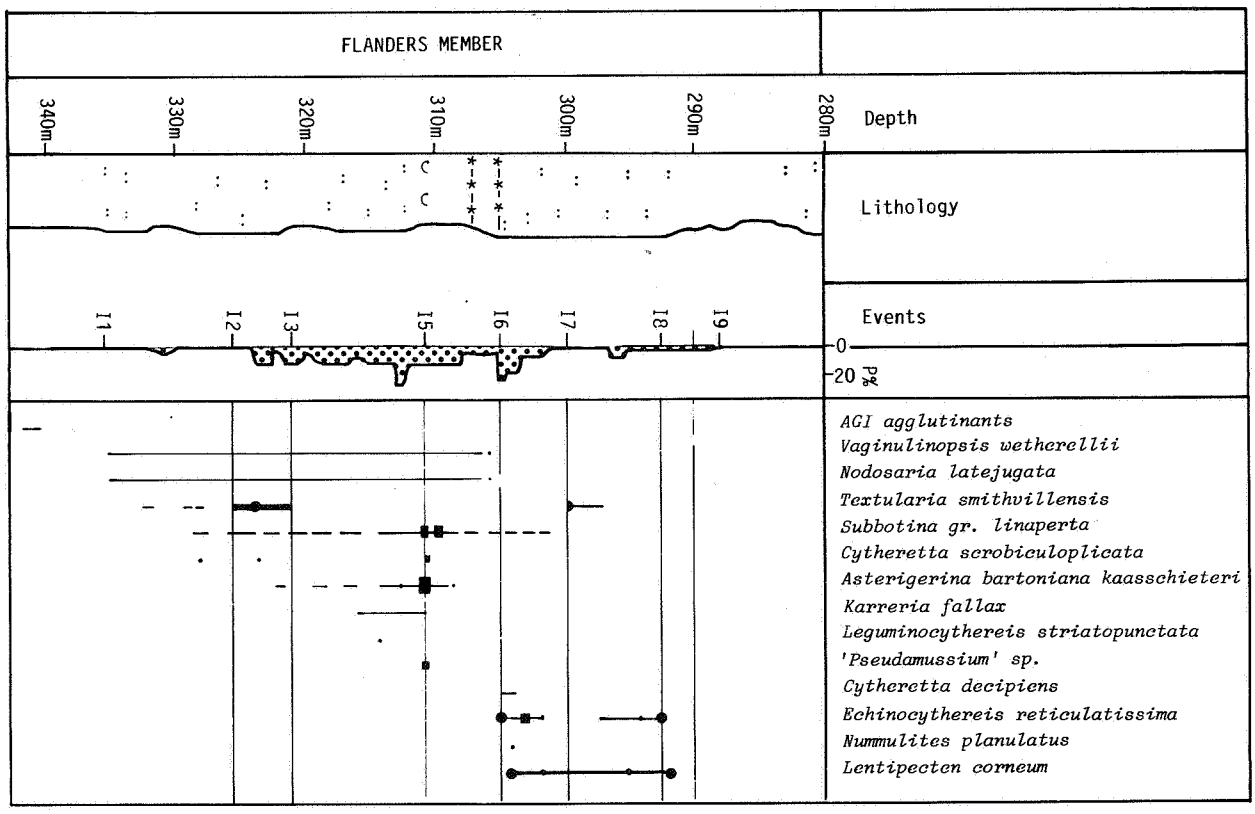
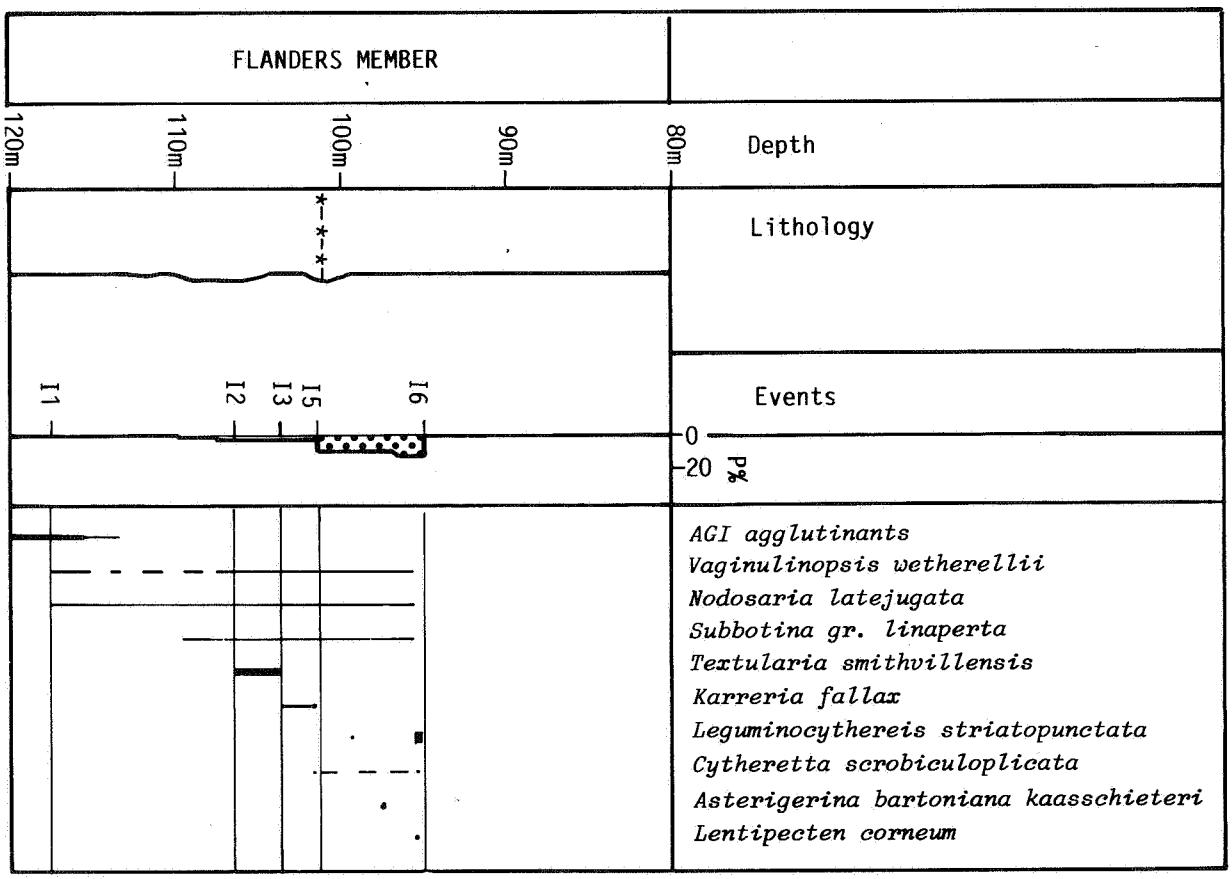


Fig. 4
Stratigraphy and key fossils of the middle Ieper Formation in the Kallo borehole.

Fig. 5
Stratigraphy and key fossils of the middle Ieper Formation in the Tielt borehole.



Flanders Member (22m) and the base of the Egem Member are exposed. Foraminiferids from the upper part of the Flanders Member are listed by Kaasschieter (1961) and Willems (1980a). The section was measured and sampled by the author between 1977 and 1979.

Egem (Ampe Quarry) (Fig. 11). A large quarry excavated mainly between 1975 and 1980 as a "borrow pit" for road construction materials. The top of the Flanders Member, the Egem Member and the lower part of the Panisel Formation are exposed. The section is described by De Coninck and Nolf (1978) and Islam (1982); foraminiferids are listed by Gerits *et al.* 1981. It was measured and sampled by the author between 1977 and 1982. Some details of the faunas are given by King (in press).

Tielt Borehole (No. 68E-169) (Fig. 5). Drilled for the Geological Survey of Belgium in 1967. The Ieper Formation was penetrated between 11.5m and 154m, and was almost continuously cored. A brief description is given by Gulinck (1967). The foraminiferids and ostracods of the Ieper Formation are described by Willems (1977, 1980a). The processed samples used by Willems were made available to the author, but no core samples have been examined. The unpublished lithological log of the borehole was supplied by the Geological Survey of Belgium.

Ooigem Borehole (No. 83E-407) (Fig. 6). Drilled for the Geological Survey of Belgium in 1967. The Ieper Formation was penetrated between the surface and 94m depth, and was continuously cored. A brief description is given by Gulinck (1967) and a few samples were studied by Willems (1980a). The unpublished log of the borehole was made available by the Geological Survey of Belgium, and samples for micropalaeontological analysis were collected by the author from a series of core samples at approximately 1 metre intervals held by the Survey.

Kortrijk area (Fig. 7). Clay pits near Kortrijk were mentioned by Lyell (1852) and sections have been described more recently by authors including Leriche (1927) and Kaasschieter (1961).

Two major lithological units within the Ieper Formation outcrop in the area to the south of Kortrijk: an upper "heavy clay" unit, mapped as "Paniselian" (P1m clay), overlying a sandy shelly clay, referred to the "Argile de Roubaix" or "Sables de Mons-en-Pevele", and mapped as the upper part of the Ypresian (Yd). Recent study of the dinoflagellates (De Coninck, 1976b) has shown that the "heavy clays" are in fact within the upper part of the Ieper Formation, as independently deduced on lithostratigraphic criteria by the present author. They are here named the Aalbeke Member (see below).

The Aalbeke Member was exposed in 1980 in a quarry at Pottelberg (3km SW of Kortrijk), and also in the adjacent E3 autoroute cutting where it was re-exposed during road works in 1977. Its base was also exposed in a cutting for the A71 autoroute at Marke (5km southwest of Kortrijk) in 1975 (see Fig. 7), where it is seen to overlie the shelly and sandy clays with beds rich in Nummulites ("Argile de Roubaix"), here named the Bailleul Member. 10m of these sandy beds were exposed at Marke (Fig. 7). They were formerly exposed also in a nearby clay pit (now disused) at Lauwe (De Coninck 1976b).

Mouscron (Moeskroen) borehole (Fig. 10, 11). A cored borehole, drilled in 1948, described by Feugueur (1963: 433). The exact site is not given by Feugueur, but Moeskroen is 9km SSW of Kortrijk. The section is interpreted by Feugueur as comprising "Paniselien" sands and clays (1.8-12.5m depth), "Ypresien superieur" (Argile de Roubaix, 12.5m-54.0m) with silty and sandy beds, "Ypresian inferieur" ("Argile d'Orchies", 54.0m-95.5m) overlying "Landenien" sands.

It is clear, by comparison with the nearby sections at Kortrijk (Fig. 10) that the "Paniselien" clays between 4.0m and 12.50m are equivalent to the "heavy clay" unit exposed at Kortrijk (here named the Aalbeke Member), and that the underlying sandy beds represent the Bailleul Member. Very brief details of the microfauna of this section are given by Feugueur and Le Calvez (1956), but these are insufficient to enable any detailed correlation with the other sections.

Heestert canal (Fig. 7). A section in the middle of the Ieper Formation is exposed in the sides of the canal cutting near the N9 road between Knokke and Heestert 8km SE of Kortrijk. The canal at this site originally ran in a tunnel through the hill, but in the 1970s the tunnel was converted into an open cutting. The recently exposed section here has been described by Herman (1982) and Delaunois (1981, Fig. 4). Halet (1939) gives a general account of the section exposed during the cutting of the original canal.

The section was measured and sampled by the author between 1979-1982 (Fig. 6), and extended by a shallow auger borehole. It comprises clays and silty sands of the Wardrecques Member, overlain by sandy clays of the Bailleul Member. The junction of these units is marked by two prominent glauconite-rich beds 50cm apart. Event I5 is at about the level of the towpath. It is important to note that the major glauconite horizons recorded here (5.5-5.9m above the base of the section) are only easily visible on the eastern side of the cutting, and were not recorded by previous authors, as they have all studied the western side of the cutting. The base of the exposed section (at the level of the towpath) is at approximately +21m; Halet records borings indicating that the base of the Ieper Formation is at about −44m.

Kwadestraat Quarry, Heestert (x = 80,500, y = 165625) (Fig. 10). This section is only 1.1km

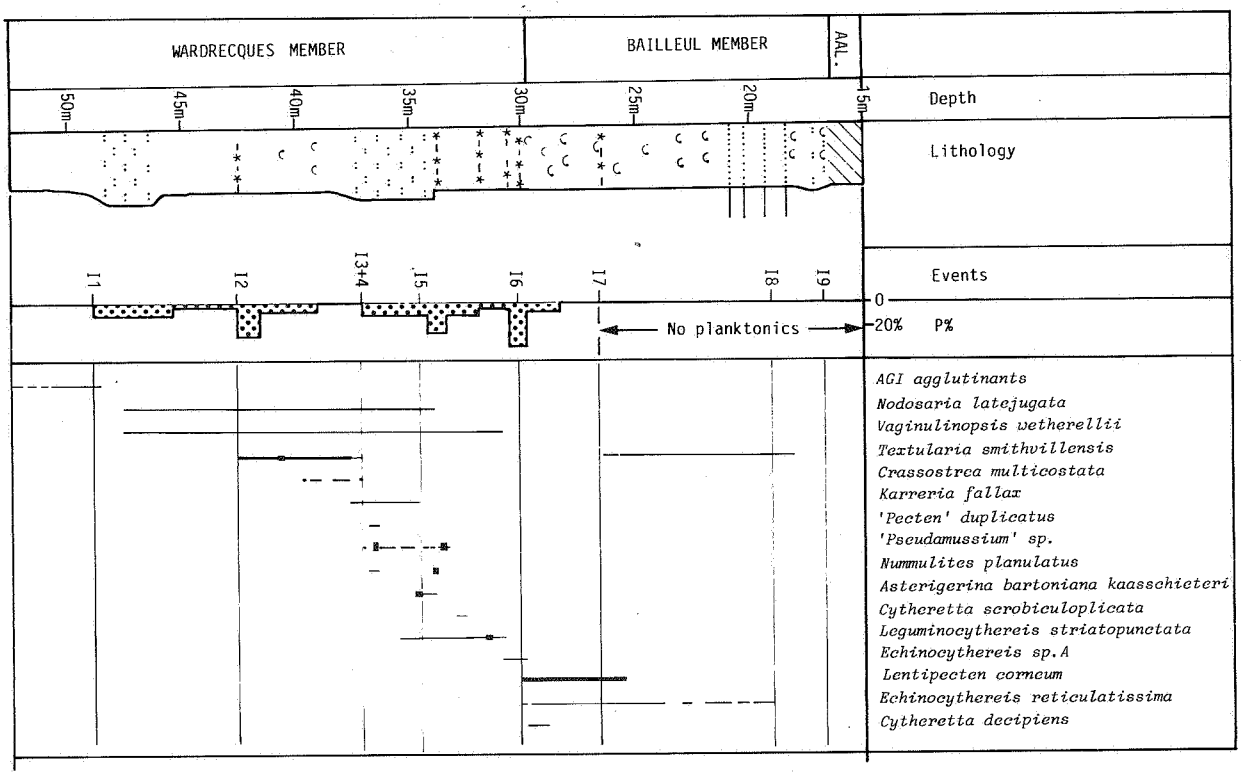


Fig. 6
Stratigraphy and key fossils of the middle Ieper Formation in the Ooigem borehole. AAL = Aalbeke Member.

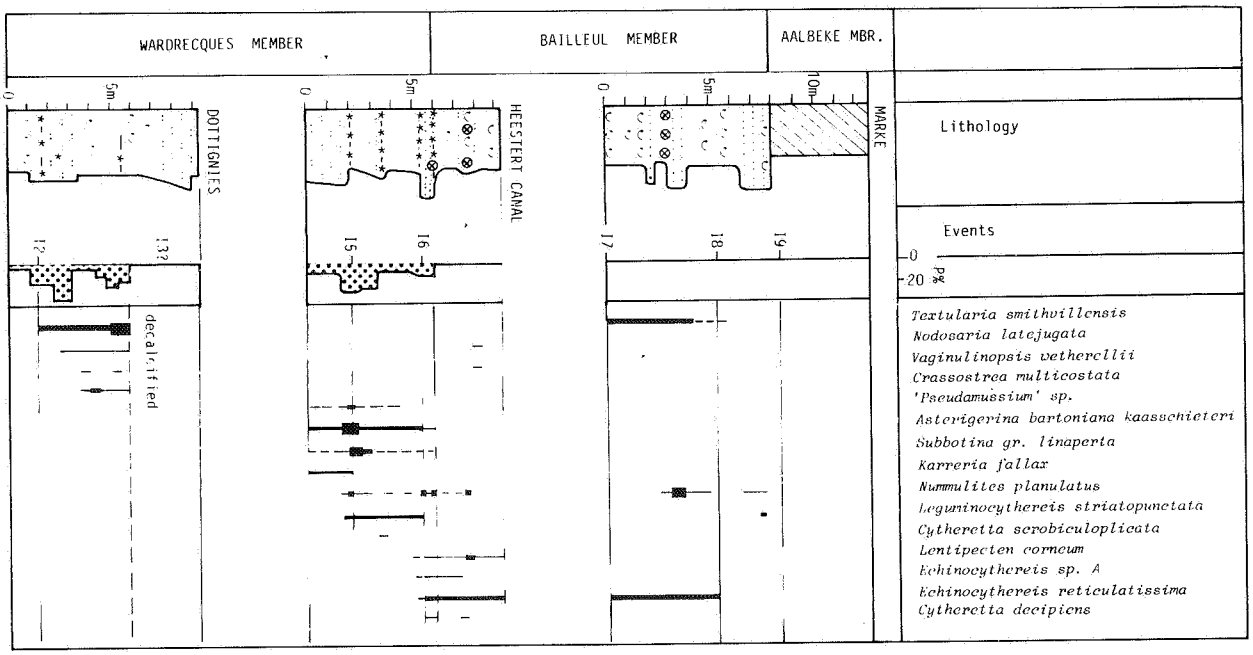


Fig. 7
Stratigraphy and key fossils of the middle Ieper Formation in the Kortrijk area. Vertical intervals between the sections are not to scale.

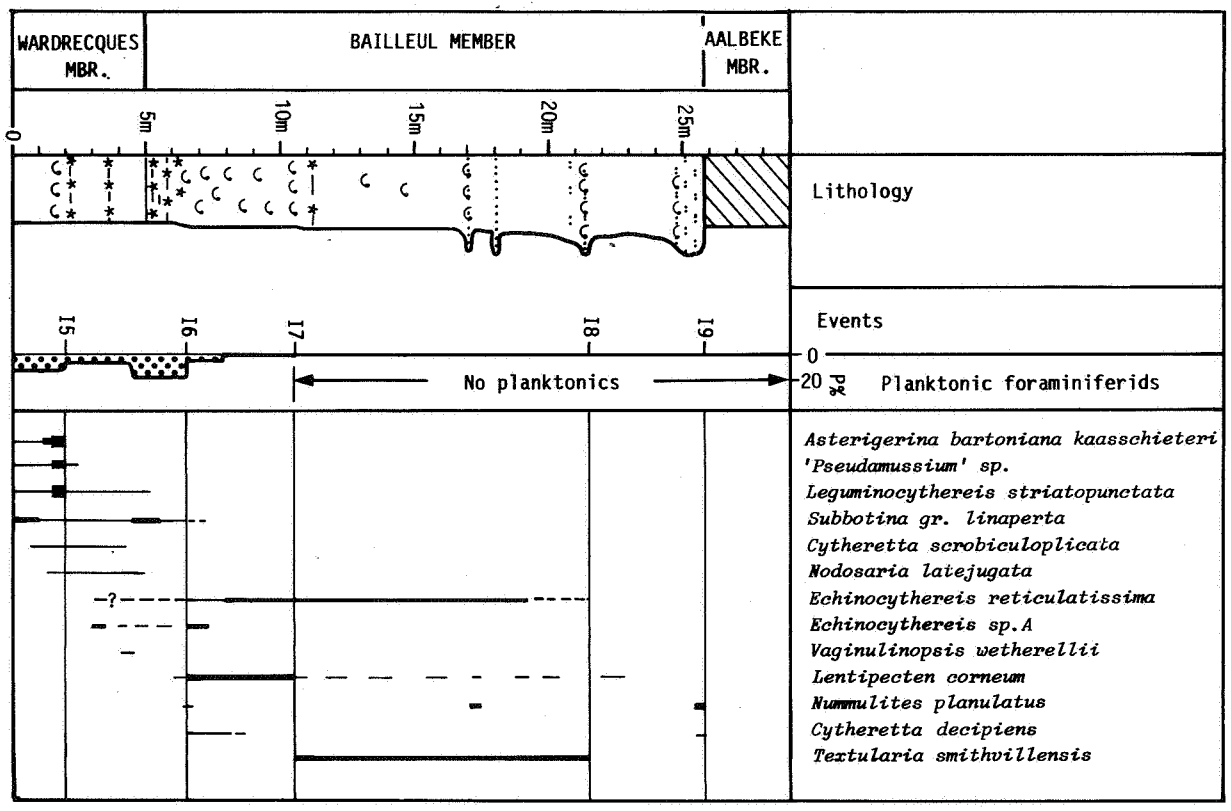


Fig. 8
Stratigraphy and key fossils of the Ieper Formation in the Bailleul clay quarry.

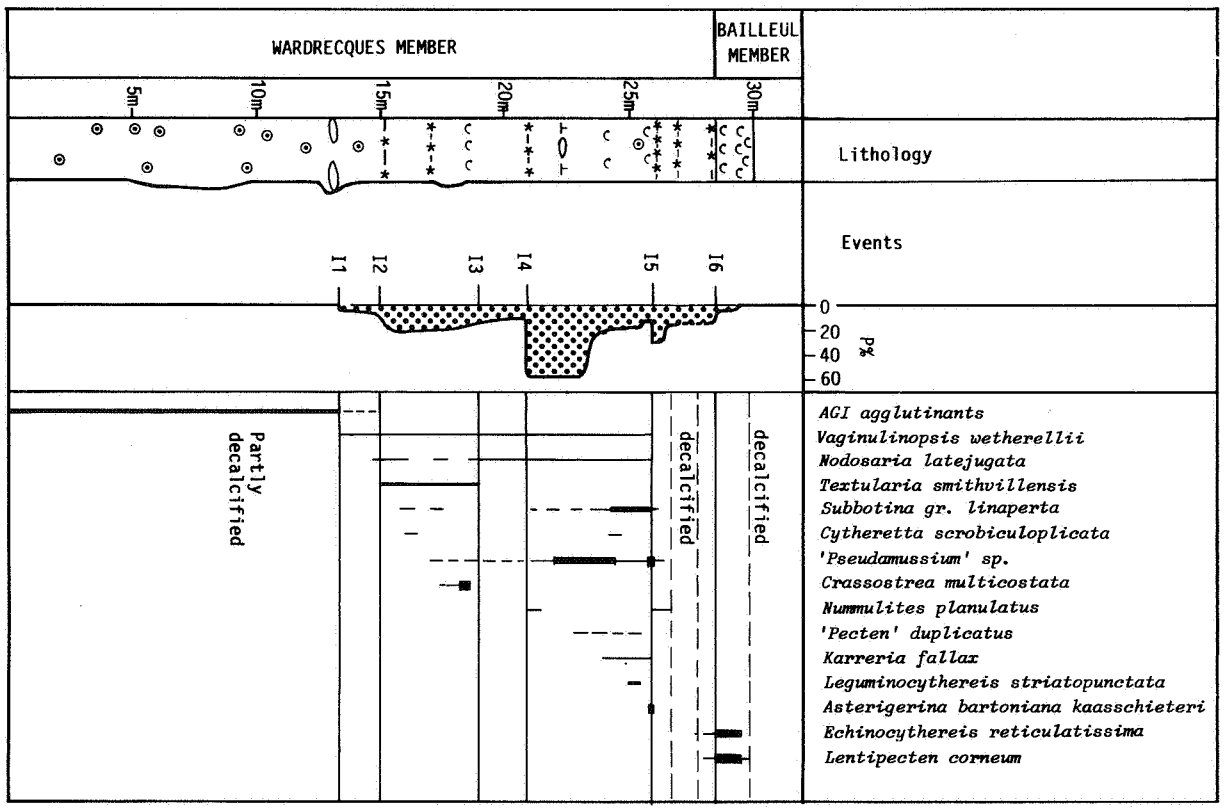


Fig. 9
Stratigraphy and key fossils of the Ieper Formation in the Wardrecques clay quarry.

from the Heestert canal section. Here the "heavy clay" unit (Aalbeke Member, 6m) is exposed, overlain by a thin glauconitic sand unit (2m) (Delaunois, 1981, Fig. 4). The base of the quarry is at c.47m; according to information from the quarry owners, the base of the "heavy clay" unit is about 2-3m lower, resting on sandy clays (Bailleul Member).

Ronse (Renaix) area (Fig. 10,11). The geology of the Renaix area was studied extensively in the nineteenth century by Delvaux, who described many sections in quarries, road and railway cuttings, and boreholes. His detailed observations have generally been ignored in more recent times, although a useful summary of his results is given by Feugueur (1963).

One of the most important exposures described by Delvaux is the Wayenberghe railway cutting (Delvaux 1884a), 2.5km. ESE of Ronse (x = 98650, y = 159225). The railway is now disused, but the site of this cutting was rediscovered using Delvaux's maps, and a new section was excavated by the author in 1980. It has subsequently been studied by Delaunois (1981, Figure 5). Both Delvaux and Delaunois have described this section (Fig. 9) as exposing the top part of the "Ypresian" sands with beds of Nummulites (Sands of Mons-en-Pévèle = Mons-en-Pévèle Sand Member as defined below), overlain by the basal "Paniselian" (Panisel Formation) clays (P1m). However, it is clear that these clays (which are decalcified) correspond to the "heavy clays" of the upper part of the Ieper Formation, as seen at Kortrijk (Aalbeke Member). About 5m of sands are exposed in the cutting, and a further 6m of interbedded very fine sands and clavey silts was penetrated by auger boreholes in the base of the cutting. There is a prominent nummulitic sandstone about 6.4m below the top of the sands (the "banc à *Nummulina planulata*" of Delvaux).

The microfauna in the "Sands of Mons-en-Pévèle" here includes abundant *Echinocythereis reticulatissima* and *Textularia smithvillensis*. *Lentipecten corneum* is frequent. Planktonic foraminiferids are rare (P 1 %) or absent. By comparison with the sections in the Kortrijk-Ooigem area this assemblage lies between events I7 and I8. According to figures given by Delvaux, the top of the "Sands of Mons-en-Pévèle" here is 80m above the base of the Ieper Formation.

At Renaix itself, the base of the "Sands of Mons-en-Pévèle" was exposed at the station, marked by a prominent glauconitic horizon (Delvaux 1887). This bed is about 50m above the base of the Ieper Formation, according to Delvaux (Fig. 11). According to Delvaux it marks the junction between the "Sables à *Nummulina planulata*" (Sands of Mons-en-Pévèle) and the "argile yprésienne". Delvaux records fossils from this section, but virtually nothing is known of the microfauna, and the correlation of this glauconitic horizon with the glauconitic beds in the argillaceous facies further west is uncertain.

The lower part of the Ieper Formation, below this level, comprises mainly clays, and is known only from borehole data, again recorded by Delvaux (1882, 1883, 1885). The microfaunas of these beds are unknown, but it is clear that a complex lithostratigraphic succession exists (see Fig. 10).

Dottignies (Fig. 7). A shallow section (4m deep) in the middle of the Ieper Formation was exposed in 1980 during construction of the A71 autoroute, where it crosses the N63 road at Dottignies, 12km south of Kortrijk. This exposed sandy clays and sandy silts with frequent small oysters *(Crassostrea multicostata)* near the base. Only the lower part of this section contained calcareous fossils. An auger borehole in the base of the cutting penetrated an additional 5m of sandy clays and sandy silts, with frequent oysters at some levels. These beds are all referred to the Wardrecques Member. The exposed section, and the upper part of the section in the borehole, contain abundant *Textularia smithvillensis* and frequent planktonic foraminiferids (P = 15 %) and lie between events I2 and I3. Event I2 is probably located c. 1.5m above the base of the borehole section, marked by the basal occurrence of *T. smithvillensis*, associated with a glauconitic horizon.

Montrœul-au-Bois. Part of the "Sands of Mons-en-Pévèle" (Mons-en-Pévèle Sand Member) is exposed in a shallow cutting (less than 2m deep) in a hollow track south of the village of Montrœul-au-Bois, 14km ENE of Tournai (Doornik). (x = 98830, y = 148370). A section here is described by Quinet, Coupatez and Wouters (1970), comprising very fine sands with thin clay beds and Nummulite-rich layers. Exposures are not good at present, but a sample was collected by the author in 1979. Oysters *(Crassostrea multicostata)* are common, *"Pseudamussium" sp.* is also present, and a diverse and well preserved microfauna was obtained, including common *Textularia smithvillensis*. Planktonics are scarce (P = 2-3 %). This assemblage would indicate a level between events I2 and I3, if compared with the sequence in the more argillaceous facies in the Kortrijk-Ooigem area. It is quite distinct from the assemblage recorded from the top of the Mons-en-Pévèle Sand Member at Wayenberghe.

This section is at +87 to +92m. According to the regional map of the base of the Ieper Formation given by Kaasschieter (1961, Map 9), it probably lies at about 57-62m above the base of the Formation. It is shown in Figure 11 in its approximate position relative to the Mont-St-Aubert section.

Mont-St-Aubert (near Tournai). This locality is a large hill rising above the surrounding area in which the lower part of the Ieper Formation outcrops, and forming an outlier of the "Sands of Mons-en-Pévèle" (fine sands with several shelly beds) and overlying Eocene beds. No exposures have been seen by the author, but details of various small exposures at different levels are given by

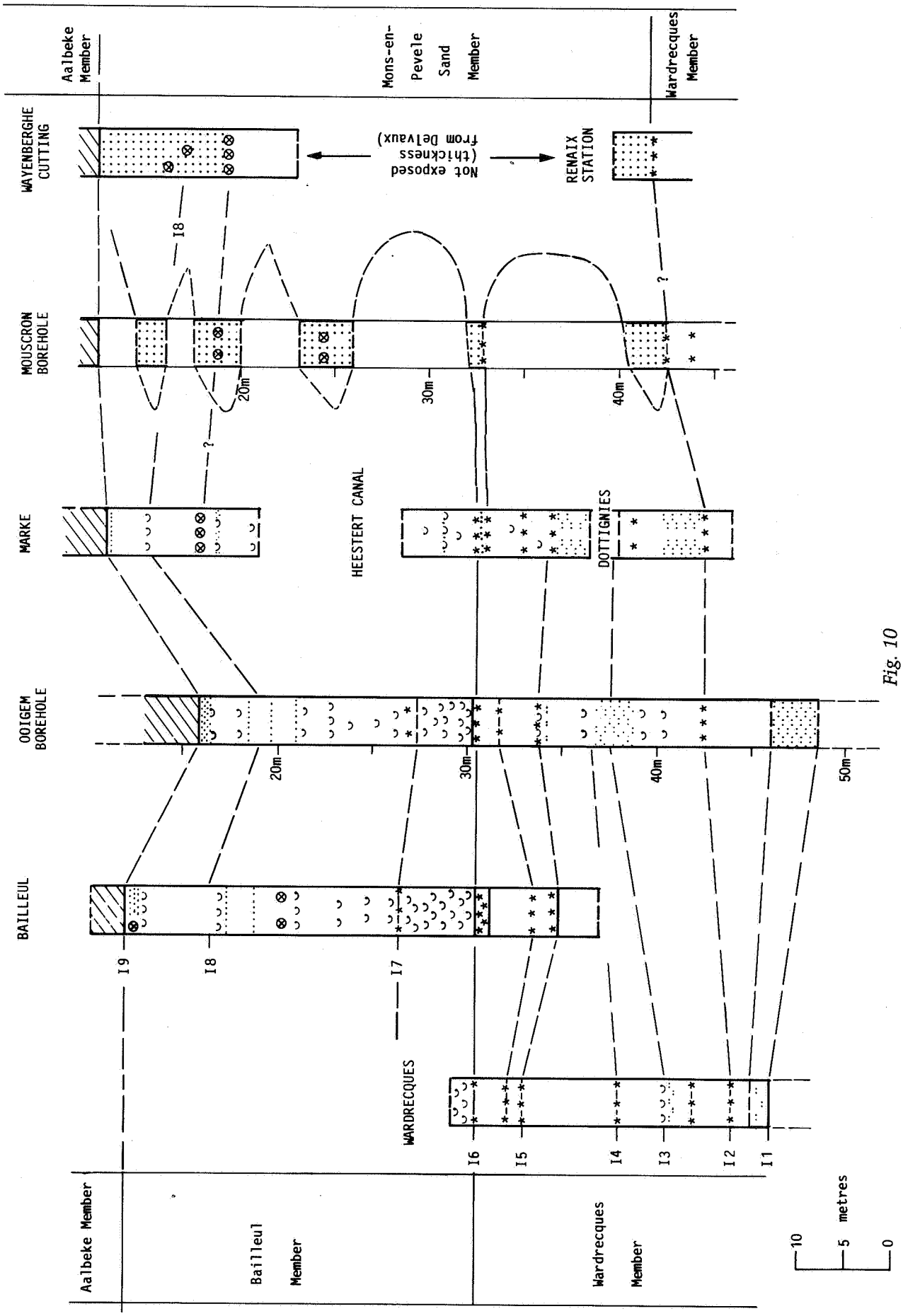


Fig. 10
Correlation of the middle Ieper Formation between Wardrecques and Renaix.
The line of this cross-section is shown by the solid line on Fig. 1. The horizontal datum (except at Renaix) is the base of the Bailleul Member.

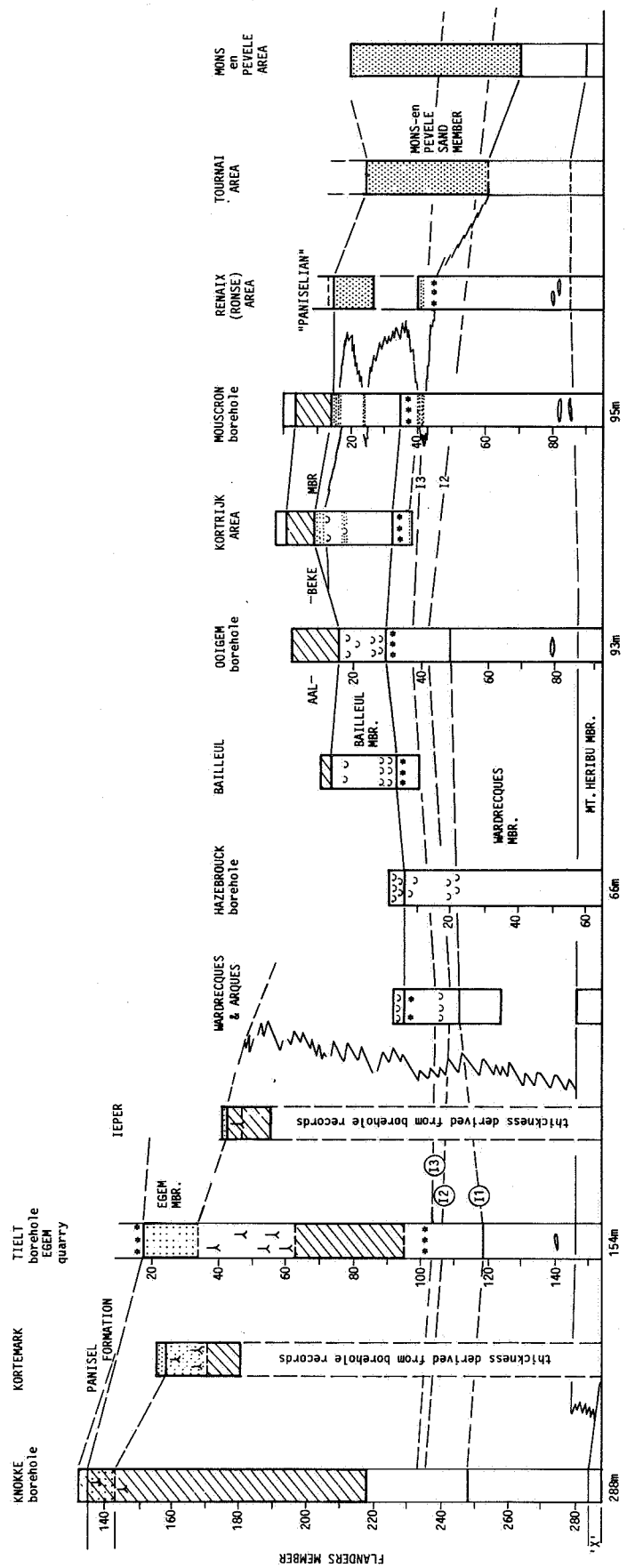


Fig. 11
Correlation of the Ieper Formation between Knokke and Mons-en-Pévèle. The line of cross-section is shown by the interrupted line on Fig. 1. The horizontal datum is the base of the Ieper Formation.

Delvaux (1884b), and summarised by Feugueur (1963, Fig. 91), from which the succession has been established (Fig. 11). There is a sandstone with *Nummulites planulatus* c. 10 m below the top of the "Sands of Mons-en-Pévèle" which may correlate with the nummulitic sandstone at a similar level at Wayenberghe. The basal unit of the overlying "Paniselian" is a "plastic clay" apparently comparable with the Aalbeke Member.

Forest (Brussels). Exposures at Forest (now a suburb of Brussels) were described already by Lyell (1852) and in more recent times sections here have been described by a number of authors, including Casier (1946) and Feugueur (1963) — see Willems et *al* 1981. The sections exposed the highest part of the "Sands of Mons-en-Pevele", here often referred to as the "Sands of Forest" with nummulite-rich beds, overlain unconformably by the Brussels Sands. Ostracods and foraminiferids are recorded by Keij (1957), Kaasschieter (1961) and le Calvez (in Feugueur 1963). No sections are now visible, but samples were provided for the author from a recent temporary excavation by Dr. J. Herman. The microfauna and macrofauna of this section is discussed below.

Mt. Panisel - Bois-là-Haut (Mons). This is the type-locality of the Panisel Formation (see Feugueur 1963, Dupuis & Robasynski 1986), which forms an outlier overlying the Ieper Formation. The upper part of the Ieper Formation comprises very fine glauconitic sands (Sands of Mons-en-Pévèle), with a fossiliferous nummulitic bed near the top. Microfossils from this bed are listed by Kaasschieter (1961) and Keij (1957). A sample was collected by the author under the guidance of Dr. C. Dupuis in 1984 from the exposure in the Bois-là-Haut. The overlying Panisel Formation is represented by sandy glauconitic clays passing up into glauconitic clayey sands, and is apparently entirely decalcified; no microfauna has been described from it.

Mons-en-Pévèle (France, Nord). The village of Mons-en-Pévèle lies at the highest point of a large hill on which an outlier of Sables de Mons-en-Pévèle is preserved. It is the type locality of these sands. The succession here is known only from boreholes and temporary exposures. The most comprehensive description is by Parent (1894).

No permanent exposures exist here, but samples were obtained from four shallow auger boreholes drilled in and near the village as a "pilot study" in 1978. These showed that the sequence comprises interbedded very fine silty sands, sandy clays and nummulite-rich beds. The microfauna differs in composition from that in the argillaceous facies of the middle Ieper Formation, but significant similarities can be recognised.

The lowest sample studied, from a nummulite-rich bed at c. +66 m (A on fig. 11) (c. 10 m above the base of the Sands of Mons-en-Pévèle) contains *Textularia smithvillensis* and frequent planktonic foraminiferids. Higher samples, from c. +75 m (B on fig. 11), also contain *T. smithvillensis* and common planktonics (P. up to 16%), *Crassostrea multicostata* and *"Pseudamussium" sp.* This assemblage is similar to the assemblage from Montrœul-au-Bois, and probably comes from a similar level. On the basis of the succession established in the argillaceous facies, these samples should correlate with the interval between events I2 and I3. The highest samples collected, at c. +92 m (C on fig. 11), contain *Leguminocythereis striatopunctata, Asterigerina bartoniana kaasschieteri* and frequent planktonics (P = 6%) and can be assigned to a level close to event I5. About 18 m of beds are preserved above this level, but have not yet been sampled.

These results, although very incomplete, strongly suggest that some of the microfaunal events identified in the argillaceous facies can also be identified within the type section of the Sands of Mons-en-Pévèle. Further, more detailed study is planned for the future.

Leforest (France, Pas-de-Calais). A large sand quarry at Leforest exposes the upper part of the Landenian sands (Sables d'Ostricourt), overlain by 8 m of the Ieper Formation (Delattre *et al.* 1973). Two distinct lithological units can be identified within the Ieper Formation:

1) a basal unit (4.5 m) of silty and very silty clays, with thin and often widely spaced partings of silt and very fine sand. This unit can be correlated with the Mt. Héribu Member of the Mons-Tournai area (De Coninck *et al* 1983);
2) silty homogenous clay with a tabular layer of calcareous concretions (3.5 m). This is the basal part of the Wardrecques Member (see below).

Bailleul (France, Nord) (Fig. 8). A small clay quarry at Bailleul (Briqueterie Dubois, x = 35625, y = 159375) has not previously been described, except for a brief description in King (1981), although it is a key section in the middle Ieper Formation. It is only 6 m deep, but exposes a gently folded sequence, cut by several minor faults. These structural complexities do not appear to be related to superficial tectonics, and may reflect proximity to a major fault. Due to the dip, a section 24 m in thickness can be measured in the quarry, comprising a complete section of the Bailleul Member and the base of the Aalbeke Member. An auger borehole in the floor of the quarry penetrated the highest 5 m of the Wardrecques Member.

Hazebrouck (France, Nord) (Fig. 11). A boring at Hazebrouck through the lower 63.5 m of the "Argile de Flandres" is recorded by Cayeux (1890). The highest beds in the boring, between 2.5 m and 6.3 m depth, contain abundant molluscs, and are tentatively correlated with the lower part of the Bailleul Member. A record of *"Ostrea flabellula" (Crassostrea multicostata)* at a depth of 19 m-23 m suggests comparison with the "oyster-bed" at Wardrecques, just below Event I3.

Wardrecques (France, Nord) (Fig. 9). A large clay quarry at Mont Noir (clay pit of the Comptoir Tuileries du Nord, x = 334500, y = 602500), which has been in use for over 50 years. It was briefly described by Dubois (1922), but has been largely neglected by later geologists. It is very briefly mentionned by Delattre et *al.* (1973:164), and some details of the biostratigraphy were given by King (1981).

This quarry is at present the best exposure of the Ieper Formation (Argile de Flandres) in France, and exposes about 32 m of clays in the middle of the Formation, comprising the upper half of the Wardrecques Member and the lowest part of the Bailleul Member. The section given here is based on measurements and sampling between 1969 and 1984.

5. LITHOSTRATIGRAPHY

Historical

The historical development of the lithostratigraphic classification and subdivision of the beds currently referred to the Ieper Formation and Panisel Formation in western Belgium and northern France was reviewed by Kaasschieter (1961), and has been summarised more recently by Willems et *al.* (1981).

In northern France, the "Argile de Flandres" of the Lille-Roubaix area was divided by Gosselet (1874) into a lower "unfossiliferous" clay unit (the Argile d'Orchies) and an upper fossiliferous sandy clay with *Nummulites planulatus* (the Argile de Roubaix). The Argile de Roubaix, typified by sections at Roubaix, now a suburb of Lille, was believed by Gosselet to pass laterally to the south and east into the "Sables de Mons-en-Pévèle". These are fine sands with beds rich in Nummulites, which overlie the Argile d'Orchies in the Renaix-Tournai area of Belgium and in the outlier of Mons-en-Pévèle, south of Lille.

The term "Argile de Roncq" was introduced by Gosselet in 1883 for the upper part of the Argile de Roubaix, believed to be equivalent in age to the "Paniselian" of Belgium. However, the section at Roncq (near Mouscron) which was used to typify this unit (Ortlieb and Chellonneix 1879) comprised sandy clays with molluscs, which are almost certainly within the middle of the Ieper Formation, and equivalent to part of the Bailleul Member as defined below. The term "Argile de Roncq" was unfortunately incorrectly utilised by Kaasschieter (1961:23), as the "Clays of Roncq", for the "heavy clay" unit which *overlies* the Argile de Roubaix in its type area, and applied also to the supposedly correlative clay unit (mapped in Belgium as P 1 m) at the base of the "Panisel Formation" in northern Belgium.

In Belgium, the "système yprésien" of Dumont (1849), originally defined to include almost all the Early Eocene sequence, was soon after restricted by the creation of the "système panisélien" (Dumont 1851) for its upper part. These "systèmes" were subsequently retitled "étages", and as such found their way into international literature, although, similarly to the other "stages" created in the nineteenth century in the Tertiary of north-west Europe, they are essentially lithostratigraphic units. The "étage yprésien" was subdivided by Dumont into a basal sandy member, the main clay-dominated member (argile yprésienne) and an upper sand unit (sables yprésiens). The Geological Survey of Belgium subsequently formalised this system by assigning letters and numbers to the main lithostratigraphic units (e.g. Y1a for the "argile yprésienne").

Kaasschieter (1961) realised that the "stages" in use in Belgium were in reality lithostratigraphic units bounded by sedimentary discontinuities, and transformed them formally into named lithostratigraphic units. He created the Ieper Formation (Ieper = Ypres) for the beds previously included in the "Yprésien", subdividing it into the Ieper Clay ("argile d'Ypres" of previous authors), overlain by the Sands of Mons-en-Pévèle (the "sables yprésiens" of previous authors), taken from Gosselet's classification. The term "Clays of Roubaix" was introduced for sandy clays supposedly laterally equivalent to the Sands of Mons-en-Pévèle, again "borrowed" from the terminology introduced in northern France by Gosselet. He created the Panisel Formation for the "étage panisélien". The "Lower Paniselian" (P 1 of the Geological Survey) was divided into three successive lithostratigraphic units, formally named the Clays of Roncq (P 1 m), Sandy Clays of Anderlecht (P 1) and Vlierzele Sands (P 1 d).

This terminology has been generally used until now, with minor modifications. The "Sands of Mons-en-Pévèle" of the Brugge-Tielt-Gent area were renamed the "Sands of Ledeberg" by De Moor and Geets (1974), but this term has not been extensively used; the term "Egem Member" was proposed for the same unit by Willems *et al.* 1981, based on a well-exposed type section at Egem. The Ieper Clay has been renamed the Flanders Member (Willems *et al.* 1981), basically to alleviate confusion with the Ieper Formation. The sandy basal unit of the Ieper Formation has been named the Mont-Héribu Member by De Coninck *et al.* 1983. The Clays of Roncq in northern Belgium were renamed the Clays of Merelbeke by De Moor and Geets (1973), and incorporated by them into the Ieper Formation, but this reclassification is not followed here. The "Sandy Clays of Anderlecht" in the Tielt area were renamed the Pittem Member by Geets (1979).

Further lithostratigraphic subdivision of the Ieper Formation has been attempted by De Moor and Geets (1975) — see Willems *et al.* 1981 — but the Members they propose are not adequately defined, and cannot be utilised without conventional lithostratigraphic descriptions.

In northern Belgium, the classification introduced by Kaasschieter and subsequent workers can be utilised satisfactorily. However, it is clear, from the discussion above and details given below, that the terms appropriated by Kaasschieter

from Gosselet's work are all inappropriate for the succession in northern Belgium, as they are applied there to units which are incorrectly correlated with their supposed equivalents in northern France. This "standard" classification is also inadequate for classifying the more complex series of lithostratigraphic units in the Kortrijk area and in the north of France.

Lithostratigraphy in southwestern Belgium and in northern France

The lithostratigraphical succession in the Ieper Formation of the outcrop between Wardrecques and the Kortrijk area is here divided into five successive units. These are, in ascending order, the Mt. Héribu Member, Wardrecques Member, Bailleul Member, Aalbeke Member, and an unnamed sand member. The three middle members pass laterally northwards into the Flanders Member, a relatively homogenous clay facies. The Bailleul Member and the upper part of the Wardrecques Member pass laterally southwards into a sandy facies, the Mons-en-Pévèle Sand Member (= Sables de Mons-en-Pévèle of Gosselet) (Fig. 11).

The other lithostratigraphic units introduced by Gosselet (Argile d'Orchies, Argile de Roubaix, Argile de Roncq) are recommended to be abandoned, as they are either inadequately defined, or, as in the case of the Argile de Roubaix and the Argile de Roncq, have been misused so extensively as to be almost valueless.

As stated above, it is intended here to extend the term Ieper Formation to include the equivalent beds ("Argile de Flandres", etc.) across the French frontier. The stratigraphic subdivisions of this Formation are intended also to be used in both countries — of the three new named Members, one is based on a Belgian stratotype and two on French stratotypes.

MONT-HERIBU MEMBER

Lithology: Silty to very silty clays with thin beds and laminae of silt and very fine sand. A thin basal poorly sorted sandy and glauconitic bed with reworked pebbles is usually present.

Distribution: This unit forms the basal Member of the Ieper Formation in this area. and can be correlated with the Mt. Héribu Member of De Coninck *et al.* 1980. It is probably present throughout the area under study. It is exposed at Arques, near Wardrecques (Pas de Calais) where it is 7 m thick, at Leforest (4.5 m), and is present in the Ooigem borehole between c. 86.5 m and c. 93.6 m. It is probably represented in the Renaix area by a unit (c. 8 m) of clays with sandy partings and lenses at the base of the Ieper Formation (Delvaux, 1883) (see fig. 10). In the quarry at Lessines (Dupuis & Robaszynski, 1986) the Mont-Héribu Member can be identified as their unit "b" (clay with silty seams and sandy layers), up to 5 m thick.

Microfauna: Characterised palaeontologically by the presence of large pyritised diatoms (especially *Coscinodiscus sp. 1* and *C. sp. 2*), associated with a limited assemblage of non-calcareous (AG1 group) agglutinating foraminiferids (Willems in De Coninck *et al.* 1980).

WARDRECQUES MEMBER (new term)

Type locality: Wardrecques clay quarry. (France, Pas de Calais) (Fig. 9). Only the upper and middle part of the Member is exposed here. The Lessines quarry section (Dupuis & Robszynski 1986) is proposed as a reference-section for the lower part of the Member; the Heestert canal section is proposed as a reference-section for the highest part of the Member (Fig. 7).

Lithology: The base of this unit is exposed at Leforest, where it is well-defined, but not marked by a discontinuity or erosion-surface. The lower part of the Wardrecques Member comprises very homogenous silty clays, with frequent phosphatic nodules. Beds of large semi-tabular calcareous sideritic concretions are present in the lower part of this unit, recorded at Renaix ("Argile terreuse" of Delvaux, between c 12 m and c. 17 m above the base of the Ieper Formation), at Leforest, in the Ooigem borehole ("septaria" at c. 79 m), in the Mouscron borehole ("argilite" between 83.5 m and 86.5 m), and at Wardrecques (as loose blocks from near the base of the excavations). The section in the Lessines quarry has not been visited by the author, but the lower part of the Wardrecques Member can be identified from the description of Dupuis & Robaszynski (1986, Fig. 4) as their unit 'c', 'grey compact clay', 8.5 m thick; a calcareous nodule layer is recorded here about 1 m above the base of the unit. There are sandier levels in the upper part of this unit at Ooigem.

The upper part of the Wardrecques Member comprises silty calcareous clays with some ill-defined beds of sandy clay and sandy silt, and several shell-rich beds. It becomes more silty and sandy southeastwards. Within this part of the succession are up to five thin glauconitic and shelly pockets or beds. The top of the Wardrecques Member is taken at the top of a prominent glauconitic bed, which is the highest important glauconitic bed in the middle of the Ieper Formation, and coincides with Event I 6.

Distribution: Throughout the area, from Wardrecques to east of Renaix. The thickness is approximately 45-55 m. The Wardrecques Member is probably present throughout the area under study, but due to lack of information in the area between Tournai and Mons, and on the Mons-en-Pévèle outlier, its extent is at present uncertain. Its upper part (at least) passes eastwards and southwards into the lower part of the Mons-en-Pévèle Sand Member.

The 'Argile d'Orchies' of Gosselet corresponds approximately to the Mont-Héribu Member and the lower part of the Wardrecques Member. The 'Argile de Roubaix' corresponds approximately to the upper part of the Wardrecques Member and the overlying Bailleul Member.

Microfauna: The basal junction of the Wardrecques Member is marked by the appearance of a moderately diverse assemblage of non-calcareous agglutinating foraminiferids, associated in some localities with calcareous benthonic and planktonic foraminiferids. This assemblage persists through the lower part of the Member, but there is a rapid faunal change at Event I 1 to a benthonic foraminiferid assemblage composed almost exclusively of calcareous foraminiferids and AG2 agglutinants, accompanied by planktonic foraminiferids which are very common at some levels. *Nummulites planulatus* is common at one level near the top of the Member in the Kortrijk area, but is recorded only very rarely at Wardrecques. Biostratigraphic events I 2 to I 5 are identified within the upper part of the Wardrecques Member.

BAILLEUL MEMBER (new term)

Type locality: Clay quarry at Bailleul (France, Nord). (Fig. 8). A reference section for the lower part of the Member is designated at the Heestert canal section (Fig. 7).

Lithology: More lithologically differentiated than the Wardrecques Member, comprising interbedded silty clays, sandy silts and thin silty sand beds; some of these beds are very rich in shells. Glauconite is not common, except near the base. This unit corresponds to the major part of the "Argile de Roubaix".

Distribution: Identified in the area from Wardrecques to east of Kortrijk, thickness c. 13-25 m. To the south and east of Kortrijk, this unit becomes progressively more sandy, and passes into the upper part of the Mons-en-Pévèle Sand member.

Microfauna: A diverse and abundant calcareous microfauna is present, differing from the microfauna of the Wardrecques Member by the scarcity or absence of nodosariid and planktonic foraminiferids. *Nummulites planulatus* occurs commonly in some beds in the Kortrijk area, but becomes progressively rarer north-eastwards.

AALBEKE MEMBER (new name)

Type locality: clay quarries in the Kortrijk area, currently visible at Pottelberg, Aalbeke (see De Coninck 1976b) and Kwadestraat (Heestert). A specific type locality is not designated here, as all these sites are liable to be infilled in the near future (if not already obliterated).

Lithology: Homogenous silty clay with some thin beds of sandy clay, generally decalcified (the "heavy clay" unit). At Bailleul and in the Kortrijk area, the base is transitional through about 0.2-0.3 m to sandy clays or silty sands of the Bailleul member; at Wayenberghe the basal contact on the very fine sands of the Mons-en-Pévèle Sand Member is sharp.

Distribution: Present in the area between Bailleul and Renaix. Thickness approximately 10 m in the Kortrijk area, but may be significantly thicker further west, where no accurate data is available. East and south of Renaix, this unit is probably still present, but cannot at present be identified positively due to lack of information. It appears to pass in this area into sandy and glauconitic facies currently referred to as the 'Paniselian'. This unit is the "P 1 m" clays and "Clays of Roncq" of previous accounts (Leriche 1927, Kaasschieter 1961).

Microfauna: This unit is apparently everywhere decalcified, except at the base, and no calcareous microfauna has been obtained at other levels, although there is evidence from the presence of pyrite casts and moulds of foraminiferids, ostracods and molluscs that a calcareous fauna was originally present.

"UNNAMED SAND MEMBER"

Type locality: this unit is introduced to complete the lithostratigraphic succession in the Kortrijk area, but as its relationships are uncertain, it is not formally named. It is exposed at the top of the Kwadestraat quarry, Heestert.

Lithology: Very fine bioturbated glauconitic sands. The basal junction is sharp but intensely interburrowed at Kwadestraat and Marke.

Distribution: This unit is recorded at the top of the Mouscron borehole, and is seen in outcrops near Kortrijk. It is the highest unit preserved in the Kortrijk area, and has a maximum recorded thickness of c. 4 m. It is tempting to correlate it with the Egem Member, but its relationship to the Egem Member of the Tielt-Ieper area to the north-east and to the sequence in the Renaix area to the east are uncertain.

Microfauna: No calcareous microfauna is preserved, but siliceous sponge spicules occur.

MONS-EN-PEVELE (Sand) Member

Type locality: This unit is a formalised version of the 'Sands of Mons-en-Pévèle', and the type-locality is taken as the outlier of the same name. No permanent exposures exist here. The Wayenberghe railway cutting is chosen as a reference-section for the top part of the Member. This is the only locality where its upper junction is exposed.

Lithology: Dominantly very fine grained silty micaceous bioturbated sands, at some levels laminated or ripple-cross-stratified, with common very fine-grained glauconite; interbedded with sandy silts, sandy clays and thin beds of silty clay. Several coarser beds packed with Nummulites are present.

Distribution: Restricted to the area to the south-east of a line from Lille to Gent, from Mons-en-Pévèle to Tournai, Ronse, and probably extending to Mons and Brussels (see comments below). Thickness c. 30 m-50 m.

Microfauna: A diverse calcareous microfauna is present throughout, including planktonic foraminiferids in the lower part of the section. *Nummulites planulatus* is common, and forms concentrated thin beds or lenses at several levels.

RELATIONSHIP OF MONS-EN-PEVELE MEMBER TO THE ARGILLACEOUS FACIES OF THE IEPER FORMATION

The Mons-en-Pévèle Member apparently 'fingers' into the Wardrecques and Bailleul Members in the area immediately to the south of Kortrijk. Beds of 'Mons-en-Pévèle facies' are present in these units at Heestert and probably in the Mouscron borehole, and the upper part of the Bailleul Member at Marke includes beds which approach the Mons-en-Pévèle Member in facies (see Fig. 10). There is therefore probably a complete transition between the two facies.

The microfauna of the Mons-en-Pévèle Member has been sampled at Mons-en-Pévèle, Wayenberghe and Montrœul-au-bois. Although continuous sections have not been available, the results appear to show that a sequence of microfaunas is present which can be correlated well with the sequence of biostratigraphic events seen in the argillaceous facies, between events I2 and I9, which occur in the upper part of the Wardrecques Member and in the Bailleul member. This essentially confirms the lithostratigraphic correlations.

RELATIONSHIP OF THE SEQUENCE IN THE WARDRECQUES — KORTRIJK AREA TO THE SUCCESSION IN NORTH-WEST BELGIUM

The Mont-Héribu Member can be identified in the Tielt borehole, but further north, at Knokke, it has passed into a homogenous clay facies which cannot be separated from the Flanders Member, although still retaining a distinctive microfauna (King, in press). The Wardrecques Member, Bailleul Member and Aalbeke Member pass north-eastwards into the homogenous clay facies of the Flanders Member. The biostratigraphic events identified in the former units can in some cases be traced into the Flanders Member, as at Tielt and Knokke (Fig. 11), and this confirms the lithostratigraphic relationships. The Aalbeke Member is similar in lithology to the Flanders Member, and can be envisaged as a 'tongue' of the Flanders Member. It corresponds approximately to the 'barren zone', decalcified clays of the upper Flanders Member. These clays pass upwards into sandy clays with abundant sponge spicules ('sponge-spicule facies' of Fig. 11), which are overlain by the Egem Member.

RELATIONSHIP OF THE EGEM MEMBER TO THE MONS-EN-PEVELE MEMBER

The lithostratigraphic and biostratigraphic evidence shows that the Mons-en-Pévèle Member is older than, and entirely separate from, the Egem Member. The two units represent separate phases of progradation of sands from the basin margins. The Egem Member overlies the Flanders Member, while the Mons-en-Pévèle Member underlies the Aalbeke Member, which probably corresponds to the middle part of the Flanders Member. There is no evidence that the two units are anywhere in contact. As demonstrated here, the microfaunas of the Mons-en-Pévèle Member show clear correlations with those of the clay facies of the middle Ieper Formation, and are quite distinct from the microfauna of the Egem Member.

THE "SABLES DE FOREST" AND "SABLES DE MONS-EN-PEVELE" AT MT. PANISEL

The lithofacies and biostratigraphical relationships identified in this study have implications for the stratigraphy over a wider area. Are the "Sables de Mons-en-Pévèle"/"Forest Sands" mapped in the Brussels area and in the outlier of Mt. Panisel near Mons equivalent to the Egem Member or to the Mons-en-Pévèle Member?

The sections at Forest and at Mt. Panisel both contain diverse microfaunas, not directly comparable to those found in the area here under study, and more akin to the Cuisian faunas of the Paris Basin (Keij, 1957; Kaasschieter, 1961). A sample from the "nummulite falun" near the top of the "Sables de Mons-en-Pévèle" on Mt. Panisel contained occasional specimens of *Echinocythereis sp. A*. Samples from the "Nummulites planulatus bed" in the "Sables de Forest" at Forest (Feugueur 1963, p. 438) also contain this species, together with *Lentipecten corneum*. This strongly suggests correlation of both these units with the upper part of the Mons-en-Pévèle Member (between events I5 and I7).

The similarity of the microfaunas from Forest and Mt. Panisel is emphasised by some statistics. 18 species of ostracods are recorded from Forest by Keij (1957); 16 of these also occur at Hyon (Mt. Panisel), where a total of 24 species are recorded; of 28 species of foraminiferids recorded at Forest by Kaasschieter (1961), 26 occur also at Hyon.

Another feature in common is the presence of the distinctive foraminiferid *Rotalia* aff. *viennoti* Grieg (*R. thouini* d'Orbigny of Kaasschieter 1961: 243 — see Le Calvez 1970) at both localities; this species is recorded from only one other locality in Belgium (Kaasschieter 1961). It is concluded that the 'Sables de Forest' and the upper part of the 'Sables de Mons-en-Pévèle' at Mt. Panisel can be correlated, and that both are referable to the upper part of the Mons-en-Pévèle Member (as here defined).

THE PROBLEM OF THE 'PANISELIAN'

The type 'Paniselian' (Panisel Formation) at Mont Panisel (Mons) directly overlies the Mons-en-Pévèle Sand Member. In the Renaix area beds currently referred to the 'Paniselian' also overlie this unit. In the Brussels area, the highest unit of the Ieper Formation is apparently the 'Sables de Forest', which are here referred also to the Mons-en-Pévèle Sand Member. Although at Forest itself they are overlain directly by the Middle Eocene Brussels Formation, they are apparently overlain by the Panisel Formation to the west of Brussels.

These relationships are consistent within themselves, but quite different from the situation

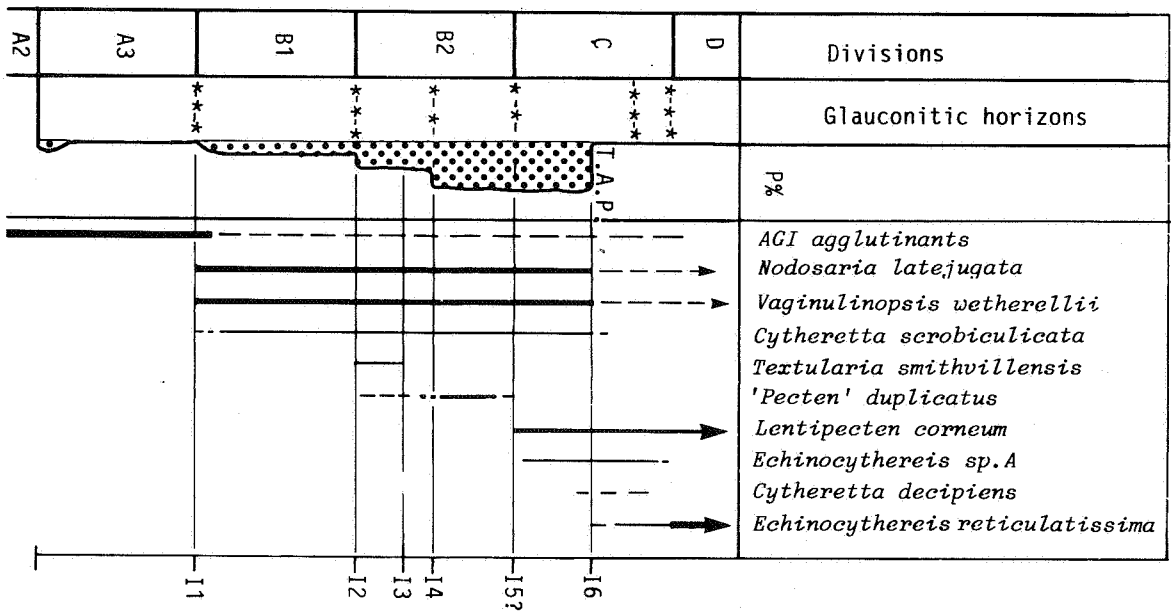


Fig. 12
Stratigraphic subdivisions and key fossils of the middle London Clay Formation and their probable correlation with biostratigraphic events in the Ieper Formation.
T.A.P. = 'top abundant planktonics' horizon (King 1981).

in northern Belgium, where the beds referred since the time of Dumont to the Panisel Formation overlie the Egem Member. Two possibilities must therefore be considered:

1. the beds referred to the 'Paniselian' in southern and central Belgium are in reality a facies of the upper part of the Ieper Formation;
2. the 'Paniselian' is a single correlative unit throughout Belgium, but there is a hiatus between the Mons-en-Pévèle Sand Member and the Panisel Formation in southern Belgium.

At present, the information available is insufficient to decide which of these alternatives is correct, mainly because the stratigraphy of the 'Paniselian' in southern Belgium is not adequately known. At Mont Panisel itself there is certainly a sedimentary discontinuity at the base of the Panisel Formation, marked by an interburrowed junction with a basal bed rich in glauconite and including coarse quartz grains. At Wayenberghe the contact is not marked by such a break, but it is possible that the sequence is more complex than implied by Delvaux's description and that there is a corresponding discontinuity at a higher level. In the Brussels area the nature of the junction is apparently uncertain.

These factors clearly have implications for the lithostratigraphic terminology of the beds involved. Resolution of the problem, in the absence of the necessary lithostratigraphic data, could most readily be obtained from analysis of the dinoflagellate assemblages.

6. CORRELATION WITH THE PARIS BASIN AND SOUTHERN ENGLAND

Correlation with the Cuisian of the Paris Basin

The conclusions of this study bring the possibilities of detailed correlation with the Early Eocene succession in the Paris Basin one step closer. The biostratigraphic correlation of the Early Eocene "Sables de Cuise" (s. l.) in the Paris Basin has recently been much improved by studies of the organic microplankton and calcareous nannoplankton (summarised by Cavelier & Pomerol 1986). However, the physical correlation of individual lithostratigraphic units, and the tracing of stratigraphic events from the Paris Basin to northern France and Belgium, has not advanced significantly beyond the conclusions reached by Feugueur (1963).

Samples collected from the upper part of the "Sables d'Aizy" (*Nummulites planulatus-Alveolina oblonga* "falun") at Mont de Magny (Gisors) (Feugueur 1963, p. 197), from the upper part of the 'Sables d'Aizy' at Breuil, and from the overlying "Pierrefonds horizon" at several localities, contain rare to frequent specimens of *Echinocythereis sp. A*, although *Echinocythereis* is not common at any locality so far sampled. This species is figured from the "Pierrefonds horizon" by Ducasse et *al.* 1985 as *E. cf. reticulatissima*. The overall microfauna of these units is similar to the microfauna of the Mons-en-Pévèle Sand Member at Mt. Panisel and Forest.

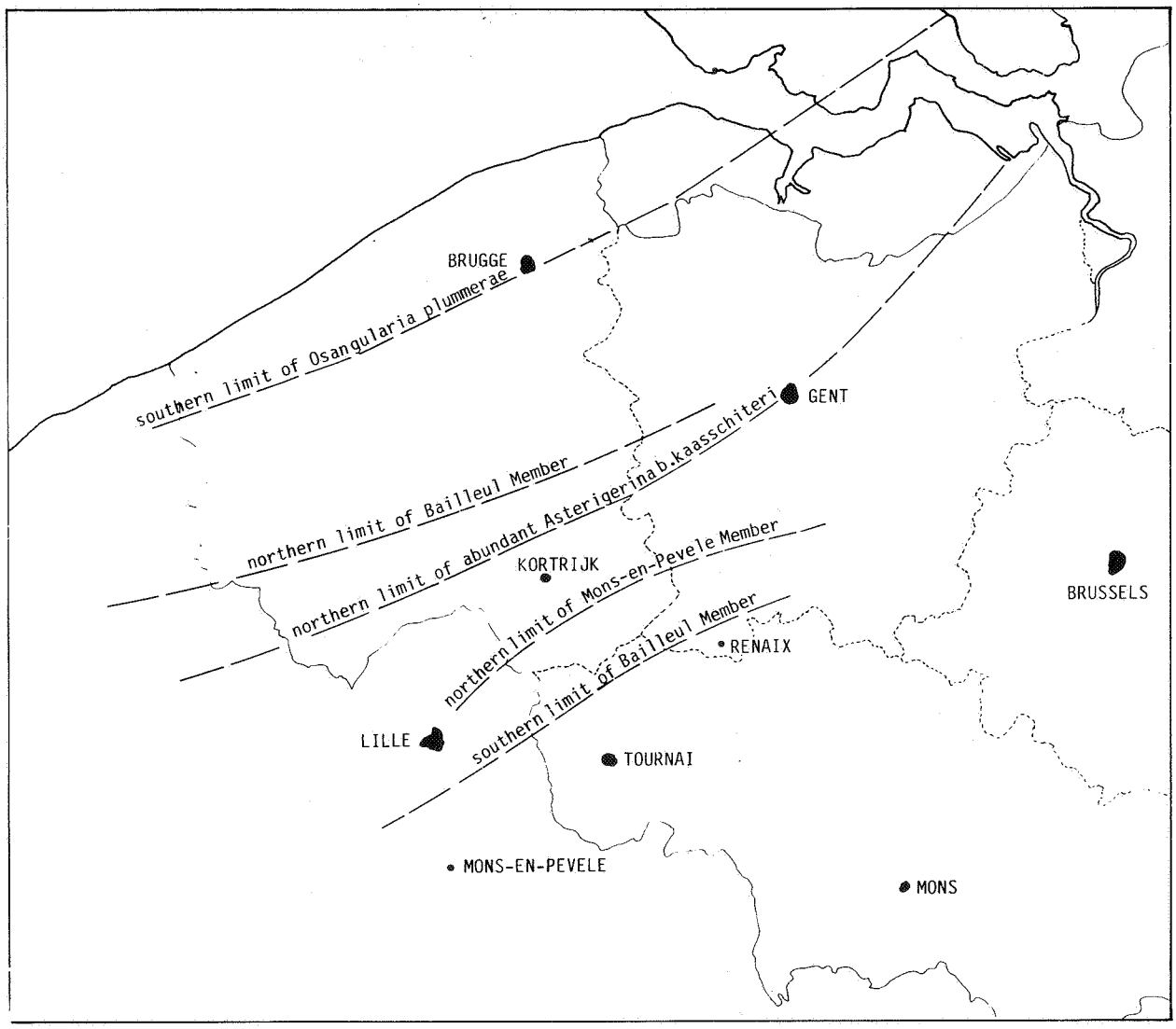


Fig. 13

Distribution of facies belts in the Ieper Formation of western Belgium and northern France

The occurrence of *Echinocythereis sp. A* implies correlation of the upper part of the "Sables d'Aizy" and the "Pierrefonds horizon" with the upper part of the Mons-en-Pévèle Member (Fig. 14). Taken together with the occurrence of rather uncommon but nevertheless widely recorded planktonic foraminiferids in these units, it implies correlation with part of the interval between events I 5 and I 7, if these biostratigraphic correlations are valid for this area. *Echinocythereis reticulatissima* has not been recorded so far in the Paris Basin; this may reflect the relatively coarse-grained facies developed towards the top of the "Pierrefonds horizon", which can be seen elsewhere to be unfavourable for *Echinocythereis*, or the general decalcification of the upper part of the 'Cuisian' (Argile de Laon and equivalent beds).

The facies change marked by the incoming of an argillaceous facies (Argile de Laon) above the Pierrefonds horizon, often with siliceous sponge spicules, may therefore correlate with the base of the Aalbeke Member. The Argile de Laon also includes glauconitic and "siliceous" facies similar to those in the "Paniselian", with which it was correlated by several authors including Feugueur, but as demonstrated above, such facies may well be present within the upper part of the Ieper Formation in southern Belgium.

Correlation with the London Clay Formation

Microfaunal correlations between the Ieper Formation and the London Clay Formation have recently been discussed by King (1981) and further details are given by King (in press). The biostratigraphic information presented here enables these correlations to be refined and extended. In particular, it is possible now to suggest that some of the stratigraphic discontinuities recognisable in the London Clay Formation, marked by pebble-beds or glauconite-rich horizons and used as division boundaries (King 1981), can be identified with the glauconitic horizons in the Ieper Formation (Fig. 13) (see comments in next section on the significance of these beds).

The Mont-Héribu Member, as seen at outcrop, is identical in lithology and microfauna with the Walton Member (Division A2) of the eastern London Basin. The A2/A3 boundary, defined in England by a lithological change to homogenous silty clays, and associated with a microfaunal assemblage change, can be correlated precisely with the Mt. Héribu Member / Wardrecques Member boundary.

The base of Division B in England corresponds approximately to benthonic and planktonic foraminiferid assemblage boundaries which correlate with those defining Event I 1, as noted elsewhere (King 1981, King in press).

Textularia smithvillensis occurs in the London Clay Formation only within the lower part of Division B2. It is therefore considered highly probable that the glauconitic horizon which corresponds to Event I 2, marking the earliest appearance of *T. smithvillensis*, can be correlated with the glauconitic bed/pebble bed which defines the base of Division B2.

The bivalve *"Pecten" duplicatus*, which is recorded at Wardrecques and Ooigem between Event I 4 and Event I 5, is a characteristic species of the upper part of Division B2 in England. The glauconite level which coincides with Event I 4 may therefore equate with a glauconite-rich bed recently identified within Division B2 in the Hampshire Basin.

The Division B / Division C boundary in England is associated with several faunal events, including the appearance of *Lentipecten corneum* and *Echinocythereis sp. A*. In Belgium, both these species appear between Events I 5 and I 6. It is considered most probable that the glauconite horizon associated with Event I 5 can be equated with the Division B / Division C boundary.

In the London Clay Formation, the highest percentages of planktonic foraminiferids are recorded in the upper part of Division B2 and in the lower part of Division C (King, 1981). As this relatively high abundance of planktonics probably reflects a basin-wide tectonic/eustatic event, it is considered logical to correlate abundance levels between the London Clay Formation and the Ieper Formation, where the highest percentages of planktonic foraminiferids occur between Events I 4 and I 6. This correlation agrees with the evidence for correlation from other sources. The abrupt fall in abundance of planktonics at Event I 6 can probably be correlated with the corresponding event in the London Clay Formation (the T.A.P. level of King, 1981) which occurs within the middle of Division C.

Echinocythereis reticulatissima is rare in England in Division C, but occurs consistently from the base of Division D. In the Ieper Formation it occurs very commonly from Event I 6. This suggests that the glauconite-rich level at Event I 6, which is at most localities the most prominent and most highly glauconitic bed in the succession, may represent a significant discontinuity, correlating with the base of Division D, or a highly condensed representative of the upper part of Division C. It is noteworthy that glauconite occurs commonly in the upper part of Division C in the eastern London Basin (King, 1981 and 1983).

Above Event I 6, detailed correlation is at the moment not possible.

7. ASPECTS OF THE LITHOFACIES

Glauconitic beds

The occurrence of a thin bed (or beds) with common relatively coarse-grained glauconite in the middle of the Ieper Formation was noted by Gulinck (1967) in the Kallo and Tielt boreholes. He suggested that they could potentially be used as a lithostratigraphic marker-horizon. De Coninck (1976) introduced the name "lit glauconifère de Tielt" for this bed. The present study has demonstrated that at least five thin beds (usually less than 15 cm thick) with common to abundant, fine to coarse grained glauconite, can be identified within the middle of the Ieper Formation in this area, and often mark the boundaries of successive microfaunal assemblages.

Similar beds occur within the London Clay Formation. Here they can be traced laterally towards the palaeo-shoreline into pebble-beds, which form the basal transgressive units of cyclic coarsening-upwards sedimentary sequences (Divisions A to E of King 1981). They are interpreted as condensed deposits, formed in a shallow marine environment during phases of marine erosion or very slow sedimentation, due to clastic starvation in the transgressive phase of each cycle.

The controlling factors in this pattern of sedimentation are inferred to be eustatic sea-level changes or intermittent basin subsidence related to the development of the North Sea Basin. In either case, they are the reflection of events which can probably be traced throughout the Basin. Their identification in Belgium and northern France not only provides valuable marker horizons for local and regional correlation, but also significantly enhances understanding of the overall pattern of sedimentation in this area.

Lithofacies trends

Three major lithofacies belts can be delimited within the middle of the Ieper Formation in this area. These are defined by grainsize trends, which, with support from the faunal evidence, can be assumed to reflect relative water depths (Fig. 12):

1. A predominantly sandy facies belt, corresponding to the distribution of the Mons-en-Pévèle Member. As indicated by its facies, geographical position, and by the local abundance of larger rotaliid foraminiferids (Nummulites), this is a relatively shallow marine facies (perhaps 10-20 metres water depth).
2. An 'intermediate' facies belt, corresponding to the distribution of the Bailleul Member and the upper part of the Wardrecques Member. Here silty clays, sandy clays and sandy silts are interbedded.

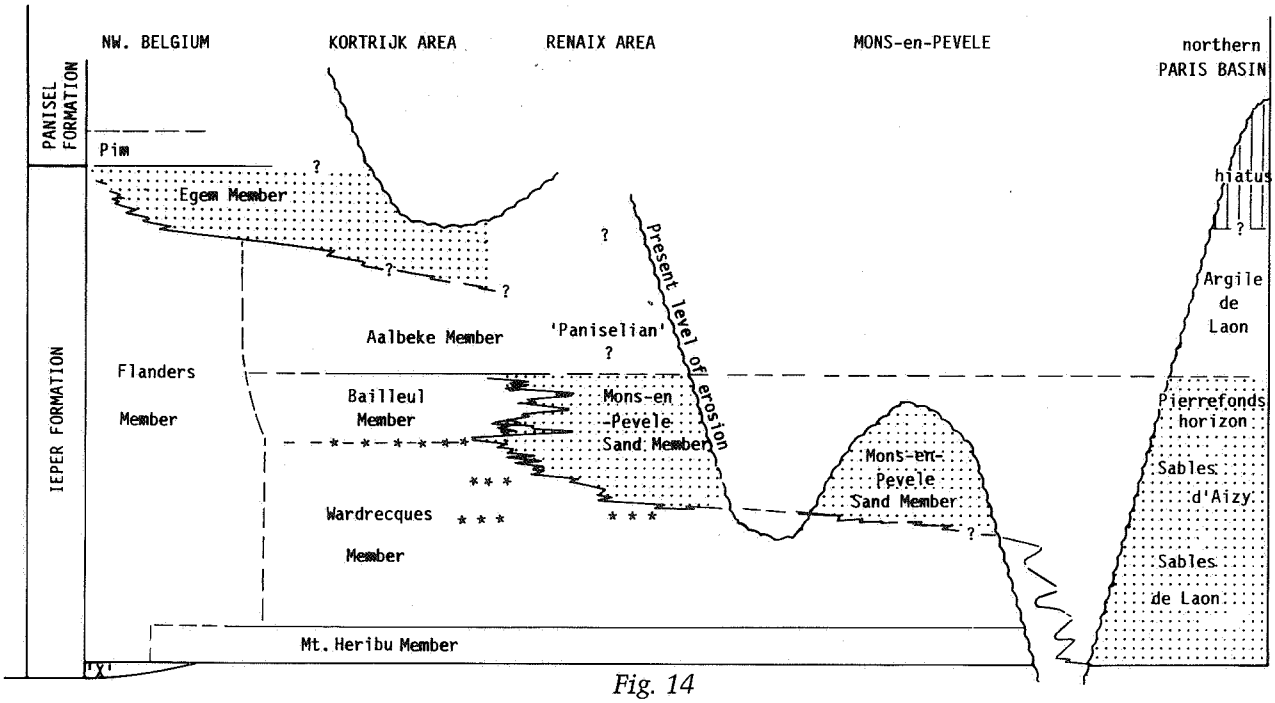


Fig. 14

Generalised model of lithostratigraphic relationships in the Ieper Formationof western Belgium and northern France.

The diverse benthic microfauna includes common *Asterigerina* and *Leguminocythereis*, which are typically shallow marine indicators, but associated with frequent planktonic foraminiferids at some levels. The fauna and facies indicates a deeper and lower-energy environment than in the previous area (perhaps 20-50 metres water depth).

3. A predominantly argillaceous (homogenous clay) facies belt, corresponding to the distribution of the Flanders Member. The microfauna includes significant numbers of nodosariid foraminiferids and planktonic foraminiferids are common at some levels. This facies was probably deposited in an outer sublittoral environment (c. 50-100 metres water depth, if compared with similar facies in the London Clay Formation).

8. CONCLUSIONS

1. A sequence of nine biostratigraphic events based on foraminiferids, ostracods and molluscs, can be identified within the middle of the Ieper Formation in western Belgium and adjacent areas of northern France. These are used to correlate outcrop and borehole sections.
2. A sequence of lithostratigraphic units is established within the Ieper Formation in this area, which are formally named as Members of the Ieper Formation.
3. Five or six thin glauconitic beds are identified within the middle of the Ieper Formation. These probably mark episodes of reduced sedimentation or minor sedimentary discontinuities, and often correspond to microfaunal assemblages changes. They can be correlated, aided by the biostratigraphic data, with similar sedimentary discontinuities in the London Clay Formation.
4. The Mons-en-Pévèle Sand Member of southern Belgium can be demonstrated by lithostratigraphic and biostratigraphic criteria to 'finger' northwestwards into the *middle* of the Ieper Formation. This unit is apparently completely separate from the higher sand development (the Egem Member) which occurs at the *top* of the Ieper Formation in northern Belgium.
5. The stratigraphic correlations within the Ieper Formation indicate that the Panisel Formation, as mapped in the Brussels area, the south of Belgium, and at Mont Panisel itself, rests directly upon beds equivalent in age to the middle of the Flanders Member. This implies that either there is a major discontinuity at this level, which is not yet supported by the available data, or else that the 'Panisel Formation' of these areas is a separate and older unit from the beds referred to the Panisel Formation in northern Belgium.
6. Detailed correlation of the middle and lower part of the Ieper Formation with the London Clay Formation is established, based on biostratigraphic criteria, and on the correlation of glauconitic beds between the two areas. Some tentative biostratigraphic and lithostratigraphic correlations are suggested with the Paris Basin.

9. FINAL COMMENTS AND ACKNOWLEDGEMENTS

This paper presents only a brief outline of the biostratigraphy and lithostratigraphy of the area studied, based largely on "reconnaisance" study of the most easily accessible outcrops and cores. Further extension and refinement of the stratigraphy depends largely on the availability of additional exposures and on detailed study of additional cored boreholes.

The area of transition between the Mons-en-Pévèle Sand Member and the argillaceous facies of

the Ieper Formation requires more study, and particularly the biostratigraphy of the Mons-en-Pévèle Member itself. The detailed stratigraphy of the "Paniselian" facies in the south of Belgium and their relationship to the Ieper Formation are not yet understood.

It will be noted that published biostratigraphic data on microplankton and calcareous nannoplankton has not been utilised in establishing the correlations. This is because it is considered that the correlations presented here should be able to stand on their own merits, independent of other evidence; it is intended that integration with other biostratigraphic data will be the subject of future work.

Further work will hopefully lead to better understanding of the regional pattern of facies, and to elucidation of the details of the Early Eocene history of this marginal segment of the North Sea Basin. These are not only of local interest, but form the basic data from which patterns of basin evolution can be established.

Sincere thanks are here expressed to colleagues in Belgium, for their hospitality, help in the field and assistance with information and samples. This study would have been impossible without their co-operation.

Dr. Pieter Laga (Geological Survey of Belgium) provided access to core samples, and supplied unpublished lithological logs for boreholes drilled for the Survey; all details from these boreholes are published with the permission of the Geological Survey of Belgium.

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Above all, the late Willy Willems' work provided the biostratigraphic foundation for this study, and his help and hospitality are greatly missed. This contribution is dedicated to him.

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POSTSCRIPT

This study was completed, and the manuscript was submitted for publication, before publication of the revision of Ypresian stratigraphy by Steurbaut and Nolf (1986). Steurbaut and Nolf have studied many of the same sections as described in the present study. It is encouraging to discover that the correlations they propose are almost identical to those proposed here, although based on different fossil groups and utilising different techniques of correlation. However, the lithostratigraphic terminology proposed by Steurbaut and Nolf differs in several ways from that in the present study, and the following comments are intended to indicate the nature of the differences between the two schemes:

1. The Orchies Clay Member of Steurbaut and Nolf corresponds to the Mont-Héribu Member and the lower and middle parts of the Wardrecques Member. The very distinct lithology, wide distribution and well-defined upper limit of the Mont-Héribu Member is considered by the present author to justify its status as a separate Member, although downgraded to the status of a 'Bed' by Steurbaut and Nolf.

2. The junction between the Orchies Clay Member and Roubaix Clay Member is taken by Steurbaut and Nolf at a change from homogenous heavy clay to interbedded clay, silt and fine sand. However, this junction is transitional, and is almost impossible to identify consistently. For this reason, these terms were abandoned by the present author, and an easily identifiable and widespread glauconite horizon was taken as marking the junction between a lower predominantly silty clay unit (Wardrecques Member) and an upper more heterogenous unit, the Bailleul Member (approximately equivalent to the Roubaix Member of Steurbaut and Nolf). In the Kortrijk area, the glauconitic bed and immediately underlying beds are included in the Roubaix Clay Member by Steurbaut and Nolf; the base of this unit is nowhere exposed in this area, and thus the problem of defining its base is avoided!

3. The Mons-en-Pévèle (Sand) Member and the Aalbeke (Clay) Member of Steurbaut and Nolf correspond exactly to the similarly named units in this study. The 'un-named Sand Member' above the Aalbeke Member is correlated with the Egem Member by Steurbaut and Nolf.

Reference:

Steurbaut, E. and Nolf, D. 1986. Revision of Ypresian Stratigraphy of Belgium and Northwestern France. *Meded. Werkgr. Tert. Kwart. Geol.* 23: 115-172.