Bull. Soc. belge Géol., Paléont., Hydrol.	T. 78	fasc. 2	pp. 111-130	Bruxelles 1969
Bull. Belg. Ver. Geol., Paleont., Hydrol.	V. 78	deel 2	blz. 111-130	Brussel 1969

THE TYPE-LOCALITY OF THE SANDS OF GRIMMERTINGEN AND CALCAREOUS NANNOPLANKTON FROM THE LOWER TONGRIAN

E. MARTINI [1] & T. MOORKENS [2]

CONTENT

SUMMARY. A. DUMONT (1839-1849) considered the Sands of Grimmertingen as the base of his Tongrian stage (Grimmertingen is at present a hamlet in the municipality of Vliermaal in the Eastern part of Belgium).
Samples have been taken from the outcrop of the type-locality and from a new boring reaching a depth of 12,5 m, towards the base of this member.
Some of these samples from both outcrop and boring yielded fairly rich assemblages of calcareous nannoplankton of which a list is given: the assemblages belong to the *Ellipsolithus subdistichus* zone, the zone which was also recognised in the sand extracted from the molluscs of the type-Latdorfian (Lower Oligocene).
The recent sampling of the Grimmertingen-locality also permitted to find fairly rich associations of Hystrichospheres and of planktonic and benthonic Foraminifera, which are under current study.

ZUSAMMENFASSUNG. A. DUMONT (1839-1849) stellte die Sande von Grimmertingen an die Basis seines „Tongrien" (Grimmertingen befindet sich heute im Stadtbereich von Vliermaal im östlichen Teil von Belgien).
In der Typuslokalität der Sande von Grimmertingen wurden horizontmäßig Proben genommen und eine Bohrung bis zu einer Tiefe von 12,5 m niedergebracht, um nach Möglichkeit die Basis der Sande zu erreichen.
Verschiedene Proben aus dem Aufschluß und besonders aus der Bohrung enthielten Nannoplankton, das listenmäßig erfaßt wurde und das eine Einstufung der Schichten in die *Ellipsolithus subdistichus* Zone erlaubt, in die ebenfalls das Nannoplankton aus Mollusken der Typuslokalität des Latdorfs (Unter-Oligozän) zu stellen ist.

[1] Geologisch-Palaeontologisches Institut der Universität, 6 *Frankfurt a.M.* Senckenberg-Anlage 32 (Germany).
[2] Geol. Instit. of the State Univ. Ghent, Rozier, 6, *Ghent* (Belgium).

In den neugewonnenen Proben von Grimmertingen wurden ferner verhältnismäßig reichhaltige Gemeinschaften von Hystrichosphaeriden sowie von planktonischen und benthonischen Foraminiferen gefunden, die zur Zeit bearbeitet werden.

RÉSUMÉ. A. DUMONT (1839-1849) définissait la base de son étage Tongrien par les Sables de Grimmertingen. (Grimmertingen est un hameau dans la commune de Vliermaal dans l'est de la Belgique).
La localité-type a été échantillonnée dans son affleurement et par le moyen d'un sondage de 12,5 m vers la base de l'assise.
Quelques échantillons de l'affleurement et du sondage ont montré une association assez riche en nannoplancton calcaires dont une liste est dressée: les associations appartiennent à la zone à *Ellipsolithus subdistichus*, zone qui fut également reconnue dans les sables extraits des coquilles de mollusques du Latdorfien-type (Oligocène inférieur).
L'échantillonnage récent de la localité de Grimmertingen a également permis de découvrir des associations assez riches d'Hystrichosphères et de Foraminifères planctiques et benthiques, qui sont actuellement à l'étude.

1. *Introduction*

Some controversial viewpoints have been expressed recently in connection with the stratigraphic situation of the Eocene-Oligocene boundary, and some of them have been discussed during the « Colloque sur l'Eocène » (Paris, May 1968).

It appears that there is a fairly good agreement between West-European geologists as to the correlation of the respective lithologic units of the Eocene-Oligocene transitional strata in the English-, Paris-, Belgian-, and North German basins.

The exact situation of the Eocene-Oligocene boundary in the stratigraphy of the basins bordering the North Sea hence becomes more a problem of convention than one of correlation difficulties within this area.

However, correlations within the North Sea area were based until recently only on paleontological groups of a rather restricted geographical distribution: Molluscs, benthonic Foraminifera, Vertebrates, a.s.o.

The first two groups are generally strongly faciesbound and a number of species seem to be endemic for this area or even in one of its basins; furthermore the third group seems not very useful in this area as the fossils are rather scarce.

The paleontological discussions during the Colloquium were therefore concentrated on the microfossil groups for which a biozonation had been established in many areas: the zonations of the Nummulites, of the planktonic Foraminifera and of the calcareous nannoplankton.

Although these three groups are represented in the basins bordering the North Sea, the endemic character of most of the species of the first group prevent wide correlations; the scarcity and small dimensions of the planktonic Foraminifera in the West-European area, make their use dubious also, for the time being.

The third group has been studied recently in the West-European basins, and it seems that the calcareous nannoplankton give the best results in wide correlations at present, as characteristic species of the zonation are generally represented both in the basins bordering the North Sea and in more tropical regions.

The importance of the West-European basins lies in the fact that a great number of the internationally recognized stratotypes of chronostratigraphic units were established here.

The rather poor results of previous paleontological research have entailed that the intensive study of these stratotypes had been abandoned during some years in the West-European countries; some recent positive results, however, justify a more thorough search in the classical localities, which also has been recommended by E. BRABB (in press) after his visit to the area.

TABLE 1

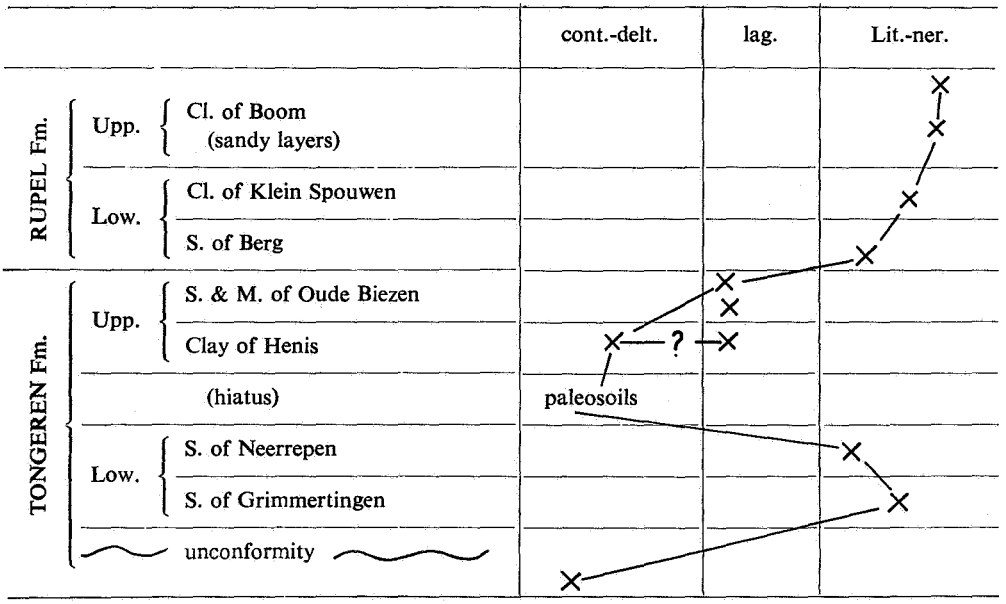
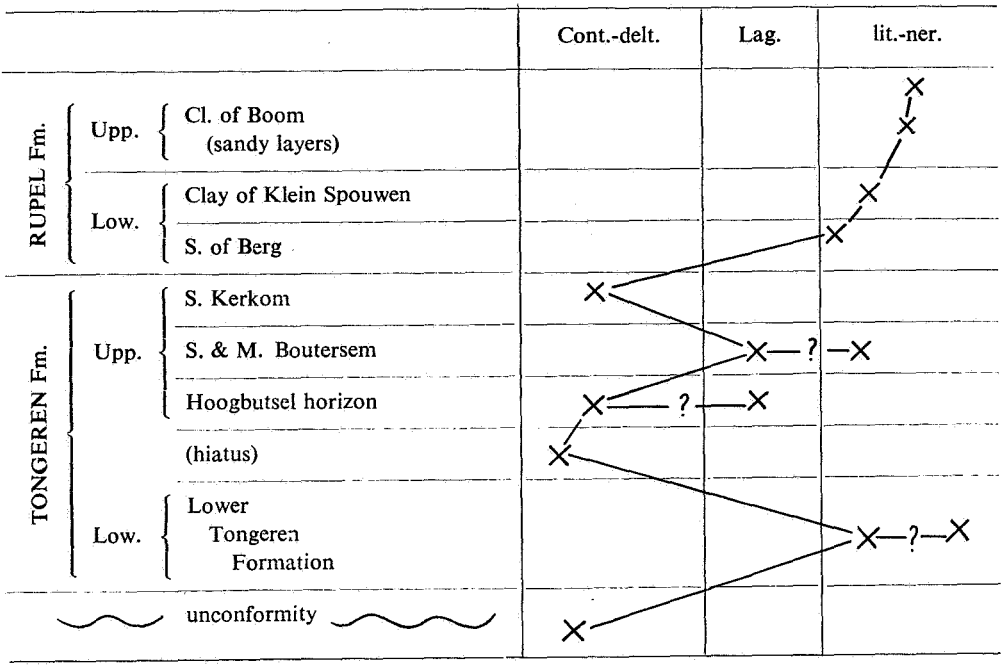


TABLE 2



2. *Historical review of some chronostratigraphical conceptions*

The division of the Tertiary in three periods (or sub-epochs) established in 1833 by Ch. LYELL was based mainly on the percentages of recent living mollusc species in the respective fossil assemblages.

This scheme of LYELL was followed by A. DUMONT (1839, 1849) when defining some of his stages and placing them in the stratigraphic column.

The Tongrian s.l. (= definition by A. DUMONT, 1839) was thus placed tentatively at the base of the Miocene; later A. DUMONT observed that the succession of lithologic units of his Tongrian s.l. reflected at least two consecutive transgressions (cf. tables 1 and 2). The succession of the second transgression was therefore defined as Rupelian (A. DUMONT, 1849) with the « sable jaunâtre » (later called the Sands of Berg) at the base. The Rupelian was thus separated from the Tongrian s.l., while the remaining basal part of this conception was redefined as Tongrian s.s. (= definition by A. DUMONT, 1849).

The basal stratum of the Tongrian s.l. and the Tongrian s.s. are the same layers from the same locality, already cited in 1839: Grimmertingen (see also the following chapter).

The Sands of Berg (in their type-locality), the full-marine sediment deposited at the beginning of the second transgression was considered as the base of the Rupelian stage, while the type-locality of the Clay of Boom, near the Rupel river (the type-Rupelian) shows sediments deposited during the upper part of this Rupelian stage.

As all the localities, and the members of these two transgressive cycles can easily be recognised and as the region shows a simple stratigraphy, the definitions of A. DUMONT (1849) can unambiguously be followed; both the basal and the top-sediments of the Tongrian and the Rupelian cycles are defined by marine deposits; only part of the Upper Tongrian consists of continental sediments [1].

The later defined Stampian s.l. (= definition by A. d'ORBIGNY, 1852) in the Paris Basin, of which the lower part was later separated, to form the Sannoisian (A. de LAPPARENT, 1893) and of which the remaining part was defined again as Stampian s.s. fall in synonymy with part of the earlier created Tongrian and Rupelian stages.

As the transitional Eocene-Oligocene layers in the Paris basin are mainly reflecting freshwater and brackish to lagoonal conditions, G. DENIZOT (1968) concludes that the succession of the Paris basin better should not be chosen to establish the stratotype of the basal Oligocene, thus controversing C. CAVELIER (1968) who proposes to consider the „Argile verte de Romainville" of this area as the basal stratum of the Oligocene.

The Oligocene conception was defined by E. BEYRICH (1854, 1856) who observed that the mollusc-assemblages found in a number of outcrops in Germany could be correlated with those of the classical Tongrian deposits described by A. DUMONT.

He had noticed that these mollusc assemblages could be distinguished from the typical Eocene associations as well as from those of the typical Miocene: the layers containing this assemblage therefore characterized a certain period which he called the Oligocene, and which was defined on a number of localities in Germany.

The basal part for this German Oligocene succession was tentatively parallelised with the "Tongrien inférieur" of A. DUMONT which is defined by the Grimmertingen-locality.

Unfortunately the cited outcrops for the lower Oligocene in Germany belong to different ages, as could be deduced from the calcareous nannoplankton (E. MARTINI & S. RITZKOWSKI, 1968).

The Latdorfian stage defined by MAYER-EYMAR (1893) and equated with BEYRICH's lower Oligocene, however refers to one locality, which unfortunately is not to be seen anymore. The calcareous nannoplankton

[1] The Upper part of the Oude Biezen member (= Vieux Joncs), considered as Upper Tongrian, shows planktonic and benthonic Foraminifera and also some calcareous nannoplankton and is thus to be considered as an open marine facies.

extracted from the mollusc-shells found at this locality belong to a zone which is younger than those found in the classical outcrops of the Bartonian and of the Priabonian (E. MARTINI & S. RITZKOWSKI, 1968).

Traditionally the base of the Oligocene has been situated at the base of the Latdorfian or of the Tongrian by the majority of the authors in the stratigraphic literature.

Some authors however (A. WRIGLEY, 1929; A.M. DAVIES, 1934; A.I. KOROBKOV, 1964; W. KRUTZSCH & D. LOTSCH, 1957, 1963, 1964; C. CAVELIER, 1968) suggested that the definition of the basal Oligocene should be altered, as it does not (according to their opinion) coincide with the major faunal break of this period: for some groups of macrofossils, like the molluscs (C. CAVELIER, 1968) and the vertebrates, the major faunal break would lie higher in the succession.

Different viewpoints for redefining the Oligocene conception by situating its base higher in the biostratigraphy than the base of the Latdorfian and the Tongrian have however been emitted, as these authors do not agree with each other where to situate the most important faunal break.

It appears now that three different main viewpoints exist concerning the situation of the Eocene-Oligocene boundary:

a) To follow as much as possible the original definition of the conception given by E. BEYRICH (1854, 1856), and to see which groups permit to situate this limit in the biostratigraphy. Except for a number of mollusc species, some species of planktonic Foraminifera and of calcareous nannoplankton have been cited. F. GRAMANN (1968) further substantiates a lineage in the benthonic Foraminifera *(Asterigerina)* and some Ostracods. E. MARTINI & S. RITZKOWSKI (1968) have restricted the classical Lower Oligocene outcrops of E. BEYRICH and of A. v. KOENEN to those which are equated to the type-Latdorfian (belonging to the *E. subdistichus* zone) while older sediments are equated with the Bartonian or the Priabonian. This calcareous nannoplankton zonation shows the advantage to lead to world-wide correlations.

b) To consider an important faunal break in the mollusc assemblages and probably also in the Vertebrates association, which would lie approximately at the base of the Upper Tongrian (Hoogbutsel horizon) in Belgium, the base of the "Sannoisian" (Argile verte de Romainville) in the Paris Basin, and the base of the "Neuengammer Gassande" and "Magdeburger Sande" in Germany. (this new definition was suggested by W. KRUTZSCH & D. LOTSCH, 1957, 1963, 1964 and by C. CAVELIER, 1968).

c) To consider another faunal break as the most important of this period, which would take into consideration the extinction of some groups of larger Foraminifera (the Discocyclines and some Nummulites) in the more northern basins of Russia; according to some Russian authors this limit would have to be situated at the base of the traditional Middle Oligocene (sensu E. BEYRICH, 1856), or at the base of the Rupelian stage, or at the base of the Stampian stage s.s. (this new definition was suggested by A. WRIGLEY, 1929; A.M. DAVIES, 1934; A.I. KOROBKOV, 1964, pp. 747-760 and pp. 911-913).

The fact that two different propositions (b, c) of redefining the Oligocene are both refering to "a major faunal break" suggests that this phenomenon is not so easy to localize as has been declared by these different authors.

None of the new propositions (b, c) refer clearly to any biozonation of planktonic organisms, which, however seem for the moment to be the only tool for world-wide correlations.

3. *The Eocene-Oligocene transitional strata in Belgium*

The Tongeren and Rupel Formations — taken together with the Voort Formation they are traditionaly called the Oligocene deposits of Belgium — are to be found in Belgium below the Quaternary in a WNW-ESE oriented area, reaching from Stekene to Tongeren (see fig. 1).

South of this region they have been almost completely eroded; to the north they are

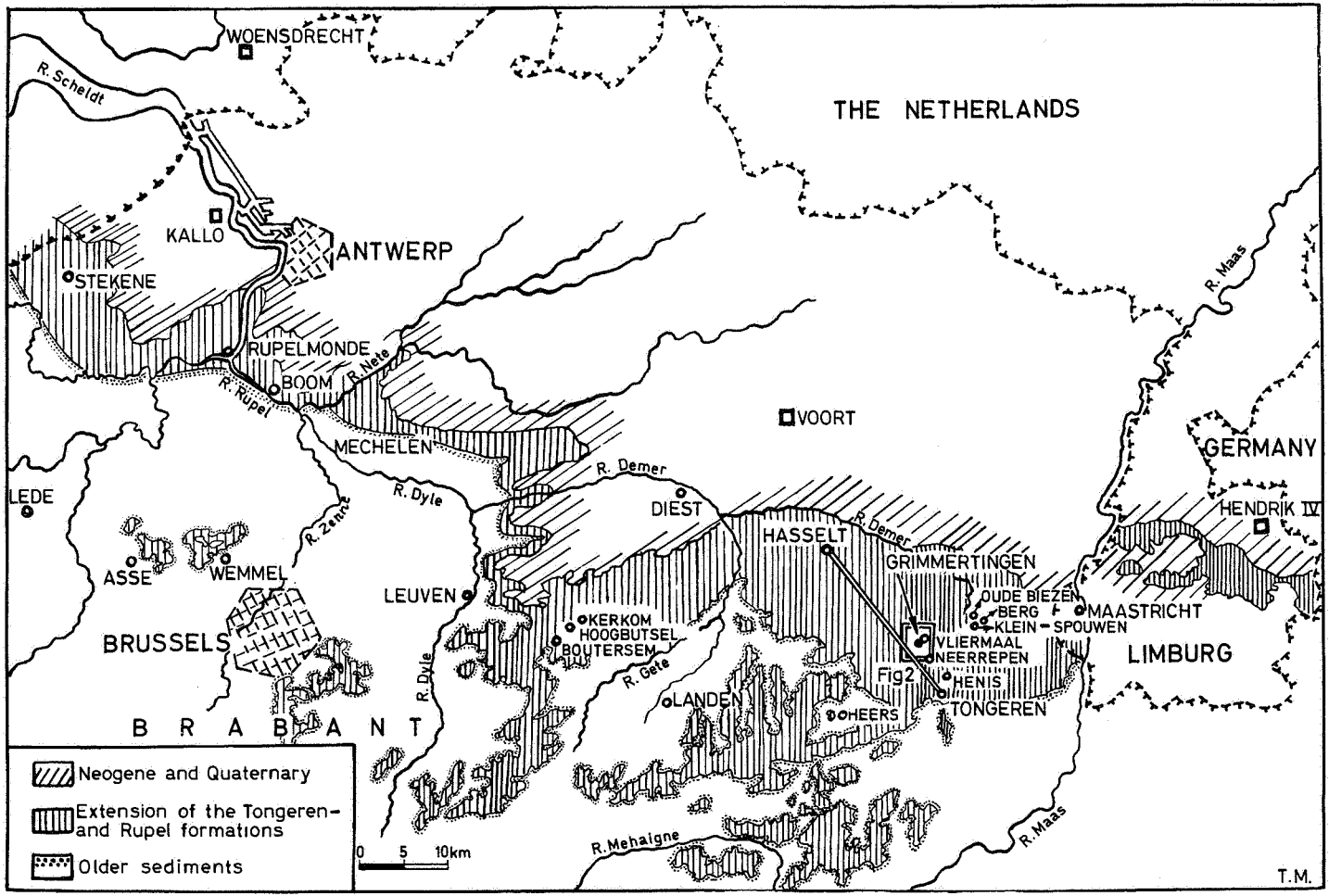


Fig. 1. Classical localities and extension of the Tongeren and Rupel formations (Oligocene) in Belgium.

dipping gently and are covered by younger (Neogene) deposits.

The members distinguished within these two Formations change from region to region: in the Tongeren region and in the Leuven-Diest region two transgressive cycles clearly can be observed, while in N.W. and North-Central Belgium the Tongeren Formation passes gradually to the underlying Eocene sediments downwards, and upwards to the Rupel formation: a possibly continuous marine series of alternating clay and sandlayers has been observed.

The different members and their superposition thus will be treated for each region separately.

Unless stipulated otherwise the denominations and historical details of the members, formations and chronostratigraphic conceptions were explained by J. DE HEINZELIN & M. GLIBERT (1957, *in*: Lex. Strat. int.).

3.1. The Tongeren region

A hilly landscape characterised by relatively deep valleys and a thin late Quaternary cover favours the geological field work, as the Tertiary can be observed in shallow outcrops and in hollow roads.

The Oligocene members are lying nearly horizontal in this region and their thickness is fairly constant over large distances.

A. DUMONT (1839), observing these facts, first incorporated in the original description of his "Tongrian system" the two formations of Tongeren and of the Rupel (and some younger deposits as well) both showing a transgressive cycle in this region, and which he placed at the base of the Miocene[1]. Later (1849) he restricted his Tongrian stage to deposits belonging to the first transgressive cycle only, while the following transgression was equated with his Rupelian stage (established in 1849).

For both definitions (the Tongrian s.l., 1839 and the Tongrian s.s., 1849) the base of the stage was, however, characterised by the same stratum: the Sands of Grimmertingen, called after the first cited locality by A. DUMONT (1839). The Grimmertingen-locality may thus be considered as the stratotype of the base of the Tongrian stage.

In DUMONT's mind however the conceptions "Tongrian system" and "Rupelian system" not only represented chronostratigraphic terms, but, as he correlated mainly on lithological facts, also litho-stratigraphical conceptions for which we now would prefer the term "formation".

In the Tongeren region the following members can be observed within the Tongeren and Rupel formations (table 1), overlying unconformably Upper Cretaceous and Paleocene deposits.

The environmental characteristics of the deposition of each of the members are given at the right of the table, showing the two transgressive cycles.

3.2. The Leuven-Diest region

The series of members which is observed in this region reflects two similar transgressive cycles, here overlying unconformably Lower and Middle Eocene deposits.

Some of the members, however show here a completely different facies as to their lateral equivalents in the Tongeren region.

The superposition of these members is given in table 2.

The Sands of Kerkom show a fluvial facies, while the Sands and Marls of Boutersem were apparently deposited in brackish-lagoonal conditions; some marine Mollusc species have however also been recorded.

The Horizon of Hoogbutsel was defined by M. GLIBERT & J. DE HEINZELIN (1952, 1954a). At Hoogbutsel and later at Hoeleden important continental vertebrate remains have been discovered in this member by J. DE HEINZELIN in 1952, which were studied partly by S. MISONNE (1957), S. MISONNE & G.E. QUINET (1967), G.E. QUINET & S. MISONNE (1965, 1967), G.E. QUINET (1965a, 1965b) and by M. HECHT & R. HOFFSTETTER (1962).

[1] At that time the Oligocene conception of E. BEYRICH (1854-1856) was not created as yet.

3.3. North West and Central Belgium

In the region of Brussels (Province of Brabant) Middle and Upper Eocene deposits can be observed in outcrops e.g. the type-localities of the Sands of Wemmel and of the Clay of Asse[1] which have also been considered by some authors as the stratotypes of the Wemmelian and Assian stages (chronostratigraphic terms which have now generally been abandoned).

These two stages (taken together) have long been considered as the Belgian equivalent of the Bartonian in England; recent studies, and mainly the calcareous nannoplankton zonation however, would suggest that the Sands of Wemmel in their type-locality (according to E. MARTINI & S. RITZKOWSKI, 1968) would be older than the type-Bartonian and would be the lateral equivalent of the Upper Bracklesham beds; probably they may also be correlated with the "Uppermost Lutetian" (Falun de Foulangues) layers in the Paris Basin, and with the "Biarritzian-stratotype" in Southern France (according to C. CAVELIER, 1968).

The base of the Asse formation (the "Bande-noire" horizon) sampled in Oedelem (according to E. MARTINI & S. RITZKOWSKI, 1968) and a sample at −174 m of the Kallo well yielded nannoplankton assemblages of the *Chiphragmalithus alatus* zone, the same nannoplakton zone in which the nannoplankton assemblage of the type Wemmelian has to be placed.

The younger layers of the Asse Formation could not be placed as yet in the planktonic zonations, except in the Kallo well (−167 m) where C.W. DROOGER (in press) observed one specimen of *Globorotalia cerroazulensis.*

Towards the north in the Antwerp region the Asse-, the Tongeren- and the Rupel Formations are burried under thick layers of Neogene deposits, whereas in Eastern Flanders the Asse and/or Tongeren Formations lie under a continuous cover of Pleistocene deposits: the Eocene-Oligocene transitional strata have here to be studied in borings.

An obviously continuous marine succession has been observed in this area between the Sands of Wemmel and the Clay of Boom; it consists of alternating clay and sandlayers, which make a lithologic interpretation very difficult, as gaps in the sedimentation could exist in this succession.

Similar difficulties of lithologic correlation for this interval occur also in the borings between Antwerp and Leuven (M. GULINCK, 1965).

In the Eastern Flanders province the most complete succession has been observed in the Kallo well, for which M. GULINCK (in press) referred to the sand- and clay layers by the symbols a1, a2, a3 (clay) and S1, S2, S3 (sand), as correlations with known members of East Belgium are still hasardous. This complete section of alternating clay and sand layers was called the "Clay and Sand complex of Kallo" by M. GULINCK (in press).

M. GULINCK also created the name "Sands of Bassevelde" to indicate the (lower?) part of the S3 member, characterised by *Nummulites* and by *Ostrea ventilabrum* in the boring of Bassevelde some km W of Kallo.

Table 3 shows the layers which have been observed in the Kallo well and of which some parts have also been recognized in other (older) borings.

The Foraminifera and Ostracoda of the −80 m to −176 m interval of this boring in Kallo have been studied by C.W. DROOGER (in press) and compared with the lists of the Eocene (J.P.H. KAASSCHIETER, 1961) and of the Oligocene (D.A.J. BATJES, 1958) Foraminifera, and the Ostracoda of both Eocene and Oligocene (A.J. KEY, 1957).

The localisation of the boring of Kallo is given in fig. 1.

3.3.1. *Possible ENE-WSW correlations by M. Gulinck (in press)*

However the boring of Kallo shows a possibly continuous series of marine sediments near the Eocene-Oligocene transition, a possible gap in the sedimentation could exist, at the −125,5 m level, where an indurated layer (with some "perforations") was observed. M. GULINCK (in press) believes that this level could be correlated with the regres-

[1] Also spelled "Assche" by some authors.

TABLE 3.

Formation		members in outcrops	members in older borings	Kallo well	Depth in m.	Environment of deposition
Rupel Fm.		Cl. of B.	Clay of Boom	Boom		a probably
			(transition)		— 80	continuous
	?		Sands of Berg (?) (alternation clay & sand)			marine series
"Clay and Sand Complex of Kallo" (M. GULINCK, in press)			"Sands of Bassevelde" (M. GULINCK, i.p.)	S_3		apparently completely
					— 125	neritic; however,
			clay layer	a_3		sedimentation
					— 137	gaps could be
			sand layer	S_2		expected in
					— 150	this succession
			clay layer	a_2		
	?				— 162	
Asse Fm.		S. of Asse	Sand of Asse (?)	S_1		
					— 168	
		Cl. of Asse	Clay of Asse "bande noire"	a_1		
					— 176	
Wemmel Fm.		S. of W.	Sands of Wemmel	Wemm.		

sion observed in the Tongeren-, Leuven- and Diest regions which is there characterised by the Hoogbutsel horizon, and the paleosoils at the top of the Sands of Neerrepen.

Thus: a_1 = Clay of Asse, as the "bande noire" occurs at its base, overlying the Sands of Wemmel facies.

S_1 = Sands of Asse overlying the Clay.

a_2 = a silty member, maybe the equivalent of the Grimmertingen sand.

S_2 and a_3 = possibly a lateral equivalent of the Sands of Neerrepen

S_3 = possibly a lateral equivalent of the continental layers of the Upper Tongeren formation. Also to be correlated with part of the boring of Bassevelde (The Sands of Bassevelde, M. GULINCK, in press).

The alternation of thinner clay and sand layers above the S_3 could then be the transition to the Sands of Berg and the Nucula clay (= Clay of Klein Spouwen). On top the Clay of Boom shows here the same facies as in outcrops along the Rupel river and is easy to recognise.

3.3.2. *Possible ENE-WSW correlation given by C.W.* DROOGER *(in press).*

The results of his micropaleontological investigations show a superposition of three different assemblages of Foraminifera which can be distinguished in the intervals (176-167 m), (131-124 m) and (80-100 m). The intervals in between seem nearly barren in Foraminifera.

a) In the interval (176-167 m) (or a_1, S_1) an assemblage was found showing much affinity with the one found in the Wemmel- and Asse Formations by J.P.H. KAASSCHIETER (1961) thus confirming the lithological correlation.

b) In the interval (80-100 m) an assemblage was found showing much affinity with the one found by D.A.J. BATJES (1958) in the Berg-Boom Formations. This correlation also fits with the lithology.

c) The interval in between (124-131 m) has shown an assemblage which indicates most affinity with the one found in the Lower Tongeren Fm. (in the Hendrik IV mineshaft) by D.A.J. BATJES (1958).

It is in this interval (at −131 m) below the crucial −125,5 m level that C.W. DROOGER observed an individual of *Cassigerinella chipolensis*, suggesting an Oligocene age.

A correlation with Grimmertingen might proove valuable when the association of the type-locality will be described (under current study by Mr. WILLEMS, Ghent).

C.W. DROOGER's, third interpretation (c) thus differs from the one given by M. GULINCK (as the 124-131 m interval falls partly in M. GULINCK's a_3 layer, partly in his S_2) and apparently denies the stratigraphic importance of the possible discontinuity at −125,5 m.

A schematic correlation scheme of the Eocene-Oligocene transitional strata of Belgium is given in Fig. 2.

3.3.3. *Possible correlations indicated by the calcareous nannoplanton.*

The results of the analysis of the calcareous nannoplankton of some samples of the Kallo well were given, together with the description and analysis in a "Mémoire" on this boring (to be communicated by M. GULINCK and others).

19 samples from the Kallo well between −82,70 m and −174,00 m have been studied for calcareous nannoplankton. Unfortunately only 4 samples contained calcareous nannoplankton, of which the sample −82,70 m yielded only a few specimens without stratigraphic value.

The calcareous nannoplankton from a sample at −85,90 m contained among others *Dictyococcites dictyodus* (DEFLANDRE & FERT), *Isthmolithus recurvus* DEFLANDRE, *Reticulofenestra insignita* ROTH & HAY, *R. umbilica* (LEVIN), and some unidentified *Cyclococcolithus* spp., *Ellipsolithus subdistichus* ROTH & HAY as well as *Cyclococcolithus formosus* KAMPTNER have not been found. This assemblage is comparable best with that of some samples from the Sands and Marls of Oude Biezen (= Vieux-Joncs) at Galgenberg near Tongeren, and probably belongs into the *Cyclococcolithus margaritae* zone or *Reticulofenestra laevis* zone.

A sample at −124,60 m shows an intriguing nannoplankton assemblage. Besides well pre-

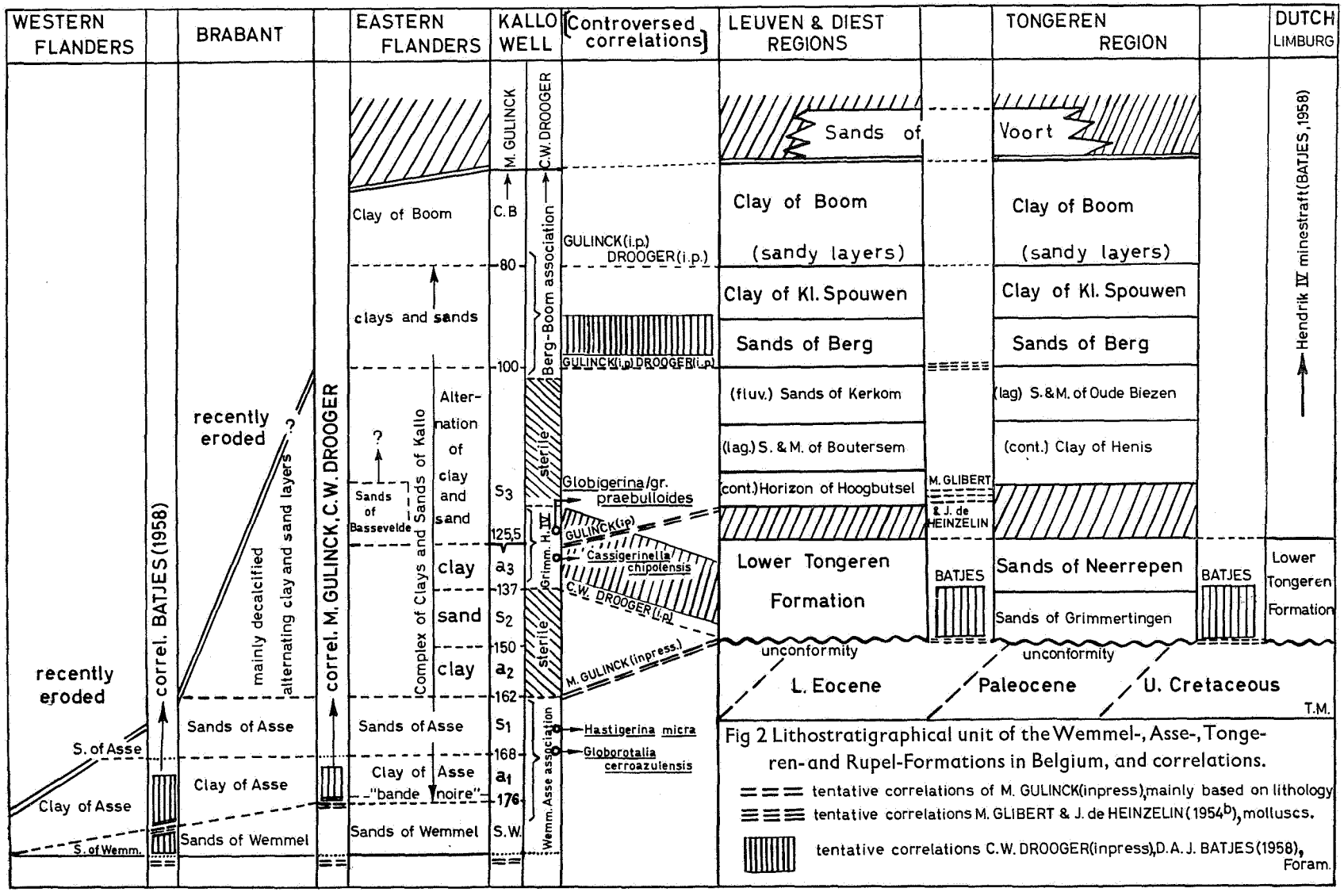


Fig 2 Lithostratigraphical unit of the Wemmel-, Asse-, Tongeren- and Rupel-Formations in Belgium, and correlations.

= = = tentative correlations of M. GULINCK(inpress), mainly based on lithology

≡ ≡ ≡ tentative correlations M. GLIBERT & J. de HEINZELIN (1954[b]), molluscs.

▥ tentative correlations C.W. DROOGER(inpress), D.A.J. BATJES (1958), Foram.

served but rare *Ellipsolithus subdistichus* ROTH & HAY, *Rhabdosphaera tenuis* BRAMLETTE & SULLIVAN, *Reticulofenestra umbilica* (LEVIN) and others, specimens of *Zygolithus* aff. *Z. minutus* PERCH-NIELSEN, which are present only in the uppermost *Discoaster tani nodifer* zone, are quite common, indicating that nannoplankton from certain layers of the Upper Eocene have been reworked into the *Ellipsolithus subdistichus* zone of the Lower Oligocene. The sample can be correlated approximately with the type-Grimmertingen. This correlation fits with DROOGER's interpretation for this interval in the boring.

The lowest sample which yielded calcareous nannoplankton has been obtained from −174,00 m. *Chiphragmalithus alatus* (MARTINI), *Discoaster barbadiensis* TAN SIN HOK, *Discoaster distinctus* MARTINI, and *Zygolithus dubius* DEFLANDRE, and others are present, an assemblage which belongs like that of the Clay of Asse and the type Wemmelian into the *Chiphragmalithus alatus* zone of the Middle Eocene.

4. *Locality Details*

4.1. The Grimmertingen locality

According to J. DE HEINZELIN & M. GLIBERT (1957) the hollow-roadside outcrop at Grimmertingen (cf. also GLIBERT & DE HEINZELIN, 1954, point 101, p. 295) is to be considered as the type-locality of the Sands of Grimmertingen, DUMONT[1], synonymous with the Sands of Vliermaal, d'OMALIUS d'HALLOY[1], and with the Sands of Lethen, DUMONT[2]. This member is indicated by the symbol Tglc on the Geological map of Belgium.

A. DUMONT (1849) established the name of this member after a fossiliferous locality of A. DUMONT (1839) then considered to show the basal stratum of his Tongrian "system" (= stage).

Grimmertingen lies at about 6 km NW of Tongeren in the Eastern part of Belgium (see fig. 1). The localisation of the hollow road outcrop in this hamlet is given in fig. 3.

The top of the hill at the crossing of the hollow road, lies approximately at +70 m above Ostende O.D. sealevel.

Recently a small quarry which now has been abandoned was opened next to the crossing of the hollow road. It belongs to Mr. A. POESMANS, Guighoven, who benevolently gave us the permission to study the section of this outcrop, and to carry out a boring in the quarry.

When D.A.J. BATJES (1958) visited the region, this quarry apparently did not exist, which explains that his sampling was less succesful; all of BATJES's samples appeared almost barren. However, we recently found a fairly rich association of benthonic and planktonic Foraminifera at the base of this quarry, whereas BATJES had taken most of his samples at higher levels.

The section in this outcrop (approx. 7 m) was described (see fig. 4) and sampled every 50 cm, on Sept. 10, 1968.

As reference level (0 m) we took the bottom of the way next to the quarry and the measurements of the boring (see fig. 4) carried out on Oct. 2, 1968, are refering to a zero level which approximately 30 cm higher.

4.2. Lithology

The lithologic description of the section is given in fig. 4.

This section has earlier been described by M. GLIBERT & J. DE HEINZELIN (1954b; point 101, and section fig. 10, p. 305) and by

[1] Grimmertingen, sometimes spelled Grimittingen (1839), later Grimmersingen (1849) by A. DUMONT; however erroneously spelled, there exists no confusion with other localities. Grimmertingen is actually a hamlet of the municipality Vliermaal: apparently the term Sands of Vliermaal of d'OMALIUS d'HALLOY (1853) refers to the same lithologic unit, and probably also to the same outcrop. Following J. DE HEINZELIN & M. GLIBERT (1957) we will only use the term Sands of Grimmertingen.

[2] The village of Lethen (sometimes spelled Leeten, or Leten by some authors) lies approximately 6 km. NE of Vliermaal.

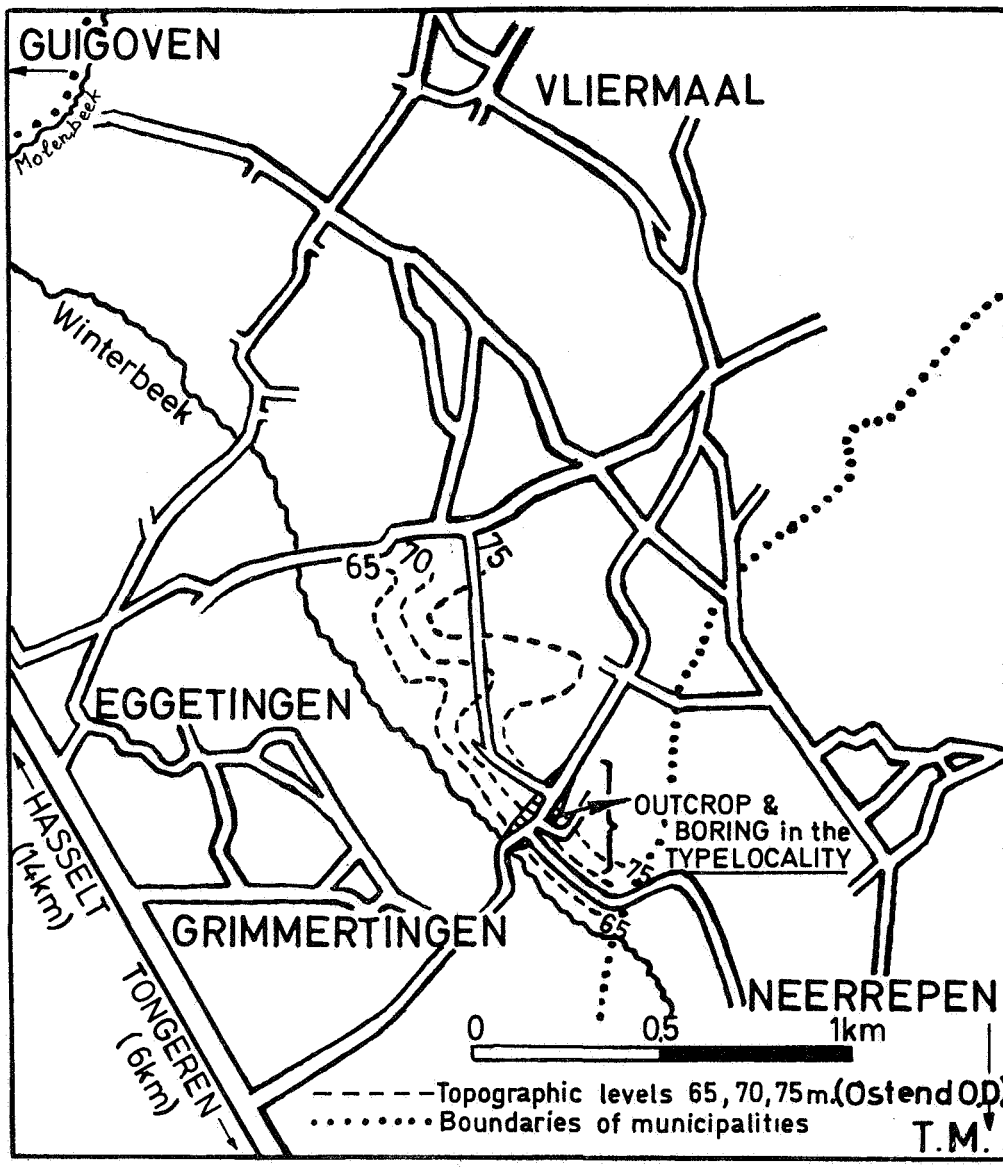


Fig. 3. Type locality of the Sands of Grimmertingen

M. GULINCK (1968: Vliermaal-Grimmertingen).

Under approximately 1 m of late Quaternary loam, one observes some 3 m of gray-green coarse sands, showing the facies of the Sands of Neerrepen ORTLIEB & DOLLFUS, 1873. Neerrepen is a village SE of Grimmertingen (cf. fig. 3), the type locality is a Sand-pit near the Castle of Neerrepen (see M. GLIBERT & J. DE HEINZELIN, 1954b, point 108). This member is indicated by the symbol Tgld on the Geological map of Belgium.

The Sands of Neerrepen in the Grimmertingen locality show some cross-bedding, mudballs, and some bifid and trifid tubular structures of unknown origin. The Sands of Neerrepen appear to be almost completely barren in Foraminifera (D.A.J. BATJES, 1958).

The contact of the Sands of Neerrepen with the underlying Sands of Grimmertingen is formed by an indurated layer of red colour (iron-oxyde) and a concentration of rolled mollusc shells and fish teeth. The latter are probably partly reworked from Eocene deposits. (M. LERICHE, 1910).

The facies of the underlying Sands of Grimmertingen is a fine glauconiferous and micaceous green-brown sand containing many mollusc shell, (*Ostrea ventilabrum* and *Turritella crenulata* appear to be quite frequent). This same facies with rusty stains persists in the boring as deep as −9 m, where apparently the sediment becomes richer in clay, and shows (abruptly) a blue-gray colour (probably reduction of iron). Shell-fragments have been observed throughout the section of the Sands of Grimmertingen in the outcrop and boring.

The level of the groundwater was at the time of the boring at −3 m. The base of the Grimmertingen member was not reached in this boring.

4.3. Sedimentology

A. KONING (1945) and R. TAVERNIER (1946) have analysed the heavy minerals of the Lower Tongeren Formation and some results are given by M. GLIBERT & J. DE HEINZELIN (1954b, pp. 308, 309).

A more extensive sedimentpetrological analysis of the samples which are now at hand is presently carried out by Mr. A. RUMES (Ghent).

4.4. Paleontology

a) *Molluscs*: In this outcrop some 214 species (84 Pelecypods, 130 Gastropods) have been recovered by M. GLIBERT & J. DE HEINZELIN (1954b).

According to these authors, the following species seem to have some stratigraphic value:

— *Pycnodonta queteleti* (NYST)
— *Ostrea ventilabrum* GOLDFUSS
— *Venericardia latisulcata* NYST (= *V. latisulca* NYST
— *Astarte bosqueti* NYST
— *Murex brevicauda* HEBERT
— *Turritella crenulata* NYST

b) *Fish teeth*: Some 8 species were recovered in the Lower Tongeren Formation at Grimmertingen, Neerrepen and Lethen by M. LERICHE (1910).

The fish teeth found at the contact of the Sands of Grimmertingen and the Sands of Neerrepen are, according to LERICHE, mainly reworked Eocene forms.

4.5. Micropaleontology

a) *Calcareous nannoplankton*: 34 samples from the zero level on downwards were analysed; a list of the species is given in the following chapter.

b) *Bryozoans*: F. CANU & R.S. BASSLER (1931) described a number of species derived from the Lower Tongeren Formation in this region.

c) *Foraminifera*: D.A.J. BATJES (1958) recorded 4 species in a sample approximately 2 m above our zero level of the outcrop; his other samples of this locality appeared to be barren. At present Mr. W. WILLEMS (Ghent) studies a fairly rich association from samples near the zero level of the outcrop section.

d) *Hystrichospheres*: This group is studied at present by Mr. W. WEYNS (Ghent).

e) *Radiolaria*: These organisms seem quite frequent in most of the samples of the outcrop and the boring.

f) *Ostracoda*: They seem to be quite rare, as only two single specimens as yet have been recorded by Mr. W. WILLEMS. Earlier A. KEY (1957) determined one specimen of *Leguminocythereis striatopunctata* (ROEMER).

5. *The calcareous nannoplankton assemblages* (cf. Table 4)

From the 34 samples between 0 and −12,70 m of the boring at the sandpit of Grimmertingen only 9 samples yielded calcareous nannoplankton. These samples are listed in table 4. The calcareous nannoplankton is poorly preserved, and only more robust forms are present

TABLE 4. *Distribution of calcareous nannoplankton at the type-locality of the Sands of Grimmertingen (Vliermaal).*

species (f = few; r = rare) \ samples	0 m	—0,10 m	—0,15 m	—0,20 m	—0,25 m	—0,80 m	—1,5/2,0 m	—2,0/2,5 m	—10,20 m
Coccolithus pelagicus (WALLICH)	f	f	f	r	r	r	r	r	f
Coccolithus sp.					f	r	r	r	
Cyclococcolithus formosus KAMPTNER	r	r	f		r	r	r	r	r
Dictyococcites dictyodus (DEFLANDRE & FERT)		r	r		r				
Discolithina distincta BRAMLETTE & SULLIVAN		r	r		r				r
Discolithina pulcheroides (SULLIVAN)									r
Discolithina sp.									r
Ellipsolithus subdistichus ROTH & HAY					r				
Helicopontosphaera sp.					r				
Isthmolithus recurvus DEFLANDRE	f	f	f	r	f	r	f	r	f
Micrantholithus vesper DEFLANDRE	r	r			r	r			r
Reticulofenestra insignita ROTH & HAY									r
Reticulofenestra umbilica (LEVIN)	f	f	f	f	f	f	f	r	f
Rhabdosphaera tenuis BRAMLETTE & SULLIVAN		r			r				
Sphenolithus pacificus MARTINI					r				r
Transversopontis obliquipons (DEFLANDRE)					r				r

except for samples at —0,25 m and —10,20 m.

The calcareous nannoplankton of the samples between 0 and —2,5 m represent the *Ellipsolithus subdistichus* zone. The guide-fossil *Ellipsolithus subdistichus* ROTH & HAY has been found in the better preserved calcareous nannoplankton assemblage of sample —0,25 m. Of interest is the presence of *Cyclococcolithus formosus* KAMPTNER in all samples, indicating that they belong below the *Cyclococcolithus formosus* extinction line (MARTINI, 1969) and are equivalent to the type-Latdorfian (Lower Oligocene).

Somewhat questionable is the status of sample —10,20 m, because *Ellipsolithus subdistichus* ROTH & HAY has not been found. The lack of rosette-shaped discoasters like *Discoaster barbadiensis* TAN SIN HOK and *Discoaster saipanensis* BRAMLETTE & RIEDEL indicates that the calcareous nannoplankton represents more likely the *Ellipsolithus subdistichus* zone of the Lower Oligocene than the underlying *Isthmolithus recurvus* zone of the Upper Eocene.

Reworked calcareous nannoplankton is extremely rare, and has been observed only in a few specimens derived from the Upper Cretaceous like *Eiffellithus turriseiffeli* (DEFLANDRE) and *Micula staurophora* (GARDET) in samples at 0 m, —0,20 m and —10,20 m.

6. *Conclusions* (cfr. Table 5)

6.1. The Sands of Grimmertingen yielded at their type-locality a calcareous nannoplankton assemblage belonging to the *Ellipsolithus subdistichus* zone ROTH & HAY, 1967.
A boring in this locality shows that the same assemblage is probably present towards the base of this member in this locality.

6.2. This Grimmertingen locality was originally and in later publications mentioned by A. DUMONT (1839-49) as the fossiliferous outcrop showing the base of his "Tongrian system" (= stage).

6.3. When E. BEYRICH (1854-56) established

TABLE 5.

Periods	ZONATIONS		BELGIUM				STRATOTYPES of some EUROPEAN STAGES		
	Plankton. Foram. zones	*Calcar. Nannopl. zones*	*Western and Central Belgium*	*North Central Belgium* (Kallo well)		*Eastern Belgium* (Tongeren)	*Germany*	*England* (Hampshire B)	*Italy*
OLIG.	Cassigerinella chipolensis/ Hastigerina micra zone	E. subdistichus zone		S_3 −125,5	Sands of Bassevelde −124	(Type) Lower TONGRIAN (at Grimmertingen)	(Type) LATDORFIAN		"Lower Oligocene"
				a_3	131?				
EOCENE	Globorotalia cerroazulensis	I. recurvus zone	?	−137 S_2 −150 a_2 −162	? ?		some other German localities mentioned by E. BEYRICH	Brockenhurst Bed (= Middle Headon)	PRIABONIAN at Possagno
		D. tani nodifer zone	Sands of Asse ?	S_1 −168	Sands of Asse ?			(Type) BARTONIAN (Upper Barton Beds)	
		Ch. alatus (= quadratus) zone	Clay of Asse "bande noire" (at Oedelem)	a_1 −176	Clay of Asse "bande noire"		and A. v. KOENEN	Upper Bracklesham Beds	"BIARRITZIAN" or "Uppermost LUTETIAN" (also in South. France and Paris B.)
			(Type) WEMMELIAN	S.W.	Sands of Wemmel				

the Oligocene conception he already correlated, on basis of the mollusc assemblages, the basal strata of the then established Oligocene in Germany with the "Lower Tongrian" of A. DUMONT.

6.4. According to the calcareous nannoplankton zonation the base of the type Tongrian can be correlated with the type-Latdorfian (MAYER-EYMAR, 1893) and with a number of the classical localities of the "Lower Oligocene" mentioned by E. BEYRICH (1854-56) and later A. v. KOENEN (1863-94), while some other localities mentioned by these authors are older than both stratotypes, (according to MARTINI & RITZKOWSKI, 1968).

6.5. The calcareous nannoplankton zonation further substantiates that the base of both, the type Tongrian and the Latdorfian, is younger than the top of the Priabonian (belonging to the *Isthmolithus recurvus* zone, according to PROTO DECIMA & TODESCO, 1968) and much younger than the top of the type-Bartonian (belonging to the *Discoaster tani nodifer* zone, according to MARTINI & RITZKOWSKI, 1968). In Belgium, the type Wemmelian and the lower part of the Asse formation even belong to an older zone (both showing assemblages of the *Chiphragmalithus alatus* zone according to MARTINI, 1969).

6.6. In the Kallo boring where the Eocene-Oligocene transitional strata show a probably continuous marine succession the *E. subdistichus* zone (with its guide fossil) was recorded from the −124 m level; this level falls in the −124 m to −131 m interval in which C.W. DROOGER recognized the Foraminiferal association of the Lower Tongeren Formation in eastern Belgium. An individual of *Cassigerinella chipolensis* was recorded by this author at −131 m; both the Foraminiferal association and the calcareous nannoplankton assemblage found near the −174 m level can be correlated with the Asse Clay formation as recovered in Oedelem (Western Flanders). The situation of the Eocene-Oligocene transitional strata of Belgium and that of some stratotypes of European stages in the biozonations of planktonic Foraminifera and of calcareous nannoplankton is given in Table 5.

The interval −131 m to −162 m of the Kallo well being nearly devoid of microfossils cannot be situated in the biozonations as yet, but it probably corresponds (at least partly) to the missing zones (the *D. tani nodifer* zone and the *I. recurvus* zone) as this succession apparently reflects a continuous marine sedimentation for this interval.

7. *Acknowledgements*

Many thanks are due to Drs. C.W. DROOGER (Utrecht) and J. DE HEINZELIN (Ghent), and to Ir. M. GULINCK (Brussels) for their discussions and critical comments.

We wish also to express our gratitude to Dr. E.E. BRABB (U.S.A.) for his valuable hints during part of the field work.

Further thanks are due to Dr. G. DEMOOR (Ghent) for his readiness to execute a boring at Grimmertingen and to the licentiate-students for their help during this work.

REFERENCES

BATJES, D.A.J. (1958). "Foraminifera of the Oligocene of Belgium" *Verh. Kon. Belg. Int. Natuurw.*, **143**, pp. 188 (Brussels).

BEYRICH, E. (1854). "Ueber die Stellung der Hessischen Tertiär-bildungen". *Ber. Verh. Kgl. Preuss. Akad. Wiss. Berlin*, 1854, pp. 640-666 (Berlin).

BEYRICH, E. (1856). "Ueber den Zusammenhang der Norddeutschen Tertiär-bildungen". *Abh. d. Kon. Akad. Wiss. Berlin*, 1855, pp. 1-20 (Berlin).

BRABB, E. (in press). "Comparison of the Belgian and German Oligocene sequences for the purpose of selecting a stratotype". Coll. sur l'Eocène, *Mém. B.R.G.M.* (Paris).

CANU, F. & BASSLER, R.S. (1931). "Bryozoaires Oligocènes de la Belgique". *Mém. Mus. Roy. Hist. nat. Belg.*, **50**, pp. 23 (Brussels).

CAVELIER, C. (1968). « L'Eocène supérieur et la base de l'Oligocène en Europe occidentale ». *In*: Colloque sur l'Eocène, Paris, mai, 1968,

Mém. B.R.G.M., **58** (1) pp. 507-525 (Paris).

DAVIES, A.M. (1934-1935). Tertiary faunas (2 vol.). Th. Murby & Co (London).

DEMARCQ (1964). « Etude critique générale sur la valeur des étages du Paléogène définis dans le Bassin Parisien ». *In*: Colloque sur le Paléocène, Bordeaux, 1962, *Mém. B.R.G.M.*, **28** (1), pp. 7-13 (Paris).

DENIZOT, G. (1968). « Bartonien, Ludien et Tongrien ». *In*: Colloque sur l'Eocène, Paris, 1968. *Mém. B.R.G.M.*, **58** (1), pp. 533-552 (Paris).

DROOGER, C.W. (1964). « Les microfaunes de l'Eocène-Oligocène du bassin nordique ». *In*: Coll. sur le Paléogène, Bordeaux, 1962. *Mém. B.R.G.M.*, **28** (2), pp. 547-552 (Paris).

DROOGER, C.W. (in press). "Microfaune close to the Eocene-Oligocene boundary in the boring at Kallo, near Antwerp", *Mémoires pour servir à l'explication des cartes géologiques et minières de la Belgique*, n° 11 Service géologique de Belgique (Brussels).

DUMONT, A. (1839). « Rapport sur les travaux de la carte Géologique pendant l'année 1839 ». *Bull. Acad. roy. de Belg.*, **1** (6) (2e part), pp. 464-485 (Brussels).

DUMONT, A. (1849). « Rapport sur les cartes géologiques du Royaume ». *Bull. Acad. roy. de Belg.*, **1**, (16) (2e part.), pp. 351, 365-373 (Brussels).

GABOUNIA, L. (1967). « Sur un Lophiodontidé de Hoogbutsel et de Hoeleden ». *Bull. Inst. Roy. Sci. nat. Belg.*, **43**, **5**, pp. 6 (Brussels).

GLIBERT, M. & DE HEINZELIN, J. (1952). « Le gîte des vertébrés tongriens de Hoogbutsel ». *Bull. Inst. Roy. Sci. nat. Belg.*, **28** (52) pp. 22 (Brussels).

GLIBERT, M. & DE HEINZELIN, J. (1954a). « Le gîte des vertébrés tongriens de Hoeleden ». *Bull. Inst. Roy. Sci. nat. Belg.*, **30** (1) pp. 14 (Brussels).

GLIBERT, M. & DE HEINZELIN, J. (1954b). « L'Oligocène inférieur belge ». *In*: Vol. jubil. V. VAN STRAELEN, pp. 281-438 (Brussels).

GRAMANN, F. (1964). "Die Arten der Foraminiferen-Gattung *Asterigerina* d'ORB. im Tertiär NW-Deutschlands". *Paläont. Zeitschr.*, **38** (3/4), pp. 207-222 (Stuttgart).

GRAMANN, F. (1968). "Zur Frage der Eozän-Oligozän-Grenze im nördlichen Deutschland". *In*: Coll. sur l'Eocène, Paris, 1968, *Mém. B.R.G.M.*, **58** (1), pp. 529-532 (Paris).

GULINCK, M. (1954). « L'Oligocène de la basse et de la moyenne Belgique ». Prodrome d'une description géologique de la Belgique, pp. 495-510 (Liège).

GULINCK, M. (1965). « Le passage du Bartonien au Rupélien dans la région de Boom-Malines ». *Bull. Soc. belg. géol. paléont. hydrol.* **74**, (2/3), pp. 115-120 (Brussels).

GULINCK, M. (1968). « Colloque sur l'Eocène: Guide des excursions en Belgique, 22-24 avril, 1968 ». *Service Géol. Belgique* (Brussels).

GULINCK, M. (in press). « Le passage Oligocène-Eocène dans le sondage de Kallo et le Nord de la Belgique ». *In*: Coll. sur l'Eocène. *Mém. B.R.G.M.* (Paris).

GULINCK, M. (in press). « Coupe résumée des terrains traversés au sondage de Kallo. Profil géologique Woensdrecht-Kallo-Halle ». *Mémoires pour servir à l'explication des cartes géologiques et minières de la Belgique*, n° 11, Service géologique de Belgique (Brussels).

HECHT, M. & HOFFSTETTER, R. (1962). « Note préliminaire sur les Amphibiens et les squamates du Landénien supérieur et du Tongrien de Belgique ». *Bull. Inst. Roy. Sci. nat. Belg.*, **37** (39), pp. 2-30 (Brussels).

HEINZELIN, J. DE & GLIBERT, M. (1957). (Terminology of Belgian Tertiary stratigraphic units). *In*: Lexique strat. int., **1**, (4a VII) (Paris)

KAASSCHIETER, J.P.H. (1961). "Foraminifera of the Eocene of Belgium". *Mém. Inst. Roy. Sci. nat. Belg.*, **147**, pp. 271 (Brussels).

KEY, A.J. (1957). "Eocene and Oligocene Ostracoda of Belgium". *Mém. Inst. Roy. Sci. nat. Belg.*, **136**, pp. 210 (Brussels).

KONING, A. (1945). „Bijdrage tot de petrologie van het Oligoceen in Belgie" (not published) manuscript Acad. thesis (Ghent).

KLJUSHNIKOV, M.J. (1964). « L'Eocène supérieur d'Ukraïne et le problème du Lattorfien ». *In*: Coll. sur le Paléogène, Bordeaux, 1962, *Mém. B.R.G.M.*, **28** (2) pp. 777-788 (Paris).

KOROBKOV, I.A. (1964). « Historique de la définition de l'Oligocène ». *In*: Colloque sur le Paléogène, Bordeaux, 1962. *Mém. B.R.G.M.*, **28** (2), pp. 747-760 (Paris).

KRUTZSCH, W. & LOTSCH, D. (1957). "Zur stratigraphischen Stellung der Latdorfstufe im Paläogen". *Geologie*, **6**, pp. 476-501 (Berlin).

KRUTZSCH, W. & LOTSCH, D. (1963). "Gliederung und Parallelisierung der Ablagerungen des

höheren Eozäns und des tieferen und mittleren Oligozäns in West- und Mitteleuropa und die Lage der Eozän/Oligozän-Grenze in diesem Gebiet''. *Geologie*, **12**, Beiheft 39, pp. 63 (Berlin).

KRUTZSCH, W. & LOTSCH, D. (1964). « Propositions à l'appui d'une tentative en vue de subdiviser les dépôts de l'Eocène supérieur et ceux de l'Oligocène inférieur et moyen et de mettre en parallèle ces dépôts d'Europe occidentale entre eux et avec ceux d'Europe centrale, et étude de la position a assigner à la limite entre l'Eocène et l'Oligocène dans ces régions ». *In*: Coll. sur le Paléogène, Bordeaux, 1962, *Mém. B.R.G.M.*, **28** (2), pp. 949-963 (Paris).

LERICHE, M. (1910). « Les poissons oligocènes de la Belgique ». *Mém. Mus. Roy. hist. nat. Belg.*, **5** (20), pp. 233-363 (Brussels).

LYELL, CH. (1833). ''Principles of Geology''. (3 Vol.) Murray (London).

LYELL, CH. (1852). ''On the Tertiary strata of Belgium and French Flanders''. *Quart. Journ. Geol. Soc. London*, **8**, pp. 277-370 (London).

MAYER-EYMAR, CH. (1893). « Le Ligurien et le Tongrien en Egypte». *Bull. Soc. Géol. Fr.*, **3** (21), pp. 7-43 (Paris).

MARTINI, E. (1969). ''Nannoplankton aus dem Latdorf (loc. typ.) und weltweite Parallelisierungen im oberen Eozän und unteren Oligozän. *Senck. leth.*, **50**, pp. 117-159, pls. 1-4 (Frankfurt am Main).

MARTINI, E. & RITZKOWSKI, S. (1968). ''Was ist das ''Unter-Oligocän''? Eine Analyse der BEYRICH'schen und v. KOENEN'schen Fassung der Stufe mit Hilfe des fossilen Nannoplanktons''. *Nachr. Akad. Wiss. Göttingen, II. Math-phys-Kl.*, 1968 (13), pp. 231-250 (Göttingen).

MISONNE, X. (1957). « Mammifères Oligocènes de Hoogbutsel et de Hoeleden, I. Rongeurs et Ongulés ». *Bull. Inst. Roy. Sci. nat. Belg.*, **33** (51), pp. 1-16 (Brussels).

MUNIER-CHALMAS, E. & DE LAPPARENT, A. (1893). « Note sur la nomenclature des terrains sédimentaires ». *Bull. Soc. Géol. Fr.*, **3** (21), pp. 438-488 (Paris).

OMALIUS D'HALLOY, J. D' (1862). « Abrégé de Géologie ». A. Schnée (Brussels, Leipzig).

ORBIGNY, A. D' (1852). « Cours élémentaire de paléontologie stratigraphique ». **2**, pp. 764 (Paris).

ORTLIEB, J. & DOLLFUS, G. (1873). « Compte rendu de Géologie stratigraphique de l'excursion de la Société malacologique de Belgique dans le Limbourg belge les 18 et 19 mai 1873 ». *Ann. Soc. Roy. Malac. Belg.*, **8**, pp. 38-57 (Brussels).

PROTO DECIMA, F. & TODESCO, L. (1968). « Observations sur le Nannoplancton de la coupe de Possagno ». *In*: M.B. CITA « Guide de l'excursion en Italie (Coll. sur l'Eocène) », pp. 73-75 (Milano).

ROOSE, B. (1965). « Contribution à l'étude des Hystrichosphères et Dinoflagellates du Bartonien belge ». *Bull. Soc. belge Géol. Paléont. Hydrol.*, **73** (3), 1964, pp. 1-32 (Brussels).

QUINET, G.E. (1965a). « Un Condylarthre de Hoogbutsel ». *Bull. Inst. Roy. Sci. nat. Belg.*, **41** (15), pp. 5 (Brussels).

QUINET, G.E. (1965b). « *Myotis misonnei* n. sp. Chiroptère de l'Oligocène de Hoogbutsel ». *Bull. Inst. Roy. Sci. nat. Belg.*, **41** (20), pp. 11 (Brussels).

QUINET, G.E. & MISONNE, X. (1965). « Les Insectivores zalambdodontes de l'Oligocène inférieur belge ». *Bull. Inst. Roy. Sci. nat. Belg.*, **41** (19), pp. 15 (Brussels).

QUINET, G.E. & MISONNE, X. (1967). « Les Marsupiaux de Hoogbutsel et de Hoeleden ». *Bull. Inst. Roy. Sci. nat. Belg.*, **43** (2), pp. 26 (Brussels).

TAVERNIER, R. (1947). « Aperçu sur la pétrologie des terrains postpaléozoiques de la Belgique ». *In*: La géologie des terrains récents dans l'ouest de l'Europe. *Sess. extraord. Soc. Belge Géol.* 1946, pp. 69-91 (Brussels).

WRIGLEY, A. (1929). ''Ueber die Molluskenfauna eines Eozängeschiebes von Cöthen (Anhalt)''. *Zeitschr. f. Geschiebeforschung*, **5**, pp. 102-110 (Berlin).

ANONYMOUS: COLLOQUE SUR L'EOCENE, PARIS, MAI. 1968 « Propositions ». *Compte rendu somm. séances, Soc. Géol. Fr.*, 1968 (7), pp. 248-251 (Paris).

TOPOGRAPHIC MAPS OF BELGIUM. 1: 20.000, Inst. Geogr. Mil. (Brussels).
sheets: 33/4 — Kortessem
34/1 — Bilzen
33/8 — Borgloon
34/5 — Tongeren

GEOLOGICAL MAPS OF BELGIUM. 1: 40.000, Inst. Geogr. Mil. (Brussels) (same sheets as topographic maps).

Communication presented April 4th, 1969.