

# DISUSED NEOGENE AND QUATERNARY REGIONAL STAGES FROM BELGIUM: BOLDERIAN, HOUTHALENIAN, ANTWERPIAN, DIESTIAN, DEURNIAN, KASTERLIAN, KATTENDIJKIAN, SCALDISIAN, POEDERLIAN, MERKSEMIAN AND FLANDRIAN

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(1 figure, 1 table)

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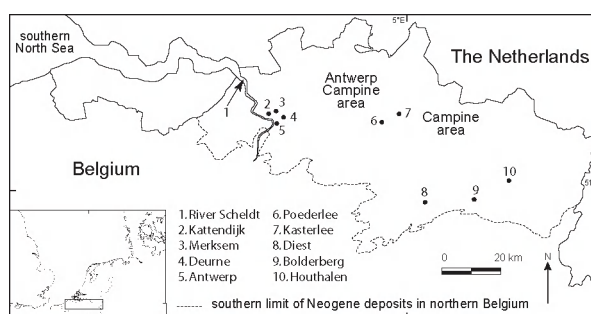
**ABSTRACT.** An overview of eleven disused Neogene regional stages from Belgium is presented. Some of the regional stages were already brought into use in the nineteenth century, but are nowadays considered ill defined and of no use in the light of the modern stratigraphic concepts. An overview of their definition and history is given, together with the argumentation for the abandonment of each unit and its present status. The disused chronostratigraphic units belonged to the Miocene, the Pliocene and the Holocene series.

**KEYWORDS:** Belgium, Neogene, Holocene, regional stages, disused chronostratigraphic units

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## 1. Introduction

The study of the Neogene deposits of northern Belgium started during the nineteenth century and was mainly based on outcrops in quarries in the Campine area (Fig. 1) and on temporary outcrops made for the construction of military defences around the city of Antwerp and the expansion of the harbour. Many regional stages were defined and in use for many years. However, during the last decades it became clear that these Neogene regional stages do not meet the modern criteria for stratigraphic classification. Consequently the usage of these regional stages should be abandoned, and replaced by the internationally accepted stages. A historical overview together with an analysis of the validity of each regional stage is given in stratigraphic order.



**Figure 1.** Overview of the localities after which the disused Neogene regional stages in northern Belgium were named. Inset: southern North Sea Basin.

## 2. Bolderian

### 2.1. Definition and history

This stage name (“Boldérien”) was established by Dumont (1850) as the youngest Miocene stage, which, in his opinion, consisted of the Bolderian, Rupelian and Tongrian stages. With the Bolderian stage, he designated the sediments nowadays known as the Bolderberg Formation, which was known at that time from the Bolderberg section (Fig. 1), situated near Zolder. The section contained two gravel levels: a lower gravel bed with well preserved silicified molluscs (a concentration of fossils belonging to the Bolderberg Sands), and an upper gravel bed with limonitic fossils, actually belonging to the Diest Sands. Nyst (1861), who discovered the Edegem Sands overlying the Boom Clay, takes the view that the Edegem Sands, with *Panopaea menardii* and other mollusc species occurring in the “Crag noir” near Antwerp, actually belongs to the Diestian. In his opinion, the Bolderian of Dumont (1850) has to be considered as the base of the Diestian stage.

During several decades, different authors discussed the stratigraphic position of the Bolderberg section (see Tavernier, 1954 and de Heinzelin & Glibert, 1956 for an overview) in relation to the stratigraphic units near the Antwerp area. The attribution of the Bolderian stage to a series (Oligocene, Miocene or Pliocene) was constantly modified according to new discoveries and interpretations. In the legend of the geological map of Belgium (Commission géologique, 1896), the Bolderian includes the Edegem Sands, the Antwerpen Sands and the Bolderberg Sands.

During the exploration of Limburg for the development of the coal exploitation, the Elsloo gravel was mapped as the basal gravel of the Neogene (Halet, 1921, 1936b; Gulinck, 1970). In the Limburg mining district, this gravel is the base of a pale to dark brownish, often very micaceous, very slightly lignitic, glauconitic, medium fine-grained sand with dispersed or concentrated occurrences of molluscs. Tavernier and de Heinzelin (1963) introduced the name Houthalen Sands after the name “Horizon de Houthaelen” given by Glibert (1945). De Heinzelin (1955) considers the “Houthaléen”, introduced by Hinsch (1952) as a more adequate stage name (with the correct spelling Houthalenian) to replace the Bolderian, because of the reworked fossils in the type-locality of the Bolderian. This opinion is included in Tavernier & de Heinzelin (1963).

### 2.2. Why the Bolderian is not an international stage

The type locality of the Bolderian Sands is an oxidized section and contains very few, mainly reworked and poorly preserved fossils. The upper and the lower boundaries are lithological boundaries.

### 2.3. Status of the name

According to modern stratigraphic criterions, the stage name Bolderian should not be used anymore. Actually, the geographic name Bolderberg is used as a lithostratigraphic term for the Bolderberg Formation (De Meuter & Laga, 1976; Laga *et al.*, 2001) and is used on the regional geological map at a 1:50,000 scale. An overview of the members included in the Bolderberg Formation is summarised in Laga *et al.* (2001).

## 3. Houthalenian

### 3.1. Definition and history

This stage name “Houthaléen” was established by Hinsch (1952) after the “Horizon de Houthalen” from which Glibert (1945) had studied the Miocene mollusc fauna. The name is derived from the village of Houthalen (Fig. 1), situated 12 km north of Hasselt. This horizon was found above the Voort Sands (Chattian) during the construction of a mineshaft at the colliery of Houthalen.

De Heinzelin (1955) considers the Houthalenian, spelt wrongly “Houthaléen” by Hinsch (1952), as a more adequate stage name to replace the Bolderian because of the reworked fossils in the type locality of the Bolderian, the lack of well-preserved in situ fossils in the Bolderian Sands and finally the confusion between the Antwerpian (=Anversien) and the Bolderian stages on the geological map. This opinion is also expressed in Tavernier & de Heinzelin (1963). The (molluscan) fauna of the Houthalenian is comparable with the fauna from the German Hemmoorian.

### 3.2. Why the Houthalenian stage is not an international stage

The type locality of the Houthalen Sands is only known from wells. The upper and lower boundaries are erosional levels (the Elsloo gravel at the base and the basal gravel of the Diest Formation at the top) and consequently they cannot be used as chronological boundaries. The calcareous fossil content (planktonic foraminifer and nannoplankton associations) does not allow unequivocal correlation with the international chronostratigraphy (Vandenberghe *et al.*, 1998).

### 3.3. Status of the name

The stage name Houthalenian has been proposed, but was in fact never used. Nowadays, the geographic name Houthalen is in use for a lithostratigraphic term: the Houthalen Member of the Bolderberg Formation (De Meuter & Laga, 1976; Laga *et al.*, 2001). The term Houthalenian is obsolete.

## 4. Antwerpian

### 4.1. Definition and history

The stage name “Anversien” (= Antwerpian is the actual correct spelling according to the procedures for establishing stratigraphic units) was proposed by Cogels in Van Ertborn (1879), as a “système” belonging to the Miocene. The name is derived from the city of Antwerp (Fig. 1) (French: *Anvers*, Dutch: *Antwerpen*). It was meant to comprise the “Sands with *Panopaea menardi*” and the “Black sands with *Pectunculus pilosus*”. It is the sequence described by several authors as the lower Crag of Antwerp, which consists mainly of dark green to black very glauconitic sands. The creation of this Antwerpian stage considerably restricted the Diestian stage. In Cogels’ opinion, the sediments with the fossils at Bolderberg, the “Sands with *Panopaea menardi*” and the Sands with *Pectunculus pilosus* are superimposed and without parallel equivalent units. Vanden Broeck (1879, 1880) accepted the Antwerpian stage, which is stratigraphically older than the Diestian stage, but he and Mourlon (1880, 1881) considered the age of the Antwerpian as Mio–Pliocene. Later, Vanden Broeck (1884) equates the Antwerpian and the Bolderian. According to the legend of the Belgian geological map of 1892 (Commission géologique, 1892), the black “Sands of Antwerpen” with *Pectunculus* and the “Sands of Edegheem” with *Panopaea* belong to the Bolderian or Antwerpian stages. However, in the legend of 1896, the Antwerpian is omitted and the Bolderian is the only Miocene stage (Commission géologique, 1896). The legend of the geological map of 1929 (Conseil géologique, 1929) again distinguished the Upper Miocene Antwerpian and the Middle Miocene Bolderian.

De Heinzelin (1955) suggested a late Middle Miocene age for the Antwerpian and an early Middle Miocene age for the Bolderian (= “Houthaléén”). Tavernier & de Heinzelin (1963) consider the Antwerpian stage as the probable equivalent of the Dingden–Reinbek Stufe and possibly also the Langenfeld Stufe, regarded at that time as Helvetian–Tortonian. The deposits indicated with the stage Antwerpian are nowadays called the Berchem Formation, which is subdivided in the Edegem Sands, Kiel Sands and Antwerpen Sands members (De Meuter & Laga, 1976). Recent micropalaeontological studies revealed the presence of a well-preserved dinoflagellate assemblage: a (latest Aquitanian?) Burdigalian to middle Serravallian age is attributed to the Berchem Formation (Louwye *et al.*, 2000).

### 4.2. Why the Antwerpian is not an international stage

The type localities of the Berchem Formation were temporary exposures along the motorway south and east of the city of Antwerp. The upper and the lower limits are lithological boundaries and correspond with relatively important hiatus. These boundaries can certainly not be considered as limits of biozones.

### 4.3. Status of the name

The stage name Antwerpian (or Anversien) should be avoided in the future, because the boundaries of the original sequence, indicated by the term Antwerpian, are erosional surfaces and do not define chronological boundaries. Actually, the geographic name Antwerpen is in use as a lithostratigraphic term: the Antwerpen Sands Member (De Meuter & Laga, 1976; Laga *et al.*, 2001).

## 5. Diestian

### 5.1. Definition and history

This stage name (“Diestien”) was defined by Dumont (1839, 1850), after the town of Diest (Fig. 1), situated approximately 50 km ENE of Brussels. It was meant to comprise the Diest Sands and the “lower Crag Sands of Antwerp”, consisting mainly of dark green to black, very glauconitic sands. According to this definition, the Kattendijk Formation should be included in the Diestian. However, Dumont has never observed deposits corresponding to the actual Kattendijk Formation due to a lack of outcrops at that time. The creation of the “Anversien” stage (= Antwerpian) by Cogels in Van Ertborn (1879) considerably restricted the extent of this stage. Only the glauconitic sands of the Diest Sands (type locality near the fortifications of the town Diest) and the “Assise des Sables à *Terebratula perforata* (= *T. grandis*, brachiopod)”, actually called the Deurne Sands, belonged to that stage. Vanden Broeck (1881) concludes that the “Sables à *Isocardia cor* (bivalve)”, the actual Kattendijk Formation, should be placed in the upper part of the Diestian. The presence of internal clasts of *T. perforata* in the limonitic sandstones of the Diest Sands in the Antwerp Campine region and in the Hageland region (region between and around the towns Aarschot, Diest and Leuven) allowed correlating the Diest Sands and Deurne Sands (Vanden Broeck, 1887; Glibert, 1963).

In 1955, de Heinzelin suggested the “Deurnien” stage name for the Late Miocene in Belgium as a replacement for the Diestian, because the sediments within the last stage were (supposed) to be unfossiliferous. This suggestion was repeated in the “Lexique Stratigraphique” (de Heinzelin & Glibert, 1956).

### 5.2. Why the Diestian is not an international stage

The type locality of the Diest Sands is an oxidized section without any macro and calcareous fossils. The upper and lower boundaries are lithological boundaries, corresponding respectively with a relatively important hiatus and with an important channel fill at the base. During a century and a half, there was no palaeontological or geochronological information available to link this regional stage with the international chronostratigraphy.

Recently a dinoflagellate cyst analysis demonstrated the diachronous nature of the Diest Formation, deposited in a marginal marine environment (Louwye *et al.*, 1999). Therefore, the boundaries can certainly not be considered as chronostratigraphic boundaries.

### 5.3. Status of the name

The stage name Diestian should not be used anymore. Currently, the geographical name Diest is used as a lithostratigraphic unit as the Diest Formation (De Meuter & Laga, 1976; Laga *et al.*, 2001) and this formation is also mapped on the regional geological map at a 1:50,000 scale. An overview of the members included in the Diest Formation is summarised in Laga *et al.* (2001). Recently, new micropalaeontological studies were carried out and revealed the presence of well preserved and rich dinoflagellate assemblages: a Tortonian to Messinian age is inferred for the Diest Formation in the Campine area and the area north of Antwerp (Louwye *et al.*, 1999).

## 6. Deurnian

### 6.1. Definition and history

This stage name was proposed by de Heinzelin (1955) to replace the Diestian, if maintaining the term Diestian would cause continuous confusion. The stage was named after the village of Deurne (Fig. 1), east of Antwerp, where this thin sand layer has been found in temporary outcrops. De Heinzelin & Glibert (1957) proposed this name again for the fossiliferous facies with Bryozoa and brachiopods (*Terebratula* spp.) of the glauconitic Deurne Sand, which was placed in the upper Miocene. In 1961, during the 2<sup>nd</sup> meeting of the Regional Committee for the Northern Neogene, de Heinzelin (1963) proposed the stage name Deurnian instead of the Diestian.

### 6.2. Why the Deurnian is not an international stage

The Deurne Sands are in the type region (east of Antwerp) only known from temporary exposures and are very thin, often only 1 m thick. The upper and the lower boundaries are clearly lithological boundaries, corresponding with important hiatus.

### 6.3. Status of the name

The stage name Deurnian has in fact never been in use and was considered of Messinian age. Neither the stage name Diestian, nor the proposed replacement Deurnian should be used as they actually correspond to lithostratigraphic units. Recently new micropalaeontological studies were carried out in the Deurne Sands and revealed the presence of a well preserved and rich dinoflagellate cyst assemblage: a Tortonian age is inferred for the Deurne Sands (Louwye, 2002).

## 7. Kasterlian

### 7.1. Definition and history

The term “Casterlien” was casually used by Dumont (edited by M. Mourlon, 1882) to indicate a body of micaceous, fine-grained sands in the Antwerp Campine area (nowadays called the Kasterlee Sands), underlying the limonitic fossiliferous sands and sandstone layers (the actual lithostratigraphic name of these deposits is the Poederlee Sands). The name is derived from the village of Kasterlee (Fig. 1), previously spelt “Casterlé”. Dumont (1882) considered the limonitic sands and sandstones (the actual Poederlee Sands) as Diestian and consequently he considered the underlying sands as Bolderian. After finding Diest Sands below the Kasterlee Sands (Van Ertborn, 1880), Cogels & Van Ertborn (1880a) suggested a correlation of the Kasterlee Sands with the “Sables à *Isocardia cor*”, the lower Scaldisian. The legends of the Belgian geological map of 1896 and 1929 (Commission géologique, 1896; Conseil géologique, 1929) incorporated this unit in the top of the Diestian stage. Halet (1936a) interprets the Kasterlian to be of fluvio-marine origin and he regards the sequence as being a regressive facies following deposition of the fully marine Diest Formation. Glibert & de Heinzelin (1955), de Heinzelin (1955) and Tavernier & de Heinzelin (1963) also considered the Kasterlian as the terminal part of the Diestian stage. On the other hand, Gulinck (1963) suggested a correlation with the Kattendijk Sands (now Kattendijk Formation) on geometrical evidence, an opinion maintained by De Meuter & Laga (1976).

### 7.2. Why the Kasterlian is not an international stage

Ages have not been defined for the upper or lower boundary of the stage. The boundaries correspond to sedimentary hiatus and are therefore unsuitable for stage boundaries.

### 7.3. Status of the name

From the given definition and history, it is clear that the stage name Kasterlian is by modern stratigraphic standards in fact a lithostratigraphic unit. The geographic name Kasterlee is now used for the lithostratigraphic unit Kasterlee Formation (De Meuter & Laga, 1976; Laga *et al.*, 2001). Glibert & de Heinzelin (1957) already labelled this stage name as an “ex-stage” and the name was abandoned.

## 8. Kattendijkian

### 8.1. Definition and history

The term (wrongly spelled “Kattendykien”) was suggested by Glibert & de Heinzelin (1957), and named after the

former hamlet of Kattendijk (Fig. 1). It corresponds to the former Lower Scaldisian, *sensu* Cogels (1874), meaning the “Sables à *Isocardia cor*”, the actual Kattendijk Formation.

### 8.2. Why the Kattendijkian is not an international stage

This stage has never been defined.

### 8.3. Status of the name

The name Kattendijkian has never been officially used, but some authors mentioned this stage name in their publications: e.g. Hinsch (1986, 1988, 1990, 1994) for the Early Pliocene of the North Sea Basin (Morsumian or Kattendijkian). The stage name should be abolished, since this term refers to a lithostratigraphic unit. The correlations made with mollusc associations at that time, did not take in account the ecological influence on the mollusc associations. Consequently, they should only be quoted by the appropriate lithostratigraphic term: the Kattendijk Formation. The geographic name Kattendijk is now used for the lithostratigraphic unit Kattendijk Formation (De Meuter & Laga, 1976; Laga *et al.*, 2001).

## 9. Scaldisian

### 9.1. Definition and history

The term Scaldisian (“Système Scaldisien”) was used for the first time by Dumont (1850) to indicate the so-called Antwerp Crag (“Crag d’Anvers”) and the Kallo Sands (“Sables de Calloo, Doel et Stuyvenberg”), defined as yellow sands, slightly glauconitic and containing many fossils at some localities in the Scheldt basin. The name is derived from the Latin name “Scaldus” of the river Scheldt (Fig. 1). The number of lithologic units grouped in this stage varies, according to numerous successive authors who have published on the deposits in the Antwerp Harbour area between 1874 and 1961.

### 9.2. Why the Scaldisian is not an international stage

Since Dumont (1850), the Scaldisian has always been considered of Pliocene age, but the range of the stage Scaldisian changed so much that a specific age is unknown (Table 1). The boundaries of the stage were never defined in terms of bio-events and a correlation with the international chronostratigraphic units was mainly based on mollusc associations. Before the formal definition of the Neogene lithostratigraphy (De Meuter & Laga, 1976), the lithological units of this stage were mainly defined by their palaeontological content, especially molluscs (zone à ..., horizon à ..., assise à ..., couche à ... crag ou coquiller à ...) and even by their colour (“crag jaune, crag

rouge, crag gris, crag noir”). Consequently, the proposed correlation with neighbouring countries (England, The Netherlands and France) was based on subjective arguments and changed constantly.

### 9.3. Status of the name

This chronostratigraphic unit was not defined adequately: there is no type locality and boundaries are not defined. Therefore, this name is ambiguous and the use of it should be abolished. The lithostratigraphic equivalent of this term is the Lillo Formation, which was formally defined by De Meuter & Laga (1976), and which is now used for the new geological map of Belgium at scale 1:50,000. Based on dinoflagellate cysts, the greater part of the Lillo Formation has a late Zanclean to Piacenzian age (Louwyte *et al.*, 2004). The two uppermost members, the Merksem Sands and Zandvliet Sands members have not been analysed for dinoflagellate cysts yet.

## 10. Poederlian

### 10.1. Definition and history

Cogels & Van Ertborn (1881) described “the rock of Poederlee, containing a mollusc fauna”. Vincent (1889) found a gravel layer in the section of the Amerika Dock (Antwerp Harbour) with vertebrate bones and attributed a transgressive character to the upper substage of the Scaldisian (= Sable de Merxem). Consequently, he correlated that substage with the limonitic sands and sandstones of Poederlee, Lichtaart and Kasterlee and introduced a new stage name, the Poederlian (“Poederlien”). The name refers to the village of Poederlee (Fig. 1) in the Antwerp Campine area, east of Antwerp. Leriche (1922) disagreed about the stratigraphic value of that stage and the latter author interpreted the Poederlee Sands as a littoral facies of the Scaldisian stage. The Poederlian stage disappeared from the stratigraphic legend of the geological map of Belgium of 1929 (Conseil géologique, 1929).

### 10.2. Why the Poederlian is not an international stage

Since 1929, this stage was not longer recognised. The type locality is a completely oxidized section with only poorly preserved shells (mainly internal casts), completely unsuitable for a stage type section. Furthermore, the stage can never be correctly defined. The range of the stage changed also considerably according to the successive authors.

### 10.3. Status of the name

In the modern understanding of stratigraphy, the term Poederlian indicates in fact a lithostratigraphic unit. The geographic name Poederlee is now used for the litho-

Lithologic units		DUMONT (1850)	COGELS (1874)	COGELS & VAN ERTBORN (1880b)	VANDEN BROECK (1880)	VANDEN BROECK (1884)	VINCENT (1889)	COMMISSION GEOLOGIQUE: Legend Geological Map (1896)	BURROWS & HOLLAND (1897) in JONES (1897)	LERICHE (1912)	VAN STRAELEN (1923)	TAVERNIER & GULINCK (1950)	LAGAAIJ (1952)	TAVERNIER (1954)	DE HEINZELIN (1955)	HACQUAERT (1961)
<b>LILLO FORMATION</b>	Sands of Merksem	Sc.		Sc.	Sc.		Po.	Po.			Sc.	Po.	Po.	Me.	Me.	
	Sands of Kruisschans								Sc.		Sc.		Po.			Sc.
	Sands of Oorderen		Sc.	Sc.	Sc.	Sc.	Sc.	Sc.	Sc.			Sc.		Sc.		
	Sands of Luchtbal										D.	D.	Sc.	D.sup.	Sc.	
<b>KATTENDIJK FORMATION</b>			Sc.	Sc.	D.sup.	D.			Cs.				D.	D.inf.		
<b>DIEST FORMATION</b>	Sands of Deurne			D.		D.		D.	D.	D.					D.	
	Sands of Antwerpen	D.														
<b>BERCHEM FORMATION</b>	Sands of Kiel		D.	An.	An.	Bd.		Bd.		An.				An.	An.	
	Sands of Edegem															

not observed or not discussed by the author in question

Me. : Merksemian      D. : Diestian  
 Po. : Poederlian      D.sup. : Upper  
 Sc. : Scaldisian      D.inf. : Lower  
 Cs. : Kasterlian      An. : Antwerpian  
                                  Bd. : Bolderian

**Table 1.** Historical overview of the use of chronostratigraphic stagenames in the Antwerp city area: illustration of the stratigraphic whimsicality.

stratigraphic unit Poederlee Formation (De Meuter & Laga, 1976; Laga *et al.*, 2001). In 1957, Glibert & de Heinzelin labelled that stage name as “ex-étage” and the name was abandoned.

## 11. Merksemian

### 11.1. Definition and history

This name (spelt “Merxemien”, the French name for Merksem is *Merxem*) was introduced by de Heinzelin (1955) to replace the stage name Poederlian. This name refers to the Merksem Sands, described by Vanden Broeck & Cogels (1877) in a temporary outcrop available during the construction of the fortress of Merksem (Fig. 1). This sand unit consists of a grey, quite homogeneous loose, fine-grained sand with small glauconite grains and contains the mollusc *Corbula striata* in high abundance, other molluscs, foraminifers, ostracods, etc. The upper reddish oxidized part resembles the Kallo Sands at the left bank of the river Scheldt and the “Sands with *Trophon antiquum* d’Austruweel (= Oosterweel)” at the North Castle on the right bank of the river Scheldt. According to de Heinzelin, the Merksemian contained the Merksem Sands, Kruiss-

chans Sands (Sands with *Cardium parkinsoni*) and the gravel of the Amerika Dock (in the Antwerp Harbour). De Heinzelin considered the boundary between the Merksemian and the underlying Scaldisian (see below) as the Plio-Pleistocene boundary. This opinion was based on climatological, palaeontological (presence of vertebrate bones in the Amerika Dock gravel) and considerations concerning stratigraphic correlations with the Mediterranean and West-European Pliocene occurrences (France: Brittany and Normandy, The Netherlands, Great-Britain and Germany). In his opinion, the term Merksem Sands of Vanden Broeck & Cogels (1877) is prior to the term Poederlee Sands (Cogels & Van Ertborn, 1881) and more accurate. The Poederlian stage name was used in the legend of the geological map of 1896 (Commission géologique, 1896), later rejected by Leriche (1922) and omitted from the legend of 1929 (Conseil géologique, 1929). In 1961, during the 2<sup>nd</sup> meeting of the Regional Committee for the Northern Neogene, de Heinzelin (1963) insists to put the Pliocene-Pleistocene boundary at the base of the Merksemian but he admits that there are other options possible: the boundary can be placed at the base of the Kallo Sands (based on the foraminiferal distribution available at that time), but also at the top of the Merksem Sands (based on the palynology).

### 11.2. Why the Merksemian is not an international stage

This stratigraphic term refers more to a lithological and biozonal unit than a chronostratigraphic one. Until now, there is no dating of these sands allowing the correlation of the unit to the international chronostratigraphic scale. Also the upper and lower boundaries are not clearly described and sufficiently dated. The gravel of the Amerika Dock has not been found in the many temporary outcrops in the Antwerp Harbour. The Pleistocene age is not confirmed, nor by the palynological spectrum of the Merksem Sands (Hacquaert, 1961, 1963), nor by the benthic foraminifers (De Meuter & Laga, 1976). Dinoflagellates from the Merksem Sands have not been studied yet.

### 11.3. Status of the name

The rank of a stage for the Merksem and Kruisschans Sands cannot be maintained according to modern stratigraphy and its use as a chronostratigraphic term is no longer justified. The chronostratigraphic term indicates in fact a lithostratigraphic unit. The geographic name is now in use for the lithostratigraphic unit Merksem Sands Member within the Lillo Formation (De Meuter & Laga, 1976; Laga *et al.*, 2001).

## 12. Flandrian

### 12.1. Definition and history

Nowadays, the name Flandrian is used to indicate deposits of the Flandrian transgression or of the Holocene as a whole, in particular in Anglo-Saxon literature. As most geological terms, the Flandrian has changed meaning and chronostratigraphic position since it was created by Rutot and Van Den Broeck (1885). At that time, the Flandrian was a Pleistocene "assise" which occurred at the end of the long series of Quaternary, Neogene and Paleogene stages. Therefore, it was and still is considered as the last stage of the geological timescale. The Calais and Dunkerque sub-stages of the Flandrian are generally used, however, only type areas in stead of type localities have been defined. Since 1900, the Belgian Geological Survey (Rutot *et al.*) used the "Flandrian" for all the Quaternary sediments in the Belgian coastal plain older than the so-called surface peat, which is essentially of Sub-Boreal age. In this view, it comprises Holsteinian, Eemian and Weichselian deposits together with Holocene sediments.

In 1924, Dubois suggested that the stage Flandrian corresponds with the last sedimentary cycle recognised in Flanders. This implies that the Flandrian corresponds with the Late Pleistocene and the Holocene.

The term Flandrian was derived from marine transgressive sediments on the Flanders Coast of Belgium. It was redefined by de Heinzelin and Tavernier (1957) and has

since been used as a synonym for the Holocene by authors who considered that the last 10,000 years should have the same stage status as previous interglacial events and should therefore be included in the Pleistocene. This usage has been losing ground in the last decades (Gibbard and Van Kolfshoten, 2004).

E.g. in the US:

The name "Flandrian" has been applied to the current sea level rise affecting the coastal regions around the globe which began approximately 18,000-19,000 years ago (Stage 1 - beginning in latest Pleistocene time and continuing progressively through Holocene to the present). This sea level rise is directly related to the melting of the Wisconsin (Stage 2) continental polar and mountain piedmont glaciers.

In the UK:

Following the temporary climatic setback of pollen Zone III, the Loch Lomond Stadial, of the Late-Devensian, the Flandrian or post-glacial amelioration begins when in Europe the ice at the Raa and Central Swedish moraines begins to decay, and when in Britain the remaining corrie and valley glaciers start to waste away. This sudden and rapid rise in temperature is dated as between 10,200 BP and 10,300 BP and marks the beginning of the Pre-Boreal period, or pollen Zone IV. The improved climatic conditions and cessation of soil disturbance allowed both rapid succession on stable maturing soils of the surviving vegetation of the Late-Devensian (in Britain, this meant the rapid spread of closed birch woodland northward, and to higher altitudes), and also northward migration of more thermophilous elements from southern refugia. Recent revision of the lithostratigraphic interpretations in Belgium (Gullentops *et al.*, 2001) learn that the Vlaanderen Formation consists of "coarse tidal channel sand, fine wadden sand and tidal flat clay with peat horizons ... due to transgression of post-glacial sea level rise" with an age of Holocene, from Boreal to the present, and equivalent with the type of the Flandrian stage. The lithostratigraphic interpretation is based on Dubois (1924) and Paepe and Baeteman (1979)

### 12.2. Status of the name

The use of the Flandrian Stage should be avoided in the future because of the lack of a well-deserved type locality and type section, and the changes in interpretation and stratigraphic position since it was first described.

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