

# DISUSED PALEOGENE REGIONAL STAGES FROM BELGIUM: MONTIAN, HEERSIAN, LANDENIAN, PANISELIAN, BRUXELLIAN, LAEKENIAN, LEDIAN, WEMMELIAN AND TONGRIAN

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(1 figure)

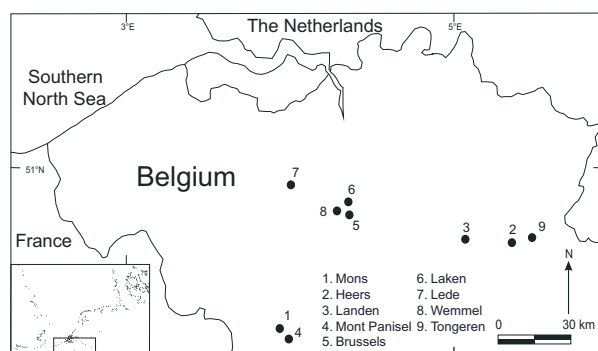
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**ABSTRACT.** An overview of nine disused Paleogene regional stages from Belgium is presented. Some of these regional chronostratigraphic units were already brought into use in the nineteenth century, but are nowadays considered ill defined and of 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 belong to the Paleocene, Eocene and Oligocene series.

**KEYWORDS:** Belgium, Paleogene, regional stages, chronostratigraphy, stratigraphy

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An overview of the localities after which the disused Paleogene regional stages in northern Belgium were named is shown in Figure 1.



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

## 1. Montian (Thierry MOORKENS)

### 1.1. Definition and history

The Montian stage has been introduced by Dewalque (1868, p.185) based on a limestone section observed in a temporary outcrop, the water pit “Puits Goffint”, located in the neighbourhood of the town of Mons. The same section had previously been used for the description of the Mons Limestone (“Calcaire de Mons”) by Cornet & Briart (1865), a rock unit characterised by its rich content of molluscs, which had a strong general Cenozoic aspect. The Cenozoic age of the deposit was a main reason to introduce the new stage, as at that time the (previously

erected) Danian stage (Desor, 1847) was still considered to be of Late Cretaceous age, and was therefore thought to be older than this newly erected Montian stage.

To this original definition of the Montian stage, as exclusively based on its type section in the Puits Goffint, some authors later suggested to add older and younger deposits to the unit stratotype. Briart & Cornet (1880) suggested to expand the original limits of the Montian stage by adding the overlying fresh water deposits called “Calcaire lacustre à *Physa*” (“Continental Montian” of authors, a rock unit now better known under the name “Marls and Limestones of Hainin”), and the underlying Mons Limestone. Cornet & Briart (1877a, 1877b) also suggested to add the rock unit “Calcaire de Cuesmes à grands *Cérithes*”, which is now considered to be an equivalent of the Cibly Calcarenes (originally called “Tuffeau de Cibly”). These viewpoints have been defended for a long time, such as by Marlière (1977).

### 1.2. Why the Montian is not an international stage

Later (micro-)paleontological studies, as discussed in detail by Moorkens (1982), proved that the above deposits are indeed of early Cenozoic age, but that they are lateral time equivalents of the middle and late parts of the previously described Danian, which has now been accepted as the basal Cenozoic stage of global stratigraphy, ranging between 65.5 and 61.7 Ma (Gradstein *et al.*, 2004). Only the freshwater deposits (Hainin Marls and Limestones), directly overlying the Mons Limestone in parts of the Mons Basin, may – entirely, or at least in their younger part – be younger than the top of the Danian stage (= base of the Selandian stage), as now considered in Denmark. However, the GSSP for the Danian-Selandian boundary has so far not been definitely designated, and its suggested age (61.7 Ma, Gradstein *et al.* 2004) is thus still preliminary.

Concerning the validity of the Montian stage, one should also bear in mind that the previously poor (and presently not existing) outcrop of the Montian stratotype section (as indicated in the original definition) would make it an invalid stage for international use.

### 1.3. The status of the name

For the above reasons the Montian is not acceptable as an international stage. However, when considering only its original definition (in which it is limited to the Mons Limestone section, as observed in the Puits Goffint), this ex-Montian time unit as defined in Belgium, would roughly represent the same time span as that of the “Late Danian”, such as now considered in Denmark. Indeed, this upper part of the Danian succession of Denmark is characterised by the incoming of some planktonic foraminifera such as *Globorotalia compressa* and *Globoconusa kozlovskii*,

(i.e. the last large evolutionary stage - with average test sizes (maximal diameter) exceeding 185  $\mu\text{m}$  - of the *G. daubjergensis* lineage, which is based on the gradually increasing test size of this group with time, Hansen, 1970). The incoming of these same taxa has also been observed in the transitional strata between the Cibly Calcarenes and the Mons Limestone of the Mons Basin (Moorkens, 1982), thus at the stratigraphic level which approximately correlates with the base of the Puits Goffint section. Furthermore, the transition of the Cibly Calcarenes to the Mons Limestone in Belgium is also characterised by the incoming of some warm water taxa of benthic foraminifera, such as *Lamarckina naeolensis*, *L. limbata*, and *Scarificatina reinholdi* (Moorkens, 1982). These taxa thus have regional correlative value in Belgium and adjacent areas.

Already during early correlations between the Danian and Montian stratotypes and studies on other classic sections, it has been suggested by some authors (as reviewed by Berggren, 1971, pp. 702-710) that the Montian could better be considered as a substage of the Danian, corresponding to its upper part, and thus roughly equivalent with the “Late Danian”. The arguments for and against accepting the Montian as a regional substage will be discussed in a forthcoming paper (when reviewing the new results obtained in the AEC 1827 cored borehole). This well is located at approximately 2 km to the west of the Puits Goffint, and appears to be stratigraphically somewhat more complete than the type section, and than the neighbouring Mons 1969 cored borehole section, which was studied by Moorkens (1982).

## 2. Heersian (Geert DE GEYTER)

### 2.1. Definition and history

The term Heersian (“Système heersien”) was introduced by Dumont (1851) to separate the glauconitic sands (“Glaucanie de Marets”) and marls from overlying stiff clays and sands, previously all grouped in the Landenian (Dumont, 1839). It was named after Heers, a small village in NE Belgium, 20 km NW of Liège. The lithostratigraphic term “Heers Formation” was introduced by Moorkens (1973, 1982). It was described more in detail by Thielens (1871), De Saporta & Marion (1873, 1877), Vincent (1873), Gosselet (1874), Rutot (1884), Gulinck & Hacquaert (1954), Herman (1972, 1977a), Roche (1973), Schumacker-Lambert (1978), De Geyter (1981) and Steurbaut (1998).

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

When introducing the Heersian, Dumont (1851) no longer considered the type deposits (“Glaucanie de Marets” de Dumont, 1839) to be Tertiary in age, but to belong to the Cretaceous system. In the legend of the geological map of Heers (Rutot, 1884), the Heersian

was described as a stage of the Lower Tertiary. Later, it was frequently incorporated in the Landenian stage (Leriche, 1903; Gulinck & Hacquaert, 1954; Herman, 1972; Schumacker-Lambry, 1978).

The term Selandian was introduced by Rosenkrantz (1924). It consists of lower (Lellinge Greensand) and middle (Ker-teminde Marl) fossiliferous units and an upper calcareous-barren Gray Clay. It lies unconformably upon the Danian Chalk Formation and is overlain by the “Ash series” (= Mo Clay). The terms Danian, Selandian and Thanetian have been accepted as subdivisions of the Paleocene chronostratigraphic scale at the 28th International Geological Congress (IGC) in Washington in 1989 (Jenkins & Luterbacher, 1992), although the terms Heersian and Landenian (see below) should have priority on historical grounds. This threefold chronostratigraphic subdivision of the Paleocene Series has been discussed in considerable detail by Berggren *et al.* (1995). According to Laga *et al.* (2001), the Heers Formation has a middle and Late Selandian age.

### 2.3. The status of the name

The term Heersian should be avoided because it was frequently considered as the lowermost part of the regional Landenian stage (see below). Instead, the lithostratigraphic term Heers Formation should be used. A description of the members included in the Heers Formation is given in Steurbaut (1998).

## 3. Landenian (Geert DE GEYTER)

### 3.1. Definition and history

The stage Landenian (“Système landénien”) was introduced by Dumont (1839). It was named after the town Landen (NE Belgium, 10 km SE of Tienen) and mainly consisted of marl, clay (“glaise”) and sand. Dumont (1850) redefined the Landenian to include a lower marine unit (now Hannut Formation) and an upper freshwater unit (now Tienen Formation), but excluding the Ypresian and later also the Heersian (Dumont, 1851). It was described in more detail and subdivided in “subassises” by Lyell (1852), Leriche (1899, 1902), Gulinck & Hacquaert (1954), Feugueur (1955), Kaasschieter (1961), Quinet (1966, 1969), Gulinck (1973), De Coninck *et al.* (1981), De Geyter (1981), Moorkens (1982), Smith & Smith (1995), Steurbaut (1998) and Steurbaut *et al.* (2003). Maréchal (1993) and Laga *et al.* (2001) elevated it to the rank of a lithostratigraphic group: the Landen Group.

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

The term Thanetian was defined by Renevier (1873) to include the Thanet Sands and the overlying Woolwich and Reading Series. Dollfus (1880) introduced the term

Sparnacian to include the “argile plastique et lignites du Soissonnais” and the Woolwich and Reading Beds of England. Since then, the term Thanetian has never been used with the meaning proposed by Renevier (1873), but always with the restricted meaning of Dollfus (1880) (see Steurbaut, 1998). During the Paris meeting in September 1999, it was decided by consensus that the Paleocene-Eocene boundary should be lowered from the base of the Ypresian stage, as defined by the base of the Mont-Hérību Member in Belgium, to the carbon isotope excursion level (CIE) (for an overview of the meeting see Aubry, 2000). This dramatic decrease in  $\delta^{13}\text{C}$  has been related to a short episode of global warming, referred to as the Paleocene-Eocene Thermal Maximum (PETM). The CIE has now been recorded worldwide, within a wide range of paleoenvironments, from continental, lagoonal, into diverse marine settings (see Wing *et al.*, 2003). According to Steurbaut *et al.* (2003), the onset of CIE occurs at the boundary between the Hannut Formation (lower Landenian) and the Tienen Formation (upper Landenian). Although the term Landenian (Dumont, 1839, 1850, 1851) has historical priority over the term Thanetian in the restricted meaning of Dollfus (1880), the last term has been proposed as an international stage and the base of the international Ypresian stage has been lowered from its original position to the Paleocene-Eocene boundary. In this sense, the Landen Group has a Thanetian (Hannut Formation) to Early Ypresian (Tienen Formation) age.

### 3.3. The status of the name

When referring to the Paleocene-Eocene boundary, the term Landenian should be avoided. Instead, the lithostratigraphic term Landen Group should be used. A description of the formations included in the Landen Group is given in Laga *et al.* (2001), an overview of the members in Steurbaut (1998).

## 4. Paniselian (Etienne STEURBAUT)

### 4.1. Definition and history

The Paniselian is an obscurely defined term, which first figured in Dumont’s (1851) concluding table on the synchronism of Tertiary formations in the southern North Sea Basin. It was introduced to denote the clayey to sandy interval between the formerly defined Ypresian (Dumont, 1850) and Bruxellian (Dumont, 1939) stages, although without any specification. It was named after Mont-Panisel, a hill within the Mons Basin, close to Mons, of which the geological importance was already known since the dawn of stratigraphy (d’Omalius d’Halloy, 1842; Nyst, 1842).

The Paniselian was adopted by most of the Belgian geologists during the second half of the 19th century (e.g. Dewalque, 1868; Mourlon, 1880), although its content

remained controversial. The “Sable à *Venericardia planicosta*” or Aalter Sands, originally included in the Bruxellian by Dumont (1852, first geological map of Belgium at 1/160,000) and by many subsequent authors (e.g. Dewalque, 1868), were transferred to the Paniselian in the legend of the second (1/40,000) geological map of Belgium (Anonymous, 1893). In its revised form, the Paniselian included a series of clays and sands, ranging from P1m (currently termed Merelbeke Clay) at the base up to P2 or Aalter Sands at the top. The deposits cropping out at the Mont-Panisel were termed P1c and P1d. Since 1919, when the legend of the geological map was officially revised (Anonymous, 1929), the Paniselian lost its status as a stage, and was downgraded to a specific facies of the Ypresian. From the 1960s to the early 1980s, the Paniselian was used in a lithostratigraphic context, as the Panisel Formation, although interpreted differently depending on the author (Kaasschieter, 1961; De Coninck & Nolf, 1979; Laga *et al.*, 1980). Because of the many correlation problems and general confusion, Steurbaut & Nolf (1986) restricted the name Panisel to the deposits at the type locality (the Panisel Sands of d’Omalius d’Halloy, 1862). It was downgraded to member status, underlying the Merelbeke Clay Member and incorporated in the Ieper Formation. Steurbaut & King (1994) grouped the Panisel Sand Member with the underlying Bois-la-Haut Member, into the newly defined Hyon Sand Formation. Recent investigations (Steurbaut, 1998) have shown that this formation is widespread in Belgium, resting on different units, depending on its position in the basin (e.g. on the Egem Sands in the Gent-Aalst area) and overlain by the Gentbrugge Formation.

#### 4.2. Why the term “Paniselian” is obsolete

Since the general revision of the legend of the geological map (starting in 1919 and finalised in 1927: Anonymous, 1929), the Paniselian was considered to be synonymous with the upper part of the Ypresian by the majority of the Belgian geologists. The International Subcommittee of Paleogene Stratigraphy officially adopted this opinion during the Geological Congress at Washington in 1989. The Ypresian was designated to be the name of the lowermost Standard Stage of the Eocene Series, and to be overlain by the Lutetian Stage (Jenkins & Luterbacher, 1992). This decision, through which the term Paniselian became obsolete, was maintained in the new Geological Time scale of Gradstein *et al.* (2004).

## 5. Bruxellian (Etienne STEURBAUT & Jacques HERMAN)

### 5.1. Definition and history

The term Bruxellian (Dumont, 1839) figured in the first stratigraphic table on the Belgian Tertiary, specifying the

sand and sandstones in the Brussel area. These deposits were already known for their rich fossil content since the late 18th century (Burtin, 1784; Galeotti, 1837). The Bruxellian concept was specified by Dumont in 1850, when introducing the term Ypresian. It was redefined to include three distinct subunits, in ascending order: glauconitic sand or the “Sable à *Venericardia planicosta*” (Dumont, 1852), also known as the Aalter Sands (Nyst, 1842); quartzitic calcareous sands and sandstones; and, marine calcareous sands. The lowermost 2 were considered to represent “étages”. By the end of the 1860s, its stratigraphic content was somewhat enlarged, as the basal part of the overlying Laekenian stage (Dumont, 1851), the *Nummulites variolarius* bearing sands of Laken (now municipality of Brussels), was incorporated in the Bruxellian (Dewalque, 1868). The Bruxellian deposits were famous at that time for their rich macrofossil content (Le Hon, 1862; Vincent, 1872, 1875).

Dumont’s original Bruxellian concept was re-established in the legend of the second geological map of Belgium (Anonymous, 1893), following the interpretation of Murlon (1880). The committee responsible for the general revision of the geological map (Anonymous, 1929) adopted Dumont’s revised 1850-version (the Aalter Sands, labelled B1, included in the Bruxellian) and, additionally, accepted the Ledian as replacement name for the Laekenian. This version of the Bruxellian has been maintained until the late 1950s (Gulinck & Hacquaert, 1954). Kaasschieter (1961) used the term in a lithostratigraphic context, the Brussels Formation, as already was done by d’Omalius d’Halloy in 1831 (“sables et calcaires de Bruxelles”) and transferred the Aalter Sands to the Panisel Formation. During the 1970s the term Bruxellian fell progressively into disuse in favour of its lithostratigraphic equivalent, the Brussel Formation (Laga *et al.*, 1980; Steurbaut, 1988; Houthuys, 1990; Damblon & Steurbaut, 2000; Herman *et al.*, 2001; Laga *et al.*, 2001; Vandenberghe *et al.*, 1998, 2004).

### 5.2. Why the term Bruxellian is obsolete

Already early on in the 20th century (Leriche, 1912a), it was understood that the Bruxellian, as outlined in the legend of the geological map of Belgium (Anonymous, 1893), represented only the lower part of the Lutetian Stage (defined by De Lapparent, 1833). Since Leriche (1939) first introduced the term Lutetian in the Belgian stratigraphy, the Bruxellian has been used as a subdivision of the Lutetian (Blondeau *et al.*, 1965; Blondeau, 1981; Cavalier & Pomerol, 1986). The Bruxellian lost its chronostratigraphic/geochronologic status, and consequently became obsolete, because of decisions made during the Geological Congress in Washington in 1989. The International Subcommittee on Paleogene Stratigraphy ratified these conclusions through designating the Lutetian as the official second Standard Stage of the Eocene Series

(Jenkins & Luterbacher, 1992). This opinion, in which the Lutetian Stage is sandwiched between the older Ypresian Stage and the younger Bartonian Stage, was upheld in the new Geological Time scale of Gradstein *et al.* (2004).

## 6. Laekanian and Ledian (Noël VANDEN-BERGHE & Jacques HERMAN)

### 6.1. Definition and history

The name Ledian was introduced officially by Mourlon (1887) for the sand overlying the gravel with *Nummulites variolarius*, between the Wemmelian and Laekanian. He used the reference to the locality Lede for the first time in 1873. Originally, the Ledian was comprised in the Laekanian of Dumont (1851), with a lower boundary that coincided with that of the actual Lede Formation. Rutot & Vincent (1879) separated the Laekanian into Laekanian *sensu strictu* and Wemmelian, causing the boundary between the latter two to go straight through the current Lede Formation. Vincent (1887) proposed to separate the sands with *Nummulites variolarius* from the Wemmelian, based on observations in the area of Zaventem. Mourlon (1887) came to the same conclusion and named the new unit with *Nummulites variolarius* Ledian, which he placed in the middle Eocene. He gave a new interpretation of the earlier description (Mourlon, 1880) of the Balegem sandpit as type section. On the Belgian geological map of 1893 (Anonymous, 1893), the Ledian is placed in the Late Eocene and the Laekanian in the middle Eocene. Leriche (1912b) proposed to group the Laekanian *s.s.* and the Ledian of Mourlon (1887) under the name Ledian. This change was confirmed at the review of the Stratigraphic Register in 1929 and 1932 (Algemeen Stratigraphisch Register, 1932) and followed by Gulinck & Hacquaert (1954). In the Stratigraphic Register (1932) and in de Heinzelin & Glibert (1956), the former Laekanian is comprised in the Ledian and interpreted as middle Eocene. The main references regarding fossils in the Ledian are: Canu & Bassler (1929), Casier (1949), Glibert (1974, 1975, 1980), Herman (1974, 1977b), Kaaschieter (1961), Leriche (1905, 1951), Misonne (1958), Nolf (1973, 1974), Nolf & Taverne (1978), Pastiels (1948), Stinton & Nolf (1970), Vervoenen (1995). Recent reviews of the stratigraphy of the Lede Sands have been compiled by Fobe (1986).

### 6.2. Why the Laekanian and the Ledian are not international stages

The term Ledian is a good example of a stratigraphic unit which by modern standards simply is a lithostratigraphic unit, but which in the practice of pre-Hedberg (1976) stratigraphic nomenclature was given the status of a time unit (Ledian).

### 6.3. Status of the name

In the present stratigraphic nomenclature (Fobe, 1986; Laga *et al.*, 2001) the unit is indicated as the Lede Formation or Lede Sands, and the term Ledian as a chronostratigraphic unit became obsolete.

## 7. Wemmelian (Patric JACOBS)

### 7.1. Definition and history

The Wemmelian was introduced as a stage by Vincent & Rutot (1878), after that Vincent & Lefèvre (1872) had defined the lithostratigraphic “Sands of Wommel” unit. Wommel is a locality in the Province of Flemish-Brabant, situated at the border of the Brussels Agglomeration. The Wommel Member debuts with a mostly well-developed basal gravel, in which next to *Nummulites wemmelensis*, numerous specimens of rolled *Nummulites variolarius* are found, as well as rolled and silicified *Nummulites laevigatus* and rolled fossiliferous calcarenite fragments. It consists of grey glauconiferous fine sand with increasing clay content towards the top, where the Wommel Member occurs as clay with coarse glauconite grains. Sometimes, thin calcarenite banks can be found in the Wommel Member. The Wommel Member outcrops along the southern border of the Oedelem-Adegem-Zomergem hill series and in the area of Asse and Wommel, where it originally was defined under its old denomination of “Wommel Sands”. Further to the North, it occurs in the subsoil under a thick Quaternary cover (as in the Eastern Coastal Plain and in the northern part of the Flemish Valley) and/or under younger early Cainozoic deposits. In the East and in the South, the Wommel Member covers the Lede Formation with a sharp basal contact. This lower boundary is often underlined by a well-developed basal gravel resting on the stone banks of the Lede Formation, which can easily be distinguished from the Wommel Member itself by the replacement of *N. variolarius* by *N. wemmelensis*, by a decrease in grain size and a slight increase in clay content. In the West, it rests on the Aalter Formation. Here also, the contact is underlined by a basal gravel overlying the stone banks of the Aalter Formation. The thickness of the Wommel Member normally averages 4 to 5 m, but can locally increase up to 10 m.

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

The exact position of the Wemmelian has been debated intensively, but Velge (1895) demonstrated that the Wemmelian cannot be distinguished from the basal glauconitic clay of the ‘Assian’. Finally, Leriche (1912b) replaced the ‘Wemmelian’ and ‘Assian’ terms by ‘Bartonian’

(*sensu* Mayer-Eymar, 1857). Around the turn of the 19<sup>th</sup> and 20<sup>th</sup> century, the Wemmelian was still indicated (as ‘We’) on the old ‘Geological Map’ (scale 1/40,000) as a regional stage, consisting of a gravel with the hexacoral *Eupsammia burtinana* and sands with *Nummulites wemmelensis*. However, in the Stratigraphic Register of 1929 and 1932 (Algemeen Stratigraphisch Register, 1932), it already formed the basal part of the Bartonian (Bar) (p.p.: quartzitic sand – Sands of Wommel). Since its upper boundary is not well-defined and the occurrence of the Wommel Sands is not continuous east of Brussels, its presence as an independent unit was abandoned by Jacobs (1975, 1978), following earlier sedimentological-lithological arguments of Gulinck (1965a, 1969) and earlier palaeontological indications of Kaaschieter (1961) and Nolf (1974).

### 7.3. The status of the name

The use of the term ‘Wemmelian’ should be avoided. Instead the lithostratigraphical term ‘Wommel Member’ should be used as the basal part of the Maldegem Formation (Jacobs 1975, 1978). A full description of the ‘Wommel Member’ as a formal lithostratigraphic unit is also given by Jacobs (1975, 1978).

## 8. Tongrian (Ellen DE MAN)

### 8.1. Definition and history

In 1839, Dumont subdivided the Belgian Tertiary into six “systèmes”, of which the third was named Tongrian, itself consisting of four major units or “étages”. In 1850 and 1851, Dumont redefined the Tongrian, by attributing the two uppermost parts of the system to respectively the Rupelian and Bolderian systems. In its new concept, the Tongrian system only comprised two “étages”, a lower marine unit named “sable glauconifère de Lethen” and an upper fluvio-marine unit named “argile verte de Henis”. Earlier work on these fossiliferous deposits was done by Nyst (1836) and De Koninck (1838), while Lyell (1852) shed light on the stratigraphic relationship with overlying and underlying units. In 1883, Vanden Broeck & Rutot applied their concept of cyclic sedimentation to the Tongrian deposits. They introduced a new stratigraphic nomenclature (lower marine unit: Tg1; upper fluvio-marine unit: Tg2), which was used in a slightly modified form in the legend of the geological map of Belgium (Anonymous, 1893; Vanden Broeck, 1893). Glibert & de Heinzelin (1954) gave a good summary of the palaeontological studies, which essentially focussed on macrofossils. The position of the actual boundaries and correlation to other basins remained obscure, although a tentative correlation between Tg1 and the German ‘Latdorfian’ or the French ‘Sannoisian’ was proposed based on the pres-

ence of *Nummulites germanicus* (Vanden Broeck, 1893; Glibert & de Heinzelin, 1954). The relationship between the Tongrian strata and the more basinward deposits in northwest Belgium was elucidated by Gulinck (1965b, 1969), but exact correlation remained problematic. Detailed sedimentological research (e.g. Van den Bosch *et al.*, 1975) and further micropalaeontological evidence pointed to a clear hiatus between the lower (Tg1) and the upper (Tg2) unit (e.g. Steurbaut, 1992; De Coninck, 2002): The ‘upper fluvio-marine Tongrian’ is time-equivalent to the Ruisbroek Sands (Steurbaut, 1986), while the ‘lower marine Tongrian’ corresponds to the uppermost part of the Bassevelde Sands. These new insights were assembled in sequence stratigraphic studies (e.g. Gullentops, 1990; Vandenberghe *et al.*, 2003), emphasising on the regional importance of the hiatus between Tg1 and Tg2 (Cavelier *et al.*, 1982).

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

Although the “Tongrian” was introduced as a regional stage, the term is not upheld as an international Stage name in the International Stratigraphic Chart (e.g. Jenkins & Luterbacher, 1992; Gradstein *et al.*, 2004). Since the restriction of the Oligocene Epoch to two Stages (Hardenbol & Berggren, 1978) and the designation of a GSSP for the Eo/Oligocene boundary (Pomerol & Premoli Silva, 1986), only the Rupelian and Chattian were retained as chronostratigraphic significant Stages for the Oligocene. Hence, the Tongrian lost its chronostratigraphic/geochronological status and should only be referred to in a pure lithostratigraphic context.

### 8.3. The status of the name

The term “Tongrian” should be avoided because of its chronostratigraphic connotation; the lithostratigraphic term ‘Tonger Group’ should be used instead. An overview of the formations and members belonging to this Group is given by Laga *et al.* (2001). Traditionally, the lower unit (Tg1) was correlated to Beyrich’s (1854) lowest subdivision of the Oligocene (‘Latdorfian’) and the upper unit (Tg2) to the Rupelian. Chronostratigraphically, the Tonger Group is now placed in the lowest part of the Rupelian Stage.

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## References

- ALGEMEEN STRATIGRAPHISCH REGISTER VAN DE UITVOERIGE AARDKUNDIGE KAART VAN BELGIË, 1932. Ministerie van Nijverheid, Arbeid en Maatschappelijke Voorzorg. Algemeene directie van het Mijnwezen. Aardkundige Raad, Bruxelles, 1-46. (French edition, 1929)
- ANONYMOUS, 1893. Légende de la Carte Géologique dressée par ordre du Gouvernement à l'échelle du 40.000e. *Bulletin de la Société belge de Géologie*, 6(1892): 217-229.
- ANONYMOUS, 1929. Légende générale de la Carte Géologique détaillée de la Belgique. *Annales des Mines de Belgique*, 30: 37-77.
- AUBRY, M.-P., 2000. The Vote on the Paleocene/Eocene criterion: the view of the Chairman of the P/E boundary Working Group. *Newsletter of the International Subcommission on Paleogene Stratigraphy*, 9: 14-17.
- BERGGREN, W.A., 1971. Tertiary boundaries and correlations. In: Funnel, B.M. & Riedel, W.R., (eds.), *The Micropaleontology of Oceans*. Cambridge University Press, 693-809.
- BERGGREN, W.A., KENT, D.V., SWISHER III, C.C. & AUBRY, M.-P., 1995. A revised geochronology and chronostratigraphy. In Berggren, W.A., Kent, D.V., Aubry, M.-P. & Hardenbol, J., (eds), Geochronology, time scales and global stratigraphic correlation. *SEPM (Society for Economic Paleontologist and Mineralogist) Special Publication* 54: 129-212.
- BEYRICH, E., 1854. Über die Stellung der Hessischen Tertiärbildungen. *Berichte und Verhandlungen der Königlich-Preussischen Akademie der Wissenschaften Berlin*, 1854(11): 640-666.
- BLONDEAU, A., 1981. Lutetian. In Pomerol, Ch., (éd.), *Stratotypes of Paleogene Stages. Bulletin d'Information des Géologues du Bassin de Paris*, Mémoire hors série 2: 167-180.
- BLONDEAU, A., CAVELIER, C., FEUGUEUR, L. & POMEROL, Ch., 1965. Stratigraphie du Paléogène du Bassin de Paris en relation avec les bassins avoisinants. *Bulletin de la Société géologique de France*, 7(7): 200-221.
- BRIART, A. & CORNET, F.L., 1880. Note sur la carte géologique de la partie centrale de la Province de Hainaut, exposée à Bruxelles en 1880. *Annales de la Société Géologique de Belgique*, 7: 131-148.
- BURTIN, F.-X., 1784. *Oryctographie de Bruxelles ou description des fossiles tant naturels qu'accidentels découverts jusqu'à ce jour dans les environs de cette ville*. Imprimerie de le Maire, Bruxelles, 1-152.
- CANU, F. & BASSLER, R.S., 1929. Bryozoaires éocènes de la Belgique. *Mémoires du Musée royal d'Histoire naturelle de Belgique*, 1ère série, 8(39), 1-68.
- CASIER, E., 1949. Contributions à l'étude des Poissons fossiles de la Belgique. VIII. Les Pristidae éocènes. *Bulletin de l'Institut royal des Sciences naturelles de Belgique*, 25(10): 1-52.
- CAVELIER, C., CHÂTEAUNEUF, J.J., POMEROL, C., RABUSSIER, D., RENARD, M. & VERGNAUD-GRAZZINI, C., 1981. The geological events at the Eocene/Oligocene boundary. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 36: 223-248.
- CAVELIER, C. & POMEROL, Ch., 1986. Stratigraphy of the Paleogene. *Bulletin de la Société géologique de France*, 8, II(2): 255-265.
- CORNET, F.L. & BRIART, A., 1865. Note sur la découverte dans le Hainaut, en dessous des sables rapportés par Dumont au système Landénien, d'un calcaire grossier avec faune tertiaire. *Bulletin de l'Académie royale de Belgique*, 2e série, 20(11):1- 20.
- CORNET, F.L. & BRIART, A., 1877a. Note sur l'existence d'un calcaire d'eau douce dans le terrain tertiaire du Hainaut. *Bulletin de l'Académie royale de Belgique*, 2e série, 43(1): 1-14.
- CORNET, F.L. & BRIART, A., 1877b. Notes sur quelques massifs tertiaires de la Province de Hainaut. *Bulletin de l'Académie royale de Belgique*, 2e série, 43(6): 1-12.
- DAMBLON, F. & STEURBAUT, E., 2000. Gobertange: site géologique remarquable. In *La Gobertange – Une Pierre, des hommes*. ASBL Gobertange 2000, Cera Holding, 19-48.
- DE CONINCK, J., 2002. Organic-walled microfossils in the Oligocene Grimmertingen and Neerrepren Sand Members from the Grimmertingen type locality. *Professional Paper, Belgische Geologische Dienst*, 294: 1-57.
- DE CONINCK, J., DE DECKER, M., de HEINZELIN, J. & WILLEMS, W., 1981. L'âge des faunes d'Erquelines. *Bulletin de la Société belge de Géologie*, 90: 121-154.
- DE CONINCK, J. & NOLF, D., 1979. Note sur les couches de base de la Formation du Panisel entre Torhout et Tielt. *Bulletin de la Société belge de Géologie*, 87/3(1978): 171-178.
- DE GEYTER, G., 1981. Contribution to the lithostratigraphy and the sedimentary petrology of the Landen Formation in Belgium. *Mededelingen van de Koninklijke Academie voor Wetenschappen, Letteren en Schone Kunsten van België, Klasse der Wetenschappen*, 43: 111-153.
- de HEINZELIN, J. & GLIBERT, M., 1956. Ledien, Laekenien. In *Lexique Stratigraphique Internationale*, Vol.1: Europe. Fascicule 4a 6. Centre National de la Recherche Scientifique, Paris.
- DE KONINCK, L., 1838. Description des coquilles fossiles de l'argile de Basele, Boom, Schelle, etc., *Mémoires de l'Académie royale des Sciences et Belles-Lettres de Bruxelles*, 11: 1-37.
- DE LAPPARENT, A., 1833. *Traité de Géologie*. Premier volume. F. Savy, Paris, 1-1280.
- DE SAPORTA, G. & MARION, A.F., 1873. Essai sur l'état de la végétation à l'époque des marnes heersiennes de Gelinden. *Mémoire Couronné et des Savants étrangers publié par l'Académie royale de Belgique*, 37: 1-94.
- DE SAPORTA, G. & MARION, A.F., 1877. Révision de la flore heersienne de Gelinden d'après une collection appartenant au Comte G. DE LOOZ. *Mémoire Couronné et des Savants étrangers publié par l'Académie royale de Belgique*, 41: 1-112.

- DESOR, E., 1847. Sur le terrain Danien, nouvel étage de la Craie. *Bulletin de la Société Géologique de France*, 2e série, 3(4).
- DEWALQUE, G., 1868. *Prodrome d'une description géologique de la Belgique*. Librairie Polytechnique De Decq, Brussels & Liège, 1-442.
- DOLLFUS, G.F., 1880. Essai sur l'extension des terrains tertiaires dans le bassin anglo-parisien. *Bulletin de la Société géologique de Normandie*, 6: 584-605.
- d'OMALIUS d'HALLOY, J.J., 1831. *Eléments de Géologie*. Levrault, F.G., Libraire-Editeur, Paris, 1-557.
- d'OMALIUS d'HALLOY, J.J., 1842. *Coup d'oeil sur la Géologie de la Belgique*. M. Hayez, Imprimeur de l'Académie royale Bruxelles, 1-132.
- d'OMALIUS d'HALLOY, J.J., 1862. *Abrégé de Géologie*, 7<sup>e</sup> édit. A. Schnée, Bruxelles, Leipzig & Leiber, Paris, 1-535.
- DUMONT, A., 1839. Rapport sur les travaux de la carte géologique pendant l'année 1839. *Bulletin de l'Académie royale de Bruxelles*, 6(11): 464-485.
- DUMONT, A., 1850. Rapport sur la carte géologique du Royaume. *Bulletins de l'Académie royale des Sciences, des Lettres et des Beaux-Arts de Belgique*, 16(2)(1849): 351-373.
- DUMONT, A., 1851. Note sur la position géologique de l'argile rupélienne et sur le synchronisme des formations tertiaires de la Belgique, de l'Angleterre et du Nord de la France. *Bulletin de l'Académie royale de Belgique*, 18(2): 179-195.
- DUMONT, A., 1852. *Carte géologique de Belgique en 9 feuilles, au 160.000e*, présentée à l'Académie en 1849.
- FEUGUEUR, L., 1955. Essai de synchronisation entre les assises saumâtres du Thanétien-Landénien (Gand-Ostende) et du Sparnacien (Ile de France). *Bulletin de la Société belge de Géologie*, 64: 67-92.
- FOBE, B., 1986. Formatie van Lede. In Maréchal, R. & Laga, P., 1988. *Voorstel Lithostratigrafische indeling van het Paleogeen*. Nationale Commissie voor Stratigrafie, Commissie Tertiair.
- GALEOTTI, H., 1837. Mémoire sur la constitution géognostique de la province de Brabant, en réponse de la question suivante: décrire la constitution géologique de la province de Brabant, déterminer avec soin les espèces minérales et les fossiles que les divers terrains renferment et indiquer la synonymie des auteurs qui en ont déjà traité. *Mémoires Couronnées par l'Académie royale de Bruxelles*, 12:1-192.
- GLIBERT, M., 1974. Quelques Turbinolidae cénozoïques des collections de l'Institut royal des Sciences naturelles de Belgique. 1. Genre Turbinolia Lamarck, 1816. *Bulletin de l'Institut royal des Sciences naturelles de Belgique*, 50(1): 1-27.
- GLIBERT, M., 1975. Les Bivalvia du Lédien (Eocène moyen supérieur) de la Belgique. I.: Paleotaxodonta, Cryptodonta, Pteriomorpha. *Bulletin de l'Institut royal des Sciences naturelles de Belgique*, 51(3): 1-61.
- GLIBERT, M., 1980. Les Bivalvia du Lédien (Eocène moyen supérieur) de la Belgique. II.: Heterodonta et Anomalodesmata. *Bulletin de l'Institut royal des Sciences naturelles de Belgique*, 52(5): 1-80.
- GLIBERT, M. & de HEINZELIN, J., 1954. *L'Oligocène inférieur Belge*. Volume Jubilaire V. Van Straelen, I: 281-438.
- GOSSELET, J., 1874. L'étage Eocène inférieur dans le Nord de la France et en Belgique. *Bulletin de la Société géologique de France*, 2: 598-617.
- GRADSTEIN, F.M., OGG, J.G., SMITH, A.G., BLEEKER, W. & LOURENS, L.J., 2004. A new Geologic Time Scale with special reference to Precambrian and Neogene from the Dabie Mountains, central China. *Episodes*, 27(2): 83-100.
- GULINCK, M., 1965a. Aperçu général sur les dépôts éocènes de la Belgique. *Bulletin de la Société géologique de France*, 7: 222-227.
- GULINCK, M., 1965b. Le passage du Bartonien au Rupélien dans la région Boom-Malines. *Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie*, 74: 115-119.
- GULINCK, M., 1969. Le sondage de Kallo (au nord-ouest d' Anvers). Coupe résumée des terrains traversés au sondage de Kallo et profil géologique NS passant par Woensdrecht-Kallo-Halle. *Mémoires pour servir à l'Explication des Cartes Géologiques et Minières de la Belgique*, 11: 1-7.
- GULINCK, M., 1973. Note sur l'extension des facies fluvio-lagunaires du Landénien de la Belgique. *Mémoires pour servir à l'Explication des Cartes Géologiques et Minières de la Belgique*, 13: 1-12.
- GULINCK, M. & HACQUAERT, A., 1954. L'Eocène inférieur – Le Landénien. In Fourmarier, P., (éd.), *Prodrome d'une description géologique de la Belgique*. H. Vailant-Carmanne, Liège, 451-465.
- GULLENTOPS, F., 1990. Sequence stratigraphy of the Tongrian and early Rupelian in the Belgian type area. *Tertiary Research*, 11(2-4): 83-96.
- HANSEN, H.J., 1970. Biometric studies on the stratigraphic evolution of *Globoconusa daubjergensis* (BRÖNNIMANN) from the Danian of Denmark. *Bulletin of the Geological Society of Denmark*, 19: 341-360.
- HARDENBOL, J. & BERGGREN, W.A., 1978. A new Paleogene numerical time scale, Contributions to the Geologic Time Scale. *American Association of Petroleum Geologists*, 213-234.
- HEDBERG, H.D., 1976. *International stratigraphic guide - International Subcommission on Stratigraphic Classification*. Wiley - Interscience Publication, 1-200.
- HERMAN, J., 1972. Les vertébrés du Landénien inférieur (L1a ou Heersien) de Maret (hameau d'Orp-le-Grand). *Bulletin de la Société belge de Géologie*, 81: 195-207.
- HERMAN, J., 1974. Compléments paléoichthyologiques à la faune éocène de la Belgique. 1. Palaeorhincodon, genre nouveau de l'Eocène belge. *Bulletin de la Société belge de Géologie*, 83(1): 7-13.



- HERMAN, J., 1977a. Les Sélaciens des terrains néocrétacés et paléocènes de Belgique et des contrées limitrophes. Eléments d'une biostratigraphie intercontinentale. *Mémoires pour servir à l'Explication des Cartes Géologiques et Minières de la Belgique*, 15: 1-401.
- HERMAN, J., 1977b. Additions to the Eocene fish fauna of Belgium. 3. Revision of the Orectolobiforms. *Tertiary Research*, 1(4): 127-138.
- HERMAN, J., STEURBAUT, E. & VANDENBERGHE, N., 2001. The boundary between the Middle Eocene Brussel Sand and the Lede Sand Formations in the Zaventem-Nederokkerzeel area (Northeast of Brussels, Belgium). *Geologica Belgica*, 3/3-4(2000): 231-255.
- HOUTHUYS, R., 1990. Vergelijkende studie van de afzettingsstructuur van getijdenzanden uit het Eoceen en van de huidige Vlaamse Banken. *Aardkundige Mededelingen*, 5: 1-137.
- JACOBS, P., 1975. *Bijdrage tot de lithostratigrafie van het Boven-Eoceen en het Onder-Oligoceen in noordwest België*. (Unpublished Ph.D.-thesis, Ghent University, 1-182 and annexes.)
- JACOBS, P., 1978. Lithostratigrafie van het Boven-Eoceen en het Onder-Oligoceen in Noordwest België. *Professional Paper, Belgian Geological Survey*, 151-1-92.
- JENKINS, D.G. & LUTERBACHER, H.P., 1992. Paleogene stages and their boundaries (Introductory remarks). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* 186(1-2): 1-5.
- KAASSCHIETER, J.P.M., 1961. Foraminifera of the Eocene of Belgium. *Verhandelingen Koninklijk Belgisch Instituut voor Natuurwetenschappen*, 147: 1-271, 16 pl.
- LAGA, P., GEETS, S., MOORKENS, T. & NOLF, D., 1980. A lithostratigraphic scheme for the NW-European Tertiary Basin. In Kockel, F. (comp.), Subgroup Lithostratigraphy and Maps (IGCP 124). *Newsletters on Stratigraphy*, 8(3): 236-237.
- LAGA, P., LOUWYER, S. & GEETS, S., 2001. Paleogene lithostratigraphic units (Belgium). In Bultynck, P. & Dejonghe, L., (eds.), Guide to a revised lithostratigraphic scale of Belgium. *Geologica Belgica*, 4/1-2: 135-152.
- LE HON, H., 1862. Note sur les Terrains tertiaires des environs de Bruxelles, leur composition, leur classement, leur faune et leur flore. *Bulletin de la Société géologique de France*, 2 série, 19: 804-832.
- LERICHE, M., 1899. Notice sur les fossiles sparnaciens de la Belgique et en particulier sur ceux rencontrés dans un récent forage à Ostende. *Annales de la Société géologique du Nord*, 28: 280-283.
- LERICHE, M., 1902. Les poissons paléocènes de la Belgique. *Mémoires du Musée royal d'Histoire naturelle de Belgique*, 2(5): 1-48.
- LERICHE, M., 1903. Les Poissons du Paléocène belge. *Bulletin de la Société belge de Géologie*, 17(1-2): 124-125.
- LERICHE, M., 1905. Les Poissons éocènes de la Belgique. *Mémoires du Musée royal d'Histoire naturelle de Belgique*, 1ère série, 3(11): 1-231.
- LERICHE, M., 1912a. Livret-guide de la réunion extra-ordinaire de la Société géologique de France à Laon, Reims, Mons, Bruxelles, Anvers, 27 août-6 septembre 1912. M. Weissenbruch, Bruxelles, 1-112.
- LERICHE, M., 1912b. L'Eocène des bassins parisiens et belges (Livret-guide de la réunion extra-ordinaire de la Société géologique de France). *Bulletin de la Société géologique de France*, série 4, 12: 692-724.
- LERICHE, M., 1939. Session extra-ordinaire de la Société belge de Géologie, de Paléontologie et d'Hydrologie et de la Société géologique de Belgique dans le Nord et l'Est de l'Ile-de-France du 18 au 22 septembre 1937. *Annales de la Société géologique de Belgique*, 62(4): 275-281.
- LERICHE, M., 1951. Les Poissons tertiaires de la Belgique (supplément). *Mémoires de l'Institut royal des Sciences naturelles de Belgique*, 118: 1-128.
- LYELL, C., 1852. The Tertiary strata of Belgium and French Flanders. *Quarterly Journal of the Geological Society of London*, 8(31): 276-370.
- MARECHAL, R., 1993. A new lithostratigraphic scale for the Palaeogene of Belgium. *Bulletin van de Belgische Vereniging voor Geologie*, 102(1-2): 215-229.
- MARLIÈRE, R., 1977. Sur le stratotype du Montien à Mons. (Historique. Le sondage de Mons de 1969. Situation, site, coupes. Vers la délimitation du stratotype). *Mémoires pour servir à l'Explication des Cartes Géologiques et Minières de la Belgique*, 17(1): 17-25.
- MAYER-EYMAR, K., 1857. *Tableau synchronique des formations tertiaires d'Europe*. Zurich, 3rd ed.
- MISONNE, X., 1958. Faune du Tertiaire et du Pléistocène inférieur de la Belgique. *Bulletin de l'Institut royal des Sciences naturelles de Belgique*, 34(5): 1-36.
- MOORKENS, Th., 1973. Foraminiferen uit het stratotype van het Montiaan en uit de onderliggende lagen van de boring te Obourg. (Met een overzicht van de stratigrafie van het Paleoceen van België). *Natuurwetenschappelijk Tijdschrift*, 54 (1972): 117-127.
- MOORKENS, Th., 1982. Foraminifera of the Montian stratotype and of subjacent strata in the "Mons well 1969" with a review of the Belgian Paleocene Stratigraphy. *Toelichtende Verhandelingen voor de Geologische en Mijnkaarten van België*, 17(2): 1-186.
- MOURLON, M., 1873. La géologie. In Van Bemmelen, E. (éd.), *Patria belgica*, t.1: Belgique physique. Bruylant-Christophe, Bruxelles, 177-192.
- MOURLON, M., 1880. *Géologie de la Belgique*, t.1. Hayez, Bruxelles, 1-317.
- MOURLON, M., 1887. Sur une nouvelle interprétation de quelques dépôts tertiaires. *Bulletin de l'Académie royale des Sciences et Lettres*, série 3, 14: 15-19.
- NOLF, D., 1973. Deuxième note sur les Téléostéens des Sables de Lede (Eocène belge). *Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie*, 81(1-2): 95-109.
- NOLF, D., 1974. *De Teleostei-otolieten uit het Eoceen van het Belgische Bekken. Reconstructie van de fauna en de biostratigrafische toepassing*. Unpublished Ph.D.-thesis, Ghent University, 1-173, 41 pl.

- NOLF, D. & TAVERNE, L., 1978. Troisième note sur les poissons des Sables de Lede (Eocène belge): les fossiles autres que les otolithes. *Bulletin de la Société belge de Géologie*, 87(3): 125-152.
- NYST, H., 1836. Recherches sur les coquilles fossiles de Houssel et de Kleyn-Spauwen (province de Limbourg). *Messages des Sciences et des Arts de Gand*, 4: 139-180.
- NYST, H., 1842. Additions à la faune conchylogique des terrains tertiaires de Belgique. *Bulletins de l'Académie royale des Sciences et Belles-Lettres de Bruxelles*, 9(1): 439-451.
- PASTIELS, A., 1948. Contribution à l'étude des Microfossiles de l'Eocène belge. *Mémoires du Musée royal d'Histoire naturelle de Belgique*, 1ère série, 8(109): 1-77.
- POMEROL, C. & PREMOLI SILVA, I., 1986. Terminal Eocene events. *Developments in Palaeontology and Stratigraphy*, 9. Elsevier, Amsterdam, 1-414.
- QUINET, G.E., 1966. Les mammifères du Landénien continental belge. Etude de la morphologie dentaire comparée des "carnivores" de Dormaal. *Mémoires de l'Institut royal des Sciences naturelles de Belgique*, 158: 1-64.
- QUINET, G.E., 1969. Apport de l'étude de la faune mammalienne de Dormaal à la stratigraphie générale du Paléogène supérieur européen et à la théorie synthétique de la molaire mammalienne. *Mémoires de l'Institut royal des Sciences naturelles de Belgique*, 162: 1-188.
- RENEVIER, E., 1873. Tableau des terrains sédimentaires formés pendant les époques de la phase organique du globe terrestre. *Bulletin de la Société Vaudoise des Sciences Naturelles*, 12: 1-70. 3 pl.
- ROCHE, E., 1973. Etude des sporomorphes du Landénien de Belgique et de quelques gisements du Sparnacien français. *Mémoires pour servir à l'Explication des Cartes Géologiques et Minières de la Belgique*, 13: 13-121.
- ROSENKRANTZ, A., 1924. De københavnske Grøn-sandslag og deres Placering i den Lagraekke (med et Skema over det danske Palaeocaen). *Meddelelser fra Dansk Geologisk Forening*, 6: 22-39.
- RUTOT, A., 1884. Explication de la feuille de Heers-Terrain Eocène, Etage Heersien. *Musée royal d'Histoire Naturelle de Belgique. Service de la Carte géologique du Royaume*, 96-102.
- RUTOT, A. & VINCENT, E., 1879. Coup d'oeil sur l'état actuel de l'avancement des connaissances géologiques relatives aux terrains tertiaires de la Belgique. *Annales de la Société Géologique de Belgique*, 6: M69-155.
- SCHUMACKER-LAMBRY, J., 1978. *Palynologie du Landénien inférieur (Paléocène) à Gelinden-Overbroek/Belgique. Relation entre les microfossiles et le sédiment*. Laboratoire de Paléobotanie et de Palynologie (éditeur), Université de Liège, Liège, 1-157.
- SMITH, Th. & SMITH, R., 1995. Synthèse des données actuelles sur les vertébrés de la transition Paléocène-Eocène de Dormaal (Belgique). *Bulletin de la Société belge de Géologie*, 104: 119-131.
- STEURBAUT, E., 1986. Late Middle Eocene to Middle Oligocene calcareous nannoplankton from the Kallo well, some boreholes and exposures in Belgium, and a description of the Ruisbroek Sand Member. *Contributions to Tertiary and Quaternary Geology*, 23 (2): 49-83.
- STEURBAUT, E., 1988. New Early and Middle Eocene calcareous nannoplankton events and correlations in middle to high latitudes of the northern hemisphere. *Newsletters on Stratigraphy*, 18(2): 99-115.
- STEURBAUT, E., 1992. Integrated stratigraphic analysis of Lower Rupelian deposits (Oligocene) in the Belgian Basin. *Annales de la Société géologique de Belgique*, 115(1): 287-306.
- STEURBAUT, E., 1998. High-resolution holostratigraphy of Middle Paleocene to Early Eocene strata in Belgium and adjacent areas. *Palaeontographica Abt. A*, 247(5-6): 91-156.
- STEURBAUT, E., MAGIONCALDA, R., DUPUIS, C., VAN SIMAEYS, S., ROCHE, E. & ROCHE, M., 2003. Palynology, paleoenvironments and organic carbon isotope evolution in lagoonal Paleocene/Eocene boundary settings in North Belgium. In Wing, S.L., Gingerich, P.D., Schmitz, B. & Thomas, E., (eds), Causes and consequences of Globally Warm Climates in the Early Paleogene. *Geological Society of America Special Paper*, 369: 291-317.
- STEURBAUT, E. & KING, C., 1994. Integrated stratigraphy of the Mont-Panisel borehole section (151E340), Ypresian (Early Eocene) of the Mons Basin, SW Belgium. *Bulletin de la Société belge de Géologie*, 102(1-2)(1993): 175-202.
- STEURBAUT, E. & NOLF, D., 1986. Revision of Ypresian stratigraphy of Belgium and northwestern France. *Contributions to Tertiary and Quaternary Geology*, 23(4): 115-172.
- STINTON, F.C. & NOLF, D., 1970. A Teleost Otolith Fauna from the Sands of Lede, Belgium. *Bulletin de la Société belge de Géologie*, 78(3-4): 219-234.
- THIELENS, A., 1871. Relation de l'excursion faite par la Société Malacologique de Belgique à Orp-le-Grand, Folxles-Caves, Wansin et autres localités voisines. *Annales de la Société royale de Malacologie de Belgique*, 6: 39-72.
- VANDENBERGHE, N., BRINKHUIS, H. & STEURBAUT, E., 2003. The Eocene/Oligocene boundary in the North Sea Area: a Sequence Stratigraphic Approach. In Prothero, D.D., Ivany, L.C. & Nesbitt, E.A. (Editors), *From Greenhouse to Icehouse. The Marine Eocene-Oligocene Transition*. Columbia University Press, New York: 419-437.
- VANDENBERGHE, N., LAGA, P., STEURBAUT, E., HARDENBOL, J. & VAIL, P.R., 1998. Tertiary Sequence Stratigraphy at the southern border of the North Sea Basin in Belgium. In de Graciansky, P.-C., Hardenbol, J., Jacquin, T. & Vail, P.R., (eds.), Mesozoic and Cenozoic Sequence Stratigraphy of European Basins. *SEPM (Society for Economic Paleontologists and Mineralogists) Special Publication*, 60: 119-154.
- VANDENBERGHE, N., VAN SIMAEYS, S., STEURBAUT, E., JAGT, J.W.M. & FELDER, P.J., 2004. Stratigraphic architecture of the Upper Cretaceous and