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Quaternary lithostratigraphic units (Belgium)

Frans GULLENTOPS[1], Frieda BOGEMANS[2], Guy De MOOR[3], Etienne PAULISSEN[4] & Albert PISSART[5]

(2 figures & 2 tables)

1. Meesberg 28, 3220 Holsbeek
2. Vrije Universiteit Brussel, Vakgroep Fysische Geografie, Pleinlaan 2, 1050 Brussel
3. Boesbeeklaan 5, 9051 St. Denijs Westrem
4. Katholieke Universiteit Leuven, Geomorfologie en Regionale Geografie, Redingenstraat 16, 3000 Leuven
5. Rue Lavaux 29, 4130 Esneux

ABSTRACT. The lithostratigraphic classification of the Quaternary deposits is based on the genesis of the sediments. The distinguished environments are marine – estuarine, fluvial, eolian and slope. The marine – estuarine deposits are restricted to certain time-intervals within the Quaternary and are limited to the northern part of Belgium. Fluvial deposits are found throughout the Quaternary. On the basis of the sedimentological – lithological differentials within the Meuse basin and the Schelde basin a bipartite subdivision of the fluvial deposits is introduced. Eolian deposits are differentiated on the basis of their grain size distribution, namely sand and silt. The sandy deposits are accumulated in the northern part of Belgium, whereas loess is deposited in the more southern part of the country. Slope deposits are not restricted regionally neither temporally.

KEYWORDS: Quaternary, lithostratigraphy, marine – estuarine, fluvial, eolian, slope deposits, palaeosols, peat, tufa deposits and tephra.

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1. Introduction

Apart from some near shore marine sediments the Quaternary stratigraphy of Belgium is essentially concerned with continental deposits laid down by fluvial, eolian, slope or organo-chemical processes. These categories form the basis for the lithostratigraphic classification. Their distribution coincides to some extent with the major geographic regions: low sandy plains with adjacent coastal area in the north; undulating loess covered low plateaux in the middle; higher sloping ground on the Palaeozoic basement in the south. The basic Formation units are conceived in such a way that general users can distinguish them, while Member units necessitate specialistic knowledge. Due to the multitude of controlling factors the quaternary deposits present however great variations. This may lead to the distinction of many local Bed units of which only a few examples will be given.

For chronological assignment the base of the Quaternary is accepted at the top of the Gelasian, the base of the Middle Pleistocene at the beginning of the Brunhes magnetochron, the base of the Upper Pleistocene at the beginning of the last interglacial, the base of the Holocene at the end of the Younger Dryas. These time assignations are mostly based on climato-stratigraphic deductions, in which sediment facies, vegetation and palaeosols are of major importance.

An earlier scale was devised during the detailed geological mapping of the country from 1880 to 1910 and materialised by symbols. A time framework was indicated by *al* for Alluvium and *q1* to *q4* for divisions of the Diluvium. To these was joined a letter for a particular

Table 1. List of Quaternary lithostratigraphic units.

Environment	Group or Formation		Member		Bed	
	Merksplas Fm	Me				
Marine - estuarine	Kempen Group	Kp				
	Brasschaat Fm	Br				
			Vosselaar	BrV		
	Weelde Fm	We	Rijkevorsel	WeR		
			Beerse	WeB		
			Turnhout	WeT		
	Herzeele Fm	Hz	Izenberge	HzI		
	Oostende Fm	Ot				
	Vlaanderen Fm	Vl	Calais	VlC		
			Dunkerque	VlD		
			De Haan	VlH		
			De Panne	VlP		
Fluvial	Meuse Group					
	Liège Fm	Lg				
	Simpelveld Fm	Sv				
	Lixhe Fm	Lx				
	Sterksel Fm	St	Bochelt	StB		
			Lommel	StL		
	Zutendaal Fm	Zd	Winterslag	ZdW		
	Lanaken m	Ln				
	Lanklaar Fm	Lk	Eisden	LkE		
			Maasmechelen	LkM		
			Geistingen	LkG		
	Stokkem Fm	Sk	Mullem	SkM		
			Heppeneert	SkH		
	Schelde Group					
	Rozebeke Fm	Rb				
	Kruishoutem Fm	Kh				
	Meulebeke Fm	Mb				
	Melle Fm	Ml				
	Adegem Fm	Ag				
	Oostwinkel Fm	Ow				
	Eeklo Fm	El	Dendermonde	ElD		
			Oostakker	ElA		
			Eke	ElE		
	Arenberg Fm	Ab	Waardamme	AbW		
			Korbeek-Dijle	AbK		
			Rotspool	AbR		
Eolian	Gembloux Fm	Gx	Hainaut	GxH		
					Warneton	GxW
			Hesbaye	GxS		
			Brabant	GxB		
	Gent Fm	Gt	Dilsen	GtD		
			St. Lenaarts	GtL		
			Wildert	GtW		
	Hechtel Fm	Ht	Kalmthout	HtK		
Slope	Ardennes Fm	Ad	Bande	AdB		
			Soor	AdS		
			Hastière	AdH		
			Fosses	AdF		
			Kanne	AdK		
Organo - chemical						
Peat					Botrange	tB
					Pervijze	tP
					Rotselaar	tR
Tufa					Treignes	uT
Iron					Booischot	fO
Weathering & soils					As	wA
					Rocourt	wR
					Usselo	wU
Tephra					Enstatite	vE
					Ertville	vV
					Laacher See	vL

lithology, making up a de facto lithostratigraphical classification. The later Stratigraphical Register (1929-1932) is essentially chronostratigraphical and recognised only two Pleistocene subdivisions on faunistical arguments. Since then Quaternary research greatly developed, but even now type localities are scanty as authors are aware of the great variability of these continental sediments and hesitate to indicate a succession as typical. It must be stressed that actual analysis, in one exposure or bore- hole, deals with much finer detail than can be expressed by generalised lithostratigraphic units and aims to reconstruct past environmental change at the finest possible scale. But the lithostratigraphy presented here is adequate for geological mapping of the Quaternary mantle, especially when the mapped units represent typical superpositions of lithostratigraphic units. The distinction of local Beds may then become very significant.

2. Marine – estuarine sediments

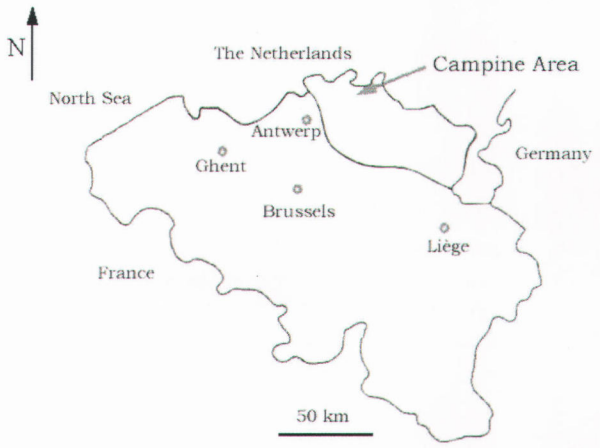


Figure1. Location of the Campine Area.

2.1. Marine – estuarine sediments in the northern Campine area (author: Bogemans)

The deposits of the Northern Campine Area (Fig.1.) belong traditionally to the research domain of the Quaternary geologists, notwithstanding the fact that the Plio-Pleistocene boundary is put on 1.75 million years (Odin, 1994). In consequence the deposits in question are described here.

2.1.1. Merksplas Formation - Me

Authors: Gulinck, 1962; de Meuter & Laga, 1976; Bogemans, 1999.

Description: Grey medium to coarse sand, with glauconite and wood fragments. Containing shell fragments in the lower part and occasionally gravel. The Merksplas Formation is partly a lateral facies of the Brasschaat Formation.

Stratotype: Merksplas.

Area: The Northern Campine.

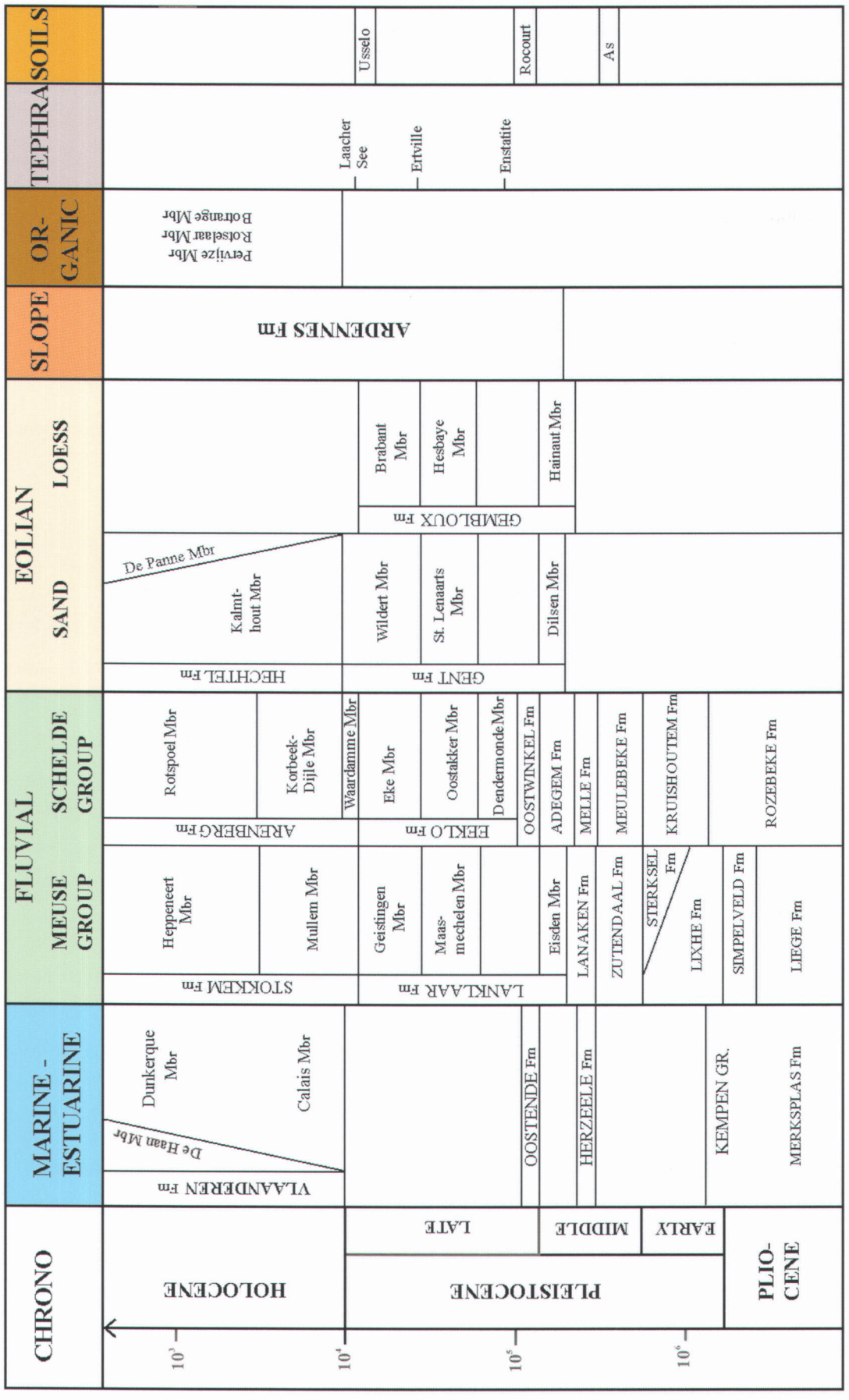
Thickness: Up to 15m.

Age: Pliocene.

2.1.2. Kempen Group – Kp

The Kempen Group consists of fine grained sandy – clayey sediments which are the result of alternating estuarine and

Table 2. Schematic distribution of the Quaternary lithostratigraphic units.



fluvial-eolian conditions at the moment of deposition. It is subdivided into two Formations, namely the Brasschaat Formation and the Weelde Formation.

2.1.2.1. Brasschaat Formation - Br

Authors: Halet, 1935; Gulinck, 1962; Bogemans, 1999.

Description: A dominant sandy complex with a grain size distribution ranging from very fine to medium sand. Beside typical minerals such as micas and glauconite, also vegetation remains, peaty dots, peat lumps and wood fragments are part of the general composition. In restricted places mud deposits dominate.

Stratotype: Rijkevorsel.

Area: The Northern Campine.

Thickness: Up to 30m.

Age: Pliocene, possible Pleistocene.

2.1.2.2. Vosselaar Member – BrV

Author: Bogemans, 1999.

Description: Consists of fining up successions. The greatest portion of a succession consists of fine to medium sand with different types of cross bedding and deformations. The uppermost layer of a succession consists of fine clastic material ranging from very fine sand to clay with or without peat, vegetation remains or parts of a palaeosol. The Vosselaar Member is the topmost part of the Brasschaat Formation.

Stratotype: Beerse.

Area: The southern part of the Northern Campine.

Thickness: Up to 9m.

Age: Pliocene, possible Pleistocene.

2.1.2.3. Weelde Formation - We

It consists of an alternation of clayey and sandy deposits.

2.1.2.4. Rijkevorsel Member – WeR

Authors: Paepe & Vanhoorne, 1970; Bogemans, 1999.

Description: A clayey – sandy micaceous complex. Vegetation remains and wood fragments are quite common but occur in rather small amounts.

Stratotype: Rijkevorsel.

Area: The Northern Campine.

Thickness: Common thickness 5 – 10m, at most 20m is reached.

Age: Probably Tiglian (TC3); Lower Pleistocene.

2.1.2.5. Beerse Member – WeB

Authors: Dricot, 1961; Bogemans, 1999.

Description: A dominantly sandy facies characterised by peat layers and cryoturbations.

Stratotype: Beerse clay pit.

Area: In the vicinity of Merksplas, Rijkevorsel, Malle, Beerse and Oud-Turnhout.

Thickness: Up to 3m.

Age: Probably Tiglian (TC4); Lower Pleistocene.

2.1.2.6. Turnhout Member – WeT

Authors: Paepe & Vanhoorne, 1970; Bogemans, 1999.

Description: A non-calcareous micaceous clayey – sandy complex with several organic or soil horizons.

Stratotype: Beerse clay pit.

Area: The Northern Campine.

Thickness: Between 5 – 10m.

Age: Probably Tiglian (TC5); Lower Pleistocene.

2.2. Remaining marine – estuarine deposits (authors: Gullentops & De Moor)

2.2.1. Herzeele Formation – Hz

Authors: Sommé, Paepe, Baeteman, Beyens, Cunat, Geeraerts, Hardy, Hus, Juvigné, Mathieu, Thorez & Vanhoorne, 1978.

Description: Sands and clays with marine fauna and intercalated peat layers and soils built up to 10m above MSL in estuarine position along the Yzer river.

Stratotype: Herzeele (France) clay pit.

Area: North-western Belgium.

Age: Middle Pleistocene, Cromerian to Holsteinian.

2.2.1.1. Izenberge Member – HzI

Authors: Tavernier & de Heinzelin, 1962.

Description: The Hz Fm ends with a silty sand with abundant molluscs, "*Cardium*", fauna and is defined as HzI.

Stratotype: Izenberge borings, paratype: Herzeele pit.

Area: North-western Belgium.

Age: Middle Pleistocene, Holsteinian on palynological grounds.

2.2.2. Oostende Formation - Ot

Authors: Dollfus, 1884; Paepe, 1965.

Description: Tidal and subtidal sand with marine fauna, tidal mudflat with Hydrobia (Meetkerke Bed, De Moor & De Breuck, 1974) and storm beach deposits. Top at 2m above MSL.

Stratotype: Borings and sandpits in coastal plain (Meetkerke and Brugge sandpits) and in the Flemish Valley (Gent-Sifferdok).

Area: Eastern coastal area and the Flemish valley.

Age: Late Pleistocene, Eemian on molluscs, pollen and diatom evidence.

2.2.3. Vlaanderen Formation – Vl

Authors: Dubois, 1924; Flandrien p.p., Paepe & Baeteman, 1979.

Description: Coarse tidal channel sand, fine wadden sand and tidal flat clay with peat horizons building finally up to 2m above MSL, due to transgression of post-glacial sea level rise. The major Pervijze peat Bed allows distinction of two Members.

Stratotype: Flanders coastal plain in France and Belgium.

Area: Flanders coastal plain in Belgium.

Age: Holocene from Boreal to the present, on pollen evidence, type of Flandrian stage.

2.2.3.1. Calais Member - VlC

Author: Dubois, 1924.

Description: Sandy wadden deposits transgressing over soil or peat with intercalated channel sand and silty tidal flat deposits towards the top.

Stratotype: Flanders coastal plain in France and Belgium.

Area: Flanders coastal plain in Belgium.

Age: Essentially Boreal -Atlantic.

2.2.3.2. Dunkerque Member – VlD

Authors: Dubois, 1924.

Description: Rhythms of tidal flat sediments with intercalated channel sand, caused by several sea ingressions.

Stratotype: Flanders coastal plain in France and Belgium.

Area: Flanders coastal plain in Belgium.

Age: Subatlantic.

2.2.3.3. De Haan Member – VlH

Author: De Moor, herein.

Description: Shelly sand of coastal barriers and associated beaches.

Stratotype: Flanders coastal plain.

Area: Flanders coastal plain in Belgium.

Age: Atlantic to the present.

2.2.3.4. De Panne Member – VlP

Authors: Depuydt, 1972; Gullentops, herein.

Description: Calcareous sand forming the coastal dunes derived from the De Haan Member; classified here with the marine environment.

Stratotype: Flanders coastal plain.

Area: Flanders coastal plain in Belgium.

Age: Essentially Subatlantic.

3. Fluvial sediments

3.1. Meuse Group (authors: Gullentops & Paulissen)

Description: This group unites all fluvial deposits in the Meuse basin, essentially of the River Meuse and its tributaries, mostly draining the Ardennes. These sediments, from the highest terraces to the actual alluvial plain, are divided into formations according to the evolution of the drainage in the basin, which is reflected in the lithological constitution. All names and type localities are chosen from a small area to assure the correct vertical succession of the terraces. Each formation comprises several terrace levels of lower rank. The first two Formations belong to the Mio-Pliocene and are described here for completeness.

3.1.1. Liège Formation – Lg

Authors: Paepe & Vanhoorne, 1976.

Description: Highest gravel reach, on or just incised in the Tertiary peneplain, weathered into red-yellow podzolic subtropical soils. It comprises the Trainée Mosane from Namur to Liège, consisting of well rounded quartz with silicified ooliths. The Meuse had still an important drainage area in the Paris Basin with a delta fan in the Lower Rhine embayment. The Formation represents the coarse proximal Meuse part of the West European "Kiezelooliet Group".

Stratotype: Bouge quarry, laying on marine Oligocene sands.

Area: Lower Meuse Valley.

Age: Miocene to Middle Pliocene, no biostratigraphical elements.

3.1.2. Simpelveld Formation - Sv

Authors: Gullentops & Paulissen, herein.

Description: Small remnants of highest terraces slightly cut down into the peneplain, due to epirogenic upheaval of the Ardennes, with incorporation of fresh Palaeozoïc materials, now weathered into reddish brown colour. Deposition of a gravel fan north of Aachen. The Formation ends with the abandonment of the Simpelveld Valley, the Meuse finding a new NNE way to the subsiding Roer Valley Graben.

Stratotype: Abandoned gravel pits in the Mortroux area.

Area: Lower Meuse Valley.

Age: Late Pliocene as Tiglian peat is found in the dry Simpelveld valley.

3.1.3. Lixhe Formation - Lx

Authors: Gullentops & Paulissen, herein.

Description: Largely developed high terraces with thick gravel deposits with around 50% of new Ardennes material. Some Members are very coarse indicating much higher discharge due to melt-water run-off in colder conditions on a rising Ardennes plateau. Reddish brown weathering colours. From Liège the new direction to the NNE causes deposition of gravel fans in Dutch Limburg.

Stratotype: Lixhe chalk quarry, capped by thick terrace gravel.

Area: Lower Meuse Valley.

Age: Lower Pleistocene, mostly estimated pre-Jaramillo.

3.1.4. Sterksel Formation – St

Authors: Zonneveld, 1947; Gullentops, herein.

Description: Coarse, gravely sands deposited by the River Rhine attracted into the Roer Valley Graben by its renewed sinking. In Belgium two Members must be distinguished based on distinctive mineral associations.

Area: Lower Meuse Valley.

Age: Mostly post-Jaramillo Early-Pleistocene.

3.1.4.1. Bocholt Member - StB

Author: Gullentops, herein.

Description: A lower hornblende rich member is underlaying the Bocholt plain, Belgian part of the Roer Valley Graben.

Stratotype: Kaulille borehole.

Area: Lower Meuse Valley.

Age: Mostly post-Jaramillo Early Pleistocene.

3.1.4.2. Lommel Member - StL

Author: Gullentops, herein.

Description: Attracted by the antithetic down warping along the Rauw Fault, Rhine sands were deposited in a deep southern bend and cover the western part of the Kempen. Different mineralogy probably due to superficial weathering.

Stratotype: Sand quarry Houthalen.

Area: Lower Meuse Valley.

Age: Mostly post-Jaramillo Early Pleistocene.

3.1.5. Zutendaal Formation - Zd

Authors: Gullentops & Paulissen, herein.

Description: Sediments from the Meuse when diverted to the northwest, depositing large fans covering the Kempen Plateau. Coarse aggrading gravel, considered fluvio-glacial with ice-rafted blocks, heavily weathered into reddish brown As Soil.

Stratotype: As quarry.

Area: Lower Meuse Valley.

Age: Basal Middle Pleistocene, "Cromerian", probably Glacial B.

3.1.5.1. Winterslag Member – ZdW

Authors: Gullentops & Paulissen, herein.

Description: A lower Member consists of a fan of gravelly sands, first sediments after the breakthrough of the Meuse to the NW.

Stratotype: Winterslag quarry.

Area: Lower Meuse Valley.

Age: Final Early Pleistocene.

3.1.6. Lanaken Formation - Ln

Authors: Gullentops & Paulissen, herein.

Description: Strong uplift caused rapid incision of the Meuse and fixed a northern course. Terraces are preserved along the valley walls, the youngest being the Caberg terrace, and in large cut-off incised meanders downstream of Visé.

Stratotype: Albert Canal sections from Vroenhoven to Lanaken.

Area: Lower Meuse Valley.

Age: Middle Pleistocene, Upper "Cromerian" to Early Saalian.

3.1.7. Lanklaar Formation - Lk

Authors: Gullentops & Paulissen, herein.

Description: A series of low terrace gravels in the valley bottom, gravel base below the modern alluvial plain. Mostly fine gravel with sand lenses. Considerably impoverished Meuse by loss of its Vosges headwaters. A number of allostratigraphic Members are distinguished.

Stratotype: Lower Meuse valley, Lanklaar area.

Area: Lower Meuse Valley.

Age: From Middle Pleistocene, Upper Saalian to Upper Pleistocene, Late Weichselian.

3.1.7.1. Eisden Member – LkE

Authors: Paulissen & Gullentops, herein.

Description: Low gravel terrace followed by interglacial weathering, heavy cryoturbation and Weichselian cover sand.

Stratotype: Eisden gravel quarry.

Area: Lower Meuse Valley.

Age: End Middle Pleistocene, Saalian, Drenthe stage.

3.1.7.2 Maasmechelen Member - LkM

Authors: Paulissen & Gullentops, herein.

Description: Lower gravel terrace with unweathered fine gravel covered by the Wildert cover sand Member with the modern soil.

Stratotype: Boorsem quarry.

Area: Lower Meuse Valley.

Age: Upper-Pleistocene, mostly Middle Weichselian.

3.1.7.3. Geistingen Member – LkG

Authors: Gullentops & Paulissen, herein.

Description: Lowest terrace of gravelly sand with modern soil without cover sand.

Stratotype: Aldeneik quarry.

Area: Lower Meuse Valley.

Age: Upper Pleistocene, Upper Weichselian Pleniglacial.

3.1.8. Stokkem Formation - Sk

Authors: Gullentops & Paulissen, herein.

Description: Sediments of the modern, meandering Meuse. 4-5m graded gravel due to lateral accretion of point bars, also distinguished by the presence of the Laacher See volcanic minerals (**vL**). Covered by overbank silts which are divided into pre-deforestation clayey **Mullem Member (SkM)** and post-deforestation silty **Heppeneert Member (SkH)**.

Stratotype: Quarries and brickyards in alluvial plain.

Area: Lower Meuse Valley.

Age: Holocene.

3.2. Schelde Group (authors: De Moor & Bogemans)

Description: The Group includes all fluvial deposits in the Schelde and Yser basins. The oldest one corresponds to terraces formed during valley incision in Lower and Middle Pleistocene, the younger are present in the valley bottom fill.

3.2.1. Rozebeke Formation - Rb

Authors: Tavernier & De Moor, 1974.

Description: Clayey-sandy rich gravel, preserved at the highest terrace level (at about 80 to 90m above the present main river in the reference area). The gravel is composed of rounded flint, often superficially weathered. Locally with flint fragments. Involutions are present at the base.

Stratotype: Road incision Rozebeke.

Area: Schelde basin.

Thickness: 1 to 2 m.

Age: Pliocene to Lower Pleistocene.

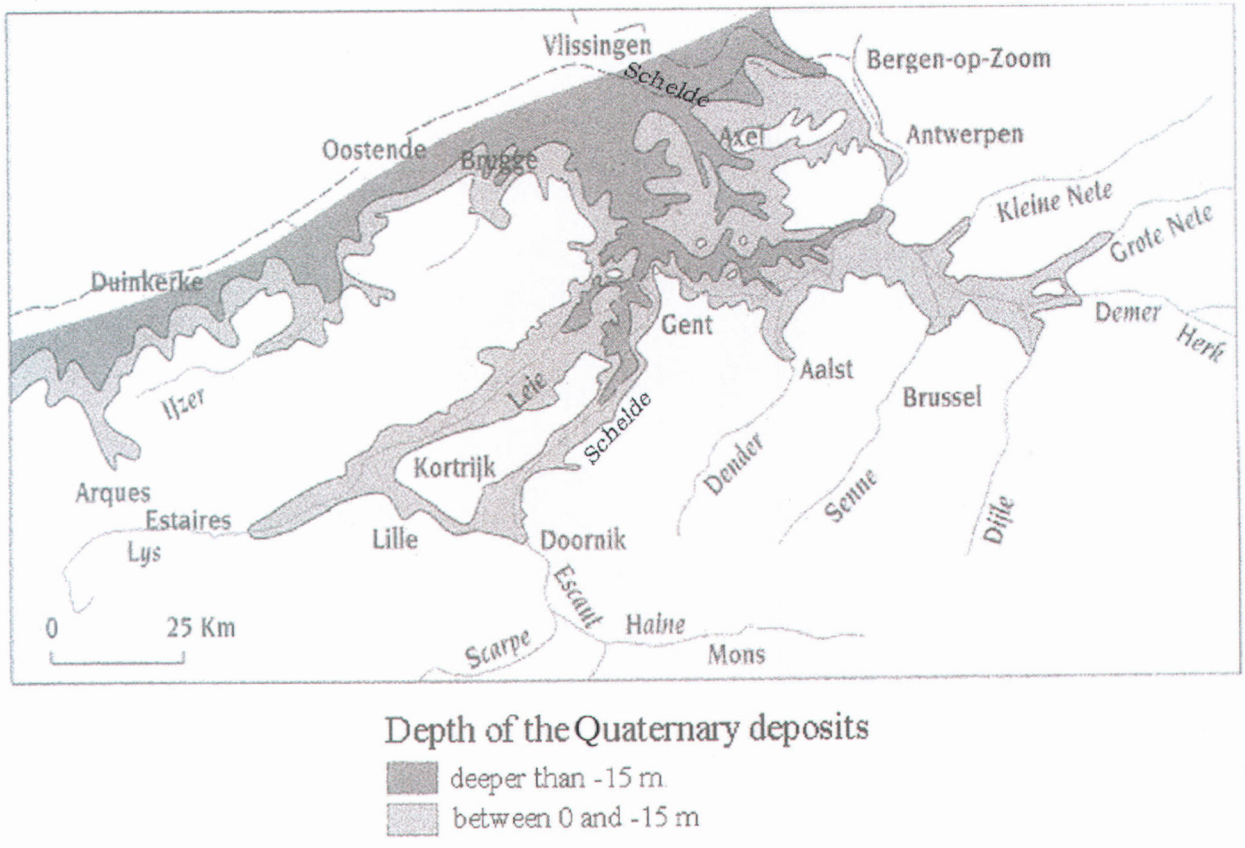


Figure 2. Delimitation of the Flemish Valley.

3.2.2. Kruishoutem Formation - Kh

Author: De Moor, 1964.

Description: Alternating layers of medium to medium coarse sand and gravel (mainly rounded flint and quartz grains) preserved at the High terrace level (at about 50 m above the main river in the reference area).

Stratotype: Excavation Wortegem – Walem.

Area: Schelde basin.

Thickness: Reaches 4 m.

Age: Lower Pleistocene.

3.2.3. Meulebeke Formation - Mb

Authors: Tavernier & De Moor, 1974.

Description: Coarse sand with flint gravel and intercalated clayey layers. This unit is preserved at the Middle terrace level (at about 20 m above the main river in the reference area).

Stratotype: Meulebeke – Hulsvelde.

Area: Schelde basin.

Thickness: Less than 1m.

Age: Middle Pleistocene.

3.2.4. Melle Formation - Ml

Authors: Tavernier & De Moor, 1974.

Description: Cryoturbated complex composed of peaty, peaty-loam layers and sandy intercalations with flint fragments. The unit is situated 5 to 10 m above the main river. The peat layers contain the pollen *Azolla filiculoides* (Vanhoorne, 1961; De Groote, 1967).

Stratotype: Melle, waterway incision.

Area: Schelde basin.

Thickness: Up to 5 m.

Age: Middle Pleistocene, Holsteinian.

3.2.5. Adegem Formation – Ag

Authors: De Moor & Heyse, 1974.

Description: A complex of sandy deposits with cryoturbated horizons. It is preserved in the main valley bottom infill.

Stratotype: Gent-Sifferdok (De Moor, 1963), Nieuwenrode (Bogemans, 1993).

Area: Schelde basin.

Thickness: Up to 7 m.

Age: Middle Pleistocene, Saalian.

3.2.6. Oostwinkel Formation - OW

Authors: De Moor & Heyse, 1974.

Description: Sandy, loamy fine sandy and peaty-loamy deposits of a meandering river system. The sandy layers contain locally *Corbicula fluminalis* and *Theodoxus fluviatilis*.

Stratotype: Berlare (De Moor & Heyse, 1974), Grimbergen (Grimbergen Member - Bogemans, 1993).

Area: Schelde basin.

Thickness: 5m and more.

Age: Upper Pleistocene, Eemian.

3.2.7. Eeklo Formation - El

Authors: De Moor & Bogemans, herein.

Description: The Formation consists of all fluvial and fluvio-periglacial sediments in the infill of the Flemish Valley (Fig. 2.) and the Coastal Plain. The total thickness may reach more than 20 m.

3.2.7.1. Dendermonde Member - ElD

Author: De Moor, 1974.

Description: Consists of gravelly coarse sand layers to gravel layers with boulders. Locally cryoturbations are present. The gravel is mainly composed of rounded flint, flint fragments, quartz grains, wood fragments, reworked shells and locally fossil remains and sandstone fragments. The very coarse elements consist predominantly of large fossil mammal bones, large tree fragments among which complete preserved tree-trunks and boulders (Palaeozoic sandstone).
Upwards and distal from the main valley edges the unit evolves into medium sand with fine gravel and contains freshwater shells and occasionally reworked Eemian shells (**Langerbrugge Bed**, De Moor, 1974) or locally into medium fine sands with intercalated peat layers (**Beernem Bed**, De Moor *et al.*, 1978). Locally it interfingers with gravelly braided river deposits (**Bos van Aa Member**, Bogemans, 1993).

Stratotype: Dendermonde lock (alluvial fan facies); Zemst (Bos van Aa, braided river deposits); Gent Sifferdok (Langerbrugge Bed facies); Beernem (Beernem Bed facies).

Area: Schelde basin.

Thickness: 3 to 5 m.

Age: Upper Pleistocene, Weichselian.

3.2.7.2. Oostakker Member – ElA

Author: De Moor, 1974.

Description: A complex of loam to sandloam layers alternating with sandy to clayey laminae. The top is often a loamy peat. The complex is intensively cryoturbated at several levels.

Stratotype: Gent - Sifferdok (De Moor 1963 – floodplain deposits of braided rivers); Hombeek (Bogemans, 1993 – meandering river, Hombeek Member).

Area: Schelde basin.

Thickness: Up to 10m and more.

Age: Upper Pleistocene, Weichselian.

3.2.7.3. Eke Member - ElE

Authors: Tavernier & De Moor, 1974.

Description: This unit is dominantly sandy with clayey and loamy layers or gravel laminae, sometimes with peaty intercalations. Within the sand clay pebbles, vegetation remains, reworked tertiary shells and Quaternary fresh water and land shells are present. It shows several levels with ice- and frost wedges. Upward the unit evolves into fine sand deposited in shallow gullies or becomes loamy, with a thickness mostly limited to 3 m. (**Sifferdok Bed**, Tavernier & De Moor, 1974).

Stratotype: Eke (De Moor, 1974), Zemst - Bos van Aa (Bogemans, 1993 - Lembeke Member).

Area: Schelde basin.

Thickness: From 5 to 20 m.

Age: Upper Pleistocene, Weichselian.

3.3. Remaining fluvial deposits (author: Gullentops)

3.3.1. Arenberg Formation - Ab

Author: De Smedt, 1973.

Description: Fluvial deposits incised into the Late-Weichselian aggradation. By increased later alluviation the Formation often transgresses out of the valley.

Stratotype: Alluvial plain of Dijle River around Leuven.

Area: Schelde basin.

Age: From Bölling through Holocene.

3.3.1.1. Waardamme Member - AbW

Author: Vandenberghe *et al.*, 1974.

Description: Coarse fluvial sediments filling renewed valley incisions.

Age: Tardiglacial.

3.3.1.2. Korbeek-Dijle Member - AbK

Author: De Smedt, 1973.

Description: Clayey alluvia with numerous layers of peat (tR) and often tufa horizons (uT) by forest rivers with very regular discharge.

Age: Early Holocene.

3.3.1.3. Rotspoel Member - AbR

Author: De Smedt, 1973.

Description: Upper silty inundation alluvia due to increasing soil erosion following deforestation.

Age: Late Holocene.

4. Eolian sediments (author: Gullentops)

4.1. Gembloux Formation - Gx

Authors: Paepe & Vanhoorne, 1976; Gullentops, herein.

Description: Contains all loess units characterised essentially by silt size (mostly 16-62 µm), an allochtonous mineralogy, a clay fraction originally ± 10% but increasing to < 30% by weathering, blanketing an independent subsoil and therefore of eolian origin.
The older units are increasingly less preserved.

Stratotype: Quarry at Harmignies, paratype at Kesselt.

Area: Middle Belgium except on erosion sensitive hilltops or slopes.

Age: Periglacial stadials of Middle and Upper Pleistocene.

4.1.1. Hainaut Member - GxH

Authors: Gullentops, 1954, Paepe & Vanhoorne, 1976.

Description: On flat surfaces or in depressions are preserved remnants of lower loesses most often strongly weathered, rarely as thicker still calcareous loess. They are characterised by the preservation of typical interglacial palaeosols; as of Rocourt, Maizières, Lafelt.

Stratotype: Rocourt, Harmignies, Kesselt.

Area: Middle Belgium except on erosion sensitive hilltops or slopes.

Age: Middle Pleistocene, Elsterian and Saalian Loesses, Interglacial Palaeosols up to MIS5.

4.1.2. Warneton Beds - GxW

Authors: Paepe, 1964; Paepe & Vanhoorne, 1976.

Description: A critical upper horizon of the Hainaut Member are the humic Warneton Beds which cover the latest interglacial palaeosol and contains the characteristic Rocourt enstatite tephra l.

Stratotype: Warneton, Rocourt.

Area: Middle Belgium except on erosion sensitive hilltops or slopes.

Age: Upper Pleistocene, Earliest Weichselian aut., MIS 5A/C.

4.1.3. Hesbaye Member - GxS

Authors: Gullentops, 1954; Paepe, 1976.

Description: Light brown to greyish, often calcareous, laminated silts, being eolian loess deposited by snow melt-waters in depressions or gullies. Grey reduced horizons alternate with layers rich in crotovinas, land molluscs (predominant *Succinea*), worm pearls; frost phenomena increase towards the top.

Stratotype: Van de Sande quarry, Veldwezelt.

Area: Middle Belgium except on erosion sensitive hilltops or slopes.

Age: Upper Pleistocene: mostly Middle Weichselian, MIS 3.

4.1.4. Brabant Member - GxB

Authors: Gullentops, 1954; Paepe, 1976.

Description: Yellow, calcareous loess, slightly cohesive when dry, deposited with some Dra trends by north-eastern winds. With mean chalk content of 10%, the upper 2-3m are now decalcified and weathered into a grey-brown podzolic soil. Most often its base is clearly delimited by a typical Bed: **the Kesselt Suite** (Kesselt Soil, Gullentops, 1954, here) **GxBK.**

Stratotype: Nelissen quarry, Kesselt.

Area: Middle Belgium except on erosion sensitive hilltops or slopes.

Age: Upper Pleistocene: Late Weichselian, MIS 2.

4.2. Gent Formation - Gt

Authors: Paepe & Vanhoorne, 1976.

Description: It encloses all sandy eolian deposits, locally reworked, with silty and peaty intercalations, known as cover sand.

Area: The northern plains of Belgium.

Age: From Middle Pleistocene, Saalian to Holocene.

4.2.1. Dilsen Member - GtD

Author: Paulissen, 1973.

Description: Slightly silty homogeneous cover sand in which an interglacial soil developed, found only on pre-Weichselian topography.

Stratotype: Dilsen gravel pit.

Area: The northern plains of Belgium.

Age: Middle Pleistocene, Saalian, Drenthe stage.

4.2.2. Sint Lenaarts Member - GtL

Author: De Ploey, 1961.

Description: Reworked eolian sands with silt and peaty layers occurring in depressions under the Wildert Member cover sand. Niveo-eolian periglacial conditions.

Stratotype: St. Lenaarts clay pit.

Area: The northern plains of Belgium.

Age: Upper Pleistocene, essentially the Middle Weichselian, MIS3.

4.2.3. Wildert Member - GtW

Author: De Ploey, 1961.

Description: A mantle of slightly silty cover sands, with granule laminae at the base, the top forming an eolian microrelief with long distance north-eastern provenance. Deposited in dry, very cold conditions.

Stratotype: Wildert clay pits.

Area: The northern plains of Belgium.

Age: Upper Pleistocene, Upper Weichselian Pleniglacial, MIS 2.

4.3. Hechtel Formation - Ht

Author: Gullentops, 1957.

Description: Inland dune sands, covering the Usselo Soil, originally building parabolic or longitudinal dunes by deflation of essentially the Wildert Member cover sand with WSW winds.

Stratotype: Hoeverbergen, Central Campine area.

Area: The northern plains of Belgium.

Age: Upper Pleistocene, Younger Dryas.

4.3.1. Kalmthout Member- HtK

Author: De Ploey, 1961.

Description: Grey blowing sands (stuifzand) reworking the Hechtel Formation dunes and their podzol capping since Subboreal climatic deterioration and human husbandry.

Stratotype: Kalmthout nature reserve.

Area: The northern plains of Belgium.

Age: Subboreal to present.

5. Slope sediments (author: Gullentops)

5.1. Ardennes Formation - Ad

Description: it encloses all deposits formed essentially by gravity from dry scree to run-off, in which the slope is determining.

5.1.1. Bande Member - AdB

Author: Gullentops, herein.

Description: Debris scree on steep slopes under quartzite or limestone rocks. Originally openwork, the pores sometimes later filled with flown or blown in fines.

Stratotype: Bande pierrier (Gullentops, 1954).

Area: Middle and Upper part of Belgium.

Age: Essentially from the last glacial stages.

5.1.2. Soor Member - AdS

Authors: Pissart and Gullentops, herein.

Description: Mixed deposits laid down by viscous flow and creep. Important silty-argillaceous matrix as driving medium. Mostly active as periglacial mud flows.

Stratotype: Soore valley, Pissart, 1953.

Area: Middle and Upper part of Belgium.

Age: The last glacial stages.

5.1.3. Hastière Member - AdH

Author: Gullentops, herein.

Description: Layered mixed deposits found at the foot of slopes, laid down by local run-off.

Stratotype: Hastière brick earth pit.

Area: Middle and Upper part of Belgium.

Age: Essentially from the last glacial stages.

5.1.4. Fosses Member - AdF

Author: Gullentops, herein.

Description: Layered, rhythmic deposits of calibrated frost shattered debris, mostly shales, deposited in open-work laminae by snow meltwaters.

Stratotype: Fosses (Gullentops, 1952).

Area: Middle and Upper part of Belgium.

Age: Snow-rich periglacial phases of Middle Pleistocene, Saalian and Upper Pleistocene, Weichselian.

5.1.5. Kanne Member - AdK

Authors: Gullentops & Paulissen, herein.

Description: Silty deposits produced by soil erosion (colluvium), impoverished in clay, in cultivated areas; ale of first geological maps.

Stratotype: Kanne, Albert Canal excavation (Paulissen *et al.*, 1981).

Area: Middle and Upper part of Belgium.

Age: Later Holocene, since deforestation.

6. Organo-chemical units (author: Gullentops)

Description: Organo-chemical processes are responsible for a great variety of deposits and soils. These are extremely sensitive to climatic conditions and so of utmost importance for stratigraphical deductions. It follows that their presence must be documented with great care. When assimilation to a well described unit is possible, the normal rules are applied. All the units are treated as of Bed rank and abbreviated to a capital letter. They are subsidiary to a Member or Formation of the marine, fluvial, eolian or mass realm. When assimilation to a described unit is not yet possible it is recorded by its lithology abbreviated to a minuscule letter.

6.1. Peat layers: t (tourbe, turf)

Examples: **Botrange Bed** (tB): oligotrophic bogs mostly on the summits of the Ardennes, Holocene; **Pervijze Bed** (tP): eutrophic peat in the maritime plain in the reach of the Calais and Dunkerque Members, Holocene, the type layer is mostly Subboreal.

Rotselaar Bed (tR): eutrophic peat layers in the alluvial plains, mostly Early Holocene.

6.2. Tufa deposits: u

Example: **Treignes Bed** (uT): spring and cascade tufa, Holocene, from Preboreal on, some still active.

6.3. Iron deposits: f

Example: **Booischot Bed** (fO): limonitic bog iron formed in the alluvial plain of rivers (in type Grote Nete) draining glauconite rich terrain, Holocene.

6.4. Weathering and palaeosols: w

It must be recalled that kaolinisation (k) is typical for the oldest peneplain and rubefaction (r) for later Tertiary planation surfaces of the Ardennes (Gullentops, 1954). During the Quaternary new sediments are weathered and complete soil profiles are increasingly preserved. They allow insight in the organo-chemical environment of sometimes very short climatic fluctuations. Pedostratigraphy is consequently an important tool in assessing past global change.

Examples: **As Soil** (wA): intense reddish-brown weathering, well preserved on surfaces of the Zutendaal Formation; essentially achieved before Elsterian Glacial.

Rocourt Soil (wR): a polygenetic soil developed on Hainaut loess Member, more mature than Holocene soils; developed until end of the Eemian.

Usselo Soil (wU): a nannopodzol formed on top of the Wildert Member cover sand and preserved through covering of the Hechtel Member dune sand; Bölling/ Alleröd Oscillation of Latest- Weichselian, ended with Younger-Dryas.

6.5. Tephra powderings: v (volcanic)

Occur in visible laminae or by dispersed grains and are individualised by their provenance or by typical mineralogy. The tephrostratigraphy allows a very time framework.

Enstatite Tephra (vE): aresence of enstatite, occurs in the Warneton Bed, probable age MIS 5b.

Ertville Tephra (vV): visible lamina in laminated loess just prior of Kesselt Suite, earliest Late Weichselian.

Laacher See Tephra (vL): important eruption on Late-Weichselian topography, just prior to Younger Dryas.

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