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QUATERNARY GEOLOGICAL MAPPING ON BASIS OF SEDIMENTARY PROPERTIES IN THE EASTERN BRANCH OF THE FLEMISH VALLEY

(Sheets Boom-Mechelen & Vilvoorde-Zemst)

by

Frieda BOGEMANS

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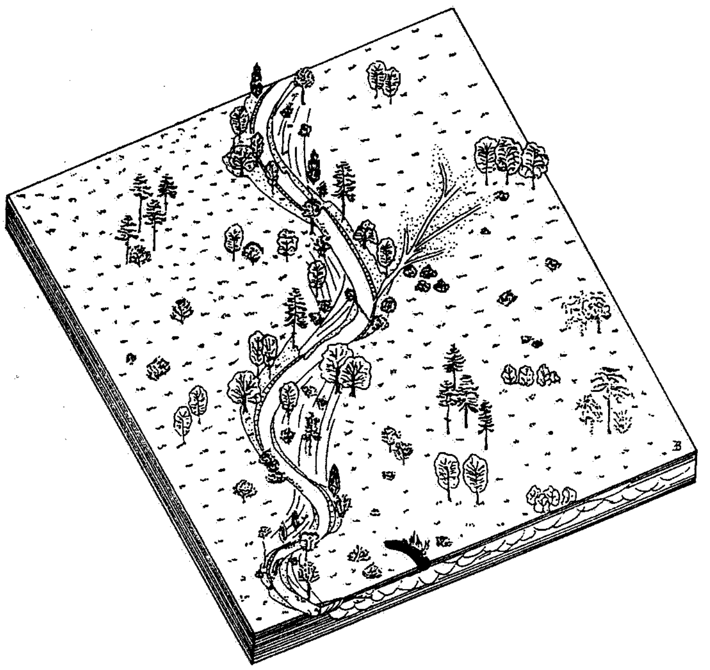

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(Sheets Boom-Mechelen & Vilvoorde-Zemst)

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CONTENT

PREFACE

This work is largely based on the author's doctoral thesis in which new graphic representations, with the accent on mapping systems, were developed in the field of fundamental and applied geology and this particular for continental deposits. Useful mapping systems for Quaternary continental deposits were indeed for the greatest part absent or still in a primary stage of development.
Among certain geologists exists still the idea that the construction of a geological map is the initial step in making the survey of an area and that the understanding of the geological constitution and evolution comes only in a later stage. This specific study is than mainly based on the already surveyed map of that particular area. This idea is only tenable to a certain level when it concerns rather homogeneous deposits extended over long distances and at a particular level, for example in a superficial or outcropping position. But once the geologist is dealing with widely differing deposits, like for instance the Quaternary deposits in Belgium, the above described method is out of question.

Besides, during the study it became clear that although the general Quaternary evolution is rather well known, essential elements necessary in both the fundamental and applied geology are still missing. Consequently the necessity forced itself to follow the next procedure in order to get a detailed overview of the geological build-up of the survey area.
Detailed information is gathered by studying primary sedimentary structures in correlation with texture and palaeontological data obtained from palaeozoölogy and palaeobotany. The basic and largest part of information is got from undisturbed cored borings, provided by the Belgian Geological Survey, and outcrop observations, both completed by hand drillings as well as borehole descriptions. The latter ones are derived from the archives of the Belgian Geological Survey. This kind of information made the reconstruction of the sedimentary paleao-environments and paleao-subenvironments possible which for their part form the building blocs of the fundamental geological map called profile type map. The construction of the profile type map however is explained in this work step by step since in the present literature such a 'manual' is still missing.
Derived from the basic data the construction of other thematic maps is possible. An engineering geological map is introduced as an example .
Usefulness and applicability of these maps are discussed in previous articles written by the author.

INTRODUCTION

In the framework of the economic development and expansion, raw materials like clay, silt, sand and gravel form a basic element. However, the extraction of these materials places the society already today in a double dilemma. Indeed these raw materials become rarer on the one hand, while on the other hand the exploitation itself forms a heavy burden on the natural environment. Consequently, the exploitation of the materials mentioned above has to be regulated so the exploitation can be carried out in an efficient and responsible way through which an equilibrium in the natural environment is preserved or (re)established.
Besides, the social importance of these particular deposits should not be underestimated. In fact, in the framework of house- and road-building, recreation facilities... the provision of the properties of foundations, of the constructional materials and the implanting itself are directly determined by the properties of the superficial layers and those situated at the immediate subsurface.
In the northern and central part of Belgium the raw materials in question are generally Quaternary deposits.

Because nowadays the target of each established authority is to create an equilibrium between the exploitation and the preservation of the natural environment the introduction of a well-balanced land-use planning is indispensable. Such a well-balanced land-use planning is only efficient when it is founded on geological knowledge, more particularly on the lithological and the sedimentological up-building of especially the Quaternary deposits. Since these particular deposits are characterized by great lateral and vertical variations over very small distances a detailed geological study up to the level of reconstructing a sedimentary palaeo-environment and even sedimentary palaeo-subenvironments is necessary in order to define the deposits in a useful way which has beyond the scientific meaning an important value in the applied geological fields, essential in land-use planning.

The reconstruction of the sedimentary palaeo-environments and palaeo-subenvironments was established on basis of the study of the primary sedimentary structures, their arrangement in correlation with the texture.
A primary sedimentary structure is defined as the shape and the relation of the component parts of a rock formed by mechanical processes (Visser, 1980). However, according to Pettijohn and Potter (1964) the primary sedimentary structures are formed in a unit of time until diagenesis. Therefore a primary sedimentary structure is indeed not only formed during the process of deposition but also during the following time span so that phenomena like bioturbations, intraformational corrugations are incorporated in the term primary sedimentary structure.
The principle to reconstruct a sedimentary environment is to define the characteristic sedimentary subenvironments. The definition of a sedimentary subenvironment is made on basis of distinct arrangements of the primary sedimentary structures within a sedimentary unit. An isolated sedimentary structure is withal generally not typifying the sedimentary environment and subenvironment.

Once the geological up-building of a certain area or region is known, the information in question becomes frequently summarized by means of different kinds of graphic representations. The most suitable graphics are on the one hand the three-dimensional models and on the other hand the geological maps.
A three-dimensional representation is an architectural model whereby the sedimentary subenvironments are shown. Such a model is frequently used in the economic and engineering geology. As such models are used in detailed studies of both scientific and applied origin, the represented area has always a limited extension, indeed usually resulting in a nihil differentiation of the sedimentary palaeo-environments.
It is true, the best known and most frequently used graphic representation is the geological map. The traditional geological map with relation to the Quaternary deposits is dissuaded because this particular map only shows the lateral distribution of the layers at the surface of the earth and this in a particular area or region (Visser,1980). On bases of the variability and complexity of the Quaternary deposits a mapping system which shows beside the lateral variations also the vertical variations of the facies is preferable. Such a mapping system is known as profile type mapping. Although this mapping method is generally used to represent coastal sediments (Barckhausen *et al.*, 1977; Baeteman 1981a & b) a new profile type mapping system was developed to represent Quaternary deposits of continental origin. More recently Huybrechts (1985a &b) used a profile type map to represent continental Late-Weichselian and Holocene deposits in the Mark Valley. The mapping units however are restricted to lithogenetic units.

In order to elaborate the above described objectives a survey area was chosen consisting of different sedimentary palaeo-environments which are individually characterized by the complexity and the variability of the facies.

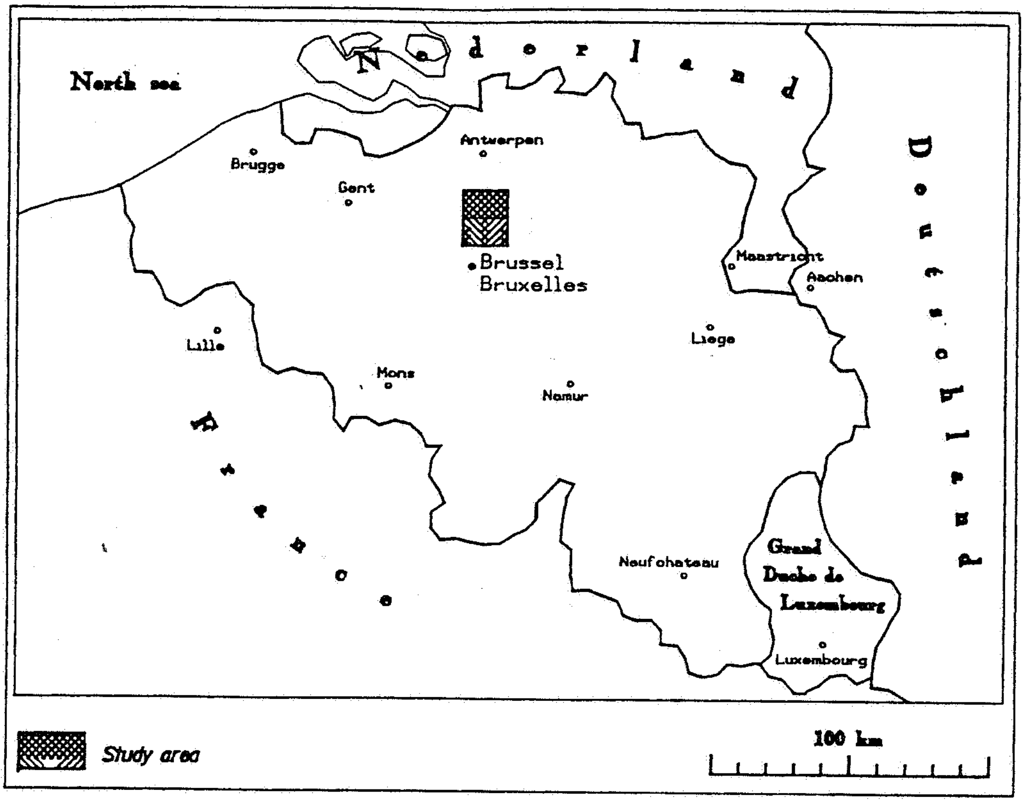


Fig.1a: Location of the study area.

The study area is situated on the topographic maps Boom-Mechelen (23/3-4 scale 1/25.000) and Vilvoorde-Zemst (23/7-8) (fig.1a) and is geographical dominated by the lower courses of the Zenne and the Dijle, both rivers confluence near Zennegat and finally discharge into the Rupel further north.
Variations of the Quaternary deposits within this area are primary the consequence of both the presence of the most eastern branch of the Flemish Valley and the neighbouring region (fig.1b). The term Flemish Valley is introduced by Tavernier in 1943 to indicate the area north of Ghent. The term "branch" was only used for the first time in 1946 by Hacquart and Tavernier on an excursion to the Campine area in order to define the flat region north of Brussels which enlarges north of Vilvoorde. De Moor (1963) described the Flemish Valley as an erosional surface, predominantly of fluvial origin, that is scoured out deep beneath the present sea level even before the Eemian trangression. According to Paepe & *al.* (1981) the incision took place before the Holsteinian, most probably during Middle-Cromerian.

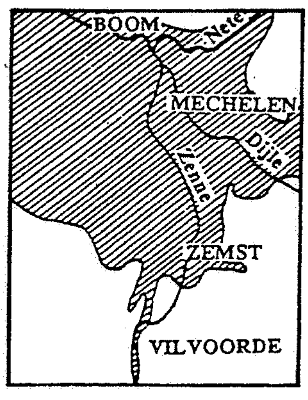


Fig.1b: Location of the eastern branch of the Flemish Valley.

In the eastern branch of the Flemish Valley , fluvial deposits typify the lithological sequences. Fluvial deposition is defined according to Allen (1978) as "the processes of transport and deposition associated with overland flows of sediment-charged water, and the processes resultants known as fluvial sediments or alluvium. Overland flows, representing runoff derived from precipitation, vary from shallow, extensive sheetfloods highly charged with debris to deep streams, low in sediment load, occupying narrow and definite courses (p 335)". In the area, surrounding this branch of the Flemish Valley, the Quaternary sequences are composed of non-fluvial sediments, consisting of mainly eolian and mass-wasting products. Last mentioned deposits are formed according to Flint & Skinner (fide Washburn, 1979) as "the movement of regolith downslope by gravity without the aid of a stream, a glacier or wind" (p 192). Moreover, in this study area all three eolian sedimentation areas (Coversand, Transitional and Loess Area, Paepe & Vanhoorne, 1967 -fig.1c-) formed during the Late-Pleistocene are present by which great variations in the superficial facies appear.

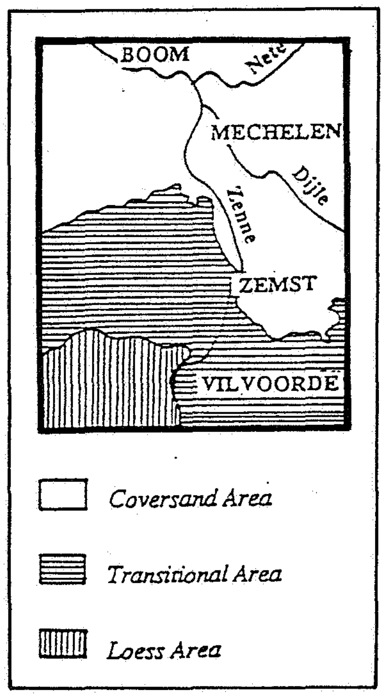


Fig.1c: Location of the three eolian sedimentation areas in the survey region.

Consequently within this area four main geomorphological regions are recognized:

- The first region, which moreover is also the largest one consists of the eastern branch of the Flemish Valley, a rather flat region wherein the topographic level falls below +5m in the northern alluvial plains.
- The second region coincides with the Loess area, where an undulating landscape is characteristic.
- The third region is situated in the surroundings of Nieuwenrode, located westerly of the branch of the Flemish Valley.
- The fourth and last distinguished geomorphological region corresponds with the vicinity of Perk and is typified by a gentle inclined relief, dipping to the north.

It is evident that the reconstruction of the sedimentary palaeo-environments and the subenvironments on the one hand and the geological mapping on the other hand are only feasible on basis of field observations. In the field two different kinds of observations were made, namely the drilling operations and the outcrop recordings.
The drilling operations used for this research project were executed by mechanical means resulting in undisturbed sampling but also by man power. The quality and the quantity of the data are however largely dependent on the drilling method and the equipment used. The interpretation of cored borings unquestionable made the reconstruction of the sedimentary environments and subenvironments possible, as well as the reconstruction of the palaeo-geographical evolution of the area in question. Data obtained from the hand auger campaigns were useful as infilling data through which the geological boundaries on the map were drawn more accurately.

Outcrops form nevertheless the most efficient instrument in the reconstruction of the former sedimentary environments because continuous layers both lateral and vertical are marked, resulting in a facilitated identification of the depositional features. Moreover, the obtained knowledge may be projected on the borings so that a better interpretation of the sedimentary environments and subenvironments is feasible.
In the survey area one outcrop is present, it is situated in the municipality Zemst, more specific in the Bos van Aa near the canal Brussel-Willebroek. The outcrop is the result of sand exploitation, which is used for local purposes.

In the following text the evolution of the survey area during the Middle- and Upper- Pleistocene will be discussed, followed by an explanation of the profile type mapping system used in the above mentioned area. Consequently, within this work scheme the flow of fundamental geological information and knowledge to the applied geological fields is set up. Indeed, thematic maps are collections of indispensable information necessary in the different applied geological fields by which not only a saving in costs occurs but also the preservation and/or efficient use of the natural environment may be obtained, if of course the established authorities and companies take the information into account.

DEFINITION OF THE SEDIMENTARY PALAEO - ENVIRONMENTS

THE MIDDLE - PLEISTOCENE DEPOSITS

The oldest quaternary sediments in the survey region are of fluvial origin and are occuring in the Loess Area as terrace alluvia. These alluvia however have a very restricted extension. The corresponding geomorphological feature, named terrace, consist of a previous valley floor in which the related stream has incised. Since in this rather small area, with a maximum altitude of + 71m TAW* at Hasselenberg successive incisions of the respective streams have been taken place, seven terracesare formed. Within these seven terraces a discernment is made between erosion terraces and accumulation terraces, the latter group of terraces containing only one single terrace.
An erosion terrace is formed when the incision give rise to a new valley situated below the level of the original valley floor. An accumulation terrace on the contrary originates when the stream only incises in its own valley fill without reaching the valley floor (Visser,1980).
The large number of terraces in the survey region is most probably related to the small dimension of the active streams in the past. It is indeed a well known fact that small fluvial systems and the upper reaches of a stream react rapidly on external environmental changes (Chorey & Kennedy, 1971; Howard, 1982; Schumm, 1977). However, the environmental changes in question have to be in relation with the changes in flow and sediment conditions of the stream, which are in turn directly related to the geomorphological response of the channel (Knighton, 1984). Besides, according to Anderson & Calver (1977) small reaches adjust to modification by means of an incision instead of adapting their plane geometry.
In the classic theory, terraces are attributed to a lowering of the sea level resulting in a regressive erosion (eustatic terraces) or to a change of the fluvial regime (climatological terraces) (Baulig, 1952). On bases of the obtained results, the incisions which took place in the study region are ascribed to modifications of the fluvial properties.
According to Schumm (1977) an incision is possible when the environmental circumstances become different, however the transformation has to appear in such a way that the dimension of the stream, the form and the channel pattern stay unchanged. An alteration of factors like moisture content, temperature and related features give rise to morphological unbalanced situations. Generally a change in the water balance is caused by a disequilibrium between climate, vegetation, geology and morphology (Huybrechts, 1985a).

More precisely the fixation of the sediments, the evapotranspiration, the infiltration and still some other factors change considerably during a state of disequilibrium. Consequently an incision may happen theoretically during the unstable state of transition that exists between a cold(er) and a warm(er) phase and *vice versa*, with the understanding of course that local factors stay unchanged.
Potentional phases of incision are present when the fluvial activity increases, however on the condition that no important increase of the sediment supply takes place.
Although the annual water volume proportionately decreases when the climate changes from warm to cold, the available water gets released quite suddenly and mostly during a short period of time, resulting in important peak discharges. Moreover, due to the remain of only a scarce vegetation the evapotranspiration is strongly reduced though this particular vegetation still prevent intensive erosion of the sediments. When local circumstances are favorable, an incision will take place. A cold- warm transition favors also an incision since the amount of moisture increases, while the still scarce vegetation give only rise to a low degree of evapotranspiration. The vegetation however ensures the fixation of most of the sediments.
Despite the large concentration of terraces in this particular area, these geomorphological features are topographically unperceptive. This phenomenon is the consequence of the erosional processes following the formation of the terraces and the deposition afterwards of mass-wasting products and/or eolian sediments through which the leveling was completed.
Within the framework of the buried and the spatial limited position of the terraces in the landscape, the rather vertically extended cover of loess and the mass-wasting deposits, field observation based on hand drillings are generally excluded. Furthermore, the results obtained from geo-electrical soundings mostly did not allow to differentiate correctly the terrace alluvium and the underlying tertiary substratum. Consequently the terraces and their alluvia are mainly known via the archives of the Belgian Geological Survey. Because a description of the sedimentary structures is mostly absent in the relevant archives the reconstruction of the sedimentary palaeo-environments on the level of channel pattern and depositional features is out of question.

* Tweede Algemene Waterpassing (Second adapted water leveling)

The three uppermost terraces (fig.2)

The alluvium of the highest terrace, corresponding with the sixth erosion terrace, is mainly built-up by coarse material consisting of gravelly sand layers and layers composed of almost exclusively gravel. A uniform sedimentation pattern is absent in these deposits.
The above described sedimentological characteristics simply point to various depositional circumstances in a fluvial environment where mainly coarse material was transported and deposited.
The finer grained facies within this coarse fluvial material accumulated most probably during the interglacial IV of the Cromerian Stage. On the contrary the coarser grained sediments are situated in the glacial C of the Cromerian (according to the nomenclature of Zagwijn, 1985).
The formation of the terrace probably took place during the period of disequilibrium that existed during the transition of the Cromerian interglacial IV and the Elsterian.

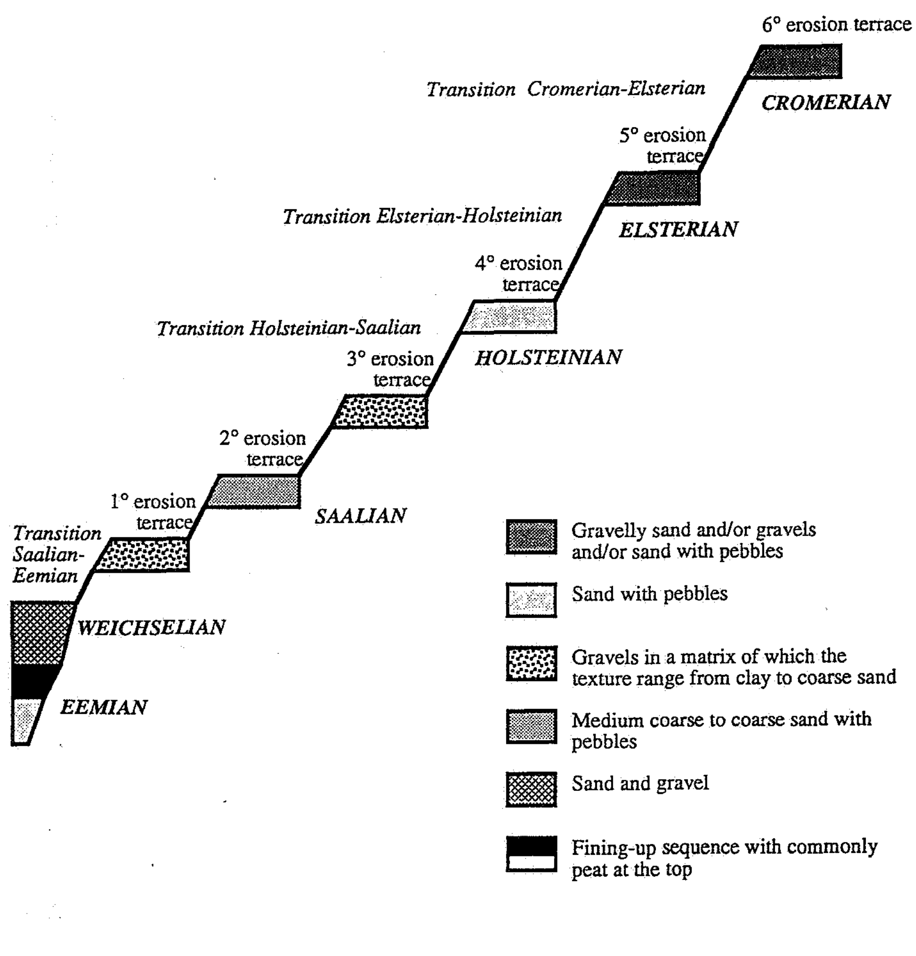


Fig.2: Schematic representation of the terraces in the Loess Area.

In analogy with the previous described facies the sediments of the fifth erosion terrace are also typified by great textural variations over rather small distances. Although medium sand with gravel generally dominates the fluvial sequence on this terrace level, gravel deposits with a toplayer of clay are not uncommon. This sedimentation pattern is possibly related to an alluvial fan in a proximal position, which occurs indeed quite common in either glacial, periglacial and desert environments. In these environments the irregular water supply forms the decisive factor concerning the sedimentation pattern. The deposits are particularly situated in a periglacial environment that existed during the Elsterian Stage, whereas the incision, necessary to create a terrace, took place during the transition Elsterian - Holsteinian.

The alluvium of the fourth erosion terrace was deposited however in two different reaches of the stream, which are indicated according to Strahler (1967) as reaches of different order. A common characteristic of both reaches is the changing lithology of the facies along the longitudinal profile of the stream course. Concerning the reaches of the lowest order, the deposits situated in the most upstream position consist of heterogeneous sand with gravel. In their downstream position both a better sorting degree of the particles exists and the particle size of the sediments itself becomes medium to fine, although gravel still remains present in the sequence. The sediments belonging to the reaches of higher order are made up in the upstream part of coarse grained glauconitic sand with some gravel layers. Downstream, however, finer material dominates the sequence. In both reaches the fluvial deposits are typified by a red color.
On bases of the nature of the above described sediments, with regard to the higher located terrace alluvia, the accumulation took place most probably in an environment where temperate climatic conditions prevailed. In correlation with their position in the landscape the alluvium of the fourth erosion terrace is chronostratigraphically situated during the Holsteinian.

The three lowermost erosion terraces

The sediments of the third erosion terrace in the Loess Area consist of flint stone embedded in a matrix of clay or sand (fig.2).
In both the Loess Area and the surroundings of Nieuwenrode (fig. 3), located in the Transitional Area north of the Loess Area, evidence of an erosional phase is found, resulting in the third erosion terrace in the Loess area. According to the locality in the surroundings of Nieuwenrode one or two successive incisions took place resulting into two successive depressions in the eastern part of the survey region and to only one in the western part.

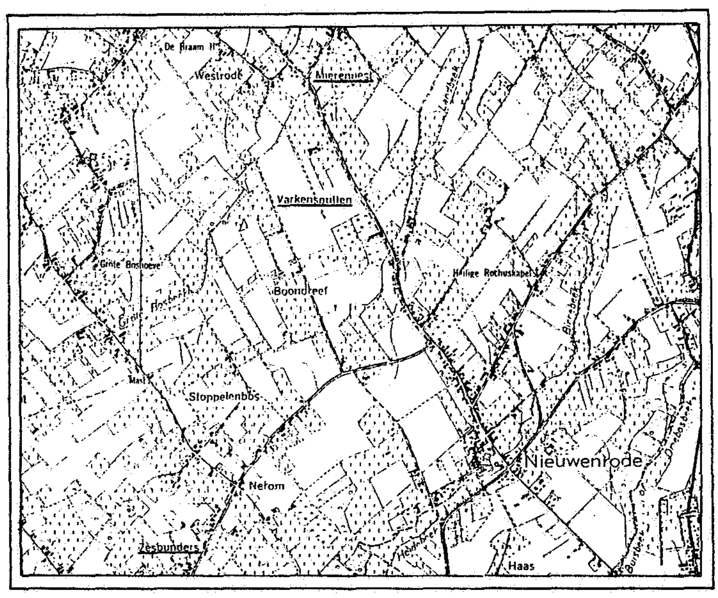
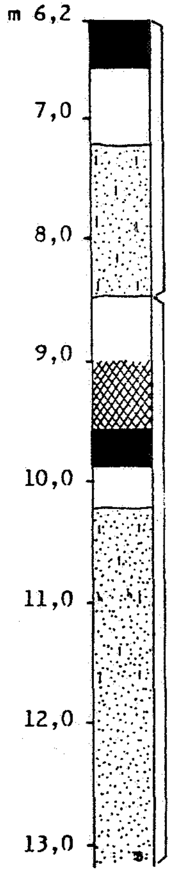


Fig.3: Location of the surroundings of Nieuwenrode (scale 1:31,250). Source: Topographic map Vilvoorde-Zemst 1/25.000 Nationaal Geografisch Instituut

The last incised depression is indeed the deepest one but also the lateral most restricted one. In the shaped depressions, unrelated their depth, fluvial facies accreted belonging to a meandering system of which the source area was situated in the south. As a result of the different evolution of the westerly and easterly situated depressions, differentiations on the level of the thickness and complexity of the fluvial sequences are recorded. The most extensive fluvial sequence is situated in the east, related to two successive depressions and is composed of one or two fining-up cycles depending on local sedimentation conditions. Within a double fining-up sequence (fig.4a) the lower cycle is built up by sands that originated as a channel fill, as a crevasse splay or as a natural levee. The upper part of the cycle however, is dominated by peat and intercalations of fine clastic material. The accumulation was stopped by a limited erosional phase which had no important morphological effects.

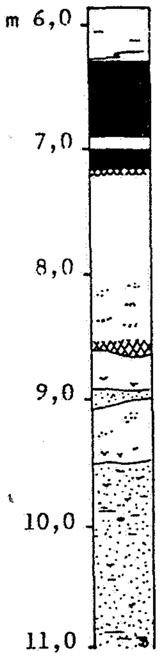


Location: Ipsvoorde
topographic map 23/7-8, scale 1/25 000
geological map 73W, scale 1/40 000
Number of the borehole: I (RUG)
Coordinates: x = 149 850
y = 186 150
z = 14.5 m

Two fining-up cycles typify this sequence. One cycle is composed of sandy material at the basis and fine clastic sediments with peat at the top. The peat is either present within the fine clastic material or is accumulated at the top.

Fig.4a: Illustration of a double fining-up sequence in the surroundings of Nieuwenrode.

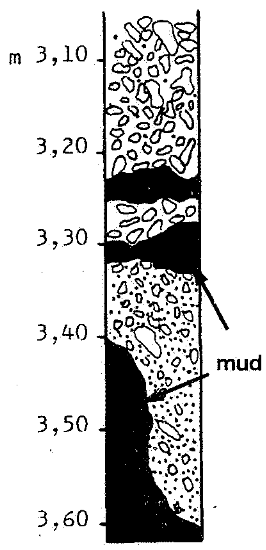
After the restricted hiatus in the sedimentation, the accumulation recommenced and resulted in the second fining-up cycle. The sandy deposits situated at the base of this particular cycle has a minor and more restricted position. Flood basin deposits consisting of very fine clastic material and an important peat development are nevertheless dominant. If only one fining-up cycle is present in the eastern part of the Nieuwenrode area, the constitution of it is similar to the latter one of the double fining-up sequence (fig.4b). The flood basin as a sedimentary subenvironment is also far dominant in this particular sequence. However, the construction of the flood basin has not progressed continuously, but is interrupted at least once due to the lowering of the ground water level which resulted in the compaction of the sediments. This event is related with the already mentioned erosional phase that occurs in between the two fining-up cycles. Analogue situation is found in the western part of the area in question where only one incision took place.
Although both fluvial facies typify the sedimentation process of a meandering system, the lowermost fluvial deposits are the result of a lateral accretion whereas the uppermost sediments are controlled by a vertical accumulation mechanism. The more restricted development of the flood basin in the lower part is also palynologically recorded (personal communication C. Verbruggen).



Location: St. Rochuskapel
topographic map 23/7-8, scale 1/25 000
geological map 73W, scale 1/40 000
Number of the borehole: 255 IIc
Coordinates: x = 149 040
y = 186 360
z = 14.036 m

This sequence consists of one fining-up cycle. Flood plain deposits composed of fine clastic material and peat are dominant. The lower part was formed at the margin of the stream since on the one hand sand lenses are found in the mud and on the other hand crevasse splay deposits are present. The peat accumulation at the top is interrupted as a result of mud deposition.

Fig.4b: Illustration of one fining-up sequence in the surroundings of Nieuwenrode.



Location: Varkensputten
topographic map 23/7-8, scale 1/25 000
geological map 73W, scale 1/40 000
Number of the borehole: 257 Ic
Coordinates: x = 146 887
y = 186 417
z = 15.805 m

The topzone is built up by almost pure gravel with only a few sand grains. This sedimentation pattern originates when the gravel accumulation goes very fast and the existing stream veolocity is high and remains high through which the simultaneous or penecontemporaneous deposition of fine material is excluded (Ramos & Sopena, 1983; Rust, 1984).

In the lower part of the sequence gravel is present in a matrix of coarse sand. Both grain size classes are deposited simultaneously, however in an environment where energetic fluctuations are quite common.

The presence of clay layers point on the one hand to stagnant water conditions and on the other hand to the absence of important erosional activities after deposition.

Fig.5: Representation of a coarse grained sequence in the surroundings of Nieuwenrode.

Meanwhile, in the Loess Area the alluvium of the second erosion terrace was deposited. The alluvium consists of medium to coarse sands, sometimes glauconitic, with flintstone and sporadic sandstone fragments.
These sediments and those in the surroundings of Nieuwenrode came into relief by an incision that was however restricted to the eastern part in the neighbourhood of Nieuwenrode. Indeed it is in this particular area that the last mentioned erosional phase formed the basis of the ultimate shape of the eastern branch of the Flemish

Valley. Both areas evolved further on a parallel and similar way. Although the sequences of the accumulated fluvial sediments are coarse grained in character, the composition however, varies from almost pure gravel to coarse sand with gravel and clay lenses and less frequently clay layers (fig.5).
According to the sedimentary characteristics these deposits are classified as bars, channel lags and channel fill deposits. The previous mentioned depositional elements were formed in a fluvial environment where strong fluctuating hydraulic regimes prevailed.
On basis of a detailed drilling survey in the surroundings of Nieuwenrode a reconstruction of the sedimentary environment, the palaeo-flow of the stream and the geomorphology of the area was possible. The fluvial system in question is interpreted as an alluvial fan with his steep slope oriented in a west-east direction. A decrease of the grain-size is recorded in the eastern direction.
The fluvial accumulation was stopped in both areas by a renewed erosional phase which formed the lowermost terrace in the Loess Area.

The lithostratigraphic classification (table 2)

According to the International Subcommission on Stratigraphic Classification (Hedberg, 1976) the Formation is a primary formal unit in the lithostratigraphic classification. However a lithostratigraphic unit is not defined on bases of distinct rules but is introduced in accordance with the geological complexity of the survey area and according to the detailed character required for the study.

The genesis of the deposits is the fundamental data in the construction of the lithostratigraphic classification in this particular area. Consequently, those sediments with an analogous origin are incorporated in a specific primary formal lithostratigraphic unit.

In the framework of this study the fluvial deposits are most commonly defined according to their sedimentary palaeo-environments and subenvironments. In particular, the channel pattern consisting of meandering or braided courses determines the sedimentary palaeo-environment.
The sedimentary palaeo-environments are lithostratigraphically defined by means of the second unit in rank, namely the Members.

However, in the Loess Area the reconstruction of the sedimentary palaeo-environments is limited as usually no description of the sedimentary structures is available. In consequence the lithostratigraphic classification in the Area in question is restricted to the level of a Formation.
In the Loess Area the alluvia of the three uppermost erosion terraces belong to the Scheldt Formation that stands for "all deposits of the Scheldt basin terraces occurring in an interfluvial position" (Paepe, 1976; p 20) and which accumulated during the time-span Late-Menapian - Late-Holsteinian.
Notwithstanding the limitation in the reconstruction of the sedimentary palaeo-environments in the Loess Area, a correlation with the fluvial deposits in the surroundings of Nieuwenrode is feasible. On bases of the sedimentological characteristics obtained from the latter mentioned area and in correlation with the morphological entity of both areas, the alluvia of the three lowermost erosion terrace are defined as the Nieuwenrode Formation, named after the type locality. The chronostratigraphic position of this lithostratigraphic unit is the Saalian Stage which is composed of several temperate and cold phases.
Because remains of two different channel pattern are preserved in the type locality of the Nieuwenrode Formation the introduction of two Members was preferable. The lowermost situated Member is called the Ipsvoorde Member. This Member stands for the meandering river deposits of which the bore logs on figures 4a and 4b are an illustration. The Ipsvoorde Member is located in a small region starting northeast of Mierennest and running southeast along St. Rochuskapel and Gravenkasteel to De Heuvel (Humbeek) (topo Vilvoorde 23/7). The lower boundary of this Member is unknown when it concerns the most western part of the area. However in the above described shallow depression a sharp/erosive boundary is present. On the contrary, the upper boundary of the Ipsvoorde Member is always sharp, with erosive and depositional characteristics. The second introduced Member is named Westrode Member and includes the gravelly, most probably braided river deposits present at the immediate subsurface. The lithological constitution is represented on figure 5. The distribution area of this Member starts in the most western part of the survey area in the Leefdaal bos and enlarges in eastern direction to Mierennest, Ipsvoorde and Gravenkasteel. The southern limit is located around Hoognerom, Velaartbos and the northern part of De Heuvel (topografic map Vilvoorde 23/7). The lower boundary of the Westrode Member is always sharp and is either erosive or depositional whereas the upper boundary is most commonly depositional.

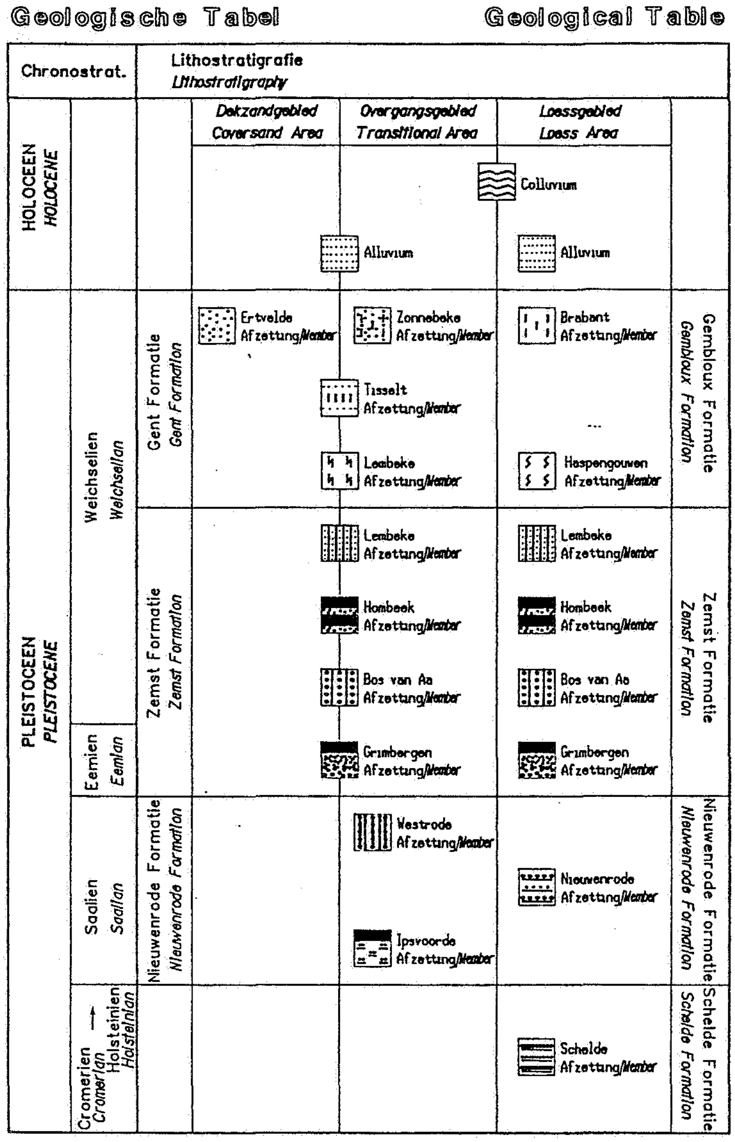


Table 2: Litho- and chronostratigraphic table of the sediments found in the survey area.

THE UPPER - PLEISTOCENE DEPOSITS

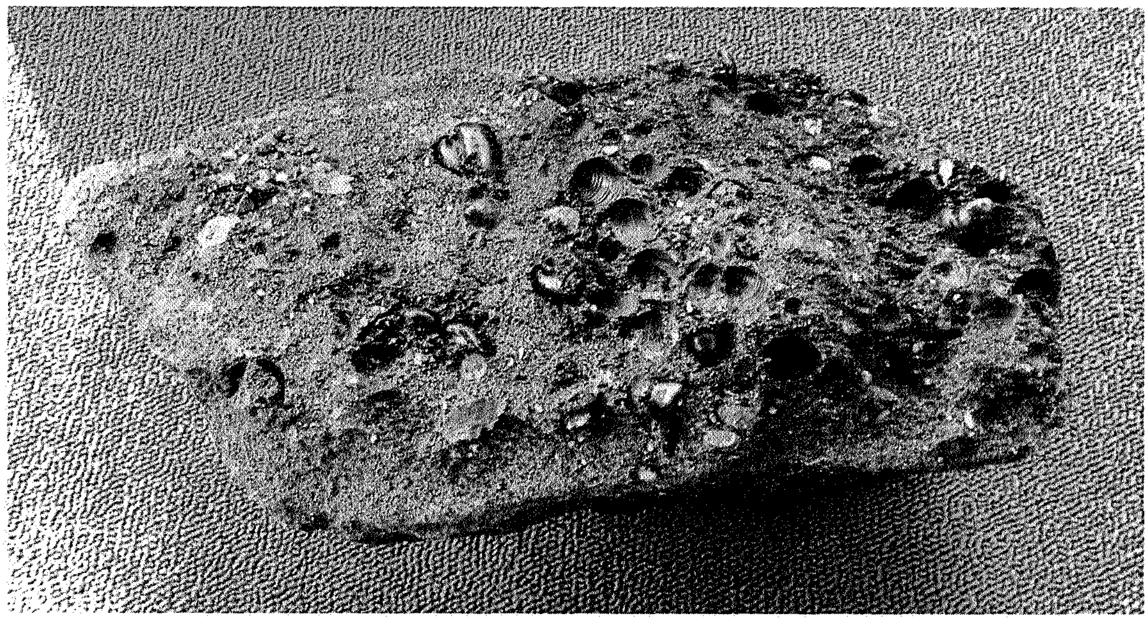
The Upper - Pleistocene deposits in the survey area have a complex genesis. In addition to the fluvial sediments, eolian and mass-wasting products originated in this area and cover an important section in the upper part of the Quaternary profile.
Therefore the sedimentary evolution during the Upper - Pleistocene will be described systematically, *viz.* the fluvial deposits will be scrutinized in the first place, followed by the eolian and mass-wasting deposits.

The fluvial deposits

The Upper-Pleistocene fluvial sediments are mostly restricted to this eastern branch of the Flemish Valley, in exception of some narrow areas in the Loess Area and in the surroundings of Perk (fig.6).
The branch in question is delimited by the +5m contour line of the Tertiary substratum (fig.6). This isohypse

forms indeed the separation between two depositional regions namely the fluvial and the non-fluvial one. However, in the non-fluvial region, situated in the Loess Area and in the surroundings of Nieuwenrode and Perk, limited fluvial deposits are retained.
The eastern branch of the Flemish Valley is in the survey area mainly concentrated in the first half (fig.6) where it covers the region which runs from Ruisbroek to Ramsdonk in the west and from Walem to Mechelen in the east. In the southern part the branch occurs as an inlet along the Verbrande Brug (Grimbergen), Eppegem and Vilvoorde.

Plate I: *Corbicula fluminalis* in a sandy matrix found in the excavation at Bos van Aa.



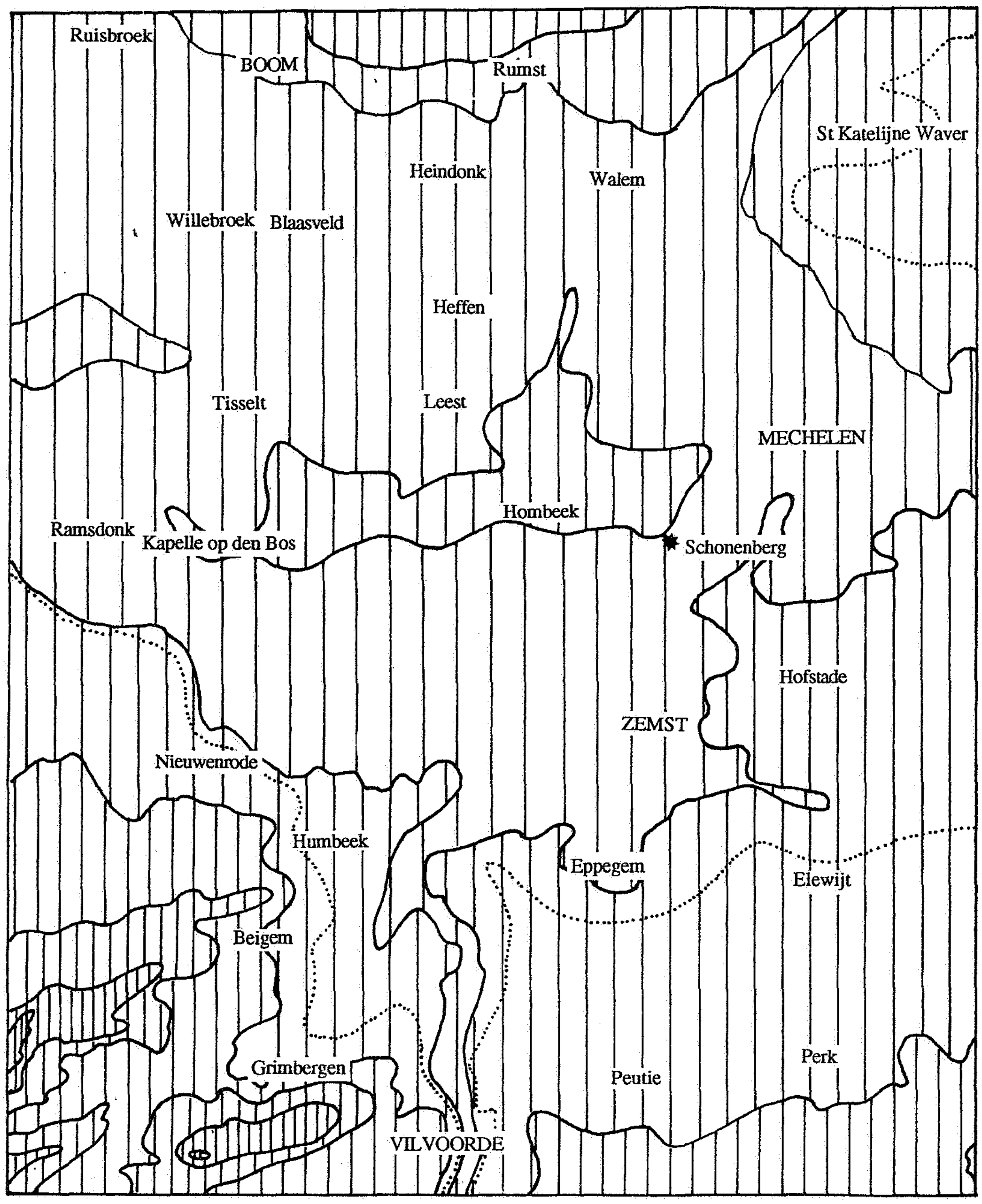
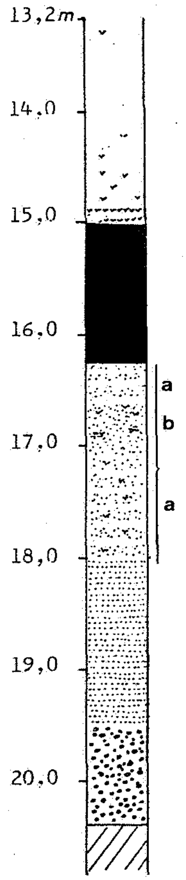


Fig.6: The delineation of the eastern branch of the Flemish Valley in the survey area on basis of the +5m contour line of the top of the Tertiary substratum.

In the eastern branch deeper depressions are present in which remnants of a meandering river are conserved. Palaeo-botanical data obtained from palynological investigations* and the identification of macro-plant remains** as well as the presence of *Corbicula fluminalis* (plate I), the position of the sediments in the sequence and the size of the palaeo-subenvironments indicate a prolonged and continuous activity of a meandering river in a tree-rich environment during the Eemian.
Depositional features like natural levee deposits intersected by crevasse splay deposits and superimposed by flood basin deposits are frequently present (fig.7), just like point bar deposits possible with swales at the top.



Location: Grimbergen
topographic map 23/7-8, scale 1/25 000
geological map 73W, scale 1/40 000
Number of the borehole: 272
Coordinates: x = 152 100
y = 182 280
z = 17.58 m

The top of the fining-up sequence consists of a flood basin deposit characterized by peat accumulation at the base. These flood basin deposits have variations in texture from which fluctuations in the sediment supply is deduced.

This part of the sequence is composed of bank deposits, most probably natural levee deposits "a" (Allen, 1965; Taylor & Woodyer, 1979 and Singh, 1972) of which the development is interrupted by the deposition of crevasse splay deposits "b" (O'Brien & Wells, 1986; Bridge, 1984).

The channel deposits are restricted to a channel lag and a sandy deposit that is not further definable.

Fig.7: Meandering river deposits composed of natural levee deposits intersected with crevasse splay deposits and overlain by flood basin deposits.

* Carried out by C. Verbruggen, Rijks Universiteit Gent
** Carried out by H. Doutrelepont, Museum van Midden Afrika te Tervuren

Peat accumulation took place in both the flood basins and the swales during the Eemian pollen Subzones E5b and E6a (after the classification of Zagwijn, 1983).

On basis of the outcrops in the Bos van Aa an architectonical reconstruction of this particular sedimentary palaeo-environment was elaborated and represented in a three-dimensional model, called Model GE on which also the palaeo-flora is indicated (fig.8). The G stands for Grimbergen Member, whereas the E stands for Eemian.

The facies exposed in the Bos van Aa excavation pit are attributed to point bar deposits and overbank deposits. In the latter ones swampy and more drier accumulated material are identified. The swampy deposits are situated in the flood basin, whereas the drier sediments are closer related to the stream as they consist of natural levee deposits (fig. 8).

In the above mentioned deposits botanical macro-rests like seeds, fruits, leafs, branches and big tree-trunks with no traces of transportation, are frequently present. These plant remains indicate a temperate palaeo-climate, some of them are even restricted today to the southern part of Europe. The tree-trunks in question are mainly concentrated in the southern part of the excavated area where point bar facies dominate the depositional environment. The large concentration of trees is closely related to the lateral migration of that particular stream since this migration brought about the destruction of the outer banks through which trees fell into the stream.

During the transition Eemian - Weichselian a limited erosional phase took place resulting in the formation of an accumulation terrace, the only one present in the research area.

The restricted and scattered position of this terrace all over the area points to the already existence of this branch of the Flemish Valley in its present form during the Eemian.

After this phase of incision a braided river system was active during the Lower-Weichselian. Its radius of action was concentrated in the southern part of the branch. On the other hand, in the northern part the fluvial activity was restricted to some narrow depressions (fig.9). The stream in question ran approximately in a south - north

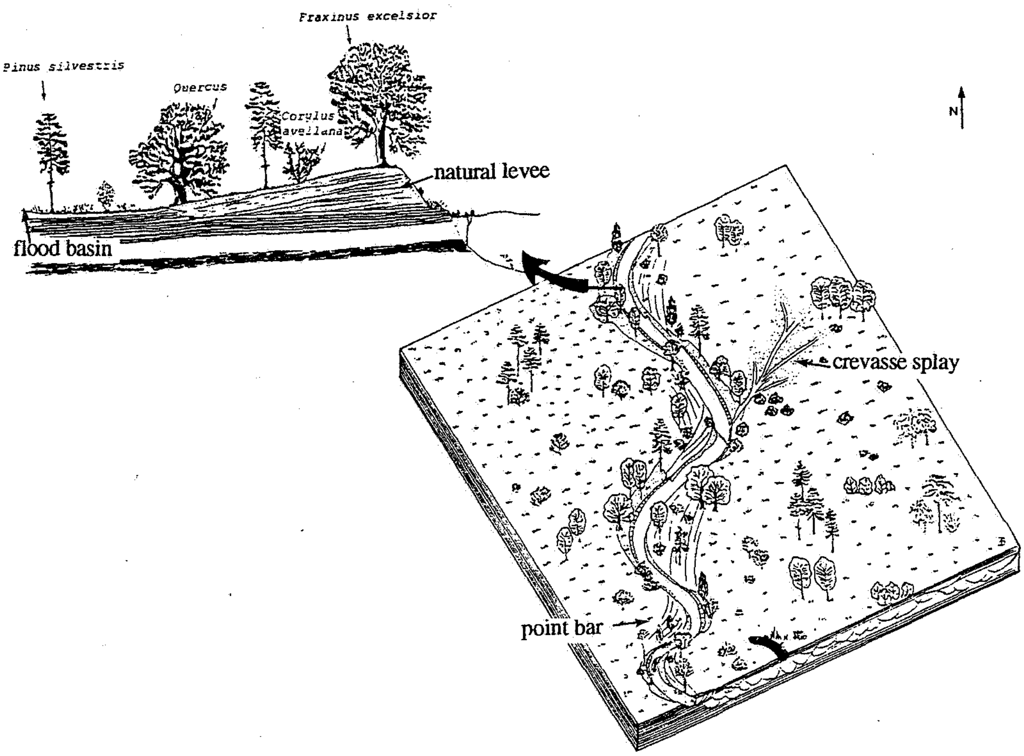


Fig.8: Local three dimensional representation of the meandering river deposits found in the excavation of Bos van Aa.

Fig.9: The distribution of the coarse grained braided river deposits belonging to the Bos van Aa Member.

direction. However, this braided river system was not only restricted to the branch of the Flemish Valley but was also present in the Loess Area and the neighbourhood of Perk, although with a limited distribution.

The aggradated fluvial sediments are characterized by the presence of sedimentation cycles. The cyclicity represents the lateral superimposition of the deposits related to the different sedimentary subenvironments within a braided river complex (Miall, 1984).
Typical sequences are on the one hand a succession of coarse grained bars and on the other hand the alternation of channel-fill, channel-lag and bar deposits. Bars are developed quite often into islands also called stable zones. Certain sequences show damming-up features in channel deposits by which an important accumulation of suspended material took place. This material consists of clay, silt and an alternating complex composed of layers with different textures and with vegetation remains. Similar material is also deposited on higher topographic levels as channel or as flood deposits.
In this sedimentary palaeo-environment prevailed a continual interaction between erosion and sedimentation through which modifications of the different subenvironments and of the topographic levels repeatedly took place. The different subenvironments present one above the other in a sequence are always indicated by an abrupt change in character and are built up without a specific sedimentation pattern. The abrupt character is not always the result of the erosional interaction of the system but is rather the consequence of the mobility and the fast response of the system. According to Williams & Rust (1969) such an abrupt transition between the facies is typical for braided river deposits.

Miall (1977, 1978) defined braided river deposits by a series of vertical profiles. The deposits of Early-Weichselian Age found in this area show analog facies accumulations as the Donjek type in the classification of Miall (1978). The applicability of the classification of Miall (1977, 1978) demonstrates that braided river deposits, although the absence of a well defined sedimentation pattern, are accreted according to a distinct order.

Within the Donjek type two different models, named model BWI and BWII are introduced. Both models were constructed after observations in the Bos van Aa sandpits (table 1).

STRATOTYPE OF THE BOS VAN AA MEMBER
Locality: Bos van AA topographic map 23/7-8, scale 1/25 000 geological map 73W, scale 1/40 000 Coordinates: the outcrop is located between 4° 23' - 4° 24' East 50° 59' - 51° 00' North Lithology: see text and the vertical profiles shown on figures 11 & 13. Regional aspects: figure 9 Boundary :the sharp nature of the lower boundary is commonly the result of erosion activities whereas in minor situations only deposition gave rise to this specific nature of the boundary. The underlying deposits may consists either of sediments belonging to the Grimbergen Member or to the Tertiary. The overlying deposits are composed of either the Hombeek Member in very restricted parts or the widespread Lembeke Member. Eolian deposits are only in exceptional cases directly superimposed on the Bos van Aa Member.

Table 1: Definition of the Bos van Aa stratotype.

The first model (BWI - B stands for Bos van Aa Member, W for Weichselian) (fig.10) consists of sandy depositional features wherein gravel is present as a channel lag deposit or concentrated along the foresets. Typical are also the fine grained clastic topfacies. These braided river deposits are situated in a sedimentary environment in which a few major channels and several topographic levels are present. Since the minor channels are little developed and only present in a small number, extensive transverse or linguoid bars with only small

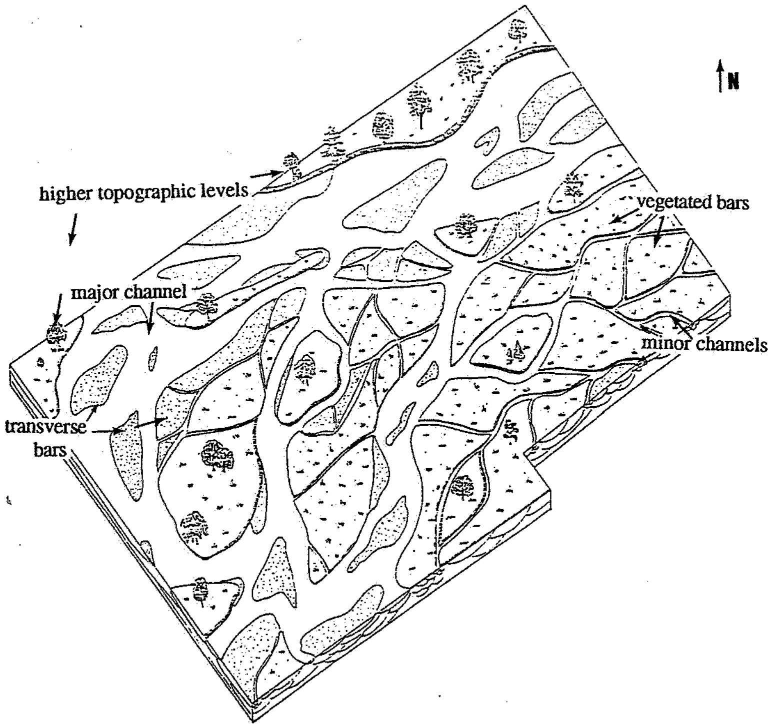
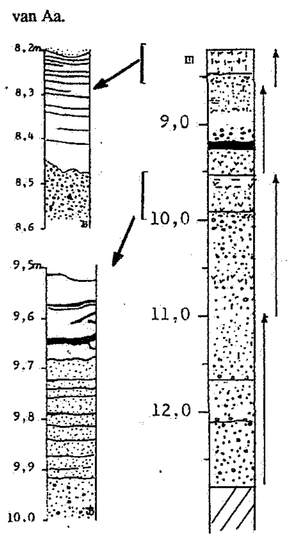


Fig.10: Three - dimensional representation of the lowermost braided river deposits occuring in the Bos van Aa.



Location:	Kerselarenwijk
	topographic map 23/7-8, scale 1/25 000
	geological map 73E, scale 1/40 000
Number of the borehole: 305 IIc	
Coordinates:	x = 157 525
	y = 185 067
	z = 11.298 m

The uppermost cycle is formed in a small gully built up by channel lag deposits (Kirk, 1983) and silty material that alternates in the uppermost zone with humic layers. The alternating complex shows both fluctuating hydraulic conditions and decreasing competence of the stream.

The vertical accretion mechanism of the third cycle is partly the result of accumulation of flood deposits. These deposits are in a later stage strongly compacted. The whole unit is situated on a higher level where gullies only contain water during high water stages.

Fig.11: Braided river deposits with well developed fine clastic topfacies.

incisions are formed. The higher situated topographic levels were only sporadically inundated by which a vegetation cover could develop trough which older depositional features were protected against erosion and preserved (fig.11).
The above mentioned sedimentary characteristics points to rather small variations in the hydraulic regimes and the limited mobility of the system. Indeed flood plain deposits were formed in certain places.
This fluvial model is situated in a cold but humid environment.

In the second model (BWII) (fig.12), gravelly deposits prevail however. The different cycles within a sequence are always bounded by erosion surfaces and by an abrupt change in texture.

These coarse grained deposits have usually a rusty colour owing to the iron coating on the grains. The iron precipitation is possibly the result of a lasting exposure in an oxidizing environment, which implicates a relative low groundwater level and the absence of any kind of fluvial activity over a longer period. Consequently, a hiatus in the sedimentation after the deposition of this particular facies is therefore not excluded.

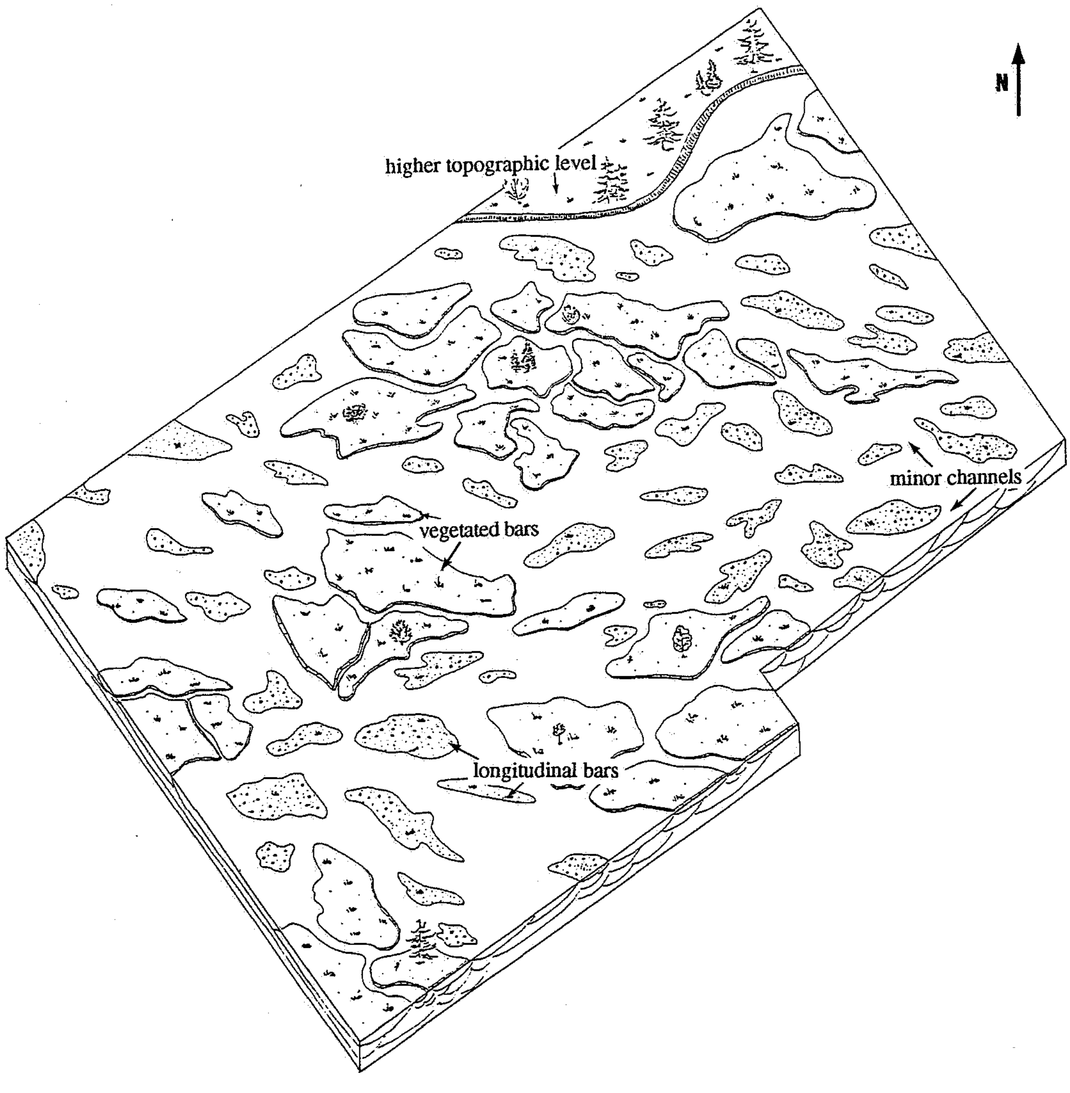
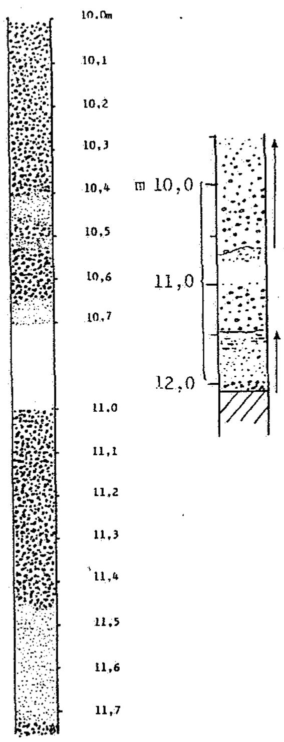


Fig.12: Three - dimensional representation of the coarsest braided river deposits occuring in the Bos van Aa.

The sedimentary features of this model illustrate a mobile fluvial system in which strong fluctuating hydraulic conditions dominate. Major channels are generally absent, the minor channels however are well developed through which the bars are cut into pieces. The vertical profile of this braided river type is shown in fig.13.



Location: Humbeek
topographic map 23/7-8, scale 1/25 000
geological map 73W, scale 1/40 000
Number of the borehole: 278 IIIc
Coordinates: x = 151 500
y = 184 810
z = 14.378

The three cycles are almost completely composed of gravel in a sandy matrix in which some sand lenses are present "a". These sand lenses exclude the simultaneous deposition of both grain size classes.
The channel deposits belong to migration longitudinal bars. The lowermost bar is formed during decreasing flood, however still during upper flow regime (Picard & High, 1973; Harms & Fahnestock, 1965 and Simons et Al., 1965) and is covered with medium sand. Because of the preservation of the sandy material no intensive erosion took place between the two cycles.

Fig.13: Representation of the building-up of the coarsest grained braided river deposits in the eastern branch of the Flemish Valley.

The sedimentary characteristics in combination with the palaeo-zoological data (Germonpré, 1989) assume cold palaeo-climatic circumstances with sudden and abrupt releases of water as a result of thawing possibly in correlation with precipitation. Bad drainage and dry physiological conditions prevailed, permanent permafrost was nevertheless not present in the area.

The above described braided river deposits are eroded in a later phase, but in well defined narrow strips. This gave rise to some small but deep depressions, orientated predominantly east - west. The main depression ran from Hofstade via Humbeek to Kapelle op den Bos. Important tributeries are present in the south (fig14).

In these depressions a meandering river system was active in which the primary accumulation mechanism consisted of vertical accretion. As a result the development of the topstratum deposits into flood basin and natural levee deposits prevailed in these sedimentary sequence.

According to palynological data, which are provided by C. Verbruggen and E. Van Overloop*, the meandering system in question was active during the interstadials Amersfoort and Brørup, situated in the Lower-Weichselian Substage.
Beside the similarity with regard to the main sedimentary depositional environment, the building up of the sedimentary sequences, consisting of a succession of subenvironments, show great variations.

The predominating sequence is composed by flood basin deposits consisting of on the one hand only fine clastic sediments and on the other hand a complex of fine clastic material and peat. Remains of terrestrial snails are no exception in these fine clastic deposits as well as the stratification and ripple mark structures. The sedimentary structures in questions indicate a deposition in the immediate vicinity of the channel (fig.15a).

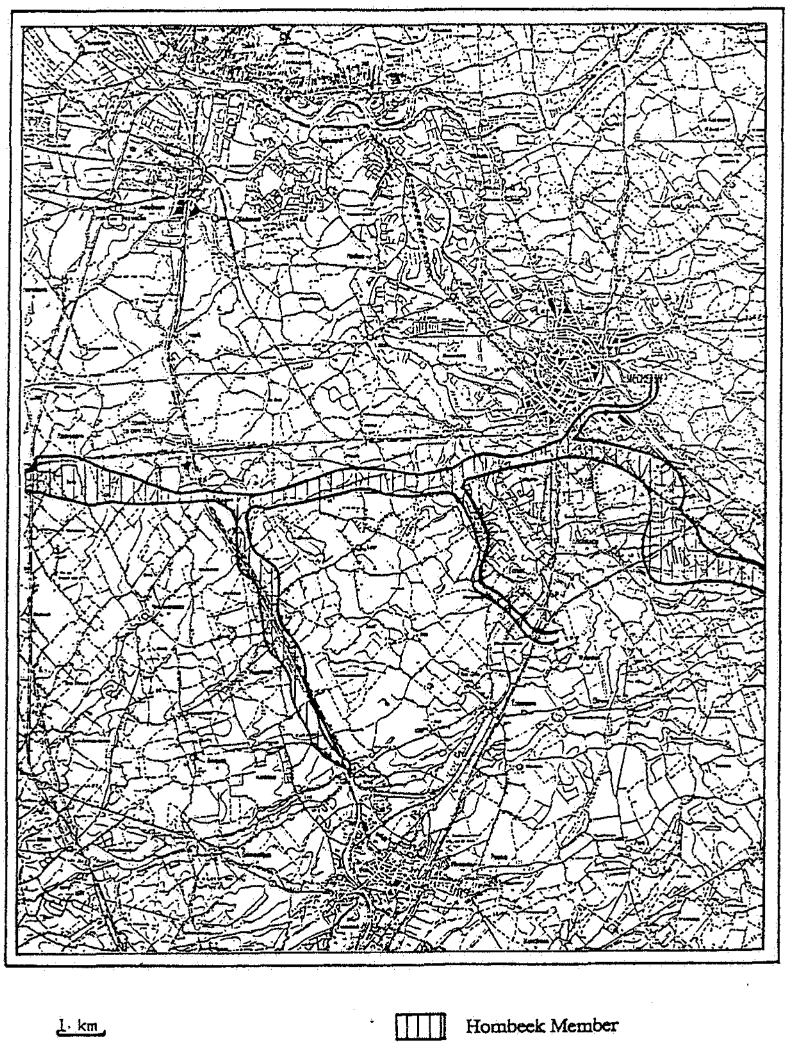
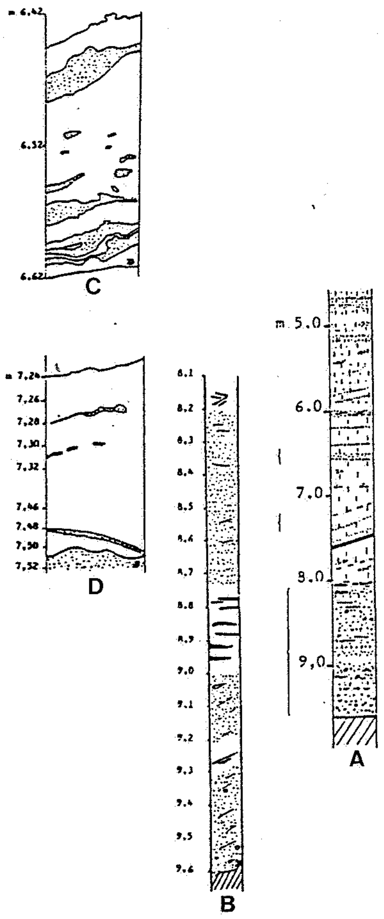


Fig.14: The distribution of the meandering river deposits belonging to the Hombeek Member.

* Vrije Universiteit Brussel



Location: Hever
topographic map 23/7-8, scale 1/25 000
geological map 73E, scale 1/40 000
Number of the borehole: 310 IIId
Coordinates: x = 161 495
y = 186 374
z = 10.032 m

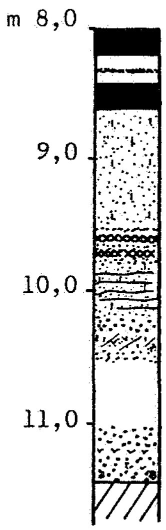
The sequence is characterized at the base by the results of a point bar slip-face migration "B" (Boothroyd & Nummedal, 1979; Puigdefabregas & Van Vliet, 1979) followed by the accumulation of undivided topstratum deposits (Allen, 1965). The distance of the active channel was rather limited because of the presence of sand intercalations with erosional lower bounding planes "C&D" in the silt and the absence of peat. Because of the diffuse stratification these sediments belong either to the upper bench along a concave bank (Taylor & Woodyer, 1978) or to a flood plain dipping to the flood basin. Miall (1978) classified these sediments as overbank or waning flood deposits.

Fig.15a: Illustration of a typical fine clastic sequence formed in a flood plain.

The peat accumulation did not happen simultaneously in the whole depression. In some parts of the area two phases of peat sedentation occurred (fig.15b) whereas in other parts only one sedentation phase took place. In a sequence of two peat units, the lower one is defined to be typical Amersfoort, whereas the upper one shows a Brørup vegetation.
In addition to the above described sequence, sedimentary successions composed almost entirely of natural levee deposits are also typical in this Lower-Weichselian depression.

These natural levee deposits are built up by an alternating complex, composed of sandy and silty layers, however with constant variations in the depositional dip angle. In the upper part of these sequences a transition to a flood basin is frequently observed (fig.16).

Although the vertical accretion predominates in this sedimentary palaeo-environment, rapid lateral migration took place in limited parts which resulted in point bar formations. Consequently point bars in different developing stages are found, even with remains of a point bar slipface migration or with parts of a swale. The evolution of a point bar was nevertheless repeatedly interrupted by a fluvial reactivation or by the formation of benches (fig.17).



Location: Zemst
topographic map 23/7-8, scale 1/25 000
geological map 73E, scale 1/40 000
Number of the borehole: 276 Ib
Coordinates: x = 155 850
y = 187 075
z = 12.492 m

Slip off facies of a point bar (Plint, 1983; Van der Meulen, 1982) form the basic deposits of the sequence and are followed by flood basin deposits composed of two peat layers separated by fine clastic material.

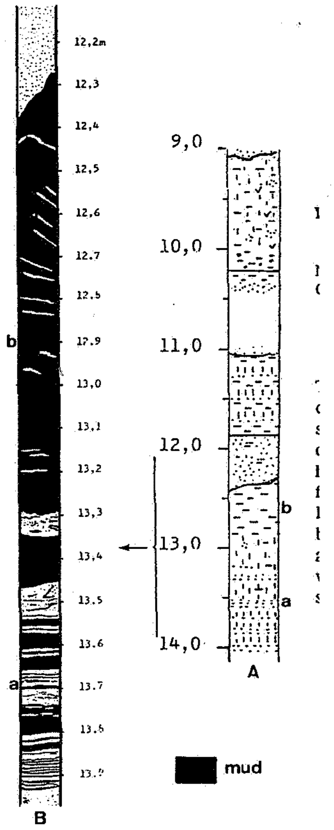
Fig.15b: Illustration of two phases of peat sedimentation.

Within the Quaternary sequence, on top of the meandering deposits or superimposed on the basal coarse grained braided river deposits, again braided river deposits are present, but sandy in nature this time. The responsible braided river system was active in almost the entire branch of the Flemish Valley during the Middle-Weichselian. During the beginning of the Late-Weichselian some remnants of the fluvial system was still present, however in very restricted areas.
In contradiction to the previous braided river system the source area is not confined to a small part in the south, but was located in the northeastern and southeastern adjacent region during this situation.

Within the sequences composed of these sandy braided river deposits, sediments of three different river types are distinguished.
The first river type has a limited spatial distribution and, if present, it forms the base of the sandy braided river facies. The predominant characteristic of this river type is the cyclic nature with a fining-up tendency, resulting in general in fine grained sediments at the top. With regard to the sedimentary structures and the nature of the sediments, the facies are formed by a braided river with little peak discharges (Soutwick *et al.*, 1986) and without intensive erosion. As a result several topographic levels are developed.

The dominant features in this fluvial palaeo-environment are aggradating channel-fills which originated during high energetic conditions and bars on which floodplain deposits sometimes accumulated (fig.18). Some of these bars developed into sandflats and islands which were consequently inundated only during very high water level. According to the classification of Miall (1978) these specific deposits belong to the South Saskatchewan river type.

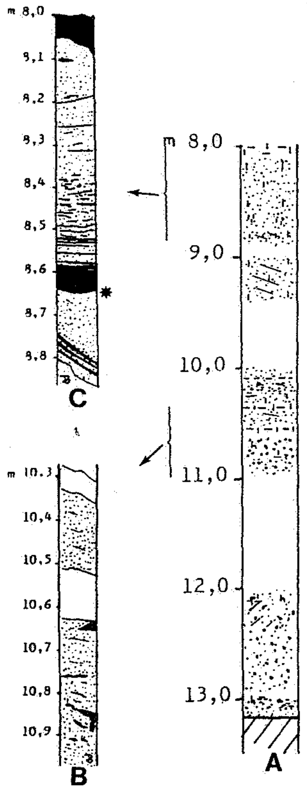
On the contrary, the facies of the second river type, which are found in almost the whole branch, are noncyclic in origin and are typified by a massive, horizontal to oblique stratification (plate II).
Although no sedimentation cycles are present, changes in the depositional environment are traceable by means of the type of stratification and by means of the shifting of the textural classes.



Location: Kouterbrug
topographic map 23/7-8, scale 1/25 000
geological map 73W, scale 1/40.000
Number of the borehole: 254 Ia
Coordinates: x = 147 375
y = 187 964
z = 12.734 m

The lowermost part of the sequence consists of natural levee deposits "A&B - (a)", silty in nature. More specific these sediments are deposited on the upper bench but at a certain distance of the edge (Reineck & singh), 1980) because of the horizontal stratification. In a next stage a flood basin is formed "b" composed of silt with very thin sand layers, the latter ones having important deformation structures. The building up of the flood plain is interrupted by a formation of a crevasse splay producting an important incision. The gully was later on filled up by sandy material without any stratification witch points to high energetic conditions.

Fig.16: Natural levee deposits evolving into a flood basin deposit.



Location: Schonenberg
topographic map 23/3-3, scale 1/25 000
geological map 58E, scale 1/40 000
Number of the borehole: 404 VIIIc
Coordinates: x = 157 517
y = 188 813
z = 11.409 m

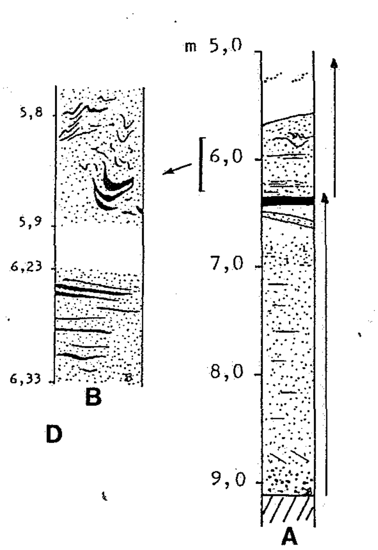
From 11 m up to the top the next depositional features are identified: two slip off facies of a point bar "B" followed by a horizontal stratified unit. Further up an oblique stratification with a very important dip is again present "C". This part belongs to a concave bench (Nanson & Page, 1983) or a point par. This lateral accretion facies is demarcated by a erosional contact "C*" followed by subhorizontal slightly curved alternating layers of humic silt and sand. Further upwards sand become diminant, whereas the sedimentary structures become rarer what is interpreted as an increase in stream power. This subunit is partly eroded en filled up with clayey silt "C top". It is situated in a swale (Allen, 1965; Bridge et al., 1986; Fraser & Fishbaugh, 1986; Stewart, 1983).
This stream was characterized by strong lateral movements through which the formation of a flood plain by means of vertical accretion was excluded.

Fig.17: Illustration of the constitution of point bar deposits.

In comparison with the first river type, the second one is situated in a sedimentary palaeo-environment in which topographic levels are strongly reduced and where channels with little vertical extended bars are the main depositional features. This particular type of braided river was most probably active during ephemeral peak discharges, characterized by a huge sediment transport and consequently a reduced erosional activity. These features indicate the existance of a continental palaeo- climate with the prevalence of extreme temperatures and little precipitation.
The generated fluvial sequence corresponds undoubtedly to the Platte river type of Miall (1978).

The third river type was operating in a very confined area and during a very limited time. The deposits are horizontal stratified, slightly oblique and massive bedding are also present sometimes (fig.19). Erosional bounding surfaces are quite common. The horizontal stratification indicates the prevalence of high velocities during upper-flow regime. Decreases in the stream power are illustrated by the above described less energetic beddings.
The corresponding facies are interpreted as channel deposits or as deposits formed nearby the channel. In the literature (McKee *et al.* , 1967; Miall, 1977, 1978, 1984; Link, 1984; Peterson, 1984; Rust, 1978) this type of streams are indicated as ephemeral.

According to the classification of Miall (1978) this river type is called the Bijou Creek type.



Location: Heffen
topographic map 23/3-4, scale 1/25.000
geological map 58W, scale 1/40 000
Number of the borehole: 271
Coordinates: x = 152 300
y = 192 840
z = 7 m

The lowermost cycle is composed of channel deposits followed by bar deposits. The horizontal discontinuous stratification (Picard & High, 1973; Cant & Walker, 1978) is formed during inundation periods typified during upper flow regime. The superimposed accumulated fine clastic material wa sonly once interrupted by a break trough. The top consists of peaty clay.

The sandy facies in the second cycle contains clayey layers that are strongly disturbed in some parts "B". The deformation is the result of partly liquefied sediment short after deposition (Collinson & Thompson, 1982). Singh (1977) has described similar deformations on fast uprising bars out of the water by which water expulsion took place. The silty deposits at the top have at their basis remains of small strippings which were filled up later on.

Fig.18: Illustration of aggradating channel-fill deposits (at the base) and the development of bar deposits.

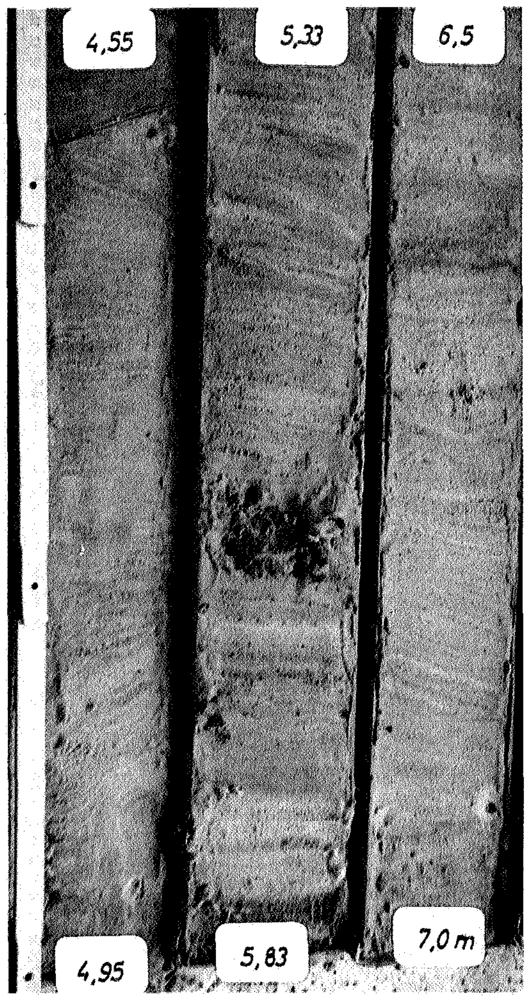
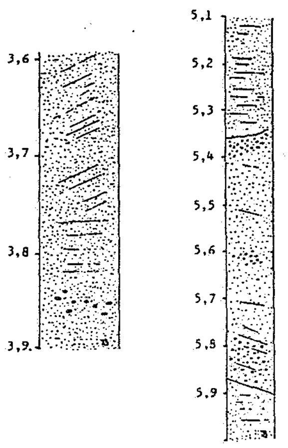


Plate II: Typical stratifications in a noncyclic sequence.

Location: Meuter
topographic map 23/7-8, scale 1/25 000
geological map 73W, scale 1/40 000
Number of the borehole: 279 IIId
Coordinates: x = 152 840
y = 185 257
z = 13.491 m

The noncyclic facies are composed of sandy material in which oblique, horizontal and massive stratification is present. The stratification and the displacement within the grain size distribution indicate modifications in the depositional environment. A continuous increase and decrease of the energetic conditions of the stream is obvious.



Location: Kouterbrug
topographic map 23/7-8, scale 1/25 000
geological map 73W, scale 1/40 000
Number of the borehole: 254 Ia
Coordinates: x = 147 375
y = 187 964
z = 12.734 m

Uniformity qua stratification is typical for this sequence. Horizontal bedding is dominant, sometimes alternating with slightly oblique and massive stratification. This bedding type indicate deposition during upper flow regime (McKee et al., 1967; Miall, 1984).

Fig.19: Characteristic stratifications in the Bijou Creek type deposits.

The lithostratigraphic classification of the fluvial deposits (table 2)

Paepe (1976) introduced the " Zemst gravel Formation" for all fluvial deposits accumulated in the deep incised valleys of Lower and Middle Belgium. This formation is situated chronostratigraphically in the Upper - Pleistocene.
Since the present data show that the fluvial deposits in these valleys are not exclusive by coarse grained but also sandy to very fine grained, misunderstandings will be prevented by using the geographic name immediately followed by the adequate lithostratigraphic unit.

However, beside the diversity in the grain size distribution, the Upper-Pleistocene sediments are typified by variations at the level of the depositional features since, indeed they are formed in different palaeo-fluvial environments.
In this branch of the Flemish Valley the fluvial Weichselian deposits are subdivided into three groups with regard to their palaeo-systems in which two channel patterns are distinguished.
Consequently a complete sedimentary sequence is composed of braided, meandering and braided river deposits. In general, in the deeper part of this branch of the Flemish Valley also Eemian deposits of a meandering river origin are preserved.
Considering the fact that the fluvial deposits are classified primary by means of their channel pattern, the Zemst Formation is subdivided into four Members in accordance with the four fluvial facies.
The meandering Eemian deposits are lithostratigraphically defined as the Grimbergen Member. This Member is restricted to the southern part of the survey area where it takes a scattered position. The facies in question are found near Zemst, south of Meuter and in the more extensive region near the type locality running from the St. Niklaashoeve over Heienbeek to Borgt and the center of Vilvoorde (topographic map 23/7-8). The boundary of the Grimbergen Member is always erosional and overlies the Tertiairy facies. The upper boundary is either sharp, depositional or erosive. The overlying deposits belong generally to the Bos van Aa Member although sporadically the Hombeek Member or the Lembeke Member is present at the immediate superimposed position. The gravelly cyclic braided river deposits of Early - Weichselian age are defined as the Bos van Aa Member. The specifications of this Member is summarized in table 1.

The superimposed Hombeek Member is built up by several specific sequences of which a number of type sequences are illustrated by figures 15a, 15b, 16, and 17. As already mentioned and illustrated in figure 14 the Hombeek Member has a rather restricted regional spreading. The character of the lower boundary is always erosive and forms commonly the contact with the Bos Van Aa Member.
Only in very limited areas this Member is lying on the Grimbergen Member or the Tertiairy substratum. The character of the lower boundary is however not so uniform, it changes from depositional to slightly erosional.The superimposed facies on the contrary are always composed of the Lembeke Members, part of either the Gent or

the Zemst Formation. The noncyclic and cyclic sandy braided river deposits, situated in the topmost position are incorporated into the Lembeke Member belonging to the Zemst Formation. Since this Member is composed of several special sequences, a number of type sequences are illustrated by figures 18,19 and plate II. The Lembeke Member is spread in the survey area all over the branch of the Flemish Valley in exception of a strip along Zemst and Eppegem Topographic map Zemst 23/8). The lower boundary of the Member is depositional or slightly erosional in exception of the contact with the Tertiairy substratum, what is always erosive and only present in restricted places. More commonly the Lembeke Member is lying on the Hombeek Member or directly on the Bos van Aa Member. The upper boundary is typified by its depositional nature. The superimposed sediments are either mass-wasting products or eolian deposists, all belonging to the Gent Formation.

The eolian deposits

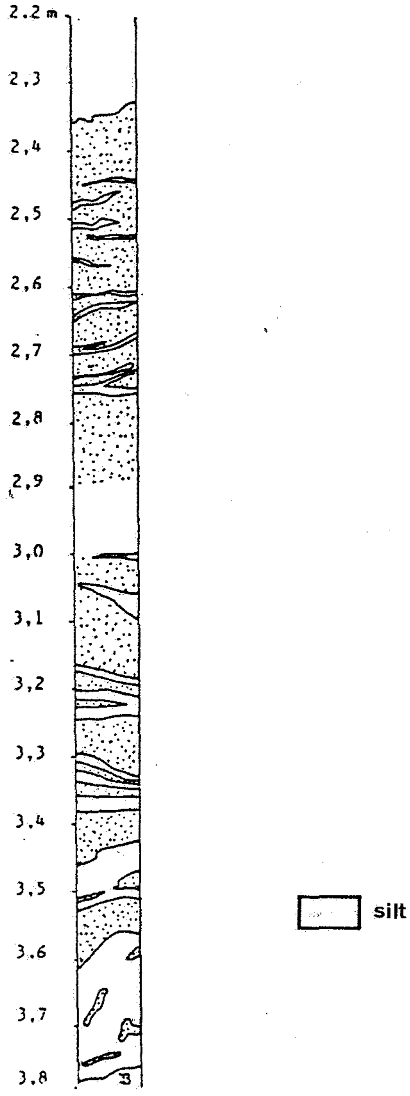
As opposed to the fluvial sediments the nature of the eolian deposits is defined according to their regional distribution. In the north, nearest to the source area, eolian sand deposits are accumulated, giving rise to the Coversand Area. In the south however, deposition of silt took place by which the Loess Area originated. The area in between these two areas, called the Transitional Area, consists of both deposits. Moreover, in the Coversand and the Transitional Area the eolian deposits are composed of non-homogeneous and/or homogeneous facies, the latter one is always in topmost position.

The non-homogenous deposits are defined as an alternating complex that consists of coarse and fine grained layers, usually sand and silt layers. However, in the constitution of this complex any form of uniformity is absent. The complex is either composed by well defined alternating layers with very distinct bounding surfaces (fig.20) and with a rather restrict vertical extension, or built up by one dominant grain size class that extends along the sequence and wherein laminae or small layers of different texture are deposited (fig,21a). The alternating pattern is nevertheless still present.
In the Coversand Area a dominance of the sand layers is observed, whereas in the Transitional Area the silt layers are preponderant.
The genesis of this alternating complex is attributed to the deposition of wind transported sediments in snow rich, wet or humid areas with the formation of adhesion ripples and wrinkle marks - also called adhesion warts - (Glennie, 1970; Reineck, 1955 fide Hunter 1973) as a result. These bedforms give rise to various adhesion structures (Hunter, 1980; Kocurek & Fielder, 1982).

If the frequency of the laminae and/or beds is small, or if only zones are present mixed with material composed of other grain size classes than the host material, the deposit is called homogeneous. The homogeneous deposits are no monomorphic facies but have indeed variable sand and silt contents which move over gradually. The term homogeneous refers only to the absence of composite bedsets.

The formation of the alternating complex is determined by changes in the physical dynamics of the environment whereby factors like variation in the wind intensity and the precipitation are considered as the primary causes. The presence of silt layers in the Coversand Area are ascribed to abate wind intensities and precipitation in the form of rain and snow through which early sedimentation of the silt particles took place.
The sand layers in the Transitional Area are, at least partial, the result of greater wind intensities through which the sand is transported over larger distances. Moreover, the sand particles may have derived from local sources and deposited in wet and humid areas. The concentration of silt layers in the Transitional Area is most probably the result of subsided wind intensities due to a loss in kinetic energy and is also ascribed in a smaller degree to the precipitation.
With the predominance of one grain size class in the eolian facies, the sedimentological characteristics point to less long term fluctuations in the wind intensity.

The so called homogeneous eolian deposits are not the result of less fluctuations in the wind intensity, but are the result of a general aridification .
The large variations in the Transitional Area of the sand content within the deposit - 2 till 60 % - in favor of the silt fraction is the result of dispersions and basal flows (De Ploey, 1977). Indeed De Ploey (*ibid.*) has observed simultaneous transport of silt and sand during deflation periods along the dune surfaces at Kalmthout. Similar phenomena were most probably active in the past.



Location: Stompershoek
topographic map 23/3-4, scale 1/25 000
geological map 58W, scale 1/40 000
Number of the borehole: 296 Vd
Coordinates: x = 151 159
y = 191 869
z = 7.912 m

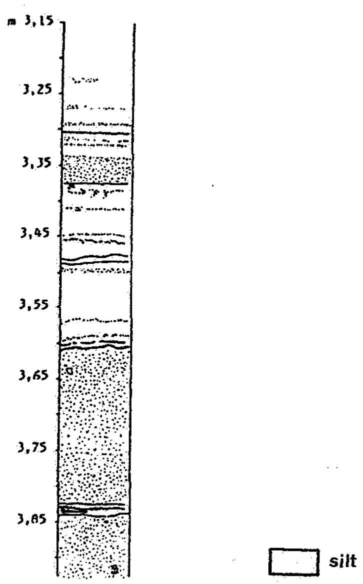
Complex composed of alternating coarse and fine grained layers, commonly consisting of sand and silt. The upper and lower bounding surfaces are irregular but distinct.

Fig.20: Illustration of the eolian deposits consisting of an alternating pattern of fine and coarse particles.

Elements like the availability of loose particles during cold periods, which are derived from snow free areas as a consequence of the sublimation of intergranular ice or ice cement (Teller, 1972) in combination with the dominant wind direction are decisive in explaning the kind of deposited material. Nevertheless, in natural circumstances not all ice or ice cement will sublimate; fine particles like silts, still glued together, are transported by saltation instead of suspension. The presence of the fine fraction can be explained because of this phenomenon in the Coversand Area.

The original eolian genesis is often completed by secondary processes which are typical for snow rich and humid environments (fig.21a &b). These humid environments may be the result of thawing of local snow niches, frozen soils and rain fall. Since in a humid environment the saturation of material run up from 80 to 100% (Kocurek & Fielder, 1982), deformations and secondary movements by means of water are quite common. These secondary processes are furthermore obvious just because of the low sedimentation speed of silt which is in accordance with Tsoar & Pye (1987) 0.5 to 1 mm a year, in exception of course of the sediments that are deposited together with the precipitation, which results in a faster accumulation. Also the presence of slopes, whatever the dip angle, favors the activation of secondary processes.

The loess deposits in the survey area are unstratified and/or diffuse stratified.
The unstratified unit is situated in general at the top, in analogy with the two other eolian sedimentation areas. An intercalated position in between the stratified deposits is not exceptional. In the stratified unit any uniformity is lacking, the bedding varies from even parallel to wavy non parallel, continuous and discontinuous.
The stratification itself has a primary and a secondary origin. As a primary stratification adhesion structures are put forwards although they are always defined in the literature in relation with sand particles. The stratification of secondary origin resulted through movements over small distances. Similar elements are already elaborately described by Manil (1949, 1952).

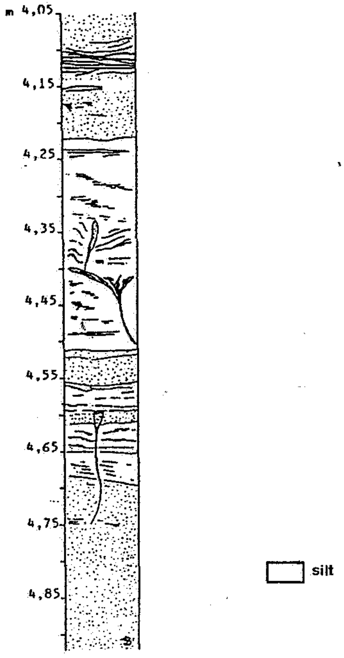


Location: Meuter
topographic map 23/7-8, scale 1/25 000
geological map 73W, scale 1/40 000
Number of the borehole: 279 IIId
Coordinates: x = 152 840
y = 185 257
z = 13.491 m

This complex is typified by a dominant grain size class in which laminae or very small layers of another textural group are incorporated. Note the absence of macroscopic sedimentary structures in the silt.

The irregular lower bounding planes are attributed to incisions and corrugations. If an incision took place, the superimposed sediments are always sandy in nature. According to the dimensions and character of the bounding planes small gullies are indicated as the source.

Fig.21a: Representation of secondary phenomena in the eolian alternating complex (Tisselt Member).



Location: Geerdegemveld
topographic map 23/7-8, scale 1/25 000
geological map 73E, scale 1/40 000
Number of the borehole: 303 IIa
Coordinates: x = 157 582
y = 188 100
z = 11.937 m

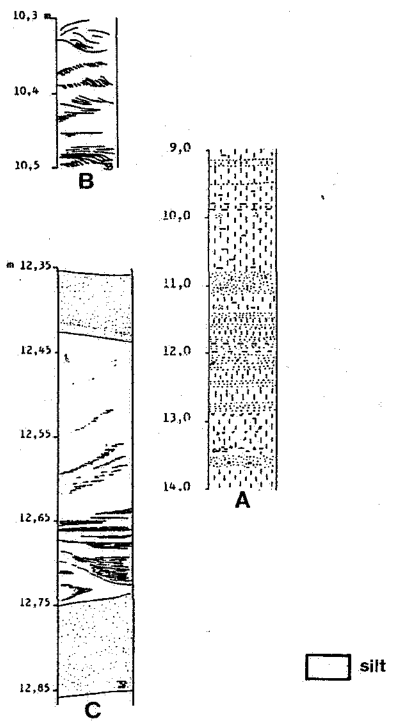
The deformations and the sedimenatry structures in the silt deposits originated in a water rich environment. The sedimentary structures are the result of secondary displacements by water of the original eolian silts. Furthermore, within this sequence several levels of frost cracks are present.

Fig.21b : Representation of secondary phenomena in the eolian alternating complex (Tisselt Member).

The mass wasting products

Because of the long-term activity and the important action radius of the fluvial systems in the Coversand and the Transitional Areas, the mass movements deposits are preserved only in very restricted places.
If present, the mass-wasting deposits are the result of solifluction or related movements and are composed of silty material with clayey and sandy beds, both with irregular upper and lower bounding surfaces. Sporadically the clastic beds are substitute by humic material, also with irregular bounding surfaces and even with microfaults.
Exceptionally these mass-wasting products are built up by a fine alternation of silty and sandy layers.

On the contrary, in the Loess Area the mass-wasting deposits have a large distribution both lateral and vertical. The slope angle has a direct influence on the presence of these sediments. On slopes above 5° no sediments are found that are composed of mass moved material. These slopes act indeed as transport zone where mass movements of different kinds are active (Kudrnaská, 1972).

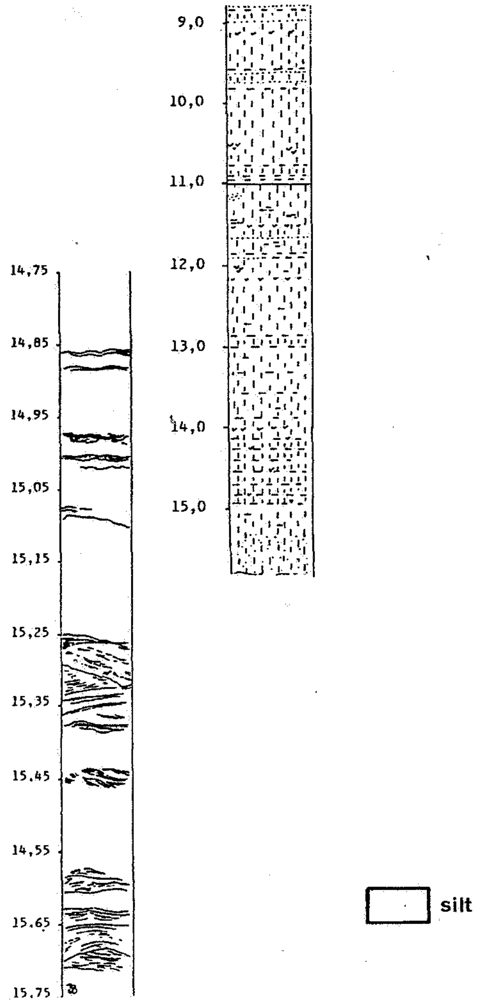


Location: Lint
topographic map 23/7-8, scale 1/25 000
geological map 73W, scale 1/40 000
Number of the borehole: 281 IXa
Coordinates: x = 152 460
y = 180 992
z = 22.781 m

The sequence "A", primary composed of silt, contains sand intercalations, however with variations in their distribution. The sedimentary structures point to the presence of water as a transport agent in depositional environment "B & C".

Fig.22: Illustration of mass-wasting deposits with water originated sedimentary structures in the Loess Area.

On slopes between 2 and 5° only those locations nearby gentle inclined places contain mass-wasting products. On slopes of 30' to 1°, mass wasting products are generally present.
The mass wasting deposits in question are present in combination with eolian sediments or are preserved as a succession of mass movement deposits with or without sheetflow deposits (definition sheetflood *sensu* Hogg, 1982). In the latter described sequence, grey humic silt is dominant with water originated sedimentary structures (fig.22) and sand intercalations on the one hand and with on the other hand clayey layers and humic bands, both formed by mass movements (fig.23). The humic bands are composed of overflowed vegetation that is embedded in the moved material. In ideal circumstances, the traveling distance of this material was restricted to a few kilometers. Therefore, although indirectly, the presence of vegetation during the accumulation period is proven. In the combined sequence of eolian and mass wasting sediments the building up consists of alternating silt layers, clayey to sandy, and clayey or sandy layers. The stratification is even, subhorizontal wavy to oblique wavy, parallel to non-parallel, continuous and discontinuous.
In the northwestern to northeastern part of the Loess Area *Succinea oblonga* and remains of other mollusks are found in the mass-wasting products. The restricted distribution of these mollusks shows indeed the relation between the geographical situation of the area and the living space of animals. For these particular snails a humid biotope is necessary.



Location: Veldkant
topographic map 23/7-8,s cale 1/25 000
geological map 73W, scale 1/40 000
Number of the borehole: 282 IXa
coordinates: x = 151 50à
y = 180 783
z = 23.756 m

This sequence consists almost completely of silt in exception of a few very fine sandlayers. Typical for this sequence is however the presence of fine dark grey clayey layers, products of mass movements.

Fig.23: Mass-wasting deposits with clayey layers and humic bands in the Loess Area .

The lithostratigraphic classification of eolian and mass wasting deposits (table 2)

Paepe (1976) introduced the Gent Formation in order to name " all Weichselian coversand deposits" (p 28). For the adjacent Loess Area the term Gembloux Formation is used to define the loam mantle (Paepe , *ibid.*, p 28).

The Gent Formation is further subdivided into units which are situated one rank lower in the lithostratigraphic classification, *viz.* Members (Hedberg, 1976). Dependent on the location of the deposits in the Coversand or in the Transitional Area, the eolian sediments are named Ertvelde Member and Zonnebeke Member respectively. The peaty loam formations, defined by Paepe in 1967, are nominated as the Lembeke Member in both the Coversand and the Transitional Areas.
The Lembeke Member stands in this study for all mass-wasting products and in a small degree for the fluvial deposits which appear however isolated from the other, underlying fluvial sediments. If any sedimentary or environmental relation exists with the previous deposited sediments the term Lembeke Member as a component

of the Gent Formation is not applicable. Since according to the International Subcommission on Stratigraphic classification (Hedberg, 1976) "a Member may extend from one Formation to another" (p 33) the Lembeke Member is assigned to two Formations namely the Gent and the Zemst Formation. The latter one consisting of fluvial deposits accumulated during the Upper-Pleistocene.

As previously described the eolian deposits in the Coversand as well as in the Transitional Area consists of a homogeneous unit, always occurring in a superimposed position, and an alternating complex. Both sedimentary facies however accumulated in different environmental circumstances. Therefore it is preferable in the framework of the reconstruction of sedimentary palaeo-environments to introduce two lithostratigraphic units on the level of a Member. The Ertvelde and the Zonnebeke Member are retained to indicate the homogeneous eolian deposits in respectively the Coversand and the Transitional Area. The alternating complex consisting of fine and coarse grained layers are named after the type locality the Tisselt Member. The same terminology is used in the two previous named eolian sedimentation areas. The spatial distribution of the Tisselt Member is better developed in the second half of the branch of the Flemish Valley where the greatest part of the surface is occupied by the Transitional Area. These deposits are predominantly found in places with a low lying topographic position in the two eolian sedimentation areas (Coversand and Transitional) but also along the flanks of the micro-depressions in the Transitional Area.

The decisive element in both situations however is the component 'moisture'. The lower as well as the upper boundary of this Member is depositional. Superimposed deposits consists always of homogeneous eolian deposits. The underlying sediments on the contrary vary from mass-wasting products to several facies of Members belonging to the Zemst and Nieuwenrode Formation.

The Gembloux Formation is subdivided by Paepe (1976) into the Brabant and the Hesbaye Member according to the stratigraphic rules, this in analogy with the already introduced chronostratigraphic terminology "Brabantien" and "Hesbayen" (Rutot, 1910).

The Brabant Member stands for the eolian sediments, whereas the mass-wasting products are incorporated in the Hesbaye Member.

THE PROFILE TYPE MAP

Representing the occurrence of various deposits on a map still remains one of the main targets in geology. Such a possibility is offered by using a profile type map. This is a geological map on which the lateral distribution of the mapped units are represented, while at the same time the vertical building up of the sequence is shown. By representing also the vertical variations of the facies a three dimensional view is indeed created. To make this aspect possible on basis of a 2D, in fact a sheet of paper can only represent two dimensions, a number of vertical profiles are introduced which are then a reflection of the different geological sequences found in the area. These vertical profiles are named special profile types.
This new idea of sequence mapping was introduced by de Jong and Hageman in 1960.

By analogy with the geological sequences, a special profile type is composed of a succession of units, called components, that are defined according to their genesis, composition, texture, sedimentary environment ... or even on the presence of palaeosols. The introduction of the kind of unit is in fact not regulated, it is actually completely free. Each mapper developing a system for a survey area may choose the kind of units which are the most suitable to represent the geological constitution of the area.
However nowadays, it is opportune to introduce these kind of units which are the most complete mirroring of the geological constitution, which form also simultaneously the fundamental data for the applied geology, so that no expensive wallpaper (term after De Mulder, 1989) is produced. With this term ones attract the attention to the fact that a geological map has to be useful for a large public and that it is not produced for the sake of just producing something. Besides, on the profile type maps both the scientists and the large public find their kind of information concerning the geological building up of a certain region.

Dependent on the geological complexity of the survey area, the geological data can be represented completely or summarized on the profile type map. Regardless of the complexity of the mapping area only these units are introduced which are clearly and easily recognizable in the field. So, no extensive laboratory analysis are entered into the mapping procedure. Moreover, these operations are to expensive on such a scale and the obtained data are furthermore only usable by a specialist-geologist.
Very important is the fact that the number of units per vertical profile or special profile type stays limited. Indeed, Mengeling & Vinken (1975) opt for a maximum of eight components with a convenient representation on bases of four or five. In the survey area of Boom - Mechelen and Vilvoorde - Zemst exceptionally six units are used; in general the number is reduced to four or five, or even less.
In order to obtain the maximal aptness and flexibility of the mapping system a hierarchic structure composed of two ranks is introduced.
The unit highest in rank is named a complex after Barckhausen *et al.* (1977) and is composed of a succession of components recognizable in the field. The components in question are different from the ones belonging to the special profile types, situated on the second and lower rank of the hierarchic system. In fact, the components which form the building blocs of the special profile types are incorporated into the components belonging to the complexes. In other words the components of the special profile types are a subdivision of the components of the complexes. Barckhausen *et al.*.(1977) define complexes as lithological units that are situated spatially next to one another. This definition implicates that in no circumstances an overlapping of the different complexes is possible. So, each succession of components within a complex differs from the other complex. Although not described in the above mentioned definition the same rule is of course valid for the special profile types, which are situated in the mapping system of Barckhausen *et al.* (1977) on the third level of the hierarchic system .

Within this specific survey area the genesis of the deposits defines the components of the complexes. The eolian, the mass-wasting and the fluvial origin determinate actually the sedimentary features originated in this particular area. Furthermore the components in question are defined by the above described genetic properties.
The number of complexes depends on the number of successions or sequences present in the survey area. Each succession is composed of at least one or a number of components. The components situated one above the other have always a different origin. Nevertheless, in one complex a repetition of genetic similar components may be present, but never in a consecutive position. As the sedimentary genesis is not necessary related to time, facies

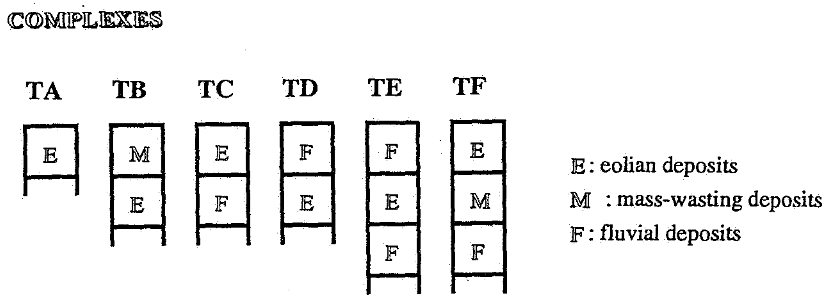


Fig.24: Composition of the different complexes in the Transitional Area.

originated during different Periods or Stages may be integrated into the same component. For instance, Holocene and Pleistocene eolian deposits consecutively present in the sequence are embodied in the same component. Since however the survey area is spread over the three eolian sedimentation areas that originated during the Upper-Pleistocene, *viz.* the Coversand, the Transitional and the Loess Area, the introduction of three groups of complexes is necessary. The first group comprises all the complexes that are present in the Coversand Area. The second group consists of complexes found in the Transitional Area. Finally the third and last group is built up by complexes existing in the Loess Area. Because of the great complexity, the three groups of complexes are indicated by a combination of two letters. The first letter stands for the eolian sedimentation area, whereas the second letter indicates the well defined succession of the components (fig.24). The first letter A is always used to indicate the most simple composition. Indeed, for the three eolian sedimentation areas the first complex consists of only eolian sediments. As a complex contains more components a further arrangement in the alphabet order of the second letter is put forwards.

In the chapter concerning the definition of the sedimentary palaeo-environments, lithostratigraphic units are introduced in order to define the sedimentary facies. A well known fact is that the lithostratigraphic classification is built up by a hierarchic level system wherein the Formation is the primary formal unit. Since the basic element in the mapping system - the complex - is made up by the genesis of the facies and the genesis itself forms the basis of the Formation, a complex is nothing else than a succession of Formations. However the situation is rather complex in this survey area. It is quite possible, like for example in the Loess Area, that the fluvial component is composed of two Formations, namely the Zemst and the Scheldt Formation. Besides, in the original definition of Paepe (1976) the eolian deposits and those of local origin, the latter one consisting of mass-wasting products, are incorporated in the same primary formal unit. Consequently two different genetic components of a complex are integrated in one Formation.

Each complex is furthermore composed of one, but generally of several special profile types.

A special profile type consists of a succession of components which are lower in rank than the components of the complexes. In this survey area each component represents at least a sedimentary palaeo-environment. So are the fluvial deposits subdivided according to their channel pattern. Here facies belonging to meandering and braided river systems are observed. As for the eolian deposits also a twofold classification is introduced depending on the circumstances where the deposition took place, namely wet-humid or dry. The mass-wasting deposits remain undivided.

As beforehand mentioned, the total number of components within a special profile type will be limited to six because otherwise the map will be too complicated and not useful anymore for any kind of purpose, in exception of being expensive wallpaper.

As described in the previous chapter the sedimentary environments are lithostratigraphically defined on the level of a Member. As mentioned before, a special profile type is composed by a succession of components each belonging to a certain sedimentary environment, so that in other words a special profile type is composed by a superimposition of Members (fig.25). An exception to the rule is formed by the fluvial deposits in the Loess Area where no subdivision of the fluvial sediments at the level of a Member could be made due to the lack of detailed information.

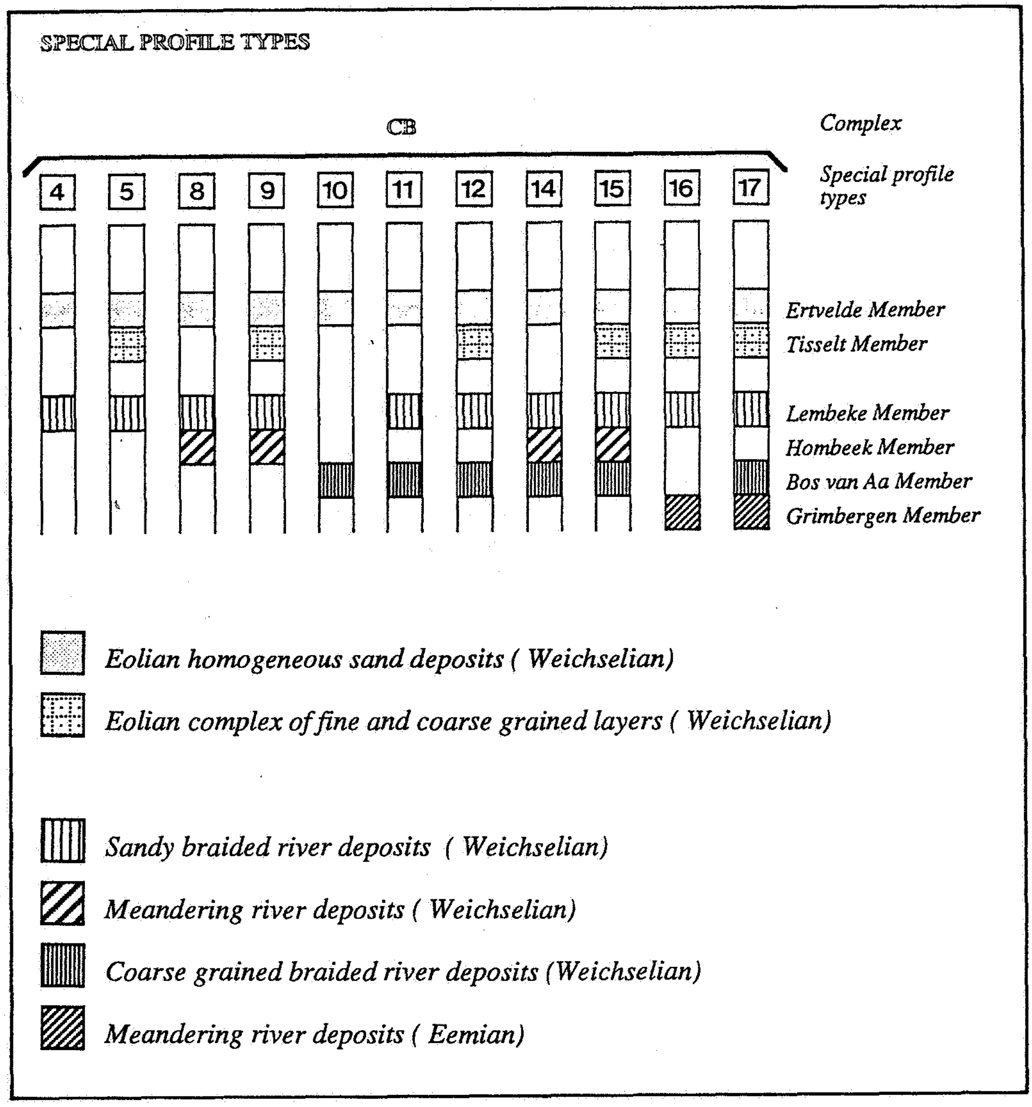


Fig.25: An example of the composition of some special profile types.

The fluvial deposits are therefore indicated on the level of the Formation.
The special profile types form without any doubt the building blocs of the profile type map. Consequently, a very distinct and clear-cut representation of these special profile types is indispensable. Each special profile type is indicated by a number. The numbering starts with one and becomes larger in relation with the complexity of the special profile type. So, the first special profile type belonging to the first complex is indicated by number 1. Within the same complex the successive special profile types (if present of course) are indicated by a larger number. The first special profile type of the next complex is numerated without interruption through which the number has just one higher position in the arithmetical series than the previous one, in spite of the fact that the special profile type belongs to an other complex.

Concerning the graphic representation of the special profile types, no general rule is followed. A large number of the mapping divisions are using on the one hand one or several cross sections of the survey area or on the other hand a model in which they define the different special profile types. This kind of representation may create a complex situation wherein great efforts of the readers are asked. To avoid this kind of situation a schematic depiction of the special profile types is put forewards. First of all the relation complex - special profile type(s) is made clear. Further on, the special profile types are illustrated by columns of identically the same size which are composed by a succession of squares. Each unit or component is indeed depicted by a square of which the dimension stays unchanged. A square however is filled up by a well defined pattern which is linked to a certain unit, more particular to a certain Member or Formation, the latter one when it concerns the fluvial deposits in the Loess Area. When a certain unit is not present the square is left blank. As a result a special profile type is composed of a sequence of patterned and blank squares according to the presence and absence of the units (fig.25). This kind of representation has the advantage that the absence of a component or several components is well indicated and that the position of the special profile types within the graphic representation is in relation with their complexity.

On the geological map the hierarchic structure is preserved. The highest rank of the hierarchic system, *viz.* the complexes, determinate the different colors used on the map. In other words each complex is indicated by a color. A special profile type, second rank of the hierarchic system, is made clear on the map by means of a shade, a shade within the color of the related complex. The intensity of the shade has indeed also a meaning. The paler the shade the less intricated the special profile type. The special profile type with the darkest shade has consequently the most complicated building up within that particular complex. To assure that no transposition of the different special profile types is possible, the planes on the map composed of a distinct special profile type will be also indicated by the corresponding profile type number.
On the map, beside the definition of the complexes and the special profile types, information is also given with regard to the different components or units of these special profile types. Each component is briefly described and indicated according to his litho- and chronostratigraphic position, the latter ones by means of a table (fig.26 & table 2).

Since on this type of geological map a huge amount of information is stored, no extra data concerning the thickness of the different units is given at the risk of overburden. An exception is made when it concerns the special profile type composed of only eolian deposits. In the Coversand and the Transitional Areas a distinction is made between the eolian deposits less and more than two meters. In the Loess Area however the separation is made at five meters since the eolian Quaternary sequence is in common thicker in this Area than in the two other Areas.
The absence of any thickness indication implicates that a special profile type in this survey area may be less than one meter to more than twenty meters thick. The number of components of which a special profile type is composed gives nevertheless an indication with regard to the relative thickness of the Quaternary sequence.

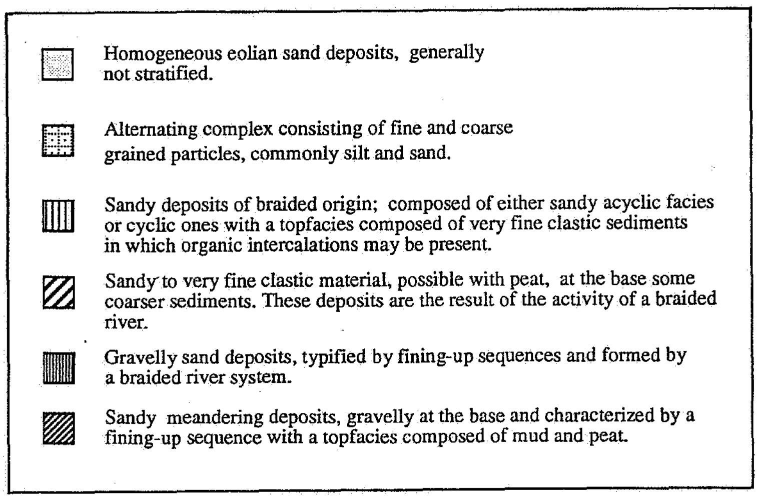


Fig.26: Example of a brief description of the Members as the components of the special profile types.

ENGINEERING AND ENVIRONMENTAL GEOLOGICAL MAPS

It is a widely accepted fact that our natural environment has to be used on an efficient and responsible way through which an equilibrium is created between on the one hand the preservation of the natural environment and on the other hand the socio-economic interests. This aim is only performable by means of a well-balanced land-use planning.
First of all such a well-balanced land-use planning has to be founded on specific geological information in relation with the environmental and economic situation of a certain region. Depending on the requests information is for instance indispensible concerning the groundwater levels, land suitable for agricultural purposes, setting properties, the presence of raw materials....
Besides the basic geological knowledge other information in the field of applied geology is also shown on thematic maps.
The thematic maps situated in the field of applied geology consists of maps on which specifications are represented that are of interest for exact distinct purposes (Bogemans,1991 & in press). These purposes are situated in the sphere of engineering and environmental geology.
It is evident that these kind of thematic maps can not be produced for the whole country since on the one hand the regional distribution of the deposits and the groundwater and on the other hand the needs are completely different. In addition the socio-economic necessities change through time so that the production of a standard set of thematic maps is not realistic and moreover should be discouraged. This kind of maps has to be produced on demand of the established authorities or interest groups. However it is necessary that before fundamental changes in the landscape are carried out, a set of thematic maps in relation with the specific situation are made in order to avoid problems and extra costs, or to prevent the complete disappearance of a part of the natural environment .

For the area Boom-Mechelen and Vilvoorde-Zemst an experimental engineering geological map was elaborated. On this thematic map the characteristics of the sand facies in relation to public works are represented. The area is indeed situated in the vicinity of Brussels the capital of Belgium where a frantic building fever is prevalent. Furthermore, within this area important cities like Vilvoorde and Mechelen are located where raw materials are in great demand.

On this engineering geological map the sand facies are shown according to the grain-size distribution defined in the Typebestek 150 of the Ministry of Public Works (Ministerie van Openbare Werken, 1978).

The sand fraction is in the above mentioned guide book subdivided into fine, medium and coarse sand. Particles are named fine sand when more than fifty percent is situated between 0,060 mm and 0,200 mm. Medium sand is obtained when the grain-size distribution of 0,060 mm until 2 mm takes more than 50% of the total percentage, but the class between 0,200 and 2 mm has to be less than 50%. Finally sand is called coarse when the fraction between 0,200 and 2 mm is more than 50%. In nature a combination of the different grain-size distributions is present. Therefore on this specific thematic map five grain-size distributions are shown, namely medium sand, coarse sand, fine to medium sand, medium to coarse sand and fine to coarse sand.
Moreover, the thickness and the initial depth of the sandfacies are also shown on the map. Three units are introduced for both the thickness and the initial depth. When it concerns the thickness of the sandbodies, units of less than 5 m thick, between 5 and 10 m and more than 10 m are mapping tools. With regard to the initial depth, a distinction is made between the sandfacies found above 5 m, between 5 and 10 m and deeper than 10 m. It is obvious that in this framework the economic feasibility is taken into account. It would be unacceptable and unrealistic to start an excavation in an area where the top of the sand facies is situated more than 10 m below the surface and when the sand deposits are less than 5 m thick. Beside the tremendous high exploitation costs, the exploitation itself would have a negative impact on the natural environment.

On the map the different grain-size distributions are made clear by means of colored lines. The total thickness of the sandfacies is shown by using three different line thicknesses. The initial depth is visualized by changing the orientation of the lines. The horizontal, the oblique and the vertical line positions are used (plate IIIa &b).

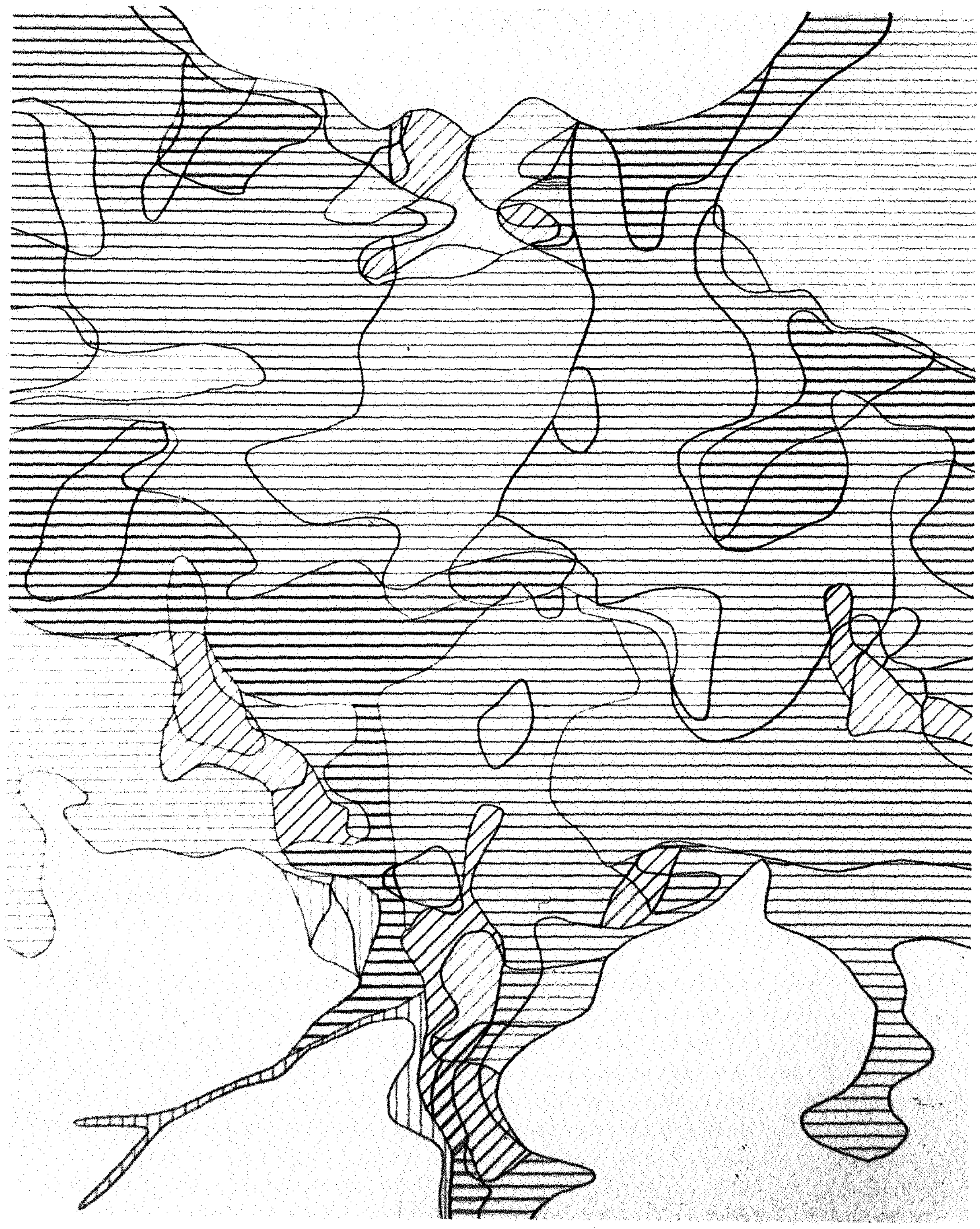


Plate IIIb: An engineering geological map of the survey area.

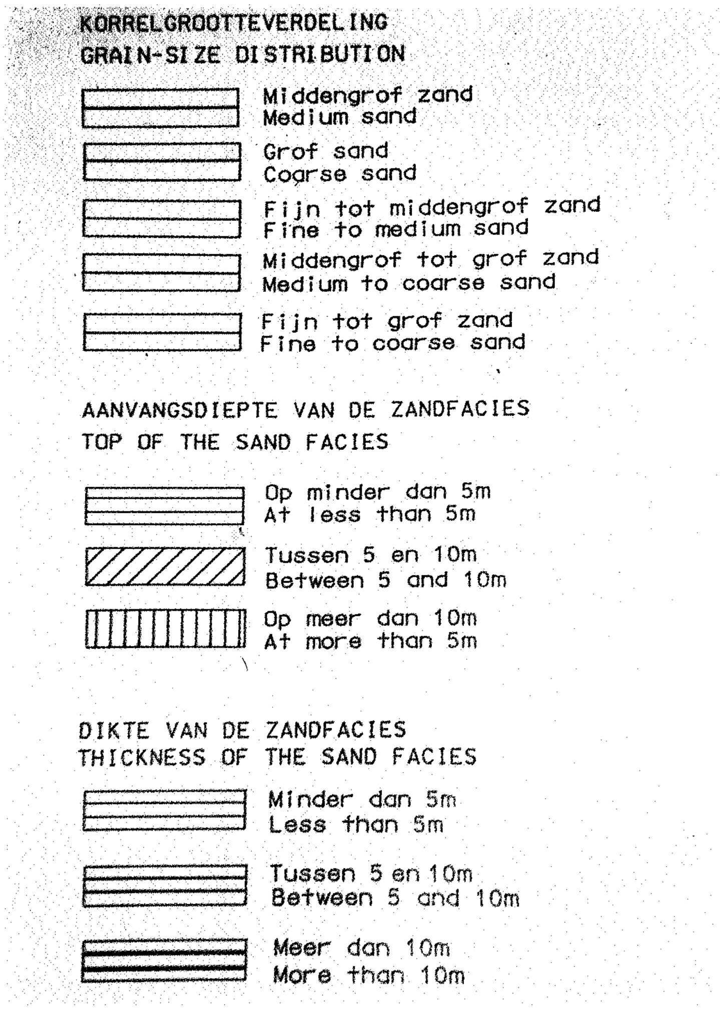


Plate IIIa: Legend of the engineering geological map.

CONCLUSION

The target of the work, namely the development of quaternary thematic maps applicable in both fundamental and applied geology is quite well succeeded. Since the construction of thematic maps requests a good knowledge of the geological and paleogeographical constitution of the survey area, a detailed reconstruction of the sedimentary paleo-environments was established. The best expedient up to now is the study of the arrangement of the primary sedimentary structures in correlation with texture and paleontological remains.

The largest part of the survey area consists of the eastern branch of the Flemish Valley in which upper - pleistocene fluvial sediments are dominant (fig.27). In the lowermost and also spatially very restricted position occurs meandering river deposits originated during the Eemian and known as the Grimbergen Member. Much more extended but still more or less limited to the southern part of the branch lay gravelly braided river deposits, indicated as the Bos van Aa Member. Within the last mentioned deposits a very narrow depression was incised in which meandering river deposits are accumulated. These deposits are lithostratigraphically defined as the Hombeek Member. Finally a fluvial cover is found all over the branch composed of sandy braided river deposits belonging to the Lembeke Member.
Out of the branch the geology history of the survey area could be traced much further. Within the Loess Area the deposits of the highest erosion terrace are of Cromerian Age, whereas the deposits of the lowest erosion terrace are accumulated during the Saalian. The latter mentioned deposits are similar to those deposited in the surroundings of Nieuwenrode. Here two types of river deposits are found namely meandering river deposits, defined as the Ipsvoorde Member and in the superimposed position the gravelly braided river deposits that are lithostratigraphically named the Westrode Member.
Above the fluvial deposits, whatever the origin and location, eolian sediments are found. However, in rather restricted places mass-wasting deposits are accumulated beneath the eolian deposits. Since within the Coversand and Transitional Area the composition of the eolian deposits is hetergeneous, two lithostratigraphic units on the level of a Member are introduced. The Tisselt Member is used in both Areas to define the eolian alternating complex, whereas the Zonnebeke and the Ertvelde Member, both indicating the homogeneous eolian deposits, are applied in respectively the Transitional and the Coversand Area. On the contrary, in the Loess Area the whole eolian sequence is incorporated in the Brabant Member.

The reconstruction of the sedimentary paleo-environments has a double function because it has on the one hand a direct influence on the applicability of the sediments in the applied fields since the nature of the deposits is directly related with the composition, amount and spreading of the sediments and illustrates on the other hand the complexity of the quaternary deposits. The latter finding exclude the use of a traditional geological mapping system when it concerns the use and utility in both the fundamental and applied geological fields. Consequently, the basic geological map consists of a profile type map which is completed with other thematic maps like for example an engineering geological map.

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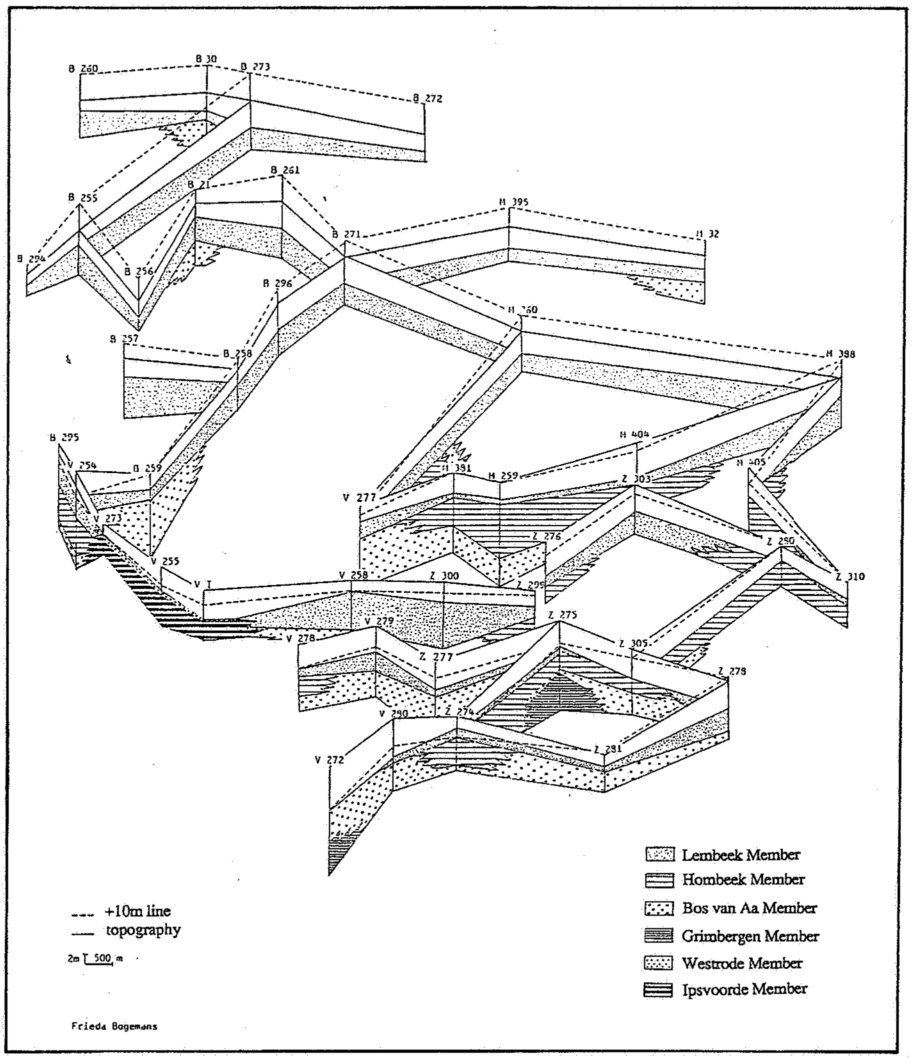

Fig.27: Panel diagram with the lithostratigraphic units as basis.

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