SERVICE GÉOLOGIQUE DE BELGIQUE

MÉMOIRE No 18

The Quaternary of Belgium in its relationship to the stratigraphical legend of the geological Map

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IMPRIMERIE CENTRALE
du Ministère des Affaires économiques
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33.B.4.75

THE QUATERNARY OF BELGIUM IN ITS RELATIONSHIP TO THE STRATIGRAPHICAL LEGEND OF THE GEOLOGICAL MAP.

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CONTENTS

1. INTRODUCTION

The first stratigraphical classification of general acceptance, with regard to the quaternary deposits of Belgium, was elaborated in the stratigraphical legend of the Geological Map's first issue in 1892. As all legends it summarizes the status of knowledge yielded by that time about the system of quaternary deposits in our country. Four modified publications of this legend appeared successively in 1896, 1900, 1909 and 1929. All were basically the same except for the very last one which excelled by its striking poorness. This was merely the result of major amputations in the Pleistocene column of the 1929 edition and soon this legend was felt to be unuseful and obselete. Quaternarists of the period in between the two world-wars and just after finally completely abandoned it.

In reaction to this situation, several independant workers of the last twenty-five years, worked out their own stratigraphical schemes especially with regard to the Upper Pleistocene sequences (R. TAVERNIER, 1943, 1946, 1948, 1954, 1957; J. DE HEINZELIN, 1948, 1957; F. GULLENTOPS, 1954, 1957; R. PAEPE, 1964, 1967, 1968; B. BASTIN, 1971). Characteristic of these systems was the application of internationally accepted and already existing climato-genetic systems.

All these attempts are relevant of the need that was felt to gain deeper insight on the lithologic framework of the Quaternary deposits of our country through the establishment of litho-stratigraphic classifications. However, they all turned out to be rather chronostratigraphic in character resulting from the use of ill-defined, so-called lithologic entities encompassing chronological phases. Keybeds, boundary stratotypes and fossil zones if not entirely missing were used in an extremely vague way, and only for better identification of the presumed existing lithologic units.

Such confusing concept about litho-chronological classifications, steadily grew under the tacit assumption that all three parameters used-litho-, bio-, and chronostratigraphy - were believed to evolve paralelly through time. Partly this way of thinking was biased by the methods used in prequaternary (marine) systems,partly also by the scarceness of the number of characteristics and observation points in quaternary deposits themselves. This limitation urged to the use of broad-scale "units" for which chronostratigraphic units, ready for correlation on a time basis, are most suitable.

Nowadays, thanks to the work executed by the Subcommission on Stratigraphic Classification (I.U.G.S.), the necessity of subdividing the study of stratigraphy into a lithological, biogical and chronological one, has been generally accepted. One and another unit may then overlap over a less or greater interval in both space and time.

In the light of these concepts, we shall first give a review of the evolution of the Quaternary stratigraphic legend of the Geological Map of Belgium till its last publication in 1929. Hereafter an attempt will be made to establish a review of the Quaternary stratigraphy of Belgium with its connected problems.

2. HISTORY AND MODIFICATION OF THE STRATIGRAPHIC LEGEND

Under the impulse of Michel MOURLON, Secretary of the Geological Commission- created in 1889 for the establishment of the Geological Map of the Kingdom- a first stratigraphic legend was elaborated in 1892. This legend considers at the Group-level, besides others such as the Tertiary, the "Groupe Quaternaire" (Quaternary Group). At a lower level,the Quaternary System is recognised as the equivalent of the Pliocene, Miocene, Oligocene and Eocene, all systems belonging to the Tertiary Group.

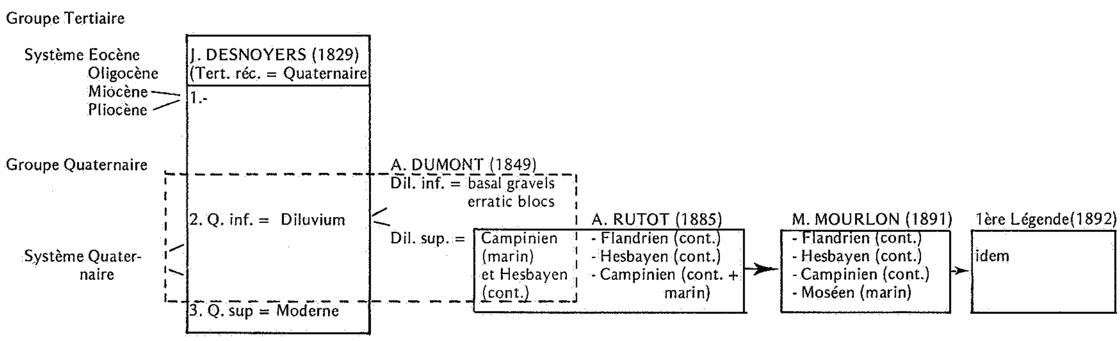
The subdivision of the Quaternary System in a Lower and Upper Quaternary goes back to André DUMONT, who already in 1849 connotated these two members respectively with "Diluvium" and "Moderne". Both terms comprise the last two members of J.DESNOYERS (1829) tricyclic "Quaternaire" which in fact was also called "Tertiaire récent". The very first member of this "Tertiaire récent" in fact corresponded with formations of Pliocene and Miocene age which indeed are fully tertiary aged at present.

In A. DUMONT's subdivision of the Diluvium a further distinction was made between a lower member (Dilivium inférieur) composed of basal gravel deposits and erratic blocs, and an upper member (Diluvium supérieur). Last mentioned encompasses A. DUMONT's formerly created Campine sands (Campinien) and Hesbayan loam (Hesbayen); both formations were considered as lateral facies provinces of the same age.

About the genetic processes involved with the deposition of these sediment provinces, A. DUMONT believed that the "Hesbayen" was a usually topographical high situated freshwater,deltaic deposit, while the Campinien was its marine counterpart in the prolongation of the first. No wonder that originally this author classified both formations as the last two members of his sixfold Tertiary system (Landénien, Bruxellien, Tongrien, Diestien, Campinien and Hesbayen) of 1839. In this classification the basal gravel deposits of his "Diluvium inférieur" were incorporated in the lower part of the "Hesbayen".

These are the basic ideas on which the Belgian Quaternary started in the middle of the nineteenth century. Gradual insight in the stratigraphical framework as well as changes in genetic concepts should lead to the very first legend towards the end of the Century (see table).

TABLE SHOWING EVOLUTION OF STAGE NAMES.



In 1885, A. RUTOT and E. VANDENBROECK amended the connotation Campinien by splitting it up into an upper Flandrien (Sands of Flanders and Campine) and a lower Campinien. The reason for doing so was the discovery of "grey loamy deposits" under the Campine Sands of A. DUMONT which till then only stood for the very sandy thin upper mantle in both Flandrian and Campine regions. The original Campinien thus underwent a twofold change; lithologically it no longer designated the sandy mantle but the underlying loamy deposits ; chronologically, because of its move to a subsurface position, it had become older. This also lead to the distinction of two different layers in A. DUMONT' s "Hesbayen" : an upper yellowish homogeneous loam and a lower grey loam, the latter being now the equivalent of the newly identified Campine loams. This redefinition of the "Hesbayen" restricting it to the upper yellowish homogeneous loam comprised a litho-stratigraphical limitation rather than a change in age. However, the lower part of the Hesbayen sensu A. DUMONT, preserving its originally defined lithological characteristics, had now become older since its correlation with the Campinien, also redefined and older. The newly created terms were referred to as : Assise Campinienne Q1, Assise Hesbayenne Q2, and Assise Flandrienne Q3. It is to be noticed that hereby the connotation "assise" replaced the former connotation "étage", while also the symbolic indication, used already by A. RUTOT, E. VAN DEN BROECK and G. VINCENT for the representation of the Geological Maps of Brussels and Bilsen (1882), was generalised.

The Flandrian sands were now considered as a non-marine, alluvial deposit, succeeding in time to the Hesbayan yellowish loam. About their origin nothing is specified, though E. VAN DEN BROECK had claimed for an eolian uppermost part of the Hesbayan already in 1880. By adhesion of the lower grey loam (with Helix and Succinea) to the "Assise Campinienne", its geographical extension becomes considerable. In considering the loams as valley fillings of a certain phase in the process of valley deepening, all sands and gravels mantling plateaus of different heights, were considered as Campinien too, as well as the thusfar enigmatic marine sands of VAN ERTBORN and COGELS in the vicinity of Antwerpen. Finally this Campinien replaces the formely used "Etage Diluvien" which RUTOT himself considered obsolete as of that moment. However, uncertainty still remained about the presence of a grey loamy zone within the Sands of Flanders.

The inconsistence of the term "Campinien" made it possible to add a new term to the legend of the Geological Map of Belgium when it was established on the 16th of December 1891 and published likewise on October 25th, 1892. Under the impulse of A. MOURLON,the formely evoked name in 1885 by A. RUTOT and E. VAN DEN BROECK, "Moséen" was introduced. It removed all plateau deposits as well as marine deposits around Antwerpen from RUTOT's Campinien, whereas the grey loam deposits from both the Campine and Hesbaye regions were added again to the Hesbayen. They now also included the grey loamy deposits within the sands of Flanders (Fig. 1).

Only the thick Maas gravel deposits of the Campine Plateau,the so-called Moll sands and Campine clays,as introduced first by A. DUMONT, remained Campinien in the legend. The Flandrien then corresponded greatly to the definition given by A. RUTOT and E. VAN DEN BROECK.

In the second legend of the geological map which appeared in April 1896, Campinien and Hesbayen underwent no major changes, and from the Moséen only the presumed marine deposits of the vicinity of Antwerpen were omitted. Instead, the Flandrien was considerably enlarged as a result of the mapping of the Flandrian deposits in the coastal plain and in the sandy area north of Gent.* If the Flandrian was considered as being entirely of fluviatile origin till now, the discovery of *Corbicula fluminalis* in it made it possible to distinguish a lower, marine, facies too. Surprisingly we could not find out why M. MOURLON did not connect these marine layers with those described earlier

** successively called "Gulf of Ghent" (A. RUTOT, 1897) and "Flemish Valley" (R. TAVERNIER, 1946).*

by G. DOLLFUS (1884) in the Sands of Oostende with *Corbicula fluminalis.* Perhaps it was the profound respect for the outstanding paleontologist which forced M. MOURLON to consider the Oostende sands separately and as very Ancient Quaternary. M. MOURLON furthermore introduced a loam member (q4l) which should not be confused with the underlying hesbayan loam (q3m), as was noticed by A. RUTOT in other places. It seems as if personal viewpoints strongly influenced the elaboration of the map and that correlation amongst different authors working in each others vicinity was far from optimal.

Of the same period dates back the adherence of the Campine clay and Mol sands to the Moséen, which, as for A. DUMONT, was considered by M. MOURLON of marine origin. Even though this assumption had already been accepted by the Geological Council in 1894, it was not until the third publication of the legend in March of 1900 that these interpretations were generally imposed. No changes affected the Quaternary stratigraphical legend at its fourth impression in 1909.

It should be stated here that none of the legends after 1896 mention the connotation Brabantian, introduced by A. RUTOT in 1899 to indicate the uppermost eolian, yellowish loams. The introduction of a special connotation for these cover loams clearly shows how much A. RUTOT had undergone the influence of J. LADRIERE's work (1890, 1891, 1892) carried out in Northern France and to which the Belgian loess stratigraphy had been correlated since 1897.

As to the origin of the Moséen and the Flandrien, they both now were considered to be deposits of marine invasions caused by a subsidence movement affecting this area of occurrence.On the contrary, Campinien and Hesbayen were thought to consist of continental deposits, laid down after phases of valley deepening encompassing periods of uplift. Still later, and under influence now of J. GEIKIE's publications, A. RUTOT (1899), related the above mentioned periods of uplift to periods of glacier advance, the periods of subsidence to those of glacier retreat.

At the XI Geological Congres in Stockholm (1910), A. RUTOT made a very first attempt to characterize the climatical variations controlling the five periods of his system. Now it were A. PENCK's ideas about the Alpine glaciations which started to dominate in RUTOT's work. The Günz glaciation being generally considered of pliocene age, a tripartite glacial subdivision was put forward.

Lower Quaternary	: Moséen	.Mindel Glaciation
Middle Quaternary	: Campinien, Hesbayen	. Riss Glaciation
Upper Quaternary	: Brabantien	Riss-Würm Interglacial
	Flandrien	. Würm Glaciation

However, one should keep in mind the rather complex genetic implications which accompanied this point of view. Periods of erosion occurred at the advance of (glacial time) glaciers, periods of terrace aggradation (Moséen, Campinien, etc.) at the withdrawal of the glaciers. It is also here that for the first time the Brabantian eolian loam is correlated with the younger loess deposits of Germany. In this view, the loess was deposited by dry eastern wind during the Riss-Würm interglacial, which as consequence was taken for cold.

By the discovery of multiple specimens of *Corbicula fluminalis* in the so-called Moséen of Hofstade, A. RUTOT (1910) also rearranged the position of this fossil in the Lower Quaternary, as was first presumed by G. DOLLFUS.

Also of the very same period dates back the tendency for correlation with prehistoric classifications, which A. RUTOT had started to work out since the beginning of this century. This last new trend in RUTOT's work was undoubtedly the result of his close contacts with V. COMMONT whose work in the Somme valley he propagated vigourously now on Belgian tribunes.

It was also the time that the concept of terraces began to grow in the Belgian literature as was stated later by R. TAVERNIER in 1943. A. RUTOT (1919) recognized at first three, later four terraces respectively at the level of 100 m, 60 m, 30 m and 3-10 m. His attempt to relate quaternary deposits to those terrace levels leading to the establishment of a new proposal of stratigraphical legend of the Quaternary in Belgium. In the light of complete parallelisation between Northern France and Belgium, A. RUTOT went as far as to the abolition of the terms Moséen, Campinien, Hesbayen, Brabantien and Flandrien. The system was then reduced to the following:

- Quaternaire supérieur (assises supérieure, moyenne et inférieure),
- Quaternaire moyen
- Quaternaire inférieur (assisessupérieure et inférieure), each "assise" comprising a great number of lithological members related to the terraces.

In the same period the position of the Mol Sands and related Campine clays, Lower Quaternary or Moséen for MOURLON (1896), had become a matter of discussion again.

Whereas E.VAN ERTBORN (1903), M. MOURLON, (1907) and X. STAINIER (1907) classified the Mol sands as a fluvial facies of the Amstelien of HARMER which was in harmony with the attribution of the Campine sands and clays to the clay of Tegelen (Eug. DUBOIS, 1901), A. RUTOT (1908) assimilated the same deposits to the uppermost fluvio-marine Poederlien. Still later, he placed the Amstelien above the Tegelen clay, so that Mol sands and superposed Campine clays were introduced in the Scaldisien. From that moment on A. RUTOT (1920) also considered these sands, now known to incorporate kieseloölite layers (M. LERICHE, 1913; F. HALET, 1920), as fluviatile and related them to the öolithic deposits of the High plateaus of the Maas and the area called "Entre Sambre-et-Meuse".

Thus was the situation encountered by the Geological Council, newly established on May 30 th, 1919 and whose first object it was the revision of the stratigraphical legend. At its 38th session (November 16th, 1922), which was the first one with regard to the Quaternary, it was proposed to incorporate the Quaternary at the Group order, together with the Tertiary, in the Cenezoic group (A. RENIER), this to avoid confusion with the Quaternary System of the first lower order. Discussions about the Quaternary (M. LERICHE, 39th session, 14.12.1922), were solved by the acceptance of Holocene for Modern and Pleistocene for the thus far called "Quaternaire". In the many discussions which followed A. RUTOT continued to stress the importance of the terrace concept which he had been defending in his most recent papers.

In this spirit as created by A. RUTOT, a subdivision of the Pleistocene in a Lower and an Upper Pleistocene was accepted, however with the geographical distinction for the latter between "coastal plain" and "inland" (P. FOURMARIER and M. LERICHE, 59th session 17.12.1925). It is to be noticed that before, at the 44th session (21.10.1923), the Mol Sands and Campine Clays had been located in the Amstelien (Upper Pliocene).

When the complete official legend was adopted at the 65th session on Novembre 11th, 1926, all collaborators were entirely conscious about the poorness of the quaternary part.

It was clear, as stated by A. RUTOT, that the confusion which existed about the use and signification of the various connotations were at the base of it. It was hoped that this generalised legend which was a chronological one, would facilitate correlations with other countries. The period of silence, during almost one quarter of a century, which characterises quaternary research hereafter, proves the bankruptcy of the legend's stratigraphical classification.

It is not untill R. TAVERNIER in 1943 tried a new attempt of classifying the Quaternary that a new start was given in this field of research. The main characteristic of R. TAVERNIER's approach was a switch-over to influence coming from the northern glaciations till now considerd as a minor controlling factor in our regions. Besides, concepts and methods of investigation were greatly inspired by those used in Northern Europe too, more especially in the Netherlands. Thus doing, the quite normal link which attached our "quaternary" field of investigations, with areas of the North Sea basin, was reestablished. Actually this meant a comeback to the situation as it existed before 1900, where the impact was laid in the first place on investigation by borings of the lithostratigraphical sequences in the northern half of Belgium.

In fact, an attempt was made to reconciliate PENK'S subdivisions* with the fourth edition of the Quaternary Legend of the Geological Map and with RUTOT's classification of the very beginning of this century.

As stress was also laid on renewed insight in the geomorphological-genetic concepts of the deposits already recognised in the former subdivions, new names and deposits were introduced as well. However,as stated in our introduction, this subdivision in the line of thought of the Geological Map and of A.RUTOT,was by-and-large a chronological classification, the boundaries of which also split off the lithological units (in so far they were to be considered as such).

The Moséen in TAVERNIER's classification comprised the Mol sands, Campine clays and all Plateau terrace deposits (including oölitic quartz gravels and all highest terrace residual gravels), in other words, the same components as in the fourth legend edition. In attributing Under-Pleistocene, including both Mindel and Günz glacial, to it, the timespan of the Moséen was enlarged again since it had been restricted in time by RUTOT.

The Campinien, essentially the Campine High terrace (considered to be a Maas alluvial fan) and all other high terraces in southern Belgium, now was parallelised with the first part of the Riss, the second part of this period being reserved for the Hesbayen eolian loam (old loam) and the middle terrace.

Quite correctly, R. TAVERNIER abandoned the term "Brabantien" as proposed by RUTOT to represent the Riss-Würn interglacial. Instead of Brabantien, he introduced the term "Eemian", ranking in between the two original Belgian terms. Despite the fact *Corbicula fluminalis* was known to exist in the Oostende Sands and was mentioned by numerous authors after G. DOLLFUS, in a position far more eastwards than the present coastal plain, it did not figure neither in deposits of the Eem transgression nor in those of

** At that time the N. German quaternary terminology had not yet invaded the Dutch literature, although attempts of lithological correlations with the German area were already common.*

the Flandrian. Actually, R. TAVERNIER, in order to conciliate both A. RUTOT and G. DUBOIS* concepts about the "Flandrien", indroduced a futher subdivision of this phase: a Lower Flandrian comprising the Würm glacial deposits, and an Upper Flandrian or Post Glacial by and large dominated by both Frandrian transgressions ("assise de Dunkerque" and "assise de Calais" of G. DUBOIS).

Thus, linking up with A. RUTOT's last interpretation, the Oostende sands with *Corbicula fluminalis* are omitted again from the Flandrian, probably because of the difficulties encountered to establish its age. In 1946 R. TAVERNIER consecrates a special paper to the position of the Oostende sands and comes to the conclusion that they belong to one of the Würm interstadial phases. Before A. HACQUAERT (1931) and F. HALET (1931) had come to the conclusion that Oostende sands and overlying Calais sands were both Upper Pleistocene (Flandrien) in age, because *Corbicula fluminalis* was found in both deposits. They respectively occurred below and above a loamy horizon which G. DUBOIS (1924) had given the name of "Zone of Leffinge" to and which in fact G. DOLLFUS in (1894) already connotated as "lehmzone" in the earliest description he gave of the Oostende sands displayed below.

New investigations, among which the finding of three loesses, each separated by a soil horizon and as a whole overlying the Oostende Sands in the Lys Valley, finally led R. TAVERNIER (1954) to the assumption of a Riss-Würm age for the last mentioned deposits. It replaces the former connotation Eemian, which is now restricted to the Dutch coversand area whereas the Lower Flandrian now has been replaced and subdivided by chronological connotations such as Würm I, Würm II and Würm III. Also the Late Glacial was later considered separatedly from the Würm Glacial and adhered to the "Epi-Pleistocene" (R. TAVERNIER and J. DE HEINZELIN, 1957). This latter connotation was introduced as a result of correlation of the Late Pleistocene subdivision with the Palaeolithic classification. It goes back in time as far as 22.000y B.P. so that the Late Glacial then also includes the upper part of the Weichsel pleniglacial in the classification of R. PAEPE (1967, 1968). We shall come back to this point later.

In the same period appeared F. GULLENTOPS' work (1954) in which the use of the old stratigraphical legend terms was advocated, with even the introduction of new ones. Besides connotations such as Brabantien and Hesbayen, to which a new content was given, he creates the new name as Hennuyen. It stands for the older, Riss age loesses found in the Hesbaye region, and formely called Hesbayen by R. TAVERNIER and predecessors, sometimes Campinien in its lower part. Actually it was J. CORNET who, in 1927, under influence of M.LADRIERE's investigations in Northern France, had first recognised this lower part of the loess as an older formation. Brabantien is now used again in the sense of RUTOT to indicate the yellowish eolian part of the loess, Hesbayen for the brown-greyish middle part of the loess deposits, most probably called Campinien at the beginning of this century. Not only the lithologic facies were well determined but also, important boundary beds, such as palaeosoil horizons are introduced by F. GULLENTOPS. Two soil horizons, a brown, weakly developed one, Kesselt Soil, and a reddish, strongly developed one, Rocourt Soil, make the limit between respectively Brabantien-Hesbayen and Hesbayen-Hennuyen loesses easy to recognise. It shows clearly that redefinition of the old names and introduction of new ones, combined with marker bed horizon permits to establish a lithostratigraphical subdivision which may possibly be correlated with a chronologic classification. Indeed, the Rocourt soil stands for the continental expression of the Riss-Würm or Eemian interglacial, whereas the Kesselt soil for an interstadial phase in the Würm.

** G. DUBOIS (1924) restricted the Flandrien to deposits of the Holocene, however, including the Oostende Sands or "Assise d'Ostende" as a lowermost member.*

The Holocene or modern deposits of the Stratigraphical legend have never been entitled for specific lithostratigraphical names with the exception of those deposits occurring in the coastal plain. A. BELPAIRE (1827) connotates the marine coastal clay deposits as"Polder clay"which A.DUMONT(1827)replaces by"Argile moderne des Flandres"or even"Argile d'Ostende". The names introduced by G.DUBOIS (1924) to indicate the three "assises" of the Flandrien (in the Holocene sense) was never given some consideration in the official stratigraphical legend. It is again R. TAVERNIER who renewed usage of the terms "Dunkerque" and "Calais" for the Coastal Plain while he also applied the Subdivision of Blytt-Sernander to the Holocene continental deposits. More recently many studies of the Holocene Continental deposits saw the light mainly on a palaeobotanical basis, however, without introduction of formation names. We will not consider an attempt for classification of the Holocene hereafter neither ,while this is still under study.

3. THE QUATERNARY STRATIGRAPHY WITH A PROJECT OF NEW LEGEND.

"Plus on embrasse un grand ensemble du pays, plus la légende doit être simplifiée"
M. LOHEST, Geological Council
24 th Session, April 21st, 1921

The penultimate result of all geological classification is a chrono-stratigraphic one, which is the "division of rock strata into useful and convenient units (chronostratigraphic units) corresponding to intervals of geologic time (geo-chronologic units) so that they may serve as a reference system for time relations of strata and the recording of events of geologic history (I.S.S.C. Report No. 6, Art. IA 1971)".

As boundaries of rock strata are never isochronous, litho-stratigraphic units can not substitute chrono-stratigraphic units,although "they may be useful as approximate guides to chronostratigraphic position (I.S.S.C. Report No 6, Art. XXII, 1971)". This will be the basic concept on which our attempt for a Quaternary Stratigraphical classification will be worked out: the sequence of rock strata will be treated in a chronostratigraphic sequence, with reference to the lithostratigraphic units by which they are built up. Ultimately it shall be tried to convert these units into the corresponding geochronologic units which then gives their relationship to geologic time.

In accordance to the above statements the connotation "Group" of 1881 which is used in the last legend of the Geological Map of Belgium (1929), to indicate commonly the "Tertiary, Quaternary and Modern" must be replaced by "Erathem"; simultaneously the withdrawal of the connotation Modern and the extension of the term Quaternary to the whole of deposits following on the Tertiary is foreseen. As of then Quaternary occupies the rank of "system", and not of "epoch" as was indicated in the last legend. Actually "epoch" being a chronologic term, it was fake to introduce it as a subdivision of a "group", this being considered since 1881, and successively in 1900 and 1960, as a stratigraphic connotation. Furthermore it was false also to use the connotation "system" for respectivily, Holocene and Pleistocene, because "system" is higher in rank than "series" (or "epoch") at which level Modern and Quaternary were then classified. In the present classification, Pleistocene and Holocene appear at the "series" level, which is a total reversion of terminology and rank in the classification with regard to the last legend of the Belgian Geological map.

Subdivision of the Pleistocene series into Lower, Middle and Upper will follow recommendations of the Commission on Quaternary Stratigraphy as decided at the IX INQUA Congress in New Zealand in 1973. In using the Northern European classification, the Upper Pleistocene should encompass all deposits from Eemian till the base of the Holocene; the Middle Pleistocene, all deposits from Cromerian till the base of Eemian and Lower Pleistocene, all deposits below the Cromerian.

Further chronostratigraphic subdivision then occurs at the Stage level, which often may cover partly a lithostratigraphic unit at the level of Formation. In this view the "Oostende Sands" are then to be considered as a Formation en compassing fully or partly the Eemian at the stage level.

On this basis it will be aimed at a classification of lithologic units with critical review of formerly used names,eventually their redefinition or introduction of new ones. Regional aspects will be kept as a principle in mind though immoderate use of new names will be avoided. From a chronostratigraphical point of view, the use of Northern European terminology finds its justification by the many lithostratigraphical links of the deposits in our country with it.

Finally this classification will lead towards a project of stratigraphical legend, which could form the basis for future activity of the Belgian National Commission for Quaternary Stratigraphy established under the auspices of the Geological Council

3.1. THE PLEISTOCENE SERIES

The tripartite subdivision of the Pleistocene series, introduced by R. TAVERNIER (1948, 1954) is a chronostratigraphical one as is customary for this period. Furthermore this subdivision is linked to palaeo-hydrographical systems and related terraces, as had be done by previous authors also. Deposits of the Lower Pleistocene have no relation with the present hydrographical system, while those of the Middle Pleistocene and Upper Pleistocene are encompassing respectively high and middle, and finally lowermost terraces.

In connecting the geomorphological evidence to stratigraphical classification, palaeoclimatic interference is inferred but not clearly shown. Nowadays,other concepts and techniques have widely contributed to this. In the light of recent investigations, as we will be able to stress several times hereafter, palaeo-climatical conditions are reflected also by soils, vegetational relicts and periglacial sedimentary structures. The use of faunal, especially vertebrate remnants though spectacular in itself, has not been very succesful so far an it may be the reason for not using them any longer as a major criterion. In fact such information has been completely overwhelmed by arguments yielded from palaeobotanical research which elements have shown to be much more precise climatical indicators. On the other hand studies of faunistical elements such as insects, rodents etc., are too few, and yet not systematically prosecuted so that it is too early to tie up stratigraphical conclusions on such results. With the exception of studies on foraminifera little if any reference will be given to it in the following.

Nevertheless, the basic subdivision of R. TAVERNIER still prevails and is now extended to deposits which show no direct link to hydrographic systems, but nevertheless are bearing palaeo-climatical evidence in the very nature of their sediments.

3.1.1. LOWER-PLEISTOCENE

3.1.1.1. Mol Sands and Kieseloölitic Terrace Gravels

The first problem in defining the Lower Pleistocene series is the fixation of its lower limit which is also the Plio-Pleistocene boundary. The limit is to be studied in the very complex area, both stratigraphically and biostratigraphically,which extends from Antwerpen eastwards till Arendonk situated east of Turnhout.It forms the southernmost extension of the marine basin which covers a great part of the Netherlands. The geometrical relation of marine deposits in the west, and continental deposits in the east is thus far not entirely elucidated, though foraminifera studies in the marine, and pollenanalytical results in the continental area tend towards some correlation.

In the Antwerpen area, the extinction of *Pararotalia scruta* is noticed (P.LAGA 1973) in the topzone of the marine Merksem sands which is the equivalent of the deposits of the Poederlien stage of the stratigraphical legend. However, *Elphidiella hannai* appears already for the first time in the underlying Oorderen (previously Kallo-) sands as well as in the still lower lying Luchtbal Sands which deposits belong to the Scaldisian stage of the legend. R. VANHOORNE (1957) states that there is no fundamental palynological distinction between the Merksem sands and Scaldisian.

Furthermore, lateral geometrical relation of Merksem sands with sands of the Poederlien stage is noticed (M.GULINCK, 1962) in the East. The latter sands are overlain by the Mol sands s.l. which consist generally of white, coarse sands, containing gravels consisting of flint, white quartz and numerous reworked shells at the base. The variety in textural facies has led to a distinction of several sediment provinces to which specific names have been given. M. GULINCK (1962) distinguishes Brasschaat fine sands in the West and South of the central Campine Clay area, as well as Merksplas sands underneath the afore mentioned clays. The Mol sands s.s. then are restricted to the very area around Mol. But all are thought to be continental and fluviatile in origin (Fig. 2 & 3).

R. VANHOORNE (1961) has studied in the Merksplas sands the floral content of a lignite horizon which extends from Arendonk via Turnhout to Kalmhout in a slightly dipping position. A typical Tertiary spectrum is obtained, characterised by the presence of *Sciadopitys, Pollenites polyformosus, Pollenites* and *Nyssa.* It recalls the results obtained by F. STOCKMANS (1943) and R. VANHOORNE (1973) in the lignites of the Mol sands at Mol, as well as the tertiary flora of the Reuverian stage in the Netherlands.

Moreover, the lignite horizon, studied by R. VANHOORNE is located in between two oölithic gravelly layers which F. HALET (1922) had found to exist, one at the base of the Campine Clays, the other at the very base of the Mol sands s.l. just above the sediments belonging to the Poederlien stage. F.HALET had come to this important conclusion after restudying the boring of Merksplas executed by P. VAN ERTBORN in 1887 and described by E. DELVAUX in 1891. In stating that kieseloölites had been found only in the lowermost gravels, F. HALET puts forward that the upper gravels should be also oölite bearing, though none was found in samples conserved at the Geological Survey of Belgium. Indeed all other characteristics, e.g. the abundance of white quartz pebbles, seem to reflect a common origin for both gravel layers which F.HALET adheres to deposition by a joined flow to the west of Maas and Rhine.

It is known since long that oolites occur in the Rhine and Mosel terraces as well as in those observed along the Maas between Liège and Namur, to which P.MACAR (1945) has given the name of "Trainée Mosane", and which appear with the connotation Onx on the Geological Map of Belgium.

P. MACAR (1954) points to the possibility of two distinct levels of terraces of the "Trainée Mosane" occurring approximately around 215m and 180m O. D.* Deposits of both terraces have been related to the kieseloolites of the Mol sands (R. TAVERNIER, 1948, P. MACAR and W., VAN LECKWIJK, 1949) earlier.

Recently R. PAEPE and J. THOREZ (unpublished) studied sections along the Ardenne Highway (Fig. 3), just North of Namur, which revealed the existence of kieseloölites at Champion in a plateau position situated at about 200m above sealevel and also at Bouge in a terrace position at 170m. The latter was covered by loess containing three fossil textural-B-horizons of truncated Gray Brown Podzolic soils. In this area, solution holes of the calcareous substratum of the Givetian stage are numerous which at Champion are filled up with yellowish sands of presumed Oligocene age. The kieseloölite terrace deposits cutting equally through sand and hard rock substratum, do not seem to

**O.D. : Oostende ordnance datum.*

be affected by irregularities of the substratum. This is why we conceive the lower Bouge terrace as a real terrace level, which morphology is clearly shaped all along the Maas river.

In agreement with former authors, we also believe that Onx gravels and kieseloölitic gravels of the Mol sands are of the same origin. Furthermore, it is quite feasible to consider the Champion gravels as the equivalent of the lowermost kieseloölite gravels, and the Bouge gravels as the uppermost kieseloölite gravels in the Mol sands.

We now come to a closer consideration of the age of both kieseloölitic deposits, which was assumed by most investigators to belong to the same period. Some are putting forward a tertiary age : Oligocene (P. FOURMARIER, 1931, M. LOHEST, 1895, E. VANDENBROECK, 1889), Lower Pliocene (J. CORNET, 1904) and Upper Pliocene (A. RUTOT, 1908, M. LERICHE, 1929). R. TAVERNIER (1948) is of the opinion that those deposits might not be of the same age at all, in stating that the base of the deposits is older in the East and younger in the West. This viewpoint encompasses the one emitted by M.GULINCK (1962) when splitting up the Mol sands in several facies. Nevertheless, with R. TAVERNIER, it is the first time that a Quaternary age, more especially an Icenian-Amstelian age is put forward, which is also the conclusion of P. MACAR and W. VAN LECKWIJCK, 1949).

In the light of our investigations, as mentioned above, we may conclude to a tertiary, pliocene age for the lower kieseloölite gravels in the Mol sands under the pliocene lignite horizon (R. VANHOORNE, 1957, 1961) and an Old Pleistocene, probably Pre-Tiglian age for the upper gravels as was also assumed by E. DRICOT in 1961. It is to be noticed that several German investigators come to similar conclusions for the deposits of the "Hochterrasse I" in the Rhine graben deposits which at Frechen show the complete succession from Reuverian till Menapian (G.VAN DER BRELIE und U. REIN, 1952).

As a consequence, we consider the Champion gravel member still as Tertiary, most probably Pliocene, and the Bouge gravel as Old Pleistocene, most probably, Pre-Tiglian in age. As we shall see furtheron, this assumption is in accordance with the age that will be proposed for the Campine clay which rests on the Mol Sands (Fig. 5).

In conclusion, we group under one single litho-stratigraphic formation the Mol sands and gravels, which bears the chronostratigraphic Plio-Pleistocene boundary. It is the "q 1 s and q 1 sa-Moséen" of 3rd and 4th edition, q2o s of the 2nd edition, and part of the q2o of the 1st edition. In the same line of thought, we shall group litho-stratigraphically all kieseloölite deposits along the Maas valley under a common formation name for which we propose: Liège Formation*; it is subdivided into a Champion and a Bouge Member. As stated above, these deposits did not figure within the Quaternary in the former legends and were connotated with Onx,indicating white quartz, fluviatile gravels of the Oligocene.

A last word should be said about the origin of the Mol sands. The former assumption of a marine character (M.LOHEST, 1889, J. CORNET, 1904) is now completely abondoned and the original idea of E. VAN DE BROECK, (1889) about the fluviatile character of these deposits is generally accepted at present. As stated by P. MACAR (1954), most of the characteristics of A. CAILLEUX point to a fluviatile origin and there is complete ressemblance with those obtained from the "Kieseloolith-terrasse".

**This connotation must not be confounded with the already informally used expression "Graviers Liègeois" by J. LORIE (1919), P. MACAR (1945), A. PISSART (1964) and A.M. CLAIRBOIS (1959) to indicate gravels occurring at variable heights and probably originating from another watercourse than the Maas, namely the Ourthe.*

At present, it is also known from the German investigators that the influence of the Maas on the Rhine course at that moment was not important. As the Rhine was occupying a much more westerly position than at present (A. SCHNÜTGEN, 1974), the Maas course was probably a tributary of the Rhine and debouching into it in a more eastern position than its present flow to the North. The Mol sands s.l. were deposited by the Rhine carrying Maas sediment load to the West along the Campine to Zeeuws-Vlaanderen and further on to the Northsea. In the German literature, all this occurs during deposition of the c-gravels member. In the absolute chronological scheme, this is taking place in the Matuyama palaeomagnetic reverse phase, maybe in between Tiglian C and A or even just before, in the Pre-Tiglian.

Important geomorphological conclusions may be derived from the afore. In considering the map of M. GULINCK, 1962, a first point to be studied is the cropping out of Rhine-Maas (Mol) deposits in between the marine pliocene Merksem sands in the South and Marine Tiglian, Campine clays just north of them (Fig. 2). Actually, R. TAVERNIER (1954) is of the opinion that both oölitic Mol Sands gravels and "Trainée Mosane" deposits belong to one and the same B-Limburg petrographic province in the sense of EDELMAN and DOEGLAS. On the other hand, M. GULINCK pointed to the difference in petrographic composition of the Mol Sands and "Trainée Mosane" gravels on the one hand and those occurring on top of the so-called Flemish Hills of Ronse, Kemmel and Cassel (France). It were those gravels who led J. DE HEINZELIN (1964) to the conclusion of the existence of an old Maas-course to the west and debouching immediately in the North Sea at Ostrevent in the Upper Miocene(Diestian) period. In the same line of thought the northwest-southeast orientation of the watercourses at that very moment are believed to be in agreement with the configuration of the Diestian shoreline (Fig.1). It is to be noticed that DE HEINZELIN does not believe in an opening of the Strait of Dover (Pas de Calais) at that moment contrary to the opinion of VAN VOORTHUYSEN. Actually both viewpoints may be supported but are of no direct importance for the Quaternary history of Belgium. J. DE HEINZELIN furthermore locates the northeastern shift of the Maas, when cutting through the Rocroi Massif, at the moment of deposition of kieseloölitic gravels in both the Namur-Liège trench (trainée mosane) and the Mol sands; this author believes that the gravels are entirely of end-pliocene age which dating is only accepted partly here for the reasons mentioned above. Moreover, the parallelism in the way of sedimentation in both Lower Rhine and Mol sands belts as advocated by J. DE HEINZELIN (1963) is not in contradiction with the double, plio-pleistocene age of those deposits. We should remind to the latest results in this field in the Rhine belt by E. BURGHARDT and K. BRUNNACKER (1973), G. VAN DER BRELIE, K. KLIPPER and R. TEICHMULLER (1959) showing a detailed stratigraphy in the plio-pleistocene transition and pointing to an even better parallelisation of both areas.

Furthermore it is our believe that the Mol Sands, just as for the Rhine graben deposits, were almost continuously laid down in a subsidence basin.

The important thickness and high inclination to the N.E. of these deposits plead in favour of such intense tectonic activity going on in marine as well as continental periods. The afore mentioned lignite horizon might then point to a phase of standstill sometime towards the end of the Pliocene.

The basin extended north of a line Vlissingen-Antwerpen and was already highly active during Merksemian times. Besides delineation and shaping of the Mol Sands belt, in other words of the old fluviatile Rhine(-Maas) branch to the West, the subsidence basin is most probably also at the origin of configuration and fixation of the southern limits of the North Sea shorelines, after retreat of the Diestian sea to the North.

The various End Tertiary deposits which can be distinguished around Antwerp show that retreat of the sea occurred in several stages to which the consequent hydrographic pattern could easily adapt itself and extend further northeast. The substitution of the tertiary marine deposits by fluviatile, at first tertiary and later, quaternary Mol sands in an East-West oriented trench did not impose major changes in the orientation of the consequent hydrographic pattern of Lower and Middle Belgium. This is of later date and will be discussed furtheron in this paper.

3.1.1.2. Campine Clays and Sands

Deposits of the first quaternary marine transgressions may be observed in the Antwerpen Campine area, just north of the Mol Sands belt. They occur in an area known as Campine Clay belt (Fig. 2) and are build up of alternating layers of clay and sand which may reach thicknesses up to 30 m or more.

Thanks to the existence of many outcrops in brick yards, good observation of the two uppermost clay deposits is possible while the third and lower one is occasionally mentioned in borings (M. GULINCK, 1962). They overly the Mol, or better the Merksplas Sands and it was also stated that a gradual lateral transition to the Mol Sands s.s. in the East could be observed (M. GULINCK, 1962).

R. VANHOORNE (1957, 1961) and E. DRICOT (1961) put stress on the mixed character of the flora of these deposits and on the appearance of cold and warm vegetation levels. The Tiglian Stage age, generally accepted since 1954 (R. TAVERNIER) for the whole of the Campine Clay, was questioned by both authors. Furthermore E. DRICOT breaks off with the concept of a fluviatile origin of the clays, in unraveling the sequence of marine tidal flat clays from marine sands and continental coversands. The latter are connotated by DRICOT with the chronostratigraphic name: "BEERSIEN". In a similar study undertaken by R. PAEPE and R. VANHOORNE (1970) and confirming E. DRICOTS's statements, distinction is made between a lower, essentially warm, Formation of Rijkevorsel, a middle, continental, cold, Formation of Beerse* and an upper, marine, warm, Formation of Turnhout. R. WEST and E. FRANCIS, at the occasion of an excursion in September 1971 of the "Quaternary Research Association", conducted in the field in Belgium by R. PAEPE, point to the similarity as to the sediment facies with deposits of presumably of the same age in East-Anglia. In E. DRICOT's study, doubt remains about the stage age of the above mentioned formations, but R.VANHOORNE (1970) succeeds to localise the presence of *Azolla tegeliensis* FLORSCHUTZ in the top of the lower clay body. This means that the Formation of Rijkevorsel now definitely belongs to the Tiglian stage. The upper clay layer,though showing also a climatological temperate spectrum characterised by the presence of *Tsuga, Pterocarya* and *Eucomnia,* however without *Azolla tegeliensis* FLORSCHUTZ should then belong to the Waalian stage, the tertiary relicts having disappeared in N.W. Europe in the next cold phase or Menapian (VAN DER HAMMEN et al, 1971). Such interpretation is in agreement with palaeomagnetic datings by H.M. VAN MONTFRANS who believed to have recognised in the Turnhout Clay the normal Jaramillo event (0.87-0.92 M.y. ago) and at the top of the Rijkevorsel Clay, reversed polarity, pointing to an age older than 1.68 M.y. for the clay, given the event corresponds to the Gilsa event.

A further step towards solvation of the age of the Campine Clays is herewith reached. Whereas E. DRICOT still showed some doubt about the age of the Beerse

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** E. DRICOT was the first to have used the term "BEERSIEN" of which the present connotation is derived at the formation rank. It should not be confused with J. DE PLOEY's "Formation of Beerse" which was introduced after the "BEERSIEN" to indicate eolian Late Weichselian Glacial deposits of the Campine region.*

formation: Eburonian or Menapian, it now became ascertained that the cold peat and continental deposits of the Beersien are to be considered as of Eburonian stage age.

It may be questioned if the formation name as formely applied by R.PAEPE (1970) to different members of the Campine Clay is quite adequate. Actually, given the upper Mol Sand member is of Pre-Tiglian age, it is quite uncertain to which stage the lowerlying clay horizon between the Rijkevorsel Clay and the Sand of Mol belongs. Therefore, it may be useful, also from the geological mapping point of view, to consider the whole of the clay and sand layers above the Mol sands, as the Campine Clay and Sand Formation whereas Rijkevorsel Clay, Beerse sand and Turnhout Clay, should be connotated as members. This new connotation covers the original "q1a and q1as-Moséen" of the 3 rd and 4 th edition, the "q2oa-Campinien" of the 2 nd and part of the "q2o" of the 1st edition of the stratigraphical legend.

The Tegelen deposits at the type locality being of fluviatile and the Campine Clay of fluvio-estuarine origin there is no doubt left about the proximity of the shoreline. It can be traced from Ludhamian via Rijkevorsel to Tegelen. As a consequence the nearness of the sea to the Belgian and Northern French hinterland at successive phases of the Lower Pleistocene must have influenced its morphological evolution considerably. If one is to consider the timespan of more than one million years, further landscape erosion under widely differing climatical conditions of the former landscape covered with kieselo-ölitic gravels was continued.

Though it is not clear which are at present the relict features of this evolution, because of lack of datable material, it is thought that the isolated, heavy boulder terraces found on many ridges and plateaux of the Ardennes, are the widespread relicts of it.

Besides plateau terrace relicts along the Maas, as those of Cerexhe- Heuseux, we find a far most striking, morphological example of it, in the Lavaux- St.Anne gravel terrace inside the Ardennes. The terraces belong to the group of P.MACAR's highest terraces(120-150 m above the floodplain). The Lavaux-St.Anne terrace is covering an elongated ridge along the southern rim of the Famenne depression. Its position has no relation to the present Lesse course, however, points to an inversion of relief (R. VERMEIRE, 1962, R. PAEPE, 1969). Though occurring at approximately the same altitude of the kieseloölitic terrace along the Maas, viz. at 190 m. O.D., its composition is entirely different, except for the reddish deeply weathered terra fusca soil in its upper part and which is named FOCANT soil. It is for the first time that we will use a pedological horizon as a possible stratigraphical marker bed in the Belgian Pleistocene sequence. This fossil soil certainly must have formed on a plateau that existed prior to the relief inversion. Indeed many of these relict soils are found in a thin clayey bed covering immediately the Paleozoic substratum on plateaus surrounding the Lavaux-St.Anne terrace ridge, at a slightly higher position (+ 210 m). In deposits of the presently lowerlying, V-shaped valleys this soil is never found again. This leads to the assumption that at the end of the Lavaux-St.Anne terrace aggradation and subsequent soil weathering, a gentle undulating relief existed, with several levels of erosion at fairly the same altitude as the terraces along the Maas. In our opinion, this stepped landscape represents the peneplaine of many authors (M.A.LEFEVRE 1934-35, P. de BETHUNE 1938, A. STEVENS, 1945, P.MACAR,1945) which connected the Ardennes and the Condroz with the Campine belt geomorphologically. Hence the reddish soil in gravel deposits at 30 m. O.D., just south of Turnhout*, is stratigraphically to be accounted for a formation of about the same stage age as the Focant soil.

**Observed along highway E39.*

Soils of the same type as the Focant soil are never found back neither within the thick mass of boulders of the Campine High Terrace (which dominates the former gravel up to an altitude of 70 m. O.D.), nor on top of it. This adds to the presumption of a pre-Campine High Terrace age for the Focant t erra fusca soil.

One may wonder about its stage age since mineralogical fossil soils of this type (as we shall see more often later) can not be dated directly; at the utmost they are an indicator of climate, in the present case of a warm climate. Most presumably, the terra fusca must be situated in one or in both of the interglacials of Tiglian or Waalian. The reason for not considering a Cromerian age, is the age of the Campine High Terrace itself, which ranges in age from Menapian to Elsterian. We shall discuss this problem again in the following chapter.

Finally we propose to indicate all plateau gravel or clay deposits with eventually a Focant soil on top of it, as Ardennes gravel Formation covering the chronostratigraphic stage from Tiglian to the "q1m-Moséen" of all four editions of the map, except for Lower and Middle Belgium.

3.1.1.3. Campine High Terrace

The Campine High terrace covers the whole of the Eastern Campine area and at present occurs as a fan shaped deposit which spreads from Lanaken to the Northwest, Arendonk and Poppel in the West and till Weert in the East. It was cut by the present Maas between Maastricht and Maaseik and it is found back again east of Maastricht where it extends as far as Heerlen and Ubagsberg (Fig. 2 & 3).

Large boulders, some of which could only have been transported by icerafts, and loamy lenses testify of cold climatic conditions at several moments in the timespan of deposition. The lack of any definite fossil red soil horizon on the other hand, may imply that fluviatile activity was never interrupted during periods of warm climatic conditions as well. However, the reddish brown tint which impregnates the whole of the gravel body may infer warm climatical conditions at certain stages of deposition. We therefore believe that cold and warm climatical conditions have reigned periodically during deposition of the Campine High Terrace.

The first phase of intense gravel formation may correspond with a long continuous period of denudation which is to be located in the Menapian. Horizontal erosion of the Waalian, Eburonian and even Tiglian deposits has been observed in many outcrops of the Campine Clay belt. Cold is stressed by the presence of numerous and important frost wedges along this line erosion. One and another infer cryoplanation under polar desert conditions, at least in the first phase of the Menapian. This is somewhat in contradiction with the opinion of some Dutch authors (Th. VAN DER HAMMEN et al, 1971) whose believe it is that the coldest parts of both Eburonian and Menapian were characterized by a tundra-like landscape. In our opinion, relative warming up of the climatic conditions occurred only towards the end of the Menapian and is supposed to be at the origin of the Campine High Terrace development. Gravel could then spread out easily over the flat cryoplanated plain established earlier and easily transported by rivers of the importance of the Maas. The sea having retreated to the North since the Waalian it seems to us that besides improvement of the climate, the distant position of the shoreline – with other words, of the base level of erosion – should also be taken into account for the explanation of such intensive erosion and simultaneous transport by the rivers.

It is known from Cl.REID(1961) in East-Anglia and from W.H.ZAGWIJN(1975) in the Netherlands that in the following so-called interglacial period,the "Cromerian", the coastline remained situated at least 150km more Northwards of the Dutch-Belgian border and that the Rhine was debouching in the Zuiderzee area.Hence the Maas continued to function,along the path to the North during Cromerian times, from which period the reddish weathering tint which affect the gravels dates back. The remote distance of the North Sea shoreline explains the location of the Campine (Maas) High Terrace in a more Western position and its orientation towards the N.N.W. Contrary to the periods of the Mol Sands and Campine Clay Formation, the Rhine had shifted its course from West to North and even North-Northwest (A. SCHNÜTGEN, 1974). It shows that after stabilisation of the coastline in the Vlissingen-Antwerpen-Tegelen belt for more than 1,5million years, (the Merksem deposits taken into account), there is now a sudden change occurring,in the timespan from Menapian to Elsterian, say in less than 0,5 million years. The marine influence from the N.E. transgressions had faded out gradually with the retreat to the North causing profound changes in the southern North Sea's configuration too. We are entirely conscious of the fact that dating of the continuity in sedimentation of the Campine High Terrace, from Menapian through Cromerian times, needs still more accuracy from the Belgian side. However, the geometrical extension into the lower part of the Formation of Sterksel pleads in favour of the proposed timespan for deposition of the Campine High Terrace. Actually, in Noord-Brabant (The Netherlands) the Sterksel Formation is overlain by the Veghel Formation the basis of which is proved to be of Pastonian age (W.H. ZAGWIJN, oral communication). It should be recalled here that this boundary must be situated near 0,7 my, since it most probably occurs in the Cromerian Glacial A phase (W.H. ZAGWIJN et al. 1971). This furthermore is in agreement with the beginning of the Middle Pleistocene subseries situated at the basis of the Cromerian. The Campine High Terrace covering the timespan from Menapian through Elsterian, has thus become older than its formerly Mindel stage age which is now generally believed to be younger than Cromerian (VAN DER HAMMEN et al., 1971). Its homogeneity leads to the recognition of an entity which we propose to call "Maas Formation", covering entirely the former "q2n" of the 1st and 2nd legend, probably also of the 3rd and 4th editions.

3.1.2. MIDDLE PLEISTOCENE

3.1.2.1. Relief Inversion - Plateau Terraces

From the afore one will find that the Lower-Middle Pleistocene boundary, situated by definition at the beginning of the Cromerian, is located in the middle of a period characterised by fargoing landscape changes and sediment transport.

In this dynamic period most features of the Lower Pleistocene have been wiped out whereas it seldom comes to a moment of rest or of aggradation with the possibility of insertion of some datable material. Hence it is difficult to obtain continuous lithostratigraphic records of this period.

Another difficulty in defining a sharp boundary resides in a contrariwise response of dynamic landscape evolution and vegetational evolution to an improvement in the climatical conditions.

Whereas vertical erosion and intense relief development already started at the end of the Menapian in response to improvement of the climatical conditions, profound changes in the vegetational evolution are noticeable only from the Cromerian complex on. This means that the landscape,as we saw before, had already undergone profound renewed modelling such as establishment of the hydrographical network before the first evident sign in the vegetation could be observed. The question now arises whether changes in the palaeobotanical or the hydrographical context should be taken into account in order to establish the Lower-Middle Pleistocene boundary.

R. TAVERNIER (1954) always based the boundary location on changes occurring in the hydrographical pattern, which he assumed to start with the Mindel period. This also explains why a Mindel stage age was given at the Campine High Terrace gravels, presently called Maas Formation. However now that it is known that all four glaciations of the Alpine sequence (Würm, Riss, Mindel, Günz) seem to fall within the Middle and Upper Pleistocene of Northern Europe (Th. VAN DER HAMMEN et al 1971), the former assimilation of Günz to Pre-Tiglian by R. TAVERNIER should therefore be abandoned. Also the use in this area - which is lithostratigraphically and geomorphologically linked to the subsidence basin of the Netherlands - of any Alpine connotation and its mixing with North European stratigraphical names is to be avoided.

Considering the palaeomagnetic datings of the Turnhout clay(0.9.m.y. for the upper part)and assuming,as stated before,that the Campine High terrace started its aggradation before the Cromerian Complex time span,it is believed that the beginning of the landscape viz. hydrographical changes, started some 0.8M years ago.

From the litho-stratigraphical point of view it seems justified to extend the formation name given to deposits of the Campine High terrace, the Maas gravel formation, to isolated important valley bounded terrace gravel deposits post-dating the Lavaux-Ste Anne plateau terrace which they partly erode and cut in at several levels. Geomorphologically it is the series of four "hautes terrasses" of P.MACAR occurring between 120 m and 150 m above floodplain level and which we jointly call the Han-sur-Lesse terrace system. They are post-dating the onset of relief inversion, and corroborating the building of the Campine High Terrace. The connotation Maas formation, extended to deposits in Upper Belgium of terraces post-dating the relief inversion seems to correspond in the old stratigraphical legend to the connotation "q2m-cailloux ardennaix et cailloux de silex, des flancs supérieurs des grandes vallées".

At the time erosion went on in Upper Belgium and the Campine terrace was build up, denudation must also have taken place in Middle and Lower Belgium. Indeed, many are the relict gravels occupying interfluvial crests and generally dated as Mindel (G. DEMOOR, 1969, L. WALSCHOT, 1967). From West to East they are gravels with fossil soils at Passendale, on the Yzer - Leie interfluvial crest, gravels with red fossil soils at Kruishoutem on the Leie-Scheldt interfluvial crest, the cryoturbated gravels with red fossil soil at Rosebeke on the Scheldt-Dender interfluvial crest and also gravels on the Bois-de-la-Houssière crest, between Zenne and Sennette.

These terraces may split up in several horizons as well when mapped in detail. However, we do believe that this is a technical mapping question rather than a stratigraphical matter. Therefore, the proposal is made to connotate all deposits of the Scheldt basin terraces occurring in a interfluvial position with the same name:the Scheldt (gravel) Formation. They have been deposited in drainage ways oriented to the North-East before the Flemish Valley East-West trench (from Mechelen via Ghent to the sea) captured their flow causing at the same time another still younger relief inversion (see later). On the geological map, they sometimes are indicated with the following connotation : "q3n" and "q2o". It is clear that only the lower part of "q3n" is to be taken into consideration here: "... cailloux et graviers sporadiques à la base".

3.1.2.2. Marine Interglacial Deposits

Little if any has been described from the North Sea properly but there is no reason why in that period erosion should not also have affected the very southern part of it, more especially in the vicinity of the Dover Strait. As we shall point to many times hereafter, there is enough evidence for the assumption that south of a line from Cromer in East Anglia towards the River area (Rhine and Maas) in the Netherlands oriented from NW to SE, and parallel to the older but southern lying coastal line the afore mentioned Ludhamian-Rijkevorsel-Tiglian line the Southern North Sea belt remained emerged (Fig. 2,3,4). The river Thames at that time must have functioned as a tributary from a watercourse cutting back into the isthm linking the Downs with the Artois ridge. The very question is when this fluvial erosion was taken over by a marine one, with other words when the Dover Strait came first into existence and was flooded by waters of the Atlantic Ocean.

This problem relates directly to the presence of marine Middle and/or Lower Pleistocene deposits in this specific area. Eemian deposits are known to have formed all along the channel rims on both British and continental sides since long and their occurrence will be discussed later in full detail (see p. 26) later. We know from it that the Dover Strait was open during the Eemian. Since how long?

The finding and location of Middle, perhaps Lower Pleistocene deposits in the IJzer basin of south-west Flanders and north-west France seems quite promising with this respect. There, so-called *"Cardium edule* deposits" of A.RUTOT (1897) are generally found beneath the coversands of Weichselian age and south of the present coastal plain, even south of the river IJzer. A. RUTOT based the marine character of the Flandrian on this very finding as well as its Pleistocene age. Furthermore, these deposits were in RUTOT's mind the equivalent of the later to be called "Calais deposits" of the coastal plain (introduced by G. DUBOIS, 1924 and dated of Holocene age) despite of their generally much higher position: in some places the *Cardium edule* sands occur at a level which is 10m above the top of the Calais deposits. It is connotated as "q4m- (Facies marin), Sable grossier, gris avec très nombreux *Cardium edule".* However we also believe that part of these deposits is confused with the "q3ms" and "q2m" also.

Anyhow, RUTOT's original Pleistocene age for the *Cardium edule* sands has been confirmed by the analysis at Lo of a peat layer underlying the shell bearing layer or crag. R. VANHOORNE (1962) concludes to an Holsteinian age for the peat. This very much seems in agreement with conclusions such as drawn by R. TAVERNIER and J. de HEINZELIN (1962) on basis of the abnormal morphological position of the Cardium crag of the Vinkem-Lo area (SW Flanders) to (Eemian) Oostende deposits of the coastal plain north of it. The non-Eemian age is also revealed by the absence of *Corbicula fluminalis* as well as *Venerupis aurea senescens* (formally *Tapes senescens var. eemiensis)* in it. Indeed, the presence of the latter guide fossil is now found to exist in many borings and outcrops of the coastal plain (R. PAEPE, 1965, 1970, 1971) the deposits of which have been proved to be of Eem stage age on basis of pollenanalytical results.

Nevertheless R. VANHOORNE (1962) does not entirely exclude a "Cromerian" stage age for het peat under the Cardium crag since *Azolla filiculoides,* thought to be typical of the Holsteinian interglacial, also appears to occur in the Tiglian, Waalian as well as Cromerian interglacial deposits and since the pollendiagram shows a resemblance to some pollenspectra of the Cromer Forest Beds. On the other hand R. VANHOORNE (unpublished) recently found a few specimens of *Azolla tegeliensis* (FLORSCHUTZ) as well in the peat underlying the crag at Lo. It is known since long that this waterfirn has never been found until now in deposits younger than Tiglian (W.H. ZAGWIJN, 1961).

Recent studies by J. SOMME and R. PAEPE in a brickyard at HERZEELE in France, south of the IJzer river,revealed the existence of peat and shell bearing sands strikingly similar to those found at Vinkem and Lo, at a few kilometers distance in Belgium. Though unpublished yet, it should be stated here that in between the peat and crag layers - contrary to the statement by R. TAVERNIER and J. DEHEINZELIN (1962) putting forward a gradual transition between the peat and the crag - several other, marine as well as continental deposits do interfere in the vertical sequence (Fig. 4). Under the loessic cover, containing two graybrown podzolic fossil textural B horizons below the modern soil, occurs from top to bottom, the series of a first marine shell *(Cardium edule)* bearing deposit or crag,and clay layers containing two pseudogley soil horizons with interfering cryoturbated sands layers;a second marine,humic deposit with sporadically shells;a new series of clay layers with two fossil pseudogley horizons, and finally a third marine layer with peat horizon in the top zone. Wedging out of the marine layers is observed in the outcrop,resulting laterally in a sequence of six palaeosoil horizons, one above the other. The latter superposed sequence of palaeosoils is known to exist from many loess sections in the Normandy (France) and the Belgian loess belt, as well as from the Lower-Austrian loess area and Czechoslovakia. Never the soils were found to interfere with marine deposits so that here a unique opportunity is given for considering the litho-stratigraphical position of the soils.

The uppermost *Cardium edule* bearing marine layers, recall the crag sands of Izenberge which due to the presence of *Macoma balthica* are to be considered younger than Waalian (W.H. ZAGWIJN,1970) and also younger than Late-Baventian (P.E.P. NORTON, 1970). The peat layer at the top of the lowermost marine, wadden deposits, assuming that it is the same as the one at Lo * should be of Hoxnian, maybe of Cromerian age. However the recent found of *Azolla tegeliensis* FLORSCHUTZ in it, if "in situ", should point to a Tiglian age (R. VANHOORNE) while the pollendiagram without *Tsuga, Carya* and *Pterocarya* does not confirm this assumption. Still more study is needed on this matter to examine the autochtonous character of the megasporangia of *Azolla tegeliensis* FLORSCHUTZ and their value as guide fossils. With other words, it is difficult to give for the moment a precise stratigraphical position on the basis of palaeobotanical arguments.

Hence, there is only left the lithostratigraphical approach. The lowermost marine, wadden deposits ending up in a peat horizon,are to be considered as a first interglacial deposit coinciding with a high sealevel position. Two fossil pseudogleys follow immediately upward in the geologic column and are likely to be accounted for interglacial formations too.

Next, a second humic, marine shell bearing deposit overlies peat and soils, both being affected by cryoturbation. It recalls a marine transgression that happened in a warm phase subsequent to a cold period which caused the periglacial phenomena. Another level of periglacial structures separates these marine deposits from the next two overlying pseudogleys, invoking again a definite climatical break between both warm marine and fossil soils deposits. Finally, the Cardium edule crag points to another sealevel rise under warm climate conditions.

This leads to the recognition of at least five warm periods, before the loess sedimentation even started. If one is to consider also the periglacial structures between the fossil soil horizon as major breaks, then there are even more climatic subdivisions to be accounted for.

** C. BAETEMAN of the Geological Survey of Belgium is carrying out a dense boring programme to investigate this problem.*

It is furthermore noteworthy that the fossil textural -B- horizons within the loess series are of the interglacial fossil soil type horizons too, so that here an additional couple of warm climatic phases should be taken into account.

A simple count-down along the chronostratigraphical chart of north-western Europe may throw some light, however with full consideration of the climato-sedimentological and geomorphological conditions involved.

On a geomorphological basis, the position of the crag at an average altitude which is usually 10m higher than the highest Eemian deposits of the Coastal Plain (R. PAEPE, 1971) occurring at around +1m O. D., exclude any possibility of correlation with an Eemian stage age. Its position below a loess series containing two fossil textural-B-horizons adds to this assumption. As we stated before the presence of e.g. *Macoma Balthica* is at the origin of R. TAVERNIER and J.DE HEINZELIN's (1962) Holsteinian age for the crag, which we believe is quite feasible and we therefore propose to name it : Izenberge crag member. Hence the two fossil soils above belong either both to the Eemian or one to the Eemian and another to the Holsteinian, or still to the warm Hoogeveen interstadial of the Saalian, which after W.H. ZAGWIJN (1973) might be considered as another interglacial, e.g. the Wacken interglacial (B. MENCKE, 1968) or Dömnitz interglacial (K. ERD, 1970) as known from the Germanies.

From what is known till present, there is little possibility to adhere the lowerlying marine deposits with intercalated fossil soil and humic horizons, as well as permaforst zones, within the Holsteinian interglacial too. This should infer rather important sea level changes for an interglacial which is generally proved to have a continuous climatic evolution.

On the contrary, the complexity of the Cromerian stage recently became obvious in various parts of Northern Europe (W.H. ZAGWIJN, 1956, 1971; R. WEST, 1966, 1969) as well as the fact that it covers a timespan as long as the one from Elsterian to Holocene (H. VAN MONTFRANS, 1971). With this in mind, the fluctuations of the sealevel alternating with continental emergence zones of soil development and even periglacial activity, as is shown by the sediment series below the Izenberge crag, may point to such period as the Cromerian.

In this light the two marine deposits could possibly correspond to either of the three "Cromerians" of W.H. ZAGWIJN (1971) most probably to the two upper ones. The reason herefore is the fact that the main peak of both upper warm phases of the Cromerian fades out into some minor warm peaks which then might be materialized by the doubled palaeosoil formation which, as we have seen before, overlies always one of the lower marine deposits. Furthermore, there is, from the lithostratigraphical point of view and apart from the wadden nature of these sediments, no relationship with the Lower Pleistocene wadden deposits of the Campine. The chronostratigraphic consequence of the foregoing reasoning is the location of all the sediments after the Glacial A Cromerian stage, which implies an absolute age younger than 0.7m years. It is been proposed * to call these series the "HERZEELE FORMATION" and the peat horizon the "LO PEAT MEMBER", assuming it is the same as the one encountered at Lo, which we believe at present.

From the geomorphological point of view the presence of these marine deposits testifies the spread of seawater all over the southern part of the North Sea. Does this infer:

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* *Detailed study of the section of Herzeele will be published later by J. SOMME (Lille) and R. PAEPE (Brussels).*

the existence of the Dover Strait or the transgression of the North Sea over its southernmost basin while still landlocked in the south; or still the existence of an Atlantic gulf into the southern part of the North Sea belt?

Further investigation, especially the pollenanalytical investigation and palaeomagnetic dating which is going on and which may last for several years, may perhaps give a definite solution. Presently the occurrence of *Macoma balthica* points to a connection with the northern part of the North Sea belt,more exactly with the boreal region between Scotland and Norway (P.E.P. NORTON, 1970).

On the other hand the sudden change in the orientation of marine trangressions, swifting from north-east Belgium to south-west Flanders and north-west France implies in our opinion the break through of the Dover Strait at that time. With other words the southern part of the North Sea became no longer landlocked which also explains the sudden eustatic rise of the water level in this part of the coastal plain since the beginning of Cromerian.

The configuration of the coastal line was certainly different too then at present. We do believe that a large gulf, extending from Sangatte to north of the IJzer,and suddenly bending due north towards Oostende was existing (Fig. 2 & 4). North of the latter locality, offshore the present delta area of the Netherlands, the coastline formed a large bow bending eastwards along the present river area to the former Rhine estuary which then abutted somewhere in the southern Zuiderzee region. This gives an explanation for the continuing of the Campine High Terrace development in the timespan from Menapian to the beginning of the Elsterian.

From investigations in the Eindhoven area we also know that tectonic movements were intense and that towards the end of the Cromerian the river Maas started to function as an independent water-course in this region, the Rhine being forced into a more easterly position by tectonic movements in the German hinterland (A. SCHNUTGEN, 1974).

In the meantime denudation from the West, with other words from the southern North Sea which is now the base level of erosion, must have started too. It is quite feasible that from this time the initiation or further deepening of the Flemish Valley (R. TAVERNIER, 1946) or Gulf of Ghent (A. RUTOT, 1894) dates back, together with erosion of the Delta area in the Southern Netherlands.

It is to be noticed finally that in the timespan from Cromerian to Holsteinian little if any eolian influence is observed. It most probably infers the absence of severe periglacial conditions which might infer the absence of a land-ice cover in the immediate vicinity of the southern North Sea belt.

3.1.2.3. Continental Deposits

The presence of continental deposits of the Middle Pleistocene seems bound to areas protected against erosion. Waterdivides and fossil basins are amongst the best situations for such preservations. Indeed, thick loess covers are known to exist in the Normandy (France) and Hesbaye(Middle Belgium) and are situated on important waterdivides, whereas in regions such as Lower Belgium and Northern France, testifying of intense erosional activity,thick loess sediments are to be sought in basins, e.g. the Lys basin between Lille and St. Omer (R. PAEPE, 1963, 1964). Moreover, basins of this kind, not to be confused with subsidence basins as e.g. The Netherlands, usually contain the very upper part of the Middle Pleistocene only.

These Middle Pleistocene deposits mainly consist of eolian sediments of similar macroscopic nature and therefore are difficult to distinguish from one another in the field. The presence of palaeosoils helps to the identification of the various layers, given there are no major erosion hiatuses. This is the situation found in the Normandy where several loess layers separated from each other by truncated textural-B-horizons occur in several places (F. BORDES, 1952; J.P. LAUTRIDOU, 1970, 1971). In Middle Belgium the situation is not so prosperous and most often one must content himself with the presence of only one older loess under the Weichselian coverloess from which it may be separated by a truncated fossil textural-B-horizon. The last mentioned has been given the name of ROCOURT SOIL by F. GULLENTOPS in 1954. This palaeosoil has been accounted for Eemian in stage age and was thought to have been found in similar positions in Lower Belgium and in the Lys basin, in between the coverloess and the older, lower-lying loess to which as a consequence, a Saalian stage age was given (R. PAEPE, 1964,1967,1971).

This simple stratigraphical scheme which for long remained unchanged,suddenly became less evident as other fossil soils below and of the same type of the Rocourt soil were found. In Belgium this fossil soil sequence was first limited to two truncated textural-B-horizons all located in loess deposits occurring to the east of Belgium more especially east of the Zenne river : Tubize, Le Marouset, Harmignies, Mazy, Barry, in the loess area; As, Opgrimbie, Genk, in the Campine area; Wanlin, Hour, Profondeville in the Ardennes. It was generally held that the lowermost fossil soil could be accounted for a Mindel-Riss stage age.G. MANIL (1947) was the first to have drawn attention to the presence of such doubled fossil soil sequences in the Gembloux loess area. This author stressed the importance for the litho-stratigraphical dating of the Pleistocene deposits in this area with the aid of paleosoils.

Systematic investigation in the last five years brought R. PAEPE (unpublished) to the insight that :

1. in between the truncated, closely overlying textural-B-horizon, a humic soil could occur (Daussoulx);

2. more than two truncated B-horizons could occur in places (Bouge, Harmignies).

At the same time several new problems have arisen:

- are the fossil, truncated textural-B-horizons still to be considered as representative for interglacial buildings ?

- if so, which of the interglacials do they represent and are there more interglacials to exist than known till present?

The confussion about fossil textural-B-horizons being buildings of the interglacial phases will certainly go on for a while, since it is rather tideous to reconstruct the climato-sedimentological environment under which they have developed.

Nevertheless, from the litho-stratigraphical point of view, soils of this type do not occur in sediment sequences which have proved to have formed under periglacial conditions within the limits of one and the same glacial phase. The study of a sequence such as the Weichselian in different sedimentary provinces, in and outside Belgium and sufficiently ascertained biostratigraphically as well as with the aid of C-14 datings, showed that soils of the Rocourt type never occurred within its limits but just under it.

Also, a similar litho-stratigraphic sequence as the Weichselian in the Upper-Pleistocene may be shown to exist in between two fossil textural-B-horizons as was pointed out by both macro-pedological and micro-pedological investigation in the loess series of the Normandy (J.P. LAUTRIDOU and R. PAEPE, unpublished).

Therefore, and in the present state of our knowledge, fossil textural-B-horizons in our areas do represent interglacial pedogenesis in our opinion.

Herewith we have come to the next problem : how many interglacials ? In itself a palaeosoil series does not offer great possibility for either relative or absolute dating in the absence of any datable material such as peat, tuffs and shell layers. The section of Herzeele described in the previous paragraph therefore is of the utmost importance again and till now the only section from which the age of the palaeosoils can be derived with some approximation.

The rather striking fact in this section is that all palaeosoils younger than the oldest marine transgression, which as we stated above we believe to be of Cromerian age, are of the gray brown podzolic or of the pseudogley type. In sections such as Bouge and Harmignies in Belgium and St. Pierre-les-Elboeuf and Mensil-Esnard in the Normandy, there is usually a continuous series of four gray brown podzolic weatherings interrupted only by loess deposits of the periglacial phases.

Soil weatherings of the "braunlehm" type, such as Terra fusca, inferring primarily another climate, are known at present to start under the afore mentioned palaeosoil series as was shown at Mesnil-Esnard (J.P. LAUTRIDOU, 1973) and at Bouge (R. PAEPE, unpublished). The four truncated textural-B-horizons of the Bouge section overly a Terra fusca soil developed in the so-called Onx gravels underneath.

Moreover, a Terra fusca soil type, as we have seen, occurs always in a quite different geomorphological and stratigraphical position, so that we are of the opinion that loess deposits containing the textural-B-horizons are of an entirely different climato-sedimentation phase than the older phases wherein the Terra fusca could develop indeed.
As a further conclusion from the Herzeele section, the lower litho-stratigraphic boundary of Middle Pleistocene loess, containing usually four, occasionally six paleosoils, should now also be placed within the Glacial A phase of the Cromerian, or around 0.7 m. years in absolute age.

As stated before, it seldom occurs to have all palaeosoils and intercalated loess layers in a vertical section. Some horizons may lack and from the erosion hiatuses it is often difficult to tell how much is missing either at the top or the base. The fact that deposits of this kind do occur in isolated groups, does not permit lateral, geometrical correlation. As a result, one will seldom be sure about the stratigraphical position of the palaeosoil he is dealing with, if only one or two are visible.

As a result this problem affects in the first place the lower boundary of the Upper Pleistocene which in continental Belgium is represented, as we know, by the Rocourt soil. However, we have strong doubts about this Rocourt soil, immediately below the Weichselian series, being of the same Eemian age in all places. It could be, as a result of erosional processes, that one of the older soils, or even loess, appears immediately beneath the Weichselian one.

If an approach to this problem can still be made in an outcrop, it becomes almost impossible in borings. This is the reason why we propose to group on a lithostratigraphic basis, at the formation level all loesses with one or more truncated textural-B-horizons under the Weichselian cover,under one and the same connotation. Where it is necessary, one can always introduce for local puroposes units at the level of member or even of bed

Parallel with the Herzeele formation of marine origin, the former connotation introduced by J. CORNET and reused by F. GULLENTOPS (1954), the Hennuyen, could then easily be extended at the formation rank, for all loess and loessoid deposits occurring below the Weichselian loess. It then should become HAINAUT FORMATION considering the general rules of the Hedberg code. The remaining problem is to know where its lower limit begins. In the case of the Bouge section where palaeosoil bearing loesses overly, fluviatile gravels from which they are separated by an important erosion boundary, the Hainaut Formation is easily to recognise in the overlying loess sequence. In sections of the Lys basin where apparently one single loess deposit, probably entirely of Saale stage age, occurs below the Weichselian loess and/or Rocourt soil, the homogeneous and continuous nature of the loess deposit, most often without any palaeosoils in it, defines the Hainaut formation as such the lower boundary being formed by tertiary deposits. More difficultly to establish is the lower boundary with loesses showing a gradual transitorial lower limit to a residual gravel. In such cases, we believe that the geomorphology of the area may solve the problem.

In the old legend deposits of the HAINAUT FORMATION are in our opinion, found in several places and indicated as : "q3m" and "q1o" in the 1st; "q3m, q3ms and q1m" in the following editions.

3.1.3. UPPER PLEISTOCENE

Much more diversity appears amongst authors of the Upper Pleistocene as was shown in several post-war studies (R. TAVERNIER, 1943, 1946, 1954, 1957, F. GULLENTOPS, 1954, J. DE HEINZELIN, 1957, R. PAEPE, 1964, 1967, 1972).

Regional distinction of climato-sedimentological provinces therefore is of still greater significance for the Upper Pleistocene than for all foregoing older deposits. Distribution of genetic-textural areas is known since long though interpretation about there origin and genesis may have varied greatly.

Therefore, application of the rules for a lithostratigraphic classification seems feasible, especially since the sedimentological provinces known to meet within the Belgian territory, belong to greater textural areas such as the coversand areas of Northern Europe and the loess belt of Central Europe. This rather exceptional situation has lead to the confrontation of two remote classification nomenclatures, the Alpine and the North-European ones.

As correlation between the two mentioned classification system at the level of the Upper-Pleistocene is more certain than for all older quaternary deposits, it will be possible to apply both systems in a regional context in Belgium.

At the level of the Group, the Sand (cover-sand) and Sand-loam (transitional sand-loess) regions belong to the so-called Group of North-Western Europe; the Loam region and the Ardennes to the Alpine group.

At the level of the Formation, the regional concept must be observed while emphasis should be laid hereby on the climatic and genetic aspects of the deposits. Names such as "Kreftenheye Formation" in The Netherlands are to be considered as the equivalent of the" "Riss Formation" if it were to exist in its type area. In this light, "Riss" and "Kreftenheye" are used to indicate deposits of the Riss-Glaciation. Formation names should neither be introduced nor abolished deliberately by individual workers since international and long distance correlations should be made at the Formation level.

Local aspects and varieties of the lithostratigraphic column may then find expression at the Member or even Bed level.

An attempt of lithostratigraphic classification was made by R. PAEPE in 1967, in correlating loess and coversand deposits of Belgium. We have no intention to do the whole discussion over again and we therefore refer to the work by R. PAEPE and R. VANHOORNE (1967). Later, this subdivision of the Upper Pleistocene was revised in an article by W.H. ZAGWIJN and R. PAEPE (1968) and correlated with the Dutch Coversand area. Still later, correlation with the Northern French loess belt was established (R. PAEPE and J. SOMME, 1970).

On basis of the afore mentioned consideration, we will make the following proposals as a project of new mapping legend for the Upper Pleistocene.

In the coversand and sandloess area, which genetically also comprises the coastal plain, the whole of the periglacial Last Glacial deposits form a continuous mantle which may be correlated with the loess mantle in Hesbaye. Though highly heterogeneous as to composition, the unity at the level of formation is felt by the steady constancy of the lithostratigraphic sequence. As for the "Kreftenheye Formation" it thus forms a continuous unit and therefore we propose to name it GENT FORMATION consisting of all Weichselian coversand deposits.

In juxtaposition, the GEMBLOUX FORMATION which is to connotate the loam mantle in the Loess Belt, should be introduced on a regional basis. The Gent Formation consists of mainly the upper part of the "Sables des Flandres avec zones limoneuses, q4" of the map, in its 1 st edition and also the "q4l" and "q4sl" of later editions except for the marine facies. The Gembloux Formation then comprises all of the "q3n" and "q3m", probably also "q3ms" of the "Hesbayen" of the Geological map.

At the level of member, former connotations "Brabantien" and "Hesbayen" could be used, in the following form : Brabant loess member and Hesbaye loess member which are known to be separated by the Kesselt soil (F. GULLENTOPS, 1954). The Brabantian member would stand for homogeneous yellow loam indicated with "q3n" and the Hesbayen member for all "q3m" deposits, partly also "q3ms". Equally in the coversand region a subdivision of the Gent Formation into an upper Ertvelde coversand member and a lower Lembeke peaty loam member is feasible. The latter member is topped by the Zelzate soil dated at 28.200y. B.P. (R. PAEPE and R. VANHOORNE, 1967) and supposed to be the equivalent of the Kesselt soil. The Ertvelde coversand member is essentially the original "q4"the Lembeke peaty loam member the "q4l" and "q4sl". In the Ertvelde coversands, no further distinction is made, especially with regard to the Late Glacial. We rapidly recall the presence of at least three palaeosoils in the Late Glacial : ROKSEM soil (11.740 + 130y. B.P.GR-129-67); STABROEK soil (12.300 + 100 y. B.P.-GR-N-4782) and ZULTE soil (17.000+ 100y. B.P.-GR-N-6462). In the Campine area, however, all Late-Glacial deposits were grouped in the Formation of Beerse by J. DE PLOEY (1961). The Pleniglacial part of the Ertvelde Coversand member therefore was also connotated with a specific name in the Campine : Wildert formation encompassing also the Kesselt soil. The St. Lenaarts formation should be the equivalent in the Campine area of the Lembeke peaty loam member, though in the Campine its lower boundary is not clearly defined.

In some cases another series of peaty or humic, sometimes cryoturbated, sandy and loamy layers, form the base of the Last Glacial Early Weichselian sequence. To the vegetational horizon which in all sedimentological areas may split up in two or more humic horizons, the name of WARNETON soil complex was given by R. PAEPE (1964, 1967). Though known with certainty since J. LADRIERE and described by many authors its place in the stratigraphical legend was never before clearly located, probably as a result of its irregular geometry of which it often testifies. We believe it has been confused with deposits of "q4sl", "q3o", "q3m", and "q3ms" of the stratigraphic legend.

Weichselian deposits usually rest on deposits of the Last Interglacial (Eemian) or directly on the Tertiary substratum, seldom on periglacial deposits of a foregoing Glacial phase.

Marine deposits of the Last Interglacial, as we have seen above were named Oostende sands since long. In the light of the recent investigations by R. TAVERNIER, (1946, 1954, 1957), W. DE BREUCK, G. DEMOOR, R. MARECHAL (1969,1973), R. PAEPE (1965), R. PAEPE and R. VANHOORNE, (1972), the presence of these deposits are ascertained and the connotation OOSTENDE FORMATION justified. It partly encompasses the former "facies marin" or "q4l" of the 2nd legend and "q4m" of the 3rd and 4th editions. They extend all over the coastal plain and also occur under the coversands (Gent Formation) in the Sand Area, especially in the Flemish Valley. Here, and towards the East, it gradually goes over into fluviatile gravel and coarse sand deposits which occupy the bottom of all deep valleys in Lower and Middle Belgium. After a recent study by R. PAEPE and R. VANHOORNE (1970) we would like to designate latter deposits with the name of ZEMST GRAVEL FORMATION. Remnants of this formation are found in the "q4l", "q4n" and "q3o" of the stratigraphic legend. Whereas in the fluviatile deposits,peat bogs are amongst the best datable material, it is by and large the faunistical content of the Oostende Formation, especially the presence of *Corbicula fluminalis* and *Tapes senescenes var. eemiensis* (R. PAEPE, 1965), which allowed determination of its age.

The top and base of the Oostende Formation may be occupied by soil horizons of the Podzol and the Gray Brown Podzolic type. Underneath the wadden deposits of this formation, we found at Brugge, however, a well developed podzol too which R. VANHOORNE (1972) has proved to be of Eemian age and which was named BRUGGE soil. It formed in the topzone of an underlying series of eolian sands (R. PAEPE, R. VANHOORNE and D. DERAYMAEKER 1972). These sands occur in the same position of the Hainaut loess Formation elsewhere, and are to be considered as a member of it : the St. Pieters sand member.

Another fossil development was found to exist on top of sediments of Eemian stage age at Eeklo. In a boring nearby this locality, a series of peaty layers of about 8 m in thickness, are resting on gravels containing *Corbicula fluminalis* and *Amygdala senescens var. eemiensis* of Eemian stage age. The sandy top of the peaty layers bears a fossil podzol which should be according to R. VANHOORNE (unpublished) of Late Eemian stage age too. We will connotate this soil as EEKLO soil hereafter. Hence it is concluded that the Eemian marine transgression phase is comprised in between two phases of soil weathering. The podzolic nature of the pedogenesis is bound to the sandy texture of the parent material. In loam textured deposits overlying Eemian estuarine gravels, and crags, at Zelzate we found the truncated textural-B-horizon of a gray podzolic soil (R. PAEPE, 1967). It was occupying a similar position as the Eeklo soil, however of the same soil type as the Rocourt soil. Therefore we believe that both soils are of contemporaneous age, and concretisize the end of the Eemian interglacial.

A specific problem arises in the sandloess or transitional area especially at the level of the Weichselian deposits where intermixing of textural facies is observed. Within the coverdeposit series of Upper-pleniglacial Weichselian age (which means younger than the Zelzate soil stage age) one may observe a pure eolian sand facies above and pure loess facies below the so-called Beuningen gravel bed level, (called by R. PAEPE in the Belgium area, "Desert pavement 3 with large frost wedges"). This marker horizon is to represent as we know the coldest peak of the Weichselian.

It becomes quite clear that in the sandloess area, the sediment province changed from loess before to eolian sand after the highest cold; with other words, the loess belt extended more to the North-West before the maximum cold, while the coversand belt gradually conquered the transitional area hereafter (J. SOMME and R. PAEPE 1970).

This genetic and dynamic aspect of the loess coversand transition is worth to be represented on the map. We therefore propose to indicate this specific double textured (Upper-pleniglacial) deposit with a special connotation at the member level : Zonnebeke member being a lateral facies member of the Brabantien in the loess belt and the Ertvelde coversand in the coversand belt.

Deposits of Eemian stage age, usually are represented in the Sand loess area either by the Rocourt soil as in the loess belt or as peat bogs with little if any gravel at the base. Last mentioned can hardly be identified with the Zemst gravel Formation as a whole of which true, it is a member and therefore is named here the Rumbeke member. At this locality, a double peat bog was found the pollen content of which pointed undubiously to an Eemian stage age (R. PAEPE and R. VANHOORNE, 1967).

The older loess below deposits of Eemian stage age in the Sand-loess area recall the loess facies of the Hainaut formation and therefore are not likely to be connotated by a specific name at the level of member.

We should briefly remind also the stratigraphical studies aiming at the establishment of partial stratigraphic legends of specific local areas.

W. DEBREUCK, G. DEMOOR and R. MARECHAL (1969) published such stratigraphic sequence for the eastern Coastal Plain of Belgium using the informal connotation "Afzetting = Bed". Above the Oostende Beds, five others were encountered successively: Beds of Uitkerke, Wenduine, Meetkerke, Houtave, Zuienkerke. The latter is covered by the so-called Peat of Nieuwmunster (Holland Peat) and Dunkerque beds. Because of the very local, informal and temporary character of such classification at the level of a "Bed",its terminology is not considered for the time being. We believe that most of the deposits are member variations of the Formation of Gent, Oostende and Calais combined.

Another local study is the one established by E.PAULISSEN (1972) for the Maas terraces downstream Liège.Besides a series of geomorphological terrace connotations, two definite lithostratigraphic units at the rank of formation were introduced : the Formation of Dilsen of Riss stage age and the Formation of Kessenich of Würm stage age. The use of Alpine connotations still leaves many doubts about the relative age of these deposits. The Dilsen Formation could encompass part of the Hainaut Formation, the Kessenich the whole of the Gembloux Formation.

In the Ardennes some Last Glacial deposits have been recorded by the Soil Survey and by individual geologists as well. In many isolated places of the Condroz and the High Ardennes, in both plateau and valley position, a rapid alternation of pure loess facies and intercalated run off layers are mentioned. These deposits are locally indicated by the name of "grèzes litées". In places fossil soil and frost wedge horizons may occur and then reflect the lithostratigraphical sequence of the Last Glacial found elsewhere (R. PAEPE, 1969). We propose to indicate this variant with a special name at the formation level: CONDROZ FORMATION. In the legend these deposits were indicated as "q1o-Limon non ossifère des hauts plateaux de la Sambre et de la Meuse" which connotation was changed into "q1n" in later editions. Part of the Condroz formation certainly occurs within deposits indicated as "q3n" too.

3.2. THE HOLOCENE SERIES

As stated before, the Legend of the Geological Map never considered holocene deposits at the rank of formal lithostratigraphic units. An entire new lithostratigraphy must therefore be worked out. It should be recalled, however, that J. DE PLOEY (1961) again, already introduced connotations such as Meer Formation and Kalmthout Formation to indicate dune sands in the Campine area.

As the aim of the present work was essentially a critical analysis of existing lithostratigraphical connotations of pleistocene deposits, we will not establish a project of classification of the holocene deposits at present.

ACKNOWLEDGEMENTS

The authors feel very much indebted to the members of the Centre for Quaternary Stratigraphy with whom this project has been thoroughly discussed, enabling important corrections such as "Hennuyen" by "Hainaut formation".

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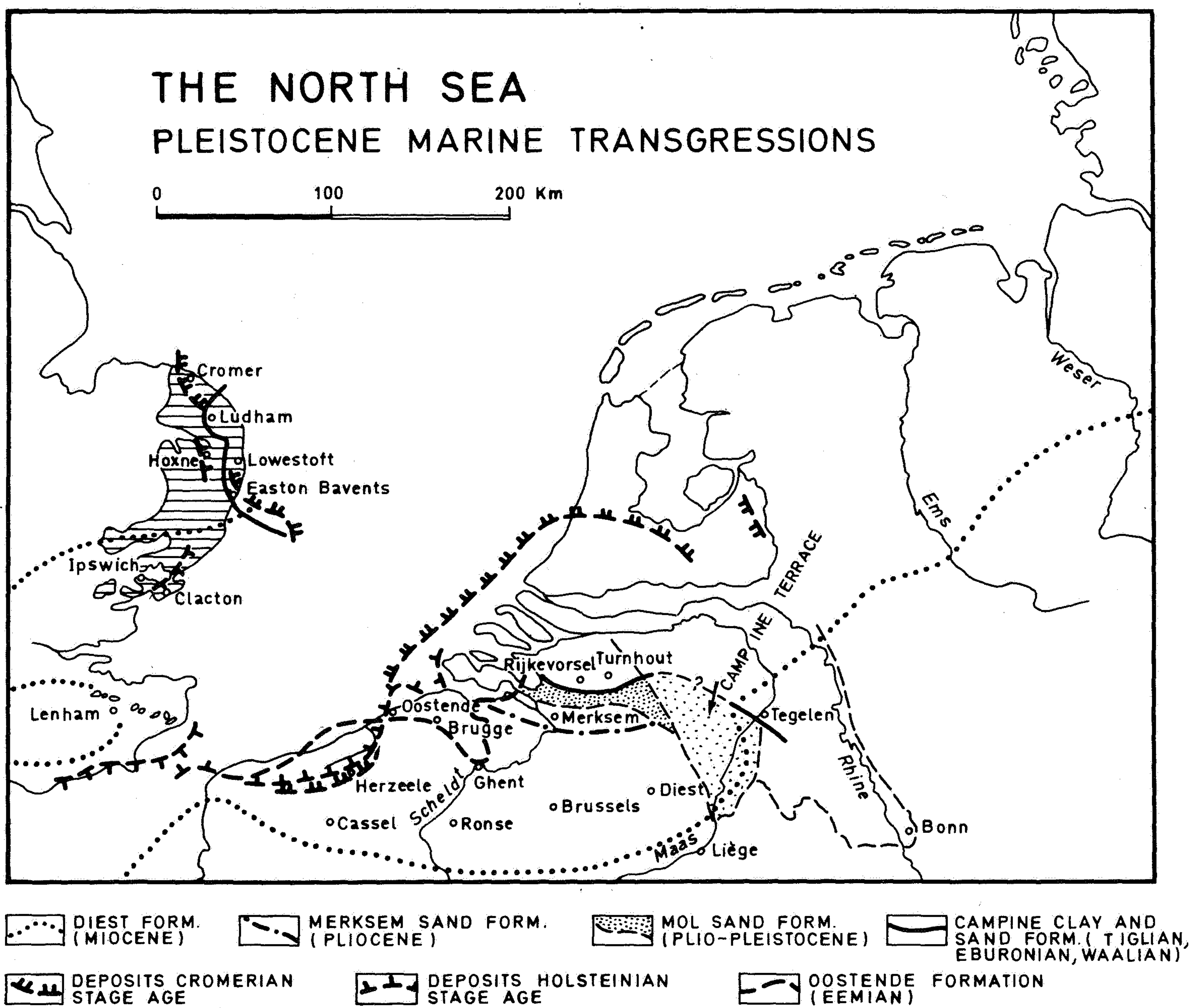
THE NORTH SEA
PLEISTOCENE MARINE TRANSGRESSIONS
0
100
200 Km
Cromer
Ludham
Hoxne
Lowestoft
Easton Bavents
Ipswich
Clacton
Lenham
Oostende
Brugge
Herzeele
Ghent
Cassel
Scheldt
Ronse
Brussels
Diest
Liège
Maas
Rijkevorsel
Turnhout
Merksem
Tegelen
CAMPINE TERRACE
Rhine
Bonn
Ems
Weser
DIEST FORM. (MIOCENE)
MERKSEM SAND FORM. (PLIOCENE)
MOL SAND FORM. (PLIO-PLEISTOCENE)
CAMPINE CLAY AND SAND FORM. (TIGLIAN, EBURONIAN, WAALIAN)
DEPOSITS CROMERIAN STAGE AGE
DEPOSITS HOLSTEINIAN STAGE AGE
OOSTENDE FORMATION (EEMIAN)

Fig. 2

CHRONO-STRATIGRAPHY
LITHO - STRATIGRAPHY - MAPPING UNITS
SOIL - STRATIGRAPHY
PALEO-MAGNET.
GEOMORPHOLOGY
Series
Stage
Marine - Estuarine
Eolian and Periglacial Deposits
Large Rivers
HOLOCENE
FLANDRIAN
DUNKERQUE
CALAIS
HOLLAND PEAT
PLEISTOCENE
Upper
Middle
Lower
PLIOCENE
Weichselian
UPPER
MIDDLE
UNDER & (EARLY)
EEMIAN
Saalian
HOLSTEINIAN
Elsterian
CROMERIAN
III
GLACIAL B
II
GLACIAL A
I
Menapian
WAALIAN
Eburonian
TIGLIAN
Pre-Tiglian
REUVERIAN
OOSTENDE FORMATION (C.P. C.S. S.L.)
IZENBERGE CRAG MEMBER (S.L.)
HERZEELE FORMATION (S.L.)
TURNHOUT CLAY MEMBER
CAMPINE FORMATION (C.S.)
RIJKEVORSEL CLAY MEMBER
MEERLE CLAY & SAND MEMBER
MERKSEM FORMATION
ERTVELDE MEMBER
GENT
ZONNEBEKE MEMBER
LEMBEKE- -MEMBER
(C.S.) FORMATION (S.L.)
GEMBLOUX FORMATION (L)
BRABANT MEMBER
HESBAYE MEMB.
CONDROS MEMB. A&C
RUMBEKE PEAT MEMBER (C.S. S.L.)
SINT PIETERS MEM.
HENNUYEN FORMATION (L.A.C.)
MELLE PEAT MEMBER (C.S.)
LO PEAT MEMBER (S.L.)
BEERSE (C.S.) SAND MEMBER
ARENDONK (C.S.) LIGNITE MEMBER
ZEMST GRAVEL FORMATION (C.S. S.L. L. A. C.)
SCHELDE GRAVEL FORMATION (C.S. S.L. L.)
MAAS GRAVEL FORMATION (A. C. L.)
ARDENNES GRAVEL FORMATION (A. C)
MOL MERKSPLAS SANDS & GRAVEL FORMAT. (C.S.)
UPPER KIESELOOLITE MEMBER
LOWER KIESEL OOLITE MEMBER
LIEGE FORMATION (A, C, L.)
BOUGE MEMBER
CHAMPION MEMBER
STABROEK SOIL (C.S.)
ROKSEM SOIL (C.S.)
ZULTE SOIL (C.S.)
ZELZATE SOIL - KESSELT SOIL
HOBOKEN SOIL
POPERINGE SOIL
(C.S. S.L.)
WARNETON SOIL COMPLEX (C.S. S.L. L. A.)
ANTWERP SOIL (C.S.)
EEKLO SOIL - ROCOURT (C.S.) SOIL
BRUGGE SOIL (C.S.)
DAUSSOULX SOIL (L)
TUBIZE SOIL (L)
HAN-SUR-LESSE SOIL COMPLEX (C)
FOCANT SOIL (C)
Brunhes
Matuyama
+
−
0.70
0.87
JARAMILLO
0.92
1.60
GILSA
1.70
DOVER STRAIT REGULARISATION
FLEMISH VALLEY N.W. SYSTEM
MAAS TERRACE SYSTEM
DOVER STRAIT OPENING ONSET N.W. DRAINAGE SYSTEM
SCHELDT TERRACES
CAMPINE HIGH TERRACE
LESSE TERRACES
NEW N.E. HYDROGRAPHIC SYSTEM (COURSES RECONSTRUCTABLE)
PEDIPLANATION & POLAR DESERT
LAVEAUX SAINTE ANNE TERRACE
INCISION
KIESELOOLITE TERRACE-LEVEL
INCISION
KIESELOOLITE PLATEAU-LEVEL
OLD N.E. HYDROGRAPHIC SYSTEM (RELICTS ONLY)

LEGENDS OF THE GEOLOGICAL MAP OF BELGIUM

1892	1896	1900	1909	1929
LEGENDE DE LA CARTE GEOLOGIQUE DE LA BELGIQUE DRESSEE PAR ORDRE DU GOUVERNEMENT à l'échelle du 40.000e.	LEGENDE DE LA CARTE GEOLOGIQUE DE LA BELGIQUE DRESSEE PAR ORDRE DU GOUVERNEMENT à l'échelle du 40.000e.	LEGENDE DE LA CARTE GEOLOGIQUE DE LA BELGIQUE DRESSEE PAR ORDRE DU GOUVERNEMENT à l'échelle du 40.000e.	LEGENDE DE LA CARTE GEOLOGIQUE DE LA BELGIQUE DRESSEE PAR ORDRE DU GOUVERNEMENT à l'échelle du 40.000e.	LEGENDE GENERALE DE LA CARTE GEOLOGIQUE DETAILLEE DE LA BELGIQUE
GROUPE QUATERNAIRE SYSTEME QUATERNAIRE	GROUPE QUATERNAIRE SYSTEME QUATERNAIRE	GROUPE QUATERNAIRE SYSTEME QUATERNAIRE	GROUPE QUATERNAIRE SYSTEME QUATERNAIRE	MODERNE SYSTEME HOLOCENE *(Ho)* Plaine maritime. *Ho. Sables éoliens (dunes)*(**V**), argile des polders *(alp)*, sables marins *(alq)* et tourbe *(t)*. Intérieur du pays *Ho.* Sables éoliens (**V**), dépôts des pentes *(ale)*, travertins *(tf)*, limon de crue *(alm)*, alluvions, parfois tourbeuses, du fond des vallées *(alt)*, tourbe *(t)* et limonite *(af)*.
QUATERNAIRE SUPERIEUR OU MODERNE Argile des Polders *(alp)*	QUATERNAIRE SUPERIEUR OU MODERNE *Dépôts de la plaine maritime.* *sp.* Sable de la plage et galets. *ale.* Sable entraîné par la pluie et les vents, ou remanié artificiellement. . Dunes du littoral. *alp2.* Argile supérieure des polders. *alq.* Sable meuble à *Cardium*, avec linéoles argileuses vers le haut, parfois lit tourbeux et graveleux à la base. *alp1.* Argile inférieure des polders. *alr2.* Sable argileux gris foncé ; alternances minces de sable et d'argile grise sableuse, avec lit de *Scorbicularia plana* vers le sommet ; parfois argile foncée ou verdâtre à la base. *t.* Tourbe. *alr 1.* Sable gris bleuâtre à grains moyens.	QUATERNAIRE SUPERIEUR OU MODERNE *Dépôts de la plaine maritime.* *sp.* Sable de la plage et galets. *ale.* Sable entraîné par la pluie et les vents, ou remanié artificiellement. ~. Dunes du littoral. *alp2.* Argile supérieure des polders. *alq.* Sable meuble à *Cardium*, avec linéoles argileuses vers le haut, parfois lit tourbeux et graveleux à la base. *alp1.* Argile inférieure des polders. *alr2.* Sable argileux gris foncé ; alternances minces de sable et d'argile grise sableuse, avec lit de *Scrobicularia plana* vers le sommet ; parfois argile foncée ou verdâtre à la base. *alr2s.* Sable blanc ou jaunâtre stratifié, avec nombreuses coquilles marines, notamment *Pholas candida.* *alr2t.* Sable gris argileux avec taches de tourbe et débris de végétaux. *t.* Tourbe. *alr1.* Sable gris bleuâtre à grains moyens.	QUATERNAIRE SUPERIEUR OU MODERNE *Dépôts de la plaine maritime.* *sp.* Sable de la plage et galets. *ale.* Sable entraîné par la pluie et les vents, ou remanié artificiellement. ~. Dunes du litteral. *alp2.* Argile supérieure des polders. *alq.* Sable meuble à *Cardium*, avec linéoles argileuses vers le haut, parfois lit tourbeux et graveleux à la base. *alp1.* Argile inférieure des polders. *alr2.* Sable argileux gris foncé ; alternances minces de sable et d'argile grise sableuse, avec lit de *Scorbicularia plana* vers le sommet ;parfois argile foncée ou verdâtre à la base. *alr2s.* Sable blanc ou jaunâtre stratifié, avec nombreuses coquilles marines, notamment *Pholas candida.* *alr2t.* Sable gris argileux avec taches de tourbe et débris de végétaux. *t.* Tourbe. *alr1.* Sable gris bleuâtre à grains moyens.	
Dépôts limoneux des pentes *(ale)* Eboulis des pentes *(e)* Tufs *(tf)* Dunes et sables éoliens *(~)* Alluvions modernes des vallées *(alm)* Alluvions ferrugineuses *(alfe)* Alluvions tourbeuses *(alt)* Tourbe *(t)*	*Dépôts continentaux.* *ale.* Dépôts limoneux des pentes. *e.* Eboulis des pentes. *tf.* Tufs. ~. Dunes continentales et sables éoliens. *alm.* Alluvions modernes des vallées. *alfe.* Alluvions ferrugineuses. *alt.* Alluvions tourbeuses. *t.* Tourbe.	*Dépôts continentaux.* *ale.* Dépôts limoneux des pentes. *e.* Eboulis des pentes et formations détritiques. *tf.* Tufs. ~. Dunes continentales et sables éoliens. *alm.* Alluvions modernes des vallées. *alfe.* Alluvions ferrugineuses. *alt.* Alluvions tourbeuses. *t.* Tourbe.	*Dépôts continentaux.* *ale.* Dépôts limoneux des pentes. *e.* Eboulis des pentes et formations détritiques. *tf.* Tufs. ~. Dunes continentales et sables éoliens. *alm.* Alluvions modernes des vallées. *alfe.* Alluvions ferrugineuses. *alt.* Alluvions tourbeuses. *t.* Tourbe.	
QUATERNAIRE INFERIEURE OU DILUVIEN FLANDRIEN *(q4)* *q4* Sables avec zones limoneuses des Flandres. – Sable supérieur ou remanié de la Campine.	QUATERNAIRE INFERIEUR OU DILUVIEN FLANDRIEN *(q4)* *q4.* Sables avec zones limoneuses des Flandres. – Sable supérieur ou remanié de la Campine. *q4l.* Sable limoneux passant au limon sableux (*Leem* des ouvriers). – Limon finement sableux, peu développé, de la région du Démer. – Limon gris, avec coquilles fluviatiles, en lentilles dans le sable. (Facies marin). Sable meuble à grains assez gros, de couleur jaune ou grise, avec alternances limoneuses. – *Corbicula fluminalis, Cardium edule,* etc. – Argile coquillière et graviers à la base. *q4sl.* Sable quartzeux stratifié, très meuble, avec alternances limoneuses. *t.* Tourbe.	QUATERNAIRE INFERIEUR, OU DILUVIEN FLANDRIEN *(q4)* *q4.* Sables avec zones limoneuses des Flandres. – Sable supérieur ou remanié de la Campine. *q4l.* Sable limoneux, passant au limon sableux (*Leem* des ouvriers). – Limon finement sableux, peu développé, de la région du Démer. – Limon gris, avec coquilles fluviatiles, en lentilles dans le sable. – *Ergeron* du Hainaut. *q4m.* (Facies marin). Sable meuble à grains assez gros, de couleur jaune ou grise, avec alternances limoneuses. – Argile coquillière et graviers à la base. *q4sl.* Sable quartzeux, stratifié, très meuble, avec alternances limoneuses. *t.* Tourbe.	QUATERNAIRE INFERIEUR, OU DILUVIEN FLANDRIEN *(q4)* *q4.* Sables avec zones limoneuses des Flandres. – Sable supérieur ou remanié de la Campine. *q4l.* Sable limoneux, passant au limon sableux (*Leem* des ouvriers). – Limon finement sableux, peu développé, de la région du Démer. – Limon gris, avec coquilles fluviatiles, en lentilles dans le sable. – *Ergeron* du Hainaut. *q4m.* (Facies marin). Sable meuble à grains assez gros, de couleur jaune ou grise, avec alternances limoneuses. – Argile coquillière et graviers à la base. *q4sl.* Sable quartzeux, stratifié, très meuble, avec alternances limoneuses. *t.* Tourbe.	QUATERNAIRE SYSTEME PLEISTOCENE *(Q)* PLEISTOCENE SUPERIEUR *(Q2)* Plaine maritime. *Q2.* Sables à faune marine et limons. Intérieur du pays *Q2.* Limons divers et sables fluviatiles. A la base, gravier et cailloutis. Faune froide : *Elephas primigenius, Rangifer tarandus*
HESBAYEN *(q3)* MOSEEN *(q1)* *q3o* Cailloux, gravier, sable et tourbe du fond des vallées principales, *q2n* Limon non stratifié, friable, homogène, jaune chamois avec éclats de silex, cailloux et gravier sporadiques à la base. *q3m* Cailloux, sable et limon grisâtre stratifié des flancs inférieurs et moyens des vallées principales et des plaines moyennes. – Limon gris à Succinées des Flandres.	HESBAYEN *(q3)* MOSEEN *(q1)* *q3o.* Cailloux, gravier, sable et tourbe du fond des vallées principales. *q3n.* Limon non stratifié, friable, homogène, jaune-chamois, avec éclats de silex, cailloux et gravier sporadiques à la base. *q3m* Limon grisâtre et brunâtre stratifié des flancs inférieur et moyen des vallées principales et des plaines moyennes. – Limon gris à *Helix hispida* et à *Succinea oblonga.* Parfois tourbe *(t)* au sommet. *q3ms.* Sable quartzeux stratifié, devenant parfois limoneux et passant au limon sableux.	HESBAYEN *(q3)* MOSEEN *(q1)* *q3o.* Cailloux, gravier, sable et tourbe du fond des vallées principales. *q3n.* Limon non stratifié, friable, homogène, jaune-chamois, avec éclats de silex, cailloux et gravier sporadiques à la base. *q3m.* Limon grisâtre et brunâtre, stratifié, des flancs inférieurs et moyens des vallées principales et des plaines moyennes. – Limon gris à *Hélix hispida* et à *Succinea oblonga.* Parfois tourbe *(t)* au sommet. *q3ms.* Sable quartzeux, stratifié, devenant parfois limoneux et passant au limon sableux.	HESBAYEN *(q3)* MOSEEN *(q1)* *q3o.* Cailloux, gravier, sable et tourbe du fond des vallées principales. *q3n.* Limon non stratifié, friable, homogène, jaune-chamois, avec éclats de silex, cailloux et gravier sporadiques à la base. *q3m.* Limon grisâtre et brunâtre, stratifié, des flancs inférieurs et moyens des vallées principales et des plaines moyennes. – Limon gris à *Helix hispida* et à *Succinea oblonga.* Parfois tourbe *(t)* au sommet. *q3ms.* Sable quartzeux, stratifié, devenant parfois lumineux et passant au limon sableux.	
CAMPINIEN *(q2)* *q2o* Gravier, sable quartzeux et argile de la Campine. – Eléments divers remaniés, d'origine voisine. *q2n* Cailloux ardennais du plateau oriental du Limbourg. *q2m* Cailloux ardennais et cailloux de silex des flancs supérieurs des grandes vallées.	CAMPINIEN *(q2)* *Cervus tarandus, Elephas primigenius, Rhinoceros tichorinus. Silex taillés et autres vestiges de l'industrie humaine.* *q2o* Eléments divers remaniés d'origine voisine. *q2o a.* Argile pailletée grise et noire, dite de la Campine, devenant sableuse *(q2o as)* et passant au sable. *q2o s.* Sable quartzeux, légèrement pailleté, devenant parfois argileux *(q2o sa).* *q2n.* Cailloux ardennais du plateau oriental du Limbourg. *q2m.* Cailloux ardennais et cailloux de silex des flancs supérieurs des grandes vallées. *t.* Tourbe et sable tourbeux.	CAMPINIEN *(q2)* *Elephas primigenius, Rhinoceros tichorhinus. Silex taillés et autres vestiges de l'industrie humaine.* *q2o.* Elements divers, remaniés, d'origine voisine. *q2s.* Sable quartzeux, blanchâtre, jaunâtre et grisâtre, généralement graveleux, avec quelques cailloux, devenant argileux *(q2sa)* et passant à l'argile *(q2a).* *q2n.* Sable grossier, gravier et cailloux de silex et de roches primaires. *q2m.* Cailloux ardennais et cailloux de silex, des flancs supérieurs des grandes vallées. *q2fe.* Minerai de fer d'alluvion (Mammouth). *t.* Tourbe et sable tourbeux.	CAMPINIEN *(q2)* *Elephas primigenius, Rhinoceros tichorhinus. Silex tailles et autres vestiges de l'industrie humaine.* *q2o* Eléments divers, remaniés, d'origine voisine. *q2s.* Sable quartzeux, blanchâtre, jaunâtre et grisâtre, généralement graveleux, avec quelques cailloux, devenant argileux *(q2sa)* et passant à l'argile *(q2a).* *q2n.* Sable grossier, gravier et cailloux de silex et de roches primaires. *q2m.* Cailloux ardennais et cailloux de silex, des flancs supérieurs des grandes vallées. *q2fe.* Minerai de fer d'alluvion (Mammouth). *t.* Tourbe et sable tourbeux.	
MOSEEN *(q1)* *q1o* Limon non ossifère des hauts plateaux de la Sambre et de la Meuse. *q1n* Dépôt à éléments marins de la région du sud d'Anvers. *q1m* Cailloux ardennais et cailloux de silex des hauts plateaux.	MOSEEN *(q1)* *q1n.* Limon non ossifère des hauts plateaux de la Sambre et de la Meuse. *q1m.* Cailloux ardennais et cailloux de silex des hauts plateaux.	MOSEEN *(q1)* *q1a.* Argile pailletée, grise et noire, devenant sableuse *(q1as)* et passant au sable, avec lits tourbeux intercalés. – Bois de Cervidés et restes de Bison. *q1s.* Sable blanc, quartzeux, légèrement pailleté (sable de Moll), devenant parfois argileux *(q1sa). Cardium edule, Mya arenaria. Cerithium, Corbula.* *q1n.* Limon non ossifère des hauts plateaux de la Sambre et de la Meuse. *q1m.* Cailloux ardennais et cailloux de silex des niveaux supérieurs.	MOSEEN *(q1)* *Elephas antiquus, var. Trogontheri. Silex utilisés éolithiques.* *q1a.* Argile pailletée, grise et noire, devenant sableuse *(q1as)* et passant au sable, avec lits tourbeux intercalés. – Bois de Cervidés et restes de Bison (1) *q1s.* Sable blanc, quartzeux, légèrement pailleté (sable de Moll), devenant parfois argileux *(q1sa). Cardium edule, Mya arenaria. Cerithium, Corbula* (1). *q1n.* Limon non ossifère des hauts plateaux de la Sambre et de la Meuse. *q1m.* Cailloux ardennais et cailloux de silex des niveaux supérieurs. (1) On est généralement d'accord maintenant pour considérer le sable de Moll et les argiles de la Campine, comme appartenant au Pliocène mais sans pouvoir les assimiler avec certitude à l'Amstelien *(Am.)* ou au Poerderlien *(Po.)* M.M.	PLEISTOCENE INFERIEUR *(Q1)* *Q1.* Graviers, cailloux, sables et glaises fluviatiles, limons. Faune chaude : *Elephas Trogontheri, Rhinoceros Merckii, Corbicula fluminalis.*
+ Blocs erratiques.	Δ Cavernes à ossements. BLOCS ET CAILLOUX ERRATIQUES : × Roches cristallines d'origine étrangère. + Roches quartzeuses.	Δ Cavernes à ossements. BLOCS ET CAILLOUX ERRATIQUES : × Roches cristallines d'origine étrangère. + Roches quartzeuses.	Δ Cavernes à ossements. BLOCS ET CAILLOUX ERRATIQUES : × Roches cristallines d'origine étrangère. + Roches quartzeuses.	X. Stations préhistoriques.
GROUPE TERTIAIRE SYSTEME PLIOCENE	GROUPE TERTIAIRE SYSTEME PLIOCENE	GROUPE TERTIAIRE SYSTEME PLYOCENE	GROUPE TERTIAIRE SYSTEME PLIOCENE	TERTIAIRE (1) SYSTEME PLIOCENE
	PLIOCENE SUPERIEUR ETAGE POEDERLIEN *(Po).* *Po.* Sables à *Corbula gibba,* var. *rotundata (Corbula striata), Melampus (Conovulus) pyramidalis, Corbulomya complanata.*	PLIOCENE SUPERIEUR ETAGE POEDERLIEN *(Po)* *Po.* Sables à *Corbula gibba,* var. *rotundata (Corbula striata), Melampus (Conovulus) pyramidalis, Corbulomya complatana.*	PLIOCENE SUPERIEUR ETAGE POEDERLIEN *(Po)* *Po* Sables a *Corbula gibba,* var. *rotundata (Corbula striata), Melampus (Conovulus) pyramidalis, Corbulomya complatana.*	PLIOCENE SUPERIEUR ETAGE AMSTELIEN *(Am)* (2) *Am.* Sables gris, parfois ligniteux, avec lentilles de sable blanc (SABLE DE MOLL) et intercalations de sables graveleux, de cailloutis à petits cailloux de quartz blanc et d'oolithe silicifiée, d'argiles parfois plastiques et de couches de lignite. *Cervus Falconeri, Cervus Ertborni, Elephas antiquus.*
ETAGE SCALDISIEN *(Sc)*	PLIOCENE MOYEN ETAGE SCALDISIEN *(Sc)* *Sc.* Sables à *Fusus (Chrysodumus) contrarius.*	PLIOCENE MOYEN ETAGE SCALDISIEN *(Sc)* *Sc.* Sables à *Fusus (Chrysodomus) contrarius.*	PLIOCENE MOYEN ETAGE SCALDISIEN *(Sc)* *Sc.* Sables à *Fusus (Chrysodomus) contrarius.*	PLIOCENE MOYEN ETAGE SCALDISIEN *(Sc)*
ETAGE DIESTIEN *(D)*	PLIOCENE INFERIEUR ETAGE DIESTIEN *(D)* *D.* Sable gris glauconifère à *Isocardia çor.* – Sable blanc quartzeux dunal (Casterlé). –Sable fin micacé rosé avec lits d'argile poldérienne (Heyst-op-den-Berg). – Sables et grès graveleux et ferrugineux de Diest à *Terebratula perforata (T. grandis).* – Sable fin rosé, très micacé, dit sable chamois ; glaise et cailloux à la base.	PLIOCENE INFERIEUR ETAGE DISTIEN *(D)* *D.* Sable gris glauconifère à *Isocardia cor.* – Sable blanc quartzeux dunal (Casterlé). – Sable fin micacé rosé avec lits d'argile poldérienne (Heyst-op-den-Berg). – Sables et grès graveleux et ferrugineux de Diest à *Terebratula perforata (T. grandis)* –Sable fin rosé, très micacé, dit sable chamois ; glaise et cailloux à la base.	PLIOCENE INFERIEUR ETAGE DIESTIEN *(D)* *D.* Sable gris glauconifère à *Isocardia cor.* – Sable blanc quartzeux dunal (Casterlé). – Sable fin micacé rosé avec lits d'argile poldérienne (Heyst-op-den-Berg). – Sables et grès graveleux et ferrugineux de Diest à *Terebratula perforata (T. grandis).* –Sable fin rosé, très micacé, dit sable chamois ; glaise et cailloux à la base.	PLIOCENE INFERIEUR ETAGE DIESTIEN *(D)* *D.* Sable gis, très fin, glauconifère, avec lits graveleux, à grands Hétérocètes (Environs d'Anvers). *Isocardia cor, Terebratula perforata (T. grandis).* Sable glauconifère (1), généralement graveleux. A la base, gravier de silex renfermant des cailloux de cacholong. (Hageland et collines des Flandres). *Terebratula perforata (T. grandis).* (1) Voir page 52, la remarque relative aux faciès d'altération. (2) Le terme Amstélien est adopté ici pour désigner les formations comprises entre le Pléistocène et le Scaldisien, et qui peuvent être provisoirement rattachées à l'étage marin défini par HARMER en 1896. Le terme comprend les formations désignées dans les précédentes légendes sous la notation *Onx.*

Campine
Hageland
Hesbaye (Loess belt)
Condroz
Ardennes
N.
Grens
Beerse
E3 POEDERLEE
Scherpenheuvel
COVERSAND BELT
SAND-LOESS BELT
S. N.W.
CHAMPION
BOUGE
MAAS
DEMER
FOCANT
LAVAUX-ST-ANNE
LESSE
VIRTON
S.W.
Grens
SEMOIS
CAMPINE CLAY FORM.
(Tiglian-Waalian)
MOL SAND FORM.
(Plio-Pleistocene)
CAMPINE HIGH TERRACE
(Menapian-Elsterian)
MAAS GRAVEL FORMATION
LIEGE GRAVEL FORM.
(Plio-Pleistocene)
MAAS GRAVEL FORM.
(Menapian-Elsterian)
ARDENNES GRAVEL FORM.
(Pre-Tiglian-Waalian)
Scale:
0 15 30 Km
O.D.
Campine High Terrace
Podzol
Rocourt Soil
As Soil
Maas Gravel Formation
Gent F.
Turnhout M.
Beerse M.
Rijkevorsel Member
(Arendonk Member)
Mol Sands
Tertiary
LIEGE FORMATION
Champion member
Bouge member
All.
FOCANT PLAIN IN FAMENNE DEPRESSION
LAVAUX-STE-ANNE TERRACE
ARDENNES GRAVEL FORM.
FOCANT SOIL
Section inside valley
Condroz & Hennuyen Form.
Weichsel Loess
All.


N.N.W.
S.S.E. | N.W.
S.E. | W.N.W.
E.S.E.
Polder
Sand lœss belt
Lœss belt
Condroz
Ardennes
IZENBERGE
HERZEELE
PASSENDALE
POPERINGE
Kemmelberg
Kluisberg
"Diestian" Inselbergs
Pottelberg
Bois de la Houssière
TONGRINNE
HENNUYEN LŒSS FORMATION
GEMBLOUX LŒSS FORMATION (Weichselian)
Dender
Schelde
Leie
Senne
Sennette
HENNUYEN LŒSS FORMATION
LIEGE GRAVEL FORM. (Plio-Pleistocene)
Champion m.
Bouge m.
Hoyoux
Ourthe
Amblève
Yzer
TERTIARY LANDSCAPE BOUNDARY
GEMBLOUX + HENNUYEN FORM.
SCHELDT GRAVEL FORMATION (Menap. - Holstein.)
HERZEELE FORM. (Cromer. - Holstein.)
DUNKERQUE
CALAIS
O.D.
HERZEELE
POPERINGE
Zonnebeke member
Rocourt soil
HERZEELE
Izenberge cray member
FORMATION
Lo peat (?) member
Ieper clay (Eocene)
J. SOMMÉ & R. PAEPE, 1974
POPERINGE
Rocourt
Zonnebeke
member
Zelzate soil
Lembeke member
Poperinge soil
Warneton soil
GENT FORMATION
HENNUYEN
FORMATION
Ieper clay (Eocene)
R. PAEPE, 1966
TONGRINNE
BRABANT
MEMBER
Kessel soil
HESBAYE
MEMBER
Warneton soil complex
Rocourt soil
HENNUYEN
FORMATION
GEMBLOUX FORM.
R. PAEPE, 1971
BOUGE
GEMBLOUX
FORMATION
HENNUYEN
FORMATION
BOUGE MEMBER (LIEGE FORM.)
R. PAEPE, 1973