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

BY

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

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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.

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

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

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 (assises supérieure 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).

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.*

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

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.

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.

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 editionof 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 kieseloölitic 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.*

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

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

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:

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

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

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 palæosoils 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

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.

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.

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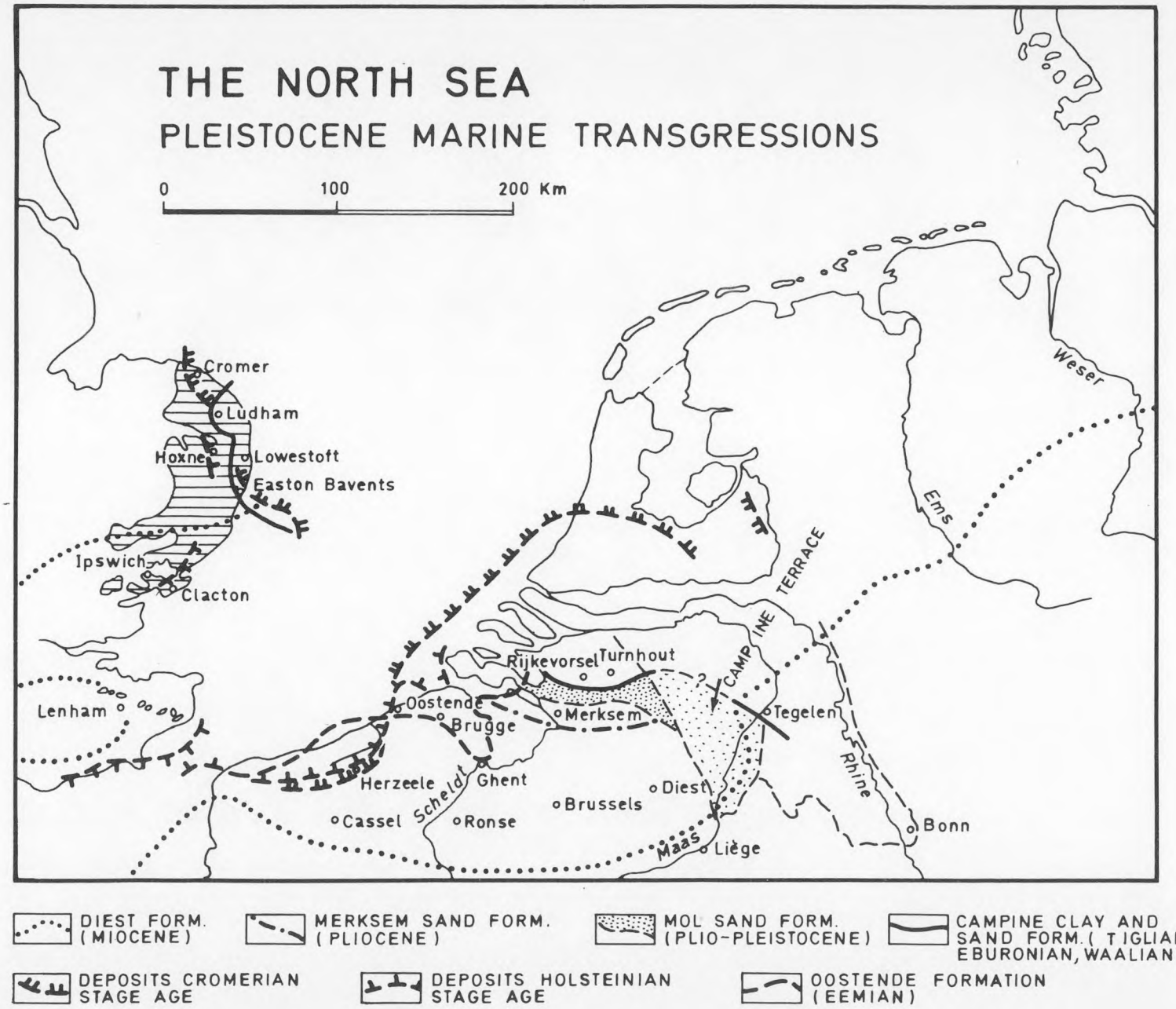
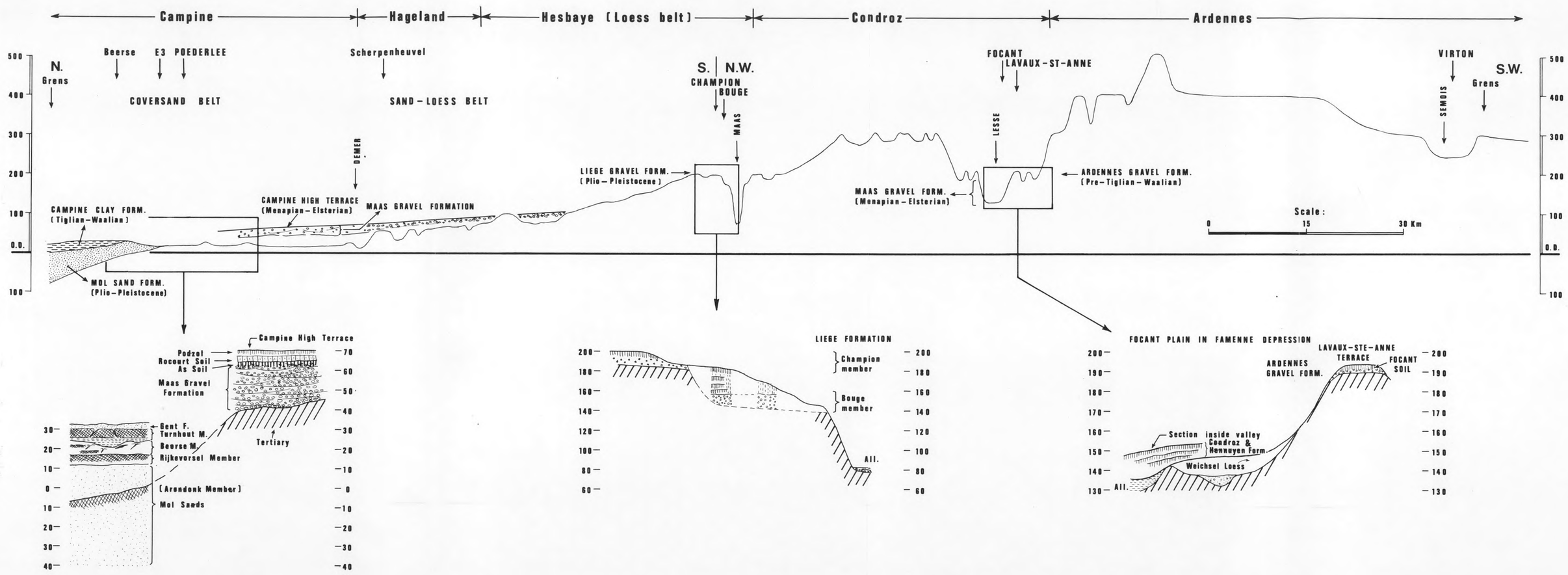
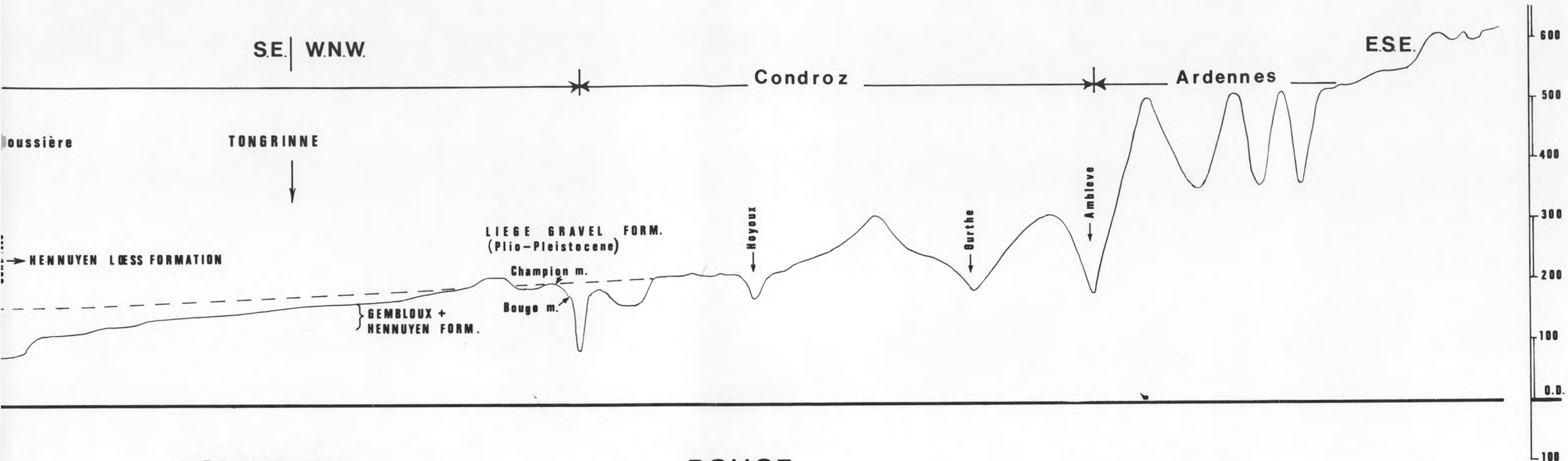
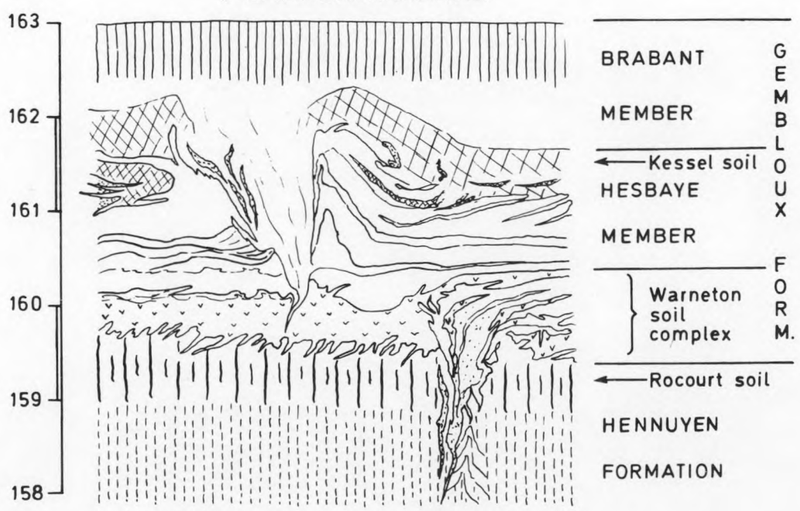

THE NORTH SEA
PLEISTOCENE MARINE TRANSGRESSIONS
0
100
200 Km
Cromer
Ludham
Hoxne
Lowestoft
Easton Bavents
Ipswich
Clacton
Lenham
Oostende
Brugge
Herzeele
Ghent
Cassel
Scheldt
Ronse
Brussels
Rijkevorsel
Turnhout
Merksem
Diest
Tegelen
Liège
Maas
Rhine
Bonn
Ems
Weser
CAMPINE TERRACE
DIEST FORM. (MIOCENE)
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)

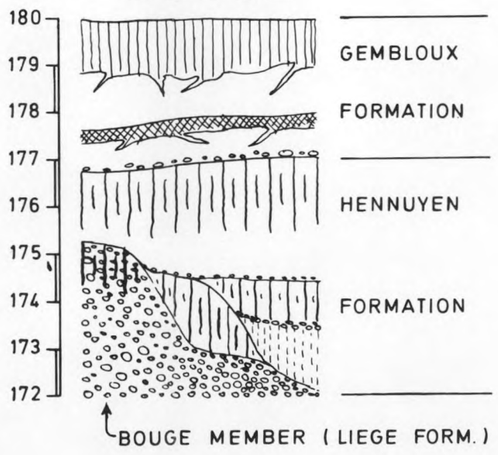
Fig. 2


Campine
Hageland
Hesbaye (Loess belt)
Condroz
Ardennes
N.
Grens
Beerse
E3
POEDERLEE
COVERSAND BELT
Scherpenheuvel
SAND-LOESS BELT
S.
N.W.
CHAMPION
BOUGE
MAAS
DEMER
LIEGE GRAVEL FORM.
(Plio-Pleistocene)
FOCANT
LAVAUX-ST-ANNE
LESSE
MAAS GRAVEL FORM.
(Menapian-Elsterian)
ARDENNES GRAVEL FORM.
(Pre-Tiglian-Waalian)
VIRTON
SEMOIS
S.W.
Grens
Scale :
0
15
30 Km
CAMPINE CLAY FORM.
(Tiglian-Waalian)
CAMPINE HIGH TERRACE
(Menapian-Elsterian)
MAAS GRAVEL FORMATION
MOL SAND FORM.
(Plio-Pleistocene)
500
400
300
200
100
O.D.
100
Campine High Terrace
Podzol
Rocourt Soil
As Soil
Maas Gravel Formation
Tertiary
Gent F.
Turnhout M.
Beerse M.
Rijkevorsel Member
(Arendonk Member)
Mol Sands
70
60
50
40
30
20
10
0
10
20
30
40
LIEGE FORMATION
Champion member
Bouge member
All.
200
180
160
140
120
100
80
60
FOCANT PLAIN IN FAMENNE DEPRESSION
LAVAUX-STE-ANNE TERRACE
FOCANT SOIL
ARDENNES GRAVEL FORM.
Section inside valley
Condroz & Hennuyen Form.
Weichsel Loess
All.
200
190
180
170
160
150
140
130

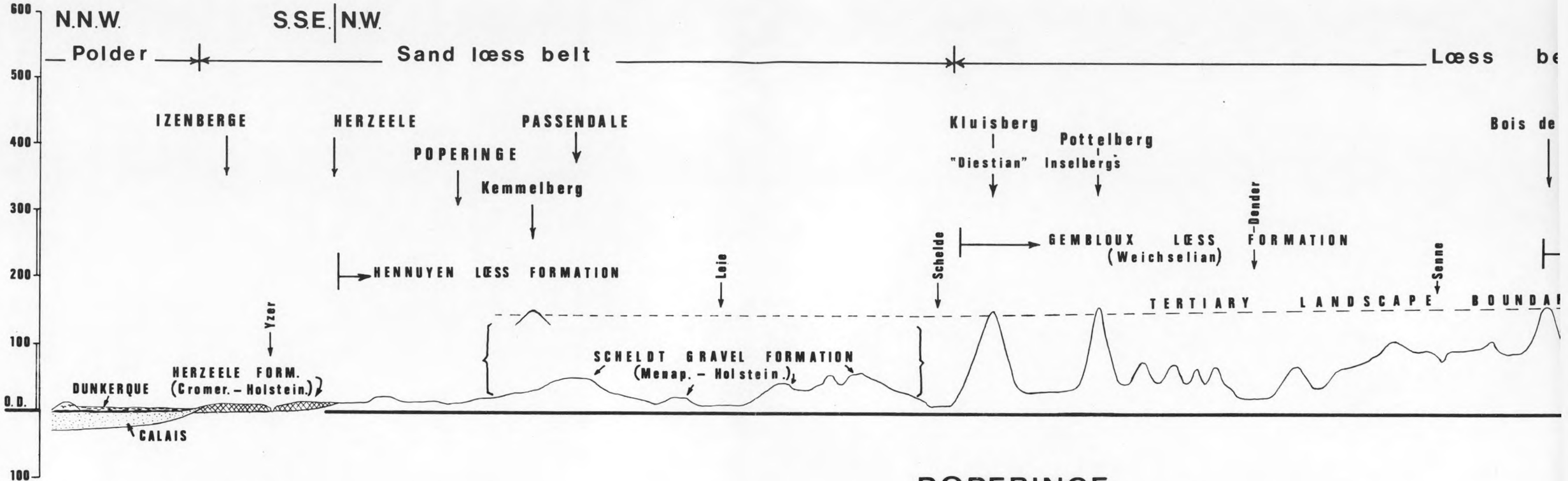




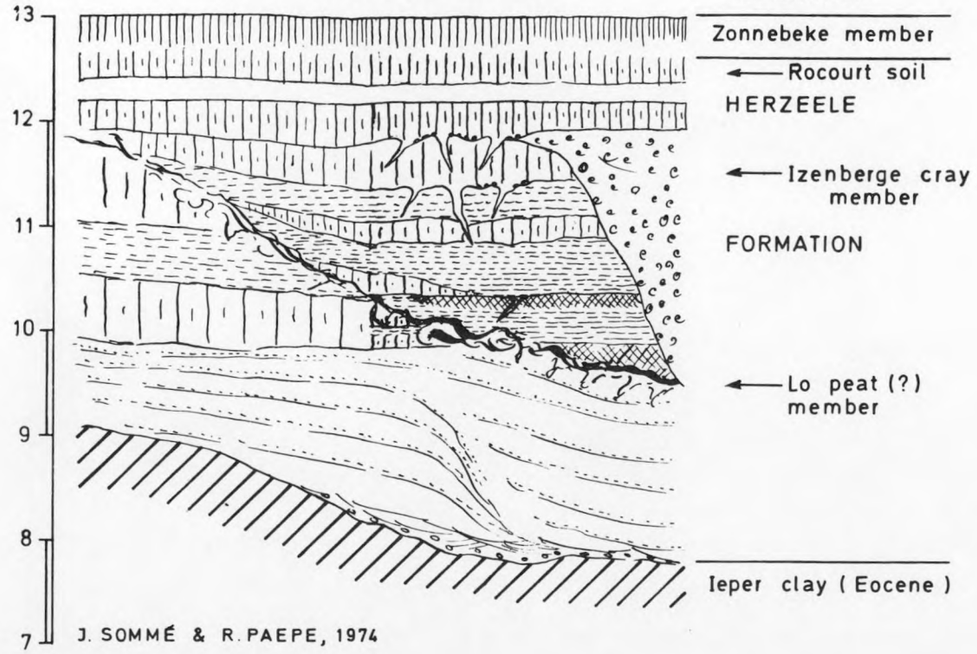
R. PAEPE, 1971



R. PAEPE, 1973

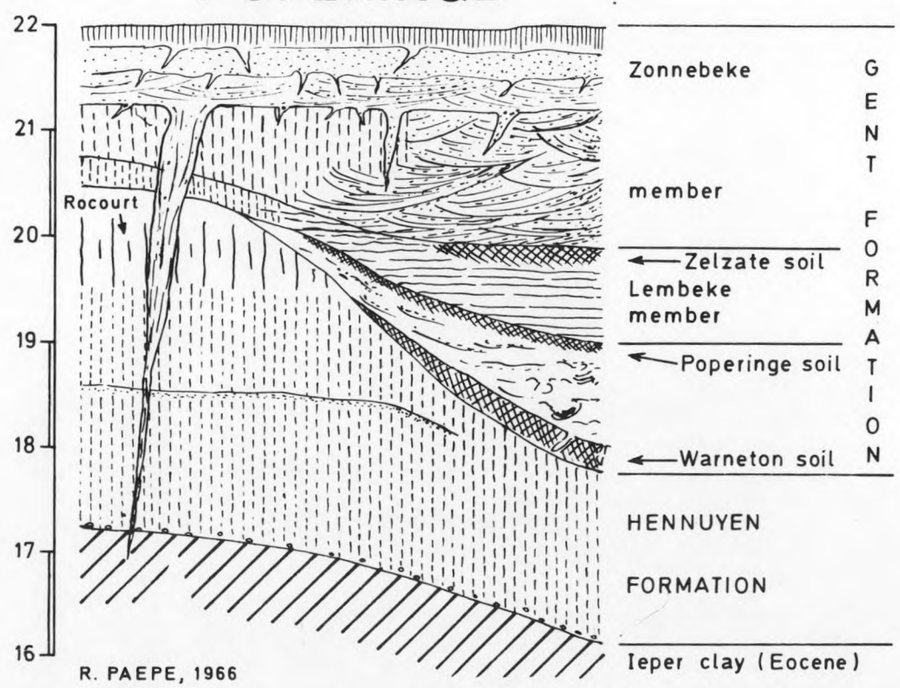


HERZEELE



J. SOMMÉ & R. PAEPE, 1974

POPERINGE



R. PAEPE, 1966

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

LEGENDS OF THE GEOLOGICAL MAP OF BELGIUM

1892

LEGENDE
DE LA
CARTE GEOLOGIQUE DE LA BELGIQUE
DRESSEE PAR ORDRE DU GOUVERNEMENT
à l'échelle du 40.000e.

GROUPE QUATERNAIRE
SYSTEME QUATERNAIRE

QUATERNAIRE SUPERIEUR OU MODERNE

Argile des Polders *(alp)*

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)*

QUATERNAIRE INFERIEURE OU DILUVIEN
FLANDRIEN *(q4)*

q4 Sables avec zones limoneuses des Flandres. - Sable supérieur ou remanié de la Campine.

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.

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.

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.

\+ Blocs erratiques.

GROUPE TERTIAIRE
SYSTEME PLIOCENE

ETAGE SCALDISIEN *(Sc)*

ETAGE DIESTIEN *(D)*

1896

LEGENDE
DE LA
CARTE GEOLOGIQUE DE LA BELGIQUE
DRESSEE PAR ORDRE DU GOUVERNEMENT
à l'échelle du 40.000e

GROUPE QUATERNAIRE
SYSTEME QUATERNAIRE

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.

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.

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.

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.

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 sablé.
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.

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.

▲ Cavernes à ossements.
BLOCS ET CAILLOUX ERRATIQUES :
× Roches cristallines d'origine étrangère.
\+ Roches quartzeuses.

GROUPE TERTIAIRE
SYSTEME PLIOCENE

PLIOCENE SUPERIEUR
ETAGE POEDERLIEN *(Po).*

Po. Sables à *Corbula gibba,* var. *rotundata (Corbula striata), Melampus (Conovulus) pyramidalis, Corbulomya complanata.*

PLIOCENE MOYEN
ETAGE SCALDISIEN *(Sc)*

Sc. Sables à *Fusus (Chrysodumus) contrarius.*

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.

1900

LEGENDE
DE LA
CARTE GEOLOGIQUE DE LA BELGIQUE
DRESSEE PAR ORDRE DU GOUVERNEMENT
à l'échelle du 40.000e.

GROUPE QUATERNAIRE
SYSTEME QUATERNAIRE

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.

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 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.

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.

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.

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.

▲ Cavernes à ossements.
BLOCS ET CAILLOUX ERRATIQUES :
× Roches cristallines d'origine étrangère.
\+ Roches quartzeuses.

GROUPE TERTIAIRE
SYSTEME PLYOCENE

PLIOCENE SUPERIEUR
ETAGE POEDERLIEN *(Po)*

Po. Sables à *Corbula gibba,* var. *rotundata (Corbula striata), Melampus (Conovulus) pyramidalis, Corbulomya complatana.*

PLIOCENE MOYEN
ETAGE SCALDISIEN *(Sc)*

Sc. Sables à *Fusus (Chrysodomus) contrarius.*

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.

1909

LEGENDE
DE LA
CARTE GEOLOGIQUE DE LA BELGIQUE
DRESSEE PAR ORDRE DU GOUVERNEMENT
à l'échelle du 40.000e.

GROUPE QUATERNAIRE
SYSTEME QUATERNAIRE

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.

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 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.

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)*

Elephas primigenius, Rhinoceros tichorhinus. Silex taillés 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)*

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 Poederlien *(Po.)* M.M.

▲ Cavernes à ossements.
BLOCS ET CAILLOUX ERRATIQUES :
× Roches cristallines d'origine étrangère.
\+ Roches quartzeuses.

GROUPE TERTIAIRE
SYSTEME PLIOCENE

PLIOCENE SUPERIEUR
ETAGE POEDERLIEN *(Po)*

Po Sables a *Corbula gibba,* var. *rotundata (Corbula striata), Melampus (Conovulus) pyramidalis, Corbulomya complatana.*

PLIOCENE MOYEN
ETAGE SCALDISIEN *(Sc)*

Sc. Sables à *Fusus (Chrysodomus) contrarius.*

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.

1929

LEGENDE GENERALE
DE LA
CARTE GEOLOGIQUE DETAILLEE
DE LA BELGIQUE

MODERNE
SYSTEME HOLOCENE *(Ho)*

Plaine maritime. Intérieur du pays

Ho. Sables éoliens (dunes) **(V)**, argile des polders *(alp),* sables marins *(alq)* et tourbe *(t).*

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
SYSTEME PLEISTOCENE *(Q)*
PLEISTOCENE SUPERIEUR *(Q2)*

Plaine maritime. Intérieur du pays

Q2. Sables à faune marine et limons.

Q2. Limons divers et sables fluviatiles. A la base, gravier et cailloutis.
Faune froide : *Elephas primigenius, Rangifer tarandus*

PLEISTOCENE INFERIEUR *(Q1)*

Q1. Graviers, cailloux, sables et glaises fluviatiles, limons. Faune chaude : *Elephas Trogontheri, Rhinoceros Merckii, Corbicula fluminalis.*

X. Stations préhistoriques.

TERTIAIRE (1)
SYSTEME PLIOCENE

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.

PLIOCENE MOYEN
ETAGE SCALDISIEN *(Sc)*

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.*