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On the basis of a number of lithostratotype sections in the southern North Sea Belt, Sardinia and southern Greece the Last Interglacial/Glacial geosoil (fossil soils, palaeosols) cycles have been comparatively studied and correlated along a north–south Geosoil Traverse in Europe.

Whichever climato-sedimentological provinces are dealt with, i.e. the northern European Coversand Region, the western and central European Loess Belt and the Mediterranean Belt, geosoils remain in a time stable lithostratigraphic position between phases of prevailing cold/dry climatic conditions. It was found that all of geosoil levels doubled or even tripled along the meridian pathway from north to south.

The 'Last Interglacial' Rocourt Soil of the Loess Belt was split up along this meridian pathway into a lower part dating of the Eemian Interglacial s.s. (Isotope Substage 5e) and respectively after the cold phases of 100 ka BP and 90 ka BP, the St Germain I/Odderade/Koroni Soil Complex (Isotope Substage 5c) and the St Germain I/Brørup/Cala Su Turcu Soil Complex (Isotope Substage 5a) of the Early Last Glacial Substage. The Ognon/Oerel/Warneton Soil Complex remains in the post 73 ka BP position encompassing the cold stage of the beginning of the Middle Last Glacial (Isotope Stage 4). Following this are a series of geosoils of the second half of the Middle Last Glacial (Isotope Stage 3), long indicated as the Moershoofd/Glinde/Poperinge, Hengelo/Hoboken and Denekamp/Zelzate geosoils after the cold phase of about 55–59 ka BP. Finally, the geosoils of the Late Glacial starting at 24 ka BP including the maximum cold of about 20 ka BP and three interstadial soils labelled as Lascaux/Zulte, Bølling/Stabroek and Allerød/Roksem geosoils were formed.

INTRODUCTION TO THE CONTINENTAL GEOSOIL TRAVERSE

Over the last two decades a series of consistent publications on the stratigraphic position of geosoils (palaeosols, fossil soils) of the Last Interglacial–Glacial cycle brought to light two evidences: first, the increasing number of these geosoils in the lithostratigraphic sequence along the north–south geotraverse from 52°N to 30°S in western Europe; second, the weakness of their dating beyond 40 ka BP. In correlating such fossil soil levels, the level of accuracy as to their dating may be questioned.

A possible source of inaccurate chronostratigraphic interpretation of fossil soil levels are the radiometric dating errors. They are, however, in general less difficult to detect than are errors in relative dating on the basis of field interpretation of lithostratigraphic sections or boreholes which rely on individual experience.

Study of the literature indicates that many of these errors with regard to the interpretation of field data remain unsolved because of a lack of systematic and precise field recording. With such precise field records, lithostratigraphic positioning of occurrences of fossil soils and biostratigraphic location of biohorizons in complex Quaternary deposits may become successful.

After the precise vertical time positioning of the geosoil comes the step by step inter-regional comparison of these accurate records, resulting in a geotraverse suitable for lithostratigraphic correlation of continental deposits. With emphasis on the position of palaeosols they are here called 'geosoil traverses'. Such geosoil traverses may then also be used for comparison with the deep sea record, as they are of the same level of accuracy.

Geosoils are fossil soils which most often do not represent a complete soil column. It is often very difficult to describe these soil levels (or what has remained) with the classical methods used in current soil classification systems. Soil scientists have often underestimated their significance for geological stratigraphy. Nevertheless, they should be considered in the lithostratigraphic framework of geological classifications as perfect marker horizons at the formal level of Member, between Formation and Bed. Members in the lithostratigraphic classification (Hedberg, 1976) may be extended from one Formation to another which means that the same geosoil may be followed from a typical loess section into e.g. a purely terrace sequence or even in sequences alternating with marine deposits.

This constancy of transference from one Formation to another is a characteristic of the geosoils. Actually, geosoils represent old land surfaces of the past that separate periods of sedimentation, for which reason it is quite normal to continuously trace them into areas where sedimentation processes occurred under totally different conditions. Geosoils from loess or loess-like deposits may be easily traced back in terrace deposits and vice versa. Geosoils show broader regional similarities than the intercalated sediments.

Under the impulse of changing climatic conditions, geosoils are subject to four other moments of development subsequent to the initial moment of sedimentation:

— an erosional phase with development of a land surface representing a total change with regard to the foregoing period, resulting in a widespread development of a vegetation cover on previously shaped surface, whatever the nature of the underlying deposits;

— a palaeobotanical phase with restitution of the vegetation cover;

— a palaeopedological phase with development of the soil from the level of the previously established land surface into the underlying sediment (viz. bedrock);

— decay of the vegetational cover with natural soil degradation (most often truncation).

If these moments of soil forming processes interfering with sedimentation cycles are regularly repeated in time, regional sequences of soil/land surface levels suitable for inter-regional correlation (i.e. from one stratotype area to another) are built up.

The step by step correlation of such regional geosoil stratotypes of the Last Interglacial/Glacial cycle in western Europe, more especially from the North Sea Basin and the Mediterranean Basin, resulted in the geosoil traverse (Fig. 1). In correlating sections along the Dutch/Belgian border (Moershoofd/Zelzate) to the Belgian/French border (Warneton) with those of Sardinia (Cala Su Turcu) and of the southern Peloponnisos (Koroni) a correlation of geosoil sequences north and south from the Alps is aimed at. Sections of the Lower Alps in Germany and Austria have not been considered here since they have been subjects for ample correlation within the framework of IGCP 24 with sections of the North Sea Basin (Fig. 2).

GEOSOIL GROUPING DURING THE LAST INTERGLACIAL/GLACIAL CYCLE

The possibility for inter-regional correlation of the geosoil levels along a north–south meridian are indisputable evidence of the synchronous space/time relationships of the geosoil levels. Global change climatic conditions for each of the soil levels involved can be inferred. As pointed out earlier by Paepe (1989) each of these geosoils show a perfect time stability, as both interglacial and interstadial type of geosoils seem to have been developed within limited periods of time, with a minimum of 500 years of development even for the most intensive interglacial soil. Moreover, for the Last Interglacial/Glacial cycle the geosoil types have taxonomically been grouped (Paepe, 1989) into four groups from bottom to top (Fig. 3):

— the 'interglacial soil' consisting of the typical lessivé type (gray brown podzolic/parabraunerde) of soil horizon; time interval from 127 ka through 115 ka; PK I of Last Interglacial age. Eemian Stage or 5e Oxygen Isotope Substage;

— the 'early Last Glacial soils' consisting of three or four soil levels, also of the lessivé type but slightly less developed (interstadial) than the previous (interglacial) one; time interval from 115 ka through 73 ka; interfering with cold phases with maxima at about 110 ka (5d) and 93 ka (5b) and henceforth maximum soil development only during the warmest Oxygen Isotope Substages 5c (GS1, GS2, GS3) and during 5a (GS4); separated from the next group of interstadial geosoils by a severe cold phase at about 70 ka;

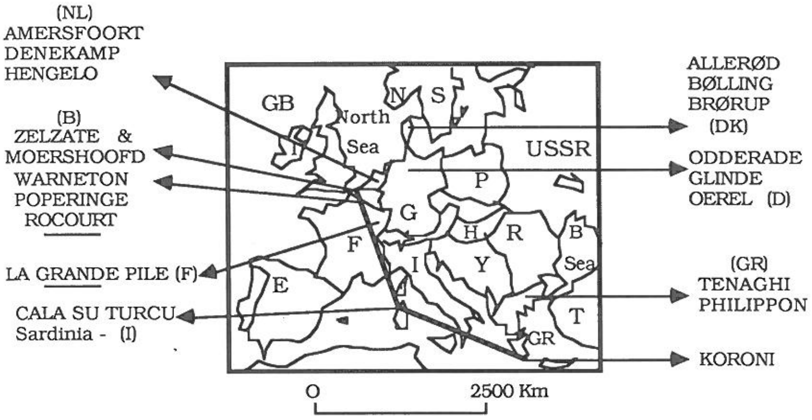

FIG. 1. Sketch map of the Late Pleistocene litho- and biostratotypes of northern Europe and of the eastern Mediterranean Belt. On the outline map only the names of the litho- and biostratotype sections of northwestern Europe (southern North Sea Belt), together with those of northern Germany (Baltic Sea) and La Grande Pile (eastern France) are shown. Stratotypes of the eastern Mediterranean (including Sardinia) have similarly been referred to although no reference is made to sections in southern France and Spain as no geosoil section has so far been studied from the point of view explained in the present paper. Type sections of the alpine area are not considered since they have been long correlated with northern Europe and to some extent with the Mediterranean, especially with northern Italy.

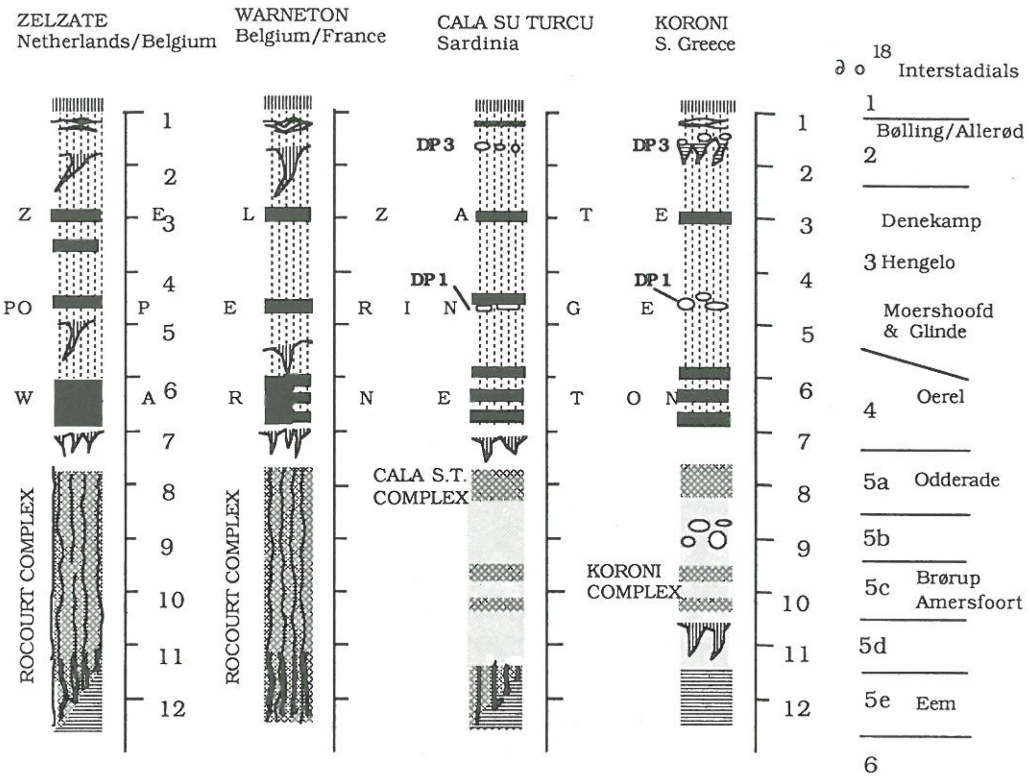

FIG. 2. Geosoil Traverse: the sequences discussed in the text.

— the 'early Middle Last Glacial soils' consisting of three soil levels of the steppe-like type with possible peat bog developments (dry mild interstadials); time interval from 73 ka through 55 ka; interfering with minor cold phases; greatly encompassing Oxygen Isotope Stage 4 (GS5, GS6, GS7); separated from the next group by a severe cold about 55 ka;

— the 'late Middle Last Glacial soils' consisting of three soil levels of the wet land soil type with possible peat bog development (wet mild interstadials); time interval from 50 ka through 24 ka; largely encompassing Oxygen Isotope Stage 3 (GS8, GS9, GS10); separated from the next group by a severe cold at 20/18 ka;

— the 'Late Glacial Soils' consisting of three soil levels of the steppe-like type with possible peat bog development (dry cold interstadials); time interval from 24 ka through 10 ka (beginning of Holocene series); interfering with minor cold (Dryas) phases; largely encompassing Oxygen Isotope Stage 2 (GS11, GS12, GS13); separated from the next 'current interglacial soil' by a minor cold event at 11 ka;

— the 'current interglacial soil' of the lessivé soil type; developed about 9000 BP, encompassing Oxygen Isotope Stage 1 (PK O).

The above lithostratigraphic grouping of the geosoils reflects firstly the specific climato-edaphic position of each of the geosoils in the vertical time sequence order, and secondly their continuity as a stratigraphical marker horizon (the geosoil Member) in the horizontal geographical and geomorphological display within one or more Formations. It indicates the stable space/time relationship of the geosoils which, added to their remarkable limited time necessary for their development, qualifies them as indisputable time-stable 'guide fossils' of the lithostratigraphic sequence suitable for comparison with the deep sea record.

Considering the importance of such time stability, it will be necessary to determine their relationship to the biostratigraphic (mainly pollen) biohorizons of the lithostratigraphic sequence.

Actually, most of the biostratigraphic evidence such as pollen assemblages have not been thoroughly controlled with respect to their lithostratigraphic position. As biohorizons show multiple occurrences in the normal geological sequence, pollen layers of a similar taxonomic assemblage may appear at different lithostratigraphical positions in the same stratigraphic sequence.

This, evidently, hinders considerably the time correlation of biostratigraphic as well as that of related lithostratigraphic layers from one section (or borehole) by another, and by and large from one geographical area to another as well. In order to check any of the possible biostratigraphical or geophysical datings of a given layer, the lithostratigraphic position should always be clearly defined within one and the same section as well as over the whole geographical area of possible occurrence.

Another reason for investigating the biostratigraphical and lithostratigraphical relationship is to identify the regional or global change nature of the

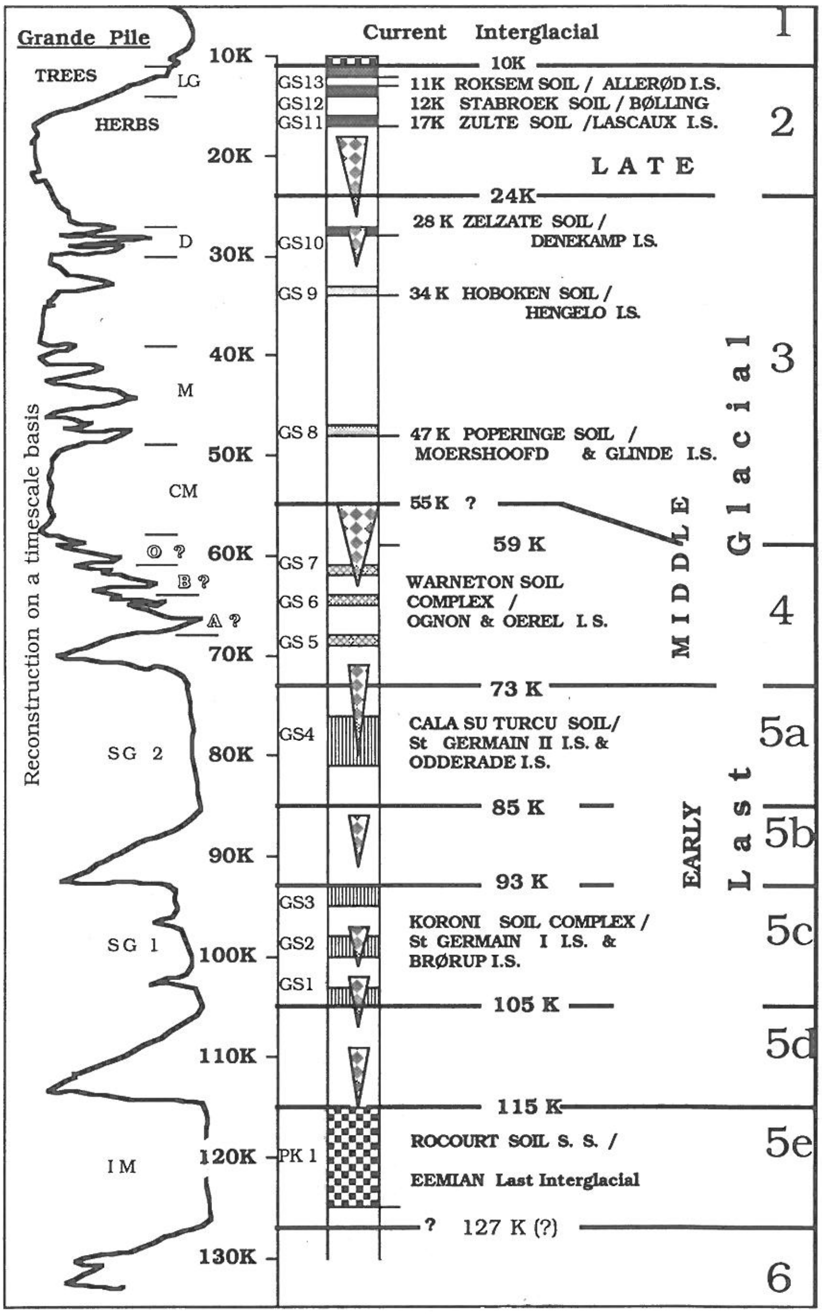

FIG. 3. The geosoil types of the Last Interglacial/Glacial cycle.

geosoils. Practically, it involves determining how much of the climatic forcing found in northwestern Europe (about 52°N) is reproduced in lower latitudes like continental Greece and Crete/Israel at respectively 30°N and 28°N, and whether it is possibly due to an external astronomical forcing of the climatic conditions.

THE LITHOSTRATIGRAPHIC EVOLUTION ALONG THE GEOSOIL TRAVERSE

In Fig. 2 the geosoil traverse of the Last Interglacial/Glacial cycle from the North Sea Basin to the Mediterranean Basin has been represented. The aim is to define on the basis of a step by step correlation of geosoil stratotype sections, the evolution of the Last Interglacial–Glacial geosoils with regard to their latitudinal position.

As all stratotype sections have been fully described in earlier publications, only additional comments will be presented with regard to the stratotype sequences represented in Fig. 2.

The Moershoofd/Zelzate Geosoil Lithostratigraphic Section

This section was studied in the early sixties in excavations on both sides of the Dutch/Belgian border, revealing the existence of a series of fossil soils alternating with cover sand/loess deposits of the Upper

Pleistocene sequence filling up the Flemish Valley (Tavernier, 1943). It actually forms the southernmost and totally fossil delta outlet of the Flemish/Dutch Delta region. All other deltas are located north of it on Dutch territory, and are still more or less active despite the Delta Works damming their outlet to the sea.

At Zelzate on the Belgian side, the lithostratigraphic sequence was a complete one showing a continuous record of the Upper Pleistocene, including the marine facies of the Last Interglacial Stage (Eemian). At Moershoofd on the Dutch side, only the lower part of the Last Glacial Stage (Weichselian) was found. Both sections were discussed by Zagwijn and Paepe in 1968 leading to the first complete standard lithostratigraphic section of the Upper Pleistocene with pollen biostratigraphic interpretations and the first climatic curve as well.

The strongly weathered truncated red clay soil horizon of the interglacial lessivé (textural B) type occurs in the top zone of the marine Eemian deposits (containing guide fossils such as *Tapes* or *Venerupis senescens var. eemiensis* and *Corbicula fluminalis*) Paepe, 1974). This represents the Last Interglacial soil named by Gullentops in 1954 'Rocourt Soil' after the type section of Rocourt (near Liège in Belgium). The soil level developed after the maximum stand of the Eemian marine transgression, but thin sections taken at various depths for micromorphological studies point to a polycyclic evolution of this soil. The question was raised if the soil above the Eemian marine deposits was solely interglacial or a mixture of Last Interglacial and Last Glacial pedological developments. Therefore the name Rocourt Soil Complex was introduced at Zelzate.

The first cryoturbatic/frost wedge boundary occurs above the Rocourt Soil Complex, for which reason the overlying loam series were deemed to belong to the Last Glacial (Weichselian) Stage. The two lowermost soil horizons in the loam series not only are the most regularly displayed ones but converge into one single humic (steppe) horizon where the topographic level rises slightly and was identified by Paepe (1964) as the 'Warneton Soil', previously named after its type locality (see hereafter). At Moershoofd less than 1 km north of the Belgian site of Zelzate, the Warneton Soil was revealed definitely to consist of three and even more levels, while pollen assemblages pointed at an Early Weichselian age (most probably between 73 ka BP and 55 ka BP).

The other three humic soils of the loam series are separated from the Warneton Soil by a line of unconformity with frequent and large frost wedges displayed on top of a desert pavement called D.P. 1 (Paepe and Vanhoorne, 1967). According to its spectrum pollen the lowermost one has been considered as the first of the three interstadial soils of the Middle Weichselian Substage, to which the label Moershoofd interstadial was given because of similar evidences found at the Moershoofd excavation to the north in the Netherlands (Zagwijn and Paepe, 1968). The lithostratigraphic position, as well as the pollen spectrum of the Moershoofd humic horizon, tallies with the lowermost of the Middle Weichselian soils recorded at Poperinge (another type locality nearby Warneton) and was, henceforth, identified as the Poperinge Soil dated 45 ka BP (Paepe and Vanhoorne, 1967).

The last two highly cryoturbated humic/peat levels at the top of the loam series only occurred at Zelzate. They belong to the Middle Weichselian Substage according to their pollen content. The uppermost one has been dated 28,200 BP and named Zelzate Soil, encompassing perfectly the Denekamp Interstadial of the Netherlands (Zagwijn and Paepe, 1968). Equally, the lower cryoturbated peat horizon, named the Hoboken Soil (Paepe and Vanhoorne, 1967), of roughly 34 ka BP (as dated at the Hoboken type section near Antwerp) was identified to represent the Hengelo Interstadial of the Netherlands.

The whole of the three Middle Weichselian loam and soil series was again capped by a second desert pavement (D.P. 2) which must have been developed shortly after the Middle Weichselian Substage when climatic conditions decayed and polar desert conditions started to develop. Instead of soil development, huge amounts of sandur deposits filled the upper part of the Zelzate section till the position of maximum cold was reached at a new desert pavement level (D.P. 3) marked with a line of frost wedges of extremely great size indicating the maximum cold of 20/18 ka BP. Aeolian sands and loess sands terminate the sequence, which is generally referred to as Upper Last Glacial Substage covering the timespan of 26 ka BP to 17/16 ka BP.

Three new humic soil levels, named after the respective type localities Zulte Soil, Stabroek Soil and Roksem Soil, indicate in the Zelzate profile the rapid warming of the climate during the Late Glacial Substage. Their dating, at respectively 17 ka BP, 12 ka BP and 11,500 BP, point to the beginning, the middle and the end of the Late Glacial within the series of Dryas deposits and tally with the interstadials of Laugerie, Bølling and Allerød (Paepe and Vanhoorne, 1967).

The following remarks may be formulated in conclusion:

— The Zelzate stratotype of the Upper Pleistocene Substages is still the most complete one for the Dutch/Belgian cover sand area.

— The maximum Last Interglacial Soil Development (Rocourt Soil) occurs after the maximum of the Eemian transgression in the North Sea. It is possible that the Rocourt Soil at Zelzate, because of its polycyclic nature, was greatly influenced by soil developments of the Early Last Glacial Substage as well, or is composed of a series of the Last Interglacial and of the Early Last Glacial.

— Three series of interstadial soil developments occur after phases of severe cold (polar desert conditions) respectively at 73 ka BP, 55 ka BP and 20 ka BP. These soils sections were believed to encompass respectively the Early, Middle and Late Weichselian.

How do these Substages correlate with the Grande

Pile Pollen Content assemblage diagram as well as with the Oxygen Isotope Stages?

The Warneton Stratotype Section

The Warneton stratotype section of the sand loess area, located in the subsidence basin of the Lys Plain on the French/Belgian border, in contrast to the Zelzate section, contains several well developed geosoil levels of the above reported Early Weichselian Warneton Soil Complex. These levels may converge into one single Warneton Soil Complex layer in particular topographical conditions, as low lying depressions of the subsidence basin. It is not very clear whether the multilevel soil development was a consequence of the subsidence or of the climatic variability within the region.

The splitting up of a single Warneton Soil Complex into several soil layers was recorded outside the site of Warneton in the loess area as well. Frost wedges and cryoturbatic features fill up the space between the soils pointing at rapidly alternating climatic conditions.

It was found that the middle soil of the Warneton Soil Complex, according to its pollen assemblage (Paepe and Vanhoorne, 1967), was slightly warmer than the ones below and above, revealing the pollen spectrum of the Brørup Interstadial (Andersen, 1965). Equally, the lower soil was considered to correspond with the Amersfoort Interstadial (Zagwijn, 1961; Zagwijn and Paepe, 1968). Dating of both soils at the type localities revealed ages of respectively 65 ka BP and 68 ka BP. The third and uppermost one was dated as 58 ka BP and named the Odderade Interstadial.

As in the Zelzate section, the Middle Weichselian above is separated from the Warneton Soil Complex by a distinct frost wedge horizon with a D.P. 1 level which was believed to have developed about 55 ka BP. In the Middle Weichselian deposits, no other interstadial soils than the Zelzate Soil of 28 ka BP were observed, with the uppermost layer with D.P. 2 clearly developed on top of it. Conditions of sedimentation in the Lys Plain were probably too wet during the Middle Weichselian, which was most probably characterized by flooding thus hampering the normal growth of vegetation as well as the normal development of soil horizons. Upon the D.P. 2 surface, aeolian sands sealed at the top by D.P. 3 with large frost wedge provide good evidence of synchronism in the polar desert conditions during the Upper Last Glacial Substage at the time of the maximum cold all over northern France, Belgium and the Netherlands (i.e. the Southern Bight of the North Sea).

The warming during the Late Glacial produced fluviolacustrine clay deposits and little if any trace of soil development could be found. Despite the absence of some geosoil levels because of local edaphic conditions, the Last Glacial sequence is as complete as the one found at Zelzate 200 km to the north. The polar desert frost wedge levels are present at the appropriate lithostratigraphic levels, as are those soils such as the Warneton and the Zelzate which seem to have been the most important ones in the climatic landscape/soil evolution.

The whole profile at Warneton rests on red clay loess or on peat deposits of Eemian Age. The Eemian soil shows a clearly developed gley soil horizon in its upper part and a red mottled clay soil horizon underneath. From micromorphological studies the complex and polycyclic nature of the Rocourt Soil became evident. The geosoil developed partly in lower loess layers of the previous glacial stage (Saalian Stage) while the peat formed laterally from the geosoil in adjacent depressions during a maximum swamp highstand of the Last Interglacial. A great number of fossil mammoth skeletons have been excavated from these bogs in the fifties. Vanhoorne came to the conclusion of a Last Interglacial age for the peat on the basis of pollen studies (Vanhoorne and Denys, 1987).

Recently Van Overloop pointed out the presence* of *Abies* in samples collected from the gley horizon just above the Rocourt Soil s.s. at the stratotype locality of Warneton. The general pollen assemblage shows furthermore the presence of an open swampy environment with *Cyperaceae* and other grasses. Besides the occurrence of *Abies*, other tree pollen such as *Pinus, Betula* and *Picea*, accompanied by typical swamp trees such as *Alnus, Myrica* and *Salix* are recorded. Water plants witness the existence of ponds, which were gradually drying up resulting in salination as is shown by the presence of *Armeria* (*t. maritima*) and *Glaux*. The latter presence indicates cooler and drier climatic conditions (Paepe and Van Overloop, 1990).

The presence of contemporaneous and *in situ* dinoflagellate forms is strange. They either could have been left in closed saline lagoons at Warneton after a marine transgression, or they could have started growing after the salination process. The above mentioned facts, compared to the results obtained by Woillard (1978) and Zagwijn (1975, 1985, 1989) plead in favour of an age of the gley part of the Rocourt Soil Complex as described before, having started towards the very end of Eemian Isotope Substage 5e.

The Cala Su Turcu Section

The Cala Su Turcu section in Sardinia in the Middle Mediterranean region is a site along the southwest coast of Sardinia, about 50 km from Cagliari. It caps a cliff of 15/20 m high above an abrasion platform cut into the substratum composed of Jurassic (Lias) limestones (Fig. 4). Upon a red coloured conglomerate composed of dolomite limestone containing *Ostrea, Cardium, Cerithium, Glycimeris, Spondilus, Trocus, Conus Cassis, Murex, Purpura, Patella, Euthria, Pyrene* and *Strombus* rests a slighter red coloured beachrock with *Strombus bubonius* as well.

Directly above are three other soils, a red one at the base and two marmorized ones above. The whole is covered by gravels disturbed by cryoturbatic features.

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*All pollen, whether *in situ* or not, has been determined by means of fluorescence microscopy.

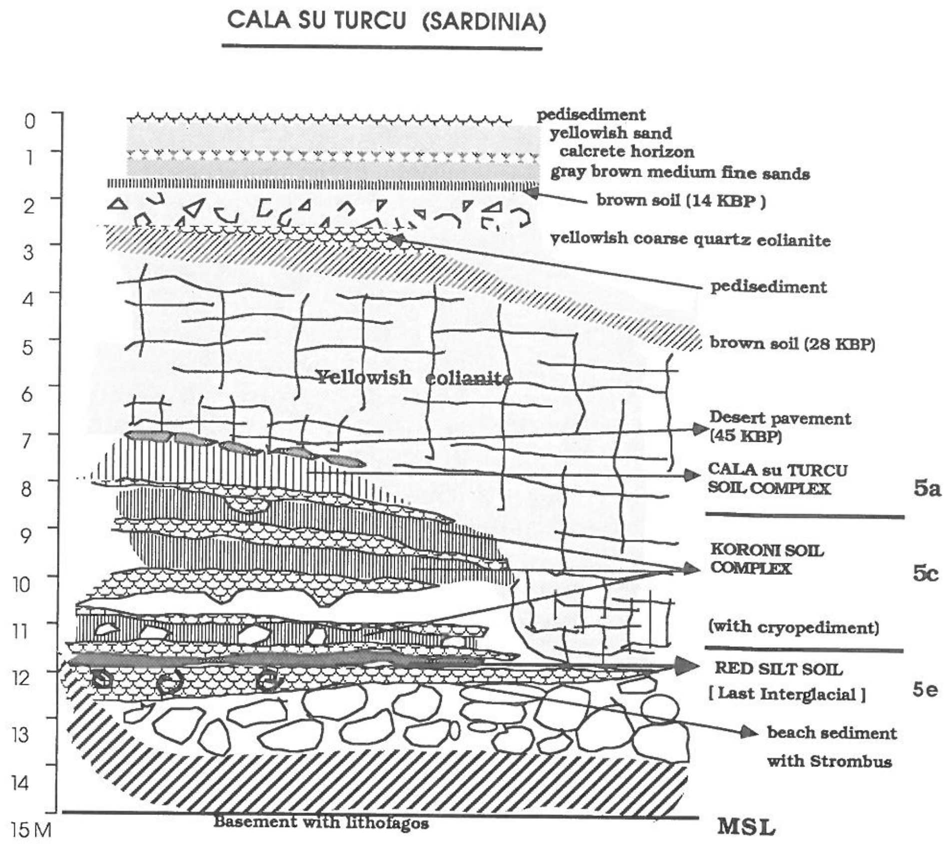

FIG. 4. Last Interglacial/Glacial cycle section in cliff along the beach of Cala Su Turcu: present MSL (mean sea level) is at bottom of section profile. It is quite remarkable that the present MSL tallies almost perfectly with the fossil one including the Neogene.

Above the cryoturbatic disturbed stoneline attesting to a cold phase, three other soil levels appear, each of them being separated by individual stonelines which locally are also affected by frost pockets.

A preliminary conclusion may be drawn at this point. The series of soils morphostratigraphically speaking recall the soil sequence as encountered at Warneton.

The base of the beachrock may coincide with the time limit of 127 ka BP, considering that the conglomerate of boulders are relicts of the former cold phase and the beachrock formation is coinciding with the maximum of the Last Interglacial transgression and subsequent interglacial soil development.

The lower group of the threefold soil series (just above the interglacial beachrock and soil) belongs definitely to another climatic period than the upper three ones from which they are separated by a severe cold period as indicated by the intermediate frost wedge level. According to the degree of soil development the upper sequence correlates better with the interstadial soils of the Warneton Soil Complex (originally defined as Early Weichselian Substage or better of the Early Last Glacial Substage) while the three lower ones of stronger development than the upper ones, occurring between the beachrock soil and the frost wedge level, occupy the position and the time interval of the Rocourt Soil Complex. The assumption is hereby made that these soils in fact belong to the upper part of the Rocourt Soil Complex, whereas the red soil developed in the beachrock should be considered as the Last Interglacial Soil s.s. The latter recalls the position of the lower red clay horizon at Warneton and Zelzate underneath the polycyclic upper part of the Rocourt Soil Complex. If this assumption is correct, the frost wedge line between the two series of threefold soils represents the severe cold marking the transition between the Rocourt Soil Complex and the Warneton Soil Complex located at 73 ka BP.

Further above, a discontinuous sandstone pavement in the lithostratigraphic position of D.P. 1 separates the upper threefold soil series from overlying yellowish coloured aeolianites which in places are filling up eroded gaps into the underlying soils which may reach as deeply as the Strombus beachrock. The position above the upper threefold soil levels of the desert pavement infers cold dry conditions about 55 ka BP similar to the ones between the Warneton Soil Complex and the Poperinge Soil in the North Sea Basin. Hereafter, as the milder climate of the Middle Last Glacial started, flooding activity (as in the Warneton section) became important and extremely intensive erosion started.

This lithostratigraphic situation of the Middle Mediterranean area yields a comparable situation to the one encountered in the Southern Bight of the North Sea Belt when the meltwaters at the beginning of the mild Middle Last Glacial Substage first eroded and subsequently filled up the gullies with the Peaty Loam

Member deposits of the Middle Weichselian.

In the windborne fine grained homogeneous aeolianites about 5 m thick, a faintly developed brown soil is developed at the bottom and another, slightly stronger soil is developed at the very top zone of this sequence. The lower soil occupies (lithostratigraphically speaking) the position of the Moershoofd/ Poperinge Soil of about 45 ka BP, whereas the top zone soil corresponds with the Zelzate Soil of about 28 ka BP of the North Sea Belt.

This long-distance lithostratigraphic correlation is furthermore attested to by a series of yellow coarse sand layers above. They contain quartz angular pebbles which are concentrated into a quartz gravel lag at the bottom (D.P. 3). Actually the quartz enriched sands attest to a windborne origin (aeolianite) at the same time as pediplanation processes (angular quartz content of the pedisediment) were active as well. These deposits which are complex in origin and are typical for many regions of European Mediterranean and desertic North African regions may be labelled (because of their complex origin) pedisediment-aeolianites. They do occur in the periglacial polar desert regions as well, although mixed up with snowmelt water deposits. Desertic conditions stronger than ever before recorded in the Cala Su Turcu must have prevailed, indicating most probably the maximum drought of the Upper Last Glacial Stage at 18 ka BP.

Finally, the pedisediment-aeolianites are capped by a brown soil which indicates the start of the Late Glacial, most probably about 17/16 ka BP. Indeed, new gray brown fine aeolian sands follow upwards encompassing the lower Dryas deposits. They are themselves capped by a thin calcrete horizon which may be occupying a similar position to the Allerød/Bølling interstadial soil levels of northwestern Europe. Coarser yellowish sands capped by a pedisediment at the top end of the series of aeolianites are believed to tally with the upper Dryas deposits elsewhere.

The section of Cala Su Turcu without any doubt dates to the Upper Pleistocene, but certainly needs more precise laboratory study and radiometric dating. However, the lithostratigraphic position of the geosoils alternating within a series of aeolianites and periglacial features offers a standard pattern of the Upper Pleistocene sequential event lithostratigraphy and, henceforth, sufficient elements for a comparable study with the stratotypes of the North Sea Southern Bight.

The Koroni Upper Pleistocene Section

The Koroni Upper Pleistocene section on the extreme southwestern 'finger' of the Peloponnisos in Greece shows a quite similar and continuous, although eastern Mediterranean Upper Pleistocene profile. The sections fills up a gully over a width of more than 100 m eroded in a substratum composed of Lower Pleistocene marine and Neogene marine deposits forming a cliff of 15 m dominating the Bight of Koroni (Fig. 5).

The sequence starts with marine beachrock deposits overlying Neogene sediments filling the bottom of the gully in which the whole of the Upper Pleistocene deposits are developed. Unlike the beachrock in Cala Su Turcu in Sardinia, no *Strombus bubonius* was found, which absence is not exceptional in the eastern Mediterranean area. However, the morphostratigraphic position of the beachrock at the base of the gully filled with an Upper Pleistocene geosoil sequence, points at a time relationship with these sediments. Therefore the beachrock is considered as of Last Interglacial age.

Windblown sands cover the beachrock and are separated from the overlying first group of three well developed reddish brown textural-B-horizons ('lessivé' type geosoils) by a line of wedges which are found regularly in this stratigraphic position in southern Greece. They are attributed to drought most probably induced by frost action (Paepe and Mariolakos, 1984). Both windblown sands and 'frost wedges' point to the start of the cold stage which was periodically interrupted by three stages of milder climate. During these milder phases vegetational growth was still sufficiently abundant to produce pedological weathering of the 'lessivé' soil type. Moreover, each of the geosoils are separated from each other by pebble lags and developed in different sediment layers which show a cross-bedded stratification.

This first series of lessivé geosoils is separated by a new aeolian layer from the second series of three geosoils. These soils, although of the lessivé type as well, are not so strongly developed as the lower lying series of three geosoils. The lithostratigraphic sequence of two soil groups occupying the beginning of the Last Glacial Stage perfectly matches the sequence of Cala Su Turcu.

Above these soils, yellowish fine meltwater deposits alternating with windborne deposits occupy the space between two brown soils: a weakly developed one at the bottom and another stronger developed one at the top of the series. It is the classical aspect of the Middle Last Glacial Substage observed at the previously discussed stratotype sites. The maximum cold conditions of the Upper Last Glacial are represented by the coarse, dominantly aeolian sands, ending in loessoid deposits. A distinct frost wedge row with a pebble band (D.P. 3) is developed on top. From this line of frost wedges, thermokarst features have been strongly developed. As well, permafrost seems to have been generally well developed in that region during the Upper Last Glacial Substage.

The Late Glacial starts directly above the frost wedge/pebble band layer with a complex brown soil horizon overlain by 1 m of loessoid deposits in which the modern soil has been developed.

LITHOSTRATIGRAPHIC AND BIOSTRATIGRAPHIC DISCUSSION OF THE GEOSOIL TRAVERSE

The discussion will have a bearing on two aspects of the geosoil sequence: (1) the time stratigraphic position of the geosoils as Members of the lithostratigraphic

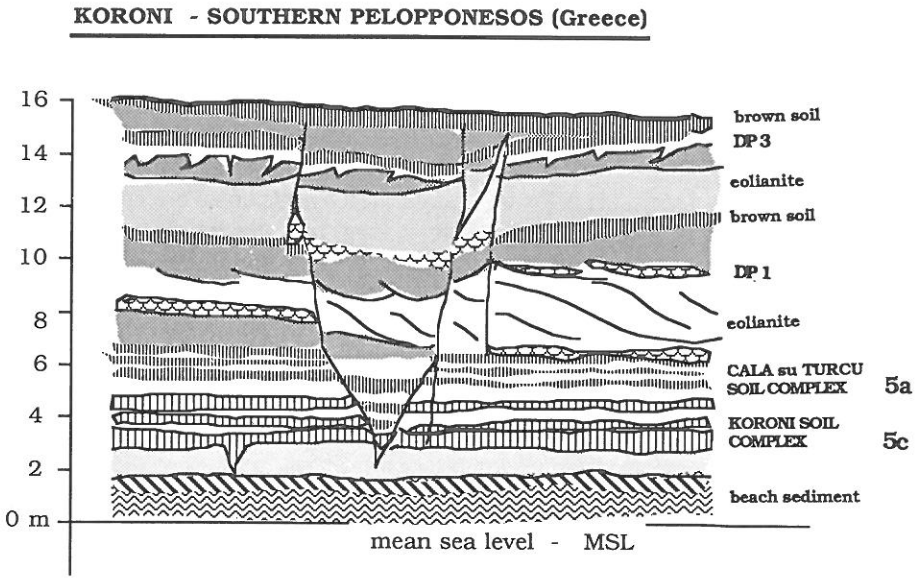

FIG. 5. Last Interglacial/Glacial section at Koroni (Greece).

Last Interglacial/Glacial cycle; and (2) their significance as interglacial/interstadial features as compared to the biostratigraphic record of the Upper Pleistocene. Both aspects are discussed together hereafter.

The Last Interglacial Geosoil Series

In the sections of Zelzate (Belgium) and Warneton (Belgium) in respectively the North Sea Belt and the (Sand) Loess Belt of western Europe, the Last Interglacial geosoils are overlying respectively marine North Sea deposits and lake deposits of the Lys Plain subsidence area. The Last Interglacial geosoils have obviously been formed after the Last Interglacial maximum high water stand, no matter whether one is dealing with marine or lake conditions. It once again points to the fact that the climatic optimum of the Last Interglacial was already finished before the fossil geosoils could start to develop under climatic conditions becoming gradually cooler and drier.

As for the sections in the typical loess area (e.g. Rocourt), the Last Interglacial geosoil is composed of only one single truncated soil layer in which the typical textural B horizon may occur at the top, the base, or in the middle. As this monolithic soil layer shows a high degree of polycyclicity it seems quite obvious that various phases of soil development took place. However, as stated above, since all developments are telescoped into each other it is not absolutely clear how many of these soil development phases occurred nor at what specific time periods. By all means, it points to the fact that the Last Interglacial geosoil is a complex composed of several stages of development which might in some particular places as in the section of Harmignies (southern Belgian/French border) lead to the development of various independent soil levels at middle latitudes as well.

The subdivision of the Last Interglacial at Cala Su Turcu into totally independent soil levels separated from each other by gravel beds with frost wedges reveals definitely that each of them represents independent warm climatic cycles interrupted by rather severe cold phases. The Red Soil developed in the beach rock points to a situation similar to the Zelzate site in the North Sea Basin, with the interglacial geosoil in the Mediterranean Basin occurring directly after the maximum sea level rise of the Last Interglacial. Similarly at Koroni (Greece), one finds the Red Soil developed in the upper part of the Last Interglacial marine deposits. Moreover, the overlying sand body with frost wedges at the top underneath the first group of three independent geosoils indicates the very first cold phase, inferring that the Red Soil together with the marine deposits below both belong to the maximum of the Last Interglacial. As the latter are identified with Substage 5e on the isotopic scale (Shackleton and Opdyke, 1973) the Last Interglacial geosoil should accordingly encompass Isotopic Substage 5e including the latter part when the interglacial climate was decaying into cooler and drier conditions.

The occurrence of frost wedges between the Red Soil of Oxygen Isotopic Substage 5e and the three independent geosoils above at both Cala Su Turcu and Koroni, indicates (lithostratigraphically speaking) that the Last Glacial Stage has been reached during development of these three soils. The three geosoils are, as stated above, still well developed although certainly not to the same degree as the Red Soil interglacial type. Therefore, they are considered as representing rather warm interstadial phases of the beginning of the Last Glacial Stage. This also explains why in places like Zelzate or Rocourt, where the Last Interglacial Soil and the soil weatherings of the Early Last Glacial form a monolithic structure, the upper part consists of one or several strongly degraded horizons whereas in the lower part only a strongly developed textural B horizon occurs.

The monolithic structure of the Last Interglacial Geosoil as the Rocourt Soil has proved to be not only of a complex polycyclic nature but of different ages as well. In some places of the typical loess area the Rocourt Soil may be solely of the Last Interglacial Age. But in other places like Zelzate and Warneton its age may be composed of an older Last Interglacial lower part (the textural B horizon s.s.) and of a younger Last Glacial upper part, which may vary from pseudogley degraded horizons to peat bogs and other soil types (Paepe and Vanhoorne, 1967, 1976). In any case, as is observed from the geotraverse sections discussed above, sedimentation rates between the levels of soil development are sufficiently high to keep soil levels separated from each other in the subtropical regions. It is clear that monolithic deep weathering horizons in higher latitudes should then be considered as a piling up of weathering horizons of different climatic origin and age with little if any sedimentation in between.

The Last Interglacial/Last Glacial Boundary and the Early Last Glacial

In considering the problem of the Last Interglacial/Last Glacial Boundary the age of the upper three geosoils of the Early Last Glacial should be discussed in conjunction with the three following geosoils of the beginning of the Middle Last Glacial.

The first statement which is confirmed by the geosoil traverse is the indubitable superposition of two series of three geosoils interfering with periods of periglacial activity and frost wedge development all over Europe, not only from the North Sea Basin to the Alps but to the Mediterranean as well.

In the sixties, as mentioned above, the three upper geosoils were generally considered as representing the classical group of three interstadials of the Early Weichselian Stage (namely the Amersfoort, the Brørup and the Odderade) with its lower boundary at 73 ka BP. This was based on the simultaneous pollen analytical studies carried out in places where these geosoils were represented by peat or organic horizons. Indeed, the Warneton Soil Complex in many places like Warneton, Poperinge, Antwerp, etc. contained pollen assemblages similar to the biostratotype section of the Amersfoort interstadial, sometimes to the Brørup but never to the Odderade. According to radiocarbon dating, this interstadial was considered to be the first after the cold peak of 73 ka BP and henceforth labelled as Early Weichselian.

From the Atlantic Ocean, cooling is known to have occurred about 115 ka BP and 70 ka BP (Juillet-Leclerc *et al.*, 1989). According to the foregoing one finds a series of three soils occurring after 115 ka BP and another series after 70 ka BP. The question is simple: to which of the threefold soil series do the classical Early Weichselian interstadials belong?

Biostratigraphically the very same question was raised when Woillard (1975) published the pollen diagram of La Grande Pile (Vosges, France) in 1975 in which the two St Germain (I and II) interstadials were represented. Even when found to be of equal intensity as to the amount of warmth-loving plant development of the Last Interglacial (which unfortunately was labelled Eemian) their pollen assemblage proved to be entirely different, essentially cooler and drier. Furthermore, both St Germain interstadial substages were separated by rather severe cold periods, firstly from the very Last Interglacial (Eemian) Stage at 115 ka BP (Melisey I), secondly from each other at 95 ka BP (Melisey II) and finally from the Pleniglacial by the severe cold temperature drop at about 70/73 ka BP. It meant that, between 115 ka BP and 73 ka BP chronoboundaries, cooler and drier climatic conditions generally prevailed than during the Last Interglacial (correlated correctly by Woillard with Oxygen Isotope Substage 5e).

When Woillard and Mook (1982) published the chronological record of La Grande Pile, it was quite clear for the authors that both St Germain interstadials were older than 73 ka BP, which date had always been hitherto conceived as the lower chronoboundary of the Last Glacial. So it became also quite logical as well to place the whole cooler and drier period between 115 ka BP and 73 ka BP in the Early Last Glacial and correlate St Germain I and II respectively with Oxygen Isotope Substages 5c and 5a on a global scale. The further correlation of these interstadials with (respectively) the Brørup and Odderade interstadials following Frenzel (1980) and Behre and Lade (1986) is generally accepted, whereas the Amersfoort interstadial is read as a minor early mild phase of the Brørup.

However, a closer view of the St Germain interstadial suggests that this interstadial is quite likely to be subdivided into three sub-interstadials. Together with the single peaked interstadial of St Germain II this implies that at least four warm peaks interfered during the timespan of 115 ka BP (i.e. the newly defined Early Last Glacial). The four interstadial soils recorded below the severe cold marking the end of the Early Last Glacial at Koroni, Cala Su Turcu, and even at Harmignies (Belgium) as described by Haesaerts (1973), are believed therefore to correspond to warm phases of St Germain I and II.

According to the above discussion on the lithostratigraphic and biostratigraphic correlation it is proposed to name, as Koroni Soil Complex, the soils immediately above the Last Interglacial s.s. (Oxygen Isotope Substage 5e). The three lower ones correspond to the St Germain I (SGI) interstadial of Woillard and the Weichsel Frühglazial II (WF II) of Behre and Lade and the sole upper one to the St Germain II (SGII) interstadial and the Weichsel Frühglazial IV (WF IV) respectively.

The position of the Elevtheropoulis, Drama and Doxaton interstadials were correlated in 1969 with (respectively) the Odderade, Brørup and Amersfoort interstadials of northern Europe. This correlation was mainly based on the early dating of the Elevtheropoulis interstadial at about 53 ka BP. Corrections on the dating in January 1970 revealed totally different evaluations of the time record. The Elevtheropoulis/Odderade interstadial becomes older than 50,900 BP and the Heraklitsa/Moershoofd interstadial younger than 49,070 BP.

It may be questioned now if Wijmstra's (1969) pollen Zone V showing a maximum cold/dry peak just underneath the dating of 49,070 BP should not be considered as the end of Oxygen Isotope Stage 4 and the Elevtheropoulis interstadial in which three rises of the mixed oak vegetation (with *Quercus pistacia*) as the beginning of this stage. The three rises of the mixed oak forest indeed may perfectly be considered to be the origin of the three soil horizons encompassing the Warneton Soil Complex above the 73 ka BP cold peak boundary. This corroborates the open *Artemisia* and *Chenopodiaceae* vegetation including *Ephedra* and *Plantago*.

The above assumption leads to the conclusion that the Elevtheropoulis interstadial should not be correlated with the Odderade Interstadial. Instead it may be correlated with the Ognon/Oerel interstadials, as referred to earlier in this paper.

In this light, the Odderade/St Germain II interstadial is correlated with the Drama interstadial and the Brørup/St Germain I with the Doxaton interstadial. In analyzing the warm peaks of the Drama interstadial one finds at least two rises of the mixed oak forest which are responsible for interstadial soil developments in GS 4/Cala Su Turcu Soil and two other rises in the Doxaton interstadial which are responsible for the soil development of Koroni Soil Complex. The smaller warm peak at the beginning of the Doxaton interstadial may be considered as the equivalent of the Amersfoort interstadial.

Quite correctly Wijmstra (1969) has correlated his pollen Zone Q with the Eemian Stage s.s. (Oxygen Isotope Substage 5e) for which stage the name Pangaion Interglacial was already introduced by Van Der Hammen *et al.* (1971).

From the above it may be proposed that the Koroni Soil Complex correlated with the Doxaton interstadial, encompasses Oxygen Isotope Substage 5c and the Cala Su Turcu Soil (complex) Oxygen Isotope Substage 5a. It points furthermore to the possibility of lowering (pedostratigraphically speaking) the Last Interglacial/Glacial boundary at 115 ka BP instead of 73 ka BP.

The Early Last Glacial/Middle Last Glacial Boundary and the Middle Last Glacial

Traditionally the Middle Last Glacial started with the severe cold of 50 ka BP and lasted until about 27 ka BP. According to the shift of the three classical palynologically determined interstadials of Amersfoort, Brørup, and Odderade into the series of the St Germain palynological interstadials, the lower time boundary of the Middle Last Glacial shifted as well to about 73 ka BP, as has been outlined above.

Pedostratigraphically, however, this boundary of 73 ka BP remains the same as the one which was long used for the lower boundary of the Warneton Soil Complex (Paepe, 1963). Even in its threefold appearance in the section of Warneton above the Rocourt Soil Complex and in the sections of Cala Su Turcu and Koroni above the newly defined threefold Koroni Soil Complex and the Cala Su Turcu Soil of Early Last Glacial age and dated older than 73 ka BP, the Warneton Soil Complex remains the same time-stratigraphic and lithostratigraphic (stable) position. It means that within the range of 73 ka BP through 27 ka BP, the Middle Last Glacial Substage is composed of six fossil soil horizons: namely the three soil horizons of the Warneton Soil Complex and the threefold group of the Poperinge, Hoboken and Zelzate soil horizons.

Biostratigraphically the latter group of three geosoils was compared by Zagwijn and Paepe (1968) to the Moershoofd, Hengelo and Denekamp interstadials. Behre and Lade (1986) introduced the Oerel and Glinde interstadials as well as the subdivision of the Moershoofd interstadial into a milder upper part and a cooler lower part: this provides (palynologically) three more interstadials between the Moershoofd *sensu* Zagwijn and Paepe and the Odderade/St Germain II interstadials.

Woillard already in 1982 had set forth the possible correlation between the Ognon I, II and III interstadials and the Amersfoort, Brørup and Odderade. The Ognon interstadials were then located in time before 73 ka BP in the very upper part of Oxygen Isotope Substage 5a announcing the decay of the climate which finally resulted in the severe cold phase of Oxygen Isotope Stage 4 located now between 73 ka BP and 91 ka BP (recent datings from Mangerud (1989) locate this stage between 74 ka BP and 59 ka BP).

The Warneton Soil Complex in most of the studied geological sections is generally between two major levels of intensive frost wedge development. The lower one is generally as stated above located at 73 ka BP and the upper one at about 50–55 ka BP. Furthermore this soil complex is characterized by the presence of numerous frost wedge levels. It really reflects in the lithostratigraphic sequence the transitional decay as shown on the pollen curve of La Grande Pile, namely the transition of the warm St Germain II (SG II) interstadial towards the Last Glacial Pleniglacial Substage. It is therefore quite possible that this complex covers the whole of Oxygen Isotope Stage 4, in which case the Warneton Soil Complex points to warmer reccurrences at the beginning of this stage. This should also explain why the Warneton Soil Complex horizons are much less developed than the Early Last Glacial soils of the underlying Cala Su Turcu and Koroni Soil Complex. In this assumption the lower boundary remains at 73 ka BP and the upper at about 55 ka BP.

If Oxygen Isotope Stage 4 is to be restricted to the deposits corresponding with the large frost wedges above the Warneton Soil Complex then the age of the soil complex should become older than 73/74 ka BP and locate the complex at the end of Oxygen Isotope Substage 5a. If Oxygen Isotope Stage 4 corresponds only with the smaller frost wedges underneath the Warneton Soil Complex then the complex is to be incorporated with Oxygen Isotope Stage 3.

Taking into account the dating of 46 ka BP of the Poperinge Soil the large frost wedge line (with desert pavement D.P. 1, Paepe, 1963) is believed to encompass the period of maximum glacier extension dated about 56 ka BP (Seret, 1984), which date corresponds with the end of Oxygen Isotope Stage 4. The lower frost wedge line underneath the Warneton Soil Complex could then be interpreted as the cold phase occurring just above warm peak 9 of the Woillard and Mook diagram and possily be of an age about 73/74 ka BP. With this assumption the Warneton Soil Complex coincides with the Ognon interstadials between two phases of severe cold. It is believed that this sequence tallies entirely with Oxygen Isotope Stage 4 which marks the beginning of the Last Glacial Pleniglacial.

Behre and Lade (1986) advocate for a possible correlation of the Oerel interstadial with the Ognon interstadials, whereas this seems (so far) not feasible with the above occurring Glinde interstadial. This may indicate that the Warneton Soil Complex which may indeed, as stated earlier, occur as a single horizon, is very likely to coincide with the Oerel interstadial. Actually the latter is also known to be separated from the Glinde interstadial by a severe cold phase. It points at the incorporation of the Glinde interglacial within the group of the Moershoofd, Hengelo and Denekamp interstadials.

Woillard (1975) as well as Behre and Lade suggest the splitting of the Moershoofd interstadial into a weakly developed lower part and a strongly developed upper part, which respectively may represent the Glinde interstadial and the Moershoofd interstadial s.s. It is quite feasible to assume that both interstadials are included into one single Poperinge Soil level. Splitting of soil levels into two or more organic horizons is not seldom observed. As stated before, doubling of the Poperinge Soil as well as of the Hoboken and Zelzate Soils are usually observed from north to south along the geosoil traverse and also when tracing a single soil horizon into an even shallow depression a few metres (Paepe 1963, 1966) as in Warneton and Tongrinne (Belgium).

This doubling or tripling is also observed at the level of the Hengelo, Denekamp and Moershoofd interstadials in both Woillard's (1978) La Grande Pile (NE France) and Wijmstra's (1969) Tenaghi Philippon (northern Greece) pollen diagrams. In the latter the interstadials of Wijmstra's Pollen Zone P are subdivided into a Krinides I and II viz. Denekamp I and II, a Kalabaki I and II viz. Hengelo I and II and a Heraklitsa I and II viz. Moershoofd with question mark! Actually the last mentioned Heraklitsa interstadial shows at least four peaks under which cooler pollen assemblages occur. The correlation of the Heraklitsa interstadial with its northern European counterpart definitely needs more study.

However, according to the above mentioned discussion with regard to the possible correlation of the Elevtheropoulis interstadial with the Warneton Soil Complex, the Moershoofd/Glinde correlation with the Heraklitsa interstadial becomes more feasible. Actually datings of the base of Heraklitsa I at 49,050 BP and of Heraklitsa II at 46,660 BP as well as the datings of 43,810 BP for the base of the Kalabaki/Hengelo interstadials and 32,410 BP for the base of the Krinides/Denekamp interstadials, strongly support this point of view.

As the top of the Zelzate Soil dated 28,200 BP is capped by another desert pavement with frost wedges (D.P. 2) it may be concluded that series of Glinde, Moershoofd, Hengelo and Denekamp interstadials and their Greek equivalents are, like the Oerel interstadial, fitting in between two cold phases. This points at a possible correlation with Oxygen Isotope Stage 3. As stated previously by Zagwijn and Paepe (1968) the trend of cooling which hereafter was continuous till it reached its maximum at about 21/18 ka BP, most probably started about 24 ka BP which date is also brought up for the boundary between Oxygen Isotope Stages 3 and 2 in deep sea core studies.

The Middle Last Glacial/Late Glacial Boundary and the Late Glacial

In the timespan of steady decay of the climate between 28 ka BP and 24 ka BP, no possible intensive soil landscape development was observed as polar desert conditions were growing, resulting in severe drought conditions with no vegetation development at all. An exception is in Wijmstra's pollen diagram where the Tursac interstadial of southern France is recorded as the Photolivos interstadial of northern Greece, dated about 23 ka BP.

Thus the Middle Last Glacial ends gradually between 28 and 24 ka BP with a sharp sudden decrease of temperature after about 21 ka BP. Extreme polar desert conditions kept on existing until about 17 ka BP whereafter the climate started to slightly improve resulting in the mild phases in between the Dryas cold phases. Three soils have been developed: the Zulte Soil at 17 ka BP, the Stabroek Soil at 12 ka BP and the Roksem Soil at approximately 11 ka BP corresponding to the Lascaux, Bølling and Allerød Interstadials. They are present in all sections whatever the latitudinal position and in Greece they are referred to by Wijmstra as the Philippi (dated at about 17,500 BP) and the Xanthi (dated between 13,500 and 10,900 BP) interstadials, the latter one encompassing the Bølling and Allerød interstadials between the Older and Younger Dryas.

GENERAL CONCLUSIONS FOR THE LAST INTERGLACIAL/GLACIAL GEOSOIL TRAVERSE

From the above discussions a series of conclusions along the meridional direction from the Southern Bight of the North Sea to the eastern Mediterranean may be drawn.

The Geosoil Grouping of the Last Interglacial/Glacial Cycle

From Fig. 2 it clearly appears that the Last Interglacial Soil (Rocourt Soil s.s./5e) developed after the maximum high water (marine or lake level) stand during the middle of the Last Interglacial. Above, five major stadial–interstadial sequences occur, each starting with a severe cold phase: the Koroni Soil Complex after the severe cold of about 100 ka BP (5d) called the lower Early Last Glacial group (5c); the Cala Su Turcu Soil Complex after the severe cold of about 90 ka BP (5b) called upper Early Last Glacial group (5a); the Warneton Soil Complex after the severe cold of 73 ka BP called the lower Middle Last Glacial group (4); the Poperinge, Hoboken and Zelzate Soils after the severe cold phase of about 55 ka BP called the upper Middle Last Glacial group (3); and the Zulte, Stabroek and Roksem Soils after the maximum cold at 20 ka BP called the Late Glacial group (2).

All these groups occupy a time-stable position in the lithostratigraphic Last Interglacial/Glacial cycle. According to their latitudinal and/or edaphic position these soils may double at lower time frequencies.

Moreover, from Fig. 1 it appears that grouping together of the Early Last Glacial group with the Last Interglacial soil s.s. into a Rocourt Soil Complex as one is moving along the meridian from lower latitudinal position towards a higher colder and more humid one has become evident.

Comparison with the Pollen Biostratigraphy

In reproducing the Grande Pile Trees/Herb Pollen assemblage curve on the left part of the diagram (Fig. 3) on a time scale basis the fitting of the warm interstadial 'tree extension' peaks with the soil groups has been indicated whereas the cold interstadial 'herb extension' peaks tally perfectly with the phases around intensive frost wedge development.

This made it feasible to correlate on a new biostratigraphical basis as discussed before, the Warneton Soil Complex with Ognon/Oerel/Elevtheropoulis interstadials, the Cala Su Turcu Soil Complex with the St Germain II/Odderade/Drama interstadial and the Koroni Soil Complex with the St Germain/Brørup/Doxaton interstadial. The Moershoofd and/or Glinde interstadials encompass the Poperinge Soil which may indeed split up in two or more levels, implying minor differences of time intervals.

As the Koroni Soil Complex is also reported from other sections outside Europe more specifically from Gihungwe (Zaire) on the equator in the West African Rift (Ilunga, 1984; Ilunga *et al.*, 1989) it points to its time stability of occurrence (Ilunga and Paepe, 1990). Geosoils therefore are far more easily recognized on a global scale than their biostratigraphical equivalent in organic horizons, i.e. in pollen diagrams. Given this constancy of occurrence of geosoils it is better to refer to the Last Interglacial and Glacial interstadials in the lithostratigraphic sequence on the basis of fossil soil layers. Indeed, whatever changes may occur in the biostratigraphic pollen analytical record this is apparently not affecting the stable time stratigraphic position of the geosoil levels. Finally, the geosoils of interglacial and interstadial origin found in sequential order in basin and plateau positions may readily be followed and recognized on terraces in stepped sequential order and thus help in the dating of geomorphological features as well.

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