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The polder area of Raversijde (Ostend, Belgium): a complex parent material affected by intense human interventions. Archaeology as a tool in geopedology.
Le polder de Raversijde (Ostende, Belgique) : un matériau parental complexe fortement anthropisé. L'archéologie, outil de la géopédologie.

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1.Introduction

A large scale archaeological research project has been set up by the Institute of the Archaeological Heritage (IAP) of the Flemish Community and the province of West Flanders to study the deserted Late Medieval fishermen's village of Walraversijde at the Flemish coast (fig. 1). It provided an enormous amount of archaeological information as well as abundant data on nature, genesis and use of the surrounding natural landscape.
A stratigraphical sequence of deposits, soil formation and human activities has been established for the Late Holocene in the area (fig. 2) by combining geological, pedological, archaeological, historical, biological and ^{14}C data. The multidisciplinary approach revealed some aspects of the major importance of human interventions such as drainage, dike building and different forms of land use during the last millennia. These intense human interventions actually created the present-day outlook of the well-known polders.
The area was mapped by the Belgian Soil Survey in the late fourties. The Soil Survey produced soil maps on scale 1/5000 and published them on scale 1/20000 (Ameryckx, 1952a), together with concomitant papers and reports in which the Holocene evolution of the coastal plain was presented (Ameryckx, 1952b, 1958, Tavernier, 1948).
The objective of this paper is to demonstrate that the pedological map, although based on a dense boring grid of 2 borings per hectare, can only give a general idea about the different soil types occurring in the area. The kind of human intervention and its chronology can only be established by means of observations in excavation pits because of the frequent variations in lithology over very short distances. The differences between the soil types of the pedological map and the reality will be illustrated with some examples of the sedimentary succession in the Late Holocene sequence, as well as the

degree of human interventions in particular those related to peat extraction for fossil fuel which was of great importance in the shaping of the landscape.

2. The study area

The Late Medieval fishermen's village of Walraversijde is located in the central part of the Belgian coastal plain just behind the present-day dunes. The study area (fig. 1) covers about 12 hectares, but most of the observations presented in this analysis are situated in a much smaller area of about 5 hectares. On the soil map (Ameryckx, 1952a) 7 different units are indicated: D5, E1, Ao, C2, Da, OC, OT (fig. 3). OC stands for lost settlements, in this case referring to the deserted village. OT stands for disturbed areas, Ao, C2 and Da respectively stand for dunes, leveled dunes and dune sands lying on polder sediments. The polder sediments are subdivided in heavy clay (E1) related to tidal-flat areas, and clay to heavy clay (D5) related to tidal-gully areas. The present paper will show that the differentiation of soil types is more complex.

3. The evolution of the coastal plain during the last millennia: from peat swamp to polder.

The last infill of the coastal plain during the Late Holocene consists of a 1 to 2 m thick unit of clay and sand formed in a mudflat, salt marsh and/or tidal channel environment. This unit is overlying a ca 1 m thick peat layer, called the surface peat. According to the Soil Survey, the upper clastic unit is the result of 3 transgressions, called the Dunkerque I, II, III transgression which are separated by the Roman and Carolingian regressions, respectively (a.o. Tavernier, 1948, Ameryckx, 1959). This interpretation and stratigraphy are still considered as an established fact in the Belgian literature. Even in some of the most recent reviews (Maréchal, 1992, De Moor & Pissart, 1992, Houthuys et al., 1993, Depuydt et al., 1995) it reverberates apparently untouched, although it has been frequently discussed and criticized (Baeteman, 1983, 1985, 1987). According to the Soil Survey, the coastal evolution was always considered in the framework of this stratigraphical division, and few attention was paid to processes of infill with the exception of the process of relief inversion which was considered as being one of the most important landscape-forming processes in the whole evolution of the coastal plain. The inversion of relief (sand areas are on a slightly higher level than the peat and clay areas) is the result of differential compaction between sand from the channels on the one hand and peat on the other hand. The dewatering and compaction of the peat was interpreted as being the result of artificial drainage after land reclamation, thus as a result of human intervention. This process is still accepted among the scientific community.
Renewed geological research in the coastal plain since the late seventies revealed different viewpoints about the infill of the plain during the last millennia. Different transgressive phases were not observed in the upper clastic unit (Baeteman, 1981) which is now interpreted as being the result of a renewed tidal influence from ca 4500 cal BP on whereby tidal inlets and channels migrated landward scouring deeply into the peat swamp and underlying deposits. The scouring of the channels caused dewatering and compaction of the peat with consequently a lowering of its surface which provided new accomodation space for tidal sedimentation. The ages of the top of the surface peat, ranging between 4500 and 1500 cal BP, suggest that this mechanism proceeded

progressively more landward and resulted in the final infill of the coastal plain (Baeteman & Van Strydonck, 1989, Baeteman & Denys, 1995).
Due to the lack of outcrops, few detailed pedogenetical research is performed on the coastal Holocene deposits although some pedogenetic processes as ripening and structuration, are very adequate to register even temporary withdrawals of water.

3.1. The surface peat and its exploitation as fossil fuel

In this paragraph, the attention will be focused on the exploitation of the surface peat in the area of Raversijde and especially on how it can contribute to the debate on the genesis of the coastal plain during the last millennia.
In the study area, the peat (where not excavated) occurs between -0.2 m TAW[1] and + 1.7 m TAW (fig. 2) and has a thickness ranging from 0.2 to 1.6 m. The top of it shows clear evidence of erosion. Peat fragments of different size are frequently encountered in the overlying mudflat deposits as well as in deposits of tidal channels which, in some places, eroded the surface peat completely. It most probably was impossible to make the distinction between the *in situ* peat and big reworked peat blocks with the Edelman handauger from the Soil Survey.
The peatlayer shows also prominent vertical cracks reaching the underlying sediments. These cracks have already been observed by Blanchard (1906) and suggest a phase of total dessication.
A map of the base of the surface peat shows that in the southern part of the area the peat lies on a higher level than in the seaward part. The surface peat where not eroded by tidal gullies, has been excavated for fossil fuel in the Raversijde-area since Roman times (Pieters, 1993). This seems to suggest that the peatlayer has already compacted before the inundation by the 'Dunkerque II' transgression in the second half of the third century (Thoen, 1978). The peat is in general thoroughly extracted. Only the lowermost centimetres of the peat have been systematically left untouched. This enabled the mapping of the base of the peat even in areas where it has been extracted (fig. 4). If the process of inversion of relief took place as described by the Soil Survey, it must have happened during the 'Roman regression' or earlier.
The archaeological research at Raversijde, however, provides some elements for discussion. A topographically very well pronounced sand- and clay-filled tidal gully, in the eastern part of the study area (fig. 4), is situated at a level more or less 1 meter above the surrounding land. The reason for this happened to be peat exploitation. In late or early postmedieval times, the surface peat has been extracted on both sides of the tidal channel while the deposits in the channel were evidently left untouched. This phase of medieval and/or early postmedieval peat-extraction still determines the actual land use because the exploited areas are nowadays dominantly used as hayfields. A comparison between the altitude in a mud flat area and that on the tidal gully, both untouched by peat extractions, shows that both of them are situated more or less at the same level. The tidal flat is even somewhat higher than the sand- and clay-filled tidal gully.

[1] Tweede Algemene Waterpassing: Belgian Ordnance Datum, referring to low water at mean spring tide, which is about 2 metres below mean sea level.

3.2. Sedimentary succession of the clastic unit overlying the surface peat

3.2.1. Buried soil (fig. 2)

A clayey deposit directly overlying the peat and occurring between + 1 and + 1,5 m TAW, can clearly be distinguished from the remaining upper sediments by the development of a soil in between them. The soil characteristics are typically those of a very young soil: a hexagonal (diameter: 0.5 m) pattern of ripening cracks which reach down to the underlying peat, numerous (up to ten per 100 square cm) biogalleries with a diameter of 0.5 to 1 cm, and a strong prismatic structure coated with pressure faces, breaking down into a strong angular blocky structure in the upper 20 cm of the soil. The soil is covered by a 5 cm thick peatlayer.
As to the age of the buried soil no data are available yet. C-14 data on shells in living position from levels below and above the soil, are in progress.
Diatom analysis of the buried soil shows a distinct drop in marine influence (figs. 2 & 5, indicated by arrow) towards the top, also indicating a temporary reduced tidal influence in the area.

3.2.2. A strongly stratified clay to silty clay (fig. 2)

The buried soil is covered by a strongly stratified clay to silty clay. This deposit, containing a lot of fine peat detritus, can reach up to 1 m in thickness. Two features seem te be linked with this characteristic deposit. A disturbed zone (fig. 2) shows parts of the above described stratified deposit in which the original lamination is still preserved but occurring in an oblique or even vertical position. A 'stabilisation'- or 'accumulation'-level (fig. 2) is enriched with organic matter which is suspected to be reworked. Four ^{14}C dates were obtained for this level: 3385 cal BP, 3690 cal BP, 4417 cal BP abd 4423 cal BP[2]. These dates are about the same age as the oldest dates of the top of the surface peat indicating that the organic accumulation originated from eroded and reworked peat. However this level is not characterised by pedogenetical structuration. Where both phenomena occur in the same profile, the latter is situated on top of the disturbed zone.

3.2.3. A sand-clay-sand succession

The uppermost deposits of the Holocene sequence at Raversijde consist of stratified sands (fig. 2) covered by a clayey deposit which at the base can be laminated (fig. 2). Generally this deposit constitutes the surface in the area and this since the end of the post-Roman inundation phase (Tys, 1997). A fossil plough layer (fig. 2) is present in its top and a well-developped prismatic and angular blocky structure with a polygonal pattern of cracks reaches the underlying sands. Slickensides are present on the structural faces of the prisms.
In the lower part of this clayey deposit, different levels with *Scrobicularia plana* in living position occur mostly in the southern part of the area. An age between 547-840 cal AD

[2] 3385 cal BP=Utc-6004, 3690 cal BP=Utc-4733, 4417 cal BP=Utc-5113, 4423 cal BP=Utc-5117 carried out at the ^{14}C laboratory of the Royal Institute for Cultural Heritage, Brussels.

is suggested by the C14-datation of the shells from the lowest level (Van Strydonck, 1995).
Windblown dune sands level out the Late Medieval topography by filling up the lower zones. These sands can as well be homogeneous and rich in humus from top to bottom or stratified and with a low content of humus. The latter are deposited in wet conditions and fill up depressions which remained after the clay- and peat-extraction behind the dunes. The former gradually buried part of the medieval village which turned into agricultural land in the 16th century.

4. Discussion and conclusion

The detailed investigations show that in the study area the soilscape is extremely complex. The complexity is mainly the result of the intense human interference in this very dynamic coastal environment. The investigations showed that the sedimentary succession which is disturbed by human intervention can only be established in detail by observations in excavation pits because of the complexity of the frequent lateral and vertical changes in lithology. The observation pits have to be sufficiently deep in order to distinguish an eroded block of peat from the peat *in situ*.
A comparison with the soil map showed that it is not possible to establish the degree of human intervention by handaugering. It can be argued that the peat-exploited areas on the soil map should be multiplied with a factor 2 or 3.
The present paper also showed that archaeological observations are of major importance in understanding the coastal evolution of the area during the Late Holocene.
The human impact on this region has been strongly underestimated in previous works although it was taken into account. The human impact even can be at the origin of relief inversion.
It is furtheron suggested that pedological research could contribute considerably to unravel the complex Holocene development of the coastal region.
It is obvious from the presented data that at the scale of several hectares, several units can be distinguished in the sequence. However, a sufficient number of qualitative observations are necessary as some 'key'-units only show up in very restricted parts of the area.
As a summary it can be stated that additional datings (on shells) combined with a dense grid of new field data in a limited area as the one at Raversijde should allow to make progress in unravelling the complex Late Holocene evolution of this region.

Fig. 1: Location map of the coastal plain with indication of the study area.
Fig. 2: Composite profile of the Late Holocene sequence of the study area: 1. Fossil ploughlayer, 2. Clay with shells in living position, 3. Stratified sands, 4. Stabilisation- or accumulation level of organic matter, 5. Disturbed zone, 6. Stratified clay to silty clay, 7. Thin peatlayer, 8. Buried soil developed in clay, 9. Peat, 10. Clay or sand.
Fig. 3: Occurrence of the different soil types according to the Soil Map. The study area is indicated in dark.
Fig. 4: Topographic map of the study area with the location of medieval and/or postmedieval peat exploitation pits in dark.

Fig. 5: Frequency of ecological groups of diatoms from a profile with the buried soil, characterised by different salinity tolerance. Arrow indicates the buried soil with a low marine influence.

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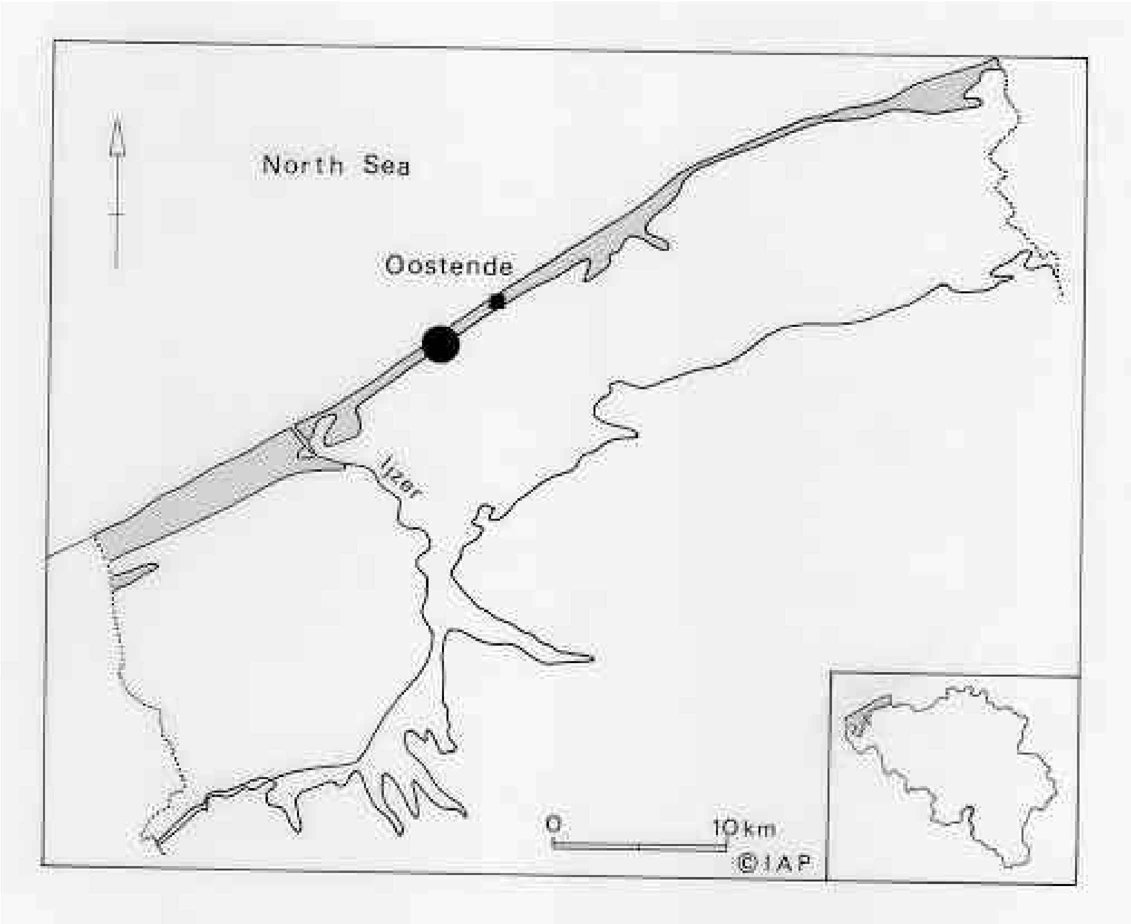
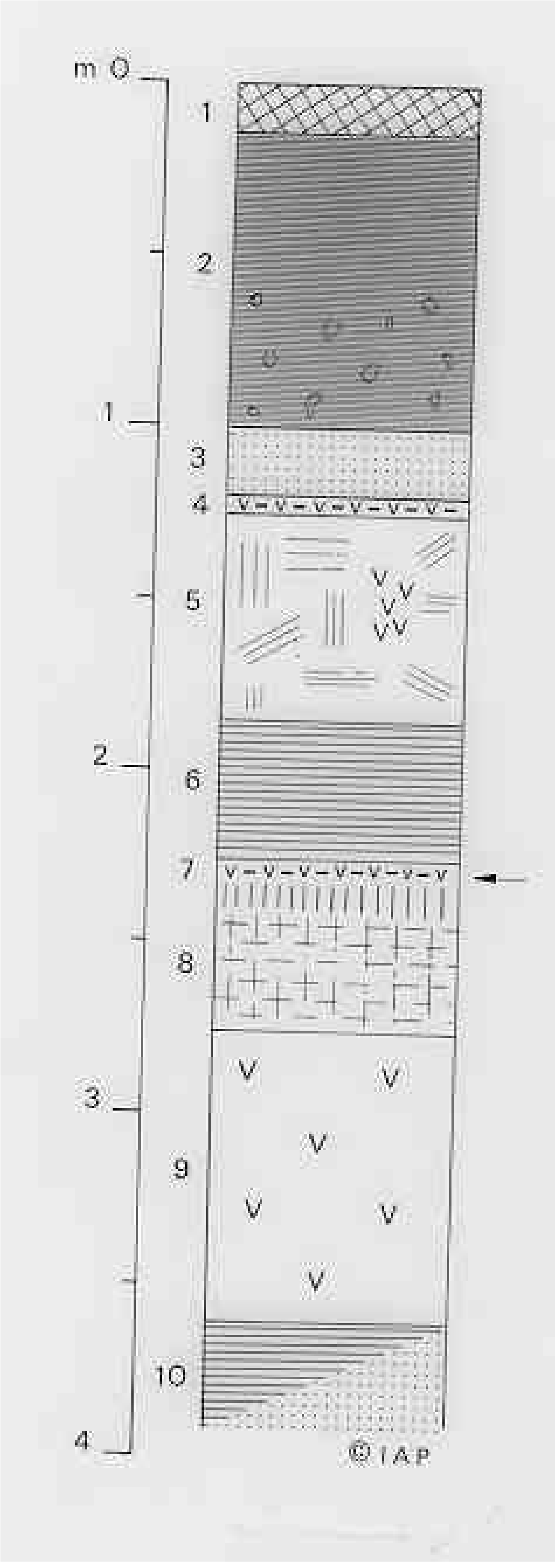
Keywords: soil variability, peat, peat extraction, relief inversion, coastal environment, human influence

Mots clés : variabilité du sol, tourbe, extraction de tourbe, inversion du relief, environnement côtier, influence anthropique

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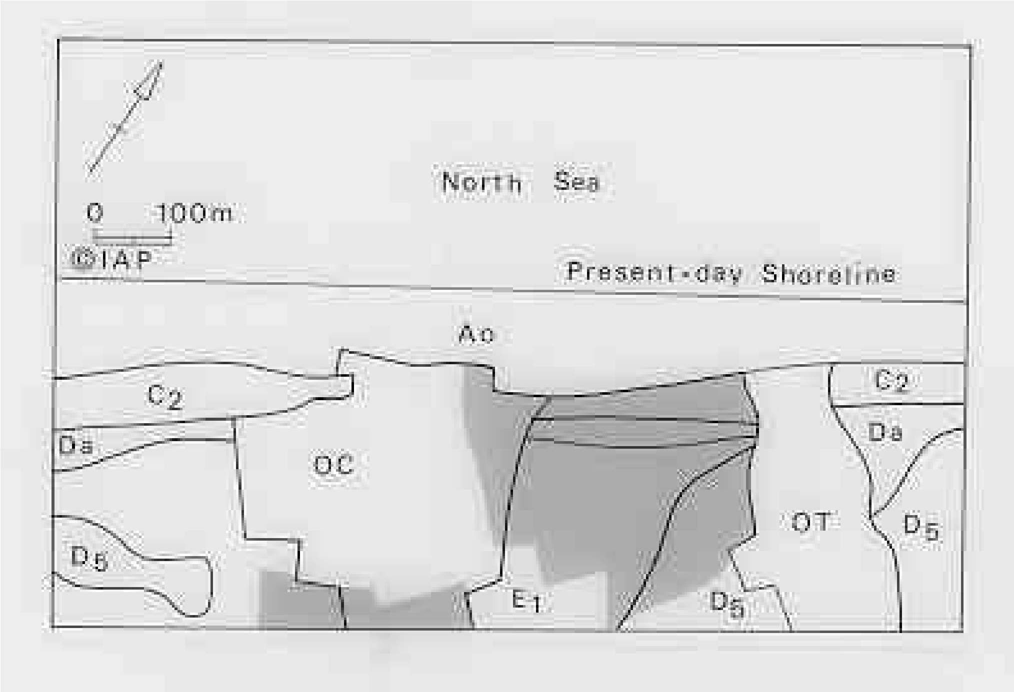
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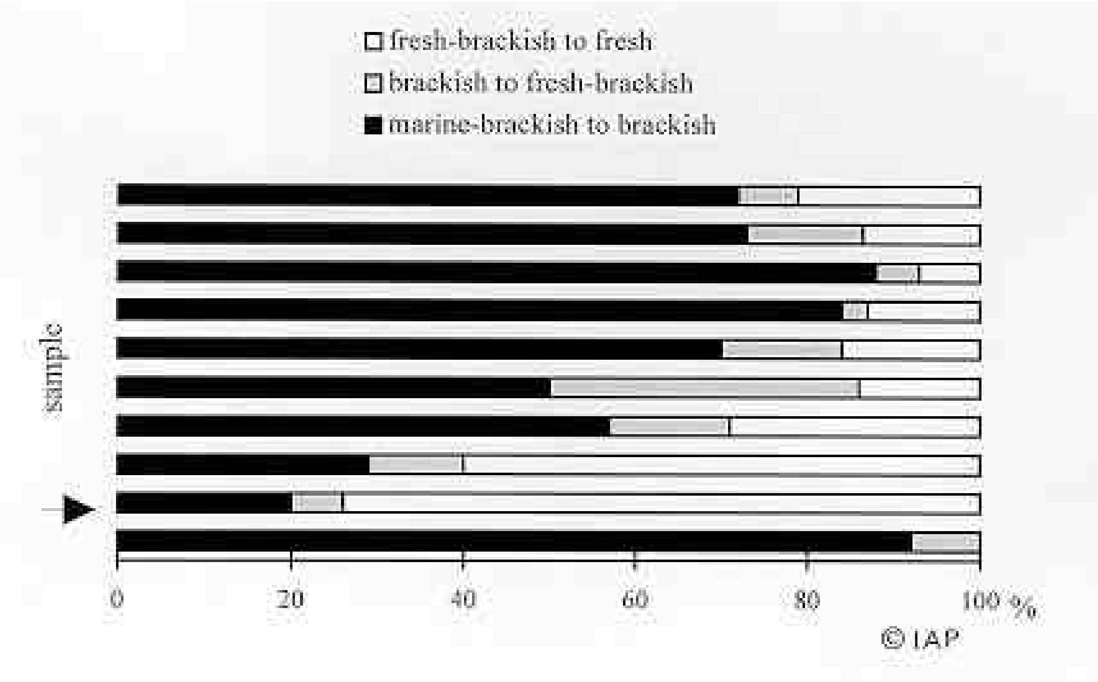
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