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Geoarchaeological research of the large palaeolake of the Moervaart (municipalities of Wachtebeke and Moerbeke-Waas, East Flanders, Belgium) From Late Glacial to Early Holocene

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Summary

The prehistoric settlement and land-use systems in the area of Sandy Flanders are being studied in a multidisciplinary research project. In this article, some preliminary results of recent fieldwork along a major Late Glacial palaeolake, called the Depression of the Moervaart, is described, including the excavation of a trench in the deepest part of the fossil lake, manual and mechanical coring and sampling and geophysical survey.

Keywords: Depression of the Moervaart, geoarchaeology, auger survey, geophysical survey, palaeoecology, sedimentology, Late Glacial, Holocene, Wachtebeke, Moerbeke-Waas, East Flanders (B).

1. Introduction

The area of Sandy Flanders in Belgium is roughly situated between the North Sea coast, the lower course of the Scheldt river and the city of Antwerp. Although remnants of older (Middle Palaeolithic) habitation have been found here (Crombé & Van der Haegen, 1994), its major colonisation started at the transition of the Pleistocene to the Holocene (the Late Glacial period). A long tradition of Stone Age research at Ghent University revealed, mainly through systematic field surveys and excavations, numerous prehistoric sites in this area dating from the Final Palaeolithic to the Neolithic. An inventory of the collected data shows a discontinuous spread of sites, both geographically and chronologically (Sergant *et al.*, 2009).

During the Late Glacial and Holocene the landscape in Sandy Flanders was subjected to major changes due to climatic fluctuations. These changes could have influenced settlement conditions throughout time. In this light a multidisciplinary project, funded by the Special Research Fund, was started in 2008 at Ghent University (Belgium), titled «Prehistoric settlement and land-use systems in Sandy Flanders (NW Belgium): a diachronic and geo-archaeological approach» (see also: www.prehistoriclandscapes@ugent.be). The project seeks to analyse the impact of the landscape on the choice of settlement location in this area. It is expected that a detailed environmental, vege-tational and hydrological reconstruction will provide insight in these conditions (Lowe & Walker, 1997). To determine the suitability of a certain land type for a certain activity, it is necessary to understand the different types of land use (hunting-gathering, farming,...) as a function of the environmental characteristics at different time intervals. Therefore a diachronic geoarchaeological study of both low and high density occupation areas is needed, comprising a detailed archaeological and environmental survey and analyses of these areas. Next to archaeological research, the project includes a GIS-based geographical study, a hydrological and pedogenesis modelling, palaeoecological research and a geophysical survey. Within the framework of this multidisciplinary research project, fieldwork has been undertaken in the area of the socalled Depression of the Moervaart (municipalities of Wachtebeke, Moerbeke-Waas, Eksaarde (Lokeren), Eastern Flanders; fig. 1).

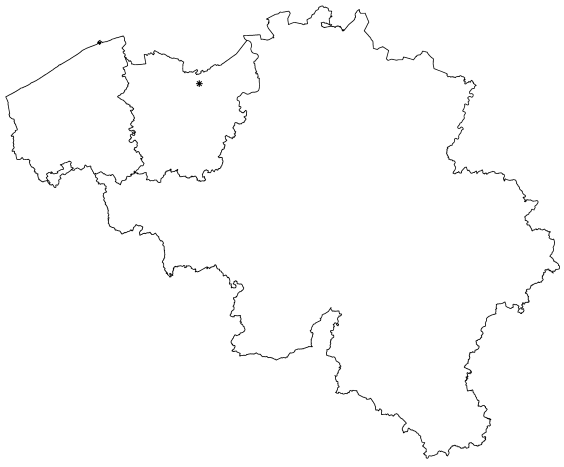

Fig. 1 — Localisation of the research area.

2. *Study area*

In this article, we focus on the recent fieldwork in the area of the Depression of the Moervaart, a vast but shallow Late Glacial fossil lake, filled with layers of peat and lake marl. The lake extends over an area of approx. 15 km by (max.) 2.5 km. In the North it is bordered by the massive cover sand ridge Maldegem-Stekene (Heyse, 1979).

Given the high amount of sites along the borders of the lake and on the cover sand ridge, this seems to have been an attractive settlement location in prehistory (Crombé, 2005; Crombé & Verbruggen, 2002; Van Vlaenderen *et al.*, 2006) and was therefore selected as one of the core study areas of the project. The distance between archaeological sites belonging to the same chronological stage is less than a few hundred meters. These close-lying sites sometimes form large site-complexes extending over several kilometres distance and covering many hundreds of hectares, probably reflecting «redundant or persistent places» with a presumed high ecological value. Habitation, however, seems to have «moved» in time, and is completely absent in protohistory. To understand the variability, evolution and change in site location, it is necessary to understand environmental parameters such as the lake's geomorphology and hydrology. Therefore several actions, including fieldwork, have been taken.

3. *Recent fieldwork*

The aim of the recent fieldwork is the reconstruction of the palaeolandscape with its hydrological system, in order to understand the evolution history of the lake and to locate possible high potential areas for prehistoric sites. Fieldwork consisted in both manual and mechanical corings, geophysical survey and fieldwalking (fig. 2). Also, a trench was dug in the deepest part of the palaeolake.

a. Manual coring

So far, five north-south transects have been made in the central part of the depression by means of manual corings at a 25 m interval. The localisation of the transects was mainly based on a combination of a Digital Elevation Model (DEM) (based on high precision airborne LiDAR - Light Detection and Ranging - data

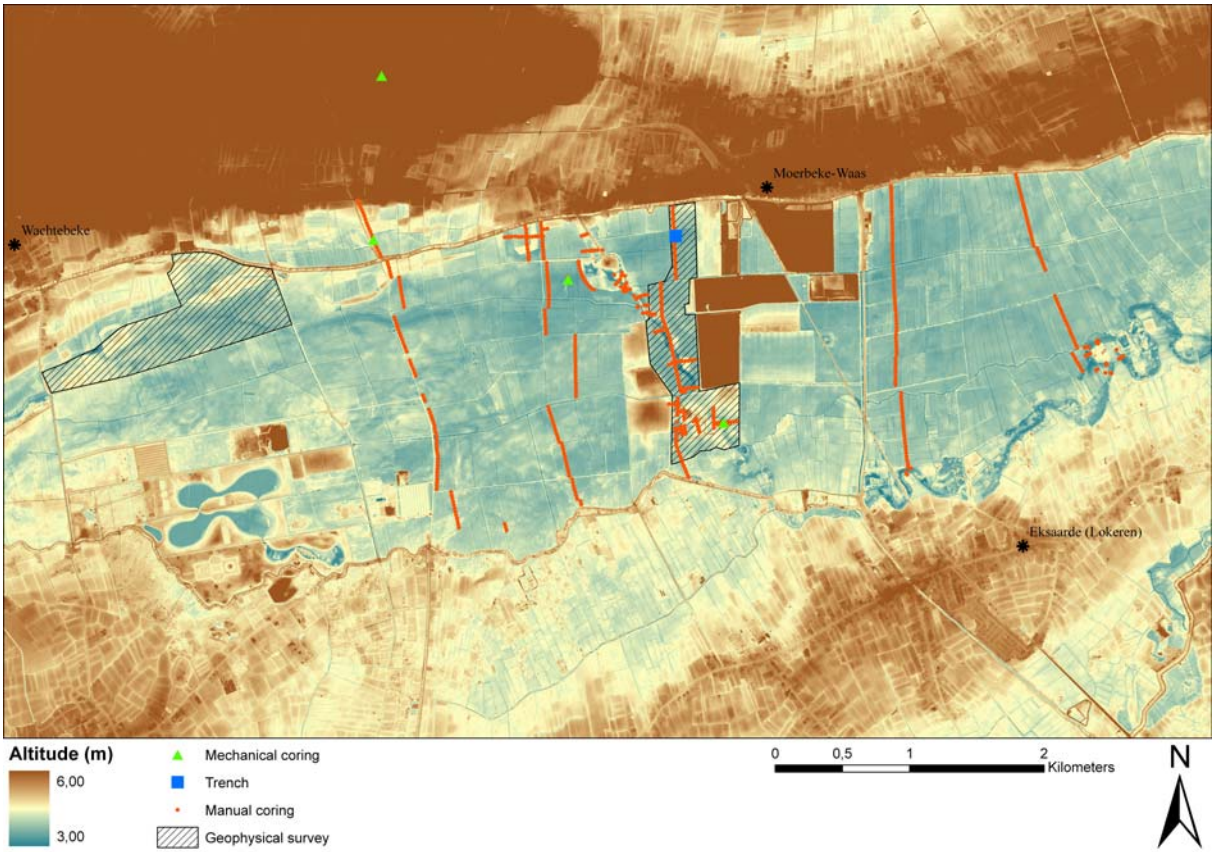

Fig. 2 — The fieldwork action in the Depression of the Moervaart on the DEM.

with an altimetric accuracy ranging from 7 cm to 20 cm depending on the surface cover), orthophotographs (scale 1: 10,000), historical- and geomorphological maps (De Moor & Heyse, 1973) and older research results (Heynderickx, 1982). When necessary, the auger interval was reduced to smaller distances between the boreholes, and several smaller transects were made when additional information was required.

Depending on the sediments, a Dutch auger (Edelman 7 cm diam.) or a gouge auger (3 cm diam.) was used. All corings were described in detail, measured with a GPS (precision 2 cm) and located within a GIS environment. The transect profiles are visualised with RockWorks 2006.

b. Geophysical survey

For detailed geomorphological reconstruction, near-surface geophysics was included in the field programme. The main focus of the 2009 geophysical fieldwork was directed to the westernmost extension and the central part of the palaeolake. In a first stage, the applied techniques were based on electro-magnetic induction (EMI).

The primary aim was to evaluate the possibilities of mapping the soil apparent electrical conductivity (ECa) and magnetic susceptibility (MS) for the reconstruction of hydrological features dating to the Late Glacial and early Holocene. Further goals included locating areas with potentially well preserved environmental data such as peat sequences and assessing the use of the DEM (Werbrouck *et al.*, 2009) as a palaeotopographical guide.

A mobile setup, combining a Dualem-21s integrated EMI-senor with a small all-terrain vehicle (ATV) enabled continuous mapping of the ECa and MS. While the ECa can be related to parameters such as clay and water content, MS-variations can be indicative of organic matter content and the presence of ferriferous or heated objects. The applied sensor combines both of these signals in different configurations so that information about these parameters is gathered at different depths (fig. 3) ranging from 0.5 m to over 3 m. This way a multi-layered dataset is obtained which enables detailed modelling of the palaeotopography (as illustrated in: Saey *et al.*, 2008). Surveyed areas were scanned by towing the sensor in parallel lines with in-between distances of 2 m and 3 m apart and a measurement interval of 20 cm to 30 cm[1]. The obtained data were then interpolated using ordinary kriging and were visualised in a GIS.

1 Measurements are taken at a frequency of 8 Hz indicating 4 ECa and 4 MS signals are processed every second. At a speed of eight km/h this results in 1 measurement set per 0.2 m. For further technical information we refer to (Simpson *et al.*, 2009).

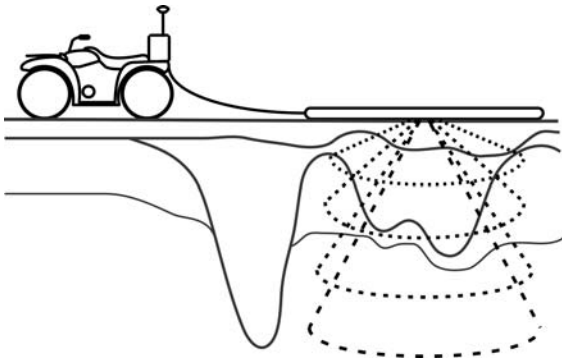

Fig. 3 — Schematic illustration of the ATV towing the Dualem-21s EMI-sensor. The dashed lines represent the 4 different signal response depths (i.e. 0-0.54 m, 0-1.03 m, 0-1.50 m and 0-3 m).

c. Trench

A 70 m long, north-south orientated trench was mechanically dug in order to study the infilling and sedimentation of the lake in detail. The complete east profile was photographed and drawn in 1/20 scale. At nine locations, more detailed drawings were made of selected parts of the profile (scale: 1/5). The profile was sampled for palaeoecological, sedimentary and dating purposes and a tentative general lithology was described.

d. Mechanical coring

Mechanical coring allows continuous sampling of sediments. A total of 15 cores were collected with a mechanical hollow auger (Nordmeyer HBS-RKR) at four different locations within the Depression of the Moervaart and on the cover sand ridge. These locations were chosen for palaeoecological, sedimentological and dating purposes (see further). All samples were collected in plastic pvc-tubes of 12.5 cm diameter and then transported to the different labs for further processing.

e. (Additional) fieldwalking

Although the area has been surveyed intensively in the past (Van Vlaenderen *et al.*, 2006), circumstantial finds during auger and geophysical survey demonstrated the high potential for stone age sites at several «new» locations. Further systematic fieldwalking has only been undertaken at a few locations in the study area so far.

4. Preliminary results

As the project is less than halfway, all results so far are provisional and incomplete. Nevertheless, all different

fieldwork actions, and especially the combination of them, proved to provide very useful data.

The systematic auger survey showed a far more complex history and genesis of the Late Glacial lake than originally suggested by Heynderickx (1982). This was mainly due to the denser auger interval, revealing more geomorphological features. The typical lake marl sediments are far more complexly stratified and distributed. Several smaller palaeochannels/gullies were recognised within the lake marl deposits. Also, the pleniglacial surface appears to be very irregular, with several smaller sand ridges.

Combined with the DEM and historical maps, a large and deep palaeochannel could be traced near the historic site of Wulfsdonk, in the centre of the research area where it crosses the Depression of the Moervaart from north to south (or possibly south to north: this remains to be sorted out). This palaeochannel is still partly visible in the landscapes due to peat extraction as it was the case in the nature reserve of the «Turfmeersen». In the north, it makes a sharp turn to the west and meanders along the course of the present Moervaart. In the South of the depression, it flows east towards the Zuidlede. The palaeochannel is 30 m wide and at least 6 m deep at some locations and is filled in with organic gyttja and peat. The top of the peat has been extracted, probably in the late Middle Ages. These peat extraction pits have been mostly filled in with sand or clay. As the palaeochannel clearly cuts through the lake marl sediments, it can be assumed that it is younger than the Late Glacial lake which probably was reduced to a mire by then.

At the inner side of the meanders of the palaeochannel, a number of sandy elevations (point bars) occur. In the wet environment of the Moervaart depression, these dry spots served as (sub)recent habitation locations such as the medieval site of Wulfsdonk. Possible earlier habitation has been wiped out this way. Others, however, are well preserved and have high potential for prehistoric sites. On several such locations, flint artefacts have been found already but more systematic research (fieldwalking and/or augering) is needed here.

The large palaeochannel has been intensively sampled at two locations by means of mechanical coring:

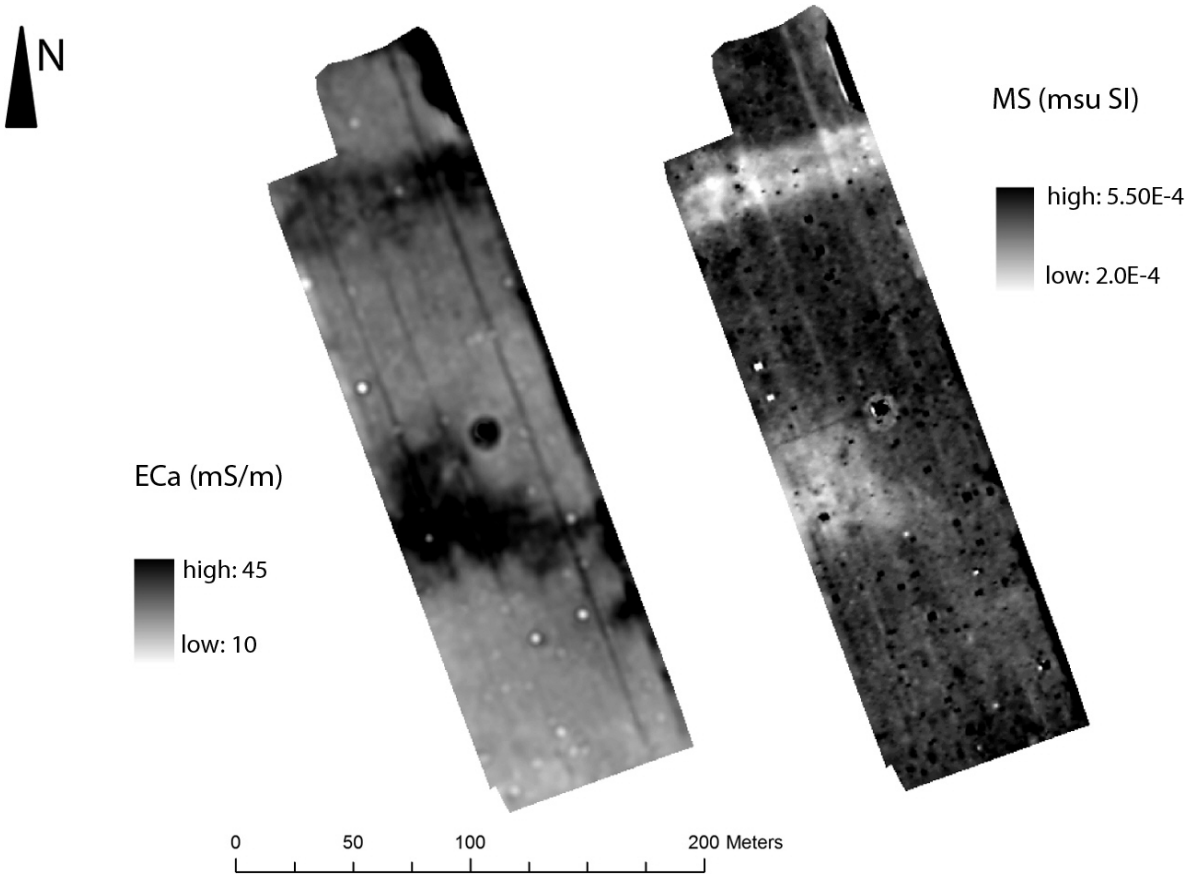

Fig. 4 — ECa and MS plots of a field in Wachtebeke. The high ECa and low MS values running in horizontal bands across the field indicate the peaty and silty filling of two palaeoriver branches.

first in the north-south running section, near the river Zuidlede, and next in the northern section that runs parallel with the present Moervaart. With these samples, which are currently being processed, we hope to gain insight in the geochronology and palaeoenvironment of the palaeochannel.

While the large palaeochannel clearly cuts through the Late Glacial lake sediments, several smaller channels/gullies were recognised within the lake marl as well. Some were already clearly visible on the DEM and/or orthophotographs, especially in the western part of the depression where they seem to show a braided pattern. These smaller gullies were far more difficult to trace with hand auger survey, as they are both shallow and narrow. Geophysical survey on the other hand, proved to be very efficient in detecting and visualising these features. The current survey campaign was set up to gain insight into the drainage patterns of the western part of the palaeolake. Until now more than 40 hectares have been surveyed using EMI, an area that will be extended over the following months. Validation and calibration of the survey dataset will simultaneously be taken on by hand coring and down hole ECa and MS probing. The first results show a clear physical distinction of the palaeochannel system within the sandy and marly sediments of the Moervaart depression. Figure 4 shows the ECa and MS plots of a field intersected by two palaeochannel branches, clearly visible in both signals.

A mechanical core sample was collected in what seems to be one of the larger, if not the largest, of these gullies in the lake marl. This gully can clearly been seen on the DEM from west to east. At the site of Wulfsdonk, it seems to be intersected by the large palaeochannel mentioned above. The coring took place west of Wulfsdonk, where the gully was nearly 2 m deep. To the east of Wulfsdonk, a long trench was dug through the deepest part of the Late Glacial lake. Further research will try to establish the relation between the described gully and this deeper part of the lake.

The trench showed a very complex stratigraphy (fig. 5). In the deepest part, the lake sequence was ca. 2 m deep, at the southern end of the trench it was about 1.20 m deep. A general lithology was described in the field, indicating observed layers. At the bottom of the trench, it is presumed that the pleniglacial sediments were reached, consisting of fine, calcareous sands. On top of this, a peaty layer of approx. 25 cm is observed (called the lower peat). This peat is stratified and contains some molluscs. Above the peat lies a thick layer of thinly laminated lake marl with more organic and more sandy layers. Molluscs are distributed throughout this layer and in the deepest part of the lake, two layers with (possibly) charred plant material were observed. Then a strongly stratified peaty layer follows (the middle peat). Molluscs are found in this peat but not in all layers. In the deepest part of the lake, a thin layer with aeolian sand occurred within the middle peat. This layer was also sampled for OSL dating. On top of the middle peat again a thick layer of lake marl is situated, which is rather sandy and laminated in broad bands below and more vaguely laminated above. Molluscs are less clearly visible but still present. The uppermost layer is a peat layer (the upper peat) which is only very locally (in the deepest part of the lake and in a tree fall feature) and partly preserved. Most of it

Fig. 5 — Picture of a detail of the eastern profile in the trench.

has degraded due to ploughing activities and it is presumed, although not yet proven, that peat extraction occurred here.

In the past, already two sequences from the deepest part of the Late Glacial lake were studied (Verbruggen, 1971; Verbruggen, 2005). These sequences were sampled ca. 1.4 km to the east of the above described trench. The studied sequences are very similar to the trench and were, based on palynological data, dated from the early Oldest Dryas (Ia) to the second part of the Allerød (IIIb). From the early Youngest

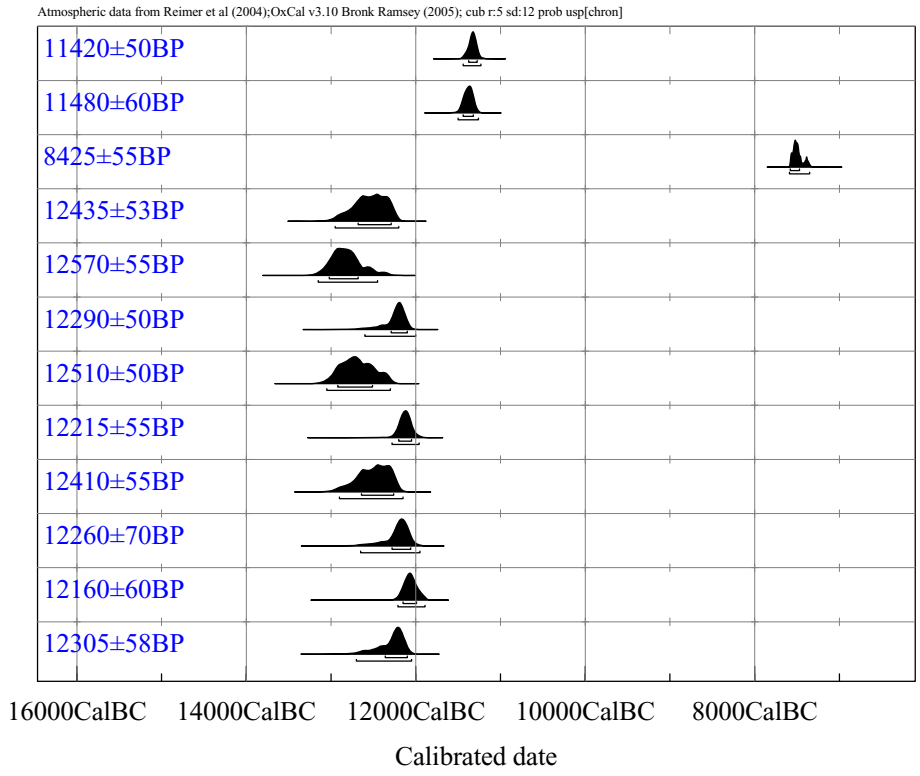

Fig. 6 — Calibrated radiocarbon dates from the lake marl sequence.

Dryas to the Boreal, Verbruggen (1971) notes a gap in the sequence chronology. The top of the sequence is placed in the Subatlantic period. Absolute dating of the first sequence however was problematic, as only the base of the sequence was dated. This dated the start of the sequence around 12000 uncal. BP (Verbruggen, 2005). The second sequence was dated between 75 and 185 cm beneath surface (Van Strydonck, 2005; fig. 6). Between 185 and 95 cm beneath surface, the sequence was dated around 13000-12000 calBC. Above, up to 70 cm beneath surface, the dates are situated around 11000 calBC. This implies that the major part of the lake sequence is dated in the Bølling period while the upper part was formed in the Allerød. With a new series of ^{14}C and OSL datings from the trench, the lake chronology will be improved.

Finally, to get more insight in the relation of the lake to the cover sand ridge, and in the chronology of both, the latter was sampled using mechanical coring at the top and at the southern base of the ridge, close to the large palaeochannel. Both samples still have to be studied. A first evaluation of the sample on top of the cover sand ridge indicates a possible distinction between the pleniglacial sediments and the aeolian cover sands, with several thin organic/peaty layers in both. Here, a second core was taken for OSL dating.

5. Conclusions

The Late Glacial and Early Holocene evolution of the Moervaart Depression is very complex but essential to comprehend when studying the prehistoric occupation dynamics of the region in prehistory. This can only be done through comprehensive multidisciplinary research. In this article, we focussed on the recent fieldwork executed in the area in order to gain elaborate palaeoecological and geomorphological/sedimentological data.

Although research is still ongoing, geophysical and archaeological auger survey revealed interesting and useful information on the possible location of prehistoric sites on the one hand and suitable locations for sampling for palaeoenvironmental data on the other.

Mechanical coring provided large, minimally disturbed samples of sequences from the cover sand ridge and palaeochannels.

In their study of a Late Glacial lake near Bruges (B), Denys *et al.* (1990) stated that «cores from very shallow lakes offer a far more local, and often more complicated and less well preserved record, than those taken in deep and large basins. On the other hand the rapid and marked response of small water bodies to environmental changes justifies their palaeolimnological study. As could be expected from such a hydrologically

and ecologically sensitive system, the ontogeny of this small lake strongly depended on regional climatic changes and basin processes such as vegetation and soil development». This can also be expected for the shallow Late Glacial lake of the Depression of the Moervaart, being the largest within Flanders. Therefore, the complete profile has been abundantly sampled for palaeoecological (e.g. pollen, molluscs, beetles, macroremains, chironomids, diatoms) and sedimentological study and for dating purposes (^{14}C and OSL).

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