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Potential of cone penetrating testing for mapping deeply buried palaeolandscapes in the context of archaeological surveys in polder areas

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A B S T R A C T

Geoarchaeological mapping of wetlands conventionally involves extensive coring. Especially in wetlands marked by a deep palaeosurface (>3 m deep) this can be very difficult and time-consuming. In this paper we therefore present an alternative approach based on Cone Penetration Testing (CPT) for structured, rapid and cost-effective evaluation of buried palaeolandscapes. Both estuarine and river floodplain environments were investigated, including the water–land transition zone (marsh). The efficiency, reliability and repeatability of the CPT method was tested through the comparison with ground-truth core data. The CPT data generally allowed highly accurate mapping of the palaeotopography of the prehistoric surfaces and the overlying peat sequences. Thin organic-rich clay intercalations within the peat layers could often still be identified. Additional pore pressure, conductivity and seismic velocity data (from CPT-U, CPT-C and S-CPT) did not add much crucial information and their main use seems to lie in the added value for near surface geophysical measurements. The results of this research clearly illustrate the importance of CPT information for mapping of palaeolandscapes in archaeology.

1. Introduction

The potential of wetlands, estuarine and riverine areas for understanding past human exploitation and palaeolandscapes has been demonstrated by many studies (Bell, 2007; Rippon, 2000; Coles, 1987). These areas are often marked by thick peat deposits known to be a rich source of archaeological and palaeoenvironmental information since they often include ecofacts and artefacts that are generally not preserved in other, dryland contexts (Coles, 1987). However, wetlands are also very complex and dynamic environments and understanding the processes of sedimentation and erosion is crucial in order to detect and study archaeological sites (Howard and Macklin, 1999).

Geoarchaeological mapping of wetlands usually involves two main phases (Groenewoudt, 1994; Tol et al., 2004; Bats, 2007; Bats and Crombé, 2007; De Clercq et al., 2011; Crombé and Verhegge, 2015). A first, crucial phase concerns the detailed mapping of the sealed palaeoenvironment, especially the palaeotopography, and its evolution (i.e. preservation) through time and in relation to the sediment dynamic regime. In a second phase, based on these results, directed archaeological surveys can be carried out on specific locations in view of detecting buried archaeological sites. Previous research in the coastal and riverine wetlands of N Belgium (Crombé, 2002, 2005) and the Netherlands (Peeters, 2007) has shown that most prehistoric occupation sites are situated right below the peat on former higher Pleistocene grounds (river dunes, levees, scroll bars, etc.) and often along open water systems (river channels, creeks), whereas younger settlement sites are usually situated on top of the peat and in the covering clay sediments. Therefore detailed mapping of the peat deposits is crucial in order to reconstruct the palaeorelief and hence to locate potential archaeological zones and levels within this buried landscape.

Until now geoarchaeological and palaeoenvironmental mapping on land has commonly been achieved through manual coring and to a lesser extent by mechanical drilling set in narrow and fixed grids or in transects (Groenewoudt, 1994; Bats, 2007). Manual cores, using 3 cm gouge augers, are effective but very time-consuming, hard work and in the case of deeper layers (below 4–5 m) they are very difficult to obtain and seldom successful. In

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addition manual drilling below groundwater level and/or through certain sediments, such as coarse sands or woody peat, can be seriously hampered by the sediment texture or presence of large organic matter. Mechanical drillings (e.g. Sonic drill, Aqualock, Begemann) on the other hand are less affected by these problems but they are slow and the high costs can be a serious burden (Hissel et al., 2005). Furthermore palaeotopographical modelling by interpolation of palaeosurface depth points often does not allow accurate delineation of geomorphological features, possibly containing archaeological sites, making this sampling strategy prone to errors. Additional methods must therefore be explored which are less expensive, faster and allow accurate correlation between coring points. Recent work in the UK (Bates et al., 2007) has shown the advantages of such a mixed method approach.

In the framework of a recent Flemish research project we have tried to develop an alternative approach that allows structured, rapid and cost-effective evaluation of the buried palaeolandscape in estuarine polder areas, including the water–land transition zone. This approach focuses both on the (combined) use of near surface geophysical methods such as seismic, electrical, and electromagnetic survey (Verhegge et al., 2015, submitted for publication), as well as on geotechnical investigations such as Cone Penetration Testing (CPT). Near surface geophysical methods can be hampered by variations in groundwater salinity in combination with the presence of peat (Orbons, 2011), a clay-rich heterogeneous or contaminated top-soil and the burial depth of the prehistoric landscape. In these cases, CPT investigations may provide an answer. The CPT method has been in use for over 70 years in Belgium (Lousberg et al., 1974) and is commonly recognized as a fast, repeatable and economical method for site investigation, but up to now it has largely been neglected in geoarchaeological research, except for a few occasional studies (e.g. Bates and Stafford, 2013; Roozen et al., 2013; Brandenberg et al., 2009).

2. Aims of the study

The main goal of this study is to assess the potential of the electrical CPT method for the palaeotopographical and palaeoenvironmental reconstruction of deeply buried prehistoric landscapes in estuarine polder areas in Flanders. This does not only regard mapping the depth of possible occupation horizons, which are often related to transitions in the sedimentary environment, but also the nature of the different depositional layers (i.e. lithostratigraphy) (Amorosi and Marchi, 1999). This palaeotopographical and lithostratigraphic information is crucial for subsequent archaeological prospection as it will allow efficient sampling at the correct location and depth of possible archaeological sites locations.

Two study-areas within the Scheldt valley of NW Belgium were chosen as test sites (Fig. 1): (1) the site of Doelpolder Noord located in the Waasland polders in the Lower Scheldt estuary, and (2) the alluvial site of Kerkhove located further upstream in the floodplain of the Middle Scheldt river. In both sites the base and top of the peat are known to be important reference horizons for (pre)historic occupation: the base of the peat reflects the relief of the underlying Pleistocene landscape (an important level for Stone Age sites), whereas the top of the peat is an important indicator related to more recent (early historic) occupation (Crombé, 2002, 2005; Bats et al., 2008). In addition, the Scheldt polders are threatened by the continuous expansion of the Antwerp harbour and imposed nature compensation through coastal realignment. Hence there is an urgent need for a detailed, rapid archaeological and palaeoenvironmental evaluation strategy. Therefore accurate mapping of the peat layers was crucial.

An important focus of this research is on the efficiency, applicability, reliability and repeatability of the applied CPT method. This is a.o. tested through the comparison with various ground-truth data (mainly shallow manual cores but also a few deeper mechanical cores) that were either available from previous (archaeological) investigations or newly obtained at the test site.

3. Shallow geology of the study area

The study area of Doelpolder Noord (Fig. 1) is located in the Lower-Scheldt polders in the NW of Belgium, near the Dutch border. The Tertiary geology here consists of a shelly sand (Formation of Lillo) and is covered by Late Pleistocene fluviatile sand

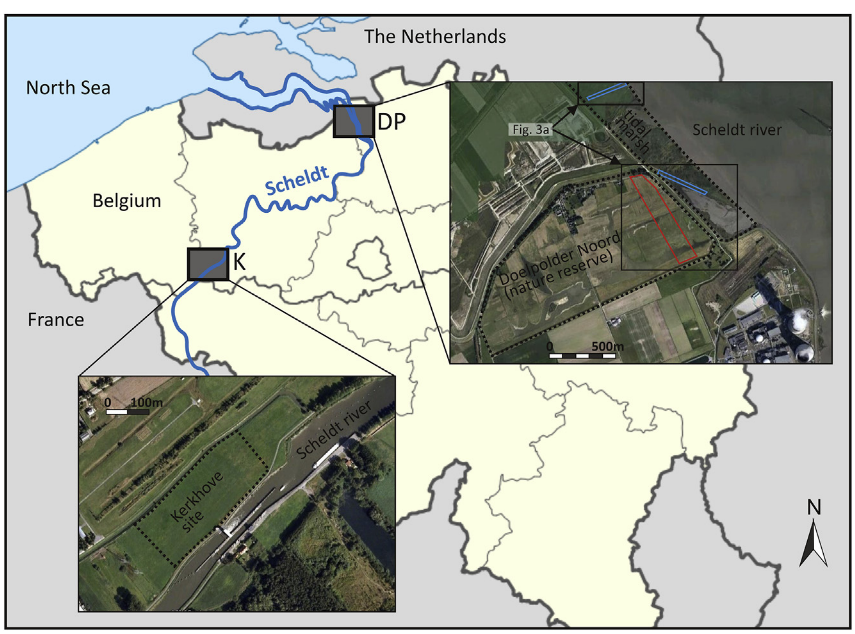

Fig. 1. Overview map of the site locations of Doelpolder Noord (DPN) and Kerkhove (K). The river Scheldt is marked in blue. Colour rectangles indicate the investigated areas in Doelpolder Noord (red: polder; blue: marsh). Aerial images © Agiv. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)