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A staged geogenetic approach to underwater archaeological prospection in the Port of Rotterdam (Yangtzehaven, Maasvlakte, The Netherlands): A geological and palaeoenvironmental case study for local mapping of Mesolithic lowland landscapes

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ABSTRACT

This study presents the geogenetic approach to detect presently drowned archaeological sites in the transgressive palaeoenvironment of the Holocene Rhine-Meuse delta. A staged and practical approach is advocated in which subsurface archaeological predictions are based on geological mapping and palaeoenvironmental reconstruction of the underwater location. The study area is located in the Maasvlakte harbour extension of the Port of Rotterdam, formerly a part of the southern North Sea. Prior to construction works, it was suggested that dredging of the new harbour (Yangtzehaven) would disturb the subsurface stratigraphy to around −21 m below present mean sea level, a zone which is known to contain archaeological remains. The staged approach makes use of geological data starting from a conceptual model that indicates the depths of layers that could be rich in Upper Palaeolithic/early Mesolithic artefacts. This initial model is used to determine the strategy of the subsequent phases of investigation, such as whether to proceed with dredging as part of the engineering work, down to 17 m water depth, to remove the upper (younger) sands and thereby improve the opportunities for underwater survey of fluvio-deltaic layers of Mesolithic age. Following the development of the initial site model, a full-area investigation was carried out using geophysics and coring, the latter providing material for palaeoenvironmental analysis. This allowed the reconstruction of the long-drowned former landscape, which included inland dune areas and local drainage systems and provided the physiographic context for the geoprospection of Mesolithic archeology. This predictive modeling identified two areas in the harbour for detailed investigation, again employing geophysics and coring at higher resolutions, allowing fine tuning of the palaeolandscape models at the localities of presumed highest archeological potential. Cores from one of the selected areas, an inland dune area within the Early Holocene wetland region, yielded in-situ evidence of Mesolithic occupation of this site in what is now the southern North Sea. These finds and the palaeolandscape context created with the data from the prospection phases were critical in the decision to undertake an underwater archaeological excavation using a large, boat-mounted grab sampling system. This paper provides an account of the geological and palaeoenvironmental work undertaken in the prospective phases leading up to the discovery of the site, highlighting the importance of the staged geogenetic approach for informing sampling strategies and securing high-quality information on landscape contexts, which in turn, informed archaeological decision-making and geoprospection strategies. Such an approach has wider generic application for palaeolandscape reconstruction and mapping at regional scales.

1. Introduction

The archaeological potential of the continental shelf has long been recognized (e.g. Fischer et al., 2011). Driven by fluctuations of

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Fig. 1. Location of the Yangtze harbour within the Maasvlakte area (Port of Rotterdam, the Netherlands).

many tens of metres in sea-level change over the Pleistocene and Early Holocene, many prehistoric archaeological sites and palaeolandscapes around the coastal margins are now submerged. Consequently, it is not uncommon to find scattered traces of Palaeolithic and early Mesolithic human activity in shallow coastal waters (e.g. Momber, 2000, 2011; Hijma et al., 2012; Stapert et al., 2013; Bicket et al., 2011). Underwater archaeological investigation has recently experienced renewed interest (Peeters et al., 2009; Peeters, 2011; Peeters and Cohen, 2014). Fitch et al. (2005) and Gaffney et al. (2007) ascribe the increasing activity on the one hand to developments in the archaeological sciences and, on the other hand, to improved technologies for reconstructing palaeolandscapes such as those of the Dogger Bank area in the central North Sea. Compared to archaeological campaigns on land, underwater investigations are particularly challenging in terms of costs, risk of failure and data uncertainties (Bailey, 2004). Consequently, an underwater archaeological study is typically carried out at substantially less sampling resolution than an equivalent terrestrial study. Palaeogeographic reconstruction (i.e. the creation of ‘palaeolandscape models’ based on a combination of geological mapping, dating and palaeoenvironmental research), is an essential methodology for determining areas of preservation and targeting geological surfaces with high archaeological potential (e.g. Schmölcke et al., 2006; Bailey and Flemming, 2008; Bailey and King, 2011), especially in drowning coastal areas that have experienced tectonically subsidence and/or sea level rise, such as the southern North Sea (Cohen et al., 2014). Furthermore, the development of palaeolandscape models is essential to place archaeological finds in their environmental context when discovered.

Site investigation using multiple techniques is key to the construction of palaeolandscape models. Geophysical methods are commonly applied in offshore environments (e.g. Gaffney et al., 2007; Van Heteren et al., 2014). Comparison and correlation of geophysical data with more rarely available *in-situ* data such as borehole logs, allows for the identification of relevant layers in the geophysical data (ground truthing). Furthermore, by combining information on Holocene sea-level rise with the elevation of the youngest terrestrial palaeosurfaces on the seabed, former environmental conditions, location of human settlement and movement/migration patterns can all be understood (e.g. Veski et al., 2005; Dolukhanov et al., 2010; Stock et al., 2013). With such knowledge charted in archaeological prediction maps, site prospection and heritage management efforts can be focused on the areas with the highest potential for finding archaeological remains, enabling systematic, efficient geoprospection, recovery, and protection of large, archaeologically sensitive areas.

This study presents the application of an innovative, staged methodological approach for predictive underwater landscape mapping, developed as part of an archeological investigation in the Yangtze harbour site (Maasvlakte, Port of Rotterdam). The Yangtze harbour was extended and deepened to connect the Maasvlakte 2 new seaward harbour extension of the Port of Rotterdam (The Netherlands; Fig. 1) to the existing Maasvlakte 1 extension that was built in the 1970s and early 1980s. Maasvlakte 2 is the latest enlargement of the Port of Rotterdam, one of the largest and busiest harbours globally. Construction work started in 2007 and the interconnecting harbour was built in several stages; in total, it is approximately 3 km long and 500 m wide, an area of about 1.5 km^2. In 2009 most of this area was deepened to 17 m −(NAP; this is the Netherlands ordnance datum and equates to present mean sea level). By the end of 2011 the harbour was dredged to the maximum depth of 20 m −NAP, destroying the former Late Pleistocene land surface and the Early Holocene deltaic deposits covering it, including archaeological-bearing strata. In order to mitigate the destruction of the cultural and environmental remains, geological and archaeological surveys were undertaken between 2009 and 2011 with the aiming of identifying potential archaeological heritage remains (Smit, 2011). The final cut-through and creation of the harbour occurred in 2012 (Fig. 2) and the area has since been renamed the Yangtze canal. The works are scheduled to finish in 2014.

From previous regional geological mapping it was known that a complex stack of deposits of Late Pleistocene and Early Holocene age was to be encountered at the broad depth range of 17–25 m −NAP, below the bed of the proposed extended and deepened harbor (Hessing et al., 2005; Moree et al., 2012; Weerts et al., 2012).

Fig. 2. Aerial view of the Yangtze harbour after the cut-through of the harbour between Maasvlakte 1 and 2 in 2013.