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Use of phosphorus mapping in assessing coastal activity zones of an Icelandic multi-period site of Vatnsfjörður

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ABSTRACT

This paper presents the results of phosphorus mapping conducted on a number of coastal activity zones on the multi-period, archaeological farm site of Vatnsfjörður, northwest Iceland. The aim of the study was to detect the exact levels and extents of shorelines contemporary with the archaeological site's activities and to use sea-level change to establish a relative chronology of coastal activity zones. Absolute dating of the coastal zones and sea-level changes was achieved by integrating an existing sea-level curve with a novel tephrochronology-based curve, created for the purpose of this research. Results were projected onto a detailed digital terrain model of the area in order to reconstruct the extent of the coastline contemporary with human activity in the respective zones. A significant component of the research was an attempt to develop the existing approach to phosphorus mapping results interpretation. This has resulted in an improved methodology that can be applied to the dynamic and challenging environments of coastal sites worldwide.

1. Introduction

Coastal zones of archaeological sites grant insight into a very specific set of past human behavioural practices. At the same time, they also present research challenges, such as shore displacement, which have consequences for past human activities and require specialised methodologies to understand. Phosphorus (P) mapping, very popular as an archaeological prospection method worldwide (Holiday and Gartner, 2007 with references; Rypkema et al., 2007; Sarris et al., 2004; Viberg, 2013), also has been suggested as a tool for identifying shorelines contemporary to human activity conducted in proximity to the water in the areas with raised shorelines (Arrhenius, 1945; Broadbent, 1979; Florin, 1948; Halén, 1994; Linderholm, 2007; Löfstrand, 1974; Nunez, 1977, 1978; Schnell, 1932; Siiriäinen, 1982; Simonsen and Lysnes, 1968; Sundström and Darmark, 2005; Sundström et al., 2006; Ilves and Darmark, 2011; Ilves, 2012). The method assumes that human activity in the coastal zone causes P enrichment of soil by means of continuous deposition of P-rich excreta and waste materials. On coastal sites, the shoreline provides a fixed border to the site, restricting the deposition of P-rich materials and affecting P distribution, which would normally decrease gradually in all directions as one move away from the core of the site. Water, as a special type of border, not only creates a limit for P deposition but also causes redeposition by tide and wave activity and has been found to cause distortions to the normal P distribution in the form of sudden drops or high-amplitude variations. The very existence of such distortions in P distribution maps at sites close to a former shoreline indicates the probable location of the former shoreline and points towards the sites being 'water-bounded' (for details, method history and wider discussion see: Ilves and Darmark, 2011). This methodology, with further development described in this paper, was therefore deemed appropriate for answering questions about the character of coastal activity zones and associated sea levels at the site of Vatnsfjörður, in the Icelandic Westfjords.

2. The site

The farm of Vatnsfjörður is located in the Vatnsfjörður fjord, in northwest Iceland, and has been continuously occupied from the

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10th century to modern day. The site consists of three components: the Viking-age settlement area, the medieval to early modern farm mound and an extensive coastal zone (Milek, 2011: 17–22). The coastline in the Vatnsfjörður area is not stable. Glacio-isostatic crustal movement and glacio-eustatic sea-level rise are responsible for relative sea-level (RSL) change in the area, first rising to at least 1 m above present-day levels in the mid-Holocene, then gradually falling to the present-day level (Norðdahl and Pétursson, 2005; Lloyd et al., 2009).

The archaeological coastal zone at Vatnsfjörður stretches c. 1500 m along the shoreline and consists of three pronounced subzones, all of which still bear visible traces of intensive use in the past (Fig. 1).

In zone A, two archaeological structures were identified near an early 20th-century building on the shoreline (Mikołajczyk and Gardeła, 2010: 42–44). One of these was a building ruin in the form of two 9 m long, turf-built, parallel walls, in which two phases were recognised, divided by a tephra layer from the Hekla volcano dated to 1693 AD (Mooney et al., 2012: 57–63). The early phase's construction technique and the turf material used resemble the Viking Age buildings at the nearby settlement site, but otherwise it is not possible to date it. Both the form of the ruin and associated finds, consisting mostly of cut and dismantled clenched nails, suggest that the building might have functioned as a boathouse. Unfortunately, there was little internal stratigraphy in the structure, making it impossible to attribute the finds to a particular phase or to confirm its function. This building is currently located 50 m from the shoreline and its use as a boathouse is debatable as the second structure in this zone – a dry-stone bank 100 m long and c. 0.7 m high – obstruct the building's access to water (Fig. 1A) (Mikołajczyk and Gardeła, 2010: 42–44; Mooney, 2011: 74–75). The H-1693 tephra layer was found in presumably *in situ* patches on the inner side of the stone bank, suggesting that it was erected before 1693 AD and thereby sheltered the tephra layer from the erosion. No other datable material has been retrieved from the area.

Zone B, located at the southernmost edge of Vatnsfjörður, is dominated by a ruin of a massive, 15 m long, U-shaped building (Fig. 1B) (Mikołajczyk and Gardeła, 2010: 48). It has been excavated (Mooney et al., 2012: 49–50, Mooney, 2013: 40–48), but despite the detailed information on its construction method, characterised by a very robust, 1.5 m thick, stone-lined, turf wall, its function and date remain unknown because it yielded neither datable material nor any other finds, and its internal floor layer is very thin and non-diagnostic (Mikołajczyk, 2013). The shape of the building is similar to boathouse constructions, but its orientation parallel to the modern shoreline seems to contradict the hypothesis that it was a boathouse. There is, however, an elongated depression in front of the structure. Long test trenches excavated across this linear depression as part of this study revealed that it was a dried-out stream bed, which, if sea levels were higher, could have been an inlet and channel facilitating watercraft access to the structure. The structure is stratigraphically below the H-1693 tephra layer, but it has so far not been possible to date it more precisely. In addition, there are three other ruins in the northern part of the same zone, all of which are in a very poor state of preservation (Fig. 1B). Two of them are c. 6 m long, U-shaped, overlapping boathouse-like structures and the third is a small, rectangular, stone-lined structure with walls abutting a natural bedrock outcrop. All three were test trenched as part of this study and were found to pre-date the H-1693 tephra.

Zone C has a 6 m long V-shaped ruin consisting of the foundations of a de-constructed dry-stone wall, with a visible keel mark in the beach in front of it (Fig. 1C). Nearby, to the north of this ruin, a narrow stone-built sea wall or quay foundation has been documented (visible in the aerial photograph in Fig. 1), but with no cultural layers detected around its base (Mikołajczyk and Gardeła, 2010: 50). Both structures are interesting because, unlike the other structures discussed above, they are close to the modern shoreline. No datable materials have been retrieved from the area.

3. Methodology

3.1. Sampling strategy

All three of Vatnsfjörður's coastal zones were subject to P transect mapping in order to determine whether past activities at these sites had been bounded by water, and, if so, to pinpoint the location of the sites' seaward boundaries, and, based on sea-level change models, the likely dates of their occupation (Fig. 1, Table 1). Each transect

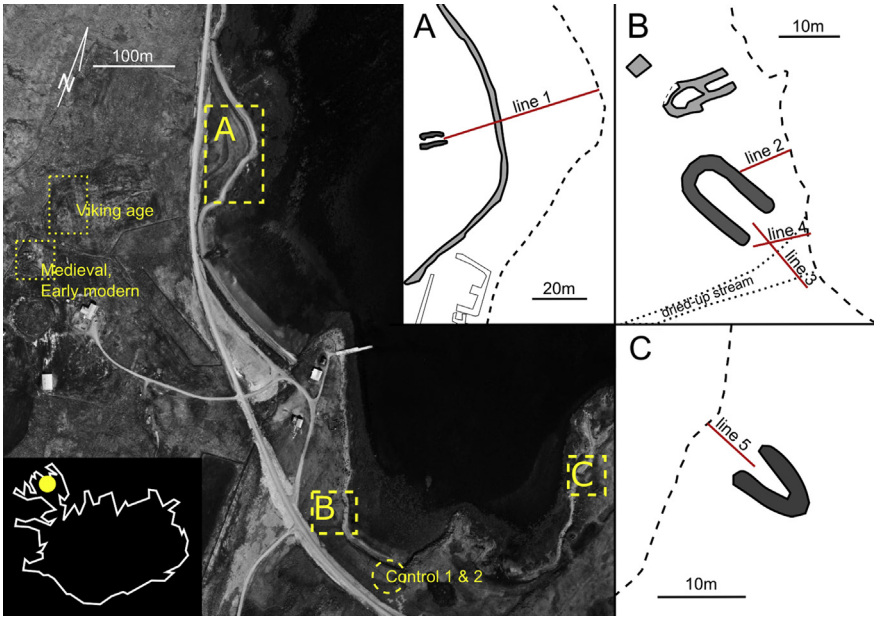

Fig. 1. Aerial photograph of Vatnsfjörður with detailed plans of sites in the coastal area. Dashed lines illustrate the location of the modern shoreline. Red lines depict the position of sampling lines. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)