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Geostatistical approach to spatial, multi-elemental dataset from an archaeological site in Vatnsfjörður, Iceland

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ABSTRACT

This paper presents the results of geochemical mapping conducted in the coastal zone of a multi-period archaeological (farm) site in Vatnsfjörður, northwest Iceland. The main aim of the study was to test the efficiency of geospatial analysis (based upon a principal component data fusion technique) in dealing with a multi-elemental dataset. The method was applied in order to distinguish between different zones of human activity across the site. The results enabled the site to be divided into discrete zones. In combination with previous studies, the new information enabled speculation about each zone's functional character, chronology and development history.

1. Introduction

Understanding the spatial patterning of human activity is of crucial importance to the interpretation of any archaeological site. Not every site has a well-defined stratigraphy, or a material record, that can be used to grant insight into the nature of the activities that were undertaken, and how these were distributed. In such cases, geochemistry can provide a cheap and effective solution for characterising the use of archaeological space. The core principle behind archaeological geochemistry is that human activity causes chemical distortion (enrichment or depletion) to the local substrate (Oonk et al., 2009; Middleton et al., 2010 with references). This chemical signal can be used to 'fingerprint' the types of activities that were taking place. There are, however, limitations to the method linked to difficulties in differentiating the origin of the chemical signal (Oonk et al., 2009). For example, problems arise when attempting to identify multiple deposition episodes, through the possible influence of diagenetic processes in altering the chemical signal (Middleton et al., 2010), and as a consequence of the statistical methods used to process multivariate datasets (Entwistle et al., 2007; Dore and López Varela, 2010). In this paper we highlight this problem and tackle it though the application of the methodological framework proposed by Dore and López Varela (2010) with some modifications. Rather than using only a limited suite of soil-chemical measurements (i.e. phosphates, carbonates, pH, protein residues, and fatty acids), we adopt an approach in which a multi-elemental dataset is produced and analyzed. In doing so we highlight the statistical procedures that we consider to be the most crucial for an informed interpretation of human activity at an archaeological site, using a farm in Iceland as our reference case. At this location, the interplay between human pressure and natural processes (e.g. relative sea level change) was considered important in influencing the pattern and character of activity, and therefore a method for establishing a wide range of elements was used (X-ray fluorescence). In such a situation, not only is the anthropogenic signal able to be studied, but also the natural processes affecting the site can be taken into consideration (Linderholm and Lundberg, 1994).

Geochemical studies of coastal archaeological sites are not unusual (see Knudson et al., 2004; Ilves and Darmark, 2011 with references; Misarti et al., 2011). There are several studies of this type in Iceland; most have used phosphate (P) analysis (Bolender, 2003, 2006; Simpson et al., 2002; Mikołajczyk et al., 2015), and there is one multi-elemental study (Milek and Roberts, 2013). This paper builds on previous research in this field through the application of archaeological geochemistry to the iron- and allophone-rich andosols that are specific to Iceland (Arnalds et al., 1995; Arnalds, 2004).

2. Study area

The farm of Vatnsfjörður is located in the Vatnsfjörður fjord, northwest Iceland, and has been continuously occupied from the 10th

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century AD to the present day. Written sources mention Vatnsfjörður as one of the original *landnám* farms that in the 12th and 13th centuries served as a Chieftain's seat. It was also the location of a church reputed to be the second wealthiest on the island. The site kept its privileged position until the end of 16th century. The site consists of three components (Fig. 1, left): 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) changes in the area. RSL was at least 1 m greater than at present during the mid-Holocene, subsequently gradually falling to the present-day level (Norðdahl and Petursson, 2005; Lloyd and Dickens, 2011; Mikołajczyk et al., 2015).

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). All three were targeted with small scale archaeological investigations (Mikołajczyk and Gardeła, 2010: 48; Mooney et al., 2012: 49–50; Mooney, 2011, 2013: 40–48, Mikołajczyk, 2013) and phosphorous (P) transect mapping (Mikołajczyk et al., 2015). The most complex situation was encountered in Zone B where at least two, not necessarily chronologically-discrete phases of activity of unknown intensity merge in a relatively small area. Henceforth results were deemed insufficient to understand the character of human occupation in this area and for this reason extensive multi-elemental mapping of the area was employed, the results of which are presented in this paper. Zone B is located at the southernmost edge of Vatnsfjörður and is dominated by the 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 – the building is characterised by a very robust, 1.5 m thick, stone-lined, turf wall – its function remains unknown. 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. Results of the P mapping (Mikołajczyk et al., 2015) revealed an unusual orientation, parallel to the modern shoreline, facing the embayment at times when sea level was higher. The aforementioned research managed to date the activity area in front of this structure to the late 15th century on the basis of its elevation relative to sea level at this that time; this agrees with the general *ante quem* date for human activity in the zone that is stratigraphically below the tephra from eruption of Hekla dated to 1693 CE. There are also three other ruins in the northern part of zone B, all of which are in a rather poor state of preservation (Fig. 1B). Two of them are c. 6 m long, V-shaped, overlapping boathouse-like structures and the third is a small, rectangular, stone-lined structure with walls abutting a natural bedrock outcrop. The activity area immediately east of the V-shaped structures was dated to late 12th century. The age of the rectangular structure is unknown. In the area to the west of the V-shaped structure, a slight depression in the terrain was noticed. A test trench placed there yielded some burnt seaweed fragments.

3. Methods

3.1. Sampling

316 soil samples were taken from 0.2 × 0.2 m shovel test pits placed according to a 1 × 1 m grid fixed on cardinal directions. Grid points were recorded with the use of a Trimble DGPS unit, with 1 cm accuracy. Special care was taken to sample soil strata recognised as corresponding to the archaeological structures. However, due to the thinness of the soil and the patchiness of the only chronological marker on the site (the H-1693 tephra layer), in some cases, samples had to be taken at an arbitrary depth of 0.05 m below the dense grass root mat (as that was the average depth of the H-1693 tephra when present). Additionally, a control group of 20 soil samples was taken in an opportunistic manner from two neighbouring areas without any visible archaeological features (Middleton and Price, 1996).

3.2. Sample processing

336 samples, each weighing c. 20 g (dry), were oven dried, gently pulverized and subsequently analyzed using an Olympus-Innov-X Delta Premium XRF scanner stocked with Au anode tube. The device was operated in a 3 beam 'soil' calibration mode and in a desktop

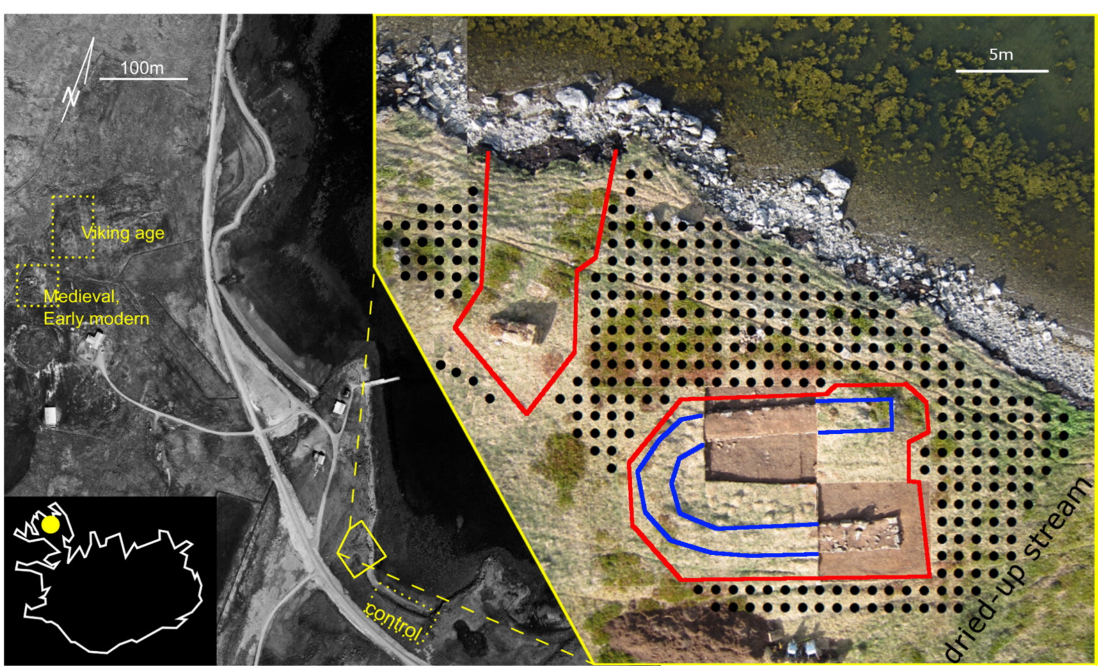

Fig. 1. The archaeological site of Vatnsfjörður: Left, aerial photography of the site. Visible are the Viking age, Medieval and Early-Modern settlements plus the coastal zone, studied excerpt and control sampling area. Right, enlarged studied section of the coastal zone. Visible, in red, are the extents of v-shaped (left) and u-shaped (right) structures' collapsed material; in blue, structural walls; in black, the location of sampling points. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)