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GEOARCHAEOLOGICAL INVESTIGATIONS AT LINDISFARNE, NORTHUMBERLAND: SOIL SURVEY AND ASSESSMENT IN 2018 AND 2019

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Introduction

This report introduces the Lindisfarne Landscapes Project, and presents the results of two exploratory field seasons on the Holy Island (NGR NU130428). It sets out the results of soil surveys and assessments conducted in order to assess the potential of geoarchaeological methods to investigate the landscape evolution of the island, and to reconstruct its environment and land-use during the Anglo-Saxon and Medieval Periods, when the island was home to one of the most important monasteries in Europe.

Lindisfarne, a small tidal island on the Northumberland coast, north-east England, is the site of a monastery founded in AD 635 by Oswald, King of Northumbria, and Aidan, a monk from Iona. It has been famous since the early medieval period as the focus of the cult of St. Cuthbert until his relics were moved to the mainland in the late ninth century in the wake of Viking attacks, and as the site of the scriptorium that crafted the most spectacular manuscript to survive from Anglo-Saxon England: the Lindisfarne Gospels (Bonner *et al*.; Brown 2003). Despite the recovery of a significant quantity of early medieval sculpture from the area of the later medieval priory, much about the life of the early medieval monastic community on the island remains unknown. This includes the locations of settlements and field systems, patterns of land use, and the origin and date of the Lough, a small pond northeast of the priory (Fig. 1). The original topography of Holy Island has likewise been lost as a result of significant landscape alterations over time, most notably sand dune encroachment from the north shore of the island during the Little Ice Age (AD 1300–1900), enclosure and drainage of fields from the 1790s onwards, and the expansion of the village since the eighteenth century (for an overview of Lindisfarne's archaeology see Petts 2013; 2017).

The landscape of Anglo-Saxon Lindisfarne was first investigated in detail during the 1980s and early 1990s when a major research campaign by the University of Leicester revealed a pre-Conquest agricultural settlement at Green Shiel, on the northern end of the island (Fig. 1; NGR NU 121436; O'Sullivan and Young 1991a, b). As part of this study, Kevin Walsh (1993) and co-workers (Walsh *et al*. 1995) examined the faunal assemblage from Green Shiel, associated buried soils, the overlying dune system, and the pollen record from the Lough (NGR NU 136429). Their analyses provided evidence for arable and pastoral activity at Green Shiel during the late ninth and tenth centuries, when at least part of the monastic community had already left Lindisfarne.

In 2012, Archaeological Services at Durham University, on behalf of David Petts, with the financial support of National Geographic, conducted a 20ha magnetic gradiometer survey around Lindisfarne village that identified a series of new features in the area of the Priory and west of the village (Petts 2013). In the Glebe Field, now used for hay crop, a series of field boundaries and enclosures were detected, including some that appeared to be westward extensions of Marygate and Prior Lane (Fig. 2; NGR NU124419). O'Sullivan (1989) had earlier proposed that the present street layout may reflect earlier spatial divisions, and that either or both streets were contenders for the course of a monastic *vallum*. *Valli*, consisting of drystone walls or earthen banks accompanied by inner ditches, were essential components – both physical and symbolic – of early medieval Irish monastic settlements and those derived from Irish monastic houses, which were used to enclose and demarcate holy spaces (Jenkins 2010). Whilst O'Sullivan (1989, 140) had postulated that the monastic boundaries may have curved south, following the line of Lewin's Lane, the magnetometer survey showed high and low resistance linear anomalies aligning with Marygate and Prior Lane that continued westwards towards the eroding cliff face on the western shore of the island (Fig. 2). In 2016, collaborative fieldwork by Durham University and DigVentures investigated the anomalies aligning with Prior's Lane, revealing a cobbled trackway and several building structures dated to the thirteenth century and later (Trench 3, Fig. 2; Wilkins *et al*. 2017). However, a monastic *vallum* was not identified.

Geoarchaeological survey and soil assessment in 2018 and 2019

In September 2018, and again in September 2019, a new geoarchaeological project supported by the Medieval Settlement Research Group, Durham University, and DigVentures combined extensive soil survey and more detailed, multi-scalar geoarchaeological analyses to evaluate the degree to which Lindisfarne's medieval landscapes are preserved below today's pasture, agricultural land, wetlands and dunes. Ten locations across the island were cored with a hand auger in order to determine soil depths and identify the presence and potential preservation of buried soils and other landscape features (Fig. 1). In addition, two soil test pits (Trenches 5 and 6) were excavated in the Glebe Field

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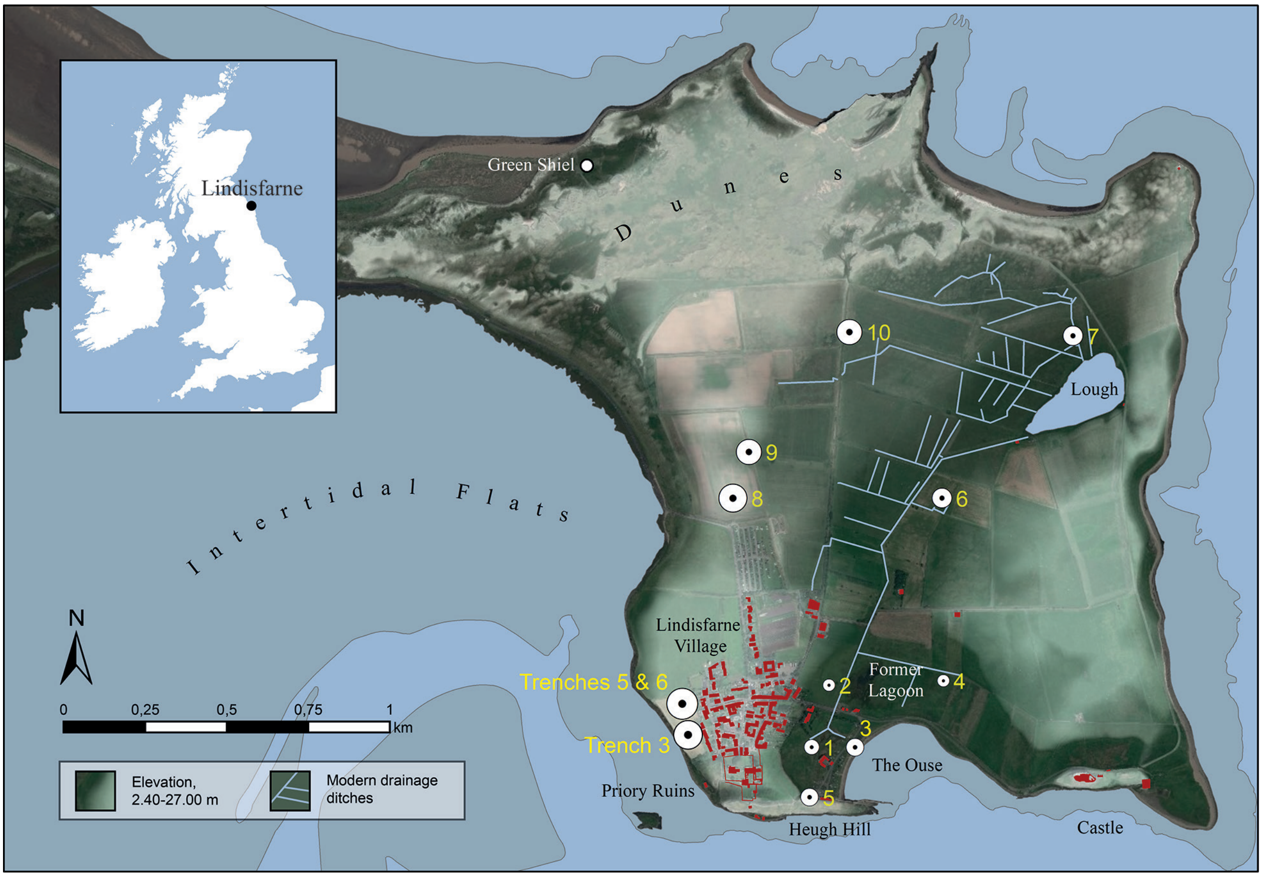

Figure 1 Map showing the location of the Holy Island of Lindisfarne, and key sites, landscape features, excavation trenches and auger holes (numbers) mentioned in the text. Figure by Raphael Kahlenberg, based on Ordnance Survey data, Environment Agency LiDAR, and Esri World Imagery. Esri Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

in order to investigate the linear geophysical anomalies that appeared to extend west of Marygate (Fig. 2), to record and sample the soils there, and to date them if possible.

Soil auger survey

Our extensive landscape survey involved soil coring and sampling at ten different locations across Holy Island using a hand-operated Dutch auger (Fig. 1). Auger holes 6–10, in the inner part of the island, were chosen to cover a diversity of environmental settings in order to identify the characteristics of places where palaeosols might be preserved. The most promising soil sequence was in auger hole 6, located on pasture that is now drained by shallow ditches. Here, we found evidence for multiple cycles of pedogenesis (soil formation) on windblown sands and subsequent burial below younger aeolian sediments, reaching depths over 1.2m. In contrast, in auger hole 8, clay till (also found at the bottom of Trenches 5 and 6 in the Glebe Field, see below) was overlain by only 28cm of ploughed soil. Auger hole 9 confirmed that lower-lying areas without modern agricultural use are more likely to preserve long stratigraphic sequences. The results from auger holes 7 and 10 point towards challenges for further fieldwork, namely high water tables near the Lough and thick sandy deposits near the dunes in the north.

Auger holes 1–5 were taken from the area of a former lagoon, which lay north and west of the modern harbour, known as the Ouse. This lagoon was cut off from the sea in the seventeenth or eighteenth century (Petts 2017, 5). The old shoreline, as well as the development of the lagoon's sand spit, are clearly visible in today's topography (Fig. 1). The sequence from the easternmost auger hole (4) shows the transition from a high-energy marine depositional environment (grey coarse and medium shell sand with large shell fragments) to a terrestrial one (dark greyish brown loam with a charcoal fragment) at 1.90m ASL, about 0.5m below today's mean high water springs. Shell fragments and shell sand are also present in auger hole 1, at about the same elevation as in auger hole 4, but the sand is much finer and dominated by quartz. At auger hole 5, close to the former inlet of the lagoon next to Heugh Hill, shell fragments and beach pebbles occur at 2.70m ASL. On the sand spit, in auger hole 3, we found homogenous medium sand with shell fragments up to a depth of 80cm, with a distinctive layer of large shell fragments and stones at 30cm below the surface. Our survey of the former lagoon suggests a gradual silting up from east to west that must have been associated with the development of new biotopes and opportunities for resource exploitation and landscape modification.

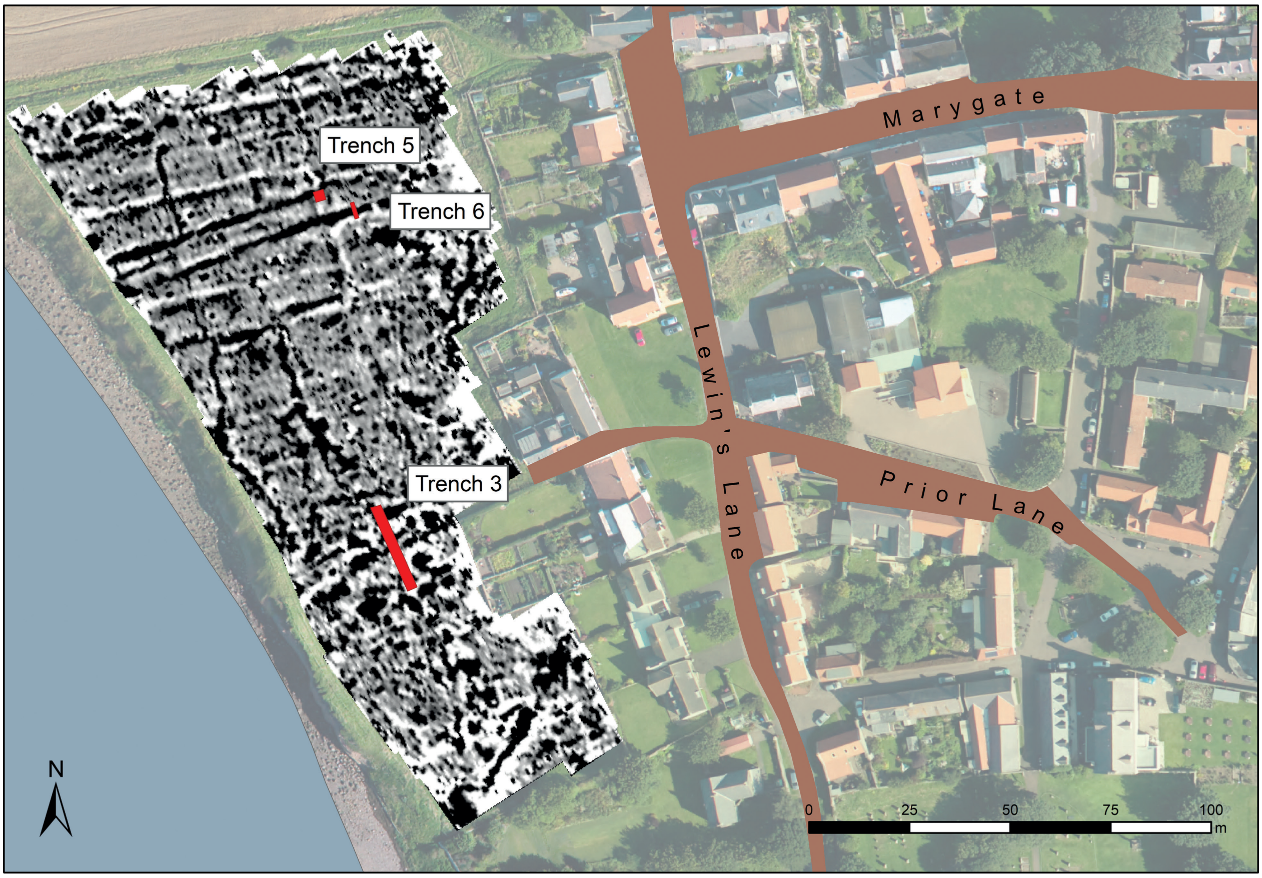

Figure 2 Magnetic gradiometer survey in Glebe Field, west of Lindisfarne Village, showing linear anomalies extending west of Marygate and Prior Lane, and the locations of the excavation trenches. Figure by Raphael Kahlenberg, based on Ordnance Survey data, Environment Agency aerial imagery, geophysics data provided by ASDU and David Petts, and GPS data provided by Chris Casswell and DigVentures, published with permission.

As a whole, our soil survey revealed that there is excellent potential to recover buried soil sequences on Lindisfarne, particularly in the northern half of the island, where windblown sands have been covering soils, often in discrete bursts (*e.g.* as may be created by a winter storm). On the southern shore of the island, buried sediments associated with the lagoon offer the possibility of reconstructing the water levels and salinity of the lagoon during the early and later medieval periods. We now plan to investigate these buried soils and sediments in greater detail using a suite of geoarchaeological and absolute dating methods in order to characterise and date the evolution of the landscape, land-use, and land management practices on the island.

Glebe Field soil assessment

In order to try to locate, date, and characterise past spatial divisions associated with the monastic and later medieval settlement, two soil test pits, Trenches 5 and 6, were excavated in the Glebe Field, west of Lindisfarne village. Trench 5, which was excavated in 2018, measured 2x2m, and was positioned in order to try to capture the northern of the two linear anomalies extending west of Marygate. Trench 6, excavated in 2019, was 4x0.75m, and was positioned to capture the southern of the two linear anomalies (Fig. 2). Both trenches were deturfed and excavated by hand, and texture, consistency, colour, structure and inclusions were noted in the field for each soil horizon/archaeological context following Munsell Soil Color (1994), MOLAS (1994) and FAO (2006). Soils were interpreted following FAO (2006) and the National Soil Resource Institute (2018). Finds and ecofacts were collected by hand and labelled with an archaeological context number. From Trench 5, four blocks for soil micromorphological analysis were taken using 10x5x5cm Kubiena tins following the method of Courty *et al*. (1989) (samples 98.1–98.4), and eight 200ml bulk samples were taken from the west section (samples 99.1–99.8) (Fig. 4).

Soil laboratory tests and preliminary assessments of soil thin sections were conducted to complement and extend the field descriptions and improve our interpretation of the Glebe Field soils. In the environmental archaeology laboratory at Durham University, bulk samples were oven dried, gently pulverized with a mortar and pestle, and sieved to remove particles over 2mm. The <2mm fraction was then analysed for magnetic susceptibility, pH, electrical conductivity (a proxy for soluble salts, or nutrient content), per cent loss-on-ignition (a proxy for organic matter content) and available phosphate (i.e. orthophosphate), following methodology described in French (2015). Micromorphology samples were air-dried, impregnated with crystic polyester resin, and

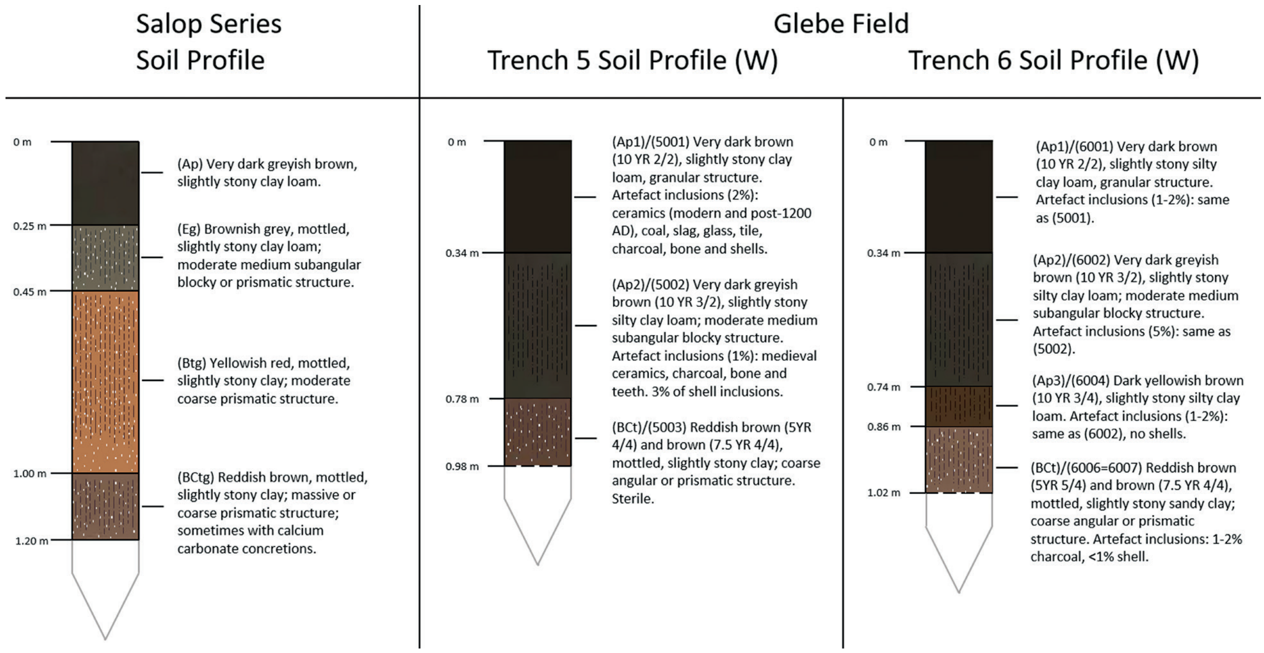

Figure 3 Soil profiles recorded in Trenches 5 and 6, and comparison of their characteristics with the Salop soil series. Figure by Agni Prijatelj, using National Soil Resources Institute data for the Salop Soil Series.

thin sectioned at the University of Ghent following protocols summarised in French (2015). We first assessed them over a light-box without magnification, and then under transmitting light microscopes using a range of light sources (plane polarised, crossed polarised and reflected light) at magnifications ranging from x5–x400. Features observed in the soil thin sections were described following Stoops (2003). For this short report, the results of soil laboratory analyses are summarised in Fig. 4 and below, where relevant.

Trench 5 (NGR NU 12406 41964)

Under the grass cover and root mat in Trench 5, two distinct ploughed topsoils were identified (Fig. 3). The uppermost, Ap1 (context 5001), was 34cm thick, and was a very dark brown (10YR 2/2) clay loam with the crumb structure typical of bioturbated surface soils. The layer contained 2% artefact inclusions, including animal teeth and bones, a variety of shells (winkle, oyster and limpet), some of which were burned, a mixed assemblage of mainly modern pottery fragments, with some dating to the medieval period (post-1200), clay tobacco pipe stems and a pipe bowl fragment, modern bottle glass fragments, indeterminate ferrous objects, slag, charcoal, and a whet stone. The colour, inclusions, thickness, and homogeneity of the soil point to a modern, amended plough soil that developed on (and derived some older artefacts from) an older, medieval soil.

In laboratory tests, the Ap1 horizon contained the highest magnetic susceptibility values, electrical conductivity (nutrient) values, and loss-on-ignition values of the Glebe Field soil profile (Fig. 4), all of which are probably associated with anthropogenic amendment of the plough soil. Magnetic enhancement is likely to be derived from inputs of hearth waste (charcoal and burnt soil) and iron objects. The enhanced loss-on-ignition levels in the Ap1 horizon were seen in thin section to include charred seeds and wood and well-decomposed, reworked amorphous (unidentifiable) organic matter, all of which contributed to the very dark brown colour of this horizon. The higher organic matter content, which would have been associated with the release of organic acids, is also responsible for the slightly lower (but still neutral to basic) pH conditions of this horizon, and for the higher nutrient content reflected in the electrical conductivity values. In thin section, the sand component comprised subrounded fine- to medium-sized sand, dominated by quartz, but with smaller quantities of feldspars and mica, much of which was probably windblown and reworked into the soil by bioturbation and ploughing. These results support the interpretation of Ap1 as a post-medieval to modern amended plough soil.

Underlying Ap1, the 44cm thick Ap2 horizon (5002), was a homogenous, very dark greyish brown (10YR 3/2) silty clay loam with medium-sized sub-angular blocky structure (Fig. 3). It contained *c*. 1% archaeological finds, including animal teeth and bones, fish and bird bones, a great variety of shells (oyster, mussel, limpet and winkle), a mixed assemblage of mainly medieval pottery fragments post-dating AD 1150, an iron nail, and a clay tobacco pipe stem. Compared to Ap1, Ap2 contained a notably higher percentage of shells, which may have contributed to the slightly elevated pH of this layer (*c*. pH 8).

In the laboratory, soil tests revealed that the lower part of Ap2 was elevated in available phosphate relative to the overlying Ap1 horizon, which was relatively depleted in comparison to the underlying BCt horizon (Fig. 4). This could have been caused by organic, phosphate-rich amendment of the Ap2 horizon through manuring or middening (cf. Koopmans *et al*. 2007; Wilson *et al*. 2008), but may also have been caused by the translocation of phosphates from upper to lower horizons, either

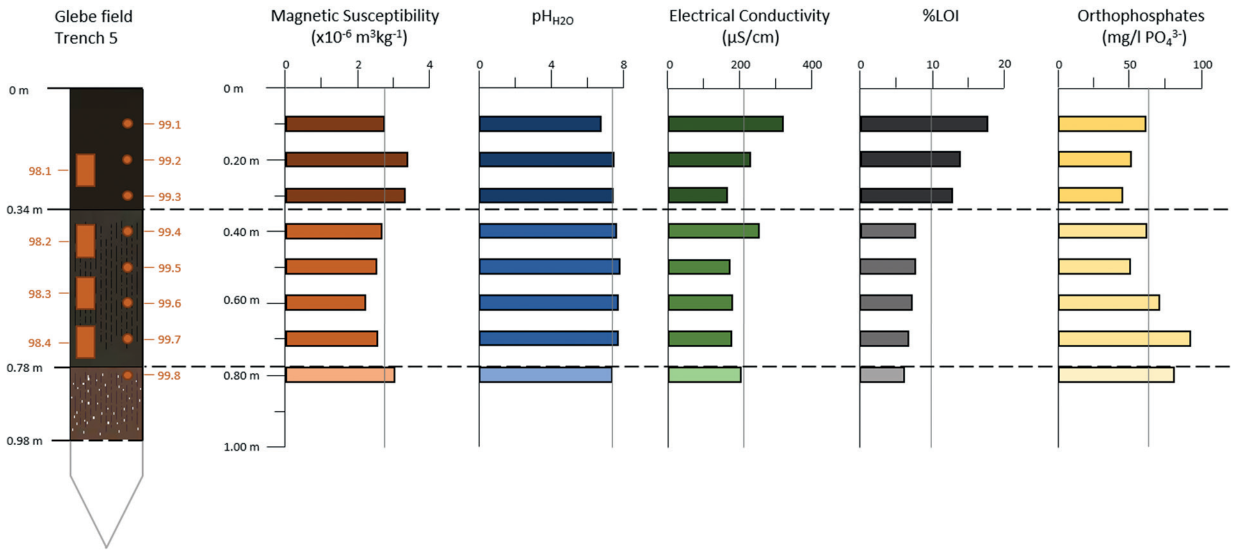

Figure 4 Trench 5 bulk soil analyses results, showing the locations of bulk samples (dots) and micromorphology samples (rectangles). Figure by Agni Prijatelj.

independently (facilitated by the neutral pH conditions in this case), or in association with the downward translocation of clay (*e.g.* Macphail 2011, 748). In thin section, the sand component of the soil clearly decreased with depth, indicating less wind-transport of sand while the earlier soil was forming. At the same time, 'dusty' clay coatings increased with depth – a product of very fine silt, organic particles, and clay being mobilised by vegetation clearance and/or mechanical disturbance of upper horizons, and redeposited by rainwater as coatings around soil aggregates in lower horizons (Lewis 2012, 22). Such disturbance may be caused by tillage or by natural processes causing similar disruption to upper soil horizons (*e.g.* animal burrowing; Adderley *et al.* 2018, 765–767). Other features observed in thin sections from the Ap2 horizon included charred amorphous organic matter (probably charred peat derived from hearth waste), and clay aggregates derived from the disturbance of the underlying BCt or C horizon (glacial till) by mechanical processes such as digging, ploughing, or the uprooting of trees (Lewis 2012, 14; Courty *et al.* 1989, 127). Ap2 is interpreted as a well-preserved, amended plough soil of likely medieval date, the upper part of which has been subject to limited mixing (by ploughing) with the later Ap1 horizon.

The lowermost soil horizon in Trench 5, which was reached at 0.78m below the ground surface, was a compact, archaeologically sterile, slightly stoney clay (Fig. 3; context 5003). It was mottled reddish brown (5YR 4/4) and brown (7.5YR 4/4), and had a coarse angular structure and *c.* 1% iron and manganese oxide concretions formed by the wetting and drying of the iron- and manganese-rich clay. Laboratory analyses showed that this horizon had a significantly lower organic matter content (see loss-on-ignition in Fig. 4) than the overlying plough soils. It was interpreted as a BCt horizon – a glacial till containing illuviated clay and silty clay coatings.

Although the National Soil Resource Institute (2018) classified soils throughout the west, south, and eastern parts of the island as slowly permeable, seasonally waterlogged soils (Salop soil series, Fig. 3), the soil was not gleyed in the location of Trench 5, possibly because a gentle slope towards the west provided adequate surface drainage. Nor were any archaeological features visible in this 2x2m trench that could be associated with the linear anomaly identified in the magnetometer survey. Although this trench failed to identify a monastic *vallum* or other linear features that could be associated with the monastic settlement or its hinterland (*e.g.* field boundaries, tracks), our field- and lab-based soils assessment showed that the area around Trench 5 had been used for arable agriculture, and had been heavily manured and amended for this purpose, since at least the medieval period. What surprised us were the depths of the preserved soils, especially Ap2, the lowermost, medieval plough soil. One explanation for this remarkable preservation of a buried Ap horizon is that the input of windblown sand had continually raised this soil and protected it from truncation by later ploughing. With further radiocarbon and luminescence dating, it should be possible to determine if the Ap2 horizon was contemporary with the early medieval monastery.

Trench 6 (NGR NU 12415 41961)

In 2019 we employed a different strategy to position Trench 6 over the southern of the two linear magnetic anomalies running west of Marygate, first using a Dutch auger to core the soils and to locate the deepest soil sequence (Fig. 2). This proved very effective, for underlying the sequence of ploughed soils in Trench 6, an east-west linear ditch feature was identified (Fig. 5). The two uppermost horizons identified in Trench 6, Ap1 (6001) and Ap2 (6002), as well as the underlying BCt horizon, were similar to those in Trench 5 (Fig. 3). In addition, a second buried plough horizon in Trench 6, Ap3 (6004), was recorded at a depth 0.74–0.86m below the ground surface. Ap3 was a dark yellowish brown (10YR 3/4) silty clay loam with a subangular blocky

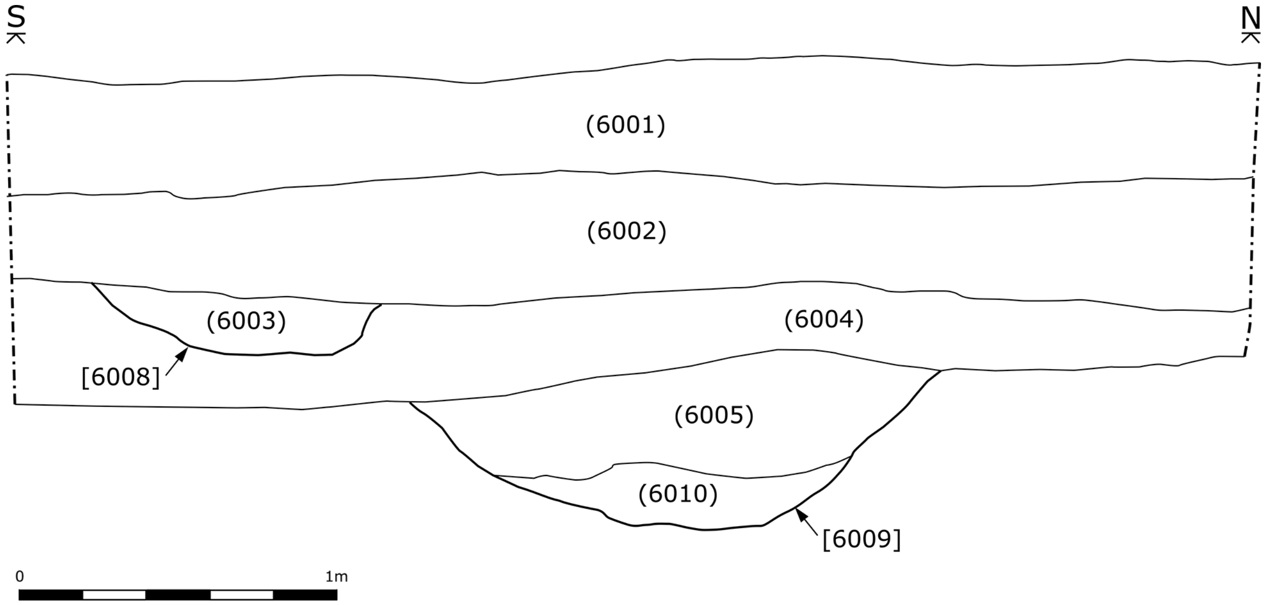

Figure 5 Trench 6, west section. Figure by Sofia Turk, based on the field drawing by David Petts and DigVentures, published with permission.

structure. It contained 1–2% artefacts, including all of the ones recorded for Ap2, with the exception of pottery, which was not found.

A ditch or plough furrow (feature 601) had been cut through the Ap3 horizon (6004). It survived to a depth of only 0.16m, but its fill (6003) was rich in artefacts (10–20%), including large pieces of green-glazed ceramics, whole shells, and fish bone. Given its width and inclusions, feature 601 was interpreted as a medieval furrow or a ditch that had been used for middening, and that was truncated by later ploughing associated with Ap2.

The earliest feature in Trench 6 (feature 602) was a much larger ditch: 1.6 m wide and surviving to a depth of 0.5m, cut through the natural BCt horizon. Its basal fill was dumped domestic waste (6010), including a fragment of medieval green-glazed pottery. This deposit was overlain by large stones and then a secondary fill with fewer inclusions (6005), which probably represents gradual sedimentation. This secondary fill might be contemporary with the early development of the Ap3 horizon, which was similar in colour and texture. No upstanding banks or dry-stone walls were found associated with this ditch feature – if they had ever existed, they were truncated by the ploughing associated with Ap3. This large and deep ditch feature, which is very likely to be the cause of the linear magnetic anomaly targeted, is interpreted as a medieval field boundary. Considering its alignment with the curved street line of Marygate, it is plausible that this ditch was associated with either an early medieval *vallum*, or a later field boundary ditch recut in the same location. Going forward, the possible association of this ditch with a monastic *vallum* will be explored further using a radiocarbon and luminescence dating programme.

Conclusion

Based on the results of our soil survey and more detailed soil assessment on the Holy Island of Lindisfarne, we conclude that there are indeed well-preserved buried soil sequences in many parts of the island that would merit further study. In addition to the soils buried by sand dunes in the northern part of the island, which were previously recognised by Walsh (1993), the central, low-lying part of the island has the potential to contain rich soil archives buried by windblown sands dating at least as far back as the Little Ice Age. As the lowermost boundaries of the sand layers in auger holes 6, 7 and 10 were not reached, deeper coring with a mechanical auger will be necessary in those areas to determine whether early medieval soils are preserved as well. In the area of the Glebe Field, west of Lindisfarne village, inputs of windblown sand had thickened the agricultural soils identified in our soil test pits, and enabled the preservation of an earlier, medieval plough soil, as well as a deep ditch, which could be the monastic *vallum* or a later field boundary cut in the same location. In the area of the former lagoon on the south coast of the island, further coring and test-pitting, and sampling for foraminifera and phytoliths, will be used to study shifts in water levels, water salinity, and plant communities. In addition, a geophysical survey and targeted coring will offer the opportunity to identify possible built structures like revetments or even remains of a tidal mill comparable those at Nendrum Monastery and Little Island, in Ireland (cf. McErlean and Crothers 2007; Rynne 2000). To follow up on this assessment project, a suite of geoarchaeological methods, including soil micromorphology and phytolith analysis, accompanied by a programme of radiocarbon and luminescence dating, will now be conducted to study changes in vegetation, soils, land use, and land management over time across the island as a whole. With time, we might be able to reconstruct a reasonable picture of the landscape and land-use on the Holy Island of Lindisfarne during the period of the monastic settlement.

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