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Soil and Spatial Analyses in the Assessment of the Focal Point of the Extinct Medieval Royal Burgh of Roxburgh

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Abstract

The 'lost' royal burgh of Roxburgh in the Scottish borders is arguably one of the most important archaeological settlement sites in Scotland of the medieval period. Although short-lived, being occupied as an urban centre for just around 300 years, in its heyday, it was a royal residence, jurisdictional and administrative seat, and regional focus of economic activity and international trade. Presently however, very little surviving above-ground trace remain of this once dynamic settlement. With a Scheduled Monument status (No. 4284), activity on-site is now restricted to prevent damage to the below-ground archaeology. This study explores the locale(s) of Roxburgh's main thoroughfare in the Friars' Haugh area during its occupation through the spatial analysis of soil data coupled with historical records and findings from past research studies. The study area encompasses the putative location of the main street as identified in a previous study by GSB Prospection and Wessex Archaeology. Suites of soil markers (phosphorus concentration, magnetic susceptibility, organic carbon content, and soil pH), were used to demarcate zones of high to low activity through quantitative changes in the concentration and/or value of these markers. Optically stimulated luminescence (OSL) analysis was used to investigate depositional history. The spatial distribution of soil markers across the site shows two zones of substantial enhancement, revealing potentially a second thoroughfare on the west of the site (site B), in addition to the main thoroughfare on site (A) which overlaps with the site identified in previous studies. Portable OSL analysis indicates progressive accumulation of materials of proximal origins, however, evidence of mixing of sediments is discernible.

Keyword: anthrosols, royal burgh, medieval, soil, magnetic susceptibility, soil organic carbon (SOC), portable optically stimulated luminescence (OSL), phosphorus concentrations, spatial analysis

1. Introduction

The geoarchaeological study of settlement sites in Scotland and elsewhere around the world has developed our understandings of the interactions between people and the environment. In a British Isles context, investigation of such interactions at scale has tended to be restricted to urban centres of the Roman era, e.g. Silchester (Clarke, Fulford and Mathews 2002; Fulford, Clarke and Eckardt 2006; Fulford and Clarke 2011), that ‘failed’ in the early medieval period, or to smaller, more rural settlements that span a long prehistoric to post-medieval chronology, such as Wharram Percy in North Yorkshire (Wrathmell 2022). Truly urban archaeology on sites of medieval and more recent date has tended to be conducted as ‘rescue’ excavations, especially in the context of urban redevelopment projects since the late 1960s, and more recently undertaken as pre-development actions through the ‘developer pays’ principle. As a consequence, despite the wealth of data recovered from such projects, the work is dispersed across the urban footprint and occurs as and when an area becomes available, rather than as part of a strategically planned programme of investigation. This relatively ad hoc situation, driven by the shifting intensities of modern urban development, has limited opportunities to explore and interrogate - at scale and systematically - the broader nature of site occupation, modes of anthropogenic soil formation, soil use and intensity of exploitation, soil and waste management practices, and their role in settlement development that can be elucidated through the use of soil-based techniques, augmented with historical records (Pape, 1970; Bethell et al. 1994; Simpson, 1997; Bull et al. 1999; Simpson et al. 1999; Holliday, 2004; Davidson et al. 2006; Holliday and Gartner, 2007; Lehmann and Stahr, 2007; Oonk et al. 2009; Woods et al. 2009; Oram, 2011; Esiana et al. 2022).

Where the density of occupation in and continuing development of the major urban centres of the modern British Isles precludes investigation across large areas, deserted or failed medieval towns as Roxburgh offer scope for such a multidisciplinary approach. Several such failed towns exist across the British Isles, from Rattray in north-eastern Scotland (Murray and Murray 1993) to Rindoon in west-central Ireland (O'Conor and Shanahan 2018) or Newtown Jerpoint in south-eastern Ireland (Oxford Archaeology 2007) to Old Sarum in southern England (Chandler 2004; James 2010), with investigations led by Southampton University continuing at the last of these. Research at such sites has generally combined non-invasive survey techniques including contour surveys, LiDAR, geophysics, possibly but relatively infrequently with targeted excavation, as well as historical documentary and place-names research. These approaches have been employed since the early 2000s in investigations, with some at the royal burgh of Roxburgh, which was arguably one of the most important settlements in Scotland in the medieval period (Martin and Oram 2007; RCAHMS 2009). As a settlement empowered by royal charter, it was the exclusive focal point for regional economic activity and international trade in what were termed customable goods (those commodities subject to custom payments on export, such as wool and hides), the latter via the port of Berwick, 37km away at the mouth of the River Tweed on the North Sea coast.

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In medieval European urban societies, the back gardens of dwellings typically represent hubs for a range of domestic and industrial activities, responding to changes in economic conditions in space and time. Historical practises that saw the composition and use of domestic and industrial waste for soil improvement are common to much of Northern Europe (Pape, 1970; Blume and Leinweber, 2004;

Dercon et al. 2005; Guttmann et al. 2005; Davidson et al. 2006; Hubbe et al. 2007; Urbanski et al. 2022). Burgesses or townsmen, in addition to their own profession, engaged in small-scale horticultural activities where they grew their own produce on the backlands or gardens of their properties for their own consumption, enriching the soil with their domestic waste (Brothwell, 1982; Goddard, 1996; Sheail, 1996; Golding et al. 2010; Oram, 2011). Larger-scale cultivation of dietary staples like cereals and livestock grazing took place on what were styled the settlement rigs and moor in the immediately adjacent hinterlands, reached via the main thoroughfares that ran into the settlement. Roxburgh was a thriving medieval royal settlement, with record evidence confirming the presence of a substantial suite of crafts and trades pursued by its inhabitants, and a regional hub for economic activities pursued by its merchant elite (Martin and Oram 2007). The main streets, where these economic activities are normally concentrated – trade through 'shop' frontages and booths not exclusively in the market square and production in backland workshops - together with the cultivation of land areas immediately behind tenements fronting the streets would result in more extensive alterations to soil characteristics from the accumulation of organic materials and the discard of waste and debris of occupational living/activities. Phosphorus is routinely used in prospecting as proxy indicators for anthropogenic activities on historical sites, as well as in the discrimination of site use intensity by variations in its concentration (Leonardi et al. 1999; Bull et al. 2001; Wells, 2004; Marwick, 2005; Holliday and Gartner, 2007; Oonk et al. 2009). Similarly, soil pH values and SOC content distribution across anthropogenic landscapes may serve as indicators, amongst others, for site use, particularly activities associated with farming (cropping and livestock rearing).

Although Roxburgh as a settlement was occupied for a comparatively short period of time, soils in and around the settled area will have measurable signature-bearing properties and deposits that are typical of human occupation. In this study, we investigated an area of the settlement purported to be the core area of medieval Roxburgh by GSB Prospection during excavation in 2003 for broadcasting company Channel 4 Television's archaeology programme, Time Team. Geophysical data of the site, together with spatial data of soil markers (phosphorus concentration, magnetic susceptibility, organic carbon content, and soil pH), and historical records were integrated to provide corroborating evidence for locations within the historical footprint of Roxburgh with notable activity and/or the main thoroughfare of Roxburgh during its occupation and the cultural milieu within which the soils were formed.

2. Materials and Methods

2.1 Study Site

Roxburgh (55° 35′ 54.59″ N, 2° 26′ 6.28″ W) is located south-west of Kelso, an inland town situated in the Scottish Borders local authority area to the south of Edinburgh. The study site lies on a fertile alluvial plain on a peninsular headland between the rivers Tweed and Teviot just before their confluence 0.75 km eastward. The climate is temperate with an annual average temperature range of between 3.9 – 11.2 °C (Met Office). The underlying parent material is derived from Lower Carboniferous sediments and basic lavas, Upper Old Red Sandstones and Silurian greywackes, with soils comprising materials of alluvial origins (Soil Survey of Scotland). The present-day land use on the site is managed grassland. The soil type may be classified as a Technic Hortic Anthrosol under the revised WRB soil classification system (WRB, 2015). The additional prefix qualifier ‘Technic’ was added to reflect the variety of Hortic soil because a diagnostic feature of “deep urban soils” is the presence of mixed material derived from building, household and industrial wastes, and debris (Rossiter, 2007).

Fig. 1a. Roy Military Survey of Scotland, 1747 – 55 map showing the location of medieval royal burgh (town) of Roxburgh in the Scottish Borders (highlighted in the polygon). Maps are available at https://maps.nls.uk/geo/roy. Reproduced with the permission of the British Library and the National Library of Scotland.

2.1.1 Site Description

First mentioned in the early 12th Century (ca. 1113) in the foundation charter of Selkirk Abbey, granted by the then Earl David (later King David I), Roxburgh flourished between the 12th to late 14th century AD, but went into rapid and terminal decline in the early 15th century (Martin and Oram 2007). In its prime, it was a prosperous royal settlement at the gates of one of the most important royal castles in south-eastern Scotland, enclosed by walls (uncommon at most medieval Scottish towns) and containing possibly two parish churches (most Scottish burghs were single parishes) and, from the second quarter of the thirteenth century, a Franciscan friary. From the second quarter of the twelfth century, it was one of Scotland's most important mint centres, where the kingdom's silver penny coinage was produced. Roxburgh stood at the intersection of major routeways and at one of the few medieval bridging-points of two of the biggest rivers that drain the eastern Southern Uplands, the Teviot and Tweed. Situated between these rivers, it was well served with a riverine transportation route to the port at Berwick, as well as a natural defensive barrier in times of war. Its market and annual fair – the St James Fair - were major venues in Scotland's international wool trade, drawing in merchants from mainland Europe and dealers from across Scotland, expanding its influence and status as a commercial hub of great importance within the central and eastern sectors of the Southern Uplands region of Scotland (for detailed discussion, see Martin and Oram 2007).

Fig. 1b shows a putative reconstruction of the area enclosed by the settlement (highlighted in red), and the locations of various features (Extract from Martin and Oram, 2007).

However, Roxburgh's development was disrupted by a series of fire incidents – both accidental conflagrations and deliberate acts in a time of war – in 1207, 1216 and 1244. Much structural damage to the built infrastructure was caused, due to the susceptibility to fire of the most common construction material (wood) of the buildings (for building construction in medieval Scottish towns, see Murray 2010). The settlement regenerated each time and continued to thrive into the 1300s. The outbreak in 1296 of the Anglo-Scottish conflict nowadays referred to as the Scottish Wars of

Independence led to over six decades of intensive hostilities and a further two centuries of intermittent warfare (Brown 2004). This conflict is arguably the single biggest overarching factor that led to the terminal decline of Roxburgh and its eventual abandonment around 1460, when the Scots finally recaptured and destroyed its English-held castle (Martin and Oram 2007). Although the main hostilities had ended by treaty in 1357, which left Roxburgh in English hands, the following century saw an increase in the frequency of Scottish raids into the English-held enclave. Cut off from access to their former regional centre and market, producers in the settlement's largely Scottish-held rural hinterland began to take their goods elsewhere for sale. This drift away of commerce led to the relocation of Roxburgh's formal trade and administrative functions to more secure locations in Scottish-held territory. As a consequence, the urban community gradually withered away as its craftsmen and merchants moved in pursuit of personal and business security. The destruction of the castle in 1460 removed the last raison d'être for the settlement, as a service centre for the garrison, and any remaining townsfolk had moved by the mid-fifteenth century into the prospering town of Kelso on the north bank of the Tweed 0.5 km from Roxburgh.

The short programme of archaeological research in Roxburgh for the Team Time investigation has revealed the extent of anthropogenic disturbances on a site that previously had been presumed free from external disturbances. Desk-based analysis by Martin and Oram (2007) identified that William Wyeth's 1736 survey showed extensive post-burghal agricultural activity (strip-cultivation) had occurred in the eastern edge of the area known as Vigorous Haugh, outside the settlement's core area. Later surveys show physical disturbance from ploughing over the whole of the settlement area. This disturbance was the result of wider and more-significant agricultural activity that post-dated Wyeth's 1736 survey but had occurred probably by 1780, as noted by the antiquarian writer Jeffery (1859, 152), and again in the 1940s for war-time agricultural production (Anon, 1947). The Time Team excavations confirmed that there had been extensive truncation of stratigraphy over the central areas of the site, often with just negative features cut into the subsoil surviving beneath the ploughsoil, but with significant archaeological layers surviving in more peripheral locations, especially where buried beneath deeper layers of hill-wash and plough-mobilised soil-creep to the south of the area known as Kay Brae. Because of the truncation, precedence is given to subsoil samples – from 20 cm, during data interpretation in order to lessen the impacts of external disturbances, including those from contemporary activities such as the point-to-point horse-racing event frequently hosted on the site.

2.2 Sampling

Soil samples were collected from freshly dug and exposed soil profiles in the area of the site known since the 18^{th} Century as Friars' Haugh. Auger samples were collected along a 300 m transect at 20 cm depth increments until the auger could go no deeper. The transect ran east-west from the 2003 excavation's Trench 3, within an area identified in this study as a secondary thoroughfare – site B, near the modern A699 road in the east, across the putative location of the medieval settlement's core area (main thoroughfare – site A), to the putative defence works at the western end of the settlement (Figure 2a). Given the size and expanse of the study area, transect sampling was deemed suitable for the scope of the study, taking into account the study's aims and objectives, sample processing time, and data resolution. Sample points were set at a regular 10 metre interval along the transect resulting in a total of 30 points (S1 – S30). Suite of soil markers (phosphorus concentration, magnetic susceptibility, organic carbon content, and soil pH), were used to demarcate zones of high to low activity through quantitative changes in the concentration and/or value of these markers. This in turn is interpreted such that areas of high activity, as revealed by spatial interpolation of sample points of these suites of indicator markers superimposed on the geophysical data, are deemed to indicate the focal point(s) of the settlement. For the geophysical analysis of the site, a gradiometer survey was carried out by GSB Prospection using a Bartington Grad601-2 instrumentation. Readings recorded every 0.25m intervals along 1m traverses (please see survey report GSB Prospection, 2006 for more methodological description).

Fig. 2a. 300 m transect line indicating sampling positions and scope (grey line), overlayed on maps of below ground features from geophysical analysis. Shaded areas within the polygons denote: 1) the putative location of the main thoroughfare (site A); 2) an area identified in the this as a seecondary thoroughfare (site B). Map produced from GSB Prospection, 2006, by kind permission of Dr John Gater.

For soil pit profile samples, Trench 3 of the Time Team's archaeological excavation work in 2003 was re-excavated. Ground identification of the trench was undertaken using a combination of measurements from site survey and from photographs taken during the initial excavation. A test trench (Trench A), measuring 2 m by 1m was dug by hand to a depth of 0.30 m onto undisturbed archaeology (stone floor or wall) (Figure 2b). The trench was backfilled and re-turfed as it was too far north relative to the desired deep ditch feature seen in Trench 3 during the initial excavation. A second trench (Trench B) was dug which corresponded to the south-western end of Time Team Trench 3 (Figure 2b) to a depth of 1.2 m, above the ditch feature which re-exposed suitable soil profile to sample as illustrated in the original trench excavated to 1.15m depth (Wessex Archaeology, 2004). Samples were collected on the west side of the exposed profile (east-facing) of the trench. A series of copper tubes measuring 25 cm X 2 cm in diameter were used to sample exposed soil profiles for portable optically stimulated luminescence (OSL) analysis (Sanderson and Murphy, 2010). Samples were collected at 10 cm intervals; both ends of the tubes were covered and sealed with adhesive tape post sampling to prevent further re-exposure to light. A total of 86 samples were collected for ex-situ analysis.

Fig. 2b. Location of Trench 3 (scale 1:2500 cm), River Teviot in blue, Scheduled area boundary in red and expanded detail (scale 1:100 cm) showing re-excavated Trenches A and B and location of samples.

2.3. Magnetic susceptibility

The magnetic susceptibility of exposed profiles was measured in the field using an MS2F surface probe sensor coupled to a Bartington MS2 susceptibility meter (Bartington Instruments, Oxford, UK). Measurements were made at 10 cm intervals to the maximum depth of the soil profile at each sample point along the transect. Corrections were made for temperature drift during measurement sequences (Dearing, 1994). Values are expressed as the dimensionless ratio Volume Susceptibility (ĸ) calculated in SI units (10^{-5}).

2.4. Site chronological profiling by portable OSL reader

Samples from each profile were analysed using a portable OSL reader (SUERC, East Kilbride, UK). For each measurement, about 10 g of the bulk sample was placed into the device in a 50 mm diameter Petri dish under red-light conditions. During sample preparation prior to analysis, the sediments at both ends of the sampling tubes were discarded to prevent contamination of OSL signal from any materials that may have been exposed to light during sampling. All measurements were carried out in continuous wave mode. Signal separation during measurement is selectively done by the excitement of feldspar with infrared (IR) light and quartz with post-IR blue OSL. These signals are plotted to produce luminescence profiles that depicts the variation of the luminescence signal with depth. To account for the effects of mineralogy on background/natural radiation dose rate, IRSL/OSL ratio was used as a proxy for mineralogical characteristics (Sanderson and Murphy, 2010).

2.5. Soil chemical analysis

Soil organic carbon was measured by dry combustion using an elemental micro-analyser (EA1108 CHNS-O, Carlo Erba Instruments, Milano, Italy). Samples were oven-dried at 105°C and ground. Aliquots of 20 mg (± 0.20) were combusted in an oxygen-rich environment (flash combustion), and elemental composition and content determined by gas chromatography. Blank values were run with empty tin capsules. For calibration, the analysis of a Low Organic Content Soil (B2152) standard was performed (reference material supplied by the instrument manufacturer). Soil pH was measured on air-dried soil in 0.01 M $CaCl_2$ (1:2.5 soil:solution ratio) suspension (McLean, 1982). Soil Phosphorus concentration was measured by microprobe analysis using an X-ray fluorescence analyser (XRF) (Niton XL3t-Goldd+, Thermo Scientific, Billerica, MA, USA). All measurements were carried out in mining Cu/Zn mode.

2.6. Differential GPS and Spatial Analysis

The differential global positioning system (DGPS) provided for the integration of various dataset, allowing spatial data of soil markers to be precisely aligned with previous geophysical data of the site (Figure 2a). Sample data position and elevation are logged in and used to produce a map/layout of the relative distribution of soil markers (phosphorus concentration, magnetic enhancement, organic carbon content, soil pH) across the site. The positions of auger samples along the transect were defined using the Leica GS09 differential GPS unit (Leica Geosystems, Heerburg, Switzerland). The Ordinance Survey map of the study site was obtained from Digimap (EDINA) as a background raster map. A site map containing the archaeological features generated by GSB Prospection (2006) was then re-produced by importing the relevant figures-maps (JPEG images) into ArcMap (ESRI, ArcGIS v10) which were then geo-referenced to create Geo-TIFF files. This was subsequently overlaid with the OS map of the study site and incorporated into the map areas within ArcGIS. A series of visual maps – interpolated horizontal surface – showing the distribution of the selected site markers (phosphorus concentration, magnetic susceptibility, organic carbon content, and soil pH) along the transect was produced by inputting point data (values of the parameters measured using graduated symbols) obtained from DGPS sampling on the map.

3. Results

3.1. Soil Organic Carbon

Soil organic carbon (SOC) distribution is segmented with visible zones of high and low values, that decreased with depth (Figure 3). Small lateral variations can be observed between soil profile depths (0 – 20 cm; 20 – 40 cm; 40 – 60 cm), and sample points (S1 – S30); however, areas of high residual SOC content are visible on the west of the site (site B), an area where Trench 3 is located, and overlaps with the putative main thoroughfare (site A) as highlighted in the polygons.

Fig. 3. Spatial distribution of soil organic carbon content across study site. Main thoroughfare (**site A**); second thoroughfare (**site B**).

3.2. Soil pH

Soil pH distribution follows a similar segmented pattern as seen in SOC, although more lateral variation between soil profile depths is visible, as well as localised and isolated spots of mid to high pH range (Figure 4). Soil pH range (low – high) did not vary significantly between profile depths, ranging from 5.05 – 5.95. This value is lowest within the putative main thoroughfare (site A), and is flanked by higher values on either side by (site B), and S22 – S29.

Fig. 4. Spatial distribution of soil pH across study site. Main thoroughfare (**site A**); second thoroughfare (**site B**).

3.3. Magnetic Susceptibility

Volume magnetic susceptibility across the site is displayed in Figure 5. Values at 10 cm and 20 cm profile depths are significantly lower, and show a broader more diffuse distribution, relative to values at profile depths of 30 cm through to 60 cm. Isolated spots of high and low enhancement are visible across the site, however, magnetic enhancement on site B in the polygon, is higher across all the profile depths. Magnetic susceptibility is unexpectedly low in the eastern part of the site, towards the putative defence works, which encompasses the putative main thoroughfare (site A) of the settlement.

Fig. 5. Spatial distribution of soil volume magnetic susceptibility across the study site. Main thoroughfare (**site A**); second thoroughfare (**site B**).

3.4. Phosphorus Concentration and Optically Stimulated Luminescence (OSL)

Phosphorus (*P*) distribution follows those of soil pH and SOC content. In Figure 6, phosphorus is enhanced in distinct bands of high/moderately high and low/moderately low zones. Lateral variation between sample points is visible, and although the range of phosphorus concentration (highest – lowest) varies between soil depths, the discernible bands are largely unchanged. The area in the polygon (site A) which encompasses the putative main thoroughfare shows high residual *P*, as does the area to west (site B), within which lie Trench 3. Conversely, S7 – S12 and S23 – S30 are regions of low P concentration. Phosphorus concentration is greatest at 40 – 60 cm depth. Portable optically stimulated luminescence (IRSL and post-IR OSL) signals fluctuate along the profile, increasing steadily with depth until 110 cm where the signal decreases at 120 cm. IRSL/OSL ratio did not deviate significantly along the profile other than at 10 cm.

Fig. 6. Spatial distribution of phosphorus across the study site. Main thoroughfare (**site A**); second thoroughfare (**site B**).

Fig. 7. (**A**) Portable optically stimulated luminescence (IRSL and post-IR OSL) of soil profiles showing site depositional history (burial sequence); (**B**) infra-red (IRSL) to blue light (post-IR OSL) ratio of soil profiles showing mineralogical characteristics.

4. Discussion

The royal settlement of Roxburgh was abandoned by the mid-15th century, over 550 years ago, but its surviving archaeological features, now mostly buried, are relatively close to the surface, and as shallow as 20 cm in some locales where post-medieval ploughing has truncated or removed archaeological stratigraphy.

The zones on Figure 3 and 6 (site A and site B) in the polygons corresponding to high SOC content and phosphorus concentration are indicative of areas of high activity within the settlement (Figure 3 and 6). The observation, coupled with geophysical examination of the site, allows for the designation of the region (site A) in the polygon as a thoroughfare within the settlement. Soil pH is generally acidic across the site. The pH values within site A, are generally lower than those on either side of the region (Figure 4). Soil amendment from agricultural activities typically give rise to higher soil pH (neutral/alkaline) due to deliberate material deposition on soil, some of high carbonate content such as eggshells, seashells, and bones. Furthermore, the introduction of charcoal, soot, and ash either as constituent elements of composts, and in the case of Roxburgh, additional inputs arising from residues of the series of fire incidents in the 13th century, were expected to increase soil alkalinity on site, amongst other soil properties including magnetic susceptibility (Ohno and Erich, 1990; Petrovsky et al. 2018; Till et al. 2021). The general observation of soils of acidic nature across the study area may have been: 1) a direct result of the comparatively shorter period of occupation and therefore duration of practises on site; 2) the burgesses and townspeople were more engaged in other crafts and professions, and fewer in agricultural activities; 3) attenuation from post-depositional processes of natural and anthropogenic origins (e.g., through natural soil acidification; disturbances or sediment movement during clearance activities).

The area to the west of site B, which houses Trench 3, show peaks on all soil parameters (SOC content, soil pH, and phosphorus concentrations), including volume magnetic susceptibility (Figure 5), which are indicative of areas of high activity. Soils/sediments may have enhanced magnetic properties through specific onsite activities of pyrogenic nature associated with fireplaces, kilns, cooking places and/or from the inputs of pyrogenic matter such as charcoal, ash, fired pottery and bricks (James, 1999; Peters et al. 2000; Crowther, 2003; Marwick, 2005; Dalan, 2006; Schmidt, 2007; Magiera et al. 2019). Roxburgh was devastated by a series of major fire incidents in the 13th century (1207, 1216, and 1244), and on two occasions in the 14th century. These fire events, which led to substantial structural damage to the infrastructure on site A due to the predominantly timber construction, would likely have altered the magnetic susceptibility of the soil in the main street from background levels, however, soil magnetic susceptibility values on site A are much lower than expected. This observation, in addition to the relative paucity of artefacts on the site, is attributed to clearance activities, that is, the movement of sediment and rubble away from the site in order to clear ground for reconstruction. Previous archaeological study by Wessex Archaeology on site B shows that the area was not subject to extensive disturbances by post-abandonment ploughing action as is visible across other areas. It revealed evidence of a building of a substantial nature (stone construction), a roadway, a possible street, gravelled/paved surfaces, a ditch feature, and generally more discarded artifacts (e.g., pottery, pottery fragments, fine wares) relative to site A where such features exist but comparatively lower in volume. The observation of significant enhancement of soil markers on site B is indicative of a secondary thoroughfare that came into use at the same period as site A (parallel occupation) or later (phased occupation).

Optically stimulated luminescence profiling is an intra-context relative dating method that allows for the determination of the chronological sequence of soils and sediments. Variations in the luminescence signals (IRSL and Post-IR OSL) indicate sediments of different ages (Figure 7a). The progressive increment of the luminescence signals with depth suggests periodic deposition and/or gradual accumulation of materials, although the sediment at the base of the trench appears to be of a younger depositional age. This observation arises from the placement of newer, completely bleached, or older, partially bleached materials, and/or from prolonged exposure of the sediment to sunlight before subsequent infilling. This interpretation is consistent with ditch infill. Variations in the IRSL/OSL ratio is used as a proxy for indicating changes in mineral characteristics within sediment stratigraphy (Sanderson and Murphy, 2010; Munyikwa et al. 2012). The fairly constant IRSL/OSL ratios of the profile, other than at 10 cm, show that the deposits are of similar mineral composition (Figure 7b), and indicative of the proximal origins in the nature of the sediments. Overall, the degree of enhancement of soil indicator parameters for anthropogenic activity in Roxburgh is lower relative to other extant settlements. These differences arise primarily from the shorter duration of site occupation. Site use intensity, and period of occupation are two factors that define the degree of modification and the resultant residual anthropogenic signatures in the soil. For comparison, the ecclesiastical settlement of St Andrews, established in the same period as Roxburgh, show more significant degrees of enhancement of these anthropogenic markers due to its continuous uninterrupted occupation (Brooks and Whittington, 1977; Martin and Oram, 2007; Esiana et al. 2022).

5. Conclusions

Pressures arising from contemporary urban developments in and around historical town centres can undermine our ability to study, understand, document, and preserve sites of historical significance and/or monuments in a timely fashion; more so in the relative absence of strategically planned programmes of investigation in place. As alluded to in the introductory section, this situation driven by the shifting intensities of modern urban development and/or redevelopment has limited opportunities to explore and interrogate - at scale and systematically - the broader nature and characteristics of such potentially historically significant sites. Furthermore, given the situation, there is also the issue of securing sufficient funding to undertake, in some cases, such large-scale investigations.

Evidence of past occupation may be produced from the inevitable impacts of occupational activities and the subsequent imprints that it leaves on the soil. These impacts are visible from changes in a number of soil parameters within and around settled areas, and can be explored together with documentary accounts to produce a comprehensive narrative of past landscapes. This synergy is of particular importance in Roxburgh where most of the built settlement remains now lie below the surface due to its tumultuous past. Furthermore, where the density of occupation in and continuing development of the major urban centres of the modern British Isles impedes investigation across large areas, deserted or failed medieval towns as Roxburgh offer scope for such a multidisciplinary approach, including investigations via relatively non-invasive and low-cost survey techniques as employed in this study. Previous assessments of the Scheduled Monument site (No. 4284) have provided valuable information and insights into its development and structural characteristics over time. The observation of significant enhancement of soil markers (SOC content, soil pH, phosphorus concentrations, and magnetic susceptibility), on site B makes a compelling argument for a secondary thoroughfare in Roxburgh, in addition to the main thoroughfare on site A. The OSL analysis of soil profile pit shows gradual infilling of the roadside ditch overtime. Our study has built upon previous findings to elucidate and to further the understanding of the occupational history and dynamics of arguably one of Scotland's most important medieval sites.

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Reference

Anon, 1947. ‘Report on Grave at St James’s Fair Green, Kelso’, Proceedings of the Berwickshire Naturalists’ Club XX, pp. 227 – 228.

Bethell, P.H., Goad, L.J., Evershed, R.P., and Ottaway, J., 1994. The Study of Molecular Markers of Human Activity: The Use of Coprostanol in the Soil as an Indicator of Human Faecal Material. Journal of Archaeological Science. Vol. 21, pp. 619 – 632.

Blume, H.P., Leinweber, P., 2004. Plaggen soils: landscape history, properties, and classification. Journal of Plant Nutrition and Soil Science. Vol. 167, pp. 319-327.

Brooks, N.P., Whittington, G., 1977. Planning the Growth in the Medieval Scottish Burgh: the example of St Andrews. Transactions of the Institute of British Geographers, New Series. 2(3), 278–295.

Brothwell, D., 1982. Linking Urban Man with His Urban Environment. In Environmental Archaeology in the Urban Context; Hall, A.R., Kenward, H.K., (Eds.), Council of British Archaeology Research: Oxford, UK, 43, pp. 126–129.

Brown, M., 2004. The Wars of Scotland 1214-1371. The New Edinburgh History of Scotland, volume 4. Edinburgh, Edinburgh University Press.

Bull, I.D., Simpson, I.A., Dockrill, S.J., and Evershed, R.P., 1999. Organic geochemical evidence for the origin of ancient anthropogenic soil deposits at Toft Ness, Sanday, Orkney. Organic Chemistry 30, 535 – 556.

Bull, I.D., Betancourt, P.P., Evershed, R.P., 2001. An Organic Geochemical Investigation of the Practice of Manuring at a Minoan Site on Pseira Island, Crete. Geoarchaeology: An International Journal 16 (2), 223-242.

Chandler, J., 2004. Where was Old Sarum?, Sarum Chronicle 4, 22–30.

Clarke, A., Fulford, M. and Mathews, M., 2002. Silchester Insula IX: The Town Life Project – *The First Six Years 1997–2002.* Reading, University of Reading.

Crowther, J., 2003. Potential magnetic susceptibility and fractional conversion studies of archaeological soils and sediments. Archaeometry 45, 685–701.

Dalan, R.A., 2006. A geophysical approach to buried site detection using down-hole susceptibility and soil magnetic techniques. Archaeol. Prospect. 13, 182–236.

Davidson, D.A., Dercon, G., Stewart, M., Watson, F., 2006. The legacy of past urban waste disposal on local soils. Journal of Archaeological Science 33(6), 778-783.

Dearing, J.A., 1994. Environmental Magnetic Susceptibility: Using Bartington MS2 System. Chi Publishing, Kenilworth.

Dercon, G., Davidson, D.A., Dalsgaard, K., Simpson, I.A., Spek, T., Thomas, J., 2005. Formation of sandy anthropogenic soils in NW Europe: identification of inputs based on particle size distribution. Catena 59(3), 341-356.

Esiana, B.O.I., Berns, A.E., Adderley, W.P., Bol, R., 2022. Organic Carbon Speciation in Urban Anthrosols—The Legacy of Historical Waste Management. Soil Systems. 6(2):53. https://doi.org/10.3390/soilsystems6020053

Fulford, M. and Clarke, A., 2011, Silchester: City in Transition – The Mid-Roman Occupation of Insula IX c. AD 125–250/300: A Report on Excavations Undertaken since 1997. Britannia Monograph Series 25, London, Society for the Promotion of Roman Studies.

Fulford, M., Clarke, A. and Eckardt, H., 2006. Life and Labour in Late Roman Silchester: Excavations in Insula IX since 1997, Britannia Monograph series 22. London, Society for the Promotion of Roman Studies.

Goddard, N., 1996. “A mine of wealth”? The Victorians and the agricultural value of sewage. J. Hist. Geogr. 22, 274–290.

Golding, K.A., Davidson, D.A., Wilson, C.A., 2010. Antiquated rubbish: The use of urban waste as soil fertiliser in and near to historic Scottish Burghs. Antiquity 84, 1–6.

GSB Prospection 2006. Geophysical Survey Report 2006/04: Roxburgh 2006 Borders. GSB Prospection Ltd. Thornton.

Guttmann, E.B., Simpson, I.A., Davidson, D.A., 2005. Manuring practices in antiquity: A review of the evidence. In Smith, D. N., Brickley, M. B., and Smith, W. (Eds.) Fertile Ground: Papers in Honour of Susan Limbrey. Symposia of the Association for Environmental Archaeology No 22, Oxford. Oxbow, pp. 68-76.

Holliday, V.T., 2004. Soils in Archaeological Research. Oxford University Press, USA.

Holliday, V.T., Gartner, W.G., 2007. Methods of soil P analysis in archaeology. J. Archaeol. Sci. 34, 301–333.

Hubbe, A., Chertov, O., Kalinina, O., Nadporozhskaya, M., Tolksdorf-Lienemann, E., and Giani, L., 2007. Evidence of plaggen soils in European North Russia (Arkhangelsk region). Journal of Plant Nutrition and Soil Science 170, 329-334.

IUSS Working Group WRB 2015. World Reference Base for Soil Resources 2014. World Soil Resources Reports No. 103, FAO; Rome, Italy.

James, D., 2010. Settlement in the hinterland of Sorviodunum: a review, Wiltshire Archaeological and Natural History Magazine 103, 142–80.

James, P., 1999. Soil variability in the area of an archaeological site near Sparta, Greece. J. Archaeol. Sci. 26, 1273–1288.

Jeffery, A., 1859. The History and Antiquities of Roxburghshire, lll. Edinburgh. Seton & Mackenzie.

Lehmann, A., Stahr, K., 2007. Nature and Significance of Anthropogenic Urban Soils. Journal of Soils and Sediments 7(4), 247 – 260.

Leonardi, G., Miglavacca, M., Nardi, S., 1999. Soil Phosphorus Analysis as an Integrative Tool for Recognizing Buried Ancient Ploughsoils. Journal of Archaeological Science. 26, 343–352.

Marwick, B. Element concentrations and the magnetic susceptibility of anthrosols: Indicator of prehistoric human occupation in the inland Pilbara, Western Australia. J. Archaeol. Sci. 2005, 32, 1357–1368.

Martin, C. and Oram, R. (2007) Medieval Roxburgh: a preliminary assessment of the burgh and its locality. Proceedings of the Society of Antiquaries of Scotland, 137, pp. 357-404. http://archaeologydataservice.ac.uk/archives/view/psas/contents.cfm?vol=137&CFID=148316&CFTOKEN=BF718B4D-7ACC-4DED-BA7468CCA3643878.

Magiera, T., Lukasik, A., Zawadzki, J., Rosler, W., 2019. Magnetic susceptibility as indicator of anthropogenic disturbances in forest topsoil: A review of magnetic studies carried out in Central European forests. Ecological Indicators 106. https://doi.org/10.1016/j.ecolind.2019.105518.

McLean, E.O., 1982. Soil pH and Lime requirement. In: Page, A. L., (Eds.), Methods of Soil Analysis: Part 2. Agronomy Monograph No. 9. 2nd edition. American Society of Agronomy, Crop Science Society of America and Soil Science Society of America, Madison, pp. 199-224.

Met Office. UK Climate Average. Available from: https://www.metoffice.gov.uk/research/climate/maps-and-data [Accessed October 6th, 2022].

Munyikwa, K., Brown, S., Kitabwalla, Z., 2012. Delineating stratigraphic breaks at the bases of postglacial eolian dunes in central Alberta, Canada using a portable OSL reader. Earth Surface Processes and Landforms 37, 1603–1614.

Murray, H., 2010. The Buildings. In, Perry, D., Murray H., Beaumont James, T., and Bogdan, N.Q. eds, Perth High Street Archaeological Excavations 1975-1977, Fascicule 1, The Excavations at 75-95 High Street and 5-10 Mill Street, Perth. Perth, Tayside and Fife Archaeological Committee.

Murray, H.K. and Murray, J.C., 1993. Excavations at Rattray, Aberdeenshire. A Scottish deserted burgh, Medieval Archaeology 37, 109-218.

O'Conor, K.D., Shanahan, B., 2018. Rindoon Castle and Deserted Medieval Town. A Visitor's Guide. Roscommon, Roscommon County Council.

Ohno, T., Erich, M.S., 1990 Effect of wood ash application on soil pH and soil test nutrient levels. Agriculture, Ecosystems & Environment 32 (3 – 4), 223 – 239 https://doi.org/10.1016/0167-8809(90)90162-7.

Oonk, S., Slomp, C.P., Huisman, D.J., 2009. Geochemistry as an Aid in Archaeological Prospection and Site Interpretation: Current Issues and Research Directions. Archaeological Prospection 16, 35 – 51.

Oram, R.D., 2011. Waste management and peri-urban agriculture in the early modern Scottish burgh. Agricultural History Review 59(1), 1-17.

Oxford Archaeology, 2007. Newtown Jerpoint, County Kilkenny. Conservation Plan. Dublin, The Heritage Council.

Pape, J.C., 1970. Plaggen soils in the Netherlands. Geoderma 4, 229-255.

Peters, C., Church, M.J., Coles, G., 2000. Mineral magnetism and archaeology at Galson on the Isle of Lewis, Scotland. Phys. Chem. Earth Part A Solid Earth Geod. 25 (5), 455–460.

Petrovský, E., Remeš, J., Kapička, A., Podrázský, V., Grison, H., Borůvka, L., 2018. Magnetic mapping of distribution of wood ash used for fertilization of forest soil. Science of The Total Environment 626, 228 – 234. https://doi.org/10.1016/j.scitotenv.2018.01.095.

RCAHMS, 2009. RCAHMS Archaeological Survey: Medieval Roxburgh. http://canmore.org.uk/event/884099

Rossiter, D.G., 2007 Classification of urban and industrial soils in the World Reference Base of Soil Resource. Journal of Soils and Sediments 7(2), 96-100.

Sanderson, D.C.W., Murphy, S., 2010. Using simple portable OSL measurements and laboratory characterisation to help understand complex and heterogeneous sediment sequences for luminescence dating. Quaternary Geochronology 5, 299-305.

Schmidt, A., 2007. Archaology, magnetic methods. In Encyclopedia of Geomagnetism and Paleomagnetism; Gubbins, D., Herrero-Bervera, E., (Eds.), Encyclopedia of Earth Sciences Series; Springer: Berlin/Heidelberg, Germany; New York, NY, USA, pp. 23–31.

Sheail, J., 1996. Town wastes, agricultural sustainability and Victorian sewage. Urban Hist. 23, 189–210.

Simpson, I.A., 1997. Relict properties of anthropogenic deep top soils as indicators of infield management in Marwick, West Mainland, Orkney. Journal of Archaeological Science 24, 365-380.

Simpson, I.A., van Bergen, P.F., Perret, V., Elhmmali, M.M., Roberts, D.J., Evershed, R.P., 1999. Lipid biomarkers of manuring practice in relict anthropogenic soils. The Holocene 9, 223-229.

Soil Survey of Scotland 1959. Soil Survey of Scotland Systematic Soil Survey: Kelso – sheet 25. The Macaulay Institute for Soil Research. Aberdeen.

Till, J.L., Moskowitz, B., Poulton, S.W., 2021. Magnetic Properties of Plant Ashes and Their Influence on Magnetic Signatures of Fire in Soils. Front. Earth Sci. 8. https://www.frontiersin.org/articles/10.3389/feart.2020.592659/full.

Urbanski, L., Schad, P., Kalbitz, K., Mourik, J., Gehrt, E., Kogel-Knabner, I., 2022. Legacy of plaggen agriculture: High soil organic carbon stocks as result from high carbon input and volume increase. Geoderma 406. https://doi.org/10.1016/j.geoderma.2021.115513.

Wells, E.C., 2004. Investigating Activity Patterns in Pre-Hispanic Plazas: Weak Acid-Extraction ICP-AES Analysis of Anthrosols at Classic Period El Coyote, Northwestern Honduras. Archaeometry 46(1), 67-84.

Wessex Archaeology 2004. Old Roxburgh, Floors Castle Estate, Kelso, Scotland. An archaeological evaluation and an assessment of the results. Wessex Archaeology Limited. Salisbury.

Woods, W.I., Denevan, W.M., 2009. Amazonian Dark Earths: The first century of reports. In Amazonian Dark Earths: Wim Sombroek's Vision; Woods, W.I., Teixeira, W.G., Lehmann, J., Steiner, C., WinklerPrins, A.M.G.A., Rebellato, L., (Eds.), Springer: Dordrecht, The Netherlands, pp. 1–14.

Wrathmell, S., 2022. Wharram Percy Digital Archive [data-set]. York: Archaeology Data Service [distributor] https://doi.org/10.5284/1000415

Wyeth, W., 1736. 'A survey of Floors…belonging to His grace the Duke of Roxburgh', Photostat copy of plan, NAS RHP3234.