ARCHAEOLOGICAL SERVICES
DURHAM UNIVERSITY

on behalf of
Professor Chris Gerrard
Department of Archaeology
Durham University

The Scottish Soldiers Project
Palace Green
Durham City

geophysical surveys

report 4209
July 2016

Durham University

Contents

Figures

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1. Summary

The project

1.1 This report presents the results of geophysical surveys conducted around Palace Green, part of the Durham World Heritage Site, to contribute towards further research as part of the Scottish Soldiers Project.

1.2 The works were commissioned by Professor Chris Gerrard, Department of Archaeology, Durham University, and conducted by Archaeological Services Durham University.

Results

1.3 Although various geophysical anomalies have been detected, none is considered likely to reflect a large pit or mass grave associated with the Scottish prisoners from the Battle of Dunbar.

1.4 Whilst some discrete low resistance anomalies were detected, which can indicate soil-filled features such as pits and ditches, no corresponding geomagnetic anomalies or radar reflections were recorded. Although the presence of services, buildings and metal fixtures may have hindered the detection of weaker positive magnetic anomalies, often associated with pits, these low resistance anomalies are considered likely to have a different origin.

1.5 Relatively slight low and high resistance anomalies in both the Fellows' and Master's Gardens probably reflect former garden features such as planting beds and paths, respectively. The shallow and perhaps short-lived nature of the flower beds could account for their absence in the magnetic data, whilst still creating resistance anomalies due to the differential drainage between the former beds and paths.

1.6 Thomas Forster's plan of 1754 depicts a small parterre in the Master's Garden; one probable former path aligned east-west across the south of the garden may be contemporary with this plan. The majority of possible garden features detected in this study appear to be on a different alignment and may reflect a later phase of garden design.

1.7 Probable rubble in the south-east corner of the Master's Garden corresponds to the location of a former building, shown on Forster's map.

1.8 An early 20th-century path across the Master's Garden has been readily detected by all three geophysical techniques.

1.9 Possible made ground or other dumped materials have been identified in small parts of the Fellows' Garden and the cathedral graveyard.

1.10 Several services have been detected in the north of the cathedral graveyard.

2. Project background

Location (Figure 1)

2.1 The surveys were located in three open, grassed areas around Palace Green, Durham City (NGR centre: NZ 2738 4225): the Master's Garden and Fellows' Garden at University College (Durham Castle), and part of the graveyard to the north of Durham Cathedral. The cathedral and castle, together with Palace Green, form a UNESCO World Heritage Site (WHS). The survey areas also fall within the Durham City Conservation Area and many of the standing structures are listed buildings.

Project history

2.2 Human remains were found during building work at Palace Green Library in November 2013. The jumbled skeletons of at least 17 and up to 28 individuals were excavated from two burial pits. Subsequent analysis determined that the adult skeletons were all male and predominantly aged between 13-25 years old. The nature and location of the remains suggested that they might be those of Scottish prisoners captured at the Battle of Dunbar in 1650, during the Civil War, however, initial radiocarbon dating results did not confirm this hypothesis. Further radiocarbon dating of four additional samples, which were carefully selected to ensure a more precise result, has now concluded that the date of death was between 1625 and 1660.

2.3 When these dates are combined with the nature and location of the graves, the results of earlier scientific and observational tests, and isotopic analysis that showed the skeletons were of likely Scottish origin, the only plausible interpretation is that the bones are those of Scottish soldiers who were imprisoned and died in Durham after the battle in 1650.

2.4 Neither of the two mass graves was completely exposed or excavated during the construction works. More bones are still present beneath the café terrace at Palace Green Library and it is likely that there are more mass graves beneath other nearby buildings, on what would have been open ground in the early to mid-17th century.

Research objectives

2.5 The principal aim of the geophysical surveys was therefore to detect sub-surface anomalies which could reflect predominantly soil-filled medium-large pits, potentially further mass graves associated with the Scottish prisoners from the Battle of Dunbar.

2.6 The *Durham World Heritage Site Research Framework* (Petts 2015) contains an agenda for archaeological research in the UNESCO WHS. These surveys directly contribute to 'Research priority 3: Mapping the archaeological resource'.

2.7 The scheme of works also has the potential to contribute towards both monument specific and period specific research aims and questions, including:

- COL5: Better understanding of sub-surface archaeological deposits (at the College); Geophysical survey of College Green and open space to the south of the College buildings
- CAS5: Better understanding of the archaeological deposits that still survive in and around the Castle; Improved coverage of geophysical survey to enhance

understanding of below-ground archaeology – particularly possible survival of traces of the east range in the courtyard

- PRH1: What evidence is there for prehistoric or Roman activity on the peninsula? Scope for geophysics in some of the open areas on the peninsula (gardens; open ground to the south of the College; College Green)
- AS1: Extent and nature of Anglo-Saxon monastery and church; Further geophysical survey including on College Green
- AS3: Is there any evidence for a defensive complex preceding the Norman Castle, as implied in *De obsessione Dunelmi*? Likely to be destroyed by later castle- but geophysics in the open spaces in and around the Castle may identify possible traces

Methods statement

2.8 The surveys have been undertaken in accordance with national standards and guidance (see para. 5.1 below).

Dates

2.9 Fieldwork was undertaken in the Fellows' Garden on 13th June 2016, the cathedral cemetery on 14th June 2016 and the Master's Garden on 23rd June 2016. This report was prepared for July 2016.

Personnel

2.10 Fieldwork was conducted by Duncan Hale, Richie Villis, Patricia Voke and Mark Woolston-Houshold. The geophysical data were processed by Richie Villis. This report was prepared by Richie Villis and Duncan Hale (the survey Project Manager), with illustrations by Dr Helen Drinkall and Janine Watson.

Archive/OASIS

2.11 The site codes are: **PGM16** for **P**alace **G**reen **M**aster's Garden 20**16**; **PGF16** for **P**alace **G**reen **F**ellows' Garden 20**16**; and **PGC16** for **P**alace **G**reen **C**athedral 20**16**. The survey archive will be retained at Archaeological Services Durham University and a copy supplied on CD to the client for deposition with the project archive in due course. Archaeological Services Durham University is registered with the **O**nline **A**cces**S** to the **I**ndex of archaeological investigation**S** project (**OASIS**). The OASIS ID number for this project is **archaeol3-257270**.

Acknowledgements

2.12 Archaeological Services Durham University is grateful for the assistance of Norman Emery (Durham Cathedral Archaeologist), personnel of University College at Durham University and the Dean and Chapter of Durham Cathedral in facilitating this research.

3. Historical and archaeological background

3.1 The general history of the Durham peninsula has been set out in detail elsewhere (for example, Bonney 1990; Roberts 2003), is widely available and need not be presented here. An archaeological desk-based assessment, conducted prior to installation of a new heating system for buildings on the peninsula, specifically summarises the archaeology and historical development of Palace Green and the North Bailey area (Archaeological Services 2008).

3.2 Geophysical surveys were undertaken on Palace Green in 2009 with the specific aim of locating possible mass graves associated with the prisoners from the Battle of Dunbar (Archaeological Services 2009). Geomagnetic and ground-penetrating radar techniques were employed over the central grassed area of Palace Green and the broad area of tarmac to its immediate south. Although no evidence was found for any large pits or possible mass graves, other features of possible historic interest were identified.

3.3 Several detailed reports on the background to the Battle of Dunbar and the 2013 excavation at Palace Green Library have been prepared (Archaeological Services 2015; Caffell 2014; Graves 2015; Millard 2015a & 2015b).

3.4 In September 1650, a Scottish Covenanting army under David Leslie was defeated by Oliver Cromwell's English Parliamentarian army at the Battle of Dunbar in southern Scotland. Over 4,000 Scots soldiers were taken prisoner by Cromwell's army and marched south to Newcastle. On the march some escaped and others died. The officers were imprisoned in Newcastle and the remainder, perhaps 3000 men, were marched to Durham where they were imprisoned in the cathedral church. At that time the church was empty and abandoned. The Dean and Chapter had been dissolved and Anglican worship was suppressed. From Durham, some were later transported to Virginia as indentured servants, others were sent to Ireland or France for military service, and some were sent to drain the Fens. It is not known exactly how many prisoners were kept in the cathedral, or for how long, but it is certain that there were very many deaths from disease and shortage of food, with some estimates of up to 30 deaths per day. Sick prisoners are known to have been lodged in parts of the castle. It has long been assumed that there were mass burials of prisoners somewhere near the castle and cathedral.

3.5 Excavation of the two mass graves during building works at Palace Green Library in 2013 concluded that the burials extended north, south and east of the excavated area, under existing buildings and walls. It is quite possible that there are more mass graves under the Library's Learning Centre and part of the music studios, the café, and the whole area to the north as far as the Exchequer Building and the Fellows' Garden, since all of these areas are believed to have been open ground in the early to mid-17th century.

3.6 Until the 17th century, a dry moat would have provided a line of defence for the castle. The moat would have passed through what is now the Master's Garden and also through the northern part of the Fellows' Garden. This moat was infilled under Bishop Cosin as part of extensive refurbishment aimed at making the castle more palatial and less like a fortress, since by this time the castle had no defensive significance. The moat would therefore have been infilled *c*.1660.

4. Landuse, topography and geology

4.1 The three survey locations comprised managed gardens and lawns at University College's Master's Garden and Fellows' Garden, and part of the graveyard to the north of Durham Cathedral.

4.2 The Master's Garden occupies the space between the Master's House on the north-east corner of Palace Green and the castle entrance on the north-west corner of Palace Green. A stone wall and flower beds bounded the survey area to the south and west, with a gravel path also in the west. A gravel path also bounded the area to the north and east, with flower beds and the terraced castle motte to the north, and flower beds and the Master's House to the east. Eight trees stood around the lawn. Survey data were collected over the lawn area, measuring approximately 640sqm.

4.3 The Fellows' Garden is to the north-west of Palace Green, immediately south of the main University College building. Stone buildings bound the area to the north, east and south, with a stone wall to the west. Gravel paths and flower beds surrounded the area; two raised terraces with stone revetment walls stood in the south. Survey was concentrated over the lawn area, with some geomagnetic and GPR survey extending over the gravel paths. The total area measured approximately 900sqm.

Resistance survey in the Fellows' Garden, looking north-east

4.4 The cathedral survey covered part of the graveyard north of the cathedral, between the War Memorial and the Music Department in the west and Dun Cow Lane in the east. Gravestones, trees and bushes, and floodlights were present across the area, and two tarmac paths. The surveyed area was roughly triangular and measured approximately 1600sqm; GPR survey targeted the central part of the area.

4.5 Palace Green is a large open space between the castle and cathedral on the Durham peninsula. The area is predominantly level, with a mean elevation of 63m OD in the north and 64m OD in the south.

4.6 The underlying solid geology of the area comprises Carboniferous sandstone of the Pennine Middle Coal Measures Formation, which is overlain by Quaternary glaciofluvial sand and gravel.

5. Geophysical survey

Standards

5.1 The surveys and reporting were conducted in accordance with Historic England guidelines, *Geophysical survey in archaeological field evaluation* (David, Linford & Linford 2008); the Chartered Institute for Archaeologists (CIfA) *Standard and Guidance for archaeological geophysical survey* (2014); the CIfA Technical Paper No.6, *The use of geophysical techniques in archaeological evaluations* (Gaffney, Gater & Ovenden 2002); and the Archaeology Data Service & Digital Antiquity *Geophysical Data in Archaeology: A Guide to Good Practice* (Schmidt 2013).

Technique selection

5.2 Geophysical survey enables the relatively rapid and non-invasive identification of sub-surface features of potential archaeological significance and can involve a suite of complementary techniques such as magnetometry, earth electrical resistance, ground-penetrating radar, electromagnetic survey and topsoil magnetic susceptibility survey. Some techniques are more suitable than others in particular situations, depending on site-specific factors including the nature of likely targets; depth of likely targets; ground conditions; proximity of buildings, fences or services and the local geology and drift.

5.3 In this instance, the specific survey targets were medium-large pits, perhaps 2-4m across or elongated in one direction, predominantly soil-filled.

5.4 It was considered likely that evidence for historic garden features might survive in the two existing garden areas, and that unmarked graves might possibly be present with the graveyard area. There was also the potential for the remains of further, possibly earlier, features to be present, such as wall footings and other structural remains, tracks, ditches, pits or fired structures (for example kilns and hearths).

5.5 Given the anticipated nature and depth of targets, and the non-igneous geological environment of the study area, three complementary geophysical survey techniques were considered appropriate: geomagnetic, earth electrical resistance and GPR. The selected geomagnetic technique, fluxgate gradiometry, involves the use of hand-held magnetometers to detect and record anomalies in the vertical component of the Earth's magnetic field caused by variations in soil magnetic susceptibility or permanent magnetisation; such anomalies can reflect archaeological features.

5.6 Given the possible presence of wall footings, hard surfaces and tracks, an electrical resistance survey was also considered appropriate. Earth electrical resistance survey can be particularly useful for mapping stone features. When a small electrical current is injected through the earth it encounters resistance which can be measured. Since resistance is linked to moisture content and porosity, stone features will give relatively high resistance values while soil-filled features, which typically retain more moisture, will provide relatively low resistance values.

5.7 GPR generates a short high-frequency radar pulse which is transmitted into the ground via an antenna; the energy is reflected by buried interfaces and the return signal is received by a second antenna. The amplitude of the return signal relates to the electromagnetic responses of different sub-surface materials and conditions, which can be features of archaeological or historic interest. The time which elapses between the transmission and return of radar pulses to the surface can be used to

estimate the depth of reflectors. As well as conducting traditional 2D area surveys, GPR also has a depth component and so can be used to create pseudo 3D models of the data, provided sufficient data are collected at closely-spaced intervals; these models can then be viewed in plan at selected depths known as 'time-slices'.

Field methods

5.8 For the geomagnetic and resistance surveys, a 20m grid was established across each survey area and related to the Ordnance Survey (OS) National Grid using Leica GS15 global navigation satellite systems (GNSS) with real-time kinematic (RTK) corrections typically providing 5-10mm accuracy.

Geomagnetic survey in the Master's Garden, looking north to the castle keep

5.9 Measurements of vertical geomagnetic field gradient were determined using a Bartington Grad601-2 dual fluxgate gradiometer. A zig-zag traverse scheme was employed and data were logged in 20m grid units. The instrument sensitivity was nominally 0.03nT, the sample interval was 0.25m and the traverse interval was 1m, thus providing 1,600 sample measurements per 20m grid unit.

5.10 Measurements of electrical resistance were determined using a Geoscan RM15D Advanced resistance meter with a MPX15 multiplexer and a mobile twin probe separation of 0.5m. A zig-zag traverse scheme was employed and data were logged in 20m grid units. The instrument sensitivity was set to 0.1 ohm, the sample interval

was 0.5m and the traverse interval was 0.5m, thus providing 1,600 sample measurements per 20m grid unit.

5.11 GPR data were collected using a Malå Ramac X3M radar system. Malå Object Mapper projects were undertaken across the majority of each area, using a 500MHz antenna. Returned energy wavelets were recorded from many depths in the ground to produce a series of reflections generated at one location, called a reflection trace. Series of traces collected along each transect produce a radar profile or radargram. Data were collected at 0.05m intervals along parallel transects spaced 1m apart, each crossing a common baseline.

GPR survey in the cathedral graveyard, looking south-west to the cathedral

5.12 Data were downloaded on site into laptop computers for initial processing and storage and subsequently transferred to a desktop computer for processing, interpretation and archiving.

Data processing

5.13 Geoplot v3 software was used to process the geomagnetic and electrical resistance data and to produce both continuous tone greyscale images and trace plots of the raw (minimally processed) data. The greyscale images, trace plots and geophysical interpretations are presented in Figures 2-7. In the greyscale images, positive magnetic and high resistance anomalies are displayed as dark grey, while negative

magnetic and low resistance anomalies are displayed as light grey. Palette bars relate the greyscale intensities to anomaly values in nanoTesla or ohm, as appropriate.

5.14 The following basic processing functions have been applied to the geomagnetic data:

clip	clips data to specified maximum or minimum values; to eliminate large noise spikes; also generally makes statistical calculations more realistic
zero mean traverse	sets the background mean of each traverse within a grid to zero; for removing striping effects in the traverse direction and removing grid edge discontinuities
de-stagger	corrects for displacement of geomagnetic anomalies caused by alternate zig-zag traverses
interpolate	increases the number of data points in a survey to match sample and traverse intervals; in this instance the data have been interpolated to 0.25m x 0.25m intervals

5.15 The following basic processing functions have been applied to the resistance data:

clip	clips data to specified maximum or minimum values; to eliminate large noise spikes; also generally makes statistical calculations more realistic
de-spike	locates and suppresses spikes in data due to poor contact resistance
interpolate	increases the number of data points in a survey to match sample and traverse intervals; in this instance the data have been interpolated to 0.25m x 0.25m intervals

5.16 ReflexW v7.5 software was used to process the GPR profiles, to stack and interpolate the profiles to produce a 3D data volume, and to produce greyscale images of profiles and time-slices (Figures 8-11).

5.17 Combinations of the following processing functions have been applied to the GPR profiles:

dewow	removes very low frequency components by subtracting the mean from each trace
static correction	moves the start times for traces in each profile to 0nS
gaining the data	compensates for energy loss as the radio pulse penetrates deeper and/or amplifies the area of interest by adding a determined value
bandpass filter	removes low-amplitude frequencies (Butterworth values)

background removal	reduces data ringing
migration	a Stolt migration was performed to reduce the axes and enhance the apexes of hyperbolic reflections to resolve individual objects

Interpretation: anomaly types

5.18 Colour-coded geophysical interpretation plans are provided. Three types of geomagnetic anomaly have been distinguished in the data:

positive magnetic	regions of anomalously high or positive magnetic field gradient, which may be associated with high magnetic susceptibility soil-filled structures such as pits and ditches
negative magnetic	regions of anomalously low or negative magnetic field gradient, which may correspond to features of low magnetic susceptibility such as wall footings and other concentrations of sedimentary rock or voids.
dipolar magnetic	paired positive-negative magnetic anomalies, which typically reflect ferrous or fired materials (including fences and service pipes) and/or fired structures such as kilns or hearths

5.19 Two types of resistance anomaly have been distinguished in the data:

high resistance	regions of anomalously high resistance, which may reflect foundations, tracks, paths and other concentrations of stone or brick rubble
low resistance	regions of anomalously low resistance, which may be associated with soil-filled features such as pits and ditches

Interpretation: features

General comments

5.20 An archaeological interpretation is presented in Figure 12.

5.21 Small, discrete dipolar magnetic anomalies have been detected in all of the survey areas. These almost certainly reflect items of near-surface ferrous and/or fired debris, such as horseshoes and brick fragments, and in most cases have little or no archaeological significance. A sample of these is shown on the geomagnetic interpretation plan, however, they have been omitted from the archaeological interpretation plan and the following discussion.

The Master's Garden

5.22 A well-defined, broadly east/west aligned, band of high resistance has been detected across the survey area. This corresponds to a band of weak positive and negative magnetic anomalies. These anomalies broadly correspond to a former path, as shown on historic OS editions dated 1919 and 1939.

5.23 GPR profiles and time-slices generated across this area also clearly show the former path. Possible kerbs have been identified along the edges of the path at a depth of

approximately 0.32-0.36m (using a wave velocity of 0.09m/ns, estimated using a hyperbola fitting technique). Many small high amplitude reflections have been recorded at between 0.36-0.73m depth, which almost certainly represent the material of the path itself. Given the nature of the anomalies associated with this feature, combined with the suggested depth and thickness, it probably represents a relatively well-preserved path with kerbs and associated bedding material.

5.24 A high resistance anomaly in the south-east corner of the area almost certainly reflects rubble from a former building shown here on Thomas Forster's detailed map of the city dated 1754.

5.25 With the exception of the former path and rubble (above) there is very little variation in the resistance data. Although linear, rectilinear and circular anomalies have been detected, they are all extremely weak. These weak variations in resistance could perhaps reflect different phases of former garden features, including paths (slightly higher resistance) and planting beds (slightly lower resistance). One possible former path has been detected aligned broadly east-west in the south of the garden, parallel to the boundary wall. This alignment is consistent with a small geometric garden shown on Forster's 1754 plan.

5.26 Other weak resistance anomalies which might possibly reflect former garden features appear to be aligned north-west/south-east.

5.27 None of the slightly low resistance anomalies has a corresponding positive magnetic anomaly, as would be expected of a soil-filled pit or mass grave. No anomalies consistent with large pits, or mass graves, have been identified in this area by any of the survey techniques.

5.28 Small hyperbolic reflections have been detected across many of the radar profiles in this area. These represent discrete objects in the near surface, most of which will almost certainly reflect tree roots and stones.

The Fellows' Garden

5.29 Regions of slight high and low resistance have been detected across this area, parallel to the long axis of the garden. These may reflect former garden features, such as paths and planting beds. No geomagnetic or GPR anomalies have been identified correlating to these features.

5.30 Strong reflections in the GPR data broadly correlate to a region of higher resistance in the north-east corner of the area. This probably reflects a lens of material, such as sand or stone rubble, at an estimated depth of 0.12-0.36m based on GPR travel time. Similar resistance anomalies in the southern part of the main lawn, again not detected magnetically, probably also reflect deposits of sand or rubble.

5.31 Hyperbolic GPR reflections across the area almost certainly reflect discrete near-surface objects, such as rocks and brick fragments.

5.32 Very strong dipolar magnetic anomalies have been detected at the southern end of the area. These reflect a metal fire escape on the building to the immediate south.

5.33 No features believed to represent possible mass graves have been identified.

The cathedral cemetery

5.34 The geomagnetic data for this area are characterised by intense anomalies associated with services, floodlights and other street furniture. The presence of these very strong anomalies has hindered the detection of weaker anomalies, which might have been associated with archaeological features including pits.

5.35 Small patches of high electrical resistance have been detected in the west of this area. These could reflect free-draining lenses of sand or deposits of rubble.

5.36 A region of high resistance has been detected in between the two footpaths. GPR profiles collected across this area have identified deposit interfaces at approximately 0.35 and 0.75m depth (Figure 11). Many small, high amplitude reflections here (shown in time-slice at a depth of approximately 0.5m) correspond to the broad area of high resistance. It is likely that this reflects a region of disturbed ground, possibly including rubble and other waste material, used either in landscaping works, such as in-filling a small hollow, or associated with the construction of the paths and services in this area.

5.37 Chains of strong dipolar and negative magnetic anomalies have been detected across this area, which correlate with linear regions of low resistance and chains of high amplitude reflections at varying depths in the GPR data. These all reflect services. Two services have been detected along both sides of the eastern path; another lies parallel to the graveyard's northern boundary wall; one is aligned north-south in the east of the area; and a curvilinear service in the north-western corner of the area almost certainly reflects the power supply for a bank of floodlights.

5.38 Small gaps in the data correspond to the locations of trees, bushes, gravestones and street furniture.

5.39 The surveys have not detected evidence for any large pit features, such as mass graves. No single unmarked graves have been identified in this part of the churchyard either, though the detection of single graves requires a very high sampling density, beyond the scope of this study.

6. Conclusions

6.1 A programme of geophysical survey, comprising geomagnetic, earth electrical resistance and GPR techniques, has been undertaken on land around Palace Green, Durham City, as part of the Scottish Soldiers Project.

6.2 Although various geophysical anomalies have been detected, none is considered likely to reflect a large pit or mass grave associated with the Scottish prisoners from the Battle of Dunbar.

6.3 Whilst some discrete low resistance anomalies were detected, which can indicate soil-filled features such as pits and ditches, no corresponding geomagnetic anomalies or radar reflections were recorded. Although the presence of services, buildings and metal fixtures may have hindered the detection of weaker positive magnetic anomalies, often associated with pits, the low resistance anomalies are considered likely to have a different origin.

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6.8 Possible made ground and other dumped materials have been identified in small parts of the Fellows' Garden and the cathedral graveyard.

6.9 Several services have been detected in the north of the cathedral graveyard.

7. Sources

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Figure 1: Site location

location of surveys

2009 geophysical surveys

0 500m

scale 1:10 000 for A4 plot

magnetic survey

2009 surveys

-20 nT 20

Master's Garden

Fellows' Garden

Cemetery

423

422

273

274

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0 25m
scale 1:500 for A3 plot

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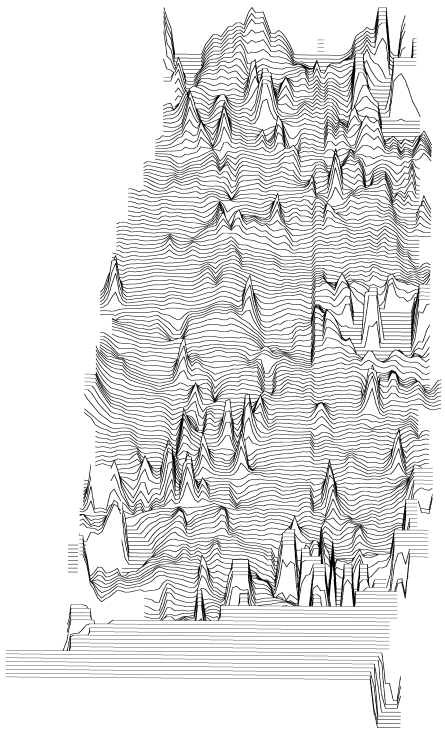
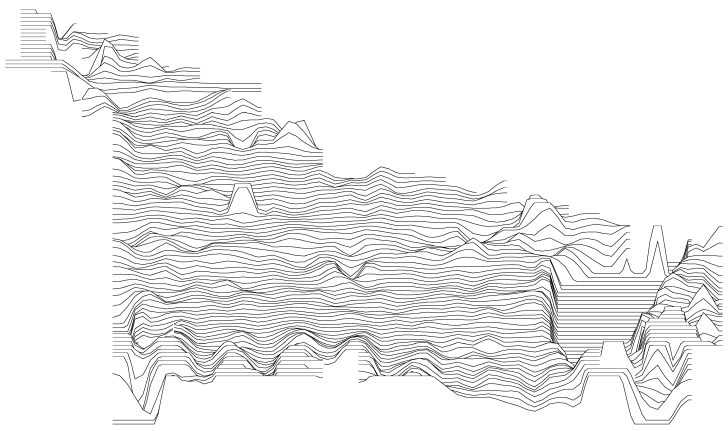
Palace Green
Durham City

geophysical surveys
report 4209

Figure 2: Geomagnetic survey

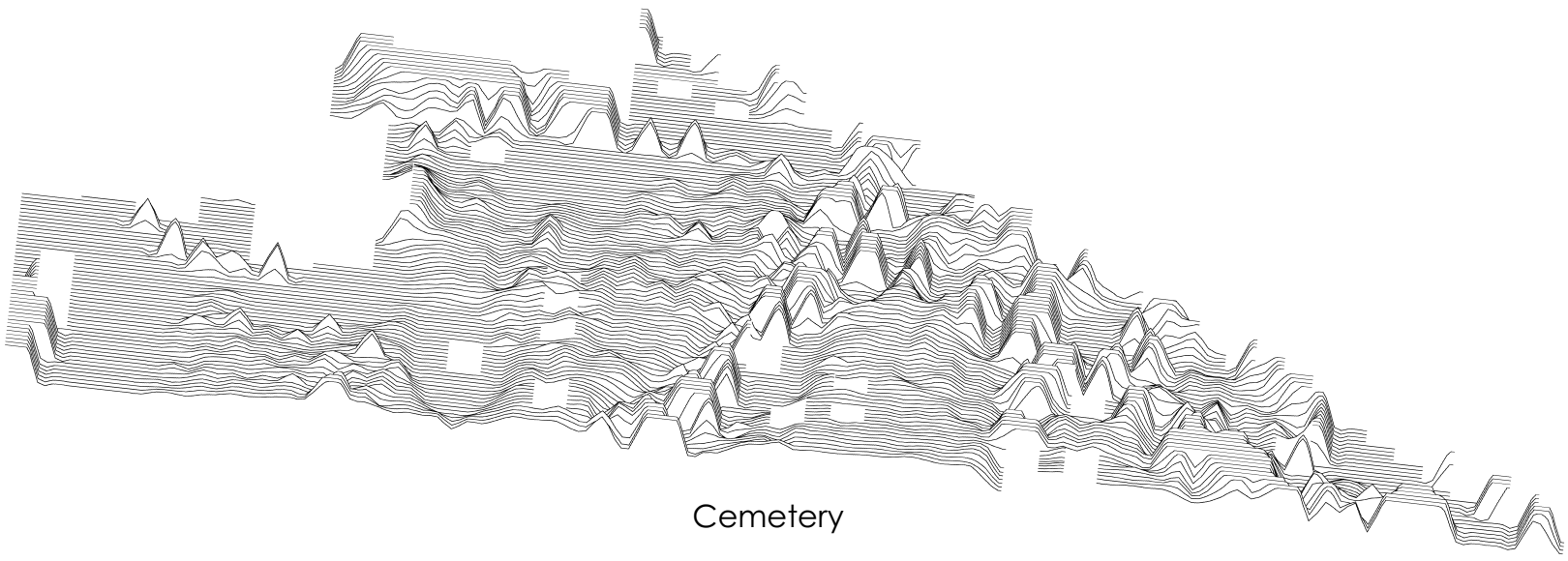


Fellows' Garden



Master's Garden

80.00nT/cm



Cemetery

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0 25m
scale 1:500 for A3 plot

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Durham City

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Figure 3: Trace plots of geomagnetic data

magnetic survey

2009 surveys

dipolar magnetic anomaly

positive magnetic anomaly

negative magnetic anomaly

423

Fellows' Garden

Master's Garden

422

Cemetery

273

274

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0 25m
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Figure 4: Geophysical interpretation of geomagnetic data

resistance survey

2009 surveys

Fellows' Garden
45 ohm 60

Cemetery
45 ohm 95

Master's Garden
45 ohm 75

Master's Garden

Fellows' Garden

Cemetery

423

422

273

274

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0 25m
scale 1:500 for A3 plot

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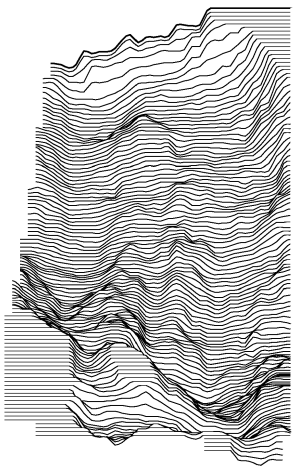
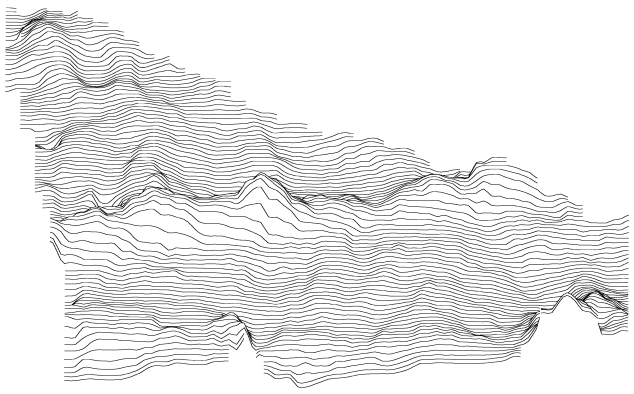
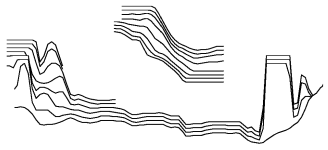
Figure 5: Electrical resistance survey



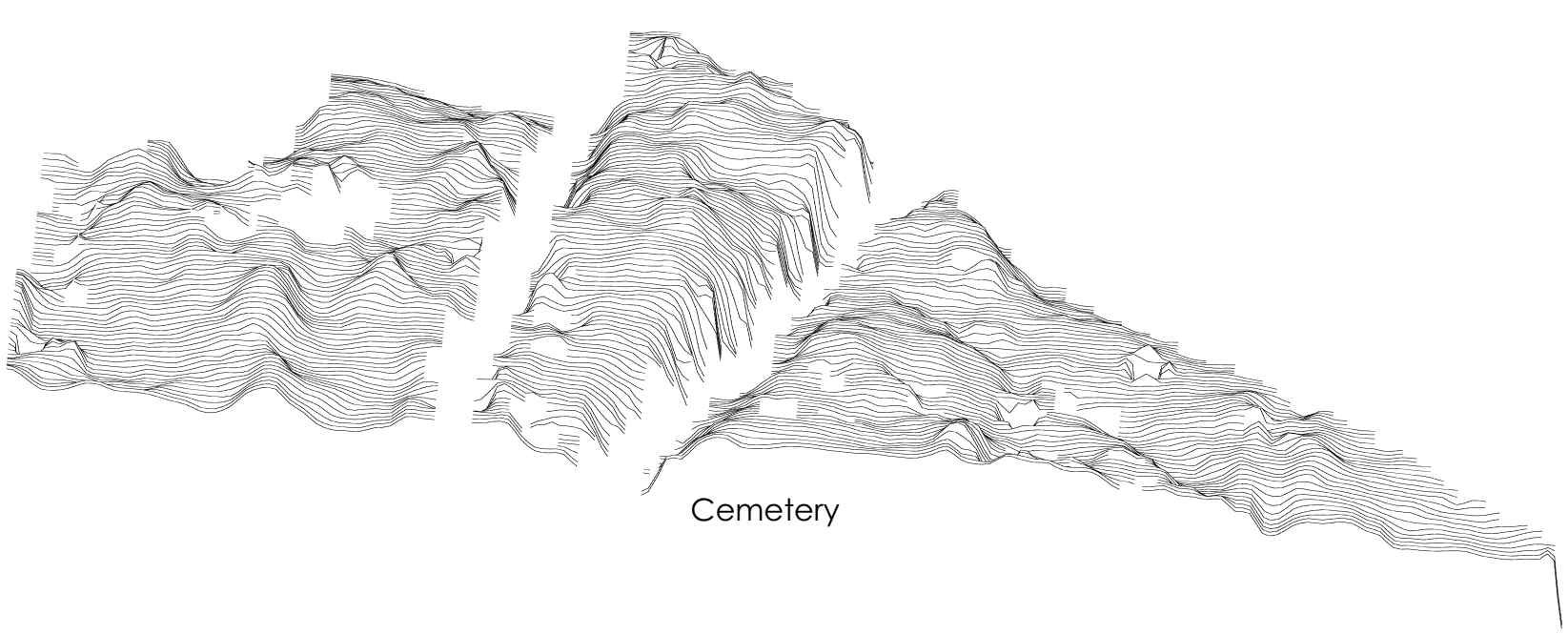


Master's Garden



Fellows' Garden

40.00ohm/cm



Cemetery

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Figure 6: Trace plots of resistance data

resistance survey

2009 surveys

high resistance anomaly

low resistance anomaly

Master's Garden

Fellows' Garden

Cemetery

423

422

273

274

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Figure 7: Geophysical interpretation of resistance data

GPR survey

GPR profiles

2009 surveys

Profile 2.2

Profile 2.1

Profile 1.2

Profile 1.1

Master's Garden

Fellows' Garden

Profile 3.1

Profile 3.2

Cemetery

423

422

273

274

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Figure 8: GPR survey overview

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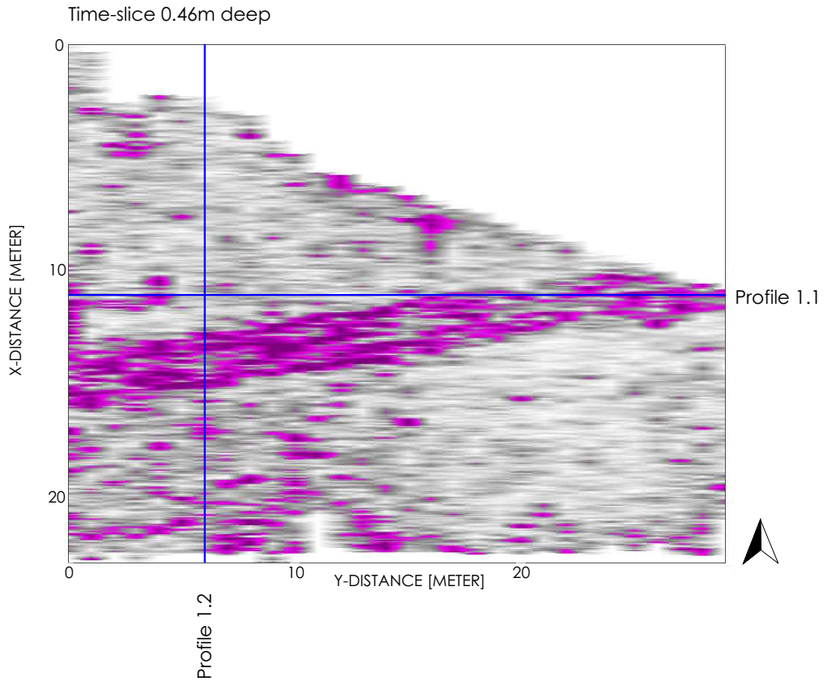
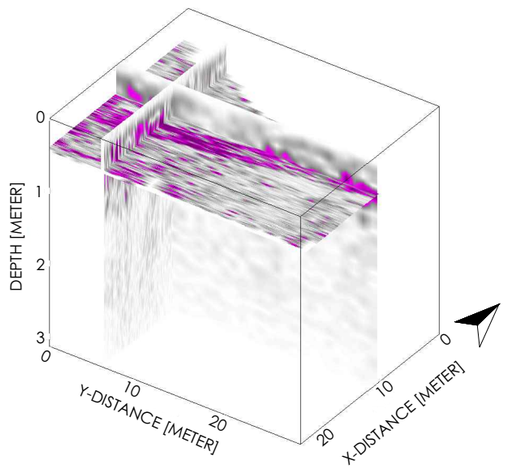
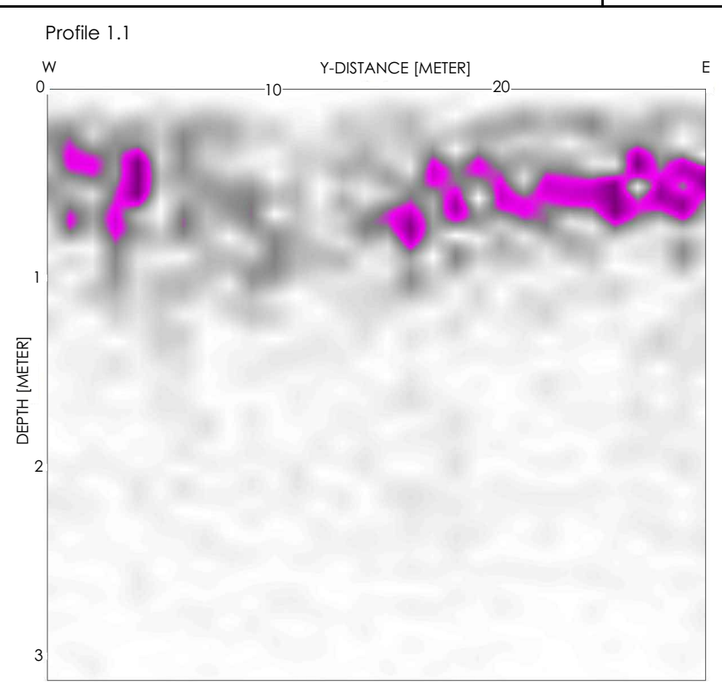
Figure 9: The Master's Garden, GPR profiles and time-slice







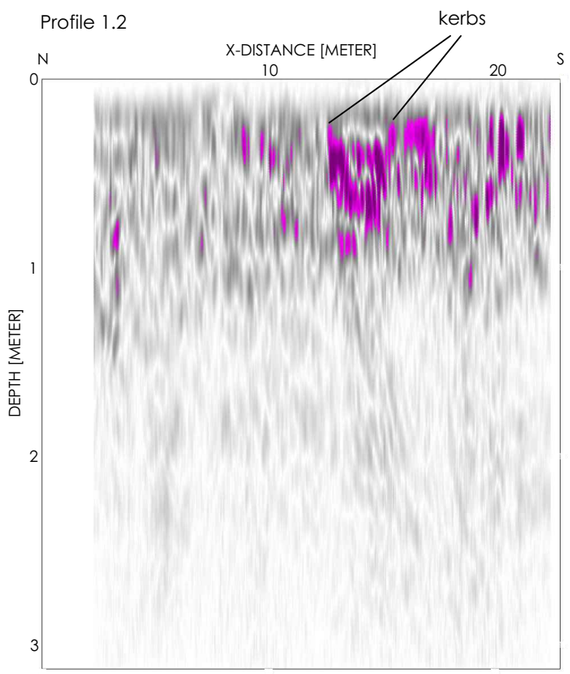


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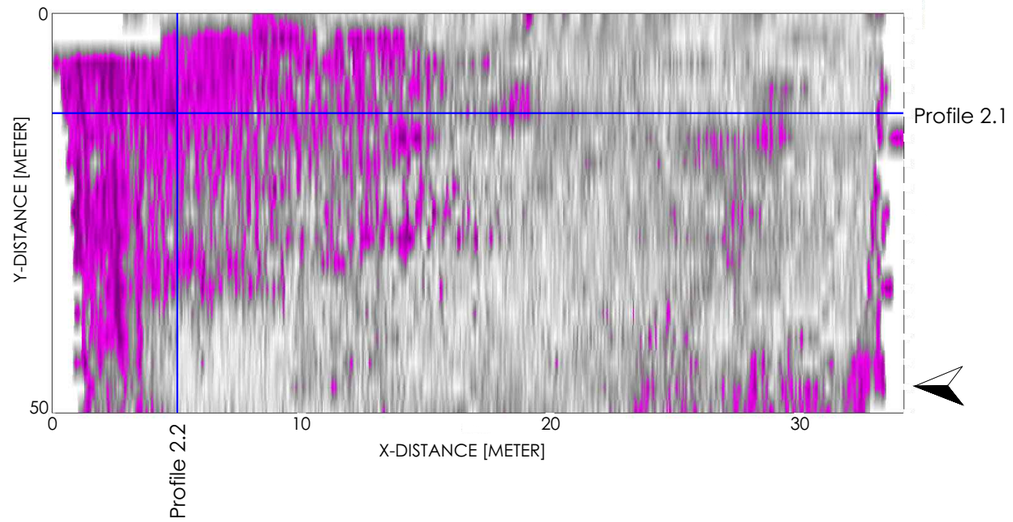
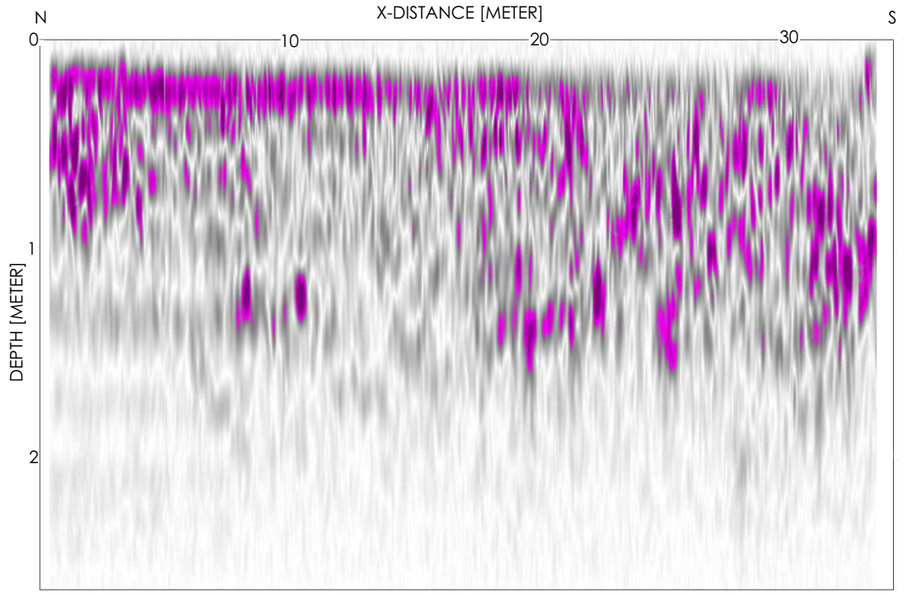
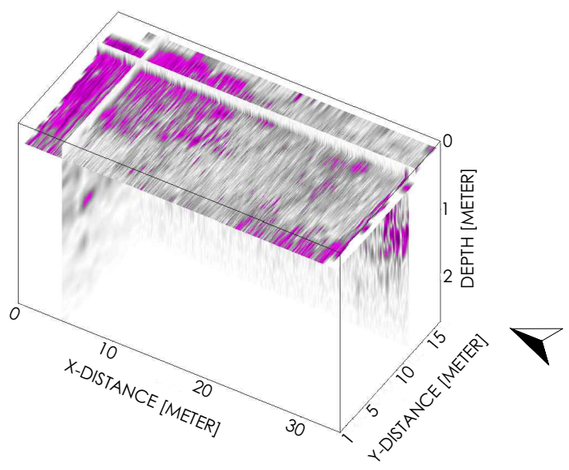
Figure 10: The Fellows' Garden, GPR profiles and time-slice

Time-slice 0.19m deep



Profile 2.1





Profile 2.2

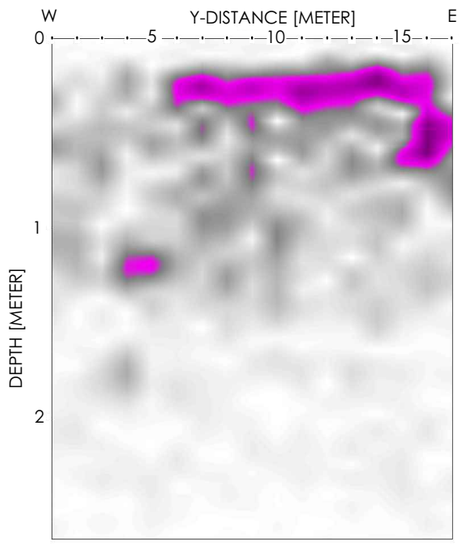


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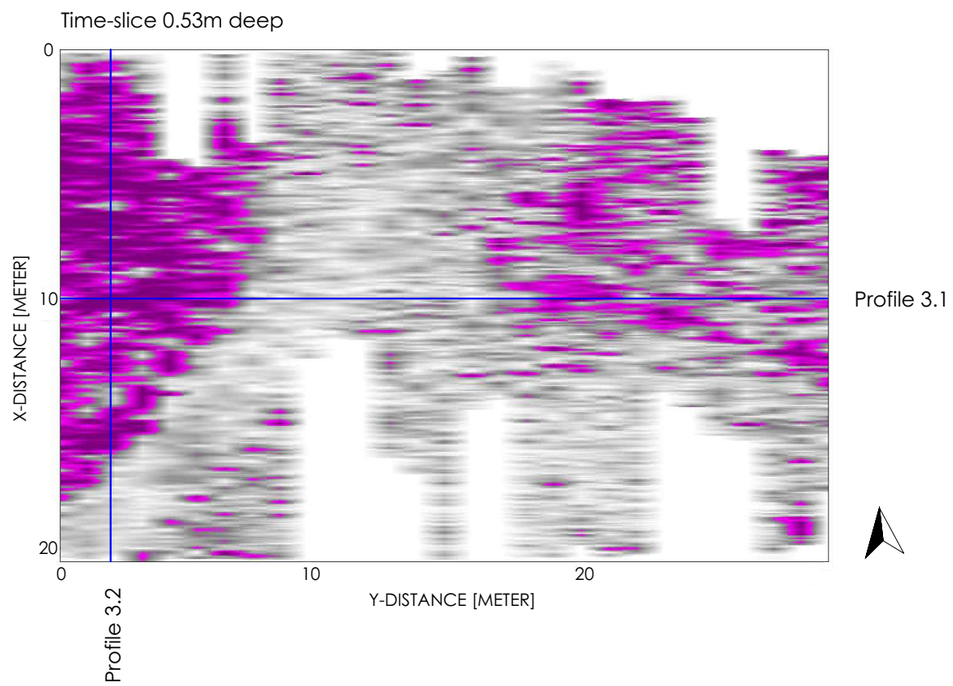
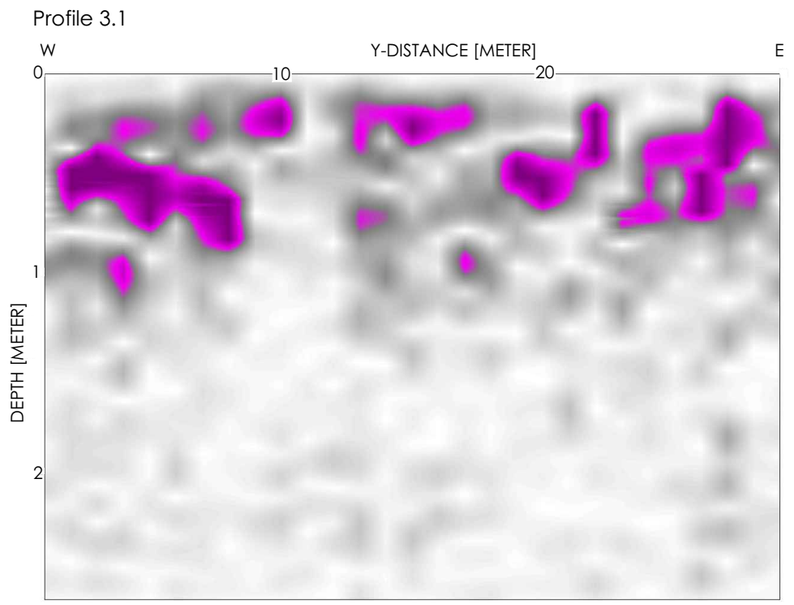
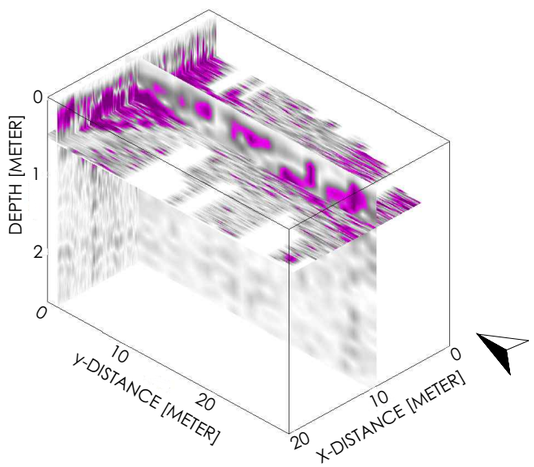
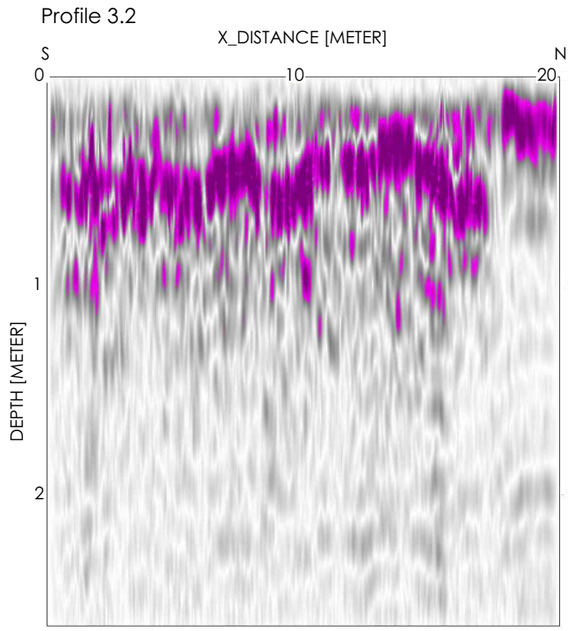
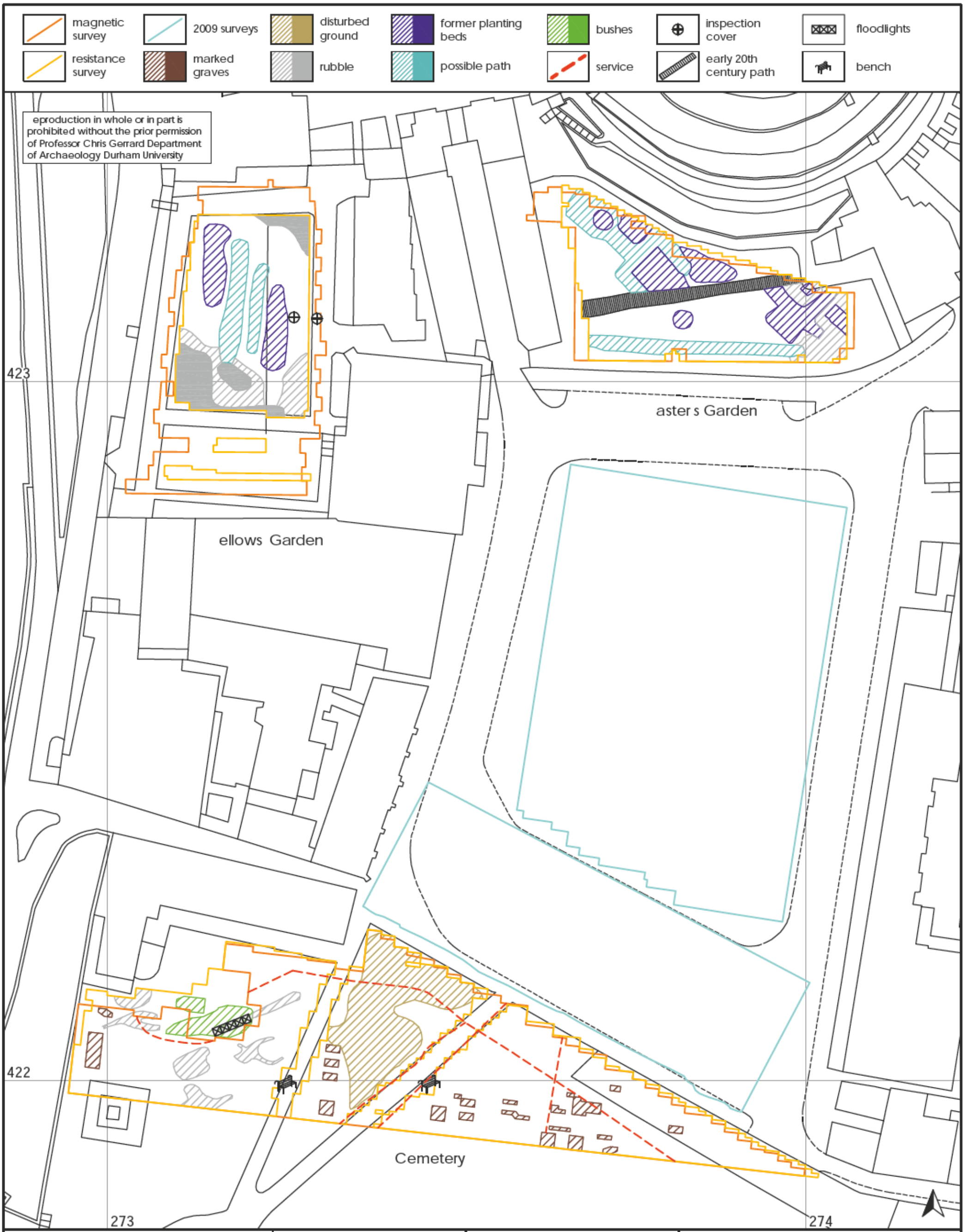
Figure 11: The cathedral cemetery, GPR profiles and time-slice











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igure 12 Archaeological interpretation