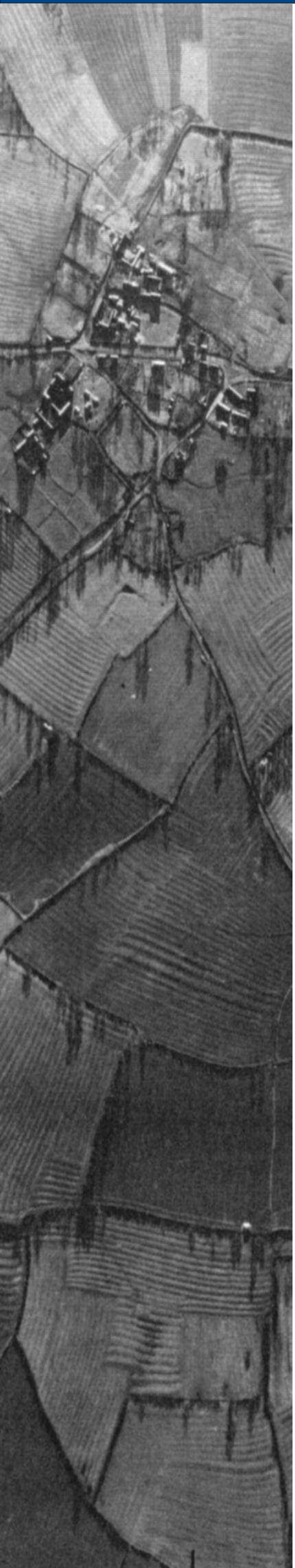

Oxford University Physics CL2
Ground Source Heating Project

MAGNETOMETER SURVEY REPORT

for

Cotswold Archaeology

on behalf of

Oxford University Fixed Assets Ltd

David Sabin and Kerry Donaldson

November 2010

Ref. no. 339

ARCHAEOLOGICAL SURVEYS LTD

Oxford University Physics CL2 Ground Source Heating Project

Magnetometer Survey

for

Cotswold Archaeology

on behalf of

Oxford University Fixed Assets Ltd

Fieldwork by David Sabin and Francis Sabin
Report by David Sabin BSc (Hons) MIFA and Kerry Donaldson BSc (Hons)

Survey date - **4th and 5th November 2010**
Ordnance Survey Grid Reference – **SP 51378 07196**

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SUMMARY

Archaeological Surveys Ltd was commissioned by Cotswold Archaeology, on behalf of Oxford University Fixed Assets Ltd, to undertake a magnetometer survey of an area of land within the University Parks. The site has been outlined for the proposed development of a ground source heating system, which is likely to comprise 85 boreholes sunk to a depth of 50m.

The survey effectively located numerous anomalies of archaeological potential within site. Most remarkable are four aligned ring ditches that are likely to indicate former Bronze Age funerary monuments. A square enclosure appears to partly cross one of the ring ditches, and the magnitude of the magnetic enhancement associated with the feature probably indicates the presence of burnt material within the ditch fill. The function of the enclosure, and its relationship with the ring ditch, cannot be confidently determined from the geophysics.

Linear and rectilinear anomalies indicate a complex of cut features that relate to former land divisions, enclosures, etc. The anomalies probably represent features formed over a considerable period of time.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Cotswold Archaeology, on behalf of Oxford University Fixed Assets Ltd, to undertake a magnetometer survey of an area of land within the University Parks. The site has been outlined for the proposed development of a ground source heating system which is likely to comprise 85 boreholes sunk to a depth of 50m. These will be 0.3m wide, with a 1m² cap. The removal of topsoil would also be necessary as part of the borehole construction . The survey forms part of an archaeological assessment of the site.

1.1.2 The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Cotswold Archaeology (2010a) and approved by the Oxford City Council Archaeologist prior to commencement of fieldwork.

1.1.3 The park has produced remarkable cropmark evidence for archaeological features thought to relate to a Bronze Age barrow cemetery and late prehistoric and Roman enclosures and field boundaries.

1.2 Survey objectives and techniques

1.2.1 The objective of the geophysical survey was to detect and precisely locate buried archaeological features within the University Parks in the vicinity of the proposed ground source heating system boreholes. The survey results will feed into and inform the evolving design scheme for the project and inform discussions with the Oxford City Council Archaeologist. The survey covers a much larger area than that actually required for the heating system, with the aim of providing further information on the nature of the archaeological resource in the area and its potential extent and significance.

1.2.2 The methodology is considered an efficient and effective approach to archaeological prospection. The survey and report generally follow the recommendations set out by: English Heritage, 2008, *Geophysical survey in archaeological field evaluation;* Institute for Archaeologists, 2002, *The use of Geophysical Techniques in Archaeological Evaluations*.

1.3 Site location, description and survey conditions

1.3.1 The survey area is located within the south western corner of the University Parks in Oxford. It is centred on Ordnance Survey National Grid Reference SP 51378 07196, see Figures 01 and 02.

1.3.2 The geophysical survey covers an area of approximately 3.4ha of mown grass including a sports pitch, hockey pitch and cricket practice pitches. The site has been separated into Areas 1 and 2 (see Plates 1 and 2), the former located to the west of a band of trees growing from a low, broad embankment, the latter located to the east of it. The site is surrounded by a path and trees immediately to the west and south, with Parks Road further to the west, and further to the south, the University Science Area. To the north there are formal flower beds and trees. The northern half of Area 1 contains a rugby pitch with surrounding rope boundary, see Plate 1 below.

Plate 1: Survey Area 1 looking south west from the north eastern corner

Plate 2: Survey Area 2 looking towards the west with the separating embankment and trees in the background and cricket practice area to the right

1.3.3 The ground conditions across the site were generally considered to be favourable for the collection of magnetometry data; however, the site boundaries were irregular and generally defined by clumps of specimen trees and beds limiting access with the magnetometer. The site contained sports pitches and equipment that produced both high magnitude magnetic disturbance and obstructions to the survey. In addition, the survey areas were constantly crossed by pedestrians often breaking the collection of data along the survey traverses. Weather conditions during the survey were variable with periods of heavy rain.

1.4 Site history and archaeological potential

1.4.1 An archaeological desk-based assessment was carried out by Cotswold Archaeology (2010b) prior to a development in the small carpark to the west of the Clarendon Buildings, as part of the Oxford University Physics CL2 project. This site lies less than 25m to the south of the south western corner of the survey area.

1.4.2 Differences in grass growth caused by the drought during the summer of 1976 revealed evidence for widespread archaeological features within the University Parks. These included several ring ditches attributed to Bronze Age funerary monuments and prehistoric and Romano-British field boundaries and enclosures.

1.4.3 Within the vicinity there has been a great deal of archaeological investigation during and prior to development of the university buildings. The work has provided evidence for prehistoric ritual and funerary monuments to the south of the site, and evidence for later prehistoric activity and Romano-British settlement.

1.5 Geology and soils

1.5.1 The underlying geology is mudstone from the Oxford Clay Formation and the Walton Formation, with overlying river terrace deposits of Summertown-Radley sands and gravels (BGS, 2010).

1.5.2 Although the overlying soils across the site are unmapped due to their urban location, it is likely that, given the parent material, they are from the Wickham 2 association which are typical stagnogley soils. These consist of slowly permeable, seasonally water logged, fine loamy over clayey soils formed upon drift overlying Jurassic clay or mudstone (Soil Survey of England and Wales, 1983).

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Magnetometry survey records localised magnetic fields that can be associated with features formed by human activity. Magnetic susceptibility and magnetic thermoremnance are factors associated with the formation of localised fields. Additional details are set out below and within Appendix A.

2.1.2 Iron minerals within the soil may become altered by burning and the break down of biological material; effectively the magnetic susceptibility of the soil is increased, and the iron minerals become magnetic in the presence of the Earth's magnetic field. Accumulations of magnetically enhanced soils within features, such as pits and ditches, may produce magnetic anomalies that can be mapped by magnetic prospection.

2.1.3 Magnetic thermoremnance can occur when ferrous minerals have been heated to high temperatures such as in a kiln, hearth, oven etc. On cooling, a permanent magnetisation may be acquired due to the presence of the Earth's magnetic field. Certain natural processes associated with the formation of some igneous and metamorphic rock may also result in magnetic thermoremnance.

2.1.4 The localised variations in magnetism are measured as sub-units of the Tesla, which is a SI unit of magnetic flux density. These sub-units are nano Teslas (nT), which are equivalent to 10^{-9} Tesla (T).

2.2 Equipment configuration, data collection and survey detail

2.2.1 The detailed magnetic survey was carried out using Bartington Grad601-2 gradiometers. The instruments effectively measure a magnetic gradient between two fluxgate sensors mounted vertically 1m apart. Two sets of sensors are mounted on a single frame 1m apart horizontally.

2.2.2 The instruments are extremely sensitive and are able to measure magnetic variation to 0.01nanoTesla (nT), with an effective resolution of 0.03nT. The data are limited to ±100nT when surveying with the highest sensitivity. All readings are saved to an integral data logger for analysis and presentation.

2.2.3 The instruments are operated according to the manufacturer's instructions with consideration given to the local conditions. An adjustment procedure is required, prior to collection of data, in order to balance the sensors and remove the effects of the Earth's magnetic field; further adjustment is required during the survey due to instrument drift often associated with temperature change.

2.2.4 It can be very difficult to obtain optimum balance for the sensors due to localised magnetic vectors that may be associated with large ferrous objects, geological/pedological features, 'magnetic debris' within the topsoil and natural temperature fluctuations. Imperfect balance results in a heading error often visible as striping within the data; this can be effectively removed by software processing and generally has little effect on the data unless extreme.

2.2.5 The Bartington gradiometers undergo regular servicing and calibration by the manufacturer. A current assessment of the instruments is shown in Table 1 below.

Sensor type and serial numbers	Bartington Grad - 01 – 1000 Nos. 084, 085, 242 and 396
Date of calibration/service	August 2010 (084 and 085) January 2010 (242 and 396)
Bandwidth	12Hz (100nT range) both sensors
Noise	<100pT peak to peak
Adjustable errors	<2nT

Table 1: Bartington fluxgate gradiometer sensor calibration results

The instruments were considered to be in good working order prior to the survey, with no known faults or defects.

2.2.6 Data were collected at 0.25m centres along traverses 1m apart. The survey area was separated into 30m by 30m grids (900m²) giving 3600 recorded measurements per grid. This sampling interval is very effective at locating archaeological features and is the recommended methodology for archaeological prospection (English Heritage, 2008).

2.2.7 The survey grids were set out to the Ordnance Survey OSGB36 datum using a Penmap RTK GPS. The GPS is used in conjunction with Topcon's TopNet service, where positional corrections are sent via a mobile telephone link. Positional accuracy of around 10 – 20mm is possible using the system. The instrument is regularly checked against the ETRS89 reference framework using Ordnance Survey ground marker C1ST7784 (Horton).

2.3 Data processing and presentation

2.3.1 Magnetometry data downloaded from the Grad 601-2 data logger are analysed and processed in specialist software known as ArcheoSurveyor. The software allows greyscale and trace plots to be produced for presentation and display. Survey grids are assembled to form an overall composite of data (composite file) creating a dataset of the complete survey area. Appendix C contains specific information concerning the survey and data attributes and is derived directly from ArcheoSurveyor; this should be used in conjunction with information provided by Figure 02.

2.3.2 Only minimal processing is carried out in order to enhance the results of the survey for display. Raw data are always analysed, as processing can modify anomalies. The following schedule sets out the data and image processing used in this survey:

- clipping of the raw data at ±30nT to improve greyscale resolution,
- clipping of processed data at ±5nT to enhance low magnitude anomalies,
- clipping of trace plots at ±100nT in order to minimise strong readings obscuring low magnitude responses,
- de-stagger is used to enhance linear anomalies,
- zero median/mean traverse is applied in order to balance readings along each traverse.

Reference should be made to Appendix B for further information on the specific processes carried out on the data. Appendix C metadata includes details on the processing sequence used for each survey area.

2.3.3 An abstraction and interpretation is offered for all geophysical anomalies located by the survey. A brief summary of each anomaly, with an appropriate reference number, is set out in list form within the results (Section 3) to allow a rapid and objective assessment of features within each survey area. Where further interpretation is possible, or where a number of possible origins should be considered, more subjective discussion is set out in Section 4.

2.3.4 The main form of data display used in this report is the greyscale plot. Magnetic data are also displayed as a trace plot. Both 'raw' and 'processed' data have been shown followed by an abstraction and interpretation plot. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing.

2.3.5 Graphic raster images in bitmap format (.BMP) are initially prepared in

ArcheoSurveyor. Regardless of survey orientation, data captured along each traverse are displayed and processed by ArcheoSurveyor from left to right; this corresponds to a direction of south to north in the field. Prior to displaying against base mapping, raster graphics require a rotation of 121.9° anticlockwise to restore north to the top of the image. Greyscale images are rotated by AutoCAD, traceplots are rotated using ArcheoSurveyor. Rotated traceplots are derived from interpolated datasets and can be considered as representative

2.3.6 The raster images are combined with base mapping using ProgeCAD Professional 2009 and AutoCAD LT 2007, creating DWG file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. Quality can be compromised by rotation of graphics in order to allow the data to be orientated with respect to grid north; this is considered acceptable as the survey results are effectively georeferenced allowing relocation of features using GPS, resection method etc.. A digital archive, including raster images, is produced with this report allowing separate analysis if necessary, see Appendix D below.

3 RESULTS

3.1 General overview

3.1.1 The detailed magnetic survey was carried out over 3.4ha and the data have been assembled in two separate composites, Areas 1 and 2, although they are considered below as one area. Geophysical anomalies located can be generally classified as positive linear and discrete positive responses of archaeological potential, positive and negative linear anomalies of an uncertain origin, anomalies relating to land management, areas of magnetic debris and disturbance, strong discrete dipolar anomalies relating to ferrous objects and strong multiple dipolar linear anomalies relating to buried services or pipelines. Anomalies located within the survey area have been numbered and are described below with subsequent discussion in Section 4.

3.1.2 Data are considered to provide an accurate representation of magnetic anomalies within the site. A number of issues may have influenced the quality of the data, although these were considered during the survey and have been controlled as far as possible. They are unlikely to have caused serious degradation.

3.1.3 One of the main factors influencing data quality was the high level of magnetic disturbance relating to modern services, large buildings surrounding the site and subsurface features/debris. The instrument set-up and adjustment procedure requires the location of areas clear of such magnetic 'noise' and this was found almost impossible to achieve. The resultant magnetic heading errors are considered minor, unlikely to have degraded the magnetic contrast associated with subsurface features and have been effectively removed during data processing. The high magnitude of magnetic disturbance, caused by steel objects and underground services, has produced highly disturbed zones that may obscure anomalies of archaeological potential in their immediate vicinity.

3.1.4 Minor positional errors occurred due to the many obstacles present within the site (trees, beds, sports equipment, boundary ropes, benches, etc.) and, to a lesser degree, low embankments and terraces. Pedestrian traffic constantly crossing the survey areas and sports field activities created additional pressures on the survey schedule.

3.1.5 The list of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the survey. A basic explanation of the characteristics of the magnetic anomalies is set out for each category in order to justify interpretation, a basic key is indicated to allow cross referencing to the abstraction and interpretation plot. CAD layer names are included to aid reference to associated digital files (.dwg/.dxf). Sub-headings are then used to group anomalies with similar characteristics for each survey area.

Report sub-heading **CAD layer names and plot colour**	**Description and origin of anomalies**
Anomalies with archaeological potential AS-ABST MAG POS LINEAR ARCHAEOLOGY AS-ABST MAG POS DISCRETE ARCHAEOLOGY AS-ABST MAG POS CURVILINEAR RING DITCH AS-ABST MAG NEG LINEAR ARCHAEOLOGY	Anomalies have the characteristics (mainly morphological) of a range of archaeological features such as pits, ring ditches, enclosures, etc.. Negative anomalies may relate to former earthworks, embankments etc.
Anomalies with an uncertain origin AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG NEG LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN AS-ABST MAG POS AREA UNCERTAIN AS-ABST MAG NEG AREA UNCERTAIN	The category applies to a range of anomalies where <u>there is not enough evidence to confidently suggest an origin</u>. Anomalies in this category <u>may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered</u>. Positive anomalies are indicative of magnetically enhanced soils that may form the fill of 'cut' features or may be produced by accumulation within layers or 'earthwork' features; soils subject to burning may also produce positive anomalies. Negative anomalies are produced by material of comparatively low magnetic susceptibility such as stone and subsoil.
Anomalies relating to land management AS-ABST MAG POS EMBANKMENT	Anomalies are mainly linear and may be indicative of the magnetically enhanced fill of cut features (i.e. ditches) or build up of soil (i.e. embankments/terraces). The anomalies may be long and/or form rectilinear elements and they may relate to topographic features or be visible on early mapping.
Anomalies associated with magnetic debris AS-ABST MAG DEBRIS AS-ABST MAG STRONG DIPOLAR	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. It often occurs where there has been dumping or ground make-up and is related to magnetically thermoremnant materials such as brick or tile or other small fragments of ferrous material. This type of response is occasionally associated with kilns, furnace structures, or hearths and <u>may therefore be archaeologically significant</u>. It is also possible that the response may be caused by natural material such as certain gravels and fragments of igneous or metamorphic rock. Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.

Anomalies with a modern origin AS-ABST MAG DISTURBANCE AS-ABST MAG SERVICE	The magnetic response is often strong and dipolar indicative of ferrous material and may be associated with extant above surface features such as wire fencing, cables, pylons etc.. Often a significant area around such features has a strong magnetic flux which may create magnetic disturbance; such disturbance can effectively obscure low magnitude anomalies if they are present. Fluxgate sensors may respond erratically and with hysteresis adjacent to strong magnetic sources. Buried services may produce characteristic multiple dipolar anomalies dependant upon their construction.

Table 2: List and description of interpretation categories

3.2 List of anomalies

Anomalies of archaeological potential

(1) – A positive curvilinear anomaly in the south western part of Area 1 (<12nT), representing a ring ditch with an external diameter of 41m. The anomaly forms a penannular feature with a 20m gap on the western side. Either side of the gap, the ditch appears to extend outwards towards the west, possibly beyond the surveyed area. It appears to have possible associated internal features (8) and also may have "cut", or have been "cut by", an earlier enclosure (12).

(2) – A positive curvilinear anomaly in the southern part of Area 1 (to the east of (1)), appears to represent a complete ring ditch with an external diameter of 46m. It contains positive and negative curvilinear and discrete anomalies (9) and is generally slightly less enhanced than (1) at up to 6nT in magnitude.

(3) – A positive curvilinear anomaly located at the extreme western side of Area 2 (<8nT), that appears to extend beneath the embanked land boundary that separates Areas 1 and 2 (complete survey was prevented by tree cover). It can be clearly seen to the east of the embankment and although is smaller than the adjacent barrows, with a diameter of 30m, it is equidistant from (2) and (4). This feature does not appear to have been previously recorded from aerial photographs.

(4) – A positive curvilinear anomaly within the central southern part of Area 2 (<10nT), forming a penannular ring ditch with an 8m gap on the western edge. The apparent gap is located in the vicinity of a steel goal which may have influenced the recorded data. It also appears to contain a negative curvilinear anomaly (10), indicative of material of comparatively low magnetic susceptibility (e.g. subsoil) which may relate to an internal former earthwork.

(5) – A positive curvilinear or discrete anomaly (<6nT), within the central western part of Area 1, may indicate a ring ditch or pit, with a diameter of 8m. It appears to be located between the corners of two rectilinear or sub-rectilinear enclosures (17) and (18).

(6) – A positive curvilinear or discrete anomaly (<7nT) located in the centre of Area

1. Magnetic disturbance from the adjacent goal post may have partly obscured this anomaly; however, it may relate to a circular feature visible on aerial photographs of the site.

(7) – A discrete positive anomaly (<9nT) probably indicates an 8m wide pit situated directly on the outer edge of anomaly (1) at the point where the ditch extends westwards. It is possible that this feature is associated with part of the ring-ditch, although superimposition cannot be determined.

(8) – Positive curvilinear and discrete anomalies, within the confines of anomaly (1), may relate to internal cut features.

(9) – Positive curvilinear and discrete anomalies and negative curvilinear anomalies within anomaly (2), may relate to internal features.

(10) – Negative and positive curvilinear anomalies within anomaly (4), may relate to an internal features.

(11) – A number of positive linear, curvilinear and discrete anomalies located in Area 2 on the eastern side. They appear to indicate former cut features such as ditches and pits with archaeological potential, although modern disturbance has obscured their morphology. Many of these anomalies have a moderately strong response, suggesting that magnetically enhanced soil has been incorporated into them.

(12) – A positive rectilinear anomaly (<30nT), located close to the south-western corner of Area 1, forms a square enclosure ditch 34m wide. The enclosure appears to have additional ditches that extend southwards and south-westwards beyond the survey area, and it also appears to be associated with anomaly (13), which extends westwards. The anomaly has a strong response, higher than many of the other anomalies within the site, which suggests that magnetically enhanced material, possibly from burning, has become incorporated into the ditches. It may have a small gap on the western side, although this has become partially obscured by a ferrous spike and anomalies (1) and (13). The north-western corner could be “cut” by anomaly (1); however, superimposition cannot be confidently determined from magnetic data.

(13) – Two positive linear anomalies extend westwards from the north-western corner of anomaly (12). The responses would be consistent with ditch-like features.

(14) – Discrete positive anomalies within anomaly (12) may relate to pits or areas of burning associated with the use of the enclosure.

(15) – A positive linear anomaly, relating to a possible boundary ditch, that extends across the entire survey area. It is oriented approximately west-south-west to east-north-east.

(16) – A positive linear anomaly in the northern half of Area 1, extending to the north-north-west from anomaly (15). The feature is comparatively weak and poorly defined.

(17) – A series of positive linear anomalies, approximately parallel to anomalies (15) and (16), appear to form a sub-rectilinear enclosure, possibly containing pits.

(18) – Two positive linear anomalies joining at right angles to form a partial rectilinear enclosure. It is located approximately 14m north-west of anomaly (17).

(19) – Positive linear anomalies appear to form an “A” shaped feature located to the north east of the junction between anomalies (15) and (16).

(20) – Discrete positive anomalies may indicate pit-like features and/or areas of burning.

Anomalies with an uncertain origin

(21) – Three parallel positive linear anomalies, located in the north-western corner of Area 1, appear to relate to ditch-like features; however, because of the fragmented survey cover due to trees, it is not possible to determine their function or relationship with other anomalies.

(22) – A series of parallel linear anomalies, located close to the north-western corner of the survey area. Although their origin is uncertain, they may be of archaeological potential.

(23) – Two parallel, weakly positive, broad, linear anomalies are located in the eastern part of Area 1. They are parallel with anomaly (24) and also (28).

(24) – A negative linear response located close to the northern edge of the survey area.

(25) – Weak positive linear and curvilinear anomalies located throughout Areas 1 and 2. Although these may relate to cut features, their form and magnitude do not allow for confident interpretation, and although an archaeological origin should be considered, they may relate to natural or modern features.

(26) – Positive and negative linear anomalies extending parallel to the southern edge of the survey area. These anomalies can be seen within both Areas 1 and 2 and may relate to modern features, such as former paths or possible services.

(27) – A fragmented positive linear anomaly extending across Area 2, parallel with anomalies (26). It is also possible that a similar anomaly is located within (2), although its origin is uncertain.

Anomalies associated with land management

(28) – Two parallel weakly positive linear anomalies extend north-east to south-west within the southern half of Area 1. There is a low terrace within the field and it is likely that these anomalies are associated. The terrace may be associated with relatively modern landscaping.

(29) – Two positive linear anomalies are located in the vicinity of the embankment that extends between the two survey areas. The anomalies may be associated with this embankment.

Anomalies associated with magnetic debris

(30) – Patches of magnetic debris, located primarily in Area 2, relate to magnetically thermoremnant material. Much of it has a strong magnetic response, indicating that it contains ferrous material. Some of it is directly associated with the sports field apparatus.

(31) – Strong discrete dipolar anomalies are a response to ferrous objects within the topsoil.

Anomalies with a modern origin

(32) – Magnetic disturbance from ferrous material such as fencing, goal posts and adjacent services.

(33) – A strong, multiple dipolar linear anomaly in Area 2 relates to a buried service.

4 DISCUSSION

4.1.1 A complex group of anomalies was located by the magnetometry and probably indicates a focus of human activity over a long period. The anomalies indicate the presence of features belonging to Bronze Age and possibly earlier funerary monuments, and also likely prehistoric and/or Romano-British enclosures and land boundaries.

4.1.2 Ring ditches relating to four round barrows have been located. All the barrows are approximately equidistant, between 13 and 14.5m apart and they are aligned east-north-east to west-south-west. They are on a similar alignment to those recorded at the Radcliffe Infirmary site, some 350m to the west (MOLA, 2009). They are approximately 41m, 46m, 30m and 44m in diameter, with the most westerly (anomaly 1) having a gap facing west and ditches that extend westwards. The geophysical survey appears to have located a fourth, smaller ring ditch (anomaly 3), located between ring ditch anomaly 2 and ring ditch anomaly 4. This does not appear to have been previously recorded from aerial photographs.

4.1.3 The westernmost ring ditch, anomaly 1, may “cut” the adjacent square enclosure ditches (anomalies 12 and 13) although the superimposition of magnetic anomalies cannot usually be determined with any confidence. There is evidence from the nearby Radcliffe Infirmary site that a round barrow had incorporated an earlier mortuary enclosure and a similarity is possible. However, these features are broadly parallel with other linear and rectilinear anomalies located within the survey and so it is also possible that these rectilinear enclosures located by the survey represent later prehistoric or Roman features after the removal of barrow mounds (presuming they were constructed and were still extant).

4.1.4 Anomalies 5 and 6 have been abstracted as small ring ditches very different in appearance to those discussed above. Their interiors are relatively enhanced, compared to anomalies 1 - 4 and it is possible that they indicate rather more pit-like features than ring ditches.

4.1.5 The site contains many linear and rectilinear anomalies that relate to former land boundaries and enclosures, although the date and function of these cannot be determined from the geophysical survey, it is likely that they relate to later prehistoric and/or Romano-British periods.

5 CONCLUSION

5.1.1 The magnetometer survey effectively located numerous anomalies of archaeological potential within both survey areas. Most remarkable are four aligned ring ditches that are likely to indicate former Bronze Age funerary monuments or barrows, though the most westerly appears to have an incomplete ring and the use of the term 'funerary monument' may, therefore, be more appropriate.

5.1.2 A square enclosure appears to partly cross one of the ring ditches, and the magnitude of the magnetic enhancement associated with the feature probably indicates the presence of burnt material within the ditch fill. The function of the enclosure, and its relationship with the ring ditch, cannot be confidently determined from the geophysics.

5.1.3 Linear and rectilinear anomalies show a complex of former cut features that relate to land divisions and enclosures. The anomalies probably represent features formed over a considerable period of time, but the clarity of the prehistoric funerary monuments may indicate comparatively little disturbance to the site in the medieval, post medieval and modern periods.

5.1.4 Although there is good correlation between the geophysical anomalies and features abstracted from aerial photographs, there are a number of features whose morphology appears subtly different between the two information sources and several that are only visible on one. It is likely that further archaeological information could be extracted from the site using different geophysical techniques (resistivity, ground penetrating radar) and by increasing the density of data collection with potential improvements to resolution.

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Appendix A – basic principles of magnetic survey

Iron minerals are always present to some degree within the topsoil and enhancement associated with human activity is related to increases in the level of magnetic susceptibility and thermoremnant material.

Magnetic susceptibility is an induced magnetism within a material when it is in the presence of a magnetic field. This can be thought of as effectively permanent due to the presence of the Earth's magnetic field.

Thermoremnant magnetism occurs when ferrous material is heated beyond a specific temperature known as the Curie Point. Demagnetisation occurs at this temperature with re-magnetisation by the Earth's magnetic field upon cooling.

Enhancement of magnetic susceptibility can occur in areas subject to burning and complex fermentation processes on biological material; these are frequently associated with human settlement. Thermoremnant features include ovens, hearths, and kilns. In addition thermoremnant material such as tile and brick may also be associated with human activity and settlement.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil can create an area of enhancement compared with surrounding soils and subsoils into which the feature is cut. Mapping enhanced areas will produce linear and discrete anomalies allowing an assessment and characterisation of hidden subsurface features.

It should be noted that areas of negative enhancement can be produced from material having lower magnetic properties compared to the topsoil. This is common for many sedimentary bedrocks and subsoils which were often used in the construction of banks and walls etc. Mapping these 'negative' anomalies may also reveal archaeological features.

Magnetic survey or magnetometry can be carried out using a fluxgate gradiometer and may be referred to as gradiometry. The gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried field. The difference between the two sensors will relate to the strength the magnetic field created by the buried feature. If no enhanced feature is present the field measured by both sensors will be similar and the difference close to zero.

There are a number of factors that may affect the magnetic survey and these include soil type, local geology and previous human activity. Situations arise where magnetic disturbance associated with modern services, metal fencing, dumped waste material etc., obscures low magnitude fields associated with archaeological features.

Appendix B – data processing notes

Clipping

Minimum and maximum values are set and replace data outside of the range with those values. Extreme values are removed improving colour or greyscale contrast associated with data values that may be archaeologically significant. It has been found that clipping data to ranges between ±5nT and ±1nT often improves the appearance of features associated with archaeology. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Zero Median/Mean Traverse

The median (or mean) of each traverse is calculated ignoring data outside a threshold value, the median (or mean) is then subtracted from the traverse. The process is used to equalise slight differences between the set-up and stability of gradiometer sensors and can remove striping. The process can remove archaeological features that run along a traverse so data analysis is also carried out prior its application.

De-stagger

Compensates for small positional errors within data collection by shifting the position of the readings along each traverse by a specified amount. Data lost at the end of each traverse are extrapolated from adjacent value in the same row.

Deslope

Corrects for striping and distortion caused by metal objects/services etc.. The process calculates a curve based on a polynomial best fit mathematical function for each traverse. This curve is then subtracted from the actual data.

FFT (Fast Fourier Transform) spectral filtering

A mathematical process used to determine the frequency components of a traverse. Repetitive features, such as plough marks, produce characteristic spectral zones that can be suppressed allowing greyscale images to appear clearer.

Appendix C – survey and data information

Area 1 raw data

COMPOSITE
Filename: J339-mag-Area1-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 04/11/2010
Assembled by: on 07/11/2010
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 960 x 150
Survey Size (meters): 240 m x 150 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -37.30
Std Dev: 5.78
Mean: 0.33
Median: 0.15
Composite Area: 3.6 ha
Surveyed Area: 2.2462 ha

Processes: 5
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 De Stagger: Grids: 01.xgd 02.xgd 03.xgd 04.xgd 05.xgd Mode: Both By: 1 intervals
4 De Stagger: Grids: 13+16.xgd Mode: Both By: 1 intervals
5 De Stagger: Grids: 04.xgd Mode: Outbound By: 1 intervals

Source Grids: 32
1 Col:0 Row:0 grids\01.xgd
2 Col:0 Row:1 grids\02.xgd
3 Col:0 Row:2 grids\03.xgd
4 Col:0 Row:3 grids\04.xgd
5 Col:0 Row:4 grids\05.xgd
6 Col:1 Row:0 grids\06.xgd
7 Col:1 Row:1 grids\07.xgd
8 Col:1 Row:2 grids\08.xgd
9 Col:1 Row:3 grids\09.xgd
10 Col:2 Row:0 grids\10.xgd
11 Col:2 Row:1 grids\11+14.xgd
12 Col:2 Row:2 grids\12+15.xgd
13 Col:2 Row:3 grids\13+16.xgd
14 Col:3 Row:0 grids\17.xgd
15 Col:3 Row:1 grids\18.xgd
16 Col:3 Row:2 grids\19.xgd
17 Col:3 Row:3 grids\20.xgd
18 Col:4 Row:0 grids\21.xgd
19 Col:4 Row:1 grids\22.xgd
20 Col:4 Row:2 grids\23.xgd
21 Col:4 Row:3 grids\24.xgd
22 Col:5 Row:0 grids\25.xgd
23 Col:5 Row:1 grids\26.xgd
24 Col:5 Row:2 grids\27.xgd
25 Col:5 Row:3 grids\28.xgd
26 Col:6 Row:0 grids\29+33.xgd
27 Col:6 Row:1 grids\30+34.xgd
28 Col:6 Row:2 grids\31+35.xgd
29 Col:6 Row:3 grids\32+36.xgd
30 Col:7 Row:0 grids\37.xgd
31 Col:7 Row:1 grids\38.xgd
32 Col:7 Row:2 grids\39.xgd

Area 1 processed data

COMPOSITE
Filename: J339-mag-Area1-proc.xcp
Processes: 9
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 De Stagger: Grids: 01.xgd 02.xgd 03.xgd 04.xgd 05.xgd Mode: Both By: 1 intervals
4 De Stagger: Grids: 13+16.xgd Mode: Both By: 1 intervals
5 De Stagger: Grids: 04.xgd Mode: Outbound By: 1 intervals
6 DeStripe Mean Traverse: Grids: 06.xgd 07.xgd 08.xgd 09.xgd 10.xgd 11+14.xgd 12+15.xgd 13+16.xgd 17.xgd 18.xgd 19.xgd 20.xgd 21.xgd 22.xgd 23.xgd 24.xgd 25.xgd 26.xgd 27.xgd 28.xgd Threshold: 2 SDs
7 Clip from -5.00 to 5.00 nT
8 DeStripe Mean Traverse: Grids: 29+33.xgd 30+34.xgd 31+35.xgd 32+36.xgd 37.xgd 38.xgd 39.xgd Threshold: 1 SDs
9 Clip from -5.00 to 5.00 nT

Area 2 raw data

COMPOSITE
Filename: J339-mag-Area2-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 05/11/2010
Assembled by: on 05/11/2010
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 360 x 150
Survey Size (meters): 90 m x 150 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 8.70
Mean: 1.85
Median: 2.16
Composite Area: 1.35 ha
Surveyed Area: 1.1562 ha

Processes: 4
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 De Stagger: Grids: SubGrid (Area: Top 36, Left 240, Bottom 49, Right 359) Mode: Both By: 1 intervals
4 Move (Area: Top 56, Left 240, Bottom 57, Right 359) to X 3, Y 0

Source Grids: 14
1 Col:0 Row:1 grids\03.xgd
2 Col:0 Row:2 grids\04.xgd
3 Col:0 Row:3 grids\05.xgd
4 Col:0 Row:4 grids\06.xgd
5 Col:1 Row:0 grids\01.xgd
6 Col:1 Row:1 grids\07.xgd
7 Col:1 Row:2 grids\08.xgd
8 Col:1 Row:3 grids\09.xgd
9 Col:1 Row:4 grids\10.xgd
10 Col:2 Row:0 grids\02.xgd
11 Col:2 Row:1 grids\11.xgd
12 Col:2 Row:2 grids\12.xgd
13 Col:2 Row:3 grids\13.xgd
14 Col:2 Row:4 grids\14.xgd

Area 2 processed data

COMPOSITE
Filename: J339-mag-Area2-proc.xcp

Processes: 5
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 De Stagger: Grids: 11.xgd Mode: Both By: -1 intervals
4 DeStripe Median Traverse: Grids: All
5 Clip from -5.00 to 5.00 nT

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at Castle Combe, Wiltshire (see inside cover for address). Data are backed-up onto an on-site data storage drive and at the earliest opportunity data are copied to CD ROM for storage on-site and off-site. Digital data are also supplied to the client on CD ROM, see below.

Surveys are reported on in hardcopy (recycled paper) using A4 for text and A3 for plots (all plots are scaled for A3). The distribution of both hardcopy report and digital data is considered the responsibility of the Client unless explicitly stated in the survey Brief, Written Scheme of Investigation or other contractual agreement.

This report has been prepared using the following software on a Windows XP platform:

- ArcheoSurveyor version 2.5.7.11 (geophysical data analysis),
- ProgeCAD Professional 2009 (report graphics),
- AutoCAD LT 2007 (report figures),
- OpenOffice.org 3.0.1 Writer (document text),
- PDF Creator version 0.9 (PDF archive).

Digital data are supplied on CD ROM which includes the following files:

- ArcheoSurveyor grid and composite files for all geophysical data,
- CSV files for raw and processed composites,
- geophysical composite file graphics as Bitmap images,
- AutoCAD DWG files in 2000 and 2007 versions,
- report text as OpenOffice.org ODT file,
- report text as Word 2000 doc file,
- report text as rich text format (RTF),
- report text as PDF,
- PDFs of all figures,
- photographic record in JPEG format.

The CD ROM structure is formed from a tree of directories under the title J339 Oxford CL2 – CD. Directory titles include Data, Documentation, CAD, PDFs and Photos. Multiple directories exist under Data and hold Grid, Composite and Graphic files with CSV composite data held in Export.

The CAD file contains externally referenced graphics that are rotated with separate A3 size layouts for each figure. Layouts are fixed using frozen layers and named views allowing straightforward plotting or analysis on screen. (Note – CAD files are prepared using AutoCAD's e Transmit function to produce a directory containing the digital drawing along with any externally referenced graphics which may need reloading).

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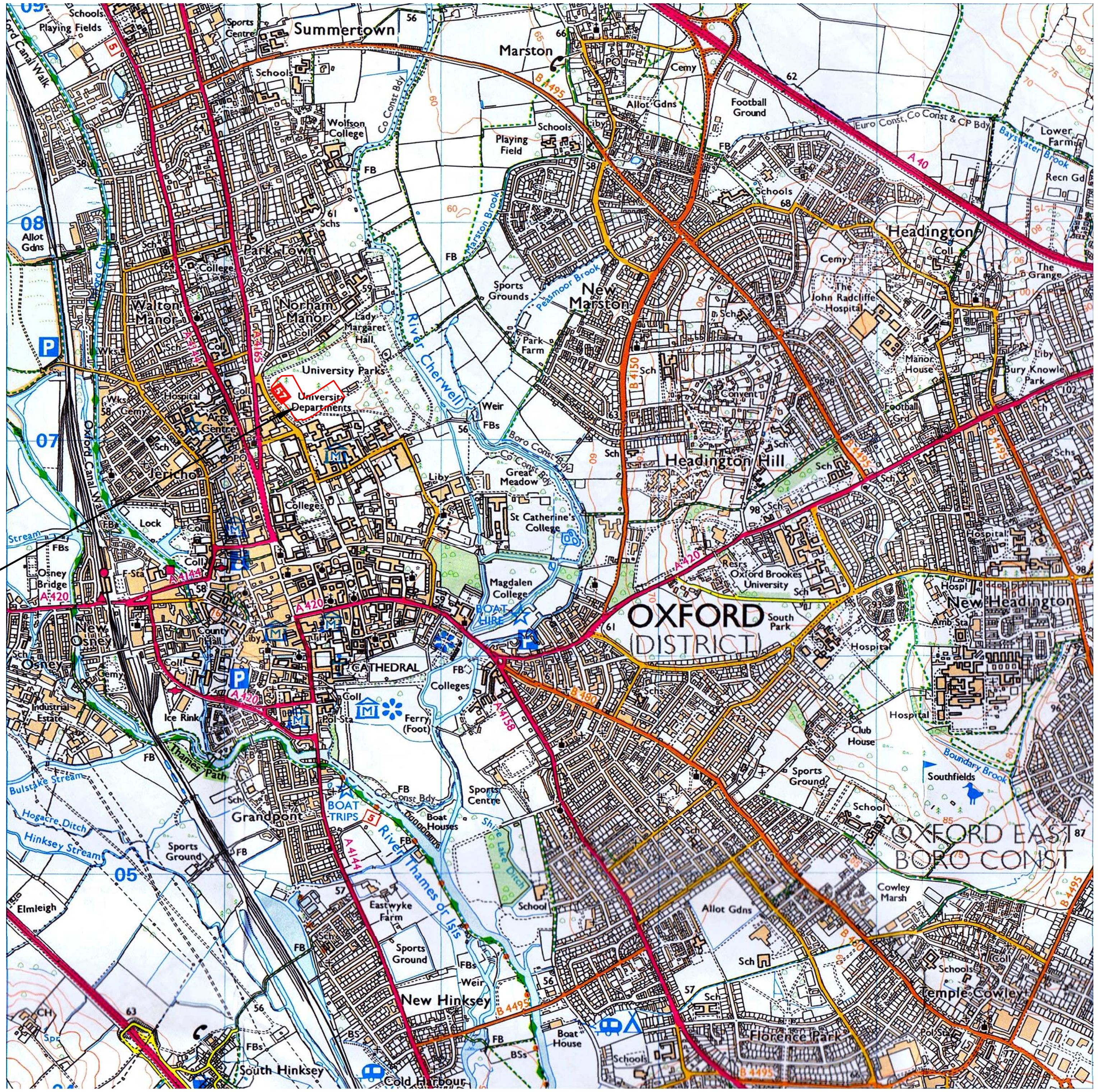
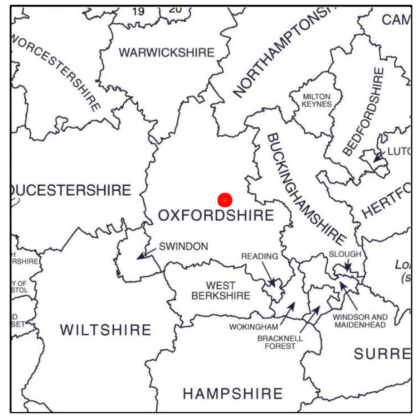
Map of survey area





● Survey location

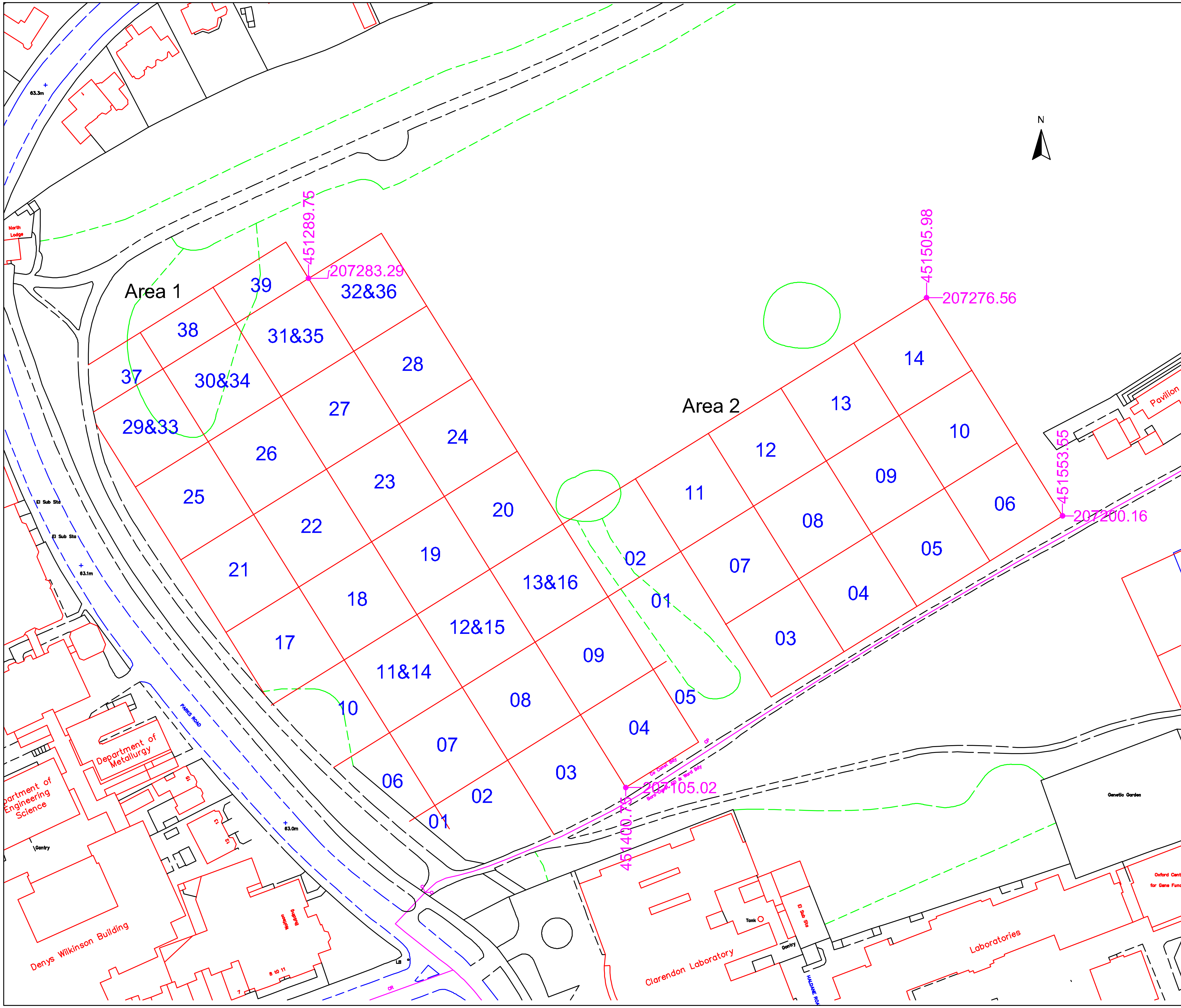
Site centred on OS NGR
SP 513 071

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01



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Referencing information

Grid coordinates based on Ordnance Survey OSGB36 datum

Grids set out using RTK GPS with Topcon TopNet correction data RTCMv2 format OSTN02 transformation

Survey grid size = 30m

Survey start and traverse direction

01 Grid reference number and filename

SCALE 1:1250

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 02

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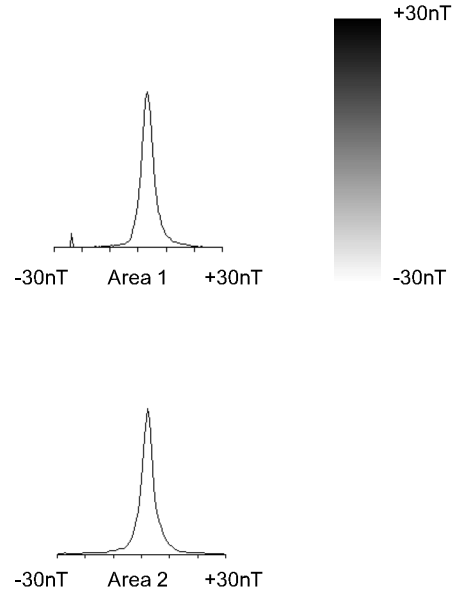
Greyscale plot of raw magnetometer data



SCALE 1:1250

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 03

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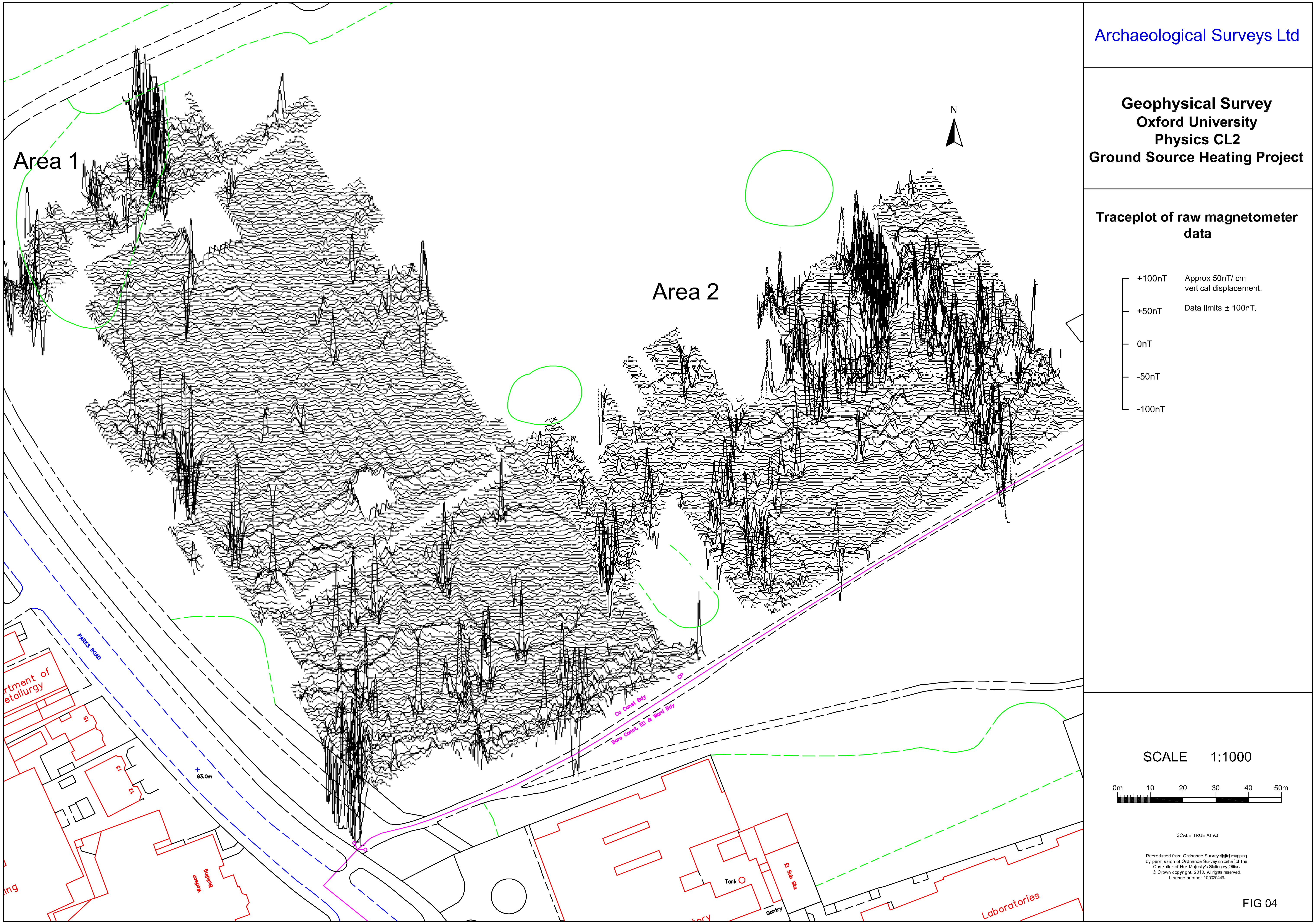
Traceplot of raw magnetometer data



SCALE 1:1000

SCALE TRUE AT A3

FIG 04

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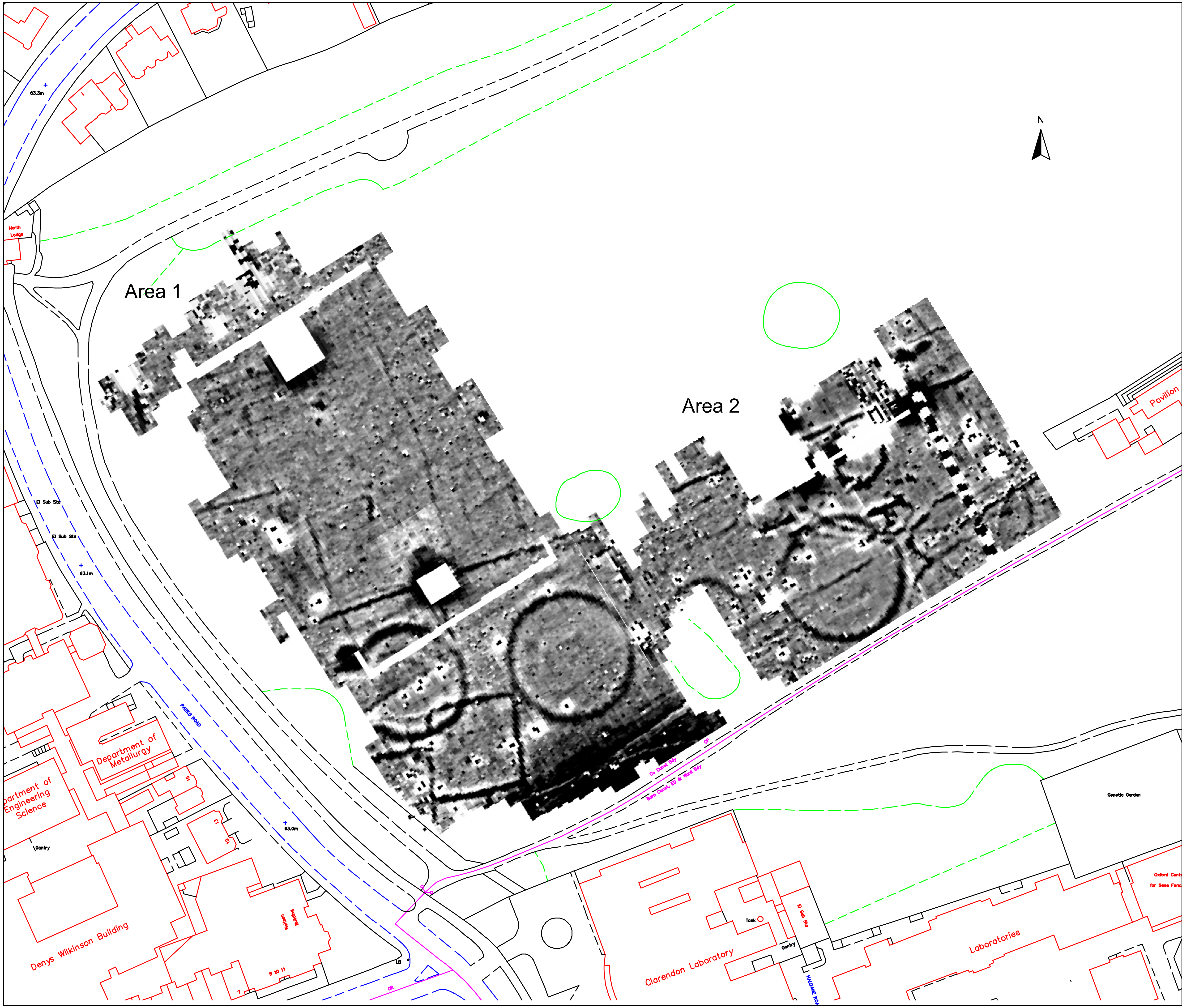
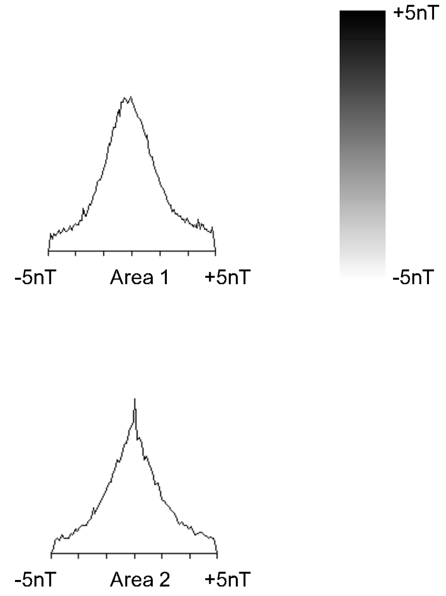


Greyscale plot of processed magnetometer data

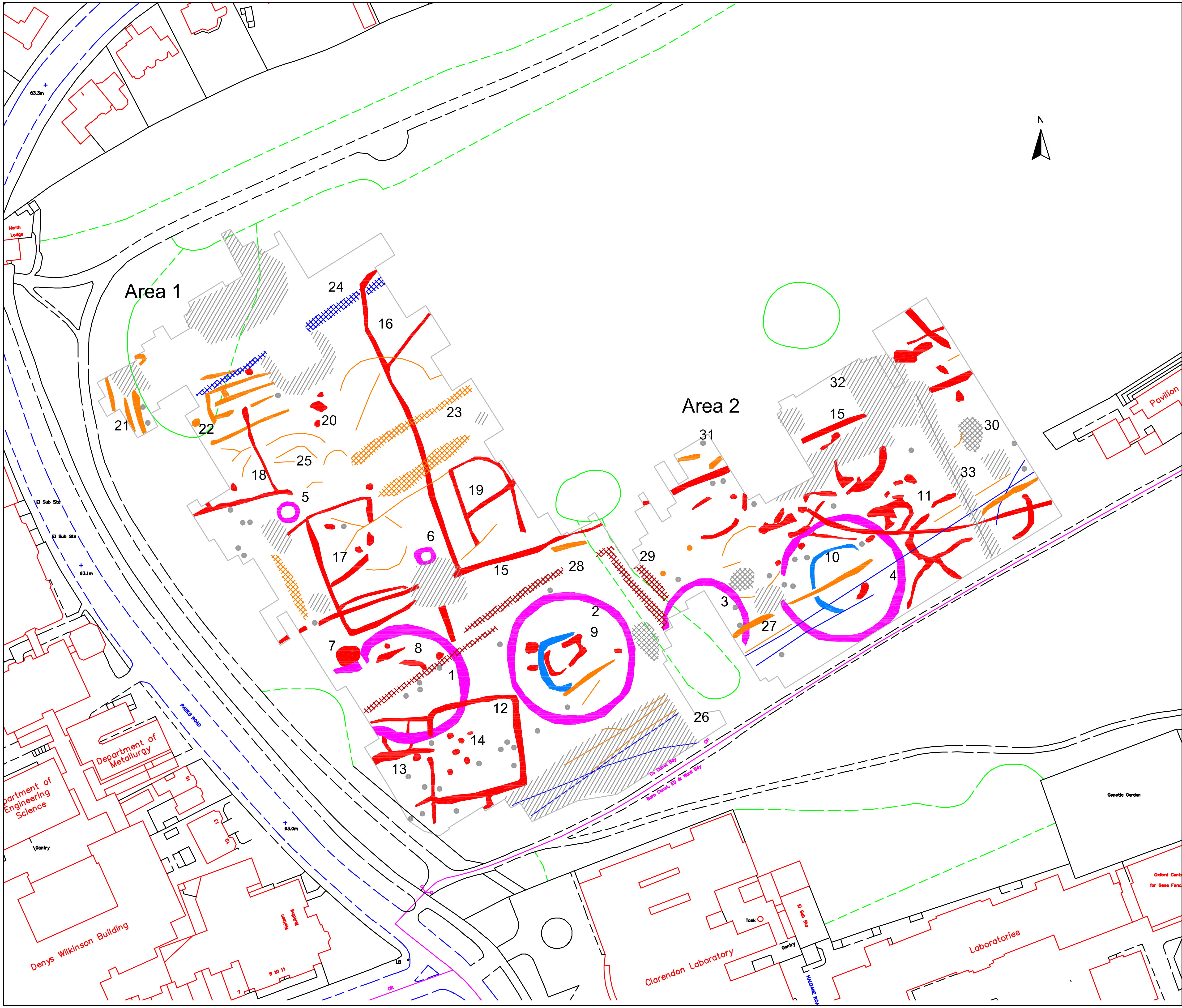


SCALE 1:1250

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 05



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Abstraction and interpretation of magnetometer anomalies

- Positive linear anomaly - cut feature of archaeological potential
- Positive curvillinear anomaly - ring ditch
- Negative linear anomaly - of archaeological potential
- Positive linear anomaly - possible ditch-like feature
- Negative linear anomaly - material of low magnetic susceptibility
- Positive anomaly anomaly - associated with embankment
- Positive anomaly anomaly - of uncertain origin
- Negative anomaly anomaly - of uncertain origin
- Discrete positive response - cut feature of archaeological potential
- Discrete positive response - possible pit-like feature
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong multiple dipolar linear anomaly - pipeline / cable / service
- Strong dipolar anomaly - ferrous object

SCALE 1:1250

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 06