

**Castlezens Farm
Veryan
Cornwall**

MAGNETOMETER SURVEY REPORT

for

CgMs Consulting

David Sabin and Kerry Donaldson

June 2014

Ref. no. 548

ARCHAEOLOGICAL SURVEYS LTD

**Castlezens Farm
Veryan
Cornwall**

Magnetometer Survey Report

for

CgMs Consulting

Fieldwork by David Sabin

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

Survey date – 5th June 2014

Ordnance Survey Grid Reference – **SW 93107 42436**



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SUMMARY

A detailed magnetometer survey was undertaken by Archaeological Surveys Ltd at the request of CgMs, close to the site of the scheduled monument of the Iron Age/Romano-British enclosure or round, known as Castlezens multiple enclosure fort, near Veryan in Cornwall. The survey located a number of positive linear, rectilinear, curvilinear and discrete anomalies which relate to ditches, enclosures and pits and are likely to be directly associated with the round, located less than 100m to the south west.

1 INTRODUCTION

1.1 *Survey background*

- 1.1.1 Archaeological Surveys Ltd was commissioned by CgMs Consulting to undertake a magnetometer survey of an area of land at Castlezens Farm, Veryan, Cornwall. The site had been initially outlined for a proposed development of a single wind turbine at the time of survey, but was subsequently withdrawn as a potential site by the landowner at the time of reporting.

1.2 *Survey objectives and techniques*

- 1.2.1 The objective of the survey was to use magnetometry to locate geophysical anomalies that may be archaeological in origin so that they may be assessed prior to development of the site. The methodology is considered an efficient and effective approach to archaeological prospection.
- 1.2.2 The survey and report generally follow the recommendations set out by: English Heritage (2008) *Geophysical survey in archaeological field evaluation*; and Institute for Archaeologists (2002) *The use of Geophysical Techniques in Archaeological Evaluations*. The work has been carried out to the Institute for Archaeologists (2011) *Standard and Guidance for Archaeological Geophysical Survey*.

1.3 *Site location, description and survey conditions*

- 1.3.1 The site is located at Castlezens Farm, Veryan, Cornwall. The centre of the turbine is centred on Ordnance Survey National Grid Reference (OS NGR) SW 193107 42436, see Figures 01 and 02.
- 1.3.2 The geophysical survey covers approximately 1.5ha within a single pasture field. This encompassed approximately 1ha over the proposed location of the turbine and a stretch of access track to the west. The area is generally flat or gently sloping down towards the north.

- 1.3.3 The ground conditions across the site were considered to be favourable for the collection of magnetometry data. Weather conditions during the survey were fine.

1.4 Site history and archaeological potential

- 1.4.1 The site is less than 100m north east of the scheduled Iron Age/Romano-British settlement site of Castlezens multiple enclosure fort. The scheduled area covers the whole sub-circular field to the south west of the site, and this contains an inner, pear-shaped enclosure with a bank and external ditch and a smaller circular ring ditch. A number of these enclosures, or rounds, are located within 1km of the site. Linear boundary features are also noted in the surrounding area and recorded from aerial photographs as part of the National Mapping Programme in Cornwall.
- 1.4.2 The location of Castlezens multiple enclosure fort immediately to the south west would indicate a moderate to high potential for the survey area to contain geophysical anomalies that relate to further archaeological features associated with the enclosure.
- 1.4.3 The surface conditions within the site were not suitable for the observation of cultural material during the course of the survey. No significant earthwork features were noted.

1.5 Geology and soils

- 1.5.1 The underlying geology is sandstone and argillaceous rocks from the Portscatho Formation (BGS, 2014).
- 1.5.2 The overlying soil across the site is from the Denbigh 2 association and is a typical brown earth. It consists of a well drained, fine, loamy soil (Soil Survey of England and Wales, 1983).
- 1.5.3 Magnetometry carried out over similar geology and soil has produced good results. The site is, therefore, considered suitable for magnetic survey.

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 thermoremanence 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 a SENSYS MAGNETO®MXPDA 5 channel cart-based system. The instrument has 5 fluxgate gradiometers spaced 0.5m apart with readings recorded at 20 Hz. The gradiometers have a range of recording data between 0.1nT and 10,000nT. They are linked to a Leica GS10 RTK GPS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged PDA computer system.
- 2.2.2 Data are collected along a series of parallel survey transects wherever possible. The length of each transect is variable and relates to the size of the survey area and other factors including ground conditions. A visual display allows accurate placing of transects and helps maintain the correct separation between adjacent traverses.

2.3 Data processing and presentation

- 2.3.1 Magnetic data collected by the MAGNETO®MXPDA cart-based system are initially prepared using SENSYS MAGNETO®DLMGPS software. Georeferenced data are then exported in ASCII format for compensation (destriping), interpolation and clipping using TerraSurveyor. Greyscale images are also produced using TerraSurveyor.
- 2.3.2 Appendix C contains specific information concerning the survey and data attributes and is derived directly from TerraSurveyor; this should be used in conjunction with information provided by Figure 02.
- 2.3.3 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 for the SENSYS MAGNETO data:

- clipping of processed data at ± 50 nT to enhance low magnitude anomalies,
- zero median traverse is applied in order to balance readings along each traverse,
- a high pass filter is applied to smooth data and remove slight variations along survey tracks.

- 2.3.4 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 the survey area.
- 2.3.5 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 the survey area.
- 2.3.6 The main form of data display prepared for this report is the 'processed' greyscale plot 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.
- 2.3.7 Data captured with the SENSYS MAGNETO cart-based system are resampled to a resolution of effectively 0.5m between tracks and 0.15m along each survey track. A TIFF file (OSGB36) is produced by TerraSurveyor software along with an associated world file (.TFW) that allows automatic georeferencing when using GIS or CAD software.
- 2.3.8 The raster images are combined with base mapping using ProgeCAD Professional 2014 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.
- 2.3.9 A digital archive is produced with this report, see Appendix D below. The main archive is held at the offices of Archaeological Surveys Ltd.

3 RESULTS

3.1 *General assessment of survey results*

- 3.1.1 The detailed magnetic survey was carried out over approximately 1.5ha.
- 3.1.2 Magnetic anomalies located can be generally classified as positive linear and discrete positive responses of archaeological potential, positive anomalies of an uncertain origin, linear anomalies of an agricultural origin, areas of magnetic disturbance and strong discrete dipolar anomalies relating to ferrous objects.

3.2 Statement of data quality

- 3.2.1 Data are considered representative of the magnetic anomalies present within the site. There are no significant defects within the dataset. Linear responses associated with former cultivation are present within the data and these have been effectively suppressed by filtering.

3.3 Data interpretation

- 3.3.1 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.






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 ARCHAEOLOGY 	Anomalies have the characteristics (mainly morphological) of a range of archaeological features such as pits, ring ditches, enclosures, etc..
Anomalies with an uncertain origin AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN AS-ABST MAG POS 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 with an agricultural origin AS-ABST MAG AGRICULTURAL 	The anomalies are often linear and form a series of parallel responses or are parallel to extant land boundaries. Where the response is broad, former ridge and furrow is likely; narrow response is often related to modern ploughing.
Anomalies associated with magnetic debris AS-ABST MAG STRONG DIPOLAR 	Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.
Anomalies associated with magnetic disturbance AS-ABST MAG DISTURBANCE 	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. It is possible for anomalies to be produced by lightning induced remanent magnetism .

Table 1: List and description of interpretation categories

3.4 List of anomalies

Area centred on OS NGR 193115 42420, see Figures 03 & 04.

Anomalies of archaeological potential

(1) – A positive curvilinear anomaly extends from the southern edge of the survey area towards the north western edge. It has a strong response of up to 20nT, with a much weaker, broader response associated with it in the south. This may suggest different phases of use or construction. Further linear anomalies extend southwards and south eastwards and are likely to continue beyond the limits of the survey area.

(2) – A positive linear anomaly extends in an east south easterly direction from close to anomaly (1). It has a 1.5m gap close to the eastern edge of the survey area and is 1.5m wide. It appears to cross anomaly (1) and have an association with anomalies (3) and (4). Another discontinuous linear anomaly extends northwards from the junction between (2) and (4).

(3) – A positive linear anomaly is located 35m north of, and parallel with, anomaly (2). It is much wider than anomaly (2) at 2.5m.

(4) – An “L” shaped positive linear anomaly is located beyond the north eastern edge of anomaly (1).

(5) – A narrow positive linear anomaly appears to extend to the east north east from anomaly (4).

(6) – Two positive linear anomalies extend northwards from close to anomaly (3). Another linear anomaly is located close to the north eastern corner of the survey area.

(7) – Narrow positive linear anomalies are located between anomalies (2) and (3). They are much weaker and less distinct than the other anomalies within the vicinity, but an archaeological origin is possible.

(8) – Discrete positive anomalies and short positive linear responses may indicate cut features with archaeological potential.

Anomalies with an uncertain origin

(9) – Weakly positive responses appear to extend towards the gap within anomaly (2). Further positive linear anomalies exist to the south east; however, it is not possible to determine if all these anomalies are anthropogenic or natural in origin.

(10) – A weakly positive anomaly may be an extension of (3); however, it is less well defined and appears to cross, or be crossed by, anomaly (4).

(11) – A number of short, narrow, positive linear anomalies are located in the southern and northern parts of the survey area. It is not possible to determine if they relate to naturally formed or anthropogenically produced features.

(12) – Discrete positive anomalies appear to relate to pit-like features. It is not possible to determine if these are of natural or anthropogenic origin.

Anomalies with an agricultural origin

(13) – The survey area contains a series of linear anomalies, parallel with the southern and north western field boundaries that relate to a plough trend. The majority are seen as negative linear anomalies and it appears that they have truncated through the archaeological features.

Anomalies associated with magnetic debris

(14) – Strong, discrete, dipolar anomalies are a response to ferrous and other magnetically thermoremanent objects within the topsoil.

Anomalies associated with magnetic disturbance

(15) – An irregularly shaped zone of magnetic disturbance in the southern part of the survey area may have been caused by lightning induced remanent magnetism, although ferrous objects may be responsible.

4 CONCLUSION

- 4.1.1 The detailed magnetometer survey located a number of positive linear, curvilinear and rectilinear anomalies that relate to ditches and possible enclosures to the north east of the scheduled Castlezens multiple enclosure fort. The anomalies show some complexity to the features, with some indication of possible phasing. The anomalies appear to extend beyond the limits of the survey area in all directions.
- 4.1.2 Several other linear and discrete anomalies have also been located throughout the survey area, and while it is possible that they also relate to cut features, such as ditches and pits, they are weaker, less distinct and fragmented.

5 REFERENCES

British Geological Survey, 2014. *Geology of Britain viewer, 1:50 000 scale* [online] available from <http://mapapps.bgs.ac.uk/geologyofbritain/home.html> [accessed 17/6/2014].

English Heritage, 2008. *Geophysical survey in archaeological field evaluation. Research and Professional Service Guideline No.1*. 2nd ed. Swindon: English Heritage.

Institute for Archaeologists, 2002. *The use of Geophysical Techniques in Archaeological Evaluations*. IfA Paper No. 6. IfA, University of Reading.

Institute for Archaeologists, 2011. *Standard and Guidance for archaeological geophysical survey*. IfA, University of Reading.

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 5 South West England*.

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 thermoremanent 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.

Thermoremanent 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. Thermoremanent features include ovens, hearths, and kilns. In addition thermoremanent 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 SENSYS gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 65cm apart. The instrument is carried about 10-20cm 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 $\pm 15\text{nT}$ and $\pm 10\text{nT}$ 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.

High Pass Filtering

A mathematical process used to remove low frequency anomalies relating to survey tracks and modern agricultural features.

Appendix C – survey and data information

COMPOSITE

Filename: J548-mag.xcp
Description: Imported as Composite from: J548-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):
Northwest corner: 193042.346621726, 42506.1717449784 m
Southeast corner: 193194.296621726, 42319.8717449784 m
Direction of 1st Traverse: 90 deg
Collection Method: Parallel
Sensors: 1
Dummy Value: 32702

Source GPS Points: 535500

Dimensions

Composite Size (readings): 1013 x 1242
Survey Size (meters): 152 m x 186 m
Grid Size: 152 m x 186 m
X Interval: 0.15 m
Y Interval: 0.15 m

Stats

Max: 50.00
Min: -50.00
Std Dev: 15.95
Mean: 0.92
Median: 0.03
Composite Area: 2.8308 ha
Surveyed Area: 1.5743 ha

PROGRAM

Name: TerraSurveyor
Version: 3.0.23.0

Processes: 2

- 1 Base Layer
- 2 Clip from -50.00 to 50.00 nT

GPS based Process

- 1 Base Layer.
- 2 Unit Conversion Layer (Lat/Long to OSGB36).
- 3 DeStripe Median Traverse: Threshold: 1.5 SDs
- 4 Clip from -50.00 to 50.00 nT
- 5 High pass Uniform (median) filter: Window dia: 300

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at their offices in 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.

Surveys are reported on in hardcopy (recycled paper) using A4 for text and A3 for plots (all plots are scaled for A3). A copy will be uploaded to the Oasis website.

Archaeological Surveys Ltd shall retain intellectual property rights for the materials and records created as part of this project. A non-exclusive, transferable, sub-licensable, perpetual, irrevocable and royalty-free licence shall be granted to the client in order for them to use, reproduce and enhance the reports, documentation, graphics and illustrations produced as part of this project for the purpose for which they were commissioned. Copyright licence will also be granted to the local authority for planning use and within in the Historic Environment Record for public dissemination upon instruction by the client. Archaeological Surveys Ltd shall retain the right to be identified as the author and originator of the material.

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

- TerraSurveyor version 3.0.23.0 (geophysical data analysis),
- SENSYS MAGNETO®ARCH version 1.00-04(geophysical data analysis),
- ProgeCAD Professional 2014 (report graphics),
- AutoCAD LT 2007 (report figures),
- OpenOffice.org 3.0.1 Writer (document text),
- PDF Creator version 0.9 (PDF archive).

Digital data produced by the survey and report include the following files:

- TerraSurveyor 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.

Geophysical Survey
Castlezens Farm
Veryan
Cornwall

Map of survey area

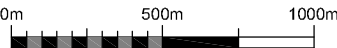
Reproduced from OS Explorer map no.105 1:25 000
by permission of Ordnance Survey on behalf of The
Controller of Her Majesty's Stationery Office.
© Crown copyright. All rights reserved.
Licence number 100043739.



● Survey location

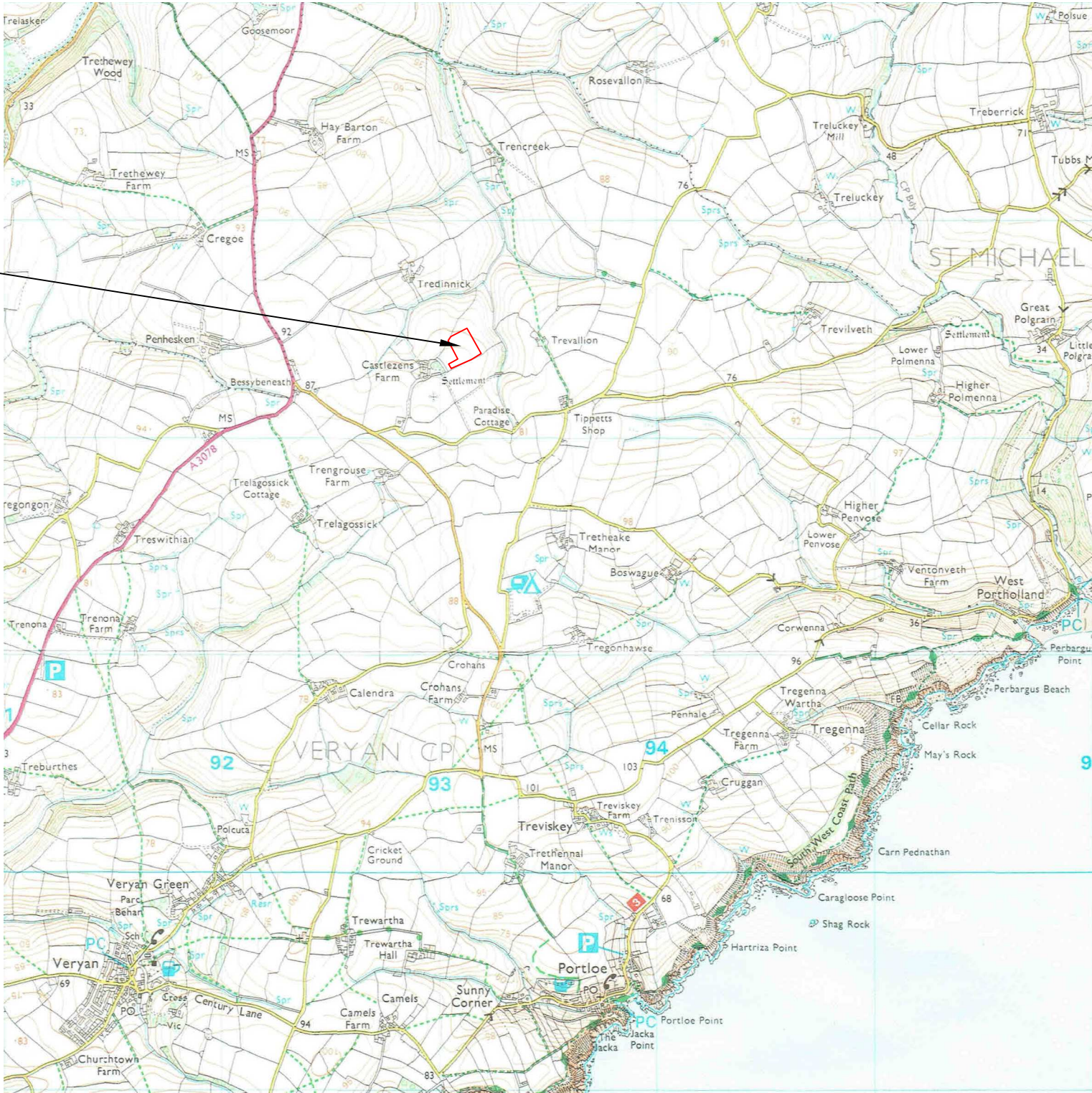
Site centred on OS NGR
SW 93107 42436

SCALE 1:25 000



SCALE TRUE AT A3

Survey location



Geophysical Survey
Castlezens Farm
Veryan
Cornwall

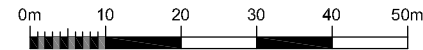
Referencing information

Referencing grid to OSGB36 datum at 50m intervals

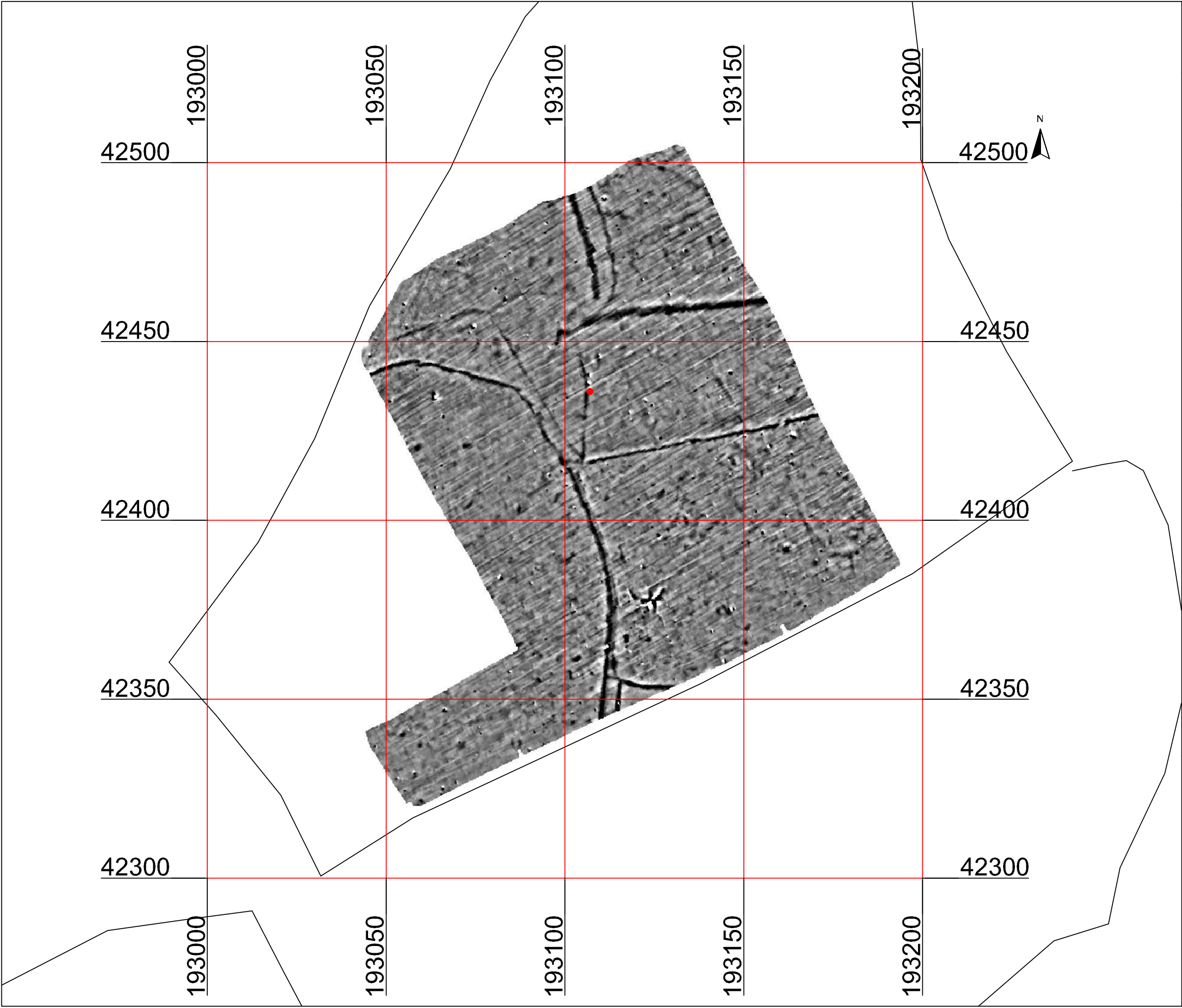
Data collected at 20Hz and georeferenced to ETRS89 zone 30 with conversion to OSGB36 using OSTN02

● Proposed centre of turbine 193107 42436

SCALE 1:1000

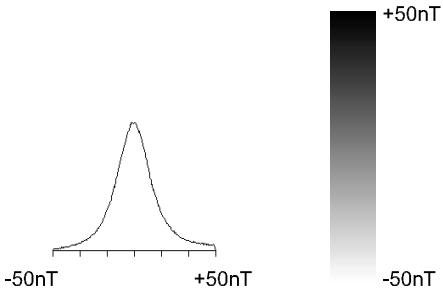


SCALE TRUE AT A3



Geophysical Survey
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Greyscale plot of processed
magnetometer data



SCALE 1:1000



SCALE TRUE AT A3

FIG 03

Geophysical Survey
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Abstraction and interpretation of
magnetometer anomalies

- Positive linear anomaly - cut feature of archaeological potential
- Positive linear anomaly - possible ditch-like feature
- Linear anomaly - of agricultural origin
- Discrete positive response - cut feature of archaeological potential
- Discrete positive response - possible pit-like feature
- Positive anomaly - magnetically enhanced material
- Magnetic disturbance
- Strong dipolar anomaly - ferrous object

SCALE 1:1000



SCALE TRUE AT A3

FIG 04

