Pen-y-Castell, Llanilar, Ceredigion

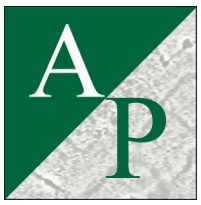
Geophysical Survey Report

Produced for RCAHMW

PCW131

1st May 2013

MJ Roseveare



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Mapping Our Heritage

Non-Technical Summary

A magnetic survey was commissioned to investigate an earthwork enclosure at Pen-y-Castell below the site of a hill fort, later re-fortified during the medieval period. The survey revealed a trapezoidal enclosure, defined by a ditch and with an entrance approximately central within the longest (and curving) side.

Within the enclosure few signs of structures were seen, however, there is good evidence for a wide bank along the inner edge of the ditch and that seems to have been revetted internally by a low wall. Against this structure and within the southern part of the enclosure there is evidence for accumulated magnetic soils likely to contain cultural material and also possible hearths and pit fills.

A scatter of enigmatic discrete strong dipolar anomalies is present across the northern part of the enclosure, all approximately aligned in the same direction. Their interpretation is uncertain but modern debris seems unlikely.

Digital Data

Data	Included?	Format
Survey outlines	Yes	Vector: AutoCAD R12 DXF
Interpretation	Yes	Vector: AutoCAD R12 DXF
XY Traces	No	Vector: AutoCAD R12 DXF
Contours	Partial	Vector: AutoCAD R12 DXF
Images	No	Georeferenced raster: GeoTIFF
Catalogue	No	Database: MS Access 2003

Media	Sent to	Date
DXF by E-mail	Toby Driver	1st May 2013

Audit

Version	Author	Checked	Date
Draft Final	MJR	ACKR	

Table of Contents

1 Introduction

Objective

1.1 A magnetic survey was commissioned to investigate an earthwork enclosure at Pen-y-Castell as part of an on-going research project, to provide information on the monument's form and possible function.

Location

Country	Wales
County	Ceredigion
Nearest Town	Llanilar
Central Co-ordinates	262995,274685

1.2 An area of approximately 0.7 hectares was surveyed.

2 Context

Archaeology

2.1 The following is quoted verbatim from Coflein:

"The interesting, multi-period earthworks at Pen-y-Castell, Llanilar, occupy the summit of a rounded hill in a very prominent position on the south side of the Afon Ystwyth. The earliest structure on site appears to be an oval Iron Age hillfort measuring c.113m north-south by 60m east-west and enclosing 0.5 hectare, with a well-defined gateway passage on the south-east side which presumably was once the site of a formal walled passage with crossing bridge between the rampart terminals to north and south. There is evidence from the interior that material was quarried around the perimeter to construct the substantial encircling ramparts. During the Iron Age an additional ditched enclosure to the east of the fort (NPRN 400288) may have been added to extend the settled area or to provide a corral for livestock.

Possibly at a later date, potentially when the Iron Age fort had fallen into disuse, a trapezoidal earthwork enclosure was built on the northern slopes of the hill below the fort (NPRN 400287). In the context of the Abermagwr Romano-British villa (NPRN 405315) which lies to the east of Llanilar this defended enclosure could be interpreted as a Romanised farmstead of the period."

2.2 In the field the earthwork is low but just about visible throughout. A possible gap in the northwest corner can be identified as likely due to erosion by livestock. Nothing about the layout or possible entrances is visible. The site lies on a steep north-facing slope.

Environment

Superficial 1:50000 BGS	Nothing recorded
Bedrock 1:50000 BGS	Mynydd Bach Formation - Sandstone And Mudstone (MYBA) – Silurian
Topography	Steep north-facing slope
Hydrology	Free draining
Current Land Use	Improved pasture
Historic Land Use	Pasture
Vegetation Cover	Grassland
Sources of Interference	None

2.3 The soil is expected to be naturally mildly magnetic but not significantly so and the magnetic susceptibility of soils formed over it may vary by hydrological situation and agricultural practices.

3 Methodology

Survey

Hardware

Measured Variable	Total magnetic field intensity / nT
Instrument	Geometrics G858 (0.5m parallel configuration), 10 Hz
Configuration	Parallel 0.5m spaced sensors
Sensitivity	0.03 nT (G858)

Resolution

3.1 The line separation for the survey was 0.5m, collected in zigzag passes using sensors spaced 0.5m apart. Data collection along each line was collected at 10Hz which equates to a sample spacing of roughly 0.16m – 0.2m along each.

3.2 Non-gradiometric data collection was used throughout so there was no compression of anomaly strength or reduction of sensitivity to horizontal structures.

Monitoring and quality assurance

3.3 Data is continually monitored during survey for unusual or obviously incorrect system behaviour or performance. Selected individual traverses are normally re-surveyed for comparison and to assess repeatability and rest-mode data is collected to assess temporal variation.

3.4 A suitably qualified Project Geophysicist was in the field at all times and fieldwork and technical considerations were guided by the Senior Geophysicist.

Processing

Procedure

3.5 All data processing is minimised and limited to what is essential for the class of data being collected, e.g. reduction of orientation effects from magnetic sensors, suppression of single point defects (drop-outs or spikes), etc. The process stream for this data is as follows:

Process	Software	Parameters
Heading reduction	Geometrics Magmap	N/A
Gridding	Surfer	Cubic spline along-line to 0.25m
Potential field processing	Proprietary	Shallow field (3m) and 1m pseudogradient models
Imaging and presentation	Manifold GIS	

3.6 Reduction to pole was carried out to investigate source body plan form and was found in this instance to have little appreciable effect upon the data set apart from an expected lateral translation of approximately 0.2m.

3.7 General information on processes commonly applied to data can be found in standard text books and also in the 2008 English Heritage Guidelines "*Geophysical Survey in Archaeological Field Evaluation*" at http://www.helm.org.uk/upload/pdf/Geophysical_LoRes.pdf.

3.8 ArchaeoPhysica uses more advanced processing for magnetic data using potential field techniques standard to near-surface geophysics. Details of these can be found in Blakely, 1996, "*Potential Theory in Gravity and Magnetic Applications*", Cambridge University Press.

3.9 All archived data includes process metadata.

Interpretive framework

Resources

3.10 Numerous sources are used in the interpretive process which takes into account shallow geological conditions, past and present land use, drainage, weather before and during survey, topography and any previous knowledge about the site and the surrounding area. Old Ordnance Survey mapping is consulted and also older sources if available.

Magnetic survey

3.11 Interpretative logic is based on structural class and examples are given below. For example a linear field or gradient enhancement defining an enclosed or semi-enclosed shape is likely to be a ditch fill, if there is no evidence for accumulation of susceptible material against a non-magnetic structure. Weakly dipolar discrete anomalies of small size are likely to have shallow non-ferrous sources and are therefore likely to be pits. Larger ones of the same class could also be pits or locally-deeper topsoil but if strongly magnetic could also be hearths. Strongly dipolar discrete anomalies are in all cases likely to be ferrous or similarly magnetic debris, although small repeatedly heated and *in-situ* hearths can produce similar anomalies. Reduced field strength (or gradient) linear anomalies without pronounced dipolar form are likely to be caused by relatively low susceptibility materials, e.g. masonry walls, stony banks or stony or sandy ditch fills.

Standards & guidance

3.12 All work was conducted in accordance with the following standards and guidance:

- David et al, "Geophysical Survey in Archaeological Field Evaluation", English Heritage 2008
- "Standard and Guidance for Archaeological Field Evaluation", Institute for Archaeologists 2008.

3.13 Archive formation is in the spirit of the following document which is, however, dated and not of direct relevance to the form and structure of data collected during non-gridded multi-sensor survey:

- Schmidt, A. et al, 2001, "Geophysical Data in Archaeology: A Guide to Good Practice", ADS

3.14 In addition, all work is undertaken in accordance with the high professional standards and technical competence expected by the Geological Society of London and the European Association of Geoscientists and Engineers.

3.15 All personnel are experienced surveyors trained to use the equipment in accordance with the manufacturer's expectations. All aspects of the work are monitored and directed by fully qualified professional geophysicists.

4 Catalogue

4.1 The numbers in square brackets in this report refer to the catalogue below and DWG 04.

Label	Anomaly Type	Feature Type	Description	Easting	Northing
1	Enhanced field linear dipolar	Fill - Ditch	The enclosure is defined by a ditch, the magnetic component of the fill of which is no more than about 2m wide. It enclosed a trapezoidal area with apparently a single entrance ([2] and [3]) through the curved northern side, the other sides being straight. Corners are all rounded. The southern side appears to be less magnetic, perhaps through truncation of the fill	262958.0	274674.9
2	Discrete enhanced field	Fill - Ditch	An entrance gap approximately 9m wide exists in the northern side and the ditch terminals defining it are more magnetic than the rest of the ditch fill. This might imply a concentration of occupation debris in each terminal in common with Iron Age enclosures elsewhere	262972.7	274719.9
3	Discrete enhanced field	Fill - Ditch	See [2]	262984.3	274724.7
4	Enhanced field linear dipolar	Fill - Ditch	See [1]	263017.4	274697.5
5	Reduced field area	Area - Stony?	Between the enhanced field anomalies [1] and [4] and the possible structures [7] and [8] there is a band of slightly (and variably) reduced magnetic field strength that would be in keeping with a stony soil, or thinner topsoil. Given the situation it seems likely that the base of an inner bank survives in these areas with a width of about 4m	262955.5	274705.7
6	Reduced field area	Area - Stony?	See [5]. There is little sign of this south of [2] and [3] which would support interpretation of the gap between ditch segments [2] and [3] as an entrance	262999.5	274722.0

Label	Anomaly Type	Feature Type	Description	Easting	Northing
7	Reduced field linear	Structure?	The angle of inclination of the ambient magnetic field means that sources of magnetic enhancement produce an anomaly that reduces the ambient field to the north and enhances it to the south. In this position we would expect the reduced field portion of the anomaly from [9], however, the intensity of the anomaly suggests a secondary source further reducing the magnetic field strength. This is also evident at [8] and hinted at along the eastern side of the enclosure and a likely explanation is that the probable bank [5] and [6] was revetted internally by a thin (< 0.5m) stone wall, against which deposits [9] and [10] have accumulated	262960.9	274705.7
8	Reduced field linear	Structure?	See [7]. This example might be traceable most of the way along the eastern side of the enclosure	263008.8	274709.3
9	Enhanced field area	Fill - Debris	The northern third of the enclosure hosts areas of anomalously magnetic ground and in these locations they are likely to be caused by an increased depth of soil, likely to contain debris from use of the enclosure and trapped against possible structures [7] and [8]. It is noticeable that in the same areas the magnetic field is also more variable and therefore some of the soil is likely to be occupation debris and to seal and perhaps contain structures contemporary with the enclosure	262958.8	274701.1
10	Enhanced field area	Fill - Debris	See [9]. In reality these areas are likely to present different concentrations or quantities of the same material and therefore the same soil horizon across the northern part of the site	263003.4	274708.5
11	Discrete enhanced field	Hearth / Fill - Pit	Against [8] there appears to be a discrete strongly magnetic structure that might be a hearth or perhaps a pit fill a little over 1m diameter	262992.8	274717.6
12	Discrete enhanced field	Hearth / Fill - Pit	This seems to be a magnetic structure less than 1m diameter within or beneath accumulated soil [10]	263004.0	274713.1

Label	Anomaly Type	Feature Type	Description	Easting	Northing
13	Discrete enhanced field	Hearth / Fill - Pit / Debris	A possible band of strongly magnetic soil exists with [9] where it is likely to be deepest against possible structure [7]. Whether this is due to the increased thickness of deposit or a different material is unclear but it is interesting that the same is not evident on the other side of the enclosure within [10] as would be expected if solely due to thickness. It is possible that this is (weak) evidence for zoning of materials and therefore probably function	262966.2	274707.5
14	Discrete enhanced field	Hearth / Fill - Pit	See [12] for a similar anomaly and therefore probably a similar structure	262963.0	274699.3
15	Enhanced field linear	Fill - Ditch?	Within the enclosure a weak enhanced field linear anomaly might mark a narrow (0.5m) ditch fill	262977.2	274690.4
16	Strong discrete dipolar (group)	Object - Ferrous	A set of very strong dipoles with their direction of strike mostly within about +/- 5 degrees of north. Each source is an approximate point and the peak to peak distance of each dipole is between 0.5m and about 1m in each case (it will tend towards a multiple of 0.5m due to the line separation). It is suggested therefore that each point source is less than 0.5m in (virtual) diameter and they are all about the same size	262971.6	274660.8
17	Strong discrete dipolar (group)	Object - Ferrous	See [16]	263028.2	274670.8

5 Discussion

Introduction

5.1 The sections below first discuss the geophysical context within which the results need to be considered and then specific features or anomalies of particular interest. Not all will be discussed here and the reader is advised to consult the catalogue (*ibid*) in conjunction with the graphical elements of this report.

Principles

5.2 In general, topsoil is more magnetic than subsoil which can be slightly more magnetic than parent geology, whether sands, gravels or clays, however, there are exceptions to this. The reasons for this are natural and are due to biological processes in the topsoil that change iron between various oxidation states, each differently magnetic. Where there is an accumulation of topsoil or where topsoil has been incorporated into other features, a greater magnetic susceptibility will result.

5.3 Within landscapes soil tends to accumulate in negative features like pits and ditches and will include soil particles with thermo-remanent magnetization (TRM) through exposure to heat if there is settlement or industry nearby. In addition, particles slowly settling out of stationary water will attempt to align with the ambient magnetic field at the time, creating a deposit with depositional remanent magnetization (DRM).

5.4 As a consequence, magnetic survey is nearly always more a case of mapping accumulated magnetic soils than structures which would not be detected unless magnetic in their own right, *e.g.* built of brick or tile. As a prospecting tool it is thus indirect. Fortunately, the mechanisms outlined above are commonplace and favoured by human activity and it is nearly always the case that cut features will alter in some way the local magnetic field.

Instrumentation

5.5 The use of the magnetic sensors in non-gradiometric (vertical) configuration avoids measurement sensitisation to the shallowest region of the soil, allowing deeper structures, whether natural or otherwise to be imaged within the sensitivity of the instrumentation. However, this does remove suppression of ambient noise and temporal trends which have to be suppressed later during processing. When compared to vertical gradiometers in archaeological use, there is no significant reduction in lateral resolution when using non-gradiometric sensor arrays and the inability of gradiometers to detect laminar structures is completely avoided.

5.6 Caesium instrumentation has a greater sensitivity than fluxgate instruments, however, at the 10 Hz sampling rate used here this increase in sensitivity is limited to about one order of magnitude.

5.7 The array system is designed to be non-magnetic and to contribute virtually nothing to the magnetic measurement, whether through direct interference or through motion noise. There is, however, some limited contribution from the towing ATV.

Character & principal results

5.8 For detailed comment the reader is advised to consult the catalogue in section four, above.

Geology

5.9 There is a weak contribution to the surface magnetic field from the geology, mostly as broad variations in texture. Smaller scale variations are numerous and are probably caused by small changes in the soil. Soil depth may also be a factor because the least variation is at the top of the slope.

Land use

5.10 There is no evidence for past or present land use apart from weak linear anomalies that might reflect ploughing, perhaps before re-seeding or from short term arable use. There are no indications of former field boundaries including no re-use or incorporation of parts of the enclosure within a later field system

Archaeology

5.11 The dominant result has to be the enclosure ditch [1] and [4], quite a narrow construction, perhaps only 2m wide, so unlikely to have been intended for defence. Within this a bank up to 4m wide is apparent as reduced field strength areas [5] and [6], most apparent along the southern and lowest limb of the monument which might imply loss of this structure higher up. Assuming this bank has a constant width throughout it encloses an area of approximately 0.24 hectares.

5.12 Passing through both ditch and bank is an entrance (between [2] and [3]) approximately central to the southern side of the enclosure. This is wide, up to 9m which again might imply a non-defensive purpose and each ditch terminal is slightly more magnetic than the ditch itself. This might imply concentrations of material like pottery, common in Iron Age farmstead ditch terminals.

5.13 The possible height of the former bank must have been low; presumably the material from this was excavated from the enclosure ditch which if only 2m wide, would have provided only a limited quantity of material for the bank. Again this might suggest its purpose was simply to enclose, rather than make defensive, an area of land. The inner face of the bank appears to be associated with a thin non-magnetic structure [7] and [8] which is tentatively interpreted as a wall.

5.14 Within the enclosure are two areas [9] and [10] of soil (more properly, perhaps more magnetic regions of a single deposit) that represent accumulated soil in the lowest point of the enclosure. It seems likely to be derived from elsewhere in the enclosure and to have migrated downhill, rather than being a relict of a more extensive deposit, although this cannot be ruled out. It appears to have features within or beneath it, e.g. [11], [12], [13], and perhaps [14] and these might be hearths or pit fills.

5.15 The only other internal feature is [15] which seems to be a small gully fill, however, it could be unrelated to the monument.

Strong dipoles

5.16 Two groups [16] and [17] of strong magnetic dipoles are present across the southern part of the site and although might easily be dismissed as modern debris there are grounds for suspecting a different origin.

5.17 The green arrows on DWG 04 indicate their direction of strike and all are within about +/- 5 degrees of north and therefore lacking the randomness expected from modern debris. Each source is an approximate point and the peak to peak distance of each dipole is between 0.5m and about 1m in each case (tending towards a multiple of 0.5m due to the line separation). Each point source is likely to be less than 0.5m in (virtual) diameter and all are about the same size.

5.18 This lack of randomness of strike and size makes accidental deposition of a set of disparate objects, e.g. farm debris, quite unlikely. If it was a scatter of iron bolts and scrap more variation would be expected, also some larger (spatial size, not magnetic amplitude) anomalies. For each item of steel debris to possess exactly the same strike would require some common means of re-magnetisation and at the same time. The apparent susceptibility of each object, if trying to discount remanence, is extremely high (e.g. 0.05 SI) so each object has to also be strongly magnetic in its own right.

5.19 There are few obvious interpretations based upon the evidence of the magnetic data; a logical one might be that these are the bases of small industrial furnaces, however, there is no indication of the spreads of magnetic debris that invariably surround such structures.

5.20 It seems more likely that each anomaly is a discrete buried object, probably ferrous and all either intentionally aligned in the same direction or subsequently remagnetised.

Conclusions

5.21 The survey seems to have mapped a small non-defensive Iron Age farmstead with good evidence for the survival of features and cultural material at least within the lower parts of the enclosure. The date is suggested from the trapezoidal shape with a curved 'façade' through which there is a central entrance, the ditch terminals being significantly magnetic which has been observed at other sites.

5.22 A scatter of strong magnetic dipoles across the southern part of the enclosure has no obvious origin and does not appear to be modern debris.

Caveats

5.23 Geophysical survey is a systematic measurement of some physical property related to the earth. There are numerous sources of disturbance of this property, some due to archaeological features, some due to the measuring method, and others that relate to the environment in which the measurement is made. No disturbance, or 'anomaly', is capable of providing an unambiguous and comprehensive description of a feature, in particular in archaeological contexts where there are a myriad of factors involved.

5.24 The measured anomaly is generated by the presence or absence of certain materials within a feature, not by the feature itself. Not all archaeological features produce disturbances that can be detected by a particular instrument or methodology. For this reason, the absence of an anomaly must never be taken to mean the absence of an archaeological feature. The best surveys are those which use a variety of techniques over the same ground at resolutions adequate for the detection of a range of different features.

5.25 Where the specification is by a third party ArchaeoPhysica will always endeavour to produce the best possible result within any imposed constraints and any perceived failure of the specification remains the responsibility of that third party.

5.26 Where third party sources are used in interpretation or analysis ArchaeoPhysica will endeavour to verify their accuracy within reasonable limits but responsibility for any errors or omissions remains with the originator.

5.27 Any recommendations are made based upon the skills and experience of staff at ArchaeoPhysica and the information available to them at the time. ArchaeoPhysica is not responsible for the manner in which these may or may not be carried out, nor for any matters arising from the same.

Appendices

Survey metadata

Project information

Project Name	Pen-y-Castell, Llanilar, Ceredigion
Project Code	PCW121
Client	RCAHMW
Fieldwork Dates	27th March 2013
Field Personnel	ACK Roseveare, D Rouse
Processing Personnel	ACK Roseveare
Reporting Personnel	MJ Roseveare
Draft Report Date	1st May 2013
Final Report Date	

Qualifications & experience

5.28 All work is undertaken by qualified and experienced geophysicists who have specialised in the detection and mapping of near surface structures in archaeology and other disciplines using a wide variety of techniques. There is always a geophysicist qualified to post-graduate level on site during fieldwork and all processing and interpretation is undertaken under the direct influence of either the same individual or someone of similar qualifications and experience.

5.29 ArchaeoPhysica meets with ease the requirements of English Heritage in their 2008 Guidance "Geophysical Survey in Archaeological Field Evaluation" section 2.8 entitled "Competence of survey personnel". The company is one of the most experienced in European archaeological prospection and is a key professional player. It only employs people with recognised geoscience qualifications and capable of becoming Fellows of the Geological Society of London, the Chartered UK body for geophysicists and geologists.

Safety

5.30 Safety procedures follow the recommendations of the International Association of Geophysical Contractors (IAGC).

5.31 Principal personnel have passed the Rescue Emergency Care – Emergency First Aid course and CSCS cards are being sought for those members of staff currently without them.

5.32 All personnel are issued with appropriate PPE and receive training in its use. On all sites health and safety management is performed by the Project Geophysicist under supervision by the Operations Manager.

5.33 Health and safety policy documentation is reviewed every 12 months, or sooner if there is a change in UK legislation, a reported breach of such legislation, a reported Incident or Near Miss, or changes to ArchaeoPhysica's activities. Anne Roseveare, Operations Manager, has overall responsibility for conducting this review and ensuring documentation is maintained.

5.34 We are happy to confirm that ArchaeoPhysica has suffered no reportable accidents since its inception in 1998.

Archiving

5.35 ArchaeoPhysica maintains an archive for all its projects, access to which is permitted for research purposes. Copyright and intellectual property rights are retained by ArchaeoPhysica on all material it has produced, the client having full licence to use such material as benefits their project.

5.36 Archive formation is in the spirit of Schmidt, A., 2001, "Geophysical Data in Archaeology: A Guide to Good Practice", ADS.

5.37 Access is by appointment only. Some content is restricted and not available to third parties. There is no automatic right of access to this archive by members of the public. Some material retains commercial value and a charge may be made for its use. An administrative charge may be made for some enquiries, depending upon the exact nature of the request.

5.38 The archive contains all survey and project data, communications, field notes, reports and other related material including copies of third party data (e.g. CAD mapping, etc) in digital form. Many are in proprietary formats while report components are available in PDF format.

5.39 In addition, there are paper elements to some project archives, usually provided by the client. Nearly all elements of the archive that are generated by ArchaeoPhysica are digital.

5.40 It is the client's responsibility to ensure that reports are distributed to all parties with a necessary interest in the project, e.g. local government offices, including the HER where present. ArchaeoPhysica reserves the right to display data from projects on its website and in other marketing or research publications, usually with the consent of the client. Information that might locate the project is normally removed unless otherwise authorised by the client.

PCW131 Pen-y-Castell, Llanilar, Ceredigion
DWG 01 Site Location

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Orthographic Centre X: 262998.70 m Centre Y: 274693.31 m Scale: 1:10000 @ A4 Spatial Units: Meter. Do not scale off this drawing

PCW131 Pen-y-Castell, Llanilar, Ceredigion
DWG 02 Magnetic Data - Shallow Model

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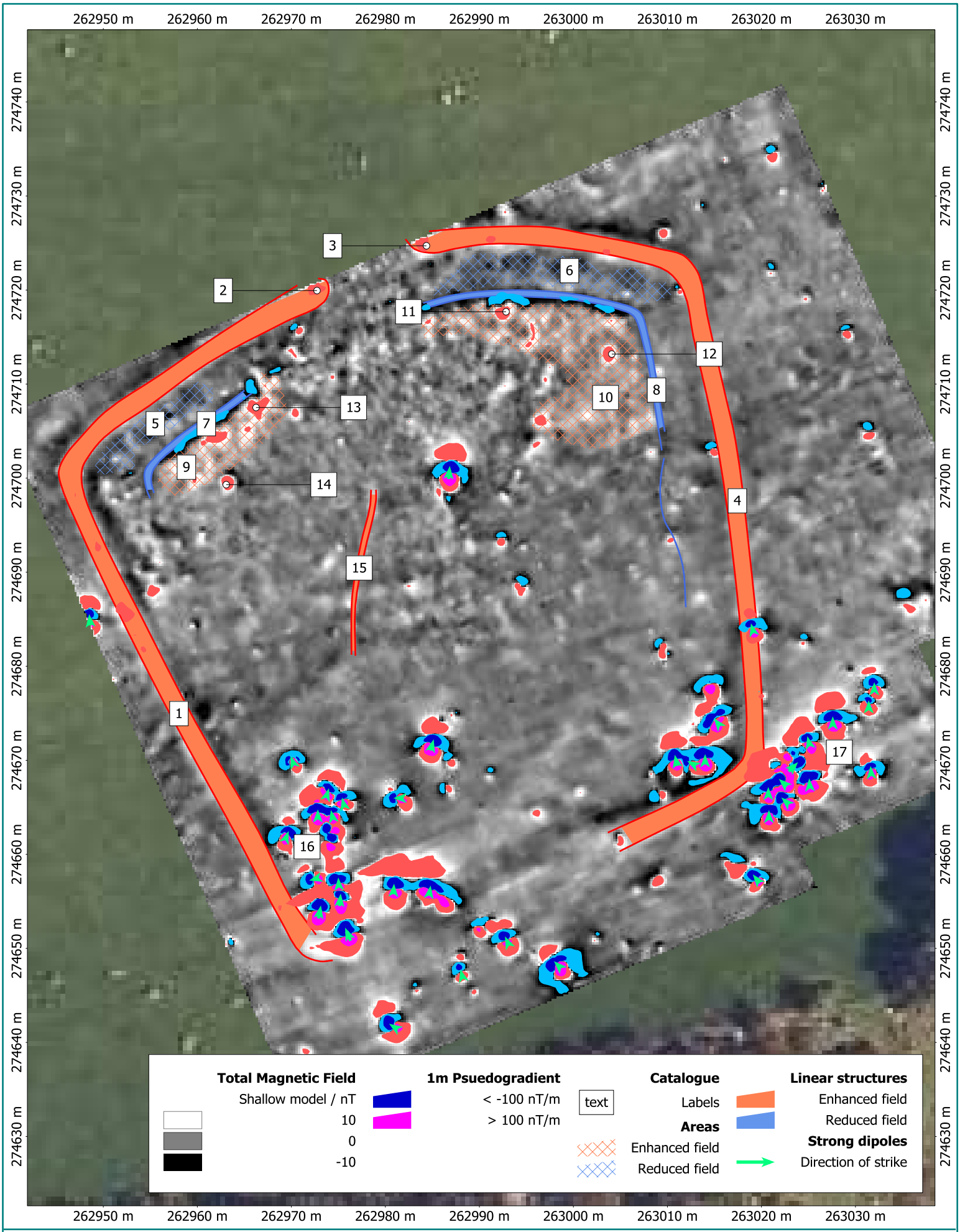
Orthographic Centre X: 262990.19 m Centre Y: 274685.15 m Scale: 1:1000 @ A4 Spatial Units: Meter. Do not scale off this drawing

PCW131 Pen-y-Castell, Llanilar, Ceredigion
DWG 03 Magnetic Data - 1m Pseudo-gradient

ArchaeoPhysica Ltd

Orthographic Centre X: 262990.19 m Centre Y: 274685.15 m Scale: 1:1000 @ A4 Spatial Units: Meter. Do not scale off this drawing



PCW131 Pen-y-Castell, Llanilar, Ceredigion
DWG 04 Catalogue

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Orthographic Centre X: 262990.19 m Centre Y: 274685.15 m Scale: 1:500 @ A4 Spatial Units: Meter. Do not scale off this drawing