

Geophysical Survey at Dinas Dinlle Hillfort, Llandwrog, Gwynedd



CHERISH

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Geophysical Survey at Dinas Dinlle Hillfort, Llandwrog, Gwynedd

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CONTENTS

1. INTRODUCTION	1
2. METHODOLOGY	1
2.1 <i>Instrumentation</i>	1
2.2 <i>Data Collection</i>	2
2.3 <i>Data presentation</i>	2
2.4 <i>Data Processing</i>	3
3. RESULTS	3
4. SUMMARY	6
4.1 <i>The fort and environs</i>	6
4.2 <i>The southern field</i>	6
5. REFERENCES	7

LIST OF FIGURES

- Fig. 1 Dinas Dinlle fluxgate gradiometer survey - grey-scale plot
- Fig. 2 Dinas Dinlle Fluxgate Gradiometer Survey - Interpretation plan
- Fig. 3 Dinas Dinlle interior of fort from 2005 and 2017 surveys showing ferrous contamination
- Fig. 4 Tithe map 1849. The parish of Llandwrog in the County of Carnarvon
- Fig. 5 Geophysical survey interpretation with transcription of 1849 Tithe map (in red)
- Fig. 6 Dinas Dinlle fluxgate gradiometer survey - trace plot, northern field
- Fig. 7 Dinas Dinlle fluxgate gradiometer survey - trace plot, southern field
- Fig. 8 Dinas Dinlle fluxgate gradiometer survey - grey-scale plot, raw data clipped to $\pm 30\text{nT}$

GEOPHYSICAL SURVEY AT DINAS DINLLE HILLFORT, LLANDWROG

PRN: 1570 NPRN: 95309

Location SH43705635c

Scheduled Monument reference CN048

1. INTRODUCTION

Fluxgate gradiometer survey provides a relatively swift and non-invasive method of surveying large areas. The current survey was designed to investigate an area of approximately 9.2ha across two fields in Llandwrog. The northernmost field contains the Iron Age hillfort of Dinas Dinlle, the southern field is an improved field laid down to pasture. The interior of the hillfort had previously been surveyed at 1.0m x 0.5m resolution by Gwynedd Archaeological Trust in 2005 (Smith 2005).

The survey was commissioned by the Royal Commission on the Ancient and Historical Monuments of Wales as part of their CHERISH – Climate Change and Coastal Heritage project, aimed at raising awareness and understanding of the past, present and near future impacts of climate change, storminess and extreme weather events on the rich cultural heritage of the sea and coast <http://www.cherishproject.eu/en/>. CHERISH is a five-year Ireland-Wales project, between the Royal Commission on the Ancient and Historical Monuments of Wales; the Discovery Programme, Ireland; Aberystwyth University: Department of Geography and Earth Sciences and Geological Survey Ireland. It began in January 2017 and will run until December 2021 and will receive €4.1 million of EU funds through the Ireland Wales Co-operation Programme 2014-2020.

2. METHODOLOGY

2.1 Instrumentation

The survey was carried out using a Bartington Grad601-2 dual Fluxgate Gradiometer. This uses a pair of Grad-01-100 sensors. These are high stability fluxgate gradient sensors with a 1.0m separation between the sensing elements, giving a strong response to deeper anomalies.

The instrument detects variations in the earth's magnetic field caused by the presence of iron in the soil. This is usually in the form of weakly magnetised iron oxides which tend to be concentrated in the topsoil. Features cut into the subsoil and backfilled or silted with topsoil therefore contain greater amounts of iron and can therefore be detected with the gradiometer. This is a simplified description as there are other processes and materials which can produce detectable anomalies. The most obvious is the presence of pieces of iron in the soil or immediate environs which usually produce very high readings and can mask the relatively weak readings produced by variations in the soil. Strong readings are also produced by archaeological features such as hearths or kilns because fired clay acquires a permanent thermo-remnant magnetic field upon cooling. This material can also get spread into the soil leading to a more generalised magnetic enhancement around settlement sites.

Not all surveys can produce good results as anomalies can be masked by large magnetic variations in the bedrock or soil or high levels of natural background "noise" (interference consisting of random signals produced by material within the soil). In some cases, there may be

little variation between the topsoil and subsoil resulting in undetectable features. *It must therefore be stressed that a lack of detectable anomalies cannot be taken to mean that there is no extant archaeology.*

The Bartington Grad601 is a hand held instrument and readings can be taken automatically as the operator walks at a constant speed along a series of fixed-length traverses. The sensor consists of two vertically aligned fluxgates set 1.0m apart. Their cores are driven in and out of magnetic saturation by an alternating current passing through two opposing driver coils. As the cores come out of saturation, the external magnetic field can enter them producing an electrical pulse proportional to the field strength in a sensor coil. The high frequency of the detection cycle produces what is in effect a continuous output.

The gradiometer can detect anomalies down to a depth of approximately one metre. The magnetic variations are measured in nanoTeslas (nT). The earth's magnetic field strength is about 48,000 nT; typical archaeological features produce readings of below 15nT although burnt features and iron objects can result in changes of several hundred nT. The instrument is capable of detecting changes as low as 0.1nT.

2.2 Data Collection

The gradiometer includes an on-board data-logger. A high resolution survey was specified in the project design for the area of the hillfort. Readings in this area were therefore taken along parallel traverses of one axis of a series of 20m x 20m grids. Readings were taken with a traverse interval of 0.5m and were logged at intervals of 0.125m along each traverse giving 6400 readings per grid. Guide-lines with marks at 1m intervals were used to ensure accurate data collection. The rest of the survey was carried out at standard resolution with readings were taken with a traverse interval of 1.0m and were logged at intervals of 0.25m along each traverse giving 1600 readings per grid without guidelines

2.3 Data presentation

The data was transferred from the data-logger to a computer where it was compiled and processed using ArchaeoSurveyor 2 software. The data is presented as a grey-scale plot (Fig. 1) where data values are represented by modulation of the intensity of a grey-scale within a rectangular area corresponding to the data collection point within the grid. This produces a plan view of the survey and allows subtle changes in the data to be displayed. This is supplemented by an interpretation diagram (Fig. 2) showing the main features of the survey with reference numbers linking the anomalies to descriptions in the written report. It should be noted that the interpretation is based on the examination of the shape, scale and intensity of the anomalies and comparison to features found in previous surveys and excavations etc. In some cases the shape of an anomaly is sufficient to allow a definite interpretation e.g. a Roman fort. In other cases all that can be provided is the most likely interpretation. The survey will often detect several overlying phases of archaeological remains and it is not usually possible to distinguish between them. Weak and poorly defined anomalies are most susceptible to misinterpretation due to the propensity for the human brain to define shapes and patterns in random background noise. Several types of archaeological sites, such as prehistoric settlement and cemeteries, often produce weak or indistinct anomalies and can sometimes not be distinguishable from natural background variations. Also features such as linear ditches could be

assigned to many periods and functions. An assessment of the confidence of the interpretation is given in the results.

Scheduled Monument Consent was granted for the geophysical survey work subject to the various conditions. Condition 10 states that "The survey report must include the raw data plots and the final plots should be presented in both 'grayscale' and 'trace' formats." The trace plots and raw data plots are included as reference plots (Figs 6-8). It should be noted that the data in the grayscale raw data plot has been clipped to $\pm 30\text{nT}$. This is because displaying the full range of data from -3000nT to $+3000\text{nT}$ would result in an almost entirely grey plot that would display no useful information apart from the strongest ferrous anomalies. The data used to produce the trace plot was clipped to $\pm 100\text{nT}$ for similar reasons.

2.4 Data Processing

The data is presented with a minimum of processing although corrections were made to compensate for instrument drift and other minor data collection inconsistencies. High readings caused by stray pieces of iron, fences, etc are usually modified on the grey scale plot as they have a tendency to compress the rest of the data. The data is however carefully examined before this procedure is carried out as kilns and other burnt features can produce similar readings. Grey-scale plots are always somewhat pixellated due to the resolution of the survey. This at times makes it difficult to see less obvious anomalies. The readings in the plots are therefore smoothed using the graduated shade function in Archaeosurveyor. This reduces the perceived effects of background noise thus making anomalies easier to see. Any further processing is noted in relation to the individual plot.

3. RESULTS

The survey was carried out in two phases. The first was carried out in November 2017 and comprised a high resolution survey ($0.5\text{m} \times 0.125\text{m}$ resolution) of the fort and its surrounding earthworks. The survey of the fort presented a range of difficult conditions with steep slopes, long tussocky grass and patches of undergrowth. This will inevitably have led to some positional inaccuracy but no major problems could be seen with the data. An area to the east of the fort could not be surveyed due to the presence of large patches of gorse and brambles. The second phase was carried out in May 2018. This comprised a standard resolution ($1.0\text{m} \times 0.25\text{m}$ resolution) survey of the moderately sloping eastern side of the northern field and the whole of the southern field. Survey conditions were generally good in the southern field which was mostly level and featureless with short grass. The boundary between the two sampling resolutions in the northern field is shown on Fig. 8. The surveys were carried out by David Hopewell, Megan Howe and John Burman.

The levels of magnetic variation across the survey were fairly low, with moderate to low levels of magnetic noise from the boulder clay substrate. There was however a high level of ferrous contamination within the fort most notably caused by the wire used in the construction of footpaths.

A large number of intersecting anomalies were detected across the whole of the survey. A list of anomalies detected by the survey along with their interpretation is presented in table 1 followed by a summary of the main phases. The interpretation of anomalies within Dinas Dinlle

has a fair degree of uncertainty given the historic range of functions of the site which include an Iron Age hillfort, a golf course, a WW2 defensive position, farmland and a tourist destination.

Anomaly number	Description and interpretation
1	Ferrous anomaly - wire in footpath
2	Ferrous anomaly- wire in footpath
3	Ferrous anomaly - wire in footpath
4	A spread of small ferrous anomalies - recent ferrous contamination not visible on the 2005 survey, possibly debris left over after removal of a fence
5	A spread of small ferrous anomalies – rubbish around golf tee/green
6	A spread of small ferrous anomalies – probably modern rubbish in the ditch
7	Ferrous anomalies - unknown origin (see 17 below)
8	Ferrous anomalies – WW2 defences: seagull trench
9	Terraced path to seagull trench
10	Large ferrous anomaly – unknown origin, on the highest point, possibly base of mast, flagpole or trig point
11	Outer rampart of hillfort
12	Inner rampart of hillfort
13	Inner rampart of hillfort
14	Feature running parallel to the hillfort defences. Possibly an outer ditch
15	Outer rampart of hillfort
16	Zig-zag anomaly, possibly the road to the fort entrance
17	A series of five anomalies along the inside of the eastern rampart The northernmost is a large mound of unknown origin, the other four could be roundhouses. There is significant magnetic enhancement in the interiors. An alternative interpretation of the second anomaly from the south, that survives as an earthwork, is a golf bunker.
18	A series of five or more rather poorly defined anomalies along the inside of the southern rampart. One is clearly visible as an earthwork and could be interpreted as a golf bunker. The rest are best interpreted as overlapping phases of roundhouses. There is significant magnetic enhancement in this band of activity.
19	Another possible roundhouse. This may have been set close to the now-lost western rampart suggesting that there has not been significant loss of area in the interior
20	Three more circular anomalies that could be interpreted as roundhouses.
21	A circular anomaly, possibly a roundhouse with an attached rectangular anomaly consisting of multiple low/medium level magnetic responses possibly indicating a stone bank. This may be somewhat magnetically enhanced due to the presence of heat-affected stones.
22	A short linear anomaly consisting of multiple low/medium level magnetic responses possibly indicating a stone bank, again possibly containing heat-affected stones.
23	A second short linear anomaly consisting of multiple low/medium level magnetic responses possibly indicating a stone bank, again possibly containing heat-affected stones.

24	A second short linear anomaly consisting of multiple low/medium level magnetic responses possibly indicating a stone bank, also possibly containing heat-affected stones. The central central/southern area of the fort contains significant magnetic enhancement but the anomalies are not well defined and cannot be interpreted with a high level of confidence
25-27	An area of magnetic variation with no obvious structure. This could be a product of variation in the natural substrate or alternatively magnetic enhancement from multiple phases of archaeological activity.
28	A significant area of magnetic enhancement in the entrance. Presumably a product of stones laid to prevent erosion in the steep entrance passage at some point in the history of the site.
29	A well-defined linear anomaly, possibly a drain or similar cut feature.
30	A sharply defined linear anomaly visible on the ground as a cut into the hillside aligned with the golf tee/green and probably associated with this activity.
31-37	A series of diffuse curvilinear features. These are not visible as earthworks and two possible interpretations can be suggested. They may be a result of natural changes in the natural boulder clay either during its initial deposition or a result of dune formations and blow-outs. The alignment of 31 with the possible road into the fort and their subrectangular layout suggests an anthropogenic origin. The anomalies are similar to some produced by the boundaries of early field systems surveyed by Smith and Hopewell (Smith 2018). It is therefore possible that these anomalies are the ploughed down remnants of fields contemporary with the fort.
38	A wide and diffuse linear anomaly, see 31-36.
39-40	A series of linear anomalies best interpreted as a series of field boundaries forming a regular field system. This corresponds in part to the field system shown on the tithe map (1849). There is no trace of this on the first edition OS 25" map. The basic layout of the fields is not identical to those shown on the tithe map but is close enough to suggest that the map was a little inaccurate. See also 41-43
41-43	Four buildings are shown on the tithe map. Two correspond exactly to areas of spreads of ferrous anomalies and other magnetic noise (41 and 42). A field boundary and a concentration of ferrous anomalies appear to mark the area of the other two.
44	Boundary 44 consists of several linear features running at varying angles suggesting that the field system had been altered over time
45	A curvilinear boundary around the building shown on the tithe map suggests an earlier phase of settlement predating that shown on the tithe map.
46-47	Further well-defined linear anomalies are best interpreted as fields associated with the probable earlier settlement marked by enclosure 45
48	A poorly defined oval feature could be interpreted as a small enclosure but is most likely to be a natural variation in the substrate or periglacial feature

4. SUMMARY

4.1 The fort and environs.

The interior of the fort is very magnetically variable compared to the surrounding land. This is probably, at least in part, a result of magnetic enhancement during occupation in the Iron Age. There appear to be roundhouses (17 and 18) marked by circular areas of enhancement, set around the inside of the rampart. A house on the south-west of the interior (19) may mark the western edge of the fort in this area suggesting that the interior survives almost to its original width towards the south of the fort. The central part of the interior contains multiple anomalies some of which could be interpreted as stony banks and further roundhouses (21-27). It seems likely that some of the anomalies within the fort are post-medieval or modern. These cannot be differentiated from early anomalies by geophysical survey alone. For example, a bunker from the golf course could produce a similar anomaly to a roundhouse. It is therefore recommended that this survey should be examined in conjunction with other sources of information and the interpretation be amended as necessary.

The defences of the fort, visible as earthworks, produced clear anomalies. A strong linear anomaly along the inner southern rampart (13) could indicate stone facing. The area to the outside of the entrance at the south-east of the fort shows multi-period anomalies. There appears to have been some modification associated with the golf course with a levelled area and earthwork (30) in front of a green (5). Two anomalies that are not visible as earthworks or lidar features lie immediately to the south of the defences. These are best interpreted as an early field boundary (31) and a zigzag path leading to the entrance (16). A clear anomaly (14) running almost parallel to the defences at the north of the fort may be an outer ditch. This is visible as a faint lidar feature that leads to a short linear earthwork at its southern end, just outside the survey area and immediately to the east of the outer bank of the fort defences.

A more recent anomaly (9), clearly visible both on the ground and on lidar, is a path leading to the WW2 seagull trench.

It is clear that there has been a considerable amount of additional ferrous contamination since the last survey was carried out in 2005 (Smith 2005, Fig. 26) This appears to be wire used in footpath construction, nails and staples from fencing and litter from visitors to the site. Fig. 3 provides a comparison between the 2005 survey and the 2017/18. The line of the fence which produced a significant anomaly in 2005 has changed, although its remains were still visible on the 2017/18 survey. Contamination by ferrous material is a significant, but often overlooked, management issue on many archaeological sites (Hopewell 2010).

4.2 The southern field

A series of diffuse anomalies (31-38) were detected that could be interpreted as the ploughed-out remnants of Iron Age or Medieval field boundaries. This is the most likely interpretation but a natural origin cannot be entirely ruled out. In contrast, a series of very clear anomalies (39-44) correspond to the field boundaries and buildings of a homestead called Penllech shown on the 1849 Llandwrog tithe map. The buildings are also shown on the Robert Dawson 1815 Ordnance survey drawing (British OSD 306/25). These features are, however, not shown on the 1889 first edition OS 25" and were presumably removed in the mid to second half of the century when

agricultural improvements created the large rectangular fields that make up the current landscape. Fig. 5 shows a transcription of the tithe map fitted to the major roads and boundaries. The match with the boundaries of Penllech is not particularly good but is close enough to estimate which correspond to the geophysical survey anomalies. These are parallel double anomalies probably indicating field boundaries comprising a wall or bank with ditches on both sides. Several anomalies are clearly additional subdivisions of the fields shown on the tithe map. Others appear to be earlier. The boundary at the east of the homestead (44) appears to have been realigned several times. A series of curvilinear boundaries at the south-east of the homestead (45) form a group of fields or paddocks around an area of noise (42) that probably corresponds to the scattered remains of one of the buildings. The character of these boundaries is different to those elsewhere in the homestead suggesting that this forms an earlier, but as yet undated, nucleus to the settlement.

5. REFERENCES

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- Smith G.H., 2005 *A Survey of Prehistoric Defended Enclosures in North –West Wales. 2004-5: West Conwy, Gwynedd (Arfon) and Anglesey* GAT report No. 580
- Smith, G. *et al.* 2018 Archaeological and environmental investigation of three prehistoric field systems in Gwynedd, north-west Wales, *Internet Archaeology* 47. <https://doi.org/10.11141/ia.47.2>



Fig. 1 Dinas Dinlle fluxgate gradiometer survey - grey-scale plot



Fig. 2 Dinas Dinlle Fluxgate Gradiometer Survey - Interpretation plan

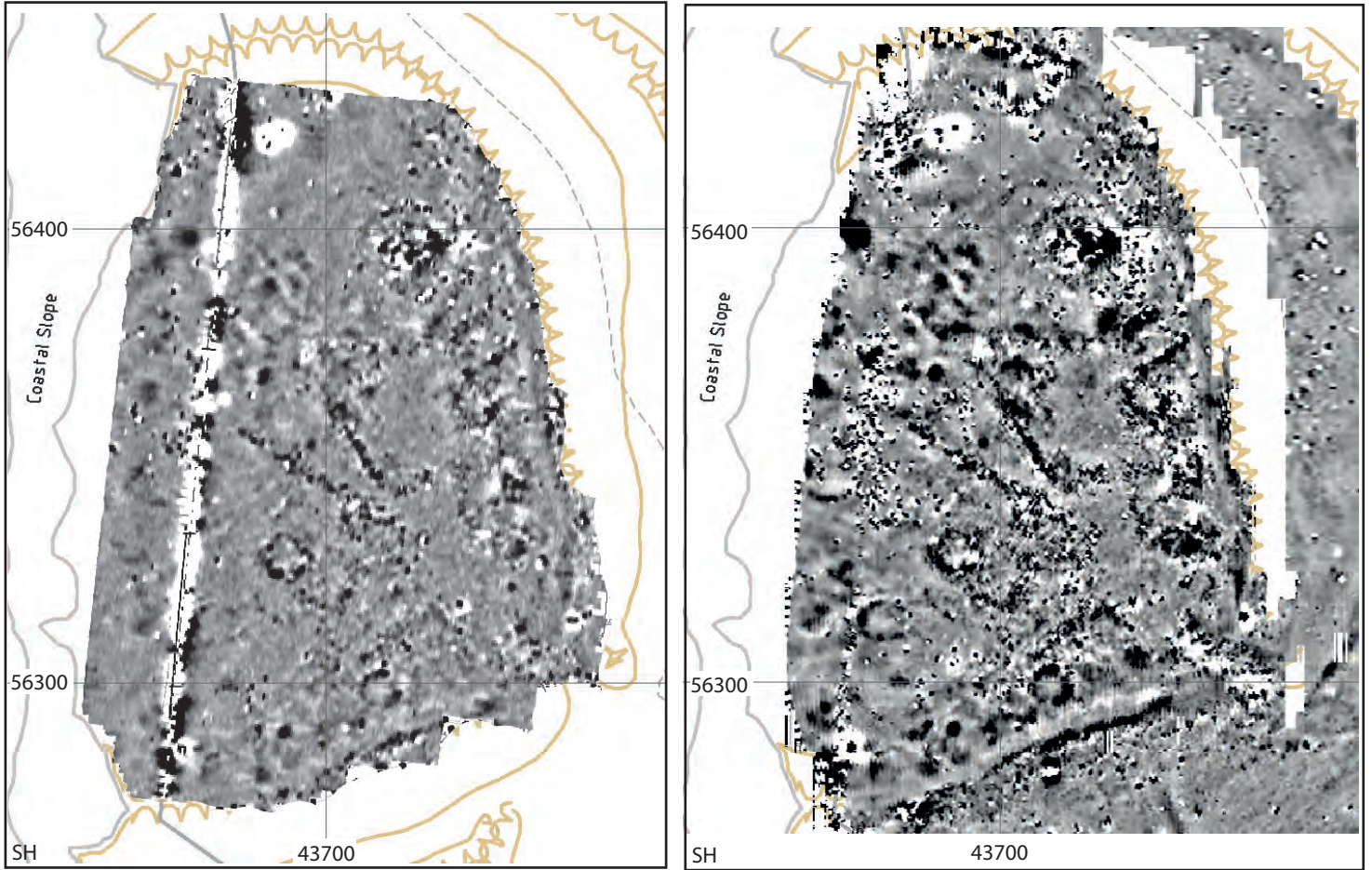


Fig. 3 Dinas Dinlle interior of fort from 2005 and 2017 surveys showing ferrous contamination

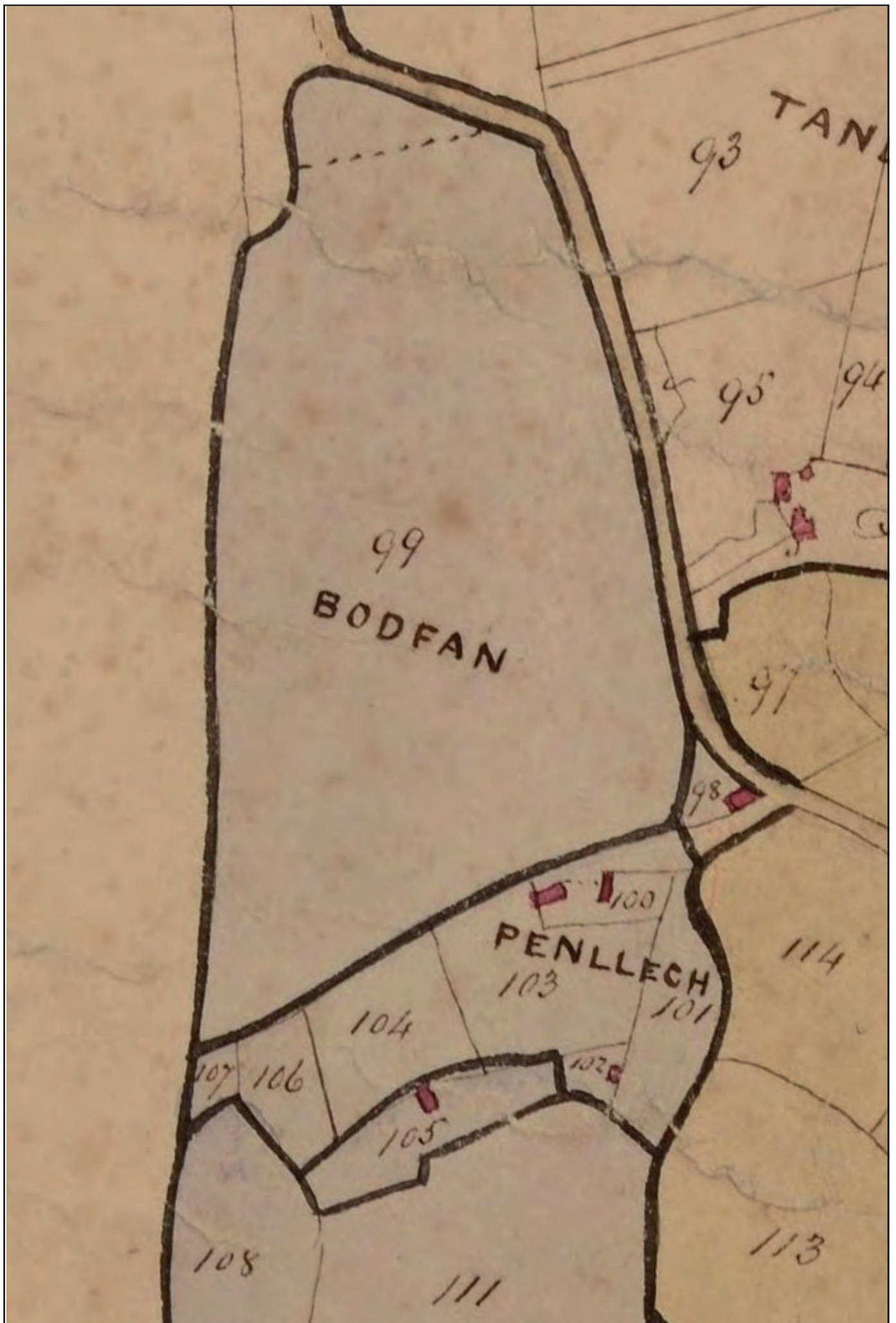


Fig. 4 Tithe map 1849. The parish of Llandwrog in the County of Carnarvon
(Llyfrgell Genedlaethol Cymru – The National Library of Wales)



Fig. 5 Geophysical survey interpretation with transcription of 1849 Tithe map (in red)

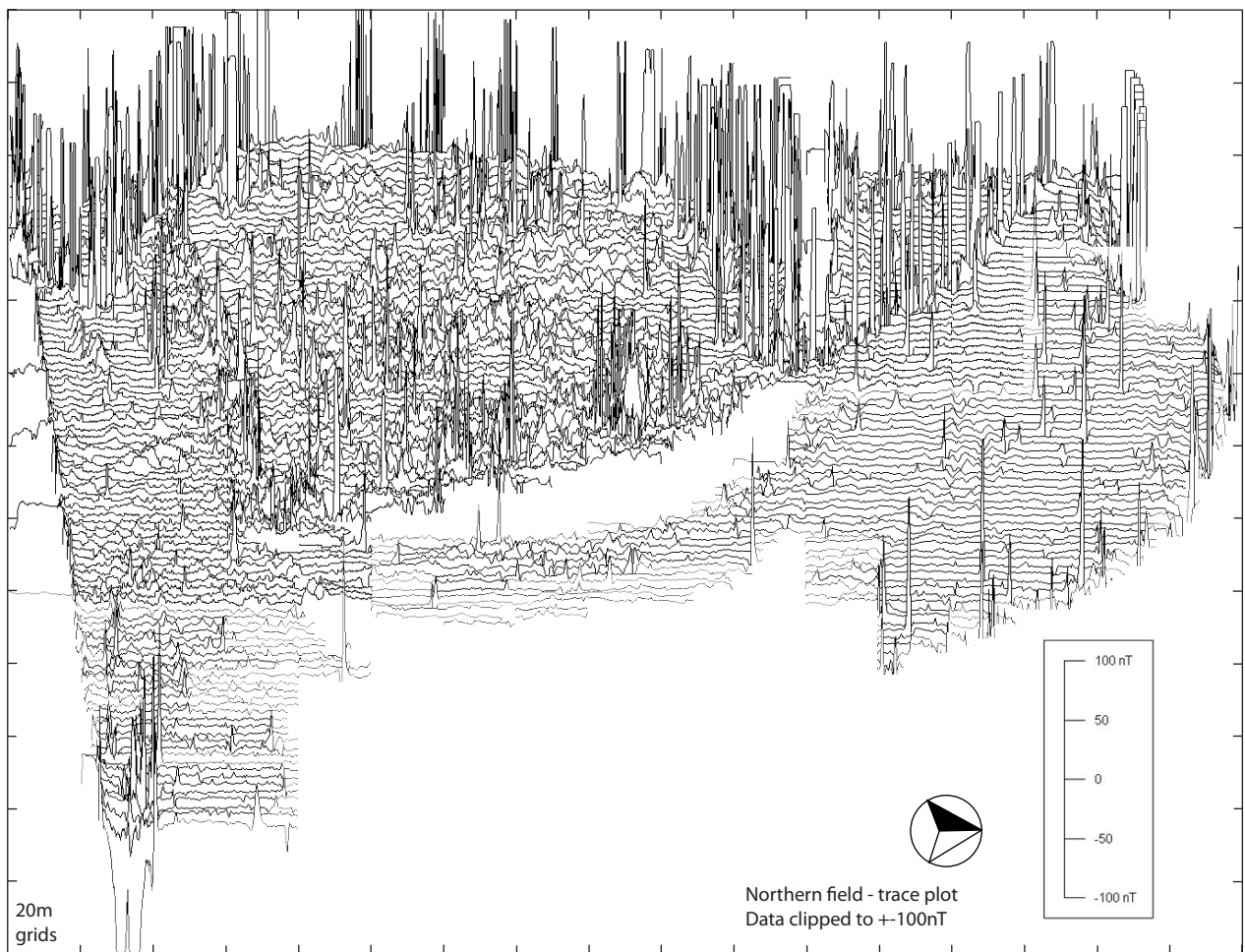


Fig. 6 Dinas Dinlle fluxgate gradiometer survey - trace plot, northern field

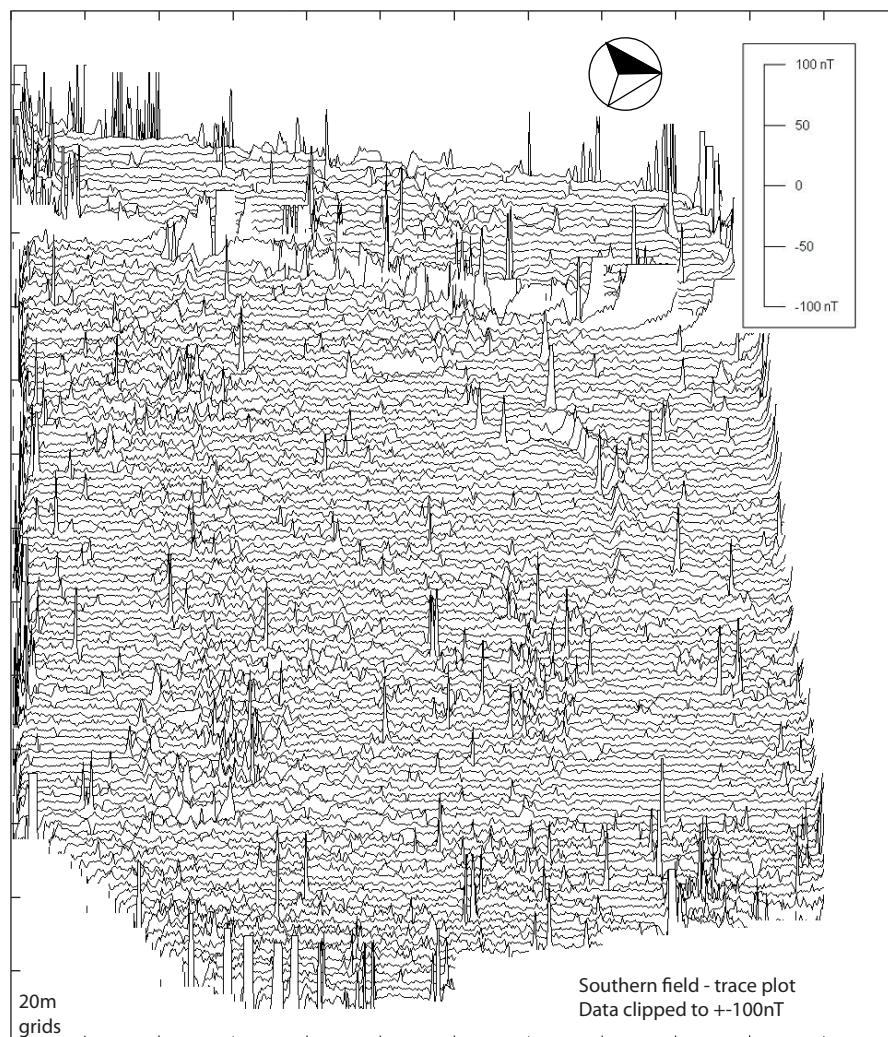


Fig. 7 Dinas Dinlle fluxgate gradiometer survey - trace plot, southern field

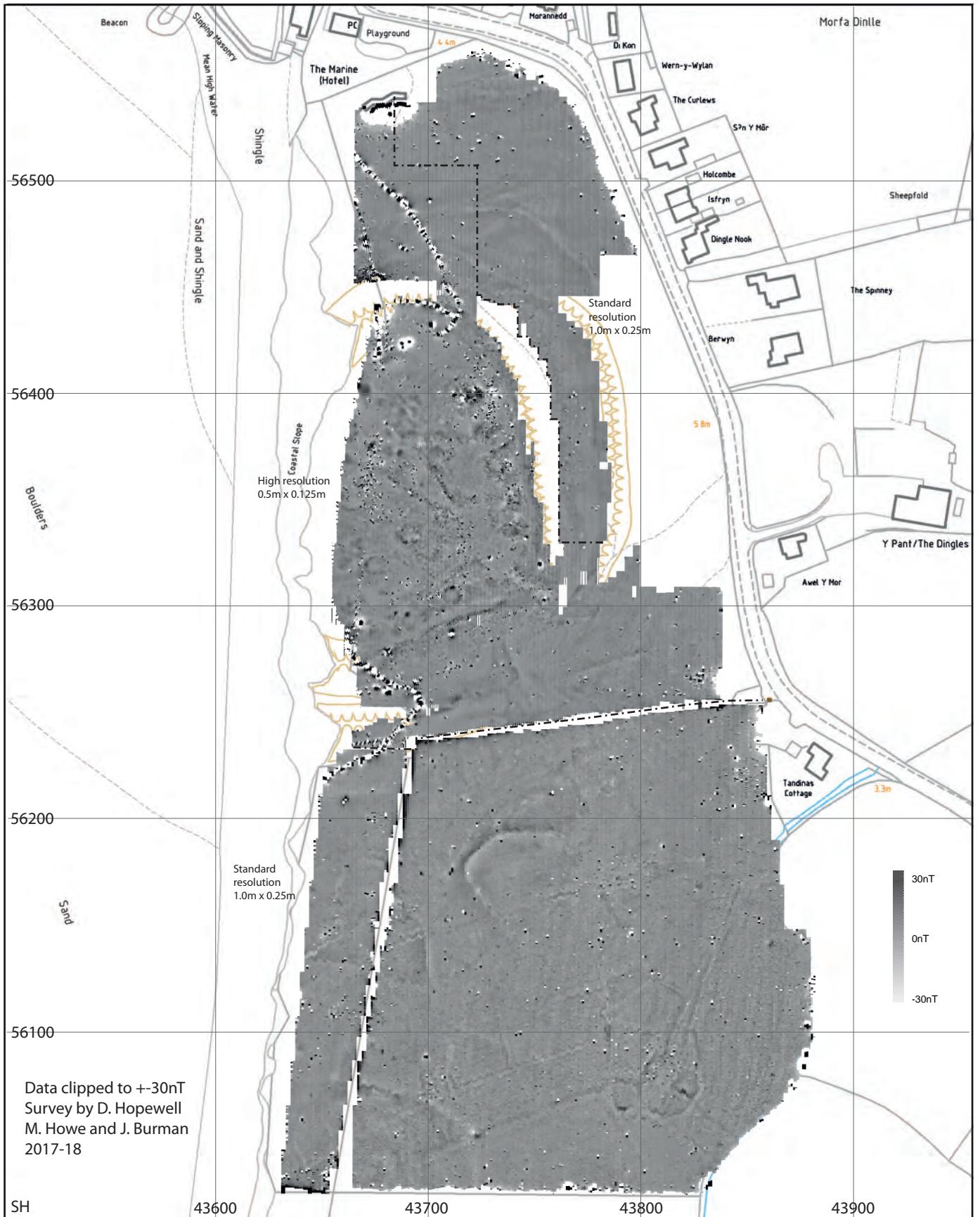


Fig. 8 Dinas Dinlle fluxgate gradiometer survey - grey-scale plot, raw data clipped to $\pm 30\text{nT}$



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