Eithinfynydd Water Treatment Works:
Tal-y- Bont, Gwynedd

Geophysical Survey

GAT Project No. 2099
Report No. 997
December 2009

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Prepared for
Caulmert Ltd.

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GEOPHYSICAL SURVEY REPORT: EITHINFYNYDD WATER TREATMENT WORKS

METHODOLOGY

Fluxgate gradiometer survey provides a relatively swift and non-invasive method of surveying large areas. The current survey was designed to investigate a series of small fields and enclosures in advance of the expansion of Eithinfynydd Water Treatment Works. The survey was carried out between 8-11th December 2009 and covered about 65% of the overall archaeological study area. An irregular area (A) with maximum dimensions of 171m x 104m comprising the fields next to the treatment works was surveyed at high resolution (0.5m x 0.25m). A second area (B) with dimensions of 60m x 36m was designed to sample the north-western corner of the study area. This was surveyed at standard resolution (0.5m x 0.25m).

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 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 Mumetal 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.

Data Collection

The gradiometer includes an on-board data-logger. Readings in the surveys were taken along parallel traverses of one axis of a 20m x 20m grid. Readings in the smaller area were taken with a traverse interval of 1.0m. Readings were logged at intervals of 0.25m along each traverse giving 1600 readings per grid. The larger area was surveyed at a resolution of 0.5m x 0.25m giving 3200 readings per grid.

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. An assessment of the confidence of the interpretation is given in the text.

Data Processing

The data is presented with a minimum of processing although corrections were made to compensate for instrument drift and other 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 producing more but smaller pixels. 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.

RESULTS

Area A, high resolution survey

The site presented several problems for geophysical survey. The surveys are carried out in a series of 20m x 20m grids. Guide lines with markers at 1m intervals are laid out for each pair of traverses to ensure maximum accuracy and the surveyor is required to walk along the traverses at a constant speed. The survey area was crossed by walls, lynchets, impenetrable thickets of blackthorn and gorse and piles of stone. As a result it was not possible to survey complete traverses in many grids. This was compensated for by surveying some grids as two part-grids and combining them during data processing or by interrupting traverses and adding the required amount of dummy readings manually. Both techniques are very time consuming compared to the survey time for an uninterrupted grid.

The survey area was found to contain significant areas of ferrous magnetic material which masked archaeological responses in the vicinity. An iron pipe (1) runs along the western side of the fields. This is surrounded by an area of disturbed ground (2) containing large amounts of stray iron or steel. This appears to correspond to a levelled working compound associated with an earlier phase of works at the plant. This area was not surveyed in its entirety but manual scanning with the gradiometer showed that the strong ferrous responses continue as far as the north-west corner of the field. Anomaly 3 was caused by a combination of a fence and the pipe and indicates the edge of the heavily disturbed area. A scatter of ferrous responses (4) adjacent to the plant probably indicate further activity but the survival of anomalies indicating ploughing in the area indicates that there was no major disturbance here. A wide band of ferrous responses (5) along the south-eastern edge of the survey were caused by iron in the treatment works.

The rest of the survey detected a series of lynchets, banks, walls and possible buildings. Two phases of fields are visible. The earliest survives as a lynchet and the clear geophysical anomaly (6) suggests that there is buried stone scattered along the edge of the scarp and down the slope. This may indicate the remains of a wall or could be the result of field clearance dumping. A spur on the anomaly (7) suggests a subdivision running to the east just to the south of the present wall. The lynchet runs along the front of a level terrace. Faint anomalies at the north end of this may indicate a rectangular building (8). Another early boundary is only visible as a magnetic anomaly (9). This may be a continuation of boundary 7. A continuation of this is faintly visible on a 1947 RAF aerial photograph (see Fig. 9 GAT

Report 831) on the northern side of the present wall where it continues to intersect or cross an east-west boundary now marked by three clearance cairns. The survey area contains several clearance cairns. One of these (10) may be associated with these boundaries. This is bounded by large stones suggesting the remains of a rectangular building. The anomaly consists of an area of noise probably indicating buried stone around the upstanding cairn/building. A stronger anomaly corresponds to the rectangular structure. A similar result was produced 45m to the south were the upstanding remains of a long-hut produced a strong anomaly and are surrounded by an area of noise presumably corresponding to a spread of clearance. Another clearance cairn (12) appears to be bounded to the north by a semi-circular ditch suggesting that it consists of dumping over an earlier feature. No additional features were detected around a cairn to the east (13) and the survey around a larger area of banks and clearance (14) was mostly masked by ferrous responses from the treatment plant. Elsewhere other areas of noise could indicate (15 and 16) further buried clearance or other archaeological features. Two ruinous field walls (17 and 18) probably dating from the 19th century (see feature 7, GAT report 831 p9) produced clear anomalies. A further linear anomaly 4m to the east of boundary 19 appears to mark the edge of a trackway of unknown date that appears to pass between cairn 10 and boundary 17 on an aerial photograph of 1971 (Fig. 10 GAT report 831). The fields are crossed by several alignments of ploughing, one of which (20) is visible on the 1947 aerial photograph. This is crossed by two other phases (21) and (22), the latter with a closer spacing than elsewhere on the site. Ploughing is also visible running parallel to lynchet (6). The alignments indicate three phases of ploughing with their direction principally dictated by topographical constraints. Neither the survey nor the relationship to the alignment of the boundaries provide any means of dating the different phases.

Area B, standard resolution survey

The area of standard resolution survey did not produce any clear anomalies; three faint and indistinct linear anomalies 24, 25 and 26 could be former field boundaries or more recent disturbance. An area of noise (27) corresponds to the boundary of a strip of uncleared ground on the 1947 and 1971 aerial photographs. A scatter of ferrous responses suggest some modern activity perhaps associated within the former works compound although there is nothing to suggest major disturbance comparable with that at the western side of the survey.

CONCLUSIONS AND SUMMARY

A 25-35m wide strip along the western end of the study area was shown to contain a pipe (1) and large amounts of ferrous objects (2) suggesting that it had been extensively disturbed by a former works compound. The rest of the survey area appears to relatively undisturbed and the survey detected a wide range of archaeology. The area contains two phases of field systems. The earliest comprises a substantial lynchet (6) along with other boundaries that survive as sub-surface features, detected as geophysical anomalies (7 and 9), or as barely visible earthworks. One possible (10) and one definite (11) building, apparently a medieval long hut, survive as upstanding features amongst field clearance heaps. Another possible building (8) was detected as a geophysical anomaly above the early lynchet. These are probably associated with the earlier field system. The second phase of field walls (17 and 18 etc.) probably dates from the 19th century. Some stones in the walls contain drill holes resulting from blasting during field clearance. A former trackway (19) associated with this phase runs in a north-south direction across the centre of the field. There are many field clearance cairns in the study area many of which were too overgrown to survey. Of the five cairns (10-14) that were surveyed two contained buildings as previously noted and one appeared to be at least partially surrounded by a circular ditch (12). A substantial cairn and probable earthworks (14) adjacent to the treatment works failed to produce useful geophysical results as a result of masking by extensive magnetic anomalies (5) caused by iron and steel within the works enclosure. The area show signs of three undated phases of ploughing (20-22).

Fig. 1 Eithinfynydd fluxgate gradiometer survey

Grey-scale plot, data clipped to +-10nT

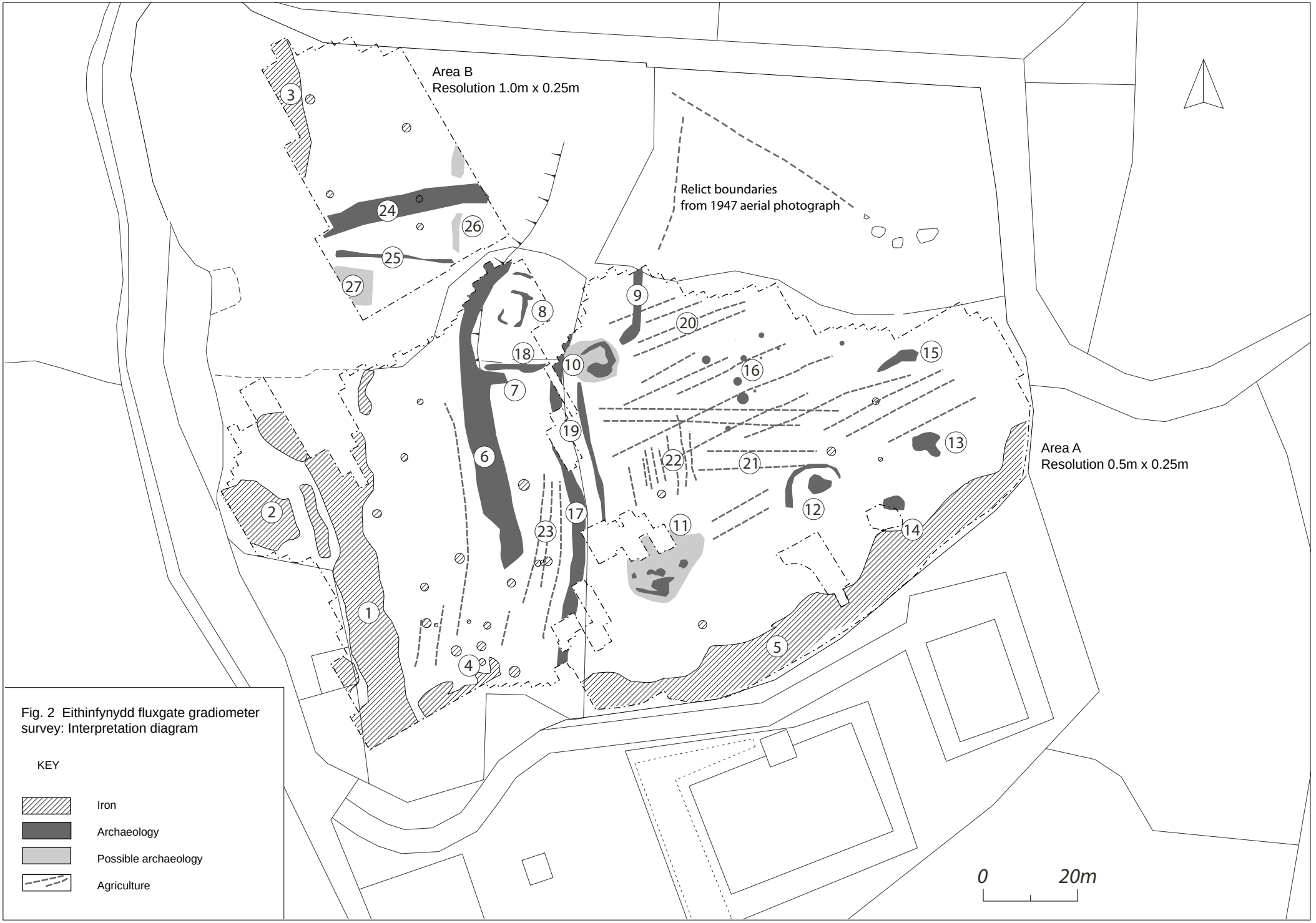

Fig. 2 Eithinfynydd fluxgate gradiometer survey: Interpretation diagram

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