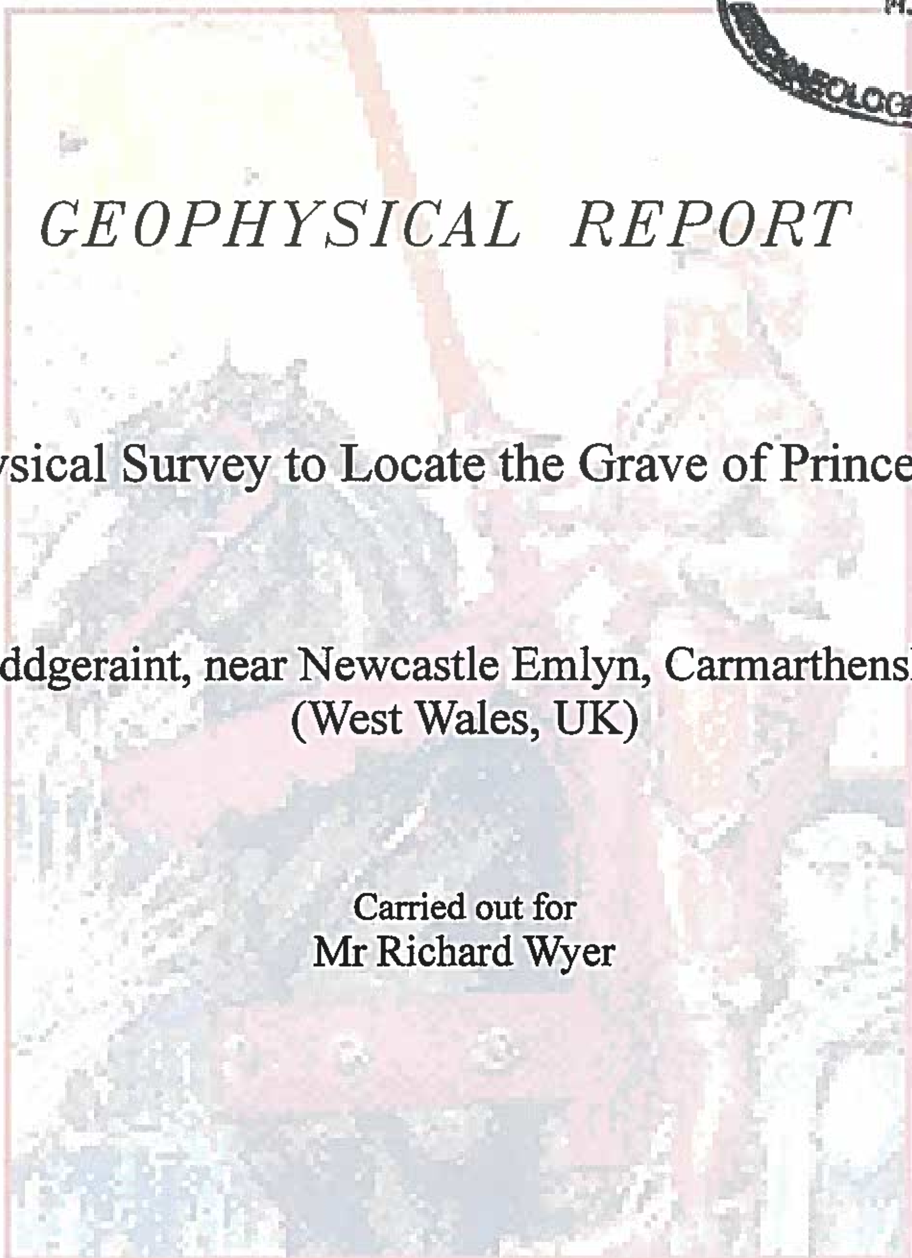

GEOPHYSICAL REPORT

Geophysical Survey to Locate the Grave of Prince Geraint

Beddgeraint, near Newcastle Emlyn, Carmarthenshire
(West Wales, UK)

Carried out for
Mr Richard Wyer

TERRADAT (UK) LTD

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geophysical innovation

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1. INTRODUCTION

This report describes a geophysical survey carried out on behalf of Mr Richard Wyer, a historian living in West Wales. The aim of the survey was to characterise a glacial drumlin that it is thought might have been used as a burial mound for Prince Geraint, a close friend of the legendary King Arthur. The site is located two fields south of the tiny village of Beddgeraint (Figure 1a and 1b), which means "Geraint's Grave" in Welsh. Legend has is that King Arthur and his army fought many battles travelling north through West Wales, and the use of a natural geological feature to bury Geraint might have been a requirement in times of a war campaign, with little time and manpower to prepare a formal burial site worthy of Geraint's status. Mr. Wyer suggested that if Geraint was buried at the site, he may well have been placed in a coffin made of lead that was believed to be used for prestigious individuals, and placed near the centre of the mound, and this would make a good geophysical target.

It was decided to survey the mound with four geophysical techniques (Figure 1b), two types of metal detector survey, and two ground conductivity surveys to different depths, to help build up a greater understanding of the mound characteristics.

The results from the geophysical surveys are presented in the form of interpreted contour plots indicating the location and physical characteristics of identified anomalies together with a text description.

2. SURVEY DESCRIPTION

The survey area was marked out using a Topcon digital theodolite, and a 40m x 50m grid with 1m line spacing was established covering the mound and surrounding area. The grid base line was also surveyed using a GPS system to establish OS National grid coordinates for the survey area, so the grid can be re-established in the future if so required.

The survey was carried out using four geophysical methods, listed below, three utilize electromagnetic techniques and a fourth uses magnetic field measurements:-

- **High resolution Metal Detection (EM61)** – to locate any metallic material buried across the site to within a depth of 3m.
- **High Precision Magnetometer Survey** – to locate and differentiate from the EM61 survey, any buried **ferrous** material across the site.

- **Ground Conductivity mapping (EM31)** – to map the variations in the deeper subsurface across the site to a depth of 5m
- **Ground conductivity mapping (EM38)** – to map the variations in the near surface material across the site to a depth of 1m, to help discern shallow anomalies identified using the other survey techniques.

Background information for each of the survey methods and a description of the survey work carried out are provided below.

2.1 Electromagnetic Surveys

2.1.1 High-resolution metal detection (EM61)

Survey Description

A *GEONICS EM-61* instrument and Allegro data-logging system was used to acquire data along a series of 1m spaced survey lines at an interval of 20cm. The instrument is comprised of two coils mounted one above the other in a trailer form, and readings are triggered by an odometer fitted to one wheel. The *EM-61* is a time-domain metal detector, which is sensitive to both ferrous and non-ferrous metal and has typical penetration depths of down to 3m below ground level.

2.1.2 Ground Conductivity (EM31)

Survey Description

A hand held *GEONICS EM-31* and Allegro data-logging system was used to acquire conductivity data along a series of 2m spaced survey lines at an interval of 1m. The *EM-31* was set in the vertical dipole mode giving an effective penetration depth of approximately 5.0 m below ground level. Due to the wide spacing of the transmitter and receiver coils to achieve greater depth penetration, the readings have limited resolution and can be affected by surface features a few meters away.

2.1.3 Ground Conductivity (EM38)

Survey Description

A hand held *GEONICS EM-38* and Allegro data-logging system was used to acquire conductivity data along a series of 1m spaced survey lines at an interval of 1m. The *EM-38* was set in the vertical mode giving an effective penetration depth of approximately 1.0 m below ground level.

Background

Electromagnetic (EM) surveys are carried out using man-portable instruments with readings taken on a regular grid or along selected traverse lines. The equipment functions by inducing current into the ground via a transmitter coil which causes the generation of secondary electromagnetic fields in any ground conductors present within the depth range of the particular instrument. These secondary fields are measured at a receiver coils and the instruments respectively record metal response *(EM-61)* and ground conductivity *(EM31 & EM38)* at each survey station.

The data is subsequently downloaded to a field computer and the dataset is then exported as an ASCII '.xyz' data file and corrected for instrument and diurnal shifts. Additional editing may be carried out to remove non-essential or 'noisy' data values/positions. The dataset is then processed to enhance any identifiable anomalies and presented as colour contoured plots.

Constraints

Power lines, buildings, metal structures (fences, rebar, vehicles, debris etc.) and buried services can interfere with the electro-magnetic measurements.

2.2 Magnetic Survey

Survey Description

The magnetic survey was carried out over the site on the same grid as the electromagnetic surveys described in 2.1. A Geometrics G858 magnetometer was used to acquire magnetic total field data in continuous 'walking-mode' at a sampling rate of 0.3 readings/sec, using a Trimble DGPS system for positioning.

Background

Magnetic surveys are carried out using a man-portable instrument with readings taken on a regular grid or coupled to a GPS positioning system. The equipment functions by measuring the Earth's magnetic field to a very high precision at each survey station. Ferrous materials in the subsurface have an induced magnetic field that is superimposed on the Earth's field at that location creating a magnetic anomaly. The spacing of survey stations depends on the width of the expected anomaly, which broadens with the size and depth of burial of the targeted feature. Continuous profiling methods may be used for a high-resolution dataset.

Magnetometer data are stored digitally by the survey instrument and down loaded to a field computer at the end of each day. Data are processed to reveal features of interest and presented as magnetic contour maps and magnetic gradient maps where applicable.

Constraints

Utilities, power lines, buildings, and metallic debris can cause interference. Solar magnetic storms may cause occasional fluctuations in readings. The size and depth of objects affect detectability.

3. RESULTS & DISCUSSION

3.1 Metal Detection Dataset – EM61 (Figure 2)

The results of the EM61 survey are presented as a metal distribution colour plot in Figure 2. The interpretation of the data is based on the principle that the greater the mass of metal within the range of the instrument the larger the response measured in milliVolts. The blue and green colours represent uncontaminated ground, and yellow through to purple indicates a proportional increase in metal located within the subsurface.

Figure 2 shows that the main body of the mound is contaminated with metal, but with a very low amplitude response of only 4-5 mV, compared to several hundred that would be encountered if the instrument passed over a buried object such as a metal pipe or in this case a metal coffin. A previous intrusive investigation on the mound discovered that the soil contained a high proportion of iron oxide that is not naturally present in glacial deposits. It seems likely that this is the cause of most of the anomalous ground, as is supported by the results from the other instruments in particularly the magnetometer survey that shows this area of ground to contain ferrous material.

Numerous other areas show metalliforous ground contamination indicating a scattering of debris over the site, with one larger elongated zone centred at (33;4), again correlating with the magnetometer survey indicating ferrous content.

3.2 Magnetometer Dataset (Figure 3)

The results of the magnetic survey are presented as a colour contoured plot (Figure 3) showing the total magnetic field across the site measured in nanoTesla. The total field data may be used to observe the general character of the magnetic field across the survey area. Generally the interpretation of a magnetic anomaly is based on observing the type (pole/dipole), amplitude and wavelength of the anomalous feature. These in turn are dependant on the targets size and depth, geometry and orientation relative to the earth's residual magnetic field. A decreased magnetic field is represented by the blue colours and is caused by ferrous objects above the magnetometer sensor, or by objects orientated in such a way that their negative pole produces a response much larger than that of the positive pole, usually caused by broad horizontally lying objects or debris. Increased magnetic field intensity is represented by yellows through to purples indicating subsurface magnetic materials that are orientated so as to increase the local magnetic field.

It should firstly be noted that similar to the EM61 survey, the response of the instrument across the site is very small. A range of 15 nanoTesla indicates either extremely low level shallow ferrous material that would correlate well with the iron oxide contamination already mentioned in 3.1, or a deeper object producing a broad but minor response at the surface. The latter seems less likely as the EM61 survey indicates the anomalous material to be within 3m, and the width of the magnetic anomalies would infer a greater depth.

The magnetic data shows large anomalous areas that correlate well with the EM61 survey, particularly across the mound itself, and the larger anomaly around (33;4) just off the mound. The dipole characteristics of this latter anomaly suggests more isolated buried ferrous objects, and simple modelling on the dipole wavelength suggests a depth greater than 1m. This is supported by the absence of the main body of the anomaly in the EM38 survey that only gives ground conductivity to within 1m. The blue colours in this general area around the corner of the mound would indicate very low level soil contamination.

3.3 EM31 Vertical Dipole Conductivity Survey (Figure 4)

The results of the EM-31 survey is presented as a colour contour plot of conductivity measured in milliSiemens, with blue colours representing the low end of the data range, i.e. low conductivity, and the reds and purples high conductivity. The site shows a general trend of low to high from left to right, and this is due in part by the ground surface becoming more waterlogged and marshy on one side of the mound, as can be seen in the photograph taken during the survey (Figure 1a). It should be noted that this could mask any subtle anomalies of a man made origin in this area. The mound itself shows zones of anomalous low readings that correlate with the previous surveys described above to within the resolution of the instrument.

An increase in conductivity values usually indicates a local increase in clay content or water saturation, but isolated features may also be the result of buried conductive objects or debris. Such a feature can be seen below the mound centred at (14;-4), and is better resolved by the EM38 survey that indicates it has three separate components and must be in the main less than 1m below ground level. Interestingly these features are only partly observed on the EM61 survey, possibly indicating the ground has been made more conductive by something other than that of metal origin, such as a patch of clay rich ground or ponding of conductive ground water. It was hoped that an anomaly of this character would be observed within the mound indicating a buried object at depth, but no such target has been observed.

3.4 EM38 Vertical Dipole Conductivity Survey (Figure 5)

The results from the EM-38 survey are presented as a ground conductivity data plot in milliSiemens, with blue colours representing low conductivity and red to purple indicating high conductivity. In general terms, a relative increase in conductivity values usually indicates a local increase in clay content or water saturation such as the area of marshy ground to one side of the mound. A decrease in conductivity suggests drier, more granular conditions.

As with the EM31 instrument, isolated features may also be the result of buried conductive objects or debris. Several of these are indicated on the figure, some within the mound believed to be iron oxide contamination, and some below the mound. These anomalies correlate in part with the EM61 and magnetic surveys, but where they do not indicates the ground has been made more conductive by something other than that of metal origin, or anomalies measured by the other methods are deeper than 1m and beyond the range of this instrument. A good example of this is shown by the absence in the main of a conductive feature centred at (33;4), although this area contains a significant elongated anomaly shown on the metal detector surveys. Part of the EM61 anomaly is detected near (30;0), but contrary to the metal content survey, the EM38 shows the ground becoming more conductive away from the mound.

4. CONCLUSIONS

- Geophysical surveys have provided a high-resolution, rapid and non-intrusive means for investigating the subsurface.

- All geophysical instruments identified numerous anomalies of low amplitude, the majority correlating between surveys indicating metal content in the subsurface within 3m of ground level, and further more it is mostly comprised of ferrous material.

could this all be clay derived

- No deep anomaly attributable to a buried metal coffin was found within the mound, but several shallow targets have been located on and off the mound confirming the area was used as a location to deposit artefacts or debris. These are of an unknown origin as it is believed that the field has not been disturbed by farming practices.

- The fact that no isolated deep anomaly was detected within the mound does not rule out the possibility that the site was used for burial but the remains have no physical properties detectable within the response depth of the instruments.

- Anomalies that are not shown on the EM38 survey suggest that the causative material is deeper than 1m below ground level.

- Isolated conductive anomalies not present on the EM61 and Magnetometer surveys indicates ground that has been made more conductive by something other than that of metal origin, such as clay patches or variations in ground water conductivity, or of particular interest in this study, they may be the result of degraded artefacts deposited at a burial mound site.

5. RECOMMENDATIONS

For each identified geophysical feature that may be of concern, it is recommended that an intrusive archaeological investigation be undertaken in order to provide physical ground truthing of their origins.

Disclaimer

This report represents an opinionated interpretation of the geophysical data. It is intended for guidance with follow-up invasive investigation. Features that do not produce measurable geophysical anomalies or are hidden by other features may remain undetected. Geophysical surveys compliment invasive/destructive methods and provide a tool for investigating the subsurface; they do not produce data that can be taken to represent all of the ground conditions found within the surveyed area. Areas that have not been surveyed due to obstructed access or any other reason are excluded from the interpretation.

Location of geophysical survey

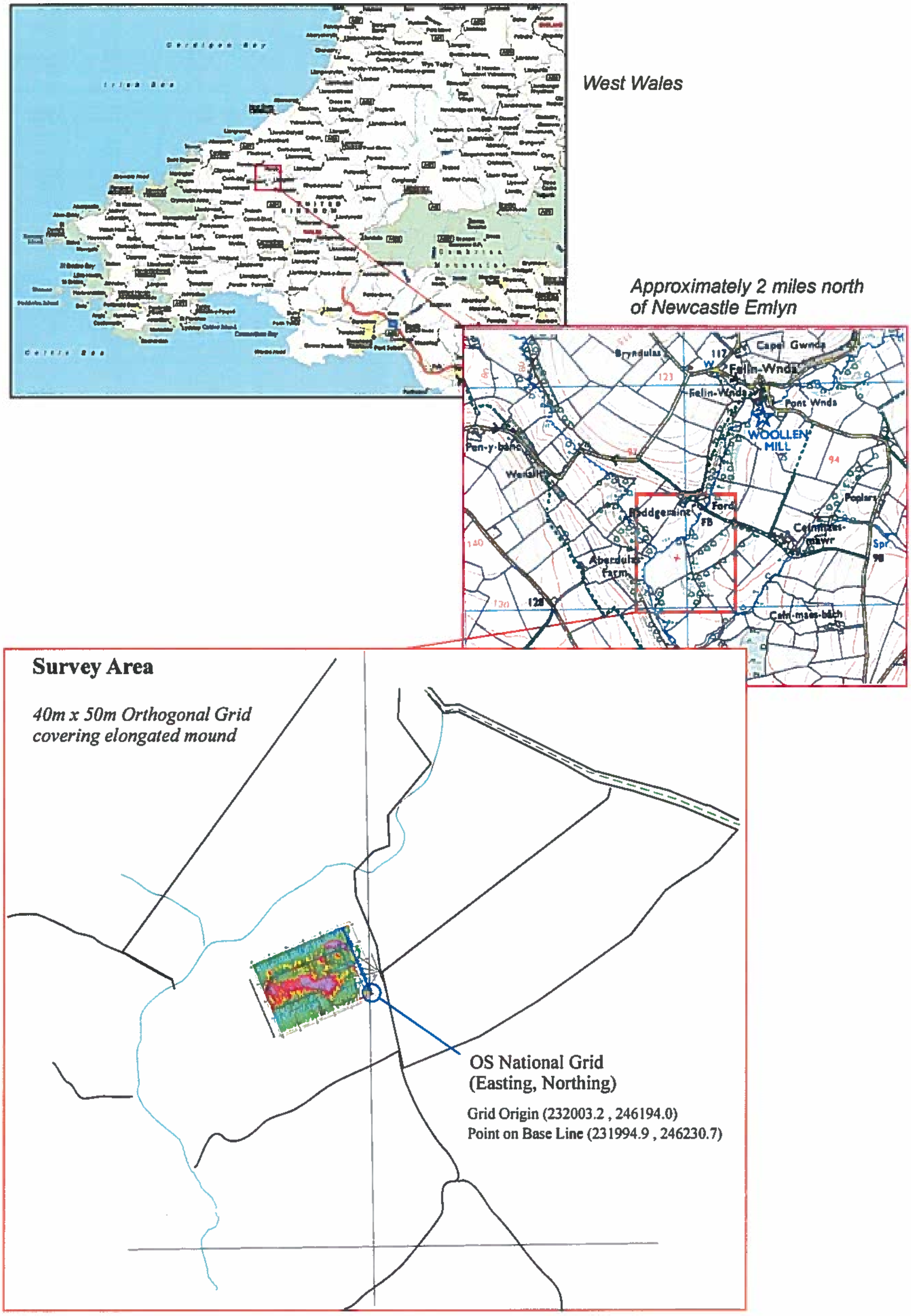


Figure 1a

Photograph taken at the site during Em61 survey showing glacial mound and marshy ground

Geonics EM38

Geonics EM31

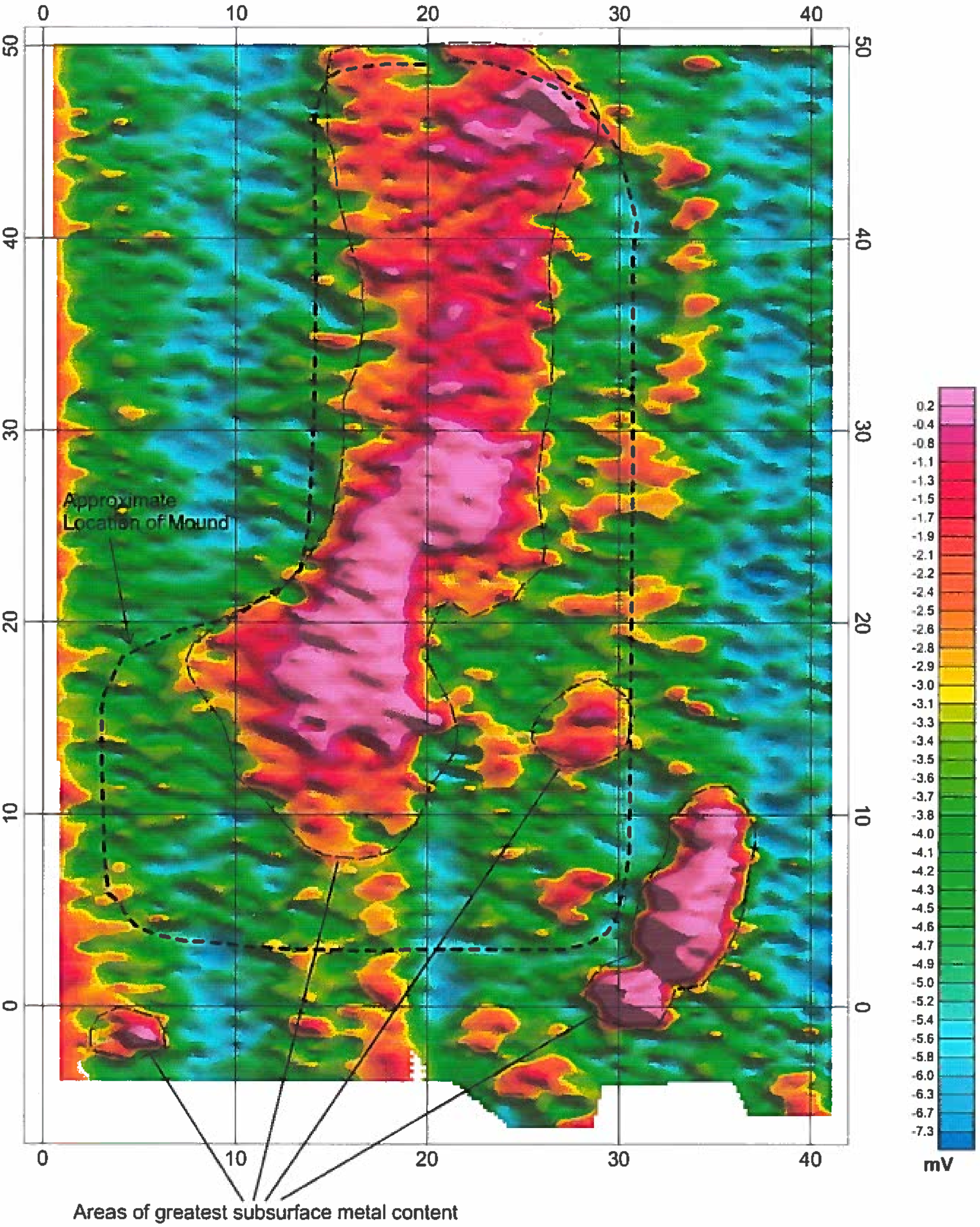
Geonics EM61

Geometrics G858

Geophysical instruments used for the survey

Figure 1b

Red/Purple Areas represent the presence of metal in subsurface

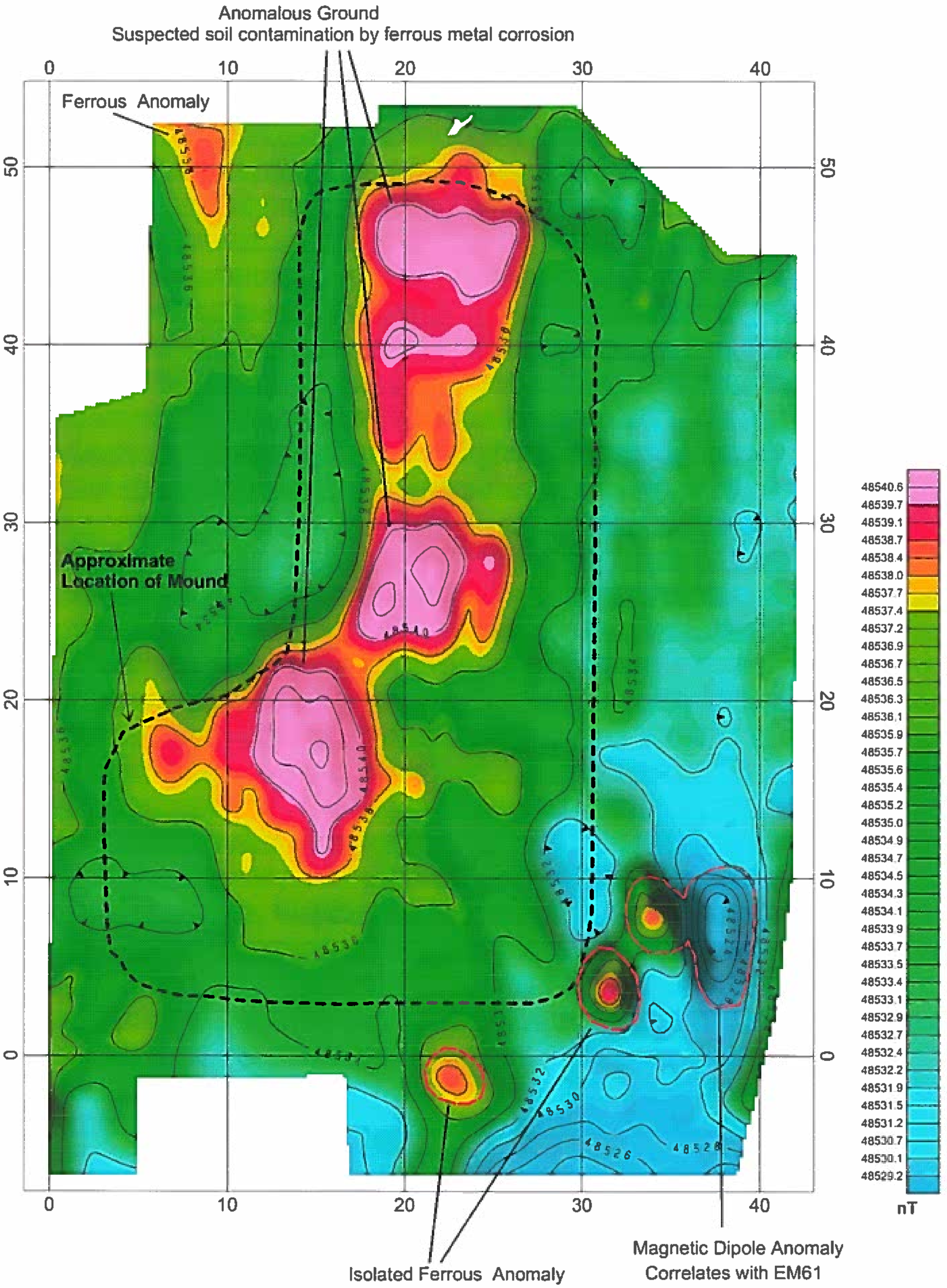


Scale 1:300

5 0 5

metre

Survey to find Prince Geraint's Grave	
Client: R Wyer Electromagnetic Survey - EM61 Ferrous & Non Ferrous metal survey to ~2m depth	
06-10-2004	**Figure 2**



Scale 1:300

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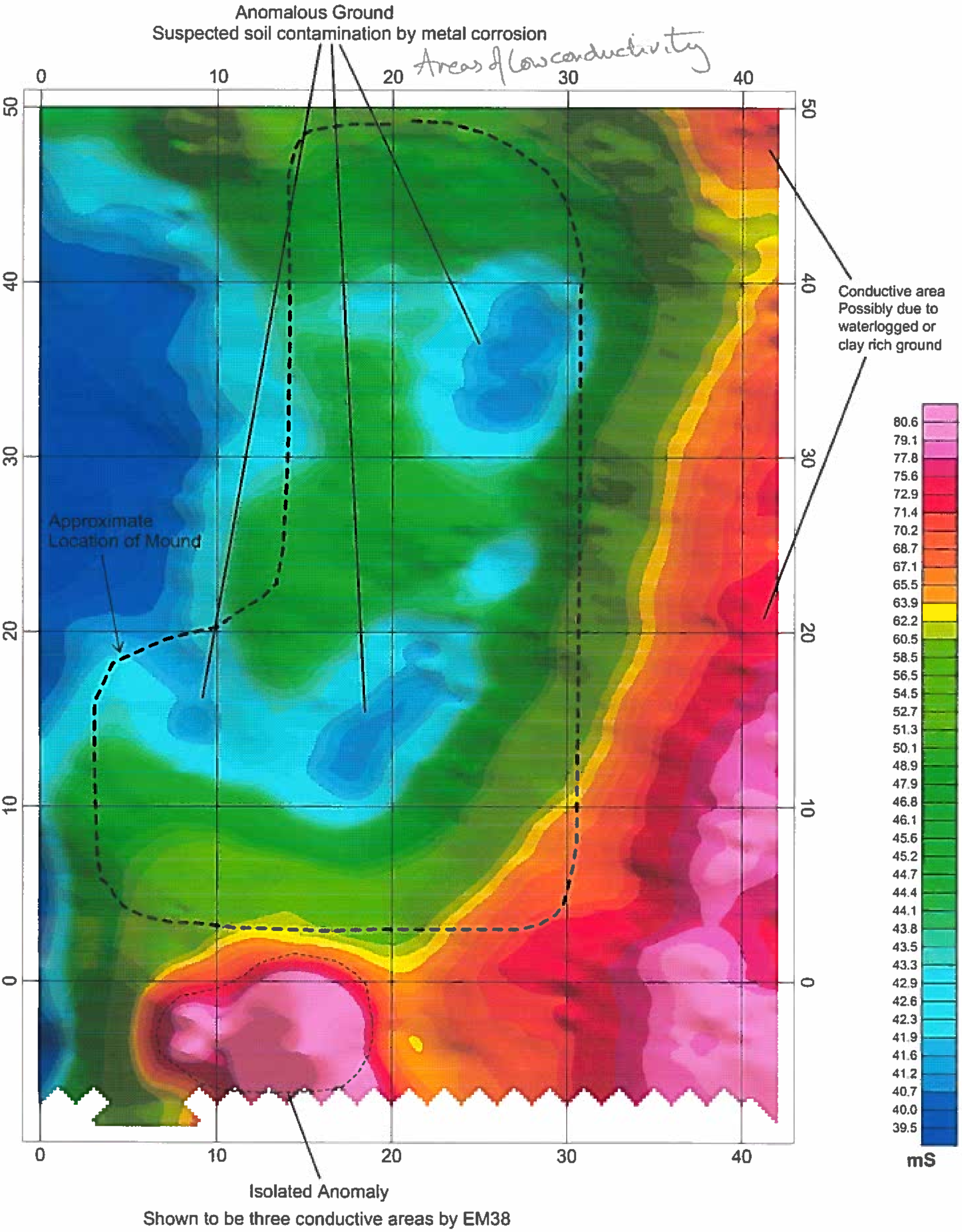
metre

Survey to find Prince Geraint's Grave

Client: R Wyer
Magnetometer Survey (Total Field)
Ferrous Metal Survey

06-10-2004 **Figure 3**



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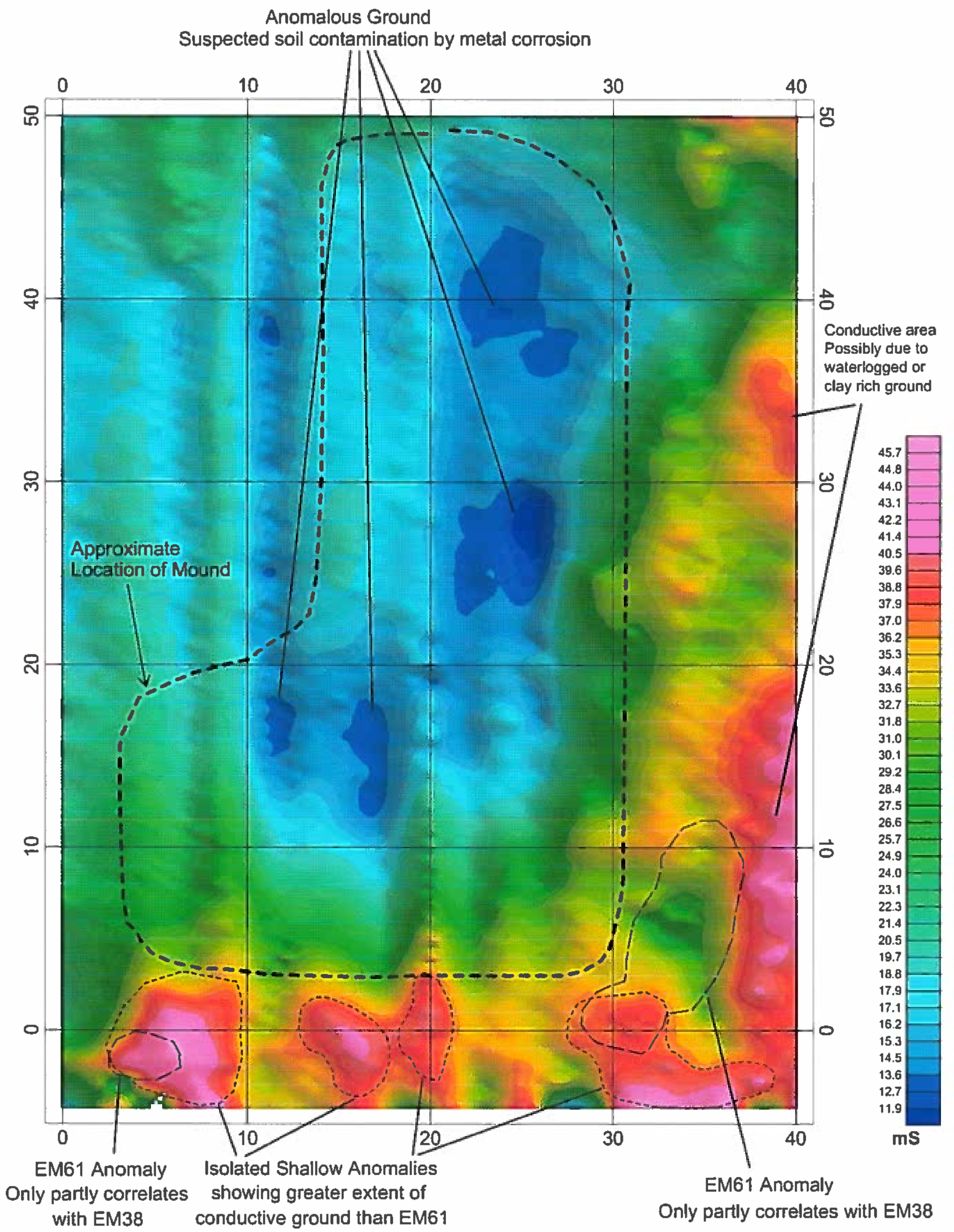
metre

Survey to find Prince Geraint's Grave	
Client: R Wyer Electromagnetic Survey - EM31 Ground conductivity to ~5m depth	
06-10-2004	Figure 4



Scale 1:300

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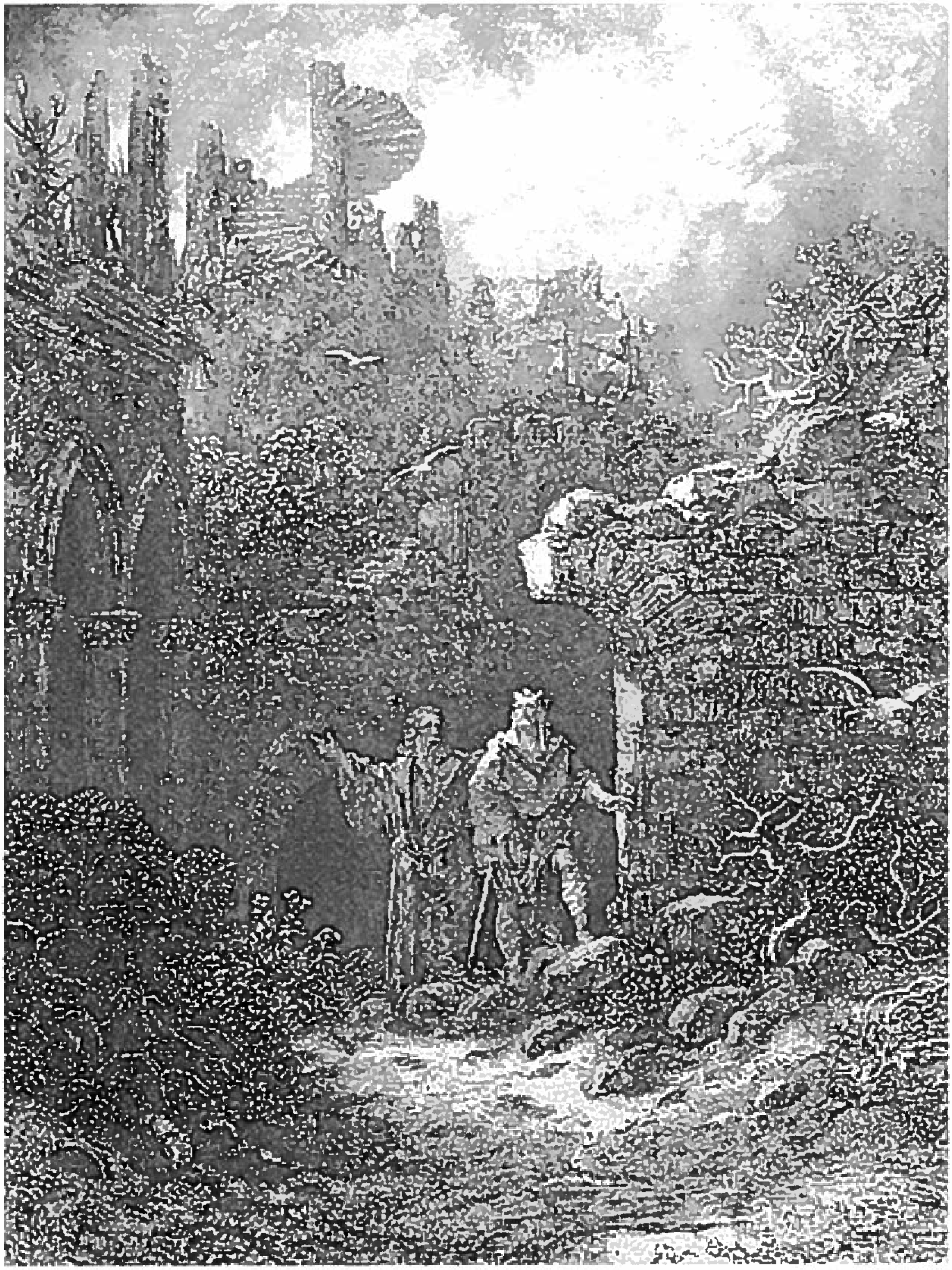
metre

Survey to find Prince Geraint's Grave	
Client: R Wyer **Electromagnetic Survey - EM38** **Ground conductivity to ~1m depth**	
06-10-2004	**Figure 5**



Yniol Shows Prince Geraint His Ruined Castle
by
Gustave Doré