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## **Geophysical (fluxgate magnetometry) survey at Seagrang Road, Baldoyle, Co. Dublin**

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## **EXECUTIVE SUMMARY**

This report details the results of an archaeo-geophysical (fluxgate magnetometry) survey undertaken at Seagrang Road, Baldoyle, Co. Dublin for the Grassroots Archaeology Project. The survey was undertaken as part of a programme of archaeological site evaluation works funded by the Royal Irish Academy. The Grassroots Archaeology Project is a community based archaeological research initiative, centred on the recorded archaeological monument DU15-018; a rectangular cropmark enclosure identified from the Cambridge series aerial photo 1970-CUCAP AIG 95-c (Plate 5).

No surface trace of DU15-018 remains today and purpose of the archaeo-geophysical survey was to identify any geophysical anomalies of possible archaeological origin that may be associated with DU15-018 within the specified survey area. The geophysical survey was undertaken by Enda O'Flaherty and Paul Duffy on March 31<sup>st</sup> 2013, and covered a total area of 0.641 Ha.

The fluxgate magnetometry survey identified geophysical anomalies that have potential to represent buried archaeological features.

## **1 Introduction**

This report presents the results of an archaeo-geophysical survey undertaken for the Grassroots Archaeology Project at, and adjacent to the site of DU15-018 in the townland of Baldoyle, Co. Dublin (Figure 1). Previous aerial photography evidence from the Cambridge University Collection of Aerial Photography (1970-CUCAP AIG 95-c) (Plate 5) showed the presence of a rectangular cropmark enclosure adjacent to the survey site prior to the construction of the Seagrang housing estate in 1973. Analysis of the aerial photography suggested that portions of the monument, particularly a curving linear cropmark extending eastwards from the north-east corner of the enclosure, lay within what is now a public green space. This archaeo-geophysical survey was undertaken to investigate whether part of DU15-018 may be still preserved *in situ* beneath the green (Figure 1 and Figure 2).

The archaeo-geophysical survey was undertaken by Enda O'Flaherty and Paul Duffy on March 31<sup>st</sup>, 2013 and covered a total area of 0.641 Ha. The survey area comprised the public green space situated in a modern housing estate (Plates 1-4). Suitable geological conditions allowed for a fluxgate magnetometry survey to be undertaken at the site. A full interpretation of these results is included in Figures 6 and 8 and is discussed in Section 6.

## **2 Aims and objectives**

The archaeo-geophysical survey was undertaken as part of a programme of pre-determination archaeological works with the potential for evaluation trenching to be carried out based on the results of these works. The aims of archaeo-geophysical survey were to:

- Identify any geophysical anomalies of possible archaeological origin within the specified survey area
- Accurately locate these anomalies and present the findings in map form
- Describe the anomalies and discuss their likely provenance in a written report

### **3 Site Discussion**

#### **3.1 Site topography**

The survey site is situated on Seagrang Road, Baldoyle, Co. Dublin at Irish National Grid reference 323820, 239720 (ITM 723798, 739721), 5.5-9m OD. Today, the area is used as a public green situated in a modern housing estate which forms part of the wider landscape of suburban north Dublin (Figure 1). The site is situated on a low rise and the surrounding topography is generally flat with the exception of Howth Head to the east. The Howth Head isthmus lies 1.2km to the east with Dublin Bay lying to the south. This location of the cropmark enclosure once commanded a view over the site of Kilbarrack Church and graveyard and the northern foreshore of Dublin Bay. Aerial photography (1970-CUCAP AIG 95-c) and the 1<sup>st</sup> and 2<sup>nd</sup> Edition OS sheet for the area show that the wider landscape comprised open green fields, prior to the construction of the Seagrang estate in 1973.

At the time of the survey, a natural spring was observed in the south-eastern quadrant of the survey site. The location of this natural spring corresponds with the approximate location of the terminus of the curving linear feature which extended north-eastward from the north-eastern corner of the cropmark enclosure (see 3.3).

#### **3.2 Site geology and soil cover**

The solid geology underlying the survey area comprises Tobercolleen & Lucan formations, sedimentary Marine basinal facies. The Tober Colleen formation is a Calcareous shale/limestone conglomerate. The Lucan Formation consists of a homogeneous sequence of dark grey massive limestones, shaley limestones, and massive mudstones.

The landscape surrounding the survey area is known to have been heavily disturbed during the construction of the Seagrang Estate. The nature of the soil and sub-soil conditions at the site are unclear and the green may be partially composed of rubble, imported soil and other overburden. Visual of the site inspection at the time of the survey suggested that the eastern and south-eastern portions of the survey area may comprise areas of significant overburden, while the western and north-western portions may represent natural ground level (Figure 2).

In the context of geophysical survey, geological noise is defined as subsurface conditions that obscure the mapping of the exploration objective. The nature of the geological conditions at the site presented no obstacle to geophysical survey (fluxgate magnetometry). However, due consideration was given to the disturbed nature of the overlying soil conditions in interpreting the survey data.

### 3.3 Cartographic record and aerial photography

Evidence from the 1st Edition OS map shows that the area of the green had been divided by two perpendicular field boundaries, one running north-south, and the other east-west (Figure 3 and Figure 4). The east-west field boundary once formed the property line to the rear of numbers 37-48, Marian Park. The grainy aerial photograph from the Cambridge aerial series (1970-CUCAP AIG 95-c) (Plate 5) suggests that a curving linear feature extended north-eastward from the north-eastern corner of the cropmark enclosure and falls within the survey area.

### 3.4 Archaeological background

SMR DU015-018 consists of a sub-rectangular cropmark, defined as an enclosure, identified from Cambridge series aerial photograph 1970-CUCAP AIG 95-c (Plate 5). This photograph, taken at an oblique angle, looks southwards over what is now Merrion Park and Seagrang in the townland of Baldoyle towards the foreshore of Dublin Bay in Kilbarrack Lower. In the photo, the houses of Merrion Park are already in evidence to the north of the enclosure and the Howth railway line can be seen to the south. Using the fixed points of the train line and the housing estate, the enclosure can be anchored in the landscape with a reasonable degree of accuracy. The enclosure lies approximately 150m to the north-west of the tennis courts at the current junction of Seagrang Road and Seacliff Avenue.

The cropmark would seem to be consistent with a rectilinear enclosure of wide, uneven ditches which stands out from the surrounding straight and narrow crop marks representing 18<sup>th</sup> and 19<sup>th</sup> century field boundaries. The surrounding field boundaries can be traced on the 1<sup>st</sup> and 2<sup>nd</sup> Edition OS maps. However, no sign of the enclosure is evident on these OS maps.

## **4 Methodology**

### **4.1 Legislative framework, statement of indemnity and guidelines**

The geophysical survey was conducted to the highest professional standards, as detailed in *Geophysical Survey in Archaeological Field Evaluation, English Heritage Research and Professional Services Guideline No. 1*, 2<sup>nd</sup> ed. (English Heritage 2008) and *The Use of Geophysical Techniques in Archaeological Evaluations*, Institute of Field Archaeologists Paper, No. 6 (IfA 2002). All data provided by the survey, is treated in accordance with the guidelines laid out in *Geophysical Data in Archaeology: A Guide to Good Practice* (Schmidt 2001).

Geophysical surveys rely on observations about the physical properties of the archaeological remains they attempt to locate. Through experience, it becomes possible for geophysicists to identify features with reasonable accuracy by the physical traces these features leave. It must be noted however, that interpretation of geophysical anomalies is subjective and no hypotheses offered should be treated as fact, until tested and proved by intrusive investigation.

### **4.2 Fluxgate Magnetometry Methodology**

A cart-mounted Bartington Grad 601-2 dual magnetic gradiometer (magnetometer) was used to conduct the magnetic gradiometer survey. The Bartington Grad 601-2 dual magnetic gradiometer is capable of surveying to an accuracy of 0.1nT. This unit comprises two horizontally aligned sensors 1m apart.

Mounting the instrument on a cart reduces the incidence of operator induced errors caused by excessive jostling of the instrument when walking over rough terrain, or by the operator having a 'beat' to their walk.

A Trimble R6 Differential Global Positioning System (dGPS), capable of Real Time Kinematic (RTK) navigation is fixed to one end of a cart and the magnetic gradiometer is connected to the other end at a fixed distance. This allows each data point to be collected with sub-cm accurate GPS coordinates, thus negating the need to set out a nominal grid prior to the survey. This increases the accuracy and efficiency of the survey. Both the GPS and magnetic gradiometer data is sent to an external mobile

computer (Trimble Nomad) *via* a serial connection. The data is then downloaded from the unit on a daily basis, using a laptop PC and the data streams are subsequently combined.

This 'irregular xy' data is then exported from the data collection software and imported into the data processing software, where it is converted to 'regular xy' data at user defined sample intervals (in this case 1 m by 0.125 m). From there, it was processed as standard magnetometer data, such as that collected from a traditional pre-defined grid survey.

The data was collected at a resolution of 1m x 0.125m. This sample density is recommended for site evaluation (English Heritage 2008).

## 5 The Results

### 5.1 Fluxgate Magnetometry Survey

For the purpose of this report, the following classifications are applied to geophysical anomalies of archaeological potential:

Table 1 Geophysical Classifications

*High Archaeological Potential (RED)* – Identifiable, known archaeological features, often, (but not always), with additional evidence exists to support identification of *High Archaeological Potential* anomalies. This classification may also be applied to definable anomalies with no obvious alternative provenance, in an area that is known to be archaeologically rich.

*Moderate Archaeological Potential (AMBER)* – Geophysical anomalies that may represent possible archaeological features based on the appearance, pattern and strength of the magnetic response.

*Low Archaeological Potential (GREEN)* – Known or possible archaeological feature types that are or are likely to be of low archaeological significance.

Areas which could not be surveyed are marked blue.

The greyscale data plot (Figures 5-8) from which the results are derived is characterised by positive anomalies (black areas) and negative anomalies (white areas) (see Table 2). In general the data plot for the Seagrang fluxgate magnetometry survey area exhibits a mottled appearance with frequent high magnetic responses. The survey area was found to be generally magnetically noisy with frequent dipole magnetic responses typical of metallic debris scattered throughout the site. These results undoubtedly reflect disturbed subsoil conditions. A mean magnetic response of -1.8 nT was recorded for the site with minimum and maximum responses of -151.1 nT and 164.5 nT respectively. A significant deviation of 38.1 nT attests to the heavily disturbed nature of the site. Data was clipped to +/- 15 nT (Figure 5 and Figure 6). The noisy data plot was also subjected to a low-pass filter (Figure 7

and Figure 8) The low pass filter, when applied to a 'noisy' data set i.e. a data set displaying too much variation that it obscures detail, will smooth the data, removing the noise and revealing anomalies that were obscured.

*Table 2 Response Classifications*

*Negative anomaly* – A negative anomaly possesses negative magnetism (as distinct from the archaeological meaning of a negative feature e.g. pit). Negatively magnetic anomalies can be caused by walls, rubble, etc. These anomalies appear as white areas in the data plot.

*Positive Anomaly* – A positive anomaly possesses positive magnetism (as distinct from the archaeological meanings of a positive feature e.g. bank). Positively magnetic anomalies can be caused by features, such as pits, ditches, etc. These anomalies appear as black areas in the data plot.

## 5.2 Interpretation

The geophysical anomalies identified during the survey and presented in Figures and 6 and 8 are labelled by area and archaeological potential. The prefixes 'H', 'M' and 'L' represent anomalies of a high, moderate and low potential category respectively. Each category is further numbered sequentially.

*Table 3 Table of possible geophysical response classifications*

<b>Classifications</b>
Bi-polar, sub-ovoid, variable anomaly: Uncertain derivation.
Bi-polar, sub-ovoid, variable anomaly: Uncertain derivation.
Broken, positively magnetic, linear anomaly: Possible drain.
Well-defined, linear, positively magnetic anomaly: Possible wall footing.
Bi-polar, sub-ovoid, variable anomaly: Uncertain derivation.
Well-defined, positively magnetic, curvilinear anomaly: Possible ditch.
Poorly-defined, positively magnetic, curvilinear anomaly: Uncertain derivation.
Broken, positively magnetic, linear anomaly: Possible field drain.
Well-defined, linear, negatively magnetic anomaly: Uncertain derivation.
Broken, positively magnetic, linear anomaly: Uncertain derivation.
Diffuse, sub-ovoid, variable anomaly: Uncertain derivation.
Diffuse, sub-ovoid, variable anomaly: Uncertain derivation.
Diffuse, sub-ovoid, variable anomaly: Uncertain derivation.
Diffuse, positively magnetic, linear anomaly: Possible ditch.
Diffuse, positively magnetic, linear anomaly: Possible ditch.
Diffuse, positively magnetic, linear anomaly: Possible ditch.
Diffuse, positively magnetic, linear anomaly: Possible ditch.
Diffuse, positively magnetic, linear anomaly: Possible ditch.
Well-defined, sub-ovoid, variable anomaly: Uncertain derivation.
Diffuse, positively magnetic, linear anomaly: Possible ditch.

*Figure 6 - Interpreted Fluxgate Magnetometry Results*

Because of the disturbed nature of the ground conditions, clear geophysical anomalies that may represent buried archaeological deposits are difficult to identify from the data plot. Two distinct, diffuse, linear and positively magnetic anomalies can be identified H:01-H:02 and H:03-H:04, which are broken at their junction. H:01-H:02 measures c.60m east-west and appears to correspond with the east-west field boundary marked on the 1<sup>st</sup> Edition OS sheet. H:03-H:04 measures c.50m north-south and appears to correspond with the north-south field boundary marked on the 1<sup>st</sup> Edition OS sheet.

M:01 represents a broken, positively magnetic, sub-circular response measuring c.6-7m in diameter which may represent wall footings or a ditched feature. However, given the diffuse nature of the

response and the generally mottled nature of the data plot, M:01 may also represent modern ground disturbance. M:02 represents a concentration of mottled, positively magnetic responses with no discernible pattern. The area L:01 represents an area of mottled positively magnetic responses with no discernible pattern and that have only a low potential to represent archaeological deposits.

*Figure 8 – Interpreted Fluxgate Magnetometry Results (low-pass filter)*

The noisy data plot was also subjected to a low-pass filter (Figure 7 and Figure 8). Again, H:01-H:02 and H:03-H:04 are easily identifiable as diffuse, linear and positively magnetic anomalies running east-west and north-south respectively. M:01 is less well defined in this plot. M:02 represents a subtle, positively magnetic, broad, curving linear response which corresponds with the approximate location of the curving linear cropmark that is visible in Cambridge series aerial photo 1970-CUCAP AIG 95-c, extending eastward from the north-eastern corner of the cropmark enclosure.

## **6 Conclusions**

The results of the fluxgate magnetometry survey undertaken at the Seagrang green space identified geophysical anomalies with varying potential to represent buried archaeological deposits. H:01-H:02 and H:03-H:04 almost certainly correspond with field boundaries marked on the 1<sup>st</sup> Edition OS map. M:01 may represent a sub-circular structure, 6-7m in diameter, though the geophysical response is diffused and unclear. The subtle response M:02 has a moderate potential to represent a curving linear cropmark identified in the Cambridge series aerial photo 970-CUCAP AIG 95-c. Importantly, the location of a natural spring identified during the survey corresponds with the approximate location of the terminus of the curving linear feature which extended north-eastward from the north-eastern corner of the cropmark enclosure (see 3.3). M:02 may represent this feature, possibly a leat which extended from the natural spring to the enclosing fosse of DU15-018.

## 7 Technical Information

### 7.1 Data archive

The site archive will contain the following, as a minimum standard:

Item	Quantity
Raw geophysical data files (xyz/txt)	1
Processed geophysical data files (asc)	2
Archaeological interpretation (shp)	2
Final report text (pdf)	1
Final report graphics (pdf)	1

Storage of the archive in a suitable format and location is required in order to provide for any future archaeological research. A physical and digital archive has been prepared and both are currently stored in the offices of Rubicon Heritage Services Ltd, Unit 2 Europa Business Park, Midleton, Co. Cork, Ireland. An additional digital archive will be provided to AB Heritage and uploaded to the OASIS (Online access to the index of archaeological investigations) database by them.

### 7.2 Data processing and presentation

*Clip* – The clipping process will clip extreme values from the data set and increase the contrast in the data values closer to the mean. As most data within a data set is concentrated around the mean clipping can produce a better visualisation of standard data sets, particularly very weak signals that tend to be lost in a myriad of grey shades.

*De-slope* – The de-slope process uses a computational process to remove or minimise the distortion caused by large iron objects such as fences or pipelines within the data set. Often, data near highly magnetic sources is obscured by its proximity to the extreme values and this process can sometimes remove the extremes and recover this otherwise obscured data.

*De-spike* – The de-spike process will **ONLY** clip isolated extreme values from the data set. Extreme values are usually caused by surface iron of non-archaeological origin. This process will remove

statistical outliers from the data set and consequently remove them from any further computational processes.

*De-stagger* – Sometimes data collected in ‘zig-zag’ mode can show a staggered effect cause by slightly different walking speeds on the inward versus the outward traverse. De-stagger can adjust the positioning of traverses by a specified intervals to ensure that traverses “match” and detail is not obscured by the staircase effect stagger can sometimes produce.

*De-stripe* – The de-stripe process can reduce the occurrence of a striping effect sometimes known as “heading error”. This error occurs when working in “zig-zag” data collection mode and is caused by the different readings being obtained by the sensors when data is collected in opposite directions. This can also be caused by problems during the initial calibration of the instrument at the start of a survey.

Some degree of heading error is inevitable when using a fluxgate gradiometer with such an acute sensitivity to the direction of travel in bi directional manner *i.e.* zigzag traverses. The error displays as a series of alternating lighter and darker stripes in the traverse direction and the function asses and corrects the mean for each line of data to bring them in to the same mean range and remove any visible artefacts.

*High/Low Pass Filters* – The low pass filter, when applied to a ‘noisy’ data set *i.e.* a data set displaying too much variation that it obscures detail, will smooth the data, removing the noise and revealing anomalies that were obscured. Conversely, high pass filtering accentuates differences in subtle data sets and can increase the visibility in data set, often uncovering very weakly magnetic anomalies.

*Two Dimensional Fast Fourier Transform (2D FFT)* – The 2D FFT algorithm examines the data set for repetitive signature that occupy the same wavelength. This is often used to mitigate the interference caused by plough furrows or other regular phenomenon.

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