Leadketty Geophysical Survey

Data Report
23-26 April 2012

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Summary

As part of the Strathearn Environs and Royal Forteviot (SERF) project a geophysical survey on elements of the cropmark complex at Leadketty, Dunning, Perthshire was conducted between April 23rd and 26th 2012.This work was done with two main objectives: to test the potential for geophysics in the cropmark area, and to help inform our excavation strategy for 2012-2014. Gradiometer survey did not add more detail to post-built features visible in aerial photography, but was considerably more successful in defining ditch-defined enclosures, and added some ephemeral features not apparent in the cropmark record. A small, targeted area of resistance survey did not add much new detail, and high-resolution gradiometer survey is recommended for future investigation in this area.

Introduction

A geophysical survey was carried out at Leadketty, Dunning (NO 019 159), between April 23rd and 26th 2012 in advance of proposed excavations on this cropmark complex as part of the SERF research project. Permission for this survey was granted by Historic Scotland as this is a Scheduled Ancient Monument. This work was undertaken at the start of Phase 2 of the SERF Project (see Driscoll et. al. 2010 for an overview of phase 1).

Aims

The aims of the geophysical survey were to:

- compare the advantages of the geophysical survey over the cropmark record alone;
- assess the efficacy of gradiometer survey in this location, and whether this sampling strategy is appropriate or needs to be adapted for the future larger survey;
- test how resistivity compares to these results, as well as those we had at Forteviot;
- enable us to target our excavation trenches, methodologies and strategies as accurately as possible within and beyond the scheduled monument area;
- test the way variation in location within the field may impact on survey results (this is a topographically variable field);
- assess the extent to which past and present agricultural activity has and continues to impact upon the surviving archaeological features.

Archaeological Description & Background

The cropmarks at Leadketty were initially recorded in 1970 by CUCAP, and regular repeat flying since 1976 by RCAHMS has revealed a remarkable complex of cropmarks (Figure 1). In fact, at least 29 aerial sorties have flown over these fields, the most recent in 2008. These are largely focused on two large fields on a ridge, and south-facing slope, on a terrace on the south side of the Earn valley. The complex consists of a range of sites which are most likely to date to the

Neolithic and Bronze Age, although some elements are probably later prehistoric, perhaps even medieval. The cropmarkings in this area have a patchy character, with variable soil depth and underlying palaeochannels creating areas of clarity, and voids in the cropmark, which are evident on all air photos taken here. Recently, RCAHMS completed a new transcription of these cropmarks which also reflects this (Figure 1). Aside from a few field walking events, with mixed results (A Wright pers comm), no archaeological work has been done on any of these sites.

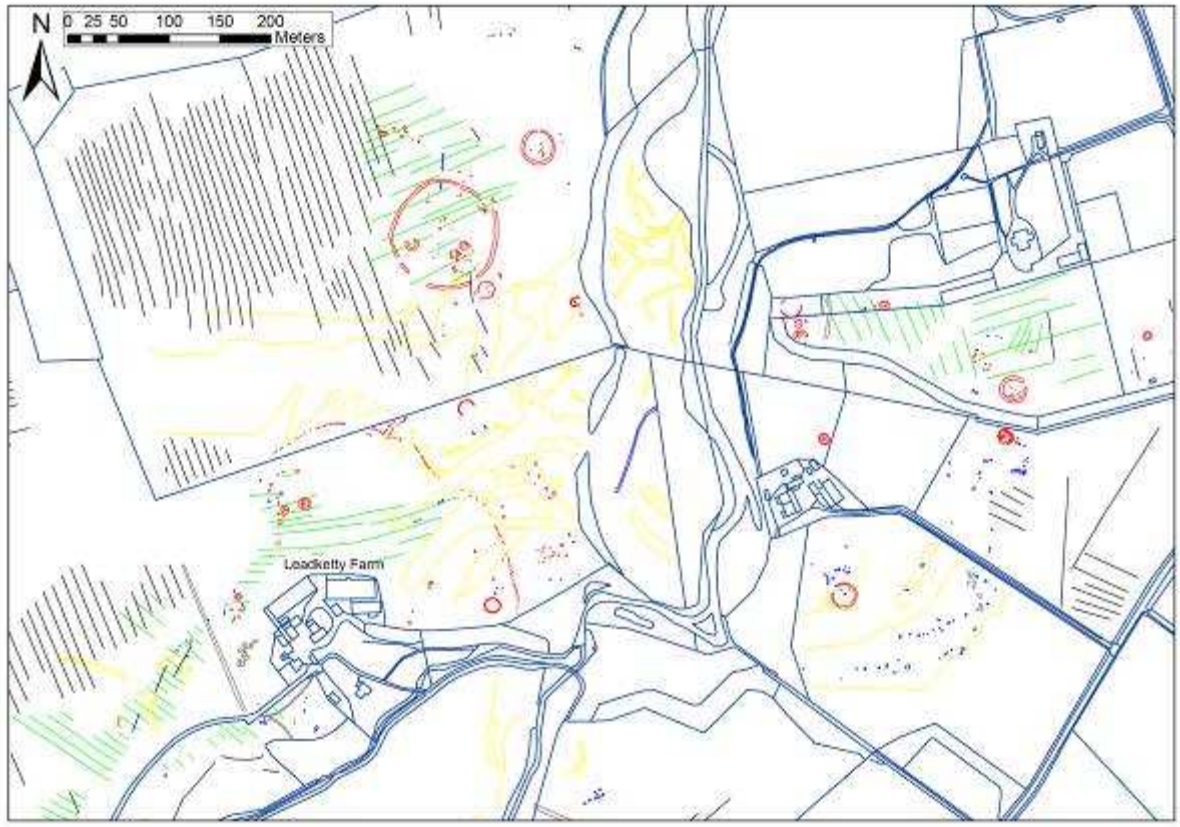

Figure 1: The most recent RCAHMS transcription of the cropmarks across two fields to the immediate north of Leadketty steadings. Green = rig and furrow; Red = archaeological sites; Yellow = palaeochannels and geological markings.

The major focus of the southern half of the complex appears to have been a huge timber-defined palisaded enclosure, one of only four known in Scotland, and potentially the largest with a width east-west of c400m. (SERF phase 1 focused on the comparable site at Forteviot 4km to the east.) The boundary of this monument is indicated by a wobbly line of (presumably) postholes, with the southern side of the enclosed space defined by an escarpment; a single entrance avenue runs from the NE sector of the enclosure. This monument is likely to date to the later Neolithic (3000-2500BC) (Noble & Brophy 2011). Cropmarks have also revealed a series of enclosures, pits and pit-structures within the palisaded enclosure, as well as some structures outwith its boundary; the chronology of these probably varies considerably. Several may be mini-henges, or cremation cemeteries, and a possible barrow is evident at the eastern edge of the enclosure. Other cropmarks will be considered at a later stage of the project. These include an unusual circular enclosure with a causewayed ditch boundary that been recorded about 200m to the north. This enclosure, about 100m in diameter, has a series of circular markings within and around it, which may be round houses; this could be an early Neolithic causewayed enclosure, but equally could date to later in prehistory or could be medieval. Other circular enclosures

within this field are of unknown date and purpose, and at least one square barrow has been identified (possibly dating to the 1st millennium AD). (The northern aspects of the cropmark complex will be the subject of a separate research proposal and SMC application.)

Geology, Topography & Vegetation

Leadketty Farm and its holdings centre on a locally prominent ridge on a terrace above the Duncrub Burn to the south. The underlying geology is Scone Formation sandstones overlain by Devensian Till giving way to glaciofluvial sands, silts and gravels in lower lying areas. The freely-draining gravels make this very fertile land and amenable to cropmark formation and was expected to respond well to geophysical survey. There was one very localized boggy patch within the area which may be a natural spring (discussed further below).

The survey area was in a recently sown agricultural field, with crops only beginning to show above ground. The ploughsoil was heavily manured in modern times as was apparent in the frequent occurrences of abraded modern glass and ceramic sherds visible on the surface. The topography was variable within the survey area, but it was broadly on a gently falling eastern slope. The field had occasional hollows and rises which may help explain the variable occurrence of cropmarks in this area, and the site as a whole would benefit from a comprehensive topographical survey.

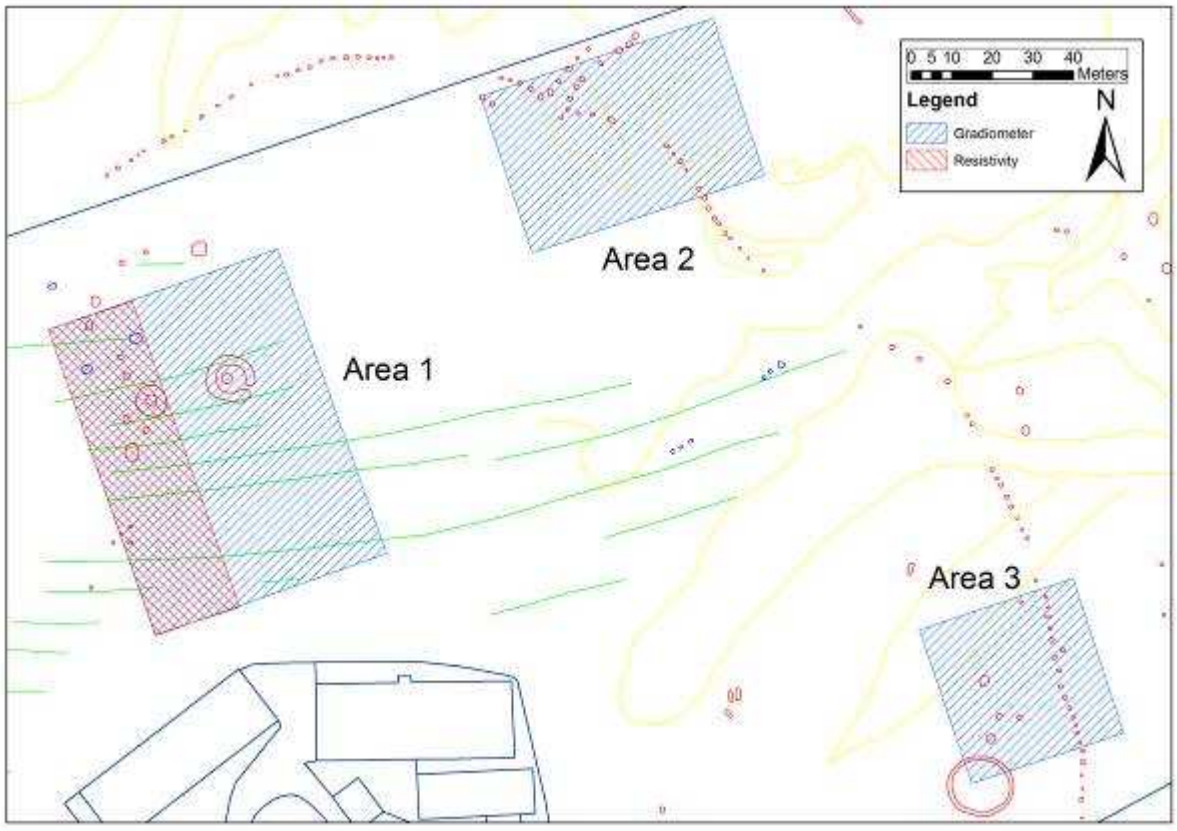

Figure 2: Plan of areas surveyed with overlain on RCAHMS cropmark transcription and OS map data.

Methodology

Survey Methodology

Two techniques of geophysical survey were employed: gradiometry and resistivity. The survey took place in three separate areas in order to sample a variety of different cropmark features across the field (Figure 2). Each area was surveyed using 20x20m grids laid out using measured offsets from tapes, tied into a baseline parallel to the modern field boundary. Area 1 consisted of 60x80m, Area 2 was 60x40m, and Area 3 was 40x40m, for a total area of 8800m^2.

The gradiometer used was a dual-sensor Bartington Grad601. Beginning in Area 1, the largest area of the current survey, readings were initially taken at 0.125m sample intervals along 0.5m traverses. This resulted in a good response, but post-built features were still not clear, and so Areas 2 and 3, targeted over the post-built palisaded enclosure, were surveyed at a higher resolution, at 0.125m sample intervals along 0.25m traverses. The western third of Area 1, which contained ambiguous small features, was also resurveyed at this higher resolution, and this area was also targeted for resistivity. The resistance survey was conducted using a GeoScan RM15 with 0.5m probe separation. Readings were taken at 0.5m sample intervals along 1m traverses.

Processing Methodology

Gradiometer data was downloaded using Bartington Grad601 software, and both gradiometer and resistivity data was processed using GeoPlot v3. Results were produced as grayscale shade plots unless otherwise noted.

Although magnetic responses were very good, the discrepancy between the two sensors had to be corrected by using a 'zero mean traverse' operation. Furthermore, walking in a zig-zag pattern taking numerous readings per meter led to some mismatching between traverses, corrected by applying a 'destagger' operation. Background noise caused by modern manuring was ameliorated by using the 'despike' function.

The resistivity data only needed a grid-matching function to correct for slight discrepancies from the repositioning of the remote probes, and a 'despike' function corrected for spurious readings.

Results

Area 1

Figure 3 shows the results of the main survey in Area 1, with an interpretative plot in Figure 8. Immediately apparent are the evenly spaced parallel lines running across the results, picked out in lime green; their wide spacing indicates rig and furrow ploughing, although they do not correspond to the cropmark rig and furrow as shown in the aerial photography transcription of the same area (Figure 10). It would appear that there are multiple levels of ploughing activity evidenced in this field, as would be expected in a fertile area such as this. It is difficult to assess how much this has affected the underlying archaeology, but in many cases the juxtaposition of magnetic anomalies with these plough marks creates misleading patterns which make the results more difficult to interpret.

Another difficulty stems from the diffuse but widespread negative signals running in a SW-NE direction across the plot (G and nearby anomalies in light blue). These are interpreted as paleochannels or relict watercourses, where the soil is more heavily sorted and thus gives off a more homogenous signal. In most cases here these fluvial soils show as markedly non-magnetic spreads. Similarly, there are at least two diffuse, weakly magnetic bands which run across the results roughly NW-SE (anomaly H). As these run across the paleochannels, they may simply be geological features; however, it is interesting to note the position of the strongly localized magnetic signal B. This was apparent on the ground surface as a distinctly boggy area in an otherwise well-drained field, and on a particularly rainy day of survey, it became clear this was acting as a natural spring. If this is the case, anomaly G may be hydrological.

The main target of Area 1 were the two large curvilinear features, which the gradiometer survey has confirmed. These are more diffuse than in the aerial photography, but they are both marked by distinct halos of negative magnetic response (D and E) with strong magnetic spreads in and around them (F) signaling anthropogenic activity. Anomaly E is not clear enough to confirm a hengiform feature with an entrance to the east as hinted by the cropmarks, but it would appear that there are numerous phases of activity and disturbance in and around it as would be expected for a long-lived prehistoric monument. If these were a henge-like monument, we would expect a bank to flank the ditch, which may also have impacted on these results.

Anomaly D is a different form to E, as it has a more clearly defined oval area with what appears to be a small inner enclosure. There are also weak shadows of curving linear trends to north and south which hint at a palimpsest of features here as well. This may be an occupation site of a different nature, perhaps a hut circle or palisaded-defined enclosure.

An unexpected sub-rectangular anomaly roughly 5m square (C) is also apparent in this area. This is reminiscent in size and shape of a Pictish square barrow which are also found in the Leadketty cropmarks. There is no clear central grave but a localized strong magnetic response is recorded from within this feature. This is adjacent to a heterogeneous cluster of linear anomalies and a possible pit feature to its south, which may also be archaeological but are too small to define further. The area to the north is also difficult to interpret but it is characterized by a markedly strongly magnetic spread, indicating anthropogenic soils.

Along with other weak linear features (J) along the western extent of Area 1, it was decided to target these four grids for comparison using different survey techniques. First, gradiometry at a higher resolution was used to clarify some of the smaller anomalies, and secondly earth resistance was used as a comparison. The results of these resurveys are in Figure 4. The high-resolution magnetic survey confirmed most of the anomalies around C and J, but added little more in terms of detail. The resistivity survey was at too low of a resolution to help with the smaller features, but it is notable that the possible square barrow is not readily apparent. An interesting result was that the strongly magnetic area A focuses on a strong linear low resistance anomaly.

Area 2

Figure 3 shows the results of the survey in Area 1, with an interpretative plot in Figure 8. Immediately apparent again are the parallel lines indicative of rig and furrow ploughing activity, although in this part of the field they are less intrusive. Cropmark formation in this area is

heavily variable due to the rolling nature of the topography here; this also seems to have affected the geophysical anomalies apparent in this survey.

Paleochannels and other geological formations account for the large negative spreads (H), but large anomalies A and B are more difficult to explain. The RCAHMS cropmark transcription classifies this area as a geological feature (Figure 11, outline in yellow) but the geophysical survey reveals a clear banana-shaped anomaly roughly 22m long and 4m wide internally. This is characterized by strong magnetic signals in its northern half and a more weakly magnetic lower half. Internal and external negative anomalies may simply be 'shadowing' caused by this strongly magnetic feature. The shape of this large feature is reminiscent of an Iron Age souterrain, but these are rare within the SERF study area, and there is no trace of an adjacent roundhouse or other structure.

The main reason for targeting Area 2 was to further define the palisaded enclosure and avenue entrance, both post-built features running across this part of the field (Figure 11). Unfortunately, individual postholes could not be accurately defined in this area due to the amount of background noise. However, localized spots of negative magnetic response (J) may represent individual posts. A weak linear trend (F) running NW-SE across this area may in part represent the line of the palisade, but it is also partially along the break of slope of a small hollow running down the centre of the survey area, which may account for the apparent linear trend here.

More intriguing are the large, strongly magnetic oval anomalies C, D and possibly also G. The largest of these are 3-4m across and their homogenous magnetic signal and cleanly oval shaped suggests deliberate human activity. These are reminiscent to some of the large pits excavated at Forteviot that contained large amounts of burnt material (Gould 2010) that provided dates in the Pictish period; such features could explain the magnetic responses here. These may be evidence for similar activity associated with the cropmark ceremonial complex at Leadketty. However, Anomaly D is of a different form, as it seems to have smaller satellite pits cut around it. Both C and D have a clear halo of negative magnetic response around them, similar to the curvilinear anomalies seen in the centre of Area 1, and may thus represent the remains of a bank, a ploughed out barrow, or other enclosing or covering feature.

Intriguingly, the space between anomalies C and D contains two very weakly defined square features each roughly 2.5m across and aligned with one another. This is again reminiscent in shape and size to Pictish square barrows, but where groups of these are found at Forteviot, these tend to be conjoined rather than merely adjacent. Again, as with the possible example in Area 1, they are on the same alignment as the rig and furrow, and they may thus be an artefact of fortuitous juxtaposition.

A few very weakly defined features occur directly southeast of the line of the palisaded avenue (E), which may be a circular structure, but this is only apparent through fragments of arcs of weakly magnetic responses.

Area 3

Figure 6 shows the results of the survey in Area 1, with an interpretative plot in Figure 9. This area was targeted mainly to test the response in this area of the field. Cropmarks of the palisaded enclosure run through this area, as well as a large curvilinear enclosure which may be a round barrow (Figure 12). The gradiometer survey confirmed the presence of the round

barrow but only clipped a small corner of it (A). As with Area 2, the palisaded enclosure was not immediately apparent, but a very diffuse linear weak magnetic anomaly runs north-south across the survey where the postholes should be. This may be the remains of a relict bank associated with the palisade, now spread out by ploughing action, which is heavily apparent in Area 3; alternatively, posts may have been set into a continuous ditch slot as was found at Hindwell, Wales (Gibson 1996).

No clear structures were found in this area, save for a few patches of strong positive and negative magnetic response. Two of these, B and D, correspond with pit-like features in the cropmark transcription, and some of the less clear examples such as F and E may resolve into a linear pattern, but there is too much background noise to be sure whether these are archaeological features.

Another intriguing possibility is the very weak linear trends G and H which appear to resolve into a rectilinear boundary, although again this is not terribly clear and other weak linear trends (J) appear throughout the area which may simply be remnants of ploughing activity.

Discussion and conclusions

We can now assess to what extent this survey met the research aims.

- The Leadketty fields respond well to geophysical survey, and add more detail to the existing cropmark record.
- Gradiometer survey works very well in the field, but due to the discrete nature of the post-built archaeological features in this area, a very high resolution is required.
- Resistivity survey was not as successful, but only a small area was attempted, and at a low resolution.
- Even where the archaeological features were not immediately clear, gradiometry allows us to target areas of magnetic disturbance which may relate to anthropogenic soils, and this allows us to more carefully structure future excavations within the scheduled area.
- The local topography was seen to have a distinct effect on the geophysical anomalies detected, and strategies for accommodating this should be worked out in the future.
- Past and present agricultural activity has and continues to impact upon the surviving archaeological features.

Recommendations

As a result of this survey, the following recommendations can be made.

A full geophysical survey of the cropmark fields is worth doing, although a less labour intensive method will be needed to complete survey of both fields in 2012-2013. A wider project design should be developed for this, with the following borne in mind:

- Parallel traverses and a slower walking pace recommended for high resolution survey. This would reduce staggering problems between traverses;

- Resistivity needs to be used across more extensive areas and with a higher resolution to compare more meaningfully with gradiometry;
- Alternative strategies and methodologies should be considered e.g. caesium magnetometry, the use of 16-channel geophysical probe array etc;

Areas of high priority for geophysical survey are the 'voids' in the cropmarks, in particular the western half, and boundary, of the palisaded enclosure. Although this will be explored by excavation in the future, it is imperative that an attempt is made to test the receptivity of this area to geophysical survey.

A full topographic survey and / or DTM of the fields with the cropmarks is vital, to contextualize the monuments, and allow a better understanding of the nature of the cropmarking in the field (and in particular the voids). This will also allow a better understanding of the appearance of the prehistoric monuments, how they relate to one another, and allow the exploration of sensory engagements with these sites (as well as tying in to ongoing viewshed analysis research and the project GIS).

The following excavation priorities can be suggested based on the results to date:

- Area 1: henge and surrounding magnetic anomalies; possible roundhouse and square barrow to the west
- Area 2: the large pits in area 2 are the highest priority, especially as one of them may be aligned/overlies the palisade; high resolution resistivity to see if the postholes are more apparent, and to test the banana-shaped feature before excavation
- Area 3: More geophysics over this and other cropmark barrows to compare responses with features from this survey; establishment of the nature of the faint linear anomaly.

Acknowledgements

We would like to acknowledge the help of Rebecca Younger and Dene Wright, without which this survey could not have been completed as extensively. We are grateful for the permission of Colin MacGregor to carry out the survey on his land, especially given the time of year in relation to the crop cycle. Thanks also to Historic Scotland for permission to undertake this survey.

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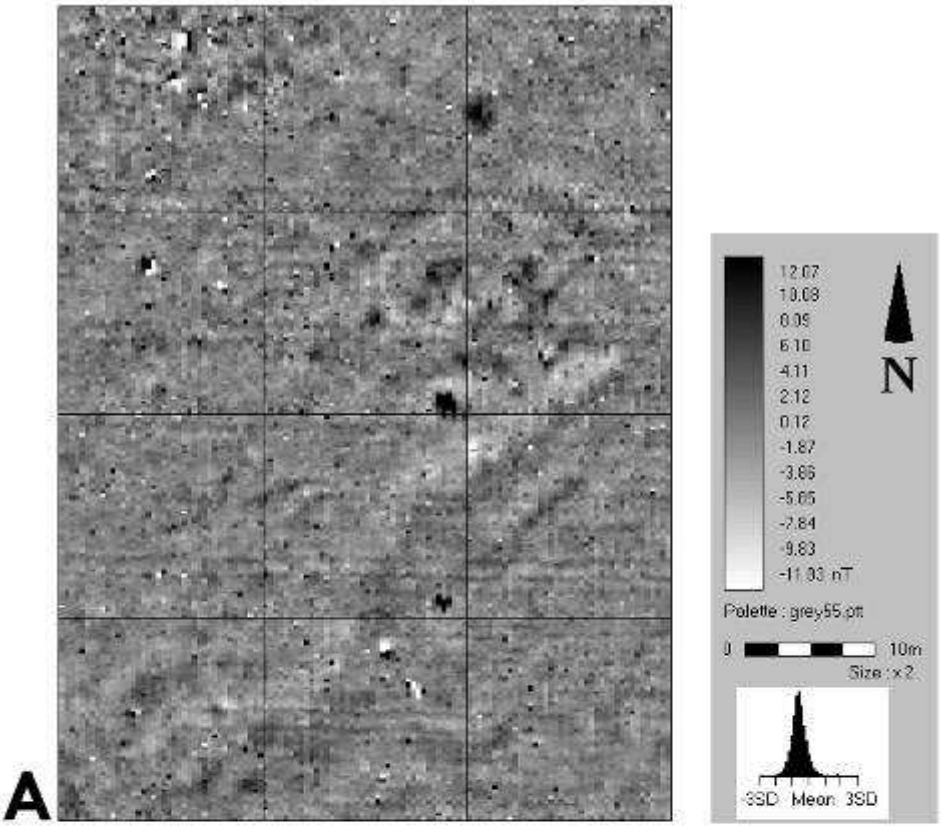

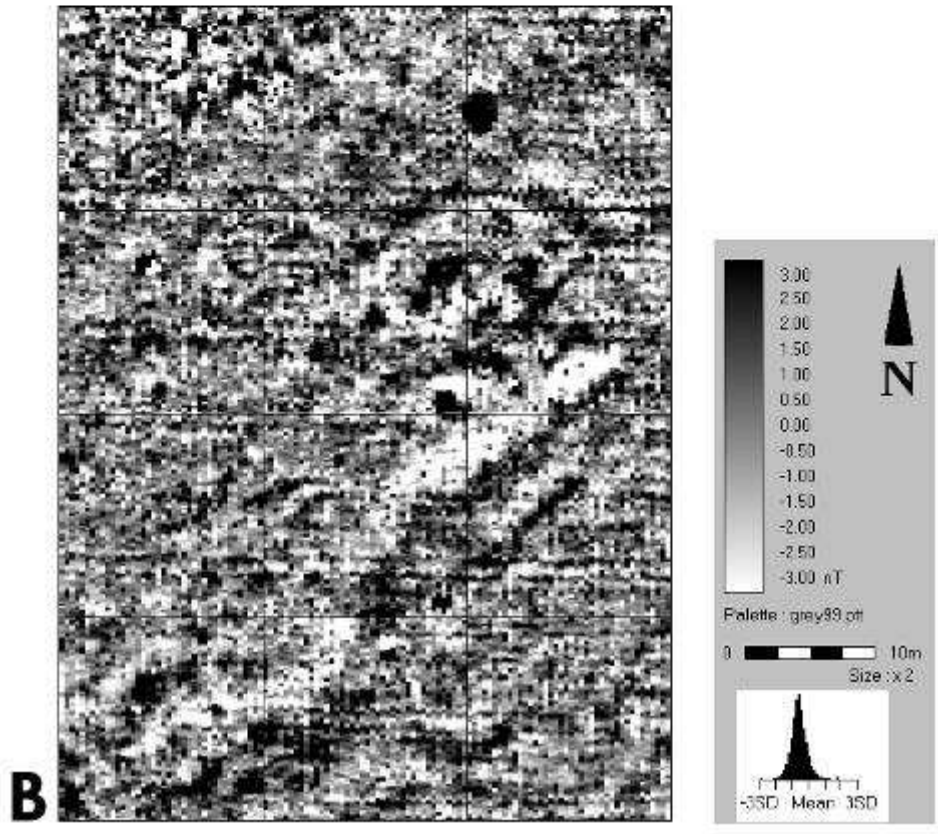

Figure 3: Gradiometer survey, Area 1; A: raw data, B: processed results.

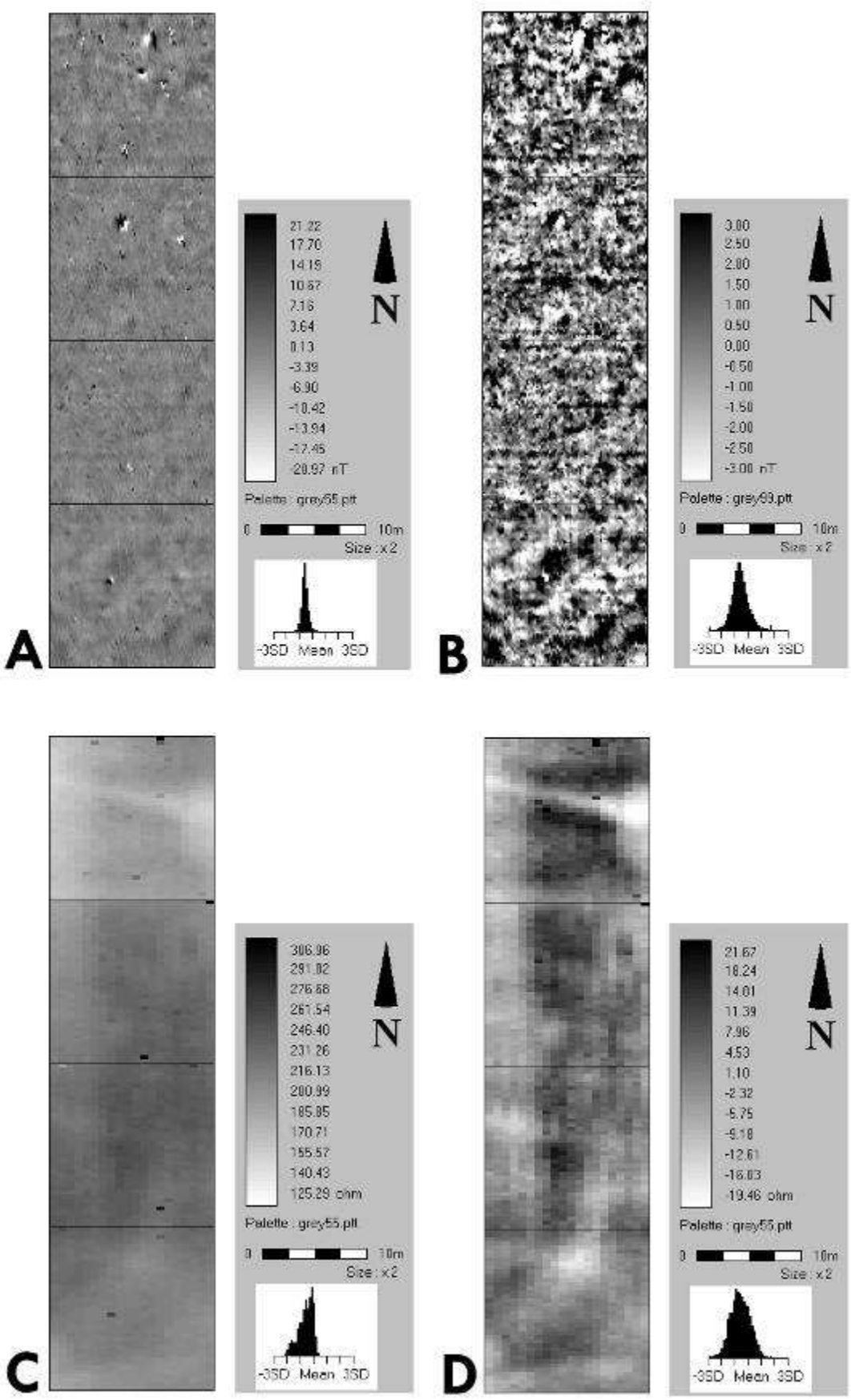

Figure 4: Resurvey of Area 1 west: A-B, higher resolution gradiometry; C-D, resistivity.

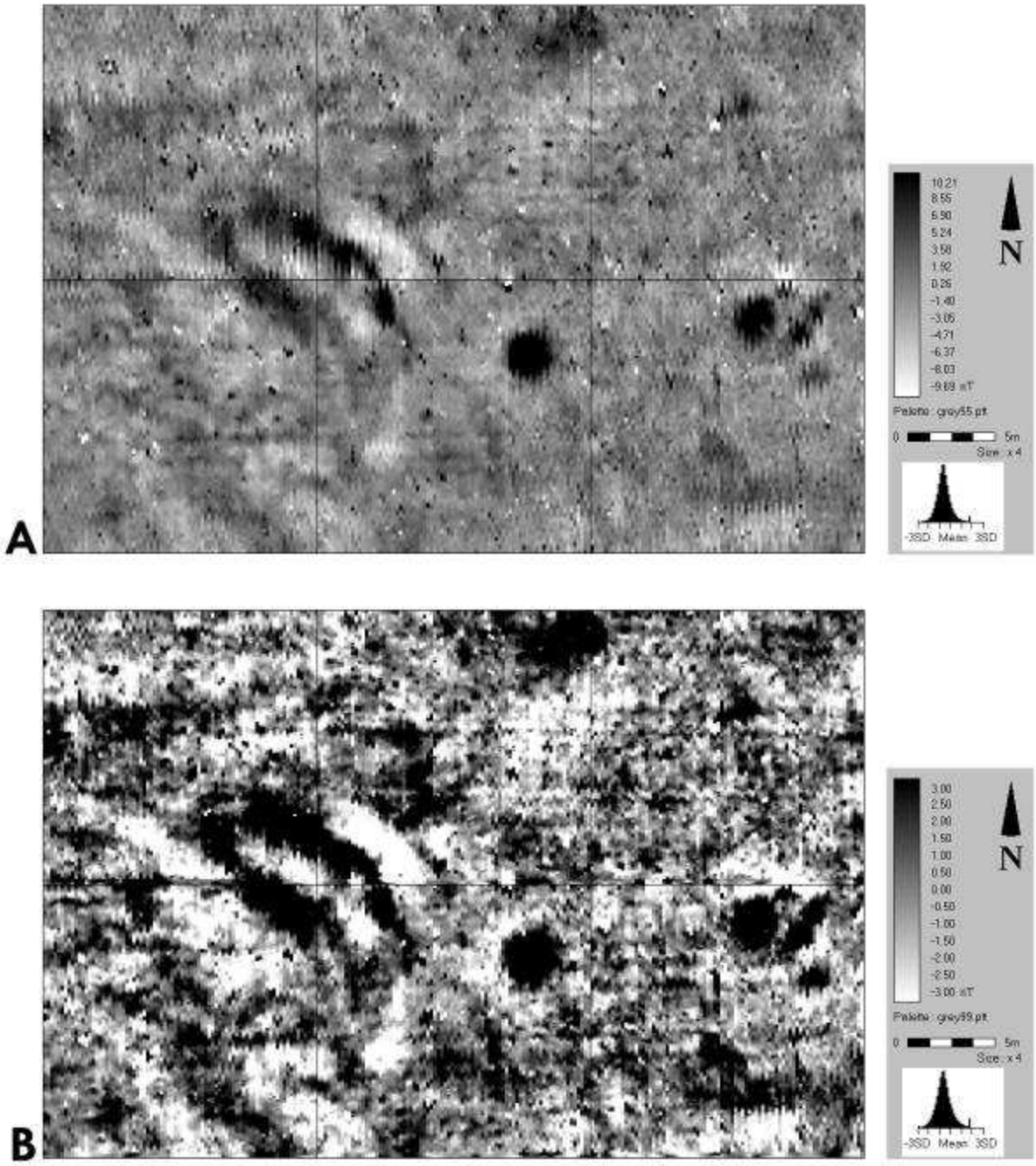

Figure 5: Gradiometer survey, Area 2; A: raw data, B: processed results.

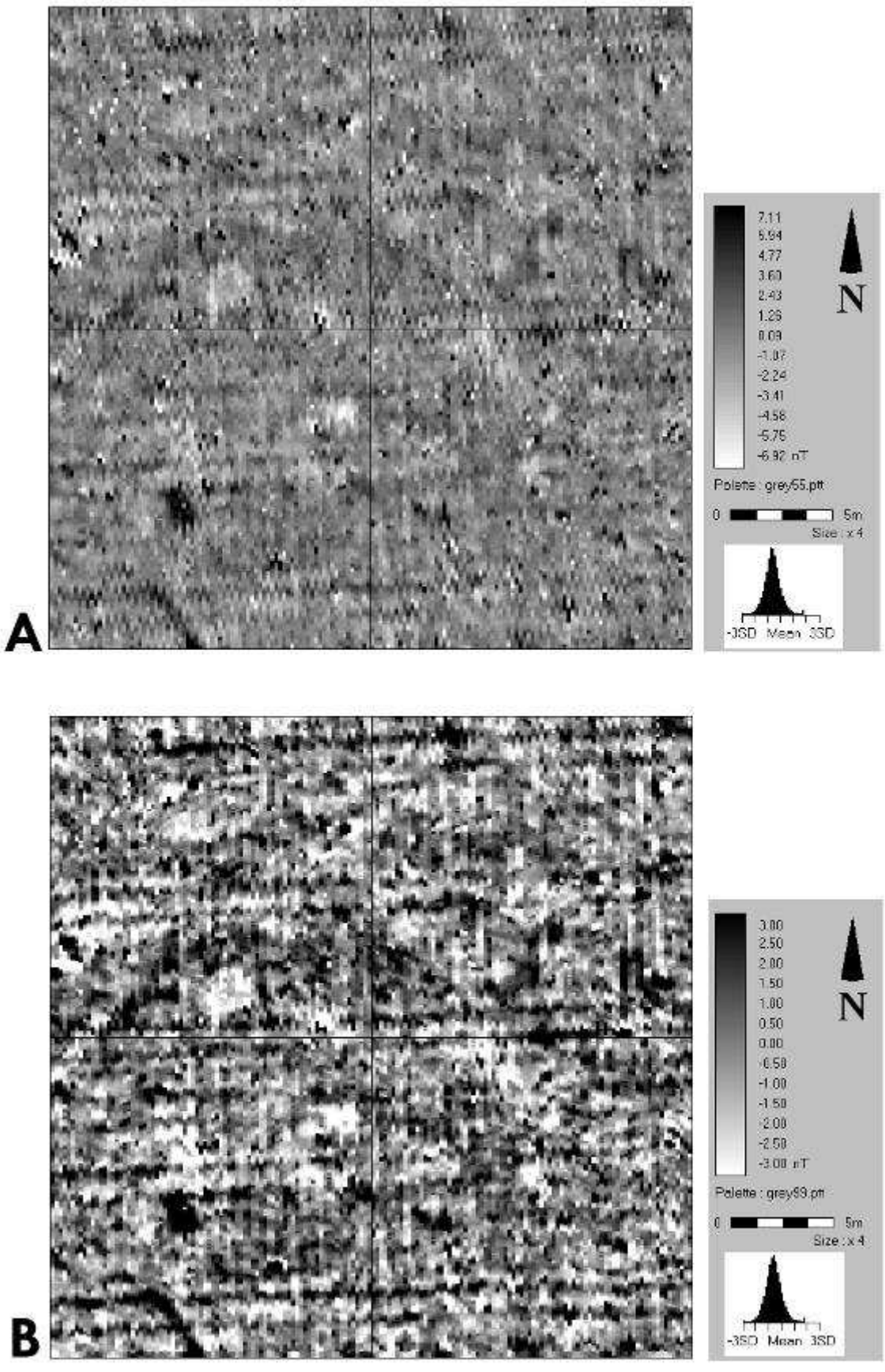

Figure 6: Gradiometer survey, Area 3; A: raw data, B: processed results.

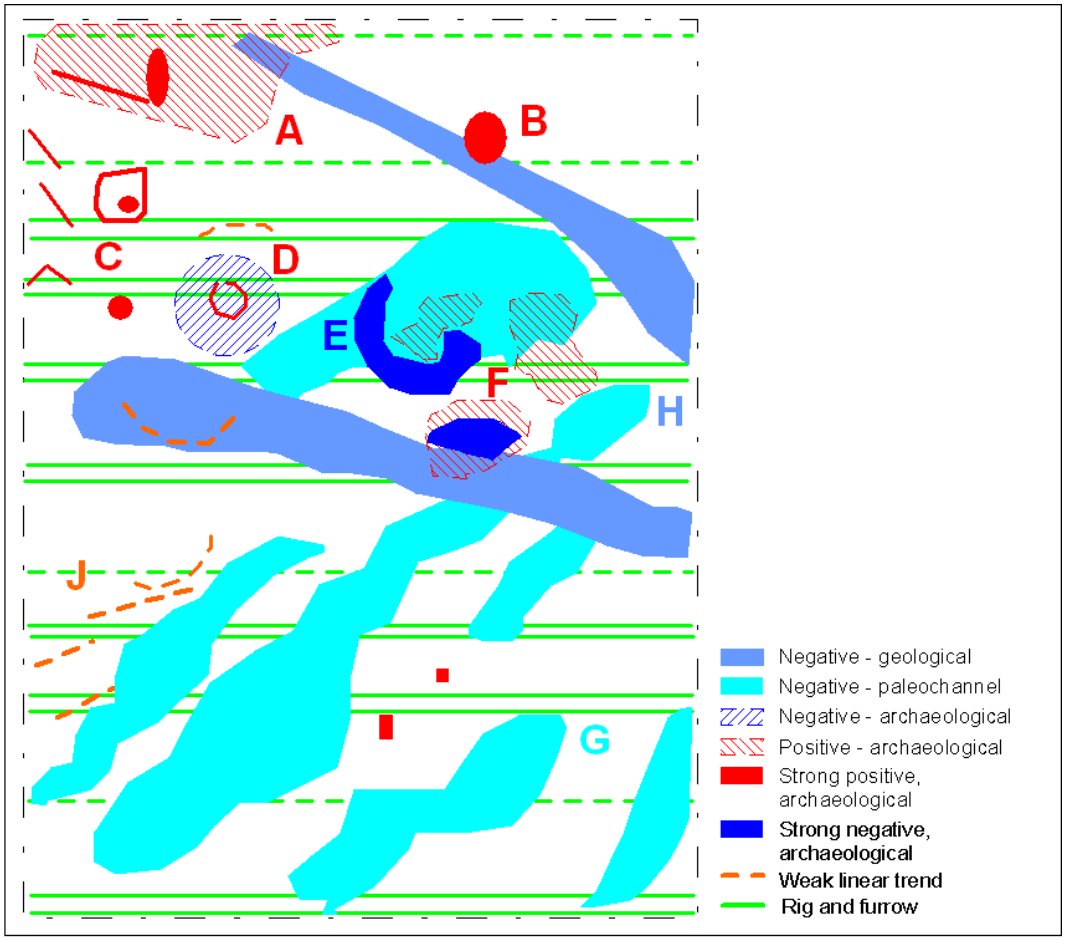

Figure 7: Area 1, interpretive plot of magnetic anomalies.

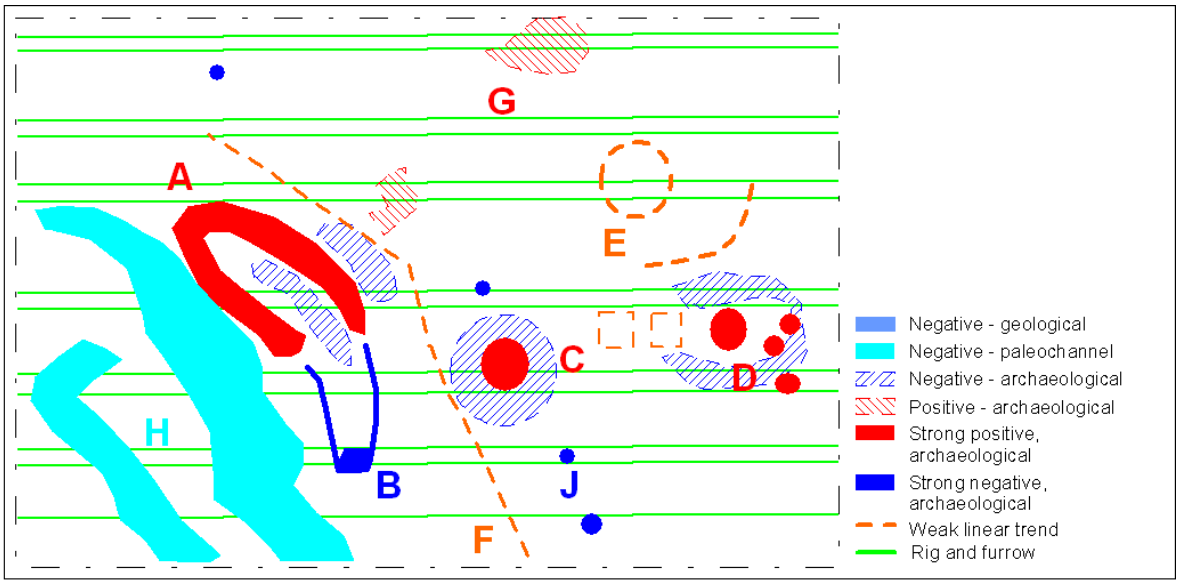

Figure 8: Area 2, interpretive plot of magnetic anomalies.

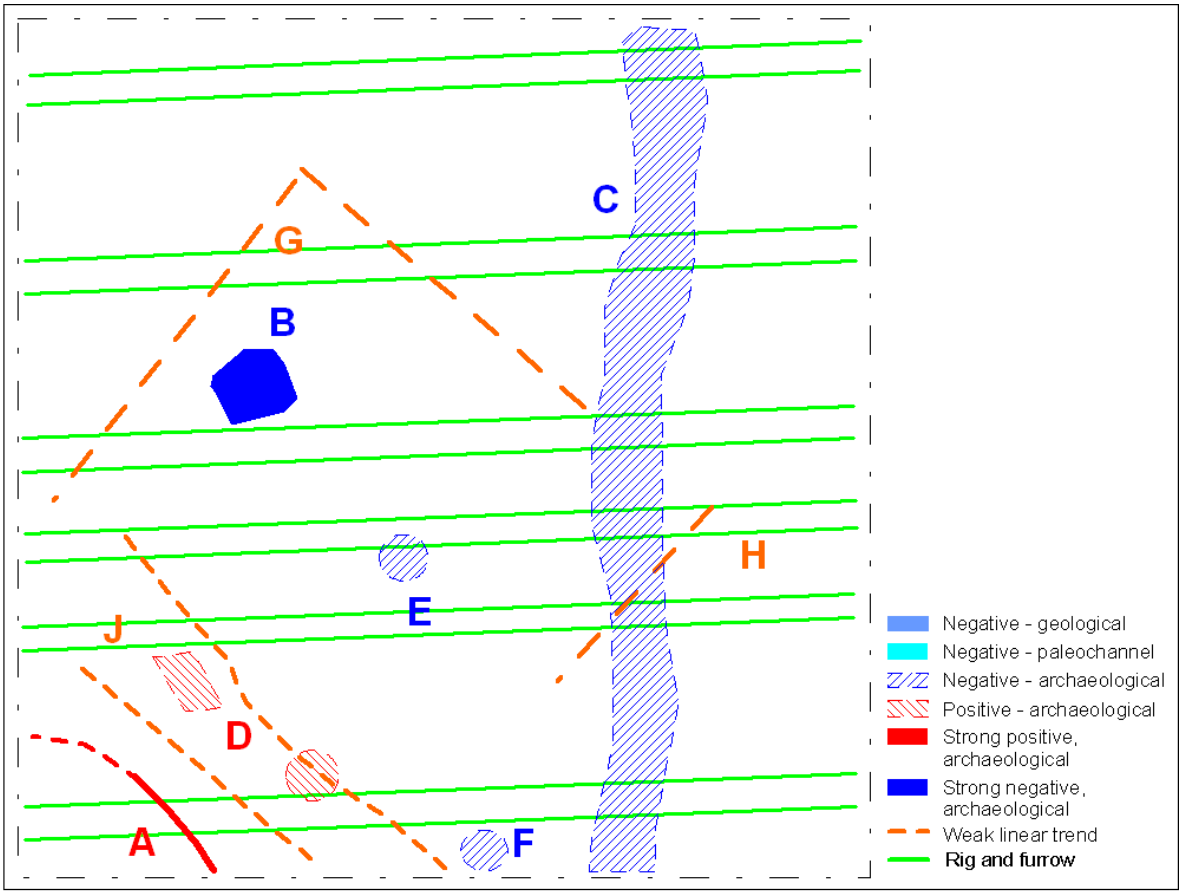

Figure 9: Area 3, interpretive plot of magnetic anomalies.

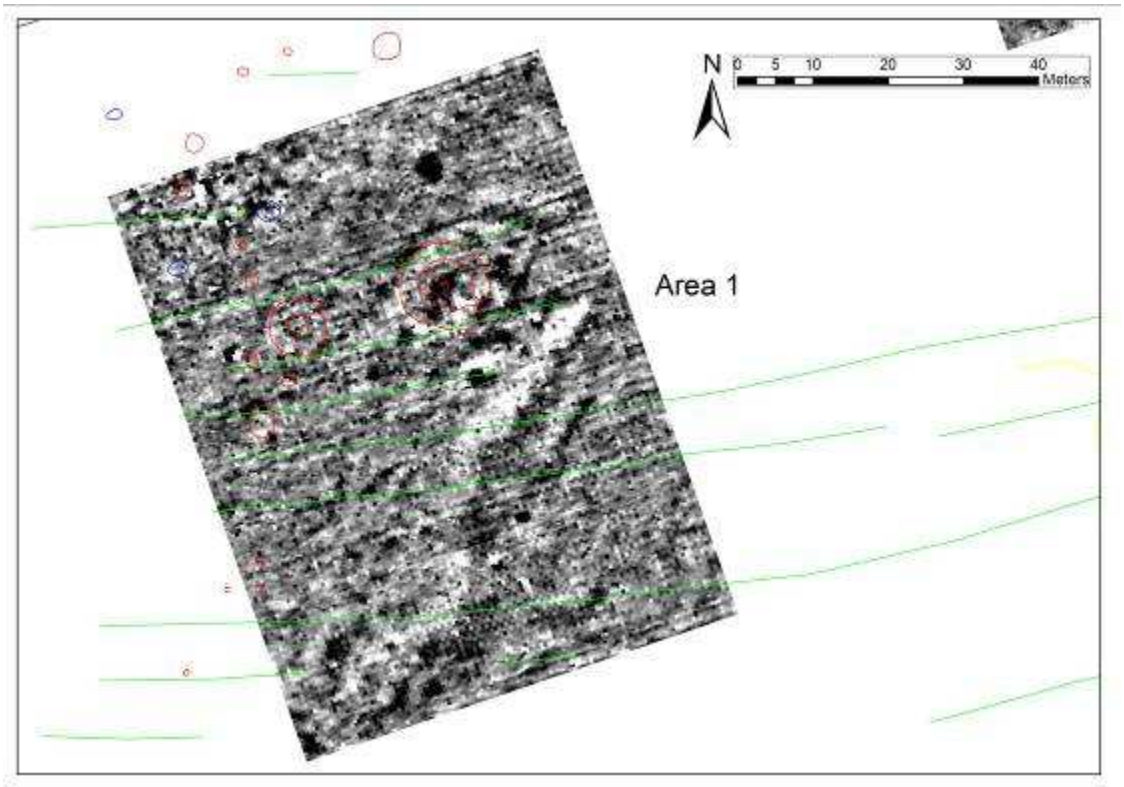

Figure 10: Area 1 gradiometer survey with cropmark transcription overlaid.

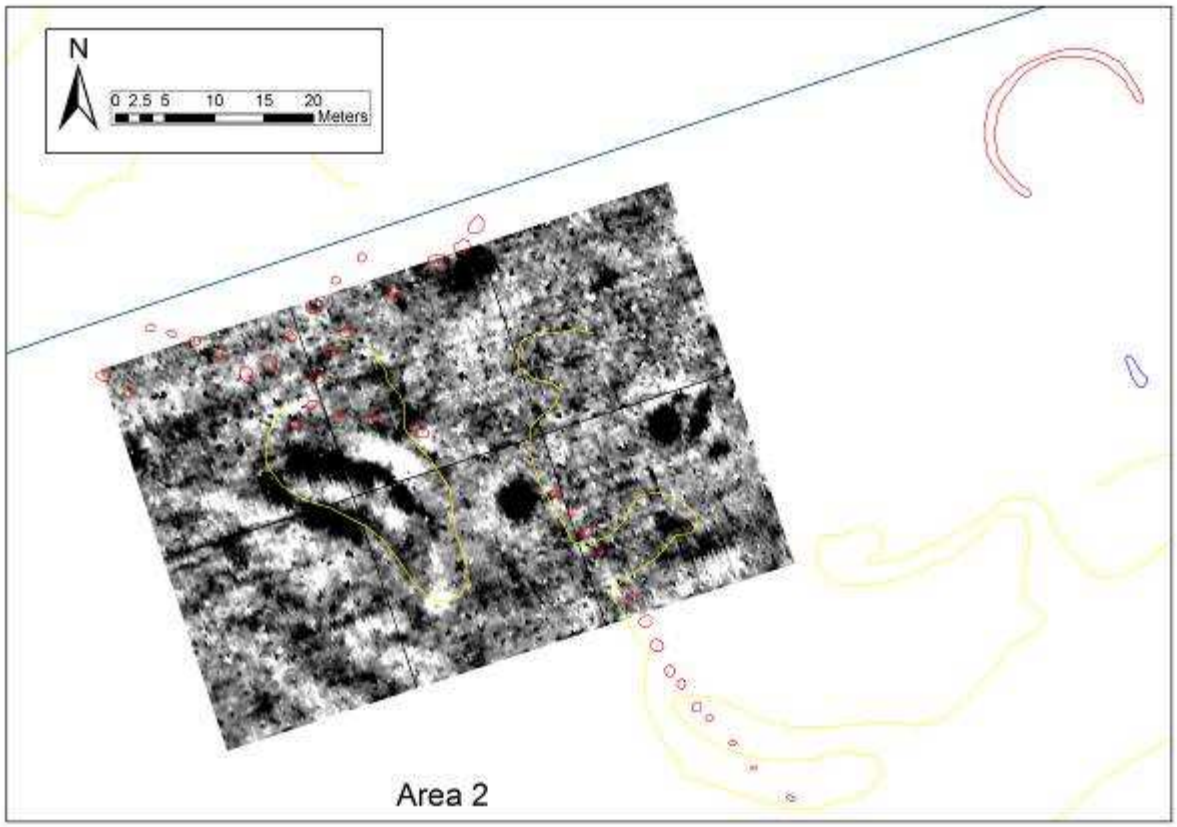

Figure 11: Area 2 gradiometer survey with cropmark transcription overlaid.

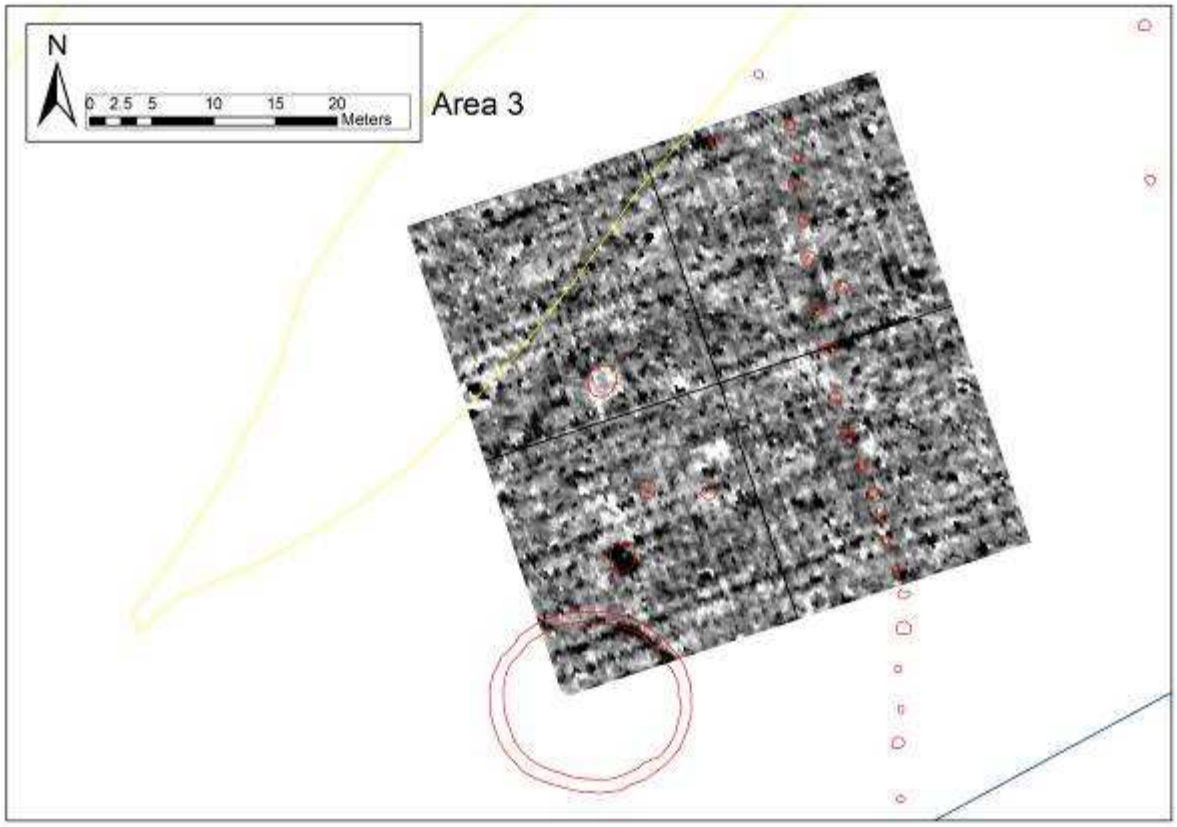

Figure 12: Area 3 gradiometer survey with cropmark transcription overlaid.