CASTLE TIORAM

PART 8 - THE GEOPHYSICAL SURVEY

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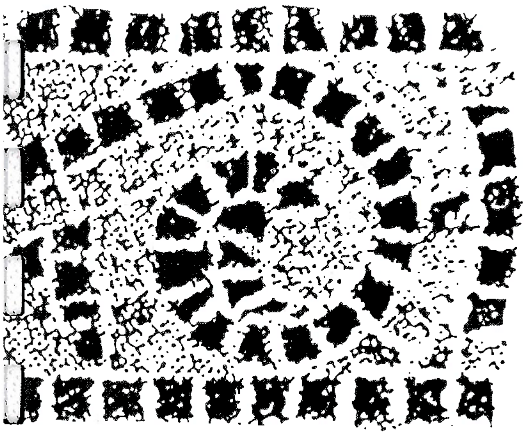

A geophysical survey of Eilean Tioram carried out as part of a continuing programme of research and the development of an appropriate archaeological resource management plan on behalf of Anta Estates by

by

Glasgow University Archaeological Research Division

Contents

Cover plate:

Eilean and Castle Tioram from the south-east.

Plate supplied by Gary Tompsett.

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by

Paul G Johnson

1999

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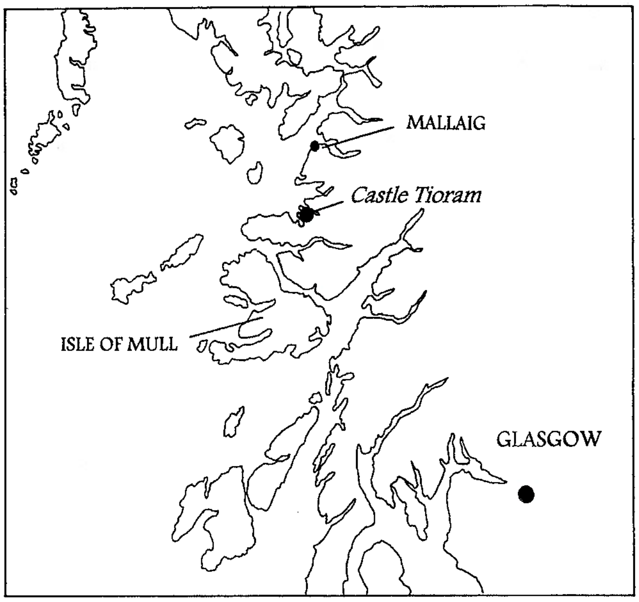

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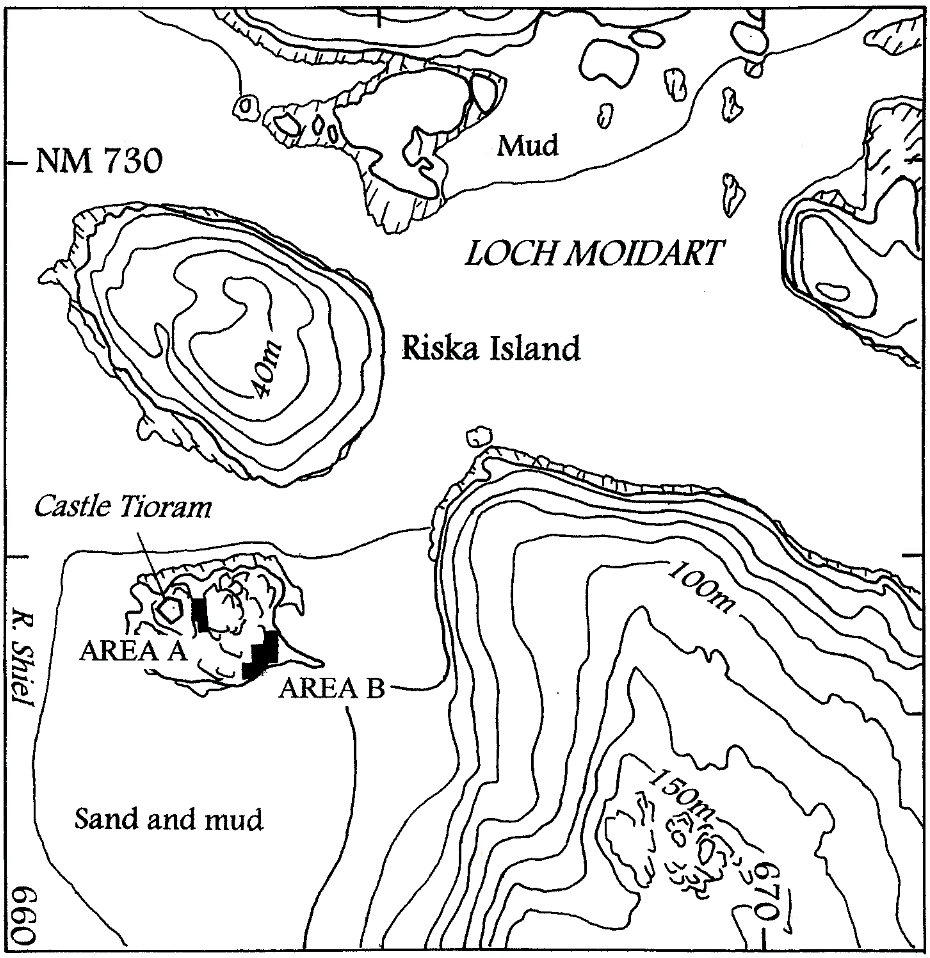

1.0 *Executive Summary*

As part of a continuing programme of research and the development of an appropriate archaeological resource management plan, a geophysical survey was carried out in two locations on Eilean Tioram in February 1999 to detect any buried archaeological remains, particularly with relation to the paths across the island. Survey was undertaken using both resistivity and magnetometry techniques. Several anthropogenic anomalies were detected.

2.0 *Introduction*

As part of a continuing programme of research and the development of an appropriate archaeological resource management plan, geophysical survey of Eilean Tioram (NGR NM 662 724) was carried out by Glasgow University Archaeological Research Division (GUARD) in February 1999 on behalf of Anta Estates. The aim of the project was to ascertain the presence or absence of buried deposits of archaeological significance, particularly below some of the pathways which cross the island. In practice, the survey was restricted to two main areas, since many of the paths on the island traverse areas unsuited to investigation by remote sensing because of space constraints or simply because they cross bare rock (Figure 1).

Figure 1:

Site Location.

The results of any geophysical survey must be treated with caution. Geophysical survey relies upon the physical properties of the soils investigated, which vary according to the conditions at the time of the survey. Furthermore, because the surveys investigate properties of the soil, the plots produced from the data show anomalies in those properties which may be the result of human activity but which may instead be the result of geological conditions. Anomalies detected can only be considered as provisional until tested through excavation, after which they may be termed features.

3.0 *Survey Location and Geology (Figure 2)*

Castle Tioram stands on a tidal island largely composed of outcropping metamorphic rock interspersed with some more level terraces. In general, soil coverage is meagre except on the terraces, often only a few centimetres in depth, and a large percentage of the surface of the island is composed of turf lying directly on the bedrock, with extensive patches of bracken. Such conditions often militate against the successful application of geophysical prospecting techniques, but a walkover assessment of the island revealed several areas where a survey could reasonably be undertaken.

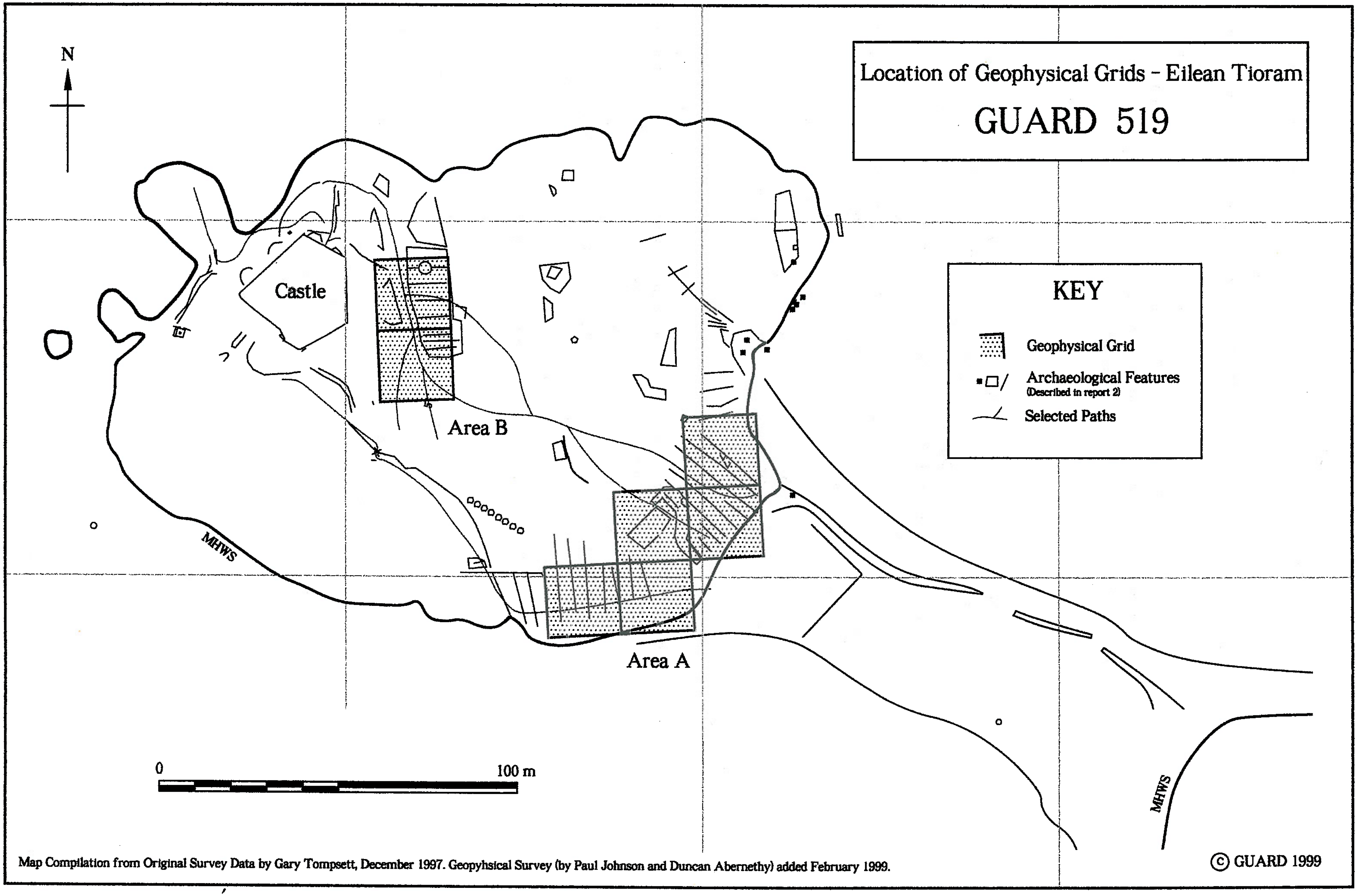
Location of Geophysical Grids - Eilean Tioram
GUARD 519
N
Castle
Area B
Area A
MHWS
MHWS
KEY
Geophysical Grid
Archaeological Features
(Described in report 2)
Selected Paths
0
100 m
Map Compilation from Original Survey Data by Gary Tompsett, December 1997. Geopyhsical Survey (by Paul Johnson and Duncan Abernethy) added February 1999.
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Figure 2

Figure 2:

Location of survey grids.

The geophysical survey of Eilean Tioram was conducted in early February 1999, and concentrated on two areas. Area A was established on a stretch of level ground at the south of the island and expanded to encompass the bracken-covered rising ground on the east of the island. As well as covering a number of footpaths, this area also contained several of the archaeological features identified in the recent survey by GUARD (Speller and Tompsett 1998). These are features 25, 27 and 31 (probable cultivation remains), 28 (pits) and 29 and 30 (an earth/stone bank and a stone structure respectively).

The second area, Area B, was established immediately below and to the west of the castle itself. This area contained two of the major footpaths leading to the castle and archaeological feature 3 (a revetted level area crossed by linear furrows) and feature 4 (a putative well). This area was not restricted solely to the platform, but was extended over revetment 3b and continued downslope toward a waterlogged area at the base of the broad gully that almost bisects the island north/south. The ground to the south of Area B might prove to be suitable for survey in the summer months, but at the time of this exercise the ground was saturated and would not have yielded useful data. Additionally, to have attempted to survey at this time of year would have caused damage to the ground surface and vegetation cover, thereby reducing the likelihood of any successful follow-up survey.

One further area was identified as potentially suitable for geophysical survey. The area below and to the west of the castle (containing archaeological features 2d, 9 and 10) might yield useful data from a vertical electrical profiling survey. The area is restricted by the walls of the gully, and probably contains a considerable depth of midden material. These factors would certainly militate against the use of a conventional area survey utilising devices with a limited depth capability, but the site might respond to a vertical electrical profiling survey undertaken along parallel transects down the length of the gully at a drier time of year.

Other than the areas identified above, very little of the island could be usefully subjected to investigation by remote sensing because of size constraints or because there is little or no soil coverage.

Areas A and B were located by triangulation in relation to the extant remains of the castle using an opto-mechanical theodolite; this allowed the grid positions to be superimposed on the base map of the island created in 1998.

4.0 *Aims and Objectives*

The aim of the survey was to increase knowledge of the archaeological remains preserved on Eilean Tioram as part of the ongoing wider programme of investigation and for use in the development of an appropriate archaeological response for the site. The objectives were to locate buried archaeological features through geophysical survey, employing both electrical resistivity and fluxgate gradiometer magnetometry techniques.

5.0 *Methodology*

5.1 *Survey Design and Instrumentation*

All geophysical survey devices currently deployed in archaeological circumstances are essentially derived from geological survey instruments. As such, local geological conditions can adversely affect the results of an archaeological survey. Bedrock morphology, drift geology and soil characteristics must be taken into account when designing an archaeological investigation and the most theoretically suitable techniques selected to perform the survey.

As far as the prevalent local geological and soil conditions at Eilean Tioram are concerned, no single technique would be ideal. The bedrock is metamorphic, with the potential for possessing high levels of thermo-remnant magnetism which could conceivably disrupt any geomagnetic survey attempted, and the topsoil conditions are non-uniform and often waterlogged, thus potentially compromising any electrical survey device. In addition, the environment is maritime, with the probability of high concentrations of extremely mobile seawater-derived ions present in the soil water solution.

It was for these reasons that two different geoprospection systems were selected for use at Castle Tioram: fluxgate gradiometry and electrical resistivity. Both techniques have proven effective in detecting archaeological features and the combination of the two techniques would offset most of the potential difficulties on Eilean Tioram.

The instruments employed in the Eilean Tioram survey were the Geoscan FM36 differential fluxgate gradiometer and the Geoscan RM15 electrical resistivity meter. The electrode configuration utilised in the resistivity survey was the twin electrode system, employing a mobile electrode separation value of 0.5 m. This configuration was chosen because of its relatively shallow (up 0.5 m) penetrative capabilities in view of Eilean Tioram's shallow soils, to minimise the possibility of the resistivity of the rock-head itself affecting archaeological measurements.

The logistics of the survey were straightforward. Each survey area was subdivided into a series of 20 m by 20 m grids, and instrument readings were taken employing an asymmetrical sampling regime of 0.5 m intervals over 1.0 m traverses. This regime was selected to obtain an acceptable degree of resolution from the data while covering a reasonable area. For reasons concerned with aliasing, the traverse directions chosen for the survey were perpendicular to the linear cultivation features identified in the survey areas. Five 20 m square grids were surveyed with the gradiometer in Area A, but only two with the resistivity meter because of the dense bracken coverage in the remaining three grids. This could be rectified in the future after strimming the bracken. Two 20 m square grids were surveyed with both systems in Area B.

5.2 *Data Processing and Presentation*

Data were processed initially using Geoscan's dedicated software package, Geoplot. Further processing was undertaken after fieldwork and the images generated by Geoplot captured by Screenthief to be directly superimposed upon the AutoCAD base map of the island.

Different processing routines were applied to the two datasets for several reasons. Geomagnetic data are essentially obtained against a uniform background, the earth's magnetic field (although this is only true of gradiometer readings, the use of two vertically displaced sensors effectively cancelling out the effect of diurnal variation in the earth's magnetic field), whereas electrical data are gathered against a constantly changing and unknowable trend reflecting changes in soil density, porosity, temperature and the salinity of the soil pore water. These facts also constrain the manner in which the respective data sets are presented graphically, and also how the data is interpreted.

The geomagnetic data from Eilean Tioram were initially screened for badly anomalous readings resulting from near-surface ferrous rubbish. Such readings adversely affect other processing routines by artificially biasing the statistics of the dataset. Any readings of this nature encountered in the data were removed and replaced by null values. The dataset was de-spiked and the resultant data balanced in order to remove intra-grid variations caused by instrument drift. Additional values were interpolated into the dataset to compensate for the asymmetrical sampling regime employed in the field, and finally the data were subjected to a low pass Gaussian filter to enhance weaker anomalies.

The resistivity data were treated in a more straightforward manner, since the instrument employed is not sensitive to metallic debris or subject to major drift problems. The individual grids of data were edge-matched to eliminate any intra-grid variations resulting from the relocation of the remote electrodes during the course of the survey, and the data were interpolated.

Both datasets are presented as greyscale plots, with black representing the maximum plotted data value and white the minimum. The result is a map of the geophysical quality being evaluated in the survey areas concerned. In addition, because resistivity data are obtained against a background trend of drift geological origin, these data have also been presented as trace plots; this shows any archaeological anomalies against the background trend which might obscure them when presented in greyscale form.

6.0 *Results*

6.1 *Gradiometer Survey (Figure 3)*

6.1.1 *Area A*

Of the 4,000 square metres surveyed by gradiometer in Area A, the easternmost portion has yielded the most information. The broad, flat area to the south of the island and containing traces of agricultural features (features 31 a-k: Speller and Tompsett 1998, Figure 3) was magnetically quiet. This is surprising because the visible remains (features 31) are upstanding features that would normally be expected to create some magnetic anomalies. The fact that this is usually the case is demonstrated by the gradiometer's ability to detect similar features (features 27 a-i) in the south-eastern portion of the island. The reason for this failure is obscure, but must relate to the fact that the agricultural features in Area A are below the flood line of the island, and are therefore subjected to regular salt water inundation, whereas the other agricultural features (27) are above this level and within a tract of bracken which does not appear to be subjected to the same level of sea water saturation. It is possible that the natural state of the iron-bearing minerals in the soil matrix of the agricultural features (31) have been chemically altered by 'aggressive' ions in the seawater into a less or non-magnetic form, thus remaining invisible to the gradiometer. This is a geophysical rather than archaeological problem, and could be addressed by the removal of soil samples from both areas for comparative chemical analysis.

Figure 3: Gradiometer survey results.

The survey area encompassed both feature 29 (earth/stone bank) and feature 30 (structure), and the instrument detected both. However, the earth/stone bank appears partially to encompass the building. It is impossible to assert that the bank completely surrounds the building (and is therefore an enclosure) on the basis of this survey because of the occurrence of anomaly A which obscures any potential return of the bank.

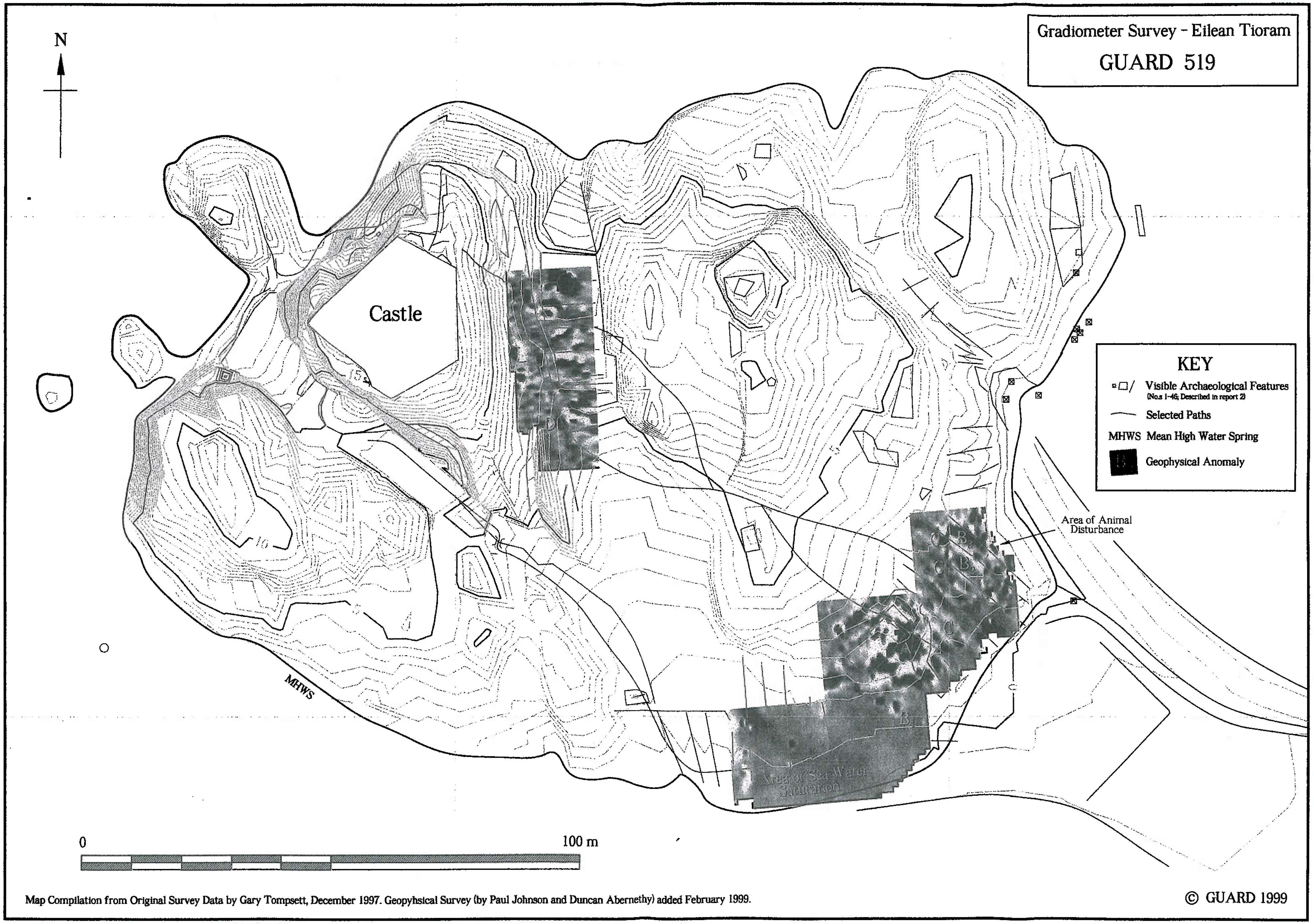
Gradiometer Survey - Eilean Tioram
GUARD 519
N
Castle
KEY
Visible Archaeological Features
(No.s 1-46; Described in report 2)
Selected Paths
MHWS Mean High Water Spring
Geophysical Anomaly
Area of Animal Disturbance
Area of Sea Water Saturation
MHWS
0
100 m
Map Compilation from Original Survey Data by Gary Tompsett, December 1997. Geopyhsical Survey (by Paul Johnson and Duncan Abernethy) added February 1999.
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Figure 3

Anomaly A is massive and probably thermo-remnant (since all near-surface ferrous interference was removed at the data processing stage), but it could be a large, deeply buried iron object or minor geological intrusion. The strength of the anomaly and its resultant effect upon the local magnetic environment (the halo around it) strongly suggests a large fire or kiln; it must be noted that the date of any fire will not emerge from the geophysical survey, and it is possible that the anomaly derives from recent activities. Discussion with the local inhabitants suggest that fires may have been lit in this area until recently. It is equally possible that the anomaly is the result of a prolonged period of ash dumping connected with the use of the structure (feature 30).

Several other dipolar anomalies were detected. These may be the result of small pieces of deeply buried ferrous material, but are perhaps more likely to be thermo-remnant events, such as small fires. Anomalies B2 and B3 are within the general area of features 28 a and b, which were interpreted in the earlier GUARD survey as possibly the remains of recent campfire pits (Speller & Tompsett 1998).

One other group of anomalies was detected within Area A. In the same area as features 27 a-i are a series of ephemeral linear anomalies (C), running perpendicular to the visible agricultural features. They are weaker anomalies than those generated by the extant remains, but this may relate more to their relative compositions rather than their depositional chronology. It is possible that they simply represent some re-orientation of the cultivation beds; however, it is also possible that they are the remains of structures associated with the castle. Their alignment is similar to the visible building (feature 30), but interpreting anomaly C as a set of similar structural remains would involve making assumptions about the date and function of Feature 30 cannot be supported on the presently available evidence.

The quality of the geomagnetic dataset in the east of the survey area is severely compromised by significant animal disturbance for several metres inland of the Mean High Water mark.

6.1.2 *Area B*

The quality of the geomagnetic data obtained in Area B was generally poor. The graphic mainly shows a scattering of minor dipoles, probably the remains of small pieces of more deeply buried ferrous material. These are quite likely to be related to the destruction of the castle at the hands of Allan of Clanranald before his death at Sherriffmuir (Rutherford 1998, 19). Since the castle was destroyed by fire, it is probable that the majority of the dipoles visible in Area B represent small nails, perhaps from put-logs or wall walks. There is also some significant magnetic activity in the area of the putative well, but this could be of more recent origin.

There are slight indications of two parallel linear anomalies (D), diagonally crossing the westernmost portion of the survey area. These peter out in an area of dipolar activity but they might represent the remains of a track or pathway leading toward the castle.

Very little geomagnetic evidence for the extant linear furrows (feature 3, Speller & Tompsett 1998) or the associated revetment of the terrace was detected, but it is probable that their weak magnetic signatures have been obliterated by stronger dipole activity.

6.2 Resistivity Survey (Figure 4)

6.2.1 *Area A*

The restricted resistivity survey of area B, depicted as a greyscale graphic, merely indicates the gradient in the electrical qualities of the soils in the south part of the island. The survey area lay directly over Features 31 a-k (Speller & Tompsett 1998) and little trace of them can be seen against the underlying geological trend. However, the trace plot of the same survey area (Figure 5) clearly depicts the extant cultivation remains, which appear to peter out in the south-eastern portion of the survey area.

Figure 4: Resistivity survey results.

This does not reflect the archaeological reality visible on the ground, but it does give some indication of the extent of salt-water saturation in this part of the island. Two factors may contribute to this: the waterlogging of the area, resulting in the resistivity system attempting to short-circuit; and a dramatic increase in highly mobile sodium, chloride and other physically small ions present in the soil pore water, resulting in a super conductive soil pore solution.

However, in the west of the survey area, the regularity of the cultivation beds is disrupted by two small linear anomalies (E). These are composed of low resistivity readings and therefore probably represent cut features, and as they were not readily visible on the surface, may underlie the cultivation beds. The anomalies are not easily mapped out when presented in trace plot form, but the results do indicate the potential significance of this area beyond the visible remains.

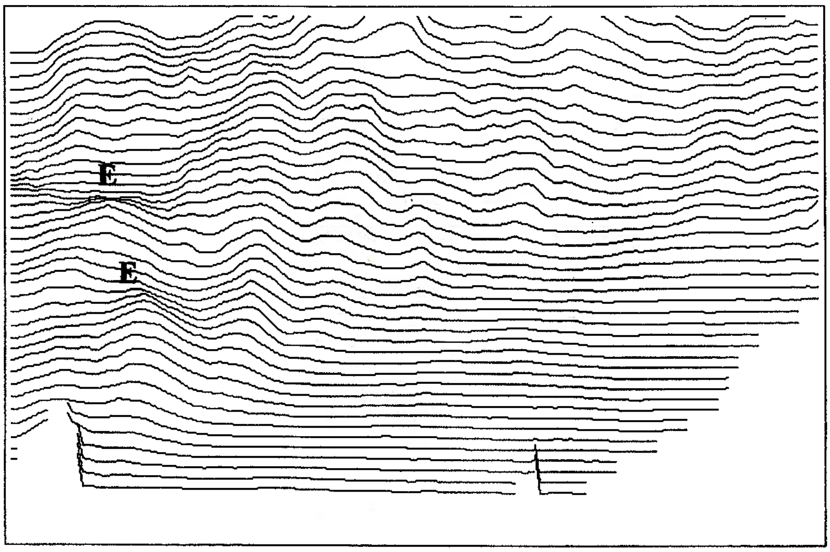

Figure 5:

Trace plot of resistivity survey, Area A.

6.2.2 *Area B*

At first glance the greyscale representation of the Area B resistivity survey appears to be composed of amorphous blobs. However, various potential features can be discerned, supported by an examination of the trace plot of the same area (Figure 6). Anomaly F is an area of low resistance, undoubtedly comprising very wet ground associated with the putative well (feature 4, Speller & Tompsett 1998). Anomaly G is a large, linear, low resistivity feature and corresponds directly to the modern footpath to the castle. Anomaly H is a deposit of material of very high resistivity, conceivably outcropping bedrock but more likely a mass of destruction debris from the castle itself or perhaps even an external building. At least some of this deposit appears to have been cleared off the modern path (anomaly G), as evidenced by the sharp linear edge of anomaly H as it abuts the path.

Anomaly J consists of two linear, high resistance features, the most southerly being interpreted by Speller and Tompsett as a stone revetted wall (feature 3b). However, because there are two anomalies, it is possible that these actually represent the remains of a small building. If this is the case and if Anomalies J and G are contemporary with the castle's occupation, then they would have had the effect of restricting the top of the gully. This would effectively have controlled movement up the pathway tentatively identified above (Anomaly D).

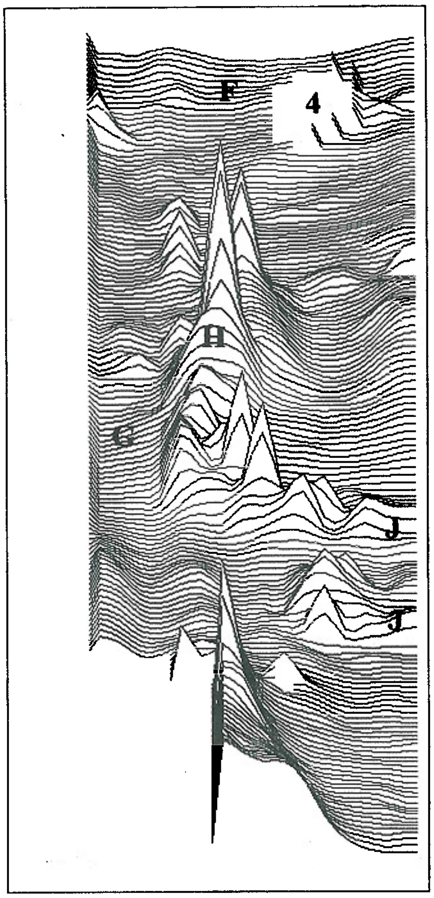

Figure 6:

Trace plot of resistivity survey, Area B.

Anomalies K and L may also represent deposits of destruction debris, but these interpretations are very tentative. Anomaly K is separated from Anomaly H by a linear band of low resistivity readings (M), and it is possible that Anomalies K and H are part of the same structure. Anomaly K is adjacent to a large rock outcrop, but the whole eastern edge of this area is similarly bounded without producing similar anomalies. Anomaly L also lies close to a large rock outcrop, and it may simply be evidence of shallow soil deposits.

7.0 *Discussion*

The geophysical survey of Eilean Tioram was necessarily a restricted exercise. Nevertheless, it has proved to be worthwhile and the duplication of survey techniques fully justified. The use of a non-contact instrument such as the gradiometer facilitated the investigation of areas with thick vegetation cover that would have been impossible to survey with a device requiring ground contact, like the resistivity meter. In return, the resistivity survey allowed features of archaeological significance to be identified in areas where effectiveness of the gradiometer was compromised by ferrous material or thermo-remnant signals associated with the castle's destruction.

The surveys were designed to cover several of the areas currently traversed by informal footpaths, and in all cases the archaeological information on those areas, observed by Speller and Tompsett (1998), was confirmed or supplemented. Many stretches of footpath are situated in areas where geophysical survey is an inappropriate method of investigation, such as narrow gullies or bare rock, and alternative approaches to the investigation of these areas should be considered. Several other locations on Eilean Tioram could be investigated by remote sensing at a more suitable time of year and/or with different instrumentation. In particular, the ground to the south of Area B might be examined in summer, preferably after reducing the vegetation cover, and the narrow gully containing features 2d and 10 could be examined using vertical electrical profiles.

In addition to the archaeological information obtained during the course of this survey, important geophysical observations were made, in particular because of the failure to detect geophysically extant agricultural features in one part of the island which seems to be frequently inundated with salt water. While this effect can be explained by waterlogging and mobile ion saturation in the case of electrical resistivity survey, the reason for the failure of the geomagnetic survey remains obscure. The problem might be of relatively little importance for the Tioram Conservation Project, but it is of profound importance to the application of archaeological geophysical prospecting techniques in Scotland. For a system to fail to detect an extant feature while detecting a very similar feature located 20 m away is a unique circumstance in Scotland and a rare opportunity for further research into the reasons behind the effect.

Finally, it must be emphasised that these survey results should only be considered as a secondary stage in the investigation of Eilean Tioram; they cannot be used to date or ascertain the function of any of the features encountered. This level of information can only be achieved through excavation.

8.0 *Acknowledgements*

The director would like to thank Duncan Abernethy for his assistance on the survey, Dr Iain Banks for project management, Olivia Lelong for editing the text, Jen Cochrane for desktop publishing and Mel Richmond for binding the report. The director would also like to thank Gary Tompsett and Allan Rutherford for their comments on the report.

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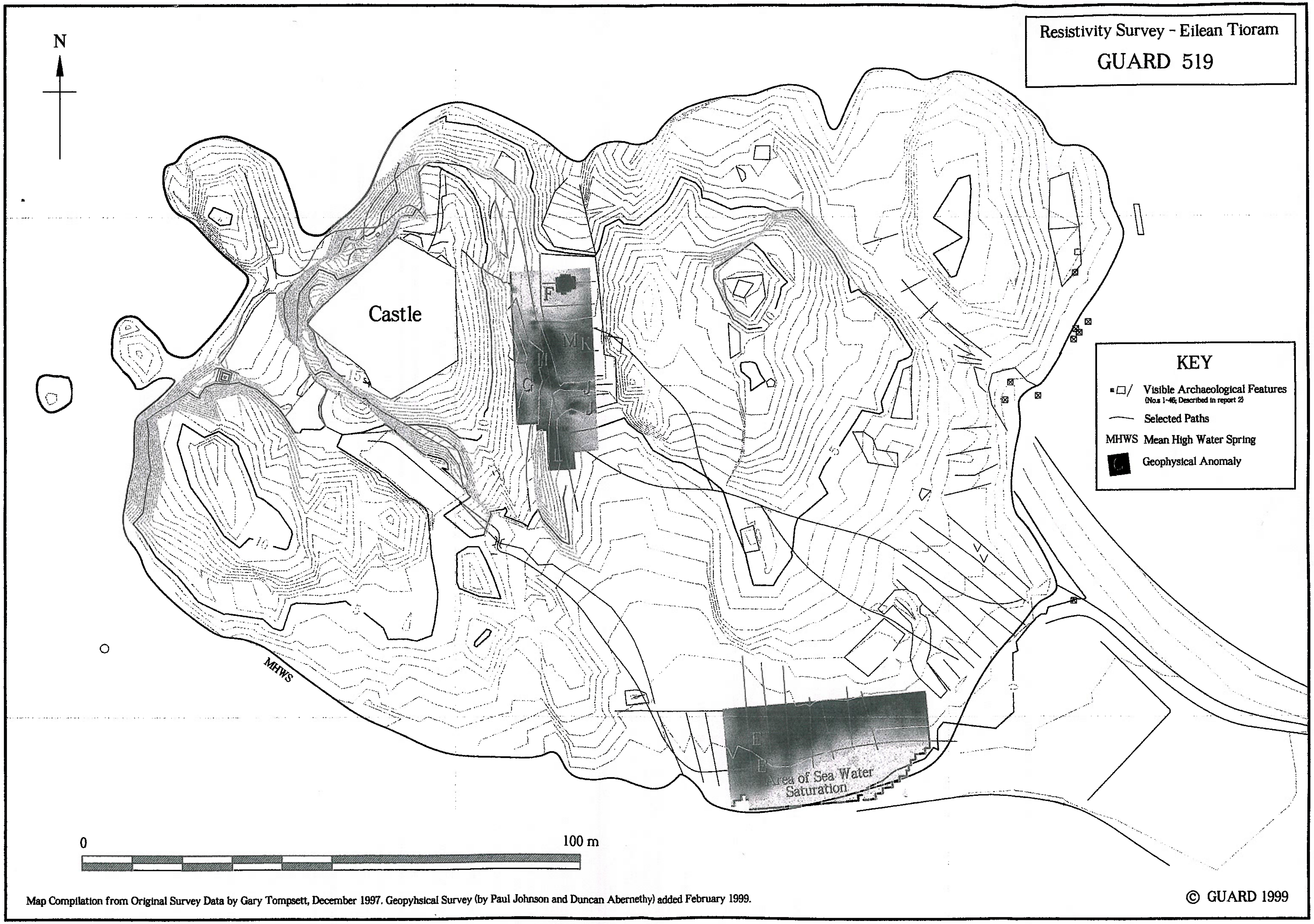
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Figure 4