STRATASCAN

Geophysical Survey Report

Ruislip Manor Farm, Middlesex

January 2005

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David Elks MSc.

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Geophysical Survey Report

Ruislip Manor Farm, Middlesex

Client:	Museum of London Archaeological Service
Survey dates:	17th - 19th January 2005
Techniques:	Resistance, Ground Penetrating Radar

Field Team:	Richard Smalley BA, Alex Bell BA
Project Manager:	Simon Stowe BSc.
Written and illustrated by:	Richard Smalley BA & David Elks MSc.
Checked and approved by:	Simon Stowe BSc.

Stratascan Ltd.

Vineyard House
Upper Hook Road
Upton upon Severn
WR8 0SA

Tel: 01684 592266
Fax: 01684 594142
Email: ppb@stratscan.co.uk

www.stratascan.co.uk

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1 SUMMARY OF RESULTS

A resistance survey and ground penetrating radar survey (GPR) were carried out at Ruislip Manor Farm, Middlesex. The resistance survey covered 0.5ha of grassed area, while the GPR covered 0.1ha of road, both within a Scheduled Ancient Monument.

The survey defined anomalies in both the area surrounding the house and the motte which suggest the presence of buried structural remains. Some linear anomalies appear to be orthogonal with the manor house indicating they may be from a similar period of construction. Other linear anomalies have been identified on a different orientation suggesting they are from an unrelated building phase. The northern extent of the bailey has been defined with enclosing earthworks and a section of infilled moat has also been located. Anomalies in the motte identify cut features that may relate to the location of former buildings.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to carry out a geophysical survey of an area outlined for archaeological investigation which is being undertaken by the Museum of London Archaeological Service.

2.2 Site location

The site is located at Ruislip Manor Farm, Ruislip, Middlesex at OS NGR ref. TQ 0894 8784.

2.3 Description of site

The survey area is within a Scheduled Ancient Monument, including a motte and bailey castle and Manor house. The bailey and the top of the motte are on relatively flat ground, however both areas have inclined edges. Sporadic trees and overgrown shrubbery were surveyed around where possible.

The underlying geology is London Clay (British Geological Survey South Sheet, Third Edition Solid, 1979). The overlying soils are unsurveyed due to the urban environment (Soil Survey of England and Wales, Sheet 6 South East England).

2.4 Site history and archaeological potential (Cockburn & Baker, 1971) (King, 2005)

The survey area at Ruislip Manor Farm covers the known site of a motte and bailey castle dating from the eleventh century and a medieval manor house of early 16th century date. The original manor house dates back to before the Norman conquest. It is also believed to be the site of Bec's Priory built in the 12th century which lies beneath and to the west of the current manor house. The site is unique in this part of England in having representations of buildings from all periods since 1300.

Given this long history, the likelihood of locating features of an archaeological origin is considered high.

2.5 Survey objectives

The objective of the survey was to locate any anomalies that may be of archaeological origin.

2.6 Survey methods

Two survey techniques were used on this site; they were Resistance survey and Ground Penetrating Radar.

More information regarding these techniques is included in the Methodology section below.

3 METHODOLOGY

3.1 Date of fieldwork

The fieldwork was carried out over 3 days from the 17th - 19th of January 2005. The weather varied from light showers to fine.

3.2 Grid locations

The location of the survey grids has been plotted in Figure 3.

3.3 Description of techniques and equipment configurations

Resistance
This method relies on the relative inability of soils (and objects within the soil) to conduct an electrical current which is passed through them. As resistivity is linked to moisture content, and therefore porosity, hard dense features such as rock will give a relatively high resistivity response, while features such as a ditch which retains moisture give a relatively low response.

The resistance meter used was an RM15 manufactured by Geoscan Research incorporating a mobile Twin Probe Array. The Twin Probes are separated by 0.5m and the associated remote probes were positioned approximately 15m outside the grid. The instrument uses an automatic data logger which permits the data to be recorded as the survey progresses for later downloading to a computer for processing and presentation.

Though the values being logged are actually resistances in ohms they are directly proportional to resistivity (ohm-metres) as the same probe configuration was used through-out.

Radar

Two of the main advantages of radar are its ability to give information of depth as well as work through a variety of surfaces, even in cluttered environments and which normally prevent other geophysical techniques being used.

A short pulse of energy is emitted into the ground and echoes are returned from the interfaces between different materials in the ground. The amplitude of these returns depends on the change in velocity of the radar wave as it crosses these interfaces. A measure of these velocities is given by the dielectric constant of that material. The travel times are recorded for each return on the radargram and an approximate conversion made to depth by calculating or assuming an average dielectric constant (see below).

Drier materials such as sand, gravel and rocks, i.e. materials which are less conductive (or more resistant), will permit the survey of deeper sections than wetter materials such as clays which are more conductive (or less resistant). Penetration can be increased by using longer wavelengths (lower frequencies) but at the expense of resolution (see 3.4.2 below).

As the antennae emit a "cone" shaped pulse of energy an offset target showing a perpendicular face to the radar wave will be "seen" before the antenna passes over it. A resultant characteristic *diffraction* pattern is thus built up in the shape of a hyperbola. A classic target generating such a diffraction is a pipeline when the antenna is travelling across the line of the pipe. However it should be pointed out that if the interface between the target and its surrounds does not result in a marked change in velocity then only a weak hyperbola will be seen, if at all.

The Ground Probing Impulse Radar used was a SIR2000 system manufactured by Geophysical Survey Systems Inc. (GSSI).

The radar survey was carried out with a 400MHz antenna. This mid-range frequency offers a good combination of depth of penetration and resolution.

3.4 Sampling interval, depth of scan, resolution and data capture

3.4.1 *Sampling interval*

Resistance

Readings were taken at 1.0m centres along traverses 1.0m apart. This equates to 400 sampling points in a full 20m x 20 grid. All traverses were surveyed in a “zigzag” mode.

Radar

Radar scans were carried out along traverses 0.5m apart on a parallel grid as shown in Figure 2. Data was collected at 40 scans/metre. A measuring wheel was used to put markers into the recorded radargram at 1m centres.

3.4.2 *Depth of scan and resolution*

Resistance
The 0.5m probe spacing of a twin probe array has a typical depth of penetration of 0.5m to 1.0m The collection of data at 1m centres with a 0.5m probe spacing provides an optimum resolution for the technique.

Radar
The average velocity of the radar pulse is calculated to be 0.10m/ns which is typical for the type of sub-soils on the site. With a range setting of 60ns this equates to a maximum depth of scan of 3m respectively but it must be remembered that this figure could vary by ± 10% or more. A further point worth making is that very shallow features are lost in the strong surface response experienced with this technique.

Under ideal circumstances the minimum size of a vertical feature seen by a 200MHz (relatively low frequency) antenna in a damp soil would be 0.1m (i.e. this antenna has a wavelength in damp soil of about 0.4m and the vertical resolution is one quarter of this wavelength). It is interesting to compare this with the 400MHz antenna, which has a wavelength in the same material of 0.2m giving a theoretical resolution of 0.05m. A 900MHz antenna would give 0.09m and 0.02m respectively.

3.4.3 *Data capture*

Resistance
The readings are logged consecutively into the data logger which in turn is daily down-loaded into a portable computer whilst on site. At the end of each job, data is transferred to the office for processing and presentation.

Radar
Data is displayed on a monitor as well as being recorded onto an internal hard disk. The data is later downloaded into a computer for processing.

3.5 Processing, presentation of results and interpretation

3.5.1 *Processing*

Resistance
The processing was carried out using specialist software known as *Geoplot 3* and involved the 'despiking' of high contact resistance readings and the passing of the data though a high pass filter. This has the effect of removing the larger variations in the data often associated with geological features. The nett effect is aimed at enhancing the archaeological or man-made anomalies contained in the data.

The following schedule shows the processing carried out on the processed resistance plots:

Despike	*X radius = 1*
	Y radius = 1
	Spike replacement
High pass filter	*X radius = 10*
	Y radius = 10
	Weighting = Gaussian

Radar
The radar plots included in this report have been produced from the recorded data using Radan software. An FIR filter has been applied to the timeslice data to remove any background noise. Example radargrams displayed in section 4.2 are raw data with no processing.

3.5.2 <u>*Presentation of results and interpretation*</u>

Resistance
The presentation of the data for the site involves a print-out of the raw data as a grey scale plot (Figure 3), together with a grey scale plot of the processed data (Figure 4). Anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing (Figure 5).

Radar
Manual abstraction
Each radargram has been studied and those anomalies thought to be significant were noted and classified as detailed below. Inevitably some simplification has been made to classify the diversity of responses found in radargrams.

i. Strong and weak discrete reflector.
These may be a mix of different types of reflectors but their limits can be clearly defined. Their inclusion as a separate category has been considered justified in order to emphasise anomalous returns which may be from archaeological targets and would not otherwise be highlighted in the analysis.

ii. Complex reflectors.
These would generally indicate a confused or complex structure to the subsurface. An occurrence of such returns, particularly where the natural soils or rocks are homogeneous, would suggest artificial disturbances. These are subdivided into both strong and weak giving an indication of the extent of change of velocity across the interface, which in turn may be associated with a marked change in material or moisture content.

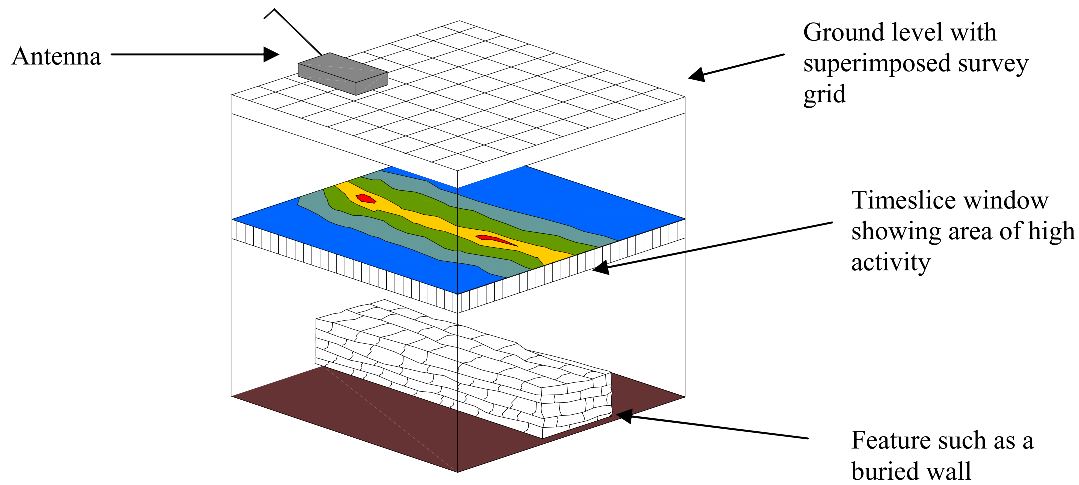
iii. Point diffractions.
These may be formed by a discrete object such as a stone or a linear feature such as a small diameter pipeline being crossed by the radar traverse (see also the second sentence in 4. below).

iv. Convex reflectors and broad crested diffractions.
A convex reflector can be formed by a convex shaped buried interface such as a vault or very large diameter pipeline or culvert. A broad crested diffraction as opposed to a point diffraction can be formed by (for example) a large diameter pipe or a narrow wall generating a hybrid of a point diffraction and convex reflector where the central section is a reflection off the top of the target and the edges/sides forming diffractions.

v. Planar returns.
These may be formed by a floor or some other interface parallel with the surface. These are subdivided into both strong and weak giving an indication of the extent of change of velocity across the interface which in turn may be associated with a marked change in material or moisture content.

Timeslice plots

In addition to a manual abstraction from the radargrams, a computer analysis was also carried out. The radar data is interrogated for areas of high activity and the results presented in a plan format known as timeslice plots (Figures 6, 7, 8). In this way it is easy to see if the high activity areas form recognisable patterns.



The GPR data is compiled to create a 3D file. This 3D file can be manipulated to view the data from any angle and at any depth within range. The data was then modelled to produce activity plots at various depths. As the radar is actually measuring the time for each of the reflections found, these are called "time slice windows". Plots for various time slices have been included in the report. Based on an average velocity calculations have been made to show the equivalent depth into the ground. The data was sampled between different time intervals effectively producing plans at different depths into the ground.

The weaker reflections in the time slice windows are shown as dark colours namely blues and greens. The stronger reflections are represented by brighter colours such as light green, yellow, orange, red and white (see key provided in Figures 6, 7, 8).

Reflections within the radar image are generated by a change in velocity of the radar from one medium to another. It is not unreasonable to assume that the higher activity anomalies are related to marked changes in materials within the ground such as foundations or surfaces within the soil matrix.

4 RESULTS

4.1 Resistance survey

The resistance survey was carried out over the motte and bailey area of the site and has produced a number of anomalies that can be broadly classified as:

- High resistance linear anomalies that are possibly caused by wall remains
- Moderate resistance linear anomalies suggesting less substantial structural remains or compacted ground
- Low resistance linear anomalies possibly related to cut features of archaeological origin
- High resistance area anomalies that may represent structural debris
- Moderate resistance area anomalies that may represent more widely spaced structural debris or compacted ground
- Low resistance area anomalies that suggest the presence of infilled pits or depressions.

In the south of the survey area, on the motte, a number of low resistance linear anomalies are evident which may represent infilled cut features of an archaeological origin. They are possibly caused by ditches or robbed out walls relating to former structures. Within the motte are also several high resistance area anomalies, particularly in the south east. These are likely to represent areas where there is buried stone beneath the surface, possibly rubble debris from previous buildings. The surrounding low resistance areas are probably 'pseudo anomalies' present because of the adjacent high magnitude response.

The majority of anomalies in the bailey area surrounding the current manor house have a high resistance. The high resistance linear anomalies to the north of the house appear to take the same spatial orientation as the house itself. This suggests the presence of stone wall structures possibly related to the manor house.

In the north of the survey area is a moderate resistance anomaly with an associated low anomaly running parallel to it on the northern side. This is likely to represent earthworks defining the northern extent of the bailey. The moderate response may be related to compacted, built up ground forming an embankment while the low response may be related to a ditch.

The remaining moderate resistance responses may be caused by less substantial and fragmentary stone remains or by ground compaction.

To the north west of the manor are several high resistance responses which do not follow the same orientation as the house. This is suggestive of stone features from a different age.

4.2 <u>GPR survey</u>

A 400 MHz radar survey was carried out over the tarmac road area from the library to the Manor Farmhouse.

The timeslices located several linear anomalies of high amplitude activity to the west and south of the small circular garden in the road. The manual abstraction has identified these as consisting of discrete, broad crested and point diffraction types of anomaly all at similar depths and traceable across adjacent transects (Figure 13). This is the typical combination of responses that would be expected from modern services such as pipes and cables.

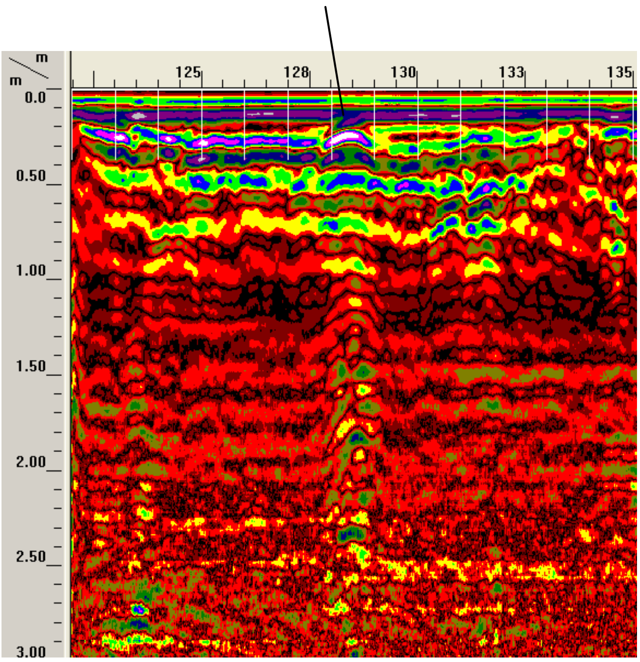


Figure 13. Example radargram from transect 90N, chainage 122E-135E.

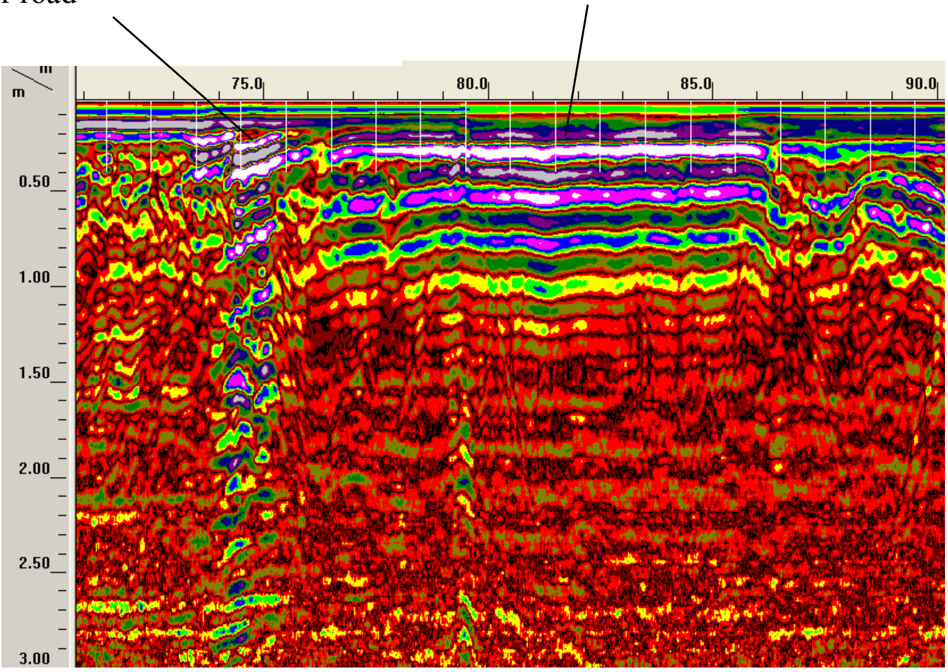


Figure 14. Example radargram from transect 100N, chainage 71E-90E.

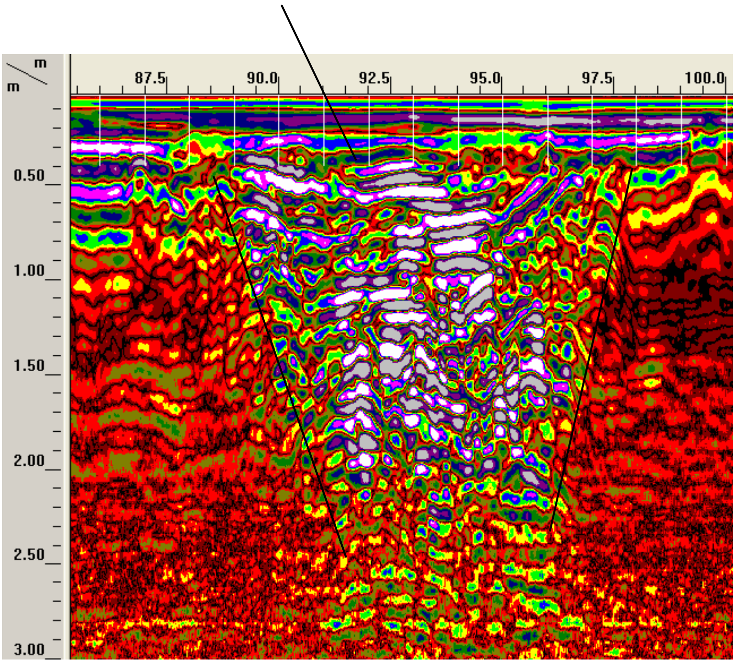


Figure 15. Extract from transect 101N, chainage 86.5E-100E. The 'V' shaped edge is defined.

In the road area to the west are three regions of planar responses. The strong planar responses in the north are shallow at a depth of approximately 0.2m (Figure 14). If they covered the entire of the road area then they would likely be associated with the current road surface and foundations. However they are only about 10m long. This suggests they are not related to the current road but possibly to a former, narrower road surface. The two areas to the south are of weaker planar response and are not caused by such a substantial feature. They are more likely to be natural horizons and may be related to a change in soil chemistry.

An area of strong complex anomalies is visible in the north of the GPR survey area. The edges of these responses take the form of a 'V' (Figure 15). This is likely to represent the infilled continuation of the moat surrounding the site and can be traced cutting through the survey area.

To the south of the manor house are two areas consisting mostly of strong discrete responses. Some of these appear to be caused by drain covers suggesting that these anomalous areas are related to modern drainage features.

On the west side of the Manor house is an area of deep inclined events. These appear to dip from around 2.1m depth in the east to 2.6m in the west (Figure 16). The origin of these anomalies is unclear, they may be related to the infilled moat, although due to the proximity of the house they may be associated with its construction, or the construction of Bec's Priory which is thought to be in this area.

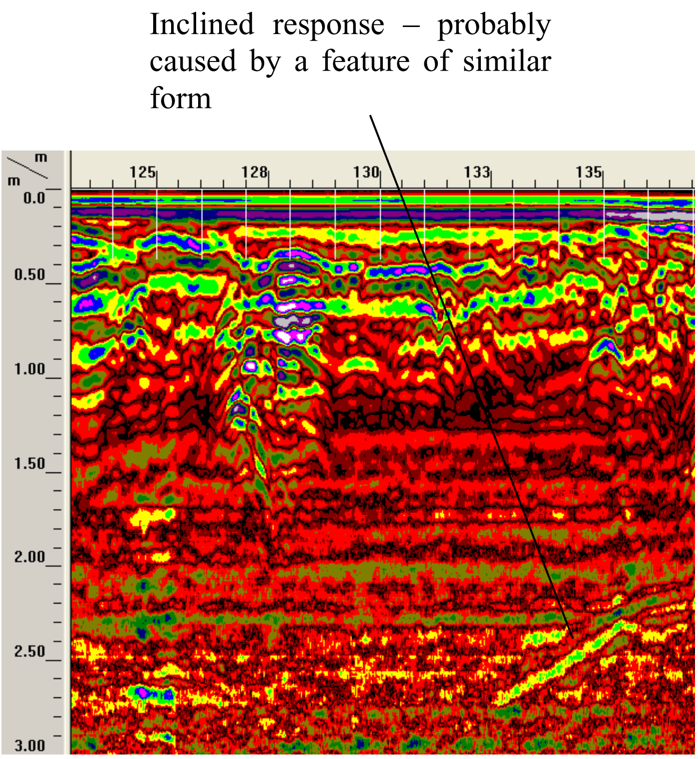


Figure 16. Extract from transect 93.5N, chainage 123E-137E.

On the west side of the small circular garden feature is an anomalous area consisting of mainly discrete and complex responses (Figure 17). The timeslice abstraction (Figure 9) is able to resolve this area into anomalies with a modern origin and those with a probable archaeological origin. Those with a probable archaeological origin appear to take the form of rectilinear features. It is possible to see continuations of these features across from the GPR results in to the resistance data. This infers that the rectilinear anomalies have a high resistance suggesting they may represent the remains of insitu stone walls.

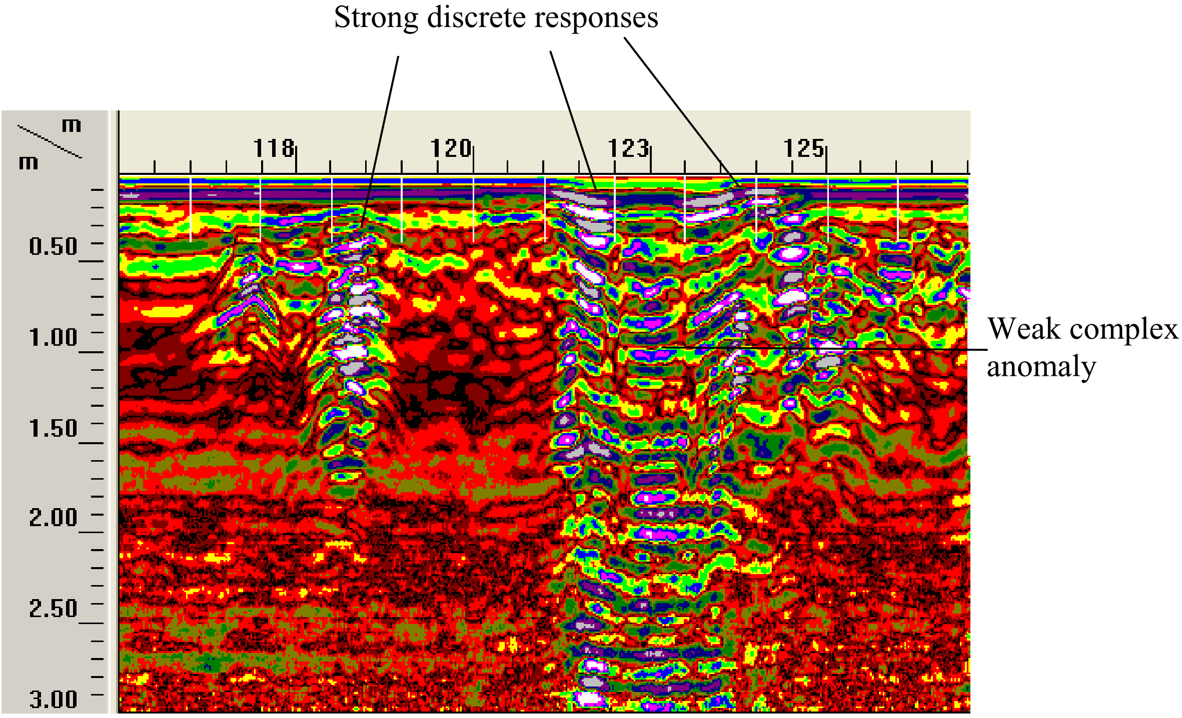


Figure 17. Extract from transect 99N, chainage 116E-127E.

5 CONCLUSION

The resistance survey identified several anomalies which probably have an archaeological origin. Surrounding the farmhouse are linear anomalies that share the same orientation as the house and may relate to its construction. There are also anomalies on a different orientation that are possibly associated with remains from other construction phases. Earthworks present on the site appear to define the northern extent of the bailey. Low resistance rectilinear anomalies are evident in the motte that may represent cut features or robbed out walls of former structures. It is possible the cut features contained timber structures which would also explain the low resistance values.

The GPR survey has defined several areas that may contain features of an archaeological origin. In the west of the survey area the probable course of the infilled moat has been detected. Adjacent to the farmhouse on the west is an area of rectilinear anomalies that probably relate to stone remains of former structures.

A previous radar survey was carried out (McCann, 2000), that reports the survival of some structures in the bailey with a possible NE to SW orientation. The resistance data seems to confirm this with linear anomalies in the north of the site taking a similar orientation.

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