SECTION 6

TWIN SURVEY INTERPRETATION

6-1 Introduction

This section gives you some background information to help you interpret your resistnace surveys. It is principally orientated towards surveys done with a 0.5m Twin, this being the most popular configuration. Further practical information on surveying with, and interpreting the 0.5m Twin configuration, along with other configurations, may be found in the references listed in Appendix I. The MPX15 Instruction Manual also gives examples of the results obtained with wider spacing Twin arrays and 0.5m Wenner and Double-Dipole arrays.

Interpretation of survey results may not always be straight-forward due to a number of complicating factors. Firstly, the response to archaeological structures depends on the nature and depth of the structure, local soil type and geology, terrain and climatic conditions. Secondly, the resistance meter may also give a response to non-archaeological structures. This can mask the required response or be misinterpreted as archaeologically significant. This section attempts to illustrate the effect of these complicating factors by giving some specific examples and an indication of their magnitude wherever possible. However, it must be emphasised that these are examples only and do not necessarily hold for all sites. The nature of each site is unique and consequently these effects and their magnitude must remain somewhat unpredictable. Nevertheless, being aware of these factors and their effects on the data will usually help to successfully extract the required archaeological information. Prior knowledge about a site can help enormously in its interpretation.

6-2 Background Resistance

All archaeological structures are seen as a change in the background resistance. The magnitude of the background resistance depends firstly on the probe configuration in use and the site conditions. Assuming the use of a 0.5m Twin probe array, and a remote probe separation of 0.5m to 1m, then Table 6-1 illustrates the tremendous range of background resistance values that may be encountered.

It is useful to look at the background resistance and the way it arises because this can act as an indicator as to the likely contrast that will be seen between an archaeological structure and the surrounding medium - see section 6-3(4). It can be seen that such factors as soil type, topsoil thickness, underlying geology, drainage and climate all combine in a complex way to determine the background resistance. However, some guidelines may be given.

Using the very broad, and somewhat arbitrary, classification of Table 6-1 it can be said that sandy soils are usually in range C since the water will be able to drain away quite readily. Clay soils are likely to be in range A (or low values of range B) because of the ability of clay to retain moisture, whilst good loam topsoils, 40 cm deep or more, are likely to be intermediate in behaviour and thus in range B. Peat can exhibit a wide range of background resistances, varying from range A (peat bog) to range C (thin peat layer on sandstone or upper layer dried out). It can be seen, especially from this last example, that drainage and topsoil thickness can have a tremendous effect on background resistance. Good drainage is likely to be found

Range	Background Resistance R ohms	Type of Site
A	< 40	Badly drained, High water table, deep topsoil, springs, boggy areas, adjacent to rivers, clay soils etc.
B	40 - 200	Typical of urban and rural sites, winter and summer, gardens, grassed areas, fields, topsoil 30-40 cm.
C	200 - 1000	Thin topsoil, less than 20 cm, dry conditions, very good drainage due to geology, for example sandy and gravely sites but with deep topsoil etc.

Table 6-1. Typical background resistances for a 0.5m Twin, remote probe separation 0.5m to 1m.

on sites which derive their soild from pervious underlying rocks (eg gravels, sands, sandstones, jointed limestones, fissured chalk etc). Even the topsoil may be fairly thsick, greater than 50 cm say, yet the coarse nature of the soil will still allow the moisture to drain away, giving a high background resistance. In contrast, soil derived from underlying imperviou rocks (eg clays, shales etc.) will tend to retain moisture and be badly drained, producing a low background resistance. If the topsoil layer is thin, say less than 20 cm, then the current from the resistance meter is able to penetrate deep enough to respond to the subsurface rocks which are generally higher in resistance than soils, thus increasing the background resistance.

Climatic changes can have a marked effect on the background resistance - the summer season brings an increase in background resistance due to water loss. The increase may be up to 100% on the winter background resistance, depending on the nature of the site and how hot, dry and prolonged the summer period is. This effect is usually most noticable on those soils that exhibit a high background resistance even in the winter months since their structure or depth is such that moisture may be easily lost. Dramatic increases, sometimes much more than 100%, may be found in long hot summers when even soils normally in range A may dry out. The effect may be exacerbated by the vegetative ground cover taking up extra water.

6-3 Response to Archaeological Structures

1 Introduction

Stone structures, such as walls and roads are generally poor electrical conductors compared to the surrounding soil and so show as an increase in background resistance. Soil filled ditches and pits generally tend to collect water which makes them better electrical conductors than the surrounding soil or rock and so show as a lowering in the background resistance. Figure 6-1 shows the typical resistance profiles as walls and ditches are traversed.

2 Response Polarity

Table 6-2 shows the sign of the response to be expected for variety of structures. In general an increase in resistance is observed over structures offering good drainage compared to the surrounding

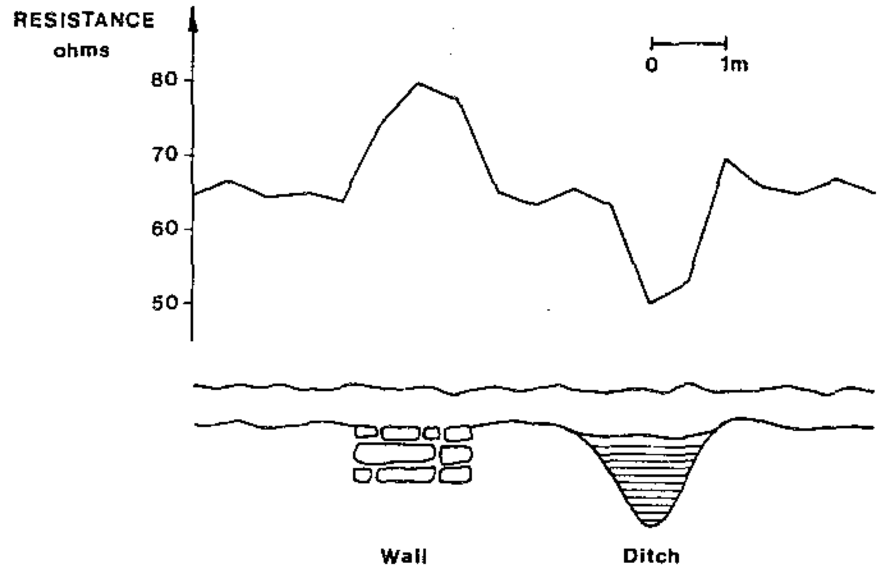

Figure 6-1. Typical resistance profiles over a wall and ditch.

medium, eg stone walls, or which are physically elevated, eg banks. A decrease in resistance is seen over structures which retain moisture, eg ditches, or into which water drains, eg furrows. Although generally the sign of the response is a good guide to the nature of the structures remember that this may not neccessarily be the case. For example, a linear high resistance feature may not neccessarily be a bank - as shown in table 6-2 a rubble filled pit, or one with a very coarse textured fill may give a similar response, since the water may drain away much more freely than the surrounding bedrock. Water collecting on top of walls constructed of impervious stone may produce a lowering in the resistance instead of the expected increase. The sign of the response may also be inverted depending on the season - see section 6-3(5).

Increase in Resistance	Decrease in Resistance
Walls	Ditches
Mounds	Pits (soil filled)
Banks	Dykes
Cobbled areas	Hut circles
Rubble areas	Foundation trenches
Paving areas	Gullies
Pits (rubble filled)	
Voids (wells, underground tomb etc.)	
Ridge	Furrow

Table 6-2. Typical (normal) response polarities.

3 Response Width and Form

In general, the form of the Twin response is simple, with the width of the response at the half intensity level, 1/2 R in figure 6-2, representing the width of the structure. The minimum width is set by the width of the mobile probes at 0.5m or by the reading interval (1m for a sample or traverse interval of 1m). If two structures are very close, then their combined responses amy merge into one peak. Very deep structures, on sites with deep topsoil, will give a broadening of the response.

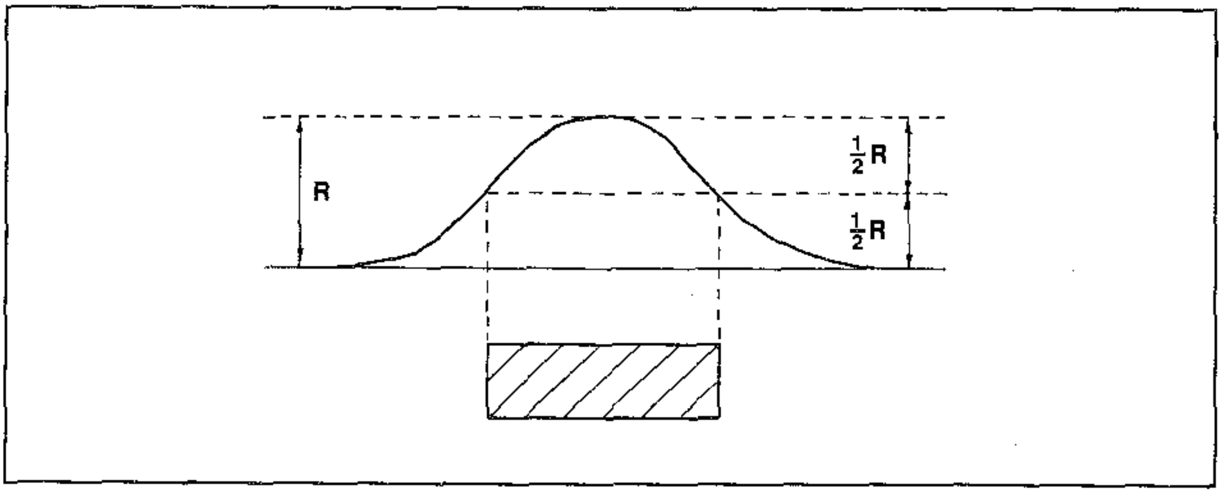

Figure 6-2. Width of response.

However, if you configure a PA5 as a Twin array wider than 0.5m, or as a 0.5m Wenner array, and if the traverse is made over a near surface structure, narrower than the array width, you may find that the response shows evidence of multiple peaking, depending on the orientation and shape of the structure. This makes simple interpretation more difficult. However, traverses using a range of Twin widths (eg 0.25m to 1.5m) are useful for obtaining depth information - see the MPX15 Instruction Manual for further details.

4 Response Strength And Variation With Depth

Typical responses are a change of 5 - 25% of the background resistance on sites with a topsoil thickness of 30 - 40 cm. If the structure is nearer the surface, is particularily massive, or contrasts extremely well with the surrounding medium (see section 6-3(5) then changes of up to 100% or more may be encountered. If the structure is small and deep then changes of only 5% or less may be observed. Whether a change is significant must be viewed in the context of surface noise. For example on a site with a very uniform background, with random changes of less than 1% in the background resistance, changes of 3% or more may be significant. On another site, with a particularily noisey background of say 10%, only changes of 15% or more may be significant, hence limiting the type and depth of structure that can be located. If the topsoil is known to be deep then a small percentage anomally is to be expected - for example an increase in topsoil thickness from 25 cm to 100 cm may reduce the anomally strength to 10% of its value at 25cm - the object would have to be fairly substantial and of good contrast to still be detected at that depth, eg town walls and ditches. This is a result of the roughly inverse square fall off of response with depth.

As a rough rule of thumb, the 0.5m Twin array can detect structures at a depth of 0.5m to 1m, with only the more substantial features showing up at greater depth. To look deeper, the width of a Twin array needs to be increased (typically using a PA5), though as cautioned in the previous section, 6-3(3), multiple peaking may occur if there are also narrow, near surface structures present.

5 Response Contrast and Dependance on Geology and Season

As indicated in section 6-2, the contrast that will be seen between an archaeolgical structure and the surrounding medium depends on a combination of factors such as soil type and underlying geology (which determine the drainage), the season, and of course the type of structure and the way in which it differs from the surrounding medium.

Stone structures have most contrast with soils that retain moisture efficiently, such as peats and those with a high humic or clay content. Soil filled structures such as ditches and pits have the most contrast when they themselves are filled with soils that retain moisture efficiently but are cut into geologies that allow moisture to readily drain away. Thus pervious underlying rocks such as gravels, sands, sandstones, jointed limestones, fissured chalks tend to provide a good contrast for ditches - they are characterised by a high background resistance. On the other hand, impervious underlying rocks such ad clays, shales, alluvium etc. do not allow water to escape and so tend to provide a good contrast for stone structures (providing the stones themselves are also impervious) - they are characterised by a generally lower background resistance.

The weather plays an important part in determining the contrast between structure and the surrounding medium but in a somewhat unpredictable manner. As a generalisation, periods of wet weather after a dry spell, as in autumn, are much better for locating stone structures since the high moisture content and hence low resistance of the soil contrasts with the high resistance of the stone but the stone has not had time to saturate. Humous filled ditches however are better located in the summer months since the ditch fills are generally better able to retain moisture than the surroundings, and produce a greater contrast than in winter, when the ditch fill and surroundings may both saturate equally.

Heavy rainfall is usually not beneficial for location of either walls or ditches, because the current flow is concentrated near the surface and does not penetrate the archaeological levels. On the other hand, if the survey is conducted where previously a field crop has been grown during a particularily dry spell the crop may deplete the moisture of the ditch, or soil surrounding a wall, reducing the contrast. The possibility of an inversion of anomaly sign, or loss of anomaly, depending on the season of the year and type of structure, also exists. This may be expected if a ditch has a particularily coarse filling, causing water to drain rapidly to the bottom of the ditch in autumn leaving the top dry compared to the surrounding soil - it behaves as a wall giving a positive anomaly. However, once saturated in winter it may loose contrast with the surrounding medium and give no response at all, or possibly a reduced negative (normal) response. In summer it may give up water as rapidly as the surroundings, giving virtually no response. On the other hand, a humous filled ditch will tend to retain the moisture in summer and in autumn retains more moisture compared to the surrounding medium, giving normal responses.

It can be seen that the response given by a ditch is influenced greatly by the nature of the back-fill. Thus it is important to appreciate that the absence of significant changes does not neccessarily mean a structure does not exist. Some features are only observed during some parts of the year, others may be too deep or masked by geological changes, or sufficient contrast does not exist.

6 Response Complexity

Interpretation of surveys to locate isolated features, such as barrows or ditch enclosures, which are most often encountered on rural sites, are in general much easier to interpret than urban sites where deep and overlapping periods of occupation may cause an extremely confusing picture. Isolated archaeological features are characterised usually by fairly sharp changes, often superimposed on a slowly changing background which represents a geological change (see section 6-4, table 6-4). A graphics plot of the results of a survey over an area larger than that covered by the feature helps define any changes in resistance due to geology, and these can subsequently be disregarded when interpreting the survey. More complex sites, such as Roman settlements, even in a rural context, may be more difficult to interpret because of the complexity and proximity of many varied features, robbing, rubble etc. Often the different structures are so close to one another that the responses overlap. In this case, reducing the sample and traverse intervals to 0.5m should help improve the interpretability. Even if individual structures cannot be identified, the resistivity survey will probably have been able define the general position and extent of occupation, which contrasts with the undisturbed surrounding areas.

Where a site has been intensively occupied, as is the case on many inner city sites (eg Roman, Viking, and Medieval York), the interpretation is likely to be extremely complex, since not only may the features be in close proximity to one another, producing sharp changes, but there may also be several layers of features directly underneath, causing a very complex response indeed, with those structures nearer the surface (usually modern) predominating. Only under ideal circumstances, might it be possible to locate major structures such as town walls, streets and occupation areas : (a) structures would need to be relatively near the surface (the 0.5m Twin has a detection depth of the order of 1m, slightly deeper for massive targets), (b) surface noise would need to be low to achieve maximum detection depth - this is very rare on inner city sites, (c) target dimensions and contrast would need to be large, (d) there should be an absence of near surface modern structures such as cellars etc. intruding into the archaeological deposites. Radar or resistivity tomography systems are probably more appropriate to inner city surveys.

6-4 Unwanted Response to other Structures and Influences

Unfortunately, the resistance meter, as well as locating archaeological features can give a response to natural variations in topology, vegetation, geology and to natural and man made features and these and their effects are summarised in table 6-4, parts 1 and 2. The list is by no means exhaustive and each site must be interpreted in its own context since the guide to strength of the interferance must neccessarily be subjective, and in some cases much greater changes may be found or virtually none at all.

It is often easier to recognise the presence of unwanted responses when a fairly large area has been surveyed and the full extent of field drains, streams, ridge and furrow, geology etc. can be clearly seen - a significant change in background resistance due to geology is often encountered on many sites. It is also useful to obtain as much information as possible about the site and its recent and past history by examining aerial photographs, asking locally about such activities as field drainage etc. and by examining soil and solid geology maps when interpreting the results of a survey.

6-5 Conversion to Resistivity

The RM15 displays and logs readings in units of resistance. No further conversion is needed if you are just wishing to locate structures in the ground. However, the readings are geometry dependant, making direct comparison between measurments made with different probe configurations difficult. To make true comparisons resistance readings should be converted to resistivity readings (see Appendix H) - these are representative of the bulk properties of the ground, not the probe configuration used. You should also convert readings to resistivity if you wish to generate pseudo-sections - see Section 5 and Appendix A of the MPX15 instruction manual for further details of pseudo-sections.

6-6 Further Information

For more information on interpretation and factors influencing resistance surveying please refer to Appendix I, where a useful list of books and papers is given. Detailed guidance on processing and presenting resistance data is given in the software manual which accompanies program GEOPLOT, also available from Geoscan Research.

Cause	Change in Backround Resistance	Appearance in data
Changes in background resistance due to non-visible features (over a distance > 2m)		
Proximity to stream or river	Up to 50 %	Gradual lowering of background resistance as stream or river is appraoched.
Springs	Up to 50 %	Localised lowering of background resistance.
Undulating geology	Up to 50 %	Usually a smooth change in background resistance.
Varying topsoil thickness	Up to 100 %	Usually a smooth change in background resistance.
Change in geology type	Up to 100 %	Often an abrupt change in background resistance.
Visible feature causing a change in background resistance		
Ploughing edges	Up to 20 %	Resistance can increase as one approaches within 1-2m of a plough edge.
Plough lines	Up to 20 %	Can appear as closely spaced ridge and furrow.
Change in vegetation	Up to 20 %	May cause a change in backround resistance.
Slope	Up to 100 %	Increase in resistance as survey up the slope.
Roots of trees, bushes etc	Up to 100 %	Increase in resistance over root area especially in summer or periods of drought.
Ridge and furrow	Up to 100 %	High readings at peaks, low in the troughs.
Proximity to standing wall	Up to 100 %	Increase or decrease as approach with 2-3m.
Proximity to open ditches	Up to 100 %	Increase in resistance as approach within 2-3m.
Platforms, banks, mounds	Up to 100 %	Increase in resistance.
Gravel paths and areas	Up to 200 %	Large increase in resistance.
Random fluctuations in background resistance (between adjacent readings)		
Probe insertion	Up to 1 %	Change in reading as probes are inserted causing a variation between adjacent readings.
Heavy rain on previously dry surface	Up to 20 %	Change in reading as probes are inserted causing a variation between adjacent readings.
Stony topsoil	Up to 20 %	Readings fluctuate about a mean level.
Ploughing	Up to 20 %	High readings at peaks, low in troughs.
Varying topsoil thickness	Up to 20 %	Readings fluctuate about a mean level.
Water on surface	Up to 20 %	Lowering in resistance associated with water area.
Vegetation	Up to 20 %	Localised change in resistance.

Table 6-4 (Part 1). Unwanted responses to non-archaeological effects (with a 0.5m Twin)

Cause	Change in Backround Resistance	Appearance in data
Non-visible features producing a response open to misinterpretation		
Ridge and furrow	Up to 100 %	Peak and trough can be mistaken for bank and ditch if only a small area is surveyed.
Old concrete foundations, mine workings and caps	Up to 200 %	May be misinterpreted as masonry, rubble etc.
Gravel pockets, rock outcrops	Up to 200 %	May be misinterpreted as masonry, rubble, stone filled pits etc. and may be as little as 1m across.
World War I, II structures made from sandbags	Up to 50 %	May be misinterpreted as hut circles, pits etc.
Ploughed out field boundaries	Up to 50 %	May be misinterpreted as banks or ditches depending on the backfill.
Depressions in gravel deposits, rock fissures filled with soil	Up to 50 %	May be misinterpreted as pits, ditches etc.
Field drains, gas, water + other service pipes	Up to 50 %	Appear as linear increases or decreases in resistance.
Sheep runs	Up to 50 %	Compacted soild gives an increase in resistance or, if water collects on the surface a decrease in resistance.
Underground streams and springs	Up to 50 %	May be interpreted as ditches and pits, though the response is usually diffuse.
Effect of weather		
Drought	Up to 200 %	Large increase in background resistance, effects of tree, bush roots made worse, contact resistance problems.
Heavy Rain	Up to 100 %	Large decrease in background resistance, especially over sandy soil types.
Frost	Up to 50 %	Differential frosting due to shading by buildings, trees etc. can produce a lowering of resistance these areas.
Snow and ice		Snow and ice are not conductors so it is not likely that they will directly affect readings. However the probes must be inserted through to obtain a reading.
Temperature		The temperature coefficient of resistance is about 2% decrease per 1 degree C increase which may cause a change in the background resistance during the course of a day. If the ground is frozen solid it will become non-conducting and it will not be possible to take a reading.

Table 6-4 (Part 2). Unwanted responses to non-archaeological effects (with a 0.5m Twin)