4.5 Geophysical Data Interpretation and Classification

All data have been processed and imported into the project GIS. Data interpretations are based on the author's knowledge of geophysical survey methods, predicted results, and site specific archaeology and geology. Due to the visual nature of geophysical data as well as the more complex 3D component of GPR data, all interpretations presented are the culmination of intensive and exhaustive examination in a number of forms.

Data interpretations and classifications are based not only on the identification of possible archaeological features in the geophysical data, but look deeper into the data in an attempt to gain greater insight into the geophysical properties of the archaeological features and their surrounding environment. This detailed interpretation is meant for integration with the results of the archaeological excavations and soil analysis.

In an attempt to keep geophysical data classifications consistent throughout, a relatively simple scheme is presented which identifies geophysical properties by levels of intensity or strength. These are high, medium high (med-high), medium-lowb (med-lowb), medium-low, low and, for magnetometry, dipole.

Not all categories are used on every site. The reasoning behind this is:

- High and low are the strongest values that appear as distinct black and white anomalies.
- med-high is a dark-grey but not black.
- Med-highb is mid -grey at the centre of the black and white scale.
- med-lowb is more to the white end of the grey spectrum (but not as light as med-low)
- Med-low is light-grey but not white.
- In the case of magnetometry, dipole groups the high and low parts of dipole features - not all black/white contrasting areas are identified as dipoles, as is evident in the case of B2, the southern part of the ring ditch is not identified as a dipole.

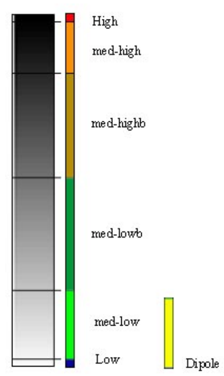

Figure 29. Greyscale division for magnetic interpretation labeling.

The variation between med-high, med-highb, med-lowb, and med-low in the magnetic data is to have distinct values that define features. As can be seen as an example in the B2_g_FM256 interpretations, the ring ditch is identified mostly as a medium-low feature, containing areas of low, and bordered by areas of med-high and high magnetic field strengths.

These differentiations are done with the thought that the actual soil properties are responsible for the signature in the geophysical data. The intent is not to simply identify the 'ring ditch', but to identify differences in the strength of the geophysical anomalies recorded irregardless of their match to a larger archaeological feature.

In addition to data strengths, data are classified in the GIS according to which data sets contain the interpretations - surface or gravel - and also the depth layers for each of the interpreted anomalies. This type of classification is done in order to create a fully analytical database, one that can be queried not only on geophysical method type, but field strength, surface or gravel survey and, where appropriate, the approximate depth of the sample. This is deemed necessary because techniques such as GPR and resistivity will map archaeological features according to the method array and survey methodology. As will be seen in the cases of pits, ditches and post-holes, resulting geophysical anomalies do not always appear in the data as may be assumed.

4.5.1 General observations

Though visible in data results, plough furrows were not identified as geophysical anomalies in the interpretations. Geophysical interpretations of the data were done to specifically highlight the archaeological features and their geophysical characteristics. Occasionally, geological background features are identified in order to place archaeological features within their geological background.

Occasionally plough furrows are highlighted but mostly because sections stand out as particular contrasts to surrounding values. Because the survey areas are quite small, it is possible that isolated areas of contrasting geophysical values, whether related to plough furrows or not, may also have some relationship to archaeological features, or contribute to the value of archaeological geophysical values. For example, if one area is particularly low resistivity that may coincide with a plough furrow, it identifies an area of slower drainage or otherwise higher water retention. This, though natural, may contribute to the resistivity of underlying archaeological features.

5.0 Geophysical Survey Results

The second phase of geophysical survey at the Catholme Ceremonial Complex produced a massive amount of data. Multiple geophysical survey methods mapped the ground surface and the natural subsoil (after removal of the topsoil) in 6 designated areas. Further geophysical surveys were conducted in four 2m x 5m excavation trenches at regular 0.2m intervals.

The dense sampling rate and careful data collection were done with the intent to collect the most detailed and scientifically rigorous data examples possible. The use of multiple geophysical methods was undertaken in order to study the results of each method individually and to study the comparison of the results. Additional sampling and testing were undertaken through the efforts of Mark Hounslow and David Jordan. Results from these three main survey efforts should be integrated to the large-scale geophysical survey in order to gain the most informed understanding not only of the response of geophysical methods to archaeological features but also the relationship between the properties of archaeological features and the relationship to their surrounding environment.

The results presented below are the culmination of intensive data assessment that has been conducted throughout the project from data collection in the field, post-processing, analysis up to the present interpretations and results in this report. The process of data evaluation employs multiple software packages, processing, assessment, and interpretation and presentation methods. Final images that are put forth below are the culmination of work conducted over the past seven months. Images in the report are data images and interpreted maps exported from the GIS. Though the graphic presentation of some of the data in this format is not the best possible, the format of a GIS enables the most accessible and comprehensive organisation of data.

5.1 *Area A1*

5.1.1 Magnetometry Survey Results

The magnetometry survey conducted over the area of the pit-alignment in A1 was dominated by a strong dipolar feature in the northeastern section of the area. This magnetic anomaly did not have any specific shape that reflected expected archaeological features and after excavation was proved to be geological in nature. The pits of the pit-alignment were not mapped from the surface of the survey area. A few medium-low magnetic anomalies were identified in the areas of the pits, but they could not be identified as archaeological in nature. The plough furrow or ditch crossing the area from the east to west was not identified through the surface survey.

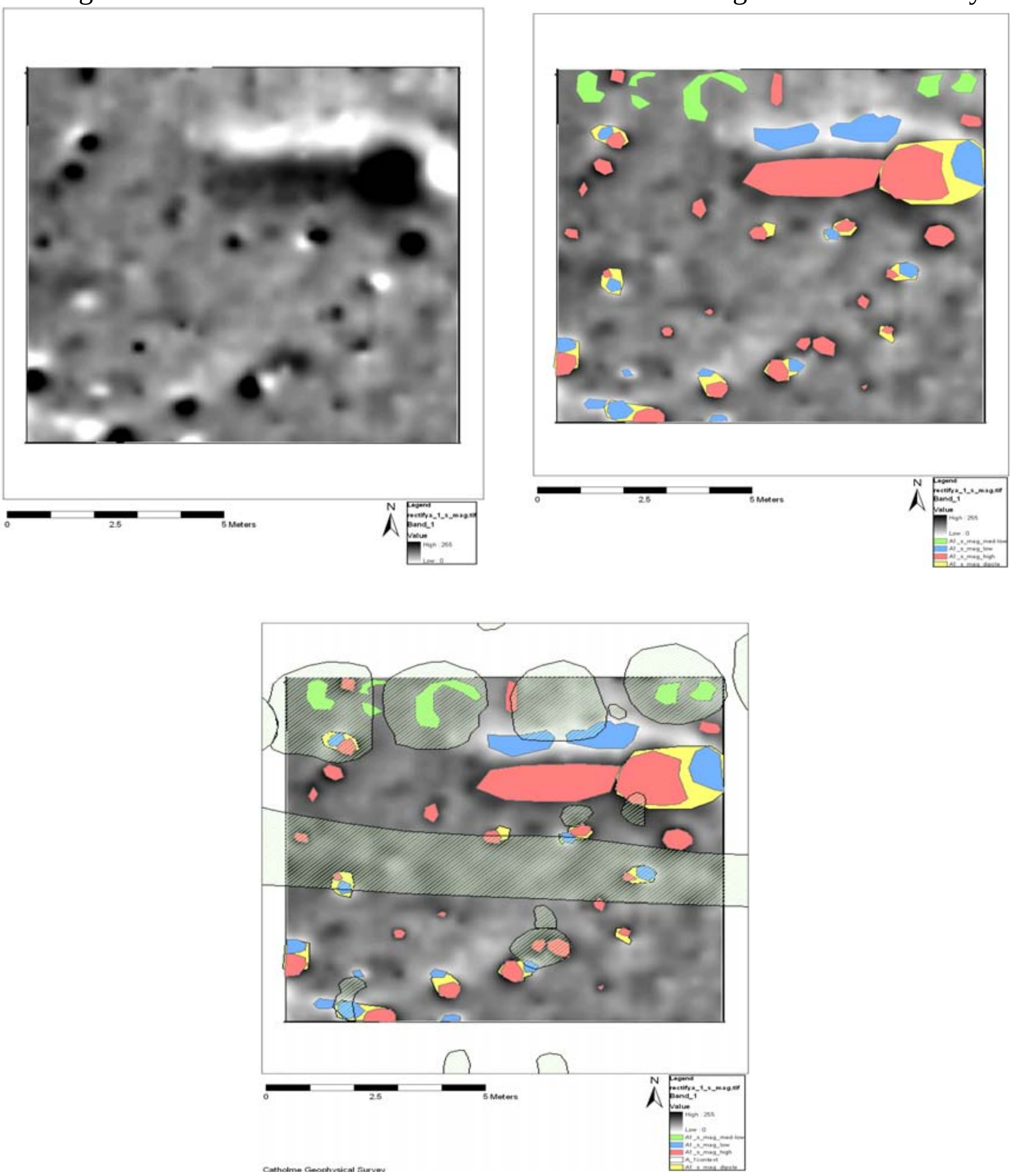

Figure 30. A1 magnetic surface survey data (top left) with interpretations (top right) and overlain excavation plan.

The magnetic survey on the natural subsoil was dominated even more than the surface survey by the strong magnetic dipole feature in the northeastern section of the area. Despite this fact, the pits of the pit-alignment were visible as weak, or low magnetic anomalies. The ditch that passes through the area could not be differentiated from the general magnetic background and patterns of the geological signature. The pit in the center of the southern edge of the area stood out as strong high magnetic anomaly.

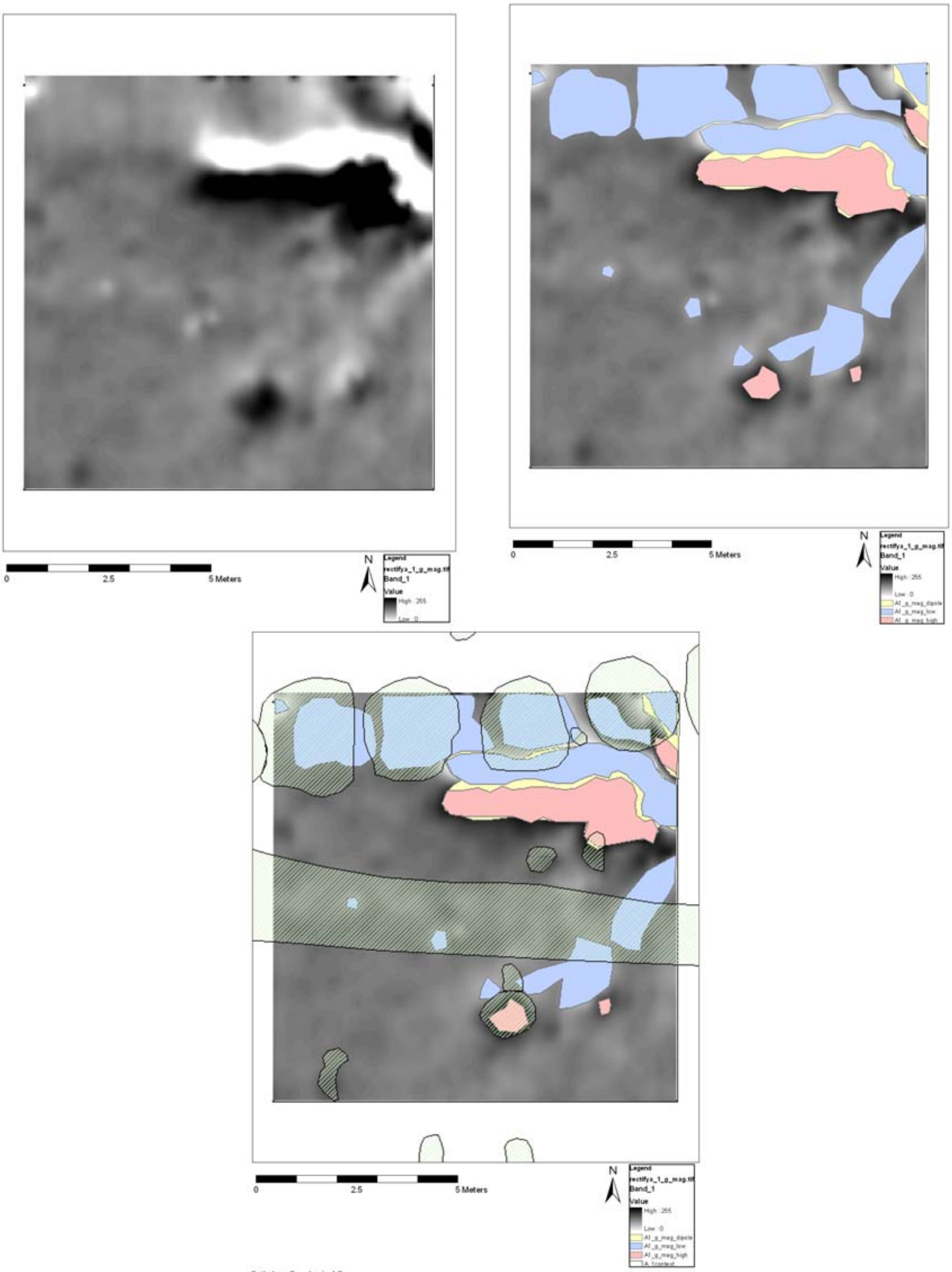

Figure 31. A1 magnetic gravel survey data (top left) with interpretations (top right) and overlain excavation plan.

5.1.2 Magnetic Susceptibility Results

Preliminary assessment of the results of the A1 magnetic susceptibility results did not show any obvious archaeological anomalies. A few linear features trending northeast-southwest were probably effects from plough furrows.

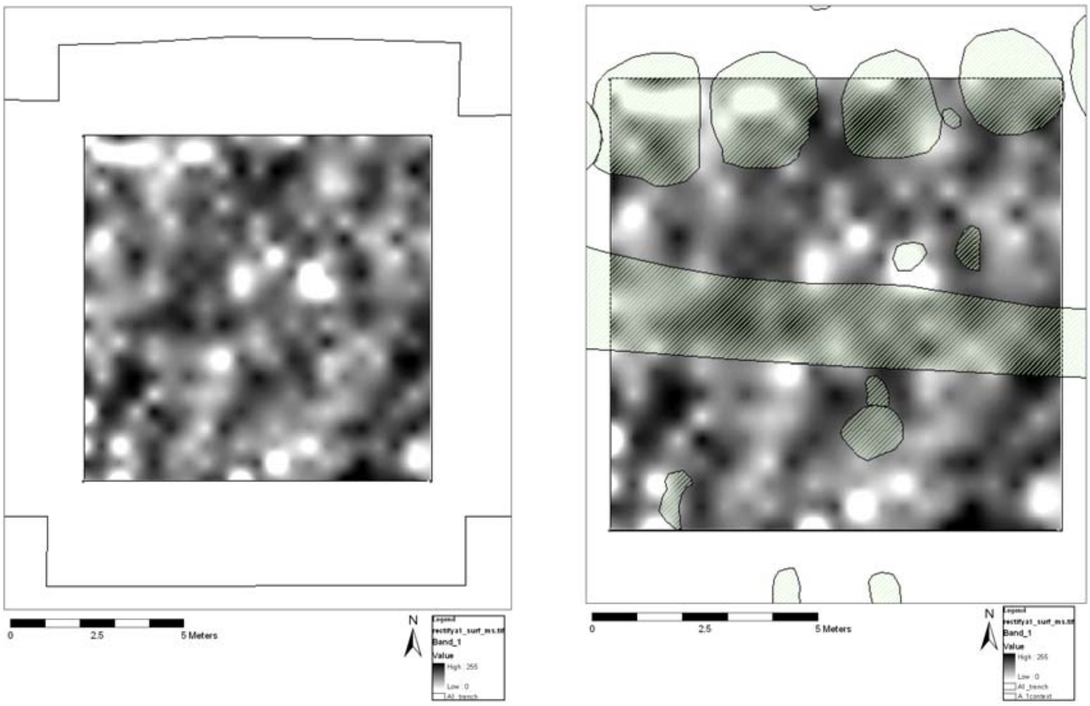

Figure 32. A1 surface magnetic susceptibility results (left) with overlain excavation plan.

The results from the gravel magnetic susceptibility survey revealed information on the archaeological features that were uncovered. Three of the pits in the pit-alignment were marked with low to medium low vales and the pit features on the southern edge were also mapped as low susceptibility features. The ditch crossing through the middle of the area was mapped as a medium low feature.

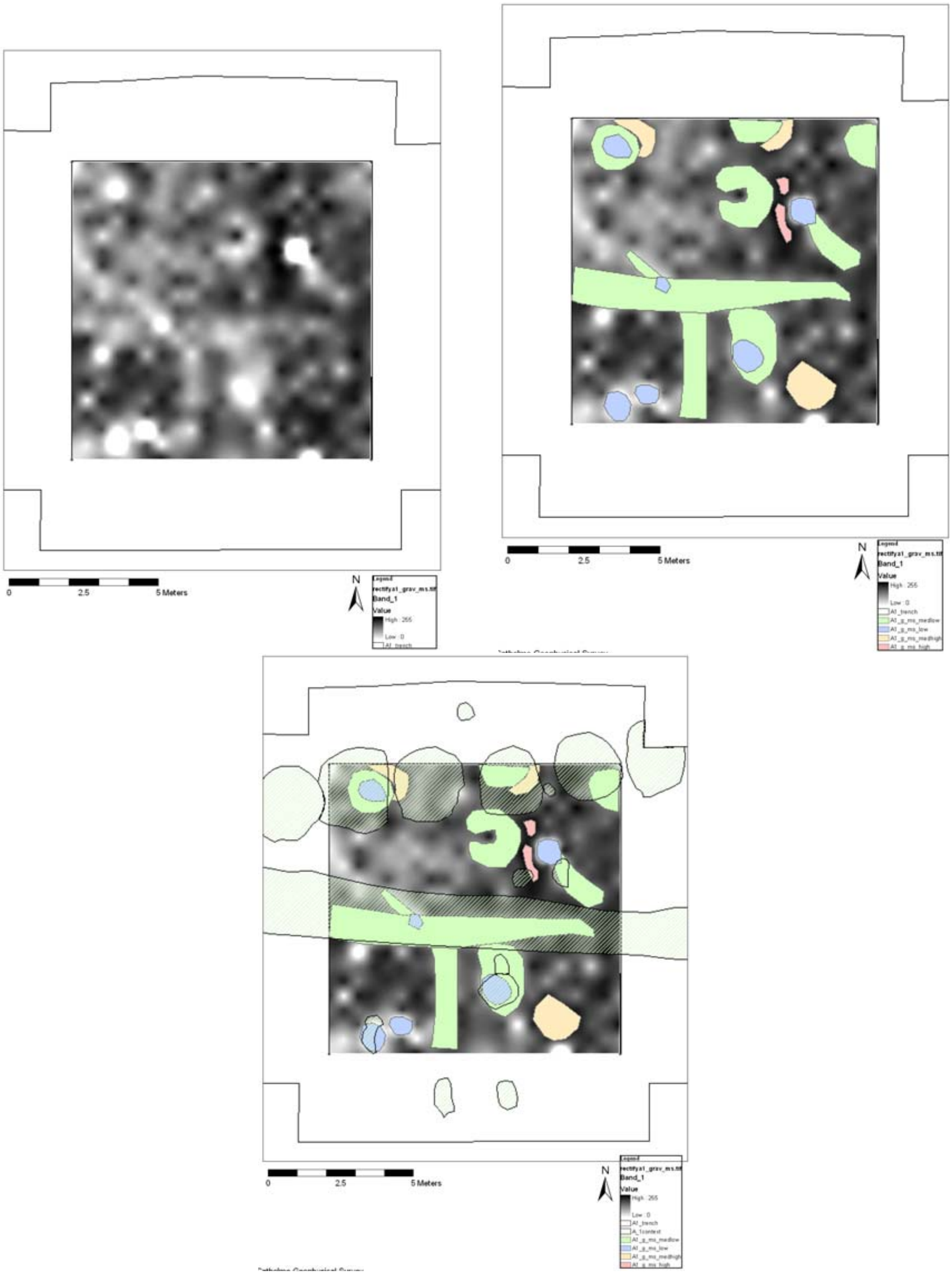

Figure 33. A1 gravel magnetic susceptibility results (left) with interpretations (right) and overlain excavation plan (bottom).

5.1.3 Resistivity Survey Results

Resistivity surface survey did not clearly reveal the underlying archaeological pit-alignment and ditch features. Plough furrows and general areas of high and low resistivity were most prominent in the surface survey data.

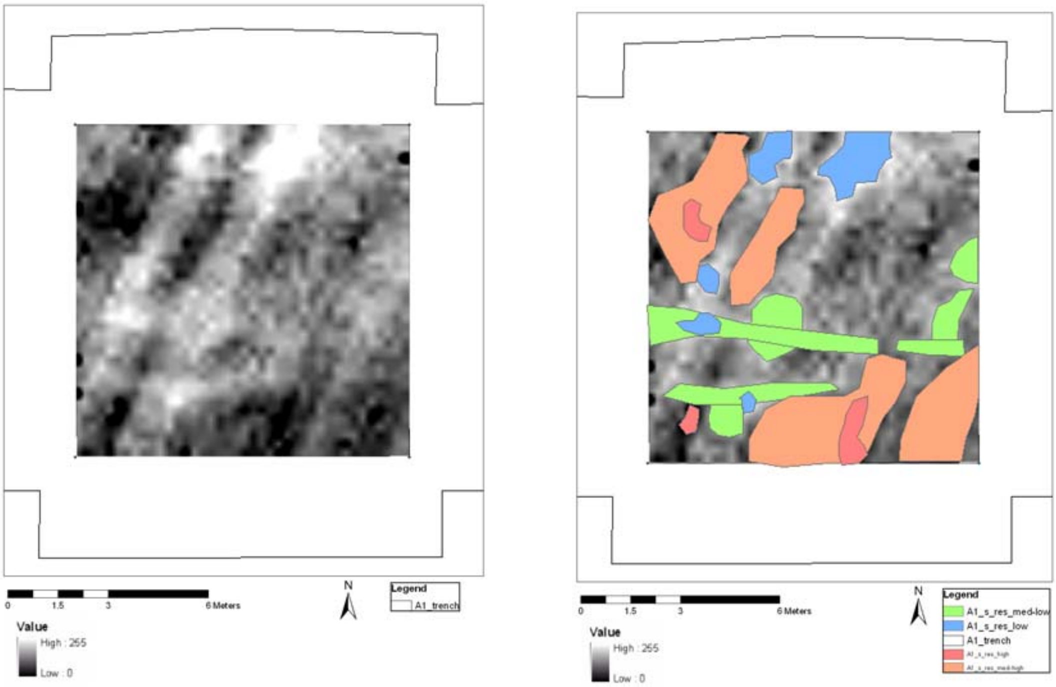

Figure 34. Resistivity survey data from 0.25m depth (left) with overlain interpretations (right).

One or two anomalies in the surface resistivity data may reflect the underlying pits of the pit-alignments. In the image below the very bright white, or low resistance anomaly in A1 resistivity level 0.50m corresponds with a pit (A) and the light grey linear feature corresponds with the shallow ditch (B) crossing the area. If background knowledge and ground truthed results were not known these anomalies would not stand out as probable archaeological features.

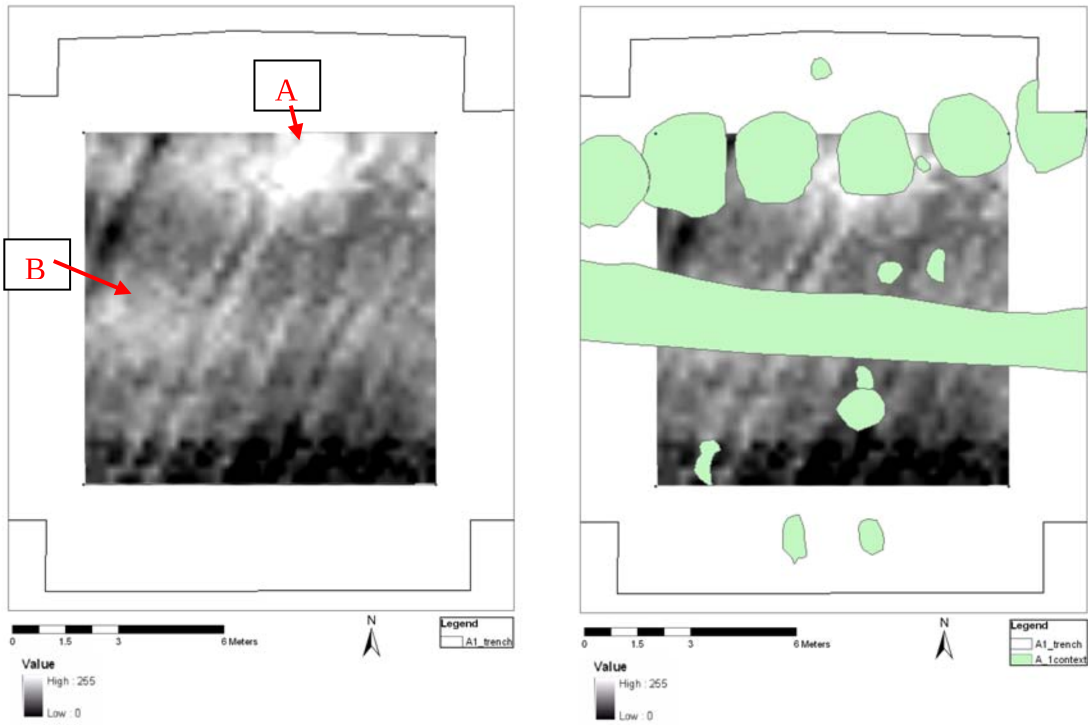

Figure 35. Resistivity survey data from 0.50m depth (left) with overlain excavation plan (right).

Despite surveying to multiple depths, the interference of the topsoil properties was significant and the archaeology was not easily mapped. If we were to rely upon just this survey, even with the high density sampling rate (0.25m x 0.25m) and multiple layers that we believe should provide more detailed information to underlying features, we would not have been able to accurately map the pit-alignment and the ditch. The criteria for identifying a feature such as a pit-alignment were to find anomalies (like the low resistivity anomaly in the above image) that may represent the pits. A pit-alignment would have multiple pits in a line, so the positive interpretation of this feature would be a repeating pattern of low resistivity anomalies. With only one high resistivity anomaly, it was not possible to identify it as a pit or as part of the pit-alignment.

After the topsoil was removed and the area re-surveyed with resistivity, not only were the archaeological features mapped, but additional information was collected regarding specific background material and archaeological feature resistivity properties. Due to the sandy gravel material in the majority of the survey areas, resistivity probe contact was difficult at times, this accounts for the missing data that are seen as black dots in some of the data layers.

The first resistivity map to a depth of 0.25m showed all of the archaeological features. The pits of the pit-alignment were low resistivity anomalies and the ditch running across the trench appeared as a medium-low resistivity anomaly. The difference between these signatures may have been that the ditch feature was much shallower than the pits, thus retained a smaller percentage of moisture. Other reasons for higher or lower resistivity values of different archaeological features were the composition of the fills that define each feature. The pits may have had a different purpose, and thus fill material, while something like the ditch across the trench may have been filled mostly with the surface plough material.

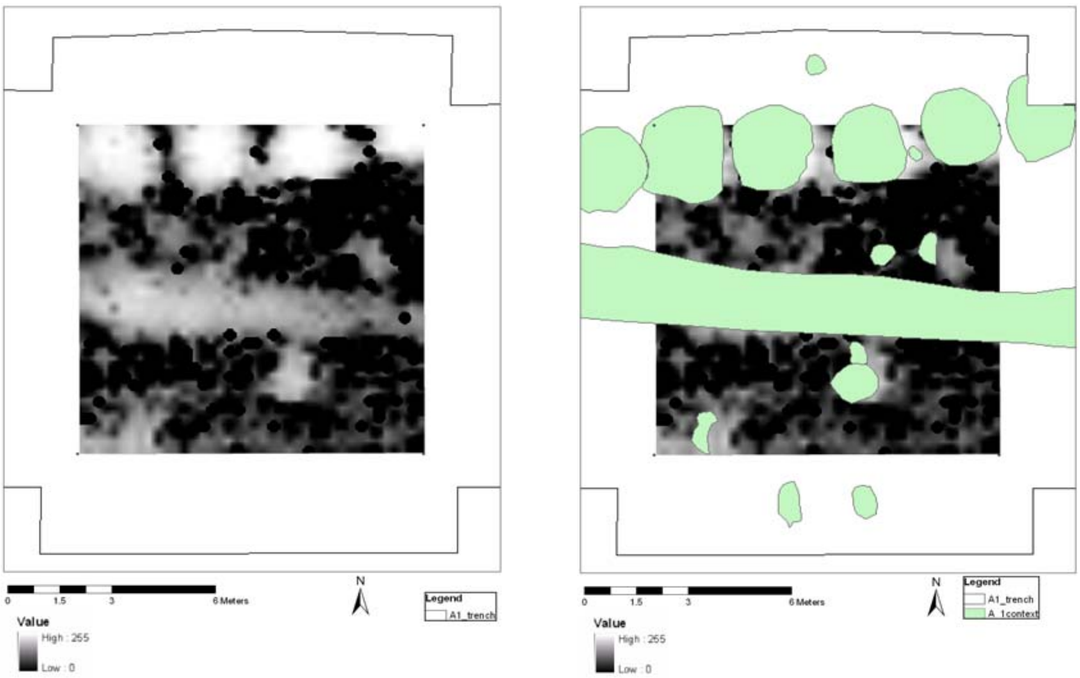

Figure 36. A1 gravel resistivity survey results at 0.25m (left) with overlain excavation plan (right).

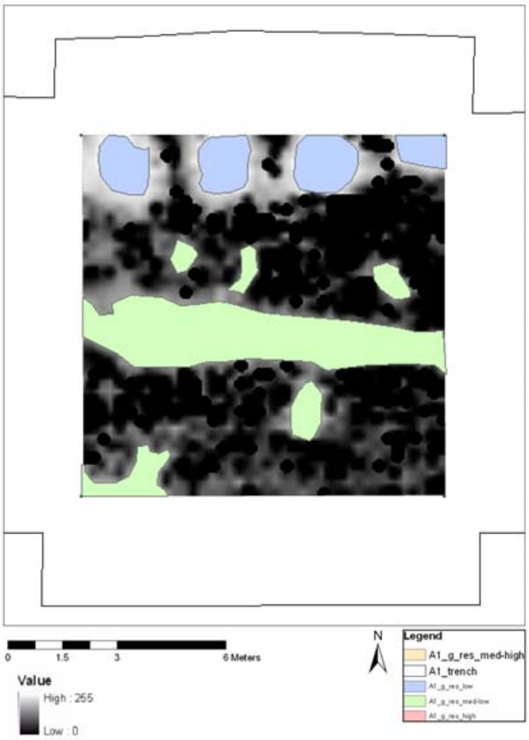

Figure 37. A1 gravel survey at 0.25m with data interpretations that map the same details as the excavation plans.

The results above were expected from the resistivity survey, as from other geophysical methods. If we can see the archaeological features, we should be able to map them by geophysical means, and if not, as in the case of the magnetic survey in this area, be able to provide an explanation.

As the resistivity maps increased in depth, it is important to keep in mind the potential introduction of artefacts from near surface features into the data. Close scrutiny of the data attempted to contribute to a better understanding of the archaeological features and their relationship with the surrounding soils but only after inversion of pseudosections could a more intrinsic comprehension of the resistivity data be gained.

Without the consideration of inverted pseudosections there is great danger of over interpreting the apparent resistivity maps. As an example, area A1 has been interpreted taking each depth of the resistivity mapping as a valid representation of the earth at that approximate depth. At the end of this section, an example of pseudosection inversion is presented which highlights that further work should be undertaken in order to gain a detailed understanding of what lies beneath the surface of our survey areas.

Example considering only apparent resistivity maps at each depth sampled:

At 0.50m depth, the pit-alignment continued to be a strong anomaly with the pits' resistance to the current passing through them slowly increases.

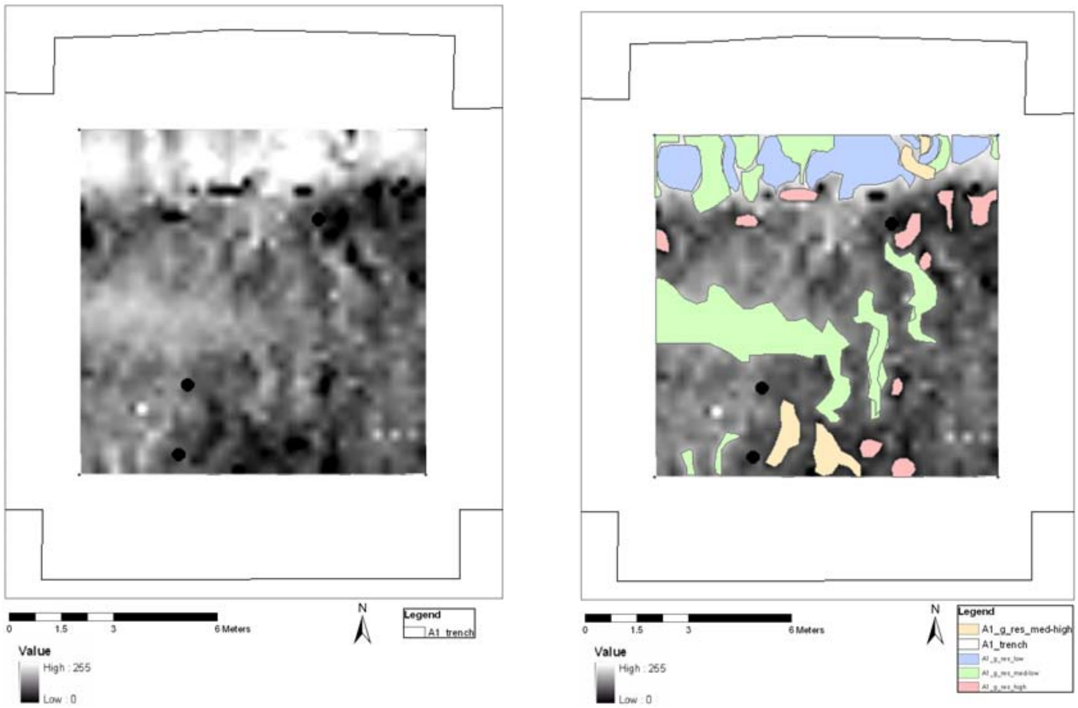

Figure 38. A1 resistivity at 0.50m depth (left) with interpretations (right).

One explanation was that the pits change in shape, becoming narrower with depth. The pits changed in the resistivity data at 0.5m and other low resistivity anomalies appeared at the same depth that did not correspond to the pit anomalies.

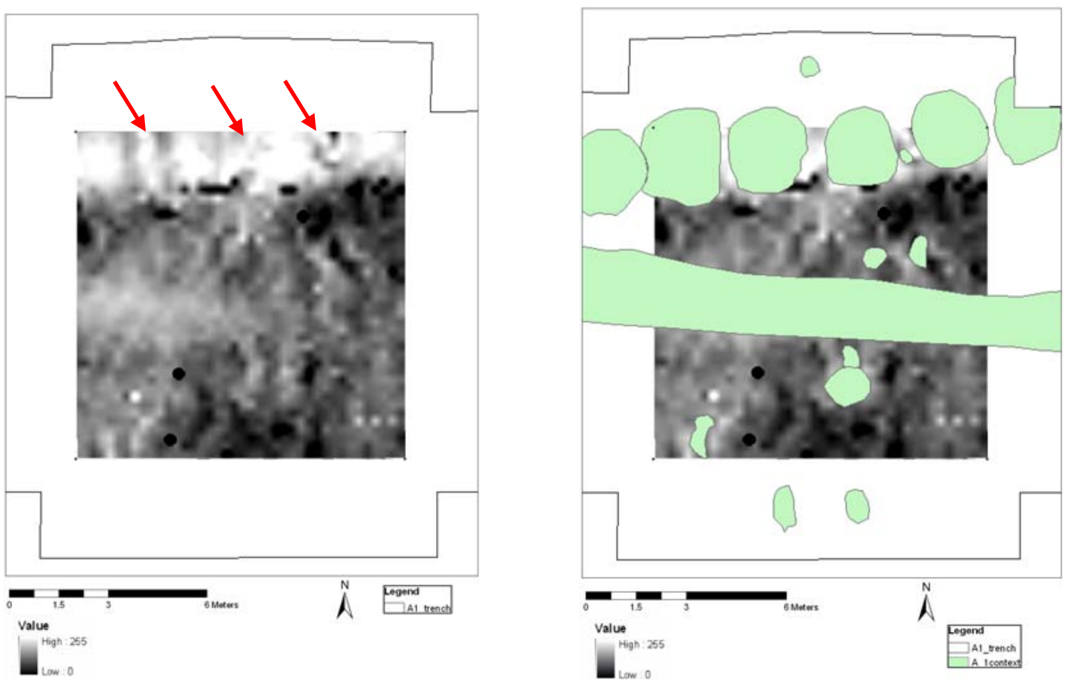

Figure 39. A1 resistivity gravel survey at 0.5m (right) with overlain excavation plans (left). The red arrows identify anomalies that do not correspond directly to the plan.

These smaller low resistivity anomalies may be mapping the actual edge of the pit where there could be a higher contrast between the saturation of the edge of the pit and the surrounding sandy gravel material of the background.

Further investigation of the data down to 0.75m depth showed the pit anomalies as higher resistivity anomalies. Some specific areas remained low resistivity. This may reflect the shape and fill of the pits in that the area toward the edges has a gradual dip (A) down toward the pit then approaches a steeper (in some cases almost vertical) dip (B) toward to bottom of the pit.

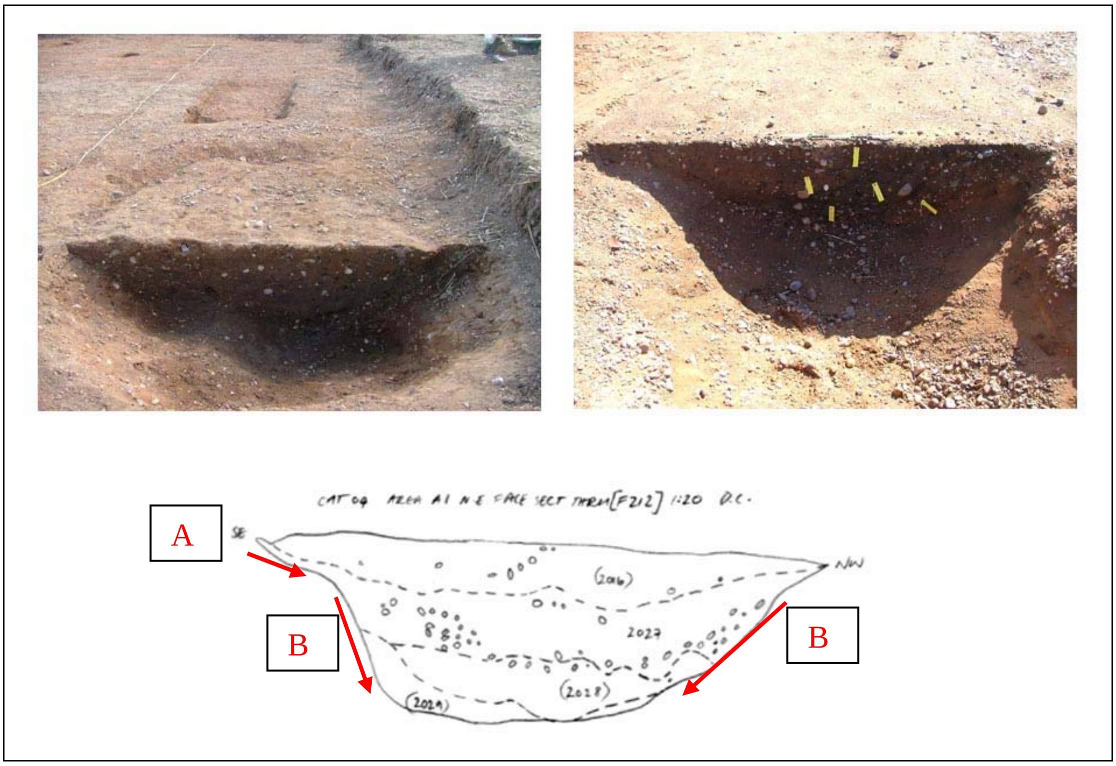

Figure 40. Two examples of pits from area A1's pit-alignment. The sketch defines F212, the pit on the eastern edge of the area.

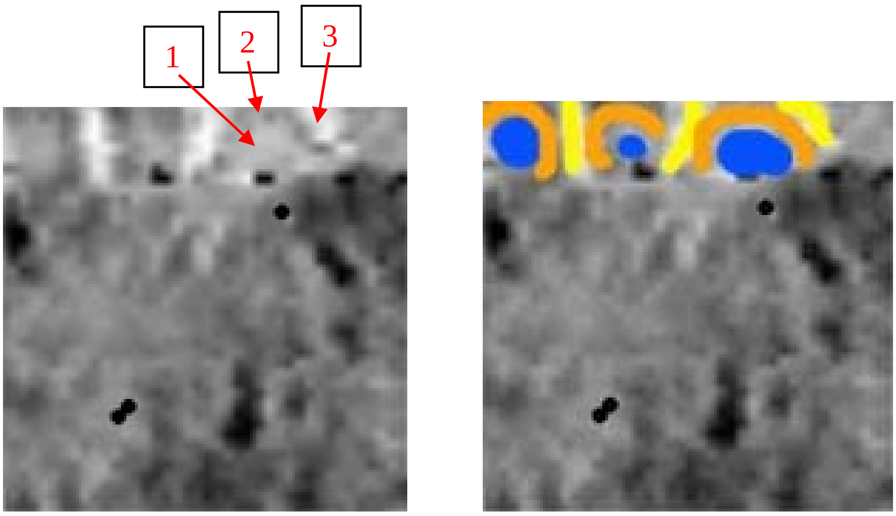

Figure 41. A1 resistivity from the gravel survey at 0.75m depth (right) highlighting possible pit structural responses to resistivity survey (right).

At 0.75m the difference between the centre of the pit as a low or mid-low resistivity anomaly (1 - blue), to the mid-high resistivity (2 - orange) again to the very low resistivity (3 - yellow) anomalies that appear may reflect the structure of the pit and pit fill detected at each point. This might explain the low resistivity (3) at the edges where it is a stronger feature on the surface that is showing in the 0.75 level; then the higher resistivity (2) reflecting the steep dip of the pit, thus the sand-gravels having some influence on the readings at the edges of the pits, and (1) the lower resistivity at the centre of the pit actually being the reading from the mass of pit fill that again would retain more moisture.

Up to this point, all the possible explanations to explain details in the resistivity maps are feasible. However, examination of inverted pseudosections over the pit-alignment feature clearly illustrates the danger of over interpretation.

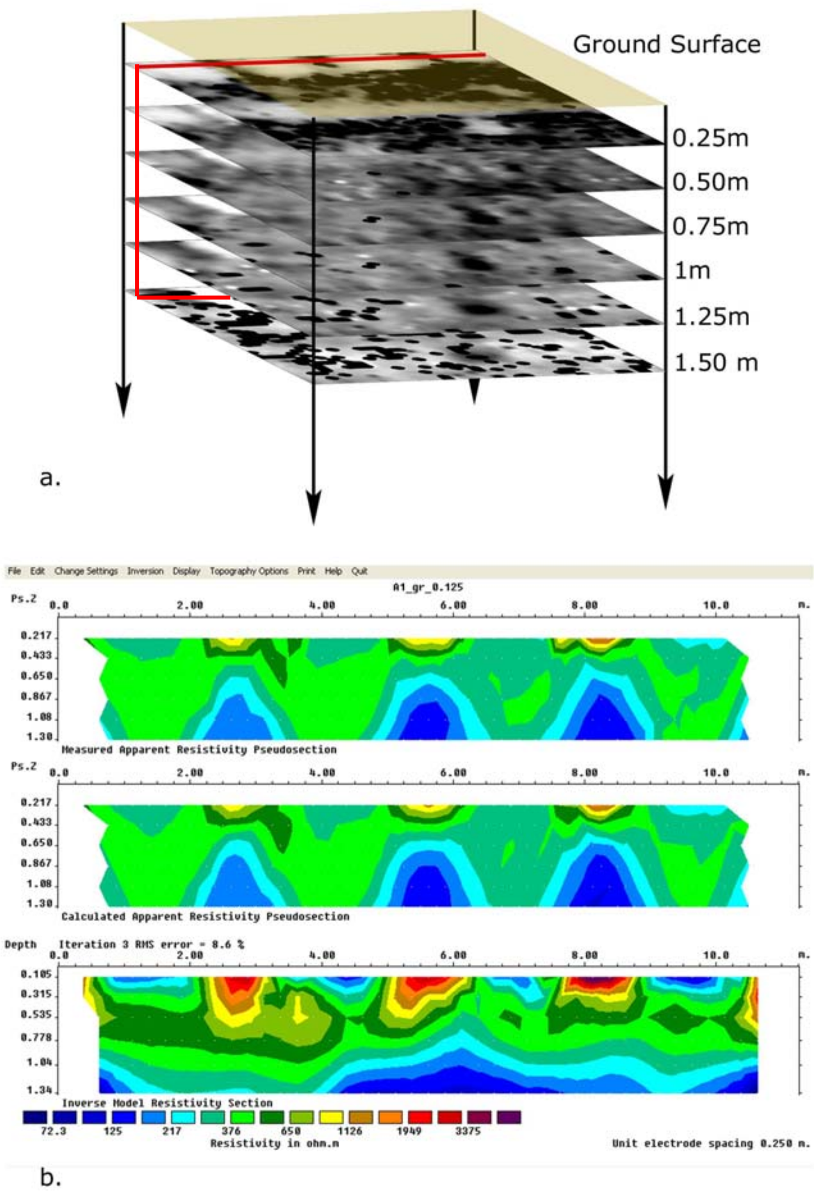

Figure 42. Image a. represents the vertical component of the multi-plexed resistivity data. The three plots of measured resistivity in b. present a single pseudosection inversion. The data represented here are a profile across the pit-alignment (red line in a.).

The resistivity plots above clearly illustrate the importance of pseudosection inversion (Figure 42b). The interpretations conducted in the section above can be directly compared with the top psuedosection of plotting raw resistivity data. The anomalies that have been identified in fact are artefacts in the data that are removed after inversion.

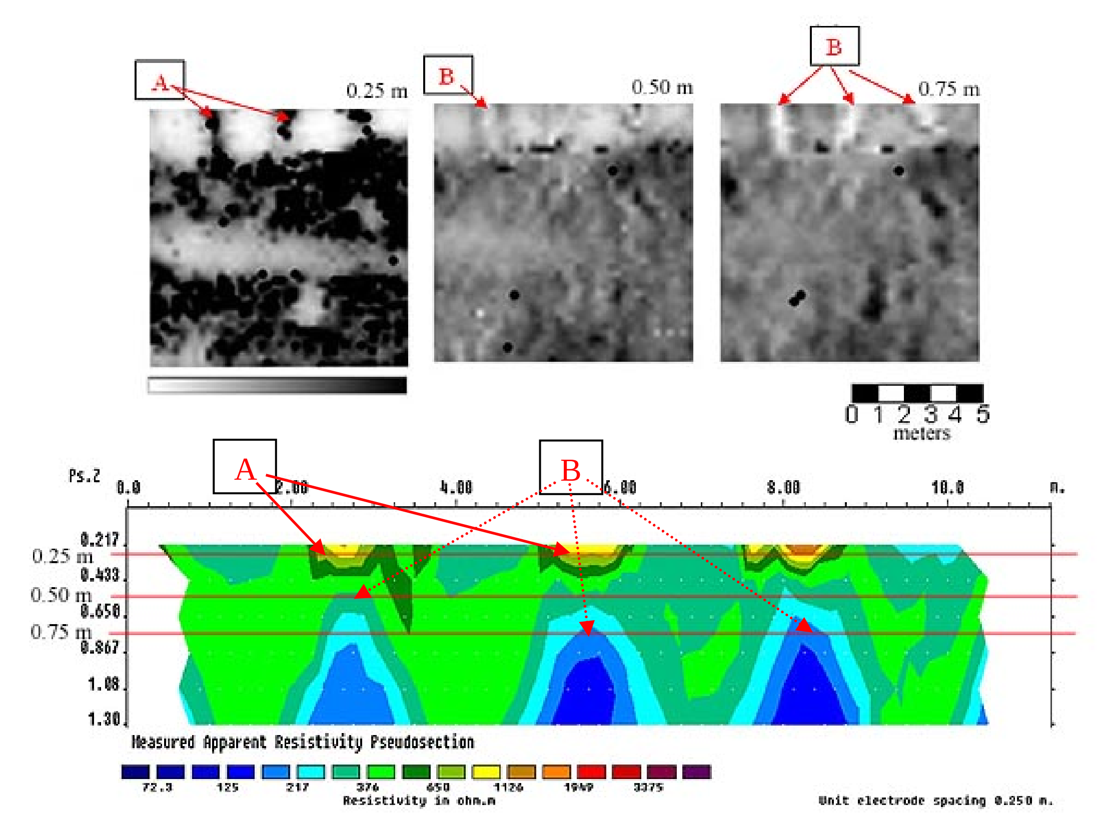

Figure 43. Comparison of apparent resistivity plan to graph of raw resistivity pseudosection.

Once the pseudosection is inverted the results sharpens the high resistivity anomalies and the low resistivity anomalies disappear (Figure 44). This confirms that the low resistivity anomalies are artefacts of the data collection method.

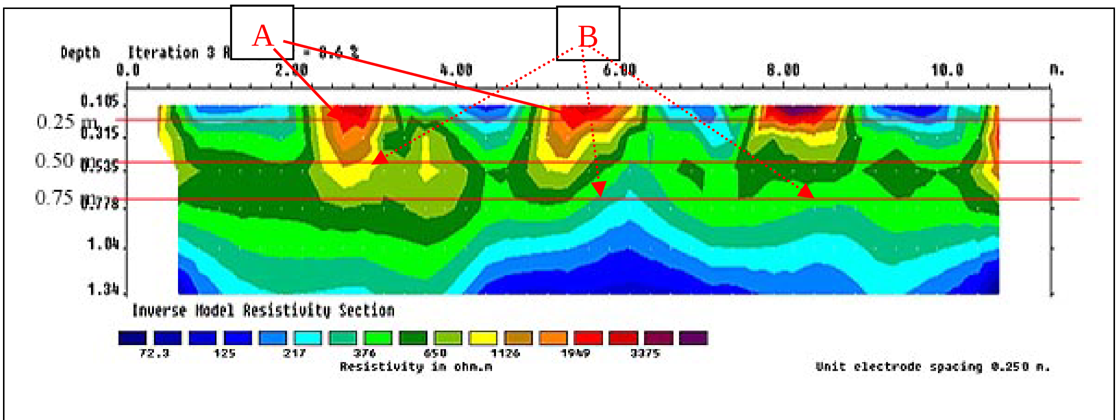

Figure 44. Resistivity inversion graph after three iterations with apparent resistivity plan.

The final inverted image gives the most realistic representation of the actual structure of the archaeological features and background materials through resistivity property mapping.