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Archaeological geophysics for mere mortals: the use of GEOSPAN© in archaeological training and site assessment

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30.1. Setting the scene

Despite silicon's meteoric strides in bringing the power of personal computing to the desktops of millions, the world of geophysics has failed to match this in bringing its own similar advances to the site-hut.

The past decade has seen the archaeologist presented with — and using — a plethora of software tools enabling him, for example, to catalogue his finds in a database, to evaluate their incidence using spreadsheets and graphs, to map stratigraphy levels using Geographic Information Systems and to publish overall results in a professional-looking document.

Just as it is no longer necessary for the archaeologist to engage a professional typesetter in order to publish a comprehensive site report, can a similar analogy be applied to the use of software tools as an aid in the interpretation and presentation of geophysical results within an archaeological environment (Fig. 30.1)?

This paper examines some of the issues which will need to be considered in arriving at an answer to this question and comes to the conclusion that, with certain important caveats, the answer is generally in favour of such an approach.

30.2. Technical and financial considerations

The increase in archaeology degree courses specialising in scientific aspects of the subject, coupled with a growing number of both undergraduate and postgraduate certification programmes and the retirement and, sadly, the laying-off, of highly experienced staff have all led to a steady rise in the number of competent and professional geophysical surveyors available to carry out commissioned work for the archaeologist. However, notwithstanding this rise, the available funds to allow excavation of the ever-increasing number of newly-found sites of historical and archaeological interest — particularly those discovered as the result of new road and building construction — are not proving sufficient to keep pace. Thus it is, that many such sites are being mapped and recorded from little more than the geophysical evidence alone.

Given the above scenario, geophysical surveys conducted by outside organisations tend to be (understandably) expensive in terms of man-hours spent, travelling distances covered, amortisation costs of equipment used and subsequent computer analysis of the retrieved data.

Whilst often recognising the potential of geophysical techniques, the price-conscious commissioning archaeolo-gist in the recession-torn 1990s is nevertheless faced with having to consider not only the costs of the survey and, in all probability, the fees of the geophysical consultant, but also the limited results available with a single type of interpretive presentation.

In some cases, the archaeologist will have access to his own organisation's resistivity and/or magnetometry equipment but in such cases he will still need to mathematically filter, statistically analyse and expertly interpret the resultant data.

If geophysical software is to have any place in the repertoire of tools used by the archaeologist, then as a minimum it must be:

- Intuitive
- Easy to learn, to teach and to use
- Free from mathematical jargon and the "buzz words" of other disciplines
- Easily interfaced to manual procedures and existing software tools
- Able to understand and differentiate data from a variety of geophysical instruments
- Context-aware in order to filter the data to emphasise the differing features' characteristics
- Capable of producing different types of presentation results (e.g. wireframes, dot densities etc.)
- Accurate and reliable
- Usable both on- and off-site
- Cost-effective.

Additionally, it should not necessitate the purchase of any additional computer equipment or peripherals other than those already used by the archaeologist.

30.3. Advantages and disadvantages

Software which complies with the above requirements confers on the archaeologist a number of freedoms not normally available without using (and paying for) a geophysicist's time (see Fig. 30.2), viz. to:

- inspect the raw field data
- analyse it according to the *archaeological* context
- view and print the results in a variety of graphical presentation formats
- work on the data both on-site and back at base
- train students in the use and interpretation of geophysical techniques and the methodologies used to distinguish real and imaginary features
- automatically export and import the results to and from other software packages such as Desk Top Publishing and Geographic Information Systems.
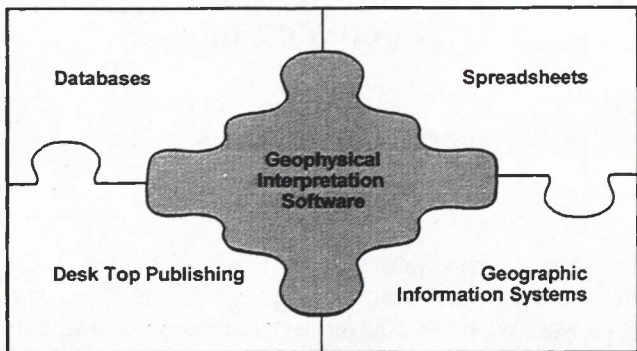
Figure 30.1: Geophysics — The archaeological missing link.

The above list clearly demonstrates some of the potential gains to be achieved by using such software; however, there are also disadvantages to this approach and they should not be underestimated:

- a machine is no substitute for the knowledge and experience of a consulting geophysicist, especially one who is also trained in archaeological technique
- there is a very real and oft-repeated danger of the archaeologist misinterpreting geological anomalies, background noise or random shapes as archaeological features
- features which really do exist (and which may be hidden in the data) are not always apparent
- geophysical software is a tool, not a guru; as such will only act as a "road map" to the underlying information; it is for the trained eye of the archaeologist to *interpret* this information in the light of his own knowledge and experience.

In a series of case studies, the remainder of this paper attempts to demonstrate how a tool such as GEOSPAN© (more fully described in Bullas 1990; 1993) may be used to meet the basic requirements outlined above, at the same time pointing out some of the (literal) pitfalls open to misinterpretation by the inexperienced user.

ADVANTAGES

✓ Multi-format analysis and presentation capabilities

✓ Immediate, realtime usage

✓ Easy to use & understand

✓ On- and off-site training

✓ GIS & DTP compatible

✓ Extremely cost-effective

DISADVANTAGES

✗ No substitute for a pro.

✗ Danger in unskilled hands:
  - imagined features
  - missed features

✗ Potentially unrealistic expectations

Figure 30.2: Own use versus professional survey.

30.4. GEOSPAN© — the product

GEOSPAN© is a DOS-based software product capable of being run on a wide range of IBM® and compatible personal computers. Under licence, it may be used by any archaeologist having access to an INTEL® 8086-based pc with monochrome screen and hard disk running under MS-DOS® Version 3 or higher. However, the use of a faster CPU with maths co-processor, VGA colour screen and a mouse will greatly enhance the computation speed, the quality of results and the general ease of use. Additionally, the product supports hardcopy output to most makes of dot matrix, laser and ink jet printers and to graph plotters.

GEOSPAN for Windows© is a series of powerful extension utilities running under Microsoft® Windows™.

30.5. Use and abuse

Fig. 30.3 shows a portion of the field data gathered at the Romano-British *oppidum* of Caerwent in South Wales using the Howell Soil Conductivity Meter (Howell 1966). This instrument was used with considerable success at South
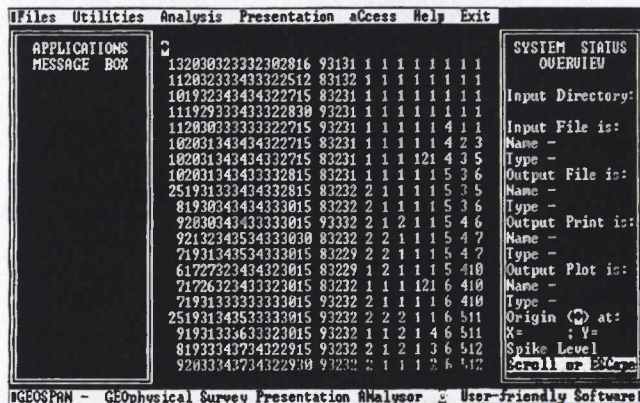

Figure 30.3: GEOSPAN© Column filter processed data.

Cadbury (Musson 1968; Alcock 1972) but its popularity declined rapidly in later years due to the seemingly inconsistent results obtained when compared with those using more conventional instruments at a number of other sites. It was subsequently demonstrated (Mullins 1974) that the name "conductivity" is somewhat a misnomer for this type of instrument in that for all but the very largest of archaeological features lying close to the surface, the majority of deflections displayed by the instrument from the background norm are due to contrasts between the magnetic susceptibility of a buried feature and that of the topsoil or are caused by the occasional spike of an underlying metallic object.

It is of vital import, therefore, that the geophysical software, or its user, is aware of the different environmental effects that geology and topology can have both on choice of instrument for a particular site and on the subsequent analysis, filtering and presentation of results. Good software will relieve the archaeologist of the need to consider this latter problem since the program should simply ask the user the
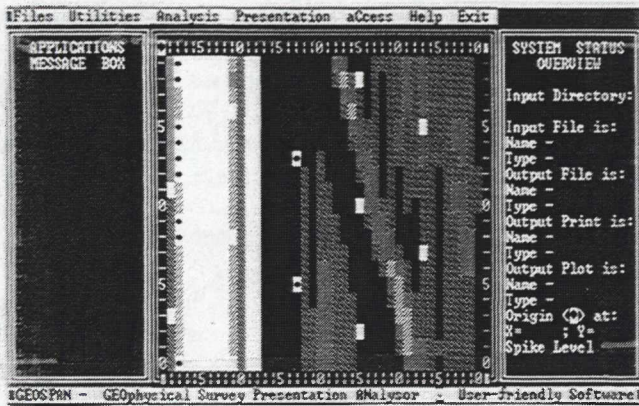
Figure 30.4: GEOSPAN© Column filter colour contour.

type of field instrument being used and then automatically apply the appropriate type of filters.

Using the above data, Fig. 30.4 shows one form of presentation output, Colour Contouring. On a colour screen, the user will usually see anomalies such as walls, roads *etc.* displayed in dark brown; pits and post holes will be shown in dark blue; anomalies between these two extremes are shown in yellow, dark green, light green and light blue similar to the colour gradients used on a standard Ordnance Survey map.

On a monochrome screen, the colours are represented in various shades of grey (grey-scales) as also they are in a monochrome publication such as this. Note that the horizontal scale (indicating the number of readings) has changed between Figs. 30.3 and 30.4 (numbers take up more space on a DOS-screen than do graphical representations).

The survey was carried out in a now-disused field lying in what would have been the south west corner of *Insula II* (Brewer 1993). The readings, which were taken at close intervals of ¼m in both axes, are aligned on the street grid system of the Roman town with North approximately at the top of the diagram. The horizontal distance shown in the viewport is therefore 10m., the vertical distance, 5m.

The large linear feature to the left shows the easterly half of the second or third century street dividing *Insulae I* and *II* with a ditch dividing it either from the contemporary outside wall of a (supposed) town house, perhaps similar to the ones found in the facing corners of *Insulae I* and *VII* or from a compacted walkway edging the street. Excavated evidence in adjacent areas demonstrates the reasonableness of this interpretation. However, the diagonal "feature" running from near the centre of the diagram in a south-south-easterly direction had been conjectured as a medieval field boundary by both the user and some of the archaeologists. Subsequent reference to the site director revealed that it was almost certainly the known course of a modern pipe (!) and herein lies the first problem with using geophysical software: the user "sees" what he expects to see and interprets accordingly.

The rivet-type "features" running north-south near the westerly edge of the diagram were viewed by some as post holes; however, this is again a faulty interpretation. In a small

area such as this (800 closely-spaced readings) and when using certain types of filter, anomalies close to a boundary may well be the result of statistically-poor data; it is never reliable to place great confidence in anything within at least one reading, preferably two, from a single edge and within two readings from a double edge. The second lesson to be learnt, therefore, is to know and understand the impact of using different filtering methods. Again, good software will be cognisant of this and its User Manuals should fully explain the consequences. As a general rule, as large an area as possible should best be surveyed *at one time and by one person.*

Fig. 30.5 shows the above readings combined with those taken from an identically-sized area to their immediate south, here displayed in a different type of presentation, dot-density. Again, note the scale change, this time in the vertical axis, indicating that there are now the results of some 1,600 readings in the viewport and representing a ground area of 10m x 10m.

Towards the bottom-left of the diagram, what is conjectured to be a modern intrusion cuts through the street; although it was originally thought that this lay parallel to the modern pipe, closer inspection of the alignment reveals that this is not the case. Neither the geophysics nor, without excavation, the archaeologist is able to definitively interpret this anomaly. It should be noted, however, that the supposed "post holes" have now disappeared.

The above examples illustrate just how easy it can be to misinterpret information which "stand-alone" surveys and their results may produce without reference to expert professionals from the related discipline. Conversely, however, it is just as easy to miss features which may be present as anomalies in the data but which do not show up clearly in certain types of presentation.

Fig. 30.6 shows the same area of 1,600 readings as in Fig. 30.5, but this time presented as a wireframe diagram. From each horizontal set of readings in this type of display, the software builds composite traces, one in front of the other, such that the user sees a pseudo-3D profile of the data under investigation; the amplitude in the z (third) axis is directly proportional to the strength of the reading after application of a smoothing algorithm using a Fourier trans-
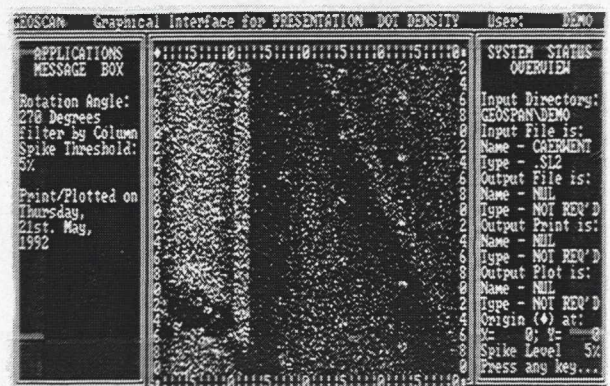

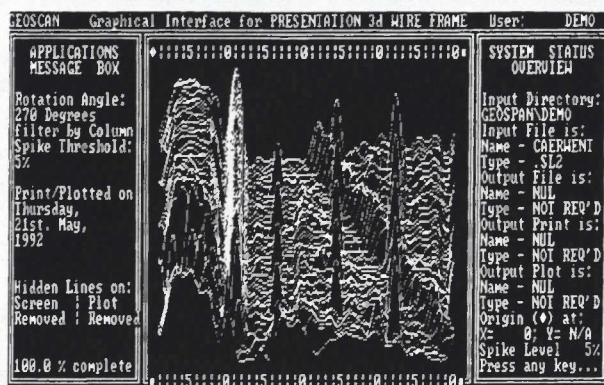*Figure 30.5: GEOSPAN© Column filter dot density.*

Figure 30.6: GEOSPAN© Column filter 3D wire frame.

form. In this type of view, therefore, a scale on the vertical axis would be meaningless.

In the bottom-left foreground, the modern (?) intrusion is shown distorting the other readings. However, the main bulk of the street, together with the possible ditch to its right and the immediately adjacent wall or pavement are clearly seen, as is the modern pipe running diagonally across the picture from centre-top to bottom-right.

This presentation introduces two new interesting questions, viz.: does the pipe really continue to the very top of the picture as seen here (cf. Fig. 30.4 which shows a possible break at around Parallel No. 7, 1¾m south of the northerly boundary) and what are the spike-shaped objects which now dominate the picture?

In order to more closely examine these anomalies, Fig. 30.7 shows the result of choosing individual sections from the composite in Fig. 30.6. Again, note the change in vertical scale.

As indicated by the markers (+) on the vertical axis and the Y co-ordinate value in the System Status Overview box, Parallel Nos. 1 and 13 (¼m and 3¼m south of the northern boundary respectively) have been selected. The profiles generated represent a geophysical approximation of what would be found in archaeological section taken at those points. In both sections, the expected street, ditch and wall / pavement show clearly as does the anomaly attributable to the pipe. The answer to the first question posed is, therefore, that the pipe does run all the way through the two ar-
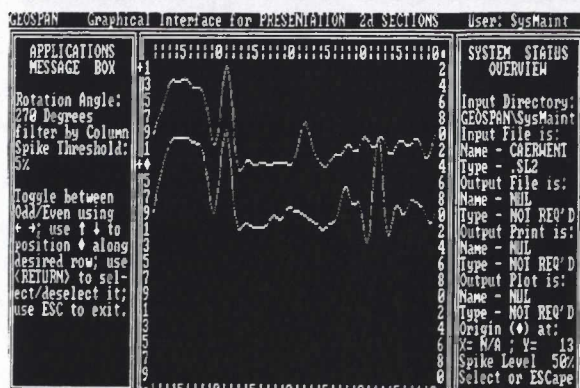

Figure 30.7: GEOSPAN© Column filter 2D sections.

eas selected. It is important to remember that this was in some doubt from the contour plan alone (Fig. 30.4).

With regard to the second question, Section 13 has been chosen as one in which a spike-shaped object is present just to the right of the pipe and at Traverse No. 32, 2m. west of the easterly boundary. This anomaly, typical of all the others of similar type, must represent a substantial masonry, mortar, rock or rubble feature — a post hole or pit, for example, would have had a downwards pointing profile. Given the benefit of similar finds in adjacent *Insulae*, it is strongly supposed that the anomalies are due to the multiple and relatively-massive sandstone *pilae* (hypocaust pillars) which were used to support the now-collapsed paved floor of a further townhouse.

From the archaeological evidence in adjacent areas of the excavation, it is known that this area sustained a period of substantial rebuilding of similar structures during the fourth century. Quite often, there seemed to be no particular empathy for maintaining the integrity of previous rights of way, with new religious buildings and other constructions encroaching over the streets of the previous century
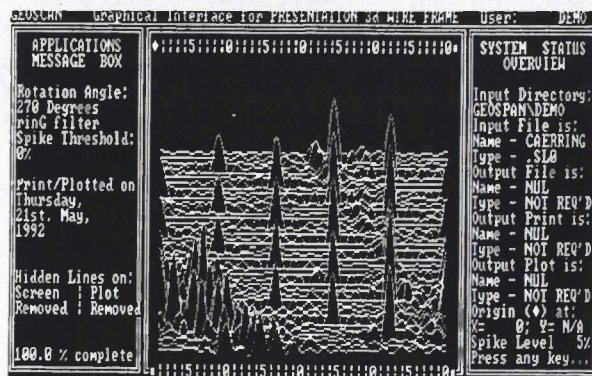

Figure 30.8: GEOSPAN© Ring filter 3D wire frame.

(Brewer 1993). Could the geophysical results from this survey make any observations in this regard?

In order to test the evidence, and also to perhaps infer something of the wealth and local political influence of the building's owner, the software can be instructed to remove the street and associated features. One method by which this may be accomplished is to use a different type of analysis known as Ring Filtering; the data can then be replotted using the wireframe presentation facility to give the results shown in Fig. 30.8.

Comparing Fig. 30.4 and 30.8, it is quite clear that these anomalies do, in fact, encroach at least partly on the street, thus upholding the theory that the building to which they belong post-dates it. Again, this was not evident from either the contour plan or the dot density diagram when using the previous (columnar) filter.

Fig. 30.9 shows the final composite plan in 3D-Fishnet presentation format with the area rotated by 35° and viewed from above at an elevation of 35°. This demonstrates the ability of a comprehensive software package to give the user a "bird's eye view" from any angle (thus enabling features
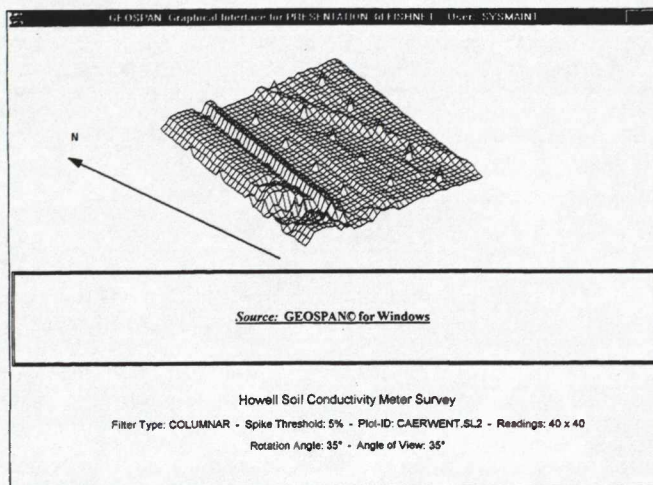
the ideal solution is probably a compromise of technology offering the archaeologist and his team the choice of carrying out, analysing and interpreting a more substantial part of the work involved and with the consulting geophysicist acting in an advisory rôle where his expert opinion can be of most benefit.

Figure 30.9: GEOSPAN© for Windows fishnet diagram.

which may be temporarily hidden behind others to be seen) and at any elevation (including from underneath — a useful facility when wishing to view the dimensions and extents of storage pits).

On a colour screen, printer or plotter, the outlines could be (optionally) gradient-filled as described above.

30.6.   Conclusions

The case studies show that there is definitely an under-utilised, perhaps also under-rated, opportunity for the archaeologist to make good use of modern advances in computer technology with only a modest financial outlay and with the potential to reap the benefits of substantial cost savings.

There are, however, a number of traps for the unwary into which it is only too easy to fall. As with most things,

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