From Artefacts to Anomalies: Papers inspired by the contribution of Arnold Aspinall
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Water tanks, magnetic coils and other wired/weird things - Geophysics at Bradford

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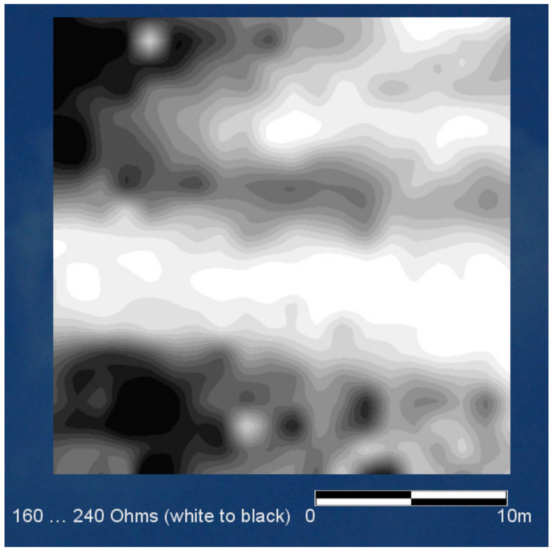
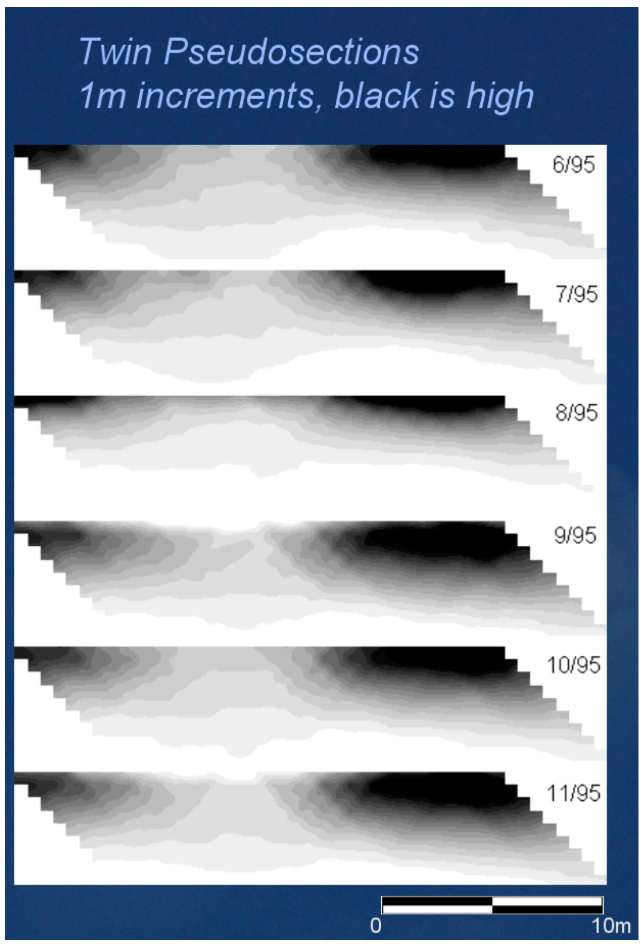
This contribution could also have been given the title 'lofty - but with a purpose'. Having its roots in a physics department, Archaeological Sciences at Bradford has always maintained its high scientific standards, looking at the basic underlying principles of modern scientific techniques to solve real archaeological questions. This strong link to purposeful applications was established by Arnold Aspinall and has been maintained ever since.

Tanks

Earth resistance measurements undertaken non-intrusively from the surface are successful because buried archaeological features often show a strong contrast in their electrical resistivity against the general soil background. It is easy to understand that a buried stone foundation has a high resistivity contrast, since it is normally drier than the surrounding soil. But what about buried ditches? The standard answer is that the looser fill of a ditch can retain more moisture. However, the details of this contrast are far more complex since the moisture regime of the soil changes considerably over the seasons and may even invert the contrast under certain conditions. To test this dependency a study had been undertaken by Peter Cott in 1995 to monitor the earth resistance responses from a major ditch at Caistor St. Edmunds Roman Fort over the course of 13 months. In addition to a standard twin-probe survey over this ditch

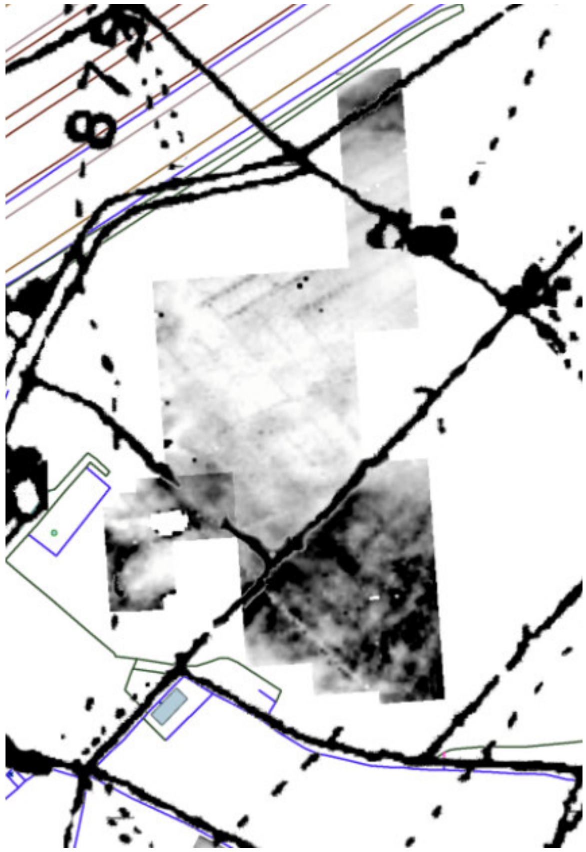


Twin-probe pseudosections were undertaken across it showing clearly the variation of resistivity, and hence moisture content, in the different layers of the fill.



Having established the relationship between environmental parameters and the changes in resistivity of archaeological features, the next question is how the earth resistance, measured from the top surface, varies across such feature. It would obviously be desirable if it were simple, for example a clear dip of measurements over the buried ditch. However, the results are more complicated. As John Lynam calculated in his PhD thesis (1970), the anomalies measured with the then newly designed ‘twin-probe array’ showed strange peaks and troughs even for a simple buried sphere if the feature was smaller than the array and relatively shallow. The question was as to who would believe such predictions. Hence simple test measurements in a water tank were undertaken to establish faith in the theoretical predictions. The good correlation found still amazes current students.

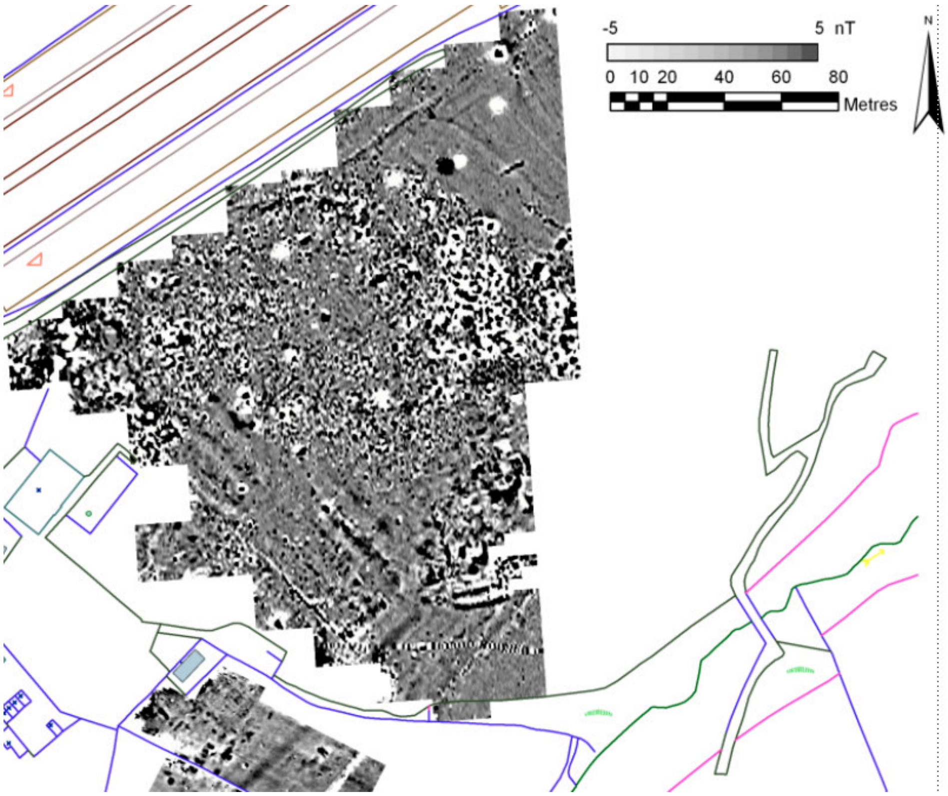
The tank experiments are also extremely useful for the test of new electrode arrays and their response to buried features. A very good example is the square array that, after several years of ‘neglect’, was thoroughly investigated by two Masters students (Mary Saunders 2001 and Thomas Sparrow 2003). After extensive testing in the tank, with new sample- and electrode-holders being built according to Arnold Aspinall’s design, field tests followed. Undertaking expanding square array pseudosections is extremely time consuming but luckily other students on Bradford’s *MSc in Archaeological Prospection* helped to build up impressive data sets. Through its links with Geoscan Research the department was able to drawn on, and feed into, the development of a new earth resistance cart that is based on the square array. Such links with commercial organisations are of mutual benefit and have always been encouraged by the University. The final and most important stage in the study of the square array was the use on archaeological sites. At Slack Roman Fort, near Huddersfield, conventional twin-probe surveys are problematic due to the very close proximity of powerful transmitters that seem to introduce unwanted signals in the cable between remote and mobile electrodes. The square array with its short connection leads proved to be ideally suited to overcome this problem. The results looked promising but on closer inspection it turned out that the majority of anomalies were caused by modern field drains from the golf course that now covers the site, or by relatively recent (ca. 1940) field boundaries.



Coils

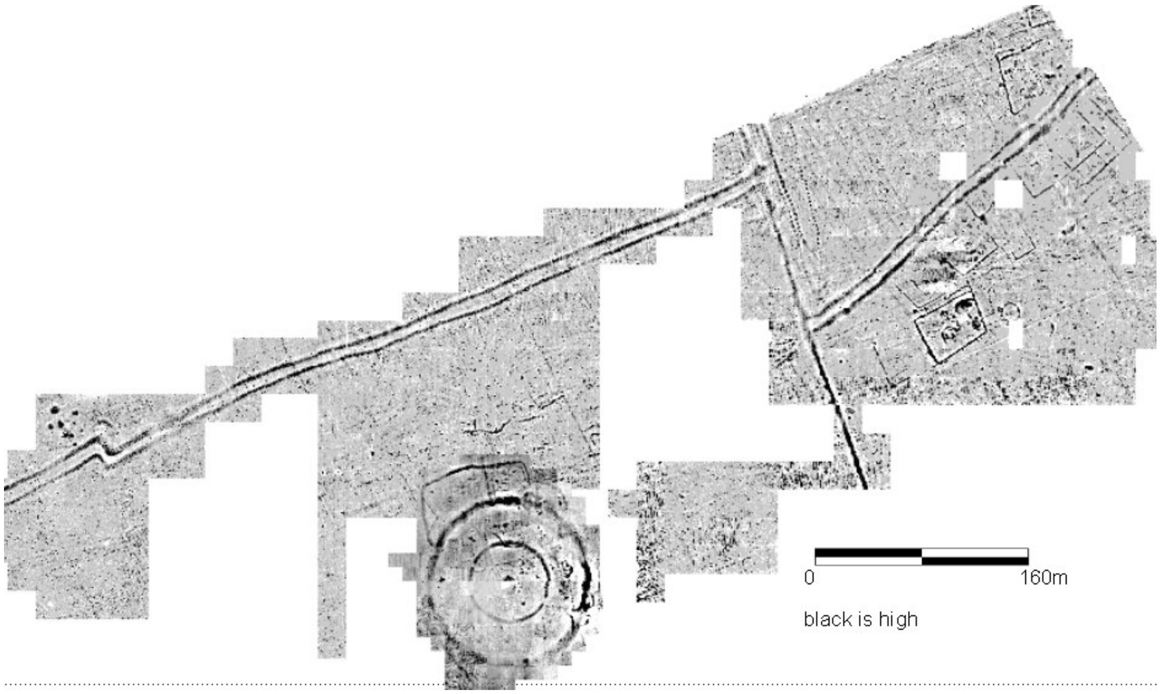
The problems encountered in the study of magnetometer surveys are remarkably similar to those described for earth resistance above. Although the relationship between archaeological features and their magnetic properties is complicated and sometimes surprising, it is a reasonably well-understood subject. However, when it comes to the shape of magnetic anomalies, it has to be conceded that the calculated results are not very intuitive. Hence laboratory experiments are required to demonstrate and proof to suspicious students that there is indeed a negative trough that accompanies every magnetic anomaly. The wooden runners of the equipment may seem old and worn – but that is exactly the point. Smoothly running and well maintained equipment that is non-magnetic is hard to come by. Students are still enjoying the fluxgate gradiometer experiment!

Fluxgate gradiometers were also used at Slack Roman Fort and they clearly showed the major features.



Despite considerable 'magnetic noise', associated with the creation of the golf course, the fort, its ditches and internal buildings are clearly delineated. This demonstrates again that it is often necessary to combine several geophysical techniques to reveal the buried archaeological features.

Processing and presentation of survey results have improved immensely over the last years, mainly fuelled by leaps in computer power. Many years ago, when it became possible to plot results for individual 20m grids on small pieces of paper and assemble all of them as a patchwork of snippets, this was seen as an enormous breakthrough (and it was!). Today, data can be re-processed and presented in seconds in all their glory in a GIS environment, as can be seen for the results from Thwing Hillfort, Yorkshire Wolds.



Wires

The study of electromagnetism (i.e. time varying magnetic phenomena) provides hours of entertainment. It promises the simultaneous measurement of magnetic and electrical properties with one instrument but it is a subject fraught with problems. Several studies have been dedicated to it but there still remains more to do. In a brave attempt Arnold Aspinall used a commercial metal detector and modified its design and data readout so that it could be used as a geophysical instrument. However, the so called 'metal' and 'cave' modes are still a mystery and comparisons with separate earth resistance and magnetic susceptibility surveys at Halifax Parish Church (and elsewhere) failed to establish conclusive relationships. But then what can one expect from an instrument that is called 'hoard hunter' …

Weird

Spin Torsion Fields seem to be of particular interest to Russian Physicist – and that tells you already something. They are caused, as long-range fields, by rotating masses, like the celestial bodies. Initial work was undertaken in the 1920s by Einstein and Cartan (Einstein-Cartan-Theory; ECT) but they have now received renewed interest and are increasingly used to explain inexplicable phenomena. One of them being dowsing. Dodd *et al.* (2002) undertook very systematic dowsing experiments and found remarkably clear interference patterns from pipes and wires on the ground and in the air. They were able to rule out electromagnetic effects but were surprised to discover very distinct and regular annual variations in the fringe wavelength that show different polarity in the northern and southern hemisphere. In a follow-up paper they explain these effects in terms of Spin Torsion Fields and experiments with workbench rotary grinders (sic!) showed remarkable results. What has this to do with archaeological prospection? Dowsing has long been considered to be a possible prospection tool (you can even attend courses: ‘From Dowse to Dig’) and if a scientific explanation can be found it may become feasible to investigate its use seriously. Certainly an idea for a Masters dissertation project!

Conclusion

It is clear that despite the current decline of interest in science, Bradford has stayed on the ‘proper’ path and, by stressing its applications in archaeology, it has brought science to new generations of students.

Bibliography

Dodd R.J., Harris J.W., Humphries C.M. & Reddish V.C. 2002. Towards a physics of dowsing: inverse effects in the northern and southern hemispheres. Transactions: Earth Sciences 93(1):95-99

