Appendix 3. The Archaeological Context of Geophysical Surveys#

A3.1 Introduction#

Archaeological geophysics is the application of ground-based geophysical methods to help elucidate the location and character of buried archaeological features.

The geophysical techniques commonly applied in field archaeology may be categorised as either active or passive:

- Active techniques are based on the injection of signals into the ground (e.g. an electric current or electromagnetic wave) and measurement of the response at the ground's surface.
- Passive techniques rely on physical attributes that would exist even in the absence of a measuring device (such as the magnetic field of a buried kiln).

Whatever the physical parameter being measured, the usual result of a geophysical survey is a matrix of data points, or transects of data, across a site. Following some data processing, patterns generated in these data can be interpreted in terms of buried archaeological features. The results are generally presented as either a two-dimensional site plan (e.g. in a conventional area earth resistance survey), or as a diagram showing the data from a transect as a section across the site (e.g. Ground Penetrating Radar (GPR) profiles). Multiple transect images can be compiled into a three-dimensional data set which can be visualised as two-dimensional images at increasing depths. These are called depth slices and for GPR data are derived from time slices.

The interpretation of geophysical surveys can be augmented by the inclusion of geoarchaeological and geochemical information, sources which can also provide archaeological insights in their own right. The former includes the use of augering and test-pitting, while the latter includes measurements of trace elements or phosphates. As geochemical data can be closely associated with geophysical surveys, and the methodologies of data acquisition and display are often parallel, this Guide can mostly also be applied to these types of data.

A3.2 History of Archaeological Geophysics#

Most geophysical techniques used today for archaeological investigations were initially developed for geological or civil engineering applications. While the underlying physical principles are the same, the shallow depth and relatively small size of archaeological features test the laws of geophysics to limits that are not often encountered by 'conventional' geophysicists. Research into these particular problems led to the development of a sub-discipline now called 'archaeological geophysics'.

Clark (1996: 11) describes how in 1893 Lieutenant-General Augustus Pitt-Rivers hammered on the ground with a pick to identify a ditch from the variation of the sound ? the first recorded application of a geophysical technique for archaeological prospecting. After 1945 the great potential of aerial photography was increasingly exploited. However, the available photographs often lacked positional accuracy which was then only achievable using ground-based techniques. In 1946 Richard Atkinson successfully started earth resistance surveying and the technique was subsequently boosted by the development of transistorised equipment (the Martin-Clark earth resistance bridge in 1956, and the Bradphys automatic earth resistance meter in the late 1960s). The adoption and theoretical study of new electrode arrangements, particularly suitable for buried archaeological features and fast area coverage (Aspinall & Lynam 1968), and the automatic logging of data (Kelly et al. 1984) again boosted the use of this technique. While improvements are still ongoing, earth resistance surveying has established itself as one of the key methods for geophysical prospecting in archaeology.

The development of another successful technique, magnetometer surveying, was started in 1958 by Martin Aitken with the use of a proton magnetometer. Interest in the technique was spurred by the discovery that not only fired kilns and ferrous objects would show magnetic anomalies but also soil features such as ditches and pits. Irwin Scollar used the differential sensor configuration for large-scale surveys from 1963, and in 1966 began with automatic digital recording on punched paper tape. Also in the 1960s, fluxgate magnetometers, which allowed continuous recording due to improved measurement speed, were introduced by John Alldred and Frank Philpot. Limitations of sensitivity then led to the deployment of Alkaline vapour magnetometers (sensitivities of 0.01nT) by Beth Ralph, Helmut Becker and Peter Melichar in the 1970s. These instruments have since been perfected and high-resolution surveys of large areas are now feasible (Eder-Hinterleitner et al. 1996; Powlesland 2009).

Active electromagnetic methods are increasingly used for the investigation of archaeological features. Most notably, Ground Penetrating Radar (GPR) is now a well-established tool that combines high sensitivity and spatial resolution. Initially greeted enthusiastically (Stove & Addyman 1989), it was deployed under unsuitable conditions (wet clay soils) and acquired a bad reputation amongst archaeologists in Britain. With better understanding of the technique and its limitations, this perception has been redressed and GPR is now used successfully on many sites (Conyers 2010).

Geophysical data capture is now entirely digital, and the increasing size and sampling resolution of modern surveys is resulting in the accumulation of vast quantities of data. An example of large-scale geophysical surveying is the Wroxeter Hinterland Project which has involved several survey teams, using a variety of methodologies. The magnetometer survey alone, of some 78 hectares, recorded nearly three million data points.

A3.3 Reasons for a Survey Project#

Before beginning a geophysical project, it is important to consider carefully the data that are required as these will structure the fieldwork. Hence it is useful to examine the reasons for undertaking the project so that appropriate survey methodologies can be planned. Reasons for undertaking geophysical surveys usually fall into four broad categories, although these are far from mutually exclusive:

Field evaluation in advance of development ? Geophysical techniques are used increasingly, in conjunction with other means of field evaluation, to provide information on the presence and character of archaeological remains on sites for which development is proposed. Since such remains must be identified prior to receipt of planning permission, and should in principle be preserved wherever possible, methods of non-destructive evaluation are now deployed with increasing frequency. There are many different types of development pressures, but geophysical methods have found particular application on sites of mineral extraction, commercial and domestic buildings, road and rail routes, pipelines and other infrastructural links. In some cases, results from such investigations have led to further archaeological research.

Site management ? Geophysical techniques are also used to help locate and characterise archaeological remains which are not covered by planning legislation: agricultural ploughing and coastal erosion are two examples. Geophysical techniques can also aid the identification and characterisation of sites of national importance where active management, including legislative protection, may be necessary. The information provided by surveys can significantly increase knowledge of sites and improve their interpretation and presentation to the public. Work within and around World Heritage Sites such as Stonehenge provides one example.

Archaeological research ? Whether or not there is a planning or management incentive, geophysical methods are often used directly in support of specific archaeological research. Research objectives can include the detailed study of individual sites (e.g. Sutton Hoo), or can be widened to address categories of monument type (e.g. Wessex hillforts), wider research themes (e.g. early iron-working), or landscape-based studies.

Technical research ? Surveys are also undertaken in order to research the geophysical techniques themselves, often in situations where there is an additional archaeological advantage. Whilst the routine methods of magnetometer and earth resistance surveys account for much of the development-led work in the UK and archaeological research referred to above, there remains a need both to refine these methods and to introduce new ones. Research is currently aimed, for instance, at increasing the sensitivity and resolution of detection and exploring methods of three-dimensional data interpretation.

A3.4 Choice of Survey Method and Procedure#

Advice on the choice of survey methods and procedures is available in published guidelines and scholarly literature (Scollar et al. 1990; Clark 1996; Gaffney & Gater 2003; Aspinall et al. 2008; David et al. 2008). Advice may also be obtained directly either from the geophysics team of English Heritage, or from other professional geophysicists or geophysical consultants. The International Society for Archaeological prospection (ISAP) represents all people interested in the subject and aims to further its use. The adequate training and qualification of personnel undertaking surveying and interpretation is essential.

A geophysical survey, if not a finite project in its own right, is more typically a component of a wider project and usually conducted at an early stage in the life of that project. It is thus important to ensure that specialist advice is sought early on and that any survey is carefully scheduled within the project timetable.

The choice of survey method(s) will depend on several variables, the relative balance of which will vary from site to site. The most important of these are:

- the survey objectives
- archaeological questions
- previous aerial photographic evidence
- previous geophysical survey results
- current land use
- previous land use
- underlying solid and drift geology
- other local geomorphological and topographic factors
- degree of access to land
- time, money and personnel available for the survey

Most of this information can be gathered and assessed by desk-top consultation, although preliminary site reconnaissance and/or a pilot survey may also be appropriate. Once these factors have been assessed, an appropriate methodology can be designed utilising the optimum combination of techniques and sampling strategy for the site in question (David et al. 2008).

Records of the planning stages of a geophysical survey project form a vital part of the project's Archive, and it is therefore essential to document any initial research undertaken and decisions made. Such documentation is generally included in the project report and produced in a standard word-processed text that will evolve into the core of the project's Archive.
