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## **Archaeology and Geophysics at the Chillicothe Site, Ohio, USA**

In this short paper, we summarize the recent proceedings of the National Parks Service Archaeology Workshop in Chillicothe, Ohio. The Workshop held May 16 to 20, 2005 brought together many of the top instructors and students in the United States to learn about the state-of-the-art in geophysical surveying and methods, such as magnetics. Morning sessions of this exciting workshop dealt with the theoretical and practical aspects of geophysics; afternoon sessions were spent at one of three sites in the Chillicothe area.



Figure: The Mounds Site, Chillicothe, Ohio

Chillicothe is of much interest to archaeologists as it was the site of a civilization that inhabited the area from approximately 300 B.C. to 600 A.D. Had the native features in the area not been largely destroyed



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through farming, it was postulated by one group leader that the Chillicothe site would have been the equivalent of the "North American Pyramids". The site was purchased by the National Parks Service over the last decade or so, and as such, there is now a huge area to test to determine the properties of the subsurface ... the main record that remains intact.

### ***Archaeology – Advantages of Geophysics***

At the beginning of the workshop, it was noted that the state of North American archaeology is somewhat less technically advanced than in Europe.

Reasons noted were the overall difference in North American archaeology which tends to focus on subtle Native American features in soils as opposed to the more massive (limestone) structures present in Europe. Other differences include the near surface location of North American artifacts (<1.5m).

Main advantages of geophysics, include the ability to:

- Locate earthworks that are obliterated
- Locate a variety of archaeological artifacts both pre-historic and historic
- Save time and money

### ***What is Geophysics?***

Geophysics is a fast, non-destructive way to map localized differences in soil properties and locate objects near surface. As noted above, these methods have been adopted practically everywhere; in the U.S. however, development with these methods only started in the mid-80's.

Geophysics fundamentally depends on contrasts in physical properties between stratigraphic units or objects which are the focus of the search. Other important factors are the presence of geologic or man-



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made “noise” and clutter; as well as the need for ground truthing at some point during the archaeological process.

## ***7 Basic Steps in Geophysics***

The following steps summarize the geophysical process in the context of an archaeological investigation:

1. Needs and objectives (time and money)
2. Survey setting (soils) and desired targets
3. Choose your instruments
4. Acquire data
5. Process data
6. Interpret data
7. Integrate results with other archaeological datasets

In terms of needs and objectives, not all sites will be suitable for geophysics (i.e. disturbed, deeply buried, extreme conditions) but assuming the site is suitable, a basic goal will be to find features

(assuming anything is left); map the extent of these features; map the location of artifacts; and map subtle layers in excavation projects. As a precautionary note, it is important to understand that geophysics will not find everything so the advice offered was, “don’t throw away your site just because there are few features.”

The survey setting and desired targets are also important to consider. What kinds of features are you expecting and will they show up on a geophysical survey? To answer this question, an understanding of the main geophysical methods involved in archaeology is required.

With instrument selection, it is possible to choose from a variety of methods, including magnetics, radar, conductivity, resistivity and remote sensing. Magnetics is used almost ubiquitously on projects due to the level of information it offers and its relative speed and ease-of-performance; however, it is always important to check other methods to ensure that the optimal combination of techniques is deployed for the archaeological challenge at hand.



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With data acquisition, good spatial control is essential as archaeological features can be very small in area or extent. Spatial control can be maintained using detailed grids, or possibly, GPS depending on the resolution of the GPS system. Archaeological surveys are typically quite dense with samples acquired every 10 centimetres or so, on lines that may be 0.25m, 0.5m or 1.0m apart.

Data processing typically involves removal of geologic or cultural "noise" so that features can be resolved with as much clarity as possible.

Interpretation relies on understanding of the products of a geophysical survey, namely, maps with / without contours that can be used to pinpoint features as well as establish the continuity of in situ soils or archaeological targets. Often multiple geophysical products can be plotted together for joint interpretation of results. Some of the parameters for interpretation include anomaly size, shape, pattern, colour, texture and association.

Integration of results with other archaeological datasets is an essential task, and one that prepares the groundwork for limited excavations by indicating which ground is prospective and which is not.

Overall, when considering geophysical methods for archaeology, it is recommended that practitioners have a good understanding of site formation (i.e. what materials are likely to be present) as this will influence survey techniques. Another general geophysical rule of thumb is that you cannot detect anything deeper than it is big. For instance, a 1m object would be detectable 1m away.

### ***Applications of Magnetometers for Archaeology***

There are two typical applications of magnetometers in archaeology:

1. Seeking features or artifacts
2. Looking for subtle contrasts in soils (harder)

However, today's advanced magnetometers provide a variety of solutions for these issues. Examples of the factors that affect magnetic readings include:



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- Iron content – This is handy since there is approximately 4% of iron in the lithosphere; providing a good starting point for magnetic mapping
- Heating
- Bio-chemical alteration
- Magnetic contrast
- Depth of burial
- Shape of object
- Sensitivity of gradiometer
- Latitude

The most important features for gradient measurements (i.e. high resolution surveys with two magnetic sensors) include:

- Sampling rate – As high as possible without introducing additional “noise”
- Portability
- Magnetic resolution to 0.1 nT/m minimum
  
- Measurement drift over grid <0.2 nT / min
- Battery life – As long as possible for field efficiency
- Cost
- Reliability – Reduces overall survey costs

Less important features, include GPS capability. Although this might seem somewhat surprising, archaeologists are used to working with “tight” or closely-spaced grids; data acquisition can be accomplished efficiently using traditional grid construction methods as opposed to GPS. GPS has the promise of very high resolution surveys; however, these are constrained in practice by the high expense of these GPS systems.

In looking at geophysical anomalies, it is often useful to develop a classification system for a site so that all anomalies can be compared on an even playing field. It was suggested that classifications such as monopolar positive (a positive peak), dipolar simple (a positive peak with a negative trough) and others be derived. On one site, it was noted that ditches tended to show as positive anomalies whereas historic objects tended to show as differences in magnetic texture. Practitioners are of course free free to develop their own classifications



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according to the actual site conditions present or alternately, who may choose to employ a uniform classification system from site to site.

### ***Magnetic Susceptibility***

Magnetic susceptibility is the physical property on which magnetic measurements are based. Specifically, it measures the ability of a material (such as soil, rock or metal), to become magnetised by an external magnetic field. Magnetic susceptibility is also an important value in its own right, helping with:

- Defining diffuse or unclear boundaries
- Characterizing the anomaly source
- Interpreting surface geophysical methods
- Mapping stratigraphy objectively
- Indicating the degree of soil development
- Defining fill areas

Magnetic susceptibility is an ideal value to use in excavations, in part, because of the difficulty of using a magnetometer / gradiometers in confined spaces. At the field school, there was an existing trench that had been mapped extensively using both sampling along the wall and "grab" samples (the latter of which was later analyzed in the lab). Results had shown the mixing model for the soils (i.e. uppermost soils had been re-deposited on the flanks through time).

### ***Ground Truthing Geophysical Surveys***

Geophysics attempts to detect, classify and assign features to geophysical anomalies. However, in practice, geophysical anomalies may be difficult to interpret and the patterns in the data can be misleading. Take, for example, a circular object ... there are many ways to interpret this relatively common archaeological feature.

Therefore, it is essential for the archaeologist to find information for ground truthing. Commonly, ground truthing depends on 5 factors:

- Information return, from maps, records, local informants or excavation



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- Cost
- Invasiveness
- Social and political issues
- Risks from Unexploded Ordnance, Industrial Sites, Financial, etc.

These must all be evaluated before determining a strategy for ground truthing. Due to the inherent risks in ground truthing, this process is often performed in a series of steps:

1. Visual Inspection
2. Metal Detection
3. Soil Probes
4. Shovel Tests
5. Test Units – target on most promising anomalies

As an example, magnetometer / gradiometer data may have anomalies due to minor deviations in surveying technique ... the exercise then becomes one of finding the best fit between the geophysics and ground truthing resources. Ultimately, it was recommended that practitioners construct a ground truthing database for their region to increase trust in geophysical responses.

### ***Summary***

In this short paper, we have provided a summary of some of the main points elaborated upon at the National Parks Service Workshop in Chillicothe, Ohio between May 16 and 20, 2005. Readers should have some appreciation of the advantages of geophysics, what geophysics represents, and the seven basic steps in geophysics. Other topics covered included applications, magnetic susceptibility measurements, and ground truthing.

Readers are advised to consider attending the workshop; it is a highly practical and valued opportunity not only to learn about geophysical methods and their practice in archaeology but also to test ideas with colleagues as to the best approaches in dealing with their own specific sites.



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