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Geophysical Survey as a Conservation Tool

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With the introduction of cultural resource management and the passage of federal preservation legislation more than thirty years ago, American archeology has recognized the need for non-invasive practices that produce significant, new data while preserving the non-renewable archeological record. In the early 1970s, Thomas Lyons and the National Park Service's Cultural Resource Management Program began to develop a non-invasive paradigm placing new emphasis on remote sensing techniques. Developments in geophysical methods over the past twenty to thirty years allow archeologists to preserve the archeological record, practice Lyons' non-invasive archeology, and collect high-quality data. A discussion of the advantages and disadvantages of geophysical applications follows.

> *"As archeologists are becoming more concerned with cultural resource management, non-destructive techniques such as geophysical surveys are becoming more valuable tools. The shifting focus in American archeology towards management and protection of the nonrenewable archeological record has resulted in less destruction of non-threatened sites through excavation. William Lipe, in his 1974 article "A Conservation Model," stressed this very need" (Lipe 1974).*

For decades the National Park Service has been the main federal agency charged with the protection, conservation, and management of the nation's cultural resources. All federal agencies were so charged as a result of legislation in the 1960s and 1970s. It is no surprise, then, that the National Park Service has been at the forefront of promoting the use of non-invasive archeological techniques. For thirty years it has been refining the applications of remote sensing and geophysical methods to study archeological sites with minimal impact.

Non-destructive Archeology

Thomas Lyons and the National Park Service's Cultural Resource Management Program began studying the applicability of remote sensing to archeology as early as 1969 (Lyons and Scovill 1978). Based upon years of experiments with sites such as Chaco Canyon, Lyons and his office literally wrote the book on how remote sensing was to be incorporated into cultural resource management (Lyons and Avery 1977). Lyons advocated a new methodological approach for "exploration, discovery, recording, evaluation, investigation, monitoring, and management of cultural resources" (Lyons and Scovill 1978:3). Rather than use the imprecise methods of surface survey and subsurface testing, these methods should be reserved for site verification instead of site discovery. He points to the flaws in the traditional methods in the following scene:

> *Frequently archeologists still in training and with varying degrees of professional accomplishment and observational prowess walk the ground on site surveys. They*

visually search for, discover and concurrently assess, sift and select a highly limited number of physical attributes deemed to be adequately descriptive and representative of rather obvious classes of archeological and natural phenomena. They record mentally massaged observations of these physical phenomena in summary fashion in logs, diaries and on printed forms, using imprecise terminology and syntax in an often undecipherable scrawl. They plot site locations with Brunton compass accuracy, a technique that often precludes rediscovery and positive identification of them at a future date. From this process comes a highly personalized statement about the archeology of an area and the natural environment, a statement that invariably concludes more surveying, more collecting and more excavating of the resources are required (Lyons and Scovill 1978:4).

His complaints extend to include the on-the-spot interpretation involved in surface collecting, the inability to replicate the initial observations once a surface survey is done, the limited nature of the data collected from survey and testing, and the limits of human senses. This dissatisfaction created a paradigm he termed *non-destructive archeology,* which utilized remotely sensed data to explore, discover, and record sites.

Twenty-five to thirty years ago, the primary tools in remote sensing available to Lyons were aerial photography, satellite imagery, infrared data, and photogrammetry (Lyons and Scovill 1978). Over the last decade or two, geophysical techniques have advanced greatly and their applicability has been tested in archeological settings. Borrowed from geophysics, these techniques measure various physical properties of the subsurface make-up. They provide a subsurface complement to the remotely sensed surface data.

Lyons recognized the vital importance of remote sensing and geophysical techniques for developing a non-destructive archeology. The application of a non-destructive archeology is, in turn, vital for judicious administration and management of cultural resources. Volumes of information about a site can be obtained without invasive excavation. Multiple surveys can be conducted while saving the site for future study and the development of new technologies.

Non-destructive Techniques

Several terms have been developed to refer to the variety of non-destructive techniques now in use. As noted earlier, the remote sensing techniques Lyons began experimenting with were of a different nature than those in use today. Remote sensing methods, as they differ from geophysical applications, refer to data obtained from a remote platform, such as an airplane, satellite or otherwise elevated instrument. Aerial photography, infrared and other measurable light in the electromagnetic spectrum are data types obtained in remote sensing (Lyons and Avery 1977, Heimmer and DeVore 1995).

Geophysical prospection implies looking beneath the surface rather than on top of it. This is the broadest, most inclusive term for all geophysical measurements taken to determine the subsurface composition. It includes both non-destructive methods as well as minimally invasive techniques such as coring or drilling. The term is used more often in British than American archeology (Rapp and Hill 1998).

Non-invasive geophysical techniques fall into two categories, passive and active. Passive methods involve instrumentation that can precisely measure physical properties of the subsurface such as magnetism and gravity. The passive method most commonly used is some form of a magnetic survey. Two magnetic measurements are usually taken for every point in the survey and the differences or gradients are calculated in order to eliminate natural daily variations in the earth's magnetism.

Active techniques involve inducing an electric or magnetic field through the introduction of a current. The introductions of acoustic and radar waves are also considered active geophysical methods. Examples of these methods include: electrical resistivity, electromagnetic conductivity, and ground penetrating radar (Heimmer and DeVore 1995).

Geophysical Advantages

As stated, the greatest advantage in the use of geophysical techniques is their non-destructive nature. To cultural resource managers, this is an attractive quality. They are able to obtain usable subsurface data while remaining true to the preservation and conservation ethic. By not destroying the archeological record, the site is preserved for future study when new technologies become available. Geophysics can give the dwindling archeological record extended life and maximize the amount of information obtainable.

In Great Britain, where archeological resources are even more limited in its volume, geophysical techniques have been incorporated into research for decades (Coles 1972). Not only can geophysical techniques aid in site discovery, but also allow British archeologists to maximize site information before excavation. The successful use of these techniques in Britain slowly helped to convince American archeologists of their utility.

The second advantage to geophysical applications is the quantity and quality of data obtained as contrasted with traditional site discovery techniques. Again, Lyons stressed the objectivity in data collecting with a geophysical instrument as opposed to human detection (Lyons and Scovill 1978). In sheer quantities, the amount of data obtained using geophysical instruments will be exponentially greater than the amount of data amassed after traditional surveying and testing.

The nature of that data is also important. Geophysical data in digital form are easy to store and retrieve. Traditional methods can produce cubic feet of artifacts and volumes of field notes that require storage in already crowded curation facilities (Lynott 1997). Improper storage has the potential to damage or destroy artifacts. Once an assemblage has been curated, rarely does it ever re-emerge for further study. Whole collections have been known to disappear into a "curational abyss." Digital data have a greater potential for re-evaluation. The quality of digital data is not likely to diminish over the course of time. Geophysical data are also very precise. Depending upon the sampling strategy, a traditional survey will predict the location of a fraction of the sites in a given area. Geophysical surveys can identify every potentially human-made anomaly in the same area. Human alterations to the landscape, such as ancient roads, trails, agricultural fields or other features without an artifactual reflection that could not have previously been identified can be represented in the geophysical data.

Thirdly, the cost-effectiveness of using geophysical methods over traditional excavation is not directly measurable in dollars and cents. Intangible factors are difficult to insert into a fiscal equation. Costs are also very situational which make comparison between projects difficult. Cost-effectiveness can, although, be measured in broad terms. Generally speaking, geophysical surveys can be conducted with fewer crew members. Most of the geophysical methods are very quick, decreasing the time needed in the field. No lab facilities are required to pre-process the data prior to analysis. As stated above, the digital format is much less costly than curational fees and needs. Although the technology is itself expensive, after the initial capital outlay to purchase the instruments, little additional costs are necessary to acquire additional data. Every few years updated software or spare parts might need to be purchased. The largest intangible to consider is that of not destroying the site. How does a cultural resource manager measure this benefit? However it is measured, it is certainly great.

Geophysical surveys have the ability to make subsurface testing itself more cost-effective. Anomalies found in geophysical surveys can be targeted for testing when time and cost constraints exist (Lynott 1997). Projects that do not involve threatened sites, but lack funds to accomplish very much, may choose to conduct a geophysical survey to obtain the maximum amount of data for their money. When more funds become available at a later time, the research can then be guided by the geophysical findings.

Because public tax dollars fund the majority of archeological projects conducted, agencies and researchers have a responsibility to the taxpayer to use the funds efficiently (Lyons and Scovill 1978). When no surface clues exist to suggest the presence of an archeological feature, geophysical surveys can look beneath the surface. These methods have the ability to locate sites and features where archeologists may not commonly look.

Finally, geophysical techniques may provide an alternative in sensitive situations such as those involving sacred sites, cemeteries, and possible human burials. Even then, geophysical techniques may be objectionable, but they offer a non-invasive solution (Lynott 1997).

Geophysical Limitations

Although geophysical surveys have numerous advantages, limitations exist. "Remote sensing is not a panacea" (Lyons and Scovill 1978). Each geophysical method has specific limitations and conditions under which it can and cannot work. Equipment limitations to be considered include power source. The instrument lasts only as long as the battery, unlike manual labor, which can be replenished with a short lunch break. The properties measured in each method are suited to detect particular types of anomalies. Geophysical surveys must be evaluated on two conditions—the environmental conditions and the type of anomaly it detects—to determine the methods most applicable to the specific project. Adequate pre-field research about the instrument's limitations, the site's geomorphology, and the probable archeological features of the area to be surveyed must be done in order to properly apply geophysical techniques.

Geophysical survey also requires a trained analyst to interpret the data once it is collected. This person can usually be found in a geophysicist or someone adequately trained in geology or physics. The specialized analyst will likely add to the cost of the survey. Without such a person the interpretation of the geophysical data takes longer. Although geophysical surveys are able to detect nearly every anomaly, the data are still interpretive. A great deal of gray area exists in which the analyst cannot be conclusive about the cause of the anomaly. As with traditional data interpretation, the issue of equifinality appears. More than one cause may explain a particular anomaly.

Ground Truthing

Although geophysical techniques are regarded as non-invasive, they require verification that can only be accomplished through subsurface testing methods. In Lyons' non-destructive archeology, he clearly states the necessity of testing as a means to verify the remotely gathered data (Lyons and Scovill 1978). Ground truth, the verification step Lyons refers to, is key to the further development and refinement of geophysical methods. Knowing what anomalies the instruments detect and what they cannot detect helps in the interpretation of the geophysical data in the subsequent surveys (Lynott 1997).

Summary

Having examined the numerous benefits of geophysical applications in cultural resource management, why would any archeologist choose to begin blind? Despite efforts by Thomas Lyons, the use of remote sensing for a non-destructive archeology has not replaced traditional methods for site discovery and exploration. Archaeologists are a stubborn breed and Lyons could not dissuade them from conducting surface survey and shovel tests as means for detecting sites. To this day the shovel remains the tool preferred over the cesium-vapor magnetometer when locating sites. To his credit, Lyons' non-destructive paradigm has made an impact within many of the federal agencies charged with cultural resource management. University researchers are applying this technology to a lesser degree with private archeology firms falling somewhere in between.

The use of geophysical surveys offers numerous advantages over traditional survey methods, the greatest of which is its non-invasive quality. Volumes of information can be gleaned without breaking ground. The instrumentation can remove a great deal of the observation and collection bias. The data produced can provide a comprehensive view of the project area and all potential features located within it. Geophysical data are easy to store and retrieve while geophysical techniques provide the ability to conduct multiple surveys. These surveys are relatively cost-effective once the equipment is initially acquired.

The applications of geophysical techniques in archeology are readily apparent when considering situations involving sacred sites or cemeteries. They can provide a snapshot beneath the surface when no evidence for a site exists on the surface. The most obvious application involves geophysical data providing guidelines for subsurface testing. Not only does this increase the efficiency of the testing phase, but it also provides feedback in furthering refining the use of these techniques in archeology. Geophysical surveys are not uniformly applicable to all projects. Knowledge of the instruments' limitations and the site's geophysical properties will enable archeologists and resource managers to better apply this technology in each specific circumstance.

Overall, geophysical applications are precisely the type of non-destructive techniques Lyons champions in order to better conserve and protect the archeological record. As American archeology enters the next century careful management of archeological resources will become more critical and geophysical surveys will become the norm as Lyons envisioned.

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