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DIFFERENCES OF SCALE - SIMILARITIES OF RESEARCH PROCEDURES: ARCHAEOLOGICAL PROSPECTION IN THE SHANGQIU AREA, NORTHERN CHINA & ITANOS, SOUTHERN GREECE.

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Abstract

Magnetometers, multi-frequency electromagnetic induction sensors, multi-point electrical resistivity prospecting instruments and ground-penetrating radar have been employed jointly during 1992 and 1998 in Shangqiu area, northern China, an archaeologically important region of investigating the origin of Shang civilization. The study was supported as part of the collaborative projects "Archaeological Investigation of Early Shang Civilization in China" between Harvard University's Peabody Museum and the Institute of Archaeology, CASS. One of the most important achievements of the past years' intimate integration work of geological and geophysical team was the discovery of a buried Eastern Zhou (770-450 B.C.) city with rammed earth walls.

Another joint campaign from the Institute for Mediterranean Studies (FORTH), the Technical University of Crete and the French Archaeological School of Athens has been concentrated in the geophysical mapping of archaeological remnants of the Hellenistic port of Itanos, NW Crete, since 1994. Seismic, magnetic, EM, resistivity, GPR and resistivity tomography surveys have mapped various portions of the archaeological site providing valuable information on the habitation patterns of the ancient settlement and its geomorphological setting.

A joint research project that is carried out by members of the above teams from China and Greece aims towards the combination of high resolution geophysical and satellite data from Itanos. This kind of interaction brought up a number of differences in
scale and similarities in research procedures that are followed in archaeological prospection. Field strategies in geophysical investigations from reconnaissance mapping to volume mapping, instruments and field procedure, data processing and interpretation, and merits and limitations of each technique are also discussed within their archaeological context, stressing the need of more comparative and joint research studies.

**Keywords**: geophysical prospection, remote sensing, GIS, China, Greece.

1. **The Shangqiu Project, China**

   The Shangqiu project "Archaeological Investigation of Early Shang Civilization in China" is a collaborative program between Harvard University's Peabody Museum, under the direction of K.C. Chang, and the Institute of Archaeology in Beijing, which aims to carry out archaeological survey and excavation in the Shangqiu area, Henan province. It is an effort to locate archaeological sites from the early period of the Shang dynasty (1750-1100 B.C.), providing a better understanding of the crucial early formation phase of the development of Shang civilization. The overall area of interest of this project is extremely large, an area encompassing roughly 10,000 square kilometers. Field survey focused on a 6×6 square kilometers area located to the south and southwest of the present town of Shangqiu.

1.1. **Geological & Archaeological Settings**

   The Shangqiu area is situated in the most eastern part of the Henan plain, which is part of the alluvial plain of the lower Yellow River in northern China (Fig. 1). The physical appearance and hydrologic conditions of the Shangqiu area has been profoundly influenced by both local and regional alluvial processes in the past 2000 years, especially from the early 12th through the middle 19th centuries when the lower Yellow River, characterized by frequent shifting of river course and by high-magnitude flooding and breaching, flowed through the region.

   The Shangqiu area is traditionally considered the homeland of the pre-dynastic and early Shang culture and the location of Great City of Shang, the political and religious center during the pre-dynastic Shang period (2000-1750 B.C.), and the sacred cult center throughout the Shang dynasty (1750-1100 B.C.). Archaeological remains dating to the pre-dynastic and dynastic Shang periods, however, have remained elusive, mainly due to the heavy late-historic flood plain alluvium from the Yellow River. The land surface of the time period to which early Shang and pre-dynastic Shang remains should be attributed was buried to a depth of, on average, 10 meters.

1.2. **Survey strategy & Results**

   The geophysical surveys were carried out in 1992. The primary objective of the geophysical survey was to assess the local conditions in the Shangqiu area and to test the
applicability of various geophysical methods for subsurface feature detection. It was also determined that geophysical survey in selected areas would be the most cost- and labour-efficient method to locate areas of possible archaeological interest within this large region, based on the anticipation that large Hangtu, or rammed earth wall, platform, and building foundations would cause detectable anomalies in the geophysical data (Fig. 2).

Besides different kind of geological coring tools (Luoyang spade, Holland auger and Car powered auger), most currently used geophysical methods in archaeology were employed in this long-term (1991-1999) project. Among the different techniques applied, reconnaissance mapping (with aerial and satellite imagery, magnetic and EM survey) was used for locating archaeological sites over the extended region of interest and high resolution mapping (with GPR and electric resistivity survey) was employed for mapping the buried features of a located city site. Geophysical instruments included Geometrics G-856 proton procession magnetometers, Geometrics G-858 cesium vapor magnetometer, Geonics EM-31, Geophex GEM-2 and GEM-300 electromagnetic terrain conductivity meter, SSI pulseEKKO IV GPR system and OYO McOHM-21 auto-electrical prospecting device (Fig.3).

One of the most important results of these past years' work was the discovery of a fairly major buried Eastern Zhou (770-450 B.C.) city (ca. 3,500×3,000 square meters) (Fig.1). The walls of the city were constructed with Hangtu or rammed earth structure. The western segment of the south wall, most parts of the west wall and the western segment of the northern wall are relatively well preserved (Fig. 4). Coring indicated that the top of the walls lie only three to four meters beneath the present ground surface, and that the rammed earth structure continues down to a depth of about 10 to 12 meters with average width of between 12 and 15 meters.

2. Itanos, NE Crete, Greece

The archaeological investigations in Itanos fall in the general framework of research carried out by a coalition of researchers from the Institute of Mediterranean Studies, the French School of Archaeology and the Technical University of Crete (Sarris, et al, 1998, 1999; Vafidis, et al, 1996). The goal of the campaign, initiated in 1994, is the study of the Early Christian/Hellenistic site of Itanos (Fig. 5), in NE Crete, and the diachronic settlement patterns of its surroundings.

Until now, a number of trenches have been excavated revealing portions of the architectural remains of the ancient settlement, including temples, a cemetery and a number of residential units. Ground-based geophysical techniques have been also applied within the limits of the city to complement the excavation results. Although the site covers an area of more than 16,000 square meters, the overall area of interest expands to 60 square kilometers over the NE edge of Crete, where numerous archaeological sites can be found, dated since the early Minoan period.

Within the framework of the above investigations, a joint research and technology programme between China-Greece has been initiated in 1998 aiming towards a) the identification of the consequences of past environmental changes on the archaeological sites through the satellite mapping of the environmental and archaeological
characteristics of the area and b) the geophysical confirmation of subsurface targets and geomorphological anomalies related to the surface archaeological features.

2.1. Prospection strategies & Results

During the 1999 survey period, electrical tomography and GPR experiments were carried out in areas, previously investigated by conventional techniques. High resolution (0.5-1m sampling interval) magnetic, soil resistance and electromagnetic techniques, together with the ground penetrating radar, were used to map the extent of the architectural relics of the necropolis hill, part of which has been excavated (Fig. 6). Some further experiments were carried out above tholos tombs outside the necropolis area. Geophysical maps showed that the necropolis extents further in a SW direction. Both electrical tomography inversion and GPR time slicing techniques outlined the continuation of wall structures that extend outside the excavation trench to the west.

A large portion of the archaeological prospection activities was also devoted to the topographical mapping of archaeological relics in the wider area of Itanos, including ancient Itanos, Vamies, Kastellas, Toplou Monastery, Stephanes, Vai, and Soros. High accuracy Global Positioning Systems were employed specifically for the above purposes. Geological and topographic maps (1:5000) of the NE part of the Lasithi Province (north of Palaikastro) were digitized in detail to be used as a demonstration model for the detailed mapping of the archaeological sites of the region. The digital mosaic of aerial photographs, together with SPOT, Landsat and Corona images were processed with image enhancement and classification techniques in order to outline the limits of the surveyed sites and register them within their environmental context (Fig. 7). Emphasis was given to the geometric correction of images and maps and the tranformation of co-ordinates to EGSA’87 topographic system of axes, which is used for the national land estate registry. The digital elevation model of the region was used for the statistical analysis of the topographical characteristics of the sites. Viewshed analysis is still under progress for studying the communication network of the area during the historical and prehistorical period.

The above digitized maps and images have been combined to an archaeological database in a dynamic Geographical Information System that is able to produce thematic maps based on the above results. In this way it is possible to integrate a diverse set of data (e.g. aerial photographs, 3-D DEM, geophysical maps and surface features), that can capture different characteristics of ancient Itanos and its environs and thus may be used for the management and study of the monuments of the wider region (Fig. 8).

3. Conclusions

High-resolution geophysical methods, including GPR, are suitable for intrasite volume mapping and are usually used to guide the excavation program within known sites. Although one could come to the conclusion that geophysical prospection should not be used as an initial method of archaeological exploration or for investigating large areas of unknown character, there are cases where a crude sampling interval geophysical
approach could be extremely useful in locating large dimension features and architectural relics. Generally, most of the geophysical techniques used were successful in detecting the subsurface targets. Still, in many cases there were problems of interpretation of the geophysical signals due to the similar properties of the archaeological remains and the surrounding soil matrix or rock parent material. This situation is similar to both China and Greece: in the former, rammed earth structures are typical archaeological remains, whereas in the latter architectural remains are coming from local material, stressing the need of more systematic measurements of the physical properties of the construction materials both in lab or in-situ. These in turn will improve the geophysical survey design and data interpretation. The above will also have direct consequences to the better definition of the spectral signatures of the archaeological sites as they registered by satellite sensors.

In the course of exploring large regions, satellite remote sensing and digitization techniques have their own merit. It is possible to map not only the archaeological monuments and sites, but also the environmental parameters within which they exist. Finally, the use of Geographical Information Systems can provide an alternative way of analysis of the settlement patterning in a specific geographical region and can be also used for superimposing diverse information databases and maps that contribute to the wider site catchment analysis.

While there is a wide range of geophysical techniques and aircraft- or spacecraft-acquired imagery for archaeological surveying which tend to complement each other as they measure different physical properties and give different information about the feature, it is also worth mentioning that the combination of geophysical prospecting with geological coring can become a fast way of surveying a location of an archaeological interest. The value of having both geological and geophysical teams working in tandem was a major advantage in the field work of tracing the walls of the Eastern Zhou city. It should be also mentioned that coring is not used systematically in the Mediterranean archaeology, due to the density of archaeological relics. On the other hand, the method could provide valuable information regarding the environmental conditions of the past.

The above approaches can be used as a guideline for the conservation and protection of the ancient sites and monuments. The importance of joint technological research programs should be stressed, since they are bringing up the similarities and differences of the approaches applied in each geographical region and widen the dimensions of our research horizon.

References


Figure 1. Location of Shangqiu area on the eastern Henan plain (left) and map showing the location of the Eastern Zhou city (right).

Figure 2. Upper left. A typical GPR data from profile across the south wall of Eastern Zhou city. The strong entirely reflections at about 68-84 meters are associated with the rammed earth structure. Upper right. A typical GPR data from the profile across the east wall Eastern Zhou city showing that the stratigraph “inside” the city is different from that of “outside” the city, thereby indicated the probable location of the wall. Lower left. (a) Gray contoured pseudosection measured across the west wall of the Eastern Zhou city; (b) Tomography result. Gray-scale is in ohm-m. Lower right. (a) Gray contoured pseudosection measured outside of the west of the Eastern Zhou city; (b) Tomography result. The central “low” anomaly below 10 meters depth was associated with the fortification ditch verified by coring.
Figure 3. Details of the geophysical survey in the Shangqiu area: A. Electrical resistivity survey (ERS), B. GEM 300 conductivity survey, C. EM and magnetic survey, D. Magnetic Survey, E. Ground penetrating radar.
Figure 4. Shaded relief image of the total magnetic field data showing a E-W oriented linear anomaly which correspond to the south rammed earth wall of the Eastern Zhou city (upper left) and the results of the excavation of the south wall of the Eastern Zhou city (lower left). Similar success was shown by geophysical prospection of mounts, as it is shown by the magnetic and EM profile sections crossing three artificial rammed earth mounds located at the Sanlintai site, approximately 15 km northwest of Shangqiu (right).

Figure 5. The Hellenistic site of Itanos in SE. Crete (above). In 1999, geophysical prospection was carried out in the ancient cemetery of the site, where excavations have brought to light a number of structural tomb remains.
Figure 6. Results of the magnetic (top) and electromagnetic survey (bottom) in the region of the necropolis of the ancient settlement of Itanos. Both methods suggest the continuation of the cemetery.
Figure 7. The topographic layout of the ancient settlement was overlayed on the aerial image of the site (top). Spot and Landsat real color and pseudocolor images (center), together with the aerial mosaic of the region of interest were employed for mapping the GPS measurements of the sites and monuments recorded during the surface survey (bottom).
Figure 8. Superposition of the results of geophysical prospection survey and the digital topographic characteristics of the terrain on the aerial photograph of the Hellenistic settlement of Itanos (top). Digital geological and topographic maps (centre). The latter were used for the construction of the digital elevation model. The results of the geophysical survey, such as the outcome of the seismic prospection, were also superimposed on the 3D rectified aerial imagery (bottom).