GIS AND ARCHAEOLOGY AT THE VOROTAN PROJECT, SOUTHERN ARMENIA

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Introduction

The Vorotan Project is an international collaborative program of archaeological research in Syunik marz, southern Armenia focused on the diachronic record of settlement and exploitation of the Vorotan River valley. Incorporating both excavation and survey methodologies, the project includes a strong GIS component. A geodatabase is being constructed using a variety of imagery and field data. Before 2007, basic Garmin GPS devices units were utilized to collect field data. To increase efficiency and accuracy, Trimble GeoExplorer GPS units were purchased for this most recent field season. The units presented initial software-related problems, but proved extremely useful mapping intensive surface collection grids, locating and re-locating geological sources in remote regions of the southern Caucasus, and collecting site-specific data. The Trimbles, and GIS more generally, have allowed us to project artifact distribution patterns and understand regionally the relationships between sites and settlements and the ways in which these changed over time.

Background – Vorotan Project

The Vorotan Project is a collaborative program of archaeological research in the province of Syunik, in the most southerly part of Armenia. This Project is being conducted jointly under the auspices of the Joukowsky Institute for Archaeology and the Ancient World (Brown University) and the Institute for Archaeology and Ethnography in Yerevan (an arm of the National Academy of Sciences, Republic of Armenia). The co-authors of this paper are the GIS consultant (Lynn Carlson) and Assistant Director (Elissa Faro) of the project, which has now completed three seasons of fieldwork from 2005 to 2007.

Our interests at the most general level revolve around the long-term record of settlement and exploitation of the Vorotan river corridor, and the strategic history of what has long been a recognized passageway for movement, contact, and exchange within and beyond the southern Caucasus. This rich archaeological landscape contains everything from prehistoric petroglyphs, to huge numbers of Bronze Age tombs, Achaemenid-period fortified citadel sites, deserted medieval villages, and so on. Although diachronic in scope, the project has a particular focus on the later first millennium BC and earlier first millennium AD, when this region was either within, or on the fringes of, several expansive imperial regimes (namely, the Achaemenid, Roman, and Parthian empires), as well as, later, powerful medieval kingdoms for which the textual documentation is particularly rich in the Syunik area.

We are pursuing these goals in several ways. 1) Analysis and ground-truthing of current high-resolution space imagery (IKONOS, QUICKBIRD), as well as inspection of earlier resources (CORONA, LANDSAT, Soviet-era air photographs) which provide data on the extent of landscape change in recent decades. Using GIS and remote sensing techniques, we have been able to begin to assess vegetation change and the signatures of specific features in the landscape. This imagery has also provided the base from which we conduct all of our intensive and extensive survey and reconnaissance. 2) Extensive pedestrian and vehicular survey within a c. 200 sq. km area mainly west of the town of Sisian, supplemented by intensive, close-spaced fieldwalking in a few selected zones. These methodologies have allowed us to discover and record new sites, identify and examine changes in settlement patterns in the river valley, as well as to assess the extent and nature of a few previously known sites. 3) Location and detailed recording of the abundant tombs of “cromlech” and kurgan type (many of them looted), to assess the changing nature of the mortuary landscapes in this region. This mortuary landscape component of the project is using GIS analysis to distinguish viewsheds and clustering of burial groups, along with the excavation of individual burials in order to more precisely classify and typologize this very visible component of the landscape. 4) Architectural mapping and test excavations at several sites along the River Vorotan: Shaghat I, Shaghat III, Balak, and Uits. Samples from these sites form the basis for a major program of AMS C-14 dating at Oxford. Excavations at these sites have yielded extensive material datable between the Early Iron Age (starting in the late 2nd millennium BC) and into the first two or three centuries AD, but they are also producing some more unexpected remains, most notably from a Middle Bronze Age settlement site located at Shaghat 1. 5) Reconnaissance of the obsidian sources about 30 km to the northwest of the main study area along with instrumental neutron activation analysis of geological and artifactual samples and detailed metrical analysis of the project's lithic assemblage from both survey and excavation contexts.

Reasons for Upgrade in GPS/GIS Technology

During the '05 and '06 field seasons, a mixture of inexpensive handheld Garmin GPS units were employed to record location-based data, and to begin building an inventory of spatially referenced information about sites, mortuary landscapes, survey grids, and other features of interest. Because these units only recorded points of latitude and longitude in a downloadable, tabular text file, a great deal of work was required during the post season to translate the coordinates into meaningful spatial data files. For example, survey grids had to be constructed by manually digitizing polygons using their corner coordinates from the GPS as reference points. In addition, field notes which were to become attributes for features - such as the number of pottery shards found in each survey grid - were entered into a non-spatial Access database. Different team members often used different acronyms, punctuation, and abbreviations when entering attribute values into the Access database. Therefore, additional post season work was required in order to reformat values, such that within the GIS framework, query statements and symbolization could be performed correctly. Thus, while the inexpensive handheld GPS units did work, there were many inefficiencies present in processing the results – some of which were avoidable, but many of which were not due to the inherent limitations of these units.

A better method was sought for the ’07 field season to enhance the data collection effort, and it was known that more robust GPS units with the following functionality would lead to a better outcome.

First, the ability of the GPS unit to display imagery was an important feature. High resolution imagery from Digital Globe had been acquired for the portion of the study area that was to be surveyed for the ’07 season. Being able to use this imagery as a backdrop would enable the field crews to see where they were in real time.

Second, it was hoped that a higher level of accuracy could be obtained for the data by adding the capability to post-process against base station files. There was some question as to whether base station files would be available for this part of the world, but even if they were not, it was felt that GPS units with this functionality would be important for other projects with which the Institute at Brown is involved, in which GPS technology would be implemented.

Third, Brown University has a university site license which includes ESRI’s ArcPad software, and the ability to install and utilize this product on the GPS data collector was significant, in that it allowed the field crews to collect complete, intact spatial data files (shapefiles) that could be immediately utilized in ArcMap, as opposed to having an enormous text file of coordinates at the end of the day requiring additional time-consuming formatting.

Trimble's GeoExplorer brand handheld units were selected for their ability to handle these functions, as well as their ruggedness. The GIS manager's familiarity with other Trimble products, as well as confidence in a specific Trimble vendor also played a role in the decision.

Software Problems

In order to achieve the goal of having the potential to post-process the GPS data against base station files (if a base station were to be available), an ArcPad extension, GPSCorrect Software by Trimble, was acquired (version 2.2). This software enables ArcPad to collect the .ssf files needed for post-processing simultaneously with the shapefiles. Prior to departing for Armenia, the hardware and software were tested and the team leader was trained in their use. Knowing that communication back to the United States would be very limited in the event of technical difficulties, backup copies of software, data files, and instruction manuals were made.

During the testing and training in RI, the units worked flawlessly. Upon arriving in Armenia however, trouble was encountered as soon as the units were turned on. The hardware was working correctly, and ArcPad was able to start; however, both units gave the error "No Position Fix". Thinking the units were simply having trouble acquiring satellites, they were left on in a static position for over an hour. This did not resolve the issue. GPS Debugging via ArcPad showed the stream of green text, indicating that ArcPad and the GPS were communicating correctly. PDOP readings were excellent (3 or less), and the readings fluctuated over time indicating that the GPS was communicating with the satellites. Within the GPS Position window, satellites were black in color, indicating a positive lock. Hardware was reset several times, but the No Position Fix signal from ArcPad continued, and no data could be collected.

In a last ditch effort, it was decided to uninstall and reinstall all of the software. Fortunately, immediately upon uninstalling GPS Correct software, the units responded with a position fix and they worked flawlessly without further issues. It was not necessary to uninstall ArcPad. Other than uninstalling GPS Correct, the solution to the No Position Fix error has never been determined. Other organizations also experienced this issue, as evidenced by entries in ESRI's Knowledge Base. It could be that a newer version of GPS Correct has eliminated the problem, although we have been unable to determine whether this is the case.

Some practical advantages of the Trimble units in the field

The decision to use the Trimbles in the field as our main method of data collection afforded us many new avenues, and helped our data collection strategies in a number of ways: 1) we reconsidered, and subsequently streamlined, our data collection strategies for archaeological survey; 2) we were able to analyze and assess results on a day-to-day basis; 3) we were able more easily to relocate and reinvestigate sites initially visited during previous seasons; and 4) we were quickly and easily able to map and lay out grids for the intensive surface collection of sites, which previously would have taken many hours or even days. I would now like to speak in a little bit more detail about each of these advantages, and illustrate them with some examples.

1) *Data collection strategies*: In the two previous seasons of the project, when we were using hand-held GPS units without ArcPad, the data on each survey tract (sherd and

lithic densities, other artifacts, ground visibility, etc.) were recorded in the field on paper forms, and often not tabulated and entered into our database until we returned from the field at the end of the season. As a result, we often had different sets of information for different types of data collection methodologies. When we moved to the Trimbles, at the beginning of the 2007 season, we were able to load shape files and their attribute tables onto the Trimbles before heading out into the field. This forced us to assess the type of data that was most useful for each method, and to create a system that allowed for cross-comparison of the different methodologies.

2) *Immediacy of result analysis*: As just mentioned, the paper forms, while a useful recording strategy, created an extra step in the data collection process – we needed to then enter the information (and post-process the GPS data), into useful ArcMap shape files, in order to assess relative densities of the material collected. While this was helpful in long-term strategizing for the project, there was little day-to-day analysis of the results, and we often made decisions about how to proceed based on general impressions of the day's work, rather than using hard evidence.

In this last season, having the Trimbles in the field on a regular basis allowed us to download and update the shape files at the end of each day. This allowed us to map our results and make decisions about how to proceed the following day. This reflexive methodology helped us to have a more flexible survey strategy and account for unexpected results in the field. Let me give you an example. When doing intensive surface survey collection in the hinterland of one of our major sites, Uits, which we saw at the beginning of the talk, over the course of weeks of work, at the end of every day, we were able to see which areas had higher or lower concentrations of material. This plot you see here is the density of pottery sherds per hectare. As a result, we focused on those areas that presented high densities of material, and in the process, most likely located a second-tier site that was closely linked to the major center at Uits. In addition, when the density of chipped stone is plotted for the same area, a very different pattern emerges. This supports our initial impression (based on preliminary pottery reading) that the high density of ceramic evidence came from a later period, during which chipped stone tools may not have been as prevalent.

3) *Relocation and reinvestigation of sites*: Another benefit of the Trimbles was the easy relocation of sites. While this was somewhat possible with the hand-held GPS units, the Trimbles facilitated site relocation and re-visitation in a much more accessible fashion, due in the part the ability to see the position of a given site against the backdrop of a map or satellite image while in the field, as opposed to just navigating to a lat/long coordinate value. For example, one of the more interesting aspects of the project involves analysis and characterization of obsidian sources, which are in a remote (even from our project) and mountainous area. A visit to these sources involves many hours of off-road driving. The Trimbles allowed us to identify areas that were impassable (e.g., huge basalt flows) and relocate our exact sampling locations from previous years.

4) *Gridded surface collection*: For the major sites in our project area we laid out grids over the site and collected surface material in tightly controlled units, in order to assess the variability of artifactual material across a site. In previous seasons, these grids were laid out by specialist surveyors with a total station, which was inevitably a time-consuming process. In the 2007 season, we were able to create the grid as a polygon shapefile in ArcMap, and create the attribute table as well. The shapefile was then displayed on the Trimbles, and using the real-time position fix, we were able to navigate to the corner of each grid unit and mark it on the ground. This made not only the

preparation and layout of the stakes marking the grid unit corners more efficient, but the data collection details were entered in the field, into the shapefile attribute table, again allowing us to assess our results immediately.

Plans for the Future

Each of these advantages greatly increased the efficiency of data collection, especially for the landscape and survey aspects of the project. However, these are the results of only one season of working with the Trimbles and ArcPad in the field. We hope to improve upon our current uses of the Trimbles, as well as explore new avenues of their use and applicability in upcoming seasons. Even at the most basic level, we will already have pre-existing shape files and templates for our data collection methods for our next season, which we can either re-use or improve upon in the future. In addition, we are hoping to be able to use the two Trimbles in tandem, like a total station, and implement this for the mapping of architectural remains.

Conclusion

We have shown that the type of archaeological methodologies used by the Vorotan Project have been made much more efficient and accurate with the introduction of the Trimble GeoExplorer GPS units and the mobile ArcPad software. Despite some initial software-related problems, these new technologies proved extremely useful mapping intense surface collection grids, locating and re-locating geological sources in remote regions, and collecting site-specific data. They allowed us to project artifact distribution patterns and understand regionally the relationships between sites and the ways in which these changed over time. Trimble GPS units in conjunction with dedicated GIS software offers new horizons for archaeological fieldwork.