A Report to the American Institute of Indian Studies (AIIS) on the Archaeos Mapping Project at Vijayanagara through February of 2002

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Summary

The following report is a summary of the mapping project conducted at the medieval city of Vijayanagara in India (a UNESCO World Heritage Site—"Unesco Site 241:Group of Monuments at Hampi") by Archaeos a non-profit research organization based in New York City. The project is directed by Dr. David Nelson Gimbel and Dr. John Fritz. This report describes the methodology behind and the results of the project through the end of the February 2002 field season.

Historical background

From the beginning of the 14th to the end of the 16th centuries, Vijayanagara, which means "City of Victory," was the capital of an empire that dominated the southern portion of the Indian subcontinent and which appears to have rivaled the greatest medieval and renaissance European cities in size, wealth, and population. The European traveler Dominigo Paes who visited Vijayanagara in the 1520's, for example, commented:

> The size of this city I do not write here, because it cannot all be seen from any one spot, but I climbed a hill whence I could see a great part of it.... What I saw from thence seemed to me as large as Rome, and very beautiful to the sight.... The people of the city are countless in number, so much so that I do not wish to write it down for fear it should be thought fabulous; but I declare that no troops, horse or foot, could break their way through any street or lane, so great are the numbers of the people and elephants. This is the best provided city in the world...

Although largely abandoned for more than four centuries, the current extent of the Vijayanagara's structural remains appear to support accounts such as the one above. The archaeological record shows that the core of Vijayanagara, known as the "Central City," consisted of a fortified royal residential quarter and separate series of bordering temple-centered religious communities that once occupied an area of approximately 20 square kilometers. The larger Metropolitan Region surrounding the Central City of Vijayanagara covered an even greater area extending to approximately 550 square kilometers.

Background and techniques

Archaeos' project at Vijayanagara focuses upon the mapping of two separate archaeological areas, the North Ridge and the Noblemen's Quarter. The project utilizes state of the art surveying technologies and computers in conjunction with digital photography and digital video to capture not only as much archaeological data as possible, but to record the actual process of mapping and working at the site for future researchers and for educational purposes.

The topographical feature known as the North Ridge, which is the project's primary area of physical interest, covers approximately 4-5 square kilometers of the site and is centered between 'Royal' and 'Sacred' precincts, or areas, of the urban core (Figure 1). In this area important historical remains have already largely disappeared due to human pressures upon the archaeological environment. Our aim is to record any surviving information that is visible on the surface of the North Ridge. Because the project focuses upon recording surface remains, as opposed to excavating, we should eventually be able to map a large portion of the extensive building and habitation remains.

The primary members of Archaeos' team are archaeologists who are attempting to utilize modern techniques and computers to record evidence that is slowly disappearing. The tools and methods of recording data are currently in wide use by professional surveyors, they are only starting to gain the attention of archaeologists. Surveying instruments, such as theodolites, alidades, and transits, have been standard tools

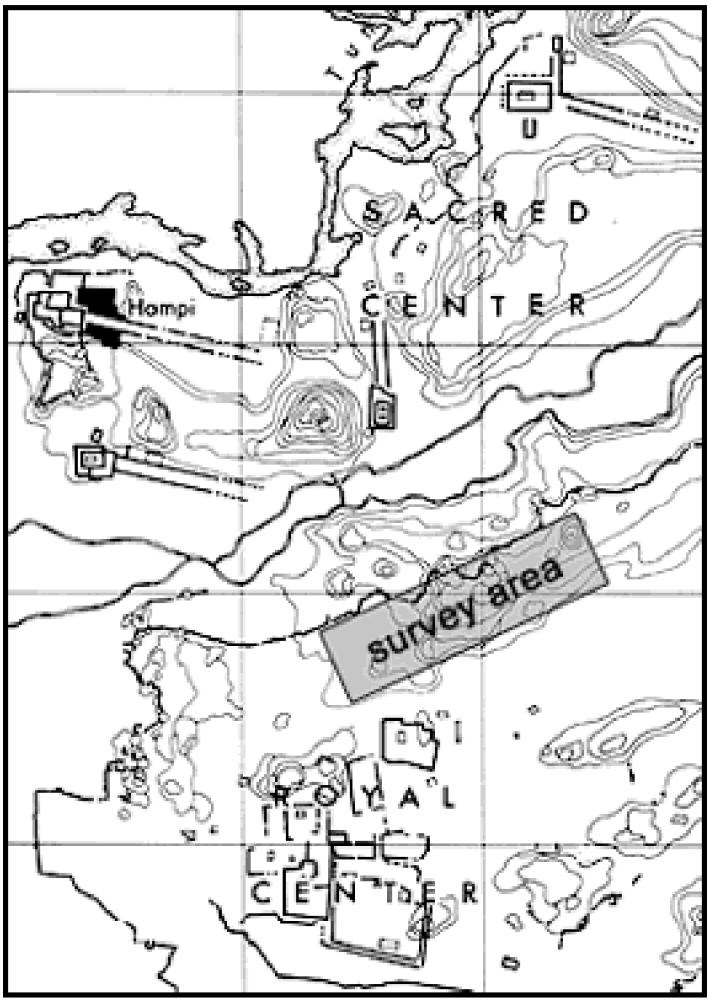

Fig. 1 Map of Vijayanagara with North Ridge survey area indicated.

among archaeologists for over a century, but the use of total stations linked to specially tailored data collection systems which import their information into Computer Aided Design (CAD) programs for rendering and analysis is only just beginning. The use of these systems, in conjunction with other new technologies that are inherently linked to technical advances in computing—includig remote sensing, GPS, satellite imaging, digital photography, digital video, and other new forms of computer rendering—are slowly enhancing the traditional ways in which archaeologists collect, utilize, and model information.

Impetus and goals

Archaeology as a whole is predicated upon the need to find solutions to discover and record hidden and/or often disappearing forms of historical data. One can understand the problems that archaeology faces by studying the case of Vijayanagara and asking what are the current threats to the preservation of remaining historical evidence at the site; and what techniques and technologies can be immediately, realistically, and cost-effectively employed to record and interpret the remaining evidence for the historical record.

We know from texts that the Vijayanagara Empire was founded in 1340 by a newly established dynasty of kings who succeeded in expelling the Muslim invaders from Southern India. These new kings established their power base by consolidating the many smaller polities and political groups with a new kingdom that lasted just over two centuries. In 1565, however, a strong Muslim military alliance under the leadership of the Sultanate of Deccan succeeded in reconquering the area, burning much of the city to the ground, killing its rulers, and defacing its temples.

Following its destruction, the capital ceased to be occupied again. Worship at Vijayanagara's many sacred shrines may never have wholly ceased, but the majority of the site was soon reclaimed by the surrounding wilderness. Today, the ancient city lies within the center of a densely populated agricultural community whose needs impact the site's archaeological remains. Although many of the city's temples, walls, and other structures still stand, a great many of them continue to be stripped of building materials in order to build farmers walls, construct new buildings, or clear new fields to make way for agricultural development. This is particularly true along the North Ridge, the main area in which we are currently working.

Ultimately, since the need for conservation and protection of the site must be balanced with the more realistic and immediate human pressures of population growth and agricultural development, archaeologists must accept the fact that although damage to the existing remains of the site may be slowed, it most probably cannot be stopped. The mission of the mapping project at Vijayanagara is therefore to collect as much information as is still possible before it disappears.

In order to do this, the project attempts to utilize each and every pertinent and economically feasible technology relevant to the task including such technologies as: total stations, CAD, GPS, conventional and digital photography, and digital video. Although the project is conceived as mainly as based upon surveying utilizing high technologies, it is also clear to us that any equipment or method that can be used to record

additional information represents a potential asset that should be investigated with a view towards possibly integrating it into the process of data collection and analysis.

A new surveying grid

Because the North Ridge at Vijayanagara is more than two kilometers in length, the first step in implementing the surveying project was to walk along the area to conduct a visual survey and to decide upon an initial area of focus. It was eventually decided that Archaeos' team should initially focus upon an approximately 50,000 to 100,000 square meter area along the southwestern end of the North Ridge where there appeared to be a very high density of building remains, which included the remains of both a small palace and of at least one other large elite complex.

One of the initial problems facing Archaeos' survey team was the lack of known, accurate surveying benchmarks upon which to base a coordinate system. Although surveying marks left behind by previous teams may be found all over the entire site, it is no longer clear to whom most of these originally belonged, what coordinates they were intended to represent, or whether they are even accurate.

It was therefore necessary to set up a newer large, closed surveying traverse—essentially an enormous triangle—containing three primary points, known as 'A1', 'A2', and 'A3'. Each of these observation and surveying points is located far from the two others and has been placed at the highest level possible. Two of these points have been marked by small bronze disks and which have been numbered so that they may be used as reference points by any other archaeologists or surveyors working at Vijayanagara in the future. At the third, a pre-existing mark of unknown origin has been used.

Because we lacked an accurate reference point in order to calculate 'true' North (as opposed to 'magnetic' North), a total station—an electronic surveying instrument similar to a theodolite—was used to shoot the bearing of the North Star in relation to a temporary backsight. The time of the 'shot', which was also recorded for future reference, was calculated by synchronizing the clock on a handheld computer used for data collection, to a radio signal emitted by the BBC to indicate the correct Greenwich Mean Time (GMT).

The first of our permanent stations, 'A1', was set up on the roof of a small temple that sits on top of a large boulder and was constructed during the Vijayanagara period. At 'A1', we were fortunate—since we did not wish to insert a bronze marker into an historical monument—that a benchmark had already been blazed onto the center of the rooftop by a different surveying team long ago. 'A1' was assigned the North-South/East-West coordinates "0, 0," indicating that it is the center point within the newly established coordinate grid. The approximate elevation of 'A1' was determined by using the total station to shoot an older benchmark that was still clearly visible and which could be correlated with the 1:400 survey maps produced in the 1980's by Indian surveyors employed by the Vijayanagara Research Project (VRP).

Two new markers were also placed on several rock surfaces where we positioned stations 'A2' and 'A3.' The first of these ('A2') was on a high bluff to the northeast of 'A1' and the second ('A3') on a flat granite formation to the southeast. The coordinates of these three points we then checked internally against one another for several days using basic trigonometric principles to ensure their accuracy.

With the accuracy of the primary traverse between A1, A2, and A3 established, the grid was then extended to include an additional 7 station points ('A3' to 'A10'), forming a mesh of interlocking triangulations over the areas in which we are currently working. In order that archaeologists and other surveyors will be able to quickly relocate these stations in the future, we have also taken GPS readings at each of the new station points and made these publicly available on our web site.

The preparation of the surveying area

During the early stages of preparation for the survey, approximately thirty workers were employed by Archaeos and were supervised by officials from the Directorate of Museums and Antiquities of the State of Karnataka in order to clear bushes, cacti, and tall grass from the project area. Several locally hired assistants also worked under the supervision of Dr. John Fritz, marking the many thousands of features to be surveyed. The marking of these features was done using a paint composed of white lime, which because it is water solvent is also non-

destructive and will wash away after several rainy seasons. In the case of complex building remains, it was also necessary for several of the team members to make rough preliminary drawings prior to surveying.

Structuring data collection at Vijayanagara

One of the most important features of Archaeos' mapping project at Vijayanagara is that it represents a series of ongoing experiments about how archaeological data is collected and eventually modeled and interpreted. One of the project's primary intentions is that each and every surveying point shot at the site must be linked to as much pertinent information as can reasonably be recorded.

During an earlier 1999 excavation season at Tell Arbid in northern Syria, Archaeos began experimenting with ways of using small digital data collectors, linked to surveying instruments in order to record both independent and nested categories of information that pertain to each of the surveying points shot. These data collectors are individually programmed with categories and codes that are specific to each archaeological site.

In "surface archaeology" projects—such as the one at Vijayanagara, for example—there is no excavation involved, archaeologists simply record as extensively as possible those features visible on the actual ground. Still many of the same types of data collection, ordering, and analysis techniques used in more physically 'invasive' forms of archaeology can be usefully applied. One of the main features that we commonly record at Vijayanagara for example, are the surviving foundation courses of stone walls and of destroyed buildings. Here, we are particularly fortunate because much of Vijayanagara sits on a series of hills and valleys that are composed primarily of granite, which means that many of the ancient city's architectural and structural features were cut directly into the metamorphic rock. These different types of distinct features are still clearly visible and can be divided into hundreds of unique categories such as: door pivots, anchor holes, mortar holes, beam sockets, quarry marks, rock cut oil lamps, and sculptures.

The data collection software linked to Archaeos' surveying instruments allows us to customize two forms of data that are entered with each point we shoot: 'control codes' and 'feature codes'. 'Control codes' function as a set of instructions which are used by a 'Computer Aided Design' (CAD) program to draw lines and points. They are used to instruct the CAD program that each and every survey point is one of the following:

Abbreviation	Full Meaning	Instruction to Vectorworks (CAD)
1.) "POB":	"polygon open begin"	the beginning point in a line
2.) "POE":	"polygon open end"	the last point in a line
3.) "PCB":	"polygon closed begin"	the beginning point in a polygon
4.) "PCL":	"polygon close"	the last point in a polygon
5.) "PPT":	"point in a polygon"	single point in a line or a polygon
6.) "PT":	"point"	a single point.

Whereas the 'control codes' listed above instruct the CAD program how to draw the surveyed points, the 'feature codes,' act as a relational database that contains several levels of nested information describing each specific point in detail. Because the data collectors linked to out surveying instruments are in fact handheld computer with standard keyboard layouts, this information can be entered fairly efficiently. The data collection software even prompts the user to enter the required data each time, though by default entering the last value put in each field to cut down on repetition of data entry.

The result is that each line of data collected contains the following types of information: 'control code', point number, X,Y, and Z coordinates, and the 'feature code' followed by its associated sub-categories of information. An example of a typical line of data exported from the data collector is as follows (N.B., in the original output form, tab stops are used to delineate breaks between each segment of information):

Raw Data	Meaning
1.) PCB*	Instruction to CAD program to begin a polygon
2.) 12	Point number in set
3.) 134.8642	X coordinate
4.) 24.2825	Y coordinate
5.) 446.6322	Z coordinate
6.) PLFB	Feature code = "pillar foundation block"
7.) VRP Map: N4E1	The reference to the VRP's 1:400 maps is "N4E1"
8.) In situ (Y or N): N	The artifact is no longer in its original position
9.) Notes: Broken	The artifact has been broken

In this example lines 7, 8, and 9 are all sub-categories of the feature code PLFB, or "pillar foundation block." Each and every type of feature code is assigned so as to prompt the surveyor to enter the appropriate sub-categories of information.

The data collection system currently being used at Vijayanagara contains approximately 150 such feature codes, each with its associated sub-categories of information. The ability to customize these codes has allowed Archaeos to gather an unprecedented amount of information about each and every point shot during an archaeological survey. As well, we were able to incorporate the large range of feature codes already in use at the site by the Vijayanagara Research Project which has been studying the area for 20 years. In total, some 19 different revisions of the feature codes have been compiled thus far in order to streamline the data collection process and without Dr. John Fritz's decades of experience at the site the process of writing the codes would have taken even longer.

Data modeling and analysis

The final step in the daily surveying process at Vijayanagara is to download the collected data from the data collectors onto a series of laptop computers where the data is then parsed into a standardized format using a series of custom scripts. The data is then checked visually by the surveyors for any errors, following which is then imported into a CAD model.

This entire process is a hybrid solution to archaeological data collection in which the Archaeos North Ridge Mapping Project has been able to collect, model and analyze data that is specifically defined by archaeological reasoning, rather than by the usual limitations of hardware and software. When we view any individual shot on the map generated in a CAD program we can click on the point and view the all of the data that was collected as feature codes and their sub-categories. We can also query the data to see how many of any given feature exists within a defined space. This offers Archaeos' archaeologists with new ways of interpreting information. A large number of mortars, or grindstones in a particular area, for example, might indicate a high level of agricultural processing and economic activity. Without the custom written feature codes used in this system of data collection stage such analysis would be difficult, if not impossible. Similarly, although many ancient buildings may have disappeared, large concentrations of rubble mounds (one of our feature code categories) containing architectural elements such as, pillar foundation blocks, roofing slabs, or door lintels—which are recorded as sub-categories of the feature—allow us to roughly interpolate the density of structures that originally existed within a given area.

Results

Archaeos' mapping the North Ridge at Vijayanagara was conceived of partially as a test project. One of its aims was to see what differences new technologies of mapping could bring to augment the methods being used by the Vijayanagara Research Project during their 1:400 mapping project conducted during the 1980's. Another was to see if the study of previously unmapped areas would bring information that would significantly alter the

previous views of the settlement patterns or spatial layout of the city.

By utilizing state of the art surveying technology, Archaeos has been able to bring a greater degree of accuracy to the ongoing documentation process. Although upon initial visual inspection the North Ridge today appears to have been largely uninhabited in ancient times, the results of the mapping process has already yielded a very different picture, based upon the approximately 75,000 to 100,000 square meters that have been precisely surveyed by the Archaeos' team thus far (Figure 2). The numbers and the massing of architectural and other cultural remains along the surface of the North Ridge, in fact, indicate dense urban development and now that many of these disparate features have been mapped, they can be more easily understood as the remains of coherent structures and indicators of economic and social activities.

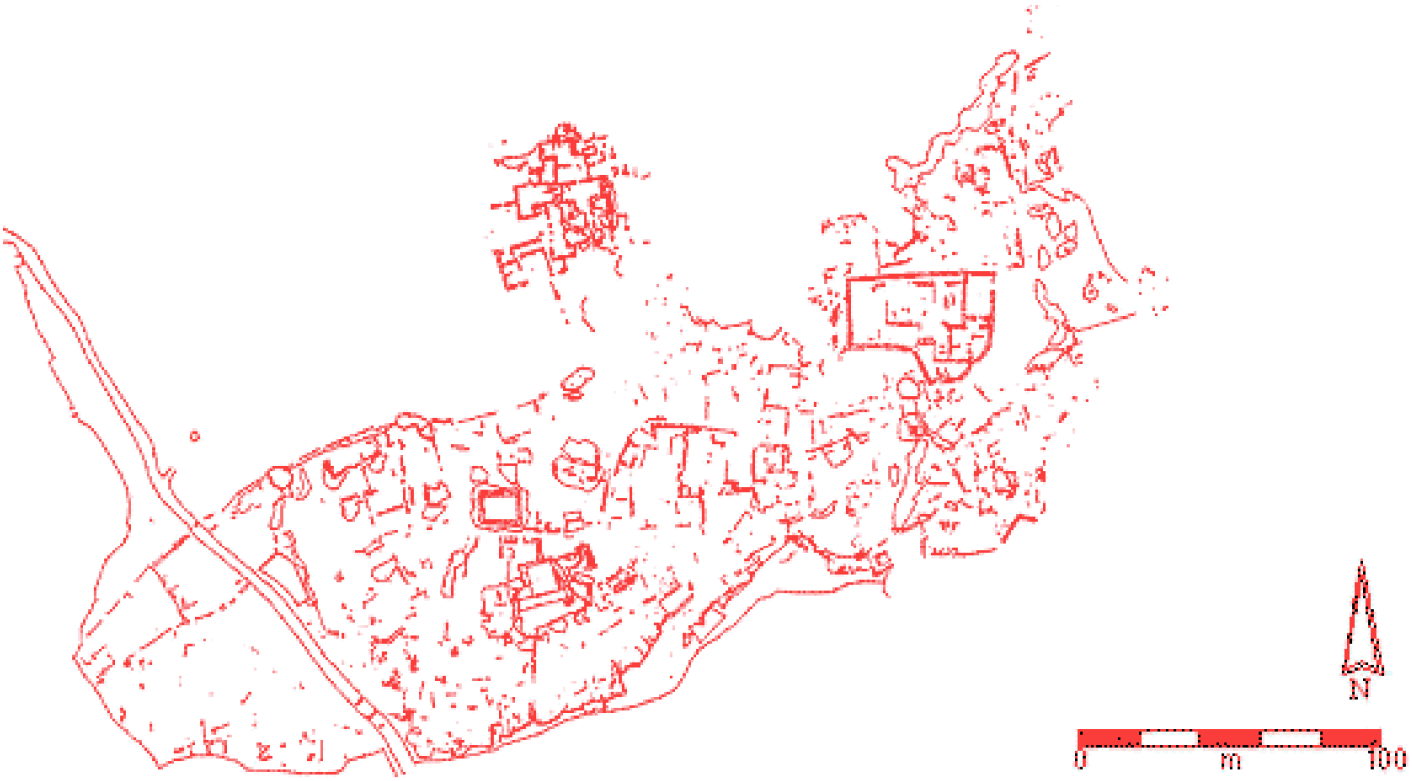

Fig. 2 Archaeos' mapping of the North Ridge through February 2002.

It is clear that this now largely denuded area, which was long thought to have been only sparsely inhabited during medieval times, was in fact a densely populated area that should be considered to have been a central part of the urban core. This result is hardly surprising given the position of the North Ridge. It is directly situated between the royal, walled complex known as the Zanana Enclosure and the outer fortification walls of the Royal City. This type of mapping and surveying that have made such an interpretation possible would not have been feasible prior to the advances in surveying and computer technologies of the last decade and a half. The project at Vijayanagara is but an initial example of how such techniques will eventually effect the wider field of archaeology as a whole.

Of particular interest in the projects' survey area are several large buildings that had been very roughly indicated on the VRP's 1:400 survey maps from the 1980's. One of these buildings had also been previously drawn by a separate archaeological team using hand held tapes. Archaeos' re-surveying of that area using modern surveying techniques, however, has revealed many inaccuracies that occurred due to the older technologies and techniques that had been employed.

The second major building within the survey area had never been previously drawn or analyzed in any detail. As a result of the survey process, we now understand that its ground plan is actually consistent with the style and layout of the small Vijayanagara 'palaces'—or perhaps administrative buildings—discovered by Indian archaeologists in an other area of the site known as the Noblemen's Quarter. At the suggestion of H. T

Talwar, the Deputy Director of Museums and Antiquities of the State of Karnataka, Archaeos has also begun to three-dimensionally map an area of the Nobleman's Quarter, both as a comparison to the palace discovered by us on the North Ridge and in order to test the viability of three dimensionally rendering of other existing buildings at a future date (Figure 3).

Fig. 3 Archaeos' mapping of the Noblemen's Quarter through February 2002.

Future directions of research

Over the last 20 years, many of the major standing structures at Vijayanagara were mapped and drawn by the VRP, under the direction of Dr. John Fritz and Dr. George Michell. The more recent work completed by Archaeos at the site through February of 2002, has confirmed the longstanding assertion of Dr. John Fritz that numerous areas of the city that were previously unacknowledged as having significant archaeological remains still need to be mapped in order to derive a more accurate representation of the area and its historical uses.

As Archaeos continues to work at Vijayanagara and to enhance its mapping and data collection capabilities, it will become possible to reach successively better levels of understanding of the spatial organization of the medieval city and its functioning. It may eventually become viable to extend the area of research to other portions of the ancient city. For the moment, however, Archaeos' project is limited to finishing surveying the southwestern portion of the North Ridge and to completing the work of mapping the series of interrelated building complexes that we have begun work on within the Noblemen's Quarter in 3-D.