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The last year of the millennium has been a decisive one for our related projects at Metaponto and Croton in Southern Italy, and Chersonesos on the Black Sea. This year, with a generous grant from the Packard Humanities Institute and the continued support of loyal donors, a new center for the study of ancient territories has come into being. For the first time we have the staff necessary to confront adequately the challenges that these wide-ranging, interdisciplinary projects present, and the assurance of being able to plan realistically for the future. Since the grant was made in May of this year we have added to the team a field director, Dr. Steve Thompson, a director of publications and pottery studies, Dr. Mariah Wade, and other key full and part time staff (see inside back cover). An organization of very talented people now exists which promises to make significant contributions not only to the research on ancient territories, but also to the study and publication of the results.

This is particularly satisfying because, when our work began over a quarter century ago, the study of this important aspect of ancient life was in its infancy. We have made important contributions, but, because of lack of resources, we had to choose between continuing research in the field or stopping to study and publish extensively. We opted to go ahead with the research. In retrospect it was the better choice, as much of the evidence of settlement in the colonial territories or chorai (no less in Chersonesos than in Southern Italy) has been compromised by development, both urban and agricultural, or has disappeared entirely. (How many hundreds of farmsites and burial grounds in the territory of Metaponto alone have been destroyed since the 1970’s?) Further, we can now bring to the final publication of the fieldwork the last quarter century of advances in technology—computer applications in archaeology have grown enormously since 1974—in scientific analyses, and a broadened perspective in interpretation. Now, at last, thanks to the PHI grant we can devote equal time to research and publication.

The results of previous field work, especially at Metaponto and Croton, even without extensive formal publication, became known over the years through articles and conference papers, and influenced, we like to think, the growing interest in “landscape archaeology” among scholars in the U.S. and Europe. It has been gratifying to be told that the Metaponto Project was a “model” for other interdisciplinary projects. But it is a great deal more gratifying to read a distinguished reviewer’s opinion that the first of our definitive publications, *The Chora of Metaponto: The Necropolis* (Austin 1998) is “a state of the art publication, and not just by the standards of Mediterranean archaeology”. More, and we trust, even better is yet to come!

We have been able to plan over the last half year an extensive program of publication. Six more volumes for the territory of Metaponto are envisioned, and three, at this point, for the territory of Chersonesos. These projects involve also a number of external collaborators, besides our staff, who have over the years have been working on various aspects of the projected volumes. Now we can give them both the assurance that these volumes will indeed be published and a schedule for completion.

The research on the ancient chora has intensified with the 1999 summer and fall field campaigns, and new approaches—for example, the use of remote sensing imagery from space to detect the ancient division of the territories both in Southern Italy and on the Black Sea—have been employed with impressive results. In particular, during the summer field campaign at Metaponto, various approaches—the study of historic aerial photographs and other remote sensing imagery, intensive field survey, and excavation—converged to produce for the first time a definitive and completely convincing demonstration of the system of land division in the chora of Metaponto. It is the oldest in the Greek world.

This report on the study of the ancient territories in 1999 will present chronologically the principal activities and the results obtained during this past year. We begin with the analysis of satellite imagery for the chora of Chersonesos, which has been carried out during the spring and fall on the campus of the University of Texas at Austin. This is a collaborative effort between the Institute of Classical Archaeology and the Center for Space Research at the University. Funding was provided by a three year grant from the National Aeronautics and Space Administration (NASA).

This year, in part because of the urgency of request by the Italian archaeological authorities and in part because of the political situation created by the Balkans conflict, we concentrated our field work in the chora of Metaponto. The Metaponto project in 1999 had four main components:

1) the study of the pottery from the Pantanello Sanctuary excavation in preparation for the definitive publication of that site

2) The interpretation of the historic aerial photos of the chora—the most important evidence for the system of land division. For this, in collaboration with CSR, we carried out an extensive GPS survey of the chora.

3) The archaeological field survey of the area of the
chora through which major oil and gas conduits will pass this year (hence the urgency of this project).

4) The excavation of a miraculously intact area of the chora in which three small necropoleis and two intersecting “division lines” came to light.

Though relative to past summers, fieldwork in Chersonesos was limited, it was not interrupted in 1999. Two team members began promising research projects. Professor Carlos Cordova began a systematic long-term palynological research project together with our Ukrainian colleagues, aimed at reconstructing past landscapes. Irina Harris carried out a brief preliminary survey of prehistoric sites on the Heraclean peninsula, while two specialists from the Getty Conservation Center sampled eighty polychromatic grave monuments to determine the characteristics of the pigment. Their results, we hope, will be included in the projected publication of these monuments.

In addition, our Ukrainian colleagues continued our joint projects of geophysical prospecting at Bezymyannaya and conservation at Site 151.

During the fall, in Austin, temporary arrangements having been made in advance for work space for the new staff members, progress began immediately on three of the projected volumes of the publication series:

1) Dr. Wade, with a small team of student-research assistants, is completing a definitive database of the pottery from Pantanello Sanctuary and has begun a program of systematic study of the clay composition of the ceramics from this and other sites.

2) Dr. Thompson will prepare the Metaponto survey volumes, in addition to his responsibilities as field director. He has begun work on the first of these volumes with a thorough study and a revision of the existing documentation, with time out for the autumn survey campaign at Metaponto.

He, Alberto Prieto, and Jessica Trelogan have made enormous headway in converting our older documentation into a consistent digital format. Trelogan has combined her study of the aerial photos and GPS campaigns of summer and fall to resolve the long-standing and fundamental question of the relationship between the grid plan of the city of Metaponto, dated ca 550 BC and attributed to the tyrant of Metaponto, and that of the chora. These two plans now can be seen to have an identical orientation and therefore were probably part of the same great transformation of the colony in the mid-6th century BC. Earlier studies had always given the two grids quite different orientations. This is a triumphal application of the new technology and a major historical breakthrough.

3) The Director of ICA has been at work on the projected volume on the Hellenistic polychrome grave monuments from Chersonesos, in addition to preparing a preliminary report—with contributions by team members—of the first five years of field work at Chersonesos.

Figure 1. Schematic map of the Heraclean Peninsula, the Chora of Chersonesos. Indicated are the excavations of the Joint Project of ICA and NPTC at Site 151 and Bezymyannaya, and locations of core samples for soil and pollen analysis (AA, NG-2 etc. See Summer Chersonesos). Maps: Paul Lehman (above); Chris Williams (below).
Remote Sensing and GIS, Chersonesos (Austin)

In recent years remotely sensed imagery, both from space and on land, has made useful and sometimes dramatic contributions to archaeology. One of the earliest and most successful of these was the application of aerial photography to the study of ancient territories and land divisions. It was the ideal and, in some cases, the only way to discover them. Aerial photography of 1950s, 1960s and 1970s has been a basic tool for archaeologists at Chersonesos and Metaponto. Remote sensing technology, both the imagery now available and the techniques for its analysis, offer possibilities for further discoveries.

It was this that prompted our decision to apply to NASA under the Solid Earth and Hazards Program (Grant NAG 5-7693), to explore the expanding possibilities of space-based imagery both for the research and the monitoring of sensitive areas, of which the territory of Chersonesos on the Heraklean Peninsula is a prime example (Figure 1). The Project has been carried out since its inception in fall of 1998 as a collaboration between the Center for Space Research and the Institute of Classical Archaeology.

This preliminary report on the results was written by Prof. Melba Crawford (CSR) and Jessica Trelogan (ICA):

Although the chora has been the object of extensive investigation by Ukrainian and Russian scholars for over a century, for reasons of Cold War secrecy, local archaeologists have had no accurate, large-scale maps of the area. In fact, until fairly recently, the only published map of the Heraklean Peninsula was a topographic map created in 1786 by a Russian military engineer, Strokov. This has been a problem for all investigators of the chora, especially those who desire to understand the unusual phenomenon of its division into lots. Chersonesos' strategic military position has also made it difficult for local archaeologists to access some important sites. Moreover, many sites (both excavated and undiscovered) are in danger of destruction by coastal erosion and urban expansion. Because of its military significance, a large quantity of remotely sensed data has been acquired over this area by space-based and airborne platforms.

Remote sensing provides an alternative means of directly determining current regional topography on which ancient sites and field boundaries can be mapped. Because of the topographic context, the imagery can potentially aid in the discovery of new sites. Remote sensing data are now available to document changes to the peninsula since the 1960s and will provide the consistent information at regular intervals that is required to monitor ongoing changes that threaten these unique cultural monuments.

The ultimate goal of the project is the development of a GIS for which the remotely sensed imagery will provide the spatial framework. The GIS will contain a series of distribution maps covering all the major periods of occupation in the chora, including the prehistoric, Greek, Roman, and Byzantine periods as well as the modern changes to the region during the last half century. Beyond the scope of human settlement, the GIS will also contain geomorphologic information including soils, vegetation, and hydrology required to recreate the paleo-environment of the chora, and trace the interaction between humans and the environment.

Mapping ancient features

The first year of the remote sensing project was dedicated to data acquisition and the development of a multi-sensor, multi-temporal database including airborne and space-based imagery, thematic analysis of these data, and the development of a digital elevation model (DEM). This work was begun at CSR in the spring of 1998 with preliminary analysis of Indian Remote Sensing (IRS) panchromatic, and synthetic aperture radar (SIR-C/X-SAR) data. The imagery was geometrically corrected and a preliminary classification was performed to provide a prototype result for fieldwork conducted in summer 1998. In June, a basic reconnaissance study was conducted of sites in the local archaeological park as well as an extended area beyond the Heraklean Peninsula for land cover, coastal erosion, and general topographic characteristics of the region. Information derived from this campaign has proved extremely useful.
in subsequent analysis of the imagery, but more fieldwork is necessary to validate and improve the preliminary results.

Two stereo pairs of high-resolution satellite photography from the recently declassified Corona missions have also been acquired, one pair from the KH-4 mission of September 1968, and the other from the KH-5 mission of October 1970. This imagery has been registered to the IRS scene, which has served as the master image for registering all the imagery acquired to date. The spatial resolution of the Corona photographs is approximately 3 meters. Preliminary analysis of the images (scanned at 1200dpi from a photographic print) indicates that, while large portions of the grid of stone-lined walls that divide the chora into plots are clearly visible as dark linear features, the individual farmsites, which are on average approximately 5 m wide, cannot be detected. Additional information will be provided by historic aerial photography from World War II and the Soviet Era, and by collaboration with Galina Nikolaenko, who has conducted extensive investigations of sites on the ground and has studied the historic aerial photography in detail. Further analysis of the Corona imagery will be conducted in collaboration with Nikolaenko during the 1999-2000 academic year.

Monitoring the sites

Although more fieldwork (planned for summer 2000) and higher resolution imagery are necessary for further analysis of the ancient remains, the medium resolution data provides the contextual spatial framework for multi-scale maps and individual site information. The investigation of sites within this larger context is key to understanding the ancient rural landscape as an integrated whole. In addition to providing a large-scale context for settlement patterns observable in airborne imagery and on the ground, space-based imagery provides valuable information about modern land use and how it has impacted the archaeological record over time. One of primary goals of this project is the identification of areas of the ancient chora in greatest danger of destruction, which will then be included in the proposed plan for an archaeological park preserve. The large temporal range represented by the imagery acquired thus far allows us to track the rate of change to the landscape that has occurred over the last half century.

The greatest single threat to the preservation of the chora is rapid urban and suburban encroachment throughout the peninsula. Comparison of the 1968 Corona and 1997 IRS scenes (see Figures 3 and 4) illustrates the growth of the urban center of Sevastopol during the 30 years between the acquisitions of the two images. A more insidious problem than the urban growth, however, is the widespread and unregulated building of dachas in the outlying countryside (see Figures 5 and 6). To define more accurately the rate of change, land use classifications of three multispectral Landsat Thematic Mapper (TM) images from 1984, 1988, and 1992 were performed. Six basic land use classes were selected for the classification (water, forest, agriculture, bare land, grasses/low-lying vegetation, and urban). Training areas for each of these classes were selected from information gathered during the preliminary fieldwork in June 1998 as well as from visual analysis of the Corona and IRS imagery. A new Bayesian algorithm, developed at CSR, that selects the most appropriate bands for each class and then classifies the data via a pairwise Bayesian scheme yielded superior results to traditional methods. Figures 3 and 4 illustrate the classification results in which six of the seven TM bands (1–5, and 7) were used as candidate inputs for the classifier. In this figure the lightest gray pixels represent the urban class (which includes dachas). The increase in this class between 1988 and 1992 for the entire peninsula was seven percent, but in the southwestern third (including the area around Site 151) the increase exceeded 25 percent within this short four-year period. Additional Landsat TM data have been acquired since 1992 but were not purchased for the initial study, in part because the greatest rate of land cover change occurred in the latter part of the 1980s. The successful launch of Landsat 7 in 1999, which now provides both affordable multispectral data and concurrent high resolution panchromatic data is critical for this project as it insures the capability for monitoring further change using a consistent data archive.

Digital elevation model

Understanding the topography of a region is essential to understanding the relationship of human settlement to the natural environment. Because no detailed topographical maps are available for the region, one of the primary goals of our project is the creation of an accurate digital elevation model (DEM), which will allow us to visualize the landscape in three dimensions. The lack of detailed maps makes this process difficult at best, but with the support of a data grant from the European Space Agency, we are undertaking the development of a DEM from synthetic aperture radar (SAR) data acquired by the ERS-1/2 satel-
Figures 3 and 4. This pair of Landsat multi-spectral images of the entire Heraclean Peninsula demonstrates the rapid urbanization during just four years between 1988 (Figure 3) and 1992 (Figure 4). In this brief period Ukraine, which includes Crimea, attained its independence.
lites. The DEM is being created using a method called repeat pass interferometry (InSAR), which exploits the relationship between the difference in the phase measurements for two acquisitions to determine topography at every point in the image. The method provides more accurate DEMs than traditional stereo-based methods for low relief topography. This is extremely advantageous for most of the nearly flat Heraklean Peninsula. A composite (Figure 7) shows the Corona image draped over a preliminary DEM developed from a single pair of SAR images. The ultimate goal is to utilize multiple pairs of ERS data from both ascending and descending passes to mitigate the effects of atmospheric artifacts and radar shadow in the mountainous eastern portion of the peninsula. New methods are being developed at CSR to combine the resulting InSAR DEMs, and where available, to integrate these with stereo-based DEMs from spaceborne platforms and aircraft.

Conclusions and future work
The Chersonesos remote sensing project is a work in progress. However, initial results indicate that analysis of a combination of remotely sensed data types in conjunction with a GIS containing information about individual sites (derived from surface survey and excavation) along with geomorphologic information will provide an effective means of recreating the ancient landscape of Chersonesos. This combination will provide the context for a more comprehensive understanding of the ancient landscape. We hope to be able to answer some fundamental questions about when and why the inhabitants of Chersonesos settled where they did, how the natural environment affected their decisions, and how they altered the landscape by their activities.

Remote sensing data also provide an excellent means of documenting and visualizing recent changes that threaten the preservation of the ancient record. Visualization tools will be used to display these changes as an aid in land use planning, site protection, and the development of the archeological preserve. The final product, which will be available for dissemination to the public both on the Internet and on CD-ROM, will contain multi-resolution visualization products, such as 3-D walk-throughs and fly-overs, as well as time-series animations that will illustrate how the landscape has been changed by anthropogenic and natural effects over time.

Figure 5. The Corona image of 1968, in which are visible the details of the ancient division (See inset enlarged detail of the area around Omega bay), has been combined here with a digital elevation model (DEM) created by interferometry from two stereoscopic radar images, to suggest how the ancient system of roads and fields was related to the topography. The view is from above and looking south.
Figures 6 and 7. This pair of panchromatic images of the same area along the Yukharina Balka (including Site 151) shows the changes that have taken place in interval of twenty years between the Corona images of 1968 (left) and IRS of 1992 (right). In the IRS image the subdivision of a large part of the area for dachas is very clear. The land of the Preserve around Site 151 (upper center) has been spared. The dark patches are recently-planted pine groves. Comparison of the scanned images was made on the computer using the ENVI program.
Figure 8. The main room in Banca pottery lab at Metaponto, with the students at work on a random sample of coarse wares from the Pantanello Sanctuary excavation. Clockwise from lower left: Mariah Wade, James Collins, Mindy Spearman, Don Wade and Bronwen Wicckiser.

Figure 9. Restoration lab of the Metaponto Museum. James Collins works on material from this summer’s excavation at Pizica, under the direction of Vita Quattromini of the Museum staff.

Figure 10. Local potter, in the pottery town of Grottaglie, demonstrates techniques for the students.
Summer 1999
Metaponto

The Pottery Study
The study of the entire ceramic material from the Pantanello Sanctuary excavation (1974–1991) is an enormous undertaking, and a pioneering project. There are on the order of 200,000 excavated and catalogued pieces of pottery from the site.

We decided in 1991 to study the whole record from this significant site. Only in this way it is possible to know about all the activities on the site that required ceramic containers, which, in the absence of written documentation, is important evidence for how the cult functioned. Further, no such comprehensive study exists for any site in Southern Italy, and few, if any, other areas of the Greek world. Indeed there is no reliable reference work for most classes for pottery represented at the sanctuary. We desperately need, for example, an accurate typology and chronology of the black gloss pottery (6th–2nd century BC) for our study of the other sites in the chora of Metaponto. Such a study would, moreover, have a wider application to the Ionian coast of Italy. The goal is a complete description, from the typological and functional, technological and chronological points of view, of the entire assemblage. Such an undertaking would have been virtually unthinkable even twenty years ago, but the computer has changed that. Now, the main requirement is a trained research team.

Directing the study project, which gained momentum dramatically in 1999, is Dr. Mariah Wade, who with her husband Don Wade, began it in 1991. She, Don and a small group of students started by tackling the coarseware, less appealing than the black gloss, and also much less well known and studied. They carried it forward until 1996, when she paused to complete her Ph.D. The acumen and commitment demonstrated by this particular team of student-workers gives this sample a high degree of reliability.

One of the tasks of the laboratory at Pantanello site, but also as a control baseline for other projects in the area. Its importance cannot be overstated.

The great variety of the vessels produced, discarded, excavated and analyzed at Pantanello should permit an unique picture of pottery manufacture, use, trade, and the relationships between Pantanello and other archaeological sites in the region.

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Random Sample Study
The decision, made this year, to select and analyze a random sample was motivated by two different objectives. First, the ceramic analytical work in the past was conducted by a team of workers, whose composition changed from season to season. This often led to uneven recording of data which complicates analyses by statistical methods. In recognition of this difficulty the laboratory team involved in the summer season of 1999 performed a careful and systematic analysis of a random sample of ceramic wares from the areas of the Pantanello site designated as Spring, Sanctuary, Farmhouse, and Factory (Figure 8). The statistical random sample was made from a total of 2,272 pottery lots. Fifty-two, or 2.3% of the total, were selected for the study. These 52 lots included 1,695 vessel parts that were analyzed and the data obtained was recorded on data sheets. The work was carried out by Bronwen Wickiser, James Collins and Melinda Spearman under my direction and that of Don Wade. The acumen and commitment demonstrated by this particular team of student-workers gives this sample a high degree of reliability.

The aim of the statistical sample is to test the accuracy of the statistical results obtained from the general coarseware database and pinpoint problems in the database as well as areas of the site that need further research. This database is innovative and very important, not only as means for understanding the various components of the Pantanello site, but also as a control baseline for other projects in the area. Its importance cannot be underestimated.

One of the tasks of the laboratory at Pantanello is to train students to process and conduct the scientific analysis of the materials that result from an archaeological excavation. A random sample is an appropriate teaching tool, since it, by its very nature, embodies a variety of ceramic specimens from all time periods and areas of the site. The random sample studied in the 1999 summer season provided the student-workers with an
unbiased overview of the archaeological materials obtained from the site and the chance to study a representative mixture of Greek and Roman ceramics.

Drawing and Restoration
Before leaving Austin, the team of students participated in a workshop I gave on pottery research. Anne Toxey (who designed and edited the Necropolis volume) instructed students in the basic techniques for drawing archaeological vessels and sherds. Bronwen, James and Melinda profited immensely from the lessons and produced very good renditions of a variety of ceramic material. Their efforts became very important in the recording of some forms and problematic pieces that had not been encountered before. James spent much of July drawing the fine Greek colonial and indigenous vessels from the multicomponent site of Incoronata (the subject of another Chora of Metaponto series of publications). The fortunate discovery of the two small necropoleis during this field campaign (see below) provided fresh material for the students to study. While some vessels were recovered intact, most had to be reconstructed. James participated in this effort under the guidance of Vita Quattrouomini (Figure 9) of the Metaponto Museum. The constant collaboration of Dr. Antonio De Siena, the Director of Metaponto Museum, and his staff, has been essential to our work and is always much appreciated.

Research on Black Gloss Pottery
The importance of black gloss vessels as chronological markers is well known in classical archaeology. The work on the black gloss collection of vessels from the Pantanello site (Sanctuary, Spring and Farmhouse) was begun by Maria Elliot and further work was recently undertaken by Kara Nicholas, whose forthcoming dissertation for UCLA will provide a catalogue of the selected archaic and classical black gloss vessels from the sanctuary. The dissertation goes beyond a discussion of the pottery to consider the importance of rural sanctuaries in the spiritual life of the community and the relationship between the Pantanello sanctuary and others in the chora and throughout Southern Italy.

Because of the great quantity of black gloss pottery of all periods and its importance for the chronology of Pantanello and the coarseware, I also am carrying out research that focuses on the morphologic changes of vessels with special emphasis on clay mineralogy, temper constituents, manufacture techniques, colors, firing techniques and firing problems. I have also concentrated my research on a series of specific manufacturing traits that are objective and measurable and which can be indicative of particular artisans or workshops. Some clues, such as potter's fingerprints and tool marks, tell of manufacturing procedures and are potentially useful internal indicators of chronology.

The research is innovative, but time and labor intensive. Reliable and profitable results can only be obtained by close scrutiny and intense concentration. This summer we recorded, sketched and photographed some 300 individual pieces. Bronwen, James and Melinda, after training, were able to contribute also to this aspect of the project. Their commitment, interest, observational skills and drafting capabilities contributed significantly to the analysis of a vast sherd collection. We hope that these students will be able to continue work on the project.

While the Sanctuary volume is a high priority now, the ceramic studies preparatory to subsequent volumes were also carried out in 1999 by several team members. The volume, dedicated to the Roman Tile Factory at Pantanello, will include a study of the remarkable material from the kiln deposit: the moulded and plain greywares by Gert Burgers and Douwe Yntema of the Free University of Amsterdam, the table wares by former UT graduate Jennifer Brehob, and the pioneering study of the entire faunal material from our excavations in the chora of Metaponto by the late Professor Sandor Bökényi of the Hungarian Academy of Science.

The Kiln Deposit/Roman Amphorae
Marsha Robbins, working with the Pantanello project since 1993, is writing her dissertation on the Roman amphorae from Pantanello at the University of Southampton—a major center for the study of ancient ceramics. The work on the Roman amphorae is particularly important because of information those vessels can provide about local manufacturing and trade connections in Greek Southern Italy under Roman domination. Marsha is also reconstructing the vessels she is researching and will prepare and analyze ceramic thin-sections of the amphorae from the site. We hope to utilize her skills in the analysis of other ceramic fabrics in order to understand the relationships between the Pantanello site and other sites in the area, particularly the urban center.

Before beginning her dissertation work, Marsha learned pottery making and experimenting with various clays, and manipulated their matrices by adding tempers and ripening the clays.
She writes of her work:

After three summer seasons I have been able to analyze methodically a total of 139 boxes of excavated material found in the kiln deposit of Pantanello, which represents the bulk of the material. Besides the analysis, all amphorae which could be conserved and reconstructed accurately I have conserved. These include numerous half profiles (rim to shoulder with at least one handle). This year I have found many of the missing pieces needed to complete them; there are now half a dozen almost-complete profiles.

This year I also began the exciting process of matching pieces from different excavation years based on form types and fabric already entered into my data base. This is essential for an accurate statistical analysis of the material. Comparing the Pantanello amphorae with those from other sites I have found that about 85% of all amphorae fall into well documented categories (Peacock and Williams, *Amphorae and the Roman Economy*, 1986), while the remaining ones need further research to determine their typology. The largest category is that of Class 2 (‘Greco-Italic’; Republican 1; Lamboglia 4), followed closely by Class 31 (Dressel 28), which had a widespread distribution in the Western Roman Empire. Next we have an equally large category of amphorae which fits into Class 36 (Tripolitanian 1; Ostia LXIV), which are thought to originate from Tripolitania. Along the same lines I have found equally as many amphorae of Class 34 (Africana II ‘Grande’; Beltran 56; Ostia III; Keay VII), probably from Tunisia. Examples of Class 10 (‘Greco-Roman amphorae’; ‘Koan type’; Dressel 2-4; Ostia L1; etc.) are also present. The most distinctive feature of these amphorae are their “double-barreled” handles. Several production areas have been suggested for these amphorae.

In smaller numbers are amphorae of Class 38 (Dressel 30; Ostia V; Keay 1), probably of Algerian origin. Even fewer amphorae were found to fit the categories of Gauloise (Classes 29 and 30) and Pelichet, both originating in France, and Class 40 (Benghazi MR amphora 1), whose origin is unknown, but, most likely, is located in Africa. Surprisingly, very few Brindisi amphorae (Class I; Ostia LXVI) have been found.

More precise data, such as thin-section analysis, are needed to substantiate any claims of origin and dates. Samples have been taken from most of the categories listed above for thin-section analysis. Through this process I hope to weed out style copies and incongruities commonly found in a site such as this, and to avoid falling into the trap of defining a type based on the superficial form only.

Mariah Wade continues:

Kitchen Ware Vessels

As part of the research on coarseware vessels, Smadar Gabrieli analyzed and researched the kitchen ware vessels from the Roman Kiln Deposit. She has just obtained her Masters Degree with Distinction from the University of Western Australia. Her work focused on the technological aspects of the manufacture of the vessels and the relation to their specific function, and on what could be learned from the kitchen assemblage about the cooking habits of the people who used those vessels.

Field Trips

The Institute of Classical Archaeology has always tried to provide its field school participants with an instructive and culturally rich experience. This year was no exception. Don Wade and I took the participants on various field trips. On weekends we visited museums of Lecce, Matera, Metaponto, Policoro, and Taranto. These visits are invaluable for the understanding specific problems of ceramic forms as well as the diversity and complexity of pottery traditions—covering some six or seven millennia—in this part of the world.

The student-workers of the also visited several ceramic shops in Grottaglie, a town of potters. At the Salvatore Trani bottega they had the opportunity to witness the preparation and production of several clay vessels from the point when clay was thrown on the wheel until the vessel was ready for drying (Figure 10). This workshop, in existence since the 1800s, provided them with a unique opportunity to understand the pottery-making procedures, ask questions, and actually discuss and participate in the trade. At another workshop they witnessed the manufacture of miniatures and saw the modern versions of traditional Greek and Roman vessel forms. These trips, which covered a good part of the territories of Basilicata and Puglia, provided the students with a picture of the physical and cultural landscape, and an insight into problems that affected past and present populations.
The Metaponto field survey was begun in 1981 with the aim of documenting settlement patterns in the territory as they changed over time, from the earliest human occupation to the present. It built on the work of previous surveys in the area by Italian and French colleagues, but differed from them in several important respects. First, it was intensive and systematic within the designated study area; a transect between the Bradano and Basento Rivers, with a total area of 42 square kilometers. Subsequently a smaller area around the Pantanello Sanctuary and Necropolis were surveyed. In these areas every accessible field was covered on foot. By 1985 well over 500 sites, the majority dating to the Greek colonial period (ca 600–250 BC), had been placed on the archaeological map of the chora. Second, it is a type of archaeological research in which computer technology—as this report will show—is not just extremely useful, it is essential. The first databases were by today's standards primitive and have had to be continually revised (See Thompson, below). The project has grown, pari passu, with advances in hardware and software applications, such as relational databases and geographical information systems (GIS).
Historically, the Metaponto survey was the first intensive field survey of a Greek colonial chora (or any chora for that matter). It was followed by our survey of the chora of Croton, which confirmed the results from Metaponto, that the territory was densely inhabited throughout the colonial period and into the period of Roman dominance. We decided in 1992 to expand the Metaponto survey to the rest of the chora. By 1994 the number of documented sites climbed above 700. Many of these were Greek farmhouses and their associated family burial grounds.

In 1999 we were able, with the generous support of PHI, to have a full-time field director for our excavations, Dr. Steve Thompson, who is also an experienced and innovative surveyor. The survey was renewed after a four-year pause. Besides adding to our knowledge of the chora, it had a very specific objective. We were invited by the Soprintendenza archeologica della Basilicata, to undertake an urgent investigation to determine the possible damage to ancient sites in the territory in the path of the new, major oil and gas pipelines from the mountains of Basilicata to the AGIP refinery in Taranto.

Steve Thompson writes of this effort:

During the summer and early autumn of 1999, ICA—at the invitation of Soprintendenza archeologica della Basilicata—conducted an archaeological surface survey along the corridor of proposed oil and methane gas pipelines as these pass through the territory of ancient Metaponto between the Cavone and Bradano Rivers. In all, ten weeks of fieldwork were devoted to this project. An initial seven-week season took place between June 23 and August 10, and this was followed by an additional three weeks of fieldwork between September 21 and October 11.

The Pipelines

Prior to the initiation of fieldwork, a map (1:25,000) of the proposed oil pipeline was provided by S.N.A.M., the firm organizing the construction. The course of the pipeline is subject to modification, and our transect was designed accordingly (Figure 11). We received news of the construction of an additional methane line towards the close of the summer field season and were only able to identify the course of this line from marker stakes found in the field during the second season.

The oil pipeline, which closely follows the route of an existing methane conduit, will cross the Cavone River in the Acinapura region, traverse the valley bottom, and ascend the marine terrace before passing through the localities of Lama S. Nicola, Mandra Feroleto, le Cesine, and San Teodoro (Nuovo and Vecchio). Approximately 600 m west of Masseria S. Teodoro Vecchio, the oil pipeline will descend the marine terrace into the valley of the Basento, crossing the modern channel of the Basento River some 800 m north of Azienda Lazzazera (Casa Furlà). Northeast of the Basento River, the proposed oil pipeline will be paralleled by an additional methane conduit. Beginning at an existing S.N.A.M. facility in the vicinity of Casa Graziaidei, the two pipelines will ascend the interfluve to the northeast and then pass through the Masseria Cardillo, San Salvatore, and Pizzica localities. The pipelines’ corridor crosses the Bradano River roughly 1 km due west of the Tavole Palatine in the vicinity of Masseria S. Salvatore. Fieldwork along the oil/methane pipeline corridor was confined to the areas lying between the channels of the Cavone and Bradano Rivers. In all, the total length of the surveyed corridor is 18 km.

Survey Methods

Archaeological survey corridor focused on a transect, with a minimum width of 200 m, centered upon the proposed route of the pipeline(s). In actuality, the survey transect often exceeded 200 m, sometimes broadening to as much as 500 m, as in most instances fields lying even partially within this corridor were surveyed in their entirety. Very occasionally, the width of the transect was reduced to less than 200 m due to poor visibility conditions and/or standing crops in fields along the corridor. The boundaries of all surveyed fields, or “plots,” as well as the routes of the one existing and two planned pipelines were recorded on a master map of the region at a scale of 1:10,000. In the main, field mapping relied on hand-held compasses and pacing, though in certain instances a Global Positioning System (GPS) was used.

The initial seven-week season provided full coverage of approximately 75% of the 18 km long pipeline corridor. Survey of virtually all of the remaining roughly 4 km was carried out during the second, short season when conditions—surface visibility and access to fields—were less restrictive. In addition to the work along the pipeline corridor, several days were devoted to surveying a series of fields within a ca. 200 x 400 m area along the western side of the Strada Statale (SS)106 in the Matine di S. Teodoro locale between the Basento and Cavone Rivers. As this area appears to contain the remnants of several ancient division line features (see below) and well as extensive scatters of surface artifacts, it was chosen for survey as it complemented contemporaneous work within
the remote sensing/GPS study of these important features.

During plot survey throughout both 1999 seasons, field walkers routinely were spaced at 10 m intervals (Figure 12). The presence of orchards or other crops planted in rows occasionally required that walker intervals be collapsed (6–8 m) or expanded (12 m) somewhat. As during earlier survey seasons between the Basento and Cavone Rivers (1991–1994), each field surveyed in 1999 was assigned a unique identifying number, or “plot number.” Plots surveyed in 1999 were numbered sequentially according to the order surveyed—beginning at 1—with each plot number being preceded by “99-” to differentiate it from plots surveyed during previous seasons. For each surveyed plot, a standardized form was completed on which was recorded a variety of information for the plot, such as walker interval, surface visibility, current land use, artifact content, sites recorded, etc. In contrast to previous seasons, sketch maps of plots were not drawn as these were deemed of little utility. Additionally, the earlier practice of collecting and cataloguing “isolated finds” from off-site contexts was abandoned. Rather, during plot survey in 1999, all diagnostic and potentially diagnostic artifacts as well as all feature sherds (rims, handles, bases), all prehistoric pottery, and all lithic artifacts encountered in each plot were collected, bagged together, and labeled by plot number. A total of 188 plots were surveyed during the two 1999 seasons (Plots 99-1 through 99-188).

Areas of noticeably higher artifact density identified during plot survey were defined as sites and accorded more thorough recording and collection. In particular, a system of surface artifact density mapping was introduced and carried out on virtually all of the sites recorded in 1999. Site surface density mapping entailed establishing a grid over the site area using hand-held compasses and 100 m measuring tapes. Site grids invariably were based upon 50 x 50 m cells, with the corners of each cell marked by a colored wire flag. Flags of different colors were then placed along the sides of each cell at 5 or 10 m intervals. Using the flags as guides, field crew then lined up for uniformly spaced passes across the site area. During these initial passes, crew members counted all artifacts in their lines of vision (typically a 2 m wide swath). Crew counters were stopped at regular intervals (5 or 10 m) by the crew supervisor and artifact counts were called out and recorded on a scaled site map. The cumulative picture of the density and distribution of surface artifacts across the site area provided by density mapping allows for a clear definition of site boundaries and of internal structure of the distribution of surface artifacts within a site area (Figure 13). Only in relatively few instances of poor or highly variable surface visibility was density mapping not conducted. Following density mapping, the field crew again used the flagged grid to orient themselves for closer interval (3–5 m) passes across the site, concentrating exclusively upon the collection of surface artifacts. As with routine plot survey, on-site artifact collection focused primarily upon chronologically diagnostic artifacts as well as all feature sherds (rims, handles, bases). (Fig. 14. Samples of roof tile and common fabrics were also taken from sites. In addition to a detailed map of each site’s surface and surrounding area, a standardized form was completed for each site recorded during survey. The labeling of sites discovered in 1999 continued the system of consecutive site numbering begun in the early 1980’s at the onset of survey work in the territory of Metaponto.

Figure 12. Survey director Steve Thompson records the numbers of pottery fragments and lithics during a pass. The entire swath, 18 km long and varying from 200 to 500 meters, was covered by the team during the 10 weeks of the summer and fall campaigns.
Using Global Position Systems

Global Positioning Systems (GPS) were used intermittently during the 1999 survey seasons (See Figure 17). The potential value of this technology is in its ability to allow us to collect spatial data in digital form so that it can be immediately imported into an ever-expanding digital Geographical Information System (GIS) database of archaeological remains in the Metapontino. During the second half of the initial season, from July 20th onwards, we used a Trimble Pro XRS to determine the coordinates of the corners of site grids and of nominal site centers as determined by density mapping. Accurate coordinate calculation using this unit is possible only when used in conjunction with a second GPS base station and, thus, “real

Figure 13. Density map of the surface finds at two survey sites, 728 and 730. The numbers record the count of ceramics, tile, lithics and other artifacts in the 10 meter square cells of the grid over the sites. These are two quite large and important sites, probably Greek farmhouses. Site 728 lies directly in the proposed path for the oil pipeline.

Figure 14. A typical selection of surface finds from a survey site, in this case Site 730. The assemblage consists of black gloss and red-figured vases of the 4th century BC date, as well as coarsewares.
time” coordinate determination was not possible. During the second season, we experimented with a Trimble Pro XRS with a differential subscription service that allowed for very accurate (c. 50 cm) real-time coordinate calculation. Once again, we used the system primarily to collect real-world coordinates for our site grids. In addition, we experimented with the possibility of using GPS for gathering spatial information for the mapping of plot boundaries. While the apparent high accuracy of the Trimble Pro XRS seems more than adequate for mapping during archaeological survey, use of the unit does require considerable time in the field. Rather than collecting line data from walking around the perimeter of survey plots, a more time efficient means is to simply gather corner points, a practice that works for all but the relatively few fields with highly irregular field boundaries. Downloading GPS data daily and converting these to an ArcView event theme allowed collected points and lines to be readily viewed. Accuracy of collected data, however, can only be determined if it can be overlayed on scanned and geo-referenced topographic maps and/or aerial photographs, a process that was also experimented with using ENVI software.

Survey Results

A total of 66 new sites (705 through 770) and one previously known site (413) were identified and recorded during this summer’s work (see Figure 11). The area of one additional previously known site (414, in Plot 99-165) also was resurveyed, however no concentration of artifacts indicative of this site was discovered. Sixty-two of the sites recorded in 1999 were discovered during survey of the oil/methane pipeline corridor, while the remaining 4 sites were located within the small area covered in the Matine di S. Teodoro locality.

With the exception of the lowest terraces within the Cavone and Bradano valleys, sites were discovered throughout the full course of the surveyed pipeline corridor. The virtually complete absence of artifacts of any date on the surface of the Cavone and Bradano valley floors suggests considerable recent alluviation. It should be noted, however, that sites (759, 742, 762) were located at the margins of both valleys at the base of the marine terrace slopes. Sites were also discovered along the margins of the Basento valley (e.g. 413, 726, 727, 729, 767, 768), however in this valley three sites (766, 769, and one unsurveyed site west of Casa Furlò) were located further out on the broad, level, lowest river terrace. Sites were also found within the valleys of minor drainages throughout the surveyed corridor (e.g. 708, 719, 720, 733, and 750). Most recorded sites, however, are located on the two high, roughly level marine terraces that lie between the Cavone and Basento and Basento and Bradano Rivers. Particularly high concentrations of sites were discovered in the Masseria Gallotta-Pizzica locale southwest of the Bradano, in the area of Masserie S. Teodoro Nuovo and Vecchio southwest of the Basento River, and in the Mandra Feroletto-Lama S. Nicola locales northeast of the Cavone.

Prehistoric ceramics were typically rare throughout the area studied, although two sites (734, 754) produced significant quantities of impasto pottery. In both of these cases, diagnostic sherds indicate at least Late Neolithic occupations. Relatively high quantities of prehistoric pottery were collected in Plot 99-59 (Mass. S. Teodoro Vecchio) in a field adjacent to an excavated Late Bronze-Iron Age cemetery. No clear concentration of prehistoric pottery could be defined here, and it is possible that material from excavations in the area subsequently have been dispersed across this field.

Artifacts of flaked stone—primary flint, but also some obsidian—were found lightly distributed throughout much of the region surveyed. Most lithics were collected during routine plot survey, though more noticeable concentrations of this material were noted, as during previous seasons, towards the edges of the region’s higher terraces. A single site (717, S. Teodoro Nuovo) covering some 160,000 m2 produced a large quantity of lithic artifacts, though no prehistoric pottery was collected here.

All but two of the 66 sites identified this summer contain material broadly dated to the period of Greek occupation (see Figures 14 and 15). The two sites without Greek material are Site 717, the extensive scatter of lithics near Mass. S. Teodoro Nuovo mentioned above, and Site 761 in Plot 99-96 which contained only fragments of iron slag. The evidence of Archaic-Early Classical period quarrying activity discovered during excavations at Sites 736 and 737, also in Plot 99-96, suggests that the evidence of iron working at Site 761 may be associated and, thus, of likely Greek date. The 66 Greek sites recorded in 1999 are widely distributed throughout the surveyed pipeline corridor, conforming to the broad patterns discussed above.

Thirteen sites contained pottery securely dated to the Roman Republican and/or Imperial period. These are Sites 716, 735 (Republican only) 726, 742, 746, 747, 762 (both Republican and Imperial), and 715, 720, 724, 727, 743, 748. 750, and 760.
(Imperial only). Without exception, these Roman sites also contained evidence of occupation during the Greek period.

Three sites (724, 748, and 762) contained Medieval pottery. Site 724 is located around the buildings of Masseria S. Teodoro Vecchio, overlooking the Basento valley to the north. Site 748, in Matine S. Teodoro, lies at the eastern edge of the marine terrace along the modern SS106. Site 762 is located on a small hill adjacent to the southern side of the Bradano valley. Site 762 produced evidence of occupation during both the Roman Republican and Imperial periods, while Sites 724 and 748 have evidence of Roman occupation only during the Imperial period. All three of these Medieval sites display evidence of earlier, Greek occupations as well.

Effects of Pipeline Construction

Two sites and three known or probable division line features will be disturbed by construction of the new methane conduit in the Masseria Gallotta-Pizzica locality. This route will disturb known division lines as follows:

1. The pipeline will cross a field-confirmed “longitudinal” (i.e. NW–SE) division line feature in Plot 99-96. (See discussion of excavation, below.)

2. It will cross a possible division line feature visible on aerial photographs and in the field as a shallow NW–SE trending depression in Plot 99-91. (cf. discussion of excavations, below)

3. It will cross a possible division line feature visible on aerial photographs and in the field as broad, deep NW–SE trending depression in Plot 99-82. (This feature also continues to SE in Plot 99-81.)

In addition, at least 16 of the sites identified this summer appear to be immediately within the area to be most heavily disturbed by construction of the proposed oil pipeline. Obviously, should the route of the pipeline vary from that indicated on the map provided by S.N.A.M. other sites may be impacted. The sites directly within the currently-proposed oil pipeline’s path number twenty-one (c.f. Figure 11).

Given the close proximity of the proposed oil pipeline along much of its route to the existing methane conduit (buried, according to local informants within a c. 3 m deep trench), many of these sites may already have been damaged to some extent by the construction of the methane conduit. Construction of the methane conduit, however, should have impacted only relatively small areas of any of these sites. In cases of shallow plowing (721, 725) or where colluvium may have accumulated (726, 733, 742, 750, 759) the presence of intact subsurface deposits is more probable. Nevertheless, anticipating undisturbed subsurface archaeological deposits on the basis of surface evidence alone is extremely difficult as the presence of any material at all on the surface indicates that some disturbance has already occurred. However, in addition to the 7 sites listed above, the potential for surviving archaeological strata should also be carefully explored at Sites 728 and 730, both in the Cardillo/Massera Gallotta locale, where extremely dense concentrations of relatively large surface fragments suggests plowing has only just begun to seriously impinge upon subsurface remains (see Figures 13 and 14). At these nine sites then, some program of subsurface testing—incorporating excavation and/or remote sensing to more accurately assess the preservation integrity of archaeological deposits—should be carried out prior to the initiation of pipeline construction. This is, of course, a minimum requirement. Ideally, all sites identified within the pipeline corridor should be explored below the surface. It is further recommended that excavation of the ca. 4 m-deep trench to receive the pipeline be closely monitored along its entire route. Particular attention should be paid to all of the site areas listed above as well as all low-lying river valleys where the accumulation of deep soils may have completely hidden all surface indications of archaeological deposits.

Figure 15. Head of the terracotta figurine in the severe style of the first half of the 5th century BC. From Site 726.
Remote Sensing, GPS project, Metaponto

The Metaponto and Chersonesos projects are two aspects of a single larger one: the study of ancient territories over the whole of their history with a particular focus on the Greek colonial period. These studies make use of the same interdisciplinary approaches. So, it should not be surprising that approaches developed for one of these two sites should find an application at the other. The Remote Sensing study of Chersonesos came first, stimulated by the NASA grant (see above). In the summer of 1999 we were able to apply some of the techniques developed for that territory to resolve one of the perennial problems of the archaeology of the chora of Metaponto: the precise locations and nature of the “division lines”, first described by aerial photography in the 1950s. These are the earliest surviving examples of Greek land division, preceding those of the chora of Chersonesos by two centuries. In fact, these techniques, combined with surface survey and excavations proved to be crucial to the success of the project. The work in the field and in the laboratory was carried out by Jessica Trelogan and by the team from CSR under the general direction of Prof. Melba Crawford.

Jessica Trelogan writes:

During the summer 1999 field season ICA, in conjunction with the UT Center for Space Research (CSR), conducted a pilot project investigating the use of remote sensing and Global Positioning System (GPS) technology as an aid to the archaeological survey in the ancient chora of Metaponto. During the initial seven-week survey season (June 23 to August 10), a preliminary GPS survey of the territory was conducted to create a base for registration of remotely sensed data (Figure 16). A trial project was also conducted using GPS in conjunction with an electronic distance meter (EDM or Total Station) for localized topographic mapping and for on-site planimetric mapping of the excavation site at Pizzica (Figure 17). GPS was also used experimentally for mapping sites identified in the surface survey during the summer season as well as during the additional three-week season between September 21 and October 11.

Aerial Photography

Aerial photography has been used extensively in the study of ancient Metaponto. Of paramount interest to researchers of the chora has been the pattern of ancient land divisions that are clearly visible from the air, but less easily identifiable on the ground due to the low topographic relief of the region. Prior to this summer’s project, ICA had in its archives a set of aerial photographs taken over the territory of Metaponto during the late 1960s which had been studied sporadically over the years by various members of ICA’s interdisciplinary team. However, because the photographs were not georeferenced (i.e. tied to a geographic coordinate system), the results of their analysis could not be easily combined with other information—most importantly, the results of surface survey collected over the past quarter century of work at Metaponto. In order to incorporate these different types of information into one easily accessible database, we are developing a digital GIS that will include, in addition to remotely sensed imagery at various resolutions, ancient sites located by survey (see above), data from our geomorphologic studies (for example the topography, soil types, ancient shorelines, detailed in Jim Abbots’ 1997 UT dissertation), and modern land use such as modern roads, structures, and field boundaries that serve as “plots” for surface survey (see Survey).

ICA’s existing archive of aerial photographs (digitized in May) was greatly expanded this summer by an extensive search of the Archives at the Aerofototeca of the Ministero dei Beni Culturali in Rome. The Aerofototeca allowed us to scan a set of over 60 photographs (at various scales) ranging in date from the 1940s (made by the
modern field boundaries that make up the survey units ("plots") are not clearly visible in the IRS image, so it was not useful as a field map. The survey team instead relied on maps at a scale of 1:10,000 created by ESACTA in the 1970s. The IRS scene is, however, extremely useful as a base for image registration, and served well as the base map for the collection of GPS data. During a three week period in July, Solar Smith and Peter Demarest from CSR collected GPS data for modern features visible in the imagery (ground control points) that could then be used to warp the image to real world coordinates. For this purpose, a combination of techniques was used. The primary technique was a kinematic survey, using a Trimble ProXRS receiver, with a real-time differential correction subscription. Using the IRS image as a base map for locating suitable ground control points, the team then drove throughout the countryside with the GPS unit mounted on top of the project's station wagon. The goal of this survey was to collect as much GPS data as possible for points visible in the IRS image. Because modern roads with clearly visible intersections are often the best points for image registration, the kinematic survey was a useful and time-efficient method of collecting large amounts of data over a large area (over 400 km²). In addition to the kinematic data, some pre-determined points (e.g. the "Tavole Palatine," the Temple of Hera on the Bradano, which is clearly visible both in the satellite image and in aerial photography) were

Geo-referencing
In order to georeference the aerial photographs (and, eventually, all of the digital GIS data), an up-to-date base image covering the entire geographic area of interest to the study was needed to serve as a base for registration. ICA purchased two quarter scenes from the Indian Remote Sensing (IRS) satellite (acquired in October 1998) to serve this purpose. We had initially hoped that the data's resolution (5 m) would be high enough to serve as a field map for the survey team onto which plot boundaries and site locations could be directly recorded. Unfortunately, many of the modern field boundaries that make up the survey units ("plots") are not clearly visible in the IRS image, so it was not useful as a field map. The survey team instead relied on maps at a scale of 1:10,000 created by ESACTA in the 1970s. The IRS scene is, however, extremely useful as a base for image registration, and served well as the base map for the collection of GPS data. During a three week period in July, Solar Smith and Peter Demarest from CSR collected GPS data for modern features visible in the imagery (ground control points) that could then be used to warp the image to real world coordinates. For this purpose, a combination of techniques was used. The primary technique was a kinematic survey, using a Trimble ProXRS receiver, with a real-time differential correction subscription. Using the IRS image as a base map for locating suitable ground control points, the team then drove throughout the countryside with the GPS unit mounted on top of the project's station wagon. The goal of this survey was to collect as much GPS data as possible for points visible in the IRS image. Because modern roads with clearly visible intersections are often the best points for image registration, the kinematic survey was a useful and time-efficient method of collecting large amounts of data over a large area (over 400 km²). In addition to the kinematic data, some pre-determined points (e.g. the "Tavole Palatine," the Temple of Hera on the Bradano, which is clearly visible both in the satellite image and in aerial photography) were

Figure 17. The meteorological station at Pantanello was chosen as the base station for the GPS. Additional data was kindly provided by the nearby Telespazio of Matera.
collected with more precision—with the unit collecting data for the same point over a longer period of time—to serve as more precise ground control points.

**Ground Truth**

Although the primary goal of the GPS survey was to collect accurate ground control points for image registration, we were also interested in locating potential archaeological features—specifically the ancient “division lines” that are visible in the aerial photographs. While we were collecting data for the highly visible modern roads and intersections, we were always keeping an eye out for “division lines”. In several areas, particularly along the west side of SS106, we were able to locate on the ground several longitudinal (NW–SE) linear features that we had previously observed in the aerial photographs. In the area around Pizzica, this “ground truth” was taken one step farther with excavation (See Excavation).

**Total Station Mapping**

During the summer campaign, we experimented using GPS in conjunction with the Total Station to create a detailed site plan of the Pizzica excavation. The coordinates of three permanent points were collected around the site using the ProXRS unit with real-time differential correction. These points were then entered as reference points into the Total Station, so that the site plan would be tied to real world coordinates and could be overlaid on the aerial photographs. The map of the three division lines excavated at this site does, in fact, line up with three linear features that are visible in the photographs.

Having confirmed independently by surface survey and excavation what were suspected to be “division lines”, we were then able to identify other potential “division lines” that are in danger of being disturbed by the oil and methane pipelines. The path of the pipeline was digitized from scanned paper maps provided by S.N.A.M., which were warped as raster images to the IRS base map (See Figure 11). In the case of the new methane conduit, for which we were provided no map, GPS points were collected during the full season on marking stakes located on the ground. The pipeline conduits were then overlaid on the aerial photographs, and division lines that lay in its path were identified.

During the full season, the ProXRS with real-time differential correction subscription was used to map sites discovered in the archaeological survey. GPS was used to map the corner points of sites, which (because the real-time differential correction requires no post-processing) we were able to download daily and overlay onto the georeferenced aerial photographs. In at least two cases, sites defined by survey were also visible in the photographs.

**Conclusions and Future Work**

The remote sensing/GPS portion of this season’s fieldwork has provided an invaluable spatial framework for the project’s existing GIS. Prior to this work, the Metaponto GIS was not tied to real world coordinates, and much of the data existed only in the form of paper maps and tabular data. The georeferenced high resolution satellite data serves as the registration base for this existing data as well as for the higher resolution aerial photography (which, as mentioned above, is a valuable tool for site detection). It also provides the important context of the modern landscape, containing more up-to-date land use information (roads, field boundaries, urban areas, etc.) than the outdated paper maps currently available for this region.

As higher resolution satellite imagery becomes available (such as the 1 m data from the recently launched IKONOS satellite), the potential for site detection should be improved. We are currently awaiting the flight of an airborne multi-spectral sensor Daedalos that will provide more information than black and white aerial photographs. Subtle changes in vegetation caused by subsurface structures may be more visible in this data, which senses in the infrared, near-infrared, and thermal, as well as the visible bands of the electromagnetic spectrum.

During the course of the summer possibilities for a joint project with the Consorzio Telaer (a branch of Telespazio, the operative side of the Italian Space Agency) were explored. After a series of meetings with Ing. Enrico Pia- gastini, and Dott. Granfranco Pandisca at the Matera branch of Telespazio, Rome, approval was given for a mission that would include a flight over the entire chora of Metaponto, with a multi-spectral sensor (Daedalos) and possibly with other sensors (see Conclusions above). For our part, we shall be working with the Italian scientists to interpret these data, providing the “ground truth”, through the results of our field work. Together we aim to develop a valid approach to monitoring archaeologically important landscapes, such as the chora of Metaponto, which could have a more universal application.
EXCAVATION: METAPONTO 1999

In late July two areas of research focusing on the “division lines” converged in the area known as Pizzica. Several of the “lines” stood out in the aerial photographs (see Figures 42-44); now, with the GPS research, it was possible to know their positions on the ground with great accuracy. At the same time the Survey team was in a field belonging to Signor DiDonna, where a Caterpillar shovel was methodically scooping up the earth and moving it about four meters to the side back and forth across the whole field (Figure 18). The soil was being turned over to prepare the field as a vineyard. The shovel was reaching depths of a meter or a meter and 20 centimeters with each movement. We were informed that this was the second time in the last 20 years that this field had been thus transformed. Steve Thompson spotted a long dark strip that stood out from the surrounding lighter-colored soil of the field. It had the orientation of a division line, about 50 degrees west of the north, and exactly the spot that it should have been according to the aerial photos. Further, a similar dark strip of soil intersected it, not quite perpendicularly. This line also corresponded with a linear anomaly in the photograph similar to the NW–SE “line”.

Steve and the team also found along the strip two areas with a high concentration of broken tomb slabs and tiles of the familiar types, known at other rural necropoleis, like Pantanello. And there were many fragments of large vessels—black gloss and red-figured craters, pelikai and amphorae—of the sort that served as grave markers. Our experience fifteen years ago, in the Pantanello necropolis, was necessary background for this summer. We knew that burials could and did cluster along a “division line” road. We found six family groups beside the one in the Pantanello necropolis and a dozen more along the main road with which it intersected.

Experience had also taught us that most burials lie not more than a meter below the surface, and are often much shallower. The chances of finding a burial or a division road intact seemed slender at best.

We took the gamble and decided to excavate. The first step was an agreement with Soprintendenza, Dottoress Maria Luisa Nava, and Dottor Antonio De Siena, to join forces in a collaborative effort. The next step was to obtain an agreement with the landowner, DiDonna. (De Siena was a master at these negotiations.) Finally, we assembled the team, composed of our students and a foreman, Giuseppe DiTaranto (who has worked with us since the project began twenty-six years ago). The Soprintendenza furnished workmen. All this was accomplished in less than twenty-four hours.

The immediate obstacle was the hundred or a hundred and twenty centimeters of recently disturbed soil that covered the surface of the field. We decided to employ the very same Cat that was doing the agricultural work to remove, as delicately as possible, this overburden. We chose to begin at the point along the “line” where the greatest concentration of tombs fragments and pottery was located. This was survey site 736. Under the eagle eye of DiTaranto, an area 20 x 20 meters cleared by early afternoon of the first day. By late afternoon not only the “division line” road, but tombs had begun to appear—the first a tile tomb of the so-called *a cappuccina* type, which were especially common at Metaponto in the 4th century BC (see Figure 19). [We excavated almost a hundred of these at Pantanello.] The second tomb exposed was of a rare type, immediately recognizable because of the large quantities of plaster that lay over and around both the skeleton and the grave goods. When the first fragment of figured pottery with a beautiful female head (Figure 20), appeared, our excitement rose. This seemed to be an exceptional burial in every way, and so it proved to be.

![Figure 18. Backhoe in action at Pizzica, surrounded by fragments of ancient tombs and pottery.](image)
The big shovel had barely scraped the upper surface of the tomb. More and more large fragments of pottery appeared and so did intact vessels, including a lebes gamikos with lid and a type of deinos of a very unusual form. In all twenty-one objects, included six red-figured vases in the best style of the late 5th century BC Italiote vase-painting, black gloss and branded ware vessels, two alabastra, a bronze strigil, an iron blade, and five iron fibulae with bone shafts (Figures 20–23, 25–29).

This burial, designated Tomb 19 (the numbering system began at 18, for bookkeeping reasons) is far and away the richest plaster-lined example we have found. We learned in our study of this type at Pantanello that they are particular not only for the plaster, but also because in almost every one we found either a bronze mirror or a representation of a mirror, often in the hands of Eros. Both the plaster—a type of gypsum—the mirror, and Eros play a role in the mythology of Orpheus, and in the complex, mystical beliefs that surrounded him, Pythagoras and Dionysos. (These beliefs were widespread in Magna Grecia in the 5th century BC and later periods.) That the occupant of this tomb shared these beliefs seems to be indicated by the subjects on three of the figured vessels: the two squat lekythoi (Figures 26–28) represent a seated woman holding a mirror, with a winged Eros hovering over her, and a larger flying Eros, carrying a coffer with a thymiaterion towards a heavily draped young woman. The perfectly intact lebes gamikos, portrays none other than Orpheus himself with a lyre, leading a young woman who carries what appears to be a flute in her left hand and a torch (?) in her right (Figure 22). One would like to think that this scene is set in the underworld and that the female is Eurydice. On the reverse of the vessel is a generic scene, also possibly set in the underworld, showing a youth extending a coffer (?) towards a young woman who sits on a stele and holds a crown in her outstretched right hand (Figure 23).

The other vessels of the corredo include a fragmentary large skyphos with a woman again seated, with a phiale (right hand) and a small lekythos (left hand). The scene “beside the tomb” is defined by the column with Ionic capitol. The most unusual and possibly the finest of the vessels is the deinos, which, though broken by the pressure of the earth (and of heavy earth-moving equipment, probably), was completely intact, held together by the soil inside it. The reserved rim is decorated with a tongue pattern, and the shoulder with parallel strands of ivy tendrils, leaves and berries (Figure 29).

In my opinion, the deinos, like four other red-figured vessels just described, is a work of the painter whom Professor A.D. Trendall dubbed The Pisticci Painter, the first decorator of pots to establish a major workshop in Southern Italy, and who was very close in style to his Attic models. He himself may have been Athenian. Trendall believed that the Pisticci Painter first worked at Metaponto, about 440 BC. He may, therefore, have been among those immigrants from Greece that included the historian Herodotus, who arrived on the Ionian coast of Italy during Perikles’ colonizing effort at Thourioi.

The sixth vessel, made in the red-figured technique, is more fragmentary. A large pelike, it must have projected above the others. In fact, it is the upper part of the vessel that is missing. In any case, we may count ourselves lucky with what we were able to recover, both of it, and the rest of the corredo.

All the artifacts from this and subsequently excavated burials were expertly restored by the Metaponto’s Museum conservation staff, under the guidance of Vita Quattrouomini. James Collins participated, and under her direction, learned the basic techniques (see Figure 9). The burials were drawn by Museum draftsman Saverio Carreccia, and the ceramic vessels by James.

A total of five more or less intact burials (T 18, 20, 21, 22) and two badly damaged ones were excavated at Site 736 (Figure 29). The two a cappuccina tile tombs (T. 18, 21) contained skeletons in poor conditions and modest grave goods. They date to about a century after T. 19, to the late 4th or early 3rd century BC. The earthen grave T. 20, without containing structure, was relatively

Figure 19. Early afternoon of the first day of the excavation at Pizzica. “The line” (right foreground) and burials (center) had begun to appear at a depth of 1.2 m.
difficult to dig. The one-handle cup, small black gloss footed cup, and the ribbed globular unguentarium are comparable to those from the tile tombs and are of similar date. The skeleton of a robust and rather large male was exceptionally well preserved in his earthen grave (T. 22) (Figure 24). His orientation, with the skull in the northern end of the grave, may indicate a date in the same period as the two tile tombs. At Pantanello there was a statistically significant correlation between skull orientation and date. The percentage of burials with such body orientation was much higher after 350 BC. At Pantanello, the cist tombs were the most expensive way to bury and were used almost exclusively in the period from 325 to 275 BC. This also is, probably, the date of the destroyed cist tomb, Tomb 23.

Though the excavation of the necropolis was expedited because of the ever present risk that the grave goods might attract the interest of a “night shift” of clandestini, the excavation of the “division line” was our real goal (Figure 31). Only one other had ever been found, and that by us in the Pantanello necropolis excavation, 1982–1986. We cut sections across the Pantanello line where it was well preserved and determined that it was a road, 20 feet wide, flanked by a ditch. Like the main road (the so-called Basento Road) which it intersected, on the flat terrain it was flanked by drainage ditches, but on a slope during a hard rain, it and the ditches became a drainage channel.

The “line” at Pizzica seems to me to be a road like those at Pantanello. It, too, is approximately 20 feet wide (6 meters). We revealed the uniform surface (Figure 32) in the excavation at the Site 736, and then cut a meter wide trench across it. The excavation yielded many sherds at every level. We reached the bedrock in this trench and discovered that the sides tapered in as we descended. The flat bedrock at the lowest point was a level surface about 3.5 m wide. What does this profile indicate? There is an ongoing friendly debate about how to interpret it. It has been suggested that what we have here is not a road, but a trough-like canal. To my eye there were no signs that water had ever flowed here. One would expect deposits and lenses of sand and gravel. In any case, we took soil samples for analysis, and, when complete, should provide strong evidence, one way or another. We shall return to this question later.

Even though it left some questions open, the excavation of the Site 736 was a success. The discovery of the division line (whatever it turns out to be) flanked by the necropolis, proving that the “line” was there already in the late 5th century BC, is a very positive result. We could have stopped here, content, but we decided to keep going, to search for further proof.

The second area of tombs and the crossroads was our next objective. Six more burials (likewise numbered 18–23) were discovered after a meter or more of the disturbed soil was removed (Figures 33–36). The first burial, T. 18, contained many vessels, but was in complete disarray. We could not even identify the tomb type, so completely had the shovel destroyed it. In fact, these burials were closer to the present day surface and had consequently been more seriously compromised. Only part of the northern end of the limestone sarcophagus, T. 19, and its floor were intact. The tomb type indicated that the burial dated to the first half of the 5th century BC, and that was confirmed by the discovery of a very fragmentary hydria of the late Archaic period, about 480 BC, which was expertly restored on paper by James Collins.

The remaining four burials were in relatively good condition: Tomb 20 was an a cappuccina tile tomb of a very particular type (Figure 33). Similar ones at Pantanello were the earliest tile tombs there, dating to the first half of the 5th century BC. Such a date was confirmed for the Tomb 20 by the corredo which included a palmette lekythos, probably a local imitation of an Attic prototype of the middle of the first half of the 5th century BC. The other burials in an earthen grave (T. 21), and an earthen grave (T. 22, Figure 36) covered by two large slabs of local conglomerate stone (see below), and another tile tomb (T. 23) contained very similar grave goods, black gloss pottery, including a distinctive Metapontine type late Archaic skyphos, and a usual cothon.

The “division line” feature appeared again even before the tombs at Site 737. But it was not quite as wide here. The reason, I think, lies in the fact that the modern surface of the field is lower here and the shovel had
scraped away the upper part of the feature, truncating the profile that was, by contrast, complete at Site 736. This was confirmed by the transverse trench across the feature which was shallower than that from the first site. Interestingly, to one side of the road, the southern side, DiTaran-to found a narrow channel where water had clearly run.

In contrast to Site 736, all the burials in the little necropolis of Site 737 are of similar date, the first half of the 5th century BC—the proof that the division line was at least that old. A similar conclusion was reached from our results at Pantanello. This is not to say, of course, that the line could not have been conceived, or even realized as a road, and as a part of a restructuring of the agricultural territory, at a much earlier date. And, in fact, work of Jessica Trelogan (See below) and GPS team strongly indicated that it was at least a half century earlier. All the necropolis really proves is that the inhabitants of the territory began to bury their dead along "division lines" in the early 5th century BC.

The third and the final large area to be excavated was where the dark strips of soil, noted by the Survey Team, intersected (Figure 39). We wanted to uncover the crossroads, if that is indeed what they really were. The four corners soon appeared. Transverse trenches were dug across both of the intersecting axes (Figure 37–38). That across the main NW–SE axis, running through both sites, was subsequently expanded, when evidence appeared that the site had once been a quarry for the extraction of the local conglomerate stone, known as pudding stone. There were very deep regular wagon wheel ruts running across the expanded surface of the stone (Figure 38). It would appear that the site had an industrial character before the "line" passed through it. And an early date for the quarry agrees well with those of the building projects for which the stone was employed, for example the earliest sacred building in the urban center of Metaponto, Oikos C, and the earliest phase of spring sanctuary at Pantanello.

The ruts of wagon wheels seem to me to be fairly conclusive proof that the "division lines" were indeed roads, rather than canals for irrigation or drainage. The ruts, which are related to the quarrying operation, may well antedate the division, but do indicate the level of which wheeled traffic passed through this area, and they the same orientation as the "lines". Other arguments that might be cited include the widespread practice in ancient (as well as modern) times of burying beside roads. Drainage, as well as irrigation, requires an adequate water source, whereas, as noted earlier, the roads could funnel water like canals in times of heavy rain fall, there is simply no adequate source upland to supply the extensive system represented by the "division lines" of Metaponto. This is, and probably has long been, a semi-arid landscape, adapted for growing winter wheat and olives, and, in certain areas, grapes. There were drainage problems, as Jim Abbott’s excellent study of the geomorphology of the chora has shown, but they occurred in the low-lying river valleys and in the city itself. These did require human intervention on a massive scale to resolve. The city acquired an elaborate system of sewers at the end of the fourth century, but the surrounding conditions in the valley never improved, and so as the survey results show, they were gradually abandoned.

A network of roads throughout the country side, however, would have served an essential function in addition to demarcating land divisions and have provided a suitable site for the landowning families’ burials. It would have provided means of access and transportation between individual land holdings, and a link to the markets and port of the urban center. Without ruling out a subsidiary use as a means of controlling run off, via the flanking ditches, this system was necessary for transport and communication.

Research on the “lines” continued during the fall, both at Metaponto and in Austin, with results which resolve a number of problems (See below).

Figure 21. Tomb 19, Site 736 from the north, the foot of the plaster-lined grave, looking towards south end where the skull lays. A total of 21 objects was recovered.
Figure 22. Lebes gamikos from Tomb 19. Orpheus with lyre and a laurel crown beckons to a young woman (Euridice?) carrying what appears to be a double flute in her left hand and a torch in her right. H: 21.5 cm. [Photo: G. Sassi]
Figure 23. Reverse of the lebes, Figure 22. A scene in Elysium? [Photo: G. Sassi]
Figure 24. Burial 22, Site 736. An unusually well preserved skeleton with its skull in the north end of the grave, and no grave goods. These facts distinguish it from all the others.

Figure 25. The complete corredo from Tomb 23. It consists of five figured vases, four of them by the Pisticci Painter in his later phase (420-400 BC), and one, the fragmentary large pelike, by Creusa painter (ca 400 BC). The deinos (See Figure 29) is shown upside down. The black gloss pottery included a skyphos, and fragments of three others, and a pyxis. The banded ware olpe and two five fibulae with bone shafts and an iron blade. The multiple fibulae are typical of female burials; the strigil, a of male's. A physical anthropological investigation of all the skeletal material from the necropoleis at Pizzica will be carried out soon.
Figure 26. Squat lekythos, an unusual form in red-figured vase painting of this period. Eros in flight approaches a young female. H: 19.5 cm. [Photo: G. Sassi]

Figure 27. Nearly complete squat lekythos with a scene of a seated female holding a mirror, approached by a servant carrying an alabastron. A small Eros flies above her. H: 14 cm. [Photo: G. Sassi]

Figure 28. A detail of the squat lekythos, Figure 27. The drawing is close to that of Attic art of the late 5th century BC, and so is the mood. They reveal the craftsman’s mainland connections. [Photo: S. Gavel]
Figure 29. Another even more unusual form. This striking deinos is decorated with an ivy tendril on the shoulder. It is an inventive masterpiece of the potter’s art. Close parallels are not known. [Photos: A. Prieto]
Figure 30. Plan of the necropolis at Site 736.

Figure 31. The “division line” at Site 736, after surface has been cleared and a meter-wide section cut across it.
Figure 32. Detail of the section across the “line” (Figure 34). Its width at the widest is six meters (20 feet). It steps down to a 3.5 m wide (12 feet) flat surface at the lowest. The fill is uniform, with numerous fragments of pottery evenly distributed in it.

Figure 34. A general view of the second necropolis, at Site 737, during excavation. See plans (Figure 35 and Figure 39) for the relationship between this and the other necropolis at Site 736 and the “longitudinal line.”

Figure 33. An elaborate aqquincia tile tomb, Tomb 20, at Site 737. Such were also typical of the early 5th century BC phase at Pantanello.
Figure 35. Plan of Site 737, with necropolis and the “longitudinal line”.

Figure 36. The corredo of Tomb 22, Site 737. The black gloss amphora, miniature lebes and lekythos date to the middle of the first half of the 5th century BC.

Figure 37. James Collins takes soil samples from one of the trenches perpendicular to the intersecting “lines” at the “crossroads.” The samples are from the fill of the “longitudinal line.”
Figure 38. The perpendicular trench across the “longitudinal line” (See Figures 37 and 38) was widened when evidence that the area had once been used as a stone quarry was discovered.

Figure 39. General plan of the three excavation sites, 736,737, various “lines” and the “crossroads,” and four soundings, Trenches 1–4.
Paleoecological Research

The fieldwork at Chersonesos, in 1999, continued to expand the investigation of the natural setting, and the interaction between humans and the landscape. Begun in 1997 and continued in 1998 by Paul Lehman, this May and June Professor Carlos Cordova of Oklahoma State University (a UT Geography PhD) initiated a project of palynological research as part of the larger paleoecological project. Professor Cordova has wide experience in coordinating pollen analysis with archaeological research and landscape reconstruction, and he has an excellent command of Russian, which facilitates his field work, and makes the rich bibliography on the subject accessible to him.

Professor Cordova carried out his research in collaboration with Dr. Volodymyr Pashchenko and Paul Lehman.

He writes of the 1999 pilot project:

The main objectives of this research are: to study the evolution of landscapes of the Heraclean Peninsula and adjacent areas during the late Holocene primarily through the study of sediments and pollen; to determine the vegetation changes occurred prior, during, and after the Greek colonization; to create a bank of modern pollen references for the determination of fossil pollen grains.

The first objective is carried out through the study of sediments primarily deposited in small valleys (balkas) and floodplains through processes of alluvial, colluvial, and eolian sedimentation. The fossil pollen grains embedded in these sediments contain information about the plant communities that existed in the region at different periods.

The second will be attained at the completion of the pollen research. A good resolution in the sequences will shed some light on plants that resulted from the agricultural transformation of the Heraclean Peninsula by the Greek colonists.

The third includes the collection of pollen produced by modern plants and a search of published catalogs of pollen grains. This bank of information not only will serve for the microscopic determination of pollen grains for the present research, but also for future investigations in the region.

Professor Cordova summarizes his spring work:

1. The collection of 48 samples of flowers for the extraction of modern pollen grains for reference. (See listed in separate appendix.)
2. The description of several Quaternary sedimentary sections in the Heraclean peninsula and adjacent areas. (Some of the sections were documented by Paul Lehman in 1998.)
3. The sampling of sediments from stratigraphic sections for fossil pollen analysis.
4. The collection of surface soil samples to estimate the representation of pollen of modern plants. The spectra obtained from the surface samples are used as a reference to interpret ancient plant communities. The collection includes 13 samples from soils and surface sediments in floodplains, balka bottoms, and upland surfaces in different ecosystems: forest, forest-steppe, steppe, and cultivated fields.
5. Observation and recording the spectrum of plants in modern communities, especially in relation with soils and land use patterns. For this purpose, the work and advice of Dr. Volodymyr Pashchenko, a specialist in landscape ecology, was very helpful.

This fall, back in his laboratories at Oklahoma State, Professor Cordova has been extracting the pollen and carrying out microscopic analysis. These are extremely time-consuming.

He observes:

Microscopic work involves the identification and counting of pollen grains. Pollen grains are identified by comparing them to the modern reference samples or to the keys in the atlases. After the grains are identified, then they are counted and tabulated for the calculation of percentages. This information is entered in a database and then graphed on the vertical axis by sample, by depth, by age, and on the horizontal axis by group of plants, families, genera, and if possible, by species. In some cases this information can simply be presented in tables.

The understanding of the distribution patterns of the present plant communities, soils, and geomorphic processes is important to understand environmental changes in the past. In the opinion of Pashchenko, vegetation communities and their associated soils are significant in the interpretation of modern and ancient landscapes, because they are important factors in the differentiation of the landscapes and of the natural and anthropic changes that occurred in them. For this reason, in this investigation the reconstruction of environments focuses primarily on the transformation of vegetation communities, for which pollen analysis is used, and on changes in soil profiles, for which the stratigraphic and geomorphological study is important.

During the course of his work this fall, Professor Cordova has reached a point where he can begin to see...
results, for example from the sample in the Chyornaya River plain to the east of the Heraclean Peninsula, in Section NG2 (See Figure 1), he can be almost certain that it was never used for cereal culturation, but is still uncertain if viticulture, which was a major component of the Chersonesos agricultural economy in the period of the Greek colony as we know from other sources, was practiced. The presence of certain weed types at the 6th century AD level, [corresponding to the period of the early Byzantine occupation of our site at Bezymyannaya, reported on in 1998] may well indicate grazing, but, in any case, farming activity. Pollen from three sections in the Heraclean Peninsula, AA, BB, and EF 1 are also being studied. (See Figure 1.)

Professor Cordova concluded his report:

The final product of this work will be the complete diagram of the three sequences within the Heraclean peninsula, which cover at least the last 8,000 years and the Chyornaya floodplain core, which includes the last 5,000 years. The data will be correlated with other paleoenvironmental information currently being recovered by Paul Lehman.

The pollen sequences from the Heraclean Peninsula will be useful for detecting some climatic fluctuations and the effects of agriculture in the upper deposits. The core from the Chyornaya floodplain will be used to correlate vegetation changes with the dynamics of the river. This core will have a better resolution so the periods of stability and instability will be clear. The modern pollen assemblages, which are those of the modern surface samples, will be used to calibrate the fossil pollen assemblages on the basis of the distribution of plants today. It is expected that this set of pollen data will be completed and available before the next field season (summer of 2000), so that further research on the paleoecology of the region can be planned.

Study of the polychrome grave monuments

At the invitation of the Director of the National Preserve, two experts in the scientific analysis of works of art from the Getty Museum, Jerry Podany, Director of Conservation, and Dr. John Twilley spent several days at the Museum taking samples of ancient pigments from the stelai and other monuments that preserve conspicuous traces of their original polychrome decoration. These monuments which were discovered in the Tower of Xeno (1961) and in the city’s walls (1970) will be the object of a joint publication by ICA and NPTC. The experts from the Getty were able to take about eighty samples, which are currently being analyzed. The results of their chemical technical study of the pigments will be presented at a conference on ancient color organized by the Getty in Thesaloniki in April, 2000, at which ICA will also present a paper on the uses of the different colors on the monuments. The results of the scientific analysis will be a part of the final publication of these important but little-known monuments (See below).

Geophysical Prospection

During the summer of 1999, a campaign of geophysical prospection, limited to the area of Bezymyannaya, was carried out by Michail Nikolaenko and his team. The results were presented in November at an international conference in Simferopol. The work was carried out with the support of ICA.

Site Conservation

Again with the support of ICA, the conservation of site 151 was monitored by Vera Nikolaenko of the NPTC staff. In the coming years an extensive effort will be made to prepare Site 151, a Hellenistic farmhouse, for visitors (The excavation of this site(1994-1996) was one of the first collaborative efforts of the NPTC and ICA.) This will be part of the overall effort to establish an archaeological park of the ancient chora (see Remote Sensing and GIS, Chersonesos, Monitoring the sites, above).

Prehistoric settlement on the Heraclean Peninsula

During August of this year Irina Harris, a doctoral candidate in archaeology at Boston University, with expertise in the prehistoric archaeology of Eastern Europe and in remote sensing, evaluated the feasibility of doing research on pre-classical period sites on the Heraclean Peninsula. She also considered the needs and applicability of various methods of surface remote sensing and geophysical prospection in the chora and adjacent areas. In a relatively brief period Ms. Harris accomplished much. She established—as she writes in her thorough report—contacts with leading prehistorians working in the area: Savelya of NPTC and Burov in Simferopol. She also collected bibliographies and information about prehistoric research on the Heraclean Peninsula.

Research in the archives yielded about 200 titles of articles bearing on the problem. The most significant work was done in 1920’s, on the Bronze Age. Ms. Harris recommends creating a database for old and rare publications of NPTC for ourselves and others, that would be placed on the Web.

Sites of interest were described by Savelya, and Deputy Director Galina Nikolaenko mentioned the possibility of excavating some kurgan (mound) burials in the Yukharina Balka, near Site 151. Further, prehistoric material already in the storeroom of NPTC needs to be investigated. Ms. Harris explored possible areas for survey and excavation. One of these is the ancient path...
that connected the valley of Balaklava with the site of Chersonesos.

The current political situation was also observed by Ms. Harris, a native Russian speaker who is well acquainted with the area. She noted that disapproval of the bombing in Kosovo and Serbia did not affect a fundamentally good opinion of the U.S. She heard a local tour guide extolling the ongoing U.S. archaeological project in Chersonesos as if to stress the archaeological heritage to the public. More of a preoccupation and a potential problem in the future, she feels, is the increasing interest of the public in religious establishments that are expanding at the expense of archaeological sites, some of which are, for this reason, becoming inaccessible to scholars. This has been a problem in the recent past for NPTC, as we have reported on other occasions. In fact, it goes back over 150 years! A letter of the Countess Uvarova (one of the pioneer archaeologists of Russia) in the late 19th century begs Tsar Nicolas II to intercede on behalf of the archaeologists and prevent the monuments of Chersonesos from being expropriated by the Church. For the moment, at least, the risk is not so great, but there is every incentive to demonstrate the viability of NPTC and the positive advantages to be gained from maintaining and improving the archaeological sites and Museum.

This fall marks the first time in the history of ICA that the majority of the personnel involved in field work could continue their research endeavors, on the Austin campus. For this we are particularly grateful to the Packard Humanities Institute. The possibility for continuity and rapid progress at last existed, and was rapidly transformed into reality, as we moved ahead in the three general areas of research of the summer. We were fortunate to find space for this expanded effort and, at least temporarily, on the Campus of the University of Texas at Austin, and are particularly grateful to the Director of the Humanities Research Center, Dr. Thomas Staley, to Professor Melba Crawford of CSR and the School of Engineering, and to Professor Cynthia Shelmerdine, Chair of Classics, for their generous assistance with the perennial problem of space in the University.

In particular we thank Professor Crawford for offering space in the Engineering building for Jessica Trelogan, who is employed on the NASA grant (see above) and others working on grant-related projects.

Upon her return to Austin Jessica worked with Solar Smith of CSR to refine the data from the GPS campaign at Metaponto. She then completed the georeferencing of

Figure 40. Mariah Wade and Christian Hartnett at work in the space provided by the Humanities Research Center for the Ceramic Research Group.
the aerial photos and assisted Steve Thompson in georeferencing the survey data for 1999 and previous campaigns (see below).

During the fall survey season Jessica and Steve took GPS points on various sites and “lines” in the choroi, and on the major axes of the grid plan of the city. This was an important step in resolving the important question of the relationship between the division of the city and the choroi, or territory. Past studies had always indicated a distinctively different orientation of the two grids. Jessica’s work demonstrates that now, when the true geographical position of the two grids is known and they have been placed on the same coordinate system for the first time, there is essentially no difference in their orientation. This clears a major obstacle to understanding the two systems as one: the historical response to a major political and economic upheaval in the Greek world, and in Metaponto. Historically, the “lines” at Metaponto are the earliest known example of Greek land division. The excavations, in Pizzica this year and Pantanello 15 years ago, indicate that the system was created no later than 480 BC. The new evidence that the division of the choroi could belong to the same restructuring going on in the city, about 550 BC, and attributable now to the Tyrant of Metaponto, allows us to see the division of the choroi as physical evidence of a new economic order, in which the power of the landholding aristocratic clans was broken in favor of individual farm families.

The Pottery Study
We are extremely grateful to the Director of the Humanities Research Center for providing office space for our Publication Director, Dr. Mariah Wade and her staff.

Mariah Wade writes:
Entering ceramic data is labor intensive and requires a good deal of individual judgment and concentration. Thus, it is not easy to find undergraduate students who will produce reliable work and who will stay with the job. We are fortunate to have Alexander Manos and Christian Hartnett working with us. Alexander, a sophomore majoring in engineering, has been entering data since last year and Christian, a senior in Classics and Archaeology, is a welcome addition to the group. Although both individuals concentrate their efforts on data entering, Christian, because of his background, also helps in locating and researching the literature for information to aid the work on specific aspects of the project.

Since September the ceramics group has been working on four principal aspects of the project. What follows is a summary of the objectives being pursued and a report on our progress.

Ceramic Database
The systematic recording of all ceramic material from the Pantanello Sanctuary site, which was done in 1993, 1994, 1995, and 1999, constitutes a unique ceramic database. When completed it will provide answers to essential questions such as: what types of wares, forms and the quantities of each can be indicative of site occupation and function and how did these change through time?

The database should help answer questions at the broad perspective of intra-site and inter-site as well as from the perspective of each archeological level and square. At the moment there is no clear way of quantifying what kinds of ceramic wares one should expect from a sanctuary site. For example, how much and what kind of cooking ware should one expect? This question becomes even harder if the site has been reused at later times for other purposes.

The Pantanello Sanctuary Database will provide answers to these and many other questions and hopefully will permit comparison with other sites. The Pantanello Sanctuary Database will provide also the basis for the chronological and typological work and serve as an indicator for the stratigraphic integrity of certain areas of the site. It should be pointed out that few typologies have ever been done solely on fragmentary material (for an exception see William Adams 1986 Ceramic Industries of Medieval Nubia). The difficulty of such work is particularly acute when the sherd material (Greek and Roman coarsewares) is minimally decorated.

Several aspects of the project depend on the completion of the data entering. All the data recorded in 1993 has been entered and we are about one third into the data for 1994. About 5000 records have been entered; this represents about one quarter of the total data set.

Work has begun on two other sets of data. I have started to enter data from a 5% random sample completed in 1995. James has begun entering data from a 2.3% random sample completed by the ceramic team during the summer of 1999. These two random samples cover the entire Pantanello site and will permit the statistical contrast between observations made by one person and those made by three people. The result of the two random samples should either verify each other or point out problems that need to be addressed in the processing of the material. They should also serve as the statistical control for the data resulting from the Pantanello Sanctuary Database. I should point out, however, that this work has barely begun because of other aspects of the project that required immediate action (see Neutron Activation).
Datable Materials

In an effort to identify other archaeological materials that could serve as specific chronological anchor points for a seriated typology, I have been locating, reviewing, and assessing various archeological finds which can be securely dated. For the moment the focus has been on metal finds (coins, fibulae, etc.), and specialty wares (red-figured, Arretine, “Ionic” cups, and loomweights). Up to now the review has provided mixed results. The metal finds, particularly the coins, provide threshold dates for the site, but they do not date many specific contexts. The other metal finds (fibulae, strigils, a plow share, and others) primarily provide relevant information about the occupation and function of the site.

The best chronological evidence for dating our undecorated wares is, after all, other pottery—the fine wares, both the decorated and plain black gloss pottery. There is a quite limited amount of black and red-figured pottery from all parts of the site, and a rather large concentration in the Basin area. This permits a close dating of the lower levels of the Basin, to the mid–late 4th century BC, a date that is confirmed by C14 dating of some of the associated organic materials. Widely distributed, and again capable of fairly clear dating is the black gloss pottery, which is the object of a special study that began this summer (see above).

In the process of locating the red-figured and black gloss pottery and the other materials, James and I have realized that the original database has many lacunae and we have been updating it.

Statistical Methodologies and Tests

During September and October, Don Wade (an unofficial but essential member of the group), James, and I have been reviewing and evaluating the literature on typological and statistical methodologies used by scholars in the field. The main objective of this work is to consider what statistical tests have been used and with what results. The other objective of this research, and quite likely the most important, is to help determine what methodologies to adopt and what typological variables to choose for statistical tests.

Neutron Activation and Petrographic Analysis

Since early October the Ceramic Group has been working to determine what objective technical analysis would be most appropriate for the Pantanello ceramic collection, what research objectives could be postulated and achieved by the scientific tests and finally to develop strategies to deal with the ceramic collection and make the most advantageous sample choice. It was considered that a combination of Neutron Activation tests and Petrographic Analysis would provide a comprehensive mineral and chemical picture of the pottery fabrics manufactured and used in the area. These two types of analysis complement each other well: while petrographic tests identify and quantify the mineralogical composition of the sample, neutron activation tests provide very accurate information on the chemical elements of the sample, including trace elements.

Several research objectives were postulated: 1) to enlarge the regional ceramic database; 2) to determine local and regional manufactured products from non-regional and foreign imports; 3) to reconstruct ancient production technology; 4) to define different ceramic fabrics that were manufactured for different functions; and 5) to attempt to utilize chemical and mineralogical fabric definition to aid in typological and chronological divisions. The mineralogical and chemical composition of ceramics from the area is still poorly defined because of the area’s geology and history of deposition and also because of the lack of a broad database.

We were fortunate to be allowed to participate in a project, of Neutron Activation analysis, organized by Dr. Cashwell, Director of the Nuclear Reactor at the University of Wisconsin at Madison. We will be able to send for analysis two hundred ceramic samples from Pantanello as well as some from Chersonesos.

During the last weeks, 64 ceramic samples from Pantanello, and 13 from Chersonesos, were selected, prepared, ground, weighed, and sent to Wisconsin. The choice of samples was restricted to the ceramic materials we previously brought to Austin. Later, others will be brought in order to provide a more even analytical sample. Concurrently, we are preparing another set of 100 samples to be sent for thin-sectioning. From the thin-sections we will choose 20 for full petrographic analysis. This report, by Petrographic Consultants International, will identify the minerals, their abundance, associations, particle orientation, void sizes, shapes and locations, surface treatment, indication of alterations through firing and any post-depositional information that can be obtained. These tests, when coupled with the extensive analytical ceramic database that is being constructed, should enhance significantly our chances to achieve the stated research objectives.
The Survey Study and Publication

We are grateful to Prof. Cynthia Shelmerdine for making temporary office space available to our Field Director, Dr. Steve Thompson. Since returning from the field and moving to Austin he has been involved in three major projects: 1) completing the final stages of the survey at Metaponto in the second half of September and first half of October; 2) organizing the first volume on the survey in the chora of Metaponto—that dealing with the 1981–1986 survey transect between the Bradano and Basento Rivers—and 3) beginning to plan the field campaign for summer 2000, at Chersonesos.

Steve Thompson writes:

Completing the work from this season’s survey at Metaponto involved, first, insuring that all field documents (notes, forms, photographs, etc.) are fully organized and archived for future access. I also have written up a summary of the season’s survey to accompany the first-order documentation that can also be used as a basis for reports and presentations on the project (See Survey, above). Albert Prieto has completed some of the work of transferring this summer’s data from paper to electronic format. He has also derived coordinates for all of the sites discovered this summer and has added these to the Metaponto master site database. We still need to enter artifactual and chronological information about the sites identified this summer and their full range of physical attributes (size, setting, land use, surface visibility, etc.).

Also remaining is the full digitization of this summer’s survey work on a plot-by-plot basis. Following the lead established by Jon Morter in the Basento-Cavone transect and methods now standard in archaeological survey, the basic unit of survey this summer was the “plot,” or individual field with homogenous land use/visibility conditions. Evaluation of site locations requires knowledge not only of where and where not survey was conducted and where it was not, but also of the varying conditions between these locations at the time of survey. Developing our inventory of surveyed plots into a digital coverage will allow rapid querying and analysis along these lines. My intent at present is to have the master field maps (containing both numbered plots and sites in outline) scanned. Jessica Trelogan will then register these scanned images to their native coordinate system and map projection. Using ENVI software, she will then re-project the scanned maps into the coordinate system/projection established as the project standard this summer (see below). Once re-projected, digitization of plot and site boundaries for the 1999 season will be carried out in ArcView. An alternative procedure will be to digitize the unregistered images directly in ArcView and then re-project the resultant digital coverages.

This summer we initiated a new method of mapping the sites discovered by survey. This technique entails gridding the entire site area, followed by close interval walking and the systematic recording of counts of surface artifacts. So far, our site surface density maps exist only on paper. Recently, however, I have developed a method of transforming these maps into fully geo-referenced, digital coverages (see Figure 14). In addition to several experiments with individual site density maps, I have written up the steps of this process in a short document to be used as a guide for the digitization of all of the 1999 site density maps.

With regards to the publication of the Bradano-Basento survey, the main object of my attention this fall, I have been working on two fronts. First, I have begun amassing and reading all of the various existing manuscripts that will be incorporated into this volume. This includes all of the preliminary reports and articles published on the survey, the manuscript on the region’s geology and geomorphology prepared by Robert Folk, and the dissertations of Jim Abbott (geomorphology) and Gianna Ayala (prehistoric settlement and land use). Below is a working outline for this volume.

Figure 41. Albert Prieto, Steve Thompson, and Antonio De Siena discuss the sites which will be hit by the methane conduit.
Survey Volume 1, Working Outline:
I. Introduction and Background to the project
   A. Adamesteanu’s role in establishing regional/territorial focus
   B. UT’s early (to 1981) excavation work in the chora of Metaponto.
   C. Development and aims of UT survey in the Metapontino

II. Physical Structure of the chora of Metaponto
   A. Overview of geological and geomorphologic structure (Folk)
   B. Geomorphologic mapping within the chora of Metaponto (Abbott)
   C. Climate (Abbott)
   D. Paleoenvironment (Abbott)

III. Archaeological Survey—Methods of recovery and recording Site gazetteer (or as appendix)

IV. Major periods of settlement
   A. Prehistoric remains (excerpted from G. Ayala)
   B. Neolithic—iron Age/indigenous
   C. Interpretation
   D. Remains of the Greek period
   E. Remains of Roman period
   F. Medieval remains

V. Excavated Farmhouses (Carter)

VI. “Division Lines”
   A. Aerial photography studies (Trelogan)
   B. Excavation (Carter)
   Conclusions: long-term patterns of rural settlement and land-use in the chora of Metaponto.

In addition to developing an outline for the volume and assembling various existing written works, the second focus of my attention over the past month has been to consolidate and familiarize myself with the project’s various databases, especially the existing Geographical Information Systems (GIS) database. For the purposes of analyses and figure generation envisioned for the Survey volume, it is imperative that all of our data sets be as closely compatible as possible. My work along these lines continues in concrete terms the vision for digital data unification laid out by Jon Morter.

With regards to the GIS database, we have a variety of digital “coverages” or map themes of the region that have been digitized in the past from the 1:10,000 scale EXACTA maps. Unfortunately, these published maps use a coordinate system and map projection (Gauss-Boaga) unique to Italy. Fieldwork this summer in the chora of Metaponto with Global Positioning System (GPS) receivers relied on a much more international cartographic basis (Universal Transverse Mercator coordinate system based upon the WGS 1984 datum). It is thus geographically accurate and its immediately relevant for the survey (particularly, the locational information derived regarding division line features). This new digital geographical data, however, is incompatible with that of the previous survey campaigns. Because of the differing coordinate systems and map projections used, geographical data from the two sources cannot be overlaid one with another. In order to avoid the time-consuming, tedious, and expensive task of re-digitizing our earlier geographical and archaeological databases, I have developed a way of “re-projecting” our existing geographical data files into the coordinate system used by the GPS work. This re-projection procedure utilizes a number of projection parameters upon which the Gauss-Boaga system is based (information that was tracked down from a variety of sources using the Internet) and is carried out using ESRI Data Automation Kit software. I have detailed this complete re-projection process and have finished re-projecting all of our existing coverages (Figure 46).

While working with the various coverages for re-projection, I also discovered that various water coverages exist, and I have consolidated these into a more useful series of discrete layers (rivers, lesser streams, canals). I also spent a great deal of time transforming the series of contour line coverages into a single coverage based upon polygon topology. The principal benefit of this change is that it allows rapid generation of easily readable maps that use color gradients to represent elevation. While not a terribly difficult process in the abstract, carrying this out required considerable manual editing of the existing ICA elevational data sets. This work, too, is now complete.

Finally with respect to our geographical database, I have identified and located two additional and very important maps of the region for which we have no digital versions. These are Jim Abbott's geomorphologic map of the region and Cesare D'Annibale's map of locations surveyed (and not surveyed) within the Bradano-Basento transect. Jim's geomorphology map is important in that it will allow us to explore the relationship between site locations and geomorphologic setting. His map also contains all of the remnant beach lines traversing the marine terraces in the region. As suggested by both Folk and Abbott, these remnant beaches often are associated with springs and probably were a strong determinant of site location, particularly during the Greek period. Having these features digitized will allow us to characterize their relationship with sites more fully and accurately. Cesare's map of survey coverage is also very important, as the development of models of site location using his survey data must of necessity take into consideration those areas not covered. Digitization of both of these maps is crucial and will begin soon.”
Figure 42. “Division lines,” identified on the historical, and now georeferenced, aerial photography of the 1960s, in the entire chora between Bradano and Cavone Rivers.
My final focus this fall has been upon organization of fieldwork at Chersonesos for the upcoming 2000 campaign. I have begun to familiarize myself with work carried out over the past two seasons at Bezymyannaya, the site we will return to next summer. I have sent out a description of the project along with an advertisement for field crew to the Archaeological Institute of America, and in the next month will begin advertising more broadly for qualified field personnel for next season. For the past month I have also been studying Russian in preparation for my involvement at Chersonesos.

Figure 43. The “division lines” in the area known as Pizzica. This is one of the few areas that has preserved both longitudinal and transverse “lines,” and there is also a unique diagonal “line.” All were verified by excavation this summer.
During the fall survey campaign the major axes of the city’s grid plan were georeferenced using the GPS. By extending the axis of the main EW Plateia of the city (on one side of the sanctuary), we discovered that the grid of the city and that of the chora have essentially the same orientation (a difference of two degrees). This is a strong argument for seeing both grids as the manifestation of one restructuring project of Metapontine space and society; ca 550 BC.

Figure 45. The pipe-laying equipment for the methane conduit, lined up at Pizzica, October 1999.
Figure 46. A new georeferenced plan of the *chora* of Metaponto with all surveyed sites since 1981.
Figure 47. Steve Thompson and Albert Prieto at work in the main office of ICA in Waggener Hall.

Figure 48. Zhenya Tkachuk, translator and RA, and Asele Surina, Administrative Associate in ICA's main offices, Waggener Hall, The University of Texas at Austin.
Throughout the fall, together with his other translating duties, Zhenya Tkachuk has been translating the published and unpublished documentation on the grave stelai, panels, architectural fragments from small funerary structures (naiskoi), and the sarcophagus which form one of the largest collections of the remnants of Greek painting. Besides translating he has also been involved in scanning the slides which document this material and together we are preparing a preliminary Catalogue. The archaeological context of the material is well known because of the excellent work of Strzheletskiy and Danilenko, whose notes and diagrams Zhenya is translating and reformatting for publication.

For a little over a quarter of a century, now, ICA has been a guest of the Region of Basilicata at the Azienda Sperimentale “Pantanello,” a modern center for experimentation in agriculture. It is also a center for plant genetics of national and international renown. We have been welcomed, sheltered and assisted by our hosts in many ways with our research, which aims to learn about the agriculture of the region in the past. To this end we have published some pioneering results of a study of a deposit of ancient plant remains, a heretofore unique in the Mediterranean world that was discovered on the spot, at “Pantanello”. In fact Pantanello has been the scene of not one, but two research triumphs. The Pantanello necropolis is only a short distance from the ancient sanctuary with its plant remains. And Pantanello has been our base for explorations in various parts of the chora. We have benefitted greatly from the dialogue about the past and the present of agriculture. Our interests are so compatible that the fact that we were hosted at Pantanello, even before we discovered the plant remains, seems more than coincidence. In short, we have grown to love this place and its inhabitants. It is a second home.

Now, twenty-six years after our arrival, the informal relationship has been cemented by a formal convention, adopted by ICA and the Assessorato di Agricoltura, made law by the Guinta Regionale. And Pantanello will become officially our home, Il centro di agroarcheologia “Pantanello”. We are to take possession of the whole of our laboratory (Figures 49, 50) building, and in addition the now-vacant home (Figure 51) of the Capo Azienda of Pantanello, our good friends Leonardo Toracco and his family. This will be for a period of five years, in return for improvements and maintenance. Strategically located between the laboratory and the Toracco home, which will house our team during their stay in Metaponto, is a modern conference hall, with up-to-date facilities for slide projection and simultaneous translation. We also plan to put it to use in the near future with a series of annual lectures on archaeology and agricultural history.
Figure 49. Pantanello. Entrance to the conference hall (foreground) and the laboratory (background).

Figure 50. The interior of the laboratory, the new Centro di agroarcheologia, "Pantanello." The laboratory contains duplicates of all records for ICA's twenty-six years of research in the chora as well as a small working library.
Pottery Study Team
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Don Wade, MS, Assistant to Director
James Collins, UT Plan II
Marsha Robbins, MA
Melinda Spearman, MA, UT Classics
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Peter Demarest, PhD candidate, UT, CSR
Solar Smith, MS, UT, CSR

Excavation Team
J.C. Carter, Director (till August 5)
Steve Thompson, Director (August 5-12)
Giuseppe Di Taranto, Foreman
Saverio Carreccia, Draftsmen
James Collins, Draftsmen
Domenico Forcillo
Antonio Marra, Equipment
Michele Resta
UT, AAR Students

Remote Sensing and GIS, Chersonesos Austin 1999
[Sponsored by NASA]
Prof. Melba Crawford, Co-Principal Investigator
Jessica Trelogan, MA
Larry Teng, BS
Ol-lg Kwon, PhD
Solar Smith, MS
Paul Lehman, MA

Figure 51. The residence of the Capo Azienda, soon to be the home away-from-home of ICA.
PUBLICATIONS OF THE INSTITUTE, 1999


AWARDS (PUBLICATIONS)

ARTICLES, APPEARING IN SCHOLARLY JOURNALS OR COLLECTIONS IN 1999
BY STAFF MEMBERS


WEBSITES:
“Chersonesos”, designed by Jessica Trelogan (www.utexas.edu/research/ica/index.html)
“Chora of Metaponto”, designed by Albert Prieto, under construction.

INVITED PAPERS AT MEETINGS, 1999
BY ICA STAFF MEMBERS
J.C. Carter:


Jessica Trelogan:


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Drs. Jerry Podany and John Twilley, Getty Conservation Center (Analysis of ancient pigment)
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