The Tanagra Survey. Report on the 2000 season.

Bintliff, J.L.; Farinetti, E.

THE TANAGRA SURVEY
REPORT ON THE 2000 SEASON

John L. Bintliff, Emeri Farinetti, Kostas Sbonias, Lefteris Sigalos & Bozidar Slapšak

Part 1: Introduction and general preliminary report
(John Bintliff, Director, Kostas Sbonias, Assistant Director)

In the month of July 2000 we directed the first stage of a complete surface survey of the ancient city of TANAGRA in Eastern Boeotia. This was a joint project, with John Bintliff (Leiden University) as Director, Kostas Sbonias (Greek Open University) as Assistant Director, and 15 Dutch archaeology students from Leiden University, but also with Greek research students (A. Vionis, E. Sigalos, Leiden) and specialists (K. Sarri, Centre for Hellenic Studies Athens, prehistoric ceramic specialist). We were based in the Ecclesiastical Research Centre, Evangelistria, through continuing close collaboration with the Bishop of Livadheia, and were very positively assisted throughout the season by the Ephor of Antiquities in Thebes, Dr V. Aravantinos. In late November and early December 2000, a small team of specialists in Geoprospection led by Professor Bozidar Slapšak from the University of Ljubljana, Slovenia, carried out a two week mapping of a small part of the city site already investigated in the summer (some 1.4 hectares), deploying a range of geophysical devices to capture information non-invasively about subsurface architectural and sedimentary structures across the intramural area. That Geoprospection mapping was integrated with the archaeological study of the Leiden summer team through the presence of Emeri Farinetti, a Leiden Geographical Information System specialist. A separate report on the provisional results of the Geoprospection team follows below as Part three of this paper.

Our aim in this first season was to build upon the excellent previous topographic research carried out by Professor D. Roller, which had produced detailed analysis of the 4th century

BC city walls and surface traces of major structures and roads within the town.[1] Our method was to make a regular grid across the surface of the site and beyond its walls, counting the total density of surface artefacts (calibrated against artefact visibility on the surface) and collecting a small sample (less than 1%) from each square for dating purposes. In this first season we completed the study of around one-third of the area enclosed by the late-Classical walls (a little less than 12 hectares studied from an intramural area of approximately 30 hectares). Our intention is to identify the proportion of the site in heavy occupation at each phase of the town's history, beginning in prehistory and continuing up to the latest human activity (Medieval). The surface gridding and ceramic collection within the city (and in the extramural transects, see below) was directed by John Bintliff, Kostas Sbonias and Athanassios Vionis, with additional supervision from Oscar Holthausen. As has been already admirably explained by Roller, the city is characterised by quite varied topography: flattish or gently sloping surfaces on the north expanses (which in the north-west may have been the location of gymnasia), a central E-W ridge identified as the acropolis - with public buildings and shrines, and then - across a depression, steep slopes into which the theatre was built, running south up into a rocky ridge (Figure 1). The area subjected to surface ceramic survey in 2000 lay in the eastern third of the intramural zone, and ran from the north to south walls and also up to the eastern wall. It thus ran from the lower slopes of the southern hillside, across the depression up onto the central acropolis ridge, then down steep and then gentle slopes to the north wall (Figure 2).

Alongside the sampling of surface ceramics, we undertook a very intensive mapping of the contours of the city surface, using a Total Station device. All standing wall fragments, stone piles and architectural pieces on the surface were noted. As this work was slower than the ceramic survey, only some 6 hectares was studied in this fashion. This work was carried out by Lefteris Sigalos and Emeri Farinetti with student assistance. The comparison of small changes in the groundsurface elevation, with remains of walls on the surface, should enable us to test further Roller's hypothetical reconstruction of the layout of the main streets, domestic house blocks and public monuments within the walls. A separate detailed report on this work follows in Part two of this paper.

A second area of our activity was extramural (Figure 2). Surface fieldwalking was undertaken in two directions out from the city wall (two strip transects each 1 kilometre long and made up of ten individual 100 m squares), to identify extramural settlement, sanctuary and burial zones. It is clear that the late-Classical walls need not have been the limits of urban activity, and at certain phases of the town's history the spread of settlement may have significantly extended beyond them. Our previous research experience has also shown for other cities in Boeotia, that after Late Antiquity, although the successor settlement of Byzantine times may lie on or very close to an ancient town, it may only occupy a small part of it or even lie outside and in its vicinity.[2]

In both the extramural and intramural studies of July 2000 important research results were obtained. Prehistoric ceramics (analysed by Kalliope Sarri) from Neolithic to Late Bronze Age 1 were ubiquitous across the intramural area so far studied, and suggest both a core village in these periods and evidence for a zone of shifting prehistoric farms which extends well into the

---

[1] Summarised in D. Roller 1987, Tanagra Survey Project 1985, The Site of Grimadha, *BSA* 82, 213-32.

[2] cf. J.L. Bintliff and A.M.Snodgrass 1988, Mediterranean survey and the city, *Antiquity* 62, 57-71

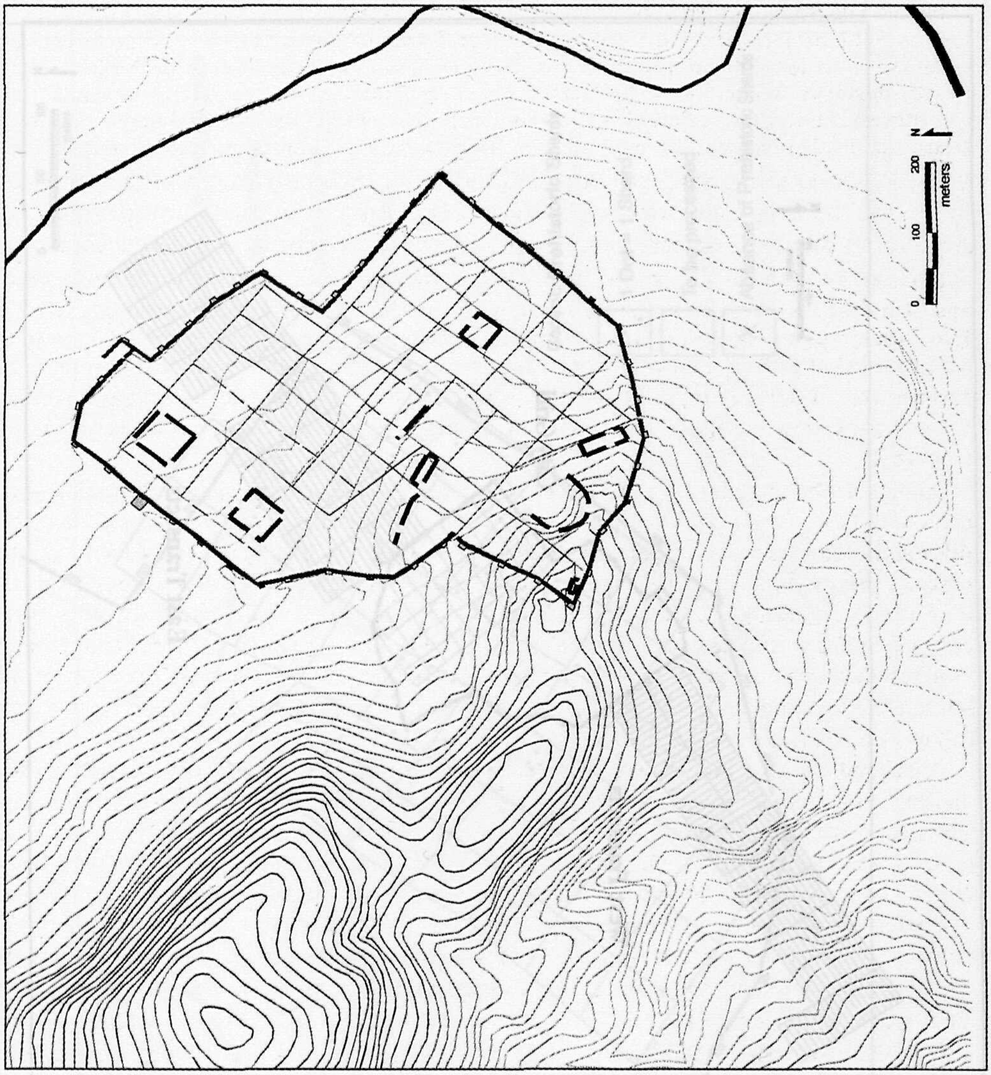

Figure 1. *The ancient city of Tanagra and its topographical situation*

countryside beyond the ancient walls.[3] Near absence of later Mycenaean pottery suggests that ancient Tanagra was not a significant focus in mature Mycenaean times, so that the Homeric references ("Graia") and rich major Mycenaean cemeteries nearby ought to be associated with

[3] For the latter concept see now: J.L. Bintliff, P. Howard and A.M. Snodgrass, 1999, The hidden landscape of prehistoric Greece, *Journal of Mediterranean Archaeology*, 12.2, 139-68.

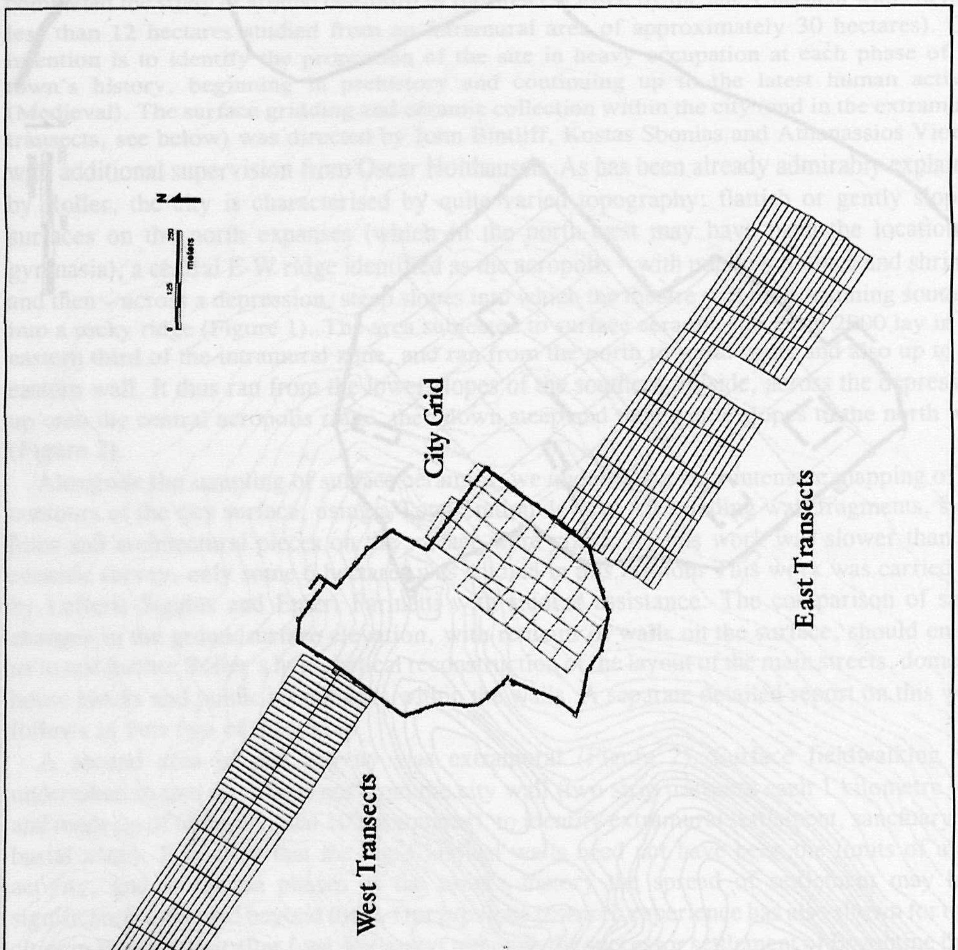

Figure 2. *The intramural and extramural surveyed area*

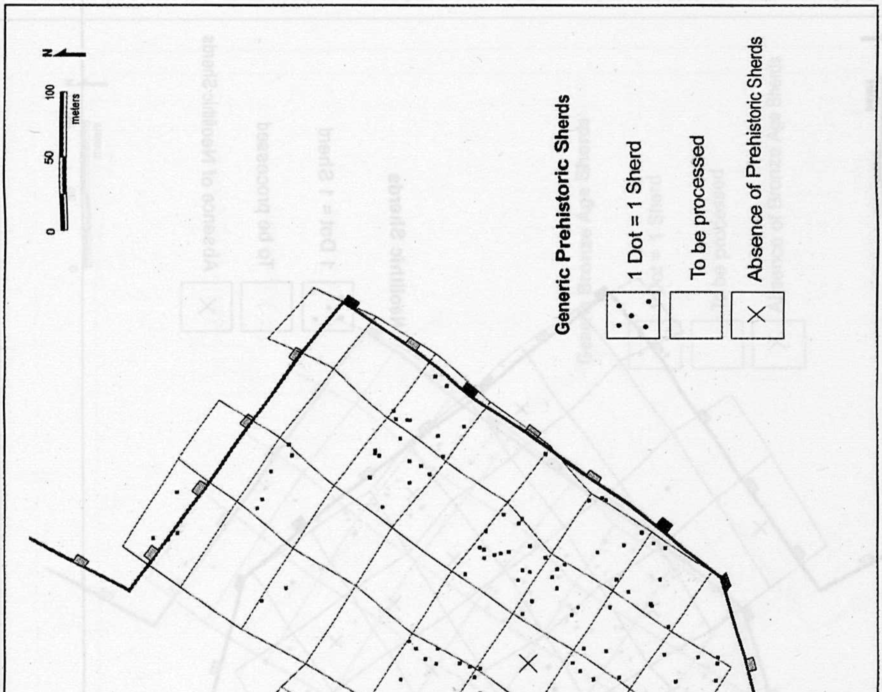

Figure 3. *Distribution of generic Prehistoric sherds*

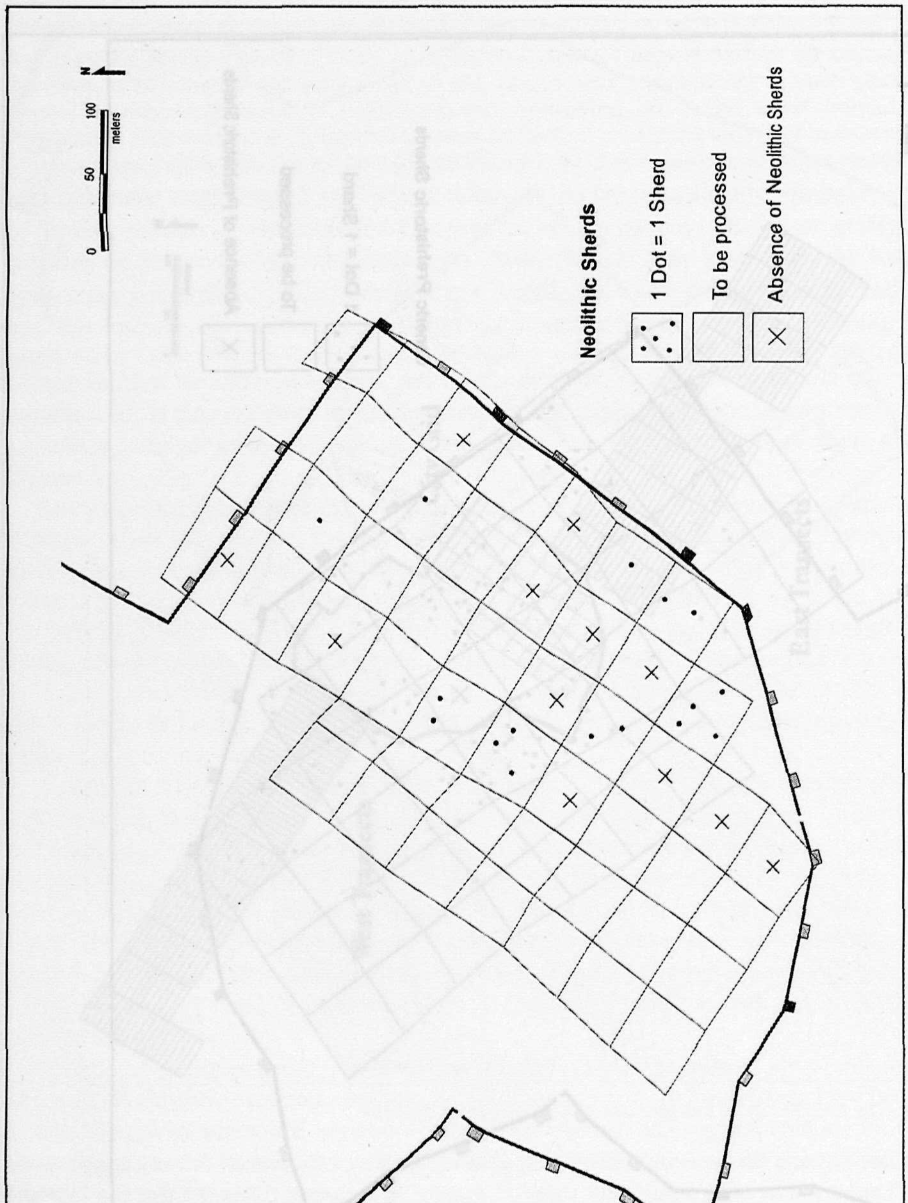

Figure 4. *Distribution of Neolithic sherds*

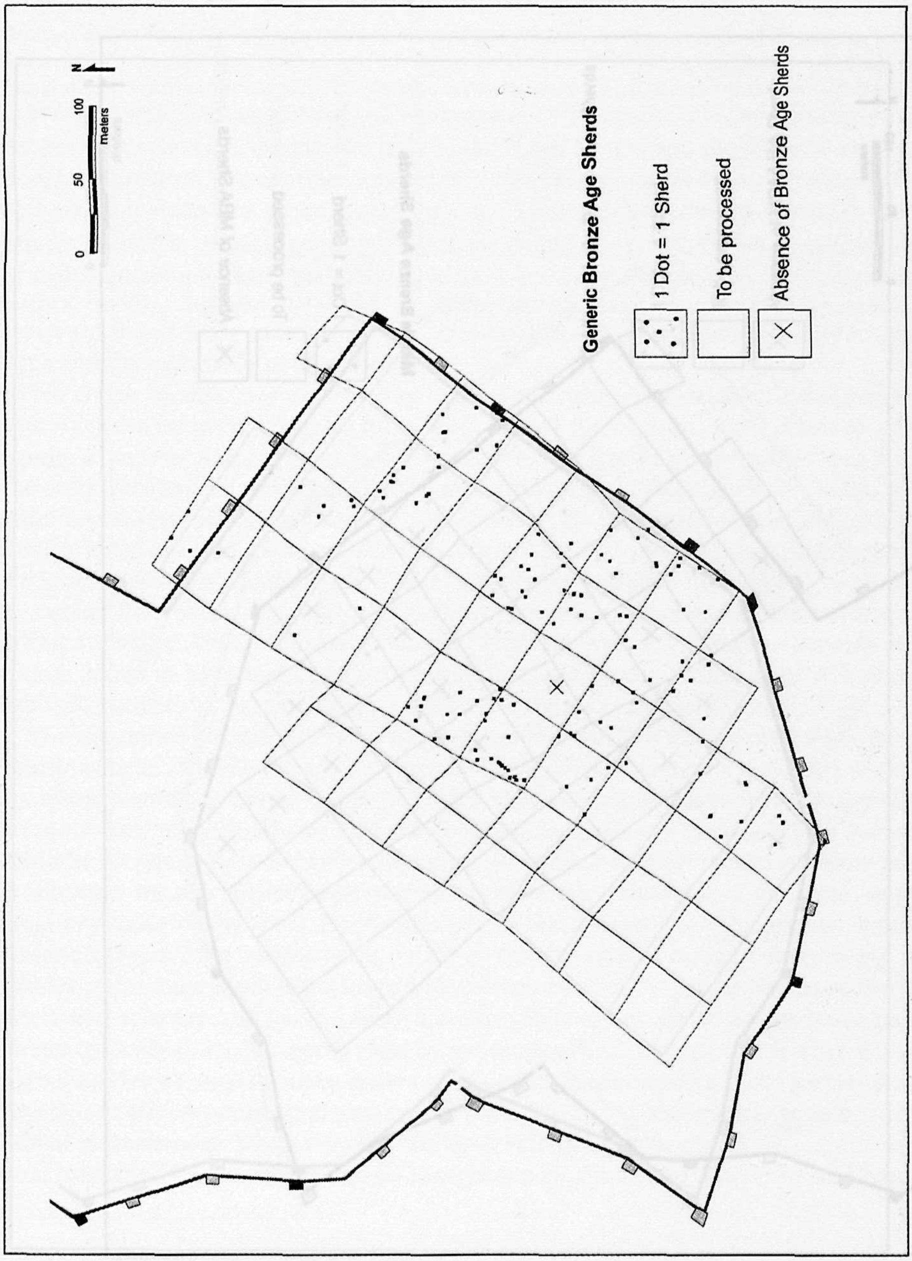

Figure 5. *Distribution of generic Bronze Age sherds*

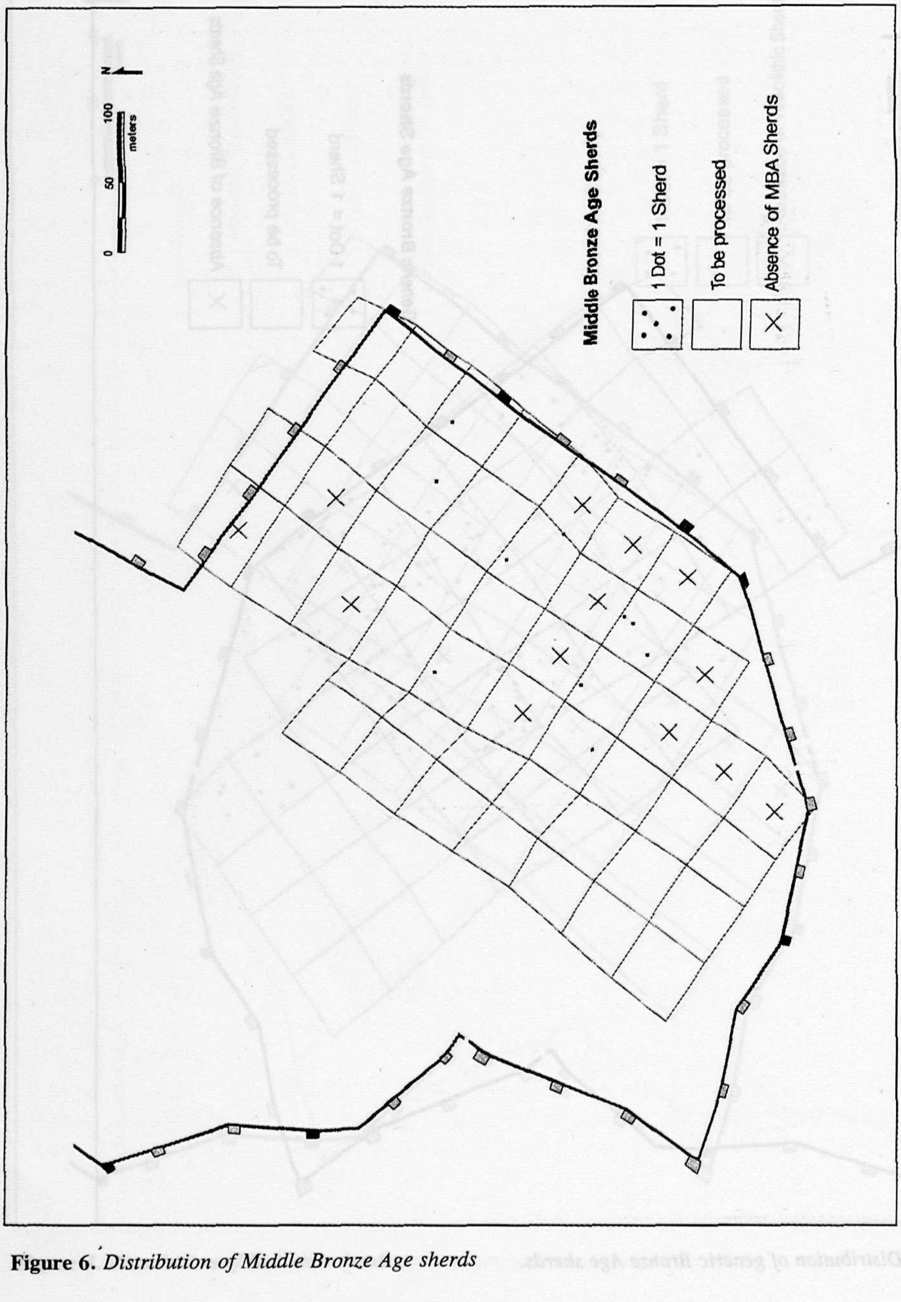

Figure 6. *Distribution of Middle Bronze Age sherds*

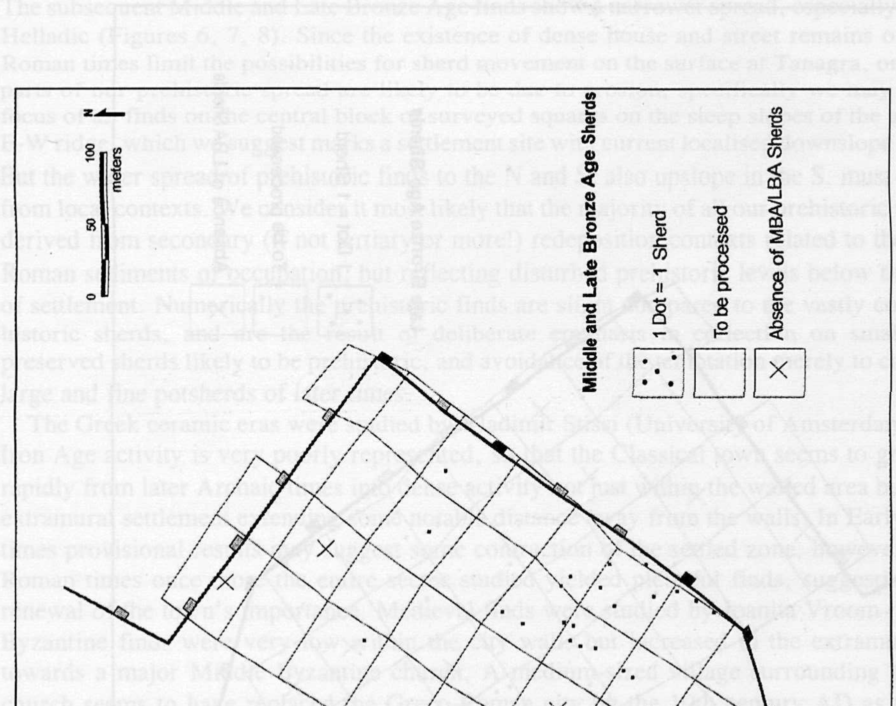

Figure 7. *Distribution of Middle and Late Bronze Age* sherds

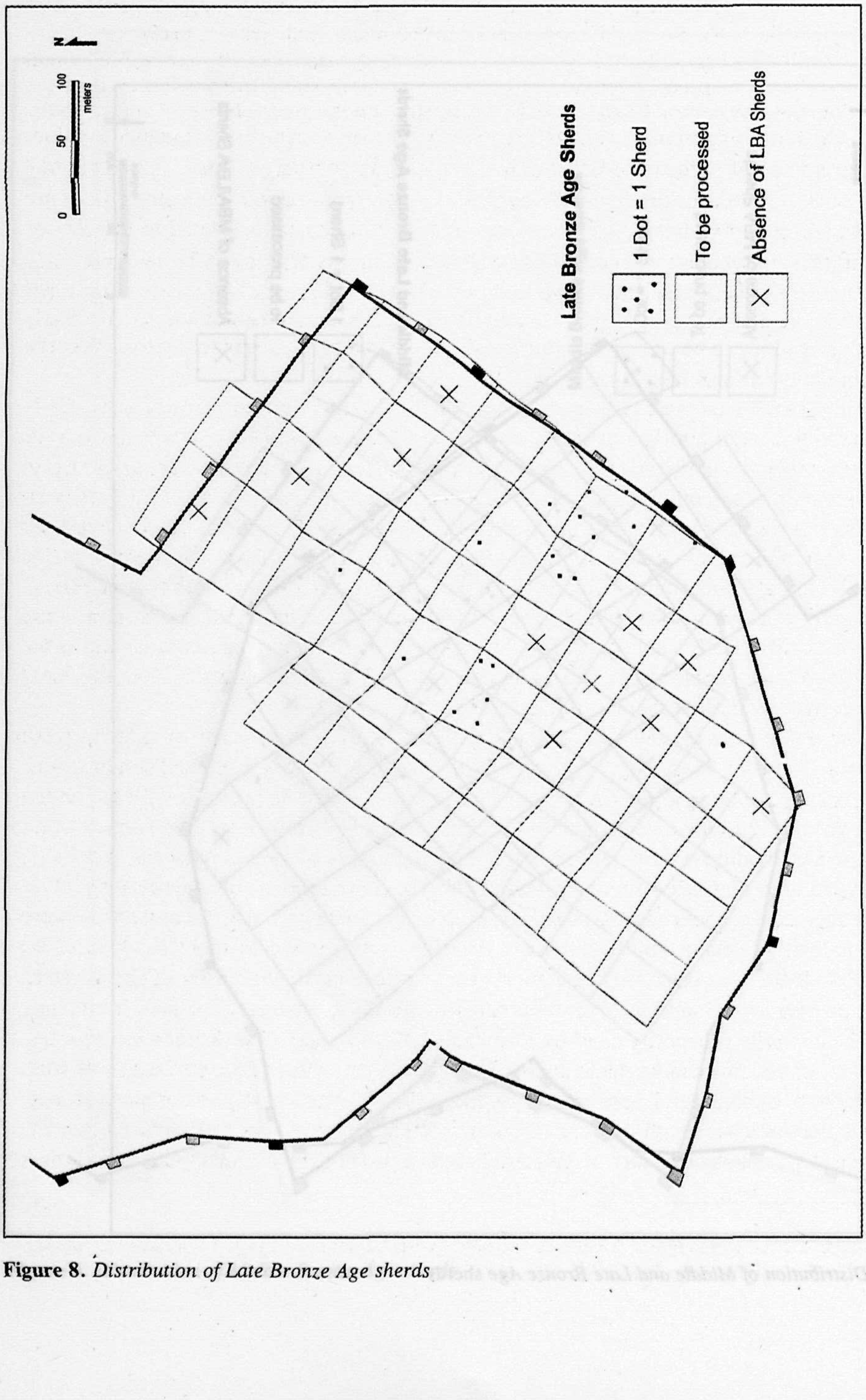

Figure 8. *Distribution of Late Bronze Age sherds*

another major site. In detail the spread of Neolithic and generic 'Bronze Age' or generic 'Prehistoric' finds shows the widest distribution, with only one grid unit where the finds so far analysed lack material at least one of these categories (Figures 3, 4, 5). This is generally coarseware and probably is dominated by finds of the era Late Neolithic to Early Bronze Age. The subsequent Middle and Late Bronze Age finds show a narrower spread, especially for Late Helladic (Figures 6, 7, 8). Since the existence of dense house and street remains of Greco-Roman times limit the possibilities for sherd movement on the surface at Tanagra, only small parts of our prehistoric spread are likely to be due to erosion; specifically we may note the focus of all finds on the central block of surveyed squares on the steep slopes of the acropolis E-W ridge, which we suggest marks a settlement site with current localised downslope erosion. But the wider spread of prehistoric finds to the N and S, also upslope in the S, must emanate from local contexts. We consider it most likely that the majority of all our prehistoric finds are derived from secondary (if not tertiary or more!) redeposition contexts related to the Greco-Roman sediments of occupation, but reflecting disturbed prehistoric levels below those eras of settlement. Numerically the prehistoric finds are slight compared to the vastly commoner historic sherds, and are the result of deliberate emphasis in collection on small, badly preserved sherds likely to be prehistoric, and avoidance of the temptation merely to collect the large and fine potsherds of later times.

The Greek ceramic eras were studied by Vladimir Stissi (University of Amsterdam). Early Iron Age activity is very poorly represented, so that the Classical town seems to grow very rapidly from later Archaic times into dense activity not just within the walled area but also in extramural settlement extending some notable distance away from the walls. In Early Roman times provisional results may suggest some contraction of the settled zone, however in Late Roman times once more the entire sector studied yielded plentiful finds, suggesting major renewal of the town's importance. Medieval finds were studied by Joanita Vroom (Leiden). Byzantine finds were very low within the city walls but increased in the extramural zone towards a major Middle Byzantine church. A medium-sized village surrounding the latter church seems to have replaced the Greco-Roman city by the 10th century AD as the local habitation centre, within less than 1 kilometre of the ancient urban walls.

The extramural surface survey, as noted, allowed us to show that the prehistoric farms were equally outside as inside the ancient walls of Tanagra and represent a dispersed settlement of the whole district, although a genuine village of Bronze Age date is provisionally suggested on and around the acropolis of Tanagra. In Classical Greek and Roman to Late Roman times domestic activities could be shown extending several hundreds of metres out from the walls. In this area we also identified several Classical Greek cemeteries of the family type. This discovery casts doubt about the standard view that the ancient Tanagra cemeteries were essentially located on major routes out from the city gates - it seems more likely that the smaller burial clusters, at least, mark rural estates. Further out on the border of the Western extramural transect was found a large suburban Roman villa, with architectural fragments, further evidence of the prosperity cited by Pausanias (IX.19.8) and other Roman-era sources.

Preliminary comments can be made on the density characteristics of the surface finds from the city and the two extramural transects (Figures 9, 10, 11), particularly in comparison with similar measurements which our previous work in Boeotia has provided, from other urban and rural contexts.[4] The intramural city of Tanagra is now a protected monument and is no longer

[4] cf. J.L. Bintliff and A.M. Snodgrass, 1988, Off-site pottery distributions: A regional and interregional perspective, *Current Anthropology* 29, 506-13; J.L. Bintliff, 1992, The Boeotia Project 1991: survey at the

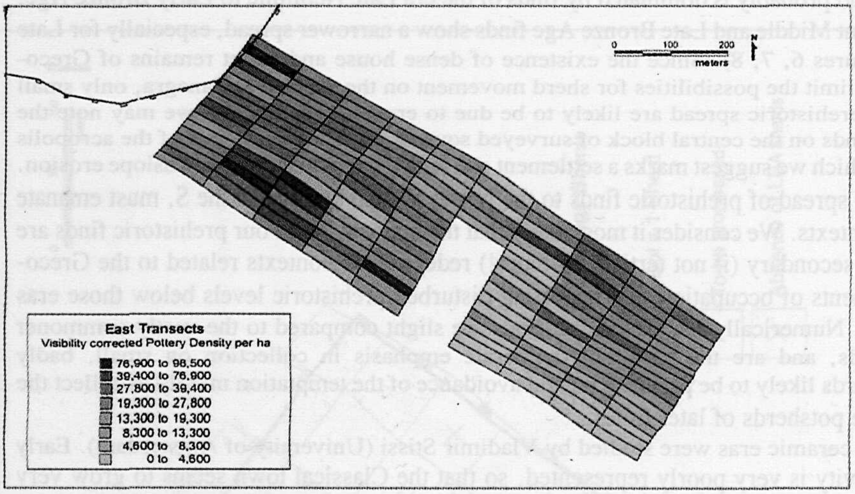

Figure 9. *Density of surface finds from the Eastern extramural transects visibility-corrected per ha*

cultivated; a herd of sheep keeps vegetation low but not minimal. These circumstances mean that the surface disturbance of archaeological layers is minor compared to that we have experienced on other Boeotian ancient cities hitherto surveyed (Askra, Haliartos, Thespiae and Hyettos). Correction for surface visibility due to vegetation cover can assist allowing for biases introduced by lack of cultivation, but the soil surface ceramic density will be unavoidably diminished where human ad natural disturbance is limited. At Hyettos, for example, a city close in size to Tanagra (20 hectares), maximal densities in a cultivated area at the core of the Lower Town rose to around 250,000 sherds per hectare on the surface, whilst those from the area so far covered at Tanagra reach 100,000. The difference should reflect far greater annual surface disturbance at Hyettos. As for the extramural transects, it is striking that in both west and east transect lines, surface densities for several hundred metres out from the city walls are very high. Here we must allow for the existence of cultivation in these zones, so that a direct comparison with the intramural densities is not possible. Given the multiplier of some 2.5 we noted between Tanagra and Hyettos for intramural densities without and with cultivation, it would seem likely that the high values immediately outside the walls show figures comparable to the lower levels inside the walls. These areas may well represent extramural suburban dwellings, industrial activity, heavily manured garden zones and cemeteries. Beyond these urban halo effects densities drop further out, but still remain significant everywhere. Our recent study of the density of surface finds in an area of over 5 square kilometers in the hinterland of the ancient city of Thespiae in Boeotia (Bintliff and Howard 1999) found an average of 2-3000 sherds per hectare, mostly the result of intensive Classical manuring out of

city of Hyettos, *University of Durham & University of Newcastle Archaeological Reports* 1991, 23-28; J.L. Bintliff and P. Howard, 1999, "Studying needles in haystacks - Surface survey and the rural landscape of Central Greece in Roman times", *Pharos* VII, 51-91

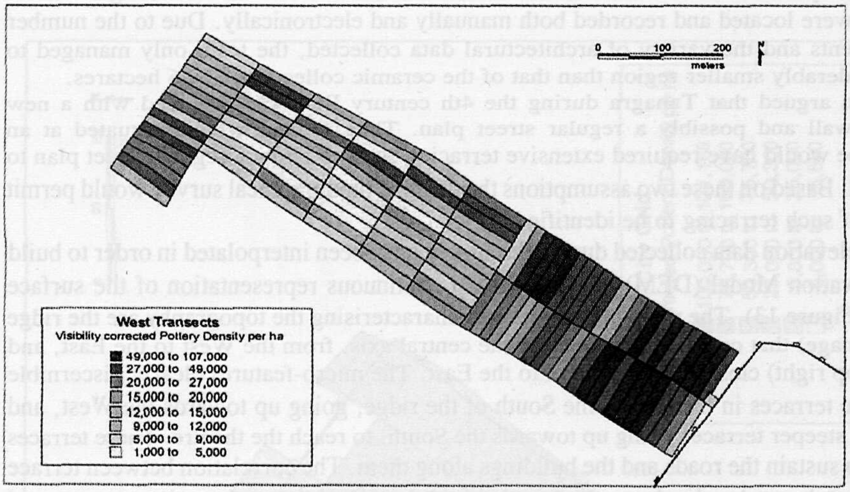

Figure 10. *Density of surface finds from the Western extramural transects visibility-corrected per ha*

Thespiae city for a radius of 2-3 kilometres. The density and condition of the finds in these Tanagra transects, beyond the immediate impact zone or halo of several hundred metres, is comparable, if we except several locations which we have identified as classical cemeteries or settlement locations.

Part 2: The detailed topographical survey of the city
(Emeri Farinetti, Lefteris Sigalos)

Within the context of the surface survey, we conducted a detailed topographical survey aiming at the precise location and mapping of the architectural features still observable on the surface, the ceramic and lithic assemblages collected, as well as the results of the geophysical prospection, discussed below. Our ultimate target though was to attempt to reconstruct the topography of the city and its functional areas through combining the multivariate material and topographical information by means of Geographical Information Systems, producing data not readily available in the field. For this purpose, the units used by the ceramic survey teams provided the basis of our investigation. Within each of the units (ca. 50 by 50 metres) we took detailed measurements, by means of a Total Station, at regular four metre intervals. Special attention was paid to topographical features such as terraces and depressions that could easily be missed by the grid of points.[5] The architectural features we recorded (fig. 12) represent

[5] This method was a development of the one first introduced to the preceding Boeotia project by Mark Gillings, who very successfully managed to capture invaluable information about the residential area of the Frankish and Early Ottoman site VM4 or Palaio-Panagia, in the vicinity of ancient Askra, in the Valley of the Muses (M. Gillings 2000, The Utility of the GIS Approach in the Collection Management, Storage and

more or less what Roller surveyed some years ago (Roller 1987). We distinguished the features (stone blocks) *in situ* in evident connection with each other and belonging to walls (walls *in situ*), from what we have called *disiecta membra*, the architectural blocks not in their original place or probably *in situ* but not in evident connection with others. All features, regardless of their nature, were located and recorded both manually and electronically. Due to the number of measurements and the variety of architectural data collected, the team only managed to cover a considerably smaller region than that of the ceramic collection, *i.e.* 6 hectares.

It has been argued that Tanagra during the 4th century BC. was provided with a new fortification wall and possibly a regular street plan. Thus, Tanagra being situated at an irregular slope would have required extensive terracing so as to allow a regular street plan to be introduced. Based on these two assumptions the detailed topographical survey would permit the plotting of such terracing to be identified.

The point elevation data collected during the survey have been interpolated in order to build a Digital Elevation Model (DEM) that is a virtual continuous representation of the surface topography (Figure 13). The main macro-features characterising the topography are the ridge (left on the image) that crosses the city along the central axis, from the West to the East, and the hollow (top right) close to the city wall to the East. The micro-features clearly discernible are quite wide terraces in the area to the South of the ridge, going up towards the West, and narrower and steeper terraces going up towards the South, to reach the theatre. These terraces were meant to sustain the roads and the buildings along them. The correlation between terrace features and roads can be clearly seen when the road system of the ancient city as suggested by Roller is overlain (Figure 14). As far as roads running South West-North East we have plenty of clues. On the other hand, as for the avenues, or the streets running perpendicularly to the previous, we have topographical proof in only one case. Here terraces have been built perpendicularly to support a crossroad. Another feature clearly visible (Figure 13) is the steep slope leading to the easternmost edge of the ridge starting a few metres from the city wall (uppermost left of the image).

In the Southern part of the surveyed area, not only the few preserved walls but also the scattered architectural features, represented by points, follow the main direction of terraces and proposed roads. In contrast some of the avenues (perpendicular to the roads) seem to be differently located to the theoretical plan of Roller (Figure 15). They are, at least in this area, running in the same direction as the slope, causing them to be more vulnerable to erosion. On the top of the acropolis ridge, where we have the 'plateau' gently ascending towards the West, the pattern is less clear, but it is easy to connect the position of the features with the presence of larger and public buildings, characterised by structures of variable size and orientation. On the slope to the North we cannot detect any pattern, and the majority of the present blocks can reflect one of the two possible processes. Either they cannot be considered *in situ* and have rolled down from the buildings on the top of the ridge, or these isolated larger could conceivably represent supportive larger blocks for houses, terraces and streets composed of

Analysis of Surface Survey Data, In: J.L. Bintliff, M. Kuna and N. Venclova (eds.), *The Future of Surface Artefact Survey in Europe*, 105-20).

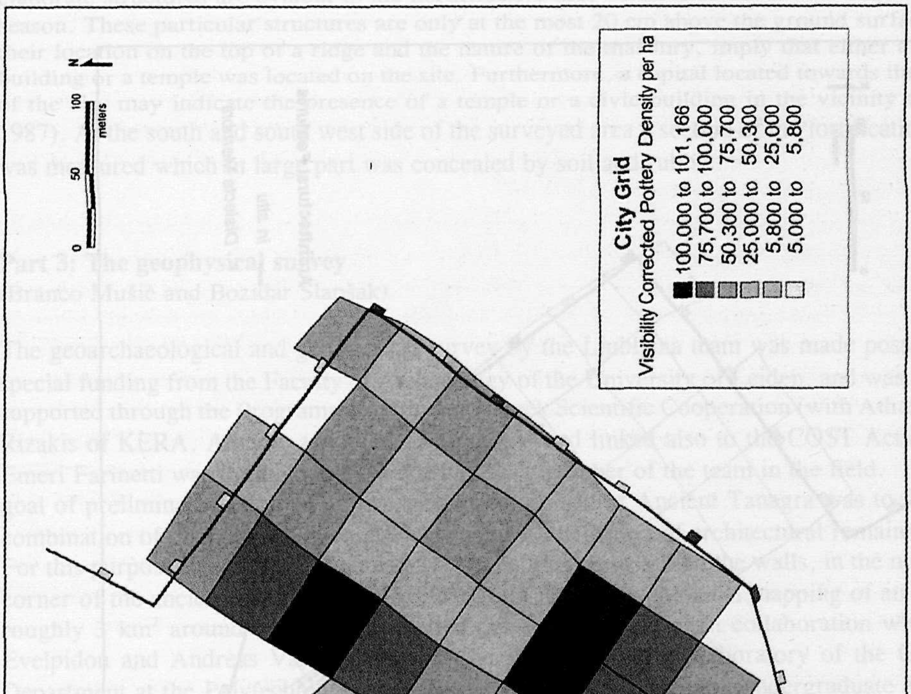

Figure 11. *Density of surface finds from the intramural area surveyed visibility-corrected per ha*

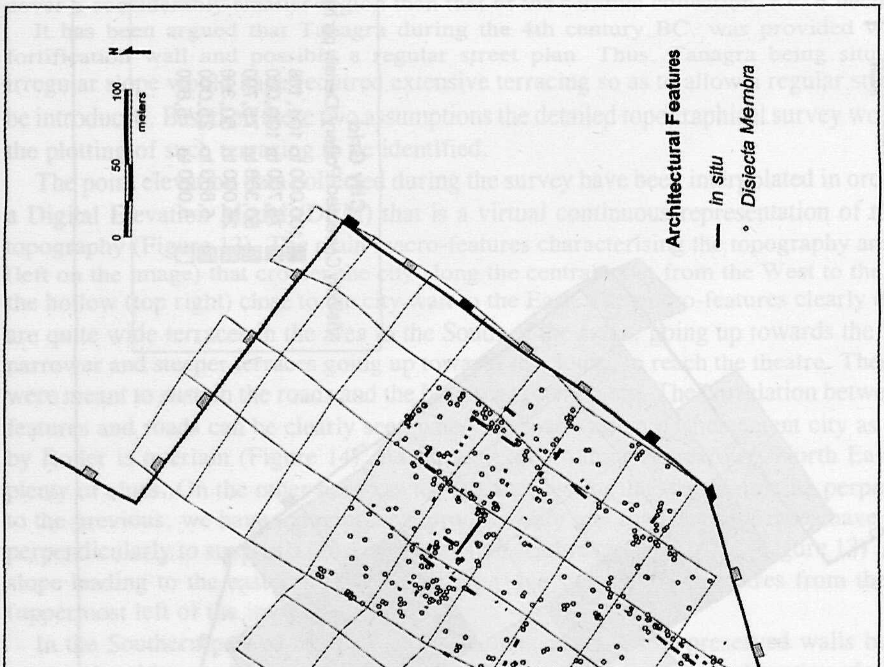

Figure 12. *The survey of the architectural features visible on the surface*

mudbrick and smaller stones.

As for the architectural features themselves, marked in bold, a series of walls were discovered and recorded that in most cases, especially in the SW corner of the city, seem to have belonged to road terracing or continuous house walls bounding the streets. Some more elaborate structures are evident in the northwestern side of the area covered during the first season. These particular structures are only at the most 20 cm above the ground surface, but their location on the top of a ridge and the nature of the masonry, imply that either a public building or a temple was located on the site. Furthermore, a capital located towards the south of the city may indicate the presence of a temple or a civic building in the vicinity (Roller 1987). At the south and south west side of the surveyed area a section of the fortification wall was measured which in large part was concealed by soil and rubble.

Part 3: The geophysical survey
(Branco Mušiè and Bozidar Slapšak)

The geoarchaeological and geophysical survey by the Ljubljana team was made possible by special funding from the Faculty of Archaeology of the University of Leiden, and was further supported through the Programme of Slovene-Greek Scientific Cooperation (with Athanassios Rizakis of KERA, Athens, as Greek co-director), and linked also to the COST Action G2. Emeri Farinetti was the Leiden University project member of the team in the field. The goal of preliminary geophysical prospection on the site of Ancient Tanagra was to find the combination of geophysical methods best suited for detection of architectural remains there. For this purpose, we chose a test area of 1.44 hectares close behind the walls, in the northeast corner of the ancient city (Figures 16 and 18). In parallel, geological mapping of an area of roughly 3 km^2 around the site was carried out by Igor Riznar, in collaboration with Niki Evelpidou and Andreas Vassilopoulos of the Remote Sensing Laboratory of the Geology Department at the Polytechnic School, University of Athens. Greek undergraduate geology students were partly involved in this survey. Results will be presented after the 2001 campaign.

For the description of geophysical results in terms of the archaeology of the site, observation 18). Here, we will only report on the results which relate to the immediate goals of these preliminary prospections as stated above. Interpretative results on map Figure 25, however accurate, must be regarded as orientative only, and will be revised after geophysical methods chosen for the site based on the 2000 work are deployed, and archaeological implications fully discussed. Archaeological results pertaining to interpretation of urban structure as proposed by Roller are presented in the concluding paragraphs of this part of the report. units weredefined based on Roller' plan of the urban area of ancient Tanagra (Figures 17 and

An array of geophysical methods was tested on sample areas of various extent (Figure 19):

Magnetic methods

- Measurements of vertical gradient of magnetic field, by fluxgate gradiometer *Geoscan FM36*, 14400 m^2 (Figure 20).
- Measurements of total magnetic field, by caesium magnetometer *Geometrics G-858*, 1600 m^2 (Figures 21 and 22).
- Measurements of apparent magnetic susceptibility, by *Kappameter KT-5* instrument, on samples of soil and rock.

Geoelectric resistivity method

- Geoelectric mapping, by resistivity meter *Geoscan RM15*, 14400 m^2 (Figure 23).

Electromagnetic methods

- Conductivity and magnetic susceptibility by *Geonics EM-38*, 6000 m^2 (Figure 24).
- Georadar GSSI SIR 3, antenna 200 MHz, profiles 1-28.

Magnetometry

Applicability of magnetic methods for detecting subsurface architectural remains was checked by measurements of apparent magnetic susceptibility of soils and of stone rubble from architectural debris on the surface (by *Kappameter KT-5* instrument). The success of magnetic measurements will depend mostly on the contrast in magnetic susceptibility between target objects (architectural remains) and the surrounding soil. The contrast is the more important if we deal with difficult surface conditions such as at our site. With high noise caused by surface morphology and inhomogeneity, we can hope for adequate signal/noise ratio only at high contrast in magnetic susceptibility.

Based on our geological survey, we may assume that most of the architectural remains consist of limestone, displaying values between 0.02 and 0.05×10^{-3} SI, which is near to zero magnetic susceptibility. Limestone is therefore relatively pure, with only small quantities of inclusions of non-carboniferous terrigenous components, which includes ferrous minerals. Susceptibility of the topsoil is much higher, its mean value is 1.23×10^{-3} SI. Given the considerable contrast in magnetic susceptibility between materials assumed to constitute the bulk of the architectural remains, and the topsoil, we came to the conclusion that, under the circumstances, magnetic methods can be expected to be appropriate for the detection of wall structures. That should be even more true for industrial activity areas with ceramic objects, which display susceptibility much higher (8.44×10^{-3}SI) than that of the topsoil. The same should go for burnt clay, with susceptibility values only slightly lower than that of ceramics (7.84×10^{-3} SI). Indirectly, we would be mapping these contrasts in susceptibility with magnetometers, which measure differences in the density of the local magnetic field: these are in turn the effect of differences in magnetic susceptibility of archaeological remains, and the

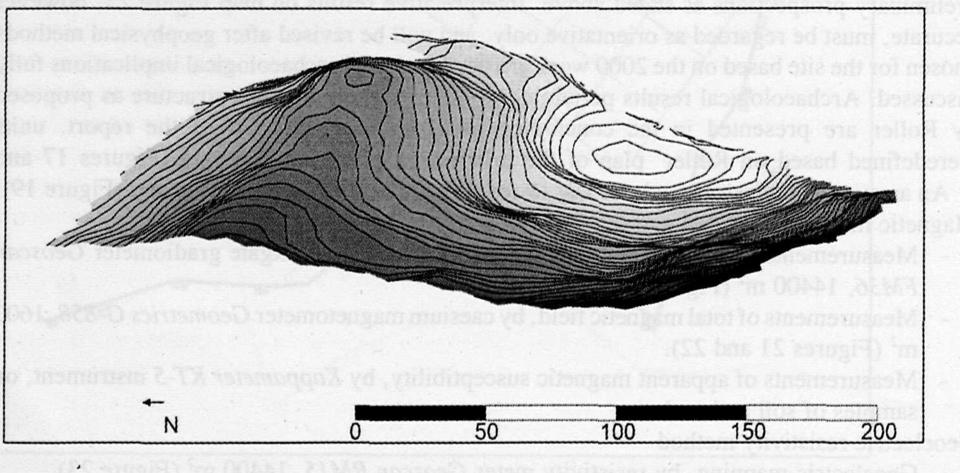

Figure 13. *A 3D reconstruction of the area covered by the detailed topographical survey seen from the West*

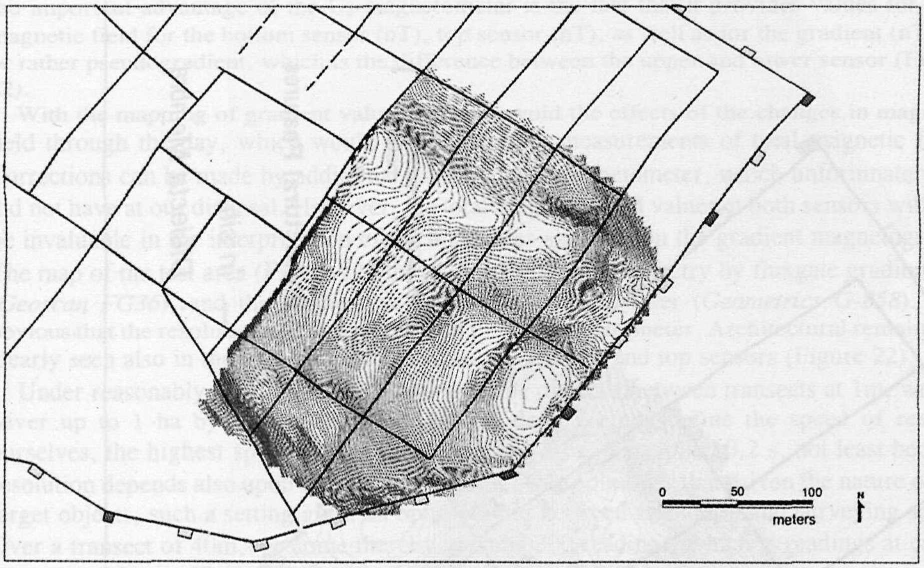

Figure 14. *A correlation between topographical features and the road plan suggested by Roller*

sediments, or rather varieties of the surrounding soil.

To detect anomalies in the local magnetic field resulting from subsurface architectural remains on the totality of the test area, we used the *FM36 Fluxgate* gradiometer, which measures the vertical gradient of the magnetic field (Figure 20). The distance between transects was 1m, with measurements along transects being taken at 0.5m. Under the circumstances, the main advantage of the instrument is its size, which permits good mobility in difficult working conditions on uneven ground. The whole test surface of 14400 m^2 was surveyed by that method. Many anomalies of the vertical gradient of the magnetic field were detected, which can be interpreted as the effect of the contrast in induced magnetisation of architectural remains, layers of ruins, and subsoil. Explicit linear magnetic anomalies in northeast-southwest direction coincide with the edges of Roller's city blocks, while in a northwest-southeast direction, such anomalies indicate a somewhat different organisation of urban space. Besides these, a number of stronger magnetic anomalies were detected, indicating areas of thermoremanent magnetisation caused by important concentrations of archaeological remains. They can plausibly be interpreted as industrial activity areas which involved the use of fire / furnaces.

Based on the results of magnetometry by the *Geoscan FM36* instrument, a suitable area was chosen (1600 m^2) to carry out measurements of total magnetic field by Cs-magnetometer (*Geometrics G-858*) (Figure 19). For this restricted test area, we had at our disposal, besides data on vertical gradient of magnetic field (*Geoscan FM36*) and resistivity (*Geoscan RM15*), also those on conductivity and magnetic susceptibility (*Geonics EM-38*). Results by Cs-

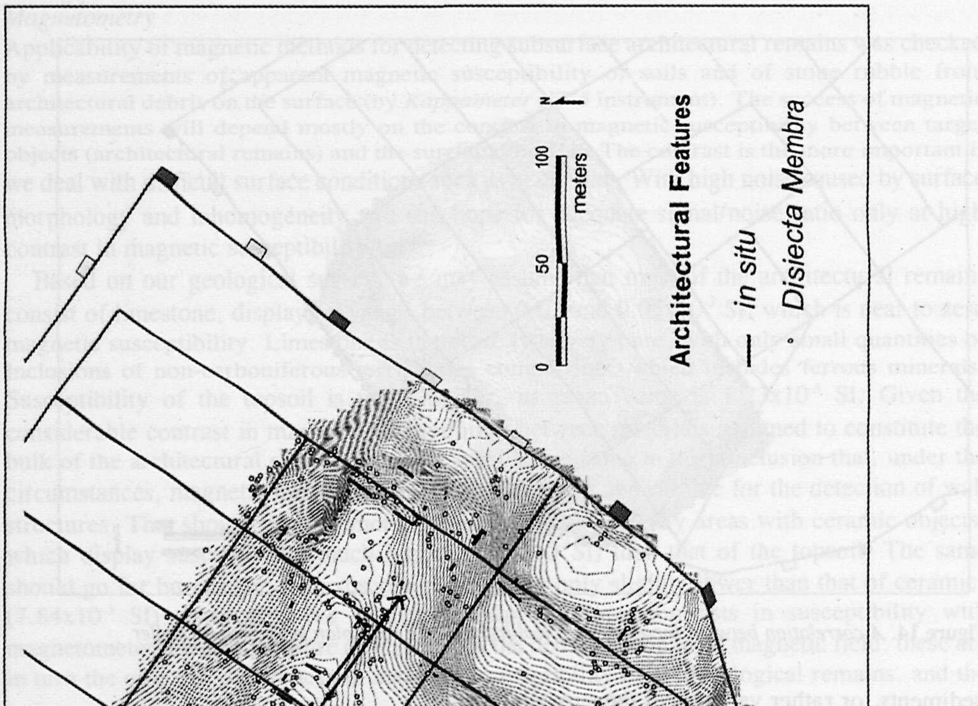

Figure 15. *A comparison between the topographical and architectural features resulting from our survey and the city plan suggested by Roller*

magnetometer (Figures 21 and 22) are by far the best and clearest. To some degree, that comes also from our taking readings by transects at 0.5m distance, while with all other methods the distance was 1m. Nevertheless, it is our opinion that the signal/noise ratio with this instrument is best suited for detection of subsurface architectural remains. On the level of interpretation, the important advantage of the Cs-magnetometer is the fact that it provides values for total magnetic field for the bottom sensor (nT), top sensor (nT), as well as for the gradient (nT/m), or rather pseudogradient, which is the difference between the upper and lower sensor (Figure 22).

With the mapping of gradient values, we can avoid the effects of the changes in magnetic field through the day, which would affect mapping measurements of total magnetic field. Corrections can be made by additional use of a base magnetometer, which unfortunately we did not have at our disposal. However, the total magnetic field values at both sensors will still be invaluable in the interpretation of the anomalies showing on the gradient magnetograms. The map of the test area (Figure 21) shows results of magnetometry by fluxgate gradiometer (*Geoscan FG36*), and the gradient values by Cs-magnetometer (*Geometrics G-858*). It is obvious that the resolution is much better with the Cs-magnetometer. Architectural remains are clearly seen also in the total magnetic field for the bottom and top sensors (Figure 22).

Under reasonably good conditions, and with the distance between transects at 1m, we can cover up to 1 ha by Cs-magnetometer in one day. We can define the speed of reading ourselves, the highest speed is at 0.1s. On our test area, we applied 0.2 s, not least because resolution depends also upon the speed of reading. Our opinion is that, given the nature of our target objects, such a setting gives an optimal ratio between resolution and surveying speed. Over a transect of 40m, we come thereby to some 300 readings, which is readings at ca. 13 cm - more than sufficient for the dimensions of our target object.

Geoelectric mapping

Geoelectric mapping was started after several days of heavy rain, which thoroughly soaked previously completely dried-out soil. While the rainfall made geoelectric survey possible in the first place, the contrast between subsurface architectural remains and the surrounding soil was weak immediately after heavy rain because of too much moisture. Nevertheless, and given the limitations of time, we decided to start immediately. Results were good under the circumstances, and especially useful in combination with magnetometry. In some sectors, results are identical, in other complementary. Roughly across the middle of the area surveyed, there is a marked border between higher resistivity values in the southern parts, and lower to the north (Figure 23). This can be explained through higher moisture in the northern lower parts, as a result of impermeable subsoil and/or deeper stratification.

Since with *Twin probe* geoelectric mapping only relative differences in resistivity are measured, we documented also distances between remote probes, so as to permit at least partial quantification of measured resistivity values, and comparison with other sites in our database. Distances between remote probes vary between 0.41 and 0.95m, mean value is 0.61m. Measured resistivity values are between 19 and 233 ohm.m, at the mean value of 35 ohm.m, and the standard deviation is 14 ohm.m. The values correspond to conditions for resistivity with pedosequences on soft carbonate bedrock such as marls. Such natural environments would normally be favourable for resistivity methods in terms of soil moisture, somewhat poorer results in our case result from too much moisture in topsoil after the rain, and from massive subsurface debris.

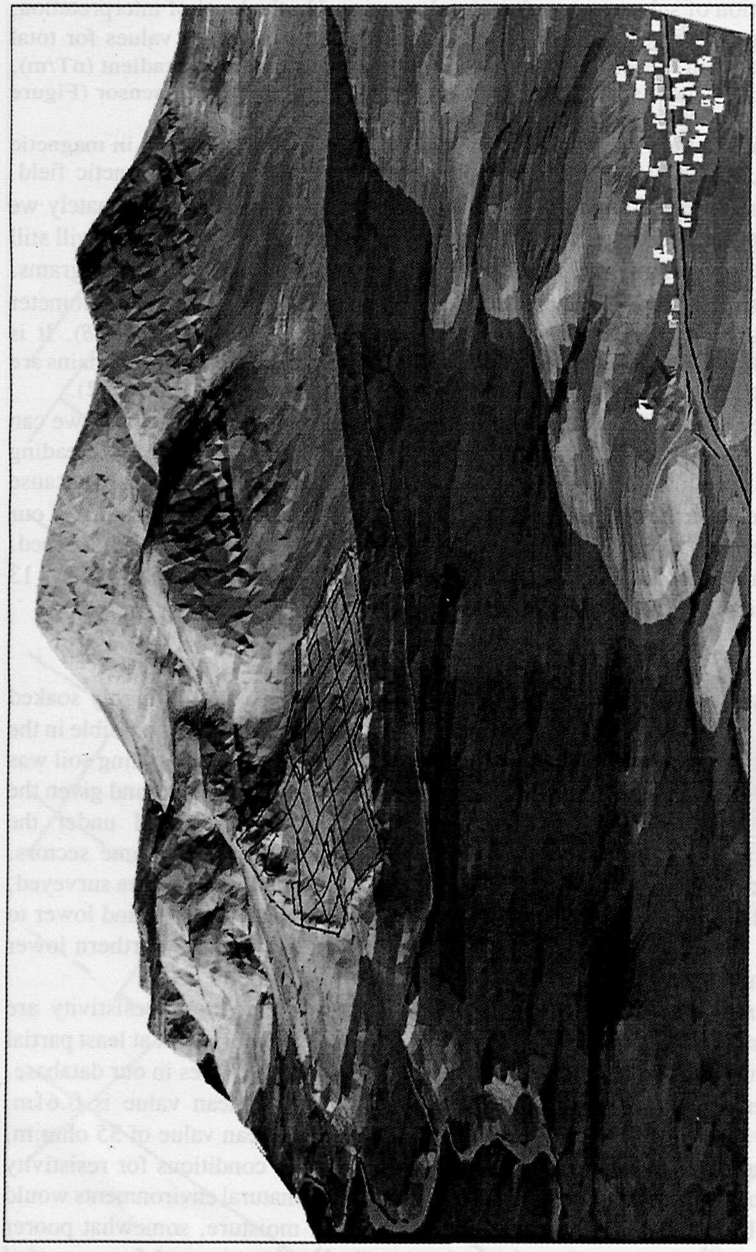

Figure 16. *Situation map of the site and location of the area investigated (bottom left corner of the town grid)*

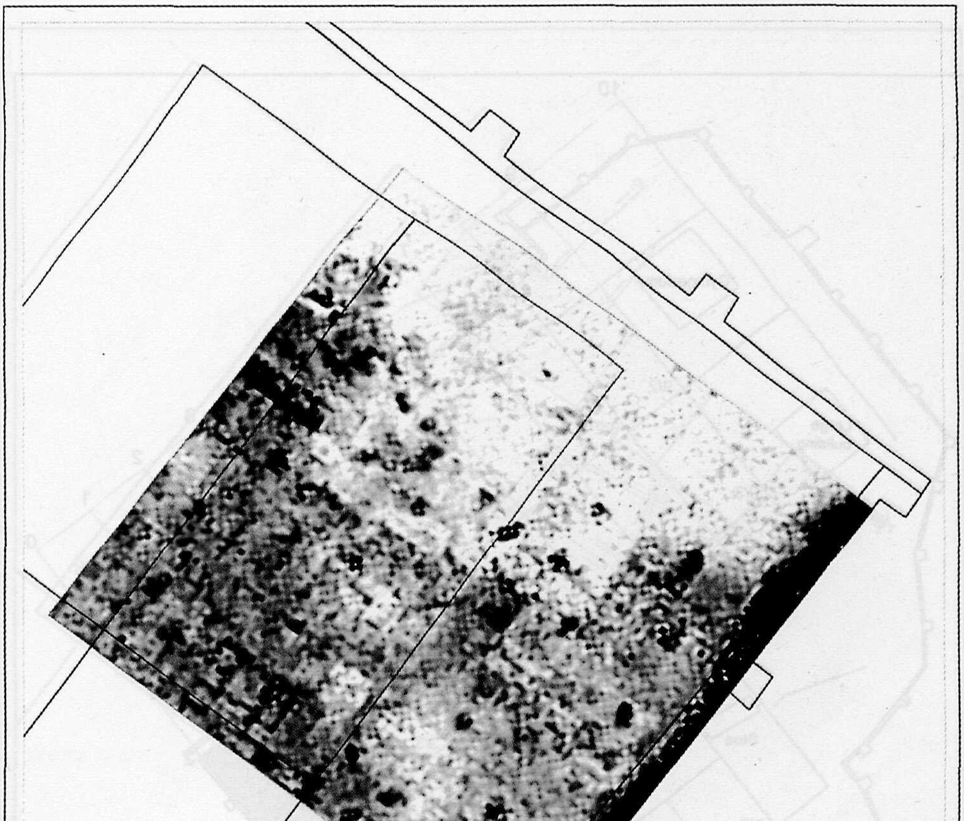

Figure 17. *Plan of the ancient city of Tanagra, with denomination of gates, towers and streets, and interpretation of public spaces, after Roller 1987*

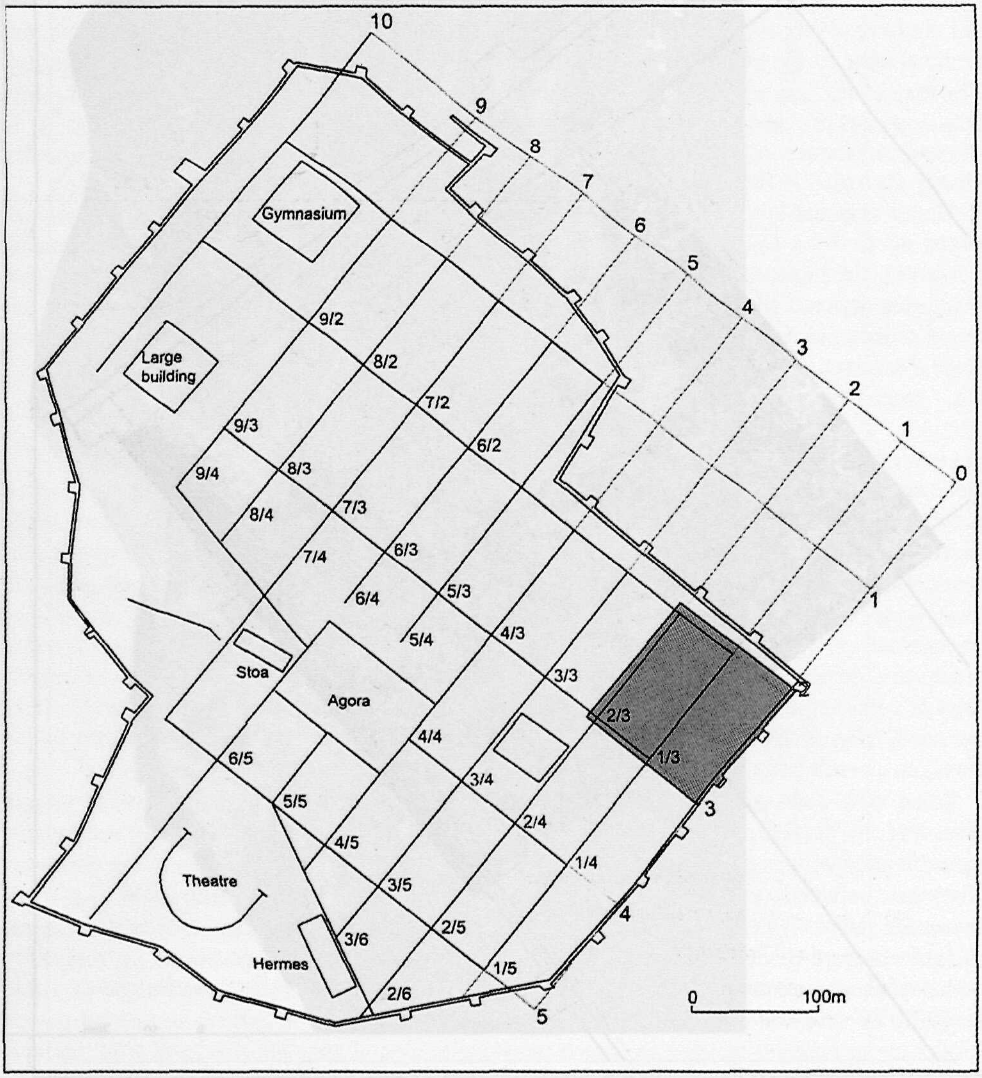

Figure 18. *Denomination of city blocks, based on Roller's denominarion of Streets, Avenues and public spaces. Investigated area highlighted*

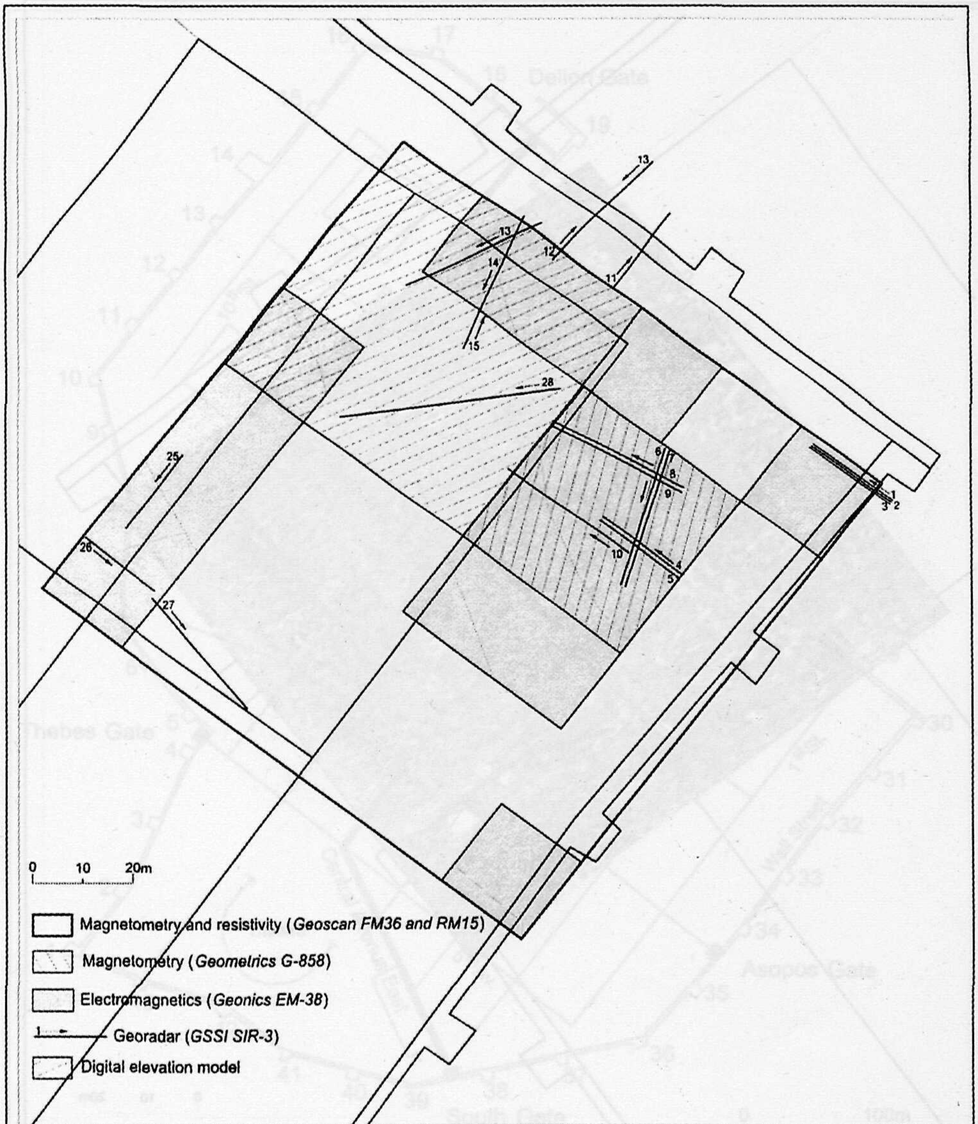

Figure 19. *Geophysical methods applied*

Figure 20. *Magnetometry. Vertical gradient of magnetic field (Fluxgate gradiometer Geoscan FM36)*

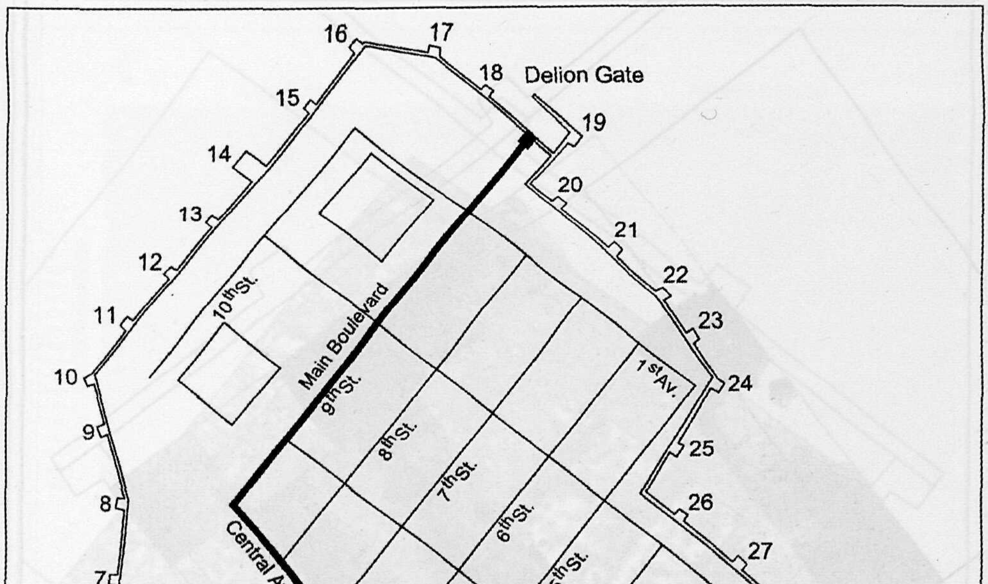

Figure 21. *Magnetometry. Gradient of total magnetic field (Geometrics G-858)*

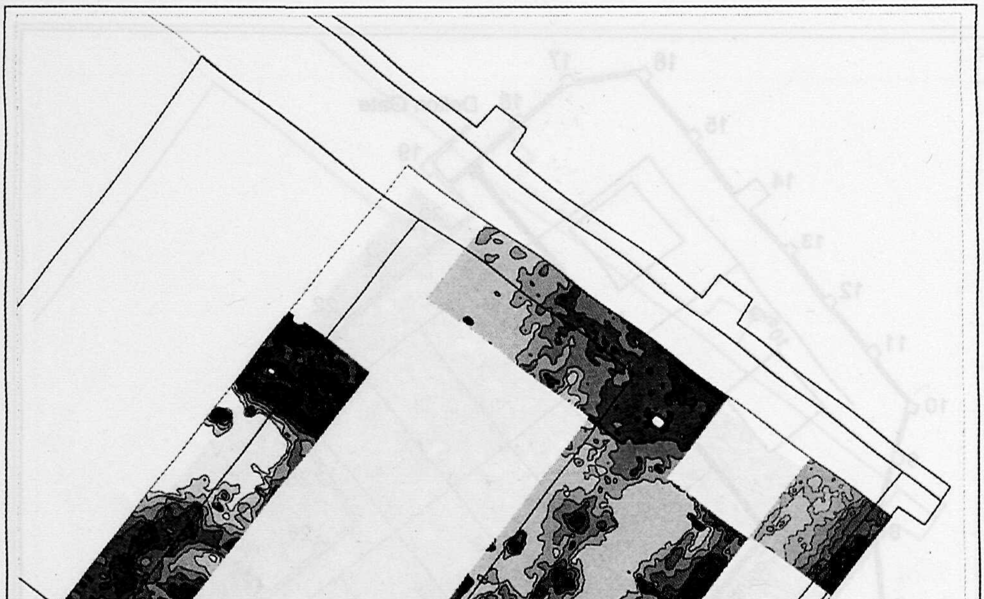

Figure 22. *Magnetometry. Total magnetic field (Geometrics G-858)*

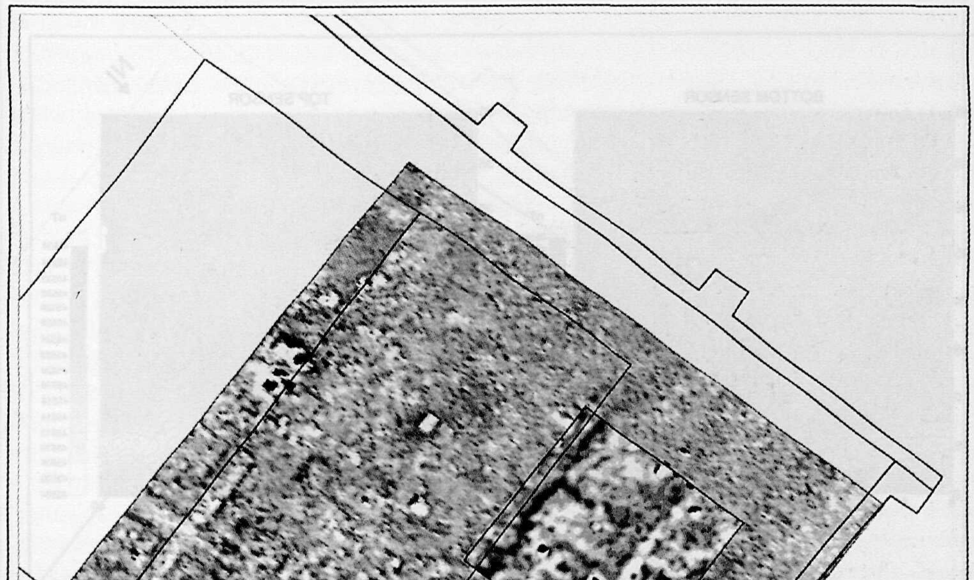

Figure 23. *Resistivity. Geoelectrical mapping by Twin probes array (Resistance meter Geoscan RM15)*

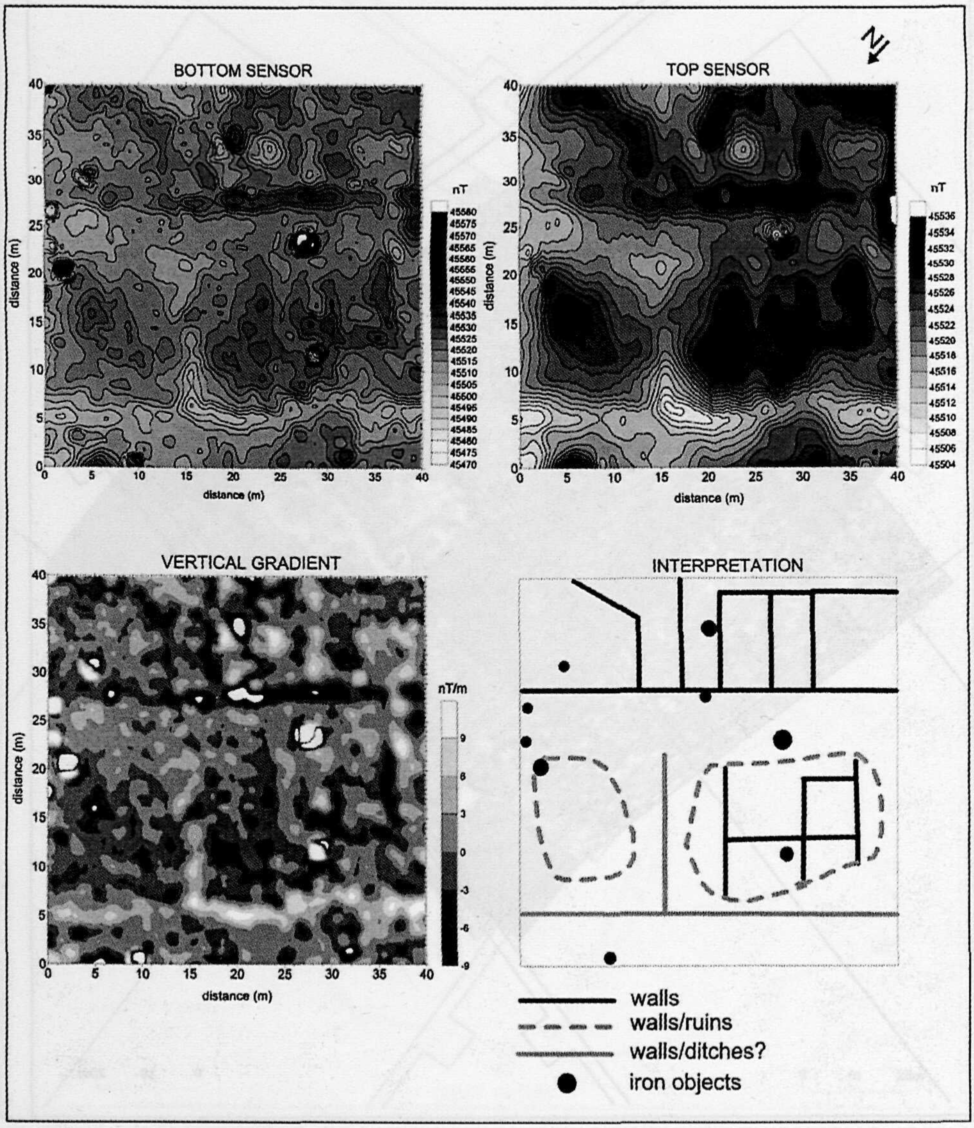

Figure 24. *Conductivity (Conductivity meter Geonics EM38)*

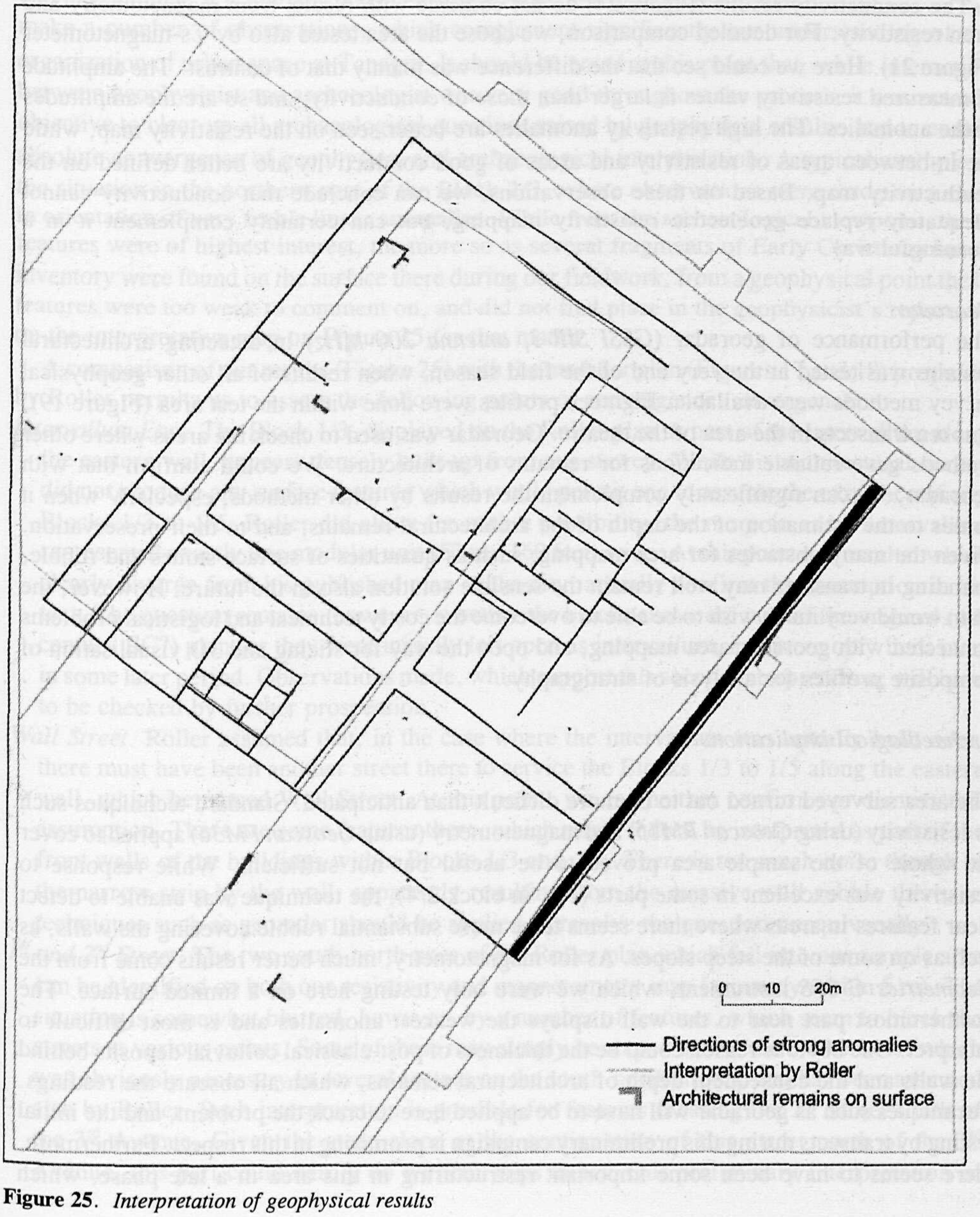

Figure 25. *Interpretation of geophysical results*

Conductivity

Since long dry seasons make the use of resistivity methods difficult if not impossible during most of the year (high resistivity contact), we tested also the conductivity meter (*Geonics EM-38*). In contrast to resistivity meters, this instrument uses the principle of electromagnetic field and therefore does not require physical contact with soil. Conductivity (mS/m) is a physical property inversely proportional with resistivity (ohm.m). We therefore anticipated comparable results from both methods. Given the expectations, the results were somewhat surprising in several sectors of the surveyed area.

The conductivity results (Figure 24) do not coincide with results from magnetometry and even resistivity. For detailed comparison, we chose the area tested also by Cs-magnetometer (Figure 21). Here we could see that the difference was mainly that of contrast. The amplitude of measured resistivity values is larger than those of conductivity, and so are the amplitudes of the anomalies. The high resistivity anomalies are better seen on the resistivity map, while the in-between areas of resistivity and areas of good conductivity are better defined on the conductivity map. Based on these observations, we can conclude that conductivity cannot adequately replace geoelectric resistivity mapping, but can certainly complement it in a meaningful way.

Georadar

The performance of georadar (*GSSI SIR-3, antenna 200 MHz*) in detecting architectural remains was tested at the very end of the field season, when results of all other geophysical survey methods were available. Eighteen profiles were done within the test area (Figure 19), plus ten transects in the area of the theatre. Georadar was used to check the areas where other methods gave reliable indications for remains of architecture. We could confirm that with georadar, we can significantly complement the results by other methods, especially when it comes to the estimation of the depth of the architectural remains, and to their preservation. Given the many obstacles for area mapping, such as quantities of surface stones and rubble, sounding in transects may well remain the sensible solution also in the future. However, the team would very much wish to be able to overcome the costly technical and logistical problems connected with georadar area mapping, and open the way for slicing and 3D visualisation of composite profiles for analysis of stratigraphy.

Archaeological implications

The area surveyed turned out to be more difficult than anticipated. Standard techniques such as resistivity (using *Geoscan RM15*) and magnetometry (using *Geoscan FM36*) applied to cover the whole of the sample area proved to be useful but not sufficient. While response to resistivity was excellent in some parts (*e.g.* in block 2/4), the technique was unable to detect clear features in areas where there seems to be more substantial rubble covering the walls, as well as on some of the steep slopes. As for magnetometry, much better results come from the *Geometrics G-858* instrument, which we were only testing here on a limited surface. The northernmost part near to the wall displays the weakest anomalies and is most difficult to interpret. One obvious reason could be the thickness of post-classical colluvial deposits behind the walls and the consequent depth of architectural remains, which all obscure the readings. Techniques such as georadar will have to be applied here to crack the problem, and the initial testing by transects during this preliminary campaign is promising in this respect. Furthermore, there seems to have been some important restructuring in this area in a late phase, which disregarded earlier building by insulae and introduced, in part of the area, a strictly east-west organization of the urban space. Such complexity demands more refined procedures that would permit a consideration of the stratification of the features observed. On the other hand, to deal with steep slopes and terracing would require the introduction of precise data on surface morphology, which may, together with data on structural remains such as walls observed on the surface, lead to an interpretation of the geophysical anomalies: such data could only be provided for part of the area under study.

Having said that, it is obvious that even at this stage, and with all the limitations above, we can make a number of observations, which complement significantly our understanding of the organization of urban space at Tanagra. It should be noted at this point that, while interaction between geophysicist and archaeologist was very good throughout the process, it was not our objective to clear up all archaeological questions raised by geophysical results, and to ensure absolute convergence of geophysical and archaeological interpretation. A typical example is the situation in the northern part of the Block 2/3, where observations were made on a shift in orientation of very feeble linear anomalies. While from the archaeological viewpoint, these features were of highest interest, the more so as several fragments of Early Christian church inventory were found on the surface there during our fieldwork, from a geophysical point these features were too weak to comment on, and did not find place in the geophysicist's report, or on the interpretative map on Figure 25 for that matter.

A comparison of our results (Figure 25) with the modular plan (Figures 17 and 18) proposed by Roller permits us to assess the following points of convergence / divergence:

Intervallum East. The Block 1/3, displayed on the Roller plan as part of the intervallum along the eastern wall, appears densely built-up from our survey. While his architectural survey did not produce any surface features which would permit one to assume the existence of city Blocks 1/3 to 1/5, Roller did allow for such a possibility, the more so as his intervallum represented exactly one modular unit (52 m - 160 feet) wide. At this point our results, which clearly diverge from his published plan of the city, actually confirm the assumption in his text. The question remains, however, whether the blocks above are part of the original (4th century BC?) plan, or they were initially left open as intervallum, and were only built over in some later period. Observations made, which support this second interpretation, will have to be checked by further prospection.

Wall Street. Roller assumed that, in the case where the intervallum was actually built over, there must have been another street there to service the Blocks 1/3 to 1/5 along the eastern wall, which he named Wall Street. At this point, we can neither confirm nor dismiss this assumption. There are some features there, which might indeed be interpreted as part of the front walls of the buildings within Blocks 1/3 and 1/4. There is too much noise though in the narrow strip by the wall, apparently resulting from the massive wall rubble there, so techniques such as georadar should be applied to resolve the question unequivocally.

1st and 2nd Street. The two south-north axes of the Roller plan which fall into our sample area can be identified on both our resistivity and magnetometry map (accuracy within 5 m). The situation is somewhat blurred, however, by a number of features, which seem to block the streets at various points. Some of these may simply be steps / stairs, the existence of which was obviously necessary in several sectors on the south-north streets, and has been assumed also by Roller. Such interpretation is possible for features crossing the 2nd Street south of the 3rd Avenue. Given the steep slope at the continuation of this street north of the 3rd Avenue, this part could hardly do without steps either. Our preliminary interpretation of geophysical features along the 1st Street north of the 3rd Avenue may be affected by this kind of features, difficult to discern from walls. There is no doubt, however, that at least in the lower northern part of the 2nd Street north of the 3rd Avenue, there are features which definitely belong to buildings, and which block communication along this axis.

2nd Avenue / Intervallum North. There are feeble linear features which coincide with the northern limit of the Blocks 1/3 to 3/3 as proposed by Roller. These features seem to be further corroborated by georadar profiles across and near the northern wall. Nevertheless, we must be cautious about these observations because geophysical anomalies detected by our standard techniques are weak in this sector, and georadar readings are few. Area georadar mapping would be needed to make any meaningful conclusions here.

3rd Avenue. This street is clearly readable both by resistivity and magnetometry. However, it is not where Roller would have it, but rather some 25m more to the North. Consequently, Blocks 1/3 to 3/3 do not fit the proposed 150 x 300 feet module, they are only 250 feet along their longer side. This is the most serious divergence from the Roller plan established so far. It should be noted that our 3rd Avenue lies half way between the Intervallum North (2nd Avenue) and the top of the ridge to the south. If we double the length of our revised blocks 1/3 to 3/3 we find that it coincides with the distance between the 2nd Avenue and the major corner where the Main Boulevard (9th Street) is met by Central Avenue West, suggesting that the dramatic angle of those two roads meeting might mark the end of two North-South blocks (9/3 and 9/4) rather than breaking up an otherwise regular series of insulae. We may therefore be up to more surprises concerning the city modular structure, as we proceed with our geophysical survey.

East wall. According to our results, the east wall within the limited area surveyed seems to have been straight, rather then deflected as suggested by the Roller plan.

Observations can be made also on the inner structure of the city blocks. Some buildings such as in block 2/4 show clearly on our maps, but most would need further prospection to interpret. We will therefore reserve our comments untill we have covered the area with the *Geometrics G-858* magnetometer and checked problem sectors with other techniques.

Conclusions

In the month mid-July to mid-August 2001 we plan to continue the Tanagra city survey. This would involve the complete surface study of a further one-third of the area within the late Classical walls. The aim would be to further test our hypotheses of the changing size of the settled zone in different phases of the town's history. We would also wish to continue with the very successful study of the immediate environs of the town, evaluating further the border of dense extramural settlement and the town's relationship to fringing cemetery clusters, sanctuaries, *villae urbanae* and the succeeding Byzantine village (a maximum zone of up to 1000 metres from the city walls will include all likely phenomena of this kind). Furthermore, we are preparing a commentary on the physical condition of the city site today and threats to conservation of its remains.

May 2001

J. L. Bintliff, E. Farinetti and L. Sigalos
Faculteit der Archeologie
Universiteit Leiden
Postbus 9515, 2300 RA Leiden
The Netherlands

K. Sbonias
35 Vernardaki Str.
Ambelokipi 115 22, Athens
Greece

B. Slapšak and B. Mušiè
Department of Archaeology
University of Ljubljana
P O B 580, 61001 Ljubljana
Slovenia