

ANCIENT TANAGRA (GRIMADHA): GEOPHYSICAL PROSPECTIONS AND MODELLING FOR UNDERSTANDING OF URBAN PLAN AND ON-SITE ACTIVITY AREAS.

ABSTRACT

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Research in Tanagra in the framework of the Boiotia Project, co-directed by John Bintliff and Božidar Slapšak, is since 2002 part of the Late Roman Cities and Countryside project, an Interuniversity Attraction Poles programme (IUAP V/09). It is a survey oriented research of a complex urban site for which no foreseeable excavation can be envisaged. It applies a battery of non-destructive methods, including archaeological, geophysical, surface morphology, and architectural survey.

The paper will concentrate on the potential of combined use of raster based GIS; 2D and 3D magnetic modelling; DEM, and of unsupervised classification for interpreting the results of geophysical prospection. 15 ha, about one half of the intra-muros area have been surveyed. Data sets acquired by geophysics are complementary in many details. Multivariate statistics is used to build up a site map in a single image, where archaeologically relevant units are discernable by spatially defined classes, based on the level of correlation between input data sets. The output is a composite image of differing, but normalised input data, and that could lead to partial automation of the interpretation procedure. 3D visualization is used for presentation of measured anomalies in physical fields, and of the final interpretation of the urban plan.

For the third consecutive year, Tanagra is the focus of research within the Boeotia Project, now co-directed between Leiden and Ljubljana Universities, and since 2002 also part of the Urban and Rural Transformation in the Western and Eastern Roman Empire Project, an Interuniversity Attraction Poles programme (IUAP V/09) funded by the Belgian federal government and co-ordinated by Marc Waelkens of the Catholic University of Leuven (Sagalassos).¹ A number of city territories in Boeotia have been studied during the 20 years or so since the project was initiated by John Bintliff and Anthony Snodgrass back in 1978 (Bintliff and Snodgrass 1985, 1988, Bintliff, Howard and Snodgrass 1999). All research within the project is survey-oriented, no excavation is envisaged as part of the scheme, and at Tanagra, no other institution is contemplating excavation at this point.

Neither has the urban area of Tanagra been the object of any substantial archaeological excavation in the past. While the cemeteries have been extensively excavated and robbed for the lovely Tanagrinans since the 70s of the 19th century, the only excavation within the city walls has been that of a Greek team of an early Christian church and possible temple structures on the acropolis, published in 1890 (Konstas 1890). Surface architectural remains are scarce, and have been largely removed at the end of the 19th century for construction in the nearby village of Ag. Thomas. An attempt was made in the mid-eighties by a Canadian team directed by Douane Roller to identify the urban plan based on architectural survey. His map published in the BSA in 1987 (Roller 1987) has the status of academic authority among classical archaeologists, and was naturally taken as the starting point of our investigations. The intra-muros area is now protected and is grazed by a flock of sheep.

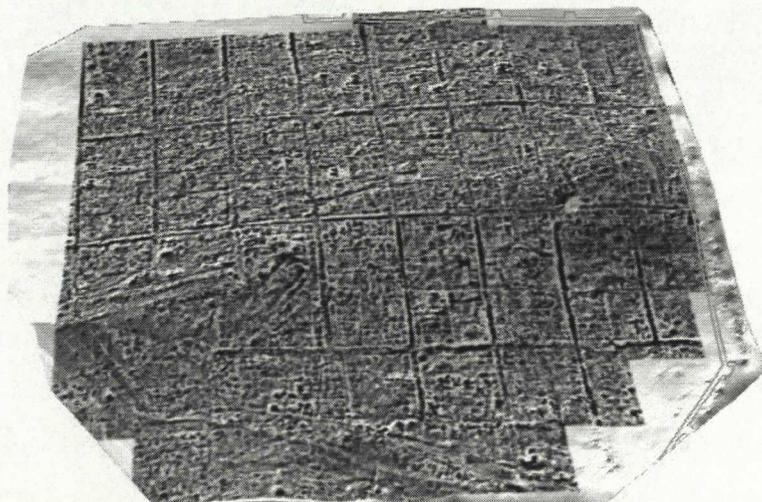


Figure 1 Results of magnetic prospection (Geometrics G-858). Dynamics: - 12 nT to +12 nT. View from the South

The novelty Tanagra brings to the Boeotia project, which has by now accumulated an impressive database from systematic archaeological surface survey, both off-site and on-site, including urban, is on the one hand, the GIS support developed by Emeri Farinetti, and on the other, the new interest in integrated urban survey, applying a battery of techniques, including surface morphology (Farinetti and Sigalos 2002) and architectural survey (tested in 2002, see Bintliff et al. 2003, and launched fully in 2003), as well as geological and geophysical prospections (Slapšak 2001). This is where the Project has developed a most fruitful synergy of the Leiden and the Ljubljana teams (Bintliff et al. 2000, 2001, 2002). The goal here is to explore the potential of non-destructive methods in the study of classical urban sites, and the rather favourable conditions in

Geographical Information System

Tanagra make it a good case in point, which permits such exploration to be pushed to the limit.

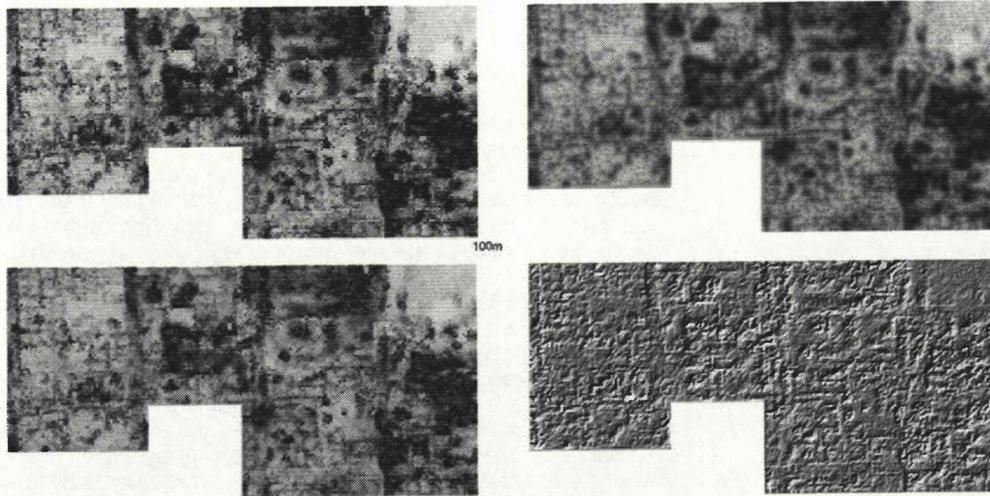


Figure 2: Resistivity. Raw data (top left) and processed images

An area of 1 ha was chosen in 2000 in the north-eastern corner of the walled city, to test the equipment and techniques of geophysical prospection for best performance in this geological and archaeological setting. Based on this testing, two methods were chosen to map the totality of the site: measurements of total magnetic field by caesium magnetometer Geometrics G-858, and geoelectric mapping by resistance meter Geoscan RM15. Such choice is justified because of the best labour input / result ratio for total mapping, and because of the complementarity of the two techniques in detecting types of archaeological features present. Further methods can then be applied for targeted survey, to address specific problems identified after completion of mapping (Bintliff et al. 2000:109-126, Slapšak 2001:10,19-23).

The geological survey identified types of bedrock and building materials at the site, as well as their magnetic susceptibility values. For the purpose of our geophysical prospection, it was important to note that both the bedrock and the prevalent building material (liassic and jurassic limestones) have very low magnetic susceptibility. Building material made of igneous rock is also found, but the frequency is low, so this material was obviously used only exceptionally, and in a limited number of buildings. Such material is not found in the vicinity of the site (Slapšak 2001:11-14, Bintliff et al. 2001:73).

On the other hand, magnetic susceptibility of the soil shows relatively high values on the site, so a good magnetic contrast can be expected between

built structures and the soils in which they are embedded. Naturally, the highest values are those of brick and burnt clay. Thus the contrast in magnetic susceptibility of the typical materials found on the site should enable us to identify both objects with induced magnetization, and those with thermoremanent magnetization. The magnetogram shows clearly that that is indeed the case here. Linear anomalies in induced magnetization point to walls and streets, and discrete areas of thermoremanent magnetization witness to activities connected with intensive use of fire.

In contrast to magnetometry, the results of geoelectric mapping seem less informative at first sight. An additional problem here is that of variable surveying conditions due to changing moisture of the soil. By filtering the results by areas surveyed under comparable moisture conditions, we can nevertheless extract important information from geoelectric maps. It is important to note here that, while the major features such as streets are less clearly discernible than by magnetometry, this methods adds important detail when it comes to identification of walls within the building blocks. The Early Christian church in the eastern part of the city is a good case in point: such crucial detail as the apse is in fact only visible on the resistivity map.

As the result of geophysical prospection, the Roller map can now be corrected in many parts. The position of the North-South axes of the urban structure are confirmed by geophysics, and so are many other details. On the other hand, the

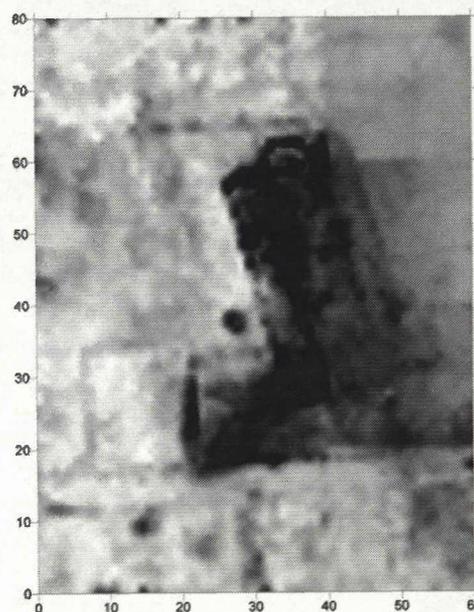


Figure 3: Results of resistivity measurements (Geoscan RM15) at the area of the Early Christian church

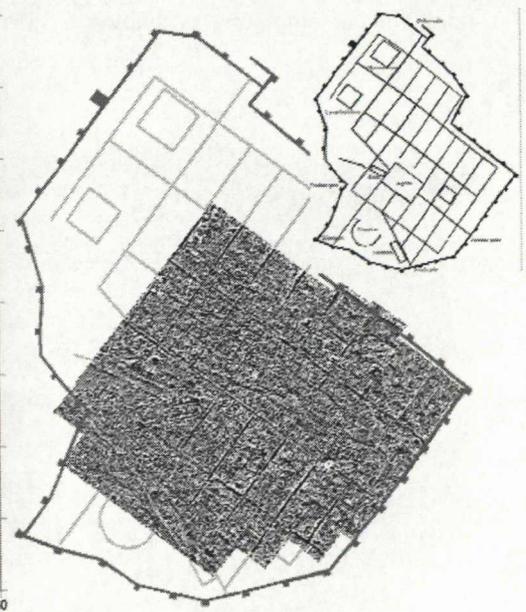


Figure 4: Results of magnetometry vs. Roller map (1987) (top right)

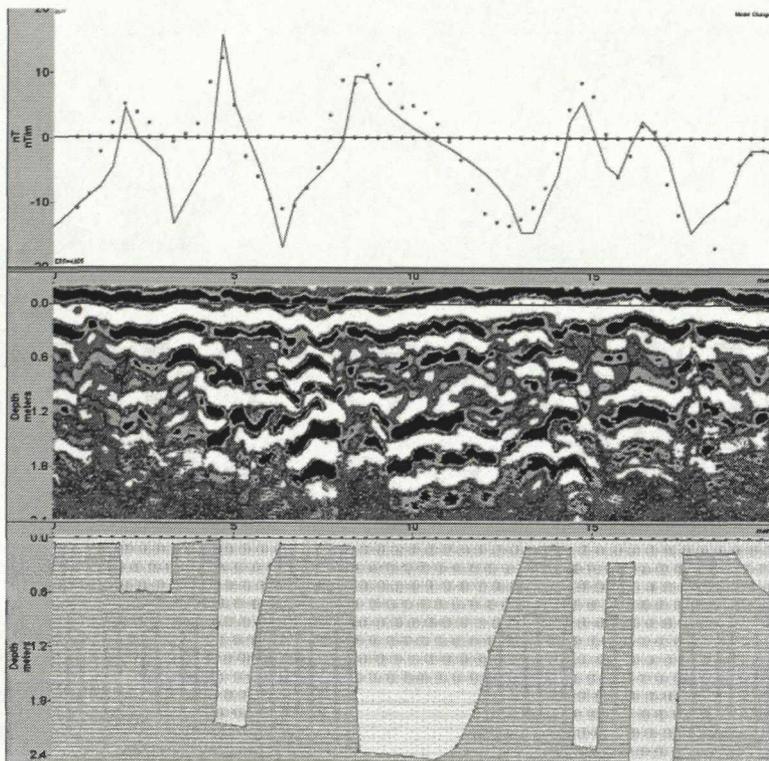


Figure 5 Magnetic modeling of architectural remains. Georadar and magnetic profiles were used for more realistic models of architectural remains. Cross-section across the street is represented

East-West axes are positioned more to the South, and the Agora is not where Roller would have it, so the main structuring axis, which crosses the central-southern part of the city looks different on our magnetogram, and consequently the South Gate must be sought in another place. The visible architectural remains, which Roller relied upon exclusively for his reconstruction of the urban grid, were for him frustratingly scarce, so we should be impressed by the many features he identified correctly (however the current Project with a larger team and more time have recorded a large number of in situ architectural features in all parts of the city).

A high priority topic in archaeological investigations in Tanagra is certainly industrial activity, and most notably its ceramic production. While the area within the city walls is not the obvious place to search for potters' quarters, geophysics did reveal foci of high thermoremanent magnetization there, which are indicative of some kind of (industrial) activity using high temperatures. If the objects with induced magnetisation are best identified by mapping the gradient of magnetic values, those with thermoremanent magnetization show best on the readings of the upper sensor of the magnetometer, which is not affected by the iron objects on the surface and in the topsoil.

Discrete areas of thermoremanent magnetisation will appear as magnetic dipoles. Ideally, their orientation will be that of the North magnetic pole at the time of the magnetization event. In practice, the orientations will be affected by the state of preservation of the objects, by the vicinity of other magnetic objects at the time of the magnetization event, and by the actual archaeological context. Regularities observed in orientations of dipoles may permit dating of the structures concerned. Interestingly enough, analysis of surface finds in the area where such features appear, point to some medieval / early modern ceramic production at the site (Poblom, J. in: Bintliff 2002).

The geometry of the structures with thermoremanent magnetization can be analysed by modelling. Again, the state of preservation will be a crucial factor determining the results. Geometry can be assumed to be based on the shape of the anomaly on the magnetogram. An hypothetical model can then be constructed, and then adapted to the measured values to develop a more realistic model of the archaeological feature. Both simple and complex objects can be analysed in this way.

The geometry of objects with induced magnetization will in most cases be rather complex, so radar profiles can be used to facilitate modelling. In Tanagra, radar profiles were taken as part of the initial experimentation over interpretable anomalies read on the magnetogram, and chosen for testing such an analysis. One profile was taken across a street, another over the city wall, and yet another over walls of a building within a city block. The profiles were taken to further refine initial hypothetical models of the structures. The degree of fit between the model and the empirical values was then observed, and the hypothetical model adapted to the measured figures. Thereby, a more realistic model of the structure could be developed.

This is only part of the experimentation, which we are engaging in, with a view to explore ways to extract the most of the archaeological information from the exciting images produced by geophysics in Tanagra. At future conferences, we hope to be able to present more of the same, and soon we hope to have also some consistent applications on architectural complexes chosen for detailed analysis.

¹ The Tanagra Project is jointly directed by John Bintliff and Bozidar Slapsak, with Kostas Sbonias as Assistant Director; for the IUAP Project, see Waelkens, M. e.a. 2003.

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