Remote Sensing And Fieldwalking Survey Applied To The Study Of Ancient Landscapes: An Integrated Approach

Stefano Campana[1] **- Cristina Felici**[2]

[1] Landscapes Archaeology, Dep. of Archaeology and History of Arts, University of Siena at Grosseto
campana@unisi.it
[2] Ph.d student, Dep. of Archaeology and History of Arts, University of Siena
felicicri@unisi.it

1. Introduction

In this paper we will discuss our experience with the gradual introduction of new methodologies and the problems of integrating different surveying techniques in the archaeological mapping of South Tuscan landscapes, specifically in the administrative areas of Grosseto and Siena.

The need to test new instruments and new approaches to surveying derives from a certain dissatisfaction with the results obtained through previous methods. The main problems encountered in the landscape analysis could be summarized as follow:

- degeneration of the surface finds due to more than half a century of ploughing.
- Low level of visibility, whether from the ground or from the air.
- The remaining land consists mainly of agricultural cultivation on heavy clay soils that are known to be an unfavourable surface for most remote sensing techniques.
- Areas with a higher level of visibility consist mainly of the alluvial plains of substantial rivers. In some of these areas, however, other problems arise from the great thickness of the layer of alluvium and from the impact of modern industry and residential development.

The strategy developed to face this situation is directed towards an integrated use of those remote sensing techniques that leave a wide choice to the archaeologist of times of the year to capture data capture and in particular towards the study of the region of the electromagnetic spectrum not visible to the human eye (CAMPANA-FRANCOVICH 2003).

1.1 Aerial Survey

We started a programme of aerial survey in 2000 averaging 45 hours of flight per year collecting more than 12000 oblique air photographs. The use of exploratory aerial survey in Italy has only become possible in recent years. In ideal conditions this technique offers an extraordinary contribution to the search for new sites and for the continuous monitoring of the cultural heritage (Fig. 1a). The flexibility of the method in allowing us to respond to the development of archaeological traces with extreme rapidity is of great benefit and importance. The archaeologist is free to choose conditions of lighting that range from soon after dawn to almost sunset as flying conditions (MUSSON *et al.* 2005).

1.2 Ikonos and Quickbird Satellite imagery

The introduction of satellite imagery was aimed in the first place at providing a total, continuous and objective view of a whole area at a particular moment of the year as planned by the archaeologist (CAMPANA 2002). The second feature is the capacity to provide multispectral data (and in particularly in the red and near-infrared region) to monitor plant health and to detect water-stress in vegetation where it cannot be seen by the naked eye (Fig. 1b).

1.3 Historical vertical air photographs

Vertical aerial photographs, spanning with their wide temporal range, represent an irreplaceable source for the analysis of the Tuscan landscape (GUAITOLI 2003). Anyone interpreting the photographs through a digital photogrammetric workstation will see a 3D replica model of landscape as it was in 1938, 1954, 1976 or 1994. In addition to their historical content, vertical photographs are of course an important source for the conduct of "aerial reconnaissance" (Fig. 1c).

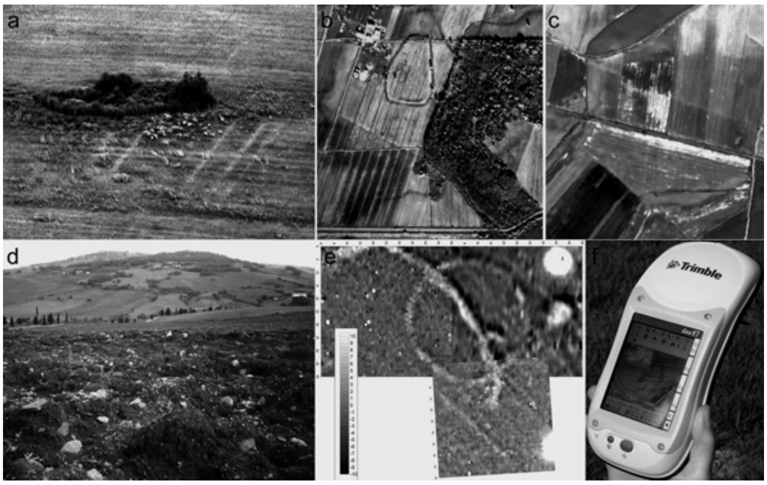

Fig.1 – a) Oblique air photograph of the ancient roman city of Heba (GR); b) vertical air photograph of an early middle age village (LI); c) Quickbird-2 satellite imagery showing at the centre a linear feature corresponding to a roman road; d) artefact scatter recognized during field-waking survey in the Orcia valley; e) example of a double enclosure detected with the gradiometric survey; f) PDA computer showing on the screen the background layer of the result of the different remote sensing analysis and on the front the GPS position.

1.4 Field walking survey

The technique of field-walking is aimed at the systematic investigation of sample areas and at the verification of the remotely sensed evidence. In the last 25 years of field-walking about 9000 sites have been detected in the provinces of Siena and Grosseto (FRANCOVICH-VALENTI 2001). Field survey constitutes therefore an important source for the archaeological study of settlement patterns. Nevertheless the collected information often turns out to be incomplete, confused and difficult to interpret because of post-depositional processes in the field, if not integrated with other sources of information (Fig. 1d).

1.5 Magnetic survey

In 2003 we tested a system of data acquisition that allowed us to cover one hectare per day at a resolution of 60 cm along traverses which were each set 1 metre apart.

So far we have only acquired data for 15 hectares surveying 12 archaeological sites. The general trend arising from the results seems to confirm that the degree of detail, although not very high, is sufficient to show with a good approximation the position of the main features, depending on the characteristics of the materials to which the magnetometer is reacting (Fig. 1e).

1.6 Field Data integration: PDA technology

The merging of PDA and GPS technologies goes far beyond the level of increased fieldwork efficiency, enabling data integration directly in the field and at best allowing the systematic application of strategies and methodologies developed in the past. These have only rarely been applied before because of the excessive amount of time required (RYAN-VAN LEUSEN 2002). Best results and a larger number of applications are possible only if the PDA mobile GIS system has the real time support of a GPS base station (Fig. 1f).

S. Campana

2. Case study: Pieve di Pava (Siena)

The site of Pieve di Pava represents an important case study for us because we undertook an archaeological excavation there, between July and August 2004, which was the first chance to verify and compare the remotely sensed data with the observed stratigraphy. The case study is a good example of the integrated research strategy illustrated in the first part of our paper. The site had been discovered during the field-walking in 2000. We repeated the surface collection in 2001, 2002 and 2003 with significant results for the understanding of the function and chronology of the site. At that stage the surface data showed the presence of a roman settlement still alive in the late antiquity and the available documents revealed the existence of an early middle age church in the same area (FELICI 2003). The second step was the study of the vertical aerial photographs taken in the 1954, 1976 and 1996 (Fig.2a). Because of the geological characteristic of the area (heavy clay soil) the analysis of the vertical aerial photographs was negative. The same results come form the aerial survey that we began in the spring

Fig. 2 – a) Vertical air photograph of year 1954; b) oblique air photograph of spring 2002; c) oblique air photograph of winter 2004; d) gradiometric survey with resolution of 1 m.

of 2002 and that we repeated over different seasons in 2003 and 2004 (Fig.2b/c).

A real improvement of the site knowledge was granted by the gradiometric survey. Firstly we acquired data for 2 hectares at a resolution of 1 metre between traverses (Fig.2d). This level of detail allowed us to recognize the position of many features that greatly enrich the interpretation of the site, thus enabling us to distinguish with a good approximation two main areas features (Fig.2d n.3 and n.4), in one case elucidating site geometry (Fig.2d n.3), and some strong dipoles (Fig.2d n.1 and n.2). Before the excavation we reduced the resolution to 25 cm along traverses and 50 cm apart in order to make a comparison. Notwithstanding an unquestionable enrichment of the data and the improvement in the resolution of the shapes, new features could not be detected. The excavation strategy had been planned following mainly the data of the magnetic survey. The correspondence after the first two months of excavation was impressive. On the dipole showed in fig.2 n.1, an anomaly with values between -13 and +73 nT/m, we made a 3 by 3 m test excavation. At a depth of about 50 cm we found the remains of a kiln, characterized by the presence of bricks, some of them showing clear traces of exposure to high temperature (Fig.3a). The second dipole (-33/+98 nT/m) corresponded,


Fig.3 – a) Kiln; b) not yet identified productive activity; c) the church

at a depth of about 2 m, to a red clay stratification related to some kind of manufacturing activity that we still have to explore stratigraphically (Fig.3b). Taking into consideretion the value of the magnetic anomaly in relationship to its depth, it is possible to assume the presence of a high temperature activity related to some kind of furnace. Another significant confirmation of the interpretation of the magnetic data come from the lager area (20 by 10 meters) that we excavated (Fig.2d n.3). The mosaic magnetogram showed numerous rectangular features with E-W orientation, which we interpreted as buildings. The northern side of the main anomaly, a rectangular feature measuring 20 by 10 meters with values between -3 and +6 nT/m, corresponds to the wall of a church, about 80 cm large, made of stones, bricks and mortar (Fig.3c).

C. Felici

Acknowledgments

The authors are indebted to Prof. Salvatore Piro (ITABC – CNR) for their invaluable comments and criticisms on geophysical survey techniques and data processing. A special thanks are due to Claus Strøander by proofreading the translation of the text and to the team of the Landscapes Archaeology and Remote Sensing Laboratories of the University of Siena at Grosseto: F. Pericci, M. Corsi, E. Vaccaro.

Bibliografia

CAMPANA, S., 2002. High resolution satellite imagery: a new source of information to the archaeological study of Italian landscapes? Case study of Tuscany. In Space Applications for Heritage Conservation, (Strasbourg, 5-8 Nov. 2002), CD-ROM.

CAMPANA, S. and FRANCOVICH, R., 2003. Landscape Archaeology in Tuscany: Cultural resource management, remotely sensed techniques, GIS based data integration and interpretation. In The Recontruction of Archaeological Landscapes through Digital Technologies, (Boston, MA 1-3 novembre 2001), BAR SERIES 1151, pp. 15-28.

FELICI, C., 2003. *Il caso della Val d'Orcia*, in *Chiese e insediamenti nelle campagne tra V e VI secolo*, Mantova, pp.276-285.

FRANCOVICH, R., and VALENTI, M., 2001. Cartografia archeologica, indagini sul campo ed informatizzazione. Il contributo senese alla conoscenza ed alla gestione della risorsa culturale del territorio. In La carta archeologica. Fra ricerca e pianificazione territoriale, Florence, 6-7 May 1999, Florence, pp. 83-116.

GUAITOLI, M., 2003. Lo sguardo di Icaro. Rome.

MUSSON, C., PALMER, R. and CAMPANA, S., 2005. *In volo nel passato*, Firenze.

RYAN, N. and VAN LEUSEN, M., 2002. *Educating the Digital Fieldwork Assistant*, in Proceedings of CAA 2001, BAR International Series 1016, pp.401-416.