

Integrated geophysical and in-situ soil geochemical survey at Dromolaxia-Vizakia (Hala Sultan Tekke, Cyprus)

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INTRODUCTION

The combination of geophysical and geochemical methods in archaeological prospection has the potential to enhance the information relating to buried archaeological features, as well as to develop a better understanding of how the setting of a site may affect geophysical and geochemical datasets (Cuenca-García *et al.* 2013; Dirix *et al.* 2013). The nuanced data interpretation and technique reappraisal capabilities of this integrated approach are based on the complementary information provided by these two disciplines. In spite of their potential, the requirements of multi-disciplinary teams as well as the lack of established, proven and integrated survey strategies are some of the reasons why these studies are not frequent in archaeological prospection.

This presentation will show the results of a combined survey using non-destructive geophysical methods and minimally-invasive soil chemical survey carried out at the site of Dromolaxia-Vyzakia between 27 October and 7 November 2014. The fieldwork was undertaken by a multi-disciplinary team integrated by researchers from the University of Cyprus, the STARLAB Project (STARC- The Cyprus Institute), GeoSat ReSeArch Lab (IMS-FORTH, Greece) and the Vrije Universiteit Brussel.

The aims of the investigation were twofold. Firstly, to map and characterise possible buried archaeological features and activity areas beyond the excavated areas, as well as to assess the extent of the site in several directions. Secondly, and from a more methodological perspective, to assess the performance of the geophysical and geochemical techniques and strategies used at the site, with particular attention on the use of *in situ* soil chemical analysis.

THE SITE

Dromolaxia-Vyzakia is located immediately west of Hala Sultan Tekke, a mosque situated on the west bank of Larnaca's Salt Lake (Fig. 1). The site was a busy industrial harbour town and is considered one of the major coastal trading centres of Cyprus during the Late Bronze

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Fig.1. Location of the site and the excavated areas

Age. The site has been explored since the late 19th century (British and Swedish archaeological missions, Cypriot rescue excavations and Belgian post-excavation research related to the Swedish 20th century excavation campaigns) (Fig. 1). The remarkable number of finds retrieved is proof of the diverse and long-distance commercial activities developed at the site. The excavations exposed a series of workshop structures and habitation quarters. However, the overall structural organization of the settlement and its full extent remain unknown.

METHODS AND SURVEY STRATEGY

GEOPHYSICAL SURVEY

Following previous experience at the site (Trinks *et al.* 2013; Cuenca-García *et al.* 2014), the techniques used for the geophysical survey were magnetometry and a ground-penetrating radar using the geophysical equipment pool of the STARLAB Project (Fig. 2). First of all, an extensive magnetometer survey was carried out using a dual Bartington Grad601. In order to clarify some of the magnetic anomalies, targeted GPR surveys were performed in specific areas of the extensive magnetometer survey using a single channel MALÅ ProEx system (250 and 500 MHz antennae).

IN SITU MULTI-ELEMENT MEASUREMENTS AND SOIL SAMPLING

Parallel to the GPR survey, multi-element soil measurements were performed in the same area covered by the magnetometer survey and along two single lines across the main known settlement. The instruments used were two hand-held XRFs (or pXRF): InnovX Delta from the University of Cyprus and Bruker Tracer IV from the Vrije Universiteit Brussel (Fig. 2). The measurements were taken directly on the fresh exposed soil and after removing the first ~20 cm of sandy topsoil. Magnetic anomalies of interest were also targeted for soil analysis using a sand-



Fig. 2. Geophysical and geochemical instruments used during the fieldwork

type Edelman auger with bayonet connection by Eijkelkamp. Further measurements were taken in areas outside of the main settlement and at different depths to act as controls. During the survey, Cu and Fe and a standard sample were used as cross-validation between the instruments.

LAB-BASED SOIL ANALYSIS

After the *in situ* measurements, small bulk soil samples were taken, dried and measured in the lab using a higher accuracy μ -XRF Bruker ARTAX 200 (STARLAB Project). Some of the samples were also re-analysed in a controlled lab-environment, using the same pXRF instruments. The purpose of these lab measurements was to compare on-the-spot and lab results to assess the use of *in situ* soil pXRF measurements. The soil samples were also analysed for lab-based soil magnetic susceptibility.

RESULTS

The results of the geophysical surveys revealed weak magnetic anomalies possibly associated with the location of structures projecting southeast of the excavated area. A concentration of strong magnetic anomalies (> 100 nT) was also detected around this area (Fig. 3). These may be linked to activities undertaken at the site. The survey also detected undocumented archaeological trenches, showing areas that have already been explored by former archaeological expeditions. The preliminary results of the geochemical survey have identified patterns in the concentration of

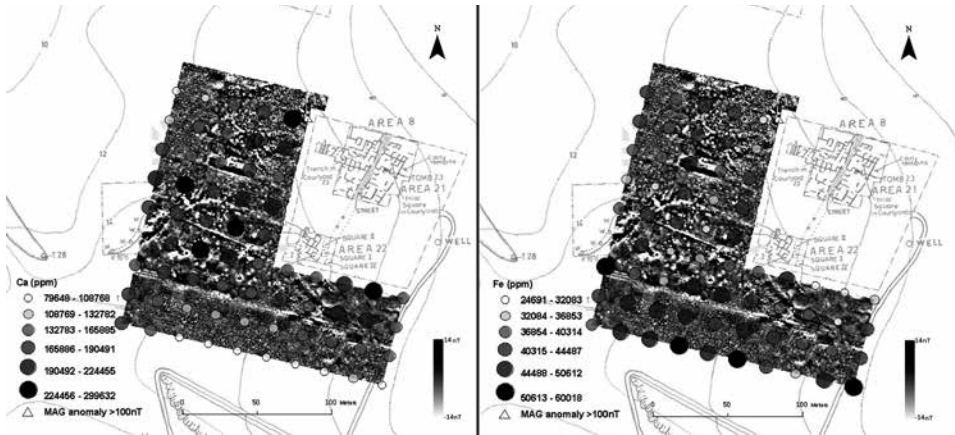


Fig. 3. Some preliminary results of the geophysical and geochemical surveys

some elements (Fig. 3). Some of these enhancements are associated with the location of the site, with particular magnetic anomalies and others suggested to be of geogenic origin. The comparison between the three XRF instruments used in this investigation showed a good correlation. Whilst some elements showed some differences in the total counts, the deviations were within accepted limits and the general concentration patterns matched fairly well.

CONCLUSIONS

As an overall outcome of the fieldwork and ongoing analysis, the combination of routine geophysical techniques and *in situ* pXRF chemical analysis have demonstrated rapid, significant and complementary proxy information relating to the buried archaeology of the area.

REFERENCES

- Cuenca-García, C., Hall, A.J., Jones, R.E. and Poller, T. 2013. From the air to the atomic level of a ditch: integrating geophysical and geochemical survey methods at the prehistoric cropmark complex of Forteviot (Perthshire, Scotland). In W. Neubauer, I. Trinks, R.B. Salisbury and C. Einwögerer (eds), *10th International Conference on Archaeological Prospection*, 129-133. Vienna.
- Cuenca-García, C., Sarris, A. and Hermon, S. 2014. The archaeo-geophysical input of the STAR-LAB Project. *Second International Conference on Remote Sensing and Geoinformation, 7-10 April 2014, Paphos, Cyprus*.
- Dirix, K., Muchez, P., Degryse, P., Music, B. and Poblome, J. 2013. Integrating geochemical survey and magnetic prospecting on an archaeological site in SW-Turkey. In W. Neubauer, I. Trinks, R.B. Salisbury and C. Einwögerer (eds), *10th International Conference on Archaeological Prospection*, 110-113. Vienna.
- Trinks, I., Fischer, P., Löcker, K. and Flöry, S. 2013. Hala Sultan Tekke revisited – archaeological GPR prospecting on Cyprus 1980 and 2010/12. In W. Neubauer, I. Trinks, R.B. Salisbury, C. Einwögerer (eds), *10th International Conference on Archaeological Prospection*, 285-287. Vienna.