PHAROS SUPPLEMENT 1

DIET, ECONOMY AND SOCIETY IN THE ANCIENT GREEK WORLD

Towards a Better Integration of Archaeology and Science

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Integrating geochemical survey, ethnography and organic residue analysis to identify and understand areas of foodstuff processing

Brendan Derham, Roger Doonan, Yannis Lolos, Apostolos Sarris & Richard Jones

Abstract

In this paper we explore the integration of science-based and ethnographic approaches that respond to the need to consider ancient economy and subsistence in the Greek world on a landscape level. It is particularly important to be in a position to understand changes and developments in the processes associated with the preparation of food as well as agro-industrial commodities such as wine and olive oil. While ancient economic and subsistence patterns are traditionally and most effectively investigated where animal and plant remains have been recovered from excavation, our strategy is less direct; operating by proxy, it is well suited in the first instance to archaeological field survey. Having first determined the soils' chemical signatures and the identity of pottery residues, a comparison will then be made with data obtained from ethnographic surveys of abandoned 20th-century farmsteads and workplaces, where particular activities are known to have taken place. Integrating these approaches, our work is applying them to archaeological field survey, specifically the current project on the city of Sikyon and its vicinity in the North Peloponnese.

Keywords

Integrated survey; geochemical; *in-situ* analysis; ethnography.

Introduction

The integration of science-based archaeological approaches with observations derived from ethnographic material offers a significant opportunity to investigate the impact of human settlement on the environment and the processes behind 'archaeo-pollution', the contamination of areas associated with the transformation and processing of resources such as food and craft materials. The work at the archaeological site at Sikyon will be compared with future work that will be undertaken at ethnographic sites in which a more thorough, oral history of the site formation processes may be used to identify possible reasons behind the accumulation of pollution in archaeological sites.

The combined approach outlined here focuses on the preparation of food and the processing of oil and wine as well as other polluting agricultural and industrial activities. the aim being to respond to a need to consider ancient economic and subsistence patterns in the Mediterranean region on a *landscape* level, in particular the processing, refining and storage of foodstuffs. While the ancient economy and subsistence patterns are traditionally and most effectively investigated where animal and plant remains have been recovered from excavation, our strategy is less direct; operating by proxy, it is well suited in the first instance to archaeological field survey.

In recent years archaeological urban and landscape survey projects have benefited from developments in integrating systematic and quantitative walk-over surveys with complementary geophysical survey techniques and test-pit excavations designed to understand the accumulated archaeological impact of human settlement and activity.[1] In particular this approach has been undertaken at urban centres at such sites as Peñaflor (southern Spain) 1987-1992,[2] Ajdovšcina above Rodik (Slovenia) 1995-2000,[3] Sagalassos (southwest Turkey) 1990 to present,[4] and the Ammaia project, Portugal 1995 to present;[5] but it has also featured in landscape surveys, as in the Leptiminus (Tunisia) Archaeological Project 1990-1999,[6] the

[1] Gkiasta 2008, 11-39; Sarris & Jones, 2000, 41-48.
[2] Keay & Creighton 2000.
[3] Music, Slapsak & Perko 2000.
[4] Martens 2005.
[5] Vermeulen *et al.* 2005.
[6] Stirling *et al.* 2000.

Körös Regional Archaeological Project (Hungary) 1999-2005,[7] the Laconia (Greece) Rural Sites Project 1992-2010,[8] the new Tanagra survey (Boeotia, Greece) 2000 to present,[9] and the Riu Mannu survey and Terralba Rural Settlement Projects (Sardinia) 1992 to present.[10]

In this paper we report on work which demonstrates progress in integrating the geochemical analysis of soils, using novel *in situ* analytical protocols, with the extensive and intensive survey work that is being carried out on different parts of the prominent plateau at Sikyon.

Application as part of the Sikyon Survey Project

The Sikyon plateau was the acropolis of the Archaic and Classical city state before the city itself was relocated there in 303BC, where it flourished. The city and its hinterland dominated an area of approximately 360km² in the North Peloponnese until Roman Imperial times. Sikyon as a settlement reappears again in the 13th and 14th centuries AD, now called Vasiliko, as one of the Frankish possessions in the Corinthia, occupying its current site in the south-eastern corner of the plateau.

The first stage of the Sikyon Survey Project was based on an extensive survey (from 1996 to 2002) of a surface area of approximately 250ha, focusing on the rural areas of the plateau and the mapping of the fortification walls.[11] Work on the urban centre was limited to the previously excavated civic monuments around the agora. This phase identified the location of the gates and the alignment of ancient streets and buildings, ultimately demonstrating that the city was laid out on a grid pattern.

The second stage of the project (2004 to 2009) involved a more intensive survey of the plateau. Geoarchaeological survey work on the subsurface remains of the civic centre or agora of the Hellenistic and Roman city, covering approximately 10ha, was undertaken using magnetic survey, soil resistance, Ground Penetrating Radar and Electrical Resistivity Tomography. An architectural survey of the modern village was also undertaken. This stage of the project also involved surface artefact collection and geophysical magnetic survey.[12] Today the plateau has a large proportion of open agricultural land resulting in a potential/possible survey area of about 180ha, corresponding to 75% of the entire plateau, of which a little over 100ha was eventually surveyed intensively (Figure 1).

The results presented here are part of a project aimed at integrating geochemical survey work into the geophysical and walk-over survey techniques that had already been undertaken as part of these first two stages. The aim was to identify any residual pollution associated with areas of the site that had been used for food processing, agro-industrial activities such as wine and oil processing as well as waste disposal.

Identifying food processing areas: the geochemical approach

The method adopts two science-based approaches: geochemical survey of soils and organic residue analysis on soils and pottery. The geochemical component reported here is based upon the application of the chemical analysis of soils in areas thought to be associated with either residential or craft and industrial activity, as inferred from high density sherd and tile scatters encountered during field walking as well as indicative anomalies from geophysical survey. The presence of elevated levels of phosphate in archaeological soils has for a long time been used to locate areas of human settlement. By widening the range of detectable inorganic elements and organic compounds, however, it is possible to identify the impact of a greater range of agro-industrial activities and craft industries by locating the characteristic pollution that these processes leave behind. A critical issue is the ability to take soil cores, on a regular 5-metre grid using an auger, and to analyse the samples using *field-based, portable* equipment that circumvents the need for extensive laboratory-based sample processing and extraction, which are both slow and costly. The qualitative and semi-quantitative data obtained from the field-based analyses can then be used to distinguish between background material and elevated levels of unusual, intrusive and therefore significant compounds. A significant aspect of our research is to investigate the advantages and limitations of *in-situ* analysis using field-portable analytical techniques such as (portable) X-ray fluorescence (pXRF) and to correlate the results with those from Raman and Infra-red analysis. These results will then in turn be corroborated

7 Sarris *et al.* 2004.
8 Cavanagh, Mee & James 2005.
9 Bintliff *et al.* 2000.
10 Van Dommelen & Sharpe 2004.
11 Lolos *et al.* 2007.
12 Lolos 2010.

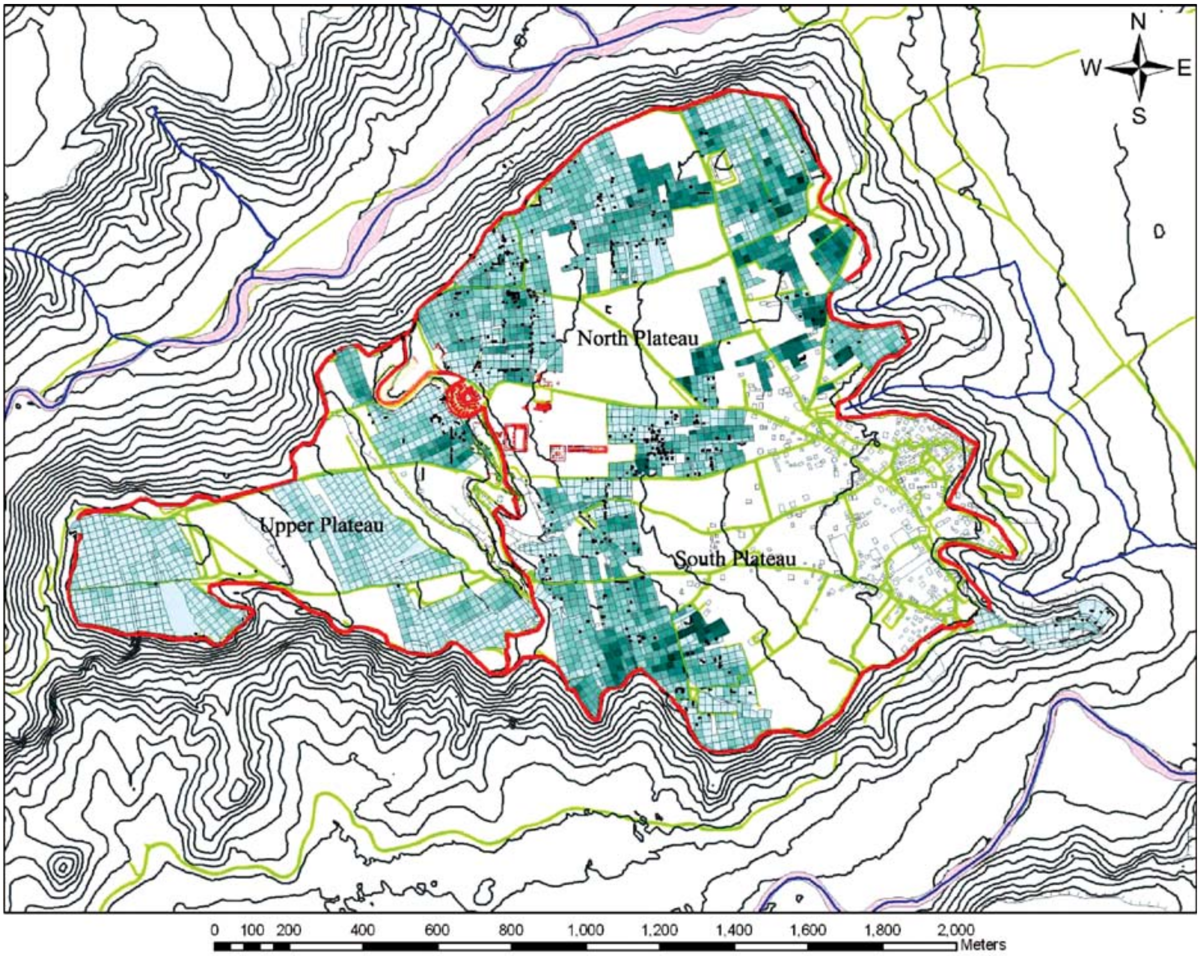

FIGURE 1. Map of Sikyon Plateau Survey.
Contour lines: 10m. The survey squares covered between 2004 and 2008. The darker the square the higher the ceramic density. Red lines are extant archaeological features such as fortification walls and civic buildings. Black lines and dots indicate *in-situ* architectural fragments. Green lines are modern roads and clear squares modern buildings. Blue lines are streams and rivers.

using more time-consuming and destructive analytical techniques based on inductively coupled plasma (ICP) as well as techniques based on gas and liquid chromatography-mass spectrometry (GC-MS, LC-MS).

The geochemical survey work is undertaken in two phases. The first will attempt to integrate the geochemical analysis of soils sampled across the same regular survey grid that had been used for the geophysical and walk-over artefact surveys. The second phase will be undertaken at the same time as the excavations are proceeding in order to integrate soil and artefact analysis data with the stratigraphic contexts of the excavation.

The first stage of the chemical analyses involves the analysis of the inorganic elements within the soil matrix. This approach has been used in the past to locate areas of human/animal occupation and industrial activity. In recent years, criticism has been applied to many of the earlier approaches adopted in archaeological geochemical survey work. In particular the range of elements that may be associated strictly with anthropogenic activity[13] as well as the statistical basis for sampling strategies capable of distinguishing areas of significance from natural background fluctuations[14] have been questioned. Also changes in micro morphology[15] as well as the composition of the soil bulk matrix (pH, particle size, soil organic matter,

[13] Rimmington 1999.
[14] Haslam & Tibbett 2004.
[15] Homsey & Capo 2006.

carbonate levels) have been shown to be capable of selectively influencing ion retention and therefore need to be considered as potentially significant variables within a survey.[16] By expanding the range of multi-variate analysis to include these components it may be possible to address the impact of these factors on the geochemical signal.

The second stage of the analyses includes analysis of the *organic* content, employing Raman and portable Infra-Red spectroscopy to screen the soils for potentially diagnostic functional groups, which we then intend to investigate further using laboratory-based organic residue analysis techniques both on the soils and on ceramic sherds found within the corresponding depositional contexts. The importance of using ceramics recovered from within sealed archaeological contexts, rather than surface scatters has already been demonstrated.[17] In entirely different analytical programmes, organic residue analysis has of course found much application in identifying the contents of (a) pottery found in kitchens and food processing areas, for instance at Apodoulou, Chania and Chamalevri in Minoan Crete[18] and Akrotiri on Thera,[19] and of (b) soils, albeit to a limited extent, for information on manuring[20] and agro-industrial processing.[21]

Having determined the chemical signatures of ceramic residues, soils and sediments, comparisons will then be made with corresponding data obtained from ethnographic collections and abandoned 20th-century farmsteads and workplaces where particular activities are known to have taken place. The archaeological data can then be interpreted in the light of a functional understanding, made available by ethnographic survey of actual site formation processes.[22] The recent increase in interest in integrating ethnography and archaeology within Greek landscape studies is well represented at several museums. These include the Museum of the Olive and Greek Olive Oil in Sparta and the Open-Air Water Power Museum of Dimitsana (Arcadia), the latter demonstrating the integration of water-mills with a range of pre-industrial craft industries including textile fulling, leather tanning and gunpowder milling. The general adaptation of human settlement and subsistence patterns to particular environments and ecosystems is well represented at the Museum of Cretan Ethnology, Voroi, Crete.

At Sikyon five locations from within the fortifications, typically of Hellenistic and Roman date, were selected for a geochemical survey lasting three days. A survey grid was established, generally following the grid of the surface and geophysical surveys, normally in multiples of 20m x 20m, and sub-surface soil cores, approximately 20cm deep, were taken every 5m. Inorganic analyses were undertaken on the cores using a Thermo Scientific NITON XL3t XRF analyser. A helium purge was included to enable the detection of lighter elements, such as phosphorus, that are otherwise obscured by atmospheric interference (Figure 2).

The individual areas within the Sikyon plateau selected for geochemical survey encompassed both urban and rural features that were thought to be associated with a range of activities such as domestic practices, the processing of agricultural products as well as kiln sites. The selection of the tracts for geochemical survey was based on the results of the geophysical and surface walk-over surveys, in particular pottery and tile density plots as well as kiln waster scatters.

NP31 (North plateau) and NP104 are at the heart of the residential blocks of the city with the latter

FIGURE 2. Analysis in progress using the hand held portable XRF. The supply cylinder for the helium purge is transported in the back pack.

16 Oonk 2009.
17 Evershed 2008.
18 Tzedakis, Martlew & Jones 2008.
19 Roumpou *et al.*, this volume.
20 Bull, Evershed & Betancourt 2001.
21 Hjulstrom & Isaksson 2009.
22 Wilson, Davidson & Cresser 2009.

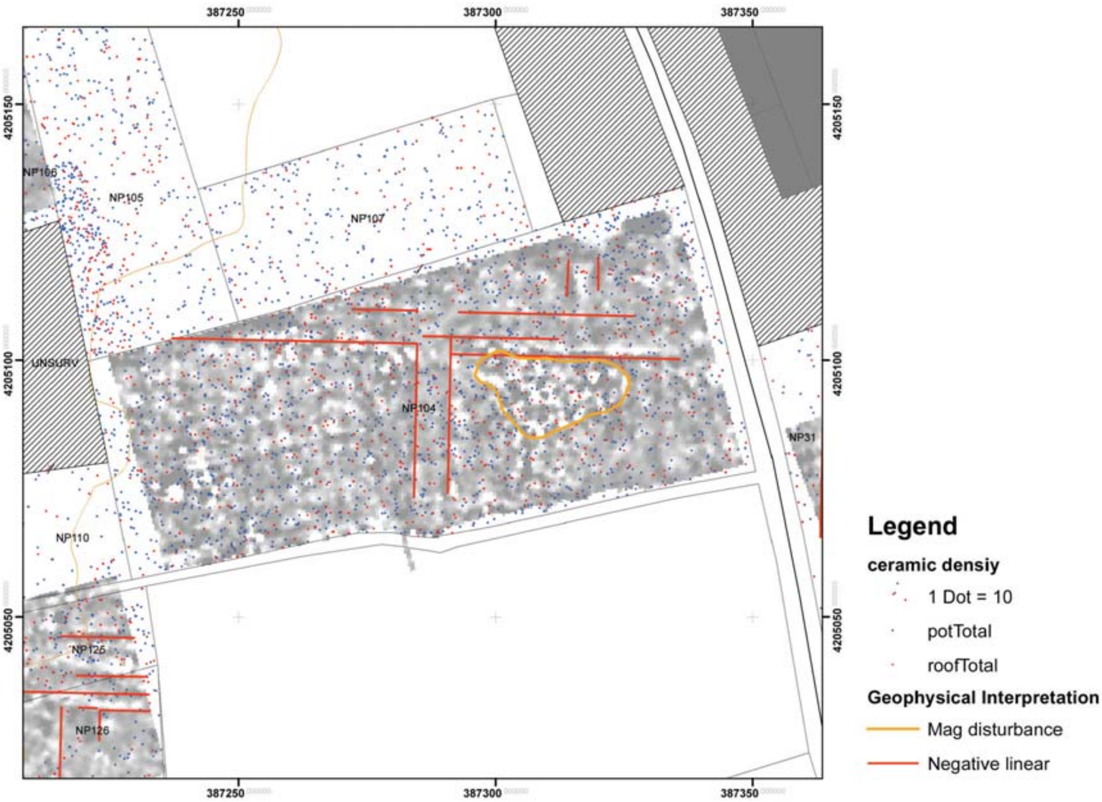

FIGURE 3. Geophysical and walk-over survey plot of grid NP104 with interpretation overlay.
A blue spot represents a pottery sherd, a red spot represents a roof tile with each spot representing 10 pieces. The orange line delineates an area of magnetic disturbance and the red lines linear negative features.

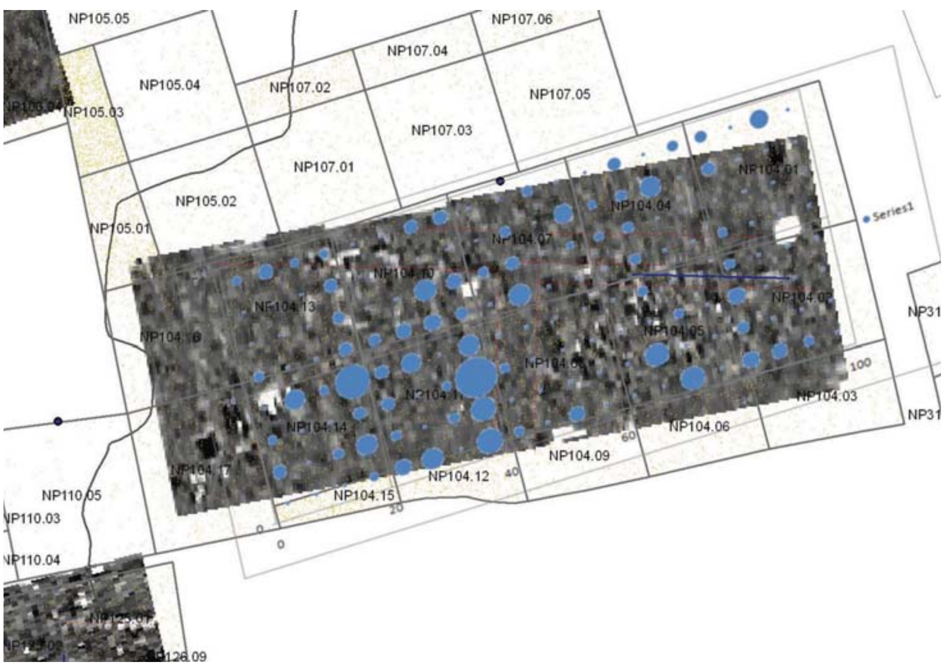

FIGURE 4. Survey of phosphorus in NP104 over a geophysical survey plot.
The levels of phosphorus are in proportion to the diameter of the blue 'bubbles' in the plot.

showing signs of a possible sanctuary. This interpretation was based upon the geophysical survey over both tracts that had revealed the outline of the *insulae* and the streets, and even inner divisions within the specific *insulae*. The geophysical survey data and interpretation along with the pottery and roof tile sherd scatters can be seen in Figure 3 whilst the phosphorus data can be seen overlaying the geophysics in Figure 4.

Geochemical survey of NP104 produced the most meaningful results: the main feature of this area was the elevated phosphorus and potassium concentrations in the spaces associated with the interior of the *insulae*, the streets themselves having lower levels similar to background. The levels of phosphorus and potassium are plotted in proportion to the diameter of the 'bubble' as this gives a more reliable representation of variations across the site.

This correlation indicates the on-site disposal of human and animal waste in the vicinity of the individual buildings parallel with the side street. Elevated levels of metals such as zinc and, to some extent, copper were also associated with the buildings, as was the presence of sulphur. It was reassuring to notice that elevated levels of phosphorous and heavy metals were not recorded along the line of the ancient 'street' or the modern road.

SP21 (South plateau) and SP22, each measuring 40m square, are at the heart of an area of ceramic production as indicated by the number of wasters and ceramic kiln debris visible on the surface. In addition, geophysical survey over part of SP22 has shown magnetic hotspots with high magnetic readings, tentatively interpreted as the actual site of the kiln. This industrial area was identified using signals normally suggestive of pottery kilns, i.e. geophysical survey data combined with the extensive presence of pottery and kiln 'wasters' recovered during field-walking.

In these two areas the levels of all significant elements fluctuated around normal 'background' levels. This is rather surprising in this industrial area where the likely presence of ceramic kilns would have been expected to yield higher concentrations (with relation to the background) of phosphorus and heavy metals.

UP77 (Upper plateau) showed higher ceramic concentrations compared to its surroundings, although at much lower levels than at the kiln site, and may represent the site of an installation probably of agricultural or pastoral nature, such as a transient farmstead and its associated debris, outside the city proper (but still within the city walls). Geophysical survey has not been undertaken on this area and little was identified in the walk-over survey apart from the ceramic sherds. The levels of all significant elements fluctuated around normal 'background' levels in this area.

Overall, the significant contrast in phosphorus and potassium levels between the settled urban area, on the one hand and the transient farmstead and kiln sites, on the other, clearly demonstrates the ability of the technique to locate the accumulated pollution associated with domestic activities, such as food preparation and waste disposal, at significant and enduring residential areas and to distinguish them from industrial kiln sites and also from the transient activities associated with temporary structures and low impact settlements. The precise mechanism by which archaeological pollution is formed, accumulated and retained within the soil matrices of archaeological and ethnographic sites remains rather poorly understood. The impact of the mixed composting of waste from different sources – kitchen, hearth, sewage and industrial – may result in a composite material that is more retentive of its individual chemical components. It is only through the integration of similar work undertaken on archaeological and ethnographic sites that the complex issues of waste may be addressed.

Conclusion

The main strengths of the approach outlined include the significant time and cost savings apparent through the use of such methods and the ability to inform either sampling or even excavation strategy 'on the fly'. The instant availability of results means that decisions concerning sampling resolution or allied programs of investigation, i.e. coring and field walking, can be informed by the results of geochemical survey. This contrasts starkly with conventional laboratory-based studies where project coordinators would have to wait months or even years for the results of such geochemical studies. Ultimately, the implementation of such techniques into field programs means that strategic decisions such as the allocation of personnel and resources can be better informed which should result in an enhanced understanding and management of the archaeological resource.

Weaknesses demonstrated over the course of the work are that whilst the use of pXRF was found to be well suited to the environmental conditions in and around Sikyon, this need not be the case for all projects. The relatively open areas of mixed agriculture and scrub or *maquis* facilitated access, visibility and use.

Whilst pXRF using cored samples is likely to be possible in any area suitable for geophysics, certain conditions can significantly impede progress. Particularly gritty soils or soils containing sharp inclusions threaten the delicate window of the instrument and therefore can hinder survey. Equally, waterlogged areas or areas with significant and particularly dense vegetation are not ideal for on-site analysis. Mitigating strategies, such as retrieving samples for analysis in a field shelter, are possible but again at the expense of slowing up survey and hence compromising either survey area or sample resolution.

The approach taken demonstrates the ability to readily integrate a geochemical analysis method, using the pXRF analysis of soil cores, with established geophysical and walk-over survey approaches to landscape surveys. This highlights the potential to undertake both more extensive and intensive applications to locate areas of 'pollution' and to subsequently resolve domestic and craft industrial activities. Work clearly remains to be done, both to develop the analytical techniques so as to be able to investigate more fully the nature of the 'pollution', and to develop approaches to understanding perceptions of waste processing and disposal in ethnographic settings, so as to understand the potential formation processes that may lead to the pollution of settlements and sites.

B. Derham
Department of Archaeology, University of Glasgow
b.derham@archaeology.arts.gla.ac.uk

R. Doonan
Department of Archaeology, University of Sheffield
r.doonan@sheffield.ac.uk

Y. Lolos
Department of History, Archaeology and Social Anthropology, University of Thessaly
ylolos@otenet.gr

Apostolos Sarris
Laboratory of Geophysical – Satellite Remote Sensing & Archaeo-environment (FORTH-I.M.S.), Institute for Mediterranean Studies, Rethymnon
asaris@ret.forthnet.gr

Richard Jones
Department of Archaeology, University of Glasgow
r.jones@archaeology.arts.gla.ac.uk

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