Archaeologia Polona, vol. 53: 2015, 417-546
PL ISSN 0066-5924

Integrated prospection approaches

Going over old ground: what can landscape-scale magnetic susceptibility data do for me?

Kayt Armstrong[a], Martijn van Leusen[a] and Wieke de Neef[a]

KEY-WORDS: magnetic susceptibility, scale, landscape, Italy, prehistory

This paper presents work carried out in the "Rural Life in Protohistoric Italy" project (funded by NWO Grant No. 360-61-010), following from pilot magnetic susceptibility (MS) studies conducted in our research area in northern Calabria and published last year (Van Leusen *et al.* 2014). We will explore the integration of magnetic susceptibility data from a variety of methods and scales with other geophysical datasets and with fieldwalking data, and examine how our research has identified gaps in the current understanding of the relationships between soil and site formation processes, magnetic susceptibility changes and the magnetic anomalies these give rise to.

One of the specific goals of the geophysical research within this project has been to develop an effective site detection methodology using MS, to be employed alongside teams engaged in extensive and intensive fieldwalking. This is intended to mitigate against poor visibility conditions that adversely affect protohistoric pottery scatters (and therefore the discovery of sites from that period). We have, as presented elsewhere (Armstrong *et al.* 2012; Armstrong 2013; Armstrong *et al.* 2013), also employed other geophysical techniques in our studies of these small rural prehistoric sites, and this has prompted a new set of questions: What gives rise to the anomalies seen in our gradiometer data? How can seemingly disparate subsurface remains give rise to similar anomaly shapes and intensities? And how can the identification of more amorphous archaeological anomalies be improved in comparison with results issuing from geological or pedological examination? These research issues are being examined within our project using MS measurements at varied scales.

The MS work has been undertaken using EM38 measurements, and measurements using the Bartington MS3 system, with a variety of sensors. This has allowed an exploration of different scales and methodologies, from detailed 1 m or 2 m gridded surveys using the EM38 and the

[a] Groningen Institute of Archaeology, Groningen, the Netherlands

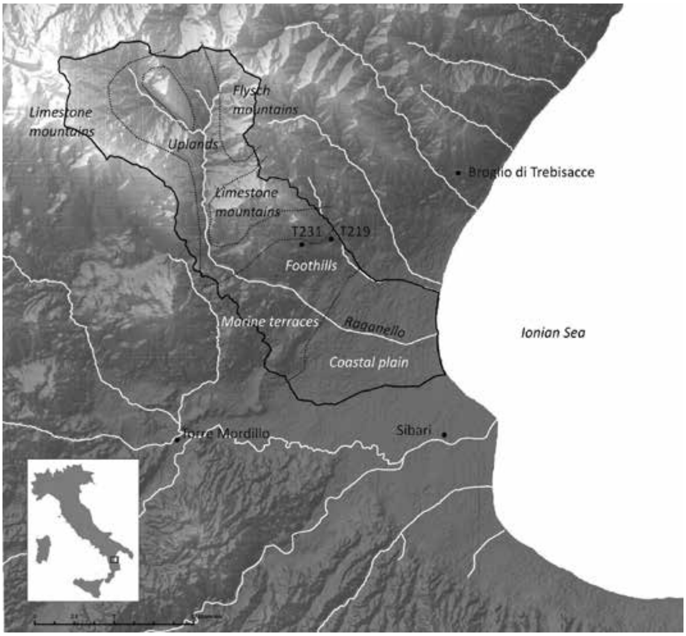

Fig. 1. Research area in northern Calabria showing the major landscape zones mentioned in the text and important local Bronze Age sites

MS3 with D loop, to measurements on sections and samples from contexts, sections and cores, high resolution downhole logs of corings, and in large scale 'transects' of data obtained across landscape units using both the EM38 and the MS3 D loop, with GPS for location.

Measurements made with the MS3 B sensor allowed us to explore the frequency dependency of soil layers and contexts, both from archaeological sites and from 'typical' soil profiles across our varied study region (see Fig. 1). It is of key importance to the presentation that our research involves the investigation of a whole landscape. The nature of that landscape (steep terrain, small fragmented terraces, much of the land not under cultivation) means that a mosaic survey strategy has to be adopted, with multiple small surveys covering available tracts of land. The large number of possible sites (155+) has also necessitated a sampling-based approach, using a site classification scheme, where 'typical' sites of each type are investigated and inferences are made to the rest of the class. This means in turn that geophysical data (primarily using magnetic techniques) come from a large variety of parent geologies and pedologies within the study region. This includes '*terra rossa*'-type soils on the marine terraces, calcareous soils on hard limestone parents and on gravel cones and conglomerates in the foothills, and marls, flysch, mudstones and schists in a dynamic upland valley. The comparative nature of our approach requires that we understand the background magnetic characteristics of these different landscapes in order to be able to make a reasonable judgement about what an 'archaeological anomaly' looks like in each environment, and whether, despite apparent differences in geophysical manifestation, they might represent similar archaeological features and behaviours.

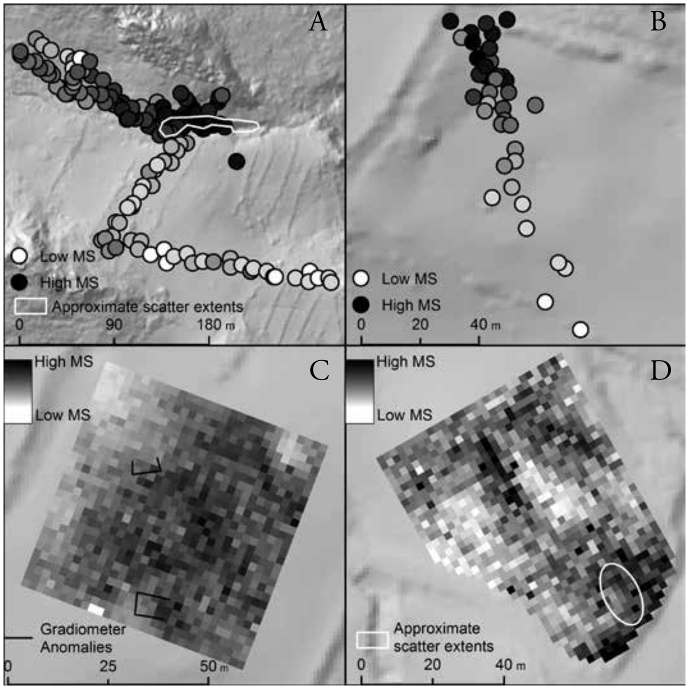

Fig. 2: Top row: 'Dense transect' approach applied on sites with strong 'on site' MS enhancement, A (top left) – Terra Masseta, multi-period site at base of a limestone cliff, showing no associated rectangular structures; B (top right) – Site T50 in the foothils, showing a pottery scatter. Bottom row: C (bottom left) – Site T94, upslope from T50, with pottery scatter but no apparent MS enhancement associated with it, and D (bottom right) – Site T73 in an upland valley, demonstrating clear MS differences not associated with the known pottery scatter; both C and D surveyed using a 2m grid

For example, a 'high MS' result on the marine terraces looks really rather different than on the gravel fans of the undulating foothills. Fractional conversion testing (Crowther 2003) was tested as a way to quantify these different degrees of enhanceability.

In this particular environment, the MS variations that occur due to soil differences were found to occur at similar scales and magnitudes as 'on site' MS enhancements that otherwise might help to verify the results of fieldwalking. When operating at 1 m grid resolutions, we could see some correspondence with gradiometer and total field anomalies, and this has helped to interpret the type and extent of the features giving rise to them. However, this gridded survey method is too time consuming to be undertaken alongside fieldwalking. A 'dense transect' approach, using the MS3 with a D-loop and logging GPS positions, has had some strong results on certain site-types, where strong MS enhancement has been seen in close correspondence with surface pottery and other archaeological material (Figs 2: A, 2: B), but this has not been the case everywhere in the landscape: there are ceramic scatters that occur without any strong local MS signal (2: C) and scatters where any possible signal is lost in 'noise' of a general variation (2: D).

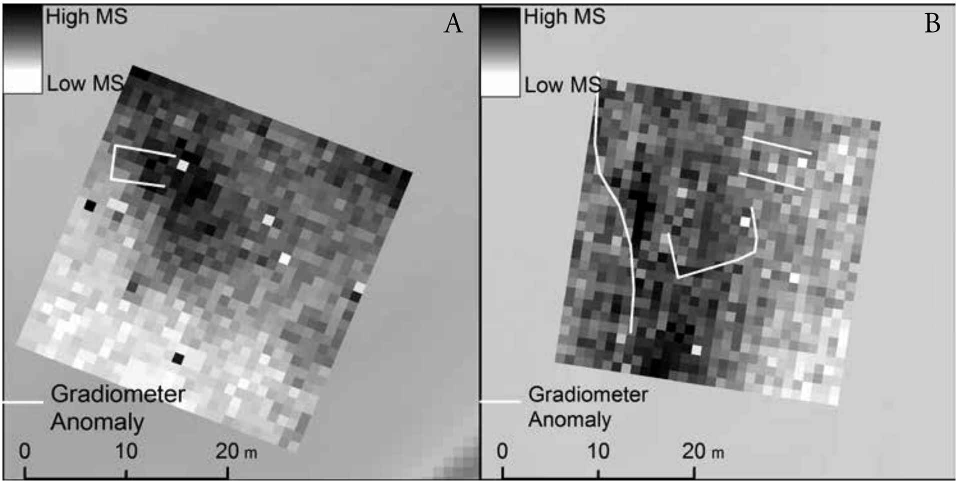

Fig. 3: Left (A), 1 m gridded survey over a gradiometer anomaly later excavated and shown to be an FBA hut, site T231. Right, (B), 1 m gridded survey over three gradiometer anomalies at site T219: a sinuous anomaly at west can be observed in the MS results, but not so the two rectangular anomalies under the northwestern part of the survey

The same mixed picture derives from gradiometer data on our sites. Very strong anomalies of varying rectangular forms have been registered throughout the foothill zone in the study region. These rectangular buildings, dated from the Late Bronze Age, exhibit very strong magnetic gradients, suggesting a thermoremnant component to the signal (Armstrong *et al.* 2012). The 1 m to 2 m resolution detailed MS surface occasionally shows an increase in the immediate location of these buildings (Fig. 3: A), but not always (Fig. 3: B), and furthermore, there is generally no wider 'halo' of magnetic enhancement that can be detected reliably with broader scale measurements (see Fig. 2). Indeed, the sites that the 'dense transect' method succeeded in identifying did not contain these rectangular structures as gradiometer anomalies. Forward modelling work has been implemented in order to examine the relationships between magnetic susceptibilities (of archaeological features and contexts, and surrounding natural soils) and the anomalies that they generate (Schmidt *et al.* 2014) to better understand the processes operating here.

Returning to our research goals, we still do not have a useable site-detection methodology. This is an interesting outcome, because it overturns a widely-held assumption in archaeological geophysics that most archaeological (habitation) sites, on most soils, will produce a detectable MS enhancement. We can, however, place our sites within their landscape context, in magnetic terms, and so make comparisons across different soil types. Our ongoing forward modelling research should help us to understand better the relationship between the MS properties, soils and gradiometer responses, but this is far from straightforward. Our studies suggests that new, fundamental research is needed into MS variations, soil properties and archaeological sites: we have opened Pandora's box, but have shown hopefully that a careful examination of these issues leads to new insights as much as new questions.

REFERENCES

Armstrong, K. 2013. Walking before you run: Geophysical explorations of Rural Life in Italian Protohistory. *19th Annual European Association of Archaeologists Meeting, 4-8th September 2013, Pilsen, Czech Republic.*

Armstrong, K., de Neef, W. and van Leusen, M. 2012. The Rural Life in Protohistoric Italy project (2010-2015): Early Results. *18th Annual Meeting of the European Association of Archaeologists*, *Helsinki, 29th August to 2nd September 2012.*

Armstrong, K., de Neef, W. and van Leusen, M. 2013. The many scales of Rural Life in Protohistoric Italy. In W. Neubauer, I Trinks, R.B. Salisbury, C. Einwögerer (eds), *Archaeological. Prospection. Proceedings of the 10th International Conference on Archaeological Prospection, Vienna, ,May 29 – June 2,* 227-229

Crowther, J. 2003. Potential Magnetic Susceptibility and Fractional Conversion Studies of Archaeological Soils and Sediments. *Archaeometry* 45 (4): 685–701.

Schmidt, A., Armstrong, K., de Neef, W. and van Leusen, M. 2014. Model-based inversion of magnetometer data in support of archaeological interpretation: the Raganello Archaeological Project. *Recent Work in Archaeological Geophysics, London, 2nd December 2014.*

Van Leusen P. M., Kattenberg, A. and Armstrong, K. 2014. Magnetic Susceptibility Detection of Small Protohistoric Sites in the Raganello Basin, Calabria (Italy). *Archaeological Prospection* 21 (4): 245–53.