Magnetic Susceptibility Detection of Small Protohistoric Sites in the Raganello Basin, Calabria (Italy)

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ABSTRACT This paper presents pilot geophysical investigations carried out in 2005–2006 by the Groningen Institute of Archaeology in northern Calabria, Italy. The aim of this work was to find out if and how surface magnetic susceptibility (MS) measurements might be of use to correct significant visibility biases in the results of earlier large-scale systematic and intensive field-walking, in particular for unobtrusive rural protohistoric sites. It was found that MS yields encouraging results under specific geopedological conditions, but that a better understanding of post-depositional site histories and large-scale geomorphology-driven MS variations is needed before an effective MS-based detection protocol in support of large-scale field-walking can be developed; follow-on studies are now being conducted by the authors to this end. Copyright © 2014 John Wiley & Sons, Ltd.

Key words: magnetic susceptibility; survey protocols; Geonics EM38; Bartington MS2; field-walking survey

Introduction

This paper presents pilot geophysical investigations that form part of a programme of archaeological methodological studies carried out since 2005 in the basin of the Raganello River in northern Calabria (Italy) by the University of Groningen (The Netherlands). It sets out how the findings are being used to help design and implement new research approaches to the region’s rural settlement and land use in the protohistoric era – the Bronze and early Iron Ages – and briefly describes research challenges. In order to understand the significance of these experiments, a brief research history will be given.

The Institute of Archaeology at the University of Groningen (GIA) has been conducting excavations at the Timpone della Motta of Francavilla Marittima, a key site for the Iron Age/Greek colonial transition in the Sybaris coastal plain in northern Calabria, since 1991. Exploratory field-walking surveys starting in 1995 were put on a more systematic footing from 2000 onwards, and by 2009 had been extended to cover the mountainous hinterland of the basin of the Raganello River (Attema et al., 2010; see Figure 1). To date, the academic debate about the pre-colonial period has been characterized by reliance on data from excavations at a few large ‘central’ sites, with inferences made out into the hinterlands based on core/periphery and territorial models (see Peroni and Trucco, 1994; Trucco and Vagnetti, 2001). Focusing on the rural settlement and economic structure of the protohistoric period, the Raganello Archaeological Project (RAP) intensive surveys by 2009 covered about 13 km² and demonstrated the presence of large numbers of small pottery scatters, occurring in clusters in the uplands and highlands. A catalogue of RAP sites and finds is currently being prepared for publication by one of us (Van Leusen); a synthesis of research to 2008 is given in Attema et al. (2010). These protohistoric sites typically consist of low-fired domestic pottery sherds called impasto, and well-fired storage vessels called dolia; infrequently, instances of burned hut-loam and structural clay may occur but building technologies of the period did not include the high-fired tiles and bricks that characterize the Hellenistic and later periods.

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In the course of the RAP surveys it became increasingly clear that the *prima facie* result (the archaeological map) was going to be severely biased by natural and anthropogenic post-depositional processes as well as by research and discovery biases. All of these tend to act more strongly on the older (i.e., protohistoric) remains, as slope processes and tillage have had longer to act on them and pottery therefore tends to be buried more deeply or suffer more plough damage; moreover, the low-fired and reduced fabrics, muted colours and high fragmentation make this pottery hard to detect by survey teams under less than ideal conditions. These processes and biases became the object of a separate methodological study, as part of which the problem of detection was tackled (Attema *et al.*, 2010, pp. 19–25; H. Feiken, 2014). If even systematic and intensive field-walking does not result in a reliable map of the region’s surface archaeology, can we perhaps produce a less biased map by using geophysics and remote sensing as complementary detection methods? Furthermore, which of the available methods would be the most efficient and effective at detecting non-obvious archaeological remains?

Although early and influential geophysical surveys were carried out in the coastal plain in the mid-twentieth century to locate the famed Greek city of Sybaris (Lerici, 1960), there have been no further published archaeogeophysical surveys in northern Calabria. For the wider Mediterranean, Sarris and Jones’ (2000) excellent summary cautions that the environment creates significant constraints to geophysical survey, due to the dryness, steep terrain and small-scale field-systems affected by agricultural terracing. They identify the same bias towards accessible coastal plains, urban or proto-urban sites, and the later archaeological periods that has also been described in recent work on field-walking surveys (e.g. contributions in Van Leusen *et al.*, 2011). This bias produces a serious lacuna: with the single exception of the Ave Valley survey in Portugal in the late 1990s (Millett *et al.*, 2000) integrated published studies of field-walking and geophysical data to explore rural settlement landscapes are lacking. There are good examples of such integrated studies of urban sites, both large and small, in the Mediterranean (see the examples presented in Johnson and Millett, 2012), but these present very different geophysical challenges.

Thus, pilot geophysical studies were needed to establish the potential of various techniques to improve detection of unobtrusive protohistoric sites under various topographical and geological conditions. In particular, the aim was to develop a rapid, low-resolution survey method able to distinguish magnetically enhanced patches of soil (such as might be expected if habitation layers were being ploughed up) from general geological background values, and magnetic susceptibility (MS) survey was thought to be the most effective method for this (Thompson and Oldfield, 1986; Clark, 1996; Dalan and Banerjee, 1998; Gaffney and Gater, 2003). Accordingly, in 2005–2006 a series of pilot investigations were carried out by two of the authors (Kattenberg and Van Leusen). Key questions centred on the ease and speed of surveys, the maximum line and sample spacing needed to reliably detect enhanced areas, and the spatial correlation between geophysical anomalies and surface ceramic sites.

**The 2005–2006 magnetic susceptibility pilot work**

As the aim of the pilot studies was to use MS contrasts as a site-detection method in areas of reduced
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visibility, and to develop a protocol for employing this alongside field-walking surveys, in 2005 a series of soil samples were collected on and around known ceramic surface sites, and additionally in a number of off-site locations covering different landscape types in order to establish typical background values and variability. Natural and cultural materials such as limestone blocks and impasto pottery were also sampled. The sampling method was to take transects across surface pottery concentrations, starting and ending well away from the first and last observed sherds, hence providing clear on/off site distinctions. Sets of samples taken over four sites in three different types of landscape (foothills, uplands and marine terraces; see Figure 1 for locations and Tables 1 and 2 for sample properties) were measured using an Agico KLY-2 Kappabridge. This is a low-frequency-only instrument, and the samples were measured as collected in the field rather than as a sieved fine fraction. Three of the transects showed a clear on-site increase in MS, while the fourth, from the marine terraces, did not. Due to location problems, it is possible that the sampling transect in this case did not, in fact, intersect the intended finds spots, but the non-detection could also be explained in other ways: (i) the soils at these locations might never have acquired MS enhancement; (ii) the enhancement was subsequently lost during post-depositional processes; or (iii) the MS signal from the archaeological deposits was swamped by larger variances in the background or geological signal.

Having established that discernible MS contrasts exist between at least some protohistoric ceramic sites and their surroundings, in the following season (2006) a series of trial MS field surveys (using a Bartington MS2 meter with the D sensor and a Geonics EM38B) were conducted in varying combinations on seven sites in three different landscape units (see Table 2 and Figure 1). Two of these had previously been sampled for laboratory measurements. The EM38B was selected as it can log the MS in continuous mode for rapid walkover surveys, but also because it can simultaneously measure the conductivity of the same volume of soil, thus in theory negating the need for separate electrical surveys. Although Benech and Marmet (1999) and Gaffney (2008) caution that the conductivity of the soil produces a potentially significant effect on the in-phase response in any type of EMI instrument, we found, as with Cole et al. (1995) and De Smedt et al. (2013), that the EM38 qudrature and in-phase responses are well differentiated in our dataset. Within the context of our pilot study and ongoing work in southern Italy, the in-phase response can therefore be taken to reflect magnetic susceptibility.

The work focused on searching for the MS enhancements that should be associated with the ploughed-up soil in and around archaeological finds scattered recorded during previous field-walking. The dimensions of these scatters were used to work out a theoretical maximum allowable sampling interval needed to locate the associated magnetic anomaly, using a variation on the ‘Law of Definite Detection’ (Banning, 2002, p. 57). The two instruments were compared with each other on five of the seven sites (see Table 2). The EM38 was used in ‘continuous’ mode with global positioning system (GPS) track logging, and set to 1 reading s⁻¹, which gives an in-line sampling interval of roughly 0.4–0.6 m depending on the terrain. Lines and tapes were used to help the operator achieve the desired coverage, which varied from site to site. The EM38 tracks were then interpolated using a cubic spline in Archaeosurveyor, taking the mean of the values where two tracks overlap (track widths were set to twice the line spacing plus 1 m). Both the in-phase (related to magnetic susceptibility) and the quadrature-phase (a measurement of conductivity) responses were recorded. The MS2 data, by contrast, were obtained on conventional grids, within local measurement systems in which the absolute position was known only to an accuracy of about 5 m because single-receiver handheld GPS units were used (Ryan and Van Leusen, 2002, pp. 405–406 and fig. 6). Measurements with the Bartington MS2 were made using their ‘D’ field-loop sensor and recorded by hand from its digital read-out. The specific parameters of each survey, and any processing applied to the results, are given with each figure.

The landscape unit ‘undulating sloping land’ (USL) occurs both in the foothill zone (up to 400 m a.s.l.) and in the highlands (400–1000 m a.s.l.). The underlying geology consists of Plio-Pleistocene fan-delta deposits derived from a limestone/fliesch hinterland, uplifted and reworked by marine incursions and by the Raganello, Caldana and Sciarapottolo rivers. Within the foothill USL, used for arable and olive farming, two sites were surveyed. At site T58 there was good agreement between the observed ceramic site and the plotted MS2D surface data (see Figure 2). This also coincided with a visible on/off site difference in soil colour. Some correlation between the in-phase EM38 data and the MS2D data is apparent at this site, but the extents of the two areas of enhancement differ. This could be due to problems with the accurate georeferencing of the EM data, or to the different depth of investigation (for extensive discussion and comparison see Benech and Marmet, 1999) of the two instruments. The MS2D ‘loop’ sensor examines the top 5–6 cm of the soil over a 15 cm diameter area, whereas the EM38 examines a
Table 1. MS values from samples taken in 2005. The measurements were made using an Agico KLY-2 Kappabridge, and have been adjusted for weight; the values are expressed in m$^3$ kg$^{-1}$.

| Site     | Sample number | Note                                             | MS $\times 10^{-3}$ m$^3$ kg$^{-1}$ | Site     | Sample number | Note                                             | MS $\times 10^{-3}$ m$^3$ kg$^{-1}$ |
|----------|----------------|--------------------------------------------------|------------------------------------|----------|----------------|--------------------------------------------------|------------------------------------|
| T58      | HL5-12.01      | Very eroded slope, should be subsoil             | 18.67                              | T18 (marine terraces) | HL5-13.08 | Off site                                    | 96.54                              |
|          | HL5-12.02      | Top of slope                                     | 29.71                              |          | HL5-13.09      | Off site                                    | 85.58                              |
|          | HL5-12.03      | -                                                | 32.83                              |          | HL5-13.10      | Off site                                    | 75.22                              |
|          | HL5-12.04      | Bottom of slope                                  | 63.89                              |          | HL5-13.11      | Off site                                    | 68.51                              |
|          | HL5-12.05      | From deflated zone just below terrace            | 45.79                              |          | HL5-13.12      | Off site                                    | 47.44                              |
|          | HL5-12.06      | Site core                                        | 46.28                              |          | HL5-13.13      | Off site                                    | 54                                 |
|          | HL5-12.07      | Site core                                        | 30.47                              | T16 (marine terraces) | HL5-13.14 | On site                                    | 58.13                              |
|          | HL5-12.08      | Lower site halo                                  | 27.42                              |          | HL5-13.15      | On site                                    | 55.05                              |
|          | HL5-12.09      | Lower site halo                                  | 29.27                              |          | HL5-13.16      | On site                                    | 84.4                               |
|          | HL5-12.10      | Centre of lower field (some finds)               | 37.73                              |          | HL5-13.17      | On site                                    | 71.29                              |
|          | HL5-12.11      | Centre of lower field (some finds)               | 44.11                              |          | HL5-13.18      | On site                                    | 51.63                              |
|          | HL5-12.12      | Top of plough bank (original surface?)           | 17.69                              |          | HL5-13.19      | Off site                                    | 37.85                              |
|          | HL5-12.13      | Bottom of plough bank, approximately 30cm        | 13.47                              |          |                |                                                  |                                    |
|          | HL5-12.14      | Eastern part of site                             | 40.76                              | T115     | HL5-11.01      | On site                                    | 294.05                             |
|          | HL5-12.15      | Centre of site                                  | 51.64                              |          | HL5-11.02      | On site                                    | 302.42                             |
|          | HL5-12.16      | Western part of site                             | 35.91                              |          | HL5-11.03      | On site                                    | 321.73                             |
|          | HL5-12.17      | Western site halo                               | 15.1                               |          | HL5-11.04      | On site                                    | 267.46                             |
|          | HL5-12.18      | Outside western edge of site                    | 19.27                              |          | HL5-11.05      | On site                                    | 181.74                             |
|          | HL5-12.19      | Impasto sherd from site core                     | 103.52                             |          | HL5-11.06      | On site                                    | 134.95                             |
|          | HL5-14.01      | Layer 1: topsoil                                | 163.52                             |          | HL5-11.07      | On site                                    | 201.50                             |
|          | HL5-14.02      | Layer 2a: this layer is slightly cleaner than layer 2b (0.15 m deep) | 125.52 |          | HL5-11.08 | On site                                    | 183.71                             |
|          | HL5-14.03      | Layer 2b: disturbed layer with some charcoal, frequent stones and some pottery (0.2 m deep) | 122.46 |          | HL5-11.09      | On site?                                   | 85.14                              |
|          | HL5-14.04      | Layer 3: layer with charcoal and pottery         | 166.23                             |          | HL5-11.10      | On site?                                   | 80.24                              |
|          | HL5-14.05      | Layer 4: yellow clay, undisturbed subsoil        | 20.71                              |          | HL5-11.11      | Off site                                    | 68.50                              |
|          | HL5-13.01      | From presumed core of site                       | 80.54                              |          | HL5-11.12      | Off site                                    | 60.07                              |
|          | HL5-13.02      | 20 m north of sample 13.01 (on site?)            | 145.03                             |          | HL5-11.13      | Off site                                    | 59.97                              |
|          | HL5-13.03      | 10 m north of sample 13.01 (on site?)            | 116.03                             |          | HL5-11.14      | Off site                                    | 37.88                              |
|          | HL5-13.04      | 10 m south of sample 13.01 (on site?)            | 77.69                              |          | HL5-11.15      | Off site                                    | 144.00                             |
|          | HL5-13.05      | 20 m south of sample 13.01 (on site?)            | 57.14                              |          | HL5-11.16      | Local schist                                | 6.84                               |
|          | HL5-13.06      | Off site                                        | 62.8                               |          | HL5-11.17      | Local limestone                             | 0.44                               |
|          | HL5-13.07      | Off site                                        | 66.16                              |          |                |                                                  |                                    |
roughly 1-m cube of soil, with a maximum response in vertical mode at about 0.4 m below the instrument. In horizontal mode it is most sensitive to MS properties at the surface, but still measures a larger volume of soil than does the MS2D. This is in agreement with recent work by De Smedt et al. (2013), which concluded that ‘sharper’ contrasts can be obtained with the Bartington field-loop than with Slingram-type EMI instruments.

![Image of site surveys and results](image-url)

**Table 2. Summary of surveys and results.**

| Site                        | RAP site number | Geomorphological unit | MS test on soil sample | Soil tests: colour, carbonate content, PSD | MS2D | EM38 |
|-----------------------------|-----------------|-----------------------|------------------------|---------------------------------------------|------|------|
| Terra Masseta               | T115            | USL (mountains)       | Y (HL5-11)             | n/a                                         | n/a  | n/a  |
| Pietra Catania/4120         | T58             | USL (foothills)       | Y (HL5-12)             | N                                           | Y    | Y~   |
| Darnale/4012                | T50             | USL (foothills)       | Y (HL5-14)             | n/a                                         | Y    | Y~   |
| Macchiabate                 | T9a             | USL (foothills)       | n/a                    | n/a                                         | ~    | n/a  |
| Fonte di Maddalena/5104     | T72             | USL (mountains)       | n/a                    | Y                                           | N    | Y    |
| Michele’s Gully             | T177b           | USL (mountains)       | n/a                    | n/a                                         | Y    | N~   |
| Demanio                     | –               | USL (hilltop)         | n/a                    | n/a                                         | Interference | Interference |
| Lauropoli                   | T16-T18         | Marine terraces       | N                      | n/a                                         | N/a  | N/a  |
| Azienda la Silva            | –               | Marine terraces       | n/a                    | n/a                                         | N/a  | N/a  |

n/a, technique not applied; Y, surface increase identified co-located with ceramic site; N, no enhancement that could be linked to ceramic site; ~, uncertainty in detection – see specific site discussion.

**Figure 2.** (Top left) Site T50, despiked and low-pass filtered MS2D data surveyed at 1 m × 1 m, plot clipped to ±3 SD. (Top right) Site T50, EM38 (vertical) in-phase data surveyed with 1 m line spacing and interpolated with a 3 m track width, plot clipped to ±3 SD. (Bottom left) Site T58, despiked and low-pass filtered MS2D data surveyed at 1 m × 1 m, plot clipped to ±2 SD. (Bottom right) Site T58, EM38 (vertical) in-phase data surveyed with 1 m line spacing and interpolated with a 3 m track width, plot clipped to ±3 SD. Surface ceramic scatters outlined in white. All plots shown over hillshade and 1 m contours derived from a 1 m resolution airborne LiDAR dataset collected in 2008. (Source: EUFAR/VITO.) This figure is available in colour online at wileyonlinelibrary.com/journal/arp
At site T50, the EM38 in-phase data also show MS enhancement in roughly the same location as the enhancement in the MS2D surveys and the distribution of surface finds (see Figure 2), but other variations in the MS response appear to be related to topography and topsoil thickness. The EM38 conductivity results largely reflect topography and superficial geology, especially in the more clayey areas where the induced fields rapidly attenuate, and so are not depicted.

Within the highland USL we investigated two more sites in an area of predominantly arable farming on shale-derived marls, located along the base of a large limestone bluff. The MS2D survey over the small but clearly defined ceramic scatter T177b produced an anomaly (see Figure 3); at site T72 the MS2D data also matched well with the observed pottery scatter. Again the in-phase data from both horizontal and vertical EM surveys produced anomalies in roughly the same locations but of different size and shape. The rough agreement between the horizontal and vertical data plots suggests that the source of the anomaly is at about 0.4 m deep, which tallies well with the mean depth of the plough layer, 0.3 m.

More widely spaced ‘rapid’ surveys were undertaken in this same landscape unit to test if the observed local MS enhancement associated with archaeological sites would also stand out against geologically driven MS variations across the landscape. We operated the EM38 in ‘continuous’ mode, logging GPS positions, with an approximate transect spacing of 4 m. The resulting data plots (see Figure 3) indicate that the local on/off site variation is much smaller than that related to the geomorphology of the wider landscape.

The 2005 Kappabridge measurements (see Table 1) show an absolute variation of $13.47 \times 10^{-8} \text{m}^3 \text{kg}^{-1}$ to $321.73 \times 10^{-8} \text{m}^3 \text{kg}^{-1}$ across all samples, whereas the range of the assumed ‘off site’ samples is $13.47 \times 10^{-8} \text{m}^3 \text{kg}^{-1}$ to $144.00 \times 10^{-8} \text{m}^3 \text{kg}^{-1}$. Although smaller, this is still significant and obscures many of the on- versus off-site MS differences, which vary from site to site with an observed minimum of $45.55 \times 10^{-8} \text{m}^3 \text{kg}^{-1}$ (site T16) and a maximum of $283.85 \times 10^{-8} \text{m}^3 \text{kg}^{-1}$ (site T115). The variability in background MS over short distances at times varies more than individual sites differ from their local backgrounds, confirming our suspicions that complex geology in some landscape types results in signal-to-noise problems that complicate the development of MS survey protocols. Further tests are currently being conducted to explore these geomorphological variations and how they might be distinguished from anthropogenic anomalies.

A final gridded MS2D survey was conducted over a cluster of pottery scatters in the third landscape unit, that of the ‘marine terraces’ to the south of the Raganello River, at Azienda la Silva. Here, the surface scatters investigated showed no association at all with the observed strong differences in surface MS. These are therefore likely to be related to the geology and pedology rather than to any archaeology, although it is also possible that the post-depositional history of this landscape unit was significantly different from that of the other units.

**Discussion**

In all tests in the lowland and highland USL landscape units, the MS2D surveys produced close matches to the ceramic surveys, so the potential for detecting anthropogenic MS peaks in these landscapes exists; in the landscape of the marine terraces, however, the variations produced by geology appear to swamp those produced by surface archaeology. The EM38 in-phase data were less easy to interpret, showing good correlation with the ceramic sites in the foothills but not with those in the mountains. Furthermore, when the spatial scale of the EM38 survey in the mountains was expanded, the on-site contrast previously observed was lost in background variation. From the 2006 work we therefore concluded that, as a technique to use alongside field-walking in areas of poor visibility, the MS2D was preferable to the EM38 because it is well suited to locating disturbed (ploughed-up or eroded) material at the surface. This differs from the conclusions of Cole et al. (1995) and De Smedt et al. (2013), who found that a 1 m EMI instrument using horizontal co-planar coil geometry is well suited to finding even small MS contrasts in their particular landscape types, and also from those of Benech and Marmet (1999), who preferred the EM38 because of its greater depth of investigation. Although these are valid considerations, for our purposes (a rapid evaluation method that can be used by non-specialists in typical Mediterranean landscape types) the MS meter with the field-loop sensor is a better tool for detecting MS-enhanced soils at the surface in areas of poor ceramic visibility. Furthermore, the greater sensitivity of the Bartington field-loop to small-scale MS changes is in fact a favourable property when trying to identify small and weakly differentiated patches of MS enhancement. Table 3 shows the calculated maximum grid spacings that would theoretically ensure detection of anomalously high or low patches of surface MS; in practice, we propose to adopt a resolution of $2 \times 2$ m to take into account the possibility of poor readings and to obtain a better picture of localized variability. However, MS surface surveys can
only help where altered soil is at the surface, irrespective of whether this is caused by ploughing, erosion or other processes. The combination of MS2D and field-walking survey will therefore still not reveal any buried sites in parts of the landscape that are not cultivated at the time of the survey.
A subsidiary goal of the pilots was to establish the lowest spatial resolution that would still result in reliable surface MS detection of small rural sites. Our work indicates that a 3-m resolution would theoretically suffice, but that in practice a safer 2-m should be employed. As this approximately doubles the time needed for gridded surveys we intend to probe this issue further by conducting subsampling experiments on high-resolution gridded data sets.

The tests discussed here showed that a more precise and robust location method would be needed for these methodological studies than was available in the 2006 field season. This is a challenge when working in mountainous terrain where GPRS reception and SmartNet GNSS coverage is poor, and where different teams have used different hardware and software. We decided to employ dGPS services, with an accuracy measurable in centimetres, to fix all local measurement systems. We further found that survey systems that require a gridded approach are wasteful and time-consuming when applied to the small and irregularly shaped fields typical of much of the Mediterranean landscape. Developing the ability to collect ‘free-form’ geophysical data based on the concurrent recording of dGPS locations will be essential to the efficiency of future surveys in the Mediterranean.

The 2005–2006 pilots in northern Calabria have been followed up in 2010–2013 by a much more extensive programme of archaeogeophysical studies, involving magnetic gradiometer surveys combined with EMI (both multiple coil and single sensor), earth resistance and ground-penetrating radar, soil studies, coring and test pits. We intend to present this research, and its implications for the development of a robust and effective geophysical site detection method to complement archaeological field walking surveys in typical Mediterranean landscapes, in future publications. This effort feeds into a wider current theme in geophysical research, which is to extend geophysics into new ‘difficult’ landscapes, and away from the traditional applications in the UK, on the plains of central Europe and of classic and near-eastern urban sites. Recent publications, projects and conference discussions (Kattenberg, 2008; Beck, 2010; Sheriff and MacDonald, 2011; Schmidt et al., 2011) show a shift towards the consideration of landscapes and archaeologies that are inherently challenging for established methods, due to a lack of geophysical contrast, the topography, or the ephemeral nature of the archaeology. This is a welcome maturation of the discipline.

Conclusions

As stated in the introduction, very little is known about the rural settlement archaeology of protohistoric southern Italy. There are no examples of excavated rural sites or ground-truthed geophysical surveys for comparison, and we therefore have little idea what a Bronze Age Calabrian family farm or seasonally occupied pastoral hut should look like, let alone how it would manifest itself geophysically (if at all). The information that can be obtained by field-walking alone about the settlement history of a landscape is inherently limited and subject to systematic biases that are difficult to overcome without having recourse to other prospection techniques.

The 2005–2006 pilot surveys in northern Calabria demonstrate that there is potential to develop a detection protocol for unobtrusive archaeological sites based on surface MS variations, using the Bartington MS2 field-loop and a measurement interval of no more than 2-m. It also became clear that such an approach could be effective only in landscape types where the potentially detectable archaeological variation is not swamped by naturally occurring MS variations. However, even if MS surveying has its problems there is still an overriding need to have an alternative method for site detection in addition to field-walking. To further this line of research, the authors are currently conducting studies to explore these natural background variations.

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| Table 3. Summary of calculated minimum sampling rates. |
|--------------------------------------------------------|
| **Table**  | **T58** | **T50** | **T72** | **T177b** |
| MS2D anomaly dimensions (m)  | 6 x 7 | 10 x 20 | 4 x 15 | 4 x 6 |
| Suggested line separation for MS2D (m) | 3 | 5 | 2 | 2 |
| Suggested grid spacing for MS2D (m) | 3 x 3 | 5 x 5 | 7 x 7 | 3 x 3 |
| Number of readings per 30-m grid if surveyed at suggested resolution | 100 | 36 | 28 | 100 |
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