Archaeologia Polona, vol. 53: 2015, pp. 380-383

Larsen, J.H. 2009. *Jernvinneundersøkelser. Faglig program. Bind 2*. Oslo.
Rundberget, B. (ed.) 2007. *Jernvinna i Gråfjellområdet. Gråfjellprosjektet bind 1.* Varia 63. Oslo.
Stamnes, A.A. 2010. *Developing a Sequential Geophysical Survey Design for Norwegian Iron Age Settlements.* Unpublished MSc Thesis in Archaeological Prospection, Bradford, England.
Stenvik, L.F. 1987. Gammel jernframstilling i Trøndelag. *SPOR* (1) 1987: 4-7. Available online: (*http://www.ntnu.no/c/document_library/get_file?uuid=847ea958-8ec9-4497-ac7c-0cae165d7768&groupId=10476)* Last accessed: 10.02.2015.
Stenvik, L.F. 1996. Fra myrmalm til jern – teknologi med økonomisk overskudd. *SPOR* (1) 1996: 28-30. (*http://www.ntnu.no/c/document_library/get_file?uuid=2fd63b12-1b07-47a3-8d59-de0bbbce984f&groupId=10476)* Last accessed: 10.02.2015.
Stenvik, L.F. 2003. Recent Results from Investigations of Iron Production in Northern Europe. In L. C. Nørbach (ed.), *Prehistoric and Medieval Direct Iron Smelting in Scandinavia and Europe*, 77-82. Aarhus.
Vernon, R.W. 2004. *Application of Archaeological Geophysical Techniques to the Investigation of British Smelting Sites.* PhD thesis. Departement of Archaeological Sciences. Bradford, England.

The application of mobile metal ion (MMI) geochemistry to the definition and delineation of a Roman metal processing site, St. Algar's Farm, Somerset, United Kingdom

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MMI is a single solution, ligand-based, soil extraction geochemical technique (Mann 2010), which has been employed for more than a decade to detect and define, in exotic overburden, metal anomalies derived from buried mineral deposits. Commercially available, it is widely used in mineral exploration. It is designed to achieve dissolution of adsorbed elements, many of them metals, without significant dissolution of the substrate to which they are attached. It does not involve acid digestion and improves the peak/background ratio.

This paper presents preliminary findings of an investigation of the Roman metal and glass processing site at St. Algar's Farm (SAF) in Somerset. It describes part of a research project to evaluate the potential use of MMI geochemistry in archaeology.

Sixty three soil samples were collected from a depth of 15 cm on a 40 m x 40 m grid in May 2014. They were subjected to MMI ligand extraction and analysed for 53 elements using inductively coupled plasma spectrometry (ICPMS) at SGS laboratories in Perth, Australia.

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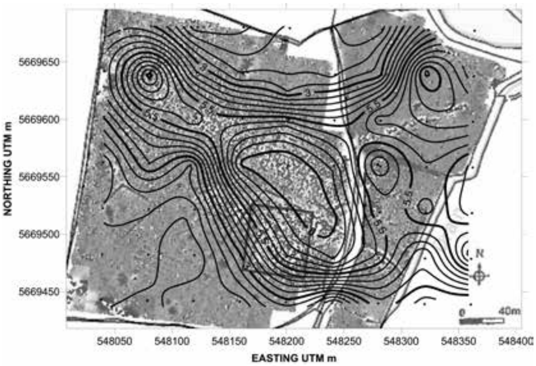

Fig. 1. St. Algar's Farm MMI Tl (ppb)

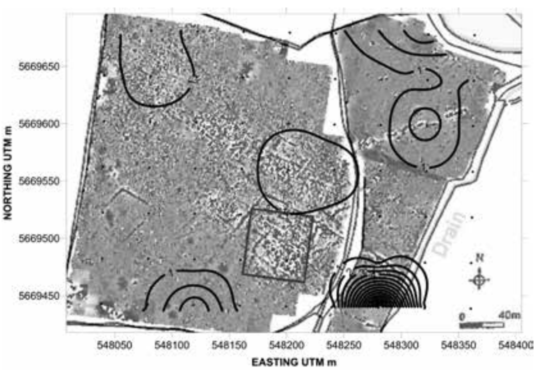

Fig. 2. St. Algar's Farm MMI Sn (ppb)

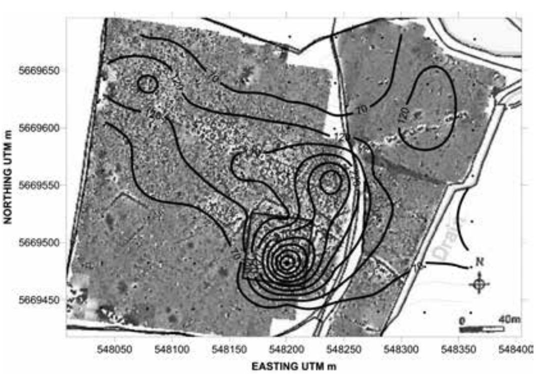

Fig. 3. St. Algar's Farm base and noble metal index

The results are compared with those obtained from a surface portable XRF (pXRF) survey (Dungworth *et al.* 2013), which provided limited data due to the inherently high lower limits of detection (compared with MMI) for very many trace elements. The MMI data are plotted (Figs 1–3) on a magnetometer survey (using a Bartington 601/2 twin fluxgate gradiometer with an automatic data logger on 1 m spaced traverses) base (Lambdin 2011), which provides an interpretation of the underlying archaeology. No surface archaeology is visible on the site, but recent limited excavations (Lambdin and Holley 2011) revealed a 1st–4th century AD winged villa, in which refining of lead and glass manufacture was undertaken. The magnetic image provides support to the excavation findings, indicating the presence of other walled structures and displaying a substantial area of disturbed magnetics around the villa considered indicative of human settlement. An interpreted trackway running from the northwest of the site through the settlement area to the villa has also been identified.

MMI data from the European GEMAS (Geochemical Mapping of Agricultural Soils) survey (Mann *et al.* 2014) are used for comparison and to determine regional elemental baseline concentrations. Statistical analysis in conjunction with visual inspection has been used to determine suites of associated elements: those which display bi- or multi-modal sample distributions and those which display elemental anomalies potentially of anthropogenic origin. Single-element classed post maps (CPM) and/or contour plots of elements of most interest have been constructed. The CPM for Pb shows a widespread distribution across the site for this element; many values are above the upper detection limit for Pb for MMI. The contour plot for Ba indicates that this element is largely coincident with Pb. It is present as gangue in the nearby Mendip Hills lead ore, the probable source of the metals processed here. Thallium (Tl) (Fig. 1) also shows a close affinity with Pb (and Ba) suggesting a common (ore) source. Fig. 2 shows the contour map for Sn. Although the number of soil samples containing anomalous Sn is limited, this element displays a different distribution range of associated elements and indicated source.

A number of elemental suites with common characteristics were identified by statistical analysis. The suite Pb, Tl, Ag, Au, Sb, Ba, (Cu), is associated with and defines the area of lead smelting operations. It overlies a lithological background moderately high in Ca, Ce and other rare earth elements. Another suite, which includes Cs, Rb, Nb, Sn, Th and Zr, occurs in a limited number of samples on the periphery of the SAF site and could be indicative of tin-bearing granite/pegmatite imported for processing.

Multi-element additive and multiplicative indices have been constructed and the distribution of the index scores plotted and contoured. This is beneficial in clearly delineating the zones of interest defined by the elemental suites. One of the most illustrative indices is the Base and Noble Metal Index: an additive index comprised of normalised (to each element's median) values for Ba, Ag, Au, Pb, Sb, Tl and Cu. This plot, shown in Fig. 3, delineates and defines the lead processing area, the human settlement area and the trackway along which the ore (from the Mendip Pb deposits) was brought. It also highlights a number of 'hotspots' particularly relating to soil anomalies for Au and Ag, which appear from the magnetometer data to be in areas of potential archaeological interest and which require further investigation.

In summary, the reconnaissance-style MMI survey has defined and characterized lead processing and other human activities and has provided much greater definition than was possible using the pXRF instrument. In addition, new areas of potential archaeological interest have been located.

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REFERENCES

Dungworth, D., Comeau, B. and Lowerre, A. 2013 St Algars , Selwood, Somerset - Geochemical Survey. *English Hertiage Technology Report* 28: 37 ff.

Lambdin, C. 2011. *St. Algar's Project Group, Geophysical Survey. St. Algar's Roman Villa*. Bath and Camerton Archaeological Society, unpublished report.

Lambdin, C. and Holley, R. 2011. *St. Algar's Project Group, St. Algar's Villa Excavation Summary*. Bath and Camerton Archaeological Society, unpublished report.

Mann, A.W. 2010. Strong versus weak digestions: ligand-based soil extraction geochemistry. *Geochemistry: Exploration, Environment, Analysis* 10(1): 17-26.

Mann, A., Reimann, C., Caritat, Pd. and Turner, N. 2014. Mobile Metal Ion Analysis of European Agricultural Soil. In C. Reimann, M. Birke, A. Demetriades, P. Filmoser and P. O'Connor (eds.), *Chemistry of Europe's agricultural soil*, Geologisches Jahrbuch B, 203-231.