Archaeologia Polona, vol. 53: 2015, pp. 311-315

Distribution of gold and silver in European soils: evidence for a Roman footprint?

Alan W. Mann[a] **and Graham C. Sylvester**[b]

KEY-WORDS: soil geochemistry, MMI, Roman gold and silver

The recently completed low-density soil geochemistry survey of Europe (approximately one sample per 2500 km^2) entitled Geochemical Mapping of Agricultural Soils (GEMAS) has produced distribution patterns for a number of elements by a number of analytical techniques (Reimann *et al.* 2014). These include XRF, aqua regia (AR) digest and Mobile Metal Ion (MMI) geochemistry. MMI is a single-solution, high-resolution, soil-extraction geochemical technique (Mann 2010), which has been employed to detect and define, in exotic overburden, metal anomalies derived from buried mineral deposits for more than a decade. Commercially available, it is widely used in mineral exploration. By preferentially accessing the recently active, mobile form of elements, it also has advantages in delineating anthropogenic soil anomalies (Mann *et al*. 2014). The technique, which utilises Inductively

[a] Geochemical Consultant, South Fremantle, Western Australia
[b] University of Western Australia, School of Earth and Environment, Australia

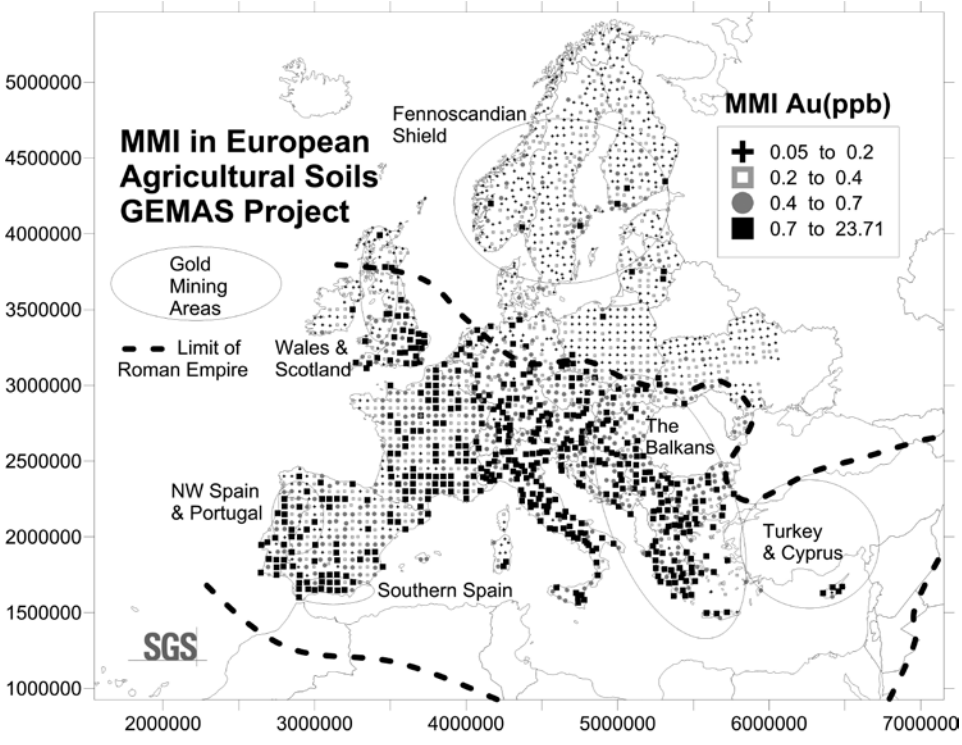

Fig. 1. Distribution of Au in European agricultural soils after MMI analysis and extraction (sample sites are depicted using MMI Au quartile symbols; there are approximately 500 samples in each quartile)

Coupled Plasma Mass Spectrometry (ICPMS) is very sensitive; it has a lower detection limit (LDL) of 0.1 part per billion (ppb) for Au and 1ppb for Ag. Gold values in soil of 0.5ppb and above (>five times LDL) are considered anomalous.

The GEMAS map with MMI Au values arranged in quartiles shows (Fig. 1) a distribution pattern in which most of the upper 25 percent of values (>0.7ppb Au) depicted by large black squares is located in the southern half of Europe. With few exceptions they lie south of the northern limit of the extent of the Roman Empire, shown as a dotted line in Fig. 1. Values to the north of the northern limit of the Roman Empire are predominantly lowest quartile (shown as small crosses). The highest value recorded, 23.7ppb, is from close to the Roman mining district of Mirandela in Portugal, but high values are not confined to the gold-mining districts (shown as ellipses). In southern Italy, which includes Rome and Naples, 34 out of 47 (=72%) of GEMAS soil sites have Au>0.7ppb.

High values of gold occur in areas of highest historical population densities — central Europe including western Germany, the Netherlands, northern and western Italy and central Britain. Northern Germany and Denmark have high population densities, but not high values of gold in soil. Roman occupation of Europe effectively ended at the river Rhine in central Europe and at the Scottish border, although some trading did occur north of these boundaries. Redistribution

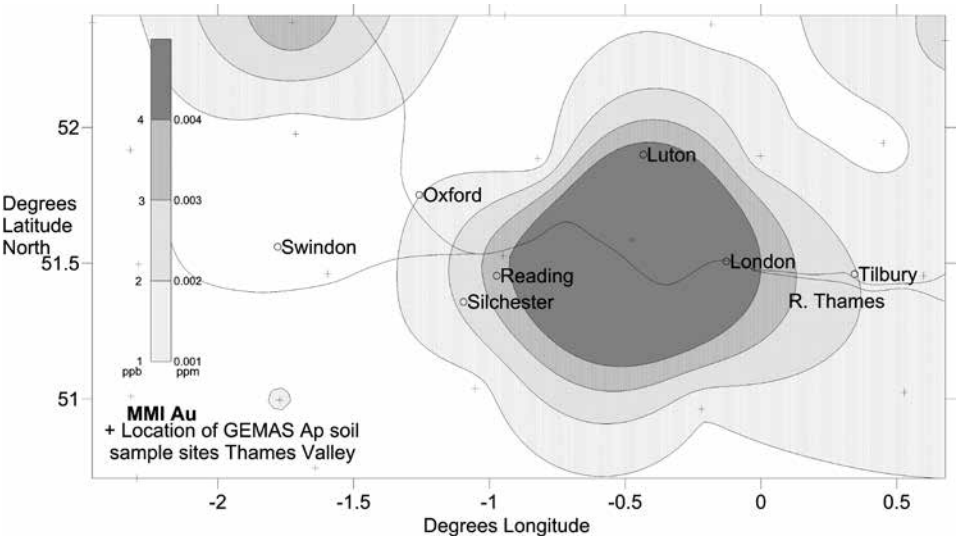

Fig. 2. Contour map of GEMAS MMI Au data in agricultural soils in the vicinity of London

of gold and silver by anthropogenic activity has taken place over at least two millennia, from the time of Roman occupation of Europe (and earlier) to the present day.

It has been estimated that between AD 100 and 300 the Romans mined between five and ten tonnes of gold per annum (see: *www.goldavenue.com*). Were this case, the Romans conservatively mined on the order of five x 200=1000 tonnes Au = one million kg Au in all. The area of the Roman Empire is approximately 2.75 million square kilometres, so this equates to approximately 0.35 kg (=350 g) Au per square kilometre of Empire, or 0.035 g (= 35 mg) Au per square metre (if it were evenly distributed, which of course it was not) — not an insignificant amount.

A 20 cm deep layer (the depth over which the samples were taken for the GEMAS survey) of soil one square metre in area contains approximately 350 kg soil. Given that soil has a density of between 1.5 and 2 (an average of 1.75 gm/ml), 35 mg Au per square metre of soil amounts to a soil concentration of the order of 35/350=0.1 mg/kg = 100 ppb Au, if all Roman mined gold is attributed to this layer. Clearly not all Roman mined gold has returned to the soil; if a 1% attrition and distribution rate is applied, a concentration of one ppb, comparable to the observed MMI upper quartile limit of 0.7 ppb Au is obtained for this layer. This suggests that a significant amount of the gold measured in present day soils could have been derived ultimately from Roman sources.

Silver shows a similar distribution pattern in European soils. The highest value for Ag in soil from the GEMAS study is 1340 ppb from southern Spain, an area which has been extensively mined for silver and gold since at least Roman times. The second, third and fourth highest values, 973 ppb, 664 ppb and 629 ppb are from Italy, London and Paris — all non-mining areas. Silver was used more extensively than gold in Roman coinage.

One of the most interesting outcomes of the GEMAS study with respect to gold is that the third and fourth highest Au values, 12.1 ppb and 11.4 ppb respectively are from the soil samples closest to

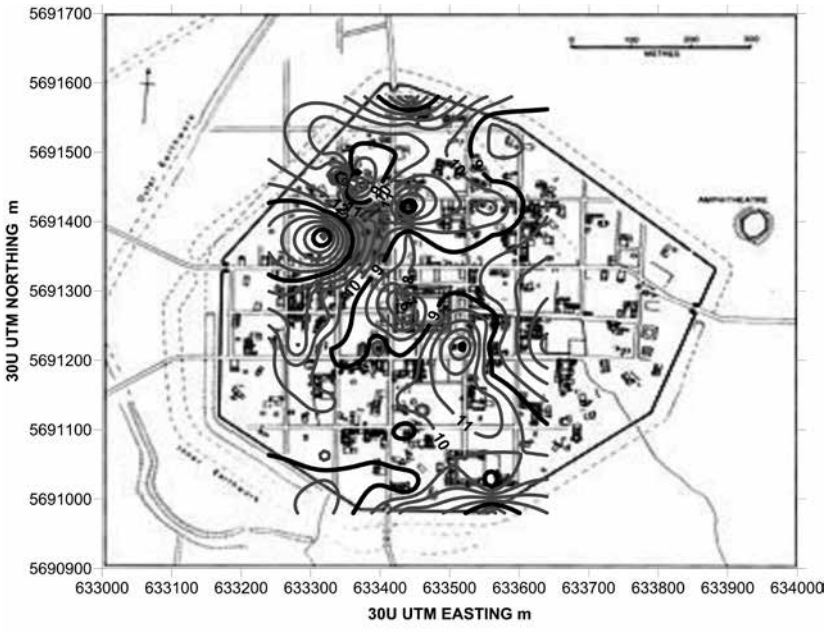

Fig. 3. Contour map of Au values after MMI extraction and analysis of soil samples from the Roman town of Calleva Atrebatum superimposed onto a town plan

Paris and London. These have never been mining towns, but centres of high population, trade and commerce for nearly two millennia. As shown in Fig. 2, the sample closest to (west of) London is anomalous in gold. This site is also anomalous in Ag, Cu, Ni, Pb, Sn and Zn. To the south-west of Londinium, and near Silchester (Fig. 2) was the Roman town of Calleva Atrebatum, the subject of extensive archaeological investigation, and recently some detailed MMI analysis.

A number of high MMI values for Au (up to 21.6 ppb) are evident (Fig. 3) in close proximity to the buried remains of buildings at Calleva Atrebatum. Silver values up to 1740 ppb also occur here. These metals were clearly not mined at this site, but as the Civitas (capitol) of the Atrebatus kingdom, it was a commodity trading centre and new coinage was minted and issued here.

It is concluded that, as a result of coincidence of high values of Au and Ag in soils with dwellings in and around Roman towns and present day cities, and as a result of estimates for the amount of gold mined and the area of the Roman Empire, that anthropic redistribution of Roman gold (and silver) has made a contribution to the distribution patterns observed by high-resolution geochemical techniques in modern-day European soils. It also suggests MMI analysis for Au and Ag in soils could be used in archaeological prospection for identifying and delineating Roman and possibly other habitation sites.

ACKNOWLEDGEMENTS

We wish to thank SGS Laboratories for kindly providing the analytical services necessary for the fulfilment of this project.

REFERENCES

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

Mann, A., Reimann, C., Caritat, P. de, Turner, N, Burke, M. and GEMAS Project Team, 2014. Mobile Metal Ion® analysis of European agricultural soils: bioavailability, weathering, geogenic patterns and anthropogenic anomalies. *Geochemistry: Exploration, Environment, Analysis,* (In press).

Reimann, C., Birke, M., Demetriades, A., Filzmoser, P. and O'Connor, P. (eds.) 2014. Chemistry of Europe's agricultural soils. Part A: Methodology and interpretation of the GEMAS data set. *Geologisches Jahrbuch* B, 102, Stuttgart.