# Reconstructing ancient commercial routes between the Roman Empire and the Indian subcontinent via lead isotope ratio analysis

D. DE MUYNCK[1], P. DELRUE[2], C. CLOQUET[1] AND F. VANHAECKE[1]

[1]Ghent University, Department of Analytical Chemistry, Proeftuinstraat 86, B – 9000 Ghent, Belgium (David.DeMuynck@UGent.be)

[2]Ghent University, Research Unit Near Eastern Archaeology, Sint-Pietersplein 6, B – 9000 Ghent, Belgium

Ed-Dur is a large coastal archaeological site on the Arabian side of the Persian Gulf. The main occupation phase at this site dates from the 1st century BC until the 2nd century AD. International sea-trade between the Roman Empire and the Indian subcontinent peaked during this period and the many imported products excavated at ed-Dur (Roman glass-work, Indian ceramics, Parthian coins,…) show that also this region was involved in the trade system.

Several metallic objects from ed-Dur with a lead content ranging from trace up to main element level – local coins made from copper/silver alloys, copper base alloy objects, silver rings and bracelets, lead and litharge fragments and a few lead objects of known origin – have been subject to study. After complete sample digestion with quantitative lead recovery, lead was isolated both quantitative and pure using an extraction chromatographic separation based on a lead-selective crown ether (Pb spec™, Eichrom Environment, France). Isotope ratio measurements were carried out using a PerkinElmer SCIEX Elan 6100 DRC*plus* ICP-MS instrument, equipped with a dynamic reaction cell. Ne was used as a collision gas in the cell in order to obtain a better isotope ratio precision. Finally, the external precision obtained was 0,11% RSD for $^{207}Pb/^{206}Pb$, 0,10% RSD for $^{208}Pb/^{206}Pb$, 0,09% RSD for $^{208}Pb/^{207}Pb$, and 0,2 – 0,3% RSD for the $^{X}Pb/^{204}Pb$ ratios, where X = 206, 207 and 208. Mass discrimination correction was performed both by standard bracketing using NIST SRM 981 Common Lead and internal correction using Tl; both techniques gave rise to the same result.

So far, 2 samples of known origin can be used as a proxy of lead sources: (i) an ingot found in the Kingdom of Characene, a vassal state from the Parthian Empire, and (ii) a *bulla* (coin) which is an imitation of a Roman original and originates from India. However, at least one more source needs to be identified to explain the isotopic range of the investigated samples. The provenance of the lead from the sources and the objects investigated will be determined by comparison to an extended database containing lead isotopic compositions from ores and objects from all over the old world.

These and additional results of this study will be presented, along with archaeological conclusions concerning trade relations in the Arabian region at that time.

# Comparing GC- and LC-C-IRMS methodologies to quantify formation and turnover rates of microbial-derived soil organic matter

K. DENEF, C. DECOCK, J. VERMEULEN, O. VAN CLEEMPUT AND P. BOECKX

Ghent University, Coupure Links 653, 9000 Gent, Belgium (karolien.denef@ugent.be; charlotte.decock@ugent.be; jan.vermeulen@ugent.be; oswald.vancleemput@ugent.be; pascal.boeckx@ugent.be)

Amino sugars are the building blocks of microbial cell walls and can be stabilized in the soil after cell death. Their abundance in the soil has been suggested to be a more useful indicator of time-averaged soil microbial responses to land-use or environmental change than the living microbial biomass. Since bacteria and fungi have different cell wall structures, relative abundance of their characteristic amino sugars have been used to assess fungal and bacterial contributions to soil organic matter. However, little is known about the dynamics of fungal and bacterial amino sugar-C. Compound-specific stable isotope analysis forms a powerful tool to quantify production, stabilization and turnover rates of organic compounds. To date, compound-specific stable isotope analysis of non-volatile biomarkers such as amino sugars has only been attempted through gas chromatography – combustion – isotope ratio mass spectrometry (GC-C-IRMS) or GC-MS, which requires derivatization to facilitate GC analysis. Yet, derivatization of amino sugars adds a large number of exogenous carbon atoms with different $^{13}C$ signature. This necessitates complex $^{13}C$ corrections which increase the error on the final $\delta^{13}C$ values of the amino sugars. A recently developed analytical technology, i.e. high performance liquid chromatography – combustion – IRMS (HPLC-C-IRMS), has enabled the high-precision $^{13}C/^{12}C$ determination of polar and thermo-labile compounds that can be chromatographically separated in aqueous phase. By avoiding the requirement for derivatization, this technology has greatly broadened the types of biomarkers that can be analyzed in conjunction with stable isotope analysis. In this presentation, an alternative method is described for $^{13}C$ analysis of amino sugars through HPLC-C-IRMS, and compared with GC-C-IRMS analysis in terms of reproducibility and experimental error. In addition, results will be presented from an incubation study with uniformly labeled $^{13}C$-plant residues to quantify formation rates of newly produced amino sugars under laboratory conditions, and to investigate the impact of substrate quality on the turnover of fungal and bacterial residues.