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30 Stable Isotope Analysis of Multiple Tissues from Peruvian Mummified Remains: Investigating Tissue-Spacing and Dietary Life Histories

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Carbon and nitrogen isotopic analysis has been performed on multiple tissues types (dentine, bone, skin and hair) from mummified human remains from the south coast of Peru. Remains from 7 looted cemeteries (c. 100 BC – 1400 AD) in the lower Ica valley have been sampled from an area that previous research has shown to have witnessed a radical shift in food production and management over approximately 1000 years (Beresford-Jones et al., 2011a, 2011b). For forty-eight individuals at least three of these tissue types were sampled. The aim of this research is to 1) investigate to what extent the tissue spacing seen in these mummies reflects our current knowledge of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ diet-tissue spacing; and 2) investigate if any discrepancies between these can be explained by taking the archaeological record and dietary life histories as a whole of particular individuals into account. Collagen has been extracted from dentine, bone and skin, which reflects diet at different life stages: childhood, long-term average and pre-mortem life stages. Segmental data from keratin analysis of the hair samples provides a month by month analysis of diet over a pre-mortem period representing, in these samples, between 6 and 40 months. We investigate the comparability of the three collagen sources with each other as well as the correlation between skin collagen and hair keratin which both reflect diet during the months of life. The results obtained so far from the bone-skin offset show similar patterns observed by Finucane (2007) in his archaeological population from the site of Vinchos in the Peruvian highlands. The bone-hair offset shows wide variation with little agreement with values published from modern samples (O’Connell & Hedges 2001). In some cases, seasonal dietary variation, as seen in the hair, can be used to explain the discrepancies in short turnover versus long turnover tissues, which in turn reflects the agricultural practices hypothesised for the valley. For individuals where this is not the case we hypothesise the potential factors that may have caused a significant dietary shift between early and late life or reasons as to why our understanding of tissue-spacing is limited.

BERESFORD-JONES, D.G., ALARCÓN, C., WHALEY, O.Q., CHEPSTOW-LUSTY, A.J., ARCE TORRES, S., GORRITI, M., PORTOCARRERO, O. AND CADWALLADER, L., 2011A. Ocupación y subsistencia durante el horizonte temprano en el contexto de cambios ecológicos a largo plazo en las cuencas de Samaca y Ullujaya, valle baja de Ica. *Boletín de Arqueología PUCP* **13**, 237-258. ; BERESFORD-JONES, D.G., WHALEY, O.Q., ALARCÓN, C. AND CADWALLADER, L., 2011B. Two millennia of changes in human ecology: Archaeobotanical and invertebrate records from the lower Ica valley, south coast Peru. *Vegetation History and Archaeobotany* **20**, 273-292. ; FINUCANE, B.C., 2007. Mummies, maize, and manure: multi-tissue stable isotope analysis of late prehistoric human remains from the Ayacucho Valley, Perú. *Journal of Archaeological Science* **34**, 2115-2124. ; O’CONNELL, T.C. AND HEDGES, R.E.M., 2001. Isotopic comparison of hair, nail and bone: modern analyses. *Journal of Archaeological Science* **28**, 1247-1255.

31 Dental Calculus: A Novel Reservoir of Health-Related Biomolecules

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Archaeologists have long been interested in the health histories of ancient peoples. However, reconstructing these histories using conventional tools can be difficult, indirect, and imprecise. Recent microscopy investigations of dental calculus have shown that this mineralized biofilm is a long-term reservoir of food remnants and bacteria (e.g., Fox et al., 1996; Linossier et al., 1996; Hardy et al., 2009; Henry et al., 2011). In this paper we present new data demonstrating that dental calculus is also a robust reservoir of ancient biomolecules, including ancient DNA.

Dental calculus samples from three individuals with evidence of moderate to advanced periodontitis (≥ 4 mm attachment loss) from the Dalheim Monastery (c. AD 1100) were investigated for human and bacterial DNA. Targeted sequencing of the bacterial 16S rRNA gene reveals the preservation of a diverse range of commensal and pathogenic oral taxa, and metagenomic shotgun sequencing further characterizes periodontal infection at the time of death. Many of the bacteria detected in the dental calculus are implicated in modern cases of periodontitis, indicating long-term continuity in the etiology of periodontal disease. Today, periodontal disease affects approximately 50% of adult Europeans and is a leading cause of antemortem tooth loss (Bourgeois et al., 2007).

Given the near ubiquity of dental calculus in the archaeological record, the discovery of well-preserved biomolecules within dental calculus promises to greatly expand our inquiry into the history of periodontitis and open up new a new line of research in the field of paleopathology.

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FOX, C.L., JORDI, J. AND ALBERT, R.M., 1996. Phytolith analysis on dental calculus, enamel surface and burial soil: information about diet and paleoenvironment. *American Journal of Physical Anthropology* **102**, 101-113.

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LINOSSIER, A., GAJARDO, M. AND OLAVARRIA, J., 1996. Paleomicrobiological study in dental calculus: *Streptococcus mutans*. *Scanning Microscopy* **10**, 1005-1014.

32 Dairying in the Early Mediterranean Neolithic

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The origin of dairying in Europe has been subject to much debate. It has been suggested that secondary products, including milk production, only developed at the end of the Neolithic period (Sherratt, 1997). However more recently, zooarchaeological evidence has pointed to a much earlier origin, pushing back the dates to the early 8th millennium BC (Mid-PPNB) in the Near East, and the mid 6th millennium BC in Mediterranean Europe. The former has been directly confirmed by organic residue analysis (ORA), where dairy residues were identified on pottery dating to the 7th millennium BC, based on structural and isotopic characteristic of individual lipid compounds using Gas Chromatography-Mass Spectrometry (GC-MS) and GC-combustion-Isotope Ratio Mass Spectrometry (GC-c-IRMS). Residue analysis offers the only method of providing direct evidence for the presence of dairy products, which complements zooarchaeological data and adds confidence to the economic interpretation of a site when the faunal assemblage is not preserved or is too fragmented for mortality patterns to be conclusive. However, very few residue analysis studies have been conducted on early pottery from farming sites in the Mediterranean, despite the fact that the speed and nature of the spread of pastoralism through this region has been much debated and might be quite different to other parts of Europe.

To address this issue, here we present a systematic study of pottery use at early farming sites from the central Mediterranean. We have improved the isotopic criteria for distinguishing ruminant products in this region by extending the reference data set with authentic modern lipid samples, sourced from the study area. Using these criteria we have classified lipid residues extracted from early Impressed Ware vessels, excavated from Apulia (Italy; 6100-5600 BC), Malta (5000-4300 BC), Catalonia (5470-5300 BC) and Croatia (5600-5159 BC). A significant number of samples matched the criteria for dairy products, showing that dairying was an important part of the early Neolithic economy and may have been crucial in sustaining pioneering farmers as they rapidly spread through this region.

SHERRATT, A., 1997. *Economy and society in prehistoric Europe*. Edinburgh University Press, Edinburgh.

33 Characterization of Maize and Manioc Residues in Prehistoric Potteries: The Contributions of GC and NIR Spectroscopy to Archaeology

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Archaeometry, a promising connection between Chemistry, Physics, Materials Science and Archaeology, constitutes a significant advance in archaeological studies. Classes of artifacts like stone objects, metal containers, coprolites and potteries can be studied, providing very useful information to archaeologists. Data obtained by chemical analyses of organic residues impregnated in pottery, for example, can give to archaeologists a set of information which can help them to verify some archaeological hypotheses as well as understand different aspects of prehistoric populations. Maize and manioc (cassava) are typical foods of prehistoric tropical populations. So the characterization of their residues in potteries is of first interest for archaeological studies. Our group have been studied these residues by gas chromatography (GC) and by NIR spectroscopy - as a non-destructive, more sensible and faster tool to characterize residue containing pottery. Initially, an extraction procedure was tested employing different solvents (hexane, chloroform and methanol 2:1 v/v and dichloromethane) to extract characteristic substances of maize and manioc. Alternatively, some laboratory-prepared samples were produced adding maize and manioc, in the ratio of 10 wt %, to pottery powders. Then, the samples were analyzed and the data were treated by bidimensional graphics, Principal Component Analysis method (PCA) and Soft Independent Modeling of Class Analogy method (SIMCA). Supplemental analysis were realized adding different maize and manioc proportions to pottery powders (0,1%, 0,25%, 0,5%, 1%, 2,5%, 5%). Moreover, some samples of historical importance (couscous kettle and manioc meal house piece) and some archaeological samples were selected to test the methodology. It was observed that among the tested solvents, chloroform and methanol (2:1 v/v) provided the best result, allowing the maize and manioc extracts identification. Employing this solvent it was possible to distinguish between potteries containing or lacking the residues and even to distinguish between potteries containing maize or manioc residues. The NIR spectroscopy results indicated a good differentiation between the simulated samples composed by ceramics and maize or manioc residues. The PCA scores allowed to differ between "organic residues free" and "organic containing" in samples and the SIMCA classification and the Coomans Graphic were sufficient to relate clearly the manioc meal house piece to manioc laboratory-prepared samples (99% Confidence Level). This approach gives a new tool for a better understanding about the Tropical Forest human life in the Prehistory. Work supported by CNPq and FACEPE.

SILVA, F.E.C., 2011. *Characterization of organic residues in prehistoric potteries: the contributions of Materials Science to Archaeology*. M.Sc. Dissertation, UFPE, Recife, Pernambuco, Brazil.

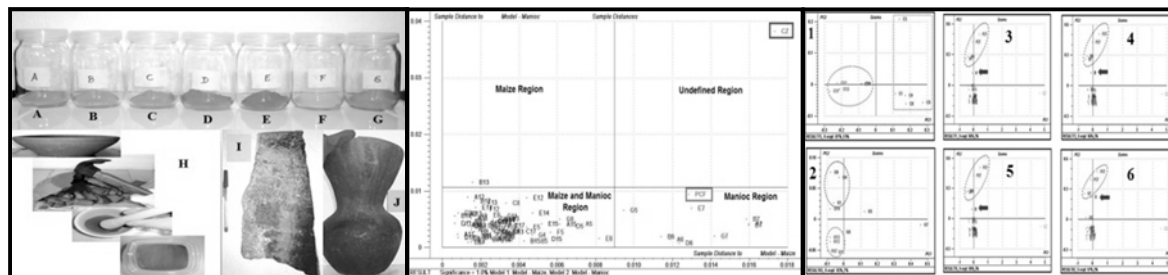


Fig. 1: Different clays used in this study to produce the laboratory-prepared samples - (A) (B) (C) (D) (E) (F) (G); Laboratory-prepared samples (H) and test samples - couscous kettle (I) and manioc meal house piece (J).

Fig. 2: Principle components analysis (PCA) scores of laboratory-prepared (1 and 2) and test samples (3 to 6) showing manioc grouping (blue lines) and maize grouping (green lines) and the relation between different clays used - 1 (C), 2 (G), 3 (A), 4 (B), 5 (D) and 6 (G).

Fig. 3: Coomans Graphic showing four regions of classification: maize region, manioc region, maize and manioc region and undefined region. The graphic shows the inclusion of the manioc meal house piece (PCF) in the manioc region (99% Confidence Level). Confirming the PCA results and the SIMCA classification table, the couscous kettle sample could not be associated with maize region.

34 Extracting Biogenic Information from Archaeological Bone Carbonate; The Potential of Density Separation to Assess the Original Composition

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We present a new approach to the isotopic measurement of diagenetically altered archaeological bone apatite carbonate. Bone carbonate provides an invaluable palaeodietary information. There are two main advantages of using bone collagen and bone carbonate together: that is, the different dietary information and the different survival period in the burial environment. However, the usage of bone carbonate has been questioned to date due to the difficulty of removing diagenetic carbonate and the lack of any suitable test for validity. In order to remove the diagenetic carbonate and to recover the biogenic signal from archaeological bone, an understanding of the characteristic differences between biogenic and diagenetic carbonate is essential (Garvie-Lok et al., 2004; Zazzo & Saliège, 2011). We describe how the existing differential dissolution method may be combined with a new approach to remove diagenetically reformed material on the basis of its greater specific gravity (Bell et al., 2001; Shin et al., 2004). We show that heavier, more diagenetically altered fraction has a higher (altered) $\delta^{13}\text{C}$ and also increased crystallinity within one individual. In addition, we proposed one potential tool to check the validity of bone carbonate by comparing bone collagen, enamel carbonate and bone carbonate values of $\delta^{13}\text{C}$ and radiocarbon content from the same individual.

BELL, L.S., COX, G. AND SEALY, J., 2001. Determining isotopic life history trajectories using bone density fractionation and stable isotope measurements: a new approach. *Am. J. Phys. Anthropol.* **116**, 66-79.

GARVIE-LOK, S., VARNEY, T.L. AND KATZENBERG, M.A., 2004. Preparation of bone carbonate for stable isotope analysis: the effects of treatment time and acid concentration. *J. Archaeol. Sci.* **31**, 763-776.

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ZAZZO, A. AND SALIÈGE, J.-F., 2011. Radiocarbon dating of biological apatites: A review. *Palaeogeography, Palaeoclimatology, Palaeoecology* **310**, 52-61.

35 Paleodiet and Human Mobility in the Oasis of Quillagua (Northern Chile) During the Late Intermediate Period: A Reconstruction through Stable Isotopes Analysis

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Quillagua is a small oasis located at the margins of the Loa River in northern Chile, 70 km from the Pacific coast. It has been intensively occupied since the Late Formative Period, and archaeological research in the area has recovered evidence of significant cultural heterogeneity in funerary contexts of the Late Intermediate Period (AD 1000-1400). This heterogeneity has been interpreted as a result of the direct influence of two different cultures in the oasis: the Tarapacá culture, which originated on the coast north of Quillagua; and the Atacameño culture, developed in highland areas to the southeast of Quillagua. This situation has been studied through analyses of textiles and pottery on the so-called Eastern Cemetery site ("Cementerio Oriente"). Here, we present the results of carbon, nitrogen and oxygen stable isotope analyses on collagen and apatite of bone and tooth from 23 individuals recovered from two sectors (Upper sector n=10; Lower sector n=13) of the Quillagua's Eastern Cemetery. Our objective was to test whether the described cultural heterogeneity was reflected in aspects of local diet and mobility patterns. Results from carbon and nitrogen isotopes show that there was an important consumption of marine proteins in the majority of the individuals, with some of them also showing high C4 plant (maize) consumption in both the Upper and Lower sectors of the cemetery ($\delta^{13}\text{C}$ average = -12,5‰ and -12,6‰; $\delta^{15}\text{N}$ average = 17‰ and 18‰ respectively). Oxygen isotope results show very low ^{18}O values for four individuals in the sample, two from the Upper sector ($\delta^{18}\text{O}$ = -8,4‰ and -8,3‰) and two from the Lower sector ($\delta^{18}\text{O}$ = -10,1‰ and 8,3‰) suggesting a possible highland origin, while the remaining individuals show ^{18}O values consistent with coastal origins (Upper and Lower sector $\delta^{18}\text{O}$ average = -4,8‰ and -5,1‰ respectively). The consumption of marine C4 plants in the cemetery is confirmed by the presence of dry fish, shellfish and maize on the burials from the site. Together, these results support the idea that the Quillagua oasis represented a relevant interaction area, with close contact with the coastal environment and a significant presence of people from the interior.

36 Uneven Distribution: Asymmetrical Mobility Patterns and Shifting Kinship Structures in Neolithic and Early Bronze Age Cis-Baikal, Siberia

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Previous geochemical work in the Lake Baikal region has demonstrated the effectiveness of Sr isotope analysis in interpreting mobility patterns among Early Bronze Age hunter-gatherer groups and helped to confirm the validity of using $^{87}\text{Sr}/^{86}\text{Sr}$ ratios for mobility research (Haverkort et al., 2008). This research has focused on the Khuzhir-Nuge XIV (KNXIV) cemetery due to its large size; however, numerous smaller cemeteries have been excavated throughout the Cis-Baikal region. Lacking the number of interments necessary to support broader interpretations, individuals from these cemeteries are analyzed to provide broader geographic framework for the interpretation of the larger sites. First, second and third molars of 16 individuals from 6 cemeteries throughout the Cis-Baikal region were microsampled for $^{87}\text{Sr}/^{86}\text{Sr}$ ratios, and rare earth and trace element concentrations using ICP-MS in order to generate mobility data with improved temporal resolution. Geochemical signatures for 363 water, plant and animal bone samples were found to be far more variable across the region than predicted based on the age and type of geologic formations (Scharlotta, 2010). $^{87}\text{Sr}/^{86}\text{Sr}$ ratios for cultural micro-regions proved to overlap significantly and required trace element data to identify more discrete geochemical groups. The level of hunter-gatherer mobility in the Cis-Baikal region was significant with individuals recovered far from Lake Baikal showing contact with areas along the western coast of the lake. Mobility patterns show preferential cultural contact and exchange between select micro-regions. The new mobility data further support the identification of different kinship structures in operation during the Early Neolithic and Late Neolithic/Early Bronze Age.

HAVERKORT, C.M., WEBER, A.W., KATZENBERG, M.A., GORIUNOVA, O.I., SIMONETTI, A. AND CREASER, R.A., 2008. Hunter-gatherer mobility strategies and resource use based on strontium isotope ($^{87}\text{Sr}/^{86}\text{Sr}$) analysis: a case study from Middle Holocene Lake Baikal, Siberia. *Journal of Archaeological Science* **35**, 1265-1280.

SCHARLOTTA, I., 2010. Spatial variability of biologically available $^{87}\text{Sr}/^{86}\text{Sr}$, rare earth and trace elements in the Cis Baikal region, Siberia: Evidence from environmental samples and small cemeteries. *Program and Abstracts of the 38th International Symposium on Archaeometry*. Tampa, Florida.

37 Applying Multiple Isotope Analyses to the Archaeological Study of Migration and Mobility in the Caribbean

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In the Caribbean, archaeologists have often interpreted spatial-temporal distribution of cultural traits as resulting from various forms of inter-community interaction between island and mainland populations. Proposed forms of interaction during the pre-Columbian period include trade, exchange of marriage partners, bride capture, village relocation and fissioning, residential mobility and migrations at multiple scales: intra-island, inter-island, and island-mainland. Later, during the contact and colonial periods the scale of these spheres of interaction expanded as the Caribbean region experienced large-scale migrations of peoples from all over the world including not only Europe and Africa but also from other parts of the Americas. Here we present the preliminary results of an isotopic study of patterns of ancient residential mobility in the Caribbean region. We tested the utility of combining strontium (Sr), oxygen (O) and carbon (C) isotope analyses of human dental enamel (n = 50) to identify first-generation immigrants from several archaeological skeletal assemblages representing different geographic, temporal, and cultural contexts. The Sr isotope results indicate varying proportions of nonlocal individuals amongst these populations. The carbon and oxygen isotope results displayed reduced variance for the majority of the sample population, with the exception of a few nonlocals from the protohistoric site of El Chorro de Maíta, Cuba. The combined isotope results 1) confirm the presence of non-Antillean immigrants at this site, including one each originating from Mesoamerica and Africa; 2) support independent assessments of their foreign origins based on osteological and archaeological evidence; and 3) constrain assessments of their possible geographic and cultural origins. The isotope data produced by this study also contribute to the development of empirical models of the spatial patterning of Sr, O, and C isotopes within the wider Caribbean region.

38 Sr Isotope Analysis for the Provenance Study of Ancient Ceramics: An Integrated Approach

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The potential of Sr isotopic analysis in provenance studies of ancient ceramics has been explored in only a limited number of case studies (Carter et al., 2011; Li et al., 2005). The current project constitutes a novel application of Sr isotopic analysis for the provenance study of ancient pottery, within the scope of an integrated analytical approach. The technique was applied to both pottery sherds and clay sediment samples from Cyprus as an effort to link the isotopic fingerprint of the raw materials to that of the final product. The results were meant to be compared to and complement pre-existing Pb isotopic analysis carried out at Vrije Universiteit Brussel (Renson et al., 2011), while an array of additional analytical techniques was considered in order to ensure a more holistic examination of the samples. Our initial motive was to determine the applicability of Sr isotopic analysis within the scope of provenance studies and investigate to which extent these results could be used to disambiguate previous Pb isotopic analysis research on the same samples. To this end a preliminary test group of a total of 46 samples from the archaeological site Hala Sultan Tekke (Dromolaxia – Vyzakia, Cyprus) was selected: 27 ceramic sherds, covering different classes of local and imported pottery (plain white wheel-made, coarse hand-made, coarse wheel-made, white slip II, Canaanite), and 19 clay sediment samples, covering a variety of soils within relative proximity to the area of production. The samples were analyzed using a MC-ICP-MS in order to determine their characteristic ⁸⁷Sr/⁸⁶Sr ratio.

The data resulting from the Sr isotopic analysis were assessed in parallel with the previously obtained Pb isotopic data, allowing a more clear distinction between the isotopic fingerprint of the raw material sources. Moreover, an attempt was made to investigate the use of the Sr data in conjunction with petrographic examination in order to reach conclusions regarding the nature of the materials added to the raw clay (temper). In this manner we hoped to achieve a mapping of the deviation of the final ceramic product from the raw material fingerprint composition, in relation to the technology used for its creation.

CARTER, S., WIEGAND, B., MAHOOD, G., DUDAS, F., WOODEN, J., SULLIVAN, A. AND BOWRING, S., 2011. Strontium isotopic evidence for prehistoric transport of gray-ware ceramic materials in the eastern Grand Canyon region, USA. *Geoarchaeology***26**, 189-218.

14 Quantitative Approach to Ancient Diet Reconstruction and Reservoir Effect Correction

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Stable isotope analysis is one of the main analytical tools used within archaeological research for ancient human diet reconstruction. However, several issues need to be addressed so that a truly quantitative diet reconstruction becomes possible. A three step approach is hereby proposed:

1) Characterization of the isotopic baseline, i.e., identifying possible food sources and characterizing corresponding isotopic signals. 2) Use of multiple isotopic signals for which dietary routing mechanisms have been well established. This implies knowledge on the dietary routing of food macronutrients (carbohydrates, lipids, and proteins) and biochemical components (e.g. amino acids). 3) Use of statistical models that allow integration of all sources of data variability (e.g. uncertainty in isotopic enrichment, isotopic variability in the food source).

An illustrative example of a quantitative approach to ancient diet reconstruction is hereby presented. Individual human remains, in an excellent state of preservation, were collected from the medieval cemetery of Oude Markt in Vlissingen (The Netherlands). Stratigraphically associated fish and animal material located in an ancient cesspit permitted a characterisation of the isotopic baseline. Archaeological data was complemented with historical information on dietary habits of medieval Dutch coastal populations. Compiled information was used to define food groups (e.g. cereals, land animals, freshwater fish, and marine fish). Estimates of food nutrient composition and isotopic variability relied on previously published data. A Bayesian mixing model was designed to take into account the dietary contribution of different food nutrients and components. For each measured isotopic signal ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ in bone collagen, $\delta^{34}\text{S}$ in collagen's methionine, and $\delta^{13}\text{C}$ in bioapatite) weight contributions of the different food nutrients and/or components were determined from an analysis of compiled results of controlled animal feeding experiments (e.g. Warinner & Tuross 2009, Froehle et al. 2010). Model output provided, for each individual, probability distributions and confidence intervals on the consumption of each food group. These results were used to provide an estimate of each individual's reservoir effect. The reliability of such an estimate was assessed by comparison with age offsets observed between collagen radiocarbon dates and the dating (dendro and radiocarbon) of wooden caskets in which the individuals were buried.

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FROEHLE, A.W., KELLNER, C.M. AND SCHOENINGER, M.J., 2010. FOCUS: effect of diet and protein source on carbon stable isotope ratios in collagen: follow up to Warinner and Tuross (2009). *Journal of Archaeological Science* **37**, 2662-2670.

B1 Analysis of the Conservation State, the Traces of Polychromy and Gilding of Ancient Ivories

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Elephant ivory used for sculpted, colored and gilded museum artefacts is a fragile biomaterial subjected to complex physico-chemical alteration mechanisms occurring over time. The aim of this study is to present a combination of analytical methods allowing the precise evaluation of the preservation state of ancient ivory taking into account alterations in the burial environment and former restorations. Additionally, it allows in some cases the determination of original polychromy and gilding, if present, as well as identifying possible sediment traces that are characteristic of the burial conditions.

On the basis of the study of museum and archaeological objects by UV photography, X-ray radiography and tomography, electron microscopy, Visible, infrared and microRaman spectroscopies, microXRD as well as microPIXE at the AGLAE accelerator installed at the C2RMF the potential of these methods is highlighted in order to gain new insights into the complex history of the ivory museum objects (Fontan & Reiche, in press) or archaeological ivory remains (Large et al., in press).

FONTAN, E. AND REICHE, I., In press. Les ivoires d'Arslan Tash (Syrie) d'après une étude de la collection du Musée du Louvre : mise en oeuvre du matériau, traces de polychromie et de dorure, état de conservation. *Archéosciences* **35**.

LARGE, D., MÜLLER, K. AND REICHE, I., In press. Approche analytique pour l'étude des ivoires archéologiques. Les défenses d'éléphant du site de *Jinsha* (1200-650 BC, Sichuan, Chine). *Archéosciences* **35**.

B2 Grave Goods in Predynastic Hierakonpolis, Egypt: Botanical and Molecular Approaches to Identify Plant Substances

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Botanical remains as aspect of Predynastic grave goods have often been neglected in the past, mainly due to poor preservation. However, they may add considerably to the interpretation of funerary equipment when they are well preserved (Buchez, 1998; Fahmy, 2005). Hierakonpolis is the largest Predynastic site known and consists of settlements and cemeteries, such as the elite cemetery HK6 (Friedman et al., 2011) and the “working class” cemetery HK43 (Friedman et al., 1999). Both of them were in use during the early Naqada II period (ca. 3700-3600 BC). Among the more puzzling finds from these cemeteries are a number of clay cones, often found in combination with leather and organic remains. These objects have also been found occasionally at other cemeteries and were considered as models of poppy-heads (Hartung, 2011). However, this interpretation is highly unlikely, if only because neither *Papaver somniferum* sp. *somniferum* nor *Papaver somniferum* sp. *setigerum* grew in Predynastic or Early Dynastic Egypt. In order to unravel the function of these cones, parts of their organic embedding were subjected to a multidisciplinary study involving both macrobotanical analysis and molecular techniques. Among the macrobotanic finds were pieces of coniferous wood, diverse plant tissues and resin-like red crystals. The latter were investigated by several analytical techniques: infrared microscopy, thin layer chromatography (TLC), high performance liquid chromatography (HPLC) and gas-chromatography coupled to mass spectrometry (GC-MS). By comparison with modern resin references, it was found that the resinous plant material most likely originates from myrrh (*Commiphora myrrha*). The modern geographical distribution of myrrh is situated in Southern Arabia and the Northeast of Africa, more than 2000 km southeast of Hierakonpolis. Considering both the long distance import of myrrh and the presence of other fragrant substances in the embedding of the cones, it would not be surprising if these objects are cheap models of the highly valuable myrrh resin. This would furthermore correspond well with imitations of other goods found in Predynastic tombs (cf. Hartung, 2011).

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B3 Investigating Childhood Dietary Variation Using Stable Isotope Analysis of Incremental Dentine Sections

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In human permanent teeth dentine is secreted and fully mineralized in approximately 3-8 days (Dean & Scandrett, 1995): because the age at which teeth develop is well-established (Hillson, 1996), high temporal resolution can be achieved when constructing isotopic profiles from dentine. The use of stable isotope ratios obtained from dentine to investigate diet has been used in a number of studies (e.g. Müldner et al., 2009). High-resolution dentine sampling offers the opportunity to investigate childhood dietary variation in individuals who survived childhood thus avoiding the need to consider pathological changes in the period immediately prior to death, i.e. the “osteological paradox” (Wood et al., 1992). Comparison of the isotopic profile of individuals who survived childhood can then be made with those who did not, to investigate dietary and metabolic differences over the same age range.

Carbon and nitrogen isotopic profiles were produced using incremental dentine collagen from individuals where historical, archaeological and documentary evidence suggests significant dietary variation or deprivation. These include individuals from cemeteries dating from the period of the Great Irish Famine (1845-1852) in London and Kilkenny, and marginal environments in prehistoric Scotland. For permanent teeth, this yielded approximately 10-20 increments, each representing an average of 9 months. Both deciduous and permanent teeth from sites in the British Isles ranging from prehistoric to 19th century were investigated. For some individuals, two or more teeth were examined, extending the period of life studied. Results are presented and compared to evaluate the potential information contained within dentine, both for dietary studies and for investigating the effect of stress on the individual. The profiles reveal variations in the isotope ratios that are consistent with expected dietary variation, however, they also suggest evidence for physiological variation in the nitrogen isotopes. The differences between individuals who died in childhood and those who survived, may allow interpretation of the state of health of individuals in these early years.

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B4 A Reconstruction of the Living Space in a Community of Early Bronze Age in Sicily: Results of a Multidisciplinary Study

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The main aim of this paper is to trace the use and the organization of space in Early Bronze Age Sicilian (2200-1450 BCE) societies. The purpose is to identify the connection among types of food consumed in relationship to vessel shape, in addition to characterising indicators of food preparation and the space in which these activities take place. This study incorporates both organic chemistry and GIS spatial analyses in order to understand vessel use in direct correlation to food preparation space in a settlement context.

The hill site of Santa Febronia, contains the remains of an Early Bronze Age hut that was destroyed by a fire leaving a sealed deposit with a large quantity of artefacts in their original position. The deposition creates an ideal scenario for GIS spatial analysis of the artefact distribution within the structure in contrast to areas of storage. Chemical residue analysis was carried out with GC-MS to extract and identify absorbed lipids within ceramic vessels (cf. Eerkens, 2005). The gas chromatographic results are used to establish relations between the food processing and the depositional space. The study reveals a multi-functionality of both space and pottery and further confirms the distinction of storage areas and in particular areas dedicated to water storage.

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B5 Stable Isotope Analyses ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) of Degraded Bone Collagen and Hair/Wool Keratin by Using Cross Flow Nanofiltration as a Cleanup Step

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Degradation and/or contamination with organic material of bone collagen and hair/wool keratin is demonstrated by measuring the C/N ratio. For bone that has not been significantly affected by diagenesis, the atomic C/N ratio should lie between 2.9 and 3.6 (De Niro, 1985) while the accepted atomic C/N ratio for hair/wool keratin is between 2.9 and 3.8 (O'Connell & Hedges, 1999). Ultrafiltration of bone collagen, dissolved as gelatin, is an effective method of removal of low-molecular weight contaminants from bone collagen but it does not remove high-molecular weight contaminants, such as cross-linked humic collagen complexes (Brock et al., 2007). However, comparative dating studies have raised the question whether this cleaning step itself may introduce contamination with carbon from the filters used (Bronk Ramsey et al., 2004; Brock et al., 2007; Hüls et al., 2007, 2009). In this study a cross flow nanofiltration method was developed using a ceramic filter as a means to avoid extraneous carbon contamination via the filter. This method should be applicable on various protein materials e.g. collagen, hair, silk, wool, leather and should be able to remove low-molecular and high molecular weight contaminants, depending on the choice of molecular weight cut off (MWCO) of the membrane. Here a filter membrane with a cutoff of 200 Dalton was used in order to collect the amino acids, released by hot acid hydrolysis of the protein material, in the permeate (MW of amino acids varies between 75.07 and 204.23 Dalton) and the contaminants (> 200 Dalton) in the retentate. Stable isotope analysis was done on the bulk material of well preserved and degraded archaeological bone collagen and hair/wool keratin, pre-treated with the conventional methods, and on the crossflow nanofiltrated amino acids. Quality assessment of the samples was performed by measuring the C/N ratio.

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B6 Death During the Scottish Wars of Independence: An Osteological and Isotopic Analysis of Medieval Individuals from Stirling Castle, Scotland

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The Scottish Wars of Independence have long ignited public interest, however to date little skeletal material relating to them has been excavated or analysed. In 1997 a small population radiocarbon dated to the 14th and 15th centuries was excavated in a lost royal chapel at Stirling Castle, one of the key garrisons of the wars. Shortly after the excavation skeletal analysis revealed that one individual suffered healed sharp force trauma to the frontal bone and a second had possible peri-mortem puncture wounds to the cranial vault. Our re-analysis has identified an abundance of previously unidentified peri-mortem trauma within this small group. Most of this is blunt force trauma, with small numbers of sharp force and penetrating trauma present. One individual suffered over 80 peri-mortem fractures, many to his post-cranial skeleton.

This paper will present the evidence of trauma from Stirling Castle, highlighting the diagnostic criteria for peri-mortem blunt force post-cranial injuries, which are rarely reported on in palaeopathology. While many of the fractures found in isolation could easily be attributed to accidents, a small number of sharp-force injuries clearly relate to inter-personal violence. It is argued that this, alongside the significant burial location within a royal castle, indicates that these are high-status individuals who died in encounters relating to the Scottish Wars of Independence.

Carbon and nitrogen isotope analysis of bone collagen indicated these individual enjoyed a mixed diet, with ratios similar to other notable high-status medieval populations. Oxygen and strontium isotope analysis of tooth enamel was undertaken to investigate the origins of all individuals with surviving teeth. Stirling Castle changed hands repeatedly during the course of the wars of independence, so one of our main aims was to establish if these people were English or Scots.

B7 Ancient Maritime Pitch and Tar: A Multi-Disciplinary Study of Sources, Technology and Preservation

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Tars and pitches are black sticky substances manufactured by destructive distillation of wood and bark from soft and hardwood trees such as pine, spruce and birch. Tar is the initial liquid pyrolysate, while further distillation produces more viscous pitch, which is solid at ambient temperatures and must be re-heated prior to use (Evershed et al., 1985; Beck et al., 1994). These materials have a long history of use as waterproofing agents and timber preservatives, especially in maritime contexts: they have been used by shipbuilders and seafarers to caulk the seams of vessels and to waterproof rope and tarpaulins (Langenheim, 2003). In the medieval period, their role in ship building and maintenance led them to acquire crucial strategic and political importance for the developing European seafaring economies and naval fleets.

Material from the Newport Ship discovered in 2002 on the right bank of the river Usk in Newport, Wales is central to this study. The wreck constitutes the most complete example of a fifteenth century clinker-built vessel ever found in the UK. The dating evidence (from dendrochronological analysis and coinage) indicates that it was constructed after AD1445 and came to rest in Newport soon after AD1468, while associated finds suggest contacts with the Iberian Peninsula (Jones, 2005, 2009). The ship predates the carvel-built Mary Rose by some 50 years and represents a late survival of northern European shipbuilding traditions (Evershed et al., 1985). A systematic study to map the use of tars and pitches over the whole vessel is currently underway to further the understanding of the construction and later repair of the ship and also to examine the economics behind the use of these substances in the shipyards of medieval Europe.

Interpretation of the Newport material is supported by the analysis of comparative material from further archaeological sites (the Roskilde wrecks, Denmark; St Peter Port wrecks, Guernsey; Doel cog, Belgium) with different preservation conditions enabling the impact of both intra- and inter-site variability in burial environment to be compared.

GC/MS analysis of the Newport tars has shown them to be conifer-derived but of variable composition and different in some ways to tars reported from other maritime contexts (Robinson et al., 1987; Colombini et al., 2003; Connan & Nissenbaum, 2003). Light stable isotope analysis (δD and $\delta^{13}C$) have also been undertaken in order to refine origin of these tars. The first results of this study will be reported here.

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B8 Archaeobotanical Study of Ancient Food and Cereal Remains at the Astana Cemetery, Xinjiang, China

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Analysis of starch grain, phytolith and cereal bran fragments were undertaken to identify the food remains including cakes, dumplings, as well as porridge unearthed from the Astana Cemetery in Turpan of Xinjiang, China. The results suggested that cakes were made from *Triticum aestivum* while dumplings were from *Triticum aestivum*, along with *Setaria italica*. The ingredients of the porridge remains came from *Panicum miliaceum*. Moreover, we present direct macrobotanical evidence of the utilization of six cereal crops such as *Triticum aestivum*, *Hordeum vulgare* var. *nudum*, *Panicum miliaceum*, *Setaria italica*, *Cannabis sativa* and *Oryza sativa* in the Turpan region during the Jin and Tang dynasty (about 200-900AD). All of these cereal crops not only provided food for the survival of the indigenous people, but also spiced up their daily life.

B9 What Did they Eat in that Dining Hall? Evidence from Faunal Remains and Material Culture at Late Antique Sagalassos (SW-Turkey)

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Ongoing excavations of the Roman imperial Baths at the archaeological site of Sagalassos (SW Turkey) have revealed the modification of a large-scale *frigidarium* annex *apodyteria* into a dining hall in late Roman times. Along the south façade of the building, as well as in specific locations inside, a series of stratigraphical deposits was identified containing considerable amounts of food waste materials (animal remains) associated with concentrations of tableware for food and beverage consumption. These dumps illustrate the relative chronology of the use of the dining hall.

The archaeozoological analysis revealed that the faunal assemblages of these dumps largely consisted of sheep and goat remains, while pig and cattle remains were less numerous. Further, the skeletal element distribution of the goats and the sheep was very peculiar: the majority of the identified bones could be attributed to the hind leg, more precisely the meat bearing parts (pelvis, femur and tibia). All other skeletal elements, such as cranial fragments, vertebrae, ribs and elements of the fore limb were heavily under-represented; canon bones and phalanges were also mostly missing. In addition to this body part selection, it appeared that the hip joint (proximal femur) and the knee joint (distal femur, patella and proximal tibia) were also almost completely absent. Therefore, the faunal material evidenced that mainly special cuts of goat and sheep meat were served in the late Roman dining hall of the Roman Baths.

The study of the material culture from the relevant layers provided the chronological framework for these practices. Moreover, these collections represent a rare archaeological opportunity to document communal dining practices in action. The deposits are considered to have formed as a direct result of the festivities, representing not only a potential to reconstruct functional tableware sets, but also to extract information on social practices of the local community when wining and dining together. Apart from patrician diner settings, communal dining traditions represented the socio-cultural framework of eating habits in late antique society.

B10 Palaeodietary Reconstruction in the Human Remains Recovered from Roopkund Lake through Elemental Analysis and Estimation of Carbon and Nitrogen Isotope Ratios

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Present study is carried out in the bone samples collected from Roopkund Lake in district Chamoli Garhwal, Uttarakhand which is located at 5029 meters from main sea level in between Nanda Ghunghti and Trishuli peak. This historical site belongs to 9th century A.D. All the samples selected for the study were dried in room temperature as well as hot air oven at 32 degree Celsius. Cleaning, pretreatment and digestion process of faunal remains was followed through established scientific methods. Chemical analysis i.e. concentration of different elements such as calcium, strontium, barium, magnesium and zinc as well as isotopic ratios of Carbon and Nitrogen was estimated with the help of Inductively Coupled Plasma Spectroscopy (ICP) and Atomic Absorption Spectrophotometer (AAS).

The results obtained from the chemical analysis are significant. On the basis of concentration of different elements and ratios of Nitrogen and Carbon isotopes, the dietary habits of the peoples buried in the Roopkund Lake are identified, which is differing from sample to sample person to person. Besides this, the results are also significantly helpful for knowing the preservation status of faunal remains in Roopkund Lake. Finally this study also indicated the potentiality of chemical analysis for reconstructing the palaeodiet behaviour and preservation status of bone remains.

B11 EDTA-Solution Based Protocols for the Cleaning of Ancient Bone Bioapatite

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Isotopic signals obtained from ancient bone material are of great importance in archaeological research, providing information on chronology, dietary habits, and mobility. Typically, radiocarbon dating and stable isotope analysis is performed on bone collagen. The inorganic phase of bone, bioapatite, is often not considered for analysis as the isotopic signal may be influenced by the deposition of foreign minerals, while bioapatite itself may undergo recrystallization and ionic exchange (Hedges, 2002). Bone cleaning protocols using a weak acid, normally acetic acid, are capable of removing foreign calcite deposits, which are more soluble than bioapatite. However, acetic acid is incapable of selectively leaching less soluble mineral deposits such as fluorapatite. The complexing agent ethylenediaminetetraacetic acid (EDTA) provides an alternative to acetic acid. The fibrillar structure of collagen (Nudelman et al., 2010) ensures the relative protection of bioapatite crystallites in a basic EDTA solution. Furthermore, in an EDTA solution the dissolution rates of geologically deposited minerals, including fluorapatite, are much higher than that of bioapatite. The present study focusses only on bone material containing a significant amount of collagen, as recent research results have demonstrated, at the osteon level, the association between collagen and bioapatite preservation (Reiche et al., 2010). Different EDTA protocols have been tested on powdered bone material. These include, variations in solvent, working pH, dissolution times and temperature. Comparison of EDTA and acetic acid based protocols was done using attenuated reflectance fourier transform infrared spectroscopy (ATR-FTIR). Study of the infra red spectra clearly demonstrates that EDTA is less aggressive towards bone's collagen. The infra red splitting factor (IRSF), a crystallinity parameter calculated from the phosphate peaks in the spectrum, is commonly used to assess the degree of crystal growth and recrystallization (Weiner & Bar-Josef, 1990). Acetic acid treatments resulted in higher IRSF values, denoting incapability in leaching less soluble foreign mineral deposits. In contrast, bone powder treated using an EDTA solution presented lower IRSF values, close to those observed in fresh bone material. This study will also present the first preliminary radiocarbon dates on bone bioapatite using an EDTA protocol. Bone material, containing collagen, from a variety of time periods and locations was selected for comparative dating of collagen and EDTA-treated bioapatite.

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B12 Influence of Cooking on the Isotopic Signals of Fish Species

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Stable isotope analysis represents the principal scientific technique used in the reconstruction of ancient human diet. Characterization of human diet, based on stable isotopes, requires that the isotopic baseline, that is the isotopic signals of the consumed food groups, is established. Ideally, the isotopic baseline for mammal or fish species, consumed by humans, is based on isotopic data from bones of these species found in association with the human remains.

Different animal tissues will present varying isotopic signals (del Rio et al., 2009). The isotopic signal of fish meat will depend on its nutrient (carbohydrates, lipids, protein) and biochemical composition (e.g. amino acids or fatty acids). Fish, a major protein source, may also have high lipid content, with lipids having a significantly depleted $\delta^{13}\text{C}$ signal when compared with protein (Post et al., 2007).

Cooking may alter the isotopic signal of meat (Warinner & Tuross, 2009), not only through fractionation processes, but also through selective loss of macronutrients or biochemical components possessing different isotopic signals.

We investigated the influence of cooking on the stable isotope values of meat for two fish species (mackerel, which has a very high fat content, and haddock, which is low in fat) using three potential prehistoric cooking methods. The fish were boiled in a pot, grilled beside an open fire, or wrapped in leaves and clay and baked in hot sand. Cooking times and temperatures were monitored, and the cooked fish was tasted for palatability.

Stable isotope ratios ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) were measured on the meat and bone collagen of raw fish and compared with measurements obtained after cooking using the three different methods. Results will be presented together with a discussion of possible implications for the reconstruction of ancient human diet.

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B13 Paleogenetic Evidence from Dental Calculus: A New Approach to Archaeological Populations

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Both the diversity and evolution of human populations have been systematically analyzed through polymorphisms in the human genome and microbiome, with several microorganisms successfully analyzed to infer microevolutionary events of their host. The aim of the present investigation is to contribute to the study of human bacterial flora as indirect genetic markers of their host by evaluating a new source of genetic material: dental calculus. Electron microscopy studies have shown the presence of bacteria preserved in samples from different geographical and chronological context, stimulating the evaluation of this material from a genetic approach. Recent and archaeological DNA samples, some of them as old as 4,000 YBP, were successfully extracted and amplified following all the necessary control procedures for ancient DNA. Previous to the DNA extraction, the samples were treated with sodium hypochlorite to eliminate surface contaminant. The demineralization was performed with 0.5 M EDTA and the proteins digested in a buffer with proteinase-K. Protein and cell components were eliminated by phenol:chloroform:isoamyl alcohol (25:24:1) extractions and the DNA was finally precipitated with isopropanol. Species-specific PCR primers were designed to identify five bacterial species (*Actinomyces naeslundii*, *Fusobacterium nucleatum*, *Streptococcus gordonii*, *Streptococcus mutans* and *Porphyromonas gingivalis*). *F. nucleatum* was the most frequently observed species in all of the recent samples and in almost 40 percent of the ancient samples. In *F. nucleatum* we also observed the presence of two or more genetic variants from a single human host, which were identified by DNA cloning and sequencing. Given that the highest presence and variability was detected in *F. nucleatum*, this species emerged as a valuable target for future analysis.

In summary, genomic analysis of bacteria from dental calculus is a promising source of evidence for paleopathological and microevolutionary studies, focused either on microorganisms or on their human hosts.

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B14 Oral Microbiome Evolution in Prehistoric Chilean Populations Using Scanning Electronic Microscopy and Isotopic Analyses

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The human oral microbiome is composed by a myriad of bacteria species, representing an enigmatic ecological community. The oral microbiome emerges, consequently, as a valuable model to inference of diet, human populational genetic structure, oral health features, and microevolutionary processes, among other factors associated to this ecological system. In this study we explored the association among geographical distribution, paleodiet and bacterial communities in human populations from different archaeological contexts in Chile: Solcor 3 (San Pedro de Atacama, Northern Chile); Cuchipuy (Central Chile); Chonos (Southern Chile), in addition with the analysis of samples from living population. The main goal of this study is to evaluate the relative frequencies of bacterial morphotypes as predictors of diet and geographical distribution of the prehistoric populations. We tested the relative frequency of three bacterial morphotypes, using scanning electronic microscopy (SEM). Dietary regimes were inferred from archaeological evidence and from isotopic analysis ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) performed in this study, as well as from previous works. Differentiation in the oral microbiome was detected at the inter-population level for filamentous bacteria, which are most frequently found in San Pedro de Atacama samples. The causal explanation of this differentiation is still unresolved. Loss of differentiation of other morphotypes in relation to dietary or geographical distribution, including populational genetic structure, refutes our hypotheses, opening new insights on microbiome evolution in past human populations: taxonomic units (species), instead of morphotypes, should be the target of evolutionary, ontogenetic and ecological processes affecting oral microbiome, as a consequence of changes in cultural practices and genetic differences among past human populations. Grants support: Fondecyt 1100643, Fondecyt 1110461, Anillo ACT-096.

B15 Bees Wax and Propolis as Sealant of Funerary Chambers during the Middle Bronze Age in South-Western Iberian Peninsula

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Recent archaeological excavations in the Portuguese region of Baixo Alentejo, carried out under the implementation of the irrigation project connected with the Alqueva Dam, have brought to light important finds dated to the South-western Iberian Bronze Age. Among those new finds are funerary hypogea, dated from the second quarter of the 2nd Millennium BC, which show some similarities with those from the Argaric Culture (South-eastern Iberian Peninsula), namely as far as rituals, architecture and grave goods are concerned. Each funerary structure is composed by an atrium connected with a chamber (an artificial cave cut into the rock) closed by vertical slabs. These slabs are involved by a black earth with a greasy aspect, suggesting an organic origin. It was already known that some stone cists, another kind of grave in use during the Middle Bronze Age in South-western Iberia, also present a similar black greasy earth covering the cist stone lid (Paço & Leal, 1962/63). Earth of one of these graves was sampled and analyzed using infrared spectroscopy and gas chromatography. IR analysis indicated the presence of organic substances being the main constituent a fatty material of animal origin. The identification of cholesterol also proves that origin. The chromatograms obtained were compared with those of well known samples, indicating that probably the fat detected in the earth is that of swine (Ribeiro & Soares, 1991). The black earth with a greasy aspect that involved the slabs closing the chamber of three funerary hypogea from the archaeological sites of Horta do Folgão and Torre Velha 3, both near Serpa, were sampled and analyzed using a FTIR spectrometer. The spectra obtained were compared with reference spectra. Two materials were identified: bees wax and propolis. As far as we know is the first time that a mixture of bees wax and propolis with a clayey earth used to seal a funerary structure was identified in the archaeological record, suggesting the importance that the Middle Bronze Age people in South-western Iberia put in the preservation of the corpses buried in their graves.

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B16 Identification of Heme in Aged Blood by Direct Analysis in Real Time Mass Spectrometry

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Identification of blood on or in archaeological materials is often done using presumptive tests adapted from forensic applications. Clinical test strips, designed for the detection of blood in urine, are arguably the most utilized of such presumptive tests in archaeological science. In forensic science, however, presumptive tests must be followed up with confirmatory tests; presumptive tests suffer from high rates of false positives due to the presence of contaminants. Confirmation that a stain or residue is blood generally requires biological methods, such as DNA or immunological tests. We report here a novel method for identification of blood through mass spectrometric analysis of the heme moiety from the blood and muscle proteins hemoglobin and myoglobin.

Direct analysis in real time (DART) ionization combined with high-resolution time of flight mass spectrometry provides exact mass information about molecules up to approximately 1000 Daltons. While DART is not applicable directly to intact proteins, a novel sample preparation method developed in our laboratory yields a molecular ion for the permethylated heme porphyrin at m/z 644.2085. Blood samples applied to surfaces and weathered for multiple years produced reliable heme signal. Control materials without heme produced no heme signal. Further studies are currently underway to determine the applicability of this method to blood on lithic materials and we are optimizing collection of residue samples from archaeological materials.

B17 Stable Isotope Ratio Analysis Elucidates Urban Subsistence and Changing Animal Husbandry Practices at Ancient Sagalassos (SW Turkey)

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The present study is based on the analysis of the stable isotope ratios of carbon and nitrogen in both human (n=49) and animal (n=465) bone samples. These samples were obtained from the site of Sagalassos (Burdur Province, SW Turkey) and Düzen Tepesi (at 2km SW of Sagalassos) and are ranging in date from the Classical-Hellenistic period (400-200 BC) up to the Middle Byzantine period (800-1200 AD). Therefore, they witness a long span of occupation at Sagalassos and its immediate surroundings.

The aim of the research is to gather information on human dietary patterns and livestock management practices (such as herding, grazing and foddering) in the past within the territory of Sagalassos. While the human diet seems to be based on predominantly C3 plants and terrestrial (domestic) animals, the data of the animal bones samples show shifting $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values.

Diachronic comparisons of the stable isotopes ratios were carried out for the main domestic mammals, i.e. dog, cattle, pig, sheep and goat, and show how different grazing areas were used through time. In addition, the consumption of C4-plants by cattle is highlighted. These results are discussed in the context of previous interdisciplinary research (including archaeozoological, archaeobotanical and geochemical analyses) to elucidate the urban subsistence and the changing animal husbandry practices at Sagalassos.

B18 Stable Isotope Studies on Humans and Animals from Tell Tweini, Syria (2600-550 BC)

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Tell Tweini is a coastal Syrian site with settlement remains of diverse periods between the Early Bronze Age and the Iron Age (2600-550 BC). Inside urban contexts in Field A at the site, eleven burials have been unearthed. Most date to the Middle Bronze Age (2000-1600 BC), including one collective grave. Stable isotope ratio analysis ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) was carried out on human remains from these Middle Bronze Age graves in order to reconstruct human dietary practices. In addition, a large sample of faunal remains from the major periods of occupation at Tell Tweini, Early Bronze Age (2600-2000 BC), Middle Bronze Age (2000-1600 BC), Late Bronze Age (1600-1200 BC) and Iron Age (1200-550 BC) have been subjected to stable isotope ratio analysis. The large dataset on animals is the first of its kind for the period and region. The results add to a reconstruction of the human diet. More importantly, they allow us to make diachronic inferences on livestock management practices and the natural environment. The results will be discussed in the context of data on the faunal composition through time at Tell Tweini as well as that of the palaeo-environmental data which points to an abrupt climatic change at the transition between the Late Bronze Age and the Iron Age.

B19 Microstructural (SEM), Chemical and Molecular-Biological Investigation of Glass Decay at the Medieval Stained Window Glasses of Tarragona Cathedral and Santa Maria del Mar Church (Barcelona), NE Spain

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The medieval stained window glass of two religious medieval buildings (the Cathedral of Tarragona and the Church of Santa Maria del Mar in Barcelona), have been investigated and provided evidence of biodeterioration (Garcia-Vallès & Vendrell, 2002; García-Vallès et al., 2003). This biodeterioration was active under Mediterranean climate and affected more selectively potash-lime glass of inferred foreign origin than the local sodium glass of Mediterranean tradition (Aulinas et al., 2009). Biological activity in both sites showed to be fossil and only remains of this activity, as orange patinas, bio-pitting and mineral precipitation, was observed. Glass surfaces were investigated by Scanning Electron Microscopy (SEM), Energy Dispersive Spectrometry (EDS) and X-Ray Diffraction (XRD). Their chemical composition was investigated using wavelength-dispersive spectrometry (WDS) microprobe analysis. The microbial diversity was investigated by molecular methods: DNA extraction from glass samples, amplification by PCR targeting the 16S rRNA and ITS regions, and fingerprint analyses by denaturing gradient gel electrophoresis (DGGE). In parallel clone libraries containing either PCR fragments of the bacterial 16S rDNA or the fungal ITS1 region were screened by DGGE. Clone inserts were sequenced and compared with sequences listed in the EMBL database. Similarity values ranged from 89 % to 100 % to known bacteria and fungi. Analyses revealed complex bacterial communities consisting of members of the phyla Proteobacteria, Bacteroidetes, Firmicutes and the dominance of Actinobacteria. Fungi showed lower diversity than bacteria and species of the genus *Cladosporium* were dominant. The detected Actinobacteria and fungi may be responsible for the observed bio-pitting phenomenon. Moreover, some of the detected bacteria are known for their capabilities of mineral precipitation. Sequence results also showed similarities with bacteria commonly found on deteriorated stone-monuments, what supports the idea that medieval stained glass biodeterioration in the Mediterranean area shows a pattern comparable to those developed on stone.

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B20 Human Mobility and Diet in Iron Age The Netherlands

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In The Netherlands cremation is the most general practice for the burial of the dead from the Late Bronze Age (1100 BC) up to the 3rd-4th century AD. However, in recent years dozens of Iron Age inhumation graves were discovered amidst cremation graves in the Dutch Lower Rhine area. In this specific area inhumation of the dead seems to be a more common practice than elsewhere in The Netherlands. Until now, the presence of these Iron Age inhumations has had two different explanations: 1) the arrival of immigrants from the Middle-Rhine area (Early Iron Age) and 2) a broader cultural influence spread from the northern France Marne-Aisne area (Middle Iron Age). Evidence of exchange and trading has already been identified from the material culture. However, isotopic evidence for human mobility has not been assessed.

This project investigates whether these buried individuals were of local or non-local descent. In addition, carbon and nitrogen isotope analyses were conducted to investigate palaeodiet. Strontium isotope analyses are reported on 26 Iron Age individuals, mostly from burial sites in the Dutch river area. Preliminary results show that migration of people has taken place. Further research will try to identify possible areas of origin. The results of the isotopic analyses will be compared with archaeological data and interpretations from the grave-sites and with relevant previous Iron Age studies concerning subsistence economy and diet. The outcome of this research gives additional insight into the burial culture and quantifies the role of mobility within these Iron Age populations.

B21 A Dietary Point of View of Neolithic-Bronze Age Transition: Stable Isotope Analysis of Central France Populations

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This paper presents the study of diachronic dietary patterns of Prehistoric populations from Central France. Stable isotope measurement ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) on bone collagen is a relevant tool to understand, at individual and group levels, the environment from which dietary resources come from and the importance or not of animal protein intake. Following a research programmes started few years ago on West-Mediterranean populations (e.g. Goude, 2007; Vaquer et al., 2008), new stable isotope analysis were performed on Middle Neolithic and Early Bronze age (EBA) human groups located in Auvergne region (Research funded by Nestlé France Foundation; 2009-2011). Added to human, faunal remains were also analysed in order to define the environmental isotopic baseline for each period concerned. Auvergne region has recently seen development of bio-anthropological works thanks to several excavations, highlighting numerous tombs and well preserved osteological material. Combined to stable isotope analysis, environmental and archaeological data, anthropological features (e.g. sex, age at death, stature) allow understanding food choices within social and cultural aspects. Both adults (n=74) and subadults (n=45) from 4 archaeological sites, close from each other, gave well preserved collagen. $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of animal indicate a possible specific feeding between EBA bovine and caprine, and a distinction between the two period, specifically for $\delta^{13}\text{C}$. This $\delta^{13}\text{C}$ shift is also recorded between humans with highest values among EBA individuals. No $\delta^{15}\text{N}$ difference is highlighting between human groups; dietary resources, dominated by herbivores meat, and probably including aquatic fish for some individuals, seems to be equal whatever the period. These results could support a local environmental $\delta^{13}\text{C}$ modification between these periods, with more open fields (deforestation?) at the EBA.

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B22 Phosphate Extraction from Enamel and Cementum: A Revised Method

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The isolation of phosphate from biological and inorganic materials for the purposes of oxygen isotopic analysis has been employed in a variety of archaeological studies (e.g. Evans et al., 2006; Kolodny et al., 1983). Migration, dietary and paleoclimate investigations employing oxygen isotope analysis have benefited greatly from the isolation of phosphate, which is argued to be resistant to diagenetic processes (Wiedemann-Bidlack et al., 2008). Advancements in extraction techniques have been significant, primarily with the transition from isolating PO_4 as BiPO_4 to isolating it as the much more stable and non-hygroscopic Ag_3PO_4 (Firsching, 1961). Although methods have been developed for use on calcified biological materials (e.g. Crowson et al., 1991) and inorganic phosphate minerals (Vennemann et al., 2002), there is no agreement on the best technique. The extraction of purified Ag_3PO_4 from sub-milligram size samples of organic-rich material was recently published by Wiedemann-Bidlack *et al.* (2008) where they obtained biogenic oxygen isotopic compositions from <1mg samples. Here we report on a simplified method for chemical precipitation of Ag_3PO_4 from small (5mg) samples of enamel and cementum. The isolation of phosphate from cementum is an avenue for accessing late-life oxygen isotopic compositions, and expands on previous studies, which primarily focus on enamel and dentine. Our method has been tested on modern cows (*B.p. taurus*), and pre- and post- purified sample collection is being optimized for application on archaeological human teeth. Analysis of the resultant Ag_3PO_4 is ongoing and will be employed to create a standard for comparison between *in situ* micro-analytical oxygen isotope results obtained by Secondary Ion Mass Spectrometry (SIMS) and bulk analytical results obtained by Thermal-Combustion Elemental Analyzer (TC-EA)-gas source mass spectrometry for each tissue. Ultimately, this comparison should facilitate the comparison of enamel to cementum using the less destructive SIMS micro-analytical technique.

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B23 Potential of Direct Analysis in Real Time Mass Spectrometry for Rapid Characterization of Organic Residues on Ceramics

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GC-MS analysis of ceramic residues is a time consuming and expensive process that has the potential to yield important information about ancient diet and materials utilization. With the widespread availability of GC-MS instrumentation, more extractions and analyses are being carried out on large collections of ceramic sherds, often yielding results of questionable utility. A screening method for selecting only the most promising samples for rigorous analysis would save both time and money.

We report here on a preliminary study utilizing direct analysis in real time mass spectrometry (DART-MS) to identify specific biomarkers on ceramics. DART-MS is an ambient ionization method widely used for identification of small (<1000 Da) molecules on surfaces without sample preparation. Food materials – garum, olive oil, wine, chocolate, chili pepper, and corn-based beer – were applied to ceramic surfaces, dried, and divided. Half of the ceramic was buried for up to six months. Samples were analyzed using DART-MS to look for biomarkers of each material, specifically pyroglutamic acid, fatty acids and diglycerides, tartaric acid, theobromine, capsaicin, and maltol.

Sample handling was critical for the characterization of surface residues. Squalene from fingerprints and erucamide slip agent from plastic bags were the most common materials observed in the DART spectra, even when care was taken to wear gloves during processing and use foil for packaging. In some cases, burial and subsequent cleaning obscured or obliterated the surface residues. Other samples, especially the olive oil, were resistant to water-based cleaning, and were readily identified even in the presence of soil. Future work will involve authentic ceramics from archaeological contexts in Central and South America and ancient Rome.

B24 Isotope Geochemistry in Dutch Archaeology. The Application of Strontium Isotopes as a Proxy for Migration

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Migration has been subject to research and debate for many decades and has become a key component of archaeological thinking. The original concepts of waves of migration in archaeology were based upon the dispersal of cultural artefacts. This approach led to an active debate about the extent to which the archaeological record represents the actual movement of people or the diffusion of ideas. A new perspective on this debate is provided by the discipline of archaeological science. In addition to aDNA studies, the application of isotope ratios, in particular those of strontium, of mineralized tissue (bone, dentine (ivory) and enamel) is used to study migration, specifically at the individual level. Isotope research in archaeology has matured over the last three decades, proved its potential in numerous studies, and is nowadays one of the most innovative research fields in archaeological science.

Despite its international success and proven potential, isotope research has rarely been applied in Dutch archaeology. The major contributing cause is the absence of a bioavailable strontium isotope distribution map of The Netherlands, which is a fundamental component for data interpretation. This PhD project therefore focuses on the collection of data to create this isotope distribution map. Based on this map, the spatial variation in bioavailable $^{87}\text{Sr}/^{86}\text{Sr}$ in The Netherlands will be evaluated and the applicability of isotope geochemistry as a proxy for interregional mobility will be assessed. The data and the bioavailable strontium distribution map ultimately will lead to more insight into the cultural diversity of ancient populations throughout The Netherlands.

B25 Herculaneum Conservation Project: Characterisation of Archaeological Waterlogged Wood from Ercolano Site by Pyrolytic and Mass Spectrometric Techniques

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The Roman city of Herculaneum, Campania, Italy, in the shadow of Mt. Vesuvius was discovered accidentally in 1708 by a farmer digging a well. Herculaneum was a smaller town with a wealthier population than Pompeii at the time of the eruption. Initial excavations revealed only a few skeletons; it was long thought that nearly all of the inhabitants had managed to escape. It was not until 1982, when the excavations reached boat houses on the beach area, that this view changed. In the suburban area, archaeologists discovered several hundred skeletons huddled close together on the beach and in 12 boat houses facing the sea. Further excavations in the 1990s confirmed that at least 300 people had taken refuge in those chambers, while the town was almost completely evacuated.

The Herculaneum Conservation Project (since 2000) was undertaken in the conviction that the extraordinary challenges of conservation of the Vesuvian sites are an international responsibility and cannot be shouldered by the national heritage authority alone. The project is the initiative of the Packard Humanities Institute (Los Altos, California, USA) and aspires to conservation and to create new archaeological knowledge of the site, and to extend the appreciation of the site among the professional communities and the general public.

Our aim in this project is the chemical characterization of waterlogged archaeological wood. Chemical characterization is crucial to assess the decay of archaeological or historical wood. Traditionally, wood analysis and determination of the content of lignin and holocellulose is performed by means of reagent- and time-consuming wet chemical methods, which require a consistent amount of sample. Recently, increasing attention is given to instrumental analysis based on analytical pyrolysis and mass spectrometry applied to the characterization of archaeological wood. The evaluation of the degradation state of the analyzed wood is based on the comparison with sound wood of the same species by Pyrolysis-Gas chromatography/Mass spectrometry (Py/GC/MS), an analytical approach that achieves semi-quantitative results on the content of lignin and polysaccharides in degraded wood, on syringyl vs. guaiacyl ratio, and on the chemical structure of lignin, avoiding the long wet-chemical procedures that are commonly used in wood analysis, and allowing us to use a minimal sample size.

Part of the analysed wood structures presented residues of the original paint in different colours (white, blue red or gold). Characterisation of the organic binders was also performed by GC/MS in order to reconstruct the painting technique.

B26 Subsistence Stability in the Syrian Coastal Area from 2600-550 BC Inferred by Archaeobotanical and Stable Isotope Evidence from Tell Tweini

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The study focuses on the evidence of continuity and stability of the ancient subsistence in the period between Middle Bronze Age and Iron Age (2600-550 BC) in the Syrian coastal area. The main sources of evidence are the plant macrofossil assemblages, and stable isotope analyses of charred caryopses of cultivated cereals extracted from the cultural layers of Tell Tweini. The archaeobotanical assemblages are generally dominated by cultivated plants like wheat, pulses and especially fruits, namely grape and olive. The high amounts and abundance of grape and olive indicate clearly that they were of great importance for the plant economy of the site. Together with the remains of cultivated plants also a variety of wild growing plants, originating from wet environments, open habitats etc. was recorded. The stable carbon isotope analyses of cereal crops from the same assemblages show relatively little general variation of $\delta^{13}\text{C}$ throughout time. There is however variation of $\delta^{13}\text{C}$ within periods considering different crop species. Particularly during the Late Bronze Age ^{13}C is strongly depleted in free-threshing wheat compared to barley and emmer. This could indicate different crop production technology, such as irrigation of free-threshing wheat or even import of free-threshing wheat from other regions.

The plant subsistence and its relation to environmental change of the studied area is also considered in regional context using the evidence from the archaeobotanical database of Eastern Mediterranean and Near Eastern sites (Riehl & Kümmel, 2005).

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B27 Paleomicrobial Lipidomics: Mass Spectrometry-Based Discovery of Ancient Mycolic Acids

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The *Mycobacterium* genus, which is hallmarked by mycolic acids, comprises several human pathogens such as *Mycobacterium leprae* and *Mycobacterium tuberculosis*. It is estimated that more than one-third of the worldwide human population is *Mycobacterium tuberculosis* infected, with nearly two million yearly deaths caused by infections. The mycobacterial cell-wall skeleton is consists of various long chain lipid, glycolipid, arabinogalactan and peptidoglycan structures. Mycolic acids (MAs) are major (40-60% of the cell dry weight) and unique fraction of the cell envelope of mycobacteria that include the ancient causative agents of tuberculosis and leprosy. In the present study, we successfully analyzed the presence of free MA fraction and their derivatives by various analytical techniques as well as matrix-assisted laser desorption/ionization tandem time-of-flight (MALDI TOF/TOF), liquid chromatography coupled electrospray ionization mass spectrometry (LC ESI MS and nanoUPLC-nanoESI MS), thin layer chromatography (HPTLC) and MALDI LTQ Orbitrap imaging mass spectrometry (UV-MALDI IMS).

B28 Linking Milk Processing to Pottery Function in Prehistoric Anatolia: Diachronic and Regional Perspectives

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The organic residues in Prehistoric Anatolian pottery sherds primarily from the Neolithic and Chalcolithic periods have been previously studied by Richard Evershed and colleagues (Evershed et al., 2008). Results of this groundbreaking work provided clear evidence for milking processing and dairying from 7th millennium BC sites in Northwestern Anatolia. Our previous study of Barcın Höyük pottery which is a Neolithic/Late Chalcolithic NW Anatolian site confirmed the results of Evershed. Building on this pioneering work, our application proposes to take the results to the level of pottery assemblages themselves. This has not yet been done for the region concerned. Correlation of milk processing and its products with specific vessel categories will be the first reliable step into assessing pottery functions and meaning in prehistoric assemblages. The extracted organic residues are mainly lipids that have been preserved in the porous matrix of potsherds. The detection and identification of the lipid components has been accomplished by using high temperature gas chromatography (HTGC) and gas chromatography mass spectrometry (GC/MS). (GC-IRMS) is used to determine the compound-specific stable carbon isotopes ($\delta^{13}\text{C}$) of major n-alkanoic acids. Approximately 20 per cent of analyzed potsherds yield significant amounts of lipid residues. GC analysis yielded abundant distribution of saturated free fatty acids and minor amounts of di- and triacylglycerols indicating the presence of degraded animal fats. The GC-IRMS results of Barcın potsherds indicate that the majority of detected lipids originated from dairying fats with only few originating from ruminant adipose fats. The thin walled, mineral tempered ceramics from Neolithic Barcın Höyük is very suitable to sustain and regulate heat while cooking, and the processing of milk into curds, butter or yoghurt may well have been of crucial importance for the adoption of pottery in NW Anatolia. The first results of our project already indicate that it is foremost S-shaped globular cooking pots with flat bases and four vertically pierced knob handles placed on the belly diameters that give evidence of milk residues. Interestingly, also a small drinking cup is yielding unequivocal traces of milk residue.

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B29 Exploring Wine Production and Consumption in the Roman Villa of Sa Mesquida (Mallorca, Balearic Islands)

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Sa Mesquida is a Roman villa occupied in the Early and Late Roman periods. The presence of wine Roman amphorae suggested an important trade of this product with other Roman provinces. The most common types are the Dressel 1 and the Pascual 1 amphorae which are supposed to be produced in Italy and in NE Spain respectively. In addition, the presence of a deposit for liquids opened the possibility of the existence of a domestic/local wine production.

In order to confirm the presence of wine in the amphorae and to determine the substance contained in the deposit and therefore to know its function a new methodology for the identification of wine residues with gas chromatography-mass spectrometry (GC-MS) has been applied.

The identification of wine markers in the amphorae type Dressel 1 type and in the plastered coating of the vat allowed demonstrating that wine was both imported and produced at the site.

Furthermore, to better understand the origin of these amphorae, a set of five Dressel 1, one Tarraconense 1, and six Pascual 1 pottery sherds were characterised by X-Ray Fluorescence, X-Ray Diffraction and optical microscopy by thin section analyses. The results were compared with the large analytical database on amphorae available at the ERAAUB. They reveal that Dressel 1 amphorae were produced in several pottery workshops located at the Tyrrhenian coast of Italy whereas the two other types came from several workshops placed at the central coast of Catalonia, in NE Spain.

In short, this contribution combines organic and inorganic analyses of pottery in order to understand wine production and consumption in a small rural Roman site yet well connected to the mainstream commercial dynamics of the Empire.

B30 Morphometric Data on Bovine Remains (*Bos taurus* and *Bos primigenius*) Found in Chalcolithic Settlements from South-Eastern Romania

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The results of osteometric analysis of the bovine remains from the archaeological sites from Romania are reported. These sites dated from Chalcolithic period (5000-3500 BC) and belong to the following cultures: Precucuteni and Cucuteni from east, Boian and Gumelnita from south and south-east of country. The linear measurements (variables) were defined according to von den Driesch (1976) for anatomical elements as: humerus, radius, metacarpus, metatarsus, tibia, astragalus, phalanges. Variables used in this analysis are based on breadth of bones especially. Our study focuses two aspects: sexual dimorphism and body size in populations while trying a demarcation of the wild of domestic forms; the distribution of measurements tends to be bimodal, reflecting the existence of two distinct populations: one domestic and the other wild. The sizes of bovines from different sites are compared by histograms using logarithm size index and coefficient of variation. Although it is difficult to clearly assign individual specimens as wild or domestic bovines, the general patterns of distribution of measurements suggest that bovines from assemblages of Precucuteni and Cucuteni cultures are more robust than those from Gumelnita culture (e.g., higher values for Bd and Bp recorded on metacarpus). An insignificant difference was revealed between cattle from Precucuteni-Cucuteni cultural complex and Boian culture.

This study was supported by the Romanian research programs POSDRU/89/1.5/S/49944; CNCS – UEFISCDI PN-II-RU-TE-2011-3-0146; CNCS – UEFISCDI PN-II-ID-PCE-2011-3-1015.

VON DEN DRIESCH, A., 1976. A guide to the measurement of animal bones from archaeological sites. *Peabody Museum Bulletin* 1. Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge.

B31 Dietary Differences between two Postmedieval Nunnery Sites from the Southern Low Countries: An Investigation Using ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) Stable Isotope Ratio Analysis

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The aim of this project is to examine past diet diversity by comparing stable isotope ratio data ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$), measured from human bone collagen. The skeletons that were studied (N=69) are derived from the cemeteries of two synchronous, postmedieval (16th to 18th century) female monastic sites that were excavated in the southern part of the Low Countries in present-day Belgium. The sites represent religious communities belonging to different orders, inhabiting different environments (i.e. urban vs. rural).

The first site investigated is the Poor Clare nunnery, located in the centre of the former and present town of Brussels. The second is the Cistercian nunnery of Herkenrode, located in the countryside, in the province of Limburg, Belgium. Both sites were built and developed by contemplative orders. As known from historical sources, the Poor Clares at Brussels followed a rule of absolute poverty. They could not become, or remain, wealthy, or possess property, and were living from alms given by the local people. The almost opposite situation is true for the Cistercian nuns from Herkenrode, who, based on historical and archaeological sources, benefited from a rich lifestyle, possessing ample land and livestock.

Based on the results of the bio-archaeological study of the human remains, clear differentiations in demographic (age-at-death) structure, appearance and frequency of palaeopathological lesions were already noticed between the two sites. Possible inter-population dietary diversity will be further evaluated by comparing the ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) stable isotope ratio data from both sites.

B32 Dietary Patterns in the Mixed Lay and Monastic Population from the Postmedieval Carmelite Friary Burial Grounds at Aalst (Flanders, Belgium), and their Relationship with DISH

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Although studies on diet reconstruction using carbon and nitrogen stable isotope signatures ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) are numerous, little research is done on Belgian archaeological populations. The focus of this study is twofold. The first goal is to examine diet composition for a postmedieval mixed lay and monastic population, evaluating possible intra-population diversity by comparing carbon and nitrogen (^{13}C and ^{15}N) stable isotope data from different social, sex and age groups. The second goal of this research is the ^{13}C and ^{15}N stable isotope analysis of skeletons that display *Diffuse Idiopathic Skeletal Hyperostosis* (DISH), a condition of the vertebral column of uncertain aetiology, of which the most prevalent theory states that it is caused by a diet rich in animal protein. Stable isotope analysis is used to test whether such a high trophic level diet can indeed be linked to the prevalence of DISH.

B33 Paleodiet and Provenance of Marbles: Case Studies by Using Stable Isotope at the CIRCE Laboratory

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Stable isotopes of the four most abundant elements of living matter (oxygen, carbon, hydrogen and nitrogen) are tracers of many processes for a wide range of applications in the field of anthropology, ecology, food industry, archeology. In this paper different examples illustrating studies recently conducted at the Center for Isotopic Research for Cultural and Environmental heritage (CIRCE) of the Second University of Naples, will be showed. In detail, for different archeological contexts (Spanish and Italian Middle Age sites, Iron Age Italian site, Roman Imperial site), studies concerning analysis of the diets of populations of the past and the identification and characterization of the origin and provenance of marble artifacts will be presented. Carbon and nitrogen isotope analyses have been applied to collagen extracted from human remains of a necropolis, in order to verify the hypothesis of presence of meat or fish in the diet of populations and we have compared these findings with studies on the coevals sites. Moreover we present the results obtained from measurements of the isotopic ratios of carbon and oxygen of a group of 20 epigraphic artifacts, found in the early Christian church of Abellinum (AV) in order to determine the area of origin of lithoid and try to draw meaningful information for the reconstruction of the history of the church. All these studies have in common the use of these powerful natural tracers, which, with appropriate techniques, can be followed to access an infinite store of information.

B34 Paleodiet in two Archaeological Sites in the Atacama Oasis Inferred by Isotopic Analysis

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The Middle Horizon period in the Atacama oasis has been characterized mainly by the influence of the Tiwanaku state. Even though there is no evidence related to presence of Tiwanaku migrants in the archaeological sites of the Atacama oasis (Central-South Andes), there is evidence suggesting improvement of health and nutritional conditions of the local population during this period. At the same time, studies on the burials of some of the cemeteries from this period show important differences, in the offerings of a few individuals suggesting possible social status differentiation within groups of the Atacama culture.

The aim of the present work is to characterize the diet of individuals from the archaeological sites Solcor 3 and Coyo 3, and to evaluate the association of dietary patterns with social status according to offerings in their burials. Evidence from carbon and nitrogen isotopes would indicate ingestion of terrestrial diet, mainly based on the ingestion of rodents, camelids and vegetables such as maize, algarrobo (*Prosopis sp.*), chañar (*Geoffrea decorticans*) and some beans. Qualitative diet differences between high and low status individuals, with the former consuming more protein resources and the second ingesting a higher amount of maize is tested. Physiological adaptation to arid conditions or by the consumption of animals that have gut bacteria, that tend to increase the values of nitrogen on their tissues, are potential factors explaining the isotopic values founded and are here discussed. Grants support: Fondecyt 1080458, Fondecyt 1110461, Anillo ACT-096.

B35 Tracing Mobility in Early Medieval Populations Using Strontium and Oxygen Isotopes – A Case Study from South-West Germany

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In the second half of the 5th century AD, a new burial practice emerged in Central and Western Europe that entailed the creation of fresh burial grounds with inhumation graves oriented in an east-west orientation, and the placement of rich grave goods with interred individuals. There remains an ongoing debate regarding the origin and meaning underlying this burial rite. More traditional interpretations consider the richly furnished graves as remains of ‘Germanic’ immigrants (Bierbrauer, 2004). Newer perspectives criticize a sheer ‘migrational’ explanation and argue this new kind of burial practice is indicative of cultural reorientation of the local population in response to the social and political dynamics of the time (Fehr, 2008). In order to find out if the ‘founders’ of the cemeteries were immigrants, we use strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) and oxygen ($\delta^{18}\text{O}$) isotope analyses of tooth enamel and dentine recovered from individuals of different early medieval cemeteries in the region Palatinate in south-west Germany. Human isotopic values are compared to those obtained from domestic animals- also recovered from graves-, which serve to define the local strontium signature at each respective site.

First results of the $^{87}\text{Sr}/^{86}\text{Sr}$ isotope ratio measurements using MC-ICP-MS indicate that the values of the individuals dating to the earliest period of the cemetery Eppstein fall outside the local range. In the following period already about half of the sampled individuals fall into the local range while in the next period most seems to be of local origin. These results suggest that population movement and reorganization was somehow tied to the emergence of a new burial rite in the early Middle Ages.

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B36 Isotopic Life History of Neolithic People from Busan Gadeokdo Janghang Site, Korea

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This paper presents the dietary lifestyle of Neolithic people in Korea. Recently, a large number of human bones (46 individuals) were found in excavated cemeteries at Busan Newport, Gadeokdo Janghang site, which is an outstanding discovery in Korean Neolithic archaeology. There are also supposed grave goods such as pottery, red pigment, shell bracelet and jade accompanying the burial. We extracted isotopic information from human bone collagen using stable carbon and nitrogen isotope analysis, which was carried out on recently established stable isotope analysis laboratory (National Research Institute of Cultural Heritage, Korea). Isotopic results show the highly marine-based diet, as we expect the dietary input in this coastal area is mainly based on marine resources. Our isotopic findings will provide the invaluable information on subsistence economy, which may be based on fishing, animal hunting and plant gathering in this period. In addition, two different burial types are investigated at the site, and one type shows that individuals are found in bended position. Stable nitrogen isotope result implies that there is trophic level difference between different burial types. Although this is the preliminary study on this site, our study will open up potential to understand the 8000 year long isotopic dietary history of Korean Neolithic people.

B37 Morphometric Data for Suines (*Sus scrofa domesticus* and *Sus scrofa ferus*) in Chalcolithic Period from Romania

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This study is based on suines pig remains recovered in excavations of Chalcolithic (5000-3500 BC) assemblage from Romania belonging the following cultures: Petresti, Precucuteni, Cucuteni, Tiszapolgar, Cotofeni, Salcuta, Boian, Gumelnita. The discrimination between domestic and wild forms is often difficult due to the coexistence of these two forms in Neolithic period and it is possible that in archaeological samples occur hybrid forms which make complicated the identification. Our results reveal biometric data for suines remains and intend to characterize and distinguish interpopulational differences. We used relevant measurements recorded on different anatomical elements which were undergone statistical analysis. Linear measurements were defined according to von den Driesch (1976). A statistical analysis of recorded measurements has been attempted using bivariate and principal components analysis. The complet metapodials providing data on withers height are few therefore the withers height was established by means astragalus and calcaneus; the great wither height was detected in domestic pigs from Tiszapolgar Culture, for the other cultures were not find significant differences on this issue. The high degree of variability in characters emphasizes the presence of pig regional structures whose size varies but that fits the "palustris" type which characterized the Neolithic period.

This study was supported by the Romanian research programs POSDRU/89/1.5/S/49944, CNCS - UEFISCDI PN-II-RU-TE-2011-3-0146.

VON DEN DRIESCH, A., 1976. A guide to the measurement of animal bones from archaeological sites. *Peabody Museum Bulletin* 1. Peabody Museum of Archaeology and Ethnology, Harvard Univesity, Cambridge.

B38 The Use of Intra-Tooth Enamel $\log(\text{Sr}/\text{Ca})$ & $\log(\text{Ba}/\text{Ca})$ Sequences to Assess Animal Foddering Strategies

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Sequential $\log(\text{Sr}/\text{Ca})$ and $\log(\text{Ba}/\text{Ca})$ measurements of enamel samples from caprines have been examined in order to provide information on paleodiet and past foddering strategies. Faunal remains recovered from Pre-Pottery Neolithic-B site of Tell Halula (Middle Euphrates Valley, Arab Republic of Syria) were analyzed to help understand changes in feeding strategies during the earliest development of domestication and herding strategies. Modern plant samples from the tell Halula site and surroundings were analyzed as well in order to evaluate specific dietary categories. Results show that elemental concentrations cycle through the growth axis of the tooth. Some observed patterns could likely be explained in terms of seasonal variation in the availability of plants while other patterns additionally suggest herd management strategies (human control of animal food, foddering herds during periods of less available resources), with distinct individual histories. The data contain significant information for understanding the kind of management strategies developed for the first herds of domesticated animals. Moreover, this work shows the potential of the qualitative information provided by alkaline-earth elements in intra-tooth variation studies from hypsodont mammal species.

B39 Non-Destructive Trace Element Analysis of Human Bones to Examine Diet and Mobility

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While the theoretical basis for elemental analysis of human bone to study diet and mobility is well-established, the number of studies done is few and far between, especially with the increasingly wide application of carbon, nitrogen, oxygen, and strontium isotope analysis over the last 25 years. Nevertheless, elemental analysis of barium, strontium, and other trace elements can support isotope-based interpretations, and be of greater use in cases where bone collagen is not preserved. One potential obstacle for any elemental analysis research project is degradation and contamination of the mineral portion of bone. In virtually all previous studies the samples have been well-cleaned, ashed, and put into solution for analysis by ICP spectrometry.

Presented here are new studies done using X-ray fluorescence (XRF) spectrometry to non-destructively measure Sr, Ba, and other trace elements, along with major elements including calcium and phosphorus. This research was initiated by several osteoarchaeological cases where isotope analysis was not permitted due to its being destructive to human remains, an increasingly common issue in the Americas and other parts of the world. The first project was on 30 individuals from 4 prehistoric native American sites in peninsular Florida. The small amounts of variability among individuals at each site suggest little contamination, while the clear differences between the sites are most likely due to varying proportions of seafood in the diet.

This was followed by analyses of several hundred archaeological skeletal remains from several sites in Belize, one in Colombia, two in Peru, several in Bolivia, and a large number in both Chile and Argentina, all previously analyzed isotopically, and with interpretations made about the dietary importance of maize and/or seafood along with patterns based on sex and status. In comparison to Florida, these regions have much greater geological-based variation in Sr and Ba concentrations, which is partly assessed by analyses of faunal remains. Multiple analyses were done on each sample, both on the original surface and on a cross-cut section when possible, to check for potential contamination and variability. XRF results for samples with noticeable iron and/or zinc peaks are carefully studied since there could also be a related contamination effect on Sr and Ba values. Tooth enamel was also tested for some individuals. Both the reliability of this method of elemental analysis of skeletal remains, and its utility in studying ancient diets will be discussed.

B40 A View into the Lives of the Early Christians of Stavanger, Norway: A Palaeodietary Reconstruction Using Multiple Stable Isotopes (C, N, H and S) of Bone Collagen

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Stable isotopes chemically record information in bone about numerous aspects of past human lives, such as diet, residence and possible migration. Stable isotopes of carbon and nitrogen are widely applied for dietary reconstructions. Hydrogen appears to be a reliable independent trophic level indicator (Reynard & Hedges, 2008), while sulphur can indicate possible migrants in the population (Vika, 2009) and aid in diet studies (Nehlich et al., 2010). Stable isotope datasets are expanding as the method is increasingly applied, which carries importance for comparison between other regions or archaeological periods. However, few stable isotope studies have been carried out for palaeodietary reconstruction using Norwegian material (Johansen et al., 1986), and none from the south west coast. In 1968, excavations revealed Christian burials predating the construction of the Stavanger cathedral, dating to the Iron Age, Viking Age and Middle Ages. The Iron Age individuals, being the earliest Christians found in Norway, raise questions about their origin and the expansion of Christianity. Additionally, excavations in 1995 in front of the cathedral yielded post-reformation burials. As the human remains from 1968 became commingled after excavation, the contextual information was lost. Still, this assemblage comprises the opportunity to draw more information from these bones using archaeometric analyses, which can provide insight in past life at individual and population level in the Stavanger region through time. Stable isotopes of carbon, nitrogen, hydrogen and sulphur were analysed on bone collagen of 18 humans and 37 animals, including a wide range of species, such as cattle, sheep, chicken, seal and various fish species. Preliminary results from carbon and nitrogen stable isotope analysis indicate the presence of marine protein in human diet. Additionally, a clear trend of enrichment in both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ is visible from the Iron Age to the Middle Ages, although the consumption pattern changes again during the post-reformation period. The production and trade of stockfish during the Middle Ages possibly contributed to this trend. The pigs display a large variation in nitrogen isotope ratios combined with narrow carbon isotope ratios. The enrichment in $\delta^{15}\text{N}$ may be induced by the proximity to the sea, e.g. salt spray or coastal salt marshes, possibly affecting human isotope ratios. The hydrogen and sulphur stable isotope analysis is ongoing. These isotopes are expected to aid in quantifying sources of human diet (Parnell et al., 2010). Overall, this provides unique first insights into both animal isotope value ranges of the region, and changes in dietary habits through time.

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hydrogen isotopes of bone collagen in palaeodietary and palaeoenvironmental reconstruction. *Journal of Archaeological Science* **35**, 1934-1942.

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B41 “For Dust thou Art and ...” with Dust You Can Cure

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In traditional pharmacopoeias approximately 10-15% of pharmaceuticals are of mineral origin (Ackerknecht, 1971; Jeszke, 1996). The majority of them are the clay minerals (Wasilewski, 2009). These very widespread minerals were and still are widely used in traditional pharmacopoeias. In some societies particular groups of people specialize (or specialized) in this kind of healing (Czubala, 1984). In anthropological studies the eating clay minerals phenomenon is usually called geophagy and was often described (e.g. Reid, 1992; Abrahams & Parsons, 1996). However the mineralogical and biological studies on this matter still are very scarce. The subject is still interesting enough to be explored, described and explained.

This study is based on the instrumental analysis (X-ray diffraction) of several mineral drugs from different parts of Egypt, Peru, Romania and Poland. The aim of the research was to compare the mineral composition of the traditional and academic medicaments and to confront it with the proposed use of them. Together with the detailed bibliographical query (e.g. Halstead, 1968; Wilson, 2003; among others) it gave the answer to several question about the reasons for using of particular clays, the efficacy of such medicaments, the mechanisms of internal and external reactions with human organism, the use-risk and the reasons for traditional restrictions, etc.

It is significant that clays and clay minerals were and are still used for the same purposes in different times and regions. This diachronic and synchronic cultural convergence together with our scientific knowledge on their biological action can prove the so called “folk wisdom” in medicine and indicate its rational rather than superstition basis.

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B42 Diagenetic Assessment of the Trace Element Composition of Classical Period Bones – A Case Study From Apollonia Pontica (Bulgaria)

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Bone and other calcified tissues can be important archives of environmental and paleodietary exposures. Bone analyses based on archaeological sample material always hold the risk of generating invalid data, since the bones might have undergone severe decomposition processes during their inhumation period. A too advanced degree of diagenetic alteration reduces the success rate of usable archaeometrical results. In this study we analyzed trabecular bones, belong to individuals who had lived in Apollonia Pontica (Bulgaria) during mid 5th – 4th century BC. Using ICP-AES and ICP-MS the concentration of Al, As, Ce, Eu, Fe, Hg, K, La, Mg, Mn, Mo, Pb, Se, Sb, Sr, V, Y and Zr had been determined both in bones and soils samples collected from excavated site. Bone surface contamination was evaluated using sequential acid leaching that included distilled H₂O, 0.1 M acetic acid, and microwave digestion in concentrated HNO₃ as this procedure was used parallel for upper layer of bone's surface removed previously by drilling in order to estimate soil effect into bones in depth. The results show a selected group of metals to be enriched by up to factor 5 in the bone surface, indicating that these elements may have a higher contamination component. However, the results of sequential acid leaching experiments indicated that mechanical removing of upper bone layer and single acid leaching step was effective in removing most surface-enriched contaminants associated with soil.

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B43 Residual Analysis of Hellenistic Time Ammoraе from Apollonia Pontika (Bulgaria): A Preliminary Results

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The Greek colonization is ubiquitous Panhellenic phenomenon in 8th – 6th century BC. Many Greeks settled in non Greek territories where polises were founded. The Greek colony of Apollonia Pontika (today Sozopol) was founded at 610 BC by settlers from the Greek city of Miletus (nowadays Turkey) and according to ancient sources from 5th – 4th century BC the number of the inhabitants is about 3000. The ancient necropolis, which is located on the shore, 2.5 km south of the city, consists so far of over 1500 burials which are studied over the last 15 years. Grave goods consist mainly of pottery, with predominance of lekythoi and occasionally other vases for scented oils and wines.

In the framework of a larger project devoted to paleodiet, technology of production of metals (manly bronze) and glass artifacts in Greeks colonies in the Black Sea coast funded by the National Scientific Fund, some of the amphorae with resin residue founded at the bottom of these amphorae were sampled to carry out chemical analysis. High Performance Liquid Chromatography (HPLC, Waters “Aliace”) and Nuclear Magnetic Resonance (NMR, Bruker, 250 MHz) had been used for the determination of organic residues with the attention of recovering further information of the use of amphorae under this study. In particular analysis of the resin residues was aimed at understanding content of the amphorae and to verify hypothesis on the transport of wine, named “Retsina”. “Retsina” is well-known Greek wine with three-thousand year old tradition which is prepared with adding of extract from resin of Aleppo pine (*Pinus Halepensis*) (Manesis, 1996). Additionally this hypothesis was confirmed by such kind of analysis of modern resin residue from Aleppo pine (*Pinus Halepensis*) growth in Attica region (Greece).

Our previous analysis of resin residues from an ancient Greek amphora, found near Sborjanovo (NE Bulgaria) also shows trade contacts of Thracians with ancient Greek towns for wine supply (Surowiec et al., 2006; Zlateva et al., 2007).

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