Isotopic evidence for the early use of ceramics in cooking meats and processing milk from sheep and goats

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14b. Reciprocal interactions between archaeology and archaeometry focusing on characterization of ancient human settlements and their environmental impacts

This paper presents molecular and isotopic evidence for prehistoric subsistence practices associated with the earliest use of clay and manufacturing of pottery vessels in a narrow geographic corridor linking the Middle East with Central Asia. Through use of our recently-developed protocol for extraction, isolation and transesterification of free fatty acids from archaeological pottery[1], $C_{16:0}$ and $C_{18:0}$ saturated fatty acids with ratios consistent with degraded animal fats[2] were obtained from fired-clay and pottery fragments from Hotu and Belt Caves in northern Iran. These rock shelters, situated on the late Pleistocene shoreline of the Caspian sea in the foothills of the Alborz mountains, were excavated by University of Pennsylvania anthropologist Carleton Coon in the fall of 1949 and the spring of 1951[3,4]. The mid-Mesolithic to late Neolithic period human occupations from which these materials were recovered date between 4850 and 13250 calBC[5,6].

Compound-specific isotopic analyses ($^{13}C/^{12}C$) of $C_{16:0}$ and $C_{18:0}$ fatty acids surviving in 16 of 37 fired-clay and pottery fragments (43%) revealed ratios of $\partial^{13}C$ values consistent with those of modern ruminant milk fats and carcass fats of sheep, goats and pigs[2,1]. These results demonstrate that clay was used in cooking meats during the late Pleistocene and pottery vessels were used in processing milk from sheep and goats at the onset of the Holocene — the earliest direct evidence of these two subsistence practices reported in this region to date. These findings raise many questions concerning core and peripheral areas of independent economic innovation in western Eurasia, and draw attention to the compelling need for additional research into the role of ceramic technologies as a catalyst for a sedentary way of life in Central Asia following the last Ice Age.

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Assessing the effect of macrobenthos diversity on the mineralisation of sediment organic matter

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Through bioturbation, macrobenthos is known to indirectly control the fate of sedimented organic matter including its mineralisation through early diagenetic processes. The diversity of macrobenthos and more specifically coastal macrobenthos is now at threat to the rise of a large variety of human-induced disturbances. The consequences of a decline of macrobenthos diversity on sedimented organic matter mineralization are still largely unknown. Up to now, they have been mostly studied through an experimental approach consisting in the *in vitro* assessment of mineralisation fluxes at the water-sediment interface in the presence of an increasing complexity of macrobenthic assemblages [1]. This approach has most often resulted in the determination of slight unpredictable effects. It suffers from major drawback including the fact: (1) that macrobenthos assemblages are reconstructed at random whereas species extinction does not, and (2) the importance of diversity relative to other potential controlling factors is not assessed.

We will present another possible approach consisting in assessing the effect of diversity by carrying out comparative *in situ* studies. In order to unravel the effects of possible confounding factors, it should be coupled with a hierarchical approach, which consists in considering that the intensity of mineralization results from the superposition of the effects of different types of ranked factors: first abiotic factors, second the quantity of organic matter, third the quality of organic matter, and only fourth macrobenthos diversity. This approach allows for the assessment of the relative importance of all main potential controlling factors given that co-correlation between them is properly handled. It requires studying a large variety of ecological/biogeochemical situations, which is currently achieved within the framework of the French National program BIOMIN.

This on-going project consists in an interdisciplinary study including the assessment of: (1) abiotic parameters, (2) sedimented organic matter quantitative (e.g., C and N) and qualitative (Chl *a* and EHAA) characteristics, (3) bioturbation (bioirrigation and sediment reworking), and (4) mineralization fluxes (oxygen and nutrients). It is carried out in five main ecosystems located along the French Metropolitan coast, namely: (1) the Rhône River prodelta, (2) the extremity of the dilution area of the Rhône River, (3) The Arcachon Bay, (4) the Garonne River prodelta, and (5) the Bay of Biscaye.

We will first report on preliminary results obtained within the Rhône river prodelta. Based on these results, we will then use the hierarchical approach described above to assess whether or not taking into account macrobenthos diversity enhances the description of mineralization fluxes by abiotic parameters and organic matter characteristics.

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