Bone, Tools, and Traditions
15th WBRG Meeting (Paris, 2024)
Organized by Nejma Goutas and Marianne Christensen
Paris, Société préhistorique française, 2026 (Séances de la Société préhistorique française, 24)
pp. 235–240
www.prehistoire.org
ISSN : 2263-3847 – ISBN : 978-2-9588382-2-5

Hard animal material industries, archaeometry, and ethics: Towards a collective reflection on the judicious use of analyses and sampling

Industries des matières dures d'origine animale, archéométrie et éthique : vers une réflexion collective sur l'usage judicieux des analyses et des prélèvements

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Over the past decade, archaeometric analyses applied to hard animal material (HAM) industries and bone remains in general have seen significant growth (see O'Connor, this volume). At the intersection of archaeology, materials science, and biomolecular sciences, these analyses allow us to explore bone objects and materials in a new light, sometimes revolutionizing our understanding of the material cultures we study. These analytical methods hold significant heuristic potential when integrated into a broader reflection on bone assemblages. They complement traditional technological and zooarchaeological studies, which remain essential to our overall understanding of past societies' animal resource economies.

Certain techniques have proven particularly insightful. Isotopic analyses, for example, offer the opportunity to trace the movements, or migrations, of animals whose bones were sometimes chosen to manufacture bone tools at specific sites, providing insights into ancient community exchange networks and subsistence practices (e.g. Bocherens, 2015; Drucker et al., 2025). Another example is the scanning electron microscope (SEM), which enables residue analysis and, more broadly, has expanded our understanding of the microscopic world by providing high-resolution observation of bone surfaces and associated marks (e.g. Hannus et al., 2018).

We also note the increasing use of radiocarbon dating of bone productions which is highly effective in ensuring the authenticity of archaeological objects, understanding technical developments over time and space, or refining our chronological frameworks. It maximizes the chances of obtaining relevant dates because the anthropogenic origin of the dated artifact is indisputable, and the selection of dated objects can be based on typological, technical, or stylistic criteria offering assured or presumed chronocultural signatures (e.g. Pétillon et al., 2009; Wood et al., 2018; Manninen et al., 2021).

In recent years, approaches combining archaeological and biomolecular analyses have also advanced rapidly. Palaeoprotein analyses, by applying the ZooMS method, is one of the most employed approaches. ZooMS, pioneered by M. Collins and colleagues at the University of Copenhagen, now allows the taxonomic identification of materials through collagen analysis (McGrath et al., 2010). While sometimes limited to the family level (e.g. Cervidae), this method is invaluable when traditional diagnostic criteria are insufficient or impossible to use, such as with highly crafted objects. For instance, interdisciplinary projects like Paleocet and Magdatis, led by J.-M. Pétillon and V. Laroulandie on French and Spanish sites, illustrate this trend (McGrath et al., 2025). Across the Atlantic, we can mention analyses by F. Zangrado and his team on whale bones used for tool making (see Zangrado, presentation during the meeting). Complementary recent developments in paleogenetics are noteworthy and complement the palaeoproteomics studies. For instance, recent analyses on antlers and bone tools from Eurasian Palaeolithic and Neolithic sites have allowed to identify the taxa exploited by humans and enabled the first complete mitochondrial genome analysis of ancient DNA from deer antlers for the pre-Holocene period (Tejero et al., 2024).

These various analytical approaches provide critical data on craft practices, the chronology and dissemination of technological innovations, and the origin and circulation of raw materials. However, the relevance of results obtained through these analyses and, also those of their implementation require certain prerequisites. Close collaboration between archaeologists and analysts is essential to ensure reasoned and contextually informed sampling. This involves considering each method's limitations and possible biases, as well as critically assessing the discovery context and the integrity of assemblages. The relevance of a methodological arsenal, however sophisticated, depends on a thorough understanding of contextual data.

Invasive analytical methods, depending on the sampling method, raises also significant considerations in terms of heritage preservation. Archaeologists, analysts, and curators must collaborate closely to weigh scientific benefits of analyses against potential risks to artefact integrity and their preservation (see Chevallier et al., this volume). The same applies to the suitability of the questions posed by archaeologists and the type of analysis envisaged. This must be discussed among all scientific partners. Precise sampling protocols developed in concert between stakeholders should guide sampling in a manner that optimally balances conservation and scientific objectives. The idea is to identify the least visible areas of the objects, or those with little technical or functional information value, while considering their potential for successful analysis (e.g. Sinet-Mathiot et al., 2021).

While many invasive analyses now require minimal material quantities, there is often a temptation to sample more than necessary, which may not necessarily improve analysis success. In this respect, the implementation of innovative non-invasive or minimally-invasive sampling methods should be encouraged to ensure the integrity of objects and their availability for further analyses (e.g. Martisius et al., 2020; Tejero et al., 2023).

Pre-testing for collagen preservation, for example, can ensure the feasibility of dating and avoid unnecessary invasive sampling if dating is likely to fail (even on seemingly well-preserved objects). Moreover, it's important to resist the rush to analyze and prevent multiple samplings of the same objects by different research teams (e.g. Van der Sluis et al., 2023). Therefore, a sampling form should be attached to each object to allow for the monitoring of analyses and to avoid them being repeated unnecessarily.

To reconcile scientific and conservation interests, it would be beneficial to incorporate restoration of sampled objects into the project specifications, when relevant. Museums don't always have in-house restoration teams nor the means to finance external services, especially for osseous material requiring specialized expertise.

Lastly, financial constraints also shape analytical strategies, whether invasive or not. Analyzing a single object, regardless of the type of analysis, is often unsatisfactory because the robustness of interpretations relies on the sample's representativeness. This naturally leads to a desire to multiply analyses for a given layer or site. While many analyses are becoming increasingly accessible, costs remain a barrier for many researchers and institutions, not to mention the initial cost of acquiring cutting-edge equipment for local, regional, or even national autonomy in conducting analyses.

In conclusion, bone artefacts are fragile and, for some periods or contexts, numerically limited. Because we all recognize that this archaeological resource is not infinite, and as invasive analyses are poised to expand further, engaging in collective brainstorming on these issues is useful. Learning from our respective experiences, successful or not, can better guide our analyses and prevent the destruction or irreversible loss of information for future generations.

Following precedents established by studies on human remains (Alpaslan-Roodenberg et al., 2021; Orlando et al., 2021), the creation of a WBRG sub-working group dedicated to these issues appears timely. From such collaborative efforts, an international charter could emerge, providing guidelines that balance scientific advancement with ethical responsibility, minimise damage to artefacts, and ensure their long-term preservation. Such a framework would safeguard these unique and irreplaceable materials for the benefit of future research.

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