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Foreword

Avant-propos

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FOREWORD

Avant-propos

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Bone materials (bone, ivory, antler) are widely spread among museum objects, owing to their archaeological and artistic value, or because they served as raw material for art works. These materials play an important role among prehistoric remains belonging to the first materials exploited and transformed by humans. As biological materials, they have registered much information on the ways of life of ancient populations. Ancient bone materials are therefore key witnesses in the field of archaeology, paleontology, prehistory, art history, ethnology and museology.

In 2007, a research programme entitled “Improvement of conservation methods for archaeological bone material (ivory, bone and antler)” (ArBoCo) was initiated at the Laboratoire du Centre de recherche et de restauration des musées de France (LC2RMF – UMR 171 CNRS), Paris, and financed by the French National Research Agency and the project number ANR-07-JCJC-0149 during 39 months.

The aims of the ArBoCo programme were:

- to enhance the knowledge on archaeological and historical osseous objects,
- to improve existing analytical methods for a detailed characterization of these materials and objects, by emphasizing the least destructive approaches,
- to establish the know-how about the processes of transformation of the material into tools, works of art and symbolic objects at different time periods and to study the traces of use wear and tools at the object's surfaces, and
- to contribute to the understanding of alteration processes as well as to establish improved conservation strategies for these objects.

An analytical procedure taking into account the hierarchical structure of these composite biominerals from the macroscopic down to the nanometer level has been estab-

lished and applied to numerous sample sets from different archaeological or historical contexts. Because of the changes induced by alteration processes the analysis of ancient biomaterials is a real analytical challenge.

ArBoCo allowed the establishment of a complex analytical methodology, which combines different elemental, structural and morphological techniques at different scales:

- chemical microanalyses using electron microscopy (SEM-EDX) and ion beam analyses (microPIXE/PIGE) at the particle accelerator AGLAE, C2RMF in Paris;
- micro- and nanostructural characterization by means of transmission electron microscopy (TEM) and scanning micro-small angle X-ray scattering (microSAXS) imaging, as well as micro-Infrared spectroscopy using synchrotron sources, micro-X-ray diffraction (microXRD) and Raman microspectroscopy;
- micromorphological observations were carried out with scanning electron microscopy (SEM) and synchrotron-induced as well as laboratory X-ray micro computed tomography (microCT).

These physico-chemical characterizations were combined with palaeogenetic investigations and ^{14}C dating of the ancient samples.

The new experimental strategy allowed identifying different alteration phenomena of archaeological bone materials and approaching conservation-restoration issues of museum objects in a systematic way. Alteration phenomena were namely studied on material from the French sites of the Hôtel de *Mongelas*, Paris (medieval period) and *Chalain* lake, Jura (Neolithic period), from the site of controlled taphonomy in Neuadd, Wales, Great Britain (ca. 30 years), as well as the Chinese site of *Jinsha*, Sichuan province (ca. 2600 years).

We established new identification and distinction indicators of ancient bone materials based on their chemical composition on the minor and trace element level (by ion beam analyses) as well as relying on micromorphological differences (by microCT at the synchrotron and in the laboratory), namely for objects made of marine mammal bones and of mammoth ivory coming from two French archaeological key sites, the *Isturitz* cave and the *Pataud* rock shelter.

The effects induced by heating were also examined by micro IR spectroscopy, SEM, TEM and scanning micro-SAXS. They were compared to the features observed after diagenetic alterations to allow a better distinction of the modifications. This research was performed on Palaeolithic and Neolithic samples from *Song Terus* site, Indonesia, *Chalain* lake site, *La Pollera* cave and *Bize-Tournal* cave, France.

Traces of polychromy, consolidation products and finally the bone material itself of museum objects were studied. Objects were coming from the collection of the Louvre museum and were constituted of carved elephant ivory pieces dating back to the Phoenician period from the *Arslan Tash* site, Syria. Additionally, medieval chess pieces made of walrus ivory kept in the collection of the National Museums Scotland, in Edinburgh were studied.

Finally, a new formulation based on a treatment with aze-laic acid could be tested for the consolidation of artificially altered model bone samples. Additionally, consolidation tests were performed with classically employed products by restorers and the effects of these treatments were evaluated by the established analytical methodology.

The ArBoCo project coordinated by Ina Reiche, LC2RMF – UMR 171 CNRS, associated among other coworkers:

– Katharina Müller, Céline Chadeaux, Dounia Large, Fanny Buscaglia, Robert Galera and Anne-Solenn Le Hô of the LC2RMF, Paris;

– Matthieu Lebon, Carole Vercoutère and Antoine Zazzo of the National Museum of Natural History (MNHN) – UMR 7194 and 7209 CNRS, Paris;

– Aurélien Gourrier of the Laboratoire de Physique des Solides (LPS) – UMR 8502 CNRS, Orsay /European Synchrotron Research Facility (ESRF), Grenoble;

– Eva-Maria Geigl of the Institut Jacques Monod (IJM) – UMR 7592 CNRS, Paris;

– Jean-Marc Pétillon of the laboratory Travaux et Recherches Archéologiques sur les Cultures, les Espaces et les Sociétés (TRACES) – UMR 5608 CNRS, Toulouse;

– Gilles Chaumat of ArcNucléart, Grenoble;

– Ludovic Bellot-Gurlet of the Laboratoire de Dynamique, Interactions et Réactivité (LADIR) – UMR 7075 CNRS – UPMC, Paris;

– Gwenaëlle Le Bras-Goude of the Laboratoire Méditerranéen de Préhistoire Europe Afrique (Lampea) – UMR 7269 CNRS, Aix-en-Provence;

– as well as German and Scottish colleagues such as Andreas Staude, Heinrich Riesemeier of the Federal Institute of Materials Research and Testing (BAM), Berlin, and Jim Tate of the National Museum Scotland (NMS), Edinburgh.

At the end of the ANR programme ArBoCo, an international workshop was organized at the C2RMF, Louvre palace, Paris, in December 2010. This international ArBoCo workshop allowed drawing a balance of three years of active research and sharing the newly acquired knowledge of the field at an international scale with about seventy participants. Fifteen contributions presented at the workshop by international colleagues or partners of the French ArBoCo programme have been selected to be published here in this themed issue.

The ArBoCo partners kindly acknowledge the different laboratories and institutions that supported actively and enthusiastically this highly interdisciplinary research programme so that it became stimulating and successful, opening up new challenging research perspectives. We also thank all the participants of the international ArBoCo workshop for the interesting and fruitful scientific exchanges.