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Editorial

Journal of Archaeological Science: Reports – Special Issue:
Contributions of Experimental Archaeology to Excavation and Material Studies

Frederik W. Rademakers, Georges Verly, Florian Téreygeol, Johannes Auenmüller

Background to this Special Issue

This *Journal of Archaeological Science: Reports* Special Issue was prompted by the organisers of the Second International Conference on Archaeometallurgy ([ICA II](#)), which was held at the Lettres Sorbonne Université and École Normale Supérieure de Cachan in Paris, and the Plateforme expérimentale de Melle (CNRS, Institut de Recherche sur les Archéomatériaux) in the Poitou region, France, from 25 September to 1 October 2019. The conference was made possible thanks to the support of the Lettres Sorbonne Université (ED 1, FIR), CNRS UMR 8167 Orient & Méditerranée (team Mondes pharaoniques) and the MSH Paris-Saclay, and took place within the framework of the Collective Research Program: “*L’expérimentation paléométallurgique : de l’analogie à la modélisation*” (SRA Nouvelle-Aquitaine, French Ministry of Culture). The conference was organised by Georges Verly, Florian Téreygeol, Claire Somaglino and Frederik W. Rademakers, further assisted by Johannes Auenmüller, Adeline Bats, Roeland Paardekooper, Jean-Philippe Marnais and Jean-Charles Méaudre.

Beyond the institutional support which made this conference possible, the conference organisers want to explicitly acknowledge here the generous funding of the Michela Schiff-Giorgini Foundation and the sponsorship by Heminex.be, which both have enabled a substantial part of our work, including the reconstruction of the Kerma casting furnace.

While still focused on archaeometallurgy, this second edition of the ICA expanded its scope to other ancient materials and technologies and included sessions on agriculture and food production, animal and human remains, cartonnage and ceramics, as well as the mining and metallurgy of various metals. The connecting feature in all the papers presented was the use of experimental archaeology as a key part of the research methodology. The conference equally invited researchers interested in integrating experimental archaeology in their work, providing an open forum to discuss ideas and refine strategies and methodologies.

The formal conference was held on 25, 26 and 27 September at two locations in Paris. The first day, hosted by the Lettres Sorbonne Université, focused specifically on research taking place in the Nile Valley. The second and third days at MSH Paris-Saclay covered sessions dedicated to individual material categories, such as technical ceramics, precious metals and imaging techniques. These more conventional conference and discussion sessions were followed by experimental sessions held at the Plateforme expérimentale de Melle from 18 September to 1 October (Figs. 1–4). There, the conference participants gathered to set up, participate in, or witness a range of experiments, many of which were prepared in the months preceding the conference. These included the casting of bronze plates in a furnace reconstructed after a recently re-excavated feature in Kerma, Sudan (Bonnet 1986, 2004, Verly and Rademakers 2019, Verly *et al.* 2020), crucible-based copper smelting based on late prehistoric finds from Laos (Cadet *et al.* 2021),

exploring recipes of silver refining from the 16th century CE (van Bennekom *et al.* 2021), identifying ancient counterfeiting through 3rd century CE coinage moulds (Méaudre *et al.* 2021), and interpreting 3rd century CE alum based fake silver recipes (Ferrari *et al.* 2021).

Following the conference, participants as well as other scholars who were unable to attend were invited to submit their papers for the Special Issue presented here in the *Journal of Archaeological Science: Reports*. As for the conference, the use of experimental archaeology is central to all contributions. This current Special Issue is preceded by a first volume resulting from the First International Conference on Archaeometallurgy (ICA I), held in Brussels in 2015 (Verly *et al.* 2019). The 2015 conference focused more specifically on non-ferrous metallurgies and some of the theoretical principles underlying the methodology of experimental archaeology (see Téreygeol 2019, Verly and Longelin 2019 and references therein). This editorial does not aim to provide an overview of the long and interesting history of experimental archaeology, with its rich and varying traditions across the academic and non-academic world. Rather, it briefly explains the framework underlying this Special Issue, and provides an overview of the included papers.

Contributions of Experimental Archaeology to Excavation and Material Studies

Experimental archeology is primarily a research tool developed and used within interdisciplinary teams, often in relation to excavation sites. The first contribution of experimental reconstructions is to allow a better *a posteriori* interpretation of archaeological findings, structures and artefacts encountered in excavation. These attest to particular techniques employed in the past, which can be more comprehensively understood in themselves through experimental archaeology.

In addition to the interpretation of structural/architectural archaeological features, experimentation is used as a tool for the interpretation of man-made materials, such as metals, glass, ceramics, pigments and others, and the specific remains associated with their production. Experimental archaeology offers a tool by which hypotheses surrounding production remains can be tested. This *a posteriori* approach has been applied to the study of ancient production systems for many decades already and is indeed foundational for disciplines such as archaeometallurgy (e.g., Coghlan 1939, Crew 1990, Dungworth and Doonan 2013, Rothenberg 1990, Tylecote *et al.* 1977, Tylecote and Merkel 1985) and lithics research (e.g., Audouze and Karlin 2017, Johnson 1978, Keeley 1980, Spear 1980, Walker and Long 1977, Warren 1914). Gaining experimental experience – and thus a fuller understanding of any kind of prehistoric and ancient material culture – is also part of several university programmes in the context of dedicated classes at, e.g., the universities of Leiden, Exeter, York and Manchester, to name but a few. Furthermore, and next to several smaller undertakings, the EXARC network has to be mentioned for its organisation and promotion of experimental archaeology across an even broader horizon beyond the academic world.

A specific aim of the ICA II conference reflected in this Special Issue was to explore the possibility to go beyond the classical approach of experimentation as a test of hypotheses formed at the end of the excavation. Firstly, experimental experience can equally be positioned upstream of the fieldwork and it can be of great help to better organise excavation strategies (e.g., Timberlake 2015). Secondly, similar structures can be excavated later by the team that carried out the

experiments. This undoubtedly allows these exceptional witnesses to be investigated more thoroughly and more data to be recorded. This *a priori* approach is, however, not yet fully integrated in experimental archaeology. As such, this Special Issue not only illustrates the utility of experimental archaeology in understanding a range of archaeological materials, but equally highlights the important contributions experimental archaeology can offer to the practice of archaeological excavation.

In this regard, some key questions can be formulated:

- How does experimentation improve the ‘reading’ and understanding of complex structures, e.g., those related to material production activities?
- What can the individual acts and processes of experimentation contribute to the various acts and processes of excavation (and vice versa)?
- How can archaeological structures be interpreted in terms of the particular requirements of a reconstructed or reconstructible craft?
- Can the use of historical texts contribute to the (re-)construction of experience and enable our sensory development for a better reading of the field?
- How can particular production chains be experimentally approached for which little or no archaeological evidence exists?
- How can we expand from craft structures to the micro-economy of a whole site?
- What are the human means put into place at the time to meet production requirements?
- How does experimental taphonomy influence our approach to sites and structures?

Each question constitutes an avenue for reflection and this list is of course not exhaustive.

An important point to stress here is that the extent to which experimental archaeology is elaborated can vary significantly, but even at different scales it can provide a useful contribution if evaluated carefully. As outlined by Verly and Longelin (2019), there are several phases through which a fully developed experimental protocol should go: gathering and evaluating the source materials, defining an interdisciplinary field, defining the *teleologies* for each individual element of the experiments, proposing a strict work protocol, defining the observation and registration methods, running the experiments and gathering data, testing and refining hypotheses, analysing results and publishing.

An experimental protocol matures over time, with the interdisciplinary team gaining experience and improving their protocol accordingly. As such, it may take many years before an experimental setup is adequate to fully address the questions initially set out by the team. However, the results of the learning phases from the preceding years are equally interesting, and worth publishing along with the guidelines set out above. Indeed, experimental work will rarely offer any final answers, but rather it will refine the hypotheses to be tested. The papers collected in this issue reflect this inevitably continuous state of research that characterises experimental archaeology: some papers present the first results of an experimental approach, while others offer the digests of many years of experimental replication. As editors, we are very happy to present a variety of contributions reflecting the nature of experimental archaeology in this way.

Overview of contributions

This Special Issue includes the following papers, in order of appearance:

Hodgkinson and Bertram (2020) present an experimental approach to the production of glass beads at Tell el-Amarna, Egypt, during the New Kingdom (c. 1550–1070 BCE). They draw on (indirect) iconographic evidence as well as excavation data to test whether such beads could be made in small-scale, non-specialised settings, which are expected to leave only ephemeral evidence in the archaeological record. They discuss their results in light of broader technological traditions attested in Egypt during this period, and within Amarna more specifically, and outline further work required to better understand this hitherto little studied technology.

Téreygeol *et al.* (2020) publish an experimental series on the use of a reverberatory furnace for silver ore smelting during the colonial period in the Andes, based on data obtained while prospecting 17th century settlements in the Bolivian Lipez. This series, which ran from 2010 to 2015, allows to observe the mode of operation of this type of furnace for the first time. The repetitions of the experiment make it possible to appreciate the performance of the apparatus. These experiments also enabled the researchers to produce an analogical structure leading to a better interpretation of the remains in the field.

Leroy *et al.* (2020) introduce the first experimental reconstruction of an Angkorian iron furnace dating to the 13th–14th century CE. On the one hand, the study aims at a better understanding of the smelting technology evidenced by the furnace itself, for which structural elements are often missing in the archaeological record. On the other hand, the experimental products provide a guide to the interpretation of the archaeological finds not only from a technological perspective, but equally towards provenancing and dating those finds. Finally, the experiments offer a platform for communicating research to the community and exchanging knowledge with local archaeologists.

Bats (2020) has developed a new *chaîne opératoire* for Egyptian Middle Kingdom (c. 2050–1900 BCE) bread production based on an integrated study of iconographical sources, archaeological evidence and a series of experiments in which earlier ideas and new protocols were tested and/or (in-)validated. Bats not only shows how the shape of the Middle Kingdom bread moulds informs about their horizontal position during firing and baking, but also how and when the unbaked bread dough was filled into the repeatedly used moulds. The use of “old wheat” and low gluten flour made from emmer and of a sourdough starter greatly facilitated the successful baking of bread according to the Egyptian evidence. The project has received public attention as it was prominently featured in the [Spanish National Geographic](#) online magazine in February 2021.

Disser *et al.* (2020) focus on changes in the chemical signature of slag inclusions introduced during smithing. Their experiments are designed to evaluate the influence of a smithing flux on the inclusions encountered in bloomery iron, while equally testing the efficiency of different flux types. Furthermore, an elaborate analysis programme is integrated within the experimental protocol, and the authors offer a detailed overview of the workflow for statistical treatment of such provenance data. As such, they provide a data processing method for the efficient identification and analysis of slag inclusions.

Chantran and Cagnato (2021) have established a reference collection for the interpretation of cooking traces through experimental archaeology. Cooking vessels were used for boiling, frying and roasting experiments and subsequently subjected to use-wear analysis. Starch grain extraction for optical microscopy analysis acted as a complementary method to establish criteria towards distinguishing different cooking methods. The diet study of early Medieval Couzan provides an example of this multidisciplinary methodology, highlighting important advantages as well as possible limitations.

Van Bennekom *et al.* (2021) conducted an experimental series on the question of silver refining in the Netherlands (17th century CE), based on the work of the silversmith Adam van Vianen. The research question arose following the analyses carried out on these silverware pieces and the experimental protocol was set up with the help of a set of three recipes reported in the *Proberbüchlein* of Calbus of Freiberg and the treatises of Lazarus Ercker. The mastery of test furnaces and refining techniques acquired over a long period of time (Téreygeol and Thomas 2003) made it possible to carry out a series of experiments showing the relevance of the proposed solutions to obtain a fine silver. Questions remain open, notably on the bismuth content.

Ferrari *et al.* (2021) present another way of experimentation that is directly integrated in laboratory practice. Here, we find the experimental dimension well known to chemists. The Leiden papyrus recipe collection from the 3rd century CE provides the starting point for this work. This time, the texts are questioned in their operational dimension. The experimental series has shown that far from being a fanciful recipe, the use of alum with copper scraps makes it possible to produce an alloy with silver and thus confirms the title of the recipe which aims at increasing the mass of the metal.

Workman *et al.* (2021) have conducted iron smelting experiments on the basis of early Iron Age evidence from Tell es-Safi/Gath, Israel. Their contribution exemplifies an approach in which structural remains for smelting (furnace) and smithing (hearth) activities are missing from the archaeological record. Drawing on a detailed characterisation of production waste from the ancient workshops, they have developed experiments to evaluate mineralogical and microstructural changes occurring in technical ceramics during bloomery smelting in a simple 'bowl-style' furnace. These serve as a reference guide for the detection of invisible hearths and furnaces, represented by the inner vitrified wall fragments of such structures.

Hunkeler (2021) reports on the cartonnage fragments found in tomb KV40 in the Valley of the Kings in Western Thebes, Egypt, and provides insights into the 22nd Dynasty (c. 945–720 BCE) dating and typology of the respective coffins. A thorough review of earlier hypotheses on the manufacture of cartonnage and an in-depth study of the fragments from KV40 and of a further data set from close-by Dra Abu el-Naga enable the author to propose fresh ideas about materials as well as manufacturing and decoration procedures of this particular type of Egyptian coffin. In the following, an innovative experimental study is presented that not only aims at gaining a better understanding of the materiality of cartonnage itself, but also at comprehending the highly fragmented state in which the fragments in KV40 were encountered due to their exposition to fire and moisture.

Verly *et al.* (2021) present the digested results of many years of experimentation on copper smelting furnaces from Middle Kingdom Ayn Soukhna, an Egyptian logistical hub and harbor on the Red Sea shore. The paper focuses on the identification of the fuel used in smelting, which is rarely targeted specifically in archaeometallurgical studies. Through an iterative protocol of experimentation, excavation and archaeometric analysis, the authors identify the combined use of fresh wood and donkey dung as the fuel of choice at Ayn Soukhna. Their work offers a detailed example of experimental archaeology informing excavation practices and vice versa, and the utility of integrating such an iterative approach in the long-term agenda for archaeological fieldwork.

Cadet *et al.* (2021) have organized a first ambitious approach on copper smelting techniques in Laos for the late Prehistoric Period. It is a rare attempt in more than one respect. Firstly, the ores chosen include chalcocite in addition to the classic chalcopyrite and malachite. Secondly, tests on the ore charge assembly led successfully to the production of matte and metallic copper. Finally, the crucibles were reproduced to show by analogy that the use of unfired ceramics seems to have been favoured.

Loepp (2021) presents a critical and detailed assessment of two copper salt bonding recipes reported by Dioscorides and Pliny and the surface treatment of gold objects based on the Leiden papyrus. Through a detailed documentation of the experimental replication, this paper offers a practical reading of ancient recipes from a goldsmith's perspective. The experimental protocol further involves (micro-)analysis of the experimental products in the evaluation of working hypotheses and sets out important guidelines for the identification of gold working techniques on ancient artefacts.

Ars *et al.* (2021) present one of the few approaches to what can be called virtual experimentation. Using virtual modelling, the authors clearly demonstrate the constraints related to ventilation in a 16th century CE French mine at Sainte-Marie-aux-Mines. Importantly, these tests strongly reinforce the hypotheses established during excavation, highlighting the existence of an artificial ventilation system that had never before been characterized during excavation but of which Agricola (1556) reported in his *De Re Metallica*.

Méaudre *et al.* (2021) discuss the discovery of a 3rd century CE brass workshop associated with the production of counterfeit money in the north of France, which provides the necessary material for thorough considerations on the production processes of counterfeit money. This reflection focuses mainly on how clay moulds were produced allowing to copy the coinage. The success of coin casting also opens up future thoughts on monetary quantification. Finally, the implemented casting processes leads to a reconsideration of certain artifacts from the excavation that could be similar to fragments of the clay envelope holding the stacks of moulds.

Concluding remarks

The first two colloquia made it possible to define a methodology and to demonstrate the importance of experimental archaeology not only as a toolkit to test and understand materials and production chains, but also as a developed instrument prior to excavating – and thus for the most part destroying – any archaeological remains. The better excavators understand the remains and findings in their individual function, development and taphonomy, the better their excavation and documentation strategy. A third colloquium is planned to address specifically the interaction

between the relevant disciplines, such as History, Archaeology, Numismatics, Chemistry, Physics and Natural Sciences. The relationship of these disciplines to experimental archaeology is already apparent in several of the papers presented here. The third conference will highlight the opportunities for multidisciplinary research supported by archaeological experimentation.

Some finishing thoughts are to be taken into consideration for future research. In particular, we need to:

- Develop dedicated places like experimental archaeology platforms to allow the scientific experimental approach to develop and mature over time
- Multiply and repeat experiences
- Use materials that meet the requirements of archaeological *teleologies*
- Reproduce the experimental protocols close to the excavation sites as well as in experimental structures linked to centres for archaeometry research
- Create multidisciplinary teams with access to laboratories to develop protocols, excavate structures and analyse samples during all research phases
- Understand the iterative character of experimental work in order to propose a specific operating chain and not an absolute operating mode
- Exclude from the objectives of experimental archaeology: the assertion of a precise production figure, production according to profitability (a modern notion), the assertion of a single action, etc.
- Understand the vitality and potential of the experimental approach to answer questions concerning history, archaeology and archaeometry

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Figure 1: The central structure at Melle, within which a large forge and closed ovens are housed (left) and visitors to the experimental platform (right).



Figure 2: A reconstruction of Late Prehistoric smelting in Laos by Méli^{ssa} Cadet and colleagues.



Figure 3: A gold experiment in a portable furnace by David Loepp (left) and a silver refining experiment by van Bennekom and colleagues beneath the central structure at Melle (right).



Figure 4: A reconstruction of the Kerma bronze casting furnace by Georges Verly, Frederik Rademakers and colleagues.

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