Casting Experiments and Microstructure of Archaeologically Relevant Bronzes

The book presents results of an archaeological experiment, the aim of which was the creation of a reference collection of bronzes which can be used for determination of prehistoric production methods.

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Quanyu Wang and Barbara S. Ottaway, have published the results of a sound archaeological experiment in a mainstream archaeological series, which happens all too rarely. This publication will further not only the understanding of the microstructures of cast bronzes, but also the importance of experimental archaeology as a methodology in mainstream academic archaeology.

The main aim of the authors was the creation of a reference collection of archaeologically relevant bronzes, cast in different mould materials, with controlled variables such as composition, pre-heating of the moulds and subsequent quenching. The reference collection of the recorded microstructures can then be used for determination of prehistoric production methods, when compared to microstructures from prehistoric objects.

After a consideration and summary of previous work carried out on the experimental casting and microstructural analysis of bronzes, the compositions, mould materials, and methodology are introduced. The authors emphasise the importance of not repeating work which has been carried out already, and give this as one of the reasons for their selection of alloys, moulding materials and cooling regimes. Although a substantial part of experimentation should include repeat experiments by different experimenters, the authors in this case wanted to tread new ground.

The moulding materials used were sand, clay and bronze and the methodology and results are described in the central chapters of the book. For each mould material, the mould making, casting, grain size, dendritic arm spacing and micro-hardness are summarised. A further three chapters deal with the comparison of the microstructure and the malleability of the metals cast in the three different moulding materials, and the behaviour of the alloying elements tin and lead, during melting and casting.

The same object (a flat axe) was cast throughout the experiments, in order to obtain comparability of results and standardisation. All the experiments were carried out in a modern foundry using a clay graphite crucible and an induction furnace. For health and safety reasons, it was not possible to carry out the experiments actually in the open air. However, a similar experiment, published in German in 2002, (Jochum Zimmermann, Kunzler-Wagner and Kunert 2002, 292) which is not referred to in the present volume reviewed, has shown that the only difference between the microstructure of objects cast under modern conditions and ‘prehistoric’ conditions, is the increased occurrence of gaseous inclusions and porosity.

The pattern used to make all the moulds, was made from pine and was varnished to avoid shrinkage. The first mould material used was sand, in this case floor sand and Mansfield sand, which have added petroleum based oils. An alternative would be to add linseed oil to the mixture (Jochum Zimmermann, Kunzler-Wagner and Kunert 2002, 292), which might be more authentic but unlikely to have been used in prehistory, due to the probable value of oil (Jochum Zimmermann, Kunzler-Wagner and Kunert 2002, 292). The effect of the type of sand on the microstructure was not addressed in either study. Other variables like the clay and water content as well as the compactness of the sand were identified and controlled. A modern cope and drag box was used to hold the sand.

Clay was the second mould material used. High silica industrial fire-clay was used, with 20% saw dust. However it is unclear if the clay was weighed dry or wet when the proportion of saw dust was added. The clay moulds were fired at 700° C, and different pre-heating regimes and cooling regimes were used.

The third mould material was bronze. There is still a lot of debate regarding the exact function of bronze moulds found in the archaeological record. They are sometimes interpreted as having been used for casting wax or lead models, and sometimes as having been used for casting the actual bronze objects.

In this experiment the exact function is less important as the aim is to create a reference collection of bronzes cast in different mould materials.

In total 84 flat axes were cast in sand, clay and bronze moulds. Twelve different alloyed compositions were used, as well as different pre- and post-treatments (preheated, un-preheated, air-cooled and water-quenched). This large number of variables meant that even with a comparatively large sample size, there are no two axes treated in the same way, which makes it difficult to come to any firm conclusions. It is a well known problem in experimental archaeology, that the sample size is often inadequate due to time and cost constraints. Sometimes it might be better to reduce the variables, in order to obtain results which might be more statistically significant.

A series of experiments similar to the one under review here (Wang and Ottaway 2004), has also a sample size which is too small for statistical analysis. Despite these problems, both experiments show common trends, which they also share with other casting experiments. The cooling down happens much faster in the bronze moulds, and the clay moulds are the slowest to cool down. The cooling times for sand and stone moulds (for the latter see Jochum Zimmermann, Kunzler-Wagner and Kunert 2002) lie between the bronze and clay moulds. The speed of cooling does have an effect on the microstructure, as the dendritic arm spacing in the objects cast in the bronze moulds is much smaller than that seen in the objects cast in the sand and clay moulds.

The present study also looked at the difference in workabil-
The archaeology of Alderley edge

This book presents the archaeology of an area rich in copper mining of various periods from the early Bronze Age to the early Industrial in Yorkshire, England.

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This BAR report covers the landscape study of Alderley edge which aside from surveys and excavations of selected sites which is normal for such landscape studies included a short programme of experimental demonstrations held on open days in order explain the work of the archaeologists to the public.

Two elements of the actual mining techniques were explored. The first was the use of fire setting, held over a period of two days. This is a widely known but often misunderstood technique especially as it fell out of use with the introduction of steel mining tools and more importantly the introduction of explosives. The basic source used in fire setting experiments is Argnicol’s De Rea Metallica. In the case of the Alderley edge experiments this source was supplemented by experience gained by one of the participants (S. Timberlake) in similar experiments on other sites. In general the experimenters concluded that the effects of fire setting occur in the first few hours of the burn with rock shattering caused by the expansion of water held within the rock and that the only reason for dousing the area with extra water is to cool the area quickly and remove a lot of the waste.

The second mining technique looked at was the construction of stone hammers as are thought to have been used during the Bronze age. This consists of two elements, the hammer stone itself and the binding or handle. Alderley edge has produced many examples of Hammer stones and it was these that were reconstructed, particularly those with a distinctive groove which, it is presumed, was used to help secure the handle. The handles’ form though is more problematic, in general the model used is that of the Chuquicamata hammer, held in the British Museum, from South America. Although an alternative style was used that had been developed during experiments at other sites, but which lacked either ethnographical or archaeological parallels. The hammers were then used in conjunction with antler picks to break up and remove rock in and around the areas that had been fire set.

The third area of experimentation in this study was the smelting of ore obtained from the locale in kilns modeled on those used in the early Bronze age. The aim of these experiments was to explore the temperatures possible with this technology and the likely achievable yield from the local ore. In addition

Wagner and Kamnert 2002, builds a great start for a reference collection of archaeologically relevant bronzes. With more research, we might one day be able to understand the casting technology and mould material used and the choices people made, simply by looking at the microstructure of the objects.