

# Experiential and experimental archaeology with examples in iron processing

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## Introduction

Experimental archaeology has experienced a great deal of attention in recent years from both professionals and lay people. As is usual with a rapid growth in interest, misunderstandings abound. In order to clarify the principles of experimental archaeology a distinction will be drawn from closely associated experiential archaeology and then some excellent examples of well informed experimental archaeology related to iron processing will be reviewed. The intention is to clarify by explanation and example a simple definition of experimental archaeology.

## Experiential and Experimental

Experimental Archaeology is a term that is used so frequently and so variedly, with different meaning and scope by different sources, that it is almost worthless as a descriptor. Over time progressive attempts have been made to define the term. Looking at them diachronically a clear maturing of the definition of experimental archaeology can be seen; it can be said to be 'coming into focus'.

The most recent work reviewed for this paper was that of Mathieu (2002), wherein he lays out a fairly detailed typology for categories of experimental research. His description allows for the categorization and understanding of a very broad range of experiment types to test different hypotheses within archaeology and is very useful in giving a perspective on the scope and usefulness of the experimental approach to archaeological interpretations.

Mathieu and the majority of the sources reviewed also sought to define clearly what makes experimental archaeology different from other approaches to understanding and interpreting material culture. This difference between true archaeological experimentation and other activities can be difficult to see without looking closely at some of the related activities and comparing them in light of their purposes, procedures and results. In conducting the overview, the work of Reynolds (1999) will be heavily drawn upon as it is of a similar scope and the divisions he suggests agree well with this author's own way of looking at the matter. Two closely related, often even intertwined, groups of activities commonly fall under the general label of experimental archaeology. Partially borrowing from Reynolds (1999), they will be labelled 'experiential' and 'experimental'.

## Experiential Archaeology

Experiential archaeology is concerned with realistically performing tasks in the manner in which they were performed in the past. As such, this 'archaeology by experience' is quite commonly confused with experimental archaeology by the lay person and even the professional. Experiential archaeology can, for example, give insight into the difficulty of manoeuvring large timbers and blocks of stone or the labour required to plant a field and grind grain. Such experiences are very valuable in discovering for oneself the workings of

ancient technologies and understanding their application to everyday problems. However, there remains a major difference between experience doing a thing and true experimentation.

## Experimental Archaeology

The critical element separating experiential projects from experimental ones is that experimental projects contain well-defined hypotheses that are to be tested and then either accepted or rejected through clearly defined procedures and reasoning. Kelterborn (1987) provided an outline of two key issues in proper experimental archaeology:

**KEY ISSUE 1: STATE OF THE ART:** When does an experiment agree with today's accepted scientific standards? When it is:

- 1.1 Clearly goal oriented.
- 1.2 Measurable.
- 1.3 Repeatable.
- 1.4 Professionally planned and supervised.
- 1.5 Executed with expert manual skill.

**KEY ISSUE 2: BASIC ACTIVITIES:** What is common to all complete experimental projects?

- 2.1 Study, conceive and plan the project
- 2.2 Procure, analyze, and exploit the existing data base and make the logical conclusions with regard to the project. The data base includes literature, archaeological originals and opinion of experts.
- 2.3 Prepare and equip the infrastructure and the location of the experiment (lab or field).
- 2.4 Supply all original or substitute raw materials.
- 2.5 Make or buy tools, instruments, fixtures and gadgets.
- 2.6 Conduct the experiment, analyze, evaluate and draw conclusions.
- 2.7 Document, store, report.

The first key issue makes very clear the elements necessary for a true experiment. Point 1.1 necessarily implies a hypothesis to be tested by means of the experiment and succinctly states the need for the experiment to be focused and oriented toward a very specific and explicitly understood end. 1.2 is very important to recognize since a major difficulty in experimentation upon archaeological materials comes from the large number of variables and unknowns that must somehow be controlled for, or at least acknowledged. This brings 1.3 - 1.5 to the forefront since, in order to be repeatable, the measurements and variables that were present must be known and accounted for in the literature. This in turn requires a skilled staff, who not only know how to effectively operate the experimental and analytical equipment, but also a staff that has the manual skill to simulate that of humans in the past.

The points in key issue 2 serve to illustrate with details that a true experiment is not taken lightly or embarked upon just

to experience an ancient way of doing something. Of particular relevance is 2.2, which points out the vital importance of drawing on all available resources and research. In order for an experiment to be meaningful it must be done in the context of what is known about the process it investigates, the culture and the other research that has already been conducted.

A third grouping was also proposed by Reynolds (1999): education. However, both experiential and experimental projects are educational in nature. Archaeology, which is normally publicly funded, owes a special obligation to relay its discoveries back to the general public and experiential and sometimes experimental archaeological projects are often a very effective way of giving back. This is very apparent in the area of public archaeology where experiential projects play a major role in most curricula.

While the distinction between experiential and experimental archaeology should be clear, it is quite common for a project to fulfil both purposes at the same time, possibly creating some confusion. This seems to be what has led to the confusion that exists today wherein any group that attempts activities done in the past may refer to themselves as doing experimental archaeology (e.g. Lothene Experimental Archaeology Group in Scotland). Additionally, the word 'experiment' is closely associated with science and as such gives a sense of authority to activities associated with it. This would seem to be at least part of the reason for the prolific use of the term by groups only marginally involved with experimentation. Even within archaeology we find confusion as in the 1981 edition of the *Bulletin of Experimental Archaeology* (1981) wherein is stated, "It is our belief that practical experiments in archaeology, responsibly conducted, can be an important educational experience both in schools and in adult education." The author then goes on to reference a teaching pack for schools on using a Roman sundial and measuring rod. While this is indeed an excellent example of experiential archaeology and could conceivably be conducted in such a way to make it experimental, as an experiment it is likely to be unwieldy and less effective for teaching. An experimental project is distinct in that it requires a rigorous scientific experiment intended to help determine the validity of a given hypothesis.

Projects such as the West Stow Saxon Village, the exhibitions in historic martial arts at the Royal Armouries or the Higgins Armory Museum and any number of battle re-enactments throughout the world are all examples of what is sometimes called historic sites or public archaeology. Other projects such as experiential projects at the Butser Ancient Farm and most of the experimental archaeology week at the Institute of Archaeology, UCL are examples blurring the boundaries with scientific experimentation because they do some recording of data and some experimental variation in their procedures. While these activities undoubtedly have shown us something of the nature of construction of ancient buildings, historic martial arts and grain grinding, they are normally not experimental in the scientific sense of carefully controlled and documented hypothesis testing. A symbiotic relationship, however, could exist as worthwhile experiential projects are informed by and serve as impetus for experimental projects, as is indeed increasingly the case with the Institute's experimental archaeology week.

## Experimental projects

A large number of 'experiments' in different areas were examined during the research for this paper. Several examples directly related to charcoal production, iron smelting and crucible steel production were selected to highlight the characteristics of well designed experimental archaeology projects and in so doing to underscore the difficulties encountered within a related context.

## Charcoal Production

Traditional charcoal production requires a great deal of skill to achieve good results and therefore poses a serious challenge to the experimental archaeologist. Charcoal production is still practiced in many parts of the world and so it is frequently studied on-site with the experiment conducted by professionals who still derive their living from charcoal production. This form of ethnographic experiment poses its own unique set of problems, however. As has been discussed, careful analysis and quantification of the individual variables involved is vital in a good experimental project. The quantification of charcoal production is entirely feasible and has been easily done within industrial settings, but when the project is moved to a remote third-world location where wood has just been cut to be charred, it is extremely difficult to implement the needed tools.

In the study of charcoal production effectiveness the most significant measurement of efficiency is charcoal yield. This is a calculation of the weight percent of charcoal generated from a given weight of wood. The average charcoal yield using the common mound kiln is generally estimated at about 15-20% (Rehder 1999: 310; Armstrong 1978: 74). Horne (1982: 11) cites 14% in an experiment in Iran although stating that European data (no source or timeframe is given) indicates 20-30% yields. While Horne and Armstrong's yield percentages seem quite similar, Rehder and especially Schenkel and co-workers (1998: 509) point out that there will be a dramatic variation in weight percent yield depending on the initial level of moisture in the wood and the type of wood being charred. Based on the research of Schenkel and co-workers using anhydrous measurements the charcoal yield in a skilfully operated mound kiln today in Africa can reach 25-30%. This is comparable to that obtained in modern kilns (Schenkel *et al* 1998: 515; Emmerich & Luengo 1996: 43). Although the data of Schenkel and co-workers at first seems to contradict that of other researchers, it is important to note that they are measuring the actual mass yield based on an anhydrous measurement from before charring. It seems likely that the experimental burns which Armstrong (1978) recounts need to be qualified according to the skill of the operator and calibrated for water content in the pre-burn weight. The data may then turn out to be very similar to those reported by Schenkel and co-workers. An interesting conclusion is that modern methods of charcoal production may not have improved the yield over that achievable by a skilled burner in antiquity, although they have dramatically reduced the time and the amount of human labour and skill required.

A very important issue apparent in the above studies is that of measurement on location. Schenkel and co-worker's method requires an adiabatic calorimeter, a tool not conducive to use in third-world forest areas. Rehder (1999: 310) deals with the problem of calibrating for weight before and

after burning by analyzing the energy produced in the furnace from charcoal in comparison to that of the same uncharred wood, measuring the change in energy to quantify the yield rather than the change in weight. This technique poses a similar problem to the adiabatic calorimeter in that it requires very exact measurement of temperatures in the furnace, which are virtually unattainable outside of a highly specialised laboratory.

As recorded by Kelterborn (1987) in key issue 1.5 above, the skill of the burner must not be neglected. When analyzing superficially comparable yield percentages it must be remembered that charcoal making is a craft that requires considerable skill and that therefore reliable and consistent data can only be gained from a project involving a skilled charcoal burner.

From the work reviewed, it is clear that data reported without careful quantification before and after may be anecdotal and interesting, but cannot accurately tell how effective a technique of charcoal production is. More careful experimentation needs to be done by skilled burners using absolute techniques, such as the anhydrous weight as proposed by Schenkel and co-workers (1998), to get a true picture of charcoal yield. This necessarily means either devising a way to take the analytical equipment to the burn or to bring the professional burner to a location where the procedure can be recorded. The situation can be even more complex in some of the projects considered below.

### Iron Smelting

The work of Peter Crew (e.g. 1991) in experimental smelting with a low shaft furnace (see front page) is one of the best, most well-developed and well-documented experimental archaeology projects to be found. Looking at his work within the framework of the key issues above, the clear overall goal has been to determine the parameters of Iron Age and Medieval bog iron smelting in northern Wales.

Crew started from experiments already conducted by Tylecote (1971) and Cleere (1970) and the archaeological evidence local to the area. Thanks to Tylecote and Cleere, Crew started with some previous experimental data, but the archaeological record showed very little evidence as to height and wall thickness of the furnace. This necessarily required that Crew develop his own interpretation of the furnace construction and thickness.

In conducting his experiments, Crew has maintained detailed records and set clear purposes for each experiment, stating precisely which variables have been altered, forming hypotheses for expected results, revising them based on evidence and evaluating the results for further experiments.

One important factor that Crew and his predecessors identified was the control of airflow into the furnace. Changes in airflow will dramatically affect the condition of the smelt and a controlled and known volume of air is important as a variable in the smelting operation. Initially Crew attempted to use different types of hand bellows to deliver air to the furnace, but the rate of flow was so variable that a large range of temperatures and conditions would exist in the furnace, making it very difficult to keep constant, or even quantify,

furnace conditions. In order to achieve a controllable and measurable airflow into the furnace he also tried using electric blowers, but airflow was still difficult to quantify and too fierce an airflow was generated. Finally, a specialized piston bellows was developed, which allowed Crew to measure and control the volume of air delivered to the furnace. So, while the furnace itself was made from local clay and stocked with local ore, a mechanical bellows was used to provide the air at a realistic and consistent rate, while providing a pulsed air flow very similar to that expected of a hand bellows. This is an excellent example of the way that a truly experimental project considers the elements of an operation that must be maintained exactly as they were in antiquity and the elements that are better handled using a modern technique that will allow for more precise control, while still maintaining an acceptable degree of adherence to the ancient process.

Crew's work has continued with variations to test different variables and he has now conducted over 90 smelts, making him possibly the most experienced bloomery iron smelter alive today. One element clearly shown by the extensive work of Crew is the paramount importance of repeated experimentation and experienced operators. Somewhat in contrast to this are some of the experimental smelting projects presented by the Historical-Archaeological Experimental Centre at Lejre in Denmark. There, at the centre, a series of individual smelts have been conducted to answer specific archaeological questions such as the type of slag and bloom retrieved from a magnetite ore (Hjarthner-Holdar *et al* 1997) or the use of straw within pit furnaces to support the ore (Mikkelsen 1997). As an example, the Mikkelsen experiment has a clear hypothesis and method, but since it is only a single experimental smelt conducted by Mikkelsen, who apparently has no previous experience, the conclusions drawn must be held as indicative or qualitative only, pending further experimentation.

An issue raised by Reynolds (1999), closely tied to Kelterborn's point 1.5 (1987), is the publication of the length of time required to accomplish tasks. Since there are few experts in bloomery iron smelting alive, suggesting a length of time for the task based on experimental evidence may be very deceptive. In the context of Crew's work, a shortening of smelting times as the operators' own understanding of the process increases is reported and a plateau was observed as the times became more consistent after a significant number of smelts. This data, as with all experimental data, is indicative only of the results of one possible method by which smelting may have been accomplished in the past. Reynolds' concern was that no sweeping claims about societal dynamics should be made based on the process durations, especially when the experiment may have been conducted by those inexperienced in the technology under consideration.

### Crucible Steel Production

A very interesting series of papers by Verhoeven and co-workers (1987, 1987, 1990, 1992, 1992, 1993, 1996, 1998, 2001, 2002) and Wadsworth and Sherby (1982, 1983, 1985, 1992), illustrate another issue in experimental archaeology not as readily apparent in the iron smelting projects discussed above. In the study of crucible Damascus steel, both

parties used ultra-high carbon steels (around 1.4% C) and more or less agree on the cause of Damascus steel patterning and even to a large part on the methodology. Procedural differences separate them, however. They are both agreed, and have provided quite substantial evidence, that patterned crucible steel is produced when steel reaches a liquid state and cools very slowly. Wadsworth and Sherby use a warm rolling machine in a steam bath in order to process pieces of steel within a very controlled temperature range. They then analyze the resulting material for patterning similar to that of known crucible Damascus steel. The tightly controlled temperature and processing allow for precision in method, but applicability is called into question. Although this modern method and the patterns it produces show similarities to ancient artefacts made of patterned crucible steel, there are also marked differences. One significant difference is that all of the visible banding is in line with the direction in which the steel was rolled. Wadsworth and Sherby claim that this is simply an artefact of the production method, but no further processing has been done to prove that their method could produce the appropriate banding if it were forged.

Verhoeven, on the other hand, has worked with a number of other scientists and skilled smiths in his research. These smiths actually forge the metal into blades and then polish and etch it to determine whether they can produce the Damascus patterns. The results are nearly identical to surviving historical examples, but the processing temperatures and working method are much less controlled. The real strength in Verhoeven's approach is that they have continued to make procedural and compositional variations in processing billets of steel, thus developing a solid experimental database. Both of these groups decry the other's methods as not applicable enough to be useful, but the reality would seem to be that both approaches have given us very valuable information. Taken together, they can illustrate the value of both modern and historical methods used in synthesis for helping to understand ancient technologies.

## Conclusion

The confusion around the term experimental archaeology is unfortunate because a clearer understanding would allow better interaction between the experiential and experimental communities and create a symbiotic relationship in which the two would be better able to aid one another, and reach the public. It is hoped that the definition of experiential and experimental archaeology offered above and then illustrated by quality experimental efforts has helped to create a clearer understanding in the mind of the reader. The examples of experimental work exemplified by Schenkel and co-workers, Rehder, Crew, Blair, Wadsworth and Sherby and Verhoeven and co-workers should demonstrate some of the varied problems of scientific experimentation in exploring the workings of ancient iron technology and differentiate it from experiential undertakings. Further efforts need to be made to inform both archaeologists and the public as to the distinction between and value of experience and experimentation in archaeology and how they can work together to enhance our understanding of the past.

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