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The awkward adolescence of archaeological science

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ABSTRACT

The rapid growth of archaeological science (and of the *Journal of Archaeological Science*) over the last 15 years has changed archaeology worldwide. New methods of analysis have allowed archaeologists to pose many new questions, and have made it possible to revisit many old ones. In spite of its many successes, archaeological science is not yet a mature field of science, for it has yet to attract adequate funding, has not solved the problem of how to reproduce itself (issues of training and employment), and still struggles with quality control. These are however all problems of archaeological science in rich nations. Looking beyond these, a particularly troubling issue is the growing inequality of access to archaeological science. Archaeologists in poorer nations are often aware of the growing importance of scientific techniques in archaeological research, but cannot obtain access to them. Archaeological scientists also need to be aware of potential political sensitivity of their work, and to work to build trust.

1. Introduction

The practice of archaeology has been utterly transformed over the last fifteen years by an infusion of new (or greatly improved) scientific methods. These have made it possible to ask many new questions, and have produced a marked revival of interest in archaeological questions that had previously lapsed for lack of firm evidence. I will give just a few examples. The surge of interest since 2000 in the origins of Neanderthals and of anatomically modern humans, and of the “cognitive revolution” in art and personal adornment, has been driven in large part by the recent refinement of methods for dating sites between 200,000 and 40,000 years ago (Roberts et al., 2015; Wood, 2015). Many formerly inconclusive debates about gene exchange between Neanderthals and modern humans have now been decisively settled by analyses of ancient DNA, and by surveys of modern genomes (Pääbo, 2014). The ability to directly date single seeds by accelerator mass spectrometry radiocarbon dating (Wood, 2015) has also been a crucial advance in studying the origins and spread of agriculture, as have genomic surveys of cultigens and potential wild ancestral varieties. The study of prehistoric migrations, which fell out of fashion in the 1970's, is now extremely popular again, thanks to the evidence provided by genomics, and by strontium and oxygen isotopic analysis of human teeth (Bentley, 2006). Novel uses of heavy radioisotope systems (uranium/lead, rubidium/strontium, samarium/neodymium) for inferring the geological provenance of materials as diverse as metals, glasses, ceramics, lithics and wood have greatly advance our understanding of long-distance exchange (e.g. Stos-Gale and Gale, 2009; Tochilin et al., 2012; Brems et al., 2013), while light stable isotopes (hydrogen, carbon, nitrogen, oxygen) have become standard tools in studies of human and animal diet, and of the spread of cultigens like maize (Schoeninger, 2014). Advances in archaeological computing have enabled archaeologists to combine data sets from hundreds of archaeological projects into “big data”, and to use these giant datasets to examine changing connections between sites and regions across large blocks of time (e.g. Knappett, 2011; Mills et al., 2013).

These selected examples make the point that new and improved scientific methods have fundamentally changed archaeological practice (in the richer nations, at least) since 2000. One can see this also in recent introductory textbooks on archaeology – words like isotopes, magnetometry and fractionation, and phrases like Bayesian calibration and trace-element analysis are now firmly embedded in the archaeologist's lexicon. What the newer methods have *not* done is to render irrelevant other ways of knowing the past. New scientific methods perfectly complement older methods of analysis like morphological analysis of bones and seeds, and stylistic analysis of pottery, fabrics and metalwork, and thus contribute to richer, more persuasive accounts of the past (Killick,

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2014). The philosopher Alison Wylie has drawn attention to the value of "cabling" in building arguments in archaeology (Wylie, 1989, 2000). This is an analogy to a physical cable made of interwoven but independent strands. Evidence from archaeological science is often quite independent of evidence produced by other archaeological methods, and thus can help build much stronger arguments. Archaeological science can also be productively disruptive by showing that a long-held idea is wrong, and thus starting a new wave of research to explore alternative possibilities. A striking example of this was the use of stable carbon isotope ratios to show that maize agriculture began much later in eastern North America than had previously been supposed (van der Merwe and Vogel, 1978). This produced a burst of new research that revealed the existence of an earlier period of agriculture based on domesticated plants that fell out of use once maize was widely adopted (Smith, 1989).

I think that the current wave of enthusiasm for archaeological science is not – as Kristiansen (2011) has argued – part of a pendulum-like oscillation in archaeology between periods of enthusiasm for scientific empiricism and periods of reaction against it, when archaeology veers more towards the humanities. This time is different, in my opinion. From the 1970's through the early 2000's archaeological science was often regarded with great suspicion by many archaeologists (Martinón-Torres and Killick, in press), and C.P. Snow's *The Two Cultures* was often invoked to explain the purported inability of archaeologists and scientists to communicate with each other (e.g. Olin, 1982; Knapp, 2000; Jones, 2002). How times have changed! The current wave of innovation in archaeological science has not met with any significant resistance – indeed, many archaeologists are arguably too enthusiastic about it. (See below).

The *Journal of Archaeological Science* has played a crucial role in the widening acceptance of archaeological science. Richard Klein and his fellow editors deserve much of the credit for this, but so too does Elsevier, which has allowed the journal to expand from 712 pages in 1990 to 5128 pages in 2014. JAS has not only provided the new wave of innovation in archaeological science sufficient space in which to grow, but the journal has – quite remarkably – become more widely cited on a per-article basis as it has grown. Its 5-year ISI Impact Factor was 2.369 in 2013, only slightly below those of the top-ranked *Journal of Archaeological Research* (2.600) and the *Journal of Anthropological Archaeology* (2.453). Conversely, the Google Scholar 5-year H-factor (h5) index for archaeology journals for June 2014 has JAS on top by a considerable margin – and other archaeological science journals at ranks 5, 8, 12, 13 and 16 (http://scholar.google.com/citations?view_op=top_venues&hl=en&vq=soc_archaeology). On Richard Klein's watch, therefore, JAS has evolved from a niche journal for archaeological scientists to becoming essential reading for many archaeologists.

Rapid growth is not an unmitigated blessing in any field, and I will use what remains of my space to discuss the growing pains of archaeological science. These need to be addressed before archaeological science can be considered a mature field of scientific inquiry.

2. Growing pains in archaeological science

2.1. Quality control – reviewing

Anyone who has reviewed for JAS for as long as I have has a list of papers that should never have been accepted for publication by the journal – either because they were fundamentally flawed or because they were trivial (analyses made for no good archaeological purpose). The fact that these papers were published in JAS is a consequence of the rapid expansion and unusual – perhaps unique – diversity of archaeological science. Every other issue of JAS seems to contain a paper that employs a method of analysis that I had not previously encountered, usually as an acronym (e.g. SHRIMP, XANES, MALDI-TOF). The major problem for JAS editors has that of been finding qualified reviewers for many submitted papers. This is why JAS went from having one editor to four co-editors, but even four prominent scholars in different subfields can't possibly be familiar with the range of techniques now used in archaeological science. Thus in 2014 JAS appointed nineteen Associate Editors to widen the range of editorial experience.

My areas of expertise within archaeological science are archaeometallurgy and ceramic petrography, but I've also reviewed papers (for JAS and other journals) on radiocarbon, on light and heavy stable isotopes, on provenance of lithics and ceramics, on Roman concrete, on purported meteorite impacts, on geoarcheology, and on organic residue analysis. Obviously I am not an expert in all of these subfields, so the fact that I was asked to review these studies is a clear indication of the scarcity of willing reviewers. Yet the number of submissions continues to grow rapidly, and to cope with this flood, in 2014 JAS has spawned a second journal – *Journal of Archaeological Science: Reports* (http://www.journals.elsevier.com/journal-of-archaeological-science-reports/). While this may make the task of producing the journals more manageable, it clearly will worsen the problem of finding qualified reviewers. The interests of the publisher are clearly at odds with those of the uncompensated reviewers. JAS also competes for reviewers with *Archaeometry*, *Anthropological and Archaeological Sciences* and *STAR: Science and Technology in Archaeological Research*, with specialist journals like *Radiocarbon*, *Geoarchaeology*, *Quaternary Research*, *Archaeological Prospection*, *Historical Metallurgy* etc., and with the numerous conference proceedings in archaeological sciences that also need reviewers.

This situation is becoming intolerable – almost everyone in my professional network complains about it. Unless a substantial pool of new reviewers can be identified, editors must make greater use of triage – rejecting a larger fraction of papers without even sending them out for peer review, as more prestigious journals like *Nature* and *Science* do.

2.2. Quality control – data

Explicit concern with quality control in measurement is the hallmark of a mature science. Few subfields of archaeological science have adequate systems of quality control in place. The first subfields to make explicit commitments to quality control were radiocarbon dating and neutron activation analysis laboratories. These began "blind" exchanges of archaeological samples and internal standards between laboratories in the 1970's. The second round of international blind testing of radiocarbon laboratories still revealed much inconsistency in measurement of samples of known radiocarbon content (International Study Group, 1982) but by the fourth round (Boaretta et al., 2003) only 10% of the results reported by 85 radiocarbon laboratories were classed as outliers. Radiocarbon dating can now be said to be a mature science (Wood, 2015). Dendrochronology, zooarchaeology and geoarchaeology are other fields with transparent and generally agreed standards for quality of data (Steele, 2015; Canti and Husman, 2015). In archaeological applications of heavy isotope analysis and organic residue analysis, archaeological scientists use instruments that are housed in, and maintained by, departments of geochemistry and organic chemistry respectively. The accuracy and precision of the archaeological data produced can be inferred from repeated measurements on both international and internal standards. In geochemistry – the mature field with which I am most familiar – no leading journal