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Introducing Archaeological Science

Kate Britton and Michael P. Richards

An introduction to the field of archaeological science and to this volume, including a brief history of the subject and a look to the future.

1 INTRODUCTION

As the study of the past through its material remains, archaeology has a long tradition of drawing on the sciences, especially the natural sciences. The multifaceted approach required in the study of human societies, and the focus on the material – artefacts and 'ecofacts', manufactured and natural – means that, perhaps more than any other academic subject, archaeology relies heavily on a diverse range of fields outside of the discipline (Pollard and Heron 2008). The plethora of scientific techniques used in modern archaeological science reflects the varied aspects of life in the past they are utilised to investigate (Brothwell and Pollard 2001: xviii). The demands of inferring of activities, motivations, behaviours, ideas and beliefs of individuals in the past requires multistranded, complementary approaches. As a consequence, archaeological science enters into many areas of the study of the past and is a fundamental component of the investigation of past societies and human behaviours.

The aim of this chapter is to introduce the field of archaeological science and the purpose and scope of this volume. This chapter will also briefly explore the development of archaeological science and provide a brief history of the field.

2 WHAT IS ARCHAEOLOGICAL SCIENCE?

Defining archaeological science, and the ways in which it differs as a subfield from the larger field of archaeology, has been a subject of great debate and is perhaps

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even reflected in indecision in what exactly to call it. 'Archaeological science', 'science in archaeology' and 'archaeometry' are all used to varying extents (McGovern et al. 1995: 79), with archaeological science being perhaps the most common term (especially in the United Kingdom).

Archaeologists would variously describe their research as falling within humanities, social sciences and/or natural sciences, and it is certainly a broad enough field that it can easily include research in all three. Perhaps many of the debates over the nature of archaeology are the result of different practitioners themselves identifying more with one of these three areas than the others. The differences between those who feel their research is in the humanities, and those that identify with the natural sciences are the most striking, and perhaps the root of some scepticism and suspicion about the area of archaeological science from some in other areas of archaeology. Those who believe in a relative view of knowledge even question the nature of the scientific method and knowledge, which conflicts directly with archaeological scientists who are often trained in the natural sciences. It is perhaps a fault of some in archaeological science that they argue that their methods can produce something approximating the 'truth' (or at least hard, irrefutable facts) in the past, without considering the differing theoretical frameworks their colleagues may use.

While committed to investigating social phenomena, unlike other social scientists, archaeologists start with surviving physical remains of human actions, and must use these to infer human behaviours and beliefs (Trigger 1988: 1). The application of diverse scientific technologies and techniques to analyse those physical remains thus forms a core part of 'the logical-positivist pursuit of understanding peoples through their material remains' (Rich 2015: 532). While some have argued that archaeological science is merely an 'assemblage of techniques', and 'is not science as it would be recognised in the natural sciences' (Thomas 1991: 31), others have argued this cross-disciplinary lack of purity is, in fact, the strength of the diverse subfield we know today (Brothwell and Pollard 2001: xviii).

For this edited volume, we are defining 'Archaeological Science' as a term that encompasses the application of techniques and approaches from the full range of natural sciences (biology, chemistry, physics) to archaeological materials – the 'active participation of the physical and natural sciences in the study of the past' (Bayley and Heron 1998: 137).

3 A (VERY) BRIEF HISTORY OF ARCHAEOLOGICAL SCIENCE

The practice of modern archaeology, and what we now conceive of as the field, has its origins in the eighteenth and nineteenth centuries and we would argue, at its heart, is intrinsically related to the natural sciences. After all, one of the fundamental frameworks of archaeological investigation is that of stratigraphy – a concern for the order and relative position of deposits or strata – an approach also fundamental to the field of geology. The tentative beginnings of laboratory analysis applied to archaeological materials, incorporating the expertise of chemists, metallurgists and mineralogists, can also be traced to the nineteenth century, such as the work overseen by metallurgist John Percy on the analysis of Assyrian bronzes and glass in Austen Henry Layard's 'Discoveries in the Ruins of Ninevah and Babylon' published in 1853, and Heinrich Schielmann's 'Mycenae' published in 1878 (Pollard and Heron 2008: 5).

While the relationship between mainstream archaeology and the sciences spans more than two centuries, the modern subfield of archaeological science is rooted in the blossoming of ecological and environmental-based approaches to archaeology, and particularly advances in chronometric dating, in the decades of the mid-twentieth century (Brothwell and Pollard 2001; Pollard 2007; Pollard and Heron 2008). This period saw an influx of new methodologies but also saw perceptions shift on the potential of physical archaeological evidence through its systematic and scientific study – the so-called New Archaeology (Killick 2015; Marciniak and Rączkowski 2001). Not without its critics, the position (and even the legitimacy) of archaeological science within the broader field of archaeology was called into question over the following decades (e.g., Thomas 1991). Critics of the subfield, and its practitioners, enjoyed a heyday in the 1980s and 1990s as the processual paradigm of the 'New Archaeology' was rejected by the post-processualist movement. Post-processualism was rooted in interpreting rather than explaining the archaeological record, and saw the rejection of the systematic views of human lifeways and social relationships that processualism and, by extension, archaeological scientists, envisaged (Marciniak and Rączkowski 2001: 11).

Despite the latter half of the last century being 'punctuated by papers criticising the lack of understanding between "science" and "archaeology"' (Pollard and Bray 2007: 246), the field of archaeological science has flourished and there are few archaeologists who would now deny the contribution scientific approaches make to modern archaeological enquiry. In recent decades, archaeological science has moved from the fringes of archaeological theory, method and practice, to become intrinsic to the modern field and the last thirty years have seen an explosion of new techniques and applications in the field (Pollard 2007; Pollard and Heron 2008). The field has also seen an infusion of new data bringing vital supporting evidence to the study of past lifeways; health and disease; subsistence and production; trade and exchange; manufacture and technology; as well as providing valuable chronologies. Old questions have been revisited with cutting edge methodologies borrowed from other fields, such as timing and nature of the Neolithic transition to farming using stable isotope analysis, or the application of ancient DNA analysis to the study of domestication, and high-throughput DNA sequencing and geometric morphometric techniques to the study of our origins as a species and our relationship to our closest extinct ancestors and cousins (Killick 2015).

Archaeological science is no longer 'niche' and the growth of archaeological science has been mirrored (and perhaps brought about) by the expansion of archaeological science publishing (Killick 2015: 243). *Archaeometry*, the first dedicated archaeological science journal, was founded in 1958, and was followed by the *Journal of Archaeology Science* in 1974. The latter grew very rapidly, with a ten-fold increase in published material over the following twenty years (Torrence et al. 2015: 2), and is today one of the largest publishers of archaeology globally.

4 THE FUTURE OF ARCHAEOLOGICAL SCIENCE

Despite firm establishment within modern archaeology, archaeological science must continue to be responsive to new archaeological queries into the future (as well as direct them), and be open to new technological developments and methodologies outside of archaeology. Furthermore, and perhaps most significantly, archaeological scientists must endeavour to better understand the theory and practice behind the methodologies they utilise, and their caveats. An awareness of the limitations of the techniques employed, which are often developed in and borrowed from other fields, is not necessarily a limitation in their application. Archaeological science in general has strength in exploring potential weaknesses in their research methods, and indeed there are whole areas of study dedicated to understanding the limitations of certain techniques and of their application to archaeological materials (e.g., the study of diagenesis in stable isotope studies).

Whatever the scientific specialism in question, accuracy and precision, along with the quantification (and articulation) of uncertainty remain of great importance (Torrence et al. 2015: 4). The detailed and systematic reporting of data – whether it's radiocarbon dates (Wood 2015: 69) or stable isotope data (Szpak et al. 2017) – is paramount. Increasingly, archaeology is moving into the era of 'big data' and the future reporting and archiving of data is most likely to involve online depositories and databanks (Britton 2017: 858). These will enable future archaeological scientists to make the best use of legacy data and to make use of the same datasets for disparate purposes (Torrence et al. 2015: 4). In many ways, the challenges for archaeological science into the future are really no different than for that of all archaeology, and we should all place the asking of valid questions, technical and methodological rigour, accurate recording, reproducibility and meaningful interpretations of data at the forefront of our work (Torrence et al. 2015: 7).

Another priority into the future must be the continued integration of archaeological science datasets, and archaeological scientists themselves, into broader archaeological frameworks. Without adequate integration, mainstream archaeologists can lack the understanding of specific scientific approaches (including their caveats), and the archaeological scientist can lack understanding of the complexity of the archaeological record of a particular place or period. Studies should embrace the complementarity of multiple lines of enquiry, using diverse theoretical and methodological approaches. Working with archaeologists from other subfields, and engaging more broadly with the field itself, can help limit data overinterpretation and promote rigour, and also ensure data are not only properly collected and analysed but also *contextualised* (Marciniak and Rączkowski 2001; Pollard and Bray 2007; Torrence et al. 2015). This can of course extend beyond archaeology, as other scientific fields might seek to make use of archaeological materials, for example, to better understand past human and animal responses to climate change. To adequately integrate archaeology, archaeological science and other scientific specialisms – such as ecology – cross-disciplinary methodologies and theoretical approaches will need to be reconciled (Britton 2017: 859).

In order to achieve the goal of a truly integrated archaeological science, it is essential that archaeology students be raised in both the social and natural sciences in order to become future researchers who are comfortable working in both spheres. While not necessarily aiming to produce entire cohorts of archaeological scientists, university courses should hopefully aim to make all archaeology students 'educated consumers' of science (Killick and Young 1997: 523). An understanding of the methods available and a grasp of the questions that can be (realistically) asked using them is essential for all archaeologists. Beyond that, the ability to be able to interpret and assimilate archaeological science literature and data into their work should be a priority (Killick and Young 1997: 523).

5 PURPOSE AND STRUCTURE OF THE VOLUME

The purpose of this book is to further the integration of archaeological science within archaeology, and to increase understanding of the subfield. We are hopeful that this volume may serve as reference text, useful for archaeologists, who want know more about a new and unfamiliar method or even archaeological scientists who may be unfamiliar with research areas outside their own specific fields. Perhaps most consciously, we aim this book at the growing number of undergraduate students worldwide who are increasingly becoming interested in learning about, and working in, the field of archaeological science.

With this book we chose to include what are, at the time of writing, the newest archaeological science methods alongside more established methods. As explored in this introduction, our interpretation of archaeological science includes any area of archaeology that applies methods originally developed in the so-called natural sciences including biology, chemistry and physics. We include well-established research fields such as zooarchaeology and human osteoarchaeology, as well as methods related specifically to materials analysis of archaeological samples, and genetic and isotopic analysis of them. We of course also include absolute dating methods, which are so crucial to our understanding of archaeology.

Many of the methods explained here have derived originally from other fields, but are now research areas in their own right, and have, in turn, influenced the original fields that they were borrowed from. For example, ancient DNA research into how DNA degrades is now used widely outside of archaeology, including in forensic research. Isotope analysis, which was largely refined within archaeology, is now widely used in ecology and medicine. The same can be said for most of the other areas of research included in this book, as archaeological science has developed into a mature research field.

For this volume we have grouped the chapters into five broad areas, which of course do not reflect the considerable overlap between these areas, and the methods themselves. The first section is in the area of 'Biomolecular Archaeology', which we have interpreted as the application of the study of ancient biomolecules in archaeological materials. This includes ancient DNA (Loog and Larson), ancient proteins, or more specifically proteomics (Hendy, van Doorn and Collins), as well as lipids and other adsorbed organic residues (Craig, Saul and Spiteri). We have also included the two chapters on isotope analysis of human (and animal) remains, separating them into isotopes largely used to look at migration and movements (Britton) and diet (Richards). The next section is the broader category of 'Bioarchaeology', which concerns the analysis (especially morphological) of human remains. This section contains an introduction to the field of human osteoarchaeological analysis (Weston), teeth (Smith) and geometric morphometrics (Gunz). Then we have grouped papers that fit more generally into the area of 'Environmental Archaeology' together. This includes reviews of vertebrate zooarchaeology (Dobney and Upex), invertebrate zooarchaeology (Mannino), palaeoethnobotany (D'Andrea) and geoarchaeology (Karkanas). Then we have grouped together applications of materials science to inorganic archaeological artefacts as 'Materials Analysis'. This includes ceramics (Shortland and Degryse), glass (Shortland and Rehren), metals (Rehren) and lithics (McPherron). Lastly, we have included two chapters on the most commonly used chronometric dating techniques as 'Absolute Dating Methods', including radiocarbon dating (Blockley) and luminescence dating (Bailey).

We were extremely fortunate to be have been able to draw on the considerable expertise and knowledge of our contributors, and we are very grateful to all of them for their contributions to this book. Of course, with such a dynamic and growing field, we were not able to cover all areas that might be called archaeological science, but we hope that this volume will give the specialist and student the tools they need to understand newly published research in archaeological science, as well as the large existing body of literature. Finally, we are hopeful that this introductory volume will also encourage some to start research themselves in the challenging, but also very rewarding, field of archaeological science.

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