Chapter 1
Introduction

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Introduction

In March 2008, a session was held at the Society of American Archaeology (SAA) conference in Vancouver, Canada, which focused on the emergence of metallurgy in the Old and New Worlds. Before this session, paper drafts had been circulated among the authors and posted on the SAA website, thereby allowing the session itself to be consumed with discussion of both a theoretical and practical nature. When we had originally organized this session and sent out invites, we envisioned gathering a group of cutting-edge researchers from every major archaeometallurgical region in the world, and sitting them all together in a small, quiet room to hash out important issues such as metallurgical terminology, the best ways to teach slag analysis to archaeologists, and whether the "origins of metallurgy" was still a valid research topic. This was what was supposed to happen.

What actually happened in March 2008 was that our small, quiet "electronic symposium" ended up being moved to one of the largest ballrooms available in the conference center. Over a hundred people joined us for what became a standing-room-only event, in which the authors sat in a line of chairs facing the audience, while we peppered them with "big brushstroke" questions. We asked them questions like: "Do you think metals were fundamental to the rise of elites and complex social hierarchies?" "Is there a case to be made for both indigenous and diffusionist viewpoints on the origins and spread of metallurgy?" "Can we use examples from the Old World and apply them to the New World, and vice-versa?" Much to their credit, our superb group of authors-*cum*-panelists handled the situation marvelously, answering our questions (and those posed by audience members)

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clearly while remembering to stay focused on themes of broader archaeological and anthropological relevance. It was, if we may say, a great success, as it managed to engage an audience of archaeologists, anthropologists, and art historians with archaeometallurgical discussion without inducing sleep (or death).

The papers from this symposium were published in a two-volume edition of the *Journal of World Prehistory* (JWP) in late 2009. As outlined in our introduction to these volumes (Thornton and Roberts 2009) and expanded upon in an *Antiquity* article (Roberts et al. 2009), the symposium provided four major conclusions:

1. Studies of metallurgical "origins" have moved beyond simplistic culture history approaches toward more nuanced discussions on the mechanisms of technological transfer, including notions of "innovation," "adaptation," and "adoption" (a la Renfrew 1978; Ottaway 2001).
2. Scholars of ancient technologies are becoming more aware of the need to study multiple crafts in tandem in order to form more robust models of craft production and technological behavior in ancient societies (cf. Miller 2005).
3. Childean associations between metallurgical production and elite dominance are outdated and must be proven, not assumed. More than any other topic, the *in*significance of the early adoption of metallurgy was emphasized in multiple regions (cf. Bartelheim 2007; Kienlin 2010).
4. The study of ancient metallurgy must adopt what Shimada (2007) has called a "holistic approach" to past technologies, in which all material remains from ancient technical practice must be analyzed. This includes fuel (e.g., charcoal), mining sites (e.g., ores and hammerstones), reaction vessels (e.g., crucibles and furnaces), tools (e.g., molds and lithics), waste products (e.g., slag), and finished artifacts (see also Ottaway 1994).

After this session at the SAA, the publisher of the *JWP* (Springer) approached us about putting these papers, many of which were subsequently revised by the authors (Chaps. 16, 19, 28) together, into a "reader" of early metallurgy, to be used for teaching archaeometallurgy to undergraduate students. This was a novel idea[1], especially given the dearth of research (let alone courses!) on archaeometallurgy in the USA (Killick and Goldberg 2009) in contrast to the slightly better situation in Europe (Rehren and Pernicka 2008). We agreed under the condition that we could supplement the conference papers with additional regional syntheses as well as a section on methodologies.

The result is this two-part volume. In the first section, we were very lucky to enlist some of the foremost experts in archaeometallurgical research methods to provide introductory chapters about their particular specialization. These chapters were designed to be informal "lectures" with, where possible, a concise bibliography geared toward archaeological undergraduates with little-to-no scientific training. Within each specialization, the available texts tend to be either dispersed, inaccessible, or designed for the advanced student. Archaeometallurgy still lacks a fundamental textbook, although there are focused handbooks on individual methods as for slag analysis (e.g., Bachmann 1982), metallography (e.g., Scott 1991; 2011), and metal conservation (e.g., Scott 2002).

[1] One for which our editor at Springer, Teresa Krause, should be credited.

The volume begins with two magisterial overviews on the fundamentals of ore formation and smelting (Chap. 2) and the material properties of metal (Chap. 3). These precede the more methodologically focused chapters, beginning with the three most underutilized methods in the study of ancient metals: metallography (Chap. 4), slag analysis (Chap. 5), and the study of technical ceramics such as molds and crucibles (Chap. 6). These three laboratory-based chapters are then followed by three more field-based approaches in archaeometallurgy, including mining archaeology (Chap. 7), experimental archaeology (Chap. 8), and the use of ethnographic analogy or 'ethno-archaeology' (Chap. 9). To round out the first half of the volume, we were fortunate to receive papers from two of the leading archaeometrists who analyze ancient metals and summarize the use of chemical and isotopic methods (Chap. 10) as well as the debate over proveniencing metal artifacts back to their original ore sources (Chap. 11). Finally, an important chapter on the kinds of research carried out by conservators (Chap. 12) completes the methodological section of this volume.

The second half of this volume provides a number of syntheses on the early development of metallurgy from various regions around the world. These papers were again geared toward an archaeological audience interested in archaeometallurgy, but with greater emphasis on synthesizing all the literature written about early metals in each area. It was hoped that as a collection, these papers would form the most up-to-date world synthesis of early metallurgy since the seminal 1988 BUMA volume (Maddin 1988).

Over the past two decades, the amount of data from each metallurgical region has increased dramatically, making such syntheses more and more difficult, while changing geopolitics has added new regions of study such as "The Caucasus" (as opposed to individual Soviet states; see Chap. 22). Sadly, many important regions—such as western Africa (e.g., Killick 2004; Holl 2009), eastern South Asia (e.g., Lahiri and Chakrabarti 1996), Australasia (e.g., Bulbeck 1999), and the Arctic (e.g., Pringle 1997; Cooper 2011)—had to be left out of this volume due to problems in receiving qualified papers. However, this volume was never meant to be encyclopedic or entirely definitive; it is meant to be an educational guide for teaching archaeometallurgy to an uninitiated audience.

The second section of the volume begins somewhat unusually in North America (Chap. 13), Mesoamerica (Chap. 14), and South America (Chap. 15), although most syntheses of early metallurgy would begin in the Old World. This is a deliberate attempt to emphasize the independent development of metallurgy in the New World without biasing the syntheses with comparisons to Eurasian archaeometallurgy. Following these chapters, three complementary chapters covering the European continent are provided (Chaps. 16–18), followed by an incredible overview of the development of metallurgy in southern and eastern Africa (Chap. 19). From these Western regions, the volume moves east to the classical heartlands of early metallurgy: Anatolia (Chap. 20), the Levant (Chap. 21), the Caucasus (Chap. 22), and the Iranian Plateau (Chap. 23).

The regions to the east of these 'heartlands' are comparatively understudied but provide important information about local adoptions and innovations to metallurgy and metal artifacts. These include two papers on South Asia (Chaps. 24 and 25), one on the Eurasian Steppe (Chap. 26), a synthesis of the rise of metals in East Asia (Chap. 27), and a stimulating paper on the possible origins of metallurgy in Southeast Asia (Chap. 28). This latter paper, when first presented in the *JWP* (White and Hamilton 2009), ignited considerable debate among Southeast Asian scholars that continues to this day (e.g., Pryce et al. 2010; Higham et al. 2011). Whether the conclusions put forth in Chap. 28 prove to be 'right' or 'wrong' is beyond the scope of this introduction. However, their innovative model of cultural transmission of metal technology using archaeometrical and archaeological data provides a significant intellectual landmark in archaeometallurgy. Due to the ever-increasing speed of scientific advancement, it is a sad truth that the data included in most of these synthetic chapters will be out of date before they are actually published. Thus, the emphasis should be on how each author combined archaeometrical and archaeological data with anthropological and sociological theory in order to reach conclusions about the role of metallurgy and metals in the lives of ancient peoples.

What is particularly striking about the superb papers in the second section of this volume is the emphasis upon anthropological theories of technological behavior and the social effects of/on technology (a la Lemmonier 1992; Pfaffenberger 1992; Dobres and Hoffman 1994). Up until the 1990s, these were largely missing from most archaeometallurgical syntheses, and their inclusion in these papers is a welcome addition, one that hopefully signals a paradigmatic shift in early metallurgical research (Thornton 2009). In archaeometallurgy (if not in all academic disciplines), such 'paradigm shifts' are never as final as they sound. Just as the introduction of copper did not cause the cessation of lithic production, the introduction of a new theoretical paradigm did not and does not necessitate the extinction of its predecessors. In fact, more than one paradigm can operate in tandem—see, for example, the prolonged existence of 'culture history' despite two highly touted paradigmatic shifts to 'processualism' in the 1960s and to 'post-processualism' in the 1980s (see Roberts and Vander Linden 2009 for further discussion).

Similarly, the study of ancient metallurgy has various schools of thought, many of them regionally based, which are complementary to each other in many ways. Some emphasize scientific analysis over theoretical understanding, seeking "facts" about the past and seeing humans as mostly rational beings that can be modeled and understood. Others apply lessons learned through ethnographic field research to understand the behavioral and cultural sides of ancient metallurgy, often using only a smattering of analytical data to argue for direct historical analogy. Neither is entirely right or wrong in its approach, but the best research usually results from collaboration between these two extremes. This volume was designed to seek a middle ground between analysis and theory, placing it firmly within the Anglo-American schools of thought in archaeometallurgy.

However, what *are* the Anglo-American schools of thought on ancient metallurgy? Can we even speak of a single paradigm in a discipline with practitioners from so many different academic fields (geology, archaeology, material science, etc.)? Archaeometallurgy as a field of study can only be traced back to the nineteenth century, when scientists such as John Percy began to report on their analyses of metal artifacts within archaeological publications. Early twentieth-century scientists such as William Gowland combined ethnographic accounts with archaeological and analytical data for the first time. It was not until the mid-twentieth century, however, that the study of ancient metal artifacts would become 'mainstream.' This florescence was driven in no small way by the rise of Marxian archaeology under the great prehistorian V. Gordon Childe (1930; 1944), whose theories on social evolution and class construction through technological advancement (particularly metals) and craft specialization continue to influence modern archaeological interpretation (see Rowlands 1971; Trigger 1986; and various papers in Wailes 1996). Remarkably, Childe was able to create these synthetic models and theories about ancient metallurgy without a hint of scientific analysis, which led the way for archaeologists not trained in metallurgy to enter the discussion.

The lack of scientific analysis should not diminish the importance of Marxian and Childean thought in archaeology and, by extension, to archaeometallurgy. Indeed, some of the most influential writers on metallurgical theory in the past few decades have also dealt with only limited technical analysis. For example, the famous Wertime–Renfrew debate on the origins of metallurgy (e.g., Renfrew 1969; Wertime 1973a, b), which has become the archetypical discussion on "diffusion" vs. "independent invention," was carried out with little mention of possible analyses to prove or refute their hypotheses (see Muhly 1988, p. 15). Even the great Russian scholar Evgenii Chernykh (1992), whose "metallurgical province" model is perhaps the most influential theory on ancient metallurgical production since Childe, only loosely refers to the technical analysis of over 60,000 metal artifacts that he oversaw from sites across the former Soviet Union.

The connection between analytical techniques and archaeological theory was first made in the 1970s by a group of scholars who are as notable for their excellent metallurgical research as for their enduring legacy as excavators and mentors. In Germany, Gerd Weisgerber and Hans-Gert Bachmann championed scientific methods of analysis in collaboration with archaeological investigations of ancient mines and metallurgical sites. In England, Ronald Tylecote and Beno Rothenberg were the first to successfully combine archaeological fieldwork, scientific analysis, and experimental reconstruction in order to understand firsthand the interaction between ancient societies and their metallurgical technology (Killick 2001; Cleere 1993). In the USA, the dominant 'archaeometallurgical paradigm' arose in the material sciences, with scholars at Massachusetts Institute of Technology (MIT), such as Cyril Stanley Smith, Martha Goodway, and Heather Lechtman, and at the University of Pennsylvania, such as Robert Maddin, Tamara Stech, James Muhly, and Vincent Pigott. All of these great men and women were instrumental in introducing metallography to studies of ancient metallurgical technology (Goodway 1991, p. 706) and convincing anthropological archaeologists that studies of ancient metallurgy could lead to a broader understanding of human behavior and social interactions.

As early as the mid-1980s, the American school of 'technological behavior' was rapidly gaining converts, but mainly among scholars interested in ancient ceramics (e.g., Wright 1985; various papers in Kingery 1986; Gosselain 1992; Hegmon 1992). It was not until the 1990s that archaeometallurgists began to adopt this paradigm (e.g., Childs 1991; Epstein 1993; Hosler 1994; Reedy 1997; Friedman 1998) often in conjunction with larger discussions about the social organization of craft production (e.g., Brumfiel and Earle 1987; Costin 1991, 2001; Pfaffenberger 1992).

More recently, this new paradigm has become almost de rigueur among American archaeometallurgists (see Killick 2004).

While the American school has not had the same effect on European archaeometallurgy as it has in the States, there has still been a theoretical shift, although of a different nature. In Britain, for example, the ‘innovation-adoption’ school, which came out of Colin Renfrew’s work on Southeastern European metallurgy (Renfrew 1969, 1973) and the Varna cemetery (Renfrew 1978, 1986), has had a dramatic effect on the ways in which archaeologists study metallurgy and metal artifacts (e.g., Sørensen 1989, 1996; Kienlin 1999; Sofaer Derevenski 2000; Kim 2001; Ottaway 2001). A theoretical shift can also be seen to some extent in Continental Europe, where the social organization of technology (if not the cultural aspects of its production and use) has become a dominant theme (e.g., Vandkilde 1996; various papers in Pare 2000; Ottaway and Wager 2002; Kienlin 2010). More recently, the trendy though ill-defined ‘materiality’ school in Britain has been dominating theoretical discussions of ancient technologies (e.g., DeMarrais et al. 1996; Renfrew 2001; DeMarrais et al. 2004; Miller 2005; but see also Ingold 2007 and responses), although we await proof that this theory has any relevance to scientific studies of ancient materials (see Jones 2004 and responses in *Archaeometry* (2005) vol. 47.1).

While the apparent shift in British and European discussions of metallurgy and other technologies is indeed significant, theoretical trends like ‘materiality’ are mostly archaeological paradigms with little interest in scientific data. Such approaches threaten to widen the gap between archaeometrists or archaeological scientists and more theoretically inclined archaeologists. As the papers in this volume demonstrate, it is the use of empirical data in conjunction with archaeological and anthropological interpretation that can provide the most holistic view of ancient technologies in their social and cultural contexts. This occurs either through close collaboration between scientists and archaeologists or by educating students in both analytical techniques and archaeological theory. Without both aspects informing the other in a discursive relationship (i.e., theory structuring practice just as practice changes theory), we are only understanding half of the story.

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