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Repealing the Çatalhöyük extractive metallurgy: The green, the fire and the 'slag'

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ABSTRACT

The scholarly quest for the origins of metallurgy has focused on a broad region from the Balkans to Central Asia, with different scholars advocating a single origin and multiple origins, respectively. One particular find has been controversially discussed as the potentially earliest known example of copper smelting in western Eurasia, a copper 'slag' piece from the Late Neolithic to Chalcolithic site of Catalhoyuk in central Turkey. Here we present a new assessment of metal making at Çatalhöyük based on the re-analysis of minerals, mineral artefacts and high-temperature materials excavated in the 1960s by J. Mellaart and first analysed by Neuninger, Pittioni and Siegl in 1964. This paper focuses on copper-based minerals, the alleged piece of metallurgical slag, and copper metal beads, and their contextual relationship to each other. It is based on new microstructural, compositional and isotopic analyses, and a careful re-examination of the fieldwork documentation and analytical data related to the c. 8500 years old high-temperature debris at Çatalhöyük. We re-interpret the sample identified earlier as metallurgical slag as incidentally fired green pigment, which was originally deposited in a burial and later affected by a destructive fire that also charred the bones of the interred body. We also re-confirm the contemporary metal beads as made from native metal. Our results provide a new and conclusive explanation of the previously contentious find, and reposition Çatalhöyük in a new narrative of the multiple origins of metallurgy in the Old World.

1. Introduction

Tracing the invention and spread of metallurgy is essential to understanding the relationship of this technology with the rise of social complexity, and ultimately, the economy of early civilisations during the transition from the Neolithic to the Metal Ages. The scholarly quest for the origins of metallurgy has focused on a broad region spanning the Balkans and Central Asia via Iran, known for the early use of metals. The site of Çatalhöyük, situated in the geographic centre of this broad region, represents a milestone in our understanding of past societies in Anatolia from as early as c. 7400 cal BC. The outstanding architectural and material legacy of this settlement has been attracting scholarly attention ever since its discovery, making it one of the best-studied prehistoric archaeological sites globally[1], with an exceptional number of specialists involved in building hypotheses on the evolution of prehistoric communities in this part of the world (Mickel, 2016).

Metallurgical activities at Çatalhöyük have long stimulated scholarly debates due to an unusually early date for a find that appeared to contain features of a metallurgical 'slag', set at c. 6500 cal BC (Neuninger et al., 1964; Mellaart, 1964; Cessford, 2005). This was based on analytical work conducted in the 1960s that identified this alleged evidence for copper smelting in an assemblage of archaeometallurgical materials dated around the mid-7th

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millennium cal BC. However, these materials have never been fully assessed within their archaeological and technological context. The argument that the Neolithic Çatalhöyük communities were possibly smelting metal has, since then, been discussed controversially in the literature, from ardent support (Hauptmann et al., 1993; Hauptmann, 2000) to plain acceptance (Strahm, 1984) and more cautious reception (Muhly, 1989; Pernicka, 1990; Craddock, 2001; Roberts et al., 2009; Birch et al., 2013) to open scepticism (Tylecote, 1976; Radivojević et al., 2010). Against such a backdrop, a full re-analysis of the original metallurgical 'slag' from Çatalhöyük was the only way to resolve this enigma.

Major progress has been made recently in our understanding of the beginnings of metallurgy in Eurasia, pushing the boundaries of what is known about the emergence of metal extraction, chronologically and spatially (e.g. Bourgarit, 2007; Radivojević, 2007, 2012; Radivojević et al., 2010, 2013; Murillo-Barroso and Montero-Ruíz, 2012; Leusch et al., 2014). Sensorial aspects of early technology in particular are growing in importance in these debates (for the Balkans see Radivojević and Rehren, 2016; Rehren et al., 2016). Some of these studies have revived the theory of multiple origins of metal extraction in Eurasia, as opposed to the long-standing argument for its single place of invention in the Near East (see Roberts et al., 2009). In this light, and drawing from the expertise gained from studying early Balkan metallurgy, our team revisited the Çatalhöyük metallurgical evidence. We were guided by the intention to investigate further the convergence hypothesis of metal invention (e.g. Renfrew, 1969; Radivojević, 2015), and to clarify the initial results from analyses by Neuninger et al. (1964).

A total of 41 items from Mellaart's 'metallurgical finds' (polished blocks and glass containers with dozens of small fragments) from Çatalhöyük and Hacılar were available to us, including the material analysed by Neuninger et al. (1964) and Sperl (1990, 1991) (Fig. S1, Supplementary Materials). The results of our analyses of the key Çatalhöyük finds are presented below, as the basis for a revised hypothesis on how metallurgy developed in this Neolithic site in Anatolia, and beyond.

1.1. Early metal use in Eurasia

The view of early metallurgy as closely interwoven with, but distinct from stone bead manufacture has been presented elsewhere (Radivojević et al., 2010: 2784; Radivojević and Rehren, 2016); the latter going back well into the 11th millennium cal BC. By c. 6000 cal BC, the use of copper minerals and native copper had spread from Anatolia and the Levant across wide parts of Eurasia, including Syria (Golden, 2010), Transcaucasia (Kavtaradze, 1999), the Balkans (Glumac and Tringham, 1990; Radivojević and Kuzmanović-Cvetković, 2014; Radivojević, 2015), Iran (Pigott, 1999; Thornton, 2009; Helwing, 2013) and Pakistan (Kenoyer and Miller, 1999). The use of copper minerals has been strongly associated with their aesthetics, as has been observed in the use of 'greenstones' as inherently related to the rich symbolism of the green colour as a fertility charm (Bar-Yosef Mayer and Porat, 2008).

By the end of the 6th millennium cal BC, green copper minerals were transformed into copper metal by extraction, or *smelting*. Pernicka (1990) showed that low trace element concentrations (particularly cobalt and nickel) in copper metal indicate the use of native copper metal, based on hundreds of analyses of both objects and (native) copper from Anatolia and the Balkans (cf. Pernicka et al., 1993; Pernicka et al., 1997). The earliest securely documented evidence for copper smelting falls at around the transition of the 6th to the 5th millennium cal BC in the Balkans (Radivojević et al., 2010), and probably around that time in the Near East (Dougherty and Caldwell, 1966); the latter is still debated due to uncertainty concerning the archaeological and chronological evidence (cf. Frame, 2012; Thornton, 2014).

Thus, the copper 'slag' that Neuninger et al. (1964: 100–107) reported in Level VI at Çatalhöyük (c. 6500 cal BC, Cessford, 2005: 69–70) as a potential evidence for local smelting of copper metal stands out as unusually early, by c. 1500 years from the earliest recorded evidence elsewhere. Neuninger et al. (1964) reported that the sample in question has a limonitic core, akin to gossan, while the structure of the outer zone reflected high temperature treatment that resulted in the formation of a slag matrix with copper dross, delafossite and metal. Many scholars supported the idea of the intentional nature of a metal-making event this sample had been argued to demonstrate. While Muhly (1989) advocated that the 'slag' sample was melting (or refining) debris, Hauptmann et al. (1993) called it 'slagged ore'. Furthermore, Pernicka (1990), although acknowledging its confusing nature, interpreted this sample as a testimony of continuing heat treatment of different minerals, anticipating Craddock's (2001) interpretation that it sat at 'the verge of true smelting' at the site of Çatalhöyük. Tylecote (1976), on the other hand, was more careful with accepting this sample as related to metallurgy, given its low content of iron, which would have been essential for a slag formation. Radivojević et al. (2010: 2776) have commented that the limited penetration of the outer slagged ('hot') zone into the core of the studied sample suggested a short-lived thermal impact, inconsistent with a mature process of early copper extraction. Here, we present a full analytical reassessment of this and other samples from the assemblage analysed by Neuninger, Pittioni and Sperl in the 1960s, in light of analytical advances made during the last half century.

1.2. Introduction to the site of Çatalhöyük

Mellaart conducted excavations at Çatalhöyük from 1961 to 1963 and in 1965. This period proved to be a 'Golden Age' for him as he had identified a Neolithic site that was hitherto unknown in central Anatolia. He had not only pushed back the boundary of the period of early farming and the domestication of cattle and plants west of the Fertile Crescent, but he also placed Çatalhöyük on the international stage of remarkable archaeological discoveries. He courted media to great effect and employed important scientific advances of the time to enhance his findings, such as ^{14}C dating, obsidian sourcing, and indeed archaeometallurgy.

The site of Çatalhöyük comprises two mounds, the East Neolithic Mound that dates from c. 7100 to 5950 cal BC (Bayliss et al., 2015; Marciniak et al., 2015) and the West, largely Chalcolithic or Late Neolithic Mound that ends at about 5600 cal BC, in a seemingly continuous occupation. The mounds formed through successively constructed houses; growing in height but also in extent as peripheral areas were expanded over. As each 'layer' of abutting buildings was exposed and excavated, Mellaart designated these neighbouring buildings into *Levels* that defined roughly contemporary neighbourhoods. Thus, at the top of the East mound, Level I represents the latest occupation horizon with Level XII towards the base of the mound; Level XII represents the earliest structures or middens excavated but not, necessarily, the earliest at the site. Although Mellaart distinguished between 'houses' and 'shrines' (see Supplementary Materials); excavations and research conducted under the directorship of Ian Hodder (from 1993 - 2017) reviewed these distinctions and led to a preference for a non-hierarchical classification of 'building', which will be used here.

Buildings were constructed independently on the footings of the old ones, and side-by-side. The walls of one building abutting the walls of its neighbouring building created tightly clustered buildings interspersed with open 'courtyard'/midden areas. Access into the buildings was via a roof opening. Internally, they followed a standard pattern of furnishing and arrangement but were

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