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Large scale smelting of speiss and arsenical copper at Early Bronze Age Arisman, Iran

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ABSTRACT

We report analyses of different slag types found at the Early Bronze Age site of Arisman in North-West Iran. Here, an estimated 20 tons of slag provide evidence of sustained and large-scale production of metal, using both furnaces and crucibles. The results show that both speiss, an iron-arsenic alloy, and arsenical copper were produced, apparently side-by-side at the same site but using different ores and processes. We offer a tentative outline of the metallurgical processes involved in the production of these arsenic alloys and an explanation why speiss needed to be produced from arsenopyrite in a separate step, instead of using the mineral in its native form as a source for arsenic. We suggest that the speiss was then added either to secondary copper ore or to separately smelted copper metal, in order finally to produce arsenical copper in a regular and well-controlled process.

1. Introduction

Arsenical copper is an important alloy in the development of copper metallurgy, typically occurring in a relatively short-lived transition period between the uses of unalloyed copper and tin bronze (Charles, 1967). This pattern has been documented for such diverse regions as the Iberian Peninsula, the Balkans, the British Isles, Siberia, Central Asia, and South America. In the Old World, Iran is exceptional in its long-lasting preference for arsenical copper at a time when most surrounding regions had already switched to tin bronze (Heskel and Lamberg-Karlovsky, 1980; Heskel, 1983; Pigott, 1999; Thornton, 2009). This makes Iran an ideal region to investigate the production of arsenical copper in more detail. Previous research has shown that a number of different routes could lead to arsenical copper, including the smelting of complex sulph-arsenide ores (fahlore, etc.) (Rostoker et al., 1989; Rostoker and Dvorak, 1991; Lechtman, 1996, Lechtman and Klein, 1999; Höppner et al., 2005), the smelting of native copper and copper-arsenide minerals (Budd et al., 1992), and the conscious addition of an arsenic-rich mineral such as realgar/orpiment, arsenopyrite or löllingite to copper metal or copper ore (Heskel, 1983; Moorey, 1999; Thornton et al., 2002; Pigott, 2008). More recently, Thornton et al. (2009) proposed that an artificial iron-arsenic alloy, called speiss, was produced in Early Bronze Age Tepe Hissar, North Iran, presumably to be added to copper metal for the production of arsenical copper. Even though finds of speiss are relatively well-known from several EBA copper workshops, suggesting that this material was widely used and traded (see Rehren et al., 1988; Keesmann and Moreno-Onorato, 1999; Hauptmann et al., 2003; Müller et al., 2004; Doonan et al., 2007), the Tepe Hissar study was based on only a small number of finds from an urban workshop – hardly enough to postulate with confidence a regular, intentional speiss production. Indeed, modern conventional metallurgical wisdom has it that the production of speiss has to be avoided at almost all cost, since it is more harmful than useful for any practical purpose (R. Maddin personal communication, 2009).

It is therefore of considerable importance that recent excavations by the German Archaeological Institute at the EBA metallurgical site of Arisman in Western Iran (Fig. 1) have uncovered large quantities of slag derived from the routine production of speiss as a material in its own right – in the context of arsenical copper production, but in an independent smelting operation leaving behind slag in the order of several tons.

First discovered in 1996 by a local resident, the site of Arisman has undergone four seasons of excavations between 2000 and 2004 by a joint Iranian-German team consisting of the Iranian Cultural

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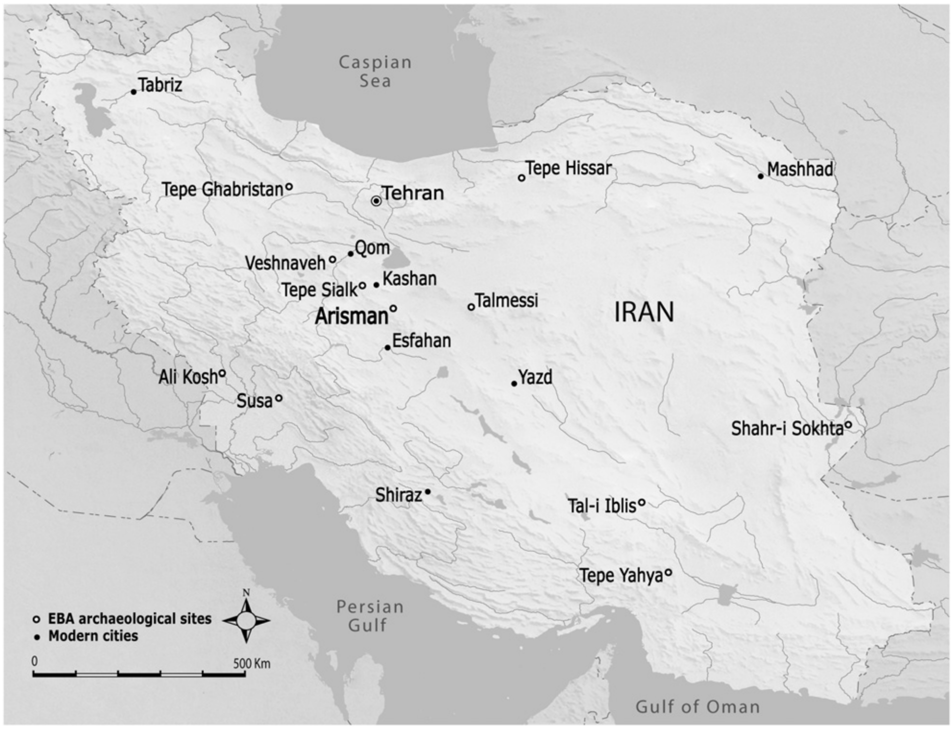

Fig. 1. Map of Iran with EBA archaeometallurgical sites.

Heritage Organisation (ICHO), the Geological Survey of Iran (GSI), the German Archaeological Institute (DAI), the German Mining Museum in Bochum (DBM) and the Institute of Archaeometry of the University of Technology Bergakademie Freiberg (Chegini et al., 2000, 2004; Vatandoust et al., 2011). Ceramic typologies associate Arisman chronologically with the Sialk III 6–7, Sialk IV, and Ghabristan IV periods, dating it from the later fifth/early fourth millennium BC to the middle of the third millennium BC (Helwing, 2008). Situated ca. 1000 m above sea level in the transitional zone between the north-eastern slopes of the Karkas Mountains and the lower plains of the Iranian Plateau (Fig. 1), the site of Arisman is located just 60 km from the well studied EBA metallurgical site of Tepe Sialk.

Excavations focused on a number of low settlement mounds that revealed distinct activities and occupations. The earliest occupation of the site, dating to the Sialk III 6 and 7b periods, is believed to be representative of domestic scale, crucible bound smelting of the late Chalcolithic to EBA. Over the course of the next several centuries, metallurgical activities appear to have intensified but also shifted geographically to several other areas of the site, culminating in the formation of a large slag heap containing an estimated 20 tons of slag in area A.

Radiocarbon dated to between 3100 and 2900 BC (Görsdorf, 2011), this slag heap corresponds well with associated ceramics tied to the Sialk IV period of the EBA. The mound consists of a series of layers of sand and slag 10–40 cm thick, with at least four major deposition events separated by thin lenses of sand (see Fig. 3 in Steiniger, 2011: 70). In addition, there are numerous micro-depositional layers in the centre of the heap associated with a mudbrick platform and furnace structure that showed signs of having been rebuilt dozens of times. Excavations revealed the slag heaps to be composed in about equal parts of grey copper rich slags

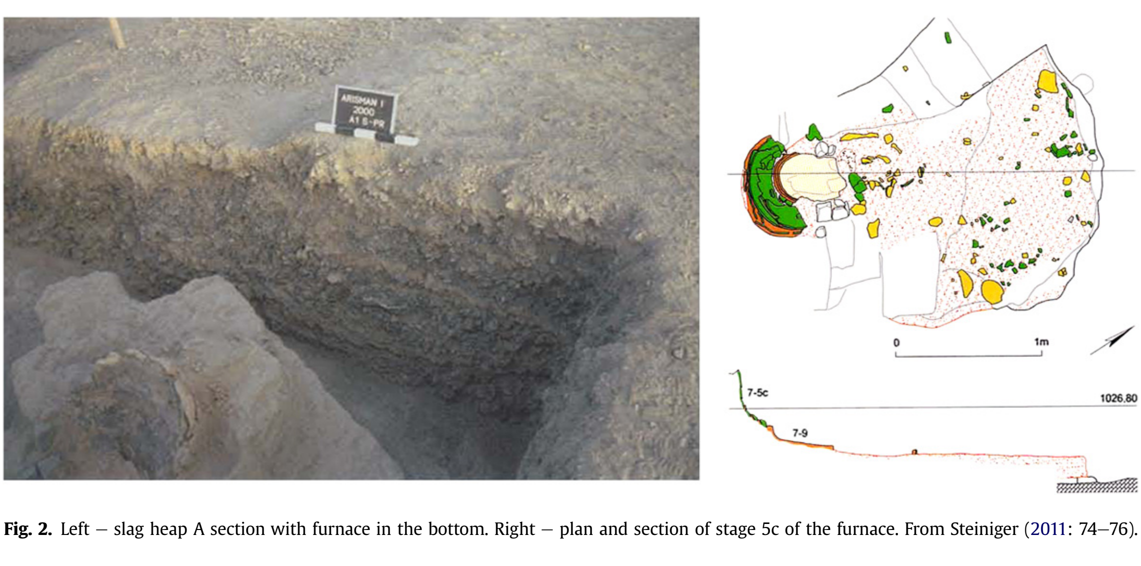

Fig. 2. Left – slag heap A section with furnace in the bottom. Right – plan and section of stage 5c of the furnace. From Steiniger (2011: 74–76).