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## Copper production landscapes of the South Caucasus

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## ABSTRACT

Studies of metal production frequently show a correlation between scale and organizational complexity. The remarkably rich landscapes of metal-producing sites of late 2nd-early 1st millennium BC Colchis provide an unprecedented opportunity to reexamine this apparent correlation. Investigations of copper smelting sites show that industries with a large aggregate output can be the result of numerous small groups of metalworkers acting independently. Spatial data on site distributions, estimates of productive output, and archaeometric data on ore procurement patterns were integrated to reconstruct the organization of production. Judicious use of a portable X-ray fluorescence spectrometer (pXRF) showed that not only were smelting sites highly dispersed, but also that metalworkers at different sites were using ores from geologically distinct deposits. This innovative approach helped to reconstruct the organization of production in a distinctive metal production landscape, bridging an enduring divide between landscape-scale and microscopic investigations of craft production.

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## 1. Introduction

Metal production systems are complex enterprises shaped by both natural and anthropogenic factors (Hardesty, 2010: 109). Geological realities constrain where ore deposits are located, and ecological factors determine where suitable fuel sources can be found. Often these areas are located in mountainous regions or in other areas of marginal agricultural potential, meaning that ore deposits are removed from both sources of labor and consumer markets. Many metallurgical technologies require specialist knowledge gained over long periods of time. These twin issues—the complexity of the production process and the spatial distribution of resources—have invited a range of different solutions, from emergent systems organized from the bottom up (Morse, 2003: 4), to highly organized expeditions by centralized authorities (Shaw, 1998).

In Western Asia, the organization of metal production, particularly bronze and iron, has figured prominently in discussions of social and technological change in the late 2nd and early 1st millennia BC (Mirau, 1997; Sherratt, 1993; Zaccagnini, 1990). The overwhelming geographical focus of research on Late Bronze and

Early Iron Age (LBA-EIA) metal production and trade is the eastern Mediterranean and the Levant (Kassianidou, 2012; Knapp, 2012; Knapp and Kassianidou, 2008; Liverani, 2003; Liverani, 2008; Pulak, 2008; Sherratt, 1993, 1998). Much of the scholarly debate has centered on the degree of state control over trade and (to a lesser extent) production (Bell, 2012; Routledge and McGeough, 2009). However, though it is clear that economic activity was organized by both merchant families independent of the palace and “men of the king” working for the crown, the pervading viewpoint is that much trade, especially long-distance large-scale movements of materials, was organized from the top down.

Studies of LBA-EIA copper production have uncovered landscapes that bear the mark of a highly centralized system of control over production. There is ample evidence of New Kingdom (LBA) Egyptian presence in major copper producing areas (Rothenberg, 1987, 1988), even if the nature of that presence is unclear. Despite new Early Iron Age dates from Timna Site 30, a site previously thought to be Late Bronze Age in date (Ben-Yosef, 2010: 567; Ben-Yosef et al., 2012), it is highly likely that Egyptians exploited copper in the Timna area (Yagel et al., 2016). By the Early Iron Age, large fortified smelting camps were constructed at Timna and Faynan (Bachmann and Rothenberg, 1980; Hauptmann, 2007; Levy et al., 2012; Levy et al., 2014; Rothenberg, 1990; Weisgerber, 2003). These smelting sites attest to both the centralization of production and the efforts to control and protect

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valuable resources and labor—a remarkable feat if, as has been suggested, significant portions of the population remained mobile (Levy, 2009).

Evidence of Late Bronze copper production on Cyprus is substantial, but there are some important gaps (Knapp, 2012). While copper slags are commonly found in urban LBA contexts on the island (Courtois, 1982; Kassianidou, 2012; South, 2012; Stech, 1982; Tylecote, 1982), LBA evidence of copper smelting and mining in the rural hinterlands near ore deposits is more scarce (Kling and Muhly, 2007; Knapp and Kassianidou, 2008). This is almost certainly due to modern mining, as well as the presence of large slag heaps of pre-modern, post-Bronze Age date (see Shaar et al., 2015). There is ample speculation that, especially in the Late Bronze Age, Cypriot mining and smelting was a highly organized enterprise directly administered by elites in coastal centers (Knapp and Kassianidou, 2008: 144), though the ubiquity of metal production at different sites suggests centralized island-wide control is less likely (Stech, 1982: 113). It is certainly possible coastal elites directed mining and smelting activities in the interior, but the small body of evidence for LBA metallurgical activities in inland mining regions leaves open other possibilities.

Outside of the Eastern Mediterranean, very few studies have looked at the spatial and social organization of LBA-EIA copper production in Southwest Asia. Investigation of copper production landscapes in the western regions of the South Caucasus reveals an industry that defies traditional models of how large metal production industries were organized. Data from field survey and test pitting of smelting sites, coupled with a detailed reconstruction of the technology of copper production (Erb-Satullo et al., 2014; Erb-Satullo et al., 2015), provide a fundamental basis for considering questions about the spatial and social organization of copper production. The large number of metal production sites, and the abundant production debris found at each of them, allow us to merge spatial and archaeometric data in new ways. This approach not only illuminates the dynamics of a metal production landscape, it also demonstrates how archaeometric data can contribute to a broader understanding of social and economic processes. The picture that emerges is one that differs from traditional notions about the links between organizational complexity and scale of production, demonstrating that industries with large-scale aggregate output can emerge through the actions of numerous independent, small-scale producers.

## 2. Space and social organization in production landscapes

Any attempt to reconstruct the organization of copper production must begin with a discussion of the spatial parameters of the industry. Where are the ores coming from? What do the spatial distribution of smelting camps and the kinds of activities taking place at them tell us about the organization of production? How is metal distributed and where are artifacts made?

The synthesis of spatial and archaeometric data allows us to approach more complex social questions about the coordination of production. Was metal production organized from the top-down or were small groups of people exploiting many different deposits? The degree to which production was controlled (and if so, by whom) is a fundamental issue. The concepts of coordination and control are related to the concept of attached production (Costin, 1991; Earle, 1981). However, the former terms, particularly “coordination,” do not assume that the producer lacks the “rights of alienation” (i.e. the ability to dictate what happens to the product), a key element of some definitions of attached specialization (cf. Clark and Parry, 1990: 298). As an index of production, coordination refers to the degree to which metal production was carried out by a large group of people acting in concert towards

a single goal. High levels of coordination encompass a range of different types of social organization, including both communal pooling of labor resources, as well as highly regimented mining and smelting expeditions organized from the top down (e.g. Shaw, 1998).

The extent of coordination and control has a direct impact on the spatial organization of production activities (Rochette, 2009; Zori et al., 2013). Highly concentrated smelting camps are easier to monitor. Direct visual oversight of production allows those organizing and controlling production to ensure compliance and obedience in the labor force, monitor the distribution of raw materials to workers, and increase organizational flexibility through easy communication between work parties. In the archaeological record, there are numerous instances where the concentration of production is correlated with other evidence of increased control (Levy et al., 2014; Olivier and Kovacic, 2006). Following Arnold and Munns (1994), one analytical approach for assessing the degree of control is to identify “choke-points,” or key nodes along the chaîne opératoire where a small minority could exert an outsize influence over production. In the case of Arnold and Munns, while Santa Barbara Channel Island bead production was not directly monitored by elites, the importance of elite-owned canoe transportation for bead distribution meant that they exerted *de facto* control over the industry. In the sequence of activities required to produce bronze objects, there are many possibilities for this kind of horizontal integration. Rich deposits of copper ores may be located deep underground, requiring significant labor to cut through overlying rock. This circumstance might result in the construction of just a few, easily controlled mines. On the other hand, ores may occur in numerous outcrops close to the surface, making control of access more difficult. The primary smelting stage of production offers another chance to exercise control over production, especially if this activity, which requires specialist skills, occurred in nucleated workshops close to centers of political authority.

Spatial nucleation of production activities and top-down control by political elites are not strictly connected, however (Campbell et al., 2011; Costin, 2011: 112ff.). Some ecological factors may push for a more dispersed pattern of production, even if it falls under the control of a regional authority. A large smelting camp will quickly exhaust fuel in its immediate vicinity, so a more dispersed landscape of smelting sites might reduce the amount of work required to bring fuel to the furnace. Lack of external threats may result in a centrally administered production system that is nevertheless somewhat dispersed (e.g. Yagel et al., 2016). A cellular model of production (see Martín-Torres et al., 2014) also permits spatial dispersion of workshops even within the context of a tightly controlled industry. Conversely, Stark’s (1991) study of community specialization among Kalinga potters reveals how production can be concentrated in certain areas, but without administrative control.

For these reasons, it is not sufficient merely to look at the spatial distribution of smelting sites and their relative sizes. In addition, the patterns of behavior at these sites must also be examined. Distance unavoidably attenuates the ability to control both end products and labor, and increases the cost of maintaining that control (Costin, 1996: 212). However, it is conceivable that controlled, or at least coordinated, enterprises might be scattered in different locales. Spatially dispersed yet highly controlled production landscapes may show a high degree of coordination in production activities, such as the types of ores used, the standardization of tools, or a homogeneous set of production practices. Highly organized, tightly controlled industries may be dispersed for some stages of production, but it is very unlikely that they would be dispersed at *all* stages of production. It is also crucial to consider the possibility that loose networks of independent metalworkers may share techniques and practices (through apprenticeship or other

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