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An integrated approach to the characterization and dating of furnaces in smelting sites in Macedonia, Greece

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ABSTRACT

Metal production sites are characterized by slag heaps which are often difficult to date due to a general lack of diagnostic pottery. This problem has been countered in recent years by the use of absolute dating techniques. Furnace fragments of severely fired clay, which are usually present in such production sites, represent an ideal material for the dating of metallurgical activity. Yet the studies focusing on the dating of furnace debris are very limited, hence there is a need to better evaluate and date such material. In order to gain absolute dates, thermoluminescence (TL) dating of ceramic refractories from sites in northern Greece has been applied. More precisely the sampled archaeological material consists of ceramic tuyères from two areas, namely Angistro and Katafyto, which were used to direct air into the furnaces and were deposited in the slag heaps shortly after the smelting of iron. In addition, fragments of clay linings used for coating the interior surface of the furnace were also studied. A measurement of their TL dose provides the dating of the actual smelting process and contributes towards establishing a chronology for iron production in northern Greece, which is currently lacking. The samples were found to date within the 16th–18th centuries, a period marked by an increase in pre-industrial Ottoman metallurgy. The tuyères were also analyzed by micro-XRF and examined under stereoscope in order to determine their chemical composition and study their morphology. Results show that coarse fabrics of local clay, tempered with various rock inclusions were used in order to produce fire-resistant refractories to withstand cracking at high temperatures.

1. Introduction

The development and organization of iron production in northern Greece and its concomitant economic importance has rarely attracted scholarly attention. This lack in the study of industrial activity is to a large extent embedded within broader attitudes towards cultural heritage strategies, which often overlooked the evidence for rural production sites or large-scale industrial districts (Cassela and Symonds, 2005, 68; Palmer and Neaverson, 1998, 22). While Western technological trajectories have been woven into narratives of industrialization and rational science, Eastern European traditions have been sidelined with the pivotal political role of metal procurement and production being tacitly accepted but not addressed. Contrasting attitudes to efficiency and consumption highlight the independent trajectories that were followed in this area and as such stress the need for a more complete understanding including both socio-economic and technological parameters.

The region of eastern Macedonia and Thrace has been one of the most important metal producing regions in Greece since antiquity. Its geological wealth in metallic minerals found as extensive oxidized and sulphidic ore deposits made it possible for the development of thriving metal producing workshops that supplied iron, copper, silver and gold at various sites (Nerantzis, 2016). A growing number of archaeometric results are now available regarding the technology of precious and base metals production and the processes through which it developed during the Classical and Roman periods (Wagner and Weisgerber, 1988; Photos et al., 1989; Kostoglou, 2008, 2010; Nerantzis 2015). The mines that supplied the ancient bloomery workshops are supposed to have

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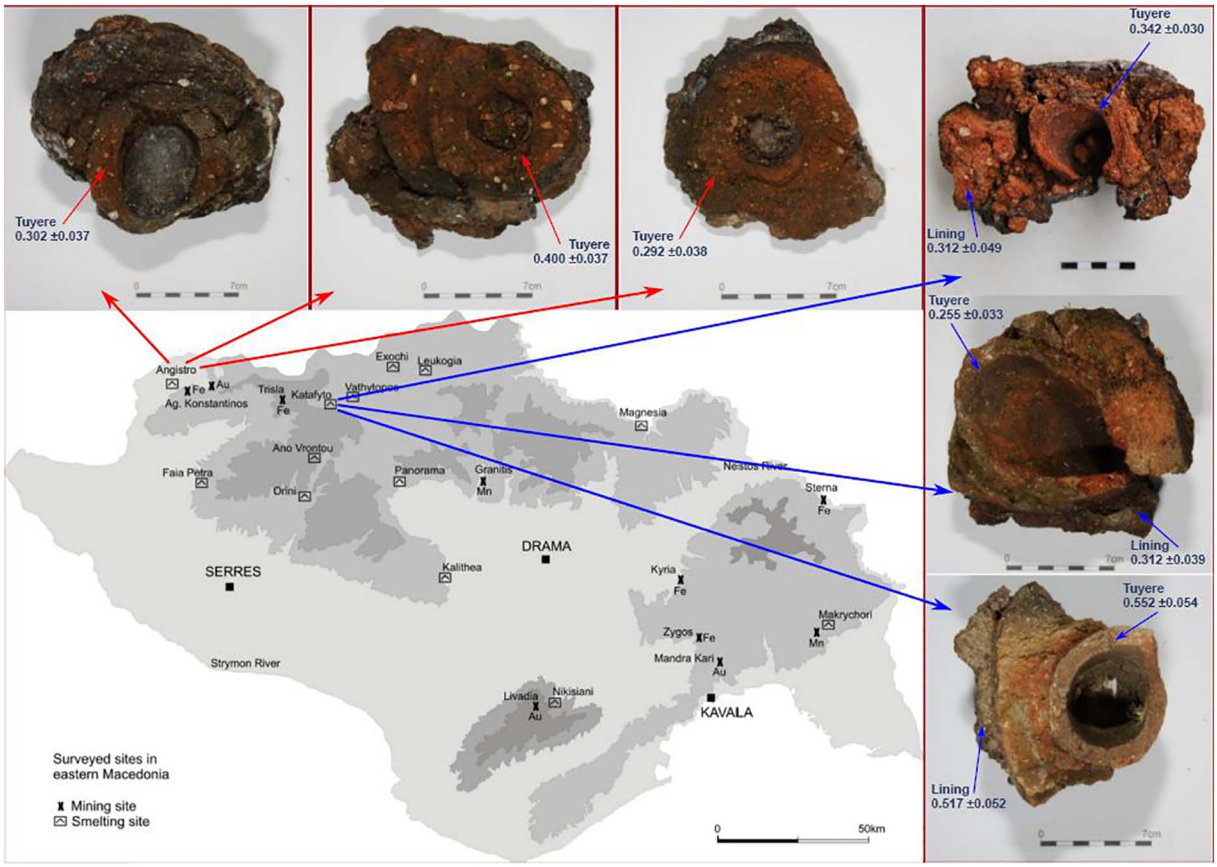

Fig. 1. Map of the survey area showing the location of Angistro and Katafyto along with three of the corresponding samples studied from each area (numbers in images refer to age found in the present study).

fallen into idleness around the 5th century AD or became a secondary source of iron and precious metals compared to the rich Byzantine imperial mines in Egypt, Asia Minor and Serbia (Vryonis, 1962; Bryer, 1983). In the following centuries although the trade in Byzantine metalwork is known to have been extensive and far-reaching (Harris, 2003) there is little archaeological evidence to be used for a reconstruction of ore procurement, mineral processing methods and metallurgy practiced in Byzantine lands. With the spread of the Ottomans and the establishment of an Empire in former Byzantine territories renewed interest in metallurgical production triggered an increase in outputs reflected in contemporary documents (Issawi, 1980; Inalcik and Quataert, 1994).

Until the previous decade the spatial analysis of metallurgical sites has been very limited and was primarily based on geological survey data acquired for reasons other than archaeological inquiry. Previous fieldwork had attempted to identify and characterize known, forgotten and suspected sites of mining and smelting across the southern Balkans (Gialoglou and Drymonitis, 1983; Photos et al., 1989; Chiotis et al., 1996). While such studies were successful, limited survey within northern Greece has highlighted the scale of unrecorded sites in this area. Although these earlier attempts provided some clues to the technology of mining and iron smelting, a critical aspect of the work, which has been completely lacking is the secure dating of these sites (Photos et al., 1986; Vavelidis et al., 1997).

Limited studies have focused on dating furnace walls, lining and tuyères deriving from Greek sites with the only available examples focusing on Early Bronze Age smelting in the Cyclades (Zacharias et al., 2006a, 2006b; Hein et al., 2007). Similar attempts to date Etruscan furnaces at Baratti-Populonia in Italy have been also successful (Benvenuti et al., 2003). For the region of interest no absolute dating methods have been applied on metallurgical ceramics in the past, with the only exception of Thasos where furnace fragments from three smelting sites were dated by TL (Hauptmann et al., 1988).

In order to contribute new data to this field, an analytical program has been conducted for the characterization and thermoluminescence (hereafter TL) dating of metallurgical ceramics directly associated with metal production i.e., the **tuyères** used to direct air into the furnaces and fragments from the furnace clay walls. Characterization of this material by micro-X-Ray Fluorescence Spectroscopy (micro-XRF) has been carried out with the aim to provide a determination of their bulk chemical composition. The results presented here provide additional technological information on the smelting process and for the first time offer absolute dates for this activity. The study focuses on iron metallurgy because the utility and ubiquity of this material means that it is produced and consumed simultaneously by state institutions and local communities. As such it provides an excellent context for exploring how the relationships between dispersed communities and state institutions changes through time.

2. Sites of metallurgical activity and previous work

The study area of eastern Macedonia, in northern Greece has been selected for a number of reasons, which could be summarized into the following: the geological-mineralogical diversity characterizing this region; the long histories of mineral exploration at numerous sites and its important socio-cultural role during the Middle Ages due to its location at a crossroads between Constantinople and Thessaloniki (these two cities have been centres of great cultural significance during both Byzantine and Ottoman periods). Compositional analyses on the various ores have been systematically conducted by the Institute of Geology and Mineral Exploration (IGME) in Greece. The mining regions consist geologically of oxidized (hematite, limonite) and sulphide