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Charcoal from a prehistoric copper mine in the Austrian Alps: dendrochronological and dendrological data, demand for wood and forest utilisation

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ABSTRACT

During prehistory fire-setting was the most appropriate technique for exploiting ore deposits. Charcoal fragments found in the course of archaeological excavations in a small mine called Mauk E in the area of Schwaz/Brixlegg (Tyrol, Austria) are argued to be evidence for the use of this technology. Dendrochronological analyses of the charcoal samples yielded calendar dates for the mining activities showing that the exploitation of the Mauk E mine lasted approximately one decade in the late 8th century BC. Dendrological studies show that the miners utilised stem wood of spruce and fir from forests with high stand density for fire-setting and that the exploitation of the Mauk E mine had only a limited impact on the local forests.

1. Introduction

The area of Schwaz/Brixlegg (Tyrol, Austria) in the Lower Inn Valley was well-known for silver mining in the late medieval and early modern times, when this region was the world's largest silver producer (Westermann, 1986; Hanneberg and Schuster, 1994; Bartels et al., 2006). However, silver makes up only a small proportion of the metals found in the ores of the Lower Inn Valley, which are dominated by copper (Gstrein, 1979). Today, there are no mining activities in the area of Schwaz/Brixlegg; however, several buildings and landscape features document the long mining history, which is not limited to medieval times. Many mines in this region may be partly attributed to activities in historic periods, but in some places, ore deposits were already being exploited in prehistoric times. These mining activities were first verified by archaeological excavations in the 1990s (Goldenberg and Rieser, 2004). More intensive excavations on prehistoric mining in the Lower Inn Valley have taken place since 2007 (Schibler et al., 2011). We conducted a detailed investigation of one of these small mines, the so-called *Mauk E* mine, which had initially been explored in the 1990s (Fig. 1).

Of key interest in the investigations at the Mauk E mine was establishing the dates and the duration of ore exploitation. While findings of stone hammer and pottery fragments in the prehistoric layers are rare, an enormous amount of pinewood chips and charcoal could be retrieved from the Mauk E mine. The latter are remains of fuelwood used to weaken the rock by fire-setting, a common technique in prehistoric times for exploiting ore deposits. Charcoal samples can be informative in two ways: (1) the charcoal can be radiocarbon dated and (2) the size and number of tree rings on some pieces, as well as the quantity of the excavated charcoal, make dendrochronological and dendrological investigations possible. By analysing the tree rings of a first group of charcoal samples, we were able to establish a 149-year-long tree-ring chronology that ends in 707 BC (Pichler et al., 2010).

This dendrochronological result agrees in general with the first radiocarbon dates based on charcoals that imply mining activities around the transition from the Late Bronze Age to Early Iron Age (Stöllner, 2009). However, the calibrated ^{14}C results are spread over a time-window of approximately 600 years (ca. 1000–400 BC). This

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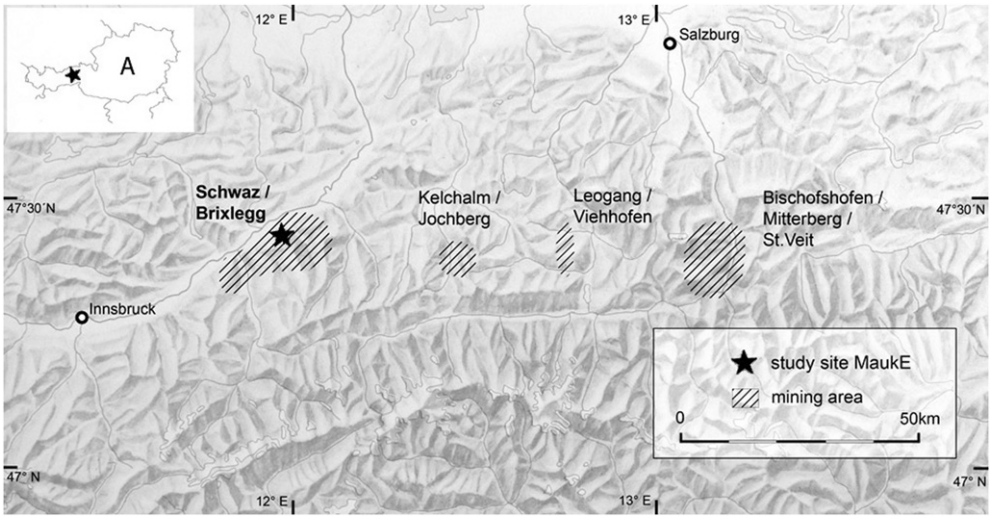

Fig. 1. Location of the study site Mauk E within the mining region Schwaz/Brixlegg. Other prehistoric mining areas in the northern part of the Eastern Alps are also shown (map based on Alpen Reliefkarte – Tirol Atlas).

first set of ^{14}C dates does not make it clear whether this spread indicates an enduring or recurring exploitation of the Mauk E mine or whether the range of dates is related to the limitations of radiocarbon dating (inaccuracy of calibrated radiocarbon dates due to the ^{14}C-Hallstatt plateau) of charcoals (possible *old wood effect*) in the first millennium BC (Pichler et al., 2011). One of the objectives of our study was to either verify a long exploitation period or determine that the spread of the ^{14}C results is merely the result of inaccuracies in radiocarbon dating.

However, our tree-ring analyses performed on charcoal material from the Mauk E mine allowed us to expand the scope of issues beyond dendrochronological dating. By determining the tree species and estimating the diameter of the timber used, we can assess whether the miners preferred a certain type of tree or tree size. Further questions outlined in this paper focus on the demand for fuelwood needed to exploit the mine and the possible impact of the firewood utilisation on the local forests. To gauge the amount of fuelwood needed for underground mining, we included 3D laser-scanning data of the volume of rock exploited in the Mauk E mine as well as data from different fire-setting experiments (O'Brien, 1994; Gätzschmann, 1846; Tereygeol, 2001; Py, 2009). Dendrochronological analyses of mining timber will continue to deepen our knowledge of the history of mining in the Alpine Region, particularly during prehistoric times.

2. Site, material and methods

2.1. Site and archaeological excavations

The Mauk E mine (Fig. 1) is located in the Lower Inn Valley (N 47°26′14″, E 11°57′12″; 997 m a.s.l.) on a north-facing slope in the Northern Alpine Greywacke zone, which holds rich ore deposits of the Fahlore-group minerals, a sulfosalt mineral family that contains copper, silver, iron, zinc, arsenic, antimony, and sulphur. In addition, this Fahlore-group minerals may include mercury, tellurium and other elements (Goldenberg and Rieser, 2004; Krismer et al., 2011).

Today, the entrance to the mine is surrounded by dense woodland dominated by spruce (*Picea abies*) and fir (*Abies alba*). The mine itself has a ramified ground plan (Fig. 2) and reaches approximately 25 m into the rock.

Some parts of the Mauk E mine were also exploited in early modern times. Dendrochronological results from wooden remains provide evidence of mining activities in this location between ca. 1560 and ca. 1600 AD (Pichler and Nicolussi, 2011). After removing stowing from the modern period, archaeological investigations of the prehistoric layers were performed in various parts of the mine (Fig. 2). For this study, we mainly analysed charcoal excavated in sections S1, S3 and S4. Some very small pieces were found in the 1990s during the first small-scale excavations in section S2. The potential for dendrochronological analyses of these charcoal samples was low; instead, the samples were subjected to radiocarbon dating.

2.2. 3D-documentation of the Mauk E mine

Terrestrial laser scanners are state-of-the-art tools for surveying the 3D geometry of objects of any type and shape (Hanke et al., 2010; Kovács et al., 2011). In this case, we wanted to calculate the volume of the Mauk E mine and to create cross-sections. As the space inside the mine is quite narrow, we needed nine individual instrument positions to guarantee a consistent 3D acquisition of the entire structure of the interior part of the Mauk E mine (Fig. 3). Scanning was accomplished with a Trimble GX 3D terrestrial laser scanner with a spatial resolution of 2 cm.

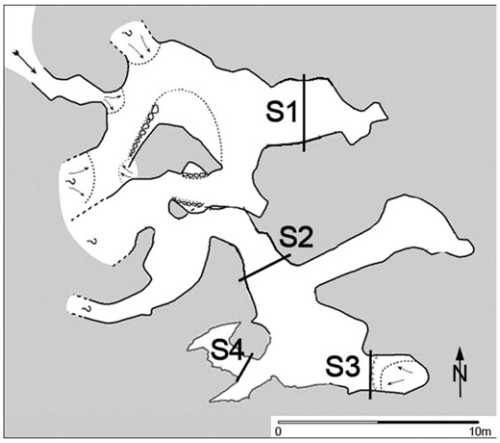

Fig. 2. Ground plan of the fire-set Mauk E mine. S1, S2, S3 and S4 indicate the locations where the samples were discovered.