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Tree-ring analyses on Bronze Age mining timber from the Mitterberg Main Lode, Austria - did the miners lack wood?

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ABSTRACT

Wood was an essential raw material for mining maintenance in historic and prehistoric times. During the Bronze Age, the Mitterberg mining region in the Austrian Alps was one of the most important producers of copper and, consequently, a consumer of huge amounts of wood. Since the 1960s, archaeological investigations at the Troiboden dressing site at the Mitterberg main lode have uncovered mining timber both single finds as well as box-shaped wooden constructions like wet-tyes which were used to wash and concentrate crushed copper ore. Dendrochronological analyses on a set of mining timber yield calendar dates for these mining activities: a boom phase from the 14th to the 13th century BC, including two felling phases – one in the 1370s and a second from the 1290s to 1270s BC – are verifiable so far. As a result, the wood supply from nearby forests may have been exhausted rapidly, which is confirmed by palynological records from bogs in the vicinity of the excavation site. By utilising a tree-ring growth–elevation model developed by Dittmar et al. (2012), the elevations of growing sites were estimated to detect where the mining timber might have originated. To examine the model outcomes, we used tree-ring data with known origin, i.e., series from living trees and subfossil samples from the Troiboden and its vicinity. The results for the mining timber suggest that the prehistoric miners utilised trees from the vicinity of the mining site in the 14th century but at least partly sought wood from growing sites at lower elevations to continue mining during the 13th century BC.

1. Introduction

Analyses carried out on Bronze Age metal artefacts prove the utilisation of different types of copper ore through the centuries in central Europe. During the Middle Bronze Age, commonly produced and distributed copper originated from chalcopyrite mines, like those of the Mitterberg mining region in the northern Eastern Alps, which is part of the greater Salzach-Pongau mining area, where the biggest copper ore deposits in the Eastern Alps are located (Pernicka et al., 2016; Ebner, 1997). At this time, chalcopyrite was also exploited in other Alpine regions, e.g., at the Kelchalm near Kitzbühel c. 50 km westwards of the Mitterberg (Pernicka et al., 2016). However, during the Bronze Age, particularly in the middle of the 2nd millennium BC, the Mitterberg region was not only the most important copper producer in the Eastern Alps but possibly in all of Europe (Pernicka et al., 2016). Copper ore exploitation and copper production on a large scale such as at the Mitterberg main lode, which is one of the most important exploitation areas of the Mitterberg mining region, has greatly affected the landscape. Currently, traces of these activities can be observed in multiple forms, with the simplest in the form of dumps and mining depressions (Stöllner et al., 2012b). Prehistoric mining in the Mitterberg region was rediscovered in 1827, and it was not long before the first archaeological finds were uncovered (e.g., Much, 1879). Since that time, the Mitterberg region has become an area of high scientific interest up to now. The long-lasting history of former research on prehistoric mining is summarised, e.g., by Stöllner et al. (2012b).

Since the 1960s (Eibner, 1972) but in the course of new archaeological excavations at the Troiboden dressing site (1576 m a.s.l.) at the Mitterberg main lode since 2008, several wooden ore-washing constructions – so-called wet-tyes, some of which were complete – have been revealed. Additional mining timber was uncovered in the vicinity of these wooden constructions. The excavated timber has been approved as suitable for dendrochronological analysis and dating. The usually well-preserved timber often allowed the determination of waney edges and, thus, the establishment of accurate felling dates (Stöllner et al., 2012a; Nicolussi et al., 2015a).

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Dendrochronological analyses on mining timber from the Eastern Alps commenced only 20 years ago and were initially focused on material from salt mines (e.g., Ruoff and Sormaz, 1998, 2000; Grabner et al., 2007). One possible reason for the late start of such analyses was the lack of multi-millennial reference chronologies for the dating of prehistoric conifer timber that dominate the wood material from Alpine mining sites. However, Holocene chronologies for the conifer species cembran pine (*Pinus cembra*) and larch (*Larix decidua*) have been established recently (Nicolussi et al., 2009, 2015b). Hence, the number of dendrochronological investigations on timber, especially from prehistoric copper ore mining areas, considerably increased recently (Pichler et al., 2009a, 2013; Nicolussi et al., 2010, 2015a; Stöllner et al., 2012a, 2012b).

Within the last several years, archaeological excavations at Troiboden have intensified, which has resulted in the identification of 14 wet-tyes until now. However, few have been excavated and removed so far. Timber from these recently salvaged constructions, together with other wooden objects, resulted in a considerable number of new timber available for tree-ring (TR) analyses. In addition, TR width measurements were carried out on timber excavated during archaeological investigations at the Troiboden site in the late 1960s (Eibner, 1972; Eibner-Persy and Eibner, 1970) and are currently archived in the Salzburg Museum and have not been dendrochronologically analysed so far.

The establishment of additional accurate felling dates to address questions about the duration of ore exploitation and processing has been of key interest in the continuous analysis of timber from the Troiboden site. The increased number of analysed timber also allows for investigations into the wood supply. Mining wood was an indispensable raw material. A large amount of exploited ore and produced copper, as proven in the Mitterberg main lode (Pernicka et al., 2016), requires huge amounts of wood. Based on TR width measurements, we searched for evidence to detect whether prehistoric miners lacked wood. Palynological analyses carried out on a peat core from a bog near the Troiboden site indicate forest clearings on a large scale in the 14th and 13th century BC (Breitenlechner et al., 2014). Therefore, we studied the growth patterns of the analysed timber in more detail. To investigate if mining timber originates from more remote sites, i.e., from sites of different elevations, we applied the TR growth–elevation model established by Dittmar et al. (2012) in this study.

2. Site, material and methods

2.1. Site

The archaeological excavation area of Troiboden is located at the Mitterberg main lode (47°24′24,9"N; 13°08′10,5″E; 1576 m a.s.l.) and is part of the best known Bronze Age copper mining region in Austria (Fig. 1). The Mitterberg mining region is a cluster of several important mining areas of rich copper ore deposits on both sides of the river Salzach, which flows north-south. A detailed description of the different mining districts is given by Stöllner (2003). Figs. 2 and 4 show the location of the investigated area where i) the mining timber was excavated in the last several years (i.e., Stöllner et al., 2011, 2012a), ii) some of the subfossil logs analysed originate and iii) the sampled living trees are growing.

2.2. Material

2.2.1. Archaeological timber

For decades, archaeological excavations at the Troiboden revealed wooden findings. The moist and anaerobic storage conditions inside separation heaps and the peat bog protected the wooden artefacts from decomposition. In 1968, excavations led to the discovery of the first wet-tye (Eibner-Persy and Eibner, 1970). Excavations were resumed in 2008 and have intensified along a drainage trench called *Rösche* from 2011 onwards (Stöllner et al., 2012c). Here, we report on 65 timber samples excavated and dendrochronologically analysed so far in our study. The selection was carried out with regard to i) dendrochronologically dated timber or ii) undated samples with at least 50 consecutive tree rings necessary to run the TR growth–elevation model developed by Dittmar et al. (2012).

The timber analysed consists of three broadly complete wet-tyes, parts of a boardwalk, a timber grate and wood piles as well as several usually small and partly charred timber pieces (Fig. 3). The preserved four boards of the first excavated wet-tye (Eibner-Persy and Eibner, 1970) called *wet-tye 1* are currently stored in the Salzburg Museum and have not been dendrochronologically analysed until recently. During this first excavation, a set of split logs was explored left unexcavated. In 2008 and 2009, new archaeological investigations took place at the Troiboden, and this set of split logs, primarily used to stabilise the floor, and timber from a wood pile, together called *timber grate*, were excavated (Stöllner et al., 2012b). Furthermore, one more wet-tye, known as *wet-tye 2,* was located within the separation heaps and excavated. Wet-tye 2 looks different from wet-tye 1; specifically, the boards indicating manufacturing by a skilled craftsman (Stöllner et al., 2011, 2012a). Intensified field campaigns during the last few years uncovered more wooden material among these few additional wet-tyes. In our study, we additionally outline the dendrochronological results from *wet-tye 3* (Fig. 3). Nine timber samples that were part of a boardwalk situated below the separation heap and uncovered in the drainage trench were analysed. The analysed timber consists mainly of small wooden objects, e.g., charred chips or broken pieces of larger timber, but the only preserved board of wet-tye 10 (sample code mita-211) also belongs to this group.

2.2.2. Subfossil logs

In the summer of 2007 to 2009, field campaigns for the sampling of subfossil wood material were carried out in the peat bogs at Troiboden (Sulzbachmoos and Langmoos) and in two peat bogs or silt up lakes near Vorderkeil, which are located approximately 1.5 km from the archaeological excavation site. The sampling of subfossil logs aimed initially at the establishment of a local TR chronology to improve both the chronological dating of mining timber, which has not been possible to date, and answering questions concerning ecological and climatological issues. In total, 193 sections were cut from subfossil logs from the upper layer (c. 1 m) of the peat bogs for dendrochronological analyses. The two sections of the peat bog Sulzbachmoos are anthropogenically disturbed and partly characterised by prehistoric mine dumps. One series of logs comes from the small peat bog (Sulzbachmoos A, 47°24′23,9"N, 13°08′09,3″E; c. 1579 m a.s.l., Fig. 1) next to the archaeological excavation site (Eibner, 1972; Stöllner et al., 2011). The peat bog Sulzbachmoos B (47°24′20,8"N, 13°07′58,1″E; c. 1585 m a.s.l.) is more extended than Sulzbachmoos A and is located approximately 300 m southwest of the excavation site. It is heavily disturbed because it was used for peat mining at the beginning of the 20th century. The recovery of the piles proves the presence of prehistoric activities even in this area (Zschocke and Preuschen, 1932). Additionally, the peat bog Langmoos (47°24‘31"N, 13°08‘08"E; c. 1588 m a.s.l.), which is situated north of the archaeological site and oriented towards the Kreuzbergmoos and is characterised by historic peat mining. The two peat bogs near Vorderkeil do not indicate a major anthropogenic impact, in contrast to the Troiboden bogs. The eastern area (Vorderkeil A, 47°24'17,1"N, 13°09′20,1″E; c. 1566 m a.s.l.) is a partly silt up lake, whereas the Vorderkeil B (47°24′14"N, 13°09′18,1″E; c. 1563 m a.s.l.) is a fully covered moor landscape. The first results of the TR analyses on the subfossil samples have already been published (Pichler et al., 2009b; Nicolussi et al., 2012).

2.2.3. Living trees

In addition to investigating archaeological timber and subfossil samples, we cored 24 spruce trees (two cores per tree) in the forest area