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Dendrochronological Analysis and Dating of Wooden Artefacts from the Prehistoric Copper Mine Kelchalm/Kitzbühel (Austria)

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Wood in general was an essential raw material for different purposes in mining: to maintain a mine, to continue ore processing and to handle everyday life man used wood. In the course of archaeological excavations between 1932 and 1953 at the Kelchalm area a huge number of wooden artefacts was found by Richard Pittioni and Ernst Preuschen. We examined the wooden artefacts archived in the Museum of Kitzbühel systematically and investigated the most appropriate one dendrochronologically. The main goal of this study was to date the wooden artefacts and thereby to establish accurate dates of the mining activities at the Kelchalm copper mine. The results of these dendrochronological investigations are published already (Pichler et al., 2009a; 2009b).

In 2009 archaeological excavations at the Kelchalm mining area were continued by Michael Klaunzer (head of excavation) and his team. The excavation focused on the so-called Scheidehalde 50 (separation heap) lying approximately 50 m north of the Scheidehalde 32 which was investigated by Pittioni and Preuschen. Apart from a large number of wooden samples (woodchips, twigs, roots, remains of woodworking) a huge amount of ceramic artefacts, some stone fragments used for ore crushing and several animal bones were recovered.

This paper provides an insight into preliminary results of dendrochronological analysis of wooden samples excavated during the campaign 2009. The main research objects included:

i) dendrochronological dating of the selected and investigated samples (do they match with the recently established Kelchalm tree-ring mean curve of samples derived from the excavation by Richard Pittioni?)

ii) Specification of the mining activities at the Kelchalm site by means of the dated samples originating from the prehistoric forest soil
The wooden artefacts of the 2009 excavation are throughout relatively small with usual dimensions of few centimetres (Fig. 1). Most of the samples derive from a cultural layer and a prehistoric forest soil\textsuperscript{1}. Within the excavation area (5 x 3 m) these two layers were separated by a man made layer mainly consisting of clay (unpubl. report by M. Klaunzer). Some of the samples examined (fig. 1c and 1d) originate from a small area a few meters north.

After a screening of the wooden artefacts regarding a sufficient number of tree rings (> c. 15) and a properly preserved wood wane the selected samples were dendrochronologically investigated. Tree-ring width (TRW) measurements were carried out on 36 samples. We also determined the tree species and estimated as far as possible the number of tree rings probably missing to the pith. On the base of at least two measured radii per artefact, mean curves of each object were established. The Kelchalm sample series were then compared with the already established local Kelchalm tree-ring mean curve I (Pichler et al., 2009a) and the Eastern Alpine Conifer Chronology (Nicolussi et al., 2009) which covers the last 9111 years and and is based on samples originating from the higher Alpine region of the Eastern Alps.

The only detected species of the dendrochronologically analysed artefacts is spruce (*Picea abies*). Other species as fir (*Abies alba*) which was established for some wooden artefacts excavated by Pittioni (Pichler et al., 2009a) or fragments of softwood (e.g. beech) have not been ascertained so far. Tree-ring series of 16 samples, which contain between 21 and 78 rings, were cross-dated and finally compiled to the 97-year long local tree-ring curve *Kelchalm II* (Fig. 2)

\textsuperscript{1} The thickness of the cultural layer (no. 9) varies, but averages c. 35 cm. The prehistoric forest soil (no. 23) partially appears c. 80 to 100 cm below the surface (unpubl. report by M. Klaunzer).
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Fig. 2: The dendrochronologically dated woodchips (a) excavated during summer 2009 and the wooden artefacts (b) excavated 1932-1953 from the copper mining site Kelchalm. Each rectangle represents a sample and its length indicates the length of the tree-ring series obtained. The tree species, the sample code and the calendar year of the last ring measured of each tree-ring series is shown. WKL: terminal ring, logging during autumn/winter; WK: terminal ring present but not distinguishable whether ending with latwood or earlywood; +: no terminal ring. c) Synchronised tree-ring series of all dated samples.

Fig. 3: Kelchalm tree-ring width mean curves I and II in cross-dated position. Kelchalm I: compiled from samples excavated by Richard Pittioni 1932-1953; Kelchalm II: compiled from samples excavated by Michael Klaunzer and team 2009. The trend of both curves show a high correlation. Thus, the growth site of the trees might be the same.
and Fig.3). This chronology matches with the tree-ring record of the Pittioni finds (Kelchalm I) significantly: overlap = 97, Gleichläufigkeit 78%, pointer interval Gleichläufigkeit 77%, t-values: $t_{BP}$ 8.4, $t_H$ 10.4. The agreement with the Eastern Alpine Conifer Chronology is lower: overlap = 97, Gleichläufigkeit 63%, pointer interval Gleichläufigkeit 65%, t-values: $t_{BP}$ 4.3, $t_H$ 5.3.

Alike the earlier investigated wooden artefacts from the Kelchalm (Pichler et al., 2009a), the new dendrochronologically analysed samples date back to the Early Late Bronze Age. The last measured tree ring of the site chronology Kelchalm II grew in the year 1243 BC (Fig. 3).

Three samples show a well preserved and completely developed wood wane. In either case we can confirm felling activities outside the growing period. One sample (kbba-13) arising from the prehistoric forest soil indicates the felling date autumn/winter 1257/56 BC. The felling date of the other two samples (kbba-21 and kbba-22) found at a small place some meters off Scheidehalde 50 is in agreement: autumn/winter 1243/42 BC. Furthermore the established tree-ring widths series are highly congruent with each other suggesting that both woodchip samples (Fig. 1c and Fig. 1d) derive from the same trunk.

According to the results of this examination it can be stated:

i) The area excavated was originally a forested site. Trees growing there were cut to prepare the site for mining activities. Remains of the prehistoric forest could be found in the forest soil layer (no. 32): twigs, spruce cones and woodchips which look like those arising by felling trees. Due to the dendrochronological dated woodchips activities at this site can be asserted at least in autumn/winter 1257/56 BC. The other felling dates established for the artefacts found by Pittioni and during the 2009 excavation spread until 1237 BC. Evidence for mining activities on the Kelchalm site can be suggested for a time span of at least two decades.

ii) Some new samples do not derive from prehistoric forest cutting. This can be inferred from varying toolmarks (e.g. Fig. 1b).

The dendrochronological results presented in this study match perfectly with the already published ones. The new data set enables to refine mining activities at the Kelchalm site. Ongoing dendrochronological investigations can be expected because of archaeological excavations planned in near future.

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