Dendrochronological analysis and dating of wooden artefacts from the prehistoric copper mine Kelchalm/Kitzbühel (Austria)

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Abstract

The potential of dendrochronological analysis of wood found in prehistoric and historic mining areas in Tyrol has remained unattended for a long time. For the first time, systematically analysed wooden artefacts from a prehistoric mining area in Tyrol (Kelchalm near Kitzbühel) can be presented here.

The investigated artefacts, related to mining and everyday life, were found in the course of archaeological excavations, which were carried out between 1932 and 1953 by Richard Pittioni and Ernst Preuschen. Taking an adequate number of tree rings and well-preserved wood wane into account, 21 pieces of mining timber were pre-selected for a dendrochronological analysis. The identified wood species are spruce (Picea abies, n = 18) and fir (Abies alba, n = 3). The length of the established tree-ring series ranges from 13 to 145. We cross-dated the tree-ring series of seven wooden artefacts among each other, which resulted in a spruce-fir tree-ring record of 153 values (Kelchalm mean curve). The last tree ring measured of the Kelchalm spruce-fir mean curve dates back to 1237 BC. This accurate dendro-result dates the Bronze Age mining activities at the Kelchalm to about two centuries earlier than the long-lasting assumption proposed by Richard Pittioni. His assumption was based on the typology of ceramic and metal artefacts.

The established dendro-date for the Bronze Age mine at the Kelchalm matches with available14C results from other important copper-mining areas in the north-eastern Alps (NE Alps). The activities at these other sites are dated between the 17th and 6th century BC. Furthermore, the radiocarbon dating, as well as the dendro-result from the Kelchalm, suggests a transition from earlier mined copper-ore deposits in the eastern areas of the NE Alps, to the later mined ore deposits in the western section. This has led to both parallel and sequential mining activities in several ore districts during the last two millennia BC in the NE Alps.

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Introduction

Metal-mining activities in the Alpine region go back to prehistoric times. The earliest findings so far were located in the region of Schwaz/Brixlegg in the lower Inn valley, Tyrol, Austria (Fig. 1) and indicate copper production during the second half of the 5th millennium BC (Huijsmans, 1996; Höppner et al., 2005). The development of mining, in a long-term perspective, is characterised by phases of expansion, consolidation, and regression. In medieval and more recent times (until 20th century) mining on metal ores played an important...
economical role in the Alps, whereas today it is only of marginal importance. When copper mining experienced its revival in the 19th century, traces of prehistoric mining activities were for instance discovered at the Kelchalm (10 km south-east of the well-known winter sports resort Kitzbühel) and the Mitterberg (province of Salzburg, about 50 km east of the Kelchalm). It can be asserted that prehistoric mining was not limited to near-surface ore deposits there. Several underground mines that had partly been back-filled by the miners or collapsed after the abandonment of the mine provide evidence of early deep mining and copper production in the mining areas of the Northern Alps. Archaeological excavations at the Kelchalm and other sites mentioned above provided a huge number of artefacts confirming mining activities in the Bronze Age (e.g. Preuschen and Pittioni, 1937, 1954; Goldenberg, 2004; Goldenberg and Rieser, 2004; Stöllner et al., 2009). In Tyrol and Salzburg there were four important copper-mining areas in prehistory (Fig. 1). These were the Leogang/Viehhofen and Bischofshofen/Mitterberg/St.Veit districts in Salzburg and the Kitzbühel/Kelchalm/Jochberg and Schwaz/Brixlegg districts in Tyrol (Fig. 1). In most of the mentioned mining districts, including the Kelchalm site, chalcopyrite is the dominating primary ore, whereas in the mining area of Schwaz/Brixlegg fahlores mainly occur.

In the Kelchalm area archaeological excavations were carried out in the mid-20th century (e.g. Preuschen and Pittioni, 1937, 1954). Based on the typology of ceramic and metal artefacts found at the Kelchalm, Richard Pittioni stated that this copper mine, and therefore the whole prehistoric mining activity at this location, started at the turn of the 2nd millennium BC (Pittioni, 1968). However, a huge number of wooden artefacts were also excavated at the Kelchalm. The first investigations of the wooden material by Josef Kisser were limited to macroscopic descriptions followed by the interpretation of the tree-ring width, to give a first estimation of a possible altitude of the growth site. Furthermore, he classified the wooden pieces according to their species (Kisser, 1937). In principle, dendrochronological dating of wooden samples achieves more accurate results than when it is only done by archaeological typological dating.

Up to now, tree-ring analyses on mining timber from Tyrol have hardly commenced. In adjacent areas, the number of such investigations is still limited as well (e.g. Ruoff and Sormaz, 1998, 2000; Grabner et al., 2007). One possible reason was the lack of a database for the dating of prehistoric samples. However, such multi-millennial chronologies for the conifer species Pinus cembra and Larix decidua have been established recently (Nicolussi et al., 2004).

The main goal of this study was to date the prehistoric wooden artefacts from the Kelchalm mining area, which were excavated more than 50 years ago. Thus, the established dendro-dates will enhance and refine the chronological understanding of the development of mining in the Alpine region. Additionally, the species used for the artefacts probably show a specific selection, according to their properties.

The local geology of the study area is dominated by the Northern Alpine Greywacke Zone (paleozoic bedrock), which holds rich copper-ore deposits. Rounded and densely forested mountains are characteristic of the Greywacke Zone. The highest peak of the Kelchalm ridge is 1812 m asl. In the mid-19th century, new copper mines were opened in the region of the Kelchalm (E 12°27’, N 47°23’). During the development of these modern mines, remains of former copper mines were discovered. The implements found and analysed by
the archaeologists were identified as being prehistoric. Thanks to extended field work by Richard Pittioni and Ernst Preuschen, Kitzbühel and its surroundings became an area of high scientific interest. From 1932 to 1953 excavations were undertaken at the Kelchalm (e.g. Preuschen and Pittioni, 1937, 1954). They were carried out at approximately 1700 m asl. The archaeological excavations focused on the so-called separation heap 32, where the investigated artefacts analysed in this study originate from. Apart from a large number of wooden artefacts, objects made of stone, pottery, and metal (bronze) were recovered. The wooden artefacts are related to mining (i.e. boards, piles, cotter pins, and nails), convenience goods (i.e. beater, spoon, and spindle) and building material of former dwellings (shingles). Two heavy troughs discovered in 1950 were of particular interest (Preuschen and Pittioni, 1954).

The moist and anaerobic storage conditions inside separation heap 32 prevented the wooden artefacts at the Kelchalm from total decomposition. After they had been excavated, it was necessary to preserve them properly for future research. After some difficulties in finding a suitable preservation technique, a glycerine–paraffin method developed by Josef Kisser was used (Kisser, 1937). Later, in 1953, a more convenient method (Cellloidin) for preserving wooden artefacts was developed. In general, objects preserved with this liquid neither expand nor shrink when the air moisture changes (Preuschen and Pittioni, 1954). The well-preserved wooden artefacts are stored in the local museum of Kitzbühel.

Material and method

In total, 145 archaeological wooden findings have been examined at the local museum of Kitzbühel, where they are stored. The investigated artefacts originate from the mining area at the Kelchalm at approximately 1700 m asl. The condition of the artefacts is stable and no additional preservation was necessary.

Dendrochronological analyses have been carried out on 21 selected pieces of mining timber. This selection was carried out after a screening of all wooden artefacts regarding a sufficient number of tree rings (> ca. 15) and a properly preserved wood wane. Seven of the artefacts are of particular interest, which include: the bottom of a heavy trough (Table 1, kbm-1), two boards with traces of handling (Table 1, kbm-7 and kbm-8), two shingles (Table 1, kbm-10 and kbm-12), as well as two wooden spoons (Table 1, kbm-14 and kbm-15).

Tree-ring width measurements on the selected artefacts were performed by means of the LINTAB measuring device or image-analytic methods. We compiled several tree-ring series on the surface of three artefacts without any additional preparation (e.g. artefact kbm-15, Fig. 2). This was possible because of the different weathered parts between the earlywood and latewood zones of some wooden objects. This approach could not be used on four wooden pieces – either due to their very narrow tree rings (e.g. Table 1, kbm-10) or the damaged outer surface of these artefacts (Table 1, kbm-1). Therefore, cross-sections were prepared to measure the tree-ring width correctly.

On the basis of several measured radii per artefact, mean curves of each object were established. A 15-year highpass filter was applied to each series before they were cross-dated. The tree-ring mean curves of seven artefacts (Table 1) were cross-dated and compiled to a 153-year long data set. This Kelchalm mean curve was then compared with a conifer reference chronology that covers the last 9111 years and is based on subfossil stone pine and larch (P. cembra and L. decidua) samples collected at sites in the higher Alpine region (> 2000 m asl) of the central Eastern Alps (Nicolussi et al., 2004). Apart from this chronology, tree-ring chronologies from the French (stone pine chronology; Edouard et al., 2002) and Austrian Alps (spruce/larch chronology; Grabner et al., 2001) were used for cross-dating the Kelchalm samples.

Results

The most common species of the dendrochronologically analysed artefacts (n = 21) is spruce (Picea abies).

### Table 1. Dendrochronologically dated wooden artefacts from the Kelchalm.

<table>
<thead>
<tr>
<th>Dendro ID</th>
<th>Inventory number</th>
<th>Type of artefact</th>
<th>Dimensions (cm)</th>
<th>Species</th>
<th>Tree ring (n)</th>
<th>Time span (BC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>kbm-1</td>
<td>Old 1547</td>
<td>Trough</td>
<td>10 × 60 × 170</td>
<td>ABAL</td>
<td>145</td>
<td>1389–1245</td>
</tr>
<tr>
<td>kbm-7</td>
<td>Old 179 a</td>
<td>Board</td>
<td>4 × 22 × 197</td>
<td>ABAL</td>
<td>111</td>
<td>1347–1237</td>
</tr>
<tr>
<td>kbm-8</td>
<td>Old 179 b</td>
<td>Board</td>
<td>4 × 25 × 197</td>
<td>ABAL</td>
<td>102</td>
<td>1357–1256</td>
</tr>
<tr>
<td>kbm-10</td>
<td>2233</td>
<td>Shingle</td>
<td>1.7 × 12 × 55</td>
<td>PCAB</td>
<td>123</td>
<td>1371–1249</td>
</tr>
<tr>
<td>kbm-12</td>
<td>2231</td>
<td>Shingle</td>
<td>2.6 × 16 × 26</td>
<td>PCAB</td>
<td>59</td>
<td>1295–1237</td>
</tr>
<tr>
<td>kbm-14</td>
<td>2129</td>
<td>Spoon/scoop</td>
<td>1.3 × 7.4 × 33.5</td>
<td>PCAB</td>
<td>68</td>
<td>1311–1244</td>
</tr>
<tr>
<td>kbm-15</td>
<td>2130</td>
<td>Spoon/scoop</td>
<td>2.7 × 9.9 × 24.3</td>
<td>PCAB</td>
<td>50</td>
<td>1305–1256</td>
</tr>
</tbody>
</table>

ABAL: Abies alba, PCAB: Picea abies.
Only a few samples \( (n = 3) \), like the bottom of the trough (Table 1, kbm-1) and the two boards (Table 1, kbm-7 and kbm-8) belong to the species of fir \((Abies alba, \text{Fig. 3b})\). Measurements carried out on the trough, the two boards and one of the two shingles (Table 1, kbm-10) resulted in tree-ring series of more than 100 values each (Table 1). In a first step these four tree-ring series were compiled to a 153-year-long mean curve named Kelchalm. One 59- and one 68-year-long tree-ring series established on two small convenience goods (Table 1, kbm-12 and kbm-14; Fig. 2) could be cross-dated with the previously built Kelchalm mean curve. Most of the investigated artefacts are characterised by relatively short tree-ring series with 50 or less tree rings (Fig. 3a). This is usually for small objects or rapidly grown wood used for some artefacts. Thus, tree-ring widths between 4 and 5 mm were measured (e.g. some fragments of the buckets were built from such a kind of rapidly grown wood). In spite of the small number of tree rings of the artefact kbm-15 \((n = 50)\), we were able to cross-date its tree-ring series (Table 1) with the Kelchalm mean curve. The rest of the established tree-ring series with lengths between 13 and 48 values could neither be cross-dated with the Kelchalm mean curve nor among each other (Fig. 4).

The Kelchalm mean curve consists of seven single-tree-ring series (details are shown in Table 1) of the species \(A. \text{alba}\) and \(P. \text{abies}\) and was initially cross-dated with the central Eastern Alpine (CEA) \(P. \text{cembra}\) chronology (Nicolussi et al., 2004). Because the fir and spruce mean curves of the seven synchronised Kelchalm tree-ring series (details are shown in Table 1) show a highly similar variability over most parts of the common period, proving a common growth signal, we established a mixed species (fir and spruce) master curve as a basis for further comparisons – matching the at least twice

\[ \text{Fig. 2. Wooden spoon from the Kelchalm near Kitzbühl. The state of the decomposition of the earlywood and latewood zones varies, due to different cell attributes. Therefore, we were able to measure tree-ring width on the radial surface of the object (wooden artefact kbm-15, inventory number: 2130).} \]

\[ \text{Fig. 3. Sample classification plotted by (a) number of tree rings and (b) species.} \]

\[ \text{Fig. 4. Cross-dated tree-ring series of the mining timber from the Kelchalm (TRW-tree-ring width).} \]
replicated sections of the mean curves of the two species, we received statistically significant values: \( \text{Gleichläufigkeit} \) 82%, \( t \)-values = 6.2, overlap = 62 years). This species-combined Kelchalm mean curve was initially cross-dated with the central Eastern Alpine \( P. \ cembra \) chronology (Nicolussi et al., 2004). The last tree ring of the mean curve marks the year 1237 BC. Therefore, mining activities in the Early Late Bronze Age can be proven by the dendrochronological dates of the investigated wooden artefacts. A shortened Kelchalm mean curve (replication of at least three single tree-ring series; 1357–1244 BC) provides high statistic values (length = 114 years, \( t \)-values: \( t_{\text{BP}} \), 6.5; \( t_{\text{H}} \), 6.6 \( \text{Gleichläufigkeit} \) 74%, pointer interval \( \text{Gleichläufigkeit} \) 87%, Table 2, Fig. 5). Additionally, high key figures (\( \text{Gleichläufigkeit} \) > 65%, \( t \)-values > 4.5) can be achieved when comparing the same Kelchalm mean curve with further chronologies from the French Alps (\( P. \ cembra \); Edouard et al., 2002) and the Dachstein/Austria (\( P. \ abies/L. \ decidua \); Grabner et al., 2001). The statistic values of the synchronised tree-ring series of the three fir artefacts – especially the boards (Table 1, kbm-7 and kbm-8) – are very high (\( \text{Gleichläufigkeit} \) 86%). The boards are supposed to be derived from the same trunk. Furthermore, a similarly good correlation exists between the mean curve of the fir artefacts and the appropriate mean curve of the objects made of spruce (\( \text{Gleichläufigkeit} \) 69%). This suggests that the examined trees were taken from the same site.

In order to give detailed information on the mining activities by means of adequate felling dates, it is necessary to detect the wood wane. This wood wane is preserved only on a few samples. Two of these samples are cotter pins both with less than 40 tree rings. So far, it has not been possible to cross-date either of them with the Kelchalm chronology.

One of the two investigated shingles (Table 1, kbm-10) has a preserved wood wane too. The last tree ring measured grew in the year 1249 BC. The tree-ring series of the other shingle (Table 1, kbm-12) ends 1237 BC.

![mean curve Kelchalm Eastern Alpine Pinus cembra chronology](https://example.com/image)

**Table 2.** Main statistics of the chronologies (CEA: Central Eastern Alps, FA: French Alps, D: Dachstein, *: replication of at least three curves; PICE: \( P. \ cembra \), PCAB: \( P. \ abies \), ABAL: \( A. \ alba \), LADE: \( L. \ decidua \); Glk: \( \text{Gleichläufigkeit} \)).

<table>
<thead>
<tr>
<th>Kelchalm site mean curve</th>
<th>Reference chronology</th>
<th>Species</th>
<th>Overlap Glk (%)</th>
<th>Glk pointer intervals (%)</th>
<th>( t )-value (Baillie &amp; Pilcher)</th>
<th>( t )-value (Hollstein)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABAL/PCAB (1389–1237 BC)</td>
<td>CEA PICE</td>
<td>153</td>
<td>67</td>
<td>75</td>
<td>4.3</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>FA PICE</td>
<td>153</td>
<td>67</td>
<td>80</td>
<td>5.4</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td>D PCAB/LADE</td>
<td>153</td>
<td>60</td>
<td>–</td>
<td>3.4</td>
<td>3.8</td>
</tr>
<tr>
<td>ABAL/PCAB (shortened*: 1357–1244 BC)</td>
<td>CEA PICE</td>
<td>114</td>
<td>74</td>
<td>87</td>
<td>6.5</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>FA PICE</td>
<td>114</td>
<td>73</td>
<td>84</td>
<td>6.5</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>D PCAB/LADE</td>
<td>114</td>
<td>66</td>
<td>–</td>
<td>4.5</td>
<td>4.8</td>
</tr>
<tr>
<td>ABAL (1389–1237 BC)</td>
<td>CEA PICE</td>
<td>153</td>
<td>62</td>
<td>71</td>
<td>3.5</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>FA PICE</td>
<td>153</td>
<td>64</td>
<td>71</td>
<td>4.3</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>D PCAB/LADE</td>
<td>153</td>
<td>57</td>
<td>–</td>
<td>1.9</td>
<td>2.6</td>
</tr>
<tr>
<td>PCAB (1371–1237 BC)</td>
<td>CEA PICE</td>
<td>135</td>
<td>64</td>
<td>64</td>
<td>2.7</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>FA PICE</td>
<td>135</td>
<td>63</td>
<td>67</td>
<td>4.0</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>D PCAB/LADE</td>
<td>135</td>
<td>59</td>
<td>–</td>
<td>2.5</td>
<td>2.6</td>
</tr>
</tbody>
</table>

![Fig. 5. Kelchalm tree-ring mean curve (Abies alba and Picea abies series) and Central Eastern Alpine Pinus cembra chronology in cross-dated position (TRW-tree-ring width).](https://example.com/image)
Unfortunately the bark edge could not be detected precisely, but the felling probably took place 1 or 2 years later. As a result of this variation of the end dates of these two shingles, the mining activities can be asserted over a period of at least 12 years at the Kelchalm. The end dates of all dated samples show a variety of about 20 years (1256–1237 BC).

Discussion

On the Kelchalm site mechanical ore dressing processes took place, including crushing, sorting, milling, and washing, in order to obtain copper-ore concentrates suitable for the smelting process. In connection with these works it was necessary to construct a system of water channels, either for water supply or for drainage of the terrain. The two dendrochronologically analysed boards were probably part of this construction. The more or less wet and muddy conditions of the ground in this area would have decomposed common timber within a short time. To prevent the boards in use from rapid decomposition, the miners chose the most resistant timber available, which was of fir (Wagenführ, 2007).

Some of the analysed wooden shingles were described as roofing shingles by the local museum. We assume a similar application of the shingles as seen at a reconstructed house in Neuchâtel/Switzerland (kind information of Michael Klaunzer). With regard to this assumption, the bore hole on one end would have been used to tie the shingle with a strap to the wall framework (Pillonel, 2007).

As was mentioned before, the Kelchalm mean curve, established with spruce and fir tree-ring series, shows a high correlation to the CEA P. cembra chronology. This documents that the tree rings of both series grew at different sites under quite similar environmental conditions. Spruce, a coniferous species, is the most dominant tree species in the area of the Kelchalm, partly penetrated by silver fir (Mayer, 1974). The mining area of the Kelchalm, located at an altitude of 1700 m asl, is relatively near to the altitude of the potential contemporary tree line in this area, which can be located at approximately 1900 m asl. The CEA P. cembra chronology in the time period between 1400 and 1200 BC is made up of samples from sites located between approximately 2000 and 2300 m asl and thus also near the local tree-line elevations, which currently range from 2300 to 2400 m asl in the central Eastern Alps. The high common signal between the dendrochronologically dated wooden artefacts from the Kelchalm and CEA P. cembra chronology can be explained by conjecturing that all samples originate from sites situated within or near the tree-line ecotone with similar climatic conditions.

In the northern part of the Eastern Alps, prehistoric copper-mining activities have up to now been dated by means of the evaluation of archaeological findings, as well as with $^{14}$C-dates (an overview of available $^{14}$C-dates from the Leogang/Viehhofen and Bischofshofen/Mitterberg/St.Veit districts in Salzburg and the Kitzbühel/ARTICLE IN PRESS

Fig. 6. Temporal distribution of cal. $^{14}$C-dates plotted by the time span of their 26-range and the Kelchalm mean curve plotted in relation to the mining area. The end date of the Kelchalm mean curve is noted. (source of $^{14}$C-dates: a: Eibner, 1982; Gstrein, 1988; Krauß, 2002; Lippert, 1992. b: Krauß, 2002; Goldenberg and Nicolussi, 2009. c: this study; d: Goldenberg, 2004. e: Goldenberg and Nicolussi, 2009)
Kelchalm/Jochberg and Schwaz/Brixlegg districts in Tyrol is given in Fig. 6). The typological features of the ceramic and metallic artefacts revealed evidence of mining during the Bronze Age. In the meantime, dendrochronological investigations on the retrieved mining timber from the famous “Arthur-gallery” (Mitterberg) were carried out. The results, stated as preliminary, range between 1427 and 1391 BC (Stößlner et al., 2009). According to Stößlner et al. (2009) the very beginning of mining at the Mitterberg must have been started 200 years earlier, at about 1600 BC, approximately at the transition of the Late Early Bronze Age to the Middle Bronze Age, which is confirmed by several 14C-dates (Fig. 6a). For each of the mining areas at Leogang and Viehhofen only a single 14C-date exists. Both results indicate activities at the beginning of the Late Bronze Age (approximately 1300 BC; Fig. 6b). Further 14C-dates from the famous mining area Schwaz/Brixlegg (Fig. 6d) prove long-term mining, which probably was not continuous over the whole time span. Based on these 14C-dates a multi-phase mining activity can be assumed. Some of the calibrated 14C-dates from the mining area Schwaz/Brixlegg cover a time span of at least 350 years, which can be explained by the course of the radiocarbon calibration curve (IntCal04, Reimer et al., 2004) during the “Hallstatt period”. A few 14C-dates were established from the smelting-site Jochberg (Fig. 6d) close to the study area of the Kelchalm. They provide information of fully developed metallurgical techniques in the 14th century BC (Goldenberg, 2004).

The results of dendrochronologically analysed artefacts from the Kelchalm (Fig. 6c) match these mentioned 14C-dates from the mining areas considered in this study (Fig. 1). Therefore, an increased mining activity can be assumed for the early Late Bronze Age in the NE Alps. With a dendro-date of 1237 BC, the mining activities at the Kelchalm can be located in the middle of the Bronze Age mining in the NE Alps, but having taken place about 200 years earlier than was conjectured in the initial assumption of Richard Pittioni (1968).

Conclusions

(a) Twenty-one pieces of mining timber from the Kelchalm/Kitzbühel were dendrochronologically investigated and sample tree-ring series with 13–145 values were established. The end dates of seven calendar-dated artefacts vary between 1256 and 1237 BC, which can be attributed to intensive prehistoric copper mining. The dating results of these wooden artefacts allow a better understanding of the development of mining in this region.

(b) The prehistoric miners had a good knowledge of wood properties. From the available wood species they used the most appropriate ones for different purposes. The wood of silver fir is not resistant to bio-deterioration, but it is well suited for water constructions.

(c) The additionally presented data set of 14C results from the mining areas of Bischofshofen/Mitterberg/St.Veit as well as Schwaz/Brixlegg cover a time period of a several hundred years. In these two mining areas in particular, a huge number of wooden artefacts can still be expected. Dendrochronological dating of these artefacts will probably refine existing 14C-based archaeological records, thereby enhancing the chronological understanding of the initiation and subsequent development of mining in the Alpine region.

(d) The established tree-ring mean curve Kelchalm, including spruce and fir series, shows good correlations (high statistical key figures) with our multi-millennial CEA P. cembra chronology. This documents similar environmental-climatic forcing for both data sets, which can be explained by location of the growth sites near the tree line. For further dendrochronological research activities on mining timber, the Eastern Alpine stone-pine reference chronology will be a solid base.

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