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Original article

Reconstructing the history of log-drifting in the Reichraminger Hintergebirge, Austria

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Summary

The watersheds of the rivers Enns and Steyer border the Reichraminger Hintergebirge. This area has a long tradition in the iron processing industry. Because mineral coal was not available, charcoal has been produced for the iron industry for the past 500 years, leading to a heavy exploitation of the vast forests (180 km^2).

From the logging sites in the mountains the timber had to be transported up to 12 km to the forges in the lowland. Most of the small rivers had insufficient water to drift logs efficiently. Therefore, at gorges or at places where there were narrow steep sided valleys wooden dams (klausen) were built to block the water, using the first cut trees of a newly targeted harvesting area. By abruptly opening the dams, the rapid flow of the raised water level carried the logs to the next klausen. Up to seven klausen were built in a valley before the rechen (rake-like grids within the river to collect the logs) of the Enns and Steyer were reached.

To reconstruct the history of log drifting in the Reichraminger Hintergebirge, 33 klausen and rechen were visited and dendrochronologically sampled. The remaining wood of the dam constructions showed progressive stages of degradation, and in some cases only a few logs remained preserved under the water. With cores from living trees added to the dataset, master chronologies were established for spruce (576 years), fir (569 years) and larch (342 years). The construction history of the klausen can be sequentially traced back to 1563 AD. The time spans of the individual chronologies varied between 40 and 392 years. All available conifer species were utilized to build the dams, except during the 19th century, when the most suitable species – larch – was used to a higher degree.

Keywords: Dendrochronological dating, log drifting, history of forest-use

Introduction

For centuries the smelting and processing of iron has been a key factor in the economic development of certain areas. In Austria, the exploitation of iron ore took place within the area of Eisenerz in Styria, about 70 km away from the Reichraminger Hintergebirge. The utilization of this important raw material was under governmental control, and to smelt iron, enormous amounts of burning material were neces-

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sary. Because mineral coal was not available, charcoal had to be used instead. Consequently, a high portion of forestlands of the region of Eisenerz was used to produce charcoal.

Consequently the smelting and the further processing of the iron had to be divided due to the lack of wood to produce charcoal. The iron processing industry settled along the trade routes of the rivers Enns and Steyer. In the year 1583 AD the register of the governance of Steyer recorded 24 forges. Along the rivers Enns and Steyer 40 forges were producing scythes in the 16^{th} century (Weichenberger 1994, 1995). Because of the huge demand for charcoal, the remote forests of the Reichraminger Hintergebirge located in the Northern Limestone Alps, Upper Austria, had to be utilized. As there were no ox-paths, it was easier to transport the logs than the charcoal. To bridge the long distances from the places of felling to the charcoal production, all logs were drifted on small rivers.

The German term "Trift" describes the transport of individual water-borne logs. Floating (in German "flößen") describes the transport of rafts built of logs, which were tied together with ropes. Therefore, we will use the term "drift" for the transport of assemblages of individual logs throughout this manuscript.

The Reichraminger Hintergebirge is located in the Limestone Alps with narrow valleys of low water depth, which were commonly unsuitable for log drifting. To raise the water level temporarily, dams – so called "klausen" – were built to dam up the water. These klausen were complex constructions of logs and stones, and they were built with trees harvested in the immediately surrounding area.

The procedure for log drifting was as follows: numerous logs were placed below the dam. The water storage area was filled with water from melting snow or heavy summer storms. The flood wave – induced by an abrupt opening of the flood gates – had enough power to drift the logs downstream. A system of up to seven klausen from the innermost forests to the rechen (rake-like grids within the river to collect the logs) 12 km away at the rivers Enns and Steyer was built. If the opening of the floodgates of each klausen was properly synchronized, the transport of the logs over the entire distance was possible within an hour. The Reichraminger Hintergebirge – nowadays part of the Limestone National Park – had the highest density of klausen in Middle-Europe. The biggest (20 m in height), most impressive, and important dam, was the Mitterwendt Klause (Grosse Klause), which was first mentioned in 1604 AD in the Forest regulation of Rudolf II (Weichenberger 1994).

By using this dam system it was possible to transport vast amounts of logs within short times. The disadvantages of log drifting were the limited availability of sufficient water levels, the high costs of building the dams, the highly dangerous labour of the timber jacks, and the fact that long or heavy logs could not be drifted. Because of the high wood-density of beech (*Fagus sylvatica* L.) and the frequent wet-heart of silver fir (*Abies alba* Mill.), these two species were not considered for log drifting. Therefore, Norway spruce (*Picea abies* (L.) Karst.) was favoured, resulting in increasing amounts of spruce in the forests with time. Because of high mineral coal imports, and the increasing availability of forest roads, the log drifting ceased shortly before the Second World War.

Before the Reichraminger Hintergebirge region turned into a National Park, historians started to reconstruct the forest utilization history of this area. It was possible to find calendar dates that indicate the construction of the klausen by searching registers, forest regulations and archives. Most of the klausen were mentioned in regulations (like that of Rudolf II in 1604 AD; Weichenberger 1994). Although this documentary evidence provides proof about of the existence of klausen at certain times, information on the actual year of building was missing. In addition, it was not known how long certain drifting constructions and dams were used, before they were abandoned.

The major objective of this study was therefore to determine the precise dates of construction and repair of the klausen. Another objective was to establish regional chronologies for the main conifer species, Silver fir, Norway spruce and European larch (*Larix decidua* Mill.) in this region.

Material and methods

The study area is situated within the Limestone National Park, Upper Austria, which is divided into the Reichraminger Hintergebirge and the Sengsengebirge. With about 180 km^2 this region is the biggest closed forestland within the Northern Limestone

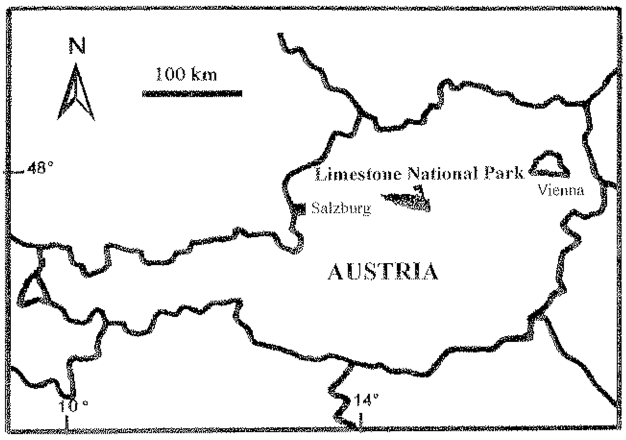

Figure 1. Map of Austria, indicating the Limestone National Park.

Alps. Figure 1 shows the location of the Limestone National Park within Austria, with the coordinates of the centre being 47°46′ N/14°25′ E.

Sites were sampled within an area spanning 19 km from East to West and 13 km from North to South (Saurwein 2000). The region is dominated by limestone- and dolomite-bedrocks, resulting in strong Karst formations (Erber 1997). The altitudinal gradient ranges from 400 m to 1963 m a. s. l. However, sampling took place between 700 m and 1550 m a. s. l. (Saurwein 2000). The natural zonal forest community is a mixed beech-fir-spruce forest (Helleboro-Abieti-Fagetum; Zukrigl 1973, Kilian et al. 1994) up to an altitude of 1200 m a. s. l., while the higher regions are dominated by spruce and fir. The sub-maritime climate is characterized by a mean temperature of 7.5 °C (Böhm 1992) with heavy rainfall during summers. Because the main wind direction is from Northwest, and several mountains have undercut slopes, an inter-annual variation in precipitation from 1200 to 2000 mm per year was observed (Auer 1993, Mahringer, Bogner 1993).

In total, samples were taken from 33 structures (klausen and rechen). Depending on the available number of logs, between one and 30 samples were extracted per structure (Fig. 2). Sampling was done by coring with increment corers, dry-wood-borers or by disk sawing. In total more than 500 historical samples were collected. The wood species were anatomically identified (Wagenführ 1989). In addition to the historical artefacts, 294 living trees located at 24 sites were selected for sampling (Saurwein 2000). Two cores per living tree were taken at breast-height. Dry disks and mounted cores were sanded until individual tracheids became visible. Tree-rings were measured to the nearest 0.01 mm using a LINTAB measuring device (www.rinntech.de). All ring-width series of living trees were cross-dated (Stokes, Smiley 1996; Swetnam et al. 1985) and checked for dating and measurement errors using COFECHA (Holmes 1983). Tree-ring series of the historical samples were dated using t-values and the Gleichläufigkeit computed by TSAP (Rinn 1996), and by visual checking of the plots. The first step was to cross-date the unknown samples against each other, including the living tree series, following Baillie (1995). To check the Limestone-Alps chronologies comparisons of each sample with the East-Austrian Spruce and East-Austrian Fir chronologies (Wimmer, Grabner 1998) were done. Holding all cross-dated series, master chronologies (Rinn 1996) were calculated.

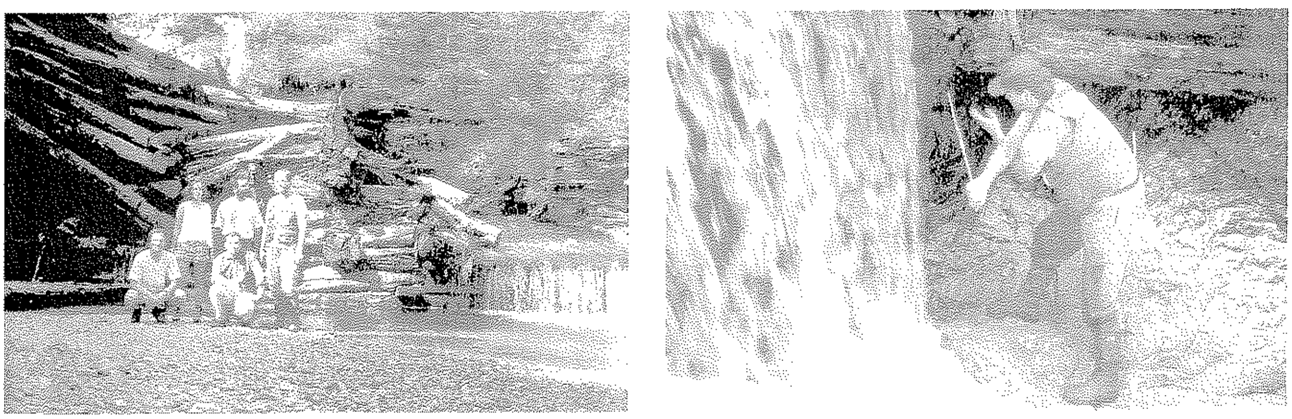

Figure 2 a) and b). Two images of wood sampling the remains of the Sitzenbachklause and Steyerstegklause.

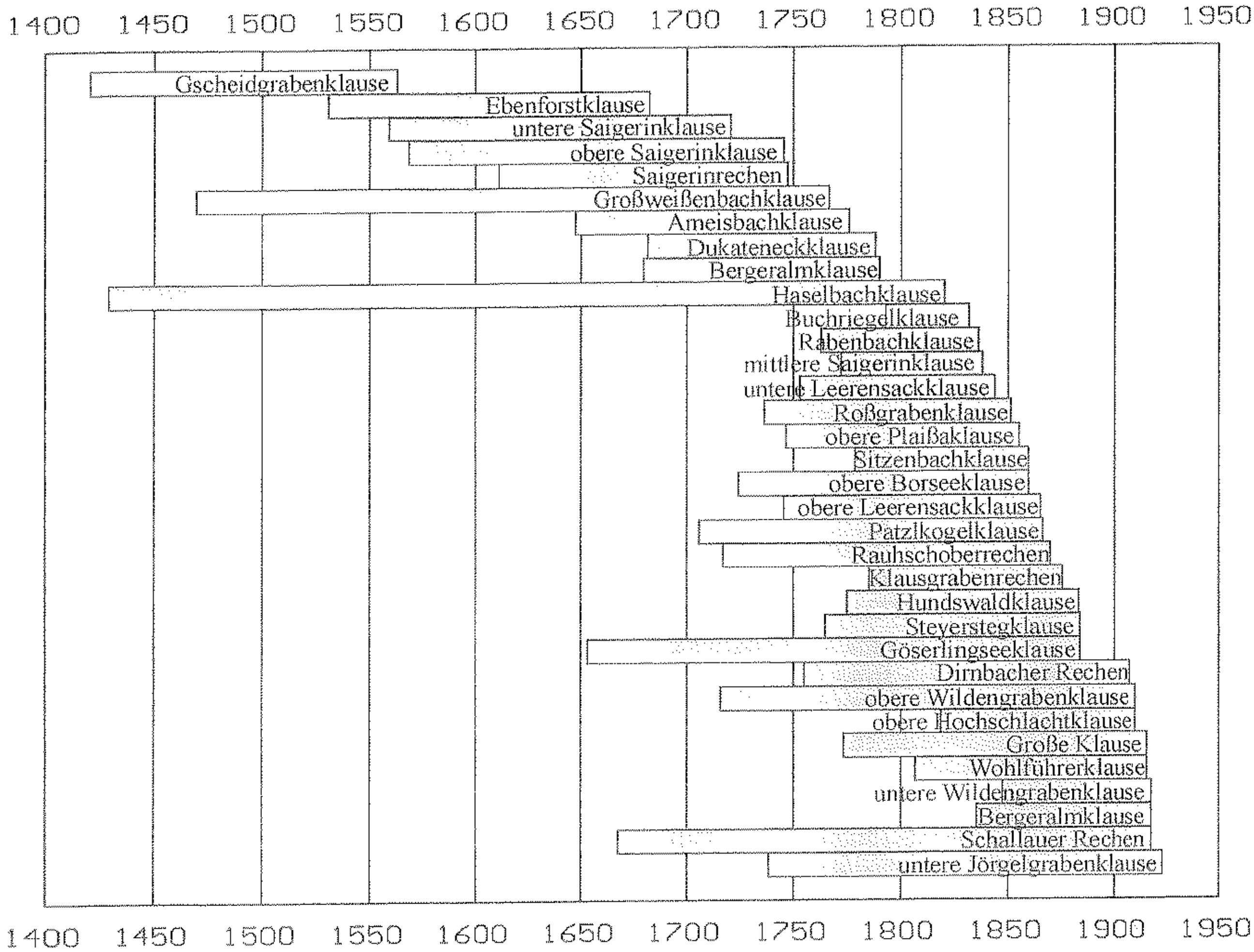

Figure 3. Bar chart indicating the length of the chronology from each structure and the date of its outermost ring.

Results

With 376 synchronized historical samples, each of the 33 sampled structures (klausen and rechen) was successfully cross-dated. Fig. 3 illustrates the chronology length and end date of each individual structure. A high level of building and repairing activity is evident in the 20th century. The construction history of the klausen can be sequentially traced back to 1563 AD. The time spans of the individual chronologies varied between 40 and 392 years.

The wood species of all historical samples were determined. 42 % of the sampled logs were spruce, 27 % fir and 31 % were larch. To detect potential changes in the use of different species over time, the time span was split into three parts: 20th century, 19th century and prior 1800 AD. The distribution of wood species from the structures with their end dates falling in each of the periods was calculated. Fig. 4 presents the proportion of wood species across the three periods. The amount of spruce decreased from 49 % to 21 % from the earliest to the middle period, followed by a strong increase up to 76 % for the most recent period (20th century). The amount of fir was more or less constant up to 1900 AD, but declined sharply to 9 % in the 20th century. Larch logs were primarily used in the 19th century (when they accounted for almost 50 % of the species composition).

The historical samples, together with the 294 cross-dated living trees, allowed for the construction of three regional chronologies, one for each species (Fig. 5). Tab. 1 presents the basic statistics of these chronologies. It was possible to develop a spruce

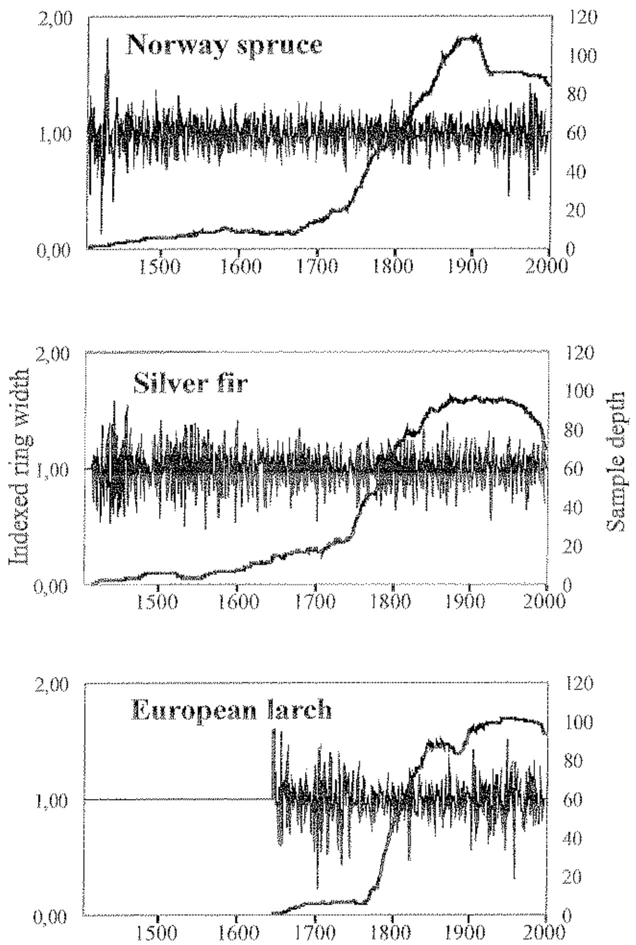

Figure 4. Graphs of the three resulting indexed master chronologies of spruce, fir and larch; along with their sample depths.

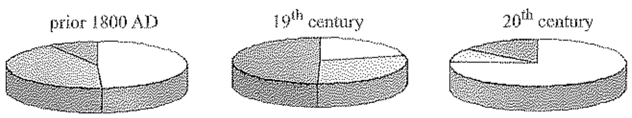

Figure 5. The changing composition of the wood species used for building the klausen over time. (white ... spruce; light grey ... fir; dark grey ... larch)

chronology back to 1421 AD, a fir chronology starting in 1429 AD and a larch chronology back to 1655 AD.

Discussion

Only the presence of the outermost tree-ring, followed by the bark, gives precise felling dates (Baillie 1995). Because none of the historical timbers in this study retained the bark, no precise felling dates could be determined. Sometimes erosion by water and debris of the logs was clearly visible. However, the number of missing rings due to erosion was assumed to be small, because the branches – having a higher wood density and therefore being less susceptible to erosion – very rarely stuck out of the log circumference. Tab. 2 presents comparisons between the dendrochronological dating of the outermost tree-ring and the dates of construction cited in different archives (Weichenberger 1994, 1995). Small differences between the dendrochronological data and the archive-data were evident for the Haselbachklause, Hundswaldklause and Grosse Klause (Tab. 2, lines A, B and C). For example, the single samples of the Hundswaldklause clustered around 1883 with dates of the outermost ring: 1883, 1882 and 1878. Just two samples with higher loss of rings (1843 and 1863) were sampled. According to these findings the average loss of tree-rings due to erosion did not exceed ten years.

Most of the archive data from registers and maps referred to particular years (e. g. Franzizeischer Kataster 1826 in Weichenberger 1994). These data represent the presence of the structures, not their date of construction. In Tab. 2, lines D, E and F compare the dendrochronological dates with the archive dates of three different klausen. The Sitzenbachklause is mentioned twice in registers and maps, once in 1789 AD and again in 1880 AD. The pre-

Table 1. Basic statistics of the three master-chronologies of the Limestone National Park (spruce, fir and larch).

Species	First year of chronology, AD	Last year of chronology, AD	Number of years	Mean segment length in years	Mean correlation with master, r	Mean ring width in mm	Standard deviation in mm
spruce	1421	1996	576	137	0.465	1.60	0.694
fir	1429	1997	569	141	0.539	1.50	0.806
larch	1655	1996	342	115	0.476	1.63	1.035

Table 2. Comparison of the calendar dates according to the last present tree-ring, with the first recorder archive dates.

	Name of the object	Date of the outermost tree-ring, AD	Date of building due to archives, AD
A	Haselbachklause	1820	around 1820
B	Hundswaldklause	1883	1887
C	Grosse Klause	1917	1923
D	Sitzenbachklause	1859	prior 1789, prior 1880
E	Ameisbachklause	1776	prior 1826, around 1826
F	Buchriegelklause	1832	prior 1884

served logs are from the second building phase. The Ameisbachklause and Buchriegelklause were built prior to their first documented record.

The klausen were often partially or totally destroyed by driftwood or by flood waves. In just a few cases, the dates of repair could be determined by the findings of historians. The number of logs preserved varied between one or two buried in debris, and hundreds of logs representing a substantial proportion of the old structure (Fig. 2). Therefore, it was not always possible to identify phases of repair. In Tab. 2, line E presents the dates of the Ameisbachklause, where the sampled logs belong to the first phase of building the klausen, prior to 1826 AD. The repair or rebuilding in 1826 AD could not be determined from the tree-ring data. At the big rechen, only the logs of the latest repair were preserved.

The distribution of the tree species used to build the klausen prior 1800 AD probably represents the forest composition of the main species at that time, with the exclusion of beech as this species was not utilized. Within the 19th century the species composition of the klausen changed to a high proportion of larch logs. This species is known for its higher wood density, higher mechanical strength and good natural durability, compared to spruce and fir (Grabner 2002; Gierlinger 2003). The historical records of the building of the klausen, suggest that larch should have been the major species used. However, this appears to be true only in the 19th century, when almost 50 % of the wood present in the structures was larch. Due to the natural vegetation of this area (Kilian et al. 1994), probably most of the larch trees were used to construct the klausen, than to produce charcoal. During the 20th century the most-used species was spruce. This may be explained by a large amount of dead spruce being available following a spruce bud worm outbreak between 1919 and 1923 AD (Weichenberger 1994). Therefore, many structures had to be repaired using the available spruce logs with a high demand of logs to be transported out of the forests. The not affected larch trees were almost not used to repair the klausen. The spruce bud worm outbreak itself may have been triggered by climate abnormities, but also by the existence of stands that were dominated by spruce. Over decades, spruce has been favoured over beech, because wet beech wood sinks in the water. Replacing beech – due to its high wood density and the high chance of sinking in water – is already mentioned in the forest register of 1586 AD (Weichenberger 1994). Similarly, fir could not be drifted if infected by wet heart.

We can assume that for klausen construction the logs were used from trees that grew very close to the location. The advantage of knowing precisely where the samples originated allowed the development of regional master-chronologies by combining series from both living trees and from historical samples. There was some variation in the degree of cross-matching between sites, probably as the result of the existing altitudinal gradient. This was expressed in some low correlations with the master chronology (Tab. 1). Silver fir is well known for good cross-matching over long distances (Wimmer 1999), and this is supported by the higher correlation coefficients with the master chronology found here.

Conclusions

It was possible to determine calendar dates for the outermost tree ring of the preserved logs from all 33 sampled klausen. With this successful application of dendrochronology, a major contribution to the understanding of the long forest management history of the area (which has been recently converted into a National Park) was gained. The composition of wood used to make the klausen was found to have changed over time. All available conifer species were utilized to build the dams, except during the 19th century, when the most suitable species – larch – was used to a higher degree.

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