Late Holocene human impact on vegetation and landscape at high altitudes: Combined palaeoenvironmental and archaeological study at the Schafberg (Vorarlberg, Austria)

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Introduction

Sensitive ecosystems, such as the Alps, respond highly to changes in terms of climate and human activity. Archaeological and palynological investigations in the Montafon Valley and adjacent regions indicate human activities at high altitudes already during the Bronze Age. The timberline was lowered to create subalpine meadows and pastures. In order to trace land use at high altitudes in the Schafberg region (2000-3000 m a.s.l) (Austria, Northern Alps), a multidisciplinary study was applied. Archaeological excavations have been carried out by the Montafon Project (Goethe University Frankfurt) since 2007. Several sites at the plateau (Fig. 1) and the nearby "Madrisatäli" (Fig. 3) indicate seasonal occupation from the Bronze Age onwards. Current palaeoecological investigations are implemented to reconstruct different phases of land use and will be compared to the archaeological results.

Fig. 1: Schafberg: Plateau (2100-2300m a.s.l.), Alpwüstungen ©Montafon project

Location

The Schafberg is located in Vorarlberg, the westernmost part of Austria, close to the Swiss border. Climatically it is part of the oceanically influenced Northern Alps with an annual precipitation of 1400mm and mean annual temperatures of approx. 5°C.

The main geological formation is crystalline. The soils, heavily disturbed by human activity, show different stages of degraded podzols.

The current timberline is located at approx. 1900m (a.s.l.) and formed by subalpine spruce forest. The recent vegetation in the Schafberg region is dominated by subalpine to alpine grass land. The south exposed plateau favours pasturing and has been used for grazing purposes up to the present time (Fig. 2).

Fig. 2: Alpe Gargälla um 1950 ©Fotoarchiv Juen

Methods: Pollen analysis

Using an Eijkelkamp corer we extracted a 1.5m long core from peat bog Madrisablick 2 (2100m a.s.l.) (see Fig. 4) situated above the current timberline. Samples (1cm^3) were taken for pollen analysis using standard physical and chemical methods (Moore et al., 1991). Lycopodium tablets were added for the calculation of pollen concentrations (pollen grains/cm^3) and pollen accumulation rates (pollen grains/cm^2 per yr) (Stockmaar, 1971).

The total pollen sum ranges between 300 and 1000 pollen grains. The pollen sum was based on pollen of trees and herbs; spores, aquatic and local pollen were excluded. The preliminary results are presented as a percentage diagram designed with the Tilia program (Grimm, 2011) (Fig.6).

Fig. 3: Madrisatäli, Abri ©Montafon project

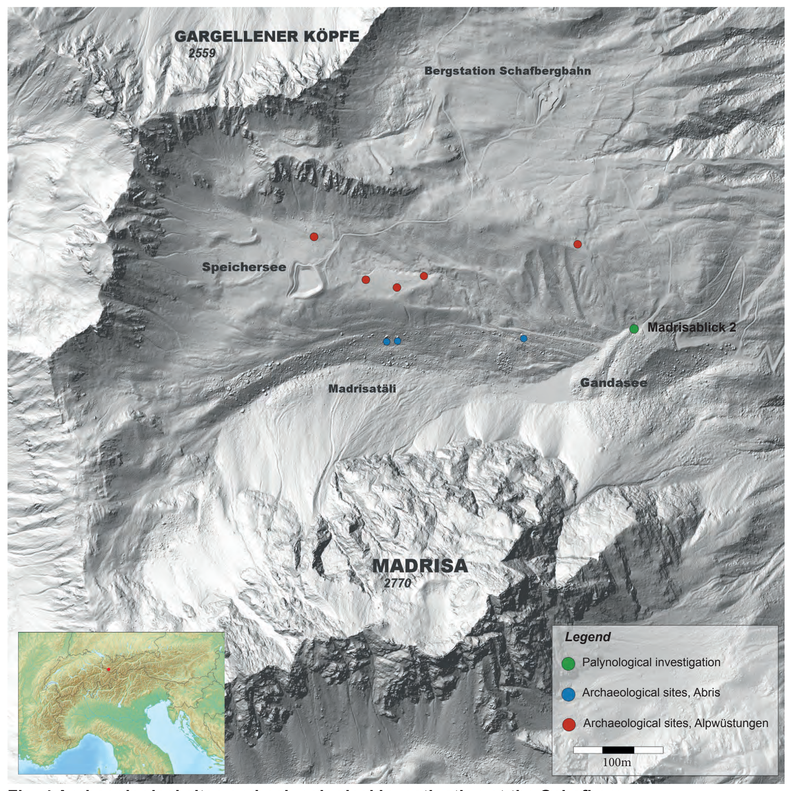

Fig. 4 Archaeological sites and palynological investigation at the Schafberg

Radiocarbon dating

Four peat samples from Madrisablick 2 and 21 samples (terrestrial plant macrofossils, charcoal) from the archaeological sites were radiocarbon dated by AMS technique at Cologne AMS Centre for Accelerator Mass Spectrometry and Beta Analytic (London, Florida) (Fig.5). The ^{14}C-results were calibrated via OxCal 4.17 (Bronk Ramsey, 2010).

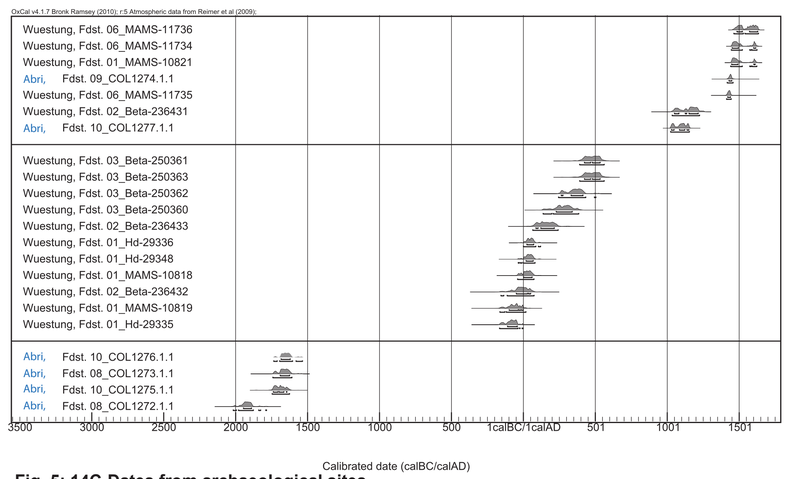

Fig. 5: 14C-Dates from archaeological sites

Preliminary results

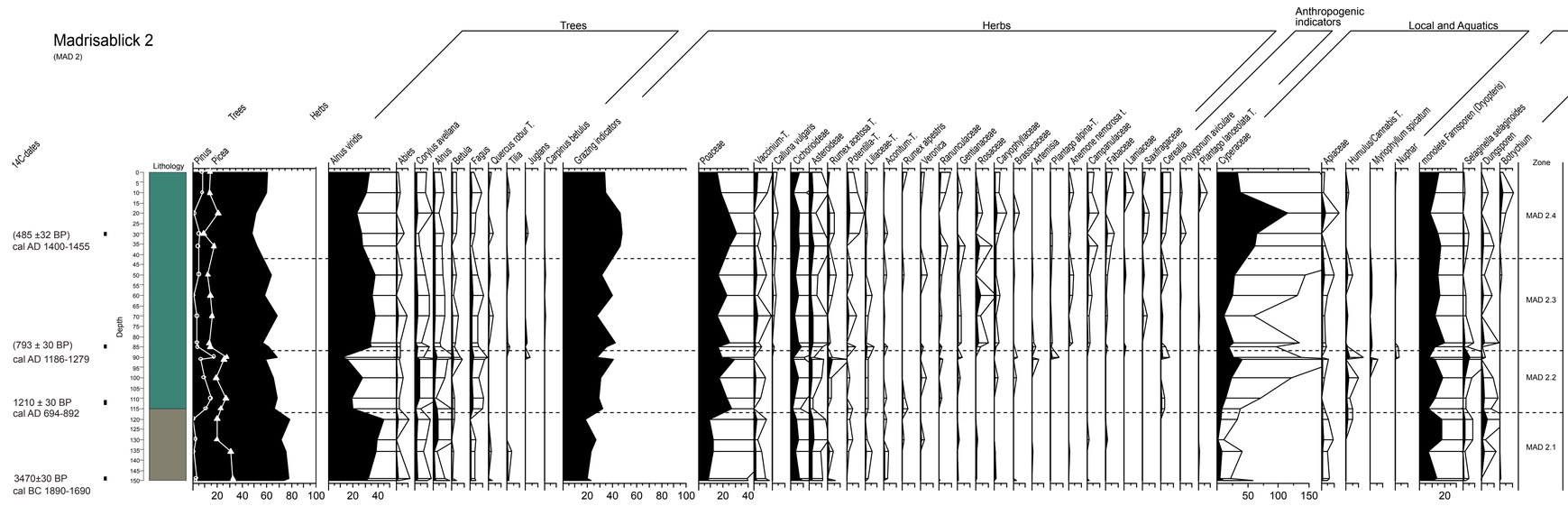

Fig. 6: Percentage diagram Madrisablick 2, selected taxa (Analysis: L. Bringemeier, A. Schmidt)

LPAZ Depth (cm)	Main curves (estimated averages)	Important pollen taxa (estimated averages)
MAD 2.4 0-42	55% trees 45% herbs	*Picea* 15%, *Pinus* 6%, *Alnus viridis* 28% grazing indicators 42%, Cyperaceae
MAD 2.3 42-82	63% trees 37% herbs	*Picea* 14%, *Pinus* 3%, *Alnus viridis* 37% grazing indicators 36%
MAD 2.2 82-117	64% trees 36% herbs	*Picea* 21%, *Pinus* 10%, *Alnus viridis* 23% grazing indicators 32%, Cerealia, Cyperaceae
MAD 2.1 117-150	76% trees 24% herbs	*Picea* 27% (33-20%), *Pinus* 2%, *Alnus viridis* 37% (30-45%) grazing indicators 22%, Poaceae

MAD2.1, 150-117cm (1800BC - AD820)

Early Bronze Age: The former spruce forest was cleared to gain pastures shown by 22% grazing indicators (Poaceae, Cichorioideae, Asteroideae, Pollen taxa such as *Rumex acetosa* t., *Potentilla* t., *Liliaceae* and *Aconitum* t. are well documented). The deforestation is accompanied by an expansion of *Alnus viridis* reaching maximum values of 30-45%. This tendency intensifies towards the end, induced by a decline of *Picea* from 33 to 20%.

MAD2.2, 117-87cm (AD820 – 1240)

Early and High Middle Ages: New pasture land was created by removing green alder shrubberies. *Alnus viridis* decreases from 45% to an average of 23%, while grazing indicators rise from 22 to 32%, *Picea* remains at 21%, *Pinus* values reach 10%. Cerealia are documented from lower regions. The beginning of this zone is marked by a lithological change from gyttja to peat. This is also indicated by an increase in Cyperaceae.

MAD 2.3, 87 - 42cm (AD1240 – 1430)

High and Late Middle Ages: Declining *Picea* values (14%), indicate further clearances in the region. *Pinus* decreases to 3%. After a phase of decrease the green alder expands again (30-40%). Simultaneously grazing indicators rise as well, reaching a higher biodiversity than before. The local vegetation is still dominated by Cyperaceae.

MAD 2.4, 42-0cm (AD1430 - present)

Late Middle Ages - present time: Grazing indicators (42%) reach the highest biodiversity. In addition anthropogenic indicators as *Polygonum aviculare* and *Plantago lanceolata* occur. *Picea* remains at 15%, *Pinus* attains 6% and *Alnus viridis* declines to 28%. Cyperaceae values rise to a maximum.

Discussion

The results from the palynological data at the Schafberg are supported by archaeological evidence. The subalpine spruce forest of the Schafberg was already cleared during the Early Bronze Age in order to gain pastures. This first sign of forest clearance fits well with the local archaeological record from the abris and coincides with the starting settlement activities in the lower areas of the Montafon at Bartholomäberg (Krause 2007, Oeggl et.al. 2005). The growing importance of mining and metallurgy might have led to population growth, denser settlement and increasing land use in the inner alpine areas.

The proceeding deforestation is associated with the spreading of *Alnus viridis*, a subalpine pioneer shrub. As proved for the adjacent Upper Engadine (Gobet et. al. 2003) and St. Antönien (Röpke et. al. 2003) fire is the main determinant for the strong expansion of green alder. In the neighbouring valley St. Antönien fire is used more frequently during the late Iron Age and the Roman period. Archaeological remains (Alpwüstungen) at the Schafberg provide evidence for an intensified occupation in the late Iron Age and Roman period as well.

In the Early and High Middle Ages the green alder is removed to extend pasture land due to increased agro-pastoral activities. Furthermore, intensive mining activities caused a high demand for wood and resulted in large-scale clearances. The High- and Late Middle Ages are characterized by maximum grazing indicator percentages and increasing biodiversity known in many regions of the Alps (Wegmüller 1976; Kostenzer 1996; Oeggl et al 2005; Röpke et al 2011).

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Acknowledgements

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