Evidence of historical mining inferred from metal concentration of alluvial sediments in the Bernese Alps

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Introduction

Metal pollution is normally associated with modern day industrialization. Nevertheless, large-scale metal pollution started during the Roman period with the increase of mining and smelting activities. These kind of activities contribute to a raise of metal concentrations in the atmosphere and subsequently in sediments and soils. The aim of this study is to identify periods of increased mining activity during the last 3000 years, though the analysis of sedimentary records.

Study Area

This work centers on two catchments located at the Bernese Swiss Alps, the upper Aare basin, situated at the east of Lake Brienz and the Lütschine basin, placed at the west of this lake (fig. 1). The focus of our study is set on the geochemical analysis of fluvial sediments. These sediments were recovered by percurssion drilling boreholes located at deltas from the outlet of both catchments (fig.1).

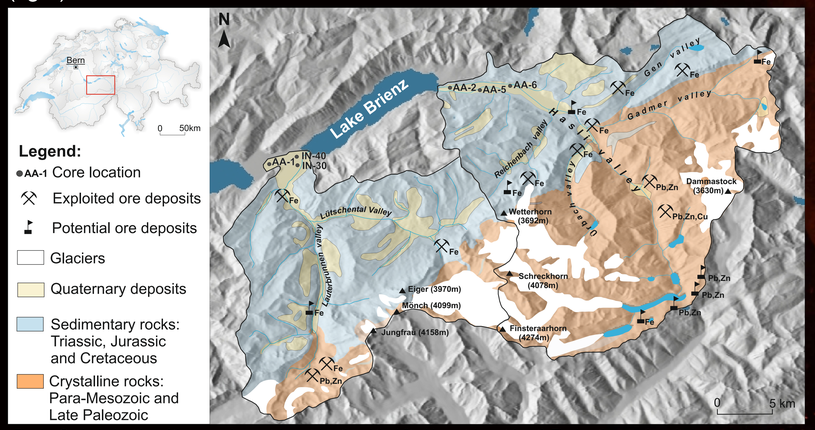

Fig. 1 - Geological setting of the upper Aare catchment (east) and the Lütschine catchment (west). The location ore deposits is also included and the sedimentary records used in this study are located near both catchments outlet with Lake Brienz. DEM from SwissTopo©.

According to archaeological studies (Ebersbach and Gutscher, 2008), this region has been a major focus of mining activity in the past. There are several ore deposits (fig.1), some of which are well documented in historical sources and were intensively exploited in medieval and modern times (Fig. 2 and 3). Older mining activity can also be inferred from archaeological sites.

Fig. 2 - Ore transportation route from the 14th century, between Hasliberg and Innertkirchen (Upper Aare catchment). Photo from Ebersbach and Gutscher, 2008.

Fig. 3 - View of the mines and smelter plants of Trachsellauenen in the Lauterbrunnen valley (Lütschine catchment). Picture from J. N. Schiel, 1790. Bernese Historical Museum.

Materials and Methods

The analysis is based on the response of the chemical elements iron (Fe), copper (Cu), zinc (Zn) and lead (Pb) contained in six cores with depths down to 10 meter. All data was filtered in order to remove the noise from natural processes such as the increase of trace metal concentrations in organic rich horizons and to select the highest metal peaks. Chronology of the sedimentary records was achieved through AMS 14C dating.

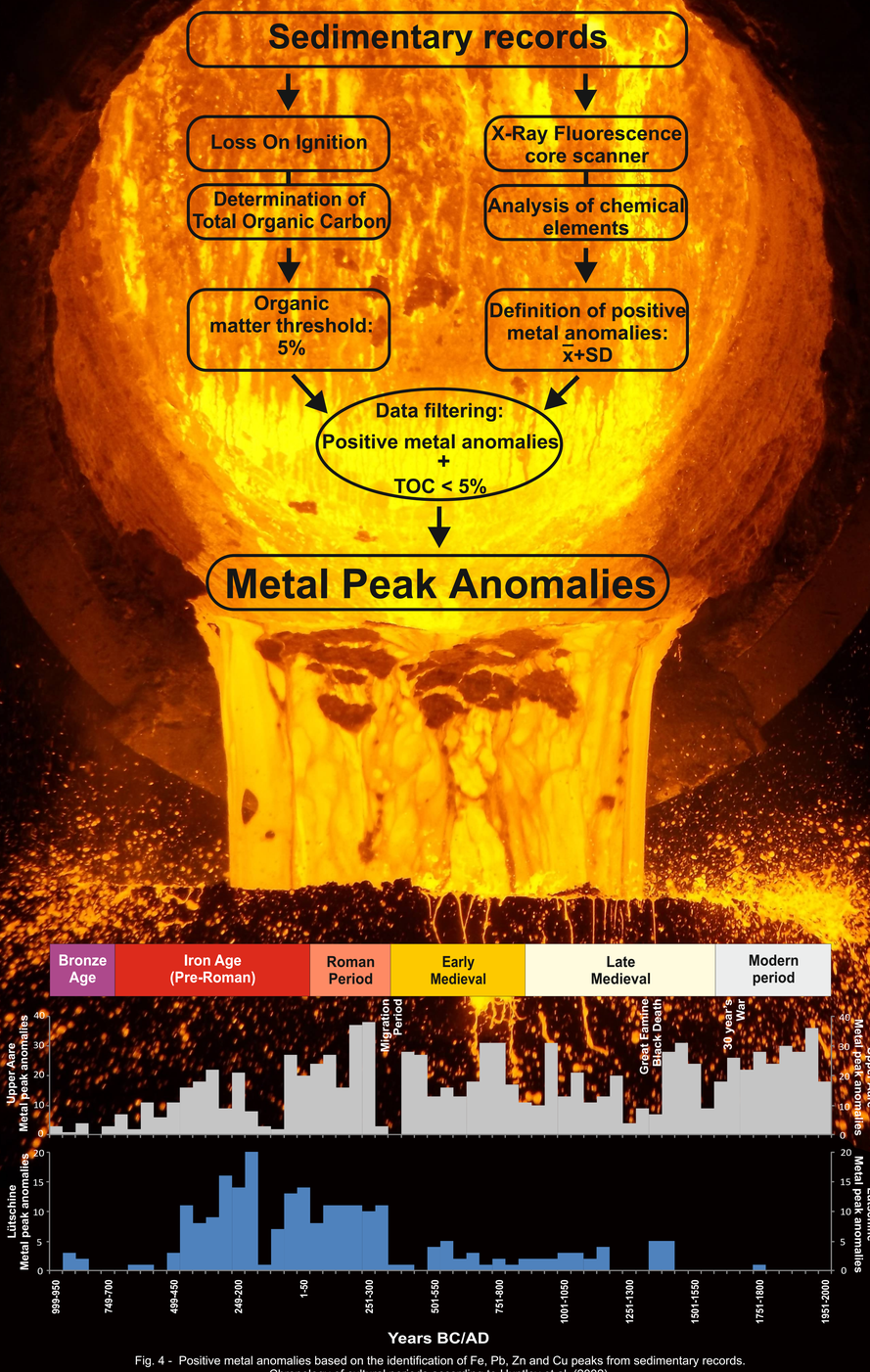

Fig. 4 - Positive metal anomalies based on the identification of Fe, Pb, Zn and Cu peaks from sedimentary records. Chronology of cultural periods according to Huntley et al. (2002).

Results and discussion

Metal anomalies from six sedimentary records allowed the identification of the most significant Fe, Pb, Zn and Cu peaks. Figures 5 and 6 exemplify the response of these chemical elements. The analysis of this data show several anomalies that were later divided into natural and anthropic influence.

The response of metal anomalies in both catchments is quite similar since Late Bronze age until the Roman Period. High concentration of metals around AD 250 in both catchments (Fig. 4) seems to coincide with the maximum expansion of the Roman Empire and an increase in deforestation (Büntgen et al., 2011). The Roman period is also usually associated with a population increase in Central Europe and a flowering of trade (Hopkins, 1980), which could have increased mining activity in this region.

In the last 1600 years the Lütschine catchment lacks significant peak anomalies. This can be due to a decrease in mining activity or to cut-and-fill processes and river management that can deteriorate the sedimentary information from the aggradation history of the distal area of the Lütschine delta (Schulte et al., 2009).

In the Upper Aare catchment a significant activity can be identified during Early and Late Medieval time and also during modern time (Fig. 4). Periods of lower trace metal concentrations and shifts in trends relate accurately with central Europe social and economic transitions, migratory events and significant demographic variations.

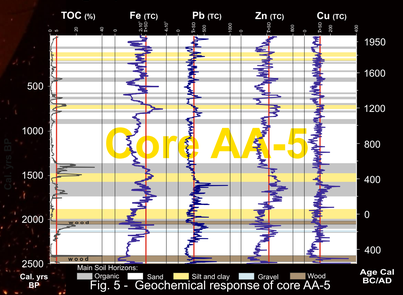

Fig. 5 - Geochemical response of core AA-5

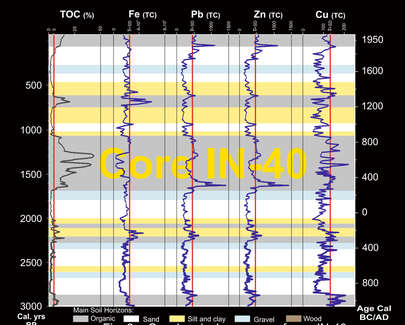

Fig. 6 - Geochemical response of core IN-40

Conclusions

The results from this work show similar trends in all the analyzed cores, especially durihg the Iron Age and Roman Period. In the Upper Aare catchment metal peaks indicate four major pulses of trace metal concentration during the Iron Age, Roman Period, Early Medieval Age and a general increase of metal concentration during the Modern era. We consider that these methodology can offer valuable evidences of mining and smelting activities.

Acknowledgements

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