Multi-proxy analysis in environmental reconstructions of the Tăul Mare peat bog, Lăpuș Mountains

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1 Introduction

Paleoenvironmental data obtained from multi-proxy analysis of sedimentary archives may provide support to the hypothesis that the current mountainous landscapes in northern Romania were shaped by various human activities over the last millennia. The aim of this study is to use multi-proxy analyzes (geochemistry, mineral magnetic properties, grain-size, macroscopic charcoal abundance and morphologies) of a peat sequence from Lăpuș Mts, Northern Romania, coupled with published vegetation and climate reconstructions, to reconstruct the paleoenvironment conditions of this area over the past 3000 years.
The ultimate purpose is to understand the complex, long-term interactions between local environment, climate, vegetation, and human component, including understanding the effect of disturbance factors such as vegetation fires. For this study, we used a peat sequence extracted from Tăul Mare peat bog (47°82'84.61"N, 24°62'24.20"E), an ombrotrophic bog located in the conifer forest belt at 1066 m a.s.l., in the proximity of a former mining area.

2 Methodology

Geochemistry and mineral magnetic properties of peat samples were employed as proxies for soil erosion, detrital input and pollution related to mining activities (e.g., Hutchinson et al., 2016; Akinyemi et al., 2013). We derived elemental geochemical composition using an X-ray fluorescence Spectrometer type Niton XL3t 900 (Hutchinson et al., 2016). Mineral magnetic properties, such as magnetic susceptibility and remanence were determined using a Molspin Limited Alternating Field Demagnetizer coupled with a Minispin Fluxgate Magnetometer (Hutchinson et al., 2016). Organic matter content was estimated via loss on ignition ($LOI_{550\,°C}$) following the method described by Heiri et al. (2001). Particle size was used as a proxy for the energy of the depositional environment and determined via the automated laser scattering (Partica LA-950) method.
To reconstruct fire history and the type of vegetation burnt, we used macroscopic charcoal abundance and morphology. Sample preparation and quantification of the abundance (number) of charred particles followed procedures described in Florescu et al., 2018. Determination of charcoal morphologies was performed using the keys and classifications presented in Mustaphi and Pisaric (2014) and Feurdean et al., 2017). The age-depth model of peat accumulation was constructed based on 4 radiocarbon dates, using the smoothing spline function in Clam (Blaauw, 2010).

3 Results and discussion

Proxy variability along the peat profile was divided into three distinct zones: zone I: 2900-2000 cal. yr. BP; zone II: 2000-700 cal. yr. BP; zone III: 700 cal. yr. BP – present.

Zone I (2900-2000 cal. yr. BP) is characterized by moderately elevated concentrations of detrital elements, a high concentration of softer and coarser magnetic minerals and an increase in median particle size (Fig. 1). This suggests the prevalence of erosion processes in the catchment of the study site, probably connected to local scale disturbances. The concentration of heavy metals, which is a proxy for airborne pollution resulting from mining activities, was also moderately low; this, in combination with elevated detrital fluxes, may indicate a provenance of these elements from the bedrock, affected by erosion. Charcoal accumulation (CHAR) had a moderate increase in zone I, and the burned material consisted mainly of morphologies specific to wood and grass. This suggests that vegetation fires were of low severity, probably affecting only the surface of the soil. Published hydroclimate reconstructions indicate that warmer and drier conditions prevailed in the study area during this time interval, and coincided with the expansion of beech, while anthropogenic pollen indicators for grazing and cultivation were present, but not abundant (Peters et al., 2020; Feurdean et al., 2008). Altogether, this may suggest that climate was the dominant driver of landscape transformation, with humans playing a secondary role.

In zone II (2000-700 cal. yr. BP), all geochemical proxies and median grain-size had low values, while magnetic parameters showed an increase in the importance of finer, magnetically hard minerals, associated with soil material (Fig. 1). This suggests a reduction in erosion processes affecting the catchment and slope stabilization, likely associated with a transformation of the depositional environment. Charcoal accumulation slightly decreased, along with the importance of all morphologies, showing low fire activity at the local scale. Published climate reconstructions showed an increase in moisture, along with a regional increase in landscape openness and anthropogenic grazing and cultivation inferred from pollen indicators (Peters et al., 2020; Feurdean et al., 2008). This suggests extending anthropogenic disturbance at the landscape scale, and low disturbance locally, at the study site.

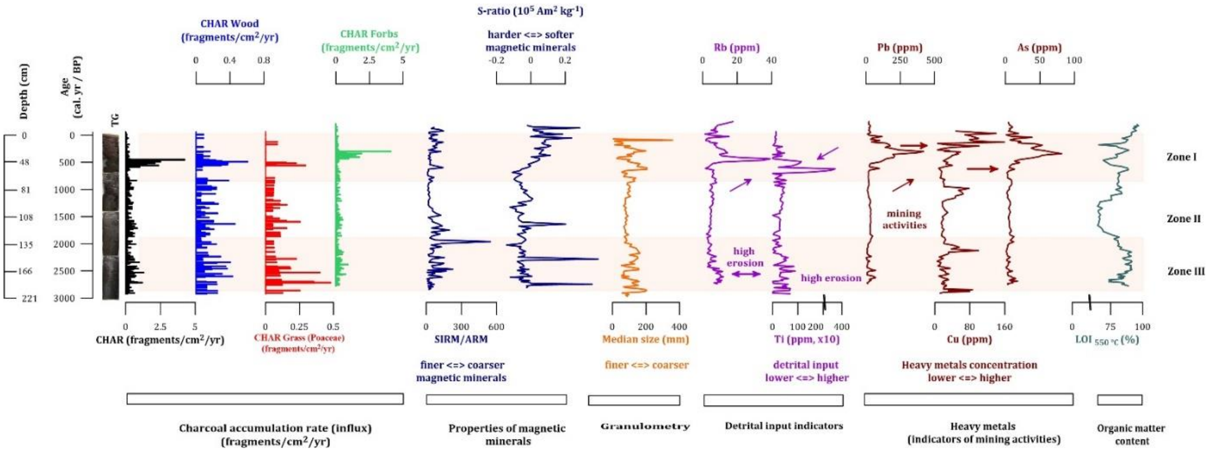

Figure 1 Multi-proxy analysis record for Tăul Mare peat bog (TG); shaded bars mark charcoal influx proxy zonation.

Zone III (700 cal. yr. BP – present) displays the maximum concentrations of heavy metals, which exceeded by up to ten times the concentrations recorded in Zone I (Fig. 1). A new increase in detrital input and grain-size accompanied these changes, and the concentration of soft, relatively fine magnetic minerals was also maximum. Charcoal accumulation was maximum around 500 cal. yr. BP, when the importance of forb and wood morphotypes increased, suggesting a massive local fire episode that may have also affected the forest canopy. These changes can be interpreted altogether as an intensification of mining activities, which were likely associated with an increase in catchment erosion and local fire activity, which also implies the likelihood that humans used fire to clear the forests and open the access to the mining sites. Such actions likely resulted in topsoil removal and bedrock left exposed to environmental and climatic factors. Over the last centuries, a recovery of the local environment is evident in the proxies, with low fire activity and low soil/bedrock erosion, which coincides with the cessation of local mining activities. Published vegetation reconstructions support our findings, showing the intensification of human activities in the region and the highest landscape openness over the last 700 years (Peters et al., 2020; Feurdean et al., 2008).

4 Conclusions

We showed that extensive anthropogenic activities (mining, use of fire to open the landscape) occurred in the study area only over the last 700 years. Our results highlight both the impact of anthropogenic activities and the recovery of the local environment and can therefore be used to predict future possible responses of the local environment to disturbances.

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