HIGH RESOLUTION ANALYSIS OF PALEOSOLS REVEALS DETAILS OF PEDOGENESIS - A MULTIPROXY APPROACH

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Introduction

Terrestrial sediments with intercalated paleosols are important archives for the study of paleovegetation and paleoenvironmental conditions like paleo-precipitation and -temperatures. To study the signal recorded in various organic and inorganic compounds from these sediment-paleosol sequences, it is common practice to collect one or two samples per sediment or soil unit, which are either taken from the middle between upper and lower limit, or which are collected over the whole depth of the unit and then pooled. This contradicts the fact that soils often develop from top downwards within sedimentary units, and therefore parameters like e.g. rooting intensity, organic matter (OM) concentration and element distribution change throughout a soil profile (e.g. Jobbágy and Jackson, 2000; Gocke et al., 2014). We hypothesized that such gradients can be preserved in Pleistocene paleosols developed from loess deposits and can give valuable insights into conditions during pedogenesis.
We sampled paleosols with ages around 30-35 ky (GIS 5-8) together with bracketing loess deposits along a transect from Central (Nussloch, Germany) to Southeast Europe (Katymár, Hungary and Irig, Serbia) in high resolution of 5 or 10 cm depth intervals. Samples were analysed for grain size distribution, bulk elemental composition, carbonatic (C_{carb}) and organic carbon (C_{org}) as well as total nitrogen (N_t) concentrations, $\delta^{13}C$, amounts of total extractable lipids (TLE) and distribution of lipid fractions like *n*-alkanes, fatty acids and alcohols. Additionally, glycerol dialkyl glycerol tetraethers (GDGTs) were investigated and used for paleotemperature reconstruction according to De Jonge et al. (2014).

Results and Discussion

In the Lohne Soil at Nussloch, the grain size index (GSI, (63-20 µm) / < 20 µm) showed a distinct minimum during maximum OM enrichment, indicating very low sedimentation rates and thus ideal conditions for the prevailing vegetation to enforce soil formation. Abrupt increase of the GSI in the upper part of the Lohne Soil and above hints to a sudden onset of sedimentation, which likely led to the 'suffocation' of the vegetation due to sediment build-up. C_{carb} decreased with depth within the uppermost 0.3 m of the paleosol, but strongly increased below that depth towards underlying loess. In contrast, C_{org} and N_t contents showed mirror-inverted graphs, indicating highest amounts of incorporated and preserved biomass input ca. 0.2 m below the top of the paleosol. Similarly, maximum TLE occurred within the Lohne Soil, with values immediately decreasing underneath towards C_{org}- and lipid-poor loess (Fig. 1). At Katymár, depth gradients were less pronounced with minor decrease of TLE and smooth increase of GSI from uppermost paleosol towards overlying loess (Fig. 1). At Irig, GSI stayed constant within the complete paleosol of 1.2 m depth, followed by a slight increase starting 0.2 m above the top of the paleosol. Also at Irig, TLE tended to decrease with depth within the paleosol, but was also high in loess directly overlying the latter, similarly to iron contents. At the two Southeast European loess-paleosol sequences, minor or absent changes of various organic and inorganic parameters with depth indicates comparably constant conditions during

pedogenesis. This includes an ongoing sedimentation, which provided the opportunity to the vegetation cover to adjust to the sediment build-up.
High-resolution analysis of three paleosols along a Central-Southeast European transect revealed two main aspects. First, it was shown that paleoenvironmental conditions during pedogenic phases 30-35 ky ago were rather stable at Southeast Europe but more erratic in Central Europe, which is in agreement with more continental and thus more arid climate in Southeast Europe and warmer, more humid climate with lower wind energy at Central Europe. Second, consistently lower TLE at the top of the paleosols than 0.2-0.3 m below the top could have been caused by two contrasting scenarios: i) At Nussloch and Katymár, the GSI already increased within the uppermost part of the paleosol, hinting at a possible dilution of the soil material by admixture of C_{org}- and lipid-poor sediment towards the end of the pedogenic phase. ii) Intense rooting and associated microbial activity might in the long-term have entailed a preferential OM decomposition in the uppermost parts of the paleosols. The second reason can be largely ruled out at Nussloch, because several alkane- and fatty acid-derived parameters hint at increasing root effects with increasing depth within the Lohne Soil.

Conclusions

Detailed information on the conditions during Pleistocene pedogenic phases are visible if the archive is analysed in high depth resolution of few cm, instead of collecting pooled samples, which masks this information. With a detailed analysis of paleosols as suggested in this study, it would be possible also to identify several phases of pedogenesis which have been amalgamated in one visible paleosol 'unit' in the profile. This information is only extractable from a sediment-paleosol sequence with high-resolution analysis.

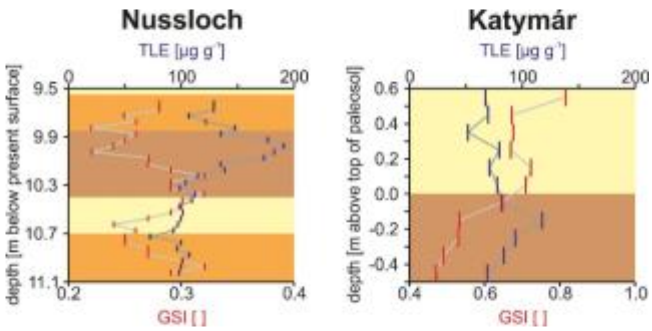

Figure 1 *TLE and GSI in paleosols (dark brown) and bracketing loess deposits (pale yellow) at Nussloch and Katymár.*

References

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