Decoding geochemical signals of the Schwalbenberg Loess-Palaeosol-Sequences — A key to Upper Pleistocene terrestrial ecosystem responses in western Central Europe

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- Located within the Middle Rhine Valley, Germany
- Intermediate position between Atlantic and continental climates
- Up to 30 m thick
 Upper Pleistocene LPS
- Extraordinary well-preserved OIS 3 section

The Schwalbenberg site hosts well-dated LPS in an unprecedented resolution for (western Central) Europe → Perfect site to test our approach



OIS 1 Topsoil

OIS 2 Loess, reworked loess and Gelic Gleysols

ET: Eltville Tephra (~24ka)

OIS 3 Calcaric Cambisols mirror-picture climate cycles in terms of frequency and intensity

OIS 4 and Transition from OIS 5 to OIS 4

OIS 5 + Early Glacial period

> OIS 5 Fluvial sediments

Stratigrapy according to Fischer et al., 2021 (Catena)



Study Details

Principal Component Analysis

- Unsupervised
- Rotation of a co-variance matrix
 → reduction of data dimensions
- Principal components display the axes containing most of the data-variance (information)
- PCs are uncorrelated and rank-ordered according to their amount of information
- → PCs are most likely to display subordinate processes

Linear Discriminant Analysis

- Supervised
- Generation of a vector that maximises inbetween-group variance and minimises intra-group variance
- → Characterisation of groups
- → Automative re-detection of structures in datasets
- → Proxies that contribute most to linear discriminant functions
- → Shifts in provenance?





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Results and Discussion

Study Details

Table 1: Re-evaluation of proxies and related dominating formation processes in weakly weathered units. Note that LOG Na/AI in loess cannot be clearly associated to certain processes

LOG-ratios	Loess	Reworked Loess	Gelic Gleysol	
Ca/Al _D	Carbonate metabolism, Initial weathering	Carbonate metabolism, Initial weathering	Brunification, Carbonate m., Metal-OC complexation, Feldspar weathering.	
Si/Al	Provenance shifts, Grain size/ Reworking dynamics	Grain size/Reworking dynamics, Provenance shifts	Grain size/ Reworking dynamics, Provenance shifts	
Zr/V	Provenance shifts, Reworking dynamics	Reworking dynamics, Provenance shifts	Reworking dynamics, Provenance shifts	
Ca/Sr	Ambiguous due PC- Scarb. neutralisation	Ambiguous due Pcarb Scarb. neutralisation	Ambiguous due PcarbScarb. neutralisation	
Mg/Ca	Provenance shifts, Carbonate weathering	Provenance shifts, Carbonate weathering	Provenance shifts, Carbonate weathering	
K/Rb	Provenance shifts	Provenance shifts	Provenance shifts	
Na/Al	Carbonate weathering?	Carbonate weathering	Carbonate weathering	

Vinnepand et al., in prep.

Table 2: Re-evaluation of proxies and	related dominating formation	processes
in strongly weathered units (Calcaric C	Cambisols and Early Glacial a	nd Interglacial soils and sediments

LOG-ratios	Calcaric Cambisols	Early Glacial and Interglacial Soils and Sediments	
		Calcareous	Decalcified
Ca/Al _D	Carbonate metabolism, Brunification, Metal-organic carbon (OC) complexation, Feldspar weathering	Brunification, Carbonate metabolism, Metal-OC complexation, Feldspar-weathering	Brunification, Weath. of primary minerals, Metal- OC complexation, Feldspar-weathering
Si/Al	Provenance, Residual weathering	Residual weathering	Residual weathering
Zr/V	Provenance, Residual weathering	Residual weathering	Residual weathering
Ca/Sr	Scarb. accumulation, if Pcarb. content is low	Carbonate metabolism	Weathering (prim. Min.)
Mg/Ca	Carbonate Weathering/metabolism	Carbonate metabolism	Weathering (prim. Min.)
K/Rb	Provenance, Intermediate weathering	Intermediate to strong weathering, Provenance	Accumulation of clay minerals
Na/Al	Carbonate weathering	Carbonate weathering	Feldspar weathering

Scores e.g. unit D:

Calcaric Cambisols mirror-picture D-O events and climatic cycles and proof that the Schwalbenberg site is the best terrestrial recorder for the OIS 3 in Central Europe



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- Decoding interfering geochemical signals through acknowledging the diversity of geochemical processes
- Quantifying the behaviour of each proxy
 - → Discrimination potential
 - → Contribution to the explained variance of principal components (processes)
- Through our integrative approach, we account for shifting provenance regimes often occurring in Aeolian records. Our approach appears to be also promising for a wider range of geological and geomorphological settings

Timing and nature of terrestrial ecosystem-response to North Atlantic climate oscillations





