A Multi-Proxy Analysis of two Loess-Paleosol Sequences in the Northern Harz Foreland

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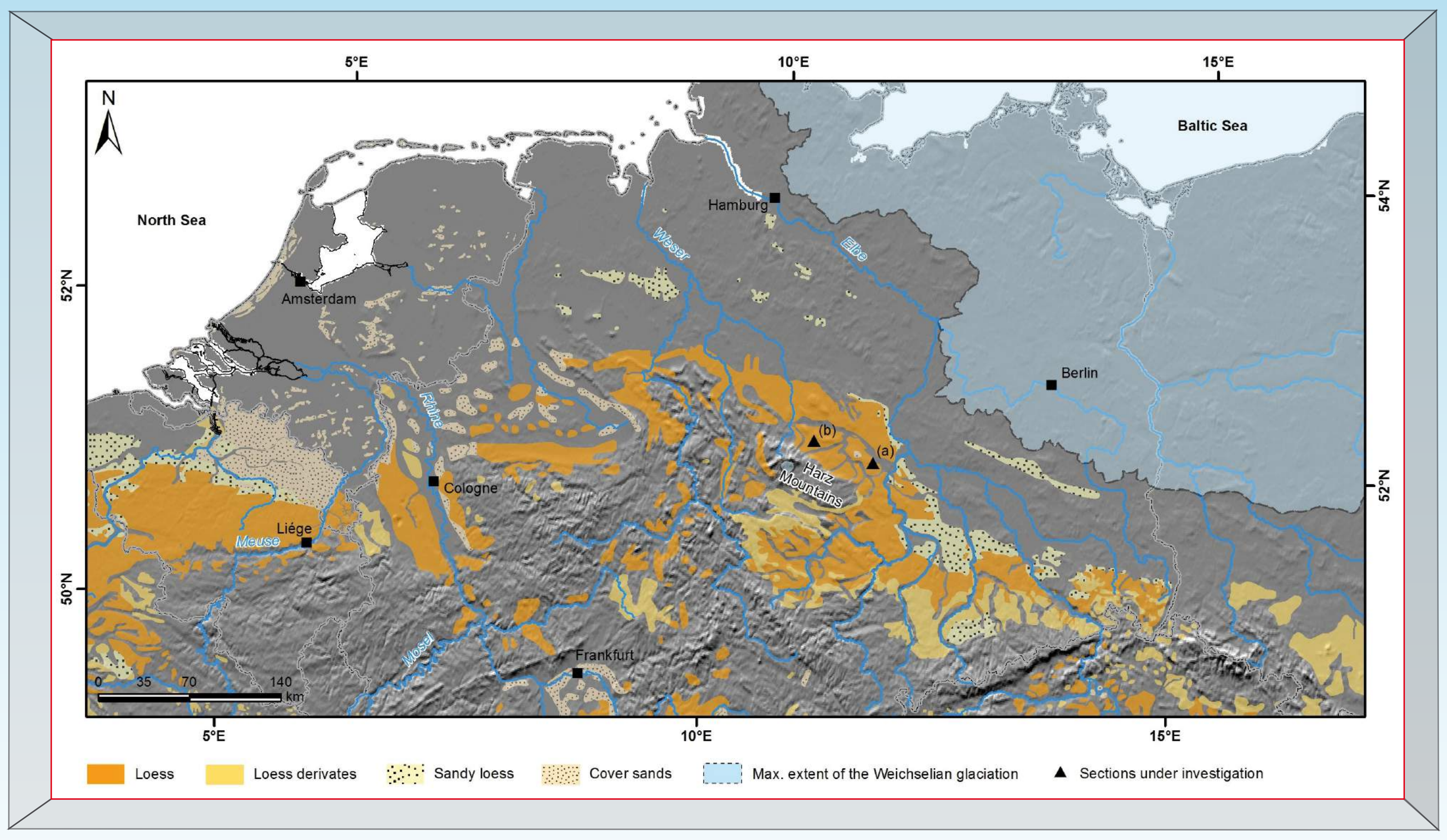

Fig.1 Distribution of Weichselian loess (orange), loess derivates (yellow), sandy loess (light yellow black dotted signature), cover sands (light brown dark brown dotted signature) (according to Haase et al. (2007); modified by integrating data given by Zagwijn &van Staalduinen (1975) and Haesaerts et al. (2011) for the Netherlands and Belgium) in context of the maximum extent of the ice sheet during Weichselian glaciation (according to Ehlers et al., 2004, 2001) in Central and Western Europe. Border of loess distribution is sharp due to Scandinavian ice sheet margin. Triangles mark the investigation sites (a) Hecklingen and (b) Zilly.

Introducing Loess-Paleosol-Sequences

For the reconstruction of regional paleoenviromental and paleoclimatic conditions during the Late Quaternary loess-paleosol-sequences (LPS) often represent the best accessible archive in terrestrial environments. Usually loess accumulates in dry and cold environments. Soils develop on loess during warmer and moister periods. Due to changes of climatic and environmental conditions a series of loess and paleosols accumulates and develops, forming LPS.

Motivation and Methods

Within the second phase of the "Collaborative Research Centre 806 (CRC806) – Our Way to Europe – Culture-Environment Interaction and Human Mobility in the Late Quaternary" two loess-paleosol sections in the northern Harz foreland have been investigated. This study is aiming towards a better understanding of the paleoenvironmental conditions during the Weichselian in an area close to the Scandinavian ice sheet. To achieve that, a multi-proxy approach is applied. During June 2014 the two profiles Hecklingen and Zilly (see Fig. 1) were cleaned, documented and sampled for sedimentological analyses. Samples were continuously taken in a high resolution of 5 cm for multi-elemental (XRF), CaCO3 content, environmental magnetism, color and grain size distribution measurements.

Regional Aspects

The northern Harz foreland is part of the northern European loess belt (see Fig. 1). In the north the maximum extent of loess sediments is marked by the northern loess boundary. Here Weichselian silt and sand sized aeolian sediments interlock. To the south the loess belt is limited by central German uplands. Here the continuous loess cover disperses into separated loess basins. In comparison to popular and intensively studied sections, e.g. along the Rhine river, investigations in the northern Harz foreland on loess-paleosol sequences have been sparse.

The Section Hecklingen

The profile in Hecklingen had a thickness of 9.6 m (see Fig. 2). We identified a recent soil of 1.2 m thickness, three around 30 cm thick tundra gleys with a typical grey matrix and red oxidation stains in 2.3, 3.6 and 4.3 m depth, an almost 2 m thick red-brownish soil with an additional 70 cm thick transition layer with krotovinas and an at least 80 cm thick tundra gley at the bottom of the sequence.

In between those layers loess was embedded. The lowermost loess layer below the red-brownish soil material showed lamination. The 1 m thick loess layer below the first tundra gley was laminated, too, but additionally showed strong cryoturbations and ice wedges in some areas. Within the uppermost loess layer no lamination but pseudomycelia and manganese oxidation stains were visible.

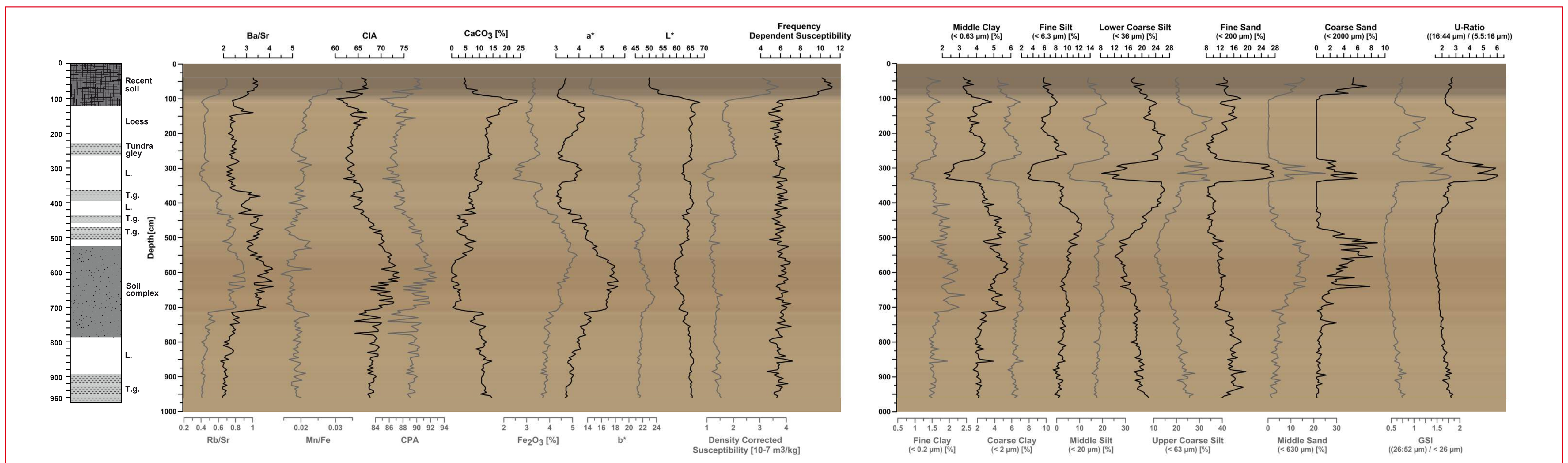

Fig. 2 **Hecklingen** (from left to right): Weathering indices (Rb/Sr, Ba/Sr, Mn/Fe, chemical index of alteration (CIA), chemical proxy of alteration (CPA), $CaCO_3$, Fe_2O_3), color data (luminance (L*), red-green (a*) and blue-yellow (b*) scales), magnetic susceptibility, detailed grain size classes (fine, middle and coarse clay; fine, middle, lower and upper coarse silt; fine, middle and coarse sand), GSI- and U-Ratio in relation to the simplified lithology based on defined units, plotted against depth [cm] (with plotted color data in the background).

The Section Zilly

In Zilly the section we investigated had a thickness of 4.4 m (see Fig. 3). On top we identified a 1.2 m thick recent soil and at least three bleached horizons which are assumed to be tundra gleys. Further, two red iron bands within two of the bleached areas were visible in the field. In between those layers loess was embedded. Within the lower part of the sequence the loess was laminated and at 2.9 m depth even slightly cryoturbated.

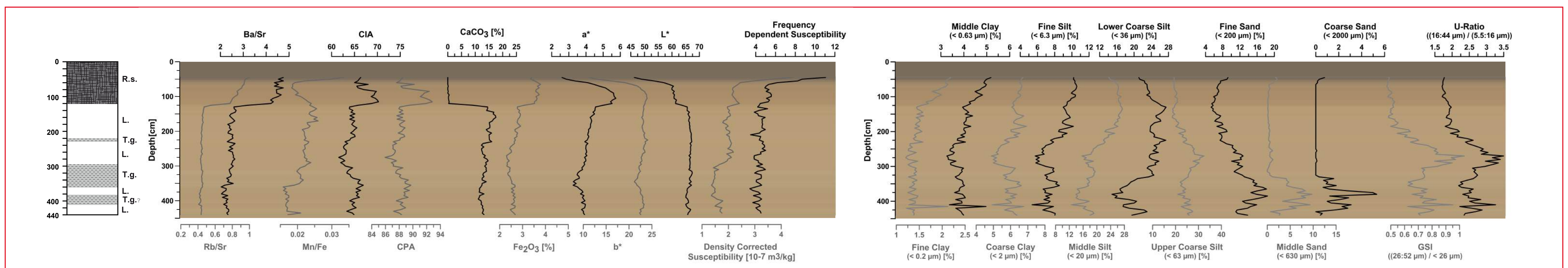

Fig. 3 **Zilly** (from left to right): Weathering indices (Rb/Sr, Ba/Sr, Mn/Fe, chemical index of alteration (CIA), chemical proxy of alteration (CPA), $CaCO_3$, Fe_2O_3), color data (luminance (L*), red-green (a*) and blue-yellow (b*) scales), magnetic susceptibility, detailed grain size classes (fine, middle and coarse clay; fine, middle, lower and upper coarse silt; fine, middle and coarse sand), GSI- and U-Ratio in relation to the simplified lithology based on defined units, plotted against depth [cm] (with plotted color data in the background).

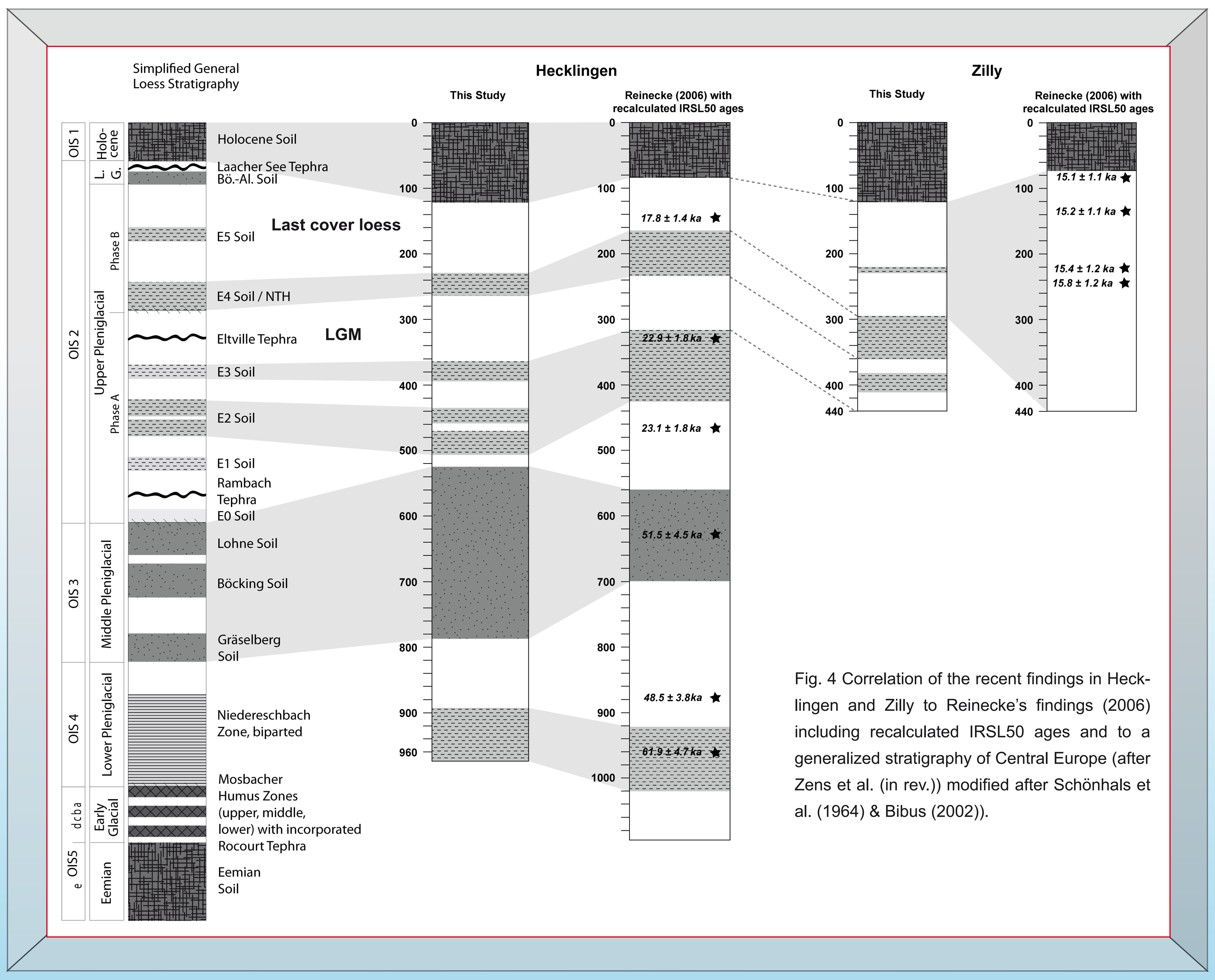

Fig. 4 Correlation of the recent findings in Hecklingen and Zilly to Reinecke's findings (2006) including recalculated IRSL50 ages and to a generalized stratigraphy of Central Europe (after Zens et al. (in rev.)) modified after Schönhals et al. (1964) & Bibus (2002)).

Summary

- Both profiles cover the last glacial maximum (LGM) and last cover loess period.
- Hecklingen and Zilly experienced an increased input of aeolian material during the last cover loess period, supporting the theory of dryer and colder conditions for this time frame.
- The same is valid for the LGM. Additionally, the considerably enhanced short distance input within the LGM sediments point towards a shift in wind direction with a higher frequency of strong easterly wind conditions with several dust storm events.
- In Hecklingen coarser material values are elevated within the OIS 3 soil, too, which speaks for the occurrence of erosion and re-deposition processes of soil material with signs post-depositional pedogenic overprinting during the OIS 3.
- The presence of OIS 3 soil material itself allows the conclusion that surface processes were less intrusive at least partially during the OIS 3 and the OIS 2 in the northern Harz foreland than in other Western and Central European regions.

In Summary, especially Hecklingen seems to represent the changes of environmental conditions during large parts of the Weichselian well (see Fig. 4). It will be beneficial for a better understanding of environmental conditions during the Weichselian to use additional proxies and dating methods at these profiles but also adding new locations for a larger scale approach.

Acknowledgments

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