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Tephra identification and discrimination in loess-paleosol sequences integrating rock magnetism and mid-infrared spectrometry experiments

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Eastern European loess-paleosol sequences (LPSs) are excellent archives of past climate change. Multi-proxy studies reconstructing past environmental and climate changes have enhanced impacts when associated to robust age models. The dating limits (< 250 ka) of radiometric dating techniques commonly applied to LPSs make achieving maximal impact challenging. The detection of widespread marker horizons such as (crypto)tephra layers is valuable and may provide a means of overcoming geochronological challenges.

Eastern European LPSs are located eastwards of highly explosive volcanic provinces of the western Italian volcanic ridge and of the Aeolian Islands. With dominant westerly winds across the European continent, volcanic emissions carrying particulate matter in the form of volcanic glass shards with source specific mineralogy and elemental composition are very likely to be transported and deposited in Eastern European LPSs for at least the last 1 Ma. Moreover, so far, there has been little attention brought to other volcanic provinces, such as those associated to the Eastern Carpathian mountain range or the Anatolian volcanic field, which may also contribute to ash preserved in Eastern European LPSs under different wind regimes.

The Pleven LPS, located in northern Bulgaria, was the target of a high sampling resolution and multi-disciplinary study integrating magnetic, colorimetric, mid infrared and granulometric data. This sequence covers 27 m of continuous dust accumulation and was sampled at a 2-cm resolution resulting in 1336 sampling depths. Magnetic and colorimetric measurements were performed on all samples. Mid-infrared spectrometry (ATR-FTIR; 719 samples) and granulometric measurements (249 samples) were acquired continuously but at a lower depth resolution. Based on mineralogical and grain-size sensitive magnetic properties and ATR-FTIR derived smectite contents, evidence for several preserved (crypto-) tephra layers, of which only one was observed in the field and, so far, for three glass shards have been observed microscopically. Multiple sampling depths represent all cryptotephra. We argue that for most (crypto)tephra counterparts can be found in other regional well-dated paleoenvironmental archives (Fucino-Basin, Lake Ohrid,

Tenaghi Philippon, Sulmona, and ODP 964). The plausibility of the equivalences is confronted with the improved correlative age model constructed for the Pleven LPS, which tunes the frequency dependence of magnetic susceptibility and colorimetrically derived goethite and hematite contents to the Lisiecki & Raymo benthic foraminifera $\delta^{18}\text{O}$ stack and, in addition for the last glacial cycle, to the NGRIP $\delta^{18}\text{O}$ ice core record.

The study results in potentially novel (paleo-) and detailed limnic-sea-land correlations based on confidently identified (crypto)tephra layers within the Pleven LPS. The current approach is strictly tephro-stratigraphical since geochemical fingerprinting of extracted volcanic glass shards enabling a robust source tracking has yet to be done. However, with only four tephra layers reported in the literature for Eastern European LPSs, the innovative integration of multi-disciplinary data evidencing cryptotephra layers in the Pleven LPS is a step forward in addressing the geochronological challenges inherent to LPSs and strengthens the potential for regional stratigraphic correlations and regional paleoclimate reconstructions in Eastern Europe.