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New chronology of the best developed loess/paleosol sequence of Hungary capturing the past 1.1 ma: Implications for correlation and proposed pan-Eurasian stratigraphic schemes

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ABSTRACT

In this paper, we are presenting a revised chronology of the best developed, longest (100 m) LPS in Hungary dating back 1.1 Ma: borehole Udvari-2A. It is based on a non-tuned age-depth model, built on the position of the Matuyama-Brunhes Boundary, Jaramillo and Olduvai Subchrons. Furthermore, on the assignment of formerly recorded uninterpreted geomagnetic reversals in both chrons. Other chronometric tools (AMS ^{14}C dating, biostratigraphy, tephrostratigraphy) yielding absolute ages and/or ensuring validation of these were also used. Records of a Middle Pleistocene gastropod index fossil *Neostyriaca corynodes* (400 -140 ka) facilitated verification of ages between MIS 10 and MIS 6. Multiple age control points at 15, 25, 27, 45, 120, 191, 362, 430, 670, 780, 900, 990, 1070 ka were established for the last ca. 1.1 Ma. The resulting chronology is the best resolved independent one so far among Danubian Basin LPSs. In light of our data, the S3-S4 units were fused as S3 in all Serbian, and some Romanian sites and re-correlated with MIS 9. The results also point to a misassignment of the S5 units at these sites to MIS 13–15 leading to erroneous conclusions regarding paleoclimatic conditions and cyclicity. In our new stratigraphic scheme, these S5 paleosols were taken to represent the S4 paleosol and recorrelated with MIS 11. Finally, an ideal stratigraphic column dating back 1.1 Ma for SW Hungary was constructed and correlated with the Chinese loess/paleosol sequence of Xifeng and the benthic oxygen isotope record down to MIS 31.

1. Introduction

Predicting climate and environmental changes is one of the most significant challenges of current research in earth sciences (Barnett and Schlesinger, 1987; Broecker, 1987; Friedli et al., 1986; Neftel et al., 1988; Huggett, 1991; Imbrie et al., 1993; Wake, 2013).

Recent advancements in science and computer technology have enabled the modeling of paleoclimatic records for the past (Joussaume and Taylor, 1995; Holden et al., 2010; Braconnot et al., 2012; Kageyama et al., 2012). To understand and model climate-ecosystem relations on a scale of multiple glacials-interglacials, continuous, well-resolved non-orbitally tuned paleoclimatic records with a firm chronology are needed. While marine and ice core sequences provide us with a reference on climate variability on such scales (McManus et al., 1999; Lisiecki and Raymo, 2005;

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Raymo et al., 2006; Jouzel et al., 2007; Parrenin et al., 2007; de Vernal and Hillaire-Marcel, 2008; Loulergue et al., 2008; Lüthi et al., 2008; Lang and Wolff, 2011), terrestrial records with a precise chronology yield us information on how these changes translate to terrestrial ecosystems (Williams et al., 1997; Kashiwaya et al., 2001; Prokopenko et al., 2001, 2002; Tzedakis et al., 2006). Among terrestrial deposits loess/paleosol sequences are among the most common and prominent type of paleoarchives of Quaternary climate changes (An et al., 1990; Pécsi, 1990, 1993; Pye, 1995; Lu and An, 1998; Kemp, 2001; Porter, 2001, 2007). Besides China (Kukla, 1987; Liu et al., 1987, 1988; An, 2000; Lu et al., 2004; Hao and Guo, 2005; Hao et al., 2012), one of the most significant loess areas, which can help us understand the climatic evolution of the past 0.8–1 million years is found in the Middle and Lower Danube Basin. The antiquity of these plateau-positioned loess paleosol sequences (LPSs) is supported by magnetostratigraphic investigations complemented by other chronometric and stratigraphic tools (for a comprehensive review see Fitzsimmons et al., 2012; Marković et al., 2015). The well-known LPSs of Krems in Austria (Fink and Kukla, 1977; Hambach et al., 2008; Terhorst et al., 2014), Paks in Hungary (Pécsi and Pevzner, 1974; Márton, 1979; Pécsi, 1993; Sartori et al., 1999; Thiel et al., 2014; Újvári et al., 2014a), Batajnica (Marković et al., 2009), Mošorin (Marković et al., 2012a, 2015) and Stari Slankamen in Serbia (Marković et al., 2011, 2015; Murray et al., 2014) of the mid-Danube Basin all belong to this series (Fig. 1). Similarly, the Lower Danube Basin profiles of Koriten (Jordanova and Petersen, 1999), Viatovo in Bulgaria (Jordanova et al., 2007, 2008), Mostistea (Panaiotu et al., 2001), Mircea Voda (Buggle et al., 2009, 2013) and Zimnicea borehole in Romania (Rădan, 2012) may be mentioned. It is therefore no surprise the glacial-interglacial paradigm was founded on Danubian loess/paleosol sequences (DBLPSs) (Kukla, 1977, 1978). Marković et al. (2015) recently proposed a pan-European loess/paleosol stratigraphic system and a master chronology, which was considered as a sound basis for Northern Hemisphere correlation and climate cycle analysis (Kukla and Cilek, 1996; Kukla, 2005; Buggle et al., 2013; Marković et al., 2012a; b; 2015; Basarin et al., 2014).

In addition, some DBLPSs display strong similarities with those of the Chinese loess plateau in terms of paleomagnetic characteristics interpreted as an outcome of similar controls on deposition and magnetic susceptibility signal acquisition (Bronger, 2003; Marković et al., 2011, 2012a, 2015). An exception is perhaps the area of Southern Serbia (Obrecht et al., 2016). However, as noted in several studies, DBLPSs tend to be thinner compared to LPSs of the Chinese loess plateau (Marković et al., 2012a, 2015). A notable exception is perhaps the LPS of Tolna Hills, SW Hungary, where a borehole has recovered the thickest Quaternary sequence (98 m) in Hungary and the entire Carpathian Basin (Middle DBLPSs) (Koloszár and Marsi, 2010a; b) (Fig. 1). Magnetostratigraphic results underline the antiquity of the LPS preserved at borehole Udvari-2A,

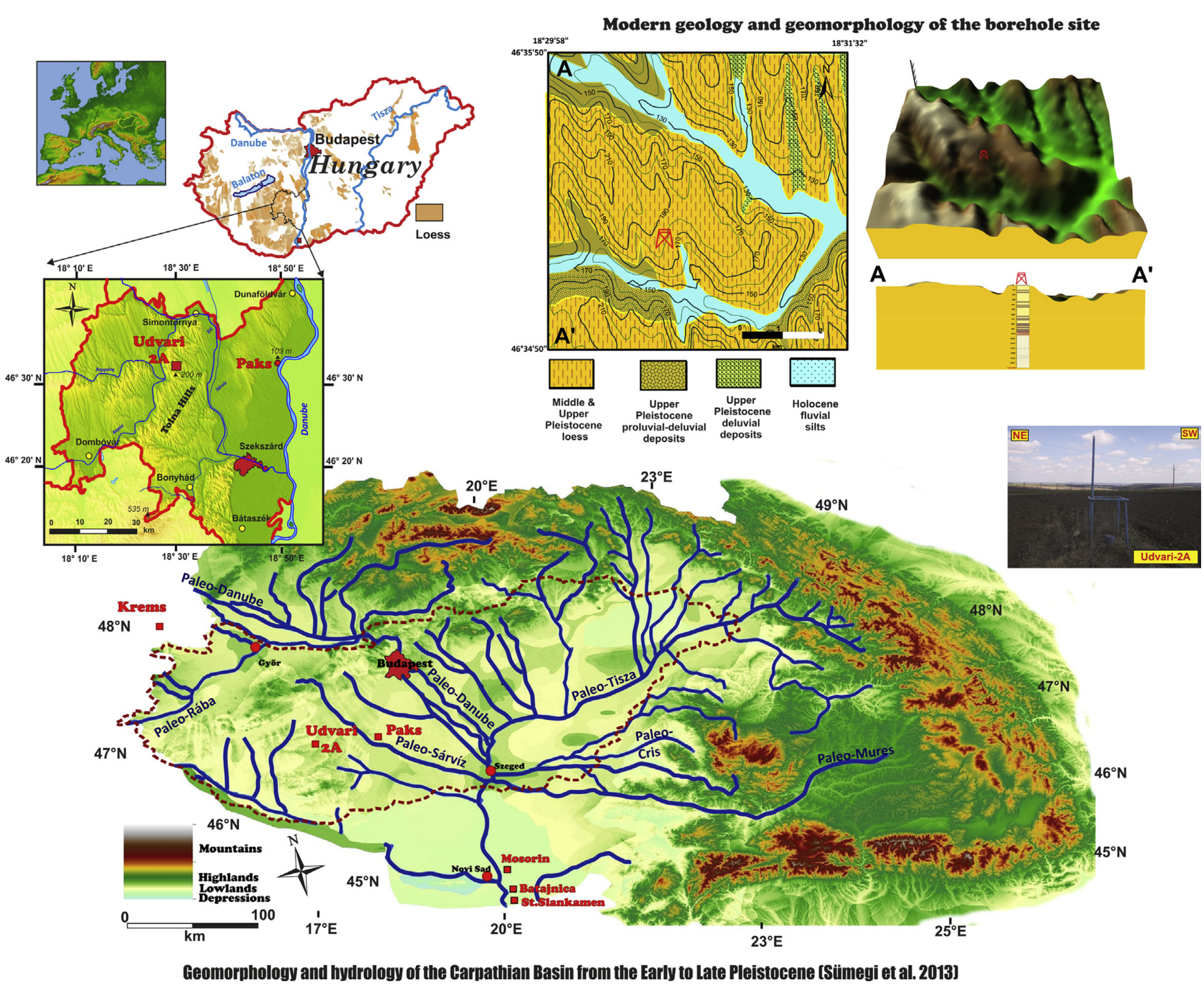

Fig. 1. Location, paleohydrology, modern morphology, geology of the study site.