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Research Paper

Infrared stimulated luminescence and radiofluorescence dating of aeolian sediments from Hungary

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ABSTRACT

Anomalous fading of the infrared stimulated luminescence (IRSL) signal from the polymineral fine-grain and K-feldspar fractions of aeolian sediments from Hungary has been studied. The samples in this study have previously been dated using the multiple aliquot additive dose (MAAD) protocol to measure the IRSL signal. The IRSL measurements using MAAD were conducted ~4 weeks after the irradiation, making it difficult to assess to what extent these age estimates were affected by anomalous fading. In this study, equivalent doses were obtained using the single aliquot regenerative dose (SAR) protocol. The fading rate for each sample was calculated using the different IRSL components and different parts of the decay curve. For each sample, the middle part of the decay curve always showed a lower fading rate than the initial part of the decay curve. The difference between the fading rates for different parts of the decay curve was greater for the K-feldspars than for the polymineral fine grains. Fading corrected ages were calculated by integrating both the initial and the middle part of the decay curve. These ages were compared with optically stimulated luminescence (OSL) ages from quartz, infrared radiofluorescence (IR-RF) ages obtained from K-feldspars and also with independent ages, provided by radiocarbon dating of shells and charcoal, and uranium-series dating of travertine.

1. Introduction

The palaeoenvironmental changes of the Quaternary are recorded in various terrestrial sediment successions. The Pleistocene loess of the Carpathian Basin in Central Europe developed under cold steppe conditions, whilst buried soil horizons in the same sequence reflect a warmer and more humid environment. Similar processes affected the sandy material; strong winds moved the sand from de-vegetated surfaces during periods of aridity, soil formation and the establishment of vegetation occurred during the wetter and warmer periods.

Luminescence dating has been applied to the loess–palaeosoil sequences in Hungary using thermoluminescence (TL) (Borsy et al., 1979; Butrym and Maruszczak, 1984; Wintle and Packman, 1988; Singhvi et al., 1989; Zöller and Wagner, 1990; Zöller et al., 1994) and more recently using IRSL dating (Frechen et al., 1997; Novothny et al., 2002, 2009). More recent results have indicated that the lower boundary of loess from the last glacial period is not in the previously assumed position, but is higher up in the loess series and it has been concluded that the majority of the last interglacial/glacial record is not exposed in Hungary (Wintle and Packman, 1988; Frechen et al., 1997; Novothny et al., 2002, 2009).

The direct dating of the wind-blown sands, and hence more arid periods was first carried out by Ujházy et al. (2003) using IRSL MAAD to date sand layers from two sites along the Danube river, and more recently some dunes have been dated by Nyári et al. (2007) using OSL SAR protocol on quartz coarse grains from the Danube–Tisza Interfluve. However, since most of the previous luminescence dating of loess and aeolian sand successions in Hungary, has utilized the luminescence signal from feldspars, it is possible that previous age estimates are affected by anomalous fading which may not have been corrected for.

The two sites investigated in this study – the loess profile at Süttő and the sand dune at Tura – have been previously dated with the MAAD protocol (Novothny et al., 2009, in press) which suggests a significant underestimation of age by the feldspars. The aim of this study is to obtain more reliable luminescence ages from these

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sequences using the SAR protocol (Murray and Wintle, 2000; Wintle and Murray, 2006) on quartz and on feldspar extracts which have had a correction for fading applied. The lower part of the Süttő loess profile was also dated by infrared radiofluorescence (IR-RF) of K-feldspars (Trautmann et al., 1999, 2000).

2. Geological settings

The loess–palaeosoil sequence at Süttő is located in northern Hungary, close to the southern bank of the River Danube (47°44.26′ N, 18°26.87′ E) (Fig. S1), and provide excellent late-Pleistocene climate archives. The loess deposits are up to 20 m thick, and contain two humus-rich horizons, two thin, brownish steppe-like soils and a thick pedocomplex including a dark brown chernozem-like palaeosoil and a reddish-brown palaeosoil, which overlie the Süttő travertine complex (Fig. 1). Independent age control is provided by uranium-series ($^{230}Th/^{234}U$) dating of the underlying travertine below the loess, where mid-Pleistocene ages, ranging between 235 ± 21 ka and 314 ± 45 ka were obtained from the travertine (Sierralta et al., in press). Five radiocarbon ages were obtained from molluscs and charcoal (Novothny et al., 2009). Ten samples (HST 1, HST 2, HST 3, HST 4, HST 8, HST 12, HST 13, HST 14, HST 15, HST 17) were collected for luminescence dating.

At Tura (47°36′ N, 19°36′ E) (Fig. S1), a 3 m thick late-Pleistocene–Holocene sand dune, containing three humus-rich horizons and a greyish carbonate-rich layer, was investigated. Seven samples (HTU 1–7) for luminescence and two (TURA 1–2) for radiocarbon dating were taken (Fig. 1). The sedimentology of both sections is discussed in more detail by Novothny et al. (2009).

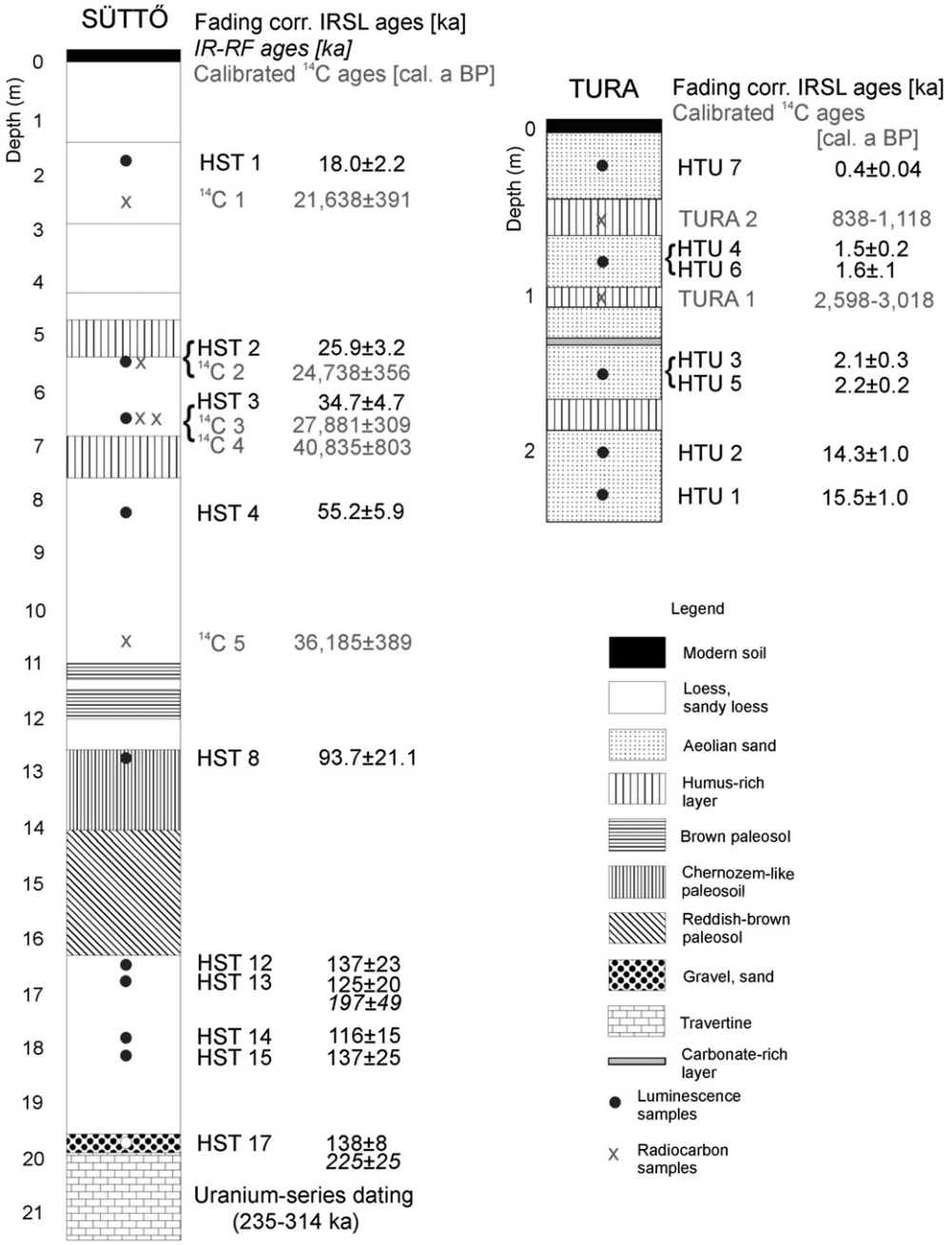

Fig. 1. Stratigraphic logs of the loess profile at Süttő and the sand profile at Tura, showing major sedimentological units and sample positions. The fading corrected IRSL, IR-RF, radiocarbon and uranium-series ages are shown.