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Quaternary Geochronology 2 (2007) 34–38
QUATERNARY GEOCHRONOLOGY
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Research paper

Luminescence investigation of loess and tephra from Halfway House section, Central Alaska

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Received 12 October 2005; accepted 1 May 2006
Available online 23 June 2006

Abstract

Infrared stimulated luminescence (IRSL) properties of the Old Crow tephra and bracketing loess from the Halfway House site in Central Alaska are investigated in order to test newly developed techniques, including SAR and recently proposed fading corrections. Loess samples investigated show a standard growth of luminescence with regenerative dose while the tephra sample is less sensitive by an order of magnitude and saturates at lower dose. The growth curves obtained using multiple-aliquots regeneration (MAR) saturate at a higher value than those with the single-aliquot regeneration (SAR) protocol. Fading rate determinations for these samples are shown to be imprecise and no noticeable difference was observed between loess and tephra materials. Anomalous fading corrections using an average g value of 5% are applied to the natural test dose signal intensity using the dose rate correction (DRC) method. IRSL ages obtained for loess are in agreement with the expected age while the tephra age is lower than expected, suggesting the measured fading rate is underestimated for this material.

Keywords: IR luminescence; Loess; Tephra; Alaska; Anomalous fading; Feldspar

1. Introduction

Successions of loess and palaeosols offer the opportunity to reconstruct palaeoenvironments and palaeoclimatic conditions in the Quaternary period. Alaskan loess have been extensively studied over the years particularly those from the Halfway House site where continuous loess deposition throughout the Pleistocene was possible given its ice-free position during the waxing and waning of the North American Ice Sheets.

The Halfway House site (HH3) is located ~50 km west of the city of Fairbanks in Central Alaska. In this 12-m thick section, several palaeosols are found intercalated with loess deposits. The presence of the Old Crow tephra dated by fission-track at 140 ± 10 ka (Westgate et al., 1990), makes this context interesting for luminescence studies.

Several luminescence ages have been published for the loess bracketing the tephra; they range from 86–90 ka (Wintle and Westgate, 1986), to 110–204 ka (Berger et al., 1994) and 68–116 ka (Oches et al., 1998). These were mostly TL, no infrared stimulated luminescence (IRSL) result has been published and no fading correction has yet been applied to any luminescence measurement. Some cosmogenic age controls are provided by ^{14}C and ^{10}Be (Muhs et al., 2003) but they are limited to the upper part of the section.

2. Samples

Several samples were collected throughout the section (Fig. 1) in the course of an exhaustive environmental magnetism study (Lagroix and Banerjee,

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doi:10.1016/j.quageo.2006.05.009

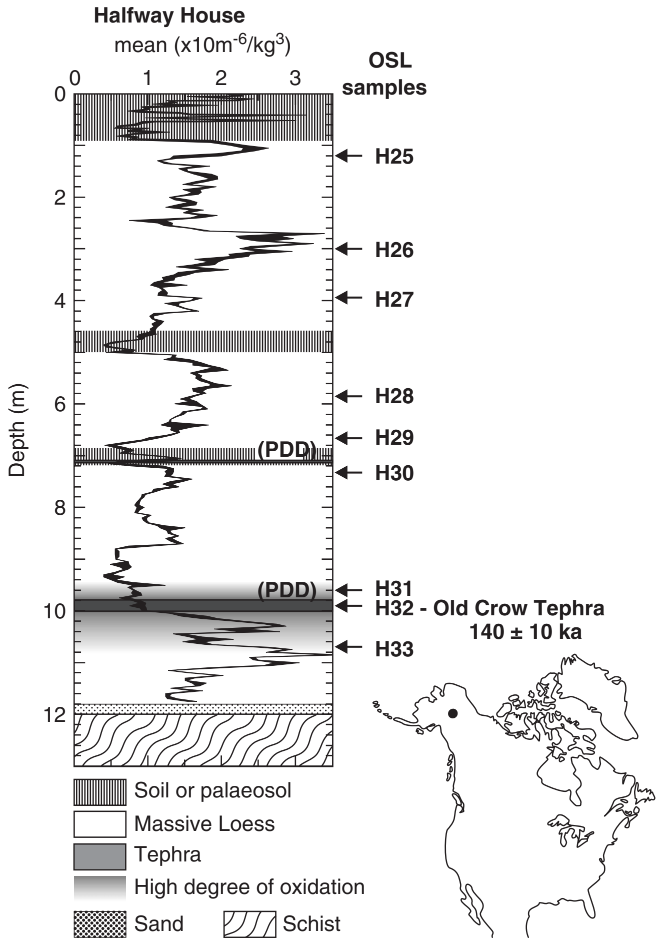

Fig. 1. Simplified stratigraphy and mass normalised magnetic susceptibility of the Halfway House profile with OSL sample locations. Two tephra layers were identified, the prominent Old Crow tephra located at ~10 m depth (OSL sample H32) and the more subtle SD tephra located in the palaeosol at ~7 m depth. Shaded intervals labelled PDD, for post-depositional deformation, have been identified as reworked loess intervals based on results from an anisotropy of magnetic susceptibility study (modified from Lagroix and Banerjee, 2004a).

2004a, b). Alaskan loess contains quartz, plagioclase, K-feldspar, mica, and small amounts of heavy minerals (Muhs et al., 2003). The tephra material is composed of dacitic to rhyolitic glass shards, pyroxene, plagioclase, and iron oxide (Preece et al., 2000). Polymineral fine grains (4–8 μm) were used for luminescence studies. The results presented here focus on the oldest samples: the Old Crow tephra (H32) and the bracketing loess (H31 and H33).

Dosimetric data for these samples are presented in Table S1. Water content values are high because of the extreme saturation values measured: up to 61% for loess and 72% for the Old Crow tephra. This is the result of segregated ice lensing caused by the presence of continuous permafrost since deposition (Lagroix and Banerjee, 2004a).

3. IRSL measurements

Multiple-aliquot measurements were performed on a Daybreak 1100 reader. The γ source used delivered 0.41 Gy/min. A hydroponic sodium sunlamp equipped with a 460 nm long wave pass filter was used to bleach the grains. Single aliquots were measured on a TL/OSL-DA-15 Risø reader, with a ^{90}Sr as β source calibrated at 6.90 Gy/min. EMI 9235Q photomultiplier tubes are mounted on both readers. Blue-violet luminescence emissions were detected through a Schott BG39/Corning 7–59 filter combination.

3.1. Luminescence characteristics

The luminescence signal intensity from the tephra material is one order of magnitude lower than that of every loess sample (Fig. 2), and laboratory saturation is reached at a much lower dose (Fig. 3A). D_e values obtained for the samples are very low in comparison to the expected geological age of 140 ± 10 ka for the tephra. Multiple-aliquots regeneration (MAR) gave ages of 55 ± 7 ka and 85 ± 10 ka for samples H32 and H33, respectively. The latter is similar to TL ages published by Wintle and Westgate (1986) and Oches et al. (1998).

With single-aliquot regeneration (SAR), our routine procedure is based on a 250 °C/1 min preheat treatment for the natural, regenerative and test doses. The SAR growth curves saturate at low doses when compared to the multiple-aliquot luminescence growth curves, yielding higher D_e values. This is thought to be caused by the accumulation of a slow component which is not bleached by the shine down. No dose-recovery test has been carried out on these samples but recycling ratios are within a few percent of unity.

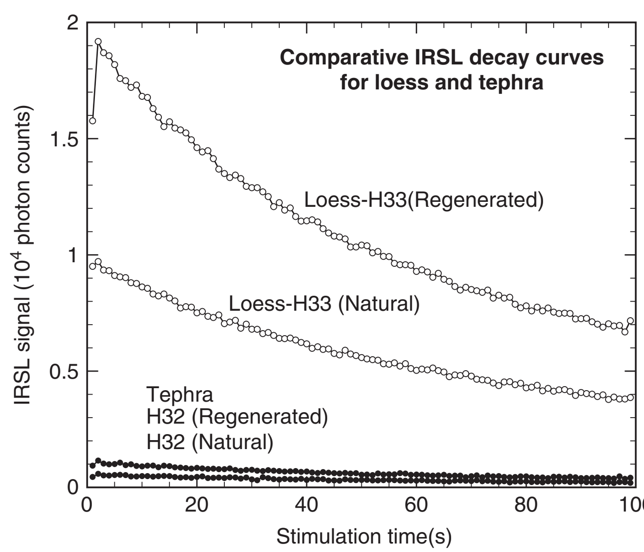

Fig. 2. Comparative IRSL decay curves for loess and tephra. Shine down curves are obtained using a Daybreak reader, measurement of 100 s at 20 °C after a preheat treatment of 250 °C/1 min. Samples were bleached for 16 h with a filtered hydroponic sodium sunlamp before γ dosing. Regenerative dose is 1143 Gy.