Quaternary Geochronology 29 (2015) 48–57

Contents lists available at ScienceDirect

Quaternary Geochronology

journal homepage: www.elsevier.com/locate/quageo

Research paper

Investigating the components of the optically stimulated luminescence signals of quartz grains from sand dunes in China

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ARTICLE INFO

Article history:
Received 13 August 2014
Received in revised form
26 May 2015
Accepted 1 June 2015
Available online 3 June 2015

Keywords:
Quartz
OSL
Component
Northern desert
Provenance

ABSTRACT

The optically stimulated luminescence (OSL) signals from quartz consist of several physically distinct components, which are commonly referred to as fast, medium and slow components. In this study, the OSL components of quartz from the Taklimakan Desert and the Hunshandake sandy land in north China are investigated. Our results show that the relative contributions of OSL components to the bulk OSL signal can be significantly different among quartz grains from both deserts. Laboratory dosing, optical bleaching and heating experiments are used to test their effects on the relative contributions of quartz OSL components. It is found that cycles of dosing and optical bleaching have insignificant impact on the relative contributions of quartz OSL components, while heating to high temperature (500 °C) can significantly enhance the contribution of the fast component to the bulk OSL signals, especially for quartz samples from the Taklimakan Desert. Such results suggest that the different heating history of natural quartz grains plays an important role in controlling OSL components. Additionally, the quartz grains from the Hunshandake sandy land can easily be distinguished from those of the Taklimakan Desert, by using a ternary plot of fast-medium-slow components. The quartz grains from the Hunshandake sandy land exhibit a much stronger fast component than those from the Taklimakan Desert. This can be explained by that the quartz grains from the Hunshandake sandy land are mainly of igneous origin, while most of the quartz grains from the Taklimakan Desert are of low grade metamorphic origin.

1. Introduction

During the last decade, the quartz optically stimulated luminescence (OSL) signal has been widely applied to date late Quaternary sediments from a variety of geographic areas (Sun et al., 2006; Wintle and Murray, 2006; Li et al., 2007; Duller, 2008; Madsen and Murray, 2009; Preusser et al., 2009; Rhodes, 2011; Gong et al., 2013, 2014a). Meanwhile, the properties of quartz OSL signals, such as sensitivity and dose saturation level, are found to be highly variable with geological source and vary even on a grain-to-grain level (Duller et al., 2000), making them a potential tool for tracing sediments. Investigations have been carried out to distinguish the provenance of quartz samples from different geographic areas, using the sensitivity and dose saturation level of quartz OSL signals (e.g. Li et al., 2002; Lai and Wintle, 2006; Li et al., 2007; Zheng et al., 2009; Fitzsimmons, 2011; Lü and Sun, 2011; Sawakuchi et al., 2011, 2012; Gong et al., 2014b; Lü et al., 2014).

The bulk OSL signal emitted from sedimentary quartz consists of several components from discrete trap types, which are broadly referred to as fast, medium and slow components (Bailey et al., 1997). The different OSL components from quartz have different characteristics, regarding photoionization cross-sections, sensitivity, dose saturation level, recuperation and thermal stability (Jain et al., 2003; Singarayer and Bailey, 2003, 2004; Li and Li, 2006; Fan et al., 2009; Steffen et al., 2009). The individual OSL components can be identified by mathematically fitting either continuous wave OSL (CW-OSL) or linearly modulated OSL (LM-OSL) curves (Bulur, 1996, 2000). For the purpose of dating, the fast component is the most favorable because it is highly sensitive to light and it is thermally stable (Wintle and Murray, 2006). However, not all sedimentary quartz contains a strong fast component. Unsuccessful applications have been reported when samples are dominated by

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http://dx.doi.org/10.1016/j.quageo.2015.06.004
1871-1014/

Table 1
The relative contributions of the fast component to the quartz CW-OSL signals.

Contribution to the OSL signal from the fast component	Signal integration region	Sample/locations	Reference
>90%	0–0.6 s	Loess/Chinese Loess Plateau in northern China	(Lai and Fan, 2014)
70-98%	0–0.8 s	Loess/Northwest Canada	(Demuro et al., 2013)
~94%	0–2 s	Sand dune/West Australia	(Wang et al., 2012)
>90%	0–0.6 s	Sand/Mu Us Desert in northern China	(Fan et al., 2011)
~70%	0–0.4 s	Sedimentary core/Northeastern Italy and northern Switzerland	(Lowick et al., 2010)
80-92%	0–0.64 s	Loess/Linxia in western China and southern Tajikistan	(Zhou et al., 2010)
Very low	0–0.8 s	Glacial sediment/Northwestern highlands of Scotland	(Lukas et al., 2007)
>80%	0–0.4 s	Aeolian sample/China	(Li and Li, 2006)
39–87.9 %	0–0.8 s	Loess/Japan	(Watanuki et al., 2005)
~80%	0–1.6 s	Aeolian dune/Sri Lanka	(Bailey, 2003)

non-fast components (Choi et al., 2003; Li and Li, 2006; Steffen et al., 2009). It has been reported that the relative contributions of the fast component to the bulk OSL signal can be highly variable for samples from different geographical locations (Table 1).

In this study, the OSL components of coarse quartz grains from the Taklimakan Desert and the Hunshandake sandy land in China are analyzed and compared. This paper aims to address the following issues: (1) investigating the compositions of the OSL signal, to see whether the different quartz aliquots from the same sample can display differential relative intensities of OSL components; (2) testing the effects of irradiation, optical bleaching and heating on the relative contributions of quartz OSL components; (3) examining whether the differential contributions of the OSL components in quartz can be a useful tool to distinguish provenances.

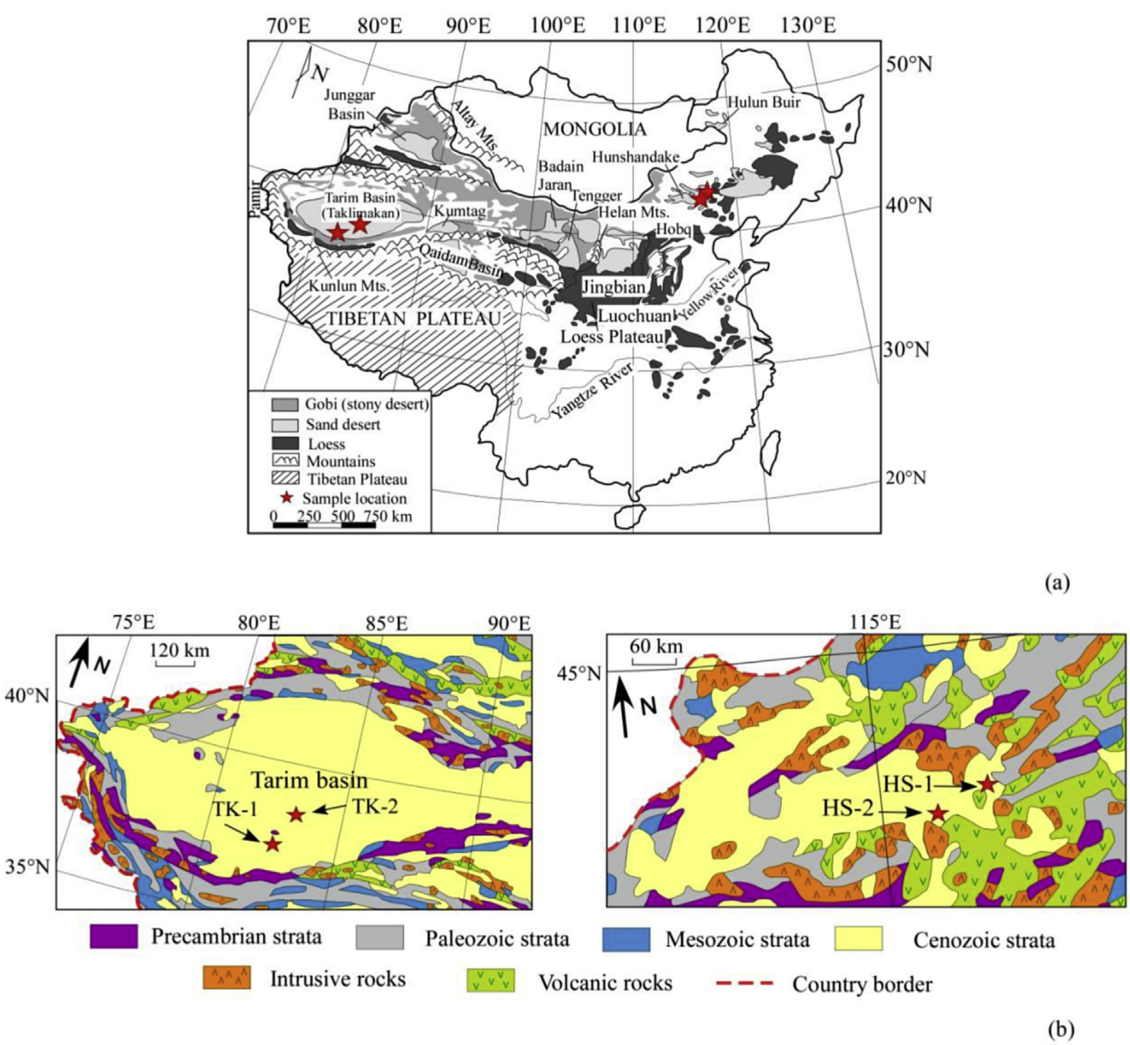

Fig. 1. (a) Map showing mountains, gobi (stony desert), sand desert, and loess distributions as well as the sampling sites in China (from Sun and Zhu, 2010). (b) Geological map showing the strata of the orogenic belts surrounding the Taklimakan Desert and the Hunshandake sandy land (modified after 1:1000000 geological map of China). Red stars indicate sample locations (from Gong et al., 2014b). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)