Research Paper

Thermoluminescence and optically stimulated luminescence signals from volcanic ash: History of volcanism in Barren Island, Andaman Sea

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ABSTRACT

The results of experiments which characterise the optically stimulated luminescence (OSL) signals of an ash sample (BI07-TL-05) from Barren Island are presented. The infrared stimulated luminescence signal decreases to 5% of its initial value when preheated at 150 °C for 10 s, suggesting that the infrared stimulated luminescence signal associated with the 290–390 nm emission in this sample arises from a single trap emptied by heating to 150 °C. The post-IR blue stimulated luminescence emission has greater thermal stability and arises from traps which are emptied by heating to temperatures between 120 °C and 240 °C. Dose recovery experiments demonstrate that a laboratory dose can be reliably determined to within 5% for the post-IR blue stimulated luminescence signal. However, the fading rate for the post-IR blue stimulation is high, and the g-value is estimated to be (9.6 ± 3.5)% per logarithmic decade for BI07-TL-05.

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1. Introduction

Barren Island is a small volcanic island in the Indian Ocean, and is a part of the Andaman and Nicobar chain of islands. It has witnessed several volcanic eruptions during historic times: 1994–1995, 1991, 1852–1804, 1795, 1789, 1787 (Raina, 1987; Shanker et al., 2001). It is the only active volcano in the Indian subcontinent region, and is located 135 km northeast of Port Blair in east Andaman Sea (Figure 1 in Alam et al., 2004). The island has been built as a result of eruptions during late Pleistocene time. The present morphology of the island has arisen from a huge collapse affecting the central part of a pre-existing volcanic cone, perhaps during the late Pleistocene. All later eruptions were confined to the central part of the caldera depression (Alam et al., 2004). Although several field, petrographic and chemical composition studies have been carried out, no absolute ages exist on any part of this island (Alam et al., 2004). Luminescence dating is revolutionising terrestrial Quaternary studies (Aitken, 1985, 1998; Wintle, 1997) as these methods can be used for dating a variety of earth surface processes and sediments that were conventionally considered undatable.

Our work aims to determine the history of volcanism and evolution of Barren Island for the first time by dating pyroclastic rock and ash bed samples from stratigraphic sections exposed through the volcano. This requires the development of a suitable dating method applicable to pyroclastic rock and ash beds on Barren Island. Initially, we extracted 106–212 μm grains from these samples after etching with 40% HF for 40 min, and tested the feasibility of determination of the equivalent dose using the SAR procedure for quartz (Banerjee et al., 2000; Murray and Wintle, 2003). Measurements on these grains showed an absence of natural OSL and IRSL signal (measured after a 240 °C, 10 s preheat) in five different samples collected from the Island. We then investigated the TL and OSL properties of an ash sample BI07-TL-05 (12°16’N; 93°51’E) from amongst these samples in greater detail. Here, we report the results of various experiments performed to characterise the post-IR blue and infrared stimulated luminescence signals from the 106–212 μm aliquots of the sample BI07-TL-05. Firstly, we investigate the thermal stability of the optical signals by performing a pulse annealing experiment. Next, dose-response curves for the optical signals and the results of dose recovery experiments are presented. Finally, the result of anomalous fading experiments and estimation of g-value is discussed.

2. Sample description and experimental procedures

The sample BI07-TL-05 has a mineralogical composition comprising plagioclase, olivine, and pyroxene. All experiments