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ScienceDirect
Radiation Measurements 41 (2006) 871 – 877
Radiation Measurements
www.elsevier.com/locate/radmeas

Characterisation of low OSL intensity quartz from the New Zealand Alps

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Received 15 August 2005; received in revised form 21 February 2006; accepted 17 April 2006

Abstract

Quartz from Westland in the western foreland of the New Zealand Alps shows low luminescence intensity and large changes in the sensitivity that are not sufficiently corrected for by the single-aliquot regenerative-dose protocol. Sensitisation of quartz occurs after repeated irradiation and luminescence read out, as well as by thermal annealing. Furthermore, some samples show a significant influence of thermal transfer on the determination of the equivalent dose. Hence, quartz from this particular area is unsuitable for use as a natural dosimeter for luminescence dating. It is demonstrated that the poor luminescence properties are not related to the source rock and cathodoluminescence characteristics but are apparently mainly the effect of the young sedimentary history of the quartz grains.

Keywords: Luminescence dating; Quartz; Low intensity; Sensitivity change; New Zealand

1. Introduction

Recent developments in luminescence dating have concentrated on improving techniques using quartz as the natural dosimeter to record the time elapsed since the last daylight exposure of sediment grains (e.g., Duller, 2004). Luminescence dating has significantly contributed to a better understanding of the evolution of early man and improved our knowledge of Quaternary climate variability (e.g., Roberts et al., 1998; Henshilwood et al., 2002; Svendsen et al., 2004). Of special interest for the reconstruction of past global change are mountain regions at mid-latitudes such as the New Zealand Alps. This particular area is rather sensitive to changes in environmental conditions and reflects an important weather divide. During the Quaternary, the Southern Alps were repeatedly glaciated as a result of global climate change. Glacial erosion caused a wide distribution of Alpine debris over the foreland, which represents a valuable archive of past environmental conditions and related geological processes. At present, the chronology of the well-developed glacial record of Westland is beyond the limit of radiocarbon dating restricted to a few initial luminescence dating studies. Most of these studies used polymineral fine grains and thus a luminescence signal that almost exclusively originates from feldspar (Almond et al., 2001; Berger et al., 2001; Hormes et al., 2003; Preusser et al., 2005). Hormes et al. (2003) and Preusser et al. (2005) demonstrated that optical dating using different feldspar signals resulted in ages that were consistent with independent age control provided by radiocarbon. However, most researchers prefer quartz instead of feldspar due to the assumed higher bleachability and the apparent absence of fading in quartz (cf. Wallinga, 2002). While these advantages of quartz apply in many areas, it is the aim of the present paper to investigate whether quartz from Westland is suitable or not for luminescence dating due to its specific physical properties. The relationship between different bedrock geology and luminescence characteristics is initially investigated through cathodoluminescence (CL) studies.

2. Samples and methods

The samples were collected west of the Alpine Fault, mainly as boulders found in river beds, from Lake Rotoroa to the north to the Waiho River to the south (Fig. 1). Four samples were collected (LR, MR1, 2, MOR) from areas with dioritic intrusions of Devonian age. All other samples (FJ1, 2, 3, OK1, 2, TAR 1, 2) were from metamorphic rocks folded during the Alpine

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1350-4487/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.radmeas.2006.04.019

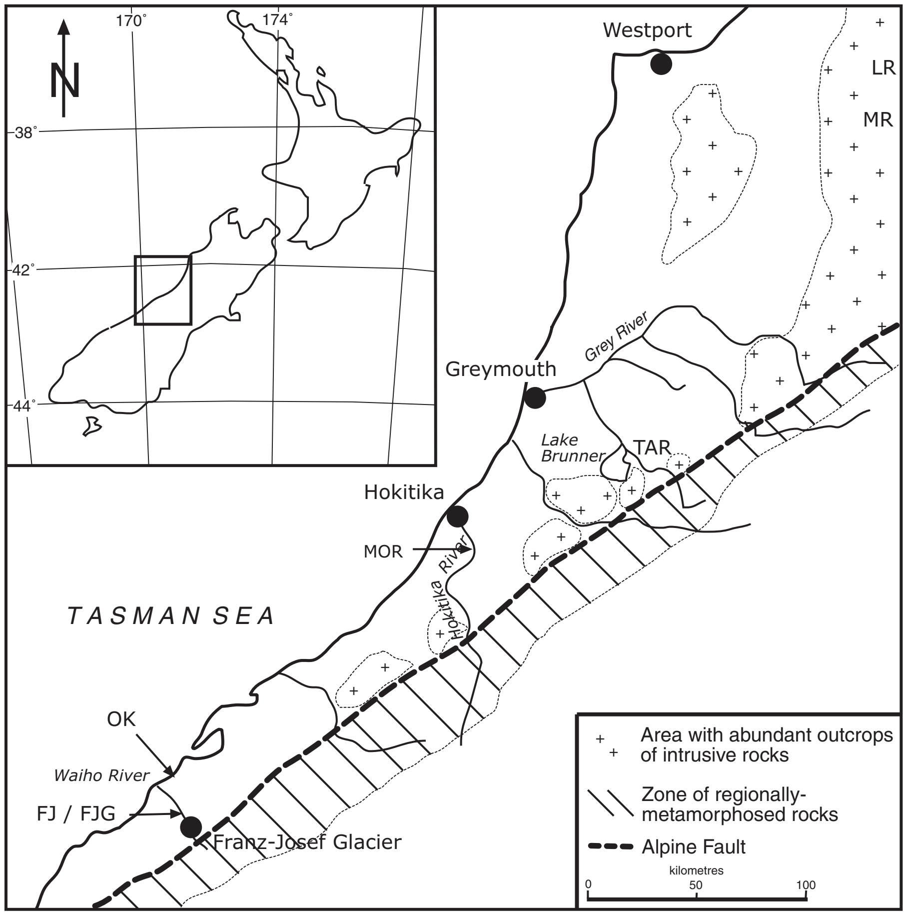

Fig. 1. Map of Westland with basic geological setting and sample location.

orogeny. These samples are mainly quartzitic schists that experienced regional metamorphosis, mainly due to high-pressure stress along the Alpine Fault. The samples thus represent a diverse spectrum of bedrock geology, different metamorphic conditions (i.e. temperature, pressure) and deformation history (Table 1).

Additional tests were carried out on sedimentary quartz from the forefield of Franz Josef glacier (sample FJG) and we used well-behaved quartz extracted from fluvial sediments from Komadugu floodplain of NE Nigeria (GW) as a reference. The headwaters of the Komadugu river are within the N-Nigerian Precambrian basement complex. It should be noted, that the origin of sedimentary quartz is less well defined as it may be derived from a mixture of different source rocks. Furthermore, the sediment from NE Nigeria (GW) was likely subjected to repeated fluvial and aeolian re-working (Gumnior and Preusser, submitted).

Unconsolidated sand samples were first sieved and then pretreated using 10% HCl and 30% H_2O_2. Density separation was applied, followed by etching the quartz-rich separates in 40% HF for 40 min. The rock samples were crushed, etched for 14 day in H_2SiF_6 and additionally etched for 40 min in 40% HF. All samples were checked for feldspar contamination by irradiation, preheating and exposing the samples to IR diodes. Any aliquot that showed a detectable infrared stimulated luminescence (IRSL) signal was rejected from further investigation.

Initial characterisation of quartz was carried out by cathodoluminescence (CL). The intensity and emission wavelength of the CL signal is related to the amount and nature of defects within the quartz crystal lattice (Götze, 2000). A high-sensitivity CL-microscope (Ramseyer et al., 1989) attached with a digital computer-controlled camera system (ColorView® 12 run under analySIS® FIVE image analysis program) was used to examine and record the faint luminescence of quartz in the visible range of the electromagnetic spectrum. The applied beam current density was 0.2–0.4 $\mu A/mm^2$ at 25 keV electron energy.

Testing of OSL and thermoluminescence (TL) properties was carried out using a Risø TL/OSL 15 reader using blue diodes as the stimulation source. An UV transmitting Hoya U-340 detection filter was used. If not noted otherwise, samples were pre-heated prior to any measurement at 270 °C for 10 s and a cut-heat of 200 °C was applied prior to all test dose measurements. All OSL measurements were recorded at a temperature of 125 °C. The integral 80–100 s was subtracted as background from the rest of the decay curves.