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Thermoluminescence dosimetry using natural calcite

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Abstract

The TL dosimetric characteristics of the natural calcite from El Bakriya, Eastern Desert, Egypt, were studied to investigate their feasibility for use in gamma radiation dosimetry. The peak that appeared at the temperature of 283 °C on the TL glow curve was found to have a linear response to the doses over the range of 0.05–1000 Gy, especially after being annealed at 600 °C for 5 h before irradiation.

Neither annealing nor irradiation changed the activation energy of the traps that produced the peak at 283 °C on the TL glow curve of the natural calcite. Accordingly, the natural calcite from El Bakriya is nominated as a good dosimeter for many dosimetric applications.

The studied calcite was dated to have an age of 102 ka, which is consistent with the age obtained by Dawood (1998).

Keywords: TLD; Dosimetry; Activation energy; Dating

1. Introduction

Thermoluminescence (TL) is defined as the emission of light from a semiconductor or an insulator due to the heating of the semiconductor that had previously absorbed energy from irradiation. The graph of the amount of light emitted during the TL process as a function of the sample temperature is known as a "TL glow curve." TL has been an active field of research throughout the present decades due to its wide application potential. The most striking application of TL has been in its use in radiation dosimetry. Ionizing radiation dosimeters, which rely on the thermoluminescence properties of materials, have helped to solve many dosimetric problems due to their long time storage capacities, independence of dose with radiation intensities, ease with which measurements are performed and lightweight packaging [1].

When a TL dosimeter is exposed to ionizing radiation (e.g., UV, X, γ-ray, etc.), material color centers are created. The number of centers, i.e., the absorbed radiation doses, can be measured by one of the TL reading techniques. To date, as many as ten TL materials have been developed and implemented in practice [2–4].

Calcite ($CaCO_3$ crystal of trigonal symmetry) is a natural mineral that is easily available in large quantities and has been studied by several workers [5–7]. Engin and Gueven [8] studied the dosimetric properties and TL parameters of three calcites of different origins in

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Turkey: stalactite, marble and flowstone. The annealing of calcite often causes a change in the response of the TL to ionizing radiation [8–11]. Recent publications have reported the kinetic parameters and dosimetric properties of calcite [12,13] and limestone [14].

Natural minerals accumulate TL centers throughout their lifetimes due to exposure to natural sources of radiation. Accordingly, based on the total accumulated TL centers, the age of a natural mineral can be calculated [15–17].

In the present study, the thermoluminescence and dosimetric characteristics of natural calcite collected from the El Bakriya area, Eastern Desert, Egypt, is studied after different thermal treatments, and tests were performed for the determination of low and intermediate gamma doses. The age of the studied calcite was estimated.

2. Experimental methods

2.1. Sample and its location

The pure calcite sample was collected by Mohamed [18] from a small calcite vein associated with fluorite mineralization that was localized and controlled by large normal faults (NNW) dissecting the El-Bakreya granitic pluton, Eastern Desert, Egypt (Fig. 1). The site of the sample is located at 25°17′27.68″ N and 33°42′14.27″ E. The F-mineralization occurs in the form of large main veins or as stockworks of small veinlets. Veins of calcite and/or dolomite are found in the altered granite within the stockwork zone. The carbonates were precipitated as a by-product of CO_2-bearing fluids during the alteration of the granite in the argillic facies [19], which was probably coeval with the fluoritization event.

The calcite sample was collected and stored in the dark; it was crushed and ground carefully with a mortar and pestle, then washed for 2 min in 1% HCl, and finally washed with distilled water and dried at the Egyptian National Institute for Standards and Technology (ENIST). Grains between 200 μm and 300 μm in diameter that were subjected to the above treatment were used for the TL and ESR measurements.

2.2. Radiation sources and dosimetry

A cesium-137 gamma source (Model GB-150) at ENIST, delivered by the Atomic Energy of Canada,

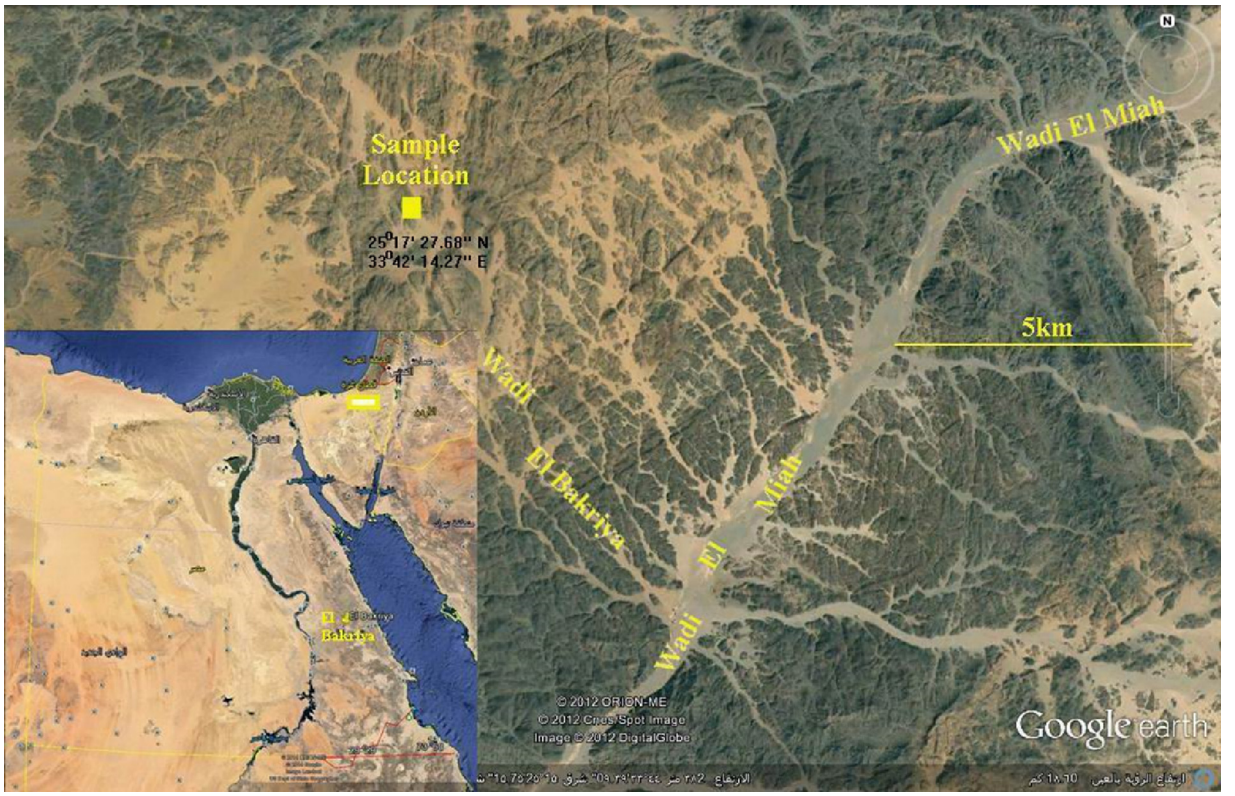

Fig. 1. Location of the origin of the pure calcite sample at the El Bakriya granitic pluton, Eastern Desert, Egypt.