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COMPARING THE MONOCHROMATIC TL RESPONSE OF A HIGH SENSITIVITY NATURAL QUARTZ IRRADIATED WITH β AND γ RAYS

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Introduction: The dating protocols employed to determine the equivalent dose are usually performed at higher dose-rate than those found in geological and archaeological sites. It is worth thinking that the thermoluminescence (TL) response does not depend only on total dose, but also on the dose-rate. Some studies using quartz have shown that TL response is not completely independent of the dose-rate, and the TL emissions related to high temperature glow peaks change in a different manner with the increase of the dose-rate [1,2]. Since the majority of dating protocols use β radiation, further studies are desirable in order to consider the dose-rate effect using different radiation sources. To progress in this direction, the effect of the dose-rate was investigated in a single crystal showing a high TL sensitivity above 200 °C.

Materials and Methods: Six single crystal samples used in previous studies [3,4] were chosen. It was defined a new starting point by submitting all samples to 700 °C/3 h (Zeroed condition, Z). Three samples were resensitized (ReS), using the combined effect of irradiation with 30 kGy (^{60}Co; 2.14 kGy/h) and heating at 400 °C/1 h. The remaining samples were kept in the Z condition. The TL curves were recorded from 25 to 425 °C (2 °C/s) using a lexsyg SMART reader equipped with an internal β particle source (^{90}Sr/^{90}Y). The TL curves were acquired with a detection window centered in the violet region (411(51) nm) [4]. The samples were irradiated with test-doses of 10 mGy of gamma rays (^{137}Cs, 0.008 mGy/s; ^{60}Co, 0.299 mGy/s) and 63 mGy of β particles (^{90}Sr/^{90}Y, ~63 mGy/s), respectively. To avoid the thermal fading of the first peak, the γ irradiated samples were stored in an ice-bath. The TL reading was repeated three times for each sample. The glow curves were scrutinized using a glow curve deconvolution method based on first-order kinetics.

Results: Comparing the glow curves shown in Fig. 1, it is observed that the violet emissions changed significantly after sensitization. The well-defined peak nearby to 260 °C in ReS samples is different than the broad signals in Z samples. The deconvolution with six components, shows that the trapping parameters are remarkably similar between glow curves registered with different radiation sources. The activation energies are systematically higher for ReS samples. The sensitization created a remarkable increase in TL signal above 350 °C. Since the background was systematically removed, this signal seems to be associated with deep traps, which is observed only in ReS samples irradiated with the minor dose-rate (^{137}Cs). This strong emission was also verified with test-dose of 1 mGy. The net TL intensities of the main peaks and the integral area of the six components, for Z and ReS samples, show that the first peak exhibits higher intensity for γ rays with higher dose rate (^{60}Co). The components above to 300 °C were more intense at lower dose-rates. The intensity of the two components responsible for the sensitized peak were also affected by radiation source and dose-rate.

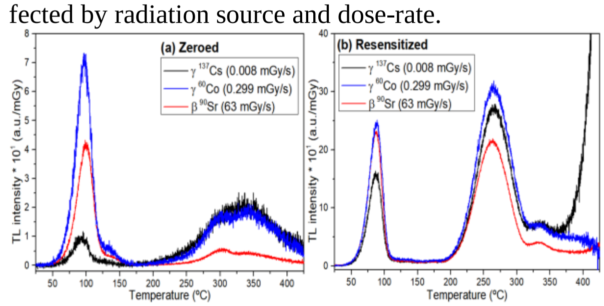

Fig. 1: Net TL glow curves for Z (a) and ReS (b) quartz samples irradiated with β and γ sources.

Conclusion: The same set of trap depths were found for Z and ReS samples irradiated with β and γ rays. Besides the creation of the strong peak at ~260 °C, the sensitization process caused a significant reduction in the intrinsic thermal fading of the first peak. The population of the deep traps shows a dose-rate dependence.

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