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THERMOLUMINESCENT CHARACTERISTICS OF JASPER SAMPLES

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ABSTRACT

Different jasper samples proceeding from Brazilian mines were powdered and mixed with teflon (composites jasper-teflon^{TM}). This paper describes a preliminary study of thermoluminescent method (TL) to verify the possibility of their use as high dose dosimeters or irradiation indicators in industrial areas. The TL emission curves of samples exposed to gamma doses of 50 Gy up to 20 kGy presented two peaks at 130 ºC and 190 ºC. Calibration curves were obtained for the jasper samples between 50 Gy and 20 kGy. All five tested jasper samples showed their usefulness as irradiation indicators and as high dose dosimeters.

1. INTRODUCTION

Radiation processing using high doses has been presenting various advantages in the areas of sterilisation of pharmaceutical products, food preservation and treatment of several materials.

The dosimeter characteristics of silicates samples were studied for application in dosimetry. The silicates are abundant and represent 92% of the volume of minerals of the terrestrial crust. Glass silicates [1-4], quartz [5-6], amethyst [7], jasper [8], topaz [9] and recently the bioglass [10] were tested for the possibility of their use in gamma dosimetry, using the technique of thermoluminescence (TL).

In this work preliminary studies of the dosimetric properties of the jasper samples are presented. Chalcedony is a group name for the compact varieties of silica composed by minute crystals of quartz with submicroscopic pores. Their color and texture vary considerably according to the impurities present, but in general such materials may be sub-divided into chalcedony (sometimes called jasper) and agate. Jasper color is fairly uniform (green, red, brown, ocean and striped), and agate color is arranged in bands or concentric zones. The results suggested that some kinds of jasper can be employed as TL dosimetric materials.

2. MATERIALS AND METHODS

Jasper samples used in the present work were obtained from different Brazilian mines. Five jasper samples in this work had been used: green, red, brown, ocean and striped. All samples were initially cleaned, pressed to break pulverized, and grain diameters between 0.074 and 0.177mm were obtained. The samples were thermally treatment at 300ºC during one hour in open atmosphere.

To facilitate easy handling, sintered jasper pellets were prepared at the Laboratory for Production of Dosimetric Materials, IPEN, using teflon for the binder, and the parts were mixed in the ratio 2 (teflon):1 (powdered sample). This mixture was cooled with liquid nitrogen to optimize the homogenization. After that it was pressed, and pellets of 50 mg were obtained with 1 mm of thickness, and diameter of 6 mm. For sintering, the samples were thermally treatment at 300 ºC for 30 min followed by 400 ºC for 1.5h.

The thermal treatments for reutilization of the materials were performed at 300 ºC for 1 h. The samples were packed in aluminum foils for the irradiations. The irradiation of the sample was made using a Gamma Cell-220 System of ^{60}Co (dose rate of 2.88 kGy/h), for doses of 50 Gy up to 30 kGy. The irradiations were made at ambient temperature, and the samples were fixed between 3 mm thick polymethyl meth-acrylate plates (Lucite), to guarantee the occurrence of electronic equilibrium during the irradiations. The TL measurements were taken with a Harshaw Chemical Co. reader, mode 2000 A/B, and the data acquisition was realized using a virtual instrument (ADC-212), Pico Technology Ltd., and a personal computer.

3. RESULTS

The main dosimetric properties of the jasper samples in this work were reutilization, lower detection limits, thermal treatments and calibration curves. Figure 1 show the thermoluminescent glow curves of the jasper samples: green, red, brown, ocean and striped taken 1h after their irradiation with 10 kGy. All the sample present two main TL peaks, one around 130ºC and the second near 190ºC.

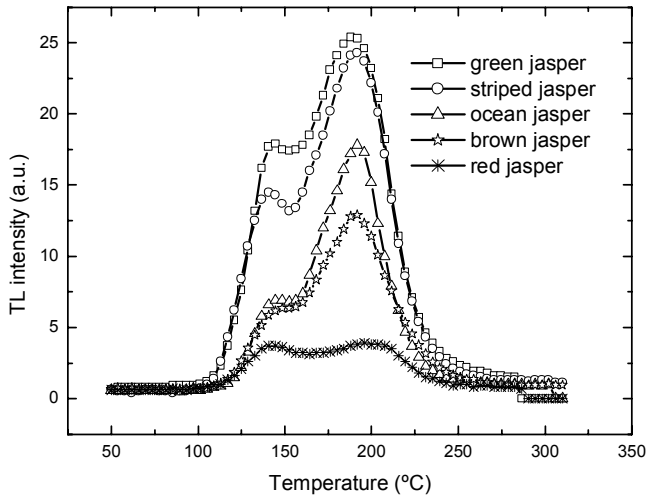

Figure 1. TL glow curve of a Jasper-Teflon pellet irradiated with 10 kGy (^{60}Co).

For the reutilization study of the TL glass samples, several types thermal treatments have been testes. Caldas and Quezada verified that a thermal treatment to 300º for 15 minutes was enough so that the samples returned to initial conditions, presenting the same measurements as previously to the irradiation. Caldas and Teixeira had verified that for coloured glasses the thermal treatment most efficient was of 300ºC for 30 min.

However, the jasper samples studied in this work did not present good results with these thermal treatments; other thermal treatments were tested: 250ºC for 1 hour; 300ºC for 15 min; 300ºC for 30 min; 300ºC for 45 min; 300ºC for 1 hour. The best results were obtained with the thermal treatments of 300ºC for 1 hour. It was verified that the samples returned to the initial conditions, reproducing the same measurements obtained prior to the second irradiation process.

To remove the TL peak 1 (130°C) of the jasper sample, thermal treatments at 130°C during different time intervals (5-60 min) were tested. All thermal treatments present the same results: peak 1 was removed (Fig. 2) and the thermal treatment of 130°C/5min was chosen as adequate. Jasper samples (green, red, brown, ocean and striped) present the same results.

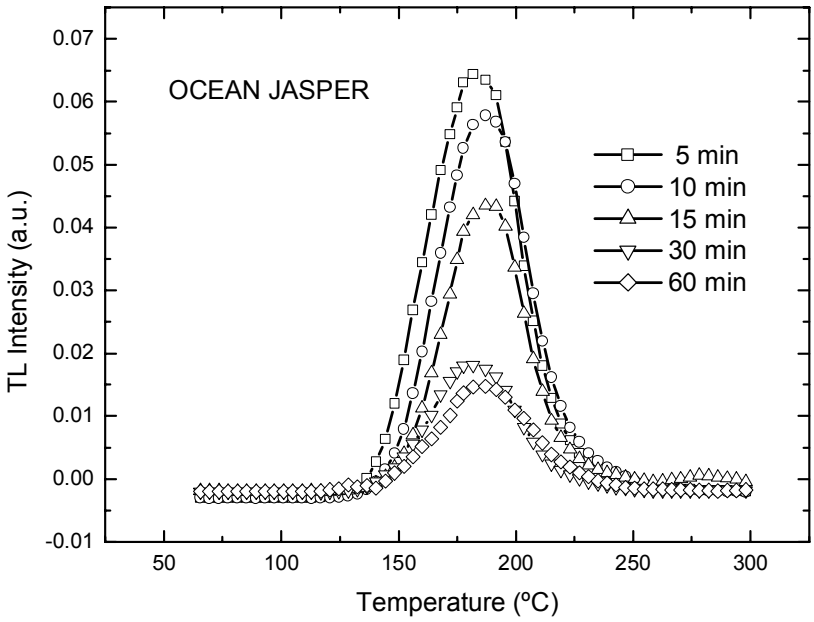

Figure 2. TL glow curves of Jasper-Teflon pellets irradiated with 5Gy (^{60}Co) and treated thermally at several time intervals after irradiation.

The jasper samples were irradiation in the ^{60}Co source beam between 50 Gy and 20 kGy. Figure 3 presents the calibration curves of the five types of jasper samples; they were thermally treated at 130°C/5min. The maximum standard deviation of these measurements was 2.3%. It can be observed that the TL response presents a suitable behaviour for high-dose dosimetry for all types of jasper samples.

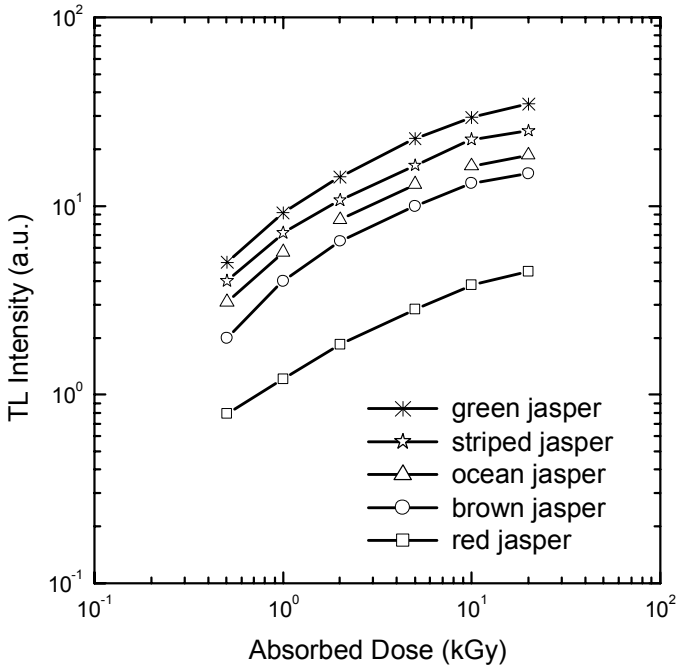

Figure 3. Calibration curves of jasper samples for ^{60}Co radiation. Measurements were taken after the irradiations and the thermally treated at 130°C/5min.

4. CONCLUSIONS

The calibration curves obtained in this work show that the five types of jasper samples may be applied to high-dose dosimetry. The TL emission curves of samples exposed to gamma doses presented two peaks at 130 ºC and 190 ºC. Green jasper sample present higher radiation sensitivity than that of the other jasper samples. The basic advantage of jasper samples is their very low cost. Jasper samples may be applied for dosimetry in the main radiation processes of seed stimulation, mutation breeding, industrial radiography, and insect population control, pasteurization and water purification.

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