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ANALYSIS OF THE PHOTO-THERMO TRANSFERENCE PROPERTY ON TL AND OSL EMISSIONS OF THE GREEN NATURAL FLUORAPATITE

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Introduction: Fluorapatite $Ca_5F(PO_4)_3$ is a type of mineral from apatites family, which is characterized for F on its structure and widely reported due to luminescent properties. TL studies have pointed out the presence of peaks at different temperatures, depending on origin and impurities. Moreover, other investigations have dedicated to the mechanisms of anomalous fading. Despite these findings, photo-thermo transference phenomenon on TL and OSL emissions is little reported yet. Therefore, this work have investigated the luminescence response systematically, of green natural fluorapatite from Brazil, by using several techniques, as TL, OSL and fluorescence; in addition, X-ray Diffraction (XRD) and fluorescence (XRF) were used to verify crystallinity and the impurities in the sample, respectively.

Material and method: Natural fluorapatite mineral of green color from Minas Gerais state, Brazil, was washed and ground with a mortar and pestle, then, sifted to obtain the powder fraction. XRD measurement was carried out using a Rigaku D'MAX 2500PC diffractometer, with CuK_α radiation, between 10-70°, with 0.02° step, and the data analyzed on X'PertHighScore Plus software with PDF2/2003 database from ICDD. XRF analysis was performed in a S2 PICOFOX spectrometer from Bruker. TL and OSL emissions were verified with a Risoe DA/20 model reader, accopled to a beta ($90^{Sr}/90^{Y}$) source, using a Hoya U-340 filter. For TL, a heating rate of 5 °C/s was adopted, in the range of 0-500 °C. T_m-T_{stop} and Computerized Glow Curve Deconvolution (CGCD) were used to estimate the kinetic factors. OSL was measured at 30 °C, using blue LEDs centered at 470 nm, with 90 % (CW) and 0-100 % power (LM). And fluorescence in a Horiba Fluorolog-3 fluorometer.

Results: XRD analysis indicated a fluropatite net, of hexagonal system (reference 01-084-1997), with estimate cristallite size of 46.09 ± 0.38 nm. XRF showed several impurities as Si, Cl, S, Fe, Sr, Y, Pb, Mn, V, Ni, Ta, Cu, Zn, U, Th, Cs and the rare earths Ce, Nd and Er with values from 2 up to 700 mg/kg. The emission spectrum (λ_{exc} = 300 nm) has three bands at 340, 371 and 458 nm. The main one at 371 nm is related to Ce transitions: $D_{3/2,\,5/2} \rightarrow {}^2F_{7/2,\,5/2}$. The emission color is centered at blueish region according Chromaticity Diagram plot.

TL glow curve (fig. 1) is composed by six peaks at 97, 147, 188, 242, 329 and 431 °C, with activation energy values varying from 0.63 to 1.09 eV, and kinetic order (*b*) between 1.45-2. These results are in agreement with those ones found in T_m-T_{stop}. CW-OSL also has supplied high intensities even for low doses (0.1 Gy). CGCD study showed the presence of three components with decay times of 0.39, 5 and 64 s, with respective values of *b* as 1.1, 1.75 and 1.44. In addition, both TL and OSL presented linear responses from doses of 0.1 up to 50 Gy. The increase in OSL readout temperature did not perform thermal assistance considering just the first point (fig. 1). However, using the integrated area, the intensity increased up to 120 °C, and then, reachs a maximum at 200 °C, maybe indicating that Very Deep Traps (VDP) were reached by photo-thermo transference.

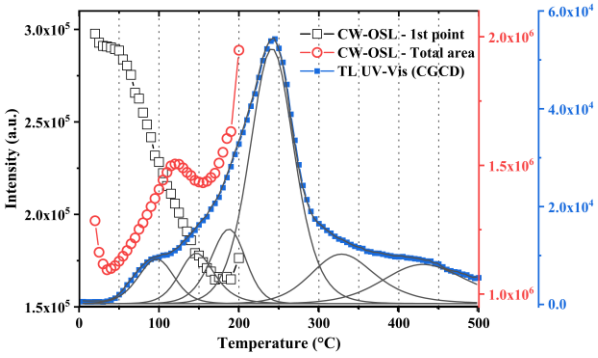

Figure 1: CGCD study for TL UV and CW-OSL intensity as function of readout temperature; dose = 10 Gy.

Conclusions: Brazilian fluorapatite shows a significant luminescent emission on UV region, related to the presence of Ce and other impurities. TL and OSL studies reveal emission parameters and photo-thermo transference process. Thereby, for the best of our knowledge, there no similar detailed results in literature.