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Assessing the potential of quartz post-blue violet stimulated luminescence to extend dating range of Brazilian fluvial sediments

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Introduction: Upon stimulation with blue light, quartz emits luminescence signal called optically stimulated luminescence (OSL) originating from the 325°C thermoluminescence (TL) trap with a depth of ~ 1.5 eV and lifetime of 10^7 years at 20°C. Quartz OSL dating is widely used to determine the time of deposition and burial of Late Quaternary sediments.

The application of the method is usually limited to the past 150 ka due to early saturation of the OSL signal. Violet stimulated luminescence (VSL) is a new development in optical dating which could possibly extend the upper age limit of OSL dating of quartz. The VSL signal is associated with a 375°C TL trap with a depth at about 1.9 eV and a lifetime of 10^{11} years at 10°C, and its source was suggested as the $[GeO_4/Li^+]^0$ center (Vaccaro et al., 2019). In the lab, it grows to ~20 times higher than the conventional quartz OSL signal.

Despite the expected advantage to extend the age range of optical dating, few applications have been reported so far, it was highlighted that more samples needs to be investigated as the VSL properties vary amongst samples.

Material and methods: Here we present the investigation and characteristics of the post-blue VSL signal in quartz from fluvial terraces from Pantanal wetland (Western Brazil), Paraná River basin (Southeastern Brazil) and Amazon River basin (central and eastern Amazonia), representative of major fluvial systems of Brazil. These samples are bright when stimulated with blue light and with expected equivalent doses (D_e) ranging between 14 Gy to 868 Gy determined by OSL and TT-OSL respectively.

We investigated the signal using single aliquot regenerative dose (SAR), single aliquot regeneration and added dose (SARA), multiple aliquots regeneration dose (MAR) and multiple aliquots added dose (MAAD) protocols. All luminescence measurements were carried out on an automated Risø TL/OSL DA-20 reader at the Luminescence and Gamma Spectrometry Laboratory (LEGaL) of the Institute of Geosciences, University of São Paulo.

Results: Under preheat temperatures between 200 and 340°C and blue stimulation at 125°C, the natural VSL signal is absent in all samples, including samples with D_e beyond OSL saturation. The natural VSL signal appears in some samples when a lower preheat at 160°C is used. The thermal stability test demonstrates that the VSL signal originates from a deep trap at about 2.02 eV with thermal lifetime of 10^{11} years at 10°C. The probable explanation of the observed difference in VSL signal intensity (dim or absent) with sample, might be the non-dominant Ge-Li center in studied samples.

The VSL SAR protocol poorly recovered a large (500 Gy) laboratory dose, with values of the measured-to-given dose ratio between 0.6 and 1.8. This behavior indicates that VSL SAR poorly reproduces the natural dose growth. For sample from Paraná River basin with bright and well bleached OSL, D_e = 14.0 ± 0.3 Gy and characteristic dose ($D_{0,2}$) of 146.4 ± 13.9 Gy, the VSL SAR protocol estimated a D_e = 44.30 ± 2.80 Gy. Applying MAAD protocol on the same sample, a characteristic dose ($D_{0,2}$) of ~805 Gy was estimated, higher than for the SAR but still lower than the reported value from Chinese loess samples ($D_{0,2}$ = 1334 Gy; Ankjaergaard, 2019, Ankjaergaard et al., 2016).

Conclusions: The present study shows that the behavior of VSL signal appears to be sample dependent, indicating the need for further investigations on behavior of VSL signals of samples from different geological settings.

Keywords: Violet Luminescence Dating; Natural dose response curve; Multiple Aliquots Additive Dose; Fluvial sediments; Quartz.

References

1. Ankjærgaard, C., 2019. Exploring multiple aliquots methods for quartz violet stimulated luminescence dating. Quaternary Geochronology. 51, 99 –109.
2. Ankjærgaard, C., Guralnik, B., Buylaert, J-P., Reimann,T., Yi, S.W., Wallinga, J., 2016. Violet stimulated luminescence dating of quartz from Luochuan (Chinese loess plateau): Agreement with independent chronology up to ~600 ka. Quaternary Geochronology 34, 33-46.
3. Vaccaro, G., Panzeri, L., Monti, A.M., Martini, M., Fasoli, M., 2019. Optical bleaching of the 375° C TL peak, $[GeO_4/Li^+]^0$ EPR center and OSL signal in irradiated natural quartz. Journal of. Luminescence. 205, 61-65.