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Synchrotron generated X-ray Excited Optical Luminescence (XEOL) from Quartz

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Quartz is the preferred mineral for optically stimulated luminescence (OSL) dating, due to its well constrained behaviour as a radiation dosimeter. However, despite the plethora of successful quartz OSL applications, no solution has been found to the problem that some quartz luminesce more brightly than others, which has limited the application of OSL in certain settings. This has been addressed through examination of the luminescence emission using a variety of excitation techniques and emission spectroscopy.

X-ray Excited Optical Luminescence (XEOL) is luminescence excited by x-rays produced by a synchrotron. XEOL analyses were conducted upon a suite of quartz samples at Diamond, Great Britain, which had previously been analysed with Ionoluminescence (IL), at Sussex University. The samples were selected to include quartz of both poor and excellent OSL sensitivities. Therefore, two Scottish glacial outwash samples prepared at St Andrews, and a calibration quartz sample, prepared at the Risø National Laboratory in Denmark were analysed for these properties respectively.

The XEOL emission spectra comprised three major emissions at 3.32, 3.81 and 4.05 eV, and one weaker emission at 1.94 eV in all samples. The calibration quartz sample had the most intense emission by an order of magnitude. Throughout increased exposure to x-rays, the intensity of the UV emission reduced, and an increase in the red (1.94 eV) emission was recorded.

The derived XEOL spectra complement the IL spectra obtained previously. The IL spectra were dominated by only two broad emissions at 3.2-3.1 eV and 1.8-1.7 eV. However, throughout the IL experiments a dose dependent effect was also observed, whereby the UV emission was depleted to the benefit of the red with increasing exposure. Furthermore the gradient of the power law relationship between the UV and red emission change with dose is similar for both the IL and XEOL data: at -1.15 and -1.05 respectively for calibration quartz, when plotted on a log-log scale.

IL and XEOL are complimentary techniques, as although the radiation dose rate of XEOL is three orders of magnitude greater than that of IL, the total experimental administered dose is similar. This contrast in dose rate is caused by the significant variation is dose per carrier for each technique. Within IL each ion delivers 1E-01 J whereas each photon delivers 1E-15 J in XEOL. It is the much greater flux of photons relative to ions, which makes XEOL the more energetic mode of analysis. Thus these complimentary techniques enable investigation of radiation dose rate, as well as cumulative dose effects. The observed variations in the XEOL and IL derived emission spectra are therefore attributed to the differences in radiation dose rate.

The radiation sensitivity of the quartz emission may provide an explanation for the varied luminescence response of different quartz. The quartz luminescence emission thus may not just record the most recent period of irradiation, but rather its entire radiation history.