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Thesis Abstracts

Thesis title : An investigation into the physics of the infrared excited luminescence of irradiated feldspars

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Infrared excitation of irradiated feldspars produces a luminescence glow in one or more broad emission bands. The processes are poorly understood, but they are suspected to occur in lattice defects, although their general identity is unknown. This thesis is about trying to understand more about the physics of these processes. I found the emission intensity increased as the temperature was increased above 20 C for emission bands with peak intensities at wavelengths around330, 400 and 570 nm, but the rate of increase dropped off for some samples as the temperature was increased over 80 C. These results were interpreted as being due to the excitation of different vibrational modes of the feldspar structure. The rate of decay in the emission intensity of one sample was independent of temperature. The latter was clear evidence against a model where charge is excited from a trap by a combination of both optical and thermal excitation. The emission intensities of some emission bands were dependent on the polarization of the infrared exciting light, and the emission itself was polarized in some cases. These results were explained by dipolar transitions occurring within unknown defect centres located at either the T1, M or OD lattice sites. This explanation was supported by studies on transitions within Fe+3 ions occupying known lattice sites. I also found that there was a small photoconductivity with green light excitation, but no measurable effect with infrared excitation. However I could not rule out the possibility that charge was excited to delocalised bands in both cases. A model is proposed to explain these results with one basic type of electron trap which is excited by the infrared light. The excited electron can either tunnel through to a recombination centre or it can be thermally excited to the conduction band or to a state just below the conduction band. Anion defects are shown to be possible centres for the traps. Changes in the fraction of electrons that tunnel to the recombination centres, and electron spin interactions are proposed as additional mechanisms that may also have some effect on the changes in emission intensity with temperature.

Thesis title: Spectral investigations of luminescence in feldspars

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Optical dating is a tool for dating the last exposure of minerals to sunlight. The technique relies on the optically stimulated luminescence of irradiated minerals, particularly quartz and feldspar. Despite the widespread use of feldspar in dating, very little is known about the defects that give rise to the luminescence in this mineral.

A new high-sensitivity spectrometer was constructed for measurement of the emission spectra of the infra-red stimulated luminescence (IRSL) for a wide range of feldspars, and an attempt made to correlate specific spectral features with feldspar type or elemental content. Comparison of the IRSL spectra with spectra of phosphorescence following - irradiation and the spectra of phosphorescence after illumination indicates that the emission spectra are highly dependent on the type of excitation. This is a clear indication that certain traps are connected to particular luminescence centers. This conflicts with the standard model involving recombination via the conduction band. Excitation spectra were also measured and these indicated that the IRSL excitation resonance near 1.45 eV sometimes exhibits a strong Lorentzian character. The excitation spectrum was generally similar for both the violet (3.1 eV) and yellow-green (2.2 eV) emission bands, was unaffected by the polarization of the excitation light, and was best described by a Voigt profile near the 1.45 eV resonance.

The luminescence decay with time was found to follow Becquerel's equation, I(t)=I0/(1+t/t0). In terms of the time-integrated applied excitation energy E, this decay law may be expressed as, I(E)=I0/(1+E/E0). The parameters E0 and were found to vary strongly with excitation photon energy. was found to increase with applied dose, but both and E0 were relatively unaffected by sample temperature.

Measurement of the initial rate of decrease of intensity with time, S0=-dI/dt, versus initial intensity I0, for a wide range of excitation photon energies from 1.2 eV to 2.54 eV indicated that the scaling S0 I02 holds for excitation photon energies from the infrared excitation resonance well into the visible band. This provides strong evidence that a single trap is involved in the luminescence.

Some emission and excitation spectra for inclusions in quartz are suggestive of these being feldspars.

Thesis title: Testing and application of luminescence techniques using sediment from the southeast African coast

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This thesis aims to test the single-aliquot regenerative-dose (SAR) technique using a selection of sedimentary quartzes from the southeast African coast. In particular, the ability of the SAR technique to correct for changes in the sensitivity of the optically stimulated luminescence (OSL) signal, which occur during measurement sequences, was tested. In addition, the SAR technique was used to date samples from the Mozambican islands of Inhaca and Bazaruto.

Several components have previously been identified within the quartz OSL signal. A new slow-bleaching, thermally-unstable OSL component was found. This component causes significant age underestimates as a larger proportion of the total signal is integrated. This effect can be avoided by using the initial channel of the OSL signal when calculating the equivalent dose.

The pattern of sensitivity change during an SAR measurement sequence was found to be dependent on sample age, preheat temperature and regeneration dose. These observations may be explained in terms of dose quenching and thermal activation. In certain circumstances, the 110°C thermoluminescence signal is not an appropriate proxy for OSL sensitivity. The SAR sensitivity correction was found to be appropriate irrespective of the sensitivity changes observed.

Several different patterns of equivalent dose distributions were found for the samples dated, ranging from limited, to considerable scatter. Possible causes for this scatter are discussed

Samples from the Inhaca and Bazaruto Islands were dated using the SAR technique. These islands are composed of large dunes, which were dated in an

attempt to understand the evolution of each island, in relationship to sea-level change. On both islands, the main sedimentary units were deposited during previous interglacials (high sea-level). However, some localised remobilisation of these dunes occurred during the Last Glacial Maximum, possibly in response to lowered regional water tables, due to low sea-levels. Significant aeolian activity is also recorded during the Holocene.