

Thesis Abstracts

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

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Grade: Ph.D.

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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 around 330, 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 Fe³⁺ 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.

(Due to an editing mistake a wrong text was associated to the thesis abstract by M.A. Short in Ancient TL 21No.1).

Thesis title: Contribution of luminescence dating to the chronology of Middle Stone Age techno-complexes associated with the first South African modern humans.

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Key words: Middle Stone Age, Howieson's Poort, Still Bay, modern Humans, South Africa, TL/OSL, burnt quartzites and silcretes

Thesis available on line (pdf file)

http://147.210.235.3/proprietes.html?numero_ordre=2725

The chronology of the evolution of anatomically modern human behaviour is a highly controversial subject. One would like to know if some behaviours considered typical of the Late Stone Age (LSA) appeared during that period, or much earlier during the Middle Stone Age (MSA). Two techno-complexes of the South African MSA, the Howieson's Poort and the Still Bay, are particularly relevant to this question since some of the stone tools are typical of the MSA period whereas others have characteristics usually associated with the LSA "modern" behaviour, like standardisation and choice of exotic materials. Stratigraphic observations as well as prior dating work have shown that these two techno-complexes originated well within the MSA. However, more precise chronology was lacking. The aim of the work summarised here was to refine this chronology by applying luminescence dating methods to burnt stones selected from three South African MSA sites: Blombos Cave, Diepkloof Rock Shelter and Klasies River. The stones were quartzites and silcretes both rich in quartz grains.

To determine the equivalent dose (Ed), the thermoluminescence (TL) as well as the optically stimulated luminescence (OSL) techniques were used, with respectively, a multiple aliquot additive and regenerative protocol and the single aliquot regenerative-dose protocol. It was observed that the

OSL signal was bleached if the stones were not protected from light as soon as discovered, even if they looked opaque to the eye. However, bleaching experiment indicated that the TL signal was still usable for the determination of the E_d and for some samples, linearly modulated OSL proved most suitable.

The external dose rate was measured by CaSO_4 dosimeters and the state of disequilibrium of the Uranium chain in the sediment samples determined by high resolution gamma spectrometry. In the case of Diepkloof Rock Shelter, the high spatial variation of the gamma dose rate precluded a precise calculation of the age. However, a preliminary interval was derived from the highest and lowest possible dose rates.

For the internal dose rate calculation, a model analogous to the one used for sediment dating was selected after an assumption of homogeneous distribution outside the quartz grains. The dose rate was calculated for each sample by combining the mean concentration of the radioisotopes, measured by the neutron activation technique, and the size distribution of the quartz grains in each stone, deduced from an image analysis of thin sections. For the Howieson's Poort layers at Diepkloof Rock Shelter a preliminary age-estimate of 55-65 ka was calculated. At Klasies River 13 age estimates averaging 56 ± 3 ka were obtained for the Howieson's Poort sequence, in good agreement with TL/OSL and ESR estimates for the same stratum. These new results, however, contradict certain hypotheses derived from palaeoenvironmental studies. At Blombos Cave, five lithic specimens yielded an average age of 74 ± 5 ka for the Still Bay level. This estimate is in good agreement with OSL and ESR results. It confirms that the Still Bay complex is older than the Howieson's Poort and sets back the beginnings of certain practices such as the use of symbols and work of bone to at least the isotopic stage 5.

Thesis title: Luminescence investigations and dating of anthropogenic palaeosols from South Mainland Shetland

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Grade: PhD

Date: September 2003

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This thesis aims to produce a chronostratigraphy of agricultural activity and sedimentary accumulation at two archaeological sites in the Shetland Islands, by directly dating the infield sediments associated with the sites. Optically stimulated luminescence (OSL) dating of a large number of samples, from often inhomogeneous sediments expected to have been subject to post-depositional mixing, is described. The samples were collected at high spatial resolution both vertically through sections, and horizontally within layers, to assess the consistency of results at different scales.

A novel approach to *in situ* environmental dose rate determination was pursued, using aluminium oxide dosimeters to measure the combined beta, gamma and cosmic radiation fields at the points of sampling. This yielded rapid and accurate measurements of environmental dose rate for the large numbers of samples taken from inhomogeneous dose rate environments.

Detailed investigation of the luminescence behaviour of quartz separates from a limited number of samples was used to optimise measurement conditions within the single aliquot regeneration (SAR) protocol. These optimised conditions were used in a simplified measurement protocol based on a standardised growth curve, which enabled the measurement of equivalent dose (D_e) distributions for small aliquots from large numbers of samples. A novel approach to direct assessment of error on the D_e was applied.

The observed D_e distributions were analysed using a model selection approach. Most distributions were found to be consistent with simpler representations than expected. However, the results from some samples indicated the presence of multiple populations in the data. Ages calculated from these results were used to assess different components in some of the archaeological deposits. However, their occurrence was not strongly associated with evidence for tilling of the soils or bioturbation.

Chronostratigraphies were established for both the infield deposits at Old Scatness Broch and the Sumburgh Hotel Gardens site using dates from 66 samples. The infield at Old Scatness contained soils, middens, and sands accumulated between the Bronze-Iron Age transition (~300 BC) and the 20th century. The Sumburgh Hotel Gardens site contained occupation deposits, sand and soils, mainly dating to the Early Bronze Age (~1500 BC). Quantitative estimates were made of the anthropogenic input to the soils at Old Scatness during the Iron Age.