Geophysical Research Abstracts,
Vol. 11, EGU2009-11135, 2009
EGU General Assembly 2009

New approaches in luminescence dating using single grains of small and large sizes

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Luminescence dating of sediments relies on the estimation of the dose absorbed by a constituent mineral grain (quartz and/or feldspar) from the natural radiation field arising from the decay of natural radioactivity viz. U, Th and K. A minor contribution is provided by the cosmic rays. Improvements in measurement technology have enabled the measurements of single grains. Using Monte Carlo simulations we explore here the implications of two realms of single grains, one where the size of grains is larger or comparable to the beta ranges (centimeter to sub centimeter scale) and the other when the size is much smaller (micrometer to sub millimeter scale),

In the case of large grain sizes, we suggest that the beta dose to the grains get attenuated with depth such that the interior of the grains receives only a fraction of total dose, mostly due to the gamma rays. This fraction is typically ∼30% of the total dose. Under the same irradiation condition, such a truncated dose rate implies a delayed onset of saturation in the growth of luminescence signal with radiation does. This implies an increased dating range. Based on a detailed calculation of the dose-depth profiles, we present a conceptual frame work for a three to four fold increase in the age range achievable by conventional dating protocols using 100-200 μm grains. This is based on removal of the beta skin of a large grain akin to the removal of the alpha skin in the case of small grains. Experiments on the optical transparency of large grains suggested a finite light transmission through 7 mm thick slices of quartz. This ensures that despite the size the geological luminescence of the grains will get photobleached, providing a way for their application in dating.

Given that the beta dose attenuation is dependent on the grain size, it is reasonable to expect that the total absorbed dose is also grain size dependent. This implies the prospects of development of an isochronal methods, where the absorbed doses are measured with variable grain of different grain sizes. This is being developed and the results will be presented. For a routine analysis, imaging technique using Electron multiplier CCD camera based TL reader is being developed. This will enable 2-D measurement of the dose profile in a slice from a large grain, enabling thereby deduction of multiple computations of the ages (Greilich et. al., 2005).

On the other extreme, the use of a single 100 μm grain was examined in respect of the heterogeneous beta dose seen by a grain. Contrary to the conventional it has been recently suggested that the dose distribution in single grains from sediment arises due both to the bleaching heterogeneity and beta dose heterogeneity arising due to spatial fluctuation of ^{40}K containing feldspar grains. We present a refinement of earlier work (Mayya et. al., 2006) by including realistic energy spectra and the beta straggling effects, so as to provide a more realistic single grain luminescence ages. The exact form of dose deposition function was found using Monte Carlo simulations. The calculations suggest a dose distribution similar to that obtained earlier but with a peak displaced to 12% higher dose. This implies that the single grain dose rates are somewhat higher. The effect of variable size dependent inter-grain void space on the beta dose distribution is being investigated.

References

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