Alpha effectiveness in ESR dating: a preliminary note on energy dependence

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A small research accelerator has been used as a source of alpha particles of selected well-defined energies to investigate the relationship between alpha effectiveness and the energy of the incident alpha particles. A general description of the accelerator and the irradiation procedure is given in Lyons et al (1985), and further details of the method will be given in due course.

The experimental method differed conceptually from the standard method in TL dating, as the sample thickness chosen was sufficiently great to allow all the energy of the incident alpha particles to be absorbed in the sample, thus simulating an infinite medium: the effectiveness of alphas of different energies could therefore be compared directly without further correction.

A range of energies from 1.5 - 8.8 MeV was used. Not all results are to hand as yet, but preliminary results strongly suggest that alpha effectiveness is dependent on the energy of the incident alpha particles (Fig.1): the total number of defects, as measured by ESR, is not simply a function of total dose but also depends on alpha energy. This can be seen clearly by the non-linearity of the ESR/particle vs MeV plot (Fig.2). When the same data is plotted vs range of the incident alpha, a straight line provides a reasonable fit (Fig.3). Thus alpha effectiveness appears to be linearly related to track length rather than to alpha energy. This is consistent with a model of local saturation along the track of the alpha particle, so that the increase in the rate of energy deposition when the alpha particle energy falls below 2 MeV does not cause a corresponding increase in the rate of defect production.

This concept underlies the *a* value of Aitken and Bowman (1975) and the *b* value of Bowman and Huntley (1984), but it is not always appreciated that direct use of the dose-rate tables of Bell (1979) implicitly assumes that alpha effectiveness is proportional to dose rather than range; consequently care needs to be taken in converting radionuclide concentration into effective dose-rate. The size of the correction depends on the reference energy used in evaluating *k*, as defined by Zimmerman (1971). For example, if a reference energy of 3.7 MeV is used, the effective dose derived for the ^{238}U chain in secular equilibrium on the assumption that the k-value is independent of particle energy is approximately 20% lower than the value calculated on the basis indicated as being correct by the results given above. A fuller report is in preparation.

Acknowledgement
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References

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PI Reviewers Comments (M.J. Aitken)
It is reassuring to find that these measurements, carried without influence from knowledge of the TL situation, indicate that the concept of constant ESR per unit length of track is valid. This is in keeping with the basic model of alpha effectiveness that stems from David Zimmerman's work.

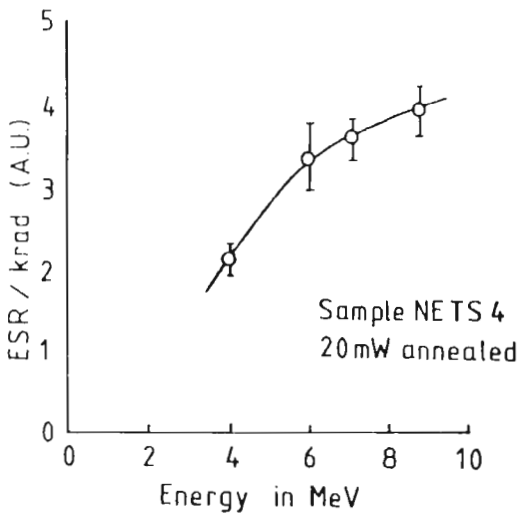

Figure 1. Alpha effectiveness (ESR/krad) as a function of energy.

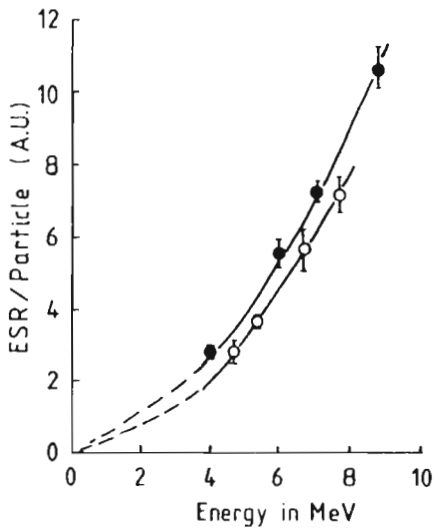

Figure 2. *ESR/particle vs. energy. The two lines arise from the different storage times of the sample sets before measurement and are due to interference from an unstable peak.*

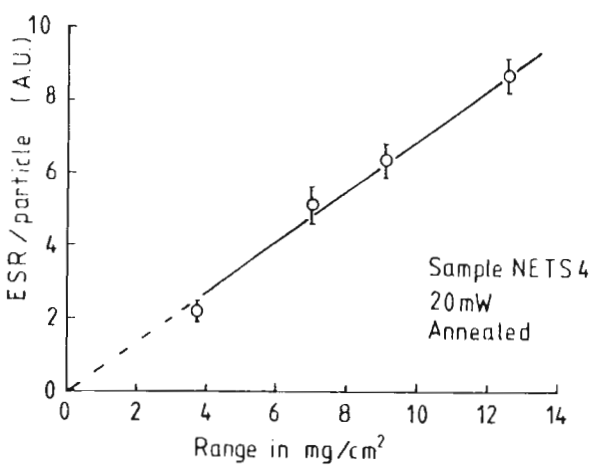

Figure 3. *ESR/particle vs. range.*