

Are ESR dose assessments on fossil tooth enamel reliable?

Mathieu Duval^{1,2*}, Rainer Grün²

¹ Program of Geochronology, Centro Nacional de Investigación sobre la Evolución Humana (CENIEH), Burgos, Spain

² Research School of Earth Sciences, The Australian National University, Canberra, Australia

* Corresponding author: mathieu.duval@cenieh.es

In ESR dating of fossil tooth enamel, the fitting function used for the evaluation of the D_E value is undoubtedly among the major sources of uncertainty. Although the single saturating exponential function (SSE) has been almost exclusively used since the late 1980's, several recent studies have shown that the behavior of the radiation-induced ESR signal is better described by a double saturating exponential function (DSE) [e.g. 1], whereas the SSE shows instead many limitations. This is actually more consistent with our current understanding of the nature and composition of this signal that is dominated by several types of CO_2^- radicals [2].

To address the question whether older (published) dose estimations have to be disregarded as unreliable, a series of dose recovery tests was performed using several proto-historic fossil teeth that were laboratory dosed to ~200 and ~1,500 Gy to present equivalents of Early to Late Pleistocene samples. Several fitting functions and data weighting options were tested, and results indicate that a combination of a DSE with data weighed by the inverse of the square intensities systematically provides reliable D_E results. Nevertheless, the SSE may produce consistent results as well if the D_{max} value is correctly constrained.

In order to obtain statistically significant results and determine exactly in which conditions the SSE could be used as a fair approximation of the DSE function, we ran additional computer simulations with thousands of randomly generated dose response curves. The results show that reliable doses can be obtained for preset dose values <1,000 Gy using 9 additive, exponentially distributed dose points with maximum dose values in the range of up to ten times the preset dose. Higher preset dose values (>1 kGy) require modified maximum doses and improving measurement precision is crucial.

In this work, we will present a synthetic overview of the results detailed in two recent studies [3,4] and provide as well some recommendations to ensure reliable fitting results with the SSE and DSE functions.

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[2] Joannes-Boyau, R. and Grün, R. 2011. A comprehensive model for CO_2^- radicals in fossil tooth enamel: Implications for ESR dating. *Quaternary Geochronology* 6(1), 82-97.

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[4] Duval, M. and Grün, R. submitted. Are ESR dose assessments on fossil tooth enamel reliable? Submitted to *Quaternary Geochronology*.