A cautionary note: apparent sensitivity change resulting from curve fitting

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Introduction

Curve fitting procedures are widely used in TL dating studies (Berger and Huntley, 1989; Mejdahl, 1985). In particular a saturating exponential curve has been applied over a wide dose range when the TL signal does not grow linearly. Exponential fitting has been used for samples of either pure or mixed minerals. The form of exponential curve can be written as

$$I = A - B e^{-CD}$$

Where A, B and C are fitting parameters, and D is the laboratory applied dose (Gy). The characteristics of the curve are governed by factors A and C, which relate to the asymptotic TL level and the saturation dose. If we assume no residual TL signal, then A = B.

In this paper I explore the effect of applying simple exponential fitting to the combined computer generated TL signals from two hypothetical minerals, each of which has different values of A and C.

Data used

Let us assume that for one mineral the TL growth curve is given by

$$I_1 = 443 - 443 e^{-0.00268 D}$$

where parameters $A_1 = B_1 = 443$ and $C_1 = 0.00268$ were used (curve 1 in figure 1). Now let us suppose that the TL of the other mineral saturates at a lower dose and that the asymptotic TL level is half that of the other mineral, i.e. $A_2 = B_2 = 221.5$; $C_2 = 0.0134$, then the TL growth curve of this mineral is given by

$$I_2 = 221.5 - 221.5 e^{-0.0134 D}$$

This is shown as curve 2 in figure 1.

The TL growth curve for a sample made up of equal weights of the two minerals is $I = I_1 + I_2$, curve1+2 in figure 1.

Let us now consider the ED determination for such a sample which has received 300 Gy. Application of an exponential fitting program to the TL for the 300 Gy point and the TL responses for the five higher doses used as an "additive dose set" produced an ED of 428 Gy, 128 Gy higher than expected. Shifting the combined curve1+2 by 300 Gy indicated that a significant sensitivity change would be observed between the regeneration and the additive dose curves (figure 1).

A similar fitting was applied for the TL signal resulting from 20 Gy and using 6 added doses up to 500 Gy. An ED of 23 Gy is given from the exponential fit, which is only 10% larger than that expected. The apparent sensitivity change is negligible (figure 2).

If the two minerals are assumed to have a similar saturation dose, no significant difference is found between the ED given by curve fitting and the expected ED. This suggests that the relative saturation doses of the minerals producing the TL signals is important in the application of exponential curve fitting.

Implications for polymineral samples

For a polymineral sample, such as 4-11 μm grains used in many TL laboratories, the saturation doses may be different for each mineral. Feldspar and quartz have been shown to have significantly different saturation doses (Mejdahl, 1985). Although real polymineral samples may not behave in exactly the same way as the above examples, use of a saturating exponential fit could result in an apparent sensitivity change when the additive dose and regeneration curves are compared.

Acknowledgment

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References

Berger, G. W., and Huntley, D. J. (1987), Test data for exponential fits. *Ancient TL* 7, 43-46.

Mejdahl, V., (1985), Further comments on extrapolation methods of dating sediments. *Ancient TL* 3, 21-26.

PI: Reviewer's Comments (S.W.S McKeever)

This note illustrates one of the dangers of curve fitting additive dose growth curves using an assumed single exponential function for the growth. The problem, as described by the author, need not be confined to the situation where one is dealing with a polymineralic sample, however. A TL signal made up of two unresolved, overlapping components, each from the same mineral but displaying different growth curves and saturation levels, may present the same difficulties.

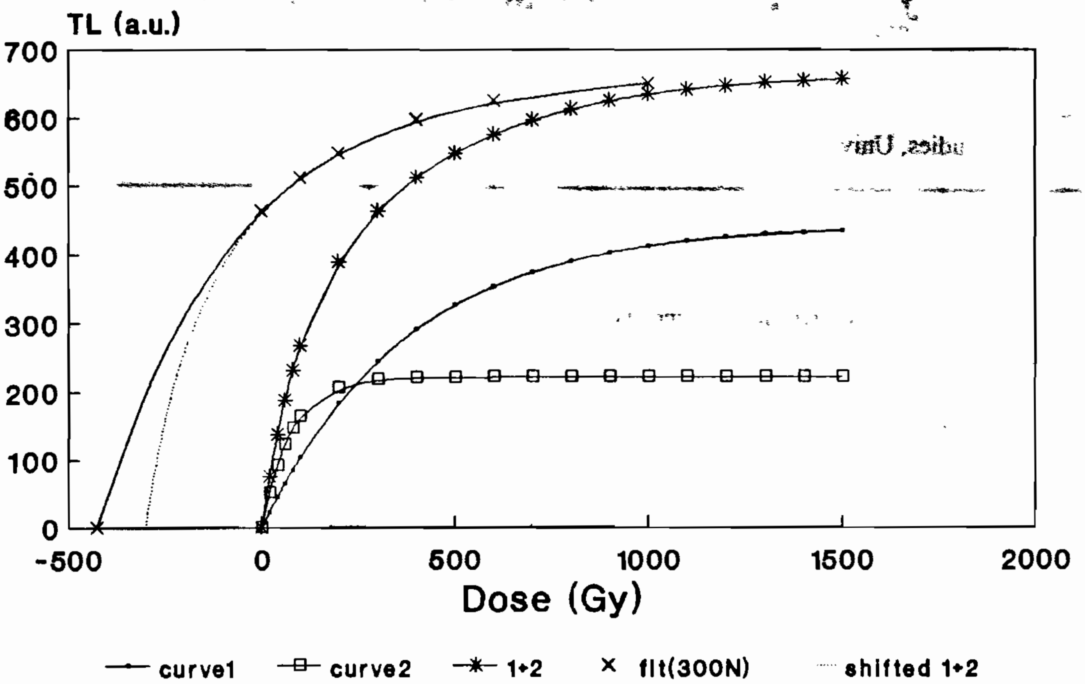

Figure 1.
Calculated TL growth curves.
(•) growth curve 1: equation I_1 (see text), (□) growth curve 2: equation I_2, (*) curve1+2, (x) saturating exponential fitting of curve1+2, 300 Gy as the natural and using added doses up to 1000 Gy, (...) shifted curve1+2.

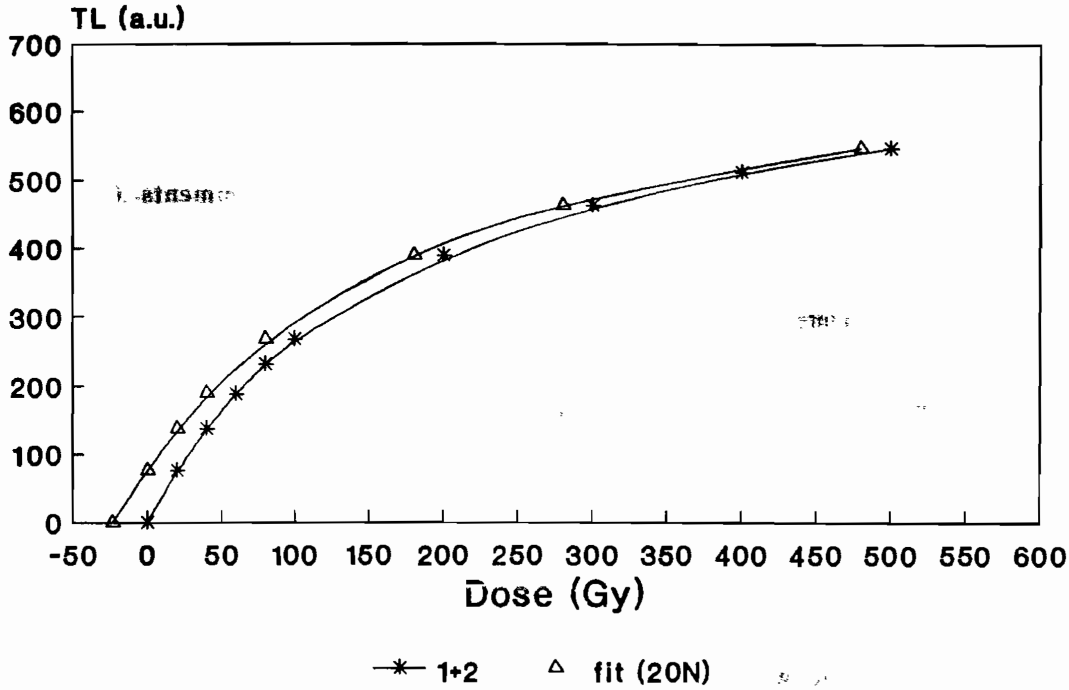

Figure 2.
Calculated TL growth curves. Parameters are the same as in figure 1, but taking 20 Gy as the theoretical natural point and using added doses up to 500 Gy.