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Compiled by Ann Wintle

Letters

• *Vlasov & Kulikov's method*

In their paper published in 1989, Vlasov and Kulikov (*Physics and Chemistry of Minerals* **16**, 551-558, 1989) provide the most comprehensive description yet of the method they use to obtain TL dates from quartz. Since some of these are over a million years this is obviously of great interest. The paper is not particularly accessible and I thought it would be worthwhile to provide a summary to the best of my ability. At the end I shall make some comments of my own. The reader is advised that I may well have misinterpreted some aspects of the paper and that what follows should not be regarded as a faithful representation of the original, but is my interpretation.

The following refers to the light sum (i.e. TL intensity) for the "high-temperature" quartz peak at 310 °C. They show that it is necessary to anneal their irradiated samples at 200 °C for 20 minutes in order to separate this peak.

(a) The rate equation used is:

$$dn/dt = (n_o - n)^2 . \sigma_1 . P_{eff} - n/\tau$$

Here the first term represents trap filling by the radiation and the second term represents thermal trap emptying.

- n is the concentration of filled traps at time t,
- n_o is the total concentration of traps,
- P_{eff} is the dose-rate,
- σ_1 is the trapping cross section, and
- τ is the mean trapped charge lifetime due to thermal emptying.

(b) The equation is solved for the case of laboratory environmental irradiation in which case the second term is omitted. The solution yields the following relation between lab dose and light sum:

$$1/\Delta S = a + b/D$$

where, D = lab dose; $\Delta S = S_\infty - S$; S = light sum and S_∞ is its value in the limit $D = \infty$; $a = 1/(S_\infty - S_{nat})$; $b = a/(n_o - n_{nat})\sigma_1$

(c) Experiments of TL intensity (S) vs lab dose (D), i.e. N + γ data, are used to evaluate the parameters a and b using a plot of $1/\Delta S$ vs $1/D$ on which the data are linear. This permits determination of $n_o\sigma_1$. The range of gamma doses used is 500 - 10,000 Gy.

(d) The full rate equation is solved for the case of the natural dose rate and independently determined τ. A graph of S vs time is produced and two points placed on the curve. The first is the natural intensity (S_n), the second is the residual (S_o). The age is taken to be the difference between these on the time axis.

(e) The value of S_o is taken to be a particular fraction (f) of the value of S that would occur at $t = \infty$ under natural conditions. A table of f values for different sediments is given.

Comments
The glow curves and growth curves shown do not look like those for quartz that I am familiar with. The authors make a point of stating that HF is not used because it would alter the radiation sensitivity; perhaps there is a connection.

The form of the first term in the rate equation is most unconventional. It would be helpful if the authors would expand on the physical basis they state for it. The data shown agree extremely well with the linear form of the solution given above.

The definition given for n_o is the 'initial concentration of vacant traps'. This has the effect of making the rate equation itself dependent on the initial conditions; the definition I give above avoids the difficulty.

Reading the paper is made easier once one realizes that in equation 17 the symbol n represents ($n_o - n_{nat}$), that the left hand side of equation 20 should be $1/\Delta S$, and that the ordinate of Fig. 4a is ΔS^{-1}.

D. J. Huntley
Department of Physics, Simon Fraser University

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• *Symbols Proposals by Martin Aitken*

I very much welcome Aitken's initiative to introduce a standardised set of symbols for TL and optical dating. I hope that it was also the aim to include ESR dating where appropriate.

The choice of some of the characters and combinations may be a matter of personal preference, however, I should like to raise the following points:

1) It seems unfortunate that dose values are expressed with four different capital characters, R, E, Q and P. The international symbol for energy dose is D (see *Handbook of Physics and Chemistry* and *The Symbols Committee of the Royal Society*, 1975). The pal(a?)eodose, as defined by Aitken, is expressed as 'effective dose' (i.e. corrected for alpha efficiency), and is actually the dose value that is equivalent to the kind of radiation that has been used in its determination (i.e. gamma or beta rays). There seems no reason to avoid the international symbol and to denote specific procedures by subscripts. D_E could be the equivalent dose as used in the age equation, D can stand generally for applied dose, D_o for saturation dose, and D_I for the supralinear correction. The relationship between measured ESR intensity, I, and dose would be:

$$I = I_{max}\,(1 - \exp(-(D+D_E)/D_o))$$

or in TL/ optical dating, using the other symbols suggested by Aitken:

$$L = L_i\,(1 - \exp(-(D+D_E)/D_o)$$

2) The selection of the character of the dose rate seems more problematic. The international symbol is $\dot{D}$, which is difficult to print (one may want to use the German notation D' instead). However, both notations, $\dot{D}$ and D', suggest an instantaneous dose rate. However, most Quaternary samples show radioactive disequilibria and the cited dose rates are usually average dose rates over the calculated age of the sample. In these cases a notation implying a derivative is not strictly correct. A concept of using a dose system (i.e. multiplying all the dose rates with the calculated age) instead of dose rates may overcome this problem. The problem of disequilibria and the citation of dose rates involving these has to be addressed.

It is evident that the introduction of a standardised set of symbols for TL, ESR and optical dating requires a rigorous discussion.

Rainer Grün
RSPacS, Canberra

Author's Response
I am glad to have some comment on my proposals and hope that this may set the ball rolling for more widespread discussion. I have also received informal critical comment from D.J. Huntley, who like Grün, strongly favours the use of *D* for those (whereas I had proposed the use of *D* for dose-*rate*). Since, as Grün points out, the international symbol for energy dose is D, there is indeed a case for using *D* for laboratory-applied dose. However I strongly favour retention of *P* for paleodose (optionally, palaeodose) both for simplicity (see below) and since, again as pointed out by Grün, it is an effective dose (at any rate when used in the age equation) rather than a true energy dose.

The reason for which I proposed the use *E*,*Q* and *P* rather than using suffixes was to reduce the need for suffixes and double suffixes. On some PC's these, whether single or double, are wasteful of time; more importantly they are confusing when spoken, increasing the comprehension difficulties of non-English speakers.

As regards the exponential equations D_s is preferable to D_o since the latter implies some connection with zero, and suffix i is preferable to suffix max since it is shorter. I agree that it would be desirable to use *I* rather than *L* so as to bring TL/OD and ESR into line, with the proviso that one should avoid the use of a font (such as Geneva) in which there is confusion with a small *l* ('ell').

Certainly there is a need to evolve a system that deals with the problem of a changing dose-rate, such as due to uranium-uptake in teeth or calcite as well as due to radioactive disequilibrium. However I think possibilities should be developed by individuals and tried out in published papers before discussion by the (Conference) Committee. In the meantime, and in any case for the many sites on which assumption of a constant dose-rate is acceptable, I suggest that *R* be used to denote average dose-rate.

Martin Aitken
University of Oxford