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Thick-source alpha counting of peat

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Some years ago we showed the potential for dating peat by thermoluminescence (Huntley et al. 1983), the details of which may be found in Divigalpitiya (1982). With renewed interest in the subject here I have been concerned with the question of whether or not thick-source alpha counting of peat gives the results expected of it. It is possible, for example, that the organic material may not be homogeneously distributed within the sample placed on the ZnS, and hence lead to an incorrect evaluation of the dose rate.

Divigalpitiya showed that the way to evaluate the dose rate when both water and organic matter were present was to consider the sample to consist of three components: mineral (m), water (w) and organic matter (o). He defined A values for water and organic matter by

$$\Delta^{w} = M^{w}/M^{m} \text{ and } \Delta^{\circ} = M^{\circ}/M^{m} \qquad (1)$$

where the M's are the masses of the three components.

The correction factor for the alpha dose rate then becomes

$$\frac{1}{1 + H_{\alpha}^{W}\Delta^{w} + H_{\alpha}^{O}\Delta^{\circ}} \qquad (2)$$

where H_{α}^{O} is the ratio of the stopping power in the organic material to that in the mineral, for alpha particles. H_{α}^{W} is the same ratio but for water to mineral and is what is in common use and denoted by H_{α}. This correction factor is to be applied to the dose rate that would exist in the absence of both organic matter and water.

Similar expressions are used to correct the beta and gamma dose rates. Divigalpitiya calculated the following values of the H^{O} values:

$$H_{\alpha}^{O} = 1.37 \pm 0.06,\ H_{\beta}^{O} = 1.20 \pm 0.03$$
$$\text{and}$$
$$H_{\gamma}^{O} = 0.948 \pm 0.08 \qquad (3)$$

With the arguments of Aitken and Xie (1990) it seems likely that this value for H_{γ}^{O} is probably too small and a value of 1.1 would be more appropriate.

In order to make the corrections it is necessary to determine the value of Δ° for each sample. We do this by drying the sample, weighing it, putting it in an oven at 500°C overnight to burn off the organic material, and weighing again. Δ° is calculated as the weight loss divided by the final weight. If storage of the dried peat is necessary, this is done in a desiccator.

Expression (2) is just the factor by which the rate at which alpha-track-length delivered to mineral matter is reduced by the presence of water and organic matter. The same factor pertains to the expected reduction of the thick-source alpha count rate. In the absence of water the reduction factor is $1 + H_{\alpha}^{O}\Delta^{\circ}$.

The experiment was designed to test this. The peat samples used were from Lynn Canyon, North Vancouver (LCP5), Double Bluff, Whidbey Is., Washington (WFP2), and Salmon Springs, Sumner, Washington (SSP2). Each was dried at ~100°C and milled well in a ring mill; this is the material called "dry peat" in the table. A subsample of this was heated overnight at 500°C to determine Δ° and the resulting material is called "ash" in the table.

The table shows the alpha count rates for the peats and ashes, their ratios, the Δ° values and the theoretically expected ratios. Because dry peat was typically dark brown and the ashed samples were much lighter in

Table: Thick-source alpha count rate

Sample	Δ°	dry peat $ks^{-1}cm^{-2}$	ash $ks^{-1}cm^{-2}$	measured ratio	reflectivity - corrected ratio	expected ratio $1 + H_{\alpha}^{0}\Delta^{\circ}$
LCP5-S	0.33	0.164±0.004	0.259±0.005	1.58±0.05	1.44±0.05	1.45±0.03
SSP2-6	1.20	0.086±0.003	0.264±0.007	3.07±0.14	2.73±0.14	2.64±0.08
SSP2	2.06	0.052±0.002	0.217±0.004	4.17±0.17	3.72±0.17	3.82±0.14
WFP2-6	6.90	0.037±0.002	0.361±0.004	9.76±0.54	9.00±0.50	10.45±0.42

colour, one can expect a significant effect of the different sample reflectivities on the measured ratio. Reflectivities were therefore measured, and the count rates corrected for them as outlined in the appendix. The ratios of the corrected count rates are also shown in the table. (An alternative to the reflectivity correction is the placement of thin aluminized mylar between sample and ZnS to eliminate the effect of reflectivity variations as outlined by Martini, 1981).

It is seen that there is satisfactory agreement between expected and corrected ratios. I conclude then that all is well, but note that this method, while suitable in principle suitable for determining H_{α}^{0}, does not yet have sufficient precision to give a value better than the calculated one. It is perhaps worthwhile reiterating here the necessity of milling or glassing most sediment samples for alpha counting because of non-uniform distribution of U and Th (Jensen & Prescott, 1983).

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Appendix

Here I discuss the correction to the alpha count rate needed when the reflectivity of the sample is different from that of the standard used to set the discriminator on the alpha counter. The model used is that of Huntley and Wintle (1978) (or see Huntley, 1978) in which the size of the light pulse incident on the photocathode of the photomultiplier is proportional to $(1+\rho)$ where ρ is the sample reflectivity. The discriminator voltage setting required to pass a specific fraction of these pulses is thus also proportional to $(1+\rho)$.

With this assumption one can show that the count rate measured for a sample should be divided by

$$\frac{(1+\rho_s) + \left(\frac{\rho-\rho_s}{0.82}\right)}{1+\rho}$$

where ρ is the reflectivity of the sample, and ρ_s is the reflectivity of the standard used to set the discriminator. The number 0.82 is appropriate for a uranium standard and should be changed to 0.85 for a thorium standard.

In the present work a glass standard was used and its reflectivity determined to be 0.5. Reflectivities of the dried peat samples were all under 0.1 and those of the ashes were in the range 0.35 to 0.63.

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