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A cautionary note: use of 'water content' and 'depth for cosmic ray dose rate' in AGE and DATA programs

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The AGE program was written by me several years ago for calculating TL ages. A similar program, DATA, has been used for calculating ESR ages. In a recent discussion, Prof. Prescott brought to my attention that the conventional water content of soil is defined as the ratio of the water mass over the dry mass of a soil sample (e.g. Foth 1984). This makes particular sense as all other analyses are subsequently carried out on the dry fraction of the soil sample (e.g. elemental composition, alpha, beta, and gamma activity, etc).

In the AGE and DATA programs, however, the sediment water content is defined as water mass over the mass of the collected, wet soil sample. For example, if the weight of a 100 g soil sample is reduced by heating at 105°C to a constant mass of 75 g, the present program input, X, would be 25%. The program then calculates water attenuation coefficients, W_{β} , according to the following formula (adapted from Bowman, 1976 and Aitken, 1985: section 4.2.3.):

$$W_{\alpha,\beta,\gamma} = \left\{ 1 + H_{\alpha;\beta;\gamma} \frac{X}{100-X} \right\}^{-1}$$

where $H_{\alpha} = 1.49$, $H_{\beta} = 1.25$, and $H_{\gamma} = 1.14$.

However, using water/dry mass the water content would be 33% (25 g water over 75 g oven dry soil). The use of this larger value will lead to overestimations of the attenuation factors, if inserted in the present version of the program.

The Table below shows the differences resulting from this problem.

In other words, if the water content in its conventional definition is 10% and this value was used in the program, the calculated beta and gamma dose rates would be about 1.2% smaller than the correct dose rates. The resulting age may be up to 1.2% older than a correctly calculated one. The problem becomes significant for higher soil moisture contents. At 40% water content, the program will calculate dose rates that are nearly 20% smaller than the correct ones.

A new version of AGE is available that uses water content expressed as % water over dry mass. The old version can still be used provided water content is expressed as water/wet mass.

water/oven dry soil (wd) %	water/wet soil (ww) %	$\dot{D}_{\beta\text{-wd}}/\dot{D}_{\beta\text{-ww}}$ %	$\dot{D}_{\gamma\text{-wd}}/\dot{D}_{\gamma\text{-ww}}$ %
10	9.1	98.8	98.9
20	16.7	95.2	95.8
30	23.1	89.6	90.1
40	28.6	81.2	82.9

Some newer versions of AGE and DATA have a depth, d, input for the cosmic ray dose rate. The program assumes an average sediment density of 2 g cm^{-3} and applies the formula of Prescott & Hutton (1988):

$$\dot{D} = 210 \exp(-0.07x + 0.0005x^2)$$

The dose rate is expressed in $\mu\text{Gy a}^{-1}$ and x is in units of 100 g cm^{-2} . This formula as used in the programs is only valid between 0.75 and 25 m. The current programs do not consider the soft component of the cosmic dose rate which is of relevance for depths less than 0.75 m. The input of "0" returns a zero cosmic ray dose rate. A version of the program is available on request which allows the user to insert the total cosmic ray dose rate directly.

References

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PR John Prescott