Ancient TL

www.ancienttl.org · ISSN: 2693-0935

Aitken, M., 1979. *The alpha particle response of fluorite.* Ancient TL 3(4): 2-5.
https://doi.org/10.26034/la.atl.1979.024

THE ALPHA PARTICLE RESPONSE OF FLUORITE

M. J. Aitken,
Research Laboratory for Archaeology,
6 Keble Road,
Oxford OX1 3QJ.

For the interlaboratory source calibration kit (Ancient TL no. 5, p.6) a substantial number of fine-grain discs were prepared from MBLE Super 'S' calcium fluoride. It was expected that these would all have the same a-value but it was found that there were occasional high values - by around 10%; this necessitated measurement of the a-value of all the discs that were sent out for calibration of an alpha source on the basis of comparison with the recipient's beta source. The purpose of this note is to warn against the use of unchecked discs for this purpose. The cause of the variation has not been identified and it is to be noted incidentally that it may also be present with other materials - including pottery.

Experimental

The fine grains were deposited from suspension in acetone on to ½-mm thick aluminium discs (10-mm diameter) in the usual manner; the grains used were those that settled between 2 and 20 minutes so the presumed size range was 1-8 microns. The fluorite had been provided by MBLE in 1969; prior to use it had been washed in hot aqua regia and heated to 650°-700°C in nitrogen to reduce sensitivity to light. Three batches of discs have been used so far, no deliberate changes in the conditions of deposition being made. The anomalous a-values were found only in Batch 2. Between batches 2 and 3 the starting material was further annealed in order to improve its insensitivity to light. Before this second anneal the TL induced in peak III (circa 300°C) by 1000 lux-minutes of light from an incandescent source (1 minute at 18 inches from a 60-watt bulb) had been the equivalent of 1½ millirads whereas afterwards it was about 0.1 millirads.

The alpha sources used were 0.5 mCi Am-241 foils in a six-seater irradiator (see Ancient TL, no. 3, p.5) the exposed area of each being a circle of 11-mm diameter. The beta sources used were of the SIP type from RCC Amersham with an active diameter of 12 mm; routinely irradiations were carried out with disc on the nichrome heater plate and a source-sample distance of 0.62 inches. The photomultiplier used was an EMI type 9635 with a Corning filter (either 7-59 or 7-51) and a Chance Pilkington HA3.

For 'strong dose' measurements, corresponding to the dosages given on sending-out, the beta dose was 100 rads and the alpha dose 0.8 micron^{-2}; for the latter the source-sample distance was 15 mm. For 'weak dose' measurements the beta dose was 3 rads and the alpha dose 0.024 micron^{-2}, the source-sample distance being increased to 40 mm for the latter.

Results

In the 4 sets, each of 6 discs, used for alpha calibration from Batch 1, all but 3 discs had a Peak III a-value within 1% of the average for the set; these 3 were within 2.5%. The set averages were 0.085, 0.088, 0.090 and 0.090. No rogue a-values were noted among the random dozen beta source calibration discs that were tested. (On the other hand discs prepared from material that had been annealed against light sensitivity on a different occasion showed a-values between 0.10 and 0.11.) In Batch 2 there were 15 rogues, having a-values higher than average by 5-15%, among 50 that were tested. In Batch 3 there were no rogues among the 24 that were tested; all a-values were within 2% of the overall average. The average values for the batches, excluding rogues, are given in Table 1.

Table 1

	a-values	
	peak II	peak III
Batch 1	0.121	0.089
Batch 2	0.113	0.086
Batch 3	0.111	0.085

The discs were usually measured in weak dose geometry. Some were measured also in strong dose geometry; there was no significant difference in a-value.

The ratio of the a-values for peaks II and III showed no significant difference between rogues and non-rogues.

Absorption effects

In case the rogue discs were abnormal in the thickness of the fluorite layer that they carried a number of the discs from batches 2 and 3 were tested for the effect of interposing 12.5 microns (3.5 mg cm^{-2}) of aluminium in the path of the alpha particles. For the weak dose source-sample distance of 40 mm this caused a reduction in TL by a factor of between 0.86 and 0.91 for all of the batch 3 discs. For batch 2 the reduction factors lay in the range 0.62 to 0.88. Of the 10 which had a factor of 0.75 or less, 7 had an anomalously high a-value; there was only one rogue a-value among the discs showing a reduction factor which was numerically greater than 0.75.

Absorption measurements were also made for some discs in the strong dose geometry, the source-sample distance then being 15 mm. The results are summarized in Table 2.

Table 2

Absorption factors due to interposition of aluminium foil

Disc ref.	bQ1	bQ2	bQ3	bQ4	bQ5	bQ6	bW3	bW4
a-value	0.089	0.088	0.093	0.093	0.088	0.089	0.088	0.098
40 mm sep.								
12.5 μ foil	0.62	0.87	0.63	0.81	0.81	0.82	-	-
15 mm. sep.								
6 μ foil	0.90	0.93	0.86	0.94	0.93	0.95	-	-
12.5 μ foil	0.48	0.78	0.48	0.74	0.71	0.70	0.67	0.45
wt. of CaF_2	-	-	-	-	-	-	0.7 mg	0.5 mg

The straightforward interpretation of the reduction in TL due to interposition of the foil is that due to energy loss in the foil not all of the emergent alpha particles are able to achieve full penetration of the fluorite layer. The effect is greater when the sample is close to the source because of the greater obliquity of the particle paths. Thus a stronger than average absorption effect presumably indicates a thicker than average fluorite layer, or, grain diameters that are larger than average. One would expect either of these alternatives to give rise to too low an a-value - whereas the opposite is observed. Also the two discs that were weighed give no credence to the notion that the rogue discs were too thick. On the other hand it is to be noted that if foil had been interposed for the a-value measurements it would have tended to bring the rogue discs into line.

Some 'ultra-fine' discs were prepared by using settling time limits of 60 to 100 minutes. As expected, these showed a weaker absorption effect than the standard discs: for the 15-mm separation the numerical value of the absorption factor was higher by about 10%.

Neutral density filters

An incidental observation from the practical point of view concerns the use of Kodak Wratten celluloid filters for cutting down the TL intensity to a manageable level. The reproducibility obtained, using these taped onto the base of the photomultiplier housing was not as good as with glass filters. This was traced to the warming that occurred during the glow-curve; a gradual decrease in transmission occurred, reading around 7% after several glows.

No such effect occurred with smoky glass filters (Chance Pilkington ON 30, obtainable from Precision Optical, 158 Fulham Palace Road, London W6 9ER). It may be useful to note that the absorption coefficient of these for the ultra-violet TL emitted by fluorite is about 1.43 times the coefficient for the light from a blue 'betalight', the

detector being an EMI 9635 photomultiplier with Corning 7-59 and Chance Pilkington HA3 filters interposed. Hence if T is the transmission factor for a smoky glass filter measured with a betalight, the transmission factor, T*, for fluorite TL is given by

$$\log T^* = 1.43 \log T$$

In Conclusion

Although it is possible to postulate that the rogue a-values are due to the chance presence of abnormal fluorite grains this does not square with the absorption observations.

Acknowledgements

The fine-grain discs were kindly prepared by Joan Huxtable. The extensive measurements involved were carried out by Bob Curtis and Gill Spencer, to both of whom I am grateful for their meticulous work as should be the recipients of the discs also.

EVEN MORE ON FILTERS FOR LABORATORY ILLUMINATION

Gary W. Carriveau

Research Laboratory
Metropolitan Museum of Art
New York, New York 10028

and

Brookhaven National Laboratory*
Upton, New York 11973

In the report of Sutton and Zimmerman (1978) on UV filters from Solar Screen Co., they did not include the information that this company also makes pink screens in addition to white and amber. Considering the fact that the EMI 9635 photomultiplier is effectively "blind" at wavelengths greater than 630nm, it was thought that exposing this type of photo cathode to "pink" light (when the high voltage is removed) may induce less dark current pulses when the high voltage is subsequently put on. In addition, this light color should reduce short wavelength bleaching effects in TL samples.

Figure 1 shows the light transmission through a single thickness of Solar Screen pink. When compared to the Solar Screen amber, it is obvious that the pink screen transmits more in the violet-green wavelength region (400-500nm) but less in the orange-red region (575-700nm). This evidence would certainly damage the argument for the use of pink filters with an exposed EMI 9635 photo cathode and indicate that it may be more harmful than amber filters for bleaching in the shorter wavelength region.

* Visiting Scientist, Chemistry Department, Brookhaven National Laboratory. Work at Brookhaven under contract with the U.S. Department of Energy and supported by its Division of Basic Energy Sciences.