THERMOLUMINESCENCE STUDIES OF APOLLO 17 BOULDER SHADOWS.

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Further work has been done on studying the thermoluminescence (TL) of soil samples collected from the shadows of certain Apollo 17 boulders as well as from an adjacent sunlit area. The objective has been to examine the effects of low-temperature storage of samples on the lunar surface, and possibly to estimate the duration or constancy of the shade. Some earlier results[1] were presented at the 6th Lunar Science Conference.

The soils were collected from two locations at the Apollo 17 site. From Station 6 came the permanently shadowed sample 76240, "taken from about 1 metre under the north overhang of a 5 x 4 x 3 m boulder"; the boulder (no. 4) is believed to have been derived from the North Massif and appears to have been moving downhill (11° slope downward to the south). For comparison, a second sample (76260), "a 2 cm deep skim soil" was collected "from just outside the shadow". From the second location, viz. Station 2, only one sample (72320) was collected: a surface soil "from about 20 cm under an east-west overhang of a 2 m boulder (no. 2) at the lower slopes of South Massif".

The two shadowed samples were each subdivided into two parts. One part has been kept continuously refrigerated (except for the first ~3 weeks) either at the NASA laboratories (at ~-20°C) or by ourselves (liquid N_2 or CO_2 snow); these portions are called the "freezer samples" (76240,22 and 72320,4). The second part has been kept at room temperature throughout; these portions are termed the "freezer counterparts" (76241,23 and 72321,3). The "sunlit sample" (76261,25) has also been stored at room temperature.

1. Natural thermoluminescence. Fig. 1 shows the natural TL observed from the three Station 6 samples. There is clear evidence of much higher TL retained by the permanently shaded sample (curves A and B) in comparison with the sunlit sample (curve C). The loss of TL in the 'freezer counterpart' kept at room temperature over the last ~3 yr, is significant (compare curves B and A); the loss is unexpectedly large at high readout temperatures and suggests 'anomalous fading'[2] (also see below). A similar relative loss of TL in the 'freezer counterpart' vs the 'freezer sample' is noticeable in the Station 2 samples (curves B and A, Fig. 2). A comparison of the 'freezer samples' from the two locations (curves A in Figs. 1 and 2) indicates that the Station 2 sample (~20 cm inside the shadow when collected) was probably not permanently shaded while under the small east-west overhang. Table 1 records the salient data on the natural samples.

2. Induced thermoluminescence. Samples from all locations exhibited similar glow curves as a result of Co-60 γ-irradiation (Figs. not shown), thus suggesting a general similarity of minerals responsible for the TL. Some differences have, however, been observed in the 'TL sensitivity' upon imparting a 30 krad dose of Sr-90 β's to annealed samples. The values obtained (TL area/mg.krad, expressed in arbitrary units) are: 1; 1.26; and 1.34, respectively, for 76241,23 (permanently shaded counterpart); 76261,25 (sunlit); and 72321,3 (partially shaded counterpart). This indicates differences in the proportion of TL phosphors present in these samples, and

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Table 1. Natural TL from shaded and unshaded samples

Sample	TL/mg (arbit.units) 0-486°C	0-162°C	Starting temp. (TL readout)
76240,22 (freezer)	100	5.3	~ 54°C
76241,23 (fr. counterpart)	59	2.6	~108
76261,25 (sunlit)	13	0	~180
72320,4 (freezer)	31	0.4	~108
72321,3 (fr. counterpart)	22	0.1	~144

possibly some 'temperature sensitization'[2] for the latter two samples. The effect of temperature of irradiation has been examined by imparting the same dose (560 krad γ's) at two different temperatures, viz. 20°C and CO_2 snow temperature (-78°C), to sample 76241,23, after first draining it of natural TL. Irradiation at the low temperature (-78°C) produced only ~60% of the room-temperature induced TL. This has a bearing on the calculation of the length of storage of this sample in the shadow of boulder 4.

3. Isothermal annealing. In order to examine the effect of the lunar day-time temperature on the natural TL of samples (whether during the sample-collecting EVA or during the exposure of the 'partially shaded' sample to the sun), isothermal annealing studies have been conducted at a temperature of 120°C (roughly the lunar maximum). The fading of the natural TL from sample 76241,23 (permanently shaded counterpart) was studied at this temperature as a function of time. The room-temperature fading of the TL induced in this sample by 1120 krad of Co-60 γ's was also measured. The results are shown in Fig. 3, and are summarized in Table 2. These observations have important consequences in interpreting the record of the wholly or partially shaded samples in the light of their collection and subsequent storage histories.

Table 2. Isothermal annealing of natural and irradiated sample 76241,23

		Annealed at 120°C			Annealed at 20°C*		
Annealing time (hr)		0	24	196	0	140	336
TL/mg (arbit. units)	0-480°C	100	65	48	2820	821	763
	0-324°C	65	34	17			
	0-162°C				2347	482	365

*Natural + 1120 krad γ's

References

1. Hwang, F.S.W., and Durrani, S.A. (1975). Lunar Science VI, p.423-425. Lunar Science Institute, Houston.
2. Durrani, S.A., et al. (1973). Proc. Lunar Sci. Conf. 4th, p.2465-2479.

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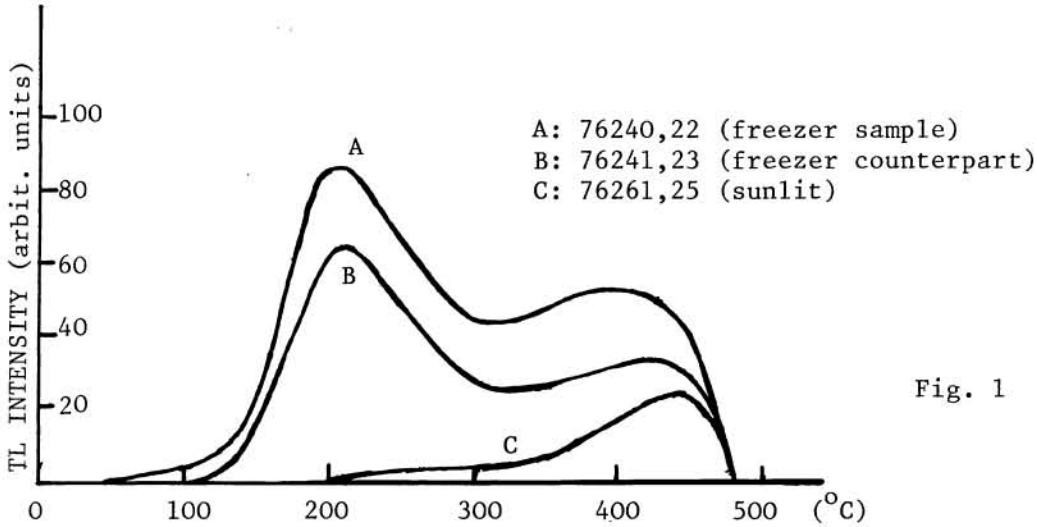

Fig. 1

Fig. 1. Natural TL of Station 6 samples. Notice the much lower TL retained by the sunlit sample. Aliquot weights, A: 1.6 mg; B and C: 1.8 mg. In all Figs., the grain size is 45<d<106μm, and the TL intensity is drawn to the same scale.

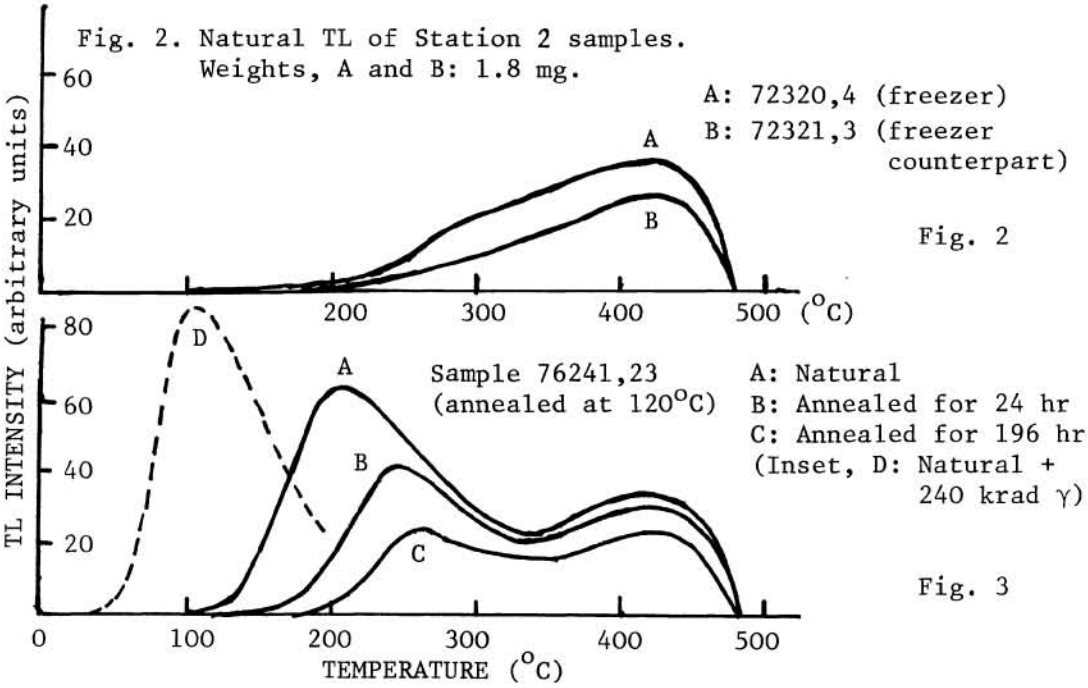

Fig. 2

Fig. 3

Fig. 3. Isothermal annealing of sample 76241,23 (freezer counterpart) at 120°C. Note that the inset D has been drawn to 1/20 of the true scale and only shows part of the artificially induced TL. Weights, A and D: 1.8 mg; B: 1.75 mg; C: 1.7 mg.