LOW TEMPERATURE THERMOLUMINESCENCE OF APOLLO 14 LUNAR SAMPLES

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We have studied the thermoluminescence (TL) of the lunar samples returned by the Apollo 14 mission as listed in Table I. The irradiations were performed at $-196^{\circ}C$ in the 160 MeV proton beam from the Harwell synchrocyclotron using a dose rate of about 140 rads per second. The heating rate was about $0.5^{\circ}C$ per second, and TL was observed in the 435-485 nm waveband. The general feature was a broad hump extending from $-50^{\circ}C$ to $+150^{\circ}C$, similar in nature to that observed for the Apollo 12 samples. As the magnitude was about twice as great as that of the latter, we were able to study in detail both the isothermal decay and the growth with increasing dose of the component peaks of the hump.

The isothermal decay was studied by starting the heating at different times after repeated equal irradiations. Neglecting re-trapping effects the response (R) is related to the response for zero delay (R_o) and the delay time (t) by the following expression:

$$R = R_o \exp(-\alpha t)$$

where α is the trap leakage rate. The growth with increasing dose was studied by varying the irradiation time. Making the same assumption as above and assuming also that no new traps are produced during irradiation, the response (R) is related to its saturation value (R_s) and the irradiation (t) by the following expression:

$$R = R_s \left[1 - \exp(-\gamma t)\right]$$

where $\gamma = \alpha + \beta$, and β is the trap excitation rate. From our data we derive values of α and β for each of the component peaks observed. These are listed in Table II. The values of β in units of $rads^{-1}$ (β') are also given. In Figure 1 we show a typical TL curve for one of our samples, and in Figure 2 the growth and decay curves for one of the peaks observed from this sample.

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Although the magnitude of the TL is about twice that observed from Apollo 12 samples it is still too small, by orders of magnitude, to provide a credible energy storage mechanism required to explain the Transient Lunar Phenomena (TLPs). Furthermore, the disturbingly large values of α, corresponding to mean leakage times of the order of an hour, indicate that the traps are incapable of storing energy for the required times of the order of 10^6 years. However, it has been suggested that rather than being purely exponential, the decay also has a constant term. We require more data to check this hypothesis.

Table I

Harwell No	NASA No	Type
M 409a	14321, 147	Dark fraction of crushed rock
M 410a	14321, 147	Light fraction of crushed rock
M 411	14163, 113	< 1 mm. bulk fines

Table II

Sample No.	Peak Temps. °C	α sec^{-1} ($\times 10^{-4}$)	γ sec^{-1} ($\times 10^{-3}$)	β sec^{-1} ($\times 10^{-3}$)	β' rad^{-1} ($\times 10^{-5}$)
M 409a	0	0.43	0.36	0.32	0.23
	+ 50	0.29	0.36	0.33	0.24
	+ 85	0.33	0.36	0.33	0.24
	+ 110	0.30	0.46	0.43	0.31
M 410a	− 10	0.40	0.47	0.43	0.31
	+ 75	0.20	0.37	0.35	0.25
M 411	− 15	1.20	0.50	0.38	0.27
	+ 90	0.67	0.35	0.28	0.20

•On attachment from the Department of Physics & Astronomy, Tel-Aviv University, Tel-Aviv, Israel.

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FIGURE 1 THERMOLUMINESCENCE OF M409a

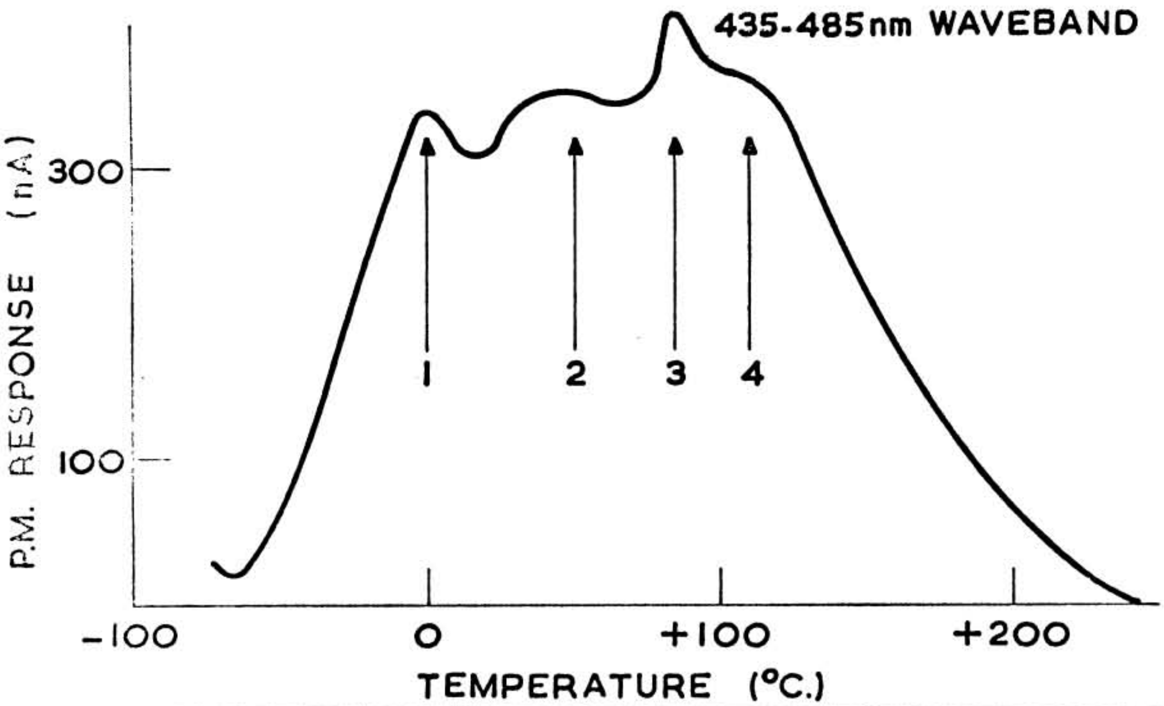

FIGURE 2 GROWTH AND DECAY CURVES FOR PEAK 3, SAMPLE M409a