THERMOLUMINESCENCE OF APOLLO 17 FINES

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The natural and induced thermoluminescence of lunar soils returned from the Apollo 17 mission have been investigated. The specimens are fines or grains of less than 106μm in diameter and were collected from different locations and different depths by the Apollo 17 crews. All specimens but one showed appreciable amounts of natural glow. The preservation of the natural thermoluminescence in specimens increases significantly with the depth of burial. Specimen 78481, 20 is a skim soil of upper ½ to 1cm depth and it contains natural glows only in the temperature region above 220°C. This indicates that the high ambient temperature on the surface of the moon during the daylight period has annealed the low temperature thermoluminescence which was induced by radiations in space. Specimen 72501, 49 was collected at a depth of 4cm from the surface on a steep uphill slope. Even this specimen shows a well preserved natural glow in low temperature regions. This indicates that the thermal insulation of the lunar soil is very effective. This probably is due to the surface dust being in a hard vacuum and to the fact that the contact among grains is poor because of loose packing. The best preserved natural glow was found in specimen 78421, 22 which was collected at a depth of 10cm from the surface of a 25cm deep trench. In addition to the thermal screening effect by the top soil, this specimen must have been lying in the shadow of the trench wall, because of the low glancing angle of the sun on the surface of the moon, ever since its formation. This shadowing effect can be seen from the well preserved natural glow of the specimen 78442, 1 which is a very cohesive soil from walls of that trench. The specimen 74220, 96 ($<$ 63μm) is the exciting "orange soil"; it contains more than 95% of glass in orange color and a very low concentration of plagioclase. This specimen came from a depth of about 5 to 8cm below the surface but did not give any natural glow at temperatures below 480°C. This specimen was irradiated with beta particles (0.5 Ci, Sr^{90}) and its thermoluminescence sensitivity is about 10 times smaller than that of the other Apollo 17 specimens. This low sensitivity is attributed to its low concentration of plagioclase.

The emission spectrum of all the specimens were analysed with a set of optical filters with different transmission bands. The glow of each specimen was divided into different emission temperatures and also normalized to a standard dose and a standard weight. The emission intensity of a given temperature is corrected for the quantum efficiency of the photomultiplier tube and the transmission band of the filters, and then plotted against wavelength in a linear scale. The emission spectrum of

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the specimen 74220,96 shows differences from the other Apollo 17 specimens and specimens from previous missions.
Successive doses, ranging from a few kilorads to a few megarads, were added to these natural samples. The response to β-particle-irradiation of these samples is linear to about 1 megarad, then the total glow area between room temperature and 480^{o}C is saturated with higher doses. This behaviour is generally found in other specimens from the previous missions.
The integrated areas of glows of various temperature ranges were plotted against the dose added. The " Half Dose" was determined for the high temperature glow of each specimen and from this the storage temperature of the specimen on the moon was estimated. The storage temperature was then used to check the depth where the specimen was found. The depth obtained from calculation was found to be in general much shallower than the actual depth where the specimen was collected. This probably is due to the fading of the natural thermoluminescence at ambient temperature since their arrival. The other explanation for this finding is that we have underestimated the thermal wavelength on the surface of the moon.
Previously, the thermal wavelength on the surface of the moon was estimated to be about 24cm for fines and 500cm for rock chips. From our calculation, using the actual depth where the specimen was found, the thermal wavelength in lunar fines should have been 10 times longer than had been estimated.
The trapping parameters, trap depth and frequency factor were determined using the initial rise technique. The results agree with the electron trapping model and are also consistent with the previous results.

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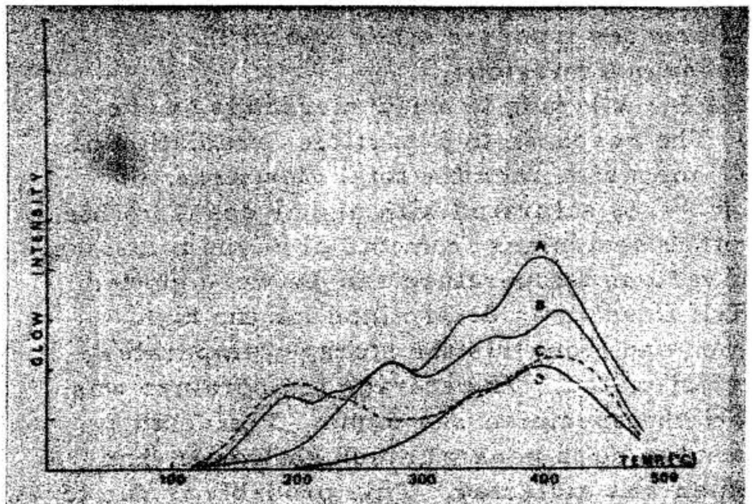

Fig. 1: Natural TL of some Apollo 17 specimens.
A) 78442,1, from walls of trench.
B) 72501,49, 4 cm deep of a steep uphill slope.
C) 78421,22, 10 cm from the surface of a 28 cm deep trench.
D) 78481,20, skim sample of upper $\frac{1}{2}$ to 1 cm of soil.

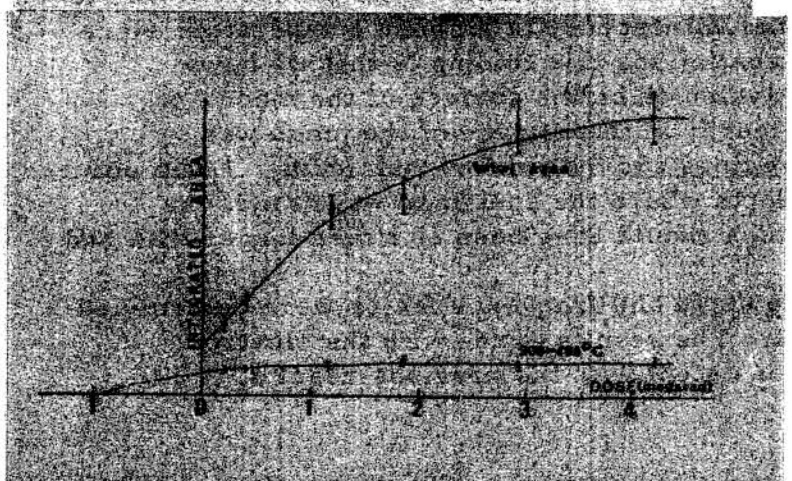

Fig. 2: Response to β-particles of specimen 75081,61.

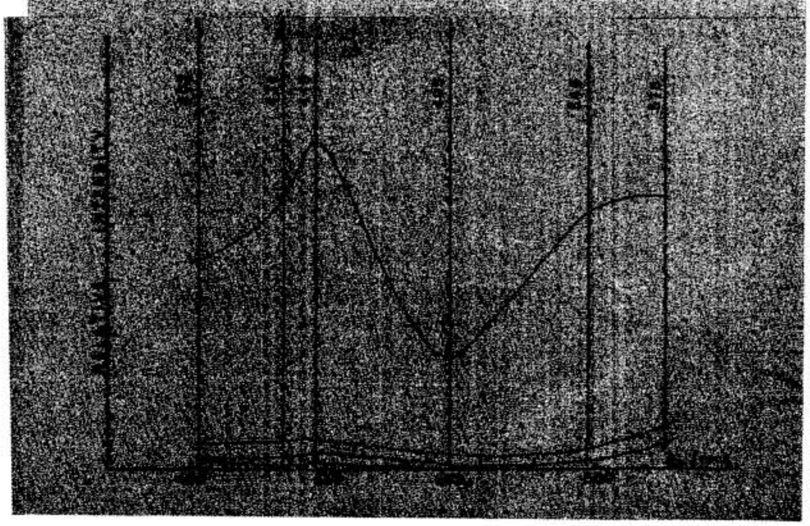

Fig. 3: Emission spectrum of specimen 74220,96 (orange soil).