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SOLAR FLARE AND GALACTIC COSMIC RAY STUDIES OF APOLLO 14 SAMPLES

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A step-wise thermal extraction of the rare gases in both light and dark fractions of 14306 shows a clear separation of spallation and fission components with little solar type gas.

The Kr-Kr ages are respectively 25.4 ± 2.9 and 23.4 ± 1.4 x 10^6 yrs. In rock 14321, the maximum surface exposure age inferred from track counts is 25 ± 3 x 10^6 yrs. The agreement of these ages and those measured in other Apollo 14 breccias suggests that this is the age of Cone Crater. Rock 14301, which has both solar gas and excess fission gas seems to have had a more complicated history giving a Kr-Kr age of 102 ± 30 x 10^6 yrs.

In most lunar soil samples the majority of crystals in the >200 mesh fraction have track densities in excess of 10^8 t/cm^2. This is also true for all six positions in the Apollo 15 long drill core. Exceptions are Layer VI of the Apollo 12 double core, 12033, 12030, and two samples from Apollo 14 - Cone Crater soil (14141) and the bottom of the trench (see Fig. 1). From thermoluminescence (TL) we estimate the average depth of sample 14141 to be 2.1 ± .4 cm. Taking twice this as the maximum depth and assigning the lowest track density crystal to this position we calculate an exposure age of ∿18 x 10^6 yrs for an undisturbed layer. In fact, the distribution of track densities are consistent with a 25 x 10^6 yr age and a maximum stirring (or sampling) depth of ∿5 cm. Thus 14141 appears to be a sample of original Cone Crater ejecta that has lain relatively undisturbed since the original impact.

The trench bottom has similar track densities and could be Cone Crater ejecta that has recently been covered over by older, more irradiated material. The data also show that the comprehensive and bulk fines do not consist solely of Cone Crater ejecta.

The depth dependence of fossil track density and TL was measured in a vertical section of 14310. The TL signal reflects an equilibrium between the rate of ionization and thermal draining. Because thermal gradients are low, the signal in rocks is determined by the rate of ionization. The rapid rise of TL towards the surface (Fig. 2) is expected from solar flares. The TL at any glow temperature also has a characteristic equilibrium time determined by the activation energy for draining. The effect is thus analogous to radioactivity measurements and can be used to look for fluctuations in solar activity over an estimated time interval of 10^2-10^5 yrs. No large fluctuations are seen.

In Fig. 3 we show a log-log plot of track density vs depth for selected lunar rocks from three missions. The data for 14310 lie close to those for 12063 and our previous conclusions on the long-term average solar flare

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energy spectrum ($dN/dE = CE^{-2.6}$) and rock erosion rates (3×10^{-8} to 10^{-7} cm/10^6 yrs) remain unchanged. We re-emphasize that the erosion rates refer to microerosion and set only lower limits for mass wastage.

Detailed studies of galactic cosmic ray tracks in the interior of 14310 will be given as part of a consortium report. From our data alone we would predict a true surface exposure age of $<3 \times 10^6$ yrs leading to the prediction that Mn^{53} should be undersaturated at the surface.

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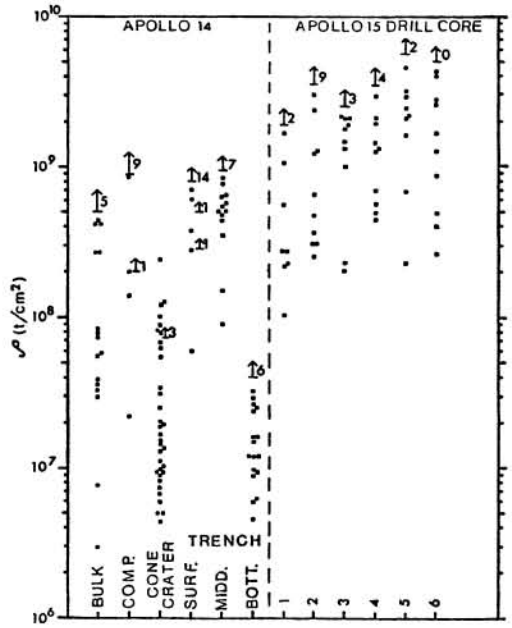

Fig. 1. Track densities (total SEM pit counts) in feldspars from Apollo 14 and 15 fines. The samples from Cone Crater and the bottom of the trench are clearly less irradiated than the others and must have been added to the regolith relatively recently.

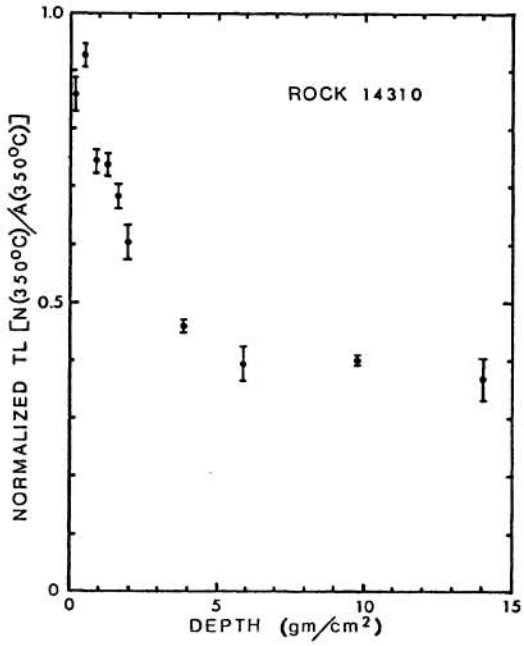

Fig. 2. Normalized TL as a function of depth in rock 14310. The points were obtained by dividing the natural TL intensity at 350°C by the intensity found in a second heating of the sample after a β irradiation of 38 krad. The near surface samples are believed to be low because of optical bleaching.

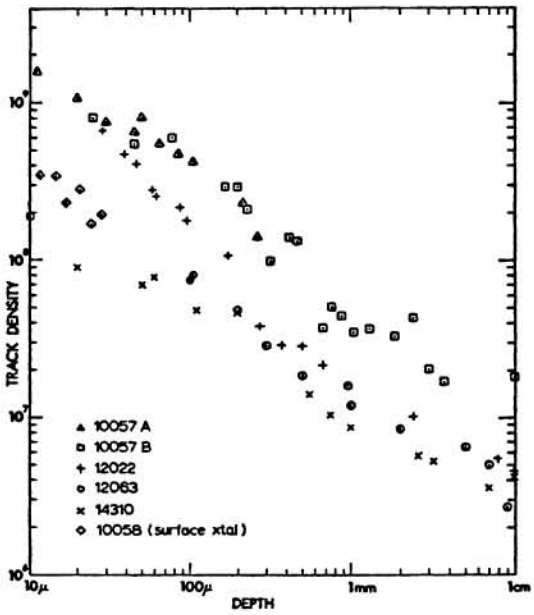

Fig. 3. Variation of track density with depth in selected lunar rocks. The tracks in this depth range are produced predominantly by solar flare particles.