PARTICLE TRACK DENSITIES IN DOUBLE DRIVE TUBE 60009

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In an effort to better understand lunar cores, a number of correlated studies have been made on a suite of samples (60009,454-458) in the double drive tube 60009/60010. Blanchard et al. (2) have determined the chemistry of these samples, Bogard and Hirsch (4) have analyzed their rare gas contents, and McKay et al. (6) have studied the petrography and ferromagnetic resonance intensity in grain size separates. We add to these studies measurements of particle track densities in plagioclase-bearing grains in the 90-150 µm fraction of this same suite of samples.

Our experimental procedure is to etch polished grain mounts for 3 h in boiling 1 N NaOH to reveal the tracks. Track densities are determined by counting tracks and measuring areas on scanning electron micrographs. Since we restrict our track density measurements to plagioclase, we consider it an arbitrary choice whether we use the bulk sample or the non-magnetic fraction (6). Because of availability of material, we made grain mounts of approximately 1 mg each from the 90-150 µm bulk sample for 60009,455, 456 and 458 and of the non-magnetic fraction for 60009,454 and 457. The results of these measurements are shown in Fig. 1.

Blanchard et al. (2), Bogard and Hirsch (4) and McKay et al. (6) have all argued that the soil in 60009 represents a mixture of two end members, one of which is immature and plagioclase-rich and the other mature and substantially mafic. The track density data strongly support this conclusion. The track densities in Fig. 1 clearly form bimodal distributions with very few grains exhibiting track densities greater than $3 \times 10^7 \text{cm}^{-2}$ or less than $10^5 \text{cm}^{-2}$. If we use the relative number of grains with track densities in excess of $10^5 \text{cm}^{-2}$ ($\% > 10^5$) as a mixing index (1,3), we obtain very good correlation with various maturity indices. In Figs. 2 and 3 we show correlation plots with the percent petrographic agglutinates in the 90-150 µm fraction and with ferromagnetic resonance intensity, Is/FeO. It is clear that the correlation of $\% > 10^5$ with Is/FeO does not have a zero intercept, and this also occurs when Is/FeO is plotted against rare gas contents (4) and against the percent of metamorphosed breccia (6). Since $\% > 10^5$ is statistically poor for immature soils, it may not be a very good relative mixing index for immature soils, but measuring additional grains in one sample (60009,455) did not change the relative number of grains with track densities $\geq 10^5 \text{cm}^{-2}$. Also, it is possible that very high density grains are systematically missed either because they become lost during the etching process or because some human factor causes a negative bias toward measuring these grains. However, the fact that Is/FeO has a positive intercept with other maturity indices for this suite of 60009 samples suggests that there may exist a component in the Is/FeO data for 60009 which is not proportional to soil maturity (4) and which we do not understand.
In conclusion we see that track density measurements support previous arguments concerning this suite of 60009 samples, namely that the maturity varies from immature to submature depending on the relative admixture of two components. The bimodal track density distributions imply that the immature component has not been reworked into a component of intermediate maturity. We would conclude that 60009 soils have undergone path 2 soil evolution in contradiction with path 1 soil evolution caused by in situ reworking (5). As far as the track density data are concerned, time stratigraphic contacts could exist between these samples, but there is no evidence that they do. Constraints placed by cosmogenic rare gases (4) and the variation in total iron (7) from samples that could exist in the same time stratigraphic layer consistent with track density measurements argue against time stratigraphic contacts in 60009.

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References

Figure 1. Histograms of the number of grains vs. the logarithm of particle track density for 60009,454-458. These histograms indicate bimodal distributions which we interpret to imply a mixture of immature and mature soil components.
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Figure 2. Percent petrographic agglutinates (6) vs. percent grains with particle track densities \( \geq 10^9 \text{cm}^{-2} \) in 60009,454-458, both in the 90-150 \( \mu \text{m} \) fraction.

Figure 3. Ferromagnetic resonance intensity in arbitrary units (6) vs. percent grains with particle track densities \( \geq 10^9 \text{cm}^{-2} \) in 60009,454-458, both in the 90-150 \( \mu \text{m} \) fraction.

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