

EARLY ACTIVE SUN?: RADIATION HISTORY OF DISTINCT COMPONENTS IN  
 FINES, G. Crozaz, G. J. Taylor, and R. M. Walker, Laboratory for Space  
 Physics, Washington University, St. Louis, Mo. 63130, and M. G. Seitz,  
 Geophysical Lab., Carnegie Institution of Washington, Washington, D.C. 20008

We report here measurements of the distribution of track densities in chemically distinct components of two mature lunar soils. The work was undertaken to see if crystals of different lithological origins would show distinct radiation histories.

Experimental Procedures and Lithologic Assignment: Plagioclase feldspars were separated from lunar soil samples 10084,72 and 12042,43 and incorporated into polished grain mounts. Their compositions were determined by electron microprobe analysis, prior to etching and track counting (this sequence was chosen to avoid biasing the results by missing high track density crystals which could be lost in the etching procedure). The measurements were made with the automated MAC-400 microprobe at the Geophysical Laboratory, using an accelerating voltage of 15 kV and an average sample current of 0.1  $\mu$ A. The x-ray counts were corrected for dead time, background, and matrix effects (1). Glasses with known compositions were used as standards. Based on counting statistics, the uncertainty in the measurements is approximately  $\pm 5$ -10% of the observed amount at the 0.1 wt. % level, or  $\pm 0.1$  wt. %. The absolute error is probably larger,  $\pm 0.02$ -0.03 wt. %.

The concentrations of Na, K, and Fe in the plagioclase crystals were used to identify the type of rocks from which they were derived (2,3). Figs. 1 and 2 show the regions occupied by analyses of plagioclase grains in anorthositic rocks, mare basalts, and KREEP breccias and basalts. The data used in constructing these fields were obtained from numerous sources in the four sets of Proceedings volumes and from unpublished analyses made by one of us (G.J.T.) and his colleagues at the Smithsonian Astrophysical Observatory. The assignment of an individual crystal's lithologic parentage was based on the location of its analysis on both Figs. 1 and 2. For example, an analysis that plotted in the mare-plus-KREEP field of Fig. 1, but in the mare-only region of Fig. 2 was considered to be derived from a mare basalt.

Results: Nearly half (68) of the 144 crystals in the Apollo 11 sample (Fig. 3) are derived from mare basalts, eight are from anorthositic rocks, and one is from a KREEP rock. Judging from the relative proportions of rock types present in the Apollo 11 soil (4,5), these are reasonable abundances. All but two of the remainder have compositions that plot in two or more fields on both Figs. 1 and 2, and, therefore, their source rocks cannot be unambiguously assigned. One of the two exceptional analyses plotted outside of the regions defined by known rock types; the other fell in the mare-only region on Fig. 1 and in the KREEP-only field on Fig. 2. Two exotic grains out of 144 is not unexpected. It would be surprising if every type of rock in the lunar crust has been analyzed.

The majority (46) of the 69 feldspars analyzed in the Apollo 12 soil are from mare basalts, three are from anorthosites, four are from KREEP rocks, and four are ambiguous. The proportion of nonmare feldspars is somewhat lower than that observed in Apollo 12 soils (5,6,7). Furthermore,

## EARLY ACTIVE SUN?

Croaz, G. et al.

there are 12 crystals (17% of the total) that either plot outside the regions defined by the major rock types or plot in the mare-only field on Fig. 1 and in the KREEP-only field on Fig. 2. Some of these crystals may derive from silicious rocks like 12013, but an insufficient number of complete analyses of plagioclase crystals in 12013 have been published to enable us to construct fields in Figs. 1 and 2 for this rock.

Using the rate of etching as their means of categorizing the origins of feldspars, Poupeau et al (8) reported that the anorthositic component of the Luna 16 soil had an average track density five times that of the mare feldspars. They ascribed this striking difference to an enhanced solar activity at the beginning of the solar system. In contrast to the Luna 16 results, the anorthositic component of 12042, although of limited statistical weight, appears to be distinctly less irradiated than the average of the mare basalts. The anorthosite in the Apollo 11 sample may be somewhat more irradiated than the mare basalts ( $\bar{\rho}_{An} = 1.8 \times 10^9$  vs  $\bar{\rho}_{MB} = 1.5 \times 10^9$ ); however, the effect is hardly striking. We thus find no evidence for an early active sun.

Additional work is continuing on other samples to determine whether the low track density anorthositic component seen in Fig. 4 is a ubiquitous feature of Apollo 12 soils indicative of a unique origin in a single, large event. Work is also continuing on soil samples that show evidence for two component track distributions.

Most soil samples contain feldspars that cathodoluminesce differently. In general, there is little correlation between CL and track densities. However, three unusual samples that have uniform CL responses are also found to have tightly bunched track distributions indicating simple radiation histories.

## REFERENCES

- (1) L. W. Finger and C. G. Hadidiacac, Carnegie Inst. Wash. Y. B. 71, 598-600 (1972).
- (2) J. V. Smith, Proc. Second Lunar Sci. Conf., Vol. 1, 143-150 (1971). MIT.
- (3) I. M. Steele and J. V. Smith, Geochim. Cosmochim. Acta 37, 1075-1077 (1973).
- (4) J. A. Wood, J. S. Dickey, Jr., U. B. Marvin, and B. N. Powell, Proc. Apollo 11 Lunar Sci. Conf., Vol. 1, 965-988 (1970). Pergamon.
- (5) E. A. King, Jr., J. C. Butler, and M. F. Carman, Jr., Proc. Second Lunar Sci. Conf., Vol. 1, 737-746 (1971). MIT.
- (6) U. B. Marvin, J. A. Wood, G. J. Taylor, J. B. Reid, Jr., B. N. Powell, J. S. Dickey, Jr., and J. F. Bower, Proc. Second Lunar Sci. Conf., Vol. 1, 679-699 (1971). MIT.
- (7) C. Meyer, Jr., R. Brett, N. J. Hubbard, D. A. Morrison, D. S. McKay, F. K. Aitkin, H. Takeda, and E. Schonfeld, Proc. Second Lunar Sci. Conf., Vol. 1, 393-411 (1971). MIT.
- (8) G. Poupeau, G. C. Chetrit, J. L. Berdot, and P. Pellas, Geochim. Cosmochim. Acta 37, 2005-2016 (1973).

## EARLY ACTIVE SUN?

Grozaz, G. et al.

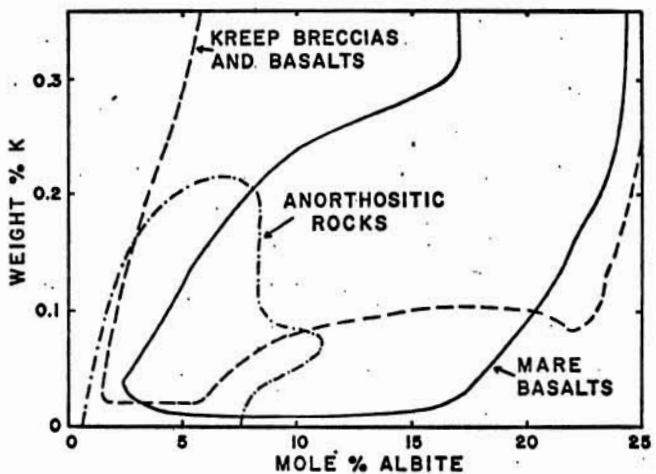


FIG. 1. WT. % K VS MOLE %  $\text{NaAlSi}_3\text{O}_8$  FOR THE THREE PRINCIPAL TYPES OF LUNAR ROCK. THE FIELDS WERE CONSTRUCTED FROM ANALYSES OF FELDSPARS IN ROCKS AND LITHIC FRAGMENTS.

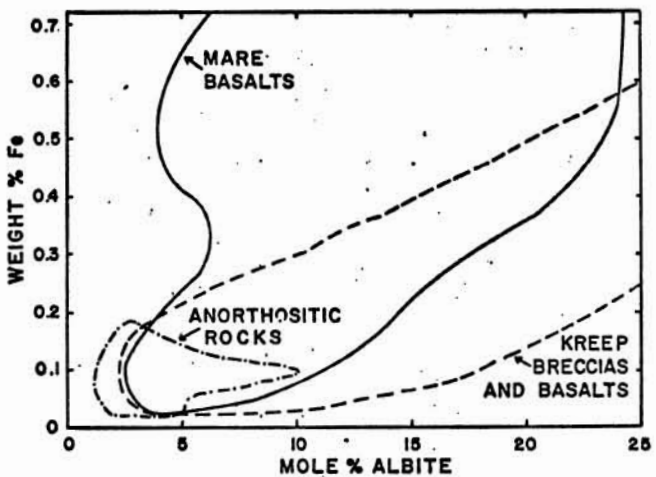


FIG. 2. WT. % Fe VS MOLE %  $\text{NaAlSi}_3\text{O}_8$  FOR THE THREE PRINCIPAL TYPES OF LUNAR ROCK. THE FIELDS WERE CONSTRUCTED FROM ANALYSES OF FELDSPARS IN ROCKS AND LITHIC FRAGMENTS.

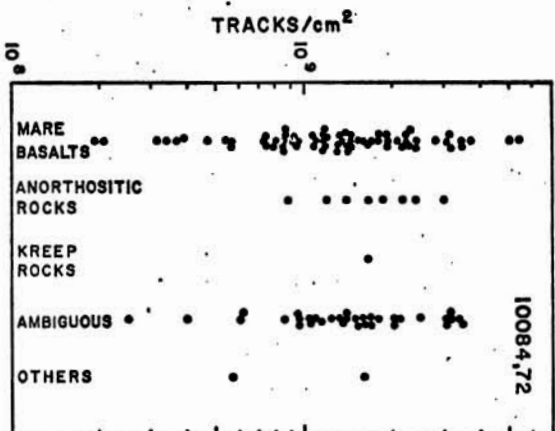


FIG. 3. TRACK DENSITIES IN LITHOLOGICALLY-CHARACTERIZED PLAGIOCLASE CRYSTALS FROM APOLLO 11 SOIL 10084, 72.

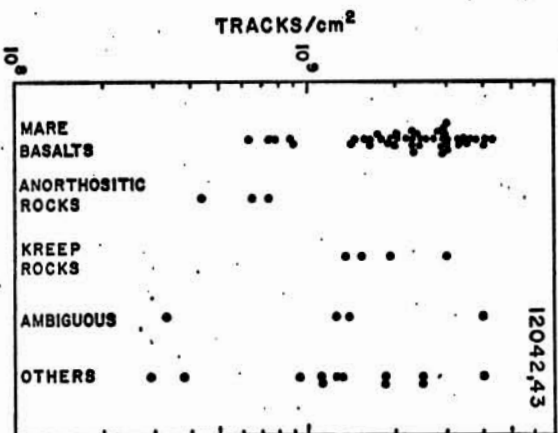


FIG. 4. TRACK DENSITIES IN LITHOLOGICALLY-CHARACTERIZED PLAGIOCLASE CRYSTALS FROM APOLLO 12 SOIL 12042, 43.