SURFACE HISTORY OF SOME APOLLO 17 LUNAR SOILS,

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The long and complex surface history of lunar soil may be divided into two periods: (A) The time prior to final re-arrangement and deposition, and (B) the subsequent period of time that a layer is exposed at the surface before either being collected or being covered by another layer. The history of the former period can be derived only in a statistical manner by considering the distribution of track densities and track density gradients in many individual grains and correlating these observed distributions with the calculations of the effects of soil excavation, redeposition, and mixing (1-3). The second period can be measured if grains are identified that have acquired their tracks at known depths only since the layer gives an upper limit for its exposure time (4-6). It is also worth noting that if track erasure occurs as a soil is deposited, either by heating (7) or shock-induced deformation erasure (5,6), the minimum track density gives the actual surface residence time rather than an upper limit.

Separate work shows empirically the effect of shock on track densities in rock. Shock supplied by a 5 kiloton nuclear explosion was used as an analogue to the shocks produced by hypervelocity impacts on the lunar surface. Within 5 meters of the impact all tracks were removed, and partial erasure extended to more than 40 meters (8).

All procedures, both experimental and analytical, are the same here as those described in our earlier paper (6). The reader is referred to that paper for detailed discussion of the reasoning used and the specific cosmic ray production rates assumed.

Data on three distinct layers that extended from 0 to 2 cm, 2 to 7 cm, 7 to 17 cm depths at Van Serg Crater fit a model in which the 7-17 cm layer was exposed for 5 m.y., then covered by the 2-7 cm layer; exposed for 8 m.y., then covered by the top layer, and exposed for 11 m.y. up to the present. The sum of the three exposure times--24 m.y.-- implies an average deposition rate of 0.7 cm/m.y, somewhat higher than the 0.3 to 0.4 we have observed in soil columns from Apollo 12 and Apollo 15 (6,9,10), but consistent with the inherent variability to be expected from the effects of random impacts on the moon. The surface exposure of 11 m.y. for the topmost layer is consistent with the inference by O'Kelley et al. (11) that the exposure lasted at least a few million years, since the ^{26}Al was saturated in this sample.

The median track densities imply long exposures of typical grains at depths greater than a few mm, approximately 60 m.y. (averaged over depths to 15 cm) for 79261 and 79241, and 300 m.y. for 79221. As in the case of the Apollo 12 core, we therefore infer a long pre-irradiation period prior to final deposition, with most of the tracks having been formed during that earlier time.

Data from Station 5 soils 75061, 75062, and 75081 from on or near rock 75775 at Camelot Crater give a surface exposure age of 36 ($\pm$ 4) m.y., the time since that top soil layer was deposited. The surface exposure of 36 m.y. is a lower limit for the surface exposure of the boulder (75075) and of Camelot Crater, on whose rim it rests. The track densities in skim sample 75062 suggests that it may contain some grains scoured from the boulder (75075), which presumably had a less extensive cosmic ray irradiation than the soil with which it was showered.

ALSEP site soil sample 70180 is an intensely irradiated soil from adjacent to the heat flow and neutron flux measurements. The minimum track density implies a surface exposure in the top 5 cm of 100 m.y., similar to the exposure of 75081 at Camelot.

Astronaut Schmitt interpreted the 7 cm-thick, gray topsoil at Van Serg as a darker mantling material that overlays a lighter colored soil ejected from Van Serg at the time of its formation (12). If we accept this interpretation, the total exposure time since the lighter soil was laid down, 24 million years, is then the time since Van Serg was formed. Since we inferred that only 5 million years passed till this soil was covered over, the alternate interpretation-that the top soil is the Van Serg ejecta-would give an age of 19 million years. Either value is compatible with the ALGIT conclusion (13) from field stratigraphy that the formation of Van Serg was contemporaneous or slightly more recent than that of Shorty, which they quoted as 25 million years and we inferred to be 28 ($\pm$ 8) miliion years (6).

The 36 million year age of the samples at Station 5 is much younger than the $\sim 10^9$ year stratigraphic age of Camelot (13) and hence presumably represents the time of some local, smaller scale event such as the single 4 to 5 m crater noted in the block field of Camelot (12).

Since soil 70180 at the ALSEP site is not clearly identified with any particular impact, it is not possible to attribute its 100 million year surface age to any specific event. The exposure time is however close to that for the deeper sample at Camelot (75081), so that the same unidentified impact could have deposited both soils.

It should be noted that self-consistencies are evident that support the assumptions upon which track surface-soil exposure ages are derived. These are firstly that track erasure is abundant (as has been extensively documented) and secondly that soil layers are not normally stirred throughout their depths by micrometeorites after deposition. This agreement in surface ages between the soils and rock samples from Plum Crater (6,14) is one example. Others are the concordances of track and radiometric exposure ages for the orange soil and South Ray Crater (6) and between track and stratigraphic ages for Van Serg, as noted here. It is reasonable that whatever fine scale micrometeorite stirring takes place in surface layers is (statistically) confined to the top of a layer, so that grains at the base

SURFACE HISTORY OF APOLLO 17

R. L. Fleischer

of a freshly deposited layer usually stay there. They therefore accumulate tracks at the rate characteristic of the base of the layer, as we have assumed.

We are pleased to give thanks to W.R. Giard and E. Stella for experimental assistance. This work was supported by NASA under contract NAS 9-11583. One of us (RLF) extends his thanks to the National Center for Atmospheric Research for its hospitality during the final preparation of this work.

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