SURFACE IRRADIATION AND EVOLUTION OF LUNAR REGOLITH,
Narendra Bhandari and Jeetendra Goswami, Tata Institute of Fundamental Research, Colaba, Bombay-5.

Samples from the Apollo 16 regolith have been examined with a view to determine the finer details in irradiation patterns due to cosmic ray nuclei. Crystalline grains, mostly feldspars, were studied for fossil tracks using standard techniques (1, 2). Results are given in Table 1.

Data obtained from Apollo 16 surface samples as well as those obtained earlier for Apollo 12, 14 and 15 core and scoop grains are discussed in terms of a simplified model of mixing due to micrometeoroid bombardment. Based on this linear excavation model, the expected variation of the parameter N_H/N, the fraction of grains irradiated on the surface, as a function of exposure time, has been determined using the micrometeoroid crater formation rates of Horz, Hartung and Gault (3) observed for lunar rocks.

The results of these calculations are plotted in fig. 1a. For a variety of reasons, e.g. simple assumption made, these calculations are not rigorous, nonetheless, they show that the point of inflection in N_H/N is expected to be a sensitive function of micrometeoroid impact rate. The observed values of N_H/N in Apollo 12, 14, 15 and 16 soil scoops are plotted in fig. 1b. The exposure times used here are those based on the quartile method (1) of Arrhenius et al. (1970). The curve in fig. 1(b) indicates that N_H/N starts saturating after an exposure time of about 20 m.y. for a 3 cm deep scoop. We can conclude that the impact rates have not varied appreciably during the last 100 m.y. or so and have been similar at all Apollo sites.

The same model indicates that for various horizons observed in different Apollo cores, (N_H/N) xd, where d is the layer thickness, should be a linear function of time till saturation occurs ($N_H/N = 1$), provided each layer is well mixed within itself. These assumptions seem to be borne out by the observations (fig. 1d) in Apollo 15 core stem 15002; this drill stem was laid down 500 m.y. ago. The case of Apollo 12 core 12025, 28 (fig. 1c) shows significant departure from linearity. One of the factors responsible for it could be an incomplete mixing within the layer, which in turn would reflect smaller rate of micrometeorite influx. Fossil track

studies in core samples representing irradiations at different times in the past should be able to resolve this question.

We have also examined fossil tracks in glassy fragments in Apollo 15 breccia 15426 and soil 15302, both collected from station 7. The data are presented in fig. 2. They suggest that processes responsible for formation of breccia rocks could be very mild resulting in only slight or no annealing of tracks. Surprisingly, no surface irradiated spherules or fragments i.e. those characterised by steep track density gradients were observed in either of these samples, although they are found to occur in other soil samples. The track density in the soil sample, on the average, is about 10 times higher than that in breccia. Our results on the breccia are in agreement with those reported by Fleischer et al. (5). These two samples are also exceptions to the general behaviour we have observed in various soil samples where the glass content (agglutinates) seems to increase with the exposure age of the sample. If therefore appears that these samples, may have had a complex formation and irradiation history.

In case of Apollo 16 surface soil samples, the calculated exposure ages are found to vary between 4 and 100 m.y. The Buster crater appears to be rather young. The North ray crater ejecta has an exposure age exceeding 100 m.y.

References:

1. G. Arrhenius et al, Proc. Second Lunar Sci. Conf. 3 (MIT Press) 2583 (1971)

2. N. Bhandari et al, Proc. Third Lunar Sci. Conf. 3(MIT Press), 1972.

3. F. Horz, et al. (1971), J. Geophys. Res. 76, 5770.

4. D.S. McKay et al. Proc. Third Lunar Sci. Conf. 3(MIT Press), 1972

5. R.L. Fleischer et al. The Apollo 15 lunar samples, LSI, 368. 1972

SURFACE IRRADIATION AND EVOLUTION OF LUNAR REGOLITH

Bhandari et al

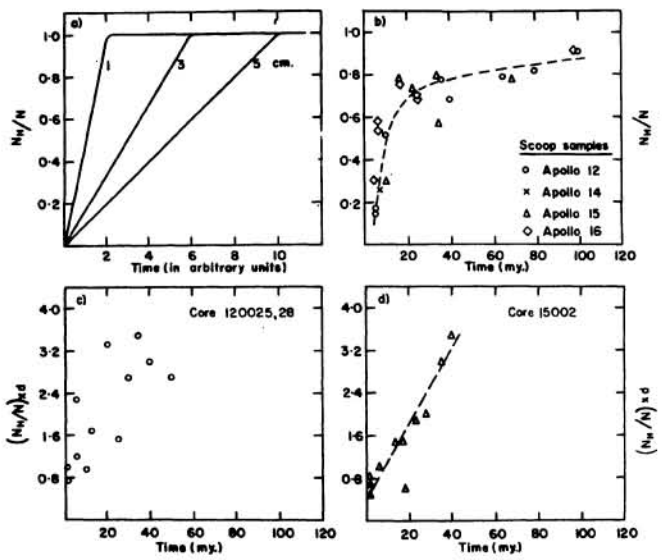

Fig 1

Fig. 1

(a) The increase in the fraction of surface irradiated grains (N_H/N) with exposure time for various mixing depths (1, 3 & 5 cms) as determined on the basis of a simplified linear excavation model.

(b) Observed values of the ratio N_H/N in Apollo 12, 14, 15 and 16 surface samples of various exposure ages.

Experimental data for Apollo 12 and 15 cores are given figs. (c) and (d).

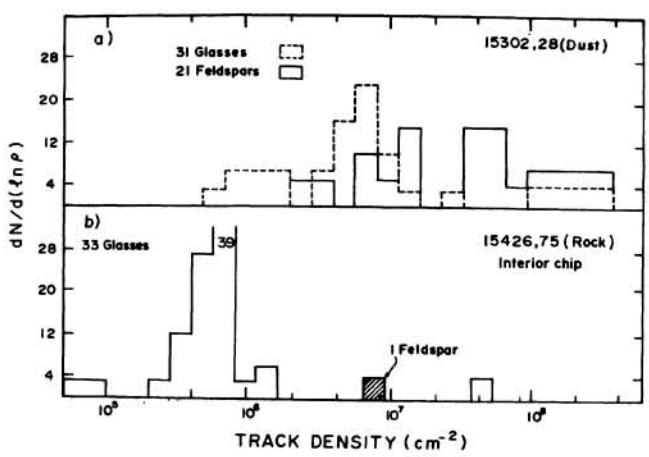

Fig 2

Fig. 2: The frequency distribution ($dN/d\ln\rho$) for glasses and feldspar crystals. Data are for soil 15302, 28 and rock 15426, 75 samples, both collected from station 7.