SEARCH FOR LOW ENERGY (10 \leq E \leq 300 \text{ keV/amu}) NUCLEI IN SPACE: EVIDENCE FROM TRACK AND ELECTRON DIFFRACTION STUDIES IN LUNAR DUST GRAINS AND IN SURVEYOR III MATERIAL.

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There is evidence based on the recent work of space "probists" for the existence of an intense flux of low energy nuclear particles in space (1), with energy smaller than 300 keV/amu. Furthermore in 1970, "trackists" at Toulouse discovered very high track densities exceeding 10^{10} tracks/cm^{2}, in micron-sized lunar dust grains observed directly with a high voltage electron microscope, and they attributed these tracks to low energy solar nuclei (2).

In this short paper we describe several new methods, based on track and lattice disorder observations, and developed to ascertain or disprove the existence of these nuclei in the ancient solar radiation.

We study tracks by using combined 1 MeV, 100 keV and scanning electron microscopies. With the 1 MeV microscope we are attempting: 1. to determine directly the track length distribution in the finest lunar dust grains, by applying a new stereoview technique; 2. to search for steep superficial track density gradients, in ultra-thin sections obtained by cutting 200 Mesh lunar grains, as well as flakes from the protective paint from the Surveyor III Spacecraft, with an ultramicrotome - such gradients constitute a characteristic "signature" for low energy ions (E \leq 0.5 \text{ MeV/amu}), with short penetration in matter; 3. to establish any possible correlation between the proportion of micron-sized dust grains with track density \rho \geq 10^{11} \text{ tracks/cm}^{2}, and that of grains coated with very thin layers of amorphous material, produced by an "ancient" solar wind implantation (3). With the 100 keV microscope we are examining the replica of very slightly etched sections of various materials, including 200 Mesh lunar dust grains and Surveyor paint flakes, in view of also detecting very steep superficial track gradients. Finally, with the scanning electron microscope, we particularly measure the proportion of 200 Mesh grains, with \rho \geq 10^{9} \text{ tracks/cm}^{2} at the center of the grains (this quantity essentially
depends on the irradiation of the grains in solar flare cosmic rays). The results so far obtained are: 1. the ultra-thin sections of the Surveyor paint are well adapted for a high voltage electron microscope observation of latent tracks, as the paint is made of 100% of mineral grains, with \( \sim 10\% \) of the grains giving very good dark field micrographs; 2. the observation of slightly etched external flakes from the Surveyor paint, give evidence for very high densities (\( \sim 5 \times 10^9 \) tracks/cm\(^2\)) of short tracks, registered at depths \( \lesssim 1 \) micron in the surface exposed to the Sun; 3. preliminary measurements subject to considerable revision - of the track lengths in micron-sized lunar dust grains, indicate that \( \sim 50\% \) of the tracks are shorter than the thicknesses of the grains; 4. in a given dust sample, the proportion of micron-sized grains with \( \rho \gtrsim 10^{11} \) tracks/cm\(^2\), seems to be only correlated to that of coated grains and not to the proportion of 200 Mesh grains with \( \rho \lesssim 10^9 \) tracks/cm\(^2\); 5. the 100 keV replica show frequently a sudden drop in the track density at depths \( \lesssim 2 \) microns (figure 1). Therefore these track observations, although very preliminary, still support the existence of low energy nuclei in the ancient solar radiation, but calibration experiments should now be conducted to check definitively the validity of this conclusion.

The 1 MeV electron diffraction search for high doses of low energy ions, implanted in the superficial layers of lunar dust grains, was attempted during a study of the lattice disorder observed in the finest grains from various dust samples (Luna 16-19, 10084, 12070, 14259, 15101), as well as in grains artificially irradiated with 20, 50 and 100 keV alpha-particles. Our main results are 1. low energy alpha-particle fluxes as low as \( 10^{16} \) a/cm\(^2\), produce a clear decrease in the total number of diffraction spots, \( \Sigma_s \), as well as a diffuse electron scattering, superimposed on the diffraction spots; 2. low values of \( \Sigma_s \) were measured in grains extracted from the Luna 16-19 and 14259 samples (figure 2); 3. a very intense diffuse electron scattering was observed in sample 15101; 4. These "disorder" features, appearing in the electron diffraction patterns of the natural dust grains, were generally strongly reduced in grains either heated 2 hours at 900°C, or slightly etched in a very dilute HF solution. From these results we conclude that both the diffuse scattering and the decrease in \( \Sigma_s \) observed for the natural dust grains, could partly be due to their irradiation in high fluxes of low energy ions, producing a shell of radiation damaged matter that do no extend completely to the center of the micron-sized lunar dust grains.

References

1. L. Frank, J. Geophys. Res., 75, 707 (1970); E. Stones, personal communication; see also the work of T. Armstrong and S. Krimigis, to be published in the Proceeding of the NASA Conference on
"Modern and ancient energetic particles from the Sun", to appear shortly in Physics to Day.
