SOLAR-WIND IRRADIATION EFFECTS ON ILMENITE. G. E. Blanford, University of Houston at Clear Lake City, Houston, TX 77058.

Blanford et al. have reported observing 0.5-1.0 μm lunar grains with a bumpy surface texture. They attributed this texture to result from solar wind radiation damage and hypothesized that the bumps may be iron droplets from the chemical reduction of iron-rich minerals by solar-wind implanted hydrogen. In order to test this hypothesis we have simulated solar-wind irradiation of ilmenite grains. We can report at this time that the bumpy texture is a result of solar-wind implanted hydrogen, but we have not yet found evidence for droplets of iron forming on the surface.

Samples were prepared from crushed, terrestrial ilmenite. The crushed material was ultrasonically stirred in a fluorocarbon solvent and allowed to precipitate onto a copper electron-microscope grid covered with a holey carbon substrate. Ilmenite grains were identified using energy dispersive X-ray analysis and the grains were documented with scanning electron micrographs, transmission electron micrographs and selected-area electron diffraction patterns using a JEOL 100CX electron microscope. The samples were irradiated with a Denton model DB-1 ion-gun using either hydrogen or helium as the operating gas. Hydrogen and helium irradiations used a nominal accelerating potential of 4 kV and 8 kV respectively resulting in an ion velocity of 550 km/sec. Irradiated samples were reexamined in the electron microscope.

Figure 1 shows electron micrographs of an ilmenite grain before and after irradiation with hydrogen. Comparing Fig. 1a and 1b, we can clearly see the resulting bumpy surface texture caused by the hydrogen irradiation. Had we irradiated with helium, the grain would have simply eroded smoothly as a result of sputtering. This fine-grained texturing, however, is distinctly different from the coarser texturing on lunar ilmenite grains. As a result of this finer texture, the opaque dots seen on transmission electron micrographs of lunar grains are not as evident with the simulated grains (Fig. 1d). Also, the simulated grains become more amorphous as a result of irradiation whereas the lunar grains appear to retain a higher degree of crystallinity. This may be associated with the higher rate of irradiation received by the simulated sample. So far, all reflections in the electron diffraction patterns appear to be associated with ilmenite. Although we will try to investigate this further in order to rule out the formation of reduced iron, we presently believe that the bumps are regions of amorphous ilmenite probably with hydrogen atoms in interstitial positions. Perhaps an appropriate description of this bumpy texture would be blistering.

We conclude that bumpy texturing seen on iron-rich lunar grains is the result of the solar-wind implantation of hydrogen. At the present, we do not understand why this phenomenon is preferentially associated with mafic minerals.

Results from Monte Carlo calculations give the average exposure of lunar micron-sized grains to the solar wind on the order of $10^3$ y (2). Assuming that this is the typical exposure time for the mafic mineral grains which have a bumpy texture, this phenomenon provides a coarse time index for exposure to the solar wind. Therefore, blistering on certain types of interplanetary dust grains will indicate an approximate lower limit to free-space exposure or the lack of blistering will indicate an approximate upper limit to free-space exposure. Further efforts to quantify this effect may permit accurate dating of free-space exposure of the interplanetary dust grains.
References:

Figure 1. Electron micrographs of an ilmenite grain. The marker in each photograph measures 0.1 \mu m. (a) A scanning, secondary electron image before irradiation with hydrogen and (b) after irradiation. (c) A transmission electron image before irradiation with hydrogen and (d) after irradiation.