SPUTTER EROSION ON THE LUNAR SURFACE: MEASUREMENTS AND FEATURES UNDER SIMULATED SOLAR He^+ BOMBARDMENT

J.A.M. McDonnell, R.P. Flavill, University of Kent, Canterbury, England.

In a program to identify features and evaluate the relative importance of microscale erosion on the lunar surface, we have experimentally investigated hypervelocity impact, thermal cycling and solar wind ion sputtering. Results of the hypervelocity impact and thermal erosion experiments have been reported elsewhere (ref. 1 and 2). Impact craters are not substantially different from those on terrestrial materials and in subsequent thermal cycling experiments no further degradation was observed. We now report on extended measurements of the sputter experiments:

The source comprised an R.F. excited plasma bottle using analytical grade Helium at an extraction energy of 2.5 KV, commensurate with a solar wind velocity of 400 Km/s. The integrated beam current was 80μA and the maximum current density 240μA/sq. cm. Measurements were performed on polished sections of sample 14321.148 and on quartz reference surfaces on which hypervelocity impact craters had been formed. Surface charge neutralisation was achieved by a 'flood' of low energy electrons. Both the effective sputter rate (i.e. the erosion required to erase a feature of certain depth) and the absolute sputter rate were measured. From the latter measurement, the ion sputter yield can be deduced. A depth of 20μ was eroded in total.

Features observed on impact craters under simulated solar wind erosion are

1) a preferential loss of material from the rim of the primary hypervelocity crater.

2) preferential etching of spall zone faults

3) an increase of the crater dimension prior to erasure, and

4) that an absolute erosion of greater than the crater depth is required for erasure. Preferential etching of the crystalline boundaries of the polished section is also very evident, where V shaped notches are formed delineating grains over which uniform sputtering is observed. Under heavier sputtering at a constant incidence angle, clusters of needles were formed indicating in these regions the sputter yield increases with high geometric inclinations to the incident beam. Computer models have also been developed to investigate

the modification of surface profiles under sputtering to understand more clearly the variety of observed features. Preliminary results are presented.

The absolute sputter rate on the lunar surface averaged over the lunar cycle deduced from these measurements is 0.043± .010 Å per annum. The equivalent ion yield ratio is calculated 0.31 atoms per incident ion. These measurements are somewhat higher than our first preliminary experimental sputter results, but still very much lower than the pre-Apollo estimates. They give excellent experimental confirmation of earlier predictions (ref. 3) of 0.021 Å/yr. In terms of the total microscale erosion the magnitude of the sputter mechanism is very much lower than micrometeorite impact erosion, but even this low sputter rate is very significant in determining the lifetime of sub-micron craters. Micrometeorite influx rates deduced from exposed lunar surfaces in sputter equilibrium (ref. 4) should be interpreted in the light of this new experimental measurement.

References

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