An Astronaut's Risk of Experiencing a Critical Impact from Lunar Ejecta during Lunar EVA

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ABSTRACT

The Moon is under constant bombardment by meteoroids. When the meteoroid is large, the impact craters the surface, launching crater ejecta far from the impact potentially threatening astronauts on the lunar surface. In the early 1960's, the ejecta impact flux was thought no more than the sporadic meteoroid flux but with speeds one to two orders of magnitude smaller. However, the Lunar Module designers realized by 1965 that meteoroid bumpers do not perform well at the smaller ejecta impact speeds. Their estimates of the Lunar Module risk of penetration by ejecta were 25 to 50% of the total risk. This was in spite of the exposure time to ejecta being only a third of that to sporadic meteoroids.

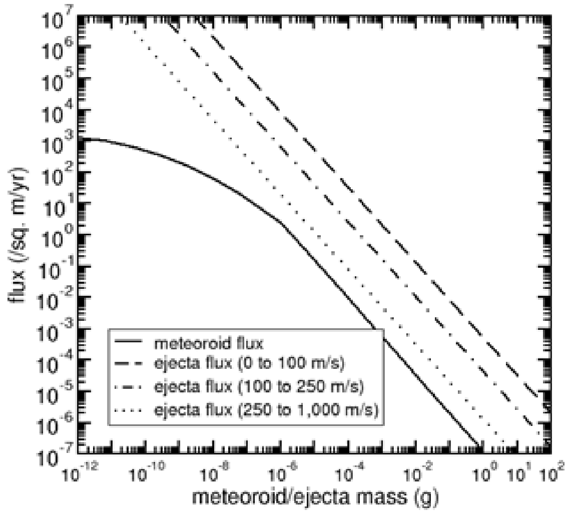

Figure 1 NASA SP-8103 Lunar Ejecta Flux at the Lunar Surface

The standard committee based the 1969 NASA SP-8013 lunar ejecta environment on Zook's 1967 flux analysis and Gault, Shoemaker and Moore's 1963 test data for impacts into solid basalt targets. Figure 1 shows the resulting flux curves for three impact speed bins. However, Zook noted in his 1967 analysis, that if the lunar surface was composed of soil, that the ejected soil particles would be smaller than ejected basalt fragments and that the ejection speeds would be smaller. Both effects contribute to reducing the risk of a critical failure due to lunar ejecta.

The author revised Zook's analysis to incorporate soil particle size distributions developed from analysis of Apollo lunar soil samples and ejected mass as a function of ejecta speed developed from coupling parameter analyses of soil impact-test data. Figure 2 is a plot of the resulting flux curves.

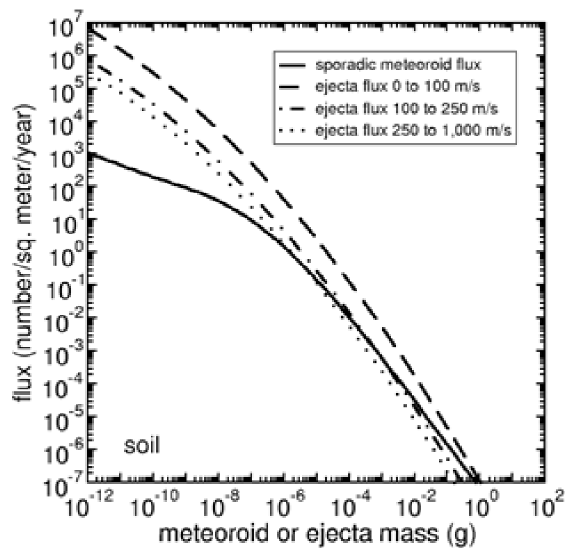

Figure 2 Ejecta flux from a lunar surface soil layer

The author estimated EVA risk by assuming failure occurs at a critical impact energy. At these impact speeds, this might be true for suit hard and soft goods. However, these speeds are small enough that there may be significant strength effects that require new test data to modify the hypervelocity critical energy failure criterion. With these caveats, Christiansen, Cour-Palais and Freisen list the critical energy of the ISS EMU hard upper torso as 44 J and the helmet and visor as 71 J at hypervelocity. The author then assumed that the lunar EVA suit fails at 50 J critical energy. This results in a 5,600,000 years mean time to failure using the *Figure 2* flux and a 10,000 years mean time to failure using NASA SP-8013.