LUNAR VOLATILES: MORE THAN MEETS THE EYE? William N. Agosto, Lunar Industries, Inc., Houston, TX 77259-0004

Because it may cost an average of $25,000 to deliver a pound of terrestrial volatiles to the lunar surface, an economic indigenous source of lunar volatiles will be in great demand for future lunar base operations. While the moon is proverbially volatile poor, 1000 ppm of combined absorbed volatiles of light species like H, He, C and N have been released from bulk lunar materials at 1000C (1). A major source of the volatiles is believed to be the solar wind which is predominantly hydrogen (2,3). Recalculated data of Gibson and Johnson (4) on lunar soil fines reveals that approximately 81% of the hydrogen is released below 600C (5). Accordingly, lunar fines may prove to be a significant source of volatiles for space industrial utilization (6).

Just in terms of the known hydrogen abundance of 150 ppm absorbed in the sub 20 micrometer size fraction of lunar soil (7), there is enough hydrogen, at 75% recovery from the top meter of regolith over the entire lunar surface, to make (when combined with lunar oxygen) an all-lunar water lake of over 1000 square kilometers at ten meters depth. The question of the most efficient method of extracting lunar soil volatiles has to be addressed in the context of concentrating other valuable lunar surface materials like oxides, metals, glasses and ceramics (8,9).

Lunar volatiles may, in fact, be much more abundant than is generally believed. Frank et al. (10), in a very controversial paper, have interpreted transient holes appearing at the rate of 20 per minute in the ultraviolet day glow of the earth as due to low density ice comets (0.1 g/cm^3) each approximately 100 tons in mass and consisting primarilly of water, carbon and dust that impact the earth's upper atmosphere. The authors predict relatively low speed impact (<10 km/sec) of these bodies on the moon. If they are correct, their estimate of the lunar infall of such comets at the rate of 300 per day (11) amounts to about 10^7 tons of impacting volatiles on the lunar surface every year. If only one part per million of that material random walks to the lunar poles and is trapped in permanently shadowed craters it would amount to a volatile deposit of ten tons per year. Such a continuous influx could, of course, add up to billions of tons of volatiles at the lunar poles over geologic time. This radical hypothesis has naturally attracted a storm of cricism (12,13,14) chiefly to the effect that it increases the extraterrestrial material influx many orders of magnitude above what has been traditionally observed in the cislunar environment and that lighter masses at far lower impacting energies like the spent Saturn IV booster (14 tons at 2.5 km/sec) have been detected by lunar seismometers while nothing like the proposed comet influx has been detected by the same instruments. In response to the objections Frank et al. have pointed out that the mechanical competence (tensile/compressive strength, elastic limit, etc.) of the postulated comets is orders of magnitude below the stony meteoroid and Apollo hardware influx that have been seismically

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detected and that, as a consequence, the thermal/mechanical partitioning and mechanical modes of the impacting comet energies are outside the detection limits of the lunar seismometers. They also point out that lunar seismic detection of the influx of bodies >1 ton is four orders of magnitude below that inferred from the frequency of incoming fire balls detected on earth by the Prairie Network (11). From the lunar volatiles perspective, it might also be noted that transient gas bursts, traditionally ascribed to volcanism, have been detected with some regularity on the moon without corresponding seismic records (15,16,17). Accordingly, the hypothesis of Frank et al. is still very much an open question.

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