SURFACE SCIENCE CONSTRAINTS TO REGOLITH MODELS. Raúl A. Baragiola and Catherine A. Dukes, Laboratory for Atomic and Space Physics, University of Virginia, 395 McCormick Road, Charlottesville, VA 22904 (raul@virginia.edu, cdukes@virginia.edu).

Introduction: Much of what we know about airless bodies in the solar system comes from observation of their surface or surface processes. From observations come hypotheses or models that, in favorable cases, can be constrained by additional observations on returned samples. Here, we show that other useful constraints arise from the extant knowledge of surface science processes occurring in other fields of research and technology.

Surface charging: Exposure to the interplanetary radiation environment produces electrical charging of surfaces by electron ejection (by photons, ions or electrons) or by implantation (electrons, ions). While the charging of dust can be inferred by observation with dust sensors we do not have direct information on surface potentials of regoliths.

It has been proposed that lunar transient events, such as the lunar horizon glow, are caused by levitation of charged grains from the surface [1,2]. Other hypotheses include electrical effects of rock fracture and venting of sub-surface gas. While electrostatic levitation has been observed under special laboratory conditions [3], it is not clear that it can occur on the Moon or on asteroids [4]. Grain charging can, rather, result in enhanced adhesion, through induced image forces with neighboring grains. Levitation requires the grain and grains below it to have charge of the same polarity and of enough magnitude to overcome adhesion forces and gravity.

Charging of heterogeneous surfaces depends on location, since electron emission yields depend on the microscopic properties of the surface grain(s) and the retention of the charge on the electrical conductivity of the surroundings. Heterogeneity in composition should result in inhomogeneous surface charging, with local electric fields, even if the net charge of the surface is zero. This, in turn, will cause increased adhesion.

Differential charging is seen in the laboratory in photoelectron emission experiments, which measure the electrostatic potential of the ejected photoelectron.

Effects of electric fields on ion migration: Ions, such as Na, in glasses drift under electric fields, and therefore their surface concentration can be enhanced or depleted by negative or positive surface charging. [5] The surface concentration is of paramount importance in determining whether a particular atom can contribute to the exosphere by sputtering or photodesorption [6]. Thus, in addition to its possible role of charging in the injection of dust into the lunar exosphere, charging may also be linked to the variability of exospheric Na with time of day and the Moon's passage through the Earth's magnetosphere.

Formation of water: Water can be formed by combining implanted solar wind protons with oxygen in lunar soil. The question of how *likely* this effect is was renewed by recent observations of ~3 µm structure in infrared spectra of three different spacecraft [7-9]. The fact that such structures were not observed by previous studies using Galileo and Clementine [10] remains unexplained. In our laboratory, careful *in situ* studies of proton irradiation of minerals [11] found no evidence for the amounts of water required to explain the 2009 reports. The LCROSS finding of ice on the lunar poles suggest that the origin of global surface water could be ejecta from the ice in cold traps. In addition, surface water may originate from sub-surface water deposited by accumulated cometary impacts. Water molecules released by meteoritic or ionic impact, or thermal desorption, will hop across the lunar surface by surface-exosphere diffusion assisted by photodesorption and sputtering, in a non-random walk affected by temperature and solar exposure.

Returned samples and lunar simulants: It is important to note that ion irradiation denatures minerals in a surface region corresponding to the depth of penetration, transforming the samples into amorphous glasses with significant oxygen depletion [12]. This occurs on lunar rocks and grains, producing the amorphous layers of exposed surfaces. Therefore, simulation of surface processes in the laboratory using lunar simulants must include ion irradiation as part of the study, not only to eliminate atmospheric contaminants such as the ubiquitous hydrocarbons and water molecules, but also to alter the surface by amorphization, ion implantation and preferential sputtering.

Although actual lunar grains have been processed by the solar wind, exposure to contaminant water even in 'dry' environments is likely sufficient to partially replenish the surface oxygen and partially erase space weathering. In addition, water reacts with radiation damaged surfaces, altering surface composition, as seen in the exceptionally fast depletion of Mg from irradiated olivine after immersion in water, or even after exposure to atmospheric humidity [13]. Strong cation depletion has recently been observed in simulations of space weathering in forsterite, augite, albite and anorthoclase [14]

Conclusion: Viewing lunar science from the perspective of surface science allows specific identification of potential processes in the complex interaction of airless bodies with their environment. Such processes should considered when establishing protocols for laboratory simulations or curation of returned samples.

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