COMPOSITION-DEPENDENT SIMULATED SPACE-WEATHERING EFFECTS ON HYDROXYL INTERACTIONS ON SILICATE FILMS

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Interactions between micrometeroites and the solar wind with regolith at the surface of airless bodies (or space-weathering) has gained increased traction in planetary science due to an increasing emphasis on human exploration beyond Lunar orbit, and clear observations demonstrating the presence of OH/H_2O species on the moon. Recently, colleagues from the REVEALS team provided a course-grained, semi-empirical kinetics model to track the formation and migration of OH/H_2O across the surface of the moon on the basis of variations in surface temperature and the rate of proton implantation by time of day and latitude. This model reasonably reproduces a number of observations indicating increased accumulation of OH groups at higher latitudes on the basis of variation in the kinetic competition between proton implantation OH-formation, recombinative desorption of H_2O, and subsequent dissociative readsorption of OH as a function of latitude. Key to achieving agreement between the model and observation is the presence of OH groups at regolith sites with recombinative desorption energy barriers low enough to overcome at typical daytime Lunar temperatures, which is something that depends greatly on mineral composition, structure, and relative OH coverage.

To help decouple the relative importance of highly complex and heterogeneous ensemble effects present at Lunar interfaces, and typical simulants thereof, we have made use of two atomically-planar and single-crystalline silicate thin-films of deliberately varied composition and structure. Using these films [bilayer SiO_2/Ru(0001) and $Al_{0.33}Si_{0.67}O_2$/Ru(0001)], we investigate the specific mineralogical importance associated with controlled variation from a pure silica form into an integrated aluminosilicate on the resultant interactions with water and hydroxyl species; both with and without exposure to electron excitation sources, which members of our group have previously shown to provide another pathway for the reintegration of water into silicates as OH groups. Previous results have indicated an apparent discrepancy in the nature of the bridging Al-OH-Si sites in the aluminosilicate films: (i) By Infrared reflection-absorption spectroscopy (IRAS), these hydroxyl groups show evidence of more facile recombinative desorption relative to isolated silanol groups present at the interface of the pure silica films. (ii) Previous temperature programmed desorption (TPD) results focusing primarily on the desorption of molecularly bound, pore-penetrating water, show no evidence of the lower temperature recombinative water desorption inferred by the temperature-dependent signal attenuation in the corresponding IRAS measurements, but also fail to account for smaller concentrations of isolated silanol groups known to produce TPD signatures at higher temperatures. Results from our TPD/XPS study will clarify this discrepancy in the thin-film silicate literature, and, in doing so, will help establish a firmer understanding for the relative difference between the expected water cycling behavior exhibited by Al-OH-Si and Si-OH sites present in regolith structures.