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Imaging the South Pole - Aitken Basin in Backscattered Energetic Neutral Hydrogen Atoms

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The Moon, not being protected by a global magnetic field or an atmosphere, is constantly bombarded by solar wind ions. Until a few years ago, it was tacitly assumed that the impinging solar wind ions are almost completely absorbed (< 1% reflection) by the lunar surface (e.g. Crider and Vondrak, Adv. Space Res., (2002); Feldman et al., J. Geophys. Res., (2000)). Recent observations by IBEX and the Sub-keV Atom Reflecting Analyzer (SARA) onboard Chandrayaan-1 invalidated this assumption, though: In fact, these measurements showed that the lunar surface very efficiently reflects impinging solar wind ions as energetic neutral atoms (ENAs) (e.g. McComas et al., GRL, 2009; Wieser et al., PSS, 2009). Most recently, a global analysis of lunar hydrogen ENAs measured by SARA showed that on average 16% of the solar wind protons are reflected, and that the reflected fraction can range from less than 8% to more than 24%, depending on location (Vorburger et al., J. Geophys. Res., 2013). Whereas it is established that magnetic anomalies reduce the flux of backscattered hydrogen ENAs by screening-off a fraction of the impinging solar wind ions (e.g. Wieser et al., Planet. Space Sci., (2009); Lue et al., Geophys. Res. Lett., (2011); Vorburger et al., J. Geophys. Res., (2012); Futaana et al., Geophys. Res. Lett., (2013)), the effects of other surface properties such as porosity, roughness, chemical composition, and extent of weathering, was not known.

To investigate the effects of these surface properties on the properties of scattered ENAs, we conducted an in-depth analysis of ENA observations near the South Pole - Aitken basin using the complete dataset collected by SARA. The South Pole - Aitken basin is an ideal object for such a study, because it highly differs in many properties from the surrounding terrain. It is very deep ($\sim$13 km), possesses strikingly elevated concentrations in iron ($\sim$15 wt%) and thorium ($\sim$7 wt%), has a low albedo and coincides with a cluster of strong magnetic anomalies ($\sim$15 nT) located on the northern rim of the basin. We compare our ENA maps to these five different surface properties by analyzing five distinct regions within and adjacent to the South Pole - Aitken basin visually and by applying a statistical correlation function. Our analysis shows that whereas, as expected, the magnetic anomalies can account well for the observed ENA depletion at the South Pole - Aitken basin, none of the other surface properties influence the ENA reflection efficiency at a significant level. We therefore conclude that the integral flux of backscattered hydrogen ENAs is mainly determined by the impinging plasma flux (which in turn is governed by the magnetic anomalies located on the surface), and that ENA imaging of backscattered hydrogen captures the characteristics of the plasma at the surface.