ION PRECIPITATION OF THE LUNAR POLAR REGIONS FROM KAGUYA OBSERVATIONS.

P. S. Szabo[1] and A. R. Poppe[1], [1]Space Sciences Laboratory, University of California, Berkeley (szabo@berkeley.edu).

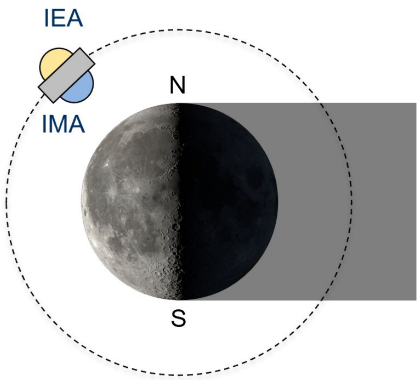

Figure 1: A sketch of the Kaguya mission. (Image credit: NASA)

Introduction: Due to limited illumination and low temperatures, the lunar polar regions are expected to contain a large number of sites that favor volatile accumulation [1]. Several remote observation studies have revealed increased water concentration or indications of water ice [2], and future exploration by VIPER and Artemis 3 will provide important findings there. In the formation and erosion of volatiles, ion precipitation represents a contribution that is still unclear. On one hand, solar wind protons will contribute to water formation on the Moon by hydroxyl or possibly direct formation of water [3,4]. On the other hand, the energy deposited by ion impacts will also induce sputtering as a contribution to volatile depletion, especially for heavy ions. Previous studies on ion fluxes into craters at the lunar poles focused on solar wind deviation [5] and non-ecliptic ion fluxes in Earth's magnetotail [6]. We now provide analysis of the ion flux measurements from JAXA's Kaguya orbiter and model the spatial distribution of ion fluxes that can be expected to precipitate different features in the lunar polar regions. The proximity to the surface and the mass resolution of some Kaguya measurements provides opportunities for additional insights compared to previous studies.

Kaguya Ion Data: Our study is based on the dataset of ion fluxes and magnetic field measured by the PACE and LMAG instruments aboard the Kaguya spacecraft [7]. Kaguya was operated between 2007 and 2009, monitoring the Moon's surface and its environment on a polar orbit of about 100 km altitude [8]. Its ion instruments included the Ion Energy Analyzer (IEA, always facing away from the Moon) and the Ion Mass Analyzer (IMA, always facing towards the Moon). While in the solar wind, IEA has a reduced sensitivity to prevent saturation, but this leads to underestimation of some ion fluxes. We thus combine the IEA data with an analytical description of the solar wind flux based on parameters of the OMNI dataset to reconstruct the full fluxes precipitating onto the lunar surface [9].

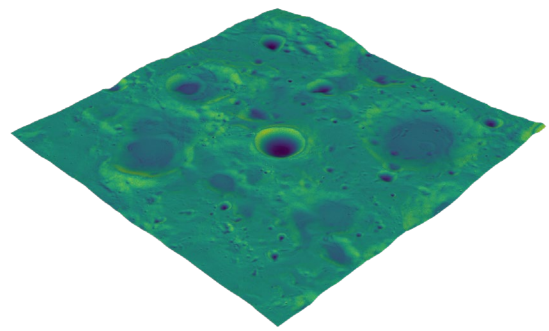

Figure 2: Local ion precipitation predicted for the lunar south pole.

Results: We compile the Kaguya data for the whole operation time of the spacecraft, tracing ions onto the lunar surface based on LMAG measurements of the interplanetary magnetic field (IMF) and the calculated solar wind convection electric field. Similar to previous findings, our analysis predicts incidence fluxes into the polar regions on the order of 10^{-3} to 10^{-2} of the solar wind flux. Using maps of the lunar topography from the LOLA laser altimeter aboard LRO [10], we then apply a ray-tracing code to map the ion fluxes onto the cratered landscape of the lunar north and south poles. These maps illustrate that most permanently shadowed regions are not completely shadowed from ion bombardment. Furthermore, they reveal regions of contrasting ion precipitation that might represent interesting sampling sites for better understanding ion-induced weathering of the surface.

References: [1] P. G. Lucey, et al., *Geochemistry* (2021), 125858. [2] S. Li, et al., *Proc. Natl. Acad. Sci.* 115.36 (2018), 8907. [3] C. Zhu, et al., *PNAS* 116.23 (2019), 11165. [4] L. Daly, et al., *Nat. Astronomy* 5.12 (2021), 1275. [5] D. Rhodes, et al., *Planet. Sci. J.* 1.1 (2020), 13. [6] Q. Nénon, A. R. Poppe, *Planet. Sci. J.* 2.3 (2021), 116. [7] Y. Saito, et al., *Spac. Sci. Rev.* 154.1 (2010), 265. [8] M. Kato, et al., *Spac. Sci. Rev.* 154.1 (2010): 3. [9] J. King, et al., *JGR Space Phys.* 110.A2 (2005). [10] D.E. Smith, et al., *Geophys. Res. Lett.* 37.18 (2010).