EGU21-1813
https://doi.org/10.5194/egusphere-egu21-1813
EGU General Assembly 2021

Quantifying Space Weathering of Phobos by Martian Planetary Oxygen Ions

Paul Stefan Szabo[1], Herbert Biber[1], Noah Jäggi[2], Markus Wappl[1], Reinhard Stadlmayr[1], Daniel Primetzhofer[3], Andreas Nenning[4], Andreas Mutzke[5], Jürgen Fleig[4], Klaus Mezger[6], Helmut Lammer[7], André Galli[2], Peter Wurz[2], and Friedrich Aumayr[1]
[1]Institute of Applied Physics, TU Wien, Vienna, Austria
[2]Physics Institute, University of Bern, Bern, Switzerland
[3]Department of Physics and Astronomy, Uppsala University, Uppsala, Sweden
[4]Institute of Chemical Technologies and Analytics, TU Wien, Vienna, Austria
[5]Max Planck Institute for Plasma Physics (IPP), Greifswald, Germany
[6]Institute of Geological Sciences, University of Bern, Bern, Switzerland
[7]Space Research Institute, Austrian Academy of Sciences, Graz, Austria

Recent modelling efforts based on MAVEN measurements suggest that the Martian Moon Phobos is affected by a unique space weathering scenario [1]. On rocky bodies in the solar system, mostly solar wind ions cause ion-induced space weathering of their surfaces. Space weathering is an important driver for the alteration of planetary surfaces [2], as well as for the creation of exospheres on, for example, the Moon or Mercury [3, 4]. As a consequence, most analog experiments aim to investigate effects by the impact of solar wind ions [5, 6].

Phobos is not only exposed to the solar wind, but also significantly sputtered by planetary oxygen ions originating from the Martian atmosphere due to its proximity to Mars [7]. O ions at energies of several 100s to several 1000s eV are responsible for the dominant erosion process on the surface of Phobos in the Martian magnetotail [1]. However, there still remain uncertainties as the sputtering by planetary O ions has not yet been investigated experimentally.

Here we present experiments on the sputtering of Phobos analog materials by O^+ and O_2^+ ions at different energies [8]. As analog material, thin films of augite $(Ca,Mg,Fe)_2Si_2O_6$ on a quartz crystal microbalance (QCM) are used. The QCM allows in-situ real-time sputtering experiments by measuring the sample's mass change [9]. Experimental sputtering yields are compared to simulations with the SRIM package and SDTrimSP [10, 11]. The latter has shown better accuracy for reproducing sputtering yields [6, 12], which is also found in the presented studies [8].

Oxygen ion irradiations of Phobos analog materials show fluence-dependent mass changes, indicating that both sputtering and O ion implantation in the near-surface region occur at the same time. The measurements can be consistently reproduced by dynamic SDTrimSP simulations that include O implantation up to local concentrations of 67%. The new experimental findings show that sputtering by O ions is about 50% lower than previously assumed. However, our

measurements still support the importance of sputtering by planetary ions in the Martian tail, where it will dominate over solar wind sputtering by up to a factor of 10 [8].

References

[1] Q. Nenon, et al., J. Geophys. Res.: Planets 124 (2019), 3385

[2] B. Hapke, J. Geophys. Res.: Planets 106 (2001), 10039

[3] P. Wurz, et al., Icarus 191 (2007), 486

[4] R.M. Killen, et al., Space Sci. Rev. 132 (2007), 509

[5] H. Hijazi, et al., J. Geophys. Res.: Planets 122 (2017), 1597

[6] P.S. Szabo, et al., Astrophys. J. 891 (2020), 100

[7] A.R. Poppe, S.M. Curry, Geophys. Res. Lett. 41 (2014), 6335

[8] P.S. Szabo, et al., J. Geophys. Res.: Planets 125 (2020), e2020JE006583

[9] G. Hayderer, et al., Rev Sci. Instrum., 70 (1999), 3696

[10] J. Ziegler, et al., NIMB, 268 (2010), 1818

[11] A. Mutzke, IPP-Report 2019-02 (2019)

[12] M. Schaible, et al., J. Geophys. Res.: Planets 122 (2017), 1968