H_2O formation process on the surface of Mercury unveiled by hydrogen ion irradiation to anhydrous minerals

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At Mercury and Moon, water molecules are created and dissociated from the surface materials via the thermal and non-thermal chemical processes driven by the solar photon and solar wind irradiations. The water supply from the surface materials is important for understanding the source of ice accumulated in the polar regions. Although recent studies demonstrated the existence of water ice in the polar regions at Mercury and Moon based on the neutron spectrometer and M3(Lawrence et al., 2013; Li et al., 2018), the source of the polar ice is still unknown. The solar wind hydrogen ion is a potential water source (Jones et al., 2020). However, the water creation process by the solar wind irradiation to the surface material of Mercury has not yet been demonstrated. This study demonstrates the water creation in Mercury's surface material by solar wind based on the hydrogen ion irradiation experiments to an Enstatite sample, which is an anhydrous silicate mineral similar to Mercury's surface composition. Absorption features of the hydroxyl groups or water were observed at around 3 μm in the reflectance spectrum of the Enstatite sample after irradiation of 6keV hydrogen ion with a fluence of about $10^{19}cm^{-2}$. In fact, based on the quadrupole mass spectrometer measurement, we found that the water vapor was released from the sample with a pressure of about 10^{-8}Pa during the hydrogen ion irradiation . Yield of water molecules by the hydrogen irradiation is estimated to be about 0.76/incident ion. If we assume that the water molecules are uniformly released from the day-side hemisphere of Mercury with the estimated yield of 0.76/ion, the water vapor of about 10^{10}kg is released through about 2 thousands years. Assuming that all of the released water condenses to the polar ice, the formation rate of ice is about 10^{7}kg/year.This is greater than the formation rate of polar ice about 10^{5}kg/year estimated by the previous simulations(Jones et al., 2020), suggesting that the solar wind irradiation is a significant source process of the polar ice.

References
Lawrence et al., 2013, Science, 339 (2013), pp. 292-296.
Jones et al., 2020, The Astrophysical Journal Letters, 891(2), L43.
Li et al., 2018, Proceed. Nat. Acad. Sci.-PNAS, 115 (36) (2018), pp. 8907-8912.

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