

Ionizing Radiation at the Martian Surface during Young and Current Sun

*Yosuke Alexandre Yamashiki¹, Hiroyuki Maehara², Vladimir Airapetian³, Yuta Notsu⁴, Tatsuhiko Sato⁵

1. Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University, 2. Okayama Branch Office, Subaru Telescope, National Astronomical Observatory of Japan, 3. NASA/GSFC, 4. Laboratory for Atmospheric and Space Physics, University of Colorado Boulder, 5. Nuclear Science and Engineering Center, Japan Atomic Energy Agency (JAEA),

The enhanced magnetic activity of the young sun was an important in the atmospheric evolution and dynamics of the early solar system. Lower solar luminosity associated provided planets a cooler atmospheric and surface environment on the early Earth and Martian surfaces and required production of potent greenhouse gasses in their atmospheres. Within these environments, the dose of ionizing radiation from solar energetic particles (SEPs) from the young Sun could have played an important role in the early phases of planetary habitability. Here, we present a theoretical model of the exposure of the early Mars to high fluence and hard spectra SEPs from the young sun by evaluating the possible magnitude and frequency of solar flares by using possible star spot area, derived from their rotational period. We evaluated annual and maximum flare energy in different cases of sunspot areas for 3%, 5% and 10% of their surfaces. The maximum dose at the Martian top of the atmosphere reaches $5.86 \times 10^3 \text{ Gy}$ ($2.65 \times 10^2 \text{ Sv}$) at the time when the sunspot area is -10% of the solar surface. Early atmospheric condition and possible hydrological cycles could have been affected by this strong ionizing radiation.

Keywords: Mars, Ionizing Radiation, Solar Flare