EPSC Abstracts
Vol. 13, EPSC-DPS2019-1690-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

The impact of mineralogical associations in weathering profiles (Al, Fe/Mg-rich clays and carbonates) on the radiation environment at Oxia Planum and Mawrth Vallis

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Abstract

The assessment of the radiation environment on Mars is of fundamental importance for estimating the potential for (past and present) habitability. Here, we present a Monte Carlo particle transport study of the radiation environment and doses at Oxia Planum, the landing site of the next ESA mission ExoMars 2020, and the previously considered Mawrth Vallis site, for: *1)* an average soil composition as inferred from Mars Odyssey Gamma-Ray Spectrometer/GRS data, and *2)* different mineralogical associations as in recently reported weathering profiles, given by a) Al-rich clays, b) Fe/Mg-rich clays, and c) each of them in combination with carbonates.

1. Introduction

Oxia Planum and Mawrth Vallis have recently attracted a big deal of attention, with Oxia being the selected landing site for the next ExoMars 2020 mission. The landing ellipse at Oxia Planum exposes a wide, layered, light-toned meters-thick clay unit, mainly explained with stable standing bodies of neutral/alkaline water in long term contact with basaltic parent material, capped by a later, amazonian-aged volcanic unit and the entire region has known intense erosion since these events [1]. Mawrth Vallis, a candidate landing site previously under scrutiny, is an ancient channel where circulation of water presumably mainly occurred through factures. The region has recently been shown to have a well preserved weathering profile [2].

The evolution of the radiation environment at Mars is of fundamental importance to extract trends on habitability. Such environment is constituted by both Galactic Cosmic Rays (GCRs) and Solar Energetic Particles (SEPs), the latter accelerated by intense flares and coronal mass ejections. radiation. GCRs are composed of 85% protons, 14% alpha particles, and a small fraction of heavy ions and electrons. In this work we will mainly consider GCRs.

1.1 Computational details

In this work, we have used the standalone dMEREM code (the ESA Mars Energetic Radiation Environment Model) [3], which contains Planetocosmics, a Geant4 tool for the transport of particles, and which is used for generating the full cascade in the atmosphere and the interaction with the soil. The European Mars Climate Database has been used in order to specify required atmospheric profile parameters. The surface topography is based on data recorded by the Mars Orbiter, Laser Altimeter/MOLA instrument. Both Solar minimum (January 2009) and Solar maximum conditions (January 2014) are considered. For the atmosphere, present conditions as extracted from the MCD database have been considered at first. We anticipate, if time allows, estimation of the qualitative evolution of the radiation environment on the basis of some preliminary past atmospheric scenarios, either from educated guesses or from atmospheric modelling tools [4,5] developed at the BIRA-IASB institute.

2. Composition of Martian regolith

For what concerns the regolith, when Fe/Mg-rich smectites are continuously exposed to water, the Fe and Mg ions are continuously removed from the molecular structure, leaving Al as the dominant cation. For carbonates, their detection in Martian weathering profiles has recently been reported [2], via analysis of CRISM L-detector data using a spectral signature exclusively attributed to the carbonates. This study [2] indicates a widespread distribution of weathering profiles with carbonates. Here we have considered different scenarios: the default basalt/andesitic-basalt composition augmented by information augmented by data from the Mars Odyssey Gamma-Ray Spectrometer, a regolith with Al-rich clay minerals, with a mixture of Al-rich clay minerals and carbonates, with Fe/Mg-rich clay minerals mixed with carbonates and with Fe/Mg-rich clay minerals.

3. Some preliminary results

Spectra of GCRs (protons and alpha-particles only) from preliminary calculations for the two sites for regolith in the default scenario are shown in Fig.1. The downward cascade is not affected by the different elevation of the two sites. For the backscattered radiation, some differences can be seen, in particular for alpha-particles (black circles in Fig. 1). This suggests that, already for the average regolith composition augmented by data from the Mars Odyssey Gamma-Ray Spectrometer, doses at the two sites can be different.

4. Summary and Conclusions

At the time of submission of this abstract, we have preliminary results and further calculations are ongoing. Nevertheless, the future analysis of the radiation environment at both Oxia Planum and Mawrth Vallis, for the different mineralogical scenarios here proposed, will shed light on trends of doses of importance to estimate habitable conditions.

Acknowledgements

This project has received funds from the Research Executive Agency under the EU H2020 RIA program (project ESC2RAD: www.esc2rad.eu, ID 776410)

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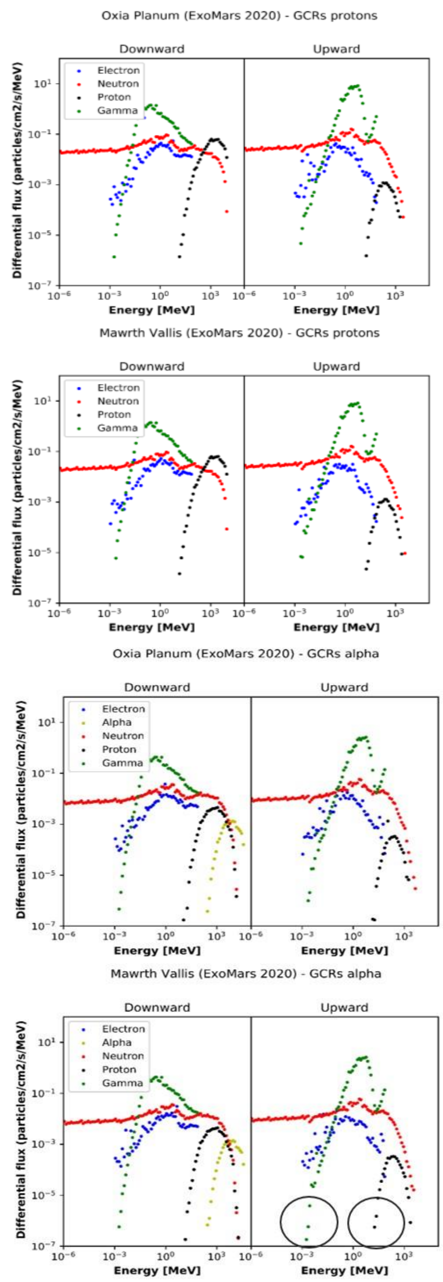

Figure 1: GRCs downward and backscattered radiation at Oxia Planum and Mawrth Vallis (period here is the declining phase of solar cycle 23)