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Modelling the surface and subsurface Martian radiation environment: Implications for Astrobiology

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The warm wet primordial Martian environmental conditions support the prospect of the development of native life. The damaging effect of ionising radiation is one of the prime limiting factors on the survival of life in such potential astrobiological habitats. Surface life on Earth is protected from solar and cosmic ionising radiation by a global dipole magnetic field and thick atmospheric column. Whereas primordial Mars is believed to have possessed a dense carbon dioxide atmosphere, and there is evidence from crustal magnetic anomalies that Mars had a global dipole around 4 billion years ago, present day Mars receives little shielding from cosmic radiation. The Martian topsoil is thought to have been rendered completely sterile by oxidising conditions created by UV radiation, but the penetration of energetic ionising particles, which are extremely damaging to life, exceeds this depth. We investigate the extent to which the Martian present and past atmosphere and various surface scenarios attenuate the radiation environment and the potential effect on the survival of life.

We have built a computer model of radiation penetration using Geant4, a simulation toolkit for particle physics. This Monte Carlo model tracks the propagation of primary particles, and the generated secondary cascades, through both the Martian atmosphere and three different surface scenarios (dry regolith, water ice, and regolith with layered permafrost) in order to calculate the particle spectra and microbial absorbed radiation dose as a function of depth underground. Both galactic cosmic rays (GCR) and solar energetic particles (SEP) over a wide energy range are considered. The persistence times of metabolically dormant cells or spores at different depths can then be calcu-

lated. Such analysis will be invaluable in the planning of sample-return missions. We will report results relevant to the question of planetary protection, life held dormant in regolith permafrost, and the possibility of deep subsurface life cryopreserved in the putative Elysium pack-ice.