EPSC Abstracts,
Vol. 4, EPSC2009-741, 2009
European Planetary Science Congress,

Implications for luminescent dating methods on Earth and Mars due to their radiation environments

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Abstract

The Martian radiation environment is radically different to that of the Earth's, a key distinction being the dominating contribution from space-borne radiation, with the most common component being proton radiation [1]. By contrast, in the terrestrial case, the main radiation source derives from radionuclides derived from meteorites that impacted the planetary surface [2]. The reason for the distinction is that the poor shielding of the surface of Mars by the rarefied Martian atmosphere links the Martian surface to the interplanetary radiation environment to an extent greater than at the Earth.

This coupling to the interplanetary environment causes the Martian surface to have its own highly variable radiation environment. This leads to potential uncertainties in the interpretation of instrumental techniques dependant on radiation dose rates, for example Optically Stimulated Luminescent (OSL) dating of the age of the surface [3, 4].

However, estimation of the dosage suggests the possibility of the practical application of future Martian in-situ age measurements. A preliminary study conducted using the SRIM code [5] demonstrates this link. The energy loss of a range of high-energy protons was calculated for passage through a gaseous medium, of uniform composition and density representative of the Martian atmosphere *[Figure 1]*, whose thickness for a constant atmospheric density was calculated as 7.81km.

The simulation toolkit GEANT4 (GEometry ANd Tracking) [6, 7] is used to model the passage and effects of particle and photon radiation through the Martian atmosphere and upper surface, the methodology taken being similar to that of Keating et al [8].

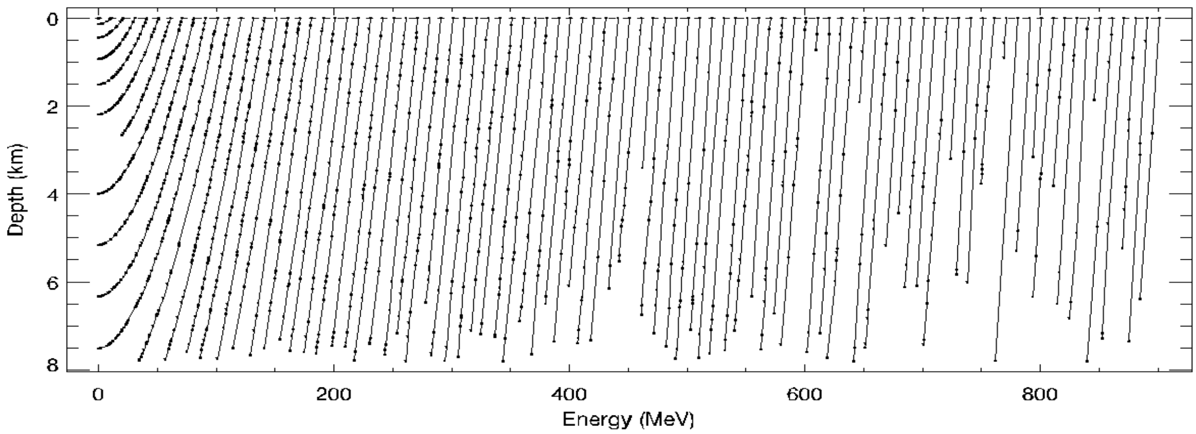

Figure 1: Energy vs depth for high-energy protons entering and passing through the Martian atmosphere. Zero corresponds to the top of the atmosphere. Each line is for a different starting energy. Points show where energy was lost, the position being new current energy and interaction depth. All particles reach the surface except for those on the left hand side, which reach zero energy in the atmosphere.

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This radiation environment model, using known parameters for the Martian surface environment can theoretically predict observational results. This information is then compared to terrestrial equivalents, in order to predict possible stimulated luminescence results in, for example sediments on both planets.

We will study the variation according to burial depth and time. One such prediction is the energy deposition with depth, due to the rate of radiation dose in the Martian regolith. Applying this directly to OSL dating methods gives us a potential technique for gaining insight into to the length of time regolith spends buried across the surface of Mars, and hence revealing the degree of the activity of the surface geology.

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