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Discussions



# *Interactive comment on* "Martian sub-surface ionising radiation: biosignatures and geology" *by* L. R. Dartnell et al.

**Anonymous Referee #2**

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Review of:

Martian sub-surface ionising radiation: biosignatures and geology

by

L. R. Dartnell, L. Desorgher, J. M. Ward, and A. J. Coates

This is an interesting effort. However, it raises more questions in my mind than it answers. I find the transport part of the study—to which I will confine my remarks–to be somewhat confused and incoherent. In general, it would be more helpful if the atmospheric pressures were expressed in g/cm2 than in mbar, since the mass thickness, as modified by the density through the scale-height, can be expressed directly in the Boltzmann transport equation, while the pressure in bar depends on the mass of the planet below the atmosphere and on its temperature, a much less direct relationship to the transport problem the authors are attempting to solve.

In particular:

p. 459, ű 1, l 3. I don't know what the authors mean by "typically," but there are 70 ground-level enhancements, or GLEs, since 1942. A GLE cannot be produced unless there are a considerable number of incoming protons with energies above 100 MeV.

p. 459, ű 1, l 9. Replace "complimentary" with "complementary."

p. 459, ű 2. At this depth, electrons result from neutral pion decay into two high-energy photons, producing electromagnetic showers, a very local phenomenon, and the neutral pions are produced by high-energy nucleon-nucleus collisions. This will take place inside the crustal magnetic fields, some of them in the subsurface soil and make their way up as albedo. Hence it is correct to say, but for different reasons, as the authors do in the same paragraph on the following page that "these crustal fields can be ignored in modelling the subsurface radiation environment on Mars.

p. 460, ű 2. Since a GLE has to penetrate the earth's atmosphere of 1000 g/cm2, this statement must be wrong. If the density of Martian soil is roughly the same as terrestrial soil, a GLE can penetrate 600 g/cm2 or more.

p. 464, ű 2, l 3. Isn't 2.65 too steep? Gaisser and Stanev (revised by Sokolsky and Streitmatter) [J. Phys G, Review of Particle Physics 33, 245( 2006)] give 2.7. That may not seem like much, but over several decades of energy, the difference may be considerable. The top energy is only 1 GeV. How was this determined to be sufficient? Are these energy bins step functions?

p. 465, item 4. Please give the Martian atmospheric depth in g/cm2.

p. 466, Eq. 1. z1 is the scale height and should be about 10.8 km for the current Martian atmosphere. Please give the value or values you used. The scale-height governs the rate at which pions and muons decay. In a thick early Martian atmosphere,



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this process will dominate at the surface as it does on the terrestrial surface.

p. 466, penultimate line. Fig. 4 should be in semi-logarithmic format. In that fashion, the scale-height would be clearly evident as the inverse of the slope of the lines.

p. 467, ű 1. After rereading several times, I realized that 1017 g/cm2 referred to an early (the earliest considered?) atmosphere. It is not clear from the text. However, the terrestrial atmosphere is not 1017 g/cm2 deep but 1033.227 g/cm2 deep.

p. 467, ű 2, last line and p. 468, first line. I must say that I am uncomfortable with this. Neglecting nucleus-nucleus collisions, which produce secondary nucleons and nuclei, and replacing these complex processes with a single weight sweeps a lot of physics under the rug. The nuclear flux is attenuated much faster than the nucleonic flux because of the larger nucleus-nucleus cross sections. Energy deposition which depends finally on ionization is somewhat different. The ionization due to an iron nucleus is 26 times that of 26 protons of the same energy per nucleon because of the Zˆ2 term in the stopping power.

p. 471, ű 2. Depths in g/cm2 please, and accompanying scale height or scale heights.

p. 471, ű 3. Exactly. That's the problem with that form of representation.

p. 471, ű 4. No, see my comment on p. 467, ű 1.

p. 473, ű 1, l 5. See my comment on p. 467, ű 2,

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