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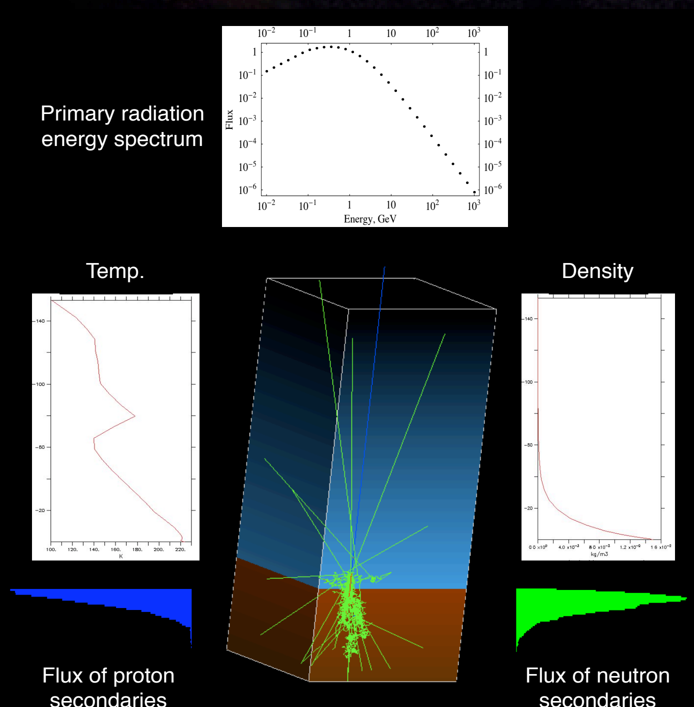
Life on Mars?

Modelling the Martian subsurface radiation environment

One possible extraterrestrial habitat is pockets of water deep beneath the Martian surface. Terrestrial bacteria survive similar environmental extremes, but the radiation levels in such refuges are unknown. A computer model of particle propagation has been built to determine subsurface radiation flux. This can be used to calculate survival times of different bacterial analogues and biomarkers as a function of depth.

1. Why Mars?

The Red Planet is the most Earth-like place we know, and thus the best chance for extraterrestrial life. Although it's surface is now bitterly cold and dry, there are clear signs that Mars was once much warmer and wetter. This water may remain trapped as an underground permafrost layer, liquid around geothermal hotspots. Could Martian microbes be living in such refuges?



2. Extremophiles

Any water on Mars is likely to be very cold, acidic, and briny. Hardy terrestrial 'extremophiles' are known that tolerate similar conditions. Certain bacteria grow at -20ºC, or thrive at pH1, or saturated saline, or live solely off inorganic energy; metabolising CO2 and H2 to release CH4. Intriguingly, plumes of methane have been detected seeping out of the ground. Another major hazard will be the radiation. Mars has negligible atmosphere or magnetic field, and so is unprotected against energetic particles from space. *Deinococcus radiodurans* can survive hundreds of times the lethal dose for a human cell, but how deep underground must a similar Martian microbe live to be shielded from the radiation above? I have built a computer model to answer this, and other questions.

3. The model

The diagram (*left*) shows the simulation of an energetic particle from space passing through the thin Martian atmosphere to strike the surface, generating an underground cascade of secondary radiation. Primary particles from the spectra of both Solar Energetic Particles and Cosmic Galactic Rays are used. Relevant physical parameters of the atmosphere and regolith, and the deflecting-effects of the crustal magnetic anomalies, are all included. The model outputs flux profiles of various secondaries, from which the biologically-weighted doses at different depths can be calculated.

4. Where to look

Where should we land future probes for the best hope of finding signs of life? The most promising locations are shown in the map (*right*) - each can be analysed individually using the model. What depth would bacteria need for complete shielding? How long would a cell remain viable if dormant or frozen nearer the surface, in a crater lake, river sediment or sea? Even if Martian life is now extinct, how long would its biosignature remain detectable?