COULD THE IMPACT OF THE MARS 2020 POWER SYSTEM INTO MARTIAN REGOLITH CREATE AN ARTIFICIAL SPECIAL REGION?

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Introduction: A key planning question for the Mars 2020 mission is whether, in certain landing failure scenarios, an impact of the rover's radioisotope power system into the martian regolith could create an artificial special region? We have evaluated two subordinate questions related to this hypothetical situation: 1). Would liquid water be created for a biologically significant period of time?, and 2). If so, would there be a mechanism for potential Earth-sourced organisms in that water to be transported to nearby naturally occurring martian Special Regions?

The Mars 2020 mission is constrained to go to a site where ice has neither been detected, nor suspected in the upper few meters of the regolith. Thus, the essense of these questions is evaluating what might happen in an impact into regolith that contains hydrated minerals. For the purpose of this analysis, we assume mineral species and concentrations as detected in Gale Crater regolith by the Curiosity rover.

Methods: We have evaluated this scenario using finite element modelling and the TOUGH code developed by George Moridis and Nic Spycher at LLNL.

Results: The scenario modeled is one in which the General Purpose Heat Source (GPHS) modules in the Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) remain together in blocks, and the target is regolith. In this case, the GPHS brick would be embedded to a depth of about 80 cm. The model shows that very quickly (within hours) the temperature near the source would rise to a point above the decomposition temperature of the minerals assumed (including allophane, smectite, gypsum, perchlorate, and iron hydroxides). These minerals would all release water vapor, which would diffuse outwards away from the heat source, where it would encounter the cold ambient conditions of the shallow martian subsurface (assumed T = -90C), and either condense (to liquid water) or freeze (to ice).

The model predicts that in the thermal gradient surrounding the heat source, there would be a thin shell where liquid water would be stable, surrounded by a second thin shell with ice, and outside of that, regolith with neither water nor ice. Saturation values within the ice and water shells have been calculated, and within 10 sols could reach values as high as $S_i = 0.23$ and $S_w = 0.16$. As time proceeds, and more heat is added, the dehydrated volume would grow. This would result in the progressive expansion of the water and ice shells until the radioactive isotopes are depleted. Once heat is no longer being added, the thermal anomaly would decay, until the previous thermal environment was reestablished. The plutonium heat source used in an MMRTG has a half-life of 88 years, so the total lifetime of this anomaly could be several hundred years.

The model was run to about 200 sols after impact, which is the period during which the system is growing and changing rapidly. By about 50 sols after impact, the introduced heat would reach the surface above the MMRTG, and heat loss into the atmosphere would become an increasingly important effect. This would also result in the progressive diffusive transfer of water vapor into the atmosphere, where it would be lost to the system. Thus, this heating process would inevitably lead to progressive drying.

Possible biological implications: Given the physical and geological conditions assumed in this scenario, liquid water could temporarily be stable at some times and in some locations. Within the water shell, this water would exist in the pore network of the regolith. The activity of this water would be affected by both matric and solute effects, and would be dependent on several factors, including grain size and mineralogy. However, there are several combinations of conditions for which the water activity threshold for Special Regions of 0.5 could be exceeded during the several hundred-year period of this scenario. **We conclude that in this scenario, Special Regions conditions could be created by this process, for a temporary period, followed by a period of inhabitability.**

If a special environment were created, could it be in communication with a naturally occurring Special Region? The subsurface scenario is characterized by vapor diffusion. This process would be spatially constrained by the limits of the ice shell. Within the water shell, short-range movement of water within the pore network may be possible, but movement of water across the ice shell would not—outward movement would result in freezing. Diffusion of water vapor to the surface and dissipation is predicted. However, since terrestrial microbes do not move by vapor diffusion, they would not be part of this mass transfer. **Thus, we have been unable to identify a means by which the transport of potential microbes outside of the ice shell would be possible, thereby preventing them from reaching a naturally occurring martian Special Region.**