PHYSICAL AND THERMODYNAMICAL EVIDENCE OF LIQUID WATER ON MARS.

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Introduction: The objective of the Phoenix Mars mission is to determine if Mars' polar region can support life. Since liquid water is a basic ingredient for life, as we know, an important goal of the mission is to determine if liquid water exists in the region. Here we show physical and thermodynamical evidence that liquid saline-water exists in areas disturbed by the Phoenix lander. Moreover, we show that the thermodynamics of freezing/thaw cycles ranging from diurnal to climatic time-scales leads to the formation of saline solutions with freezing temperatures much higher than current summer ground temperatures on most of the areas where Mars Odyssey's Gamma Ray Spectrometer detected near surface water. Thus, we hypothesize that liquid saline-water is common on Mars. This discovery has important implications for the stability of water, weathering, glaciology, mineralogy, geochemistry and the habitability of Mars.

Liquid Water on Mars: The water vapor pressure at the triple point of water is below the present day atmospheric pressure on the lowest regions of Mars such as the Phoenix landing site, but the low surface temperature and dry atmosphere inhibits the presence of pure liquid water. However, liquid water can be present in the form of saline solutions because many salts depress the freezing temperature well below present day values in these regions [1,2,3]. Indeed, even the presence of saline solutions with relatively high freezing point temperatures such as that of NaCl might allow liquid saline water to form sporadically on most of the surface of Mars [3]. Here we report the discovery of liquid saline-water in polar areas disturbed by the Phoenix lander. Moreover, we postulate that soft ice found on the first trench excavated by the Phoenix robotic arm is salty and therefore suggests that saline water is also present in undisturbed areas of Mars.

Eutectic Solutions: We postulate that eutectic solutions form when the soil temperature oscillates around the eutectic temperature (T_{Eut}) so that ice precipitates from solutions with salt concentration smaller than χ_{Eut} and water molecules from it diffuse into deliquescent salts present in the soil, if any. This drives the concentration of the solution toward the eutectic value. The eutectic temperature T_{Eut} is depressed from the freezing point by $\Delta T_{Eut} \sim 70\ ^{o}C$ for salts discovered by chemical analysis of soil at the Phoenix landing site. Because of the large ΔT_{Eut} of these salts, liquid saline-water (eutectic solutions of these salts) can form almost anywhere on Mars. Indeed, it has been shown that even eutectic solutions of salts with modest freezing point depression such as NaCl ($\Delta T_{Eut} \sim 20\ ^{o}C$) can sporadically be liquid almost anywhere on Mars.

The Discovery of Liquid Water on Mars: Phoenix's supersonic thruster plumes excavated the regolith efficiently, exposing the subsurface ice. Compression of the plume over the ice during the last second of descent produced pressure and temperature perturbations of about 10-35 kPa and 1200 ^{o}C. This melted about 1 mm of the exposed ice and splashed a hot mixture of soil and water (mud) under the lander. In order to minimize contamination of the landing site, high purity hydrazine was used to power the Phoenix descent engine, producing ammonia as the only significant contaminant. However, like hydrazine ammonia is highly volatile and the high temperature of the exhaust plume forces them to evaporate quickly leaving only traces (ppm) in the soil. Indeed, chemical analysis of the soil at the Phoenix landing site did not show either ammonia or hydrazine. Images of the lander legs' struts show mud and "droplets" on a strut that remains in the shadow most of the day. The fact that many small droplets grew in the interval of a few weeks, while some large droplets shrank suggests that these larger droplets were less saline than the smaller droplets that grew. Indeed, it suggests that the smallest droplets have grown on concentrated solutions and salt particles from the dried mud that was splashed on the strut during landing, while the larger droplets that shrunk where from more diluted mixtures. Images of the strut also shows that various tiny droplets grew on tiny features, probably salt particles splashed during the landing. The fact that some tiny droplets grew while larger droplets shrank supports the idea that the tiny droplets are highly saline because this goes against Kelvin's law that states that the water vapor saturation pressure is inversely proportional to the droplets' radius.

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