VOLATILES AND ICES ON MARS. N. Hoffman, WNS GeoScience, 22 Marlow Place, Eltham VIC 3095, Australia (nhoffman@vic.bigpond.net.au).

Introduction: Models of the vertical structure of volatiles in the regolith of Mars are typically simplified in terms of a single volatile species – water. The presence of Carbon Dioxide as a significant additional volatile leads to a much more interesting analysis.

A number of Authors have explored the distribution and evolution of volatiles in the porous regolith of Mars e.g. [1]. Generally, an equilibrium is found with liquid water at modest depths and a thick cap of water ice sealing the volatile reservoir from the surface. A thin dry layer composes the uppermost layers of Regolith. Inferences from these models have been drawn to suggest the evolution and distribution of volatiles on Mars at the present day.

Two Volatiles: These models are generally based on the dominance of the volatile inventory by H_2O, despite the fact that the atmosphere is dominated by CO_2, and fluid inclusion analysis of Martian Meteorites reveals CO_2 to be the active fluid phase [2].

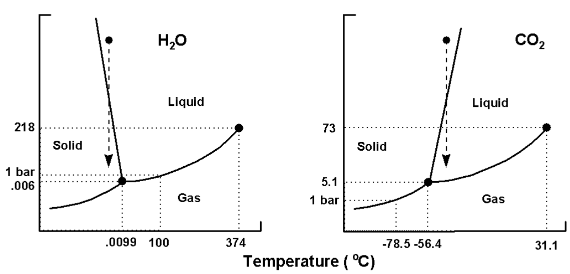

Figure 1: Phase diagrams for water and CO_2 in isolation. Note that near the solid/liquid boundary, water tends to freeze on decompaction while CO2 liquefies.

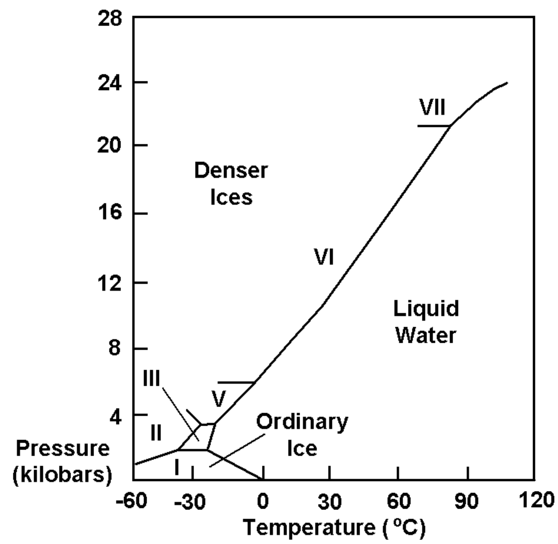

Figure 2: High Pressure phase diagram for water showing the minimum stable temperature for water at minus 25°C, 2Kbar.

The formation of cage lattice clathrates is a major modifier to the Phase behaviour of water and ice. Liquid water is suppressed in the subsurface by the stability of this phase under pressure, leading to the surprising conclusion that the most likely liquid in Mars subsurface is liquid CO_2, not water.

Once a liquid phase has formed, convective processes and phase changes tend to moderate the geothermal gradient to the proximity of the phase boundary, much as terrestrial geothermal systems often track the water/steam phase boundary.

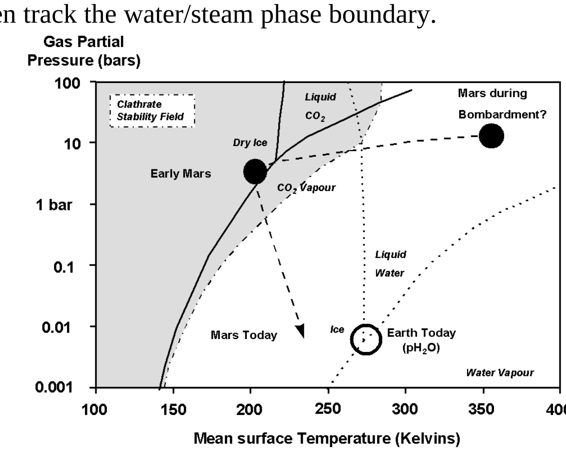

Figure 3: Phase diagram for the mixed system CO_2/H_2O after Miller [3] showing the suppression of liquid water stability by CO_2 clathrate formation. In the subsurface, if CO_2 is present in sufficient concentration, then liquid CO_2 will form before liquid

water. Water will tend to be a refractory component of the regolith. In fact, it seems likely that CO_2 is the main working volatile on Mars. Other contributions in this series address the consequences of this.

Water ice is sufficiently refractory that it needs large shock pressures (>10 Gpa) to liquefy [4], whilst solid CO_2 melts far more easily. The evidence of splash and rampart craters which has traditionally been interpreted as evidence for liquid water in the regolith has to be reviewed. We now see that liquid water is unlikely, and solid water ice cannot melt easily enough, therefore the volatile in splash craters must be CO_2 which has been excavated as subsurface ice or liquid. Shock melting and adiabatic decompression easily account for extensive melting of solid CO_2.

The work of previous authors regarding subsurface ices [5] needs to be updated to incorporate this more sophisticated understanding of Mars' volatiles and ices. In general, the results are translatable from a water cycle to a CO_2 cycle at lower temperatures, with water ice being regarded as a refractory mineral.

On the other hand, subsurface ices may well become mobilised as do evaporite salts on Earth and icy glaciers may extrude laterally from layered regolith into canyon crater walls, and diapirs may occur where a large enough body of subsurface ices has formed, for example in the impact melt zone of large craters. The domal uplifts of Ori and Baliva [6], and the enigmatic White Rock on Mars may be usefully seen in this light.

References: [1] Clifford. (1997) *JGR, 90,* 1151–1154. [2] Bodnar R. J. (1999) Abstract - 30th *Lunar and Planet. Sci. Conf.* [3] Miller S. L. (1974) *Meteoritics & Planet. Sci., 32,* A74. [4] Boyce J. M. Roddy D. J. and Craddock R. (1996) Abstract - *Div. Planet. Sci., Amer. Astro. Soc., 28th Ann. Mtg.* [5] Barlow N. G., Perez C. B. and Saldarriaga P. C. (1999) Abstract - 30th *Lunar and Planet. Sci. Conf.* [6] Ori & Baliva) *LPS XXVII,* 1344–1345.