HIGHLY CONDUCTIVE EUTECTIC BRINES RATHER THAN WATER EXPECTED IN THE MARTIAN SUBSURFACE L. P. Knauth, D. M.Burt and J. A. Tyburczy, Department of Geological Sciences, Box 871404, Arizona State University, 85287-1404; Knauth@asu.edu, Dburt@asu.edu, Jim.tyburczy@asu.edu.

Due to low temperatures, subsurface water on Mars is unlikely. However, highly concentrated brines can have exceptionally low freezing points and are also remarkably susceptible to supercooling. Brass [1] reviewed brine compositions and concluded that eutectic brines could be stable under current martian temperatures. Kuz'min and Zabalueva [2] used Brass's work to suggest that subsurface brines could account for the "softened" terrains as well as other peculiar aspects of martian topography. Brines with freezing points lower than average current martian surface temperatures (ca -65°C) are found on Earth, so concentrated brines are excellent candidates for martian subsurface fluids if there is a mechanism by which they could have developed on Mars. We argue here that IF: 1) a hydrosphere was outgassed early in martian history; 2) large amounts of H_2O subsequently escaped from the atmosphere; and 3) the planet subsequently froze down; THEN: highly concentrated brines reside today in the megaregolith. The electrical conductivity of such brines should be vastly greater than that of pure H_2O and should therefore be much easier to detect geophysically.

The conventional view is that on Earth, Mars, and Venus, H_2O was outgassed following accretion. Cl is a volatile element that does not fit readily into silicate minerals and would therefore have outgassed as HCl along with the H_2O. In the earliest hydrospheres, HCl was therefore an important dissolved constituent. Subsequent leaching of Na from the earliest crust produced largely NaCl-bearing hydrospheres. On Venus, the initially high CO_2 levels resulted in a runaway greenhouse in which most of the water was lost via gravitational escape. On Earth, greenhouse temperatures were moderate enough to allow retention of the early hydrosphere, and it has persisted. The Earth's earliest hydrosphere appears to have had a salinity 1.5 – 2 X the modern value and that salinity declined with time as evaporite and brine deposits became sequestered on evolving continental platforms [3]. If the Cl/H_2O ratio of outgassed volatiles on Mars was similar to that on Earth, then the earliest martian hydrosphere would have had a similarly high salinity. However, the apparent absence on Mars of continents with huge sedimentary basins sequestering giant salt deposits precludes using the subsequent development history of terrestrial brines as an analog for martian brine.

Hydrogen produced by photodissociation of water vapor in the upper atmosphere escapes from Mars much more easily than it does from the more massive Earth. Based on the high D/H ratio of water vapor in the current atmosphere, up to 95% of the original martian hydrosphere was lost by this mechanism [4]. Loss of water to space leaves the residual hydrosphere enriched in its nonvolatile dissolved constituents. The early martian hydrosphere therefore necessarily evolved into a NaCl brine. This brine became pore fluid in a megaregolith composed of high surface area particles (fractured and fragmented glasses, impact breccia, pyroclastic debris, ash sheets, melt sheets, and small rock fragments) of basaltic or komatiitic composition. Chemical interaction with these particles was inevitable and would have converted the NaCl brine into a concentrated Ca-Mg-Na-Cl brine with numerous other dissolved constituents. Mars subsequently froze, and the subsurface brines underwent eutectic freezing to produce a mixture of H_2O ice, salts (mostly $NaCl\bullet 2H_2O$ and $CaCl\bullet 6H_2O$), and highly concentrated brine. Such brines could still be seeping out of escarpments and readily account for the remarkable and otherwise perplexing outflow gullies recently reported [5]. Eutectic brines therefore inevitably follow from current ideas regarding initial outgassing of volatiles, atmospheric water loss, and later freeze-down.

If the scenario above is correct, past (and any present) surface and ground waters on Mars should have been primarily brines with concentrations greater than that of modern terrestrial sea water. During the "warm, wet" early history of Mars, fresh water could have occurred locally as rain, runoff, and groundwater reservoirs. Amounts of such precipitation-derived water would have been very limited because erosional channels attributed to runoff (as opposed to catastrophic outflow) are not developed planet-wide. However, freeze-down of the planet should have generated widespread and extensive amounts of subsurface H_2O ice cements as a consequence of eutectic freezing. Later melting of this ice by igneous activity could have produced liquid H_2O in convecting cells and possible hydrothermal springs. On the other hand, such geothermal heating would also mobilize eutectic brines and re-melt ice-brine-salt eutectic mixtures where they were still physically associated. Mixing of these diverse fluids during hydrothermal circulation combined with dissolution of megaregolith salts would probably prevent sustained hydrothermal reservoirs of dilute H_2O for any significant length of time.

The physical and electrical properties of brines are vastly different from those of pure H_2O. For eutectic brines, models of subsurface martian hydrology need to consider flow of near-freezing, highly viscous (possibly even gel-like) fluids with specific gravities of 1.3 to 1.4. The electrical conductivity is likely to be greatly enhanced for brines, so geophysical methods to detect subsurface fluids may work far better than expected.

References: [1] Brass G. W. (1980) *Icarus, 42*, 20-28. [2] Kuz'min R. O. and Zabalueva E. V. (1998) *Solar System Res. 32*, 187-197. [3] Knauth L. P. (1998) *Nature 395*, 554-555. [4] Yung Y. L. et al. (1988) *Icarus 76*, 146-159. [5] Malin M. C. and Edgett K. S. (2000) *Science 288*, 2330-2335.