**PROPERTIES OF LARGE WATER-FILLED CRATER BASINS ON MARS**. C. Barnhart[1], E. Asphaug[1], S. Tulaczyk[1], [1](Department of Earth Sciences, University of California Santa Cruz, 1156 High Street, Santa Cruz, California, 95064, barnhart@pmc.ucsc.edu, asphaug@pmc.ucsc.edu)

**Introduction:** MARSIS (Mars Advanced Radar for Subsurface and Ionospheric Sounding) recently detected an approximately 250 km diameter circular structure under the surface of Chryse Planitia, Mars [1]. Within this structure, a series of arc-shaped reflectors and a planar reflector are geometrically consistent with a flat-floored basin. Radar returns also indicate a large >1 km thick volume of low-loss material which maybe ice-rich [1]. In this work we apply a critical examination to the possibility that the detected subsurface feature in Chryse Planitia is a buried ice filled crater (Figure 1) and explore its thermodynamic and gravitational properties.

**Crater In-Fill:** Large impact craters on Mars are natural locations for ice lake systems. Because crater interiors are topographic minima, they serve as catchments for surface fluids and groundwater. Large craters in particular set the geologic stage for hydrothermal evolution by creating extensive fracture networks for fluid migration, enhancing heat flow in the basin through mantle upwarping [2], and triggering climatic episodes in response to the energetic collision. We adopt the view that liquid water on the surface of Mars has been a transitory event, or events, driven by catastrophic occurrences. Under this paradigm the purported crater within Chryse Planitia could have been inundated by water and sediment through a variety of ways, such as outflow flooding originating in the highlands [3], aquifer tapping [4], or impact-generated climate episodes which support the presence and transport of liquid water [5].

**Ice-Lake Thermodynamics:** A 1-2 km ice lake within a 250 km diameter crater takes a very long time to freeze. As water freezes it requires the latent heat of fusion, $L_i$. The temperature at the base of the ice sheet is maintained at the eutectic point by this heat. Heat is lost by the system to the martian atmosphere (and radiatively to space) by conduction across the ice sheet. As the ice sheet grows, the temperature gradient across the sheet $\Delta T / \Delta z$ becomes more shallow, reducing the rate of freezing. Freeze rate is determined by calculating energy fluxes at the ice water interface (below), where geothermal flux (q), density (ρ), liquid (l), ice (I), specific heat (Cp), thermal conductivity (k) are the key variables.

$$E_{INPUT} = E_{OUTPUT}$$

$$q + \rho_i L_i \frac{dz}{dt} + \rho_l h_l C_{p_l} \frac{\Delta T_{eut}}{dt} = -k_i \frac{dT}{dz}\bigg|_{ice/water_{int.}}$$

Two effects further retard freezing rates: a layer of surface sediment and an elevated geothermal flux. A layer of sediment placed on top of the ice, as in the case of a buried or subsurface crater, has an insulating effect that causes the gradient across the ice to be even shallower. A hypothesized martian geothermal flux is only 30 mW $m^{-2}$ [6]. However, crater excavation thins the crust, drawing mantle closer to the crater floor. This in turn, raises the geotherm, increases the energy into the system, and reduces the freezing rate.

**Preliminary Results:** A simple 1d diffusion model was constructed to estimate the minimum amount of time it would take for the lake to freeze. In this model the martian atmosphere was held fixed at 215K and ice convection was ignored. (The liquid water is assumed well-mixed.) Figure 2 charts ice lid thickness and freezing rate with time. A 1.0, 1.5, and 2.0 km column of water requires 32,700, 73,400, and 130,600 years to freeze respectively. At the conference we will report on more detailed calculations including effects that would enhance the persistence of liquid water such as salinity, layers of insulating sediment, and increased geothermal flux.

**Gravity Anomaly Calculations:** A 250 km diameter circular depression filled with 1.5 km of water ice is probably not detectable in current Mars gravity maps. Assuming a generous density contrast of ~2 g $cc^{-1}$ between the ice filled crater and the surrounding regolith, simple calculations give a surface gravity anomaly of ~126 mGal. At 400 km, the mean orbital altitude for MGS (Mars Global Surveyor), a 126 mGal anomaly generated by 250 km feature will be attenuated to about 1-10 mGals. This signal is too fine for confirmation by models of free-air gravity expanded to spherical harmonic degree and order 60 [7]. A instrument and model with a sensitivity of at least degree $l$~85 is needed before a 250 km subsurface ice-filled crater can be confirmed by gravity measurements from this elevation.

**Future Work:** We are in the process of introducing more layers including a sediment lid and an alluvium deposit underneath the lake (Figure 3). We are also considering ice sublimation, lake salinity, and the effects of an elevated geotherm. Broadly speaking, lacustrine systems on Mars are probably transitory. It is more probable that life would have a greater opportunity to proliferate in an aqueous environment under an ice plug rather than in ephemeral lakes exposed to the myriad hostilities of Mars' surface [8,9]. Development of thermal models exploring ice lake systems will provide insight into Mars' climate history and its potential for biology.

**References:** [1] Picardi G. et al. (2005) *Science, 310,* 1925-1928. [2] Newsom H. E. et al. (1996) *JGR-Planets 101,* 14951-14955. [3] Tanaka K. L. et al. (2003) *JGR 108,* 10.1029/2002JE001908. [4] Clifford S. M. and Parker T. J. (2001) *Icarus, 154,* 40-79. [5] Segura T. L. et al. (2002) *Science, 298,* 1977-1980. [6] Carr, M. H. (1996) *Water on Mars,* Oxford, New York. [7] Zuber M. T. et al. (2000) *Science, 287,* 1788-1793. [8] McKay C. P. et al. (1985) *Nature, 313,* 561-562. [9] Cabrol N. A. and Grin E. A. (1999) *Icarus, 142,* 160-172. *Special thanks to Francis Nimmo and Erin Kraal for their advice and insight.*

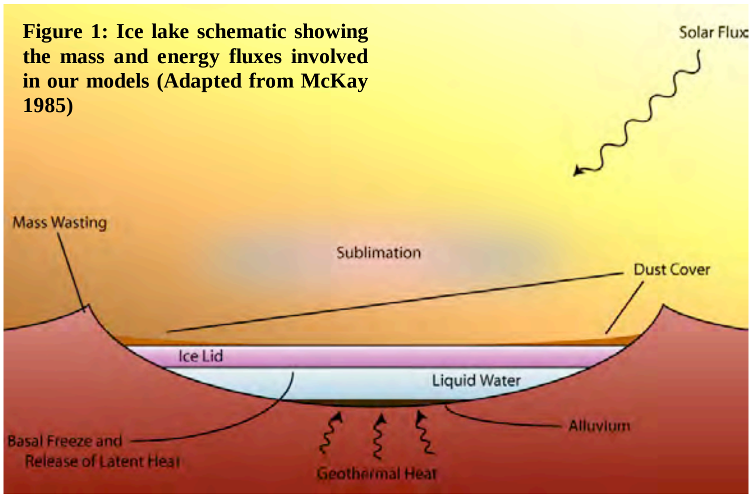


**Figure 1: Ice lake schematic showing the mass and energy fluxes involved in our models (Adapted from McKay 1985)**

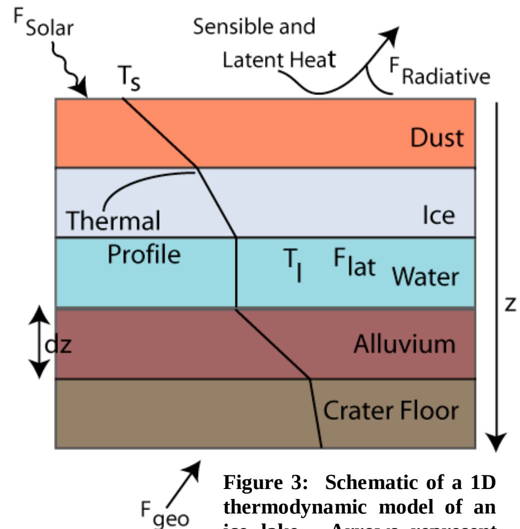


**Figure 3: Schematic of a 1D thermodynamic model of an ice lake. Arrows represent energy fluxes and $T_s$ and $T_l$ are surface and eutectic temperatures respectively.**

**Figure 2: Ice lid thickness and freeze rate vs time for pure water exposed to a surface temperature of 215K.**