**THARSIS FORMATION FROM DENSITY DRIVEN THERMO-CHEMICAL PLUMES DURING PLANETARY DIFFERENTIATION** J.R. Fleck[1] and D.S. Weeraratne[1], [1]California State University, Northridge (18111 Nordhoff St., Northridge, CA 91330, jenna.fleck.16@my.csun.edu, dsw@csun.edu).

**Motivation:** The formation of Tharsis rise on Mars is a highly debated topic. The timing of Tharsis formation likely occurred early in Mars history in the Noachian but post dates the hemispheric crustal dichotomy which it overprints [1,2]. Several models have been proposed to explain a localized orogeny but use of boundary layer theory or convection studies result in multiple evenly spaced plumes globally [3]or have instability growth times which are longer than estimates for Tharsis formation and in some cases longer than Mars' existence [4,5]. We propose a new model for the formation of Tharsis which considers a thermo-chemical plume that is formed during differentiation and core formation processes on Mars.

The impact history of Mars is extensive, evidenced by the crater density of the southern highlands. These impacts are violent energetic collisions that may melt surface and/or impactor material causing segregation of silicates and liquid metal iron [6,7]. Recent studies of the Borealis Basin suggest this large basin may have been formed by a single large impact centered within the northern lowlands [8,9,10]. An impact of this size is likely to produce widespread melting and magmatism to allow metal-silicate differentiation and perhaps a localized or global, magma ocean. Although theoretical studies have been done with conceptual models for metal diapir descent (Fig. 1) to form the Mars core [11,12], physical studies testing these models are scarce due to the strong variations in physical properties between liquid metals and solid silicates.

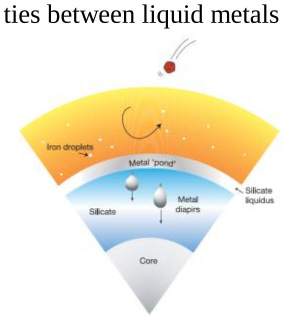


**Figure 1.** Theoretical sketch where a meteorite impacts the surface causing metal and silicate to differentiate. The liquid metal droplets pond, become unstable, and sink to the core [12] the form of liquid iron descent is not well understood.

Here we perform laboratory fluid experiments of core formation processes using liquid metal gallium and high viscosity glucose syrup which indicate that the physical process of sinking metal diapirs to form the Mars core (Fig. 2a) may drag large volumes of low density surface magmatic material to the base of Mars mantle through trailing conduits. The low density material grows at the base of the box and rises back to the surface (Fig. 2b) in a single event. Experiments are described below.

**Fluid Experiments:** We use liquid, metal gallium and high viscosity glucose syrup to model and study the rheological and buoyancy contrasts for metal-silicate differentiation. Fluid experiments scaled to the Mars interior mantle have Reynolds numbers between $2.7x10^{-7}$ to $1.9x10^{-4}$ (where viscous forces dominate) and Bond numbers between 0.7 and 50.

**Preliminary Results:** We compare emulsion gallium pond layer experiments to coalesced liquid metal pond cases [13,14] and find that emulsion experiments entrain greater amounts of low density fluid to the base of the box and, in nearly every case, produces a secondary buoyant chemical plume that rises to the surface. This secondary chemical plume is not observed in coalesced gallium pond experiments. The volume of entrained material in the emulsion cases is at least 50% of the sinking metal plume volume. The buoyant chemical plumes are driven by chemical density alone, as these preliminary experiments have no heat sources.

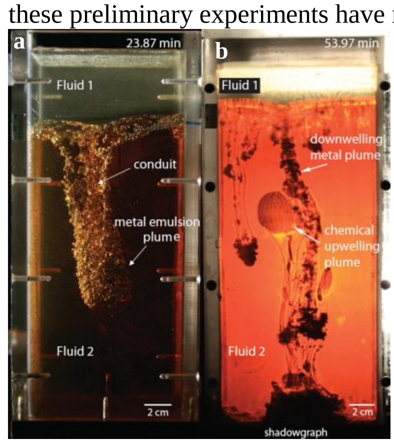


**Figure 2.** (a) Fluid experiment showing a sinking metal diapir. Fluid 2: Fluid 1 viscosity ratio is 80,000. (b) Later, a thermo-chemical plume is seen rising to the surface in shadowgraph.

Metal plume descent and chemical plume rise velocities are consistent with Stokes velocity. Scaling of preliminary experiments to the Mars interior dynamics gives a time line for the plume travel. The instability, growth, and descent of the liquid metal pond/diapir may occur within 0.2-9 Ma. Growth and ascent of the secondary buoyant chemical plume from the Mars core-mantle boundary to the surface occurs within 6-70 My. In each case, the time for growth of the instability is far greater than travel time for plumes.

We suggest this thermo-chemical plume as a source for orogeny at the surface that may have produced Tharsis rise in a single event. Time scales for this model indicate metal plume descent and subsequent rise of a buoyant anomaly could occur within 80 Ma following a large impact. In this model Tharsis formation will postdate a Borealis sized impact event and the crustal dichotomy.

**References:** [1] Johnson C.L. and Phillips R.J. (2005) *Earth and Planet. Sci. Lett.*, 230, 241-254. [2] Solomon S.C. et al. (2005) *Science*, 307, 1213-1220. [3] Turcotte D.L. and Schubert G. (2002) *Geodynamics* [4] Harder H. And Christensen U.H. (1996) *Nature*, 380, 507-509. [5] Thienen P.V. et al. (2006) *Icarus*, 185, 197-210. [6] Folkner W.M. et al. (1997) *Science*, 278, 1749. [7] Yoder C.F. et al. (2003) *Science*, 300, 299. [8] Andrews-Hanna J.C. et al. (2008) *Nature*, 453, 1212-1216. [9] Marinova M.M. et al. (2008) *Nature*, 453, 1216-1219. [10] Nimmo F. et al. (2008) *Nature*, 453, 1220-1224. [11] Stevenson D.J. (1990) *Origin of the Earth*, 231-249. [12] Wood B.J. et al. (2006) *Nature*, 441, 825-833. [13] Nguyen C.T. (2010) *Master's Thesis,* 1-164. [14] Nguyen C.T. et al. (2010) *AGU Fall 2010 Meeting*, Abstract # DI43A-1951.