COLD CASE: FRACTIONAL CRYSTALLIZATION IN CRYOMAGMATIC SYSTEMS. J. J. Buffo[1], B. E. Schmidt[1,] and C. C. Walker[2,3], [1]Georgia Institute of Technology (jacob.buffo@eas.gatech.edu), [2]Jet Propulsion Laboratory, [3]Woods Hole Oceanographic Institution.

Introduction: With a diverse array of putative hydrological features (dikes, sills, lenses, fractures, plumes) linked to geophysical and transport processes on a number of potentially cryovolcanically active bodies in our solar system [1-3] understanding and quantifying the multiphase physics that govern these unique systems is imperative in constraining their formation, evolution, and persistence. Akin to terrestrial volcanism, the thermo-compositional properties of the melt will likely dictate its density, eutectic point, reactivity, viscosity, and solidification dynamics [4-5]; quantities and processes that will govern the transport, longevity, and astrobiological relevance of the melt, as well as the thermal and physicochemical characteristics of both the melt and the ice it forms [6]. A similar comparison has been made between magmatic systems and the formation of terrestrial sea ice [7], whose multiphase reactive transport dynamics are well documented in the literature [8-9].

A key process occurring in these ice-ocean/brine systems is fractional crystallization. While more commonly used to describe high temperature magmatic processes, or the carefully controlled separation of chemical species in a laboratory, perhaps the most familiar example of fractional crystallization is the freezing of water into ice. When an aqueous solution is depressed below its freezing point pure crystalline ice begins to form, rejecting impurities into the remaining, concentrated, solution. The result is a complex and ever evolving two phase system, governed by a combination of diffusive and advective heat and mass transport, ever seeking thermodynamic and chemical equilibrium [6-9]. The complex physics governing these two-phase systems pose a significant hurdle to numerical representations of these environments, and thus they are frequently parameterized, if not wholly excluded from models [6].

Here we discuss the ubiquity and importance of these environments in our own polar oceans as well as the oceans and ice shells of other bodies in our solar system. We present a one-dimensional reactive transport model capable of simulating the solidification dynamics of these interfaces using both terrestrial and putative Europan ocean/brine chemistries. The model is validated against terrestrial sea ice and is applied to hypothetical basal fractures on the Galilean satellite Europa to investigate their re-freeze dynamics and resulting chemical properties. The models applicability to other hydrological features on Europa (e.g. sills, dikes, lenses) is discussed and future model improvements are outlined.
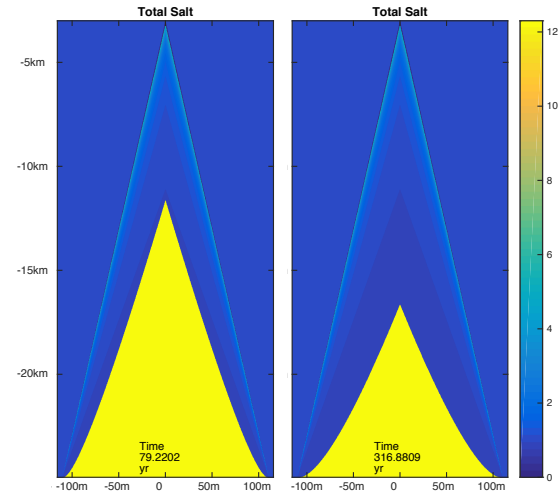

Figure 9 – Plots showing the re-freezing of a simulated basal fracture, along with its associated bulk salinity profile.

References: [1] Schmidt B. E. et al. (2011) *Nature, 479.7374,* 502-505. [2] Walker C. C. and Schmidt B. E. (2015) *GRL, 42.3,* 712-719. [3] Manga M. and Michaut C. (2017) *Icarus, 286,* 261-269. [4] Kushiro I. (1975) *AJS, 275.4,* 411-431. [5] Pinkerton H. and Stevenson R. J. (1992) *JVGR, 53.1-4,* 47-66. [6] J. J. Buffo et al. (2018) *JGR: Oceans, 123.1,* 324-345. [7] J. S. Wettlaufer et al. (1997) *JFM, 344,* 291-316. [8] E. C. Hunke et al. (2011) *The Cryosphere, 5.4,* 989-1009. [9] D. L. Feltham et al. (2006) *GRL, 33.14.*