TERRESTRIAL MAGMA DYNAMICS AS AN ANALOG FOR CRYOMAGMA TRANSPORT ON ICY WOLRDS. Lynnae C. Quick[1] and Bruce. D. Marsh[2], [1]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, DC 20560, QuickL@si.edu [2]Johns Hopkins University, Department of Earth and Planetary Sciences, Baltimore, MD 21218.

Introduction: The basic characteristics of silicate magma ensure that volcanism on Earth and other terrestrial planets is frequent and multifaceted. These basic characteristics include: (i) magmatic superheating during ascent (ii) the presence of a substantial sub-liquidus "mush", which can extrude onto the surface as lava (Fig. 1) (iii) positive buoyancy with respect to the country rock through which it must ascend [1-3]. In the case of cryomagma, the addition of low-eutectic contaminants such as NH_3, H_2SO_4, and salts to pure water is required for the formation of sub-liquidus mush zones [3-6] (Fig. 1). In addition, owing to their negative buoyancy with respect to the crusts through which they must ascend, cryomagma must undergo processes such as volatile exsolution, diapir-induced brine mobilization, or overpressurization in order to successfully reach the surfaces of icy worlds [7-9]. In an effort to determine the extent to which terrestrial magmatic transport is a suitable analog for cryomagmatic transport on icy worlds, we review the associated modes of magma transport in terrestrial systems.

Transport Mechanisms: The principal modes of magma transport on Earth are diapiric ascent, diking, and ascent in vertical, pipe-like conduits [1-2]. The velocity of an ascending diapir is determined by its ability to warm and soften adjacent wall rock on its way to the surface [2]. Once a diapir has melted its way to the surface, successive generations of diapirs may use this path for millions of years afterwards [1-2] (Fig. 2). Owing to a small surface area to volume ratio, diapirs are efficient at retaining heat. However their slow movement, on the order of 10^{-9}-10^{-6} m/s [1, 3], may prevent them from reaching the surface before crystallization. Conversely, the large surface area to volume ratio of dikes requires relatively rapid propagation, on the order of 10^{-3}-1 m/s, to prevent freezing of the fluid within prior to reaching the surface [1, 3]. Pipe-like conduits form when rapidly ascending magmas melt and/or remove dike walls [10-11]. As the surface area to volume ratio of cylindrical conduits is intermediate between that of diapirs and dikes, fluids within must ascend at rates on the order of 10^{-7}-10^{-6} m/s to arrive at Earth's surface in a molten state and facilitate volcanism [1, 3].

Implications for Cryomagma Transport: The aforementioned mechanisms have been considered as modes of cryomagma transport on bodies such as Europa and Ceres [3, 6, 12-13]. While many features imaged on these worlds support the possibility of diking and diapirism in the geologically recent past (e.g., [6, 13-15]), the frequency within which these modes of fluid transport operate is unknown. Moreover, it remains to be seen whether or not the subsurface structures of the icy worlds in our solar system can support the development of cryomagmatic plumbing systems similar to the intricate magmatic plumbing systems on Earth. Notwithstanding, we will present scenarios for the transport of cryomagmatic fluids via the aforementioned mechanisms, and hope to generate discussion concerning the likelihood, and plausible rates of occurrence, of these processes on icy worlds.

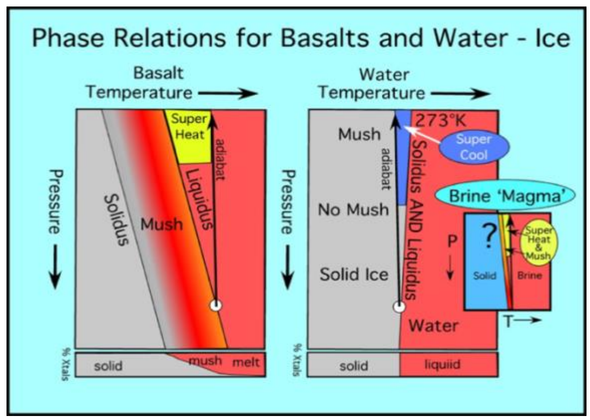

Fig. 1. Pressure-temperature diagrams for silicate magma and cryomagma. Figure from [3].

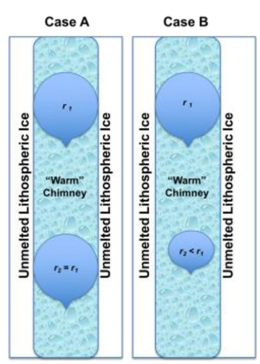

Fig. 2. Diapirs may travel to the surfaces of icy worlds via insulated crustal paths that were "melted away" by previous generations of diapirs. Figure from [12].

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