BRINE-DRIVEN VOLCANISM ON CERES. J. C. Castillo-Rogez[1], L. Quick[2], J. E. C. Scully[1], M. A. Hesse[3], C. A. Raymond[1], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA (Julie.C.Castillo@jpl.nasa.gov), [2]Center for Earth and Planetary Studies, Smithsonian Institute, Washington, DC, USA, [3]Department of Geological Science, The University of Texas at Austin, Austin TX, USA.

Background: With 22wt.% of water, the dwarf planet Ceres is representative of large icy bodies. Such bodies were subject to pervasive ice melting, due to short-lived radioisotope decay and/or accretional heating. The extent of aqueous alteration in these bodies depends on the temperature reached in the ocean and other environmental parameters. Salts have been found at most large icy bodies, which reflects the leaching of certain elements from the rock, such as alkali and alkaline earth metals during that period of aqueous alteration. The Dawn mission has returned extensive observational evidence for advanced aqueous alteration and chemical differentiation of the dwarf planet Ceres [1,2,3, 4]. Ceres' surface displays high abundance of carbonates in many sites, in particular Ahuna Mons [5] and the faculae in Occator Crater [2] which are both believed to involve brines [2,6,7]. This is the first demonstration of brine-driven activity in the solar system, consistent with earlier prediction that this phenomenon could occur in large asteroids [8]. This presentation will review our understanding of Ceres' brine chemistry and its role in geological activity.

Brine Composition: Geochemical modeling of rock aqueous alteration, assuming a solar composition for the rock and the presence of carbon dioxide and ammonia, yields an initial oceanic composition enriched in chlorine, bicarbonate and carbonate ions, and alkalis [4]. Sulfur preferentially combines with metals. The ocean is also potentially rich in organics [9]. Upon freezing, which we model with FREZCHEM [4], the salts precipitate in several stages: first, hydrated sodium carbonate (~265 K), then hydrohalite and ammonium chloride (~245 K). Chlorine accumulates in the relict ocean with sodium and potassium. The interpretation of Ceres' surface topography suggests a few percent brines could remain at the base of the crust until present [10]. The corresponding temperature is ~ 220 K and the liquid is saturated in sodium and potassium chlorides [11]. However, lateral variations in temperature and thus brine composition are possible. Preliminary models for the temperature profiles below Hanami Planum and Occator (55 km depth) suggests a temperature in excess of 245 K, allowing for ammonium chloride to be in solution.

Brine Role in Geological Activity: Ceres' brines are sourced in two manners. The emplacement of the large Ahuna Mons appear to require a few percent of melt to lubricate material that is otherwise highly viscous [12]. While the origin of that construct remains to be fully understood, the most viable explanation from a thermal standpoint is that it takes its root in the deep brine layer. However, this model is not consistent with the high concentration of sodium carbonate observed across Ahuna's flanks [5]. The situation at Occator is different. Heat produced upon impacting could put crustal salts in solution, which explains the abundance of sodium carbonate and ammonium chloride found in the faculae [13]. These are extruded upon compressive stresses building up in the melt reservoir as it freezes [14,15]. The occurrence of ammonium chloride suggests that the melt reservoir is still in the process of freezing, although keeping that reservoir alive beyond ~10 My is proving challenging [15].

Implications for Other Large Icy Bodies: Sodium carbonate and chlorides have also been found at Enceladus [16] and chlorides are suspected at Europa [17]. A major difference between Ceres and these bodies is that the former is nearing freezing completion. Brines help keep some activity going but the processes behind the formation of Cerealia Faculae and Ahuna Mons are most likely of passive compressive origin as a consequence of volume changes [11, 18]. Nevertheless, salts may be incorporated in the shell of icy moons as they develop [19], which might help promote local melting [20].

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