MODELING ROCK ALTERATION AT THE WATER-ROCK INTERFACE OF ICY MOONS. J. Semprich[1], A. H. Treiman[2] and S. P. Schwenzer[1], [1]School of Environment, Earth and Ecosystem Sciences, The Open University, Milton Keynes, MK7 6AA, [2]LPI, USRA, 3600 Bay Area Blvd., Houston TX 77085.

Introduction: A number of observations point towards the interaction between liquid water and the rock core on icy moons and dwarf planets. In the case of Enceladus, the presence of a liquid water layer is suspected due to the high heat flux and plume activity in the south polar region [1-3]. The detection of salt-rich particles [4], ammonia, ^{40}Ar [5], and H_2 [6] in the plume also suggest a subsurface ocean in contact with its rock core. Furthermore, the interaction scales are even higher if the rocky core is fractured or unconsolidated [7,8], allowing for alteration reactions of silicates, possibly in the form of serpentinization, even at great depth. The observation of silicon-rich dust grains in the plume [9] suggests hydrothermal activity and hence widespread serpentinization. While changes in water geochemistry at the fluid-rock interface have already been investigated [10,11], this study aims to model alteration phases of the rock core with variations in fluid composition.

Methods: Phase diagrams are calculated with the Gibbs free energy minimization software Perple_X 6.7.5 [12] and an internally consistent thermodynamic data set [13, and 2002 update]. We use a graphite-saturated C-O-H fluid where the fluid composition is represented by X_O ($X_O = n_O/(n_O + n_H)$; n_O and n_H number of moles of oxygen and hydrogen [14]), which is directly proportional to fO_2 and hence a measure of redox conditions. The system is defined as FeO-MgO-CaO-Al_2O_3-SiO_2 (FMCAS) with the following solid solutions: dolomite, magnesite, olivine, clinopyroxene, orthopyroxene, and talc [13]; antigorite [15]; amphibole (actinolite) [16] and chlorite [17]. The composition of a CM chondrite (Murchison [18]) is taken as a representative for the rocky core.

Results: Fig. 1a shows phase stability fields as a function of fluid composition and a fixed pressure of 0.1 GPa. At $X_O < 1/3$, H_2O and CH_4 are the dominant fluid species with H_2 present. At $X_O > 0.6$ CO_2 is predominant, while CH_4 and H_2 decrease rapidly at $X_O > 1/3$. Consequently, phases typical for serpentinization such as antigorite, chlorite and magnetite are stable at $X_O < 1/3$. Due to the presence of H_2O, CO_2, CH_4, and H_2 in the plume [6], a value of $X_O = 0.33$ was chosen to model phase stability in *P-T* space (Fig 1b).

Discussion: Serpentinization of a rock core with CM chondrite composition is very likely in the presence of a fluid with CH_4, H_2O, H_2, and CO_2 species at relatively low pressures and within the temperature range of 200-400 °C. Slow reaction kinetics may inhibit serpentinization reactions at *T* below ~150 °C. Although the present model already reflects a significant amount of fluid species detected in the plume, future research would have to incorporate C-O-H-N fluids due to the observed ammonia [5].

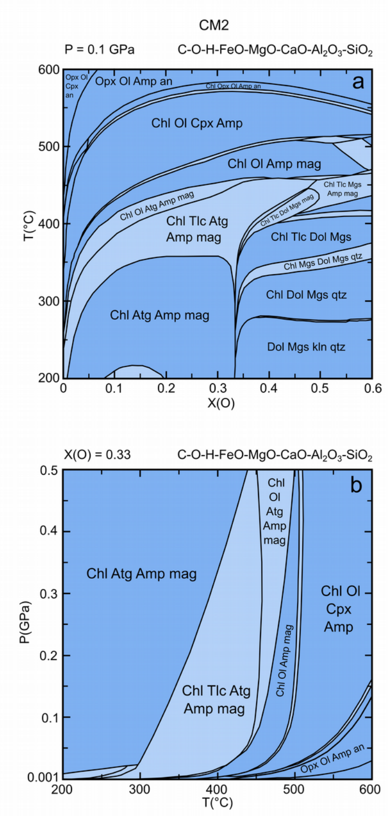

Fig. 1: Phase stability fields for a CM2 protolith with a) variations in T and fluid composition (X_O) at a fixed pressure of 0.1 GPa and b) P-T variation at X_O = 0.33.

Mineral abbreviations: **an**-anorthite, **Amp**-amphibole, **Atg**-antigorite, **Chl**-chlorite, **Cpx**-clinopyroxene, **Dol**-dolomite, **kln**-kaolinite, **mag**- magnetite, **Mgs**- magnesite, **Ol**-olivine, **Opx**-orthopyroxene, **qtz** -quartz, **Tlc** -talc

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