OLIVINE DISSOLUTION IN PARTIALLY FROZEN AMMONIA-WATER SOLUTIONS. A. E. Zandanel[1], R. Hellmann[1], L. Truche[1], [1]Université Grenoble Alpes, CNRS, ISTerre, F-38058 Grenoble Cedex 9, France

Introduction: The identification of a liquid ocean beneath the ice crust on Saturn's small moon Enceladus has invigorated discussion of low-temperature water-rock interaction as a driver in developing habitable worlds [1], [2]. The preservation of ammonia and volatiles that depress the freezing point of water in small, cold satellites suggest that the heat generated from exothermic mineral dissolution at below-0 °C could even initiate the ice melting processes that create liquid oceans [3]. However, conceptual and numerical models of mineral dissolution in these environments often rely on thermodynamic data extrapolated from 25°C or above. Despite abundant research on primary mineral weathering in the lab and field, no consensus exists as to the lower temperature limits or rates of critical weathering processes that produce heat, hydrogen, and secondary mineral assemblages [4], [5]. To address this, we completed experiments showing olivine dissolution in alkaline solutions at -20 to 22°C using multiple replicate batch reactors, where textural and bulk (melted) solution chemical changes are monitored for up to one year.

Methods: We designed and completed a set of batch experiments investigating olivine dissolution in partially frozen solutions. Batch experiments combined olivine with one of three solutions, having 0, 0.8, or 8 wt % ammonia. All solution types were reacted at -20, 4, and 22 °C for up to 442 days. Solution chemistry changes were monitored at intervals to evaluate mineral alteration over time. The ice-fluid-mineral interface was physically and chemically characterized using Raman spectroscopy and geochemical modelling. In addition, the olivine surface is analyzed at the nanoscale with TEM microscopy.

Results: and show that olivine dissolution reactions continue even in partially frozen solutions. Initial dissolution rates show a surprisingly weak dependence on changes in temperature, pH, and NH_3, while long-term rates show an apparent weak inverse relationship with temperature. Our findings imply that olivine dissolution is not significantly retarded at -20 °C compared to 22 °C, and that in high water-rock ratio environments olivine alteration is a geologically rapid process. In addition, high-resolution TEM analysis of the olivine surface after 442 days of reaction shows a thin (< 1 nm) surface altered layer at the olivine surface, unambiguously demonstrating that secondary reaction products can form in partially frozen solutions even at experimental timescales. The olivine dissolution rates are of interest to evaluating mineral weathering processes in frozen or partially-frozen icy worlds such as Enceladus, (1) Ceres, or Uranus' moon Ariel, as well as terrestrial and lunar polar processes.

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