

DISSOLUTION OF NONTRONITE BY HIGH IONIC STRENGTH BRINES AND IMPLICATIONS FOR HABITABLE ENVIRONMENTS ON MARS M. H. Steiner¹, E. M. Hausrath¹, R.E. Schofield¹, ¹University of Nevada, Las Vegas 4505 South Maryland Parkway, Las Vegas NV 89154, Steine18@unlv.nevada.edu.

Introduction: Water is needed to support all life on Earth, and water is therefore a crucial consideration for habitability on other planets. While pure water is not stable on the surface of Mars, it is likely that brines may exist at least temporarily[1]. However, brines, which have been shown to host life at temperatures as low as -30°C and water activities above 0.60[1], have different implications for life than dilute waters. Studying the impact of brines on dissolution can therefore provide insight into the possible past and present habitability of Mars.

Nontronite is an iron-rich clay mineral that has been detected on the surface of Mars[2,3]. Since nontronite is found in ancient terrains, it may provide a record of previous alteration on Mars, possibly including alteration that occurred in habitable environments. An alteration signature could be produced by brine dissolution which could shed light on past conditions on Mars.

In this work, we are measuring dissolution rates of nontronite as a function of activity of water (a_{H_2O}) and temperature to allow further interpretation of aqueous conditions on Mars. An alteration signature of past interaction with brines could therefore be important in providing insight into possibly habitable environments on Mars.

Methods:

Materials: Nontronite for dissolution experiments was purchased from the Clay Mineral Society (NAU-1), crushed using an agate mortar and pestle and sieved to 120-325 mesh. Crushed and sieved nontronite was ultrasonicated in ethanol at two-minute intervals until the supernatant was clear and the surface was free of fine surface particles when examined by Scanning Electron Microscope (SEM).

Experimental Setup: In each experiment, 200ml of solution of either 0.01M NaCl, saturated NaCl brine, 0.01M CaCl₂, 33wt% CaCl₂ brine, or 50wt% CaCl₂ brine was added to 0.5-1.0g of NAU-1 in a 250ml LDPE batch reactor. NaCl brine was made by adding 150 g of NaCl to 356 g of 18.2 MΩ water, 33wt% CaCl₂ brine by adding 250g of CaCl₂ to 500g of 18.2 MΩ water, and 50wt% CaCl₂ brine by adding 250g CaCl₂ to 500g of 18.2 MΩ water all after the methods of [5]. High purity HCl was used to adjust the pH of each solution to the pH of interest. Batch reactors were agitated at 100 strokes per minute in a 25°C water bath. Ten ml of sample were removed at each sampling pe-

riod, the pH of the sample was measured on an aliquot of unfiltered sample, and the remainder of the sample filtered through a 0.45µm polypropylene syringe filter, acidified to 1% v/v with high purity HNO₃, and stored at 20° C until analysis. Each condition was run in duplicate, with at least one blank at each condition.

Analyses: Ca and Fe concentrations were measured using a Thermo Scientific iCE 3000 series Atomic Absorption spectrometer (AA). Brine samples were diluted 1:8 before analysis by AA, after the methods of [5], and standard solutions were prepared in a matrix that matched the solution chemistry of the sample (either brines diluted 1:8 or dilute solutions). LaCl₃ was added to samples analyzed for Ca, and CaCO₃ to samples analyzed for Fe to reduce interferences[6]. Si concentrations were measured using colorimetry on a UV-Vis spectrophotometer[7]. Silica standards were prepared in the NaCl brine and 0.01 M NaCl solutions and treated in the same way as the samples. At the end of the experiments, samples were rinsed in 18.2 MΩ water and frozen for at least 24 hours to be freeze dried. Freeze dried samples will be analyzed for alteration using techniques such as SEM, XRD, IR, and Raman spectroscopy.

Calculations : Measured concentrations were corrected for sample removal using the equation[8]:

$$m = m_{t-1} + (c_{(t)} - c_{(t-1)})V_{(t-1)} \quad (1)$$

where m is moles of silicon released, c is concentration of silicon in moles•liter⁻¹, and V is volume in liters.

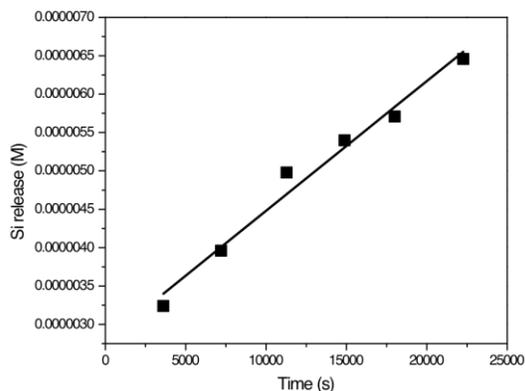


Figure 1. Moles released of silicon as a function of time at $a_{H_2O} = 1.0$. Linear regression is used to calculate the rate of dissolution, with a steeper slope indicating a faster rate.

Rates were calculated by linear regression on at least five successive samples (Figure 1).

Results:

Silicon release increases over time (e.g. Figure 1). Silicon concentrations were higher in waters with $\alpha_{\text{H}_2\text{O}} = 1.0$ than $\alpha_{\text{H}_2\text{O}} = 0.75$. This indicates that the dissolution rate is faster in more dilute solutions. Measured concentrations of iron were very low for all samples, which is likely caused by iron precipitation.

Conclusions and Future Work:

Nontronite dissolution rates were faster under lower pH and more dilute conditions. These results suggest that signatures of alteration caused by brines may occur over longer periods of time than a similar signature of alteration caused by more dilute solutions. This difference in alteration could have implications for the habitability of Mars. Since nontronite is abundant on Mars, an understanding of alteration of nontronite could give a better understanding of water chemistry on Mars throughout the billions of years that nontronite has likely been exposed at the martian surface.

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