BORON ADSORPTION IN CLAY MINERALS: IMPLICATIONS FOR MARTIAN GROUNDWATER CHEMISTRY AND PREBIOTIC PROCESSES. M. A. Nellessen1, L. Crosseys1, E. Peterson1, P. Gasda2, N. Lanza2, C. Yeager2, B. Parsons2, A. Labouriau2, R. C. Wiens2, S. Clegg2, 1University of New Mexico, 2Los Alamos National Laboratory.

Introduction: Boron is a rare element found in organic-rich soils on Earth affected by biologic activity [1]. Boron is typically found as borate in clay-rich environments bound to 2:1 phyllosilicates [2] when introduced by groundwater or other fluid process to allow boron adsorption [2]. The pH of the borate-carrying water affects how well the soil takes up boron, with a pH range of 8-9 [1] providing the most adsorption at around 300 ppm [1]. As Martian groundwater is likely to have been neutral or alkaline [3], this means that Martian groundwater was optimal for boron uptake by clay minerals. Recently, boron has been detected in Martian calcium sulfate veins by ChemCam on the NASA Curiosity rover in relatively significant quantities [4].

It has been hypothesized that boron may be a vital aspect for prebiotic processes to occur on Earth and possibly on Mars [5]. The formation of boron-ribose complexes [6] might allow the formation of RNA. Borate-ribose complexes are relatively stable in water; without borate, ribose will quickly break down in solution [6]. With boron found on Mars, this creates the potential for life to develop independently on Mars [4].

Methods: We will generate boron-enriched clay minerals in the lab that will be used to test their interactions with ribose and their ability to allow biotic processes to begin. The relationship between boron adsorption and pH will be studied in both Mars-like and common terrestrial clay minerals including montmorillonite, bentonite, kaolinite, and analogs to Martian saponite and nontronite [7].

Using methods described in [1], we mix a 50 mg B/L solution made from borax (Na2B4O7·10H2O) to each clay sample and shake for 3 hr. Samples are centrifuged at 5000 rpm for 20 min and supernatant is removed. The remaining boron-enriched clay is rinsed with a pH-similar fluid. We will vary pH from 6 to 11 in increments of 0.5 for each clay type to determine the relationship between pH and boron adsorption.

Clay samples will be analyzed with Laser Induced Breakdown Spectroscopy (LIBS), the method used by ChemCam that detected boron, as well as with Raman Spectroscopy, X-Ray Diffraction (XRD), Nuclear Magnetic Resonance (NMR) spectroscopy, and Gas Chromatography-Mass Spectrometry (GCMS). LIBS spectra collected with the ChemCam engineering unit at LANL can be directly compared with ChemCam on Curiosity. Thus, these spectra can be added to the set of standard boron calibration spectra and improve the quantification of boron in ChemCam Mars data. XRD and Raman will provide mineralogical analysis, NMR will provide organic structural analysis, and GCMS will provide the organic concentration and identification analysis. The organic chemical fraction of these clays will also be analyzed with gas chromatograph mass spectrometry [8]. These methods will characterize these samples and be used for comparison with the current Curiosity rover and the future Mars 2020 rover datasets.

Expected Results: We will produce an array of terrestrial and Mars analog clay standards treated with borate at a range of pH values. This will provide us with the optimal pH for boron adsorption for typical Mars clay minerals. We expect to have a series of clays with a wide range of borate concentrations that will be used for calibrating ChemCam. We expect to generate a series of clays enriched with 100-300 ppm of borate that will be used to improve the ChemCam calibration for targets on Mars. Further experiments will be carried out by reacting these borate-bearing clay standards with ribose by [9].

Implications: Our project represents the first boron-clay adsorption experiments for Mars-like clays, which will provide new insight on the geochemical behavior of borate in Martian groundwater, and allow us to infer the amount of boron that could be present in Martian bedrock. Understanding boron-clay relationships will allow us to make some clear comparisons between terrestrial and Martian boron-enriched clays and improve our techniques for boron detection on Mars. Boron-clay relationships will form the basis for later work on the impact of boron-enriched clays on prebiotic processes on Mars [9]. Evidence supports there being multiple diagenetic episodes [3] on Mars and boron may provide clues to the timing and origin of groundwater activity on Mars and how this relates to habitability in Gale crater.

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