PREBIOTIC CHEMISTRY OF BORATE-BEARING CLAYS: A POTENTIAL MARS BIOSIGNATURE.

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Introduction: Boron has been detected in calcium sulfate filled fractures (Fig. 1) in Gale crater, Mars with the NASA *Curiosity* rover ChemCam instrument [1]. Calcium sulfate veins on Mars are a product of groundwater [2]; hence, the detection of boron in calcium sulfate means boron was a constituent of martian groundwater. Since borates adsorb to terrestrial 2:1 phyllosilicates [3], boron in the groundwater potentially became adsorbed by clay minerals on Mars.

The discovery of boron on Mars has important implications for Mars astrobiology. Borates stabilize prebiotic molecules, including pentose sugars [4], and the formation of borate-pentose complexes could be an important step in the prebiotic synthesis of ribonucleic acids (RNA) on the early Earth [5]. The presence of borate in Mars groundwater thus opens up the possibility of prebiotic reactions on early Mars [1].

Experiments have shown, separately, that organics [6] and borates [3] can be adsorbed to 2:1 phyllosilicates. Hence, these materials could have interacted with each other in the early Mars groundwater, potentially allowing for prebiotic chemical reactions to occur on Mars. Our project focuses on studying the role of clay mineral chemistry on the reaction of ribose and borates under typical Mars groundwater conditions, including understanding the role of clays and pH in borate uptake and borate-organic reactions. The goal of the work is to test hypotheses of prebiotic chemical reactions that occur between borates and organics on early Earth and Mars.

Methods: We will produce borate-bearing clay minerals at various pH conditions [7]. Clay mineral samples include common terrestrial clay minerals, kaolinite, montmorillonite, and bentonite, and Mars analog clays, nontronite, and saponite. We will mix ribose with the borate-bearing clays suspended in water and monitor for the breakdown of ribose using an alkylsilyl derivatization gas chromatography mass spectrometry (GC-MS) technique [8]. The resulting half-life of ribose mixed with the borate-bearing clays will be compared to control experiments to determine the effects of clays on the reaction.

Discussion: Not only are borate-sugar complexes important for prebiotic chemical reactions, the study of sugar stability in the martian subsurface is important for determining if sugars, and other important organic biosignatures, could be preserved in the martian subsurface by reaction with clays and borate-bearing clays. Sugars have been detected in carbonaceous meteorites in very small quantities [9], which may preclude them from being true biosignatures. Cyclic sugars, however, are unstable during aqueous alteration [4,9], making them unlikely to be found on Mars without being replenished by life. If our experiments show borate-sugar complexes [10] are formed and are stable, then this class of molecule and their derivatives could be potentially preserved in the martian subsurface, allowing for detection by instruments on Mars, or returned samples.

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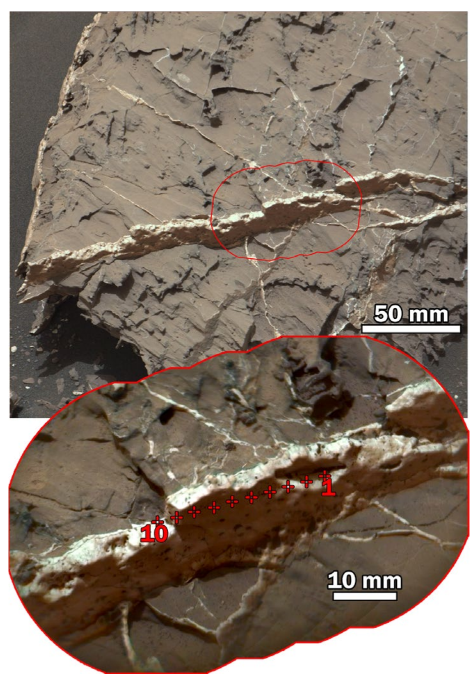

FIG 1: ChemCam target "Catabola" where boron has been observed in light-toned calcium sulfate filled fractures within clay mineral rich lacustrine bedrock.