NASA Astrobiology Early Career Collaboration Award Report

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– Aleisha Johnson, PhD candidate Arizona State University

Description of Research

Current models of trace element release during early oxidation events are constructed using pyrite oxidation rates determined from very pure pyrite at relatively high O_2 conditions. However, none of these models adequately represents the low O_2 conditions in the Archean or the effects of trace element contamination of pyrite because it is unknown how fast pyrite oxidizes at very low O_2 concentrations and how the incorporation of trace elements into pyrite affect oxidation rates. I am working on the latter problem at the University of California, Riverside (UCR) while Stephen Romaniello and Aleisha Johnson are working on the former at ASU. These parallel projects provided a great opportunity for collaboration between the two research groups, namely examining the high trace element pyrite investigated in UCR project with the extremely low O_2 analytical setup at ASU.

Figure 1: Trace element-rich pyrite in low oxygen pyrite oxidation experimental apparatus. Pyrite is suspended via stirring in the deionized water at low pH (sulfuric acid buffer) with no oxygen while a known amount of oxygenated water is pumped into the vessel.

During the two week visit to ASU, I brought sieved powders (106 to 150 μm diameter grains) of two trace element-rich pyrite samples that had been characterized using LA-ICPMS. These samples from the Belt Basin and the Leicester Pyrite Member represent the high and medium reactivity examples for pyrite oxidation. During the trip we utilized the glass reactors that Johnson and Romaniello have developed to conduct the very low O_2 (10^{-5} to 10^{-3} PAL) experiments on the pyrite samples. Three vessels were available, so we conducted duplicate experiments on the samples from the Belt Basin (expected to be most reactive) and a single experiment on the Leicester Pyrite Member (expected to be moderately reactive). We found that that the impurities in the trace element-rich pyrite enhance the rate of pyrite oxidation by 1-1.5 orders of magnitude compared to literature predictions from pure pyrite oxidation experiments.

Outcomes of Collaboration

This collaboration was a success. Without this opportunity, I would not have been able to investigate pyrite oxidation rates at such low levels of oxygen and thus it would have been much more difficult to apply my results to understanding pyrite weathering in low O_2 environments, such as those found in the Archean or possibly on other planets. Johnson's expertise in the experimental method made the experiments easy to complete and extremely successful. For my part I was able to supply natural pyrites to compare with the synthetic pyrite that they had been using at ASU. My knowledge of naturally forming pyrite also allowed me to suggest additional improvements to their methodology, such as ultrasonic cleaning of pyrite to help achieve better results.

This collaboration opened the door to future work together such as additional analyses of the Leicester pyrite member and oxidation experiments of a natural, low trace element pyrite sample that I can provide. These will help us construct a more comprehensive understanding of how trace element abundance affects abiotic pyrite oxidation. I am thankful for the NASA Astrobiology Early Career Collaboration Award for funding this project and the opportunity to work with the excellent researchers at ASU.