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Phosphate Adsorption Detection on Iron and Amorphous Nanophases via Raman Spectroscopy

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Phosphate availability within terrestrial environments significantly impacts metabolic functions of microbes, where phosphate exhibits a strong affinity for adsorption to iron nanophases in Earth soils. Therefore, detecting phosphate adsorbed into poorly crystalline materials is likely important for systems like Mars, where amorphous iron nanophases are observed across the planetary surface alongside phosphate-bearing minerals. Indeed, hydrothermal lab-analog basalt and mafic glass brine alteration experiments conducted in this study show nearly complete apatite dissolution within glass-rich mafic sands, but no aqueous P was detected within the hydrothermal solutions. However, additional amorphous material was produced, suggesting that aqueous P released during apatite dissolution may be strongly adsorbed to new and preexisting amorphous phases, or incorporated into new amorphous material.

We used Raman spectroscopy to investigate organic and inorganic phosphate adsorption on ferrihydrite and hematite and evaluate the effectiveness of this method for studies of adsorbed phosphate sinks on Mars. Using lab synthesized materials, we reacted 2-line ferrihydrite and hematite with aqueous solutions of organic ($C_6H_{18}O_{24}P_6$) and inorganic (KH_2PO_4) phosphate solutions for a period of 24 hours. After the reaction period, we filtered the solid materials from solution and analyzed them via Raman spectroscopy with a 532 nm laser source. Despite aqueous evidence of adsorption, we were was unable to detect phosphate peaks with reliable consistency using Raman spectroscopy. At 1% laser power, very minor peaks are detectable only within a few samples and do not provide the information needed to distinguish between organic and inorganic sources. Increasing laser power to 10% for ferrihydrite samples marginally increases peak detection, but thermally alters ferrihydrite to hematite/goethite. Phosphate peak detection was virtually nonexistent on our hematite experiments. Therefore, Raman analyses may be unable to detect a potentially large, and relatively bioavailable, phosphate sink on Mars.