

Oxygen Isotope Fractionation of Phosphate During Adsorption onto Mars-Analog Clay Minerals

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Phosphate on Mars may preserve isotopic signatures indicative of biological activity. Both phosphate (PO_4 includes PO_4^{3-} , HPO_4^{2-} , $\text{H}_2\text{PO}_4^{1-}$, H_3PO_4) and clay minerals have been detected on Mars, and their interactions may play a key role in evaluating PO_4 as a potential biosignature. On Earth, PO_4 is extensively cycled by biological processes and is an essential component in biomolecules, including nucleic acids, phospholipid membranes, and adenosine triphosphate (ATP). The oxygen isotopic composition of PO_4 may reflect biological processing; however, subsequent interactions with mineral surfaces may alter this signature. Therefore, to determine whether PO_4 preserves a biosignature, it is necessary to understand how abiotic processes, such as adsorption onto clay minerals, can affect the PO_4 oxygen isotope composition.

In this study, we examine the oxygen isotopic composition of PO_4 adsorbed onto Mars-analog synthetic clay minerals (nontronite, Fe-rich allophane, Fe-saponite, and Mg-Saponite) to determine whether any fractionation occurs between adsorbed and dissolved PO_4 . Previous work has shown that PO_4 is adsorbed onto iron-rich clay minerals and iron oxides, however, only studies with iron oxides have reported PO_4 oxygen isotope data. To address this gap, we conducted PO_4 adsorption experiments using Mars-analog clay minerals to evaluate adsorption behavior and oxygen isotopic fractionation between dissolved and adsorbed PO_4 . Batch experiments were performed using 30 mM PO_4 and 1.00 g of clay minerals and 37.5 mM PO_4 with 1.25 g of clay mineral at a pH 5.00.

Results indicate that PO_4 adsorption varies by clay mineral type. In experiments with 30 mM PO_4 and 1.00 g of clay mineral conducted over three months, maximum adsorption reached 50.08 %, 59.18 %, and 57.20 % PO_4 adsorbed onto nontronite, Fe-saponite, and allophane, respectively. Additional analyses were conducted to characterize our clay minerals including, pH_{pznpc} (point of zero net proton charge), specific surface area, porosity, mineralogy. Ongoing analysis of experiments with 37.5 mM PO_4 and 1.25 g of each clay mineral will be used to determine the oxygen isotopic composition of PO_4 .