

Nano-inclusions versus lattice-bound trace elements in pyrite: Implications on formation history and paleo-ocean chemistry

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Pyrite is an important component of many carbonaceous sedimentary rocks and is a major host of several trace elements including those that are redox sensitive. The nature in which trace elements are held within the pyrite have important implications on how we interpret what the variations in trace element concentrations are telling us about the environment of formation, especially with the increased use of pyrite trace element content to interpret paleo-ocean chemistry. It has been argued that the manner in which certain trace elements are incorporated can significantly affect the partition coefficients of other elements. For example, when As^{3+} substitutes for Fe^{2+} , there must be a void in the lattice for every two As atoms to balance the charge. This creates more room to accommodate larger cations such as Pb^{2+} or Au^+ . However, when As^{2-} substitutes for S, the substitution enhances the uptake of elements such as Co and Ni. Differentiating how trace elements are held within pyrite is important because lattice-bound substitutions have more profound effects on the partition coefficients of other trace elements, whereas trace elements that are held within nano-inclusions have minimal effects on the incorporation of other elements. Instead, when trace elements are held in inclusions variations to the system that directly affect the nucleation rate of different minerals and crystal growth are ultimately more important for our interpretation of the geochemistry of the fluids associated in pyrite formation.

This study uses a suite of micro- and nano-analytical techniques to determine the mode of trace element incorporation in sedimentary pyrite. These high resolution analytical methods include laser ablation ICPMS, nano-scale secondary ion mass spectroscopy, transmission electron microscopy, and atom probe tomography.