Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.22997

Hematite Nanocrystal in Early Archean Dresser Formation Jaspilite: Implications for Surface Oxygen Level ~3.5 Ga

TIANYU ZHOU[1], SEUNGYEOL LEE[2], ERIC E RODEN[3] AND HUIFANG XU[3]

[1]Univeristy of Wisconsin-Madison
[2]Department of Earth and Environmental Sciences, Chungbuk National University
[3]University of Wisconsin-Madison
Presenting Author: tzhou89@wisc.edu

The debatable origin of the oldest known jaspilite, from the Dresser Formation, Pilbara Craton, northwestern Australia, has the potential to provide information about the surface oxygen environment ~3.5Ga ago. Hoashi et al. (2009) assumed that hematite in adjacent Marble Bar Chert directly nucleated from highly oxygenated seawater. Johnson et al. (2022) argued that the hematite precursor ferrihydrite likely precipitated from fluids as a result of photoferrotrophic Fe(II) oxidation. In contrast to both these explanations, Rasmussen and Muhling (2022, 2024) argued that hematite can be a secondary oxidation product of greenalite and siderite. Here, we provide new observations on hematite crystals from Dresser Formation jaspilite using X-ray diffraction and Rietveld refinement, optical microscopy, scanning electron microscopy, and transmission electron microscopy. The Dresser jaspilite comprises well-preserved chert and jasper lamination (< 1cm) and each layer exhibits extremely fine-grained and mosaic texture. The hematite grains are below 100 nm existing in hematite-quartz ~30-µm-large clots. These clots are made of disseminated hematite and quartz crystals, instead of oolitic granules like the greenalite. The micron-sized euhedral rhomb holes left behind by partially or completely dissolved siderite were replaced by late-stage quartz. Back-scattered electron imaging showed that nano bright domain in hematite-chert clots has an Fe: Si atom ratio of ~ 1:2, implying the precursor to chert and hematite was aggregates of ferrihydrite and amorphous silica colloids, not greenalite nor siderite. PHREEQC geochemical modeling simulated the initial chemical precipitation process using a Fe(II)-silicate metal complex as the source of Fe(II) input. The calculations reveal a competition between formation of siderite and ferrihydrite, suggesting that pO_2 value was extremely low ($< 10^{-6}$) but not negligible to Fe redox. Integration of our new mineralogical results with geochemical findings from Johnson et al. (2022) demonstrates the iron oxides and chert were chemically co-precipitated as aggregates of colloidal ferrihydrite and amorphous silica gel under extremely low in the early Archean shallow seawater.