In our quest to decipher the biogeochemistry of the Precambrian world, key targets to understand the geobiology of early Earth are marine iron- and silica-rich chemical precipitates that form the Iron Formations (IFs) dispersed across Earth today. We analyzed the time distribution of IFs with preservational biases removed and determined that there was widespread and unchanging deposition of these iron formations across the ancient oceans for two billion years – implying that the (bio)chemical process responsible for making IFs was independent of environmental factors and operating for over two billion years. While this IF-precipitation process was previously thought to involve light or oxygen to produce iron oxides, recent discoveries of iron silicate inclusions within early-silicifying chert in 2.45 to 2.63 billion-year-old BIFs suggest that primary minerals forming from the Archean oceans were actually iron silicates (Rasmussen et al., 2015). We previously characterized the chemistry of these inclusions and determined that they are dominantly low-Fe(III) greenalite (Johnson et al., 2018). In complementary laboratory-based experiments, we are now replicating Archean-like oceanic conditions to explore how low-Fe(III) greenalite can form under both abiotic conditions and in the presence of iron-oxidizing phototrophs. We have characterized the crystal structure and iron redox state of our raw and aged experimental iron-silica precipitates using a suite of methods including X-ray absorption spectroscopy, X-ray diffraction, and Raman spectroscopy. As our investigation into the mechanism of Fe(II/III)-silicate formation continues, this research will provide new constraints on the activity of silica, pH, and pO2 in the Archean ocean and ascertain whether microbes could have mediated the precipitation of the iron silicates observed in ancient Banded Iron Formations.

Challenging the Paradigm of Iron Formations: Widespread Iron Silicate Deposition in the Archean Ocean

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My research is driven by one of the fundamental questions in Geobiology: How can we identify and interpret the record of early life and its impact on the environment, preserved in sediments and rocks? My research integrates using microscale and nanoscale geochemical techniques to extract original information from Precambrian rocks with laboratory experiments to mechanistically understand microbe-mineral interactions and biogeochemical processes.