Using novel coupled microscale techniques to investigate iron-bearing minerals in Precambrian sedimentary rocks and their use as a redox proxy

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Observing changes in iron chemistry and mineralogy in different sedimentary rocks over time is a vital tool for studying ancient environments primarily due to iron's redox sensistivity as it cycles between +II and +III valence states. A popular bulk geochemical technique employing this redox chemistry is iron speciation, which estimates proportions of different reactive iron species which are mapped to redox conditions based on empirical calibrations from modern sediment samples. However, it is poorly understood how diagenesis, metamorphism, and metasomatism affect the iron speciation of a sample and impact paleoenvironmental interpretations based on these redox proxies. We have developed and applied coupled microscale techniques of synchrotron-based x-ray fluorescence spectroscopy, optical microscopy, scanning electron microscopy, and SQUID magnetic microscopy to understand the complex history of iron mineralization within a sample and determine which phases are primary containing paleoenvironmental information. Additionally, complementary bulk rock magnetic techniques aid in ferromagnetic mineral identification and potentially can provide a tool for quick screening of complex samples. Using these techniques, we can assess the strengths and limitations of iron speciation as a redox proxy. We present observations from samples collected from the ~1460Ma Pritchard Formation and stratigraphic equivalents, Belt Supergroup, MT and ID, USA, which span a range of metamorphic grades and diagenetic environments. The observation of prevalent secondary iron-bearing phases such as chalcopyrite, pyrrhotite, magnetite, and chlorite highlight the importance of these microscale techniques, allowing one to connect chemistry and mineralogy with petrographic textures within the rocks. Data from this study do not support the prior hypothesis of ferruginous conditions in the Belt Basin water column during the mid-Proterozoic.