

Three decades exploring the Fe mineral-water Interface with Mössbauer, isotopes, and electrochemistry

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I have been fascinated by iron minerals for a long time. I remember walking into a cold room in Oregon where reactors that had contained only a couple grams of grey Fe metal particles the night before had transformed into *beautiful*, fluffy blue-green flocs. Those green rust flocs seemed like magic pixie dust to me and I've spent the last three decades working with my students and partner in science, Drew Latta, to use Mössbauer, isotopes, and electrochemistry to explore the Fe-mineral water interface.

We found lots of things that surprised us. We observed interfacial electron transfer (IET) between sorbed Fe(II) and structural Fe(III) in Fe oxides and Fe clay minerals. In some cases, a cool templating effect occurred that resulted in growth of the underlying oxides (e.g., homoepitaxy on goethite and hematite), whereas in other cases, it remains unclear what is happening (e.g., ferrihydrite). We were also surprised by how difficult it was to shut down IET. IET happens in the presence of carbonate, phosphate, silicate, organic matter — you name it, we tried it. About the only thing that inhibited IET was removing defects by hydrothermal treatment or reaction with Fe(II). Even more surprisingly, we observed that the newly formed Fe(II), in some cases, mixes with the surrounding water. The extent of mixing varies, but in some cases, we observed near complete mixing of the Fe atoms. That blew our mind.

Despite learning a lot, we still have many questions. For example, why can't we find any change in goethite after an electron is donated to it from sorbed Fe(II)? For magnetite and hematite, we see specific changes, but not for goethite. Why? And, then there is the Protean beast known as ferrihydrite — what happens in those early phases after IET but before goethite, etc. forms? And, what happens to IET, mixing, and redox potentials when Fe oxides contain other metals (as they do in most soils and sediments)? We continue to explore these fascinating questions about the Fe mineral-water interface and I look forward to sharing highlights of our past work and findings from our newest work.