Terraced iron formations: Biogeochemical processes contributing to microfossil preservation

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Terraced iron formations (TIFs) are comprised of alternating schwertmannite/goethite and gypsum layers, which cover meter-size areas of weathered bench faces and tailing piles at Mount Morgan Mine, Australia. The bacterial community from TIFs was more diverse in comparison to the tailings on which they had formed. The detection of both chemolithotrophic iron-oxidizing and iron-reducing bacteria suggests that iron oxidation and reduction were likely continuous processes occurring within these formations. Acidophilic, iron-oxidizing bacteria were enriched from the TIFs. High-resolution electron microscopy was used to characterize iron biomineralisation, which served as an analog for identifying and interpreting structures within schwertmannite/goethite layers as microfossils. Kinetic modeling estimated that it would take between 0.25 to 2.28 years to form approximately 1 g of schwertmannite as a lamination over a 1 m^2 surface, thereby contributing to TIF development. This length of time could correspond with seasonable rainfall or greater than average annual rainfall. In either case, water is critical for sustaining microbial activity and iron oxyhydroxide precipitation. The TIFs also contain alternating laminations of gypsum. These layers likely represented drier periods of the year in which millimeter-size crystals precipitated as water evaporated. Gypsum acted as a substrate for the cell attachment and biofilm growth that eventually became mineralized within schwertmannite. The dissolution and reprecipitation of gypsum suggests that cirucumneutral pH microenvironments could exist within TIFs, thereby supporting iron oxidation under these conditions. In conclusion, this study highlights the relationship between microbes for the development of TIFs and also provides interpretations of biogeochemical processes contributing to the preservation of bacterial cells and entire biofilms under acidic conditions.