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Modelling rate limitations on dissimilatory iron reduction

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Iron oxyhydroxides in various mineral forms are ubiquitous in sediments and sedimentary rocks in the Earth's subsurface. The ability of microbiota to respire using Fe(III) as the terminal electron acceptor is widespread, and is an important process in the transformation of organic electron donors in a variety of environments. Bioavailability of Fe(III) is limited by low solubility of the mineral phase, accessed primarily through reductive dissolution.

We detail a mathematical model that compares the rate limitations on reductive iron dissolution and growth of a microbial population on a flat mineral surface. Overall iron reduction rate is limited by extent of mineral/cell membrane contact and slow release of reduced Fe^{2+} from the mineral surface. Various mechanisms for electron exchange (nanowires, endo- and exogenous electron shuttles) may mitigate the need for all cells to make direct surface contact, but the total growth remains limited by the rate of electron flow to the mineral surface.