

Thermodynamic versus kinetic specificity in biological iron acquisition

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Plants, bacteria and fungi exude iron binding ligands, the so-called siderophores, in order to acquire Fe from their external environment. Siderophores are typically characterized by a high affinity for iron. They increase the bioavailability of iron by increasing the solubility and dissolution rates of iron(oxyhydr)oxides. However, in complex natural environments a range of other metal ions may be present as solutes or associated with solid phases. In principle, competitive binding of such non-target metal ions by siderophores could inhibit iron acquisition.

A solution to this problem is specificity of the acquisition system to iron on various biochemical, coordination chemical and geochemical levels. On the biochemical side, specificity can be attained by selective uptake based on steric recognition or the redox potential of the iron complex. However, even if selective uptake prohibits the uptake of non-target metals, their competitive binding by the siderophore could decrease iron dissolution rates and solubility and therefore inhibit iron transport to the organism. Coordination chemical specificity of siderophores for iron binding is assumed to solve this problem. However, various previous studies seem to indicate that thermodynamic specificity may often not be sufficient to explain successful iron acquisition by plants and microorganisms in natural systems.

In this presentation, we explore the role of kinetic specificity in iron acquisition. We show that thermodynamic specificity may be sufficient in some cases to mobilize iron from complex matrices containing potentially competing metal ions such as Co and Mn. However, we also demonstrate that the fast mobilization of iron from solid phases may lead to iron mobilization even if other metals eventually exchange iron in metal exchange reactions from the siderophore complex, as predicted by thermodynamic calculations.

With our presentation we hope to contribute to a better understanding of thermodynamic and kinetic factors controlling iron acquisition in complex geochemical environments.