Geophysical Research Abstracts, Vol. 7, 02350, 2005
SRef-ID: 1607-7962/gra/EGU05-A-02350

Ligand Controlled and Light Induced Weathering of Iron Oxides in the Presence of Siderophores

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The bioavailability of iron, an essential nutrient to almost all known organisms, is limited by the low solubility and slow dissolution kinetics of iron bearing minerals. Iron limitation of microbial or plant growth has been observed in carbonatic soils and in marine surface waters. Iron limitation of primary productivity in marine 'High Nutrient Low Chlorophyll' (HNLC) regions has a significant effect on global carbon cycling. Important iron sources in these regions are upwelling and atmospheric dust inputs. Iron limited marine bacteria exude iron specific low molecular weight organic ligands, the so called siderophores. Complexation of iron by siderophore like compounds dominates the speciation of soluble iron in marine waters.

In this context we investigated the effect of various microbial siderophores on the dissolution of iron from iron oxides in the dark and in irradiated suspension. Irradiation was emitted by a solar simulator with a similar spectrum as sunlight. We observed that the presence of various siderophores facilitated accelerated iron oxide dissolution in irradiated suspensions compared to dissolution rates in the dark. This accelerating effect was independent of the structure of the siderophores and of the photo reactivity of their corresponding dissolved iron complexes. The acceleration of dissolution rates by light increased with increasing pH in the pH range from 6 to 8.1 (seawater pH). In contrast to previously observed light induced reductive dissolution or iron oxides, the presence of oxygen had only a small effect on dissolution rates in the presence of siderophores. Moreover, the presence of siderophores decreased the inhibitory effect of oxygen on light induced dissolution promoted by other chromophores such as oxalate and citrate. In this presentation we will propose a conceptual model of these effects.

The observations suggest that siderophore promoted photo reductive dissolution may constitute an important pathway for increasing the dissolution rates of iron oxides in marine surface water. The formation of Fe(II) by this mechanism may lead to an increase of the availability of iron to bacteria and phytoplankton.