Cosmic origin of volatile species on the early Earth and Mars

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The early Earth's atmosphere was astonishingly "pure", being made of a single component released by "juvenile" micrometeorites similar to those recovered from Antarctica blue ices, and made of a fine-grained hydrous-carbonaceous material loaded with solar neon. This purity would result from a coupling between the last giant "cleaning" impact of a Mars-sized body with the young Earth (around 4.45 Gy ago), that both formed the Moon and blew away any previously acquired complex atmosphere, and the onset of a gigantic "storm" of "juvenile" micrometeorites that lasted ≥ 100 My. This storm was likely produced by a family of large "parent" bodies (probably Kuiper belt comets) which also yielded the big impactors that heavily craterized the Moon during this period of *late heavy bombardment*. The variation of lunar cratering rates with time (as conjectured by W.K.Hartmann), and observations showing that the composition of the micrometeorite flux was invariant with time, allowed to develop a simple model to estimate the total amounts of Ne, N_2, CO_2 and H_2O injected by this "post-lunar" micrometeorite storm on the now fully grown young Earth. The fit between the predictions of this model coined as "EMMA" *(Early MicroMeteorite Accretion*) and the corresponding observations is amazingly good.

This justifies extrapolating EMMA to both other species such as organics (as to get clues about the prebiotic *"organo-mineral"* chemistry that gave birth to life) and other terrestrial planets. It predicts that the last giant "cleaning" impact on Mars occurred much later than on the Earth, about 4 Gy ago. This impact would have dramatically stopped the evolution of possible early life forms on the red planet while blowing out water. Thus, the search for microfossils in future Martian samples to be returned to the Earth could be even more rewarding than previously thought. Indeed, they would bear informations about the earliest still unknown life forms which have all disappeared on our very active blue planet.

Microbially mediated dissolution of clays: Effects of siderophores

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Although Fe is an essential nutrient for almost all microorganisms, the bioavailability of Fe in aerobic, circum-neutral environments tends to be limited by Fe(III)(hydr)oxide solubility. In such environments, bacteria often use siderophores as an important component of the Fe acquisition process. Siderophores are microbially produced metal-complexing ligands with strong binding affinities for Fe(III); siderophore-Fe complex formation constants are on the order of 10^{23} to 10^{52}. Siderophores also can bind a variety of other trace metals, including Al^{3+}. Several studies have shown that siderophores enhance the dissolution rates of both Fe(III) (hydr)oxides and aluminosilicates.

Our research focuses on the effects of siderophores on dissolution of the aluminosilicate clay, kaolinite. Two specific projects will be discussed: (1) adsorption to and dissolution of kaolinite by the trihydroxamate siderophore, desferrioxamine B (DFOB), and (2) siderophore production by an aerobic *Pseudomonas mendocina* bacterium as a means of acquiring Fe from kaolinite.

Overall, the results of these two studies show that (1) siderophotes can play an important role in microbially mediated dissolution of clays and (2) natural kaolinite samples with trace Fe contents may serve as sources of Fe to aerobic bacteria under conditions of Fe stress. The potential role of bacteria in kaolinite genesis and diagenesis likely important and warrants further geomicrobiologic research.