Life at the dry limit: Microbial colonization of evaporites in the Atacama Desert

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The hyper-arid core of the Atacama Desert is considered the driest region on Earth, one of the most challenging environments for life, and a Mars analog, due mainly to water scarcity. While Atacama soils are essentially lifeless, we have shown that hygroscopic halite crusts are colonized by endolithic communities composed of cyanobacteria, heterotrophic bacteria and archaea [1, 2]. The interior of the crusts provides shelter against extreme temperatures and UV radiation, and facilitates cell hydration through mineral deliquescence [3]. We also found that microporous and translucent gypsum crusts represent another evaporitic habitat for life in Atacama. This substrate is colonized by endolithic and hypoendolithic free living algae, fungi, cyanobacteria and heterotrophic bacteria, as well as by epilithic lichens [4]. The colonization of gypsum crusts appears to be controlled by atmospheric water potential. Based on our work in Atacama, we propose that putative Martian microorganisms withdrew to similar evaporitic micro environments as the planet dried out [5]. As such, evaporitic deposits would be primer targets for the search for life.

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Trace element mobilisation in a natural analogue CO_2 storage site

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Natural analogues present a unique opportunity to study fluid-mineral interactions and transport processes that may occur in geological CO_2 storage systems [1,2]. Near Green River, Utah, USA, regionally extensive portions of the red-bed Entrada sandstone have been locally bleached white/yellow by low temperature diagenetic fluids [3]. Fluid inclusion studies [3], field relationships and modelling suggest that the fluid responsible for the bleaching is a low Eh-pH, CO_2-rich brine, containing variable amounts of methane.

Analyses reveal systematic patterns of trace element mobilisation and transport resulting from CO_2-promoted oxide dissolution (Fig. 1). Trace metals and REE concentrations are enriched at the transition from bleached to red facies. Element distribution is controlled by partitioning between the fluid and secondary minerals (carbonate, oxide, and clay phases), that precipitate as geochemical fronts propagate through the host rock. These fronts separate reduced, acidic fluid from oxidized groundwater.

Modelling suggests that bleaching results from dissolution of hematite from the red sandstones by a reaction of the form:

$$20Fe_2O_3 + 64CO_2 + 5CH_4 + 19H_2O + 11H^+ = 30Fe^{+2} + 59HCO_3^- + 10FeHCO_3^+,$$

in which CO_2 and a small fraction of methane complex the iron in solution. This reaction combined with Eh-pH diagrams suggest the precipitation of an iron-bearing carbonate and/or iron oxide phase, consistent with petrological observations.

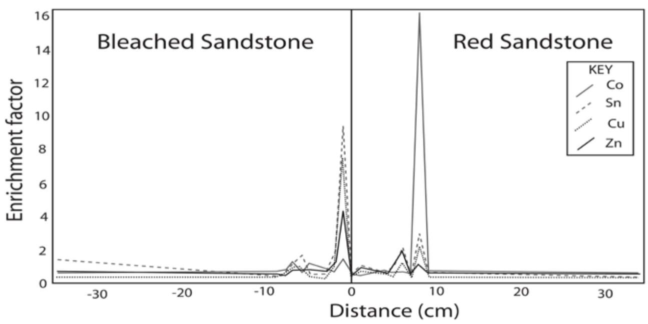

Figure 1. Plot of enrichment factor of metals relative to unaltered Entrada sandstone, versus distance from the bleached-unbleached contact.

[1] Moore *et al* (2005), *Chem. Geol*. **217**, 365-385. [2] Kampman *et al* (2009), *Earth Planet. Sci. Lett*. **284**, 473-488. [3] Kampman (2010), PhD thesis.