Hints of habitable environments on Mars challenge our studies of Mars-Analog sites on Earth

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Life as we know it requires water with a chemical activity (α) >~0.6 and sources of nutrients and useful energy. Some biota can survive if favorable conditions occur intermittently, but the minimum needed frequency of occurrences is poorly understood. Recent discoveries have vindicated the Mars exploration strategy to 'follow the water'. Mars Global Surveyor's Thermal Emission Spectrometer (TES) found coarse-grained hematite at Meridiani Planum. Opportunity rover confirmed this and also found evidence of ancient sulfate-rich playa lakes and near-surface groundwater. Elsewhere, TES found evidence of evaporitic halides in topographic depressions. But α might not have approached 0.6 in these evaporitic sulfate- and halide-bearing waters. Mars Express (MEX) and Mars Reconnaissance Orbiter (MRO) found extensive sulfate evaporites in Meridiani and Valles Marineris. MEX found phyllosilicates at several sites, most notably Mawrth Valles and Nili Fossae. MRO's CRISM near-IR mapper extended the known diversity and geographic distribution of phyllosilicates to include numerous Noachian craters. Phyllosilicates typically occur at the base of exposed ancient rock sections or in sediments in early Hesperian craters. It is uncertain whether the phyllosilicates developed in surface or subsurface aqueous environments and how long aqueous conditions persisted. Spirit rover found very pure ferric sulfate, indicating oxidation and transport of Fe and S, perhaps due to fumaroles or hot springs. Spirit also found opaline silica, consistent with hydrothermal activity. CRISM mapped extensive silica deposits in the Valles Marineris region, implying aqueous weathering and deposition. CRISM also found ultramafic rocks and magnesite at Nili Fossae, consistent with serpentinization, a process that can sustain habitable environments on Earth. The report of atmospheric methane implies subsurface aqueous conditions. A working hypothesis is that aqueous environments persisted in the near-subsurface for hundreds of millions of years and might exist even today. Studies of Mars-analog environments must better understand subsurface nonphotosynthetic ecosystems and their biosignatures in mafic and ultramafic terranes. Studies also must determine minimum needs for water activity and energy and establish survival limits when conditions that support active metabolism and propagation become progressively less frequent over time.

δ^{30}Si constraints on silicon cycling in the low-latitude thermocline

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The oceanic cycle of silicon is linked to that of carbon due to the importance of diatoms for the export of organic matter to the deep ocean. Their floral dominance in regions that are important for ocean-atmosphere interaction, such as the Southern Ocean, results in diatom productivity being especially relevant to both the uptake of anthropogenic CO_2 and glacial-interglacial changes in atmospheric pCO_2. The fractionation of silicon isotopes by diatoms alters the stable isotope composition of silicon (δ^{30}Si) dissolved in seawater in the photic zone. Since the differing δ^{30}Si signatures of surface waters in deepwater source regions are advected into the deep ocean by deepwater formation, δ^{30}Si of seawater is a quasi- to non-conservative oceanographic tracer that could prove to be a useful constraint on particle dissolution fluxes and/or mixing parameters in inverse models of the ocean.

We will present δ^{30}Si values for seawater of the subtropical and tropical eastern Atlantic Ocean, with emphasis on the waters of the surface mixed layer (where Si is present at concentrations ≤ 1 μM and is highly enriched in its heavier isotopes) and the thermocline, since it is in this section of the water column that the cycling of silicon is most intense. Vertical advection-diffusion-reaction models will be applied to provide a first-order quantification of the processes determining the observed silicon isotope composition of the waters of the eastern Atlantic thermocline.

The detailed results of local studies such as this will aid the improvement of models of nutrient dynamics and regeneration in the global ocean. A better understanding of the behaviour of silicon and its isotopes in the ocean is also vital for reliable application of the δ^{30}Si record of diatomaceous marine sediments to the reconstruction of the nutrient state of the surface ocean in the past. Furthermore, the vertical models presented are generally applicable to the novel stable isotope systems of other elements that interact with biology in the surface ocean.