The martian critical zone: Concept and experimental example

NICO PERDRIAL[1], JESSE ARMFIELD[1], GRANT REEDER[1], ALEX GAGNON[1], ELIZABETH B. RAMPE[2] & JULIA PERDRIAL[1]

[1]Department of Geology, University of Vermont, Burlington, USA. nicolas.perdrial@uvm.edu
[2]NASA Johnson Space Center, Houston, USA. elizabeth.b.rampe@nasa.gov

The critical zone (CZ) is defined as the thin layer of the Earth extending from the top of the tree canopy, through the soil to actively cycled groundwater. It is the zone that, powered through a multitude of complex and coupled processes, provides us with ingredients needed to sustain life on Earth. Interactions between the atmosphere, hydrosphere and lithosphere are integral to the terrestrial CZ as are disturbances that disproportionally impact CZ evolution. The martian CZ exhibits similar features, only missing the biosphere. We suggest that Mars surface processes could be studied using similar tools and concepts as the terrestrial CZ, namely an integrative, multidiscplinary systems approach.

As a starting point we designed a set of experiments to simulate weathering on Mars that were informed by the CZ concept. Specifically we decided to test the effect of atmospheric composition and one disturbance that might play a role in weathering on Mars, i.e. freeze-thaw dynamics. We performed flow-through column experiments where a pH2, $HCl-H_2SO_4-H_2O$ solution was infiltrated into columns packed with martian regolith analogue (JSC-MARS1). The 10 day long experiments were performed in duplicate under CO_2 atmosphere (Mars analog) and ambient conditions (Earth conditions) under both continuous flow and freeze-thaw cycling. Aqueous leaching products were analyzed for pH, cations and anions to investigate variations in weathering as a function of the experimental variables. Solid products are currently being characterized by SEM and XRD.

Our results suggest that changes in atmospheric composition and disturbances did not affect the nature of weathering reactions (dissolution due to proton attack) but lead to fundamentally different weathering rates. Higher weathering rates were found under CO_2 atmosphere and freeze-thaw cycles, lowest rates were found in the terrestrial atmosphere and continuous flow. Applying CZ thinking to martian processes prouved to be a helpful guiding principle in designing experiments that reflect martian conditions more closely. This approach could inform future experiments but, more importantly, could guide our thinking about the past, present and future of planetary surface processes.