The impact of the dissolution of aeolian dust on nutrient availability, Taylor Dry Valley, Antarctica

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The Taylor Dry Valley (TDV) trends generally east to west, terminating to the east in McMurdo Sound and to the west in the Taylor Glacier, an outlet glacier of the East Antarctic Ice Sheet. Katabatic winds off the ice sheet, probably responsible for the bulk of lithogenic dust movement, dominate during the winter months; coastal winds from the east add salts and marine aerosols to the system and influence in the summer months.

Previous studies have examined the dissolution of aeolian material during the austral summer melt season when a hydrologic continuum is set up between the glaciers and endorheic lakes of TDV. A general spatial decrease in solute content westward and with elevation has been noted

For this study, samples of aeolian material were collected from glacier and lake surfaces, elevated sediment traps (EST), and aeolian landforms. Aliquots were subjected to a water leach (25 g sample, 50 mL water) and resulting leachates were analyzed on a Skalar nutrient analyzer.

Species examined here are PO_4^{3-}, total phosphorus (TP), NO_2+NO_3^-, and total nitrogen (TN). PO_4^{3-} ranges from below detection (BD) to 1.2 $\mu g*g^{-1}$; TP BD to 4.75 $\mu g*g^{-1}$; NO_2+NO_3^- BD to 2.48 $\mu g*g^{-1}$; and TN BD to 22.7 $\mu g*g^{-1}$. Aeolian landforms consistently demonstrate the lowest values in all nutrient species. TN and TP show a more recognizable trend: glacial sediments have higher TN content, while EST have higher TP content. PO_4^{3-} and NO_2+NO_3^- exhibit a more dispersed pattern. Notably, glacial samples have higher PO4 content and EST have a higher NO_2+NO_3^- content. Aeolian transport and dissolution is an important means of nutrient availability and transport in the TDV.

Surface complexation modelling of phosphorus availability and bioavailability for plants

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Plant nutrition models do not properly account for the effects of root-induced chemical processes in the rhizosphere, e.g. pH changes, on the availability of nutrients such as phosphorus (P). As a result, they underestimate the actual P uptake, i. e. P bioavailability for plants, in low P soils. We used a mechanistic description for the adsorption of cations and anions by soil constituents to simulate P availability in rhizosphere and bulk soil over a range of pH values. We also measured and simulated the availability of calcium (Ca) and the bioavailability of Ca and P for wheat.

Results of modelling were found in excellent agreement with experimental data. In the rhizosphere, the achievement of the goodness-of-fit required to account for the uptake of Ca by plants, in addition to P uptake and root-induced alkalisation. Calcium uptake significantly increased P availability, when assessed by water extraction, by decreasing the promoting effect of the adsorption of Ca onto that of P. The calculated amounts of Ca and P taken up by plants corresponded to the measured amounts, i. e. Ca and P bioavailabilities. Our modelling investigation showed that P was primarily adsorbed onto Fe-oxides and clay minerals depending on soil pH. The major source of bioavailable P for wheat was P desorbed from goethite and kaolinite.

In addition to confirming the validity of our approach to model P availability and bioavailability, the present investigation suggested that in the studied soil, a novel root-induced chemical process was controlling P nutrition under low P conditions, namely the uptake of Ca.