

Reactive soil components and pedogenesis of highly productive coastal podzols

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Scope of Presented Work

We investigate pedogenic processes and biogeochemical characteristics of acid forest soils (humo-ferric podzols) from the Sunshine Coast of southern British Columbia. The general objective is to gain insight into the processes governing soil formation and nutrient availability in this watershed. We specifically focus our efforts on poorly crystalline phases due to their high reactivity, their ability to retain negatively charged plant nutrients (NO_3^- and PO_4^{3-}), and the control they may exert on organic matter distribution.

Site and Methods

Soil samples were collected in the Roberts Creek study forest. This watershed has been monitored since the early 1990s to study the effects of forest harvesting on drinking water quality [1]. We analyzed samples from each pedogenic horizon in 26 soil profiles using a combination of chemical extractions, electron microscopy and IR spectroscopy.

Pedogenetic Processes and their Implications

These acidic soils formed on base poor, compact basal till derived from granitic material. High precipitation and mild climate promotes strong leaching in the upper horizon of these coarse texture soils (loamy sands). The light-coloured eluvial horizon (Ae / E) is commonly up to 15cm in thickness and exhibit high acidity ($\text{pH}_{\text{H}_2\text{O}} = 4.5$) and high exchangeable Al values. The Ca/Al ratio is below 0.75, suggesting possible toxicity to shallow rooted vegetation such as young seedlings.

The illuvial horizon (Bf / Bs) is characterized by a higher pH ($\text{pH}_{\text{H}_2\text{O}} = 5.5$), and an accumulation of organic matter (OM) and poorly crystalline inorganic phases. OM shows a strong association with the clay fraction. Poorly crystalline phases consist of imogolite-type material (ITM). ITM forms as a result of high release rates of Al and Si and is an essential component of these soils. In about 30% of the samples the clay fraction consists in ITM almost exclusively and no detectable amount of phyllosilicate is present.

Conclusion

The reactivity and nutrient holding capacity of these soils are accounted for by a very small proportion of the soil matrix, which is the organic and ITM-rich clay fraction. The high productivity of these coarse soils is likely to be a direct consequence of the abundance of clay-sized OM and ITM.

[1] Hudson, R. & Tolland, L. (2002) Roberts Creek Study Forest. B.C. Min. For., Nanaimo, Tec. Rep. TR-019.

Alkali activities in silicate melts

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We have conducted a series of experiments at ambient pressure and temperatures of 1400-1500°C in order to determine the activity coefficients of a number of moderately volatile elements in silicate melts as a function of melt composition. Experimental procedure was similar to that described previously [1]. Each experiment contained five samples, each with a unique bulk composition in the CMAS system, and a sixth with a composition on the join $\text{X}_2\text{O-SiO}_2$ (where X was either Li, Na or K). Samples were suspended in a vertical furnace along with a source of Li, Na, or K. Inclusion of the $\text{X}_2\text{O-SiO}_2$ bulk composition allows us to couple our experimental results with thermodynamic models of the relevant alkali metal oxide-silica binary melts [2] and define absolute activity coefficients for alkali components in the synthetic CMAS melts.

Our results suggest that $\text{LiO}_{0.5}$, $\text{NaO}_{0.5}$ and $\text{KO}_{0.5}$ activities in the melt are not affected by degree of melt polymerization, and indicate that Al-Li, Al-Na and Al-K and interactions are not of great importance in these synthetic melts. At fixed alkali activity we find that all of the alkali ions we examined are most soluble in SiO_2 -rich compositions. Na solubilities measured in this study are in excellent agreement with O'Neill, 2005 [1]. On a molecular basis, Li, Na and K exhibit virtually identical activity-composition dependences. Finally, at fixed $\text{LiO}_{0.5}$, $\text{NaO}_{0.5}$ and $\text{KO}_{0.5}$ activities, the concentrations of these components in silicate melts with identical bulk compositions increases with decreasing $f\text{O}_2$.

Our findings imply that crystal-melt partitioning of alkali ions is only weakly sensitive to melt composition.

[1] O'Neill (2005) *Am. Min.* **90**, 497-501. [2] Romero-Serrano, A. *et al.* (2005) *J. Am. Ceram Soc.* **88**, 141-145.