# Sensitivity of mineral dissolution rates to physical weathering : A modeling approach

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Abstract:

There is continued interest on accurate estimation of natural weathering rates owing to their importance in soil formation, nutrient cycling, estimation of acidification in soils, rivers and lakes, and in understanding the role of silicate weathering in carbon sequestration. At the same time a challenge does exist to reconcile discrepancies between laboratory-determined weathering rates and natural weathering rates. Studies have consistently reported laboratory rates to be in orders of magnitude faster than the natural weathering rates (White, 2009). These discrepancies have mainly been attributed to (i) changes in fluid composition (ii) changes in primary mineral surfaces (reactive sites) and (iii) the formation of secondary phases; that could slow natural weathering rates. It is indeed difficult to measure the interactive effect of the intrinsic factors (e.g. mineral composition, surface area) and extrinsic factors (e.g. solution composition, climate, bioturbation) occurring at the natural setting, in the laboratory experiments. A modeling approach could be useful in this case. A number of geochemical models (e.g. PHREEQC, EQ3/EQ6) already exist and are capable of estimating mineral dissolution / precipitation rates as a function of time and mineral mass. However most of these approaches assume a constant surface area in a given volume of water (White, 2009). This assumption may become invalid especially at long time scales. One of the widely used weathering models is the PROFILE model (Sverdrup and Warfvinge, 1993). The PROFILE model takes into account the mineral composition, solution composition and surface area in determining dissolution / precipitation rates. However there is less coupling with other processes (e.g. physical weathering, clay migration, bioturbation) which could directly or indirectly influence dissolution / precipitation rates. We propose in this study a coupling between chemical weathering mechanism (defined as a function of reactive area, solution composition, temperature, mineral composition) and the physical weathering module in the SoilGen model which calculates the evolution of particle size (used for surface area calculation) as influenced by temperature gradients. The solution composition in the SoilGen model is also influenced by other processes such as atmospheric inputs, organic matter decomposition, cation exchange, secondary mineral formation and leaching. We then apply this coupled mechanism on a case study involving 3 loess soil profiles to analyze the sensitivity of mineral weathering rates to physical weathering. Initial results show some sensitivity but not that dramatic. The less sensitivity was attributed to dominance of resistant primary minerals (> 70% quartz). Scenarios with different sets of mineralogy will be tested and sensitivity results in terms of silicate mineral dissolution rates and $CO_2$-consumption will be presented in the conference.

References
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