

Can Experimental Dissolution Studies Reproduce Natural Weathering Rates?

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Introduction

Chemical weathering rates are controlled both by intrinsic mineralogic properties (e.g., defects and surface areas) and extrinsic effects (e.g., solution compositions and saturation states)[1]. During natural weathering, these properties are expected to evolve over geologic time scales which are not reproducible under laboratory conditions. A long term (12 years) experimental column study characterizes the changes of both the relative importance of individual mineral phases and their kinetic reaction rates for 4 pairs of crushed fresh and weathered granite rocks obtained from well-characterized watersheds.

Results

Effluents from the fresh granites indicated a progression in mineral reactivity, dominated initially by defect-dominated plagioclase surfaces (< 1 week), followed by the successive contributions from trace amounts of disseminated calcite (< 1 year) and the oxidation of biotite (<2 years) and finally, by the end of 12 years, by the stoichiometric dissolution of plagioclase. For weathered granites, accessory phases are absent or already oxidized, and effluents are dominated by bulk plagioclase dissolution throughout the experiments.

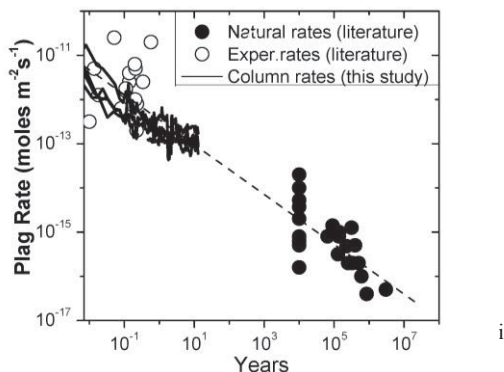


Figure 1: Comparison over time of weathering rates of plagioclase from this study and literature experimental and natural rates.

While initial plagioclase rates for the fresh granites, normalized against BET surfaces, were significantly faster than for weathered granites, the rates converged by the end of 12 years, indicating that extrinsic effects were removed during the course of the experiments. However both sets of rates, while less than those reported for previous experimental studies, remained 1 to 3 orders of magnitude faster than natural rates (Fig. 1). Calculations indicate that while effluents were saturated with respect to gibbsite and kaolinite, they remained significantly undersaturated with plagioclase due to fluid flow rates faster than for most natural conditions.

[1] White & Brantley (2005) *Chem. Geol.* **202** 479-506.

Updated and extended activity–composition models for thermodynamic calculations in metapelitic systems

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The direct application of calculated phase diagrams to metamorphic rocks is dependent on the availability of sophisticated activity–compositional ($a-x$) models in large chemical systems. While the development of such models has advanced considerably in the last decade, existing models span a range of approaches and degrees of sophistication. The development of a new internally-consistent thermodynamic dataset [1] necessitates the modification of these models to be consistent with the dataset. However, this also provides the opportunity to undertake a thorough expansion, and modernisation of the models.

Updated models for chlorite, cordierite, biotite, staurolite, chloritoid, ilmenite-hematite and melt are presented. Key changes include consideration of ferric iron in chlorite & staurolite, with the additional inclusion of titanium in staurolite, a non-ideal model for cordierite and Fe-Mg order-disorder in chlorite. Calibration of the models has been undertaken in the NCKFMASHTO system utilising a large dataset of coexisting mineral pairs from experimental studies and rocks and via comparison with observed phase relationships in experimental studies and rocks. By developing all the models at the same time, each of the models utilises a consistent approach to formulation, order-disorder and the size of the mixing parameters (W). Thus, many of the inconsistencies between earlier models, which were developed at different times, are eliminated. Diagrams calculated with the new models compare favourably with previous diagrams, with some notable improvements. Extension of the models to include Mn is currently underway.

[1] Holland & Powell (2011) *Journal of Metamorphic Geology* **29**, 333-383.