

Driving mineral dissolution studies in a new direction

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Recent studies by [1] have demonstrated that intrinsic rate variations in mineral dissolution are common and of up to 2.5 orders of magnitude. As a major consequence, we have abandoned the concept of simple closed-form rate equations. Instead, we have introduced the concept of rate spectra. Such rate spectra are the direct result of the fact that dissolution rates depend critically on surface energy distribution. This alternative avoids the highly problematic use of concepts such as reactive surface area that have proven to be mainly not quantifiable.

It is not sufficient to just criticize the existing approach that has certainly produced a sound large data base and many valuable observations. However, we are increasingly skeptic that we will gain much new insight from this approach. Instead we would like to encourage a competition for a new, more powerful approach. As a start, we suggest here one possible method that consists of experiments with analytical tools such as atomic force microscopy, RAMAN-coupled vertical scanning interferometry, among others, and comprehensive theoretical methods such as kinetic Monte Carlo (KMC) calculations. The latter tool provides the capability of predicting crystal dissolution mechanisms and rates. As an example, we will discuss a couple of two recent studies by [2,3] that have focused on phyllosilicates and quartz. In these studies, we demonstrate that complex KMC models which are parameterized with results from *ab initio* and DFT calculations can indeed successfully predict the behavior and development of dissolving crystals.

[1] Fischer *et al.* (2012) *Amer. J. Sci.* **312**, 885-906. [2] Kurganskaya & Lüttge (2013a) *GCA*. [3] Kurganskaya & Lüttge (2013b).

Contamination of DM-sourced magmas produced diverse flood basalts in the Karoo province?

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Continental flood basalt (CFB) provinces represent large emplacements of mantle-derived magmas that frequently exhibit incompatible element and isotopic affinity to silicic continental crust. Whether or not this affinity stems from predominantly lithospheric mantle sources rather than crustal contamination of hotspot magmas has remained controversial.

The Middle Jurassic lavas and dikes of Vestfjella were generated during the breakup of Gondwana and represent remnants of the Karoo CFB province in Antarctica. The Vestfjella CFBs record notably diverse geochemical compositions (e.g., initial ϵNd from -15 to +8). The well-exposed 1-km-thick lava succession and the crosscutting dike swarm are dominated by three variably enriched geochemical types (CT1, CT2, and CT3), but the dikes also include rare lamproitic, ferropicritic, and MORB-like (initial $\epsilon\text{Nd} = +8$) types. The Sr, Nd, Pb, and Os isotopic compositions of the MORB-like dikes overlap with those of modern Southwest Indian Ridge MORB, but the trace element compositions indicate melting at high pressures (below thick Gondwanan lithosphere).

Our calculations using the energy-constrained assimilation and fractional crystallization (EC-AFC) model demonstrate that the diverse CFB types could have been derived from a single MORB-like parental magma type by contamination. Importantly, calculations using Archean and Proterozoic granitoids and local lamproite as crustal and lithospheric mantle contaminants infer that even the most enriched CFBs of Vestfjella contain >90% of a depleted sublithospheric mantle-derived component.

These results lend support to the view that lithospheric contamination of voluminous sublithospheric mantle-derived melts may be chiefly responsible for the predominance of enriched magma types in CFB provinces.