

A physical model for a chemical flux: An attempt to integrate Ganga and Brahmaputra particle composition

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Large rivers are powerful integrators of geochemical and physical processes at work in their catchment area. They are also central in global biogeochemical cycles as they redistribute mass and elements across the earth surface. While river solute fluxes provide insights into chemical weathering fluxes and rates, suspended sediments are also of prime interest as they provide a record of the processes sediments undergo from source to sink in terms of erosion, weathering and biological activity. Evaluating the chemical composition of the material that is transported by rivers is thus a key point in our understanding of large scale Earth surface processes and mass transfer. Any of these attempts raises the problem of integrating sampled sediments both spatially and temporally through a river section. It has long been recognized that sediment composition is not uniform through the water column as a result of hydrodynamic mineral sorting and flow conditions of the river. These effects have to be accounted for in order to derive realistic sediment compositions.

This work focuses on the Ganga and Brahmaputra (G&B) rivers that transport the products of Himalayan erosion to the Bay of Bengal. Depth samplings of sediments were performed on these two rivers in Bangladesh at different water levels along with Acoustic Doppler Current Profiling (ADCP) of the river sections to record water velocities and fluxes. The data was used to fit a Rousean suspended sediment model to predict the grain size distributions of the river sections. These grain size distributions are then used to derive chemical compositions of the river sediments as a strong correlation exists between grain size parameters and chemical compositions. By extrapolating these instantaneous fluxes through the monsoon hydrological cycle we attempted to estimate the chemical average composition of the G&B sediments. These chemical compositions are compared to the average Himalayan crust composition, and using a chemical mass balance approach we infer total erosional fluxes of the two Himalayan basins.

Kink site reaction kinetics: A new model unifies crystal dissolution and growth theory

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It has been long recognized that crystal growth and dissolution processes are mainly governed by kink site reaction kinetics (Fig. 1). Traditionally, it has been assumed that equilibrium is achieved if arrival and departure rates of lattice-building molecules are equal. New considerations, however, raise significant doubt that this simple model is correct. A detailed analysis of the processes that occur at kink sites during the overall dissolution reaction leads to the initially surprising result that the probability is always in favor of lattice destruction – this result is in agreement with the thermodynamic rule of increasing entropy.

The destructive processes are eventually countered by the arrival of molecules at the kink sites. This model scenario can explain a number of critical experimental observations and predicts that the reaction rate as function of distance from equilibrium must be continuous at equilibrium, i.e. $\Delta G = 0$. Ultimately, our model allows us to unify crystal dissolution and growth theories.

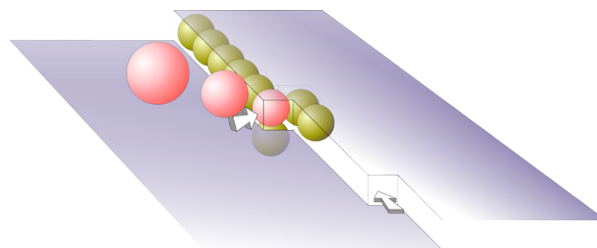


Figure 1: Schematic rendering of kink site at step edge.