Solutal convection induced by dissolution

Julien Philippi[1], Michael Berhanu[2], Sylvain Courrech du Pont[2] & Julien Derr[2]

[1] TIPs, Université Libre de Bruxelles, C.P. 165/67, Avenue F. D. Roosevelt 50, 1050 Bruxelles, Belgium
[2] Laboratoire Matière et Systèmes Complexes, Université Paris Diderot, CNRS UMR 7057, 10 Rue Alice Domont et Léonie Ducquet, 75205 Paris Cedex 13, France
julien.derr@univ-paris-diderot.fr

The dissolution of minerals into water which erodes and shapes exposed solid surfaces made of soluble rocks becomes significant in geomorphology, when the erosion rate is controlled by the hydrodynamics transport of the solute[1,2,3]. This situation can occurs even in absence of an external flow, when the dissolution induces itself a convection flow due to the action the gravity (see our experimental work [4]). Here we perform a study of the physics of solutal convection by the means of numerical simulations of the hydrodynamics and of the solute transport in 2D geometry, corresponding to the case, where a soluble body is suddenly plunged and suspended in water. The convection flow starts after an onset time, which is characterized. Then, after a time of few onset times, a quasi-stationary regime is reached corresponding to a constant global erosion rate, controlled by the structure of the concentration boundary layer at the dissolving interface. Assuming that the destabilization of this boundary layer occurs at a specific value of the solutal Rayleigh number, we derive scaling laws both for fast and slow dissolution kinetics. These laws are then successively validated by the simulations. As a consistency test, a common value of the Rayleigh number is found *a posteriori* during the quasi-stationary regime, showing that the structure of the boundary layer is well controlled by the hydrodynamics. Finally, by applying the scaling laws previously established to the case of real dissolving minerals, we can predict the typical dissolution rate in presence of solutal convection. Our results suggest that the solutal convection could occur in more natural situations than expected even for minerals with a quite low saturation concentration, leading to an increased erosion rate as the dissolution is controlled by the hydrodynamics.

Références

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