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Solutal convection induced by dissolution. Influence on erosion dynamics and interface shaping.

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Rock fractures invaded by a water flow, are often subjected to dissolution, which let grow and evolve the initial fracture network, by evacuating the eroded minerals under a solute form. In the case of fast kinetic of dissolution, local erosion rate is set by the advection of the solute. The erosion velocity decreases indeed with the solute concentration at the interface and vanishes when this concentration reaches the saturation value. Even in absence of an imposed or external flow, advection can drive the dissolution, when buoyancy effects due to gravity induce a solutal convection flow, which controls the erosive dynamics and modifies the shape of the dissolving interface. Here, we investigate using model experiments with fast dissolving materials and numerical simulations in simplified situations, solutal convection induced by dissolution. Results are interpreted regarding a linear stability analysis of the corresponding solutal Rayleigh-Benard instability. A dissolving surface is suspended above a water height, initially at rest. In a first step, solute flux is transported through a growing diffusion layer. Then after an onset time, once the layer exceeds critical width, convection flow starts under the form of falling plumes. A dynamic equilibrium results in average from births and deaths of intermittent plumes, setting the size of the solute concentration boundary layer at the interface and thus the erosion velocity. Solutal convection can also induce a pattern on the dissolving interface. We show experimentally with suspended and inclined blocks of salt and sugar, that in a linear stage, the first wavelength of the dissolution pattern corresponds to the wavelength of the convection instability. Then pattern evolves to more complex shapes due to non-linear interactions between the flow and the eroded interface. More generally, we inquire what are the conditions to observe a such solutal convection instability in geological situations and if the properties of dissolution patterns can be related to the characteristic of the convective flow.

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