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# An interplay of two different length scales in reactive-infiltration instability

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The reactive infiltration instability, which develops when a porous rock matrix is dissolved by a flowing fluid, is a mechanism for pattern development in geology, with a range of morphologies and scales from kilometer-scale scalloping of dolomitization fronts to laboratory acidization on the scale of centimeters. Theories of the reactive-infiltration instability have proceeded from two different standpoints: those with an emphasis on natural processes taking place over thousands of years have started from the limiting case where diffusion dominates, whereas work derived from interest in petroleum recovery has focused on much more rapid flows assuming diffusion to be negligible. Here we present a general theory of the reactive-infiltration instability, valid for all flow rates and reaction rates, which shows that the dynamics of this process is a result of an interplay of two length scales characterizing the reactant concentration in a propagating front: an upstream length where the material is fully dissolved and a downstream length over which it transitions to the undissolved state. Previous work considered one or other of these lengths to be dominant, which limits the region of applicability more severely than is generally appreciated. In addition, we obtain a closed form solution for the growth rate of the instability spanning entire range of geologically feasible flow, diffusion and reaction rates in the limit when the permeability contrast is small. Finally, we identify the parameters characterizing the scale of the developing porosity perturbations and discuss the physical conditions under which they can be observed.