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Estimation of a dimensionless group containing the product of matrix viscosity and a diffusive transport parameter from data on infilling of a boudin gap by component diffusion and matrix inflow: a back-of-the-envelope model with FEM refinement

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In many instances, simple field observations – requiring, however, extensive search for suitable examples – lead to estimates of rheological and transport parameters that may be obtained from simple analytical models. The structure of interest is the gap between separating boudins. The gap is filled initially by formation of a "pressure shadow", followed by matrix inflow. Here, flow of a viscous fluid between separating rigid plates is used to estimate the latter, with the pressure shadow assigned the same viscosity as the matrix. Dissolution along the upper boudin surface and precipitation along the gap surfaces, the two mediated by diffusion along a fluid film, is added to inflow to provide a back-of-the-envelope model for the process. The ratio of matrix inflow to the whole provides an estimate of the dimensionless group

$$\Omega = \frac{24\eta\left(D\xi\right)c_0V_0^2}{H^2\left(H+L\right)RT}$$

where the quantities in the numerator are matrix viscosity, bulk diffusivity in aqueous fluid, interfacial film thickness, mean concentration of diffusing component, and specific volume of precipitating solid, and in the denominator, boudin layer thickness (2H), length (2L), gas constant and temperature kelvin. The rate of growth of the boudin gap (2Δ) is

$$\frac{d}{dt}\left(\frac{\Delta}{H}\right) = 4\bar{D}_{xx}\left[\left(\frac{\Delta}{H}\right)^3 + \Omega\right]$$

where $\bar{D}_{xx}$ is the bulk rate of extension. We apply this model to estimate parameter combinations that allow for observed boudin gap geometries. A further refinement of the present model has been carried out using the FEM. The implemented FEM model is free from the stringent constraints, especially regarding geometry, that underlie the analytical model. We compare the two and demonstrate where they are valid approximations to nature.