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Analytical and numerical investigation of pore-boundary separation

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We consider stationary coupled migration of pores and grain boundaries in two dimensions (2D). The conditions for pore drag and separation are of great interest for geoscientists and material scientists. The pores are situated on either grain boundaries or triple junctions. Their mobility is realized by surface diffusion. The boundaries migrate owing to surface tension effects. Our analytical approach is based on a small velocity approximation where the perturbation method can be used. We analytically obtain the pore mobility and estimate the critical velocity at which separation occurs. The estimate suggests that the critical pore velocity is only slightly affected by the dihedral angle. The analytical approach is then refined by numerical solution. We demonstrate that the pore separation occurs in 2D resolving contradictory results of previous authors. We also demonstrate that the critical velocity for the dihedral angle $\Phi = \pi$, i.e., pore with circular cross-section, is nonzero. This result, that agrees with the phenomenological approach based on the concept of Zener drag, again clarifies contradictions in previous papers. Our numerical approach is further confirmed by bifurcation analysis of the separation phenomenon. The critical velocities for 2D pores are about 3 times smaller when compared to critical velocities of 3D lenticular pores on grain boundaries. Our analysis is then extended to pores at triple junctions. Here we also obtain mobility and critical velocity. We also determine the coupled pore-boundary mobility and demonstrate that the boundary mobility is practically always reduced by pores.