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Channel formation in analog lowly consolidated gouges due to interstitial fluid flow

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In lowly consolidated granular materials, when interstitial fluids flow at sufficient speed, the drag can rearrange the grains beyond poroelastic deformations. Applying pressure gradients to confined granular/fluid mixtures, we show that instabilities arise during such flow, leading to pattern formation, and to a strong channelization of the flow. This is the granular/fluid analog to Saffman-Taylor instabilities arising in two fluid flows. This structuration of the medium has a strong influence on the subsequent transport properties. Notably, in lowly consolidated gouges in fault cores, such channelization could have an impact on heat and fluid transport, thus affecting significantly the potential role of fluid and temperature on fault dynamics. We study this process both experimentally and numerically, in circular and linear setups, and show that these restructuration instabilities are generic, and happen both during compaction and decompaction processes. We also show that instabilities in mixed granular/fluid flows arise during sedimentation processes, when the pressure difference comes from gravitational fields. The channelization observed in this case, analog to the Rayleigh Taylor instability, also strongly affects the material's transport properties. We perform laboratory experiments on such flows, and compare the results to numerical models which render for complex hydrodynamic interactions between mobile grains. This model treats the solid phase as discrete particles, interacting mechanically with the other particles and with the intersticial flowing fluid. The fluid is described by continuum equations rendering for its advection by the local grains, superposed to a pressure diffusion ruled by a Darcy flow with a permeability depending on the local solid fraction. Numerical and experimental results are shown to be consistent with each other.