28*th* IUGG Conference on Mathematical Geophysics, June 7-11, 2010, Pisa, Italy
Session 2: Geophysical fluid dynamics II - Sub-surface and surface flows

Sedimentation and aerofracture: Sedimentation instability and fracturing/channeling transitions in mixed grain/fluid flows - impact of viscosity and compressibility

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Keywords: *modelling; fluid dynamics; granular dynamics*

We present systems where we inject a fluid at high pressure in a porous material saturated with the same fluid, or where gravity overpressurizes the fluid in intercticial pore space during granular deformation. This fluid is either a highly compressible gas (air), or an almost incompressible and viscous fluid (oil or water). We compare both situations. These porous materials are designed as analogs to real rocks, but their cohesion are tuned so that the hydrofracture process can be followed optically in the lab. The fluid is injected on the side of the material. At sufficiently high overpressures, the mobilization of grains is observed, and the formation of hydrofracture fingering patterns and transition to thin branching fractures is followed and analyzed quantitatively. We study the pattern formation in the decompaction process starting from free boundaries, and the formation of channels and fractures around injection chambers or gravitationally pressurized chambers. Thresholds of pressures are determined for the formation of these preferential paths. The geometry of these channels, their fractal dimension and other characteristics, are extracted from experiments and simulations. The two situations with air or oil are compared together. Many similarities are observed about shape selections and dynamics, when time is rescaled with the viscosity of the fluid. We also investigate systematically the change of intersticial fluid, in compressibility and in viscosity, over a sedimentation Rayleigh/Taylor instability. The adaptation of hybrid granular fluid modelling algorithms to tackle the different types of flows will be presented. In practice, these problems are relevant for important aspects in the formation of increased permeability networks as seen in nature and industry: e.g., in active hydrofracture in boreholes, piping/internal erosion in soils and dams, sand production in oil or water wells, and wormholes in oil sands. It is also important to understand the formation of channels, and the behavior of confined gouges when overpressured fluids are mobilized in seismic sources. Indeed, the formation of preferential paths in this situation can severely affect the fluid and heat transport properties in this situations, and thus affect the pore pressurization effects. Eventually, the impact of lubrication effects in avalanches with long runoff, is also urging for models, as tested on the simple flows presented here.