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Multidisciplinary approach for mud volcano eruptions

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Mud volcanism, representing the episodic eruption of mud, water, oil and gas, is observed in many sedimentary basins, and its causes and triggers have long been debated. Contributing processes include basin compression, rapid subsidence and sedimentation rates, illitization of clay minerals, and expansion of interstitial fluids. However it is broadly recognized that the overpressure generated by hydrocarbon-rich fluids (e.g. methane) can be extremely effective as an eruption trigger. The hydrocarbon generation and maturation together with the cracking of heavier fractions in organic-rich units is probably the main engine preparing the mud volcano system at great depths (i.e. several km).

A multidisciplinary approach combining field observations, sand box experiments and numerical modeling eruption simulations is being conducted in order to investigate the effects of overpressure.

Field observations reveal that mud volcanoes are associated with hydrocarbon reservoirs and that their eruptions commonly initiates with a sudden gas release. The gas discharged often self ignites generating spectacular flares of burning hydrocarbons. To this follows the expulsion of brecciated sediments and mud that fluidizes after the initial burst.

Analogue and numerical simulations indicate that, even if the fluids originate and rise from great depth, the effective overpressure is produced when the fluids are gathered at shallower intervals (<km). Eruption occurs when the overburden cannot any longer

contain the pressure generated by the continuously rising fluids. Once the overpressured zone is breached the pressure drops significantly generating a fluidization of the brecciated sediments that are vacuumed to the surface. Fluid pressure estimates obtained from the analogue sand box modelling are compared to independent pressure estimates based on physical properties and structural analysis. We report on a system size dependency (i.e. the dependency of the width of the fluid feeder over the distance from the feeder to the surface) of the critical pressure at which the piercement structure forms.

We have began constructing a three dimensional high resolution numerical model coupling an explicit solver for solid skeleton deformation to the Darcian fluid flow solver via so-called seepage forces. In addition we aim at adding boiling-like phase transformations with large volume expansion. Through a comparsion between laboratory and numerical experiments as a validation exercise, we will use numerical experiments to investigate geologically relevant scenarios. Simulations show that the morphology of the surface manifestations of breaching depend strongly upon the strength and cohesion of the sedimentary layers and the magnitude of the overpressure compared to the overburden. External factors like e.g. seismic activity can facilitate the eruption fracturing the upper layers.