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Multiphase modelling of mud volcanoes

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Mud volcanism is a worldwide phenomenon, classically considered as the surface expression of piercement structures rooted in deep-seated over-pressured sediments in compressional tectonic settings. The release of fluids at mud volcanoes during repeated explosive episodes has been documented at numerous sites and the outflows resemble the eruption of basaltic magma. As magma, the material erupted from a mud volcano becomes more fluid and degasses while rising and decompressing. The release of those gases from mud volcanism is estimated to be a significant contributor both to fluid flux from the lithosphere to the hydrosphere, and to the atmospheric budget of some greenhouse gases, particularly methane.

For these reasons, we simulated the fluid dynamics of mud volcanoes using a newly-developed compressible multiphase and multidimensional transient solver in the OpenFOAM framework, taking into account the multicomponent nature (CH4, CO_2, H_2O) of the fluid mixture, the gas exsolution during the ascent and the associated changes in the constitutive properties of the phases.

The numerical model has been tested with conditions representative of the LUSI, a mud volcano that has been erupting since May 2006 in the densely populated Sidoarjo regency (East Java, Indonesia), forcing the evacuation of 40,000 people and destroying industry, farmland, and over 10,000 homes. The activity of LUSI mud volcano has been well documented (Vanderkluysen et al., 2014) and here we present a comparison of observed gas fluxes and mud extrusion rates with the outcomes of numerical simulations.

Vanderkluysen, L.; Burton, M. R.; Clarke, A. B.; Hartnett, H. E. & Smekens, J.-F. Composition and flux of explosive gas release at LUSI mud volcano (East Java, Indonesia) Geochem. Geophys. Geosyst., Wiley-Blackwell, 2014, 15, 2932–2946