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0.0.1 Modeling and classification of overpressure-driven vent structures in sedimentary basins

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Vent structures, such as mud volcanoes, dewatering pipes, hydrothermal vent complexes, breccia and kimberlite pipes, are typically caused by rapid fluid pressure build-up and subsequent transport of fluids with mobilized rocks towards the surface.

For simplicity we assume that vent formation does not depend on the particular physical process that generates the fluid overpressure. For a given fluid pressure rise we model the follow-on vent formation processes.

We systematically investigate the formation of different vent morphologies and classify them according to fluid overpressure, stress state in the rock before fluid pressurization, porosity, permeability, cohesion, friction and dilation angles, weight of the overburden and elastic constants.

We have developed a fully dynamic 2D finite element code that allows us to model porous fluid flow in an elasto-plastic medium. The failure criterium used is a combination of Mohr-Coulomb and Griffith, allowing shear and open fracture modes and finite thickness shear bands. The fluid pressure rise prescribed in a localized region as a lower boundary condition leads to a change in the effective stress causing hydrofracturing and vent formation.

Locally, vent geometries can be well described by a conical shape. For example, a kimberlite pipe shows an acute cone angle near the source and an obtuse cone angle near the surface.

The main and most important result of our numerical modeling and data collapsing is that the initial fracture direction depends only on one non-dimensional parameter, which allows us to scale our simulation results to the whole range of length-scales observed in both field and experimental studies of vent structures. Based on this single non-dimensional parameter we are able to predict the evolution of various vent morphologies in space and time. Consequently, we can use our model to classify the different vent structures observed in nature, ranging from centimeter scale seeping structures to kilometer scale kimberlite pipes, and infer the underlying physical processes.