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Experimental modelling of piercement structure formation in sedimentary basins

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Piercement structures such as pipes or mud volcanoes, are often observed in sedimentary basins. Structural and geochemical observations and the presence of large amounts of fluids indicate that these result from high fluid overpressure in the sediments. Although these features are common in nature, the mechanical details of formation are still poorly understood.

We report on experiments developed to understand the processes of piercement structure formation in sedimentary basins. The experimental setup consists of a vertically oriented Hele-Shaw cell filled with glass beads. We study the effect of injecting air into the bed of glass beads while varying the two geometrical main parameters; the inlet width and depth to the surface. Simultaneous logging of video, inlet flow velocity and pressure represent the data for this study.

In each experiment, the inlet flow velocity and pressure increased by slowly opening a valve. At a given critical air velocity the bed fluidizes and a piercement structure forms between the inlet and the surface. When fluidization occurs, the material is ejected upwards in the center forming a conical conduit of fluidized material. Along the margin of the conduit, downward movement of the material results in a inward dipping structure.

By collecting the critical fluid velocity for all experiments we develop a phase diagram for the onset of fluidization. A data collapse between the critical inlet flow velocities and the ratio of the filling height to inlet area is documented. Using dimensional analysis and scaling, we report pressure estimates for the formation of fluid induced piercement structures in natural settings. These pressure estimates are compared to

other independent estimates for the formation of mud volcanoes and hydrothermal vent complexes.