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Simulations of the Explosive Eruption of Supercritical Fluids through Porous Media

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Superheated or overpressured fluids at depth can cause surface disturbances in the form of vents, mud volcanoes, or seafloor pockmarks. In sedimentary basins, magmatic intrusions heat organic-rich sediments, releasing volatiles produced by metamorphic reactions. Confined by impermeable clays or metamorphic rocks, the heated fluid is pressurized up to several times the overburden pressure. If confinement is then breached in such a way that the superheated fluid has access to weak or porous sediments, a violent eruption of a mixture of fluid and sediment may result. Manifestations of this include hydrothermal vents, as in the Karoo Basin (South Africa) and in the North Sea (Norwegian margin), and mud volcanoes as in Azerbaijan, Indonesia, and Trinidad. These are widespread on Earth, and they are also likely to exist on other terrestrial planets where water or other volatiles are present.

We have performed simulations with the Sage hydrocode (from Los Alamos and Science Applications International) of supercritical venting in a variety of geometries and configurations. The simulations show several different patterns of propagation and fracturing in porous or otherwise weakened overburden, dependent on depth, source conditions (fluid availability, temperature, and pressure), disposition or layering of sediments, and manner of confinement breach. In simulations performed so far we have seen upward propagating cylindrical pipes with hardened walls, narrowly diverging conical pipes, cone sheets, downward-propagating cracks, funnel-shaped craters,

and irregularly spaced vents.