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Coupled hydromechanical modeling of focused fluid flow structures

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Gas chimneys, fluid escape pipes, and diffused gas clouds are common geohazards above or below most petroleum reservoirs and in some CO2 storage sites. However, the processes driving the formation of such structures are poorly understood, as are the timescales associated with their growth or their role as long-term preferential fluid migration pathways in sedimentary basins. Here we present results from high-resolution simulations of geological processes leading to the formation of focused fluid flow structures. Our analyses indicate that time-dependent rock (de)compaction yields ascending solitary porosity waves forming high-porosity and high-permeability vertical chimneys that will reach the surface. The size and location of chimneys depend on the reservoir topology and compaction length. Our simulation results suggest that chimneys could have been formed and lost their connection to the reservoir on a time scale of a few months. We compare our modeling results with seismic data from the Ringhorne Oil Field, located in the central part of the North Sea over the Heimdal Terrace and the Utsira High [1].

[1] Yarushina, V.M., Wang, L.H., Connolly, D., Kocsis, G., Fæstø, I., Polteau, S., Lakhlifi, A., 2021. Focused fluid-flow structures potentially caused by solitary porosity waves. Geology.