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Integrated seismic and geomechanical/flow modelling study of focused fluid flow

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The improved resolution of recent seismic surveys has made seismic chimney structures a common observation in sedimentary basins worldwide and on the Norwegian Continental Shelf. Focused fluid flow in vertical chimneys is an important and poorly understood feature in a petroleum system. Oil and gas migrate through preferential pathways from source rocks to structural traps where they form reservoirs. Further migration or leakage from reservoirs leads to formation of shallow hydrocarbon accumulations and gas pockets. In some cases, leakage through preferential pathways can be traced up to the surface or to the sea floor, where it leads to formation of mud volcanoes, mounds and pockmarks. Here, we present results of an integrated case study, which is performed on a 3D seismic data set that covers an area of approximately 3000km2. The seismic sequence stratigraphic interpretation is complemented with a study of seismic fluid migration paths. Detection of seismic chimneys is a challenging task. State-of-the-art chimney cube technology based on self-educating neural networks was used to automatically identify possible structures. The results of seismic inversion in combination with available well data provided a set of surfaces distinguishing various stratigraphic layers and their properties. Obtained geological model was used as a basis for coupled geo-mechanical / fluid flow modelling that reconstructed the fluid flow processes in the geological past that lead to formation of chimney structures. Our numerical model of chimney formation is based on the two-phase theory of fluid flow through (de)compacting porous rocks. Viscous bulk rheology and strong nonlinear coupling of deforming porous rocks to fluid flow are key ingredients of the model. Chimney formation is linked to pressure build-up in the underlying reservoir. We reconstruct the fluid flow processes in the geological past that lead to formation of chimney structures and provide expectations for their present-day morphology, porosity and fluid pressure. Conditions of chimney formation, their sizes, spatial distribution and times of formation are investigated. The fate of the chimney after it has been created and its role as a fluid pathway in the present-day state is studied.