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Time Constraints on Seepage Through Fractured Regions on the Vestnesa Ridge off the W-Svalbard Coast

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Evidences of subsurface fluid flow-driven fractures (from seismic interpretation) are quite common at Vestnesa Ridge (around 79ºN in the Arctic Ocean), W-Svalbard margin. Ultimately, the fractured systems have led to the formation of pockmarks on the seafloor. At present day, the eastern segment of the ridge has active pockmarks with continuous methane seep observations in sonar data. The pockmarks in the western segment are considered inactive or to seep at a rate that is harder to identify. The ridge is at ~1200m water depth with the base of the gas hydrate stability zone (GHSZ) at ~200m below the seafloor. Considerable free gas zone is present below the hydrates. Besides the obvious concern of amount and rates of historic methane seeping into the ocean biosphere and its associated effects, significant gaps exist in the ability to model the processes of flow of methane through this faulted and fractured region. Our aim is to highlight the interactions between physical flow, geomechanics and geological control processes that govern the rates and timing of methane seepage.

For this purpose, we performed numerical fluid flow simulations. We integrate fundamental mass and component conservation equations with a phase equilibrium approach accounting for hydrate phase boundary effects to simulate the transport of gas from the base of the GHSZ through rock matrix and interconnected fractures until the seafloor. The relation between effective stress and fluid pressure is considered and fractures are activated once the effective stress exceeds the tensile limit. We use field data (seismic, oedometer tests on calypso cores, pore fluid pressure and temperature) to constrain the range of validity of various flow and geomechanical parameters in the simulation (such as vertical stress, porosity, permeability, saturations).

Preliminary results indicate fluid overpressure greater than 1.5 MPa is required to initiate fractures at the base of the gas hydrate stability zone for the investigated system. Focused fluid flow occurs through the narrow fracture networks and the gas reaches the seafloor within 1 day. The surrounding regions near the fracture network exhibit slower seepage towards the seafloor, but over a wider area. Advective flux through the less fractured surrounding regions, reaches the seafloor within 15 years and a diffusive flux reaches within 1200 years. These times are controlled by the permeability of the sediments and are retarded further due to considerable

hydrate/carbonate formation during vertical migration. Next course of action includes constraining the methane availability at the base of the GHSZ and estimating its impact on seepage behavior.