A Natural Gas Hydrate System Overlying a Conventional Hydrocarbon Accumulation: Implications for Geohazard and Exploration

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ABSTRACT

In the exploration for conventional hydrocarbon reservoirs, gas hydrates are frequently considered a shallow geohazard. The bottom-simulating reflector (BSR) is interpreted as the seismic expression of the interface between gas hydrate and free-gas bearing sediments Further seismic-scale elements characterizing many gas hydrate provinces are fluid-escape pipes or gas chimneys, serving as vertical conduits for free-gas seepage across the gas hydrate stability zone, up to the seafloor. Here, 3D seismic, well-log and core data from a natural gas hydrate system overlying a conventional oil and gas field, offshore Sabah, are used to show that hydrates are stable below a BSR. Hydrates form from thermogenic C2+-rich fluids leaking from the underlying accumulation. Hydrates coexist with free-gas below the BSR and crystallize as structure II and H, which have broader stability conditions than the more common structure I ~100% methane hydrate. The hydrate crystallization depletes the upwardly migrating fluids of C2+ components. This results in a progressive increase in the C1/C2+ ratio towards shallower depths, with an almost pure methane structure I hydrates occurring above the BSR. The only features allowing the rapid migration of fluids with clear thermogenic signatures at the seafloor are fluid-escape pipes, used by free-gas to rapidly by-pass the zone of hydrate occurrence. Hydrates below the BSR are confined where free-gas is clearly leaking from the underlying accumulation. Elsewhere in the study area, hydrates are present only with a pure methane composition. The existence of a shallow biogenic methane source or a scarcely effective leakage from underlying accumulations are the likely reasons explaining such compositional change. In conclusion, the gehazard associated with gas hydrates should be extended below BSRs where thermogenic fluid fluxes exist. The geochemistry of a leaking thermogenic fluid is further heavily impacted by hydrate formation and the interpretation of seafloor samples needs to account for this process.