

The impact of flow focusing on gas hydrate accumulations in overpressured marine sediments

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This study demonstrates the potential for flow focusing due to overpressuring in marine sedimentary environments to act as a significant methane transport mechanism from which methane hydrate can precipitate in large quantities in dipping sandstone bodies. Traditionally, gas hydrate accumulations in nature are discussed as resulting from either short-range diffusive methane migration or from long-range advective fluid transport sourced from depth. However, 3D simulations performed in this study demonstrate that a third migration mechanism, short-range advective transport, can provide a significant methane source that is unencumbered by limitations of the other two end-member mechanisms. Short-range advective sourcing is advantageous over diffusion because it can convey greater amounts of methane to sands over shorter timespans, yet it is not necessarily limited by down-dip pore blocking in sands as is typical of updip advection from a deep source.

These results are novel because they integrate pore size impacts on spatial solubility gradients, grid block properties that evolve through time, and methane sourcing through microbial methanogenesis into a holistic characterization of environments exposed to multiple methane hydrate sourcing mechanisms. We show that flow focusing toward sand bodies transports large quantities of methane, the magnitude of which are determined by the sand-clay solubility contrast, and generates larger quantities of hydrate in sands than a solely diffusive system; after depositing methane as hydrate, fluid exiting a sand body is depleted in methane and leaves a hydrate free region in its wake above the sand. Additionally, we demonstrate that in overpressured environments, hydrate growth is initially diffusively dominated before transitioning to an advection-dominated regime. The timescale and depth at which this transition takes place depends primarily on the rate of microbial metabolism and the sedimentation rate but only depends loosely on the degree of overpressuring.