**Linking pore-scale and basin-scale effects on diffusive methane transport in hydrate bearing environments through multi-scale reservoir simulations**

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We explore the gas hydrate-generating capacity of diffusive methane transport induced by solubility gradients due to pore size contrasts in lithologically heterogeneous marine sediments. Through the use of 1D, 2D, and 3D reactive transport simulations, we investigate scale-dependent processes in diffusion-dominated gas hydrate systems. These simulations all track a sand body, or series of sands, surrounded by clays as they are buried through the gas hydrate stability zone. Methane is sourced by microbial methanogenesis in the clays surrounding the sand layers. In 1D, simulations performed in a Lagrangian reference frame demonstrate that gas hydrate in thin sands (3.6 m thick) can occur in high saturations (upward of 70%) at the edges of sand bodies within the upper 400 meters below the seafloor. Diffusion of methane toward the center of the sand layer depends on the concentration gradient within the sand: broader sand pore size distributions with smaller median pore sizes enhance diffusive action toward the sand's center. Incorporating downhole log- and laboratory-derived sand pore size distributions, gas hydrate saturations in the center of the sand can reach 20% of the hydrate saturations at the sand's edges. Furthermore, we show that hydrate-free zones exist immediately above and below the sand and are approximately 5 m thick, depending on the sand-clay solubility contrast. A moving reference frame is also adopted in 2D, and the angle of gravity is rotated relative to the grid system to simulate a dipping sand layer. This is important to minimize diffusive edge effects or numerical diffusion that might be associated with a dipping sand in an Eulerian grid system oriented orthogonal to gravity. Two-dimensional simulations demonstrate the tendency for gas hydrate to accumulate downdip in a sand body because of greater methane transport at depth due to larger sand-clay solubility contrasts. In 3D, basin-scale simulations illuminate how convergent sand layers in a multilayered system can compete for diffusion from clays between them, resulting in relatively low hydrate saturations. All simulations suggest that when hydrate present in clays dissociates with burial, the additional dissolved methane is soaked up by nearby sands preserving high hydrate saturations.