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Modeling dynamic marine gas hydrate systems

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ABSTRACT

Dynamically changing marine gas hydrate systems are the subject of this study. The changes may result from varying pressure or temperature at the seafloor, exploration and exploitation operations, rapid sedimentation or wasting at the seafloor, etc. Pressure and temperature may not be used as independent state variables at the same time to specify the overall state of such dynamic systems. Consequently, a pressure-enthalpy-gas concentration-salinity phase balance model is constructed for calculating phase distribution and transition of the system of marine gas hydrate, which is assumed to contain a liquid phase consisting of water, gas, and salt, a vapor phase consisting of gas only, solid halite, and solid gas hydrate consisting of gas and water. Calculations of phase transition processes demonstrate various dynamic feedback mechanisms involved in dynamically evolving marine gas-hydrate systems. A comprehensive model of fluid flow and transport of heat, water, salt, and gas in marine sediment is developed. Simulations show that gas hydrate dissociation resulting from increasing temperature or decreasing pressure at the seafloor may lead to the development of a three-phase zone with coexistent gas hydrate, free gas, and liquid solution and excess pore pressure in marine gas hydrate systems. The changes considered in this study are rapid ($<10^5$ years) with respect to the geological time scale but are sufficiently slow ($> 10^{-2}$ years) to allow thermodynamic equilibrium throughout. The applicable pressure, temperature, and salinity ranges for the calculations used in this study are sufficiently wide to cover those likely occurring in gas hydrate-bearing marine sediments.