

## Nucleation and Growth of Hydrate in Marine Environments

O.Ye. Zatsepina\* and Bruce A. Buffett  
University of British Columbia, 2219 Main Mall, Vancouver, BC  
[olga@geop.ubc.ca](mailto:olga@geop.ubc.ca)

### ABSTRACT

An experimental study of nucleation and growth of carbon dioxide hydrate in the natural porous medium is used as an analog for understanding how hydrate forms in marine environments. Detection of hydrate is achieved by monitoring the bulk electrical resistance in the porous medium. Carbon dioxide is chosen as the hydrate-forming gas because it ionizes in water to provide with the main source of charged particles for conduction. Since hydrate formation causes a decrease in the dissolved gas concentration (and hence the number of ions in solution), we use the measured changes in the conductivity over time to obtain quantitative information about rates of nucleation and growth.

Our experiments indicate that the rate limiting process for hydrate formation is nucleation. Once hydrate crystals nucleate, their subsequent growth is controlled by mass transport. This means that the local equilibrium in the immediate vicinity of hydrate crystals is readily established and kinetics of growth and dissociation is mainly regulated by diffusion of gas.

We have developed a theoretical model to recover nucleation rates from our experimental data. Estimates of these rates for carbon dioxide hydrate are used to infer nucleation rates for methane hydrate, which is the most abundant in the natural environment. The results are applied to marine situations to show that nucleation occurs well above BSR when methane migrates into the hydrate stability zone from below. Hydrate formation is only possible if the stability zone is deep enough to ensure that sufficient overcooling can be achieved in the sediments. During the Paleocene, when the seafloor was warmer and the stability zone was narrower, nucleation of hydrate in sediments would have been much less probable than it is today. A similar difficulty may arise in shallow water where the lower pressure yields a narrow stability zone. This may explain why hydrates are rarely found in the minimum water depth of 500-600 meters even though thermodynamic conditions predict stability.