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Borehole Pressure Coring and Laboratory Pressure Core Analysis for Gas Hydrate Investigations

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Abstract

Marine gas hydrate investigations, whether they be conducted as resource evaluations for national governments, as geohazard assessments for major oil companies, or as climate-related scientific endeavors funded through international funding agencies, have begun to develop common strategies. Gas hydrate can occur up to several hundred meters below the sediment-water interface, depending on the water depth and thermal gradients; consequently, for a full assessment of gas hydrate occurrence, nature, distribution, and concentration, samples must be obtained through drilling and coring. Samples retrieved and analyzed at full in-situ pressures using pressure coring techniques are the only way to ground truth the findings from other techniques, including physical and chemical analysis of non-pressure cores or the interpretation of seismic and borehole log data.

Thermal imaging of non-pressure cores provides an immediate and valuable method for observing the endothermic behavior of dissociating gas hydrate but does little in itself to characterize the gas hydrate morphology or concentration. Porewater analysis techniques rely on the freshening of porewaters when gas hydrate dissociates, generally measured via chlorinity; these analyses provide excellent spot measurements of the concentration of gas hydrate if the background chlorinity profile is well established, but tells the investigator little about the nature of the gas hydrate. Furthermore, in lakes or nearshore environments where the porewaters may have very low or highly variable chlorinities, this technique will be far less reliable or accurate. Only methane mass balance calculations from depressurization of cores recovered at full pressure provides the benchmark or "gold standard" for gas hydrate concentration assessment.

Measurements of the density and volume of pressure cores through X-ray imaging and gamma densitometry have removed errors in estimation of pore volume, making this methane mass balance technique accurate and robust. Non-destructive testing and analysis of gas-hydrate-bearing cores at in-situ pressures and temperatures also provides detailed information on the in-situ nature and morphology of gas hydrate in sediments. The detailed profiles of density and V_P, together with spot measurements of Vs, electrical resistivity, and hardness, provide background data essential for modeling the behavior of the formation on a larger scale. X-ray images show the hydrate morphology in relation to the sediment, which will control the kinetics of methane release. Gas-hydrate-bearing pressure cores subjected to X-ray tomographic reconstruction provide compelling evidence that gas hydrate morphology in many natural sedimentary environments is particularly complex and impossible to replicate in the laboratory.

Review of strategies and techniques for gas hydrate expeditions

Gas hydrate is studied in oceans around the world for a variety of reasons, including resource assessment, geohazard evaluation, and general scientific interest including climate change. Recent expeditions that have focused on gas hydrate studies include Ocean Drilling Program (ODP) Leg 204 to Hydrate Ridge, Oregon Margin (Tréhu et al., 2003); the Chevron/DOE (US Department of Energy) Naturally-Occurring Hydrates JIP (Joint Industry Project), Gulf of Mexico (Claypool et al., 2005); Integrated Ocean Drilling Program (IODP) Expedition 311, Cascadia Margin (Riedel et al., 2006); the Indian National Gas Hydrate Program Expedition 1 (Collett et al., 2006), Bay of Bengal; the Chinese Guangzhou Marine Geological Survey Expedition 1 (Zhang et al., 2007), South China Sea; and the Korean Ulleung Basin Gas Hydrate