ODP DRILLS GAS HYDRATES, THE WORLD'S LARGEST SOURCE OF FOSSIL FUEL

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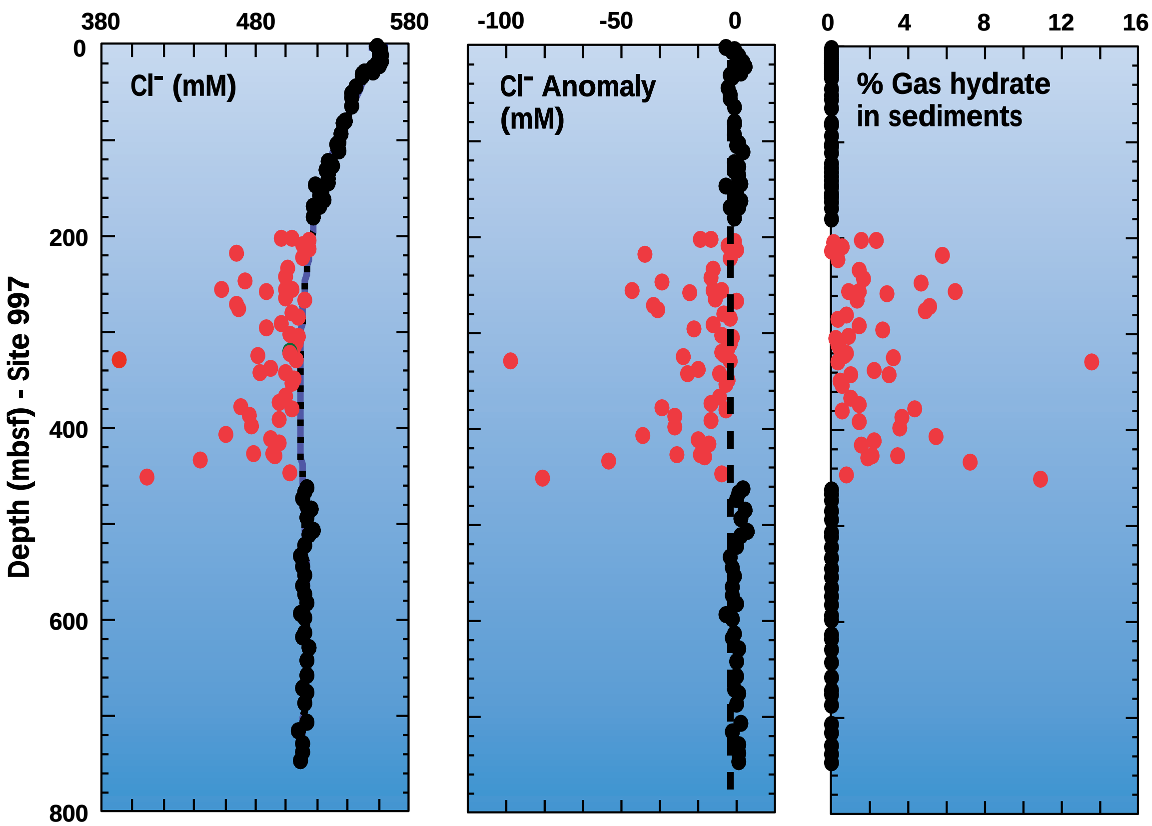
Enormous volumes of natural gas are stored in marine sediments as gas hydrates — ice-like deposits of crystallized methane and water that form under high pressures and frigid temperatures in the deep sea. Large fields of methane hydrates are scattered throughout the world's oceans and are thought to contain about as much energy as all other forms of fossil fuel combined. This unconventional hydrocarbon energy source has remained untapped, however, because traditional sources are still plentiful and less expensive to develop. Nevertheless, scientists have recently been taking a closer look at hydrates, and not only as a possible energy source. Hydrates may affect climate because when warmed or depressurized, they decompose and dissociate into water and methane gas, one of the "greenhouse" gases that warms the planet. Seafloor dissociation of hydrates lowers sediment strength and can lead to sediment failure and slumps, posing a hazard to the safe design and emplacement of offshore drilling/production platforms, subsea equipment, and pipelines [*Borowski and Paull,* 1997]. Despite the tremendous importance of these geological deposits, they remain poorly understood. For example, we don't have accurate estimates of the global distribution of hydrate fields, nor the volume of methane therein, nor the amount of free methane gas often trapped beneath them.

To better understand these mysterious deposits, ODP drilled into a gas hydrate field in the Blake Ridge off the coast of North Carolina in 1995. The Leg 164 scientific party sought to quantify the amount and characteristics of the methane in this area — the size of New Jersey — that lies within a sediment-drift deposit of microfossil-rich clays. Multiple holes were drilled to depths as great as 750 mbsf, and the gas hydrate zone was found between about 200 and 450 mbsf. Finely disseminated gas hydrate pieces were observed within this sedimentary zone and nodules as large as 30 cm thick were recovered. Nevertheless, direct shipboard observation of these deposits is notoriously difficult because warming and depressurizing during the very act of retrieving them from the seafloor causes them to rapidly decompose.

To overcome this problem, ODP has developed and used several clever approaches. The first is direct sampling of the hydrate with a new research tool, called a pressure core sampler (PCS) [*Pettigrew,* 1992], which was successfully used for the first time on Leg 164. This tool enables scientists to take and maintain samples of the hydrates at the *in situ* high pressure conditions in which they form until they are returned to the shipboard laboratory for analysis of gas quantity and composition. Seventeen PCS deployments during Leg 164 were used to construct the first vertical profile of *in situ* methane volumes through a subseafloor sequence containing hydrate, dissolved methane, and free methane gas [*Dickens et al.,* 1997]. Results indicate that hydrate occupies 0-9% of the pore volume in the hydrate zone and that gas comprises up to 12% of the pore volume in the underlying free-gas zone. PCS measurements also demonstrate that the volume of methane in the free-gas zone rivals the amount of methane within the overlying hydrate zone.

Other ways to study hydrates are based on indirect evidence gathered from geochemical measurements, well-logs, and vertical seismic profiling. Because fresh water is released by the dissociation of hydrates, geochemical analyses of the pore waters squeezed from sediment cores recovered from the drill holes can be used to infer the presence of hydrates, even if they are no longer there. Pore water profiles of salinity (indicated by the chloride concentration) show a high variability in the hydrate zone between 200 and 450 mbsf that is characterized by local, anomalously fresh values (see figure), indicating drilling-induced dissociation of the hydrate. Translation of these data suggest that the sediments contain 1-12% gas hydrate in their pore spaces (figure panel c). Well-logs show distinct zones of higher electrical resistivity that coincide with these chloride anomalies. Hydrate abundance has also been estimated from seismic velocities measured in the drill holes. Seismic results of Holbrook and collaborators suggest that hydrate fills 2-7% of the pore volume in the hydrate layer, in close agreement with the independent PCS and chloride anomaly estimates. The seismic data further suggest that free gas bubbles fill 1-2% of the underlying 250 m thick free-gas zone, whereas the PCS and pore water data argue for higher values, up to 12%. The difference between these two estimates of free gas reflect variations in the scale and sensitivity of the seismic and PCS measurements. The seismic data average sonic velocities over a broad, vertical zone, whereas the PCS measurements are from discrete sedimentary layers, and are thus more likely to encounter a range of values. We know from



Downhole geochemical profiles define the gas hydrate zone. Pore water concentrations of chloride (a) show great variability in the hydrate zone between 200 and 450 meters below the seafloor. Low values indicate lower salinity waters indicative of dissociation of gas hydrates into fresh water and methane gas. Deviations from baseline chloride values (b), below and immediately above the gas-hydrate-containing zone, show the hydrate zone more clearly. Chloride dilution is directly related to the amount of gas hydrate in the sediments (c).

the seismic data that free gas is concentrated in specific, heterogeneous layers below the gas hydrate, and that the greatest concentration of free gas occurs in a thin (<20 m) layer directly beneath the hydrate zone, but further research is needed to better define these layers and to determine the amount of gas in each.

Our best estimates suggest that there are about 2.3 x 10^{15} ft^3 of methane (containing 35 billion metric tons of carbon) in the Blake Ridge hydrate field. Based on a U.S. consumption rate of 2.2 x 10^{13} ft^3 in 1996, this field alone contains enough methane to supply U.S. needs for 105 years.

References:

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