The Curiosity of Gas Hydrates

by

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Gas hydrate is an ice-like material consisting of a structure of water molecules, like ice, but having an expanded crystal lattice that encages a gas molecule, generally methane. It occurs naturally within ocean sediments in a layer commonly several hundred meters thick, just below the sea floor at temperatures and pressures existing below about 500 meters water depth. Gas hydrate also is stable in conjunction with permafrost in the Arctic. Most marine gas hydrate is formed of microbially-generated gas. It binds huge amounts of methane into the sediments. Worldwide, gas hydrate is estimated to hold about 1019 grams of organic carbon in the form of methane (Kvenvolden, 1993). This represents an amount of organic carbon that is twice as much as in all other fossil fuels on earth (conventional natural gas, oil, and coal) and an amount of methane that is about 3,000 times as much as exists in the atmosphere. Gas hydrate is important primarily because it contains huge amounts of methane in a concentrated form and because it influences the physical properties of sedimentary deposits, particularly sediment strength.

Energy resource - Use of methane from hydrate could provide a very large energy resource. Exploration requires new methods to identify concentrations. Extraction will present engineering problems, but access to the hydrate is easy because it exists in the upper hundreds of meters of ocean floor sediments. Methane is considerably less polluting than other hydrocarbons because it has the highest hydrogen/carbon ratio of all fossil fuels and therefore its combustion produces a minimum amount of carbon dioxide per energy unit – 34% less than fuel oil and 43% less than coal. Furthermore, methane does not produce any other pollutants such as particulate matter or sulfur compounds.

Drilling safety - Oil and gas exploration and production has moved at an accelerating pace into deeper water where gas hydrate is stable. Gas hydrate poses a safety concern for deep-water petroleum operations. Small changes in pressure or temperature, for example the results of drilling or production of (warmer) oil at wells, can cause a breakdown of hydrate, thus substituting a much weaker material (gassy, watery sediment) for a stronger one and perhaps generating gas at high pressures, which could cause hazards. Submarine landslides also occur because of breakdown of gas hydrate due to natural temperature or pressure variations. Many landslides on the U.S. Atlantic continental margin have occurred on low slopes that would be expected to be stable and landslide scars are concentrated at depths near the top of the range of hydrate stability (500-700 m), thus circumstantial evidence implicates hydrate processes as a cause of slides. With understanding of the effects of gas hydrate in sediments, proper planning and engineering can provide safety for energy extraction and other uses of the seafloor.

Climate change - Methane is much more effective as a greenhouse gas than carbon dioxide, although the amount presently in the atmosphere is small. The release and absorption of large volumes of methane from sea-floor hydrate may have had major impacts in modifying the Earth's climate in the past. The global warming potential (GWP) of methane is calculated to be 56 times by weight greater than carbon dioxide over a 20 year period. That is, a unit mass of methane introduced into the atmosphere would have 56 times the warming effect of an identical mass of carbon dioxide, over that time period.

Chemosynthetic Communities - Methane and other gases associated with gas hydrates are the energy source for seafloor communities. The nature of these communities and processes operating there are just beginning to be understood.

Finally The study of gas hydrate in nature continually produces surprises to the scientists involved. Thus field studies are critically important to learn about the distribution of hydrate and processes affecting gas hydrate in nature. These require application of both sampling and remote sensing techniques, and further development of these approaches. Laboratory study of both natural samples and artificial gas hydrate are difficult and critically needed. Modeling ultimately provides concepts of how nature works. These three types of studies, field, laboratory and modeling, are all necessary and must be coordinated to gain an understanding of this exciting phenomenon.