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Methane hydrates: energy in cold storage

Beneath the sea and under the frozen Arctic lie vast reserves of energy in the form of gas hydrates that scientists believe could extend our fossil-fuel reserves over several hundred years.

Enormous pressures and low temperatures at the sea bottom shape water and gas molecules into gas hydrates, unique structures that resemble ice. Unlike ordinary ice, however, the water molecules bond together in a three-dimensional network of spherical cages that trap neighbouring gas molecules, such as methane, formed from organic sediment deposited over millions of years. The solid hydrate retains its stability until conditions, such as higher temperatures or lower pressures, cause it to "decompose" or melt, releasing enormous volumes of gas.

Large reserve

According to National Research Council (NRC) of Canada chemist Don Davidson, more natural gas is probably caught up in gas hydrates than in all the known natural gas deposits under land. In order to exploit such a ready source of energy, NRC scientists are taking a close look at how hydrates behave under different conditions. They hope to take advantage of the fact that the energy needed to release the gas is little more than what is needed to melt ice.

Dan Getz

Don Davidson

The methane in turn can be applied to a recovery process; in fact, combustion of as little as 7 per cent of the methane released from the decomposing hydrate provides enough energy to melt more hydrate.

Oceanographic surveys indicate that by far the greatest deposits of methane hydrates lie under the sea. Some scientists predict that hydrate zones may in fact extend over 85 per cent of the sea bottom.

The sea will provide the cheapest source of energy for gas hydrate recovery. At 20°C, for example, the surface water is warm enough to melt the hydrate, if it can be pumped down into the hydrated zone. The gas might then be collected by some type of umbrella arrangement and piped away or transported by ship.

In northern Canada, the greatest hydrate deposits are found under the Beaufort Sea in an almost continuous layer, but deposits underlying terrestrial permafrosts occur sporadically and usually to a thickness of a few metres. By understanding the nature of the hydrates, scientists hope to predict where these seams occur, partly to minimize fire hazards and other problems encountered by exploration drilling crews who have accidentally punched through and heated up the hydrate, releasing the gas.

Gas hydrate deposits also tend to form in drill holes and natural-gas transmission lines. Warm, moist gas brought up from the well crystallizes when it hits the colder surface temperature, and eventually constricts or completely plugs up the opening.

Continued research

According to Don Davidson the exploratory techniques being studied for the recovery of heavy oil, such as steam injection or injection of hot gases might be applied to gas hydrates, although the inaccessibility and harsh environment of the Arctic will forestall attempts to harness the energy for some years. While the nature of the hydrate is becoming better understood, the abundance of natural gas and relatively cheaper production costs make gas hydrate recovery too expensive at present.

Continued research will help tackle some of the problems already encountered with hydrates. One such problem, the mysterious disappearances of ships and aircraft at sea, could be the result of natural gas blowouts.

Some researchers suggest that the hydrate zone acts as an impermeable barrier to underlying gas fields that accumulate where temperatures are too high for the formation of gas hydrates. If the seal cracks or breaks up because of an earthquake or other disturbance, free gas and chunks of decomposing hydrate shoot to the surface, erupting as waterspouts or causing turbulent patches of water. A large enough gas flow could produce a highly concentrated flammable bubble above the surface of the sea, posing a danger not only to ships but to low-flying aircraft.

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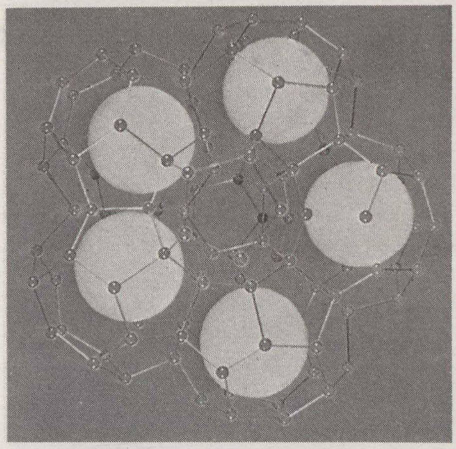
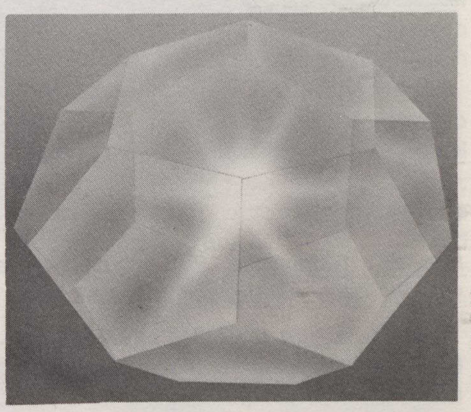


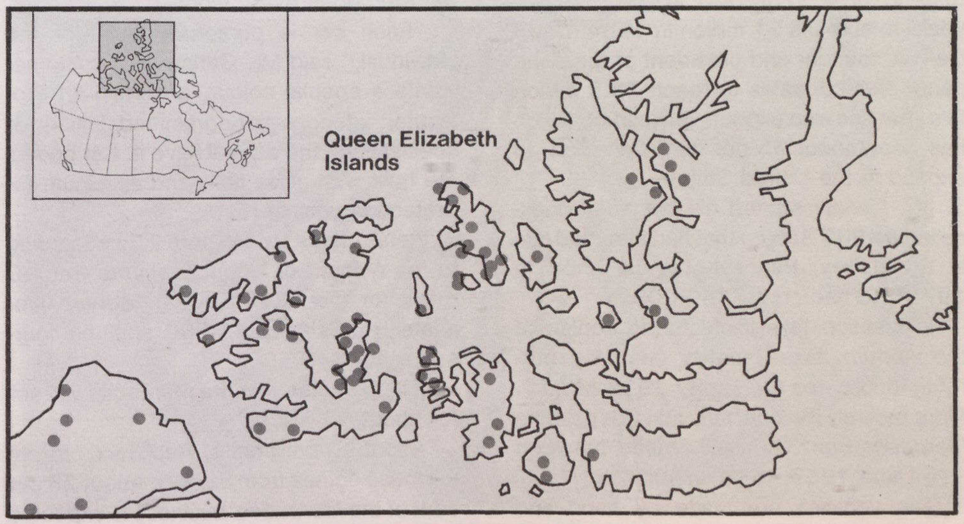
NRC

A model of the molecular structure of the gas hydrate. Enormous pressures and low temperatures shape water molecules (small balls) into a network that traps methane molecules (large balls) in spherical cages.



John Bianchi

Artist's impression of the gas hydrate structure — a molecular 'cage' that traps gas molecules.



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Arctic drilling sites where methane hydrates have been found.