

GLOBAL CARBON PROJECT AND IIASA VULNERABILITY AND OPPORTUNITY OF METHANE HYDRATES WORKSHOP

DRAFT MEETING PROPOSAL AND AGENDA
 13-14 MARCH 2008, GVISHIANI ROOM, IIASA, LAXENBURG, AUSTRIA

Background and Motivation

Hydrates or clathrates are ice-like compounds in which various gases are held in crystalline cages formed by water molecules. Methane hydrates or clathrates contain methane, the main constituent of natural gas. They form under conditions of high pressure and low temperatures. During the 1940s problems with pipeline transmission of natural gas in cold regions led to widespread recognition that methane hydrates would be stable below ground in regions of permafrost. In these cold regions, drilling operations have to take special precautions to prevent explosive release of methane as the drill penetrates zones of methane hydrates. Methane clathrates or hydrates are widespread in areas of permafrost on and off-shore such as in the polar regions and in sediments on the continental shelf below the ocean floor at shallow depths where conditions are appropriate for their formation (MacDonald, 1990 and 1998; Kvenvolden, 1998).

Methane hydrates are an energy source of potentially staggering magnitude compared with other known hydrocarbon deposits. It is thus not surprising that a number of scientific inquiries around the world are evaluating gas hydrates as a potential energy source (eg. Nakicenovic et al., 2000, IGU, 1997). It is plausible that technologies for recovering these resources economically could be developed in the future, in which case gas resource availability would increase enormously (MacDonald, 1990a; MacDonald, 1990b).

At the same time, methane hydrates are a factor in climate change. Methane is a potent greenhouse gas which can be released from hydrates by pressure reduction due to giant submarine landslides or by warming of the subsurface sediments (MacDonald, 1998). Methane hydrates have outgassed in the deep past in periods of warmer climates most recently some 55 million years ago. Therefore, there is an increasing concern today that global warming would result in substantial methane releases into the atmosphere causing catastrophic climate change.

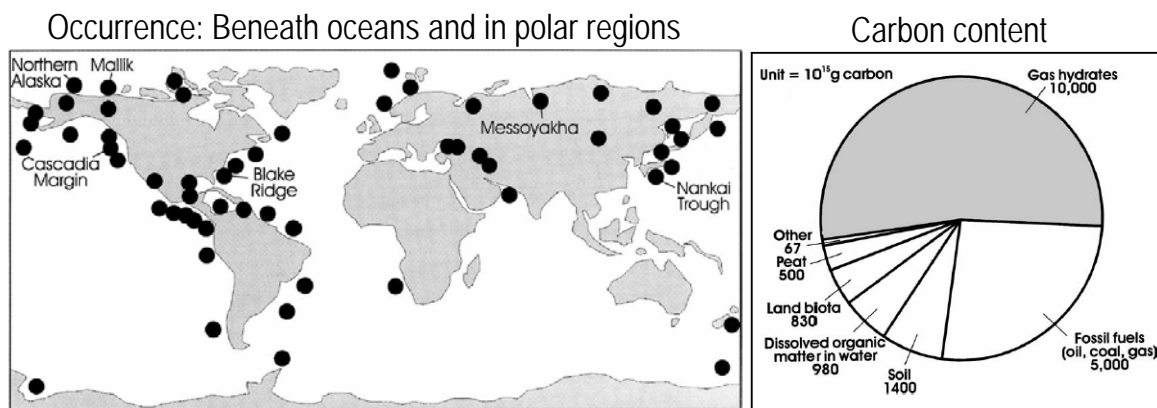


Figure 1: Distribution and carbon content of clathrates. Source: Beauchamp 2004

The exact quantities of methane that might be in the form of clathrates are subject to speculation (Figure 1). However, the existence of gas hydrates has been confirmed by direct evidence through sampling and by indirect evidence through geochemical and geophysical investigations. In 1972, the first successful recovery of natural methane hydrate occurred during pressurised coring operations in Prudhoe Bay at depths between 577 and 766m (MacDonald, 1998). Despite the difficulties associated with the recovery of material that rapidly decomposes at low pressures, numerous samples of methane hydrates have been recovered in the course of the scientific program of deep drilling in the

ocean. To date, samples have been recovered in 14 areas of the world, while indirect evidence has been found in 30 other areas. Many occurrences of methane hydrates on the continental shelves of all oceans have been inferred based on special geophysical exploration techniques such as bottom-stimulating reflection. At this juncture, resource estimates for gas hydrates are highly uncertain. BGR (1998) reports global clathrate occurrences of more than 9,000 Tm³ (333 ZJ). Other estimates report clathrates as high as 20,000 Tm³ (740 ZJ) (MacDonald, 1990a; MacDonald, 1990b; Kvenvolden, 1988; Collet, 1993). Thus, the methane hydrate resource base measured in energy content might be up to five times larger than that of coal. In terms of carbon, it could contain up to ten thousand times more carbon than the atmosphere equaling in orders of magnitude to carbon dioxide dissolved in the oceans.

Methane can be recovered from natural gas hydrates by depressurization or thermal disassociation. How much can be practically recovered at affordable costs is however highly uncertain. Many offshore hydrate occurrences appear to contain free methane as a gas beneath solid hydrate layers. This is because the stability of hydrates depends both on pressure and temperature. Even at high pressures, the reservoir temperature can be too high so that free gas may accumulate and be trapped beneath solid hydrate. An emerging view is that this free gas is easier to recover directly than the gas from solid hydrates (Max *et al.*, 1997). For example, free gas recovery would depressurize the reservoir, which would lead to hydrate melting and thus to free gas replenishment. The process could continue as long as the hydrate layer remains thick enough to cap the free gas below.

The direct recovery of methane from solid hydrate would in any case have a positive energy balance. The energy required to liberate the methane is likely to be 13 to 17 times smaller than the thermal energy contained in the released methane (MacDonald, 1998). However, the economics of methane production from hydrates are very uncertain due to the lack of operational experience. Also uncertain are the prospects for developing technologies for commercial exploitation of methane clathrates as a source of energy. Nevertheless, such technologies might bear fruit at some stage and radically alter current perceptions regarding natural gas availability (IGU, 1997).

The first known production of natural gas from hydrates occurred in the Soviet Union with the partial development of the Messoyakha gas field, estimated to contain billions of cubic meters of methane hydrates. The production method involved injecting methanol to decompose the hydrates. Unfortunately, this project has been an economic failure because of the high cost of methanol (MacDonald, 1998).

Currently, attractive technological proposals are still outstanding on how methane hydrates could be recovered economically. However, given its enormous resource potential, it is plausible to expect that extraction methods will eventually be developed if long-term global gas demand warrants clathrate recovery. At present, there is little private-sector interest in better understanding the magnitude and cost dimensions of the methane hydrate resource, because conventional natural gas supplies are abundant on the time scales of interest to business (Williams *et al.*, 2000). But having such an understanding is important in decisions about relative RD&D priorities that relate to unconventional gas resource development and associated technologies in the near term. For this reason, as well as to better understand the theoretical potential of the hydrate resource and the attractions of natural gas as an energy carrier in general, there are several research projects underway in Japan, Russia, Norway, India and the US to examine the viability of future gas hydrate recovery (Collet *et al.*, 1998 and BGR, 1998). Most recently, the panels convened by the US President's Committee of Advisors on Science and Technology in the United States urged international collaborative RD&D in this area building on embryonic efforts already launched in Japan, Russia, and India (PCAST, 1997 and PCAST, 1999).

Workshop Goals

Given the importance of methane hydrates as both a potential source of natural gas and as a catastrophic danger if substantial quantities outgas with climate warming, we propose to organize an explorative meeting to discuss both of these dimensions of methane hydrates. The emphasis would be on the review of the current knowledge and on major controversies surrounding hydrates both as a potential energy source and as a potential source of catastrophic climate change. The meeting would last two days, with the focus on the first day on the climatic dimensions of methane hydrates, ranging from outgassing during paleoclimates to future dangers of substantial releases of methane to the atmosphere due to climate warming. The second day would focus on energy-related dimensions, ranging from possible technologies for natural gas production from hydrates and storage of captured carbon from the produced methane to assessment of the potential methane resource base. The last

session would be devoted to the review of major controversies surrounding hydrates and to a panel discussion of the ways forward including possible agenda of future research priorities and experiments.

The group will explore writing a short paper for Science/Nature showing the potential vulnerabilities of clathrates to global warming (climate forcing) and due to the possibility of clathrates becoming a source of energy sometime this century (human forcing). Another related question is whether carbon captured as the result of converting hydrates to carbon-free energy carriers such as hydrogen and/or electricity (hydricity) could be also stored as clathrate deposits.

A short document will identify the key research and synthesis priorities for the global community and for the GCP and IIASA.

Organizers

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Draft Meeting Agenda

Day One

Opening / Welcome Statements

Keynote Address: tba

Session 1: Methane Hydrates (Geochemistry and Occurrences)

Session 2: Hydrates and Linkage to Climate Change and Carbon Cycle (Paleoclimatic)

Day Two

Session 3: Hydrates and Linkage to Climate Change and Carbon Cycle (Current and Future)

Session 4: Possible Implications for Energy Systems and Climate Mitigation

Session 5: Concluding Session / Panel Discussion and Paper Outline
