The Oil Drum: Europe
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Update on US GOM: Methane Hydrates

Posted by Luis de Sousa on July 17, 2009 - 10:14am in The Oil Drum: Europe
Topic: Geology/Exploration
Tags: deepwater, gulf of mexico, jean laherrère, methane hydrates, original [list all tags]

This is a guest post by Jean Laherrère, the second of a series on the current knowledge of the deepwater Oil and Gas reserve at the Gulf of Mexico. In this second installment Jean analyses the Methane Hydrate resource of the region, in face of recent claims of great drilling results in the region.

The first article of the series, on the conventional Oil and Gas reserve, can be found here. Thanks to ace's diligence an error was identified and corrected, resulting in an update to the graph on Commulative Oil and Gas Discovery over 400 meters deep.

Last year I wrote a paper on worldwide hydrates: Hydrates updated, published by The Oil Drum on April 17, 2008. But since then, a survey on hydrates was carried out in the Gulf of Mexico (GOM). Seven deepwater slim holes were drilled last April as part of Leg II of the Joint Industry Project (JIP Leg II). The results were claimed by Dr Collett to be "very encouraging":

> Our drilling at Walker Ridge block 313 and Green Canyon block 955 has discovered the **most promising marine gas hydrate accumulations** in the world [...]
>
> What's unique about the Gulf of Mexico accumulations identified is this. It's the first time we've seen highly concentrated hydrates in conventional sand reservoirs that could **be commercially producible**,[...]

Let's see on what the basis for this claim is.

Oil and gas fields reserves need well samples and production tests to calibrate all the other measurements. In particular porosity and permeability, estimated from well logs, need to be calibrated with cores.

To be brief: **no core, no reserve estimate**.

After my previous paper, one of the comments was that it does not matter that hydrates weren't recovered in the core, because they are very unstable and disappear. So hydrates should be in the ground, even if not recovered in the corer! The pressure corer is supposed to fix the problem and exactly that was used in the GOM JIP. Furthermore, it is surprising to see that in other places like at Lake Baikal it is very easy to recover hydrates (see TOD 3819). Why is GOM hydrate so hard to recover if present everywhere?

All hydrate programmes mention the **need for coring**:

> For marine hydrates, there is a need for multi-well drilling expeditions in the Gulf of Mexico, **with coring** and logging (similar to the 2006 Indian hydrate expedition) to characterize hydrate deposits and to validate emerging exploration technologies. (p. 6)
>
> Key Elements of an Accelerated Hydrate R&D Program. . . 1. Fund the Chevron Gulf of Mexico JIP for a multi-well transect with full logging and **coring programs for Spring 2008**. (p. 14)
>
> Key Cross-cutting Programmatic and Procedural Milestones:
> 4.1.17 FY2007: Finalize design and conduct field tests of new pressure coring tools (DOE (Chevron JIP)). (p. 23)
>
> Current Program Portfolio: **Chevron Gulf of Mexico Joint Industry Project** with research partners ConocoPhillips, U.S. Geological Survey, Minerals Management Service, Total, Schlumberger, Rice U., Georgia Institute of Technology, Reliance Industries, JOGMEC, and Scripps Oceanographic Institute. Phases 1 and 2 resulted in the 2005 drilling, logging, coring of two sites in the Gulf of Mexico to investigate safety aspects of hydrates in fine-grained sediments. Phase 3 (currently in planning) **will pursue improved pressure coring tools**, evaluate locations for gas hydrates within coarse-grained (sand) sediments, conduct initial drilling and LWD evaluation of those sites (4Q2007) and conduct follow-on drilling and **coring operations (FY2008/2009)**. (p. 35)
>
> *Above quotes from Report to Congress: An Assessment of the Methane Hydrate Research Program and An Assessment of the 5-Year Research Plan of the Department of Energy [pdf!], June 2007*

> **Pressure core analysis** has become the keystone that links these data sets together and is an essential component of modern gas hydrate investigations [...]
>
> *Schultheis et al , Pressure core analysis: the keystone of a gas hydrate investigation [pdf!], International Conference on Gas Hydrates, 2008, Vancouver.*

> The main objective of the JIP cruise was to collect **sediments cores** and a full suite of logs on seismically well-characterized sediments that show evidence for occurrence of gas hydrates. Although the petroleum industry has operated in the Gulf for decades, relatively little information has been collected on the nature of the shallow sediments, and **seismic records and well logs have not been calibrated** for the interpretation of gas hydrates.
>
> *In JIP GOM gas hydrate coring update [pdf!] G.Claypool NETL Fire in ice, Summer 2005.*

> Gas hydrate saturation cubes such as those shown in Figures 17 and 18 must be

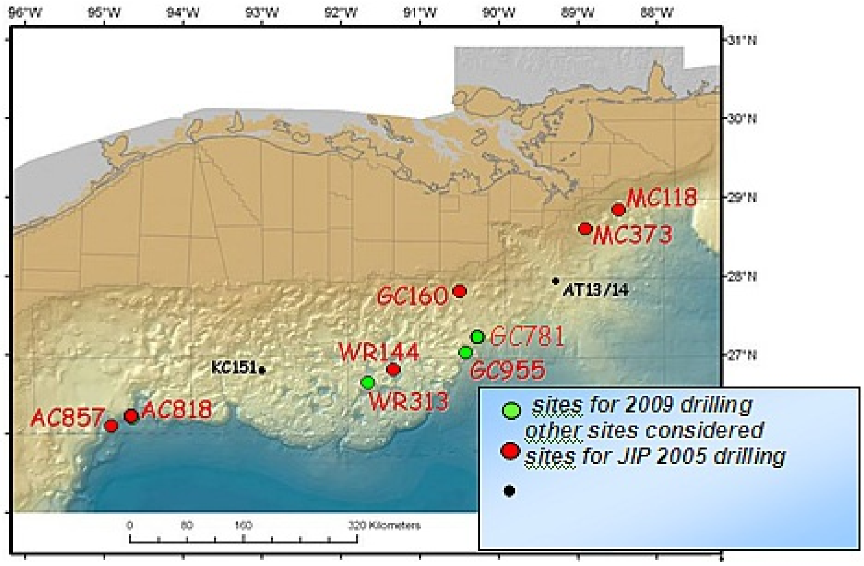
> calibrated. It should be noted that, despite the large number of drilled hydrate wells worldwide, quality hydrate logging and coring data are scarce, especially in the Gulf of Mexico. *Such data are urgently needed.* Until we devote resources to undertake such logging, **coring**, and laboratory measurements, **current estimates of possible gas that can be obtained from gas hydrates must be questioned**.
>
> *Dai et al , Detection and estimation of gas hydrates using rock physics and seismic inversion: Examples from the northern deepwater Gulf of Mexico [pdf!], The Leading Edge, Jan.2004.*

> Phase III of the project is to collect data on hydrate bearing sands. Both logging and coring operations are planned. Phase III of the project began in September of 2007 and will focus on obtaining logs and **cores of hydrate bearing sands in the GOM** [...]
>
> *I n Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities [pd!] Semi-Annual Progress Report #41330R16, October 2008 – March 2009.*

But there was no coring in JIP leg II, completed last month, only well logs within slim holes were obtained (lack of funds, lack of suitable rig?)! There is no explanation for the absence of cores, especially since it was in the planning!

Coring is now planned for 2011

> Phase 3A is currently ongoing. Site selection and detailed scientific and operational planning for the drilling/logging expedition have been completed. The expedition was initiated on 3/16/09 and sites involved are to include Green Canyon 955, Walker Ridge 313 and East Breaks 992 (contingency sites include Green Canyon 781/825 and Alaminos Canyon 21/65). The multi-location, multi-hole program will include a full suite of well logs and will provide vital information related to occurrence of hydrate in coarse grained sediment in the Gulf of Mexico, will help prove out the prospecting methodologies used in the selection of targeted sites and will lay the ground work for Phase 3B coring expedition.
>
> Phase 3B will involve **the planning and carrying out of a separate hydrate coring cruise (anticipated in 2011)**, the follow on analyses, interpretation and dissemination of information generated from project activities.



Sites for the drilling/logging expedition in April – May 2009. Sites are in Green Canyon 955, Walker Ridge 313, and potentially Green Canyon 781.

> *From The National Methane Hydrates R&D Program webpage.*

We have to wait until 2011 to know more about the GOM hydrate potential!

What are the hydrate in-place resource estimates?

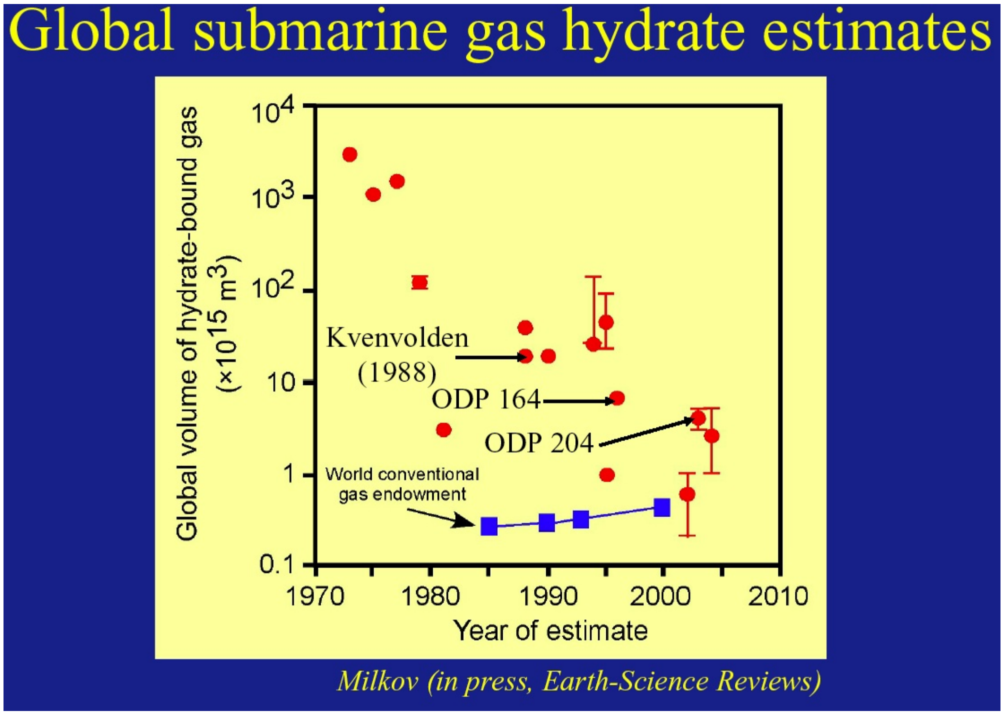
In its 2000 report Oceanic gas hydrate research and activity review [pdf!] (MMS 2000-017), the MMS claimed (Kvenvolden 1993) that the distribution of worldwide organic carbon in gas hydrate (onshore and offshore = 10 000 Pg) was twice the amount of fossil fuels (coal, oil and natural gas = 5 000 Pg). This figure was still being used by the USGS in 2006 (Collett et al). This was unrealistic because most hydrates are located in the first 600 m of recent oceanic sediments (water depth > 500 m) which covers a period of time of a few millions years, while fossil fuels sediments cover a period of about one billion years, with larger surface and thickness (>6000 m).

In his book "The Deep, Hot Biosphere" Thomas Gold in July of 1992 (which convinced the Swedish government to drill two wells on the Siljan meteorite crater looking for abiogenic oil and gas. He justified his theory by the large volume of oceanic hydrates:

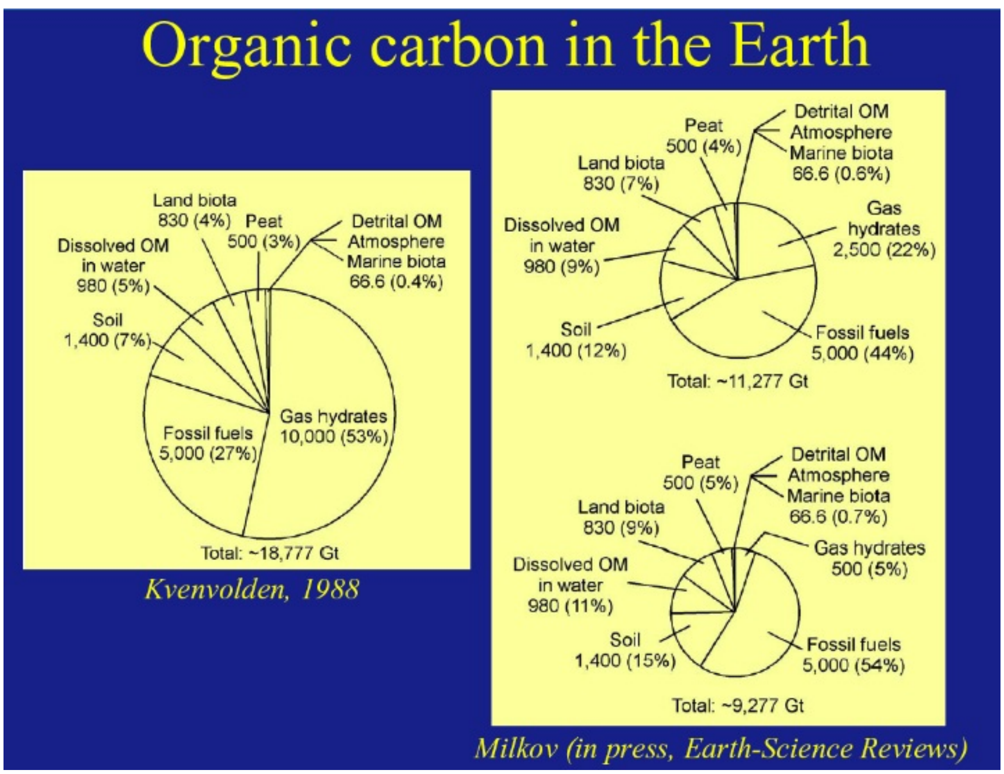
> The large quantities of methane hydrates (methane-water ices) found in many areas of the ocean floor, and thought to contain more methane than all other known methane deposits, suggest a widely distributed methane supply from below.

There is no convincing occurrence of abiogenic oil anywhere and this explains the failure of Gold's theory, based on hugely wrong hydrate estimates. However, if oil is a complex product needing organic matter to be generated in Nature, methane is a simple molecule and can be generated from chemical reactions involving mantle rocks (it is, for instance, found in space), explaining the desire of Gold to find abundant methane in the Earth's mantle.

But Alexei Milkov (the most respected hydrate expert with experience from Russia and US hydrate surveys) shows a graph (present in my previous hydrates article) which shows that hydrates estimate have been in decline since 1973. The estimated quantity has fallen by a factor of more than 1000, with the resulting volume now similar to that of conventional gas, but without any technique to produce them.



Milkov estimates hydrates to be between 500 and 2500 Gt, to compare with 10 000 Gt by Kvenvolden in 1988 (which is unrealistic, looking at the geological time involved for hydrates compared to fossil fuels).



If the quantity of hydrates is 500 Gt, the quantity of hydrates is lower than that of geopressured dissolved methane, which 30 years ago was described (50 000 Tcf in the Gulf Coast) as the energy of future (as hydrates are now described by some, in particular in the [IPCC's SRES scenarios](#)). But pilot production projects of geopressured dissolved methane were commercial failures, unable to handle pollution problems.

This unrealistically huge estimate is still found in a 2008 Canadian report on hydrates:

> Recent estimates suggest that the worldwide volume of gas trapped in hydrate accumulations is in the range of 1 to 120 x 1015 m3 (35,000 to 4,200,000 trillion cubic feet, Tcf). The French version is 35 000 to 4 200 0000 billions de pieds cubes, because for the SI of units (which is the official rule in Canada but also for the US Federal agencies since 1993) billion is square million or 10E12 cf or Tcf, T being tera and not trillion (trillion in SI is cube million = 10E18 or exa)
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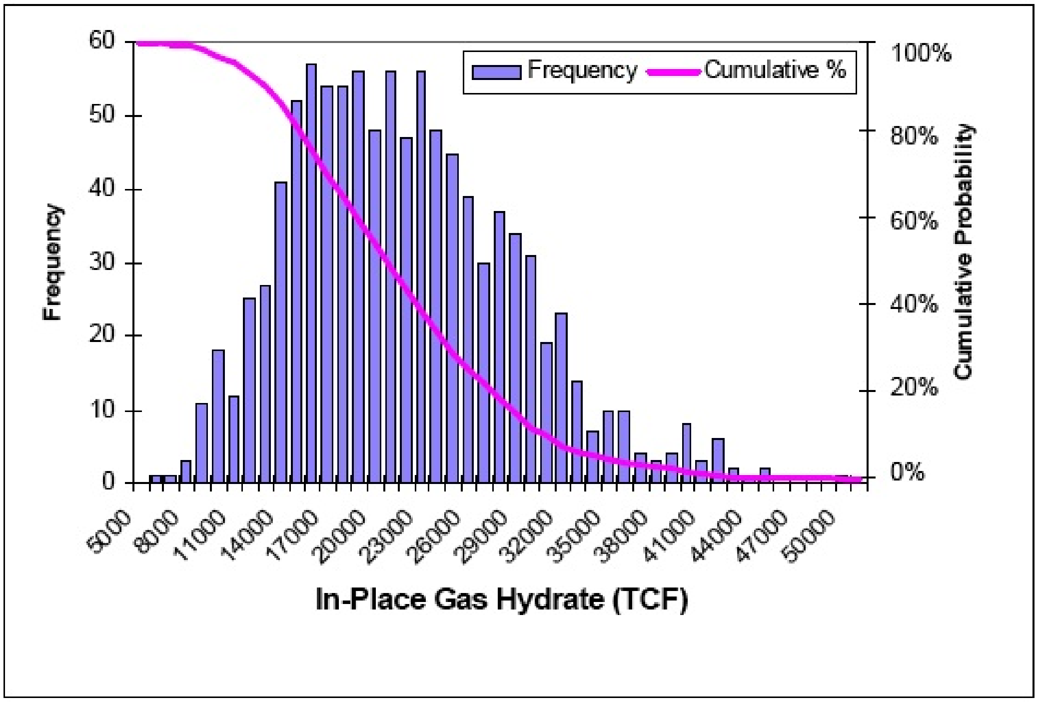
> 
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>
> **Figure 75. Distribution of in-place gas hydrate resources, Gulf of Mexico.**
>
> *In [Energy from gas hydrates: assessing the opportunities & challenges for Canada The Expert Panel on Gas Hydrates [pdf!]], Council of Canadian Academies, 2008-11-05* .

This shows that billion (or trillion) should not be used in papers outside the US, but only symbols as M for mega, G for giga, T for tera, E for exa or 10E3, 10E6, 10E9, 10E12. The SI rule is also not to use the comma for thousands but a space, because in some countries the comma is used as the decimal separator.

> **With very few drilling and coring data sets available, a reliable estimate of global volume of natural gas hydrate appears to be elusive.** It is also difficult to assess the quantity of gas hydrate present on a given margin because of the heterogeneous sedimentological environments along each margin deposits varied significantly, even within tens of metres (Riedel et al., Proceedings of the IODP, 2006). Extrapolation from the local scale can be unreliable without additional knowledge of the scale of heterogeneity.

MMS 2000-017 indicated that:

> In the Gulf of Mexico, drill core samples are especially needed to characterize gas hydrate deposit locations and behaviors before any kind of production is attempted
> [...]
> Gas hydrate extraction may become a reality as soon as 2015
> [...]
> « In 1995, the USGS completed its most detailled assessment of US gas hydrate resources. The USGS study estimated the in-place gas resource within the gas hydrates of the US to range from 112 000 Tcf to 376 000 Tcf, with a mean value of 320 000 Tcf. Subsequent refinements of the data in 1997 using information from the Ocean Drilling Program have suggested that the mean should be slightly downward, to around 200 000 Tcf.

In a later report, entitled Preliminary Evaluation of In-Place Gas Hydrate Resources: Gulf of Mexico Outer Continental Shelf [pdf!] (MMS 2008-004) the estimate (through Monte Carlo runs) of gas hydrate in-place was a 95% chance of 11 112 Tcf and a 5% chance of 34 423 Tcf (in fact the text confuses T trillion (or Tera) and thousand):

> For instance, there is a 95-percent chance that at least 11,112 thousand cubic feet (TCF) of gas hydrate are in place in the GOM, and a 5-percent chance that more than 34,423 TCF are in place.

The probabilistic distribution of in-place gas-hydrates resources for the GOM is given as below; it is obviously the result of a Monte Carlo run (usually tens of thousands) which transforms a very simple guess into something looking like a looking real data plot!

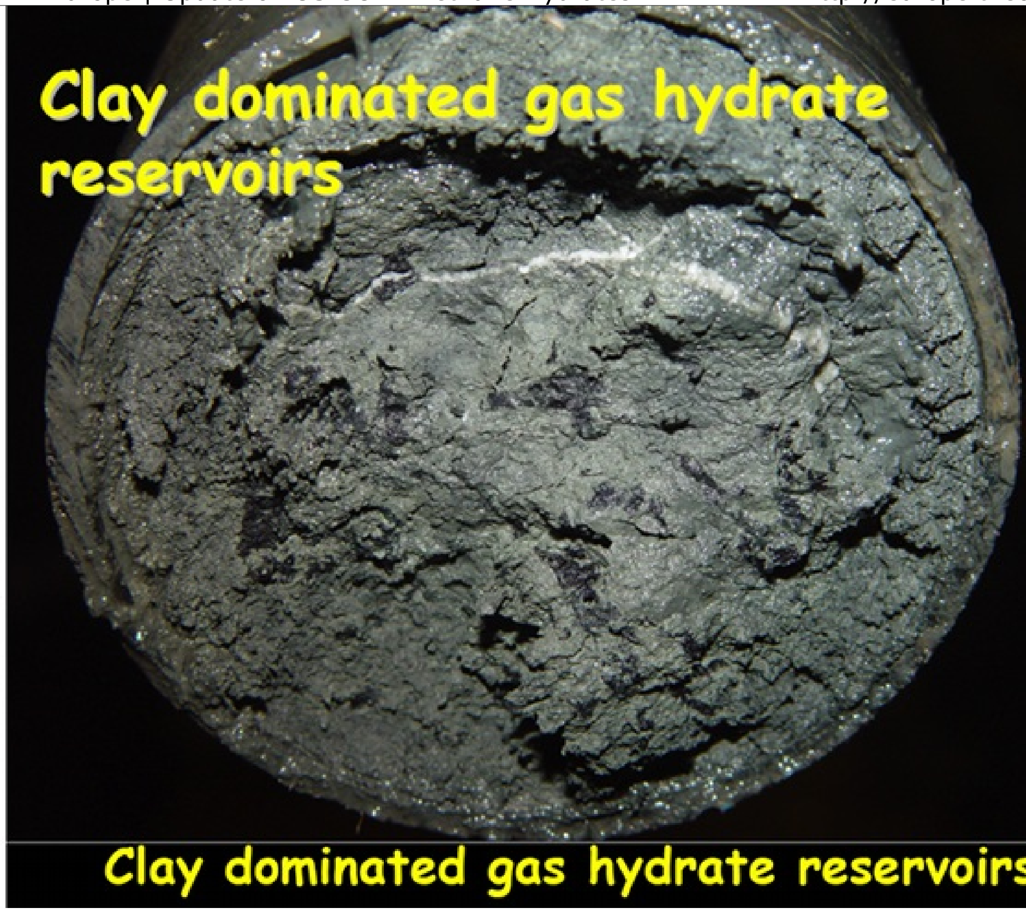
But as indicated before, most of these estimates have been carried out guessing the occurrence of hydrates without the backing of core data.

Where are the cores showing oceanic hydrates?

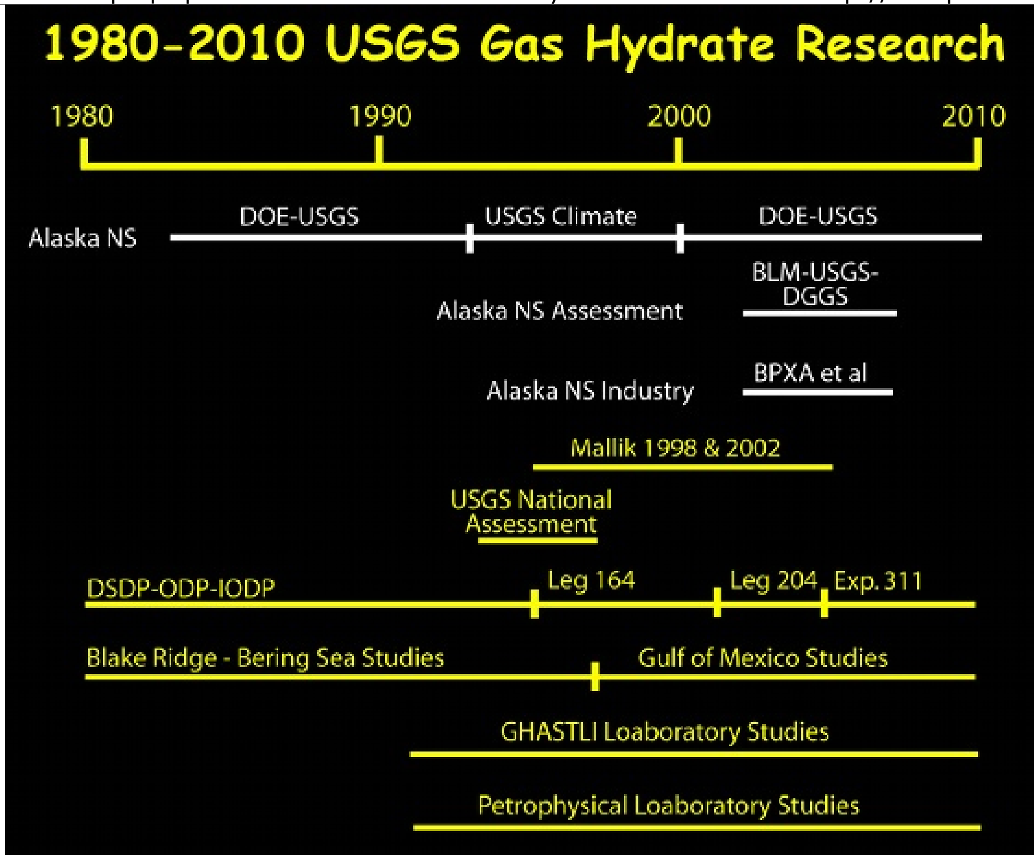
It is very difficult to recover hydrate in cores, because hydrate melts with the change in temperature and pressure when they are brought to surface. It is necessary to keep the pressure within the core. Different core equipments were built since this problem occurred when JOIDES drilling began (it was a main concern when I was a member of the JOIDES Safety Panel in the 1970s). Each new survey tests a new equipment (pressure corer like HYACE, HYACINTH, Fugro,..) and concludes that better equipment or a new survey is needed.

The first industrial hydrate survey in Nankai Japan in 1999 did not recover any hydrate in the recovered cores and JNOC decided to get some hydrate core from permafrost sediments in Canada (logged since 1972 as Mallik 2) to know more on hydrate behaviour. But permafrost hydrate accumulations in Mallik (or Messoyakha in Russia) are completely different from oceanic hydrates, being gas fields in good sandy reservoirs trapped before the glaciation (about 2 million years ago). These shallow reservoirs are now within the hydrate stability zone (deeper reservoirs are just conventional natural gas).

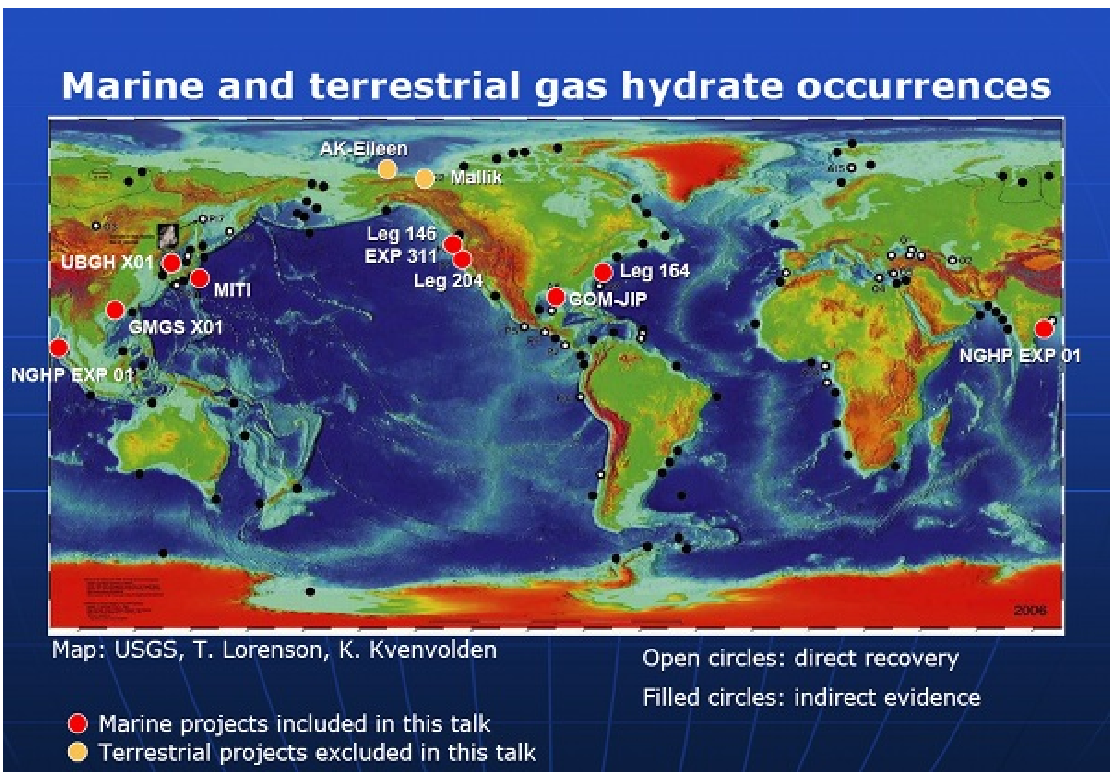
From Collett et al 2006 in permafrost (Alaska) :



Instead, oceanic hydrates occur in clay sediments where gas was converted into hydrate, being unable to migrate, for the pressure and temperature keeps it in the solid state. Only gravity can eventually move the hydrate, because it is lighter than water.



The USGS is active in the US hydrate programme. From Collett et al 2006:



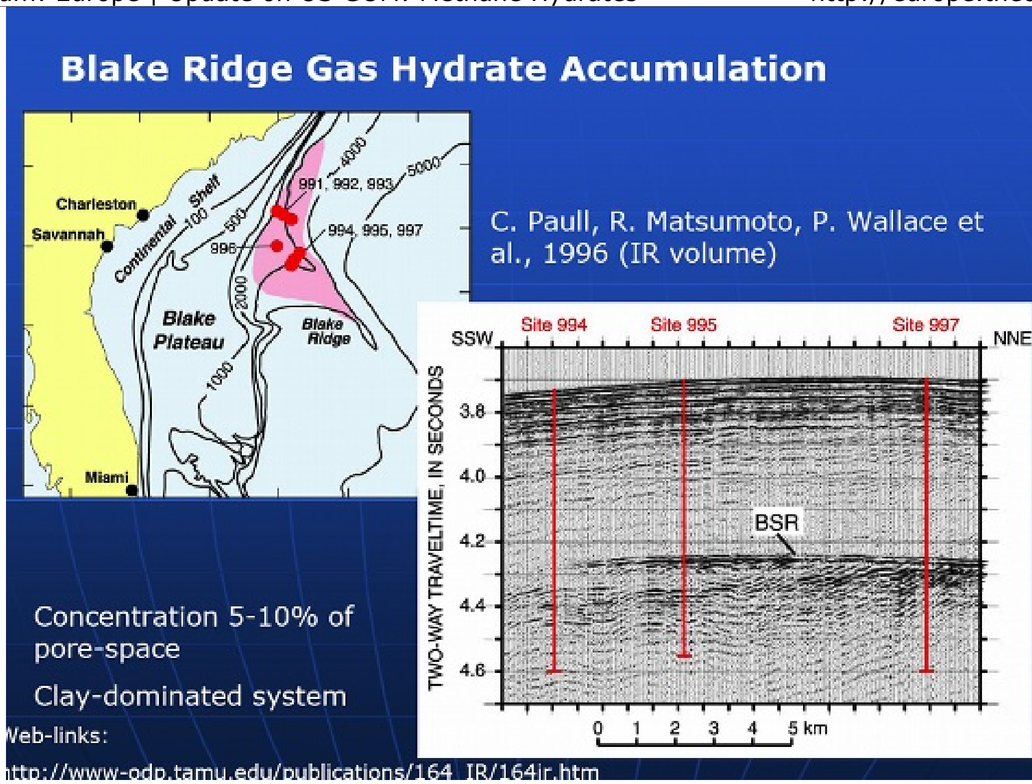
Ten years later, Japan conducted two drilling surveys in 2001 and 2004, amounting to six months drilling with a JOIDES resolution ship. This time they finally did core some hydrate, but very little geological information is published and no picture of these cores can be found on the Internet. According to a presentation delivered by Abe at IIASA in March of 2008, the estimate for the hydrate reserves in Nankai is 20 Tcf (with 40 Tcf for resources). But production experiments are planned only for 2012 and 2014 (METI, AIST & JOGMEC). For a country in great need of domestic energy, hydrate is either not a priority, or they feel that the potential for domestic hydrate production is weak!

The oil industry knows hydrates well because they are a nuisance: plugging pipes and production tubing are vulnerable to hazards caused by hydrates when drilling in deepwater. The MMS requires in the Application for Permit to Drill an evaluation of the hazards of hydrates in order to avoid them.

In 2001 a JIP group was formed, led by Chevron, to investigate the problems of hydrates in the GOM within the oil industry. JIP includes Chevron, ConocoPhillips, Halliburton, JOGMREC (Japan), MMS, Reliance, Schlumberger, Total, KNOC (S. Korea) and StatoilHydro (who joined recently). In 2005 the JIP Leg I drilled 7 wells on AT 13/14 and KC 151 in the course of 35 days (Ruppell et al 2008) with a dynamic positioning semi-sub that recovered 19 cores (total length 6 m):

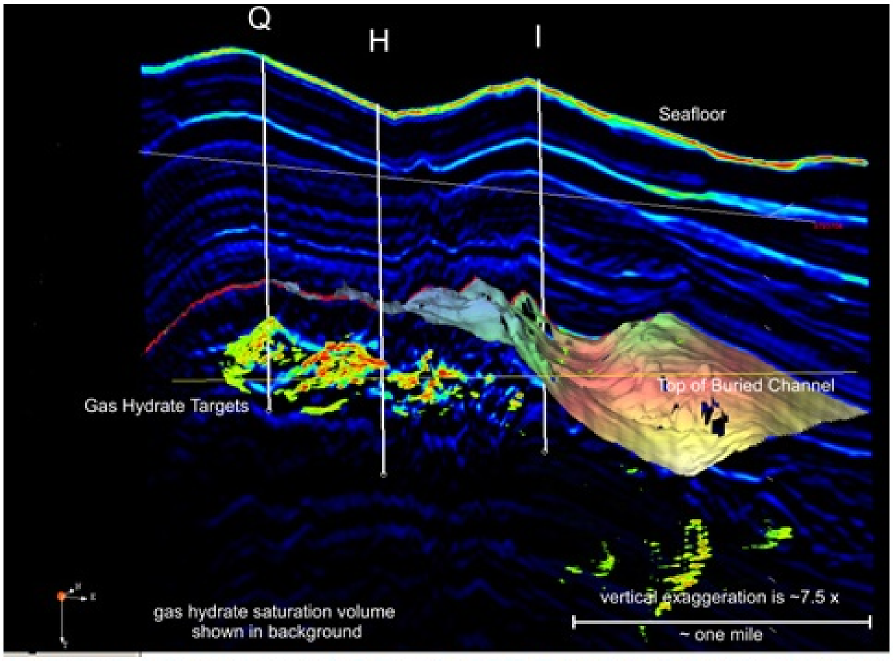
> The JIP launched a 35-day expedition in Spring 2005 to acquire well logs and sediment cores at sites in Atwater Valley lease blocks 13/14 and Keathley Canyon lease block 151 in the northern Gulf of Mexico minibasin province. No gas hydrate was recovered at the drill sites, but logging data, and to some extent cores, suggest the occurrence of gas hydrate in inferred coarser-grained beds and fractures, particularly between 220 and 330 m below the seafloor at the Keathley Canyon site. The expedition did not recover visible gas hydrate during any of the coring operations, nor was gas hydrate directly imaged in pressure cores that were subjected to X-ray analyses (Claypool, 2006) .
>
> *C. Ruppel, R. Boswell, E. Jones Scientific results from Gulf of Mexico Gas Hydrates Joint Industry Project Leg 1 drilling: Introduction and overview Marine and Petroleum Geology 25 (2008) 819–829*

In my 2008 review I indicated that because of finding of no hydrate in the 2005 cores, the oil industry concluded that hydrates pose a minimum-drilling hazard.



Michael Riedel, Marine gas hydrate occurrence -15 years of research ocean drilling for gas hydrates Results from ODP/IODP drilling and commercial projects (1992 –2007) -Recent advances in our understanding of marine gas hydrate provinces [pdf!].

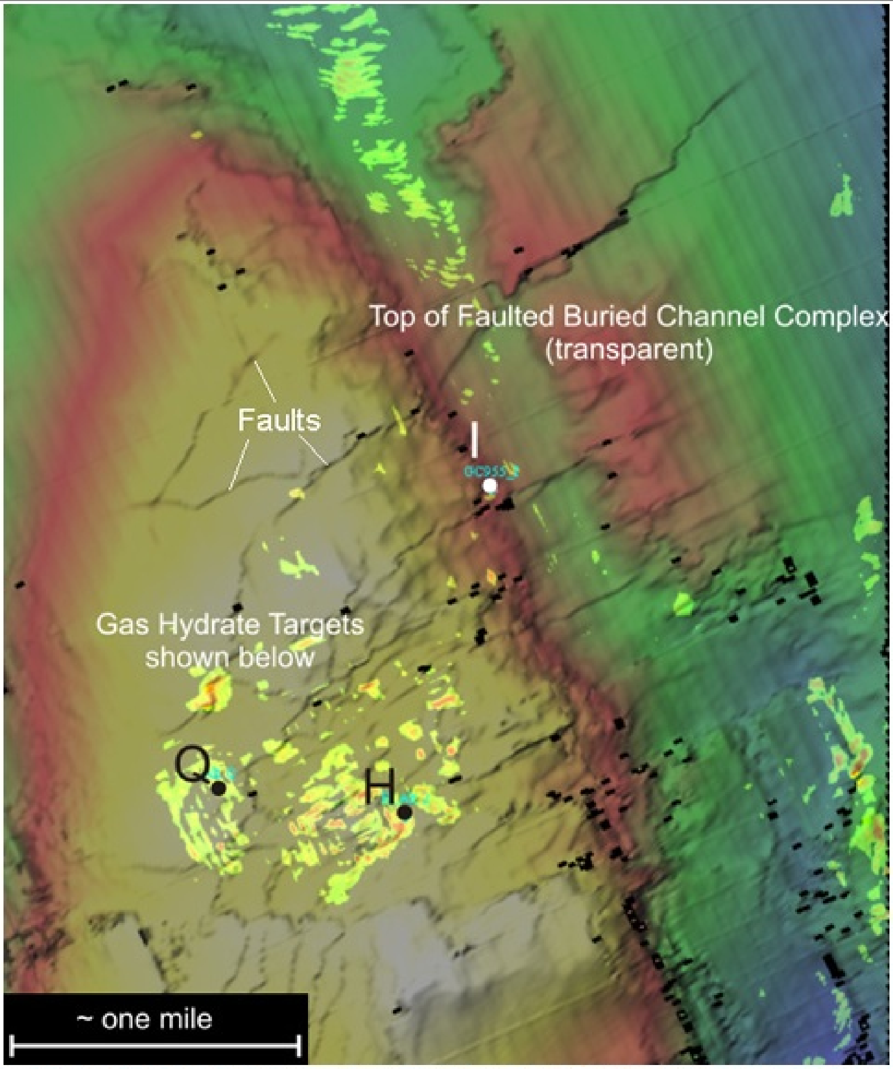
The seismic section of leg 164 is shown with 3 sites: 994, 995 and 997. The so called BSR (Bottom Simulating Reflector) was absent on site 994 and present in sites 995 and 997, but the log on these three holes was similar to the hydrate zone. It is now well established that BSR depends on the gas below the hydrate stability zone, before a small concentration of fizzy water (lemonade) drastically changes the velocity of the sediments. BRS has nothing to do with hydrate concentration, even though this was assumed in most of the resource estimates.



Perspective View to the northwest showing wells Q, H, and I in GC955. The surface is the top of the channel system and top of sand-rich interval. Below the channel are the gas hydrate targets.

In Leg II three wells were drilled in Green Canyon 955 between the April 22 and April 28, 2009. The first well encountered more than 300 ft of porous sands as predicted; however, these sands contained primarily water – with only modest indications of gas hydrate:

> The JIP's discovery of thick gas hydrate-bearing sands at GC955 validates the integrated geological and geophysical approach used in the pre-drill site selection, and provides increased confidence in assessment of gas hydrate volumes in the Gulf of Mexico. It is expected that further evaluation of the complex geology of these sites, including both fracture-filling and pore-filling gas hydrate in numerous fault blocks (with potentially varying geochemical conditions and gas hydrate/free gas configurations) will add significantly to the understanding of the nature and occurrence of gas hydrate-saturated sands in the marine environment [...]



Map view of the top of the highly faulted buried channel (transparent) showing gas hydrate targets below and wells Q, H, and I.

The so-called hydrate target looks dispersed and of limited horizontal extent (100 m!). It was written that:

> Phase III of the project is to collect data on hydrate bearing sands. Both logging and coring operations are planned. Phase III of the project began in September of 2007 and will focus on obtaining logs and cores of hydrate bearing sands in the GOM [...]

Coring is indicated in the planning of the several selected locations, but it was not carried out in Leg II, without any explanation.

> Phase 3A is currently ongoing. Site selection and detailed scientific and operational planning for the drilling/logging expedition have been completed. The expedition was initiated on 3/16/09 and sites involved are to include Green Canyon 955, Walker Ridge 313 and East Breaks 992 (contingency sites include Green Canyon 781/825 and Alaminos Canyon 21/65). The multi-location, multi-hole program will include a full suite of well logs and will provide vital information related to occurrence of hydrate in coarse grained sediment in the Gulf of Mexico, will help prove out the prospecting methodologies used in the selection of targeted sites and will lay the ground work for

> Phase 3B coring expedition. Phase 3B will involve the planning and carrying out of a separate hydrate coring cruise (anticipated in 2011), the follow on analyses, interpretation and dissemination of information generated from project activities.
>
> *From The National Methane Hydrates R&D Program webpage.*

Alaska

The USGS estimates hydrate resources in the North Slope in the range of 25 Tcf to 157 Tcf, with a mean of 85,4 Tcf. This mean was 590 Tcf in the 1995 estimate, (quite a drop!) but they claim that back then it was in-place whereas now it is technically recoverable gas.

Two hydrates wells were drilled and cored in the last 5 years:

Hot Ice 1

In 2003 & 2004 a well was drilled by Anadarko with the goal to recover hydrate, because its name was clear: Hot Ice. It was cored for more than 200 ft and no hydrate was found, neither in the core or in the logs!

> During the winter operations seasons of 2003 and 2004, Anadarko Petroleum in cooperation with Maurer Technology and Noble Corporation and with the partial support of DOE drilled and cored a shallow well, Hot Ice 1, located at 30-T9N-R8E, Umiat Meridian, on the North Slope of Alaska.
>
> The Hot Ice 1 well was drilled from the surface to 2300 ft. There was almost 100% core recovery from the bottom of surface casing at 107 ft to TD at 2300 feet measured depth from the surface. Based on the best estimate of the bottom of the methane hydrate stability zone core was recovered over its complete range. Approximately 565 ft of good sandstone reservoir rock was recovered in the Ugnu formation and approximately 215 ft were recovered in the West Sak. There were gas shows in the bottom part of the Ugnu and throughout the West Sak. No hydrate baring zones were identified either in the recovered core or on the well logs.
>
> *Signal et al, Characterization of potential hydrate bearing reservoirs in the Ugnu and West Sak formations of Alaska's North Slope.*

Milne Point BP 2007 Mt Elbert gas hydrate project

500 ft of continuous core were recovered in 2007 with the stratigraphic well "Mount Elbert"; logs indicate 30 m (in two layers) of gas-hydrate saturated, fine grained, sand reservoir. But the only picture that I found shows grey sediment (they mention *ice cementation with gas saturation of 45 to 75%*) different from the typical white spots oceanic hydrate. Tests were conducted recovering methane (thermogenic and microbial gas).

Figure 5. Whole round core sample of gas hydrate-bearing sand. Rind of oil-based mud coats the left end of the core.

Investigation of gas hydrate-bearing sandstone reservoirs at the "Mount Elbert" stratigraphic test well [pdf!], Milne Point Alaska, R. Boswell ICGH 2008 Vancouver

There is a video showing the gas dissociation of the Mt Elbert at the NETL webpage (direct link to mpeg file here).

There is obviously methane release from these cores, like it happens with marshy gases or with cow flatulence (1 m3/d). 50% of green house gases (GHG) emissions in New Zealand come from cows and sheep. This figure is only 14% in Australia, where kangaroos do not emit any methane because of a special bacteria in their guts (they are trying to move it to cows and sheep!). A long production test is needed to know more about Mt Elbert's potential, but that it is not yet decided!

Production

A Permafrost hydrate in sandy sediments is quite different from an oceanic hydrate in clay, mostly unconsolidated sediments. Permafrost hydrates were drilled in oil and gas producing basins: they are old accumulations and mainly thermogenic. Oceanic hydrates were drilled in oil and gas producing basins (e.g. GOM). In the North Slope hydrates seem quite uneconomical (the Mallik test was less than a CBM test) and their interest is negligible when Prudhoe Bay free gas reserves are still stranded (in unconventional production the size of the tank does not matter, it is the size of the tap!). It is a far future prospect, needing first a gas pipeline and much higher gas prices because of the small flow (no pressure because shallow depths). Collett et Petrotech 2009 (Geologic and engineering controls on the energy resource potential of gas hydrates [pdf!]) states that the maximum rate on Mallik 2008 was 4000 m3/d .

There is no production concept for oceanic hydrates, because no one knows how to extract them, if they mainly lie in unconsolidated impermeable sediments. Furthermore, the heterogeneity of oceanic hydrates (few centimetres vertically and few meters horizontally) seems to be a difficult obstacle to overcome.

Conclusions

Hydrate is the Santa Claus of many who do not want to change their way of life. But hydrate occurrences are hard to evaluate, mainly because of a lack of samples (cores), which is the only way to calibrate all the visible proxies: well logs and seismic data.

The GOM is now claimed to have the "**most promising marine gas hydrate accumulations in the world**", but unfortunately this is only wishful thinking without the coring, which is now planned only for 2011 or later. As usual, the data is incomplete to back up such optimistic claims, in particular for the GOM.