PS Global Resource Potential of Gas Hydrate*

Arthur H. Johnson[1]

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[1]Hydrate Energy International, Kenner, LA. (art_johnson@hydrate-energy.com)

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Abstract

A new evaluation of gas hydrate resource potential, utilizing a petroleum systems approach, has resulted in calculations that support the probability of a large volume of hydrate being present in sand reservoirs in polar and deepwater sediments. Previous global estimates published during the past 30 years have reported large volumes but have included the hydrate present in low concentration in shales that is not commercially viable. More recent estimates have utilized a petroleum systems approach but have only covered individual basins.

The new assessment includes every coastal margin on Earth along with Polar Regions. Of the total volume of hydrate in place, it is likely that only a relatively small percentage is technically recoverable, and an even smaller percentage will be commercially viable. Yet, even at the low end, the resource potential is significant.

Due to the lack of subsurface data for the hydrate stability zone in many parts of the world, the resulting range of values for the assessment extends over several orders of magnitude. With future drilling results and improved seismic evaluation techniques, the estimate of hydrate volume in place will be further revised.

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Arthur H. Johnson, Hydrate Energy International, 612 Petit Berdot Drive, Kenner, LA 70065, art_johnson@hydrate-energy.com

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Background

Estimates of global gas hydrate abundance that have been published during the past thirty years (Table 1) have pointed to a truly vast hydrate natural gas potential.

While these estimates have been widely quoted, they include hydrate in low-grade (shale) deposits as well as in high-grade (sand) deposits, and are misleading as to actual economic potential. As noted in recent publications (Max, et al, 2006, Collett et al, 2010, and many others) high-grade gas hydrate deposits are best viewed as an extension of the conventional petroleum system, and a petroleum systems approach is essential for a valid assessment of hydrate resource potential.

	Tcm	Tcf
Trofimuk, et al. 1977	5,000-25,000	176,574 - 882,868
Meyer, 1981	3,100	109,475
Kvenvolden, 1988	20,000	706,294
MacDonald, 1990	21,000	741,609

Table 1. Some Previous Estimates of Global Gas Hydrate Volumes

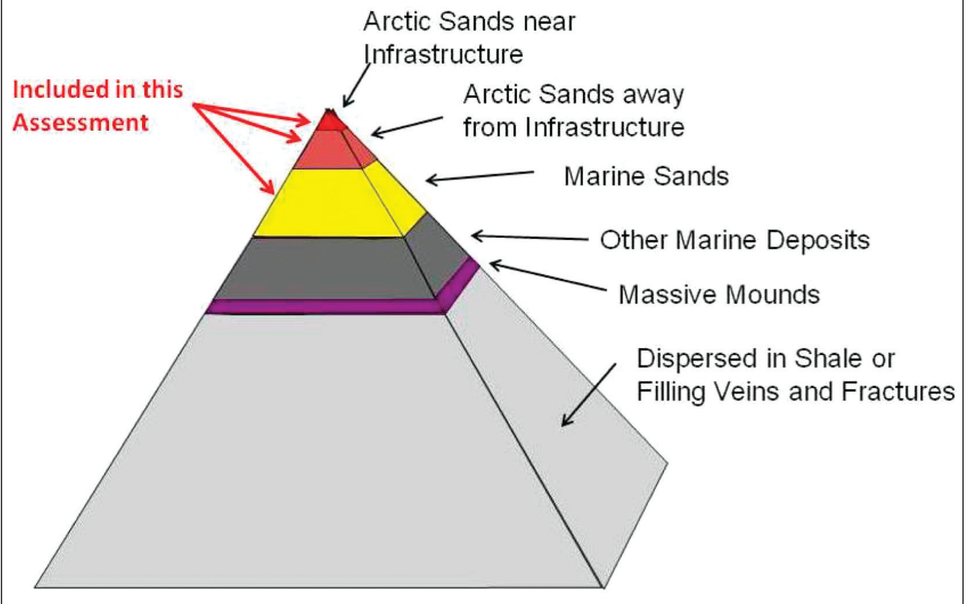

Figure 1. Gas Hydrate Resource Pyramid (Adapted from Boswell and Collett, 2006)

The combination of lithology and methane flux required for deposits of concentrated hydrate in producible reservoirs removes most of the world's gas hydrate from consideration as an energy resource (Figure 1). However, the high concentrations of hydrate that may be present in Marine and Arctic sediments lead to the possibility of exceptionally large volumes of natural gas occurring in porous, permeable reservoirs.

Few hydrate resource estimates have been published that have used a petroleum systems approach. Those that have used a valid methodology cover specific locations or regions, and include the U.S. Minerals Management Service estimate for the Gulf of Mexico (6,717 Tcf in place in sand reservoirs), the U.S. Geological Survey estimate for the North Slope of Alaska (85.4 Tcf technically recoverable from hydrate reservoirs), and the Japanese estimate for a limited area of the Nankai locale (39 Tcf).

New Global Hydrate Assessment

HEI has undertaken a global assessment of gas hydrate potential as part of the Global Energy Assessment being conducted by the International Institute for Applied Systems Analysis (IIASA) with funding from the World Bank, United Nations Organizations, and national governments. In undertaking this study, HEI assessed data from every continental margin and utilized appropriate depositional models. Under the guidelines of the IIASA, the results are reported for the 18 Regions defined by the United Nations. In addition, separate resource assessments were conducted for the Arctic Ocean without regard for national boundaries, and for the Southern Ocean (from the coast of Antarctica north to 60 degrees south latitude).

Results of the entire Global Energy Assessment will be published by IIASA in summer, 2011.

Methodology

High-grade gas hydrate deposits are located where pressure-temperature conditions for hydrate formation occur with appropriate reservoir lithology and adequate gas input. Other than a few locations, such as those noted above, these parameters have not been adequately quantified at the shallow depths where gas hydrate may be present, even in areas with extensive conventional oil and gas drilling. Most of the marine gas hydrate systems that have been studied to date are fine-grained, with very poor reservoir potential. Since 2007, a general consensus has been growing for the need to adopt a petroleum systems approach that includes assessment of all of the parameters required for high-grade deposits.

For this study, three critical parameters were used: the thickness of the hydrate stability zone, probability of reservoir lithology within the hydrate stability zone, and probability of adequate gas charge.

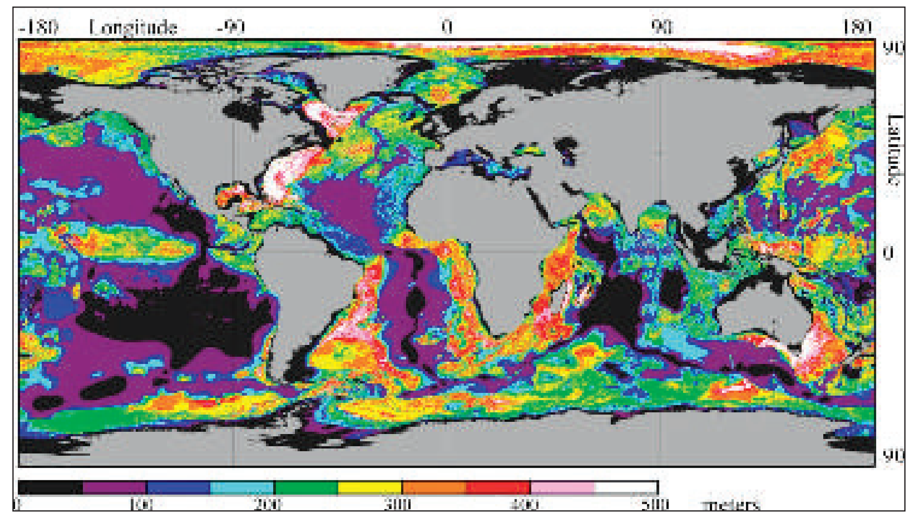

Figure 2. Thickness of the Gas Hydrate Stability Zone (from Wood and Jung, 2008)

The thickness of the gas hydrate stability zone was determined with the use of data and reports obtained from the U.S. Naval Research Laboratory, and we gratefully acknowledge the contribution of Warren Wood (NRL) in the success of the project. The NRL data was gridded by Wood and Jung at 2 minutes of latitude and 2 minutes of longitude to produce a global map. Figure 2 illustrates their results.

Calculation of the gas hydrate resource potential for of each of the 18 regions was undertaken by first segregating each region into separate sub-regions based on the local depositional setting. For marine gas hydrate, a range of values for the volume of sediment within the gas hydrate stability zone (corrected for sulfate reduction of methane near the seafloor) was calculated using the model developed by Wood and Jung (2008). This volume was multiplied by:

- a range of estimates of the percentage of sand within the hydrate stability zone,
- a range of values for the percentage of those sands that would be hydrate-bearing,
- a range of values for sandstone porosity,
- a range of values for hydrate saturation of the pore space

This calculation provides an estimate of the gas in place for the gas hydrate resource.

As each of these parameters is poorly constrained in most of the world's depositional basins, the resulting resource estimates extend over several orders of magnitude. A narrower range of values will be obtainable in the future as additional data is collected. Where detailed analyses have been conducted, those results have been integrated into this study.

For Arctic sediments, the estimate of technically recoverable gas hydrate was determined using recent analyses such as Collett (2008), and extrapolating the range of results to areas where the parameters for a petroleum systems approach are not available.

Results

REGION (United Nations Designation)	Gas in Place Range (TCF)	Gas in Place Median (TCF)
USA	1,500 – 15,434	7,013
Canada	533 – 8,979	2,228
Western Europe	36 – 14,858	1,425
Central & Eastern Europe	0 – 105	13
Former Soviet Union	1,524 – 10,235	3,829
North Africa	6 – 1,829	218
Eastern Africa	42 – 25,695	1,827
Western and Central Africa	79 – 26,672	3,181
Southern Africa	121 – 26,369	3,139
Middle East	31 – 3,848	573
China	10 – 1,788	177
Other East Asia	14– 2,703	371
India	36 – 6,268	933
Other South Asia	20 – 3,497	557
Japan	71 – 471	212
Oceania	38 – 6,750	811
Other Pacific Asia	64 – 25,946	1,654
Latin America and the Caribbean	258 – 31,804	4,940
Southern Ocean	144 – 45,217	3,589
Arctic Ocean	178 – 55,524	6,621
Total	4,705 – 313,992	43,311

Table 2: Gas in Place in Hydrate-Bearing Sands

Summary

The global volume of gas hydrate is enormous, and a significant portion of the total volume occurs in reservoirs from which natural gas is technically recoverable. While the resulting resource estimates extend over several orders of magnitude, a narrower range of values will be obtainable in the future as additional data is collected.

References

Boswell, R. and T.S. Collett, 2006; The gas hydrates resource pyramid: Fire in the ice, Methane hydrate newsletter, US Department of Energy, Office of Fossil Energy, National Energy Technology Laboratory, Fall Issue, p. 5-7.

Collett, T.S., Agena, W.F., Lee, M.W., Zyrianova, M.V., Bird, K.J., Charpentier, T.C., Houseknect, D.W., Klett, T.R., Pollastro, R.M., and Schenk, C.J., 2008, Assessment of gas hydrate resources on the North Slope, Alaska, 2008: U.S. Geological Survey Fact Sheet 2008-3073, 4 p

Collett, T., Johnson, A., Knapp, C., Boswell, R., eds., Natural Gas Hydrates -- Energy Resource Potential and Associated Geologic Hazards: American Association of Petroleum Geologists Memoir 89, 137p.

Kvenvolden, K.A., “Methane Hydrate – A Major Reservoir of Carbon in the Shallow Geosphere?” Chemical Geology, Vol. 71 (1988), pp. 41-51.

MacDonald, G.J., “The Future of Methane as an Energy Resource,” Annual Review of Energy, Vol. 15 (1990), pp. 53-83.

Max, M.D., Johnson, A., & Dillon, W.P. 2006. Economic Geology of Natural Gas Hydrate. Springer, Berlin, Dordrecht, 341p.

Meyer, R.F., “Speculations on oil and gas resources in small fields and unconventional deposits,” Long-term Energy Resources (1981), pp. 49-72.

Trofimuk, A.A., N.V. Cherskii, and V.P. Tsaryov, “The Role of Continental Glaciation and Hydrate Formation on Petroleum Occurrence,” in R.F. Meyer, ed., The Future Supply of Nature-Made Petroleum and Gas (New York, 1977), pp. 919-926.

Wood, W.T., and W.Y. Jung, 2008, Modeling the Extent of Earth's Marine Methane Hydrate Cryosphere, Proceedings of the 6th International Conference on Gas Hydrates (ICGH 2008), July 6-10, 2008, Vancouver, British Columbia, Canada, 8 p.