Assessing Gas Hydrates in the OCS

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DOE/NETL
Methane Hydrate Conference
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Today's Discussion

- MMS plan of action
- Present thoughts and status
- Schedule of completion

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Objectives

- To develop an assessment model for gas hydrates in the OCS. Model needs to be:
  - Statistically rigorous
  - Able to assess technically recoverable amount
  - Capable of assessing economic value and fair market value
  - Applicable at various levels of geologic setting.
- Assess technically recoverable amount of gas hydrates in the OCS using the new methodology and model

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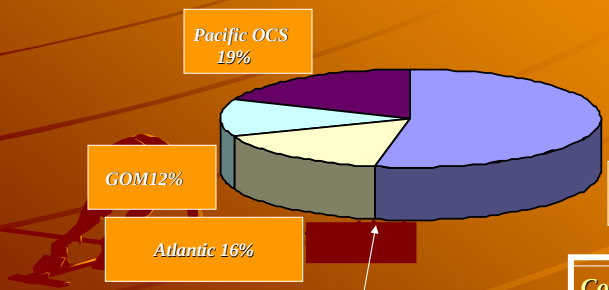
Last OCS Hydrate Assessment

1995 USGS Hydrate Resource Assessment

Collett 2003

In-Place Gas Hydrate Resource Distribution of the United States



Conventional:
362 Tcf

Hydrates:
Total US: 320,192 Tcf
Total Offshore: 319,602 Tcf

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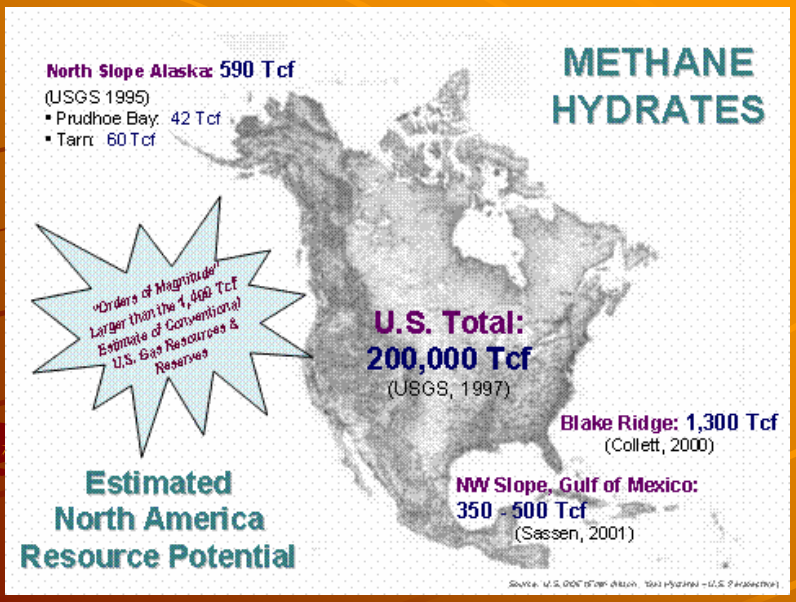

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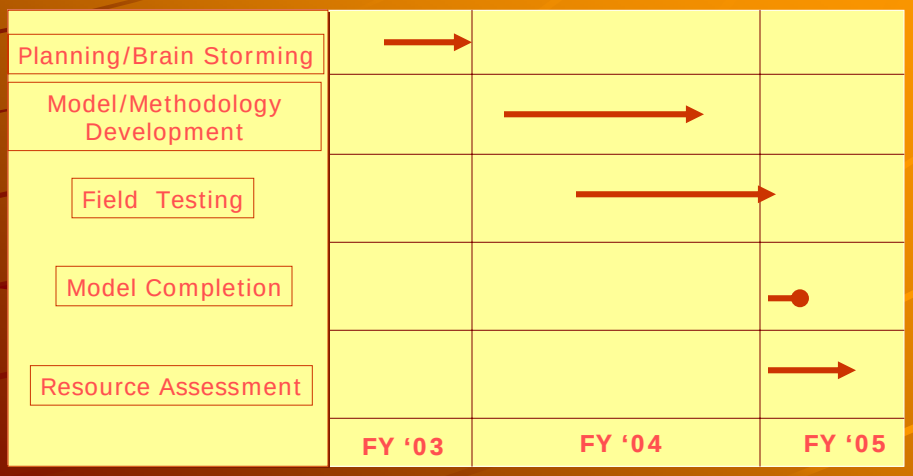
Collett 2002

MMS Assessment Schedule



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Oct '03 Oct '04

Unconventional Petroleum Systems

- ***70's – Subeconomic or marginally economic gas resources such as coalbed methane, shale gas, and tight gas (low perm)***
- ***Present – Economically viable, not buoyancy-driven pervasive accumulations, commonly independent of structural or stratigraphic traps.***

- Law & Curtis (2002)

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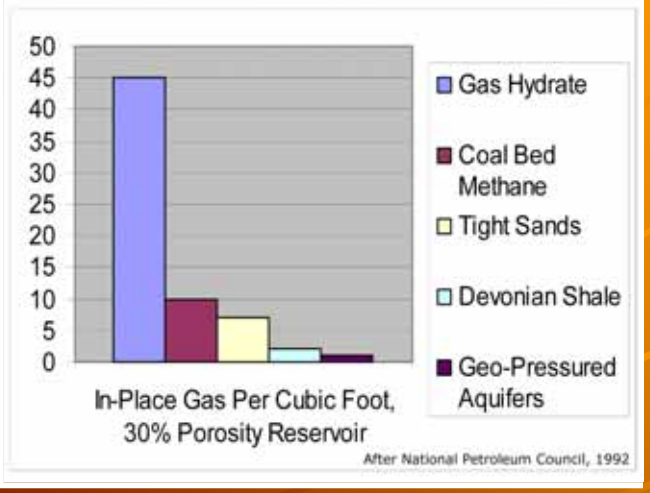
Unconventional Gas Resource – Gas Hydrate Comparison



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From: BP

Hydrate Deposit Types

- Structurally Controlled Hydrate
- Stratigraphically Controlled Hydrate
- Hydrate Associated Free Gas
- Surficial Unstable Hydrate*

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For the purpose of this assessment the hydrate deposits will be treated as two separate types

- Hydrates with definable boundaries
- Continuous deposits - unbound

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Major Challenges

- Defining the Boundaries
- Defining the Recovery Process-Rates
- Challenges in Applying an Economic Model

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Kumar et al 2003

Defining the Boundaries

- Description of distinct entities
  - Continuous vs. discrete
- Mathematical Description
  - Clustering and spatial relationships

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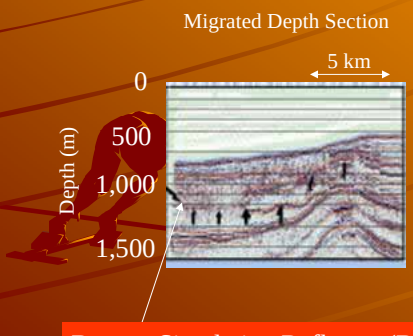
Kumar et al 2003

Limitations of Current Seismic Technology

Seismic Data are currently not sufficiently accurate to determine the amount, location, or presence of hydrates



- Hydrates have been found with no BSR present
- BSR's have been present with no hydrates present
- Advancement in seismic attribute Analysis could improve the ability to determine the presence of hydrates and concentration estimations

Source: Chevron Technology

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Kumar et al 2003

Defining the Recovery Process- Rates

- Describing boundary conditions for various ***types*** of accumulations
  - Need to improve definition of parameters in each type of accumulation
    - Area
    - Thickness
    - Porosity
    - Saturation, etc. etc.

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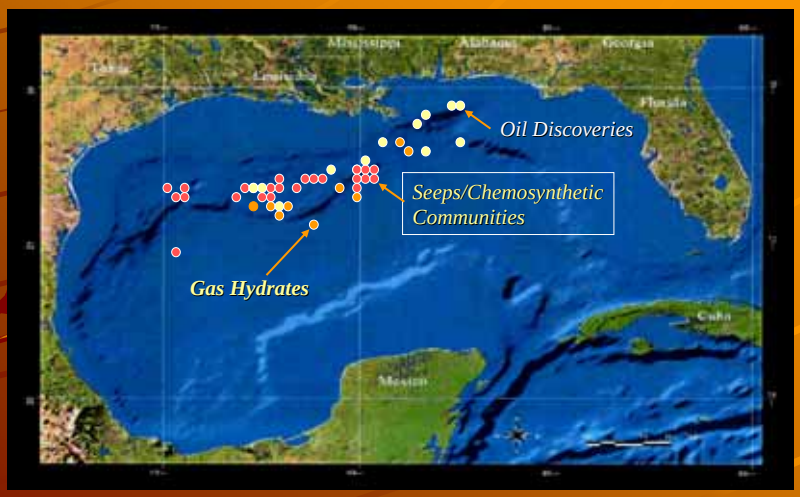
Kumar et al 2003

Gas Hydrates in the Gulf of Mexico



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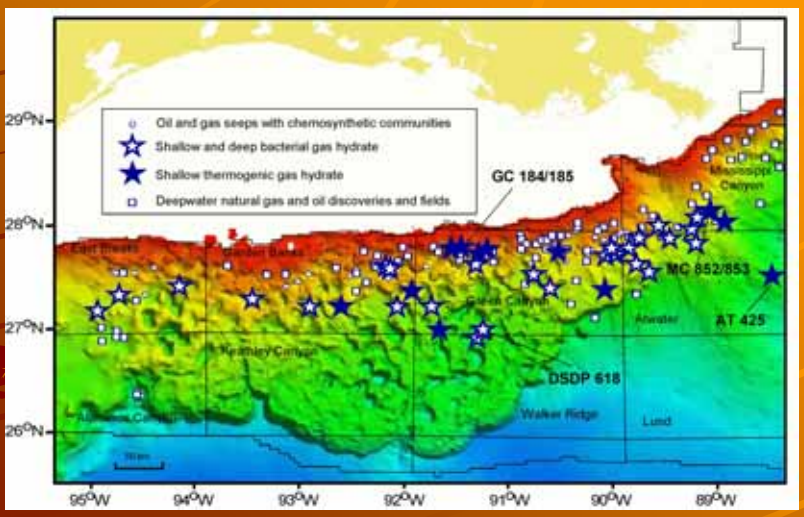
Gas hydrates in the Gulf of Mexico



Gas hydrate, seeps, and fields after Sassen et al., 1999 *Bathymetry courtesy of Dr. W.Bryant*

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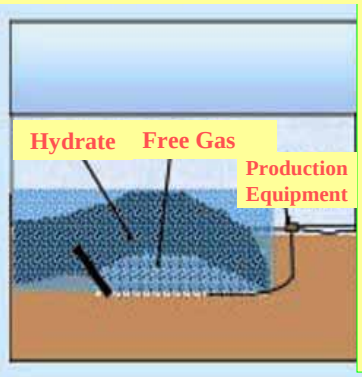
From: Milkov 2003

Challenges of Estimating Recovery Factor/Rates

Various Possible Methods to Produce and Enhance the Flow Rate of Hydrate Gas



- Depressurizing of free gas zone
- Very long horizontal wells
- Multilateral wellbores
- Circulating heated water from the surface or a deeper formation
- Circulating oil from deeper formations
- Carbon dioxide replacement
- Microwave or acoustic energy input
- Mining

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Source: Chevron Technology

Challenges in Applying an Economic Model

- Timing (next 10 or 30 years or more?)
- Hydrates as a primary or secondary objective?

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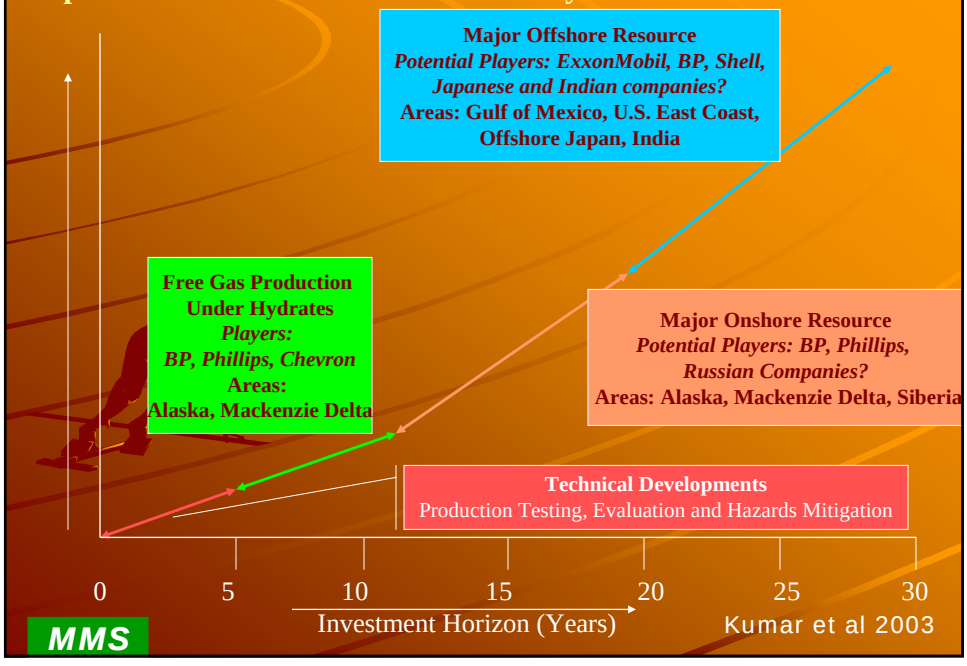
Kumar et al 2003

Speculative Time Horizons For Gas Hydrate Commercialization



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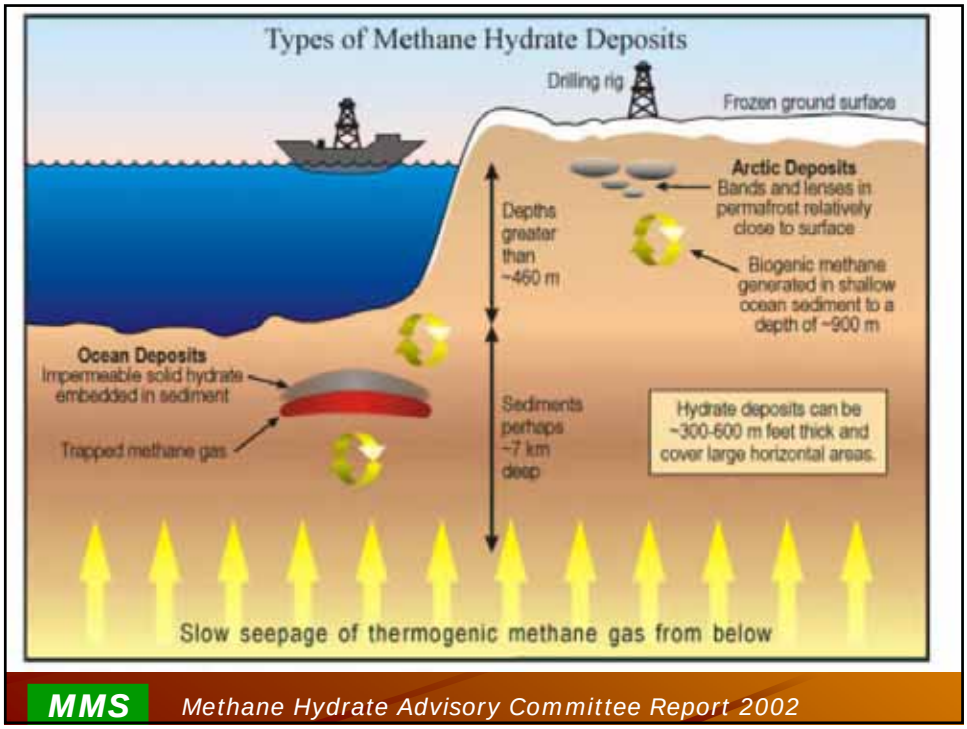
Types of Methane Hydrate Deposits
Drilling rig
Frozen ground surface
Arctic Deposits
Bands and lenses in permafrost relatively close to surface
Biogenic methane generated in shallow ocean sediment to a depth of ~900 m
Depths greater than ~460 m
Ocean Deposits
Impermeable solid hydrate embedded in sediment
Trapped methane gas
Sediments perhaps ~7 km deep
Hydrate deposits can be ~300-600 m feet thick and cover large horizontal areas.
Slow seepage of thermogenic methane gas from below
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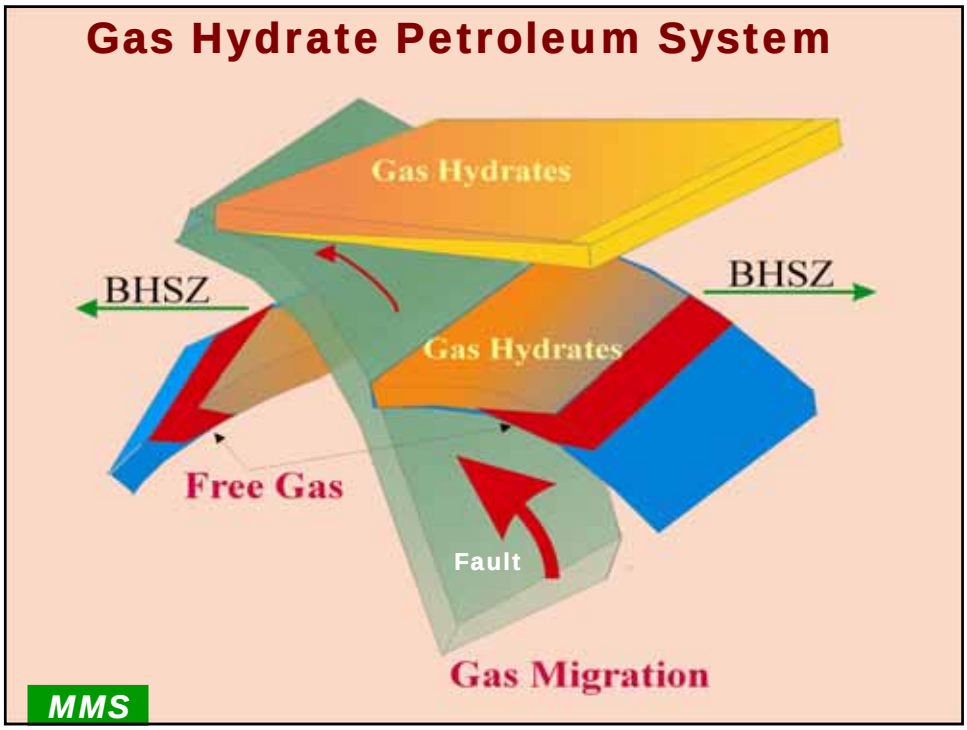
Methane Hydrate Advisory Committee Report 2002


Gas Hydrate Petroleum System
Gas Hydrates
BHSZ
BHSZ
Gas Hydrates
Free Gas
Fault
Gas Migration
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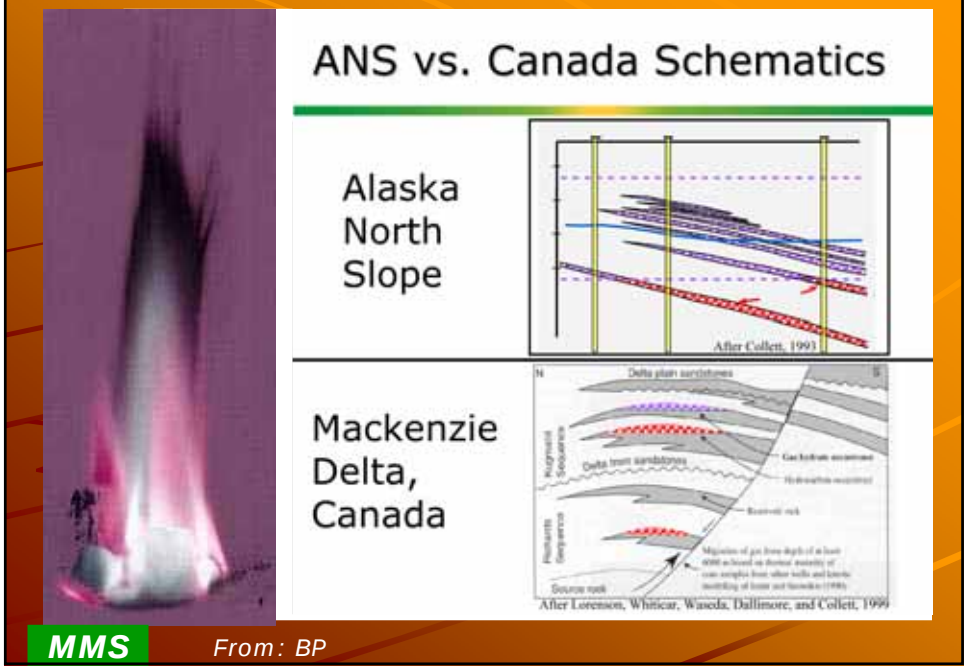
ANS vs. Canada Schematics
Alaska North Slope
After Collett, 1993
Mackenzie Delta, Canada
After Lorenson, Whiticar, Waseda, Dallimore, and Collett, 1999
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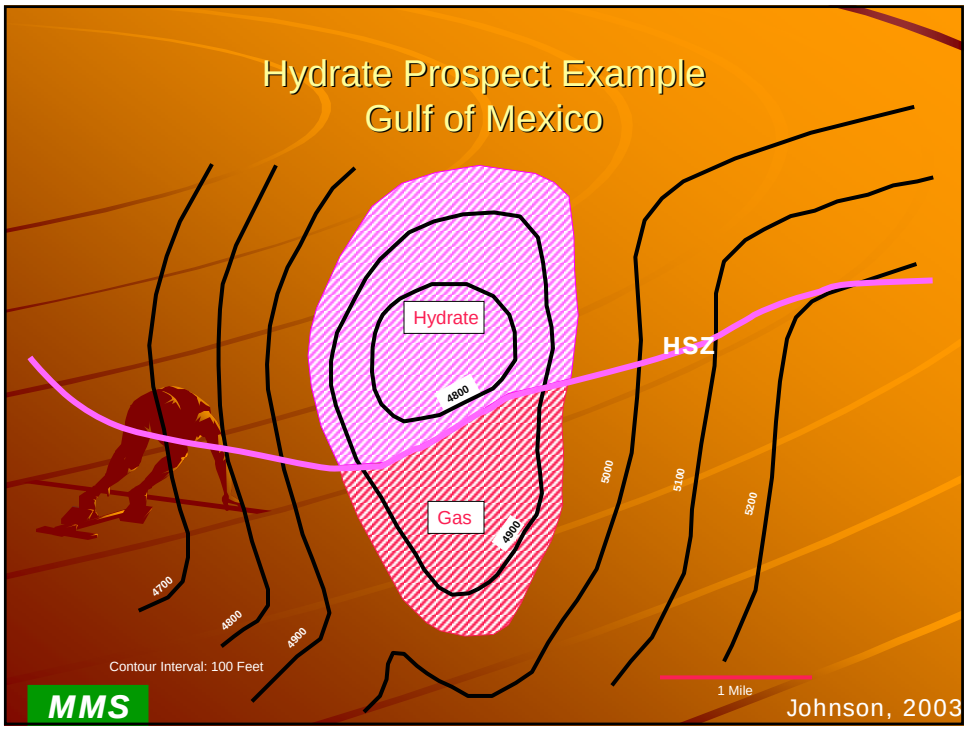
From: BP


Hydrate Prospect Example
Gulf of Mexico
Hydrate
Gas
HSZ
4800
4900
5000
5100
5200
4700
4800
4900
Contour Interval: 100 Feet
1 Mile
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Johnson, 2003

Hydrates with definable boundaries

Modified
Conventional Methodology

Continuous deposits - unbound

Geospatial Statistical Methodology

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Pool Size Equation

Pool Size =
(Constant x Pool Area x Net Pay
x Porosity x HC Saturation x
Recovery Factor) / Gas Formation Volume Factor

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Variables to Consider

- In addition to conventional
  - Source
  - Migration (timing)
  - Reservoir
  - Seal
- We need to consider
  - Reservoir Temperature &
  - Reservoir Pressure
  - Gas hydrate conc. in pore space etc.
  - Resource density

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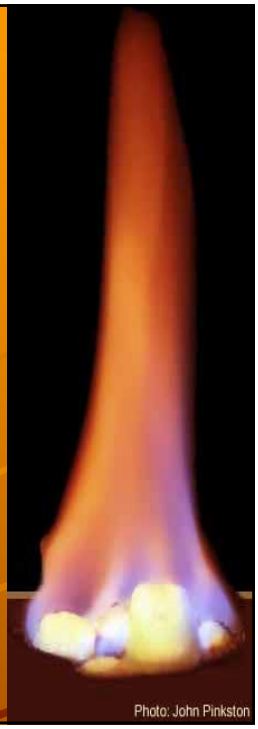
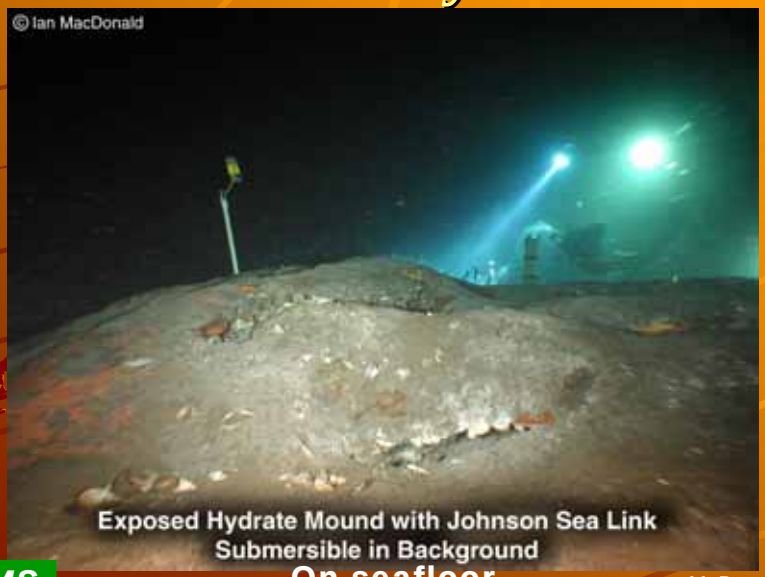


Unbound hydrates



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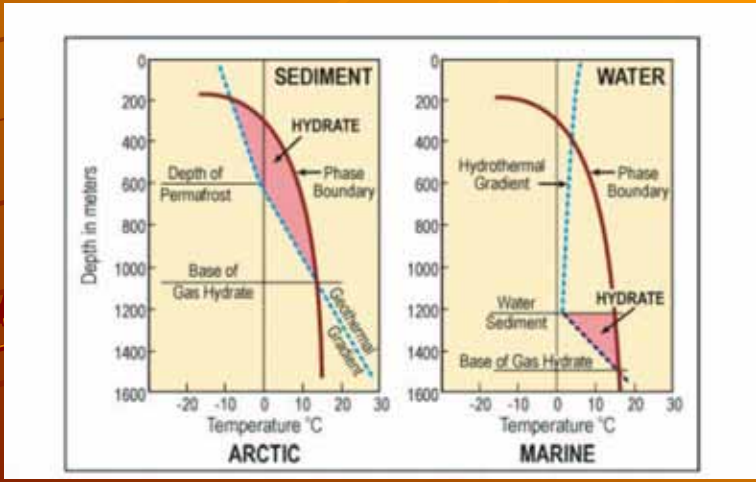
On seafloor

McDonald, 2003

Gas Hydrate Phase Diagram



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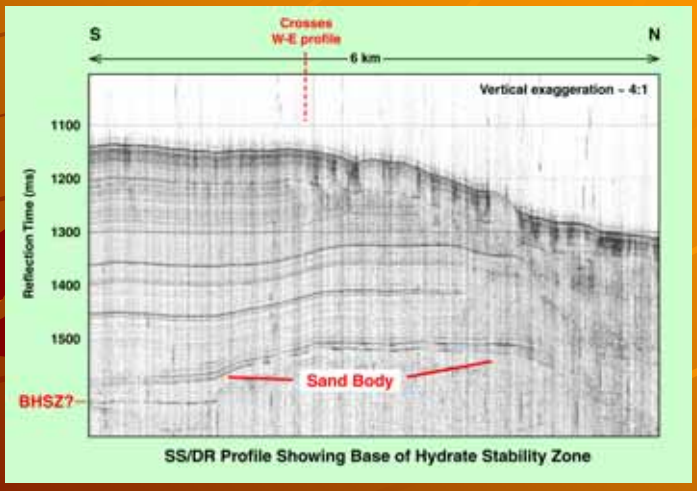
Methane Hydrate Advisory Committee Report 2002

Resource Characterization



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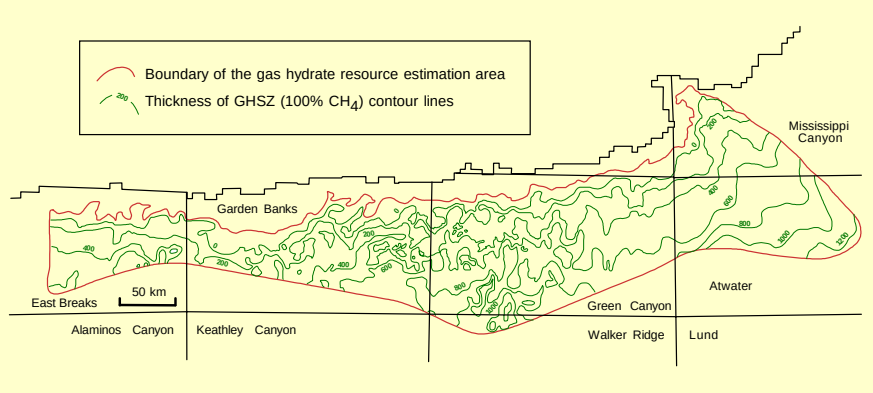
Thickness of the methane GHSZ



From: Milkov 2003

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Clay dominated gas hydrate reservoirs

Site/Well	Depth of gas hydrate (m)	Thickness of hydrate (m)	Porosity (%)	Hydrate saturation (%)	Volume of of gas per square km (cubic m)
ODP Site 994	212.0-428.8	216.8	57.0	3.3	669,970,673
ODP Site 995	193.0-450.0	257.0	58.0	5.2	1,267,941,673
ODP Site 997	186.4-450.9	264.5	58.1	5.8	1,449,746,073
ODP Site 889	127.6-228.4	100.8	51.8	5.4	466,635,705

Collett 2003, USGS

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Sand dominated gas hydrate reservoirs

Site/Well	Depth of gas hydrate (m)	Thickness of hydrate (m)	Porosity (%)	Hydrate saturation (%)	Volume of gas per square km (cubic m)
Eileen-2 Unit C	651.5-680.5	29.0	35.6	60.9	1,030,904,796
Eileen-2 Unit D	602.7-609.4	6.7	35.8	33.9	133,382,462
Eileen-2 Unit E	564.0-580.8	16.8	38.6	32.6	346,928,811
				Total --	1,511,216,069
Mallik 2L-38	888.8-1,101.9	213.1	29.3	47.0	4,812,744,164
METI Nankai	190.0-268.0	10-20	35.0	75.0	----------

Collett 2003

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Three Kinds of Spatial Data Analysis

- Point Pattern Analysis
  - Longitude and latitude, x and y
- Geostatistical Data
  - Continuous spatial surface
- Polygons or Lattice Data
  - Counties, cities, Census tracts
  - Discrete Objects

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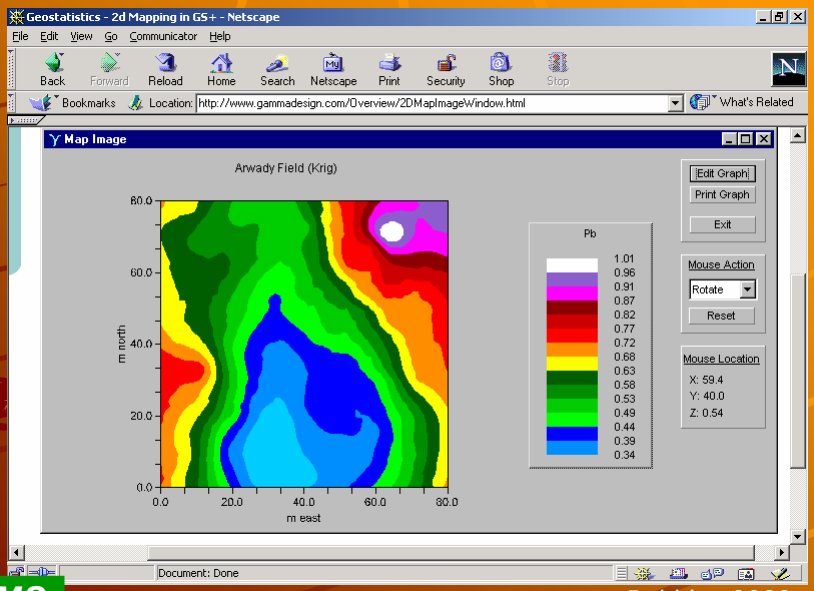
Geostatistical Data



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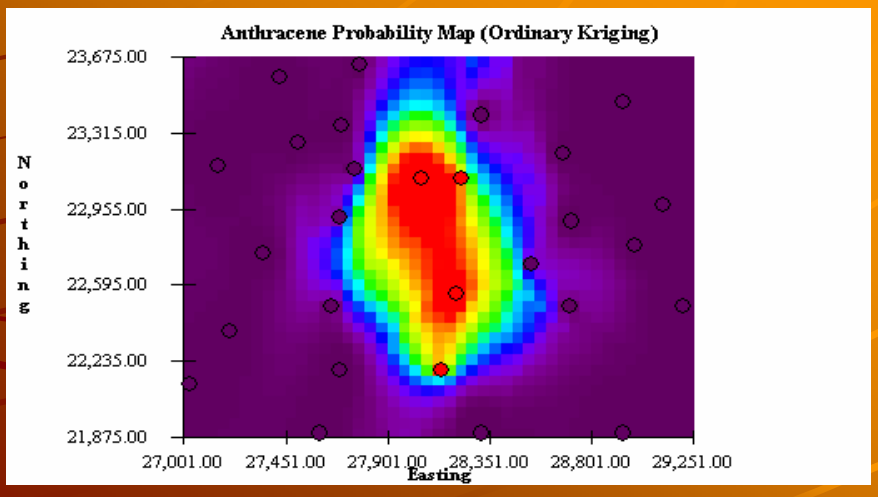
Robbins 2002

Spatial Analysis & Decision Assistance (SADA)



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Summary

- Gas Hydrate is a viable resource of the near future
- It can supply nation's energy demand for many years to come
- Quantitative assessment of some hydrate plays can be done using existing play based probabilistic methodologies with some modifications to adjust for additional risks.
- In some cases, however geospatial probabilistic analysis may provide better result.

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