Methane Hydrate Issues -- Resource Assessment

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Abstract

The estimated amount of gas in the hydrate accumulations of the world greatly exceeds the volume of known conventional gas reserves. However, the role that gas hydrates will play in contributing to the world's energy requirements will depend ultimately on the availability of sufficient gas hydrate resources and the "cost" to extract them. Yet considerable uncertainty and disagreement prevails concerning the world's gas hydrate resources.

Gas hydrates occur in sedimentary deposits under conditions of pressure and temperature present in permafrost regions and beneath the sea in outer continental margins. The combined information from Arctic gas-hydrate studies shows that, in permafrost regions, gas hydrates may exist at subsurface depths ranging from about 130 to 2,000 m. The presence of gas hydrates in offshore continental margins has been inferred mainly from anomalous seismic reflectors known as bottom-simulating reflectors, that have been mapped at depths below the sea floor ranging from about 100 to 1,100 m. Current estimates of the amount of gas in the world's marine and permafrost gas hydrate accumulations are in rough accord at about 20,000 trillion cubic meters.

Gas hydrate as an energy commodity is often grouped with other unconventional hydrocarbon resources. In most cases, the evolution of a non-producible unconventional resource to a producible energy resource has relied on significant capital investment and technology development. To evaluate the energy resource potential of gas hydrates, will also require the support of sustained research and development programs.

Despite the fact that relatively little is known about the ultimate resource potential of natural gas hydrates, it is certain that gas hydrates are a vast storehouse of natural gas and significant technical challenges need to be met before this enormous resource can be considered an economically producible reserve.

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Methane Hydrates Interagency R&D Conference,
March 20-22, 2002, Washington, DC

Timothy S. Collett
U.S. Geological Survey

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Outline of Presentation

- Unconventional Resources Flow Chart
  - WHY Do Gas Hydrates Occur?
  - WHERE Do Gas Hydrates Occur?
  - HOW Do Gas Hydrates Occur in Nature?
  - HOW MUCH Gas Hydrates and Gas?
  - Production Methods
  - Motivations – Economics and Political
  - Gas Hydrate Resources -- CONCLUSION

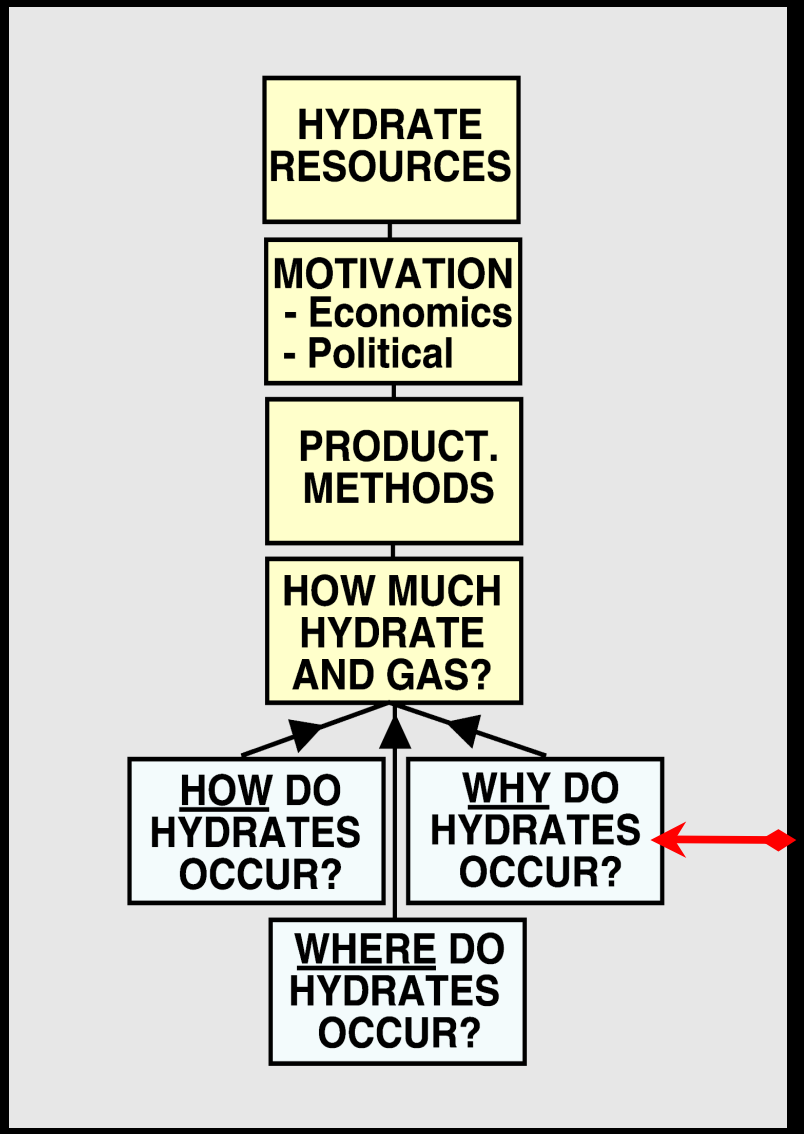
Question

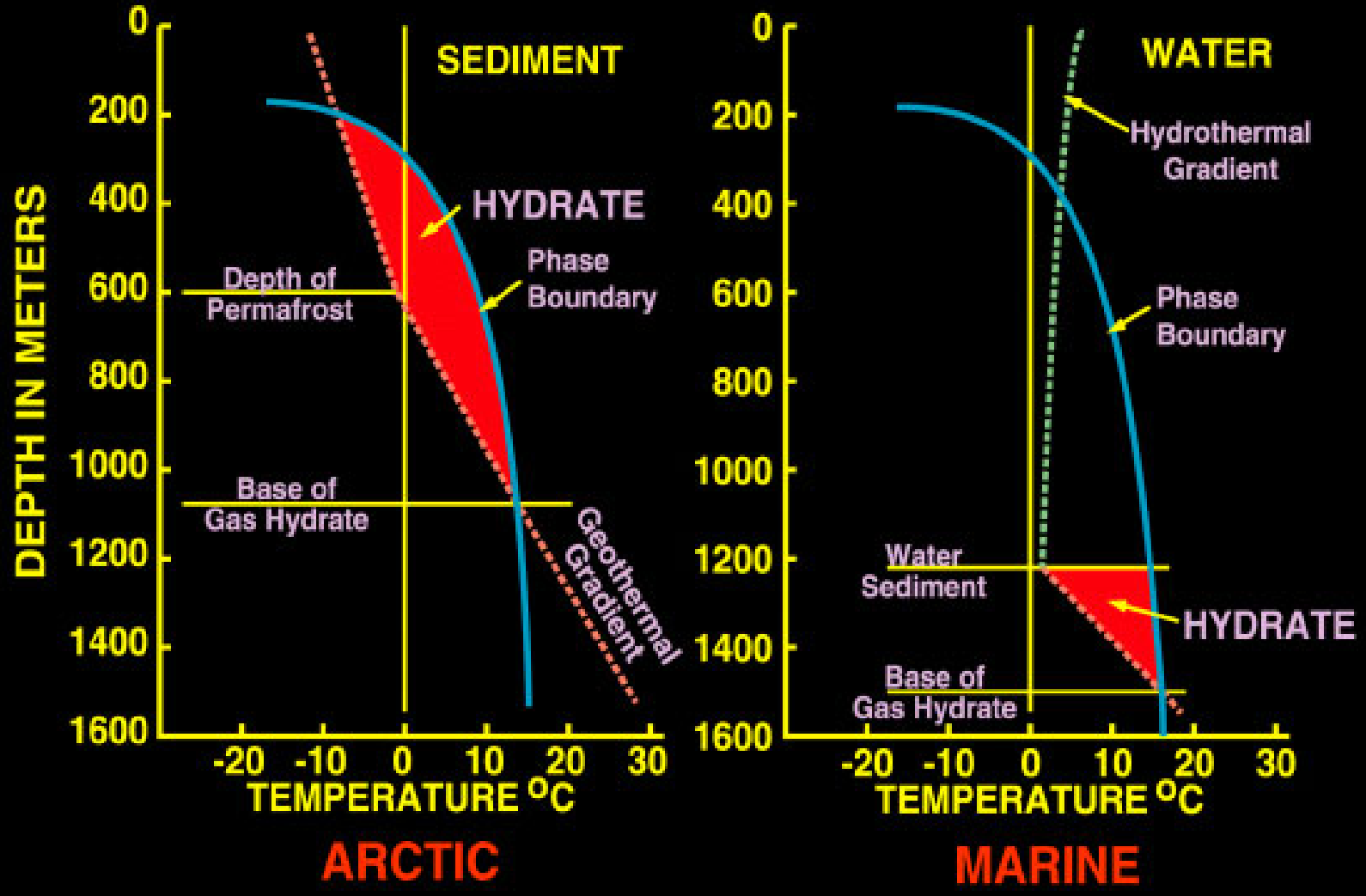
- **What is the ultimate resource potential of natural gas hydrates?**

  - Issues to be considered: WHERE-HOW-WHY, HOW MUCH, PRODUCTION METHODS, MOTIVATIONS

Gas hydrate energy resource flow chart

- Evolution from a nonproducible unconventional gas resource to a producible energy resource





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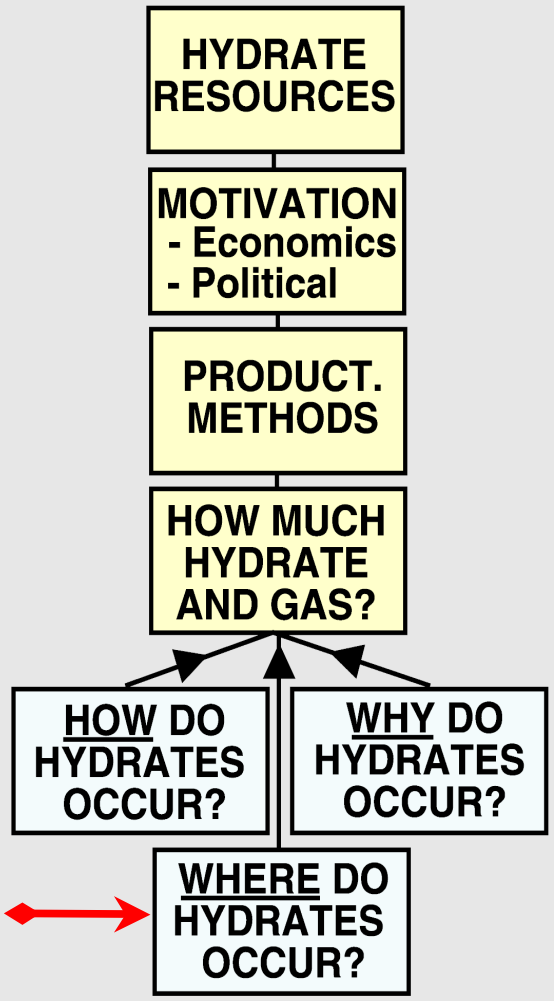
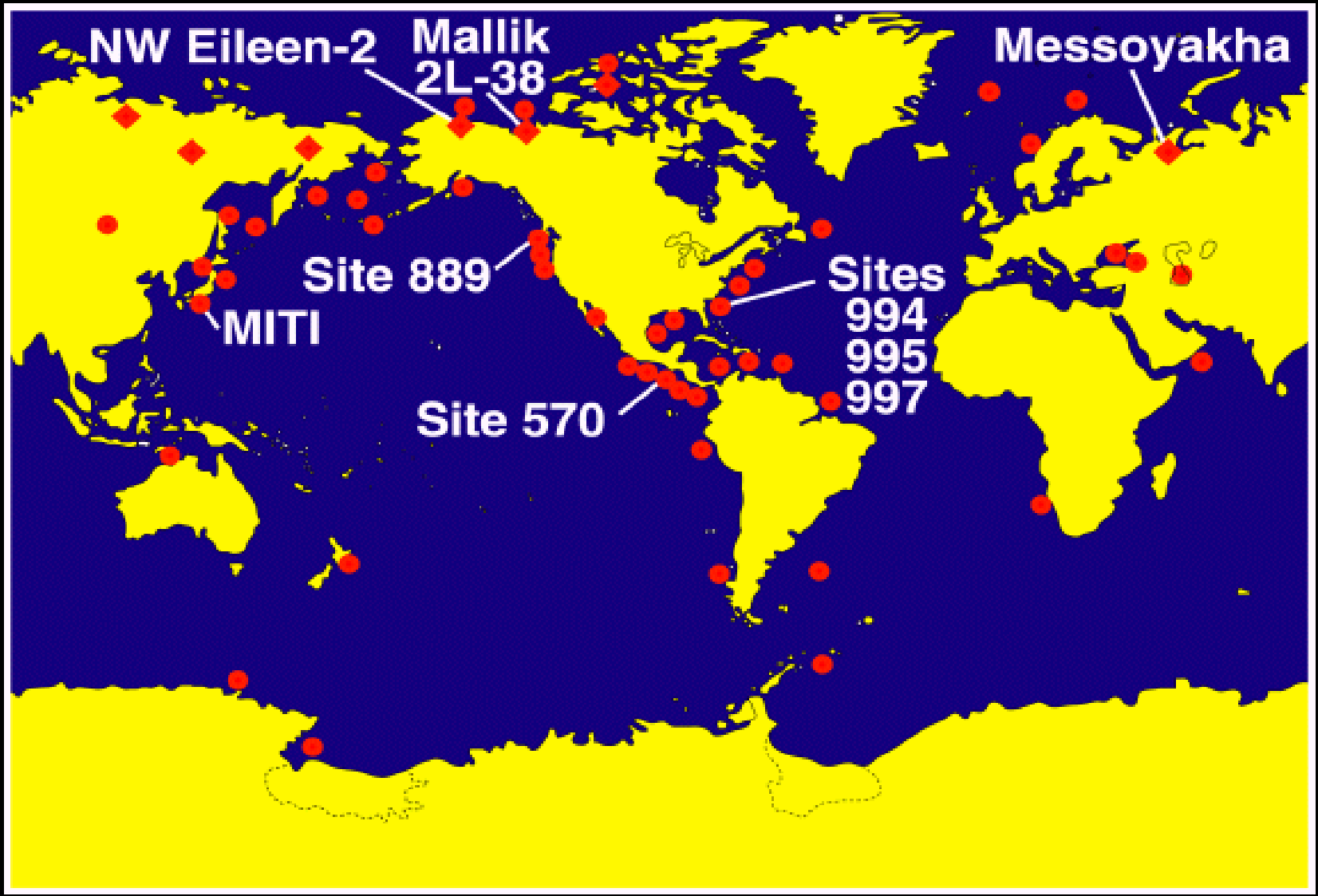
Geologic Controls on the Stability and Formation of Gas Hydrates

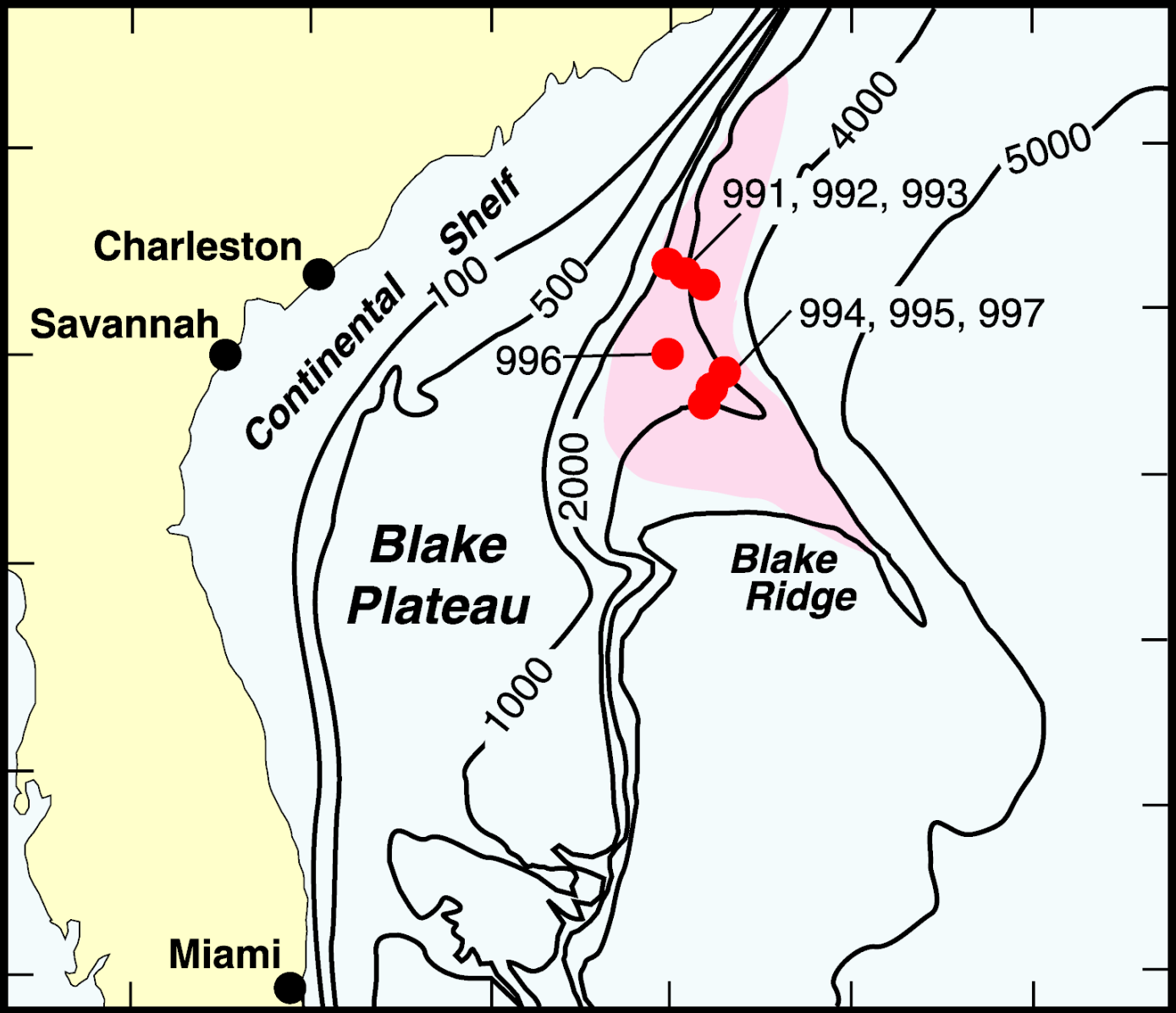
- Formation-Temperature
- Formation Pore-Pressure
- Pore-Water Salinity
- Gas Chemistry
- Availability of Gas and Water
- Gas and Water Migration Pathways
- Presence of Reservoir Rocks and Seals

Gas hydrate energy resource flow chart

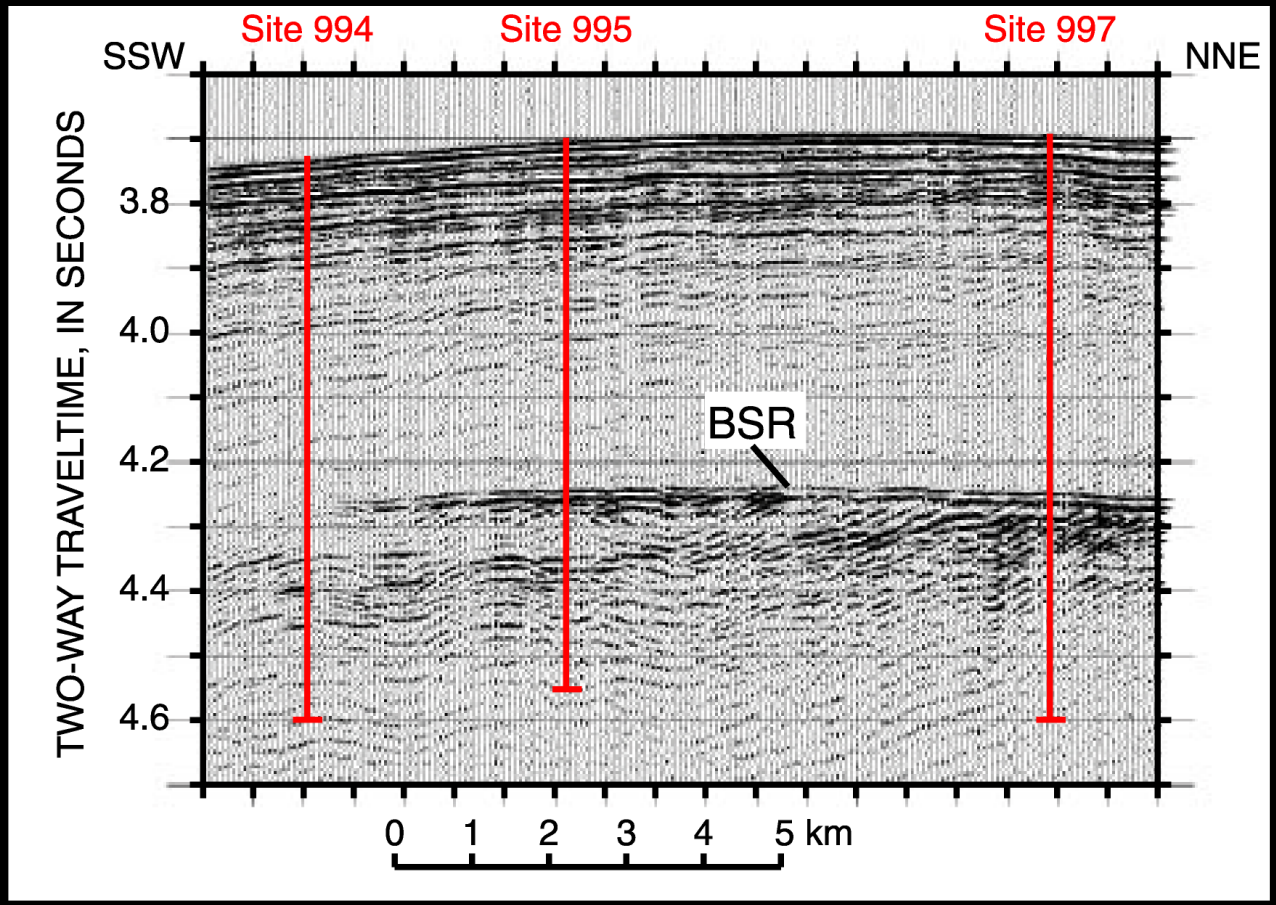
- Evolution from a nonproducible unconventional gas resource to a producible energy resource

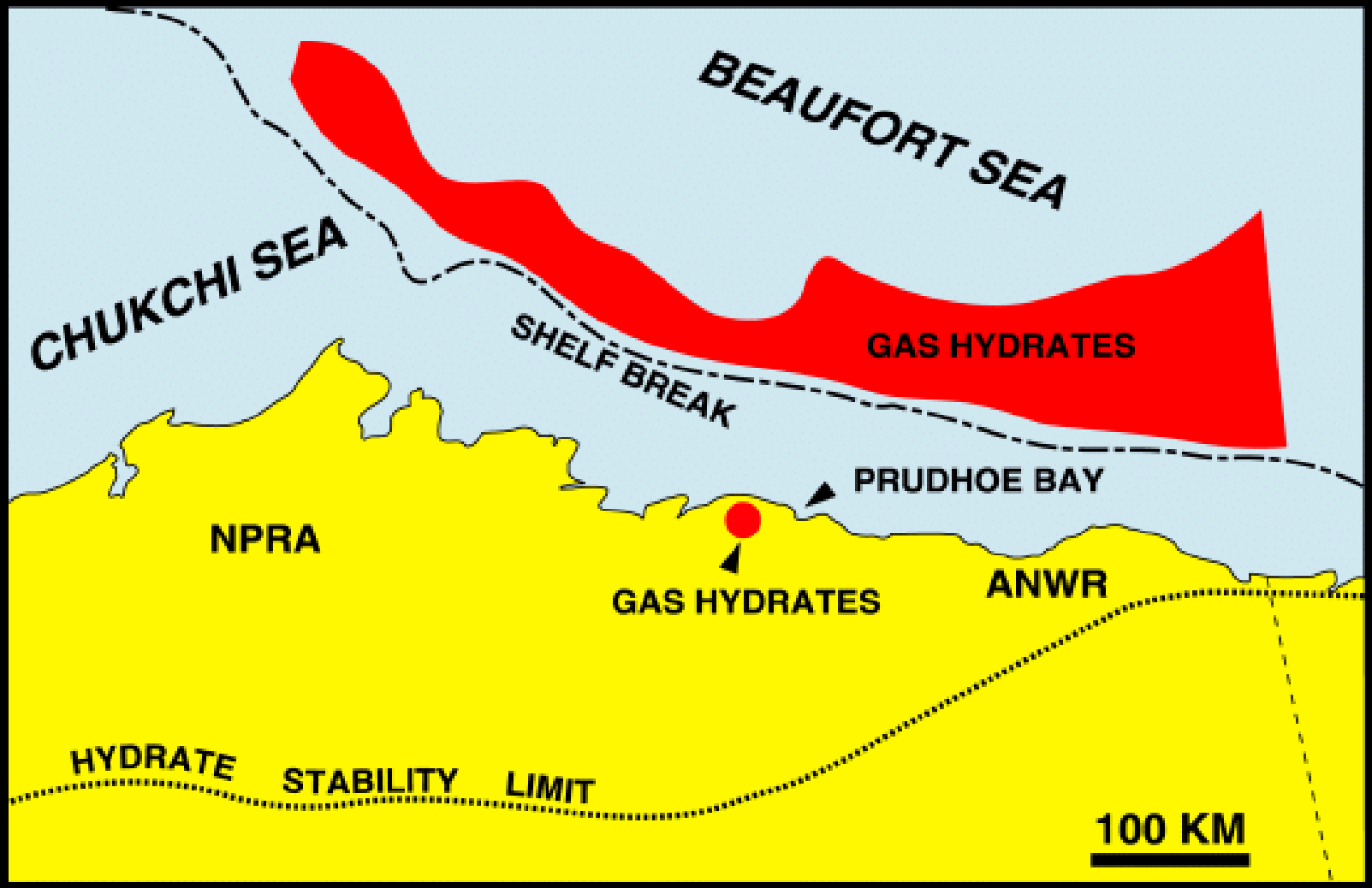


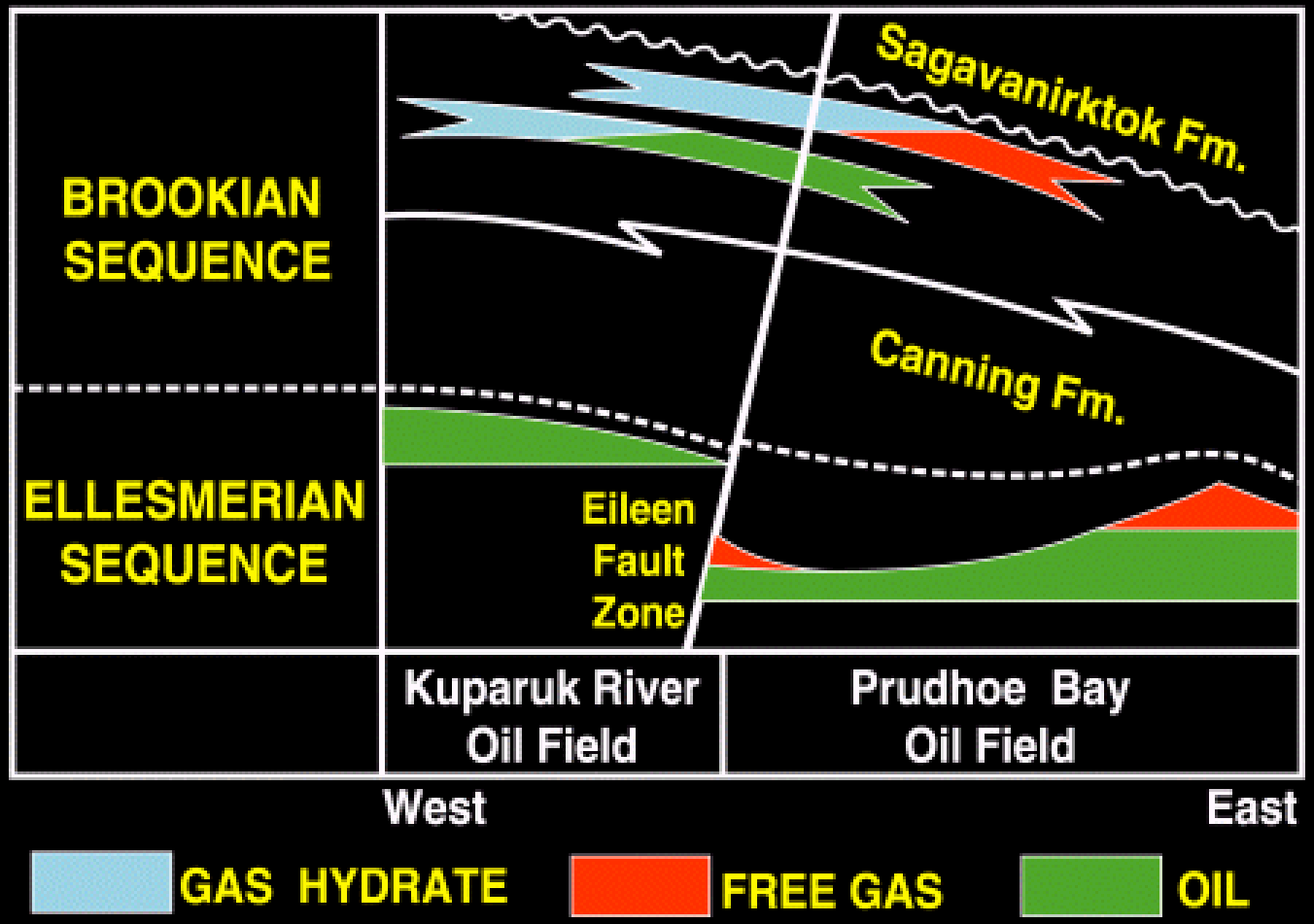

NW Eileen-2
Mallik
2L-38
Messoyakha
Site 889
MITI
Sites
994
995
997
Site 570


Charleston
Savannah
Miami
Continental Shelf
100
500
1000
2000
4000
5000
991, 992, 993
994, 995, 997
996
Blake Plateau
Blake Ridge

Blake Ridge Gas Hydrate Accumulation

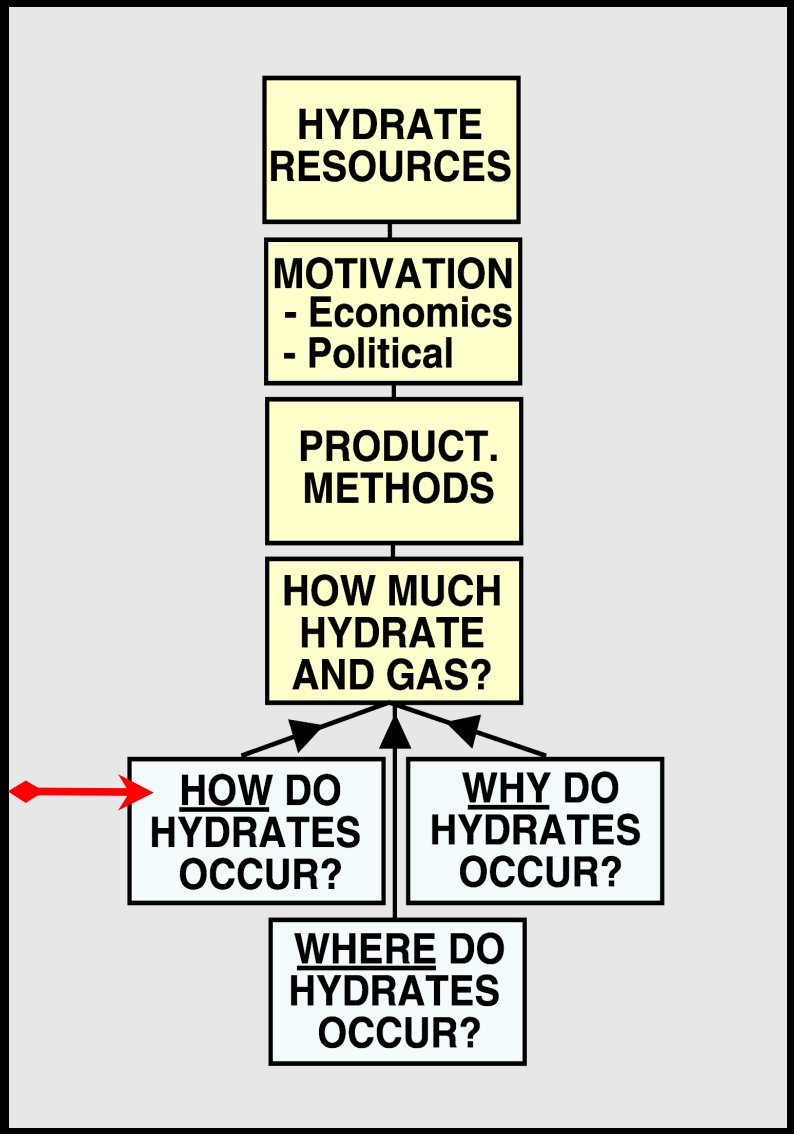



BEAUFORT SEA
CHUKCHI SEA
SHELF BREAK
GAS HYDRATES
PRUDHOE BAY
NPRA
GAS HYDRATES
ANWR
HYDRATE STABILITY LIMIT
100 KM

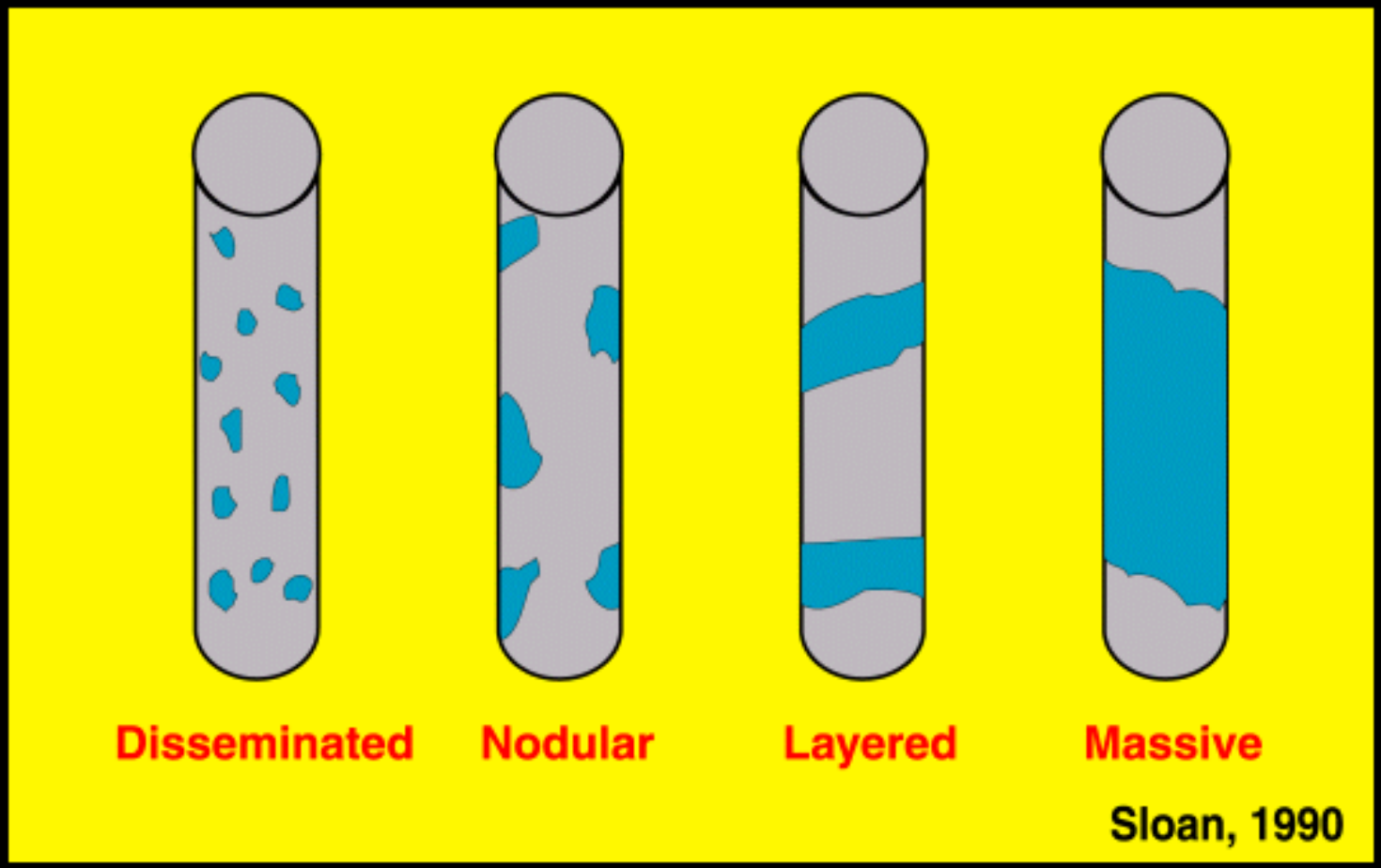

BROOKIAN SEQUENCE
ELLESMERIAN SEQUENCE
Sagavanirktok Fm.
Canning Fm.
Eileen Fault Zone
Kuparuk River Oil Field
Prudhoe Bay Oil Field
West
East
GAS HYDRATE
FREE GAS
OIL

Gas hydrate energy resource flow chart

- Evolution from a nonproducible unconventional gas resource to a producible energy resource



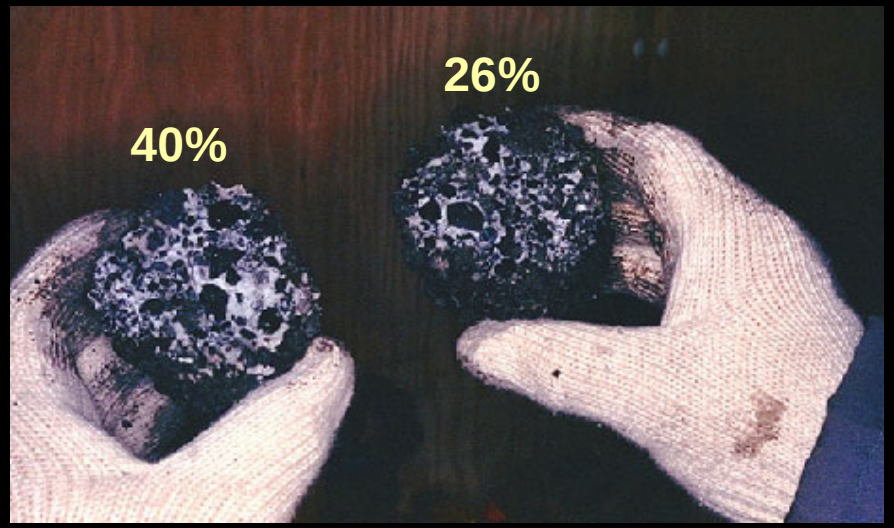
Gas Hydrate Occurrences



Field Observations of Gas Hydrates Granular Sands and Gravel - 897-952m

Gas hydrate forms

- pore space within granular sands
- intergranular fill forming matrix
- particle coatings
- nodules/clasts (<2cm)

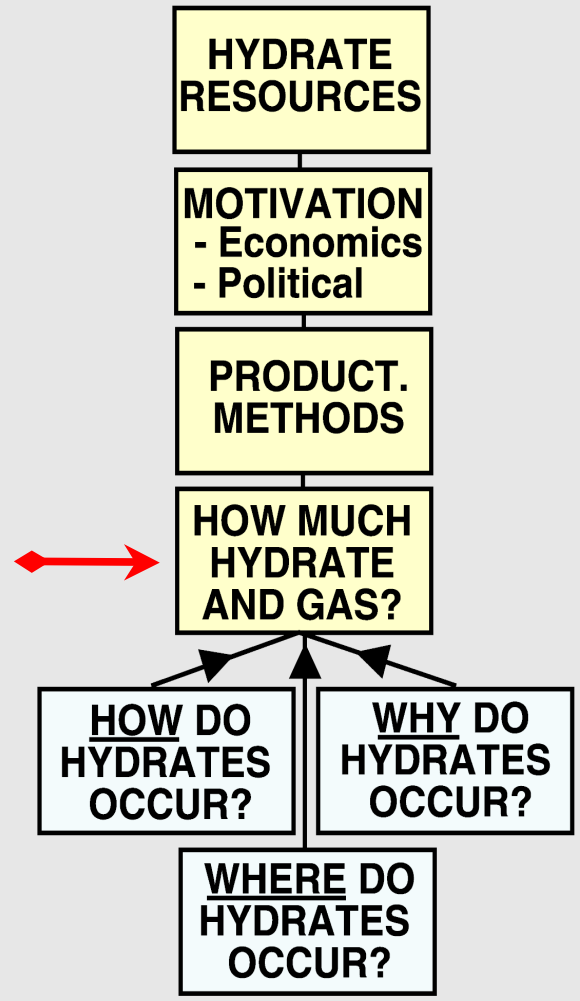


Field Observations of Gas Hydrates Sands - 897-952m

- pore space hydrate
- hydrate coating sand grains (<2mm)
- vein hydrate (<2mm)
- nodule/clast hydrate (<5mm)
- porosity 30-40%

Gas hydrate energy resource flow chart

- Evolution from a nonproducible unconventional gas resource to a producible energy resource



Gas hydrate "resource" assessments – world estimates

WORLD ESTIMATES OF THE AMOUNT OF GAS WITHIN HYDRATES

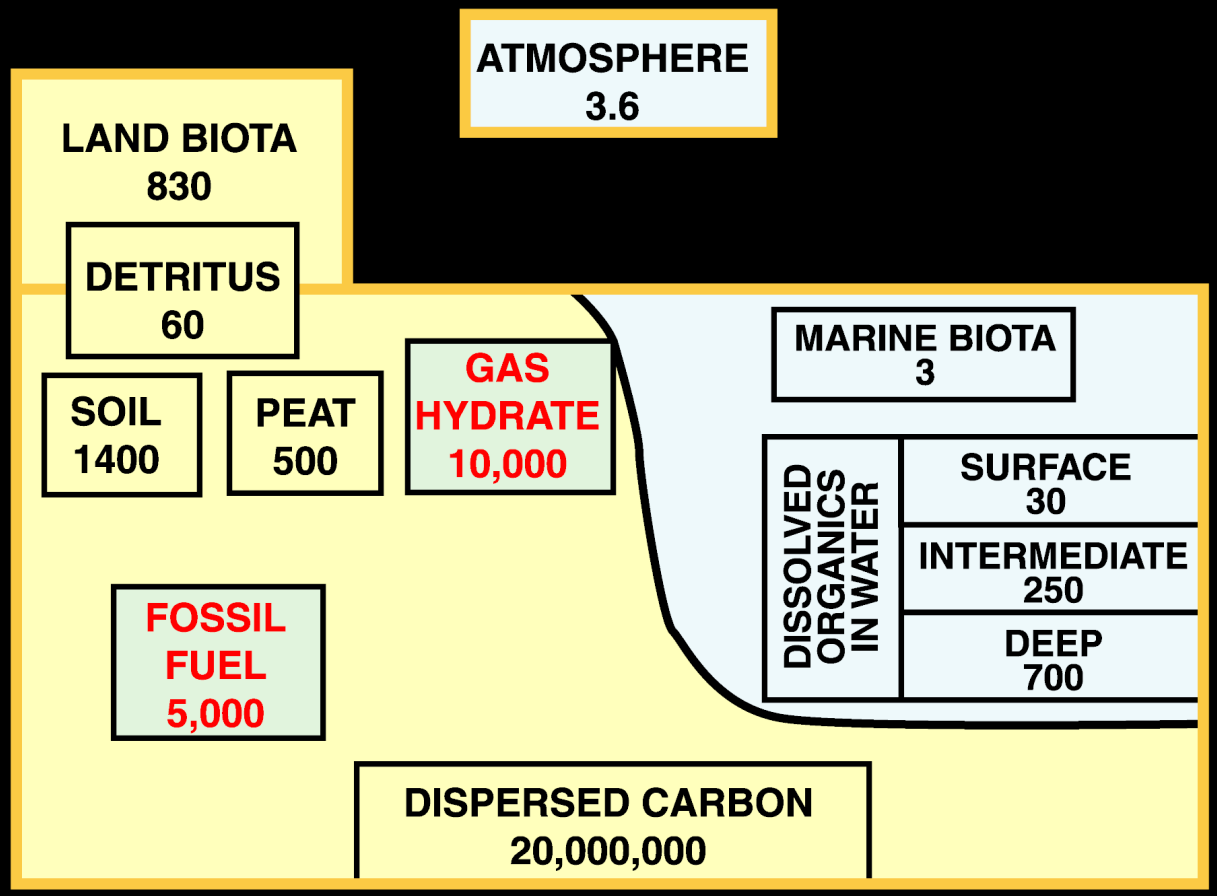
In-Place Natural Gas Resources Terrestrial Gas Hydrates

Cubic meters	Reference
1.4×10^{13}	Meyer 1981
3.1×10^{13}	McIver 1981
5.7×10^{13}	Trofimuk & others 1977
7.4×10^{14}	MacDonald 1990
3.4×10^{16}	Dobrynin & others 1981

In-Place Natural Gas Resources Oceanic Gas Hydrates

Cubic meters	Reference
3.1×10^{15}	Meyer 1981
$5 - 25 \times 10^{15}$	Trofimuk & others 1977
2×10^{16}	Kvenvolden 1988
2.1×10^{16}	MacDonald 1990
4×10^{16}	Kvenvolden & others 1988
7.6×10^{18}	Dobrynin & others 1981

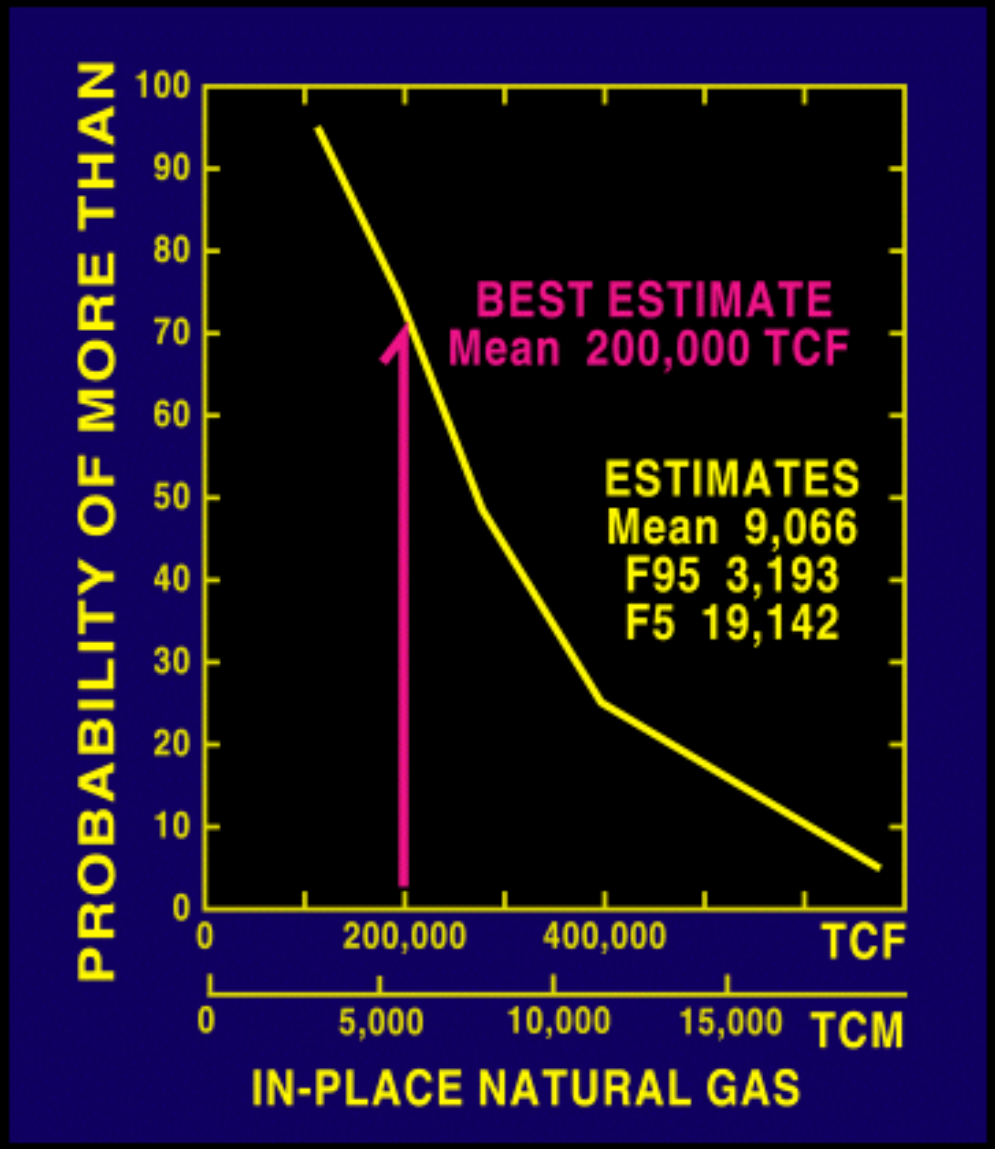
GLOBAL CARBON CYCLE
METHANE CARBON IN GIGATONS (10^{15} g)



Kvenvolden, 1988

USA Gas hydrate "resource" assessment

- Estimated volume of gas trapped within the marine and permafrost associated gas hydrate accumulations of the USA



Gas hydrate "resource" assessments – national & regional scale

NATIONAL/REGIONAL ESTIMATES OF THE AMOUNT OF GAS WITHIN HYDRATES

(cubic feet)

UNITED STATES		
	$317{,}700 \times 10^{12}$	Collett 1995
INDIA		
	$4{,}307 \times 10^{12}$	ONGC 1997
BLAKE RIDGE, USA		
	635×10^{12}	Dillon & others 1993
	$2{,}471 \times 10^{12}$	Dickens & others 1997*
	$2{,}824 \times 10^{12}$	Holbrook & others 1996*
	$2{,}012 \times 10^{12}$	Collett 2000*
	$1{,}331 \times 10^{12}$	Collett 2000
NANKAI TROUGH, JAPAN		
	$1{,}765 \times 10^{12}$	MITI/JNOC 1998
ANDAMAN SEA, INDIA		
	$4{,}307 \times 10^{12}$	ONGC 1997
NORTH SLOPE, ALASKA		
	590×10^{12}	Collett 1997

* Includes associated free-gas

Gas hydrate "resource" assessments – accumulation scale

ESTIMATES OF THE AMOUNT OF GAS WITHIN KNOWN HYDRATE ACCUMULATIONS

(cubic feet)

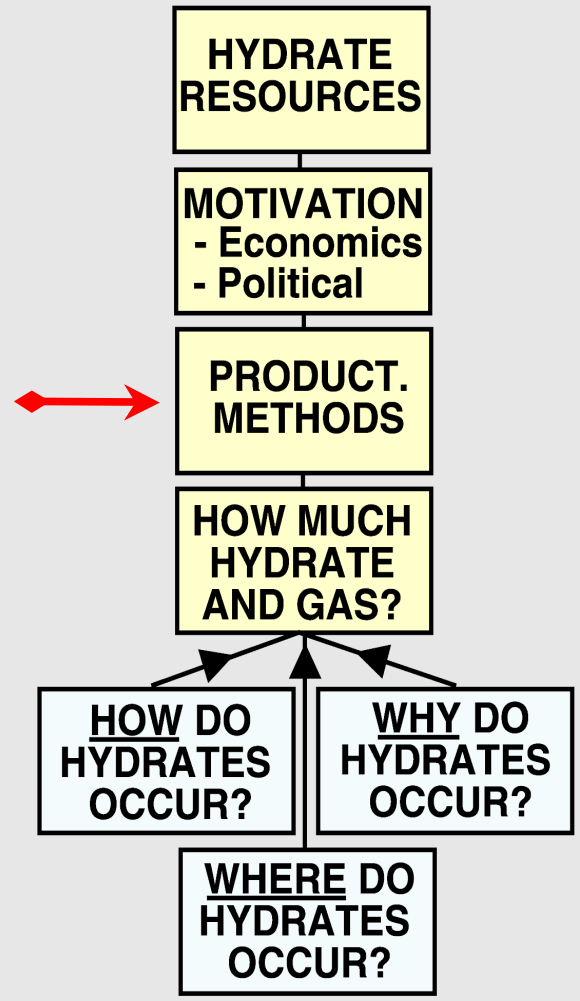
Prudhoe Bay, Alaska
42×10^{12} Collett 1993

Cirque-Tarn, Alaska
60×10^{12} Collett 1999

Mackenzie Delta, Canada
6.6×10^{12} Collett 1999

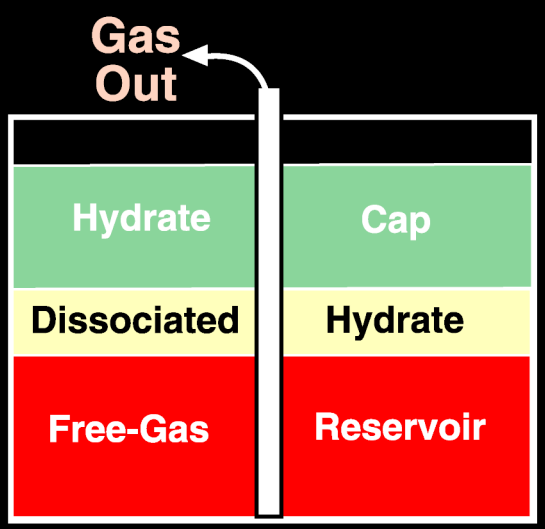
Gas hydrate energy resource flow chart

- Evolution from a nonproducible unconventional gas resource to a producible energy resource

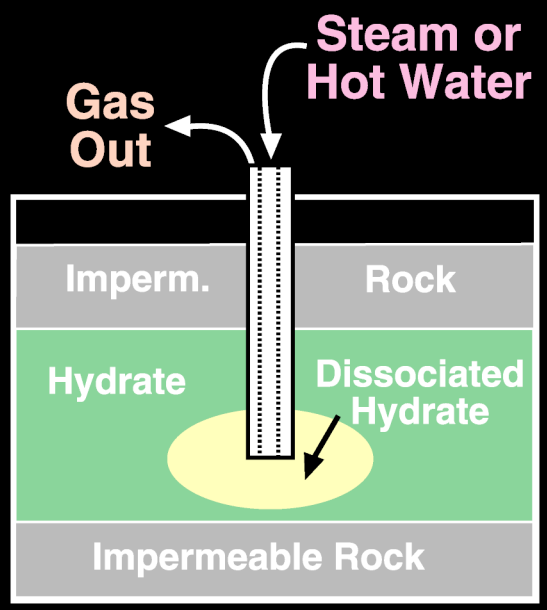


Gas Hydrate Production Methods

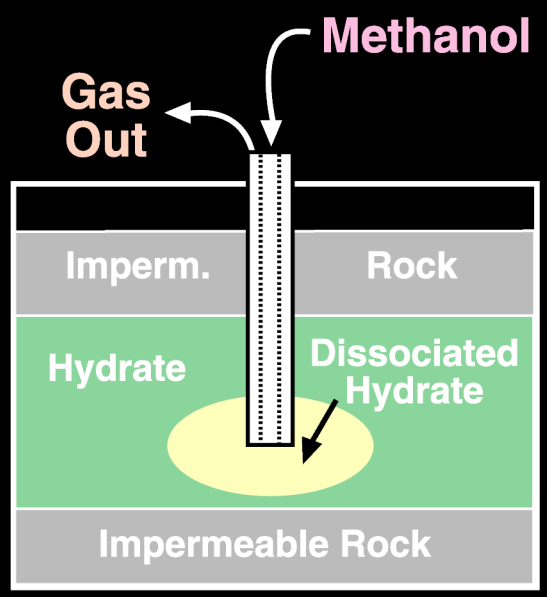
Depressurization



Thermal Injection



Inhibitor Injection



Gas hydrate energy resource flow chart

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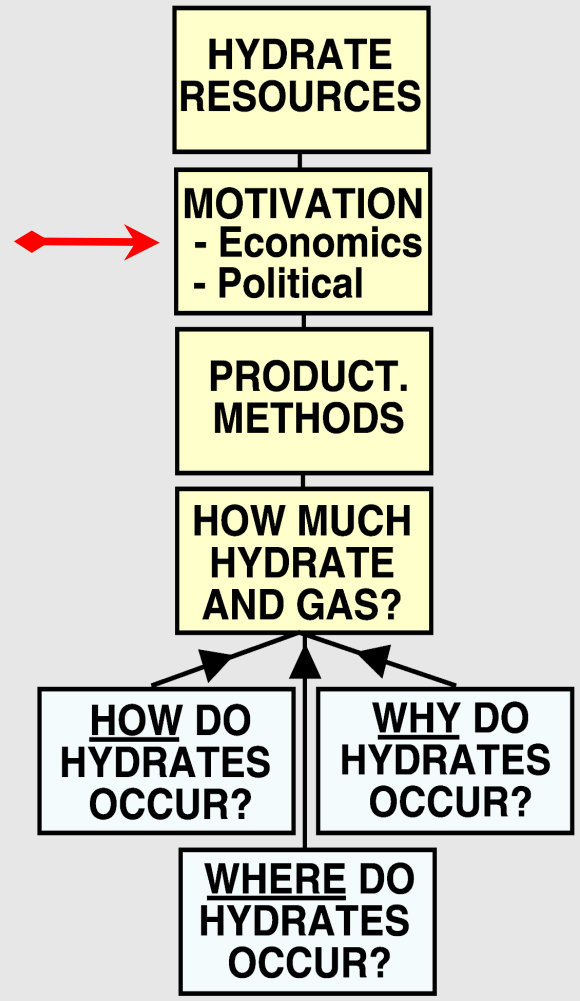

ECONOMIC STUDY OF HYDRATE PRODUCTION*

	Thermal injection	Depres-surization	Conventional gas
Investment (M US$)	5,084	3,320	3,150
Annual cost (M US$)	3,200	2,510	2,000
Total production (MMcf/year)**	900	1,100	1,100
Production cost (US$/Mcf)	3.60	2.28	1.82
Break-even wellhead price (US$/Mcf)	4.50	2.85	2.25

* Assumed reservoir properties: h=25ft, φ=40%, k=600md
** Assumed process: injection of 30,000 b/d of water at 300 F

ECONOMICS OF NATURAL GAS

	(US$/Mcf)
U.S. Future Price	1.90 - 3.00
Japan (LNG)	3.50 - 4.50
Japan (industry)	15.00
Japan (residential)	35.00

POLITICAL MOTIVATIONS LEADING TO GAS HYDRATE PRODUCTION

- Government Regulatory and Taxation Policy: Carbon dioxide emissions - tax, Unconventional energy tax credits

- National Security: Concerns over the reliance on imported energy, Trade balance

Gas hydrate energy resource flow chart

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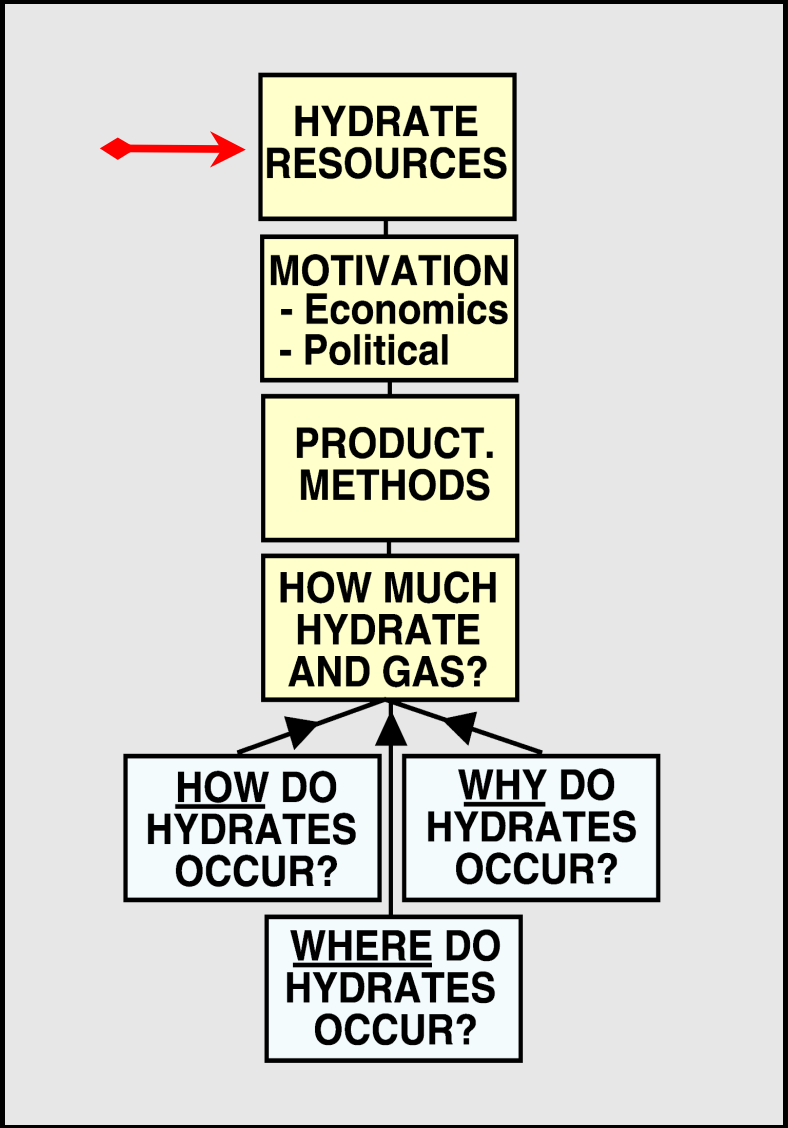

Question

- **What is the ultimate resource potential of natural gas hydrates?**

- We will not likely see "significant" worldwide production from gas hydrates for the next 30 years.

- HOWEVER..In certain parts of the world, with unique motivations, gas hydrates will become a sustainable source of natural gas much sooner – possibly within 5 years.