

Title, Date and Place of Meeting

GAS HYDRATES OF NORTHERN ALASKA

-USGS Project Review-



Briefing Outline

1. What and Why Gas Hydrates?
2. Hydrate Resources Flow Chart - **ALASKA**
 - **WHERE-HOW-WHY** Hydrates Occur in Nature?
 - **HOW MUCH** Hydrates and Gas?
 - **Production Methods**
 - **Motivations - Economics and Political**
 - **Gas Hydrate Resources**
3. Ongoing Research Activities
 - **USGS-USDOE Project**
 - **USDOE-Industry-et al Projects**
 - **BLM-USGS-DGGS Project**



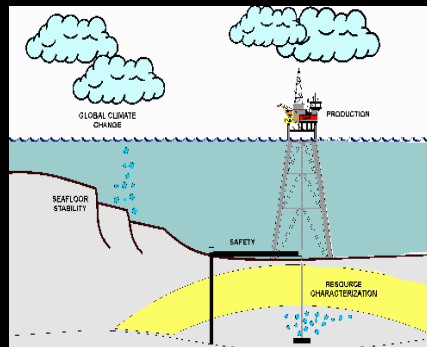
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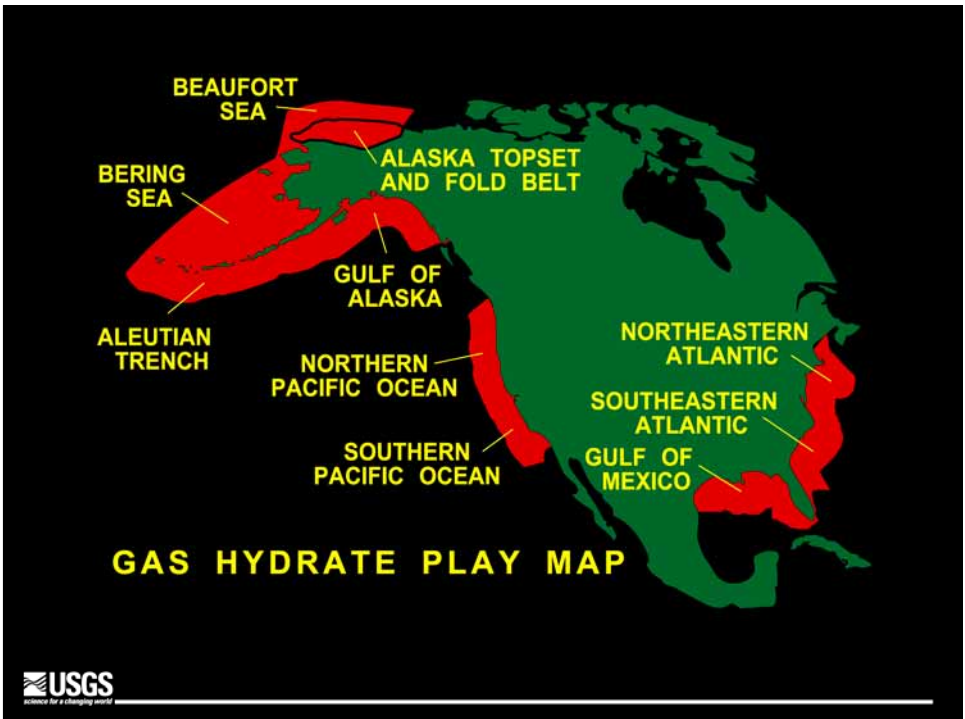
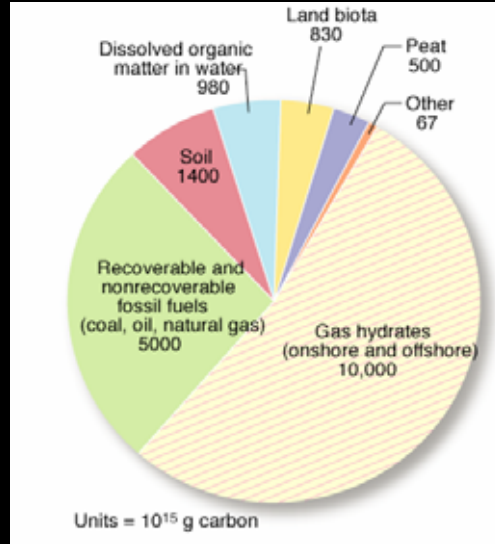


Interest in Gas Hydrates

- Energy Resource
- Operational Hazard
 - Slope stability and platforms
 - Drilling
- Global Warming
 - Methane 20 times more effective greenhouse gas than CO₂

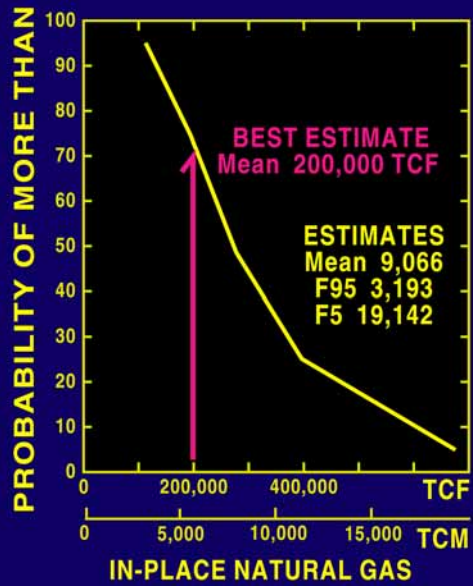


Volume of Organic Carbon



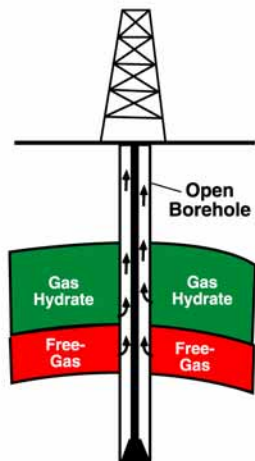
USA Gas hydrate "resource" assessment

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

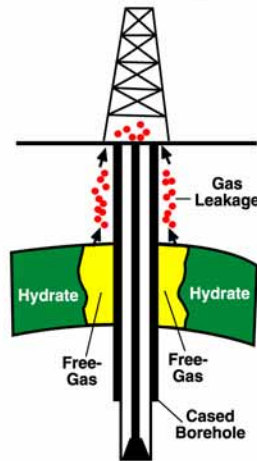


Gas Hydrate Drilling and Production Problems

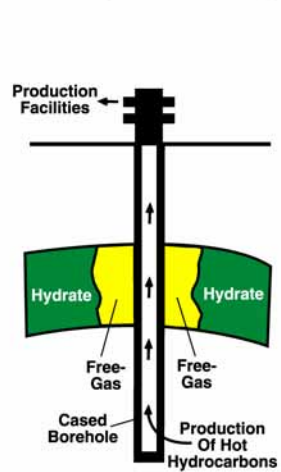
Gas Release



Gas Leakage

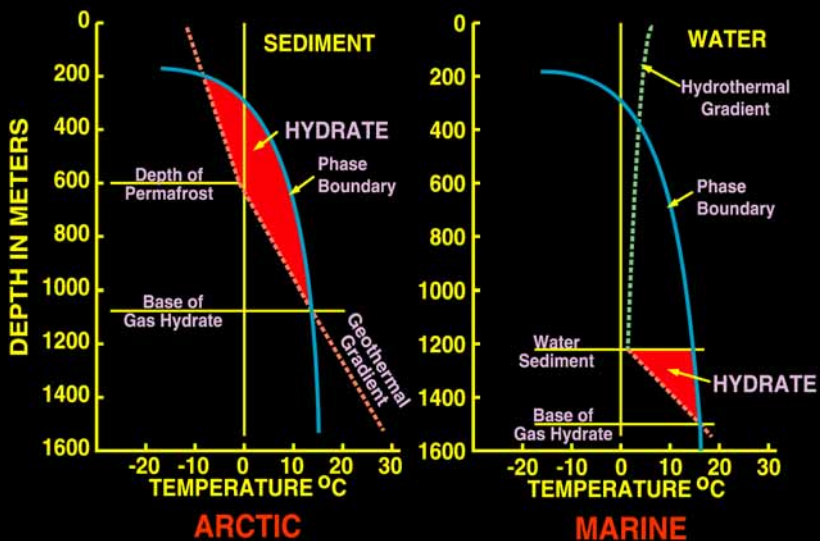


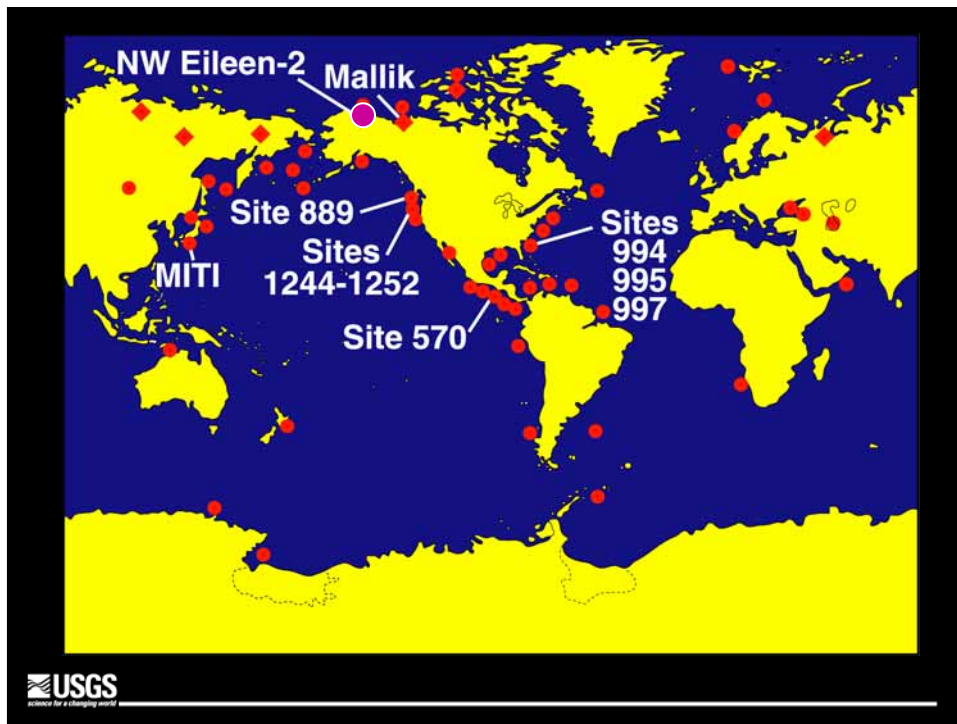
Collapsed Casing



What is a Gas Hydrate?

- Crystalline solid consisting of gas molecules, usually methane, each surrounded by a cage of water molecules
 - One volume hydrate typically equivalent to 160 volumes methane gas
 - Occur in Arctic regions and in marine sediments



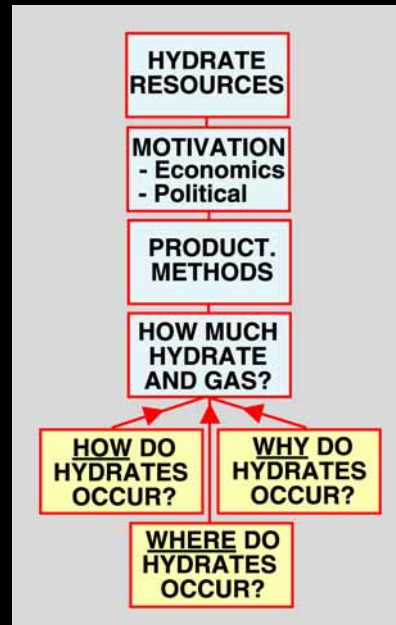


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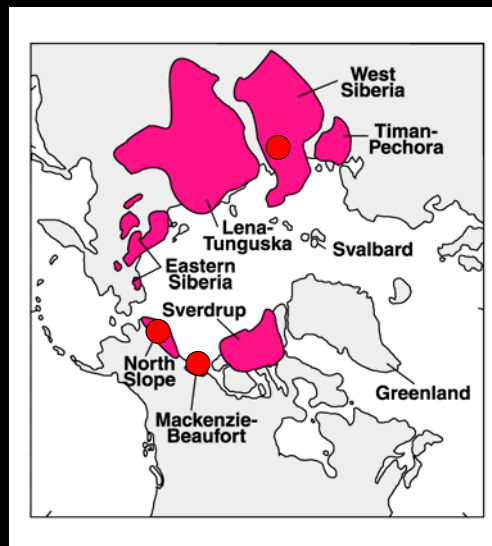
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Gas hydrate energy resource flow chart

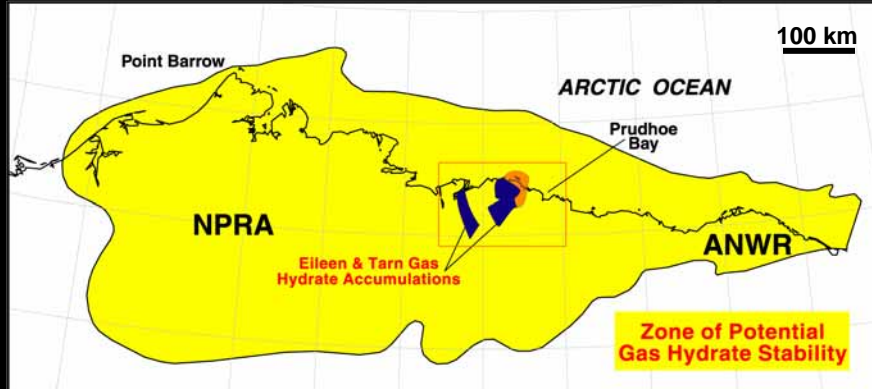
- Evolution from a nonproducing unconventional gas resource to a producible energy resource



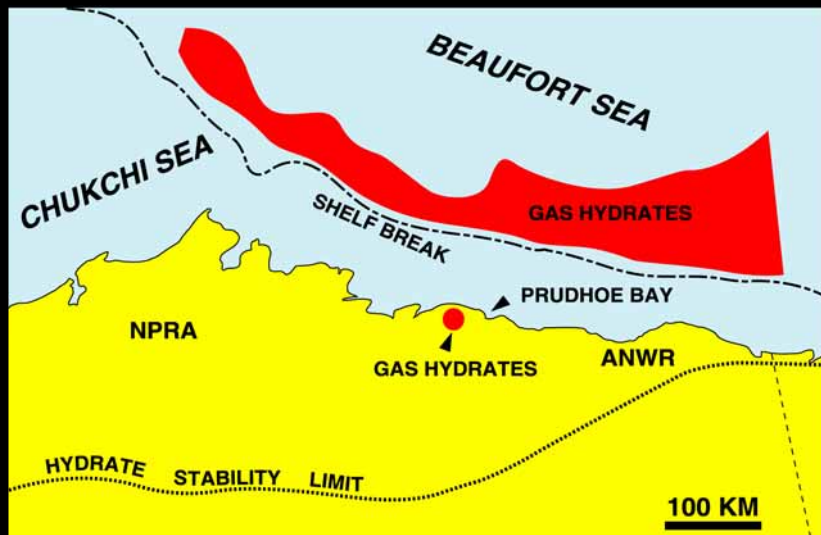
Arctic Basins - Area of known or inferred gas hydrates



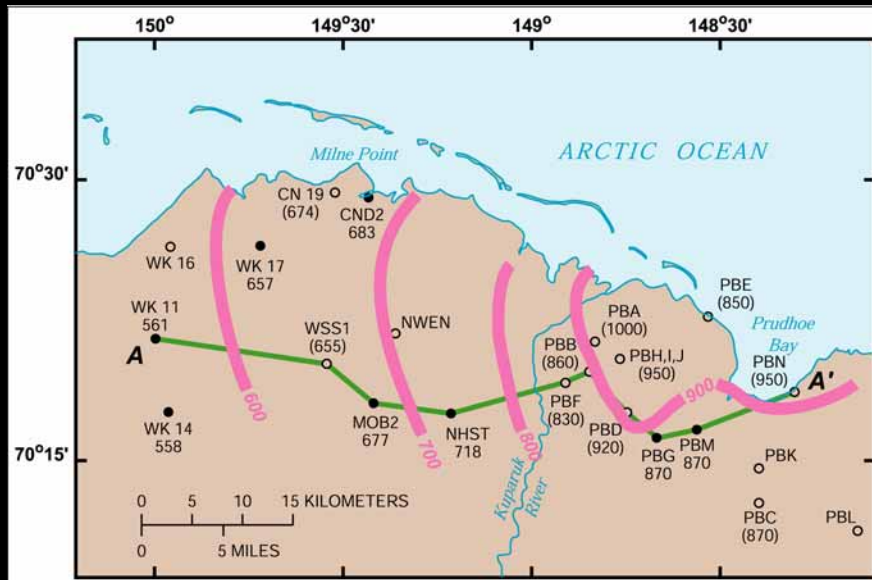
Alaska NS Gas Hydrates



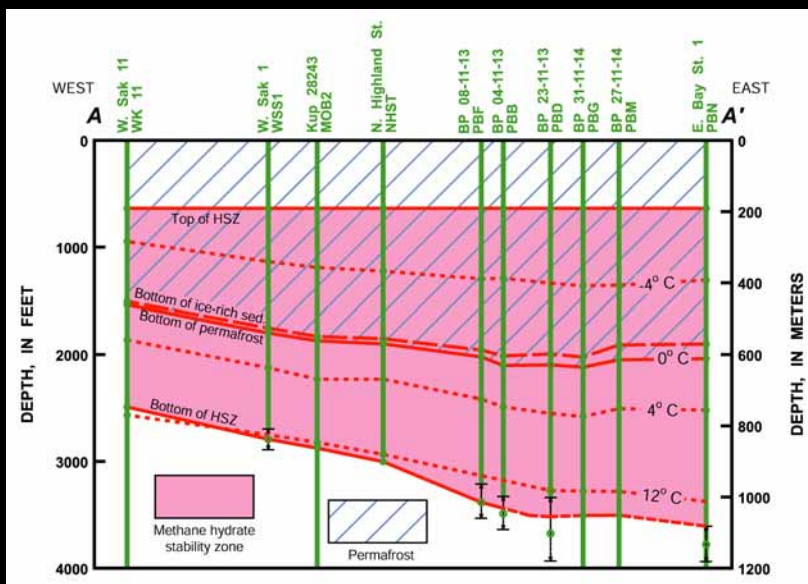
Alaska NS Gas Hydrates



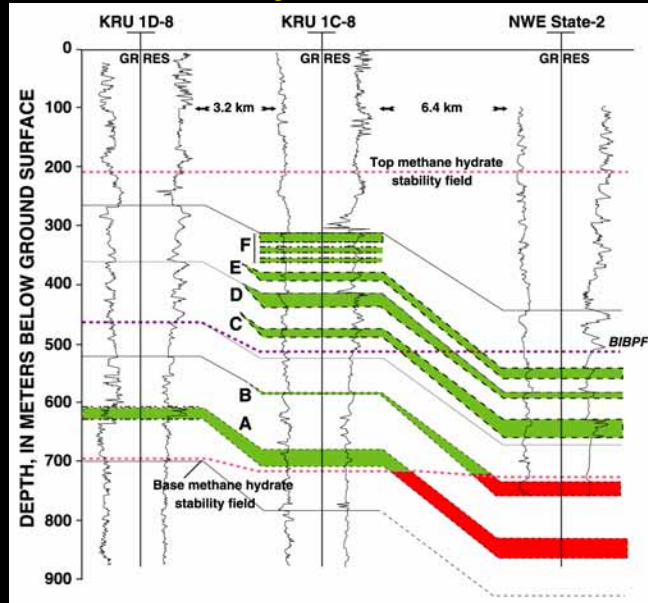
Prudhoe-Kuparuk Permafrost Conditions



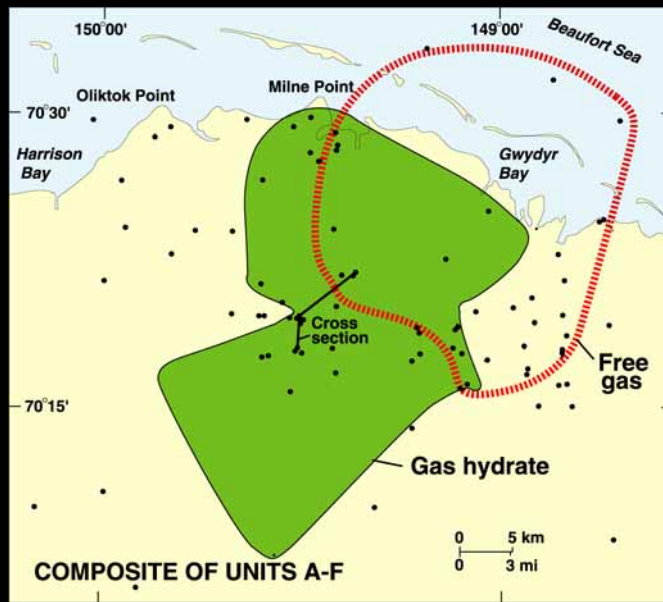
Prudhoe-Kuparuk Methane Hydrate Stability



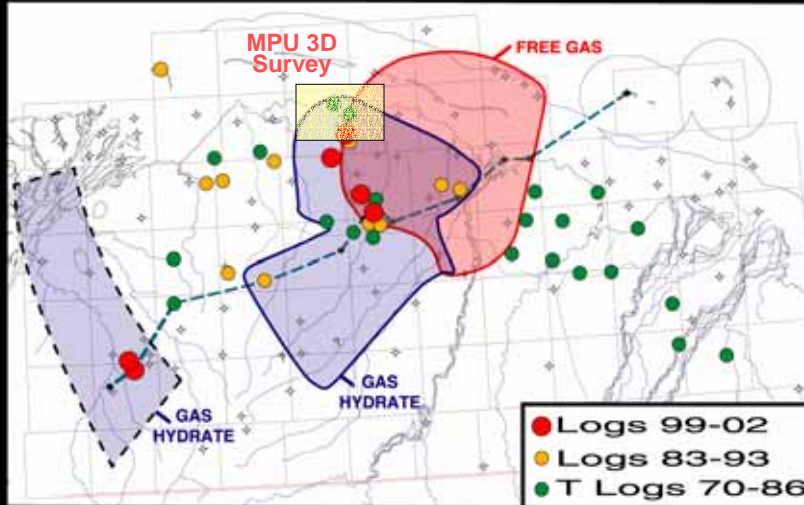
Eileen Gas Hydrate Accumulation



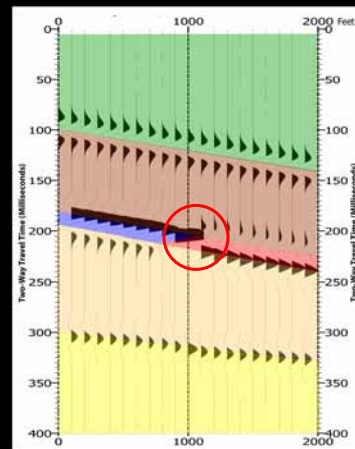
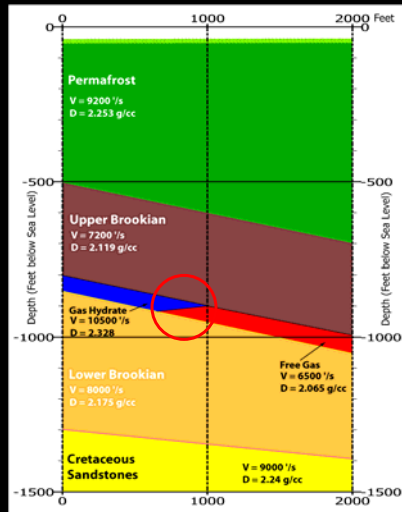
Eileen Gas Hydrate Accumulation



Wells of Opportunity & Seismic Studies

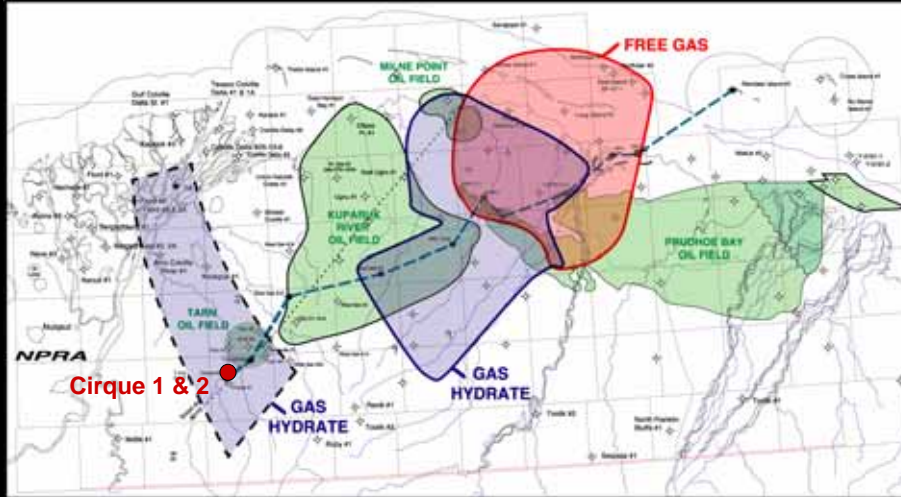


Simple 2-D Gas Hydrate to Free Gas Transition Model



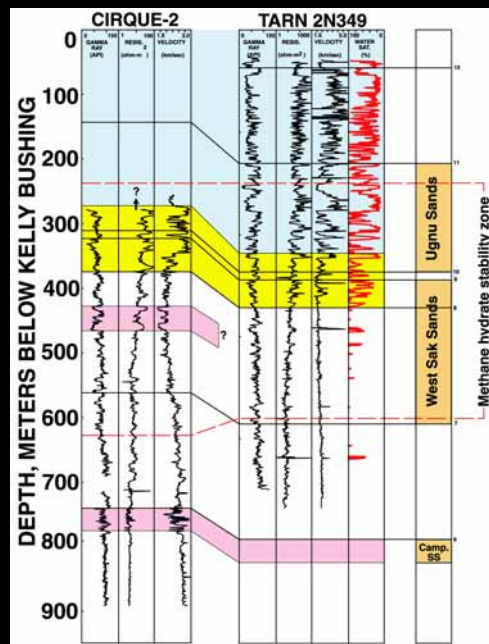
Taylor, Collett, Lee, 2003

Tarn Gas Hydrate Accumulation



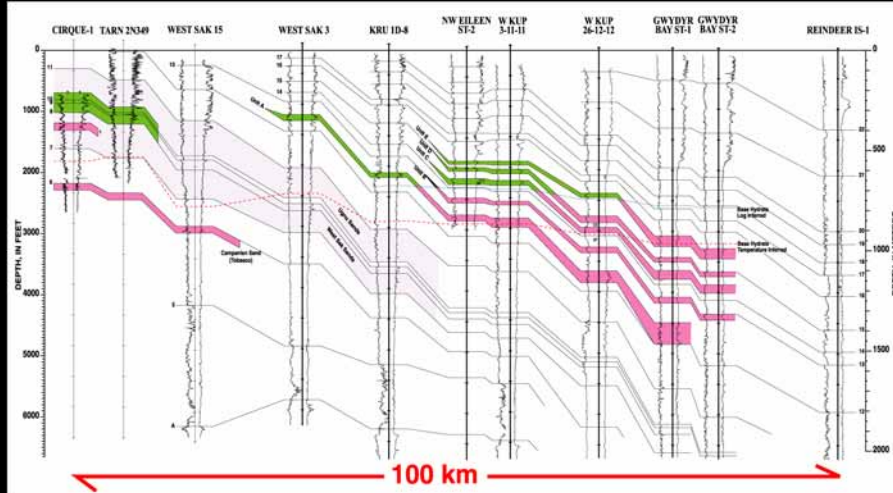
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Cirque-Tarn Well Display



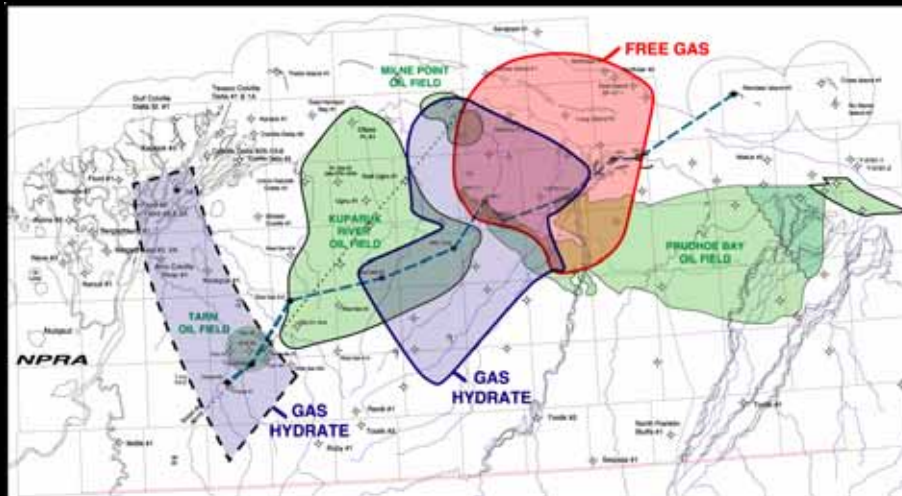
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Eileen and Tarn Gas Hydrate Accumulations



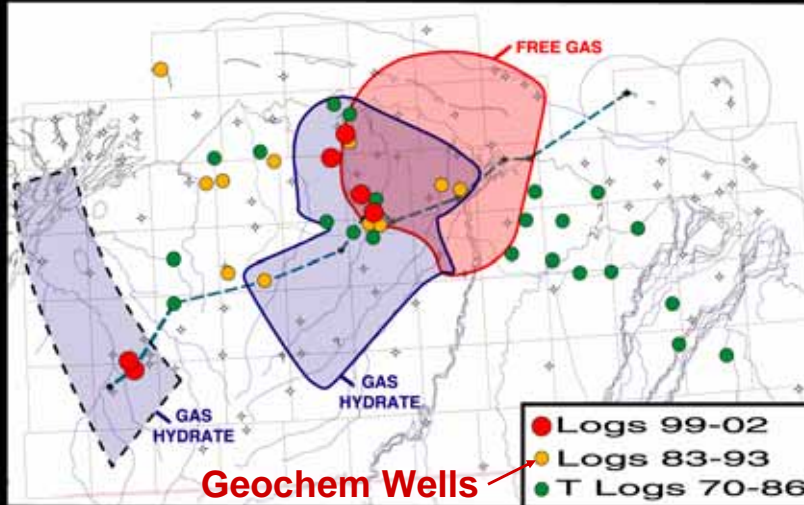
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Eileen and Tarn Gas Hydrate Accumulations



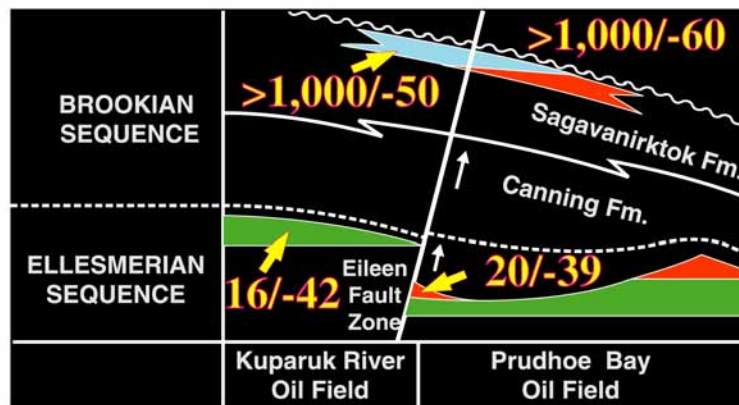
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Wells of Opportunity – Geochemical Sampling



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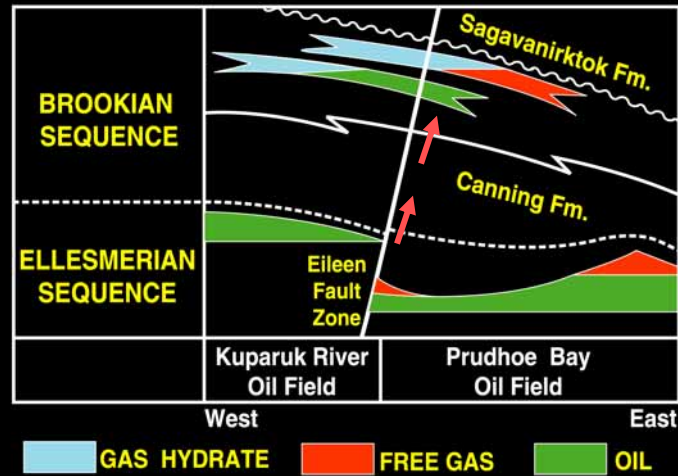
$$\left[\frac{\text{CH}_4}{\text{C}_2\text{H}_6 + \text{C}_3\text{H}_8} \right] / [\delta^{13}\text{C}-\text{CH}_4]$$



■ GAS HYDRATE ■ OIL
■ FREE GAS ← MIGRATION PATH

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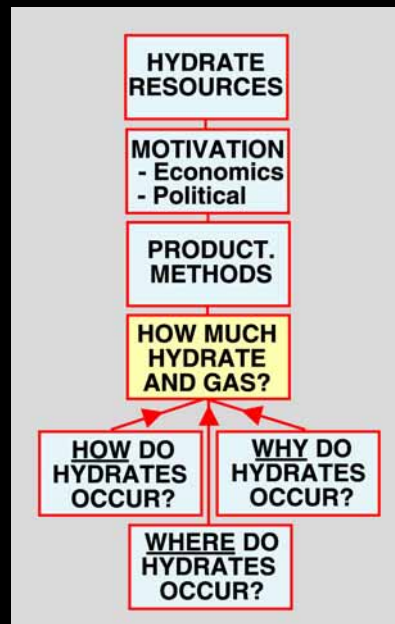
Eileen and Tarn Gas Hydrate Petroleum System



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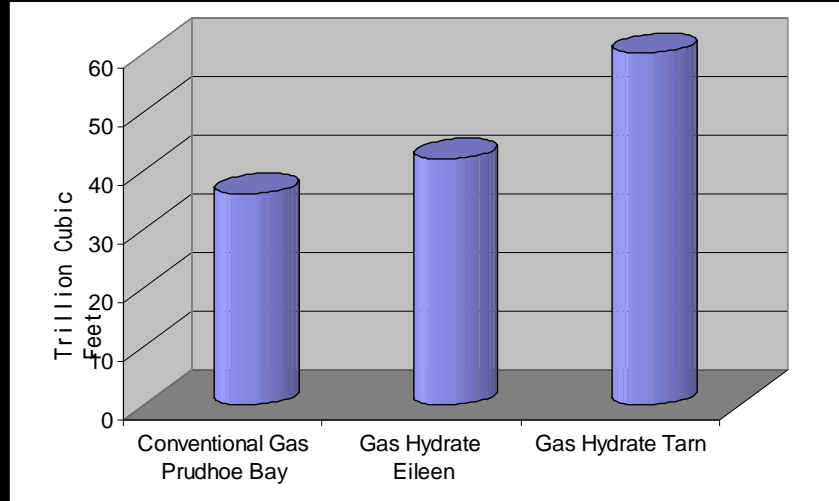
Gas hydrate energy resource flow chart

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

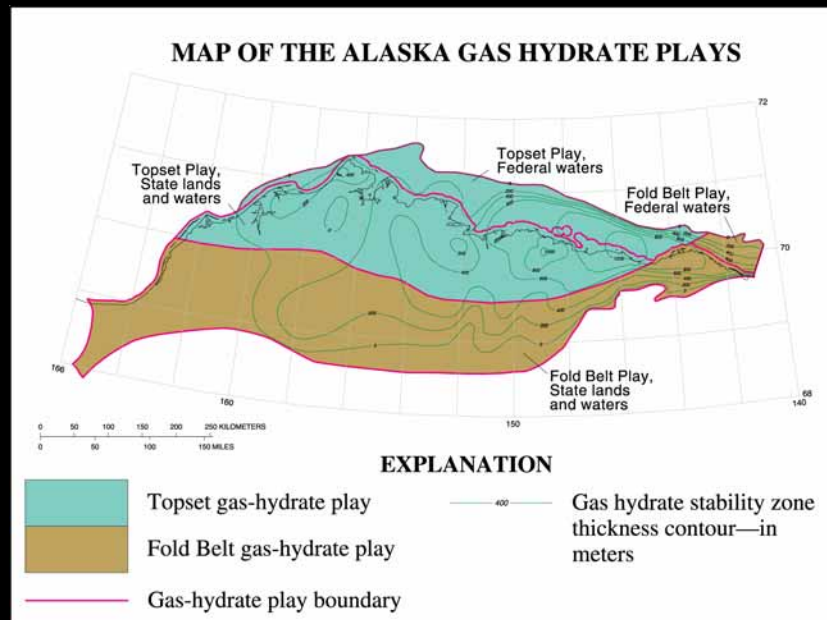


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Alaska Gas Hydrate "Resource" Assessments

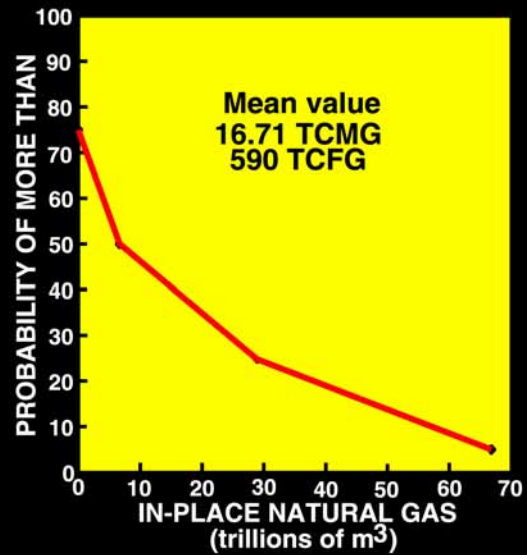


MAP OF THE ALASKA GAS HYDRATE PLAYS



Alaska Gas hydrate resource assessment

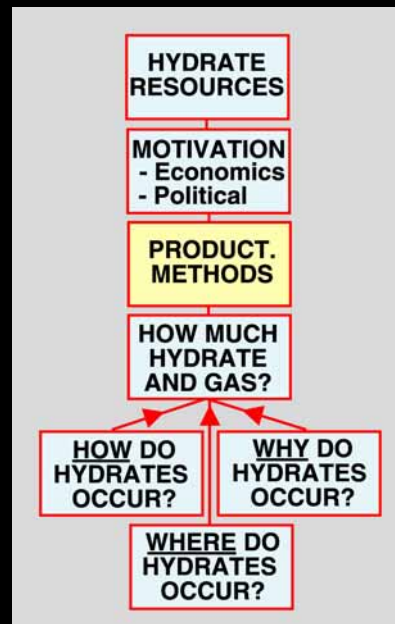
- Estimated volume of gas trapped within permafrost associated gas hydrate accumulations in northern Alaska



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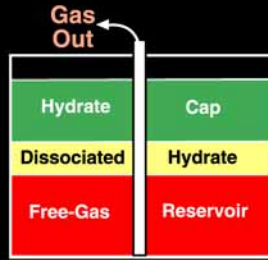
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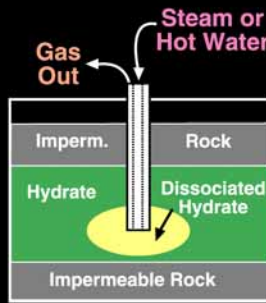
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Gas Hydrate Production Methods

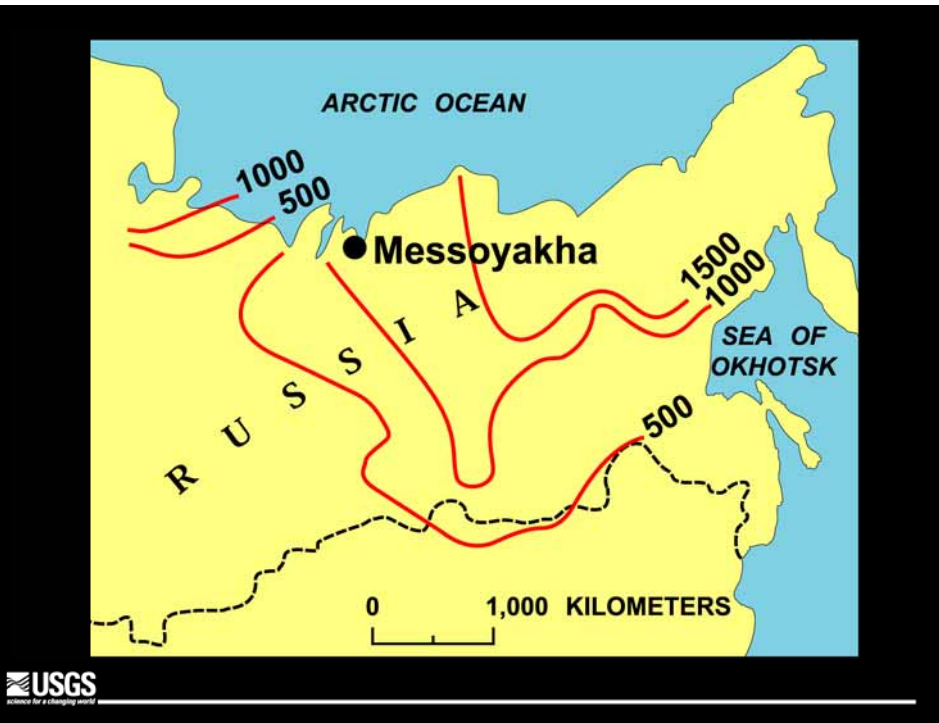
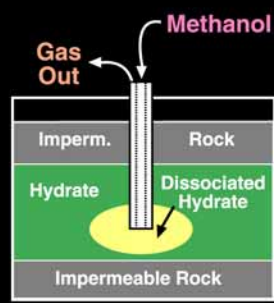
Depressurization

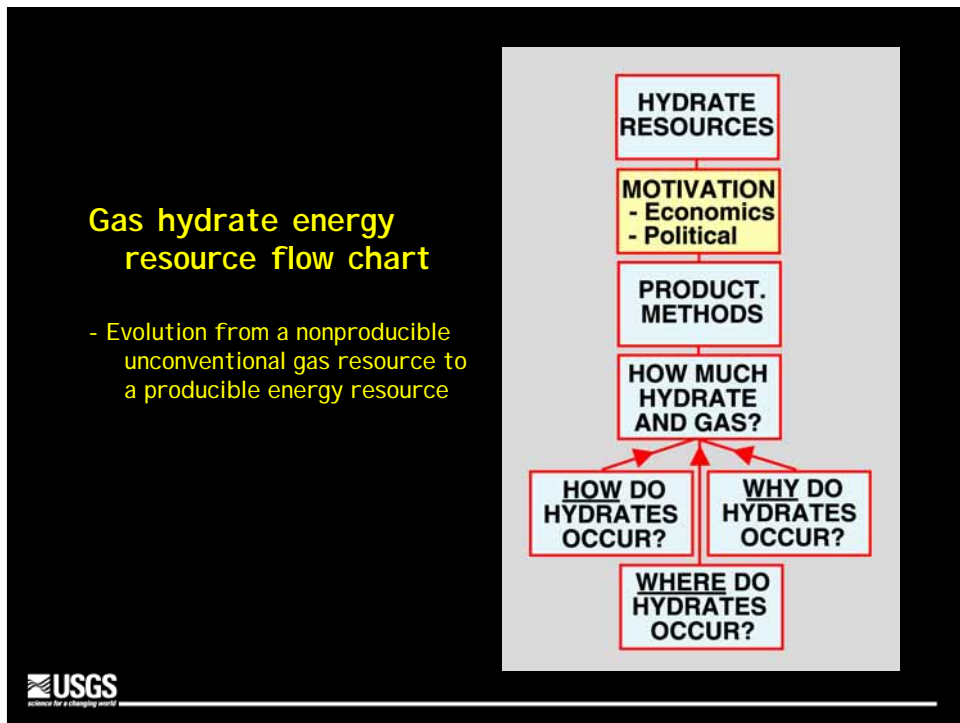
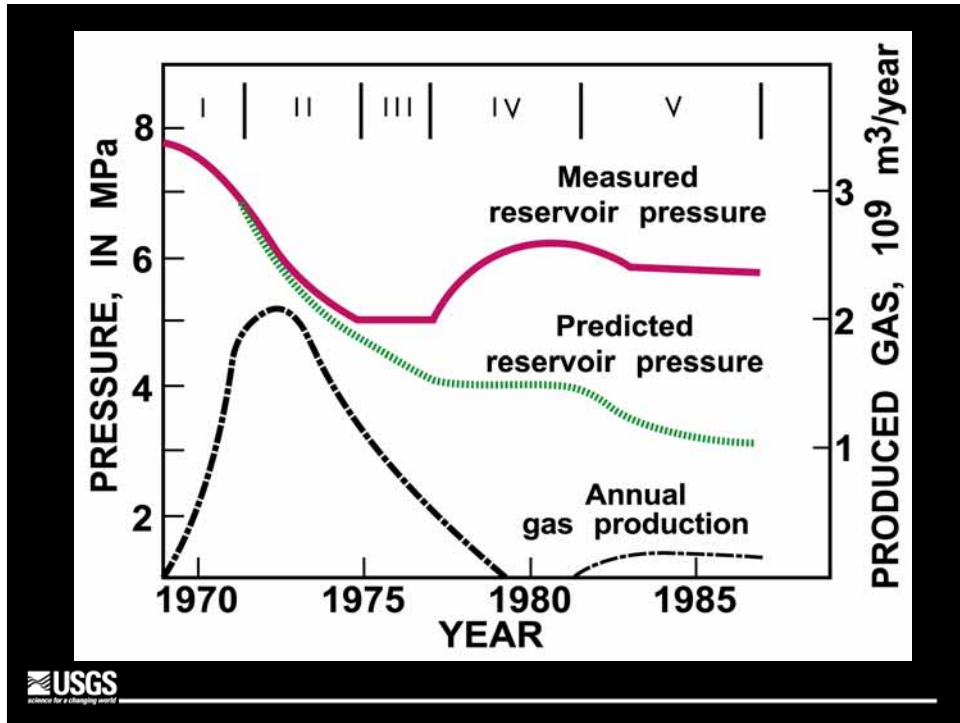


Thermal Injection



Inhibitor Injection





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**

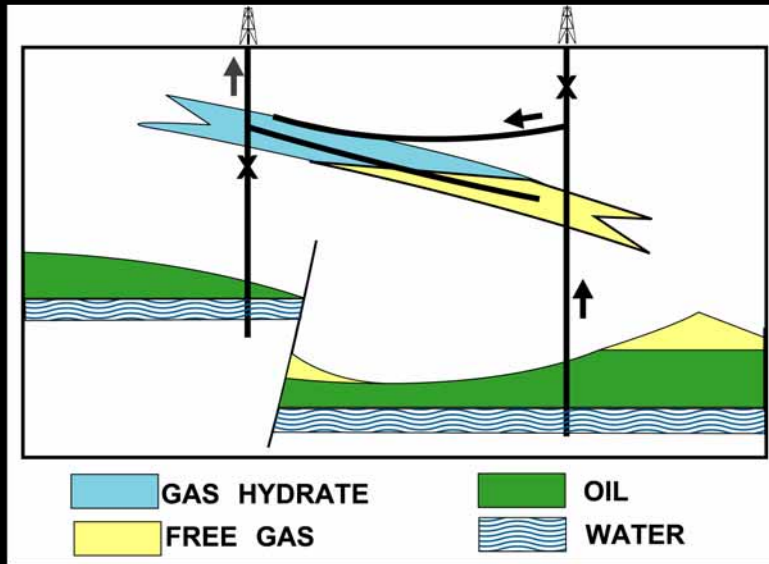


UNIQUE MOTIVATIONS LEADING TO GAS HYDRATE PRODUCTION

- **Industry uses of natural gas in northern Alaska:**
 - Generate electricity for field operations
 - Miscible gas floods
 - Gas lift in producing oil wells
 - Reinjection to maintain reservoir pressures
 - Steam generation for EOR projects



Gas Hydrate Thermal Stimulation

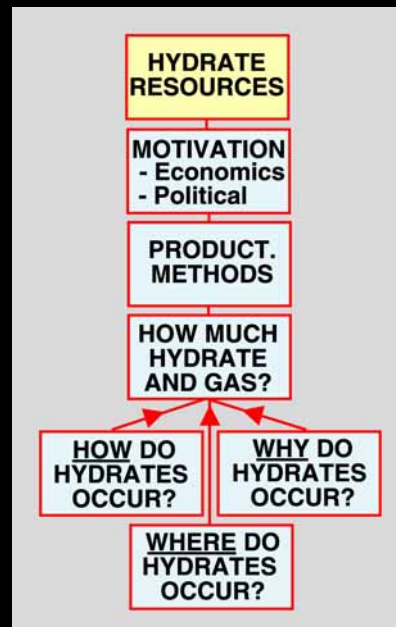


ALASKA GAS EXPORT



Gas hydrate energy resource flow chart

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GAS HYDRATE PROJECTS IN NORTHERN ALASKA

- USGS-USDOE Gas Hydrate Project
- USDOE-Industry-et al Projects
 - USDOE/Maurer/Anadarko/et al., Hydrate Production
 - USDOE/BPXA/et al., Hydrate Commerciality
- BLM/USGS/DGGS Gas Hydrate Assessment