

**Evaluation of Alaska North Slope Gas Hydrate Energy Resources:
A Cooperative Energy Resource Assessment Project**

**US Bureau of Land Management, US Geological Survey,
State of Alaska Division of Geological and Geophysical Surveys**

**Assessment of Alaska North
Slope Gas Hydrates
-Project Briefing-
June 2004**

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Tim Collett, USGS, Denver, CO

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Briefing Outline

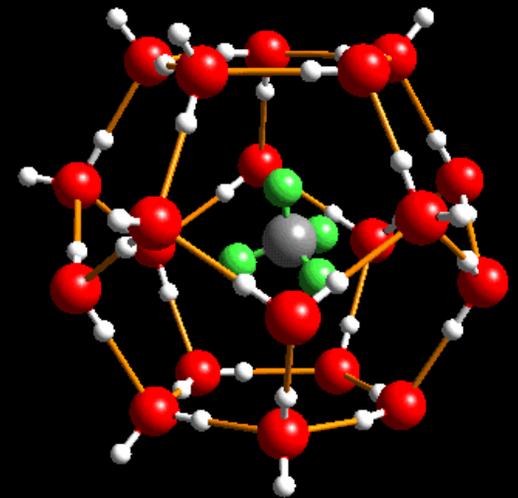
1. What and Why Gas Hydrates?
2. Ongoing Research Activities
 - Industry-USDOE Projects
 - BLM-USGS-DGGS Project
3. Review of Potential Gas Resources on the North Slope

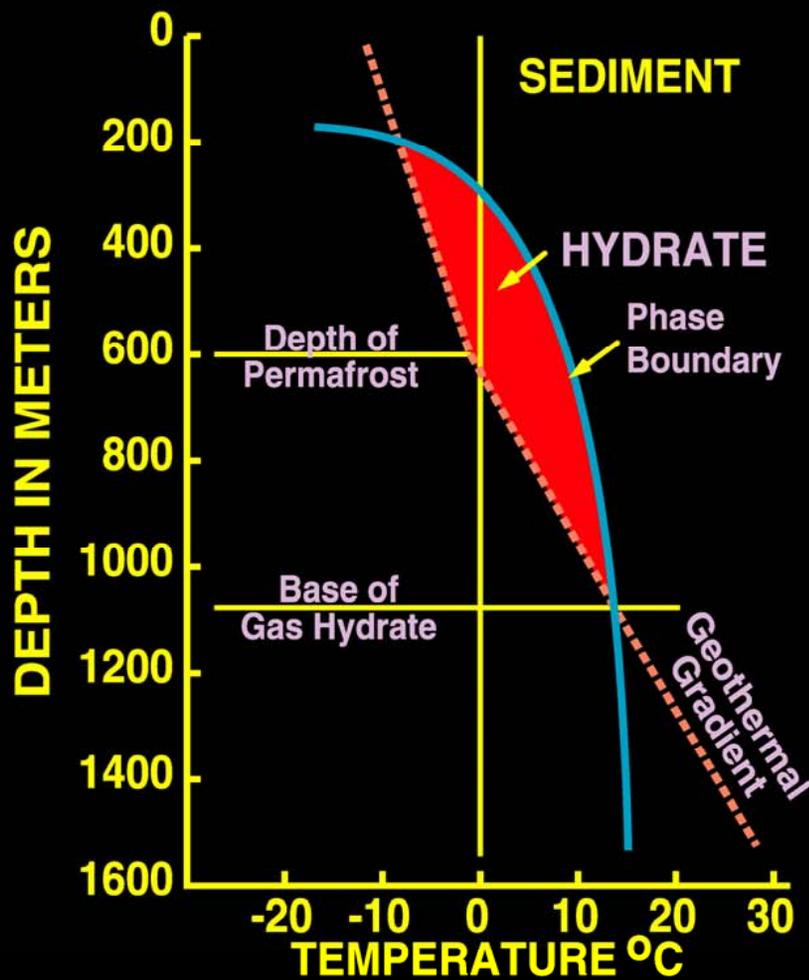
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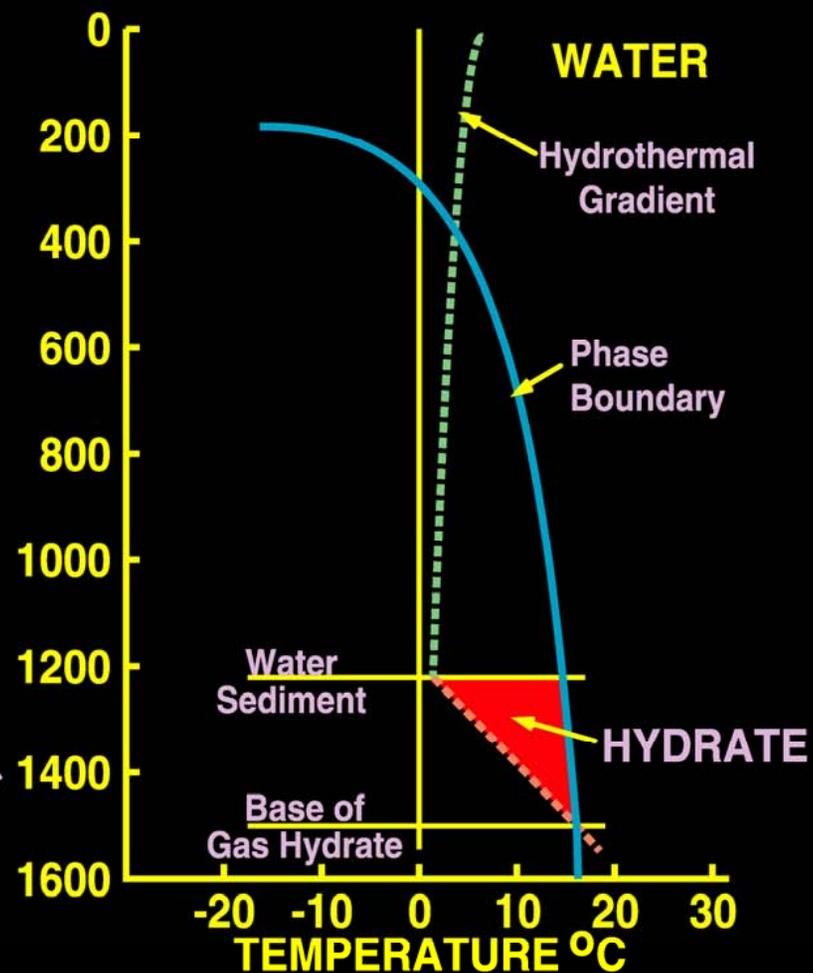
What is a Gas Hydrate?

- 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

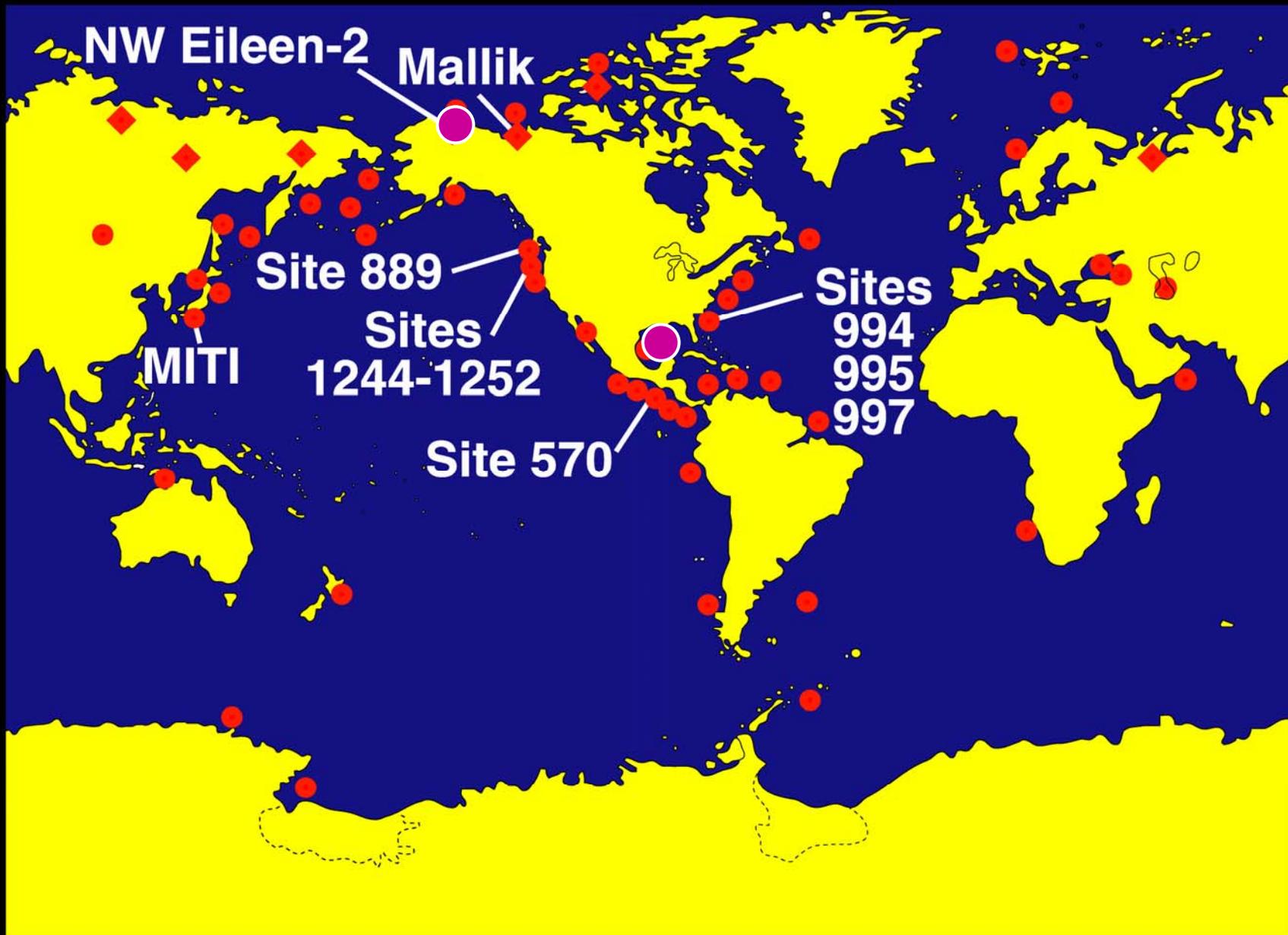




ARCTIC

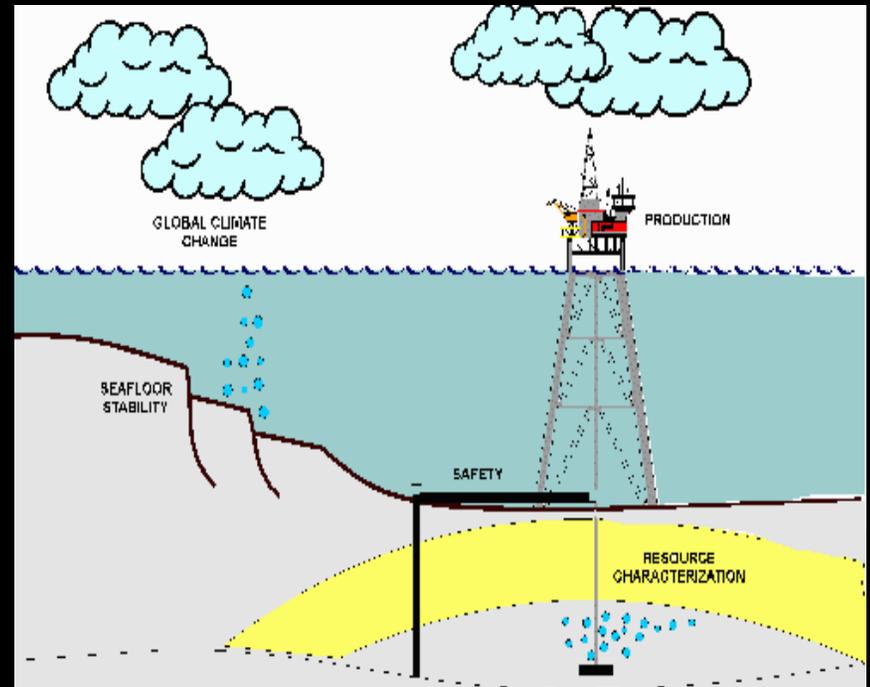


MARINE

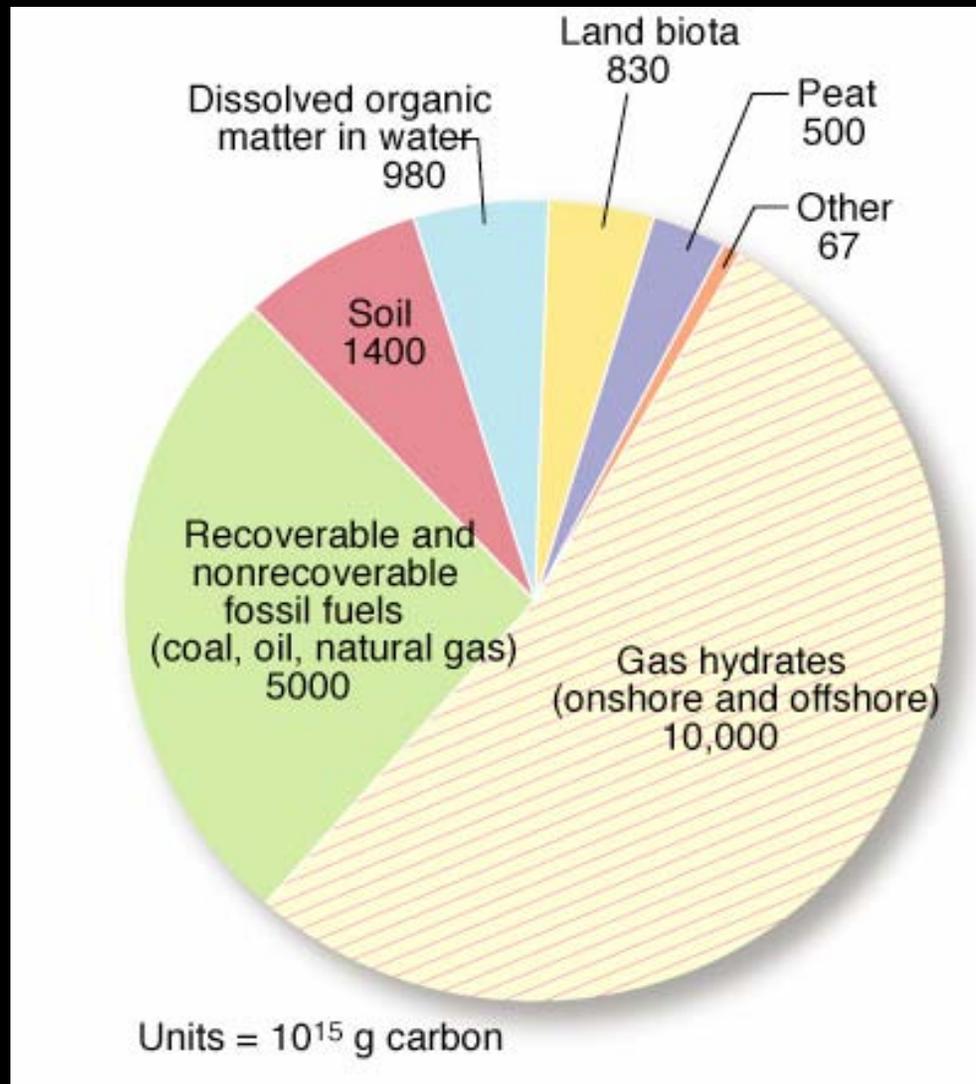


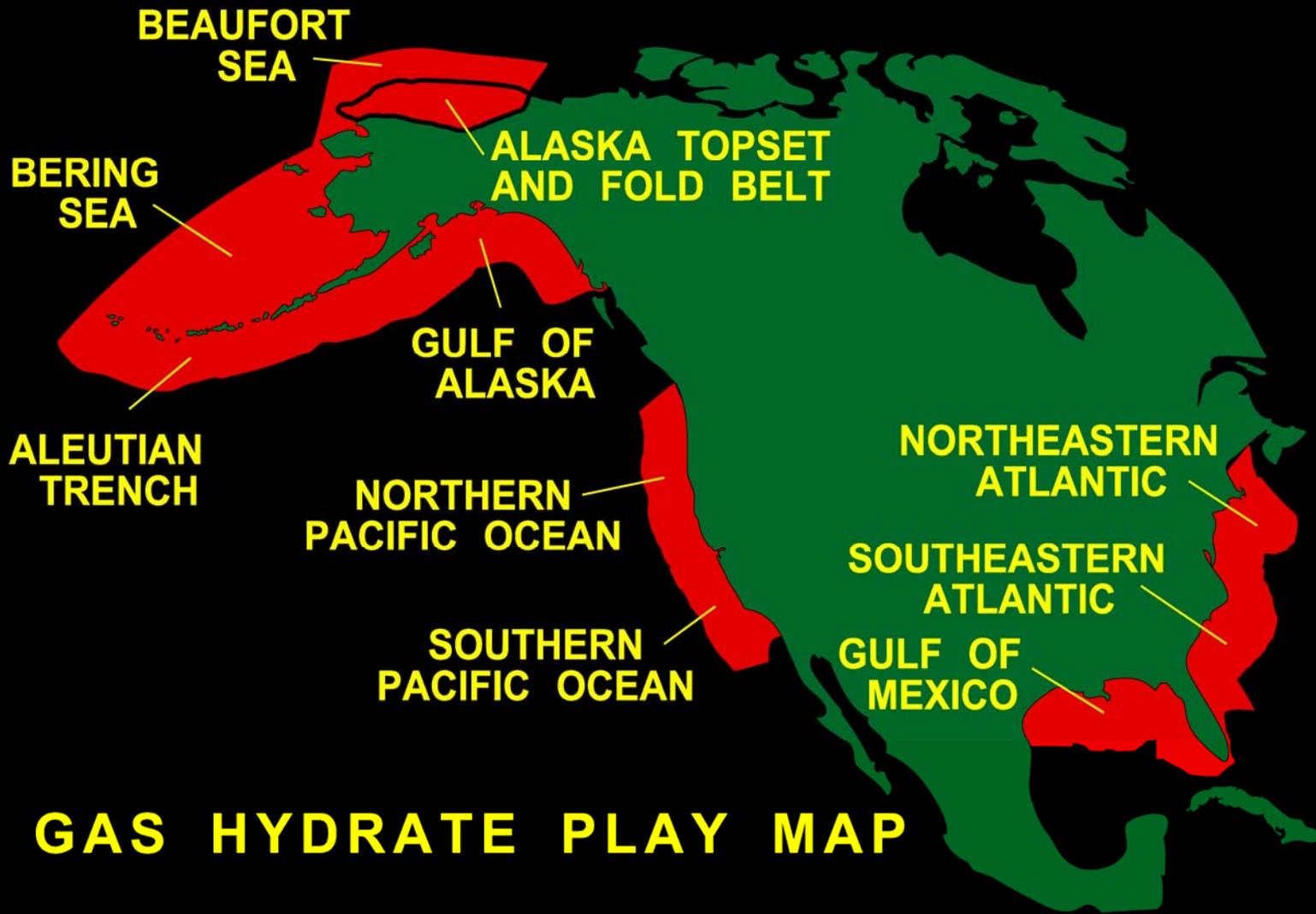
Interest in Gas Hydrates

- Energy Resource
- Operational Hazard
 - Slope stability and platforms
 - Drilling
- Global Warming
 - Methane 20 times more effective greenhouse gas than CO_2



Volume of Organic Carbon

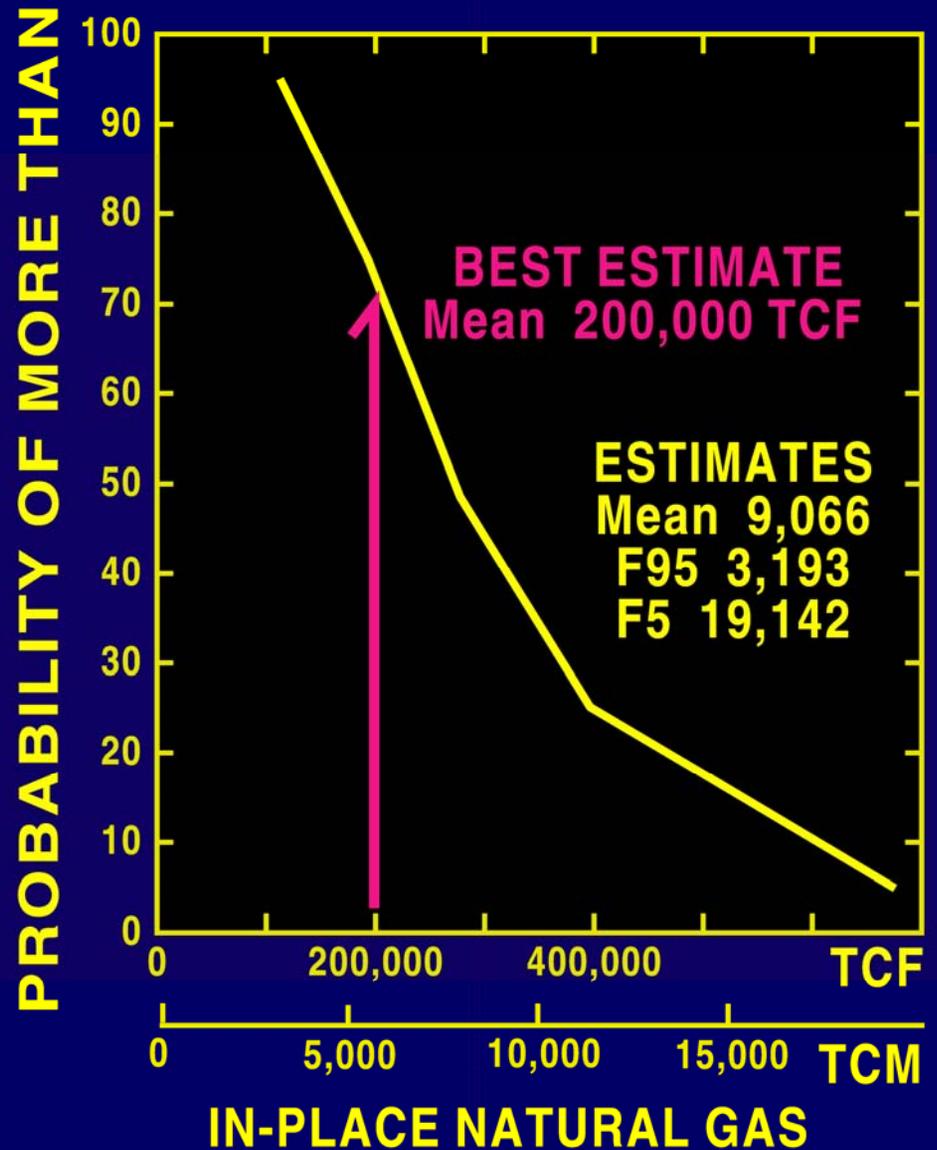




GAS HYDRATE PLAY MAP

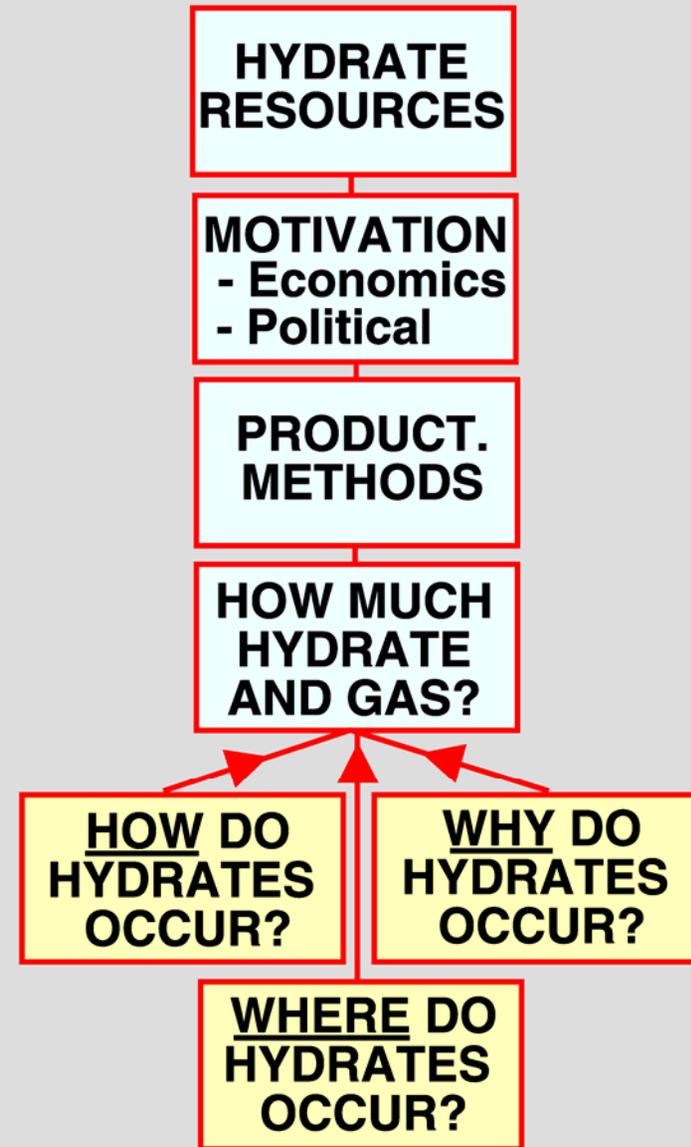
USA Gas hydrate "resource" assessment

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



Gas hydrate energy resource flow chart

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



Briefing Outline

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GAS HYDRATE PROJECTS IN NORTHERN ALASKA

- **Industry-USDOE Projects**

- USDOE/Maurer/Anadarko/et al., Hydrate Production

- USDOE/BPXA/et al., Hydrate Commerciality

- **BLM/USGS/DGGS Gas Hydrate Assessment**

Methane Hydrate Production from Alaskan Permafrost

US Department of Energy, Maurer Technology Incorporated,
Anadarko Petroleum Corporation, Noble Engineering and
Development, University of Alaska, University of Oklahoma

-Project Objective-

The objective of this project is to analyze existing geological and geophysical data and obtain new field data required to predict hydrate occurrences; to test the best methods and tools for drilling and recovering hydrates; and to plan, design, and implement a program to safely and economically drill and produce gas from hydrates.

Methane Hydrate Production from Alaskan Permafrost

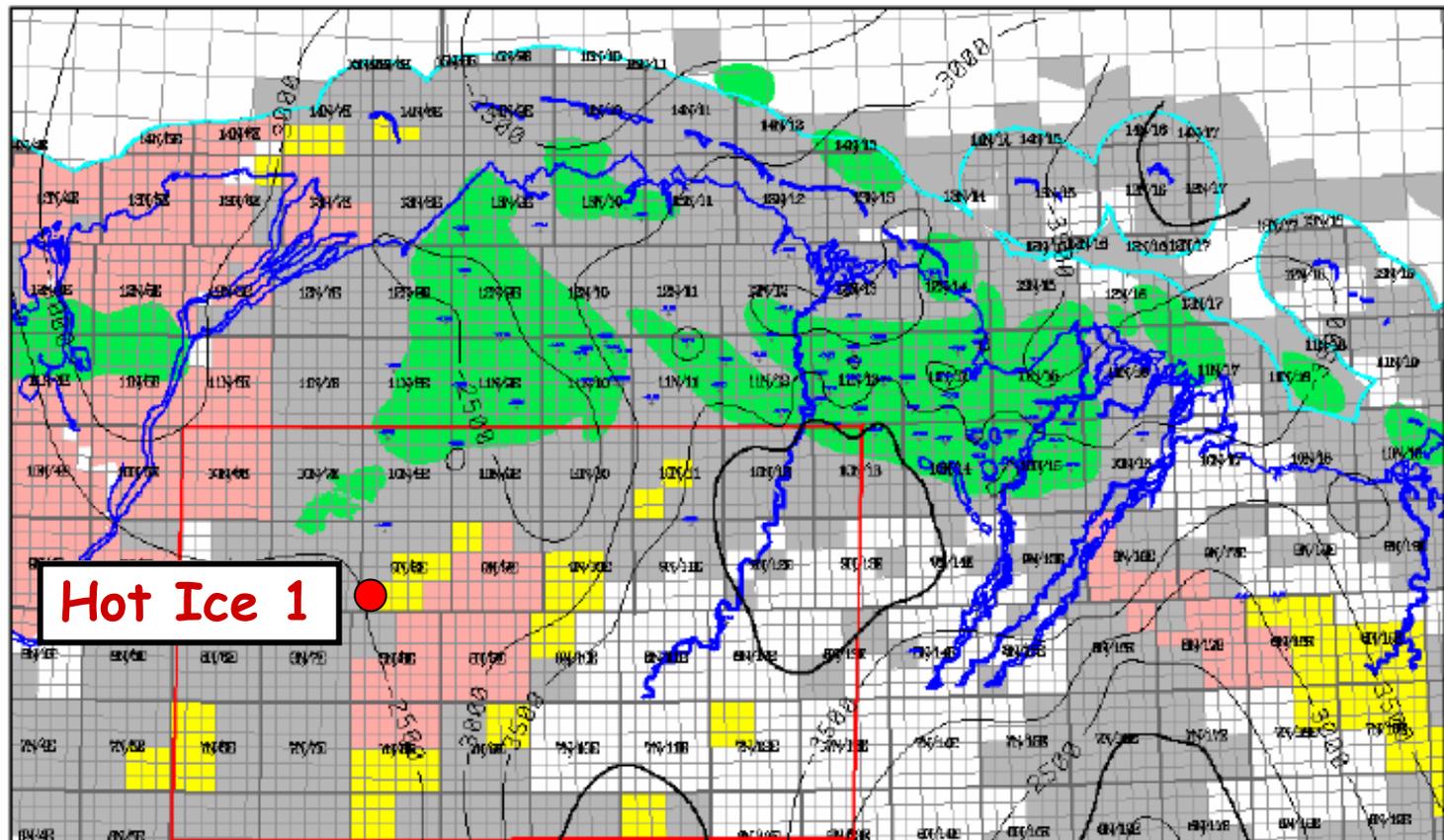
US Department of Energy, Maurer Technology Incorporated,
Anadarko Petroleum Corporation, Noble Engineering and
Development, University of Alaska, University of Oklahoma

-Research Approach-

Phase I. Comprehensive review of geological and geophysical data, identify well locations, and develop well plans and budget. HOT ICE wells 1, 2, and 3.

Phase II. Drill/core a hydrate well. After drilling, this well will be thoroughly logged and tested. Core will be analyzed on site using an innovative mobile laboratory. After completion, shallow seismic (VSP) will be shot. A production test will be performed for 5-10 days and the well will then be monitored for up to 9 months. An advanced hydrates simulator developed by LBNL will be calibrated with field data and used in the development of economic and production models for these and other hydrate accumulations.

Base of Hydrate Stability Zone



Hot Ice 1

AKADARKO PETROLEUM CORP
NORTH HORN 2004

BASE OF HYDRATE STABILITY ZONE
C.S. = 500 FT

CONTOURS ARE SUBSEA DEPTHS



Resource Characterization and Quantification of Natural Gas-Hydrate and Associated Free-Gas Accumulations Prudhoe Bay - Kuparuk River Area, North Slope of Alaska

US Department of Energy, BP Exploration (Alaska) Inc.,
University of Arizona, University of Alaska, US Geological Survey

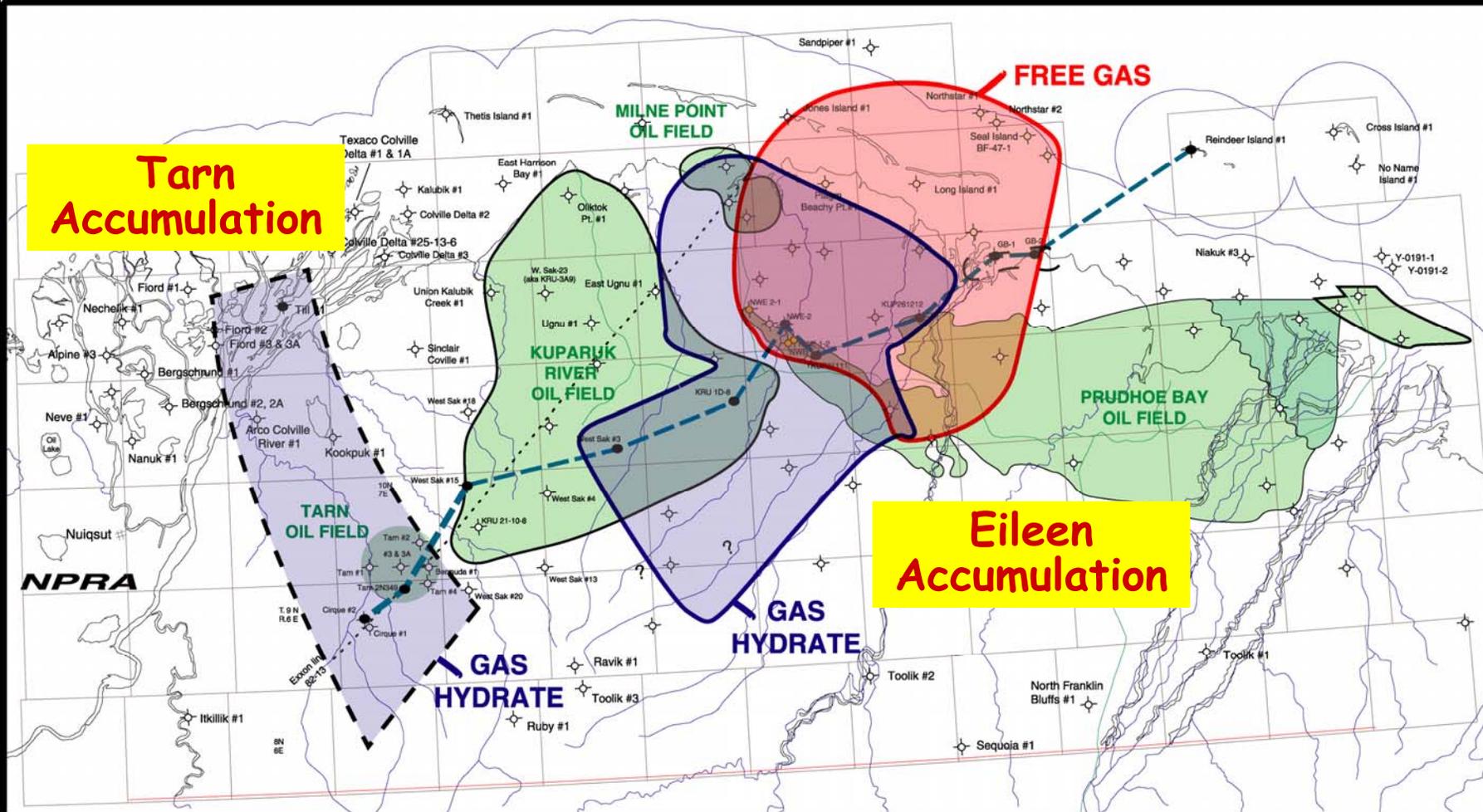
-Project Mission-

Characterize, quantify, & determine commerciality of gas hydrate & associated free gas resources in arctic regions through integrated academic, industry, & government collaborative research to promote safe, low cost, & environmentally responsible production of abundant, strategic, & secure energy resources.

bp



Alaska Methane Hydrate Estimated Resource Extent





Alaska Gas Hydrate Project

Year/Phase/
~ DOE Cost
(\$13.2 MM)

2001

Project Proposal to DOE

2002

2.0

2003

Reservoir and Fluid Characterization
& In-Place Resource Calculation Studies
Drilling/Production RE/PE Studies

2004

Wells of Opportunity – Data
Reservoir and Economic Modeling

2005

3.6

Drilling, Data, Production Testing
& Reserves Calculation Studies
Reservoir and Economic Modeling
Proceed if Commercially Viable

2006

7.6

Possible Pilot Development

Evaluation of Alaska North Slope Gas Hydrates

US Bureau of Land Management, US Geological Survey, State of Alaska Division of Geological and Geophysical Surveys

-Project Work Plan-

Phase-I. Assess existing geologic, geophysical, and engineering data to characterize the resource potential of the Eileen and Tarn gas-hydrate/free-gas accumulations (FY 03-04).

Phase-II. Assess existing geologic, geophysical, and engineering data to characterize the resource potential of the undiscovered gas hydrate accumulations in NPRA, ANWR, and the State lands between the Canning and Colville Rivers (FY 05-06).

Phase-III. Conduct an assessment of the economically recoverable resource potential of gas hydrates and associated free-gas accumulations in northern Alaska (FY 07).

Authorities:

I. Federal Land Policy and Management Act of 1976 (Public Law 94-579, Section 307 (b)).

Authorities:

II. ANILCA (Alaska National Interest Lands Conservation Act), Sections 809, 1010, 1002, and 1008.

Section 809, The Secretary may enter into cooperative agreements or otherwise cooperate with other Federal agencies, the State, Native Corporations, other appropriate persons and organizations, and, acting through the Secretary of State, other nations to effectuate the purposes and policies of this title.

Section 1010, The Secretary shall, to the full extent of his/her authority, assess the oil, gas, and other mineral potential on all public lands in the State of Alaska in order to expand the data base with respect to the mineral potential of such lands.

Section 1008, Part (b)(1)(A), In such areas as the Secretary deems favorable for the discovery of oil and gas, he/she shall conduct a study, or studies, or collect and analyze information obtained by agencies authorized to conduct studies under this section.

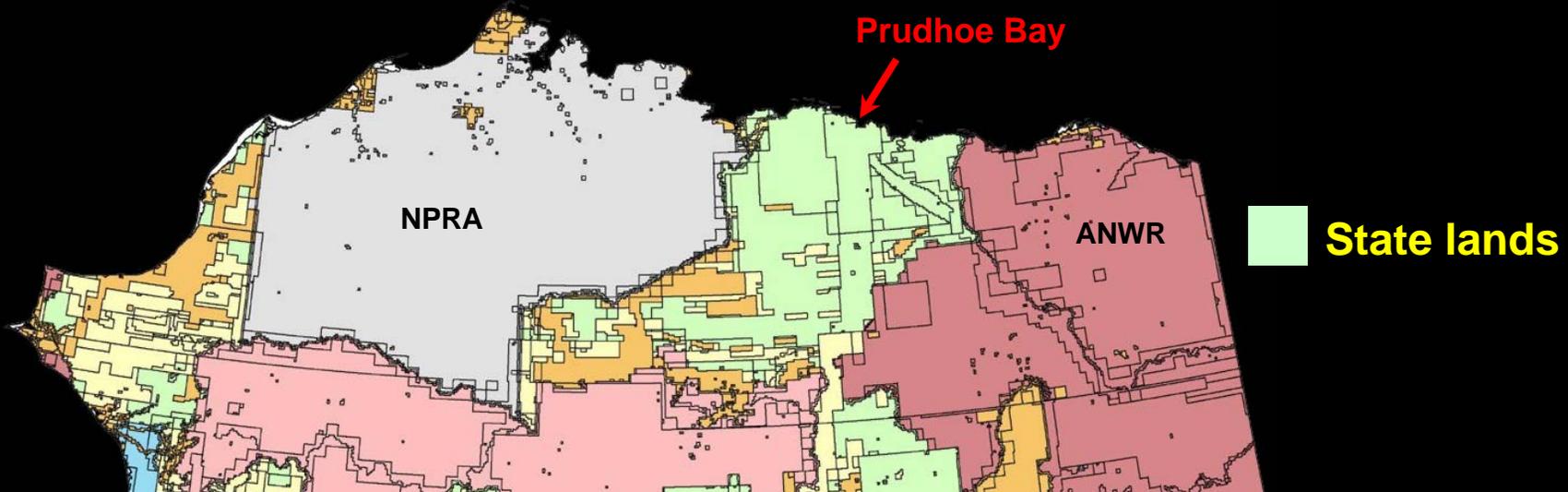
Section 1002. Arctic National Wildlife Refuge Costal Plain Resources Assessment.

Authorities:

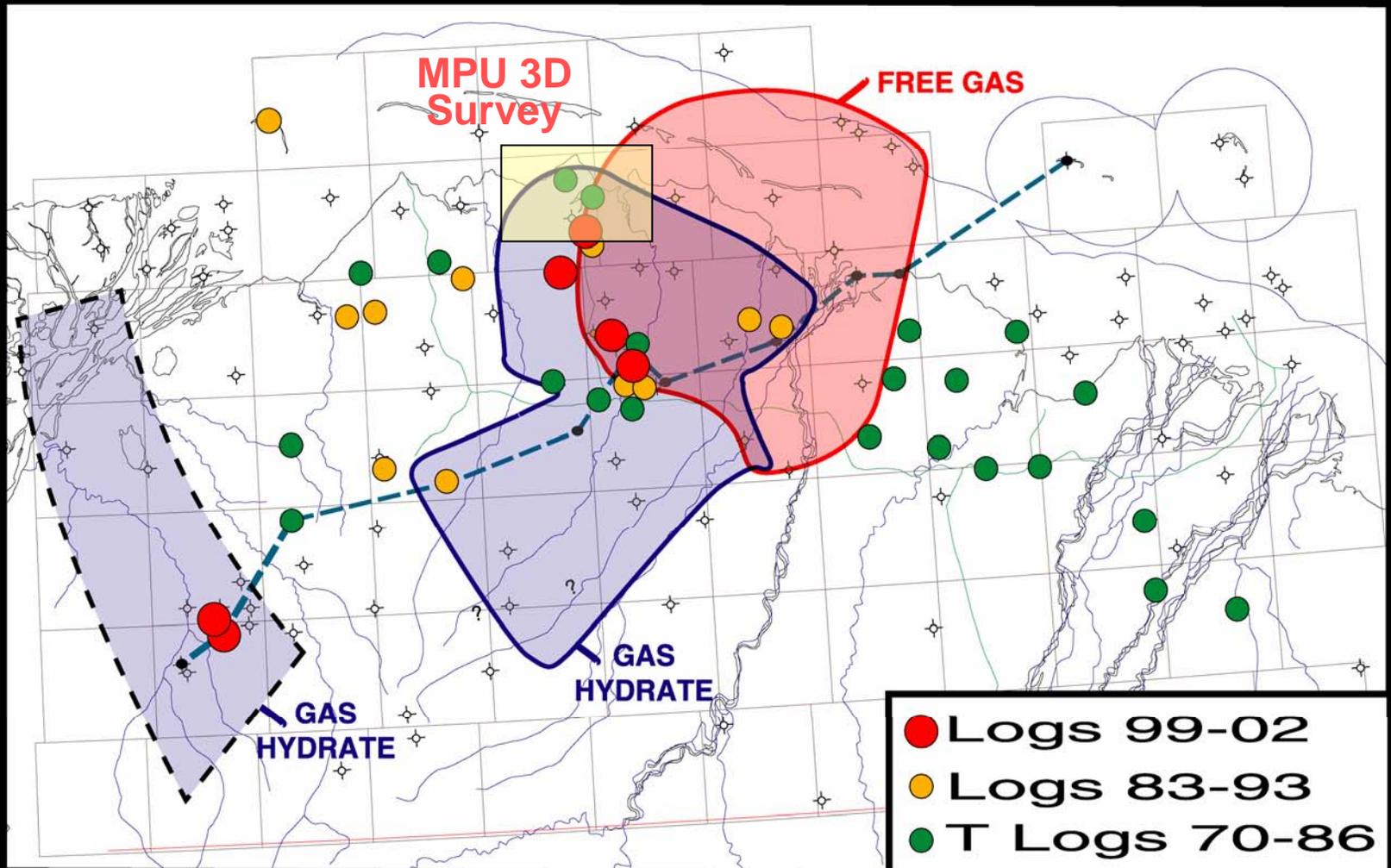
III. State Statutes 41.08.020 and 41.08.040.

41.08.020. Powers and duties. The state geologist shall conduct geological and geophysical surveys to determine the potential of Alaskan land for production of metals, minerals, fuels, and geothermal resources (abbreviated).

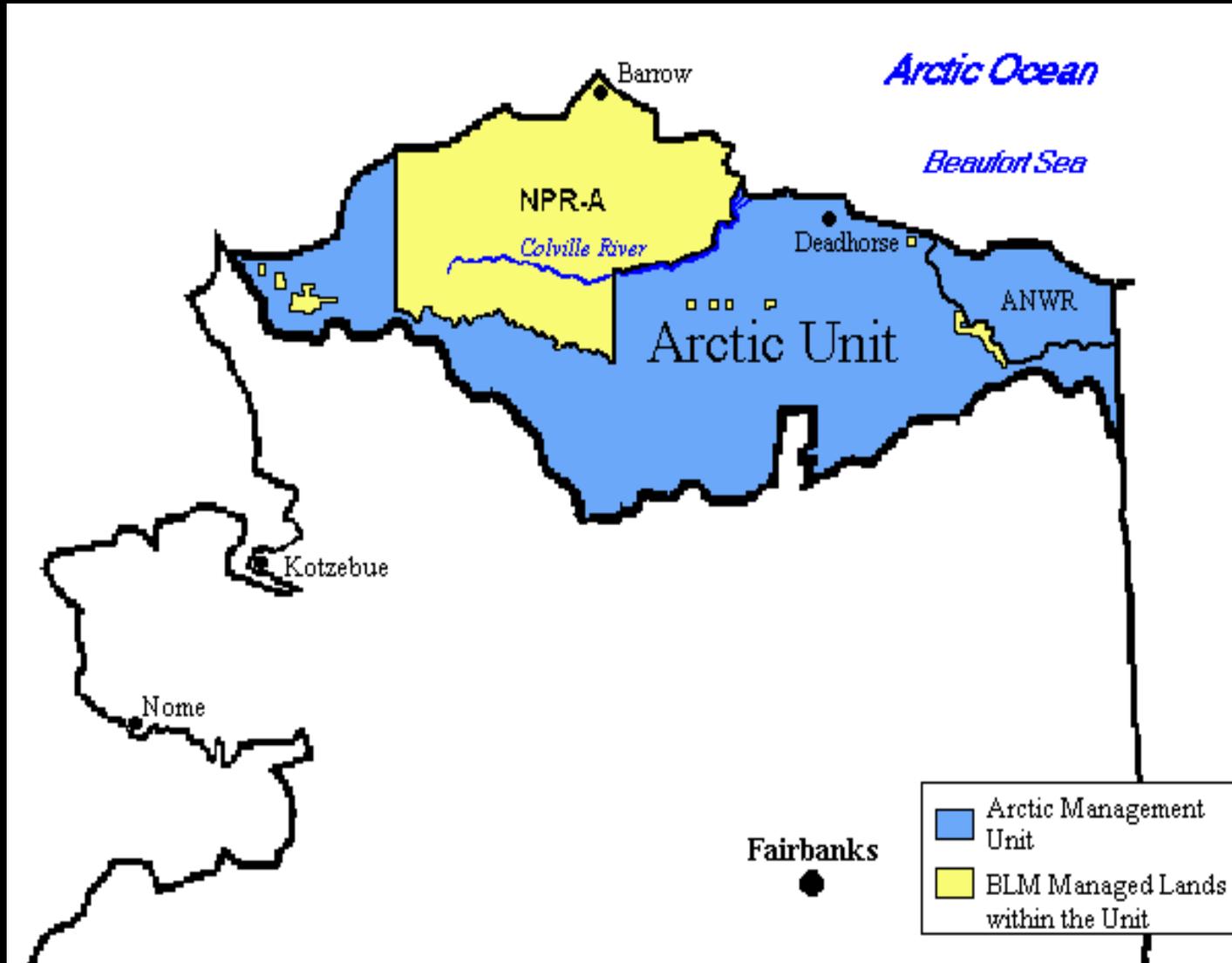
41.08.040. Cooperation with other agencies. The state geologist, with the consent of the commissioner, may enter into cooperative agreements with federal, state, and local governmental agencies to perform geological and geophysical surveys, studies, investigations, and services.



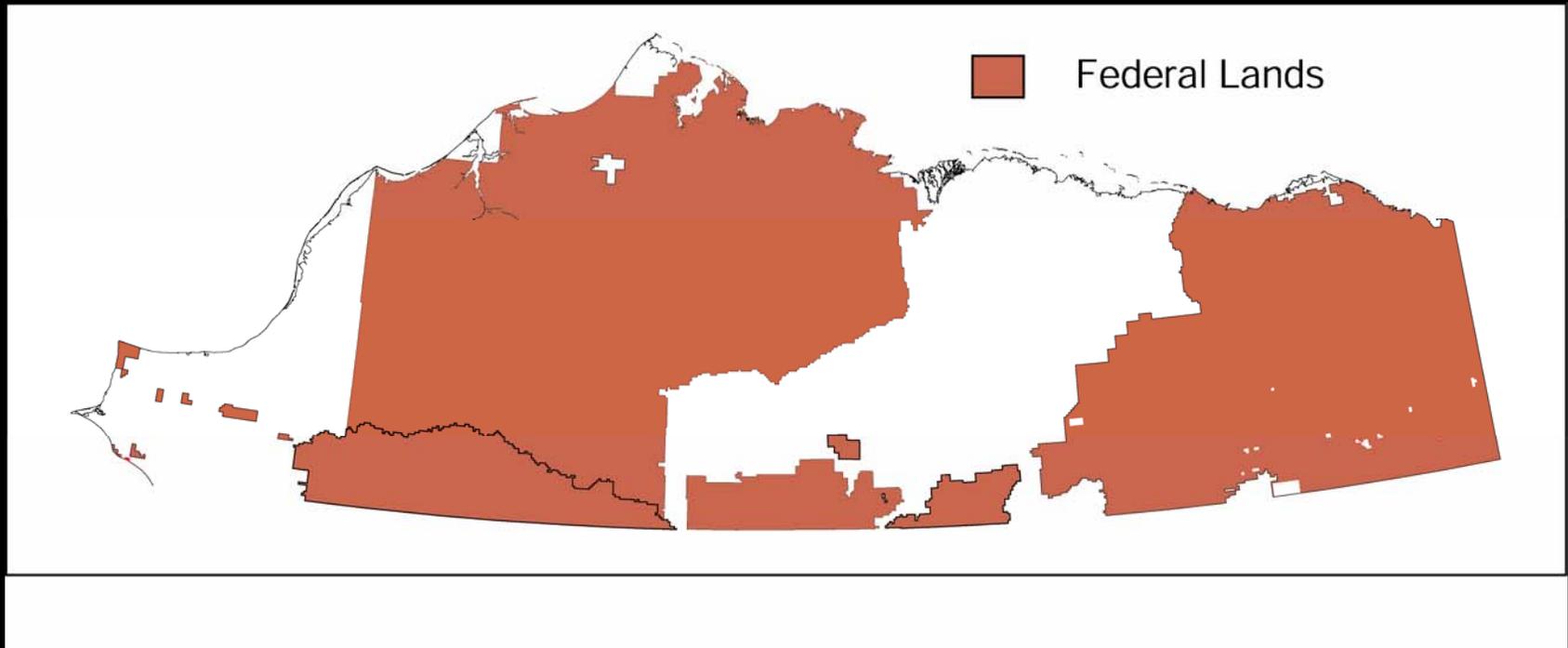
Phase-I. Eileen and Tarn Hydrate Accumulations



Phase-II. Hydrates in NPRA, ANWR, and State Lands



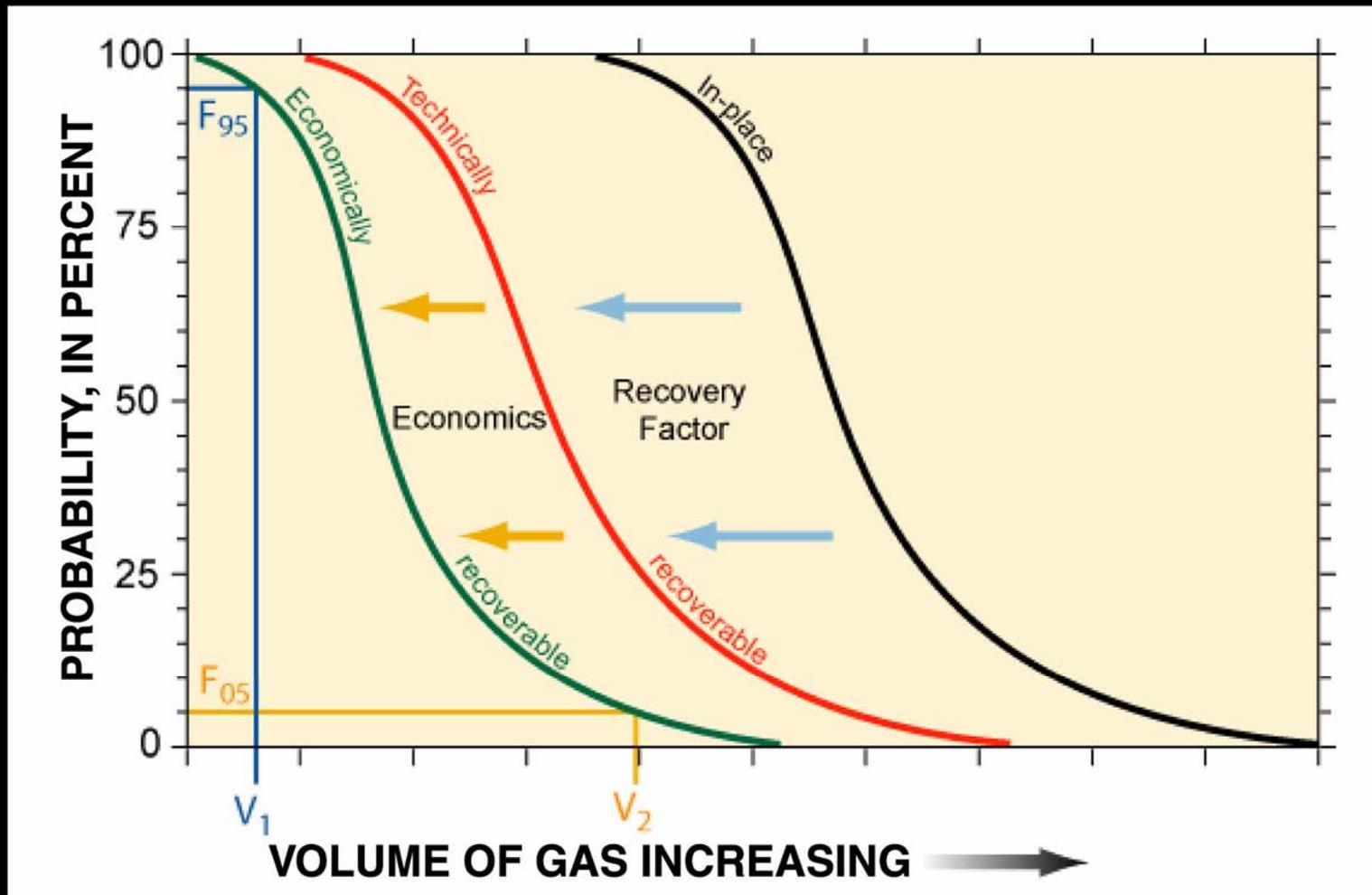
North Slope Federal Lands



NPRA 3D Seismic Surveys

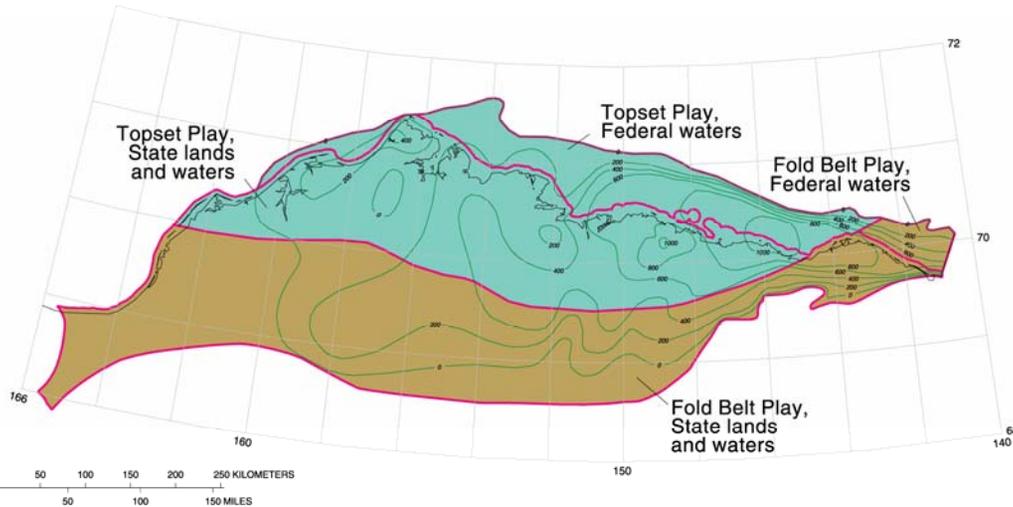


Phase-III. Hydrate Resource Assessment "Economically Recoverable Assessment"



1995 USGS Hydrate Resource Assessment

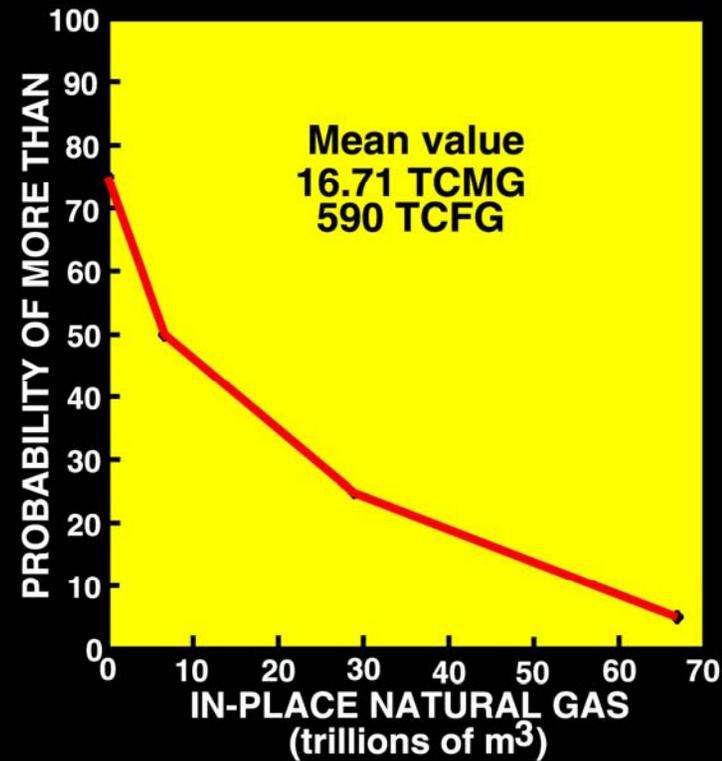
MAP OF THE ALASKA GAS HYDRATE PLAYS



EXPLANATION

- Topset gas-hydrate play
- Fold Belt gas-hydrate play
- Gas-hydrate play boundary
- 400 Gas hydrate stability zone thickness contour—in meters

Alaska Gas Hydrate Play Based Assessment



Alaska Gas Hydrate Play Based Assessment

Gulf of Alaska Play -- Gas Volume Parameters

Attribute	100	95	75	50	25	5	0
Volume of hydrate stability zone (10 ¹² m ³)	322	342	383	403	424	464	484
Reservoir thickness in nonmarine system (m)	x	x	x	x	x	x	x
Effective porosity (%)	30	33	44	58	69	78	80
Hydrate saturation (%)	2	3.2	8	14	21	25	27
Hydrate gas yield (m ³)	139	140	145	152	158	163	164

Gulf of Alaska Play

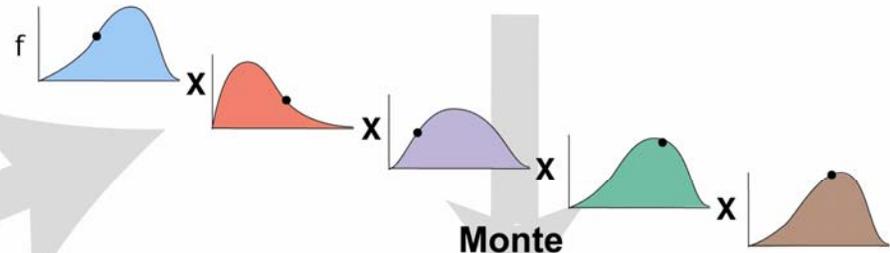
	Attribute	Prob. Fav.	Comm.
Play Attrib.	Microbial hydrocarbon source (S1)	0.4	S1xS2 = S3 If S3 = 1, GS = 1 Use the > value of S3 or S4
	Microbial source sediment thickness (S2)	1.0	
	Thermogenic hydrocarbon source (S4)	0.0	
	Timing (T)	1.0	
	Migration (M)	0.8	
	Potential reservoir facies (R)	1.0	
	Marginal play probability (GS x T x M x R = MP)	0.32	
Prosp. Attrib.	Trapping mechanism (TM)	0.8	
	Effective porosity (>3%) (P)	1.0	
	Hydrocarbon accumulation (C)	0.8	
	Conditional deposit probability (TM x P x C = CP)	0.64	

USGS Deposit Simulation Method -NPRA (1980/2002) and ANWR (1987/1998)-

Play A

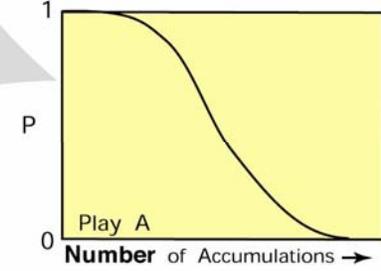
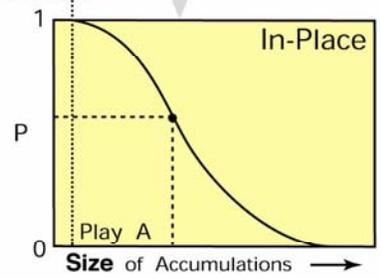
Probability of Greater than
100 50 max

Closure Area					
Res. Thick					
Porosity					
Water Sat					
Trap Fill					



Monte Carlo

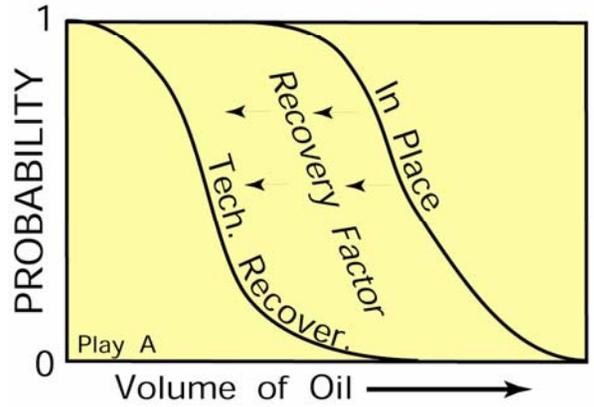
50 mmbbo truncation



Oil vs. Gas

Probability of Greater than
100 50 max

No. of Containers (>50 mmbboe)					
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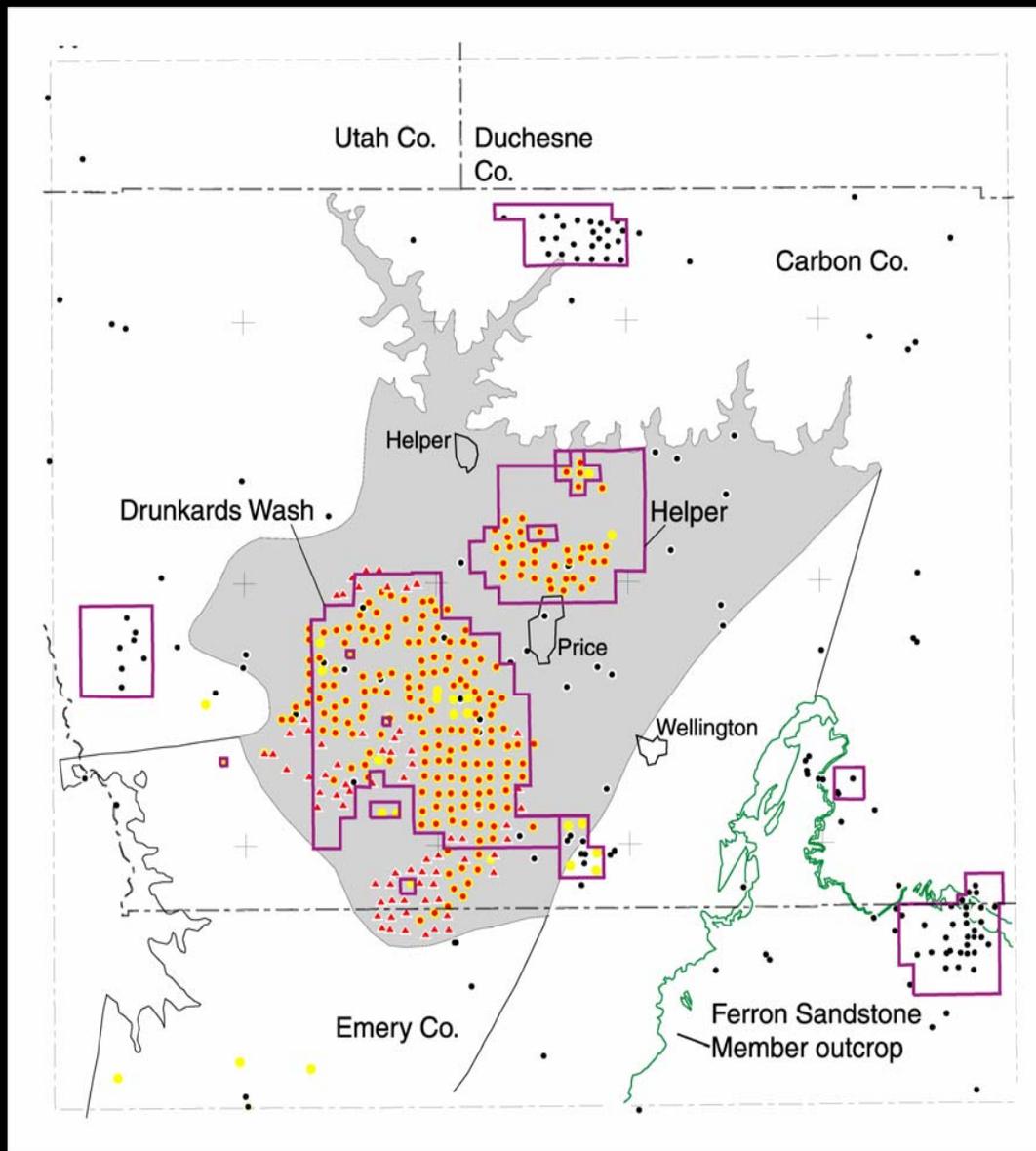
Play Risk

Charge	
Reservoir	
Trap	

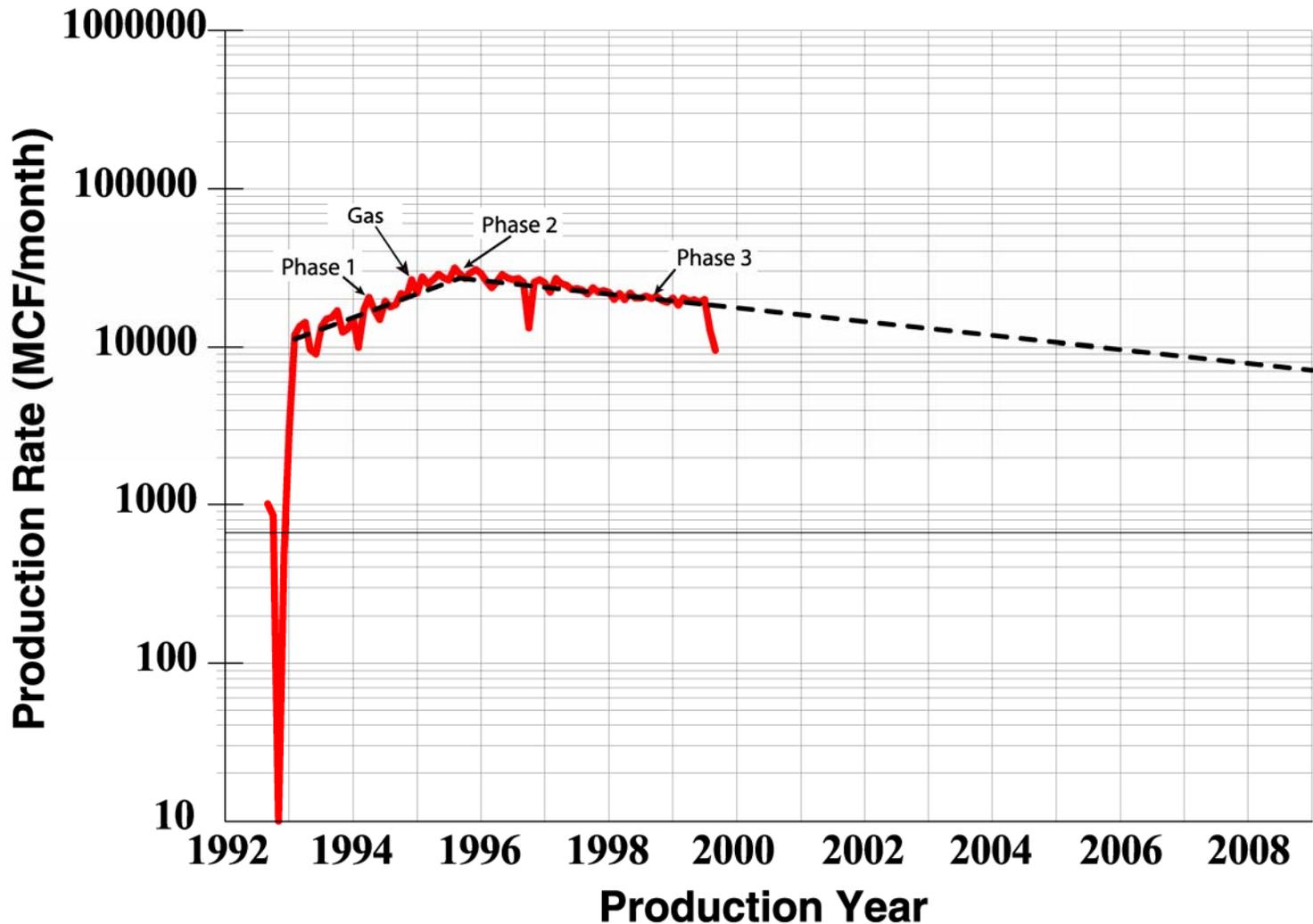
Monte Carlo

Coalbed Methane Assessment Unit

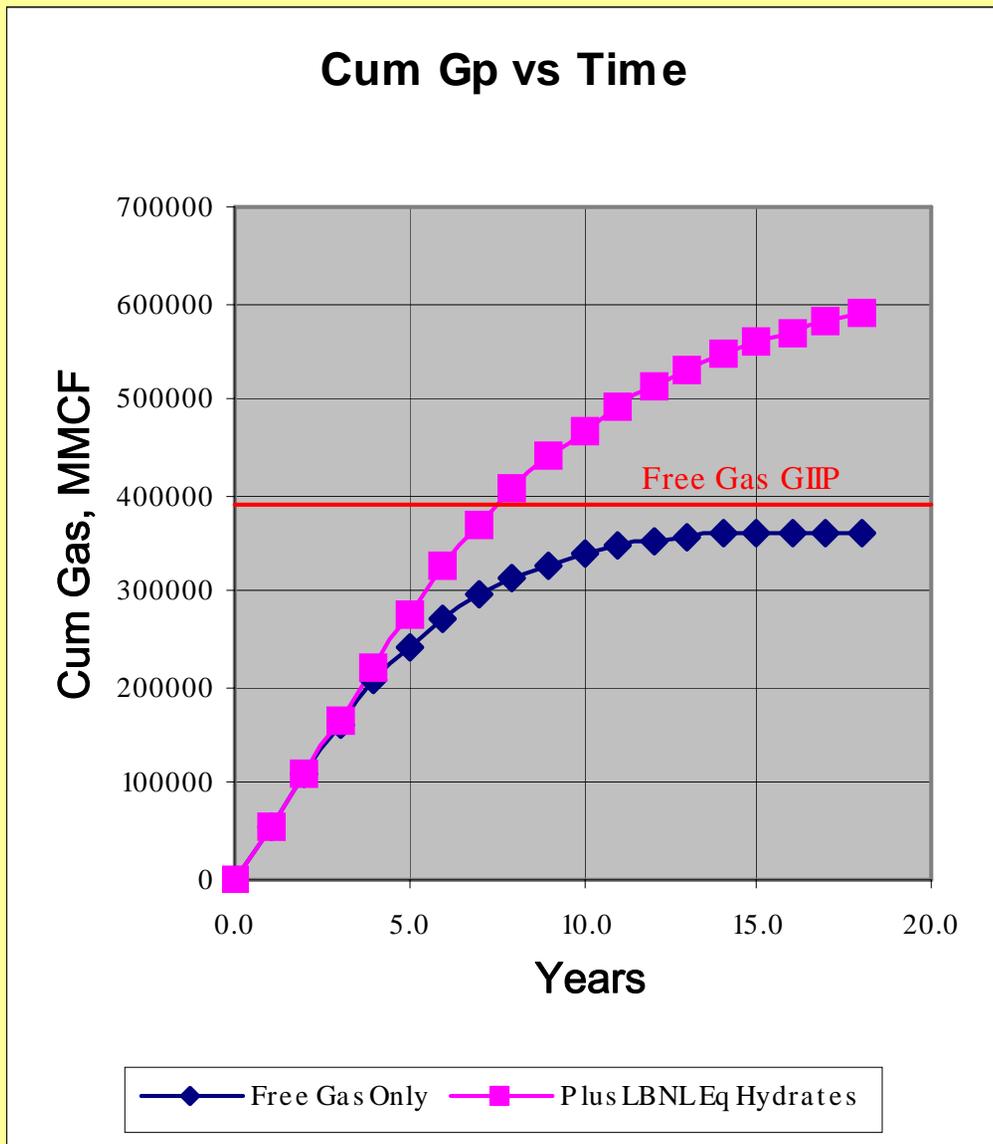
- Continuous type accumulation
assessment - Cell Based
Approach



Coalbed Methane EUR Calculation



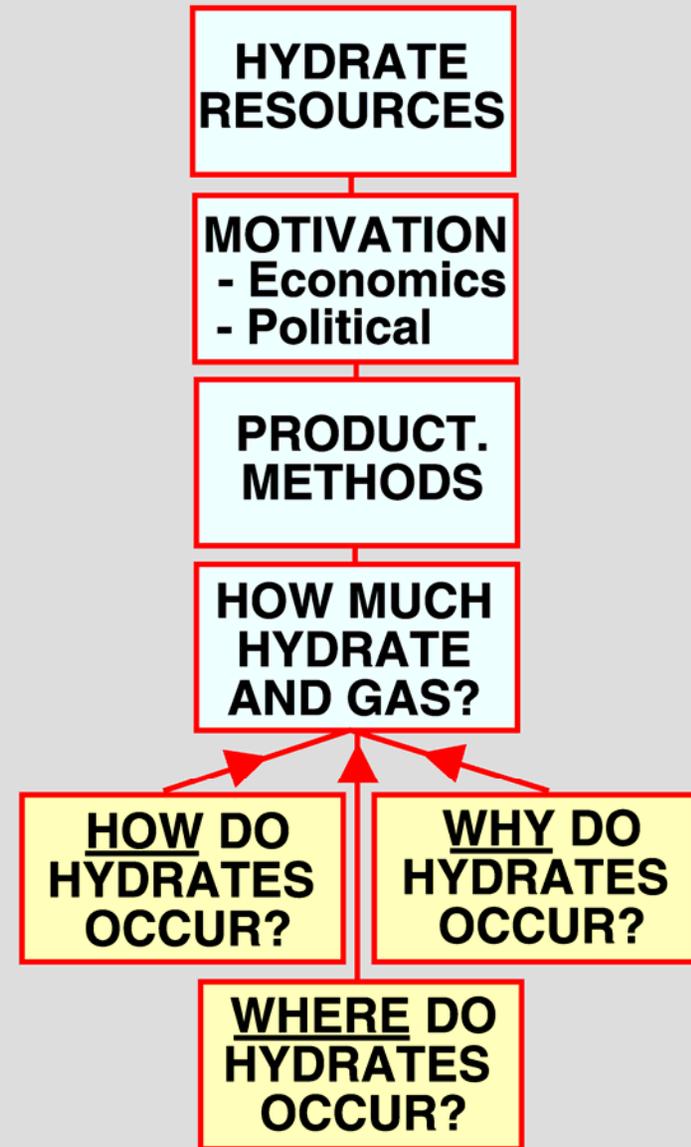
Cumulative Gas Production



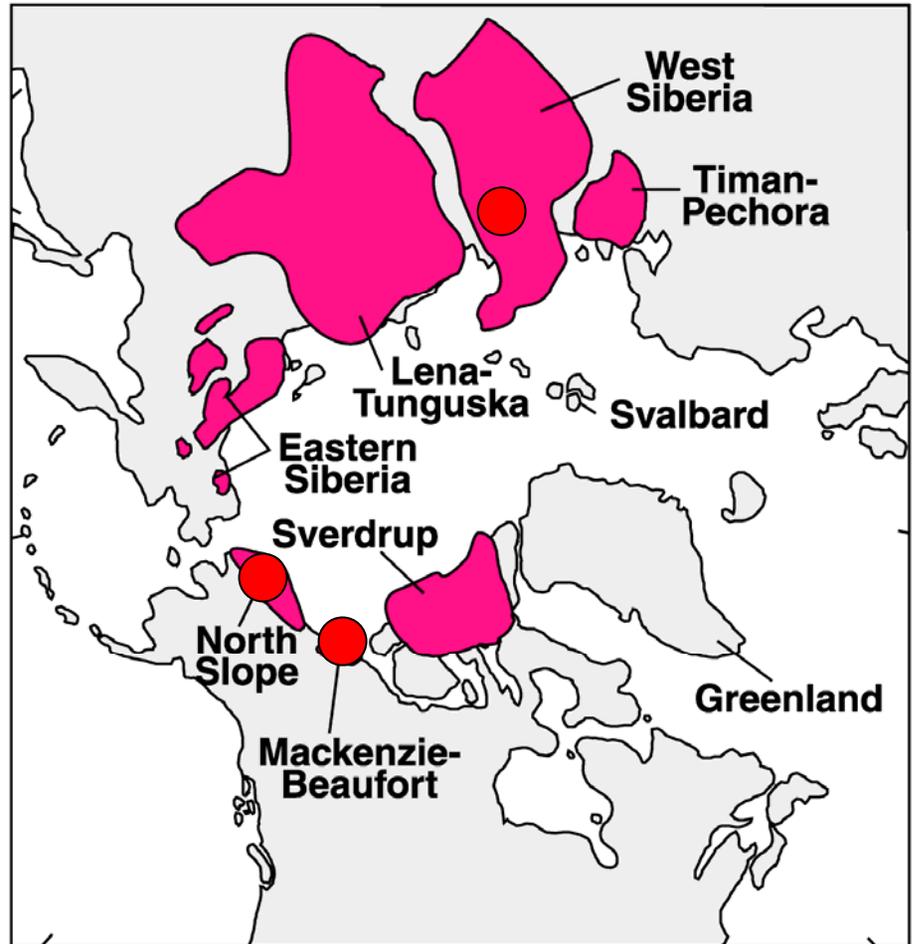
**USDOE-BPXA-UA-UAF-USGS
ANS Gas Hydrate Assessment
Pre-Phase 1 Commercial Scoping**

Gas hydrate energy resource flow chart

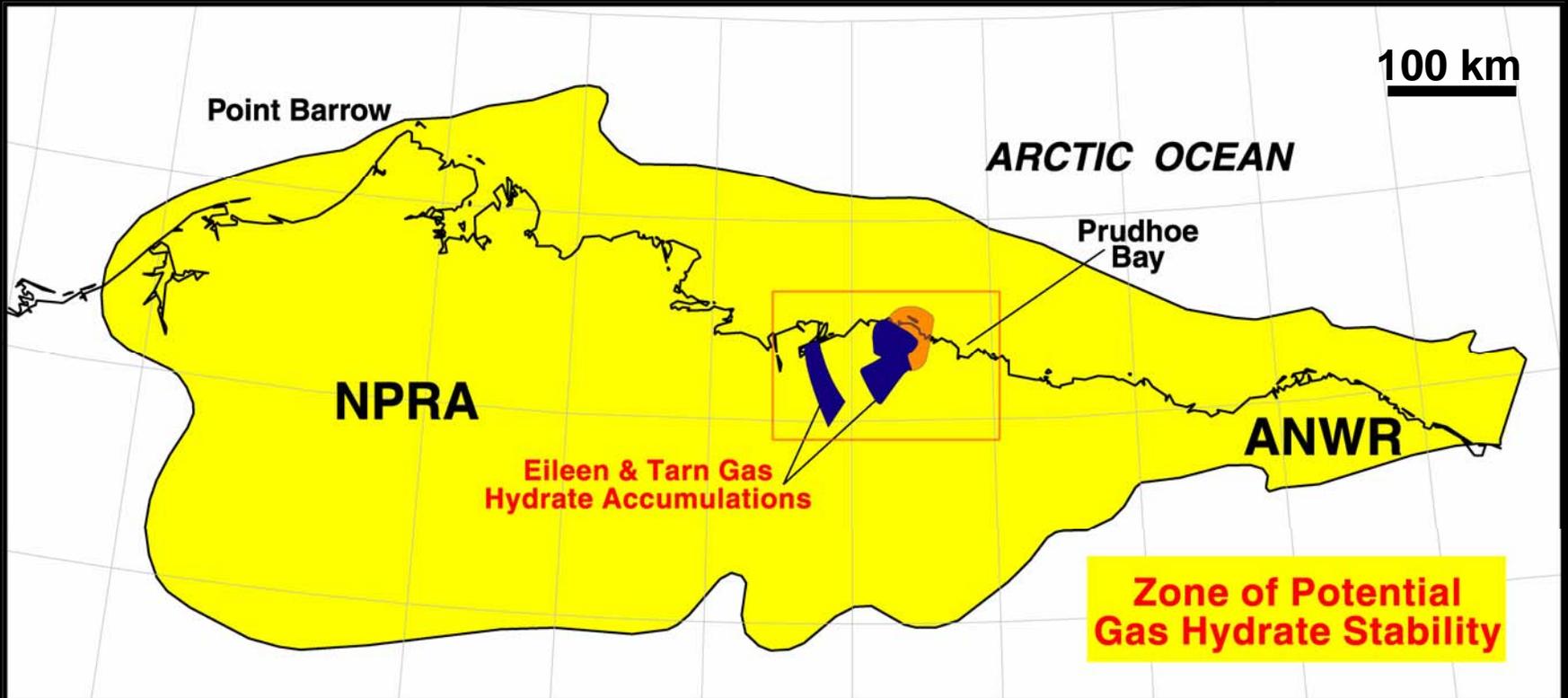
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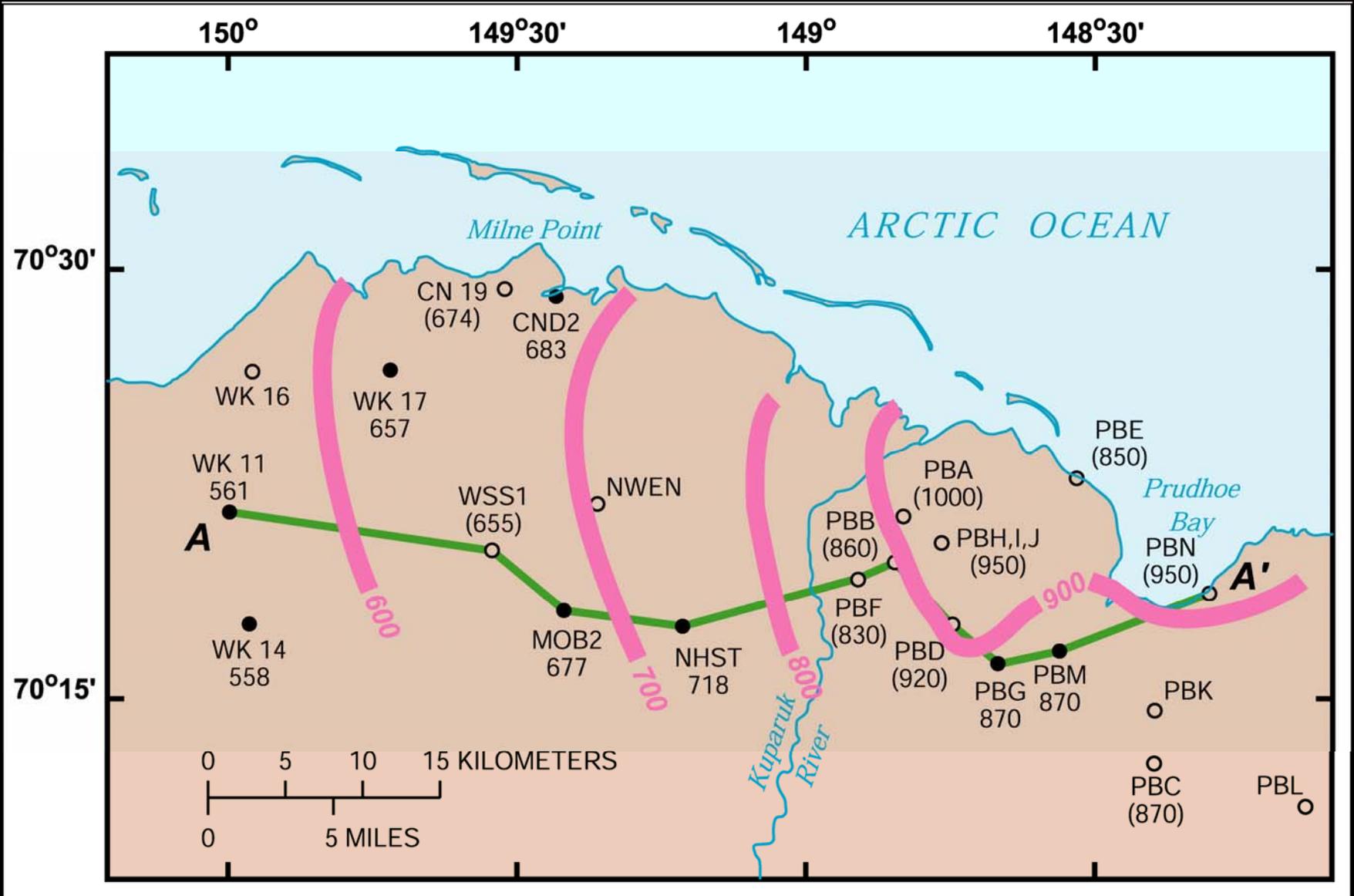
Arctic Basins - Area of known or inferred gas hydrates



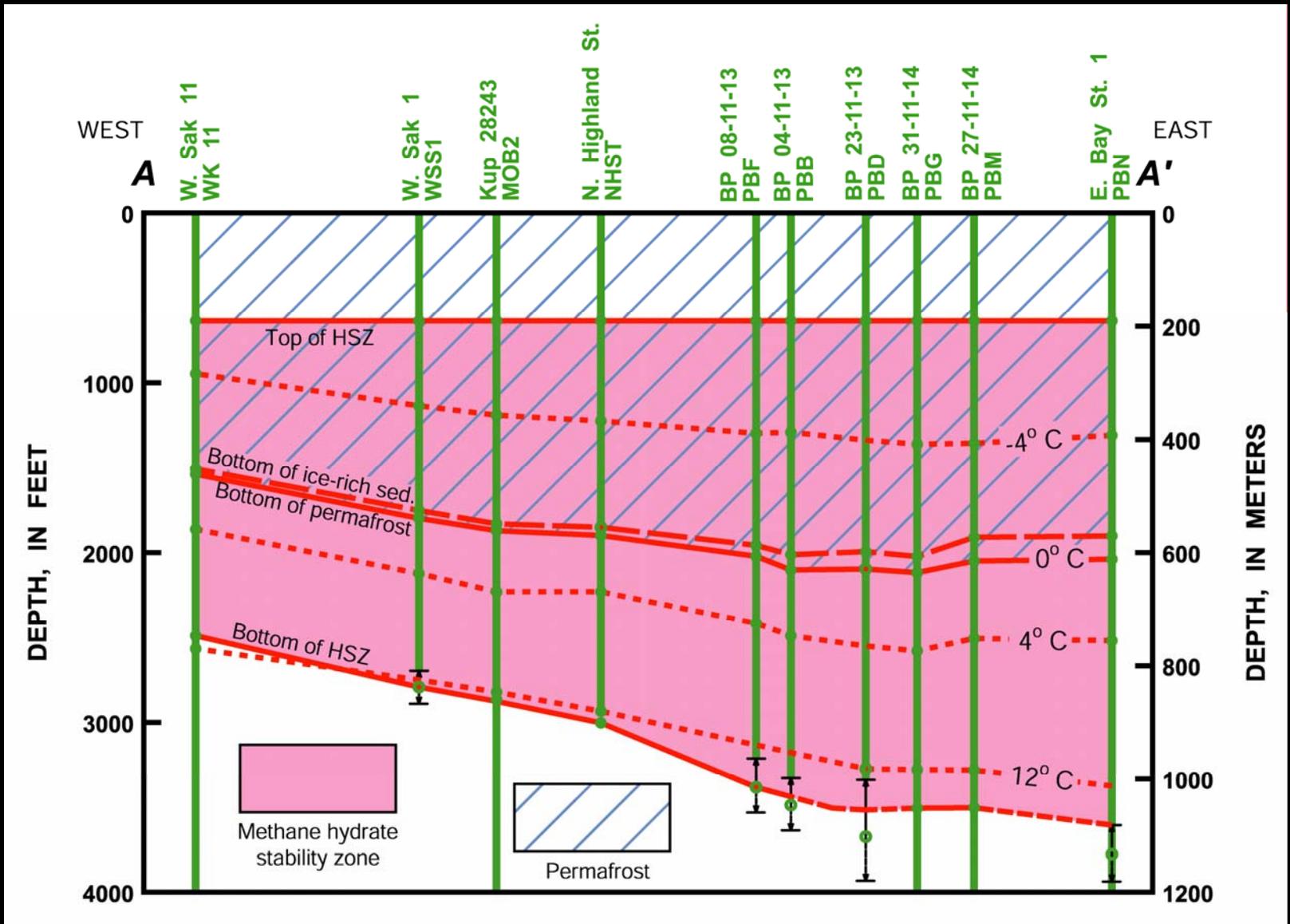
Alaska NS Gas Hydrates



Prudhoe-Kuparuk Permafrost Conditions



Prudhoe-Kuparuk Methane Hydrate Stability



Eileen Gas Hydrate Accumulation

