



ALASKA DEPARTMENT OF NATURAL RESOURCES  
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

SPECIAL REPORT 66  
SWENSON AND OTHERS, 2012  
SHEET 2 OF 2  
REPORT ACCOMPANIES SHEET



# ALASKA RESOURCE ASSESSMENTS\*

- FEDERAL ESTIMATES – UNDISCOVERED,  
TECHNICALLY RECOVERABLE -

Region	Mean Oil Estimate (Million Barrels)	Mean Gas Estimate (Billion Cubic Feet)
Onshore Arctic	15,908	98,960
Offshore Arctic	23,750	108,180
Interior Basins (only partially assessed)	234	5,641
Upper Cook Inlet	599	19,037
Other Southern Alaska	2,859	23,458
<b>TOTAL</b>	<b>43 BBO</b>	<b>255 TCF</b>

\*Excludes shale oil, shale gas, methane hydrates, and most coal bed methane

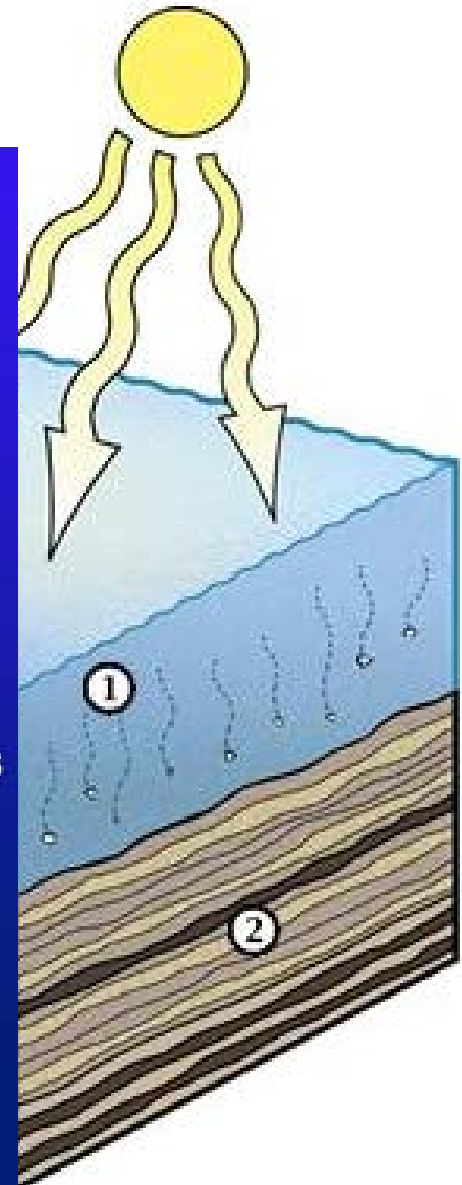
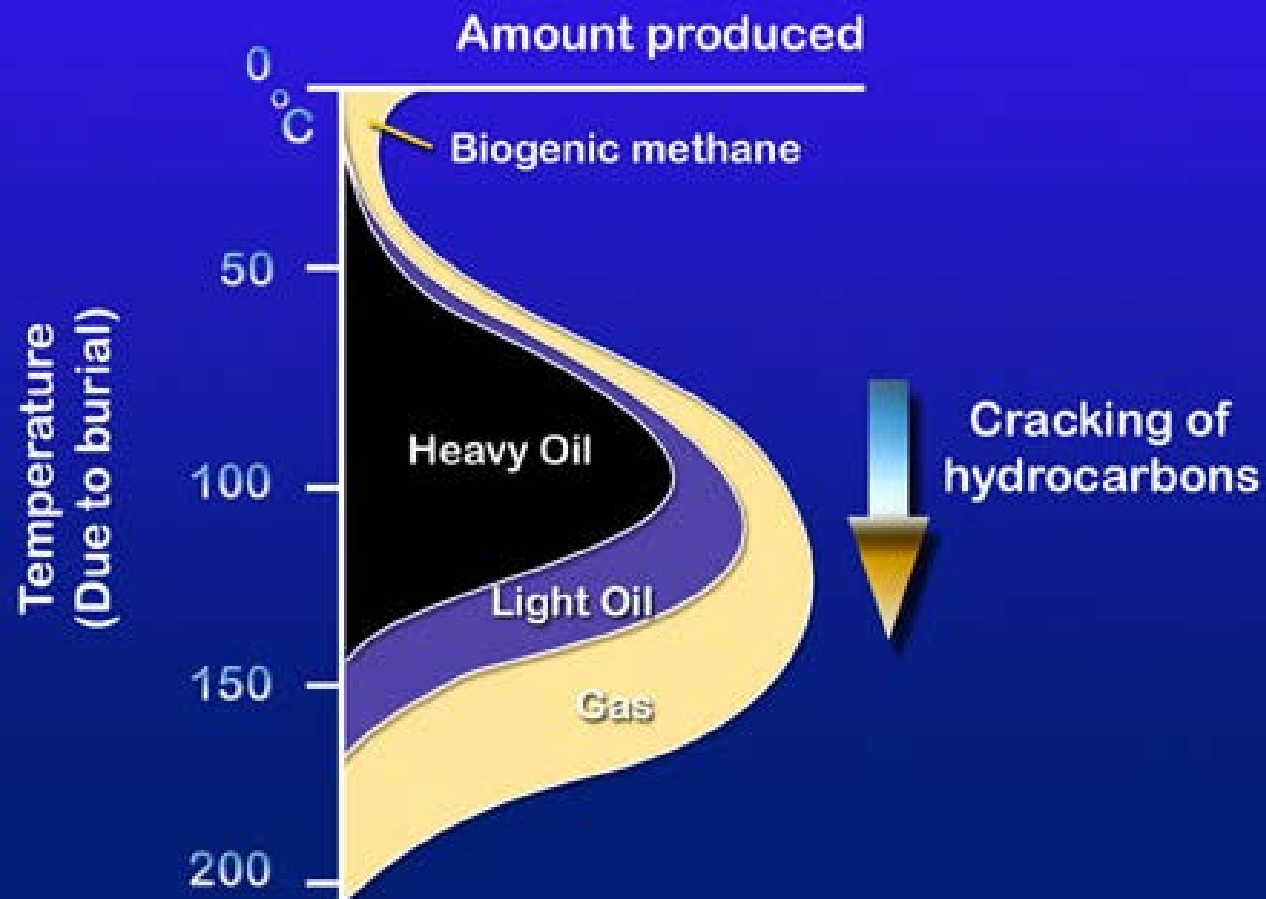
# SEDIMENTARY BASINS - PETROLEUM SYSTEMS RESERVES - RESOURCE ESTIMATES

- **Petroleum Systems – necessary components**
  - *High organic source rock & maturity*
  - *Migration pathway*
  - *Reservoir quality rock – sandstones, porosity, permeability*
  - *Sealing Rock (or ‘cap rock’)*
  - *Trap*
- **Reserves vs. Resource Estimates**

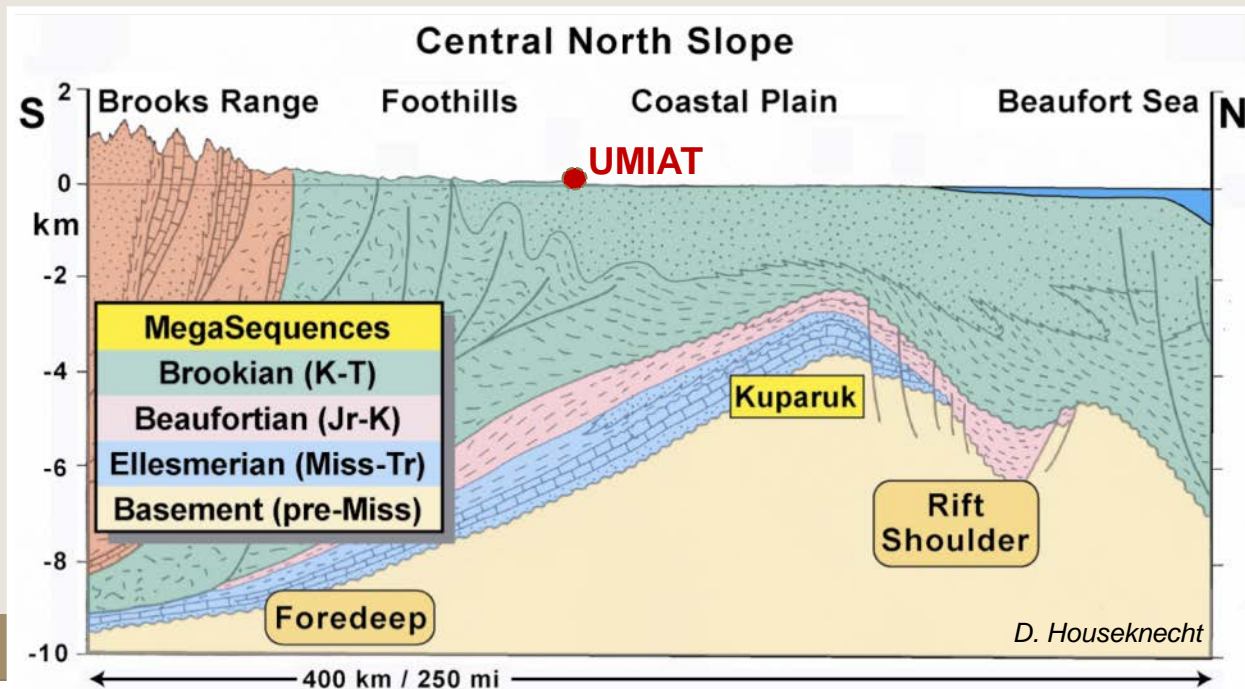
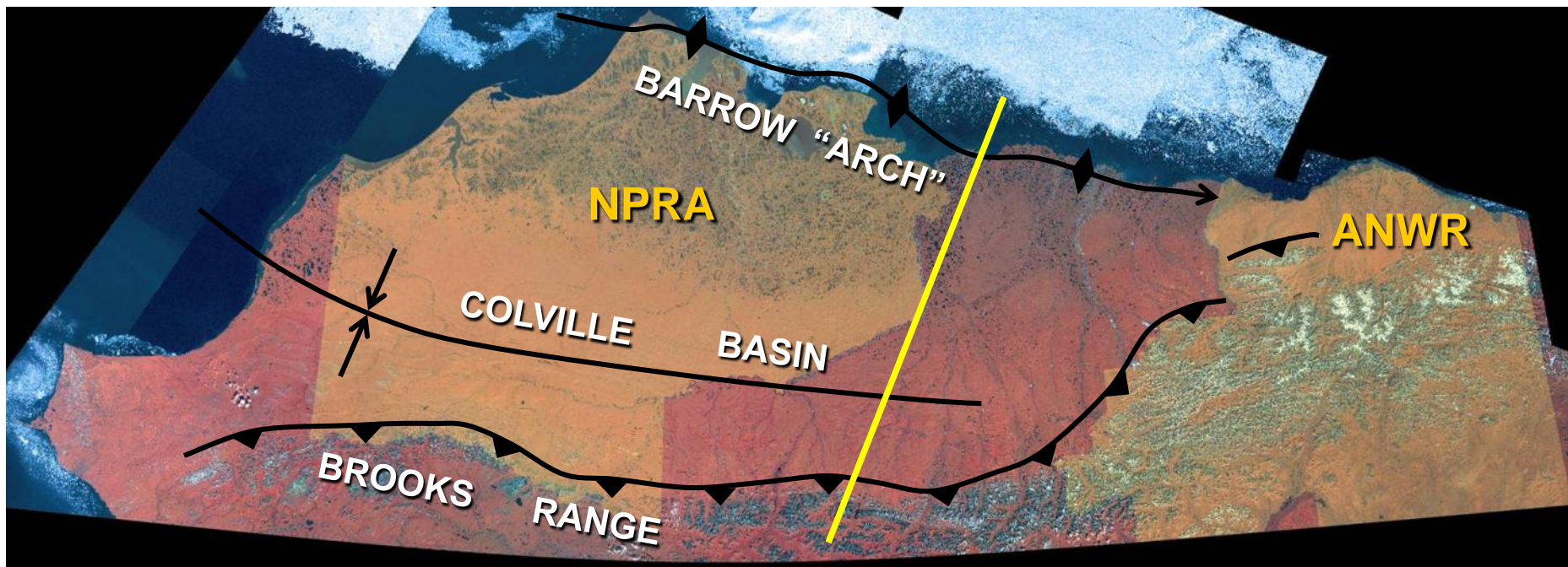
# Sedimentary Basins & Petroleum Geology

## 1. Source

### Hydrocarbon maturation

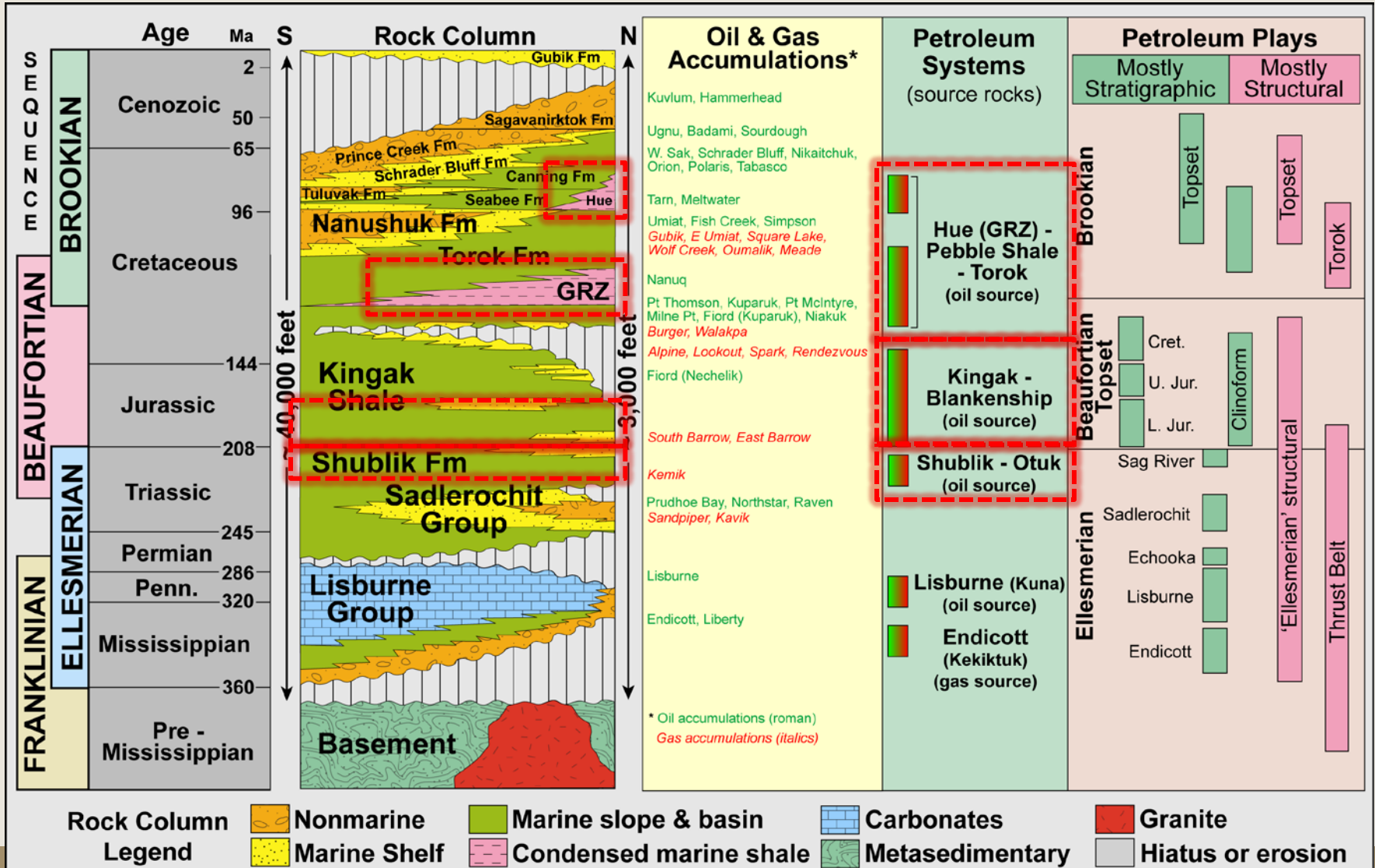






# North Slope Petroleum Systems

3 prolific source rock intervals



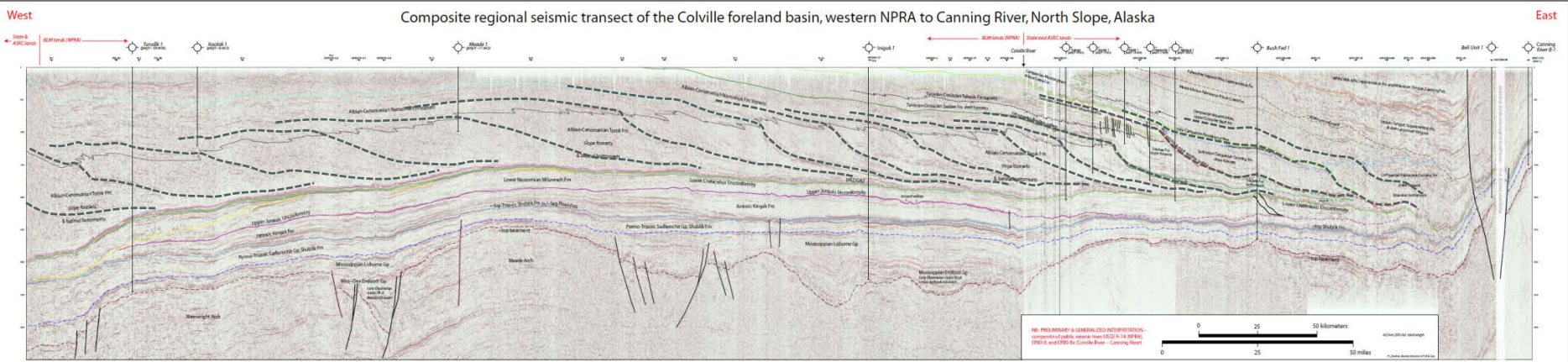
Modified by Alaska Division of Oil and Gas staff from Ken Bird and David Houseknecht (U.S. Geological Survey), personal communication, 2002



# West-East Seismic Transect

## Western NPRA-Colville River-Canning River/ANWR

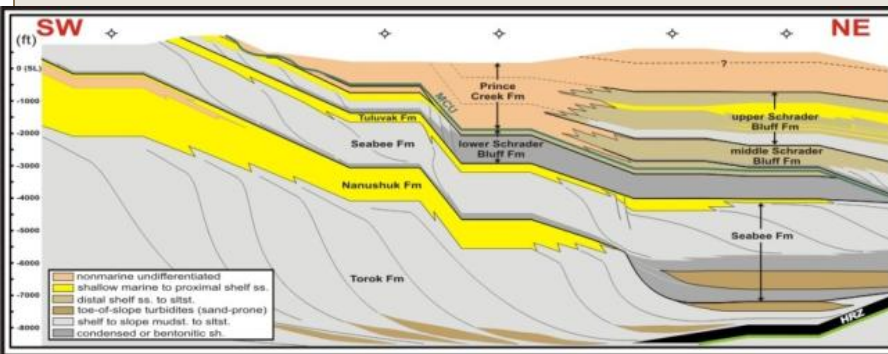
← NPRA → ← State Lands →



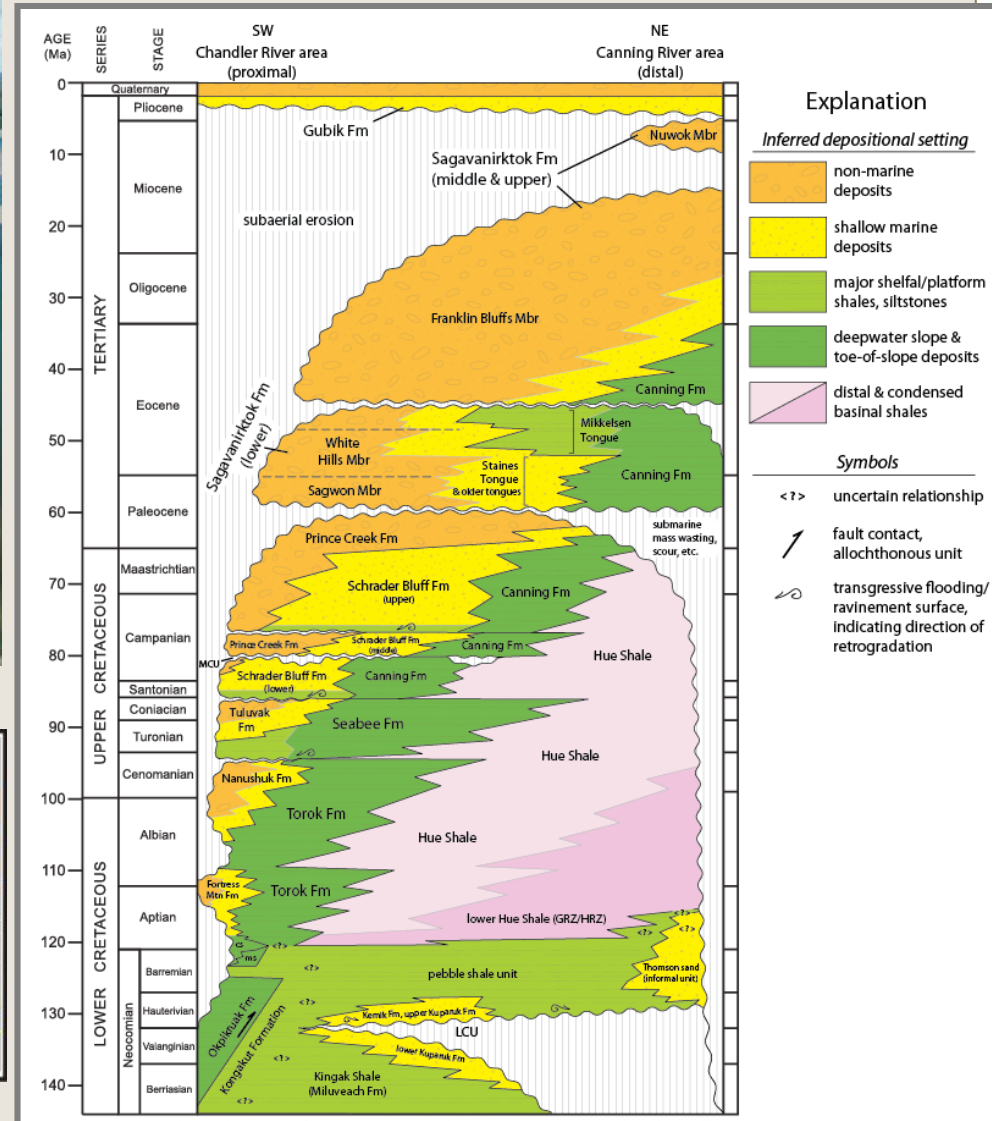
*pld, Alaska Division of Oil and Gas*

Eastward progradation of Brookian clinoforms drives source rock burial and maturation, ~110 – 50 Ma

# Colville Basin Stratigraphy



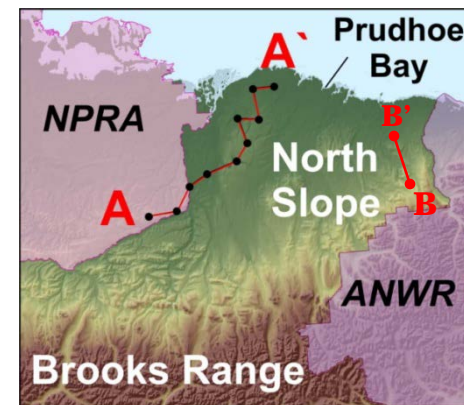
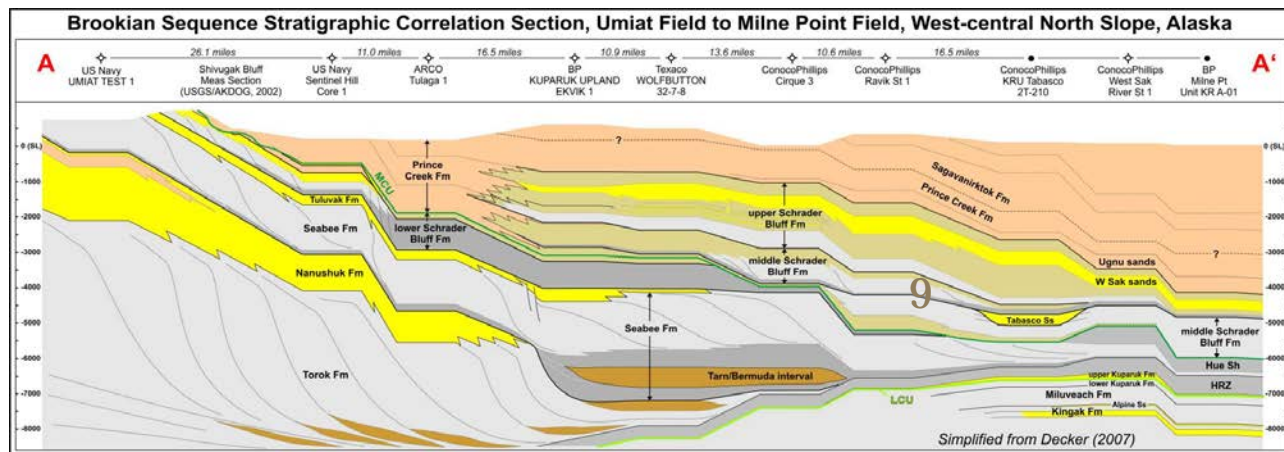
*Simplified from Decker (2007)*



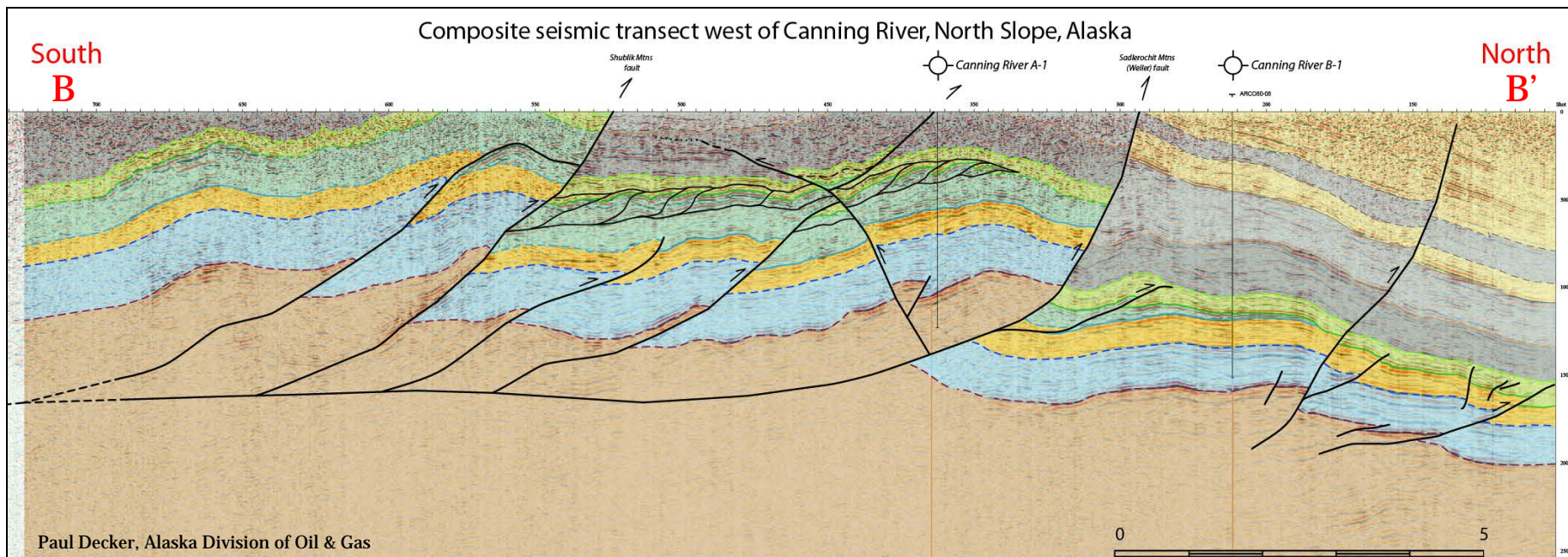
*Decker and Others (submitted)*



# Merging Surface and Subsurface Data

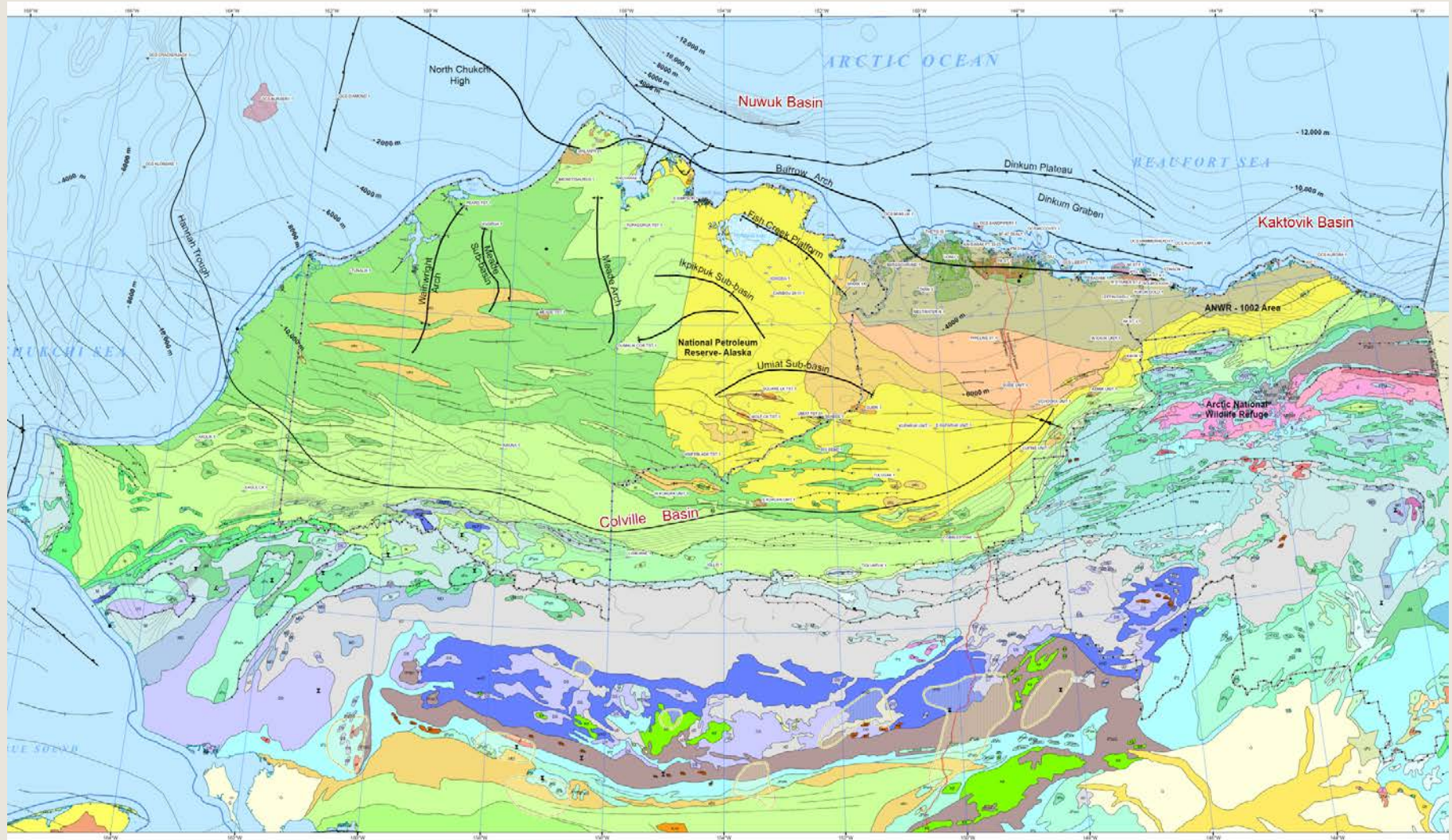


- nonmarine undifferentiated
- shallow marine to proximal shelf ss.
- distal shelf ss. to sltst.
- toe-of-slope turbidites (sand-prone)
- shelf to slope mudst. to sltst.
- condensed or bentonitic sh.



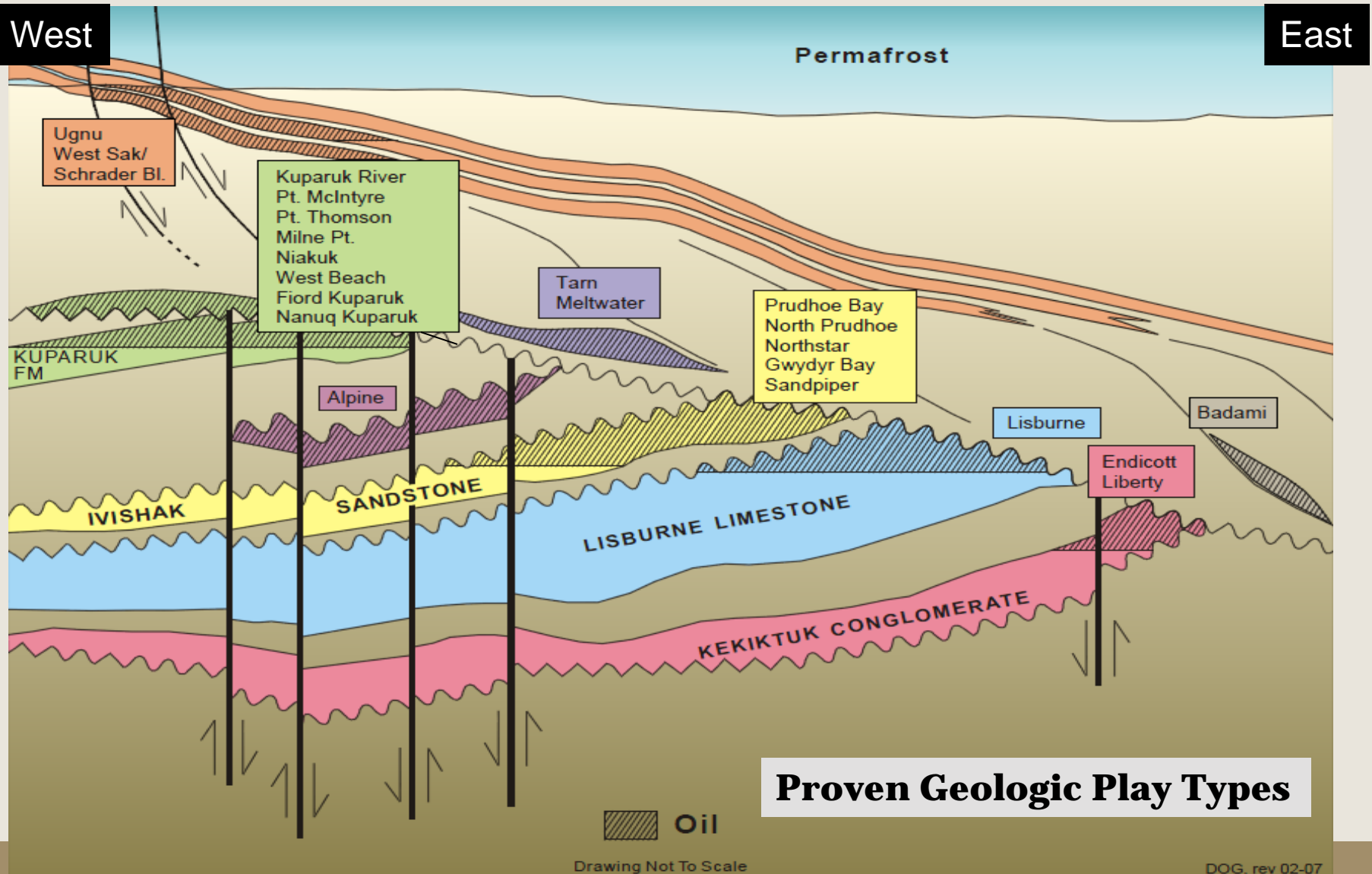


# North Slope Regional Geology

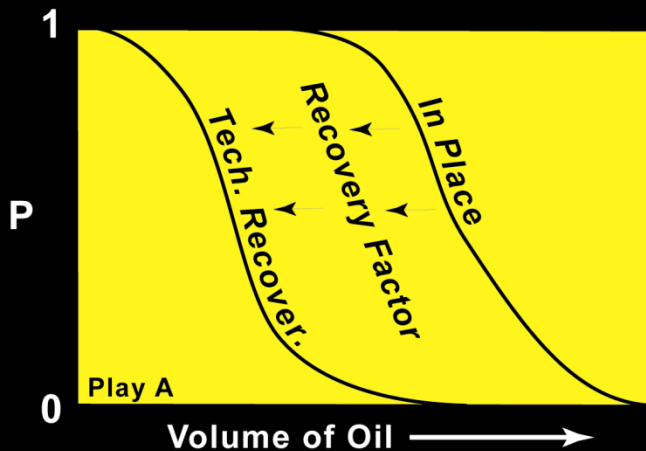
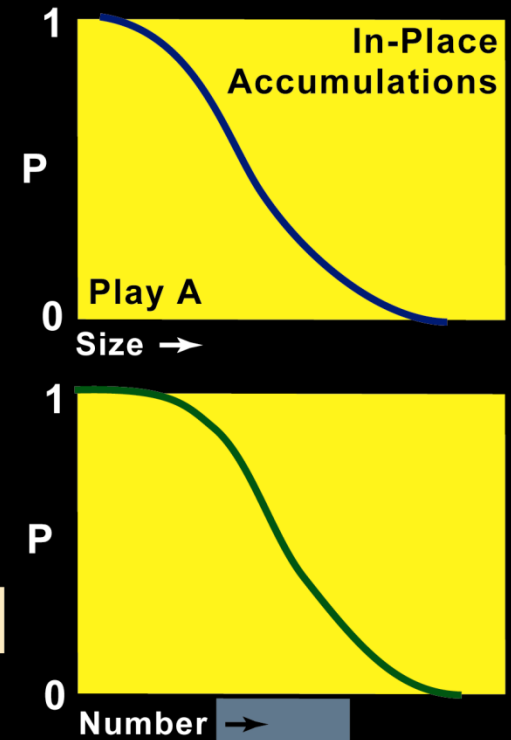
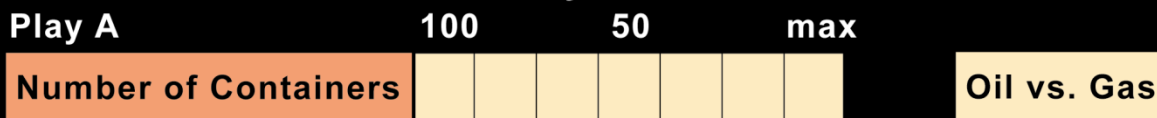
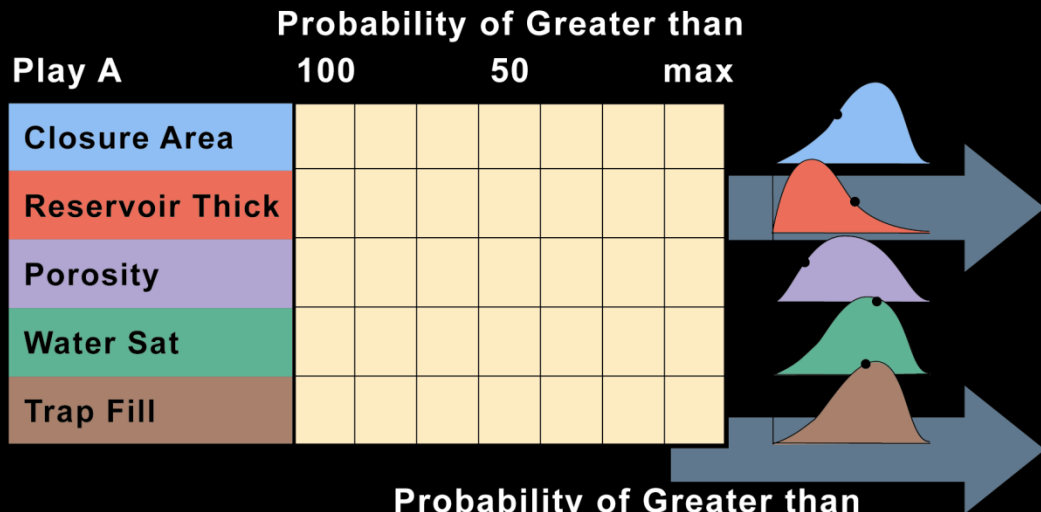


# Schematic Geologic Cross Section

## Central North Slope – Barrow Arch Province



# USGS Assessment Methodology – Geologic Basis



Prospect Risk

Charge	
Reservoir	
Trap	

Play Risk

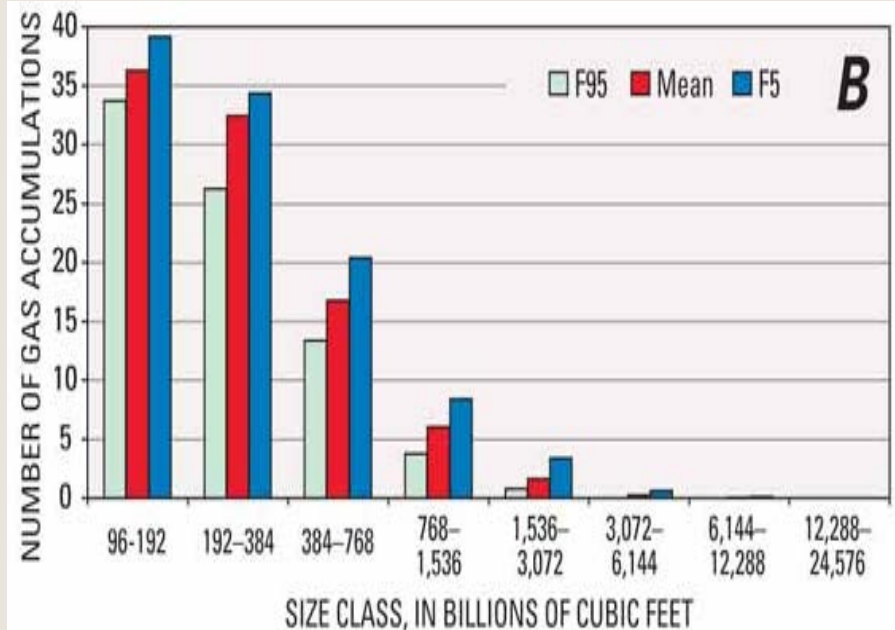
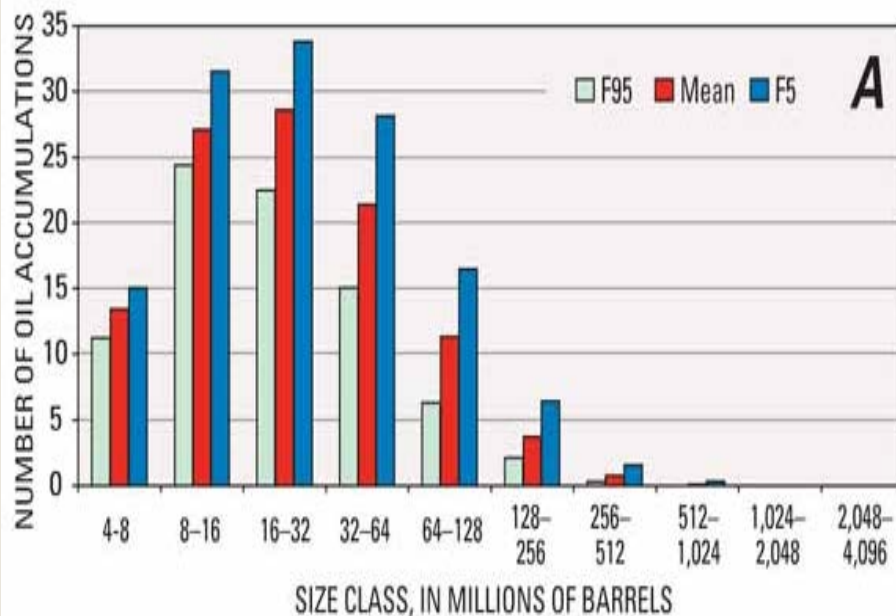
Charge	
Reservoir	
Trap	



# Undiscovered Mean Field Size Distributions - USGS

## State Land assessment area:

- ~ 1 undiscovered oil accumulation  
> 250 MMBO recoverable.
- ~ 2 undiscovered gas accumulations  
> 1.5 TCF recoverable.



# Current Federal Assessments

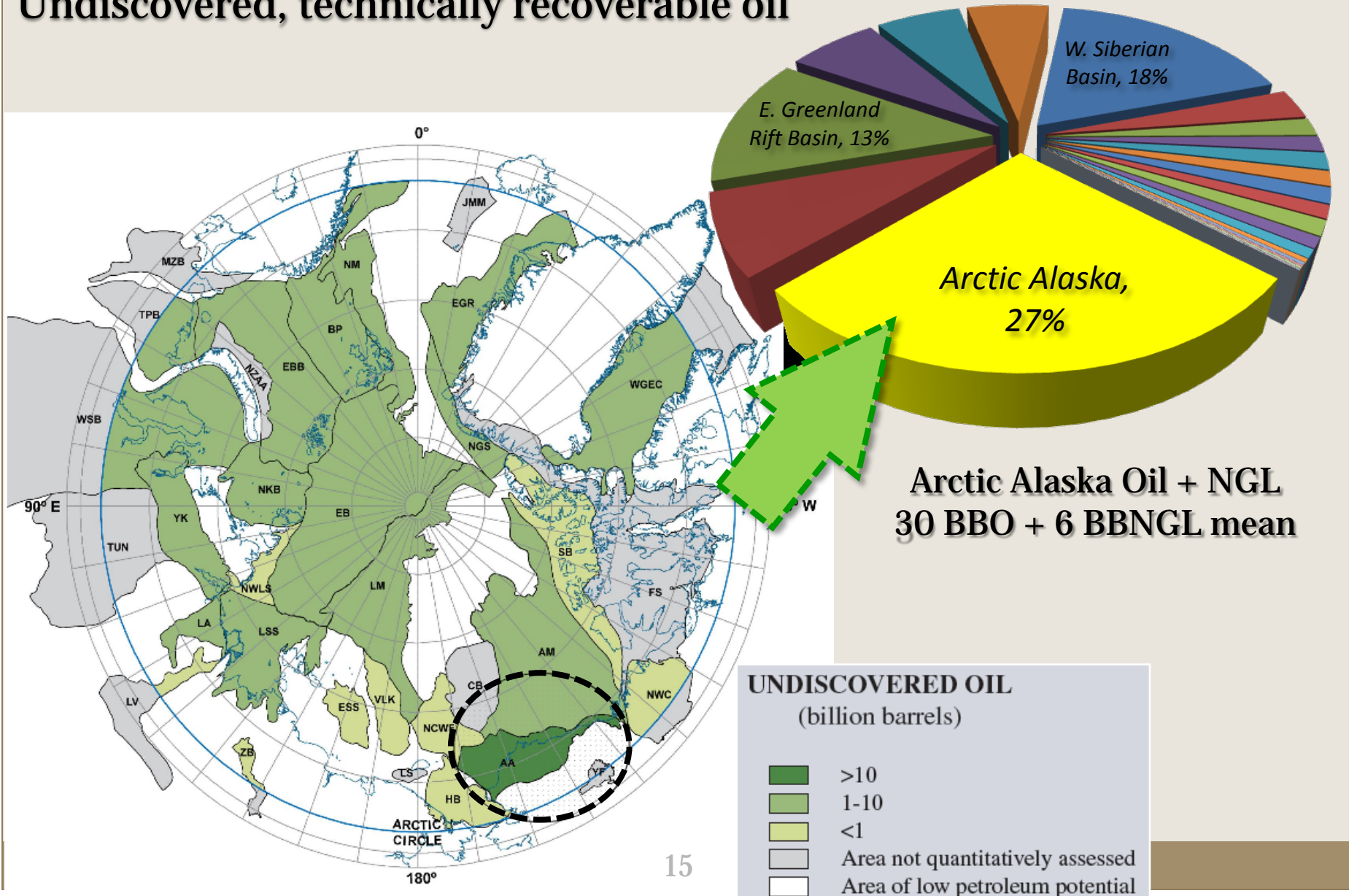
## Arctic Alaska Undiscovered, Technically Recoverable Conventional Oil and Gas

Region and Assessment Segment		Oil, MMSTB (million stock tank barrels)			Gas, BCF (billion cubic feet)		
		Probability Distribution			Probability Distribution		
North Slope Onshore & State Waters <sup>2</sup>		F95	Mean	F05	F95	Mean	F05
Central North Slope	<i>Oil &amp; Associated gas</i>	2,565	3,984	5,854	2,681	4,198	6,092
	<i>NGL &amp; Non-associated gas</i>	-- <sup>3</sup>	478	-- <sup>3</sup>	23,939	33,318	44,873
Nat'l Petrol Reserve Alaska	<i>Oil &amp; Associated gas</i>	--	896	--	--	--	--
	<i>NGL &amp; Non-associated gas</i>	-- <sup>3</sup>	--	-- <sup>3</sup>	--	52,839	--
ANWR coastal plain <sup>2</sup>	<i>Oil &amp; Associated gas</i>	5,724	10,360	15,955	--	4,764	--
	<i>NGL &amp; Non-associated gas</i>	-- <sup>3</sup>	190	-- <sup>3</sup>	0	3,841	10,852
total - North Slope Onshore		-- <sup>3</sup>	15,908	-- <sup>3</sup>	-- <sup>3</sup>	98,960	-- <sup>3</sup>
Arctic Alaska Outer Continental Shelf (OCS)							
Chukchi Shelf	<i>Oil &amp; all gas</i>	2,317	15,380	40,075	10,316	76,772	209,527
Beaufort Shelf	<i>Oil &amp; all gas</i>	412	8,224	23,235	649	27,645	72,178
Hope Basin	<i>Oil &amp; all gas</i>	0	150	600	0	3,770	14,980
total - Arctic OCS (offshore)		6,030	23,754	53,170	27,830	108,187	247,190
TOTAL - Arctic Alaska		-- <sup>3</sup>	39,662	-- <sup>3</sup>	-- <sup>3</sup>	207,147	-- <sup>3</sup>



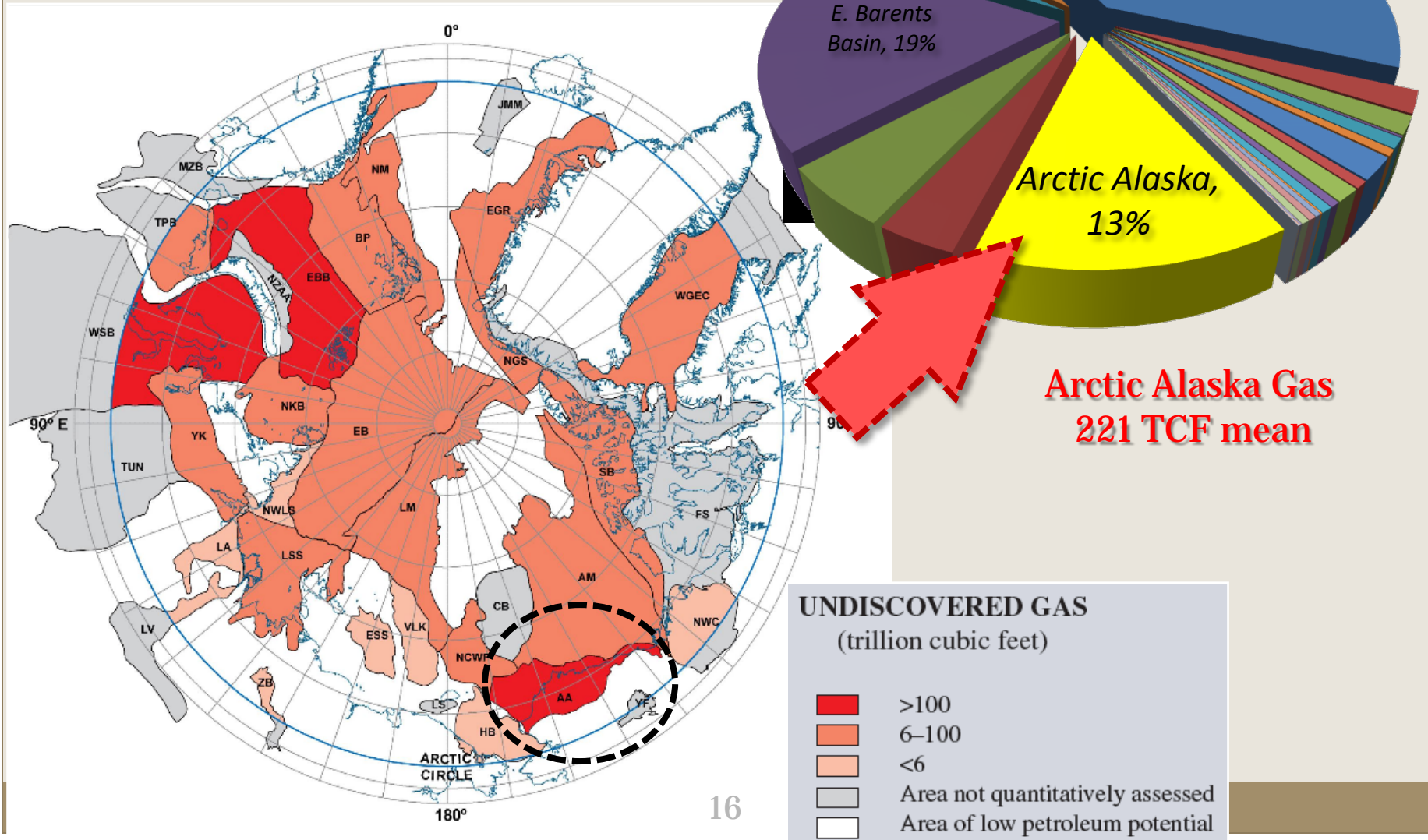
# USGS Circum-Arctic Resource Appraisal

Undiscovered, technically recoverable oil

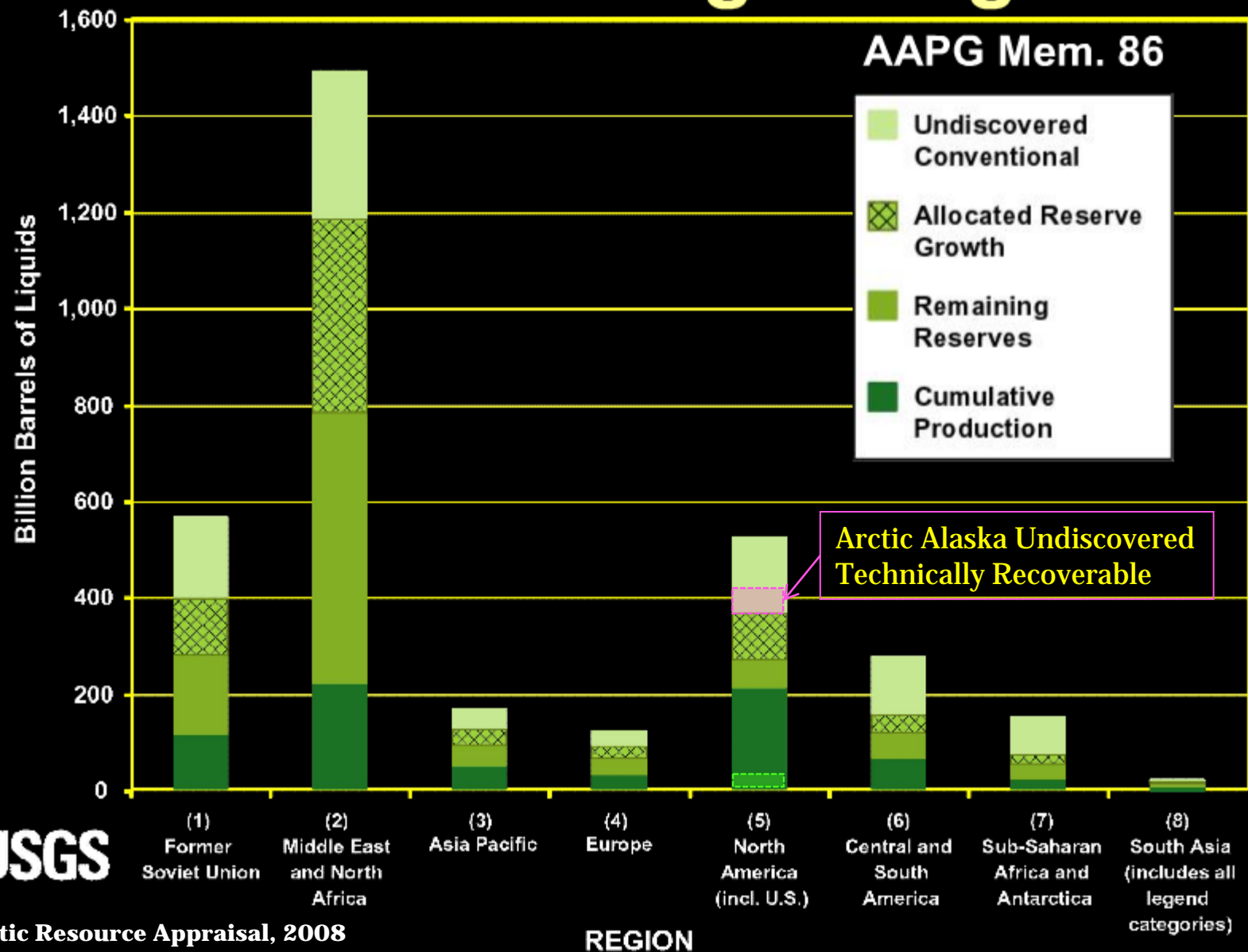


# USGS Circum-Arctic Resource Appraisal

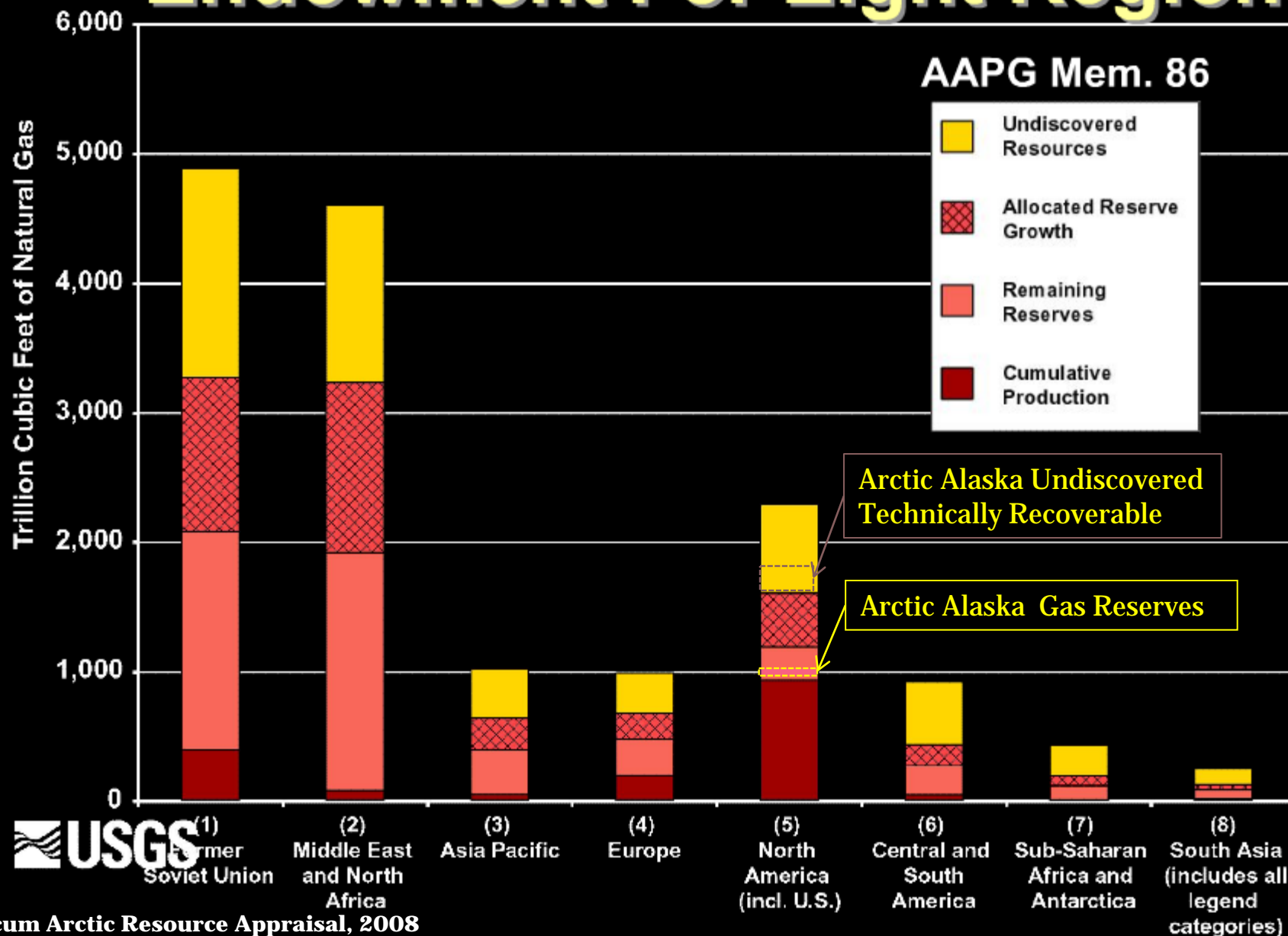
## Undiscovered, technically recoverable gas



# Conventional Liquid (Oil and NGL) Endowment for Eight Regions



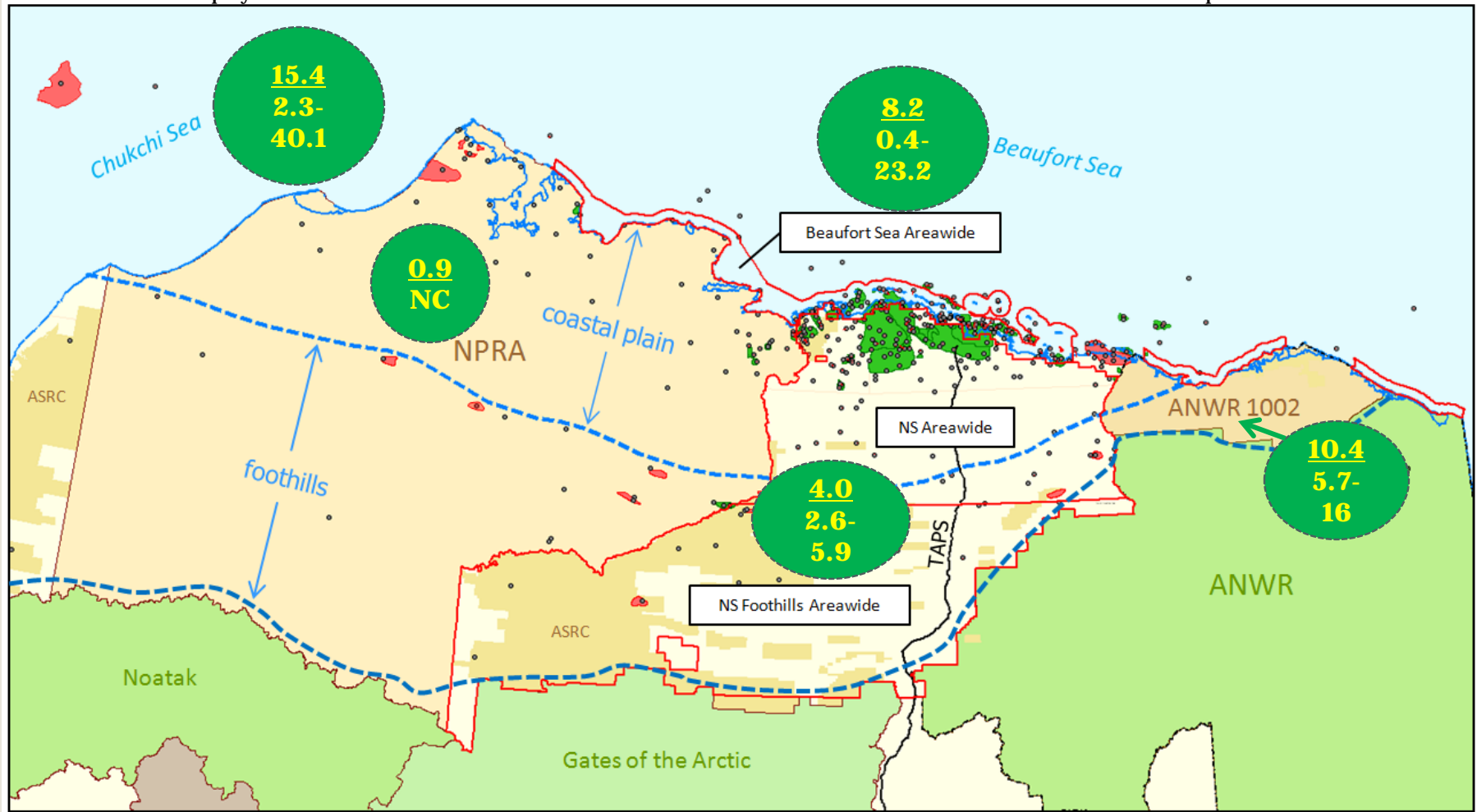
# Conventional Natural Gas Endowment For Eight Regions





# Undiscovered Oil Potential in Arctic Alaska

The North Slope region contains more than 150,000 square miles of land with high oil and gas potential. The green ovals represent the latest statistical estimates for technically recoverable conventional oil as determined by Federal agencies. These estimates do not include unconventional resource plays such as shale oil and have not been screened for economics. Small dots are locations of historic exploration wells.



- OCS estimates includes crude oil & natural gas liquids
- Data from MMS 2006; Alaska OCS assessment
- Onshore includes crude oil only
- Data from USGS assessments, 1999 -2011

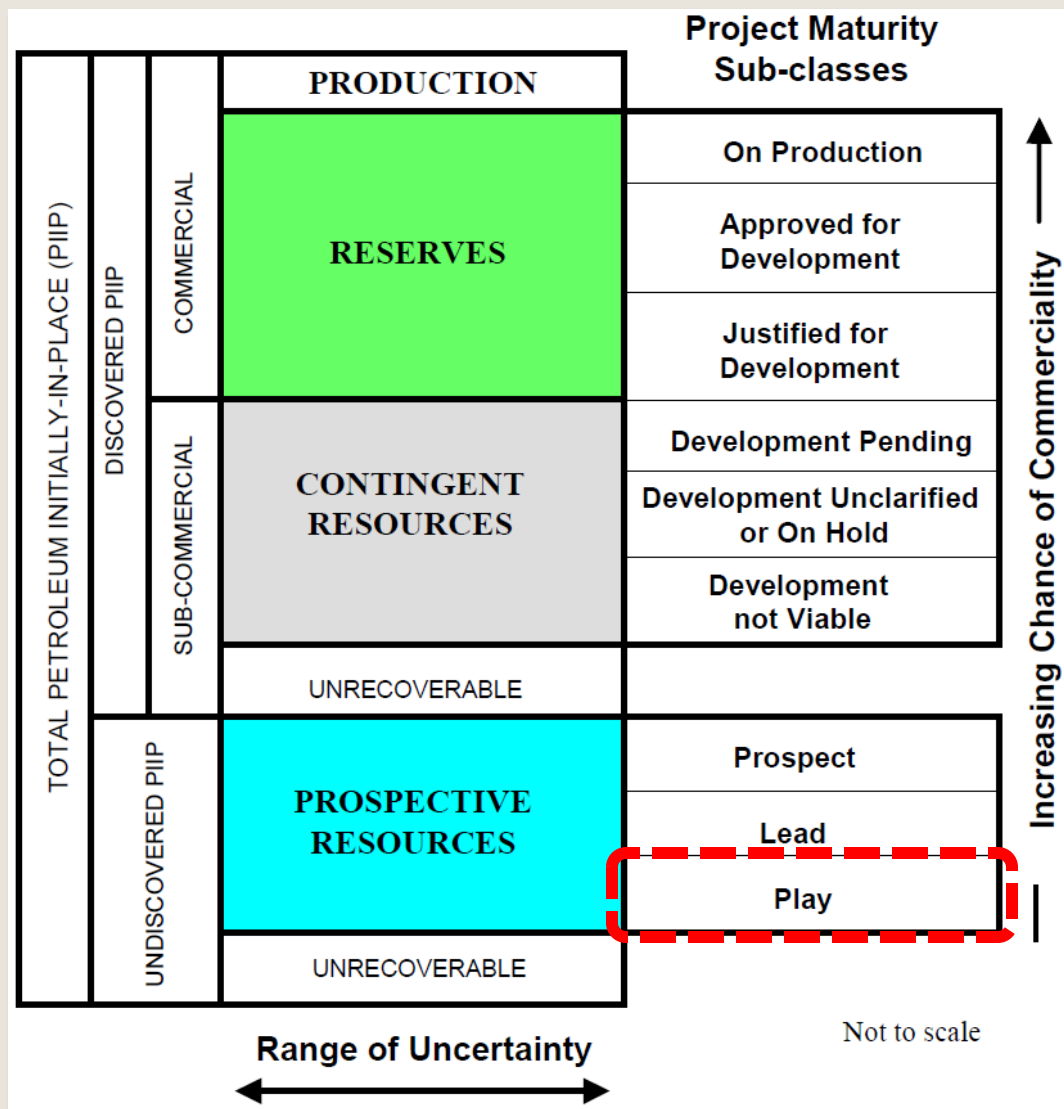
**Mean  
Range**

**Statistical Estimates for Technically Recoverable  
Undiscovered Conventional Oil in Arctic Alaska  
Billions of Barrels**

\* Does not include estimates of shale oil plays



# Petroleum Reserves & Resource Definitions



# The Resource Development Chain

Development



Geology

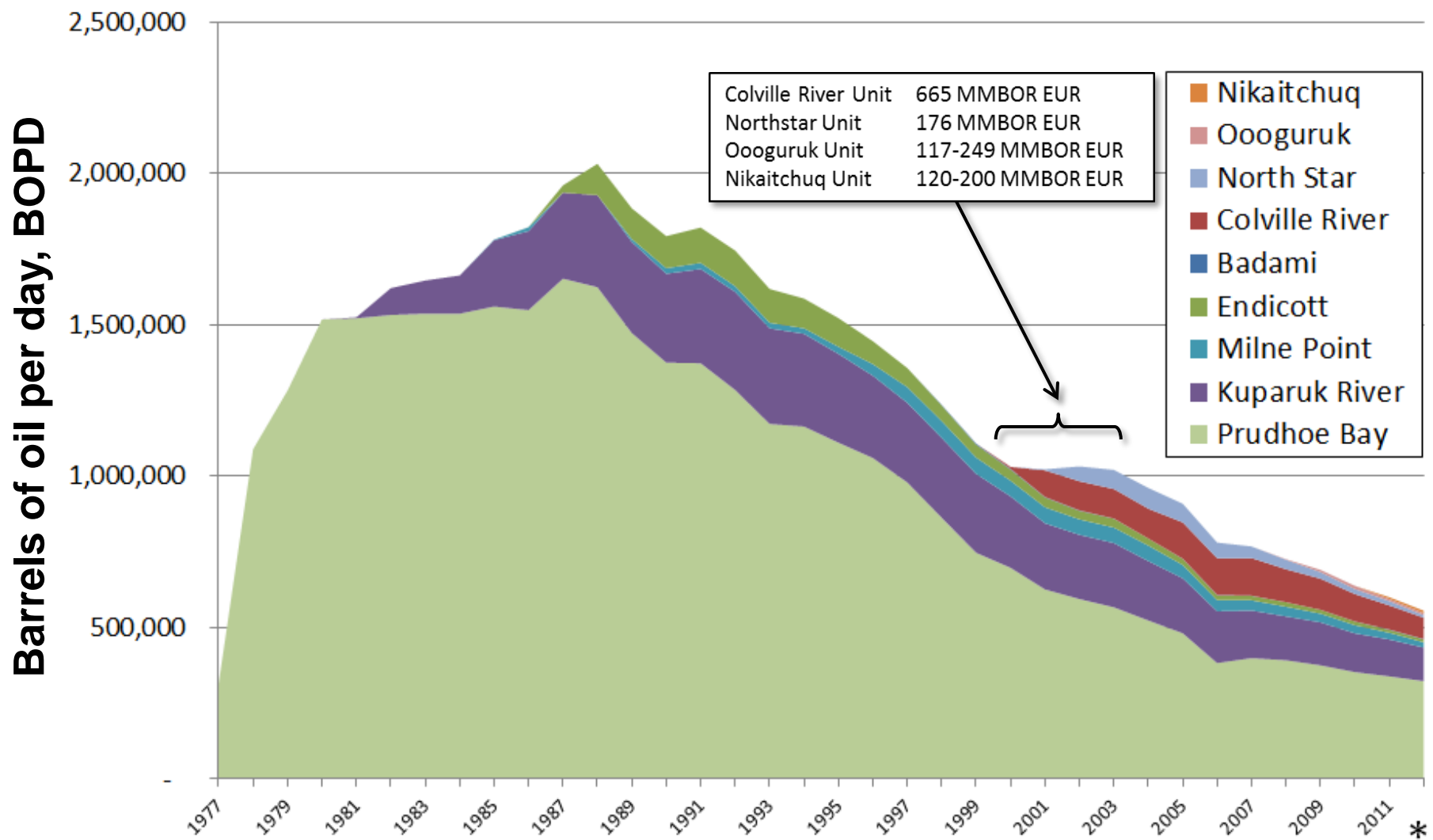
# Northern Alaska Reserves and Resources

## Presentation Outline

- Production to date
- Reserves Estimates
- Discovered Resources
- Undiscovered Resources
- Unconventional Resource Potential

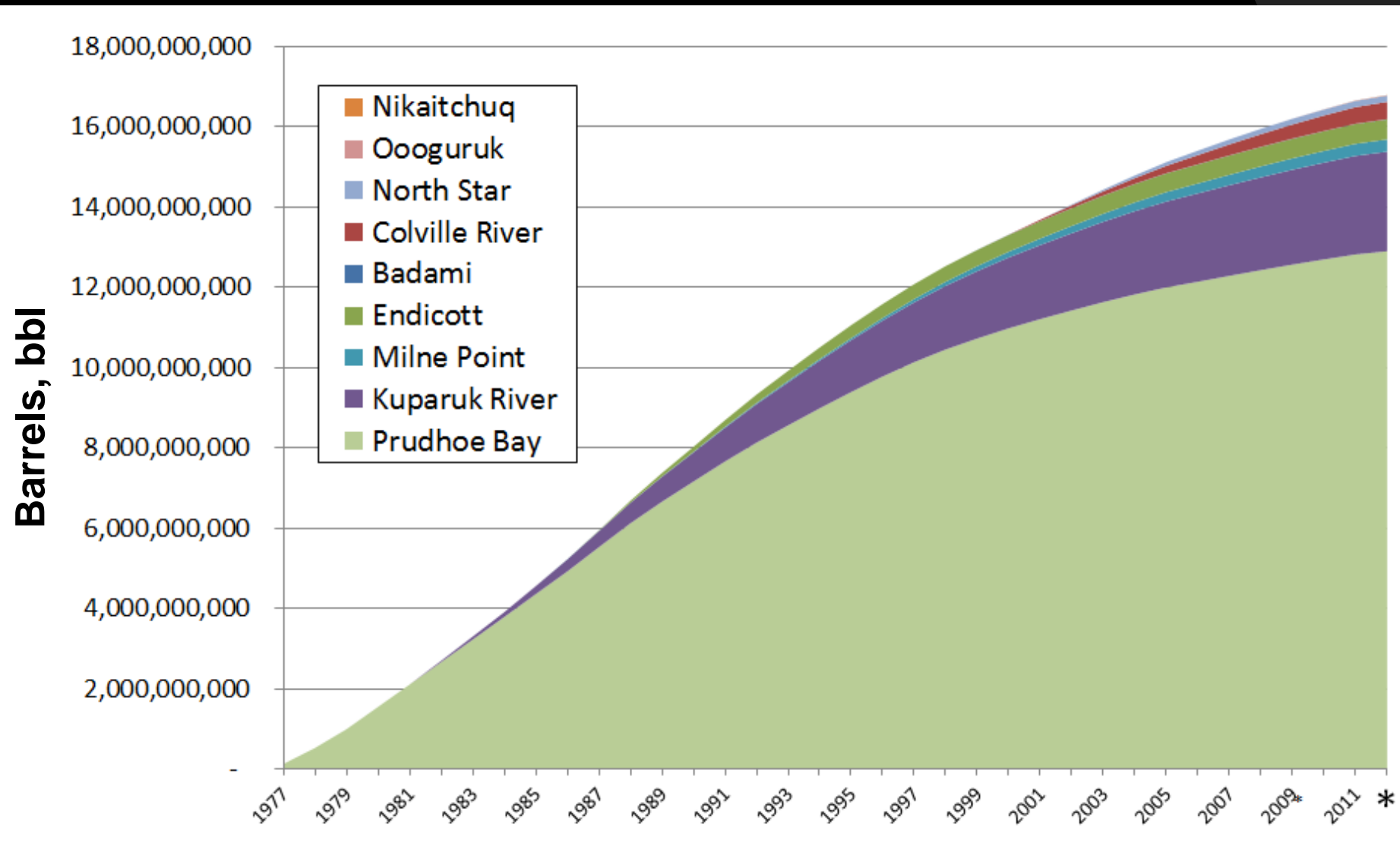
# Oil Production History by Unit

## North Slope fields



# Cumulative Oil Production by Unit

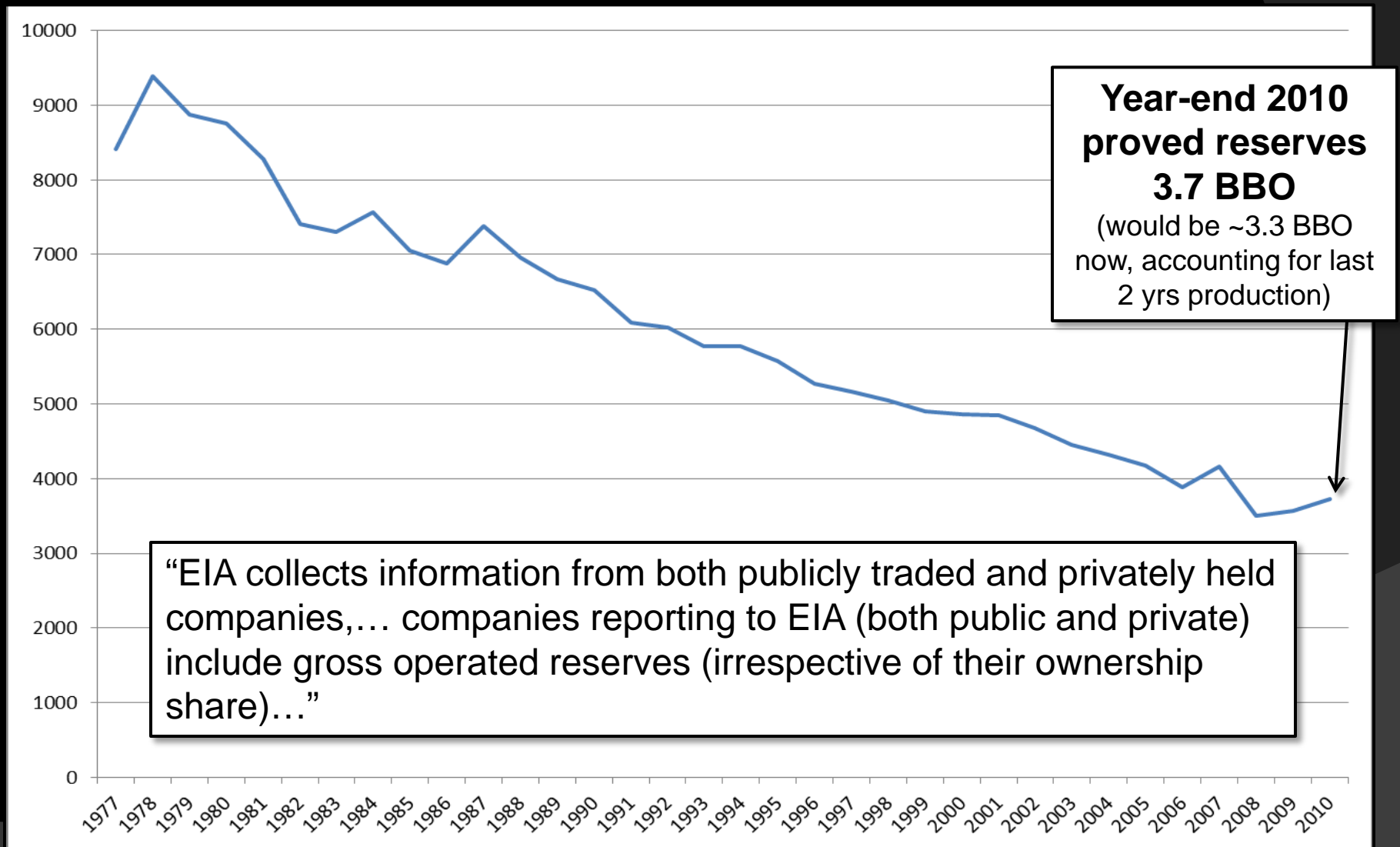
## North Slope fields





# Alaska Crude Oil Proved Reserves

Energy Information Administration, latest available data (2010)



# North Slope Oil Decline and Reserves

## Estimates and Sensitivities (Preliminary)

- Remaining calculated North Slope oil reserves based upon average annual decline rates from 5.17% to 7.43%:

**~2.05 - 3.24 Billion barrels remaining reserves**

*Assumes a minimum TAPS flow rate of 100,000 barrels per day*

- Potential impact of average rate of decline as above:

**~1.19 Billion barrels recoverable reserves**

- Potential range of impact of changing TAPS minimum throughput by +/- 30% (70K, 100K, 130K barrels per day) for the above decline cases\*:

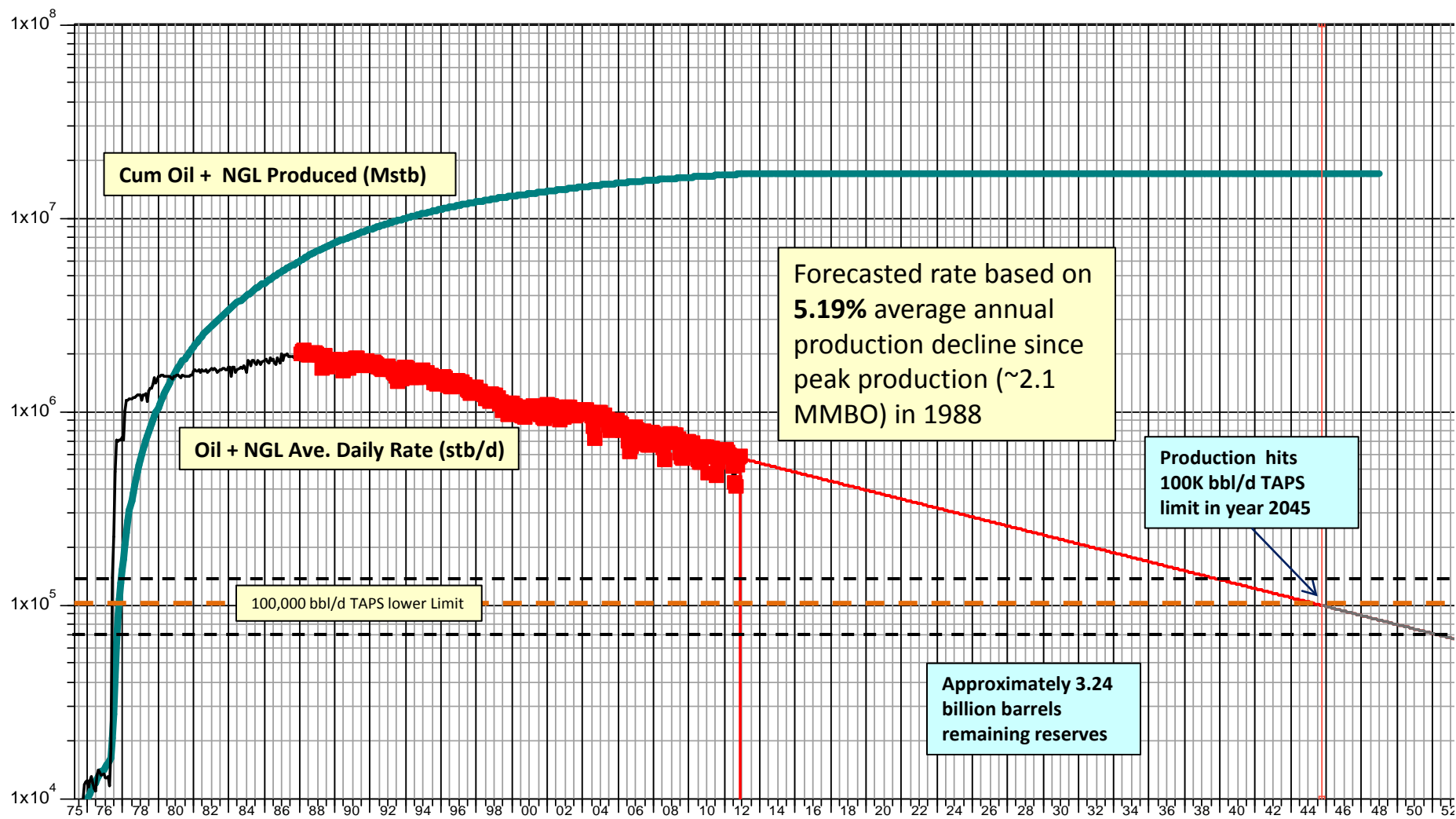
**~282 to 412 Million barrels**

*\* For the high decline rate (7.43%) case the absolute range of impact due to changing TAPS low-flow rate is 282 MMBO.*

*For the low decline case (5.19%) the absolute range is 412 MMBO.*

# North Slope Oil + NGL Production

Forecast based on decline rate since 1988

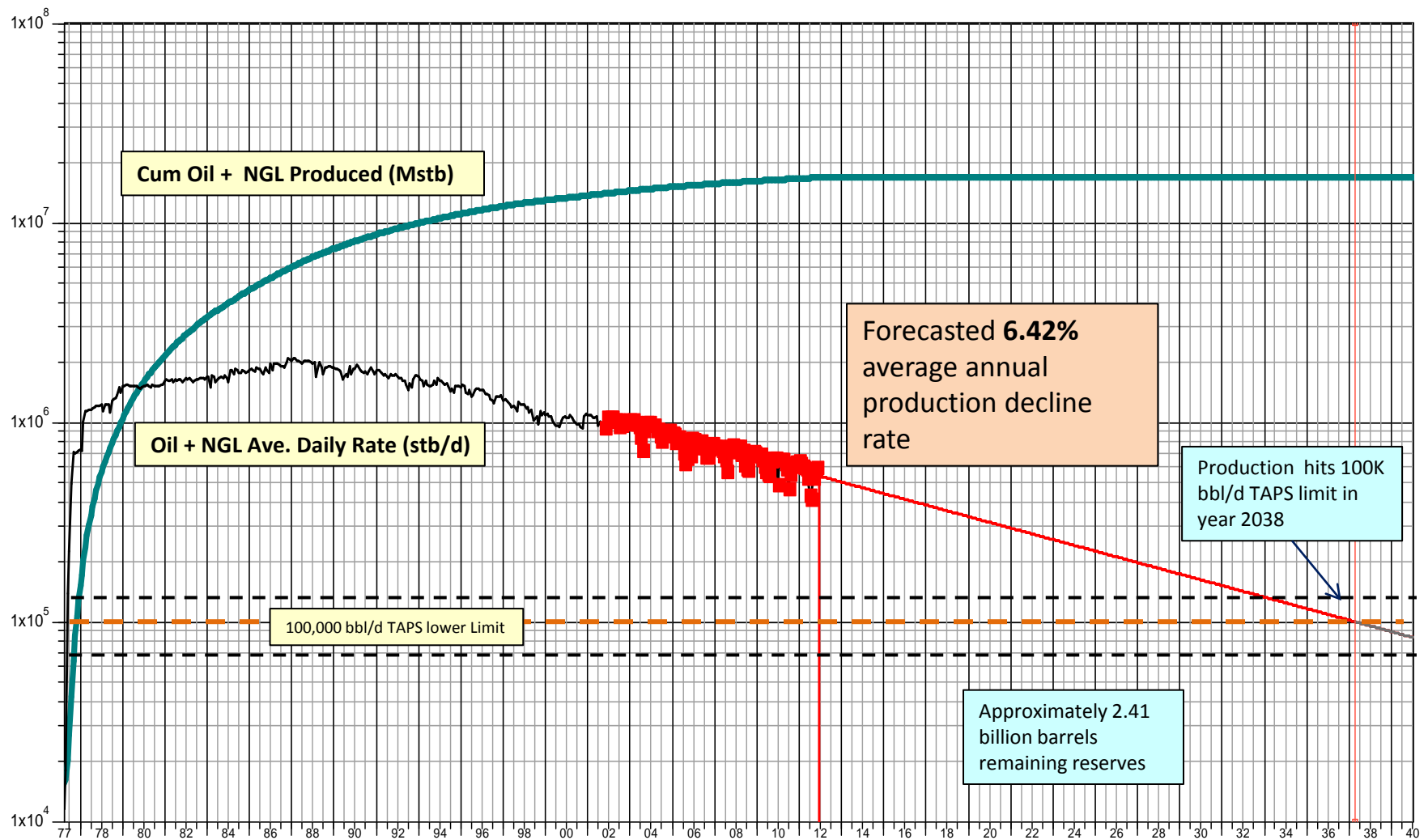


Rate Stream	CDOil_Ngl	Forecast Decline	5.19 %	Forecast Years	32.8
Cum Stream	CumOil_Ngl	Beginning Date	12/1/2012 00:00	Cumulative, STB	16846879770
Fit Type	Exponential, 0	Beginning Rate, STBD	571645	Remaining, STB	3235264159
Fit Decline	5.19 %	Ending Date	9/30/2045 00:29	Ultimate, STB	20082143929
Forecast Type	Exponential, 0	Ending Rate, STBD	99252		



# North Slope Oil + NGL Production

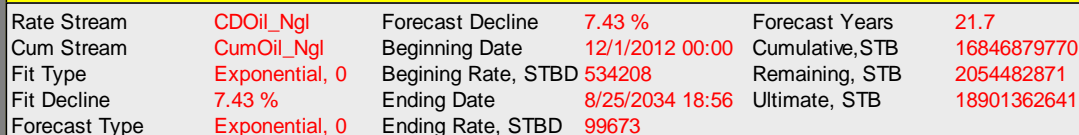
Forecast based on decline rate since 2002



Rate Stream	CDOil_Ngl	Forecast Decline	6.42 %	Forecast Years	25.4
Cum Stream	CumOil_Ngl	Beginning Date	12/1/2012 00:00	Cumulative, STB	16846879770
Fit Type	Exponential, 0	Beginning Rate, STBD	538773	Remaining, STB	2414209357
Fit Decline	6.42 %	Ending Date	4/16/2038 07:59	Ultimate, STB	19261089127
Forecast Type	Exponential, 0	Ending Rate, STBD	99971		

Alaska Division of Oil and Gas, Jan 2013

## Forecast based on decline rate since 2009

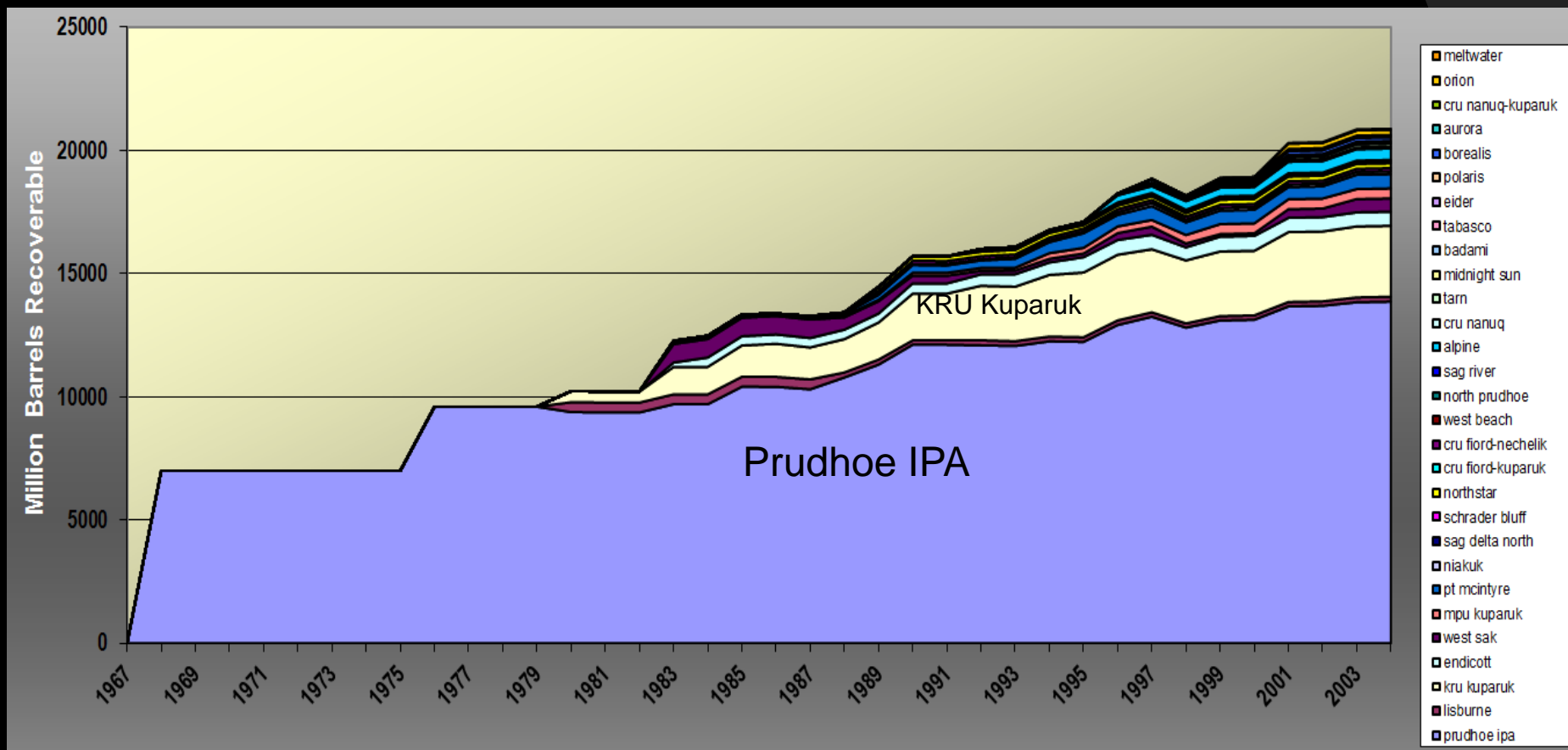


Alaska Division of Oil and Gas, Jan 2013

# Reserves Growth by Reservoir

## North Slope Pools/PAs

Hartz and others, 2007



Estimates of recoverable oil increase over time for most reservoirs as new development investments are made



# Viscous and Heavy Oil

Estimated total resource breakdown

<u>Resource Category</u>	<u>Resource, barrels</u>
<b>Total in-place resource</b> <i>(Hartz and others, 2007 + AOGCC)</i>	<b>24 – 37 billion</b>
<b>Potential economically recoverable</b> <i>(assuming 15% average recovery of all in-place resource)</i>	<b>3.6 – 5.6 billion</b>
<b>EUR, 6 areas under active development</b>	<b>~ 1.1 billion</b>

# Viscous and Heavy Oil

Estimated recoverable in areas under development

## Kuparuk River Unit

- KRU West Sak PA 541 million barrels
- KRU Tabasco PA 23 million barrels

## Milne Point Unit

- MPU Schrader Bluff PA 117 million barrels

## Prudhoe Bay Unit

- PBU Orion PA 209 million barrels
- PBU Polaris PA 48 million barrels

## Nikaitsuq Unit

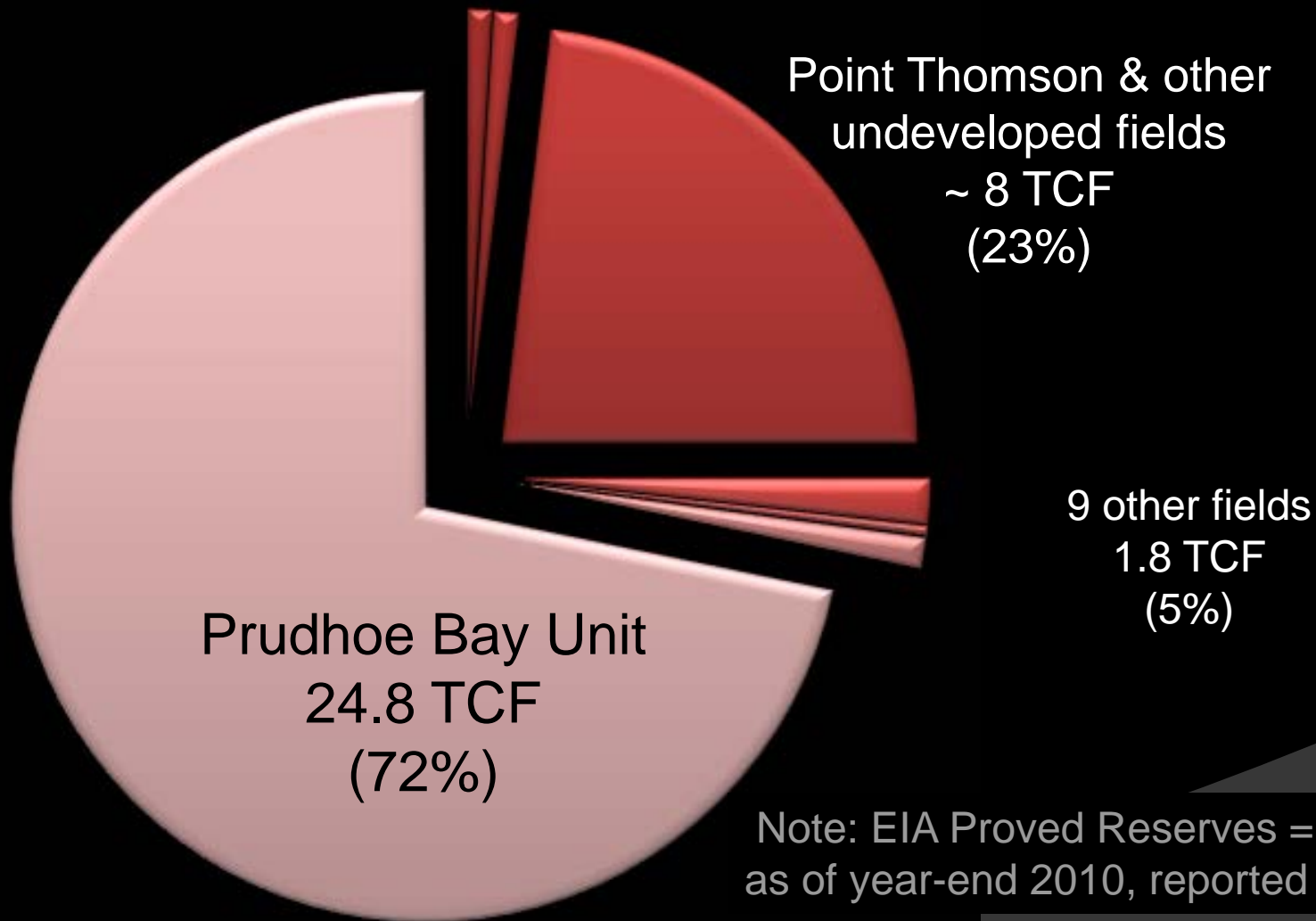
- NU Schrader Bluff PA 120-200 million barrels

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TOTAL EUR in these developments ~ 1.1 billion barrels

# Northern Alaska Discovered Gas

35 TCF in existing fields awaiting transportation infrastructure





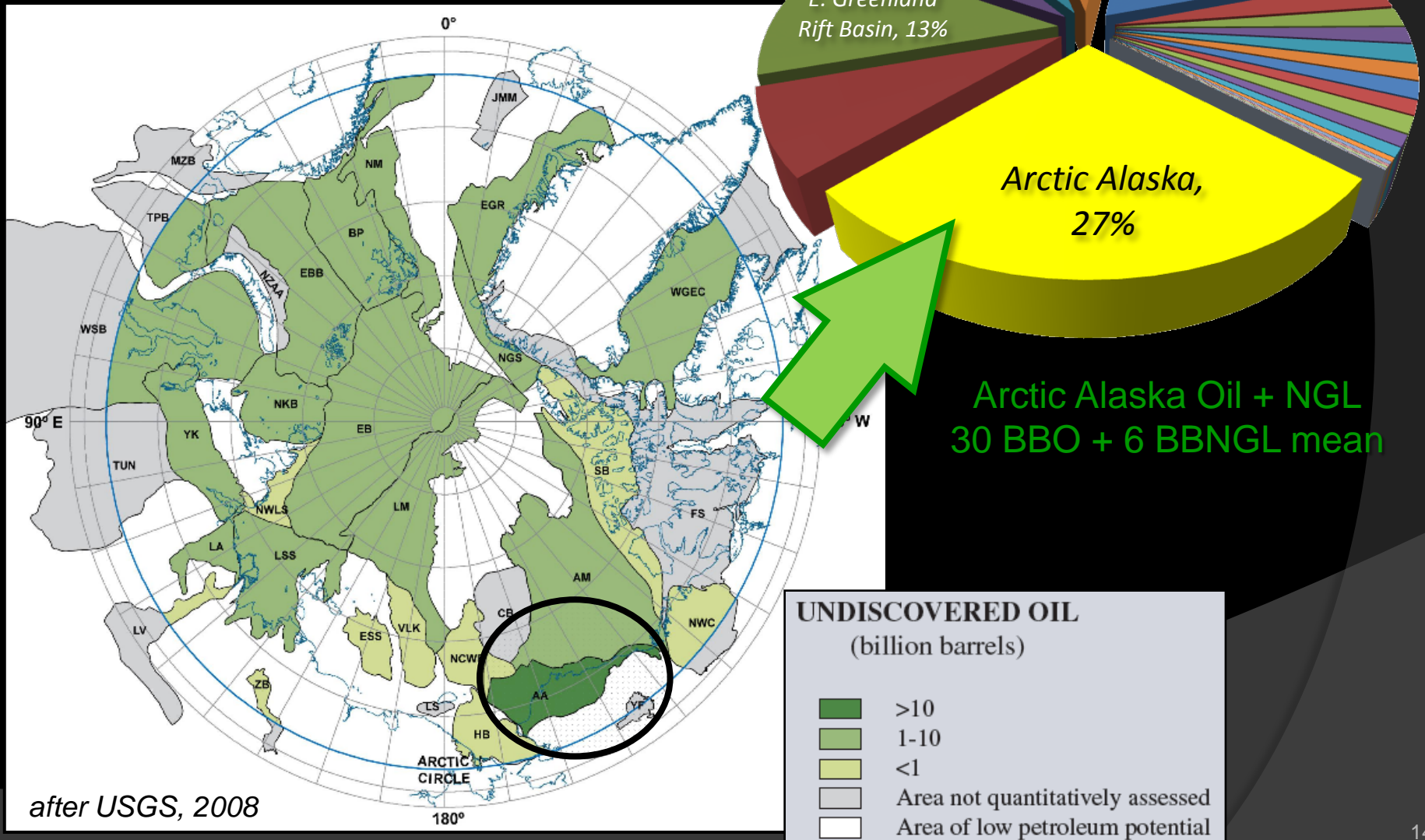
# Undeveloped Discoveries

Table 2.8. North Slope, Alaska—Undeveloped oil and gas accumulations as of January 1, 2005 (after Bird, 1991 and Thomas, and others, 1991 and 1993)

Accumulation or Field/ Reservoir Formation(s)	Year of Discovery	Estimated Technically Recoverable Resources
1. Burger—gas and con	1946	70 MMBO, 50 BCF
2. East Kurupa—gas (N	1949	OIL (? MMBO)
3. East Umiat—gas (Nat	1950	12 MMBO
4. Fish Creek—oil (NPR	1950	20 BCF
5. Gubik—gas (Native la	1951	GAS (? BCF)
6. Gwydyr Bay—oil (Sta	1951	600 BCF
7. Hammerhead—oil (Fed	1951	58 BCF
8. Hemi Springs—oil (Sta	1952	4 BCF
9. Kalubik—oil (State off	1964	115 BCF
10. Kavik—gas (State onsh	1969	30-60 MMBO
11. Kemik—gas (State onsh	1969	100 + BCF
12. Kuvlum—oil (Federal of	1972	OIL (? MMBO)
13. Liberty—oil (Federal off	1975	GAS (? BCF)
14. Meade—gas (NPRA)	1976	300 MMBO, 5000 BCF
15. Mikkleson—oil (State on	1977	OIL (? MMBO)
16. Mooses Tooth—oil (NPR	1978	150 MMBO
17. Rendezvous—oil (NPRA)	1982	OIL (?MMBO)
18. Sandpiper—gas and conde	1984	~200 MMBO
19. Sikulik—gas (Native lands	1985	150 MMBO/GAS (? BCF)
20. Simpson—oil (NPRA)	1986	16 BCF
21. Square Lake—gas (NPRA)	1988	OIL (? MMBO)
22. Stinson—oil (State offshore)	1990	14,000 BCF, 724 MMBO
23. Umiat—oil (NPRA)	1990	400 MMBO
24. Wolf Creek—gas (NPRA)	1993	OIL (? MMBO)
	1993	~100 MMBO
	1994	OIL (? MMBO)
	1997	19 MMBO(?)
	1997	70 MMBO(?)
	2003	70 MMBO(?)
	2004	OIL (?MMBO)
	2005	2,300 + MMBO/ 20,000 + BCF
<b>Total</b>	<i>Thomas and others, 2007</i>	

# USGS Circum-Arctic Resource Appraisal

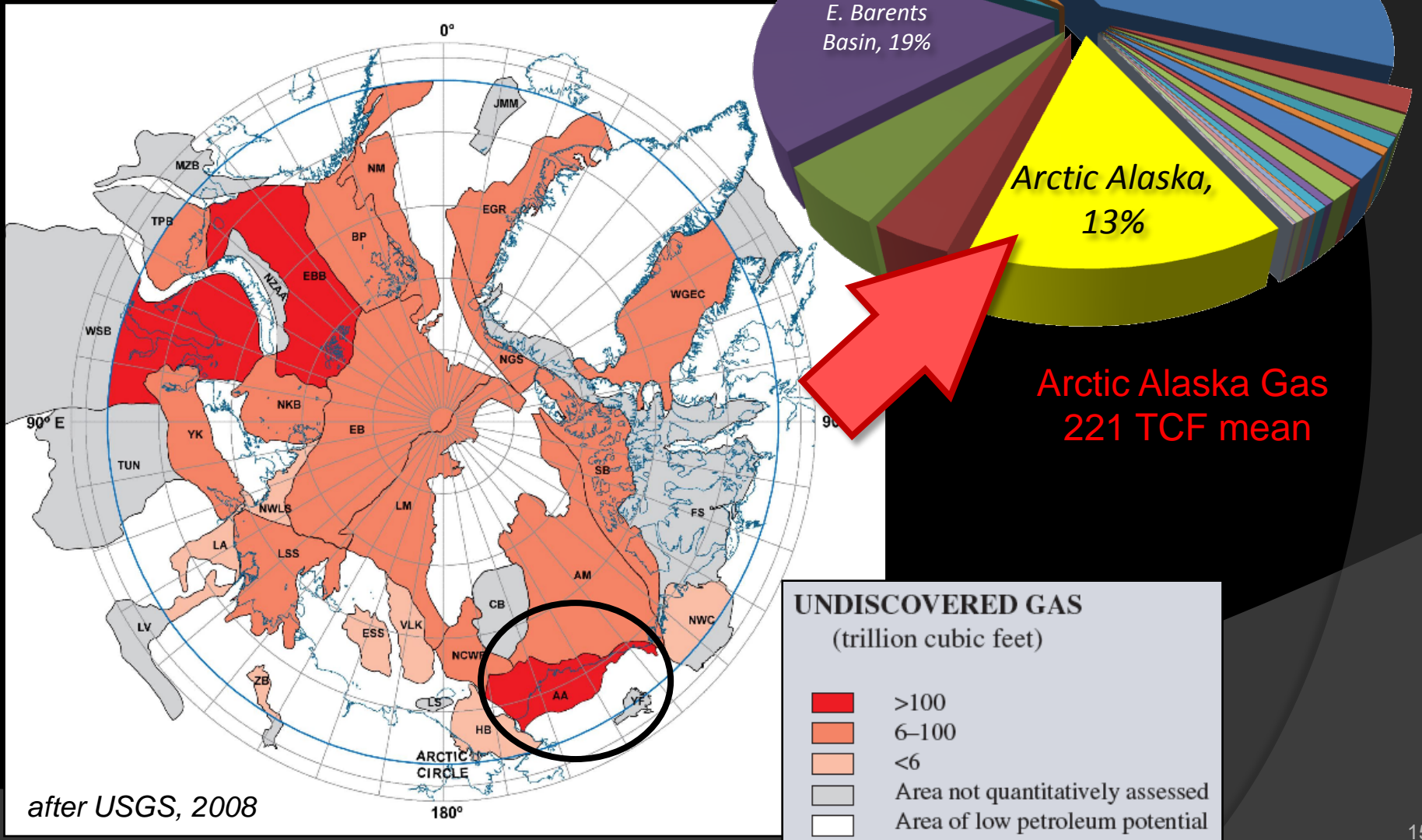
Undiscovered, technically recoverable oil





# USGS Circum-Arctic Resource Appraisal

Undiscovered, technically recoverable gas





# North Slope Shale Oil & Gas Resources

## Hue Shale/GRZ

Type section outcrops at Hue Creek, ANWR



## Total assessed resources:

Shale Oil: 0 – 2 BBO (mean **940** MMBO)

Shale NGL: 0 – 571 MMBO (mean **262** MMBO)

Shale Gas: 0 – 80 TCF (mean **42** TCF)

## Shublik Formation

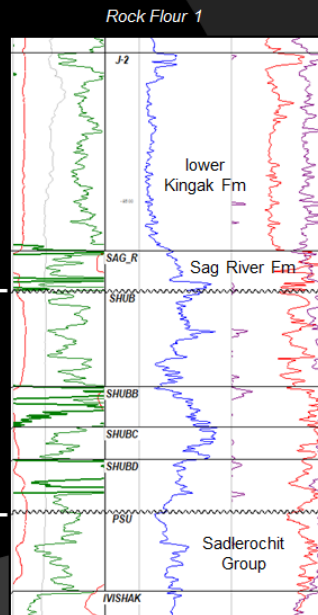
Variability in outcrop and well logs



Interbedded shale & limestone, silty-muddy, phosphatic, pyritic (up to 600 ft thick)

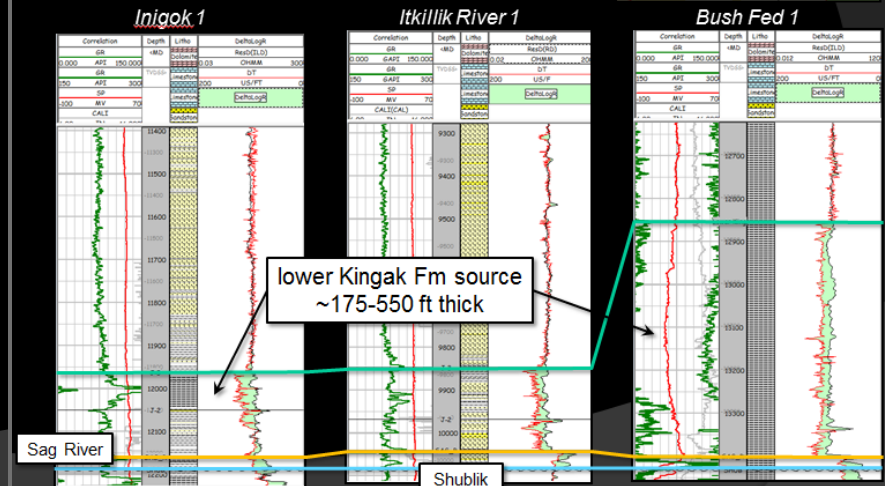
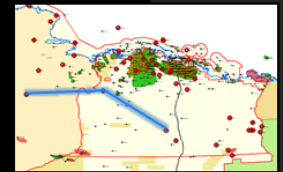
Shublik Fm

Zone A  
Zone B  
Zone C  
Zone D



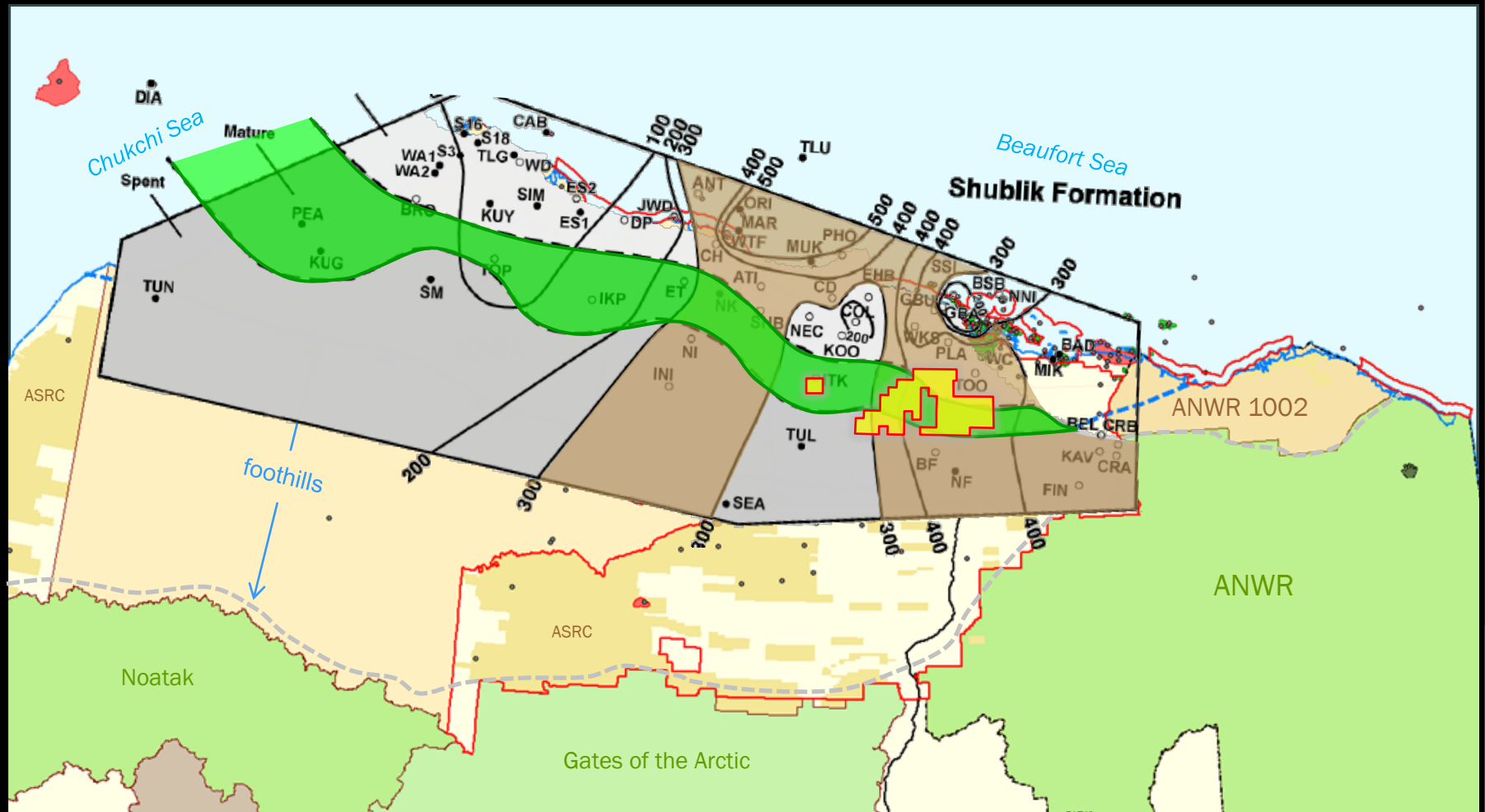
## Lower Kingak Formation

Δ Log R source rock screening



# Shublik Formation

## Hydrogen Index and Thermal Maturity



(overlay figure from Peters and others, 2006)

# Methane Hydrate Resource Estimates

Mean estimated onshore  
hydrate resource is  
**590 TCF**  
gas-in-place

Extraction remains experimental

Recovery factor unknown

