

**01/28/13  
PRESENTA-  
TION:  
ALASKA  
PETROLEUM  
SYSTEMS BY  
DNR**

<TARGET><BILL></BILL><SUBJECT>01-28-13 PRESENTATION  
ALASKA PETROLEUM SYSTEMS BY  
DNR</SUBJECT><COMM>SRES28</COMM></TARGET>

# ALASKA STATE LEGISLATURE

Sen. Cathy Giessel, Chair  
Sen. Fred Dyson, Vice Chair  
Sen. Lesil McGuire  
Sen. Anna Fairclough  
Sen. Click Bishop  
Sen. Peter Micciche  
Sen. Hollis French



State Capitol, Room 427  
Juneau AK 99801-1182  
907-465-4843  
Fax: 907-465-3871  
800-465-4843

## Senate Resources Committee

Butrovich Room 205  
Monday, January 28, 2013  
3:30-5:00 p.m.

## AGENDA

### ➤ SB 29 CRUISE SHIP WASTEWATER DISCHARGE PERMITS

#### ➤ Petroleum Systems-

##### Division of Geological & Geophysical Surveys

Bob Swenson, State Geologist/Director

##### Division of Oil & Gas

Paul Decker, Sr. Petroleum Geologist

Teleconference



# STATE of ALASKA - OIL & GAS RESOURCES -

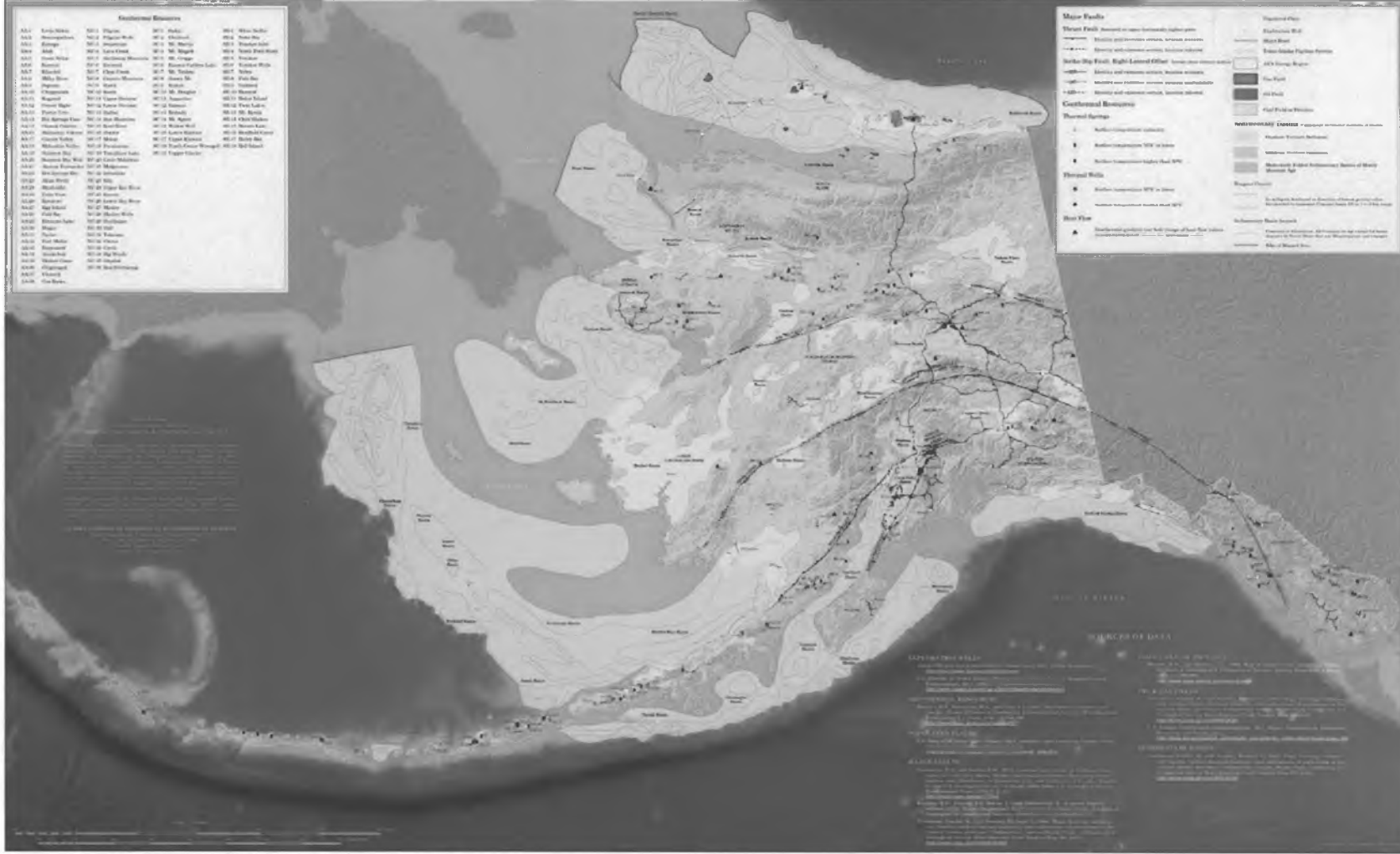


ALASKA DEPARTMENT OF NATURAL RESOURCES  
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

## GEOLOGIC BASINS AND ENERGY RESOURCES OF ALASKA

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

Geographic Coordinates			
AA-1	141° 00' W	66° 00' N	141° 00' W
AA-2	140° 00' W	66° 00' N	140° 00' W
AA-3	139° 00' W	66° 00' N	139° 00' W
AA-4	138° 00' W	66° 00' N	138° 00' W
AA-5	137° 00' W	66° 00' N	137° 00' W
AA-6	136° 00' W	66° 00' N	136° 00' W
AA-7	135° 00' W	66° 00' N	135° 00' W
AA-8	134° 00' W	66° 00' N	134° 00' W
AA-9	133° 00' W	66° 00' N	133° 00' W
AA-10	132° 00' W	66° 00' N	132° 00' W
AA-11	131° 00' W	66° 00' N	131° 00' W
AA-12	130° 00' W	66° 00' N	130° 00' W
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AA-96	46° 00' W	66° 00' N	46° 00' W
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AA-98	44° 00' W	66° 00' N	44° 00' W
AA-99	43° 00' W	66° 00' N	43° 00' W
AA-100	42° 00' W	66° 00' N	42° 00' W



# 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>

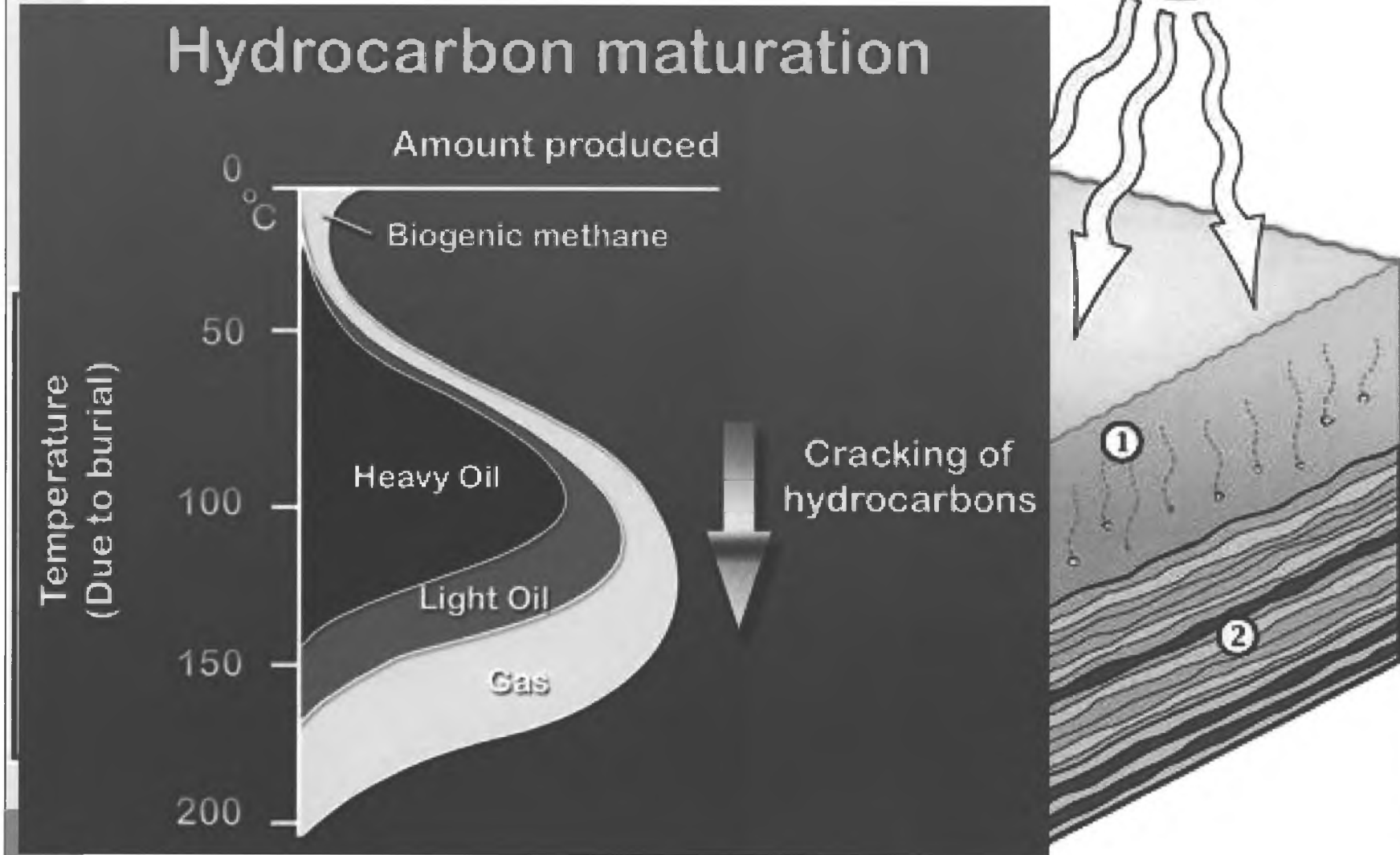
\*Excludes shale oil, shale gas, methane hydrates, and most coal bed methane

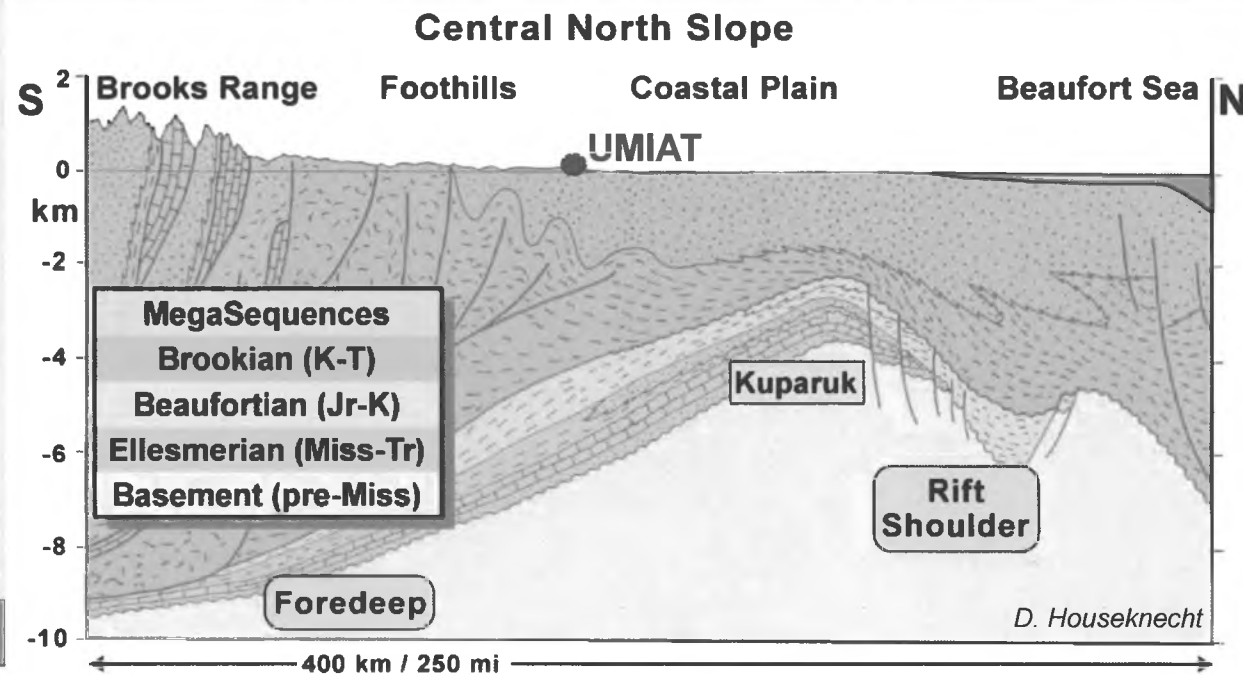
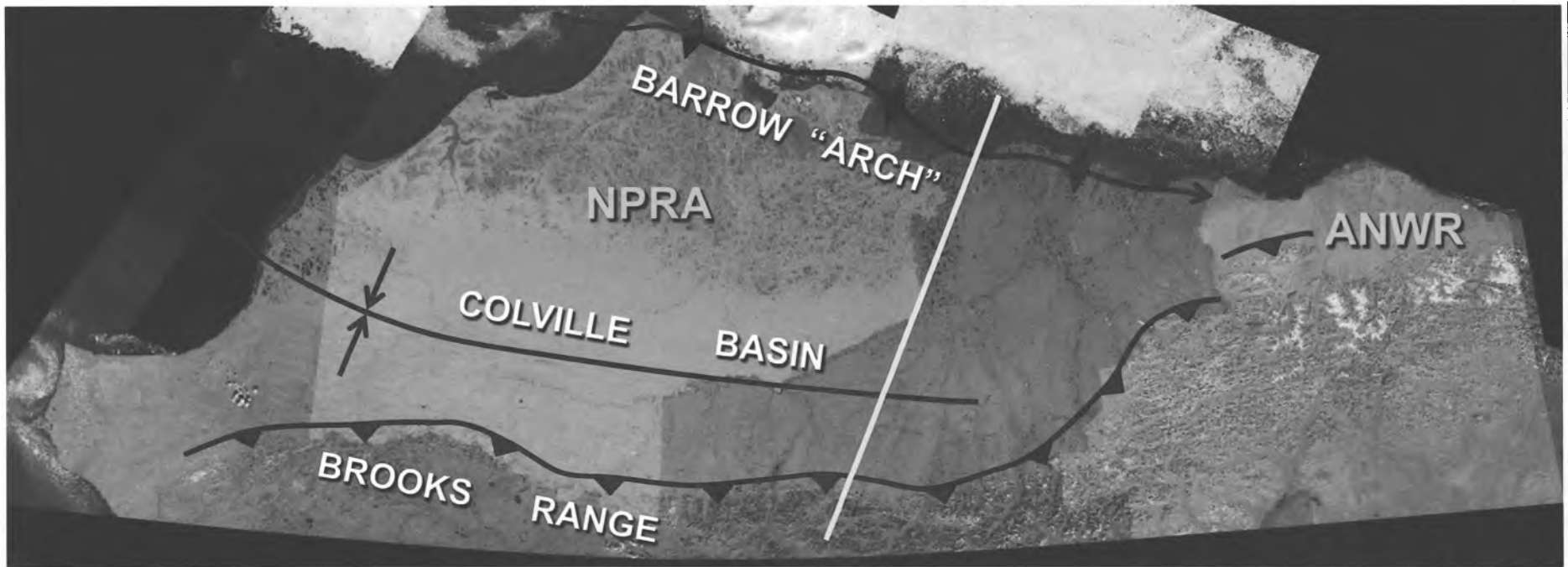
# SEDIMENTARY BASINS - PETROLEUM SYSTEMS RESERVES - RESOURCE ESTIMATES

- **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

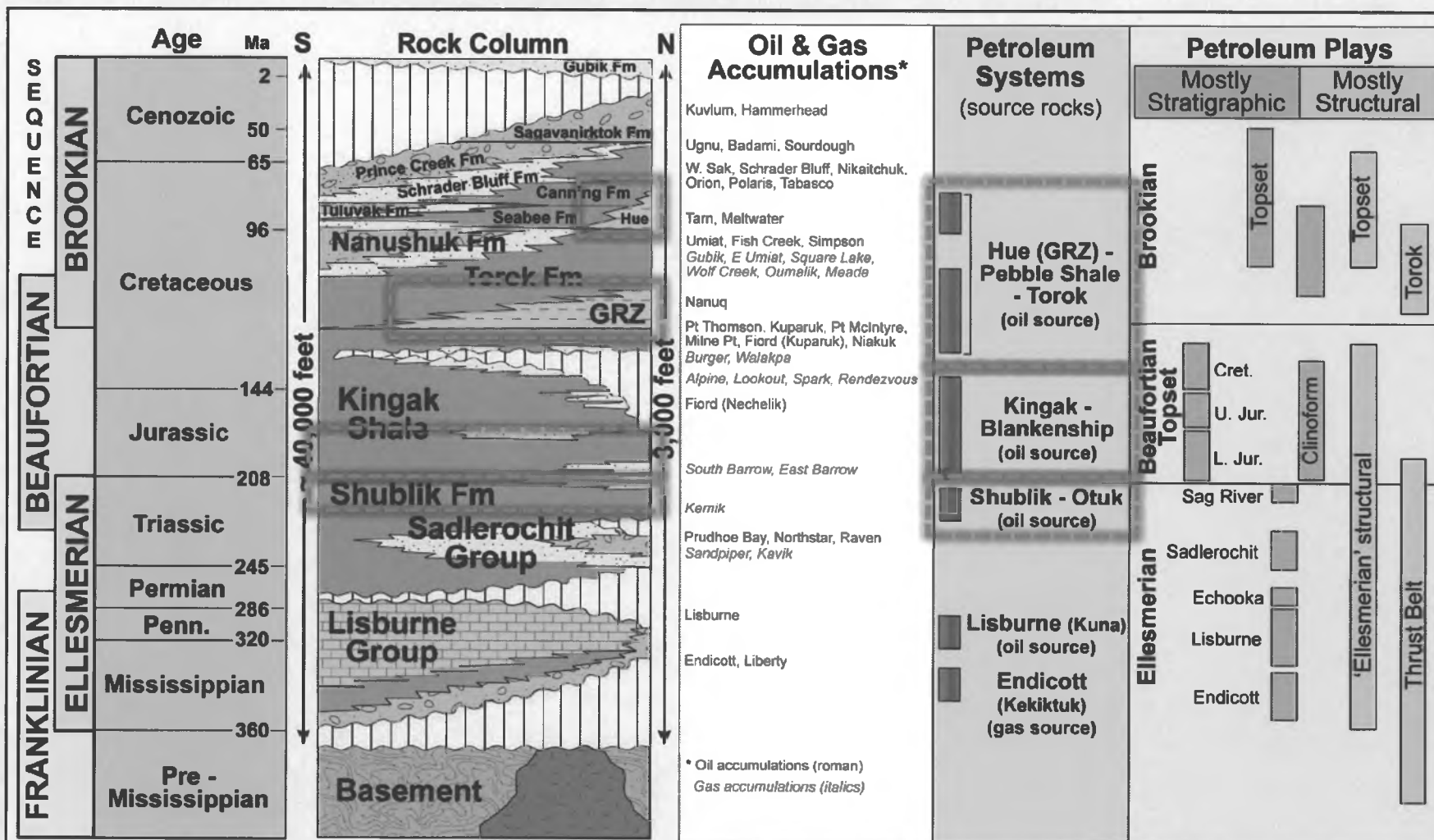
## 1. Source





# North Slope Petroleum Systems

## 3 prolific source rock intervals



**Rock Column Legend**

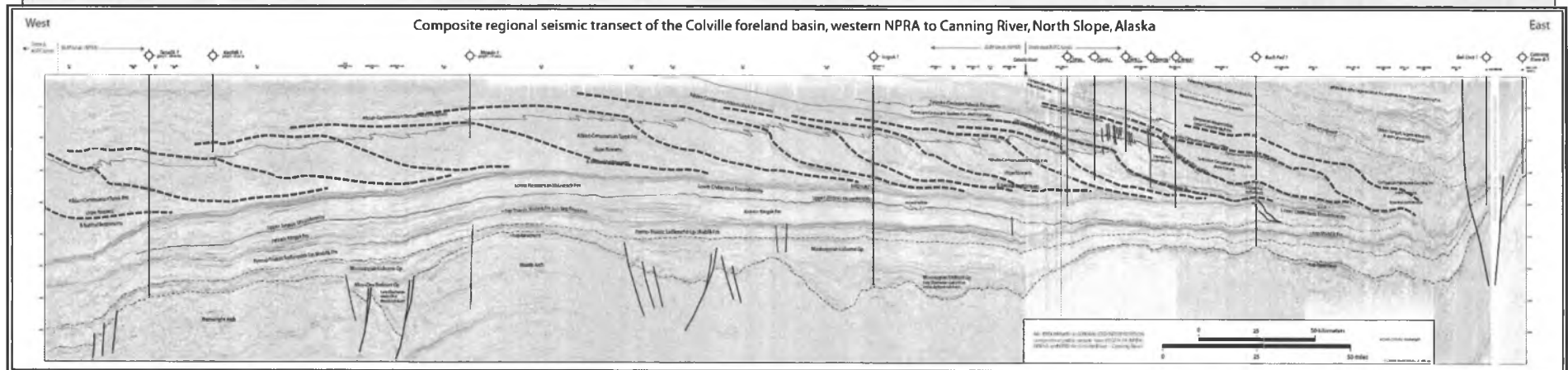
	Nonmarine		Marine slope & basin		Carbonates		Granite
	Marine Shelf		Condensed marine shale		Metasedimentary		Hiatus or erosion

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

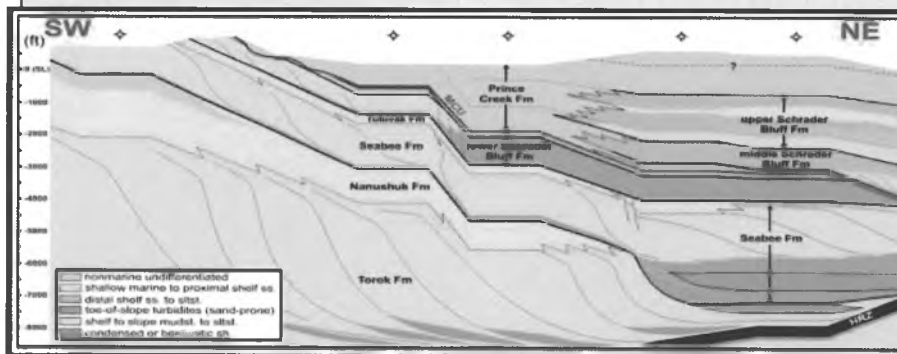
← NPRA → ← State Lands →



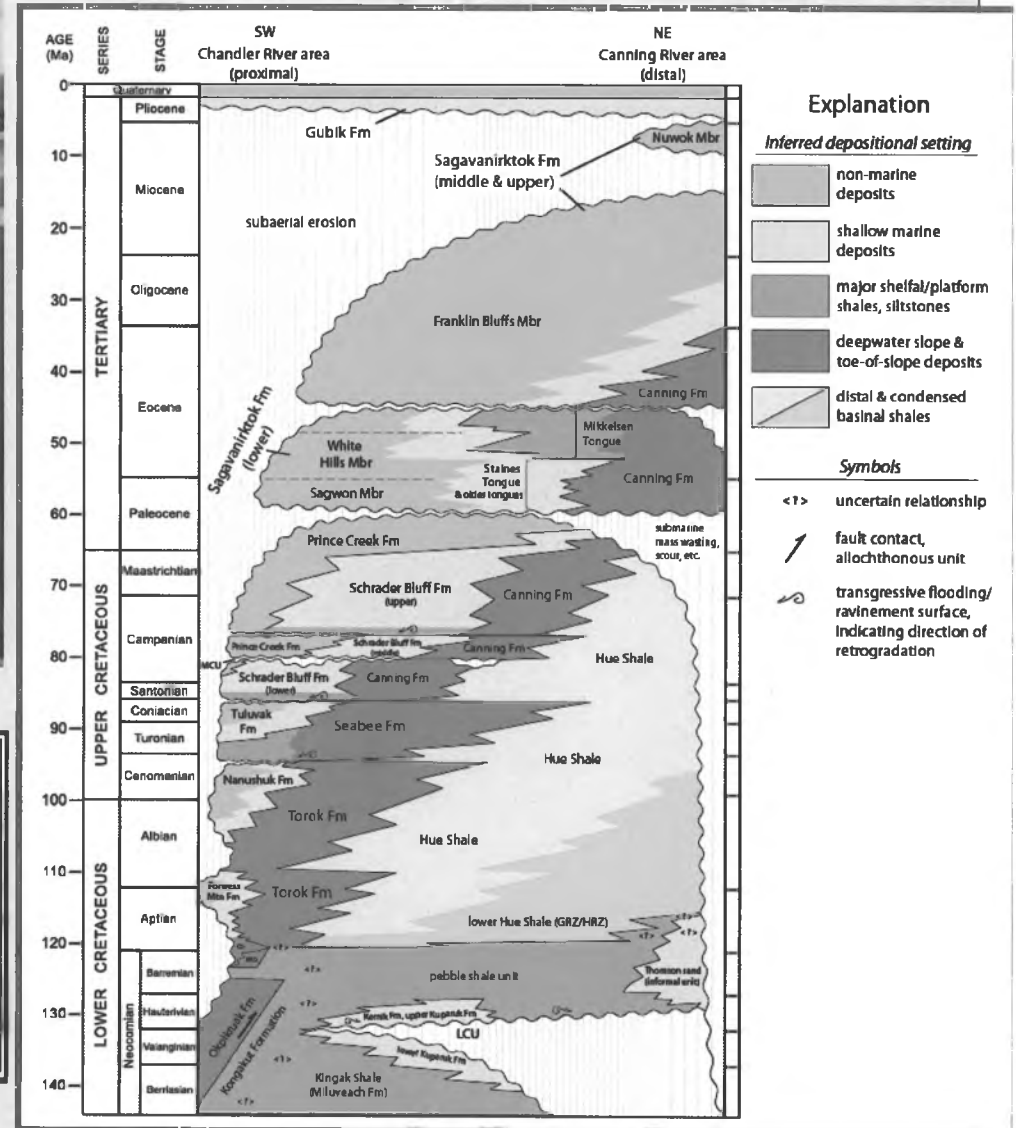
*pld, Alaska Division of Oil and Gas*

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

# Colville Basin Stratigraphy

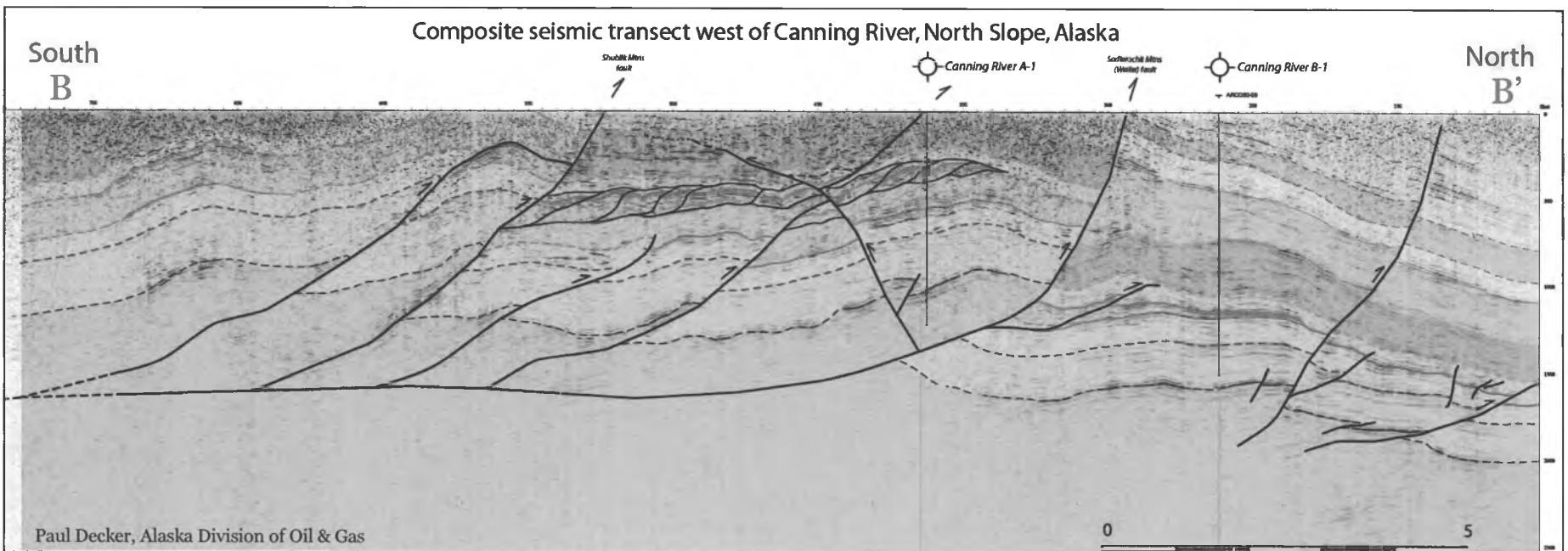
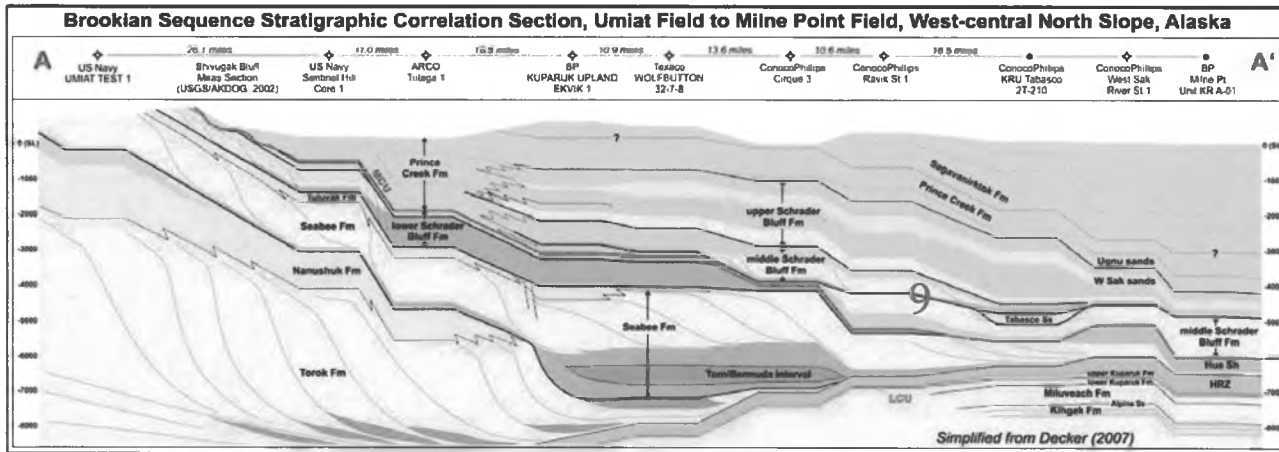
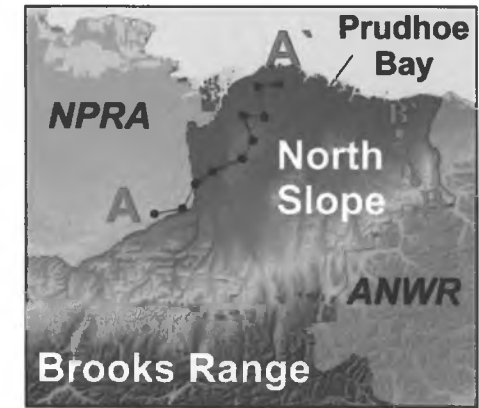


Simplified from Decker (2007)

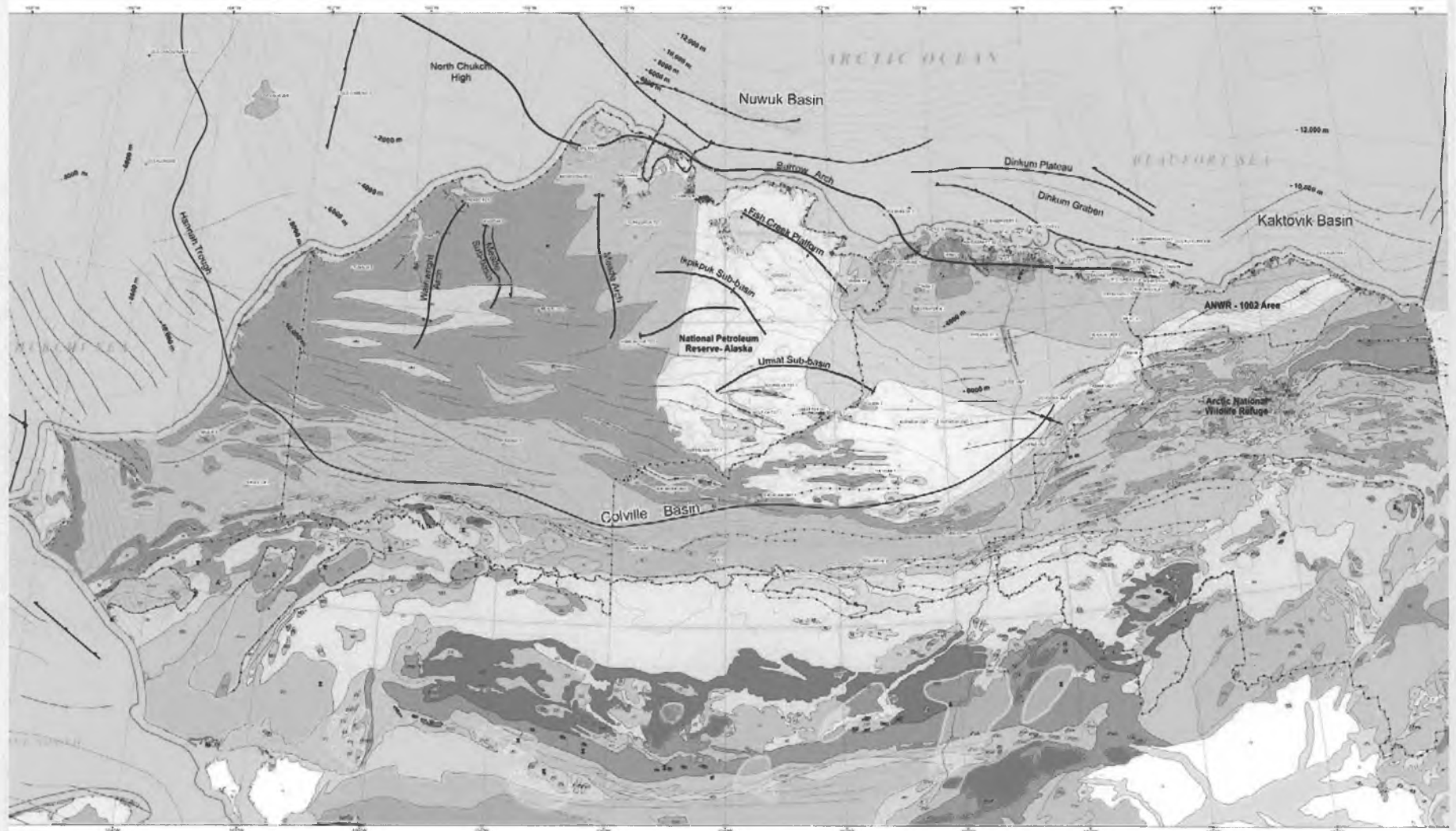


Decker and others (submitted)

# Merging Surface and Subsurface Data



# North Slope Regional Geology



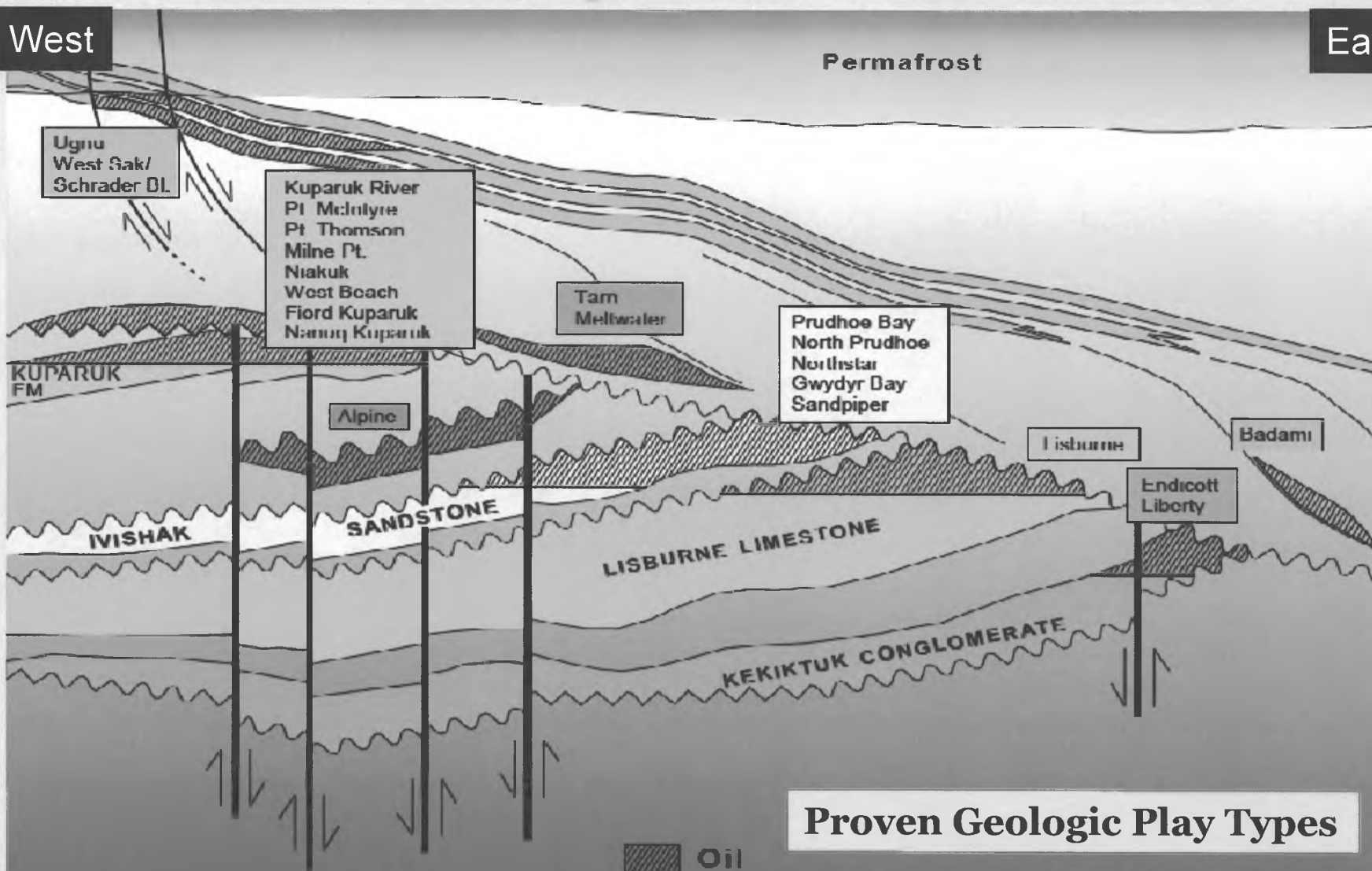
# Schematic Geologic Cross Section

## Central North Slope – Barrow Arch Province

West

East

Permafrost

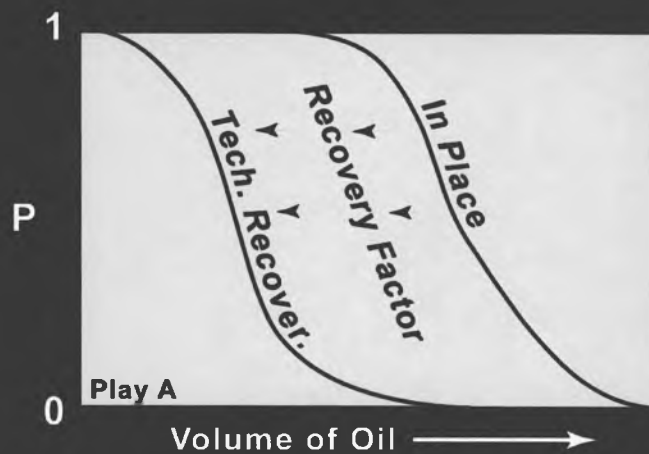
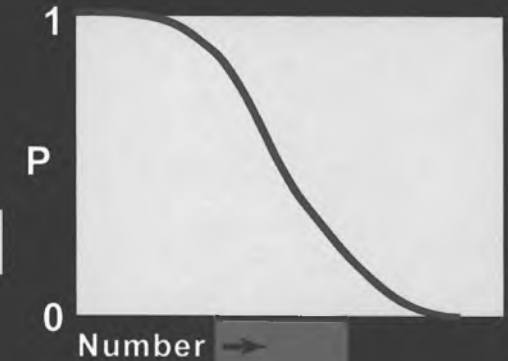
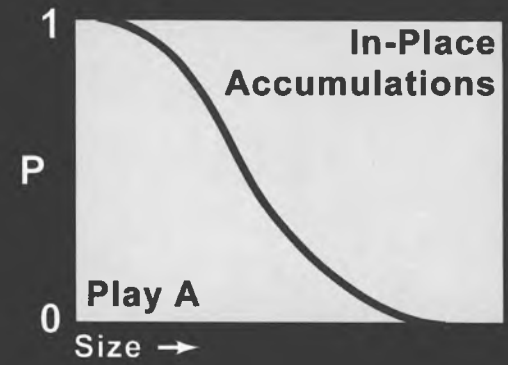
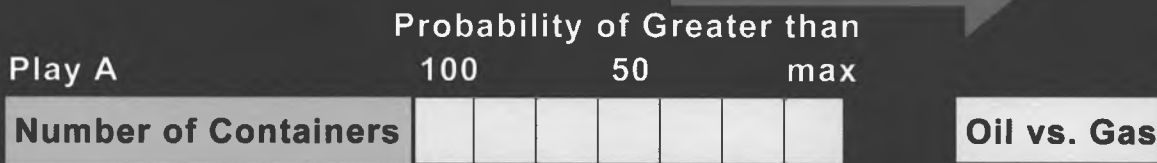


**Proven Geologic Play Types**

Drawing Not To Scale

UJCG, Rev 02-04

# USGS Assessment Methodology – Geologic Basis



Prospect Risk

Charge	
Reservoir	
Trap	

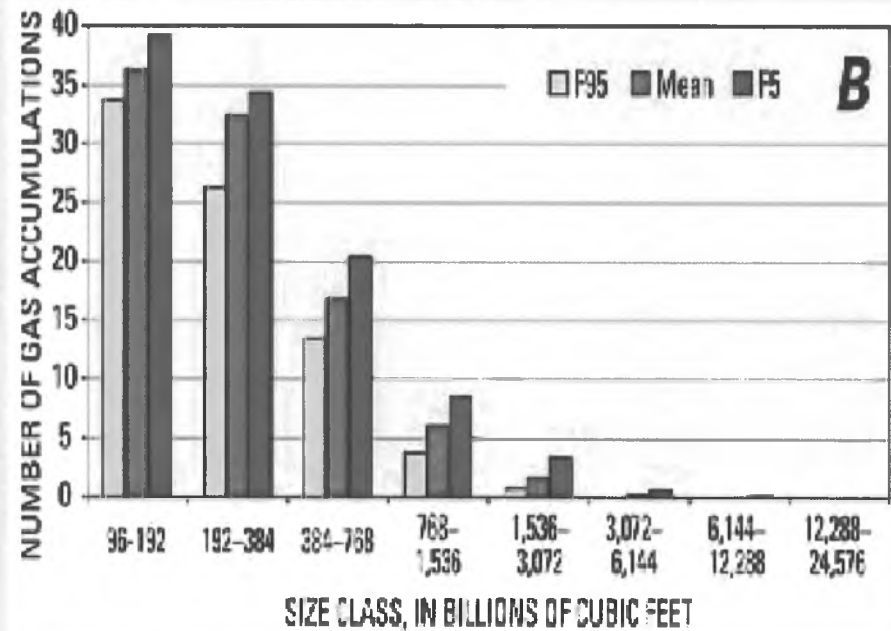
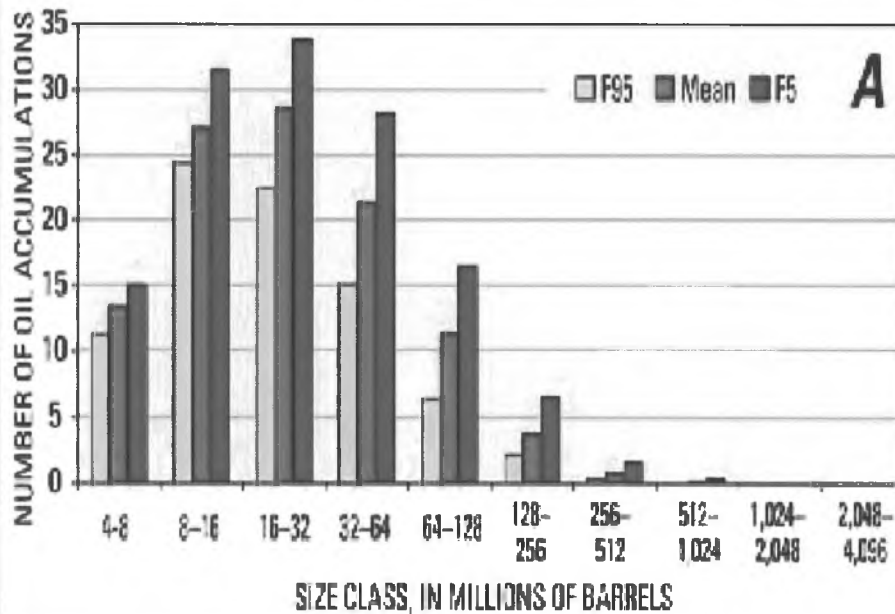
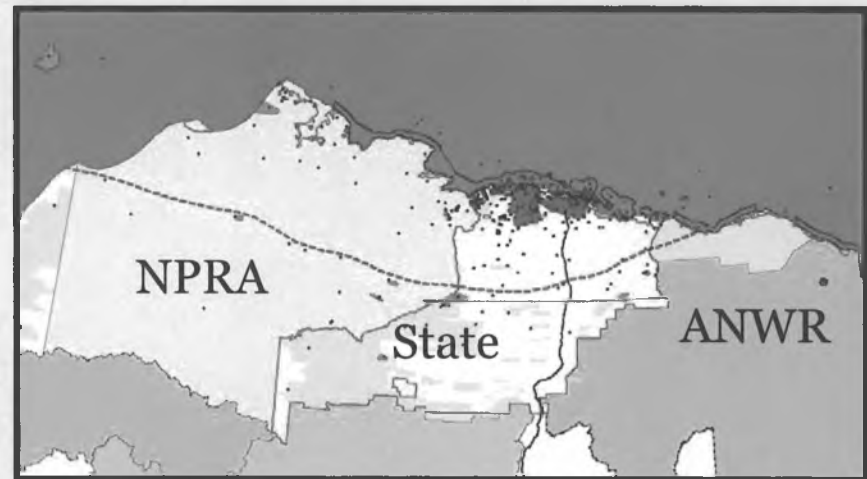
Play Risk

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.



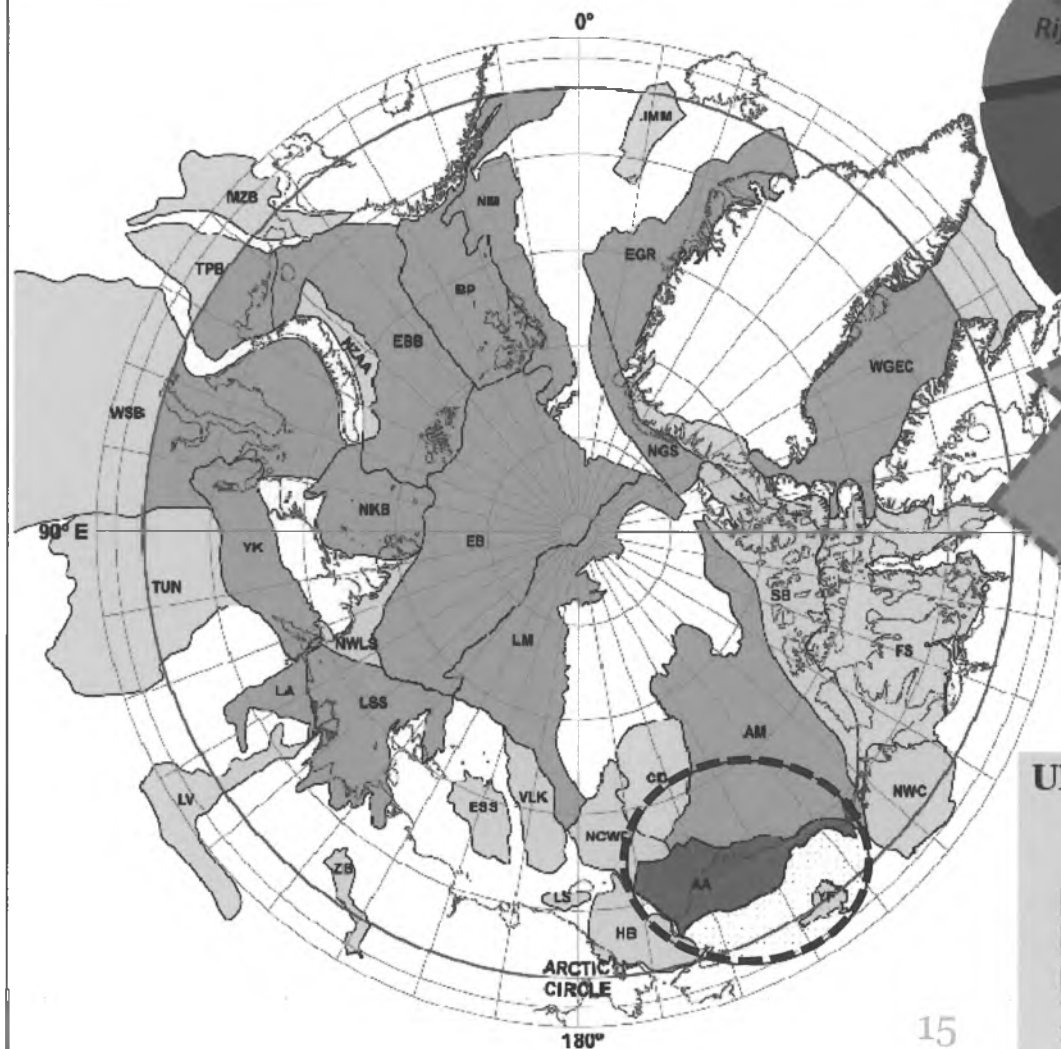
# Current Federal Assessments

## 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		
	F95	Mean	F05	F95	Mean	F05
<b>North Slope Onshore &amp; State Waters<sup>2</sup></b>						
Central North Slope	2,565	3,984	5,854	2,681	4,198	6,092
<i>Oil &amp; Associated gas</i>						
<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	--	896	--	--	--	--
<i>Oil &amp; Associated gas</i>						
<i>NGL &amp; Non-associated gas</i>	-- <sup>3</sup>	--	-- <sup>3</sup>	--	52,839	--
ANWR coastal plain <sup>2</sup>	5,724	10,360	15,955	--	4,764	--
<i>Oil &amp; Associated gas</i>						
<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>
<b>Arctic Alaska Outer Continental Shelf (OCS)</b>						
Chukchi Shelf	2,317	15,380	40,075	10,316	76,772	209,527
<i>Oil &amp; all gas</i>						
Beaufort Shelf	412	8,224	23,235	649	27,645	72,178
<i>Oil &amp; all gas</i>						
Hope Basin	0	150	600	0	3,770	14,980
<i>Oil &amp; all gas</i>						
total - Arctic OCS (offshore)	6,030	23,754	53,170	27,830	108,187	247,190
<b>TOTAL - Arctic Alaska</b>	-- <sup>3</sup>	<b>39,662</b>	-- <sup>3</sup>	-- <sup>3</sup>	<b>207,147</b>	-- <sup>3</sup>

# USGS Circum-Arctic Resource Appraisal

Undiscovered, technically recoverable oil



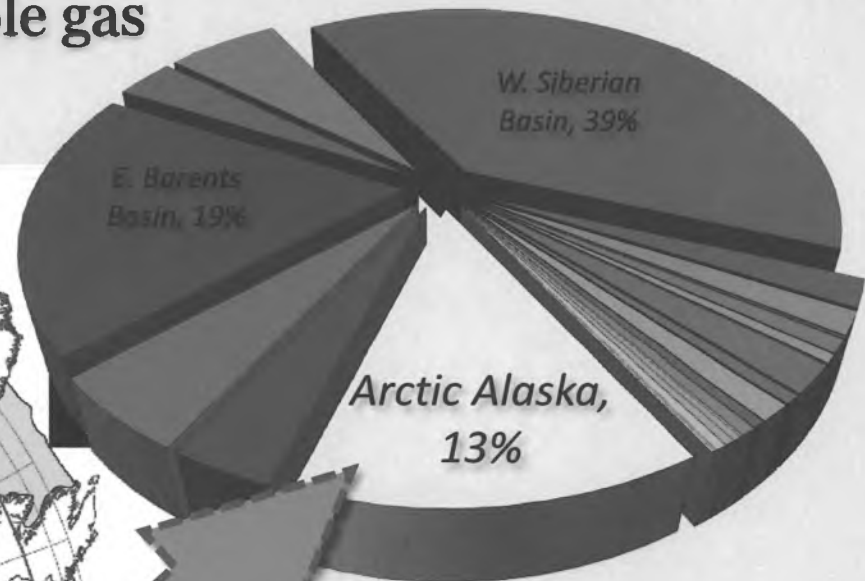
Arctic Alaska Oil + NGL  
30 BBO + 6 BBNGL mean

**UNDISCOVERED OIL**  
(billion barrels)

- >10
- 1-10
- <1
- Area not quantitatively assessed
- Area of low petroleum potential

# USGS Circum-Arctic Resource Appraisal

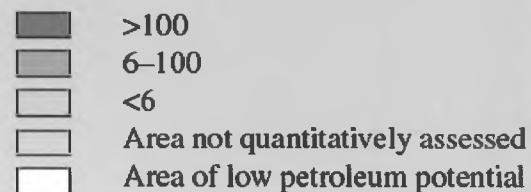
Undiscovered, technically recoverable gas



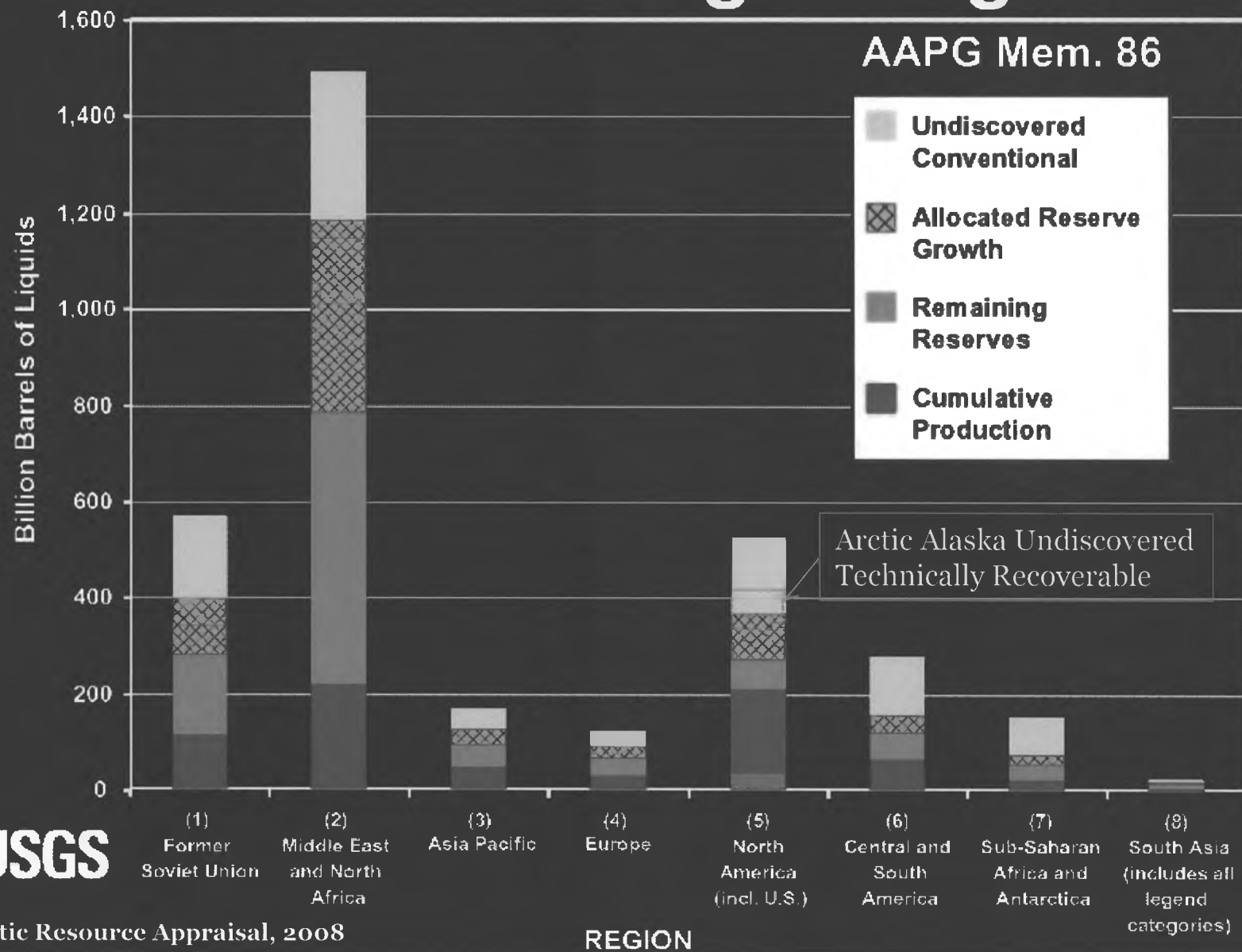
Arctic Alaska Gas  
221 TCF mean

## UNDISCOVERED GAS

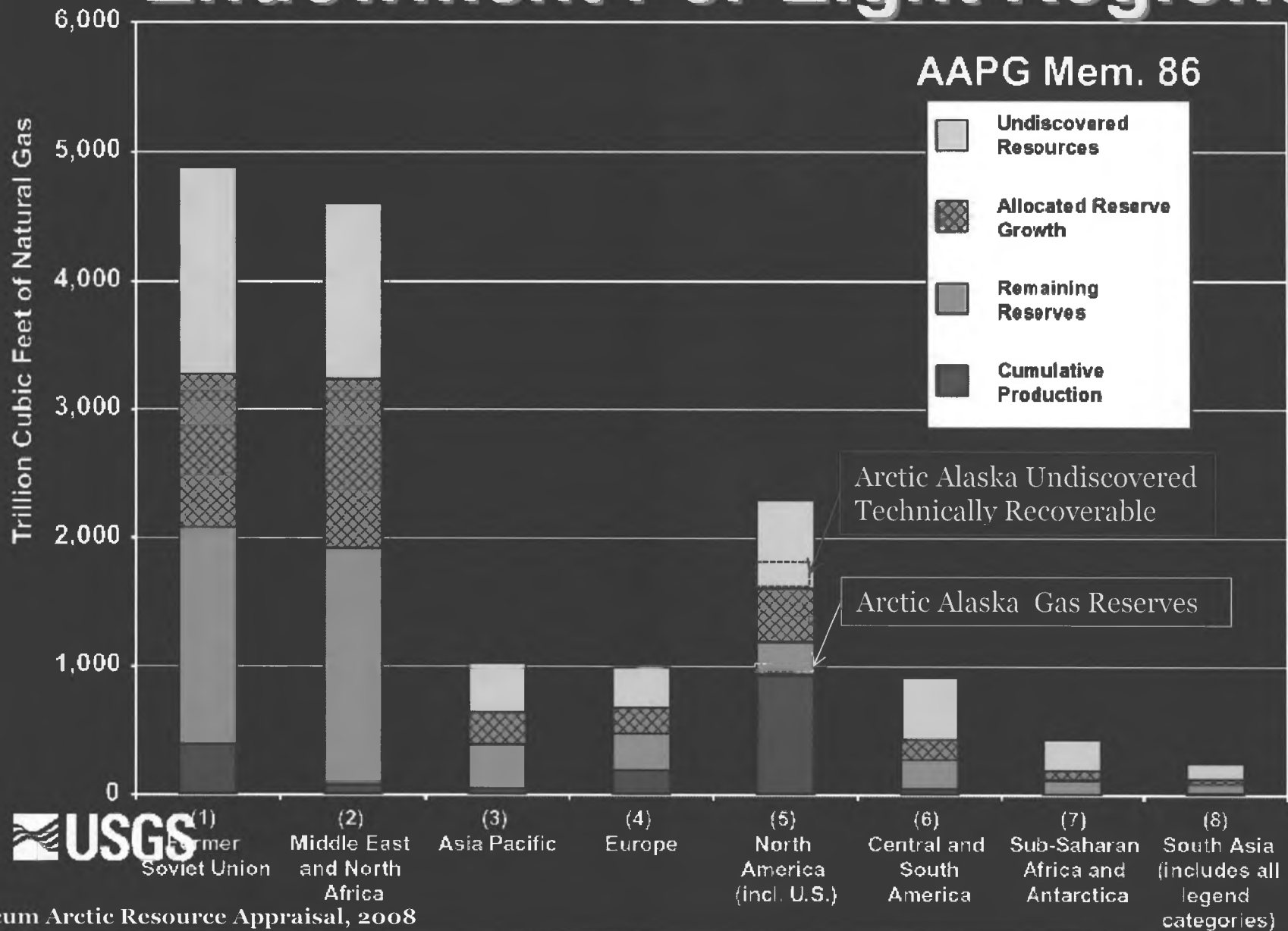
(trillion cubic feet)



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

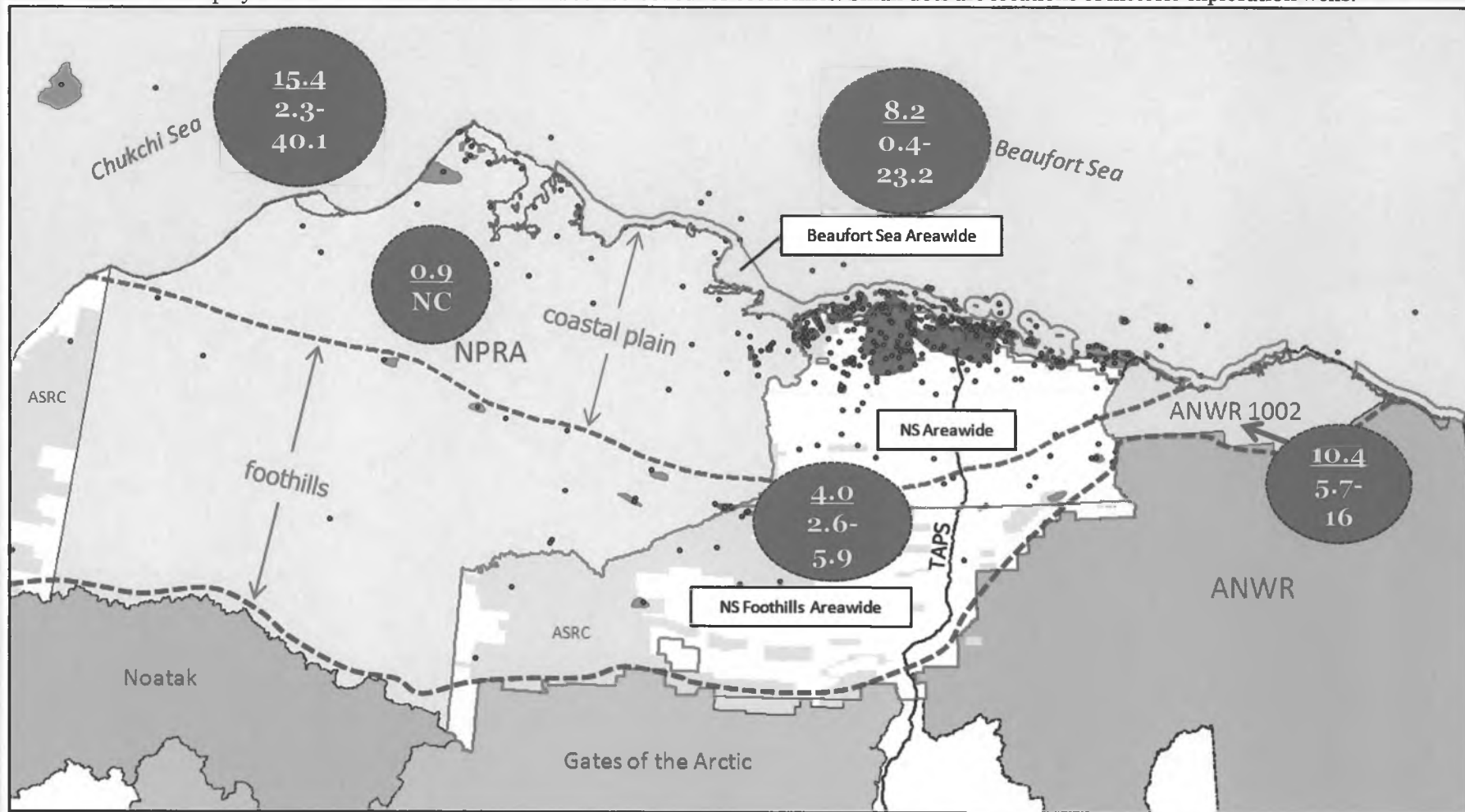


# Conventional Natural Gas Endowment For Eight Regions



# 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.



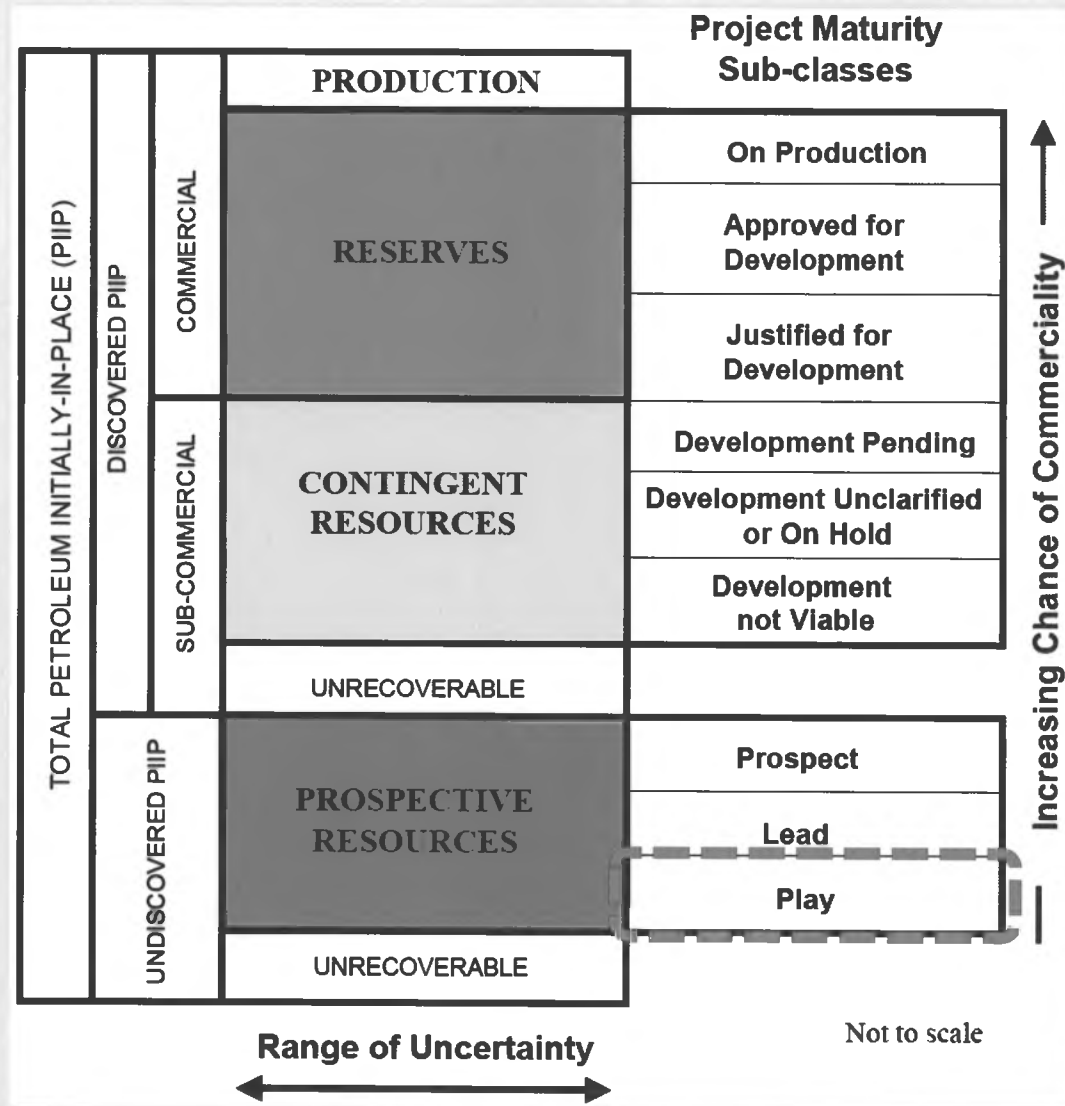
- OCS estimates includes crude oil & natural gas liquids
- Data from MMS 2006; Alaska OCS assessment
- Onshore includes crude oil only
- Data from USGS assessments, 1999 -2011

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

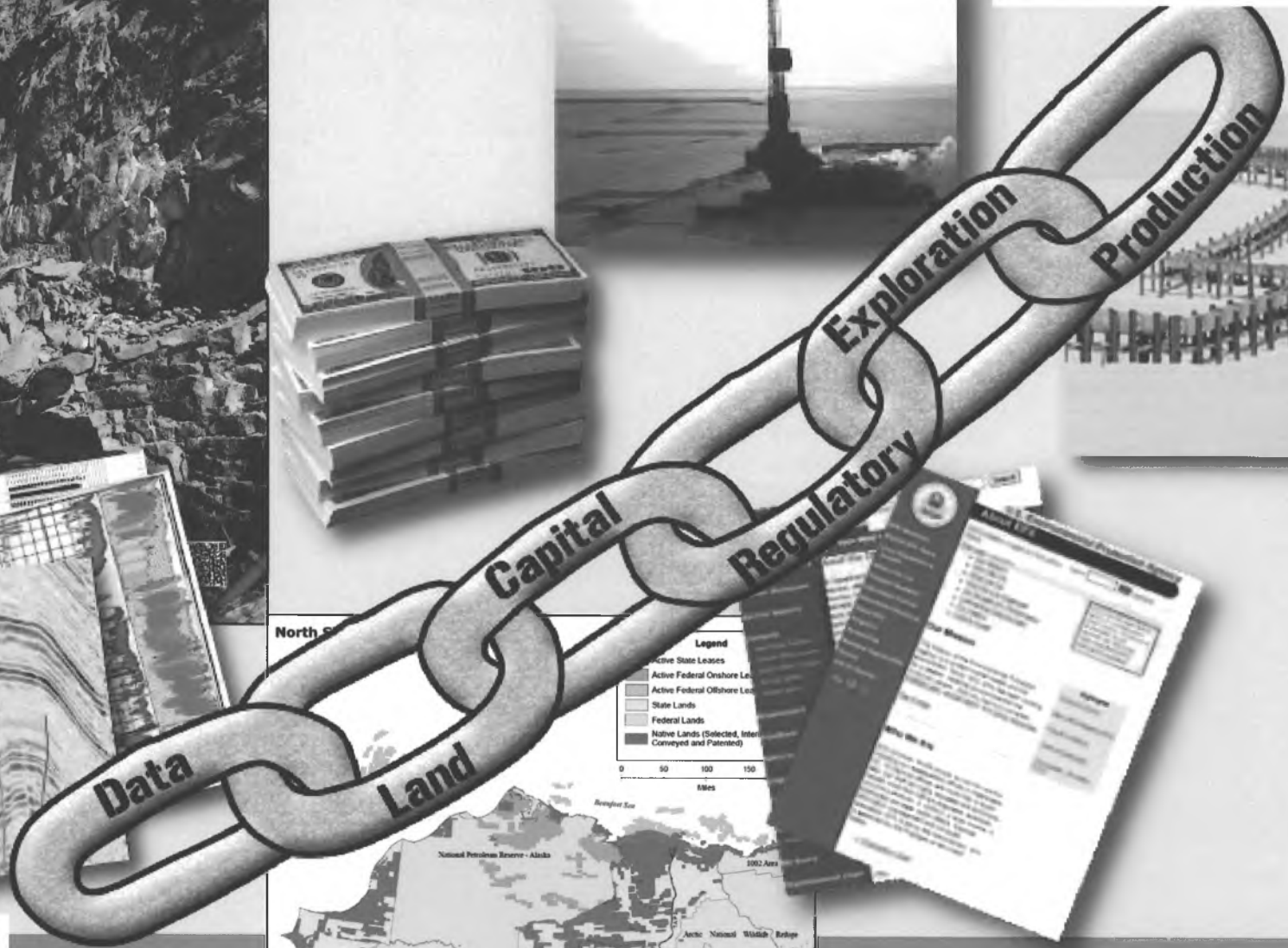


# The Resource Development Chain

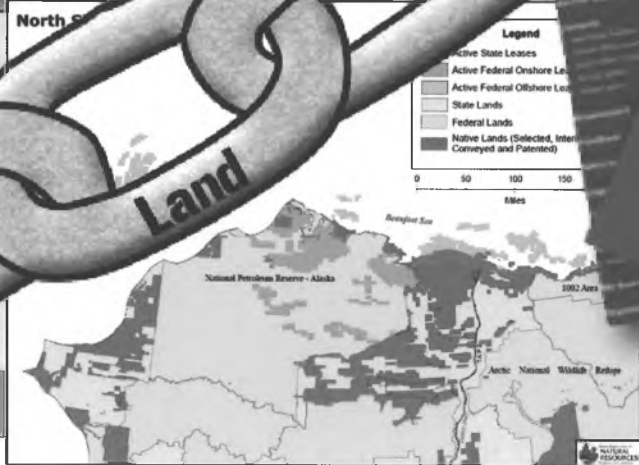
**Development**

Alaska Division of  
Geological &  
Geophysical Surveys

Annual Report  
2010



**Geology**



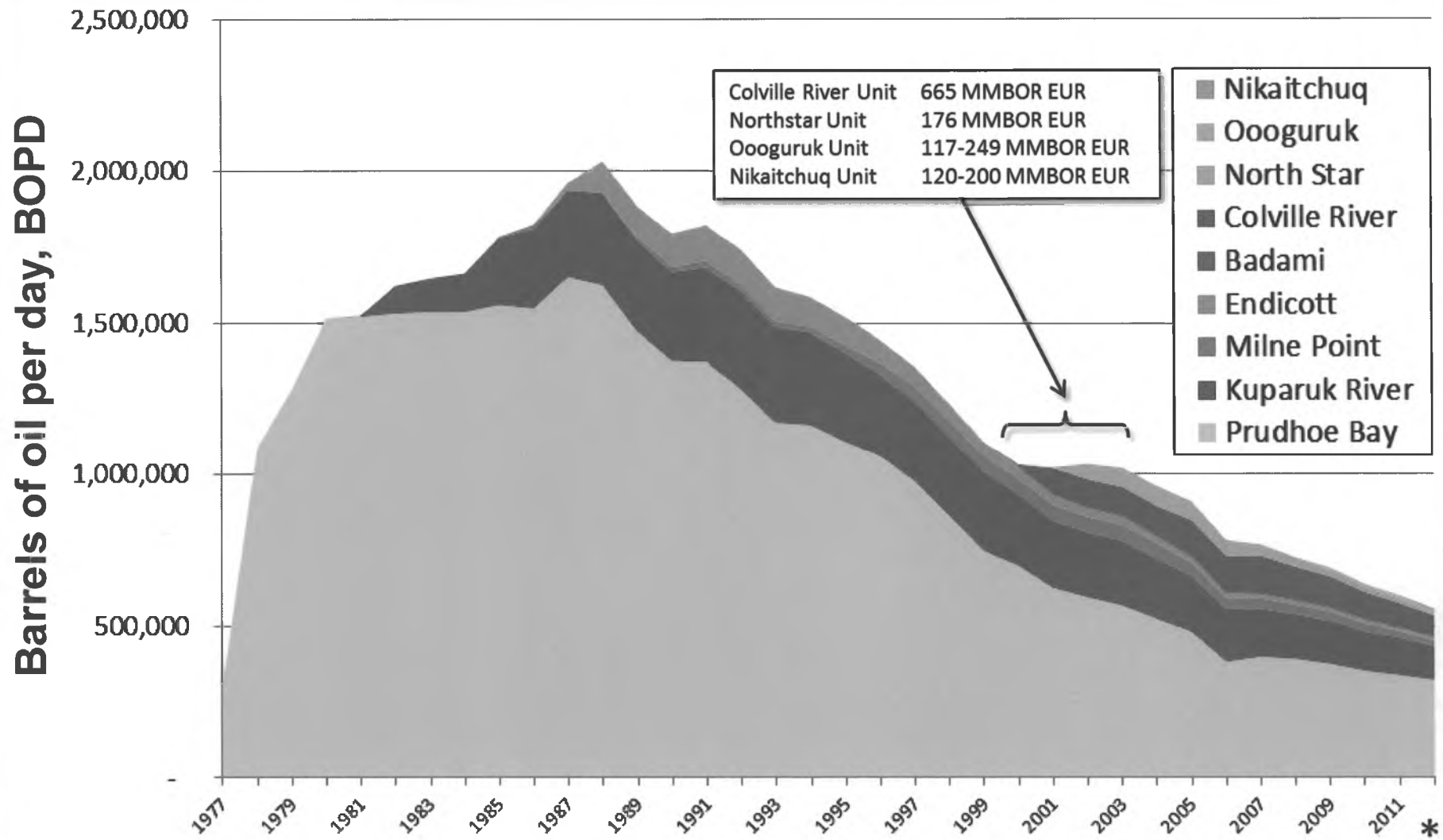
# Northern Alaska Reserves and Resources

## Presentation Outline

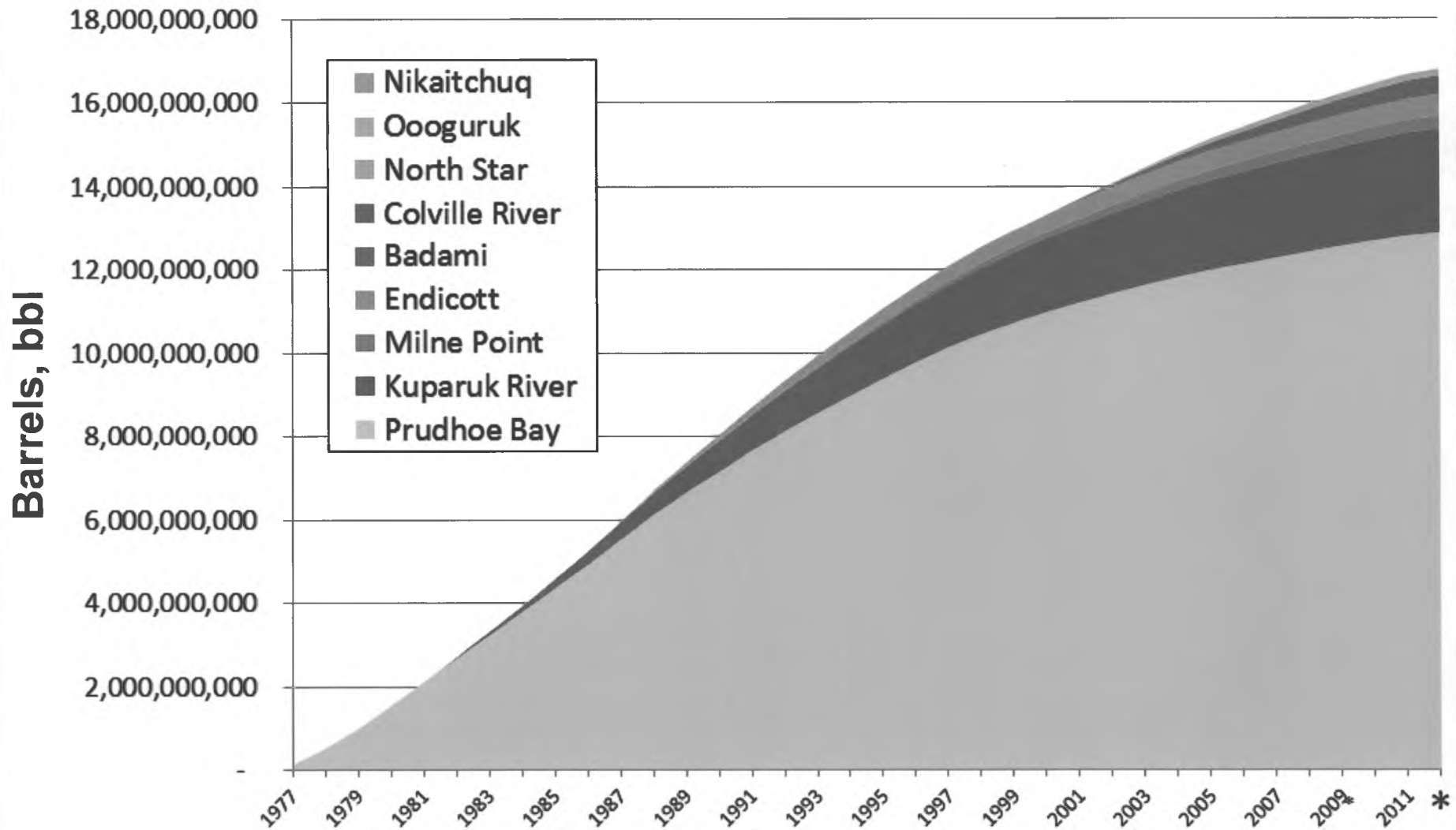
- Production to date
- Reserves Estimates
- Discovered Resources
- Undiscovered Resources
- Unconventional Resource Potential

# Oil Production History by Unit

## North Slope fields

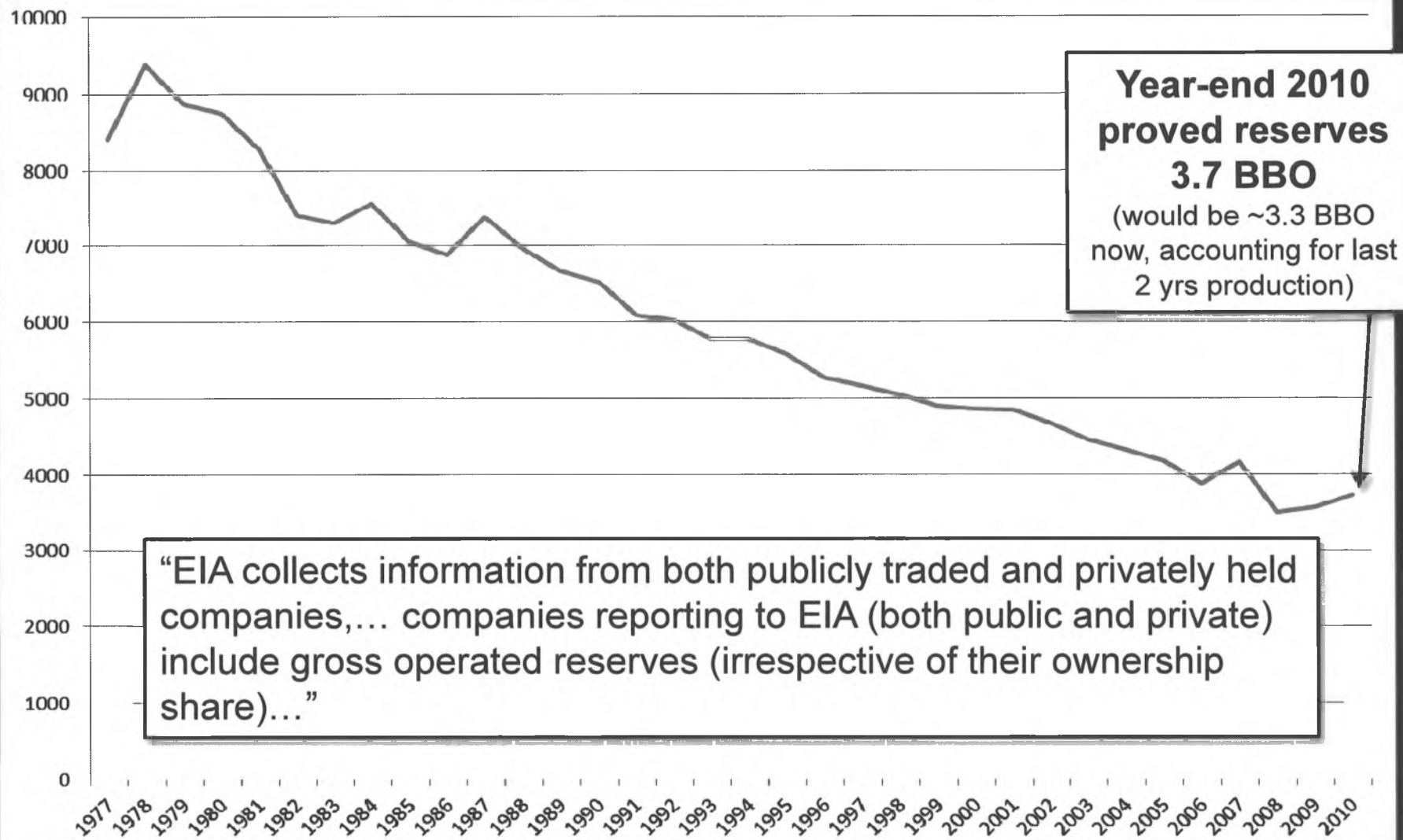


# Cumulative Oil Production by Unit North Slope fields



# 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\*:

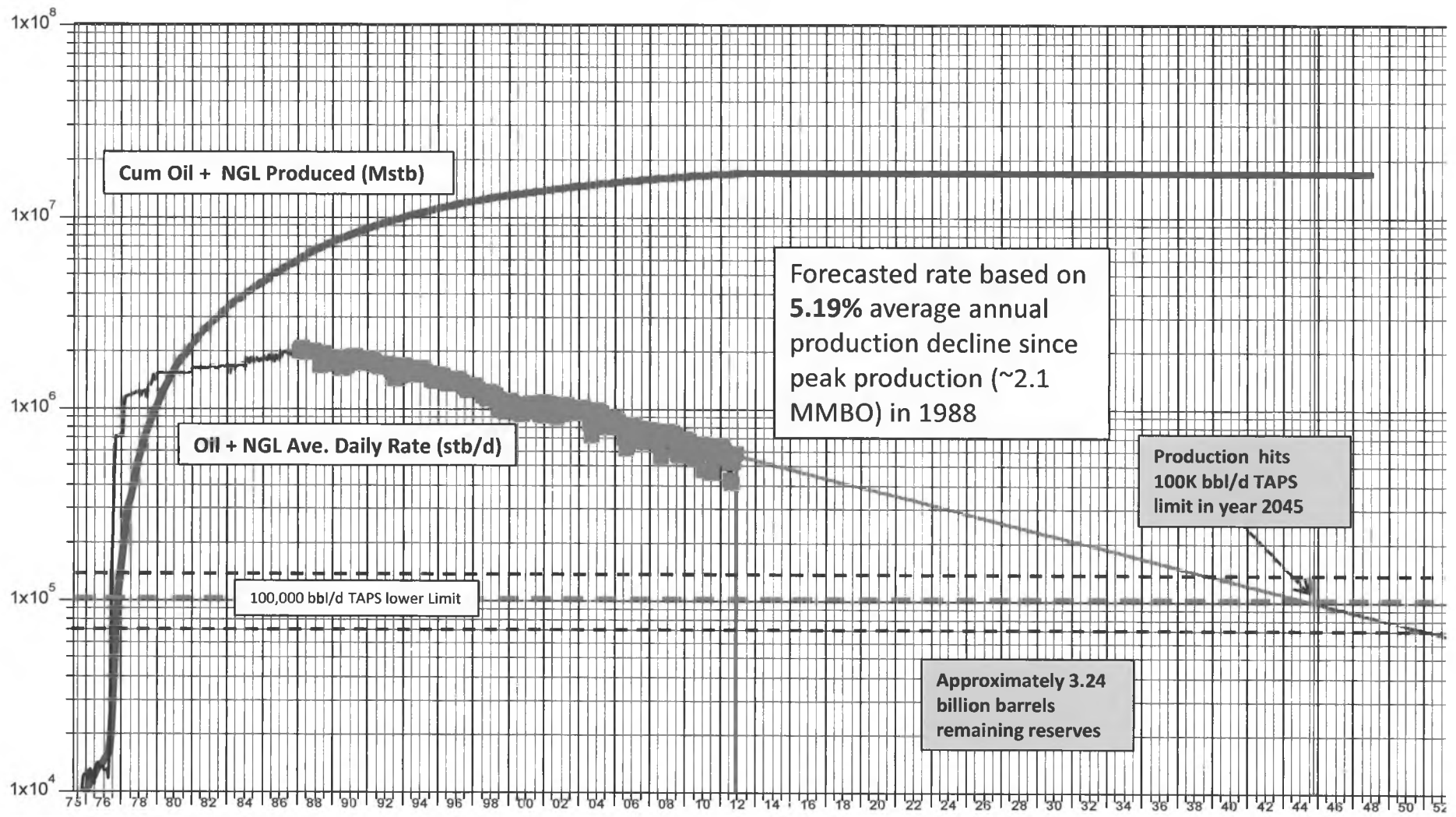
**~282 to 412 Million barrels**

*\* 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

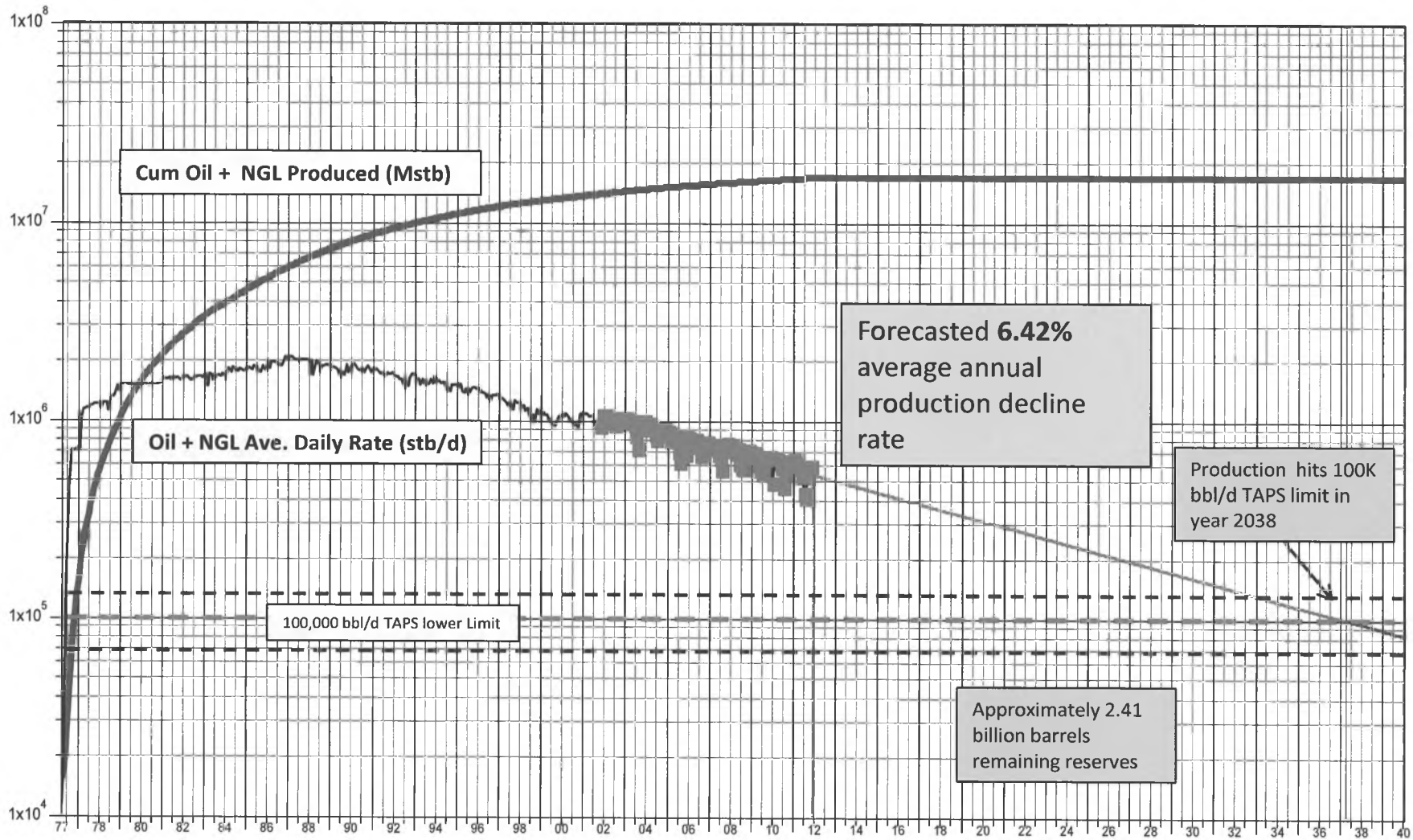


Rate Stream	CDOi_Ngl	Forecast Decline	5.19 %	Forecast Years	32.8
Cum Stream	CumOil_Ngl	Beginning Date	12/1/2012 00:00	Cumulative, STB	16846879770
Fit Type	Exponential, 0	Beginning Rate, STBD	571645	Remaining, STB	3235264159
Fit Decline	5.19 %	Ending Date	9/30/2045 00:29	Ultimate, STB	20082143929
Forecast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

Alaska Division of Oil and Gas, Jan 2013

# North Slope Oil + NGL Production

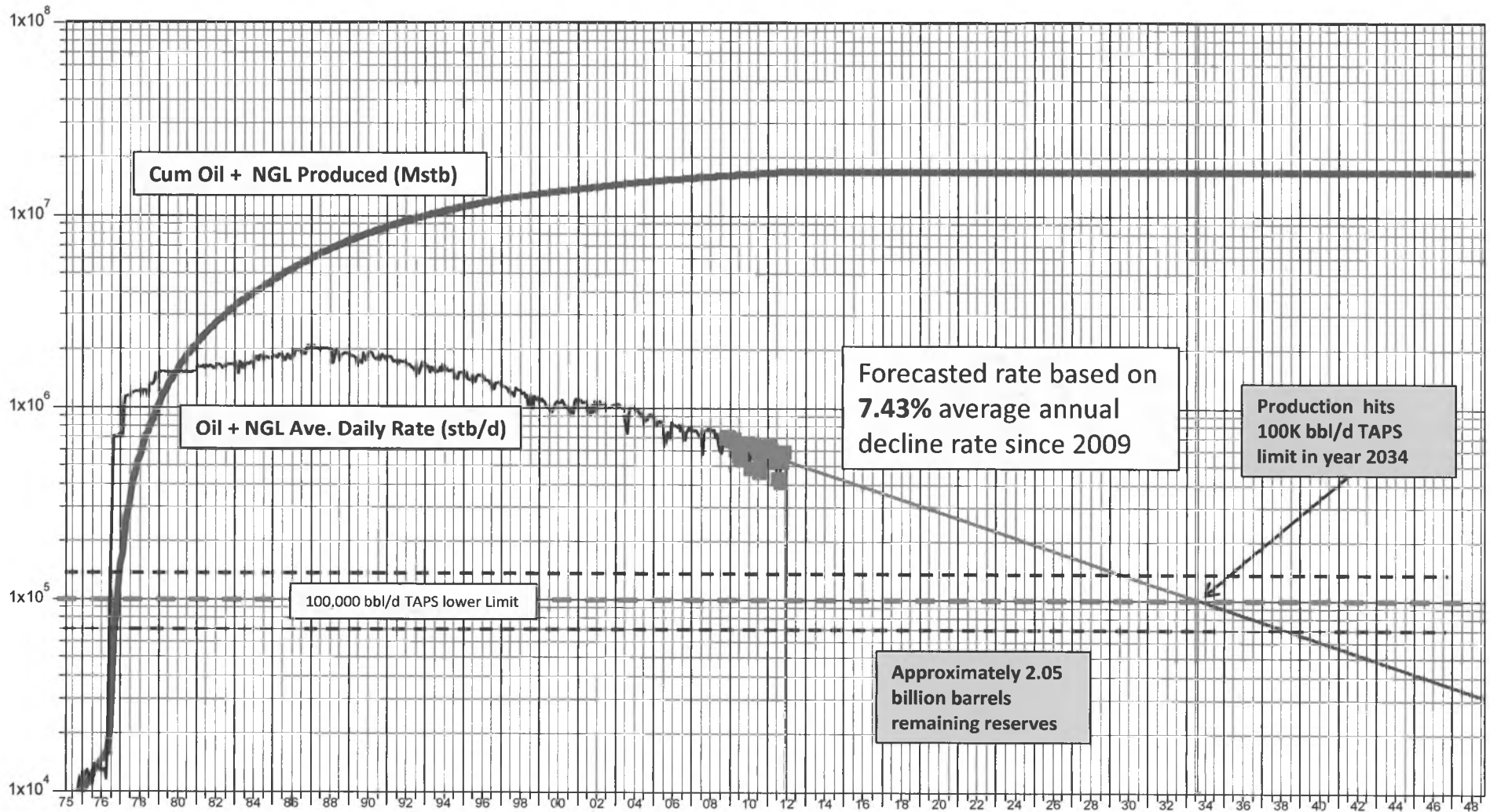
## Forecast based on decline rate since 2002



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		

# North Slope Oil + NGL Production

## Forecast based on decline rate since 2009



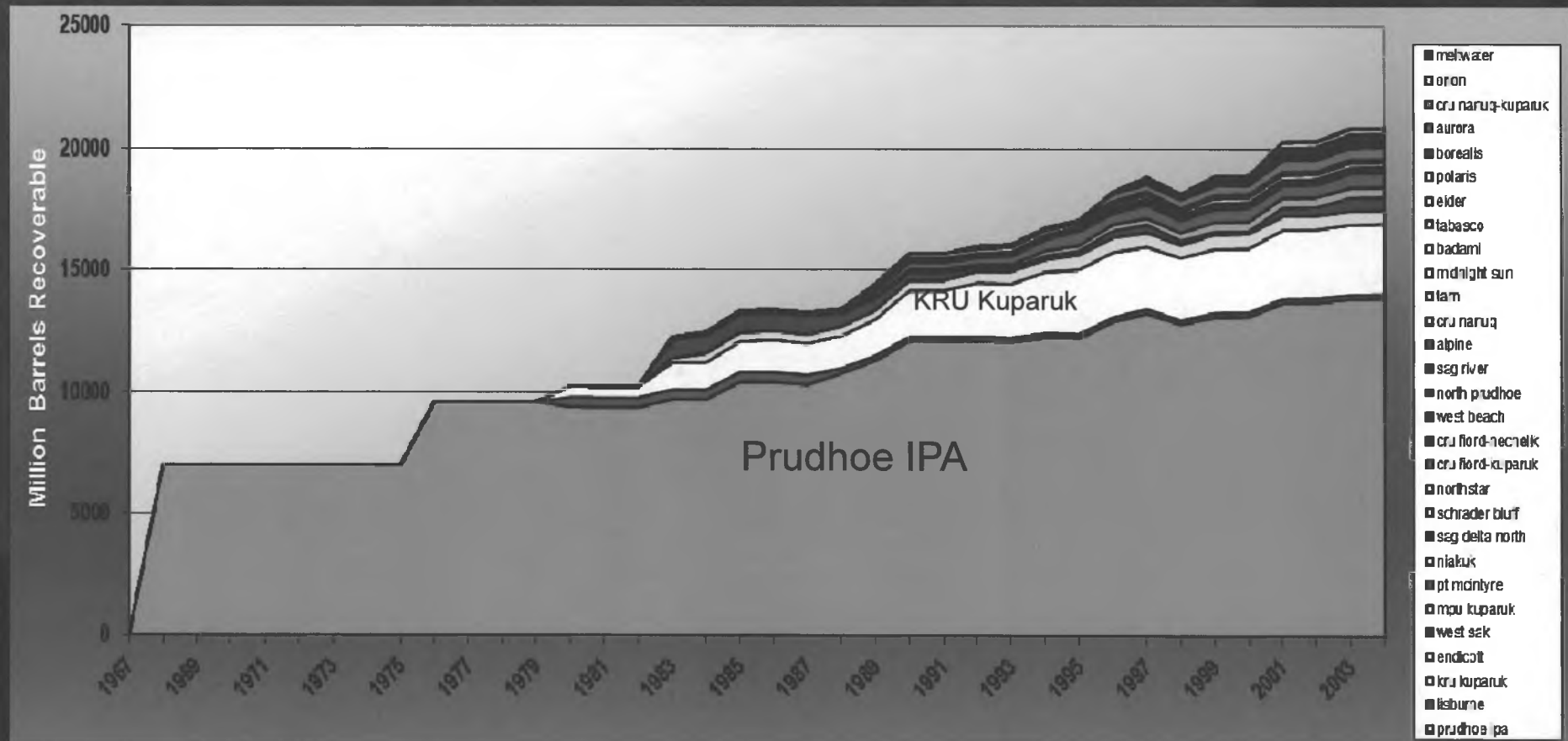
Rate Stream	CDOil_Ngl	Forecast Decline	7.43 %	Forecast Years	21.7
Cum Stream	CumOil_Ngl	Beginning Date	12/1/2012 00:00	Cumulative, STB	16846879770
Fit Type	Exponential, 0	Beginning Rate, STBD	534208	Remaining, STB	2054482871
Fit Decline	7.43 %	Ending Date	8/25/2034 18:56	Ultimate, STB	18901362641
Forecast Type	Exponential, 0	Ending Rate, STBD	99673		

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

## Nikaitchuq Unit

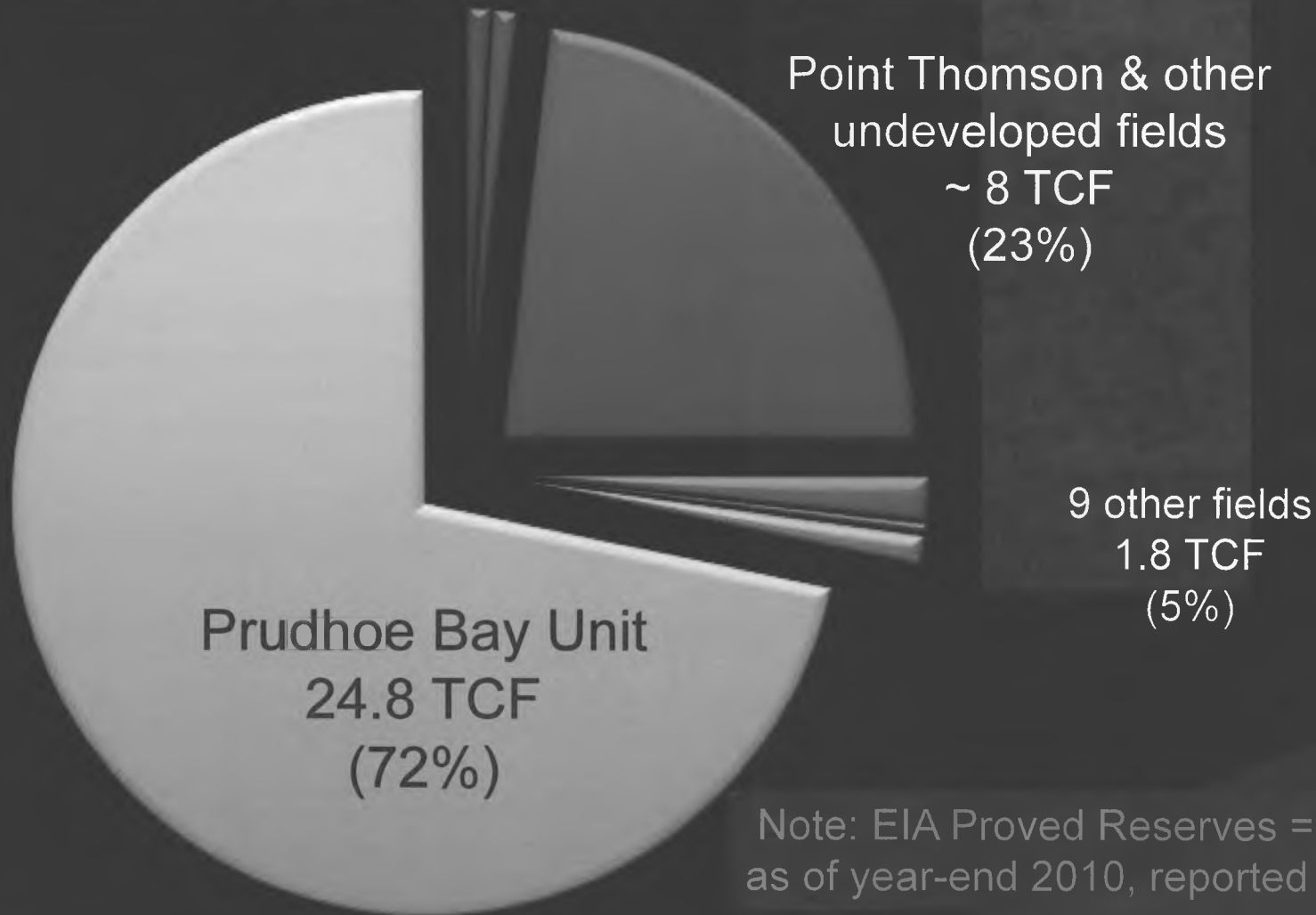
- NU Schrader Bluff PA 120-200 million barrels

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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

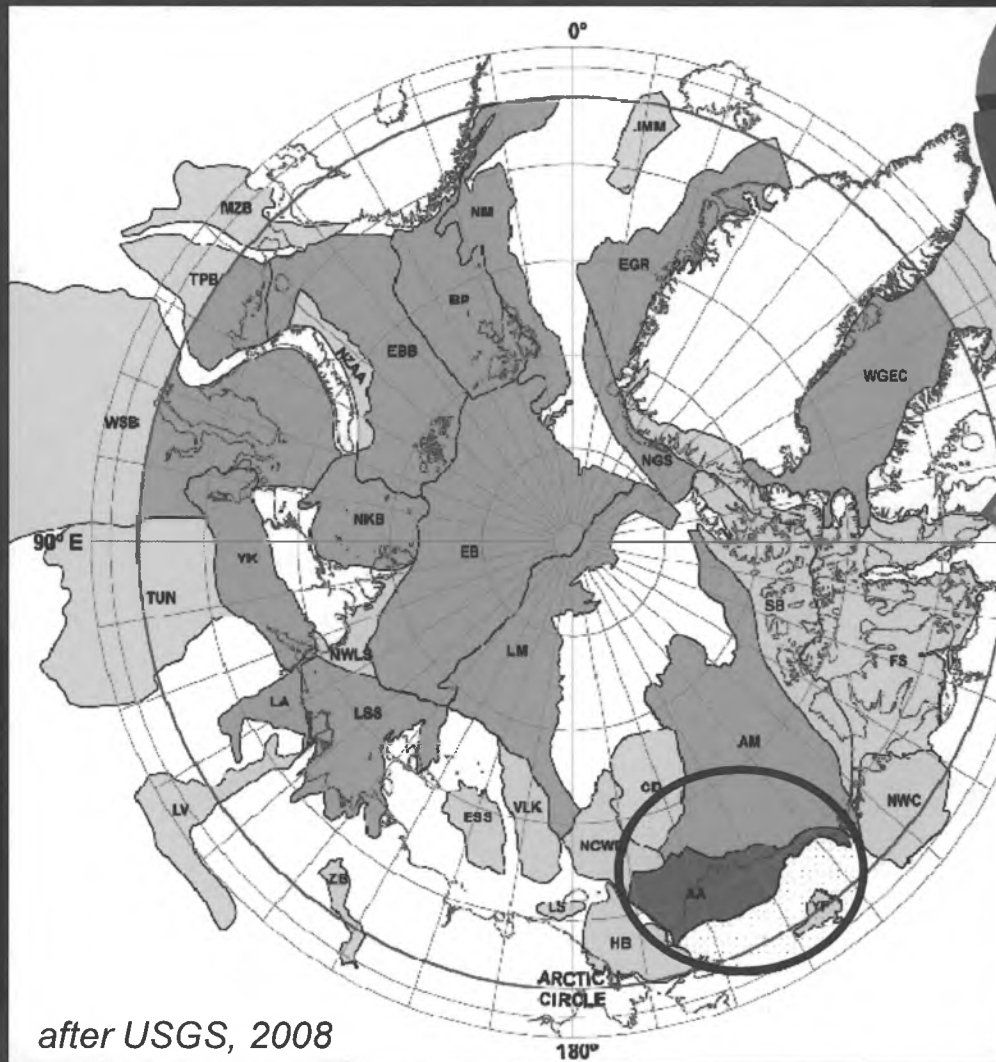
Table 2.8. North Slope, Alaska—Undeveloped oil and gas accumulations as of January 1, 2005 (after Bird, 1991 and Thomas, and others, 1991 and 1993)

	Accumulation or Field/ Reservoir Formation(s)	Year of Discovery	Estimated Technically Recoverable Resources
1. Burger—gas and con	Umiat <sup>11</sup> /Nanushuk Fm.	1946	70 MMBO, 50 BCF
2. East Kurupa—gas (N	Fish Creek <sup>11</sup> /Nanushuk Fm.	1949	OIL (? MMBO)
3. East Umiat—gas (Nat	Simpson <sup>11</sup> /Nanushuk Fm.	1950	12 MMBO
4. Fish Creek—oil (NPR	Meade <sup>11</sup> /Nanushuk Fm.	1950	20 BCF
5. Gubik—gas (Native la	Wolf Creek <sup>11</sup> /Nanushuk Fm.	1951	GAS (? BCF)
6. Gwydyr Bay—oil (Sta	Gubik <sup>11</sup> /Tuluvak And Nanushuk Formations	1951	600 BCF
7. Hammerhead—oil (Fed	Square Lake <sup>11</sup> /Nanushuk Fm.	1952	58 BCF
8. Hemi Springs—oil (Sta	E. Umiat/Nanushuk Fm.	1964	4 BCF
9. Kalubik—oil (State off	Kavik/Ivishak Fm.	1969	115 BCF
10. Kavik—gas (State onsh	Gwydyr Bay <sup>12</sup> /Ivishak Fm.	1969	30-60 MMBO
11. Kemik—gas (State onsh	Kemik/Shublik Fm.	1972	100 + BCF
12. Kuvlum—oil (Federal of	Flaxman Island/Canning Fm.	1975	OIL (? MMBO)
13. Liberty—oil (Federal off	East Kurupa/Torok-Fortress Mtn. Formations	1976	GAS (? BCF)
14. Meade—gas (NPRA)	Pt. Thomson/Thomson Sandstone and Canning Fm.	1977	300 MMBO, 5000 BCF
15. Mikkleson—oil (State on	Mikkelson/Canning Fm.	1978	OIL (? MMBO)
16. Mooses Tooth—oil (NPR	Tern Is. (Liberty)/Kekiktuk Conglomerate	1982	150 MMBO
17. Rendezvous—oil (NPRA)	Hemi Springs/Kuparuk Fm.	1984	OIL (?MMBO)
18. Sandpiper—gas and conde	Hammerhead/Sagavanirktok Fm.	1985	~200 MMBO
19. Sikulik—gas (Native lands	Sandpiper/Ivishak Fm.	1986	150 MMBO/GAS (? BCF)
20. Simpson—oil (NPRA)	Sikulik/Barrow Sandstone	1988	16 BCF
21. Square Lake—gas (NPRA)	Stinson <sup>13</sup> /????	1990	OIL (? MMBO)
22. Stinson—oil (State offshore	Burger/Kuparuk Equivalent	1990	14,000 BCF, 724 MMBO
23. Umiat—oil (NPRA)	Kuvlum <sup>13</sup> /????	1993	400 MMBO
24. Wolf Creek—gas (NPRA)	Thetis Island <sup>13</sup> /Nuiqsut	1993	OIL (? MMBO)
	Sourdough <sup>13</sup> /?????	1994	~100 MMBO
	Pete's Wicked <sup>13,14</sup> /Sagavanirktok and Ivishak Fms.	1997	OIL (? MMBO)
	Sambucca <sup>13</sup> /Ivishak Fm.	1997	19 MMBO(?)
	Oooguruk <sup>13</sup> /Nuiqsut Sandstone(?)	2003	70 MMBO(?)
	Nikaitchuq <sup>13</sup> /Nuiqsut and Sag River Sandstones(?)	2004	70 MMBO(?)
	Tuvaag/Schrader Bluff Fm.	2005	OIL (?MMBO)
	<b>Total</b>		<b>2,300 + MMBO/ 20,000 + BCF</b>

Thomas and others, 2007

# USGS Circum-Arctic Resource Appraisal

Undiscovered, technically recoverable oil








after USGS, 2008



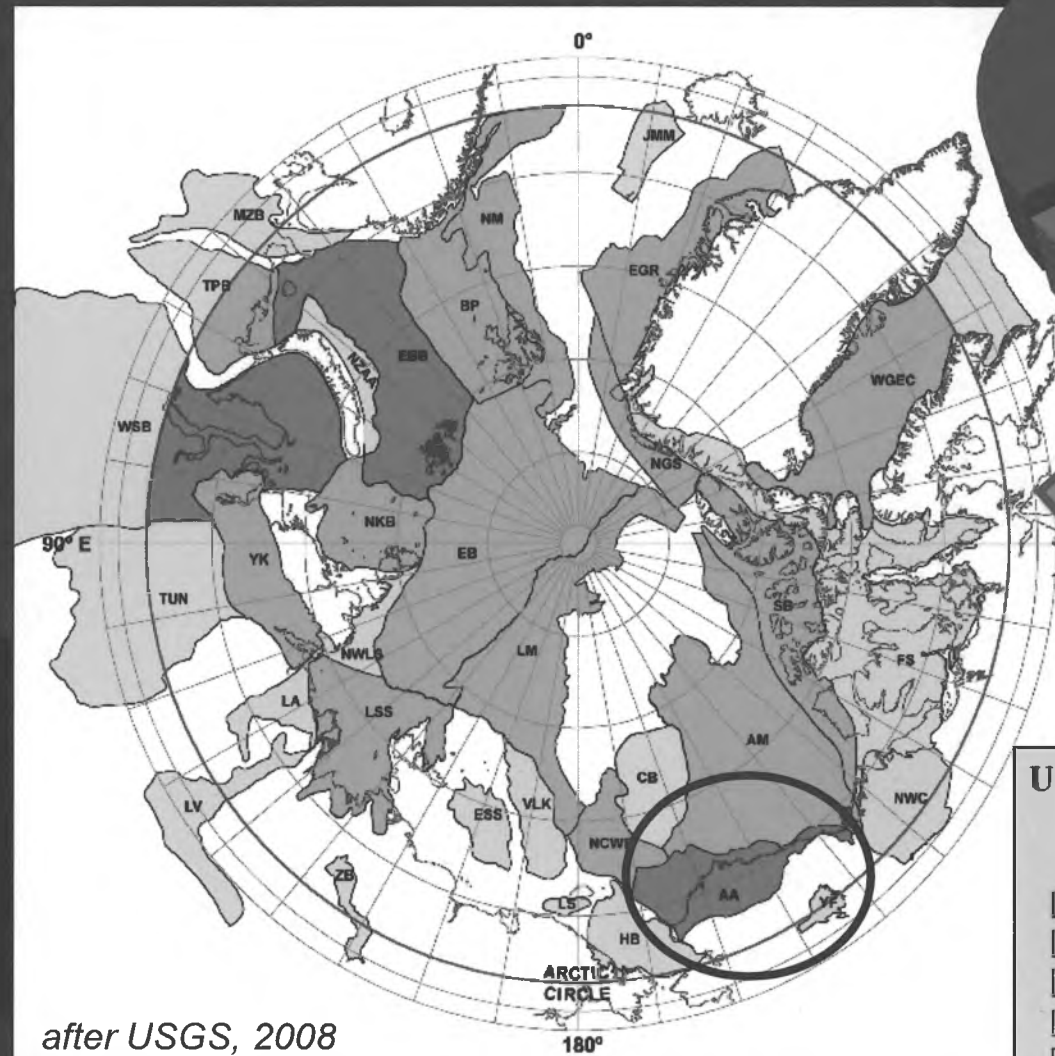
Arctic Alaska Oil + NGL  
30 BBO + 6 BBNGL mean

## UNDISCOVERED OIL (billion barrels)

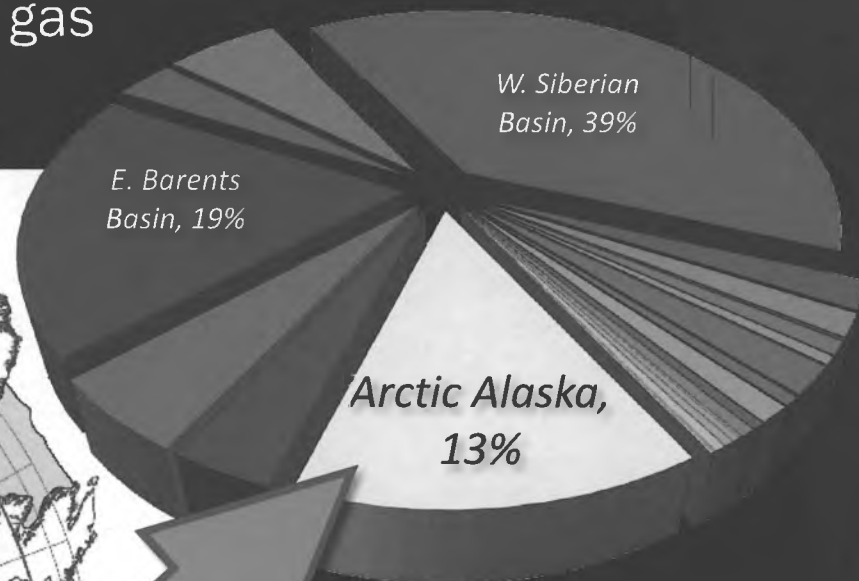
-  >10
-  1-10
-  <1
-  Area not quantitatively assessed
-  Area of low petroleum potential

# USGS Circum-Arctic Resource Appraisal

Undiscovered, technically recoverable gas








after USGS, 2008



Arctic Alaska Gas  
221 TCF mean

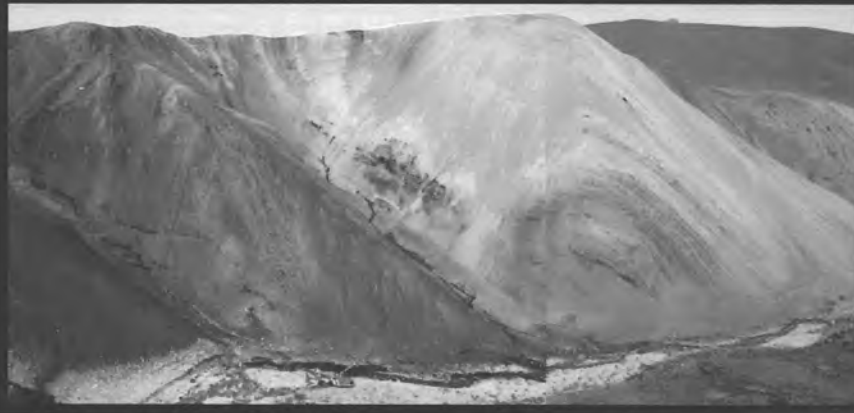
**UNDISCOVERED GAS**  
(trillion cubic feet)

-  >100
-  6-100
-  <6
-  Area not quantitatively assessed
-  Area of low petroleum potential

# North Slope Shale Oil & Gas Resources

## Hue Shale/GRZ

Type section outcrops at Hue Creek, ANWR



## Shublik Formation

Variability in outcrop and well logs



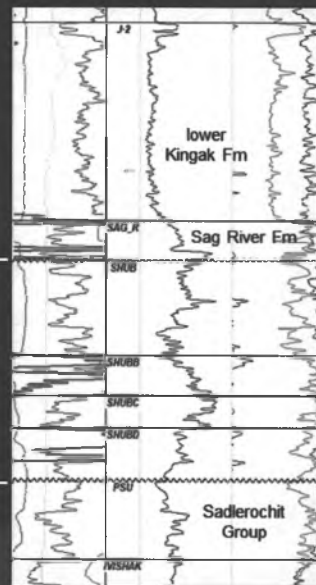
Interbedded shale & limestone, silty-muddy, phosphatic, pyritic (up to 600 ft thick)



Shublik Fm

- Zone A
- Zone B
- Zone C
- Zone D

Rock Flow: 1

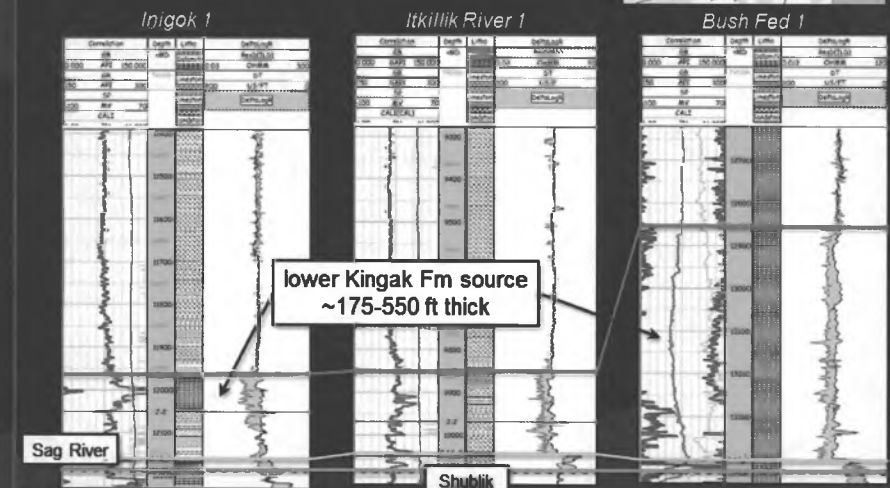
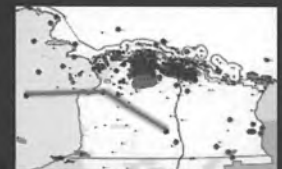


## Total assessed resources:

- Shale Oil: 0 – 2 BBO (mean 940 MMBO)
- Shale NGL: 0 – 571 MMBO (mean 262 MMBO)
- Shale Gas: 0 – 80 TCF (mean 42 TCF)

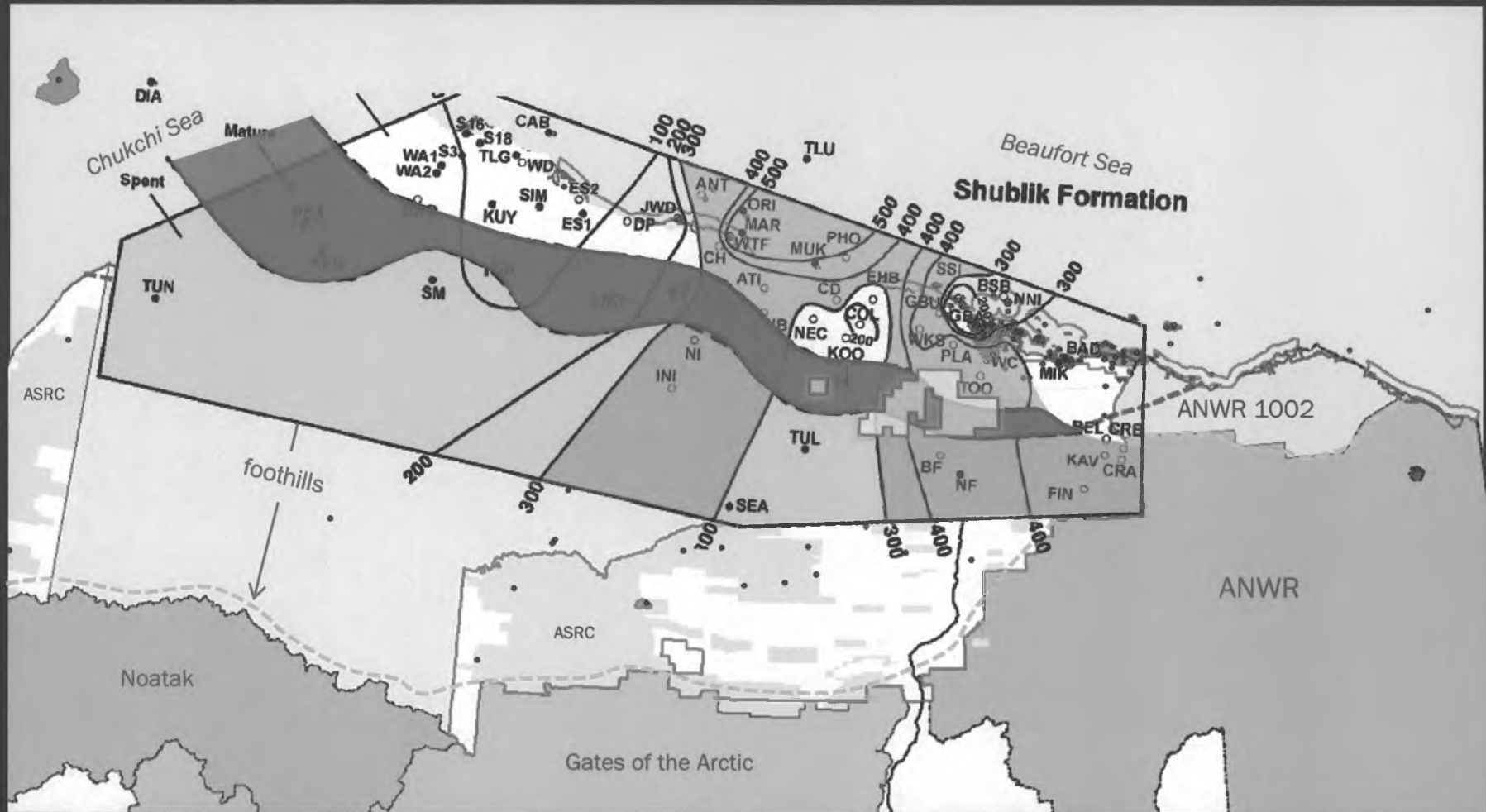
## Lower Kingak Formation

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*

