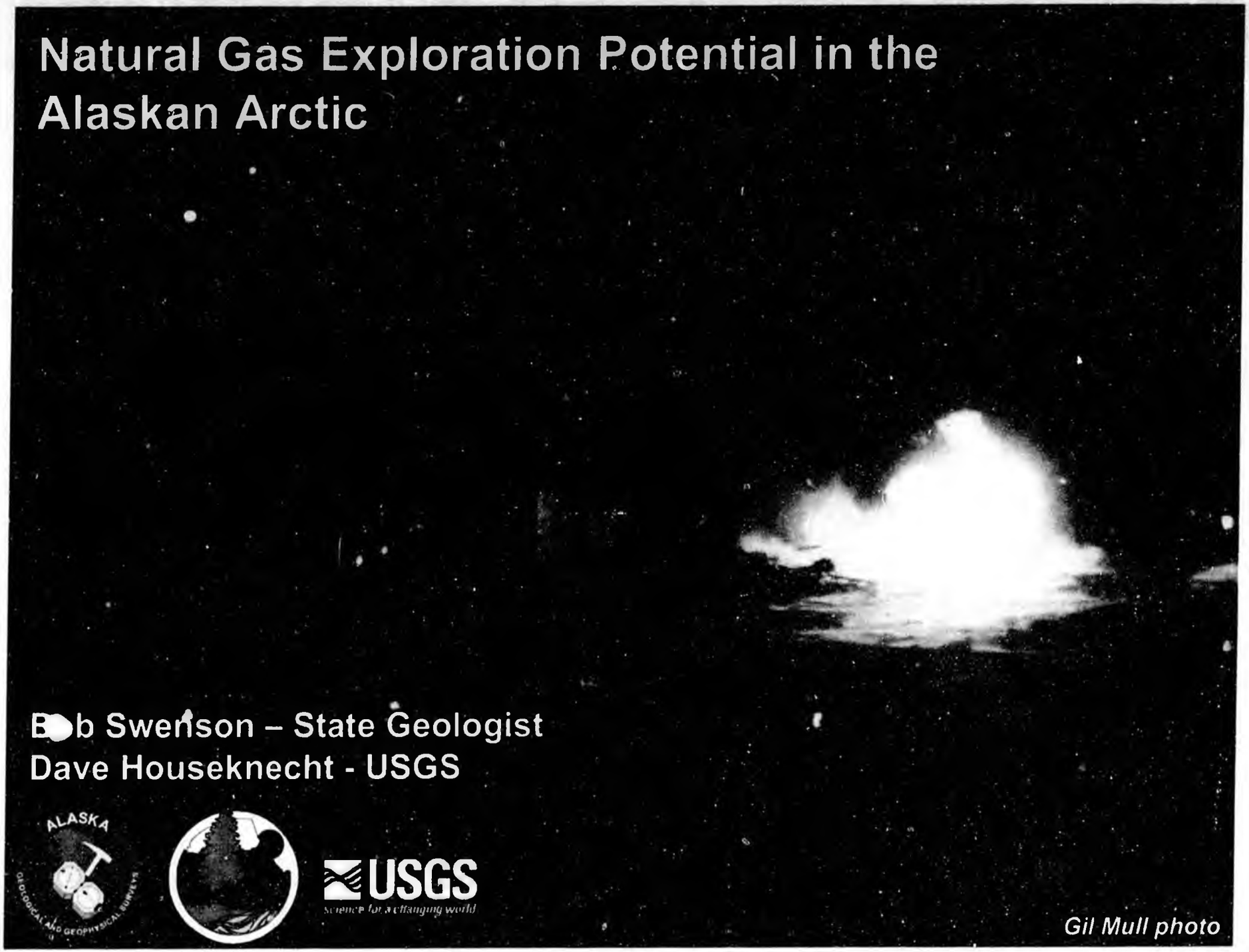
HB 3001
SB 3001
6/7/08
SPECIAL SESSION DOCUMENTS

Natural Gas Exploration Potential in the Alaskan Arctic

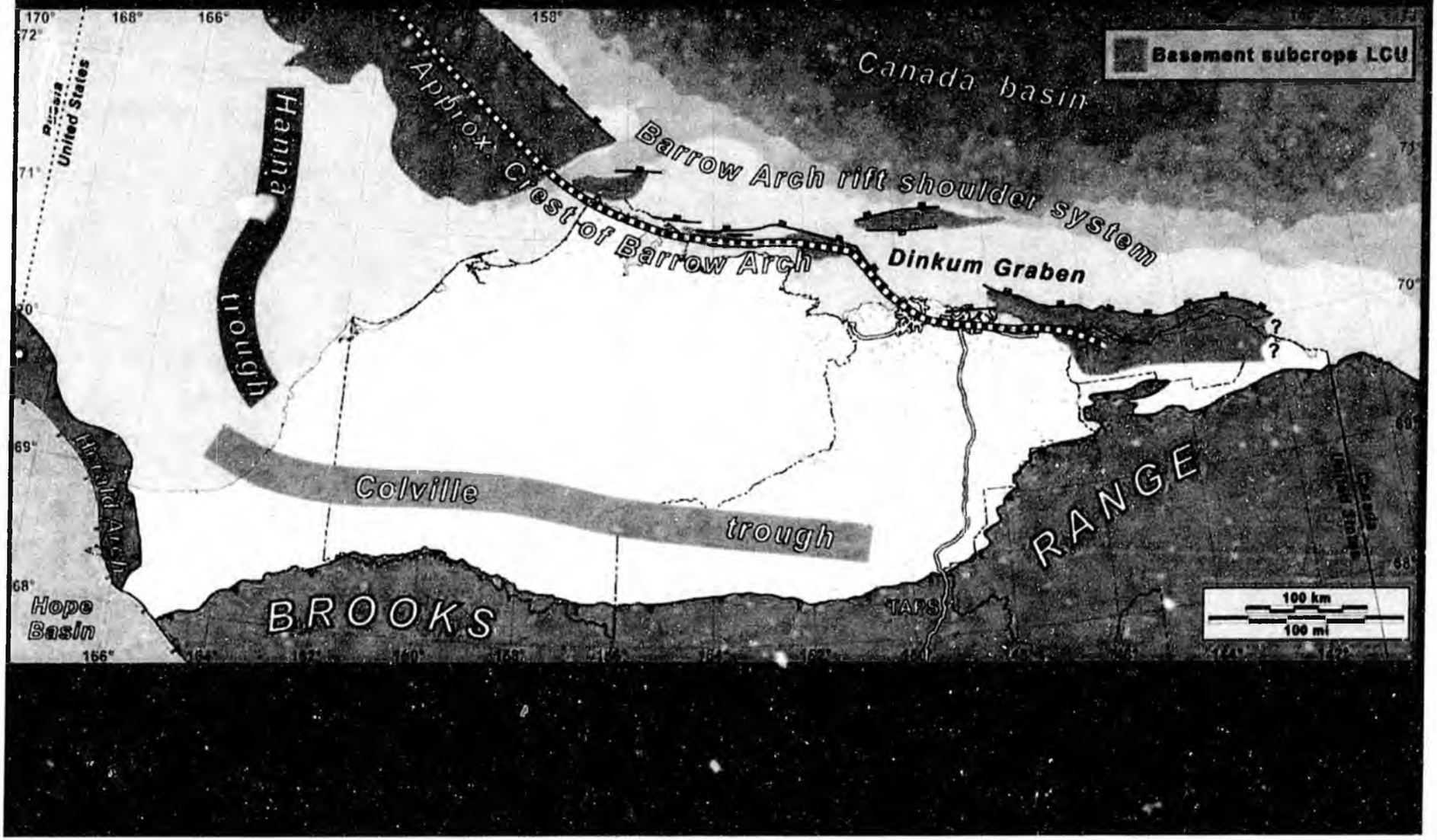


Bob Swenson – State Geologist
Dave Houseknecht - USGS

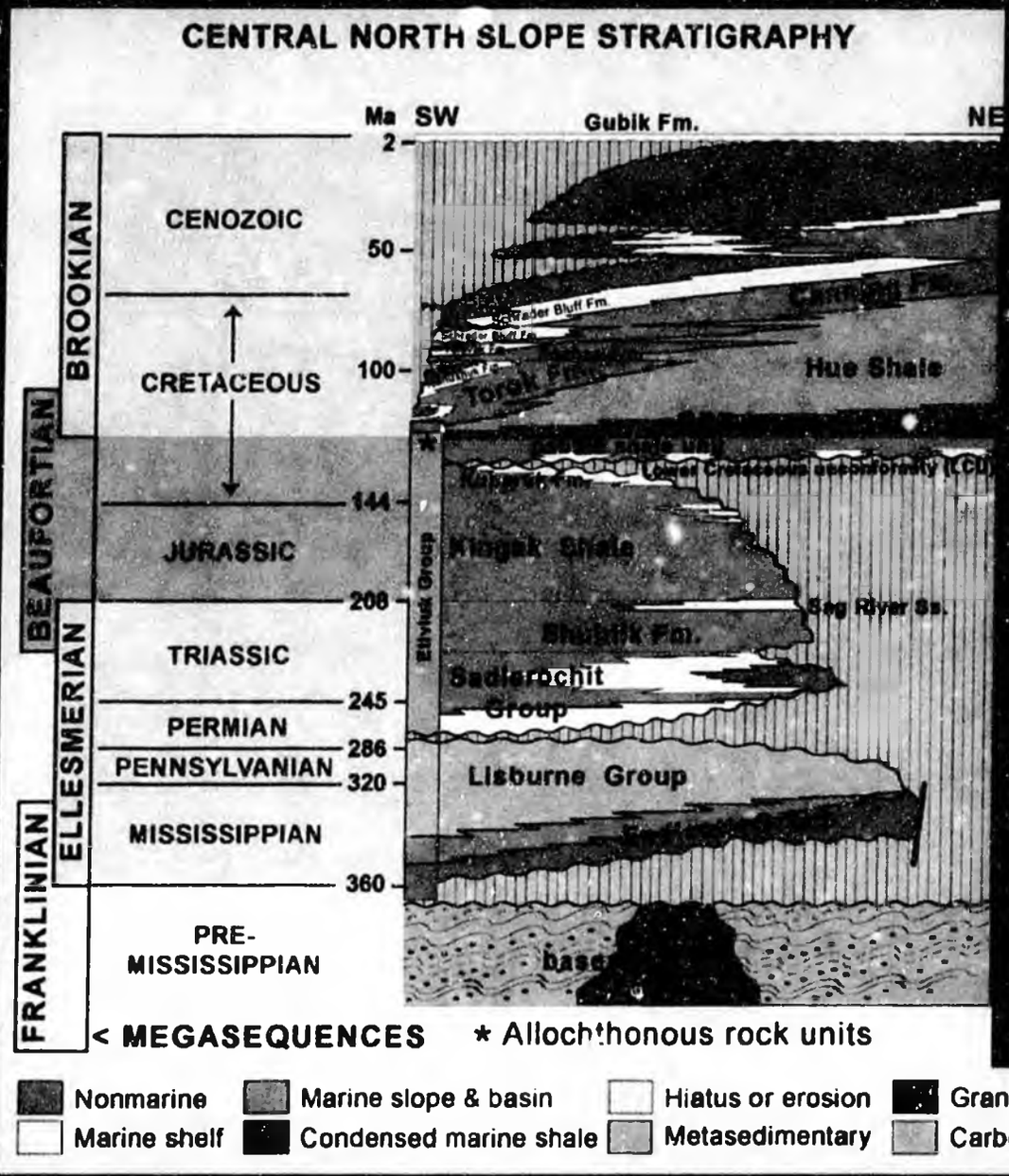
USGS
science for a changing world

Gil Mull photo

Arctic Alaska - Key Geologic Features



Stratigraphy – Known & Potential Source Rocks

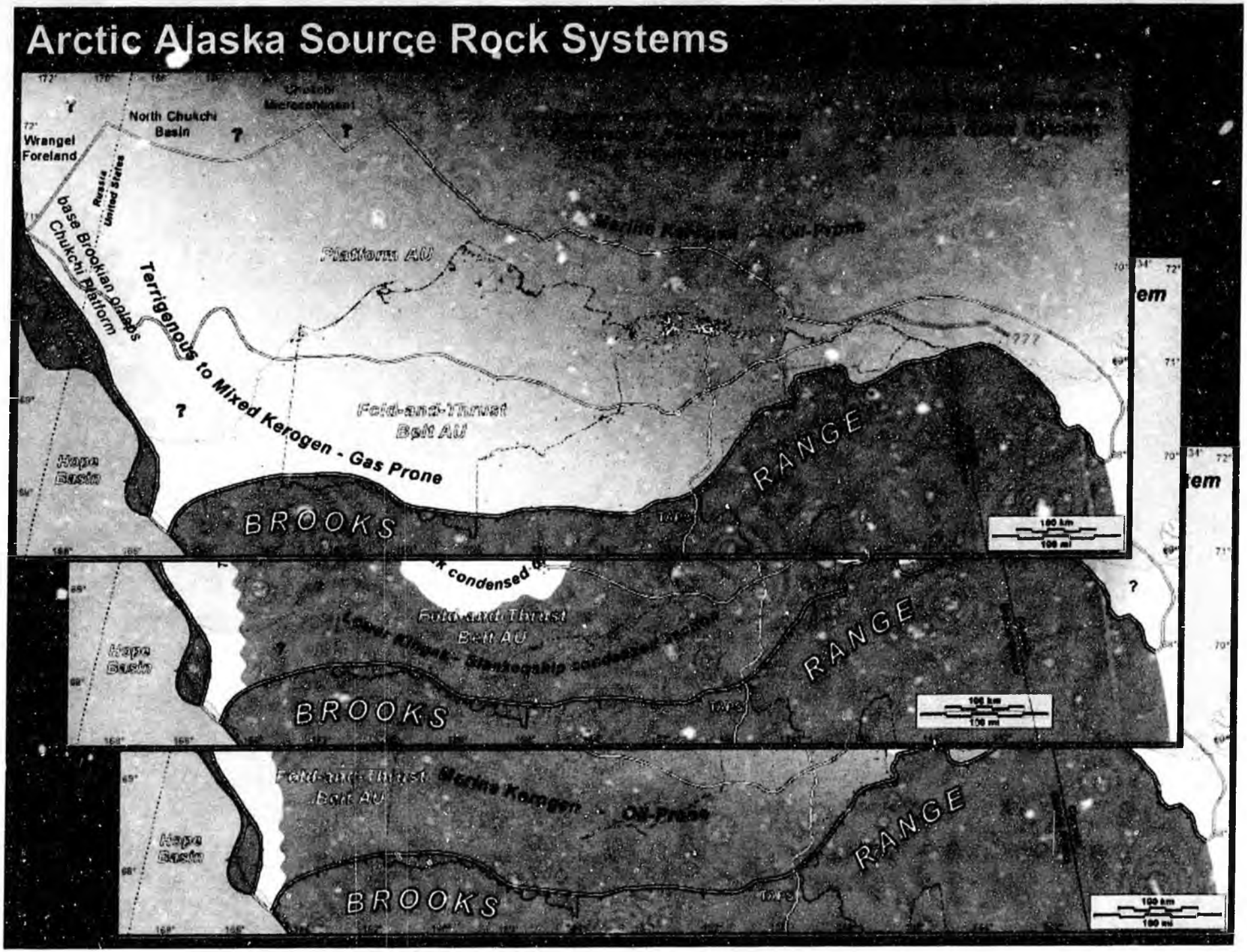


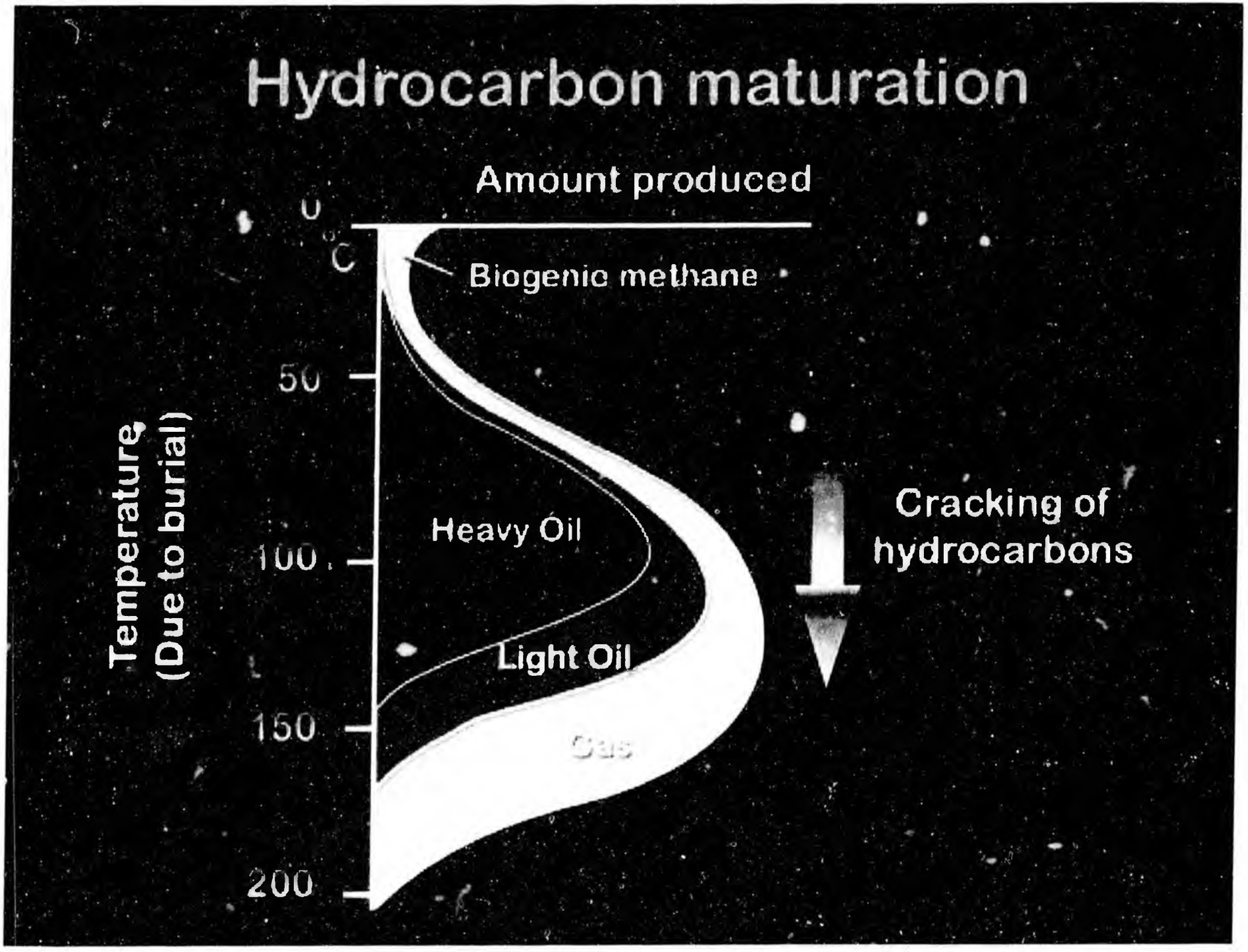
< *Paleogene Canning*

< *Seabee*
< *GRZ (HRZ)*

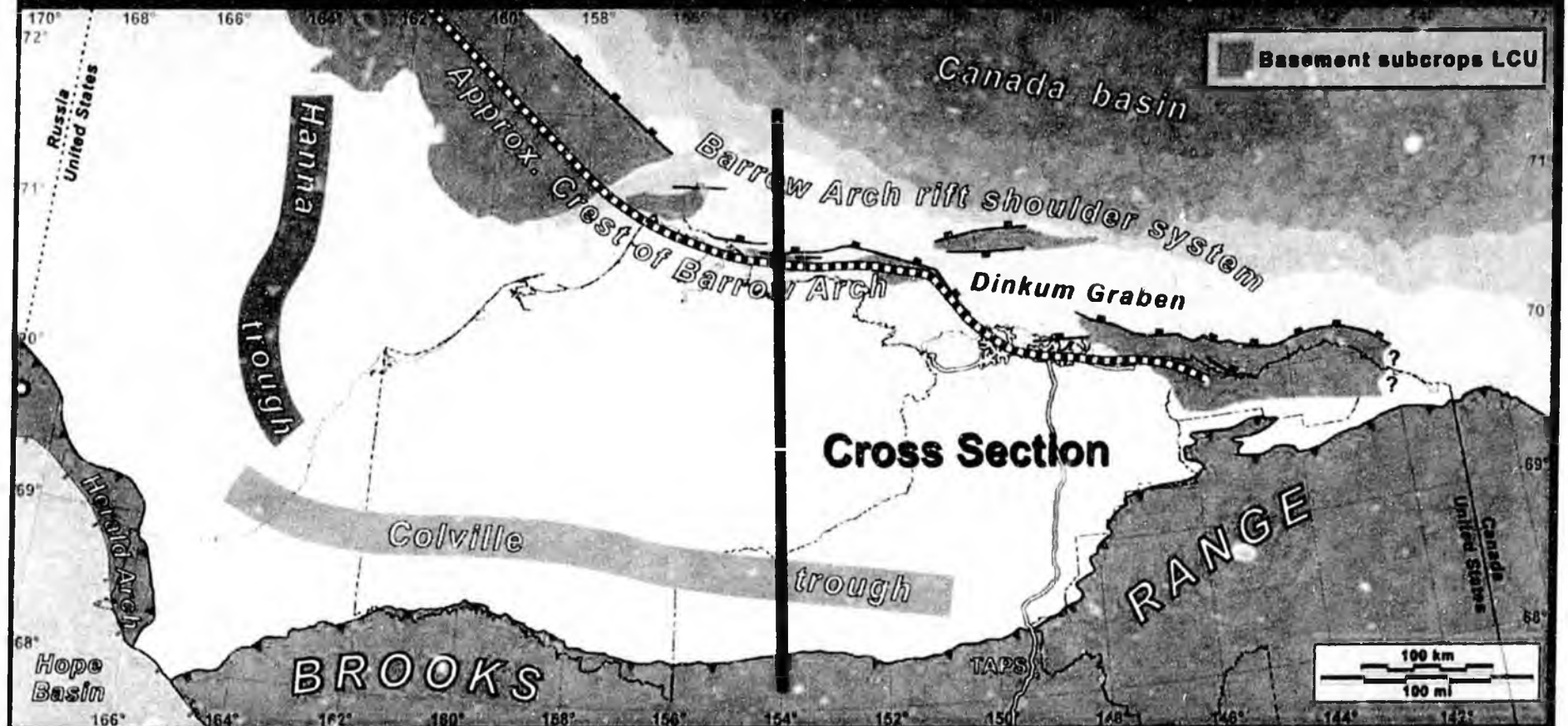
< *Lower Kingak*
< *Shublik*

< *Lisburne (Kuna)*
< *Kekiktuk*

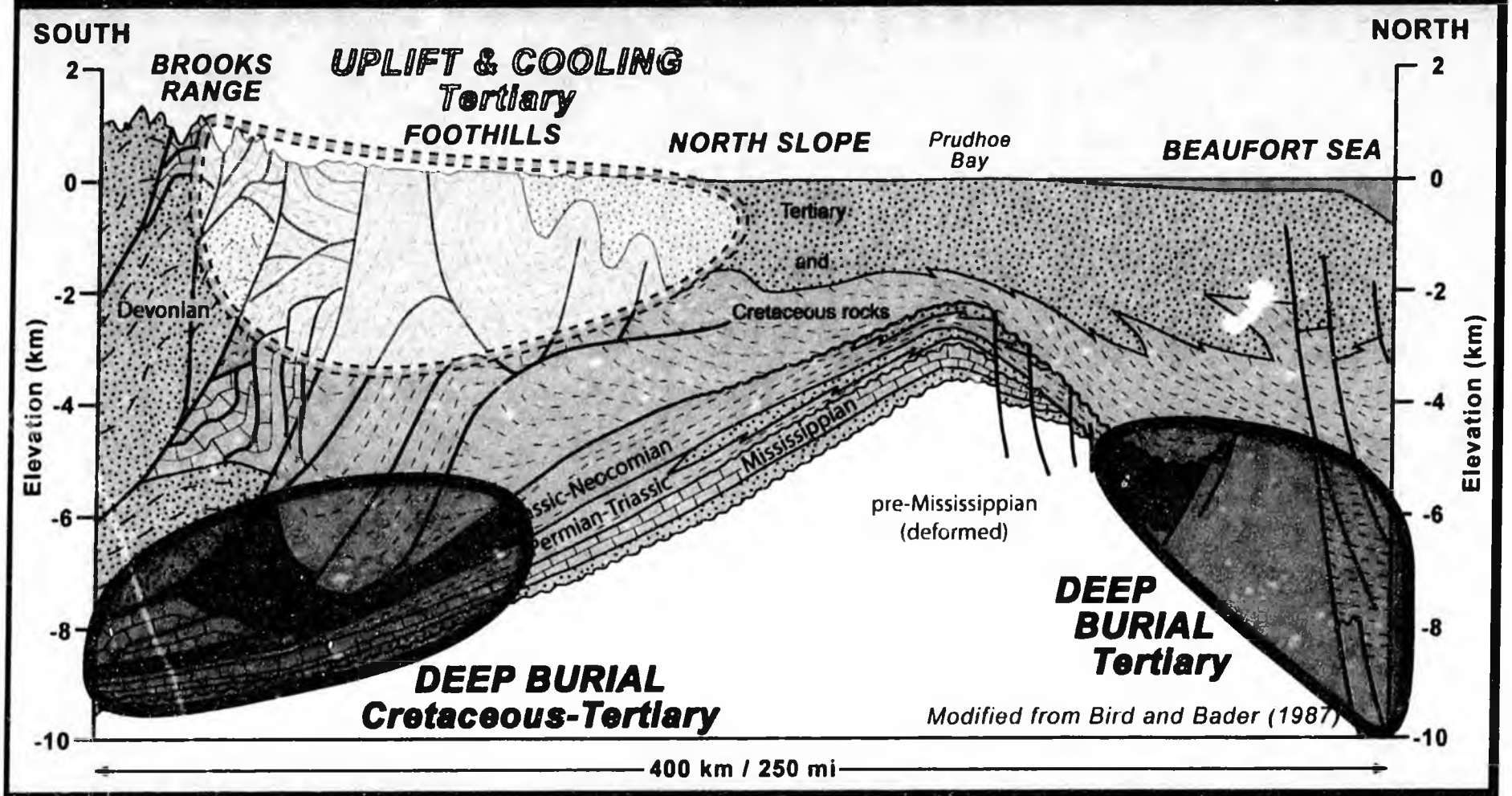

Arctic Alaska Source Rock Systems
North Chukchi Basin
Wrangel Foreland
Russia
United States
base Brookian Onlaps
Chukchi Platform
Terrigenous to Mixed Kerogen - Gas Prone
Platform AU
Fold-and-Thrust Belt AU
Hope Basin
BROOKS
RANGE
Marine Kerogen - Oil-Prone
Fold-and-Thrust Belt AU
Lower Cretaceous condensed section
Hope Basin
BROOKS
RANGE
Fold-and-Thrust Belt AU
Marine Kerogen - Oil-Prone
Hope Basin
BROOKS
RANGE


Hydrocarbon maturation
Amount produced
0 °C
Biogenic methane
50
Temperature (Due to burial)
Heavy Oil
100
Cracking of hydrocarbons
Light Oil
150
200

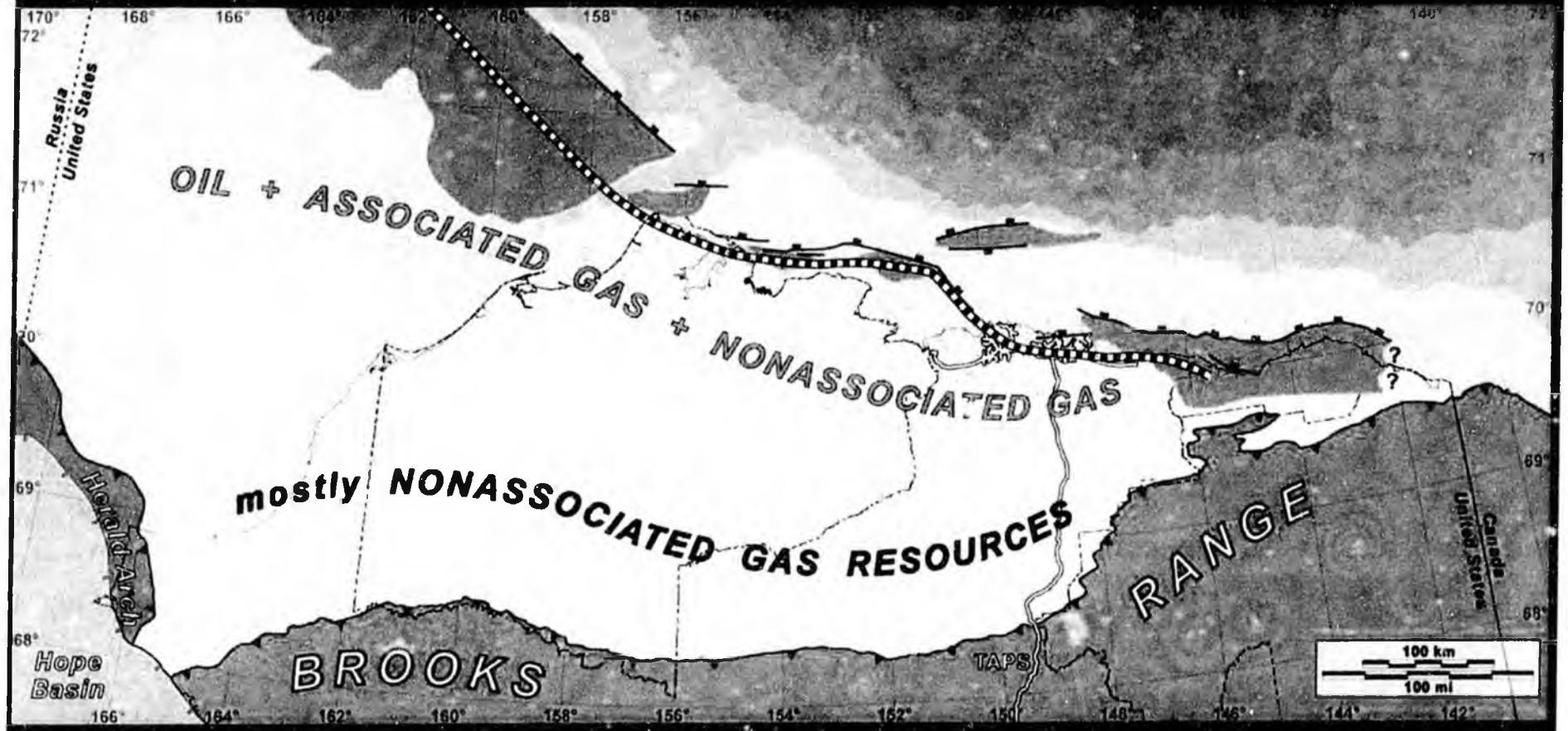
Arctic Alaska - Key Geologic Features

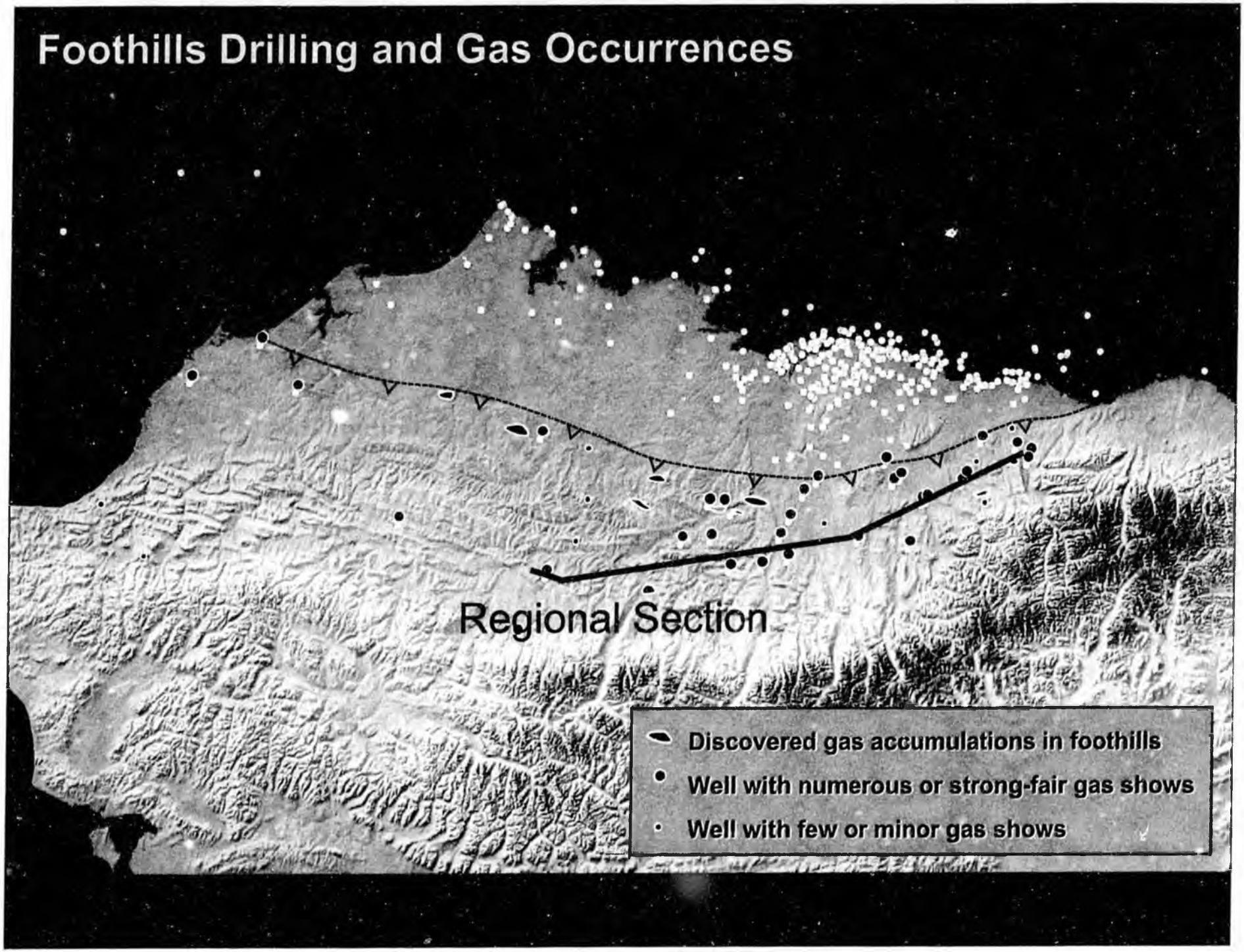


Overview of Regional Geology



Arctic Alaska Generalized Potential for Oil and Gas

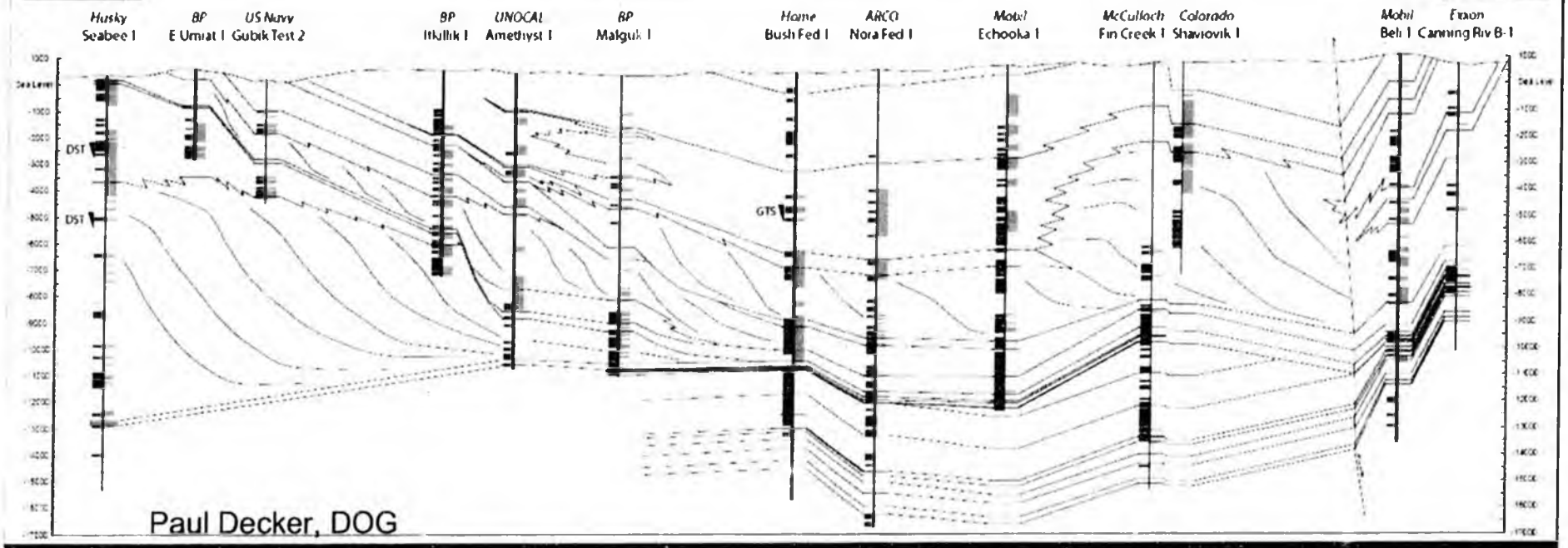



Foothills Drilling and Gas Occurrences
Regional Section
Discovered gas accumulations in foothills
Well with numerous or strong-fair gas shows
Well with few or minor gas shows

Foothills Cross Section - Oil and Gas Shows

West

East



Source Rock & Hydrocarbon Characterization

Synthesizing a decade of organic geochemical analyses and integrate with regional geologic data

Characterization of hydrocarbon occurrences

Reservoir Quality 1

Locations of Porosity and Permeability Outcrop Samples 1999-2002, Brooks Range Foothills and North Slope, Alaska

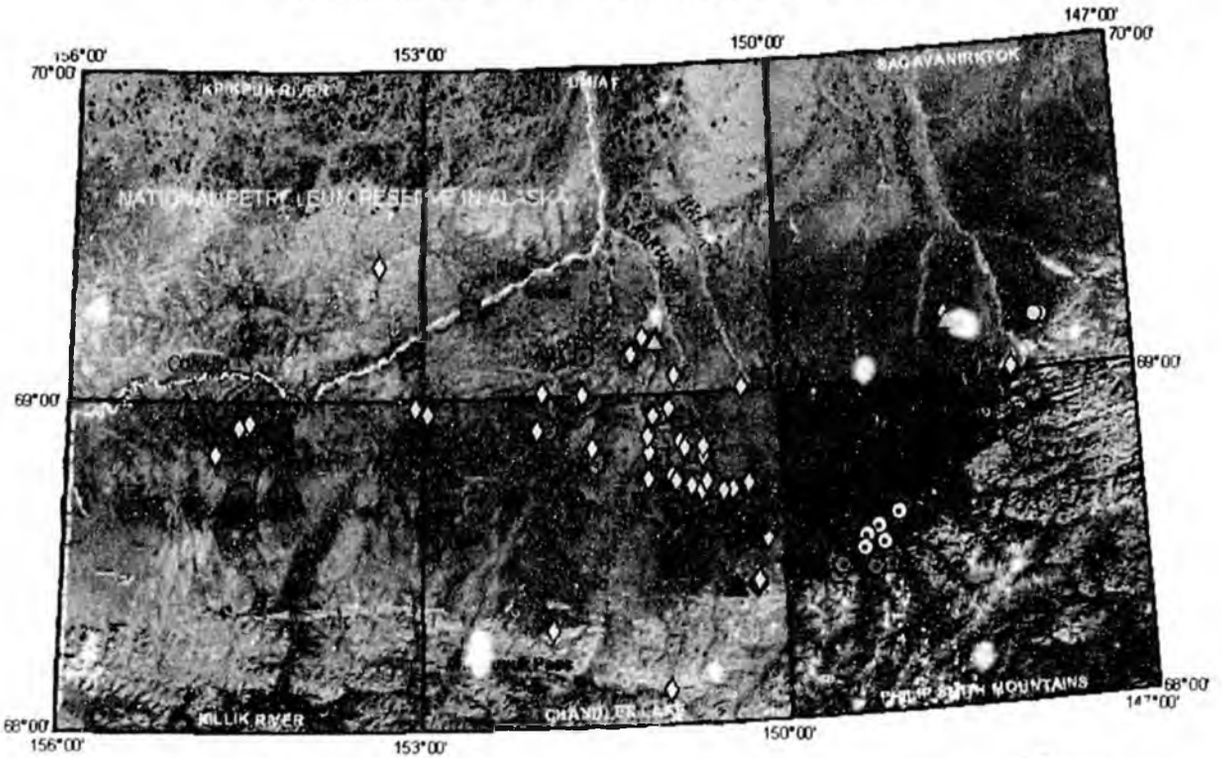
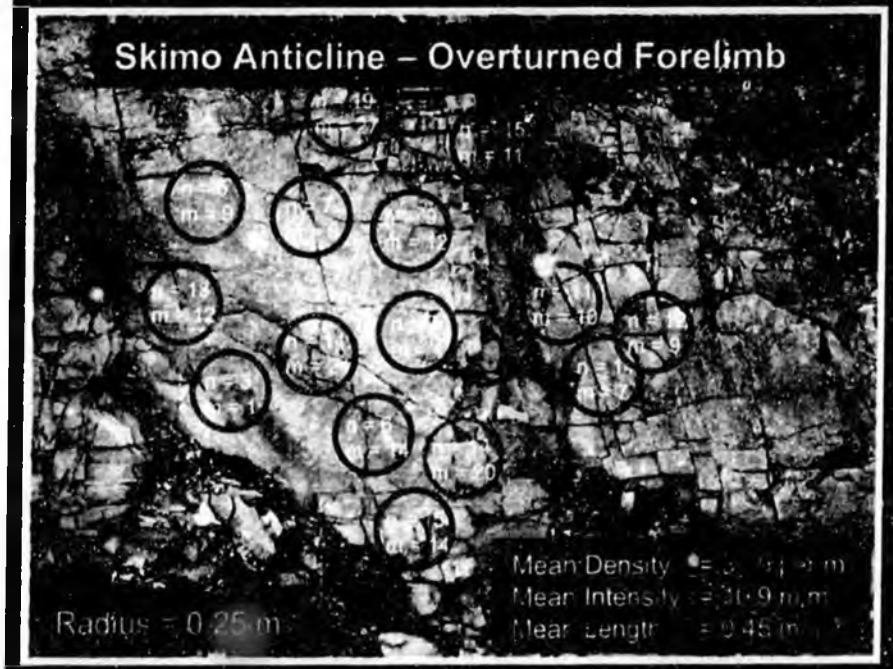
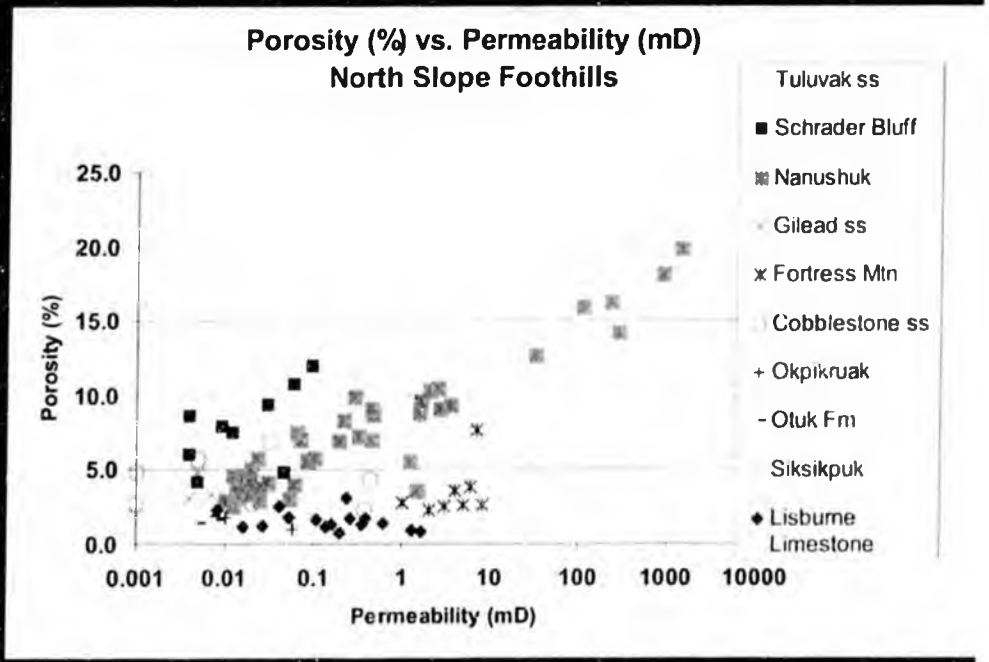


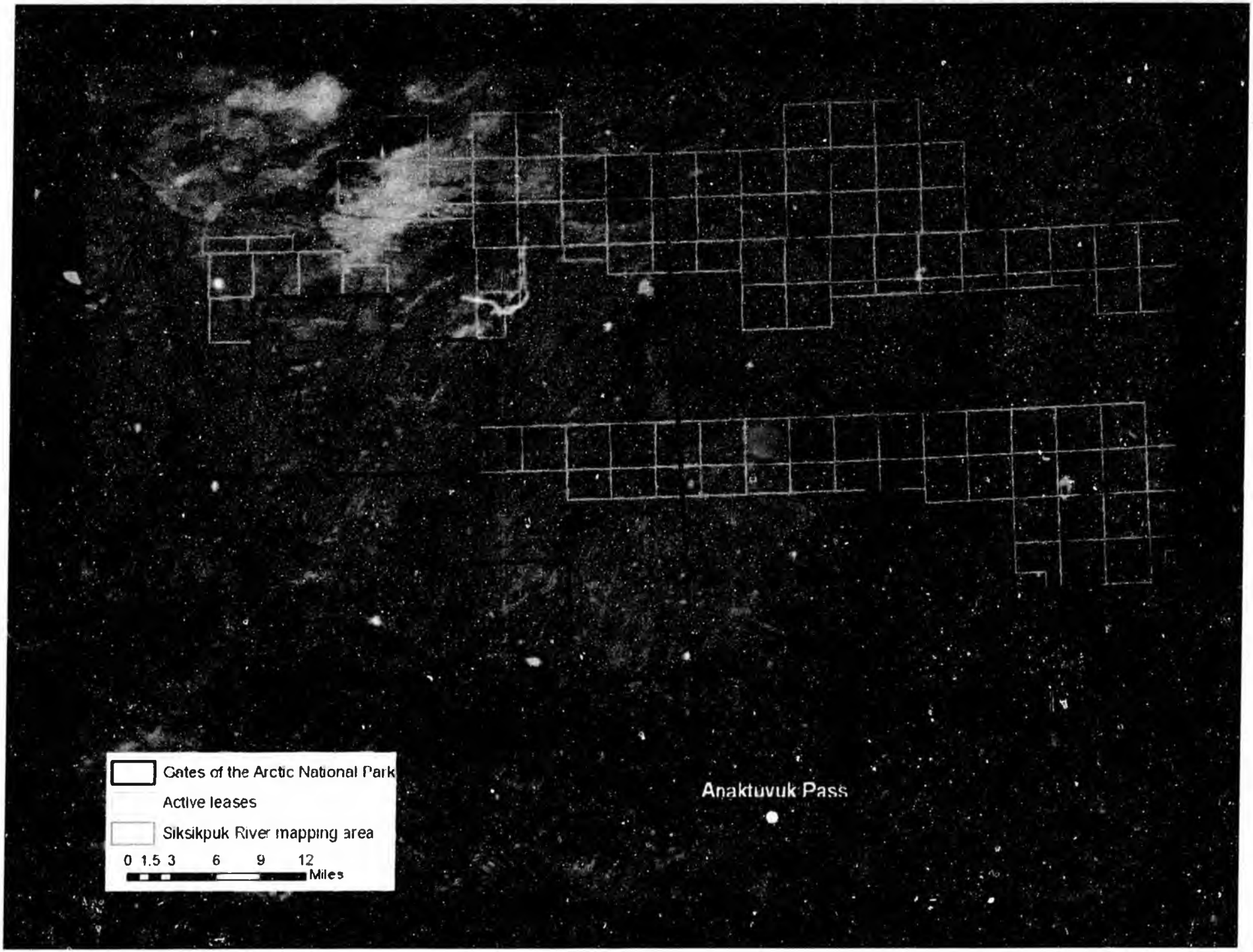
Figure 1. Satellite image showing locations and geologic formations of porosity and permeability samples from 1999-2002, Brooks Range Foothills and North Slope, Alaska

Reservoir quality studies

- Continued sampling for porosity and permeability
- Correlation of reservoir quality with depositional environment, petrology, and diagenesis
- Fracture analysis and reservoir characteristics

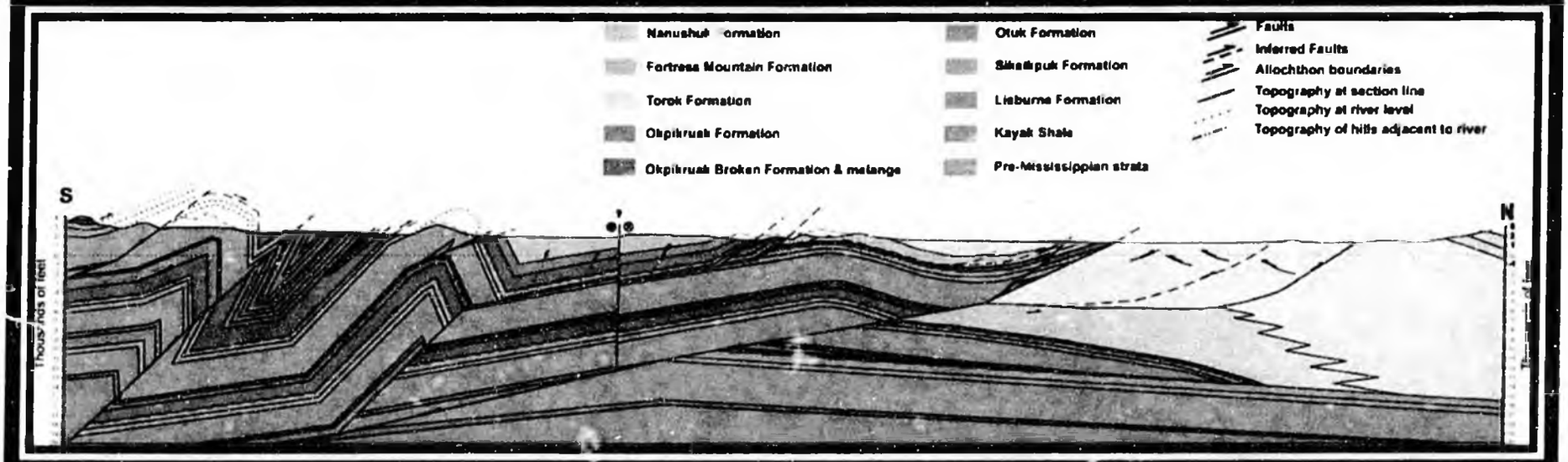




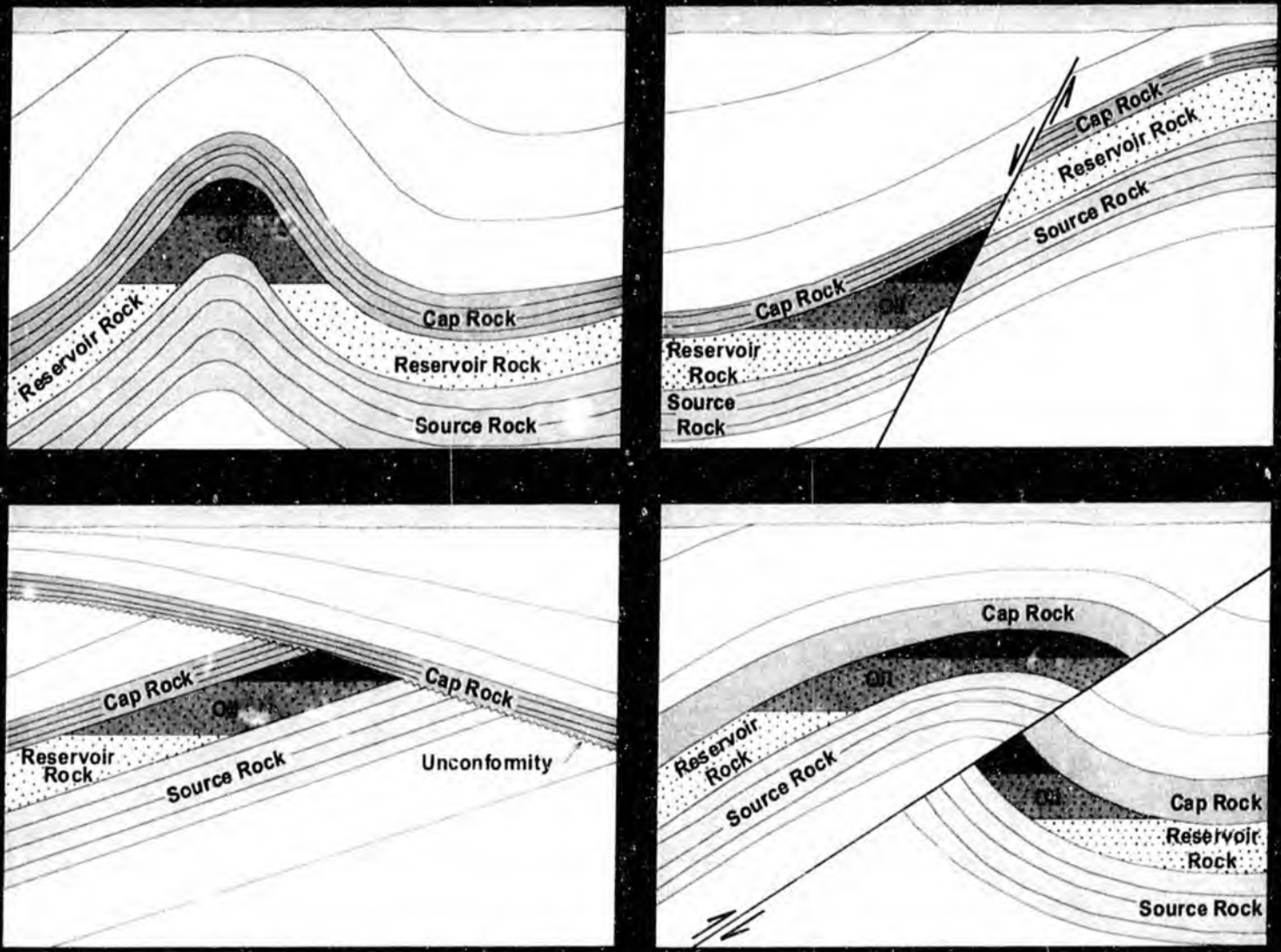

Gates of the Arctic National Park
Active leases
Siksikpuk River mapping area
0 1.5 3 6 9 12
Miles
Anaktuvuk Pass

Regional Burial and Exhumation History of the Southern Colville Basin

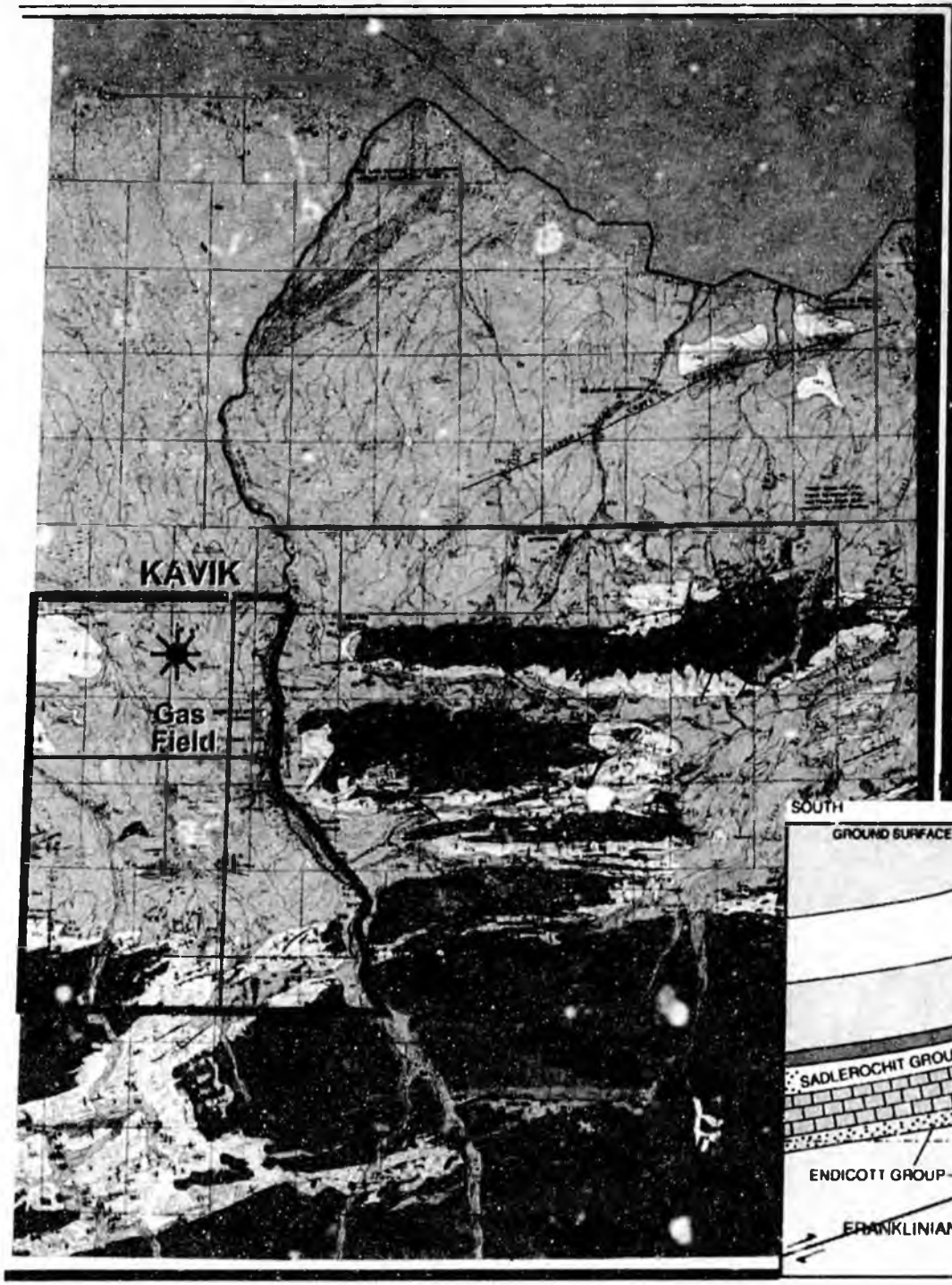
- Building balanced structural cross sections
- Fission track data confirm zone of low thermal maturity
- Evidence for mid-Cretaceous syntectonic sedimentation
- Constraining timing of key events affecting petroleum system



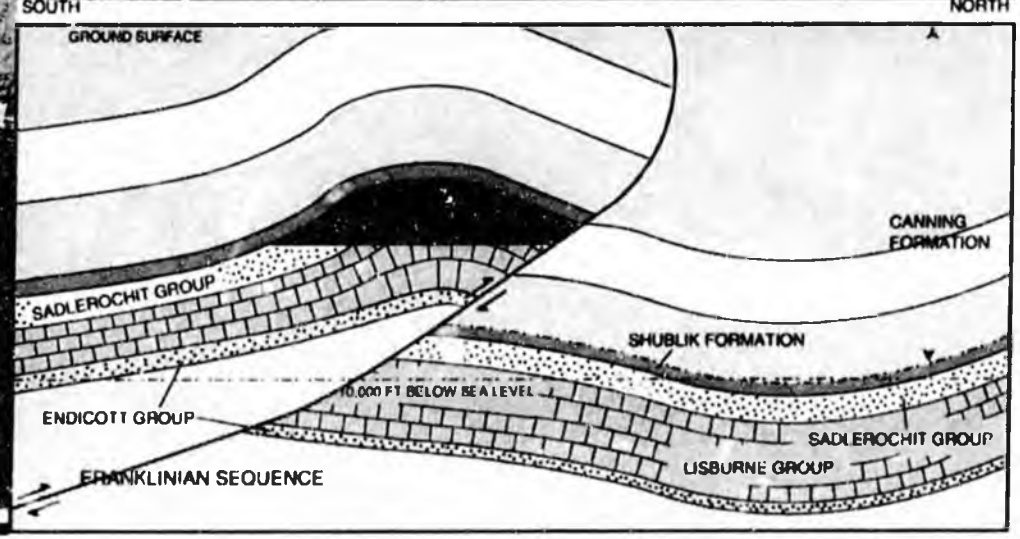
Conventional Exploration Play Types



Oil and Gas Trapping Mechanisms

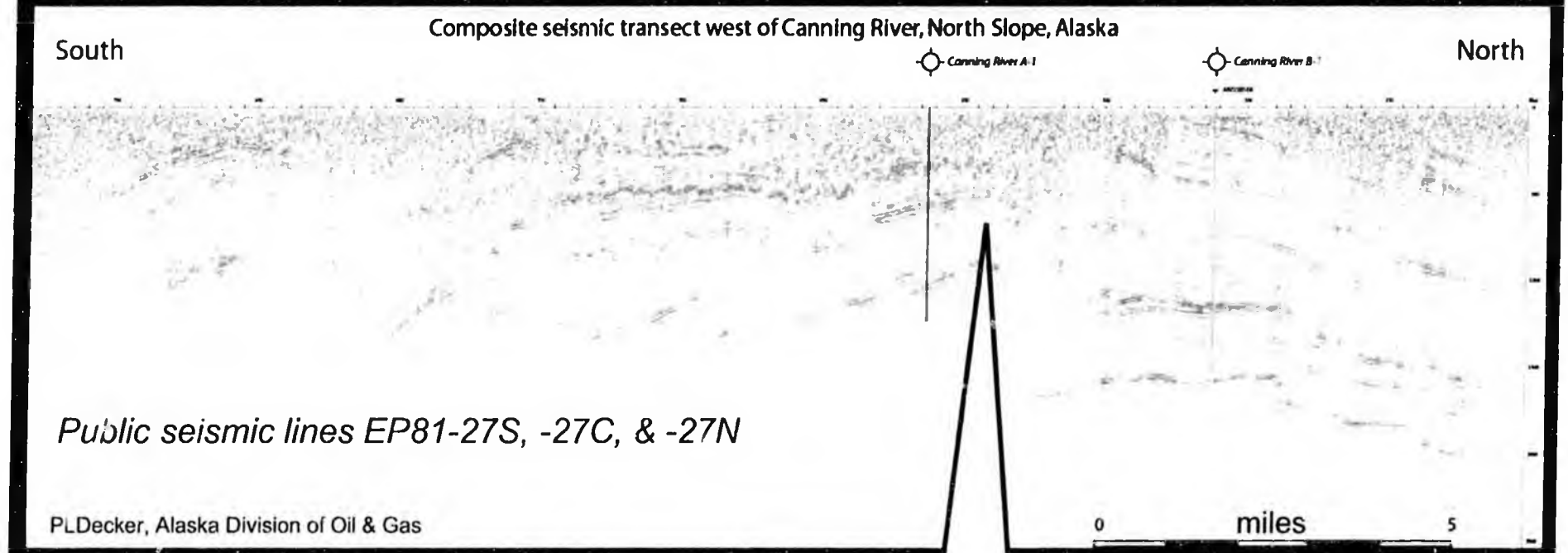


Kavik River Gas Field

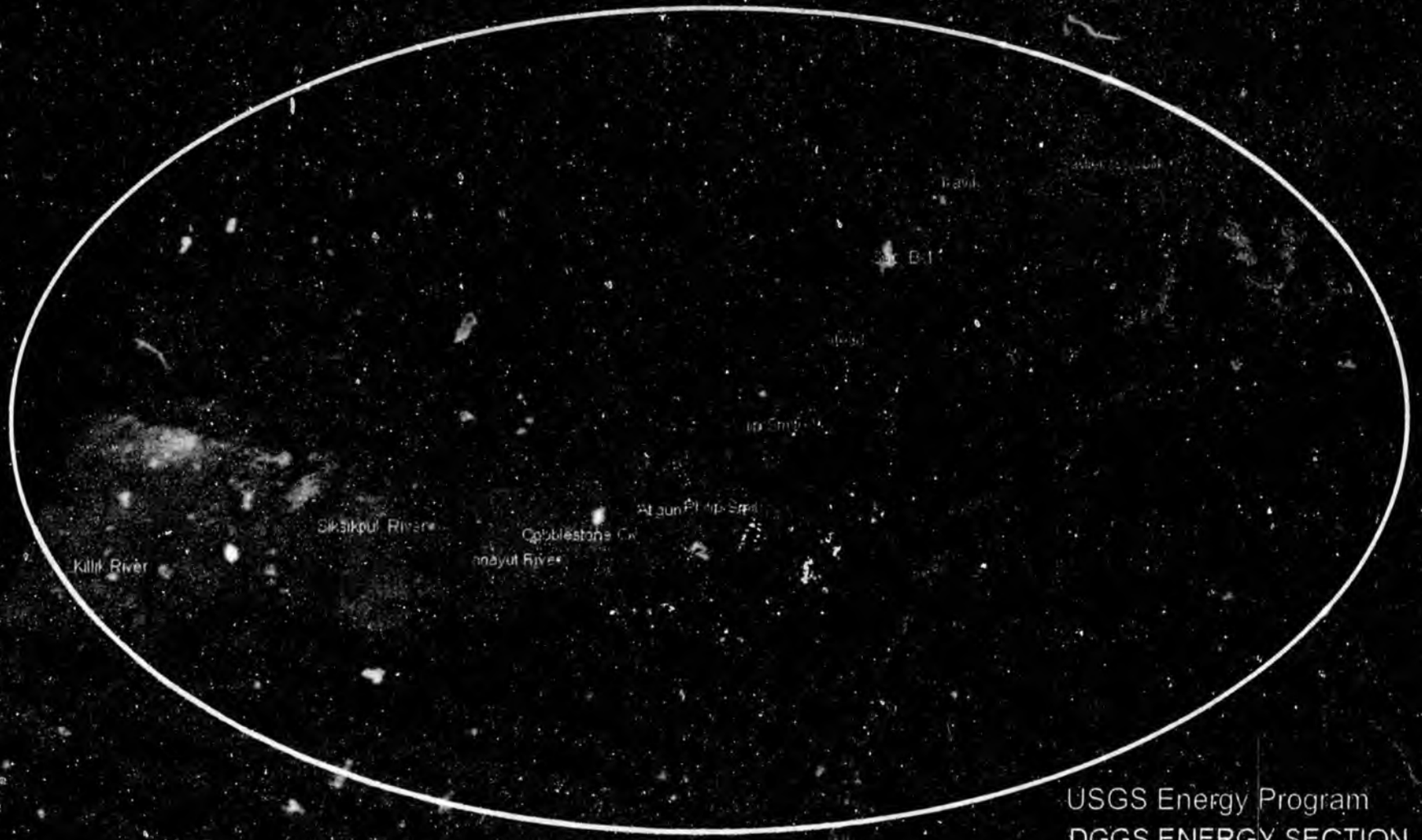


Foothills Structural Plays

Seismic Interpretation



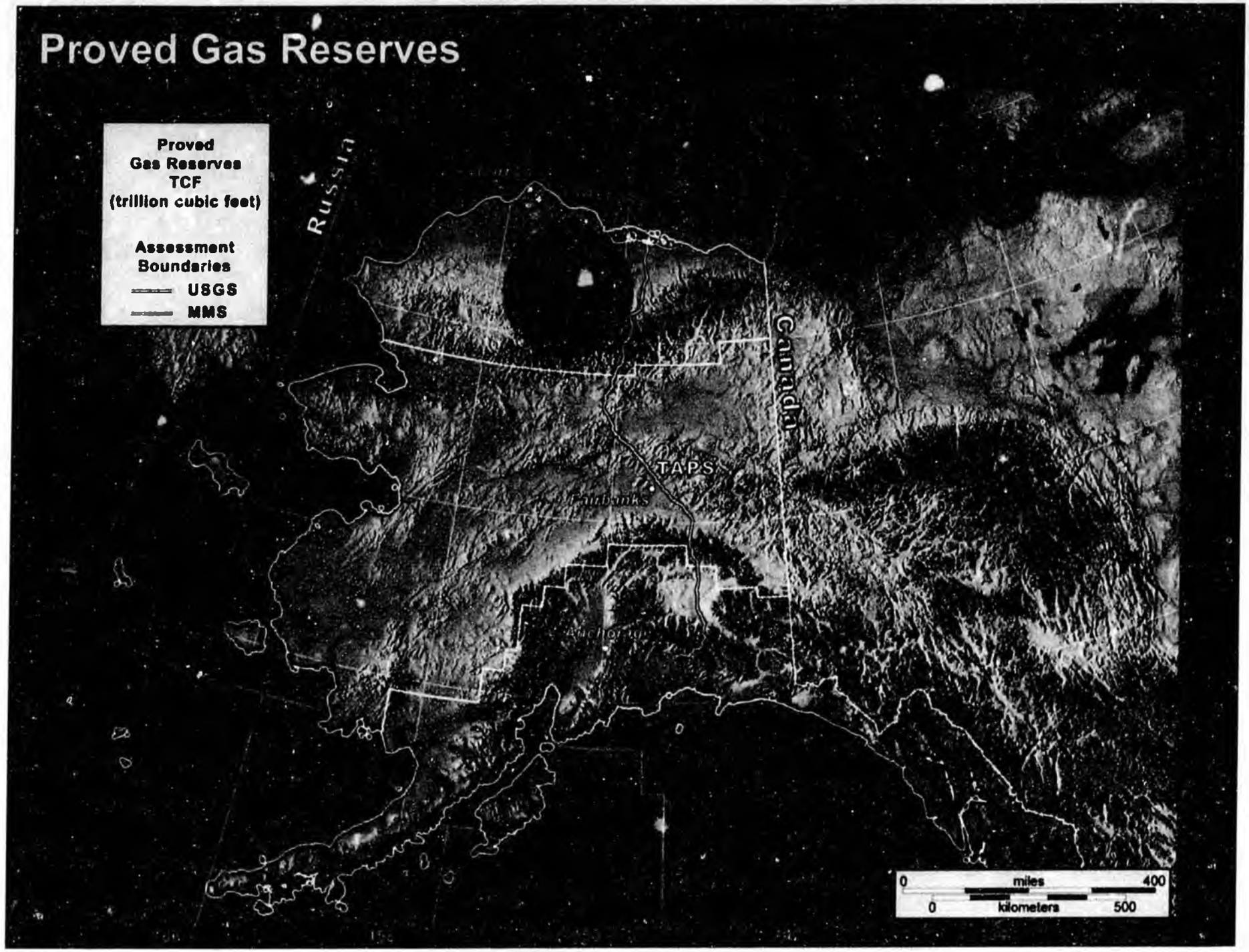
Brooks Range Geologic Mapping
Regional Geologic & Resource Analysis



USGS Energy Program
DGGS ENERGY SECTION
GEOLOGIC MAPPING
Eastern Brooks Range Foothills

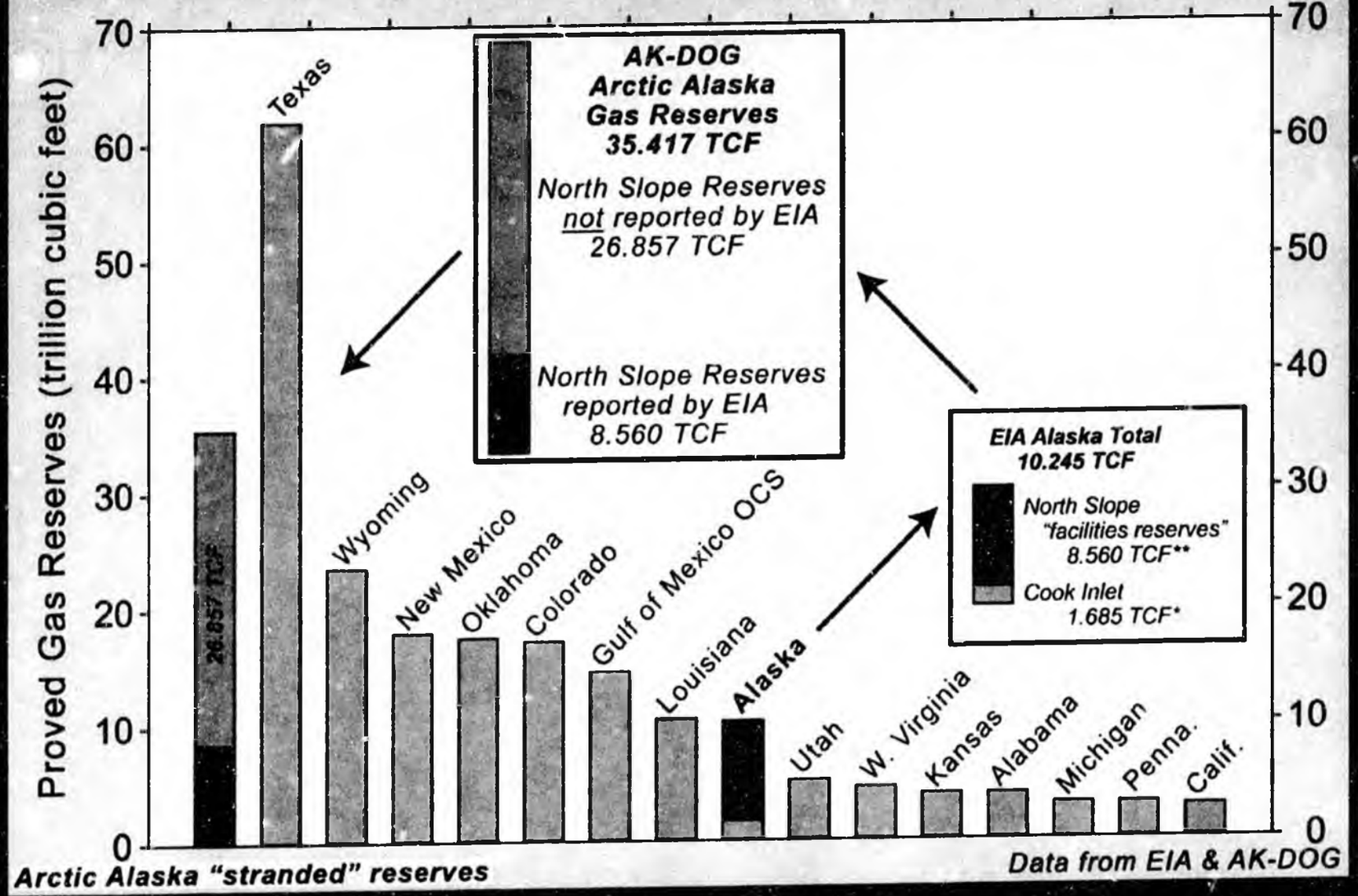
1.2 053 606

USGS Role


Proved Gas Reserves
Proved
Gas Reserves
TCF
(trillion cubic feet)
Assessment
Boundaries
USGS
MMS
Russia
Canada
TAPS
Fairbanks
Anchorage
0
miles
400
0
kilometers
500

2006 Proved Gas Reserves: Top 15 States – OCS Region

Public-Domain Data



*AK-DOG estimate; **difference between EIA state total and AK-DOG Cook Inlet estimate

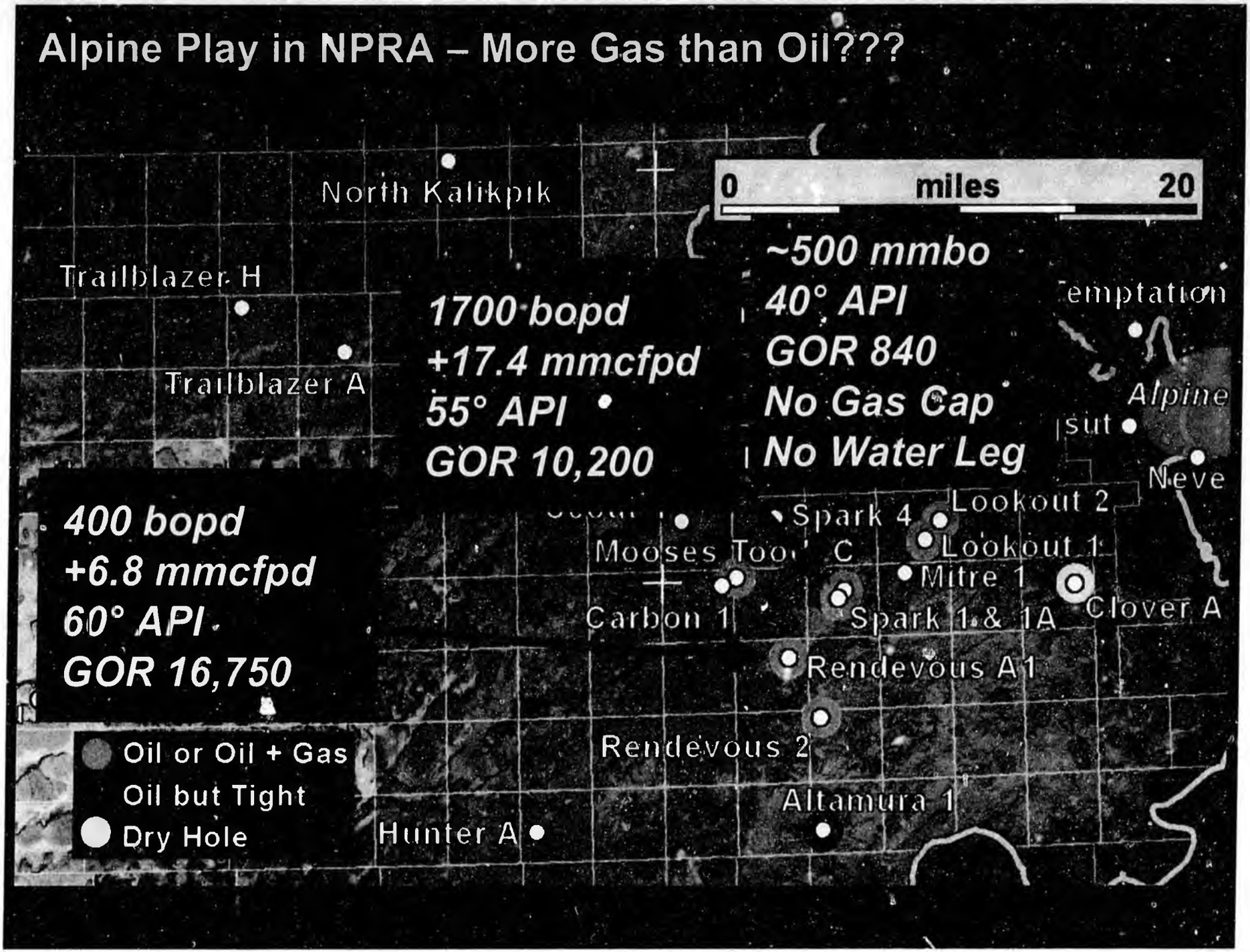
Known Gas Accumulations in Arctic Alaska

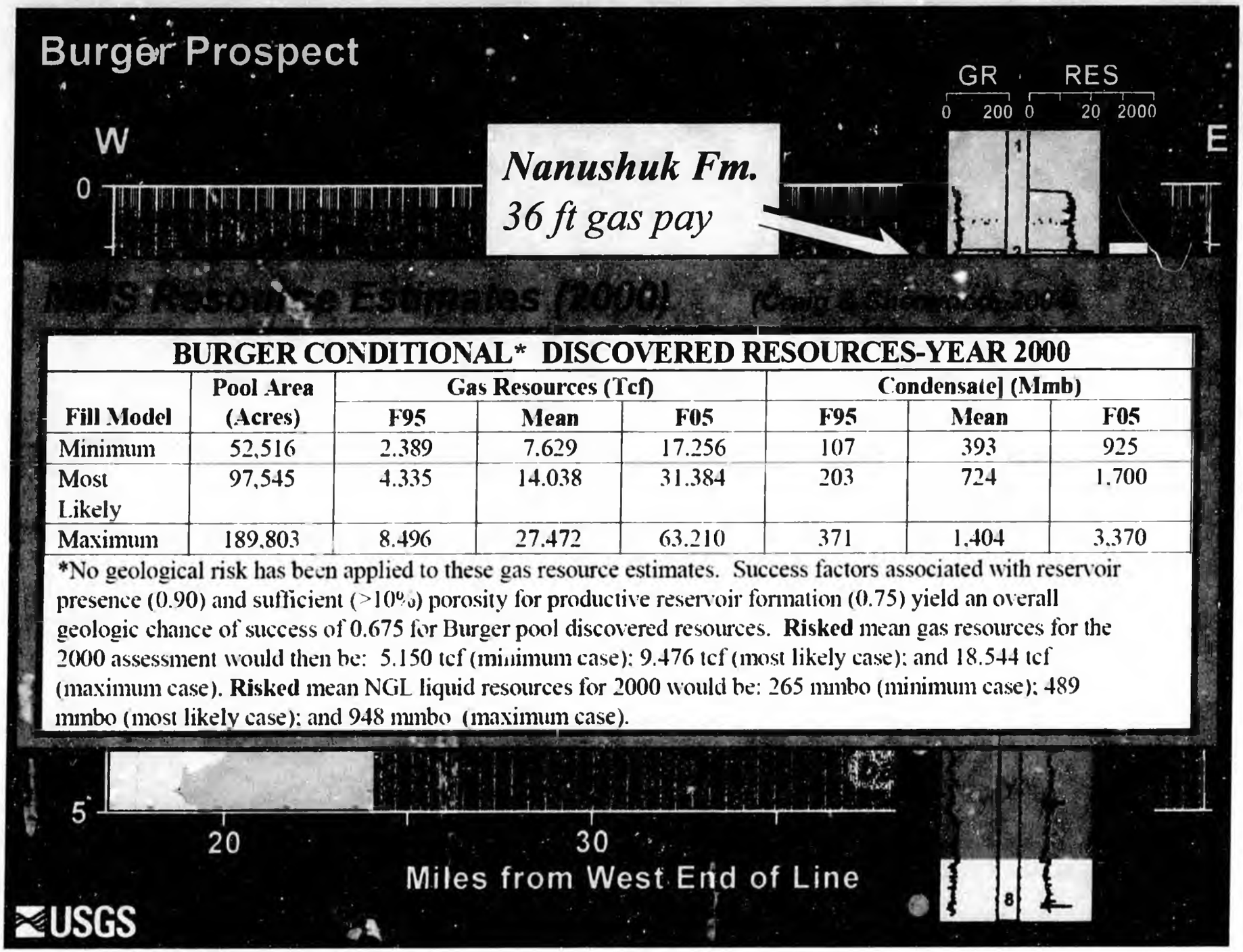
Known Reserves Unit & Gas Reserves (BCF)	
Prudhoe Bay	24,526
Pt. Thomson	8,000
Pt. McIntyre	1,526
Kuparuk River	1,150
Duck Island	843
North Star	450
Colville River	400
Barrow-Walakpa	34
Milne Point	14
TOTAL	35,417

Data from AK-DOG Annual 2006 Rpt.

Other Known Accumulations Possible Gas Reserves (BCF)	
Onshore	
Gubik	600
Kavik	115
Square Lake	58
Meade	20
Umiat	5
East Umiat	4
East Kurupa	?
Kemik	?
Wolf Creek	?
Offshore - OCS	
Burger	14,000
Sandpiper	?

Data from Thomas et al., 1996 (DOE)
Craig & Sherwood, 2004 (MMS)
Bird, pers. comm., 2008 (USGS)

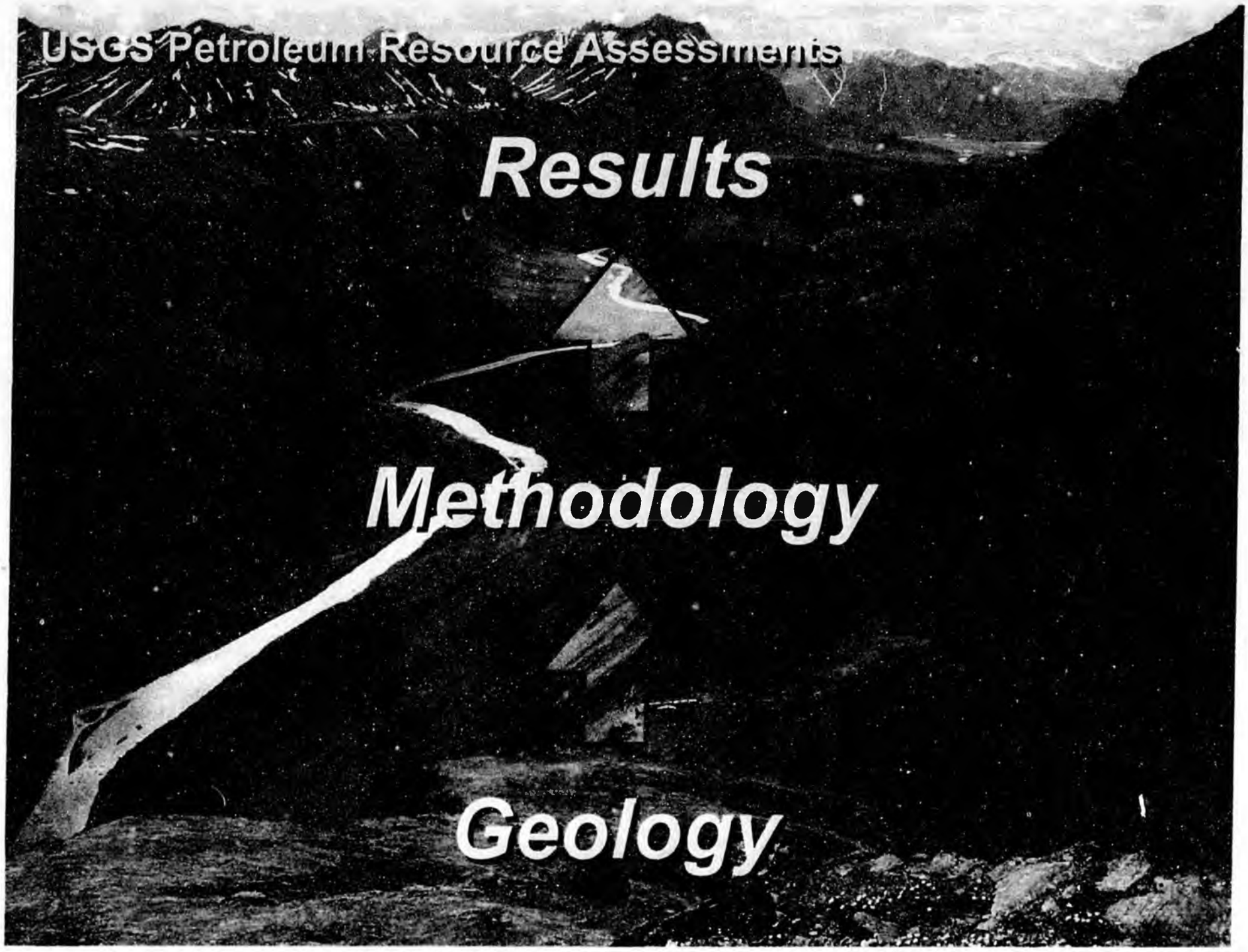

Alpine Play in NPRA – More Gas than Oil???
North Kalikpik
0 miles 20
Trailblazer H
Trailblazer A
1700 bopd
+17.4 mmcfpd
55° API
GOR 10,200
~500 mmbo
40° API
GOR 840
No Gas Cap
No Water Leg
Temptation
Alpine
Nieve
400 bopd
+6.8 mmcfpd
60° API
GOR 16,750
Spark 4
Lookout 2
Lookout 1
Mooses Too
C
Mitre 1
Carbon 1
Spark 1 & 1A
Clover A
Rendevous A1
Rendevous 2
Altamura 1
Hunter A
Oil or Oil + Gas
Oil but Tight
Dry Hole



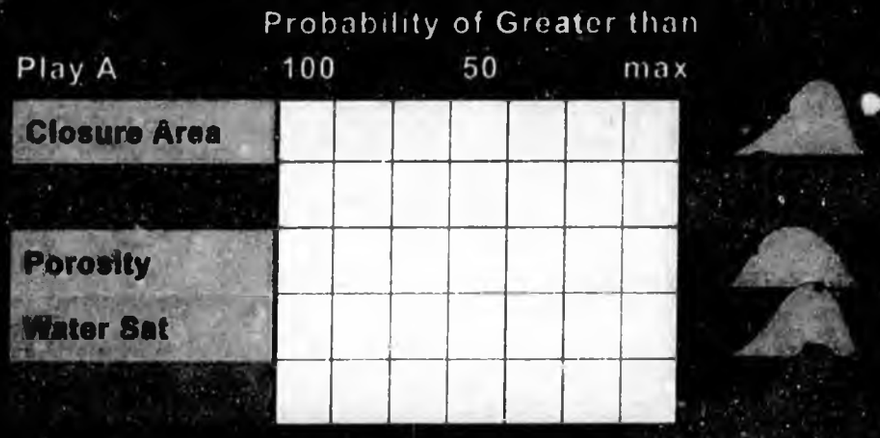
BURGER CONDITIONAL* DISCOVERED RESOURCES-YEAR 2000

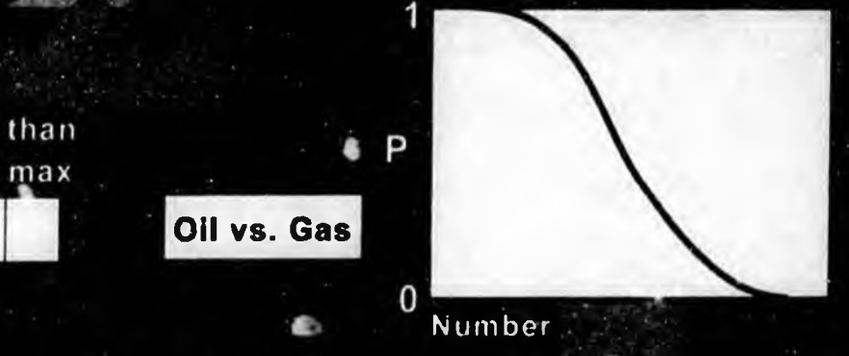
Fill Model	Pool Area (Acres)	Gas Resources (Tcf)			Condensate] (Mmb)		
		F95	Mean	F05	F95	Mean	F05
Minimum	52,516	2.389	7.629	17.256	107	393	925
Most Likely	97,545	4.335	14.038	31.384	203	724	1,700
Maximum	189,803	8.496	27.472	63.210	371	1,404	3,370

*No geological risk has been applied to these gas resource estimates. Success factors associated with reservoir presence (0.90) and sufficient (>10%) porosity for productive reservoir formation (0.75) yield an overall geologic chance of success of 0.675 for Burger pool discovered resources. **Risked** mean gas resources for the 2000 assessment would then be: 5.150 tcf (minimum case); 9.476 tcf (most likely case); and 18.544 tcf (maximum case). **Risked** mean NGL liquid resources for 2000 would be: 265 mmbo (minimum case); 489 mmbo (most likely case); and 948 mmbo (maximum case).

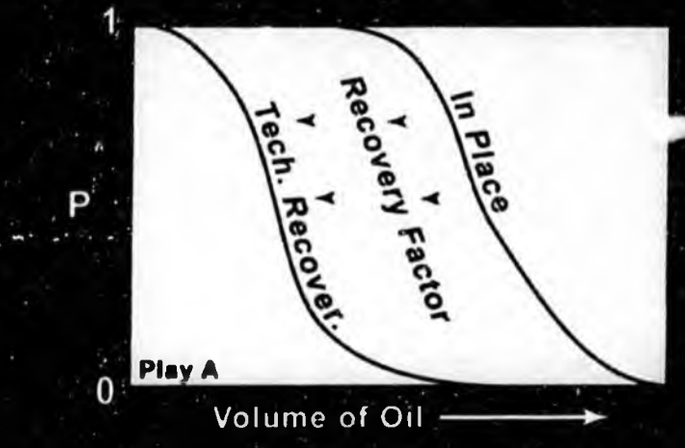

USGS Petroleum Resource Assessments
Results
Methodology
Geology

Assessment Methodology – Geologic Basis





Oil vs. Gas



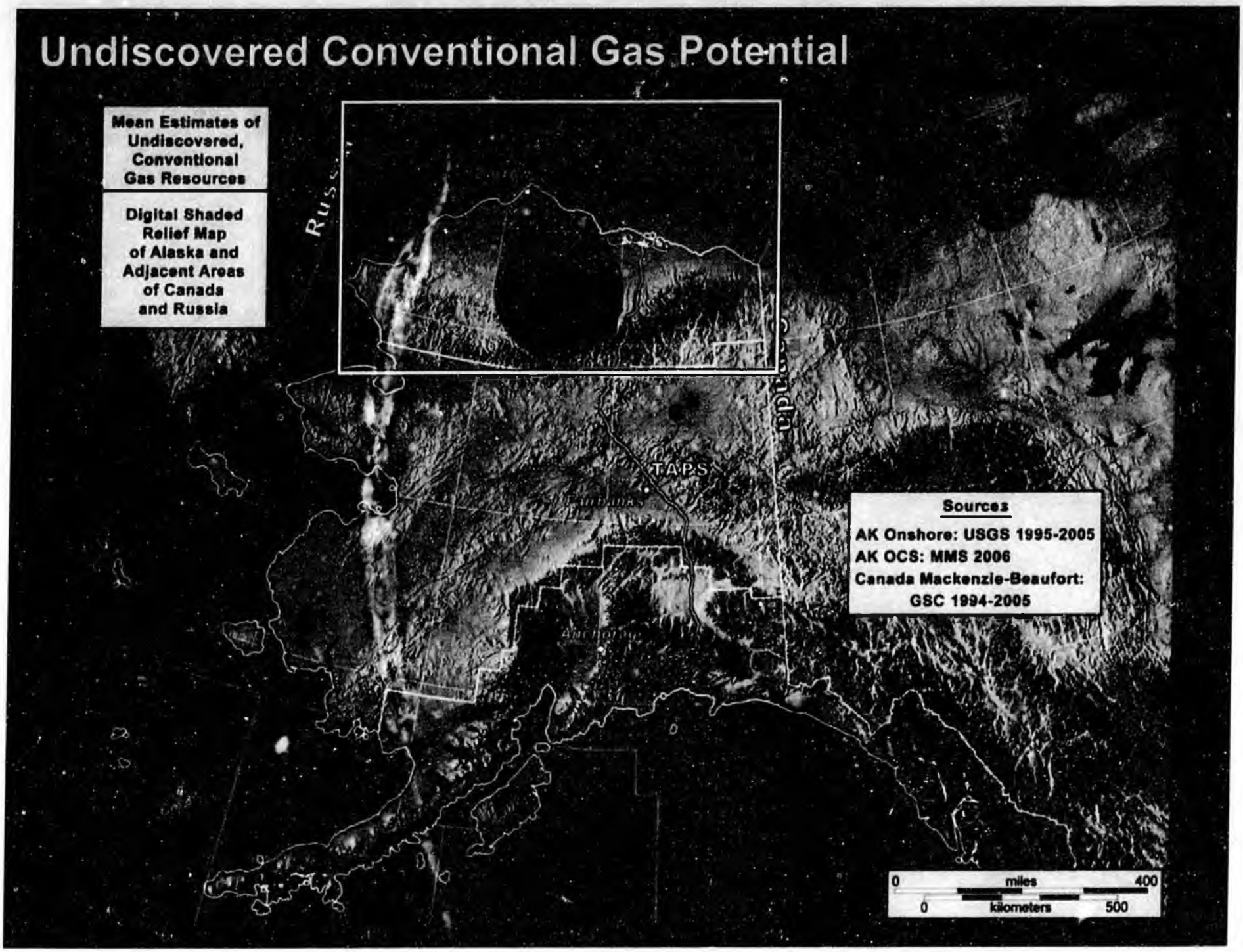
Prospect Risk

Charge	
Reservoir	
Trap	

Play Risk

Charge	
Reservoir	
Trap	

Undiscovered Conventional Gas Potential



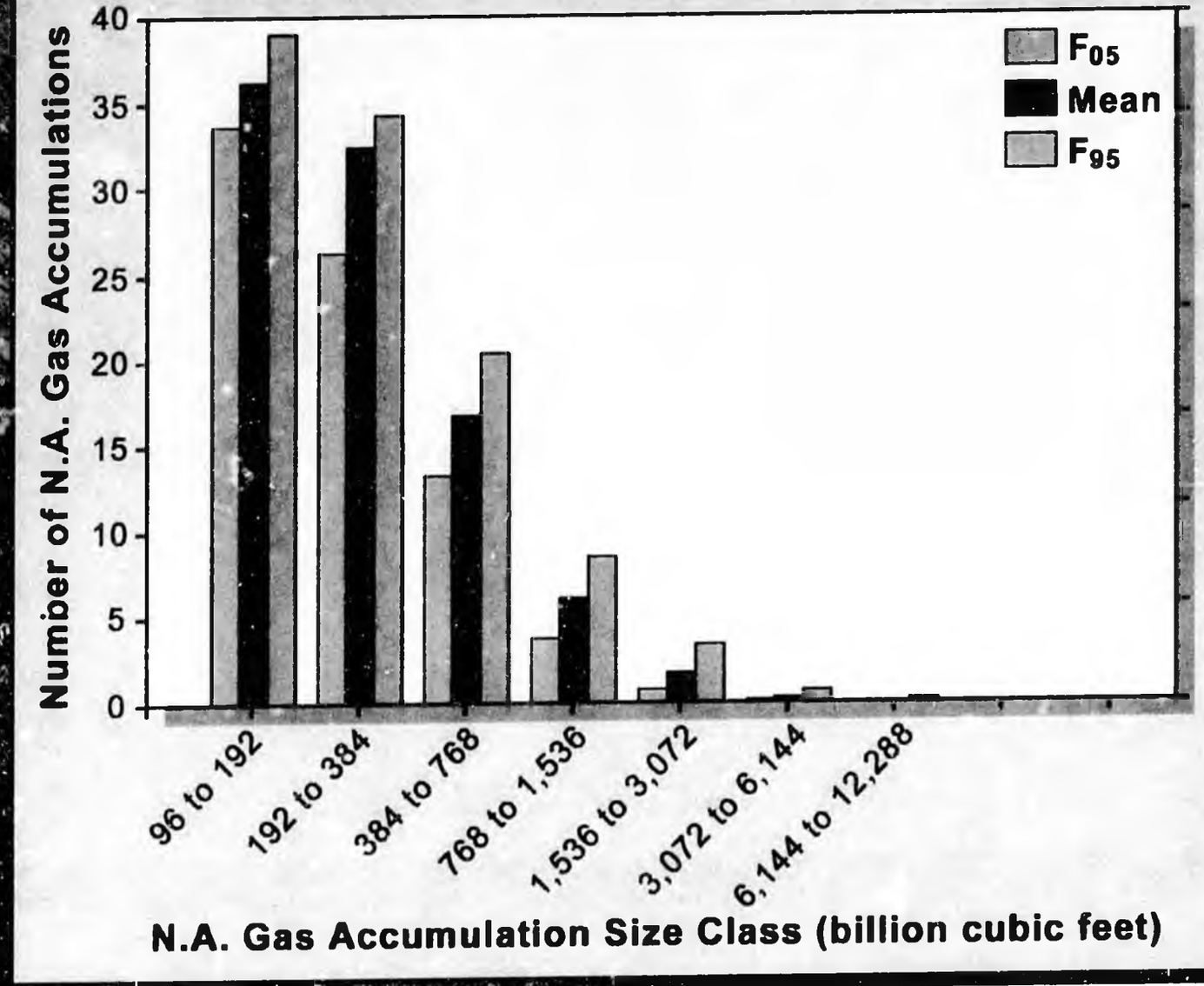
Potential for Undiscovered Petroleum in Arctic Alaska

Mean Estimates of Undiscovered, *Conventional* Natural Gas in Arctic Alaska (trillion cubic feet)

	Non-Associated Gas	Associated Gas	Total Gas
Onshore & State Offshore Areas (USGS estimates)			
NPRA	61.35	11.68	73.03
Central North Slope	33.32	4.20	37.52
ANWR, 1002 Area	3.84	4.76	8.60
Subtotal	*98.51*	*20.64*	*119.15*
Federal Offshore Areas (MMS estimates)			
Chukchi Shelf	na	na	76.77
Beaufort Shelf	na	na	27.65
Hope Basin	na	na	3.77
Subtotal	na	na	*108.19*
TOTAL			*227.34*

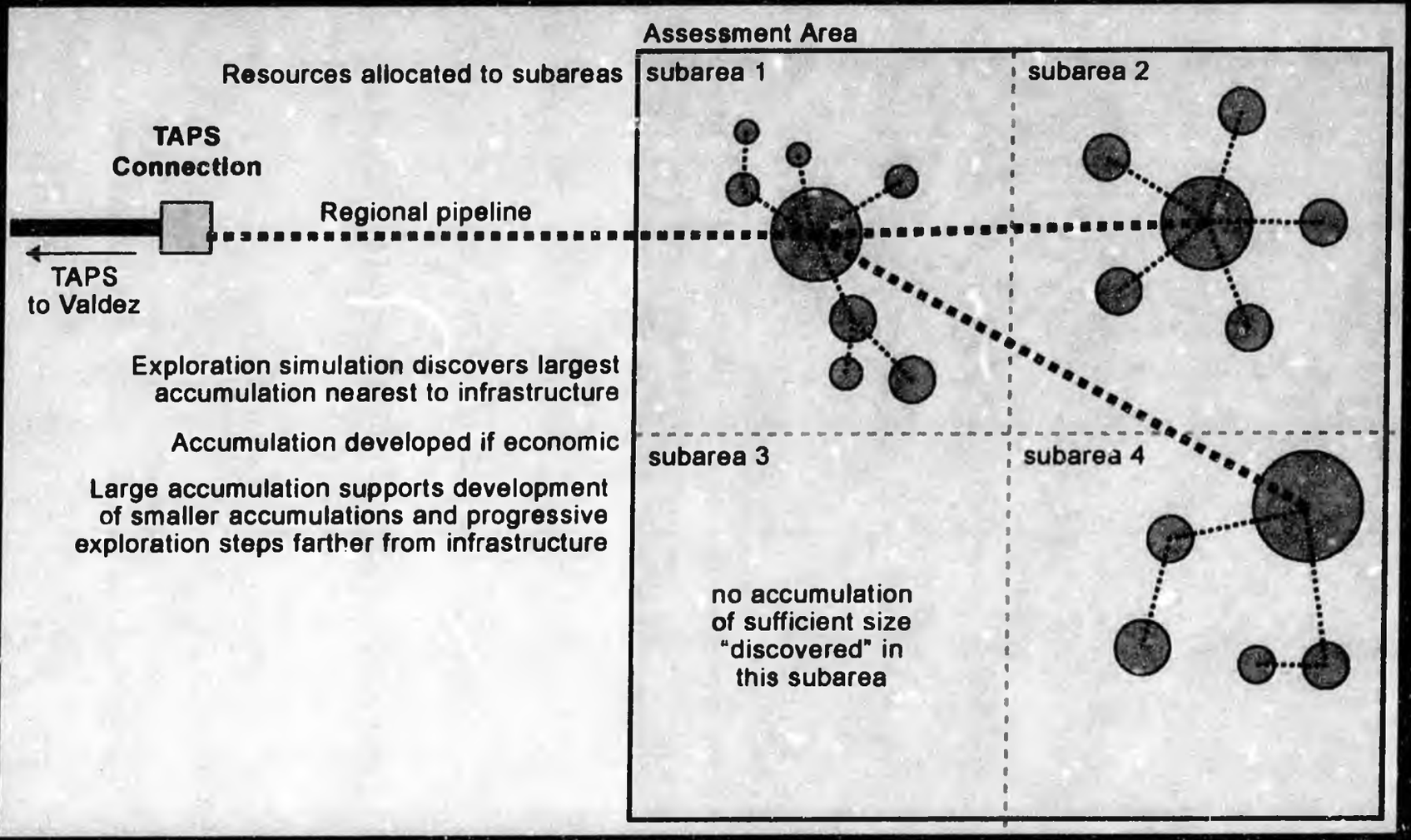
Sources: OCS estimates from MMS; onshore & state waters estimates from USGS

Estimates of Gas Accumulation Sizes



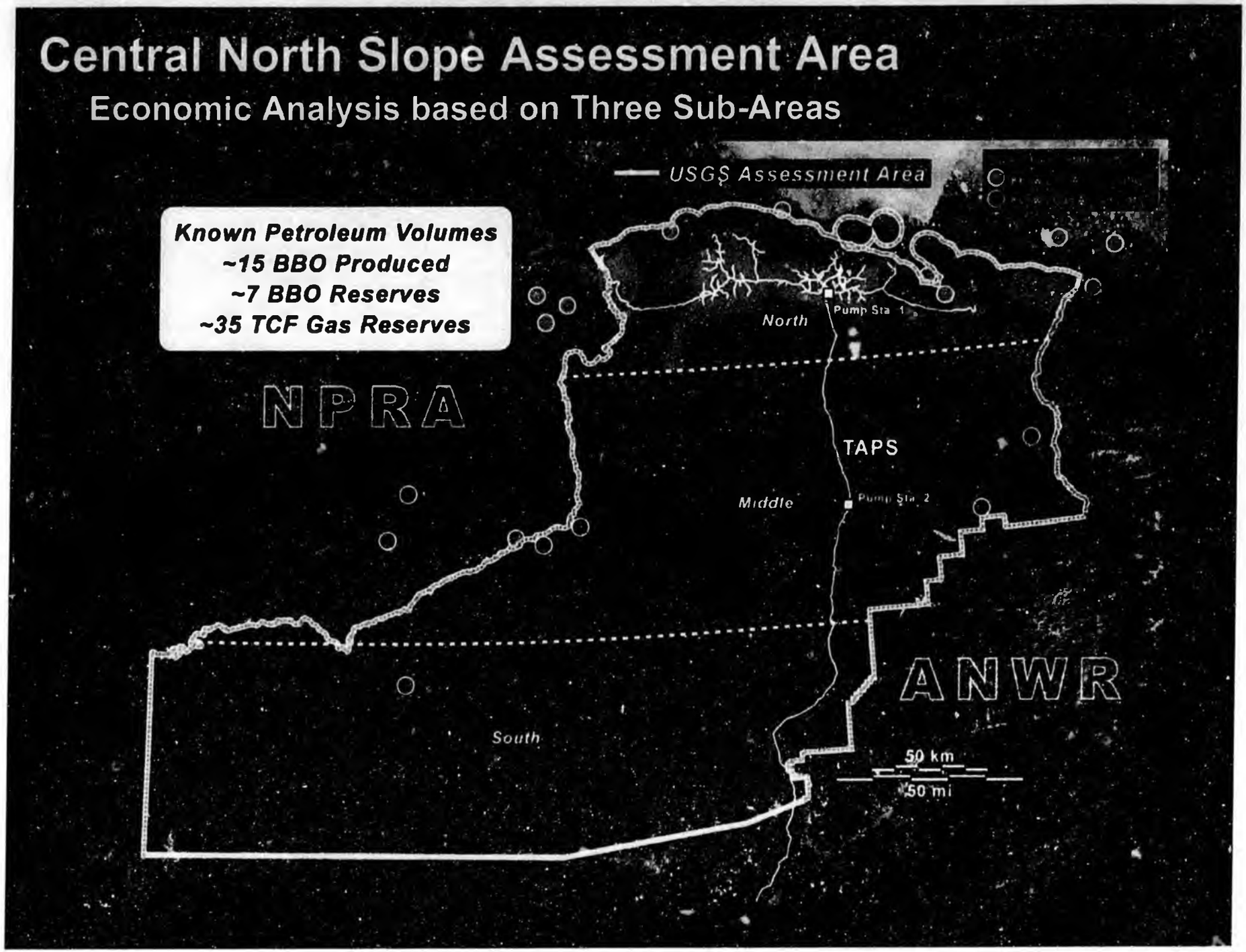
USGS

Economic Analysis Simulates Exploration and Development



Central North Slope Assessment Area

Economic Analysis based on Three Sub-Areas



Costs Included in Economic Analysis

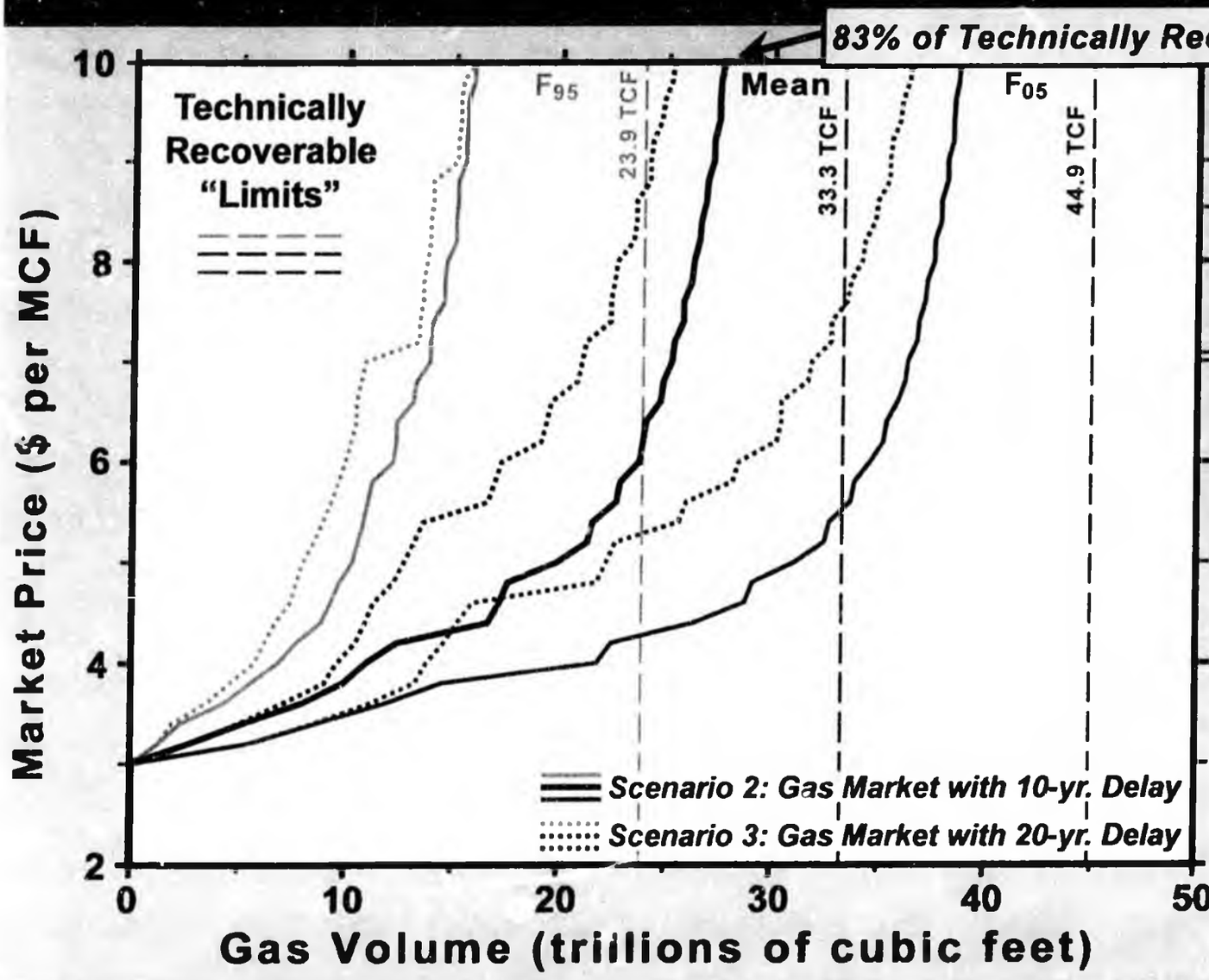
- **Exploration**
  - Geology & Geophysics
  - Exploration Drilling (including all preparation & mobilization)
- **Development**
  - Construction of production pads
  - Development wells
  - Construction of processing facilities
- **Production**
  - All operational costs
  - Abandonment costs
- **Transportation**
  - New pipelines from fields to gas-processing plant near PB
  - Pipeline tariff to market in lower-48
- **Taxes**
  - All applicable Federal and State
- **Return on Investment**
  - 12% rate of return

Analysis conducted in 2005 using 2003 dollars & costs

USGS

Central North Slope Economically Recoverable Gas

Undiscovered, Non-Associated Natural Gas Resources

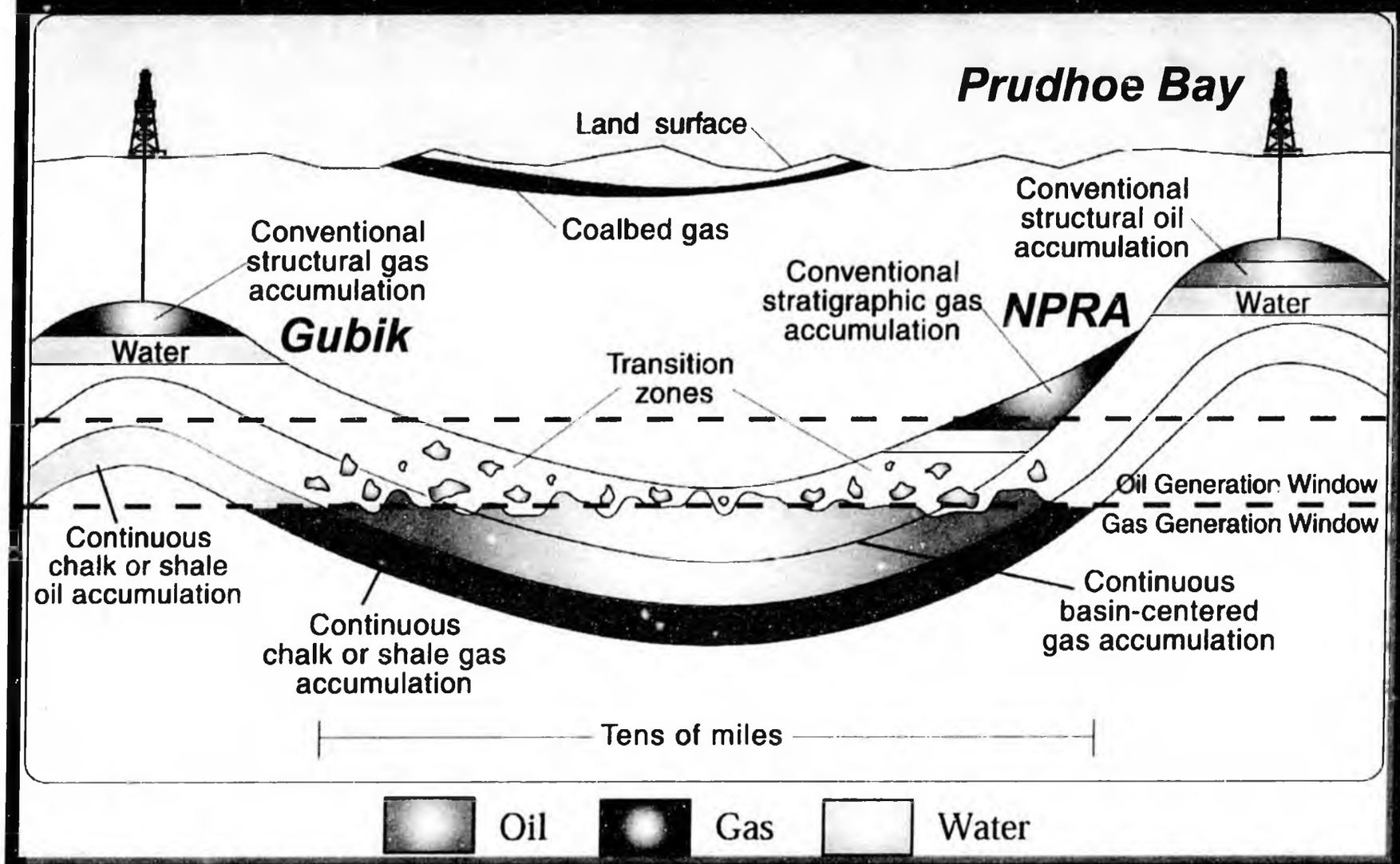


Market Price ($/MCF)	Economically Recoverable Gas (trillion cubic feet) Sc. 2	Sc. 3
2	0	0
3	0	0
4	10.9	9.6
5	19.9	12.7
6	23.7	17.2
7	25.2	21.0
8	26.2	22.6
9	27.1	24.1
10	27.6	25.2

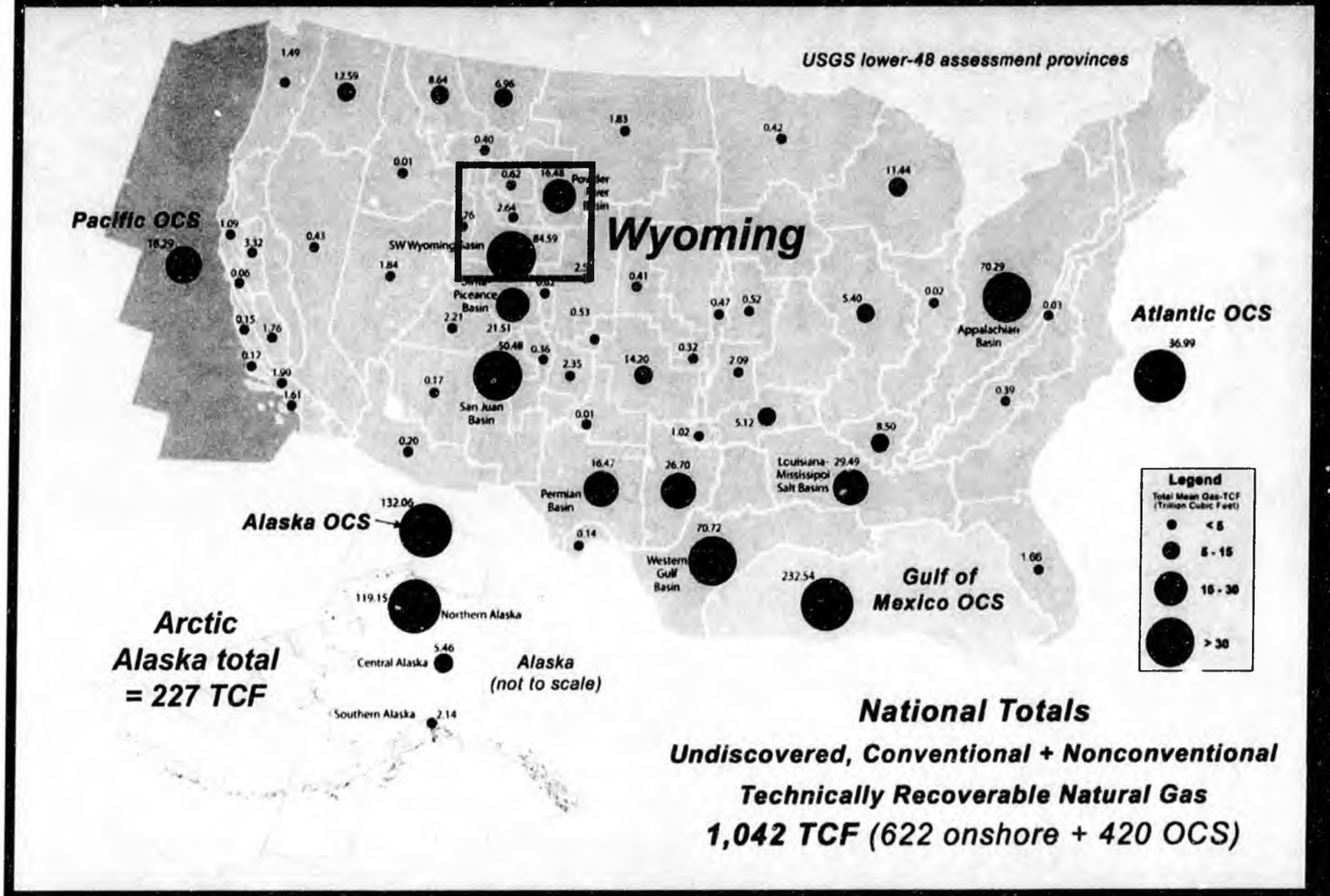
Based on mean estimates of technically recoverable oil resources

Scenario 1 - No Gas Market

Conventional and "Unconventional" Accumulations



Undiscovered, *Total* Gas Resources of the U.S.



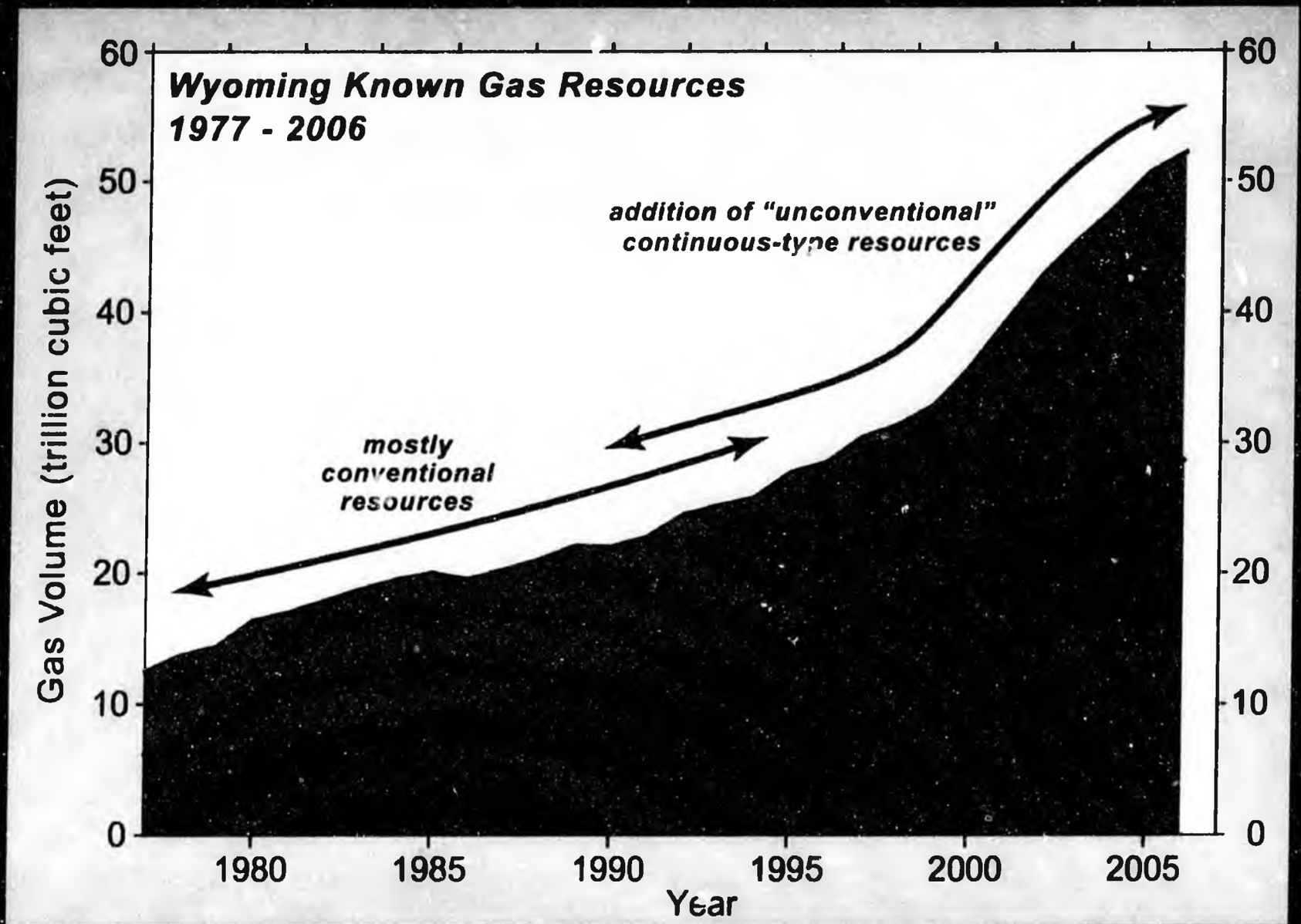
National Totals

Undiscovered, Conventional + Nonconventional

Technically Recoverable Natural Gas

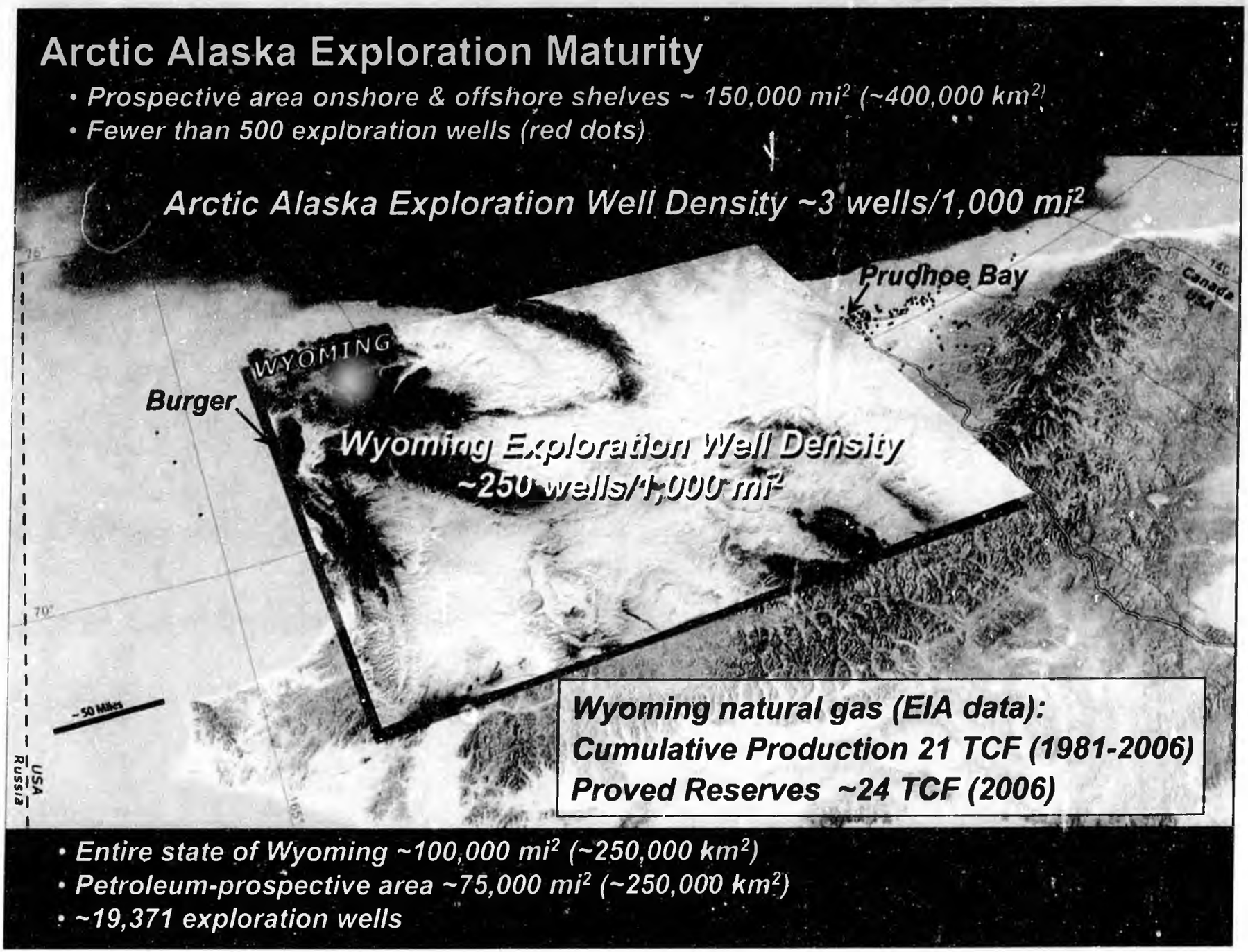
1,042 TCF *(622 onshore + 420 OCS)*

Wyoming Gas Reserves & Production History



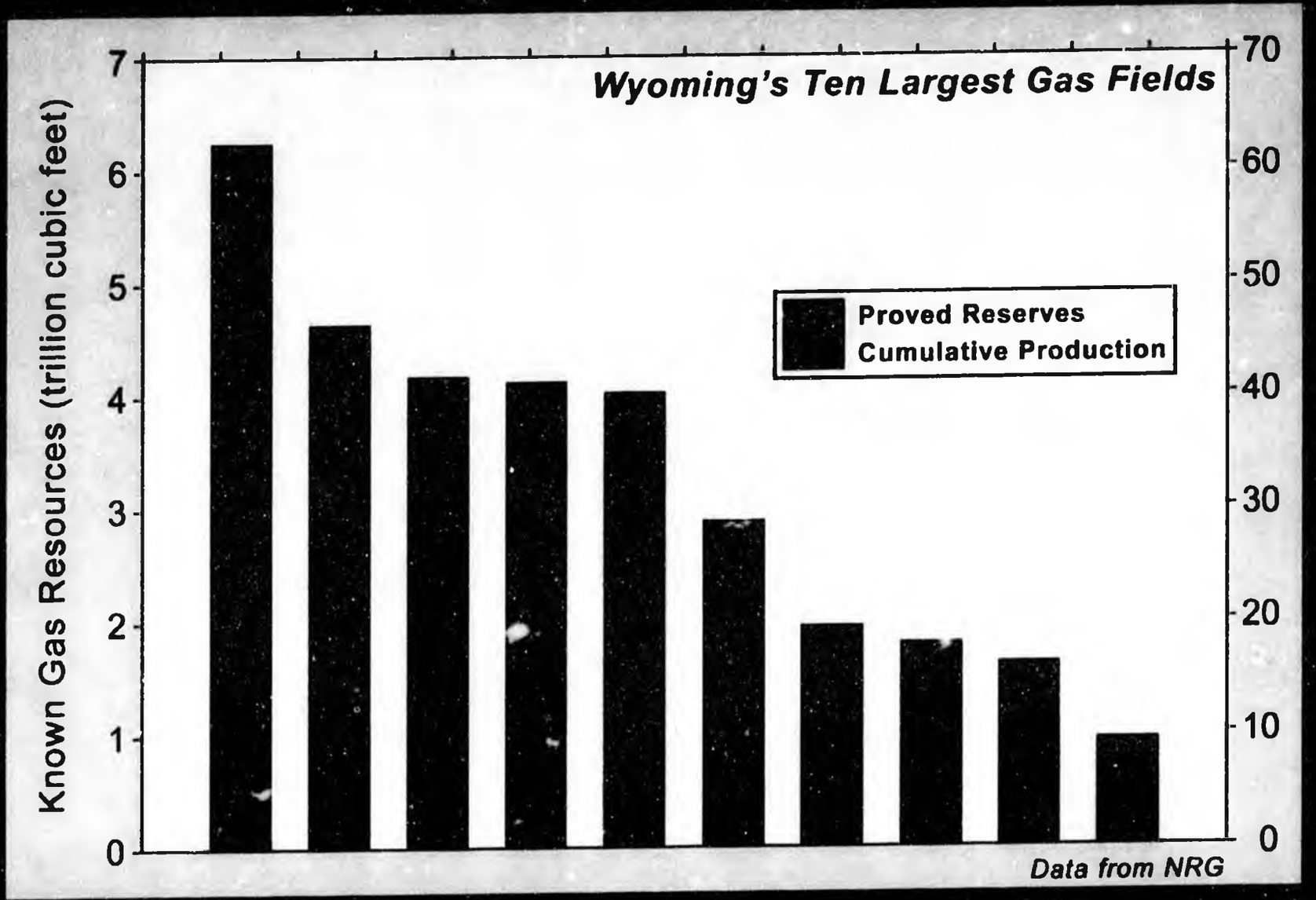
Arctic Alaska Exploration Maturity

- *Prospective area onshore & offshore shelves ~ 150,000 mi² (~400,000 km²)*
- *Fewer than 500 exploration wells (red dots)*



- *Entire state of Wyoming ~100,000 mi² (~250,000 km²)*
- *Petroleum-prospective area ~75,000 mi² (~250,000 km²)*
- *~19,371 exploration wells*

Wyoming – Ten Largest Gas Fields

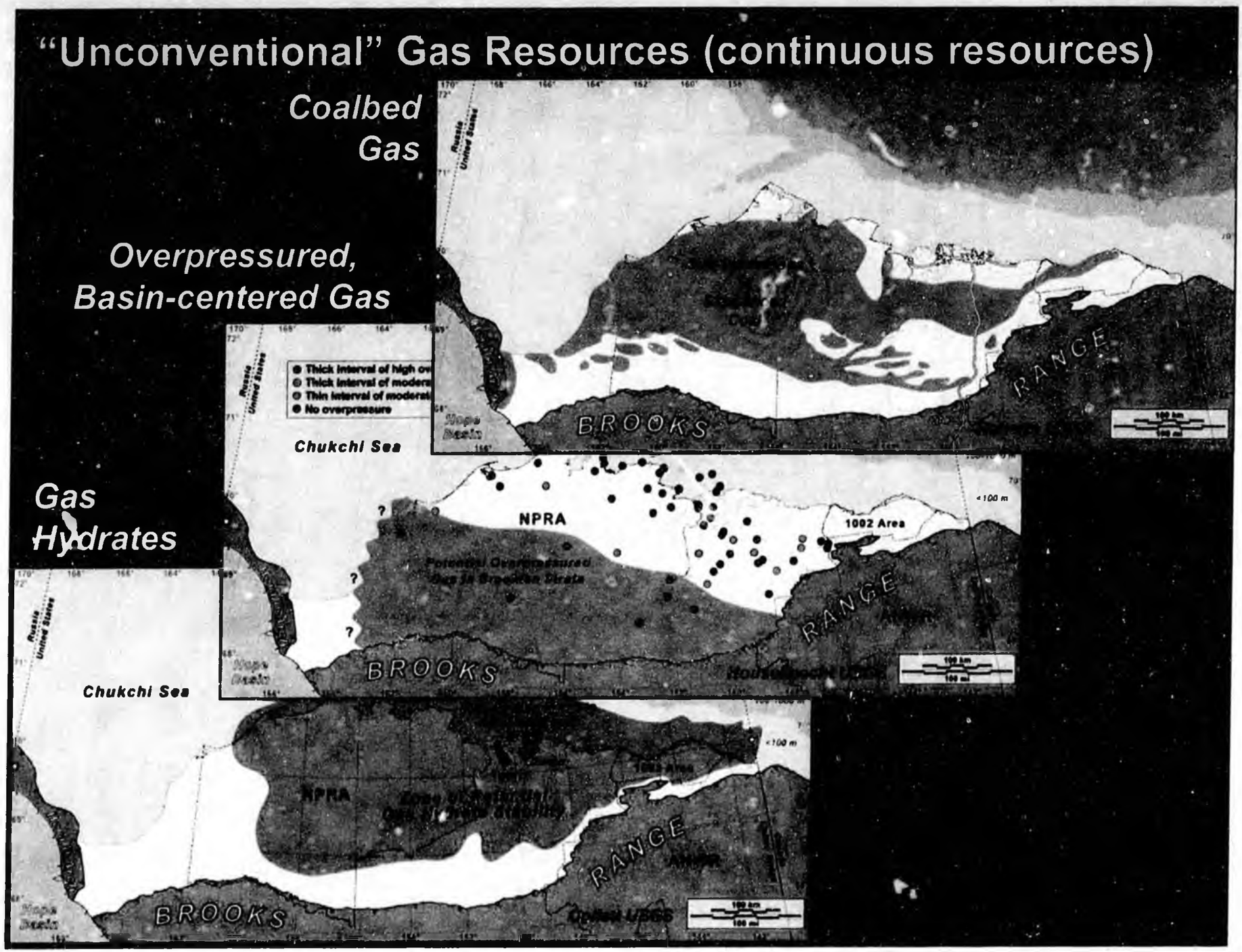


"Unconventional" Gas Resources (continuous resources)

Coalbed Gas

Overpressured, Basin-centered Gas

Gas Hydrates

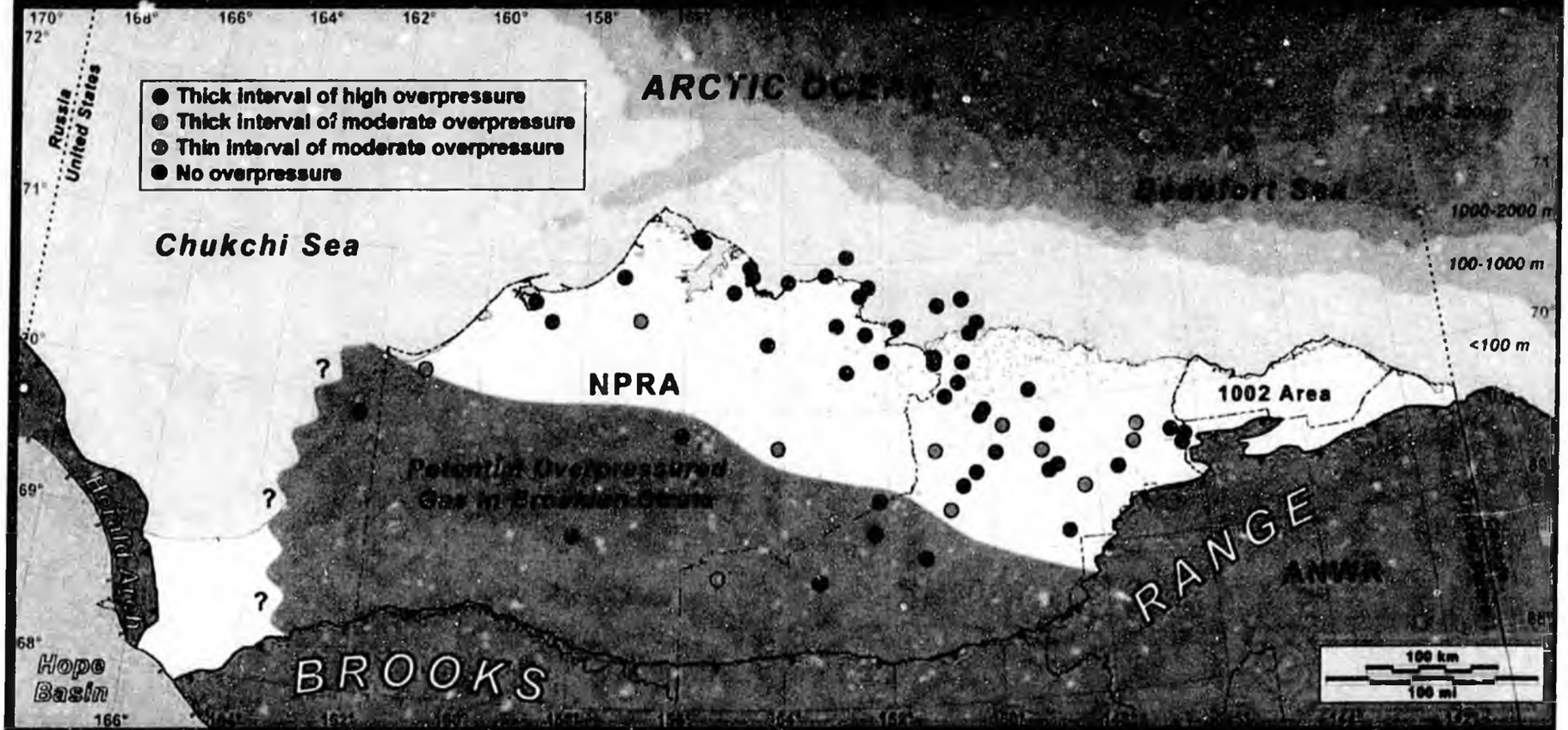


Overpressured Natural Gas in the Colville Basin

Brookian strata (Torok & Fortress Mountain Formations)

Potential reservoirs mostly low-permeability sandstone

Shale reservoirs possible



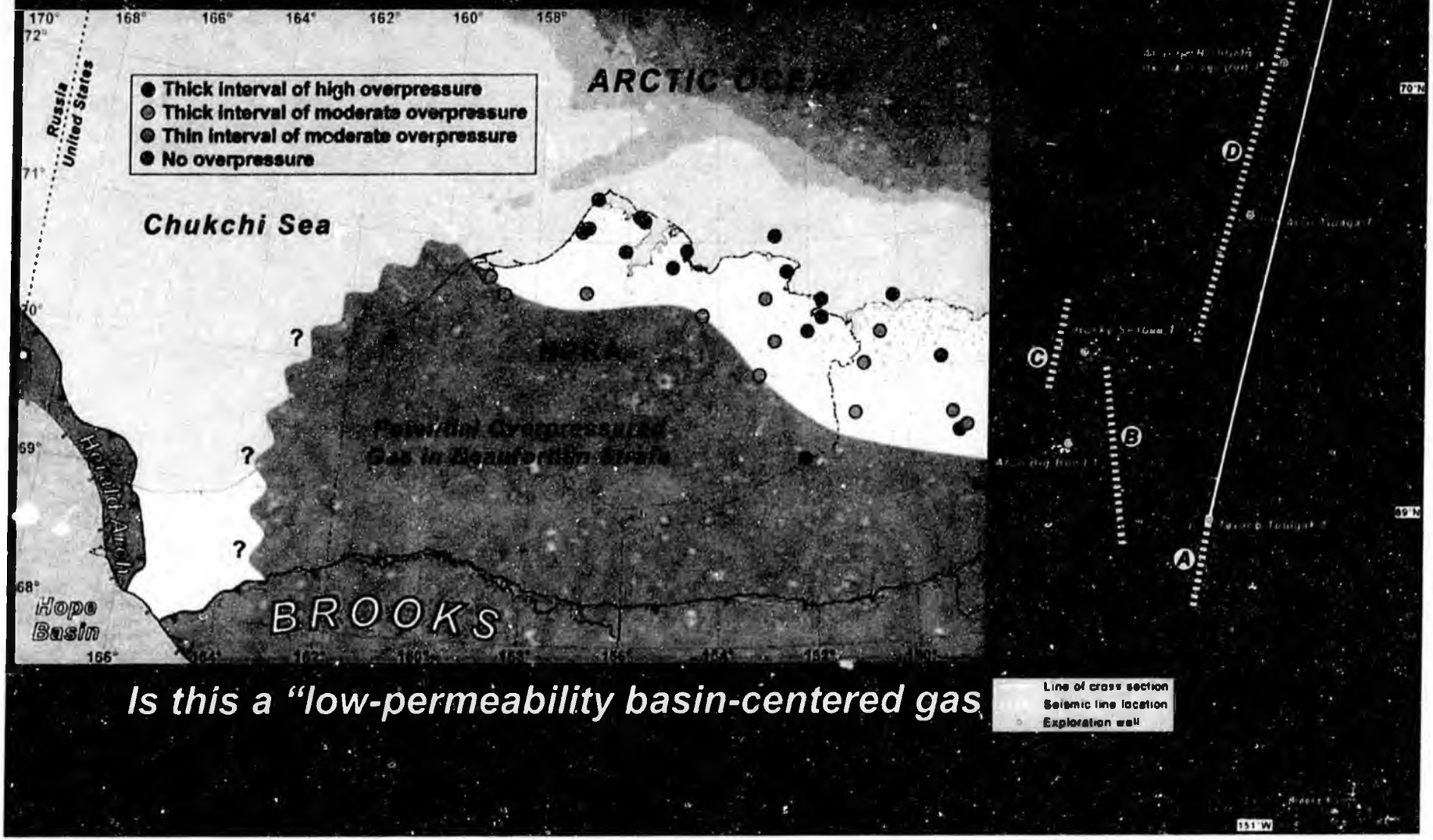
Is this a "low-permeability basin-centered gas accumulation" ?

Overpressured Natural Gas in the Colville Basin

Beaufortian Strata (Kingak Shale)

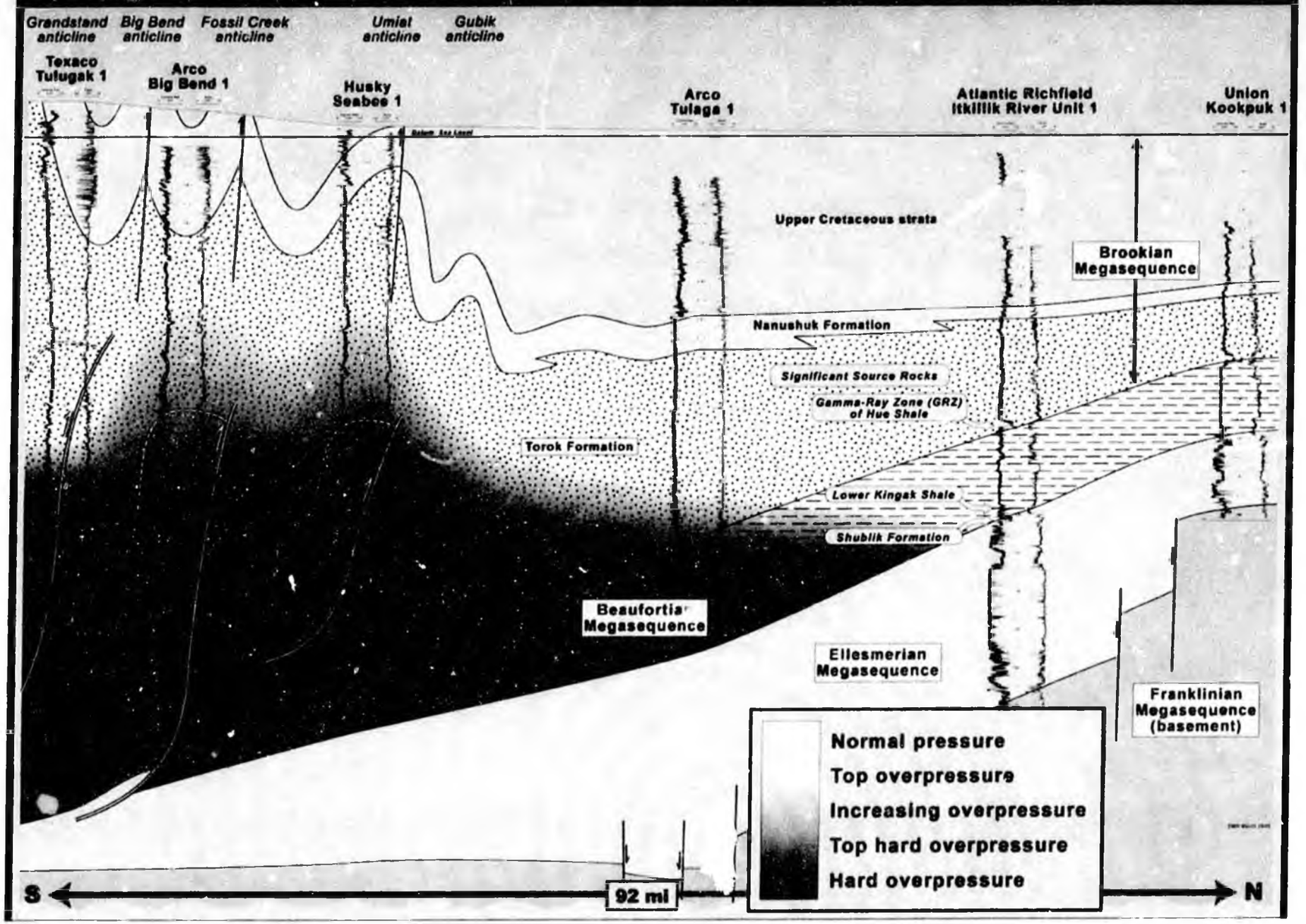
Potential reservoirs mostly shale

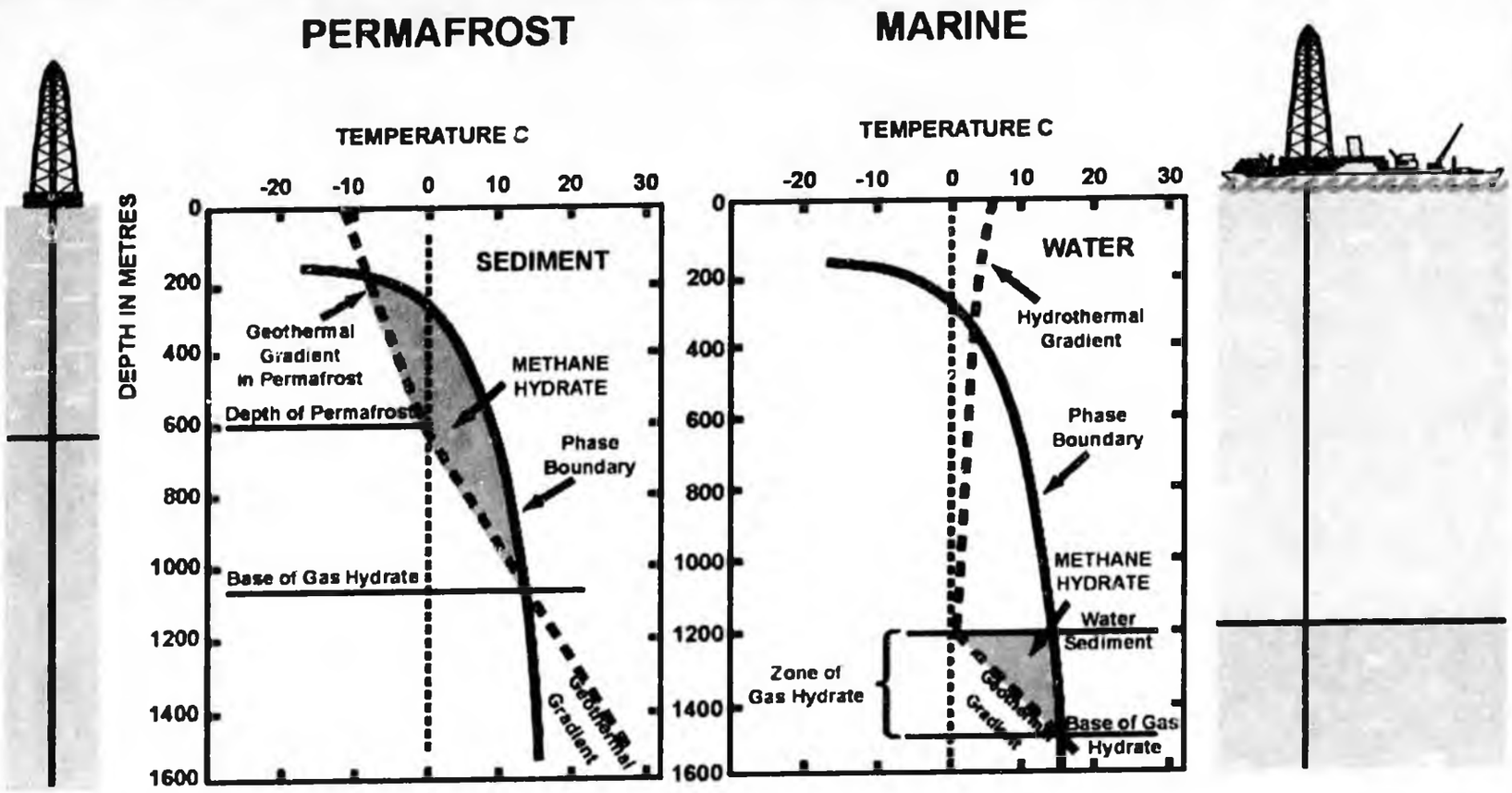
Low-perm sandstone reservoirs possible

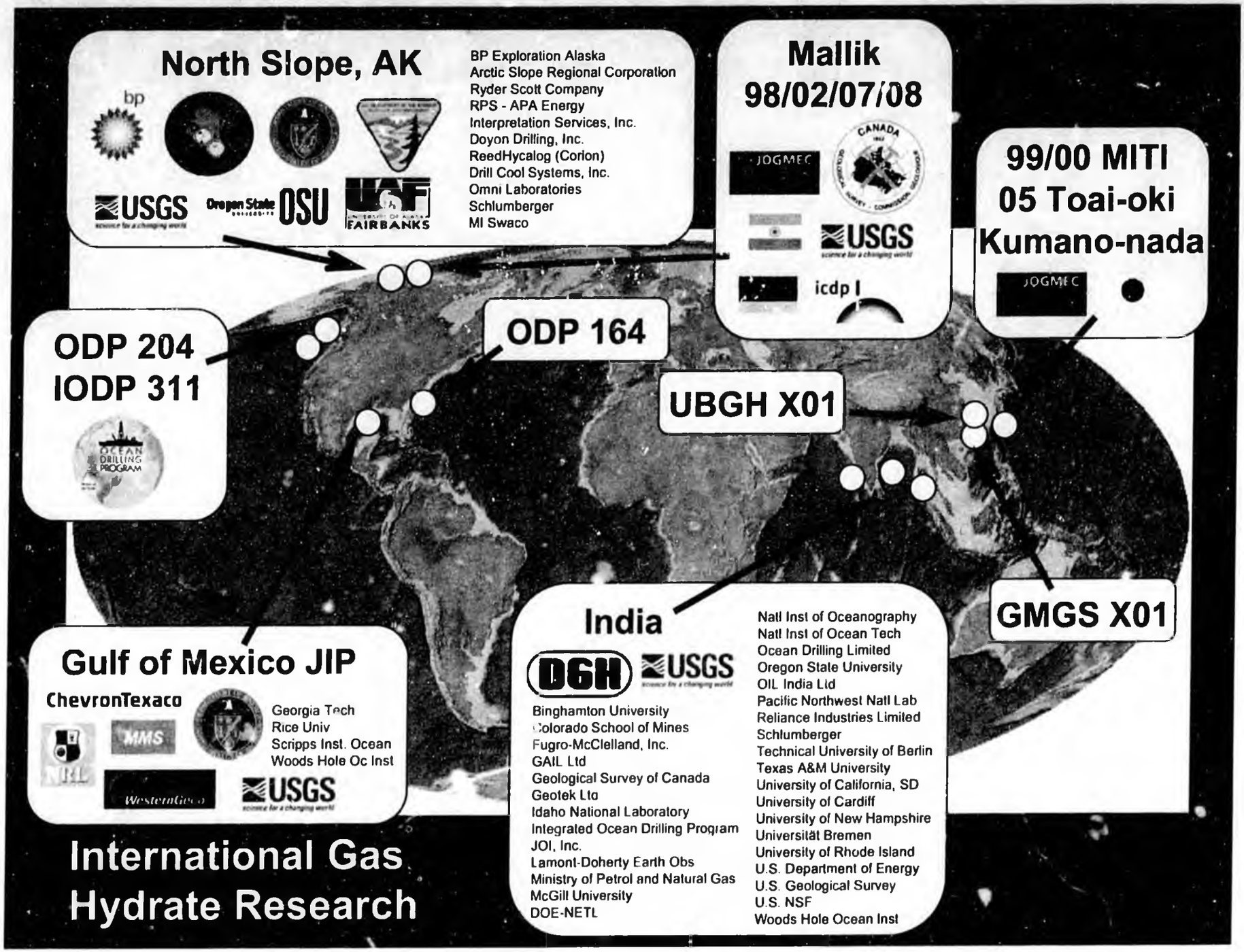


Is this a "low-permeability basin-centered gas

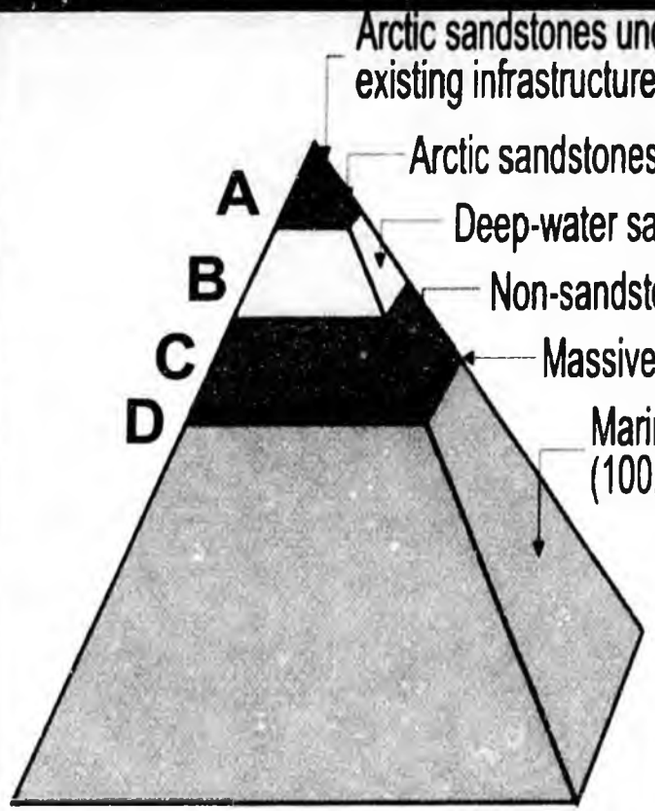
Overpressured Natural Gas in the Colville Basin




PERMAFROST
MARINE
TEMPERATURE C
-20 -10 0 10 20 30
DEPTH IN METRES
0 200 400 600 800 1000 1200 1400 1600
SEDIMENT
Geothermal Gradient in Permafrost
Depth of Permafrost
METHANE HYDRATE
Phase Boundary
Base of Gas Hydrate
Geothermal Gradient
WATER
Hydrothermal Gradient
Phase Boundary
METHANE HYDRATE
Water
Sediment
Zone of Gas Hydrate
Geothermal Gradient
Base of Gas Hydrate


North Slope, AK
BP Exploration Alaska
Arctic Slope Regional Corporation
Ryder Scott Company
RPS - APA Energy
Interpretation Services, Inc.
Doyon Drilling, Inc.
ReedHycalog (Corion)
Drill Cool Systems, Inc.
Omni Laboratories
Schlumberger
MI Swaco
Mallik
98/02/07/08
99/00 MITI
05 Toai-oki
Kumano-nada
ODP 204
IODP 311
ODP 164
UBGH X01
GMGS X01
Gulf of Mexico JIP
Georgia Tech
Rice Univ
Scripps Inst. Ocean
Woods Hole Oc Inst
India
Binghamton University
Colorado School of Mines
Fugro-McClelland, Inc.
GAIL Ltd
Geological Survey of Canada
Geotek Ltd
Idaho National Laboratory
Integrated Ocean Drilling Program
JOI, Inc.
Lamont-Doherty Earth Obs
Ministry of Petrol and Natural Gas
McGill University
DOE-NETL
Natl Inst of Oceanography
Natl Inst of Ocean Tech
Ocean Drilling Limited
Oregon State University
OIL India Ltd
Pacific Northwest Natl Lab
Reliance Industries Limited
Schlumberger
Technical University of Berlin
Texas A&M University
University of California, SD
University of Cardiff
University of New Hampshire
Universität Bremen
University of Rhode Island
U.S. Department of Energy
U.S. Geological Survey
U.S. NSF
Woods Hole Ocean Inst
International Gas
Hydrate Research

The Gas Hydrate Resource Pyramid



Arctic sandstones under existing infrastructure (~10's of Tcf in place)

Arctic sandstones away from infrastructure (100s of Tcf in place)

Deep-water sandstones (~1000s of Tcf in place)

Non-sandstone marine reservoirs with permeability (unknown)

Massive surficial and shallow nodular hydrate (unknown)

Marine reservoirs with limited permeability (100,000s Tcf in place)

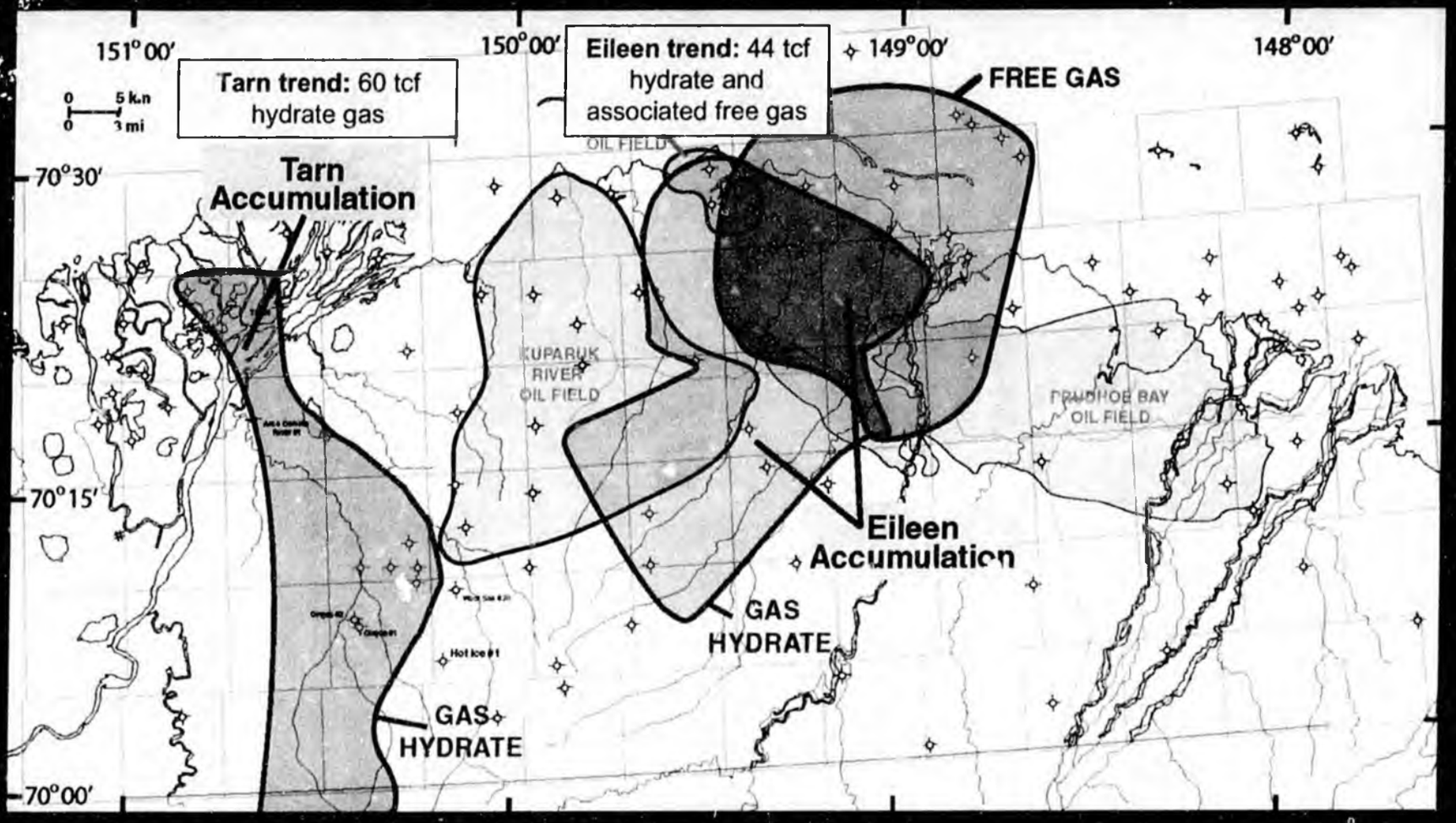
- increasing in-place
- decreasing reservoir quality
- decreasing confidence in resource estimates
- increasing technical challenges and likely decreasing % recoverable

Gas Hydrates

Northern Alaska Zone of Potential Hydrate Stability

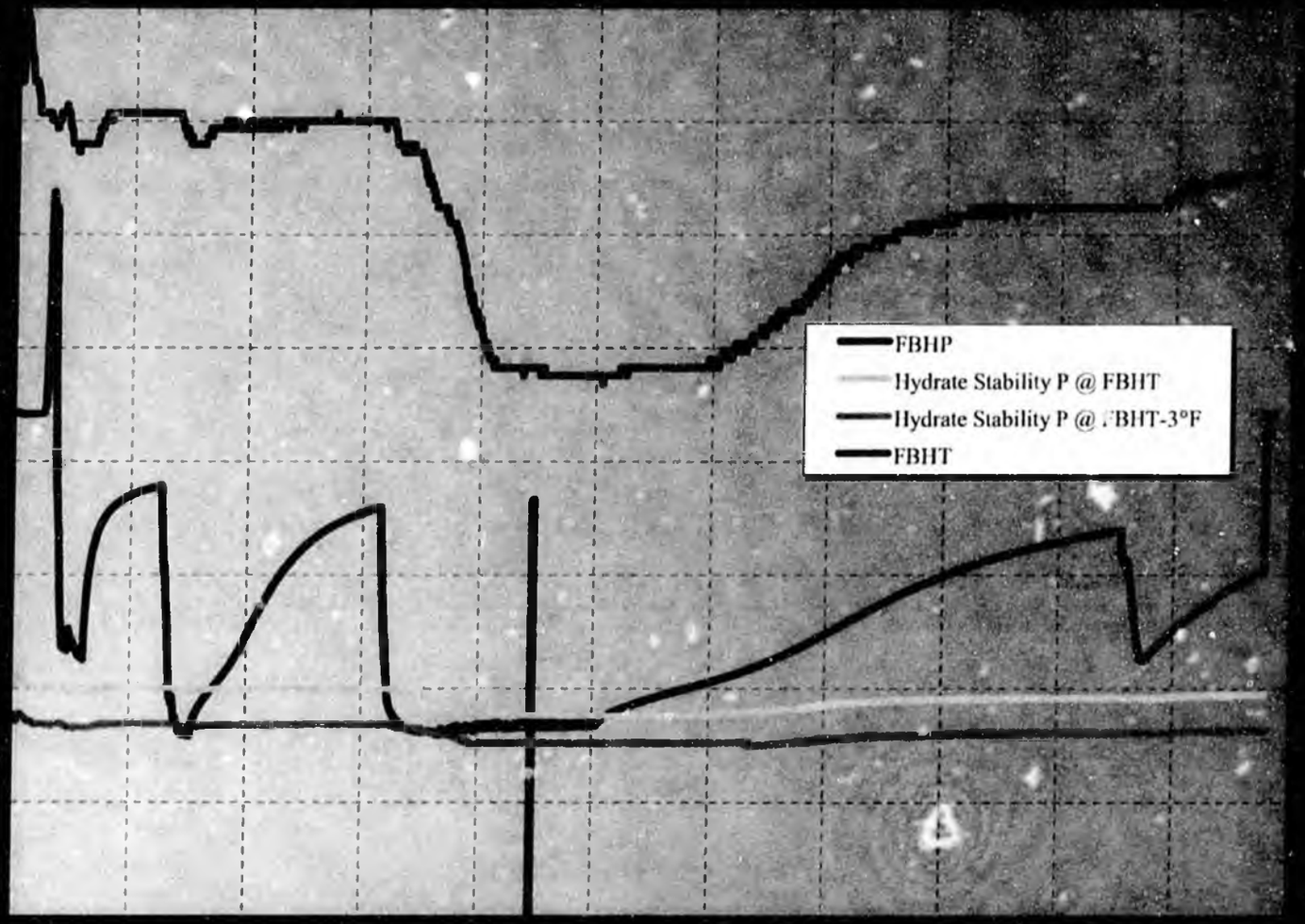
Information from Tim Collett (USGS)

Known Gas Hydrate Accumulations

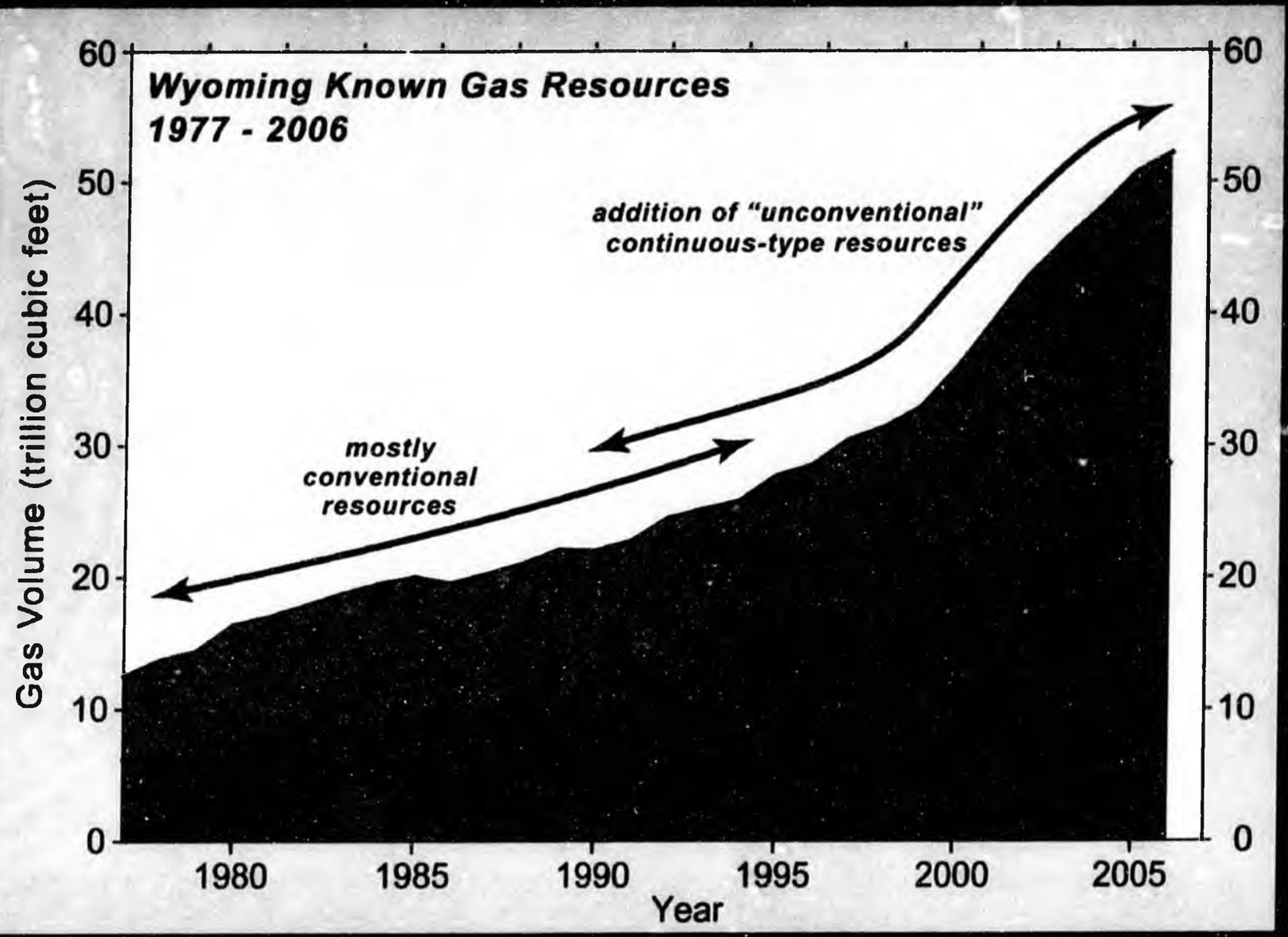


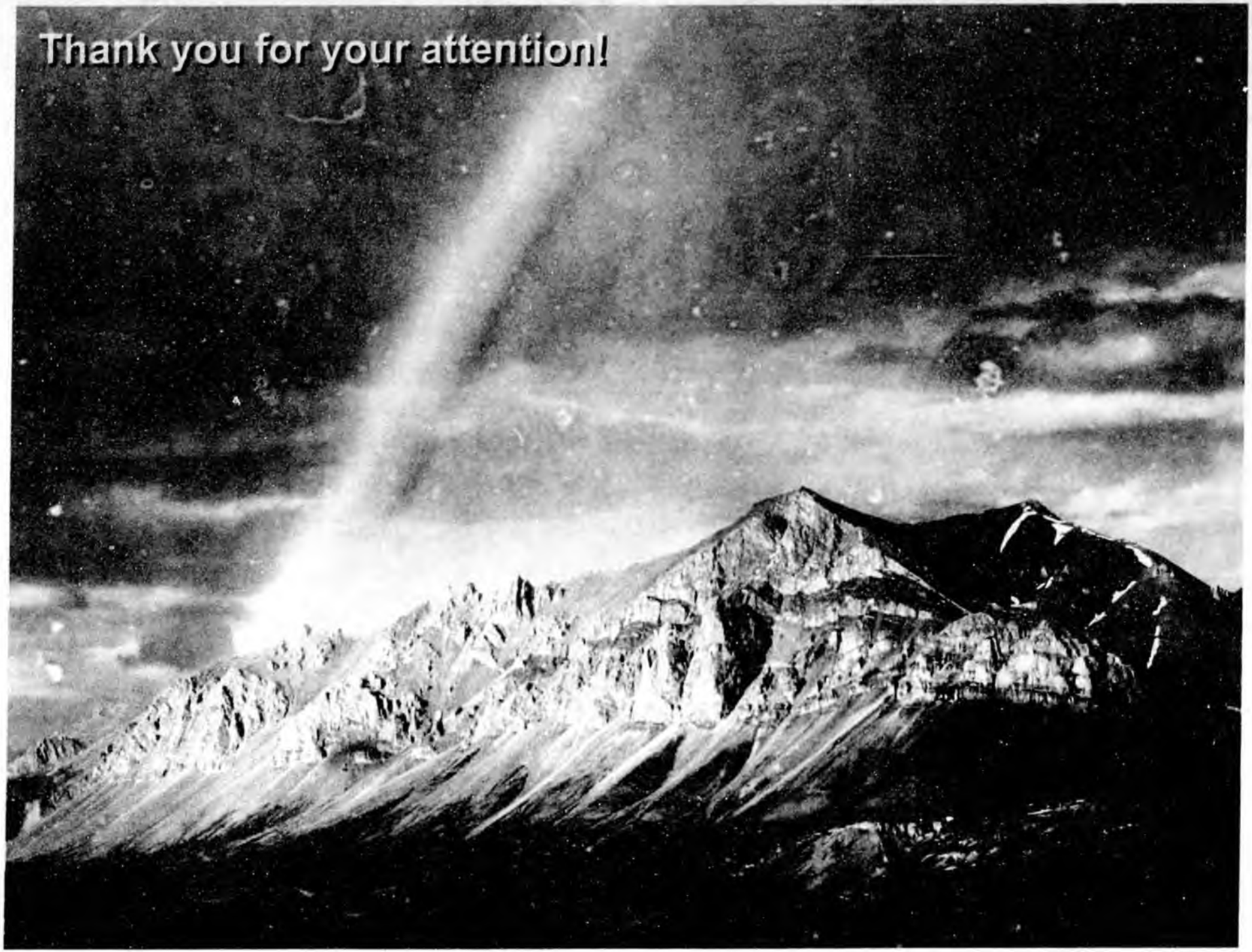
Known gas hydrate accumulations (blue) and hydrate-associated free gas accumulations (orange) in the vicinity of the major North Slope oil fields (green). The USGS estimates up to 100 tcf in place of hydrate in the Eileen and Tarn trends combined. From U.S. Geological Survey (2001) and Hunter and Collett, (2004).

BP DOE Mt Elbert-01 MDT C2



Wyoming Gas Reserves & Production History




Thank you for your attention!