HYDROCARBON SYSTEMS, BASIN ANALYSES, 2004-2007 FIELD & SUBSURFACE DATA:

BRISTOL BAY - ALASKA PENINSULA FRONTIER BASIN

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Bob Gillis & Andrea Loveland
*AKDOG
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Support provided by:

Division of Oil & Gas

National Energy Technology Laboratory

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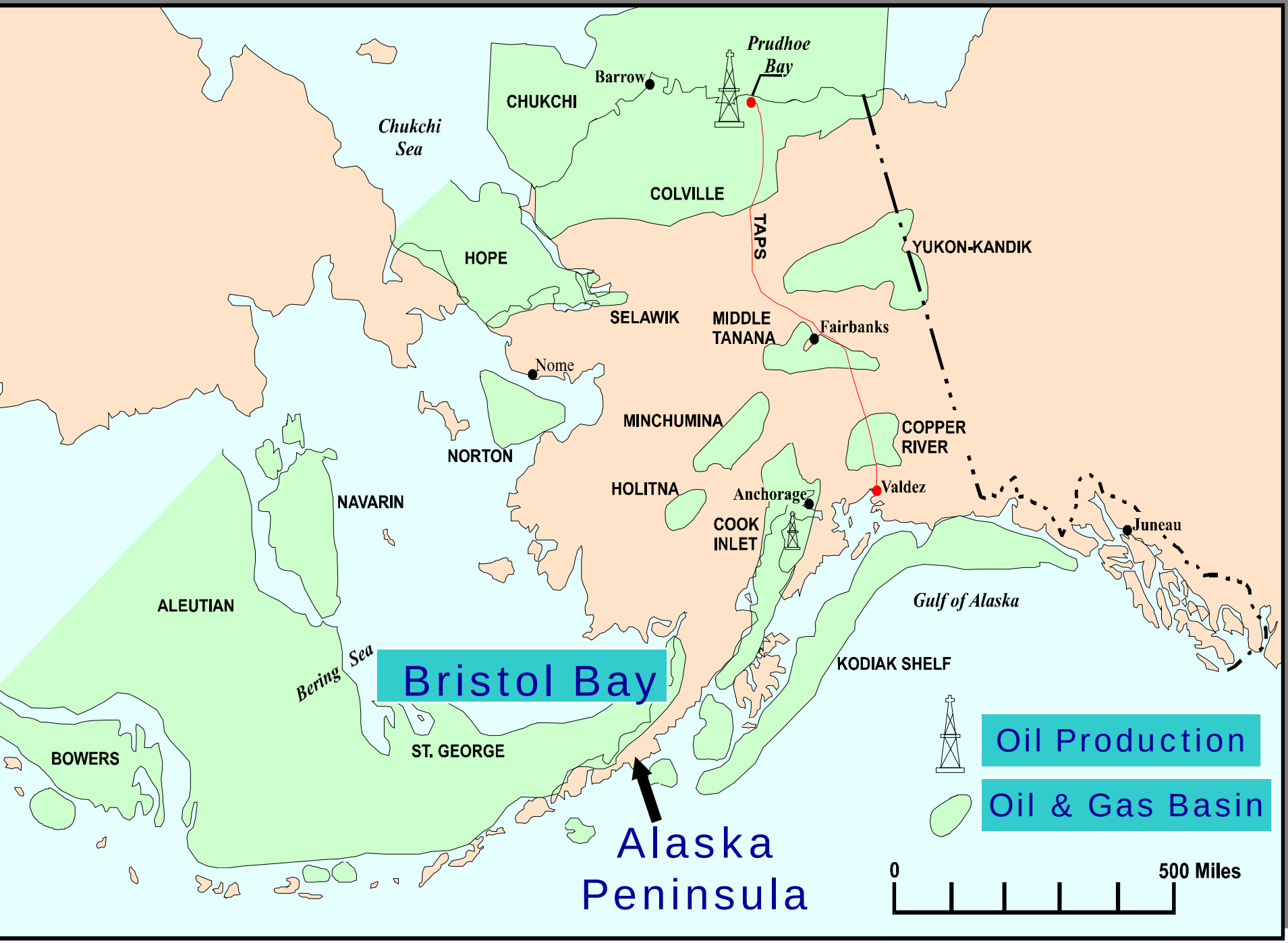

Prudhoe Bay
Barrow
CHUKCHI
Chukchi Sea
COLVILLE
TAPS
YUKON-KANDIK
HOPE
SELAWIK
MIDDLE TANANA
Fairbanks
Nome
MINCHUMINA
COPPER RIVER
NORTON
HOLITNA
Anchorage
Valdez
NAVARIN
COOK INLET
Juneau
ALEUTIAN
Gulf of Alaska
Bering Sea
Bristol Bay
KODIAK SHELF
BOWERS
ST. GEORGE
Oil Production
Oil & Gas Basin
Alaska Peninsula
0
500 Miles

Summary Points

RESERVOIRS - good Tertiary strata

SEALS - 250-2,500 feet hydrocarbon column; intra-reservoir seals (Cook Inlet-like)

STRUCTURES & TRAPS - numerous; structural, strat.

SOURCES - THERMOGENIC GAS @ Port Moller hot springs
Mz source in SW basin & Oil seep
TOC: 5.3; HI 756
Tert. / K coals; Carb-shales

MATURITY – Tertiary strat./ Bear Lake Fm. Ro = 0.5 – 0.8
Mz source @ Puale Bay (Ro= 0.4-0.7)

GAS RESOURCES (assume Cook Inlet-like system) = ?? TCF

COLLABORATORS

AKDGGS	**Rocky Reifenstuhl, Project Lead** **Bob Gillis** **Andrea Loveland**
AKDOG	**Paul Decker** Ken Helmold
UAF	Paul McCarthy
Anchorage	Robert Blodgett
Purdue University	*Ken Ridgway* *Emily Finzel*

Overview

New Public Data
Regional Elements
Stratigraphy, Reservoir char.
Maturity, Seals
Hydrocarbon Typing
Thermogenic gas & Oil Seep
Mapping / X-section & Seismic
Summary

Alaska DNR Bristol Bay Products:

All Web-accessible

- 2004 Field program results
- 2005: Surface-subsurface interpretations
- 2005 Field program results
- 2006 Field program results
- 2006 AKDOG Reservoir quality report

3 CD-ROM Data compilation:

- Digital seismic & well logs/mud logs
- Quad. maps: Geology, Gravity, & Magnetics; Regional info.

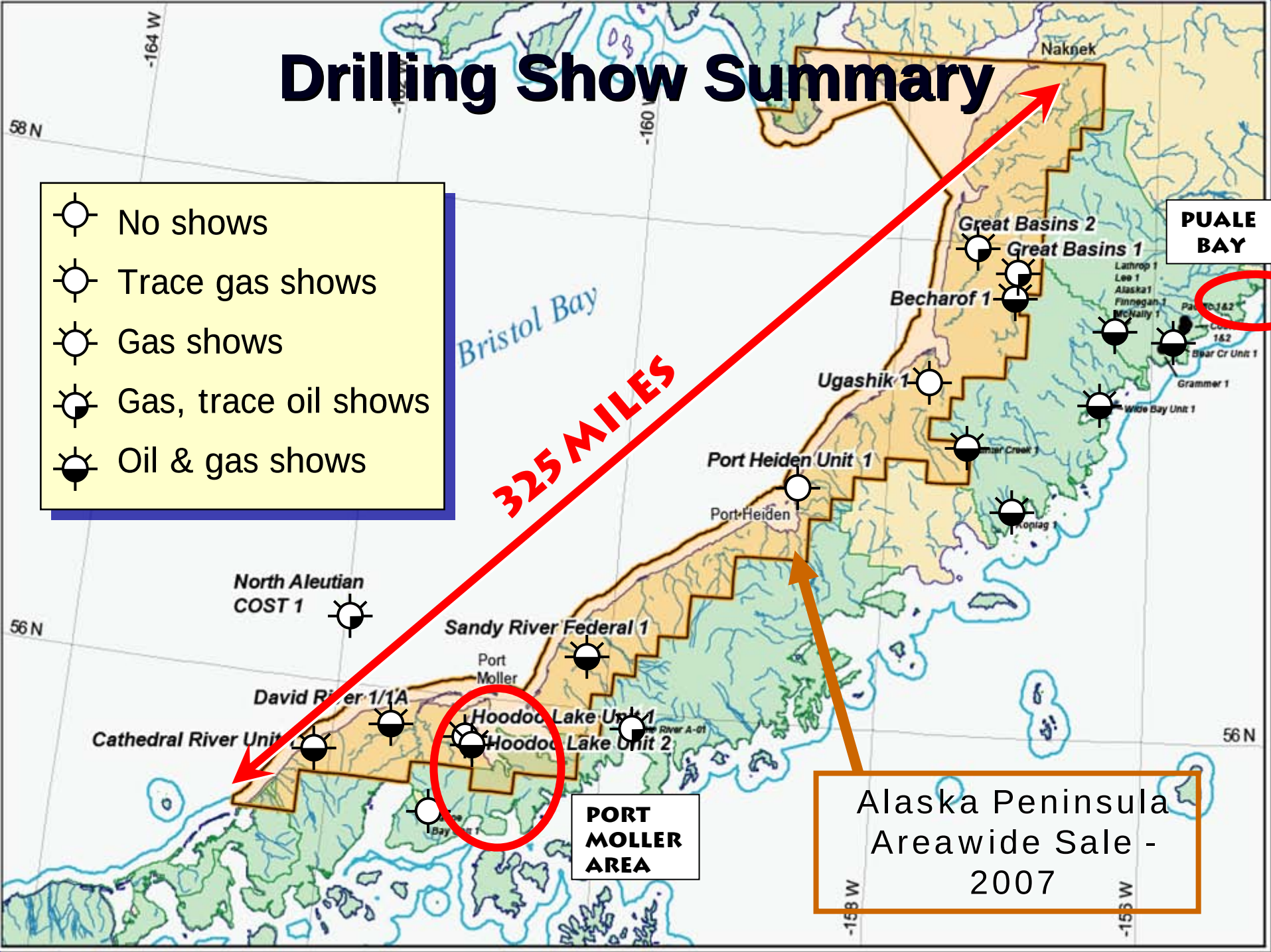
Biostratigraphy Study:

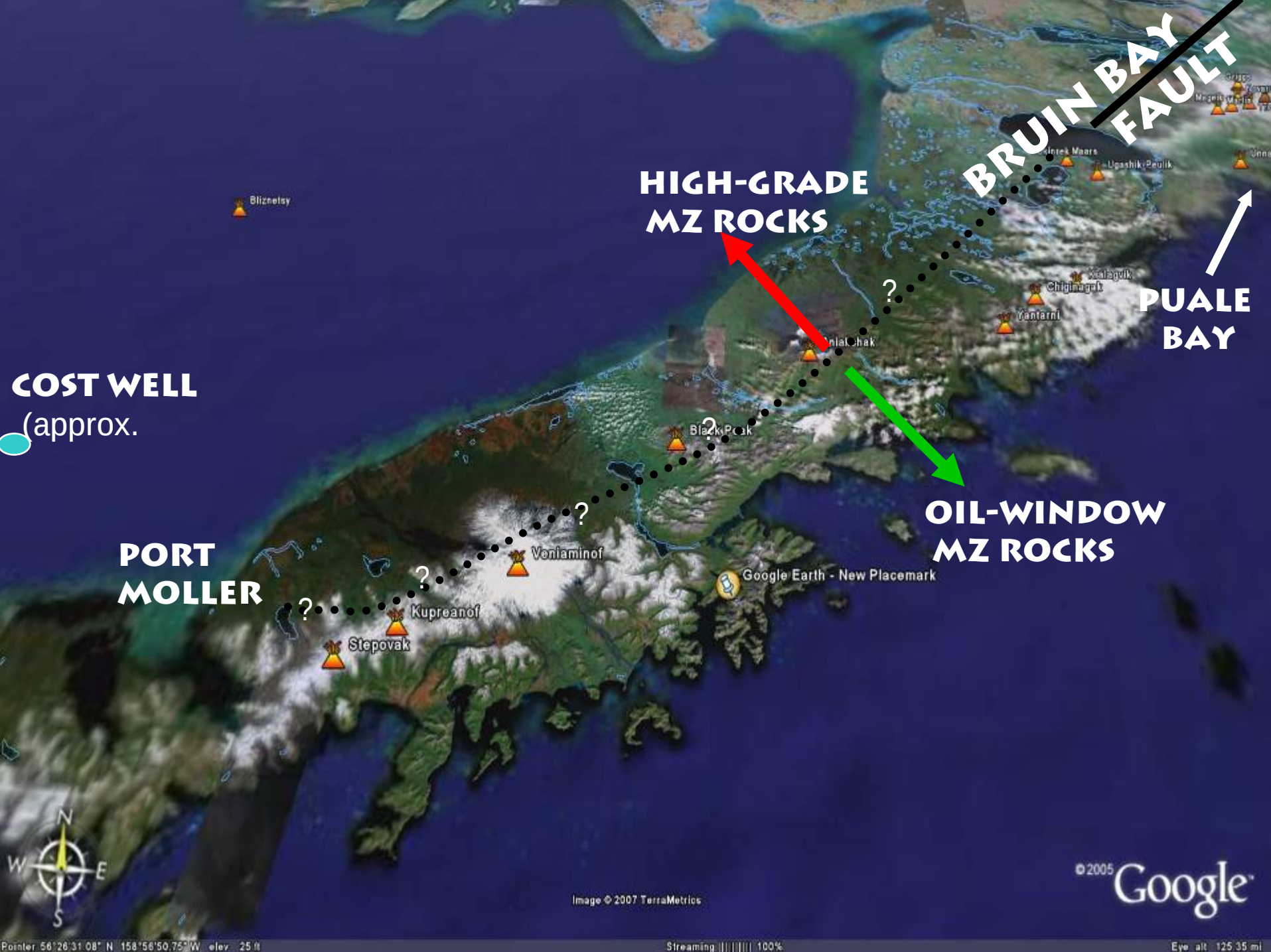
- 10 of 11 wells in sale area + North Aleutian COST 1

www.dog.dnr.state.ak.us/oil

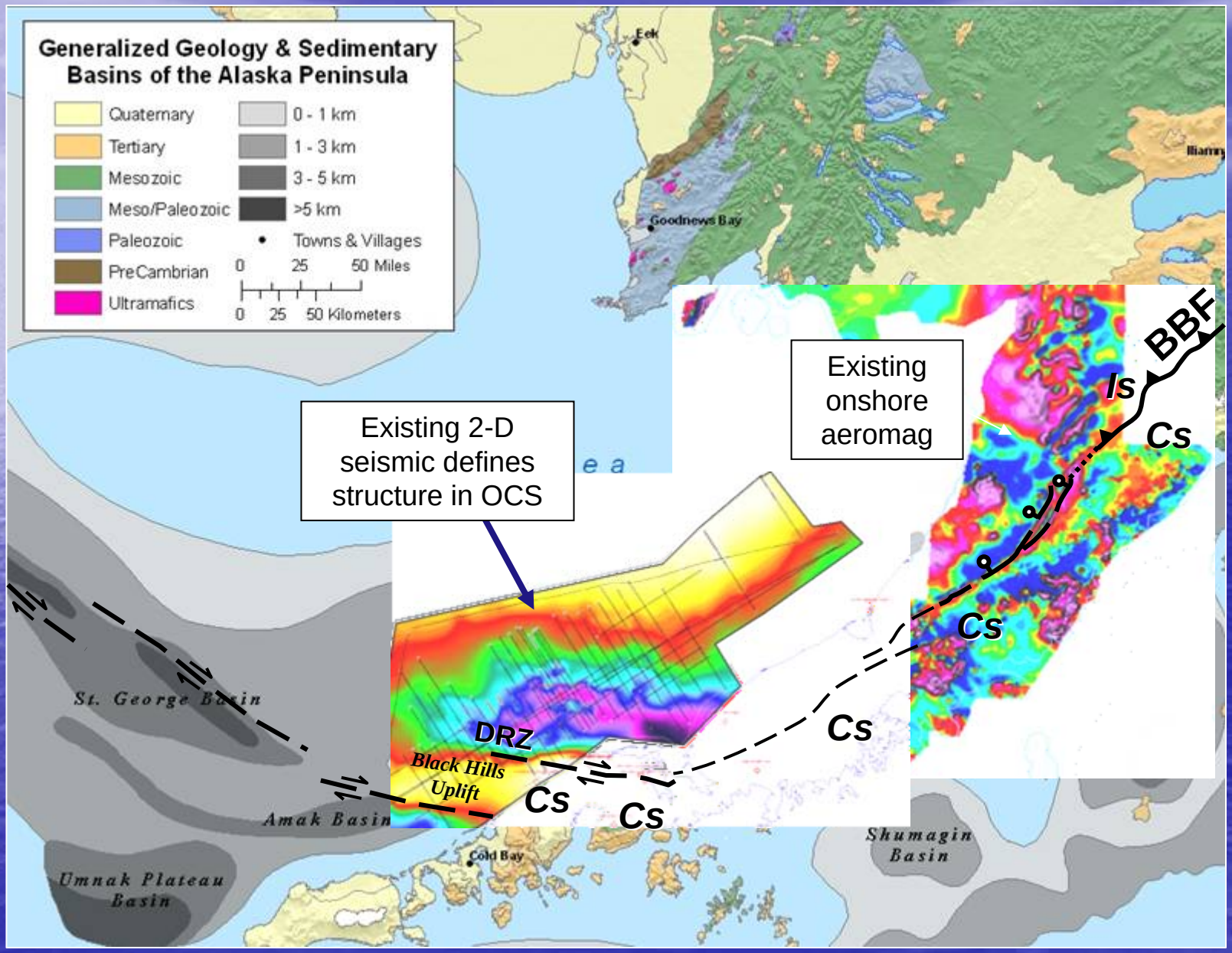
www.dggs.dnr.state.ak.us/publications

Drilling Show Summary

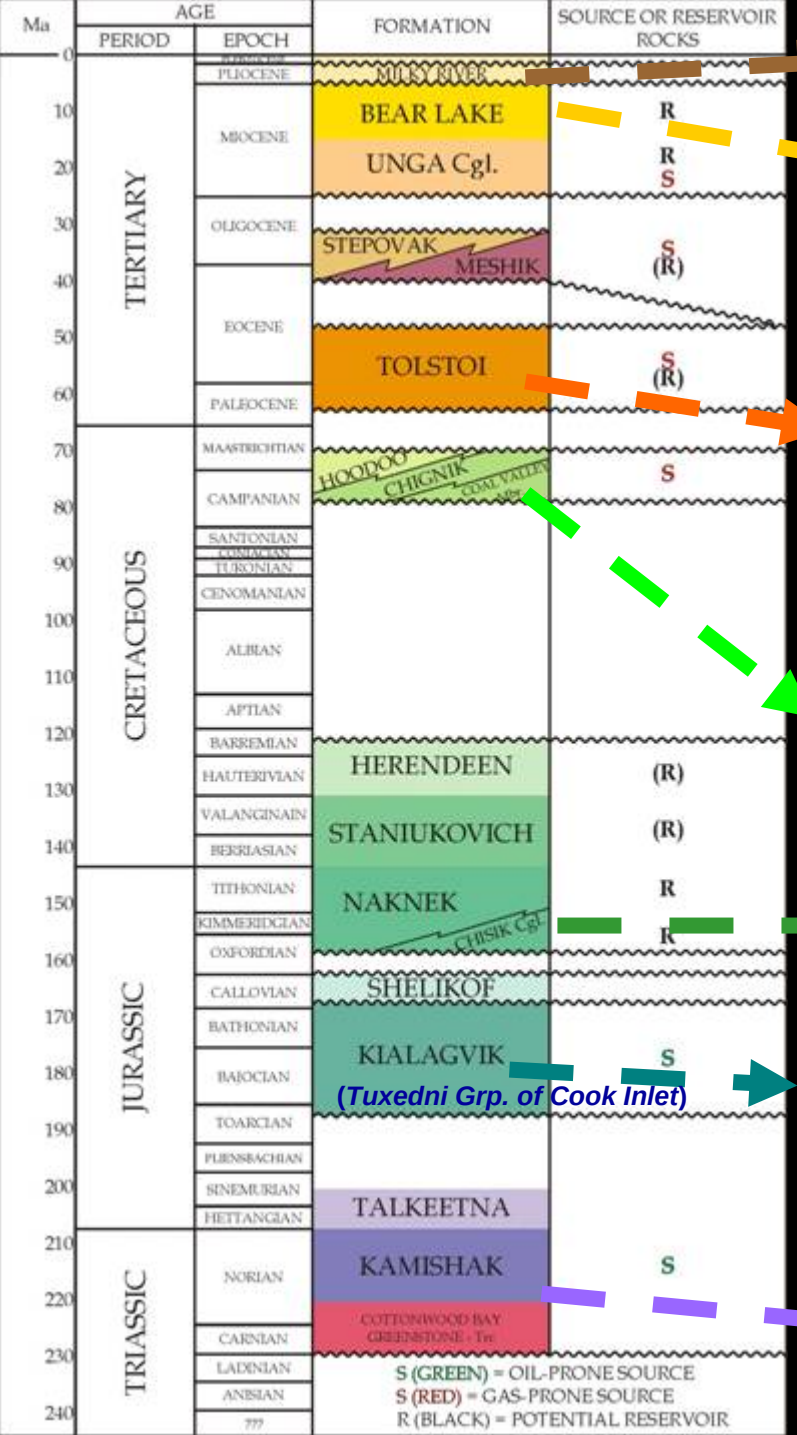



BRUIN BAY FAULT
HIGH-GRADE MZ ROCKS
PUALE BAY
COST WELL (approx.
OIL-WINDOW MZ ROCKS
PORT MOLLER
Bliznetsy
Chiginagak
Yantarni
Black Peak
Veniaminof
Kupreanof
Stepovak
Google Earth - New Placemark
Image © 2007 TerraMetrics
©2005 Google

BRISTOL BAY BASIN REGIONAL TECTONIC ELEMENTS



AK PEN. STRAT.


Ma
AGE
PERIOD
EPOCH
FORMATION
SOURCE OR RESERVOIR ROCKS
TERTIARY
CRETACEOUS
JURASSIC
TRIASSIC
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
PALEOCENE
MAASTRICHTIAN
CAMPANIAN
SANTONIAN
CONIACIAN
TURONIAN
CENOMANIAN
ALBIAN
APTIAN
BARREMIAN
HAUTERIVIAN
VALANGINAIN
BERRIASIAN
TITHONIAN
KIMMERIDGIAN
OXFORDIAN
CALLOVIAN
BATHONIAN
BAJOCIAN
TOARCIAN
PLIENSBACHIAN
SINEMURIAN
HETTANGIAN
NORIAN
CARNIAN
LADINIAN
ANISIAN
???
MILKY RIVER
BEAR LAKE
UNGA Cgl.
STEPOVAK
MESHIK
TOLSTOI
HOODOO
CHIGNIK
COAL VALLEY
HERENDEEN
STANIUKOVICH
NAKNEK
CHISIK Cgl.
SHELIKOF
KIALAGVIK
(Tuxedni Grp. of Cook Inlet)
TALKEETNA
KAMISHAK
COTTONWOOD BAY GREENSTONE - Trc
R
R
S
S
(R)
S
(R)
S
(R)
(R)
R
R
S
S
S (GREEN) = OIL-PRONE SOURCE
S (RED) = GAS-PRONE SOURCE
R (BLACK) = POTENTIAL RESERVOIR

Milky River Fm

Bear Lake Fm.

Tolstoi Fm

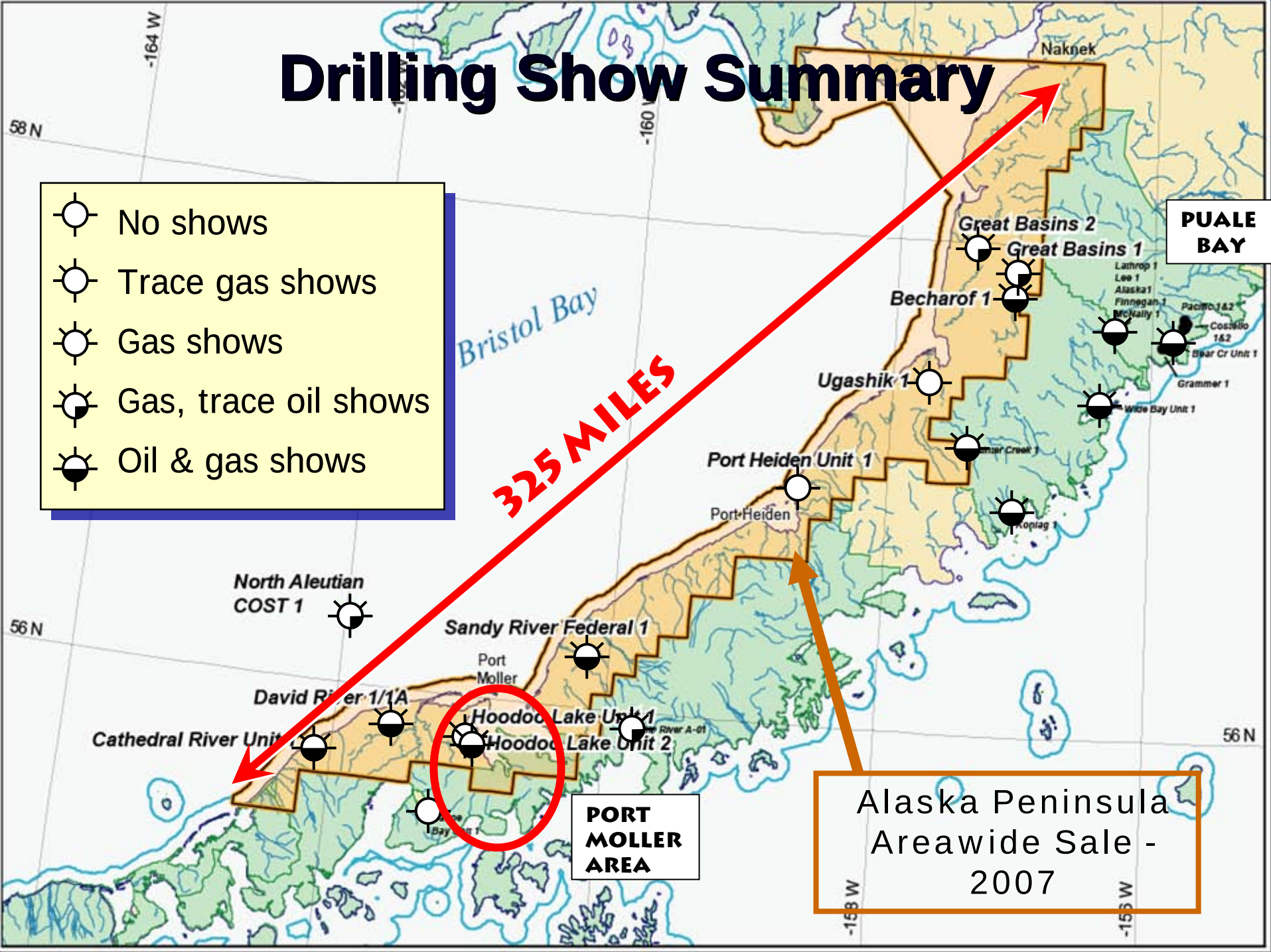
Chigik Fm Coal

Naknek Fm
Chisik Mbr cglm

Kialagvik Fm

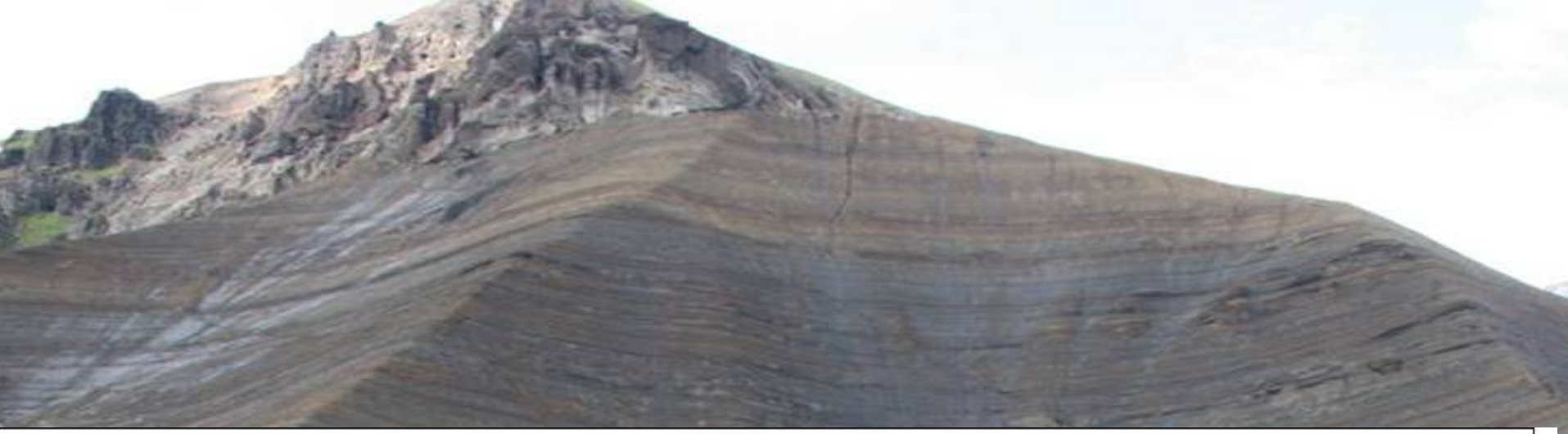
Kamishak Fm.
biohermal limestone
TOC
2.4%

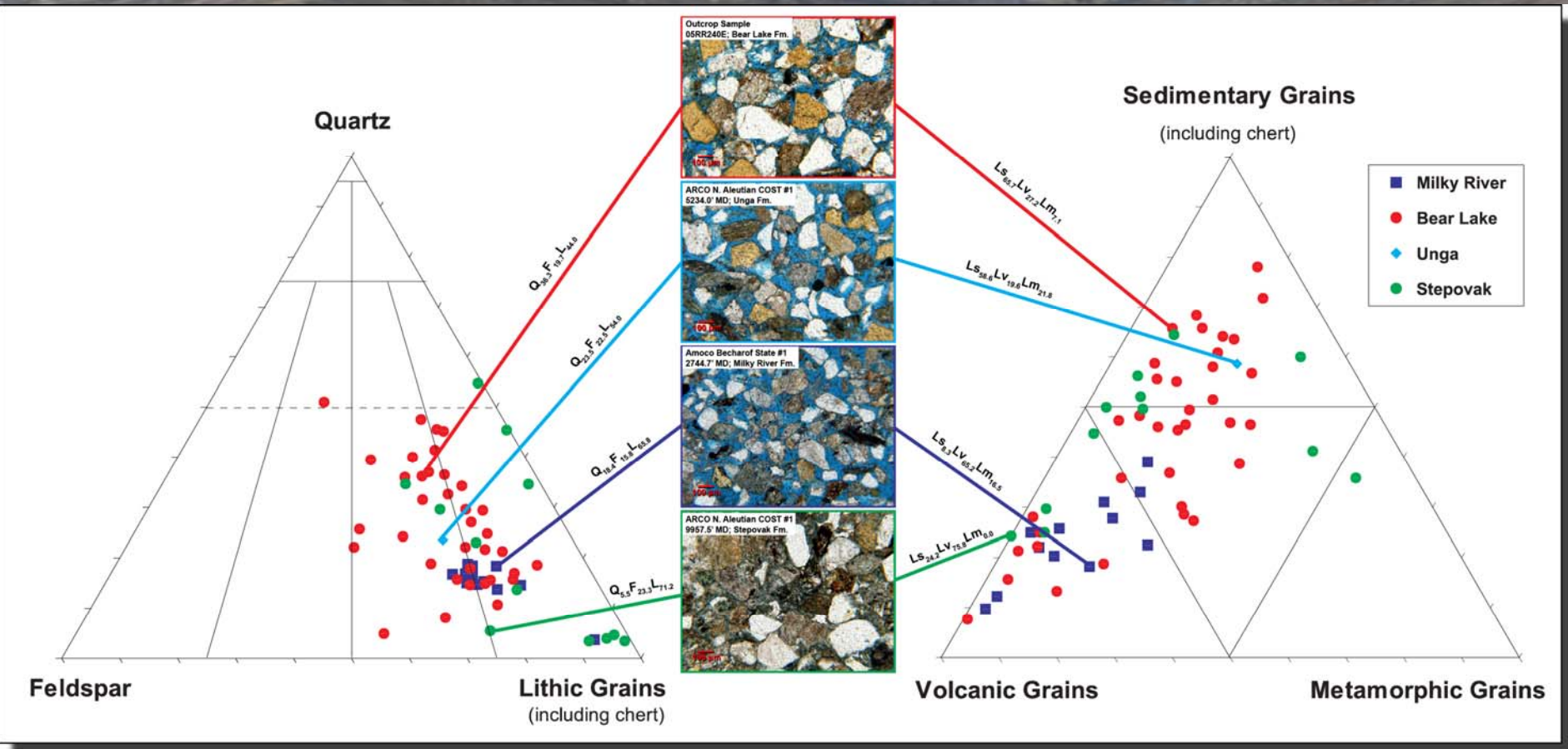
Drilling Show Summary

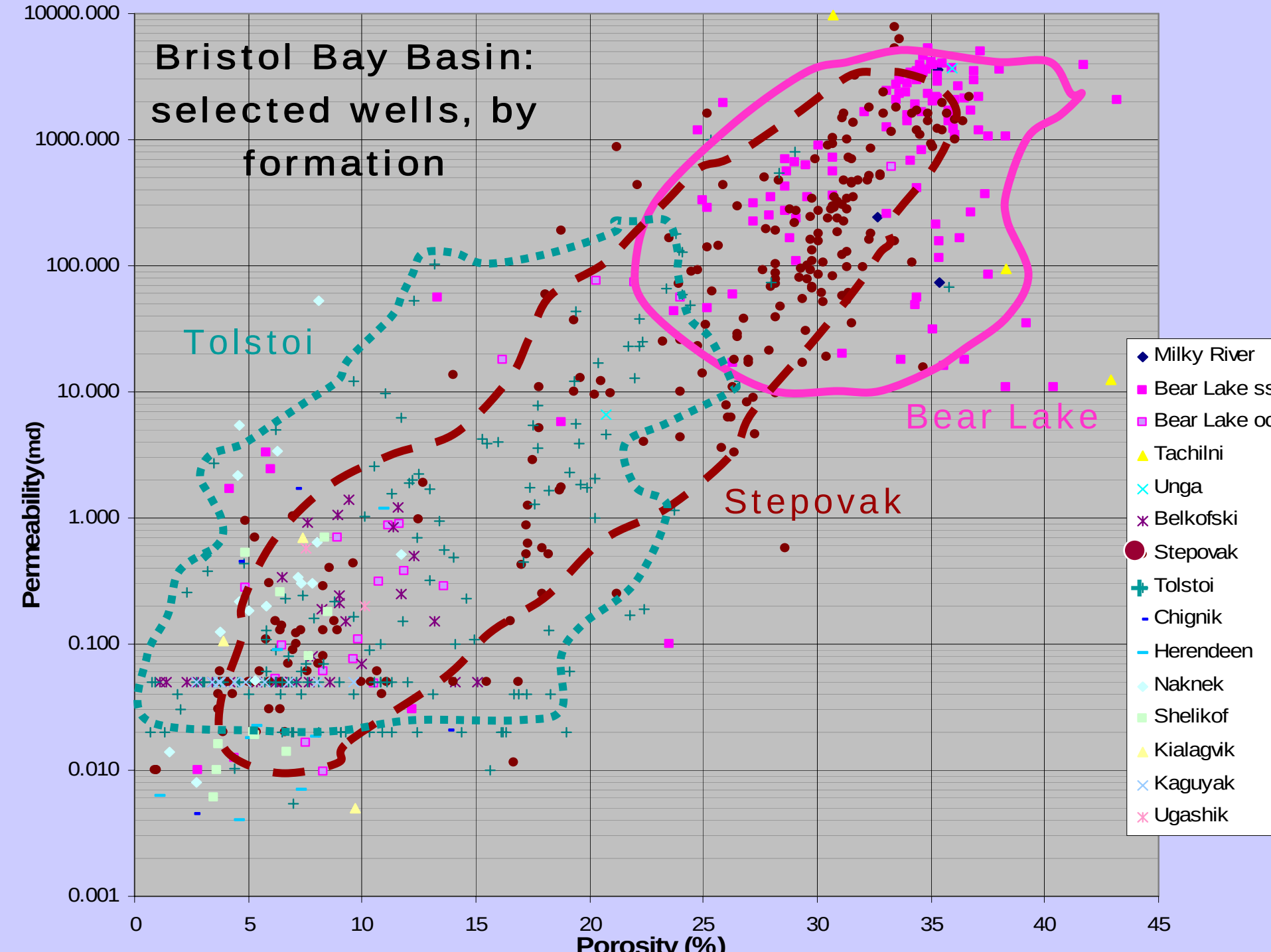


Chronostratigraphic Correlation of Bear Lake Formation Measured Sections with Sample Locations

Bear Lake Fm. Chronostratigraphy

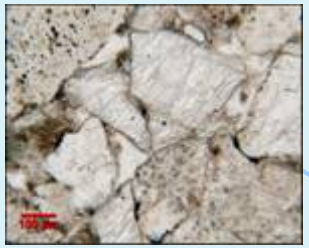


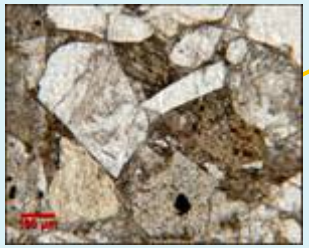

Quartz
Feldspar
Lithic Grains
(including chert)
Sedimentary Grains
(including chert)
Volcanic Grains
Metamorphic Grains
Milky River
Bear Lake
Unga
Stepovak
Outcrop Sample
05RR240E; Bear Lake Fm.
ARCO N. Aleutian COST #1
5234.0' MD; Unga Fm.
Amoco Becharof State #1
2744.7' MD; Milky River Fm.
ARCO N. Aleutian COST #1
9957.5' MD; Stepovak Fm.
$Q_{36.3}F_{19.2}L_{44.5}$
$Q_{23.5}F_{22.5}L_{54.0}$
$Q_{16.4}F_{19.8}L_{63.8}$
$Q_{5.5}F_{23.3}L_{71.2}$
$Ls_{65.7}Lv_{27.2}Lm_{7.1}$
$Ls_{58.8}Lv_{19.6}Lm_{21.6}$
$Ls_{6.3}Lv_{65.2}Lm_{16.5}$
$Ls_{24.2}Lv_{75.8}Lm_{0.0}$

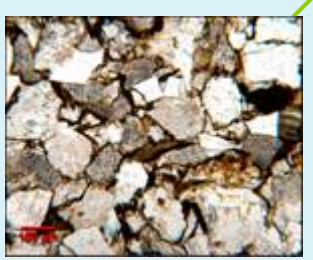

Bristol Bay Basin: selected wells, by formation
Tolstoi
Stepovak
Bear Lake
Permeability(md)
Porosity (%)
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
0
5
10
15
20
25
30
35
40
45
Milky River
Bear Lake ss
Bear Lake oo
Tachilni
Unga
Belkofski
Stepovak
Tolstoi
Chignik
Herendeen
Naknek
Shelikof
Kialagvik
Kaguyak
Ugashik

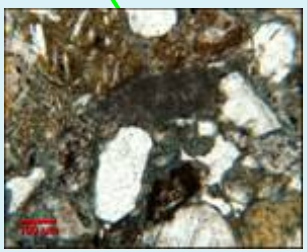
Phi-K Trend

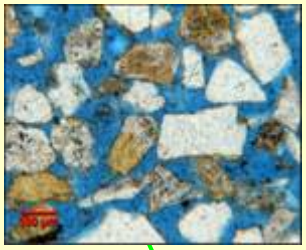
Unconventional Reservoirs

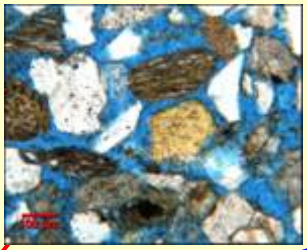


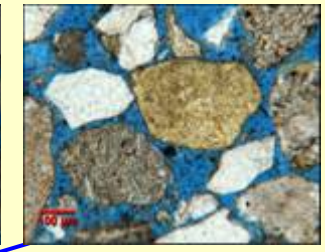


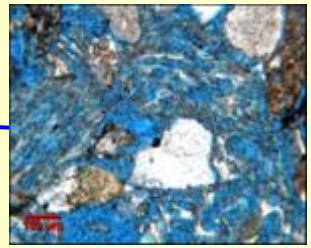


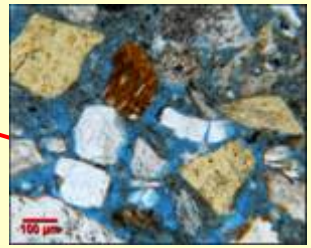


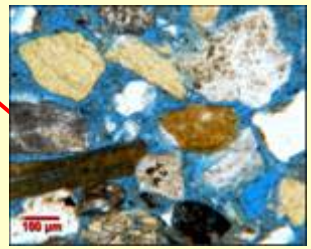


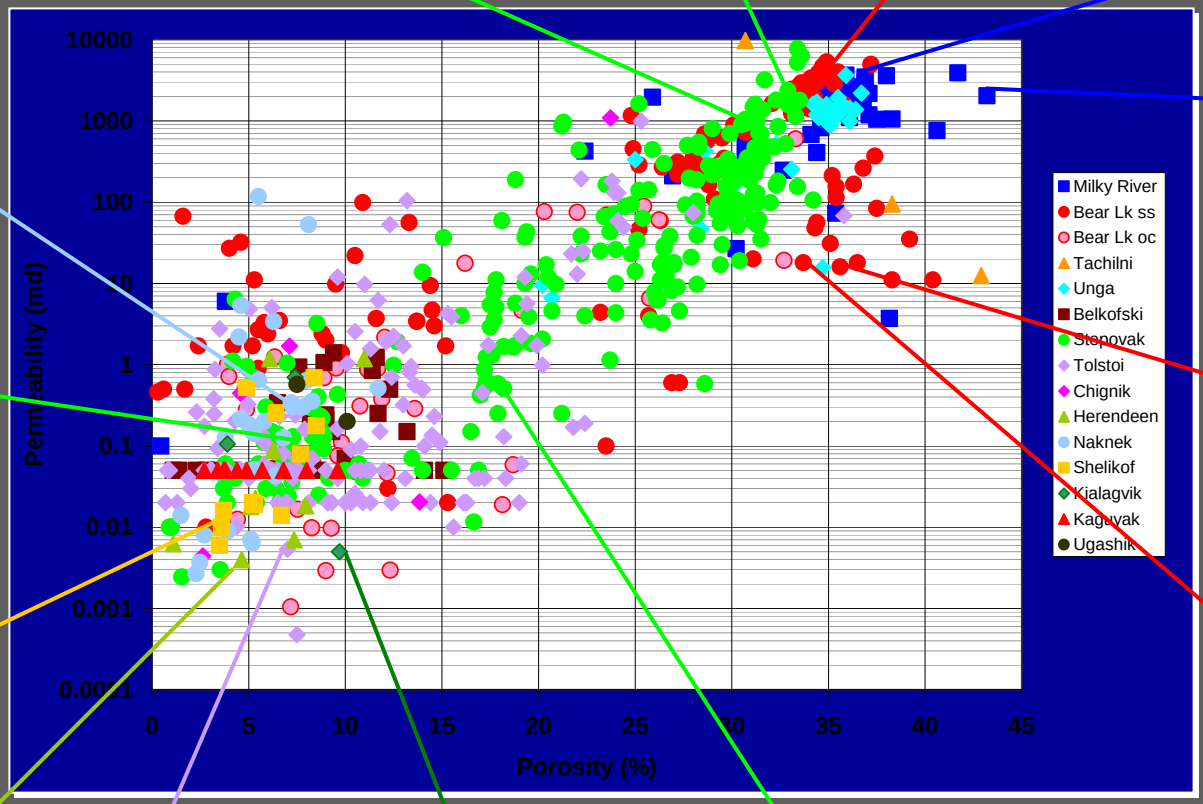






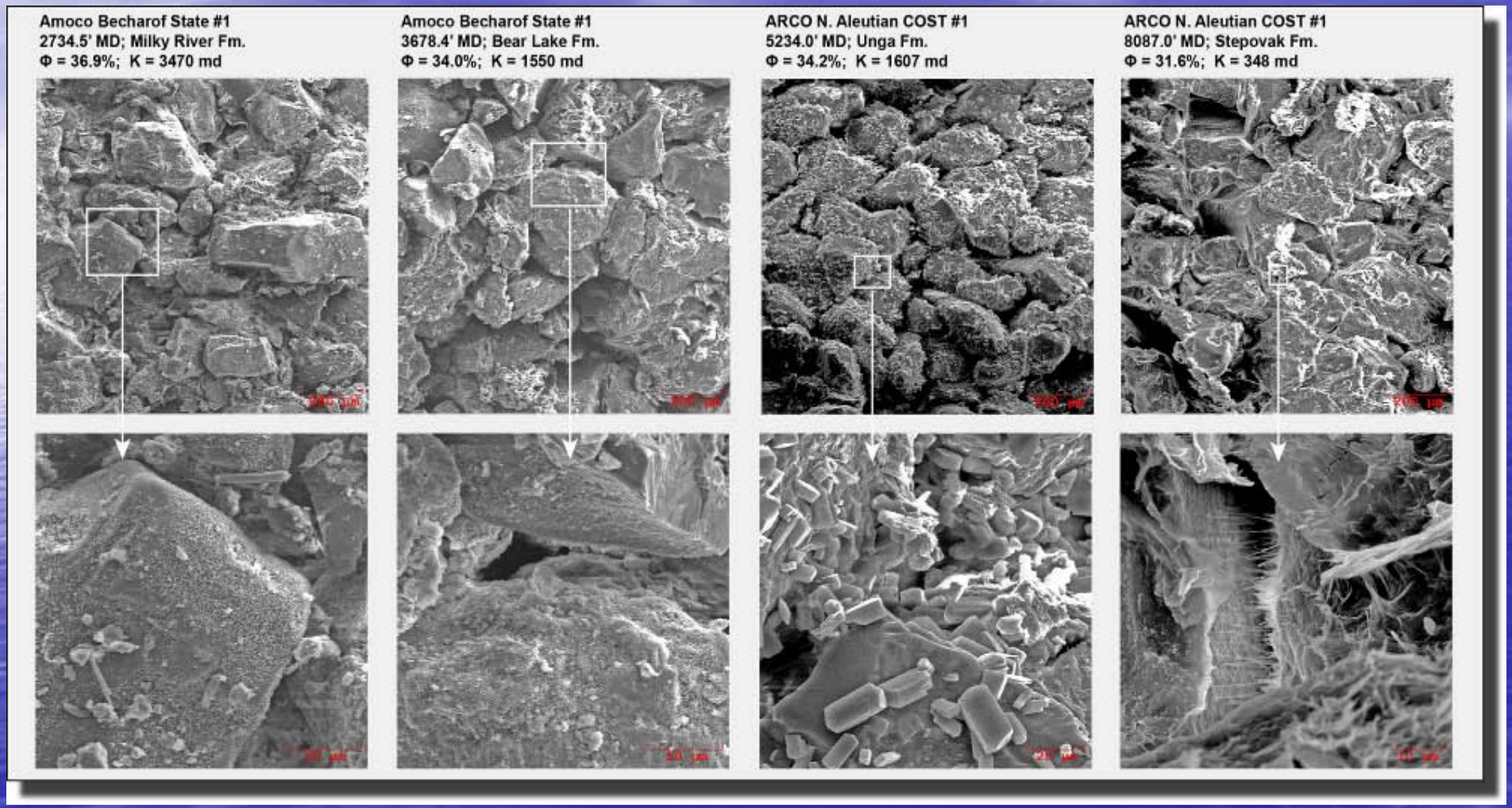




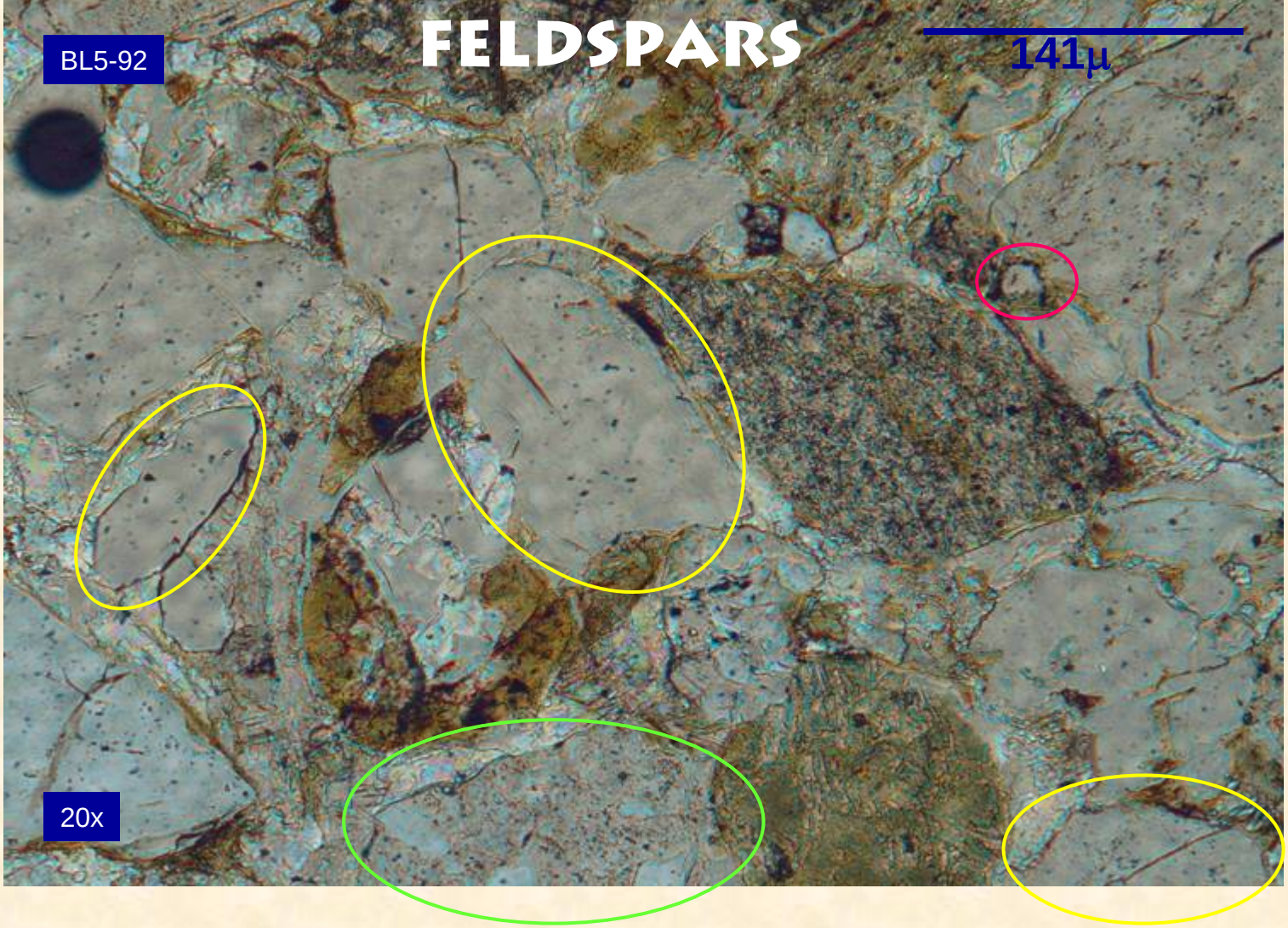


Sandstone Reservoirs

Scanning Electron Microscope (SEM) Images
Cost Well Samples

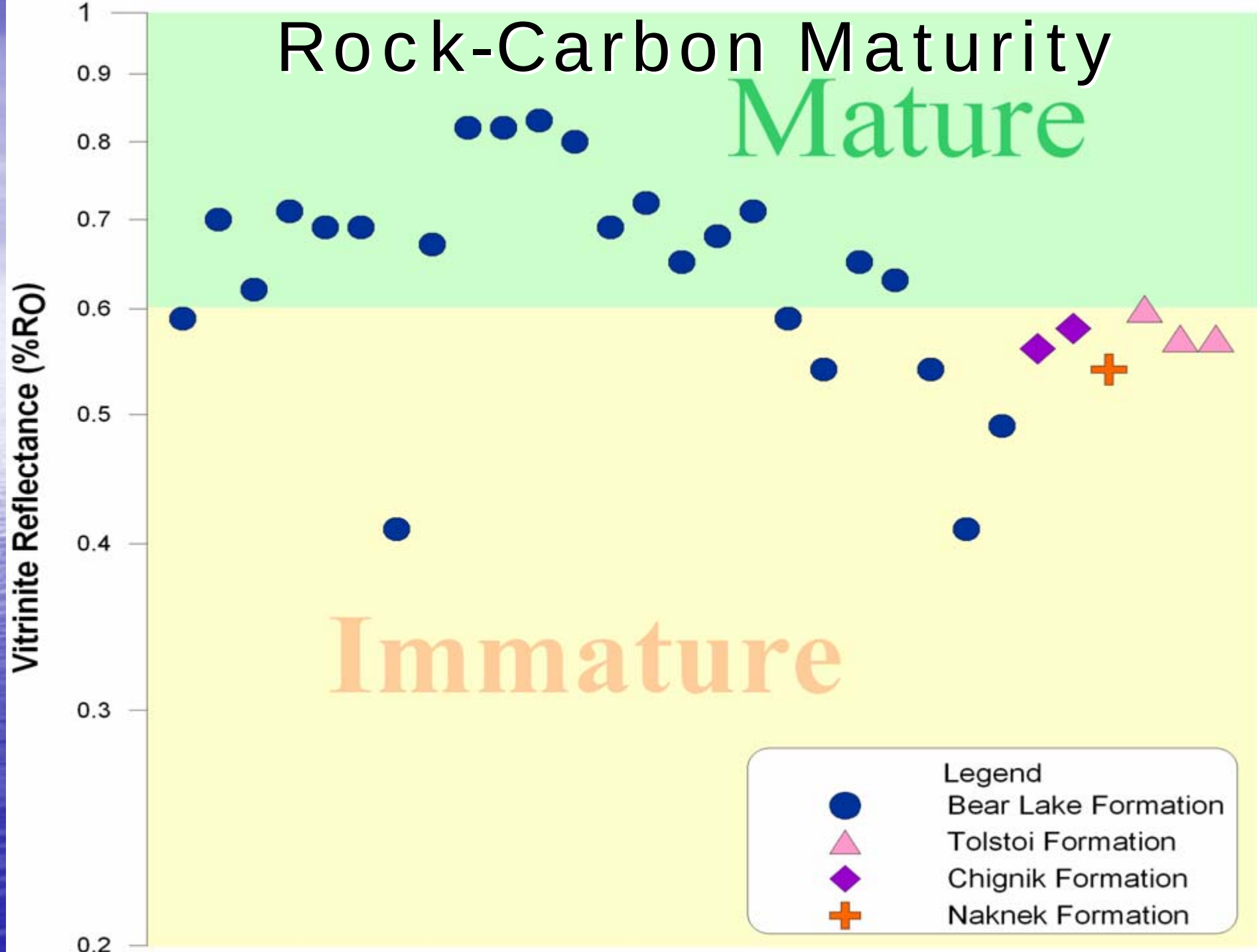


FELDSPARS

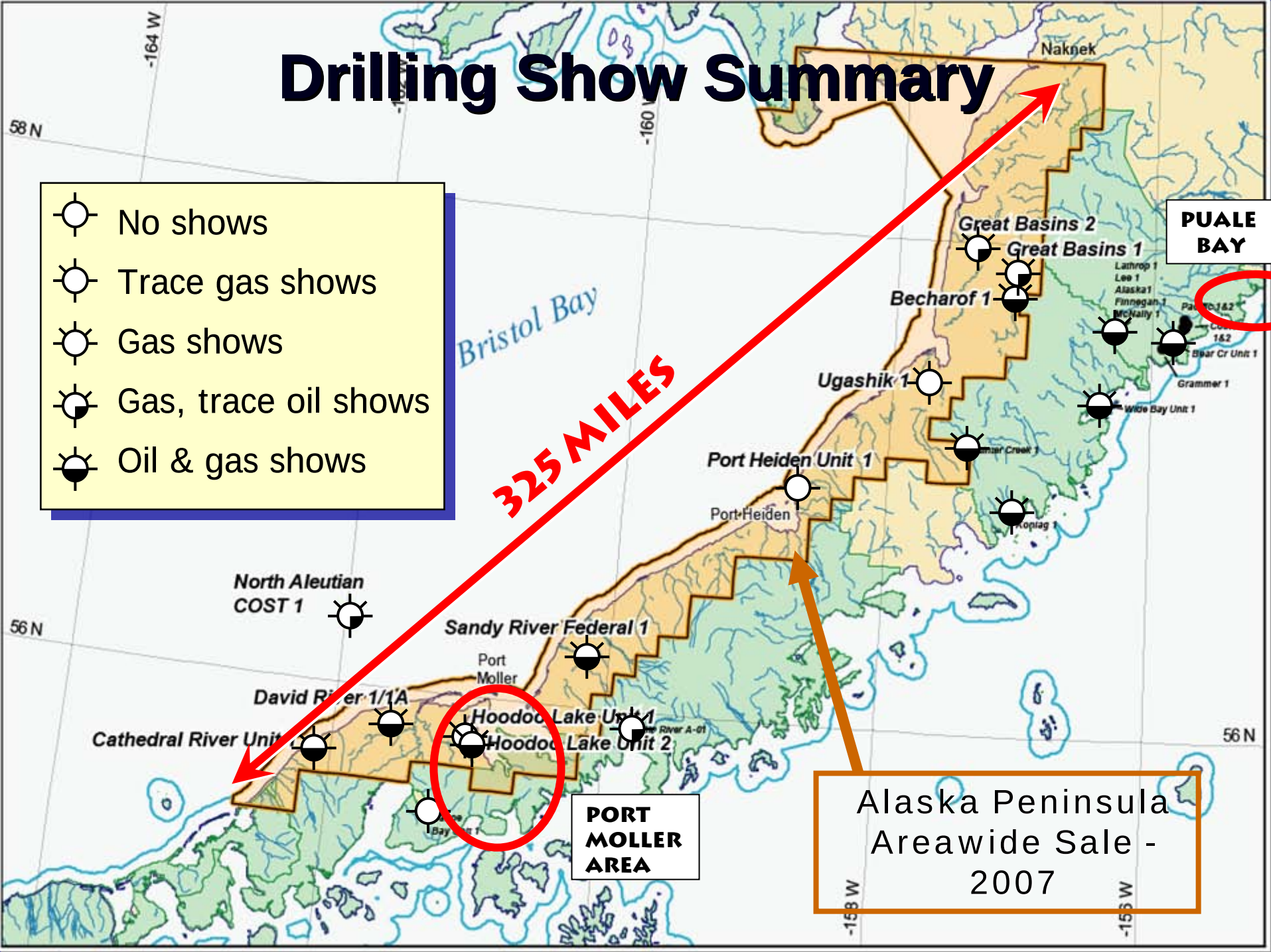


	Wt %	CaO	SiO_2	Al_2O_3	MgO	FeO	K_2O	Na_2O	TiO_2	MnO	Total
K-Feldspar	x	0.25	67.85	18.80	0.03	0.31	10.65	3.52	0.08	0.00	101.49
Plagioclase	z	5.64	63.49	24.57	0.01	0.07	0.10	8.18	0.04	0.00	102.09
Plagioclase	y	3.31	66.58	22.33	0.02	0.15	0.46	9.30	0.01	0.04	102.21
Plagioclase	r	9.54	58.53	27.49	0.06	0.49	0.17	5.82	0.00	0.00	102.11
Albite	n	0.25	70.15	20.08	0.08	0.34	0.11	11.35	0.00	0.00	102.36

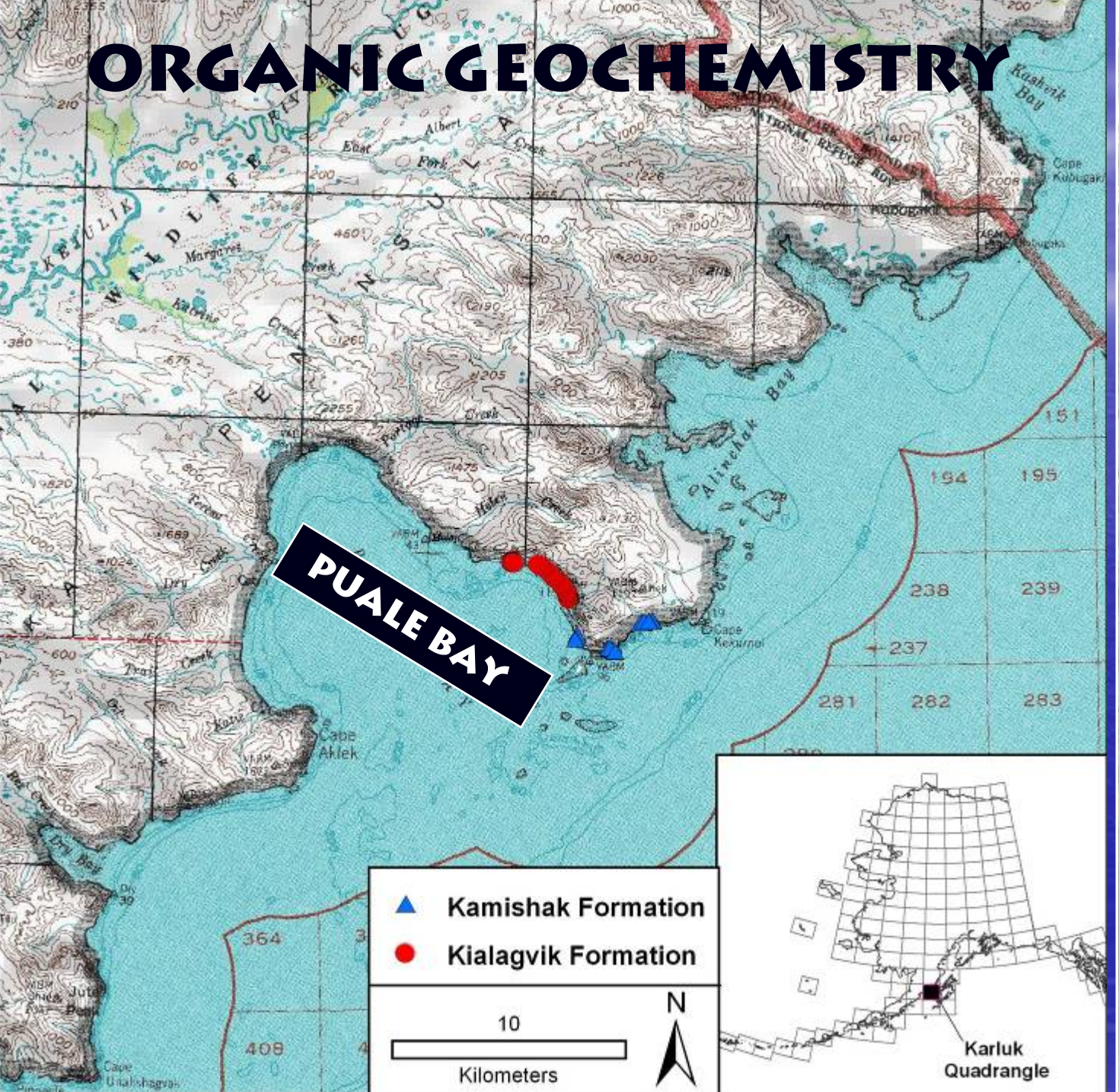
Rock-Carbon Maturity



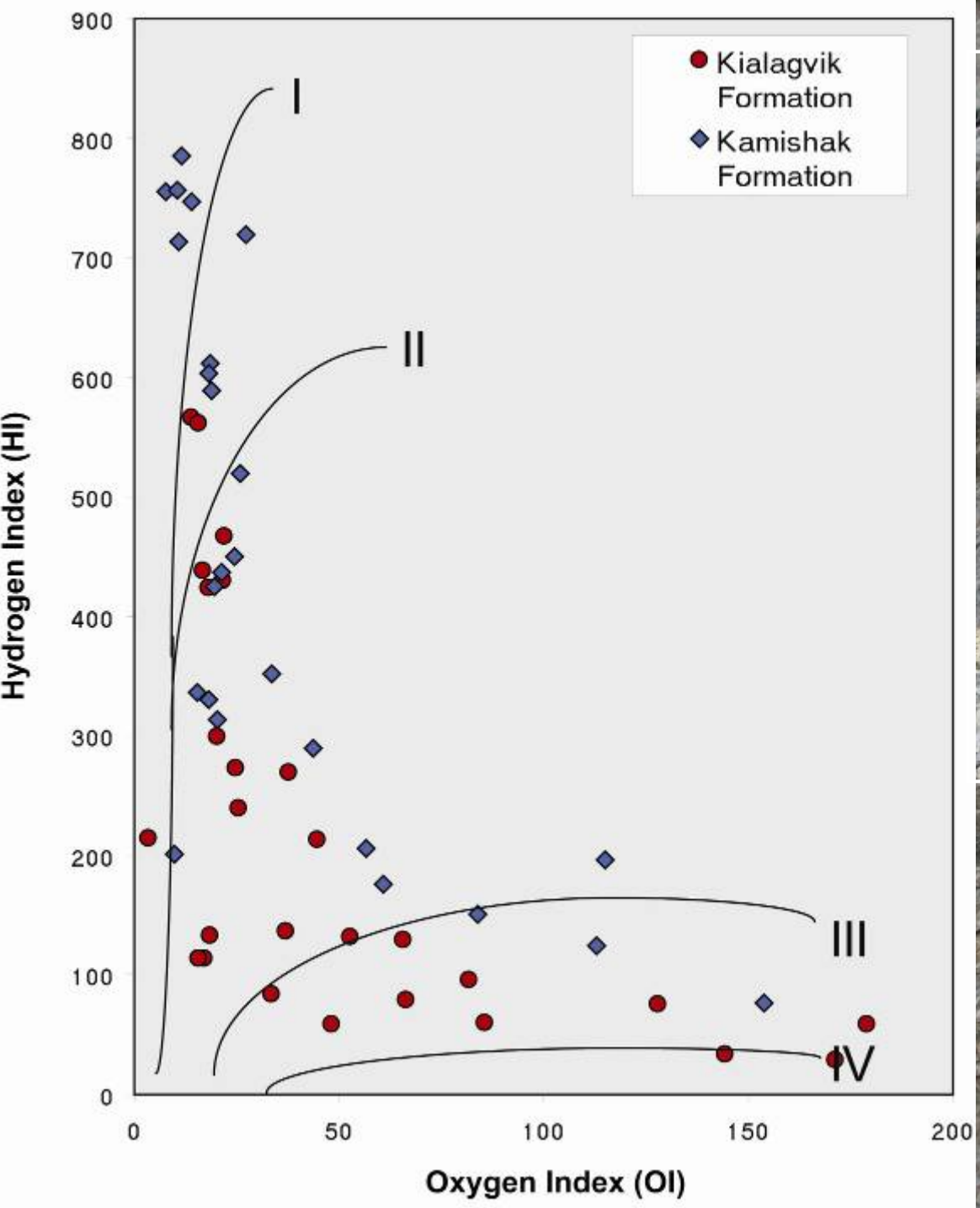
Drilling Show Summary



ORGANIC GEOCHEMISTRY



Kamishak Limestone
~reef, TOC=5.28%



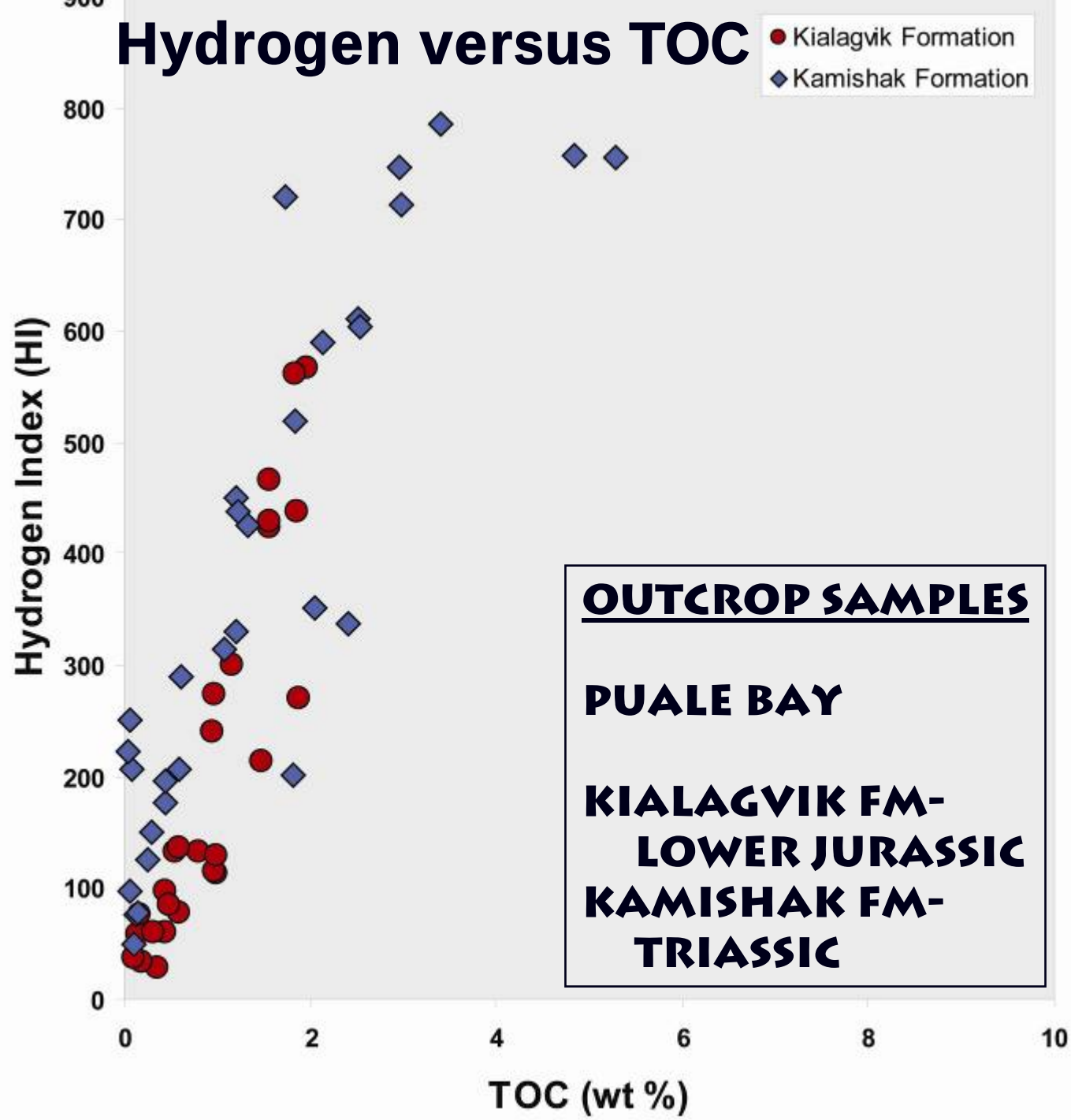
HYDROGEN/OXYGEN INDEX OUTCROP SAMPLES

PUALE BAY

KIALAGVIK FM- LOWER JURASSIC

KAMISHAK FM- TRIASSIC

Hydrogen versus TOC

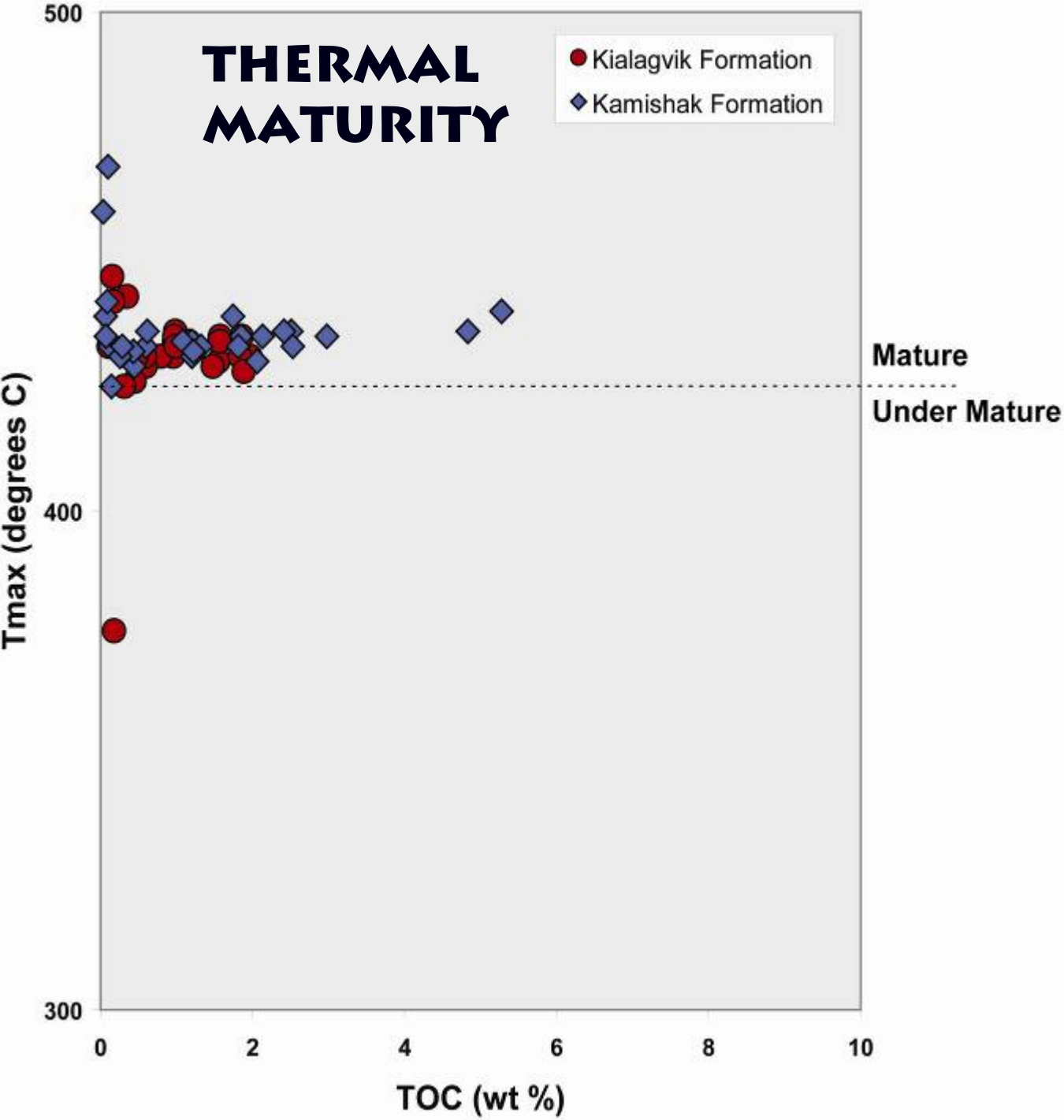


OUTCROP SAMPLES

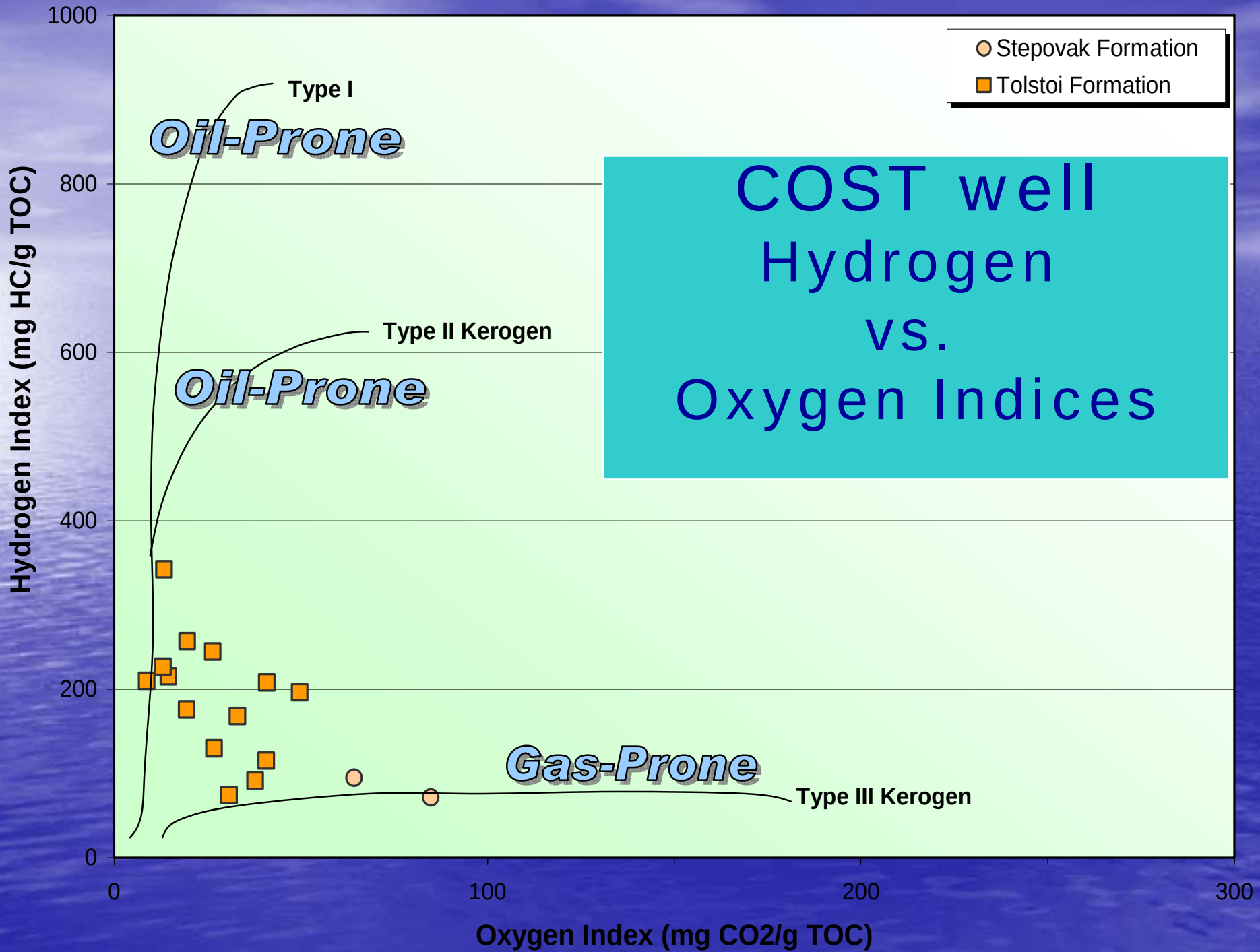
PUALE BAY

KIALAGVIK FM- LOWER JURASSIC

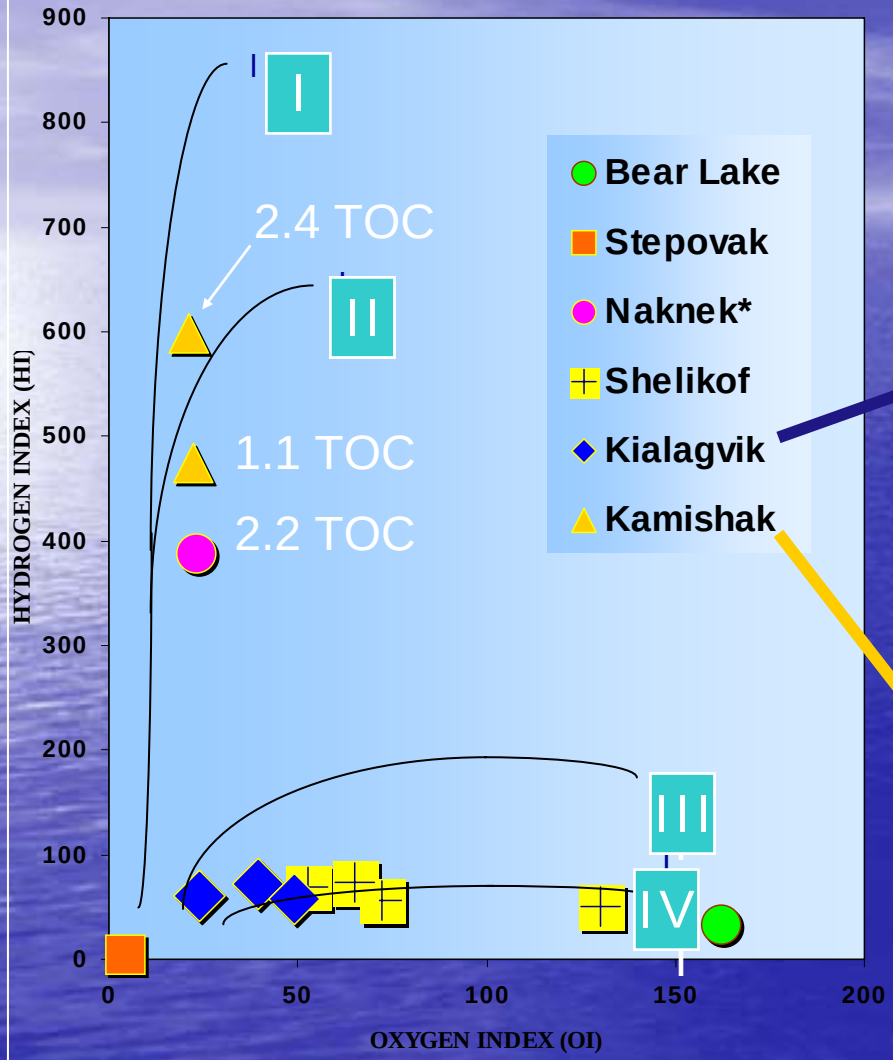
KAMISHAK FM- TRIASSIC


THERMAL MATURITY
Kialagvik Formation
Kamishak Formation
Mature
Under Mature
Tmax (degrees C)
500
400
300
0
2
4
6
8
10
TOC (wt %)

Kialagvik Formation-
Lower Jurassic

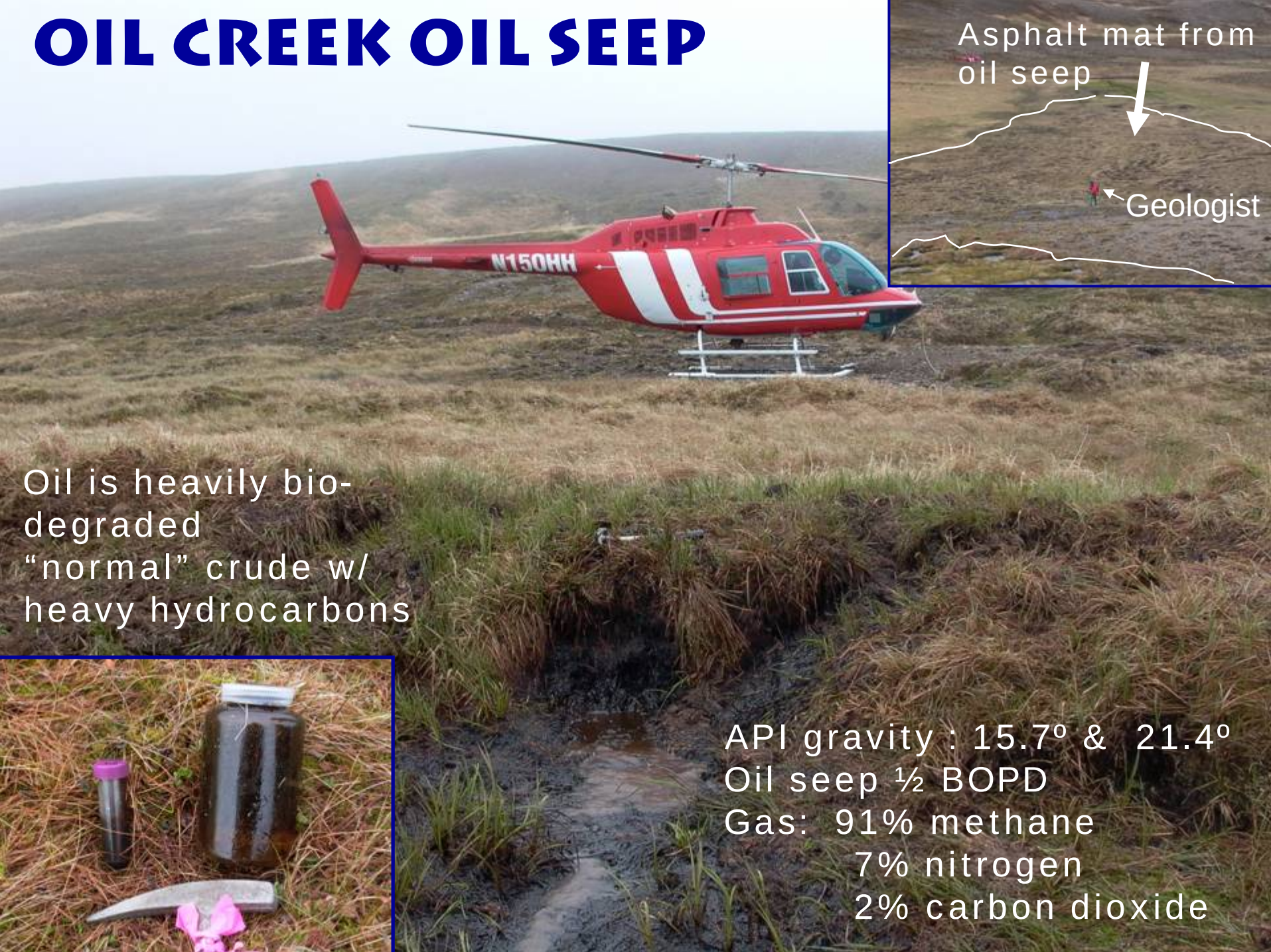

COST well
Hydrogen
vs.
Oxygen Indices
Stepovak Formation
Tolstoi Formation
Type I
Oil-Prone
Type II Kerogen
Oil-Prone
Gas-Prone
Type III Kerogen
Hydrogen Index (mg HC/g TOC)
Oxygen Index (mg CO2/g TOC)
0
200
400
600
800
1000
0
100
200
300

Triassic, Jurassic, Tertiary Rock Samples



(Types I & II will generate oil, type III gas; type IV little or no hydrocarbons)

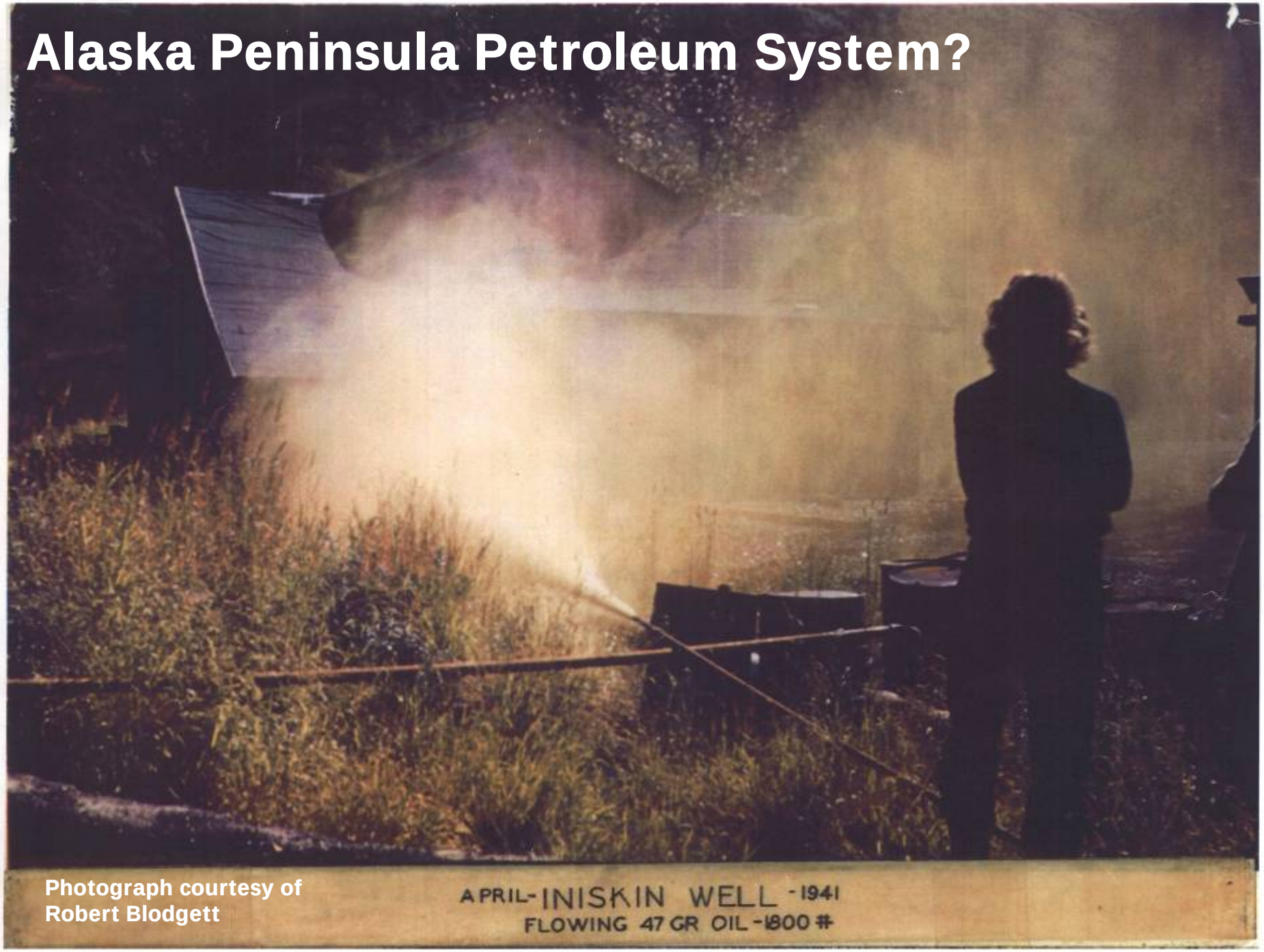
OIL CREEK OIL SEEP



Oil is heavily bio-degraded "normal" crude w/ heavy hydrocarbons

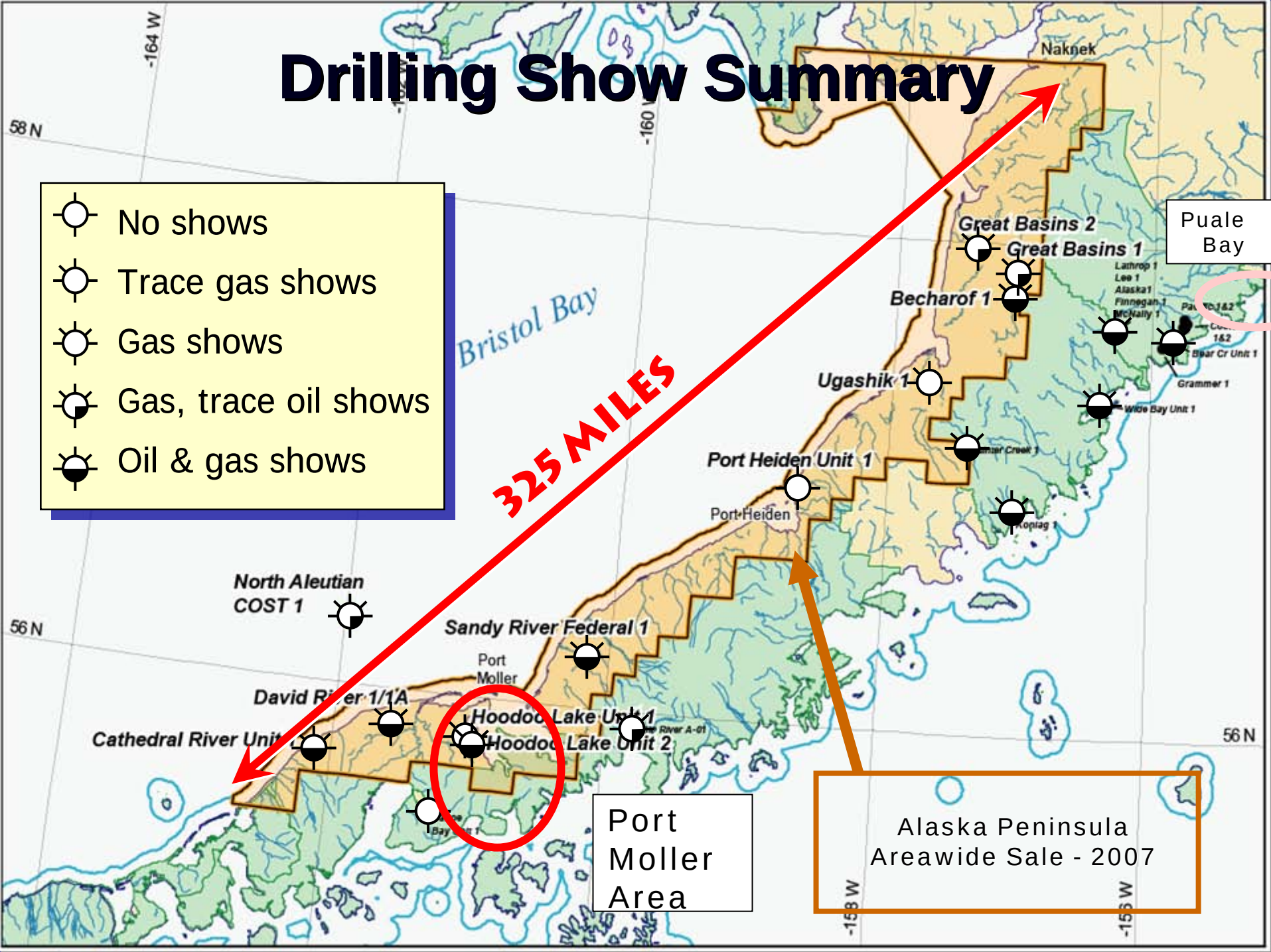
API gravity : 15.7º & 21.4º
Oil seep ½ BOPD
Gas: 91% methane
7% nitrogen
2% carbon dioxide

Alaska Peninsula Petroleum System?

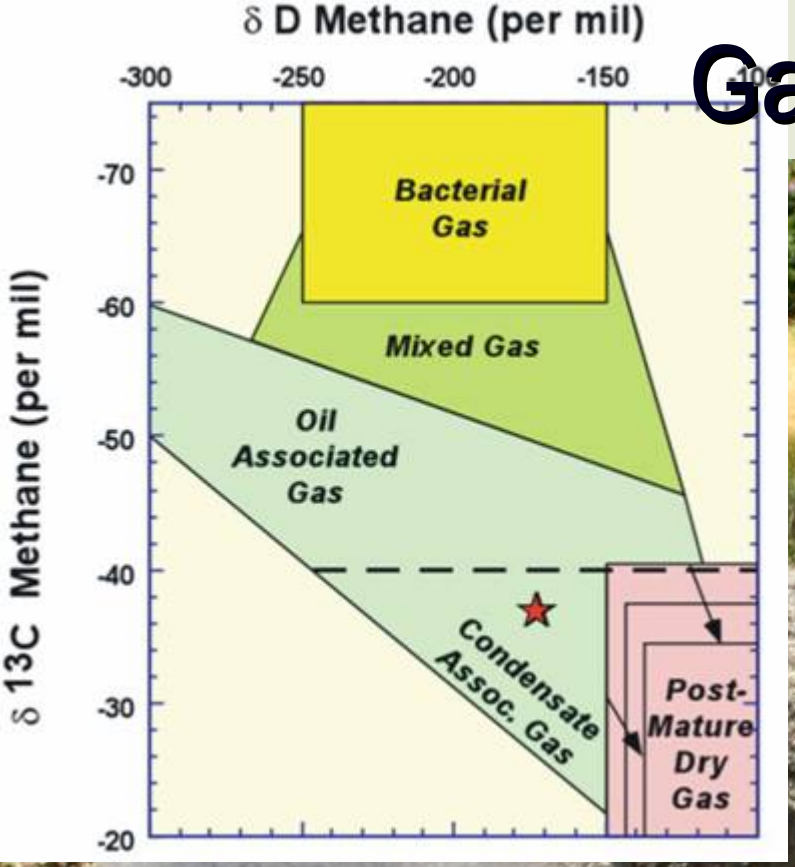


Photograph courtesy of
Robert Blodgett

Drilling Show Summary

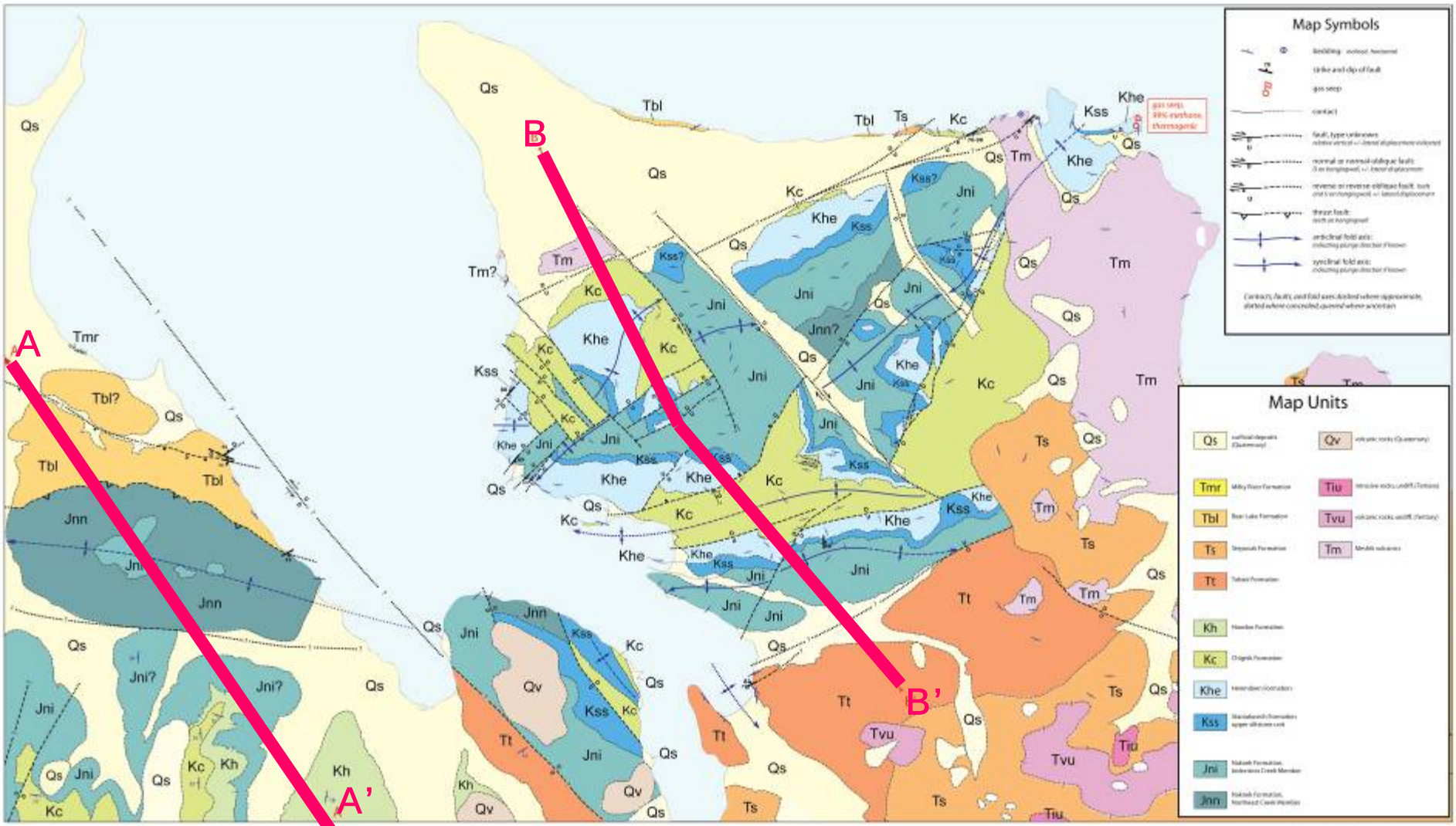


Gas sample:Thermogenic



Coal: Mine Harbor, Herendeen Bay

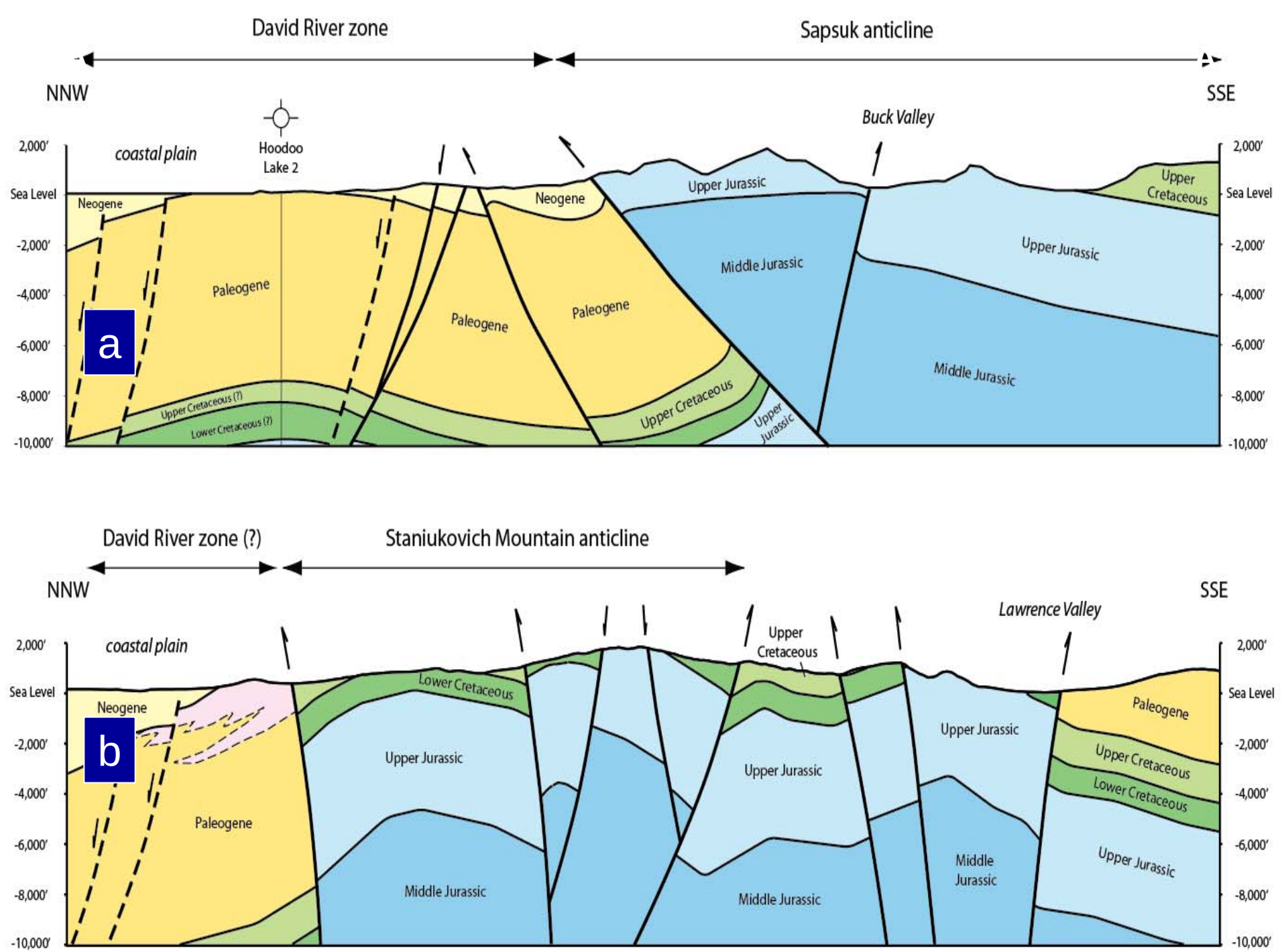
FIELD-GENERATED GEOLOGIC MAP



Simplified revised geologic map of the Staniukovich Peninsula -- Herendeen Bay area, Alaska Peninsula

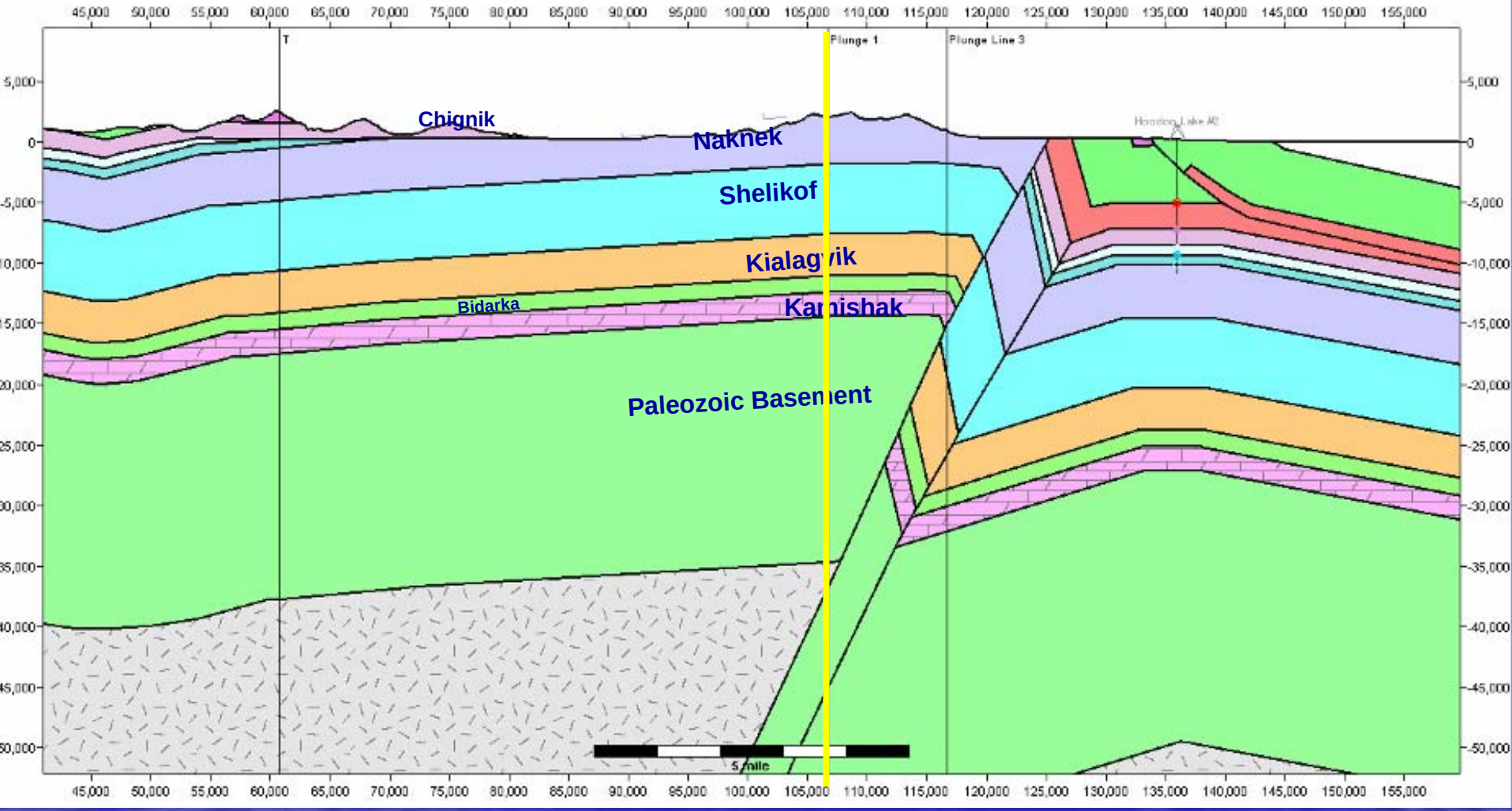
0 1 2 mi
0 1 2 3 km

Map extensively revised after Wilson and others (1995) based on 2005-2006 DNR field studies.


David River zone
Sapsuk anticline
NNW
SSE
Buck Valley
coastal plain
Hoodoo Lake 2
2,000′
Sea Level
-2,000′
-4,000′
-6,000′
-8,000′
-10,000′
Neogene
Paleogene
Upper Cretaceous (?)
Lower Cretaceous (?)
Upper Jurassic
Middle Jurassic
Upper Cretaceous
a
David River zone (?)
Staniukovich Mountain anticline
Lawrence Valley
Lower Cretaceous
b

Transverse Cross Section #1

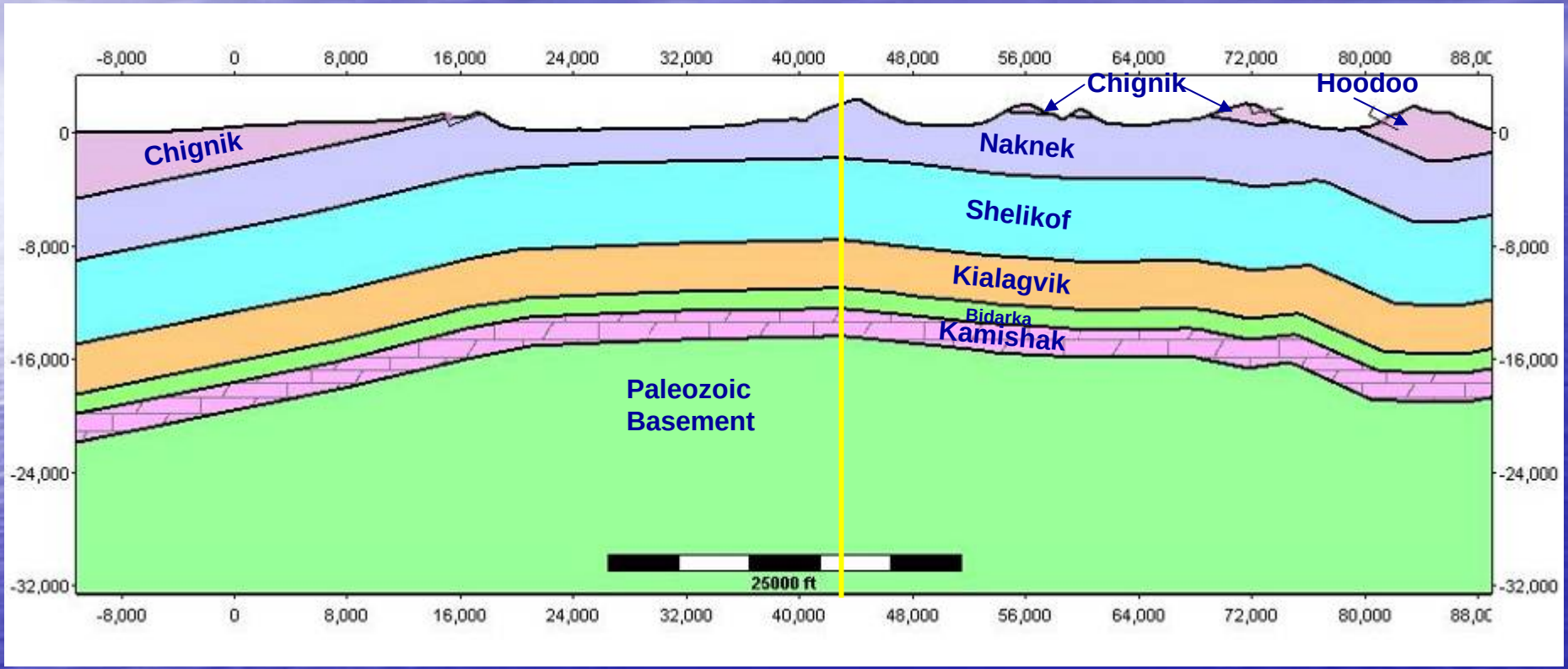
SOUTH **NORTH**



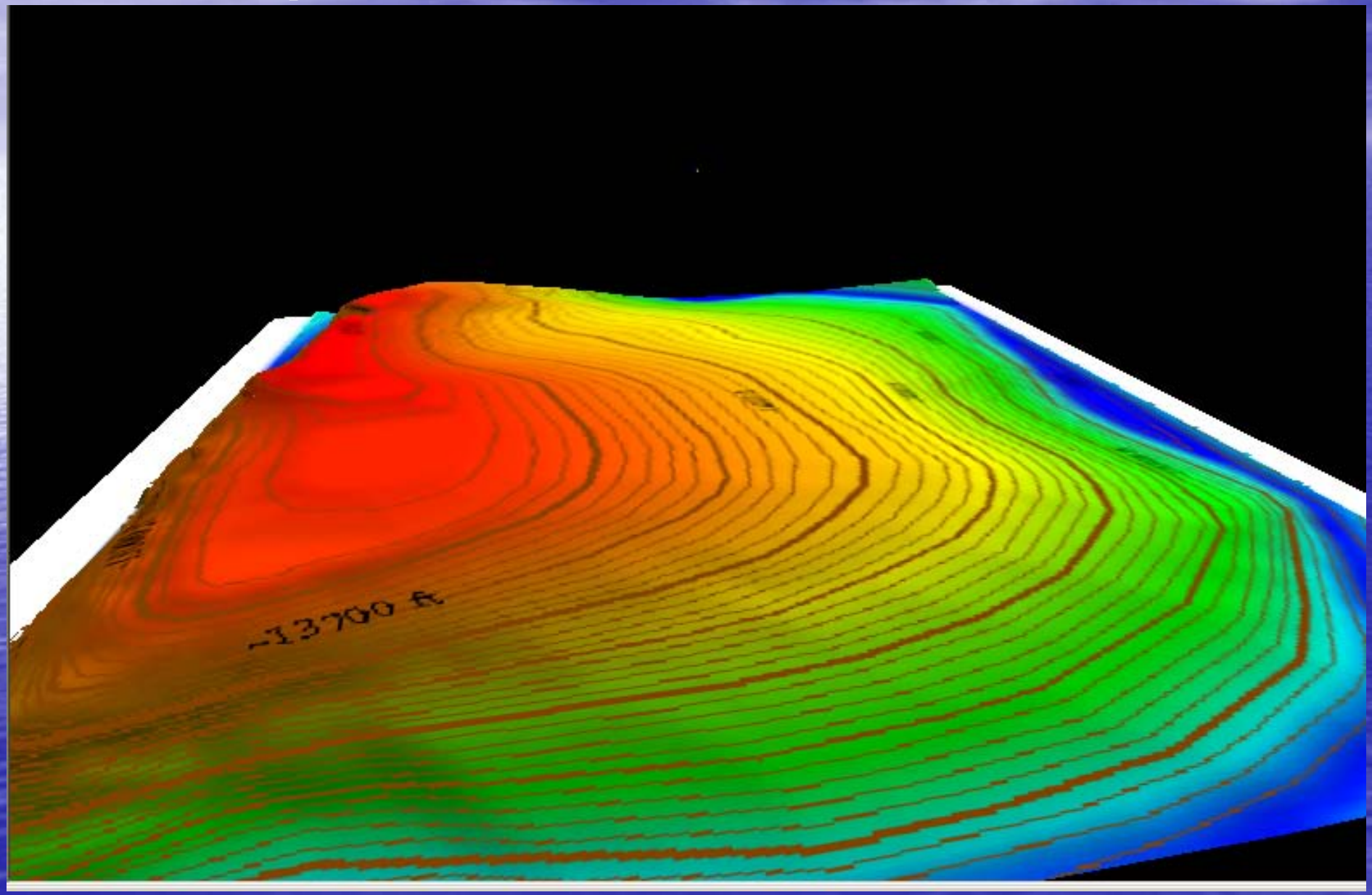
Longitudinal Cross Section

West

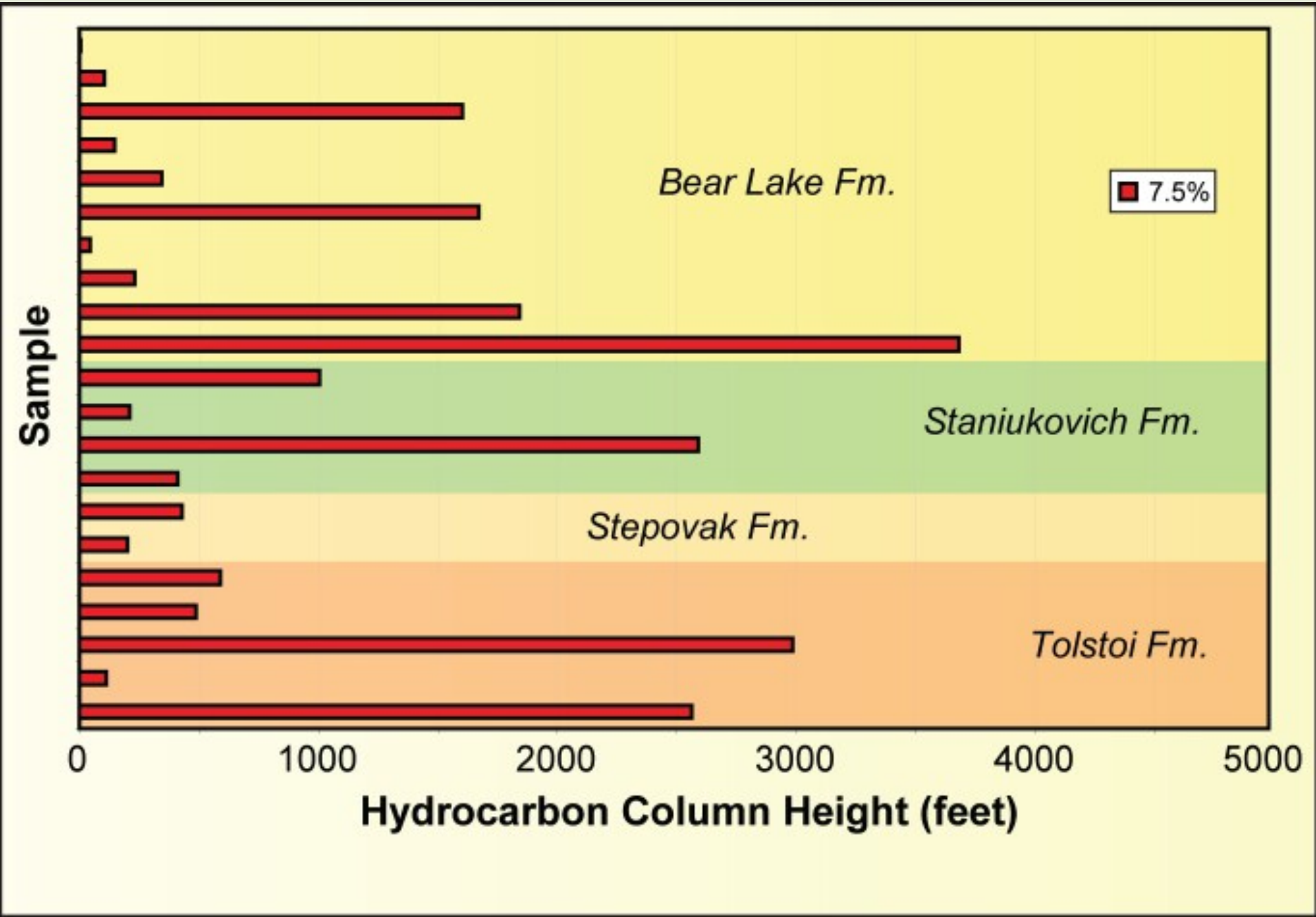
East

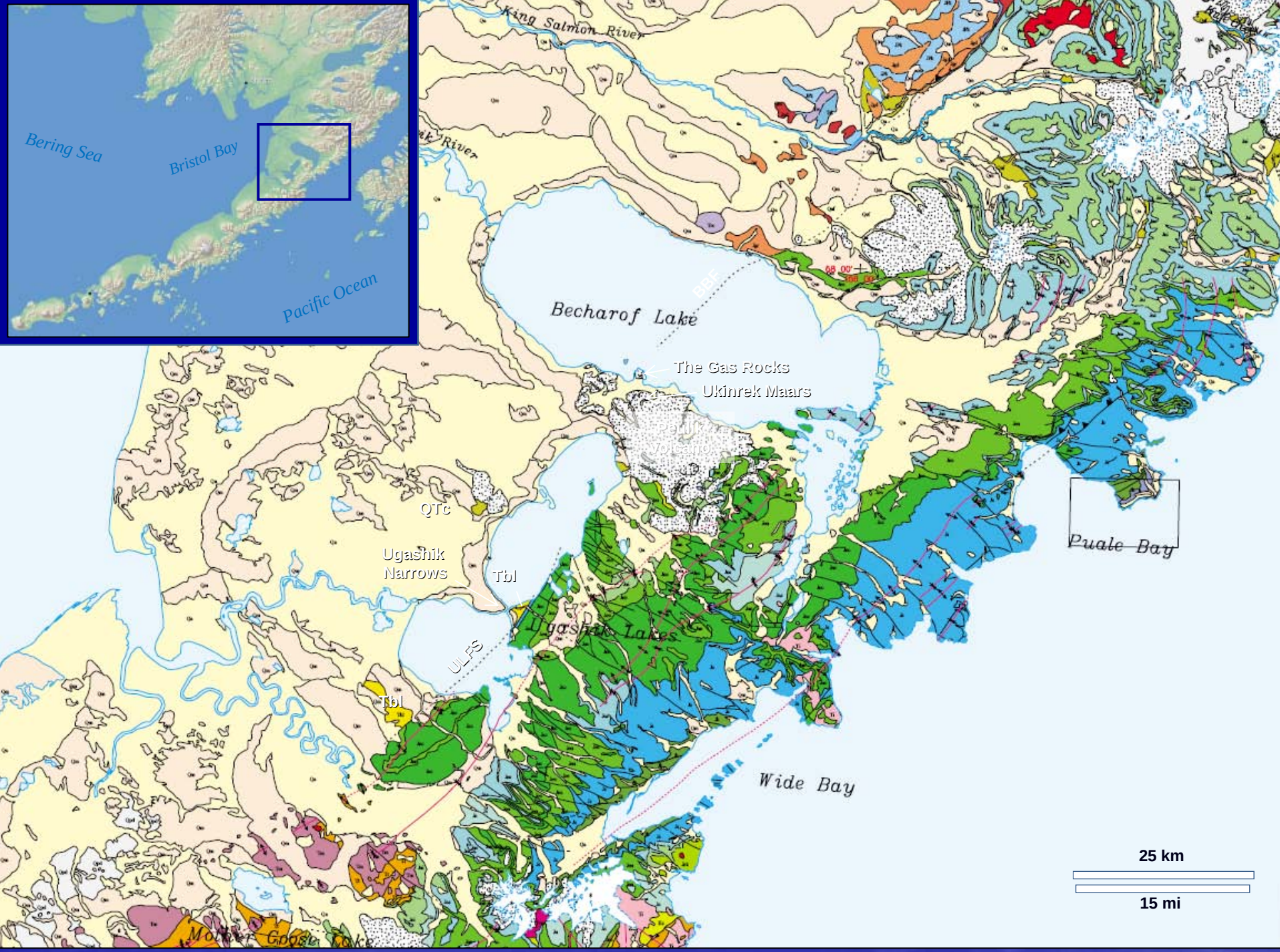


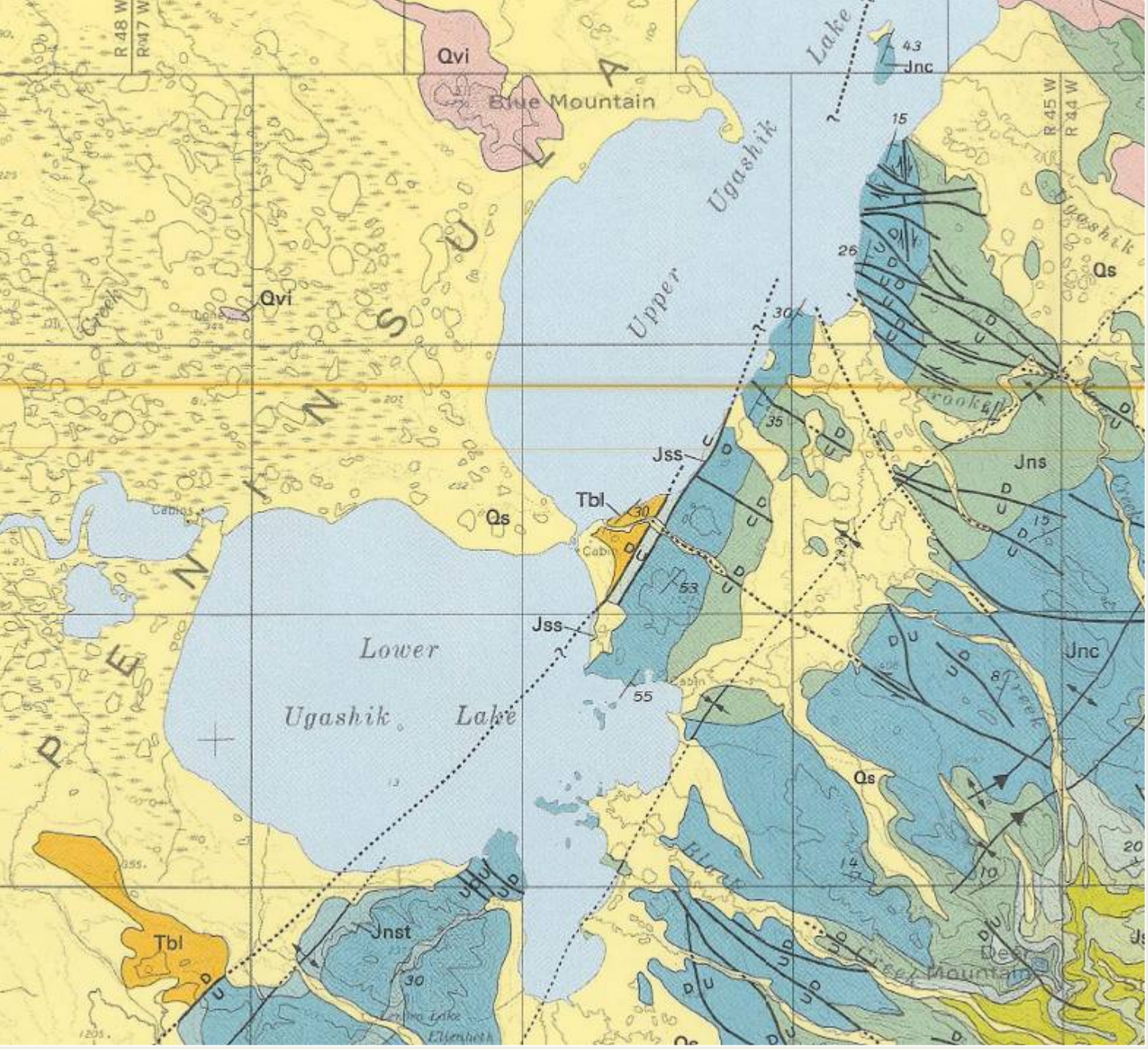
3-D View of Sapsuk Lake Anticline top of Kamishak Formation

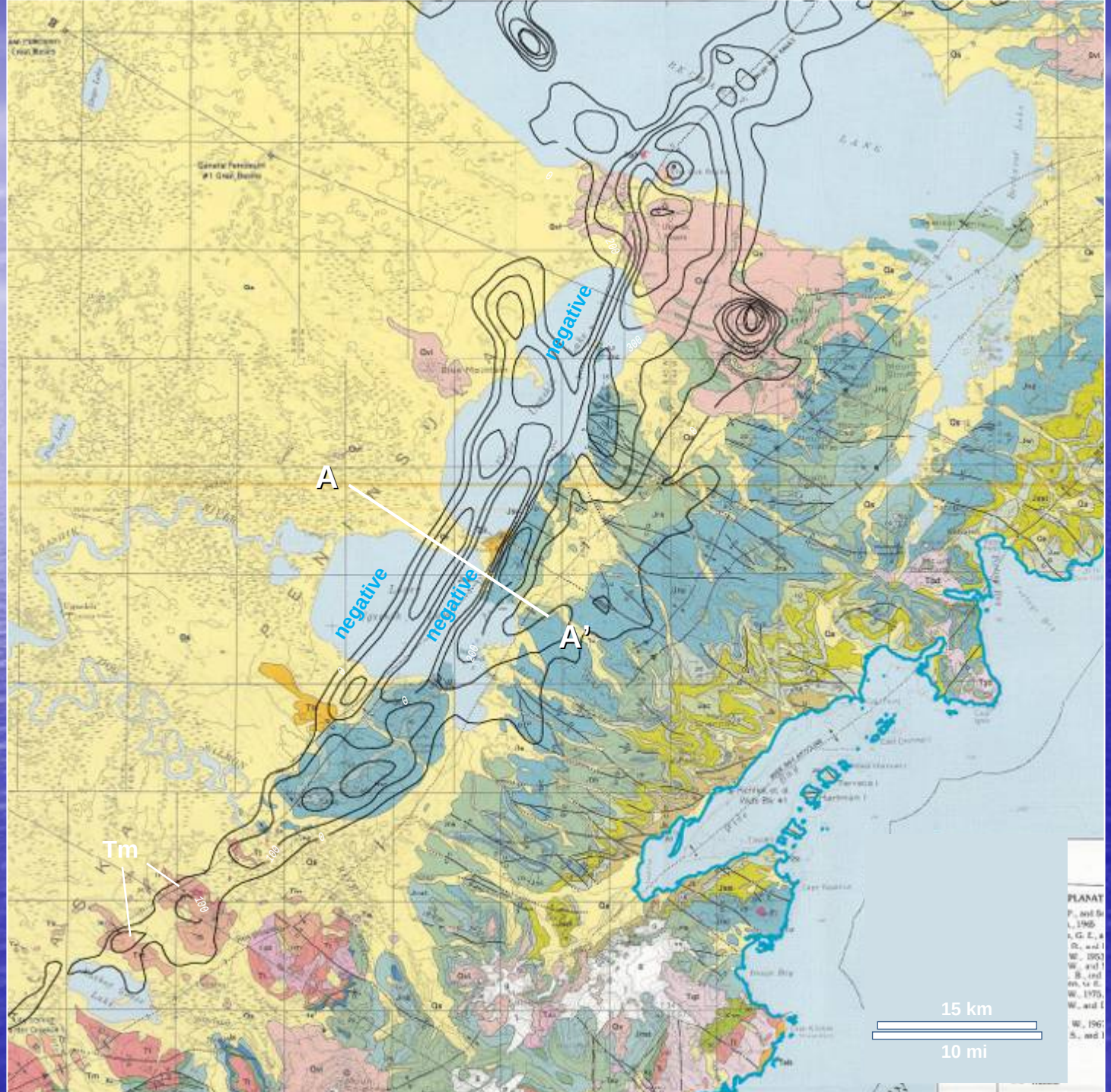


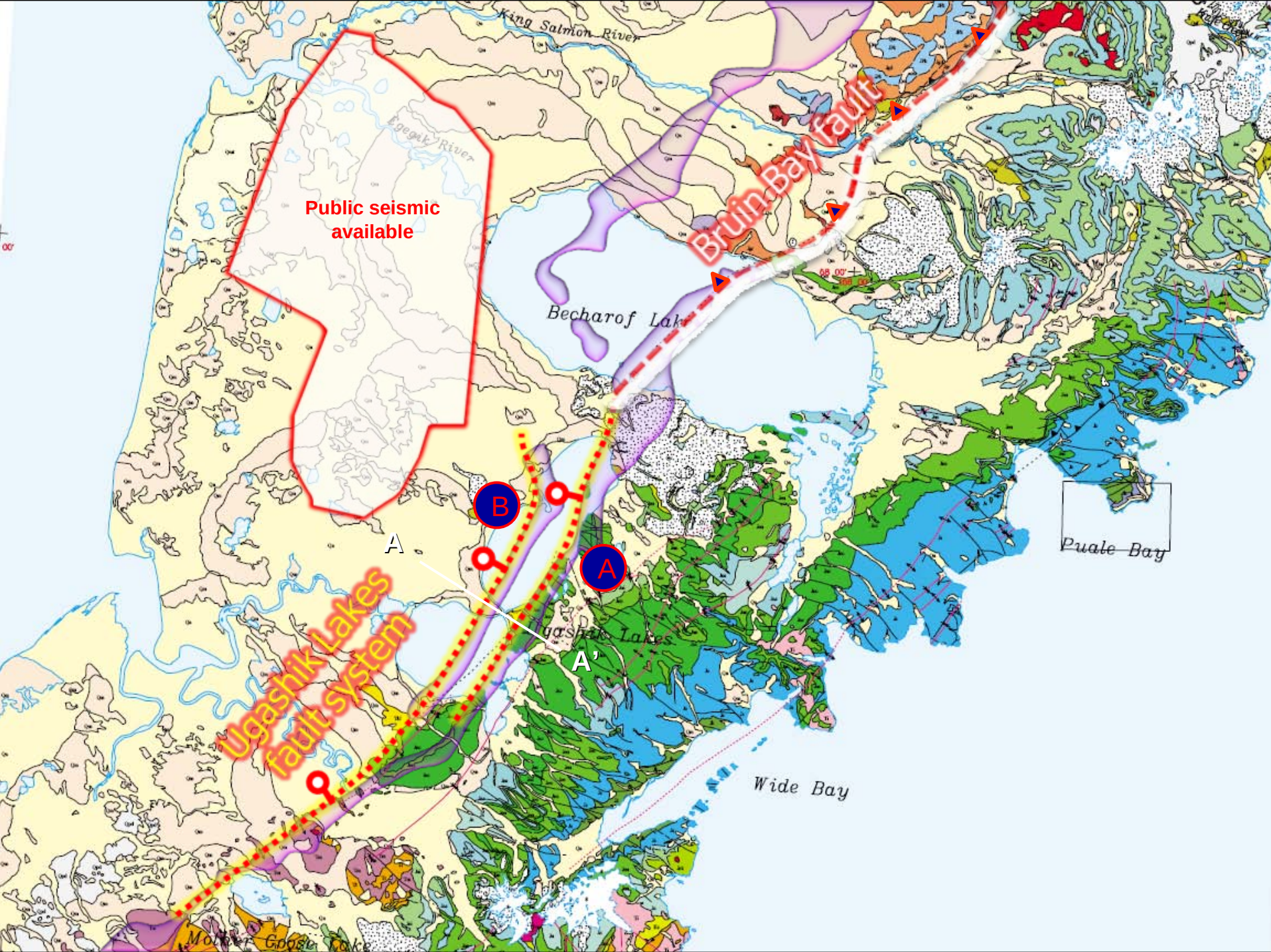
SEAL CAPACITY: HYDROCARBON

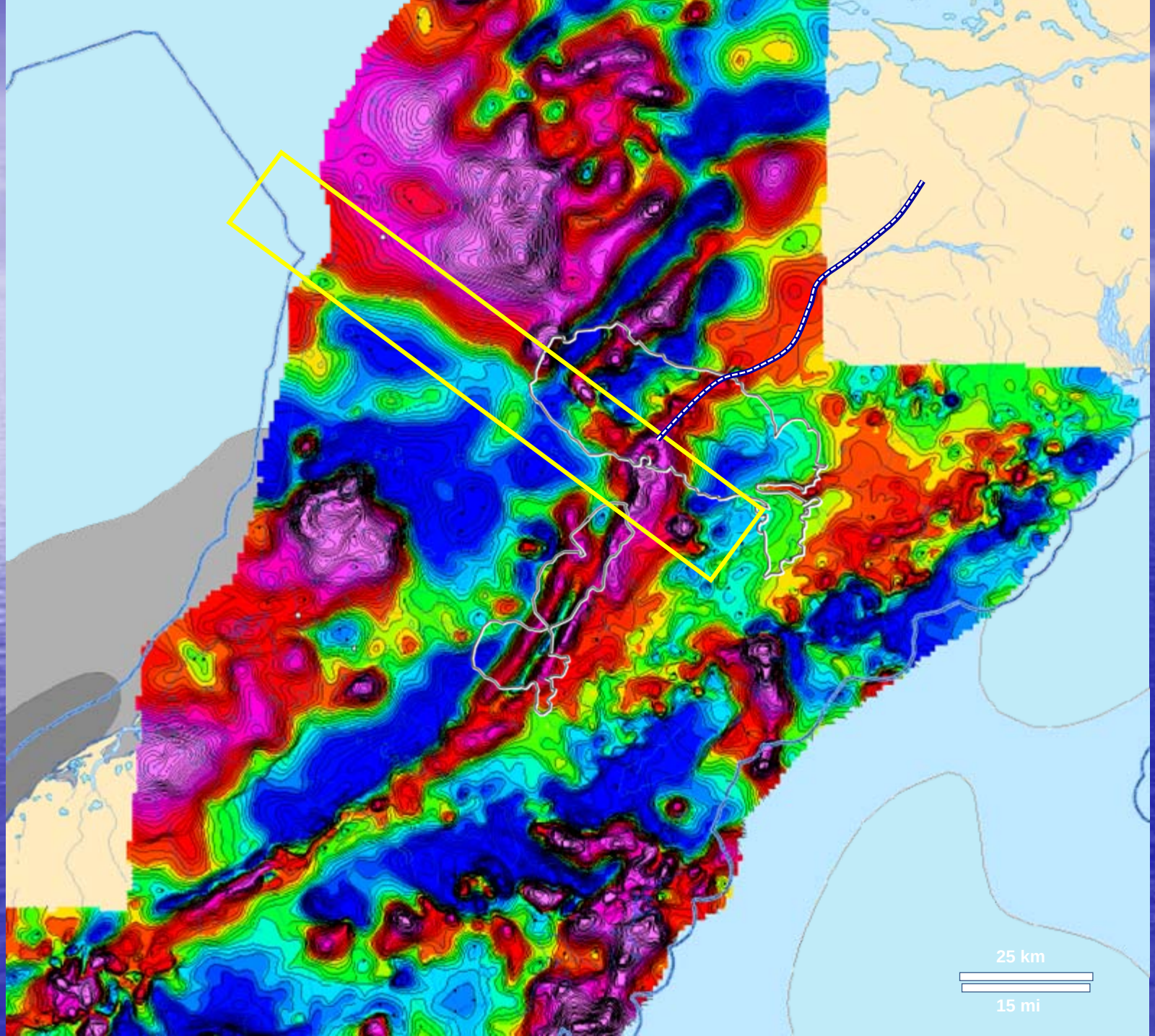


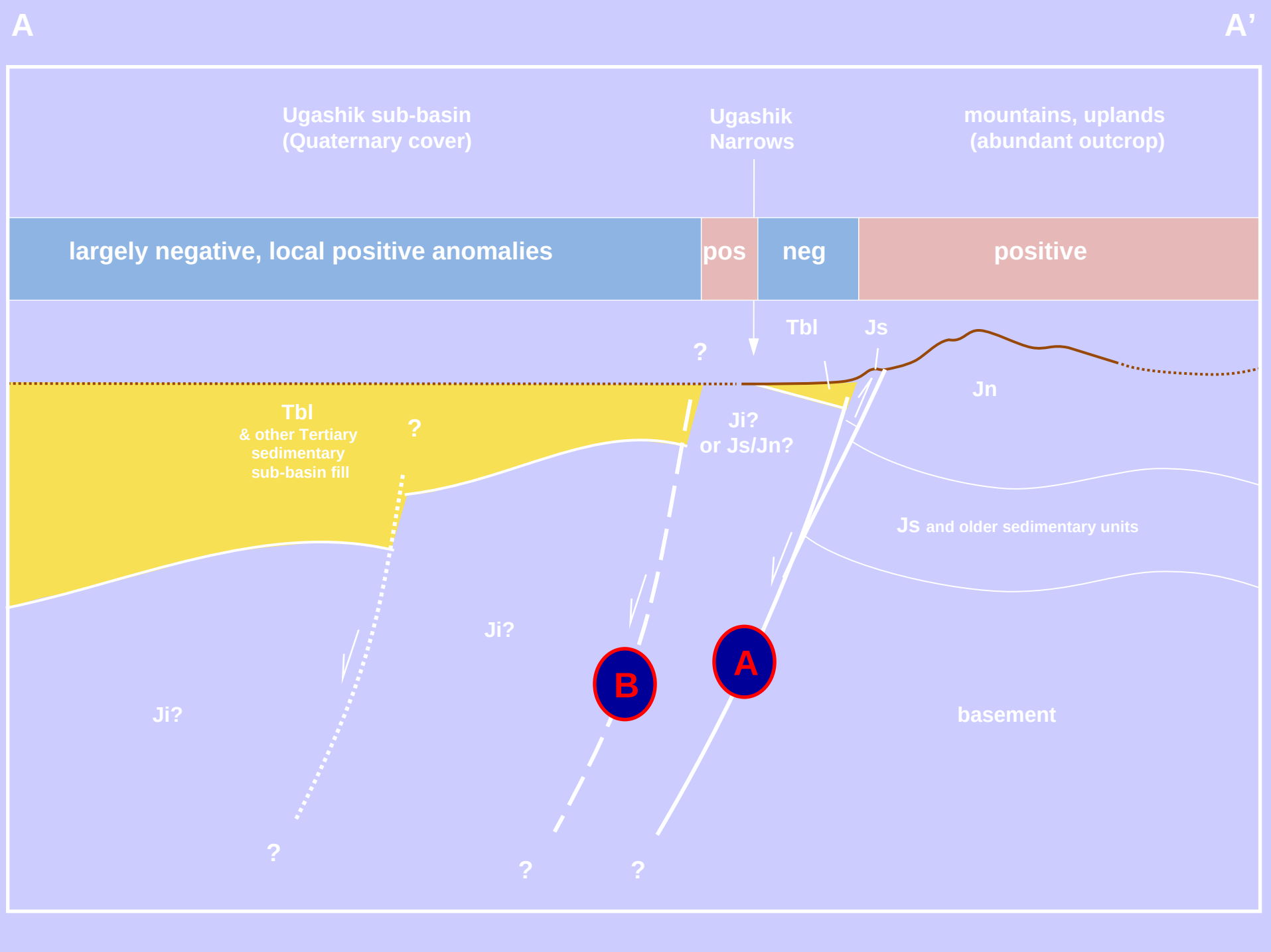

Bering Sea
Bristol Bay
Pacific Ocean
King Salmon River
Becharof Lake
The Gas Rocks
Ukinrek Maars
QTc
Ugashik Narrows
Tbl
Ugashik Lakes
ULFS
Tbl
Wide Bay
Puale Bay
Mother Goose Lake
25 km
15 mi

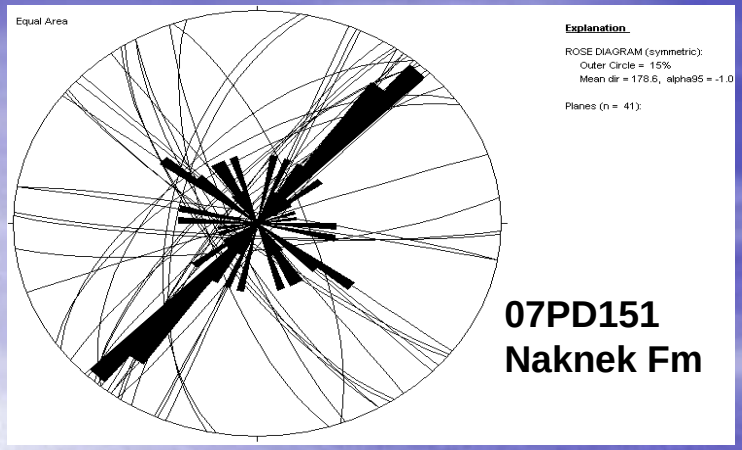

R 48 W
R 47 W
R 45 W
R 44 W
Qvi
Blue Mountain
Lake
43
Jnc
15
Upper
Ugashik
26
Qs
Qvi
30
35
Jss
Tbl
30
Qs
53
Jns
15
Jss
Lower
Ugashik
Lake
55
Jnc
Qs
14
10
20
Tbl
Jnst
30
Qs


negative
negative
negative
A
A'
Tm
15 km
10 mi


King Salmon River
Egegik River
Public seismic available
Bruin Bay fault
Becharof Lake
B
A
A'
Ugashik Lakes fault system
Ugashik Lakes
Puale Bay
Wide Bay
Mother Goose Lake

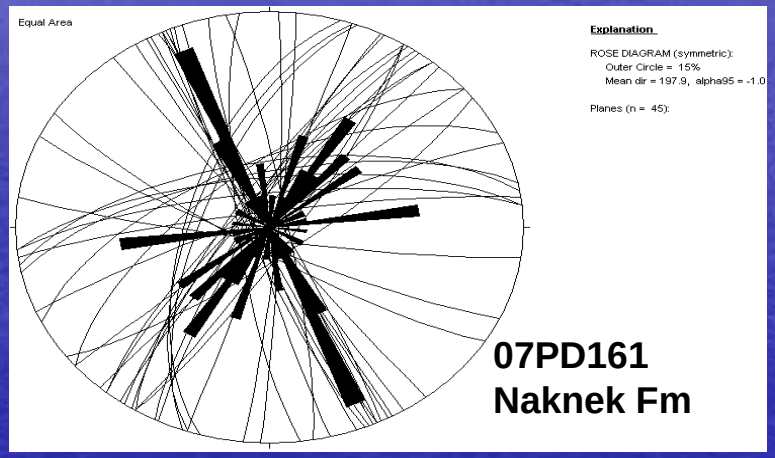

25 km
15 mi


A
A'
Ugashik sub-basin
(Quaternary cover)
Ugashik
Narrows
mountains, uplands
(abundant outcrop)
largely negative, local positive anomalies
pos
neg
positive
Tbl
Js
?
Jn
Tbl
& other Tertiary
sedimentary
sub-basin fill
?
Ji?
or Js/Jn?
Js and older sedimentary units
Ji?
B
A
Ji?
basement
?
?
?

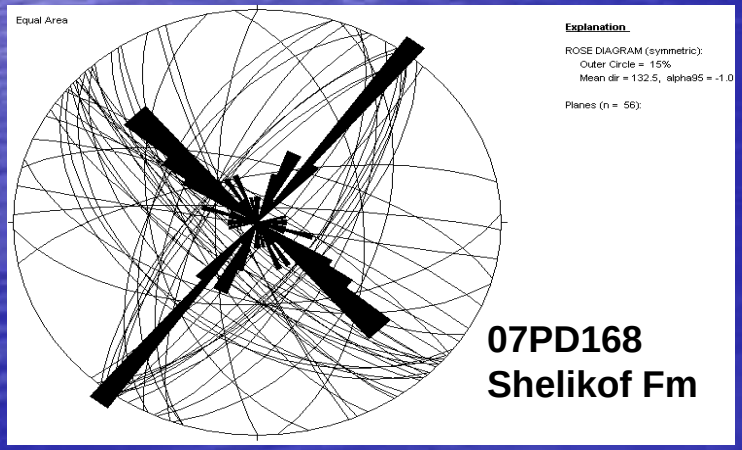


07PD151
Naknek Fm

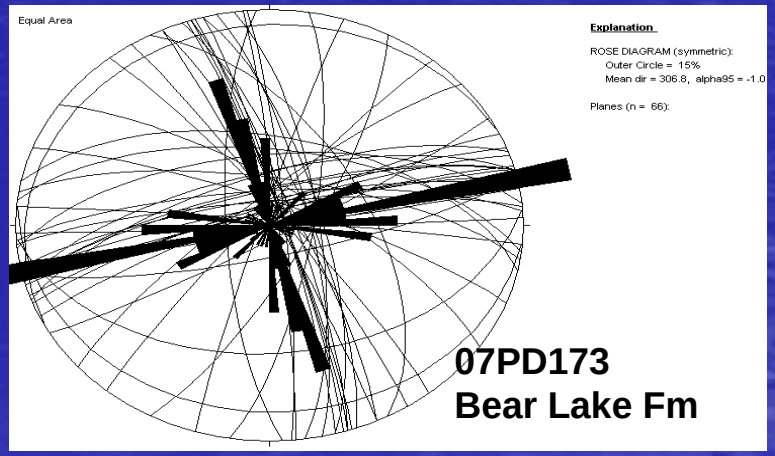
07PD154
Bear Lake Fm



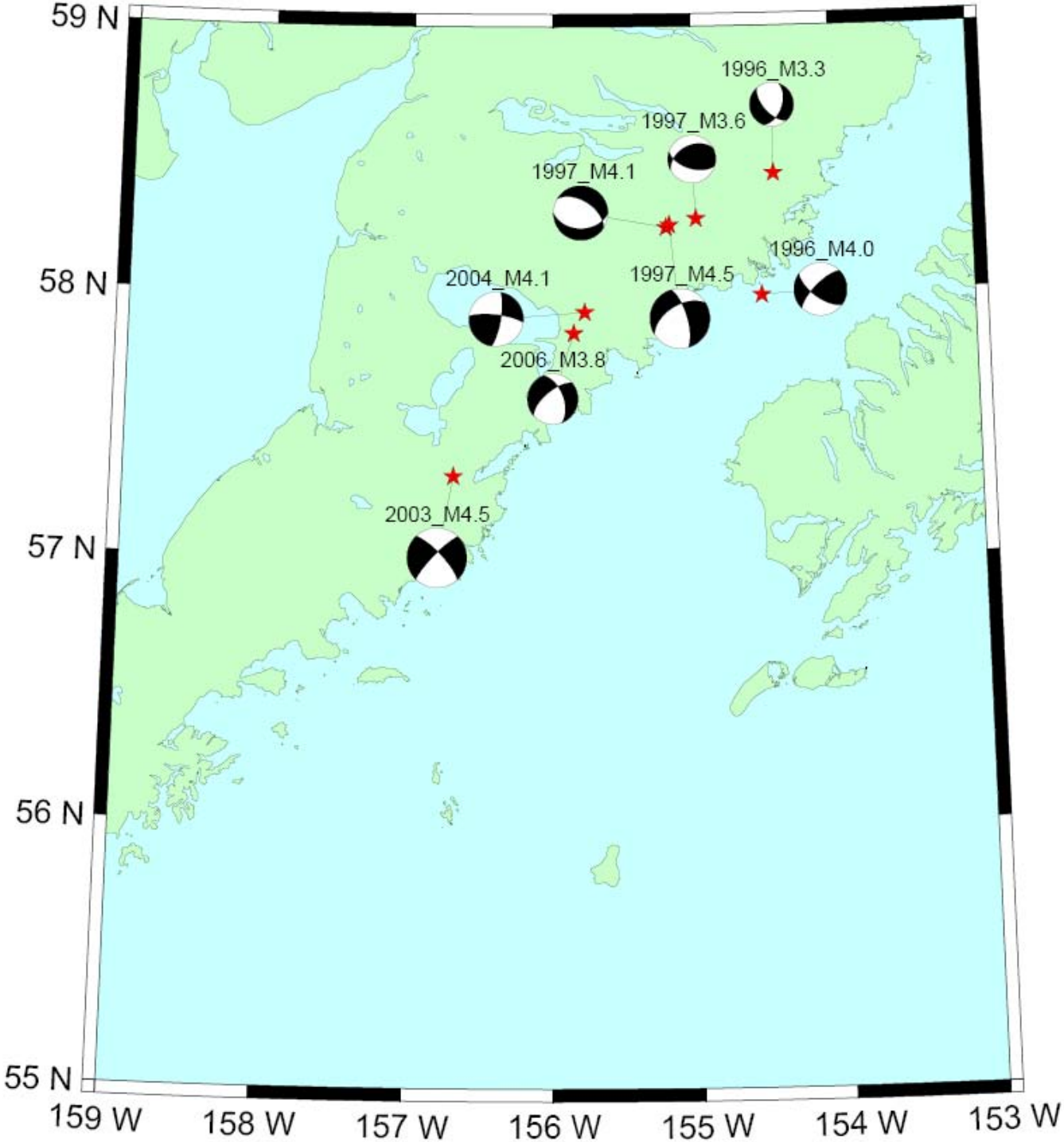
07PD161
Naknek Fm

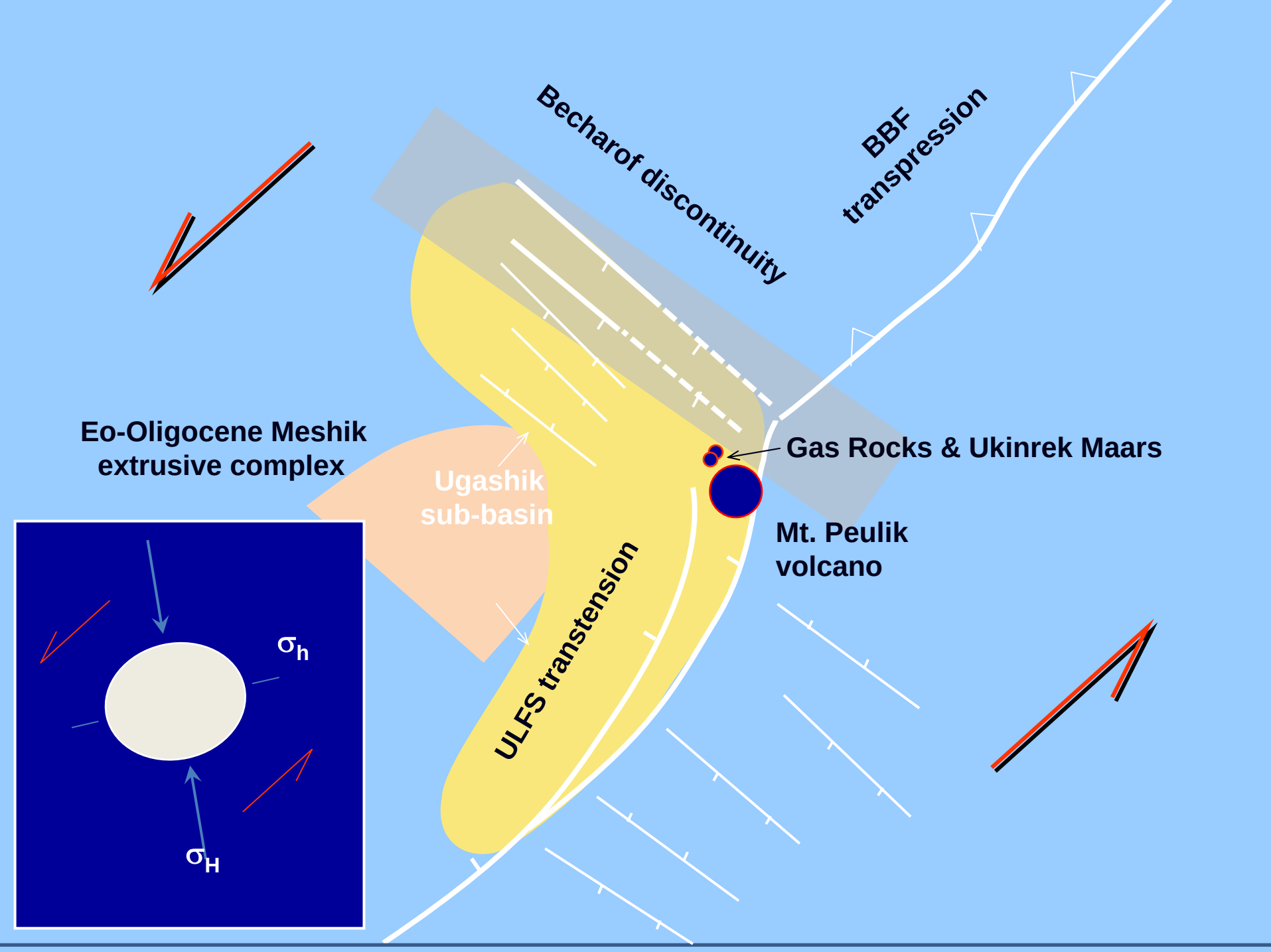


07PD168
Shelikof Fm

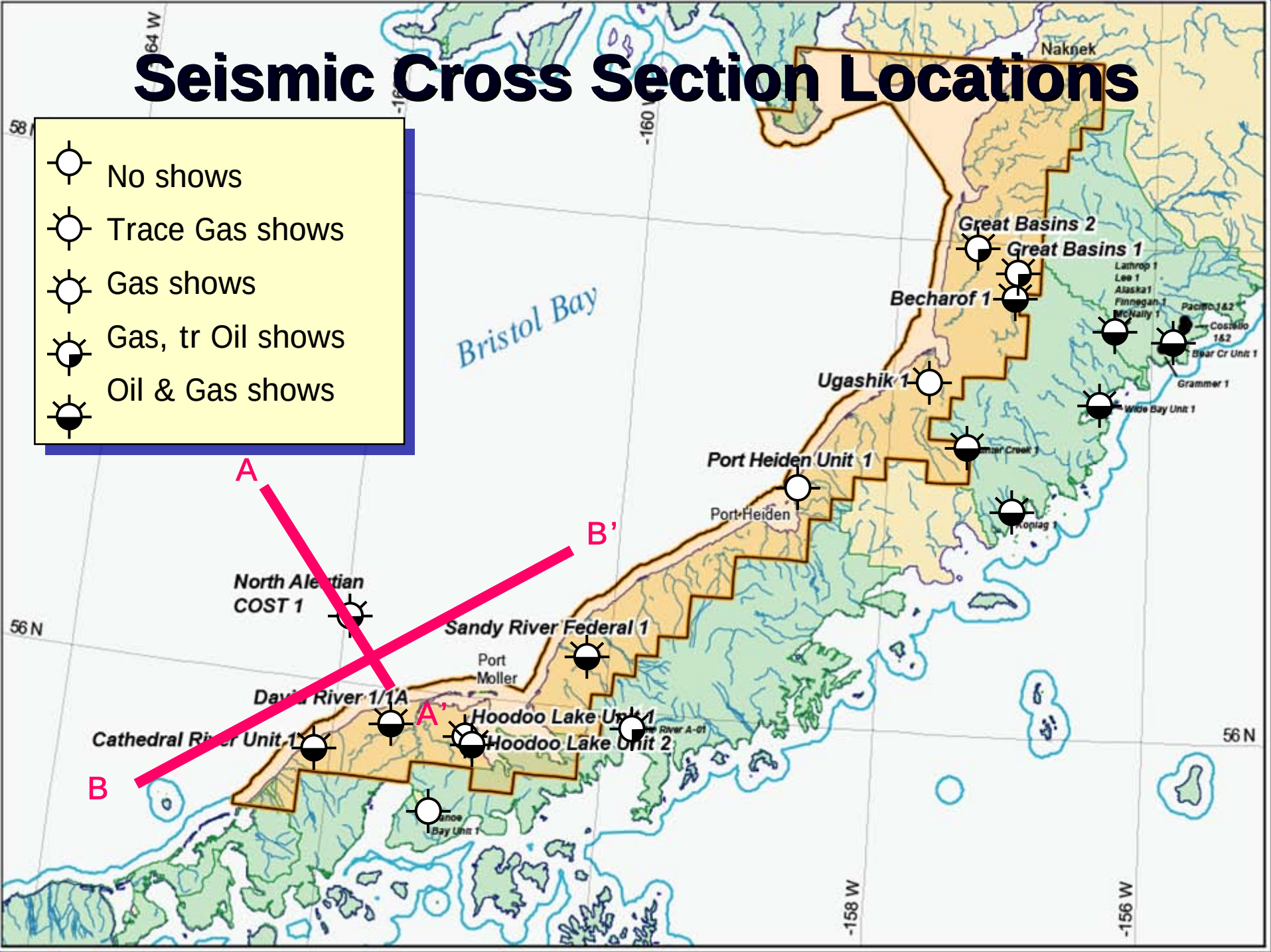


07PD173
Bear Lake Fm

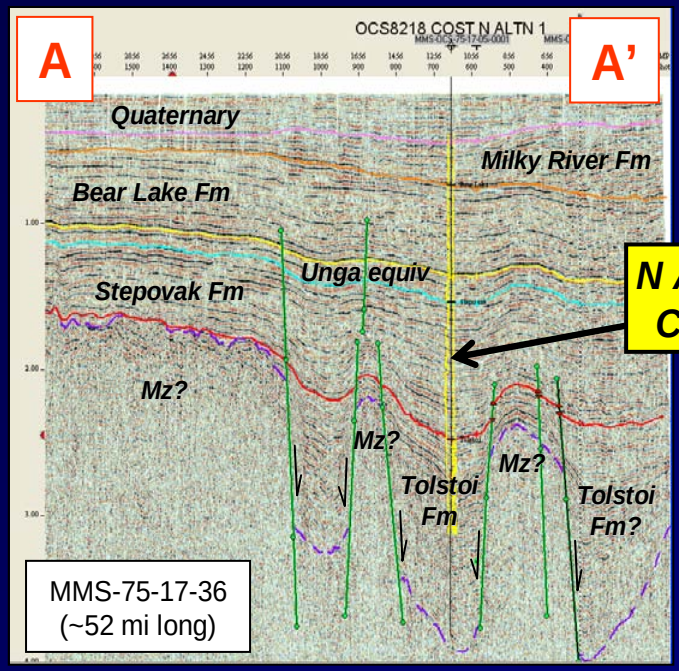

59 N
58 N
57 N
56 N
55 N
159 W
158 W
157 W
156 W
155 W
154 W
153 W
1996_M3.3
1997_M3.6
1997_M4.1
1996_M4.0
2004_M4.1
1997_M4.5
2006_M3.8
2003_M4.5

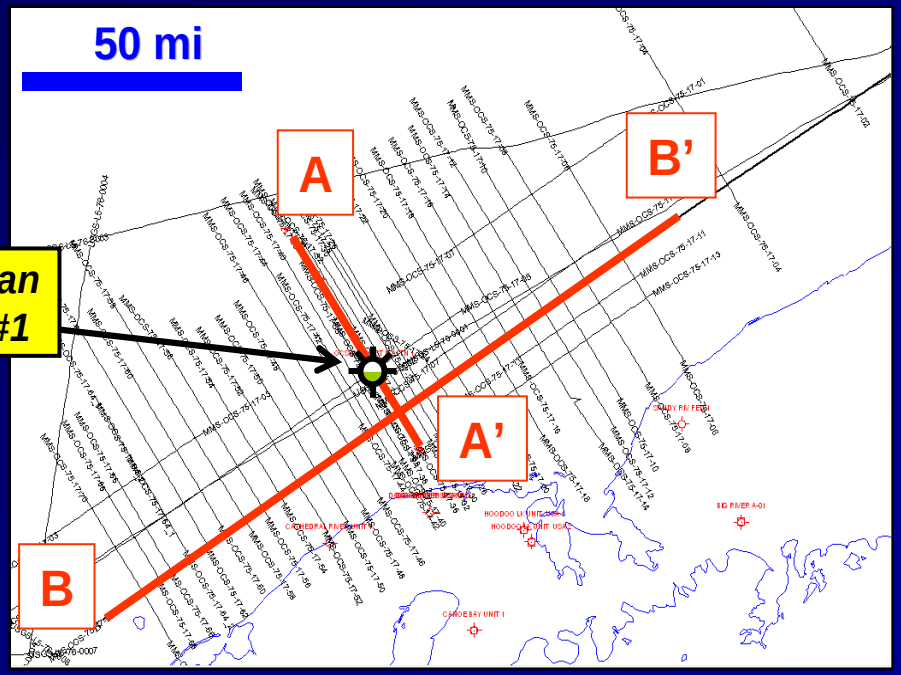

Becharof discontinuity
BBF transpression
Eo-Oligocene Meshik extrusive complex
Ugashik sub-basin
Gas Rocks & Ukinrek Maars
Mt. Peulik volcano
ULFS transtension
σh
σH

Seismic Cross Section Locations

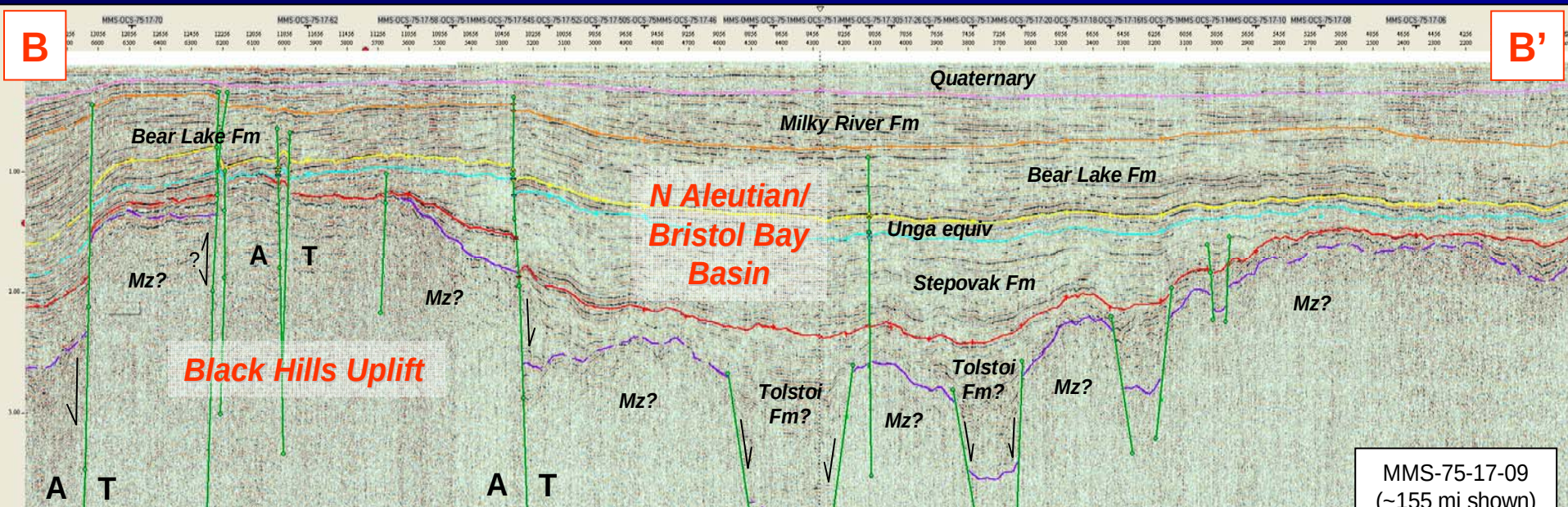


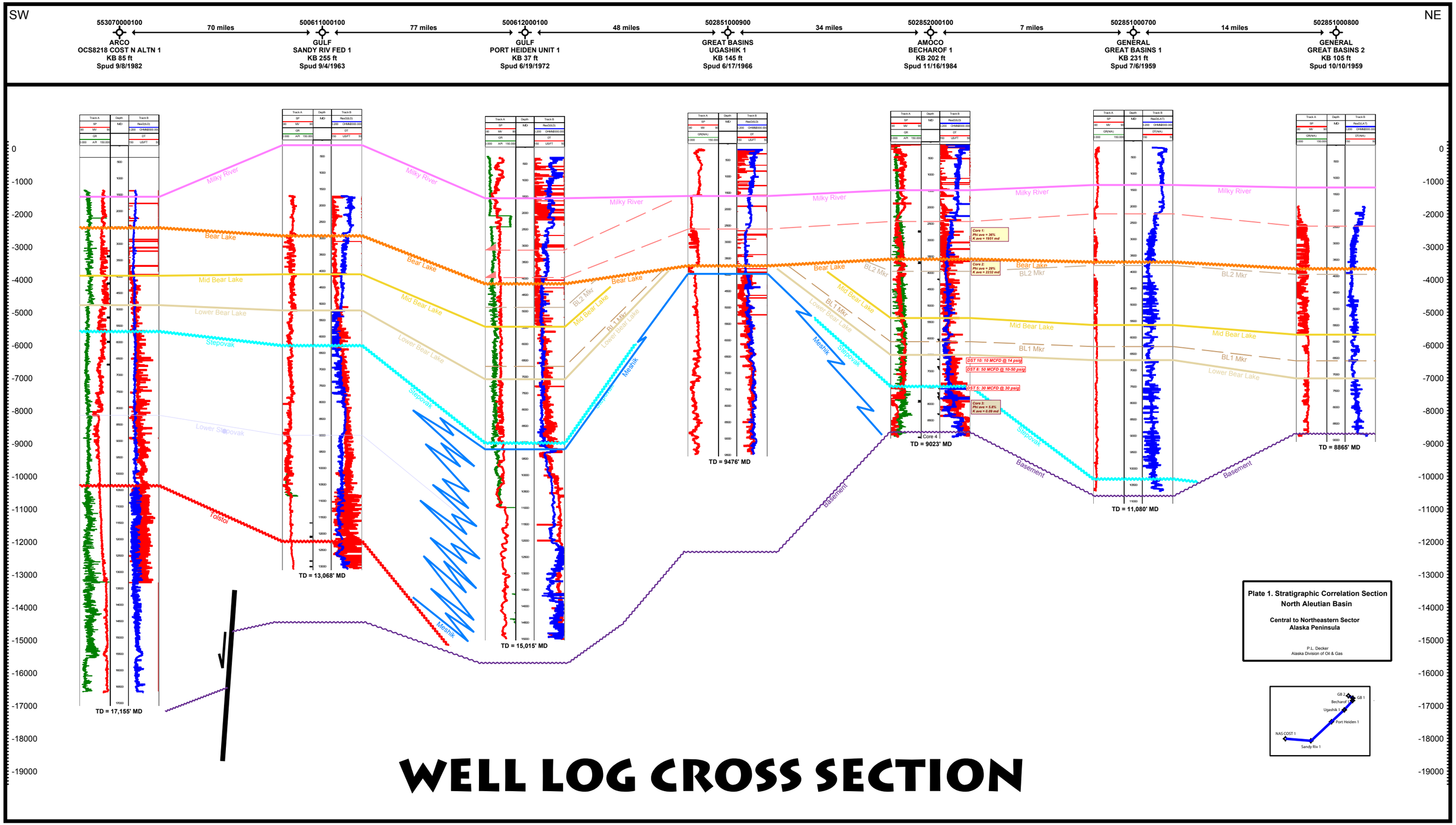
Bristol Bay Seismic Interpretation





N Aleutian COST #1




SW
NE
553070000100
ARCO
OCS8218 COST N ALTN 1
KB 85 ft
Spud 9/8/1982
70 miles
500611000100
GULF
SANDY RIV FED 1
KB 255 ft
Spud 9/4/1963
77 miles
500612000100
GULF
PORT HEIDEN UNIT 1
KB 37 ft
Spud 6/19/1972
48 miles
502851000900
GREAT BASINS
UGASHIK 1
KB 145 ft
Spud 6/17/1966
34 miles
502852000100
AMOCO
BECHAROF 1
KB 202 ft
Spud 11/16/1984
7 miles
502851000700
GENERAL
GREAT BASINS 1
KB 231 ft
Spud 7/6/1959
14 miles
502851000800
GENERAL
GREAT BASINS 2
KB 105 ft
Spud 10/10/1959
Milky River
Bear Lake
Mid Bear Lake
Lower Bear Lake
Stepovak
Lower Stepovak
Tolstoi
Meshik
BL2 Mkr
BL1 Mkr
Basement
Core 1:
Phi ave = 36%
K ave = 1951 md
Core 2:
Phi ave = 29%
K ave = 2232 md
Core 3:
Phi ave = 5.8%
K ave = 0.09 md
Core 4
DST 10: 10 MCFD @ 14 psig
DST 8: 50 MCFD @ 10-50 psig
DST 5: 30 MCFD @ 30 psig
TD = 17,155' MD
TD = 13,068' MD
TD = 15,015' MD
TD = 9476' MD
TD = 9023' MD
TD = 11,080' MD
TD = 8865' MD
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
-13000
-14000
-15000
-16000
-17000
-18000
-19000
Plate 1. Stratigraphic Correlation Section
North Aleutian Basin
Central to Northeastern Sector
Alaska Peninsula
P.L. Decker
Alaska Division of Oil & Gas
GB 2
GB 1
Becharof 1
Ugashik 1
Port Heiden 1
NAS COST 1
Sandy Riv 1
WELL LOG CROSS SECTION

Recapitulation

RESERVOIRS - good Tertiary strata

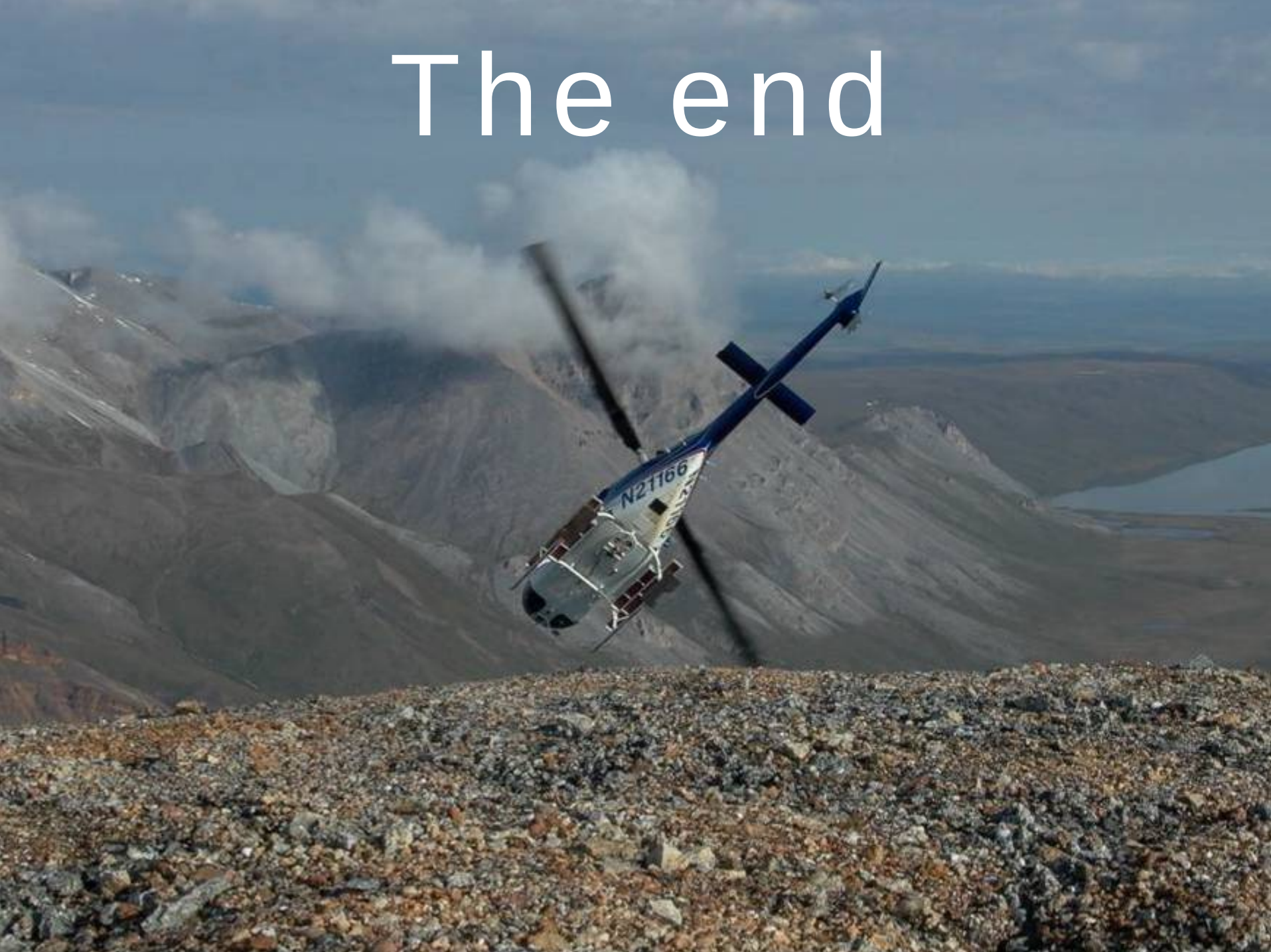
SEALS - 250-2,500 feet hydrocarbon column; intra-reservoir seals (Cook Inlet-like)

STRUCTURES & TRAPS - numerous; structural, strat.

SOURCES - THERMOGENIC GAS @ Port Moller hot springs
Mz source in SW basin & Oil seep
TOC: 5.3; HI 756
Tert. / K coals; Carb-shales

MATURITY – Tertiary strat./ Bear Lake Fm. Ro = 0.5 – 0.8
Mz source @ Puale Bay (Ro= 0.4-0.7)

GAS RESOURCES (assume Cook Inlet-like system) = ?? TCF

Bear Lake Fm.

The end