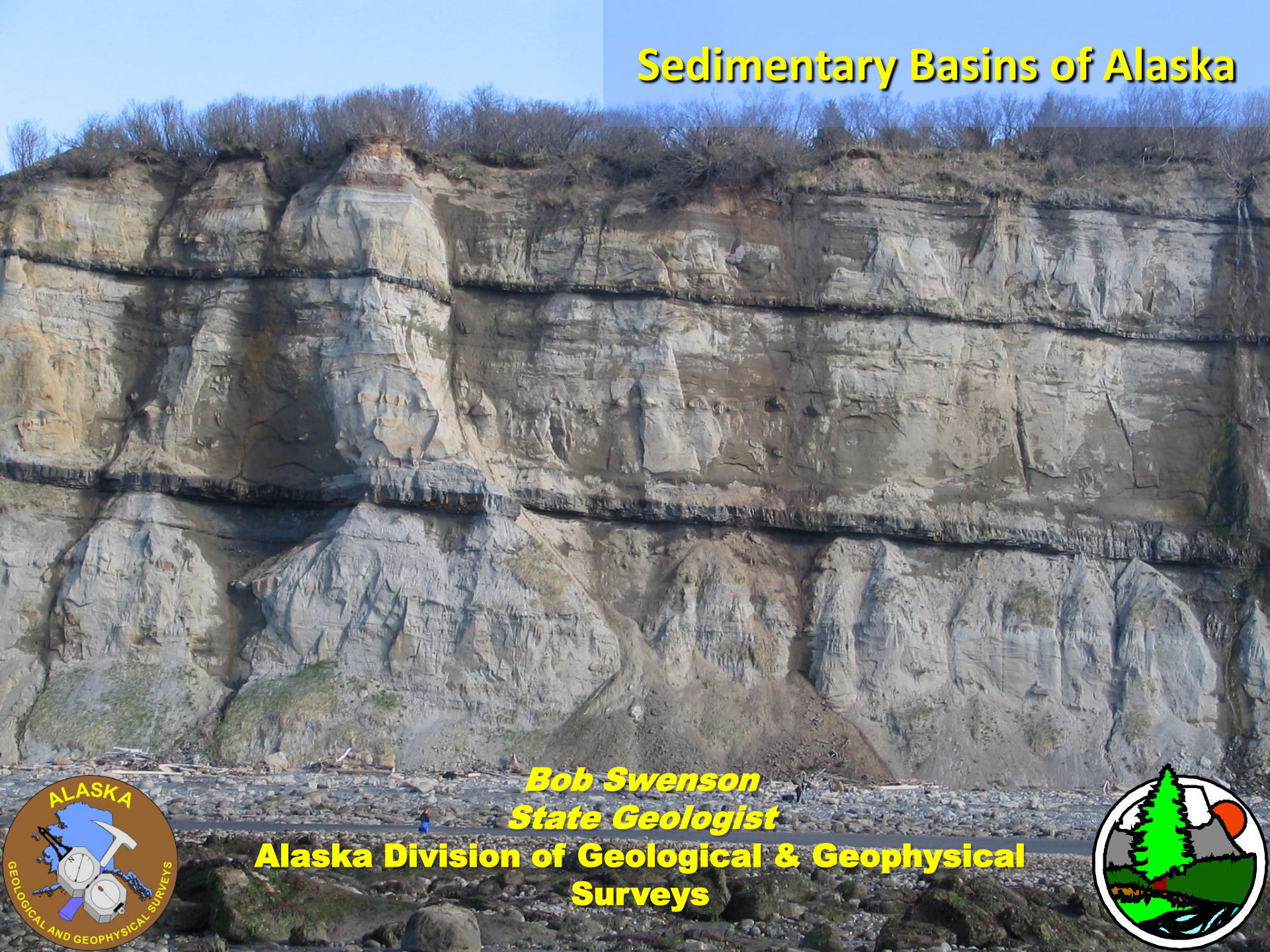
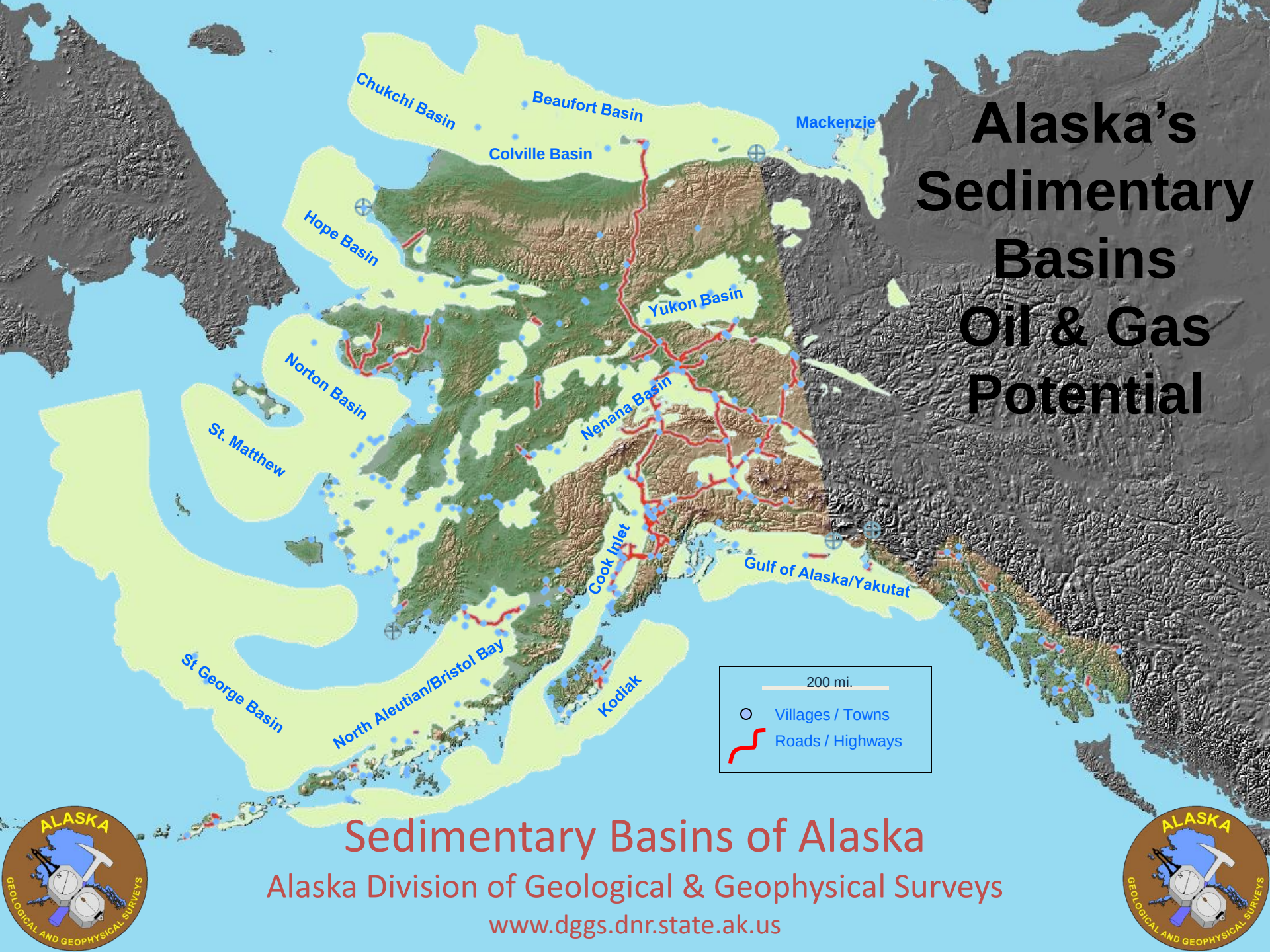
Sedimentary Basins of Alaska



Bob Swenson
State Geologist
Alaska Division of Geological & Geophysical Surveys

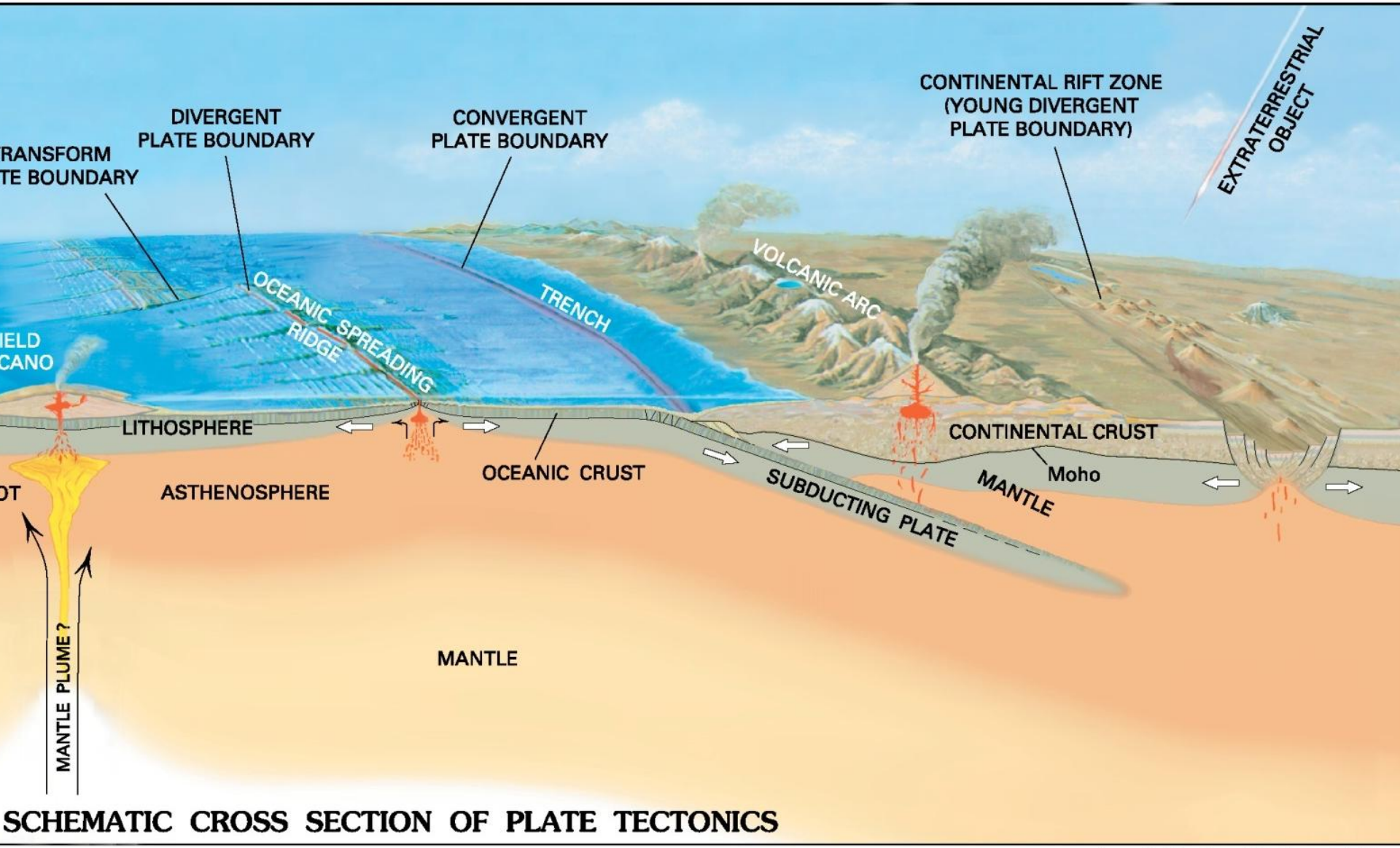


Sedimentary Basins of Alaska

Alaska Division of Geological & Geophysical Surveys

www.dggs.dnr.state.ak.us

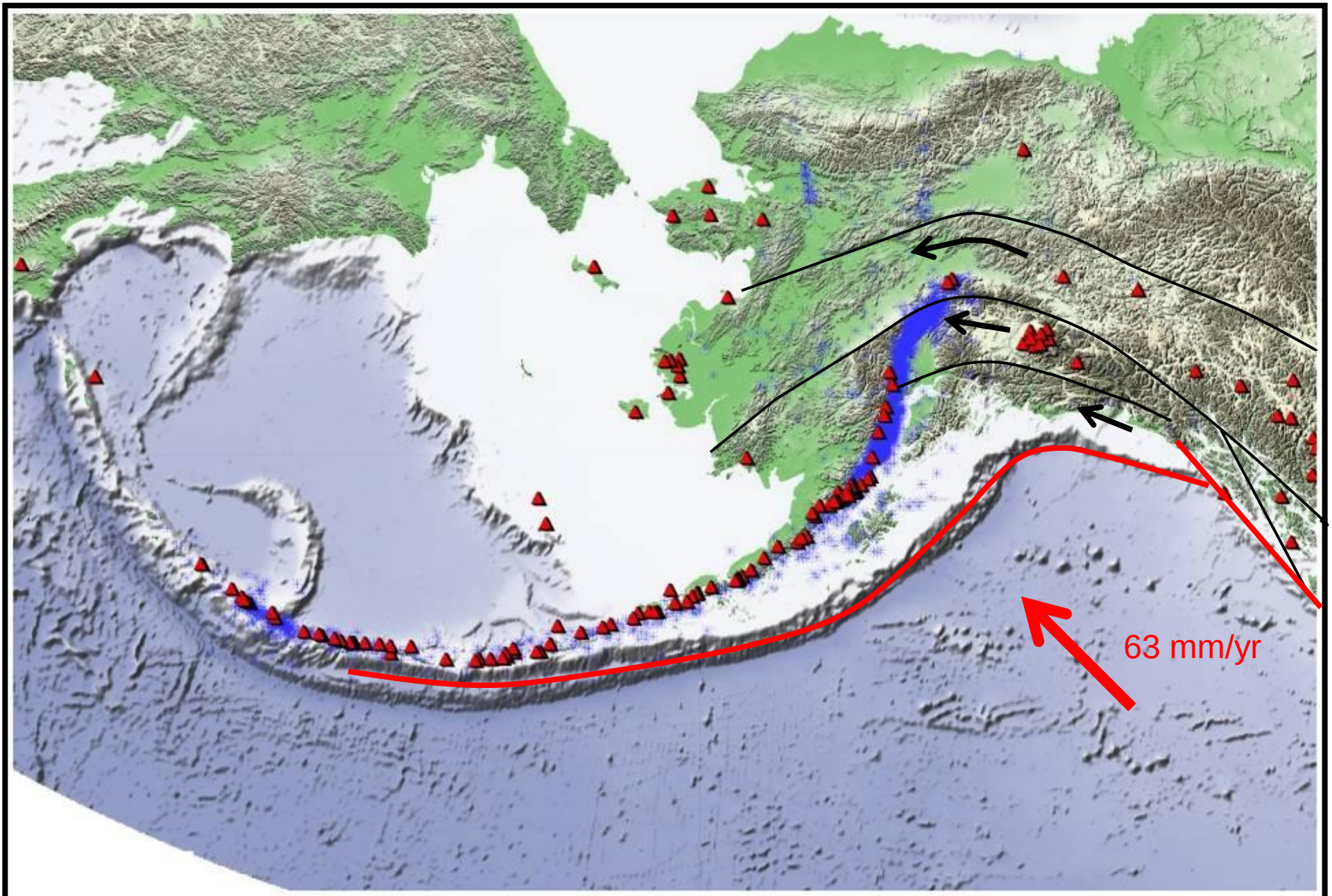
Subduction and Tectonics Drive the System



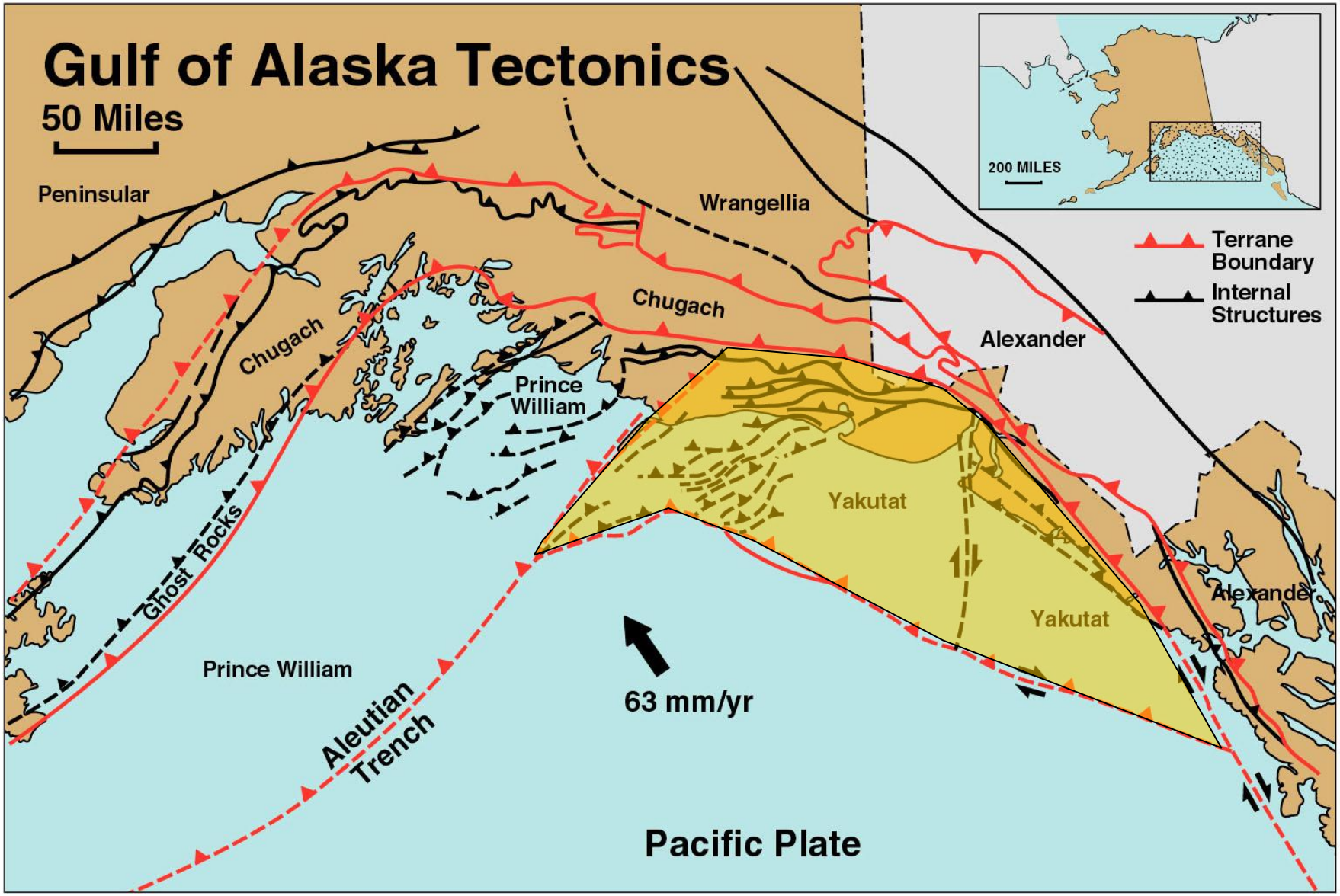
SCHEMATIC CROSS SECTION OF PLATE TECTONICS

José F. Vigil and Robert I. Tilling

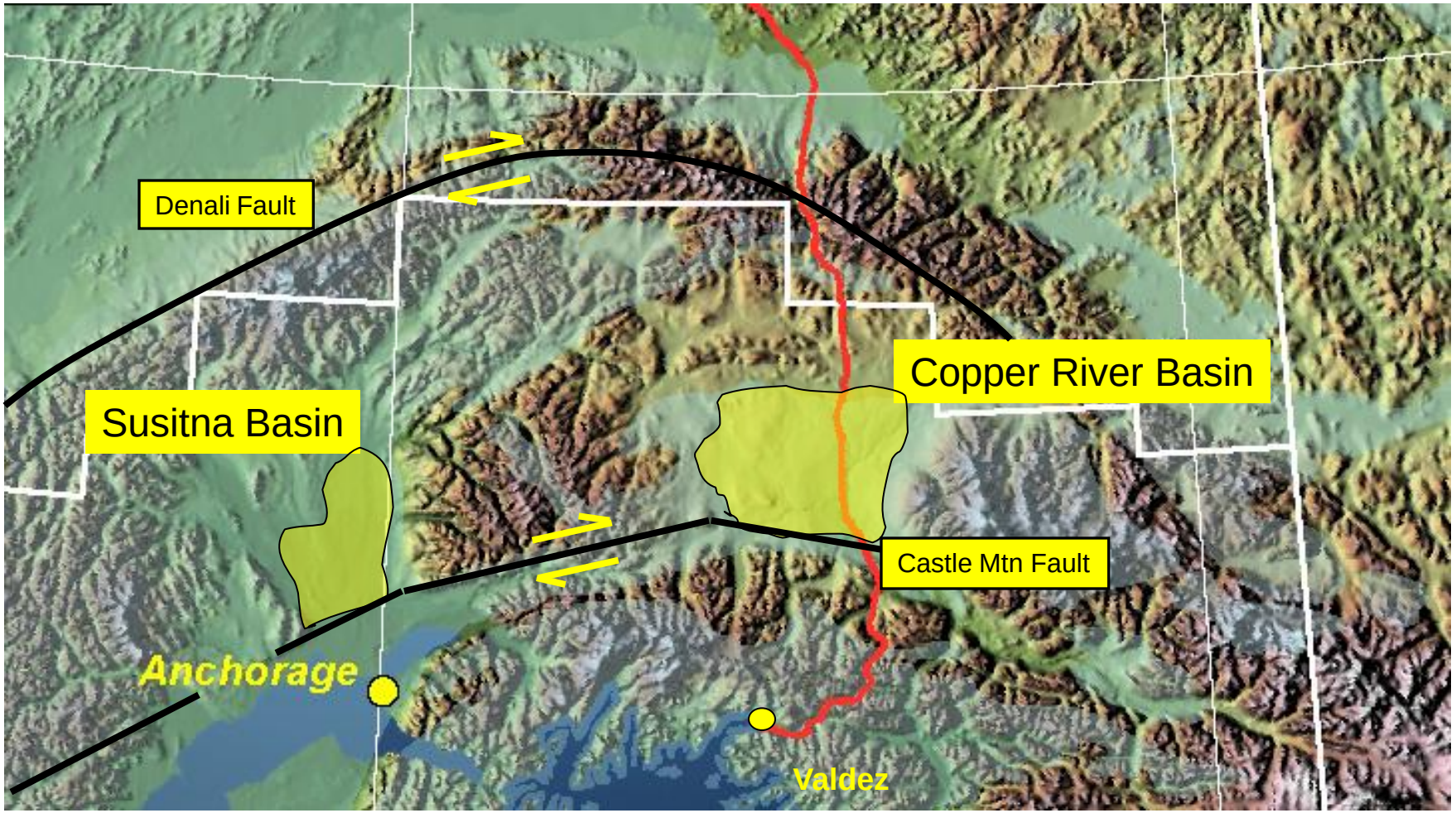
Alaska is Complex, Both Topographically & Geologically



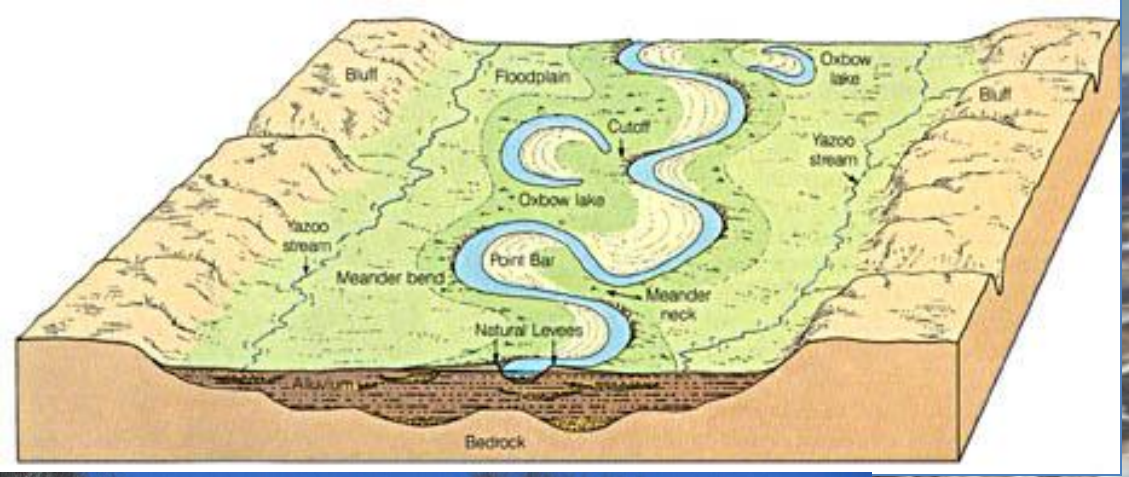
South Alaska Terranes



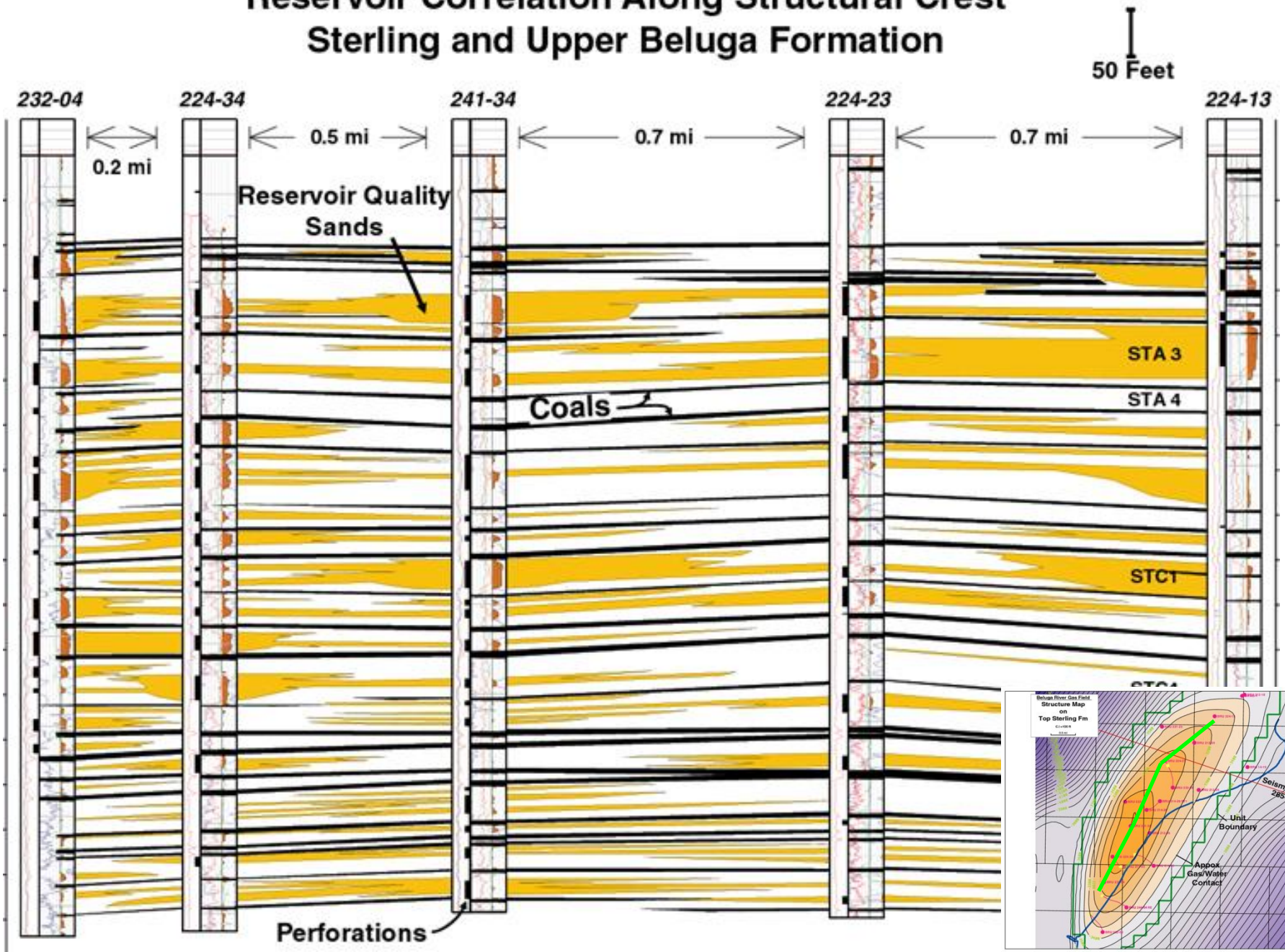
Mountain Building and Depressions

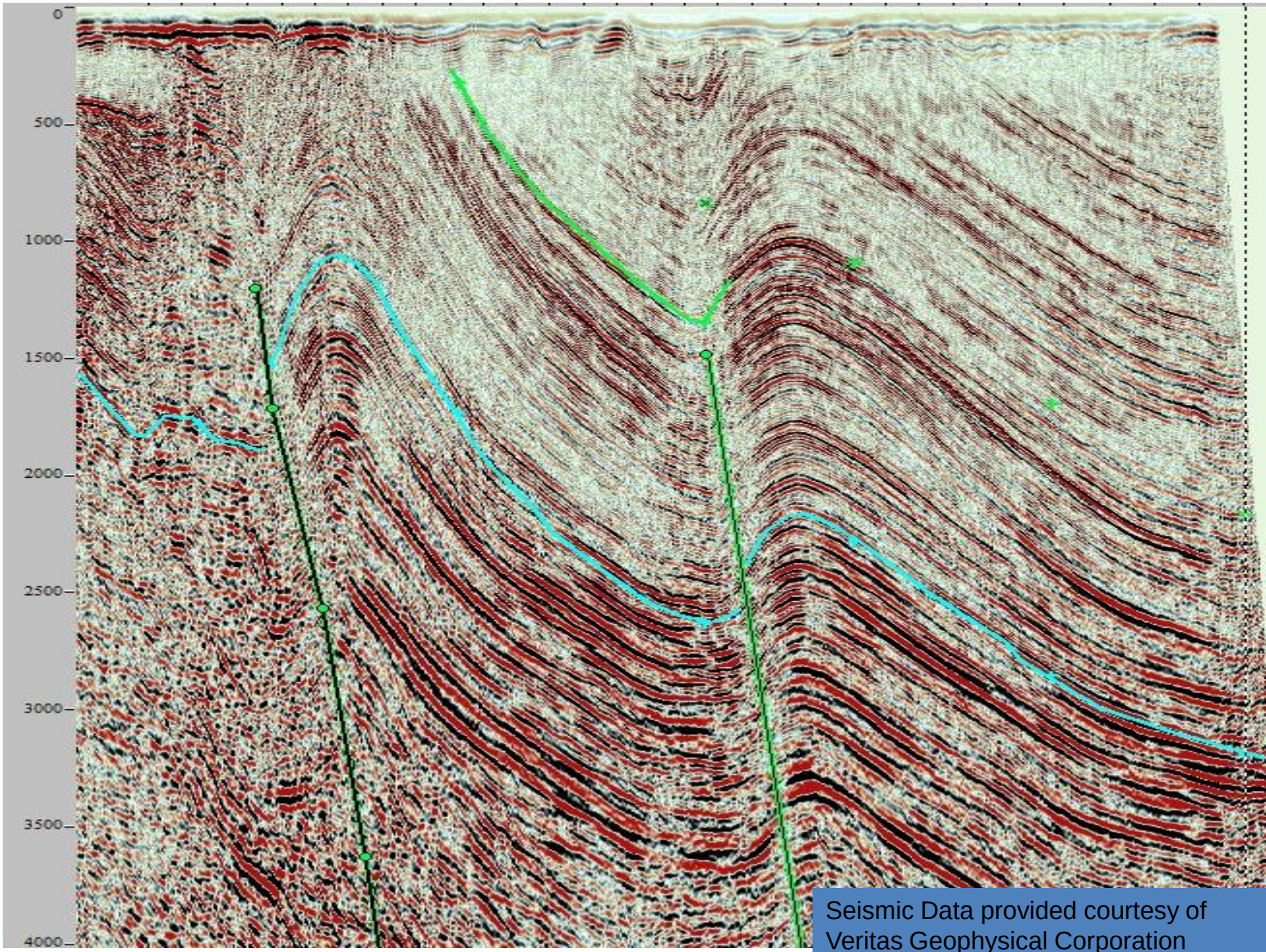


Tertiary Basin Depositional Systems

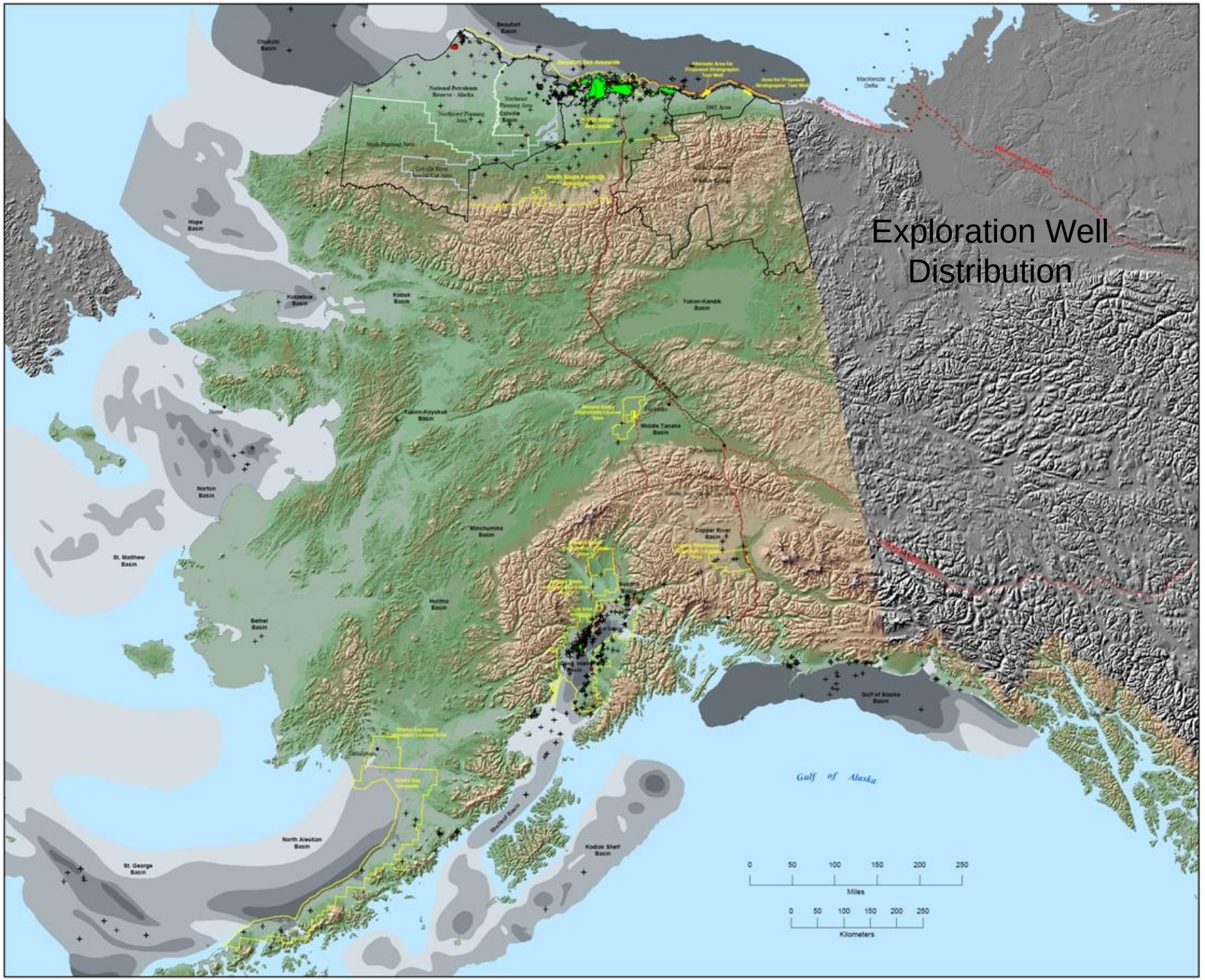


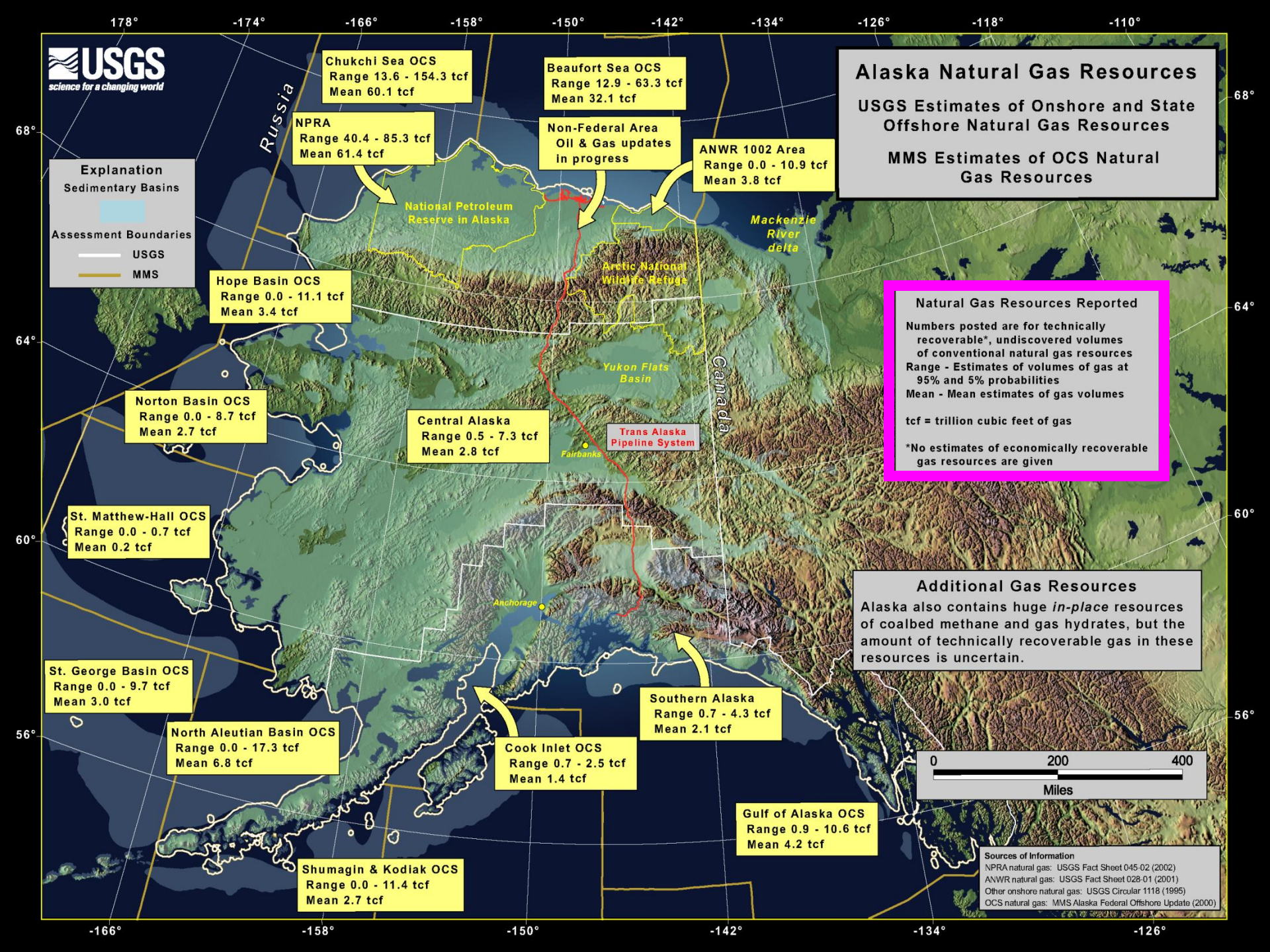
Beluga River Gas Field
Reservoir Correlation Along Structural Crest
Sterling and Upper Beluga Formation



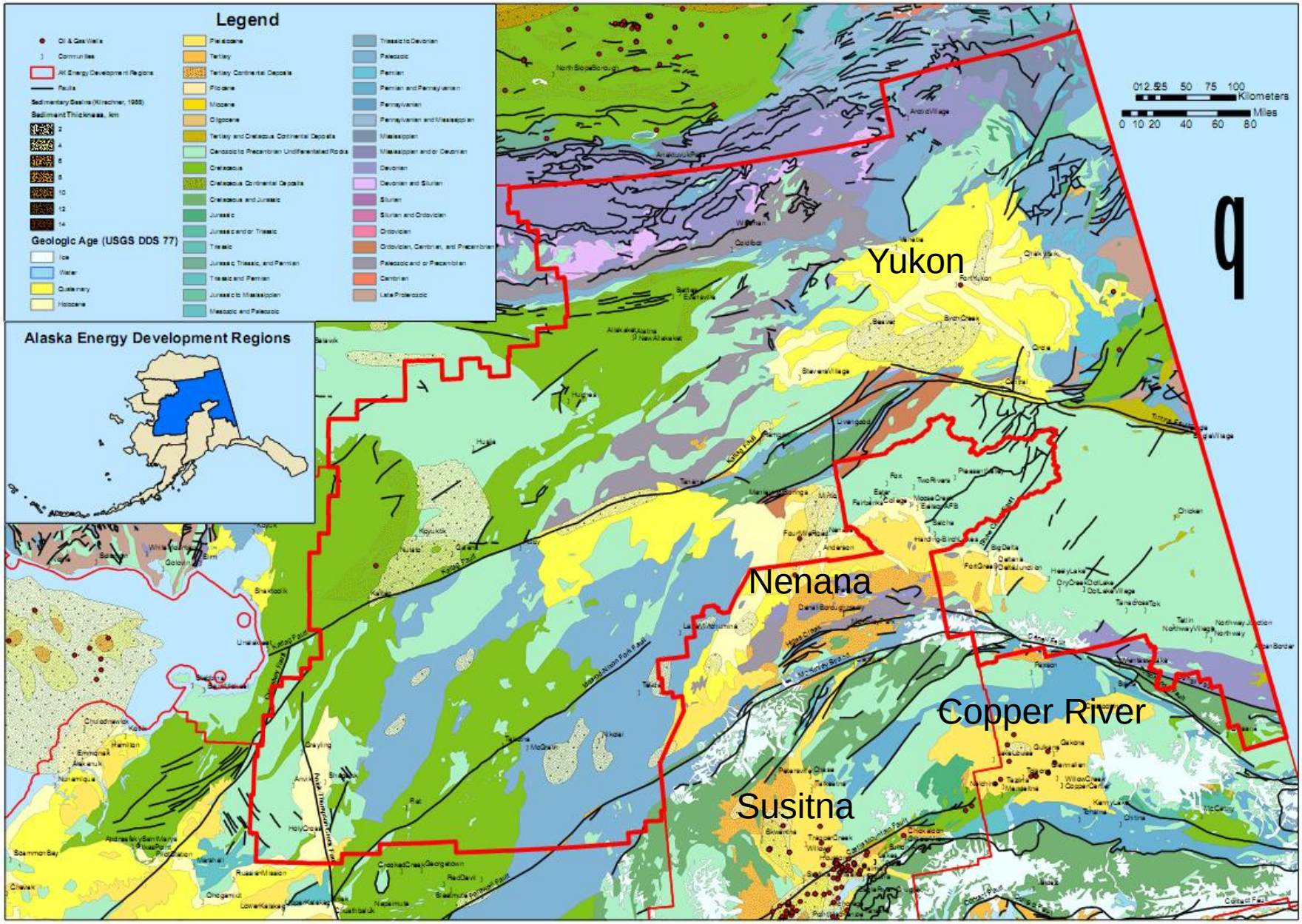


Seismic Data provided courtesy of Veritas Geophysical Corporation


Exploration Well Distribution
Chukchi Basin
Beaufort Basin
National Petroleum Reserve – Alaska
Northeast Planning Area
Northwest Planning Area
Colville Basin
Central Planning Area
Southern Planning Area
Corridor Site Areawide
Alternate Area for Proposed Stratigraphic Test Well
Area for Proposed Stratigraphic Test Well
1002 Area
MacKenzie Delta
Hope Basin
Kotzebue Basin
Kobuk Basin
Yukon-Kandik Basin
Yukon-Koyukuk Basin
Middle Tanana Basin
Norton Basin
Minchumina Basin
Copper River Basin
St. Matthew Basin
Holitna Basin
Bethel Basin
Gulf of Alaska Basin
Gulf of Alaska
North Aleutian Basin
Shelikof Basin
Kodiak Shelf Basin
St. George Basin
0 50 100 150 200 250
Miles
0 50 100 150 200 250
Kilometers

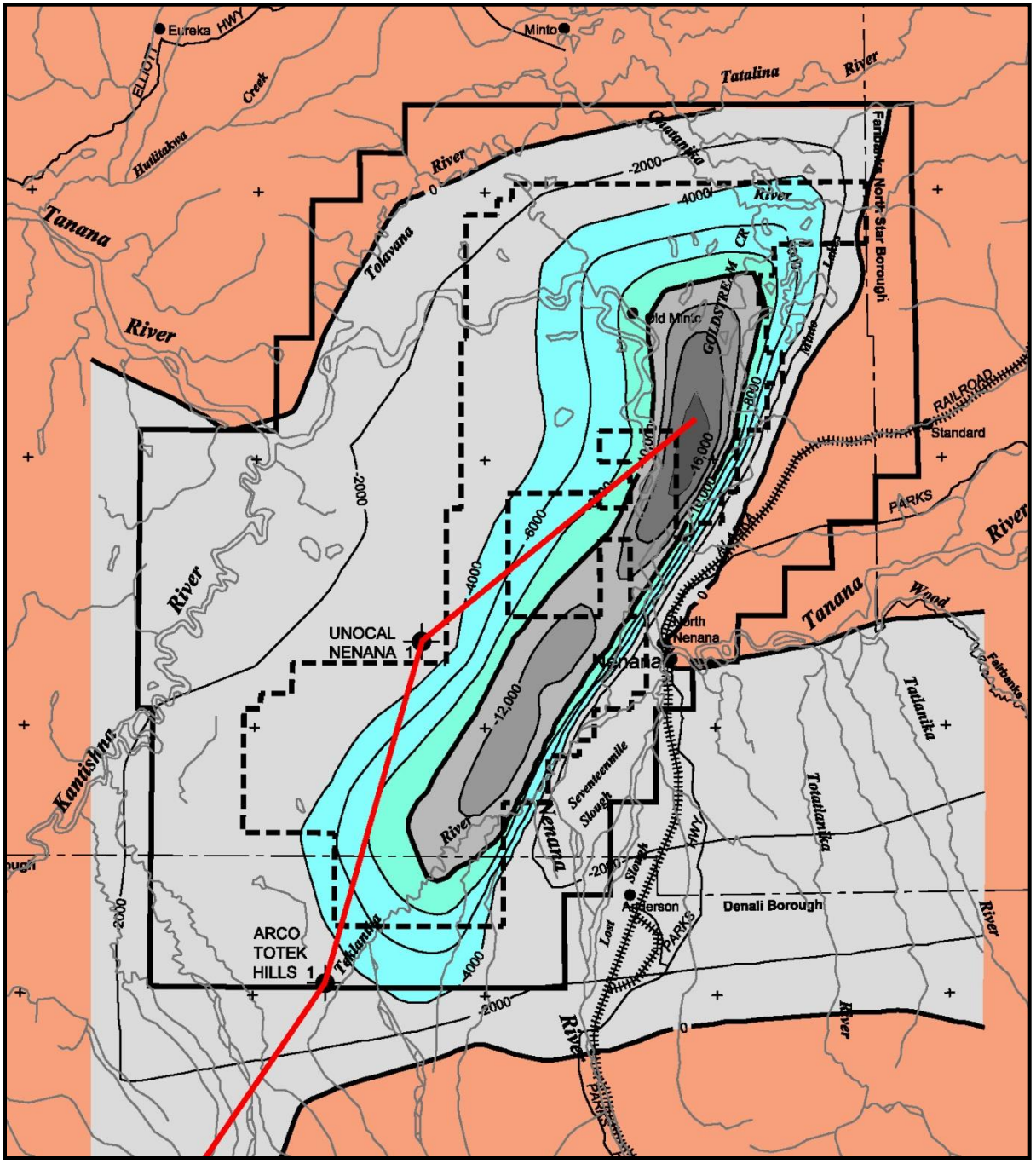

USGS
science for a changing world
Alaska Natural Gas Resources
USGS Estimates of Onshore and State Offshore Natural Gas Resources
MMS Estimates of OCS Natural Gas Resources
Explanation
Sedimentary Basins
Assessment Boundaries
USGS
MMS
Chukchi Sea OCS
Range 13.6 - 154.3 tcf
Mean 60.1 tcf
Beaufort Sea OCS
Range 12.9 - 63.3 tcf
Mean 32.1 tcf
NPRA
Range 40.4 - 85.3 tcf
Mean 61.4 tcf
Non-Federal Area
Oil & Gas updates
in progress
ANWR 1002 Area
Range 0.0 - 10.9 tcf
Mean 3.8 tcf
National Petroleum Reserve in Alaska
Mackenzie River delta
Arctic National Wildlife Refuge
Hope Basin OCS
Range 0.0 - 11.1 tcf
Mean 3.4 tcf
Yukon Flats Basin
Canada
Norton Basin OCS
Range 0.0 - 8.7 tcf
Mean 2.7 tcf
Central Alaska
Range 0.5 - 7.3 tcf
Mean 2.8 tcf
Trans Alaska Pipeline System
Fairbanks
St. Matthew-Hall OCS
Range 0.0 - 0.7 tcf
Mean 0.2 tcf
Anchorage
St. George Basin OCS
Range 0.0 - 9.7 tcf
Mean 3.0 tcf
Southern Alaska
Range 0.7 - 4.3 tcf
Mean 2.1 tcf
North Aleutian Basin OCS
Range 0.0 - 17.3 tcf
Mean 6.8 tcf
Cook Inlet OCS
Range 0.7 - 2.5 tcf
Mean 1.4 tcf
Gulf of Alaska OCS
Range 0.9 - 10.6 tcf
Mean 4.2 tcf
Shumagin & Kodiak OCS
Range 0.0 - 11.4 tcf
Mean 2.7 tcf
Natural Gas Resources Reported
Numbers posted are for technically recoverable*, undiscovered volumes of conventional natural gas resources
Range - Estimates of volumes of gas at 95% and 5% probabilities
Mean - Mean estimates of gas volumes
tcf = trillion cubic feet of gas
*No estimates of economically recoverable gas resources are given
Additional Gas Resources
Alaska also contains huge in-place resources of coalbed methane and gas hydrates, but the amount of technically recoverable gas in these resources is uncertain.
0
200
400
Miles
Sources of Information
NPRA natural gas: USGS Fact Sheet 045-02 (2002)
ANWR natural gas: USGS Fact Sheet 028-01 (2001)
Other onshore natural gas: USGS Circular 1118 (1995)
OCS natural gas: MMS Alaska Federal Offshore Update (2000)
178°
-174°
-166°
-158°
-150°
-142°
-134°
-126°
-118°
-110°
68°
64°
60°
56°

Geology of the Yukon-Koyukuk/Upper Tanana Energy Region, Alaska



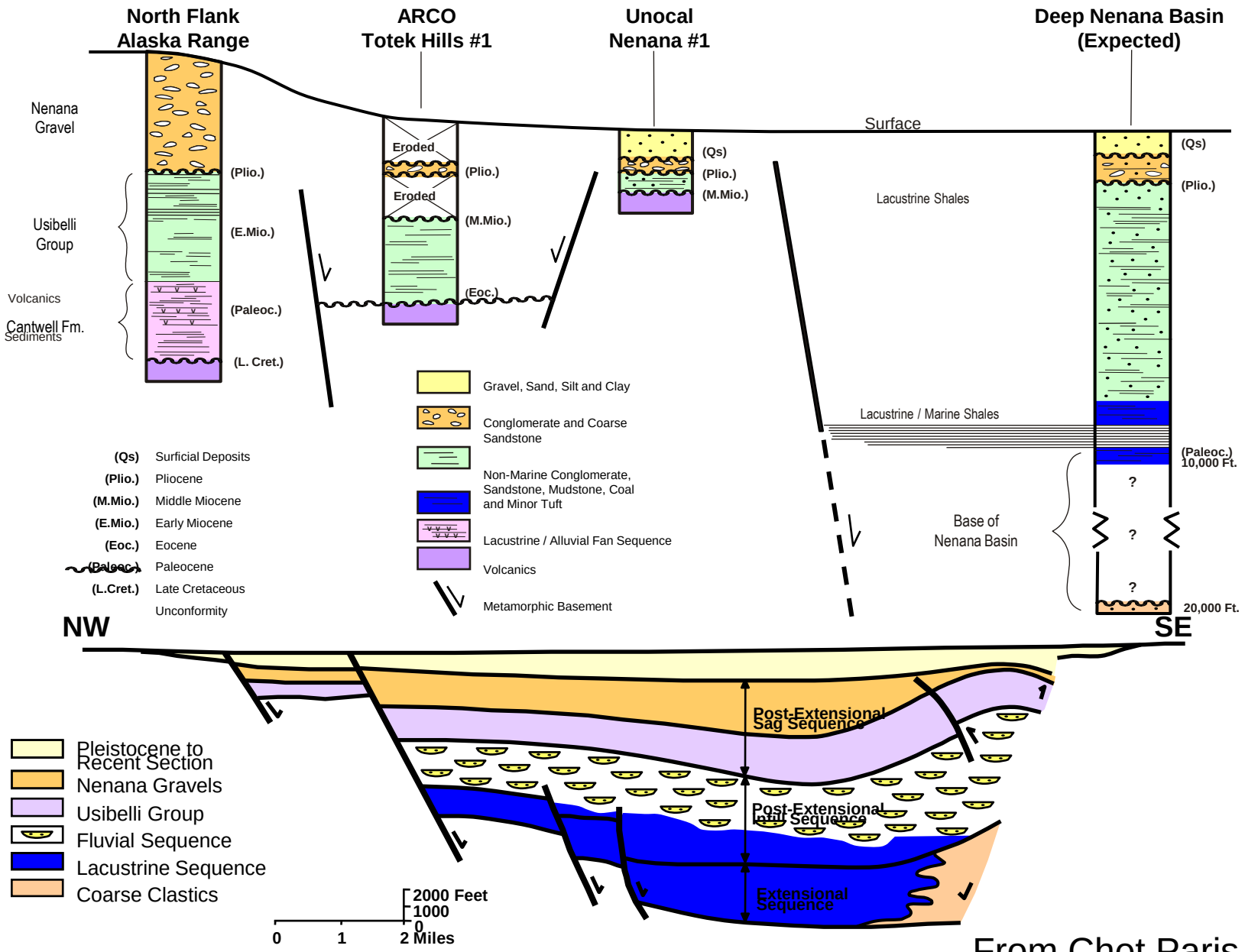
Nenana Basin

Thickness of Sedimentary Basin (Tertiary)



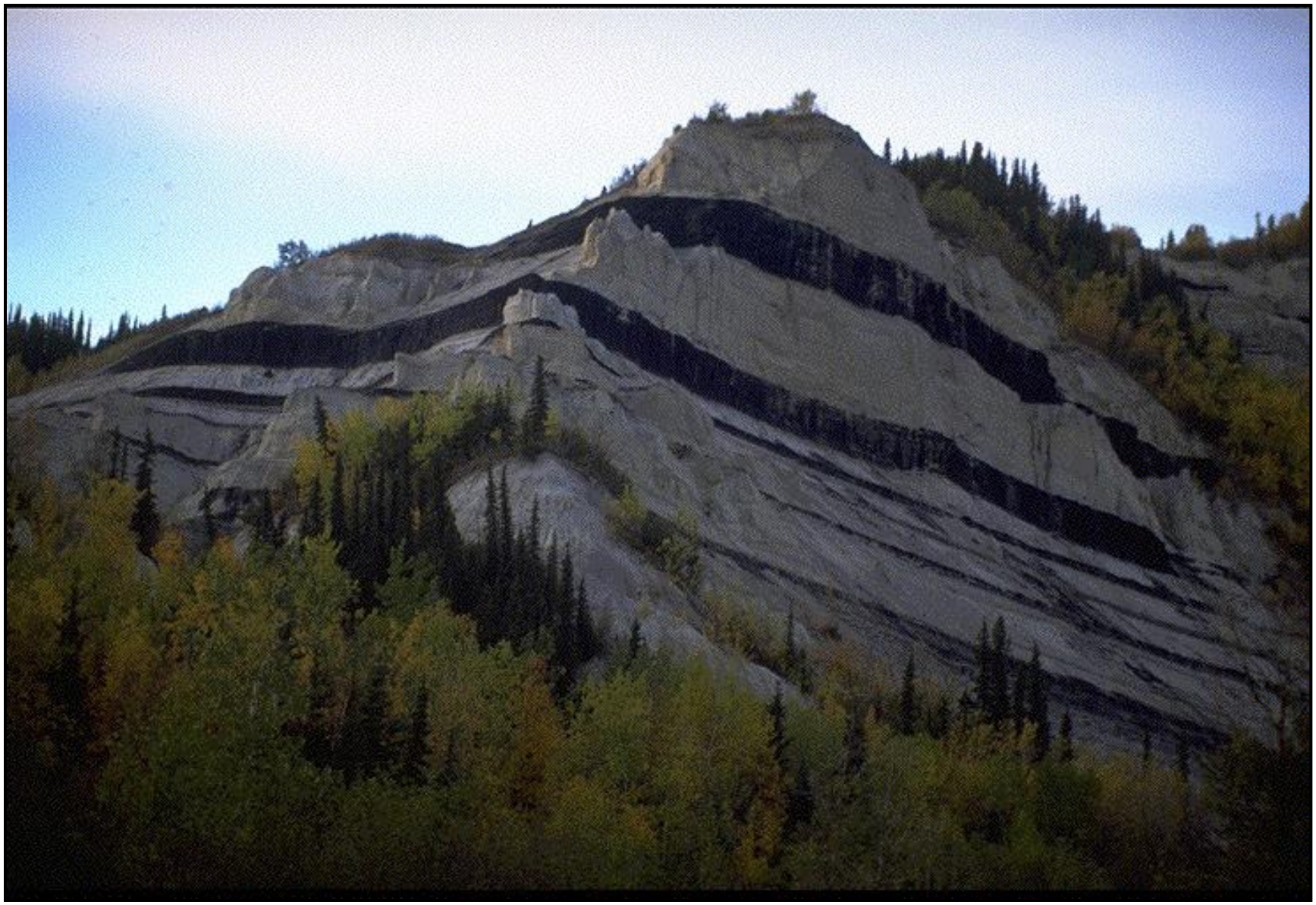
Contour Interval = 2,000 Ft.

Nenana Basin



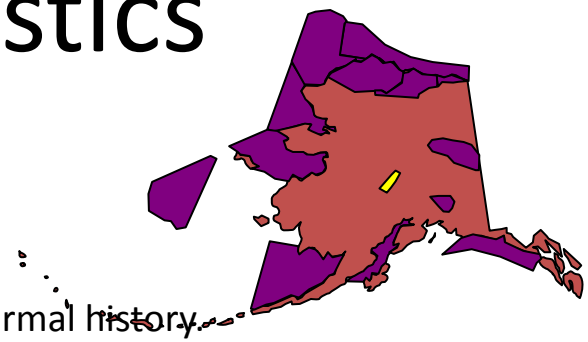
From Chet Paris, PRA

Usibelli Group in Outcrop Belt South of Nenana Exploration License Area



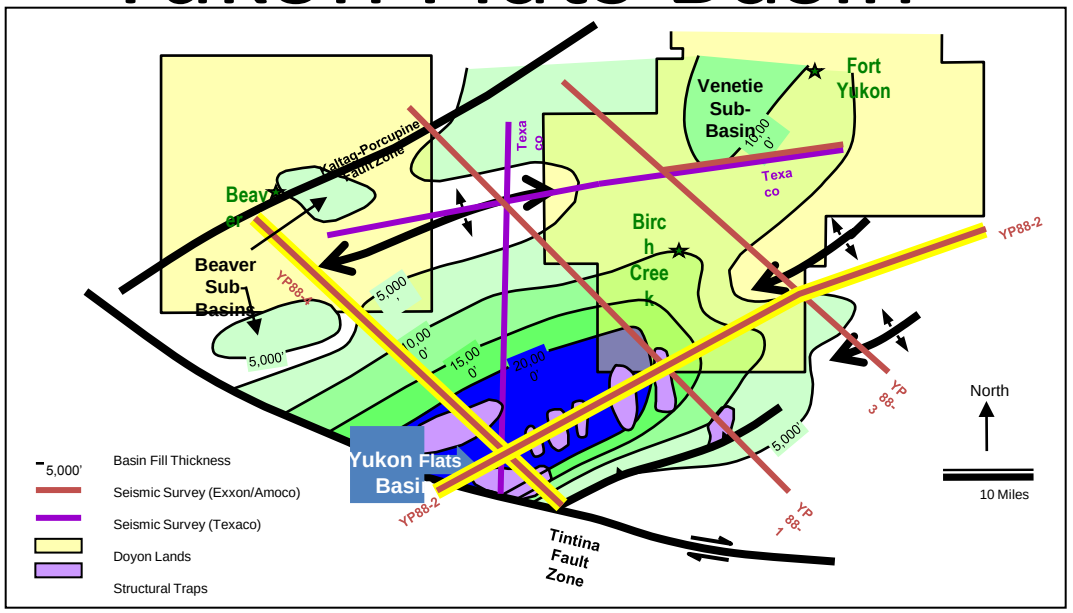
Roy D. Merritt, DGGS 08/95

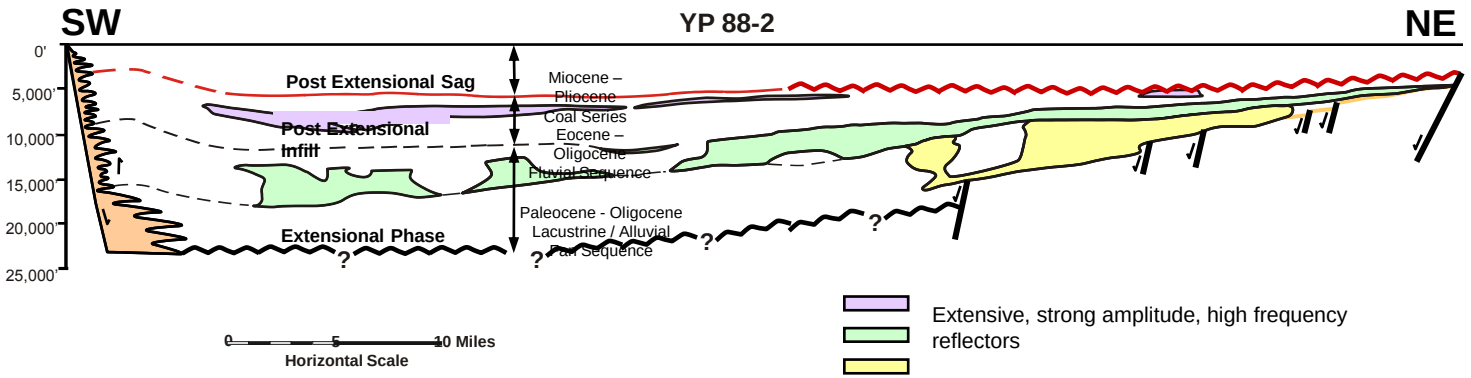
Nenana Basin Statistics



- Tertiary Non Marine Basin Fill
  - Up to 18,000 Ft Thick (Seismic).
  - Time-equivalent to Cook Inlet's productive Kenai Group.
  - Potential for oil is low due to thin low-organic source rocks & thermal history.
  - 350 miles 2-D seismic data in southern and central basin areas (1981-82)
- The range of possible reserve outcomes is wide and poorly constrained
  - Terrestrial Kerogens and Coal Sourced Gas
- 2 Wells Drilled on Basement Highs
  - Unocal Nenana #1 (1962) – 3,062' deep, coal seam gas shows.
  - ARCO Totek Hills #1 (1984) – 3,590' deep, coal seam gas shows.
  - Entire Section not Penetrated
  - Good Reservoir in Shallow Section
  - Potential for CBM and conventional gas is good
- Significant Deformation on Southern Margin
  - Likely Associated with Strike Slip on Basin Bounding Faults
- Recent Seismic Work and Exploration Well
  - No commercial discovery announced

Yukon Flats Basin





Extensive, strong amplitude, high frequency reflectors

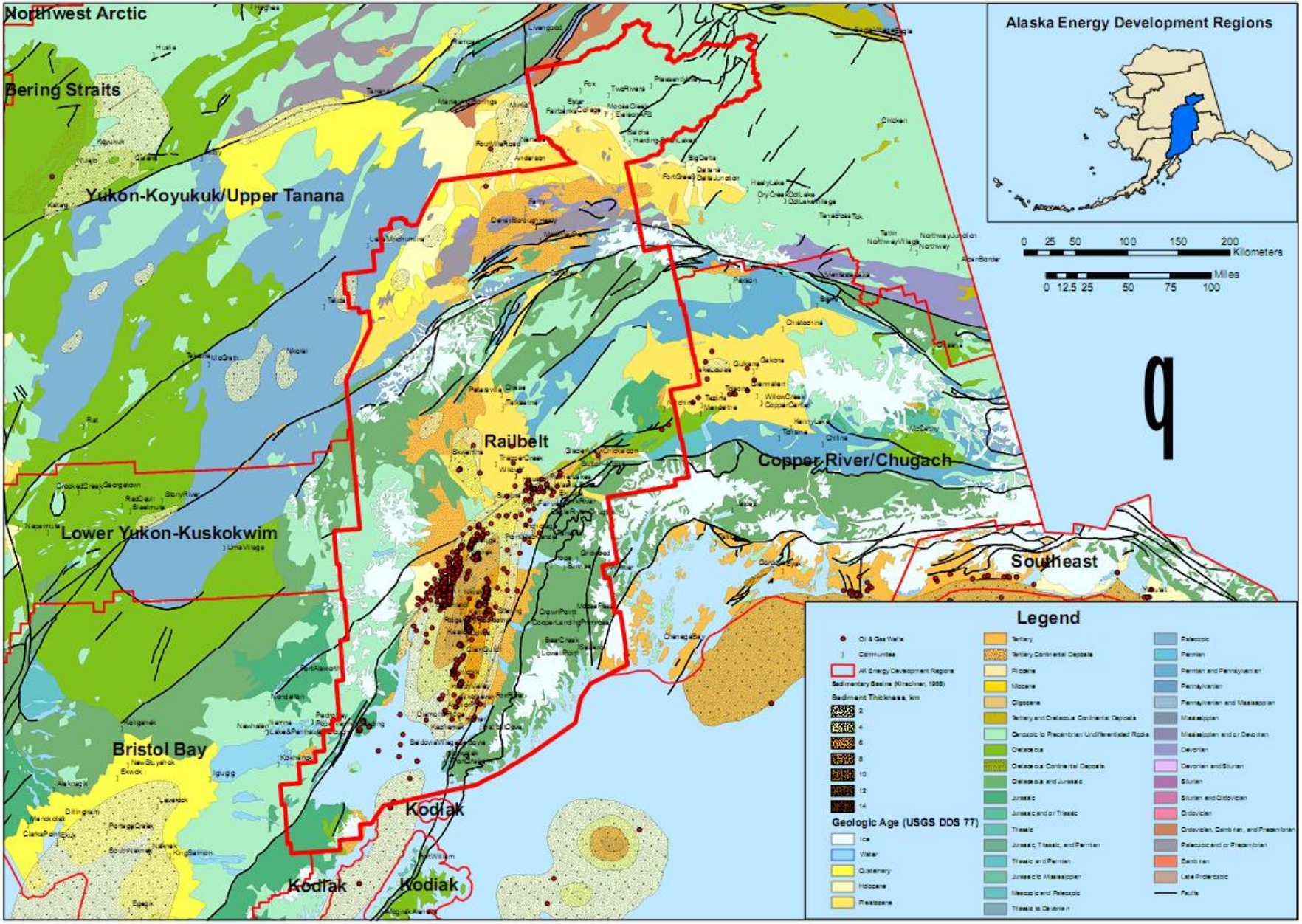
Extensive, strong amplitude, low frequency reflectors

Local, strong amplitude, low frequency reflectors

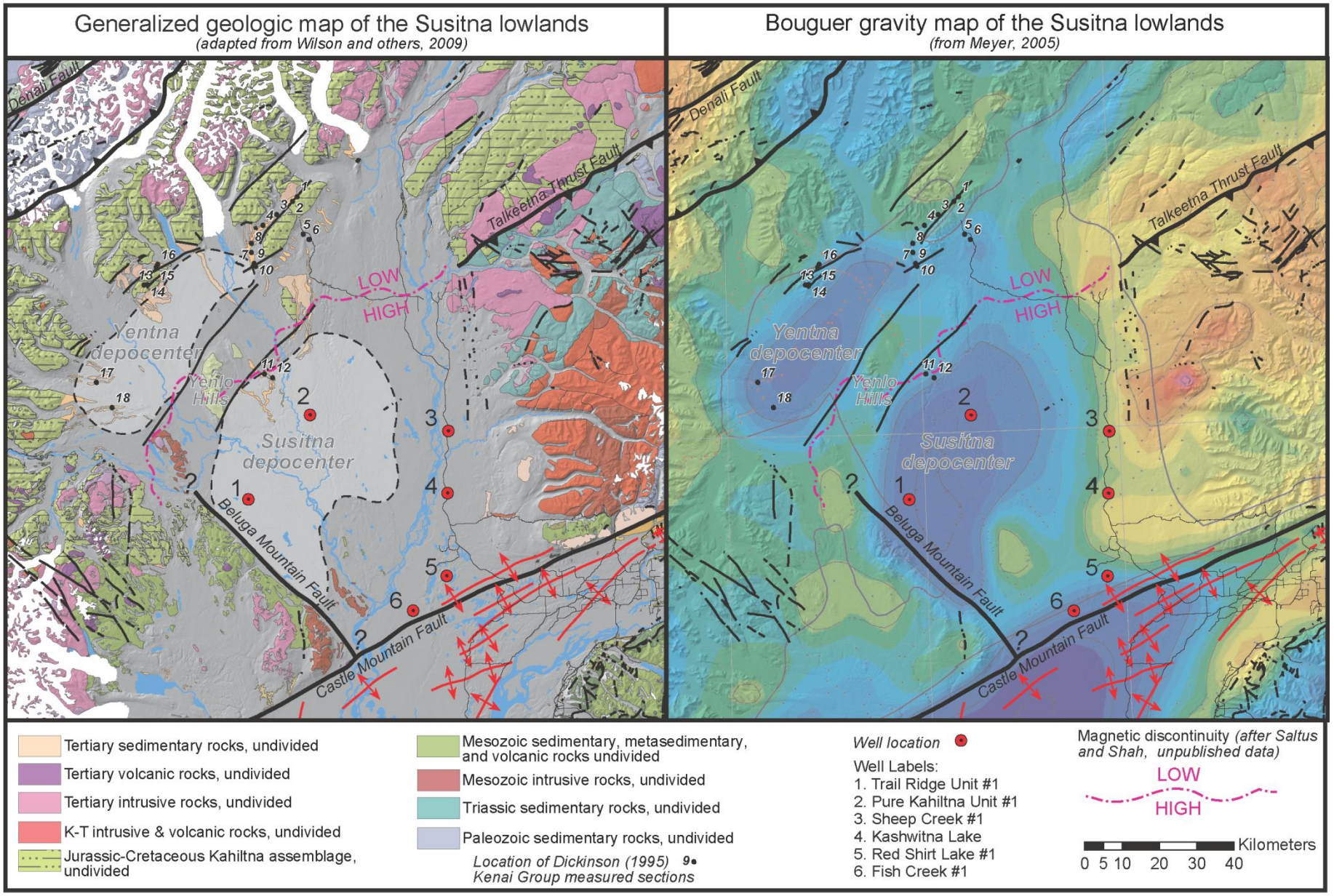
Coarse clastic wedge

From Chet Paris, PRA

Geology of the Railbelt Energy Region, Alaska



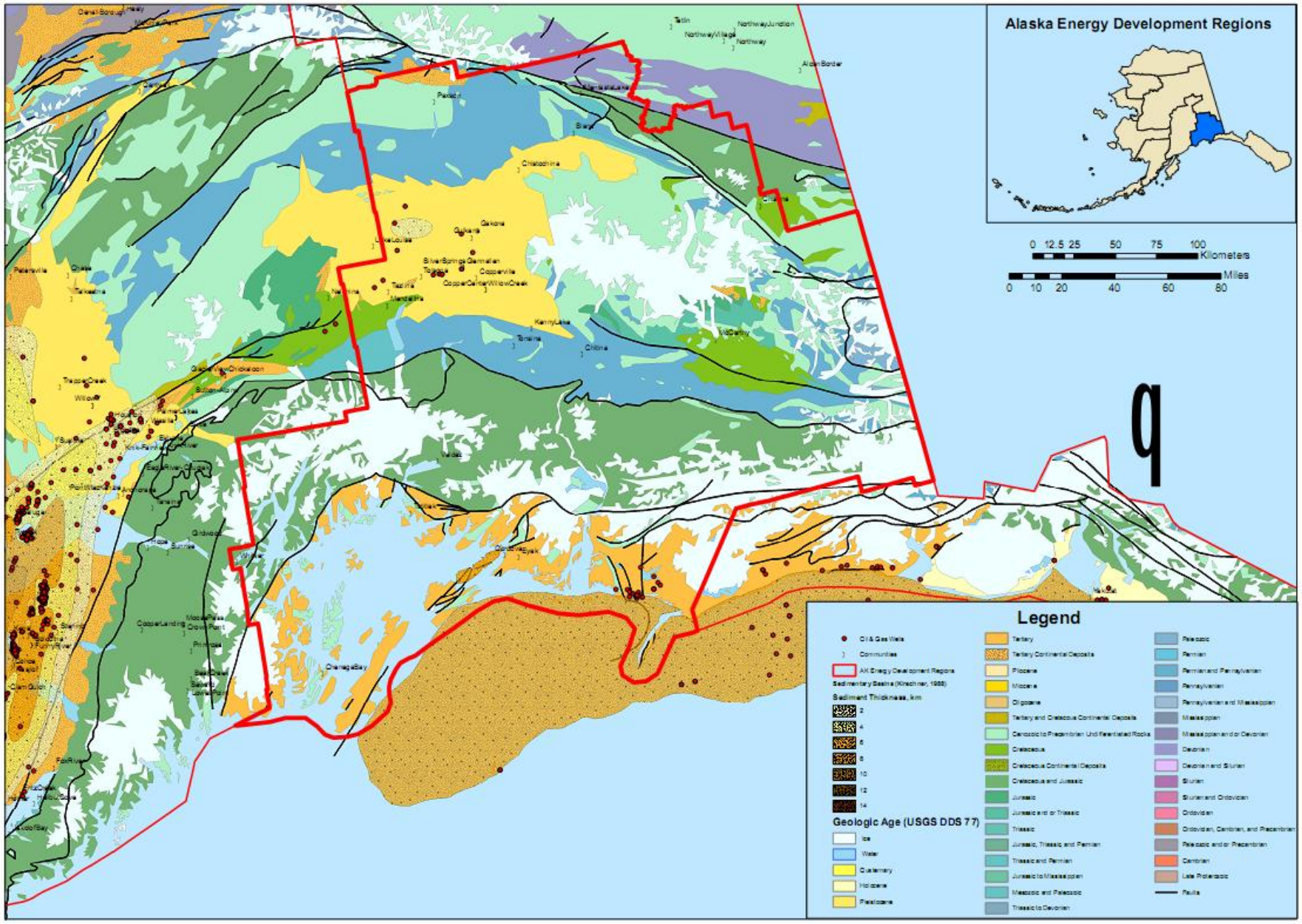
Susitna Basin



Susitna Basin Statistics

- Similar Stratigraphy Cook Inlet
  - Separated by Crustal Scale Castle Mountain Fault
  - Up to 15,000 Ft of Tertiary Section (Based on Gravity in Sub-basins)
    - Overlies Mesozoic Metamorphic Complex and Tertiary Volcanics
  - Lacks Paleocene and Early Oligocene Strata
- 2 Wells and Limited ’60’s Vintage Seismic
  - Some Gravity and Magnetic Data Available
- Tertiary Gas Prone Basin
  - No Viable Oil Source Identified
- Currently Under Exploration License by Cook Inlet Energy
- Focus of detailed mapping and analysis in 2011 by DGGS

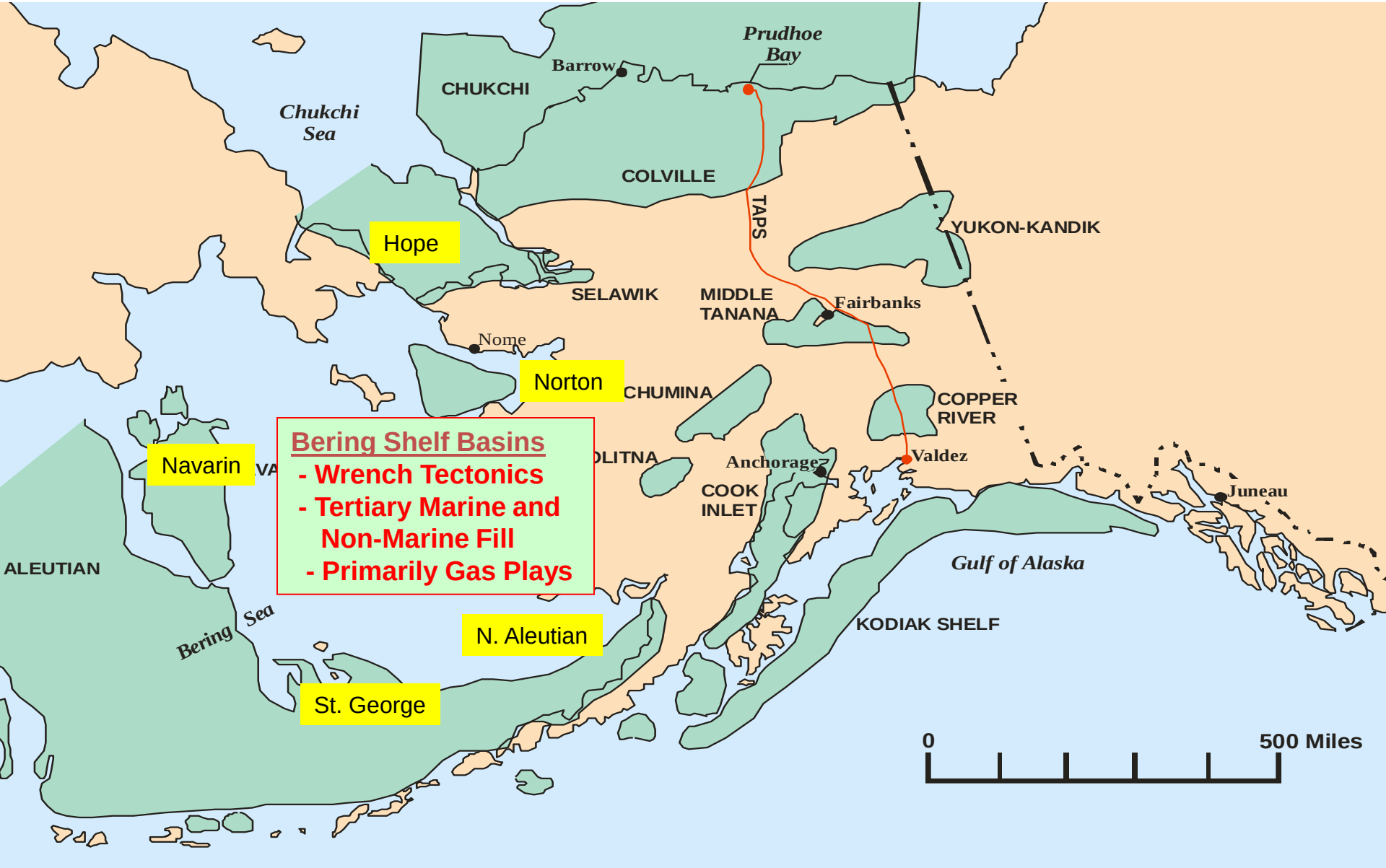
Geology of the Copper River/Chugach Energy Region, Alaska

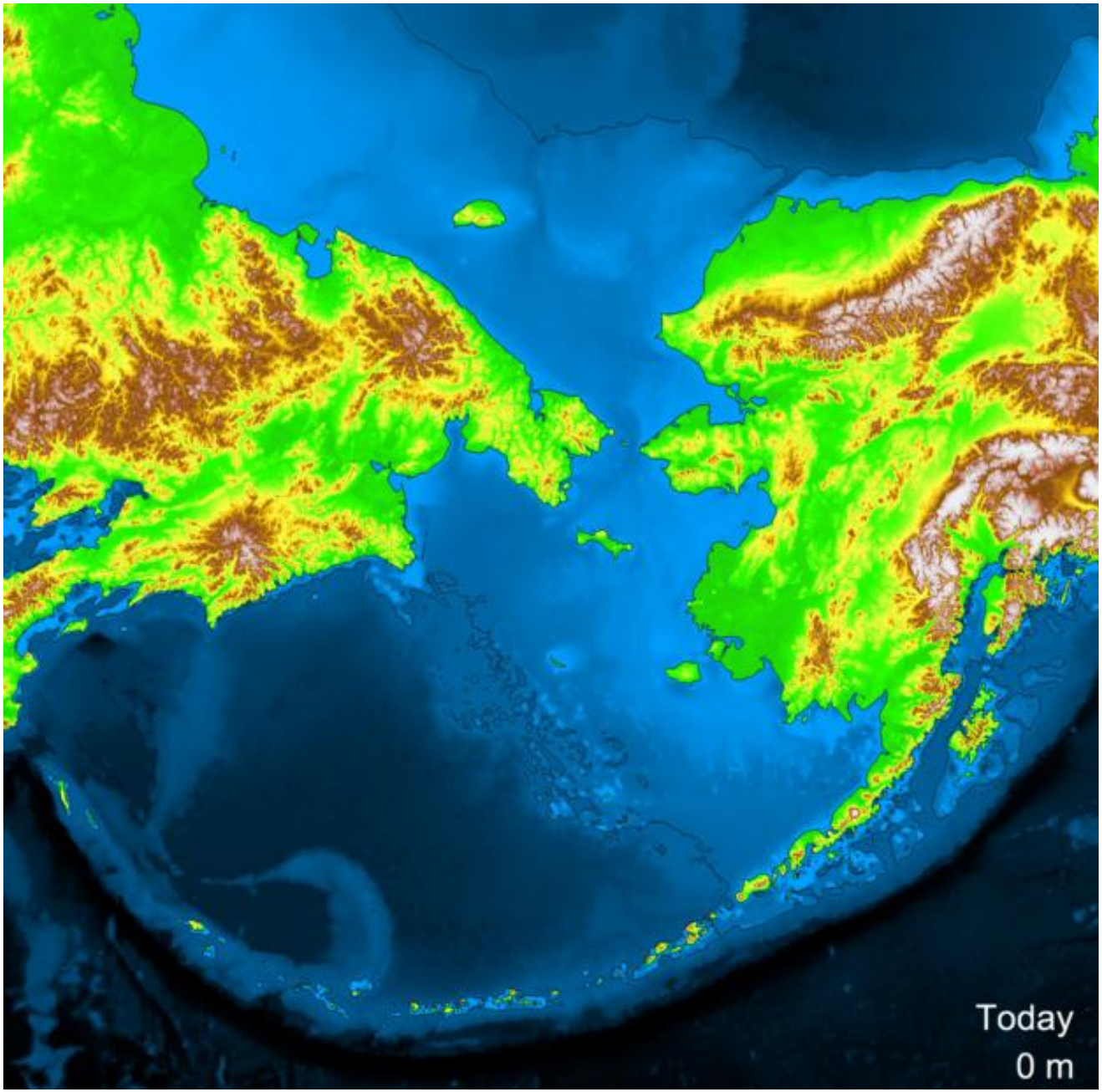


Copper River Basin Statistics

- Tertiary Stratrigraphy Similar to Cook Inlet
  - Less Than 3,000 Ft of Tertiary Section
  - Immature Mesozoic Source Terrane on Western Boundary
    - Remainder of Basin Surrounded by Metamophic and Volcanic Rocks
    - Some potential in Mesozoic marine section
- 11 Wells and Limited ’70’s Vintage Seismic
  - Limited Gravity and Magnetic Data Available
- Tertiary Gas Prone Basin
  - Oil Source in Mesozoic Section Immature where Encountered
- Recent Exploration Well
  - No Commercial Discovery

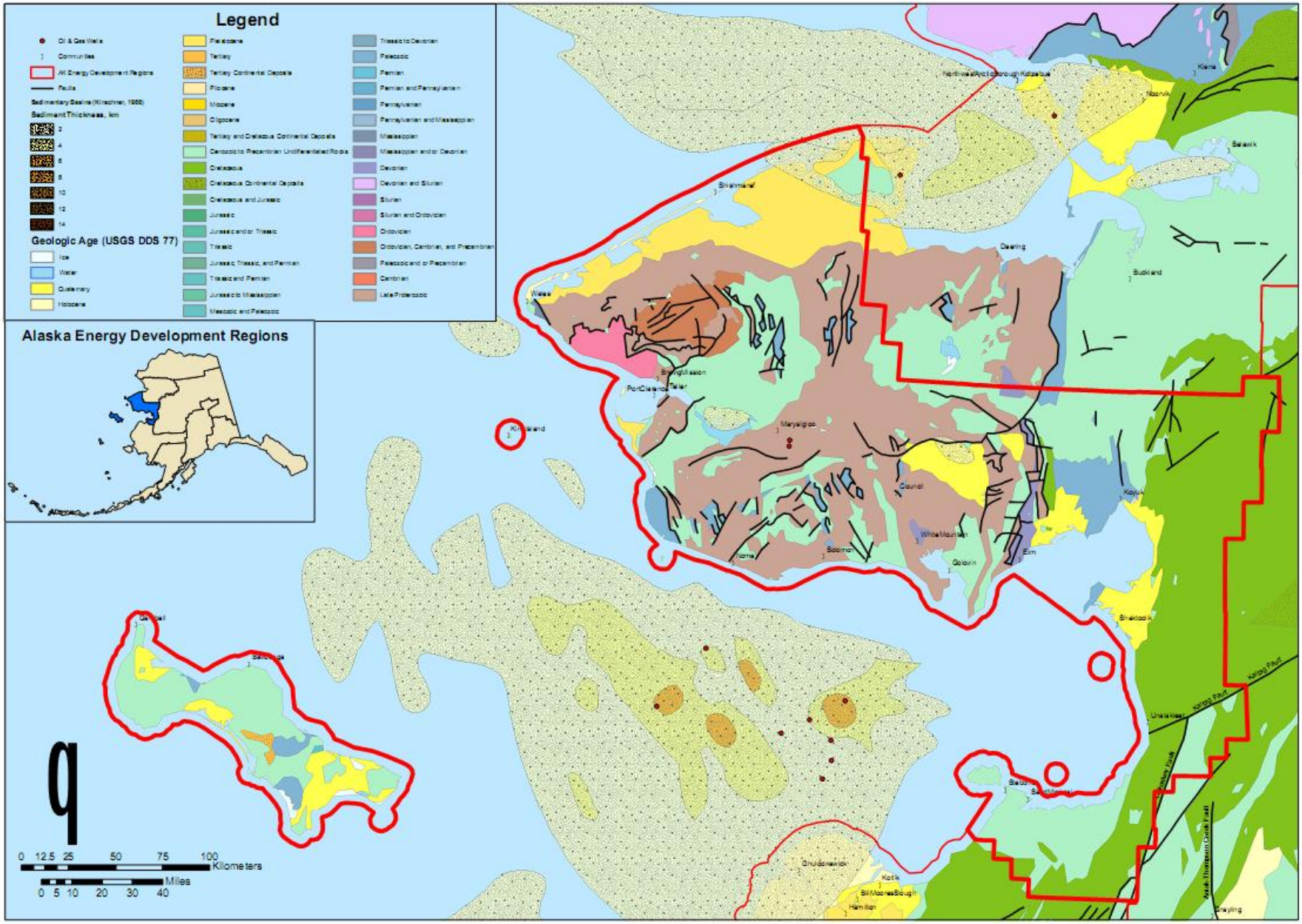
Bering Shelf Basins



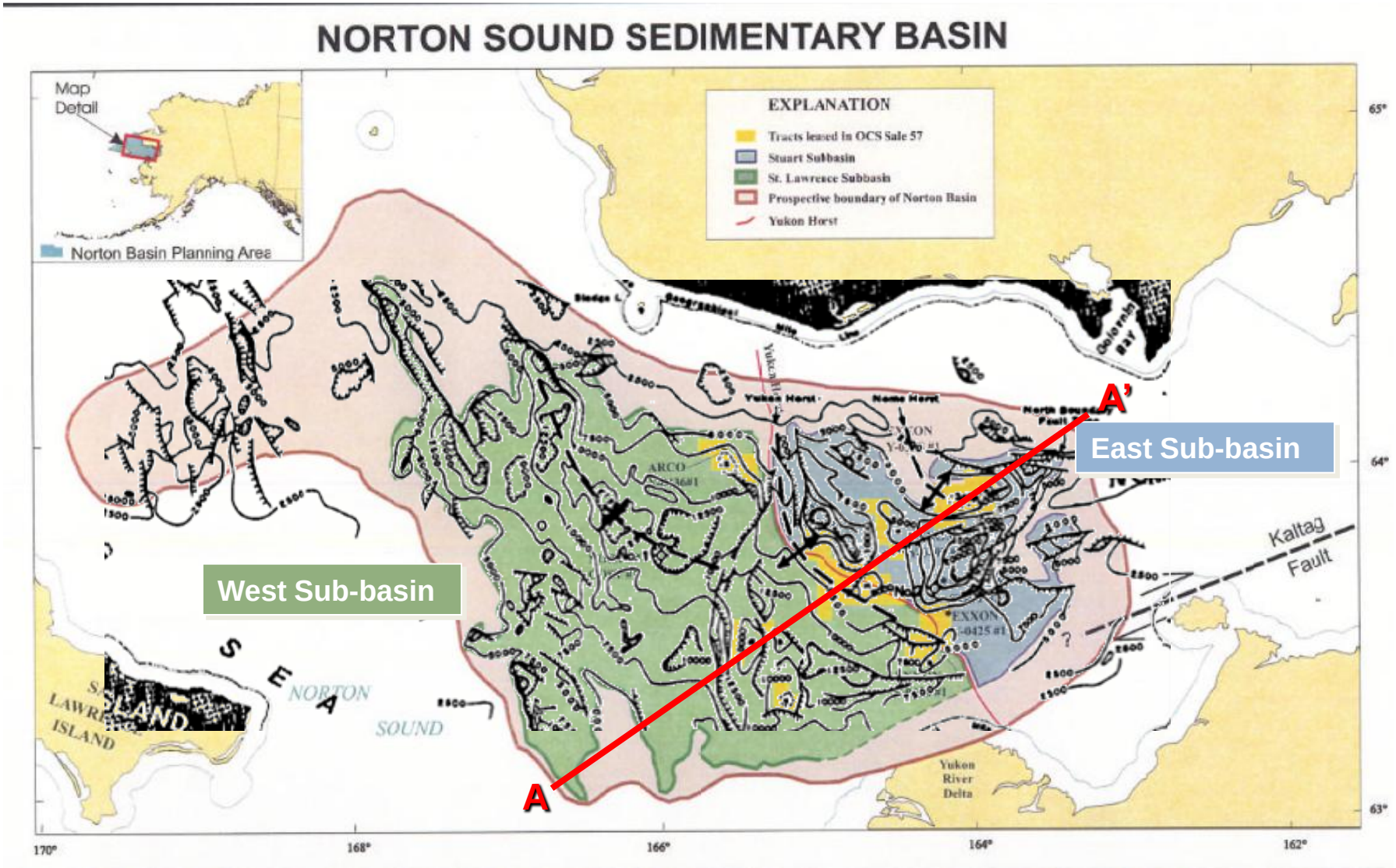


Manley, W.F., 2002, Postglacial Flooding of the Bering Land Bridge: A Geospatial Animation: INSTAAR, University of Colorado, v1, http://instaar.colorado.edu/QGISL/bering_land_bridge.

Geology of the Bering Straits Energy Region, Alaska



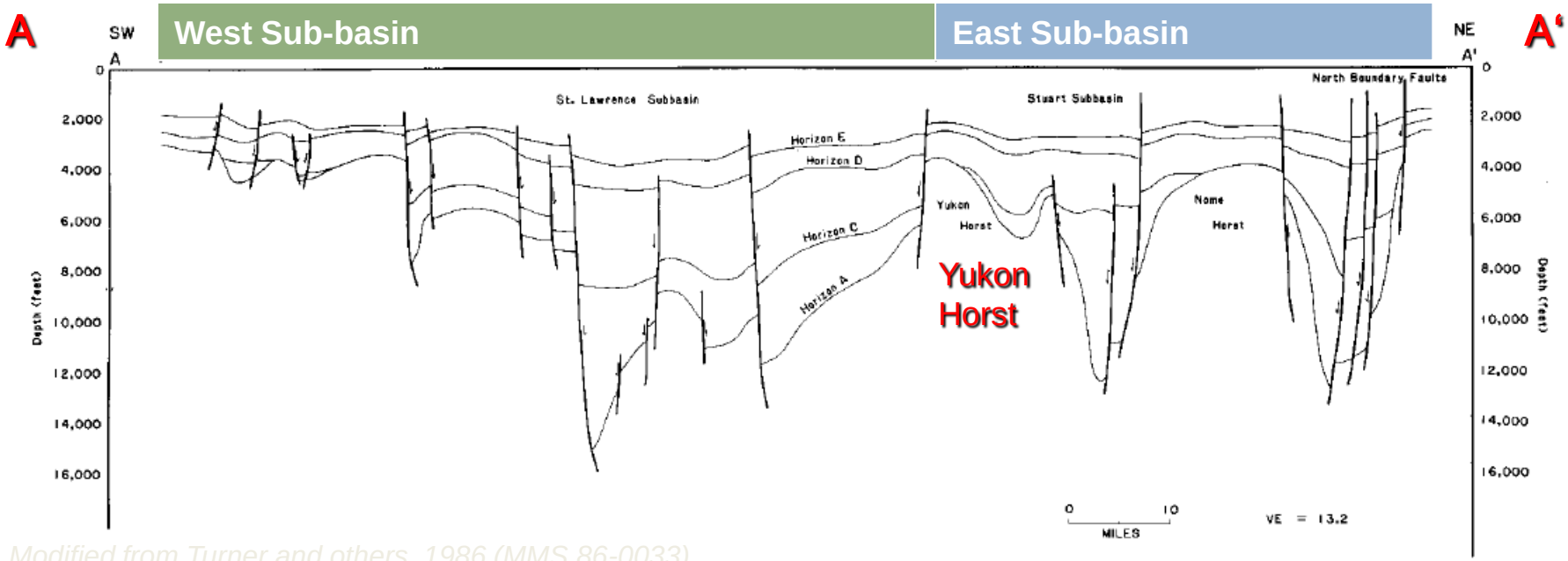
Depth Structure: Base Tertiary unconformity



Modified from "Exploring the Frontier – Alaska's Norton Sound" (MMS) and Turner and others, 1986 (MMS 86-0033)

Norton Basin Structure

Cross Section from Seismic Transect



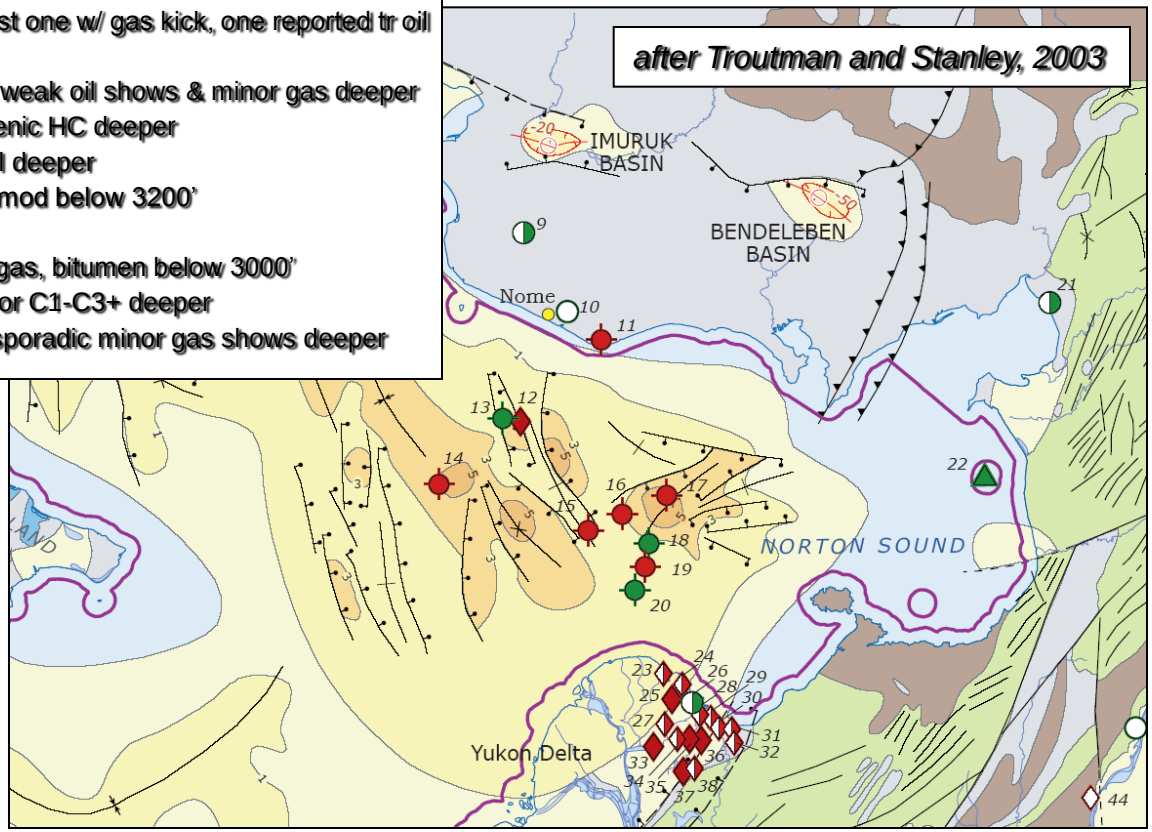
Modified from Turner and others, 1986 (MMS 86-0033)

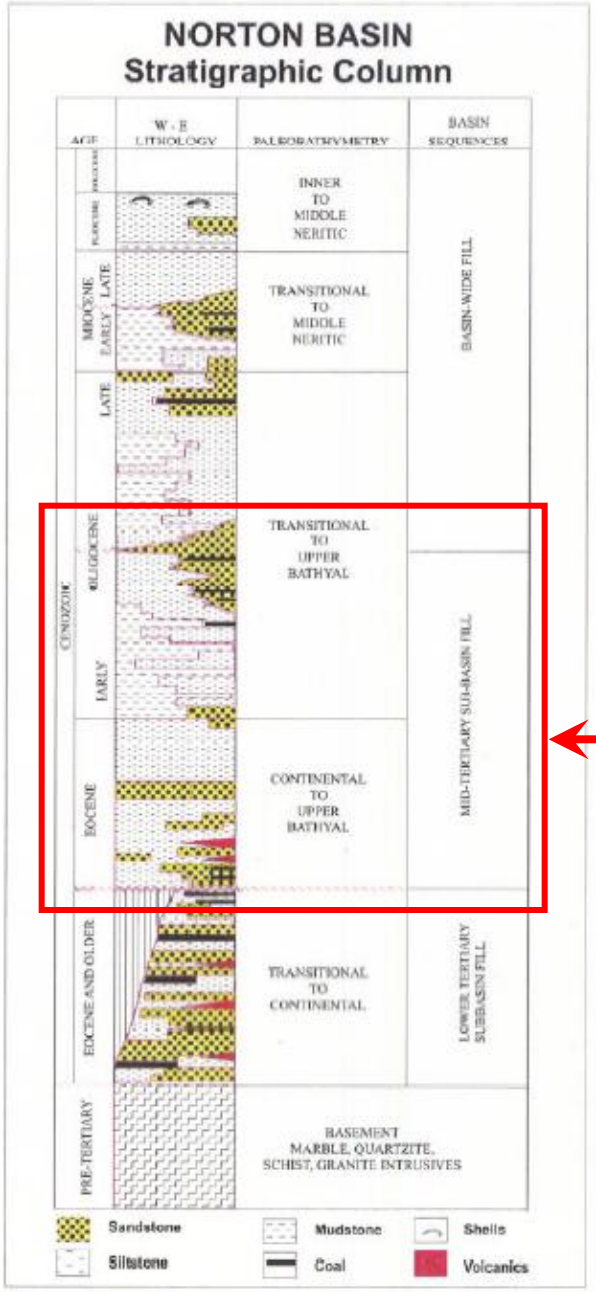
Norton Basin Exploration History

- 2 COST wells in 1980, 1982 (ARCO)
- OCS Sale 57 in March 1983: 59 tracts sold for $325 million
- 6 exploration wells 1984-85 (Exxon-ARCO)
- Gas shows in all wells (moderate to strong shows in 2), weak oil shows in 3 wells

Key to Wells and Hydrocarbon Occurrences Shown on Map

9, 10	Reported oil seeps, unconfirmed and/or regarded as doubtful
11	Four wells (2 in 1906, 2 in 1918): All < 210' deep, at least one w/ gas kick, one reported tr oil
12	Gas seep: 98% CO2, < 0.1% C1-C8 hyrdrocarbons
13	ARCO OCS Y-0436, 1984: Strong gas shows shallow, weak oil shows & minor gas deeper
14	ARCO COST 1, 1980: Biogenic C1 shallow, tr thermogenic HC deeper
15	Exxon OCS Y-0414: 1984, Mod-strong C1 shallow, tr oil deeper
16	Exxon OCS Y-0407: 1985, Mod-strong C1 shallow, wk-mod below 3200'
17	Exxon OCS Y-0398: 1985, Minor C1 shows
18	ARCO COST 2, 1982: Biogenic gas shallow, minor oil, gas, bitumen below 3000'
19	Exxon OCS Y-0425, 1985: Mod-strong C1 shallow, minor C1-C3+ deeper
20	Exxon OCS Y-0430, 1984: Abdt minor shows shallow, sporadic minor gas shows deeper





Source: "Exploring the Frontier – Alaska's Norton Sound" (MMS)

Norton Basin Geology Summary

- Tertiary extensional basin associated with strike-slip on Kaltag fault
- Tertiary clastic basin fill up to 23,000 ft thick overlies Paleozoic and Mesozoic metamorphosed sedimentary and igneous rocks
- Two sub-basins separated by narrow horst system that controlled depositional environments; east sub-basin mostly nearshore marine to shelfal deposits, west sub-basin mostly shelfal to deep water units

Mid-Tertiary West Sub-basin Fill Play

Age: Eocene to middle Oligocene clastic sediments of St. Lawrence sub-basin

Reservoirs: Shelf sands and turbidites, possible alluvial fan and deltaics on flank of Yukon horst and basin margin; avg depth ~ 5500 ft, avg porosity 14%, avg permeability 0.9 md, avg net pay 178 ft

Traps: Faulted anticlines and stratigraphic onlap against basement

Source: Thermally mature, mostly Eocene strata, Type III (gas-prone) terrestrial kerogen, lean in total organic carbon (TOC)

Potential: MTWSF play contains > 50% of basin's assessed endowment (1.6 TCF Mean); 1 COST well + 1 prospect tested

Navarin Basin Statistics

- Largest and Most Remote Bering Shelf Basin
  - 32,000 sq. mi
  - Wrench Fault Related Structures
  - Up to 36,000 Ft. of Tertiary Strata
- 1 Cost Well and 8 Exploratory Wells from 1983 to 1987
  - Gas and Limited Oil Prone Source Rocks in Eocene and Paleocene
  - 7 Marine Reservoir Quality Intervals in Tertiary Section
  - Trace to Minor Gas and Oil Shows in 5 of the Wells
- Considered Gas Prone Basin
- Not on Federal Lease Sale Schedule
  - Future Sales (post 2007) Will Depend on Industry Interest
- Mean Risked Resource (MMS)
  - 500 mmbo; 6 tcf Gas / Conventionally Recoverable

Alaska Energy Data Inventory

- Consolidating Alaska's energy resources data
  - Resource data suitable for electrical power generation and space heating needs
  - Natural gas, coal, coalbed and shalebed methan gas hydrates, geothermal, wind, hydro, and biomass
  - Available energy meeting local needs?
- Making the data accessible
  - Alaska Mapper, Google Earth, and Terrago Technologies' GeoPDF format
  - http://energyinventory.alaska.gov
  - Query and download data; view data with existing infrastructure
- Involvement
  - DGGS, Alaska Energy Authority, DNR Division of Forestry, DNR LRIS, UAF/GINA
  - CCHRC, USGS, USDOE, DNR DOG, BLM, DMLW, Div. Agriculture, DEC