

# WESTCARB Annual Business Meeting

## Alaska: Assessment of Saline Formation and Deep Coalbed Storage Potential

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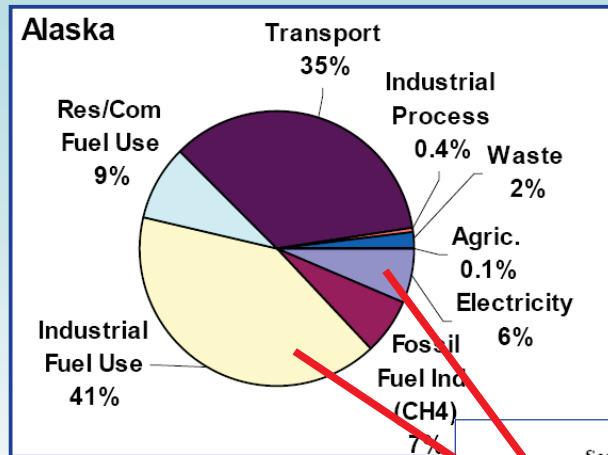


## Outline

- **Background**
  - Alaska CO<sub>2</sub> Sources
  - Alaska Geologic Sequestration Potential
- **Saline Basin Potential (qualitative)**
- **Unmineable Coal Seam Assessment**
- **Conclusions**

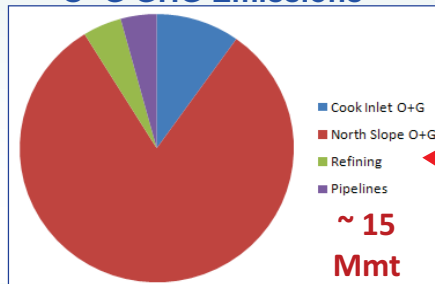
# Alaska Gross GHG Emissions by Sector (2005)

~ 52 Mmt CO<sub>2</sub>e

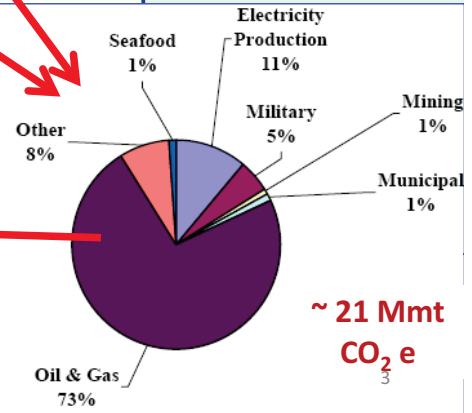


## Alaska Title V GHG Emissions

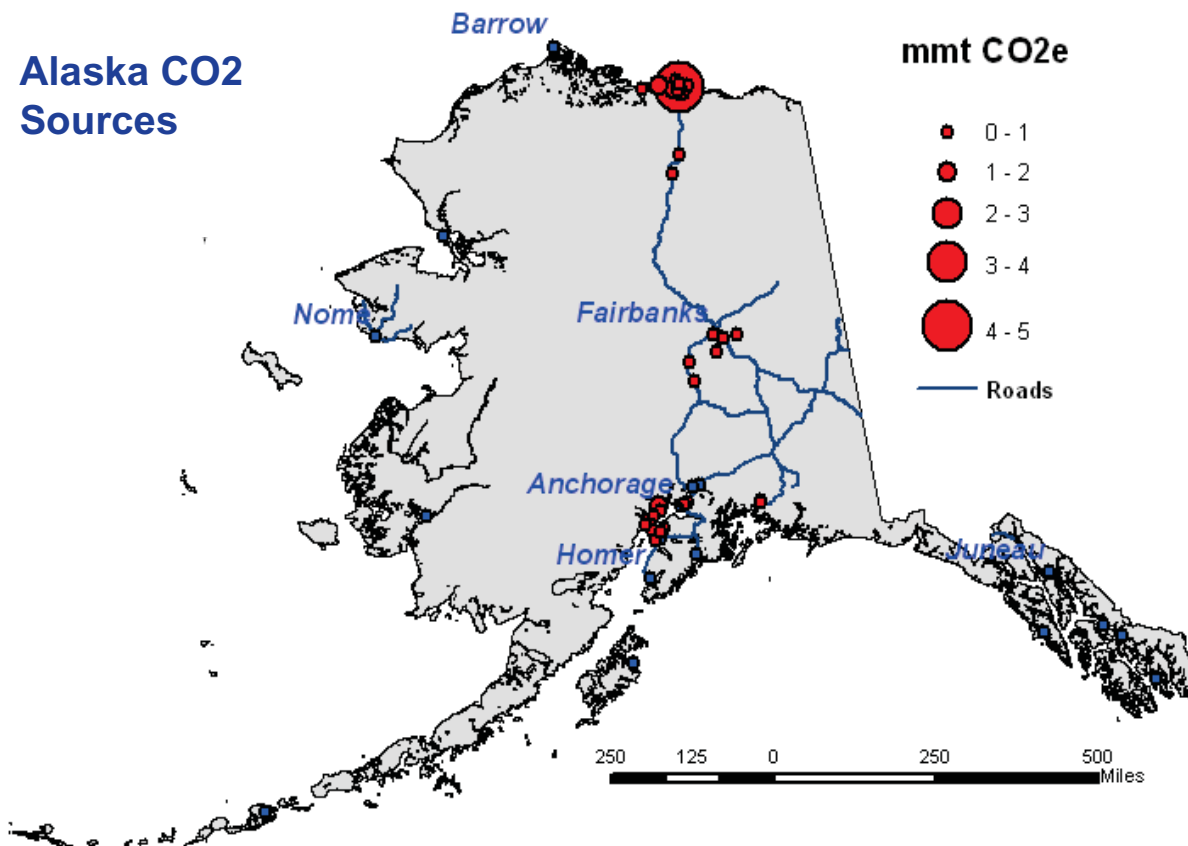
### O+G GHG Emissions

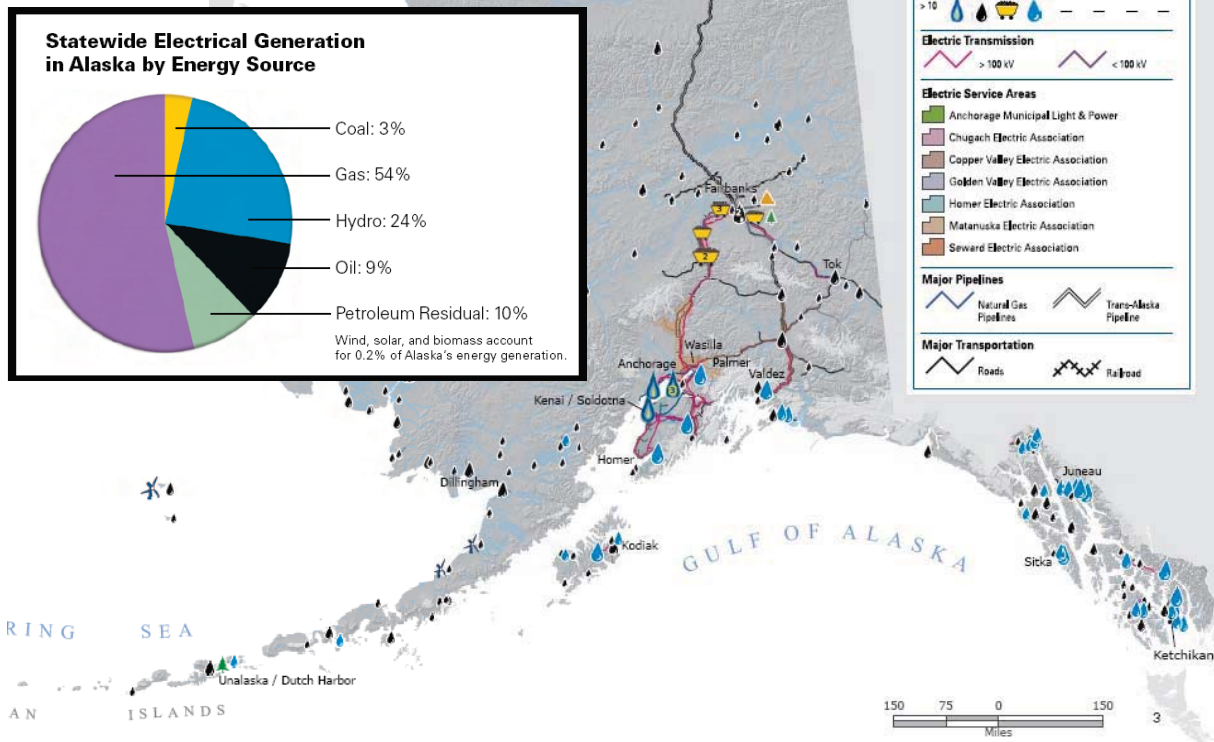


DRAFT - Alaska DEC Summary Report of Improvements to the Alaska Greenhouse Gas Emission Inventory, January 2008

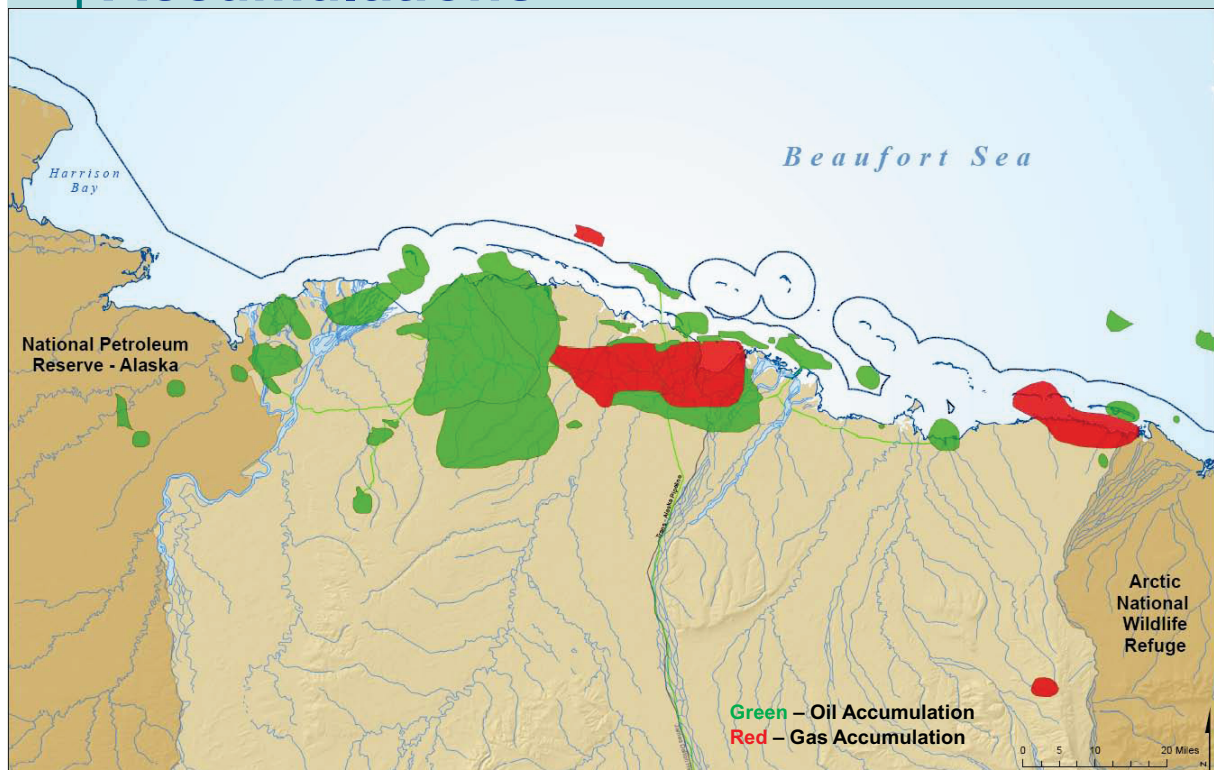


## Alaska CO<sub>2</sub> Sources





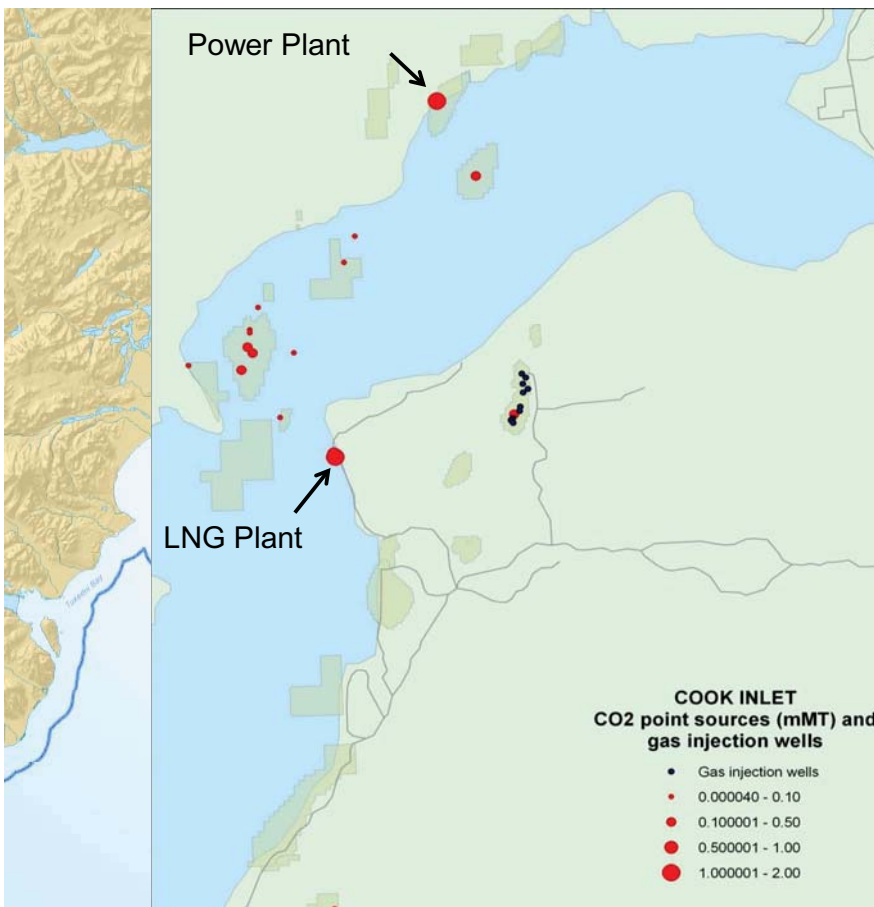
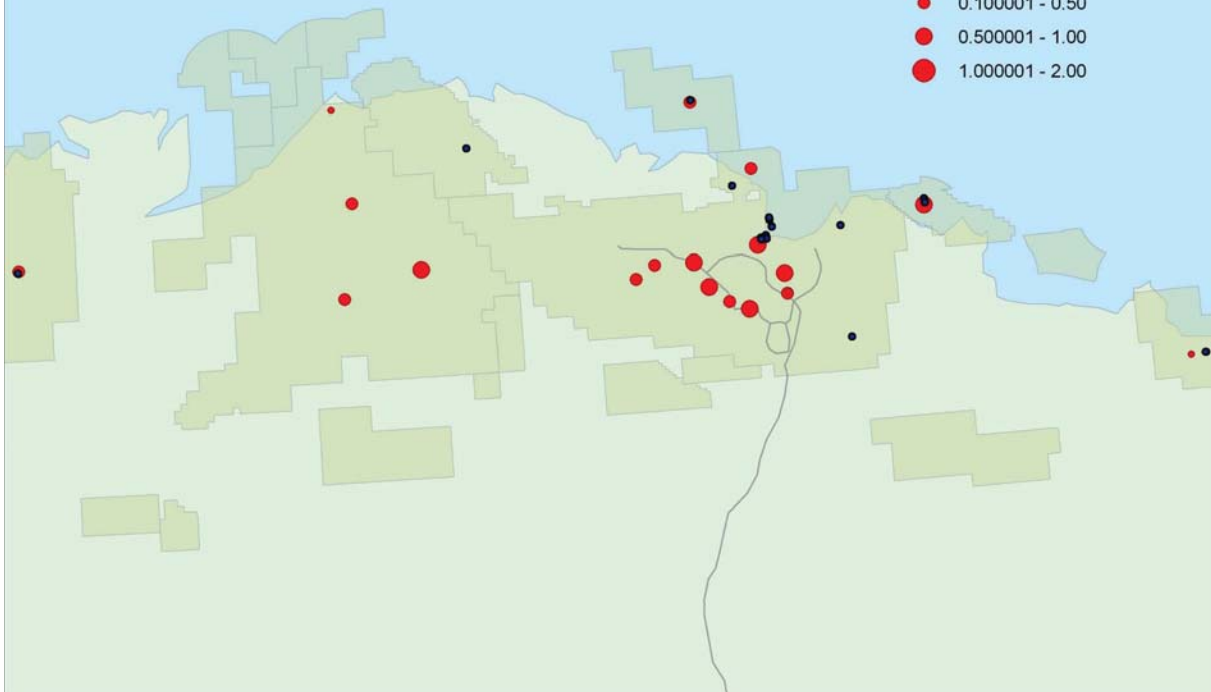
## Alaska North Slope Oil and Gas Accumulations



# Alaska North Slope GHG Emissions Sources

**NORTH SLOPE**  
CO<sub>2</sub> point sources (mMT) and  
gas injection wells

- Gas injection wells
- 0.000040 - 0.10
- 0.100001 - 0.50
- 0.500001 - 1.00
- 1.000001 - 2.00



**Cook Inlet**  
Oil and Gas  
Accumulations

**COOK INLET**  
CO<sub>2</sub> point sources (mMT) and  
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- Gas injection wells
- 0.000040 - 0.10
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## Prospective CO<sub>2</sub> Geologic Sinks

- **Oil and Gas Reservoirs**
  - Enhanced Oil Recovery
  - Depleted Reservoirs
- **‘Associated’ Saline Reservoirs**
- **‘New’ Saline Reservoirs**
- **Unmineable Coal Seams**
  - Enhanced Coal Bed Methane (ECBM)

## Prospective CO<sub>2</sub> Geologic Sinks

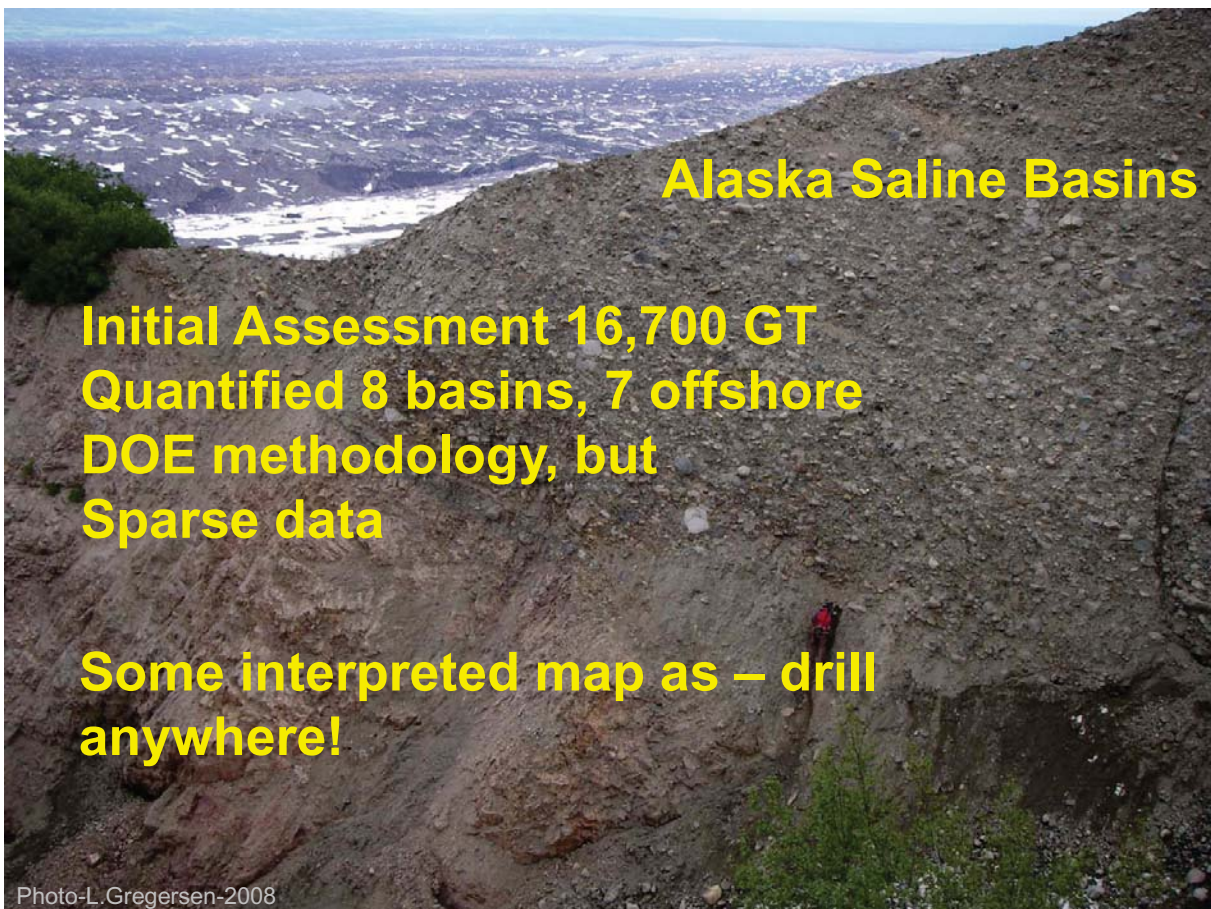
- **Oil and Gas Reservoirs – rich in data**
  - Enhanced Oil Recovery
  - Depleted Reservoirs
- **‘Associated’ Saline Reservoirs- more data**
- **‘New’ Saline Reservoirs – little data**
- **Unmineable Coal Seams - mixed**
  - Enhanced Coal Bed Methane (ECBM)

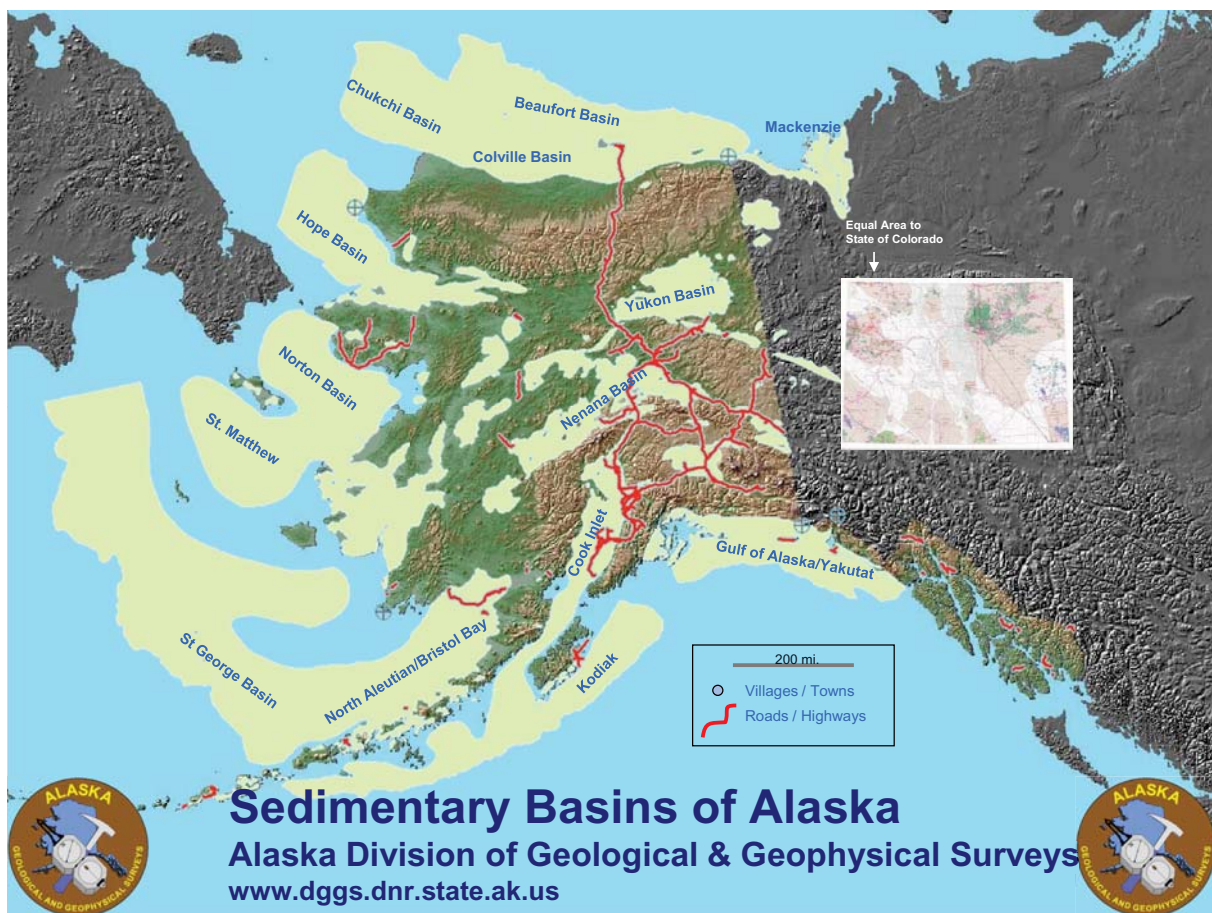


# Alaska Geologic Sinks

- **Oil and Gas Reservoirs**
  - Enhanced Oil Recovery
  - Depleted Reservoirs
- **'Associated' Saline Reservoirs**
- **'New' Saline Reservoirs**
- **Unmineable Coal Seams**
  - Enhanced Coal Bed Methane (ECBM)

WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP



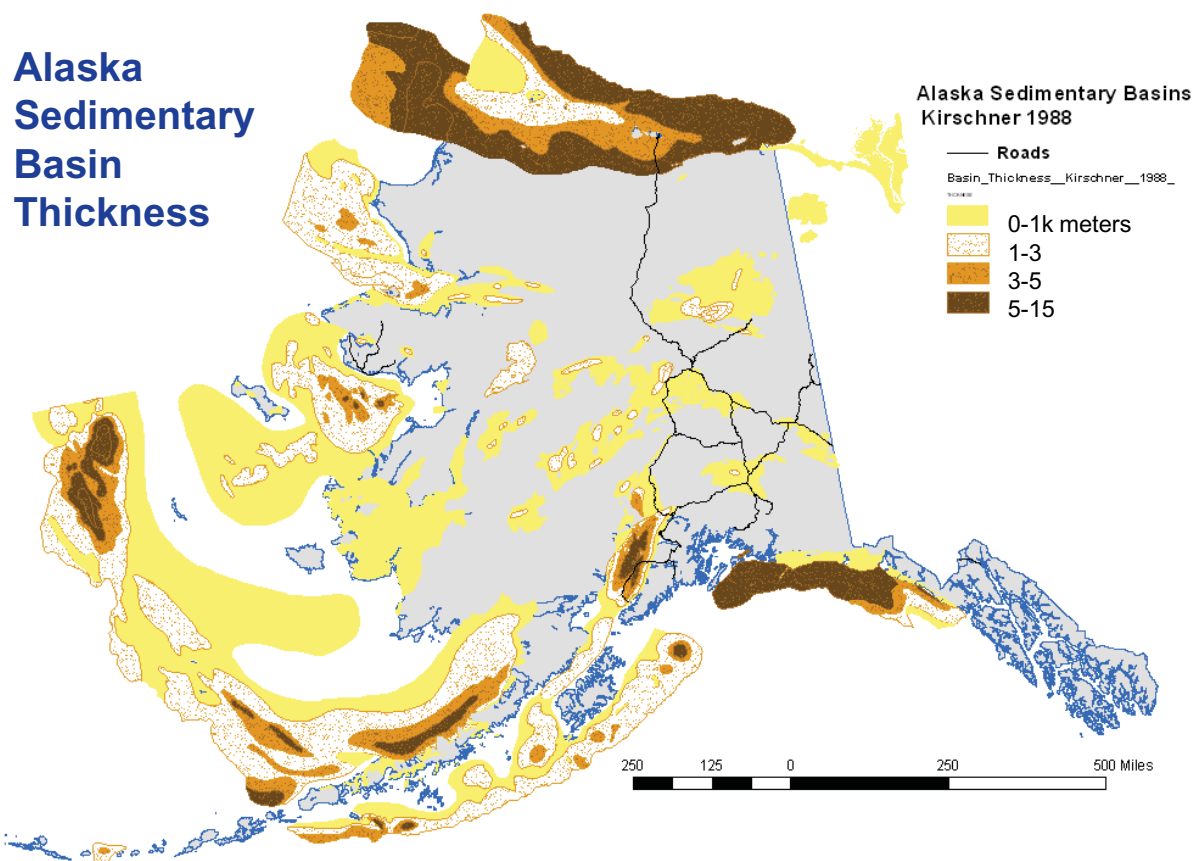


## Saline Reservoir Observations

- Offshore basins (except Cook Inlet) won't be used for other than local oil and gas emissions
  - Harsh environment
  - Ice some or most of the year
  - no infrastructure
  - far from emission sources
- Most interior basins predominantly unexplored, sparse to no wells, seal integrity unknown
- All interior basins (except NS) are Tertiary, non-marine (fresh waters) and structurally complex
- Most interior basins a long way from CO<sub>2</sub> sources

## Alaska Saline Basin Screening through integrating:

- Depth
- Amount and quality of data available to screen the basin
- Likelihood of sufficient porosity and permeability, traps and seals
- Distance from infrastructure and sources of CO<sub>2</sub>
- Likely depositional environment (impacting predictions of salinity)
- Contribution of seismic (tectonic activity) risk to long term storage risk





## Alaska Saline Basin Screening Attributes

Exploration Wells  
Seismic Coverage  
Depositional Environment  
(Salinity)  
Porosity and Permeability  
Oil and Gas Production  
Map Unit  
Seismic Risk  
Distance from infrastructure (offshore?)  
Reservoir and Seal Potential

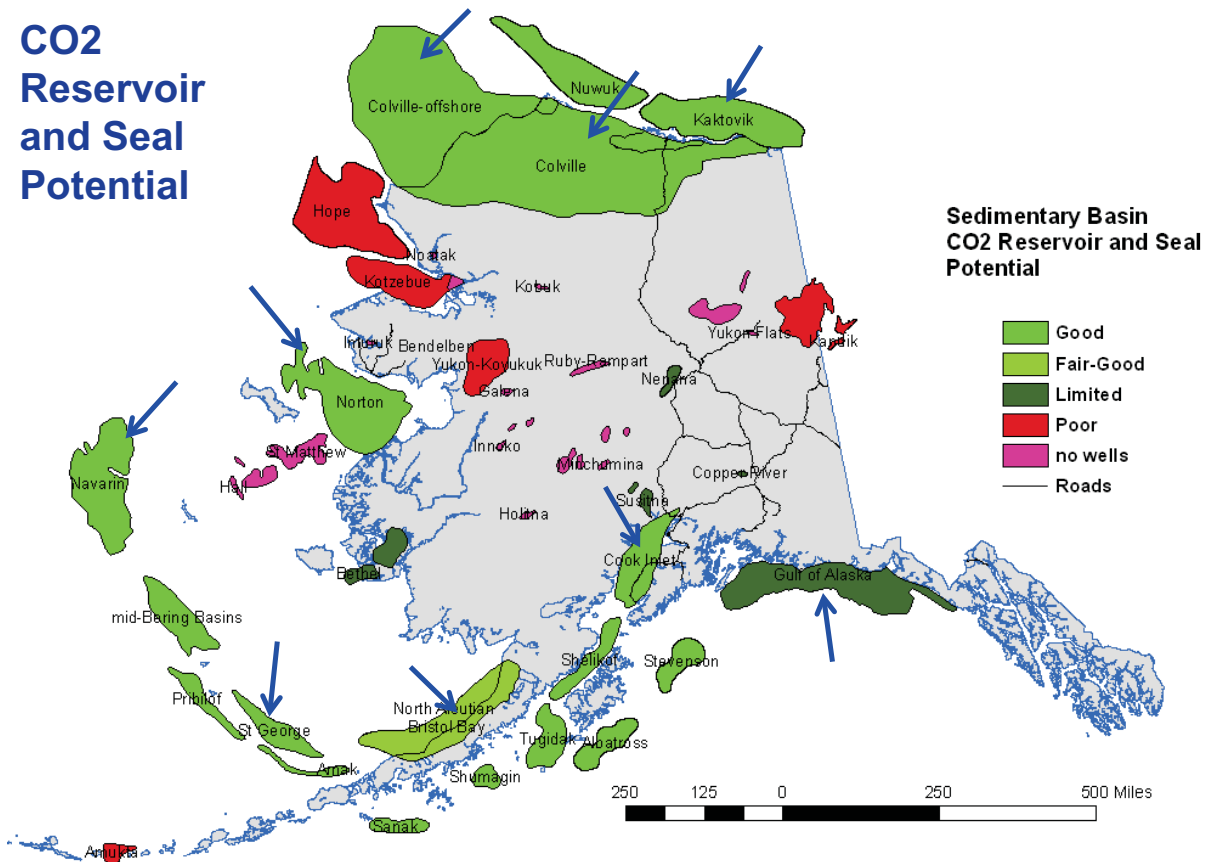
### Sequestration Potential

## Alaska Saline Basin Attributes

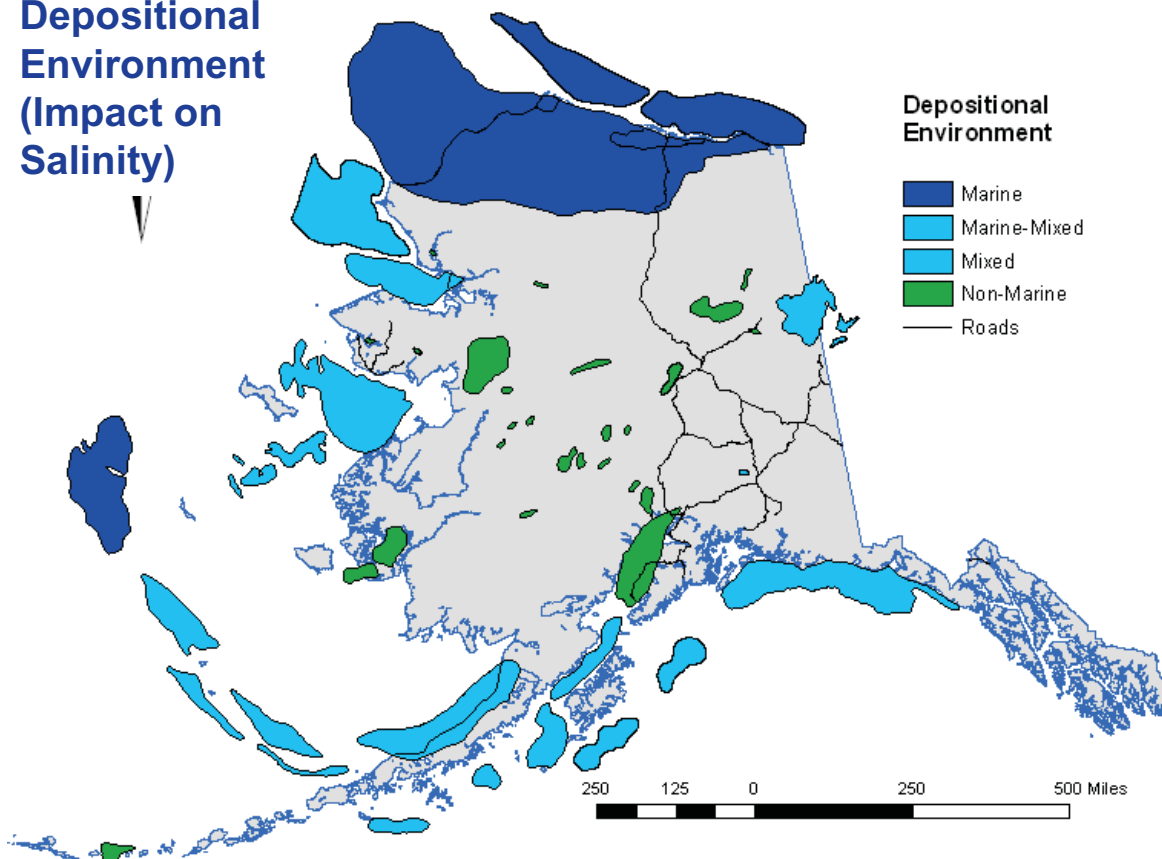
Exploration Wells  
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### Sequestration Potential

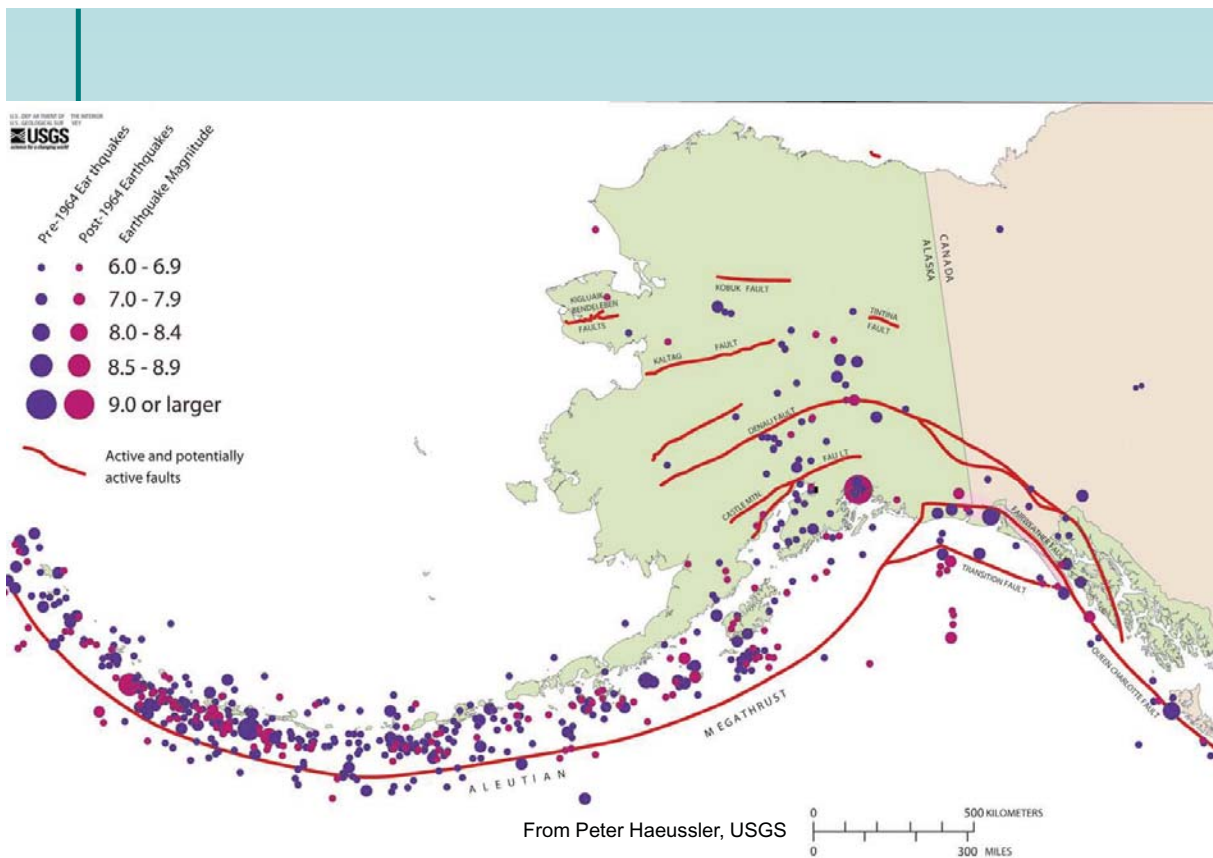
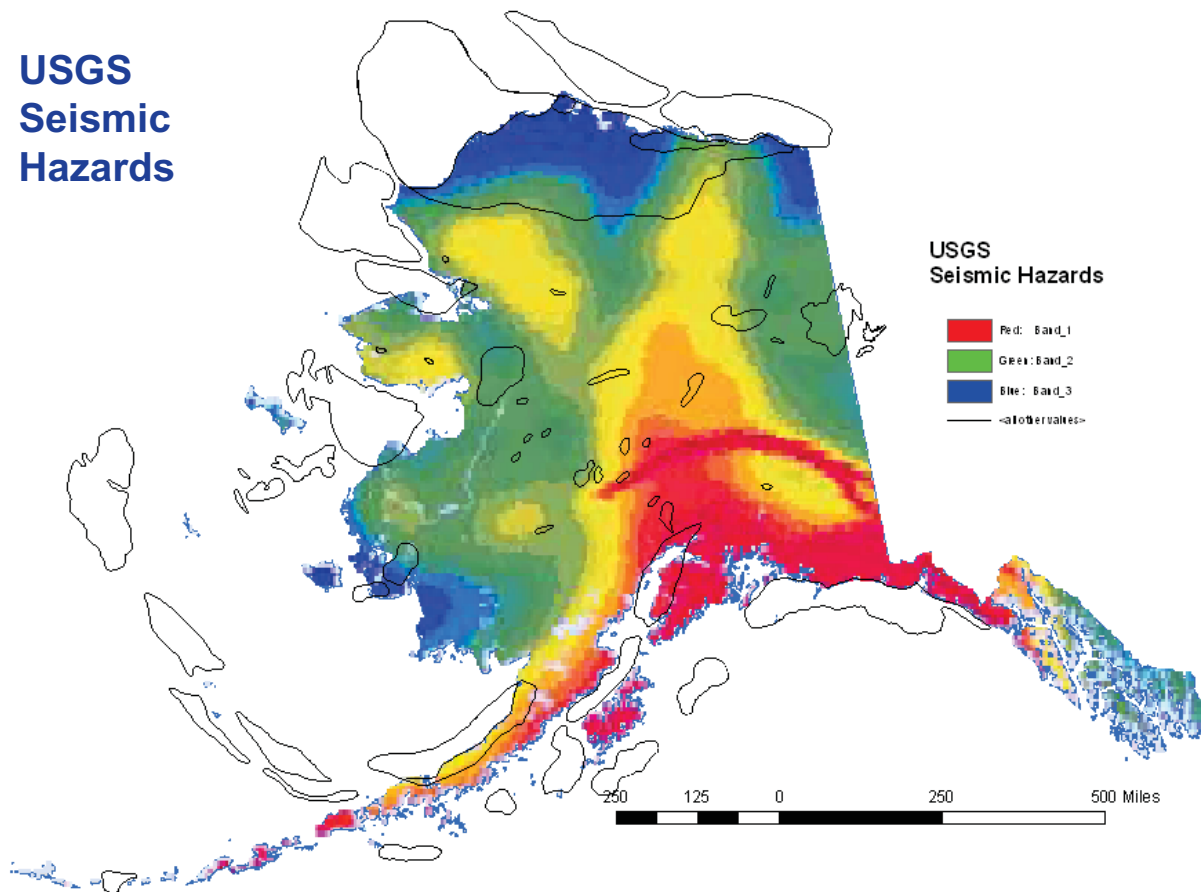
## CO2 Reservoir and Seal Potential



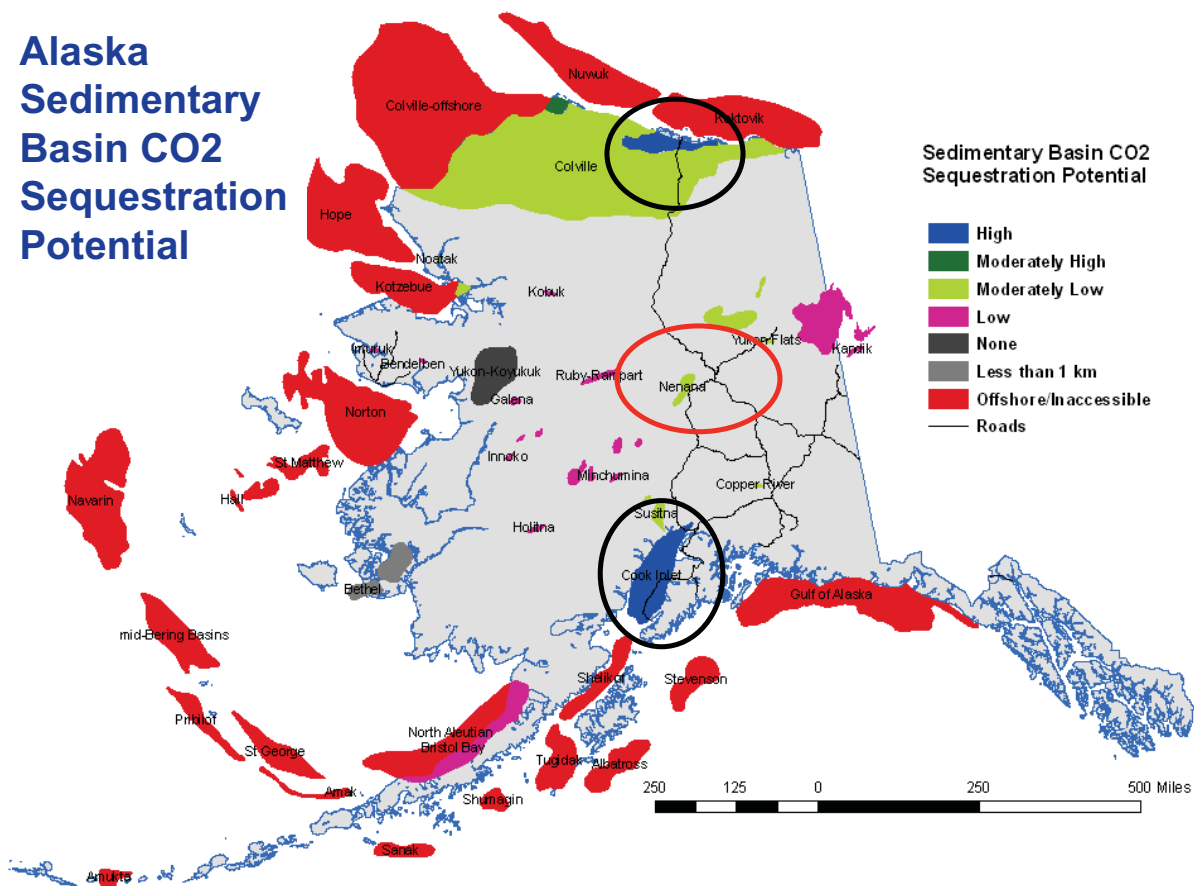
## Depositional Environment (Impact on Salinity)



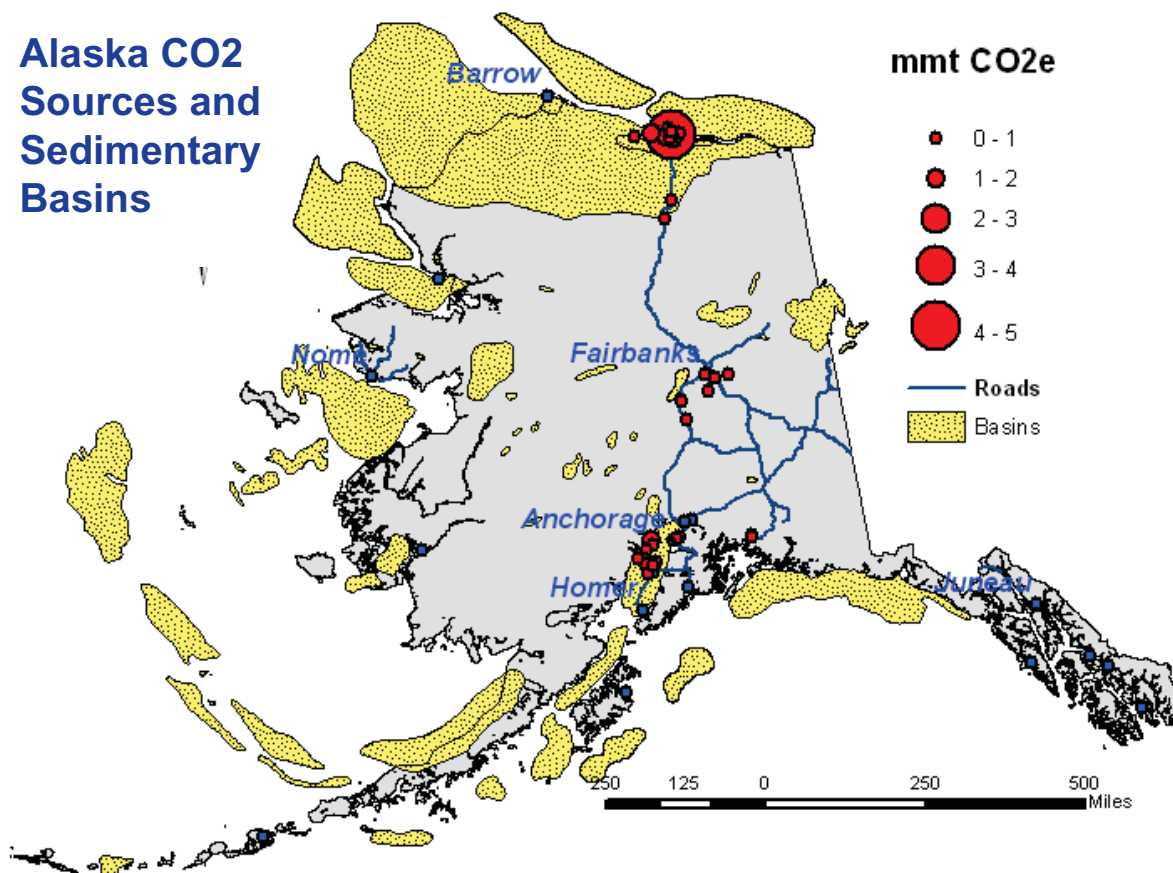
# USGS Seismic Hazards



## Alaska Sedimentary Basin CO2 Sequestration Potential



## Alaska CO2 Sources and Sedimentary Basins





## CO2 Factors in Storage Resource vs Capacity

### Resource includes

Physical Constraints –por,area, injection formation fracture propagation pressure, caprock capillary entry pressure, thickness,chemistry,salinity efficiency terms

### Capacity includes

Current Economic Conditions

CO2 injection rate and pressure, number and type of wells,expenses, distance from CO2 source

Requires adequate injection tests to measure injection rates, or at a minimim, in-situe permeability.

Regulatory

Protection of potable water, mim well spacing, max injection rates, surface usage considerations

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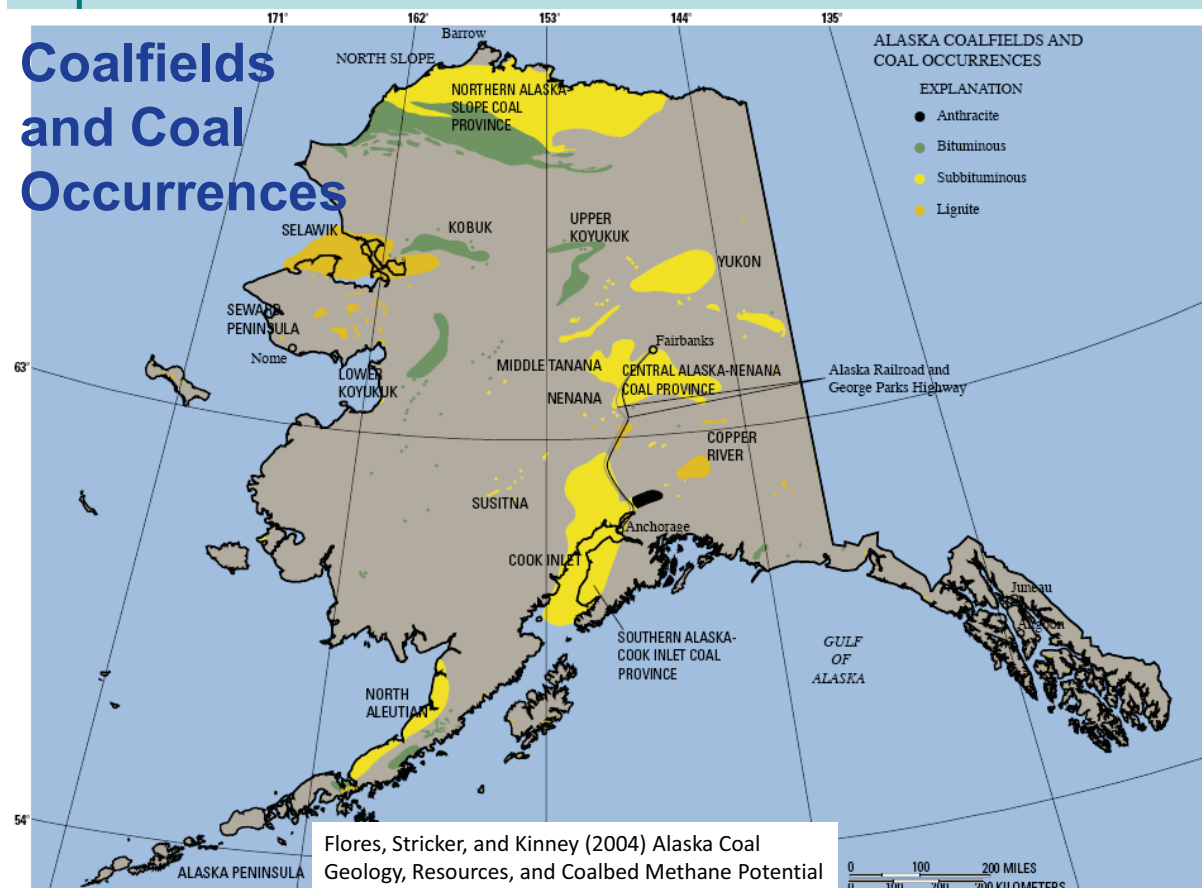


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Photo – D.Shellenbaum

# Coalfields and Coal Occurrences



## Alaska Coal Basin Storage Potential

Results summarized in report reflect augmented and refined estimates for storage potential for coal seams in Alaska by:

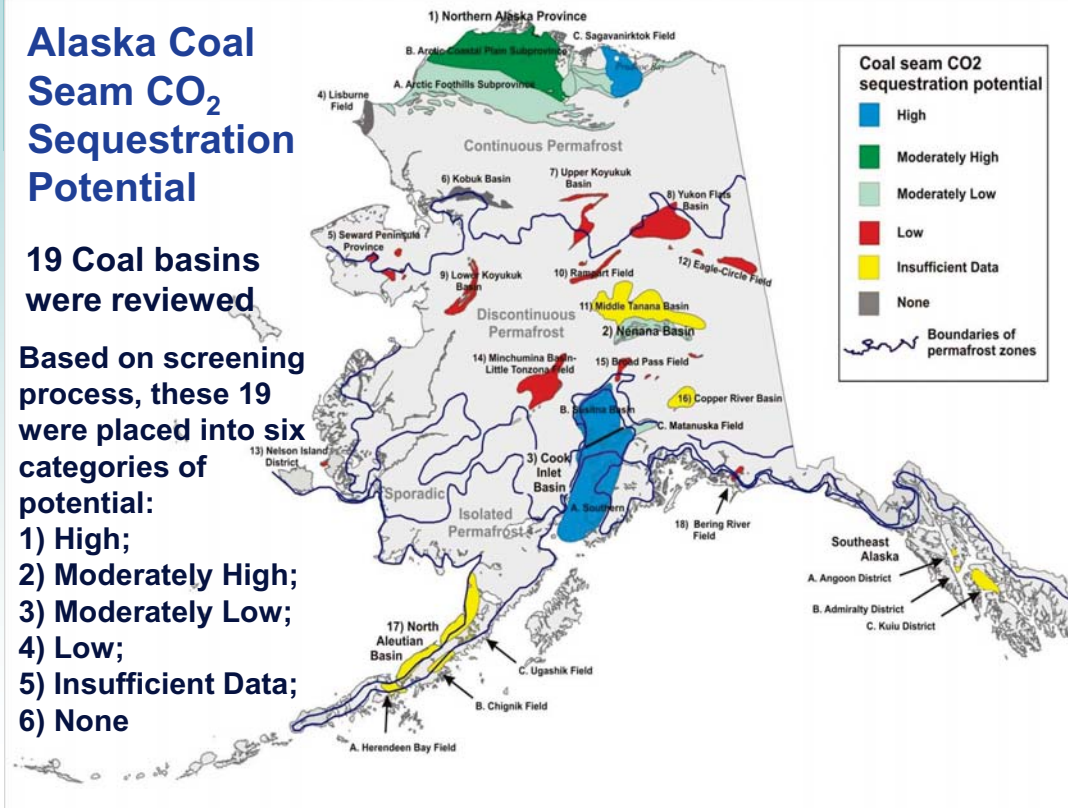
- Constraining the volumetric estimate of coal distribution and depth using new data and existing mapping, and
- Producing a derivative map of coal available for sequestration using filters that include coal rank, depth, lateral distribution, permafrost presence and depth, cleating and availability of infrastructure.

## Alaska Coal Seam CO<sub>2</sub> Sequestration Potential

19 Coal basins were reviewed

Based on screening process, these 19 were placed into six categories of potential:

- 1) High;
- 2) Moderately High;
- 3) Moderately Low;
- 4) Low;
- 5) Insufficient Data;
- 6) None



## 16 Coal Seam CO<sub>2</sub> Storage-related Attributes were determined for the nineteen Alaska coal basins

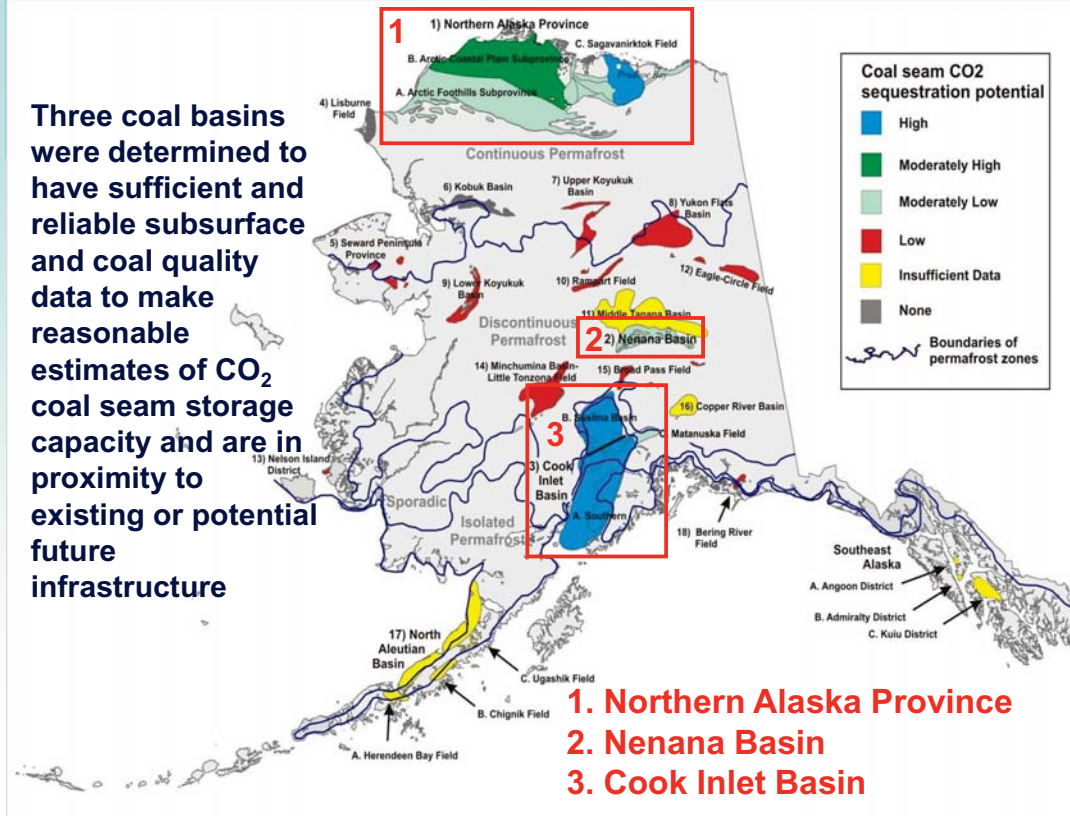
The following main attributes used in the screening process:

Basin Age  
Depositional Environment  
Structural Setting  
Rank of Coal  
Net Coal Thickness  
Coal Volume

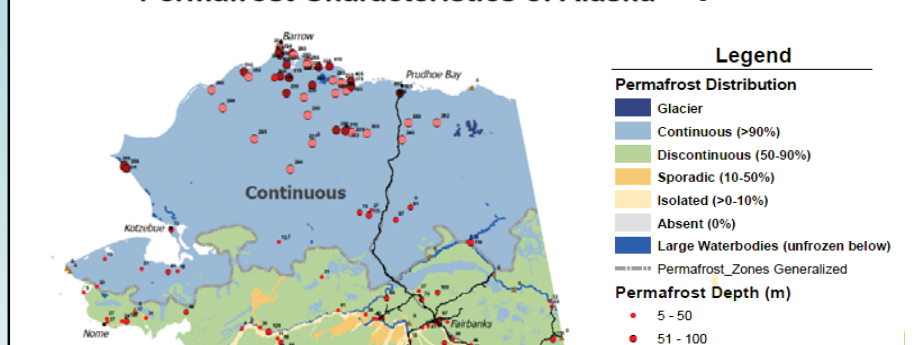
Coal Quality data  
CBM Data  
Infrastructure  
Type of Permafrost  
Depth of Permafrost



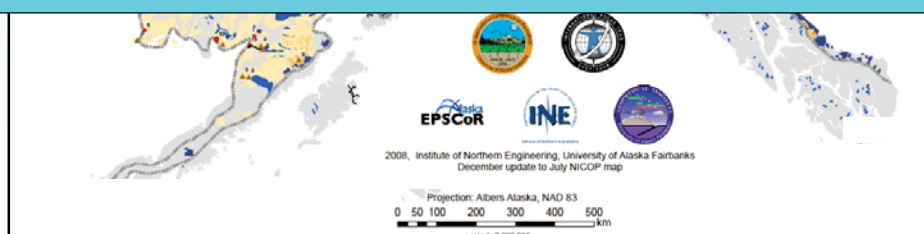
Three coal basins were determined to have sufficient and reliable subsurface and coal quality data to make reasonable estimates of CO<sub>2</sub> coal seam storage capacity and are in proximity to existing or potential future infrastructure



## Permafrost Characteristics of Alaska Jorgenson, et al., 2008



Therefore, storage of CO<sub>2</sub> in the North Slope region can only be considered within thick coal seams **beneath** the base of the permafrost that can extend to **depths of greater than 660 m**





**The presence of permafrost, and particularly the depth of the permafrost was a major factor in determining the CO<sub>2</sub> Storage Capacity of coal seams in the Northern Alaska Province.**

**This resulted in our much lower estimate of coal seam CO<sub>2</sub> storage capacity of 5.83 Gt than the 98 Gt reported by in earlier estimates by Stevens and Moodhe, 2009.**



*Ice wedge, Colville River*

Photo by Matt Bray, UAF GI



*Ice wedges in North Slope tundra*

Photo by Torre Jorgenson, UAF GI

## **Northern Alaska Province: Cretaceous-age Nanushuk Fm. and Tertiary-age Sagavanirktok Fm.**

**Thick Subbituminous to Bituminous coals (Nanushuk) and lignite (Sagavanirktok)**





## Thick Nanushuk Formation coal in Arctic Foothills Subprovince



Photo by Gary D. Stricker, USGS

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## Nanushuk Formation coal bed at Corwin Bluff



Photo by Gary D. Stricker, USGS

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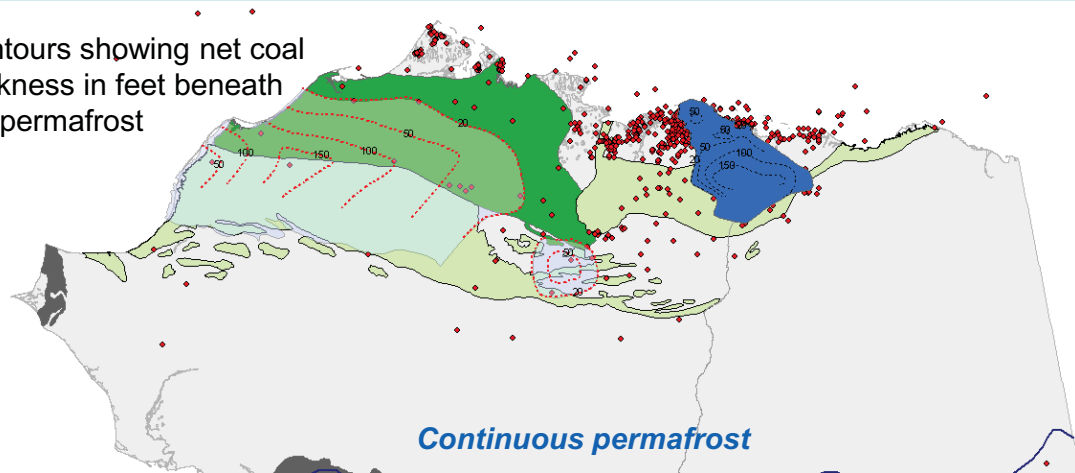
## Northern Alaska Province summary

Nanushuk Fm.- Thickest coals are to the west, where they also lie within the thick permafrost zone

Arctic Foothills and Coastal Plain subprovince – 5.83 Gt

Sagavanirktok Field - Thickest coals are in the vicinity of Prudhoe Bay, where permafrost is as thick as 660 m – 0.75 Gt

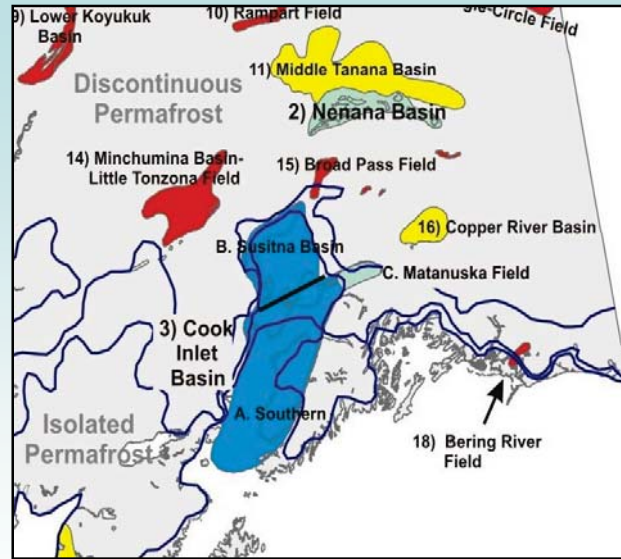
Contours showing net coal thickness in feet beneath the permafrost



West side of Cook Inlet- Tertiary coals of the Tyonek and Hemlock formations, near Redoubt Volcano

## Cook Inlet Basin

Contains extensive Tertiary-age coal resources in the Tyonek Formation at favorable depths for CO<sub>2</sub> sequestration. Includes both onshore and offshore deep unminable coal resources of 1,570 billion short tons. Extensive infrastructure of roads and pipelines, combined with nearby CO<sub>2</sub> emission sources makes this basin prospective for near-term CO<sub>2</sub> injection into coal seams



Permafrost is in the isolated to discontinuous zones and shallow where present, not affecting sequestration potential

## Cook Inlet- Tertiary coals of the Tyonek Formation, Beluga River



Photo by Bob Gillis, DGGS



## Cook Inlet- Cleating in the Tyonek Formation, Beluga River



## Cook Inlet- Capps coal bed, Capps Creek (Tyonek Formation)



Photo by Bob Gillis, DGGS

Similar thick and continuous coal seams are present in the subsurface

## Differences with earlier studies (Stevens and Moodhe, 2009)

REGION	COAL RESOURCES Billions of short tons	AVG COAL RANK	CO <sub>2</sub> Storage Capacity in Gt ARI Stevens & Moodhe, 2009	CO <sub>2</sub> Storage Capacity in Gt THIS STUDY
Arctic Foothills	1,290.00	Bituminous		5.08 Gt
Arctic Coastal Plain	1,910.00	Subbituminous		
Sagavanirktok Field	553.00	Subbituminous		0.75 Gt
<b>Total North Slope</b>	<b>3,753.00</b>		<b>98 Gt</b>	<b>5.83 Gt</b>
Nenana Basin	17.00	Lignite to subbituminous	0	0.41 Gt
Cook Inlet Basin: Southern, Susitna and Matanuska	1,570.30	Subbituminous to Anthracite	21 Gt	43.00 Gt
<b>TOTAL</b>	<b>5,340.30</b>		<b>119 Gt</b>	<b>49.24 Gt</b>

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<b>TOTAL</b>	<b>5,340.30</b>		<b>119 Gt</b>	<b>49.24 Gt</b>

## Updates from earlier studies (Stevens and Moodhe, 2009)

### Northern Alaska –

Addition significant impact of permafrost on permeability

98 Gt → 6 Gt (~6%)

From : Total Petroleum CBM Assessment of Roberts et al., 2008, that concluded with a much lower number (17.2 Tcf) of methane storage capacity (based on permafrost) than previous (621 Tcf)

## Updates from earlier studies (Stevens and Moodhe, 2009)

### Nenana Basin

Based on recent studies of lower rank coal CO<sub>2</sub> storage capacity, increased CO<sub>2</sub> storage capacity from 3:1 CO<sub>2</sub>:CH<sub>4</sub> ratio to 10:1 ratio

0 → 0.41 Gt storage

### Cook Inlet

Increased coal resource base from 1,290 billion short tons of coal and a CO<sub>2</sub>:CH<sub>4</sub> ratio of 3:1 to 1,570 billion short tons of coal and a CO<sub>2</sub>:CH<sub>4</sub> ratio of 7:1

21 Gt → 43 Gt



## Conclusions

- Capacity vs Resource matters – public perception important
- Additional work needed on quantifying saline resource, USGS methodology is preferred way forward
- Coal resource strongly impacted by permafrost
- More data is needed to fully quantify coal resource in many Alaska basins
- Coal capacity (?)

## Identified Alaska Projects

- EOR/EGR capacity for oil and gas fields
- Depleted Oil and Gas reservoir capacity
- Associated saline reservoir capacity
- New saline basin reservoir capacity near CO<sub>2</sub> sources

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## Who Owns/Manages Alaska?

**Private Ownership - 12.1%**  
45.2 Million Acres

**State of Alaska - 24.1%**  
89.8 Million Acres

**U.S. Government - 63.8%**  
238 Million Acres

Russian traders arrived in Alaska in the mid-1700s and established small, scattered trading posts and settlements. Alaska Natives (the Eskimo, Indian, and Aleut peoples) continued as the primary landowners during this period of Russian occupation. On October 18, 1867, Russia sold Alaska to the United States government. As a result, the federal government owned the Alaska Territory, approximately 373 million acres—about one-fifth the size of the rest of the U.S.



**State of Alaska - 89.8 million acres**

Under the terms of the Alaska Statehood Act of 1959, the federal government granted the new state 25% ownership of its total area. Approximately 100,350,000 acres were to be divided under three types of grants:

- 1) Community - 400,000 acres
- 2) National Forest Community - 400,000 acres
- 3) General - 102,550,000 acres

Additional territorial grants, for schools, university and mental health trust lands, totaling 1.2 million acres were combined with departmental lands.

All grants combined gave the State of Alaska approximately 100 million acres. To date, 89.8 million acres has been granted, with the balance expected to be granted by 2030.

**ANCSA Native Corporation (Private) - 39.3 million acres**

On December 18, 1971, P.L. 92-203, the Alaska Native Claims Settlement Act was signed into law. The purpose of ANCSA was to legislate the terms by which Alaska Natives could acquire title to their lands. This claim had been unresolved for more than 100 years since the United States purchased Alaska from Russia in 1867.

Native lands are private lands. ANCSA mandated the creation of regional and village native corporations to manage 44 million acres and payment of one billion dollars. Twelve regional corporations were created for the distribution of ANCSA land and money. Twelve of these shared in sections of 10 million acres, the thirteenth corporation, based in Seattle, received a cash settlement only. 224 village corporations, of 25 or more residents, shared 20 million acres. The remaining acres, which include historical sites and existing native-owned lands, went into a land pool to provide land to small villages of less than 25 people. To date, 39.3 million acres have been transferred to ANCSA corporations.

**Non-ANCSA Private & Local Government - 5.9 million acres**

Land in private ownership (other than Native land) comprises less than one percent of the total land in Alaska. Much of the best land for development around Alaska's communities is, or will be, privately owned. Private land development meets people's needs by providing places to live, work, shop and recreate. It also provides a tax base for cities and communities to help support public services.

Because local governments in Alaska have individual methods of transferring land into private ownership, land currently owned by them is grouped into this category.

Alaska is one-fifth the size of the conterminous 48 states.



**Bureau of Land Management - 82.5 million acres**

In Alaska, BLM's focus is conserving land, habitat for management, overseeing the Joint Pipeline Office in partnership with the state and other federal agencies with oversight responsibility of the Trans-Alaska Pipeline, and responding to the public demand for use of the land they manage.

**U.S. Fish & Wildlife Service - 78.8 million acres**

The USFWS manages 10 wildlife refuges in Alaska. The two largest are the Yukon-Charley National Preserve Refuge and the Wrangell-St. Elias National Preserve Refuge (ANWR), both of which are approximately 10 million acres.

**National Park Service - 52.4 million acres**

There are eight national parks in Alaska, including the two largest in the national park system:

Wrangell-St. Elias National Park & Preserve - 13,175,001 acres

Denali National Park & Preserve - 6,472,580 acres

Denali National Park & Preserve - 6,075,000 acres

Katmai National Park & Preserve - 4,500,220 acres

Lake Clark National Park & Preserve - 4,000,000 acres

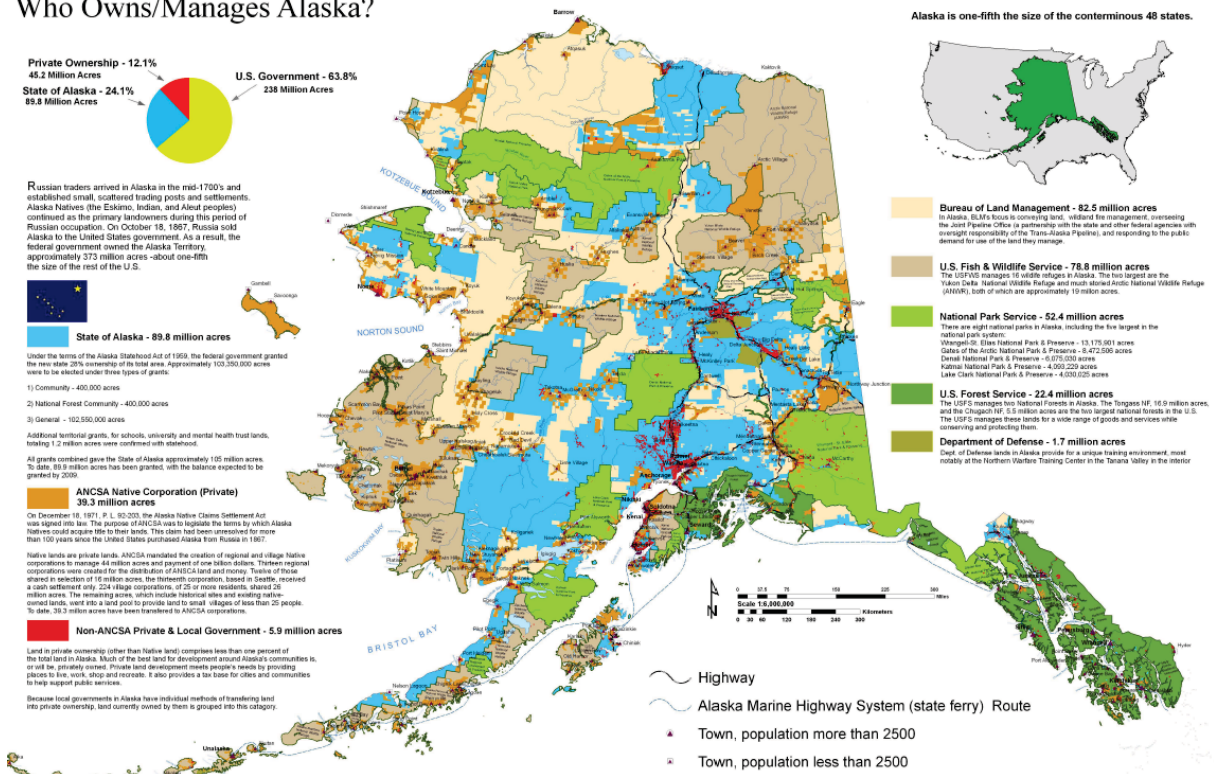
**U.S. Forest Service - 22.4 million acres**

The USFS manages two National Forests in Alaska. The Tongass NF, 16.9 million acres, and the Chugach NF, 5.5 million acres are the two largest National Forests in the U.S.

The USFS manages these lands for a wide range of goods and services while conserving and protecting them.

**Department of Defense - 1.7 million acres**

Dept. of Defense lands in Alaska provide for a unique training environment, most notably at the Northern Warfare Training Center in the Tanana Valley in the interior.





# Acknowledgments

## ***Alaska Department of Natural Resources***

Bob Swenson  
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Steve Roberts *(retired)*

## ***Advanced Resources International***

Keith Moodhe

Photo - P. Decker 2007

## **Alaska Department of Natural Resources**

### **Division of Oil and Gas**

*Activity Maps, Unit maps, sale information, Annual Reports, reports ...*

<http://www.dog.dnr.state.ak.us/oil/>

### **Division of Geologic and Geophysical Surveys**

*Geologic and Geophysical Publications, Projects, Energy, Volcanology, presentations ...*

<http://www.dggs.dnr.state.ak.us/>

*Thank You*



Photo courtesy of Alaska Volcano  
Observatory, Tom Hamish, 9-25-06