WESTCARB Annual Business Meeting

Alaska: Assessment of Saline Formation and Deep Coalbed Storage Potential

Diane Shellenbaum
Petroleum Geophysicist
Alaska Division of Oil and Gas

Jim Clough
Senior Geologist
Alaska Division of Geological and Geophysical Surveys

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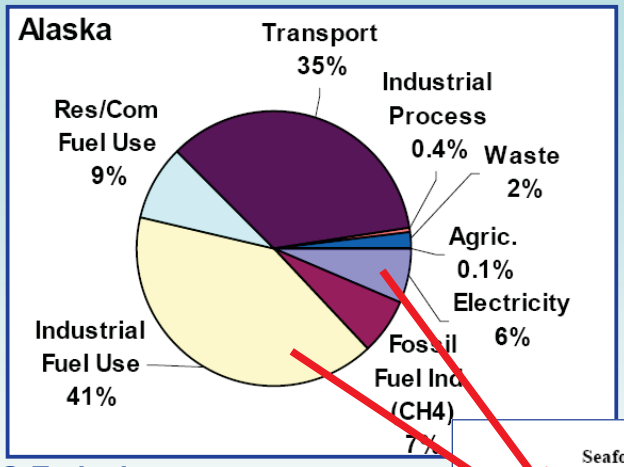
Outline

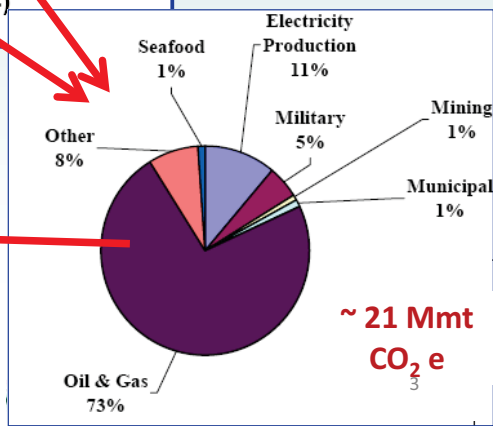
- **Background**
  - Alaska CO_2 Sources
  - Alaska Geologic Sequestration Potential
- **Saline Basin Potential (qualitative)**
- **Unmineable Coal Seam Assessment**
- **Conclusions**

Alaska Gross GHG Emissions by Sector (2005)

~ 52 Mmt CO_2e

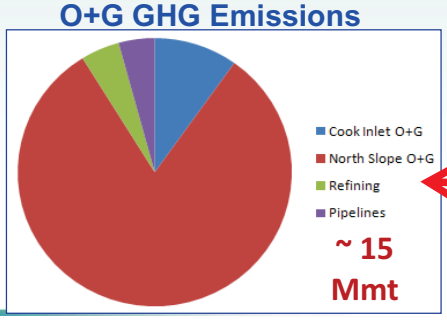


Alaska Title V GHG Emissions



~ 21 Mmt CO_2 e

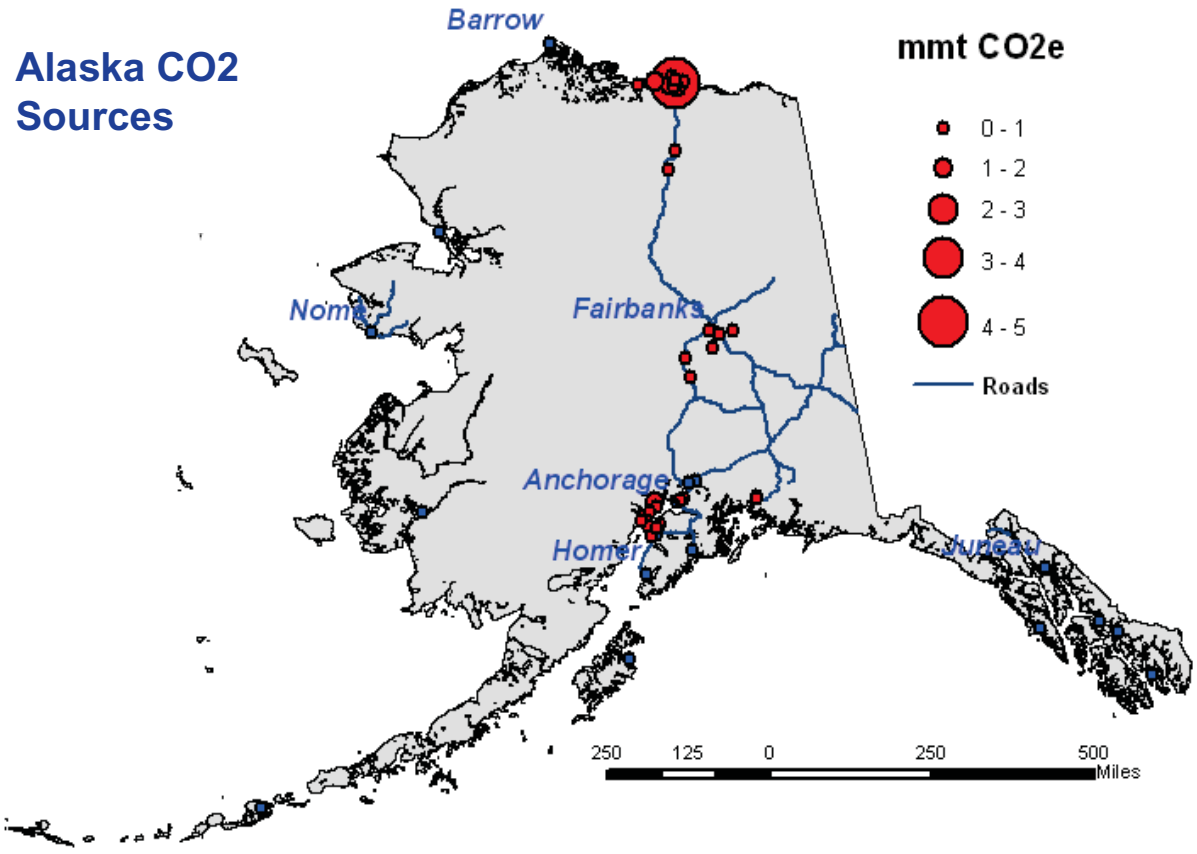
O+G GHG Emissions



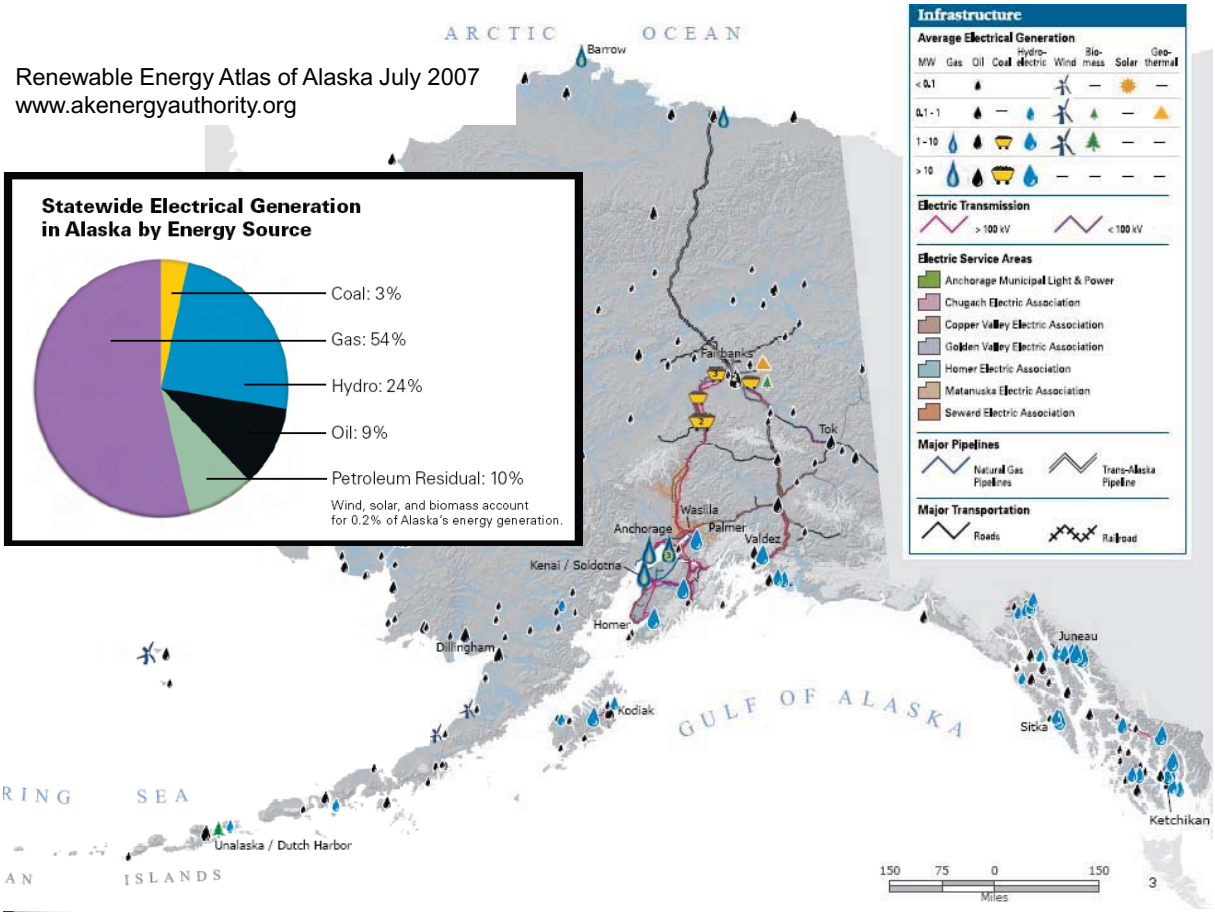
~ 15 Mmt

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

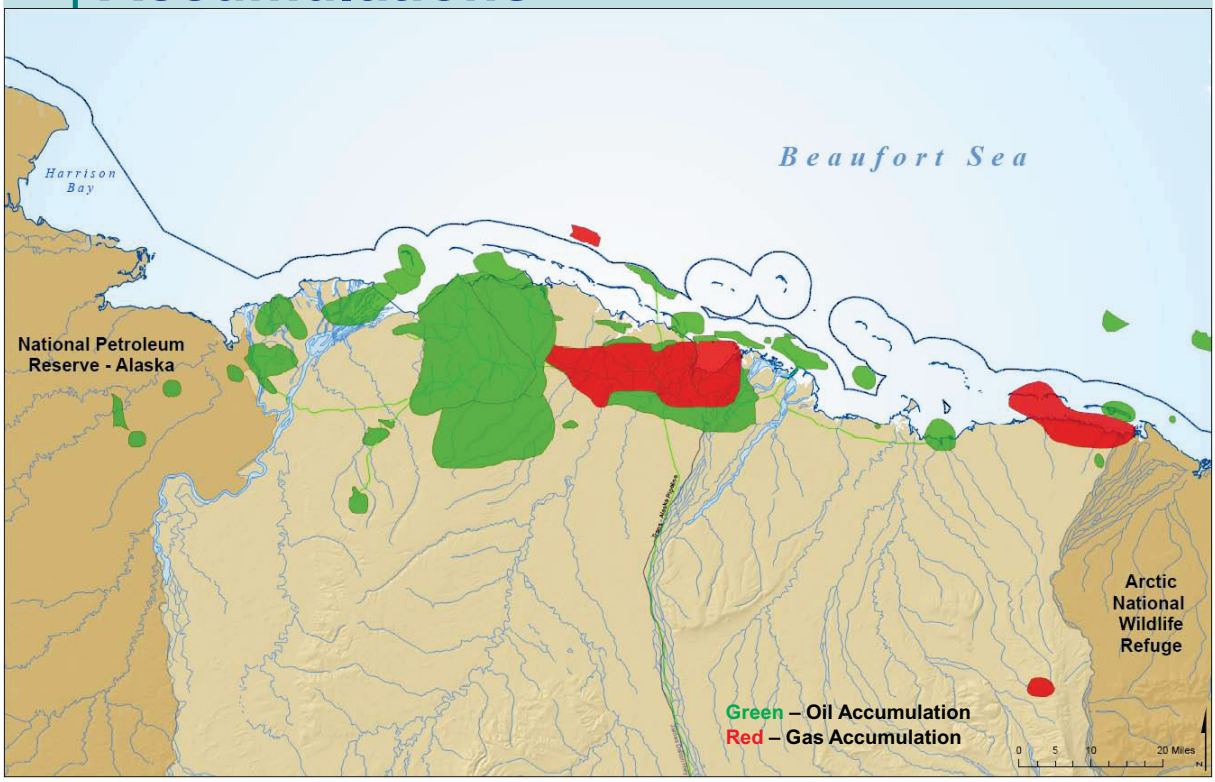
Alaska CO2 Sources



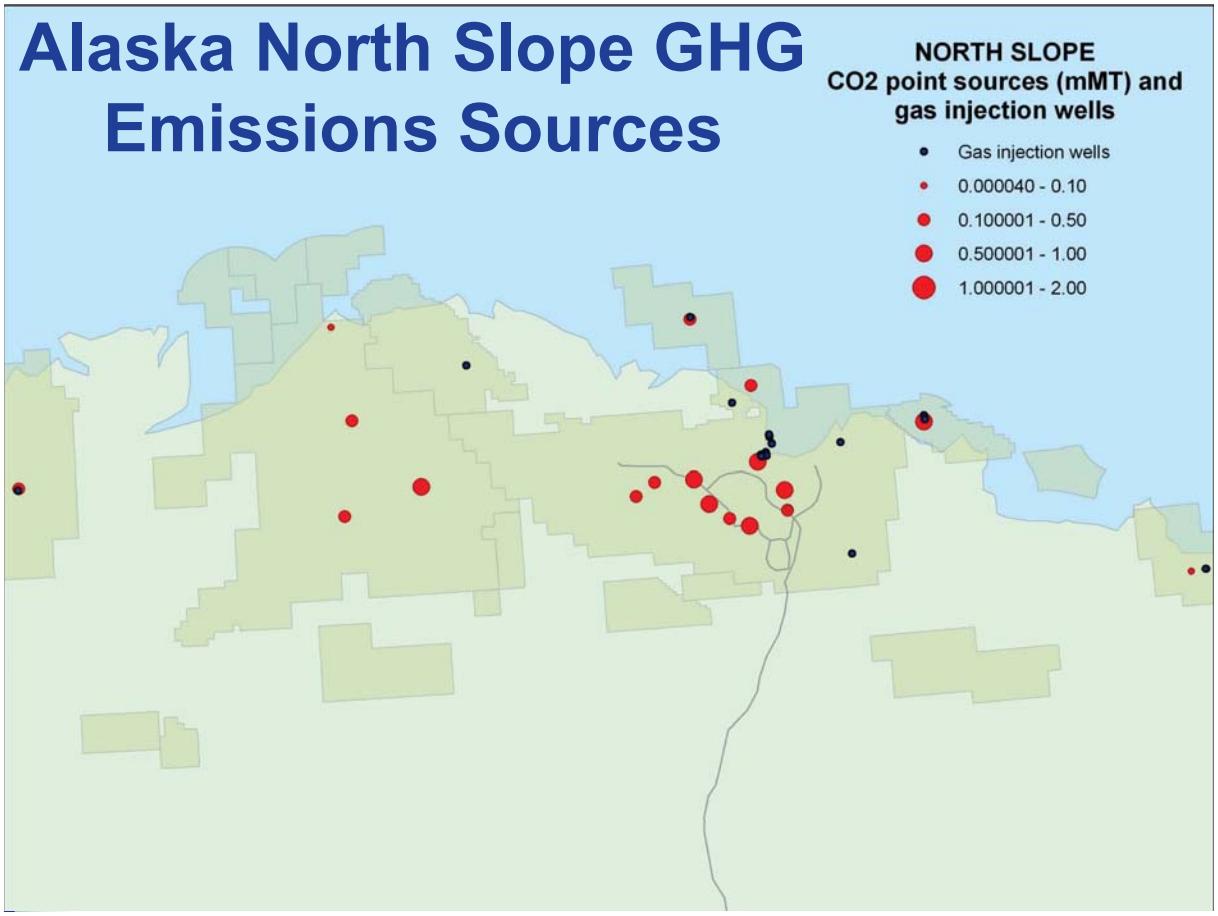
Renewable Energy Atlas of Alaska July 2007
www.akenergyauthority.org



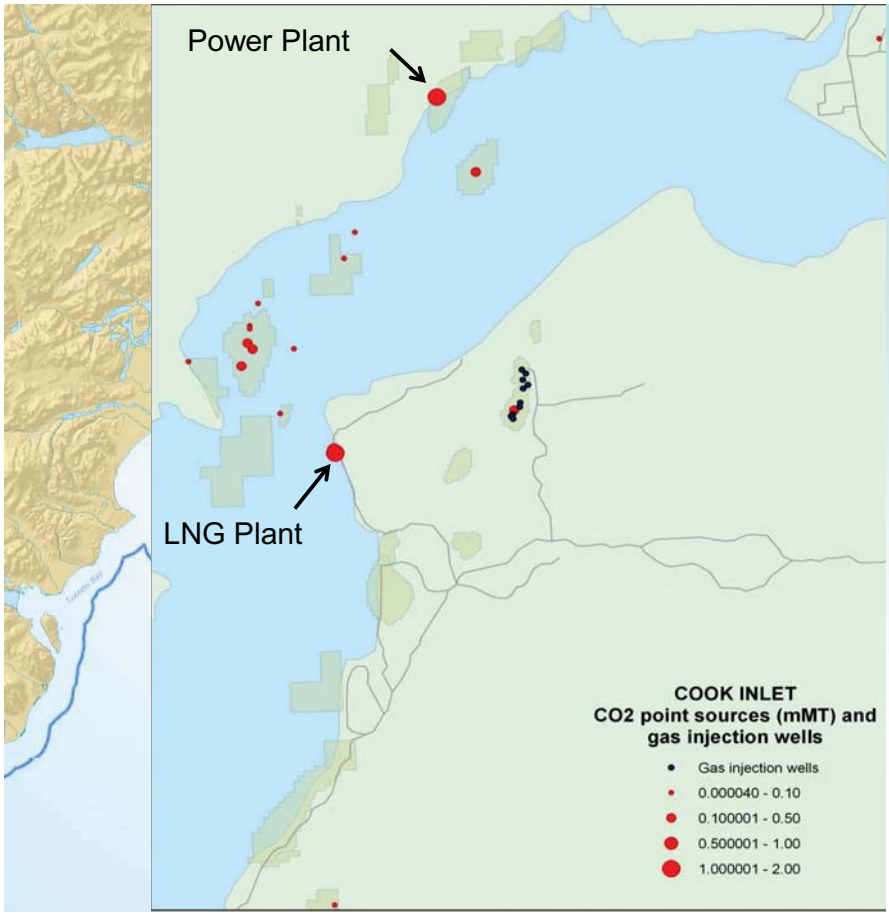
Alaska North Slope Oil and Gas Accumulations



Alaska North Slope GHG Emissions Sources



Cook Inlet Oil and Gas Accumulations



Prospective CO_2 Geologic Sinks

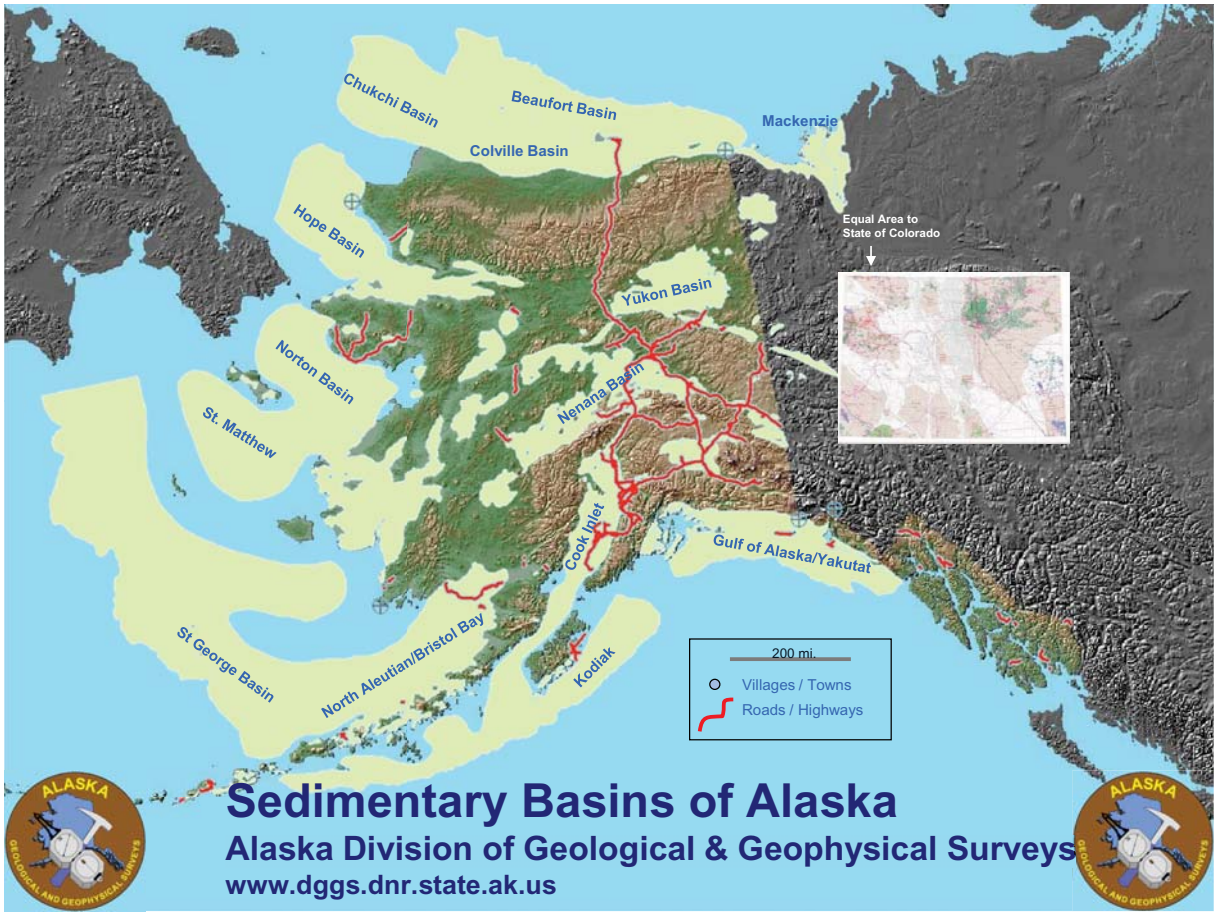
- **Oil and Gas Reservoirs**
  - Enhanced Oil Recovery
  - Depleted Reservoirs
- **'Associated' Saline Reservoirs**
- **'New' Saline Reservoirs**
- **Unmineable Coal Seams**
  - Enhanced Coal Bed Methane (ECBM)

Prospective CO_2 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)



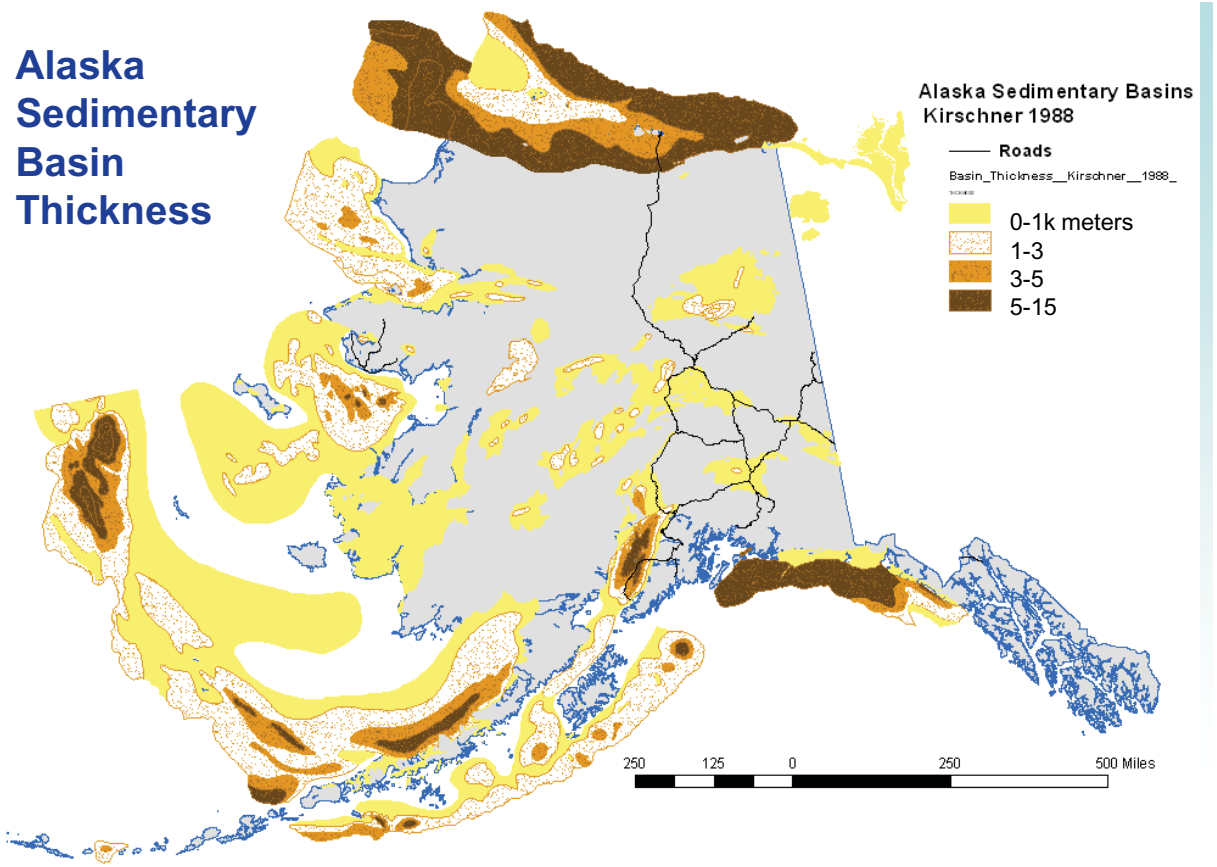
Saline Reservoir Observations

- 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_2 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_2
- Likely depositional environment (impacting predictions of salinity)
- Contribution of seismic (tectonic activity) risk to long term storage risk

Alaska Sedimentary Basin Thickness



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

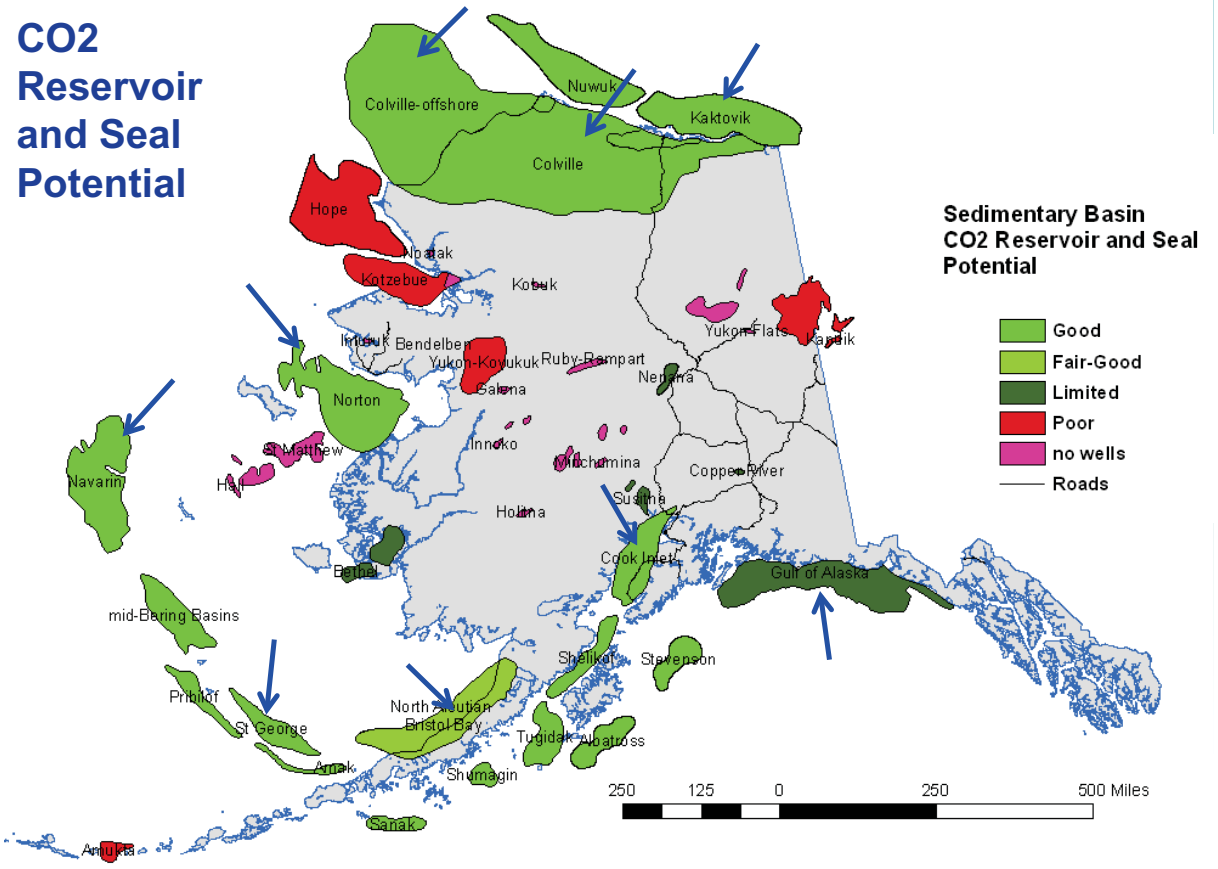
Sequestration Potential

Alaska Saline Basin Attributes

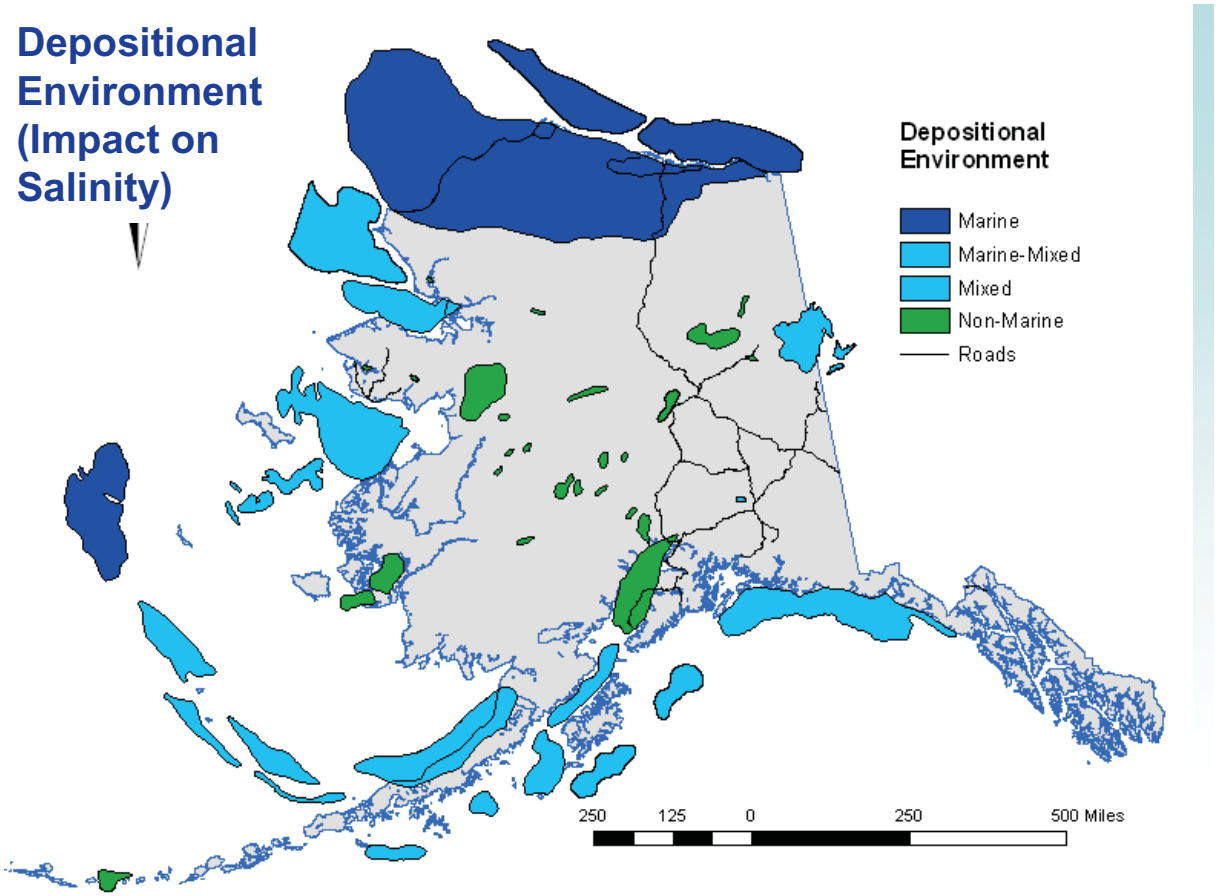
Exploration Wells
Seismic Coverage
Depositional Environment
(Salinity)
Porosity and Permeability
Oil and Gas Production
Map Unit
Seismic Risk
Distance from infrastructure (offshore?)
Reservoir and Seal Potential

Sequestration Potential

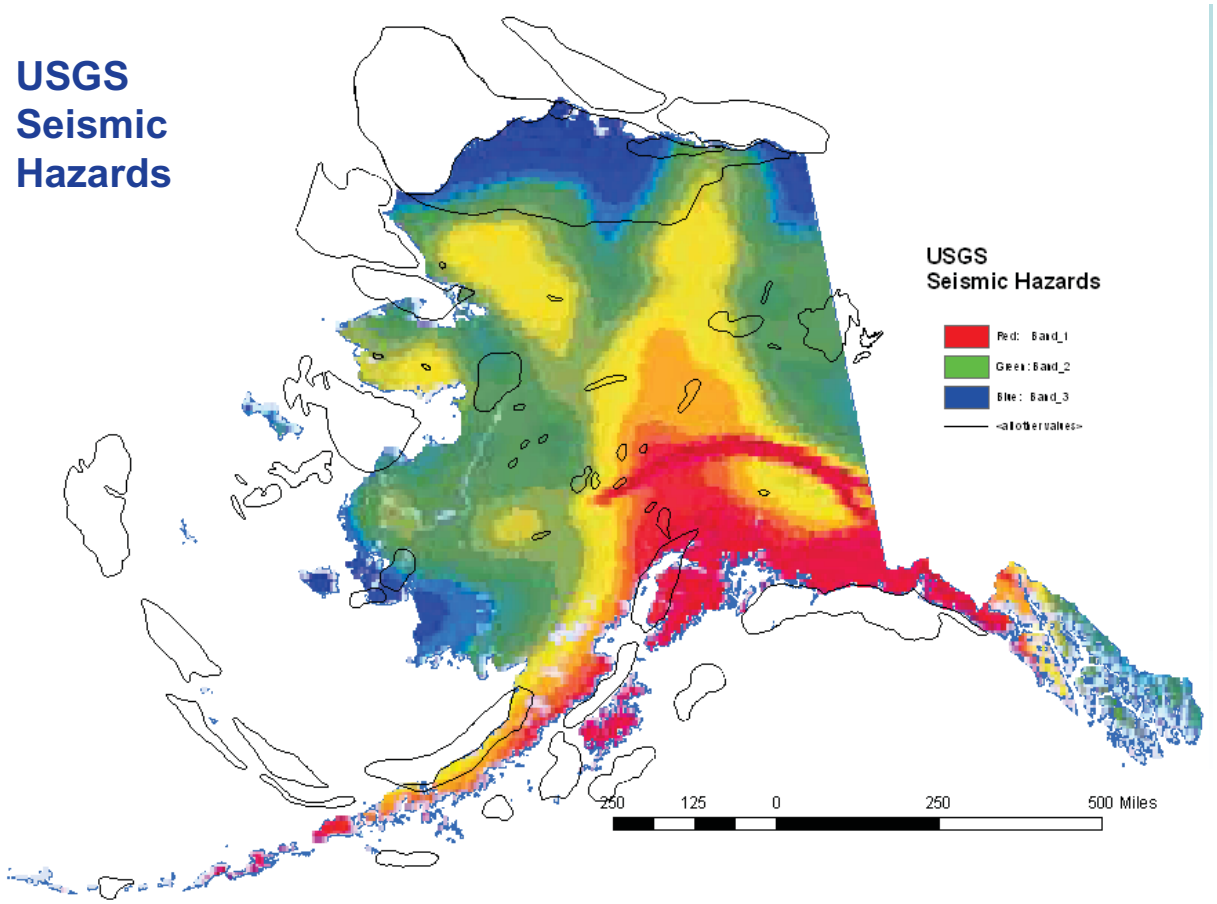
CO2 Reservoir and Seal Potential

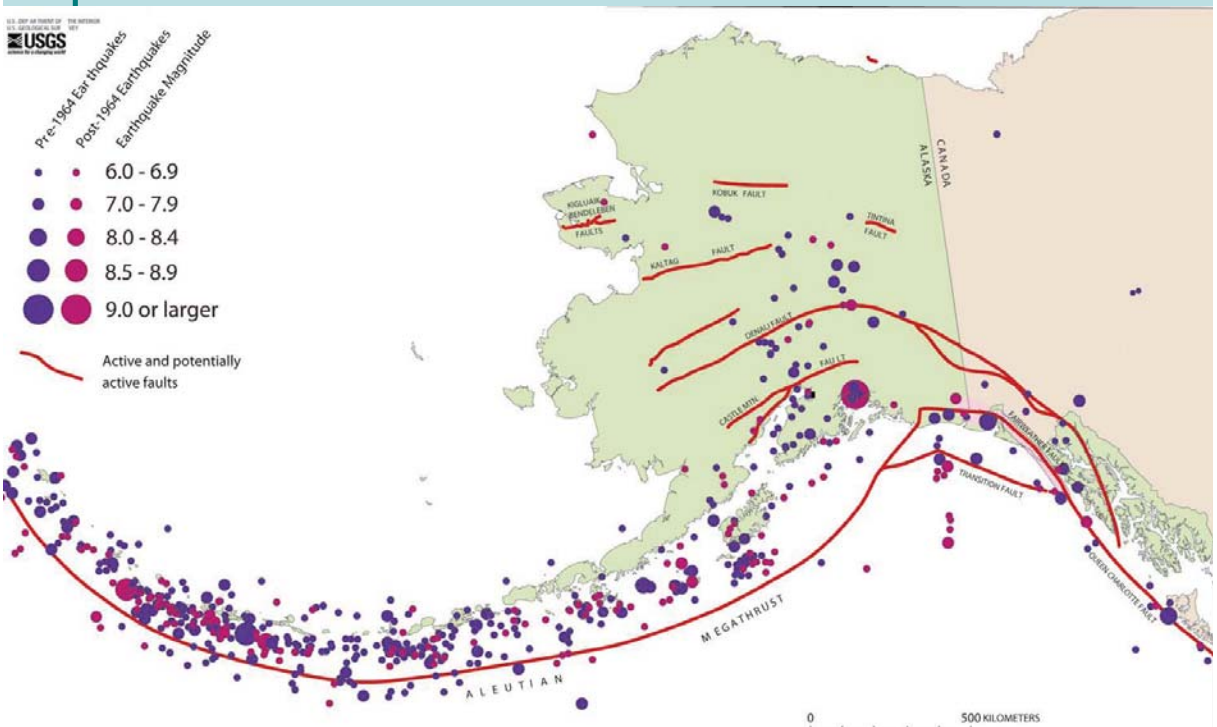


Depositional Environment (Impact on Salinity)



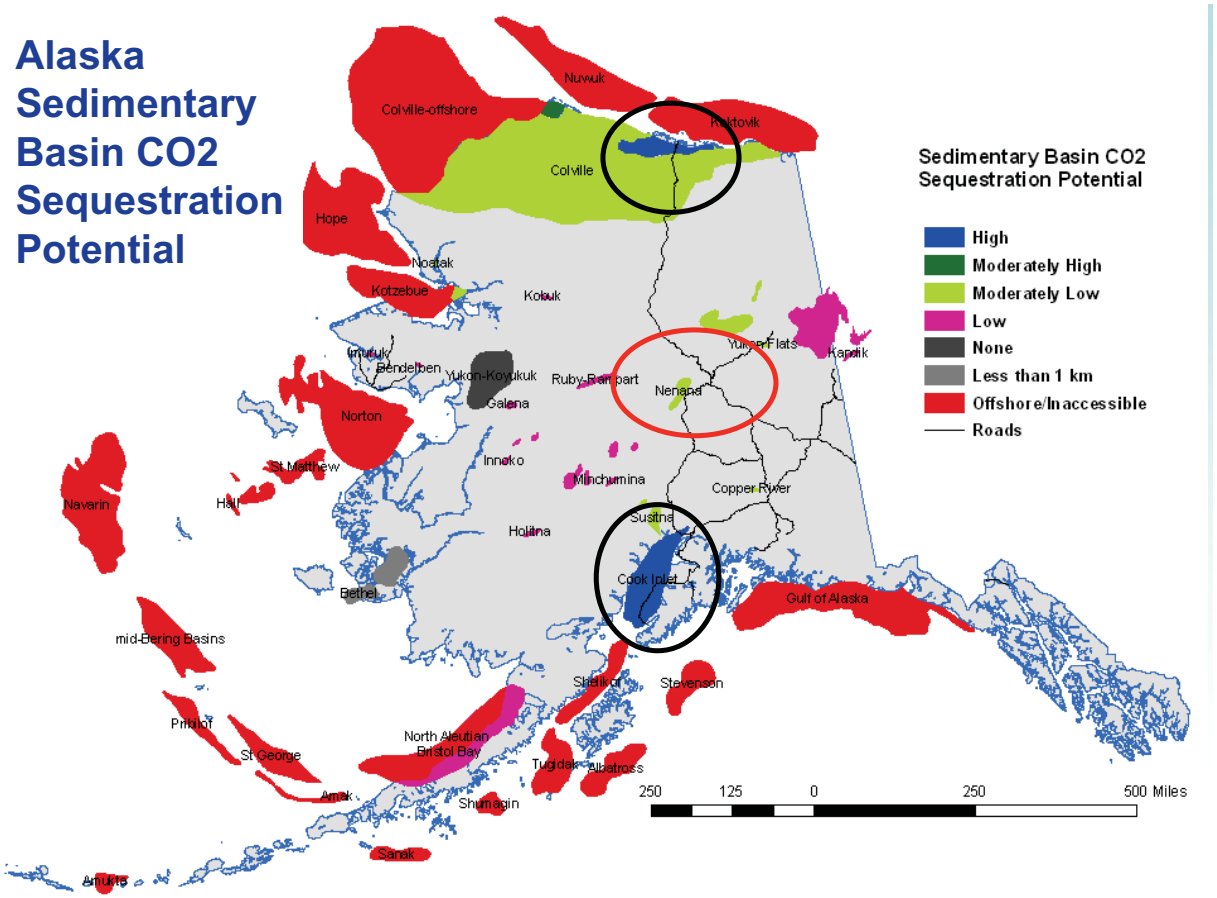
USGS Seismic Hazards



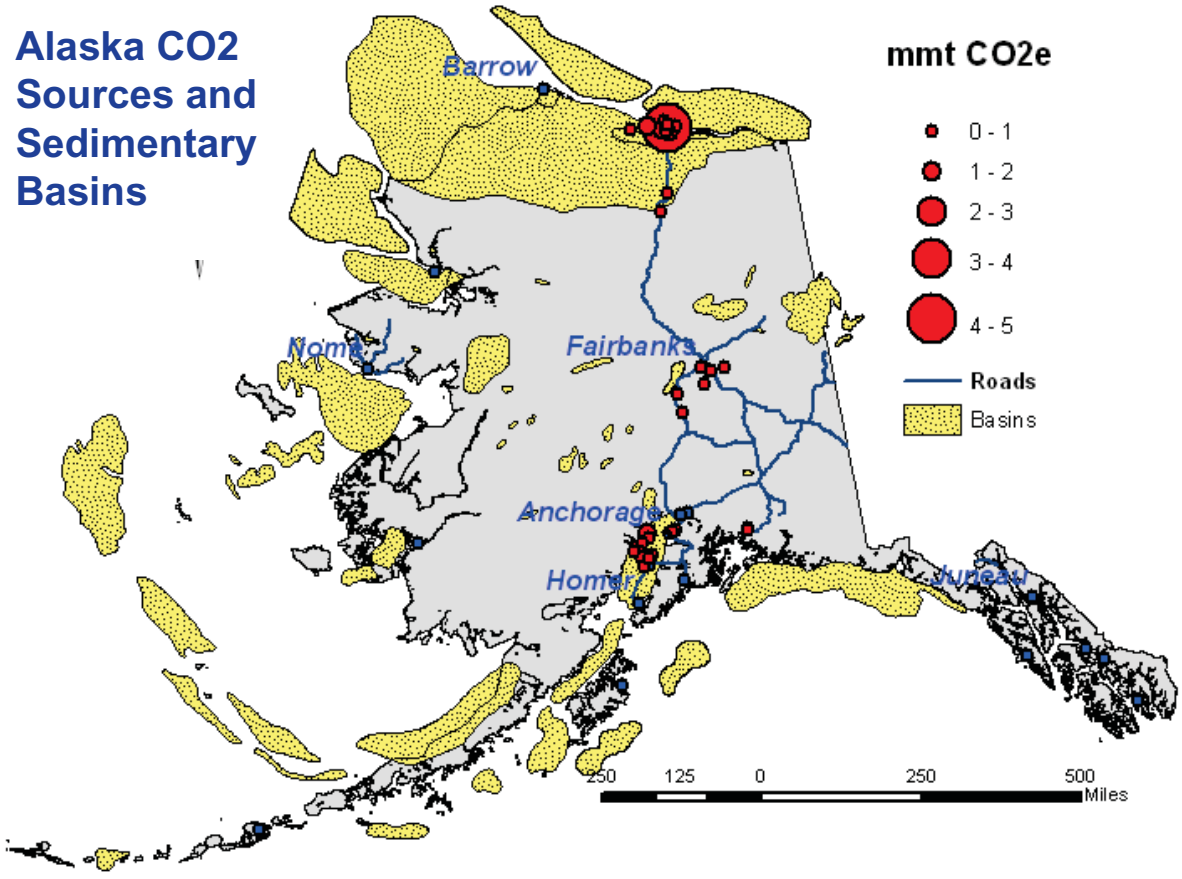


From Peter Haeussler, USGS

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

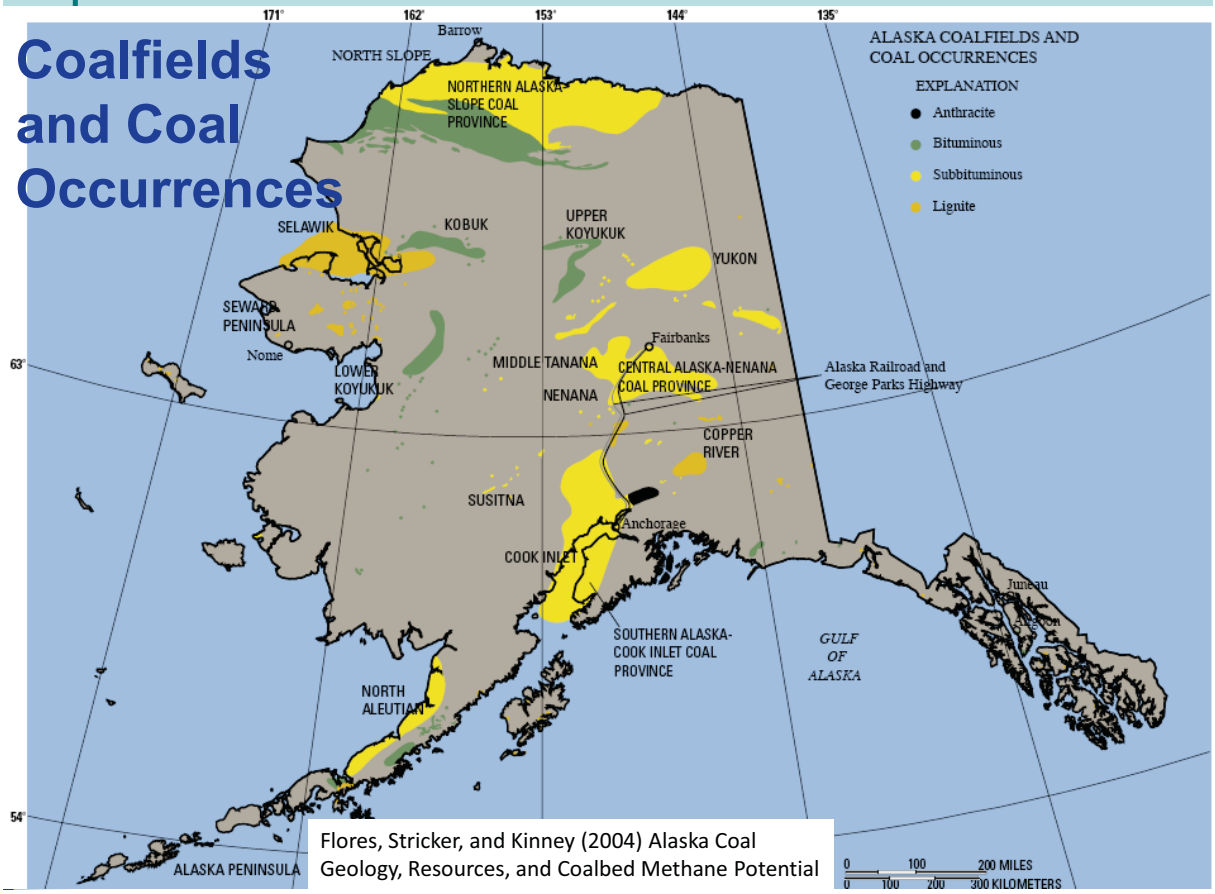
CO2 injection rate and pressure, number and type of wells,expenses, distance from CO2 source

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

Coalfields and Coal Occurrences



Flores, Stricker, and Kinney (2004) Alaska Coal Geology, Resources, and Coalbed Methane Potential

Alaska Coal Basin Storage Potential

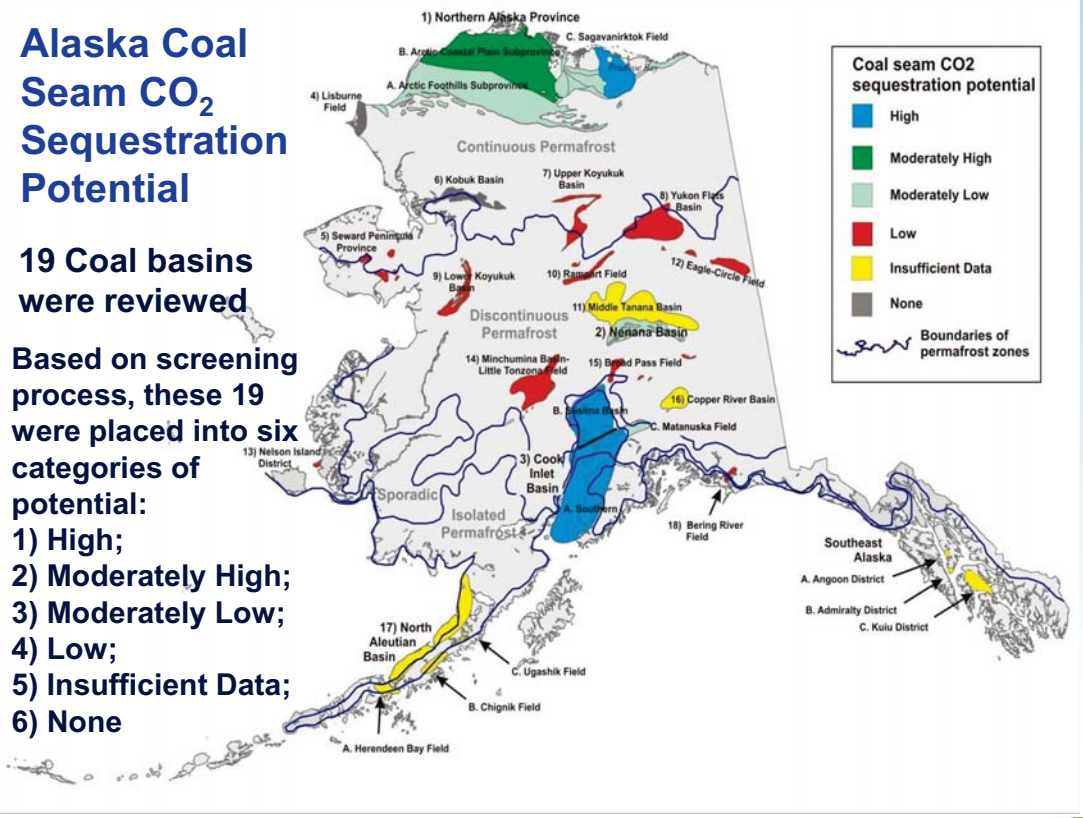
Results summarized in report reflect augmented and refined estimates for storage potential for coal seams in Alaska by:

- 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_2 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

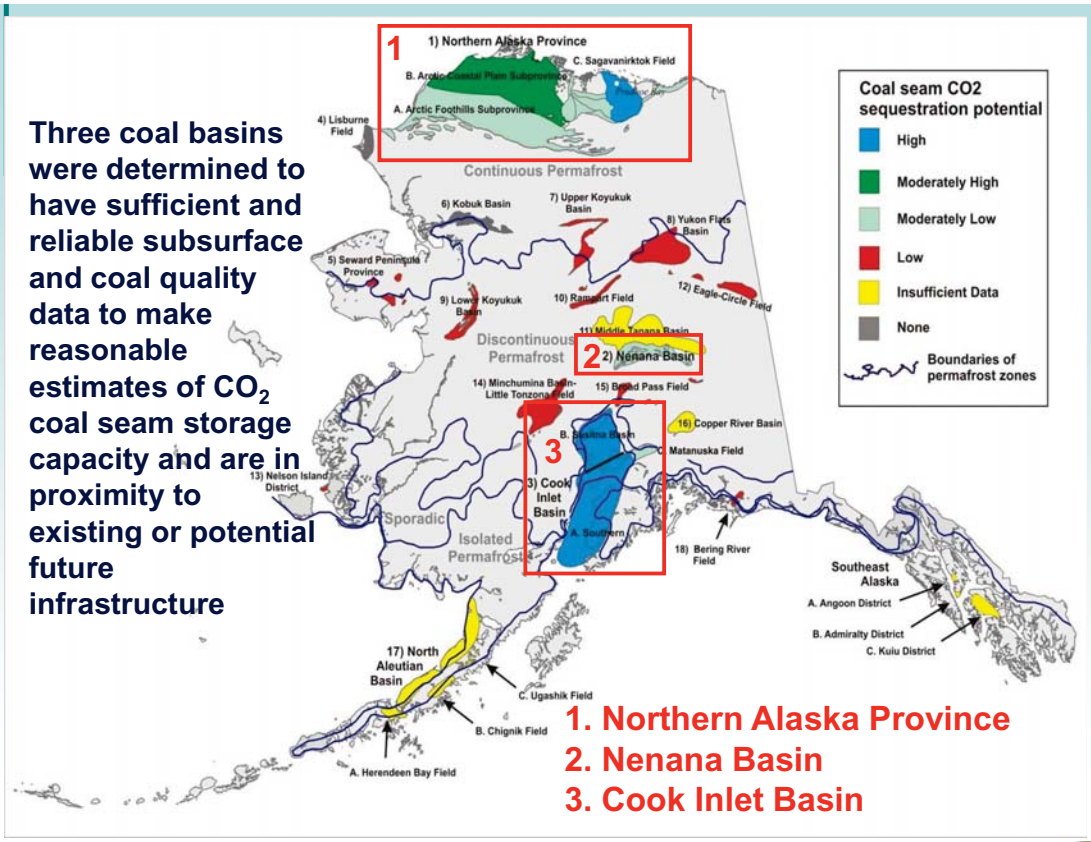


16 Coal Seam CO_2 Storage-related Attributes were determined for the nineteen Alaska coal basins

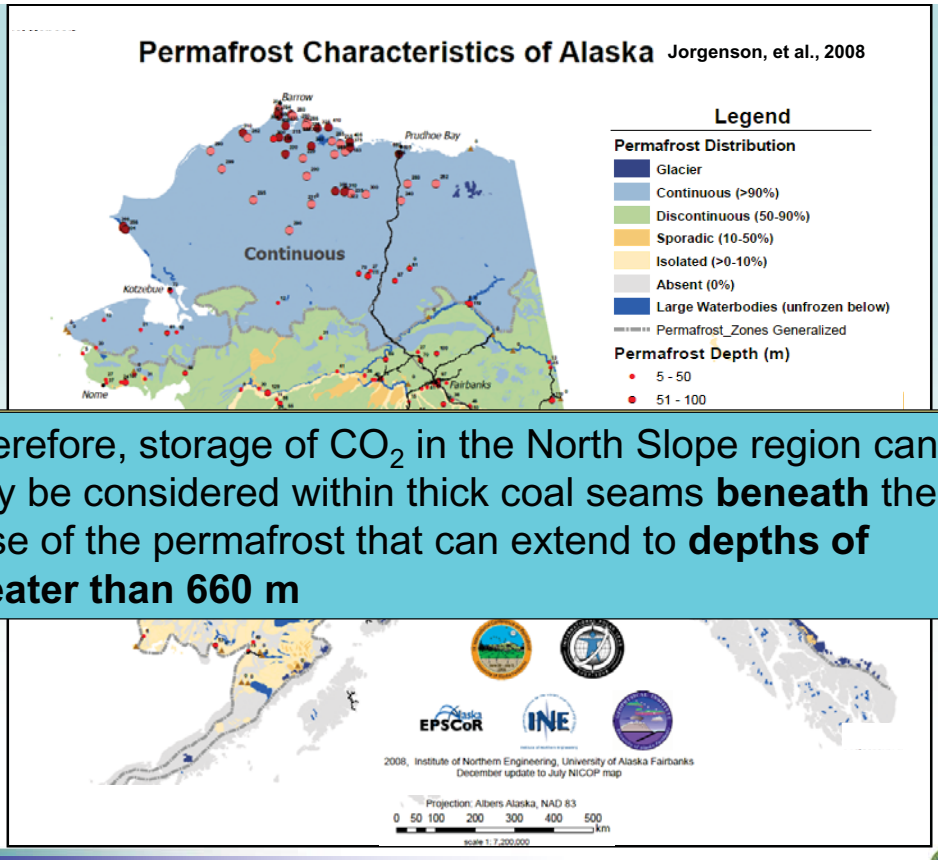
The following main attributes used in the screening process:

- **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_2 coal seam storage capacity and are in proximity to existing or potential future infrastructure



1. Northern Alaska Province
2. Nenana Basin
3. Cook Inlet Basin



Therefore, storage of CO_2 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_2 Storage Capacity of coal seams in the Northern Alaska Province.

This resulted in our much lower estimate of coal seam CO_2 storage capacity of 5.83 Gt than the 98 Gt reported by in earlier estimates by Stevens and Moodhe, 2009.

Ice wedge, Colville River

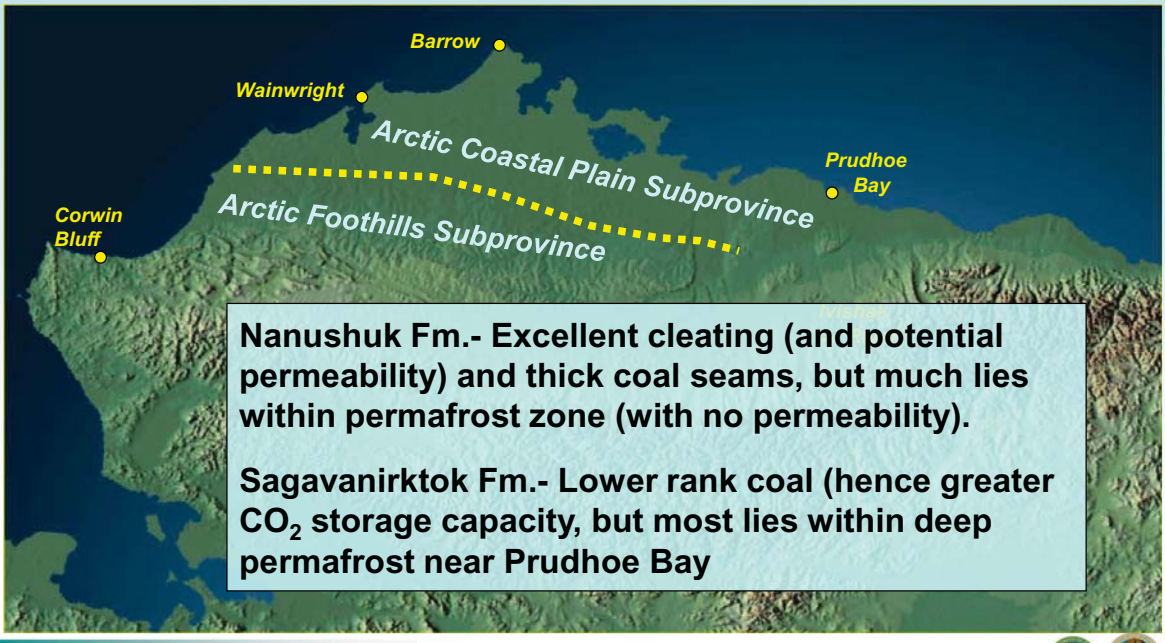
Photo by Matt Bray, UAF GI

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)



Nanushuk Fm.- Excellent cleating (and potential permeability) and thick coal seams, but much lies within permafrost zone (with no permeability).

Sagavanirktok Fm.- Lower rank coal (hence greater CO_2 storage capacity, but most lies within deep permafrost near Prudhoe Bay

Thick Nanushuk Formation coal in Arctic Foothills Subprovince

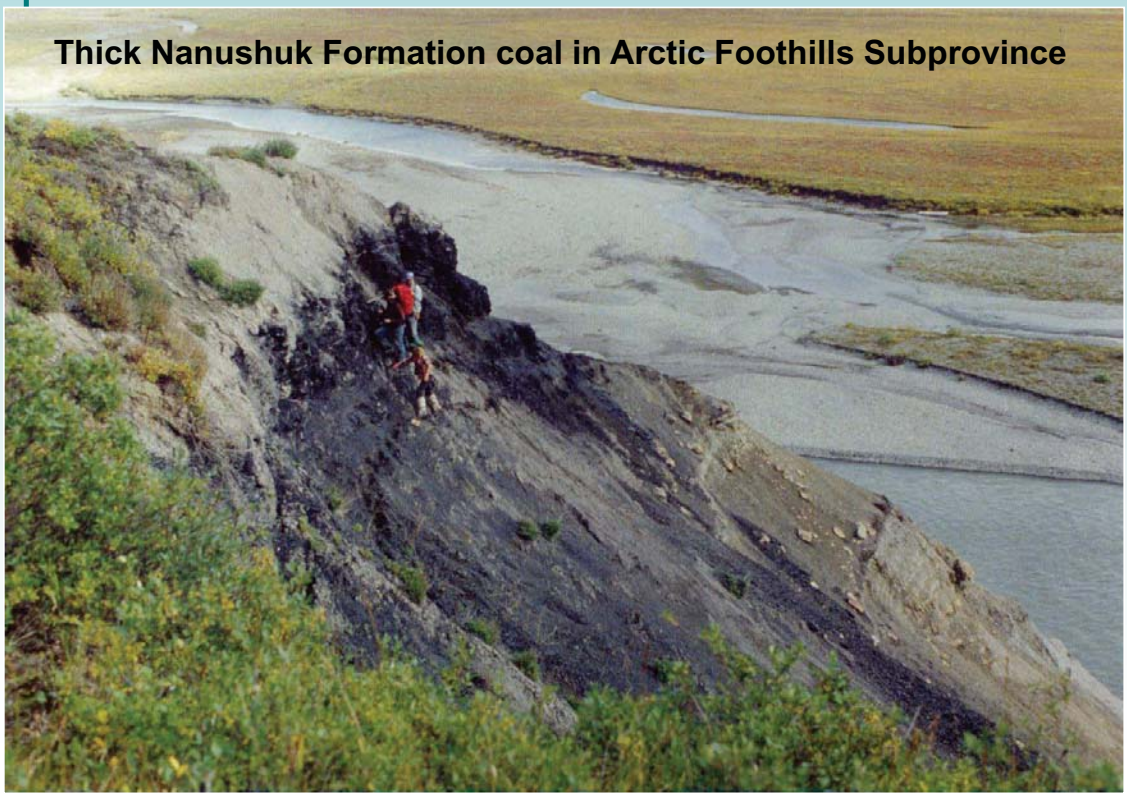


Photo by Gary D. Stricker, USGS

Nanushuk Formation coal bed at Corwin Bluff

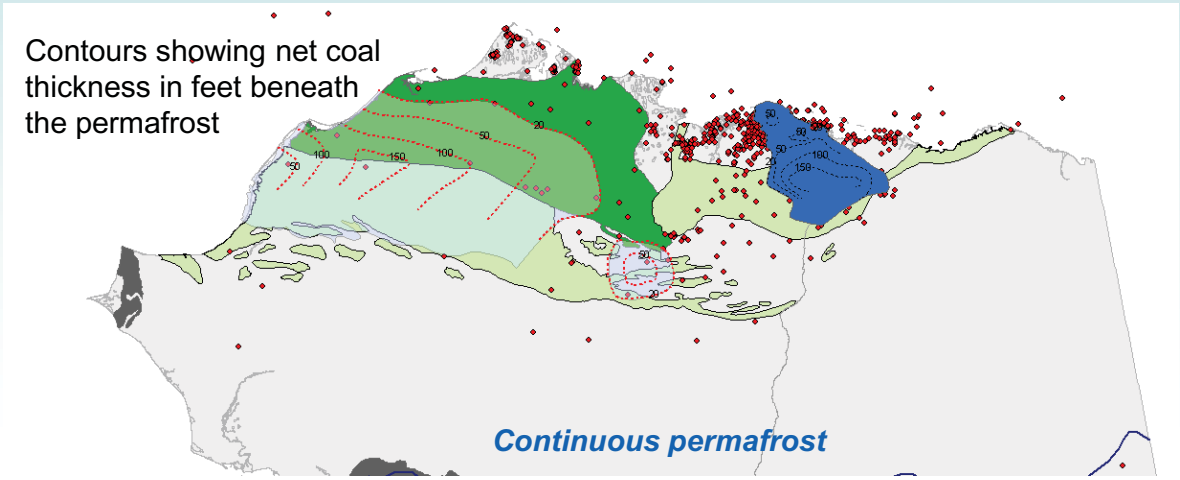
Photo by Gary D. Stricker, USGS

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

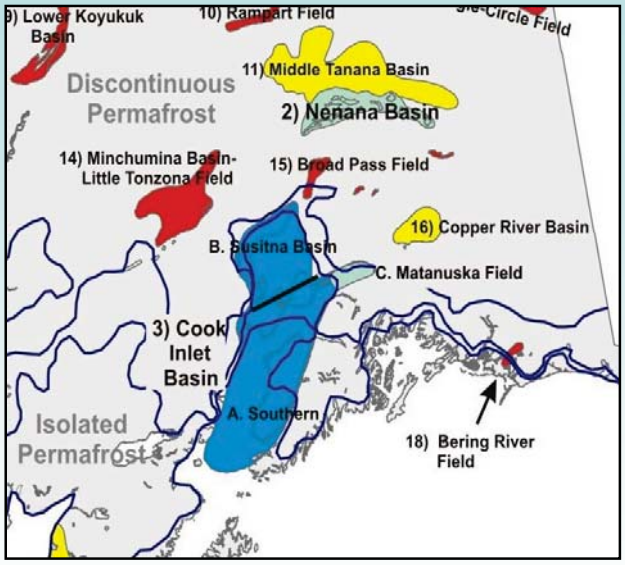
Sagavanirktok Field - Thickest coals are in the vicinity of Prudhoe Bay, where permafrost is as thick as 660 m – 0.75 Gt



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_2 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 CO2 emission sources makes this basin prospective for near-term CO2 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

Photo by Bob Gillis, DGGS

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_2 Storage Capacity in Gt ARI Stevens & Moodhe, 2009	CO_2 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
Total North Slope	**3,753.00**		**98 Gt**	**5.83 Gt**
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
TOTAL	**5,340.30**		**119 Gt**	**49.24 Gt**

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Total North Slope	**3,753.00**		**98 Gt**	**5.83 Gt**
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
TOTAL	**5,340.30**		**119 Gt**	**49.24 Gt**

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_2 storage capacity, increased CO2 storage capacity from 3:1 CO2:CH4 ratio to10:1 ratio

0 → 0.41 Gt storage

Cook Inlet

Increased coal resource base from *1,290* billion short tons of coal and a CO2:CH4 ratio of *3:1* to *1,570* billion short tons of coal and a CO_2:CH_4 ratio of *7:1*

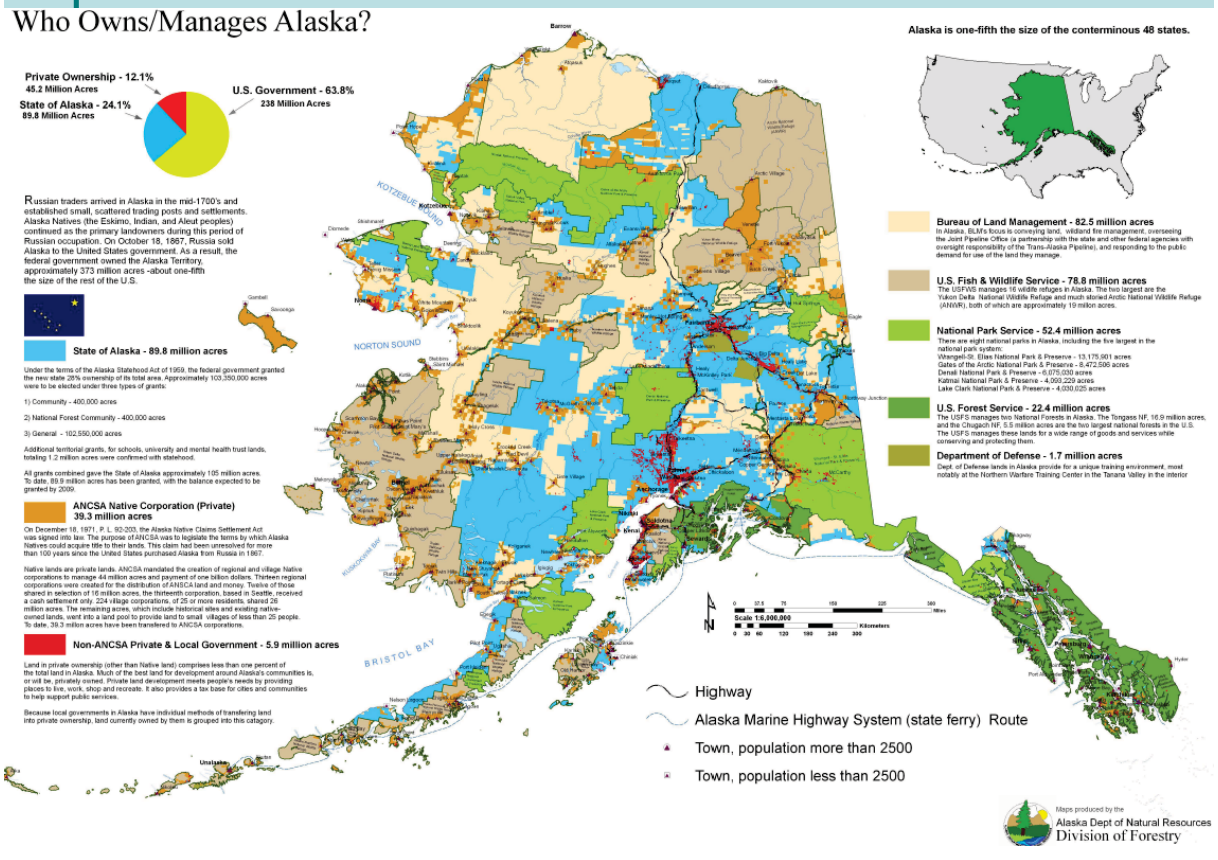
21 Gt → 43 Gt

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_2 sources



Acknowledgments

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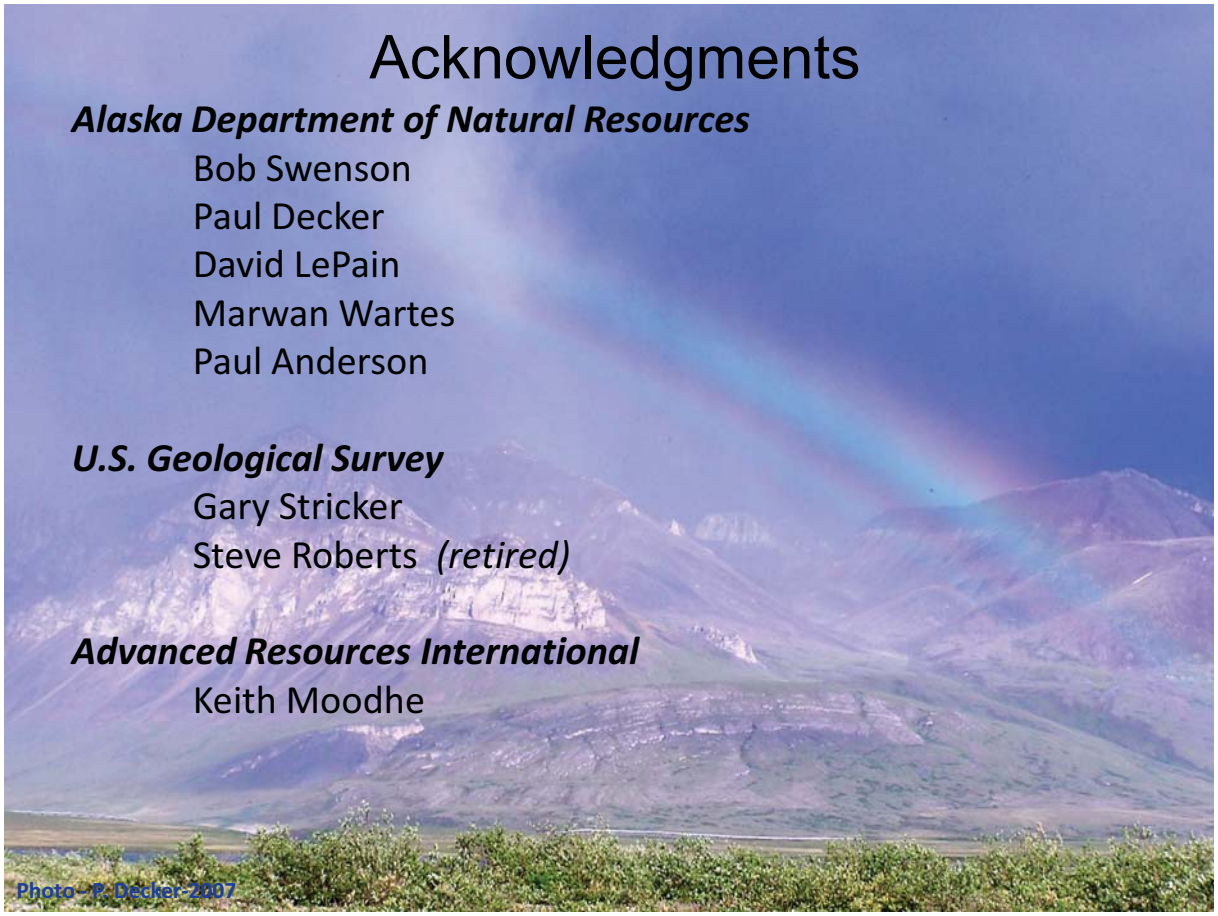

Alaska Department of Natural Resources

Division of Oil and Gas

Activity Maps, Unit maps, sale information, Annual Reports, reports …

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

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Thank You

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