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## Characterizing Commercial-Scale CO<sub>2</sub> Storage Potential in Onshore Fluvial Reservoirs in a Seismically Active Forearc Basin, Cook Inlet, Alaska



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*Beluga Fm. overlooking Cook Inlet, Kenai Peninsula*

# Standard Disclaimer

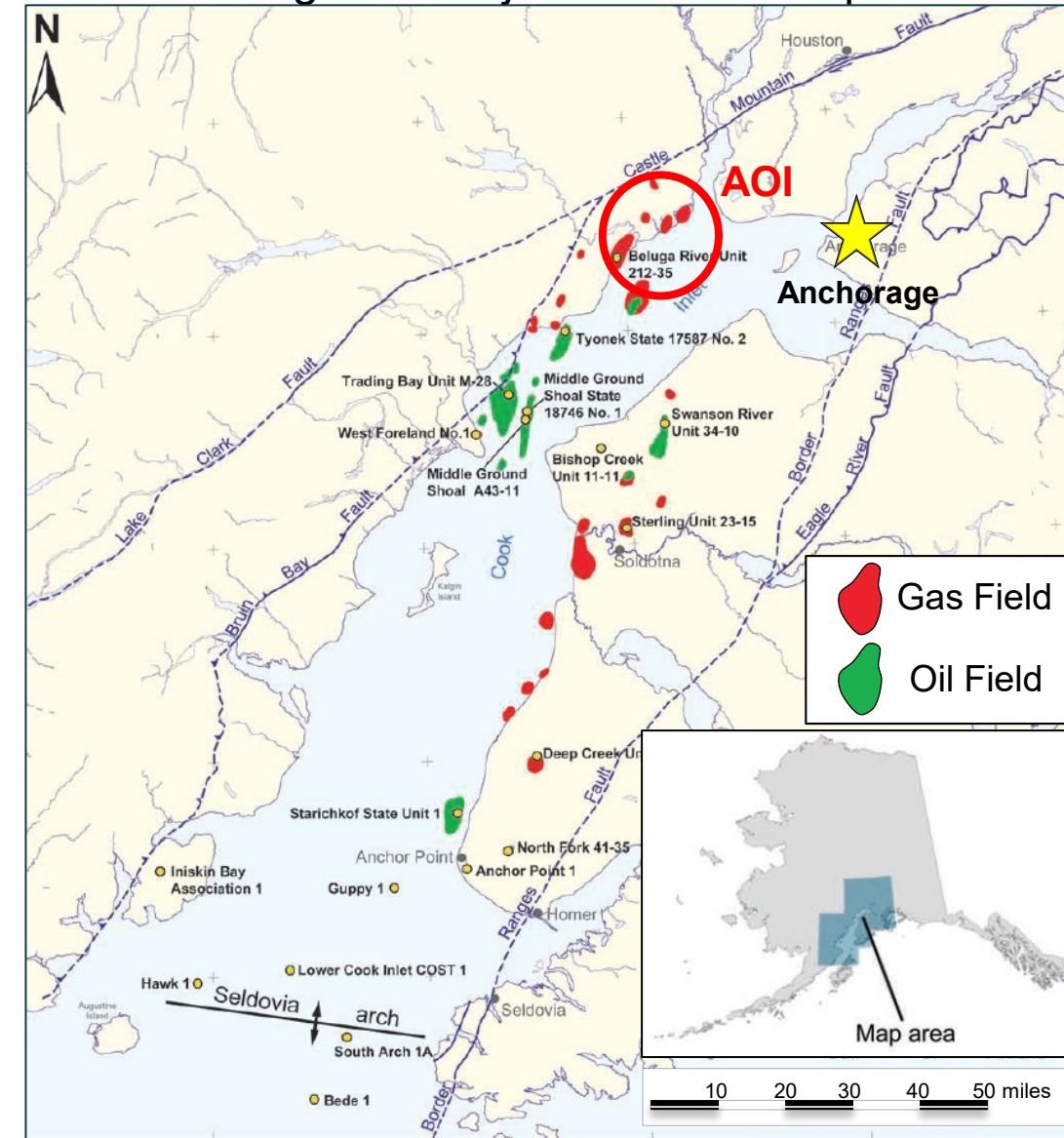
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# Introduction

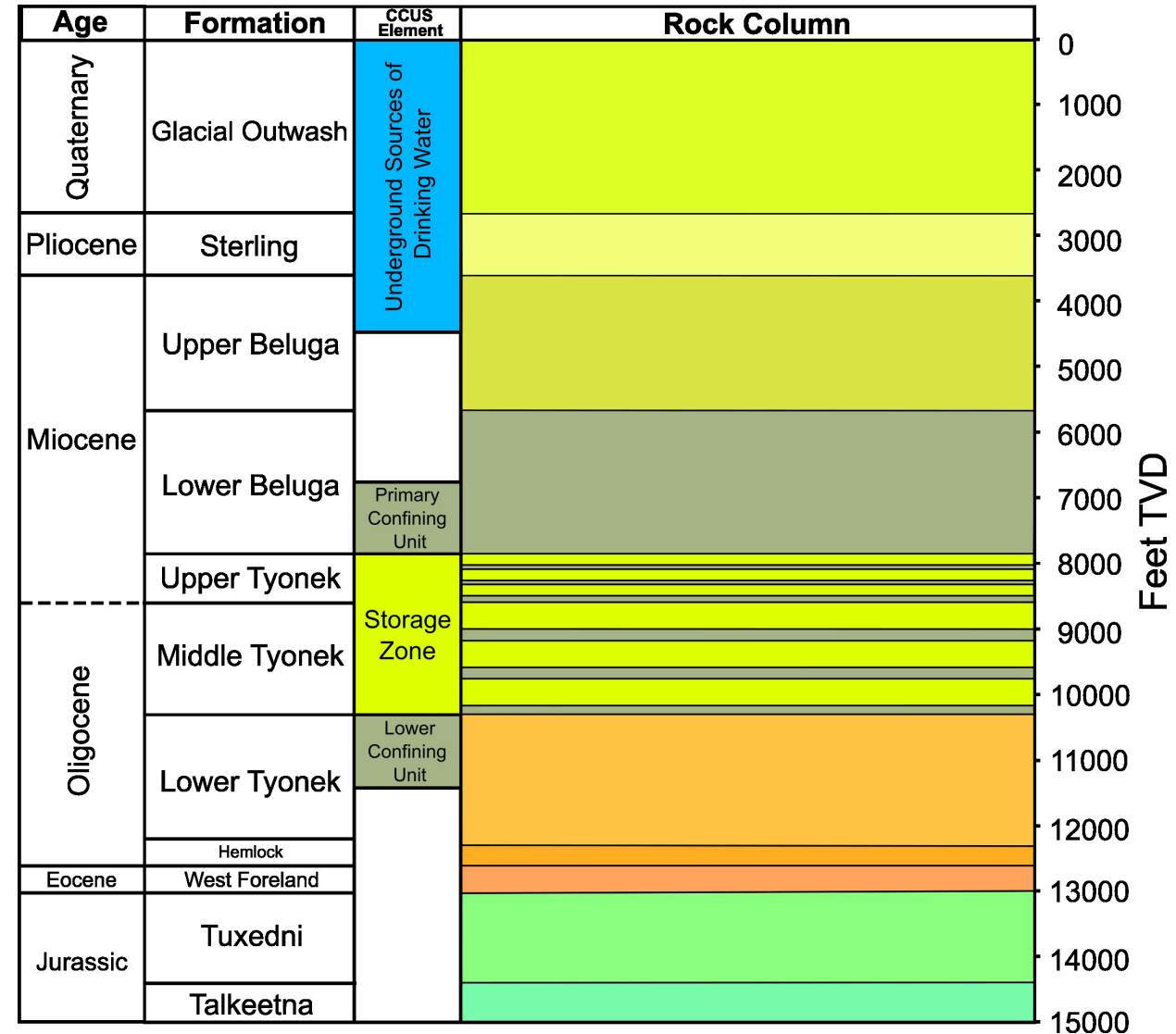
- The goal of the Alaska Railbelt Carbon Capture and Storage (ARCCS) project is to assess the feasibility of a commercial-scale geologic CO<sub>2</sub> storage complex in Cook Inlet Basin.
- The project aims to capture and store CO<sub>2</sub> emissions from a newly proposed coal powerplant in Susitna Basin, and two gas plants located in Anchorage.
- Expanded energy demand from AI data centers in Anchorage has created a potential storage requirement 100 million metric tons (Mt) CO<sub>2</sub> over 30 years.
  - Equivalent to 1.92 Tcf CO<sub>2</sub> at STP.
- ARCCS AOI located 32 miles west of Anchorage on the west side of Cook Inlet.
- Is the subsurface geology capable of safely and securely storing 100 Mt of CO<sub>2</sub> over long-term timescales?

## Regional Project Location Map



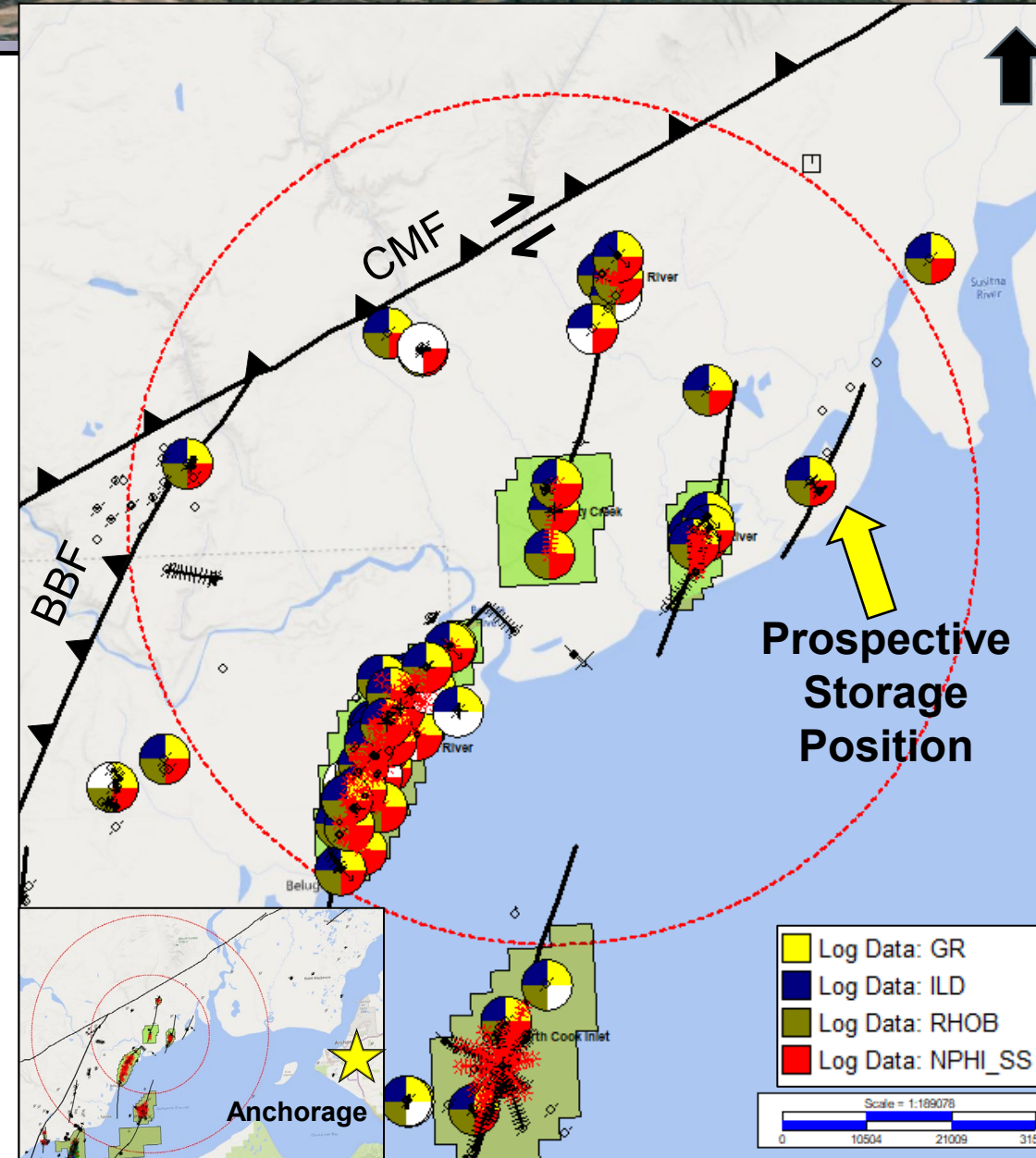
# Cook Inlet Basin Stratigraphy

- Cook Inlet Basin dominated by a 25,000 thick wedge of Cenozoic-aged nonmarine alluvial stratigraphy.
- Identified Primary Confining Unit in the Lower Beluga Formation.
- Primary Storage Zone within the Upper and Middle Tyonek.
- Lower Confining Unit in the Lower Tyonek – regional seal for overpressure.
- The formations of interest are fluvial systems.



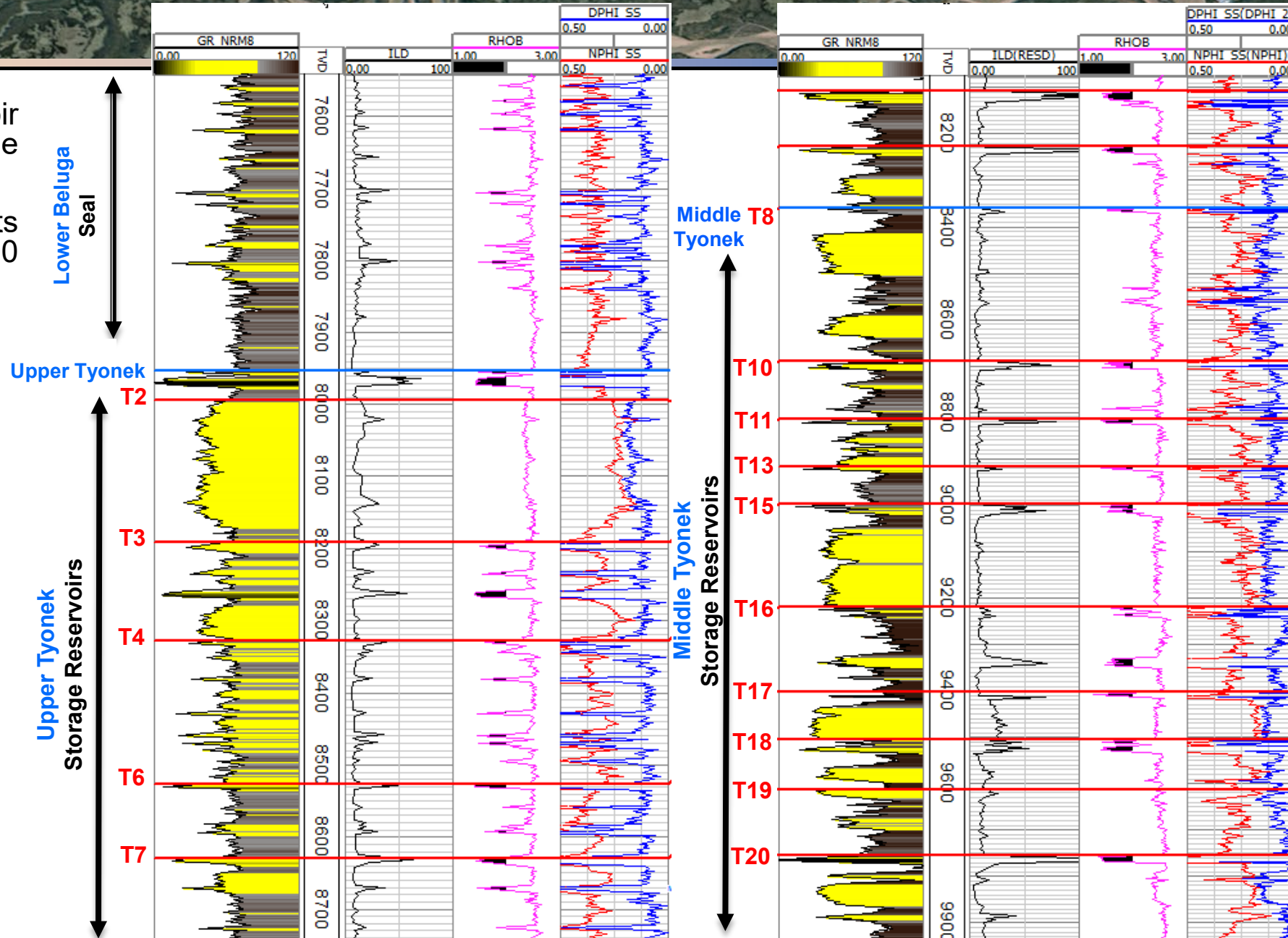
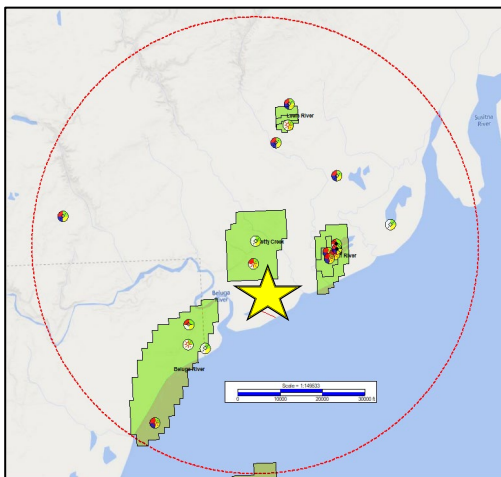
# Methodology

- Delineated AOI around five producing gas units completed in the Beluga Formation and Sterling Formation.
- The AOI is bounded to the north by the dextral strike-slip/reverse Castle Mountain Fault and to the NW by the Bruin Bay reverse fault.
- 76 digital well logs used to construct a stratigraphic framework and identify reservoirs, baffles, and top seal.
- Geologic model generated from well logs, core data, wellbore pressure and formation integrity tests, drilling mud weights, and operator reports.
- Six boreholes with whole-core used for core description and interpretation.
- Geologic model fed into a Dynamic Reservoir Simulation to model injection of 100 Mt CO<sub>2</sub> over 30 years.



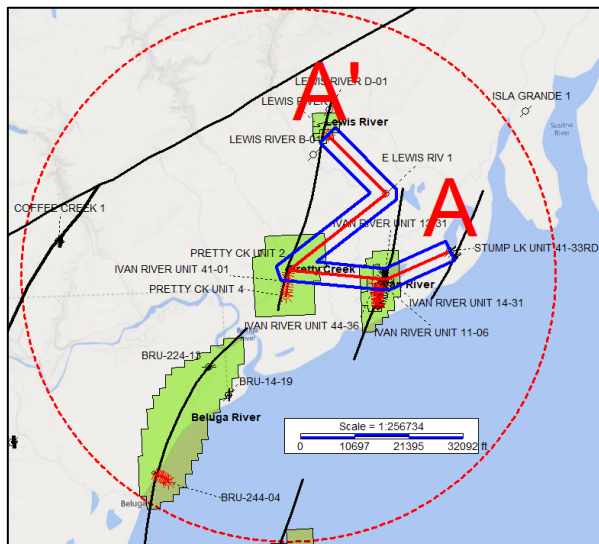
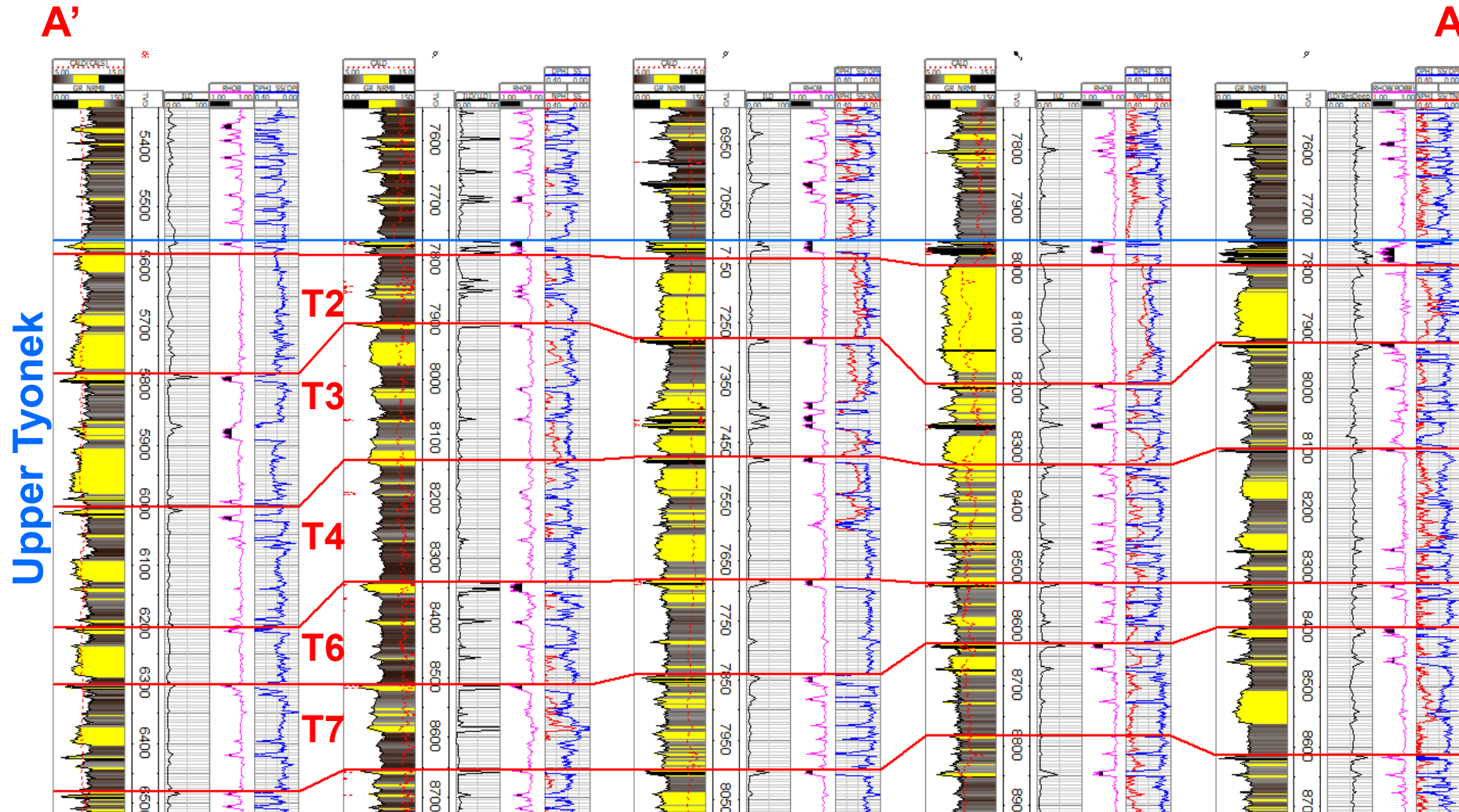
# Type Logs

- Tyonek is the primary reservoir while the Lower Beluga is the overlying top seal.
- Water Quality measurements indicate base of freshwater at 5,000 feet within Upper Beluga.
- **Upper Tyonek (T2-T7)**
  - Mean depth: 7985 ft.
  - Avg. porosity/net reservoir: 22%, 389 ft.
- **Middle Tyonek (T8-T20)**
  - Mean depth: 8700 ft.
  - Avg. porosity/net reservoir: 19%, 463 ft.



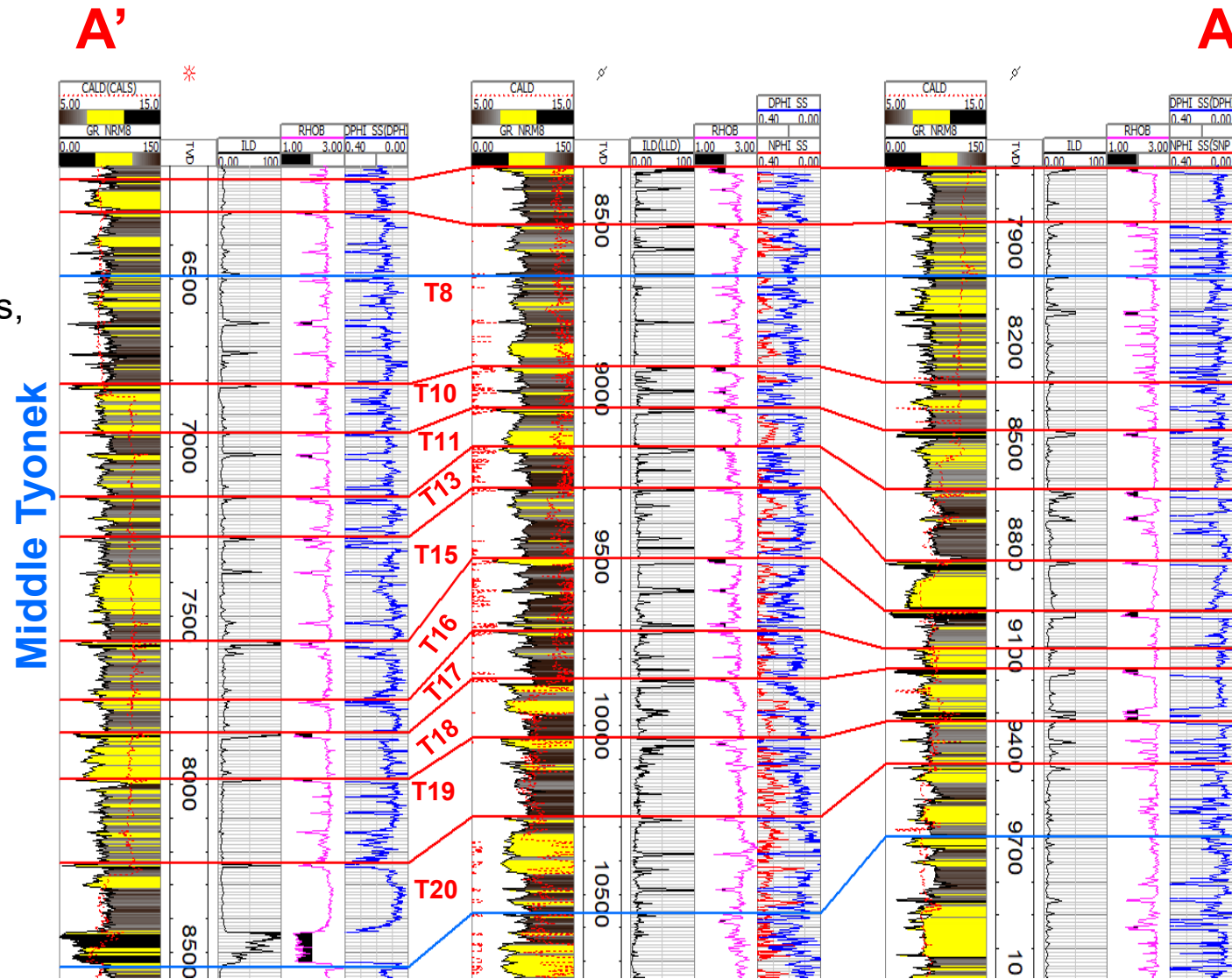
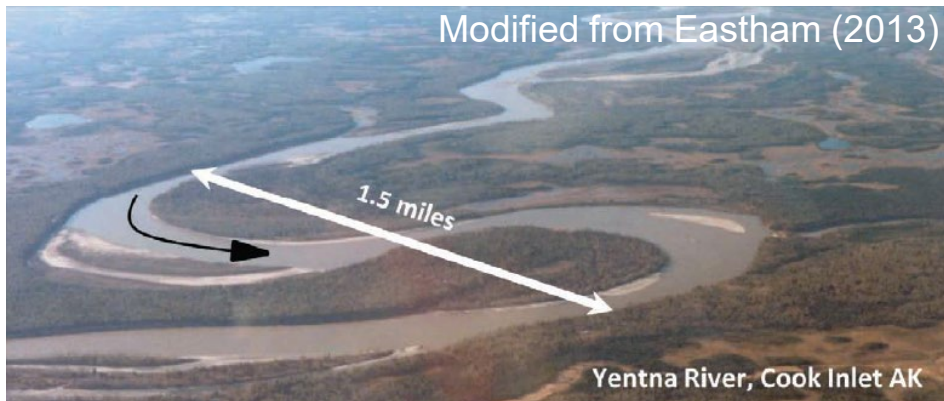
# Reservoir Connectivity (Upper Tyonek)

- Coals enable stratigraphic correlations across the AOI.
- Tyonek sandstones tend to be correlated from well to well suggesting potential for lateral continuity.
- Upper Tyonek does show some variability in reservoir thickness and occurrence.
- Continued characterization needed to reduce uncertainty of reservoir connectivity.



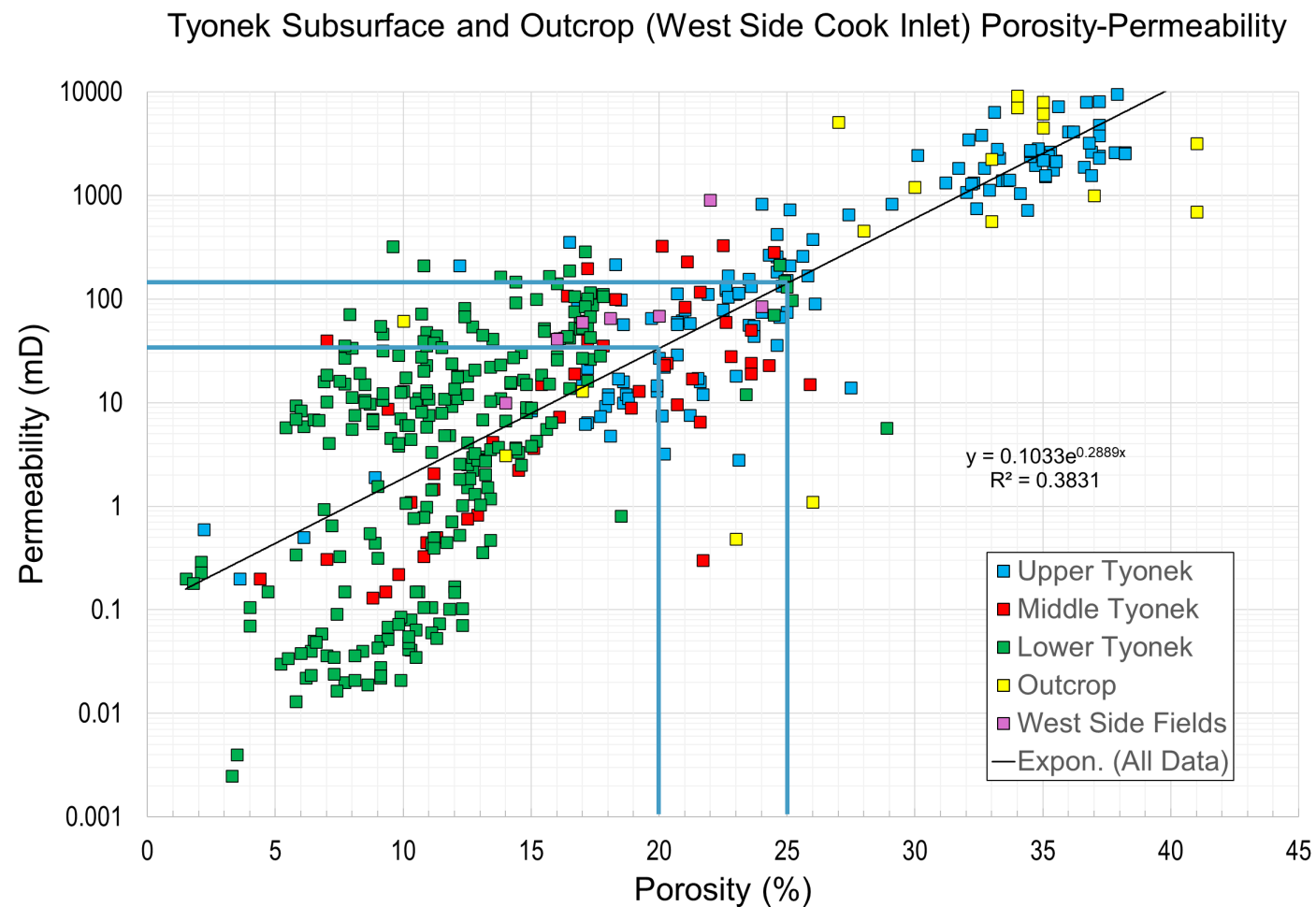
# Reservoir Connectivity (Middle Tyonek)

- Sand packages within the Middle Tyonek thicker and more laterally continuous than the Upper Member.
- Together the Upper and Middle Tyonek represent stacked sandstone reservoirs.
- Tyonek interpreted as sandy meandering fluvial deposits, Yenta River (30 miles NE) is a modern analogue (Eastham, 2013).
- Thick, high porosity, laterally continuous sandstone reservoirs represent lateral accretion elements of meandering point bars.



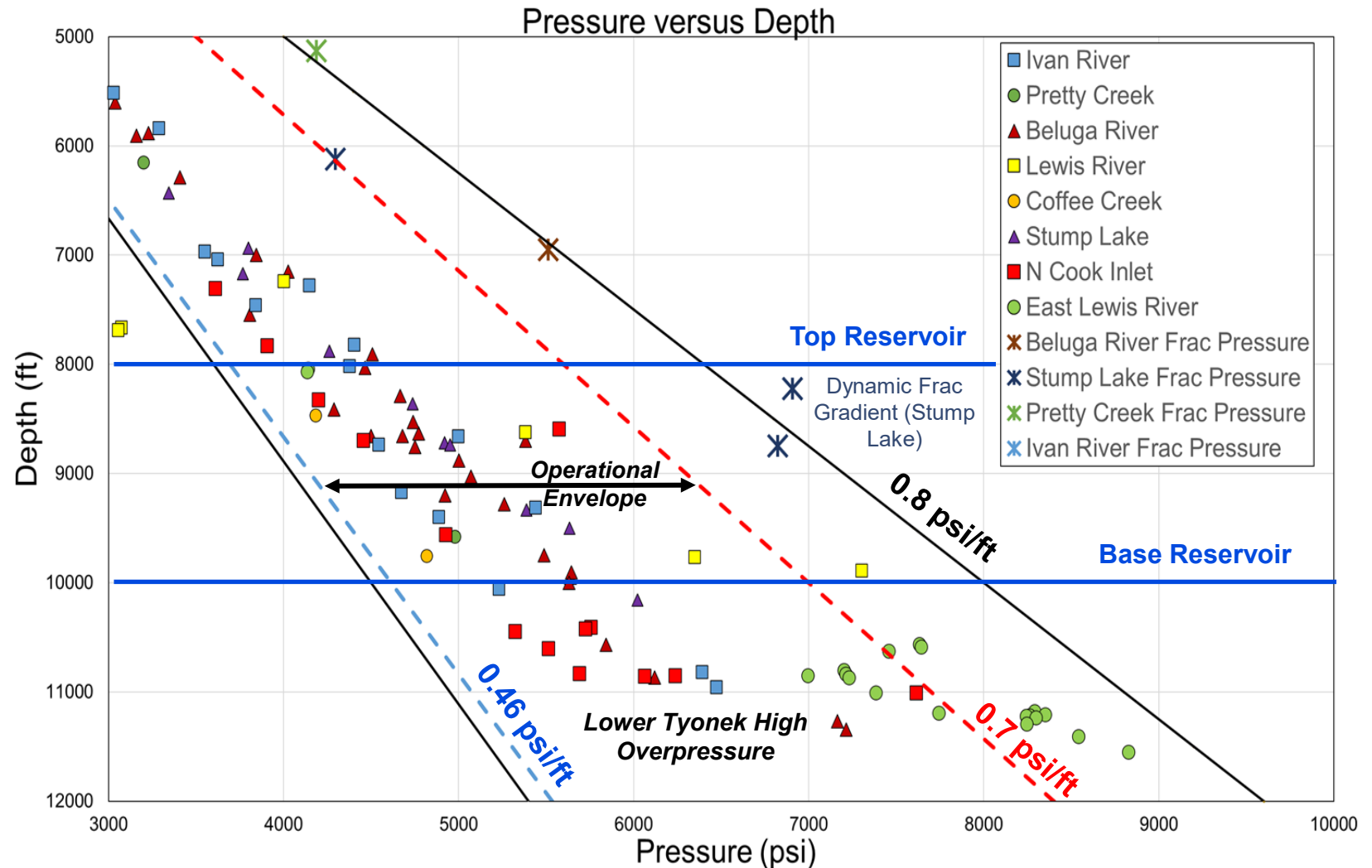
# Reservoir Quality

- Porosity-permeability cross-plot generated from RCA of core plugs and whole-core within the **Upper**, **Middle**, and **Lower** Tyonek.
- Tyonek Subsurface Data
  - Published West Side Cook Inlet fields (Trading Bay, McArthur River, Granite Point).
  - Eight wells within the ARCCS AOI (Beluga River, Lewis River, Ivan River, Sunfish, Beluga River, E Lewis River).
  - West Side Cook Inlet outcrop sampling (17 samples).
- Wireline log porosity measure from AOI well logs ranges from 20 – 25%, predicted permeability 33 – 110 mD.



# Operational Envelope

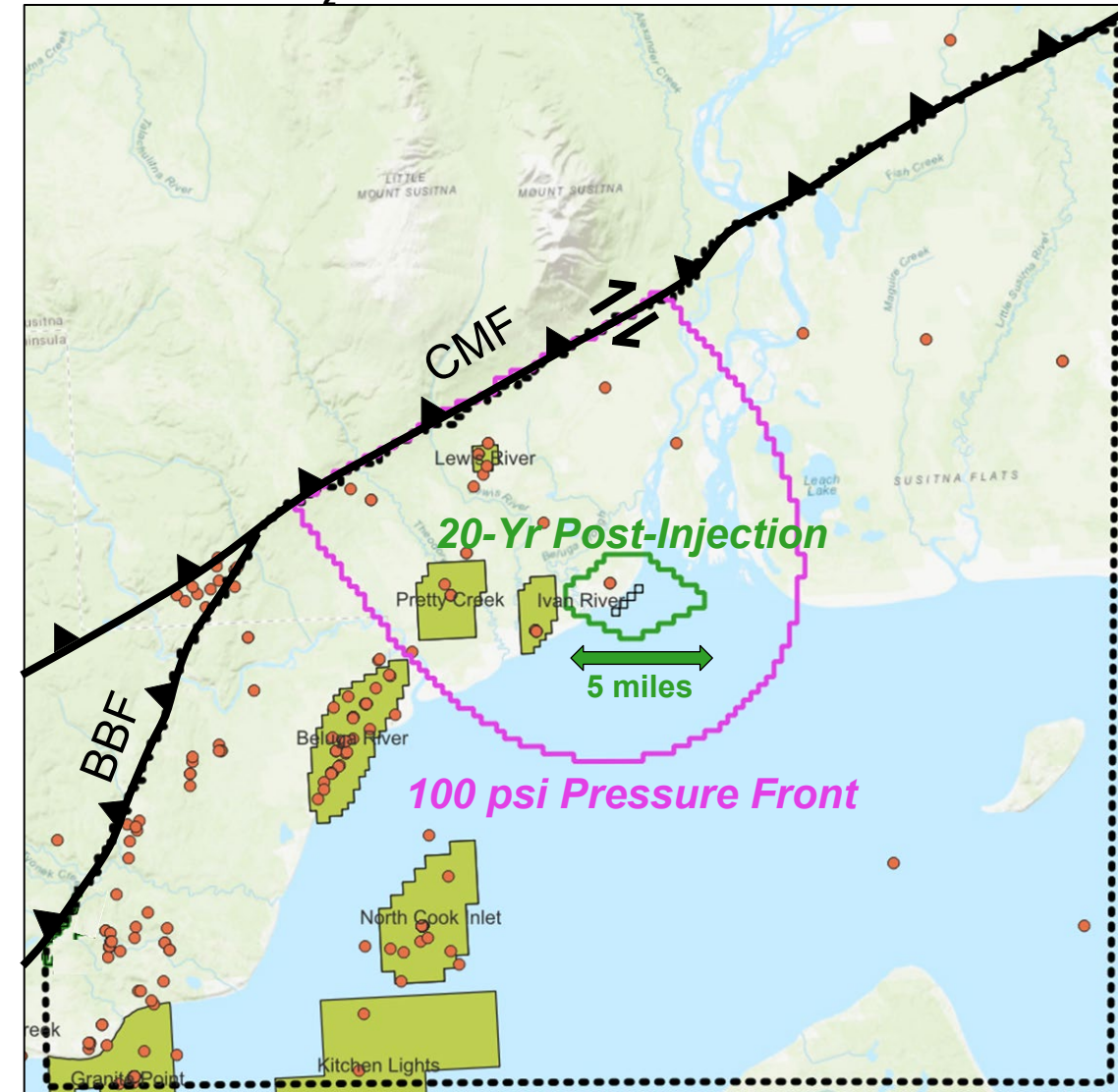
- Pore pressure gradients determined from reported drilling mud weights, DST, RFT, LOTs.
- Pore pressure determined to be 0.46 psi/ft, higher values thin overpressured sands.
- Geomechanical model created using acoustic shear and compressional logs.
- 90% fracture gradient of the weakest unit is 0.70 psi/ft.



# Baseline Dynamic Model Results – CO<sub>2</sub> Plume

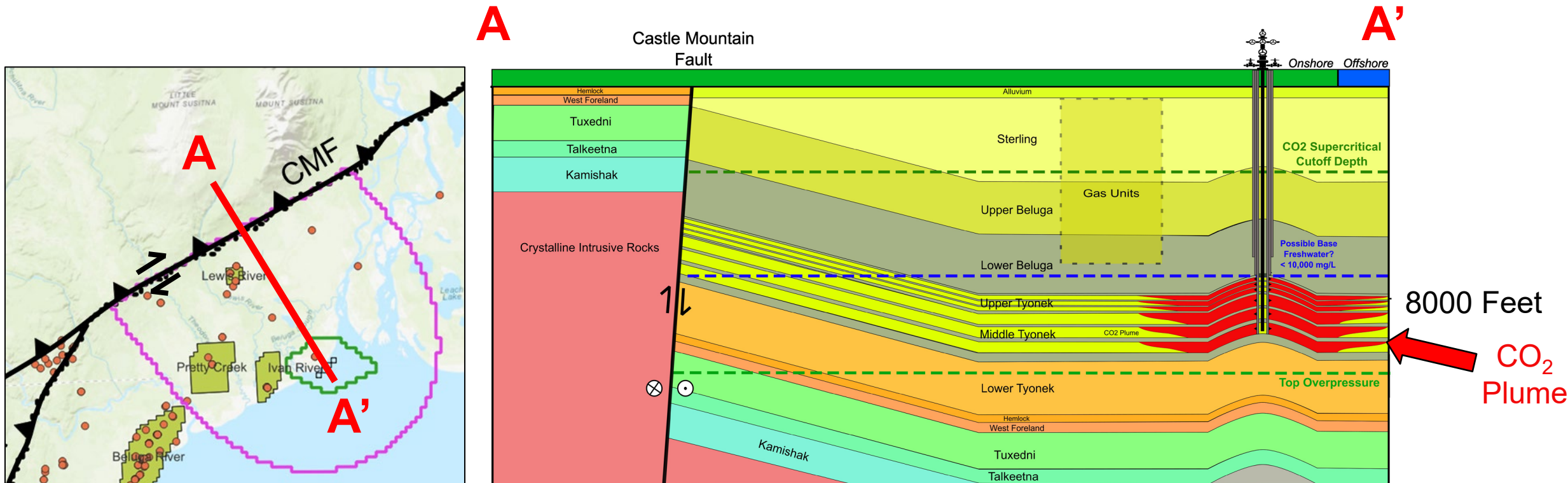
- Utilize four injectors, resulting 20-year post-injection CO<sub>2</sub> saturation plume diameter ~ 5 miles from east-west and extends offshore.
- 100 psi pressure front extends toward the Castle Mountain Fault (CMF).
- Fault Slip Potential Analysis by EERC indicates CMF is likely critically stressed and marginal pore pressure increase could induce seismicity.
- Induced seismicity creates a leakage risk.
- Risk Mitigation strategies:
  1. Additional fault stress characterization – Refine  $Sh_{max}$  azimuth/ $Sh_{min}$  stress magnitude, borehole breakouts, drilling induced fractures, shale frac data.
  2. Confirm reservoir connectivity to CMF.
  3. Move injectors south 5 – 10 miles offshore.
  4. Reduce maximum injection volume, 50% of current model case?

100 Mt CO<sub>2</sub> Pressure Front and Saturation Plume



# Conclusions

- Subsurface data indicate the Tyonek Formation as the prospective reservoir with the lower Beluga Formation acting as the top seal.
- Dynamic modelling indicates the saturation plume is largely confined to a small area while the pressure front reaches the Castle Mountain Fault to the north.
- Probabilistic Fault Slip Potential analysis indicates the Castle Mountain Fault is critically stressed and that marginal increase in pore pressure could induce seismicity on the fault plane.
- Additional data needed to characterize the Castle Mountain Fault, other mitigation strategies include moving injectors or reducing CO<sub>2</sub> injection volume.



\*Vertically exaggerated. Horizontal and vertical sections not to scale. Conceptual diagram only.



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