Mitigating Geologic Risk Uncertainty for Carbon (CO2) Sequestration in Multiple Subsurface Targets in the Iron Springs District, Iron County, Utah

Eugene Szymanski, Michael D. Vanden Berg, Elliot A. Jagniecki, Austin Jensen, and Nathan Moodie

UTAH GEOLOGICAL SURVEY

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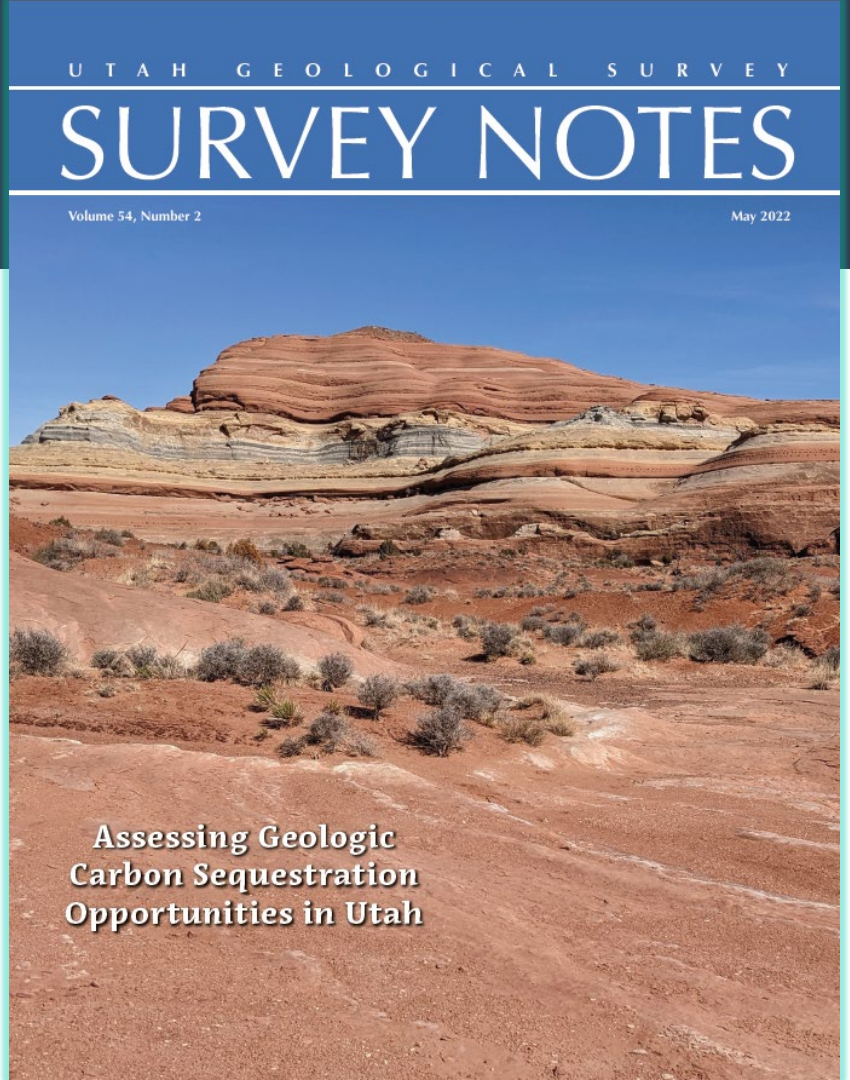
RMS AAPG
July 26th, 2022

Today's Talk

- Opportunity for Geologic Carbon (CO_2) Sequestration in Utah
- Iron Mountain CCS Project
- Reducing Geologic Risk Uncertainty with Multidisciplinary Site Characterization



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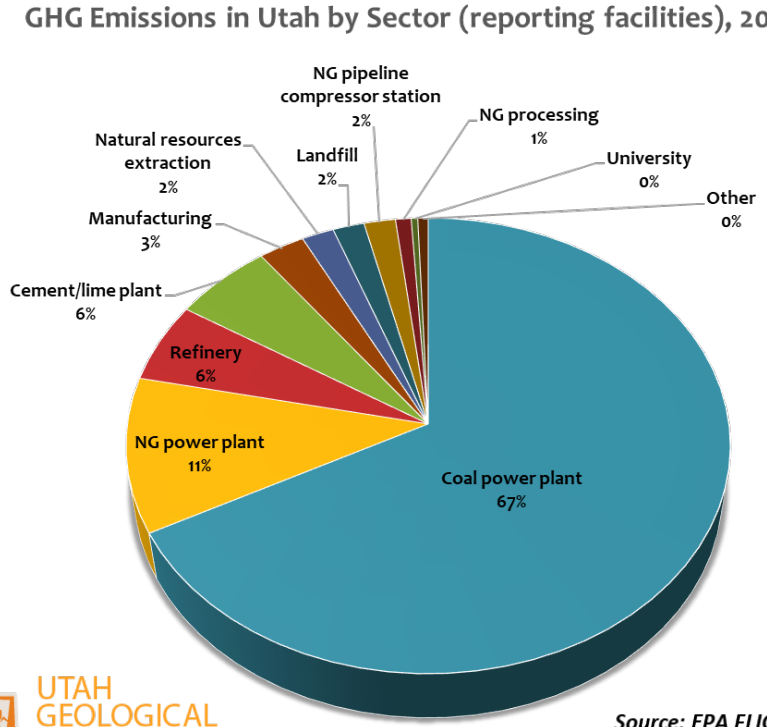
google "UGS Survey Notes"

CO2 Sources in Utah

State of Utah Virtual Webinar | *Utah CCS Infrastructure* | 8 Nov. 2021



Source: EPA FLIGHT data

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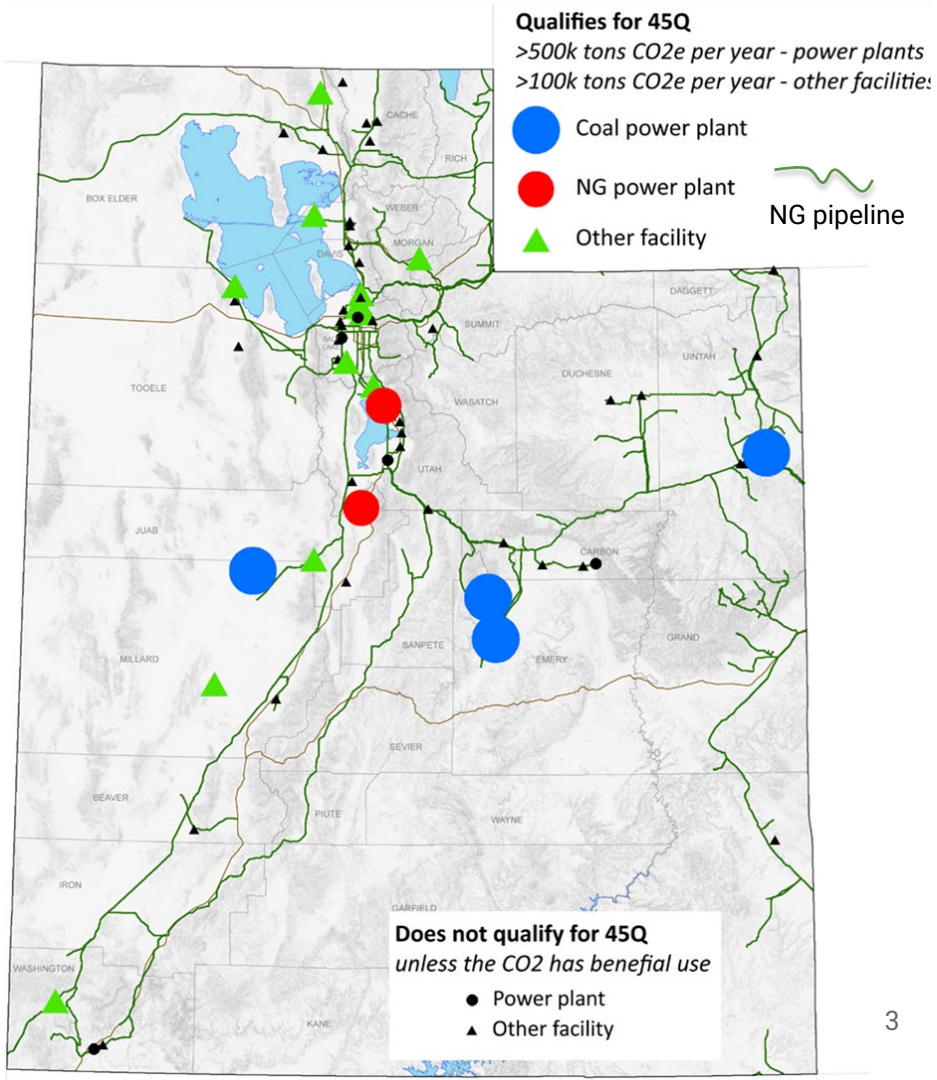
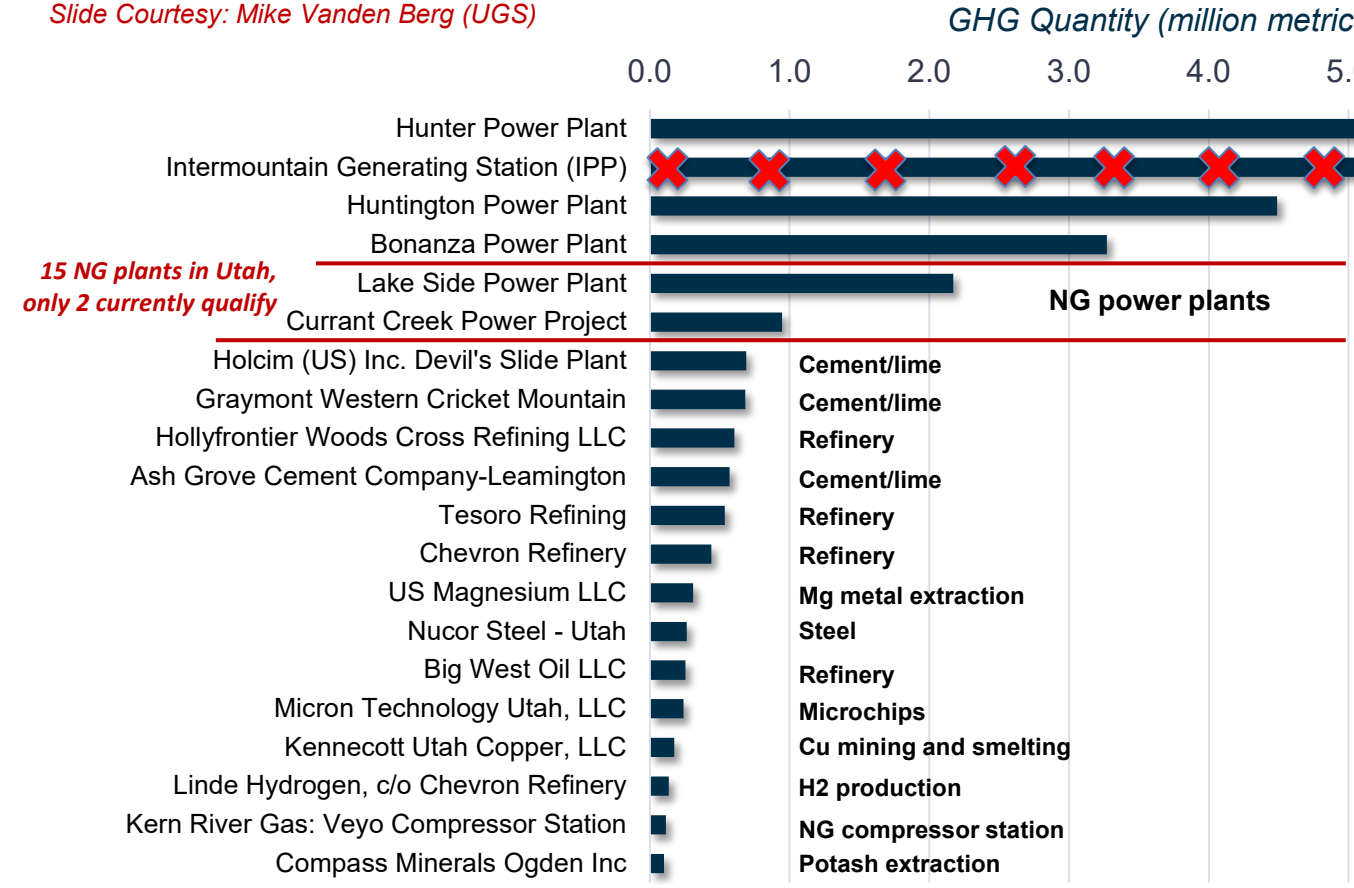


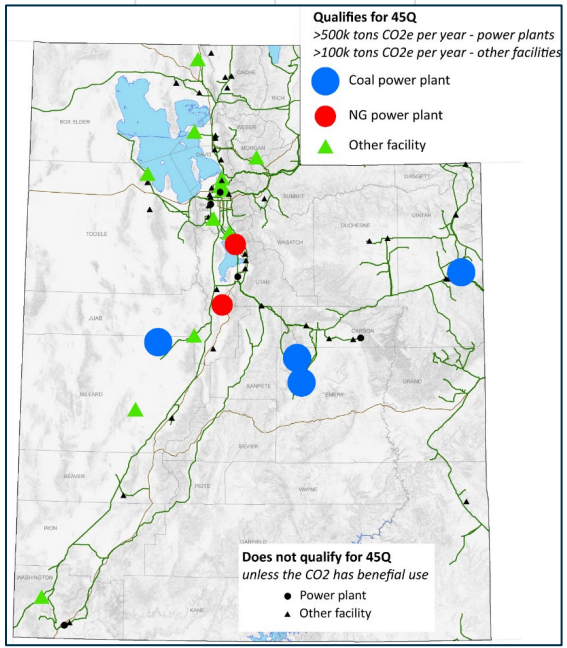
CO2 Sources in Utah

Facilities that qualify for 45Q tax credit

Source: EPA FLIGHT data

Slide Courtesy: Mike Vanden Berg (UGS)

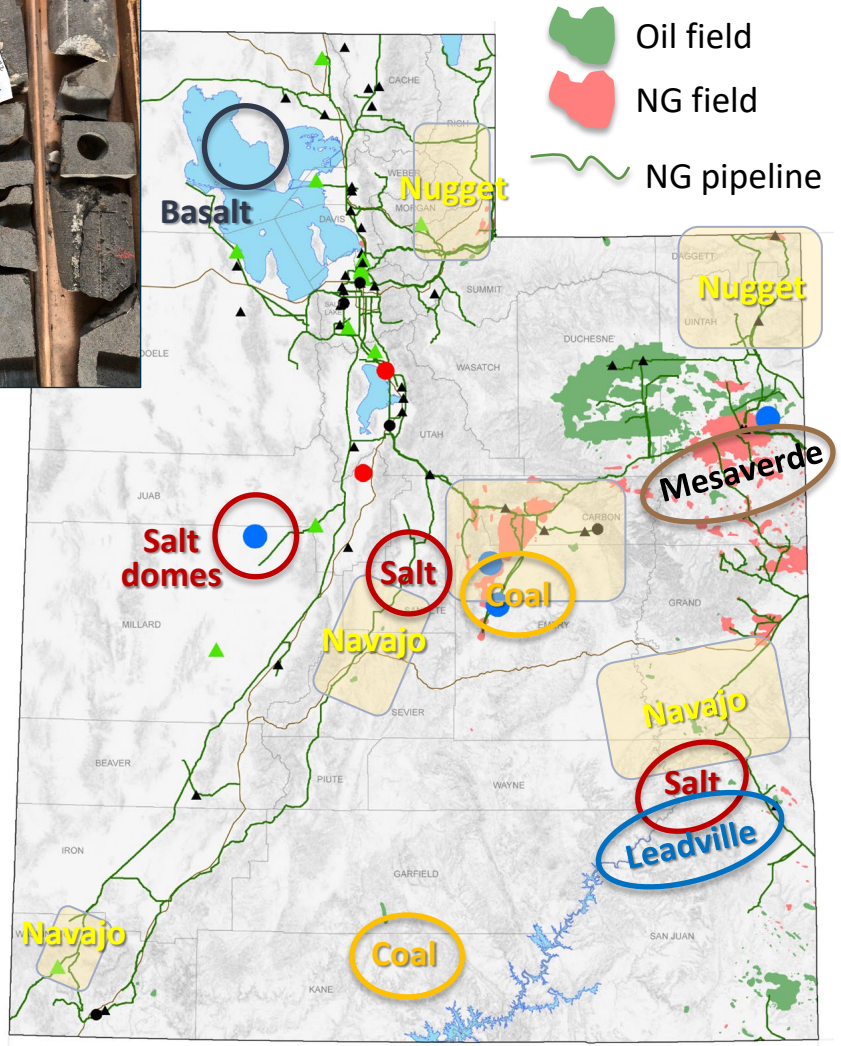




CO_2 sequestration potential is almost everywhere in Utah!

- Current oil and gas fields / *EOR*
- Navajo/Nugget SS / *saline aquifers & EOR*
- Leadville/Redwall LS / *saline aquifers & EOR*
- Wasatch Fm. & Mesaverde Gp. / *saline aquifers & EOR*
- Coal bearing strata: Blackhawk SS; Ferron SS; Straight Cliffs SS
- Basalts, Salt domes & layers
- Other sandstone & carbonate units:
    - ss: White Rim; Wingate; Coconino
    - carb.: Twin Creek; Thaynes; Kaibab

"sinks in search of sources"



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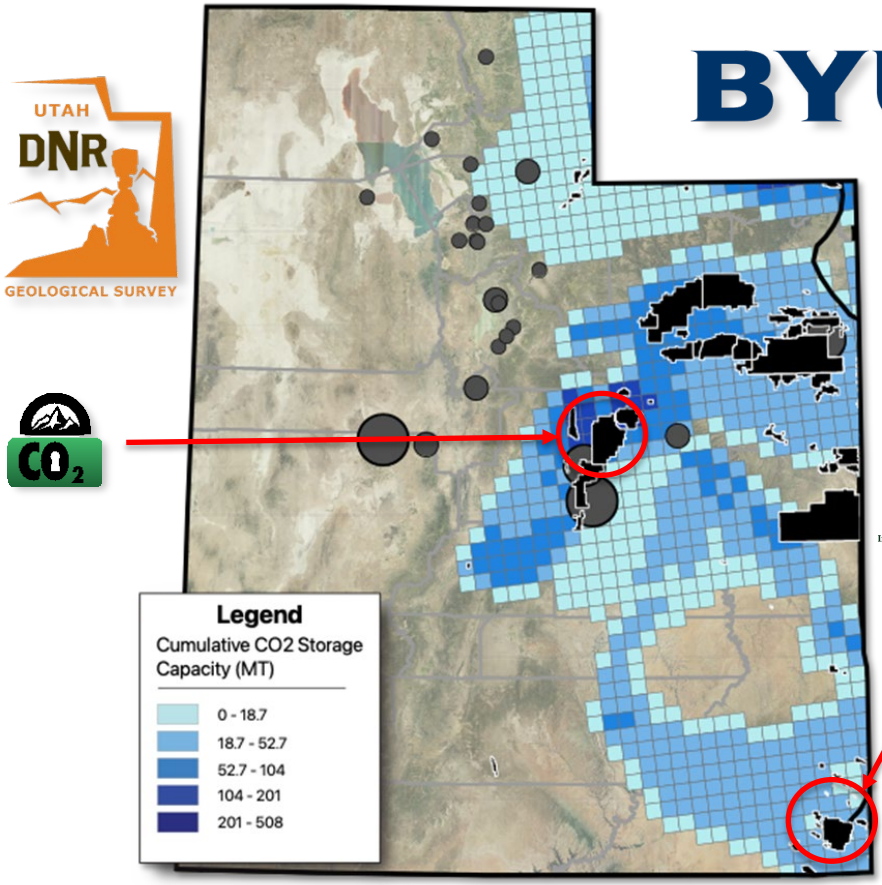
UTAH DNR GEOLOGICAL SURVEY



CO_2

SWP Southwest Partnership
Optimizing Enhanced Oil Recovery Today
Investigating Resulting CO_2 Storage for Tomorrow

Carbon Utilization Storage Partnership (CUSP) of the Western United States

- DOE-funded Regional Initiative established to accelerate onshore CCUS technology deployment in the Western Region of the United States.
- Research consortium consisting of organizations throughout the western United States including academia, government agencies, national laboratories, and industry.

https://cuspwest.org/wp-content/uploads/2021/07/CUSP_Brochure_210715r.pdf

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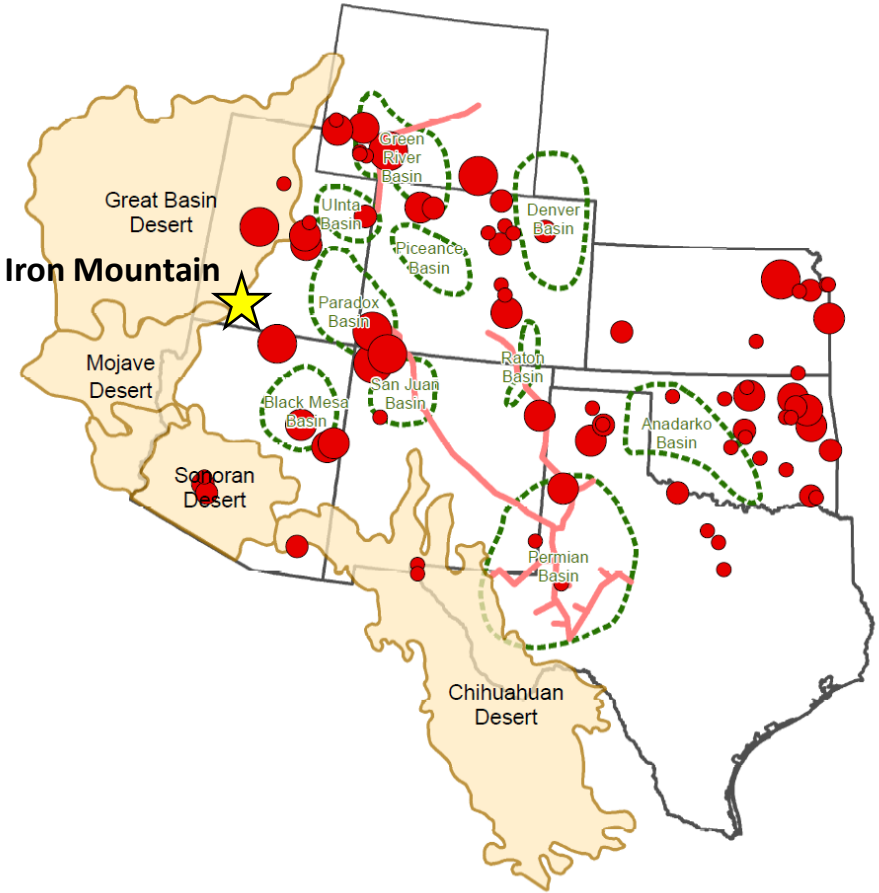
CUSP West Carbon Utilization and Storage Partnership of the Western USA

Carbon sources and sinks

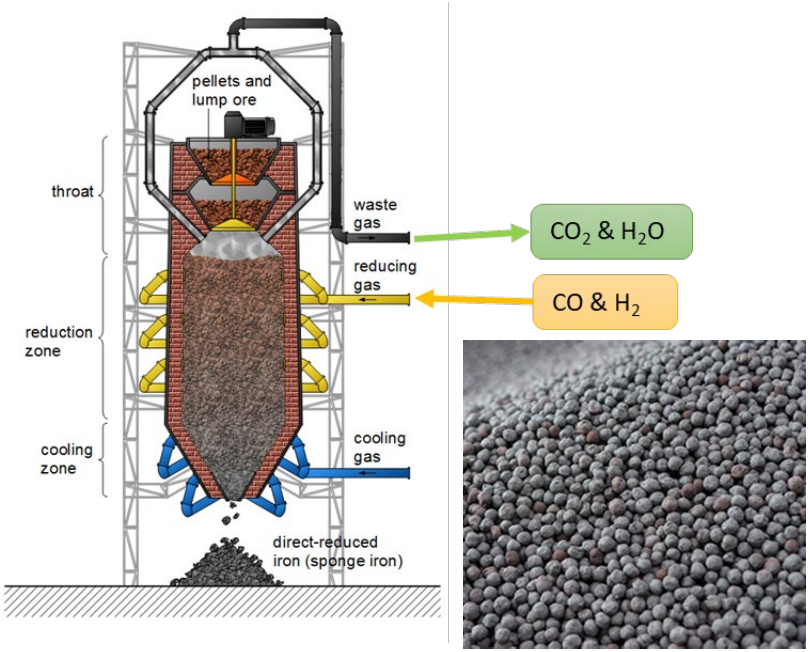
- “String of pearls” to link sources and sinks and create a regional CCS ‘economy’
- Major point sources are easy to identify
- Suitable GCS sites are much more work to identify and characterize
    - the Great Basin is one such poorly characterized potential carbon sink

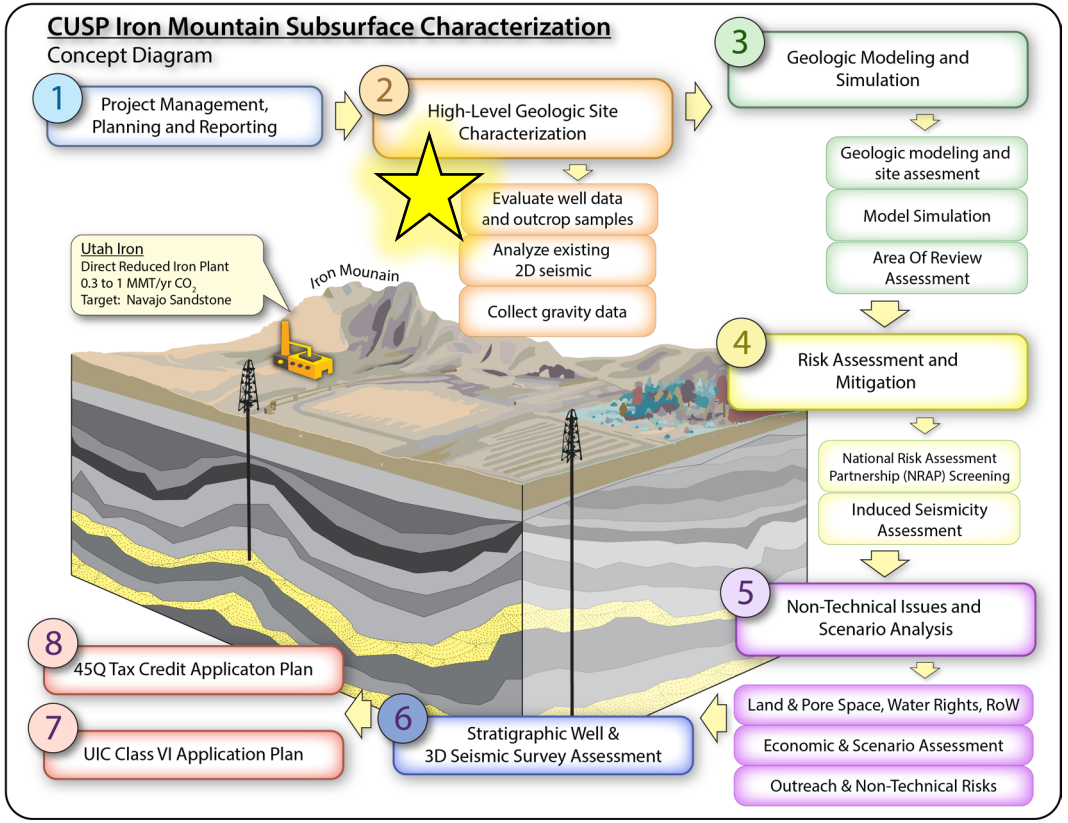


Iron Mountain: Iron Mine & Green Steel Plant

Carbon Utilization and Storage Partnership of the Western USA

- Commercial-scale iron ore processing + CCS. It will prove the viability of using CCS to make *green* steel.
- Iron reduction reactions produce CO_2 and H_2O
- CO_2 storage targets: 300,000 to 1 million metric tons annually



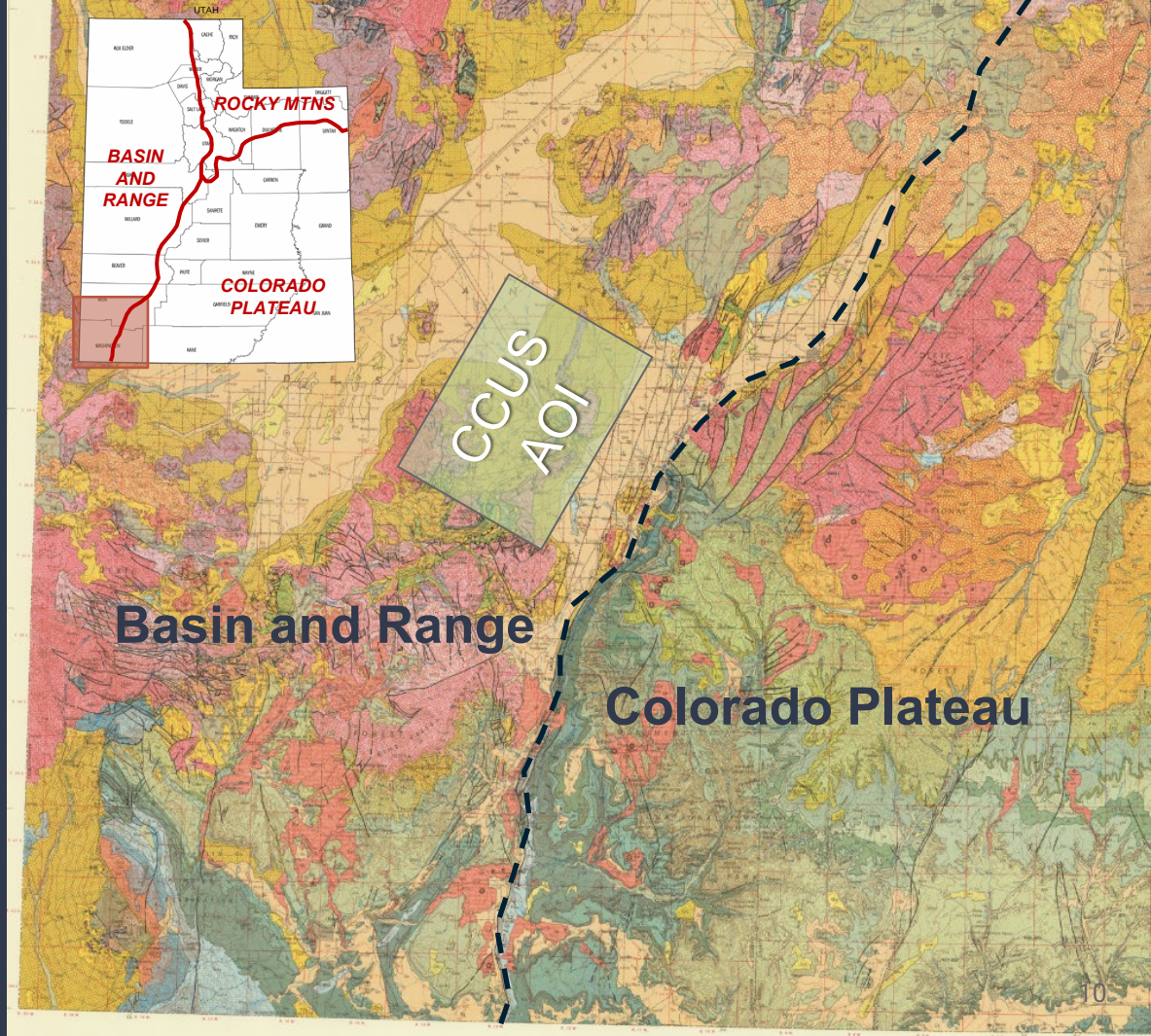


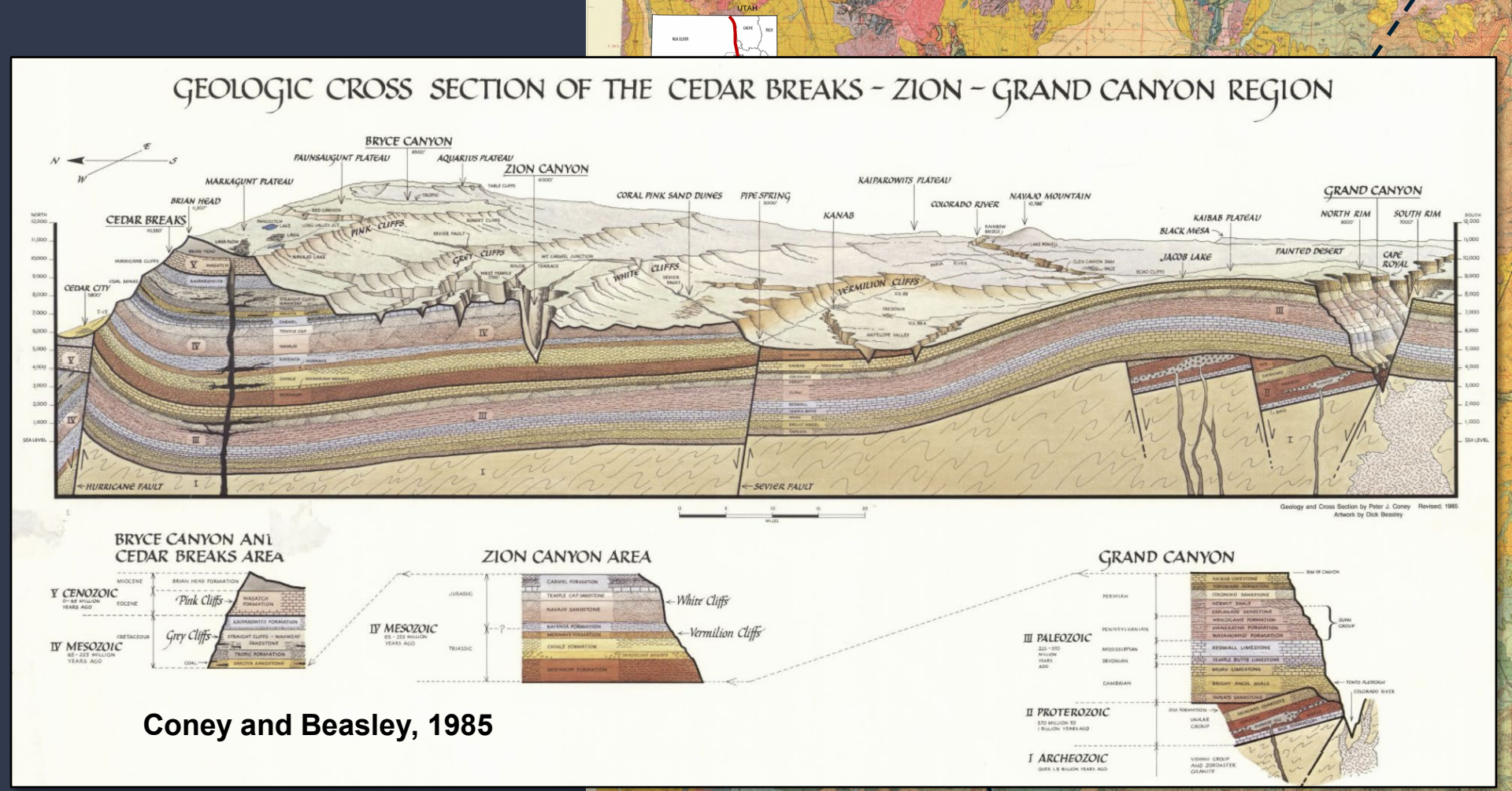
https://www.lmmgroupcn.com/direct-reduced-iron-process/

CO2 Sequestration Potential in the Iron Springs District, Utah

- Primary target reservoir formation is the Jurassic **Navajo Sandstone**
- Navajo SS is a prolific aquifer south of the Pine Valley Mountains (Heilweil et al., 2002) and throughout SW Utah (Chidsey and others, 2020).
- Sealing units in overlying Jurassic sedimentary and Miocene intrusive rocks

William L. Stokes, 1961-63, Geologic Map of Utah. Q-2thru5. 1:250,000 scale.





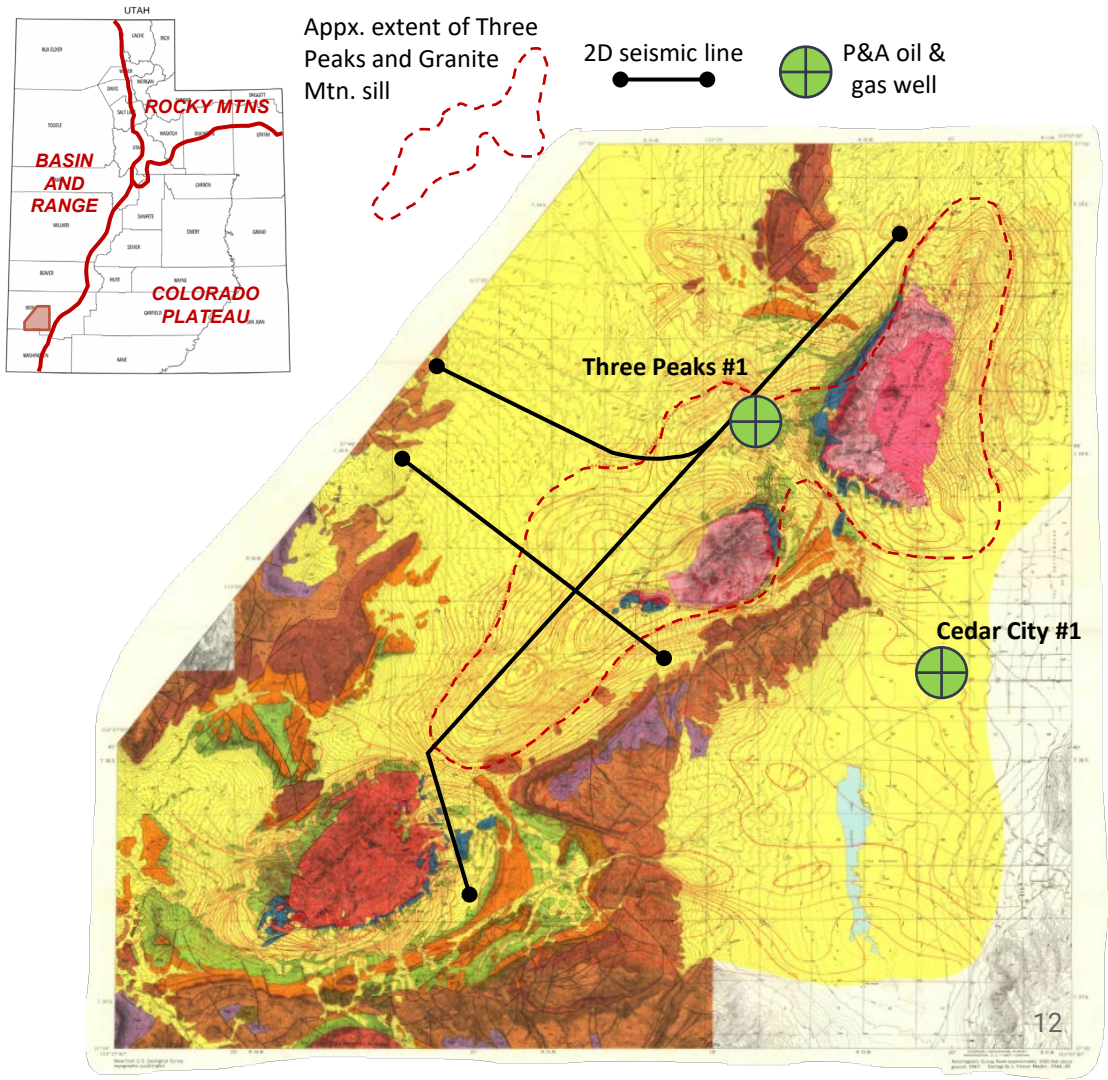
Coney and Beasley, 1985

William L. Stokes, 1961-63, Geologic Map of Utah. Q-2thru5. 1:250,000 scale.

CO2 Sequestration Potential in the Iron Springs District, Utah

Subsurface Characterization Plan:

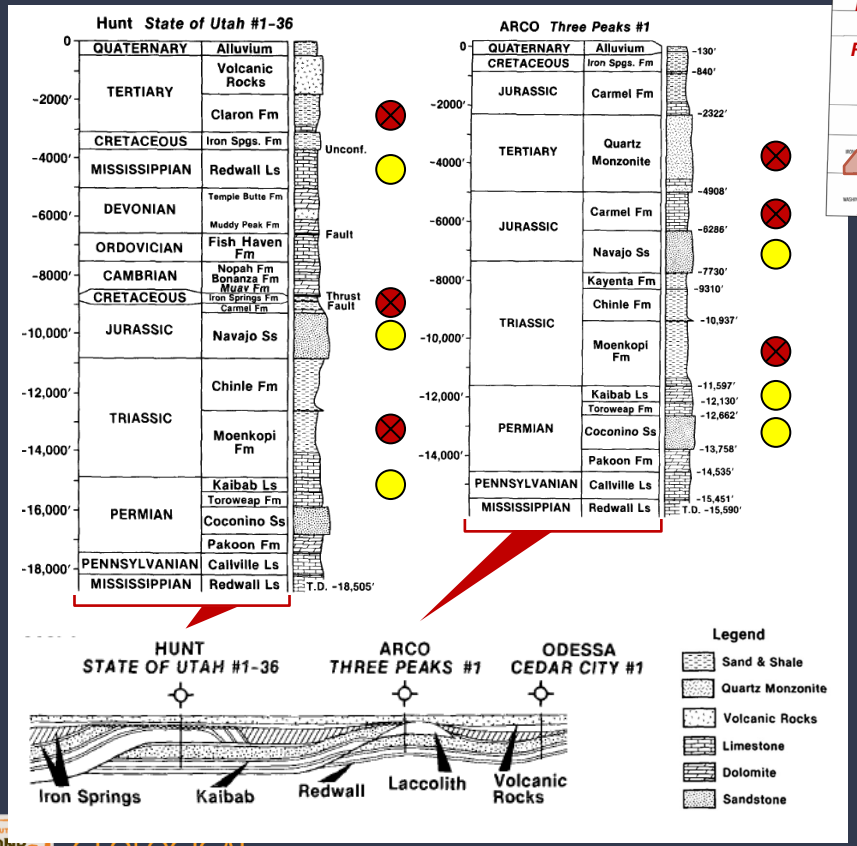
- Groundwater / Aquifer Characterization
- ***Stratigraphy / Chronostratigraphy Refinement***
- ***Subsurface Isopach Mapping***
- Structural & Tectonic History Analysis
- ***Petrophysics and Reservoir Quality Characterization (core / cuttings / outcrop)***
- ***2D Seismic Interpretation***
- ***Outcrop Study of Navajo Fm. and other strata***
- Gravity Survey and Mapping
- Historical and Modern Seismicity

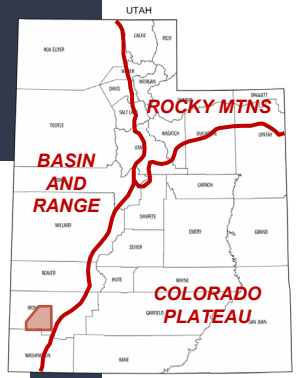


Figures: Generalized geologic maps of the greater Iron Springs District, Utah showing the location of wells and schematic outline of volcanic intrusions (modified from Blank and Mackin, 1967).

key reservoirs & sealing units

3+ trap styles: structural, stratigraphic, & volcano-stratigraphic





Appx. extent of Three Peaks and Granite Mtn. sill

P&A oil & gas well

line of x-section

Three Peaks #1

Cedar City #1

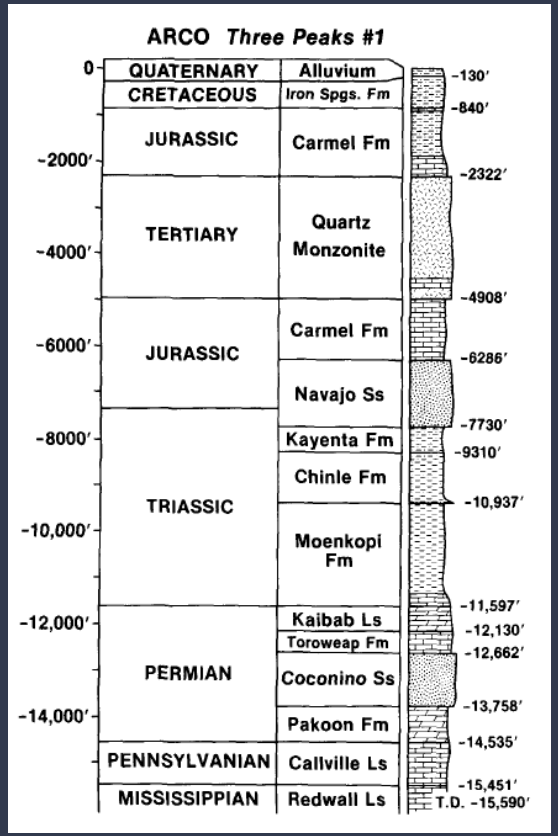
Regional Subsurface CO2 Sequestration Risk Profiling:

- presence of several reservoir/seal pairs at different depth intervals
- no evidence of a working (or paleo?) HC system which lowers the risk of unavailable pore space and overpressure
- relatively low drilling and injection costs since some are reservoirs relatively shallow with potentially world-class character

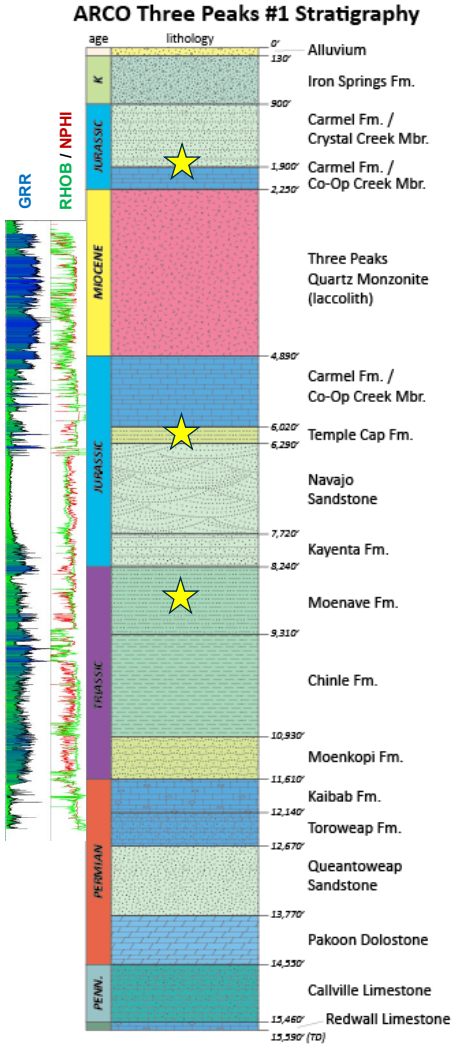
van Kooten, 1988

GEOLOGICAL SURVEY

ARCO Three Peaks #1



van Kooten, 1988



- revised Jurassic & Triassic stratigraphy with control from local wells, outcrop & open mine pits (Sprinkel, *pers. comm*)
  - **Carmel Fm.**
  - **Temple Cap Fm.**
  - **Moenave Sandstone**

- detailed core and cuttings analysis is ongoing…
  - MICP analysis of Carmel Fm. seal rocks
  - thin section petrography
  - pXRF as a screener
  - XRD *(planned)*

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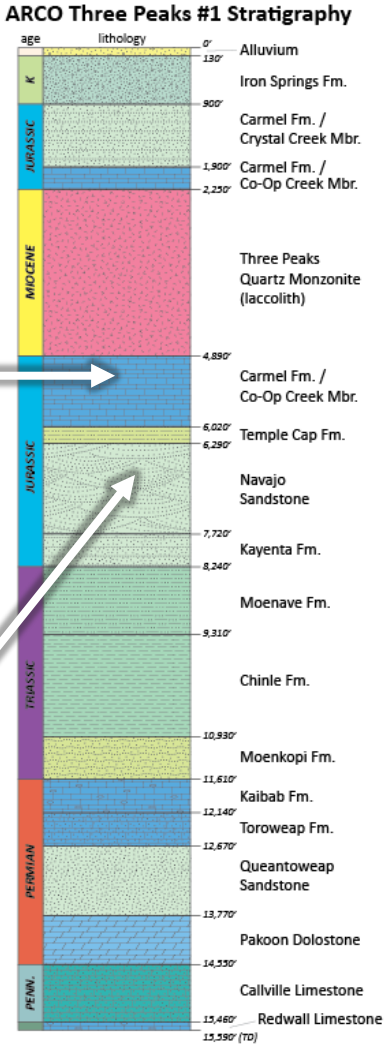
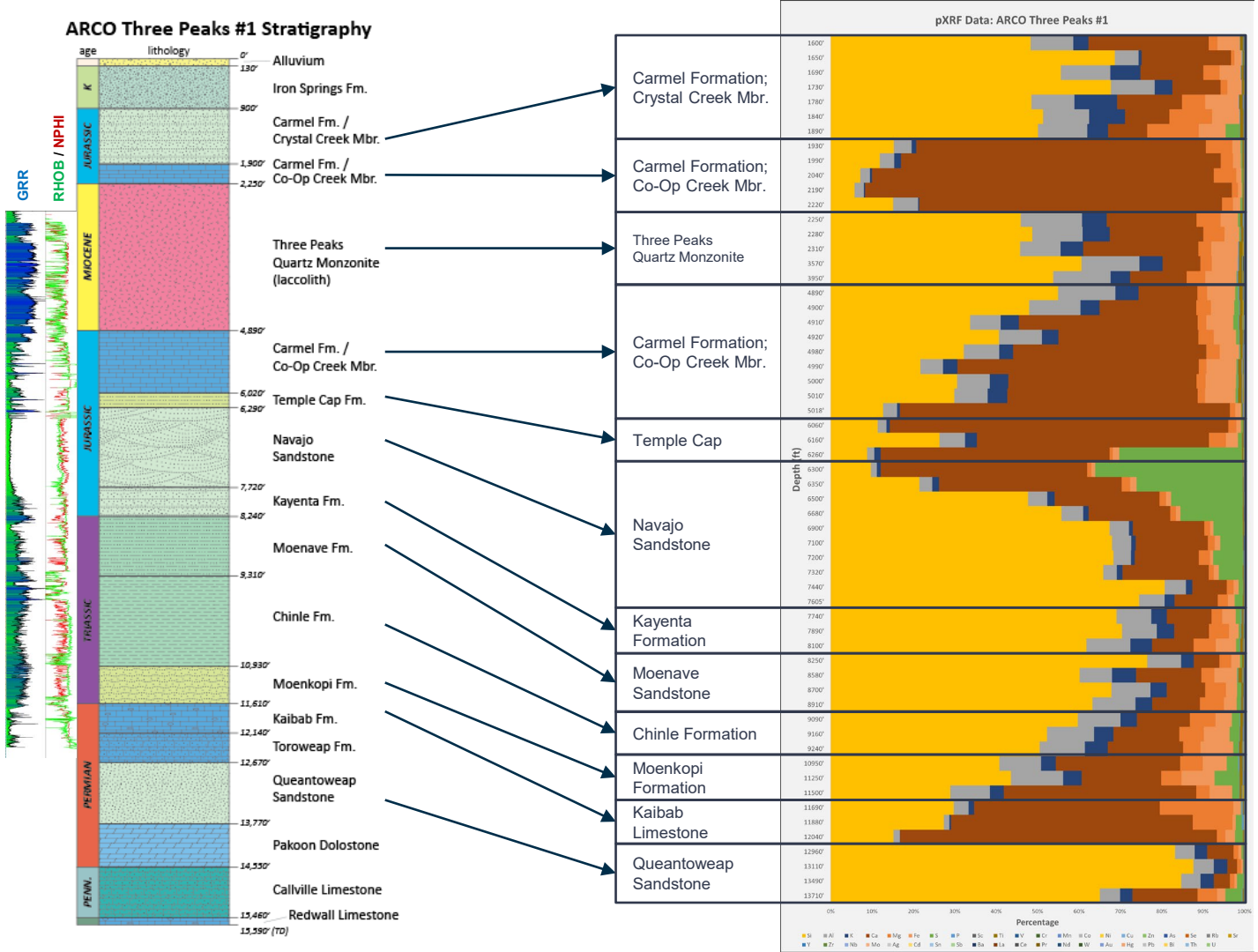
- at least two calcite-filled fracture sets that x-cut and disturbed primary bedding structures
- Timing TBD: fractured during thrust fault development in the Cretaceous? paleo-fluid mobilization events related to ~20 m.y.o. monzonite sill?
- remobilized, high-Ca fluid from the Carmel could be responsible for high Ca in upper Navajo SS, precipitating CaCO3 in the pores (hence lower porosity on the logs)



pXRF data collection



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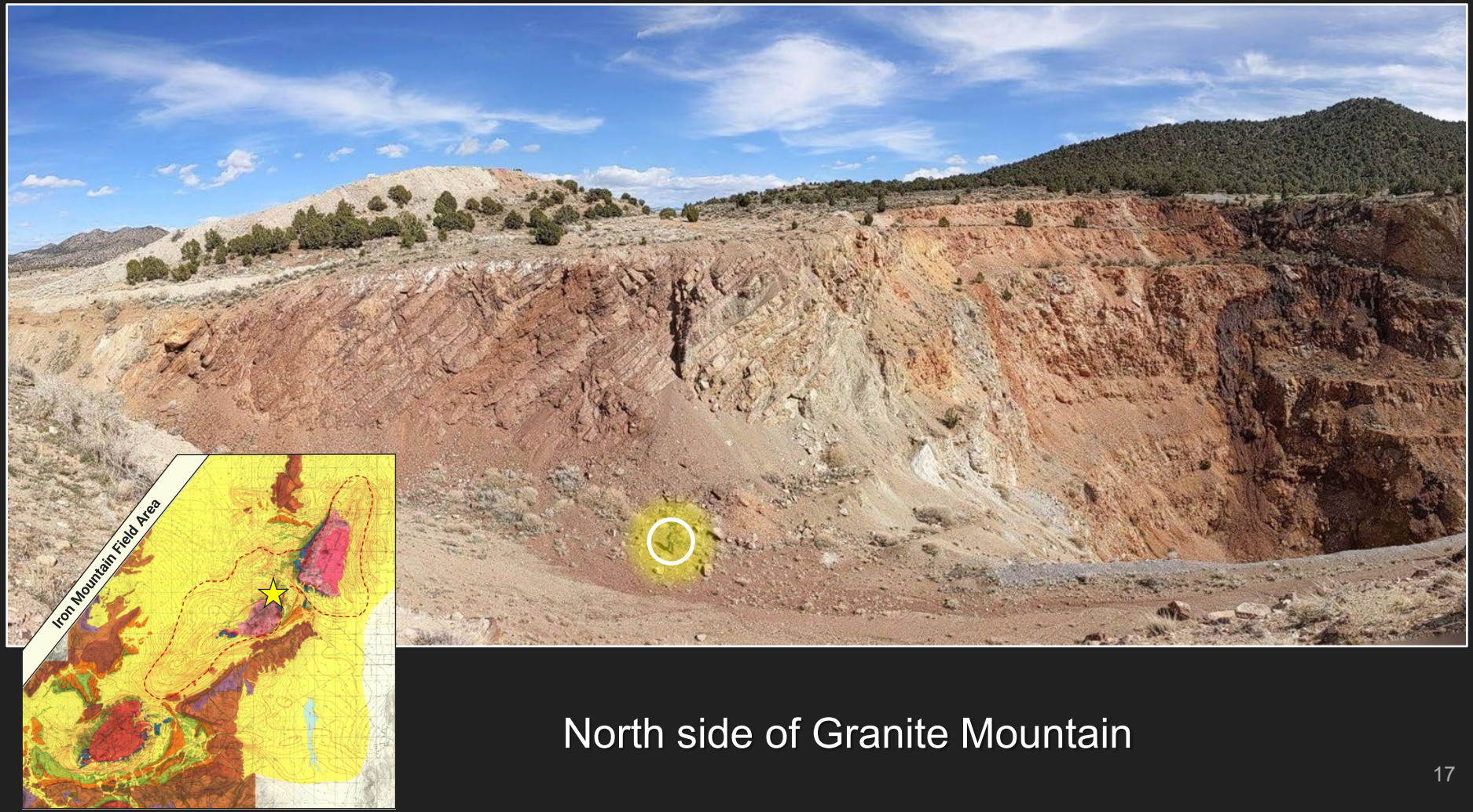
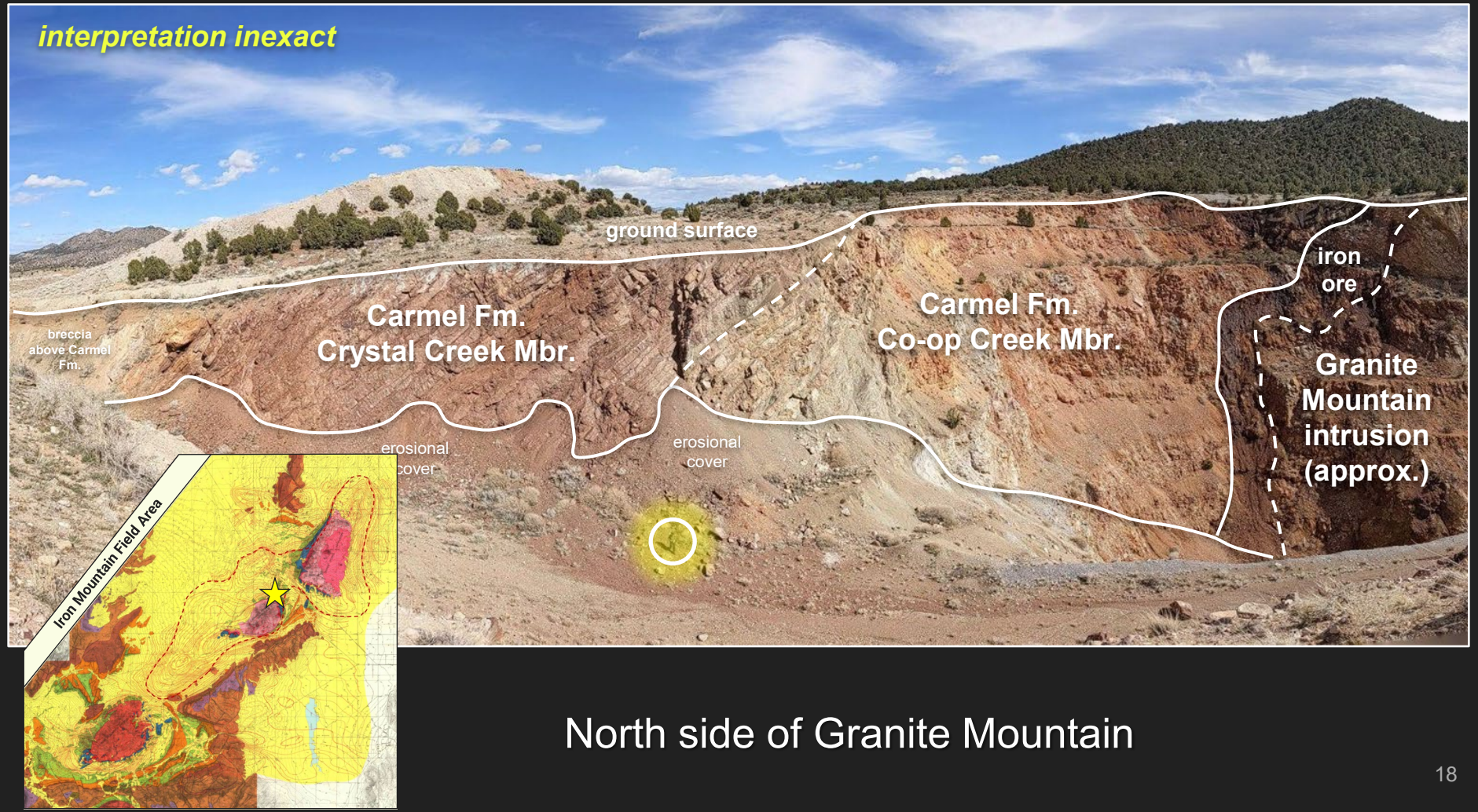


North side of Granite Mountain



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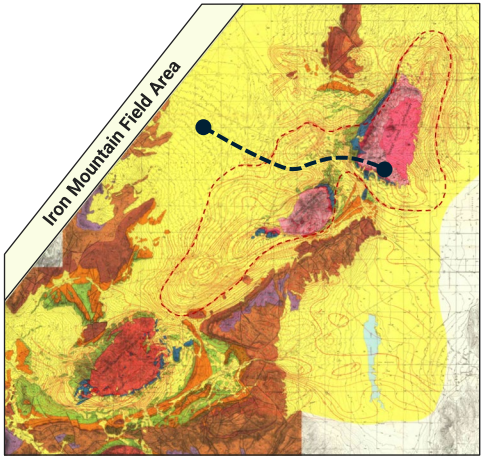
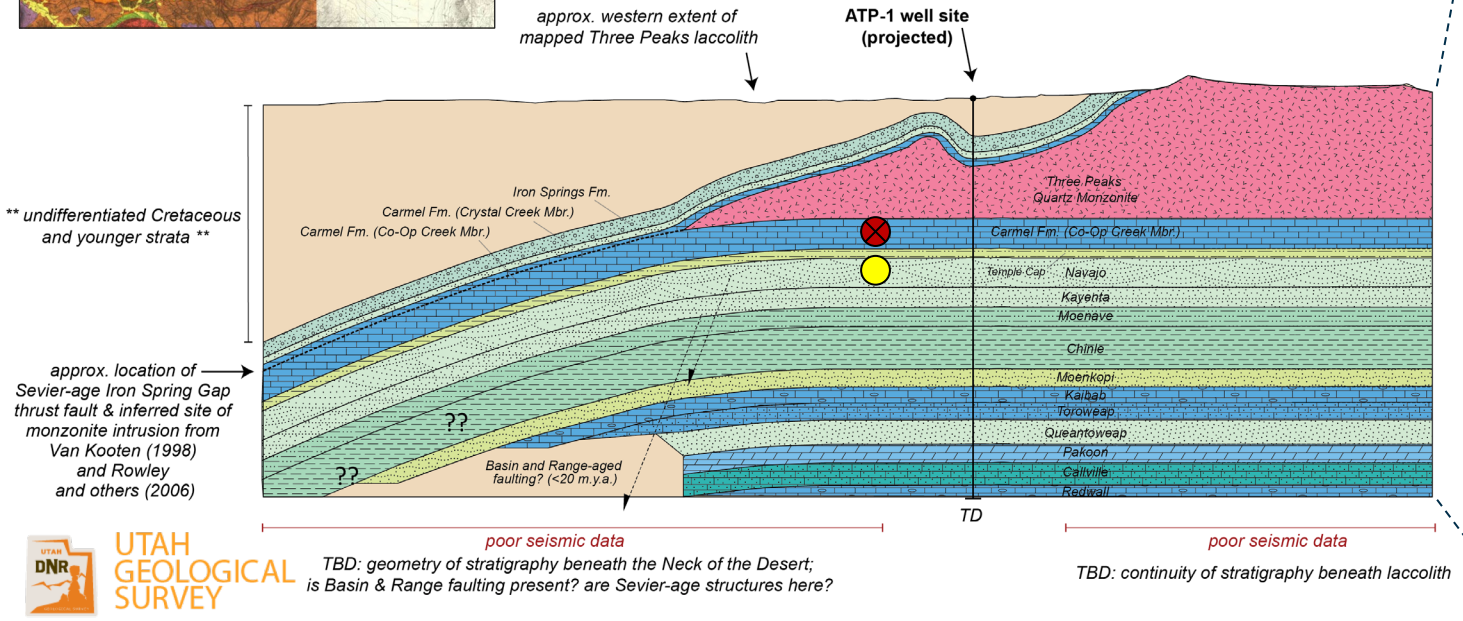
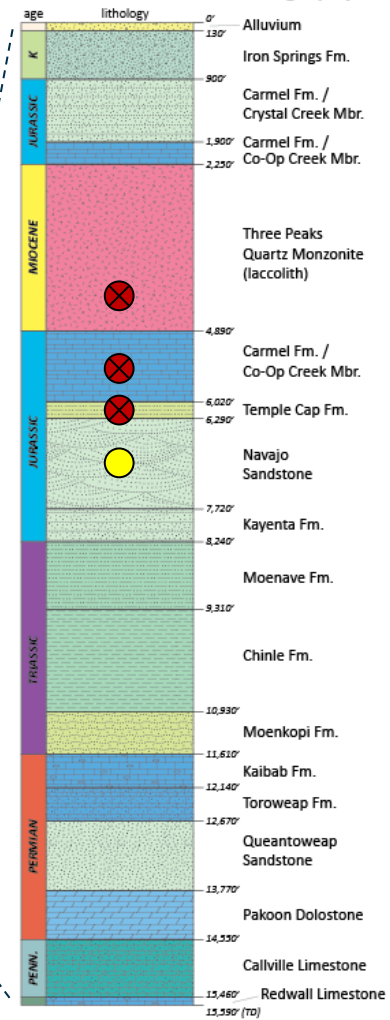


- subsurface geometry in progress
- limited control points





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Outcrop and Subsurface Analogue Database (in progress)

- Outcrop analogues ~15 miles east
- Subsurface analogues from other parts of state and similar lithology

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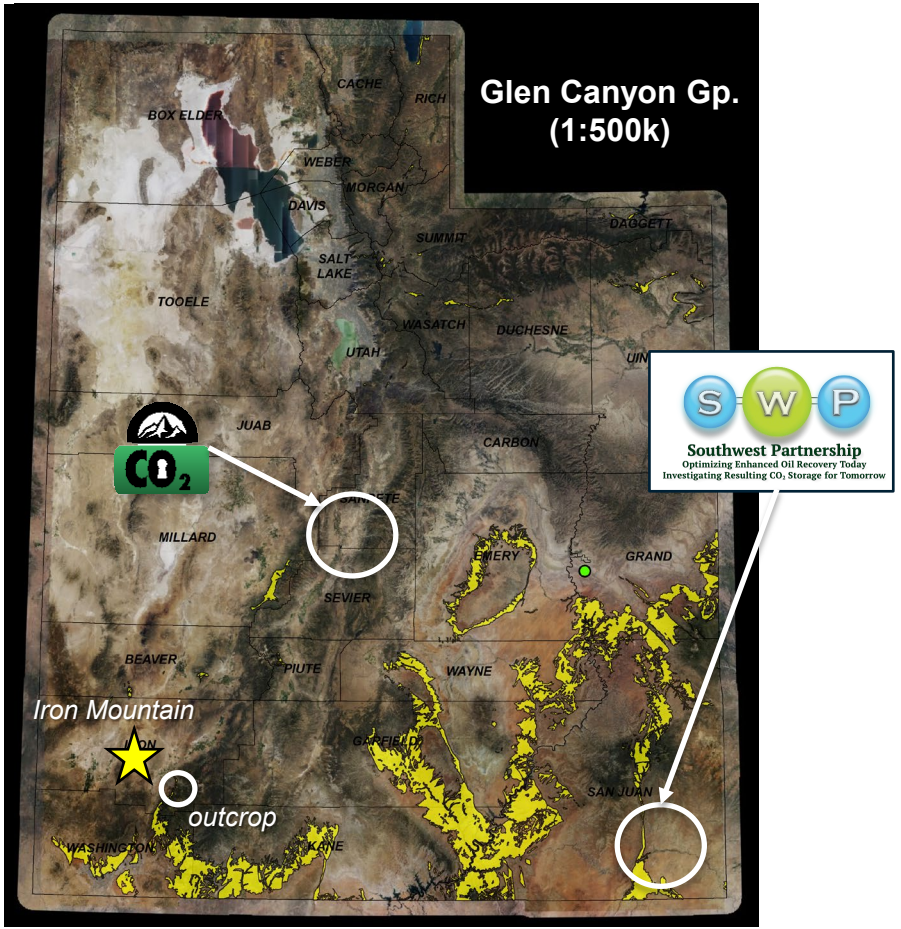
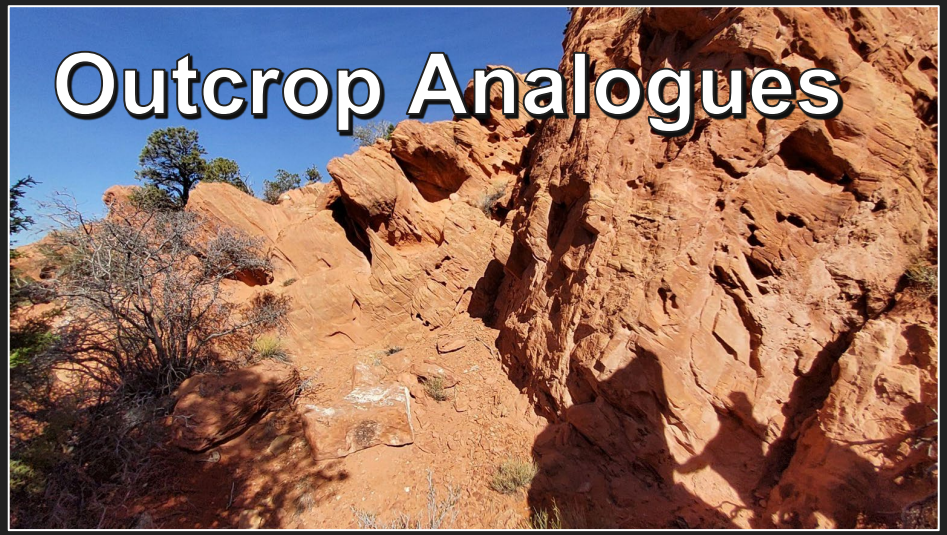
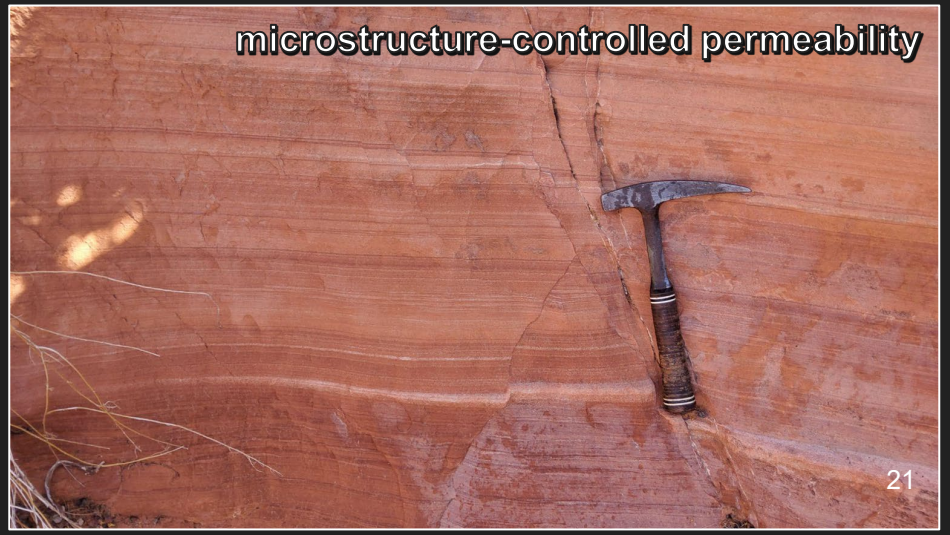
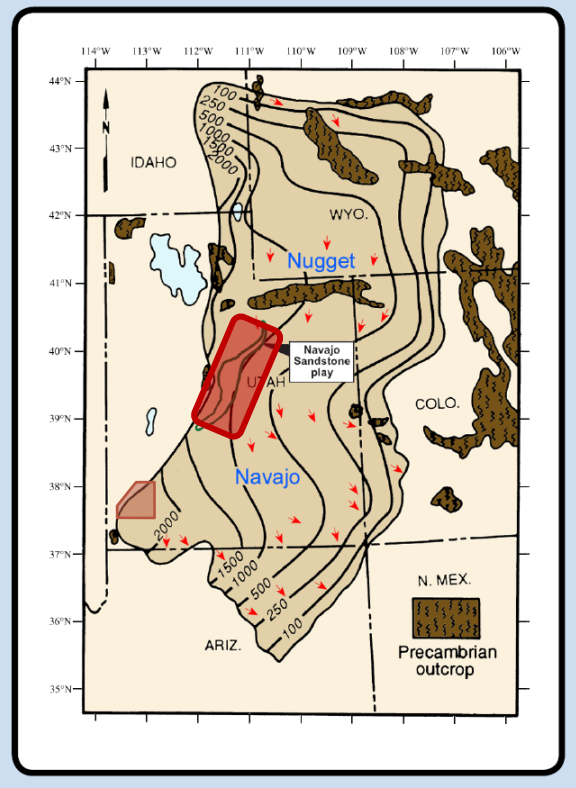


Outcrop Analogues

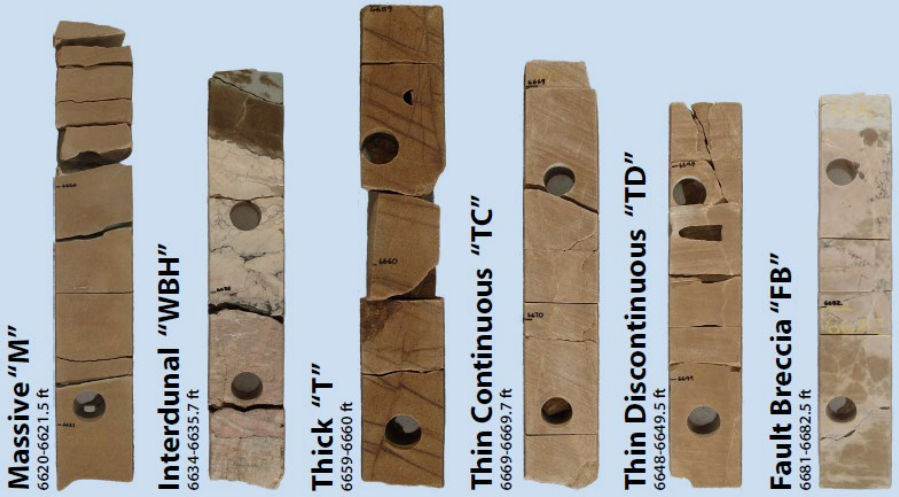


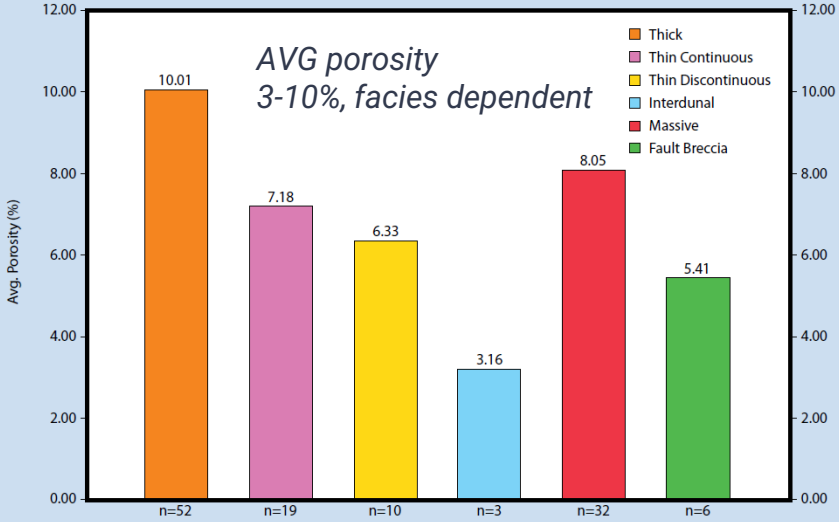


Depo. Facies Variability in Navajo/Nugget Sandstone



Laine et al., 2007





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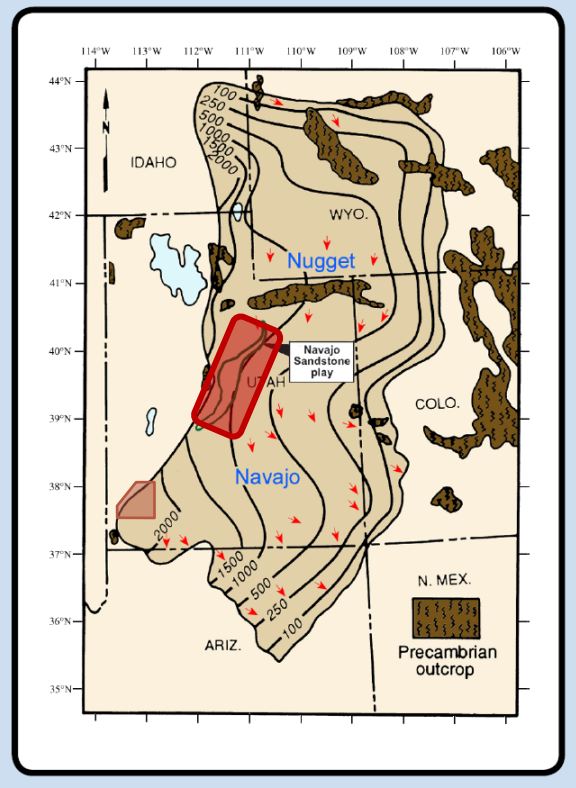

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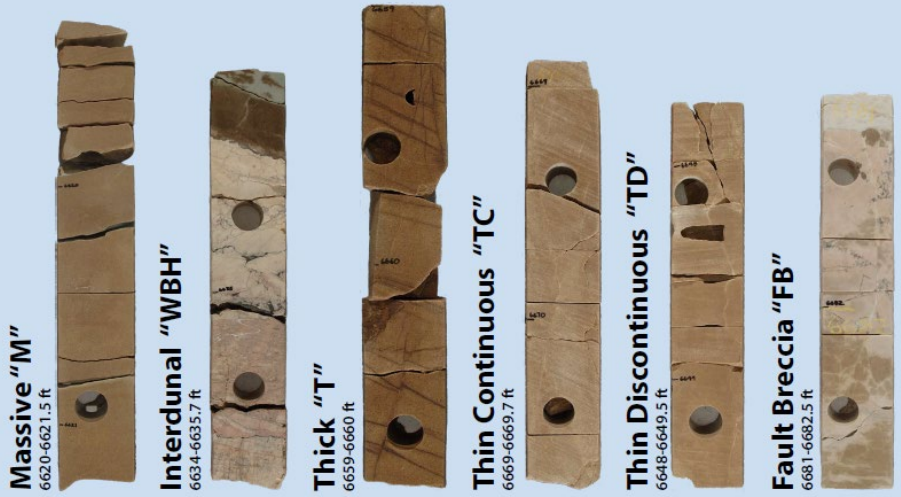

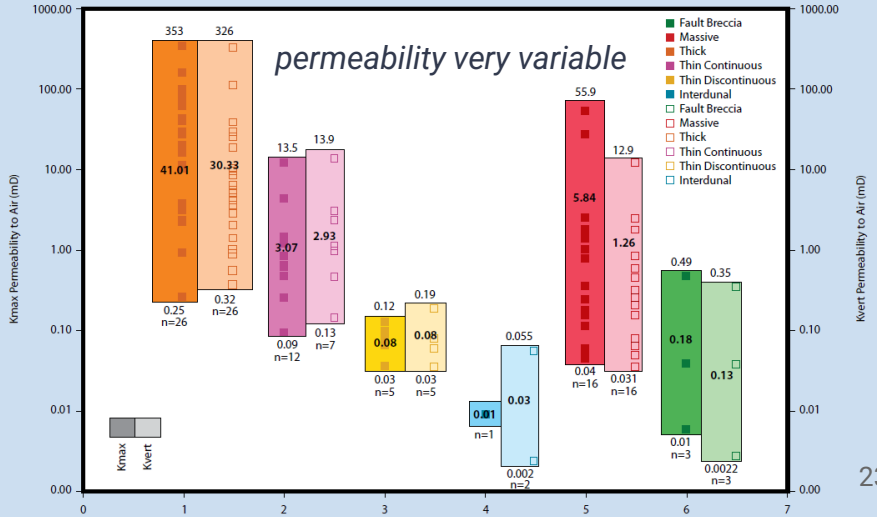

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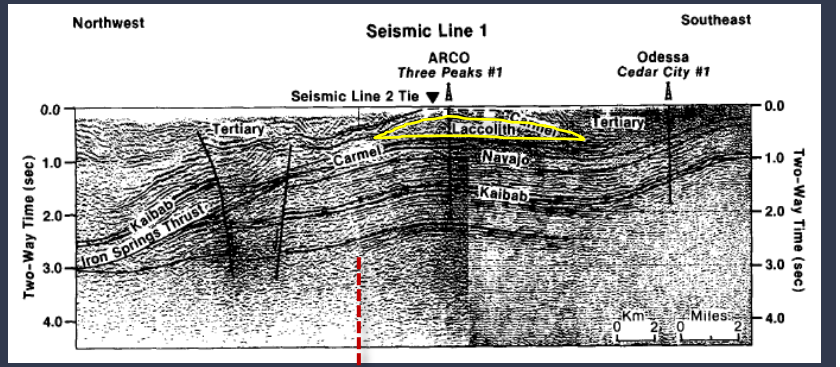
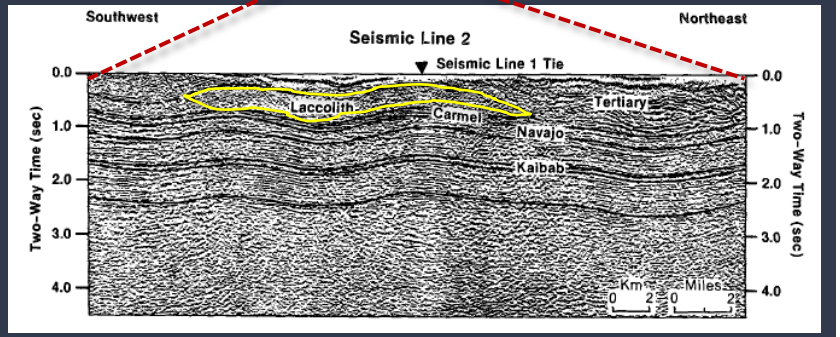
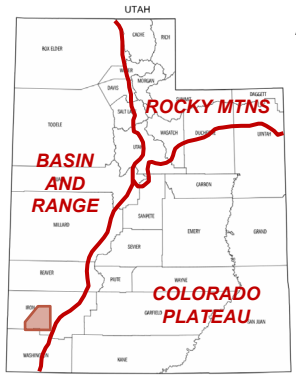
ARCO 2D TWTT Seismic Lines







Appx. extent of Three Peaks and Granite Mtn. sill

2D seismic line

P&A oil & gas well

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2D Gravity Survey

Newcastle

Antelope Range

Escalante Desert

2D seismic line (approx.)

inactive open pit iron mines for study

Cedar City #1

380

Arco Three Peaks #1

2D seismic line (approx.)

local outcrop of overburden & seal rocks

← Cedar City

NORTH

Google Earth

Image Landsat / Copernicus

Data LDEO-Columbia, NSF, NOAA

Ongoing and Future Work

Newcastle

Antelope Range

Escalante Desert

2D seismic line (approx.)

inactive open pit iron mines for study

Cedar City #1

Arco Three Peaks #1

local outcrop of overburden & seal rocks

2D seismic line (approx.)

Cedar City

NORTH

- MICP analysis; thin section petrography; XRD
- complete gravity data collection
- Time-temperature history from thermochronology
- develop rigorous kinematic structural framework (?)
- develop seismic risk profile

personal acknowledgements

- Tom Chidsey, *Utah Geological Survey (retired)*
- Doug Sprinkel, *Azteca GeoSolutions*
- Tyler Knudsen, *Utah Geological Survey*

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