Improving Production in the Emerging Paradox Oil Play

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Dr. Brian McPherson

University of Utah

U.S. Department of Energy

National Energy Technology Laboratory

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Acknowledgements

NATIONAL ENERGY TECHNOLOGY LABORATORY

U.S. DEPARTMENT OF ENERGY
Office of FOSSIL ENERGY AND CARBON MANAGEMENT

ZEPHYR ENERGY

Presentation Outline

- Improving Production in the Emerging Paradox Oil Play
  - Background & Objectives
  - Accomplishments to Date
    - Project well drilled & core and logs collected
    - Core analyses
    - Model development
  - Lessons Learned
  - Synergy Opportunities
  - Summary

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Background & Objectives

- **Objective**: determine / test best strategy to drill emerging unconventional northern Paradox Basin Play - maximize production, minimize impact by better understanding of natural fractures
- **Key Tasks**: characterize, quantify, and interpret natural fractures in the Paradox Play: geology, structure, hydrodynamics, petrophysics and rock mechanics (fracture play vs resource play)

~1.2 billion undiscove resources i Cane Cre assessmen (USGS, 2(

Characterization of the Regional Play
- Petrophysical Characterization
- 3-D Seismic Interpretation
- Coupled Model Development

ZEPHYR ENERGY

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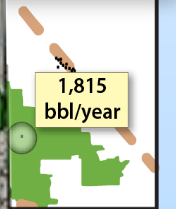
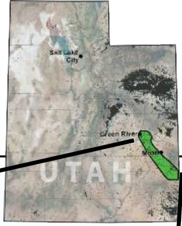
PARADOX

- **Experimental Design and Work Plan:**
  - Characterize fundamental geology, hydrology, and geomechanics
  - Forecast location, extent and mechanisms of natural fractures throughout the play
  - Develop drilling strategy to maximize intersection with (dominant) natural fractures
  - Use high-resolution characterization data to develop a tactical stimulation strategy
  - Test the best approach (New drilling design? Tactical stimulation? Other?)

Major Outcomes:
- detailed facies analysis c
- core-to-log petrophysica integration
- Fully coupled fracture m
- innovative 3D seismic interpretation
- THMC basin model for forecasting



Background & Objectives



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~1.2 billion BOE undiscovered resources in the Cane Creek assessment unit (USGS, 2012)

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- core-to-log petrophysical integration
- Fully coupled fracture model
- innovative 3D seismic interpretation
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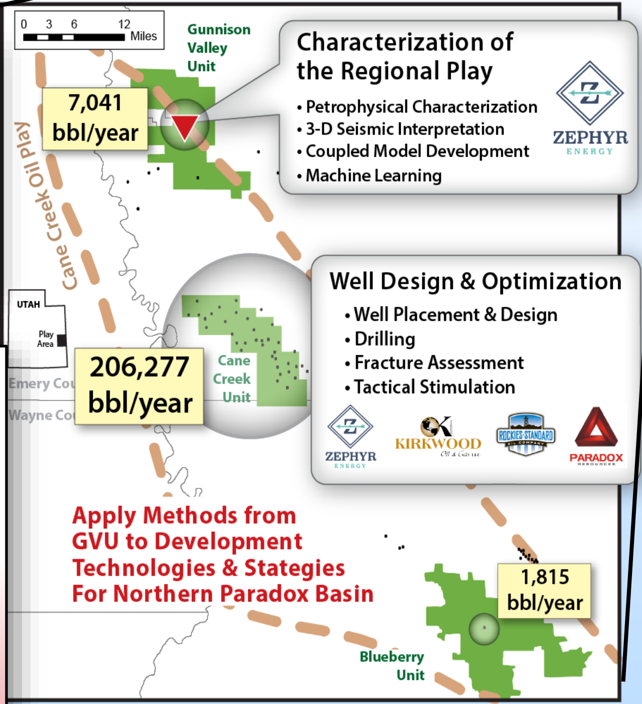
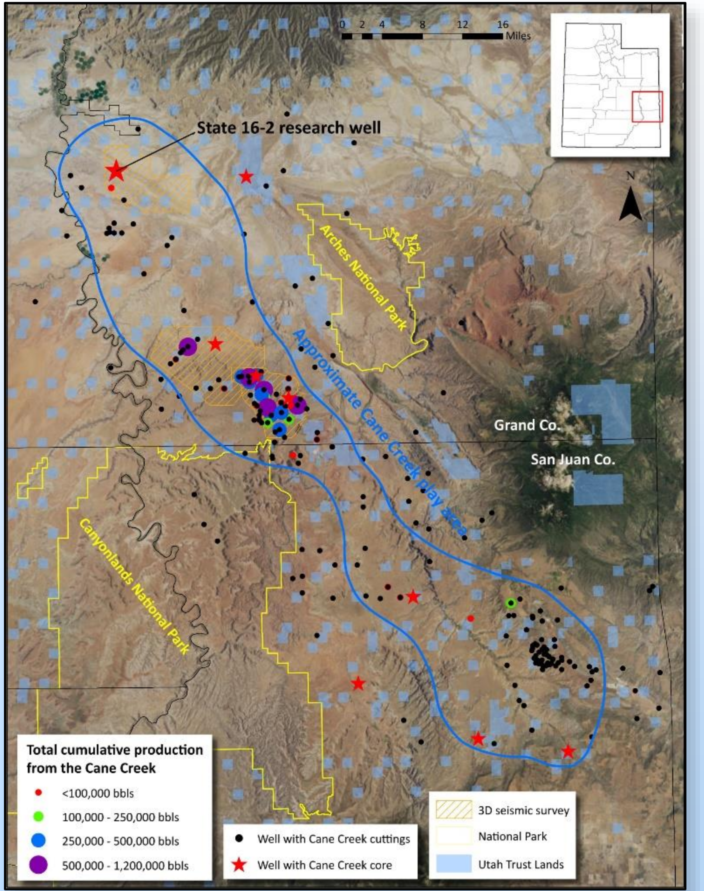
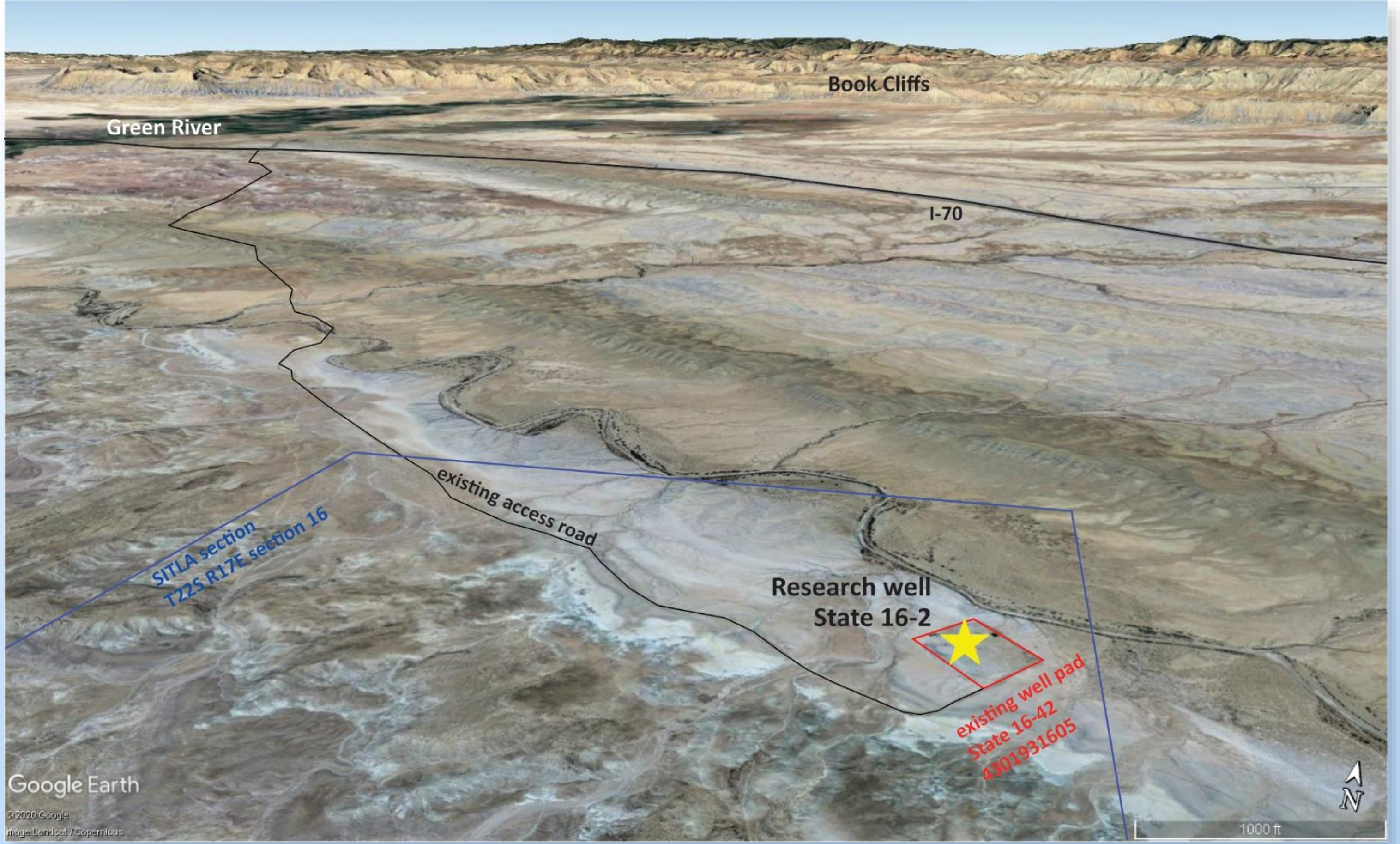


Drilling the Research Well

- Zephyr State 16-2, Gunnison Valley Unit, Utah
  - December 2020 to January 2021



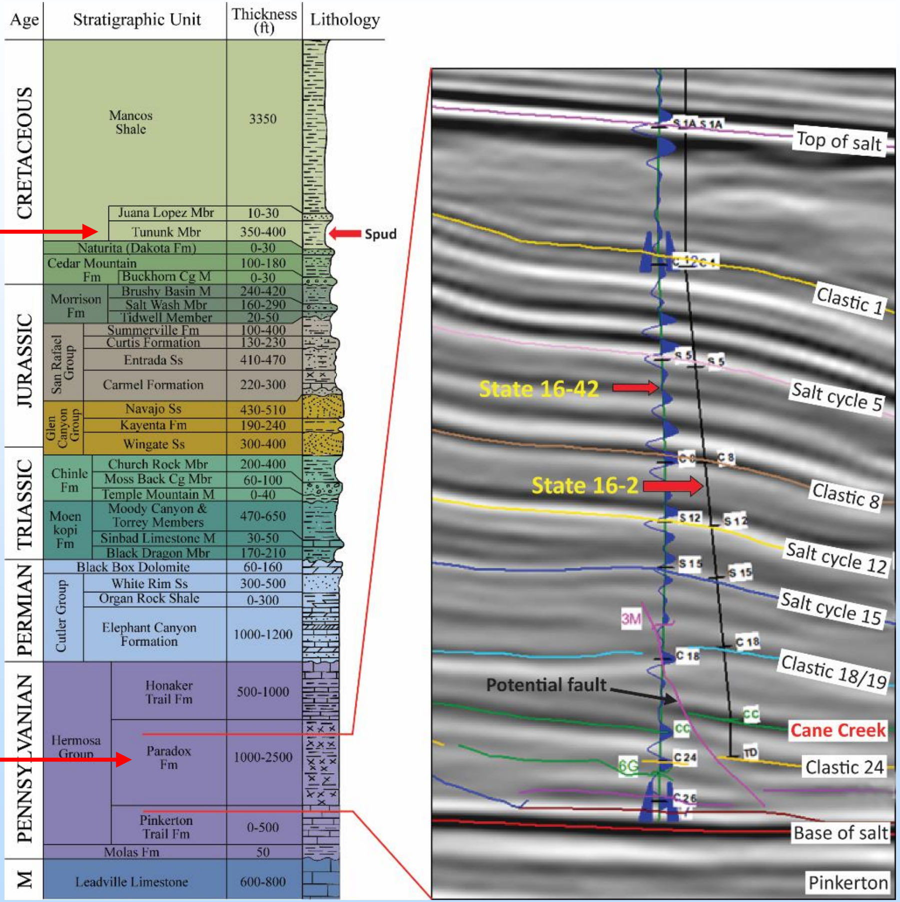
Drilling the Research Well

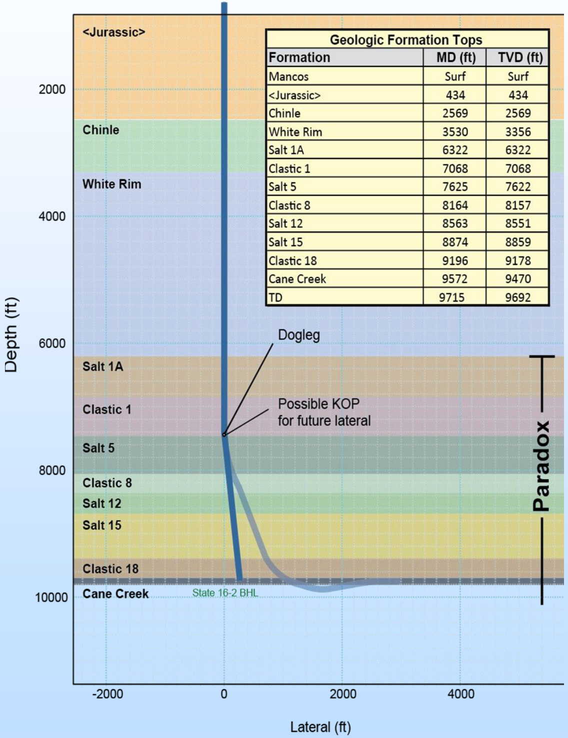


Drilling the Research Well

Surface

TD – 9748 ft





Geologic Formation Tops

Formation	MD (ft)	TVD (ft)
Mancos	Surf	Surf
<Jurassic>	434	434
Chinle	2569	2569
White Rim	3530	3356
Salt 1A	6322	6322
Clastic 1	7068	7068
Salt 5	7625	7622
Clastic 8	8164	8157
Salt 12	8563	8551
Salt 15	8874	8859
Clastic 18	9196	9178
Cane Creek	9572	9470
TD	9715	9692

Drilling the Research Well

- **Timeline - Drilling of the State 16-2 well**
  - Rig equipment started moving to site on Dec 11
  - Rig setup finished on Dec 18
  - Well was spud on Dec 19
  - Drilled down to 1530’, set surface casing (Dec 19 to Dec 23)
  - Drilled down to 6465’, set intermediate casing in Clastic 1a of Paradox Formation (Dec 23 to Jan 4)
  - Drilled with OBM through Paradox Fm. down to core point (Jan 4 to Jan 7)
  - Hit top of Cane Creek at 9638’ on Jan 7
  - Drilled 15 ft of core and jammed, tripped out of hole (Jan 7)
  - Drilled 95 ft of additional core
  - Well TD – 9748’
  - Logged well and cut sidewall cores (Jan 12 to 13)
  - Rig released on Jan 16

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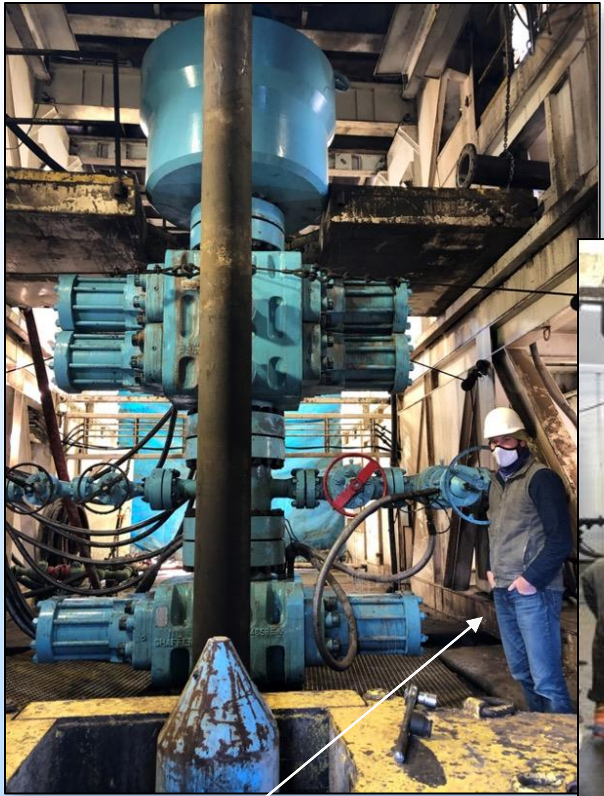
ENERGY

Drilling the Research Well

Drilling the Research Well



Elliot Jagniecki (UGS)

Data Collection From Well

- **Data Collected from State 16-2 well**
  - Core – 110 ft
    - 9638’ to 9728’ – Cane Creek
    - 9728’ to 9748’ – Salt 22, Clastic 23 (~8 ft), Salt 23
  - Cuttings
    - Surface to 6465’ – 50 ft sample spacing
    - 6465’ to TD – 10 ft sample spacing in clastic zones
  - Sidewall cores
    - 31 sidewall cores in 11 upper clastic zones
    - Clastic 1, 2, 3, 4, 5, 7, 8, 9, 11, 17, 18/19
  - Geophysical logs
    - Triple combo, sonic, lithoscanner

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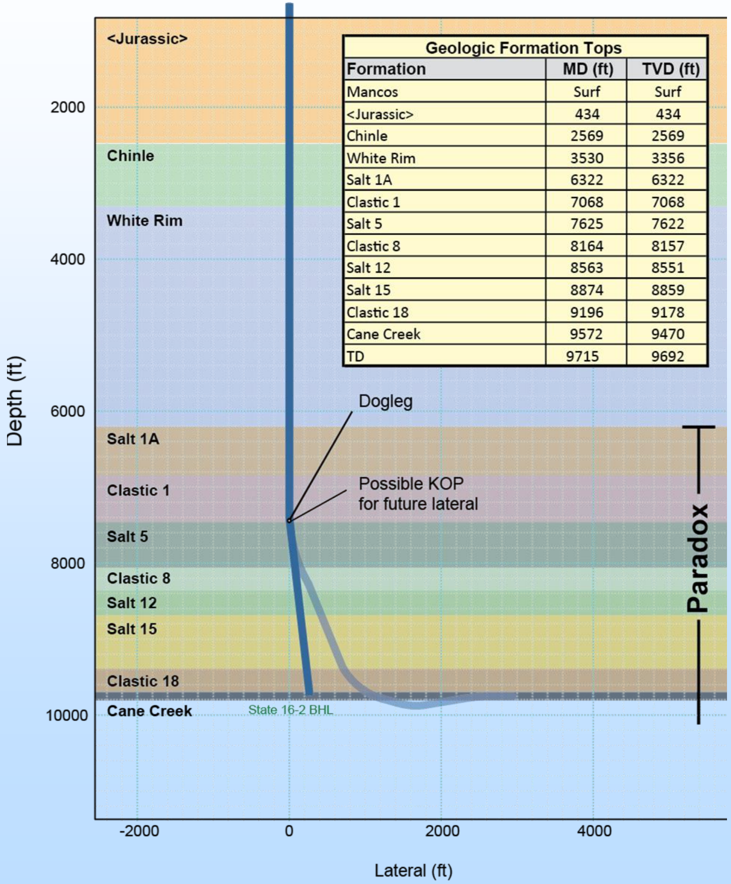

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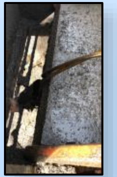
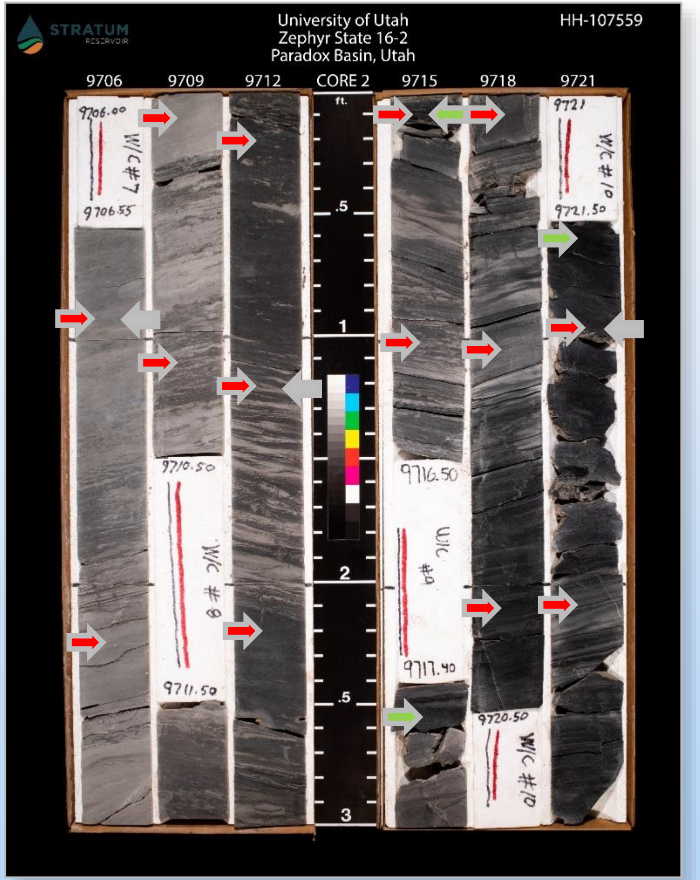


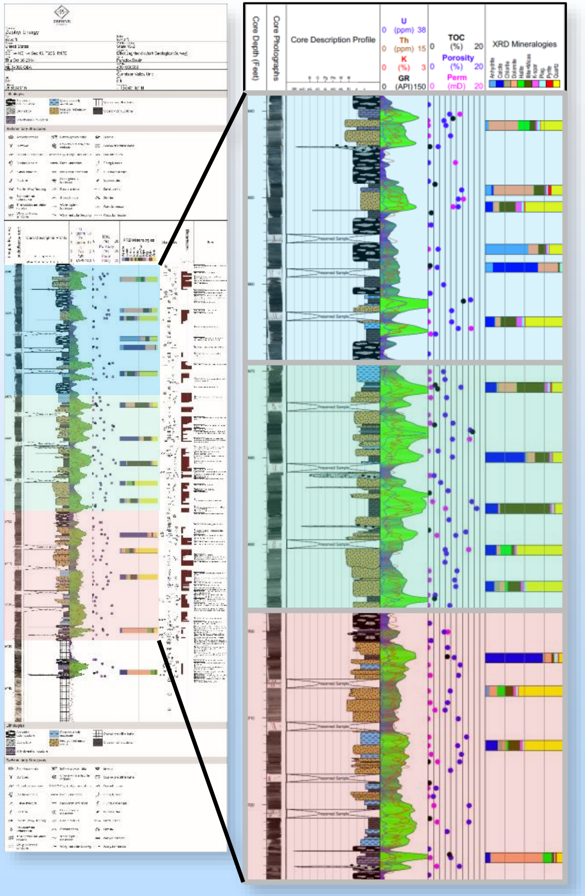
Data Collection From Well

- **Core Data from State 16-2 well**
  - Cane Creek core
    - UV and regular light photography
    - 81 RCAs and Dean Stark
    - 19 SRAs
    - 17 XRD
    - 2 vitrinite analyses
    - 16 thin sections (more planned)
  - Sidewall cores – 31 total
    - Photographs
    - 19 RCAs and Dean Stark
    - 11 SRAs
    - 20 XRD
    - 3 vitrinite analyses
    - 31 thin sections

RCA/DS
SRA
XRD



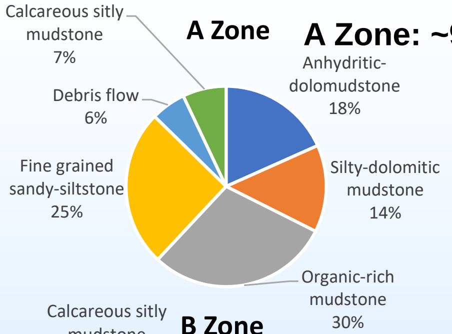
Core Description



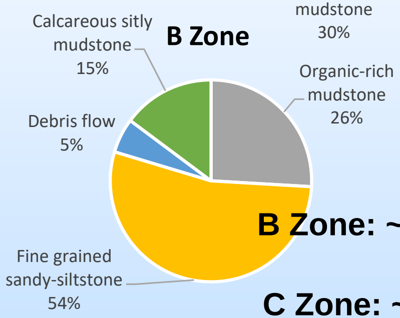
A Zone

B Zone

C Zone

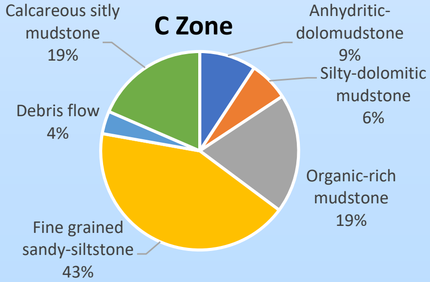


A Zone: ~9650 ft



B Zone: ~9695 ft

C Zone: ~9725 ft



Depositional System

Abundant anhydrite-dolomite throughout, low proportion sandstone/siltstone, several thin-beds organic-rich mudstone, low bioturbation; anoxic-saline conditions; low-high % TOC; low pore-perm

Abundant sandstone/siltstone, absent anhydrite, low dolomite high calcite, several thin-beds of organic-rich mudstone, wave rippled, high bioturbation; oxic-fresh conditions; low-high % TOC; low-high pore-perm

Abundant sandstone/siltstone, lower proportion of anhydrite-dolomite, lower proportion organic-rich mudstone, medium proportion sandstone/siltstone within middle medium-high bioturbation; mixed oxic-anoxic conditions; low % TOC; medium-high pore-perm

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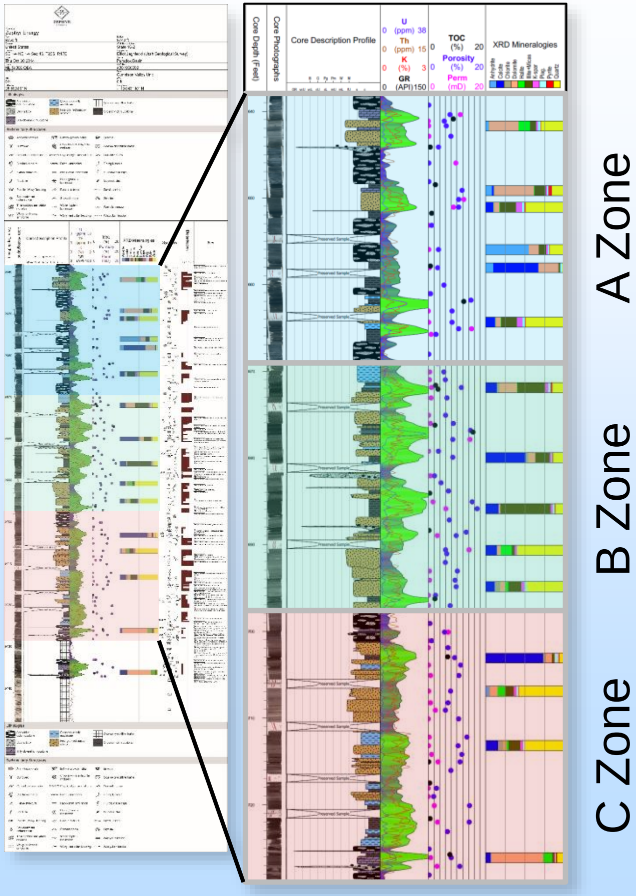

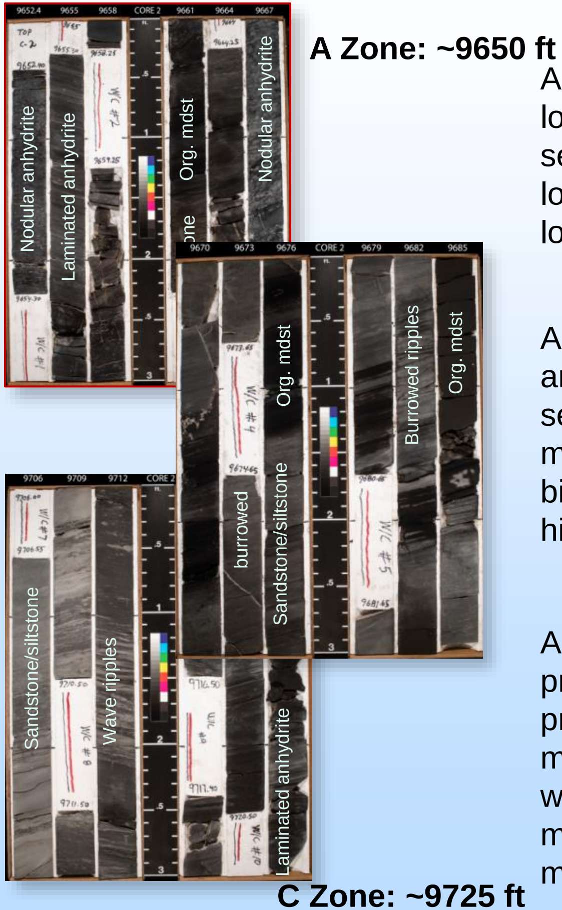

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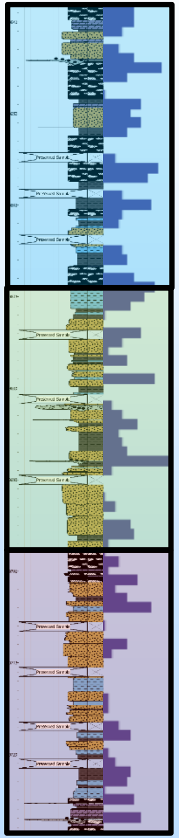
Core Description - Fractures

Lithology # Fractures

A Zone

B Zone

C Zone

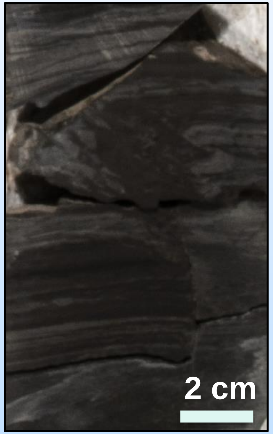


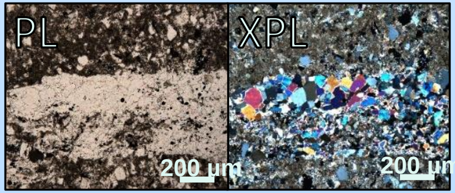
Fractures			
Zone	Cemented	Open	Total
A	79	90	169
B	74	62	136
C	68	52	120

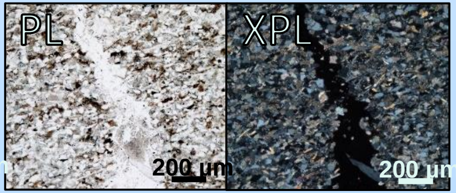
A Zone: 9650.5 ft

B Zone: 9704 ft

C Zone: 9723.5 ft

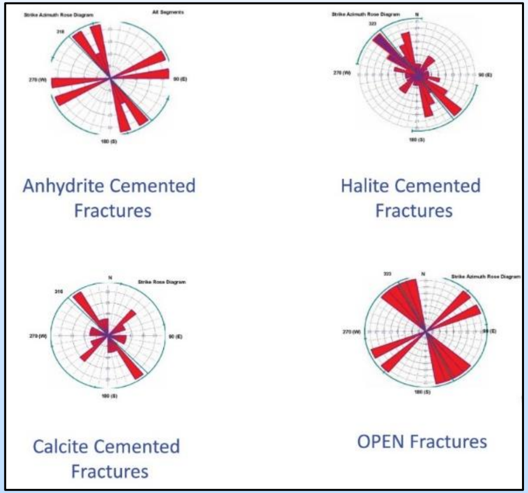






- Non discrete for specific rock types
- Variety of open vs cemented
- Halite, anhydrite, calcite cemented filled & lined
- Aperture range is nm to mm scale
- Apparent micro to macro scale faulting

Fractures in the Cane Creek unit 26-3 well



Fracture orientation is dominantly northwest-southeast parallel to the regional structure and depositional trend of the Paradox Formation.

Core Scale - Geomechanics

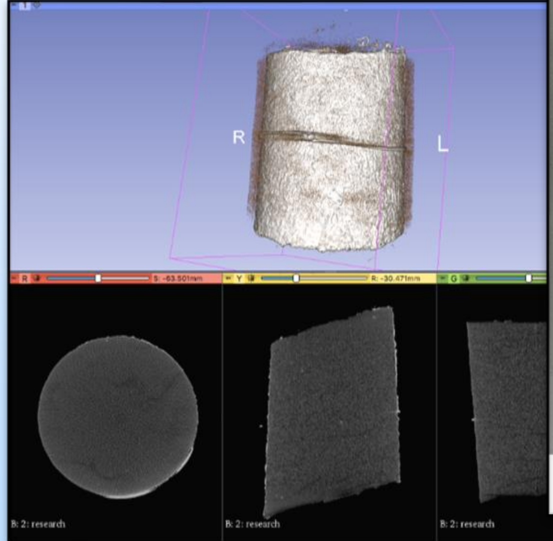
Task 3 – Core Analysis: Geomechanical Characterization Plans

- **Goals**
  - Determine failure loci (for wellbore stability assessments, DFN simulations of natural fracture interaction during treatment)
  - Measure static mechanical properties including Young's modulus and Poisson's ratio (the former for stimulation design as appropriate, the latter for stress field inferences; correlation with sonic log dynamic data)
  - Measure fracture toughness (in order to assess the potential for new fracture formation during hydraulic stimulation, as opposed to fracture/fault reactivation)
  - Measure creep parameters (for refined in situ stress predictions)
  - Carry out uniaxial strain testing to determine pore volume compressibility and formation compressibility to refine decline curve predictions
- **Status**
  - Preserved samples received, CT scanned, and being plugged (refer to accompanying slide)

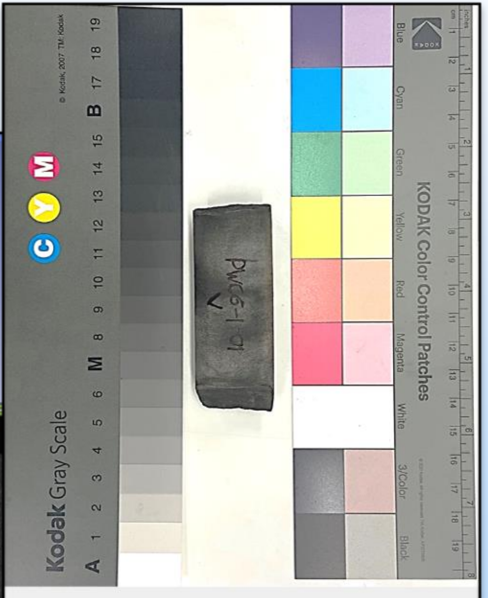
Core Scale - Geomechanics

- Five horizontal plugs **in representative facies** from which plugs **can be successfully acquired** for UCS (1), triaxial (3), creep (1), and one vertical plug for uniaxial strain (1)
- Two disks (Brazilian tensile strength, fracture toughness)

Siltstone preserved core with one-inch diameter plugs extracted



Pre-plug CT Scan



Five plugs from 9689.58-.78 ft MD

Micro-Scale - Geomechanics

Task 3 – Micro-Scale Core Analysis: geomechanical characterization plans

- Goals
  - As there are potentially a limited number of competent core plugs available from the State 16-2 well (due to ubiquitous fractures), determine the consistency among conventional and unconventional mechanical tests on reservoir rocks
  - Evaluate relative impacts of hydraulic properties, heterogeneity, and ductility on mechanical properties
- Compare conventional triax to min—triax, micro-scratch, and nano-indentation testing
  - Different formations will be compared as well, to isolate rock-specific vs method-specific issues
  - Rock samples:

	Depth (ft)	Permeability (m^2)	Porosity (%)	Location
Entrada Sandstone	9012.2 – 9043.7	2.57×10^{-17} – 3.15×10^{-13}	3.64 – 18.7	Rocky Mountain, CO
Morrow B Sandstone	7644.4 – 7704.1	3.35×10^{-18} – 5.62×10^{-14}	3.0 – 11.8	Anadarko basin, Farnsworth unit, TX
Cane Creek Sandstone (tight)	7426 – 7460	9.87×10^{-19} – 3.24×10^{-15}	0.63 – 9.26	Paradox basin, Cane Creek unit, UT

Micro-Scale - Geomechanics

- Characterization plan

Unconventional method (nanoindentation test, scratch test, mini-triaxial test)		Conventional method – triaxial test
• Above or below REV • Millimeter scale • Microscale • Nanoscale	Compare to →	• Above representative elementary volume (REV) • Centimeter scale • Meter scale

- Mechanical property measurements
  – Young's modulus, Poisson's ratio, bulk modulus, Biot's coefficient, uniaxial compressive strength.
- Primary outcomes
  – Quantitative comparison of different-scale geomechanical testing methods: nano, micro, core scales.
  – Multi-scale uncertainty quantification of geomechanical data, with implications for upscaling.

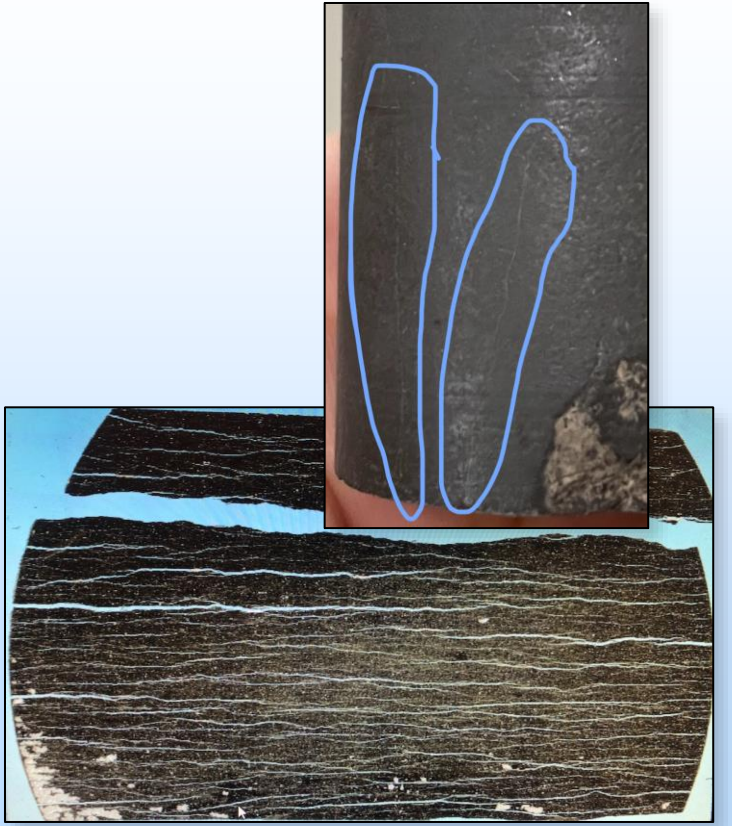
Stress Dependent Relative Perm

- **Goal and Experimental Testing Parameters**
  - To understand the role of changes in effective stress on relative permeability for at least two horizons within the Cane Creek.
  - Three stress states selected, based on log extrapolation from State Well #16-40 and stress measurements from the 3-Mile 43-18-H:

State	Stress (psi)	Pore Pressure (psi)
State 1	1914	1500
State 2	3184	1500
State 3	4383	1500

Stress Dependent Relative Perm

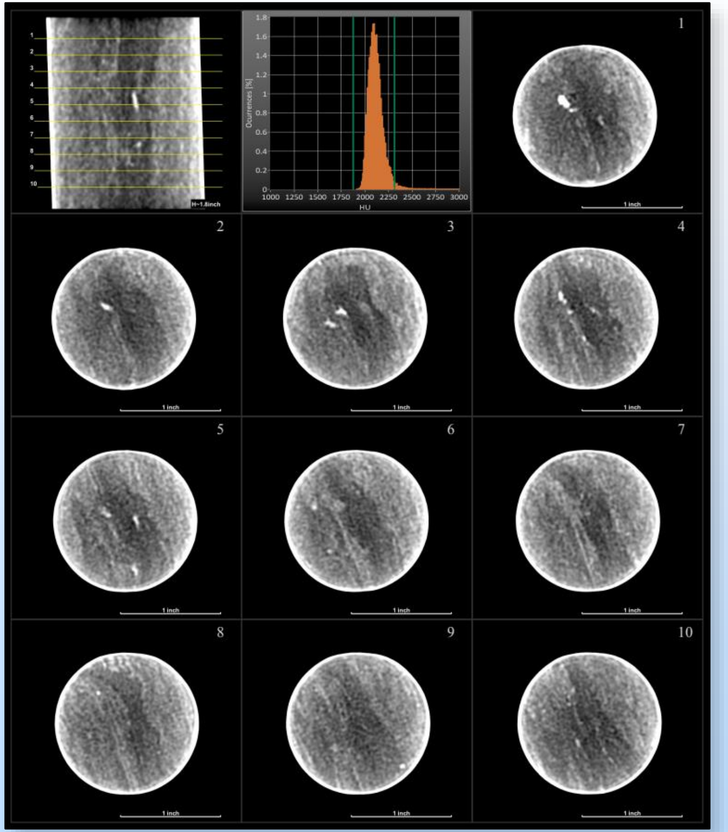
- **Sample Selection**
  - Two rock types within Cane Creek (fine-grained sandy siltstone and organic-rich mudstone) selected for relative permeability analysis
  - We hypothesize that permeability of the Cane Creek fine-grained sandy siltstone is pore driven and the permeability of its organic-rich mudstone is augmented by micro-fracture swarms within depositional sequence
  - Changes in effective stress will help understand relative role of both flow mechanisms on Cane Creek permeability

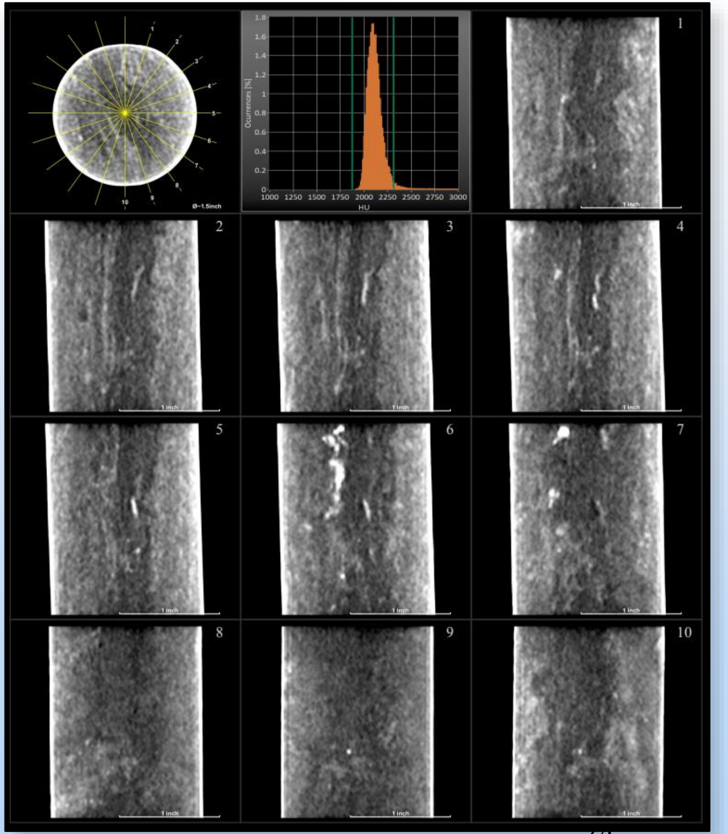


Fractures within the organic-rich mudstone sample and thin section

Stress Dependent Relative Perm

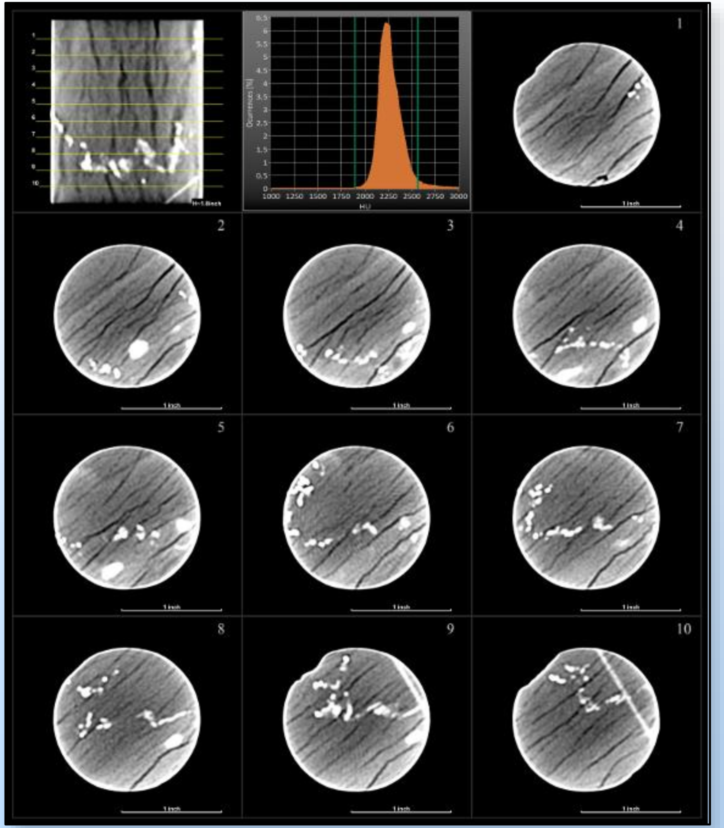
- **Sample Selection – CT Scans**
  - Fine Grained Sandy Siltstone: Sample 2-40-1 (Depth: 9,691.30')

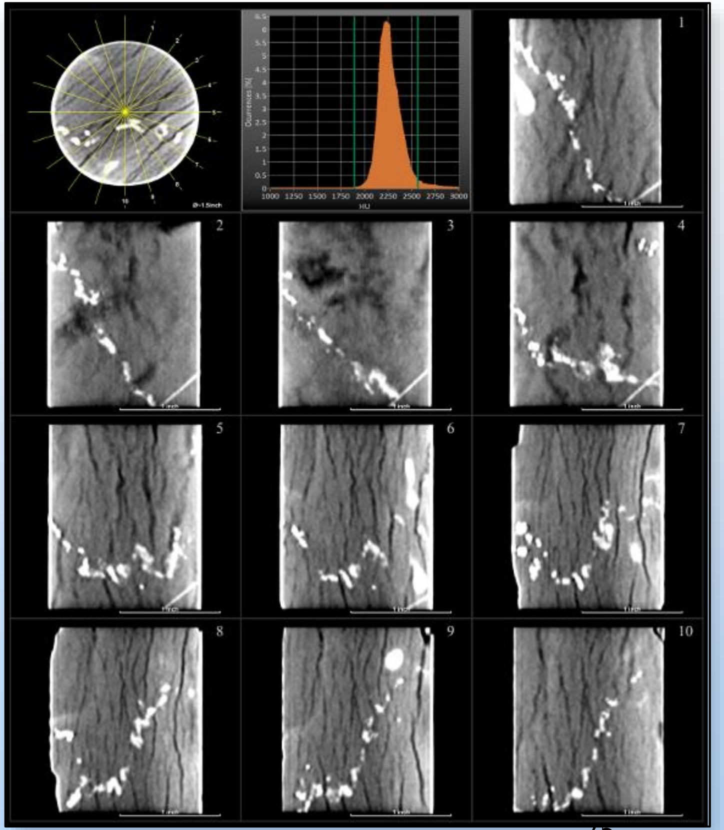




Stress Dependent Relative Perm

- **Sample Selection – CT Scans**
  - Organic Rich Mudstone: Sample 2-34-2 (Depth: 9,685.45')

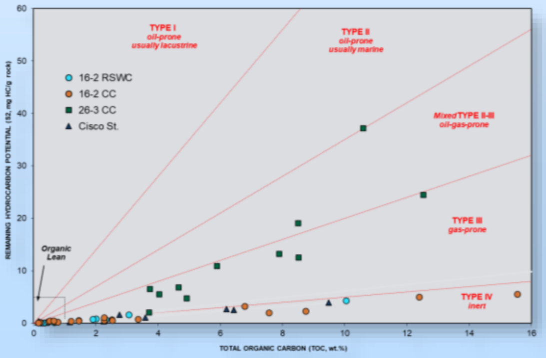


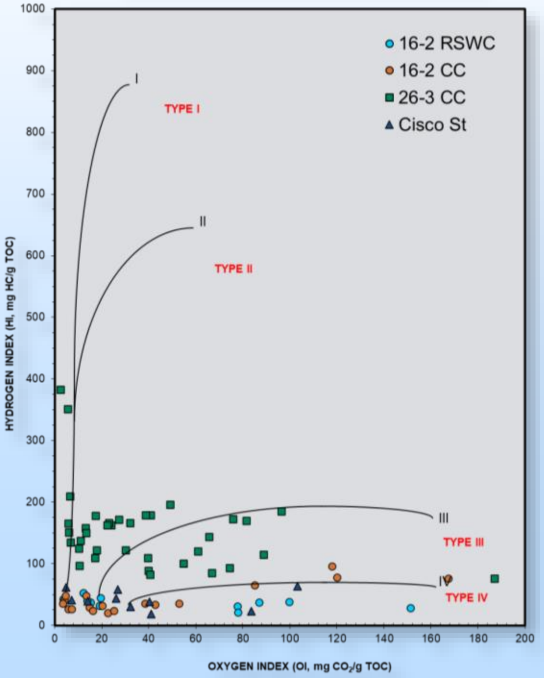


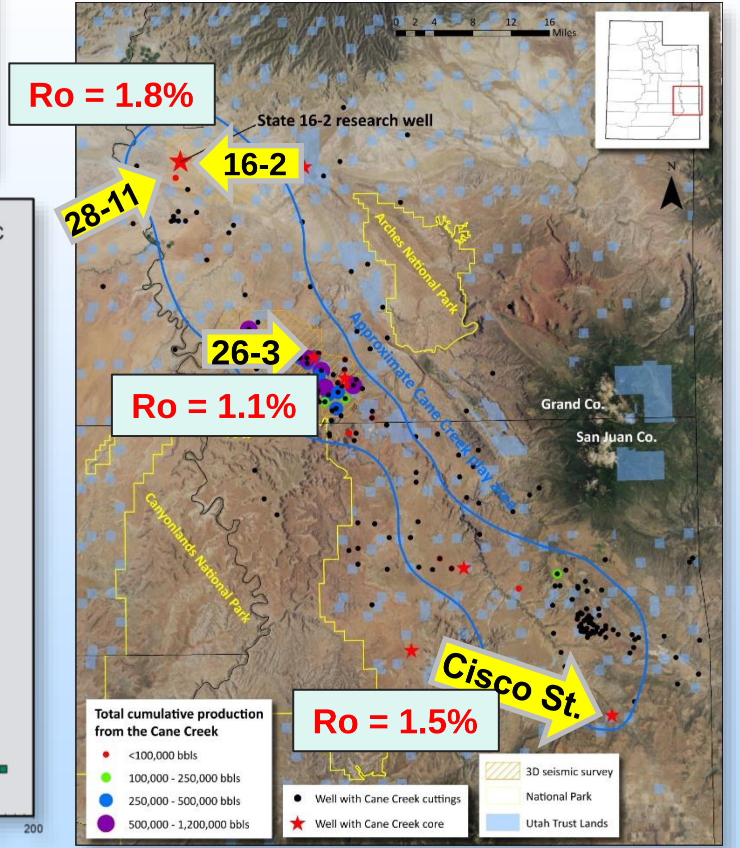
Source Rock Analyses

- **State 16-2 Source Rock Analyses**
  - TOC up to 15% (average in shales = ~4%)
  - Low HI (average of 35), plots within Type IV inert
  - Low S2 (average = 1.3)
  - Ro from VR = 1.8%
  - T_{max} averages 465 (ranges from 451-484)

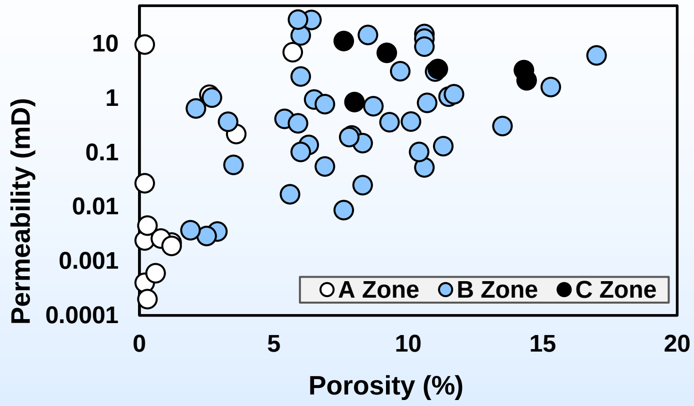
Importantly, Federal 28-11 produced ~92,000 bbls of oil and ~360,000 Mcf of gas from 2008 to 2019. API>50.

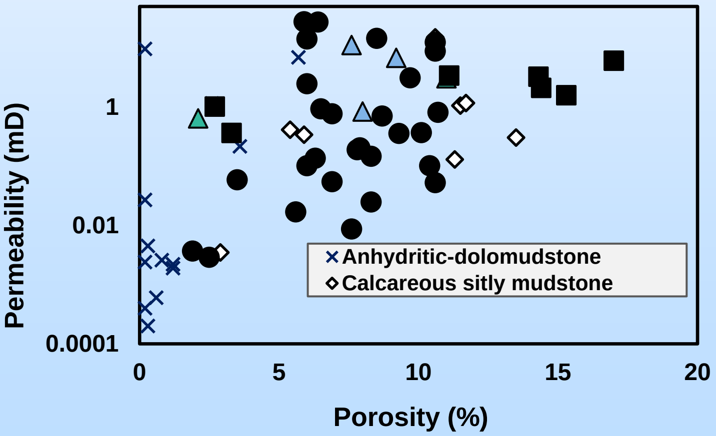




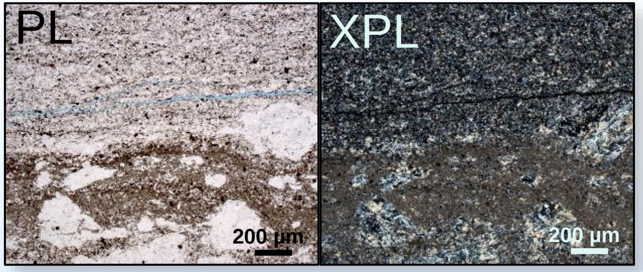


Reservoir Quality



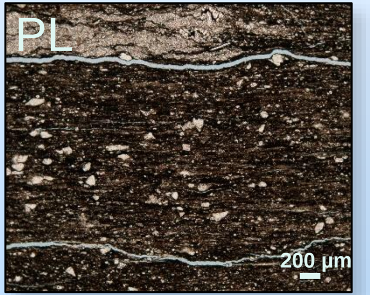


A Zone: 9656.05 ft



Nodular anhydritic-dolomudstone with 0.217 mD and 3.6 porosity; fractures are observable porosity.

C Zone: 9725.75 ft



Algal laminated calcareous silty organic-rich mudstone; parting fractures (blue) with 3.26 mD and 14.3 porosity and TOC of 7.56 wt %

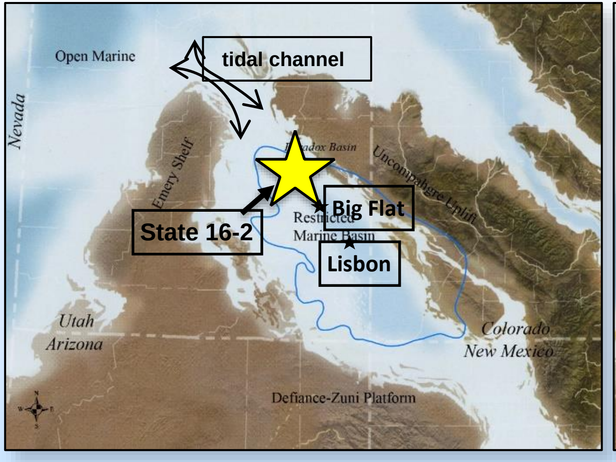
B Zone: 9694.9 ft

Sandstone/siltstone with 0.359 mD and 9.3 porosity; intergranular and micro porosity observed (arrows), abundant calcite cement

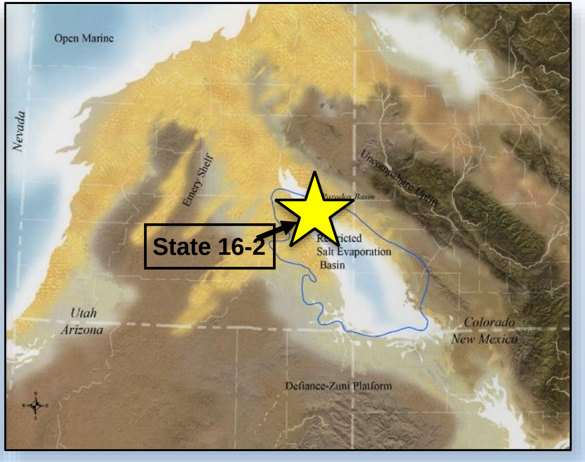
Facies Interpretation

- Depositional Environment: Pennsylvanian paleogeography, eustasy, and subtropical arid climate

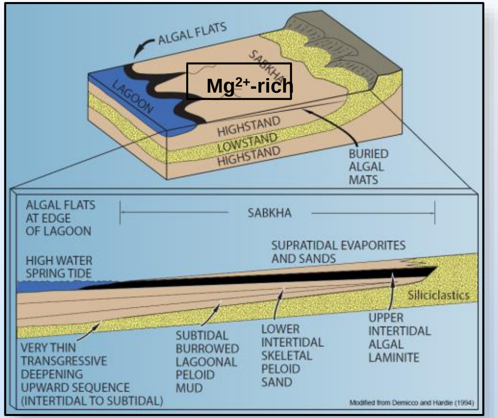
Conceptual Depositional Model

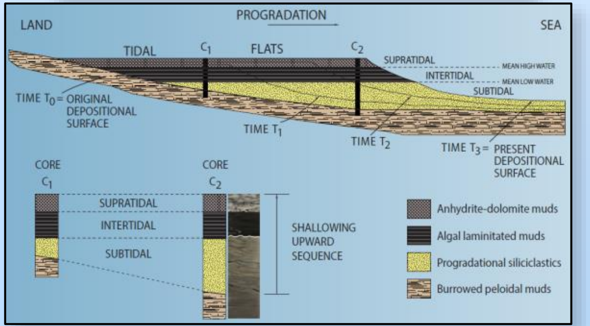


Highstand: Glacial retreat, open basin and tidal influenced



Lowstand: Glacial advance, closed evaporative basin

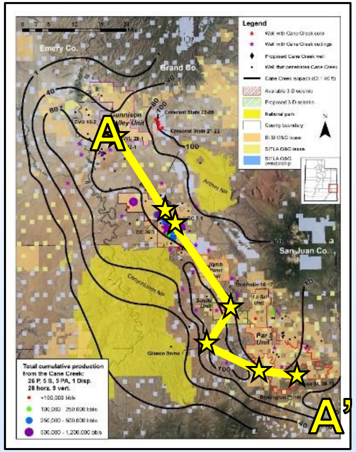




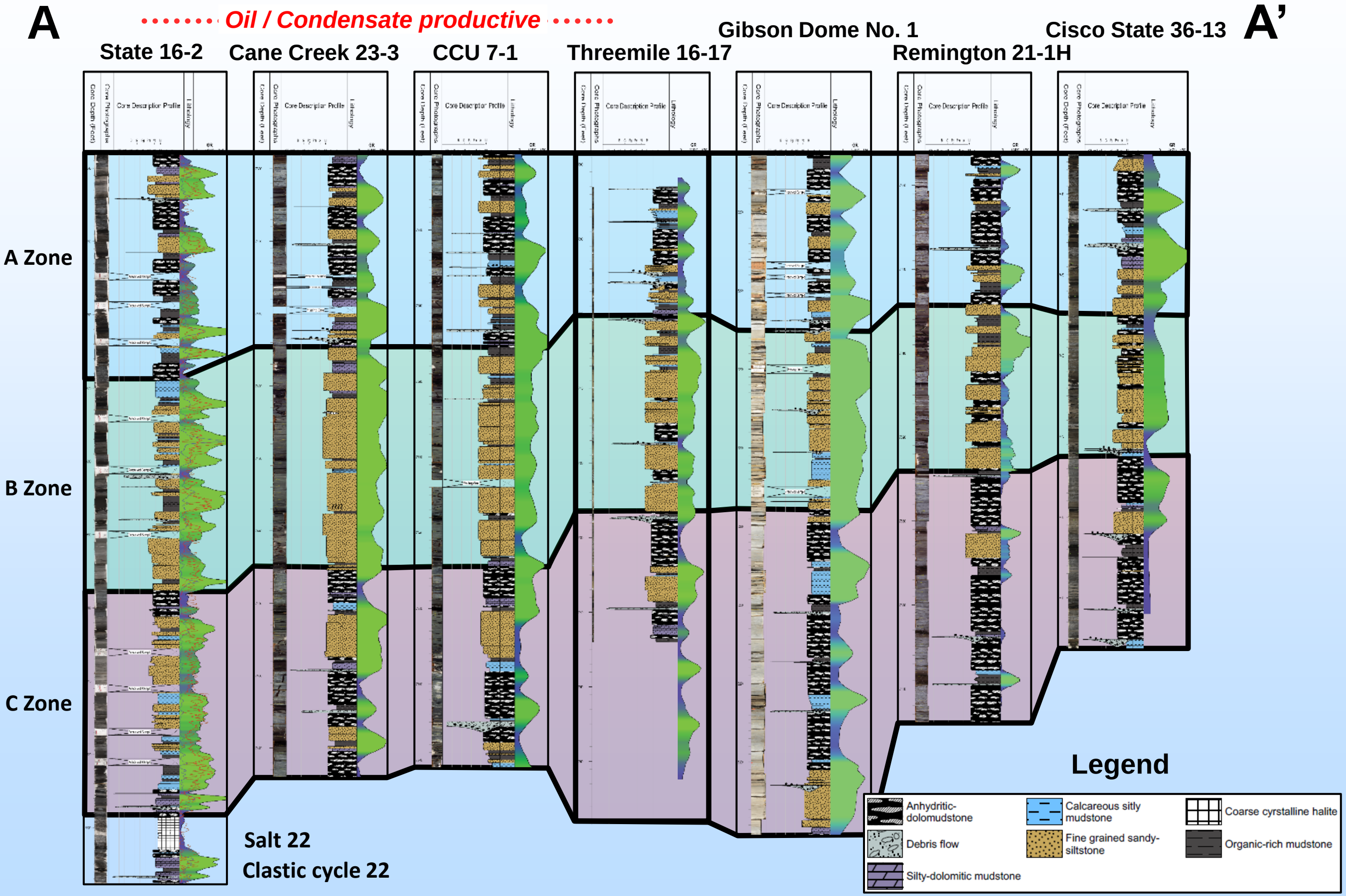
- ***Glacial and interglacial climatic cycles in the southern hemisphere of the Pangean continent caused cyclic fluctuations in relative sea level and salinity***

Paleogeographic map from Blakey
http://cpgeosystems.com/images/NAM_key-85Ma_LateK-sm.jpg

Basin Stratigraphic Correlation



- A-A' shows a general stratigraphic thinning of the B Zone from north to south
- Clastic sediment supply controlled by tectonic accommodation, hydrology (climate, eustasy) and geomorphic modifications
- State 16-2 contains less anhydrite and more clastics in the *C Zone*, implying greater tidal/fluvial influence and less evaporation



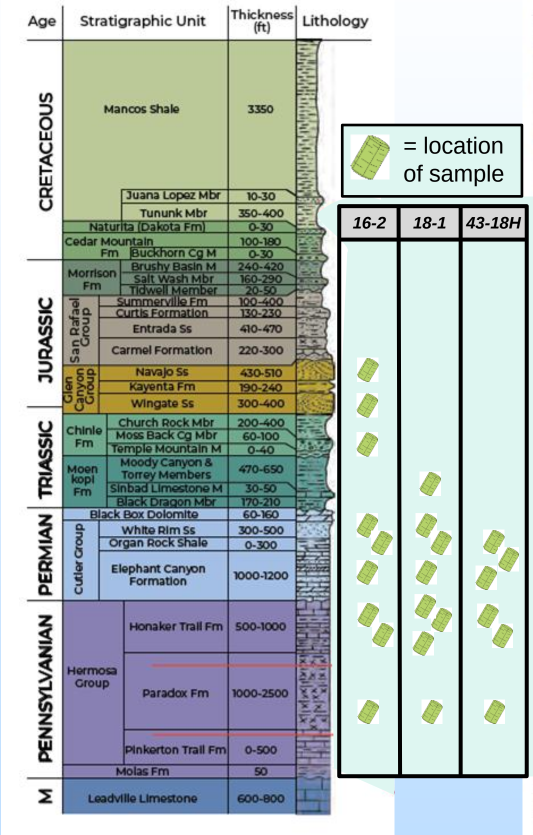
Basin Thermal History

Rationale & Scope of Work

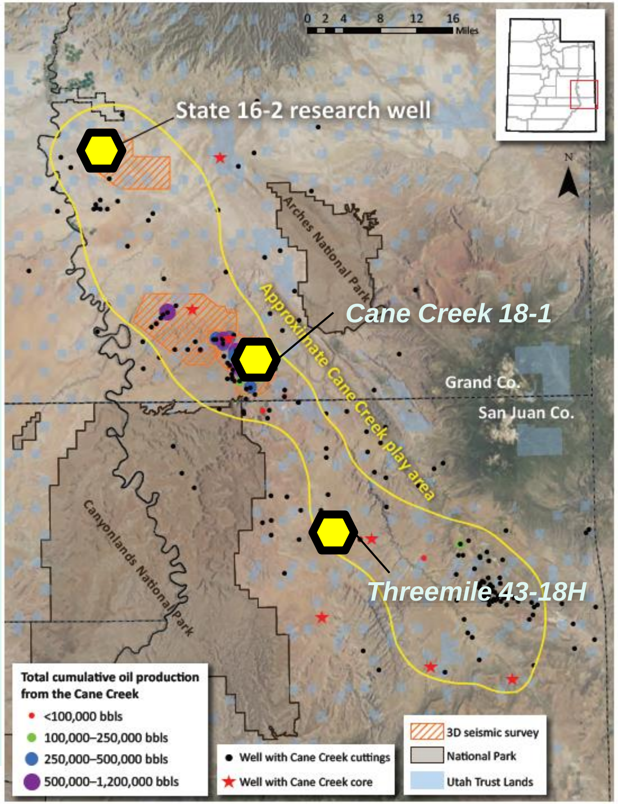
- Evaluate whether the thermal history of the northern Paradox Basin differs significantly across the areas of interest (see figure at right)
- Quantify how individual thermal histories impacted oil & gas systems within prospective zones
- novel data will be integrated with data from published thermochronology studies in the area to form a regional framework
- all data integrated into basin models, structural restorations, and regional fracture & stress models

Sample Set

- SR 16-2 (9 samples)
- Cane Creek 18-1 (8 samples)
- Threemile 43-18H (6 samples)



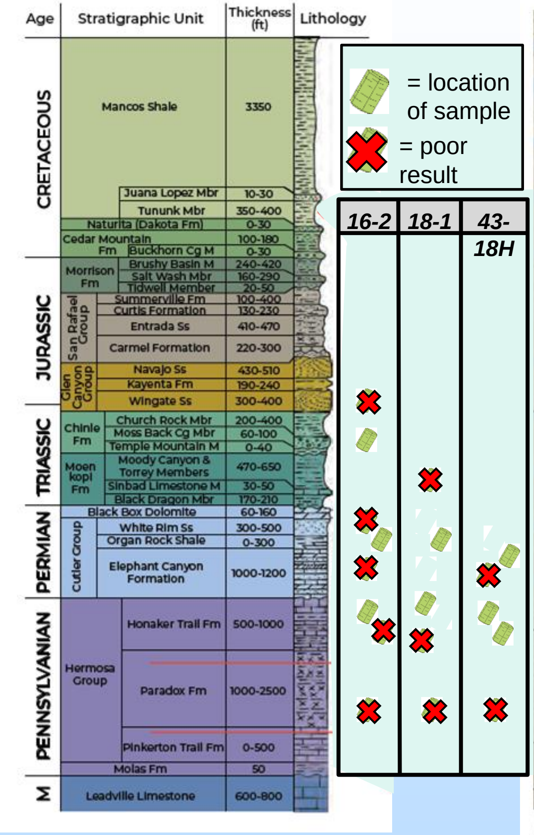
modified from Vanden Berg, 2021 – Survey Notes 53-1



Map of Cane Creek play area showing available legacy data. bbls = barrels

Basin Thermal History

- **Project Status (8/12/21)**
  - sample identification & collection - COMPLETE
  - mineral separation & analysis - COMPLETE
  - numerical modeling - IN PROGRESS
  - interim results:
  - due to inherent rock mineralogy and subsurface conditions, apatite yields varied greatly b/t samples -- no viable apatite yielded from Cane Creek Shale
  - each well yields data consistent with current understanding of subsurface geothermal conditions -- ages young with depth
  - SR-16-2 shows potential sign of post-depositional thermal disturbance
  - numerical modeling necessary to derive time-Temperature history from each well, if possible
  - more work being done to extract better grains and/or analyze the zircon (U-Th)/He system too



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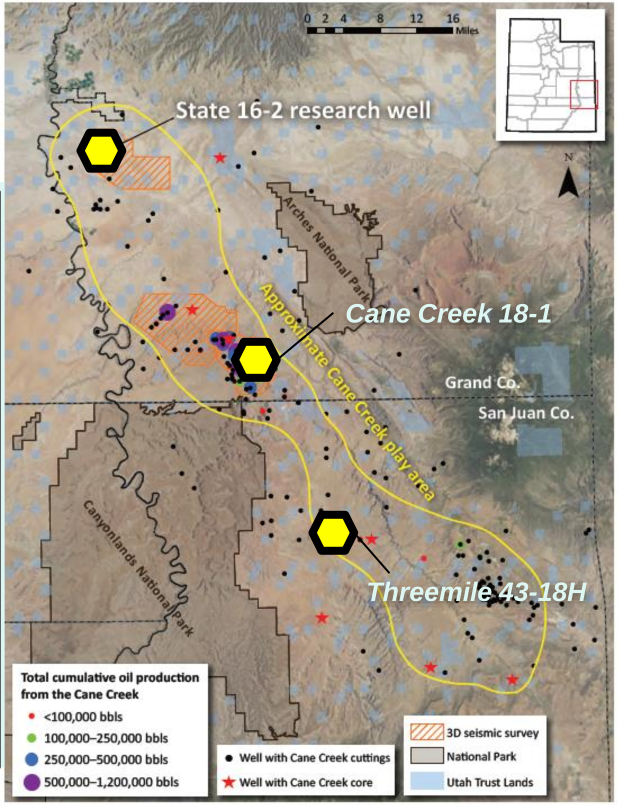

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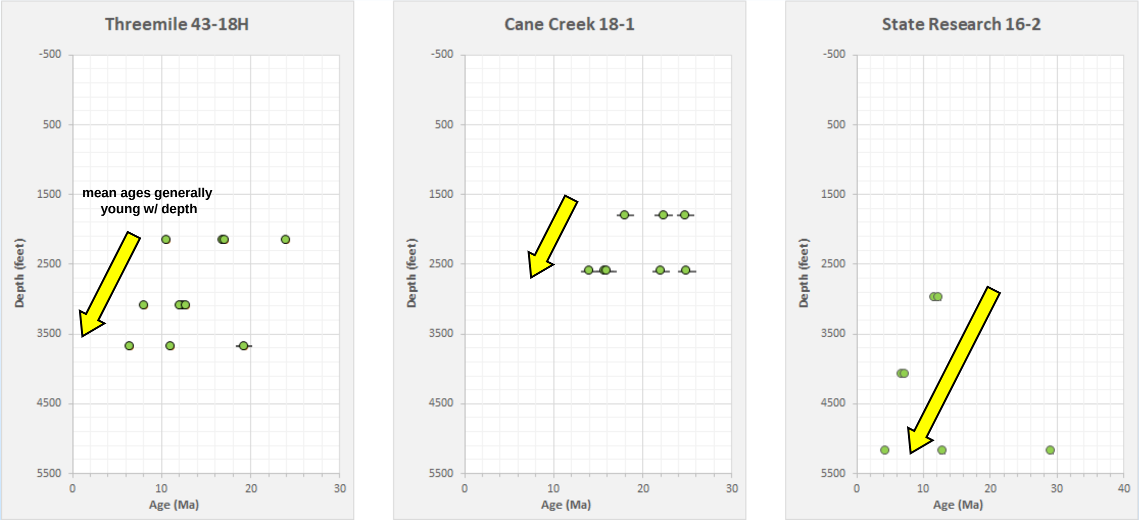


Cuttings Fracture Analysis

- **Samples from 98 depth intervals from clastic units**
  - Tasks
    - Correction for vertical mixing of cuttings -- complete
      - Petrology sample selection scheme
      - Refinement of mud log lithology units
    - Fractures identification & characterization -- in progress
      - Microfractures mostly observed in shale-rich units
      - Probable fracture-related mineralization also identified; microscopy to be used
      - Detailed microscopy to help distinguish in-situ (natural) from induced fractures
    - Fracture geological context – final step
      - Correlation of fracture types and occurrence to;
        - Lithology
        - bedding-scale sedimentary features
        - stratigraphic locations

Cuttings Fracture Analysis

- Fracture Petrology & Microscopy
- Objective: Distinguish between in-situ and induced fractures on the basis of the <u>composition</u> and <u>crystal microstructure</u> of minerals filling the fractures and forming the fracture walls

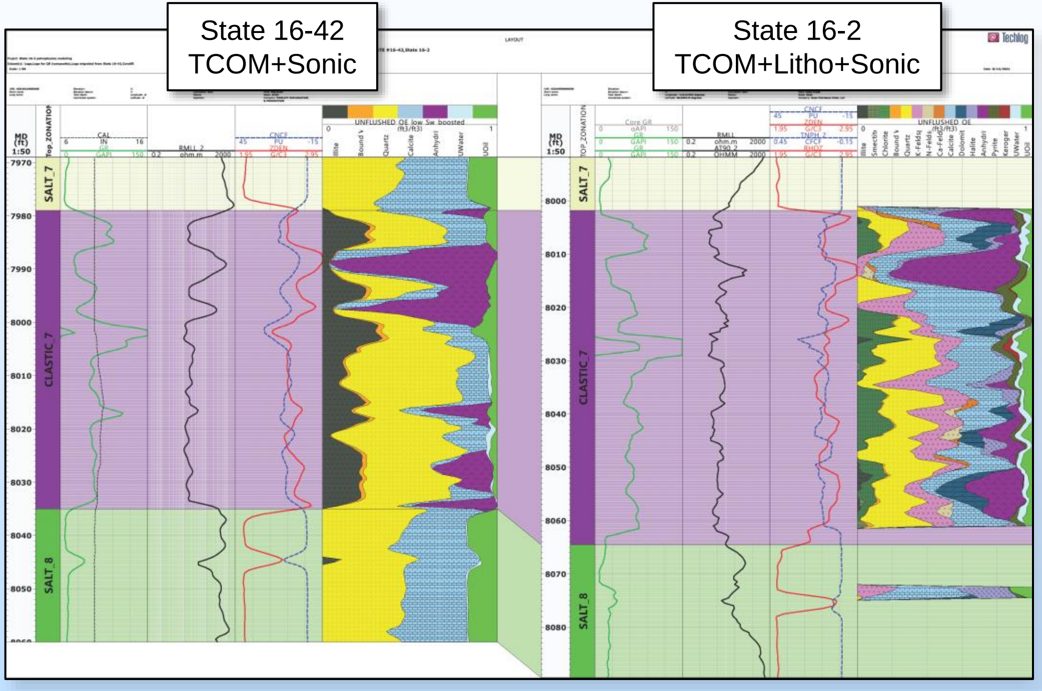
- X-Ray Microscopy (Micro-CT) -- in progress
  - ❑ At least 10 micron resolution; for imaging microfracture and mineral crystals
  - ❑ Multiple energy (kv); for isolation and mapping of different mineral phases

- SEM Microscopy (Cathodoluminescence, EDX) – next step
  - ❑ Fracture-mineral paragenesis; diagenetic associations and correlations based on the trace composition and microstructure of mineral phases

- X-Ray Diffraction (XRD) – next step
  - ❑ Identification of distinct crystal microstructures of present mineral phases; used for interpretation of timing between fractures and associated mineral phases

Comparison of Log Suites Between Adjacent Wells

- **State 16-42 is a legacy well ~500' from the State 16-2 well and served as a proxy pre-State 16-2 drilling**
- **Log suite in that well not as comprehensive as the one in the State 16-2.**
  - State 16-42: Triple Combo + Dipole Sonic
  - State 16-2: Triple Combo + Lithoscanner + Sonic Scanner
  - Sonic currently not used for petrophysical model (will be used for geomechanical model)
  - Sonic Scanner to provide anisotropic properties. Dipole only provides isotropic properties.
- **Additional log inputs (esp. Lithoscanner) allows much more detailed interpretation.**
  - Ignore results in salts in State 16-42 b/c halite not solved for in model - its not a major constituent of the clastics.
  - In State 16-2, Lithoscanner was not activated over salt intervals to cut costs. They are not reservoir, so it wasn't needed.
  - Model calibration is ongoing.
- **A focus of Machine Learning team is to model Lithoscanner log responses in Cane Creek Fm.**
  - Allows for more detailed interpretation (4 minerals for TCOM only, 12 minerals + organics for TCOM+Lithoscanner).



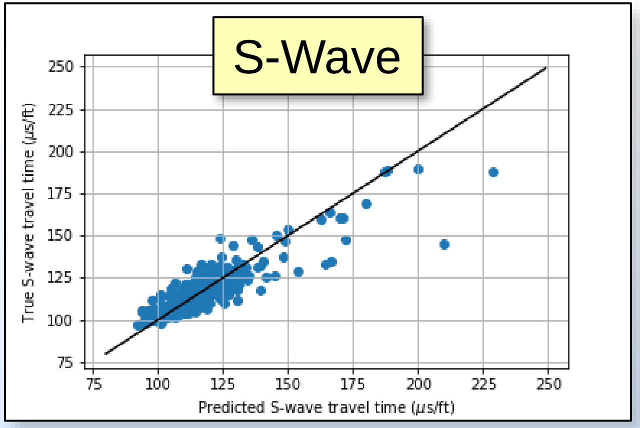
  - More robust interpretation (e.g., improved saturation and porosity discrimination).
  - Note additional detail in model (right-hand column of each well) for Clastic 7 of the Paradox Fm. in the State 16-2 vs. results from TCOM data in State 16-42.

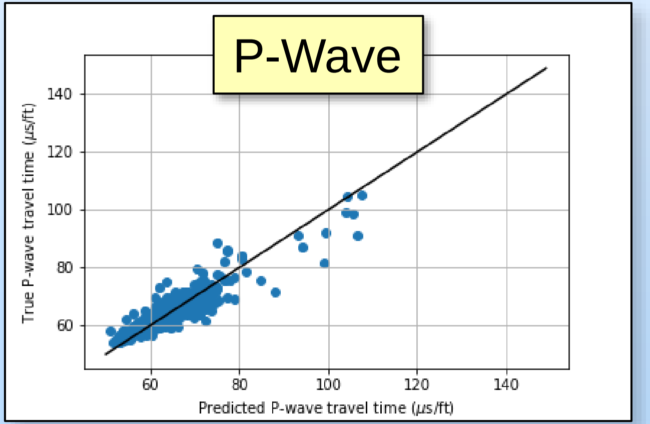
ML Model Development

Objective: Model sonic velocities in the Cane Creek section of State 16-2 based on training in the overlying clastics. Validate with shifted 16-42 logs. This is a test case to ultimately be used on Lithoscanner prediction as we have validation data for the sonic velocities.

Progress to date: Model developed for 16-2 clastics section

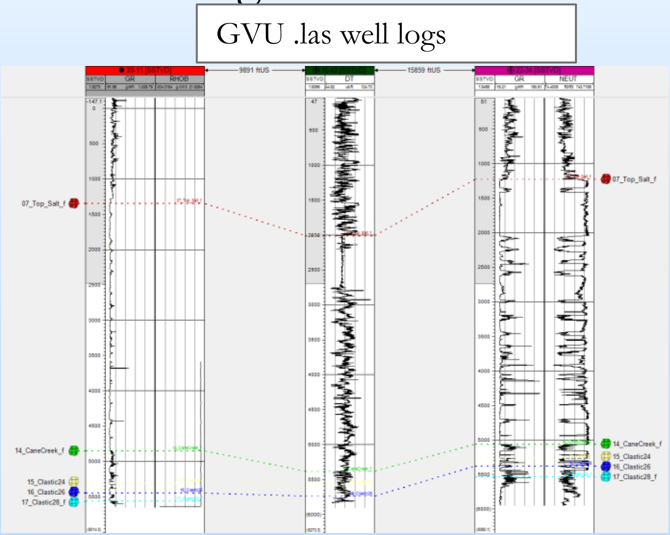
- **Algorithm**: Decision Tree Ensemble (Random Forest)
- **Training Data:** 16-42 Triple combo logs, Photoelectric data
- **Validation:** Held-out (randomized) data in 16-2 overlying clastics
- **Figure (right):** 1:1 parity plots of measured vs. ML-predicted P, S-wave travel times.

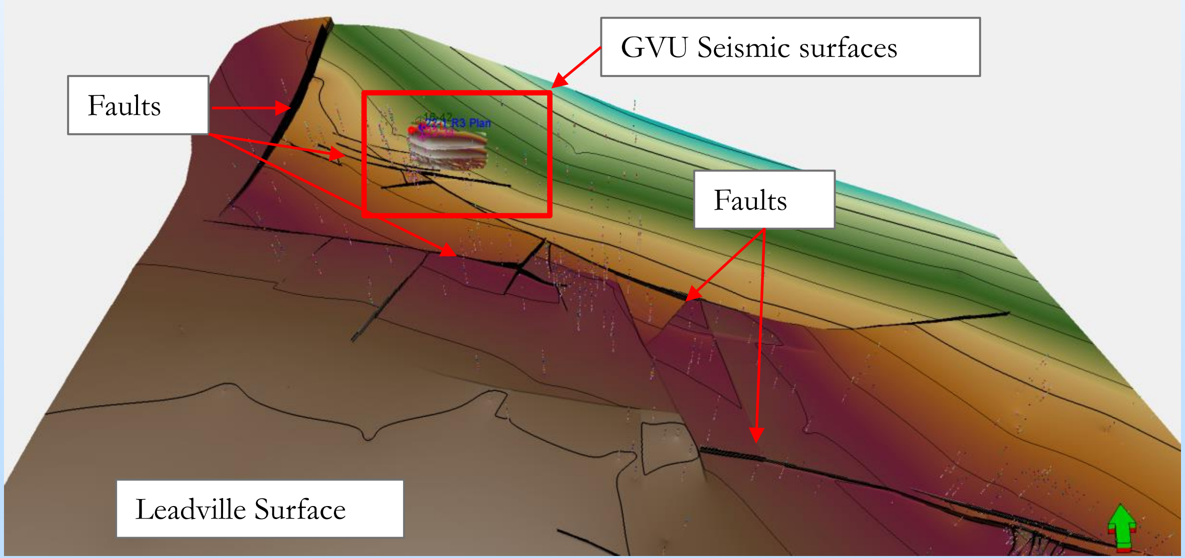




Regional Geologic Framework

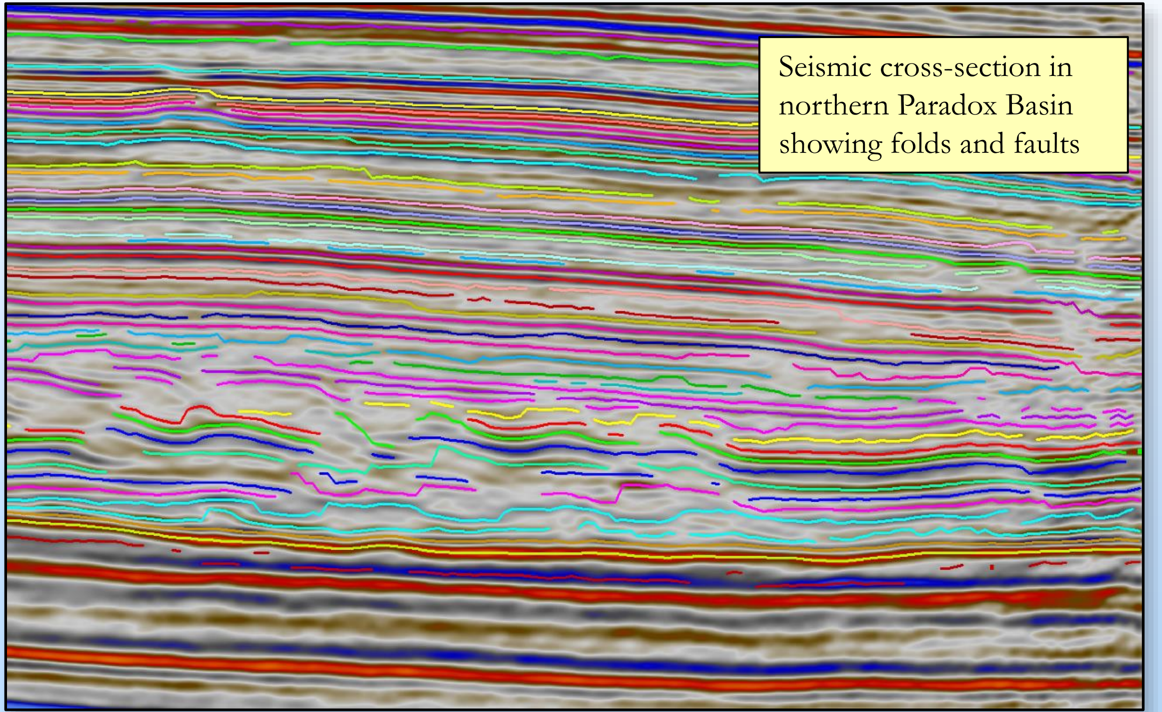
- Created basin wide basement fault framework based on obvious offset in nearby well tops
- Well logs for GVU wells incorporated into regional model
- Seismic data and surfaces delineated by Schlumberger and Zephyr incorporated into regional model





GVU Seismic Surfaces

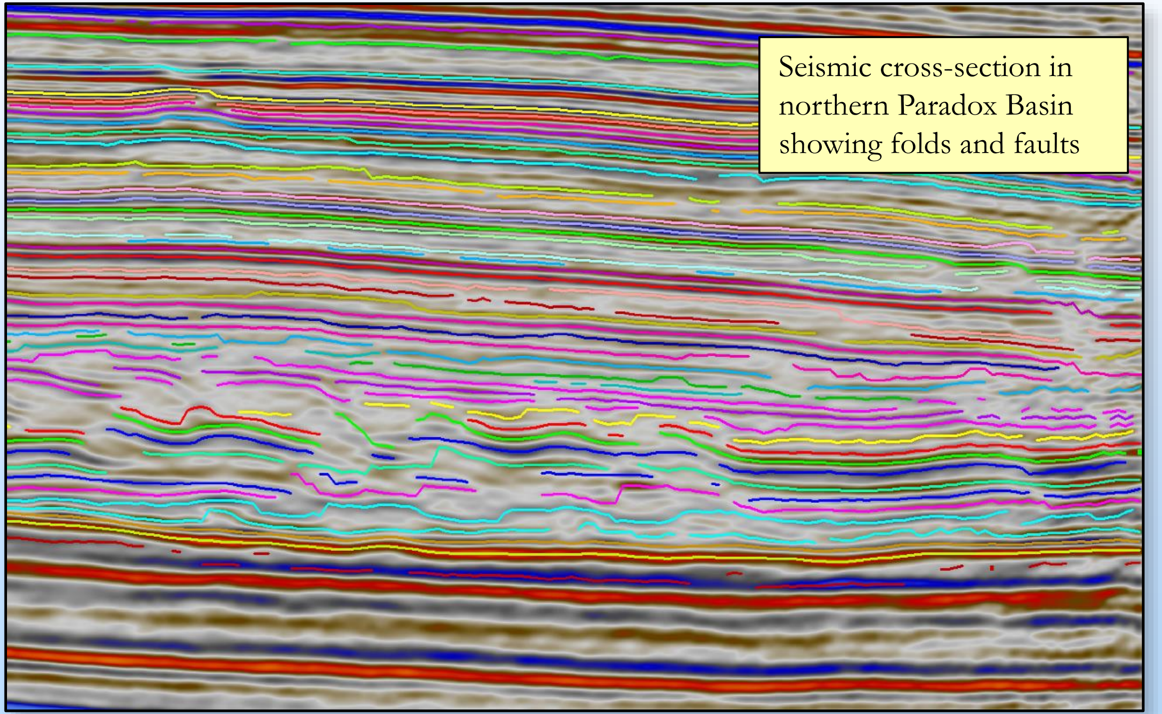
- Petrel project provided by Zephyr included seismic surfaces and some faults delineated by Schlumberger & Zephyr
  - Chinle, White Rim, Top Salt, Clastic 01, Clastic 18, Cane Creek, Clastic 28 (bottom of salt) and Cambrian
  - Salt and clastic cycles show very complicated geometry due to salt movement



Seismic cross-section in northern Paradox Basin showing folds and faults

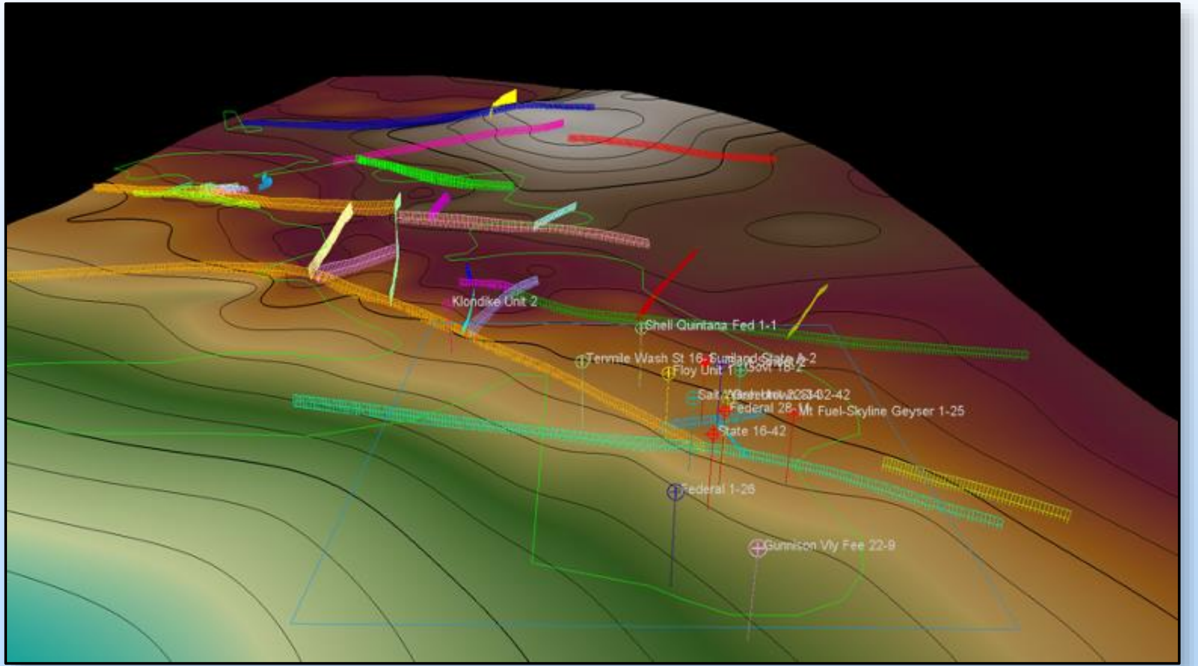
GVU Seismic Surfaces

- In process of delineating remaining resolvable seismic surfaces using the seismic cube
  - Delineating all salt and clastic interbeds within the Paradox Formation
    - 40 additional surface in the process of being delineated, including:
    - Paradox top
    - Ismay
    - Hovenweep
    - Gothic
    - Desert Creek
    - Chimney Rock
    - Akah
    - A, B, and C Markers
    - Alkali Gultch
    - Cane Creek Base
    - Leadville



Interesting Findings

- Complex geometry within the Paradox makes surface delineation more challenging
  - Salt and clastic cycles show very complicated geometry due to salt movement
- Salt withdrawal within the Paradox
  - Part of the seismic volume is unresolvable within the upper Paradox Fm.
  - The result of salt withdrawal
- Leadville show incised valley network



Accomplishments to Date

- **Descriptions of geology of Cane Creek (North to South) and Development of Facies Model (using existing data plus new project data (Milestone))**
- **Drilled project stratigraphic well (Zephyr State 16-2 well)**
  - Collected 110 ft of whole core in Cane Creek and adjacent salts/clastics
  - 31 sidewall cores in 11 upper clastic zones
  - Geophysical logs (Triple combo, sonic, lithoscanner)
- **Conducted Core Analyses**
  - Porosity, Permeability, fluid saturations, source rock work on the Cane Creek core and associated clastic zones
  - Specialty core analyses (MICP, wettability, relative perm) and geomechanics plans are in place, with lab work starting soon
- **Petrophysical log analyses/correlations, Models**
  - Work to correlate State 16-42 Paradox Fm logs to those in State 16-2
- **Delineating seismic surfaces for Reservoir Model**

Synergy Opportunities

- Oil & Gas Program
  - Seismic monitoring using fiber optics
  - Machine Learning – Full-waveform inversion in seismic imaging
  - LANL – pressure control & fracture management
- Other NETL-funded Partner Initiatives
  - CarbonSAFE San Juan Basin – investigations into induced seismicity using mechanical Earth Models
  - CUSP and SWP – knowledge base & detailed analyses on geomechanics in the region
  - DE-FOA-0002401 - detection and characterization of faults and quantification of fluid migration through the caprock layer

Project Summary

- **Project:**
  - $11,000,000 project over 4 years ($8M Federal, $3M cost-share by local operators)
  - Project drilled a 9,748 ft stratigraphic well in January, 2021 (110 ft of core, cuttings, sidewall core, geophysical logs with accompanying analyses)
  - Multiple operators & service companies in/around Paradox Basin to benefit from optimized drilling strategies (and reduced environmental impacts)
  - Coordination with educational institutions and company-led training to transfer technological skills for development of play

THE UNIVERSITY OF UTAH

ZEPHYR ENERGY

UTAH DNR UTAH GEOLOGICAL SURVEY

THE UNIVERSITY OF ARIZONA

Statistical Petrophysics LLC

KIRKWOOD Oil & Gas LLC

NATIONAL ENERGY TECHNOLOGY LABORATORY

BYU

U.S. DEPARTMENT OF ENERGY | Fossil Energy
OFFICE OF OIL & NATURAL GAS

Drilling of project stratigraphic well – Jan 2021,

Benefit to the Program

- The primary project objective is to characterize the emerging Cane Creek play and develop technologies and strategies that can accelerate the development the play, including the evaluation of:
  - Economic viability
  - Optimal well completion design
  - Fracture treatment design
  - Field development choices that can lead to maximum ultimate recovery
- Cane Creek Play
  - Natural fractures = key to maximizing production and minimizing environmental impact
  - It will also be evaluated as a resource play (not just a fracture play)
  - Well stimulation will be considered (How do you stimulate wells without fracking into salt?)
  - The project has access to a quality 3D seismic critical to fracture density and orientation and follow up data from the recently drilled State 16-2LN CC lateral well

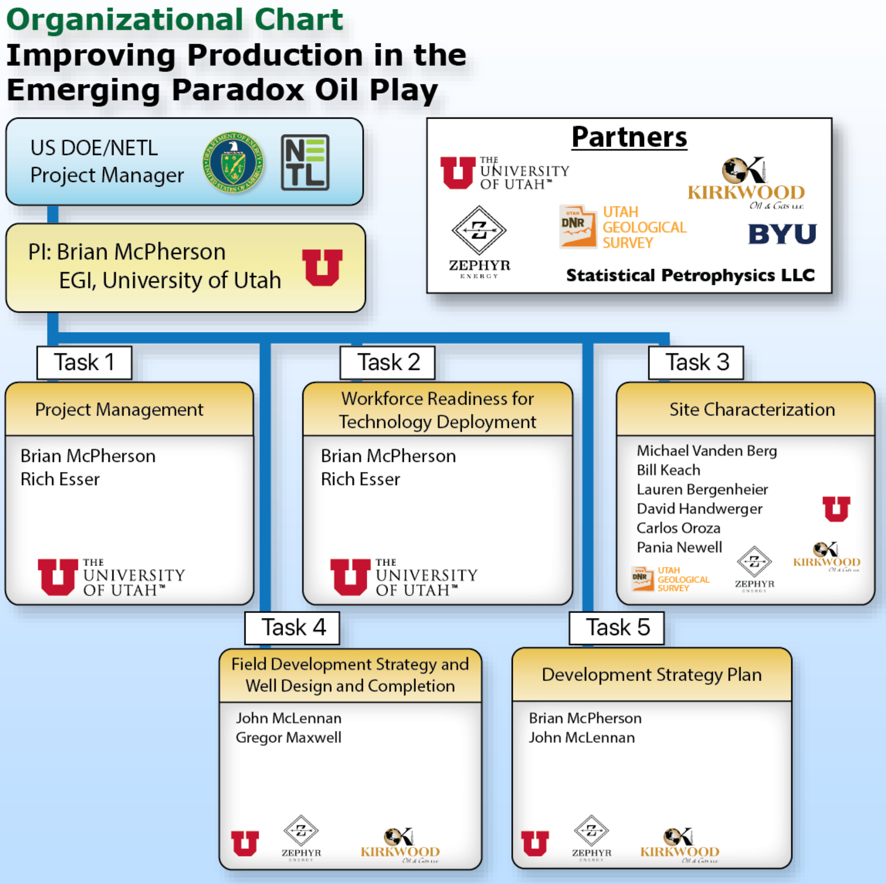
Project Overview - Goals and Objectives

- **Primary objective: assess/evaluate optimum strategies to drill economic wells in the structurally complex, but highly prospective, emerging unconventional Paradox Basin oil play – to improve the understanding (economic viability, optimal well design, fracture treatment design, field development) of emerging unconventional plays**
  - Characterize the fundamental geology, hydrology, and geomechanics of the Paradox Oil Play
  - Forecast the location & extent of natural fractures throughout the play using integrated geological, geophysical, hydrological and geomechanical data
  - Develop a drilling design that maximizes intersection with dominant natural fractures
  - Develop a tactical stimulation strategy that mimics or creates proven successful production conditions (access to conductive natural fractures)
  - Determine whether the new drilling design to maximize natural fracture exposure (i.e., strategic drilling location and trajectory), or the new tactical stimulation approach (tailored for the play) will be more effective, and test one or both in the field in new well(s) to be drilled and produced by the operator(s) in collaboration with the project

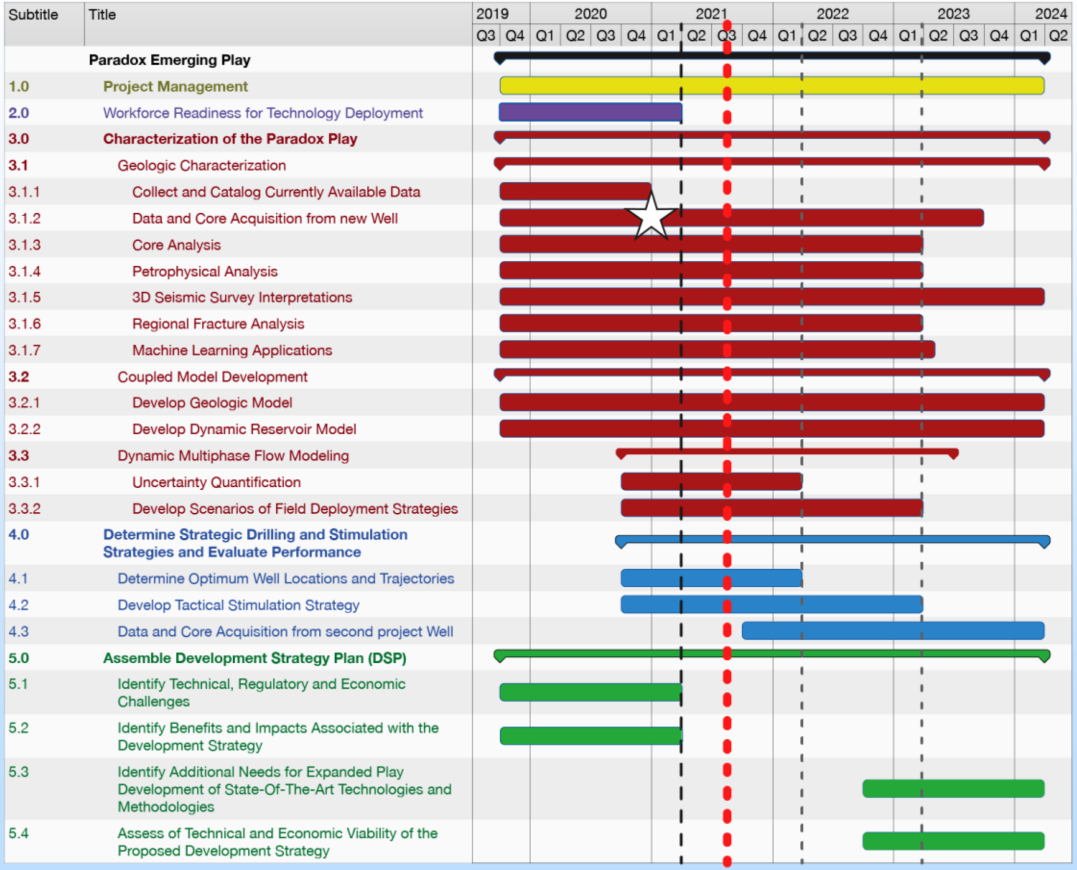
Project Overview - Goals and Objectives

Task/Subtask	Description	Date	Success Criteria
2.0	Workforce Readiness Plan	First continuation application	A detailed plan ready after reviewing the required skill sets and training/certifications (if any), and identifying the appropriate source or personnel for the workforce.
3.1	Geologic Characterization	Q4 2022	A geologically characterized basin model integrating 3D seismic data, well logs, core data, and production histories using machine learning algorithms.
3.2	Coupled Model Development	Q2 2023	A multi-continuum dynamic reservoir model, that combines the geological and discrete fracture network models, ready for simulating multiphase flow in the play.
4.3	Well Drilling	Q2 2022	Cased and cemented horizontal well that yield at least 50 feet of horizontal core to study the fracture network and its changes throughout the basin.
4.3	Well Characterization	Q4 2022	Fracture characterization and assessment of productive potential, reservoir properties, and stimulation treatment effectiveness.
5	Development Strategy Plan	Q4 2023	Develop a plan to effectively assess the technical and economic viability of further development of emerging UOG plays in the area and others across the US.

Organization Chart



Gantt Chart



Subtitle
Title
2019
2020
2021
2022
2023
2024
Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2
Paradox Emerging Play
1.0 Project Management
2.0 Workforce Readiness for Technology Deployment
3.0 Characterization of the Paradox Play
3.1 Geologic Characterization
3.1.1 Collect and Catalog Currently Available Data
3.1.2 Data and Core Acquisition from new Well
3.1.3 Core Analysis
3.1.4 Petrophysical Analysis
3.1.5 3D Seismic Survey Interpretations
3.1.6 Regional Fracture Analysis
3.1.7 Machine Learning Applications
3.2 Coupled Model Development
3.2.1 Develop Geologic Model
3.2.2 Develop Dynamic Reservoir Model
3.3 Dynamic Multiphase Flow Modeling
3.3.1 Uncertainty Quantification
3.3.2 Develop Scenarios of Field Deployment Strategies
4.0 Determine Strategic Drilling and Stimulation Strategies and Evaluate Performance
4.1 Determine Optimum Well Locations and Trajectories
4.2 Develop Tactical Stimulation Strategy
4.3 Data and Core Acquisition from second project Well
5.0 Assemble Development Strategy Plan (DSP)
5.1 Identify Technical, Regulatory and Economic Challenges
5.2 Identify Benefits and Impacts Associated with the Development Strategy
5.3 Identify Additional Needs for Expanded Play Development of State-Of-The-Art Technologies and Methodologies
5.4 Assess of Technical and Economic Viability of the Proposed Development Strategy

Bibliography

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– Jagniecki, E.A., Vanden Berg, M.D., Maxwell, G., and Szymanski, E., "Newly acquired core enhances geologic understanding of the northern Paradox Basin Cane Creek play, southeastern Utah" 2021 AAPG meeting, Denver, CO.