Shale Oil and Shale Gas Reservoirs – Utah Geological Survey Research to Define and De-Risk These New Plays in Utah

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Mission Statement

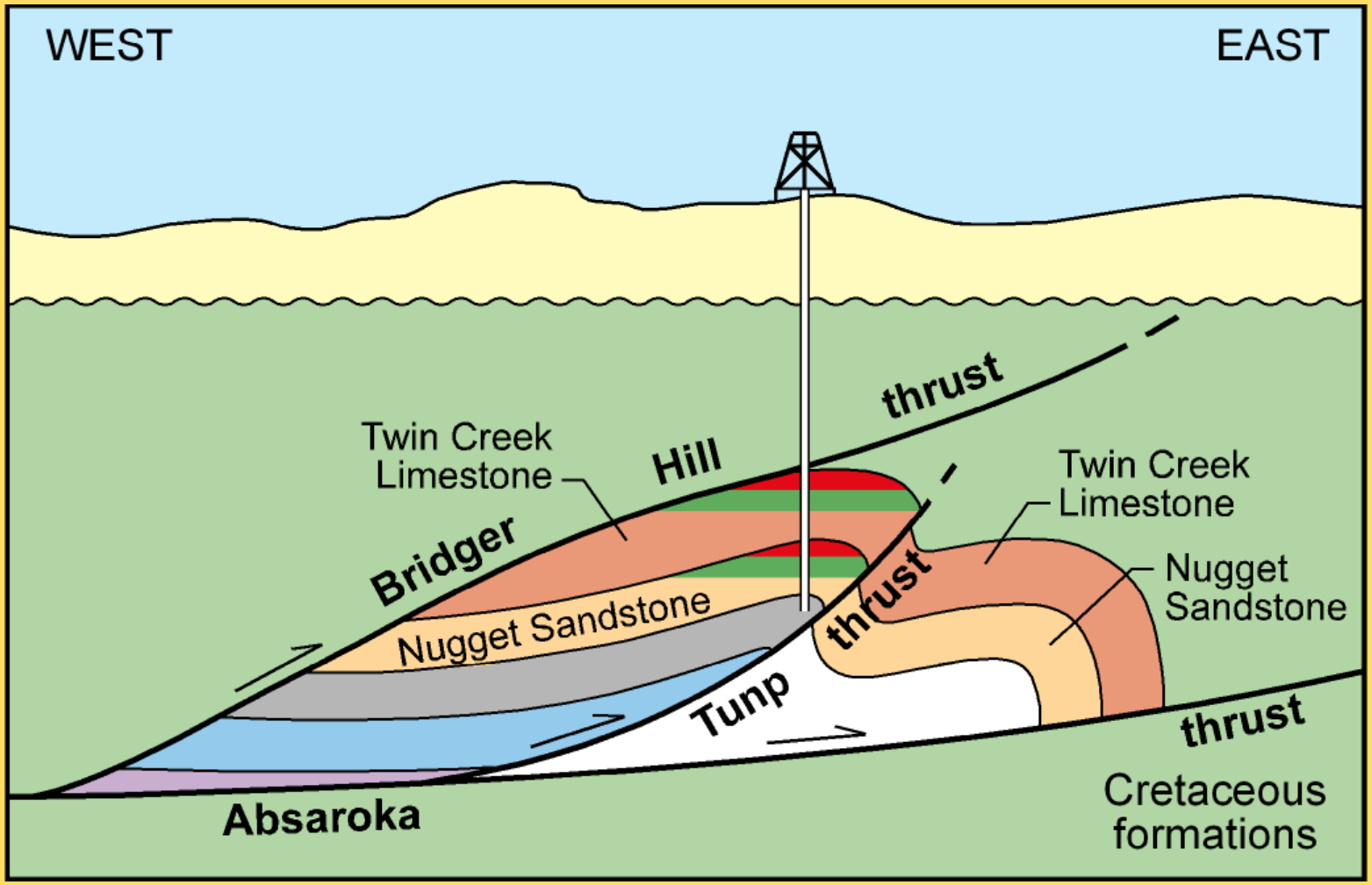
The Utah Geological Survey creates, interprets, and provides information about Utah's oil and gas resources to promote safe, beneficial, and wise use of the land

"Petroleum Geology 101"

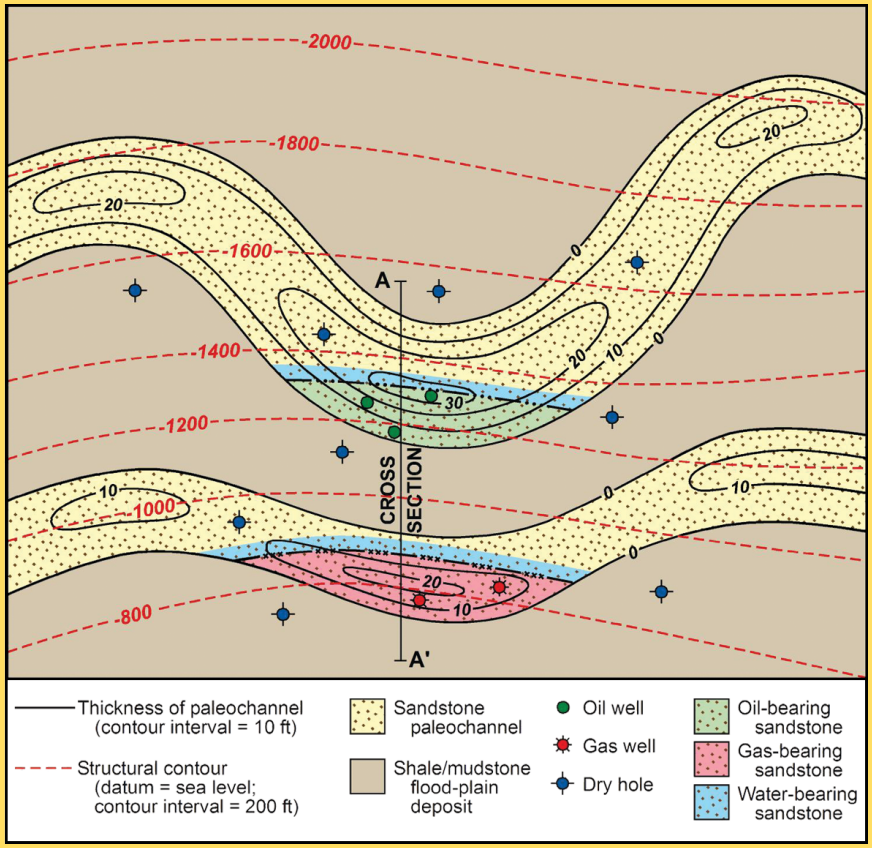
Why are there oil and gas fields?

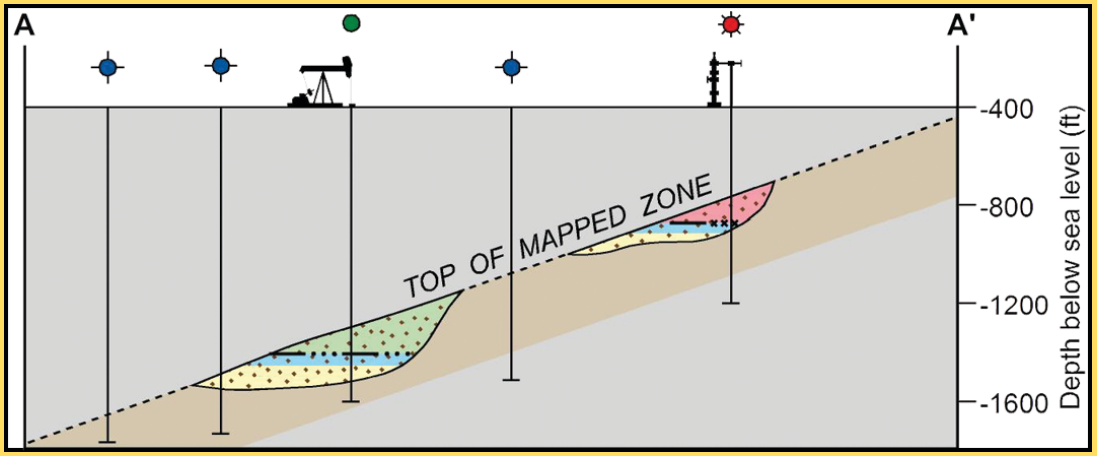
- Trap
- Source
- Seal
- Reservoir
- Timing of oil and gas migration

Trapping Mechanisms - Structural



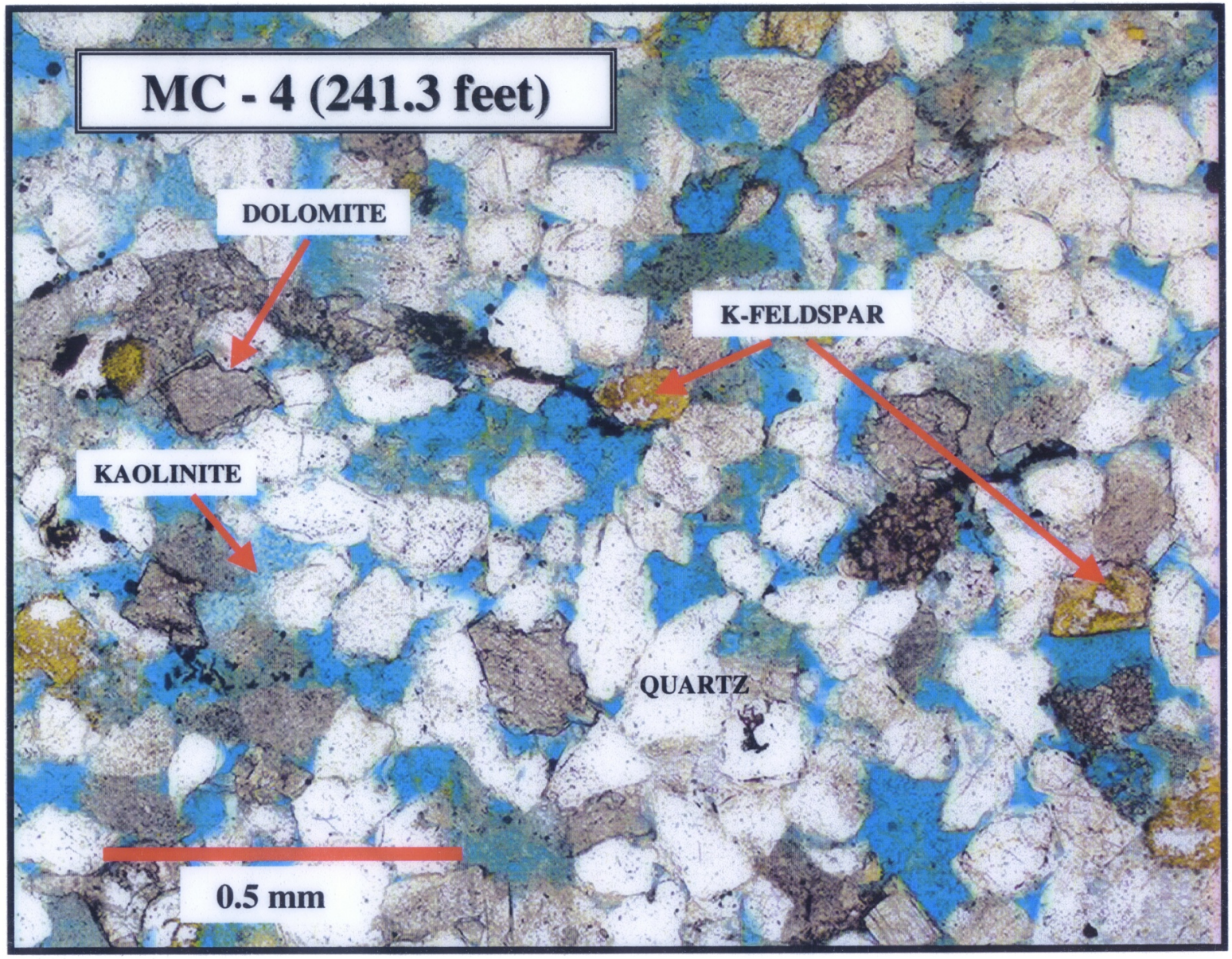
Anschutz Ranch East Field, Summit County





Trapping Mechanisms - Stratigraphic

Reservoir Rocks



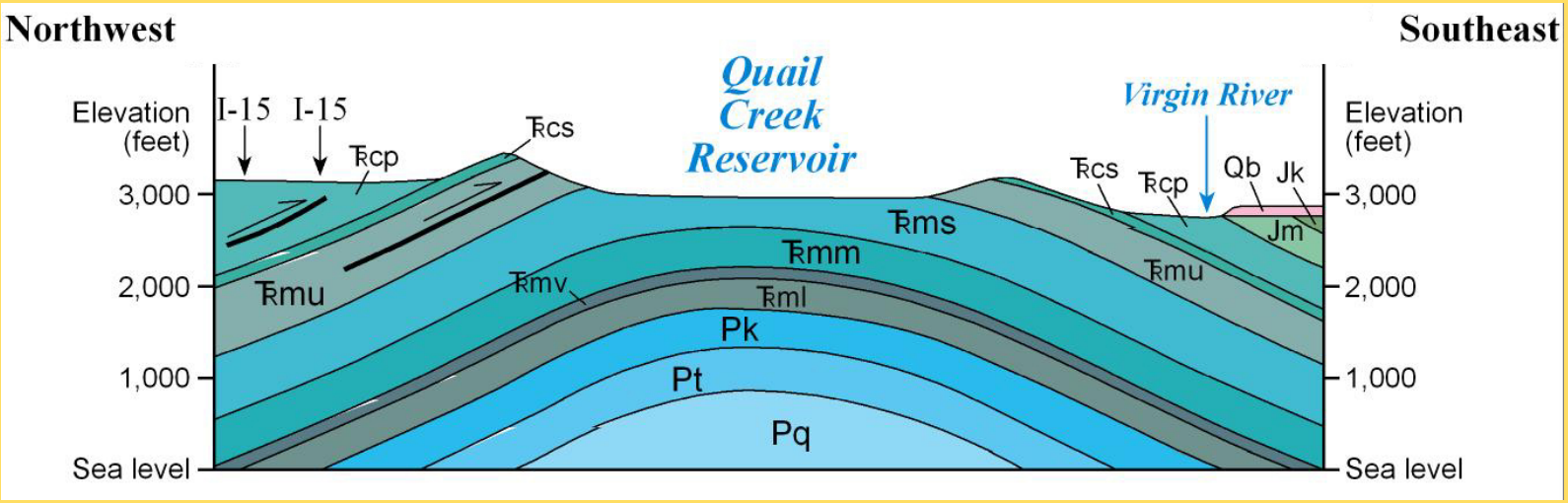
Seal - Jurassic Arapien Shale

Salina Canyon

Source Rocks

Mississippian
Manning
Canyon Shale

Timing of Oil Migration



Virgin Anticline, Washington County

Oil Shale vs Shale Oil (& Shale Gas): What's the Difference?

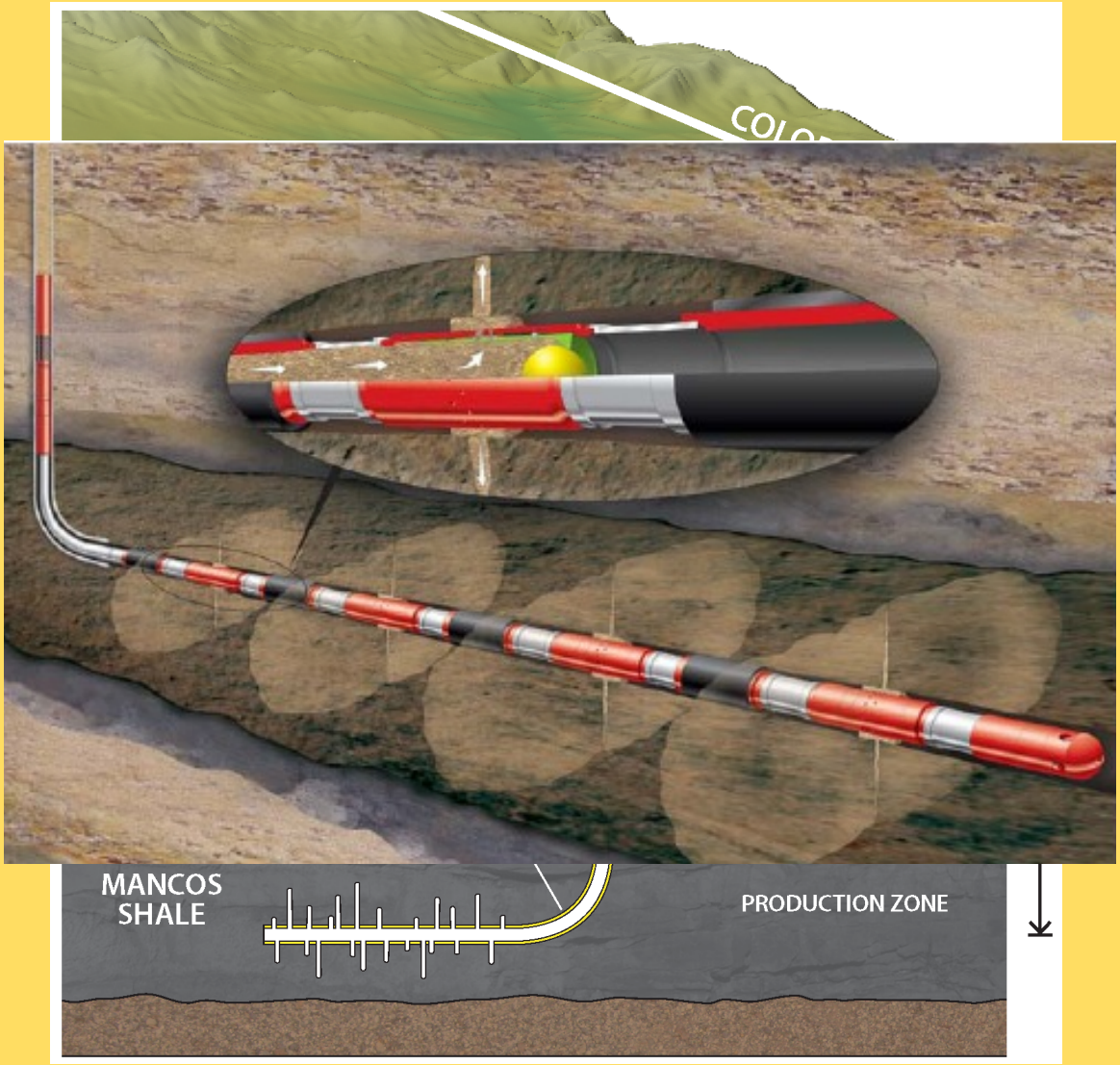
Shale Oil, Cane Creek Shale, Long Canyon Field, Paradox Basin

ale, Green River Formation, Uinta Basin

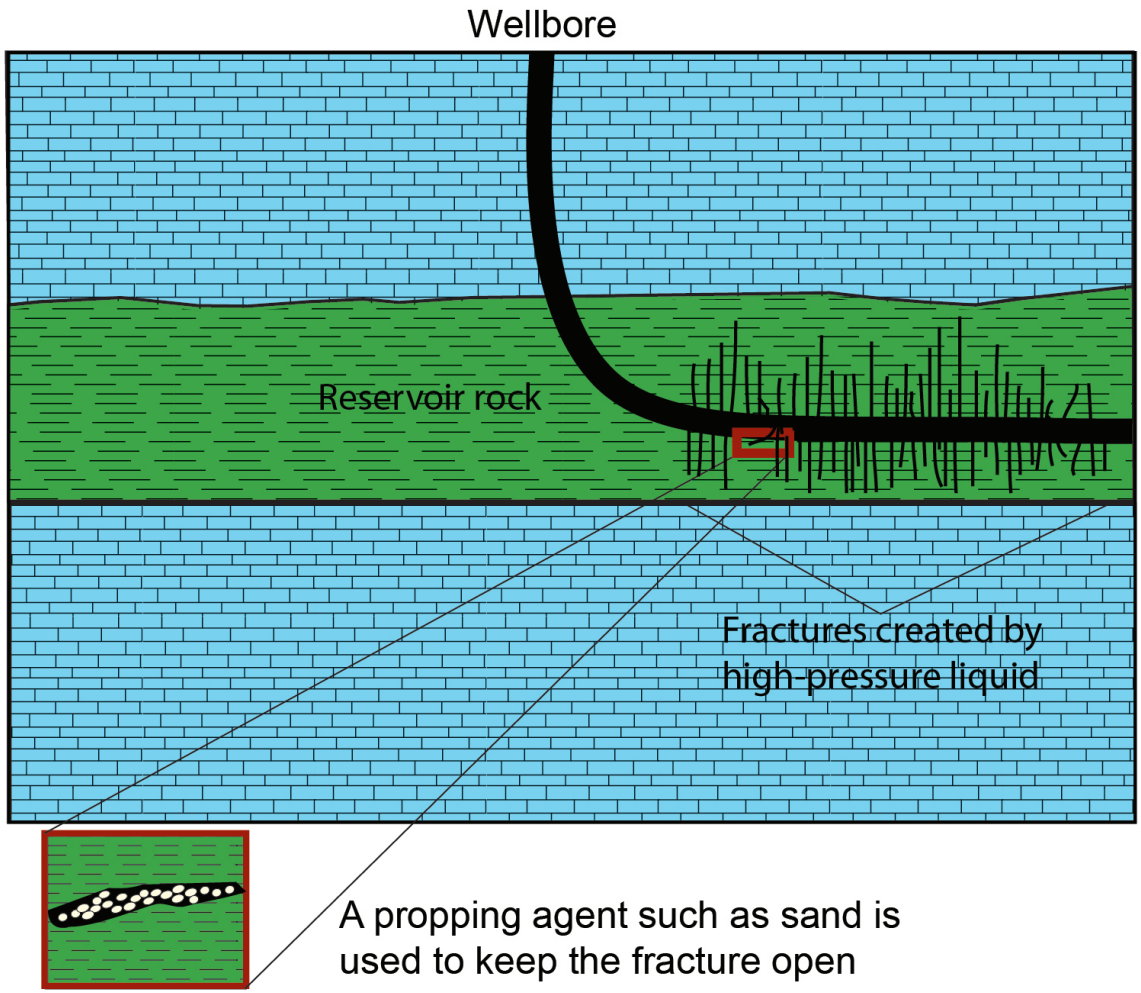
Technological Advances

- Horizontal Drilling
- Hydraulic Fracturing of Reservoirs - “Fracking”

Horizontal Drilling



Fracking Basics



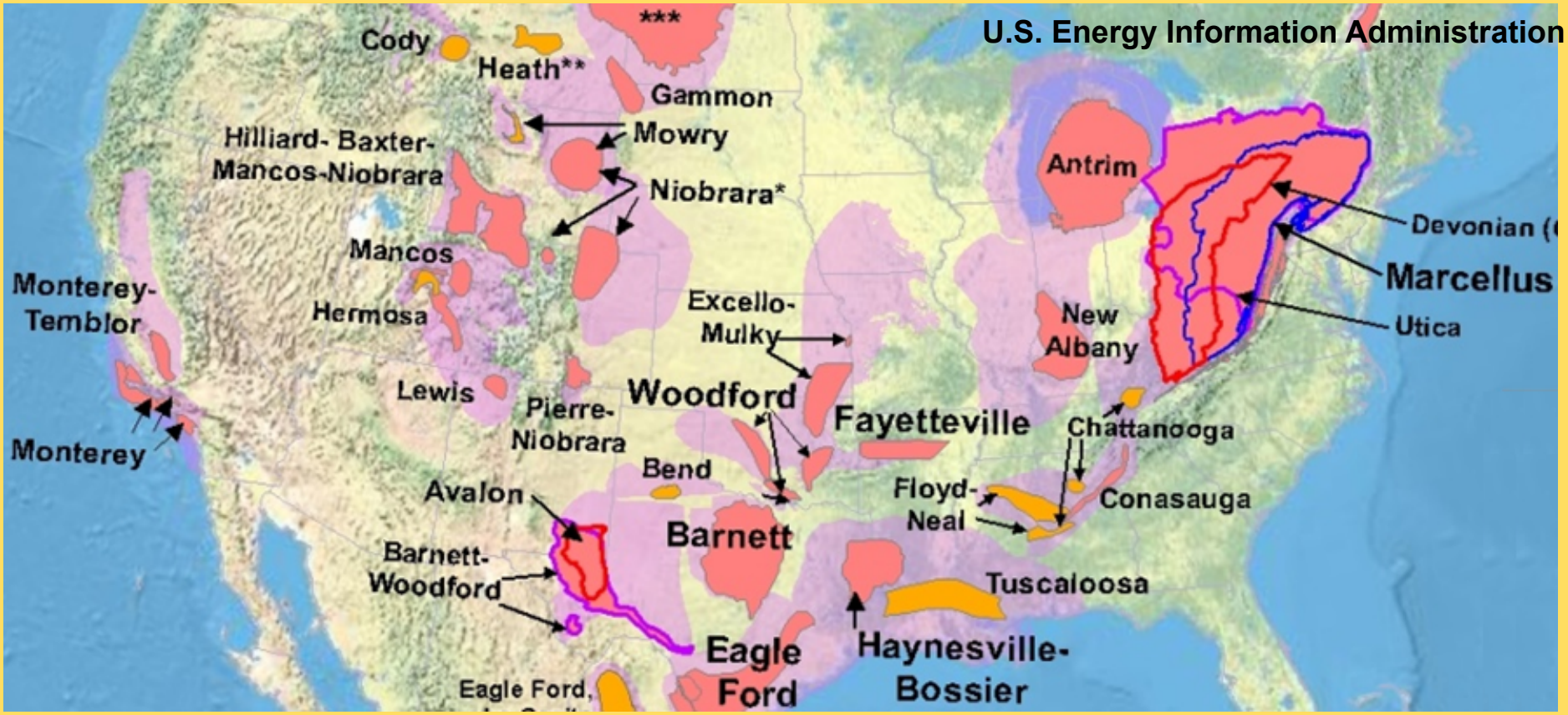
Fracking Basics

Fracking Basics

Frack Fluids

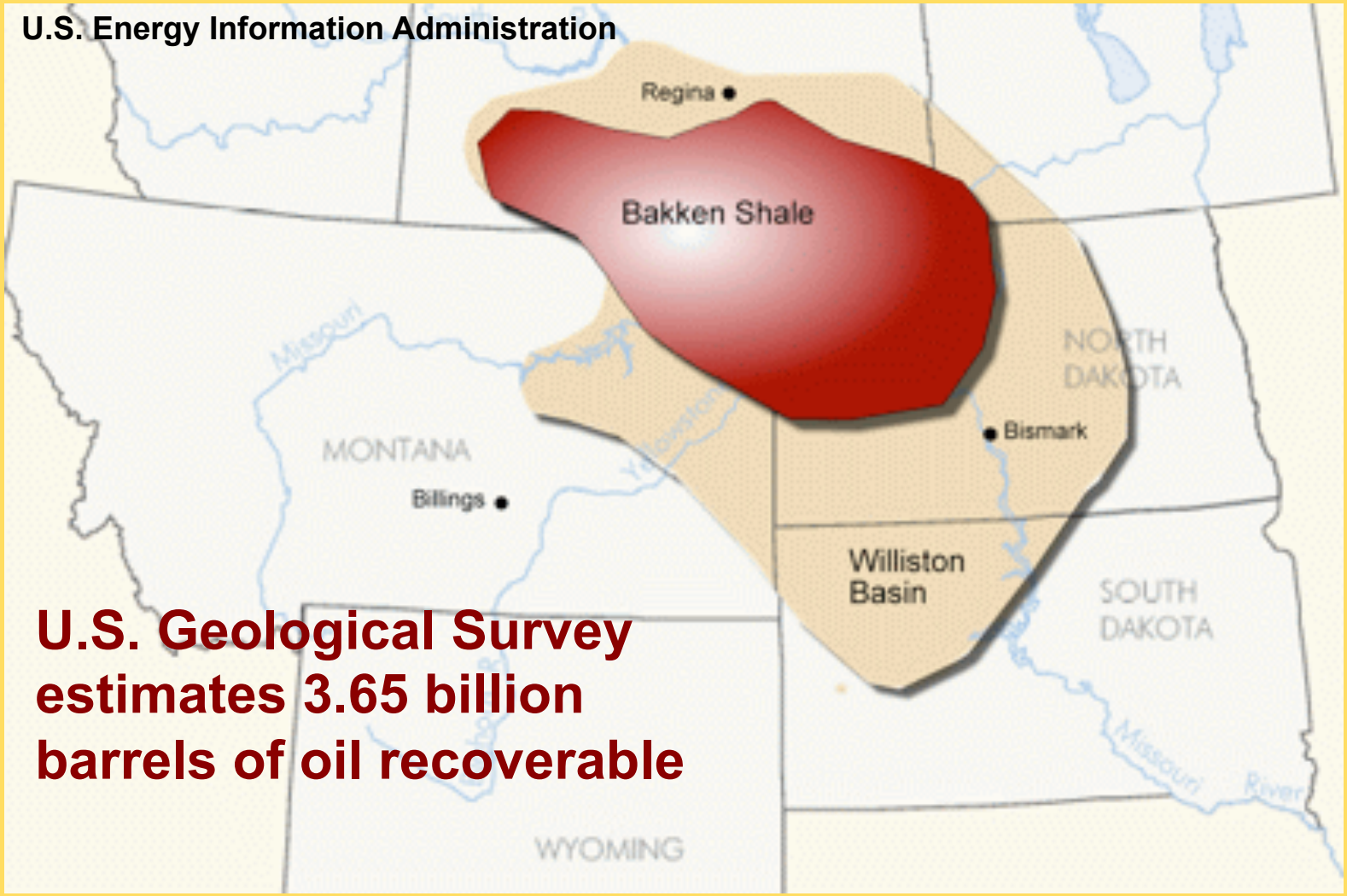
- 95% water
- 3% proppant
- 2% chemicals
  - Flow enhancers
  - Scale preventers
  - Bactericide

Major Shale Gas Plays

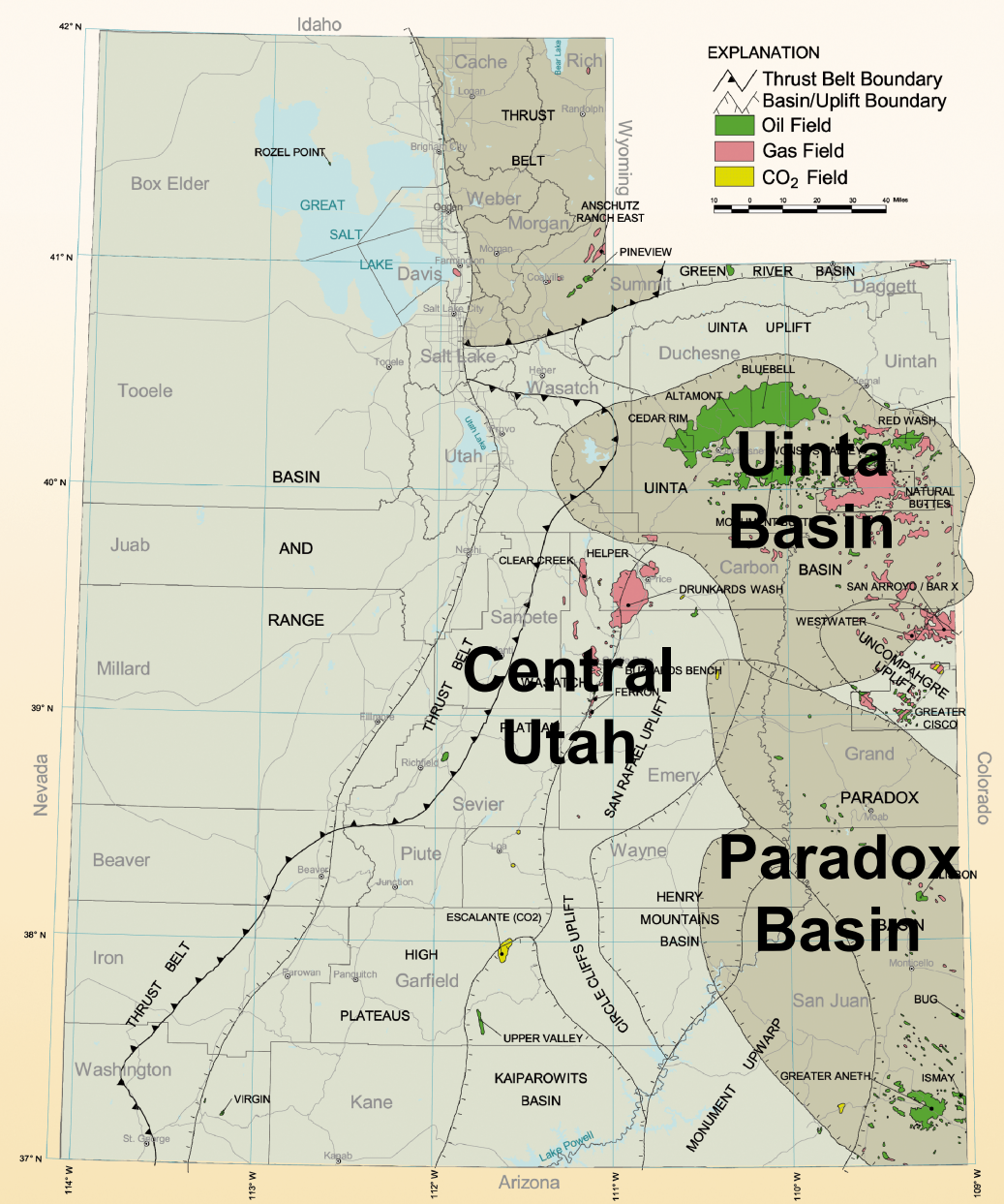


Halliburton estimates 500-1,000 trillion cubic feet of shale gas recoverable

Bakken Shale Oil Play



U.S. Geological Survey estimates 3.65 billion barrels of oil recoverable



Oil and Gas Fields of Utah

Utah Geological Survey Research Projects

- Paleozoic Shale-Gas Resources of the Colorado Plateau and Eastern Great Basin, Utah: Multiple Frontier Exploration Opportunities
- Cretaceous Mancos Shale Uinta Basin, Utah: Resource Potential and Best Practices for an Emerging Shale Gas Play

RPSEA
Research Partnership to Secure Energy for America

- Liquid-Rich Potential of Utah's Uinta and Paradox Basins: Reservoir Characterization and Development Optimization

NETL

Industry Participants

- Shell E & P
- QEP Resources
- Bill Barrett Corp.
- CrownQuest Operating, LLC
- ST Oil Utah, LLC
- Anadarko Petroleum Corp.
- Berry Petroleum Co.
- Newfield Exploration Company
- Fidelity Exploration & Production
- SM Energy Co.
- Southwestern Energy,
- Patara Oil & Gas LLC.
- Stone Energy Corp.
- Gasco Energy, Inc.
- Pioneer Natural Resources
- Wind River Companies
- XTO Energy
- Halliburton

Collaborators

- Energy and Geoscience Institute, University of Utah
- Eby Petrography & Consulting, Inc.
- GeoX Consulting Inc.
- Bereskin & Associates

EGI Energy & Geoscience Institute AT THE UNIVERSITY OF UTAH

Eby Petrography & Consulting, Inc.

Bereskin & Associates

Paleozoic Shale-Gas Resources of the Colorado Plateau and Eastern Great Basin, Utah: Multiple Frontier Exploration Opportunities

Project Goal

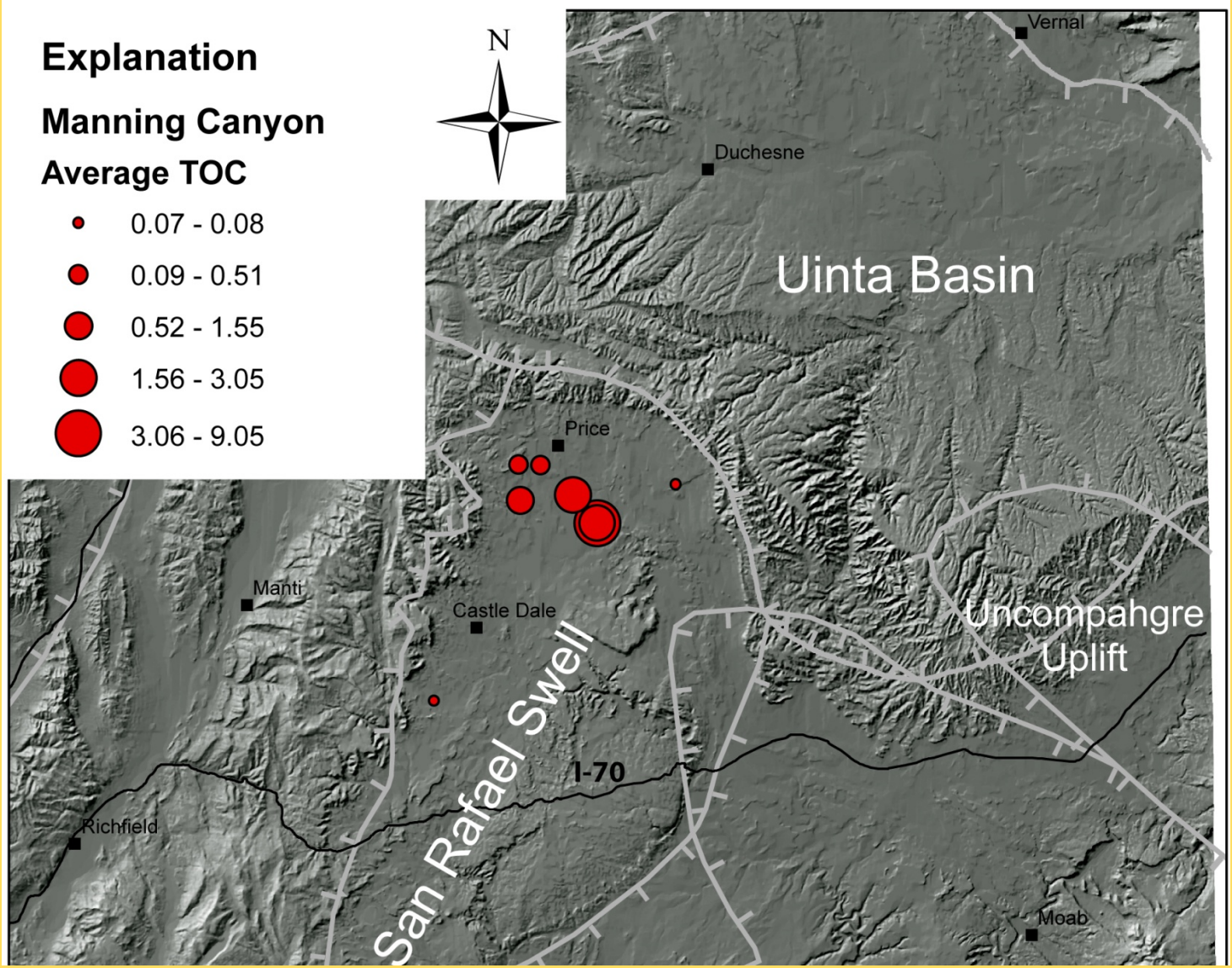
Provide basin specific analyses of shale-gas reservoir properties to develop the best local completion practices that can be applied to the emerging Manning Canyon and Paradox frontier gas shales.

Mississippian/Pennsylvanian Manning Canyon Shale Petrographic, Geochemical, and Facies Analysis

Organic-Rich Manning Canyon Shale Interbedded with Thin-Bedded Micritic Limestone, Western Provo Canyon, North-Central Utah

Black Shale

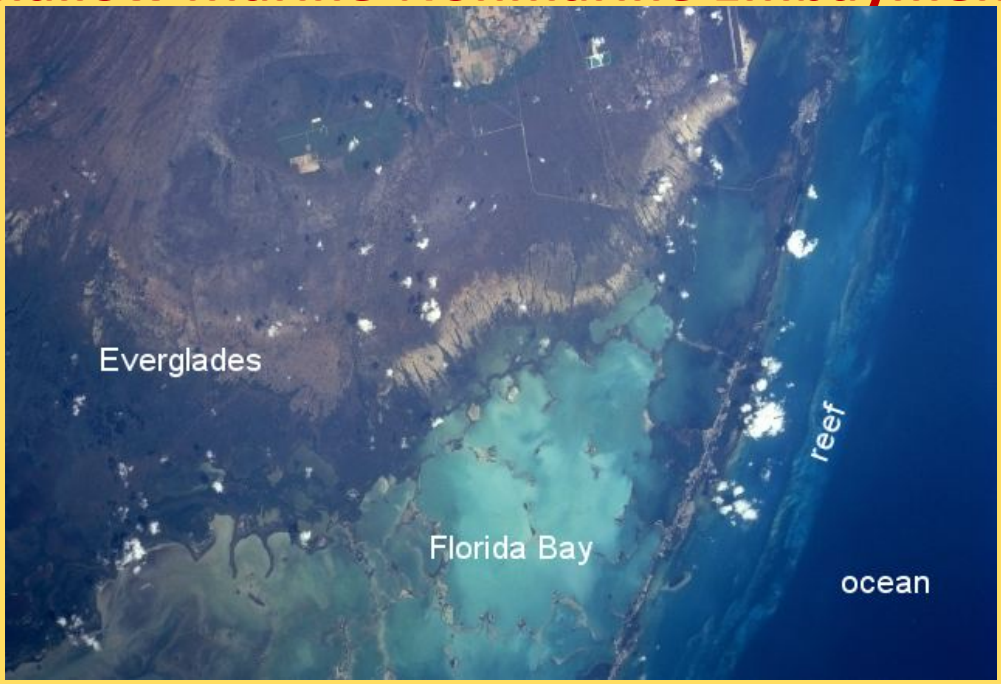
Total Organic Carbon: Manning Canyon



Depositional Setting: Modern Analog Model

- Evidence points to a restricted, shallow-water depositional setting that is dominantly non-marine or brackish, with secondary marine influence.
- The organic matter is terrestrial.
- The marshes of the Everglades and shallow brackish to marine carbonate factory of the Florida Bay might serve as a conceptual model.

Shallow Marine-Nonmarine Embayment

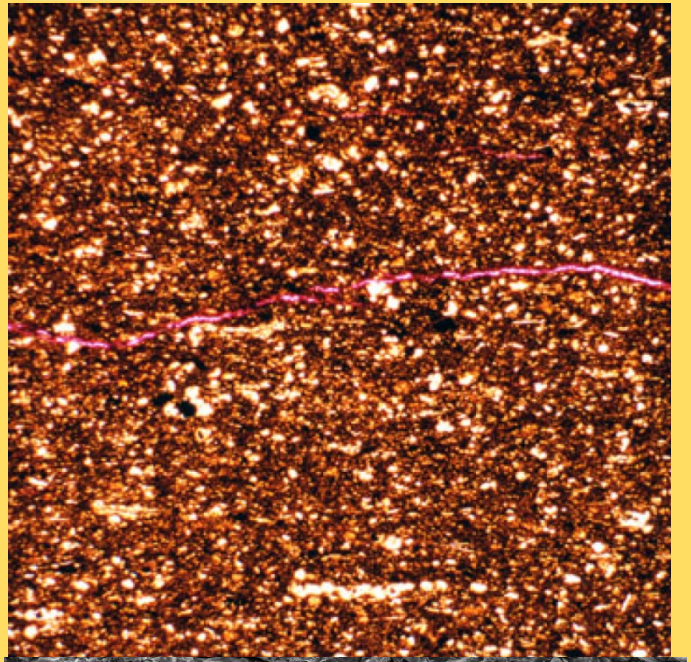


Mississippian Manning Canyon Shale: Conclusions

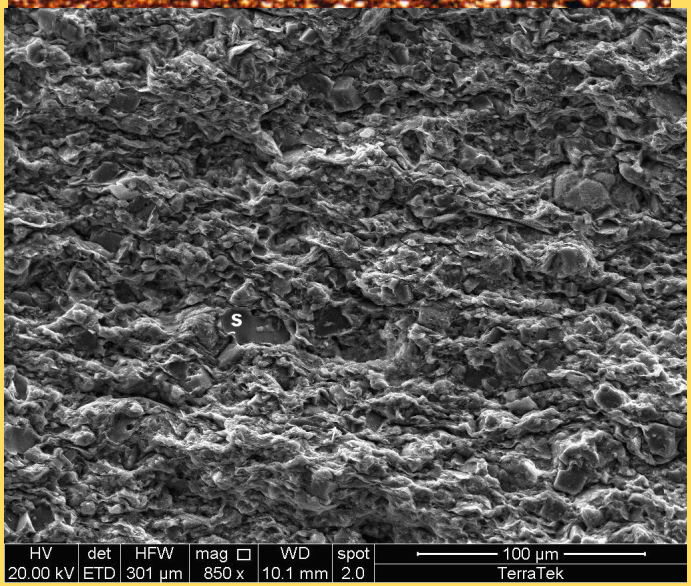
- 600 mi^2 potential area at north end of San Rafael Swell
- Manning Canyon is 300-1500 feet thick.
- Organic matter of terrestrial origin and of good to excellent richness is distributed throughout the shale, limestone and even siltstones that comprise the unit. Vitrinite reflectance measurements indicate that the kerogen is in the dry gas thermal maturity window.
- Manning Canyon may have been deposited in a shallow restricted carbonate- and organic-rich marine, brackish and fresh-water setting like the modern Everglades and Florida Bay.

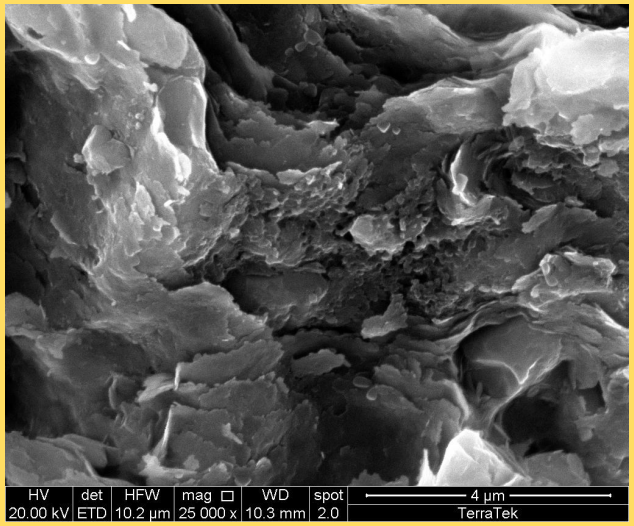
Pennsylvanian (Paradox Formation) Hovenweep, Gothic, and Chimney Rock, Petrographic, Geochemical and Geomechanical Analysis

Gothic Shale along the Honaker Trail, San Juan River Canyon, SE Utah

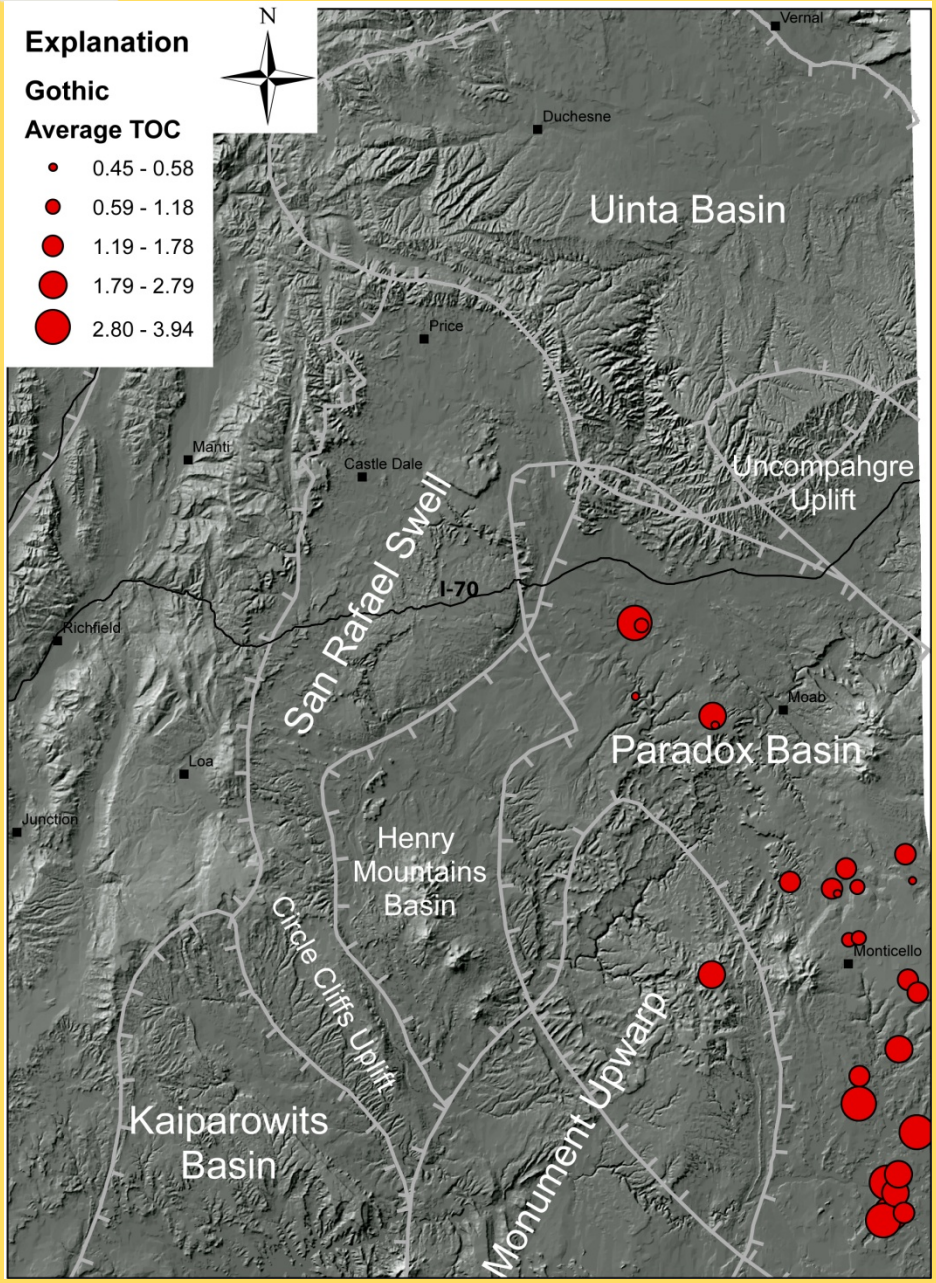


- Silty argillaceous mudstone
- Calcareous skeletal material and compacted agglutinated foraminifera
- Disseminated pyrite & authigenic minerals
- Very poorly laminated (microlamination defined by wavy clay flakes)
- Nanoporous kerogen contains numerous gas adsorption sites
- Intercrystalline pores between clay flakes are well connected





Lake Canyon 1-27, 5774 ft.



Total Organic Carbon: Gothic Shale

Pennsylvanian Paradox Formation: Conclusions

- The three shale intervals are gas productive in Hovenweep, Gothic, Chimney Rock mudstones.
- Thinly interbedded, black, organic-rich marine shale
- Thicknesses of individual shale units generally range in thickness between 25 and 50 ft; the cumulative shale thickness is typically 100 to 200 ft.
- TOC are modest – 1 to 5%
- Naturally fractured (usually on the crest of anticlinal closures), and often overpressured
- Estimated total undiscovered recoverable gas reserves = 6.5 trillion cubic feet (U.S. Geological Survey, March 2012)

Cretaceous Mancos Shale Uinta Basin, Utah: Resource Potential and Best Practices for an Emerging Shale Gas Play

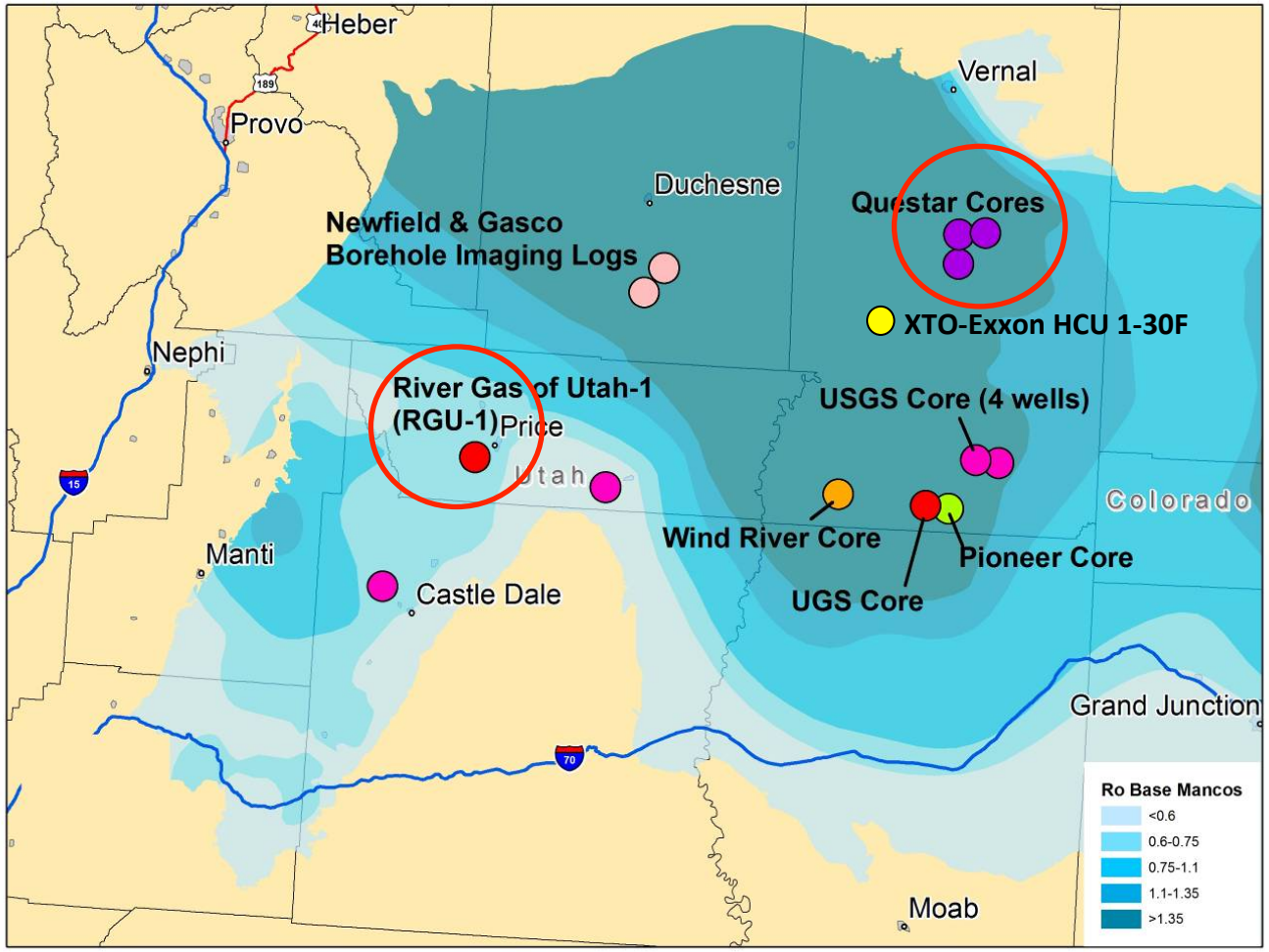
PROJECT GOALS

Characterize the of the Mancos in order to identify premium target zones, and determine the resource potential. Define the geologic controls on geomechanical properties (e.g., brittleness, “frackability”), which are currently poorly understood. Use the geologic parameters to predict regions of brittleness and Mancos shale-gas prospectivity, from an engineering perspective. Establish best drilling, completion, and production techniques for specific targeted intervals based on their rock properties.

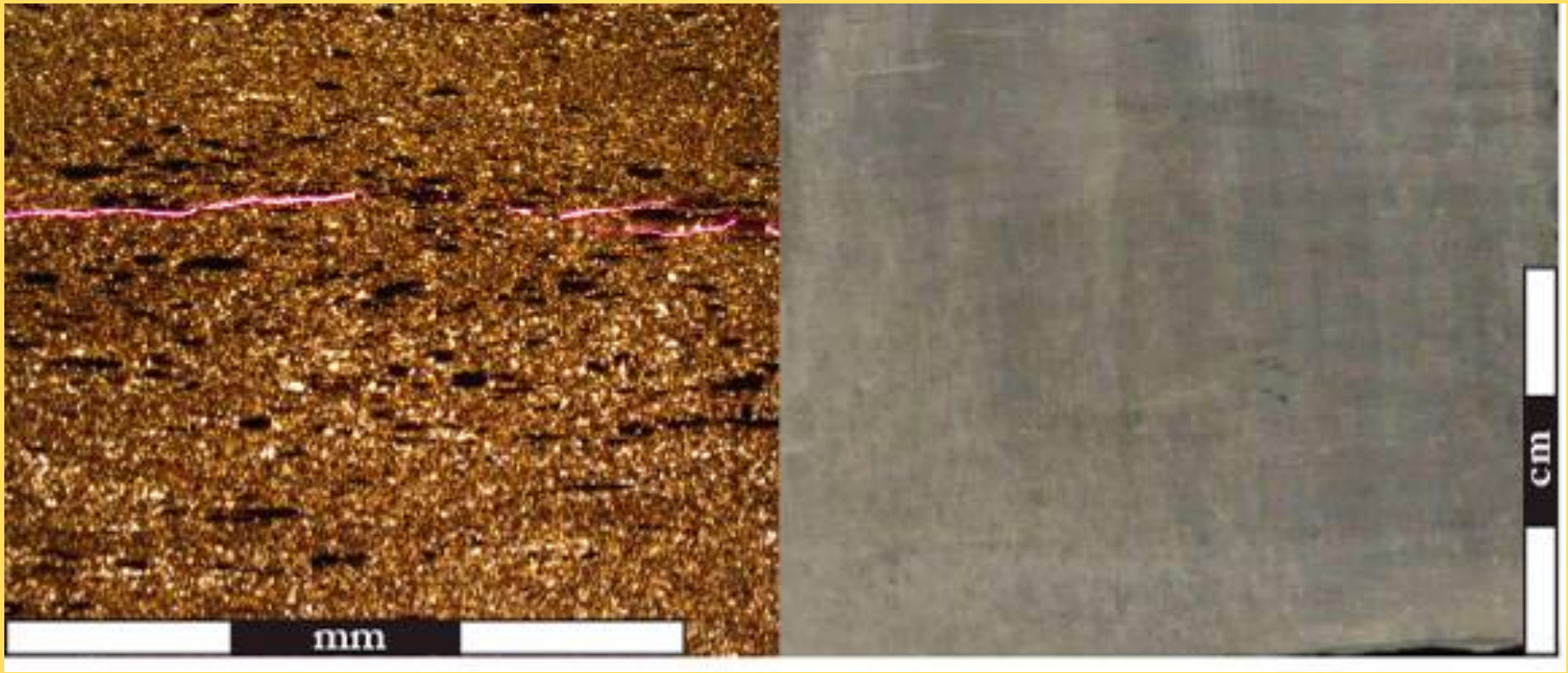
In outcrop the Mancos appears to be a monotonous gray shale. But this view obscures subtle yet possibly significant variations in lithology, texture, and mechanical properties

Photo by Jessica Allen, ChevronTexaco

Mancos Core Locations



Massive Siltstone (Distal Shelf)



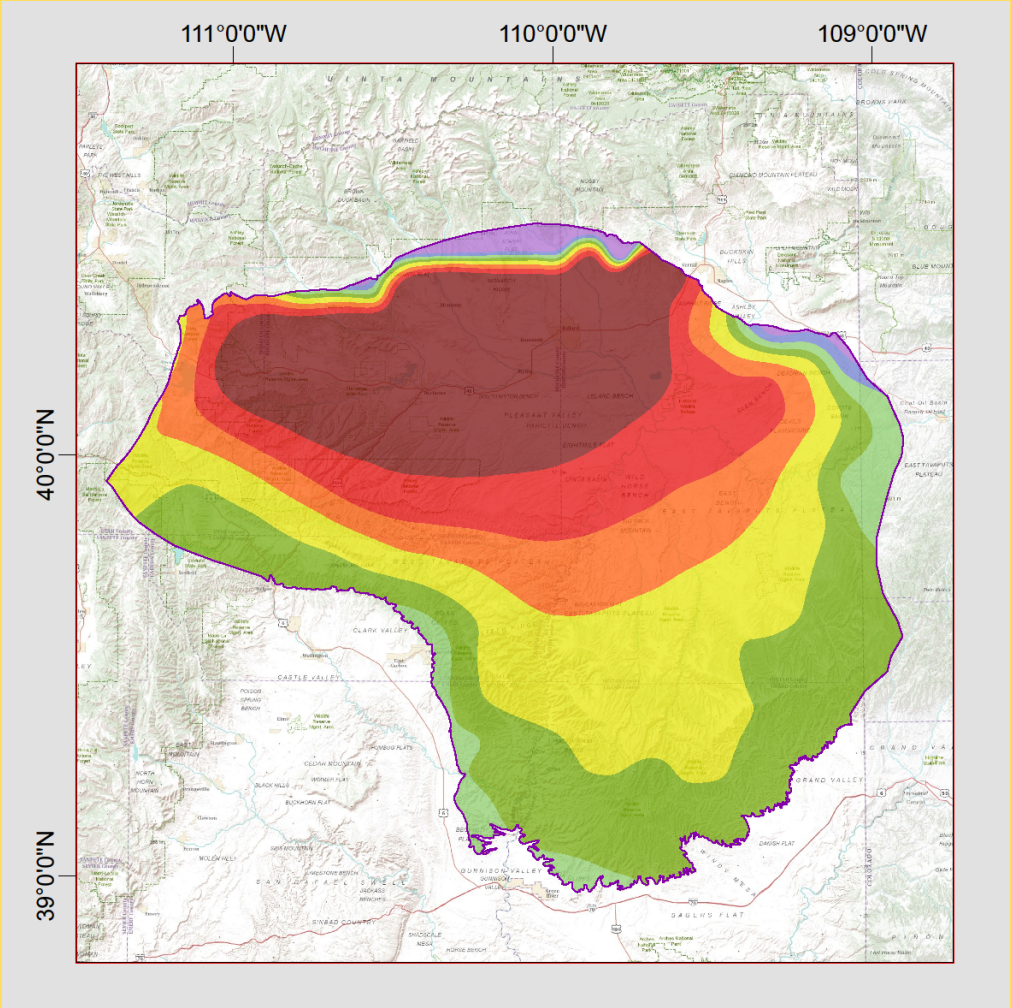
From Horton, 2012.

Sedimentologic & Stratigraphic Core Description

Cm to sub-cm scale description of:

- grain size
- color
- lamination style
- sedimentary structures
- bioturbation index (0 to 6)
- fossils
- mineralogy
- stratigraphic packaging

Maturity at Base of Mancos



% Ro	stage
< 0.4	immature
0.4 – 0.6	
0.6 – 0.8	early oil
0.8 – 1.0	peak oil
1.0 – 1.3	wet gas
1.3 – 1.6	dry gas
1.6 – 2.0	
> 2.0	

Cretaceous Mancos Shale: Conclusions

- Average thickness across the Uinta Basin is 4000 feet
- Thicknesses of organic-rich zones in individual highstand system tracts exceed 12 feet
- Vitrinite reflectance at the top of the Mancos ranges from 0.65% (early oil generation) at the basin margins to >1.5% (dry gas generation) in the central basin

Key characteristics applicable to shale gas play:

- Poro/perm from silt & sand content
- High clay content (~40%) compared to other shales
- Bioturbation may be significant for mechanical properties

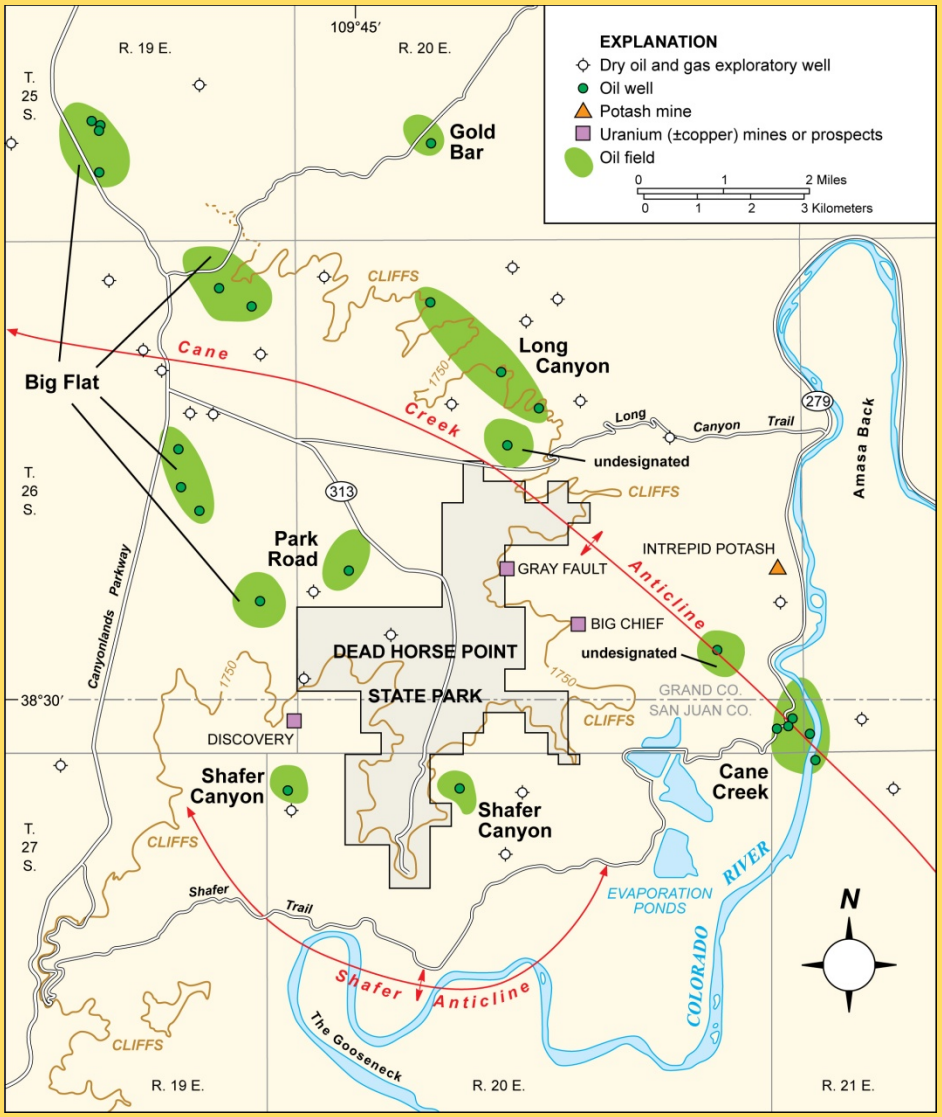
Liquid-Rich Potential of Utah's Uinta and Paradox Basins: Reservoir Characterization and Development Optimization

Project Goal

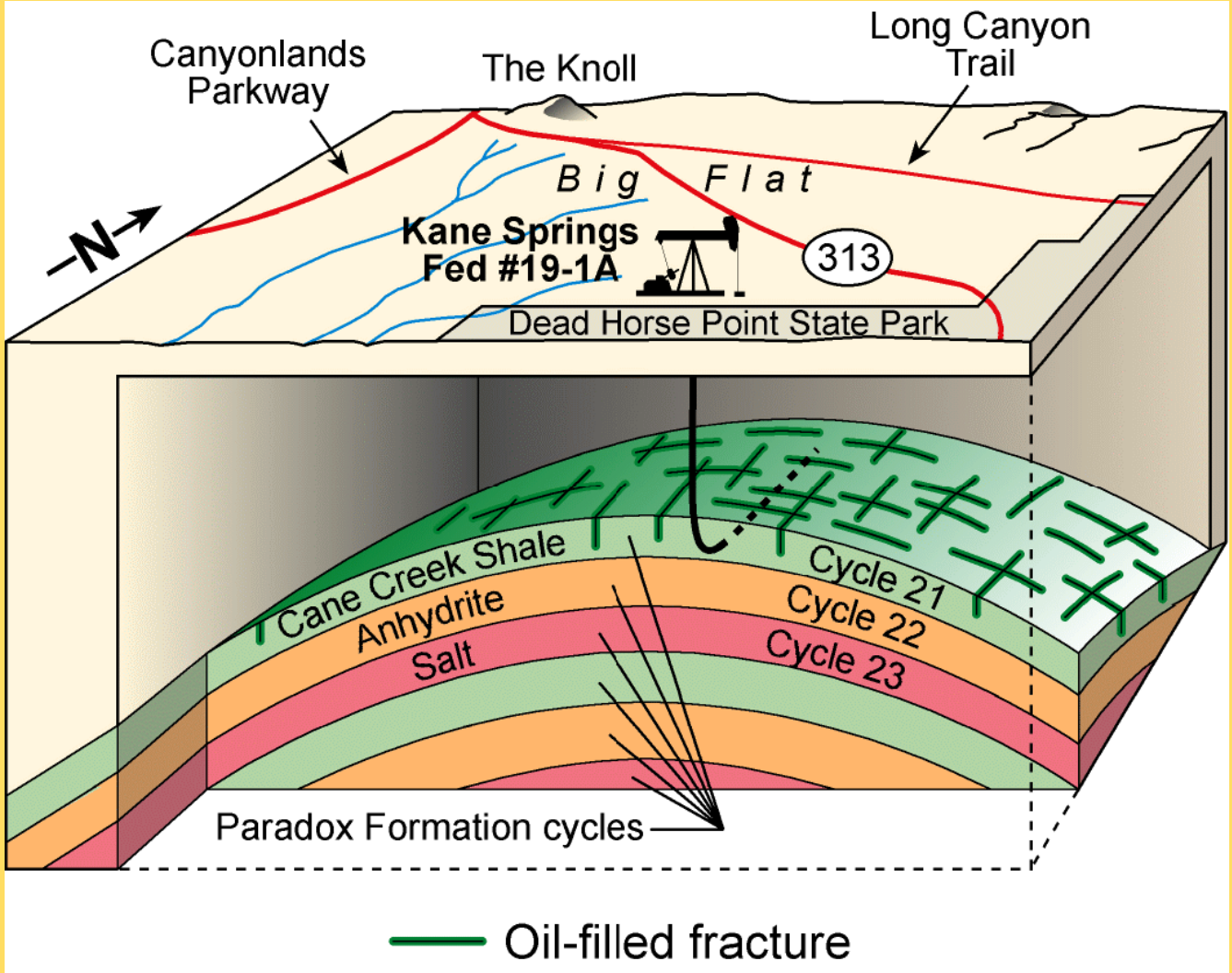
Provide reservoir-specific geologic and engineering analysis of the (1) emerging green river formation shale oil (tight oil) plays, such as the Uteland Butte Limestone, in the Uinta Basin and (2) the established, yet understudied Cane Creek shale (and possibly other shale units of the Paradox Formation in the Paradox Basin.

Cane Creek Shale, Paradox Basin, Southeastern Utah

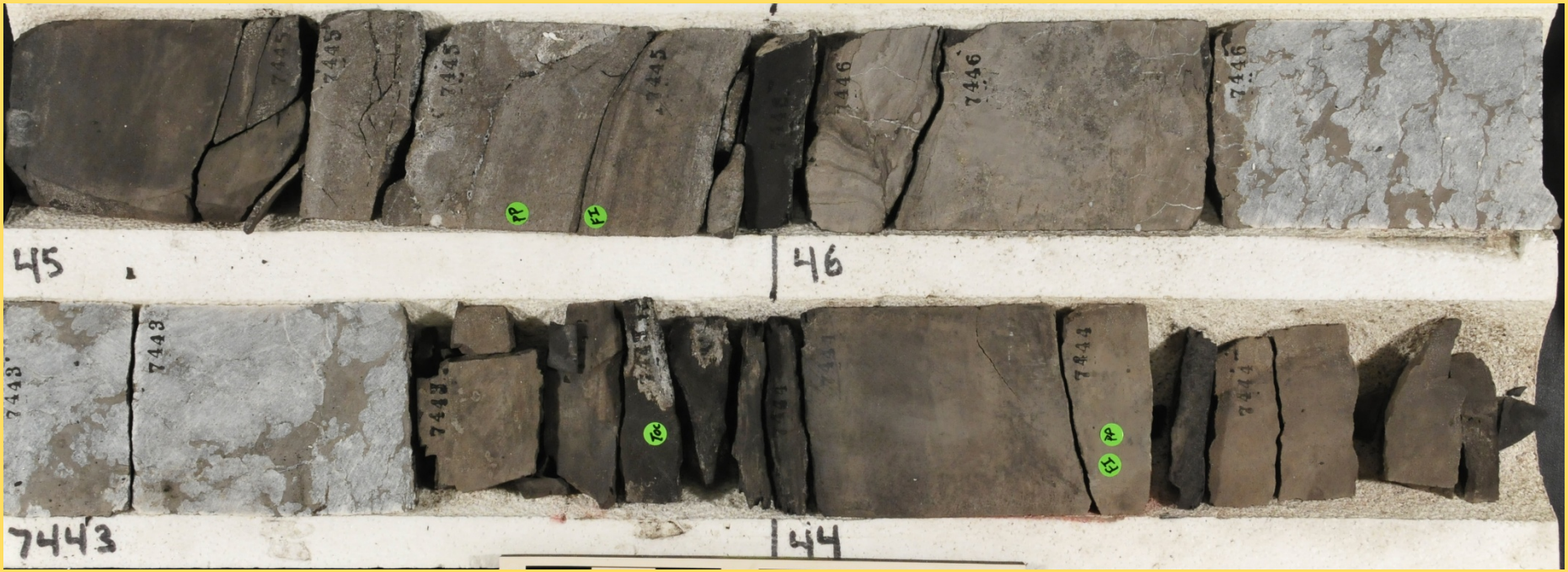
Cane Creek Shale Oil Fields



Park Road Oil Field



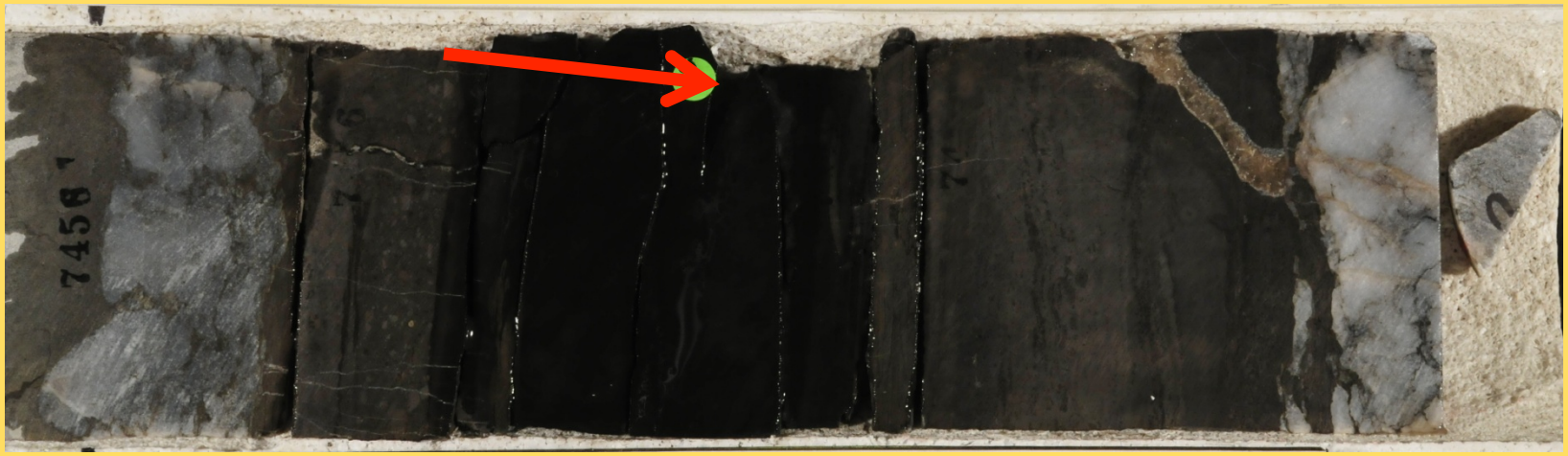
Cane Creek Shale



UP Resources, #21-1H Remington, San Juan County

Organic-Rich Zones

7452 ft.



7456 ft.

UP Resources, #21-1H Remington, San Juan County

Fractures

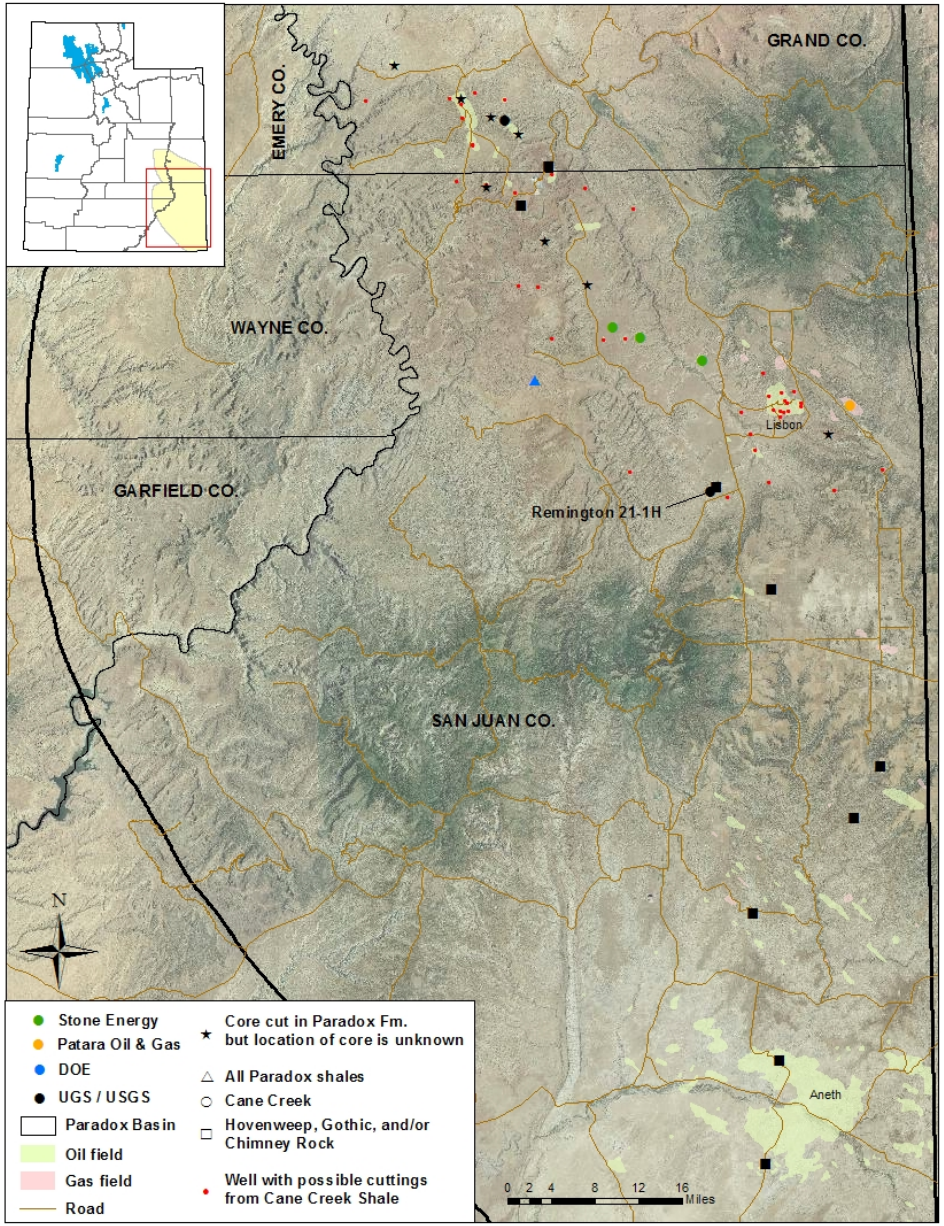
7462 ft.

7463 ft.

UP Resources, #21-1H Remington, San Juan County

Cane Creek Characteristics

- Highly fractured
- 40 to 70 feet thick
- The total organic carbon as high as 15%
- Overpressured
- Wide aerial extent
- Little associated produced water
- Estimated total undiscovered recoverable oil reserves from the Cane Creek and other shales in the Paradox Basin = 471 million barrels (U.S. Geological Survey, March 2012)
- Requires horizontal drilling and fracking
- Cumulative oil production = 3,280,702 barrels (Utah Division of Oil, Gas, and Mining, September 1, 2012,)



Cane Creek Shale Cores, Paradox Basin

Uteland Butte Limestone, Green River Formation, Uinta Basin

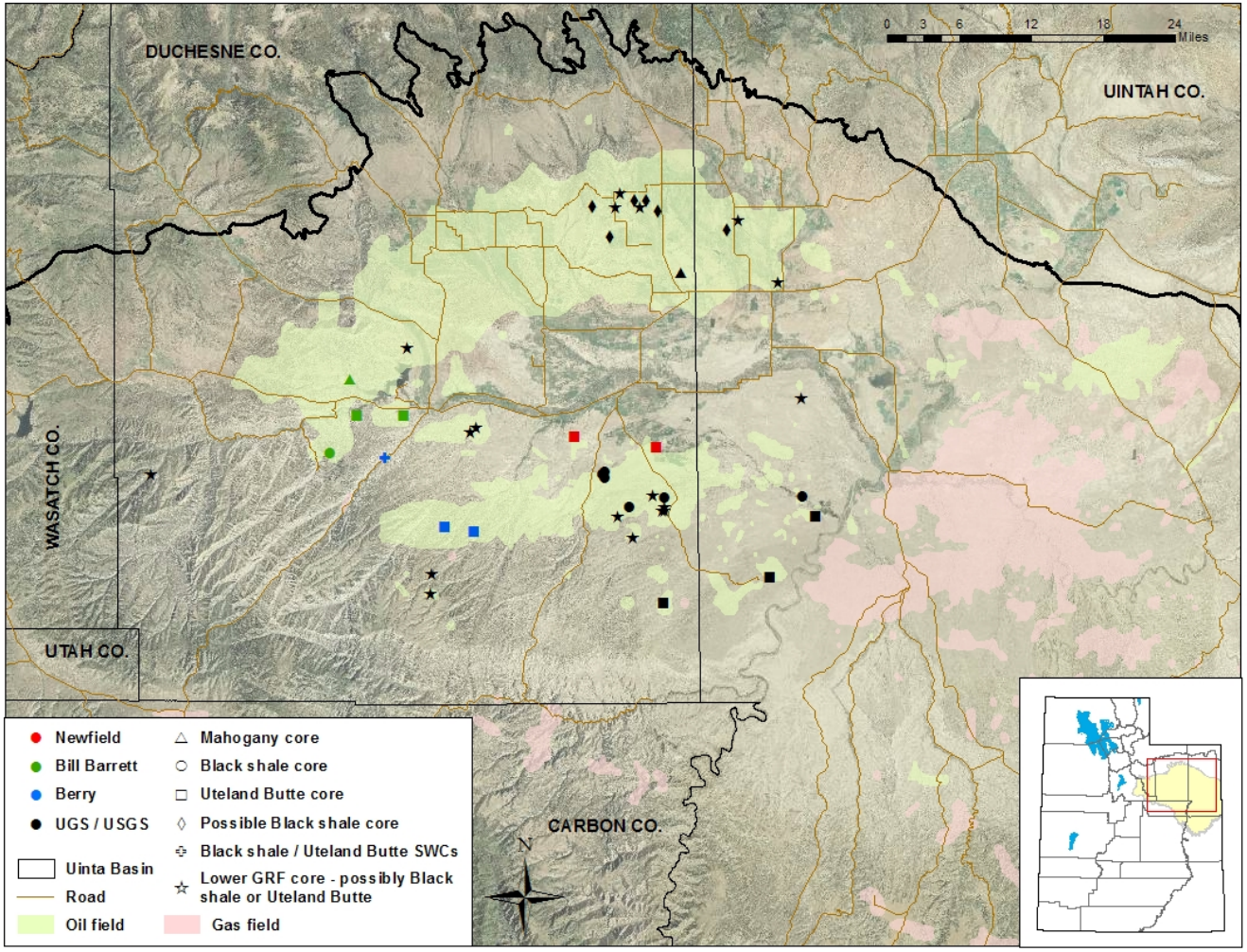
Uteland Butte Limestone Core

Bill Barrett 14-1-46, Duchesne County

Uteland Butte Characteristics

- Highly fractured
- 30 to 40 feet thick
- Similar rock characteristics to the middle Bakken Formation
- Estimated recovery from 150,000 to 275,000 barrels of oil per well
- Requires horizontal drilling and fracking

Uteland Butte Limestone Cores, Uinta Basin



Core Research Center

Technology Transfer

- Technical Advisory Boards
- Geologic Society Meeting Exhibit Booths
- Publications
- Technical Presentations
- Core Workshops
- Field Reviews
- Project Web Pages
  - (http://geology.utah.gov/emp/shalegas/index.htm)
  - (http://geology.utah.gov/emp/shaleoil/index.htm)