Utah's Oil Shale Deposits: Stratigraphy and Resource Evaluation

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Utah Geological Survey

27th Oil Shale Symposium – October 2007

Outline

1) Utah Oil Shale Database

2) Historical oil shale research in Utah

3) Scope of work - Developing a new state-wide oil shale assessment

4) Methods

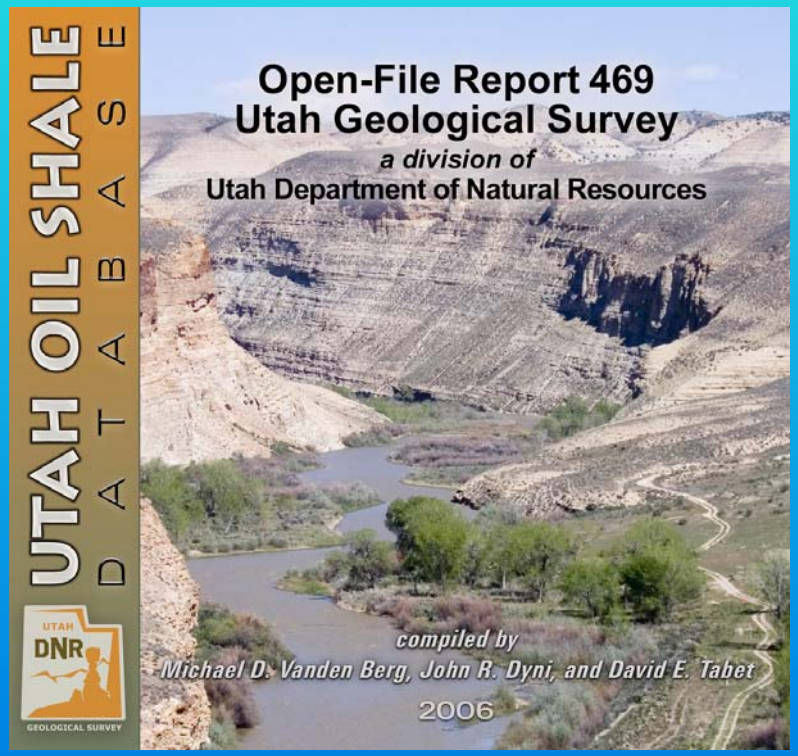
5) Results - Preliminary maps…**work in progress**

Utah Oil Shale Database

UGS Open-File Report 469

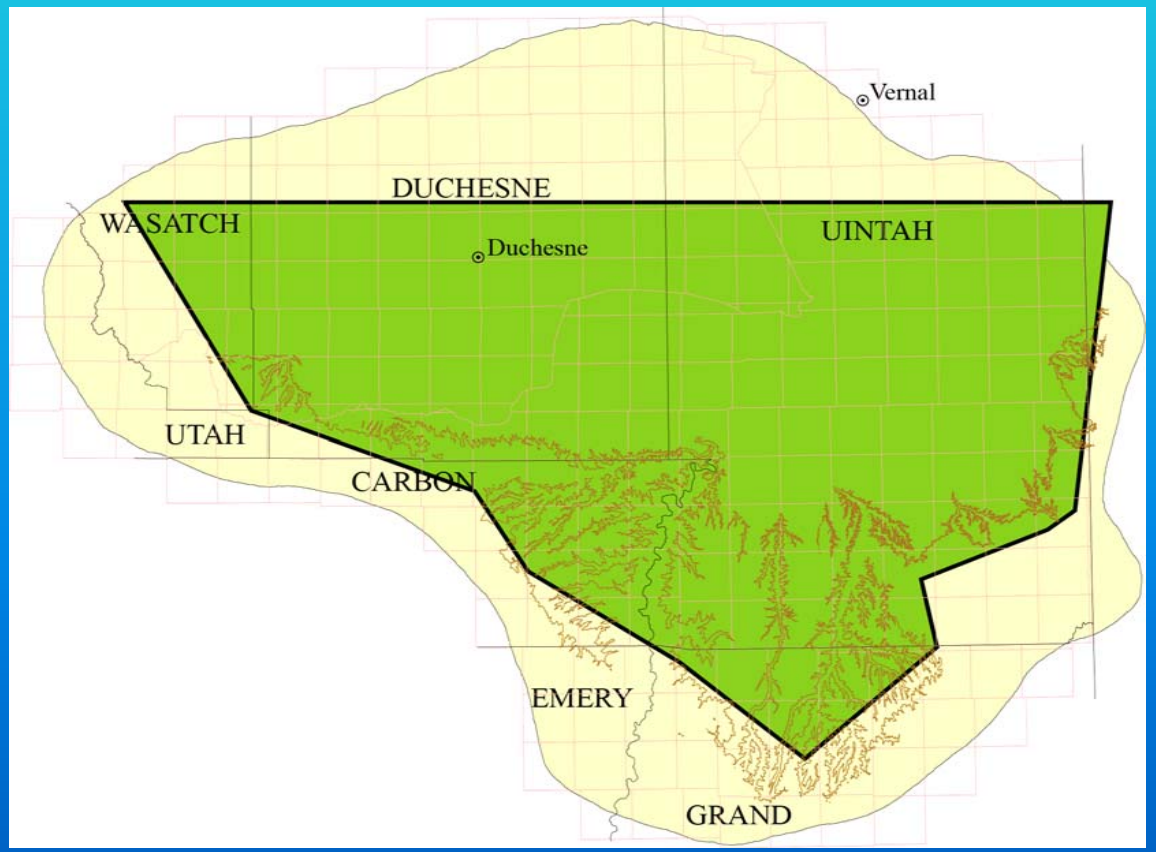
Preservation of historical oil shale data presented in a useable electronic format:

- Digital Fischer assays for 581 wells
- Scanned geophysical logs for 173 wells
- Lithologic descriptions for 168 wells
- Formation tops information for over 1,000 wells
- Extensive Utah oil shale bibliography with nearly 1,000 references



Past attempts at quantifying Utah's oil shale resource

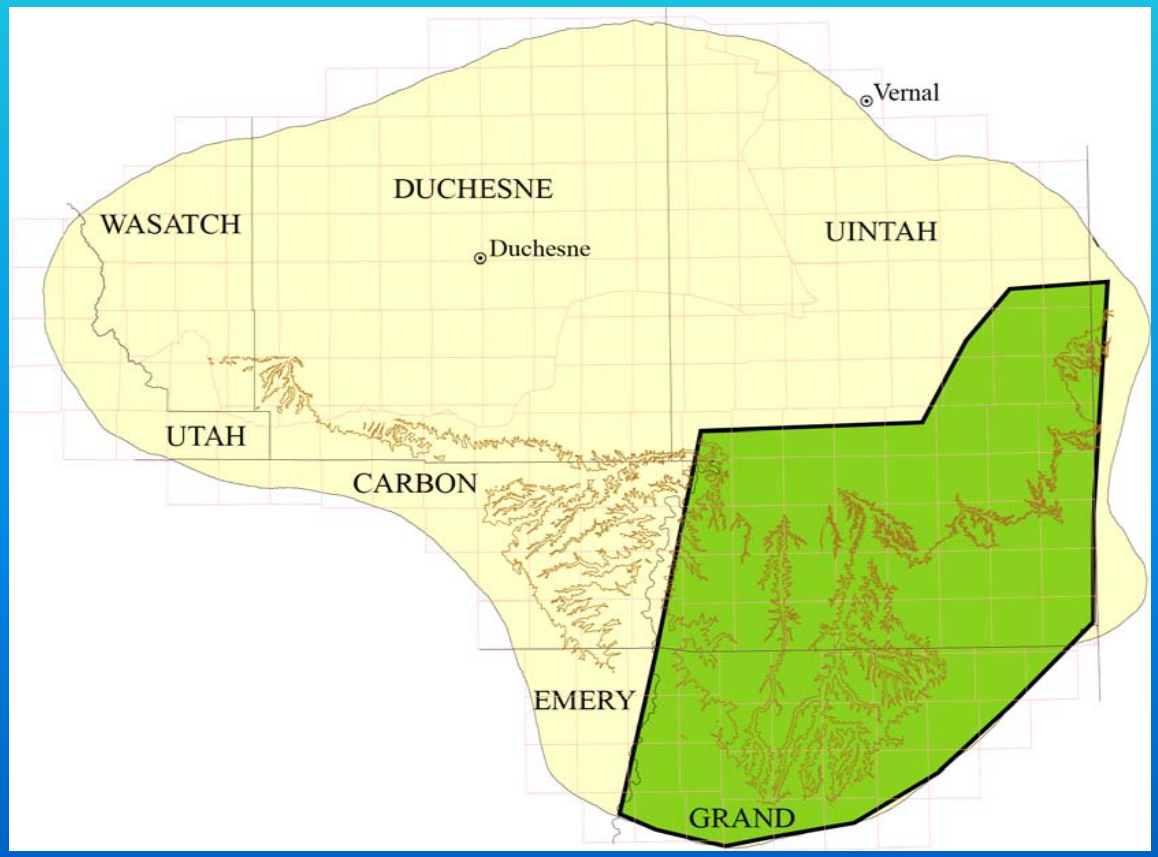
1) Cashion, 1964 - 321 billion barrels
   - Entire Uinta Basin
   - Very limited data – only sparse Fischer Assay data
   - 15 feet thick, minimum of 15 gpt



Past attempts at quantifying Utah's oil shale resource

2) Cashion, 1967 - 53 billion barrels

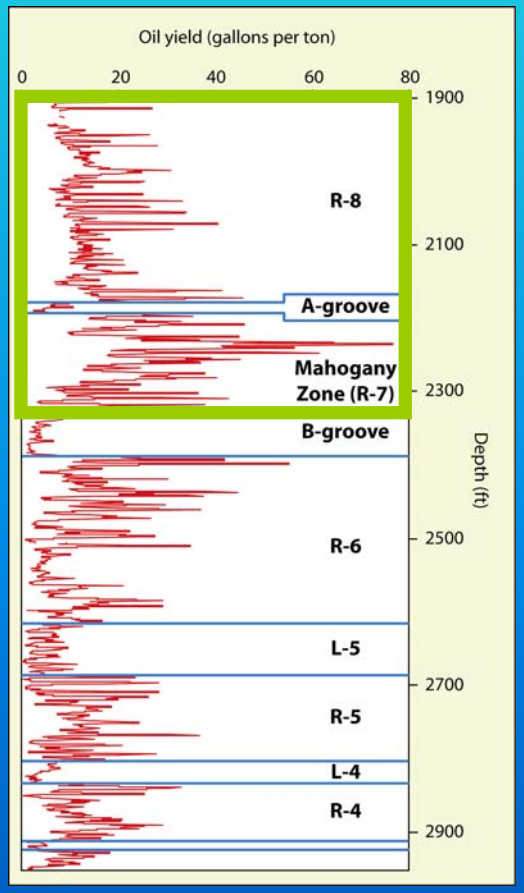
- 15 gal/ton, 15 feet or more thick, southern Uintah County and northern Grand County

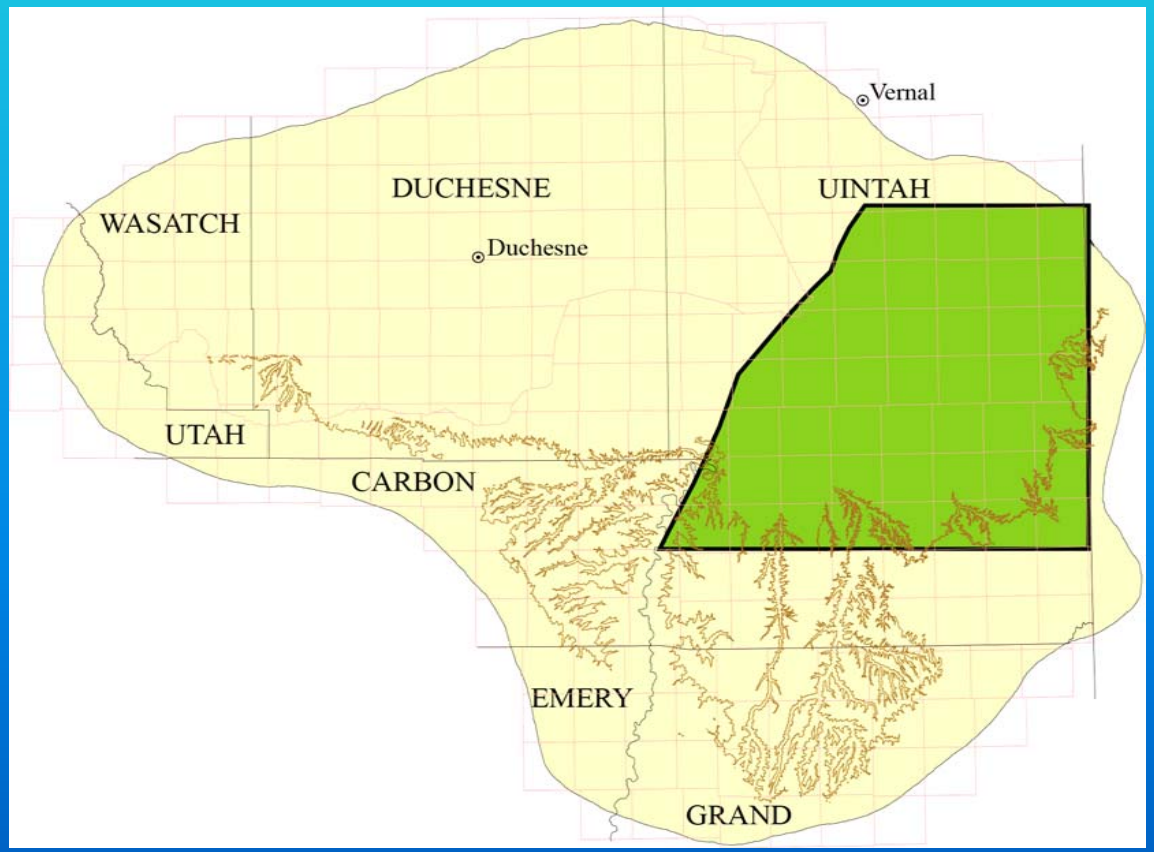


Past attempts at quantifying Utah's oil shale resource

3) Smith, 1980 - 165 billion barrels

- Eastern Uinta Basin
- Only R-8 through Mahogany Zone

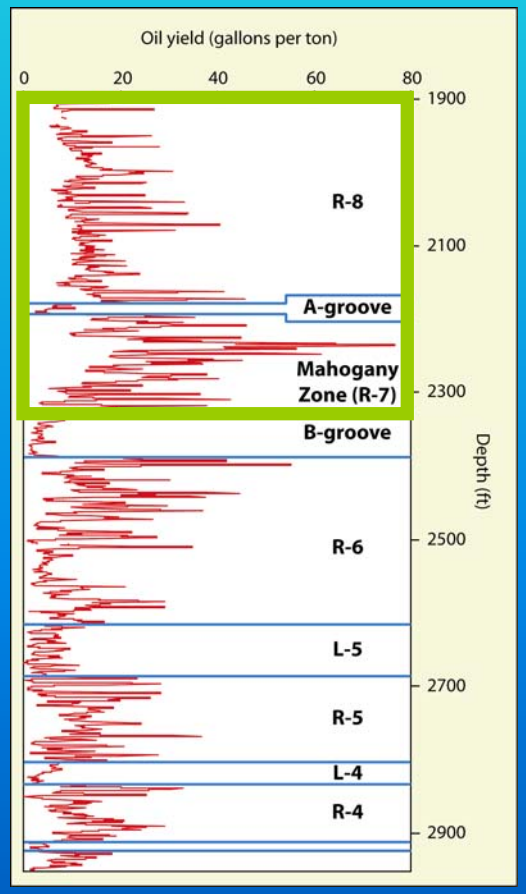


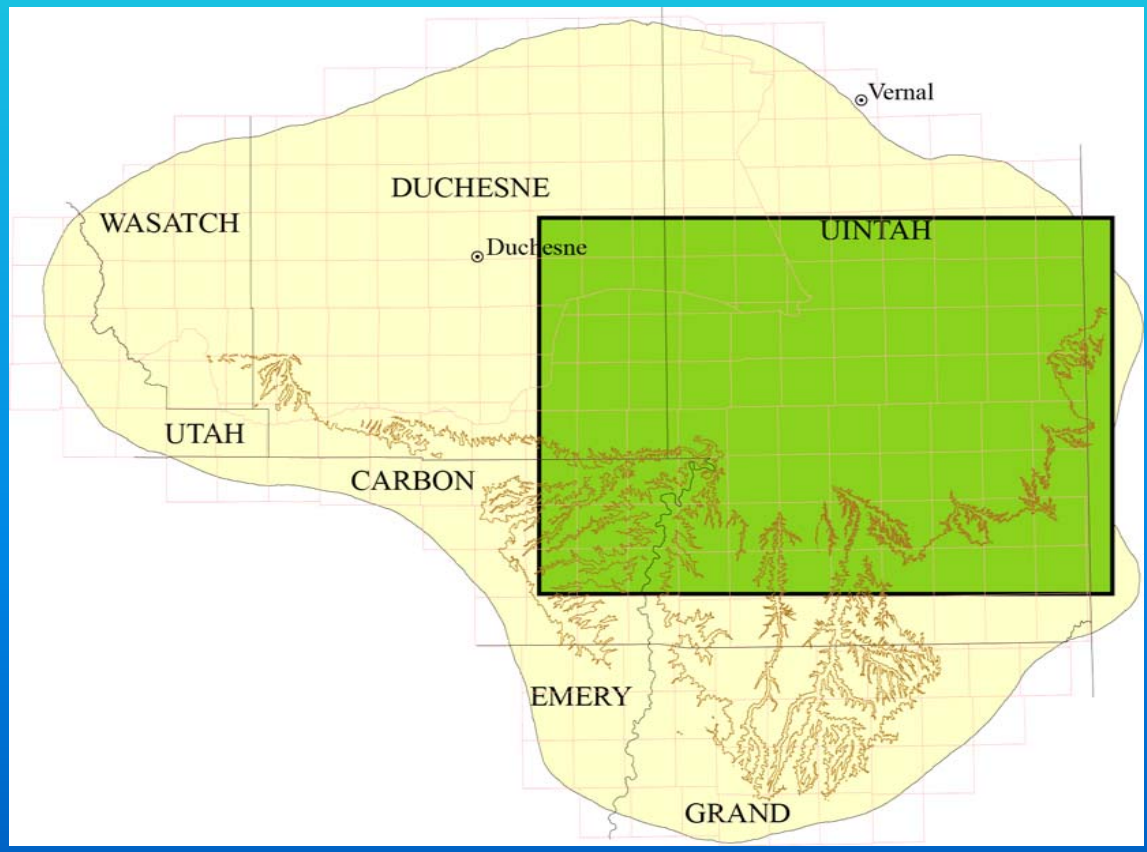


Past attempts at quantifying Utah's oil shale resource

4) Trudell et al., 1983 - 214 billion barrels

- Eastern Uinta Basin - only R-8 through Mahogany Zone
- 68 billion barrels within the Mahogany Zone





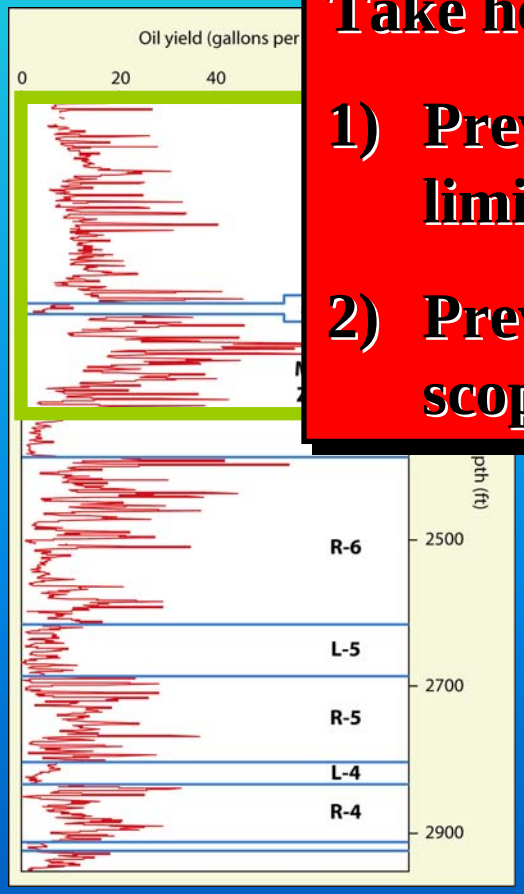
Past attempts at quantifying Utah's oil shale resource

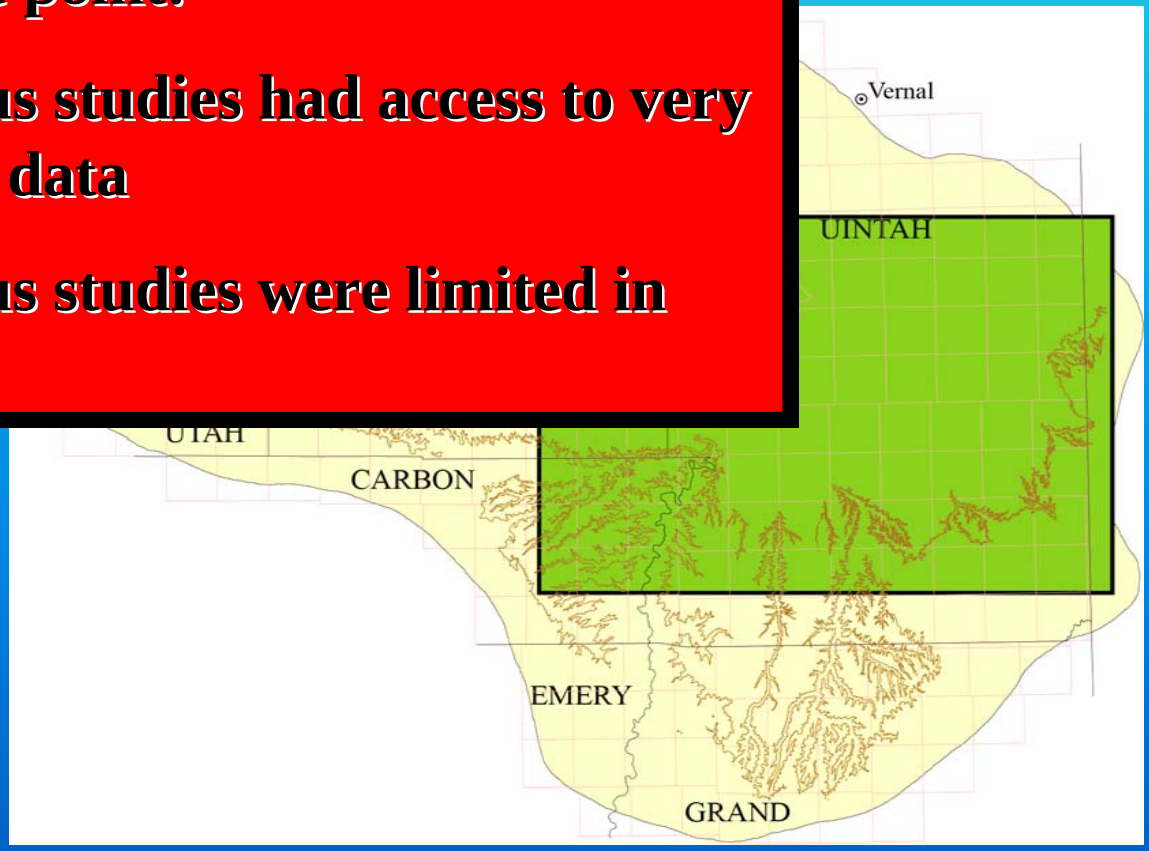
4) Trudell et al., 1983 - 214 billion barrels

- Eastern Uinta Basin - only R-8 through Mahogany Zone
- 68 billion barrels within the Mahogany Zone

Take home point:

1) **Previous studies had access to very limited data**
2) **Previous studies were limited in scope**



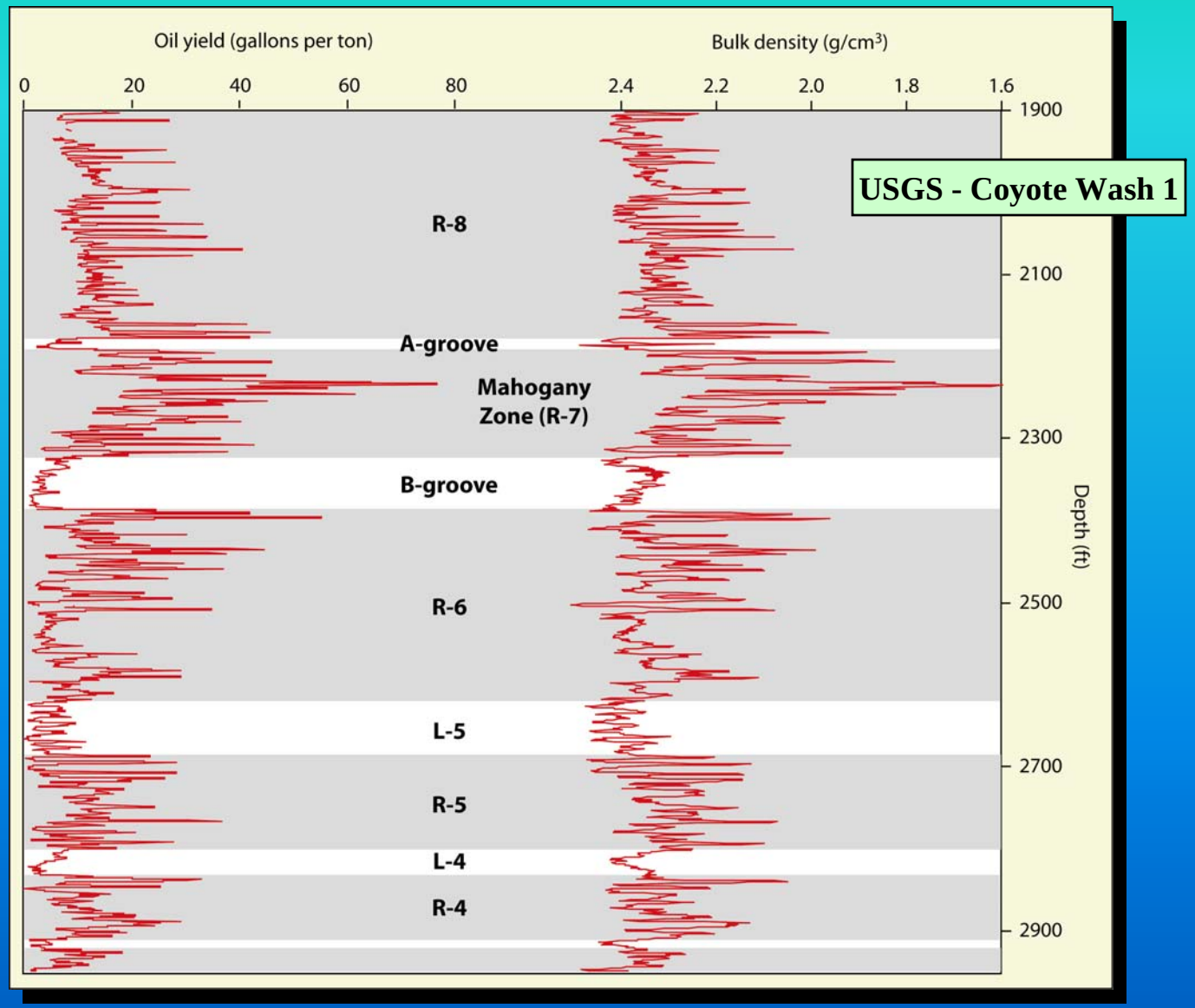


Scope - Our New Resource Evaluation

1) Focus - Entire Uinta Basin
2) Stratigraphic control
   - Geophysical logs from hundreds of oil and gas wells
   - Oil shale cores
3) Resource measurement
   - Fischer assays from oil shale cores
   - Pseudo-Fischer assays from density and sonic logs
   - DID NOT use Fischer assays from rotary cuttings
     - Underestimates resource
4) Map making
   - Isopachs
   - Structure contours
5) Ultimate goals…**work in progress**
   - New comprehensive oil shale resource estimates of Utah

Methods

1) Compared Fischer assay data to density and sonic logs



Methods

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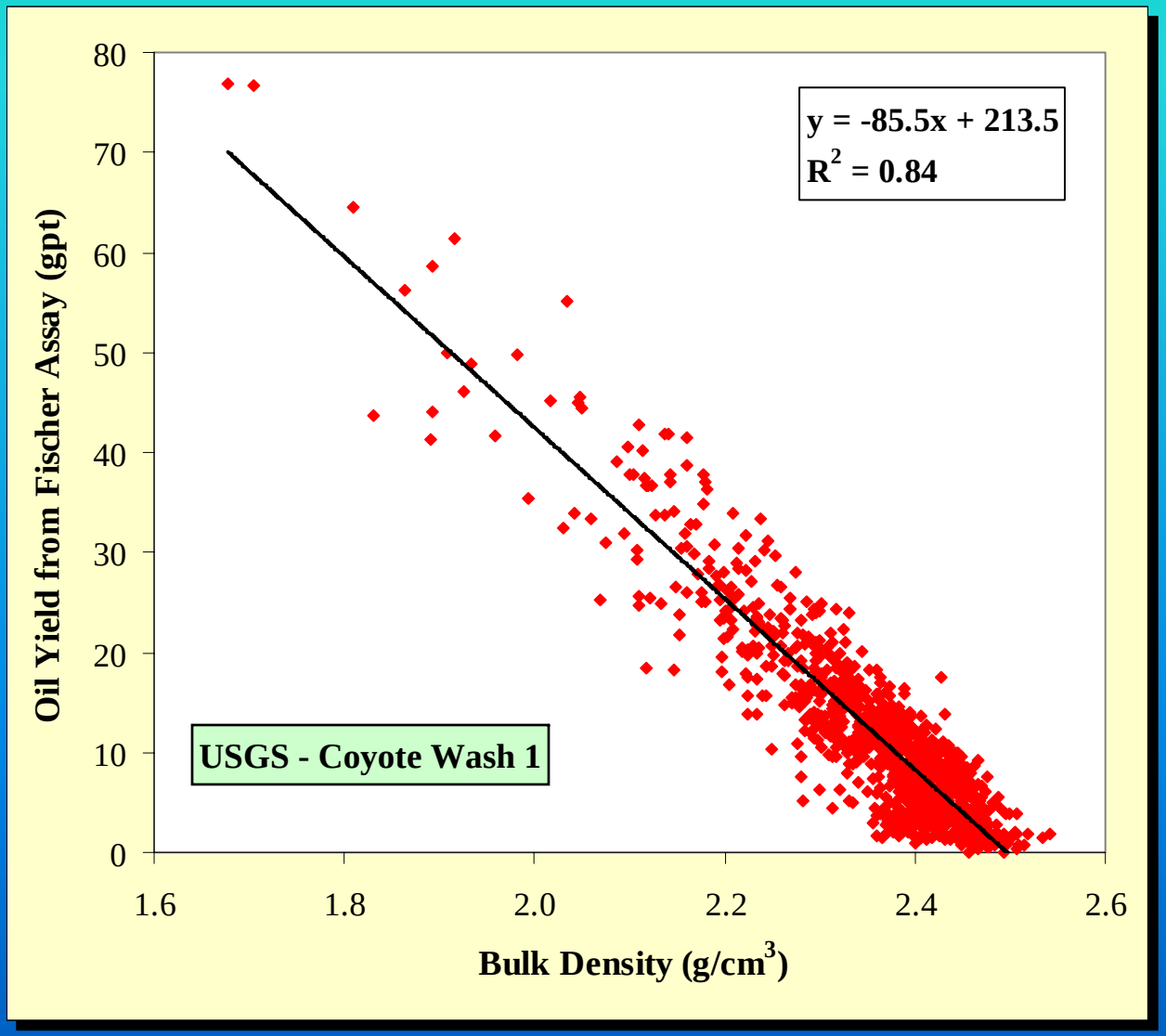
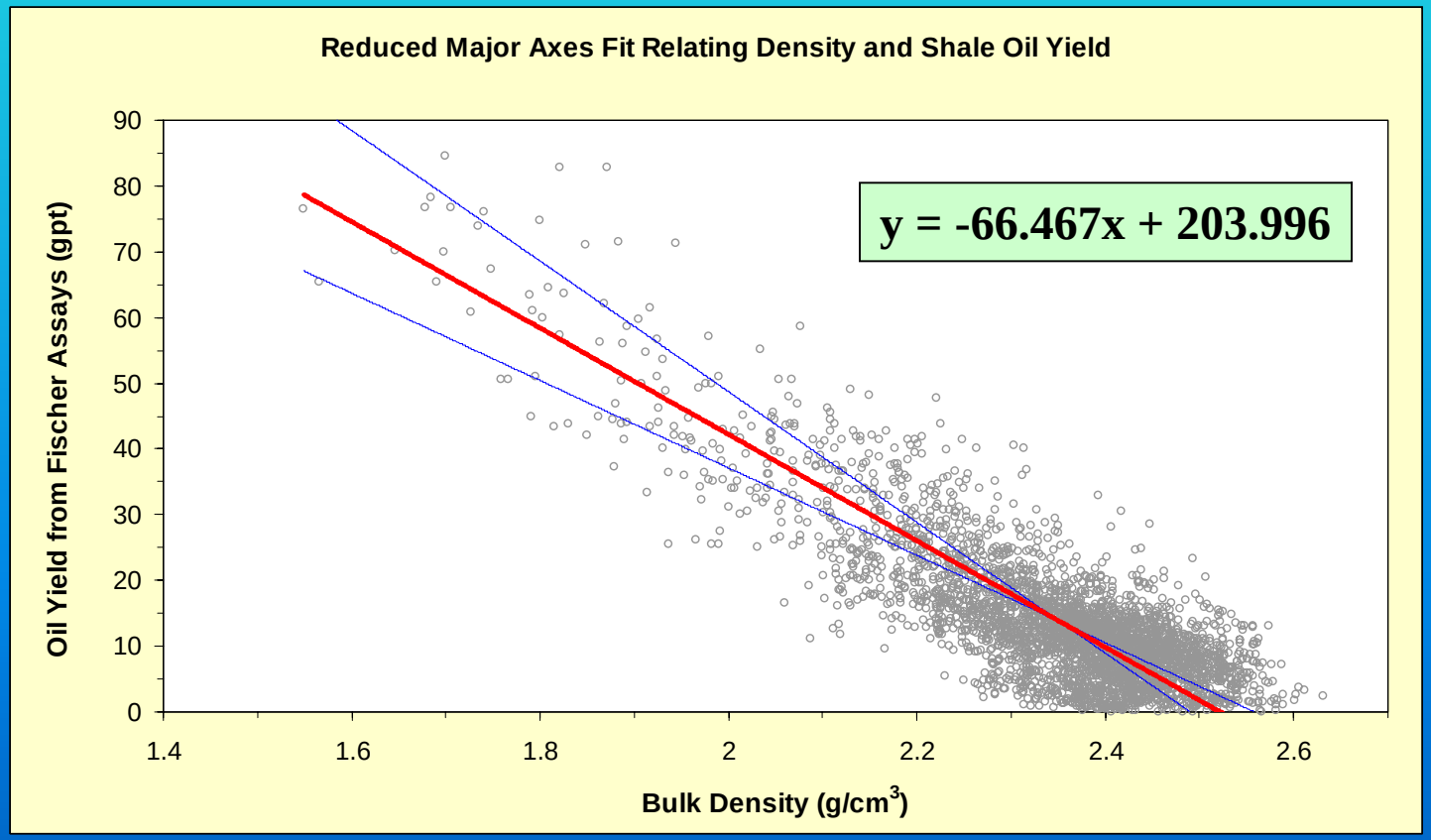


Methods

2) Created equation comparing bulk density to Fischer assays

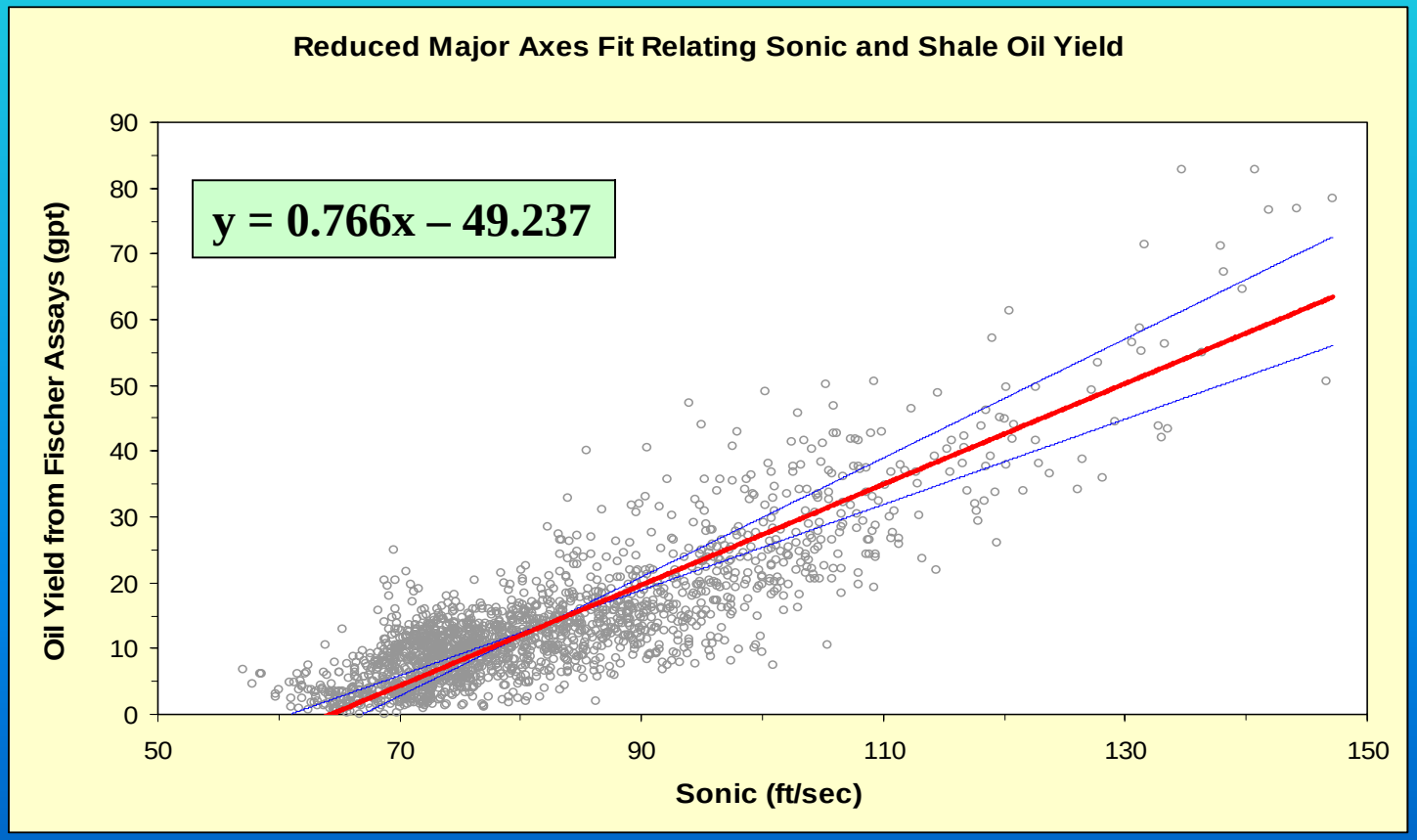
- Used 8 wells with R^2 ranging from 0.71 to 0.87
- Used a reduced major axes regression fit



Methods

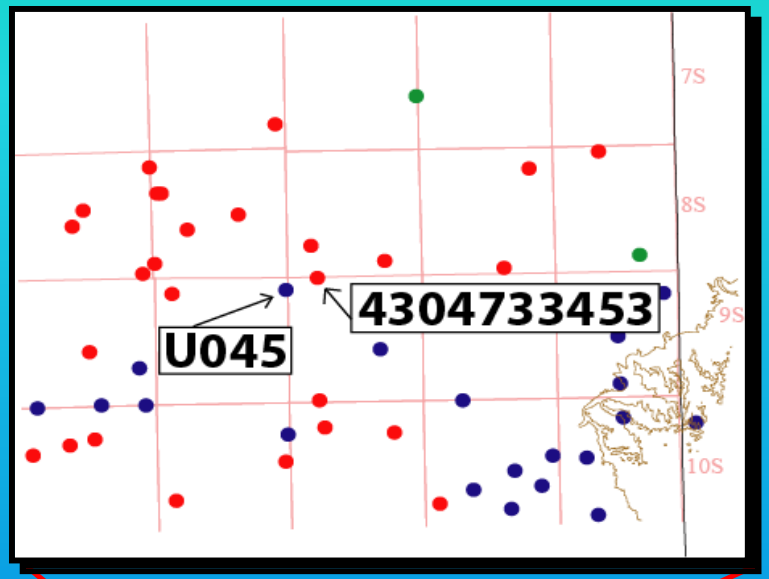
2) Created equation comparing sonic to Fischer assays

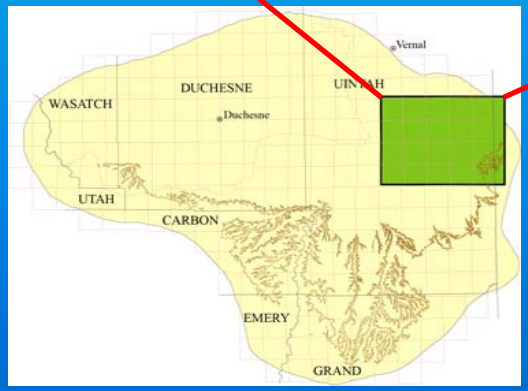
- Used 4 wells with R^2 ranging from 0.64 to 0.77
- Used a reduced major axes regression fit



Methods

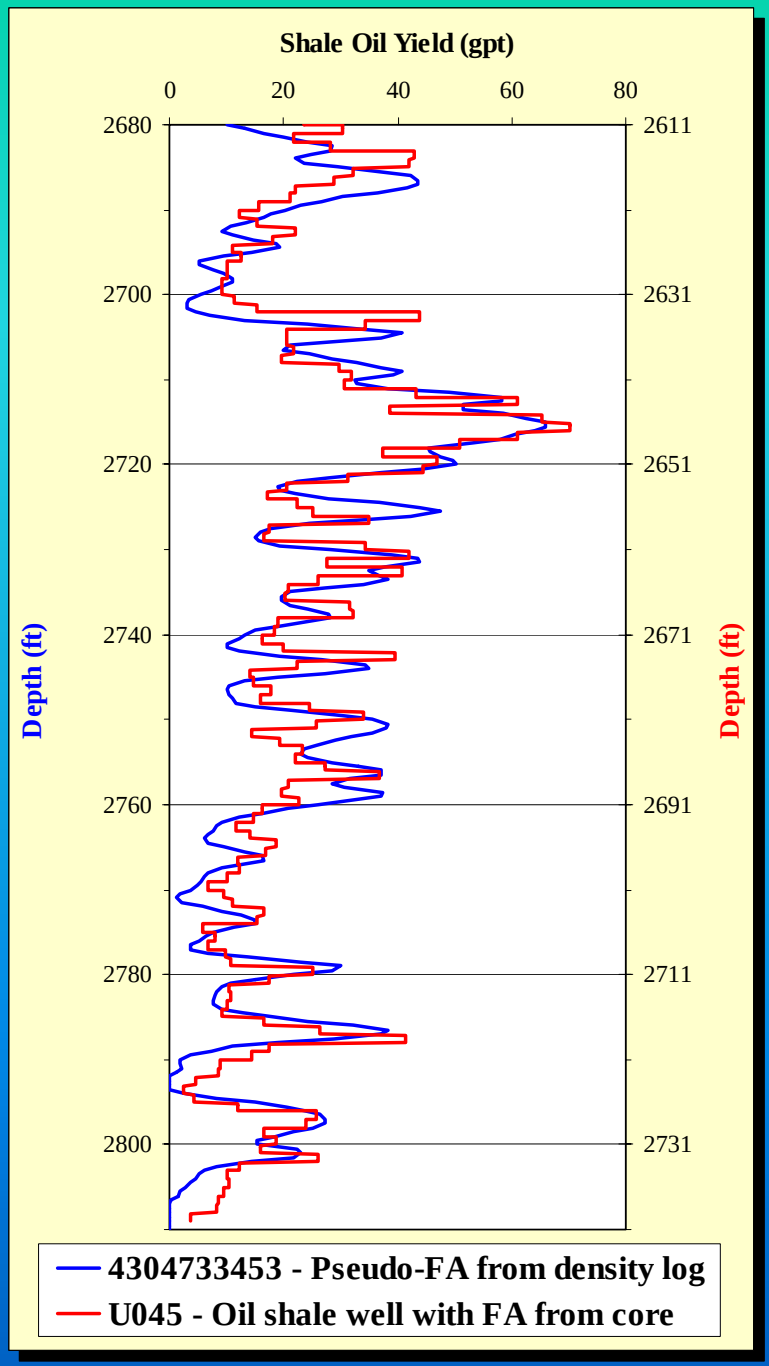
- Ground truth verses calculated yield





1.5 miles apart

Average gpt of datasets:
Gas well = 21.4 gpt
U045 = 21.7 gpt



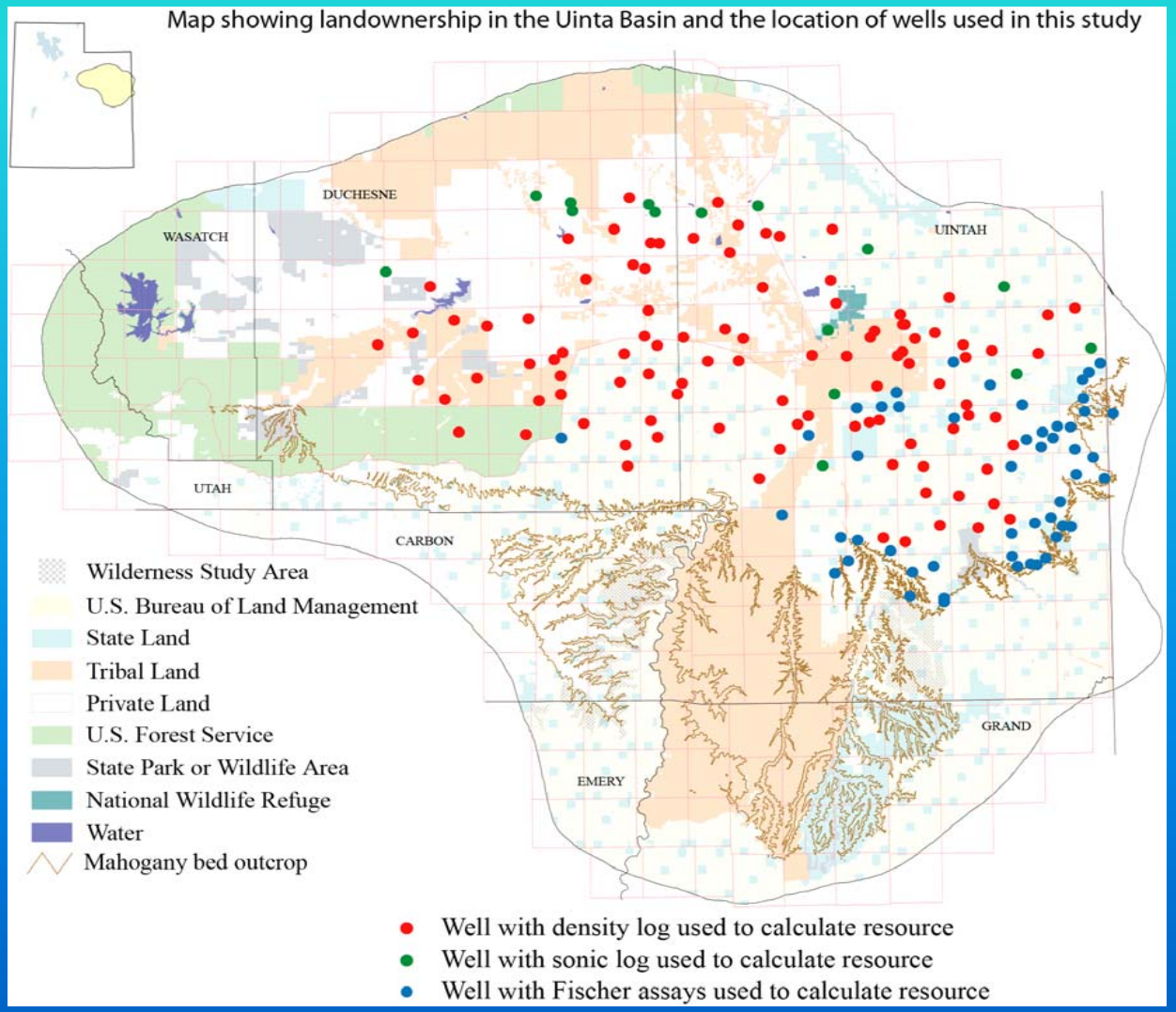
Methods

3) Created pseudo-Fischer assay logs from geophysical logs for wells throughout the Uinta Basin

- 100 wells using density
- 16 wells using sonic
- 52 wells with Fischer assays on core

Landownership

- BLM – 40%
- Private – 28%
- Tribal – 22%
- State – 10%

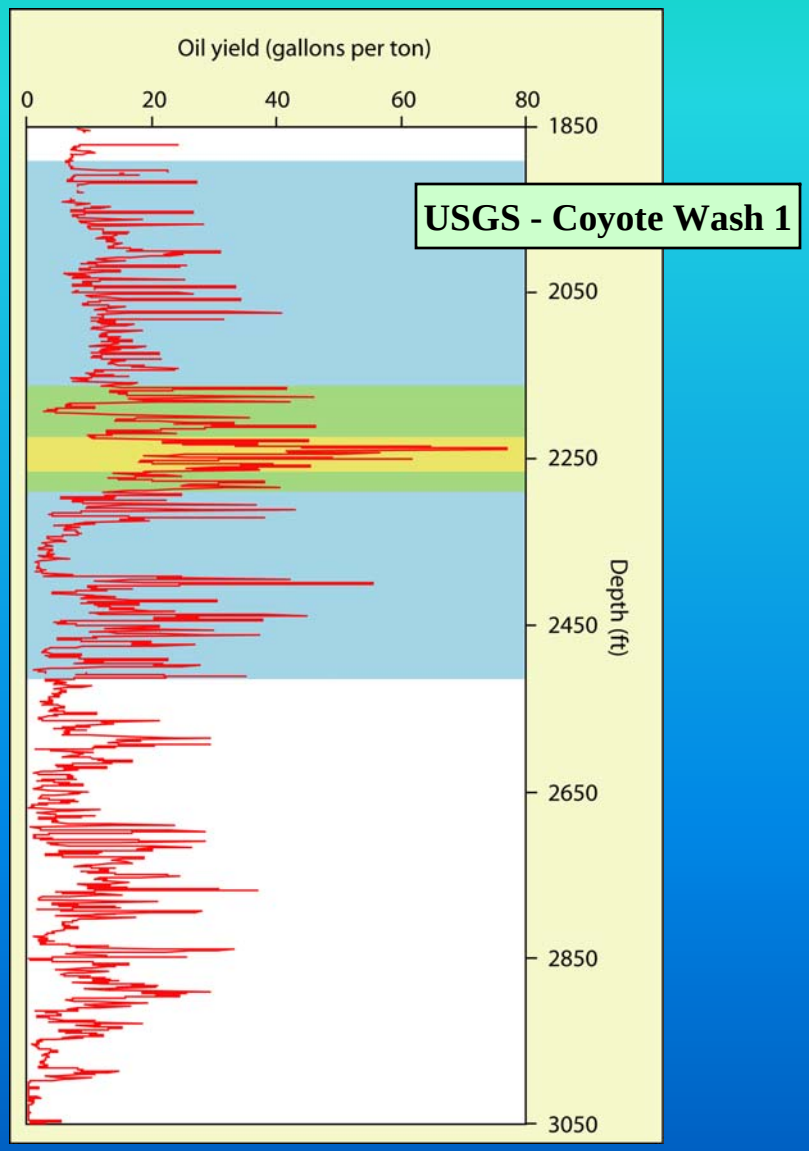


Methods

4) Calculated thickness of zones averaging 15, 25, 30, 35, 40, 45, and 50 gpt

Average of 15 gpt

617 ft

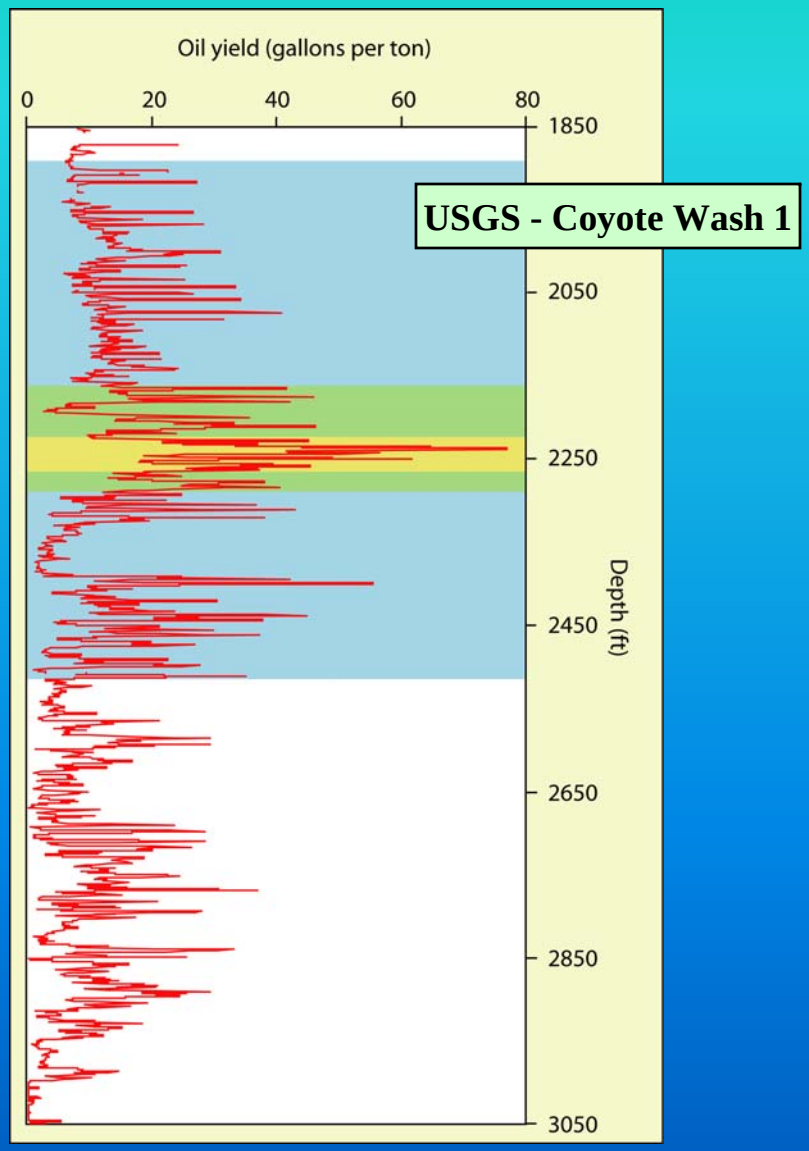


Methods

4) Calculated thickness of zones averaging 15, 25, 30, 35, 40, 45, and 50 gpt

Average of 25 gpt

124 ft

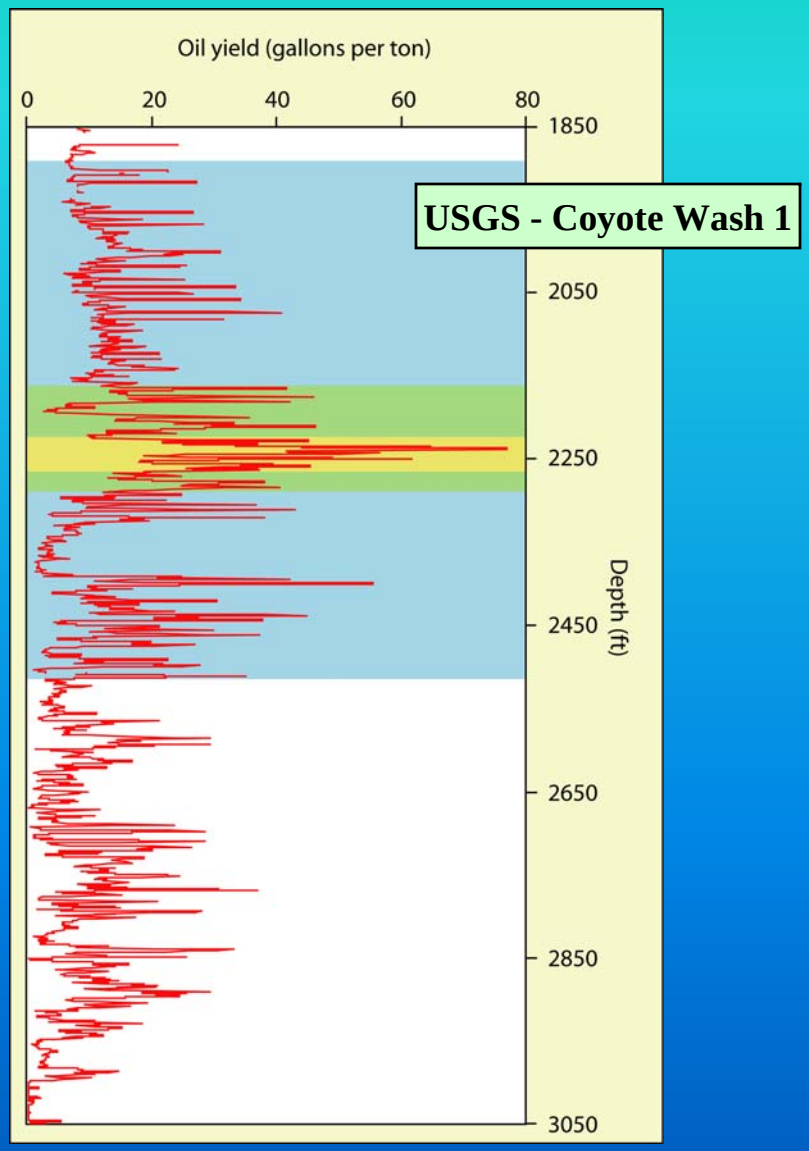


Methods

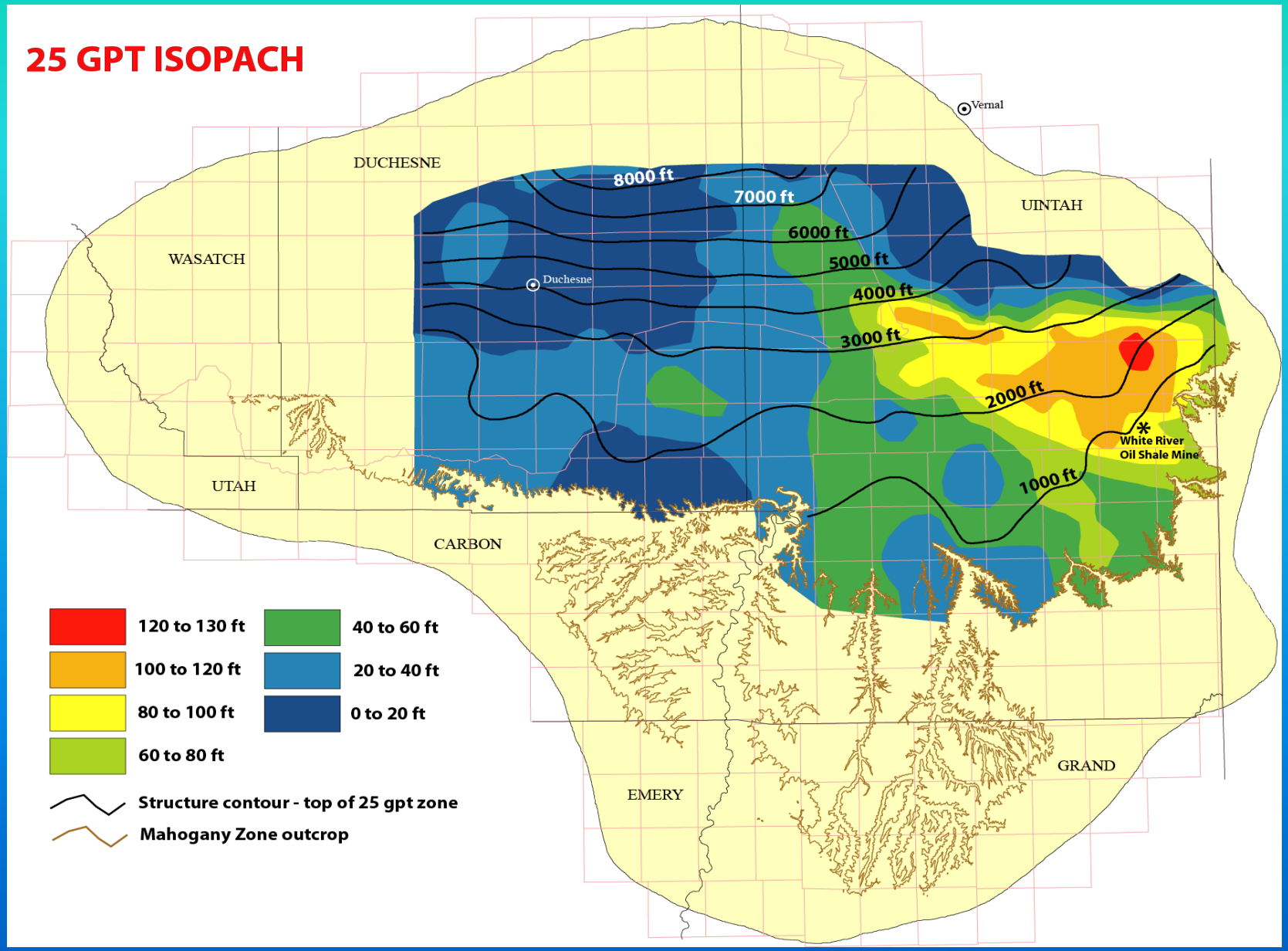
4) Calculated thickness of zones averaging 15, 25, 30, 35, 40, 45, and 50 gpt

Average of 35 gpt

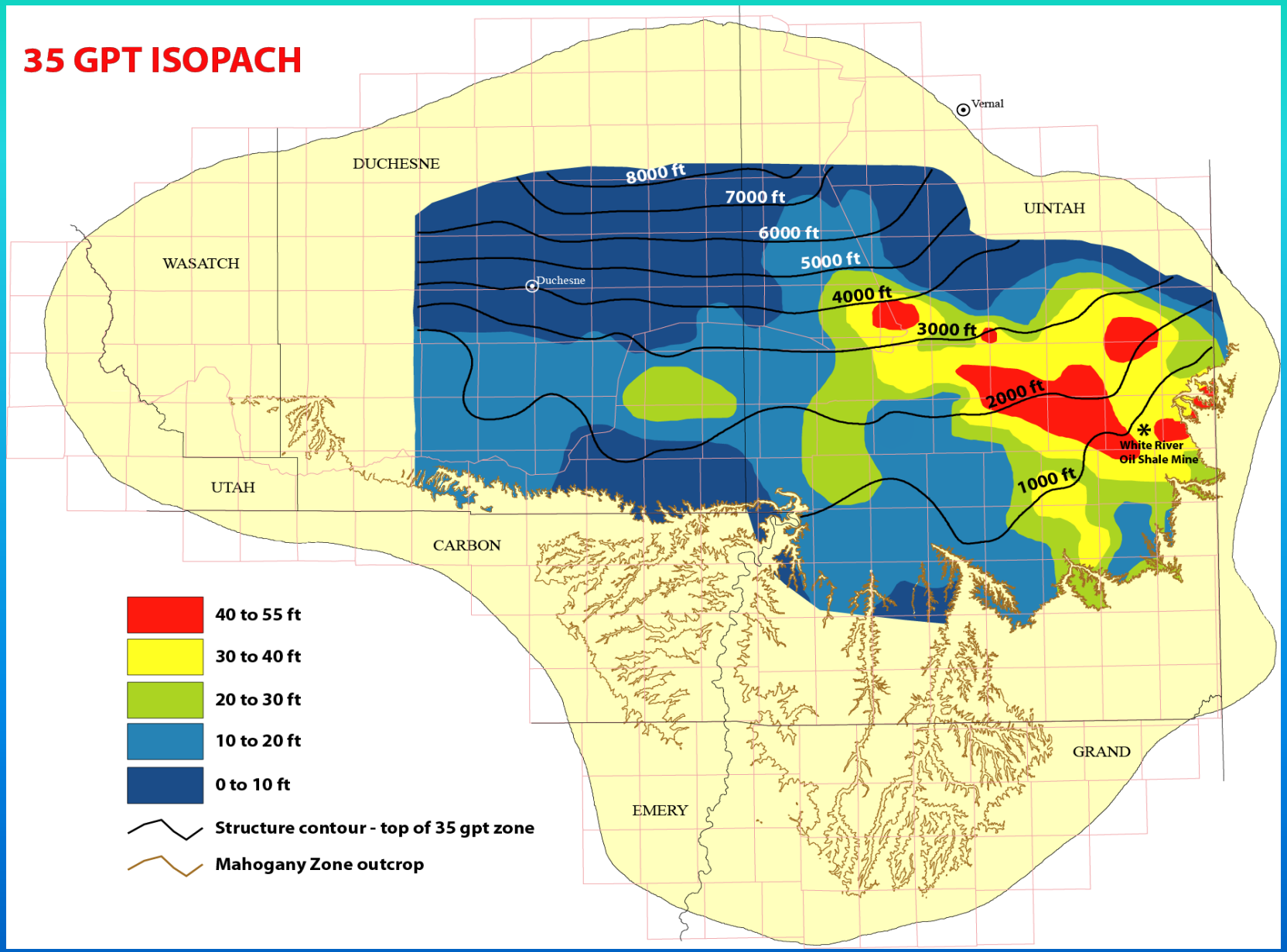
40 ft



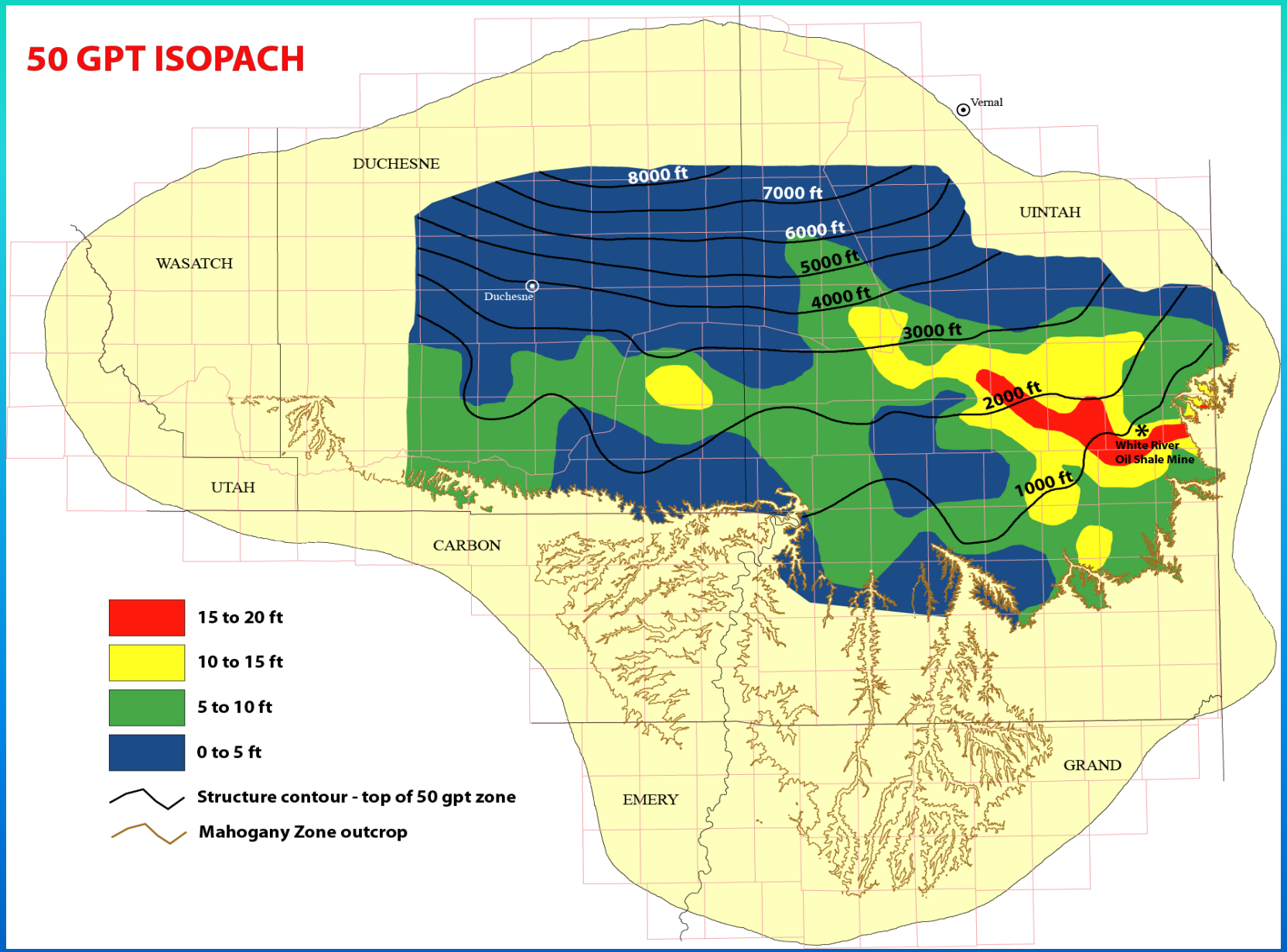
Results


25 GPT ISOPACH
Vernal
DUCHESNE
UINTAH
WASATCH
Duchesne
8000 ft
7000 ft
6000 ft
5000 ft
4000 ft
3000 ft
2000 ft
1000 ft
White River
Oil Shale Mine
UTAH
CARBON
EMERY
GRAND
120 to 130 ft
100 to 120 ft
80 to 100 ft
60 to 80 ft
40 to 60 ft
20 to 40 ft
0 to 20 ft
Structure contour - top of 25 gpt zone
Mahogany Zone outcrop

Results


35 GPT ISOPACH
Vernal
DUCHESNE
UINTAH
WASATCH
Duchesne
8000 ft
7000 ft
6000 ft
5000 ft
4000 ft
3000 ft
2000 ft
1000 ft
White River
Oil Shale Mine
UTAH
CARBON
GRAND
EMERY
40 to 55 ft
30 to 40 ft
20 to 30 ft
10 to 20 ft
0 to 10 ft
Structure contour - top of 35 gpt zone
Mahogany Zone outcrop

Results

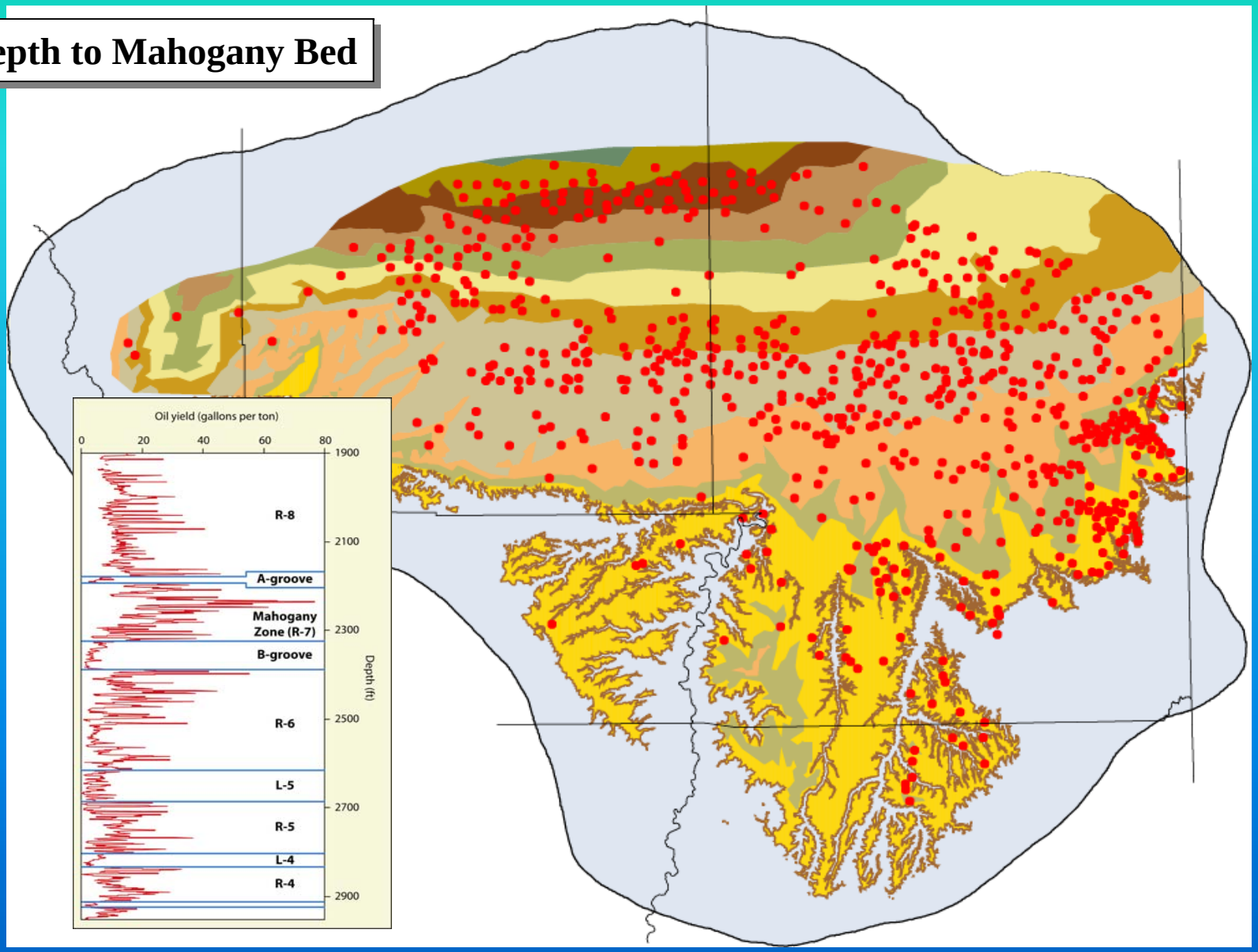

50 GPT ISOPACH
Vernal
DUCHESNE
UINTAH
WASATCH
Duchesne
8000 ft
7000 ft
6000 ft
5000 ft
4000 ft
3000 ft
2000 ft
1000 ft
White River
Oil Shale Mine
UTAH
CARBON
GRAND
EMERY
15 to 20 ft
10 to 15 ft
5 to 10 ft
0 to 5 ft
Structure contour - top of 50 gpt zone
Mahogany Zone outcrop

Future Work

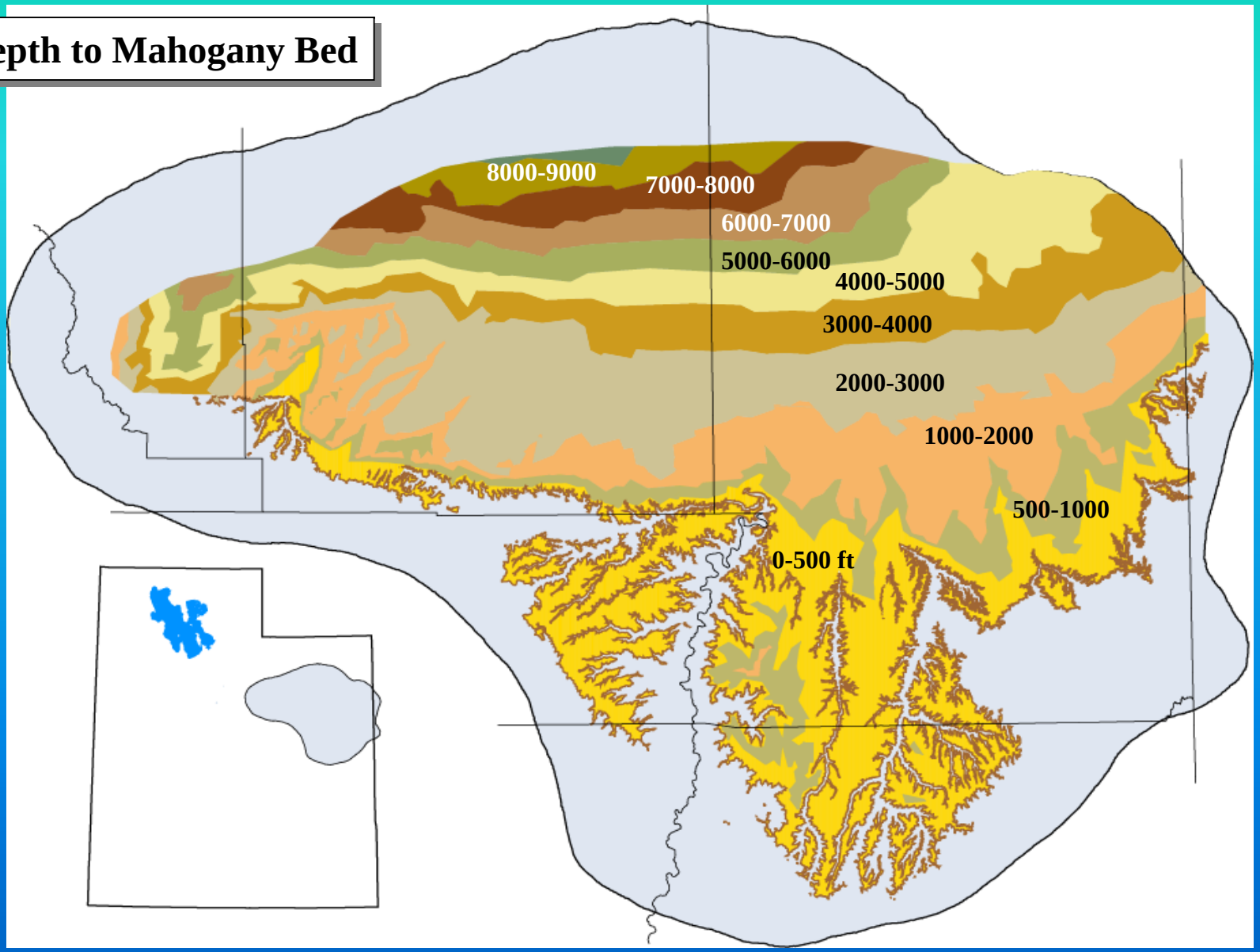
1) Create isopachs and structure contour maps of the different oil shale zones

Additional Work – Depth to Various Zones

Depth to Mahogany Bed



Additional Work – Depth to Various Zones



Future Work

1) Create isopachs and structure contour maps of the different oil shale zones
2) Calculate resource numbers
    - Reserves according to different parameters
        - e.g. 15 gpt with a thickness of at least 15 feet
    - Reserves according to different recovery methods
        - surface mining
        - underground mining
        - in-situ

UGS Collaboration - Upper Green River Formation Projects

1) Dr. Royhan Gani – Energy and Geoscience Institute – University of Utah
   - Depositional heterogeneity and fluid flow modeling of the oil shale interval of the Green River Formation, eastern Uinta Basin, Utah
     - Detailed sedimentological and ichnological documentation of cores housed at the Utah Core Research Center
     - Facies descriptions
     - Fluid flow modeling
2) Dr. Jessica Whiteside – Brown University
   - Multiproxy paleoclimate reconstruction of Earth's most recent extreme hothouse
     - Milankovitch cyclicity in the upper Green River Formation
     - High-resolution geochemistry from cores housed at the Utah Core Research Center
3) TerraTek, a Schlumberger Company, Salt Lake City, UT
   - Continuous unconfined compressive strength profiling (TSI™ scratch testing) and other physical property analyses of upper Green River oil shales

"Back-of-the-envelope"

Underground mine:

- Assumptions:
  - 40 ft of 35 gpt oil shale
  - 5,000 acre lease
  - 50% material recovery
  - 90% shale oil extraction efficiency
- Results:
  - **200 million bbls of oil**
  - **30,000 bbls per day for 20 years**

In-situ methods:

- Assumptions:
  - 124 ft of 25 gpt oil shale
  - 5,000 acre lease
  - 60% shale oil extraction efficiency
- Results:
  - **700 million bbls of oil**
  - **95,000 bbls per day for 20 years**

(2006 data)

- **Utah crude oil production = 50,000 bbls per day**
- **Utah petroleum consumption = 145,000 bbls per day**
- **U.S. crude oil production = 5 million bbls per day**
- **U.S. petroleum consumption = 21 million bbls per day**
- **U.S. crude oil imports = 10 million bbls per day**

- **Utah's refinery capacity = 167,000 bbls per day**
- **Utah's refinery inputs = 151,000 bbls per day**
- **Utah's spare refinery capacity = 16,000 bbls per day**

Hell's Hole overlook at Evacuation Creek, Uinta Basin