Re-examination of Utah's oil shale deposits: Historical database and new resource evaluation

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GSA - Rocky Mountain Section - May 2007

Outline

1) Oil shale overview

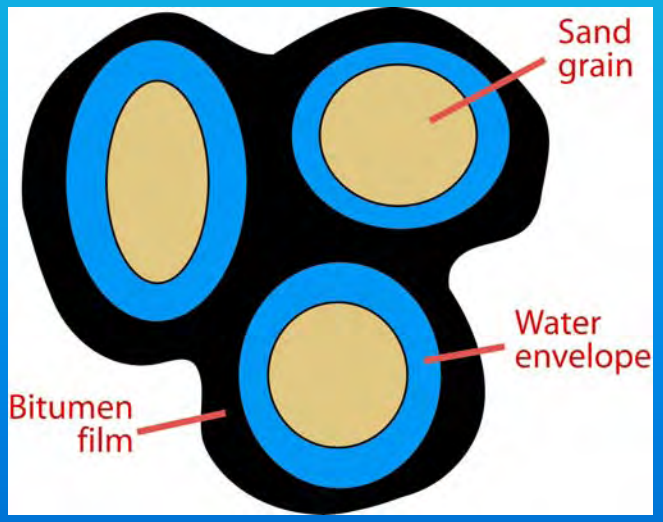
2) Utah Oil Shale Database

3) New research – revised resource evaluation

Oil Shale vs. Tar Sands

- **"Oil shale"**
  - Silty marlstone containing relatively large amounts of organic matter called kerogen
  - Kerogen can be heated to produce shale oil and natural gas
  - Considered a source rock for conventional crude resources

- **Tar sands**
  - A type of sandstone from which the lighter fractions of crude oil have escaped, leaving a residual asphalt to fill the pore spaces
  - Considered a reservoir rock – bitumen coats the sand grains



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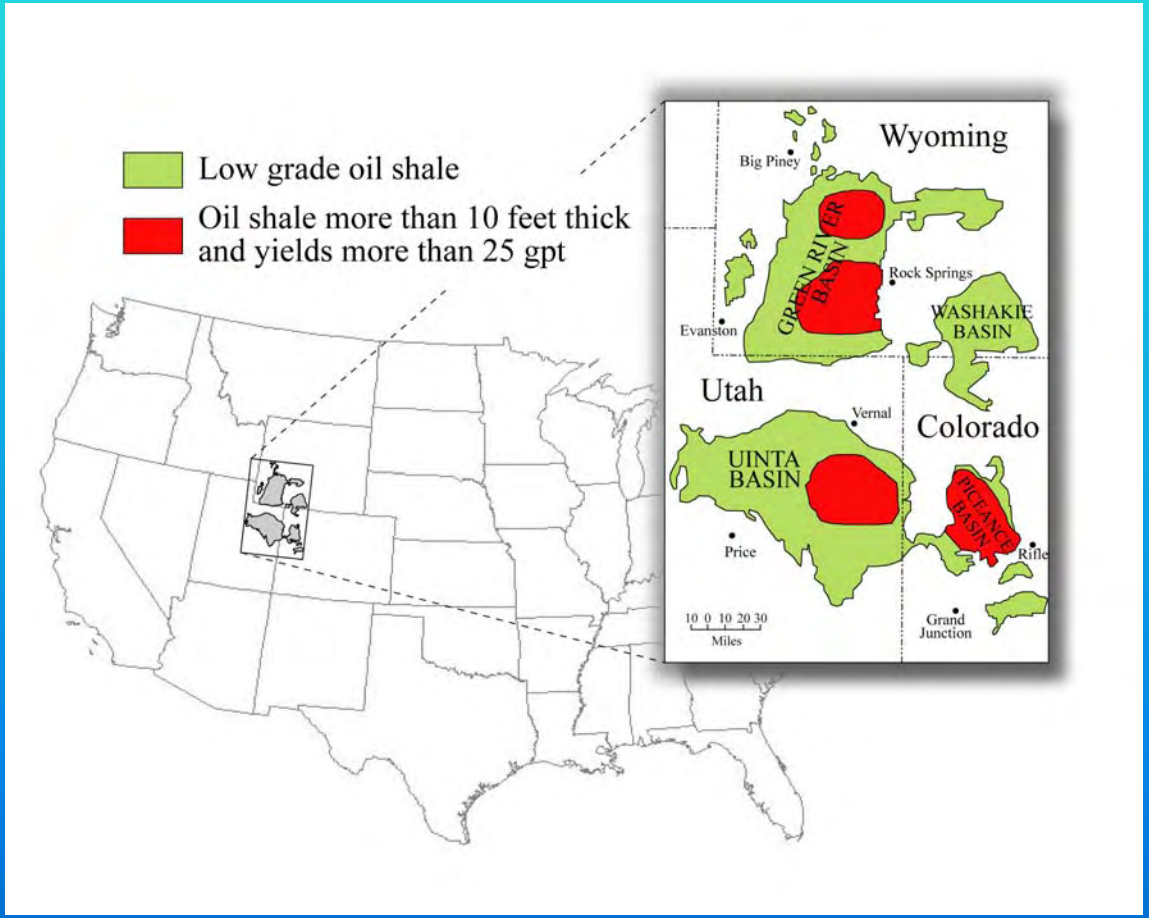
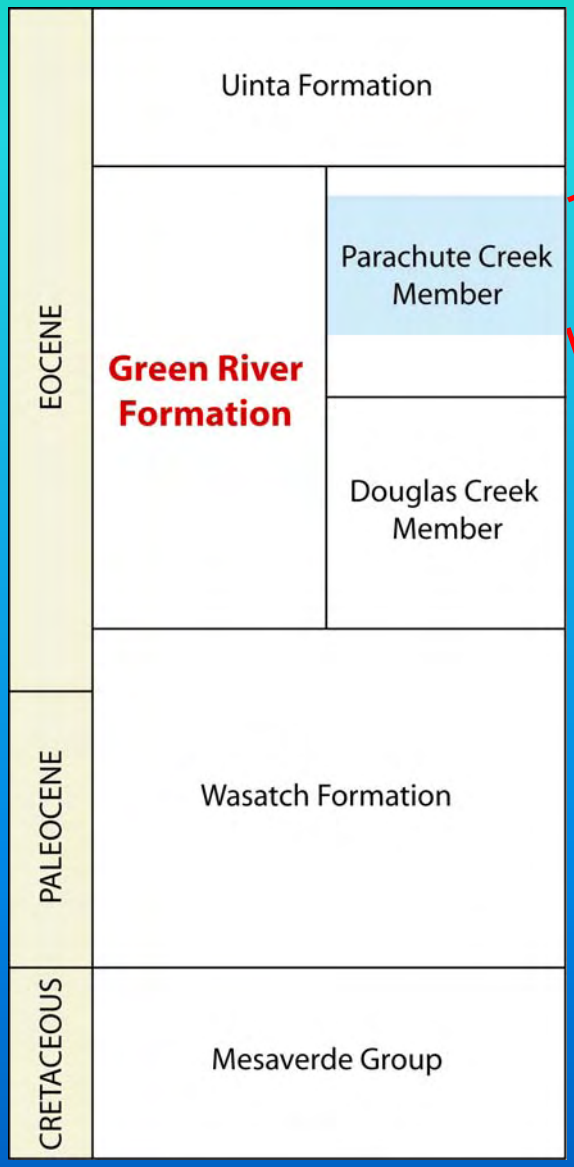
- **Tar sands**

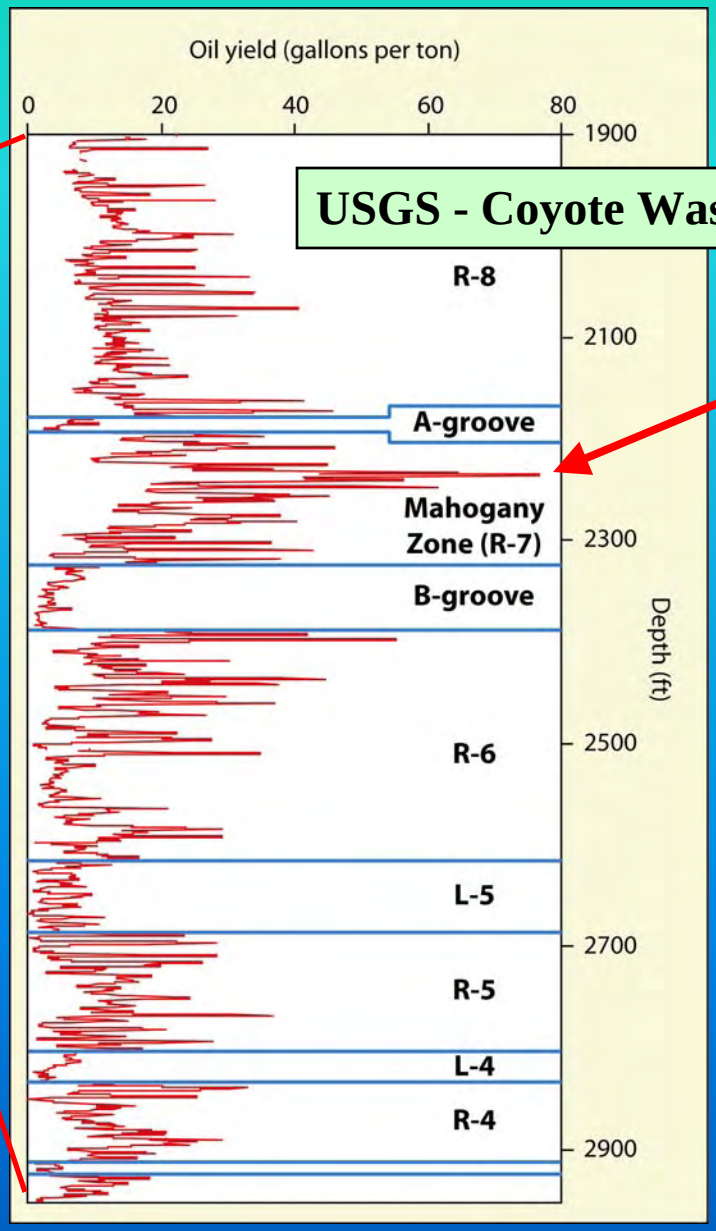
Oil Shale in the Western U.S.

- U.S., Israel, Estonia, China, Australia, Morocco, Jordan, and Brazil
- Largest oil shale deposits in the world are located in the Eocene Green River Formation in Utah, Colorado, and Wyoming



Oil Shale Stratigraphy





Mahogany bed

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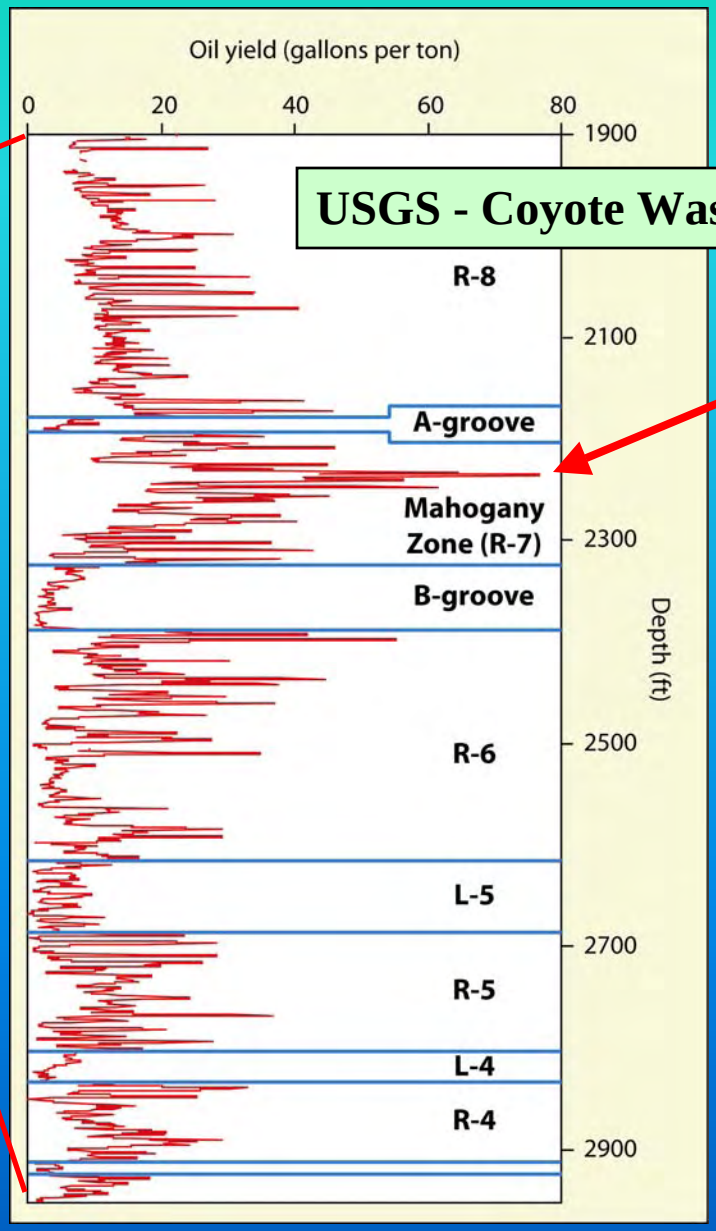


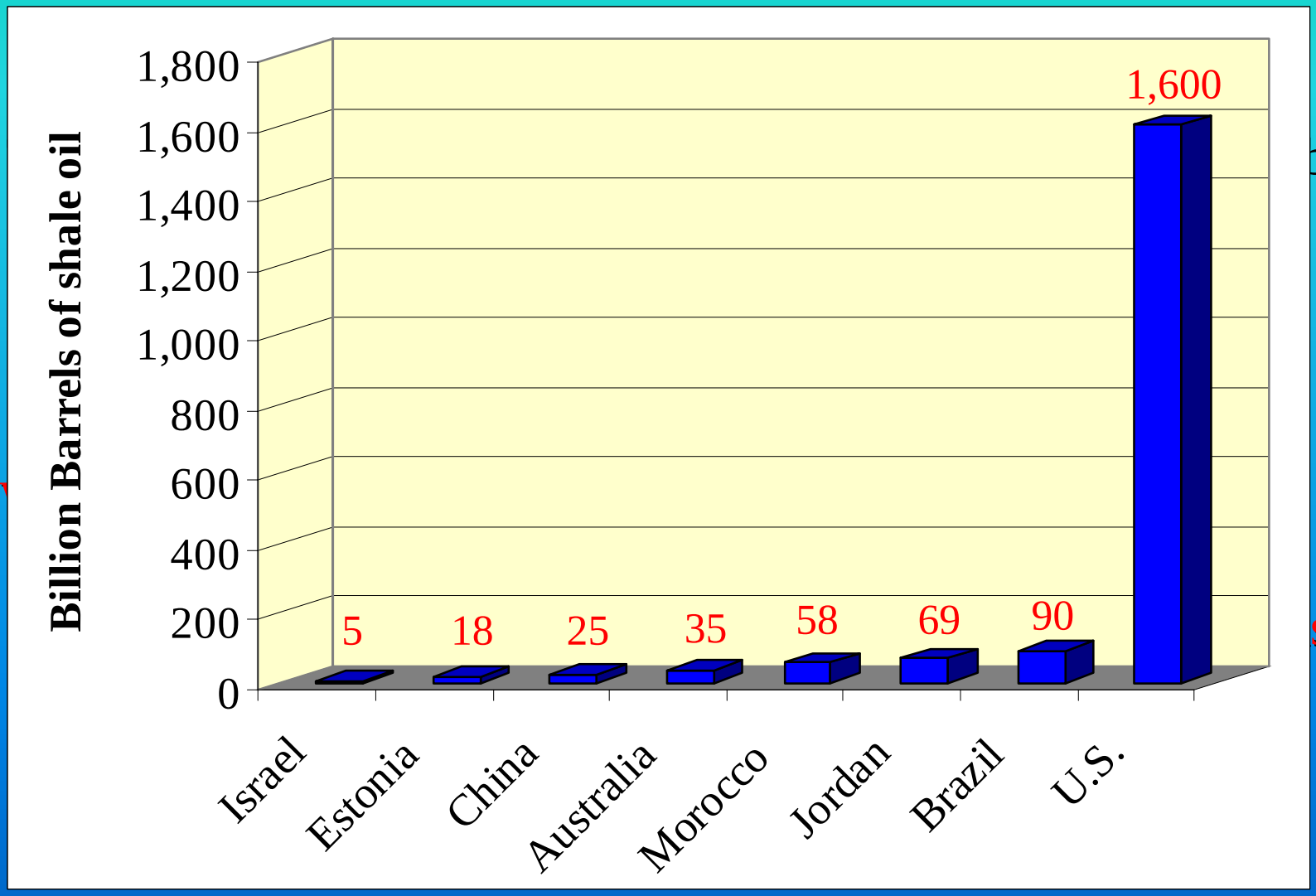
Hell's hole overlook at Evacuation Creek, Uinta Basin

In-Place Reserves

- Total within the Green River Formation – 1.5 to 1.8 trillion bbls
  - Colorado – 1.0 trillion barrels
  - Wyoming – 300 billion barrels
  - Utah – 165 billion to 321 billion barrels

World conventional crude reserves – 1.3 trillion barrels
U.S. conventional crude reserves – 22 billion barrels
Saudi Arabia conventional crude reserves – 262 billion barrels

In-Place Reserves



Recoverable Reserves in Utah

- Short answer
  - ??????
  - No proven technology for commercial recovery

Recoverable Reserves in Utah

- Short answer
  - ??????
  - No proven technology for commercial recovery
- Long answer
  - Possibly 50% of in-place reserves – 80 to 160 billion bbls
  - 30 gpt with a thickness of 15 feet – 20 billion bbls ??

Recovery Methods

- Underground/surface mining and surface retorting


Oil Tech's surface retort


Room and pillar oil shale mine in Estonia

Recovery Methods

- Underground/surface mining and surface retorting

  Environmental concerns:

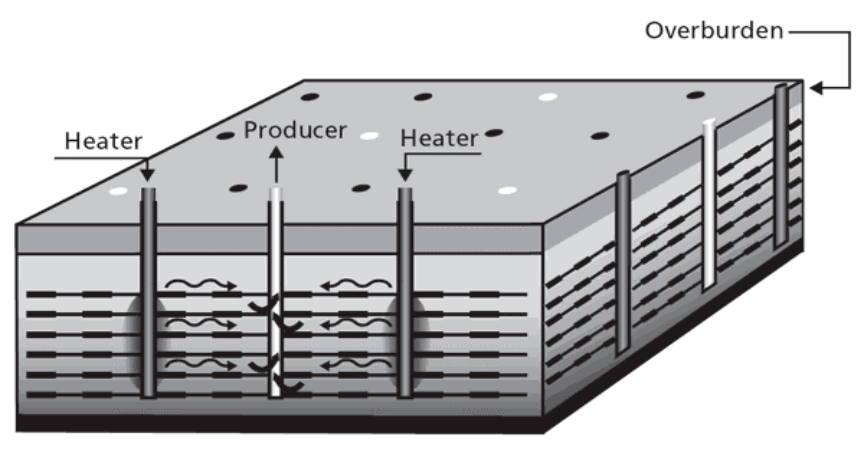
  - Disturbance of mined land
  - Disposal of spent shale
  - Use of water resources
  - Greenhouse gas emissions
  - Impacts on water and air quality


Oil Tech's surface retort


Room and pillar oil shale mine in Estonia

Recovery Methods

- *In-situ* retorting
  - Heat shale slowly to 650 to 700 degrees F
  - Recover 1/3 gas and 2/3 light oil
  - In Colorado, potential for 1 acre to yield 1 million barrels of oil



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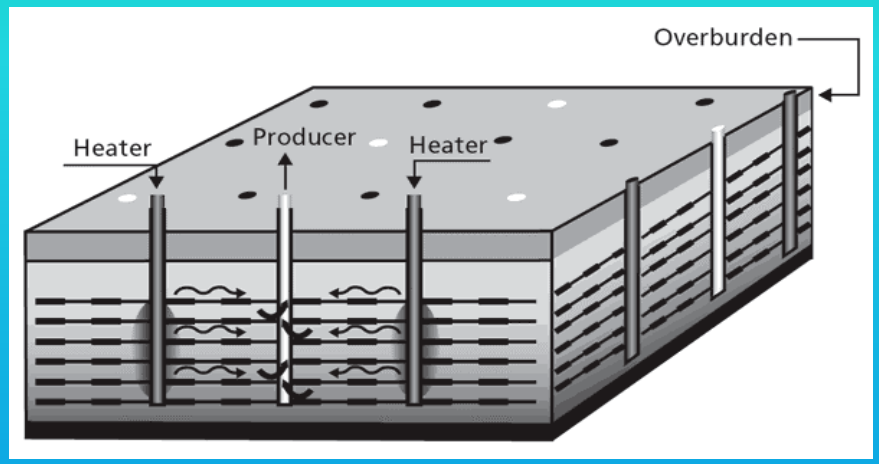

Advantages:

- Much less land disturbance
- No tailings
- Better recovery efficiency
- Allows access to deeper oil shale reserves
- Higher-quality product

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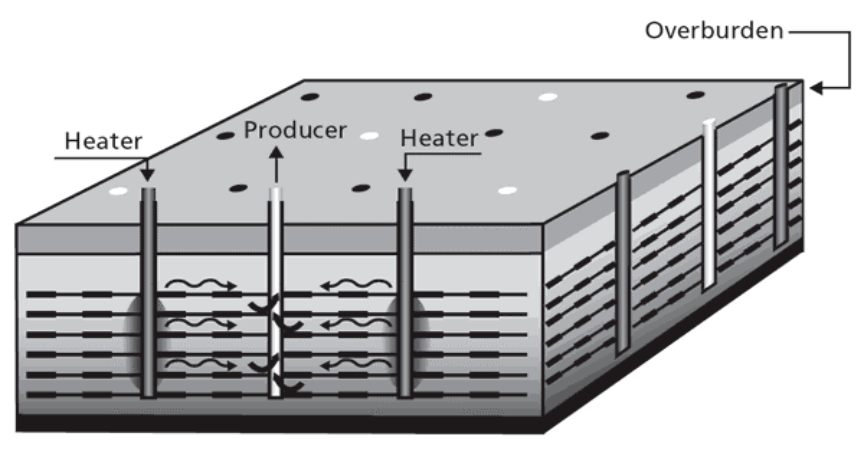

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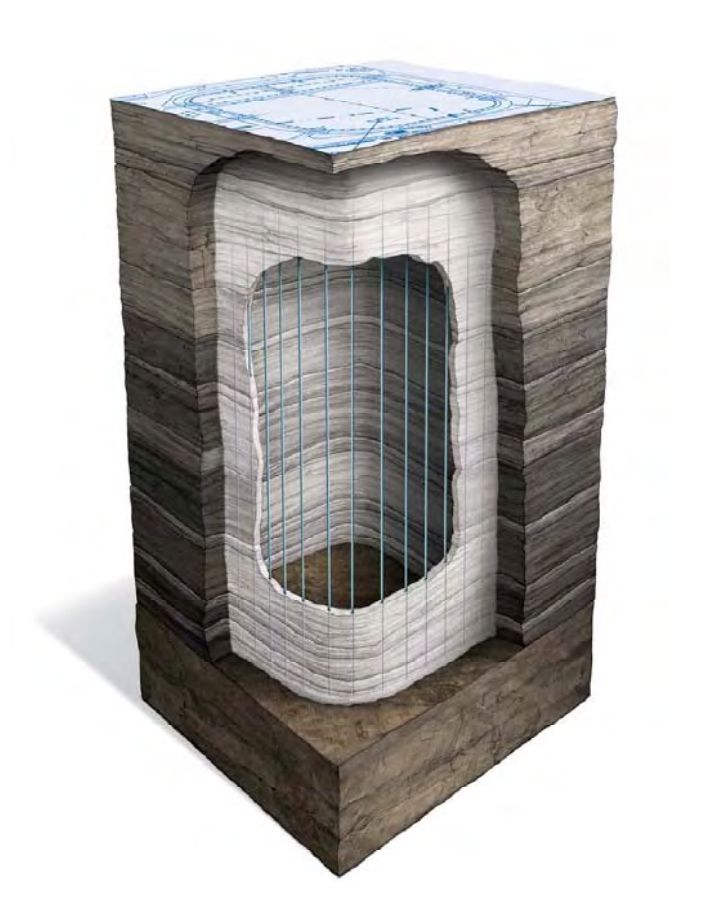
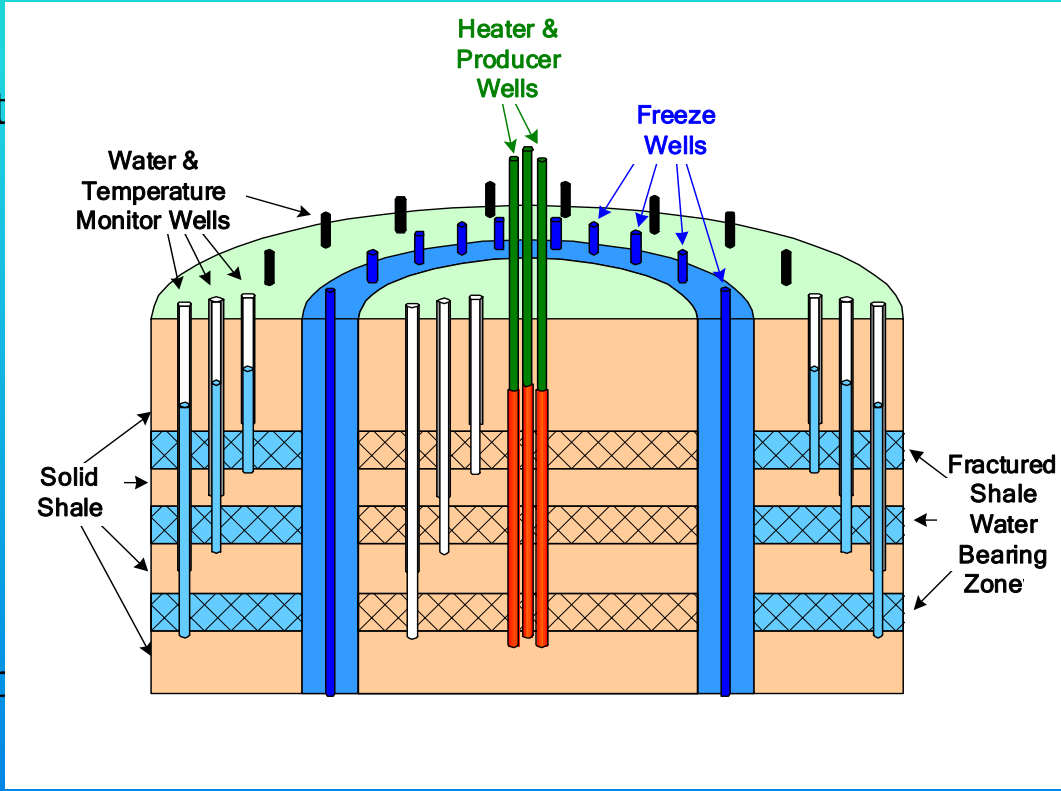
Environmental concerns:

- Groundwater contamination
- Energy consumption

Recovery Methods





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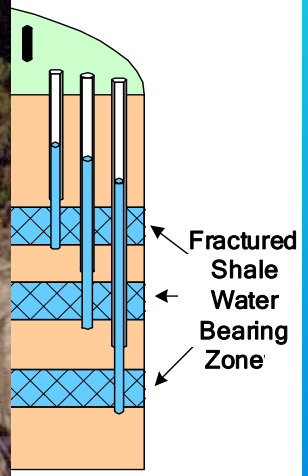


– A
s
– Higher-quality product

Federal Lease Recipients

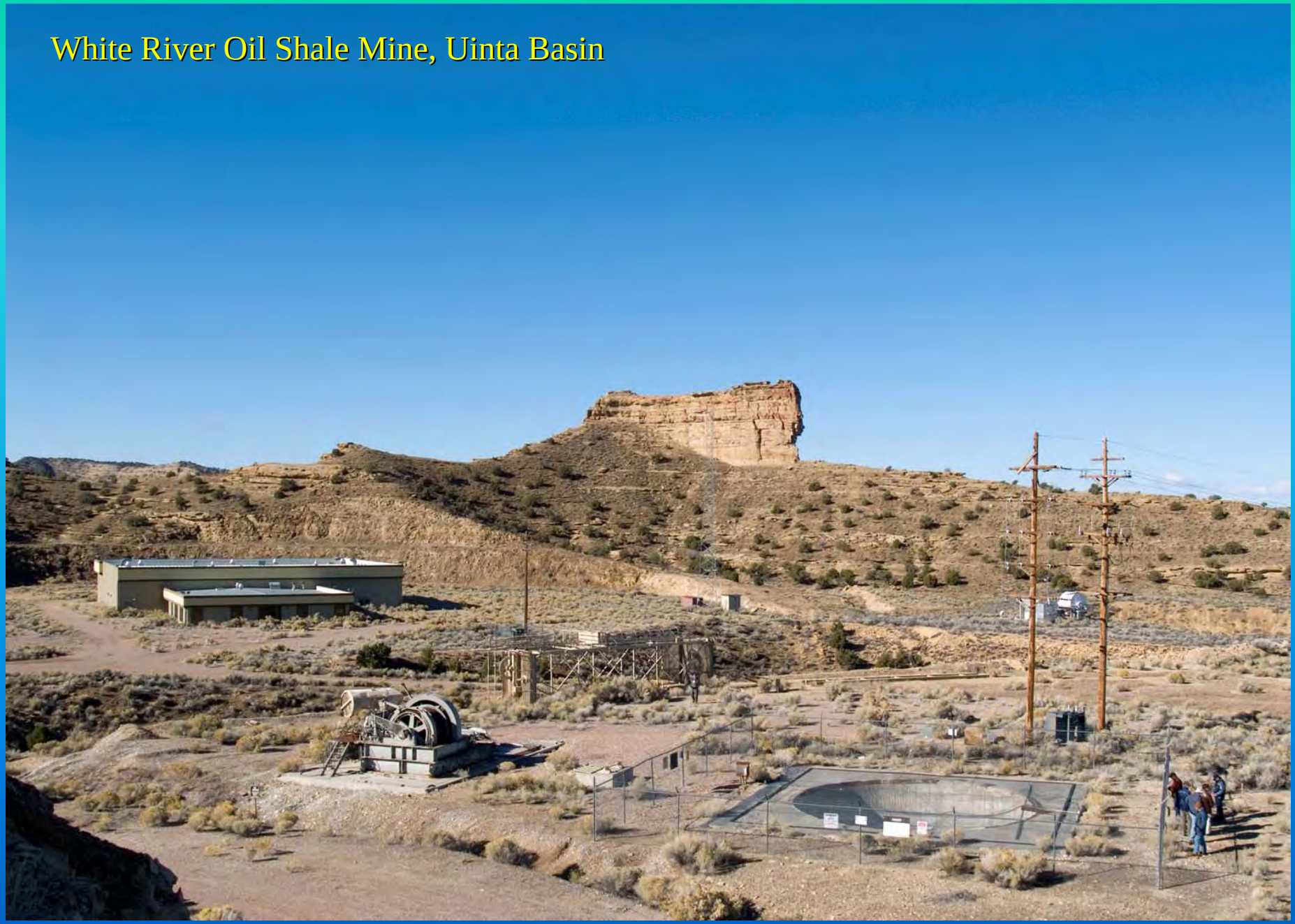
- Colorado – *in-situ*
  - Shell Frontier Oil & Gas Co.
  - Chevron Shale Oil Co.
  - EGL Resources Inc.

- Utah – surface retort
  - Oil Shale Exploration Co.
    - Plans to use 30,000 tons of shale left outside the White River mine

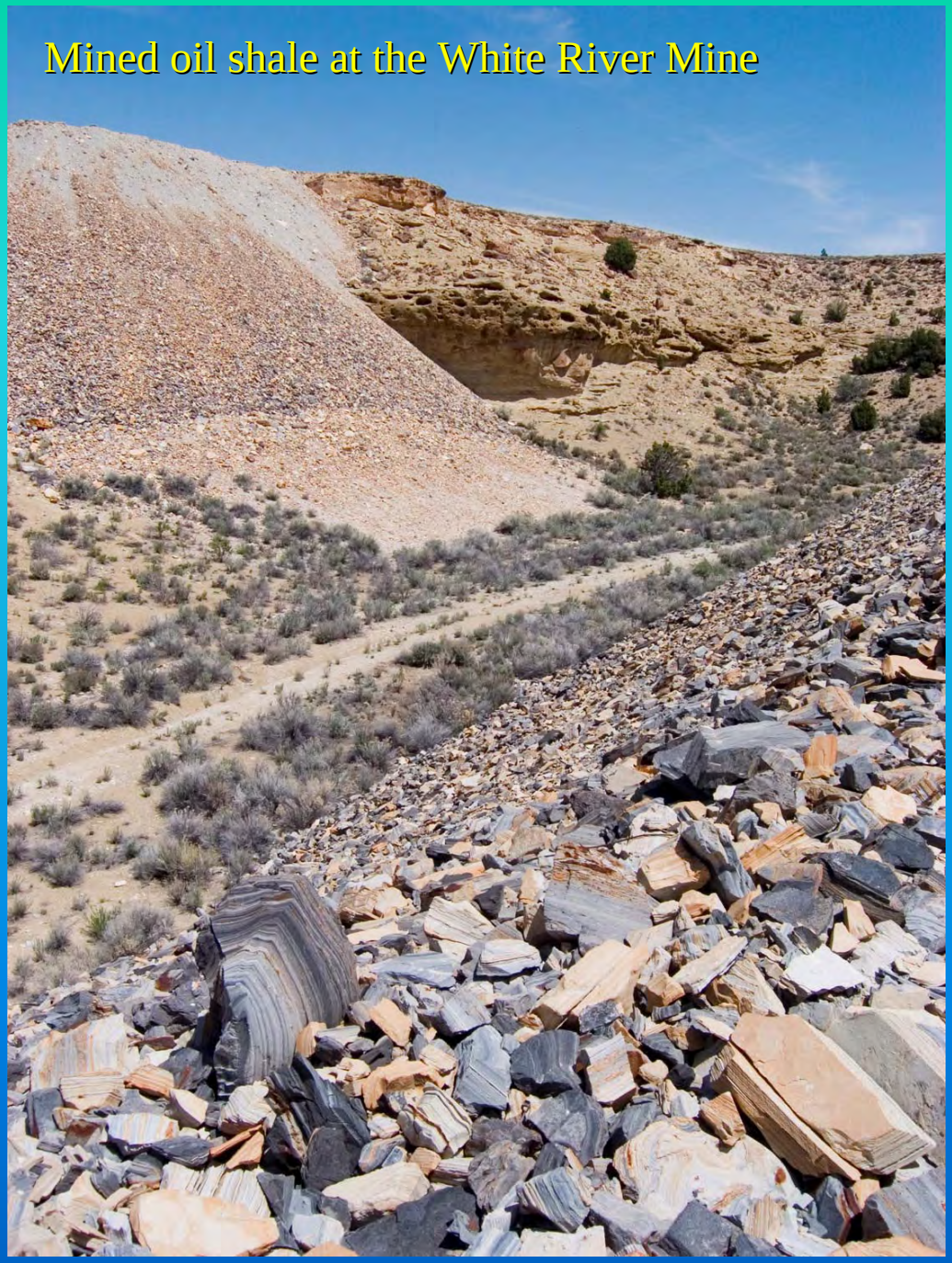
State Lease - Oil Tech, Inc. (Millennium Synfuels, LLC)

- Surface retort
- No access to rich oil shale

White River Oil Shale Mine, Uinta Basin



Mined oil shale at the White River Mine

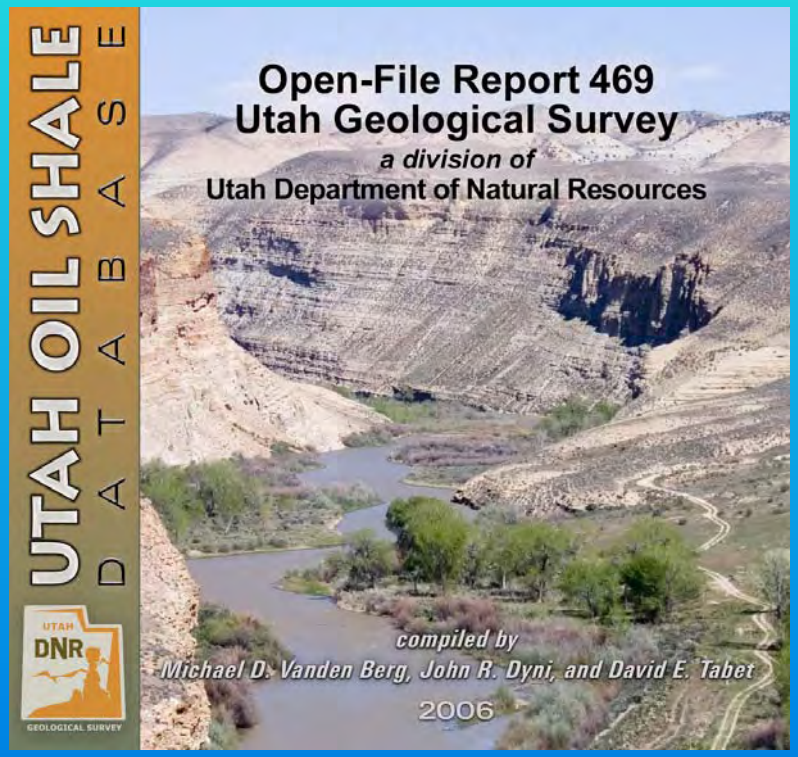


Utah Oil Shale Database

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



New Research

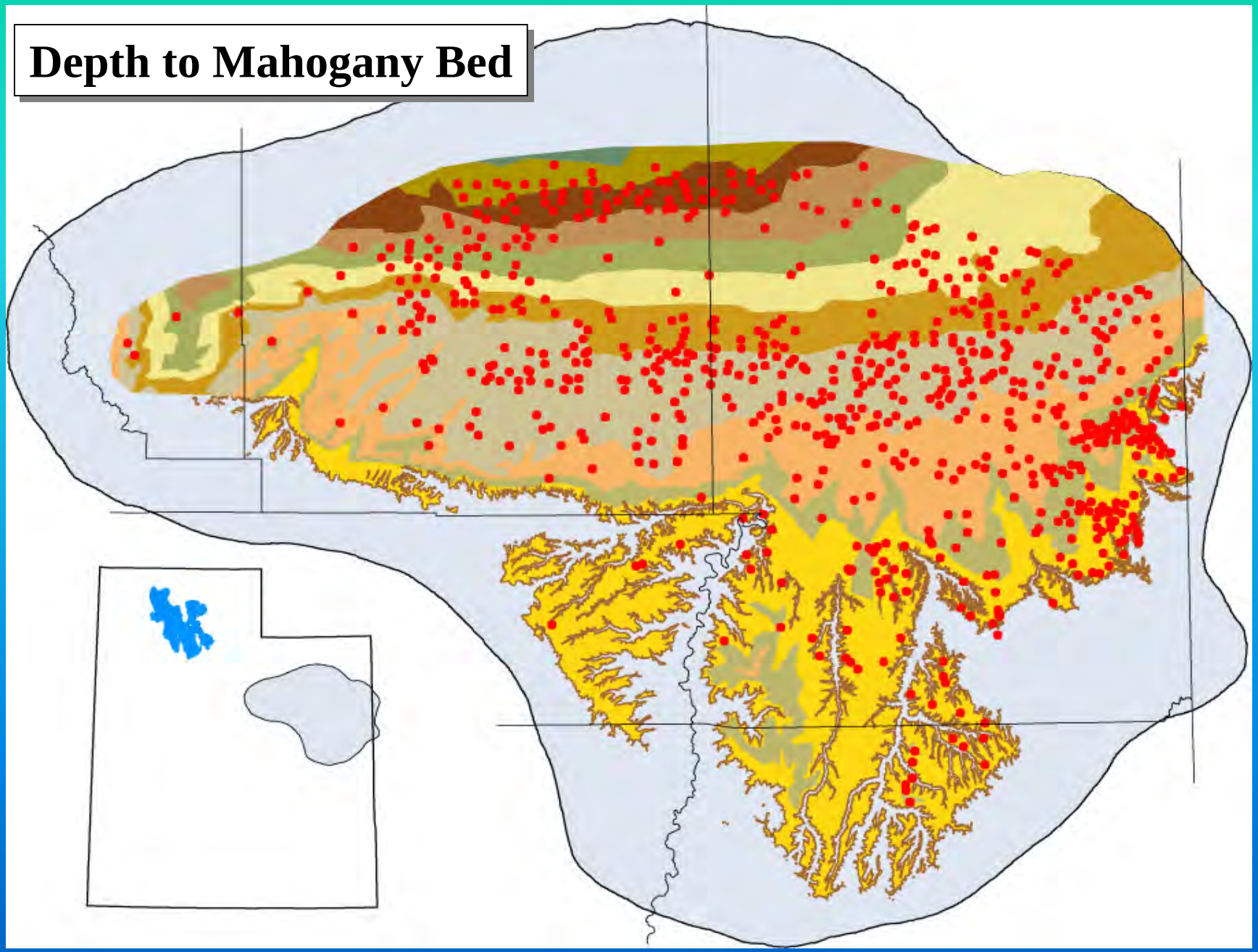
Goals:

- New comprehensive resource evaluation for entire Uinta Basin
- Improved surface minable, underground minable, and in-situ resource maps
- Improved structure contour and isopach maps for selected oil shale zones

Methods:

- Use oil and gas logs to pick tops of several important oil shale zones
- Create pseudo-Fischer assay logs from digitized density or sonic logs of oil and gas wells
- Determine zones of richness – 15 gpt, 25 gpt, and 35 gpt

Depth to Mahogany Bed



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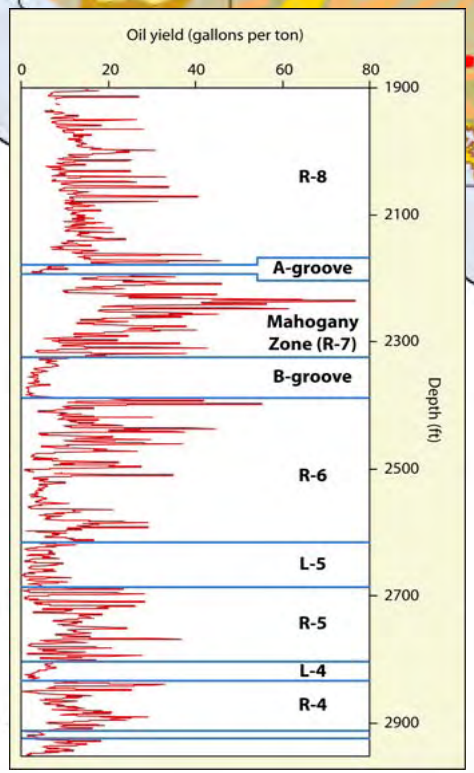

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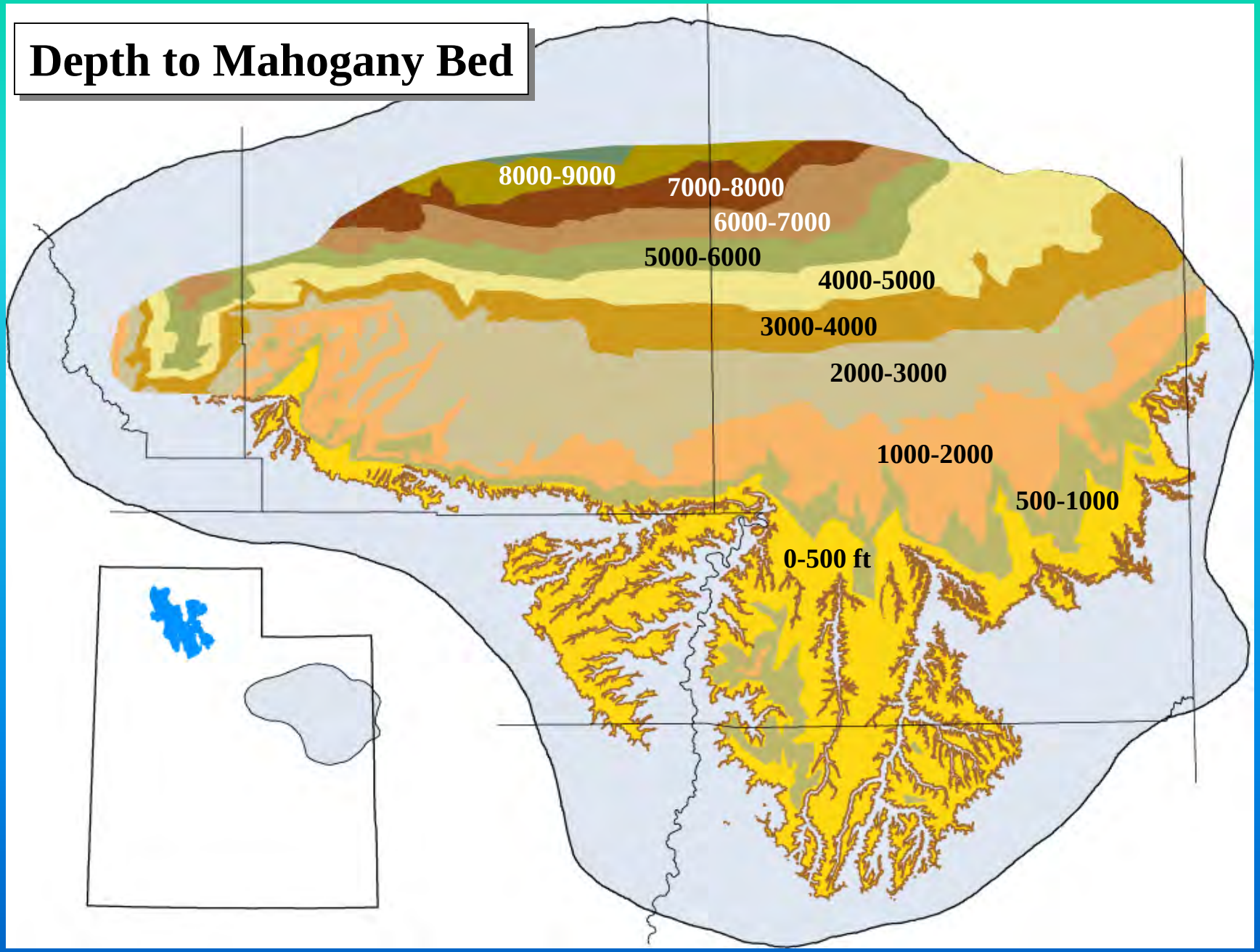
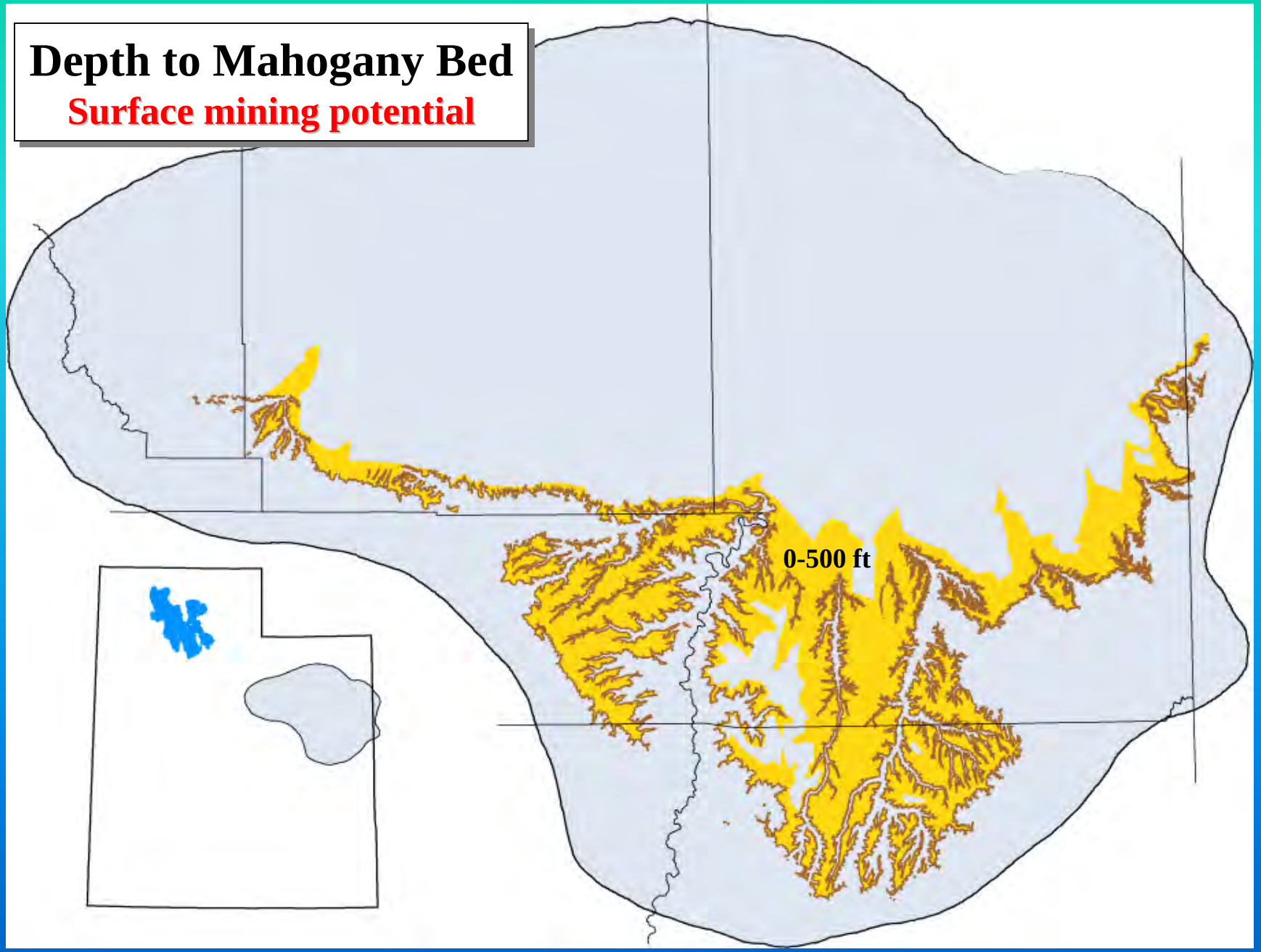


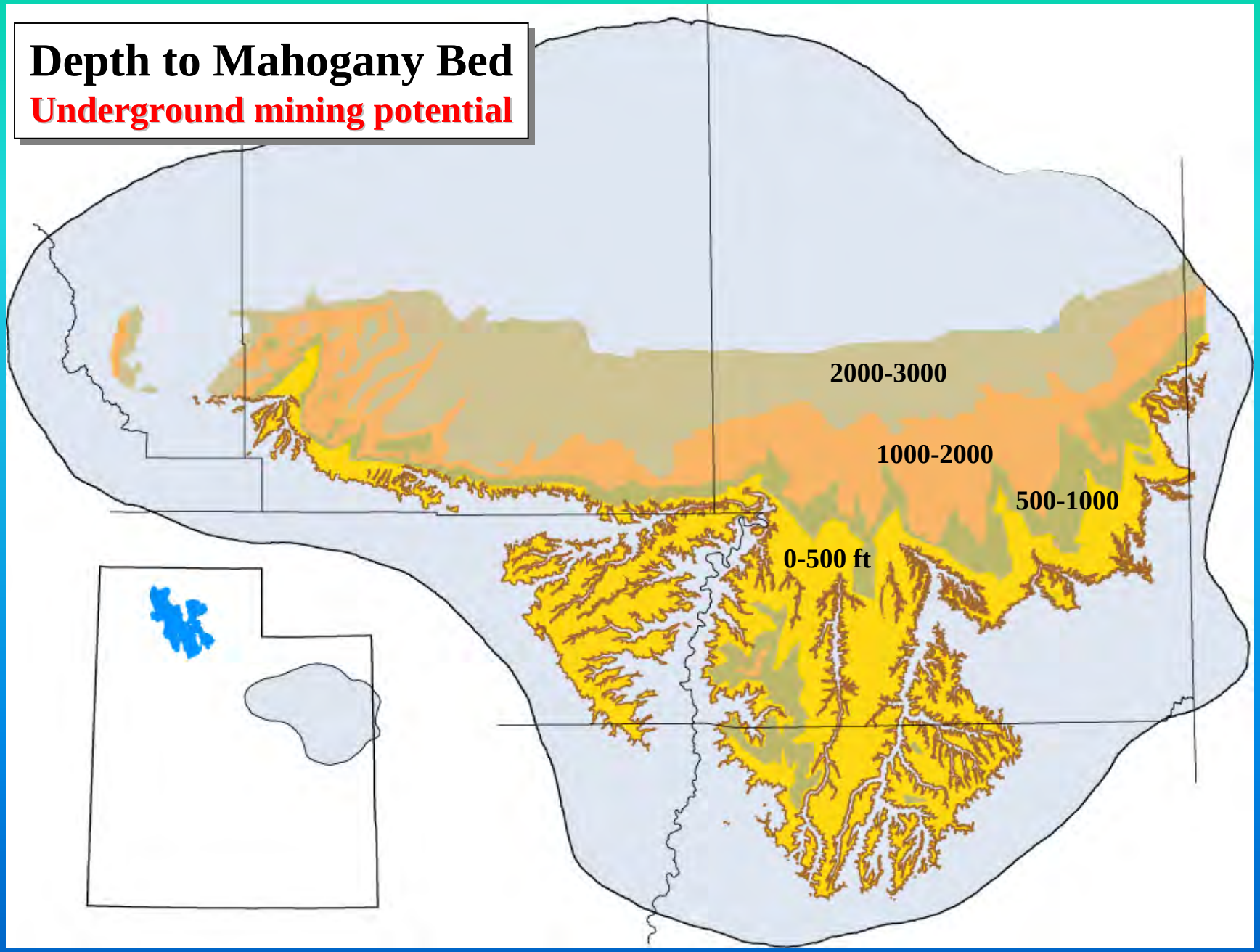
Depth to Mahogany Bed

Surface mining potential



Depth to Mahogany Bed

Underground mining potential



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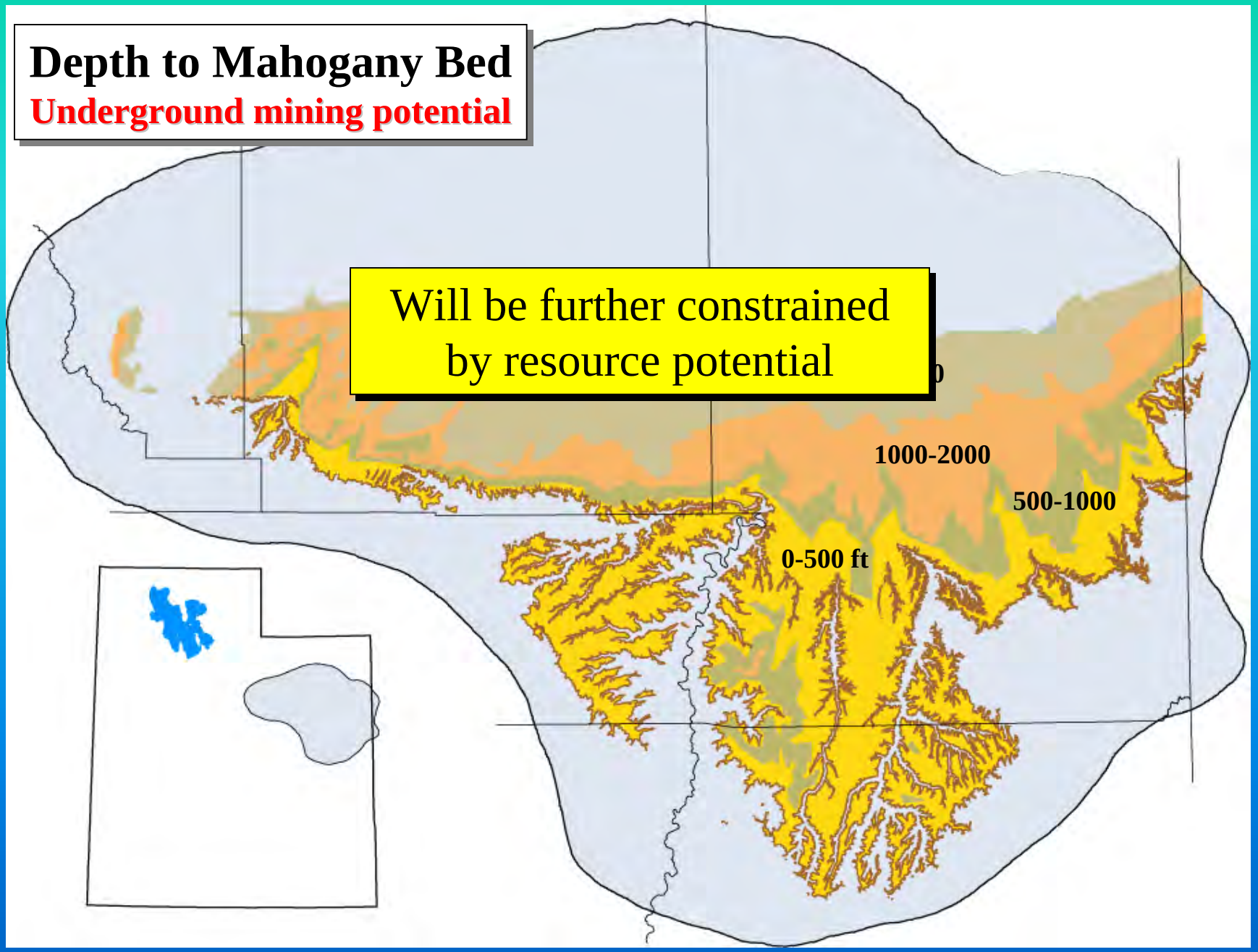
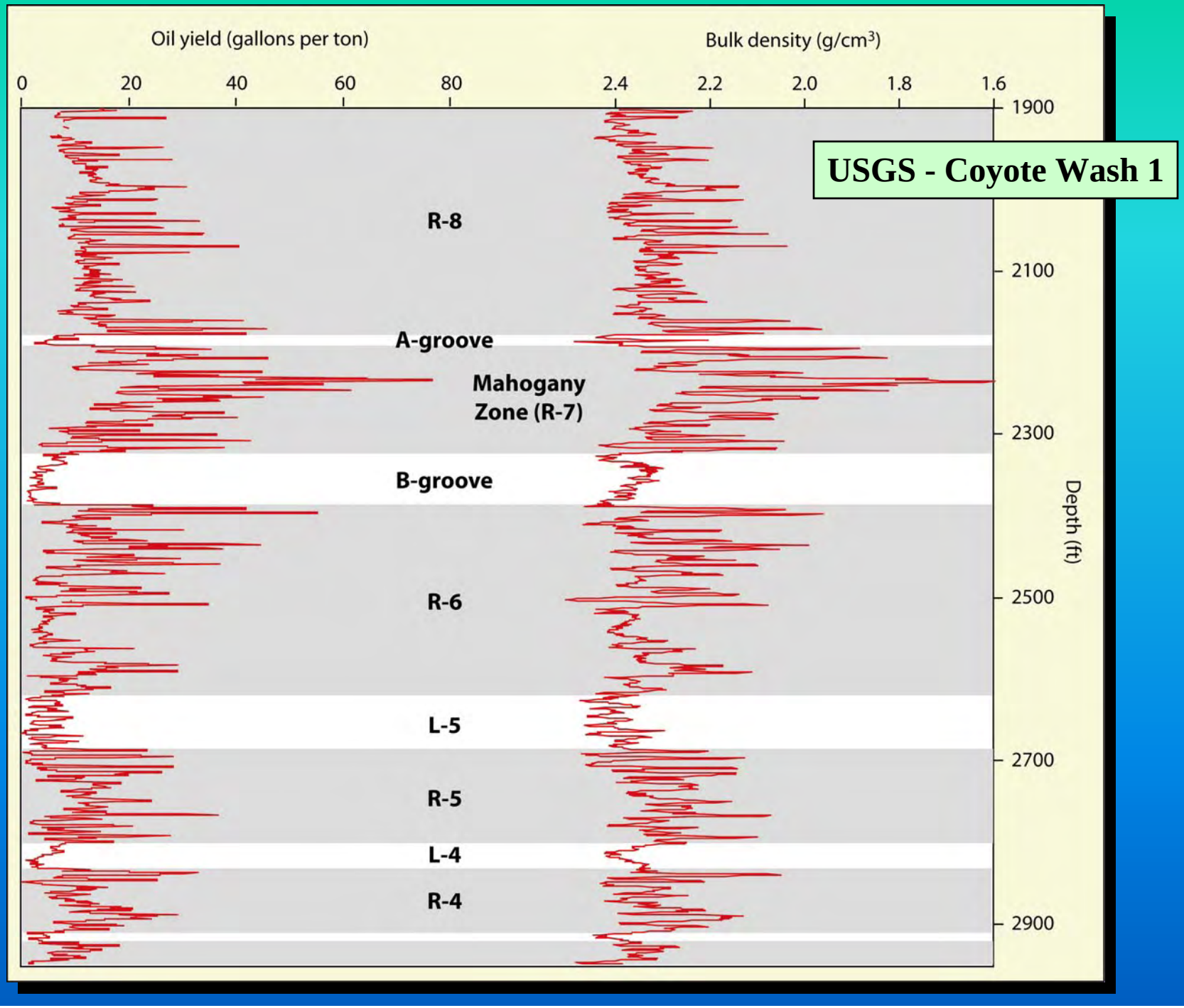
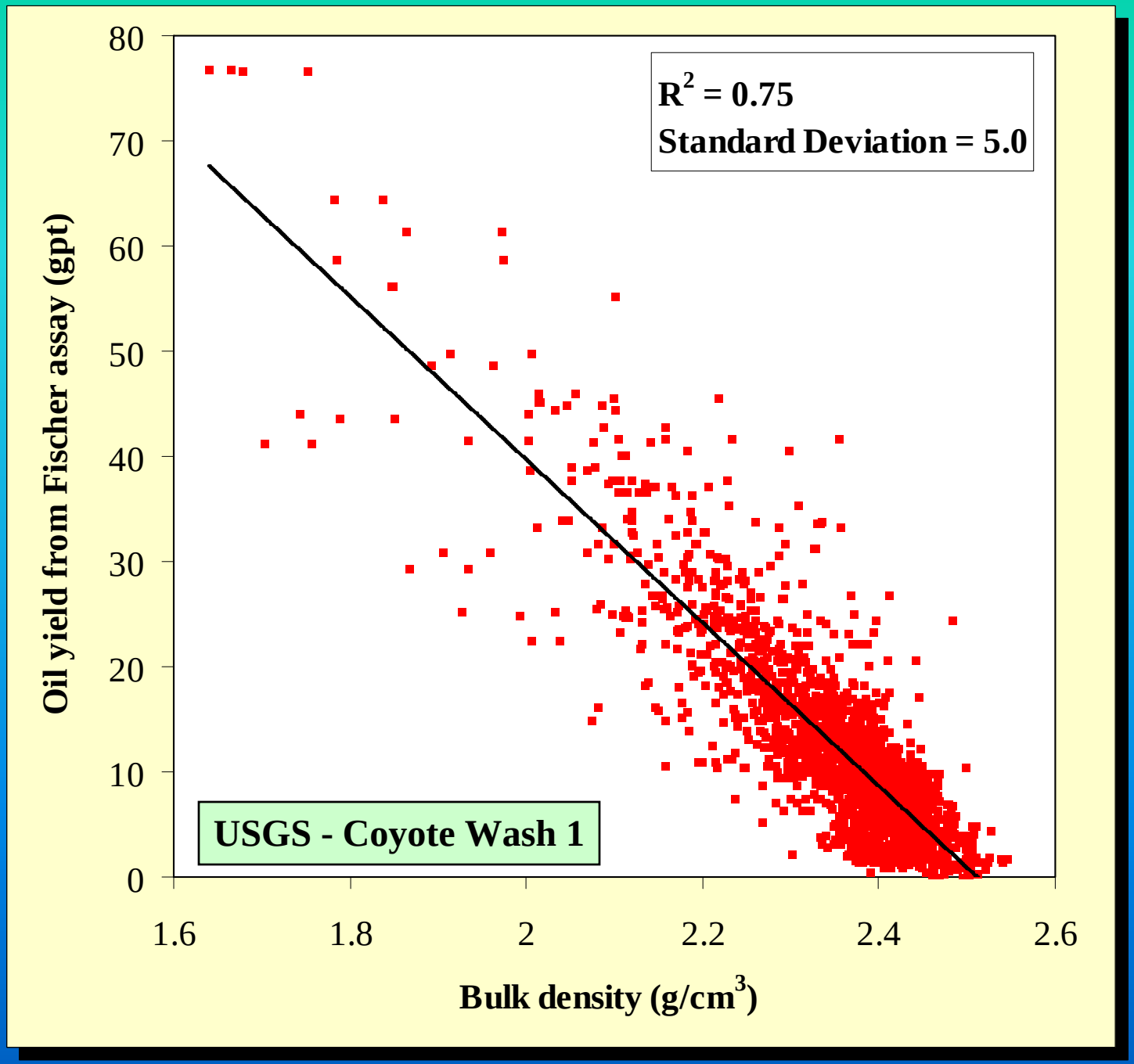
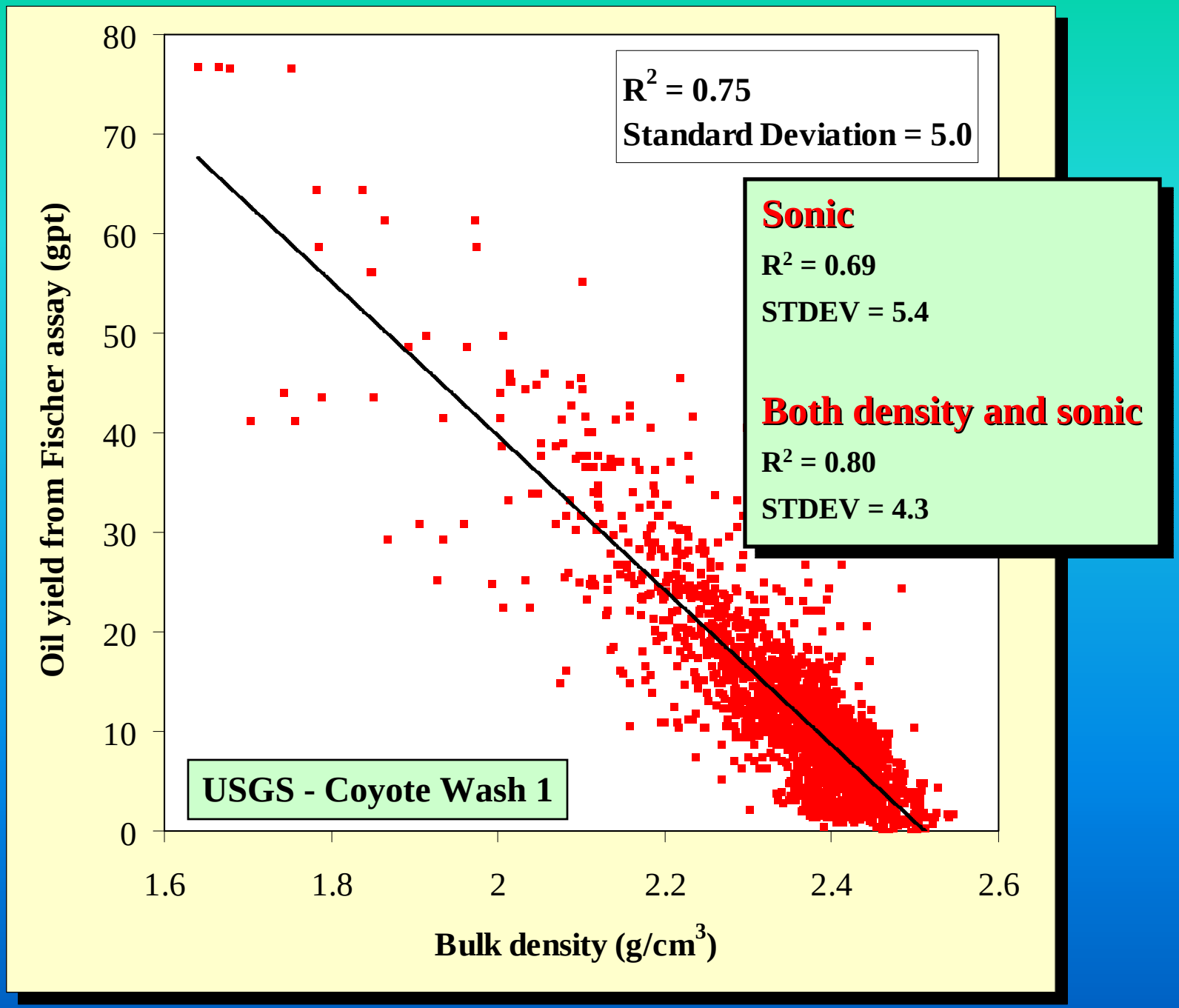



Oil yield (gallons per ton)
0
20
40
60
80
Bulk density (g/cm3)
2.4
2.2
2.0
1.8
1.6
1900
2100
2300
2500
2700
2900
Depth (ft)
USGS - Coyote Wash 1
R-8
A-groove
Mahogany
Zone (R-7)
B-groove
R-6
L-5
R-5
L-4
R-4


R^2 = 0.75
Standard Deviation = 5.0
USGS - Coyote Wash 1
Oil yield from Fischer assay (gpt)
Bulk density (g/cm^3)
80
70
60
50
40
30
20
10
0
1.6
1.8
2
2.2
2.4
2.6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40
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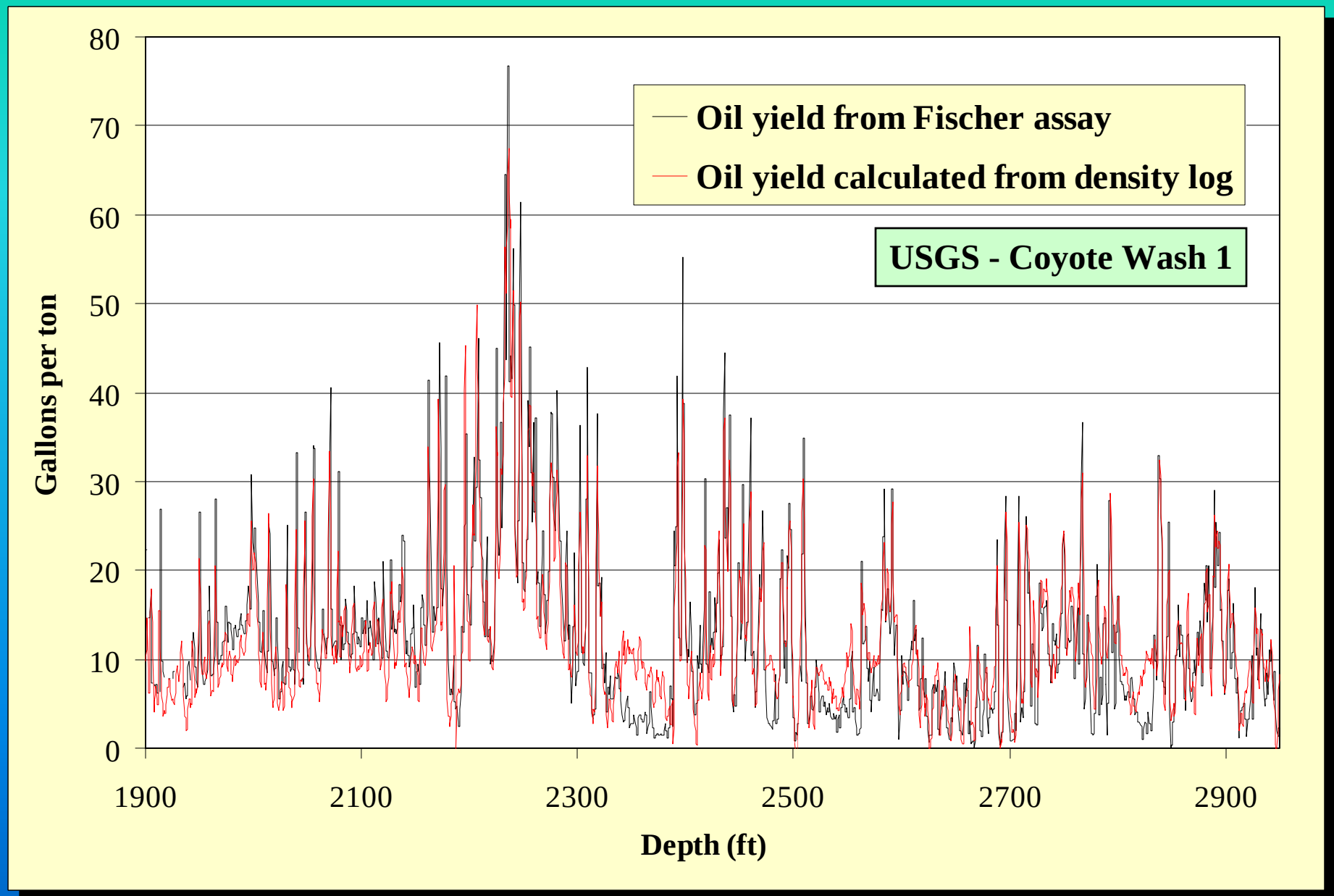
1.6
1.8
2
2.2
2.4
2.6
Oil yield from Fischer assay (gpt)
Bulk density (g/cm3)
R2 = 0.75
Standard Deviation = 5.0
Sonic
R2 = 0.69
STDEV = 5.4
Both density and sonic
R2 = 0.80
STDEV = 4.3
USGS - Coyote Wash 1


Oil yield from Fischer assay
Oil yield calculated from density log
USGS - Coyote Wash 1
Gallons per ton
Depth (ft)
80
70
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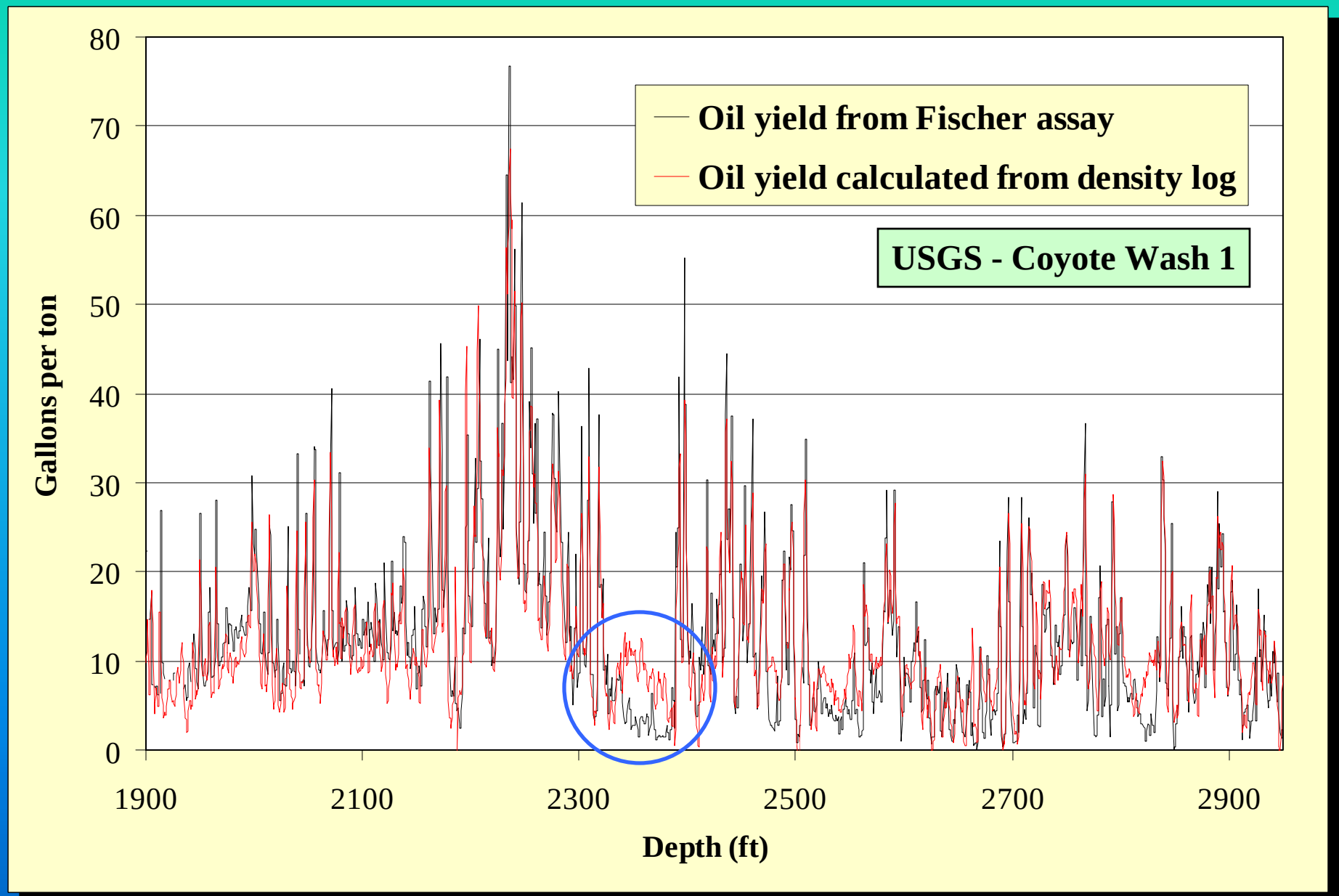
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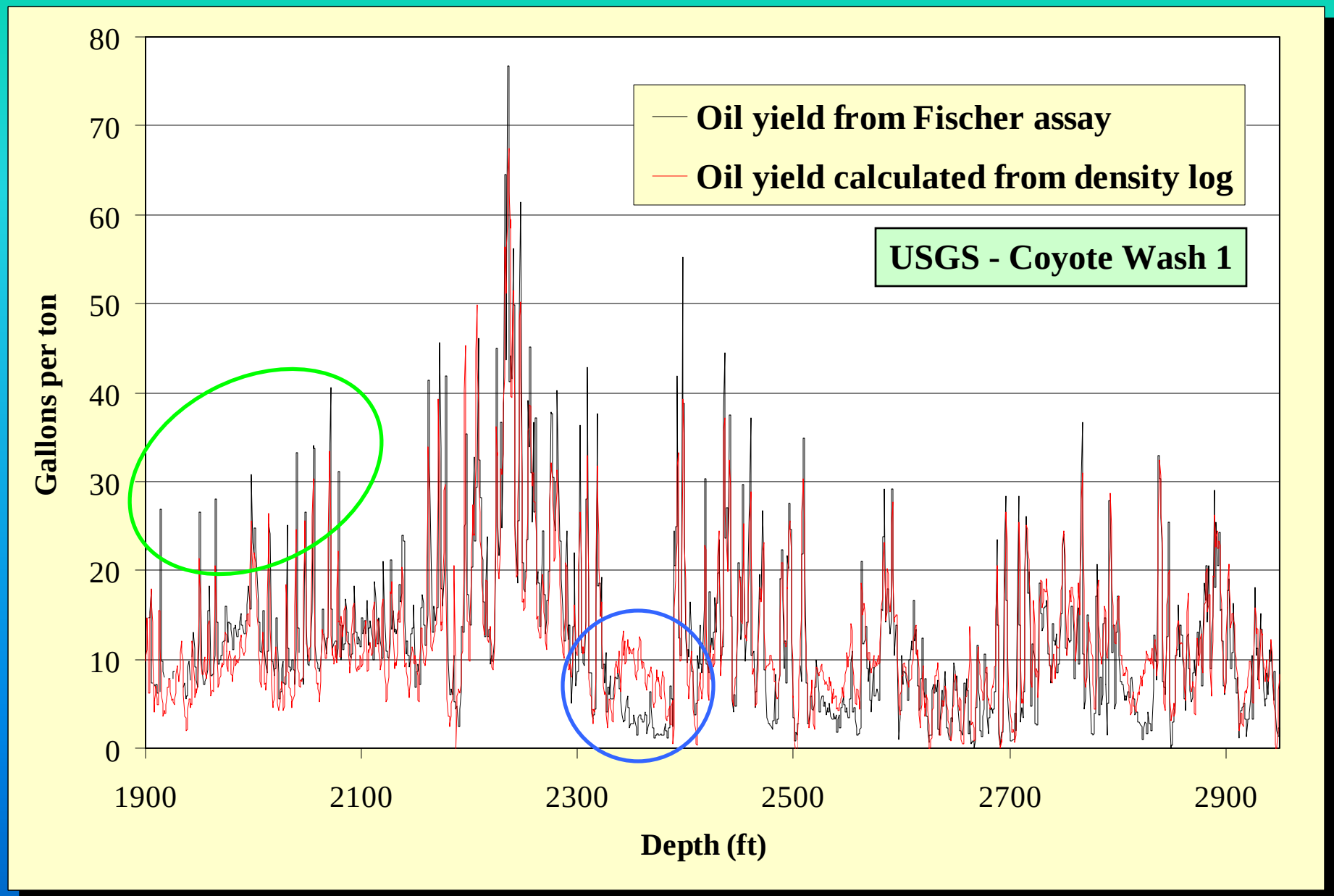
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2700
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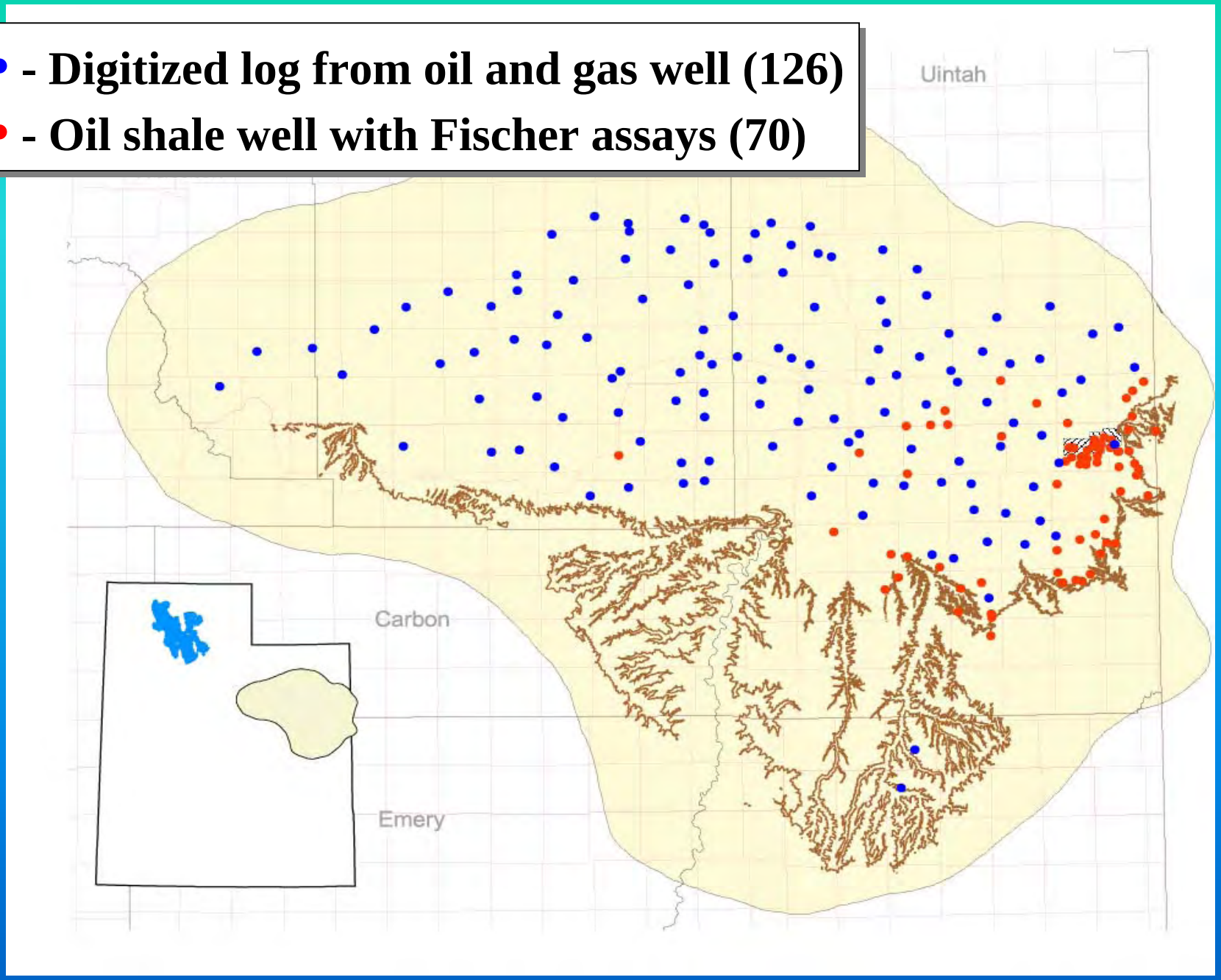
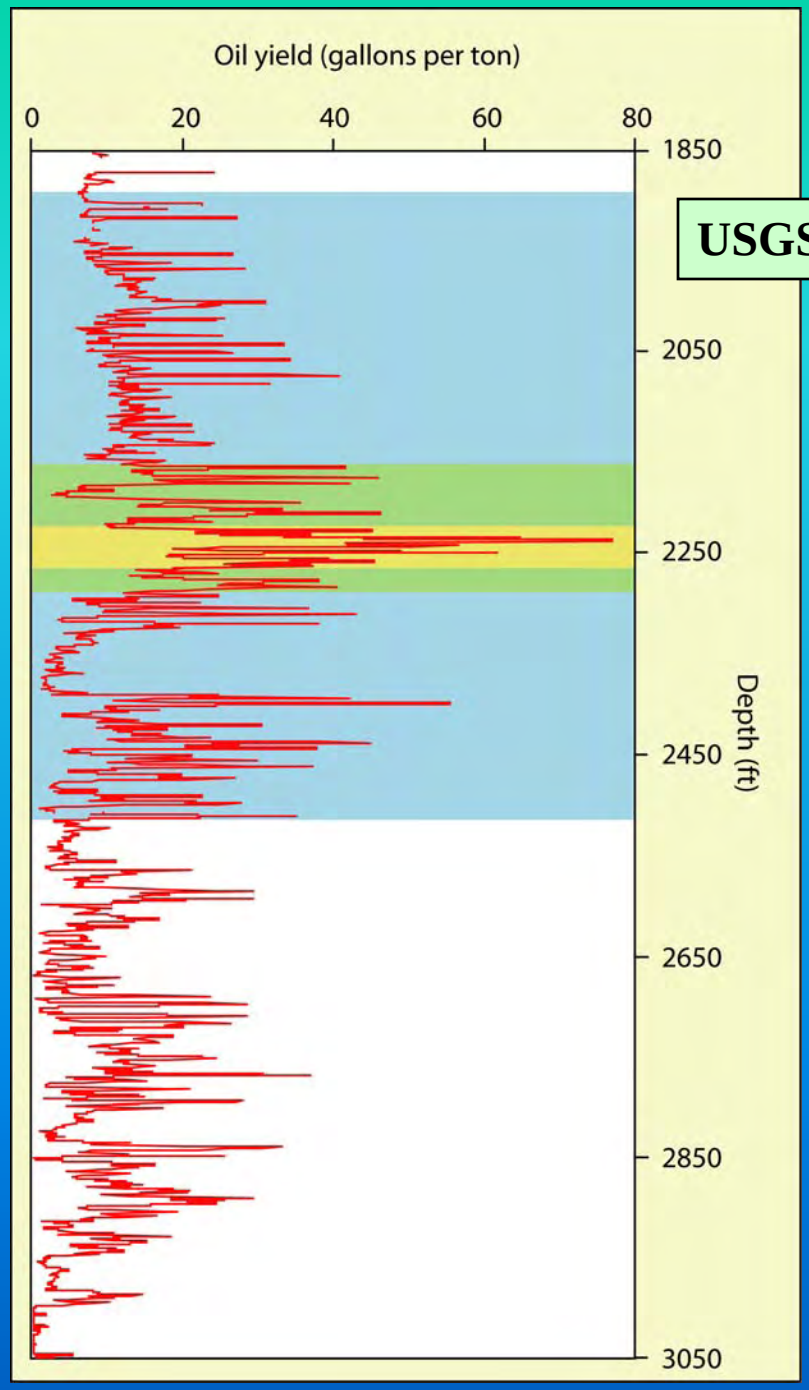
Depth (ft)

- **- Digitized log from oil and gas well (126)**
- **- Oil shale well with Fischer assays (70)**



Average of 15 gpt

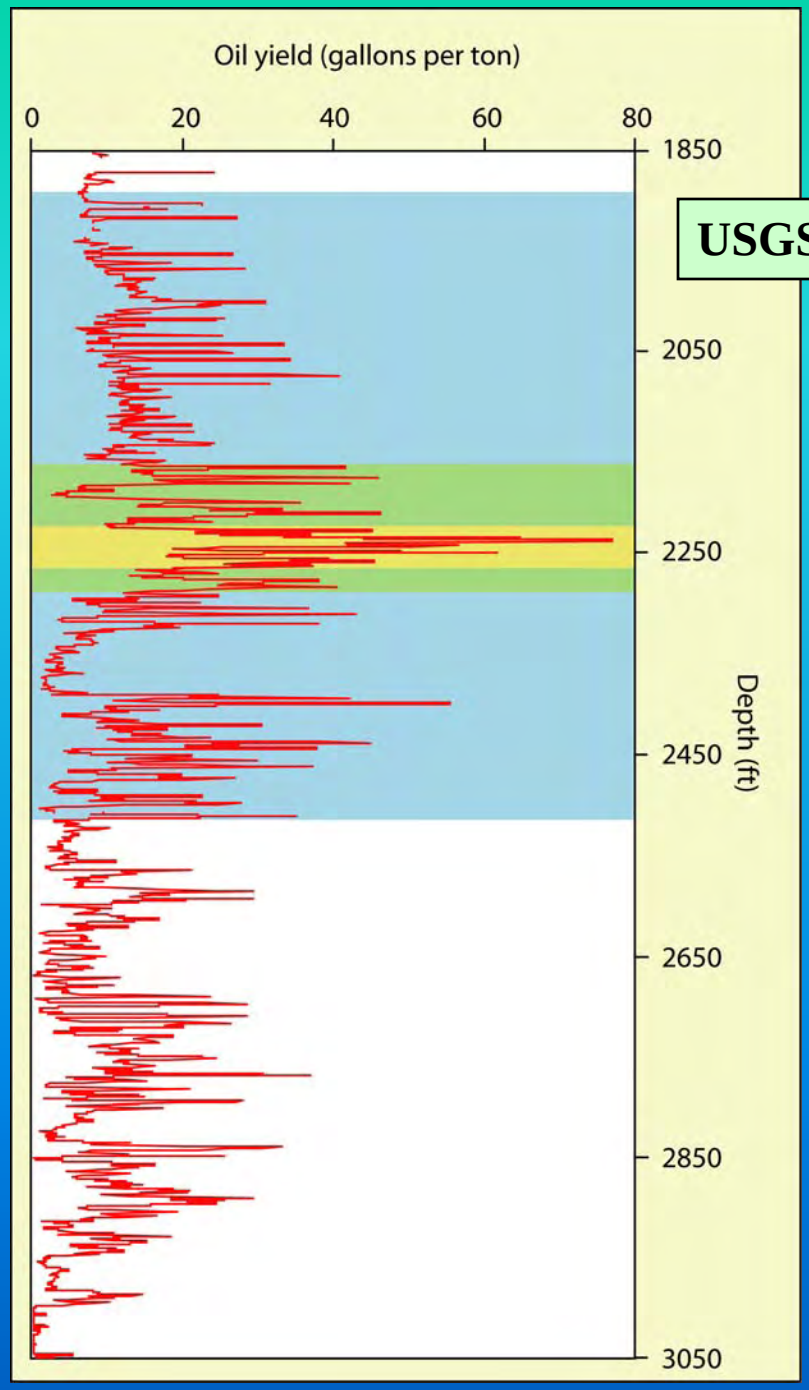
617 ft



USGS - Coyote Wash 1

Average of 25 gpt

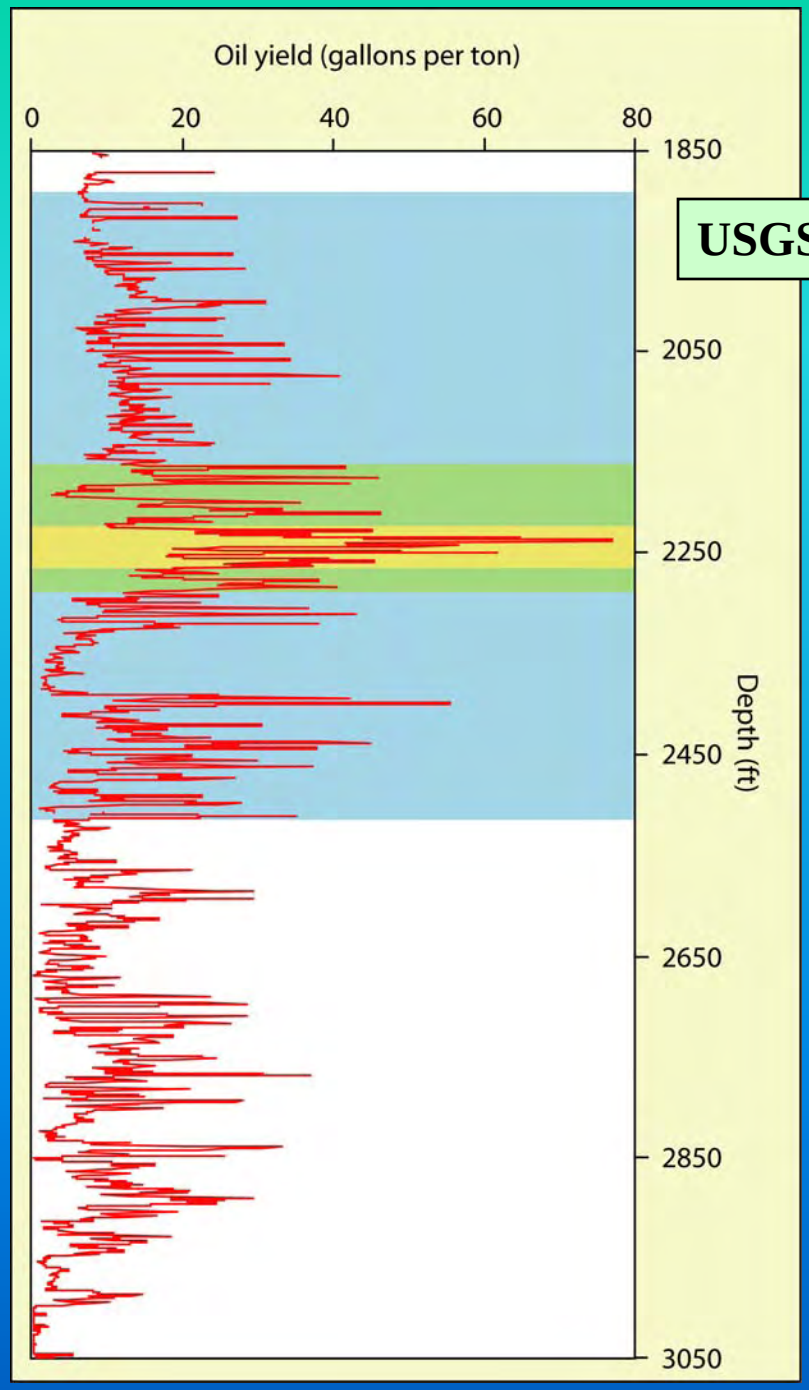
124 ft



USGS - Coyote Wash 1

Average of 35 gpt

40 ft



USGS - Coyote Wash 1

"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**

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(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**