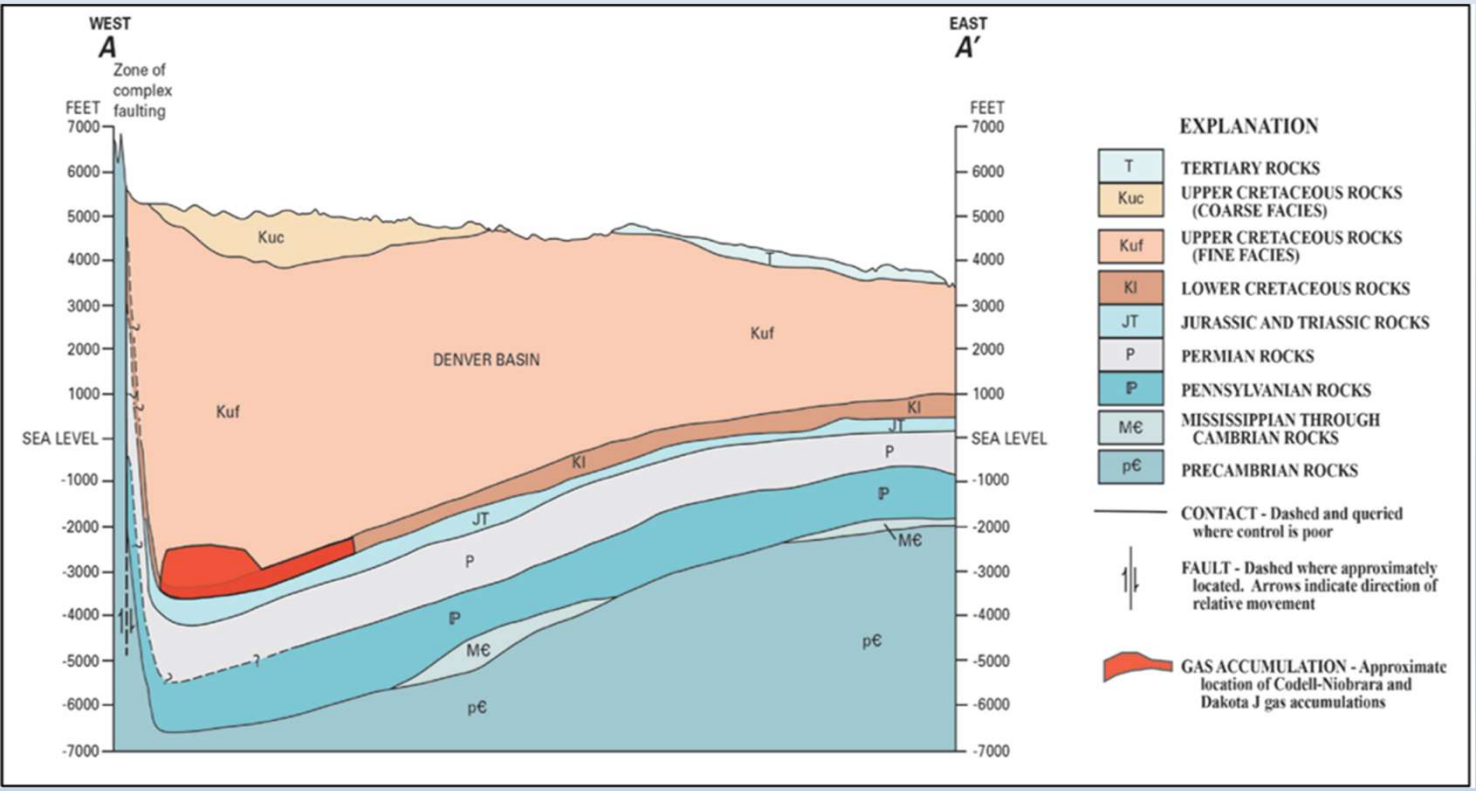
Eric Hillman, MS Student, Expected Graduation: Fall 2023

RESERVOIR CHARACTERIZATION OF THE CODELL & NIOBRARA FORMATIONS, POSTLE AREA, WATTENBERG FIELD

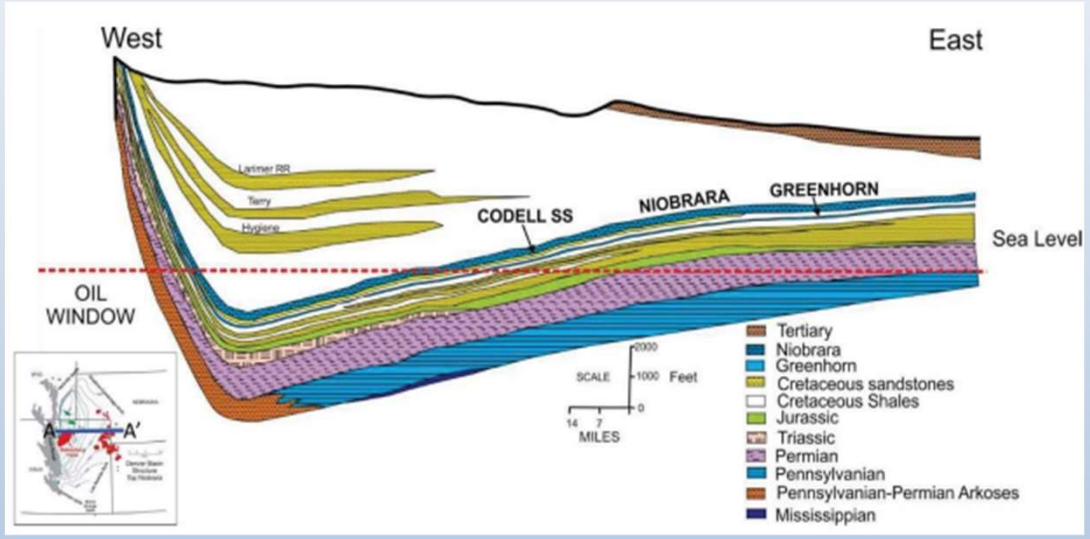
Geological Setting: Denver Basin



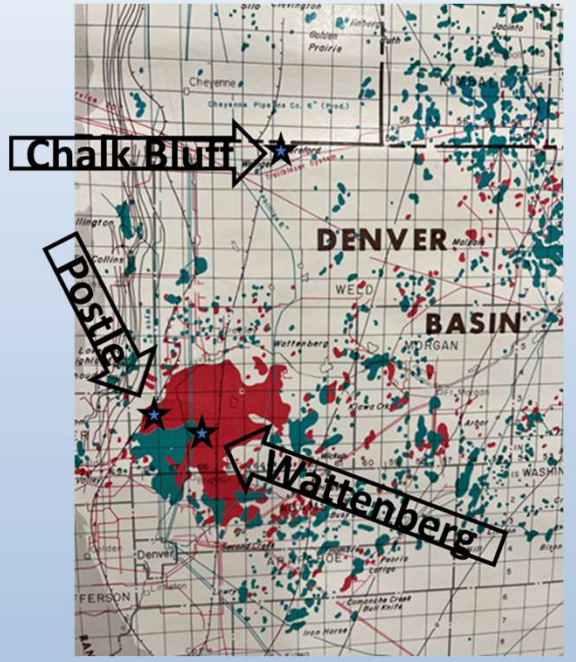
Credit to Nelson, P.,H., and Santus, S.L., USGS (2011)

- Formed ~ 300 Ma during orogeny of Ancestral Rocky Mountains, Late Cretaceous (Carey, Daniel L., 2011).
- The Denver Basin encompasses more than 70,000 square miles (mi2) (180,000 square kilometers [km2]) in eastern Colorado, southeastern Wyoming, and southwestern Nebraska.
- Contains Wattenberg Gas field
- Greater than 10 TCF equivalent out of multiple horizons

Burial History- Wattenberg Field



Credit to:
(Sonnenberg, 2015).



- Covers ~ 3200 square miles
- Codell sediments derived from major deltaic source extending into the Western Interior Seaway and deposited on the flat floor of the Seaway by waxing and waning shelf currents as well as storms and waves (Longman et al., 2021).
- Niobrara was deposited within the Western Interior seaway as chalks/marls
- Source Rocks in Cretaceous- Mowry, Huntsman, Graneros, Greenhorn, Carlile, Niobrara, Sharon Springs

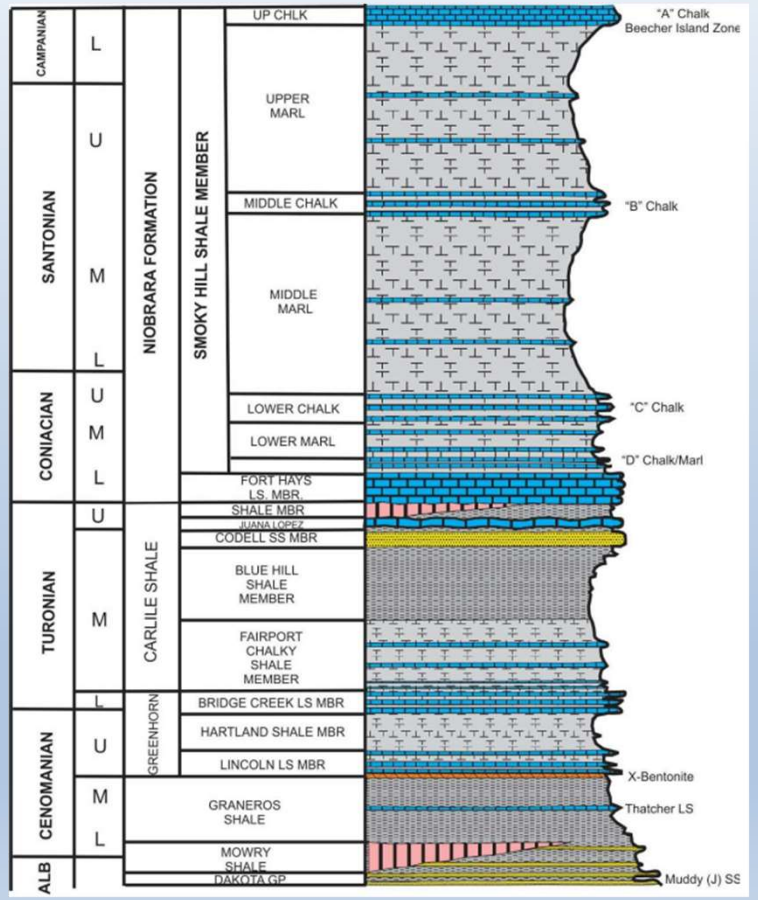
Postle Geology & Wattenberg Field Area Description

- Geological Factors:
  - Thermally mature source beds; thickness; geothermal gradients; pressure gradients; fault bounded reservoir compartments; gas-oil ratios; sufficient reservoir quality

- Niobrara A, B, C chalk ~ 20-50 ft thick
  - Characterized by combination of chalks/marls/sandstones/shales
  - Unconventional system
  - Porosity: (6-10%) & permeability (<0.1 mD)
  - Geothermal gradients range: 16-25°F/100 ft (hotspot)
  - Gas-oil Ratio: 28-29°F/1000 ft

- Fort Hays Unconformity exist at top & base of Niobrara
  - Barrier & possible potential reservoir in certain areas

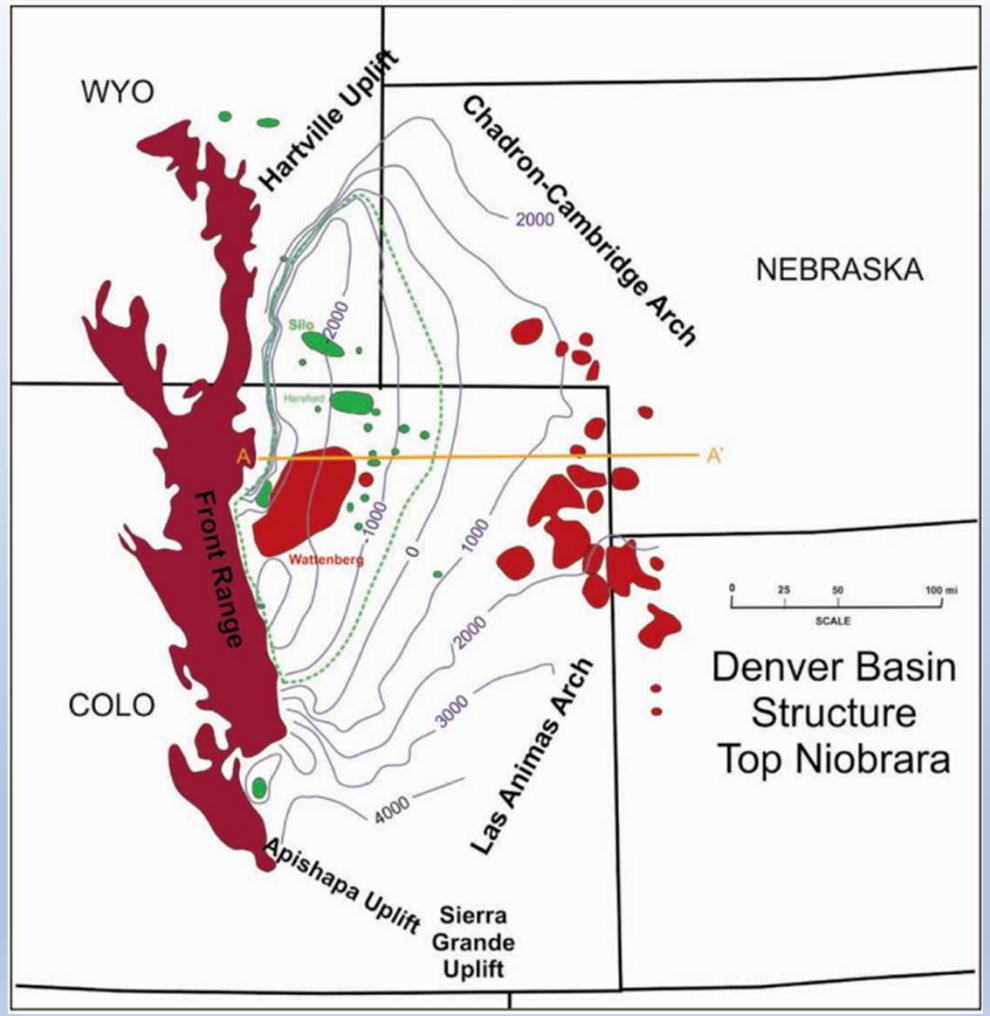
- Codell Sandstone ~ 5-20 ft thick
  - Characterized by tight sands , low porosity (<12%) & permeability (<0.1 mD)
  - Tight unconventional reservoir



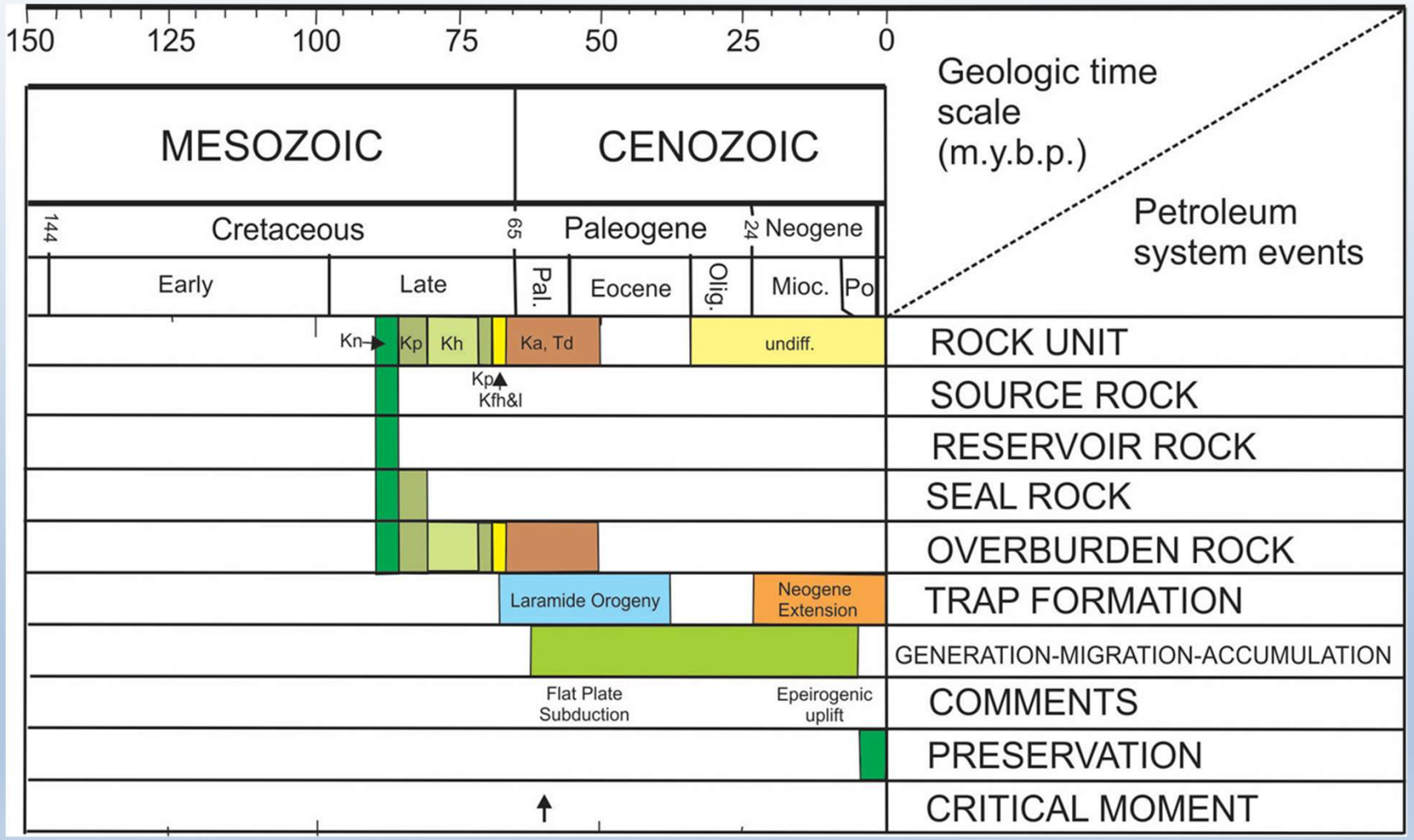
Credit to: (Kauffman, 1969)

Petroleum System

- Production in Wattenberg found in Dakota, J Sandstone, D Sandstone, Greenhorn, Codell, Niobrara
- Thermogenic oil & gas accumulations in deeper part of basin
  - Biogenic gas accumulations in shallow east flank of the basin
- Niobrara production turns from gas to oil as geothermal gradients decrease in all directions away from Wattenberg “hotspot”

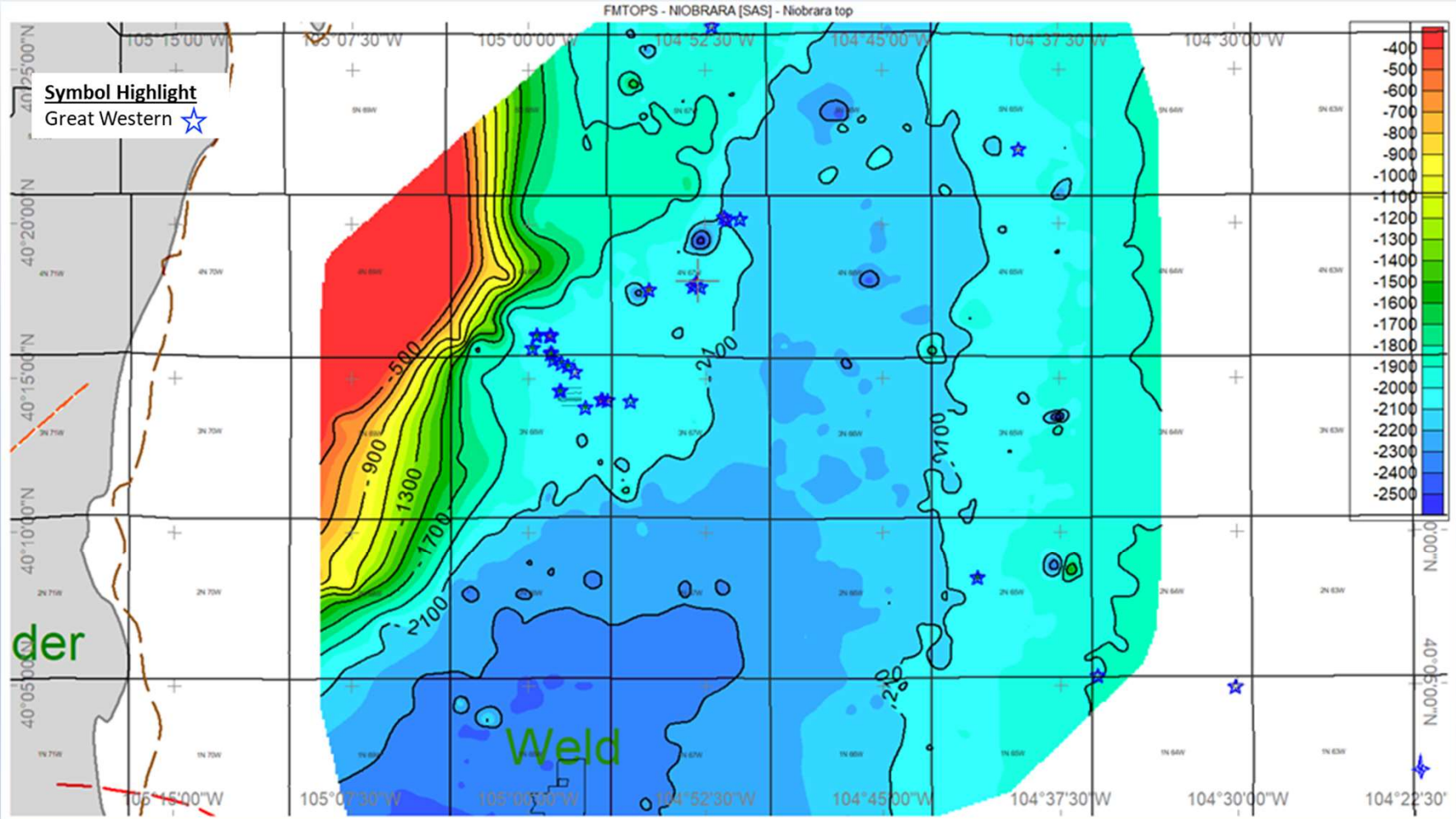


Credit to: (Sonnenberg, 2011)



Credit to: (Sonnenberg, 2011)

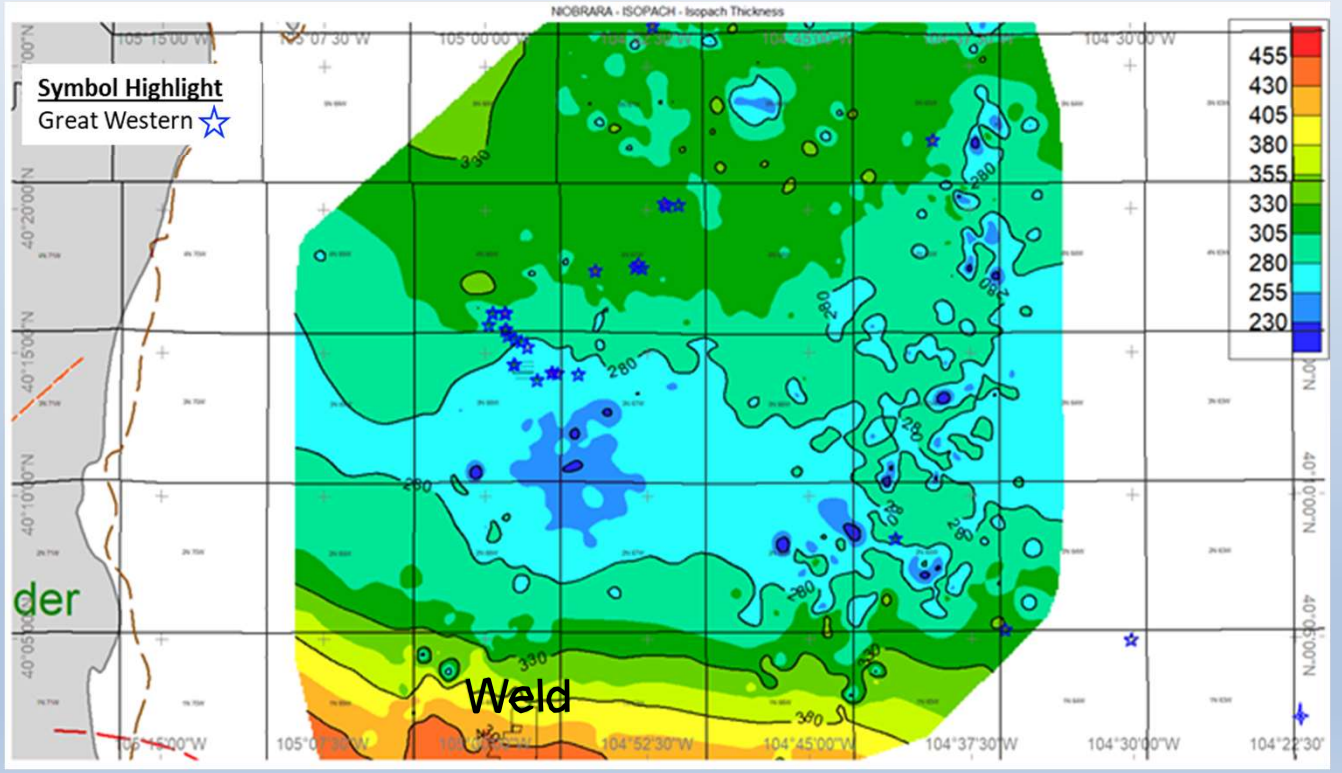
Structure Map

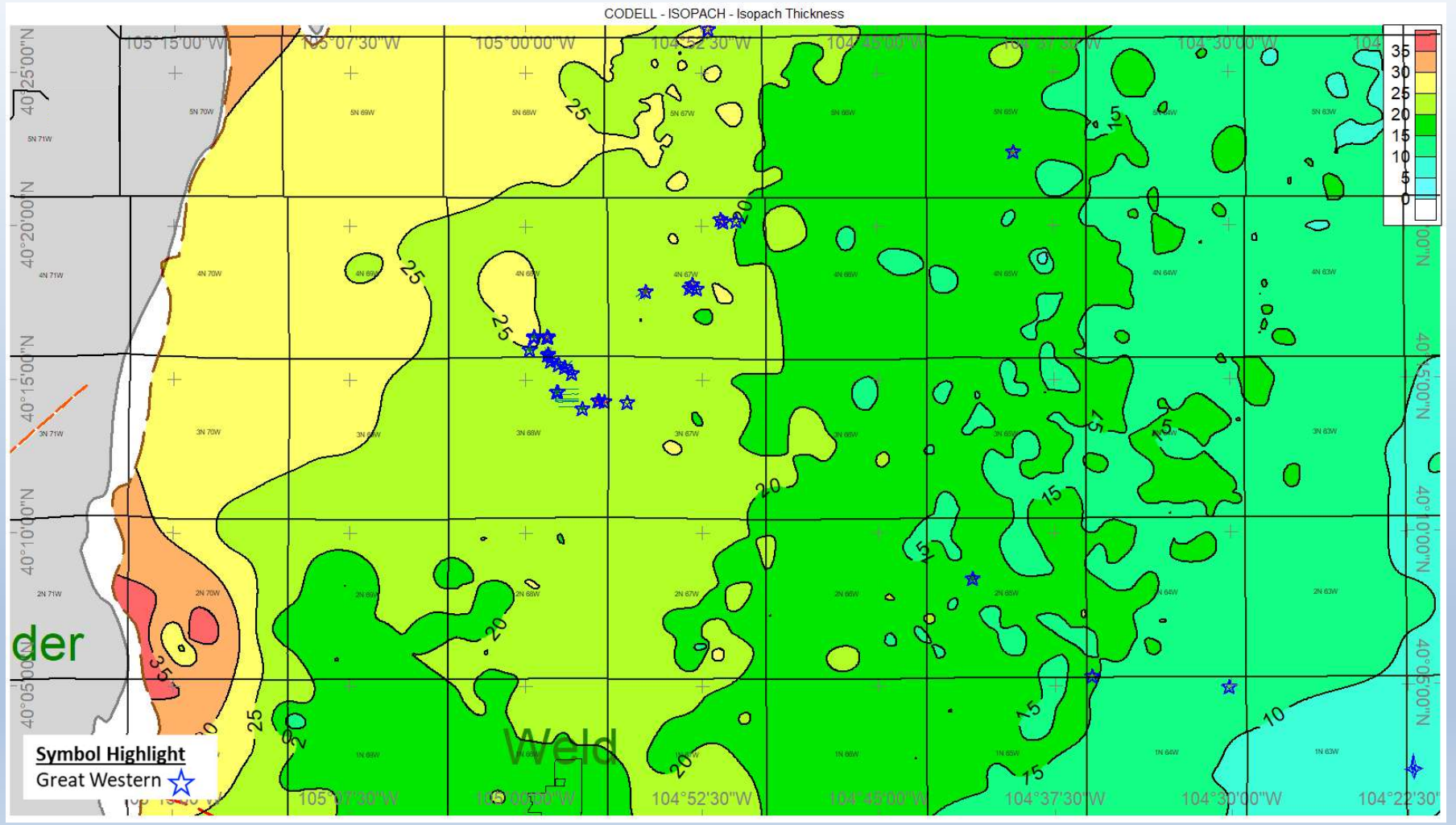


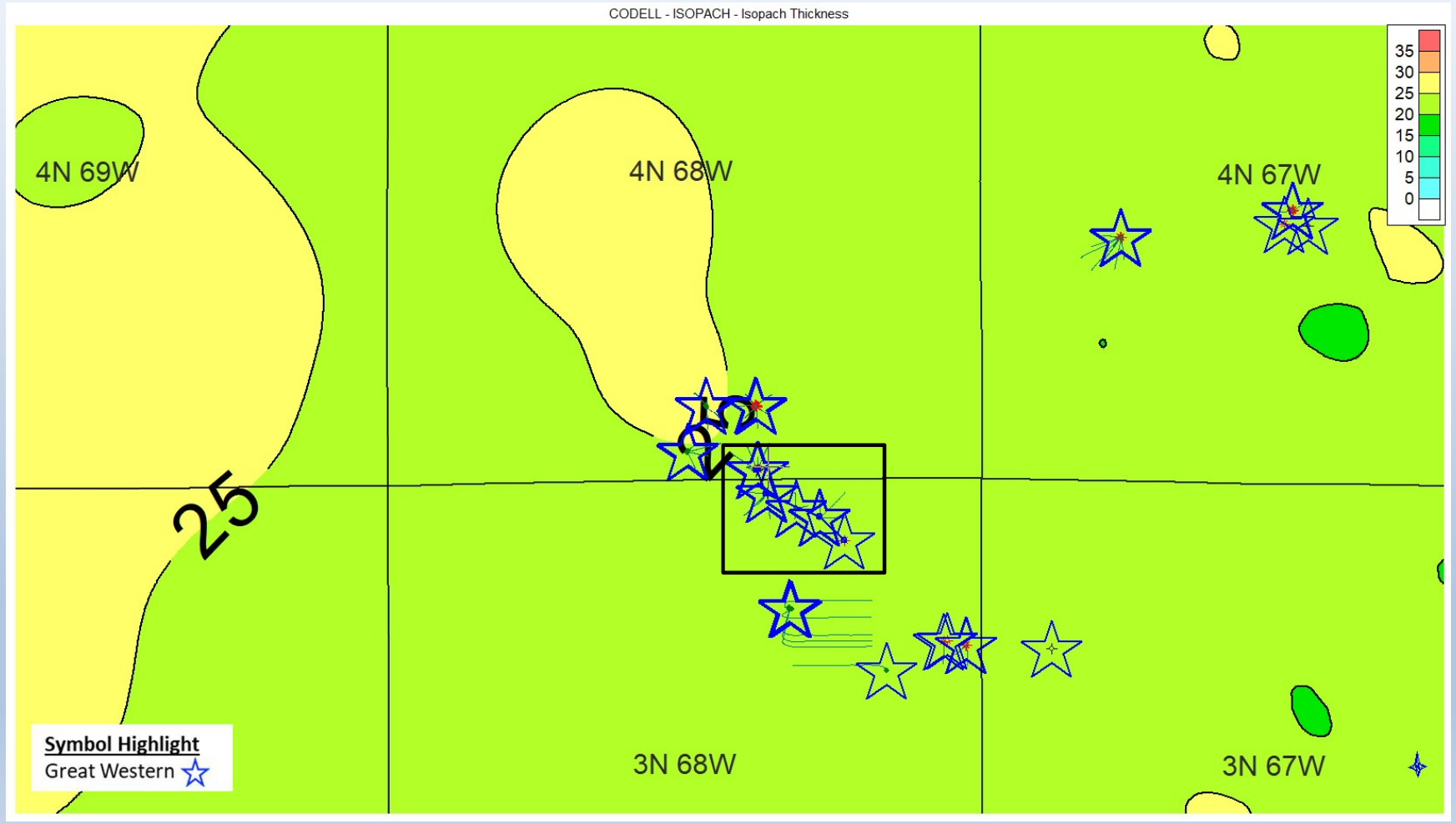
Isopach maps

- Isopach map of the Denver Basin that were based on subsurface thickness measurements

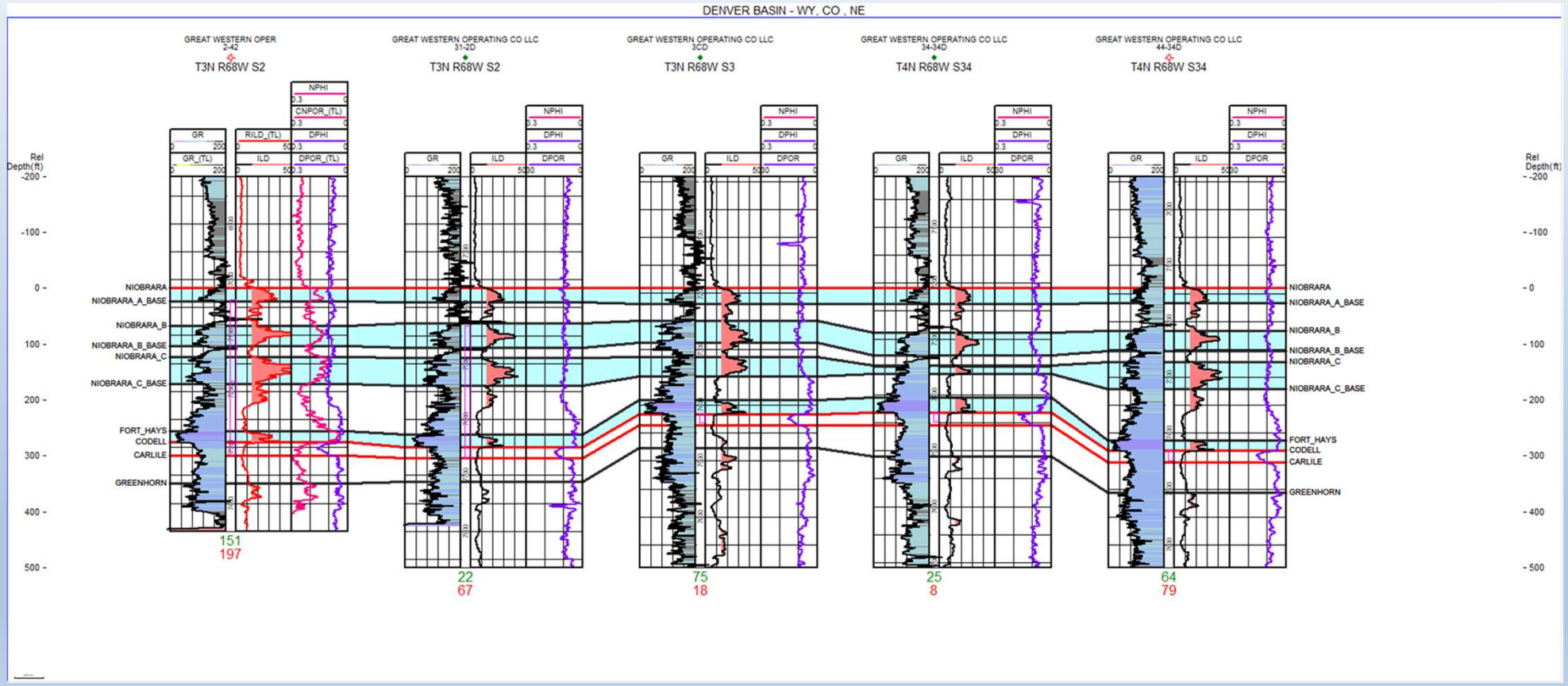
- A few thousand Raster & Digital logs were used to make this Isopach map for the Great Western
  - Great western wells highlighted by ☆




CODELL - ISOPACH - Isopach Thickness
105°15'00"W
105°07'30"W
105°00'00"W
104°52'30"W
104°45'00"W
104°37'30"W
104°30'00"W
104°22'30"
40°25'00"N
40°20'00"N
40°15'00"N
40°10'00"N
40°05'00"N
35
30
25
20
15
10
5
0
Weld
Symbol Highlight
Great Western

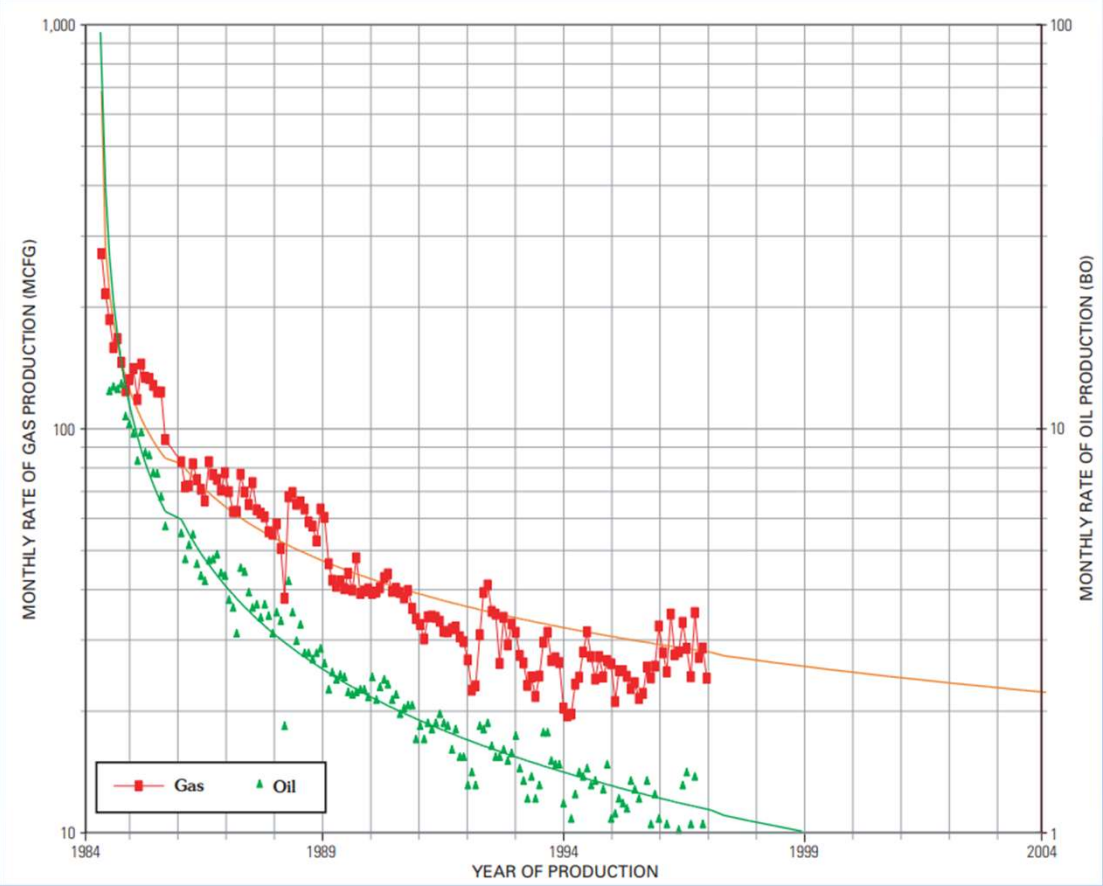

CODELL - ISOPACH - Isopach Thickness
4N 69W
4N 68W
4N 67W
3N 68W
3N 67W
25
25
35
30
25
20
15
10
5
0
Symbol Highlight
Great Western

Stratigraphic Cross-Section



Production Decline Curve

- Wells are hydraulically fractured
- Large initial production results from induced fracturing
  - Associated with radial flow of oil & gas to well bore
- Production performance follows a power-law decline
  - Average exponent of 0.5 for gas and an average exponent of 0.7 for oil



Credit to: (Cox, 1998)

Future Work

- Core description, petrophysics on the Niobrara & Codell.
- Subdividing the Niobrara in the Postle area into the A, B, C, Fort hays intervals and creating Isopach maps.
- Tie the subsurface well log information into the 3D seismic information.
- Possible image log interpretation.

References

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