Using Old and New Data to Characterize the Lawrence Field, East-Central Illinois, for Alkaline-Surfactant-Polymer Flooding*

Suzanne Cluff[1], Robert Cluff[1], Catherine Murphy[1], Joe Alfano[1], Daniel Hallau[1], Ryan Sharma[1], Andrea Simenson[1], Stephen Whittaker[2], Bruce Schonert[2], and Bryan Clayton[2]

Search and Discovery Article #40710 (2011)
Posted March 14, 2011

*Adapted from oral presentation at AAPG Geosciences Technology Workshop, "New Ways to Look at Old Data: New Pay Zones, Increased Production, Expanded Regional Plays", Houston, Texas, November 8-9, 2010.

[1]The Discovery Group Inc., Denver, Colorado (suecluff@discovery-group.com)
[2]Rex Energy Corporation, Bridgeport, Illinois

Conclusions

- Log data from various vintages needed to be normalized to be used
- If the old data is ignored, even ES logs, geological complexity would be difficult to identify
- Understanding the complex geology is essential to the success of the ASP flood

Using old and new data to characterize the Lawrence Field, east-central Illinois, for alkaline-surfactant-polymer flooding

Suzanne Cluff, Robert Cluff, Catherine Murphy, Joe Alfano, Daniel Hallau, Ryan Sharma, and Andrea Simenson

The Discovery Group Inc., Denver, Colorado

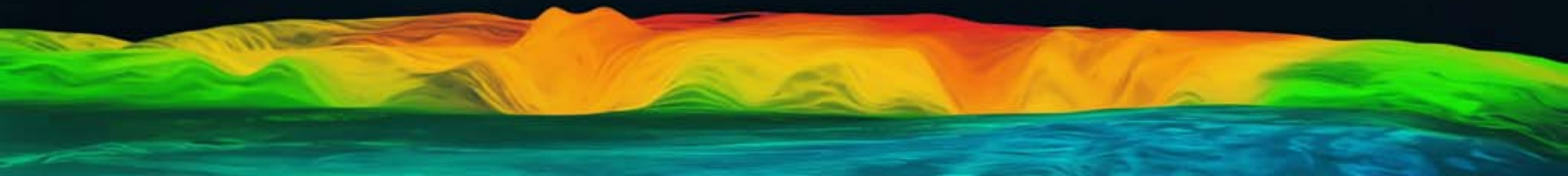
Stephen Whittaker, Bruce Schonert, and Bryan Clayton

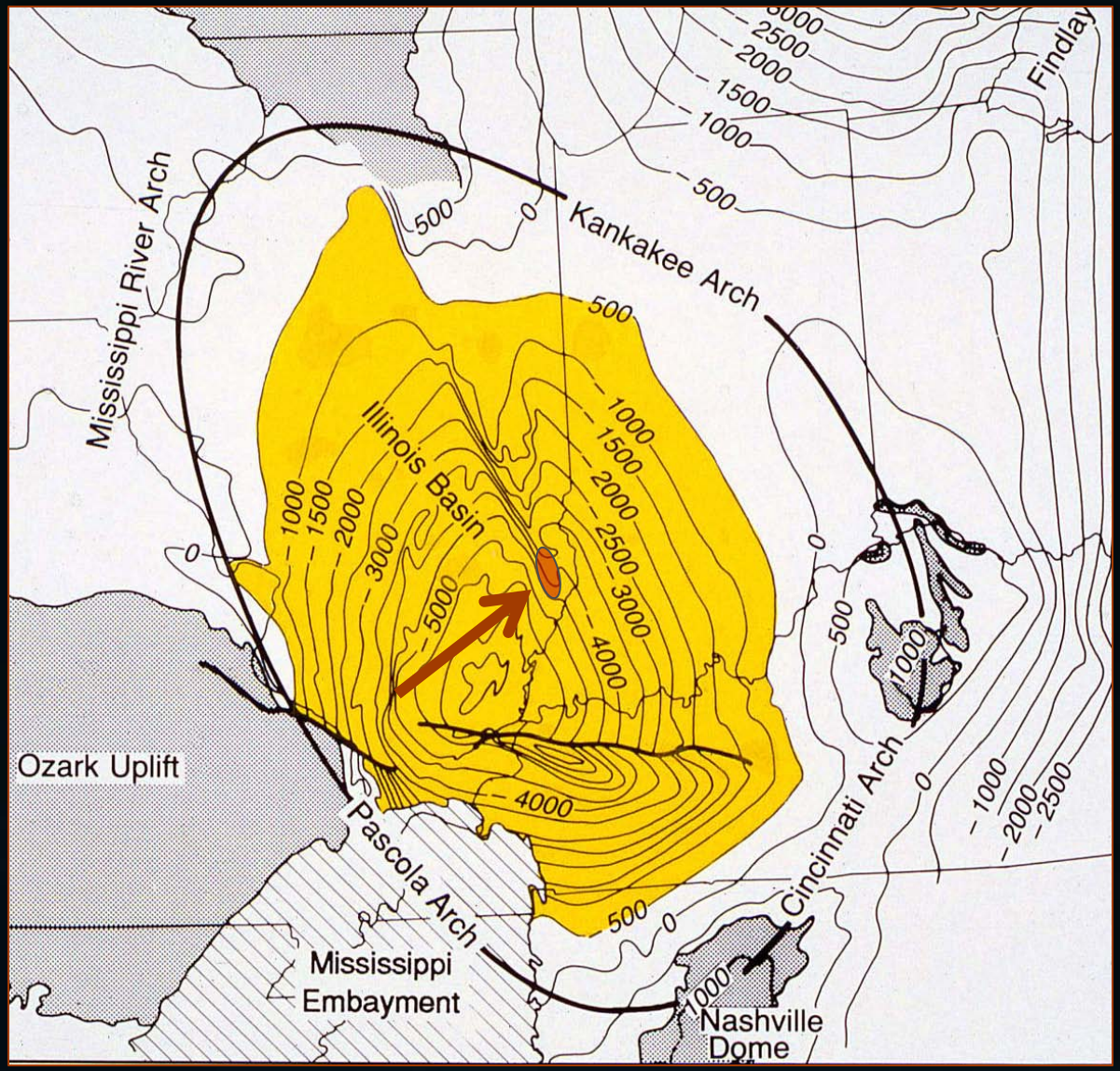
Rex Energy Corporation, Bridgeport, Illinois

AAPG GTW
Houston, TX
November, 2010

Agenda

- Project overview and objectives
- Building the database
- Stratigraphy and correlations
- Define and map the sand bodies
  - get the container volumes right
- Log and core data analysis
  - get the pore volume right

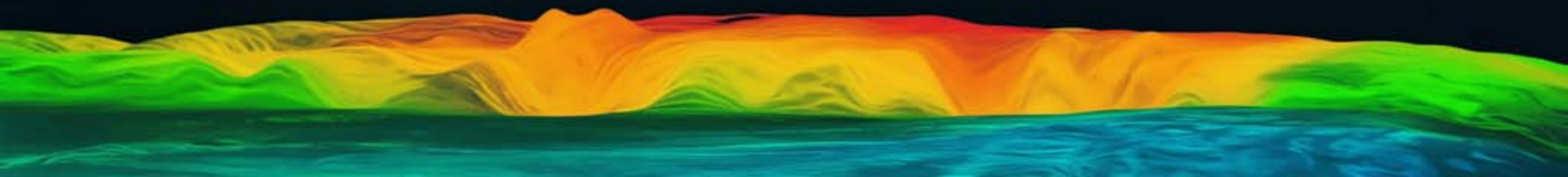


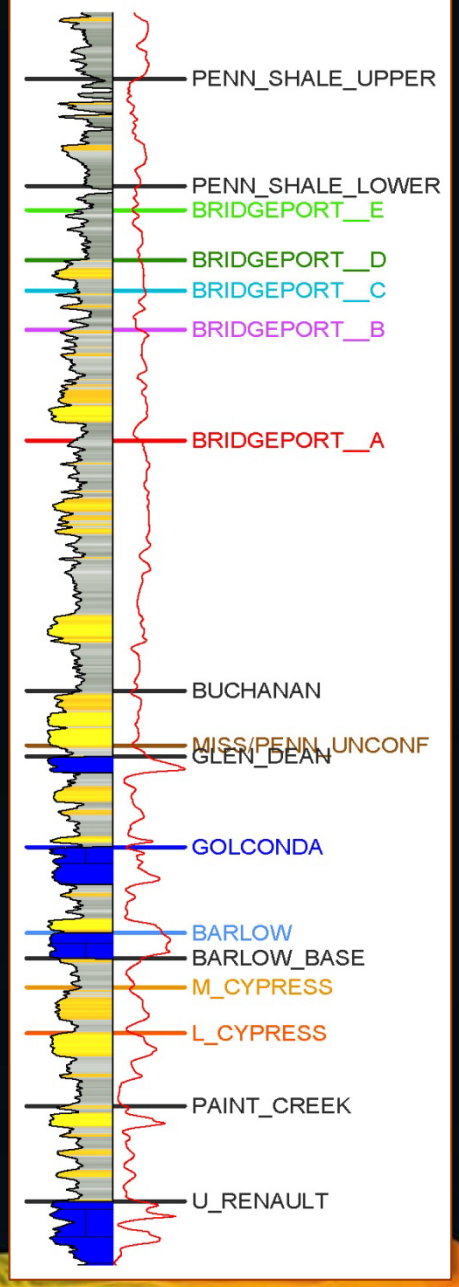


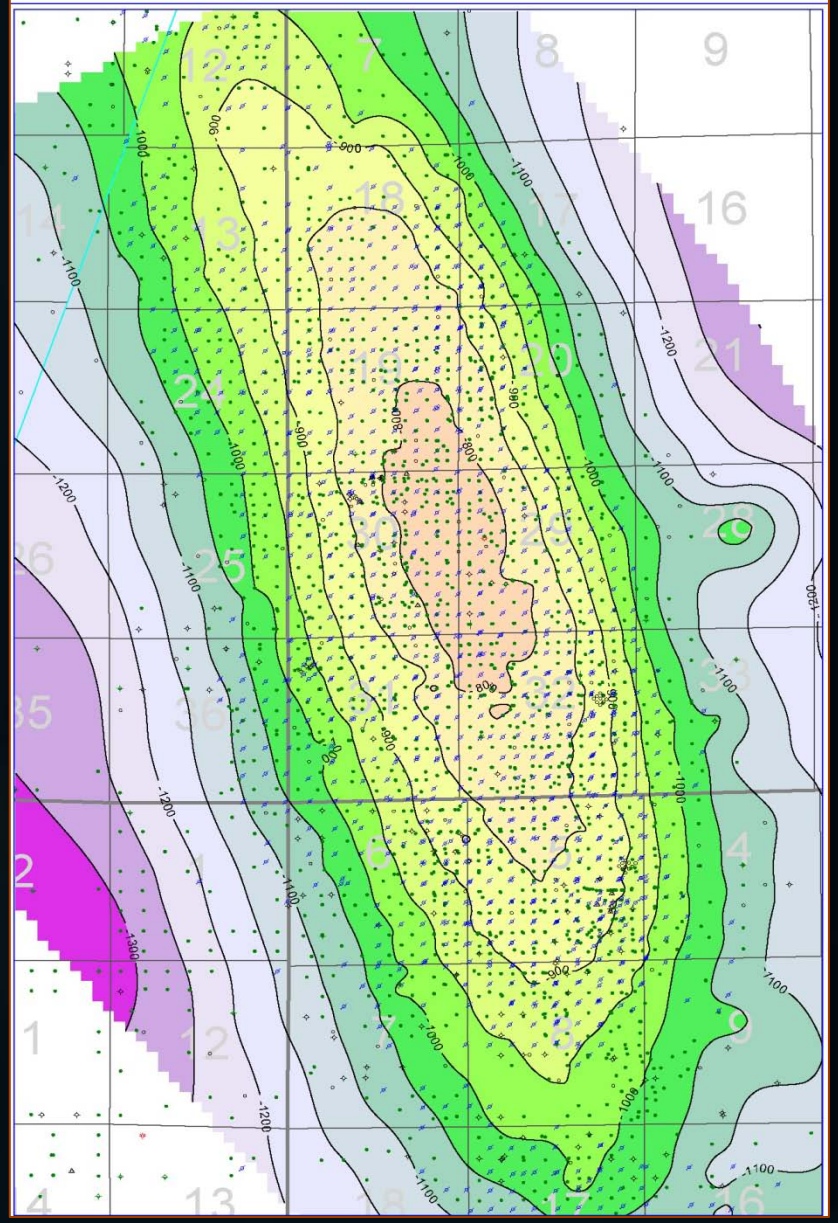
- Discovered 1906
- 20 pay zones
  - Penn. – Ord.
- Produced 400 MMBO
- Rex Energy owns ~12,500 acres
  - Producing 1800 BOPD
- Penn. Bridgeport and Miss. Cypress are most significant pays
  - Estimates of up to 40 million BO recoverable with EOR from Cypress and Bridgeport

Project overview

- Rex Energy acquired Lawrence field in 2006 for its large residual oil in place and EOR potential
- Field was formerly owned an operated by Marathon Oil Company, sold in early 1990's
  - Marathon used Lawrence field as a test bed for chemical EOR methods in the 1960's-1980's
  - Two "proof of concept" surfactant polymer floods were technical successes, but uneconomic at the time







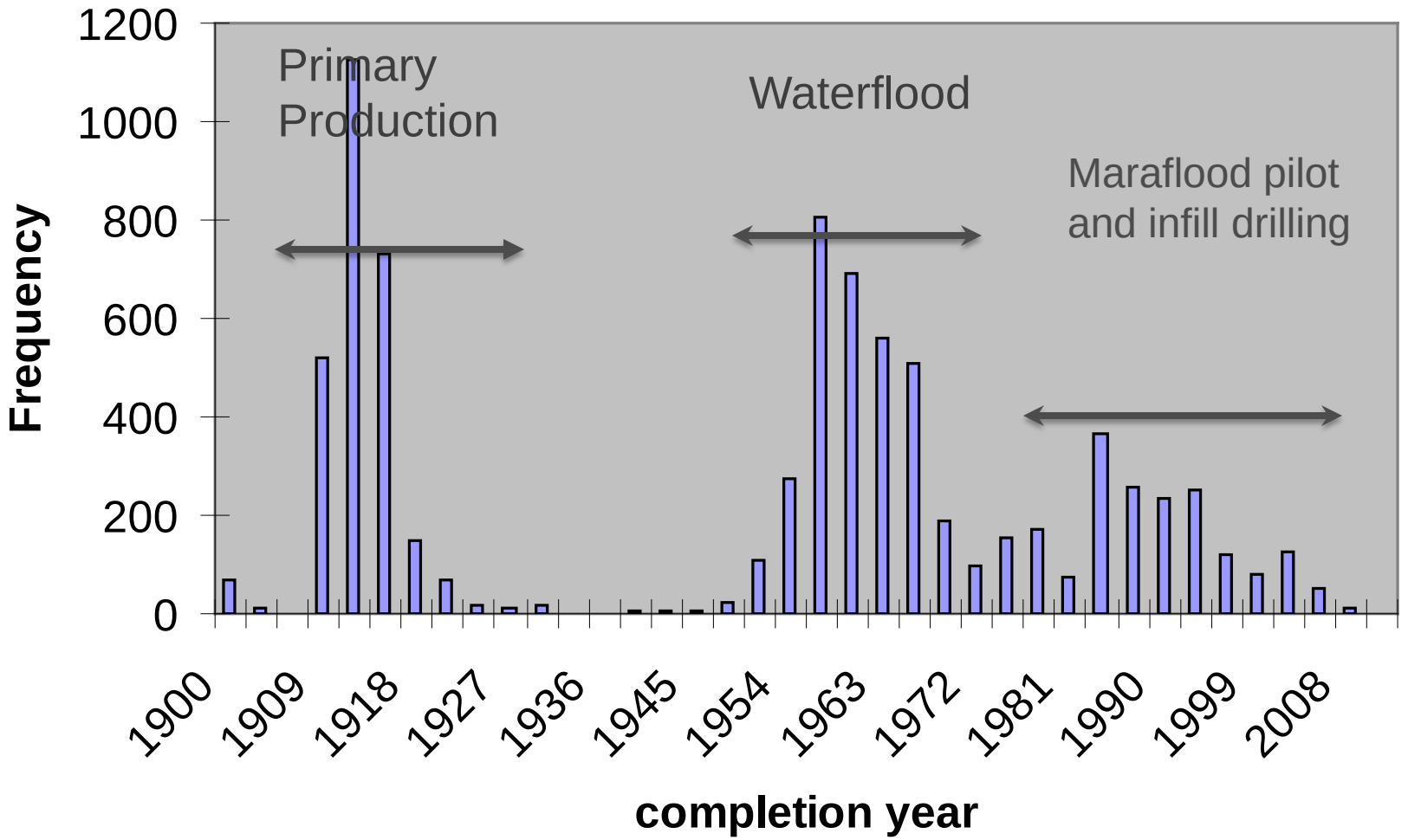
4N

3N

C.I. = 50’

12W

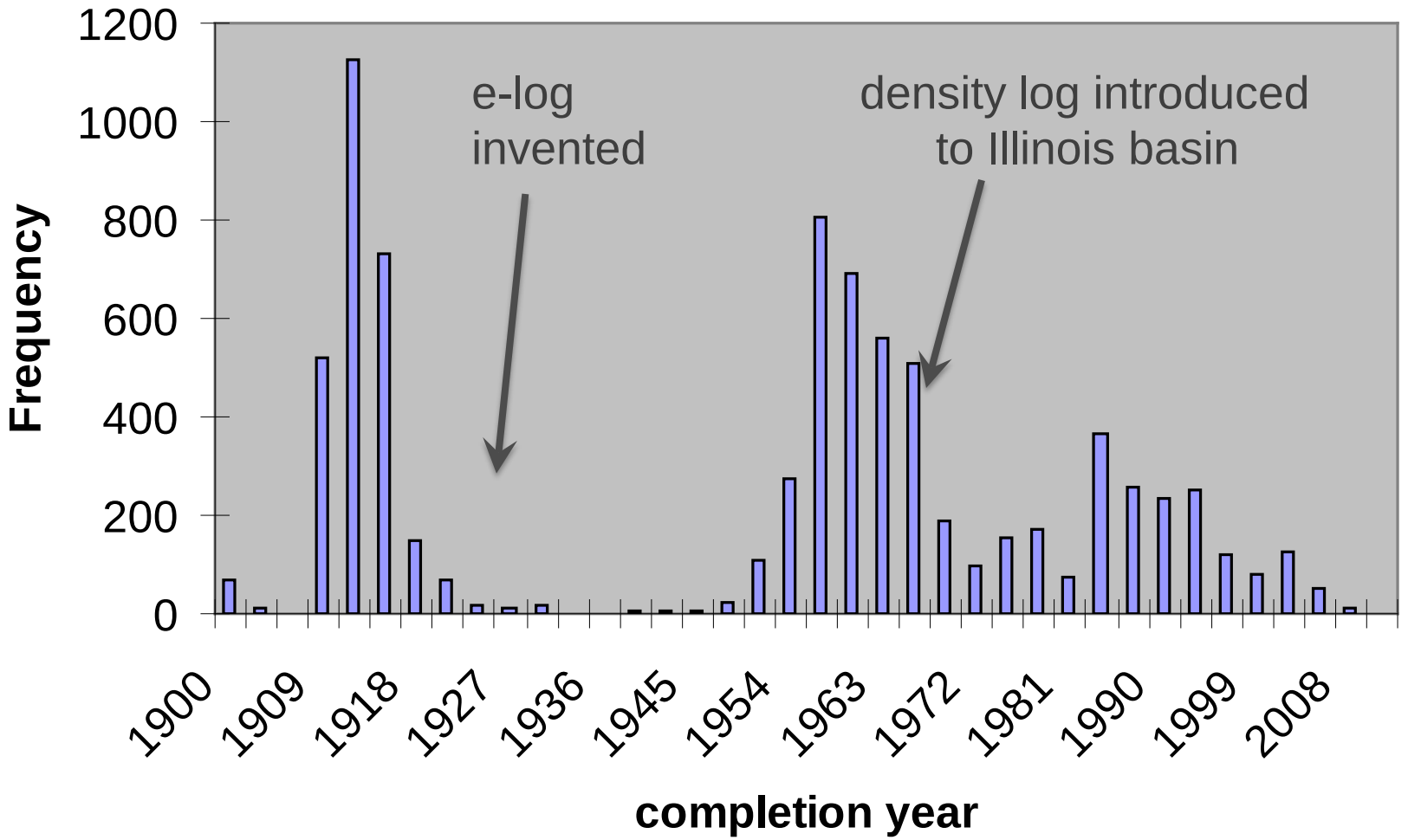
Drilling history



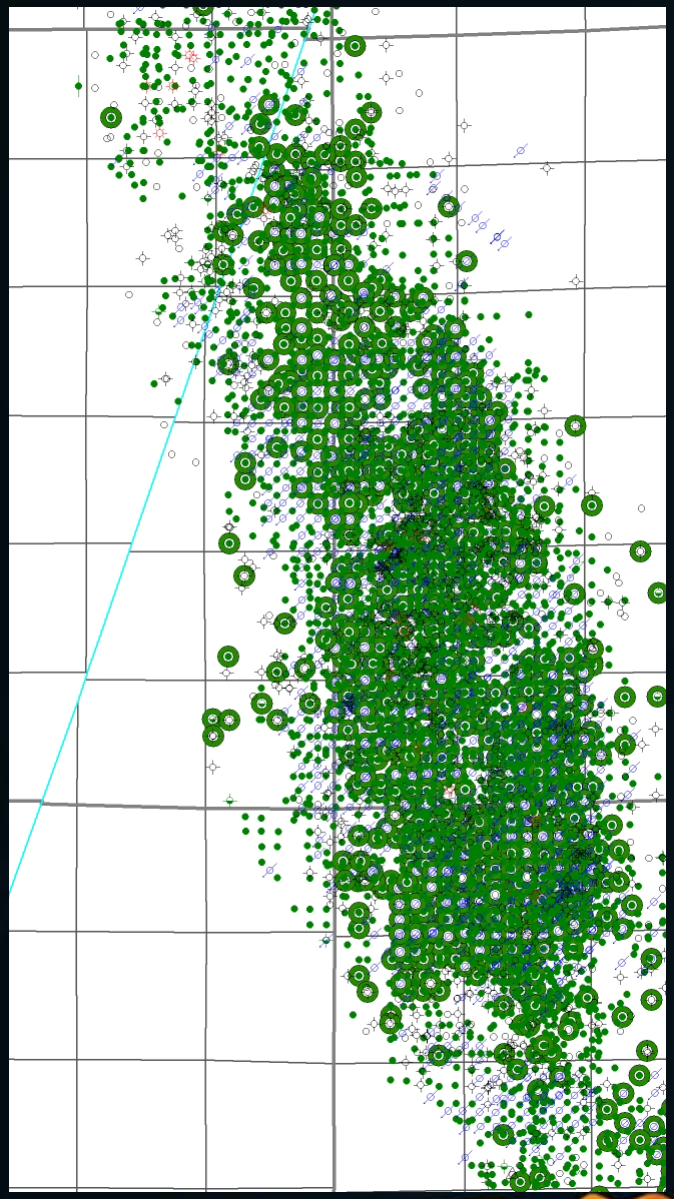
Building the database….

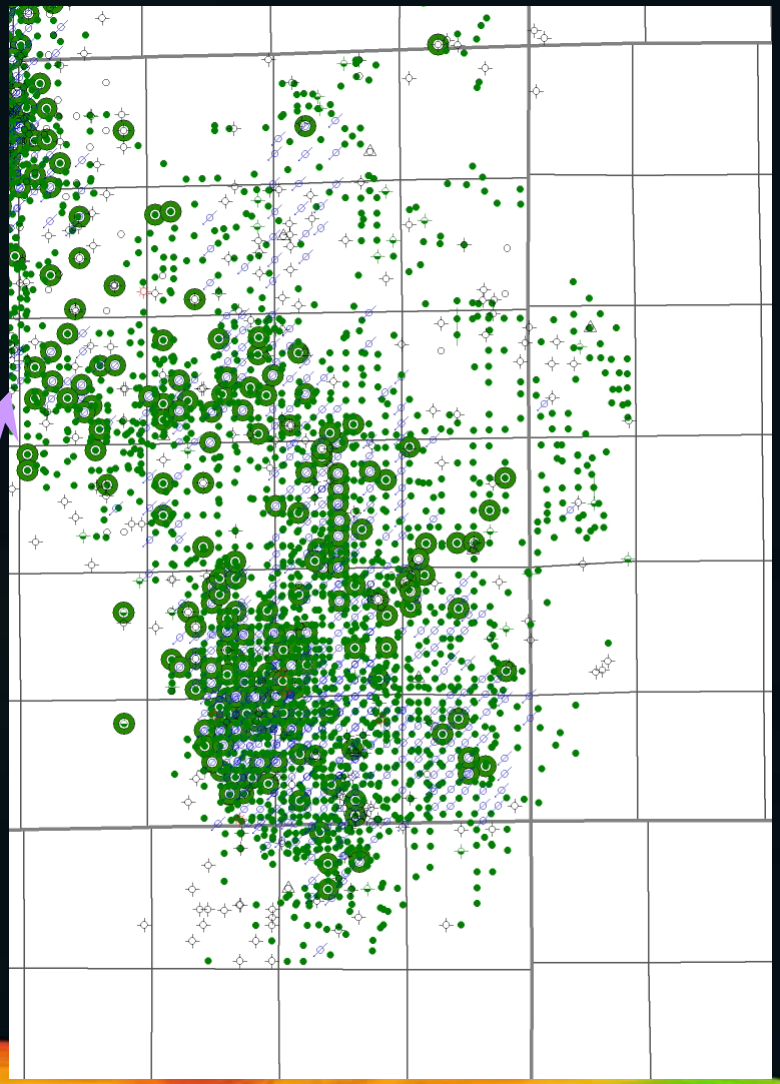
- Very old field, discovered in 1906
  - Lots of location problems
  - Mis-match of state records and commercial databases
  - Mostly paper records, had to scan/digitize logs & many other records
- Large well count (nearly 12,000 in the database)
  - Depth registered raster log images for 5600 wells
  - Digital logs for ~2400 wells
    - includes 900 wells with neutron or density logs, plus wells with core analysis data
  - Digitized core analyses and intervals for ~1500 wells
  - Perforations, tests, engineering data
  - Old operator tops were inconsistent & of minimal value

Drilling history



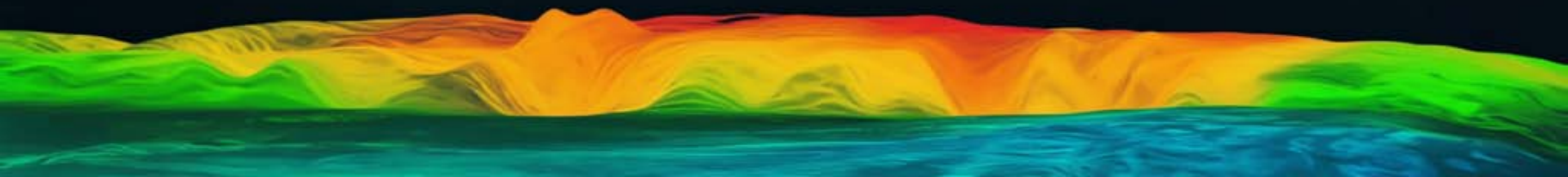
Modern porosity log control



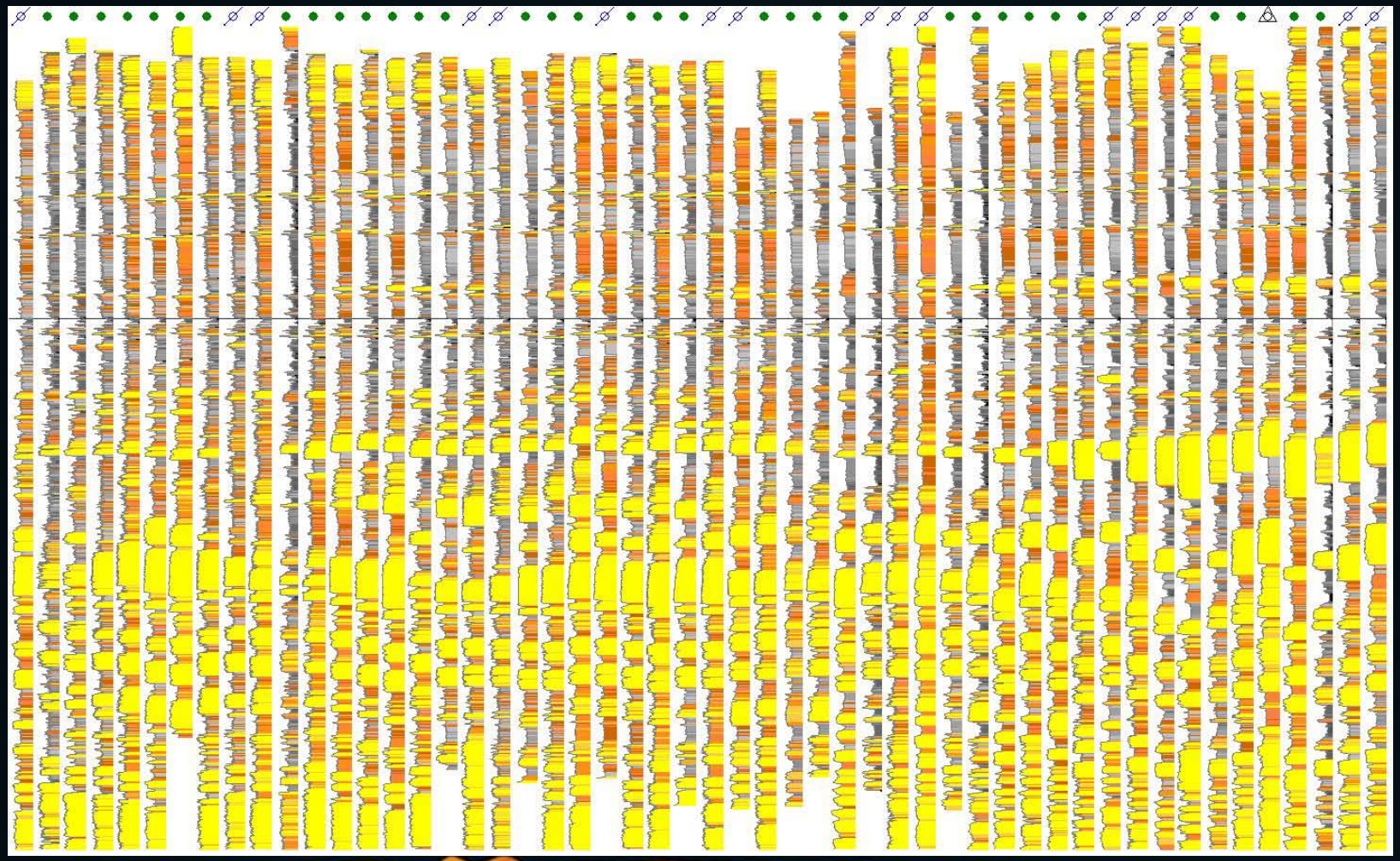


Petrophysical process

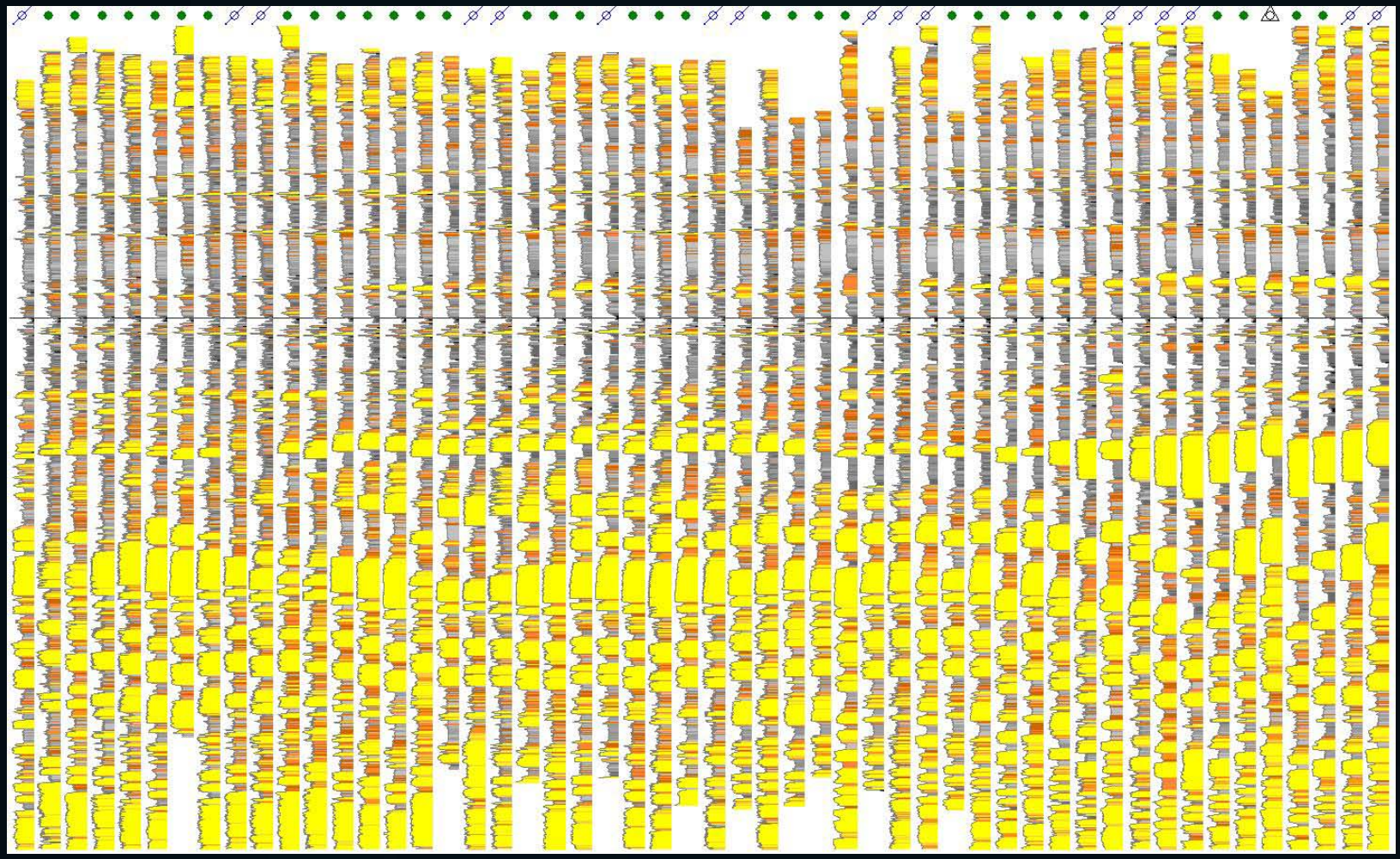
- all GR, RhoB, and Nphi logs needed to be corrected and normalized
  - over 70 yrs of logging history, all vendors, all kinds of tools
- Developed separate petrophysical models for Bridgeport and Cypress
  - Varied Rw, ρ_g, etc.
- Every well with a porosity log was calculated for mapping



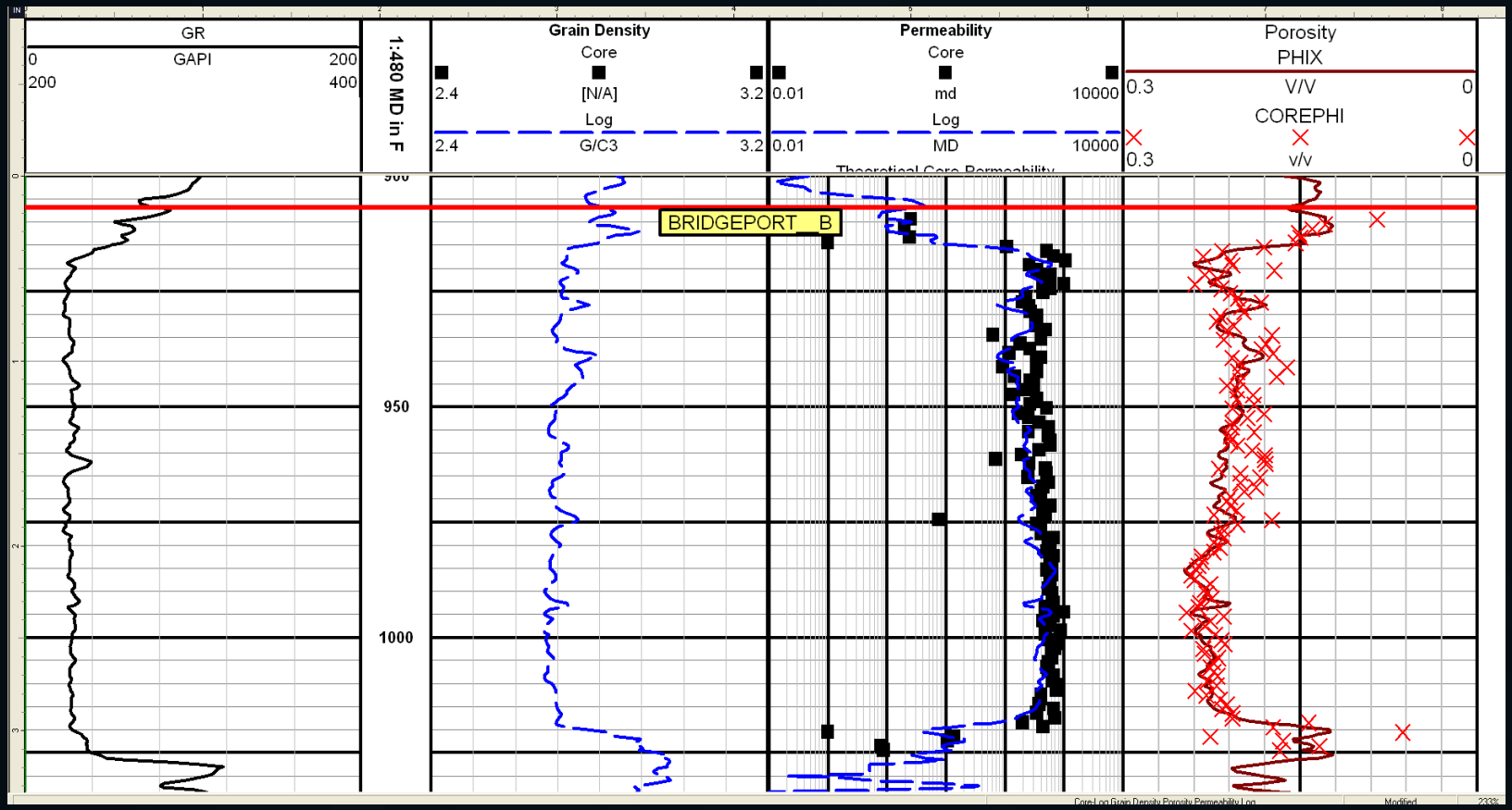
GR logs, un-normalized



Normalized GR



Calibrated with Core Data

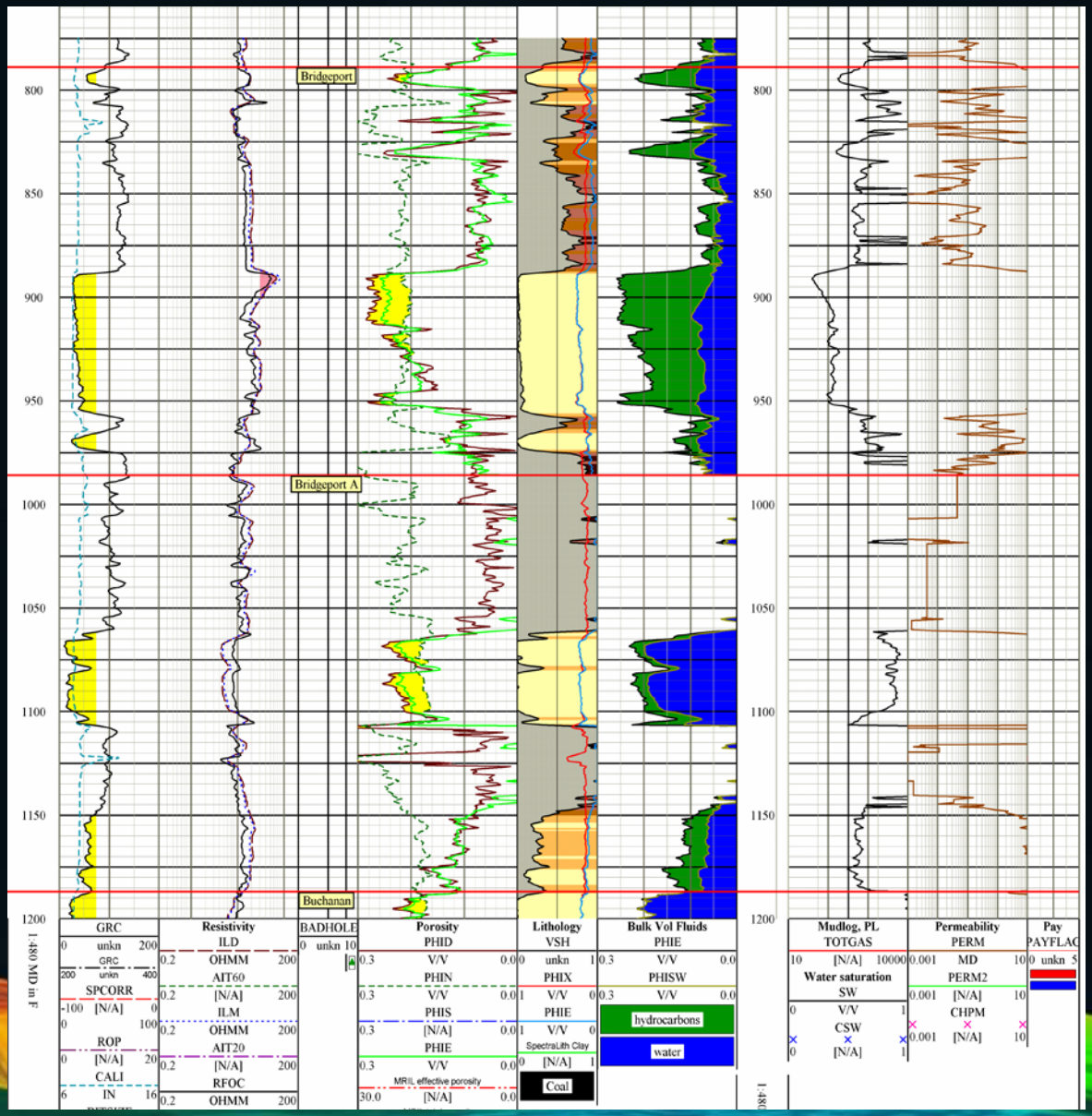


Example calculated log

Everything higher
Is oil sat'd

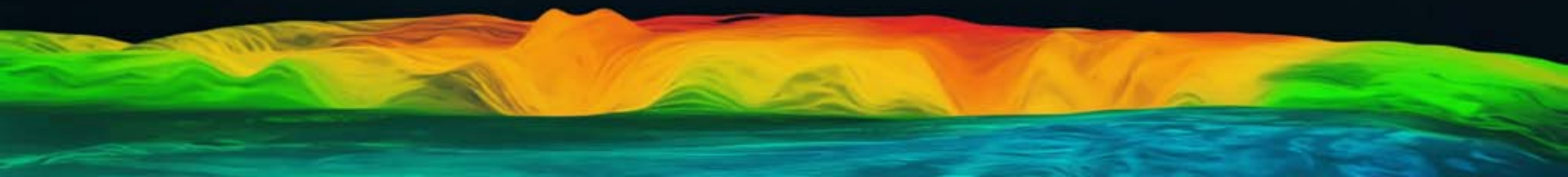
oil pay in BP B

wet sand in BP A



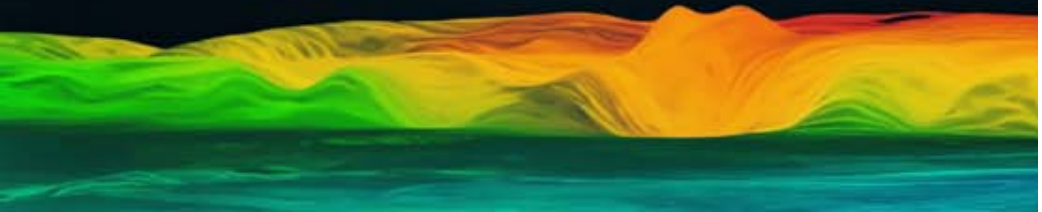
The Correlation Problem

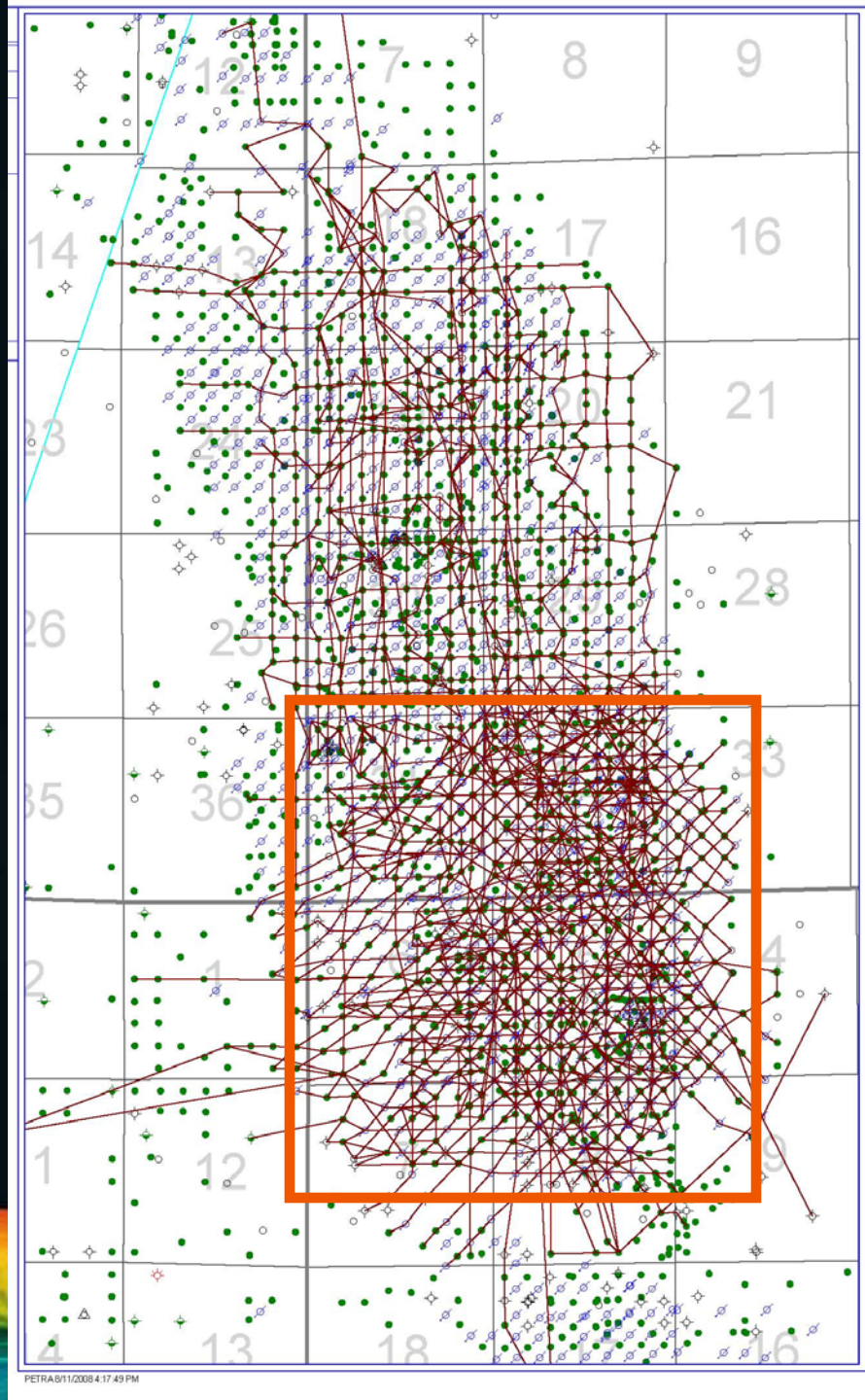
- Massive correlation project, about 6000 wells with logs of various vintages to correlate
- Lots of location problems, bad API numbers, etc. to catch and correct on the fly
- Stratigraphically complex Pennsylvanian section with several cross-cutting incised valley fill (IVF) sequences
- Marginally simpler Upper Mississippian section with good marine limestone markers, but overlapping and shingled sand bodies with internal complexities



Stratigraphic x-section grid

- NS, EW, and diagonal sections in both directions
- Mix of old and new logs because horizons look different on each
- Tight spacing between sections

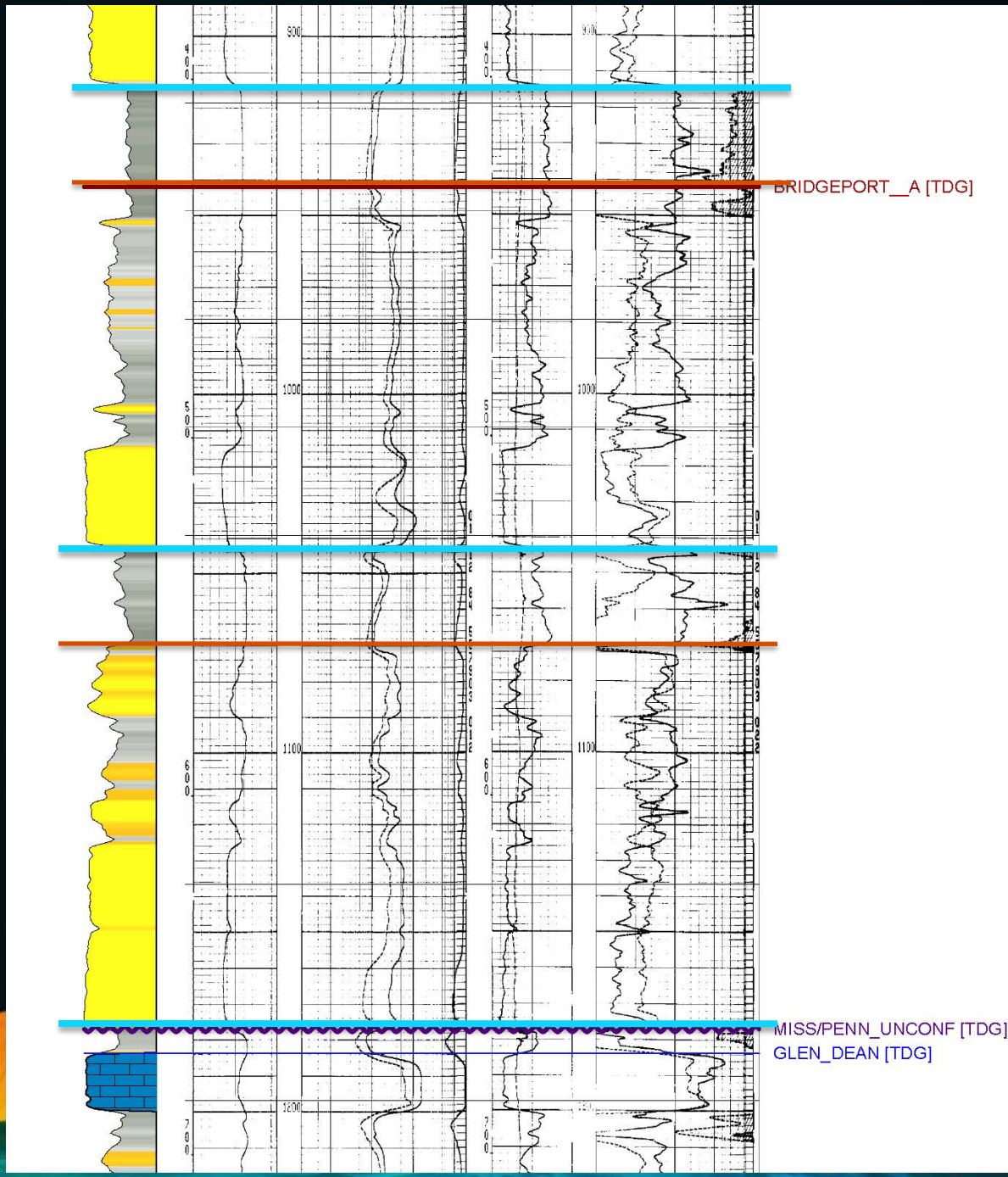




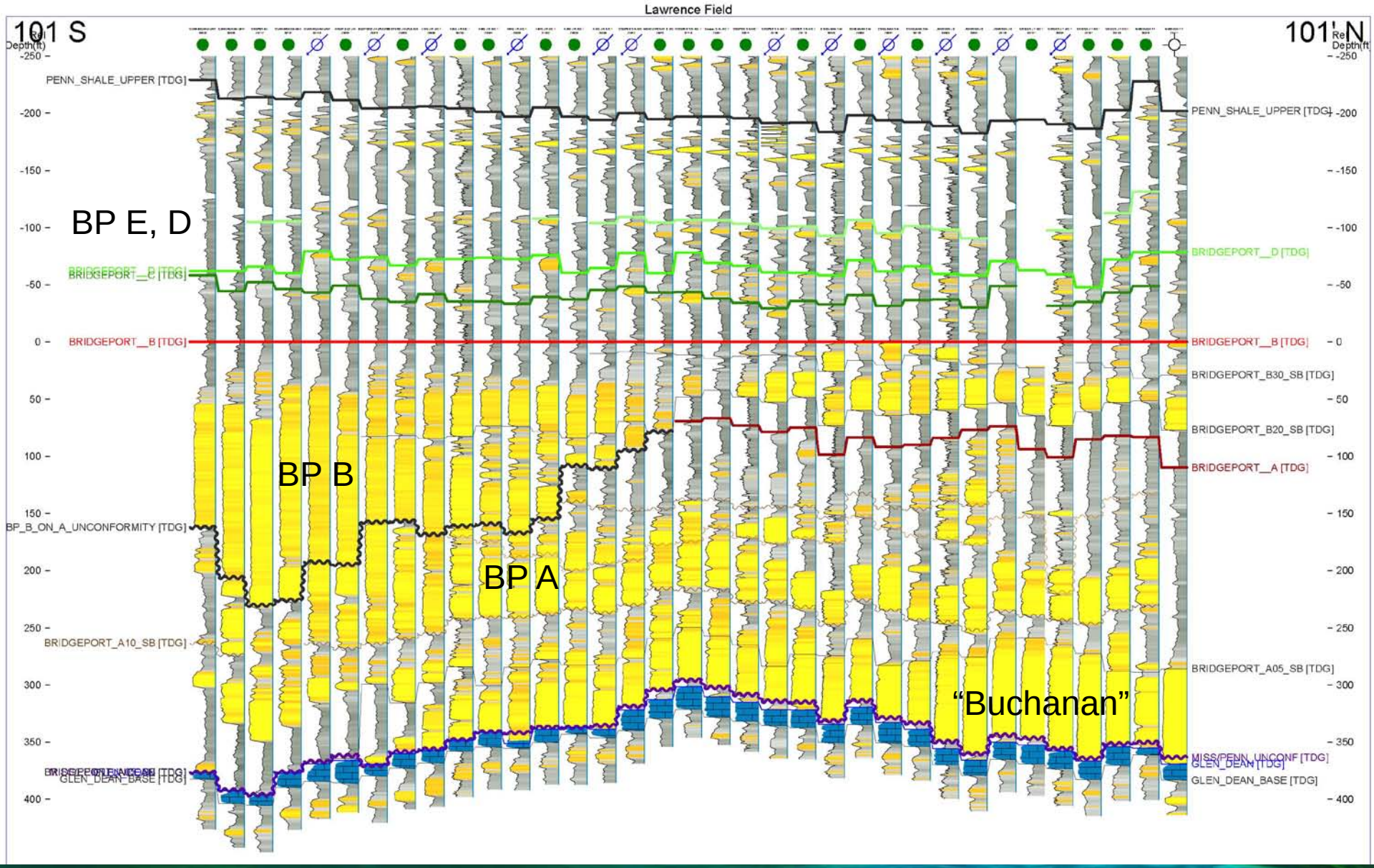
Sequence Stratigraphic Framework

flooding surfaces picked at resistivity log inflection points, usually maximum GR and maximum ϕd-ϕn separation

sequence boundaries placed at sharp bases of channel sand sections

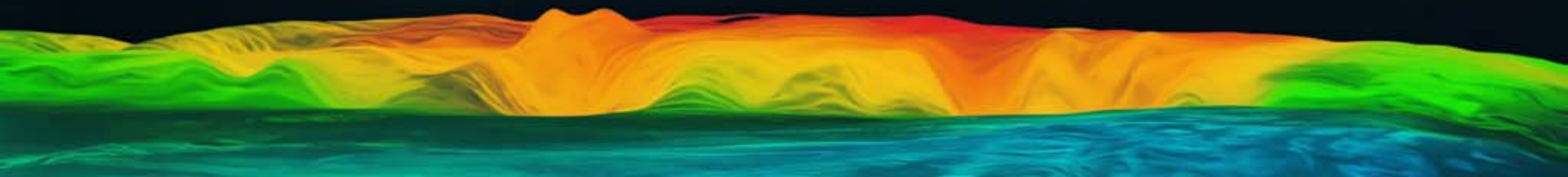


Bridgeport normalized GR section

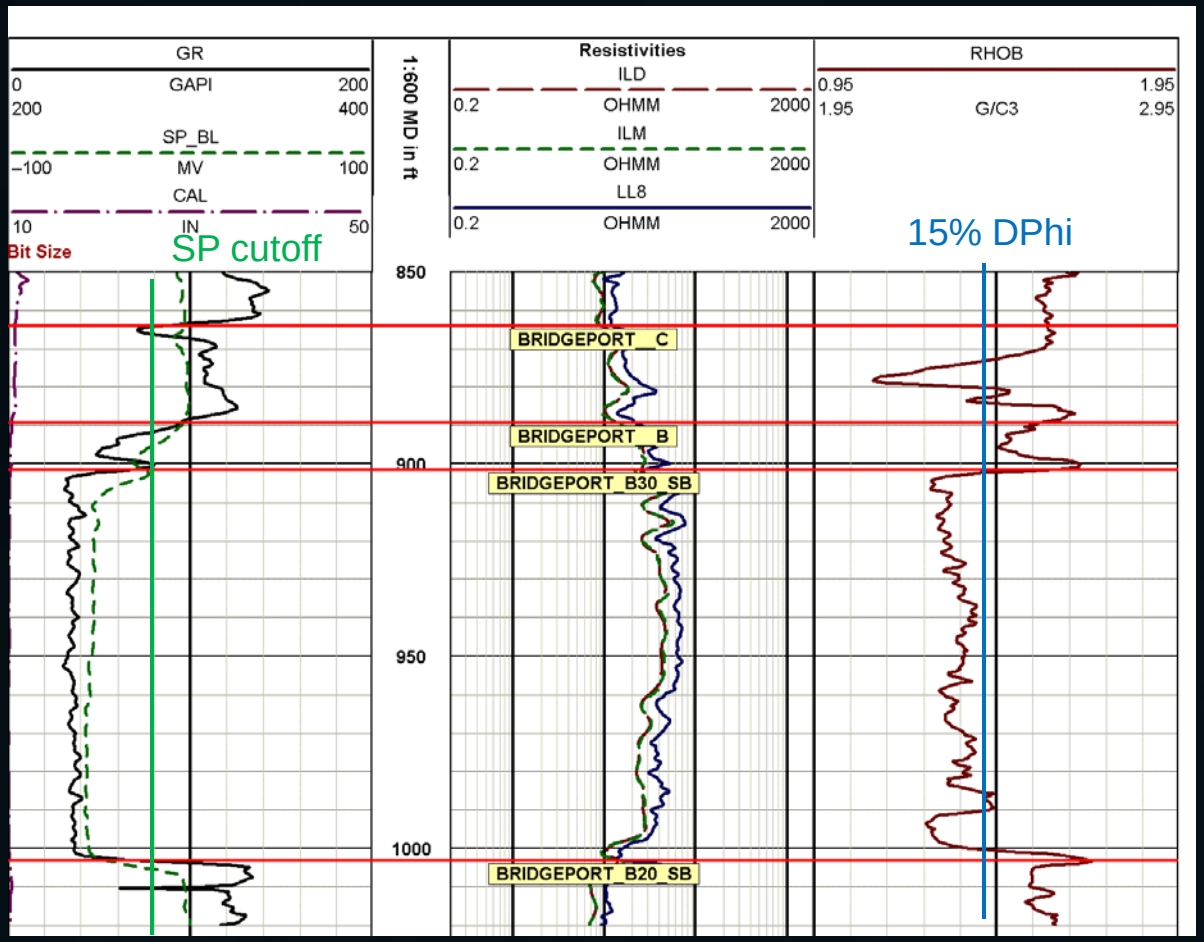


Reservoir property mapping

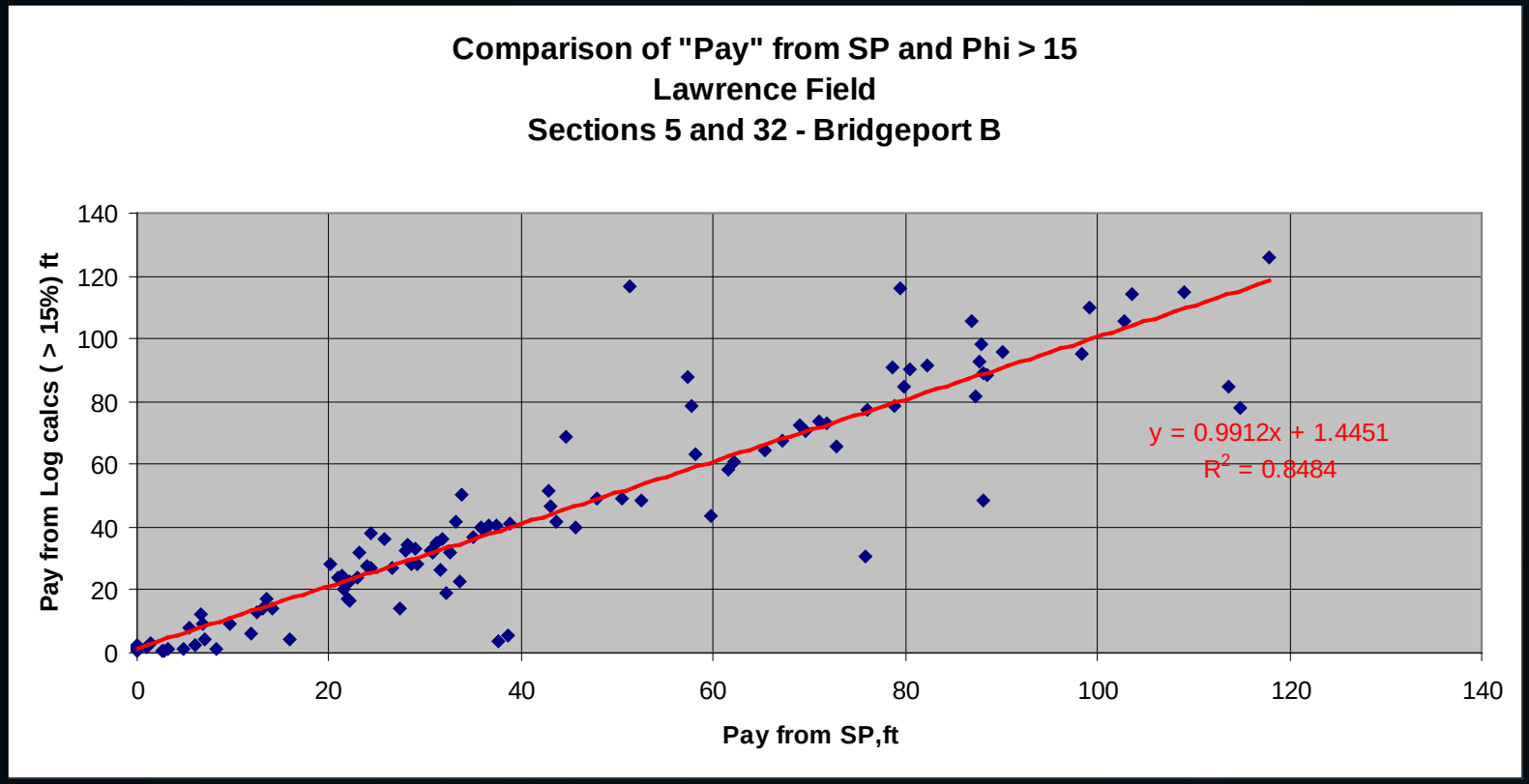
- mapped all key intervals (in 2D)
  - gross interval thickness
  - net sandstone above porosity cutoff (h)
  - average net porosity (ϕ)
  - total net pore volume (ϕ–h)
  - average net water saturation (Sw)
  - net hydrocarbon pore volume (So-ϕ–h)



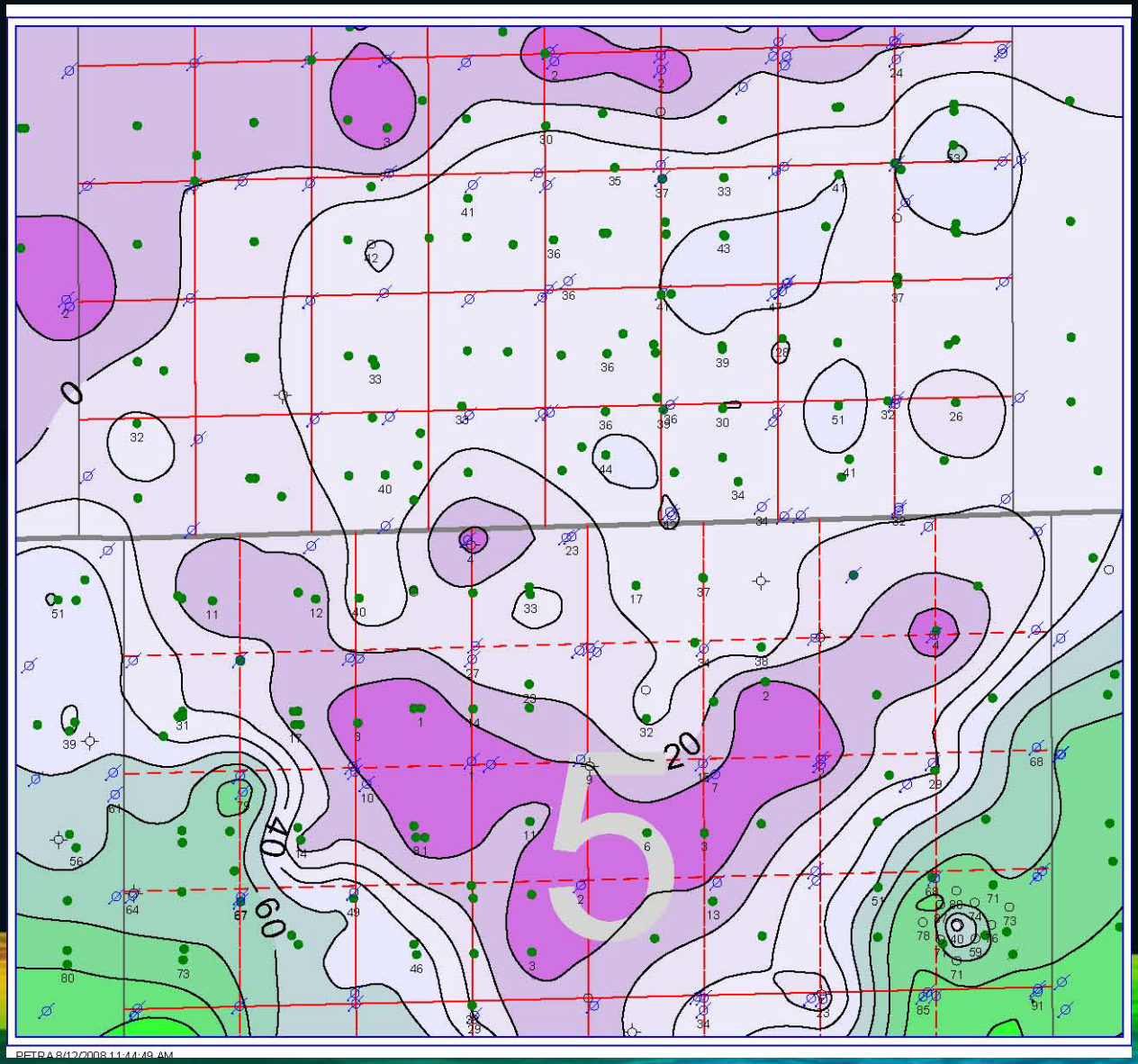
Comparison of SP and Density “Pay”



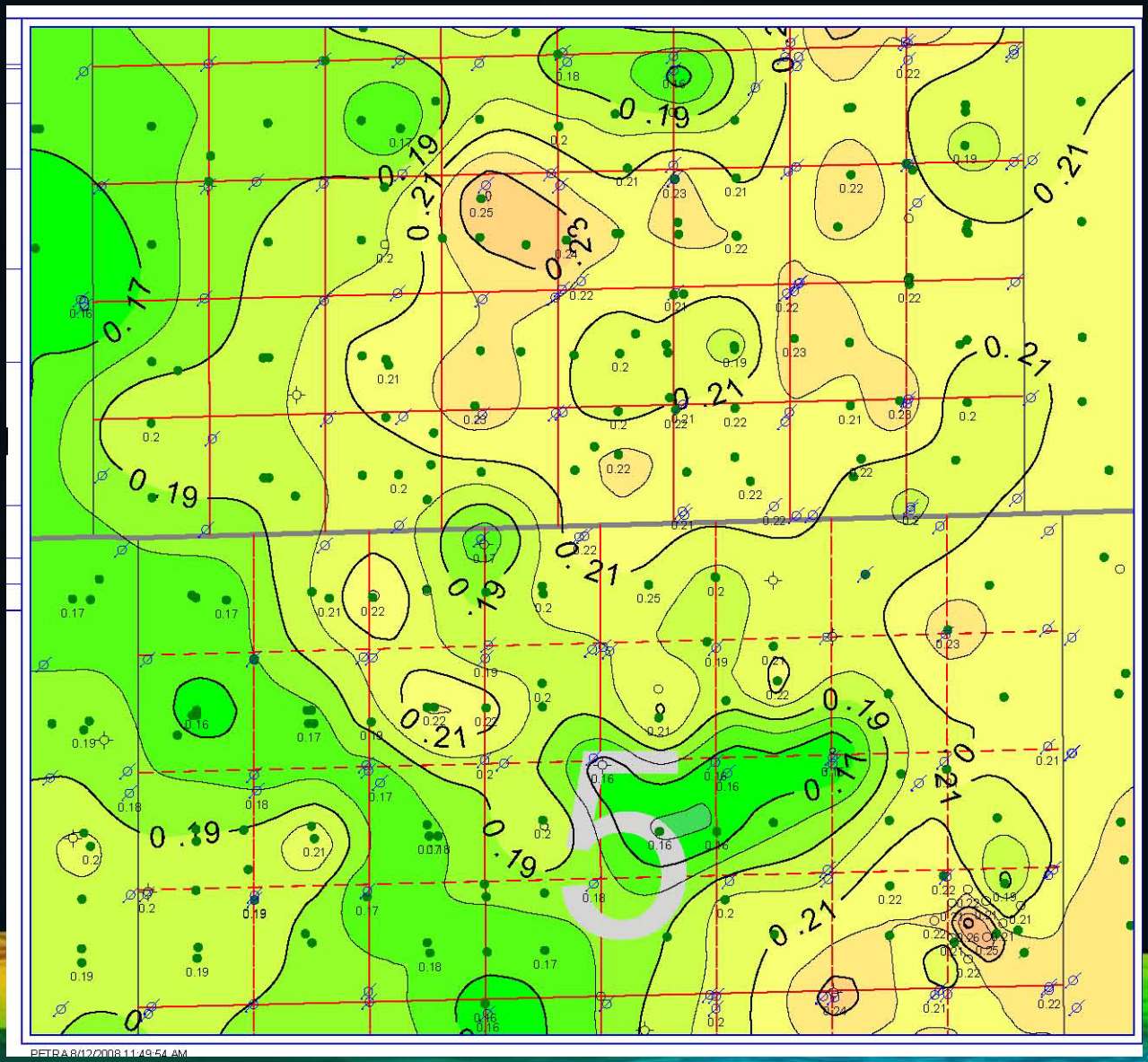
Comparison of Sand Counts



Bridgeport B Net Sand Thickness



Average Porosity



Conclusions

- Log data from various vintages needed to be normalized to be used
- If the old data is ignored, even ES logs, geological complexity would be difficult to identify
- Understanding the complex geology is essential to the success of the ASP flood