Relation of Reservoir Petrophysical Properties to Horizontal Codell Production in the DJ Basin of Colorado and Wyoming*

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Abstract

A collaborative geologic, engineering, and data mining effort has yielded insights into Codell production in the northern DJ. Data mining facilitated the access and download of over 6,500 public domain .las files for modern vertical wells in the Wattenberg/Silo corridor. Raster logs were used to supplement the .las data, net sandstone pay was picked based on a bulk density cutoff of 2.525 gm/cc, and a grid was constructed using values from over 8,000 wells. Using the top of the Codell and the base of net sandstone pay as depth limits, and an 8 - 25% density porosity calculation range (based on matrix and fluid density of 2.68 and 1.0 gm/cc, respectively), phih was computed in Petra for over 5,000 wells with .las files only, and a phih grid constructed. Both grids were "sampled" to over 900 horizontal Codell producers within the study footprint, and the assigned petrophysical values were cross-plotted against length-normalized production data. Phih correlates better than net sandstone with length-normalized production. However, both correlations vary with geographic area, and break down to some extent outside of Wattenberg Field. Normalized production in the Silo, Fairway-Brensee, and Redtail areas displays relatively poor correlation with net sandstone and phih. In contrast, the Codell horizontal production in all areas (including Wattenberg) shows a consistent, inverse, correlation with water-oil ratios from vertical and horizontal producers, suggesting an important role for thermal maturity in Codell productive potential. Cross-plots of normalized production with hydrocarbon pore volume show the best overall correlation, and support the hypothesis that thermal maturity may be a more important production driver than mechanical reservoir properties in some areas. This conclusion informs the consideration of Codell sourcing, and whether migrated portions of the play may exist. While mainly a subject for follow-on study, preliminary analysis of elemental Uranium log data (from over 300 .las files) has also been conducted for this study. The analysis outlines possible subdivision of the play

into thermal maturity categories, even within Wattenberg. The northern DJ Codell play has evolved in a very rich data environment, with respect to both geologic and engineering data. Optimization and expansion of the play will surely benefit from further analysis of this wealth of existing data.

References Cited

Domenick, M., 2016, Relation of Reservoir Petrophysical Properties to Horizontal Codell Production in the DJ Basin of CO and WY: Rocky Mountain Association of Geologists Fall "Hot Plays" Symposium, Denver, CO.

Lewis, R.K., 2013, Stratigraphy and Depositional Environments of the Late Cretaceous (Late Turonian) Codell Sandstone and Juana Lopez Members of the Carlile Shale, Southeast Colorado: M.S. Thesis, Colorado School of Mines, Golden, CO, 190 p.

Weimer, R.J., 1986, Relationship of Unconformities, Tectonics, and Sea-Level Change in Cretaceous Western Interior, U.S.: American Association of Petroleum Geologists Memoir 36, p. 7-35.

Relation of

Reservoir Petrophysical Properties

to

Horizontal Codell Production

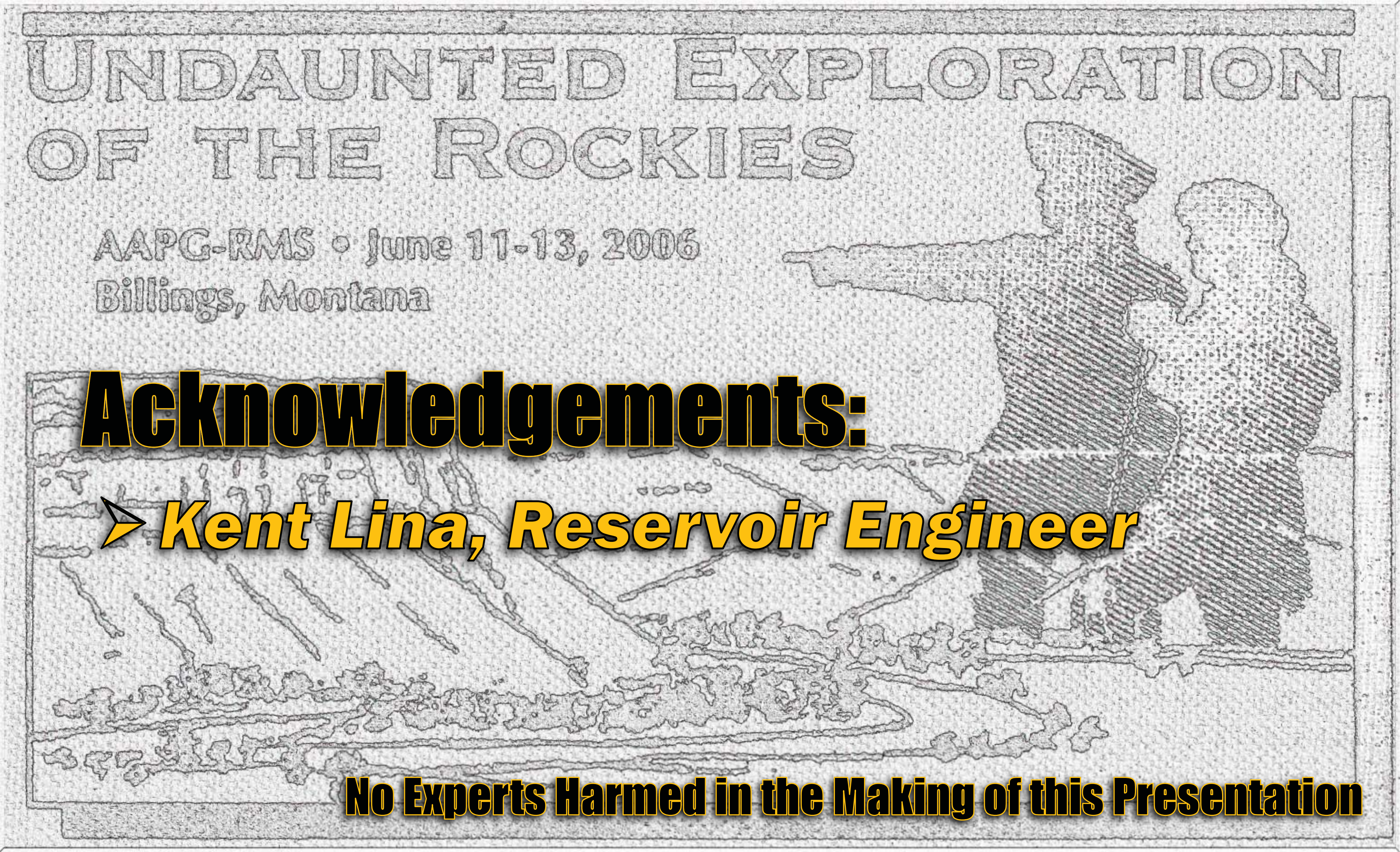
in the

DJ Basin of CO and WY

AAPG-RMS, 26 June 2017, Billings

Mick Domenick, Slick Oil Limited

Wheat Ridge, Colorado



Acknowledgements:

- *Kent Lina, Reservoir Engineer*

No Experts Harmed in the Making of this Presentation

Discussion Outline:

1. Codell Background and Production Metrics
2. Study Methodology
3. Results and Conclusions
4. Local Example

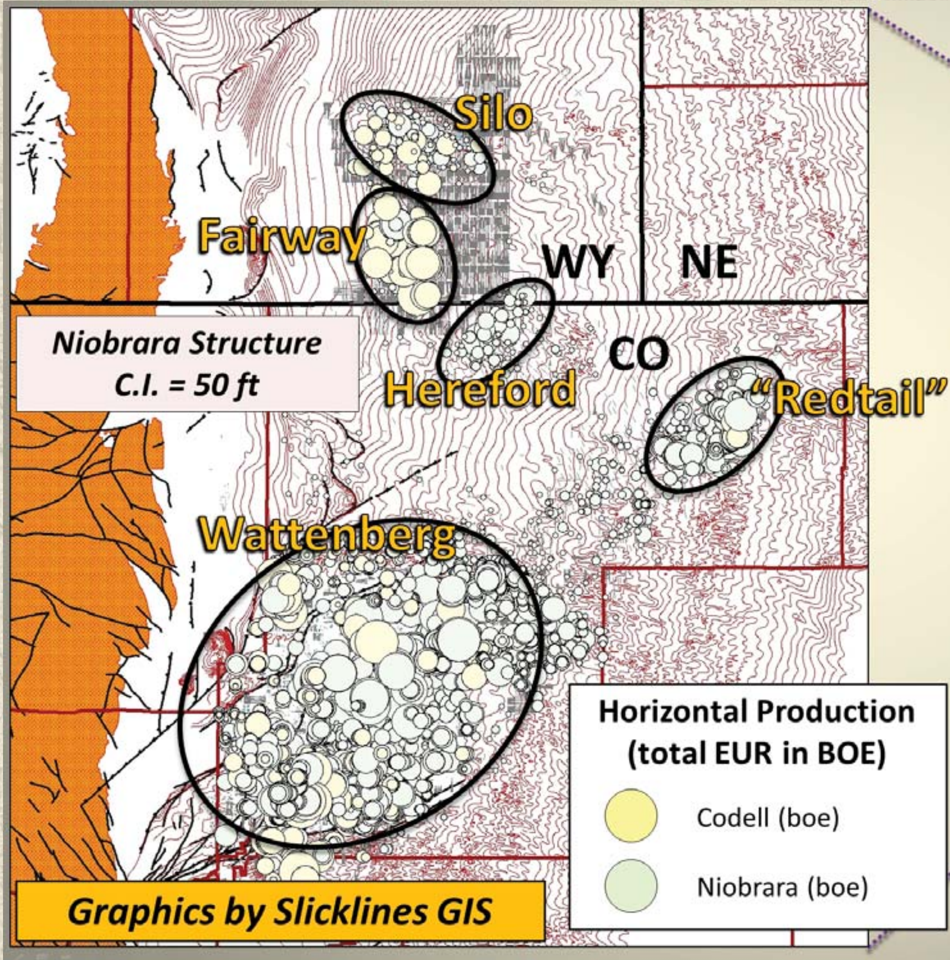
from Domenick "Hot Play" Symposium Presentation, September 2016

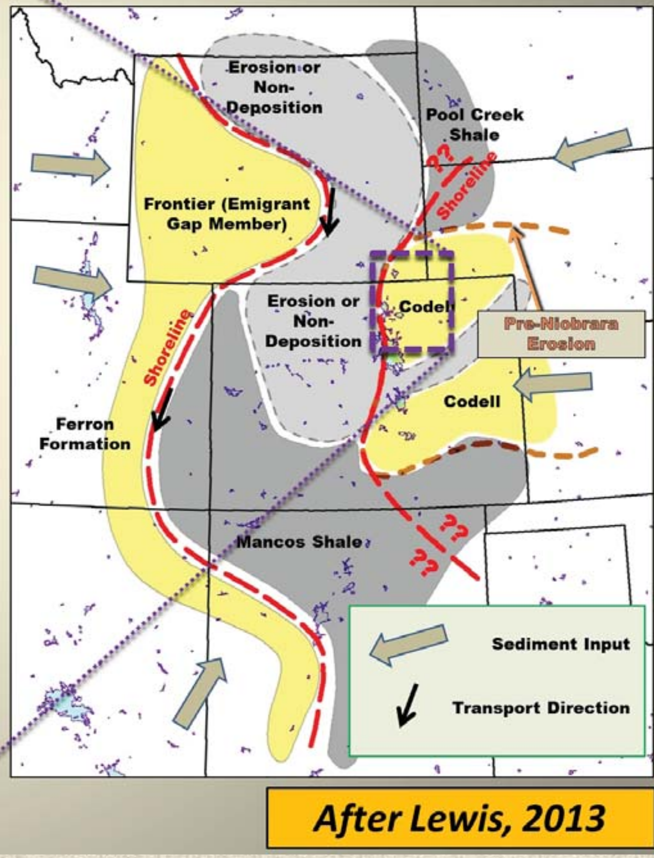
Codell Background

and

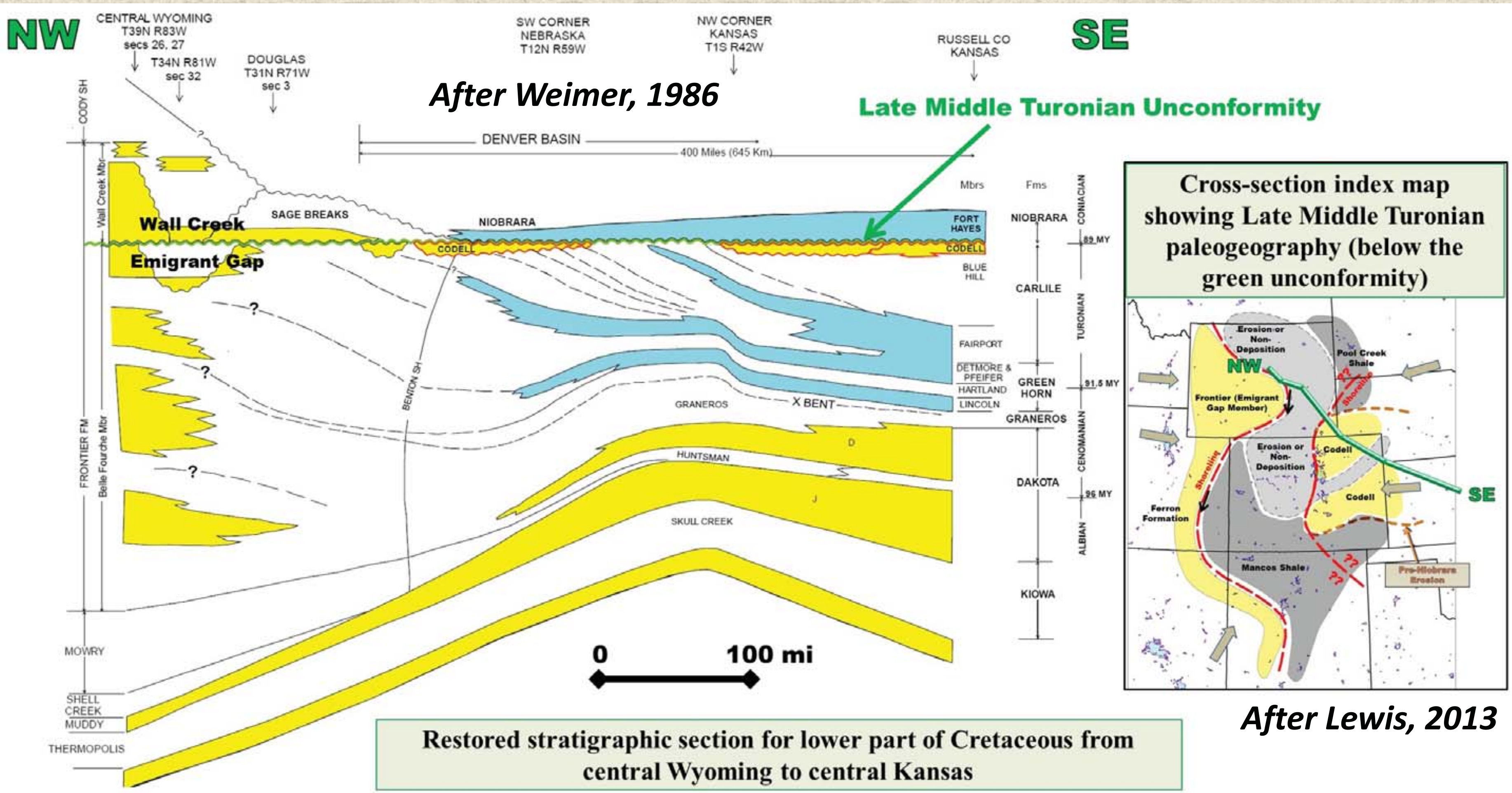
Production Metrics

“Codell” in 5 Producing Areas . . .



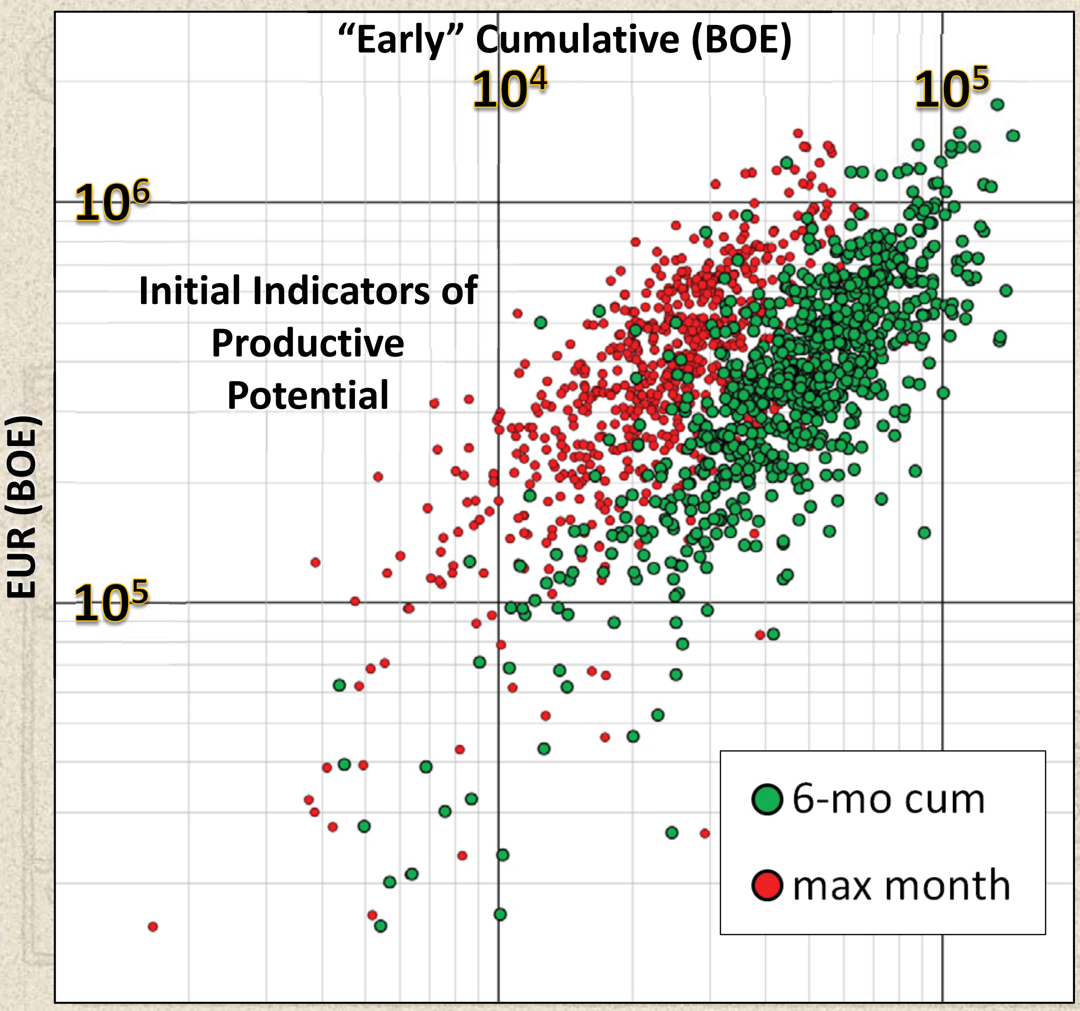


Regional Stratigraphy



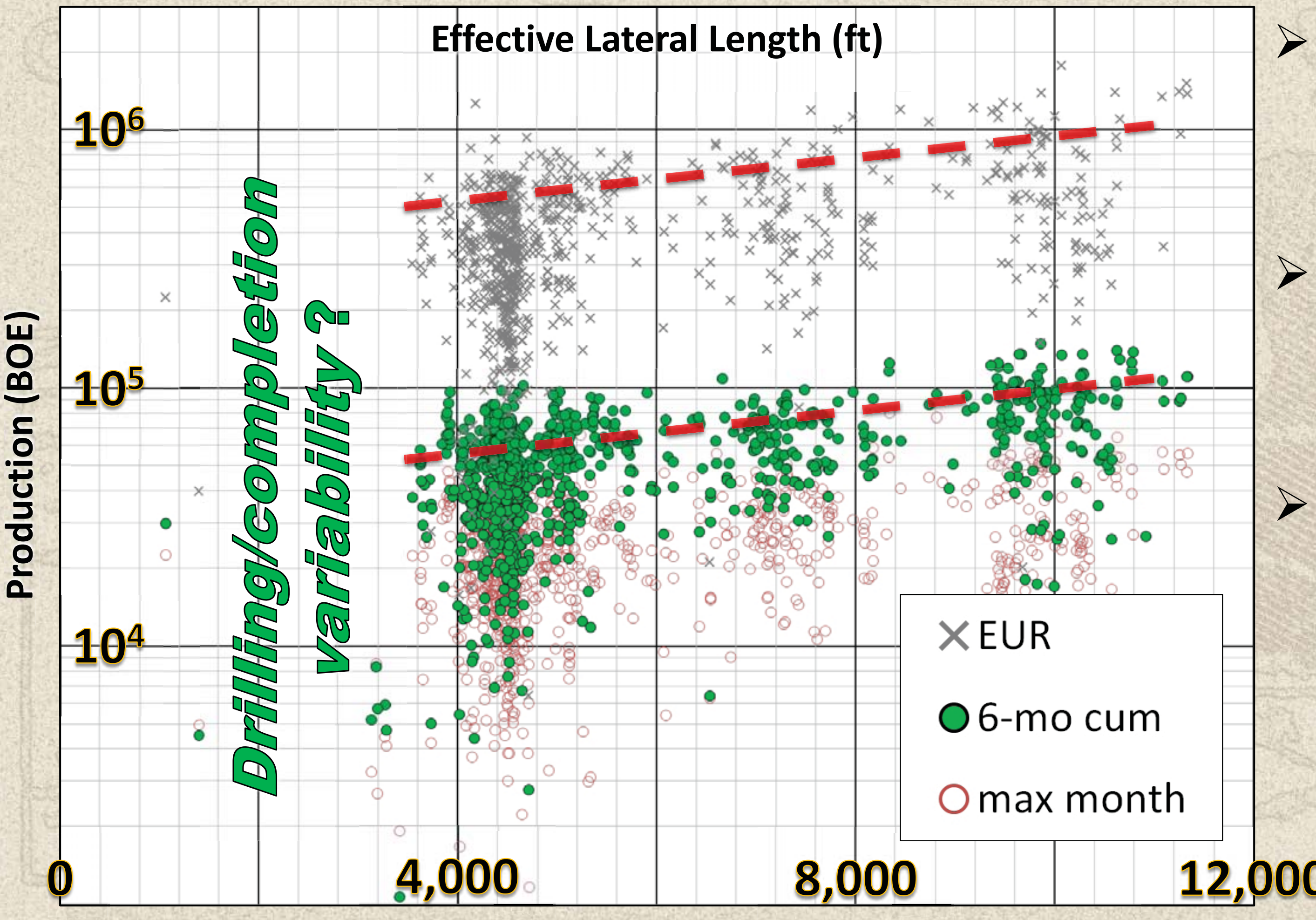
Restored stratigraphic section for lower part of Cretaceous from central Wyoming to central Kansas

Production Metrics



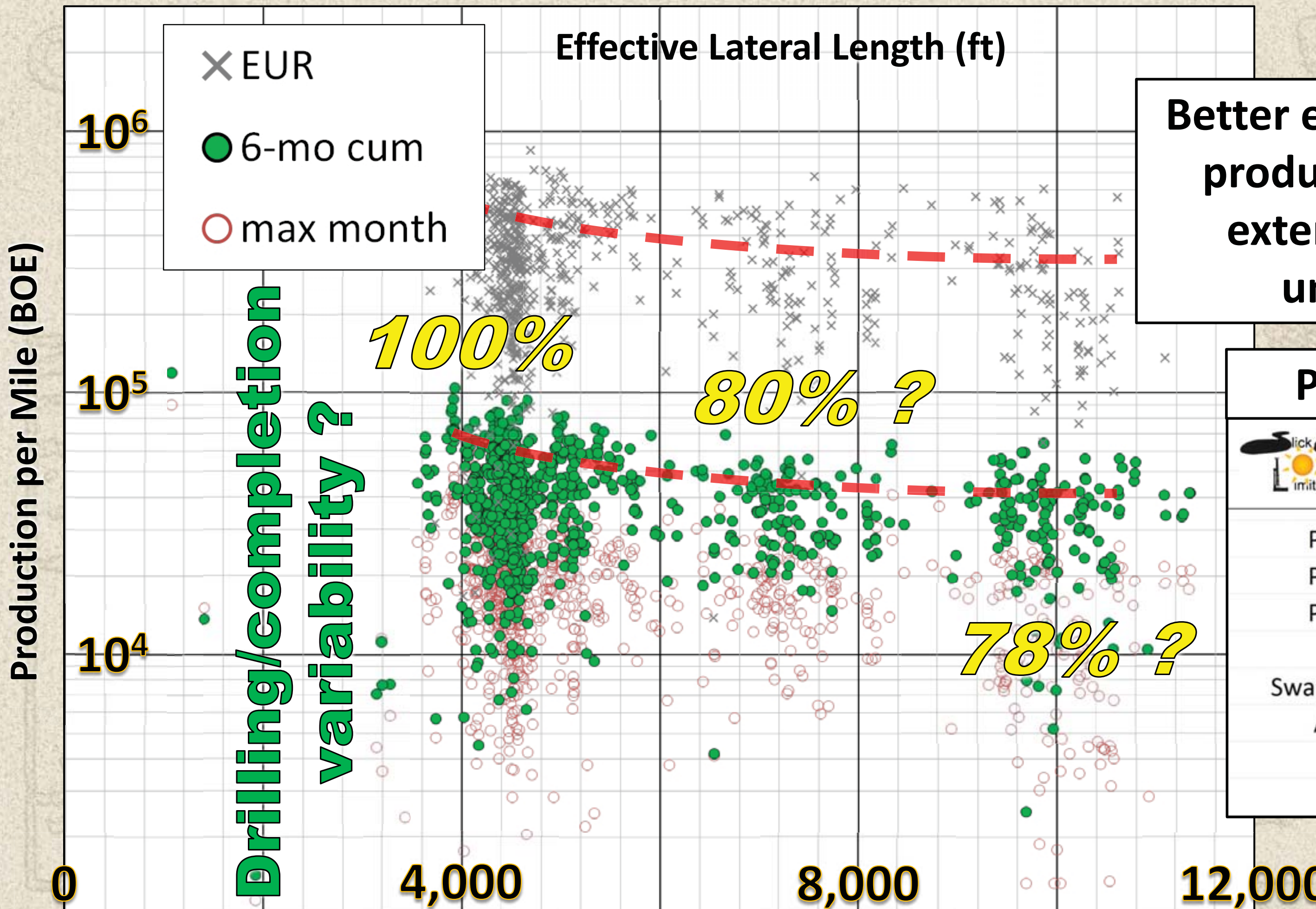
- EURs calculated for ~800 Codell horizontal producers (thanks Kent) and compared to early production
- Differences in reporting, and constraint of early production at wellhead, limit the utility of maximum month data
- **<u>6-month cumulative</u>** (BOE) data show a good log-normal correlation with calculated EURs (BOE)

Production v Lateral Length



- Adequate data over a wide range of lateral lengths
- EURs of ***1 million*** boe not un-common for 2-mile laterals
- Production increases with lateral length on a semi-logarithmic basis

Norm Production v Lat Length



Better economics, but lower production efficiency for extended laterals on a unit-length basis

Prob Distribution

	Codell EUR	
	Mboe	Mboe/mile
P10 =	713	562
P50 =	375	329
P90 =	152	141
Swanson	423	343
Arith	413	343
n =	820	820

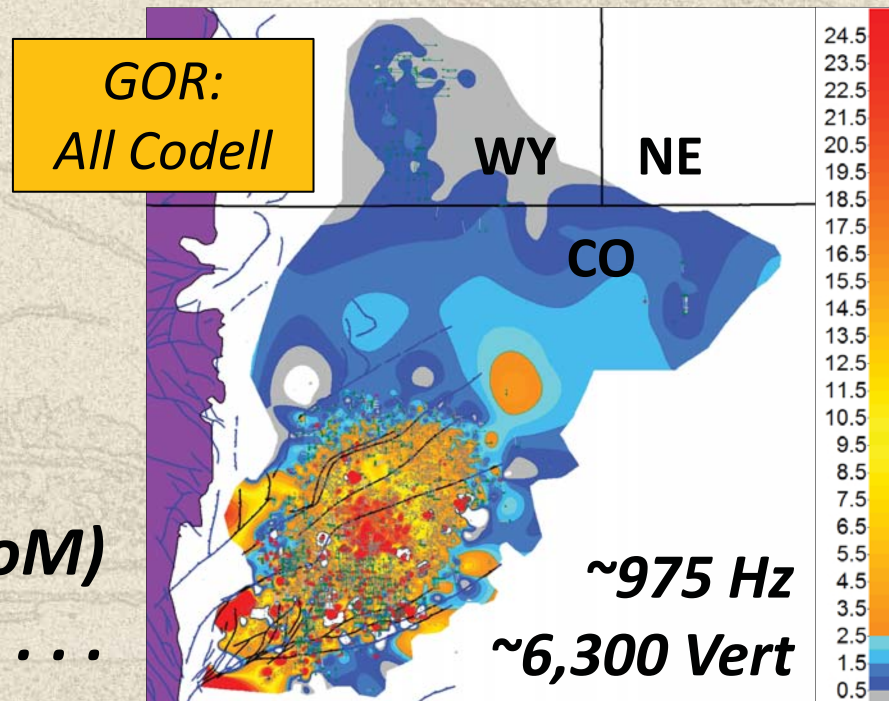
Study Methodology

$$Dpor = \frac{(RhoM - RhoB)}{(RhoM - RhoF)}$$

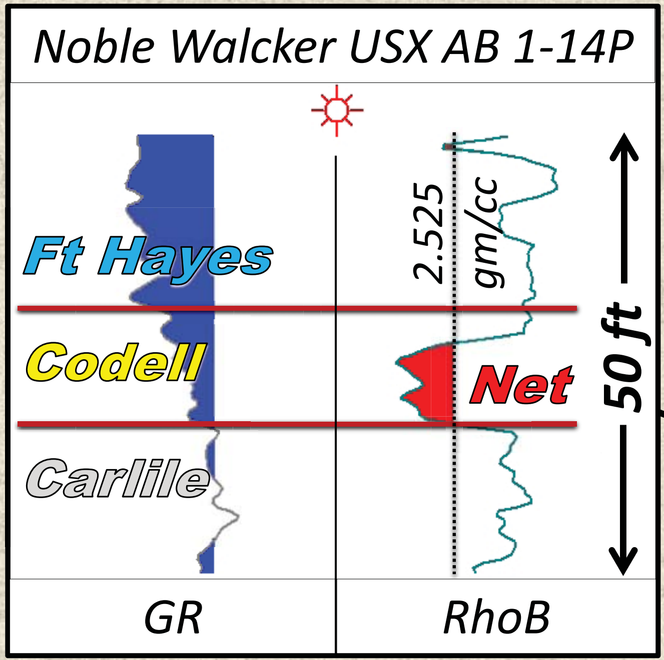
Assume:

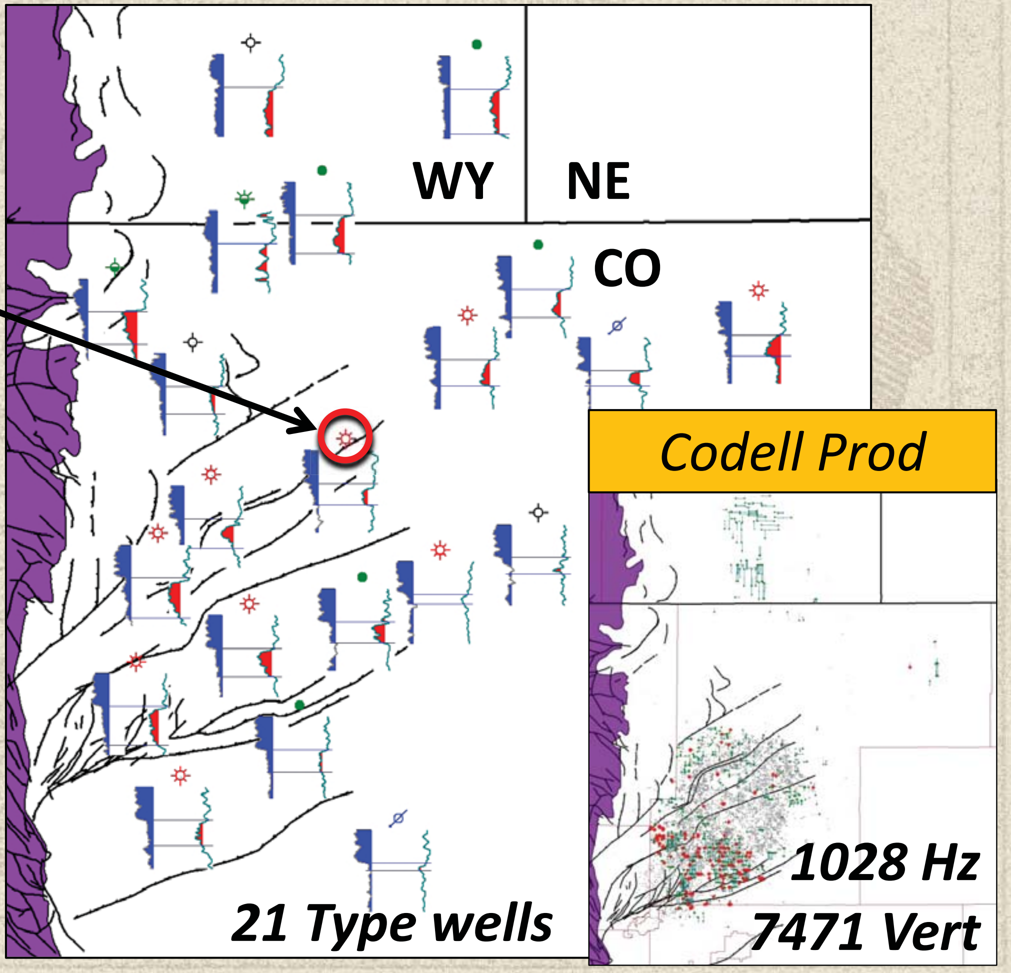
- *RhoM = 2.68*
- *RhoF = 1.00*

CAVEAT EMPTOR: RhoF (and RhoM) vary across study area . . .



Type Wells





- **Don't include Carlile carbonate or shale**
- **Beware fractures, mainly in Carlile**
- **Use mineralogic and lithologic indicators**

Net Sandstone Distribution

Dpor = 9.2%

(RhoB = 2.525)

(RhoM = 2.68)

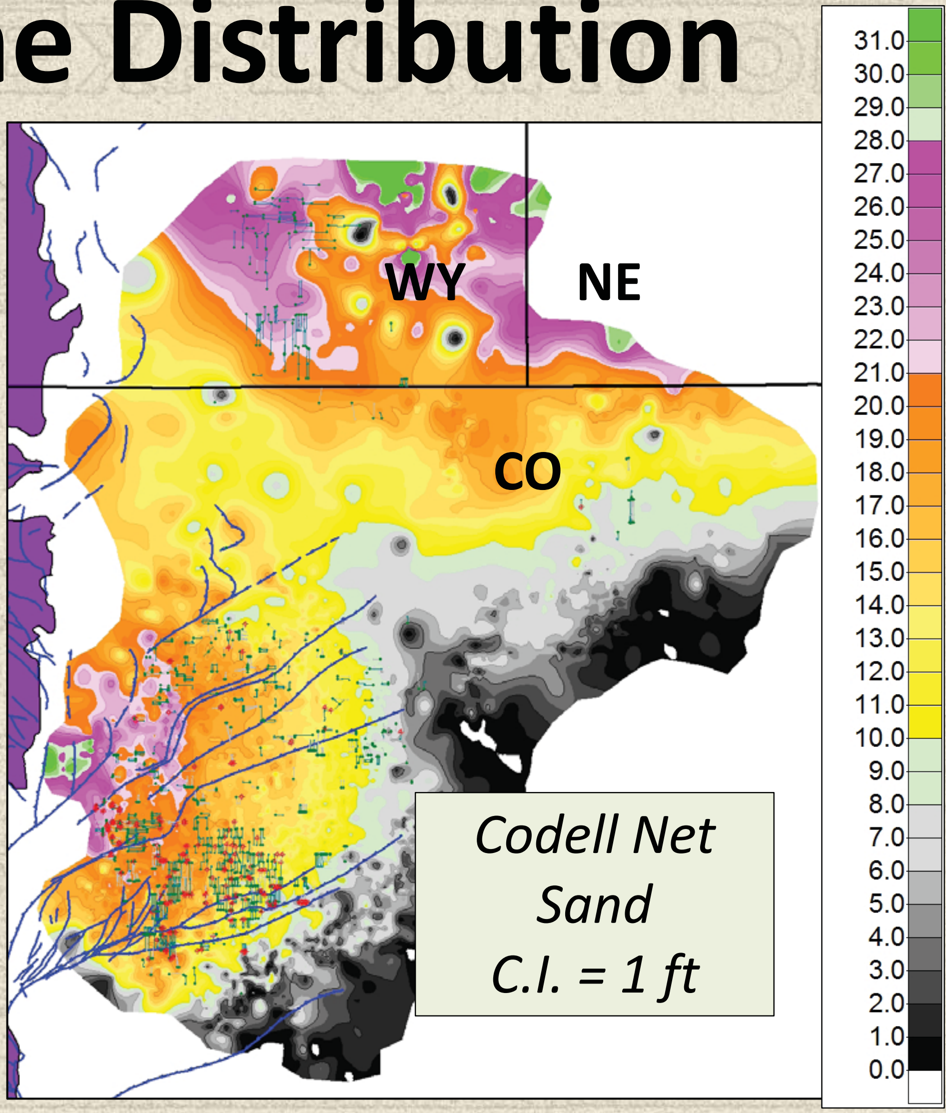
(RhoF = 1.00)

Net Sand picked in

~ 8,500 vertical wells

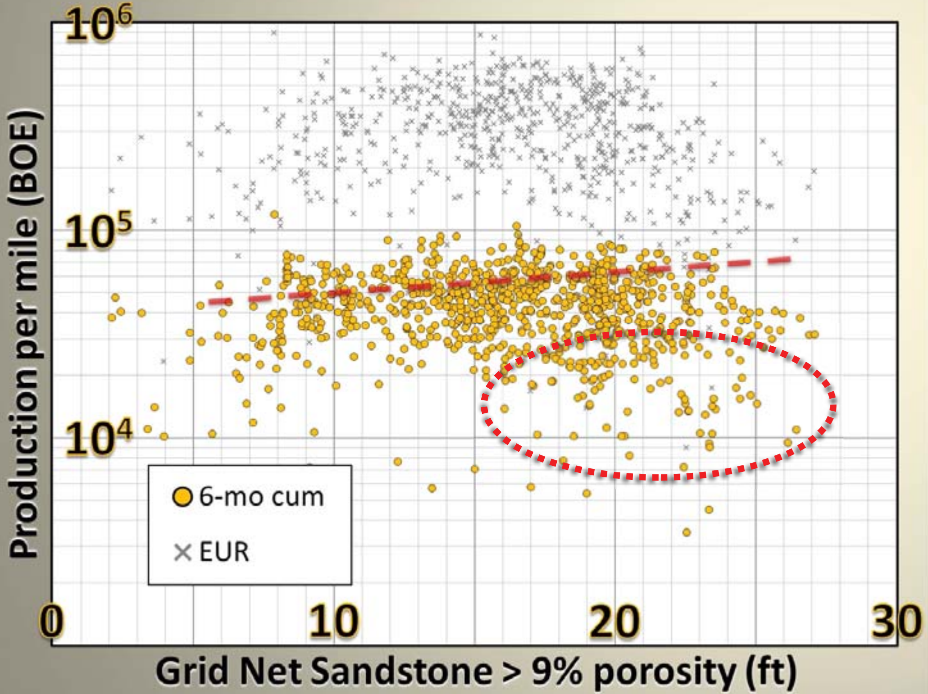
6,000 LAS files

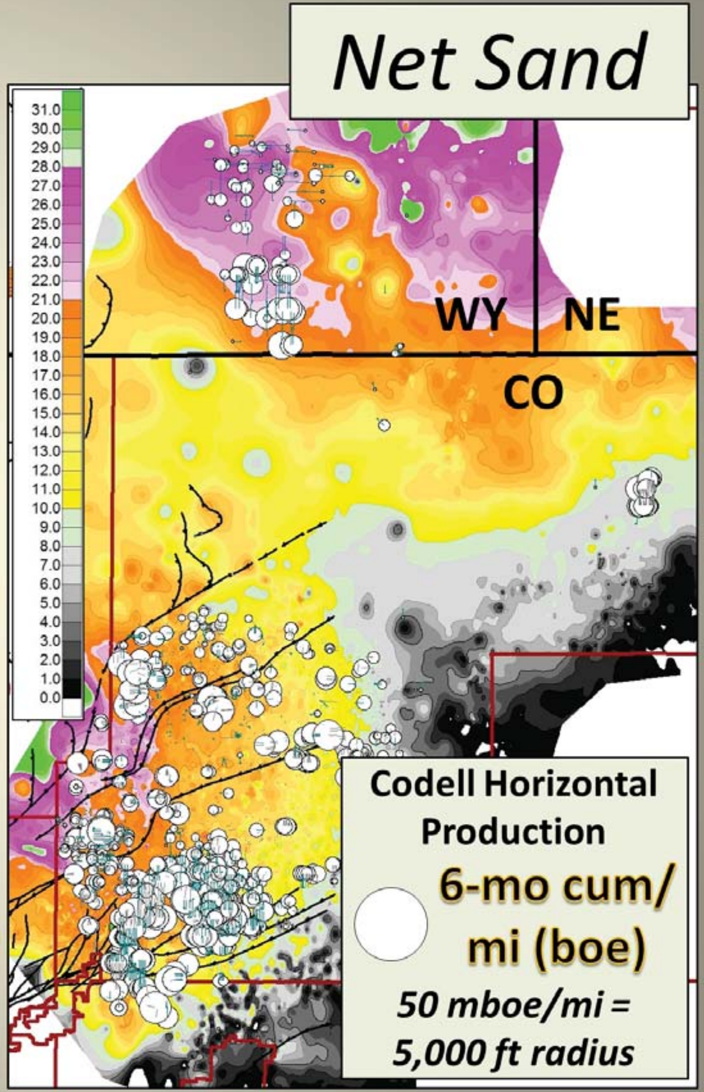
2,500 Rasters



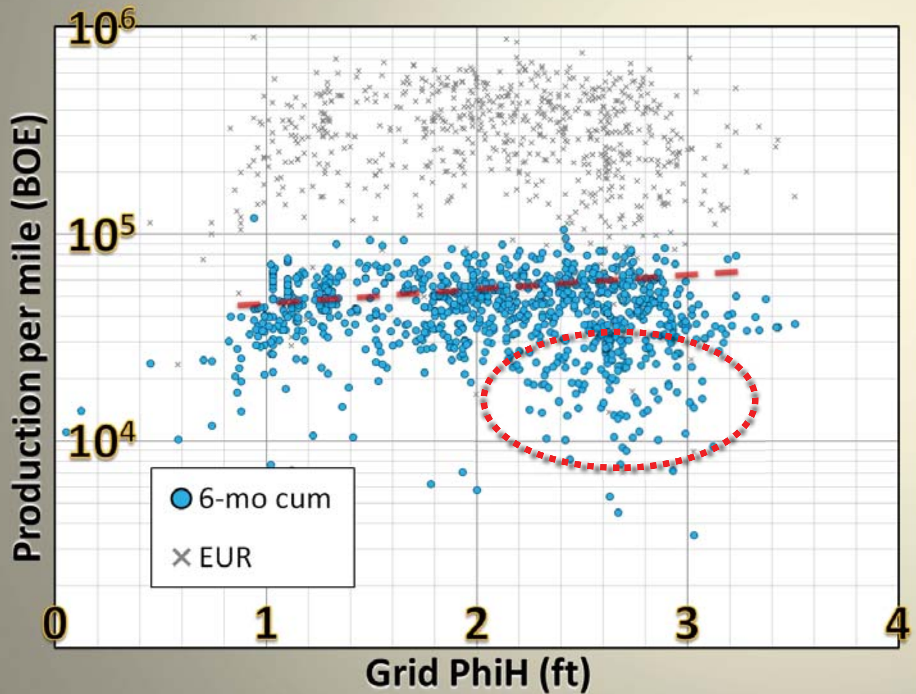
Results

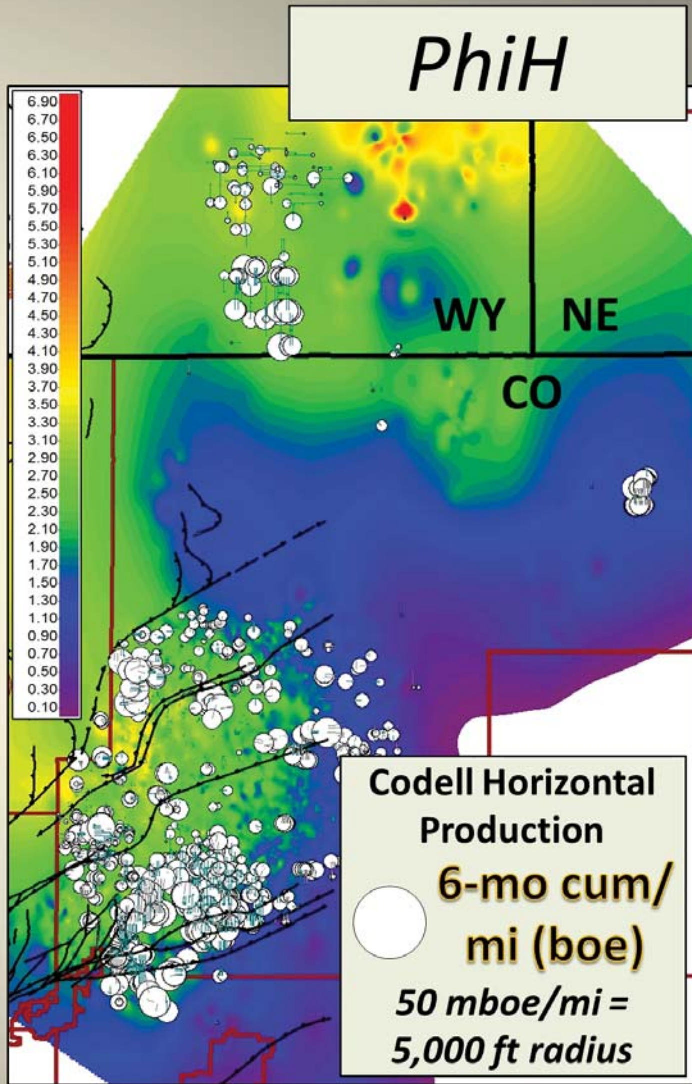
Sampled Net Sand Grid to ~900 Hz Codell Wells with Known Lateral Length:



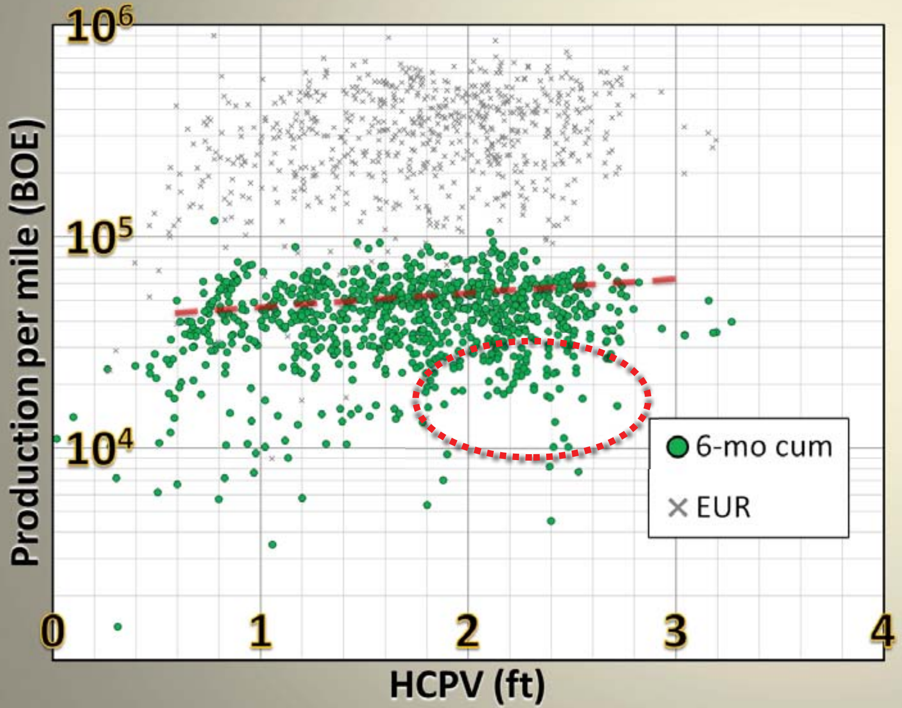


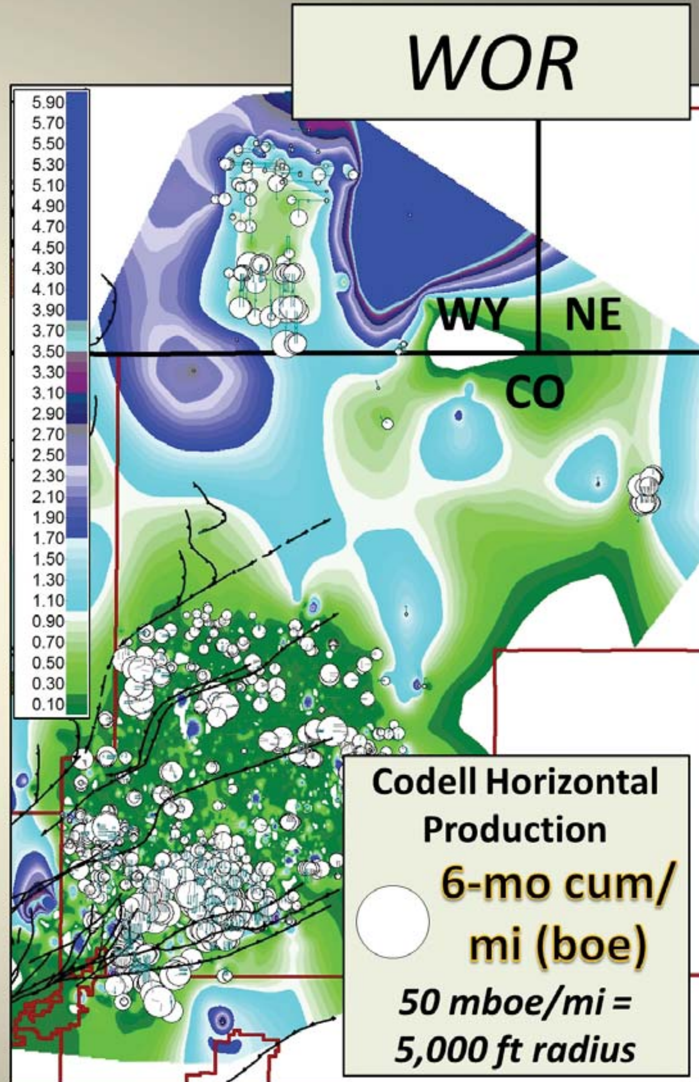
PhiH calculated for 5,200 wells, grid sampled to Codell horizontals:



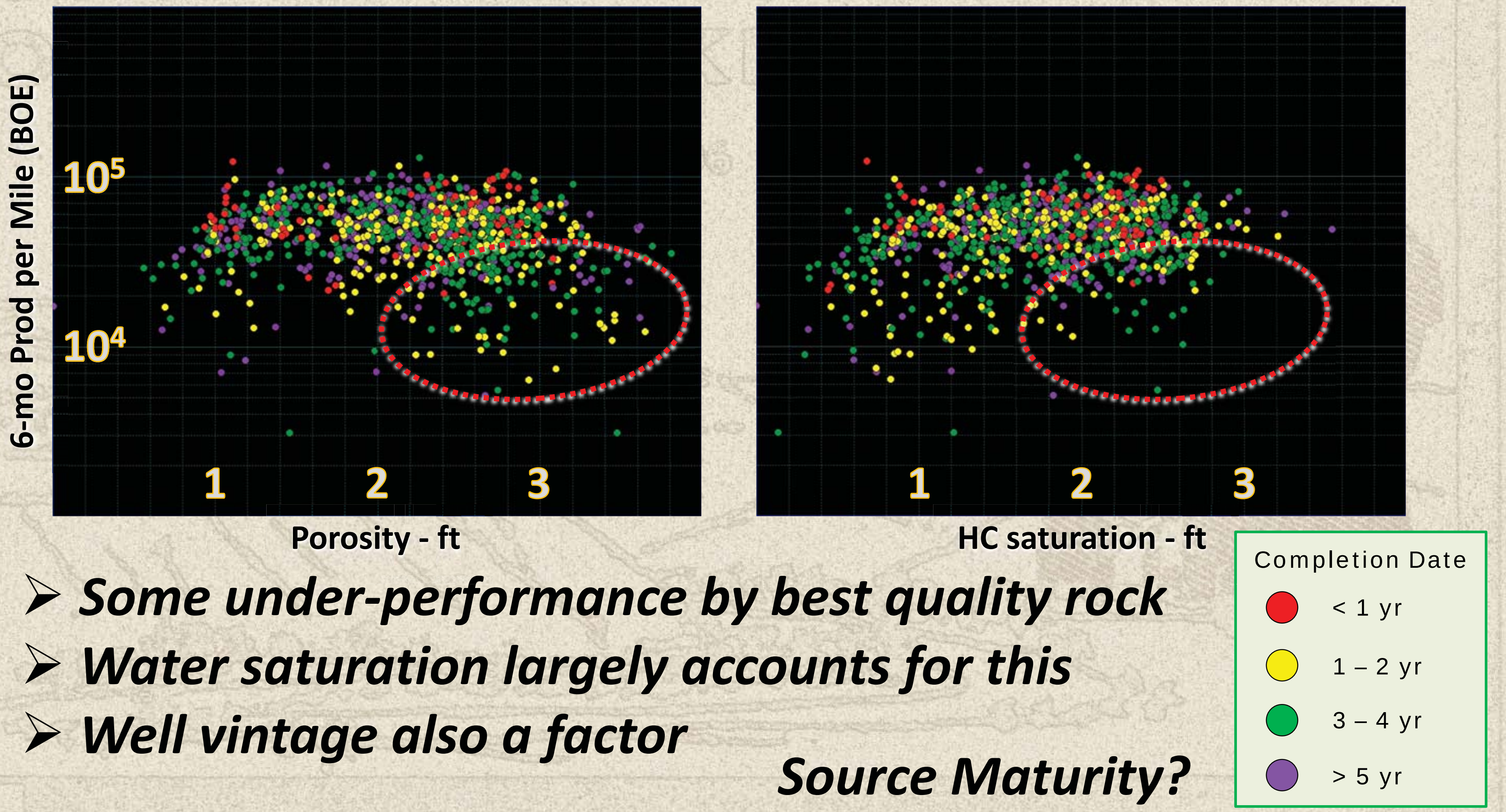


Codell WOR mapped, HCPV calculated using hz well So and grid PhiH:





PhiH and HCPV



- ***Some under-performance by best quality rock***
- ***Water saturation largely accounts for this***
- ***Well vintage also a factor***

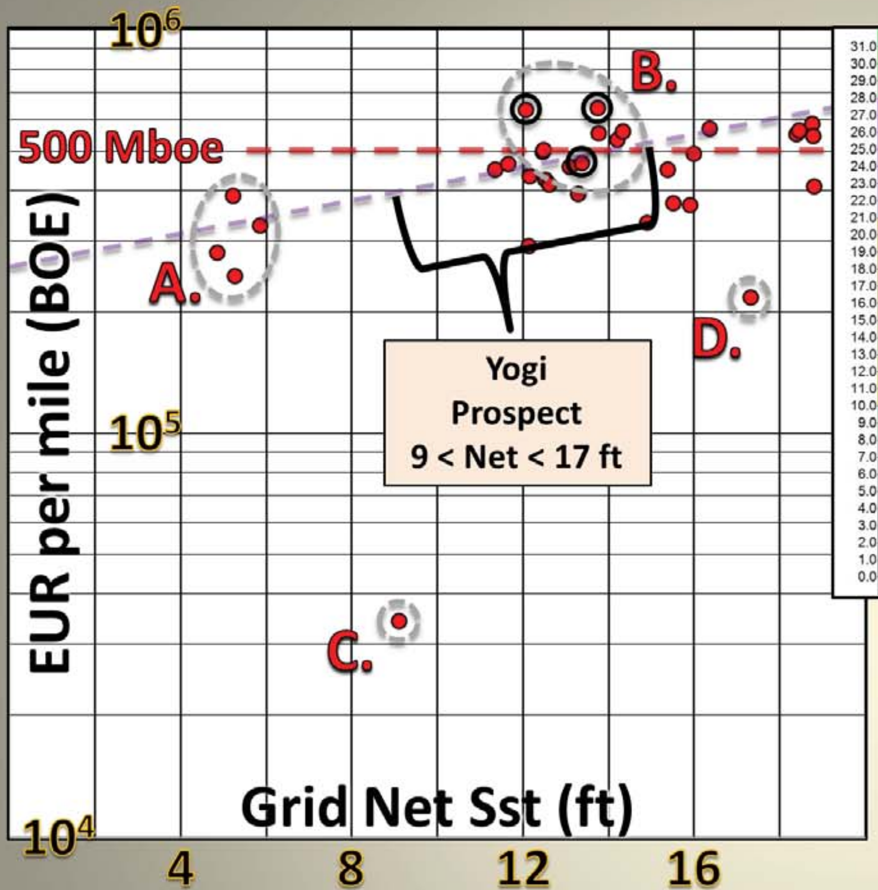
Source Maturity?

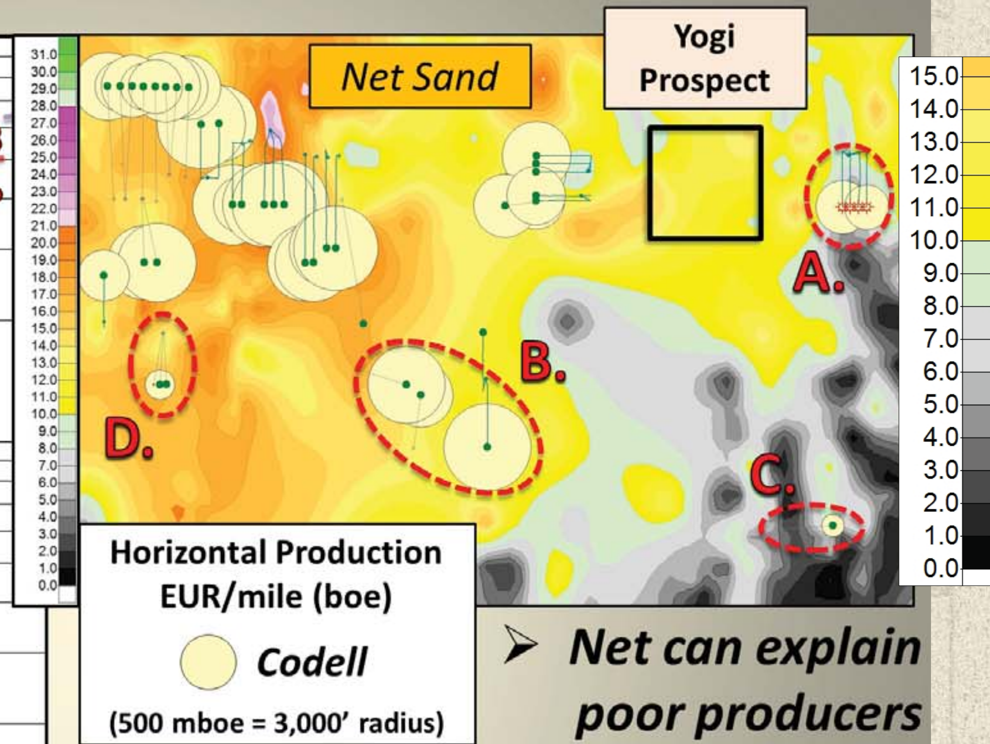
Undaunted Exploration of the Rockies

AAPG-RMS • June 11-13, 2006
Billings, Montana

Yogi’s Conclusion:

6 Slices, or 8 ?





- *Net can explain poor producers*
- *Anticipate 400 to 500+ Mboe/mile – Million boe extended laterals!!!*

"Yogi" Prospect (__Hypothetical__ Prospect/__Real__ Wattenberg)

EUR/mile versus Net Sandstone (37 Wells Plotted)

“90% of this game is half-mental”

Rock Quality has Anticipated Effect on Production

How Do We Best Assess Effects of Source Maturity and Area HCPV ?

THINK GLOBALLY, ACT LOCALLY, and Stay Tuned for PART 2