Status of SPEE Monograph 4—Estimating Developed Reserves in Unconventional Reservoirs

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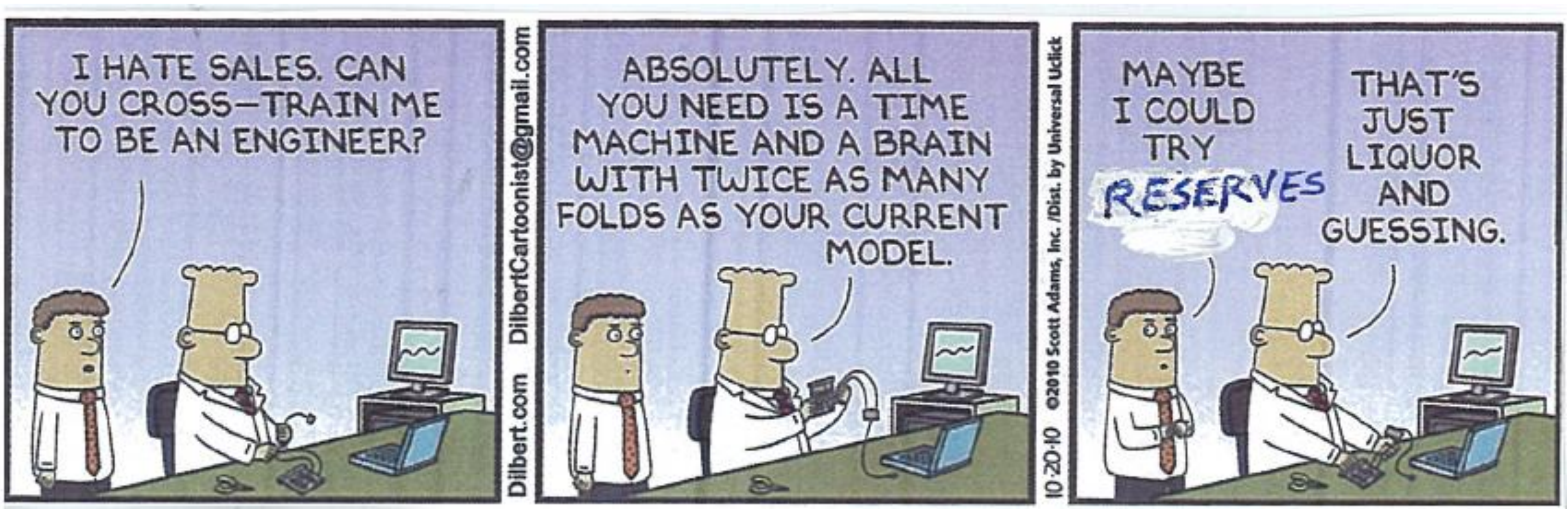
Denver SPEE Chapter Luncheon
8 January 2014


I HATE SALES. CAN YOU CROSS–TRAIN ME TO BE AN ENGINEER?
Dilbert.com DilbertCartoonist@gmail.com
ABSOLUTELY. ALL YOU NEED IS A TIME MACHINE AND A BRAIN WITH TWICE AS MANY FOLDS AS YOUR CURRENT MODEL.
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MAYBE I COULD TRY RESERVES
THAT'S JUST LIQUOR AND GUESSING.

SPEE Monograph 4 -- Committee Members

Jim Erdle (CMG)

Creties Jenkins (Rose & Associates)

John Lee (SPEE, Univ of Houston)

Casey O'Shea (IHS/Fekete)

John Ritter (SPEE, Occidental Petroleum)

John Seidle (SPEE, MHA Petroleum Consultants)

Darla-Jean Weatherford (TextRight, technical editor)

Scott Wilson (SPEE, Ryder Scott)

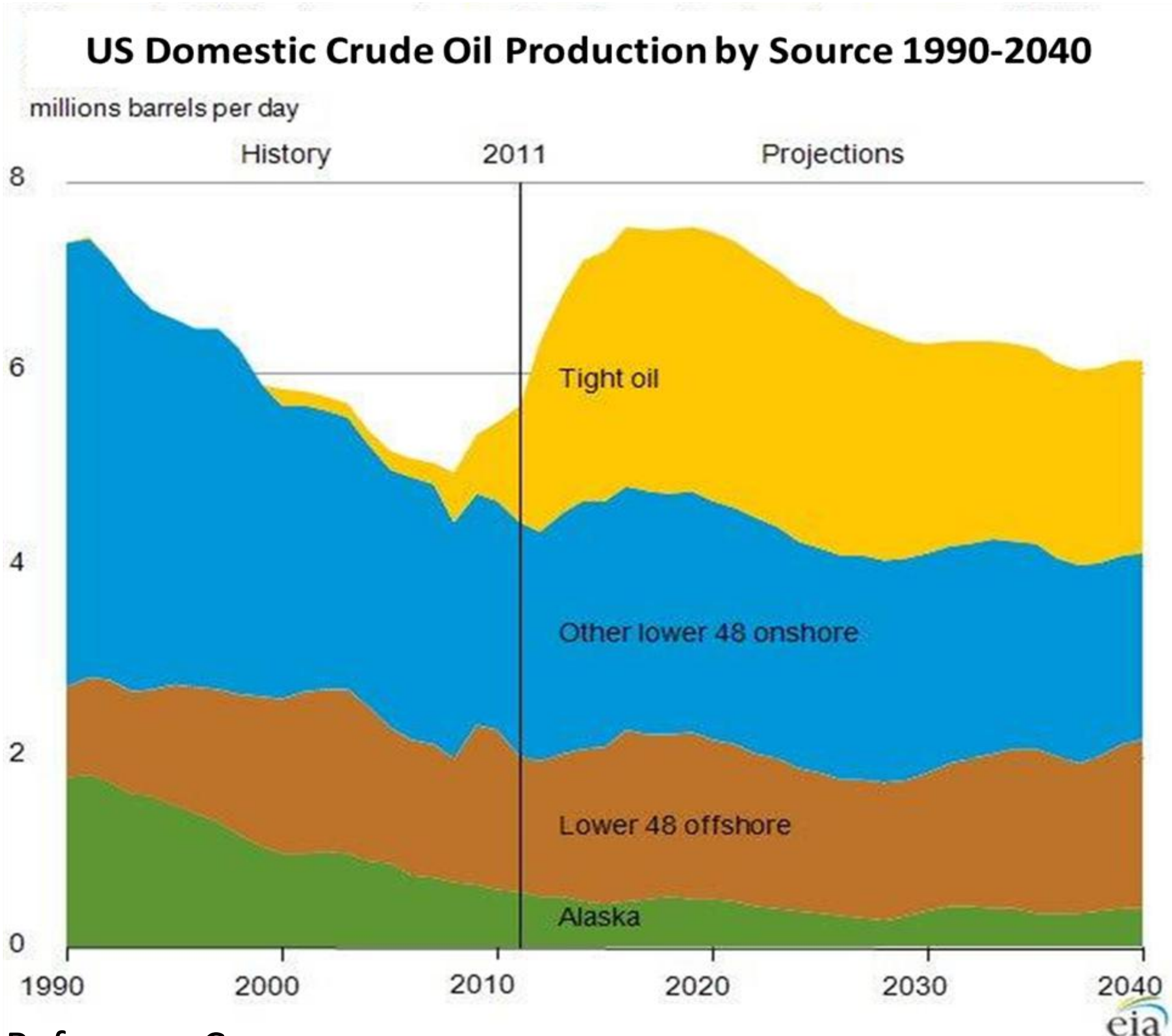
SPEE Monograph 4 -- Outline

1. Definition of Unconventional Reservoirs (UCR)
2. Reservoir Characterization Aspects of Estimating Developed Reserves in UCR’s
3. Drilling , Completions, and Operational Aspects of Estimating Developed Reserves in UCR’s
4. Classical Arps’ Decline Curve Analysis (DCA)
5. Fluid Flow Theory & Alternative Decline Curve Methods
6. Analytical Models
7. Modern Performance Analysis
8. Discretized Models
9. Probabilistic Methods and Uncertainty in Forecasts and Estimated Ultimate Recovery
10. Summary of Current Technology and Expected Future Trends

SPEE Monograph 4 -- Timeline

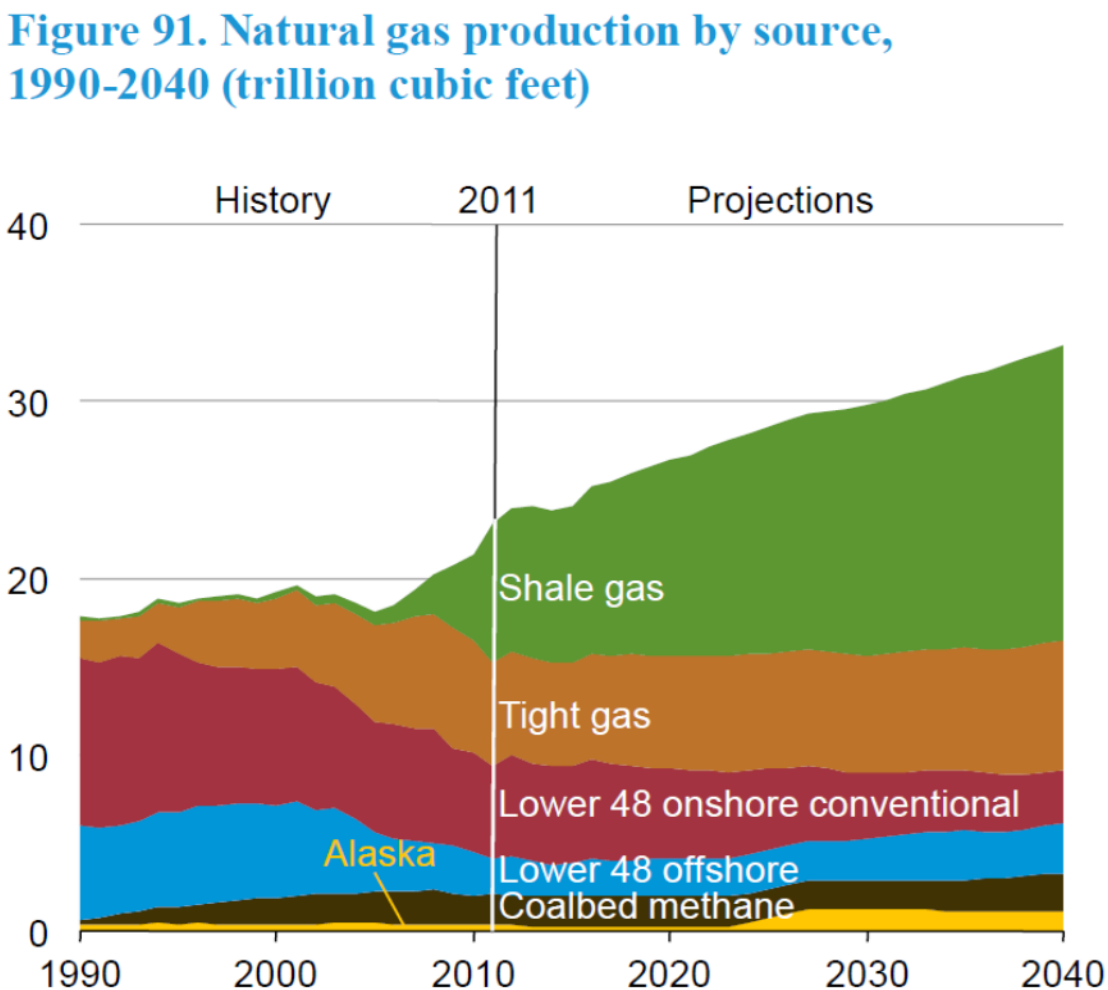
- 1 Dec - Revised chapter drafts to editors
- 1 Jan 2014 – Manuscript draft to authors
- 1 Feb – Revised manuscript to SPEE Executive Committee & RDC
- 1 Apr – Comments back from SPEE Ex Comm & RDC
- 1 May? 1 Jun? – Manuscript released to sister societies
- Release + 2 mons – Comments back from sister societies
- Release + 4 mons – Respond to sister societies, final to SPEE Ex Comm
- Monograph in print 4Q 2014?

US unconventional oil production forecast to be a major source for next 30+ years



EIA AEO 2013, Reference Case

US unconventional gas forecast to be increasing fraction of domestic production over next 30 yrs



US Natural Gas Production by Source, EIA Annual Energy Outlook 2013

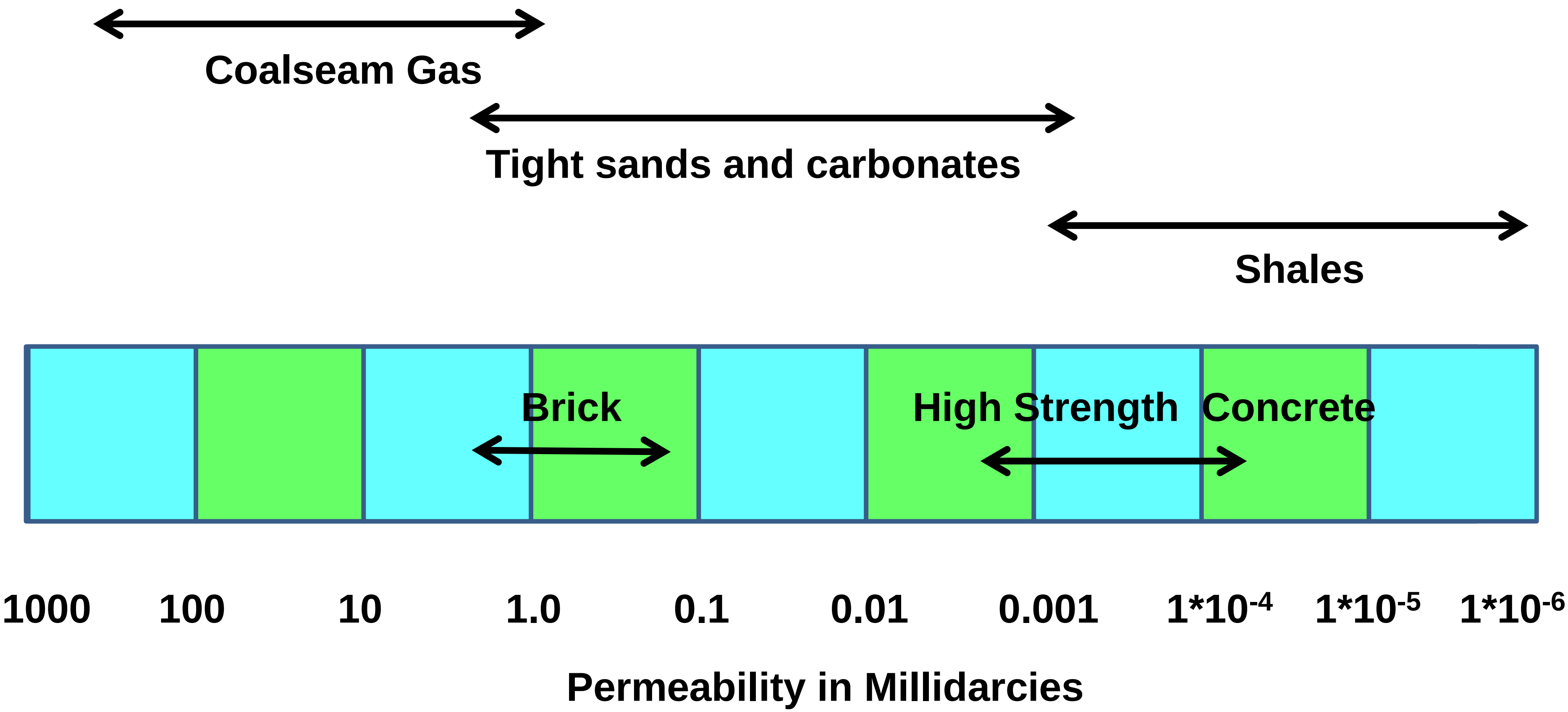
SPEE Monograph 4 –
Concerned with 3 unconventional reservoirs

1. Shales

2. Tight sands and carbonates

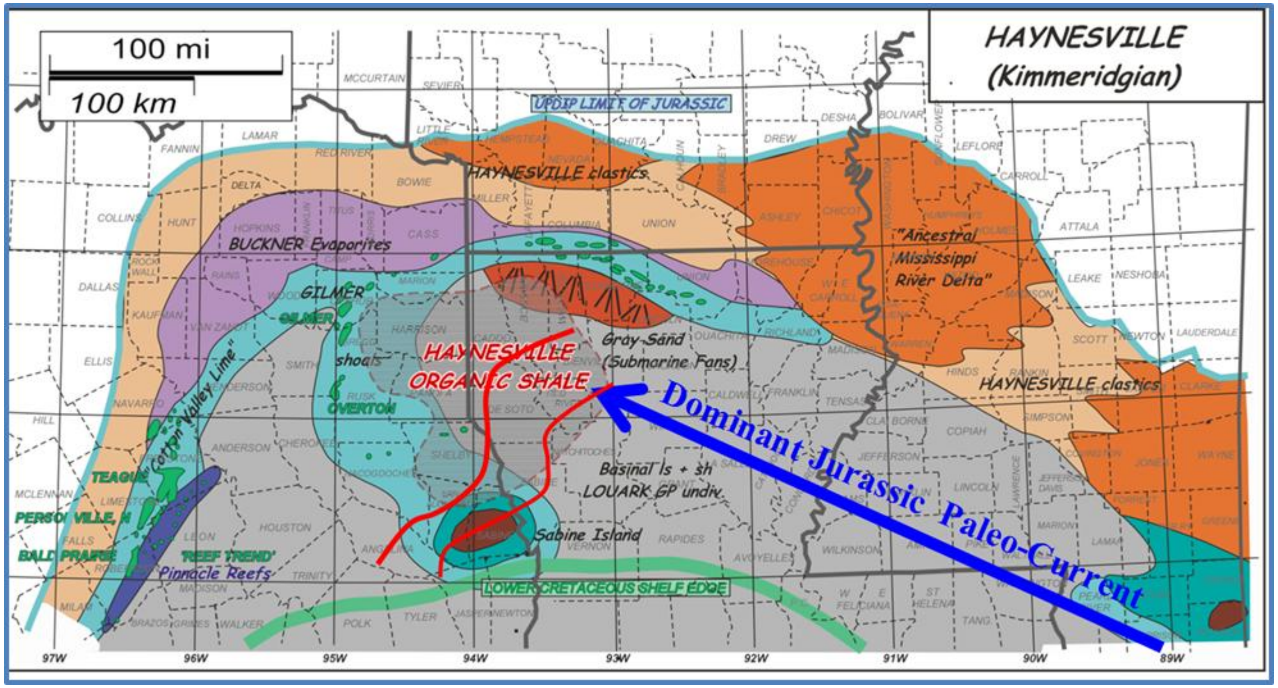
3. Coals

Permeabilities of unconventional reservoirs



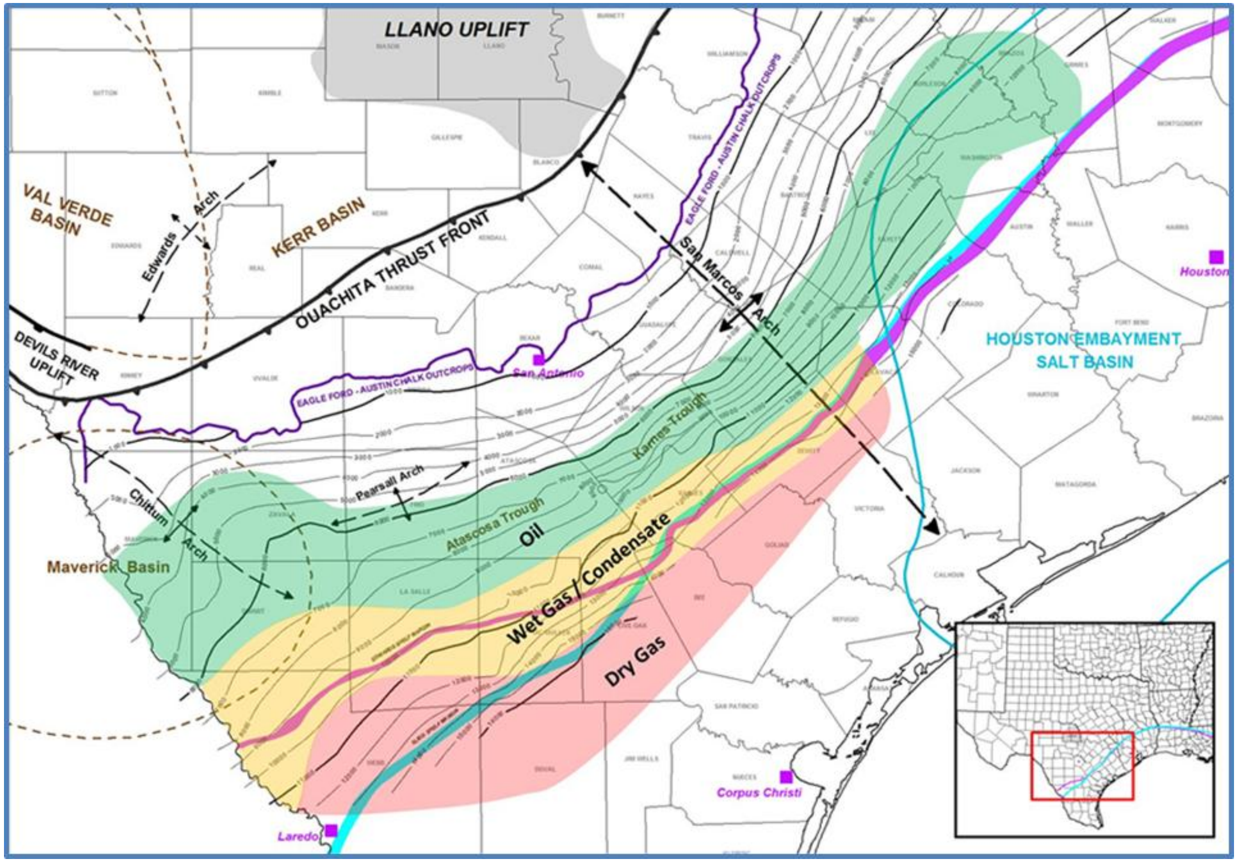
Ref: Schlumberger “Oilfield Review”

Geology is important – Haynesville deposition



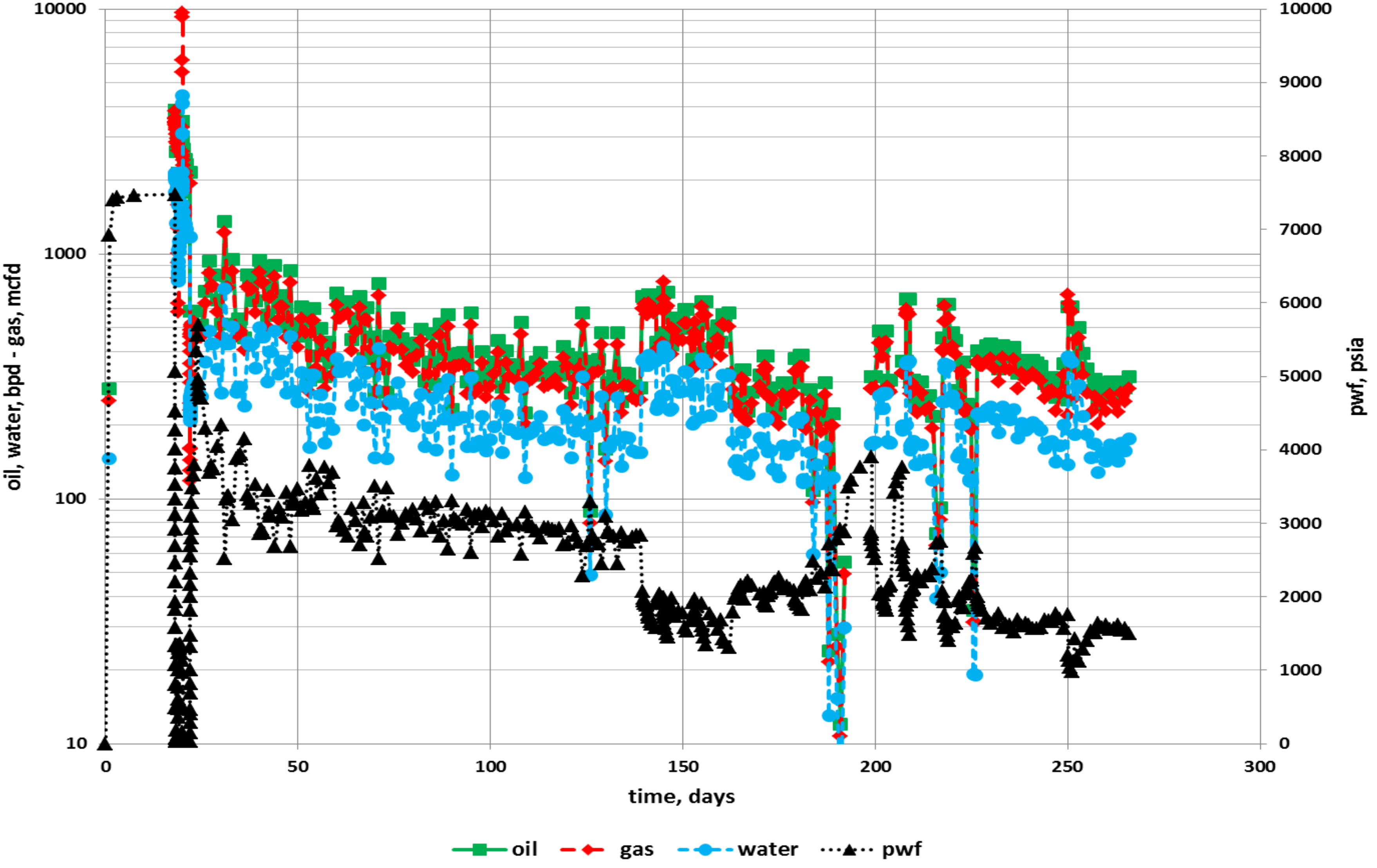
Ref: Martin & Ewing, 2009

Geology is important – Eagle Ford geochem

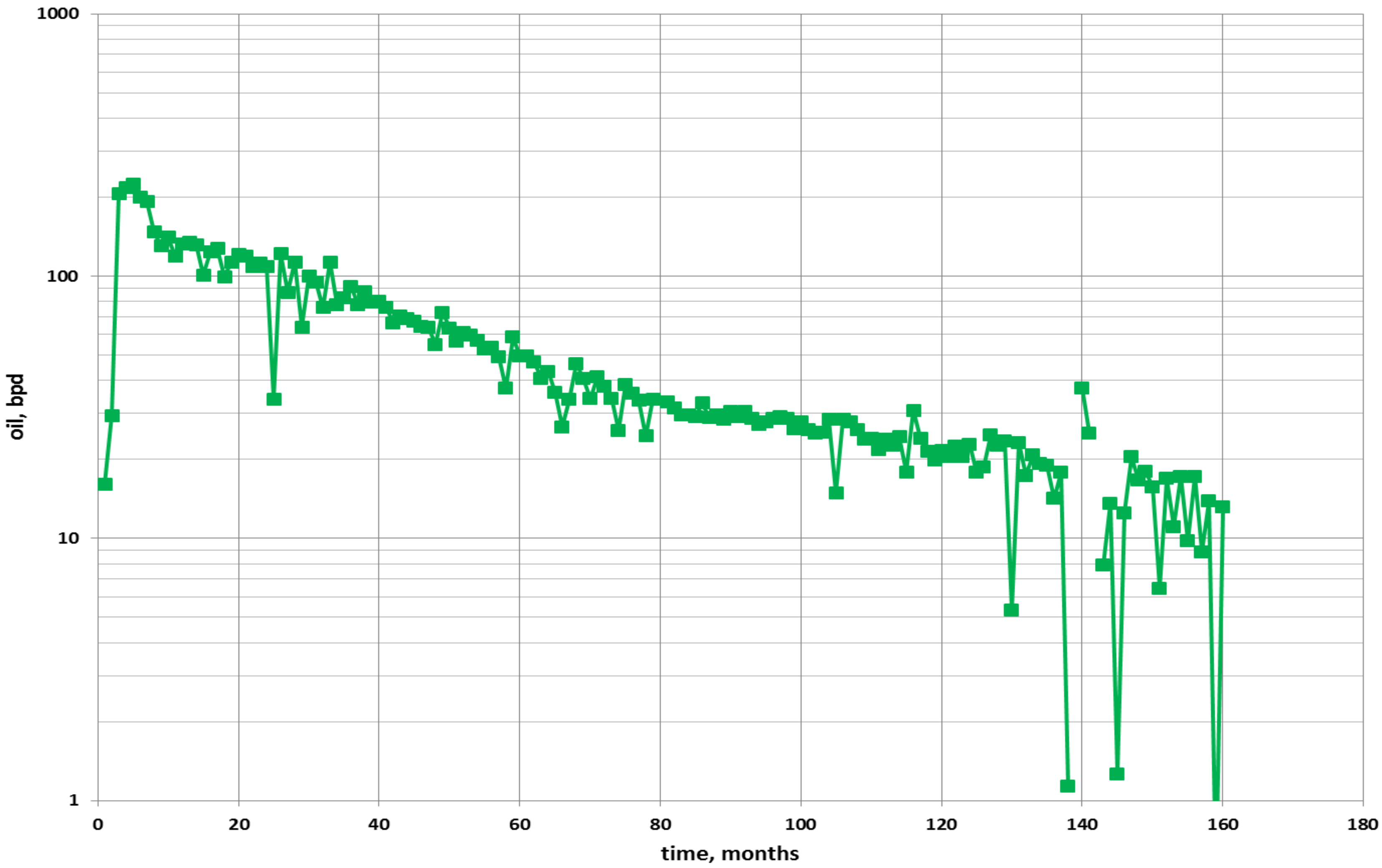


Ref: US EIA

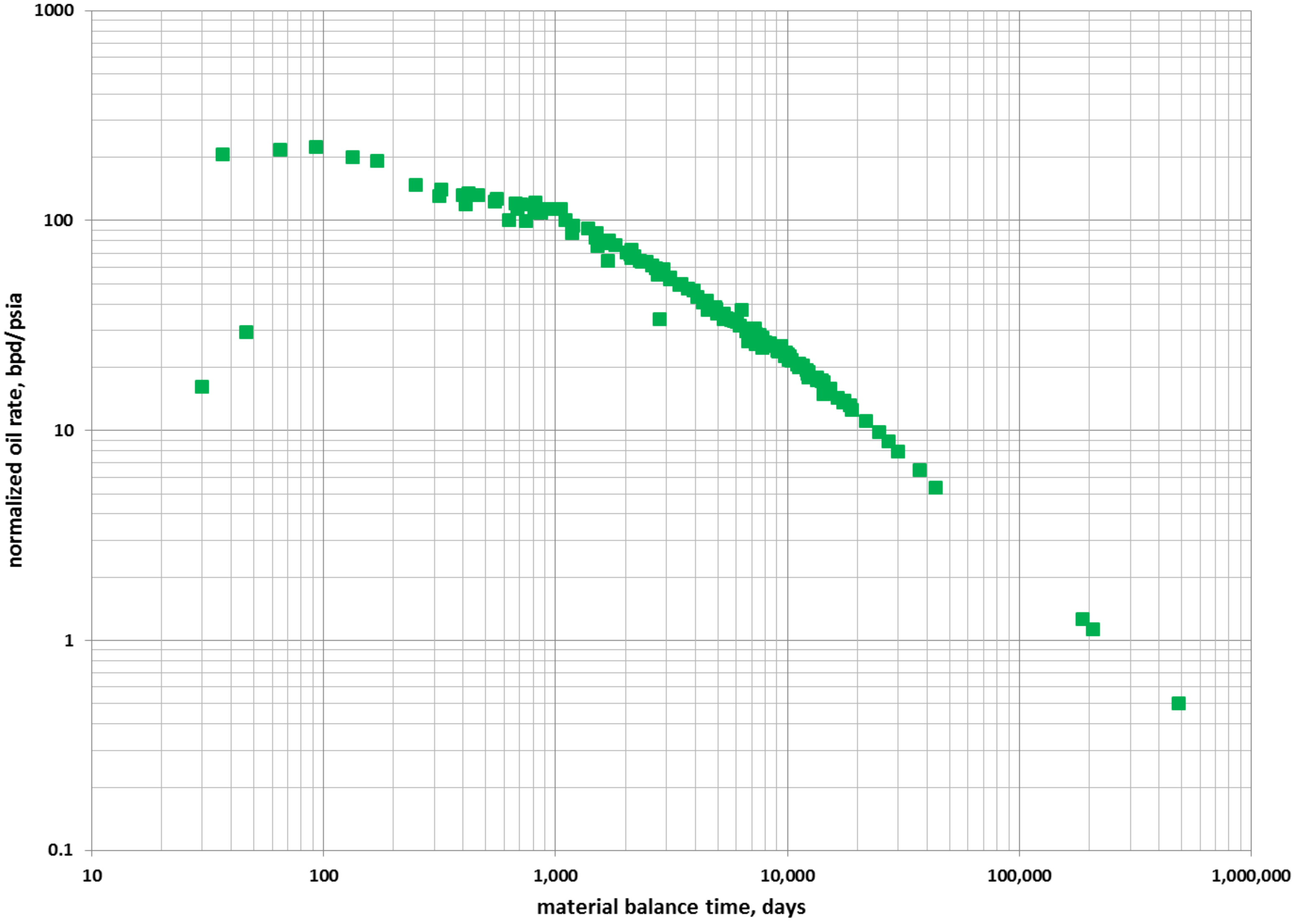
Workflow 1a – Validate data – Bakken well



Workflow 1b – Validate data – DJ Niobrara well



Workflow 2a – DJ Niobrara well - construct diagnostic plot(s)

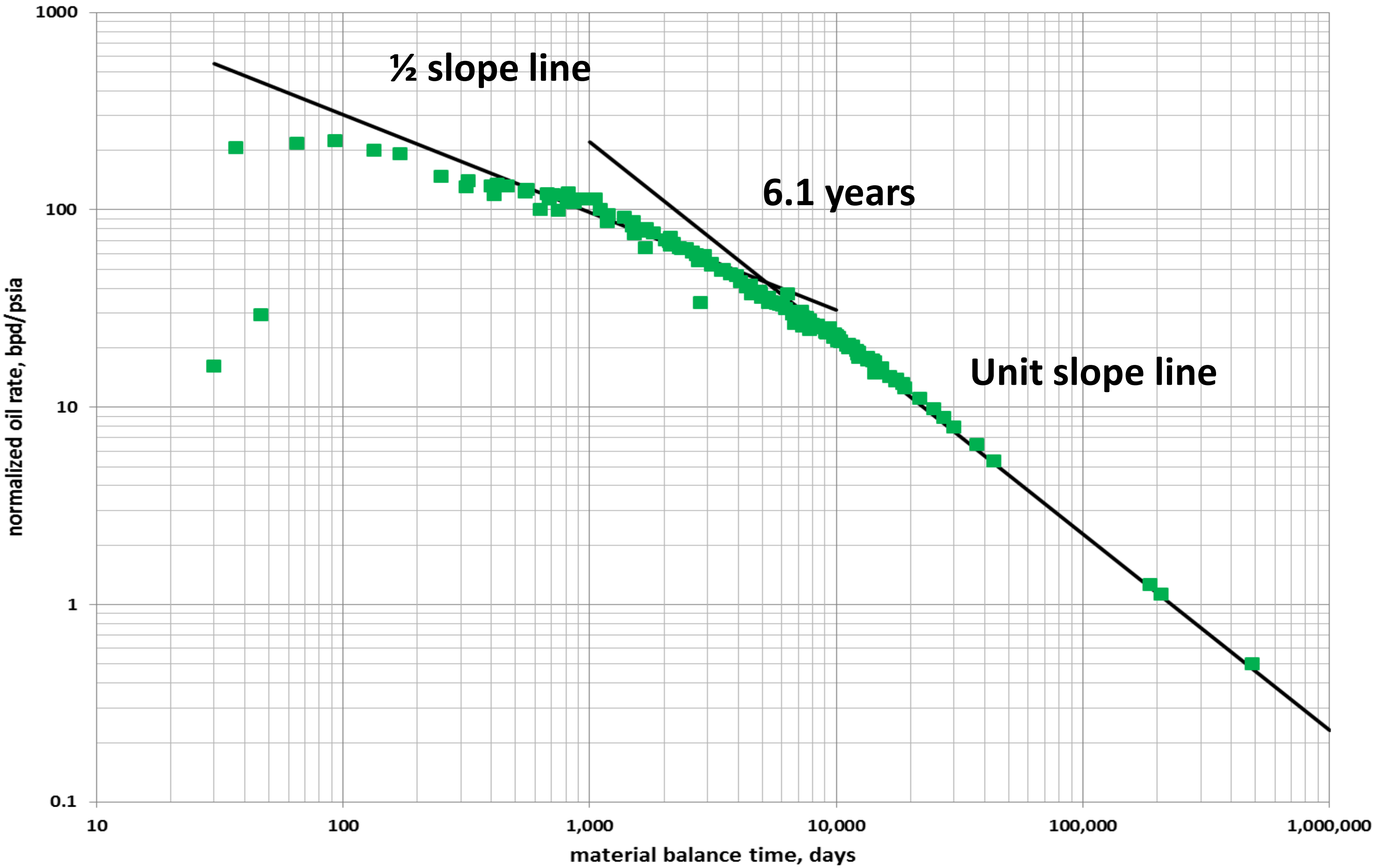


Workflow 2b – Diagnostic plot variables

Normalized rate = qo/(pi – pwf)

Material balance time = Np/qo

Workflow 2c – DJ Niobrara well - identify flow regimes



Workflow 3 – Fit data to selected models

Hyperbolic

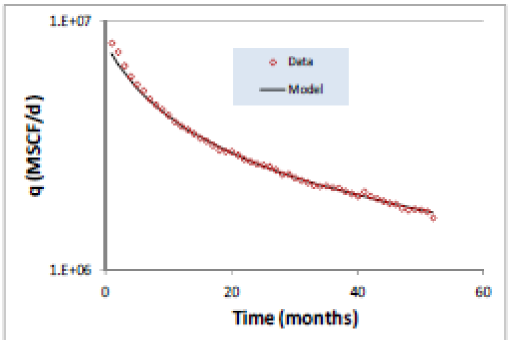


Figure 17 Example 2, Hyperbolic fit to *q* data

Stretched Exponential

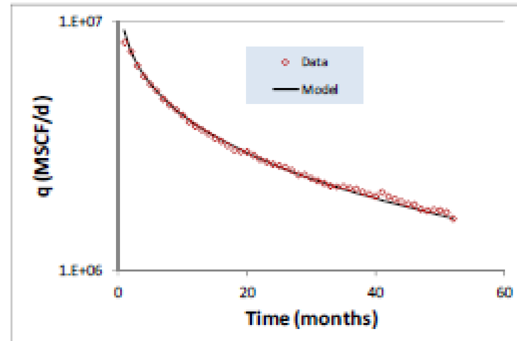


Figure 18 Example 2, SEDM fit to *q* data

Duong

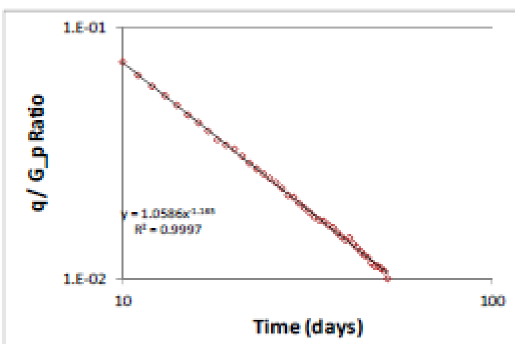


Figure 20 Example 2, Duong fit to q/G_p ratio

Weibull

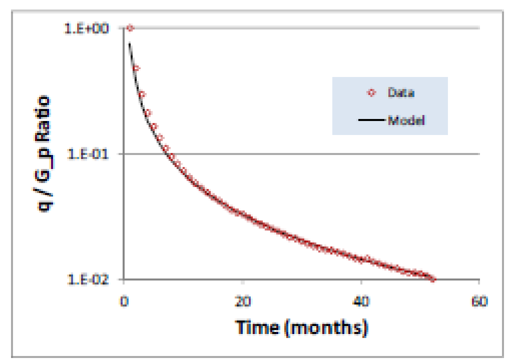


Figure 24 Example 2, Weibull fit to q/G_p ratio

Ref: Mishra, 2012, SPE 161092

Workflow 4a – Forecasts with selected models

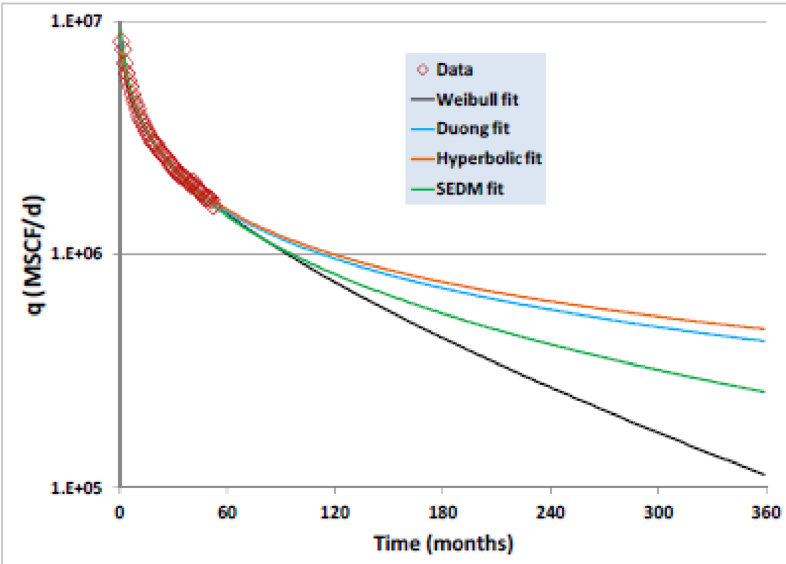


Figure 27 Example 2, comparison of 30-year forecasts for q

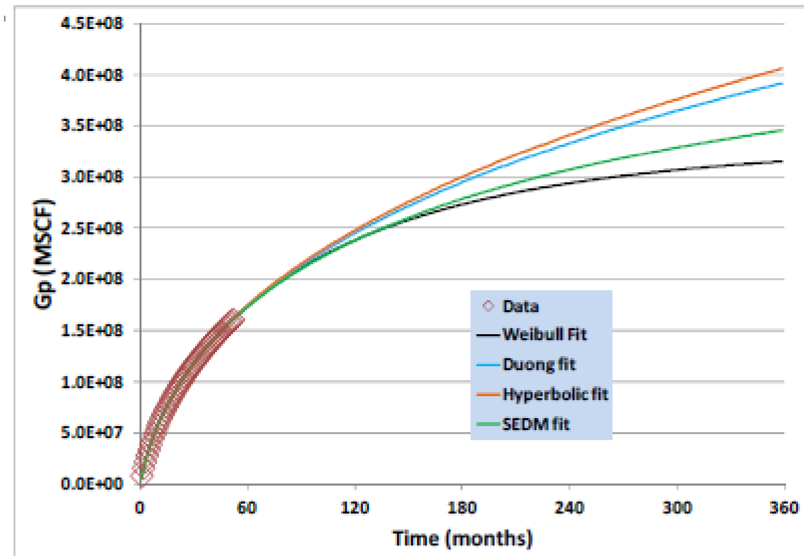


Figure 28 Example 2, comparison of 30-year forecasts for Gp

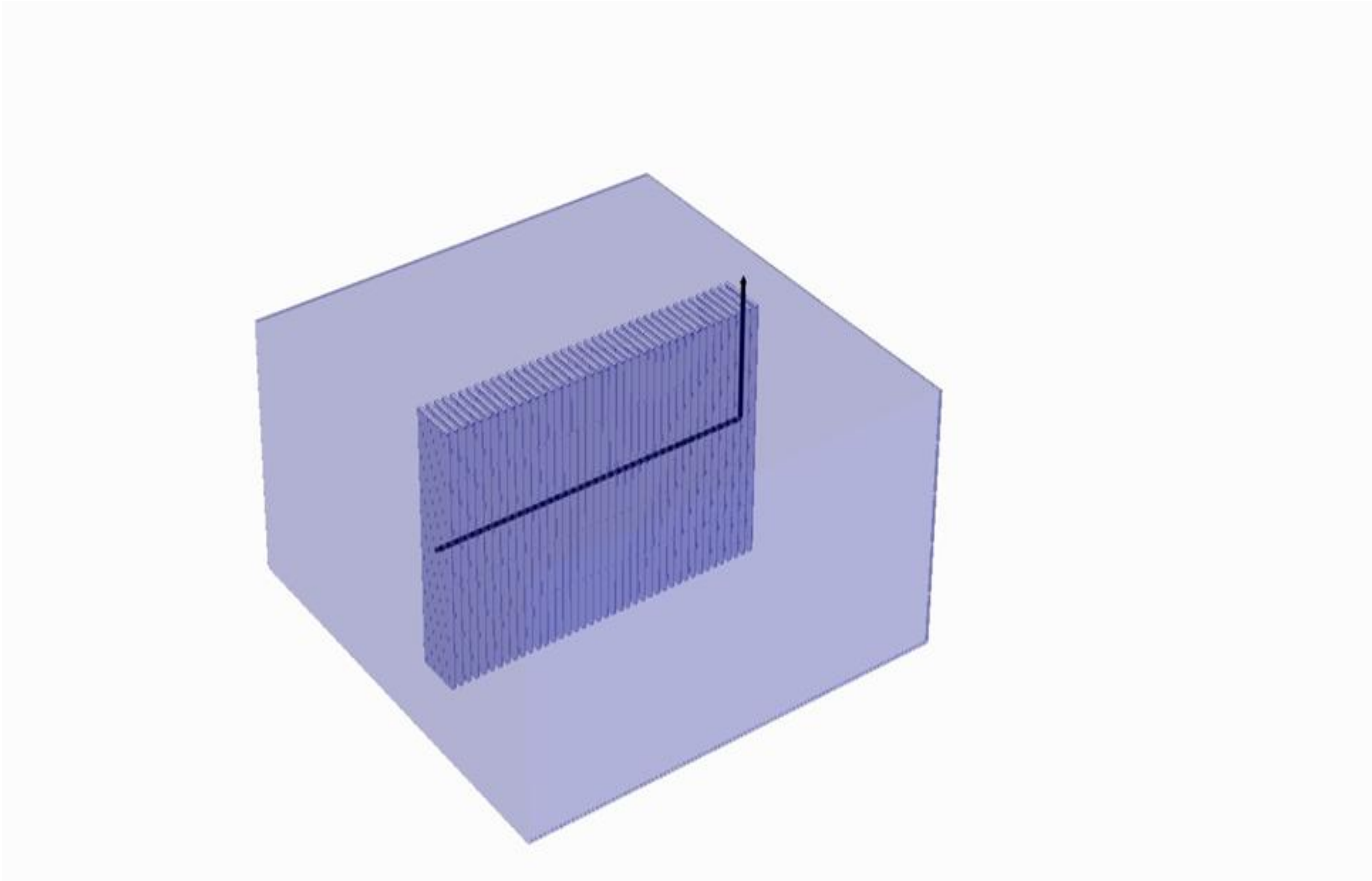
Ref: Mishra, 2012, SPE 161092

Workflow 4b – Forecast summary

model	30 yr EUR, mmcf
Arps	407
SEDM	346
Duong	392
Weibull	315

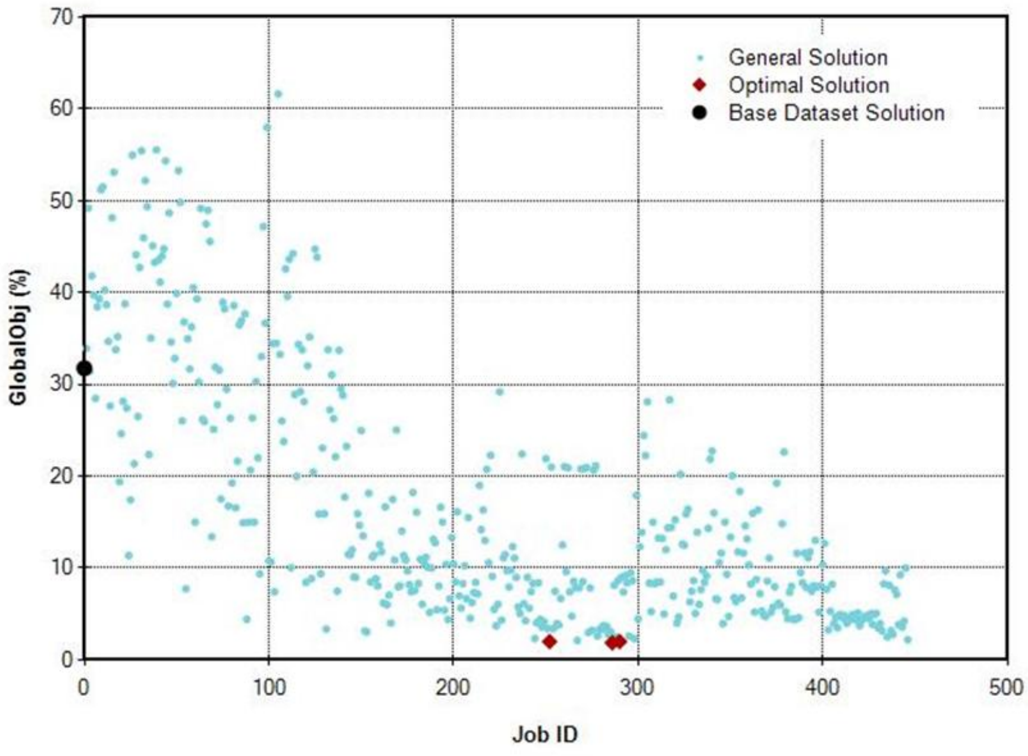
level	30 yr EUR, mmcf
P90	324
P50	369
P10	403

Workflow 5a – Eagle Ford well - Simulation grid



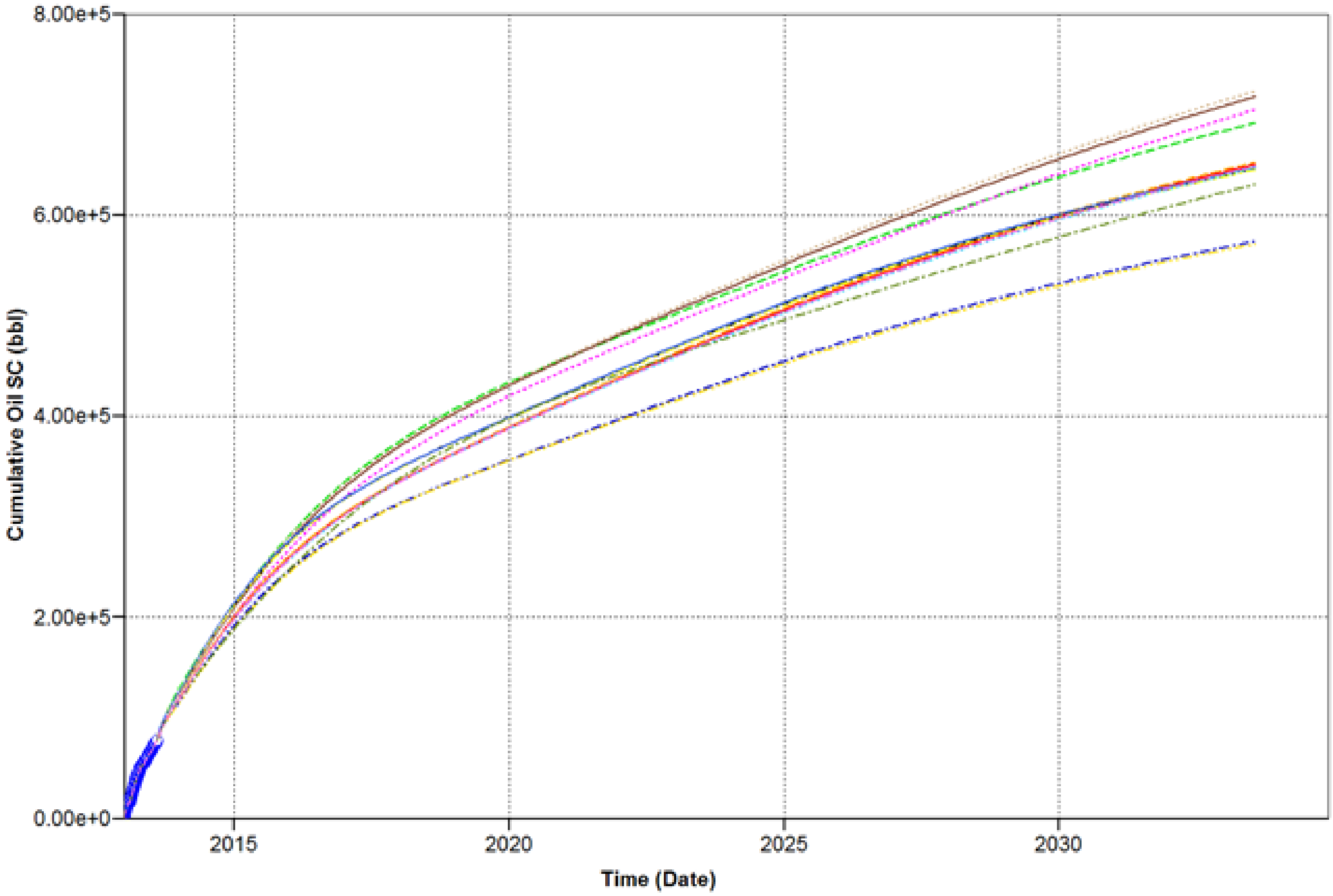
Ref: Erdle, SPEE mono 4

Workflow 5b – Model history matches



Ref: Erdle, SPEE mono 4

Workflow 5c – Simulation forecasts



Ref: Erdle, SPEE mono 4

Workflow 5d – Eagle Ford well - Simulated EUR's

Run #	HM Error (%)	Oil EUR (stb)	Gas EUR (MMscf)
286	1.865	651,310	915
252	1.9974	653,342	917
290	2.0028	649,340	909
295	2.596	648,504	900
278	2.5966	646,719	967
284	2.6838	646,419	966
438	2.7735	649,306	902
285	3.0777	648,042	975
153	3.0389	574,492	870
131	3.3639	705,861	941
254	3.4003	724,059	981
251	3.4224	718,745	967
166	4.0191	571,847	859
372	5.1966	631,359	851
373	5.7327	692,528	976

Oil EUR's, stb

P90 - 597,239

P50 - 649,306

P10 - 713,591

Gas EUR's, mmcf

P90 - 863

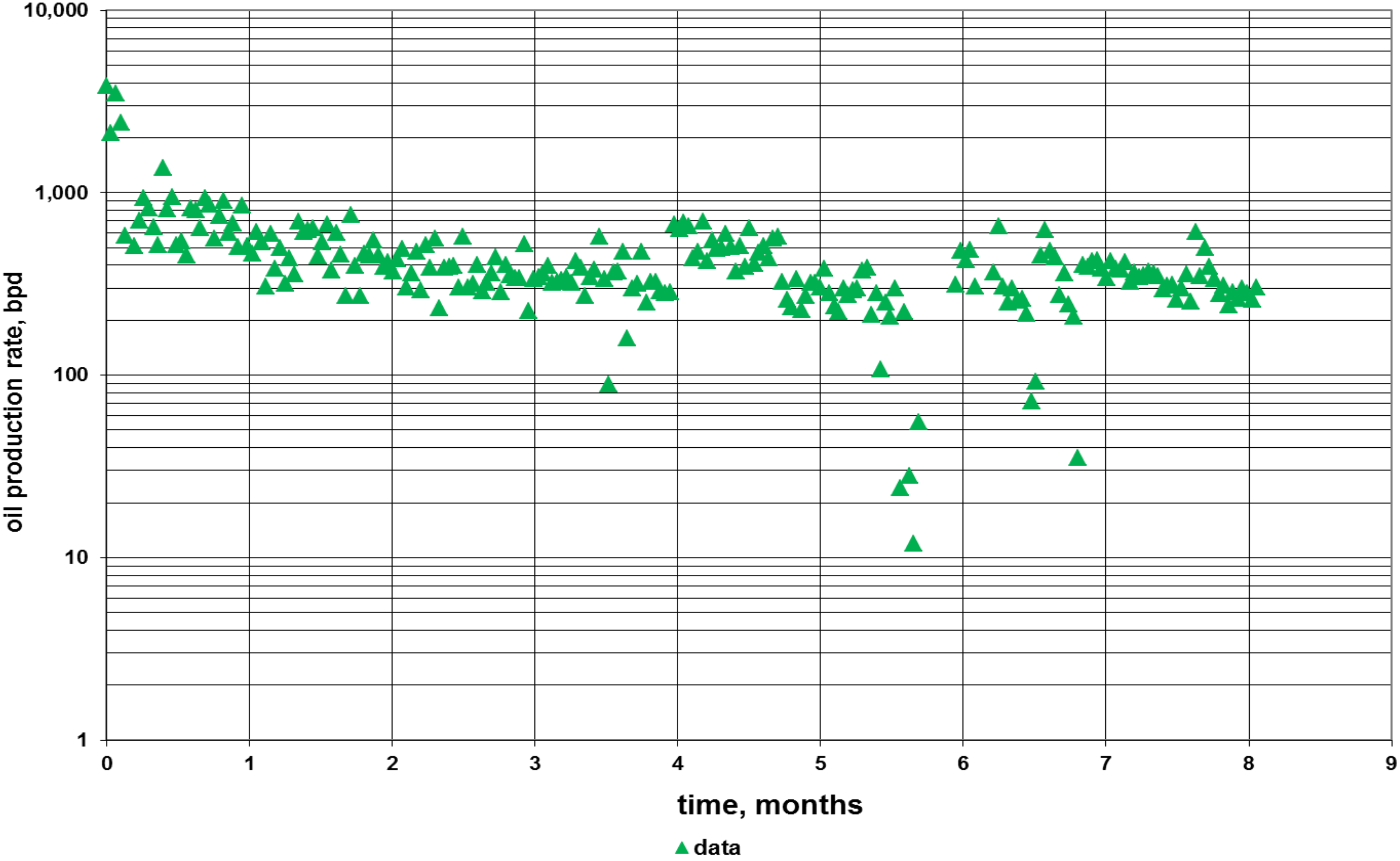
P50 - 917

P10 - 976

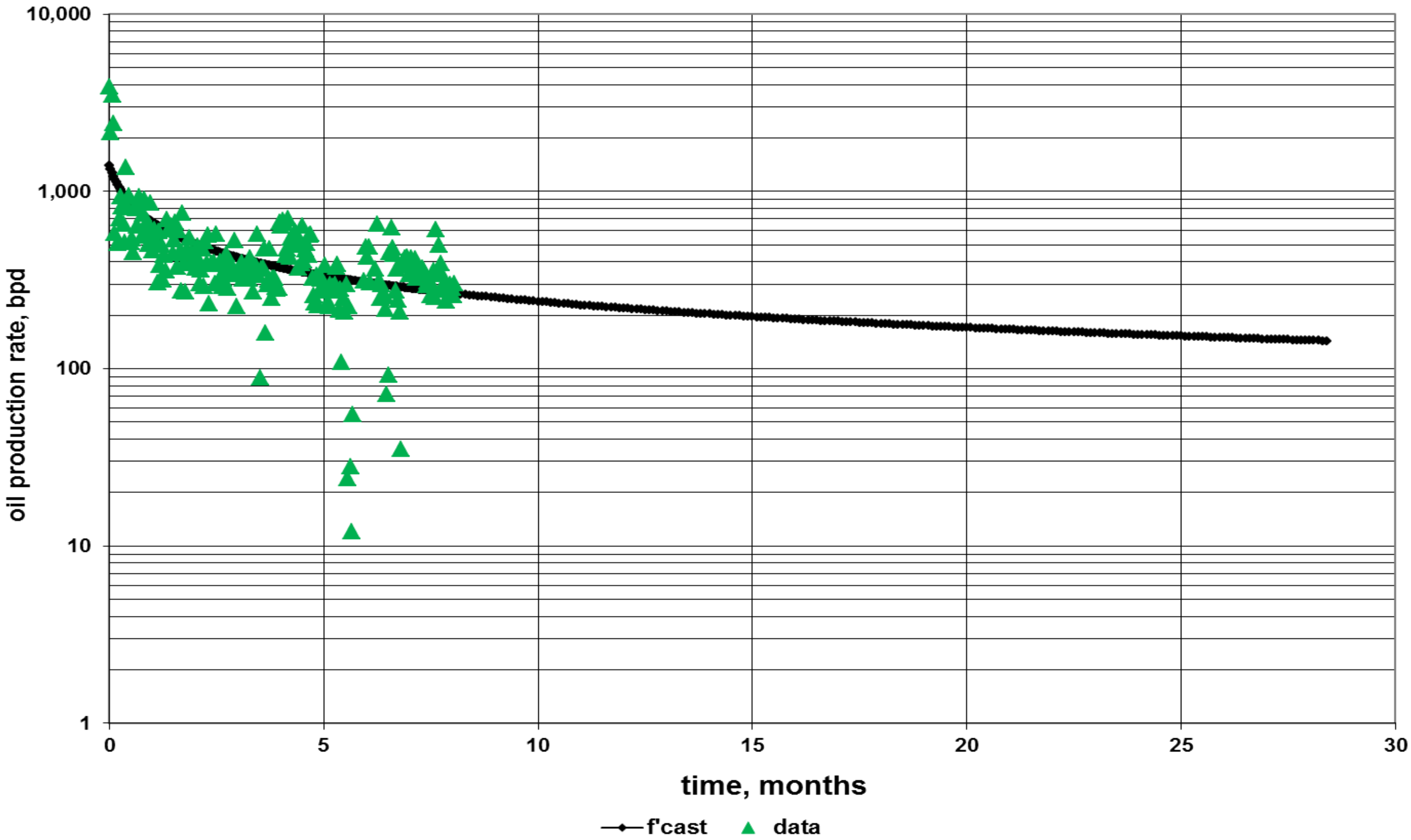
Interesting but…

What do we do when we have to evaluate 800 wells in a week?

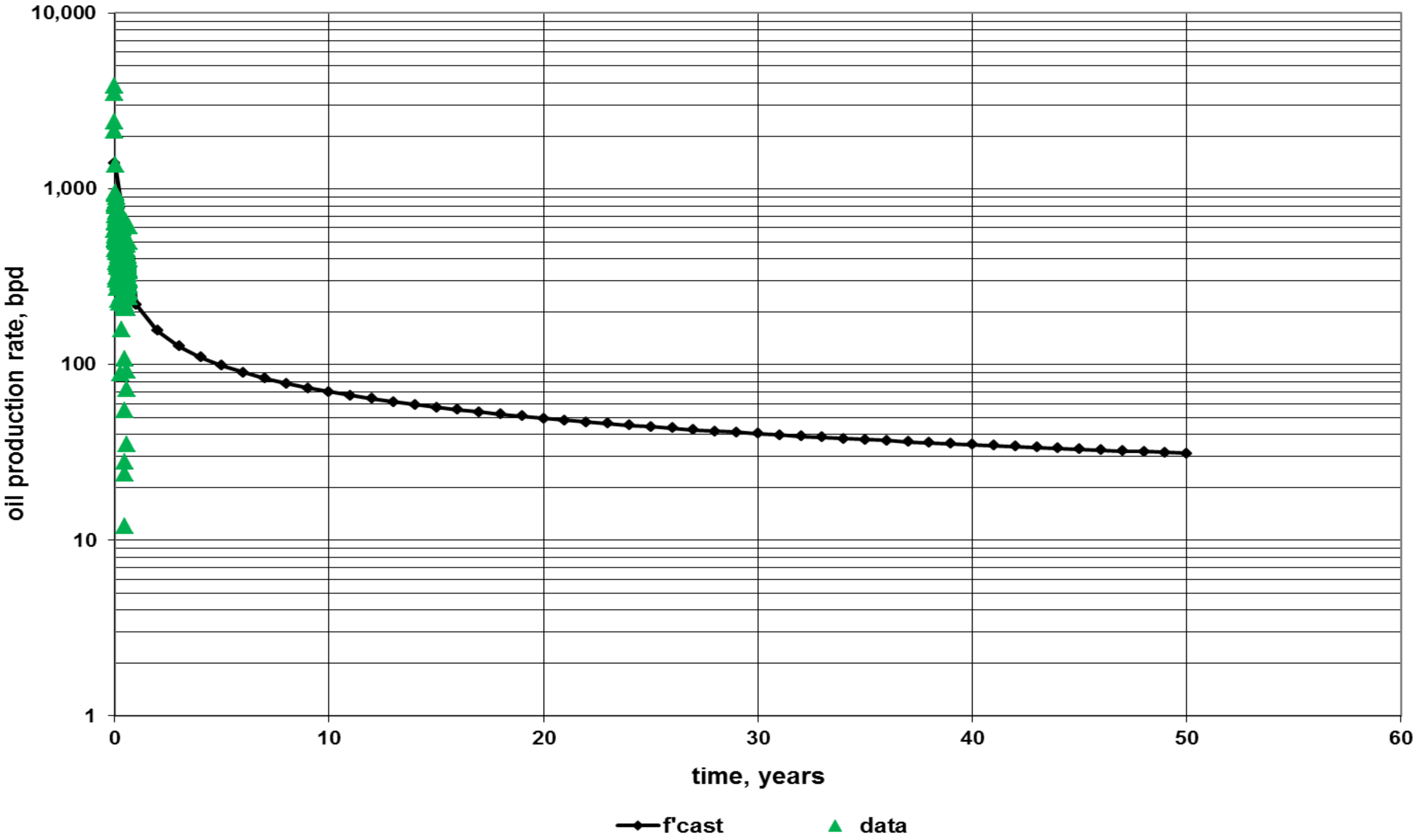
Real life 1 – Bakken data



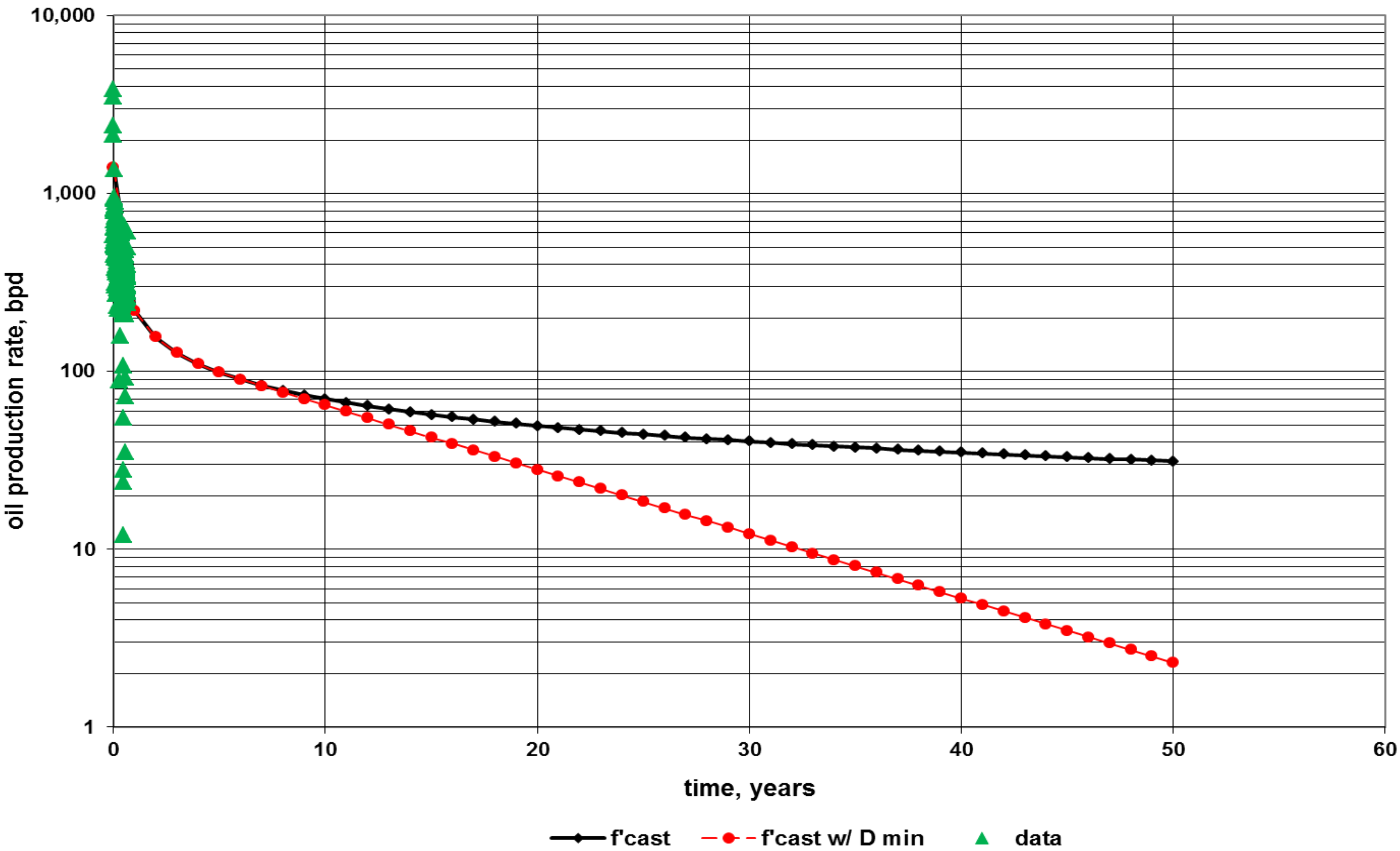
Real life 2 – Bakken data & decline curve



Real life 3 – Bakken 50 yr forecast
EUR = 1,117 mmbo



Real life 4 – Bakken 50 yr forecast w/ 8% min decline
EUR = 740 mbo



What do you do when you have to evaluate 800 wells in a week?

1. **Decline curve analysis with minimum decline?**
2. **DCA w/ min decline + add'l analysis of high value wells?**
3. **Other?**

SPEE Monograph 4 – Summary 1

- **UCR's important US oil and gas source for next 30+ yrs**
- **Geology is important UCR control**
- **UCR developed reserves workflow—Ideal case**
    1. **Assess data quality**
    2. **Construct diagnostic plots**
    3. **Fit simple models**
    4. **Forecast simple models**
    5. **Simulation**

SPEE Monograph 4 – Summary 2

- **UCR developed reserves workflow—Common case**
  1. **DCA with minimum decline**
- **Monograph 4 in print 4Q 2014?**

Thank you!

Monograph 4 committee is interested in your comments--

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