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Two Vital Secrets for Building Reliable Type Wells

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AGENDA

TYPE WELL

What is a type well
The challenge

1st SECRET

All type wells
3 Inherent Errors
Case Study

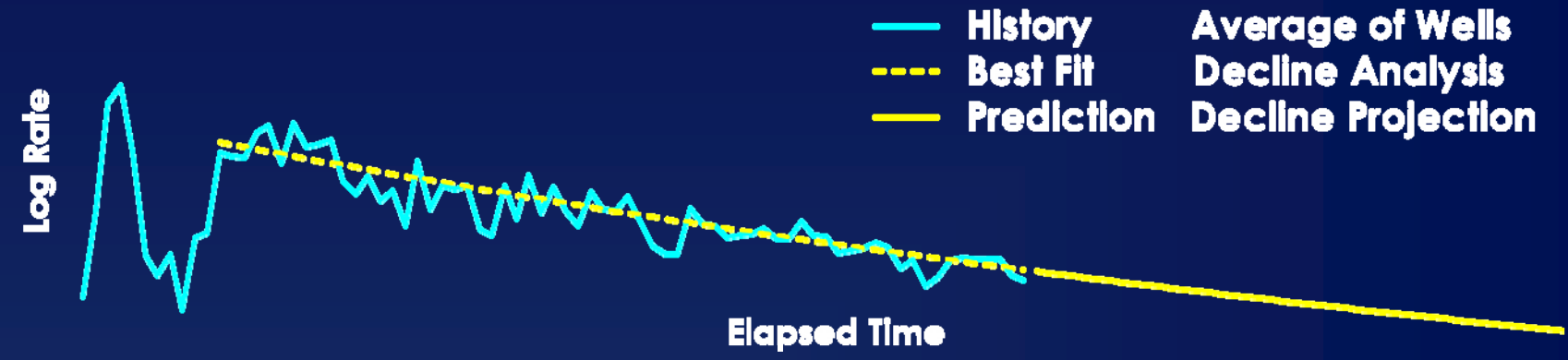
2nd SECRET

Probability type wells
Time slice method
Aggregation method
Comparison

WRAP UP



TYPE WELL What is a type well?



Rate-time production profile

Shift representative wells to a common start date

Average them to represent new wells

Common method comprised of two parts

- History average rate until too few wells
- Prediction projection of best fit of history



TYPE WELL The Challenge

Dr. Lee, 2015 Reserve Summit

- *SEC's experience (circa 2008)
type wells exceed results by about 25%.*

2013 Proprietary Research Report

- *Drilling results did not meet the objectives set out in 40 of 100 published play specific type wells.*
- *Only 14 of 40 companies consistently met targets.*

Personal Experience

- *EUR more likely to be over estimated, as much as 40%.*

Pervasive ... Capital Intensive ... Errors



1st SECRET

Applies to All Type Well Methods

***FORECAST EACH WELL
THEN AVERAGE HISTORY & PREDICTION***



3 ERRORS

1. Forecast groups

- Never forecast groups, always group forecasts

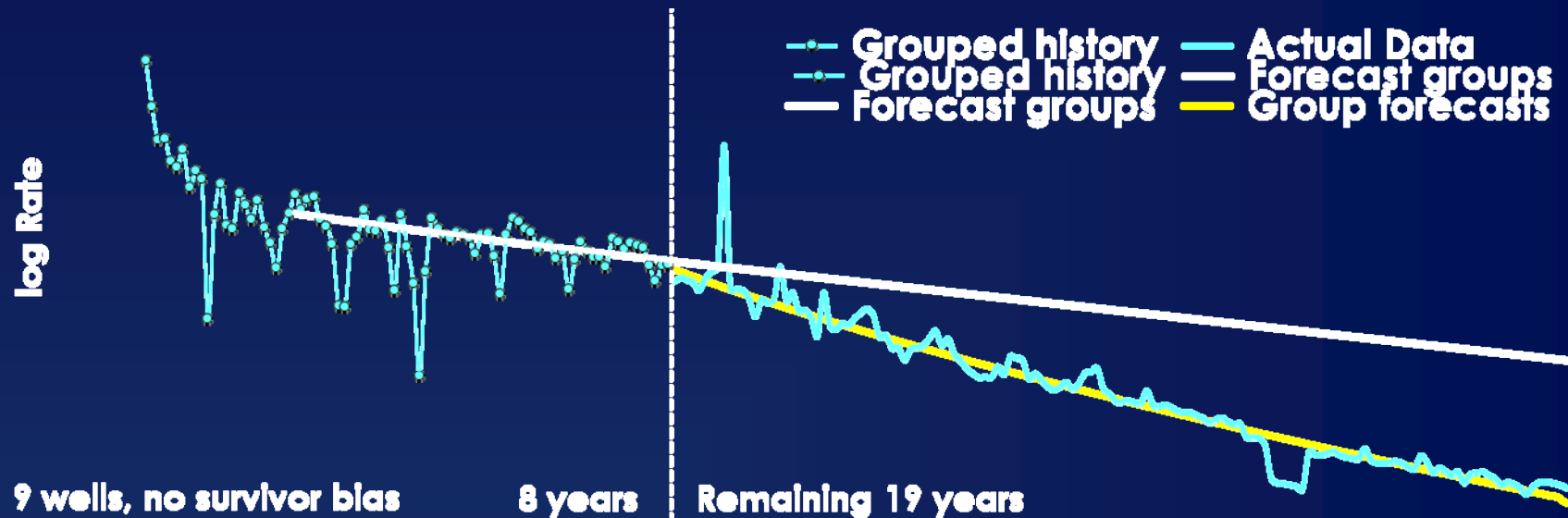
2. Survivor bias

- Concentrating on things that survive
- The treatment of depleted wells
- Depleted wells produce with rate = 0

3. No production (declining well count)

- Recent wells that have no rate to average
- Also a form of survivor bias
- Use best available forecast

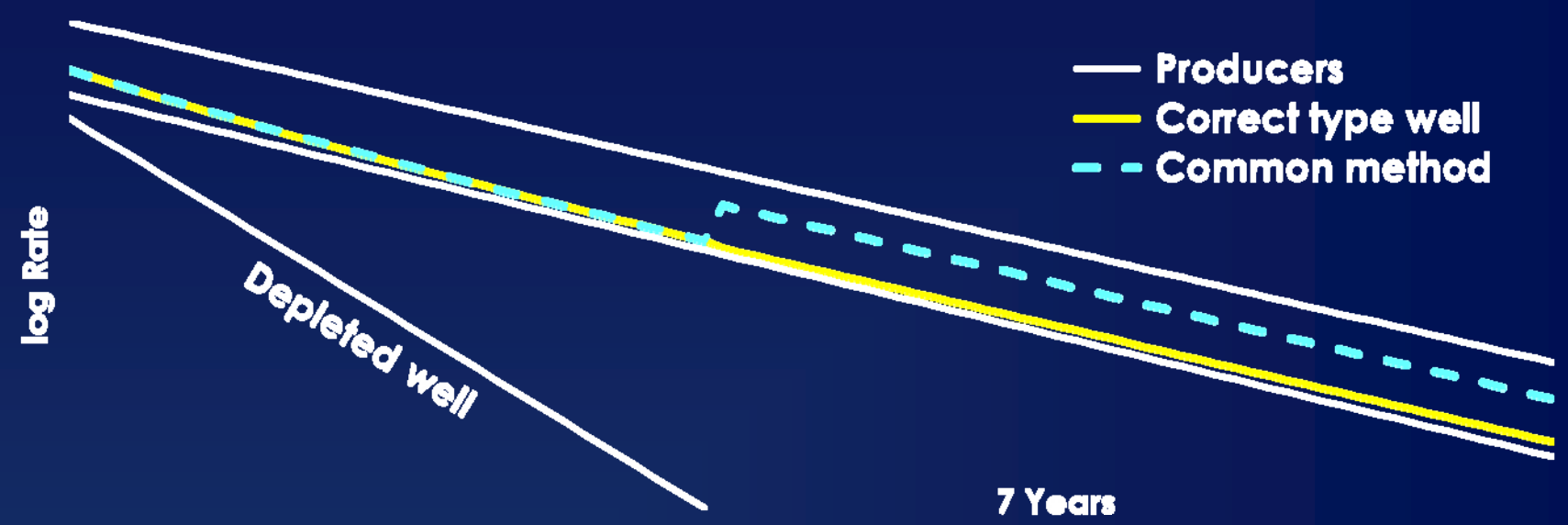
3 ERRORS #1 Forecast Groups



Forecast Groups
Usually no clear trend
High quality best fit
Bad business decision
Grouping masked a trend

Group Forecasts
New trends are visible
Forecast errors cancel
Accuracy improves
Type well is accurate

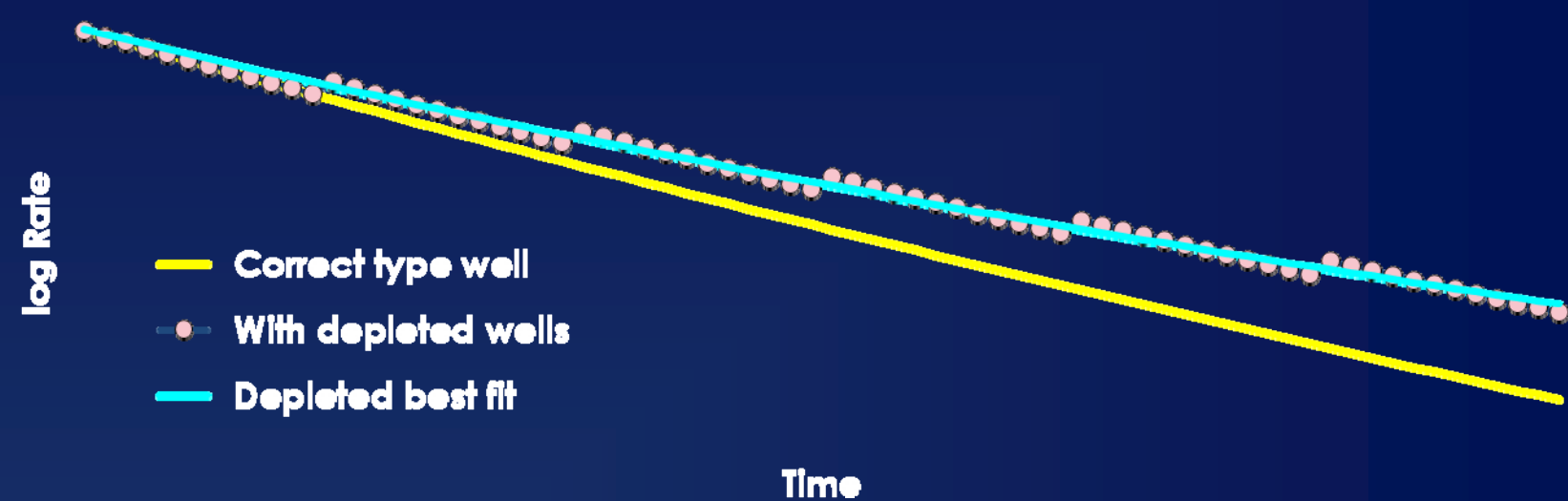
3 ERRORS #2 Survivor bias



Common method
Correct treatment

Depleted rate = type well rate
Creates false rate and reserve
Each well must have a rate

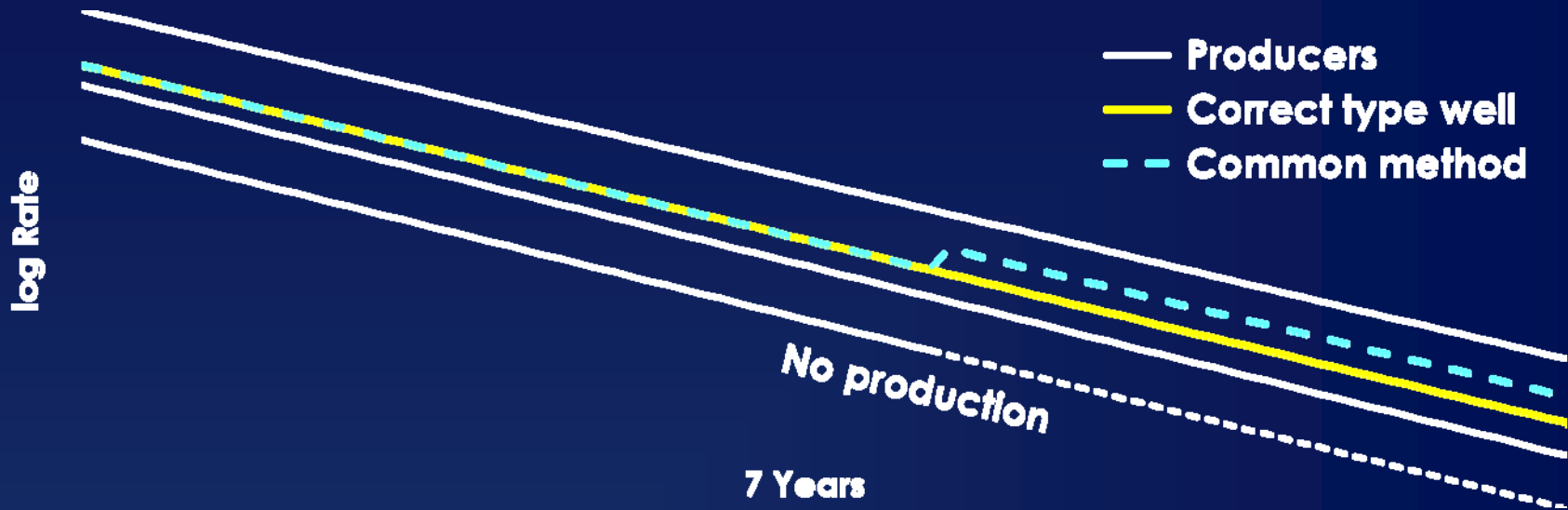
3 ERRORS #2 Survivor bias



Common method

Compounding effect

3 ERRORS #3 No production



Common method

Well rate = average rate
Best wells drilled first

Correct treatment

Include every well
Use best available forecast

AVOID ALL 3 ERRORS

Forecast, then average history & prediction

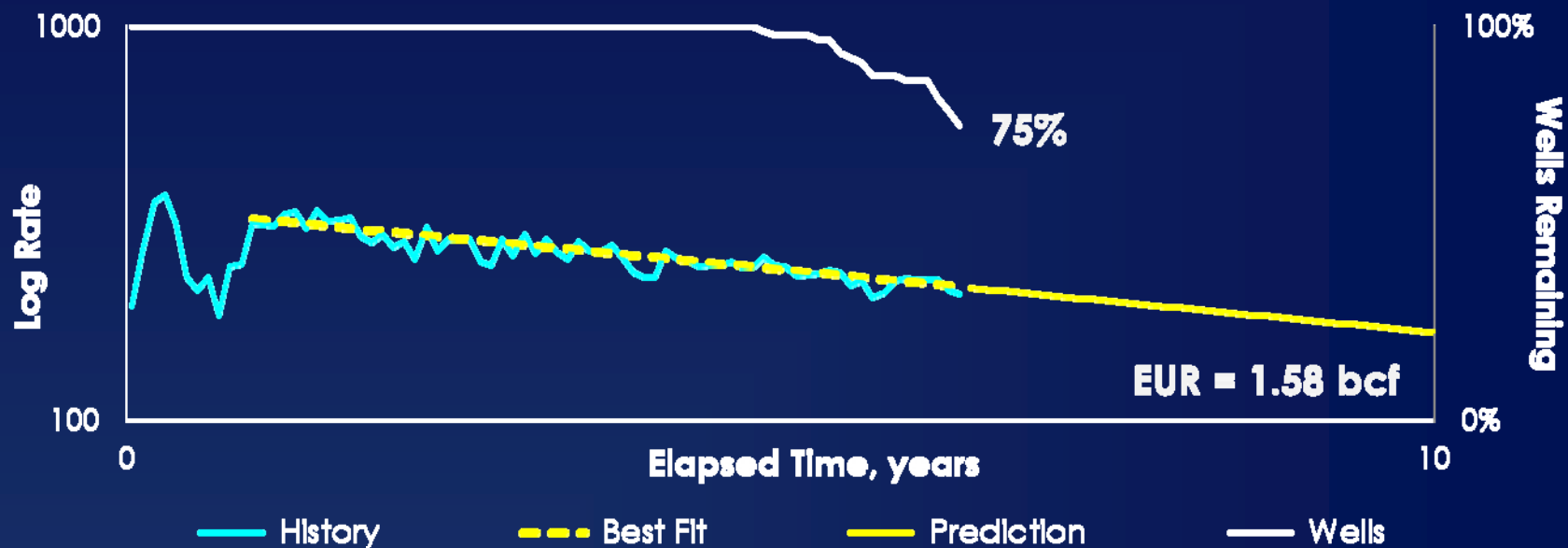
3 ERRORS

Numerical example



Well	Monthly Production Rate			
	Month 23	Month 24	Month 25	Month 26
1	1200	1100	1000	900
2	1000	900	800	700
3	35	25	no prod	no prod
Field Total	2235	2025	1800	1600
Type Well	$2235 / 3$ = 745	$2025 / 3$ = 675	$1800 / 2$ = 900	$1600 / 2$ = 800
Drill 3 Wells	3×745 = 2235	3×675 = 2025	3×900 = 2700	3×800 = 2400

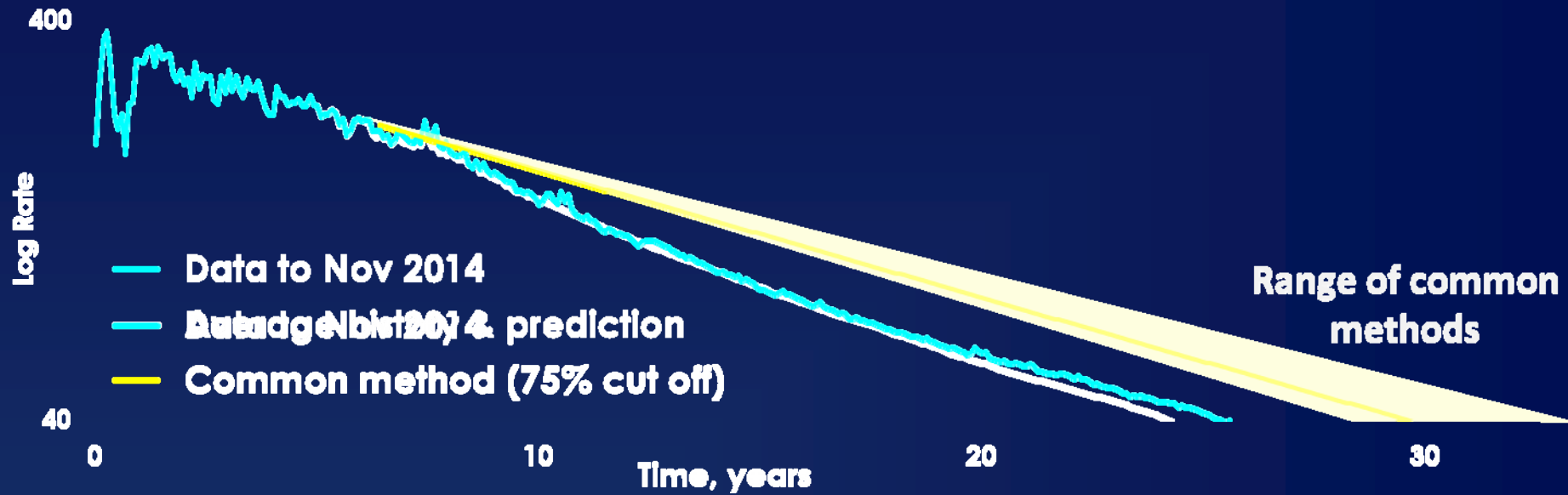
CASE STUDY 88 Hugoton Kansas wells



Data truncated
Cut off
Type well

5 years drilling + 5 years producing
Stop when too few wells
Looks reliable

CASE STUDY 88 Hugoton Kansas wells



	History Only Cut Off			History & Prediction	Known Nov 2014
<u>To Dec 1996</u>	<u>100%</u>	<u>75%</u>	<u>50%</u>		
EUR, bcf	1.53	1.58	1.74	1.34	1.36
Error, %	13%	16%	28%	-2%	

1st SECRET
average history & prediction



2nd SECRET

Applies to Probability Based Type Wells

***STOP USING THE TIME SLICE METHOD
USE THE AGGREGATION METHOD***

Certainty (P10, P50, P90)

What is uncertain?
(EUR, Present Value, Cash Flow, ...)

How many wells?



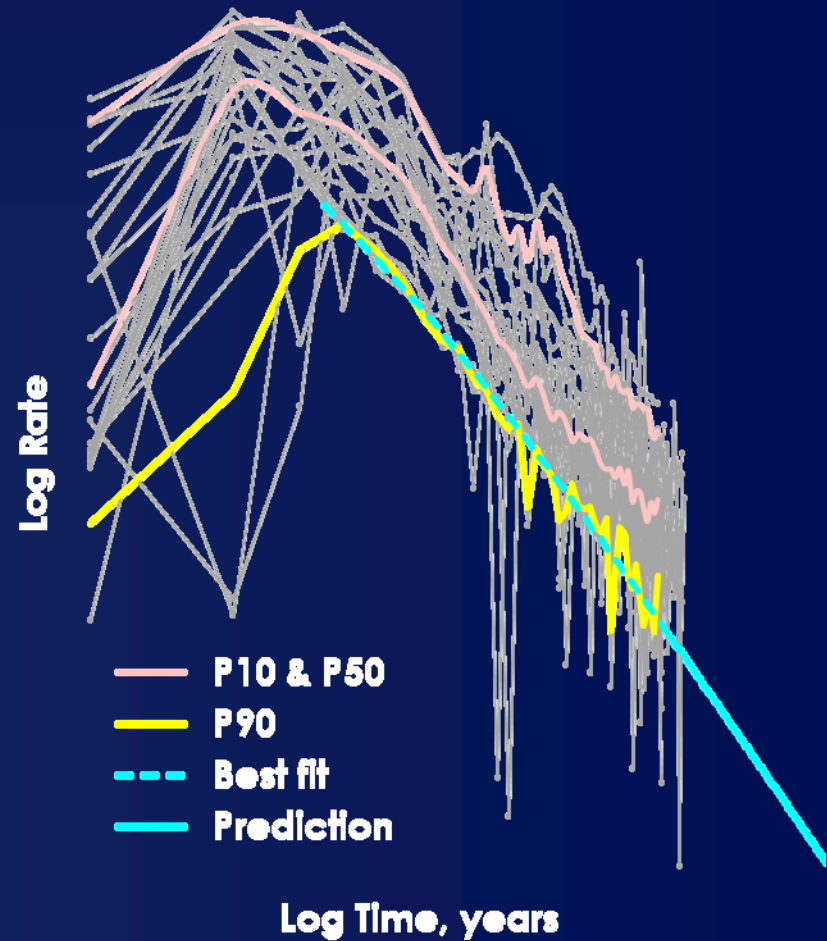
TIME SLICE METHOD

Uses only history

Normally P10, P50 or P90

For Each Month

- Sort by rate
- Get the P90 or P50/P10 rate
- Decline to complete

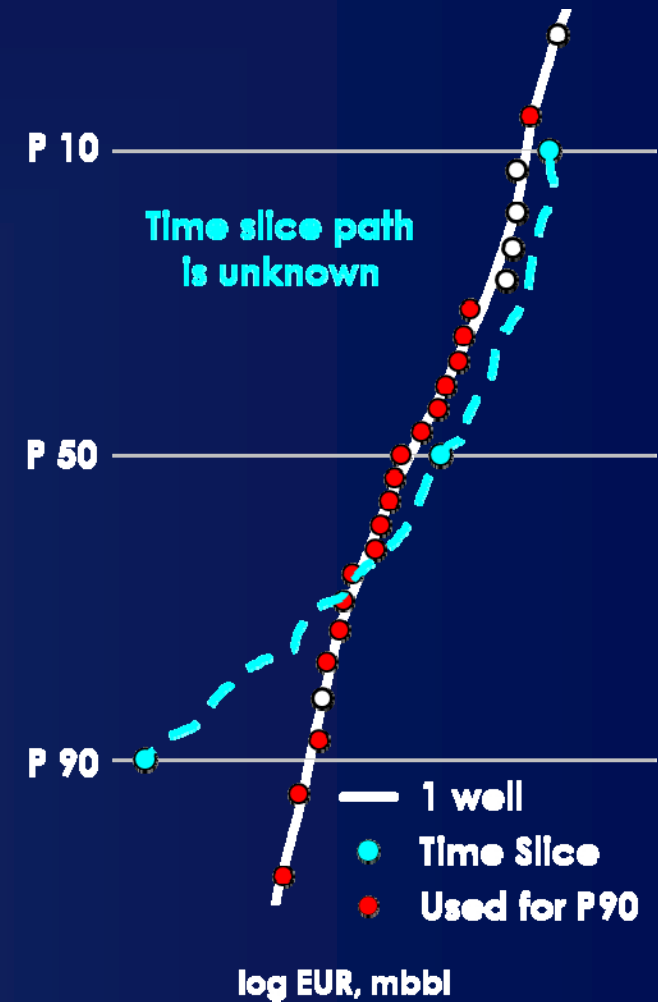




TIME SLICE METHOD

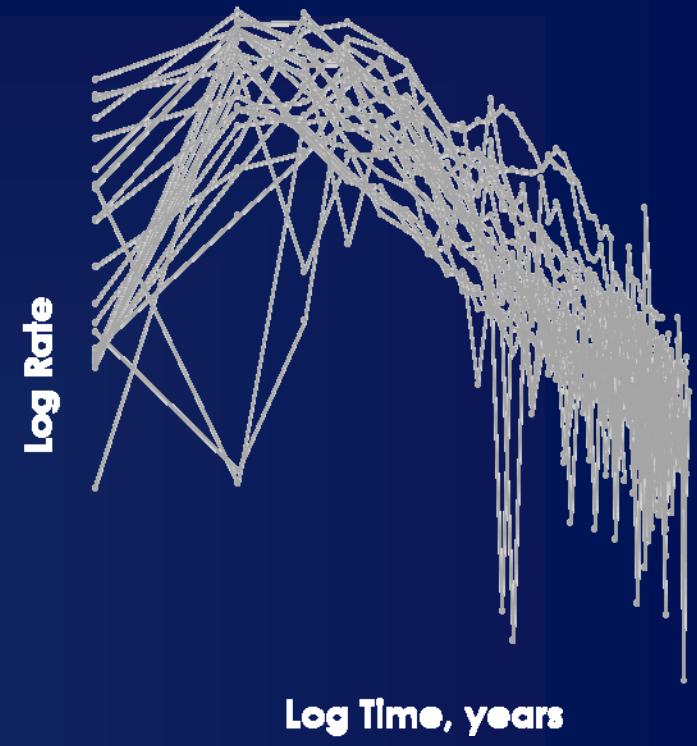
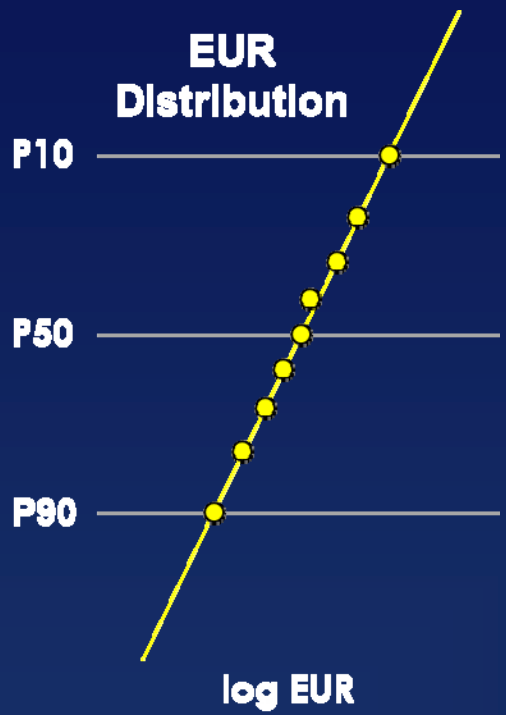
Probability

- What is uncertain?
Unknown
- No Aggregation (1 well)
- Rates from the full distribution
- Ignores EUR distribution





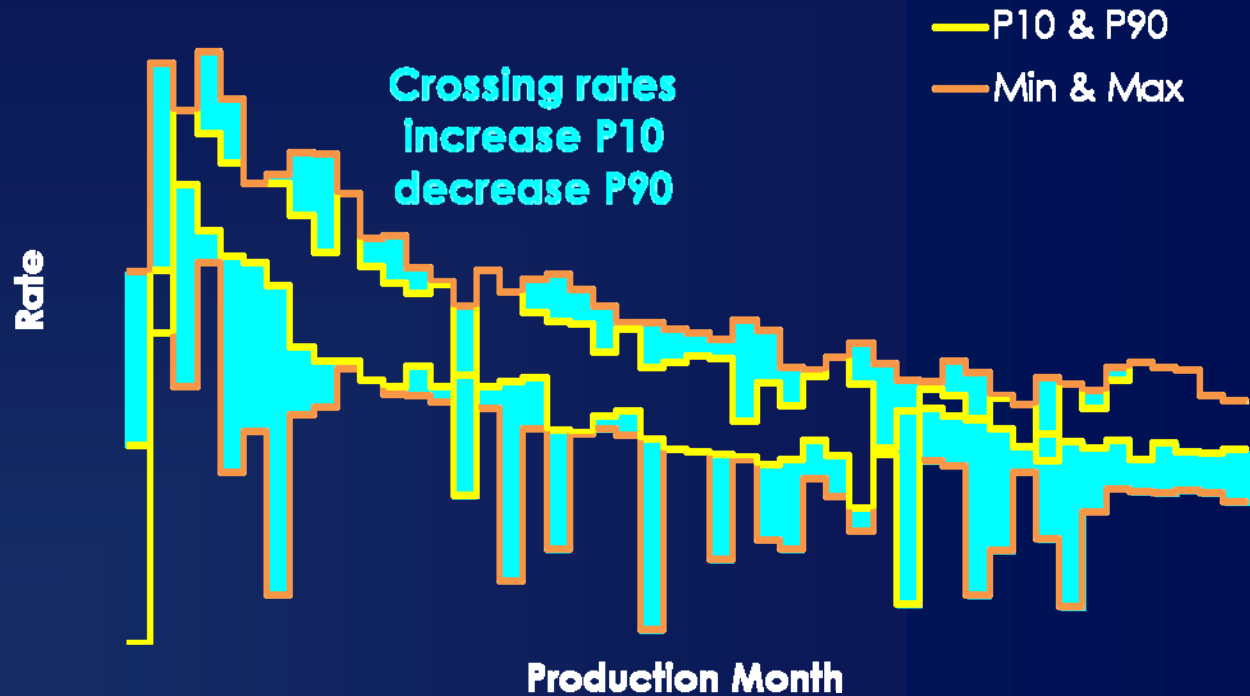
TIME SLICE METHOD



- 9 well example
- Crossing rate/time

There is a P10 & P90 well
Creates additional error

TIME SLICE METHOD



- Shaded area
- P90 low, P10 high

Rate < P90 or Rate > P10
Where is the EUR right?

TIME SLICE METHOD

Disadvantages

Probability of what?

- Cannot choose at value , e.g. EUR, NPV
- Type well does not match the EUR

Prone to error

- Errors from using only history
- Crossed rate-time profiles
- Rates selected from all wells and probabilities
- Doesn't represent a defined group of wells
P90 rates from 19 of 25 wells, P4 to P96



AGGREGATION METHOD

Resolves 4 type well questions

- Which wells to use?
- Should wells have equal weighting?
- How does one account for drill program size?
- What is the right way to handle probabilities?

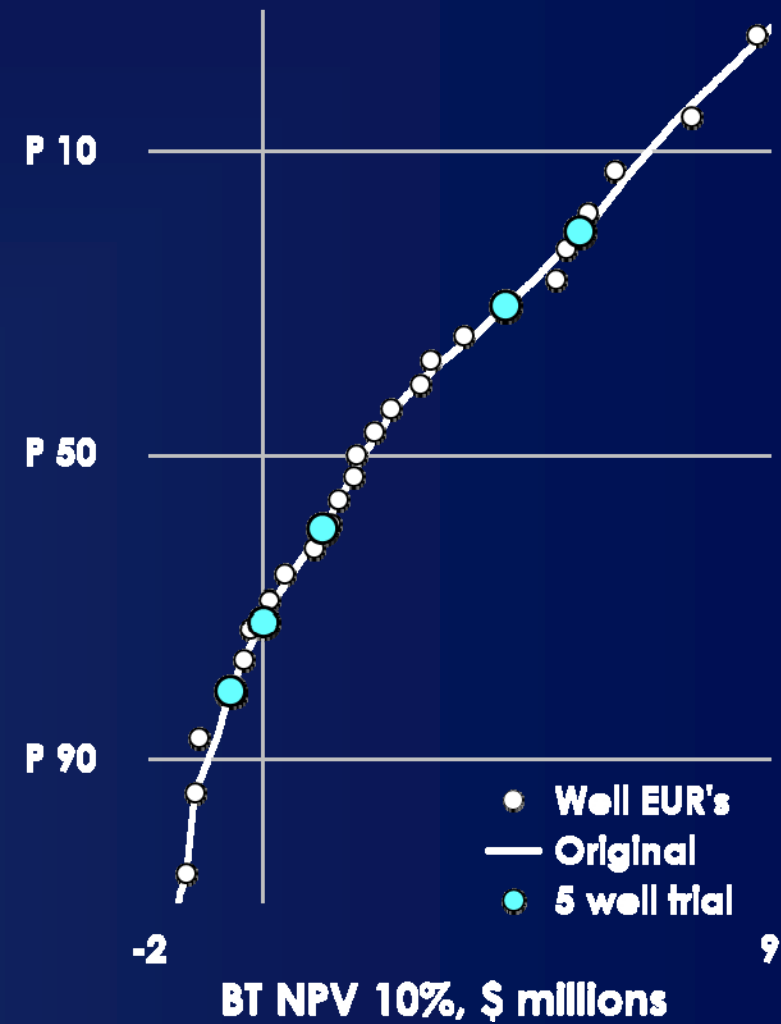
The Approach

- Find appropriate weighting factors

AGGREGATION 101

Aggregated Distribution

- Pick 5 random probabilities
- Get values for each
- Average the values



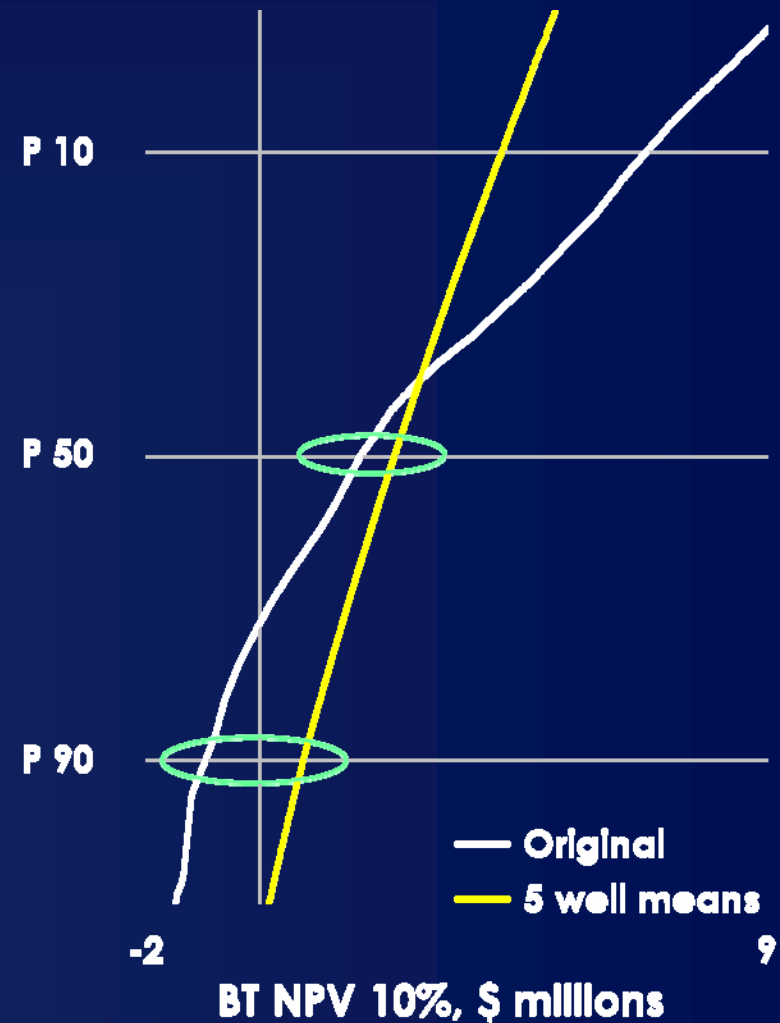
AGGREGATION 101

Aggregated Distribution

- Pick 5 random probabilities
- Get values for each
- Average the values
- Repeat 100,000 times
- Plot distribution of means

Aggregated Results

- P90 & P50 values increase
- Certainty improves P10/P90
- P90 economic with 5 wells



AGGREGATION METHOD

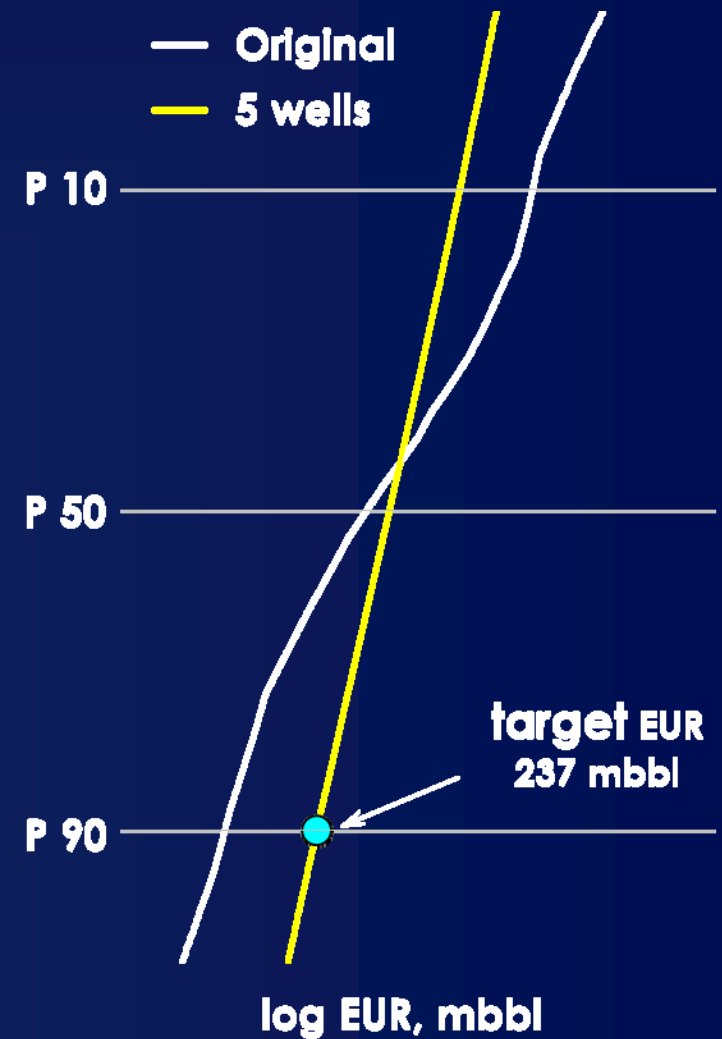
Step 1 Get Target EUR (237)

Step 2 Weighting Factor

- Continue 5 well trials
- When mean \sim target
Tally the selected wells
- Tally more than 1000 trials
- Calculate weighting factor as a % of the total tally

Step 3 Build type well

- Multiply history and prediction by the weighting factor and sum



AGGREGATION METHOD

Step 1 Get Target EUR (237)

Step 2 Weighting Factor

- Continue 5 well trials
- When mean ~ target
Tally the selected wells
- Tally more than 1000 trials
- Calculate weighting factor as
a % of the total tally

Step 3 Build type well

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the weighting factor and sum

Calculate Weighting Factors

Well	EUR	Tally	Weight
8	175	81	8.9%
24	197	69	7.5%
7	203	73	8.1%
25	214	28	3.1%
9	220	67	7.3%
21	241	33	3.7%
5	277	53	5.8%
16	293	25	2.8%
17	326	42	4.6%
3	378	4	0.5%
30	396	7	0.8%
6	434	3	0.3%
		910	100%

AGGREGATION METHOD

Advantages

Designed for new drilling

- *Based on probability of drilling each well*

Properly uses aggregated probabilities

Will use any uncertain parameter

Proper ratios for secondary products

- *Calculated with the correct weighting*

Aggregation

- *Increases P90 & P50 reserves*
- *Adds certainty*



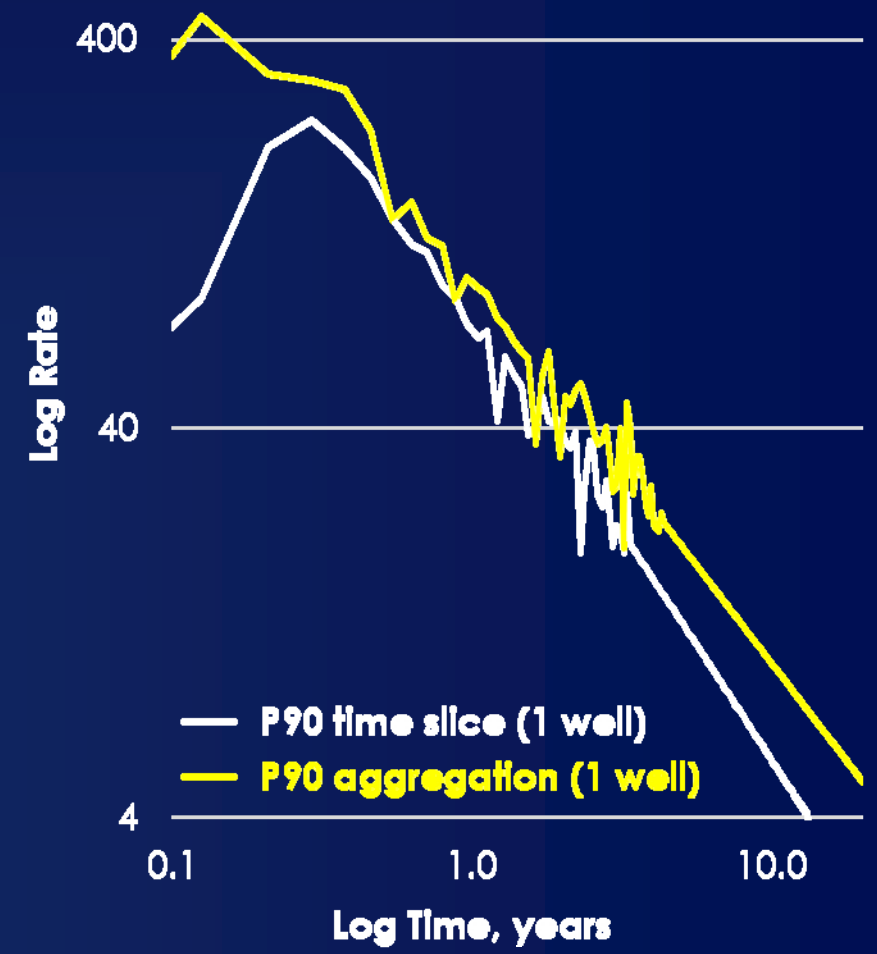
COMPARISON P90 type wells

Time Slice Comparison (1 well)

	Btax	Atax	EUR
NPV 10% & EUR	\$mm	\$mm	mbbl
P90 aggregation	-0.8	-0.9	191
P90 time slice	-3.4	-2.5	111
Difference	2.6	1.7	79

Method is critical

I choose the aggregation method

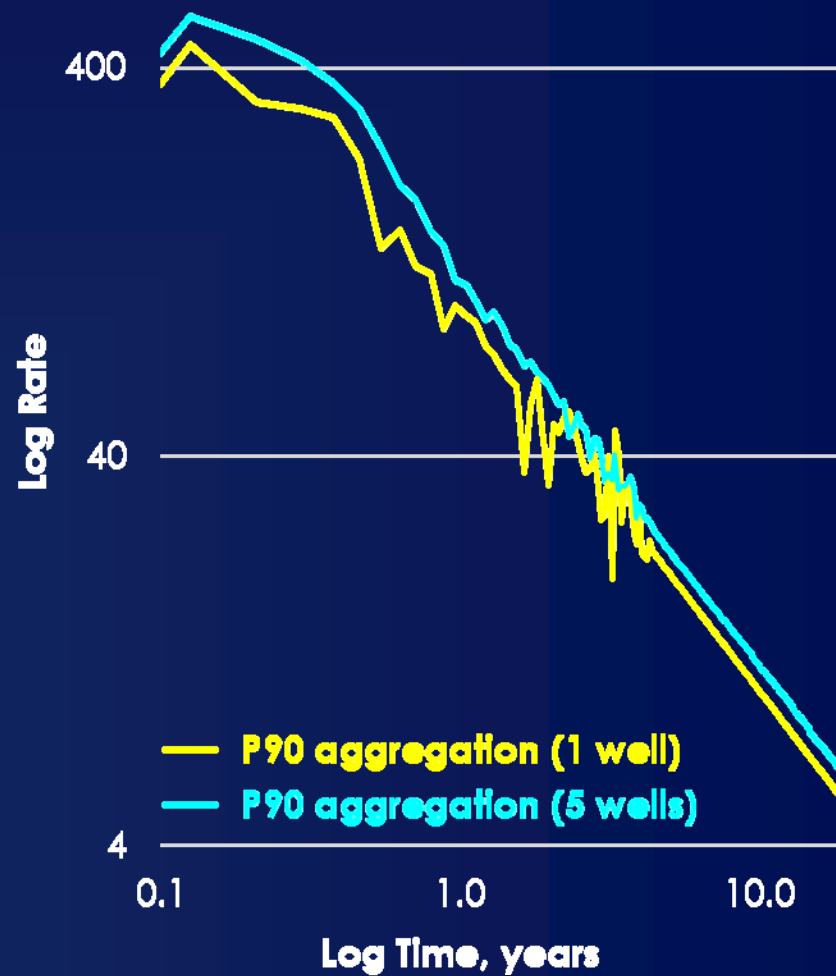


COMPARISON P90 type wells



Benefit of Aggregation

NPV 10% & EUR	Btax \$mm	Atax \$mm	EUR mbbl
P90 drill 5 wells	1.1	0.4	237
P90 drill 1 well	-0.8	-0.9	191
Difference	1.9	1.2	46



TWO VITAL SECRETS

As a Type Well Builder

- Average both history and prediction
- Use Aggregation method for new drilling

As a Consumer of Type Wells

- Avoid type wells that use only historical data
- Type wells should represent the number and quality of wells you plan to drill



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