How certain are we about uncertainty?

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2014.03.28., Balatonföldvár

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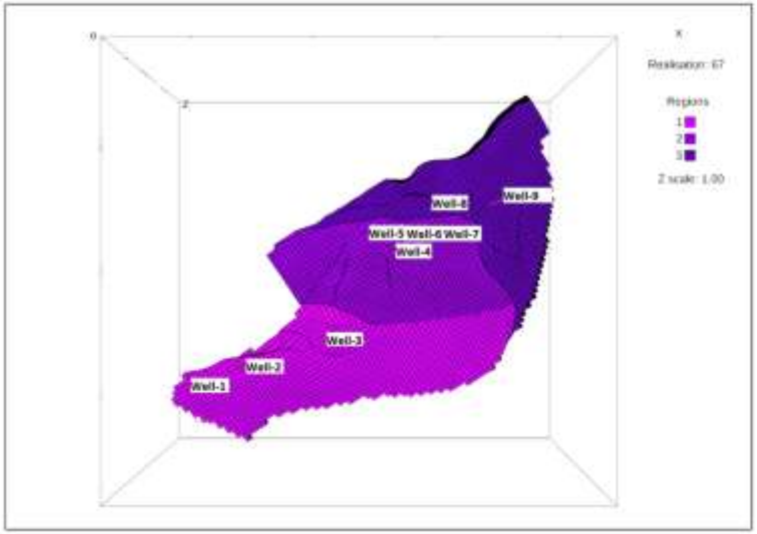
Outline

- Why and how do we need this?

- Softwares
  - Roxar Irap RMS 2012.0.3
  - REP 5.25c1
  - Microsoft Excel 2010

- Case-study
  - Representing an extensive dataset



Why and how do we need this?

- ***Heisenberg's Principle of Uncertainty: „...the act of observation affects the particle being observed..."***

- **Surveys, loggings, measurements, interpretations have errors (natural thing)(„model!" ≠ reality)**
  - **Resolution**
  - **Error of the employed tools**
  - **Empirical regressions**

No one ever said: *„Here is the sand body, but lets drill a well into the shaly part to gather representative data for the geologist."*

- **Well data unintentionally biased → questionable representativity**
  - **What about the interwell space, spatial uncertainty?**

- **Errors inheriting, accumulating → growing (Must account for them!)**

Scenario uncertainty

Data uncertainty

Why and how do we need this?

Seismic data

- surfaces
- faults
- well-picks
- pinch-out polygons
- attributes

Petrophysical data

- well data (trajectory, wellhead)
- porosity
- lithological composition
- water saturation
- permeability
- FWL

$$HCIIP = \frac{V_{bulk} * NtG * \phi * (1 - Sw)}{B_i}$$

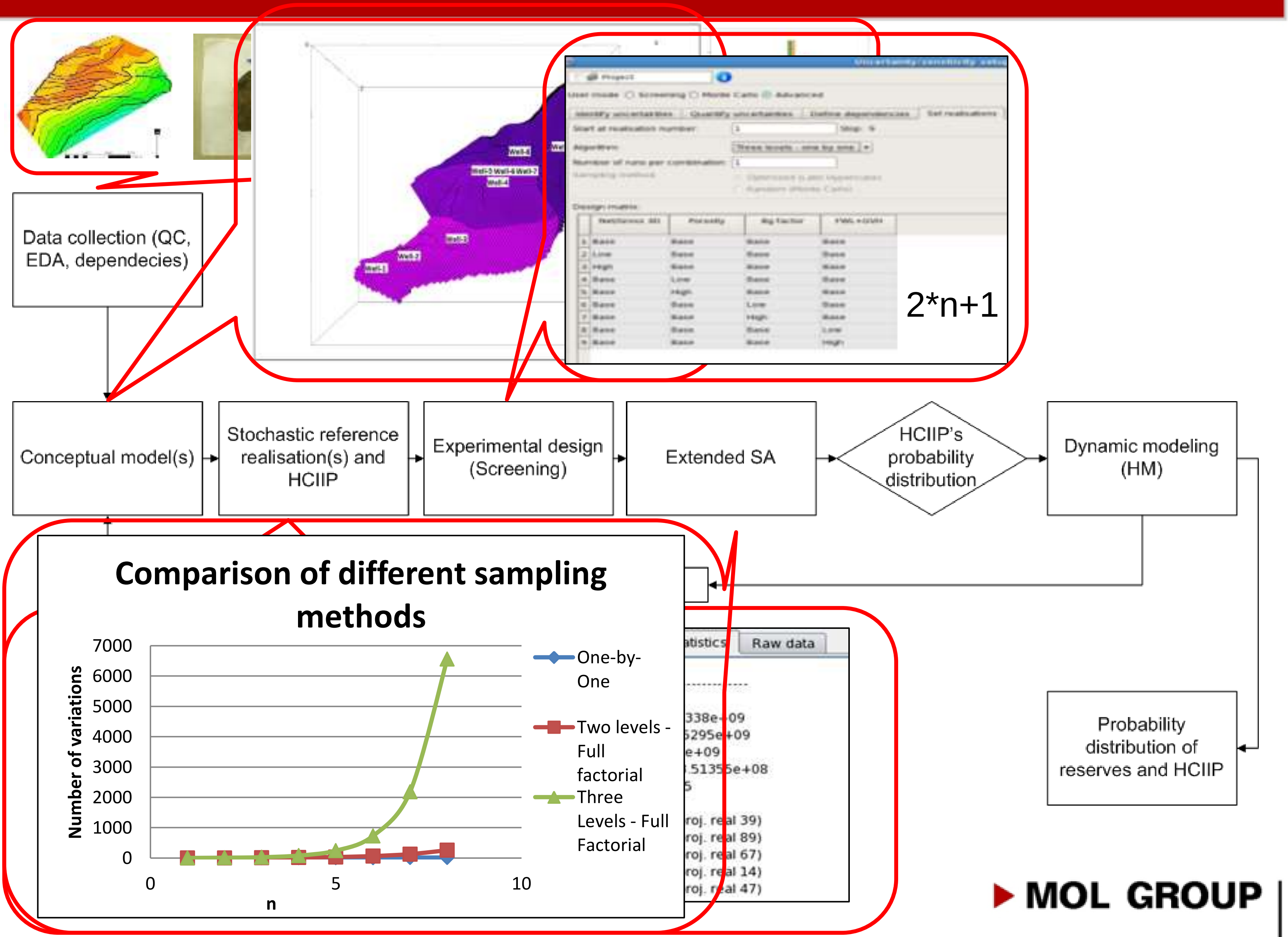
PVT data

- B_i
- R_{si}
- GCR
- Composition data
- Density

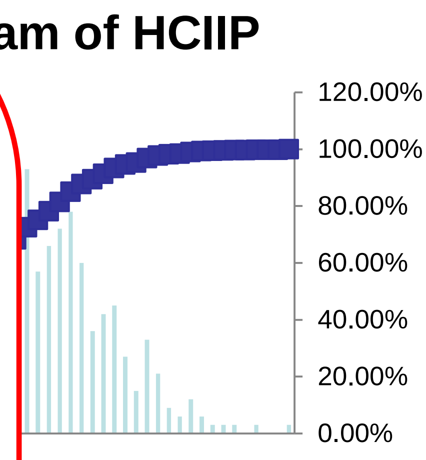
Core data

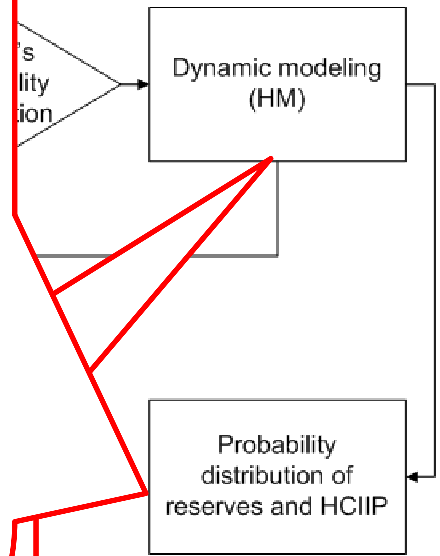
- capillary curves
- density
- horizontal and vertical permeability
- calcite content

Why and how do we need this?



Why and how do we need this?





Softwares

- Uncertainty and sensitivity analysis
  - Reference case
  - Input ranges, parameters
  - Sampling methods
  - Simulation

- Statistics
  - EDA
  - Correlations, regression
  - Partial correlation
  - Cluster analysis
  - Charts, diagrams

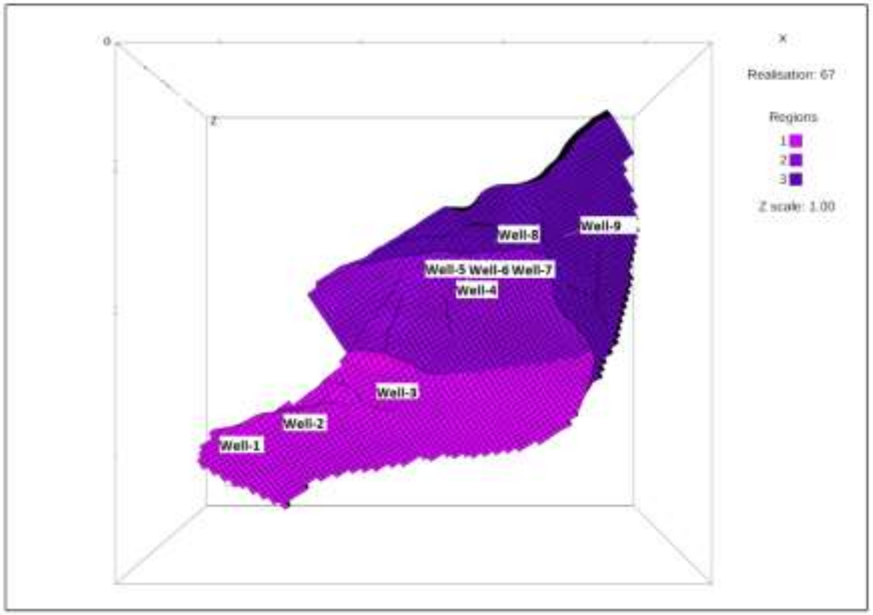
roxar MAXIMUM RESERVOIR PERFORMANCE

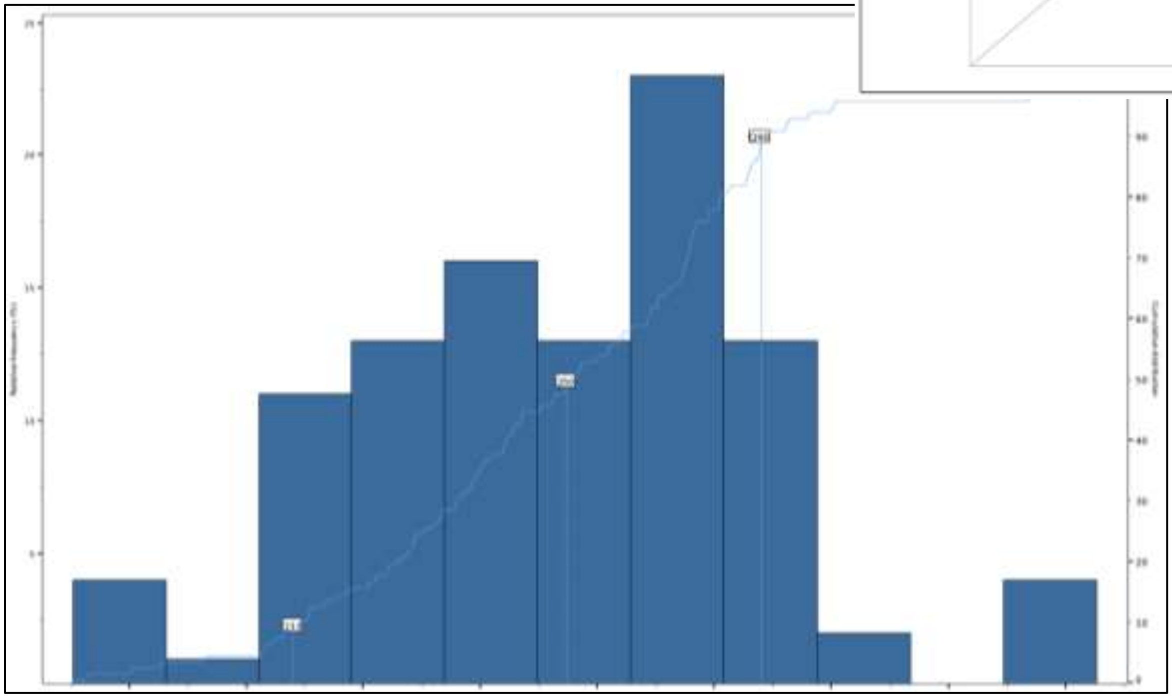
Schlumberger Petrel

Grapher 10

Case study

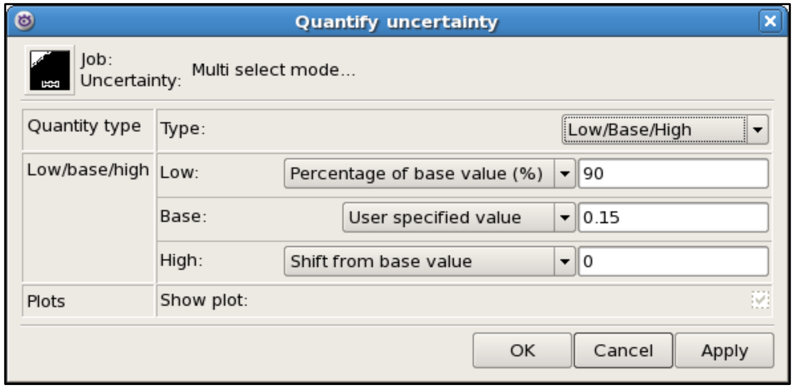
- Hungarian gas reservoir
- Two scenarios
  - A – West and Central one unit
  - <u>B – West and Central separated</u>
- Reference case (50 realisations)





Case study

- **Uncertainty analysis**

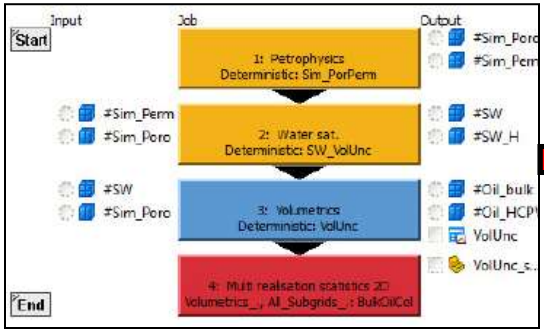


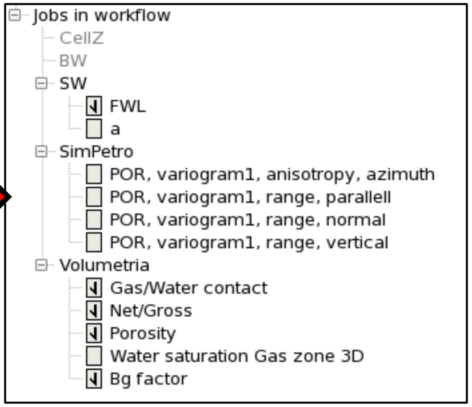
  - **Analyzed factors**
    - **Horizons (GRV)**
    - **Cut-off sets**
    - **Capillary curves**
    - **FWL≈GWC (merged)**
    - **Porosity**
    - **B_{gi}**
    - **LGR**

3^7 = 2187 realisations (H/B/L) (Three levels - Full Factorial)

Merge ≠ Group

  - **Responses**
    - **GIIP, Ass. Liquid**





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Case study

Paraméter	Low	Base	High
Top – Bottom horizon	Interpreted	Interpreted	Interpreted
FWL (m TVDSS)	A-8	A	A+18
Sw_{irr} (%)	B+10	B	B-10
Cut-off(Por %; Sw_{Log} %; V_{SH} %)	More strict	C	Less strict
Porosity	D*0.95	D	D*1.05
Bgi	E*0.93	E	E*1.07
LGR	F*0.95	F	F*1.05

- *Top-Bottom horizon:* Multireal. 2D Statistics
- *FWL:* becsléssel
- *Sw_{irr}:* capillary curves
- *Cut-off:* cut-off tables
- *Porozitás:* analogy
- *Bgi:* different empirical equations (Standing, Sutton, MBal)
- *LGR:* variability in wellstream composition

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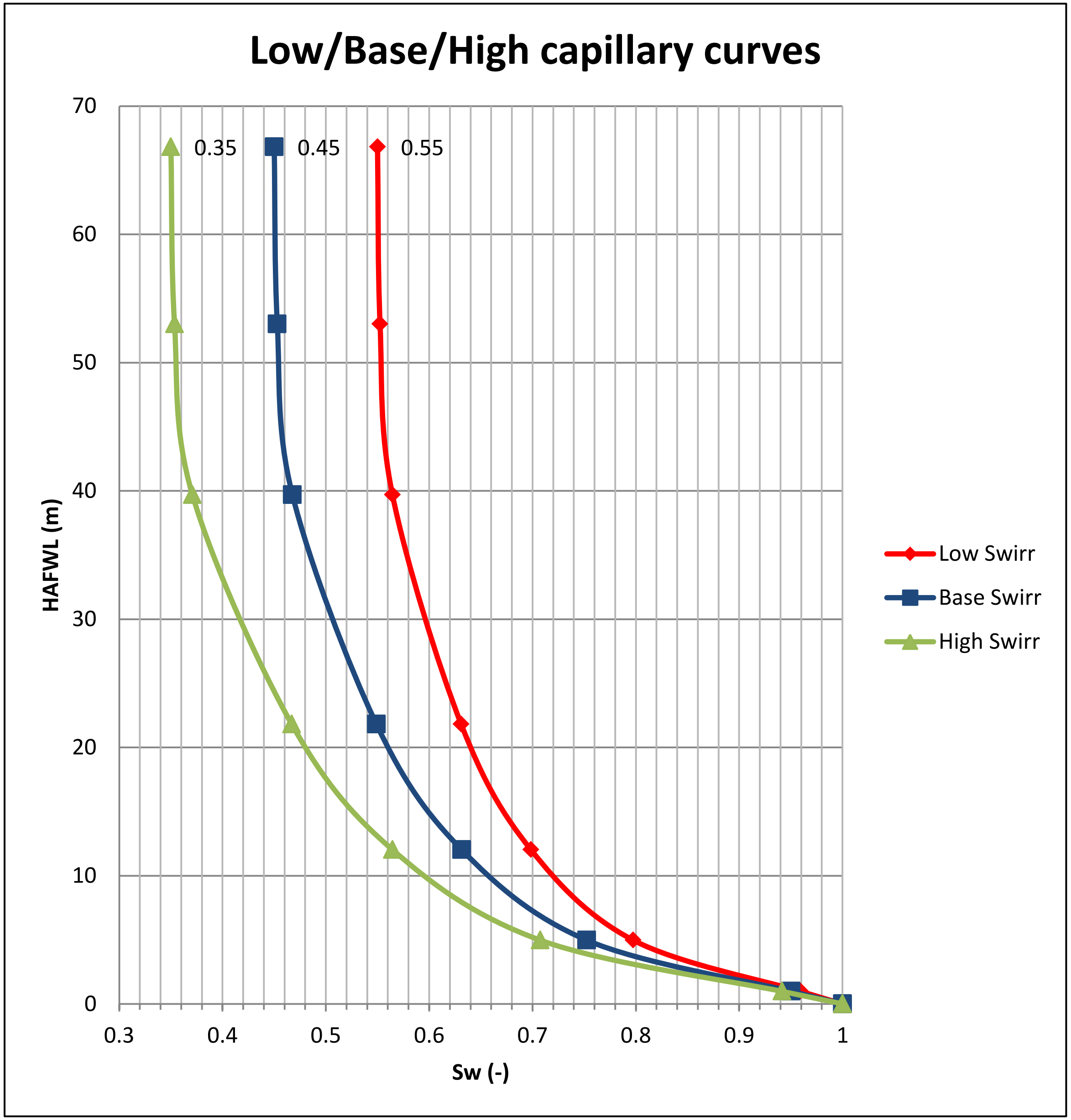
Case study

Relative tornado diagram of GIIP (Screening)

	Bgi	Horizons (GRV)	Porosity	FWL	Cut-off	Sw
RSpearman (GIIP)	-0.20	0.28	0.30	0.34	0.60	-0.62

Case study

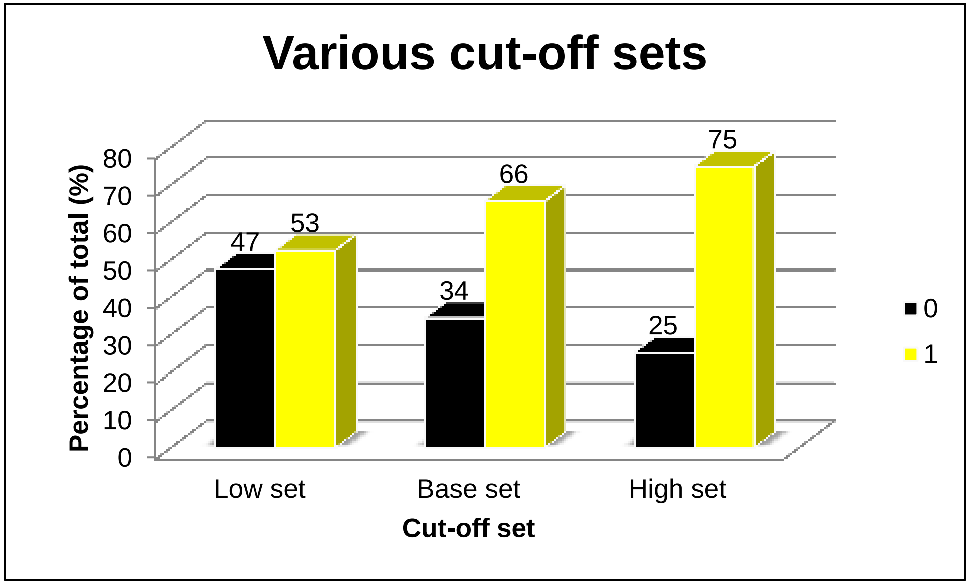


Capillary curves

- Various irreducible water saturation values
- IFT, contact angle, p, T, relative density not examined

Case study

Cut-off (N/G)

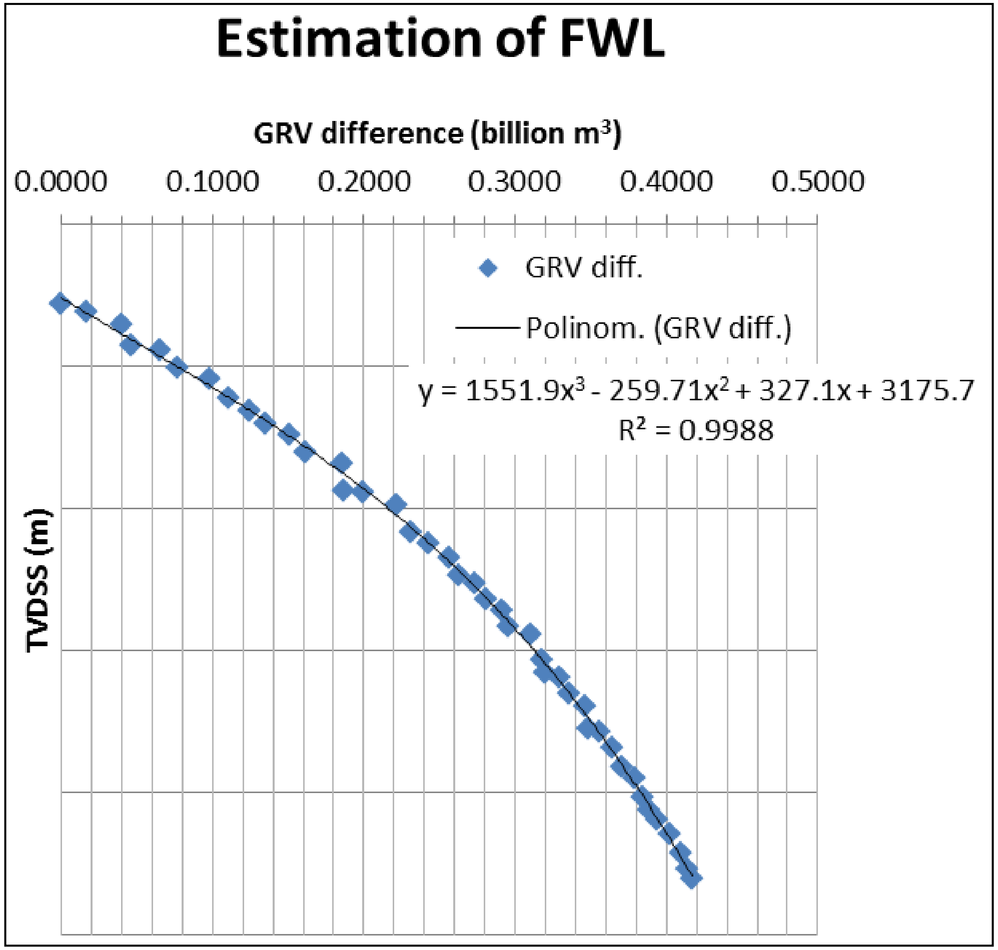


Logical operation

IF $S_w \leq 75\%$ AND Porosity $\geq 8\%$ AND $V_{SH} \leq 30\%$ THEN N/G=1 ELSE N/G=0

	Porosity	S_w	V_{SH}
Low set	▲	▼	▼
Base set	-	-	-
High set	▼	▲	▲

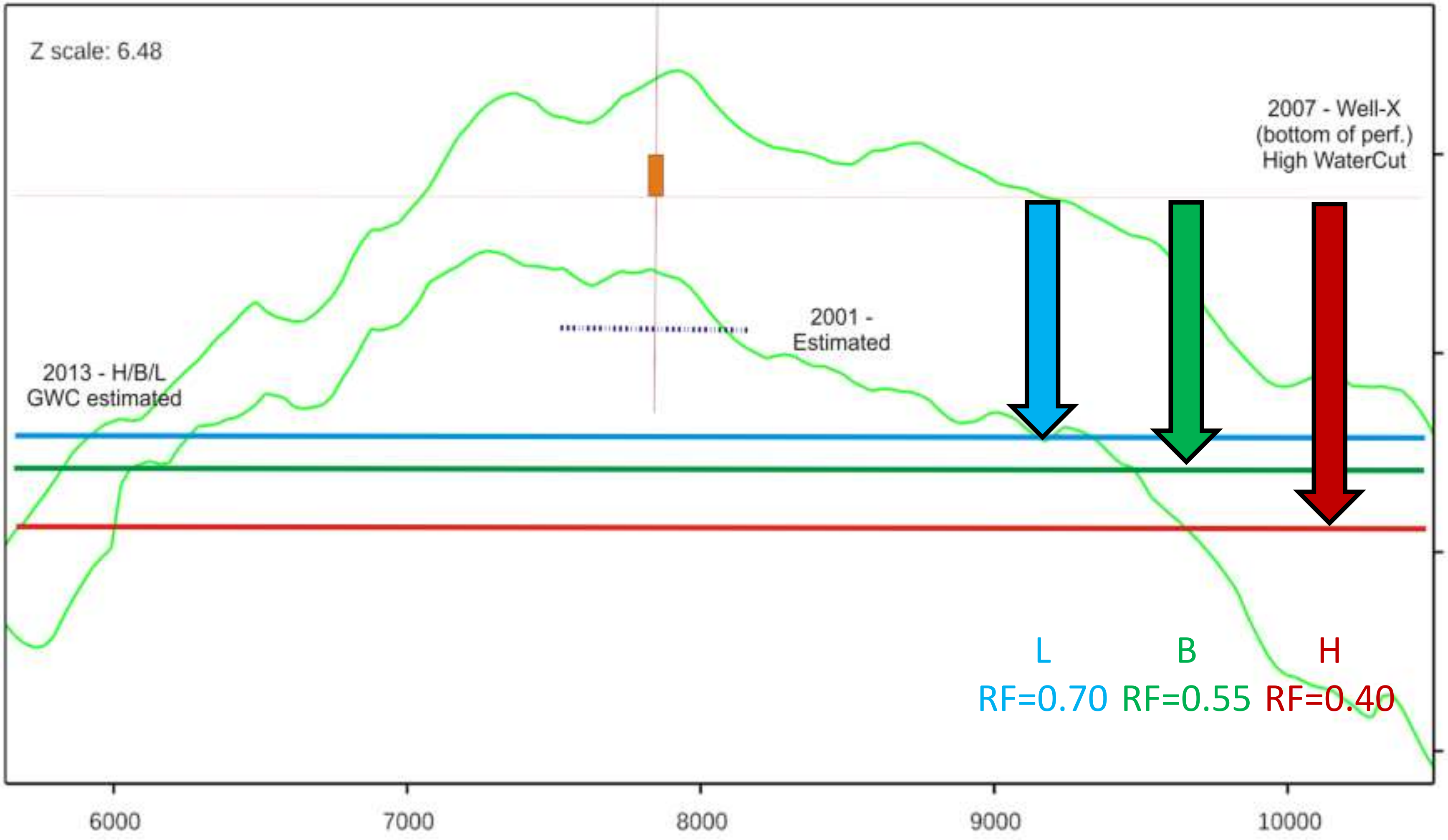
Case study



FWL

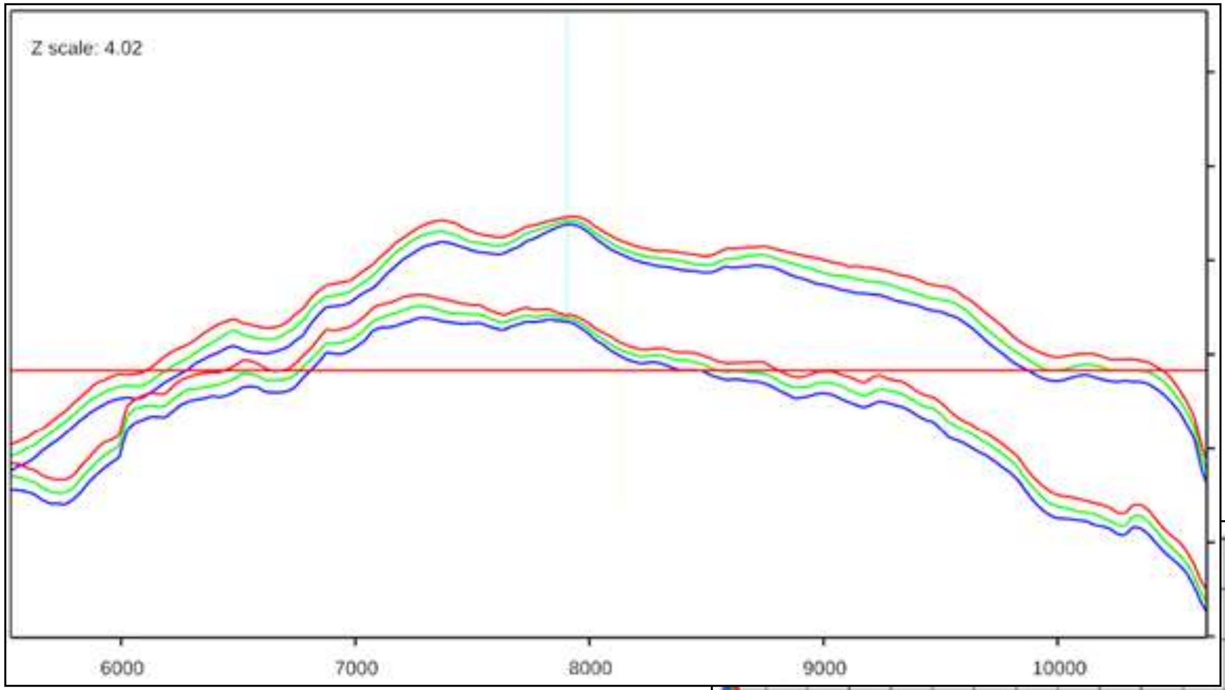
- p_d ~ negligible
- Major influencial parameter:
  - recovery factor
- Other values (GRV, Porosity etc. on base level)
- Ideal rise of GWC supposed

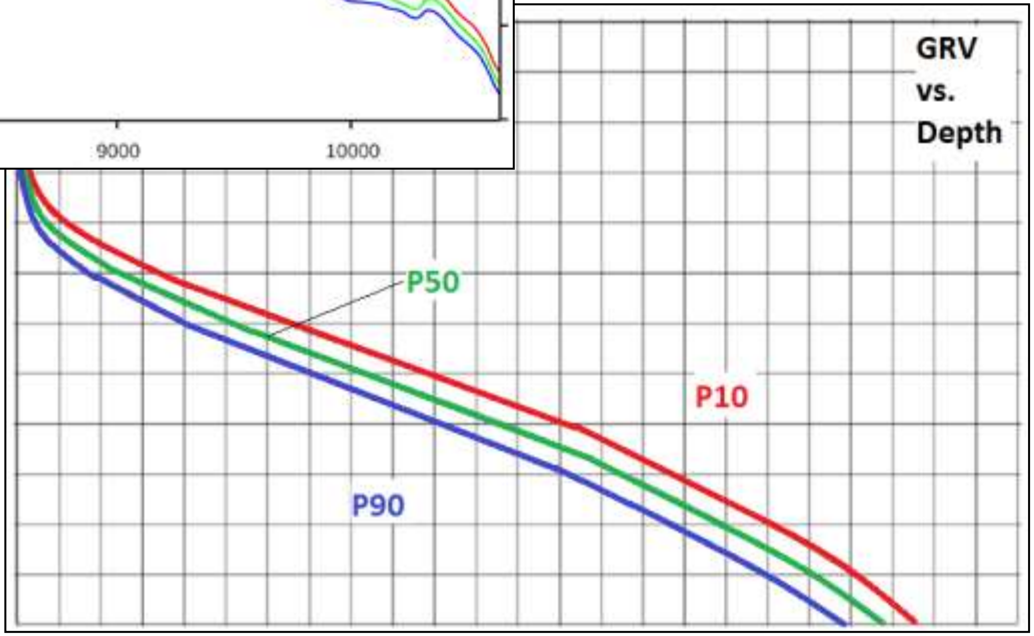
Case study


Z scale: 6.48
2007 - Well-X
(bottom of perf.)
High WaterCut
2001 -
Estimated
2013 - H/B/L
GWC estimated
L
B
H
RF=0.70
RF=0.55
RF=0.40
6000
7000
8000
9000
10000

Case study

Top - Bottom





Case study

- *Porosity*
  - Esimated based on cores and analogy
- *B_{gi}*
  - p, T (HPHT)
  - Variability in samples' composition
  - Different methods for empirical calculation
- *LGR*
  - Variability in well stream samples

Porosity

B_{gi}

LGR

Case study – Results

- *Microsoft Excel – Analysis ToolPak*

EDA

	Reference case	Uncertainty analysis								
	Reference case	**Mean**	**P90**	**P50**	**P10**	**Std. dev**	**CV**	**P10/P90**	**P90-P50 diff. (%)**	**P10-P50 diff. (%)**
	MMm^3	*MMm^3*	*MMm^3*	*MMm^3*	*MMm^3*	*MMm^3*	*%*	-	*%*	*%*
GIIP	7.3275	7.3319	6.3344	7.3244	8.3593	0.7666	10%	1.32	-14%	+14%

Shifting by 10 MMm^3

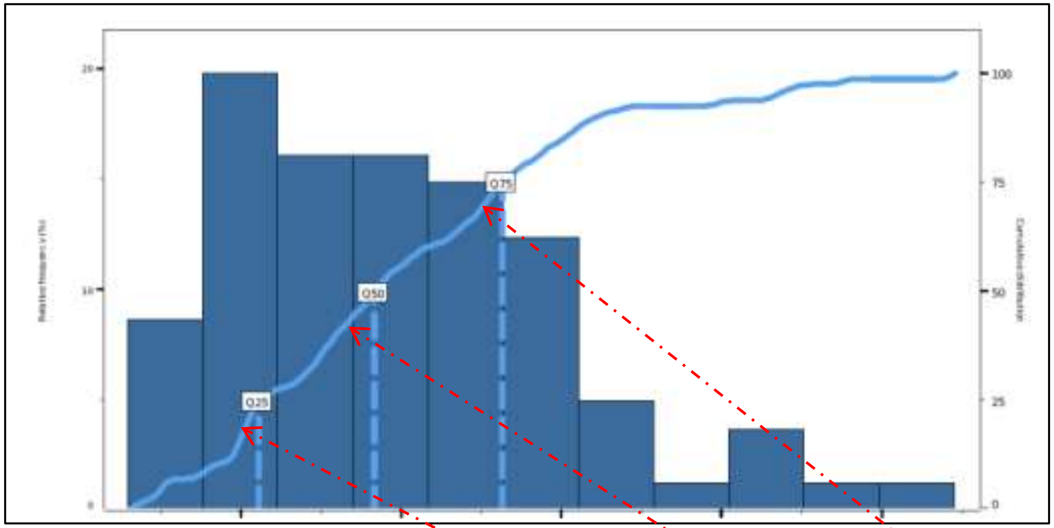
Coefficient of variation

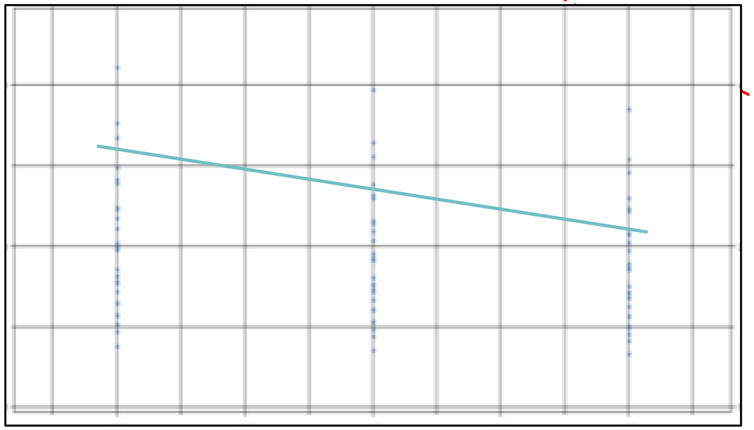
	Reference case	Uncertainty analysis								
	Reference case	**Mean**	**P90**	**P50**	**P10**	**Std. dev**	**CV**	**P10/P90**	**P90-P50 diff. (%)**	**P10-P50 diff. (%)**
	MMm^3	*MMm^3*	*MMm^3*	*MMm^3*	*MMm^3*	*MMm^3*	*%*	-	*%*	*%*
GIIP	17.3275	17.3319	16.3344	17.3244	18.3593	0.7666	4%	1.12	-6%	+6%

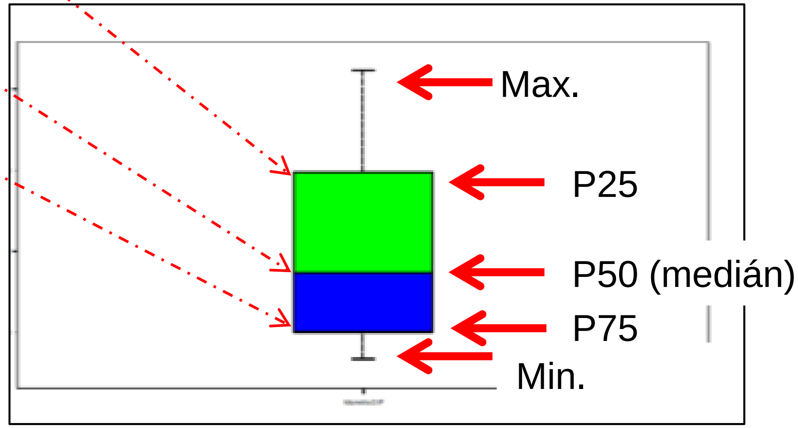
- *Descriptive statistics*

Case study – Results

S/D, box-whisker

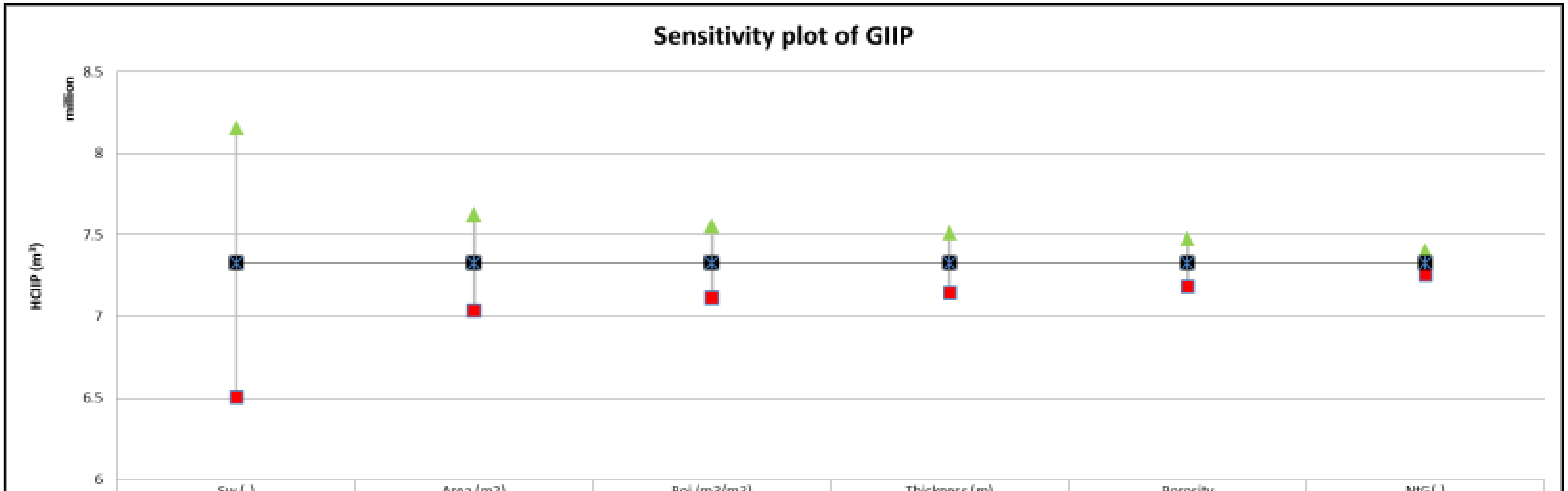




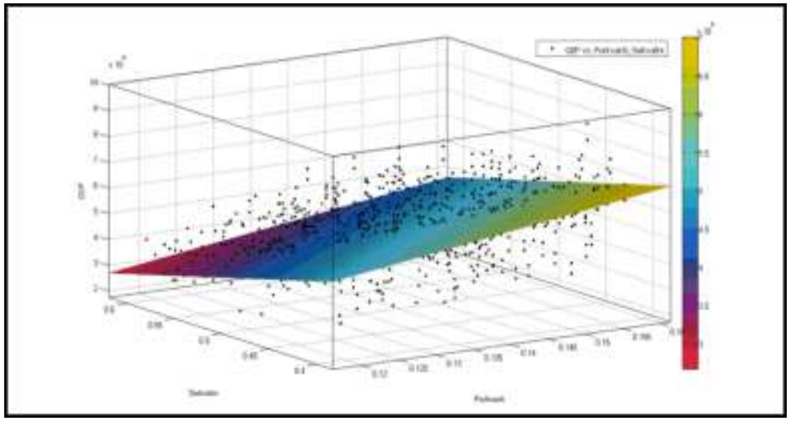


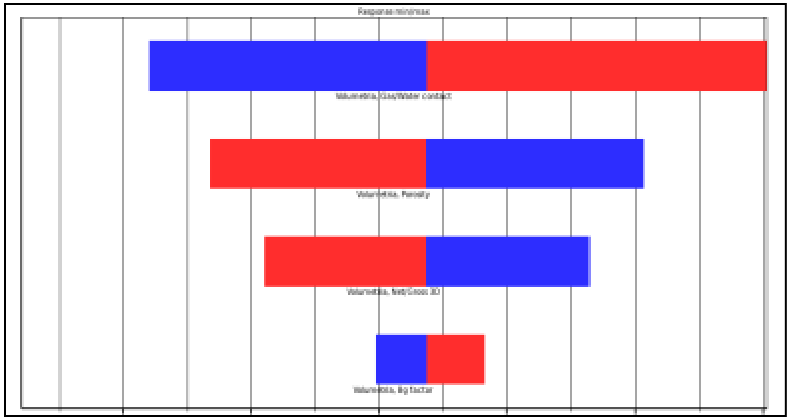
Case study – Results

Plots



	Sw (-)	Area (m2)	Boi (m3/m3)	Thickness (m)	Porosity	NtG(-)
Low	6501136.19	7034367.549	7114044.851	7144279.542	7180916.873	7254191.535
High	8153796.203	7620564.845	7554088.863	7510652.852	7474015.521	7400740.859
Base	7327466.197	7327466.197	7327466.197	7327466.197	7327466.197	7327466.197





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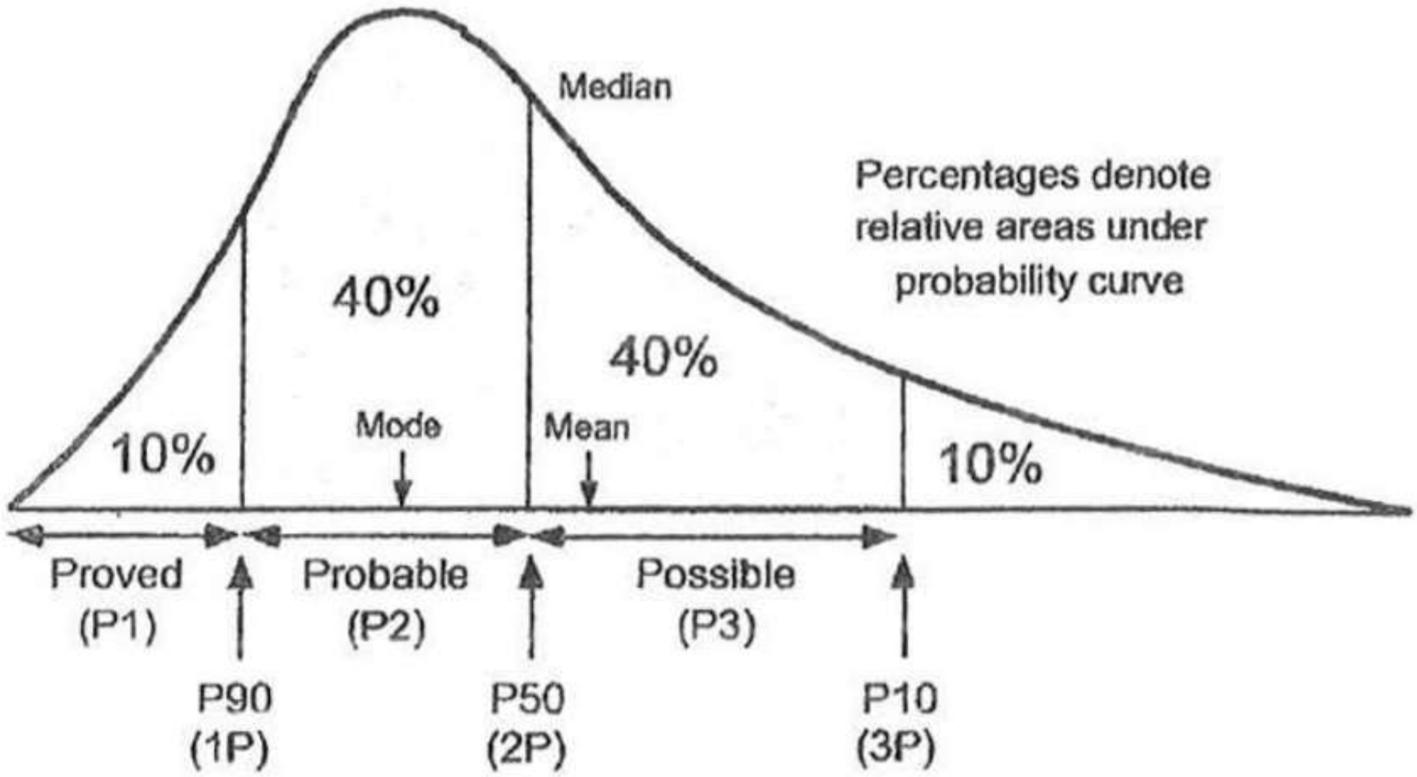
Case study – Results

Reserve categories



Ferruh Demirmen: Reserves Estimation: The Challenge of Industry JPT May 2007

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Your kind
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