Intrinsic Fault Seal Uncertainties in Hydrocarbon Migration Analysis*

Øyvind Sylta[1] and Are Tømmerås[1]

Search and Discovery Article #40775 (2011)
Posted July 26, 2011

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Houston, Texas, USA, April 10-13, 2011.

[1]Migris AS, Trondheim, Norway. (oyvind.sylta@migris.no)

Abstract

Fault seal dependent oil and gas prospects are explored for in many sedimentary basins. Changes in the sealing properties of the faults may be critical for the prospectivity of such exploration targets. The outcomes of migration analyses may for many fault seal prospects be quite uncertain. Detailed hydrocarbon migration modeling can often help to describe and thereafter reduce the uncertainties. However, the uncertainties cannot be reduced below the intrinsic uncertainties of the system. The intrinsic uncertainty is an inherent property of the prospect, and helps us focus our analysis towards the more critical uncertainties.

The a-priori uncertainty distribution of the input parameters for the hydrocarbon generation and migration system is described in detail. This includes uncertainties in the thermal field, source rock properties, rock fluid flow properties and fault seal properties. The intrinsic uncertainties of these probability distributions are described as fractions of the standard deviation of each distribution. Hydrocarbon generation and migration software is then used to simulate the transfer of oil and gas within the sedimentary basin from sources to traps through geological time. These simulations are done using a Quantum approach within Monte Carlo simulations.

In the Quantum approach, the simulator draws input values from the a-priori statistical distributions with fixed distances from the mean value of each parameter, and uses only these exact values. The exact value used in each simulation is controlled by a Quantum distance parameter, which is defined as a percentage of the standard deviation. In a typical case, several hundred faults would be modeled with multiple carriers and seals and using between 10 and 20 input variables for each fault. A random sampling of the input variable spaces in a small but significant number of simulations runs (> 1,000) produces trap volumetric results. These results can be used to compile the intrinsic uncertainties of each trap and may relate the intrinsic uncertainties of the traps to the fault seal properties.

The study of uncertainties is a key issue in basin modeling and analysis. When volumetric estimates of uncertainties for prospects can be made using hydrocarbon systems modeling techniques, the next step is to try to reduce these uncertainties. Important questions to address are how small the uncertainties can become, and which of the fault seal input properties can reduce the uncertainties.

References

Childs, C., J.J. Walsh, T. Manzocchi, J. Strand, A. Nicol, M. Tomasso, M.P.J. Schopfer, and A.C. Aplin, 2007, Definition of a fault permability predictor from outcrop studies of a faulted turbidite sequence, Taranaki, New Zealand *in* S.J. Jolley, D. Barr, J.J. Walsh, and R.J. Knipe, (eds.) Structurally complex reservoirs: Geological Society Special Publications, v. 292, p. 235-258.

Sperrevik, S., P.A. Gillespie, Q.J. Fisher, T. Halvorsen, and R. Knipe, 2002, Empirical estimation of fault rock properties *in* A.G. Koestler, and R. Hunsdale, (eds.) Hydrocarbon Seal Quantification: Norwegian Petroleum Society Special Publications, v. 11, p. 109-126

Sylta, O., A. Tommeras, and C. Zwach, 2009, A Quantum Approach to Studying Intrinsic Uncertainties in Basin Modeling: AAPG Search and Discovery, Article #90091. Website accessed 13 July 2011, http://www.searchanddiscovery.com/abstracts/html/2009/hedberg/abstracts/short/sylta.htm

Intrinsic fault seal uncertainties in hydrocarbon migration analysis.

Øyvind Sylta oyvind.sylta@migris.no

Are Tømmerås **Migris AS**

Conclusions

- Intrinsic probabilities are important for fault seal studies
- Intrinsic probabilities of input parameters can be defined from probability density functions (SGR,diagenesis,...).
- Results from a quantum approach can easily be compared to regular Monte-Carlo simulations.
- Intrinsic propabilities of trapped petroleum can be computed.

Method may show:

How much better fault seal predictions can we achieve?

Content

Introduction

Why migration modelling of faulted systems?

- Investigate uncertainties, e.g.:
  - Risk of not finding HC
  - ”The critical factor of the petroleum system”
  - Hydrocarbon phases
  - Hydrocarbon volumes
  - Hydrocarbon column distributions
  - Hydrocarbon properties in traps

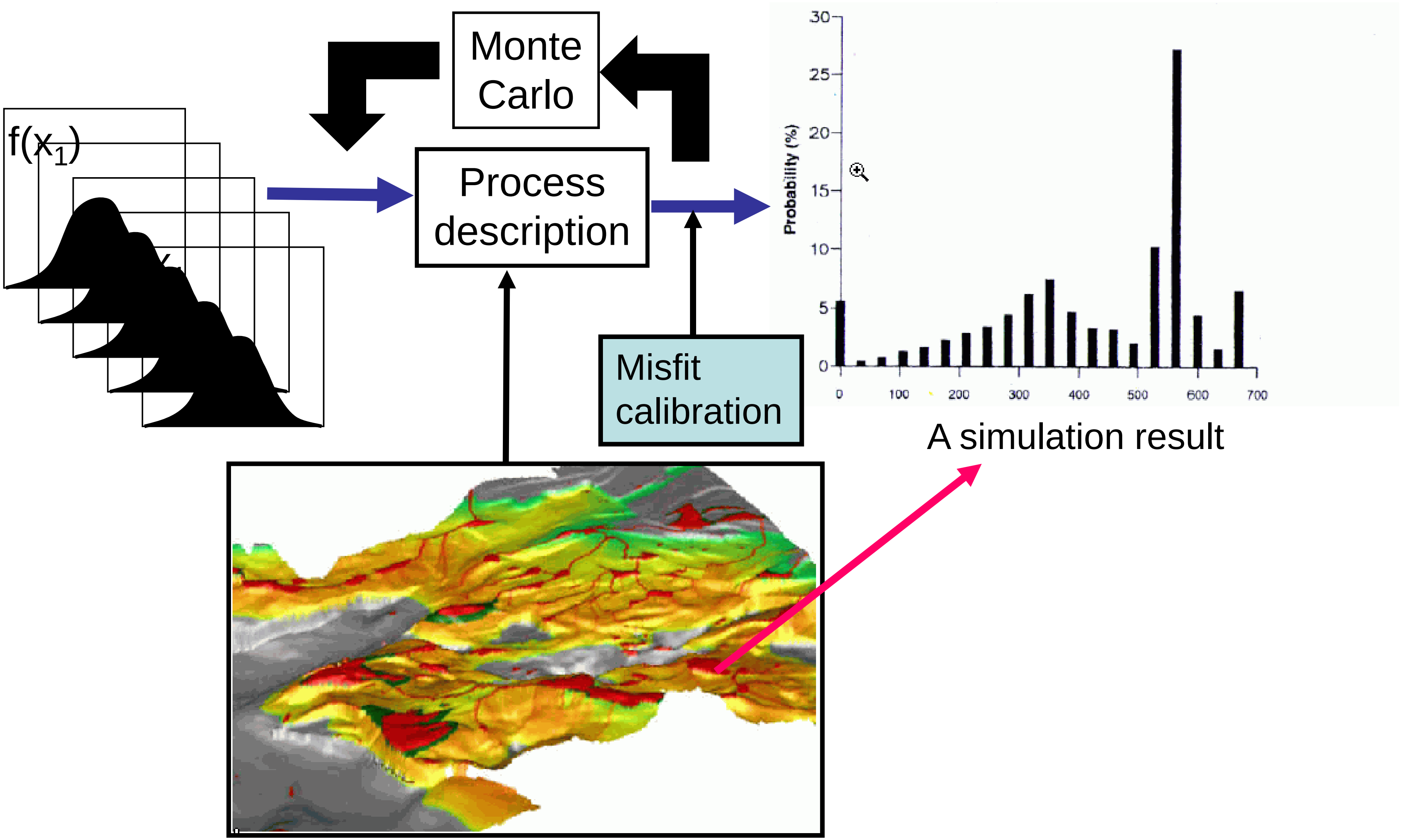
Which uncertainties?

- Processes modelled
- Algorithms coded
- Geohistory (ages,fault mapping...)
- Input values
  - Selected value ranges
  - Intrinsic uncertainties

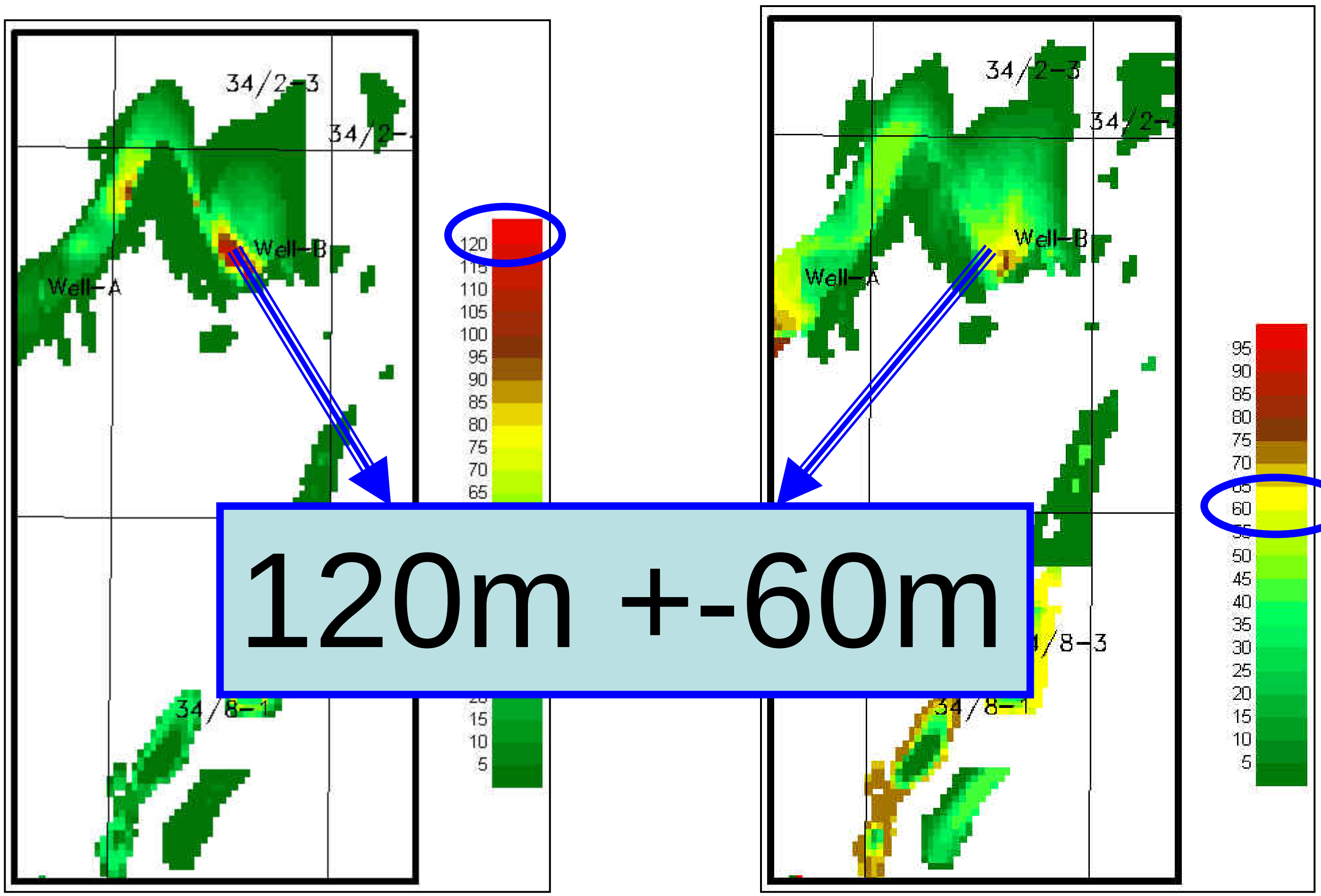
Content

- Introduction
- Modelling approach
- Intrinsic uncertainties
- Examples
- Intrinsic uncertainties of trapped hydrocarbons
- Discussion
- Conclusions

Weighted Monte Carlo simulation



How much can we reduce the uncertainty for well B before drilling it?



Most likely Oil columns (m) Standard deviation

Content

- Introduction
- Modelling approach
- Intrinsic uncertainties
- Examples
- Intrinsic uncertainties of trapped hydrocarbons
- Discussion
- Conclusions

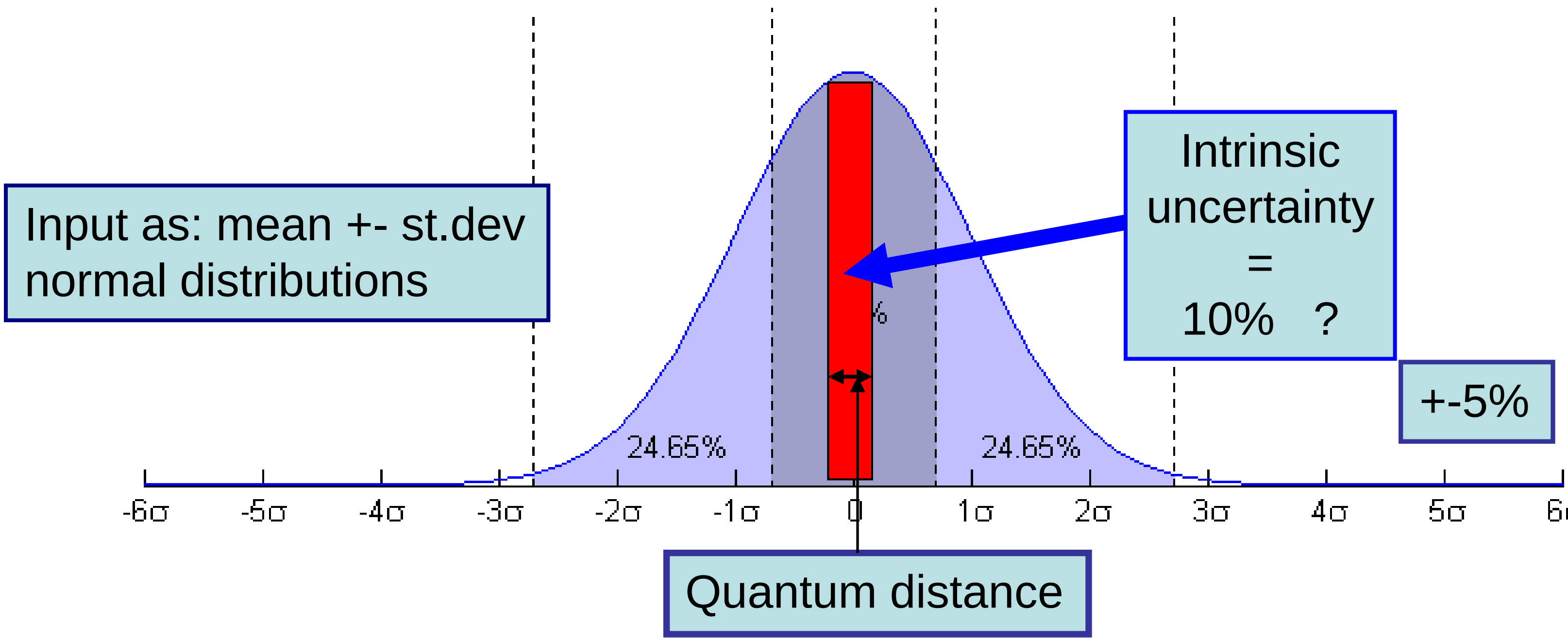
A ***Quantum*** approach to studying ***intrinsic uncertainties*** in basin modelling.

”Small (step) changes”

”The best we can do, ever”

(Sylta et al, AAPG Hedberg conf. 2009)

Intrinsic uncertainty tied to parameter range?



Intrinsic uncertainty=10% => Quantum distance=12.5% of st.deviation

Vshale example:

- Vshale = 0.7 +- 0.16
- Quantum distance = 0.16 * 12.5% = 0.02

- Use Vshale = 0.68 , 0.7 , 0.72 in simulations

Intrinsic uncertainty=10% => Quantum distance=12.5% of st.deviation

Vshale example:

- Vshale = 0.7 +- 0.16
- Quantum distance = 0.16 * 12.5% = 0.02

- Use Vshale = 0.68 , 0.7 , 0.72 in simulations

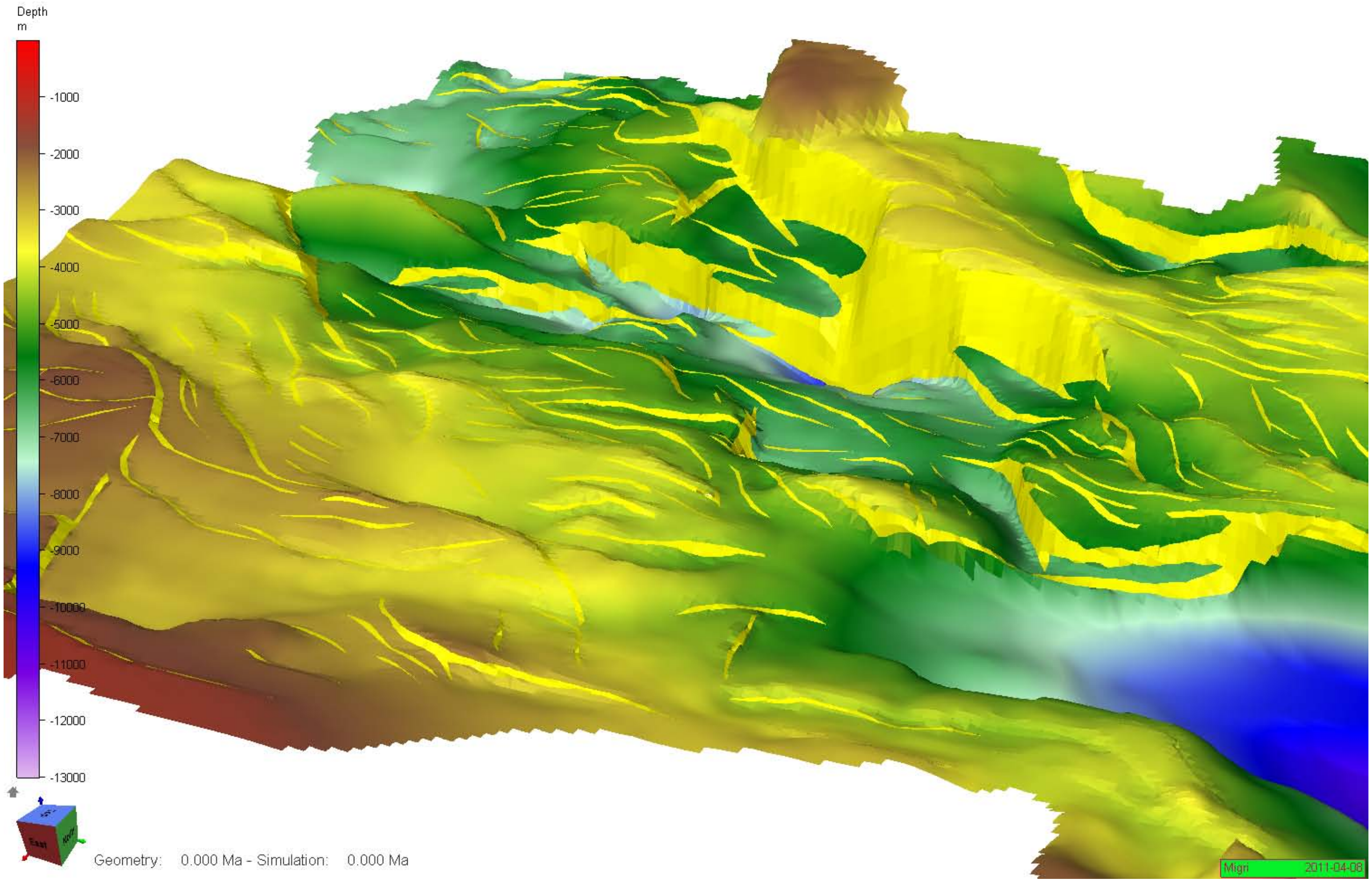
DO NOT USE ANY OTHER VALUES

Intrinsic uncertainties how well can we do?

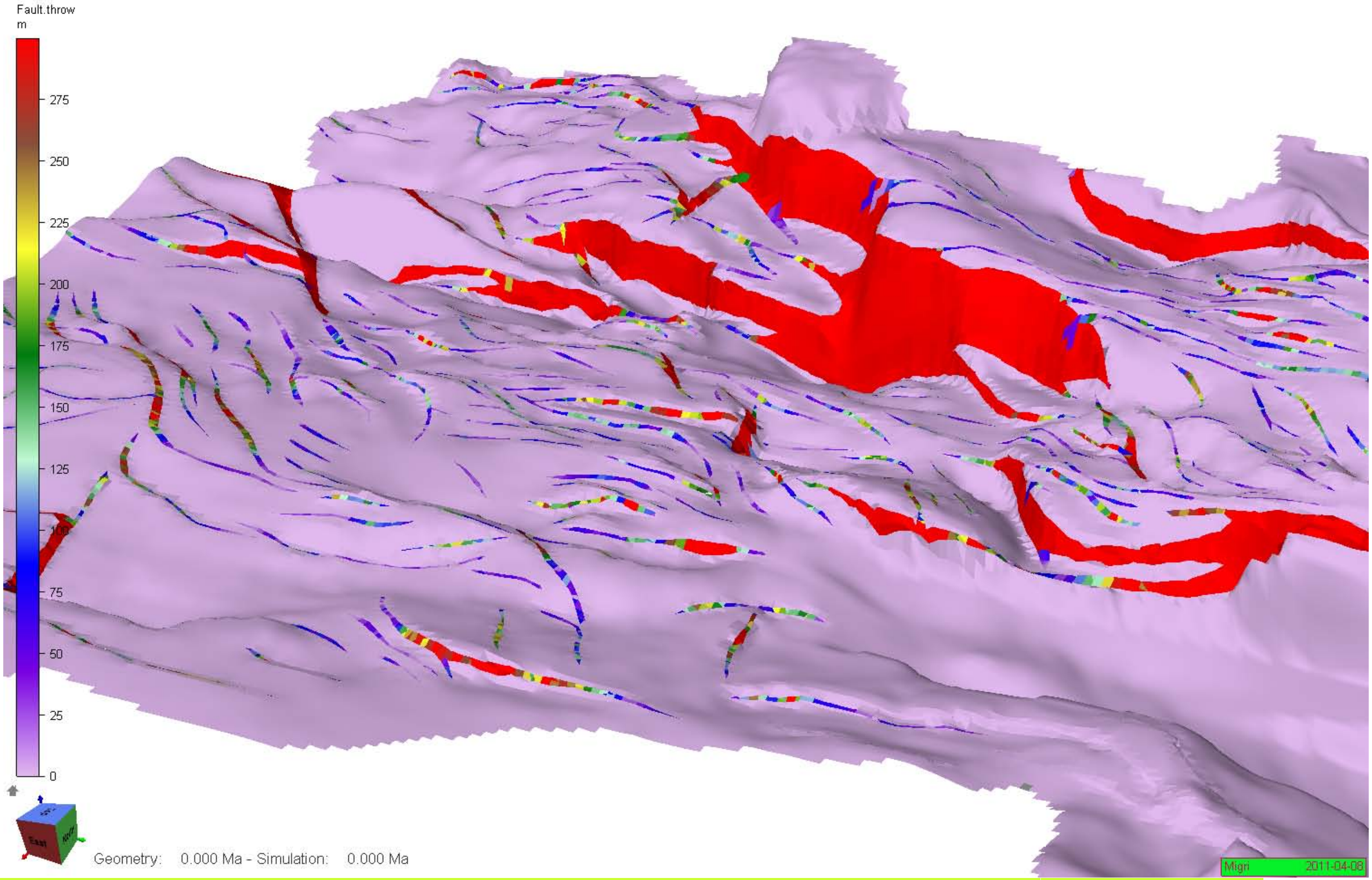
- Uncertainties that cannot be reduced pre-drill
- How significant are they?
- Which parameters contribute the most?
  - Source rock description, or...
  - Geometry, thermal, hydraulics, migration, or
  - Fault seal properties, or……

Content

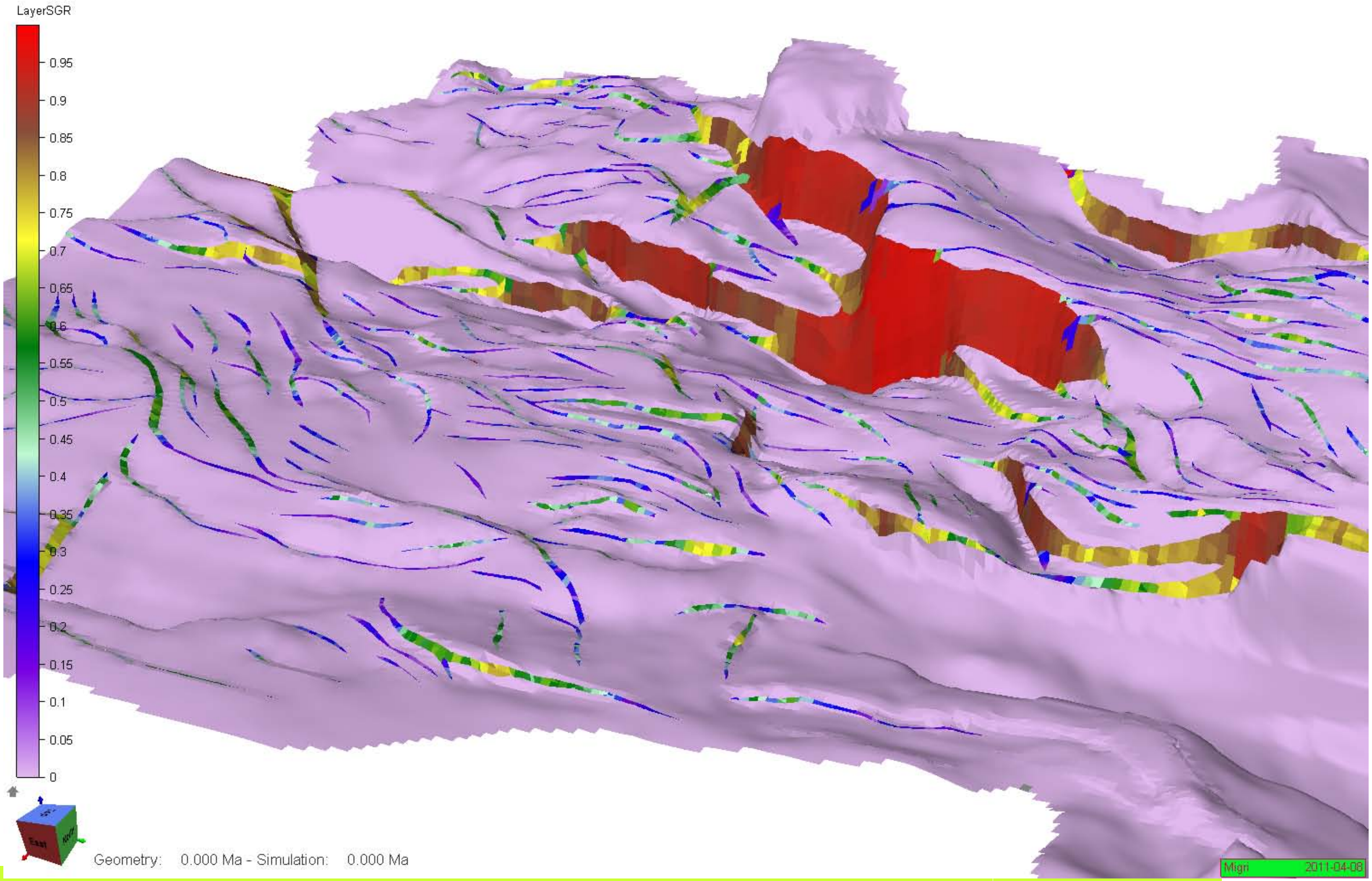
Fault plane definition



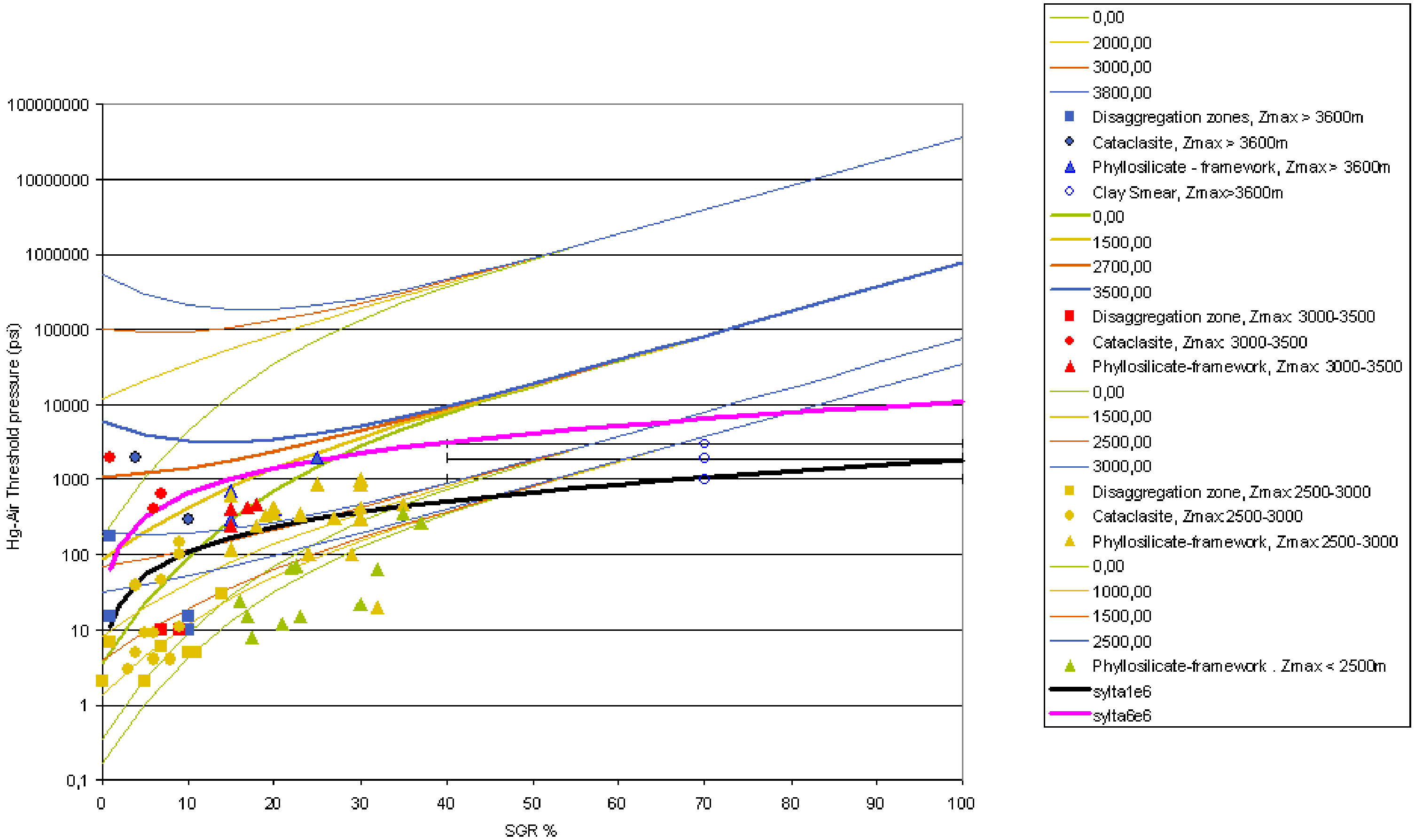
Fault throws



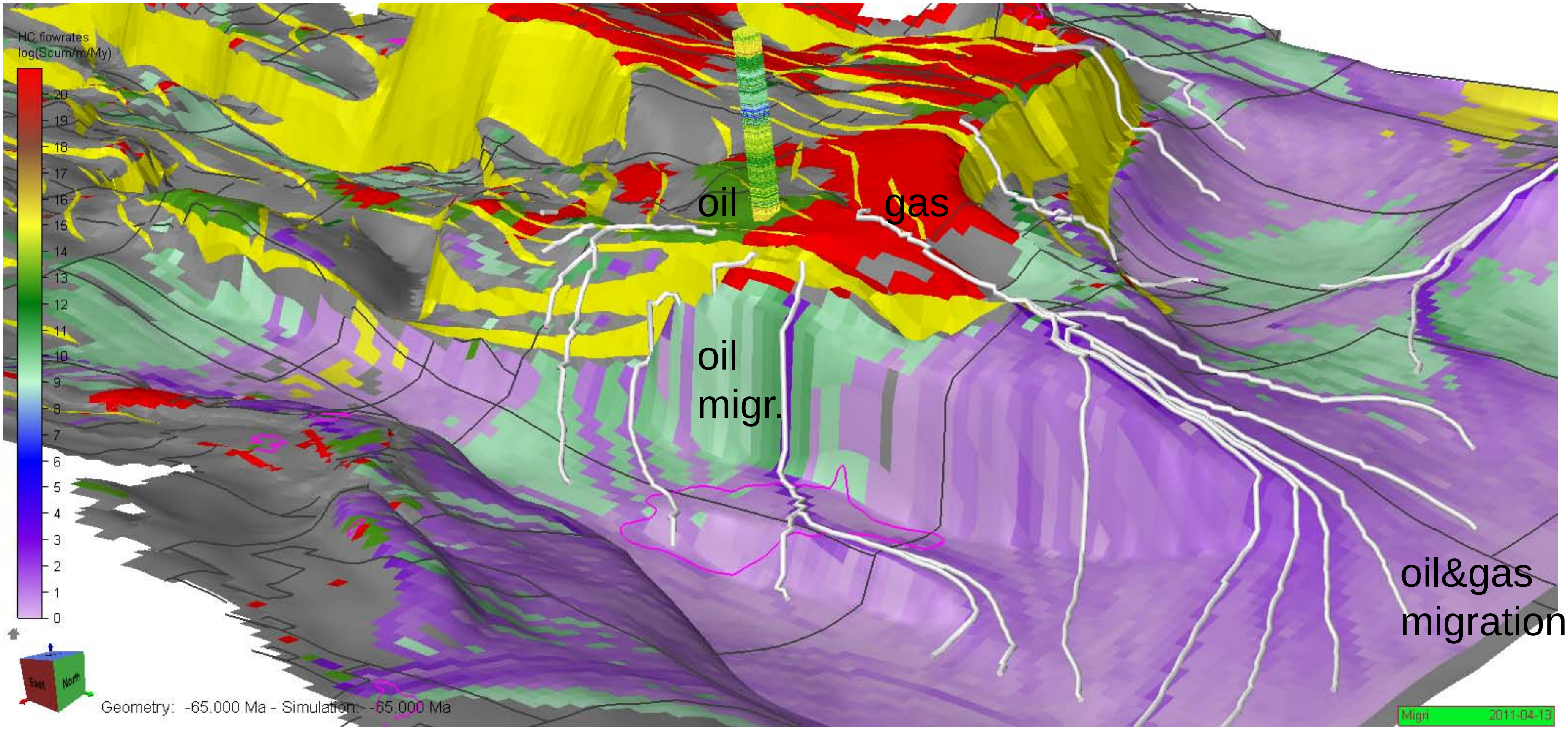
SGR along fault planes



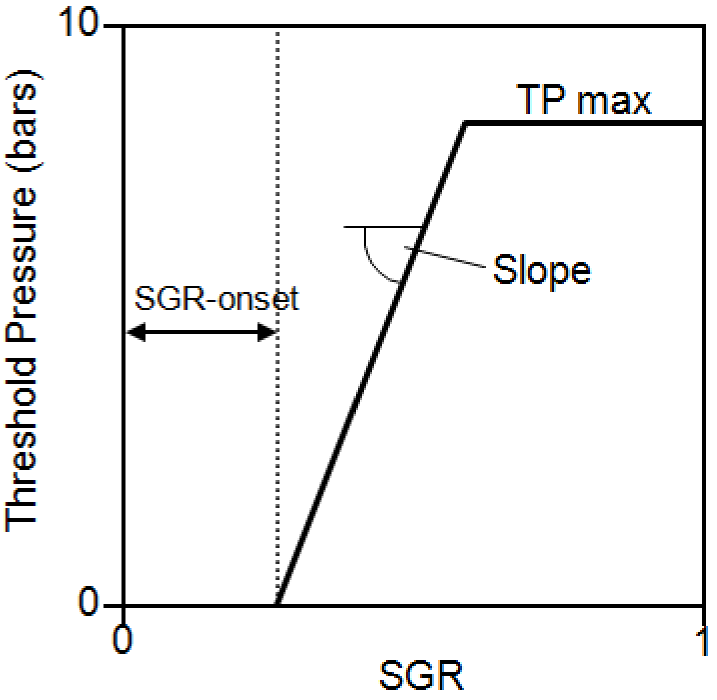
Sperrevik et al, 2002:
Pe=f(SGR,burial_depth,faulted_depth)

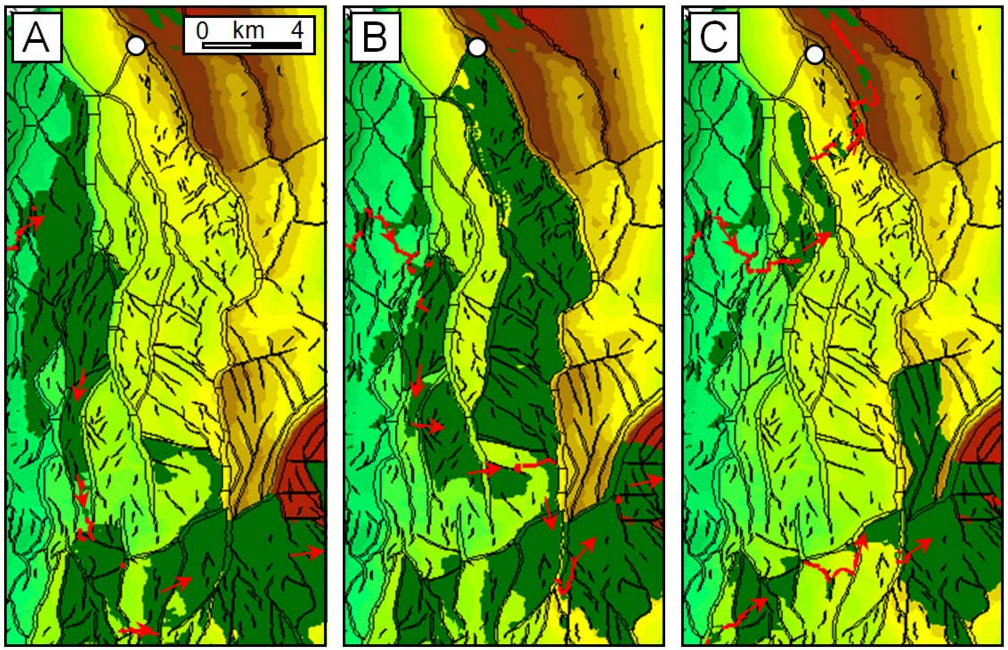


Oil and gas migration into faulted structure



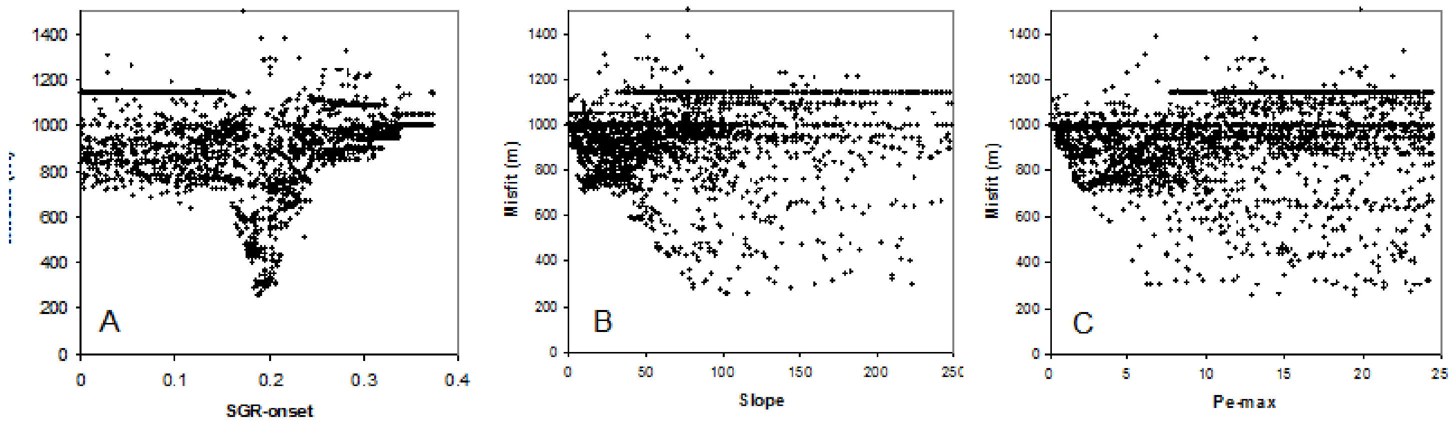
Oseberg Field example

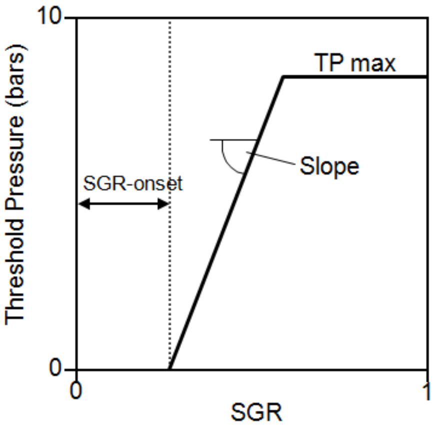


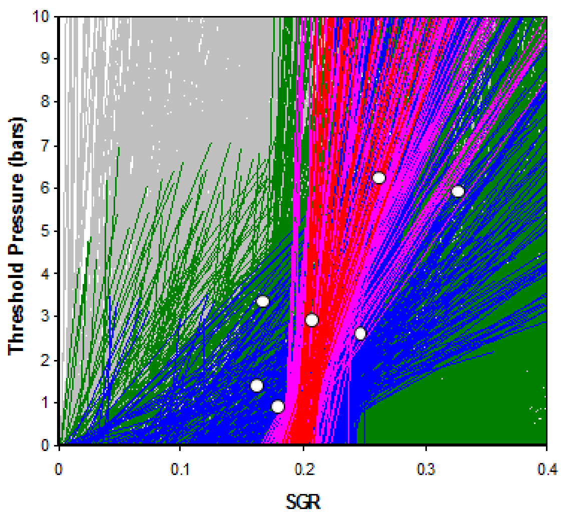


(Childs et al., 2007)

Oseberg Field - Monte Carlo







__Misfits__

>1000

800 - 1000

600 - 800

400 - 600

<400

(Childs et al., 2007)

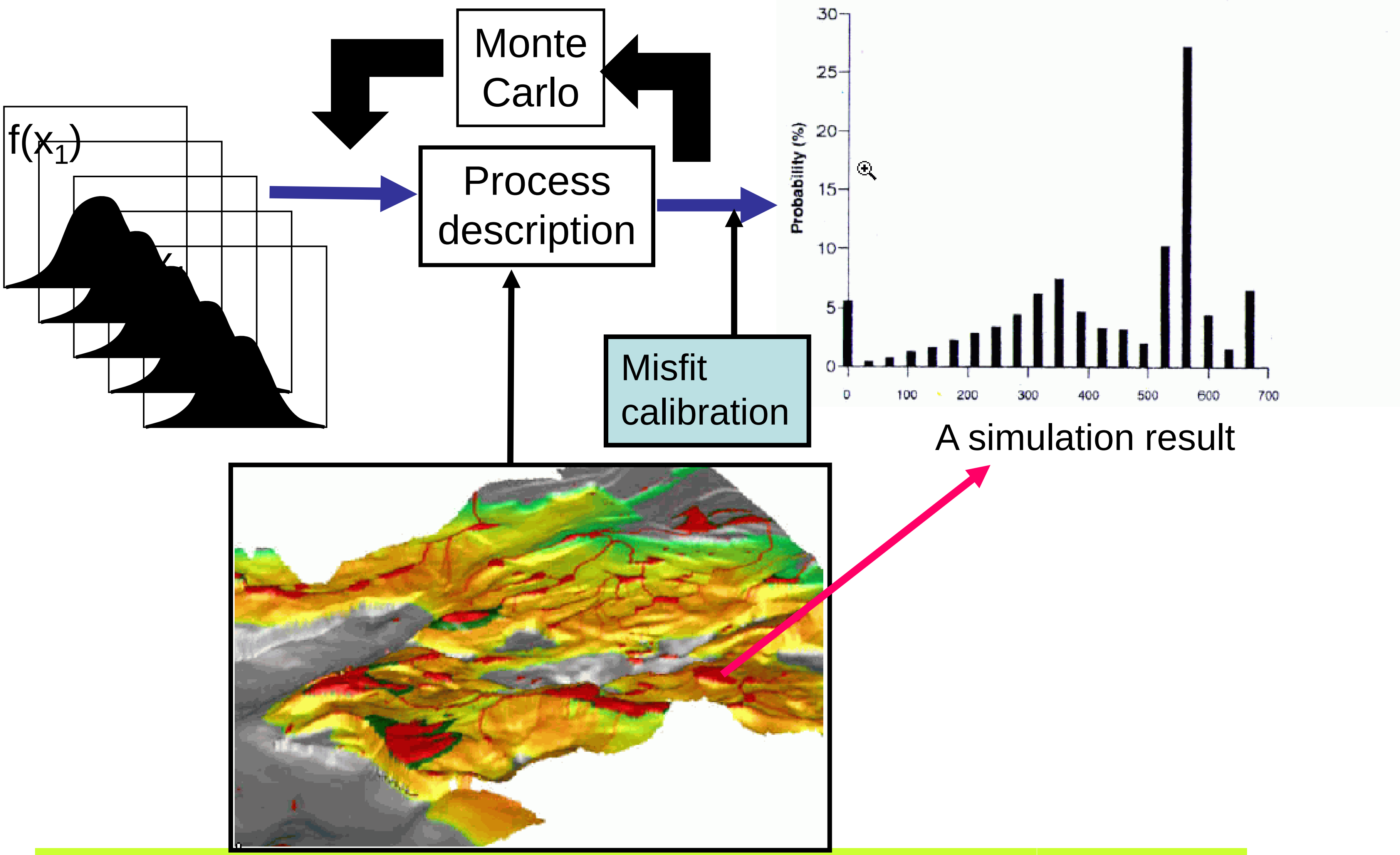
Fault seal parameters

- Position of fault plane(s)
- Fault throws, widths, dips, strikes
- Vshale within carriers and seals
- Vshale fraction in faulted sequence
- Depth of faulting
- Diagenesis depth (fault fully sealed)
- Pe-scale (laboratory to basin scaling factor)

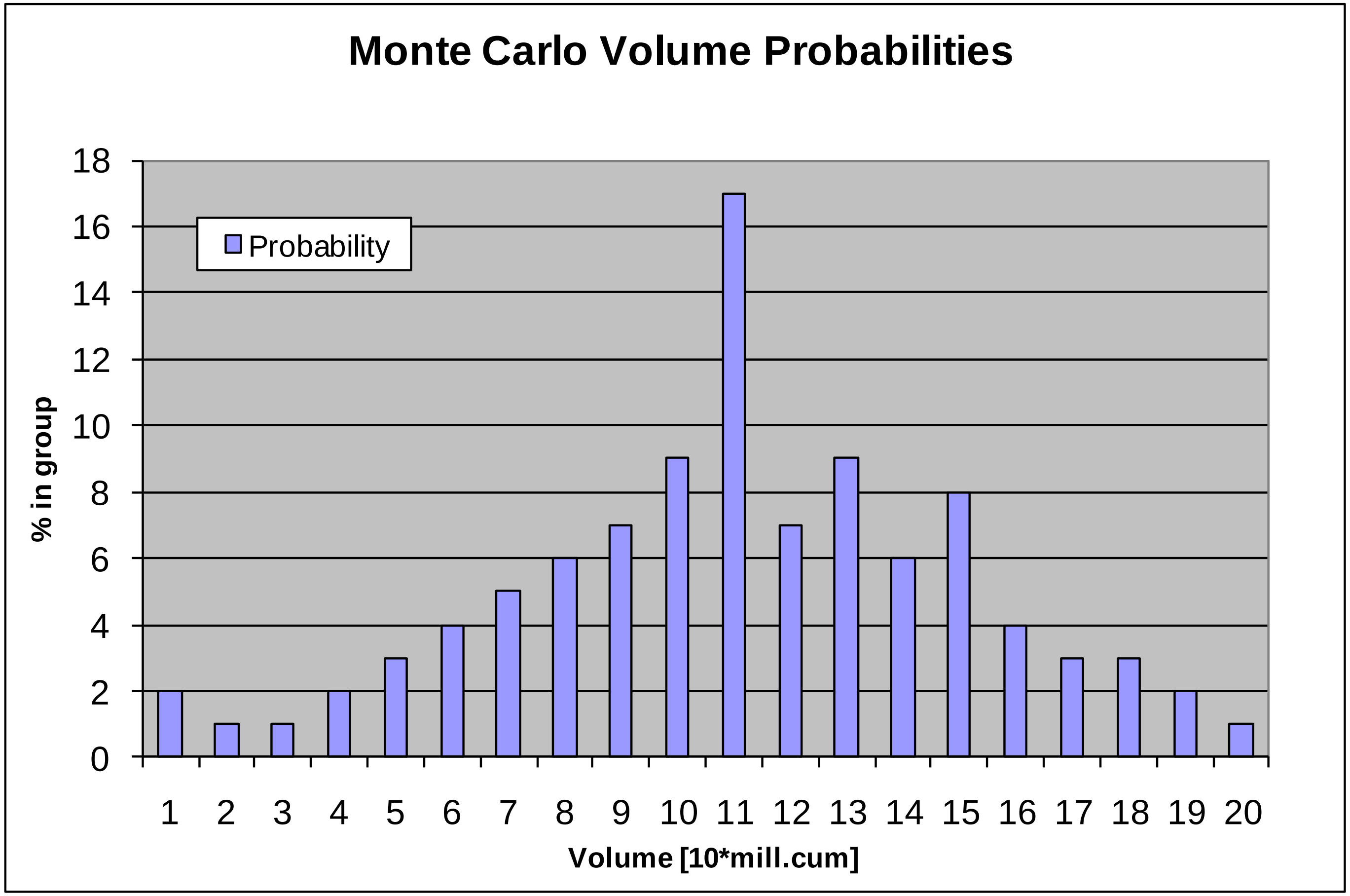
Content

- Introduction
- Modelling approach
- Intrinsic uncertainties
- Examples
- Intrinsic uncertainties of trapped hydrocarbons
- Discussion
- Conclusions

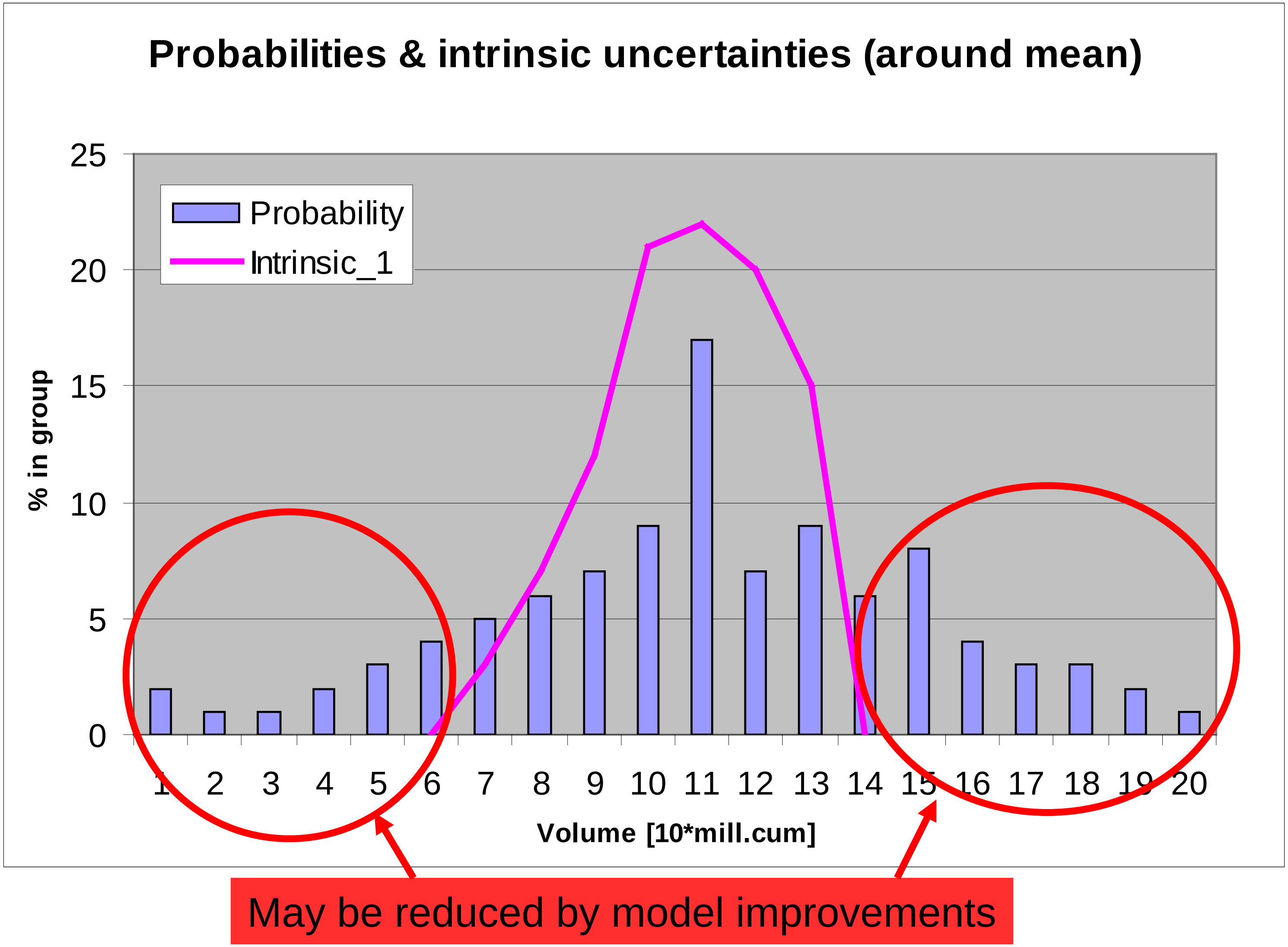
Weighted Monte Carlo simulation



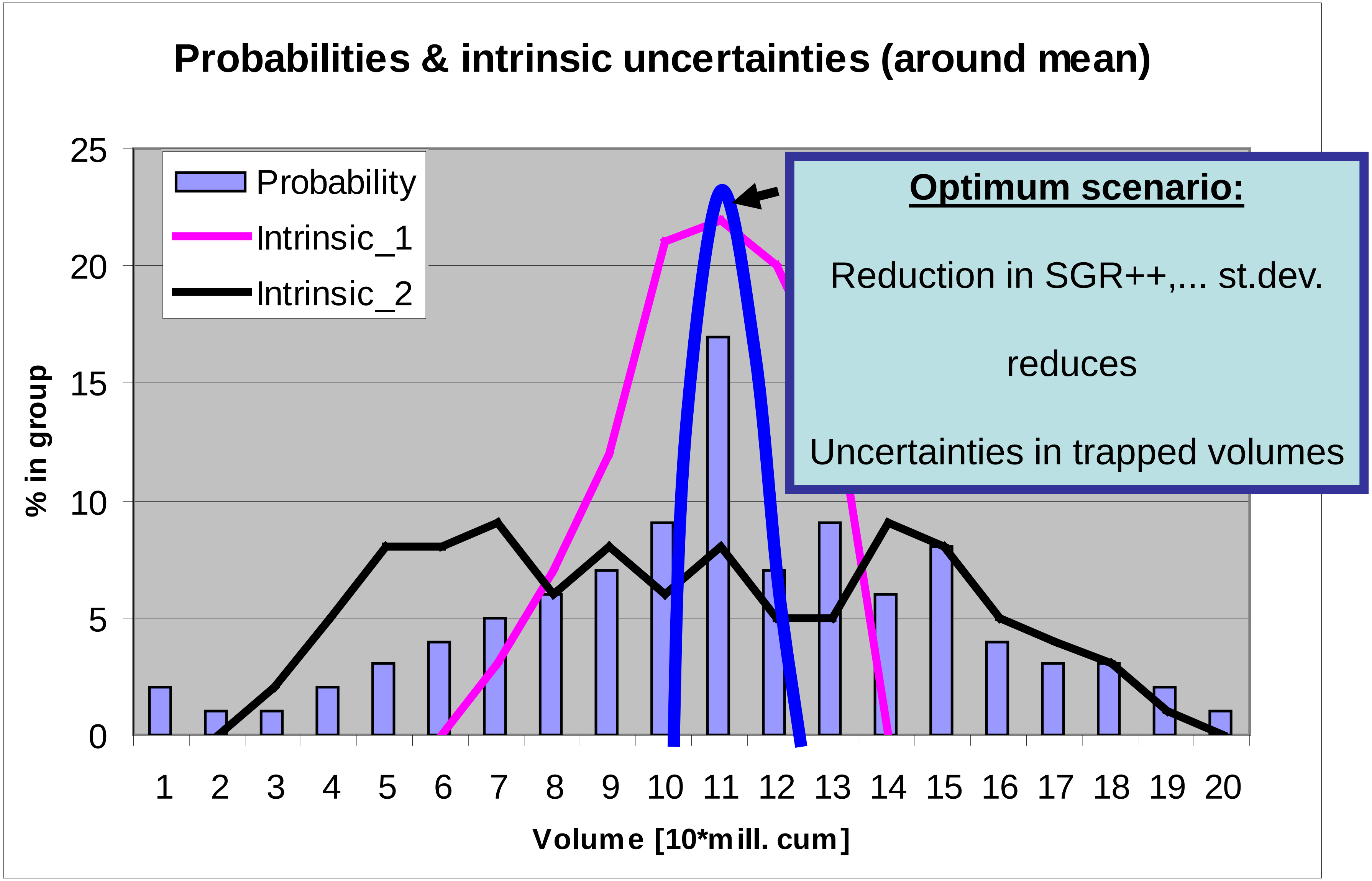
Trapped volumes in a prospect after weighted Monte Carlo simulations



Trapped volumes



Discussion


Probabilities & intrinsic uncertainties (around mean)
25
20
15
10
5
0
% in group
Probability
Intrinsic_1
Intrinsic_2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Volume [10*mill. cum]
Optimum scenario:
Reduction in SGR++,... st.dev.
reduces
Uncertainties in trapped volumes

Conclusions

- Intrinsic probabilities are important for fault seal studies
- Intrinsic probabilities of input parameters can be defined from probability density functions (SGR,diagenesis,...).
- Results from a quantum approach can easily be compared to regular Monte-Carlo simulations.
- Intrinsic propabilities of trapped petroleum can be computed.

Method may show:

How much better fault seal predictions can we achieve?