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INSTITUTE OF APPLIED GEOSCIENCE

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Reservoir modelling strategies for intra-reservoir faulting

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Conference: Handling Fault Seals, Baffles, Barriers and Conduits: Cost Effective and Integrated Fault Seal Analysis, 15th to 17th November 2017

PhD Title: Addressing structural uncertainty through seismic forward modelling

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Issue:

Acquisition of new data ~~often~~ normally modifies our understanding of past interpretations…

e.g. dynamic data and seismic horizon geometry

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Aims:

1) Discuss modelling strategies for newly interpreted small-scale intra-reservoir faulting

2) Consider the sensitivity of production forecast to modelling strategy

Acknowledgements

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Industry practitioners	Jamie Hilton (Premier Oil)	Anon.
Academic supervisors	Quentin Fisher	Douglas Paton, Isabelle Lecomte
Academics	Tom Lynch	Simon Oldfield

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Exploration interpretation

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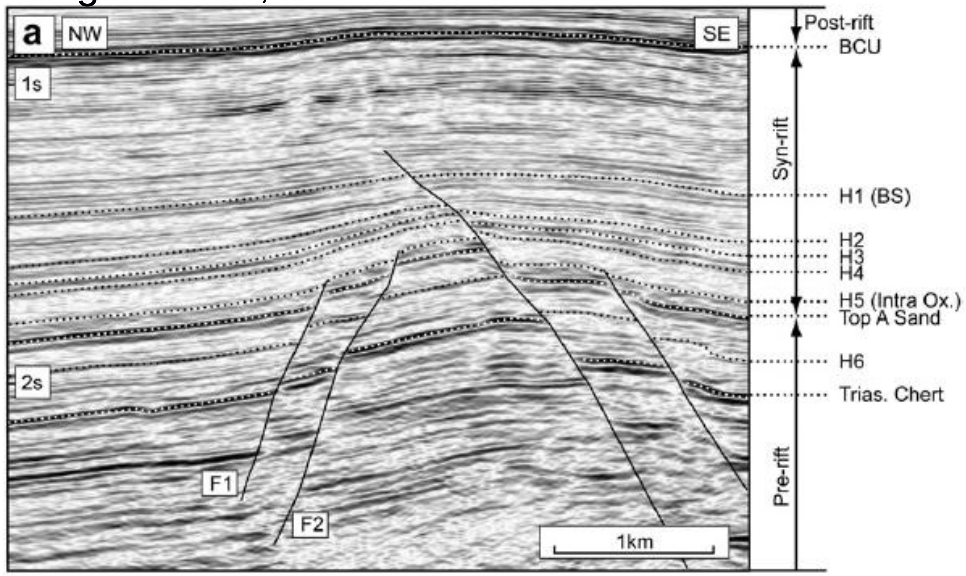
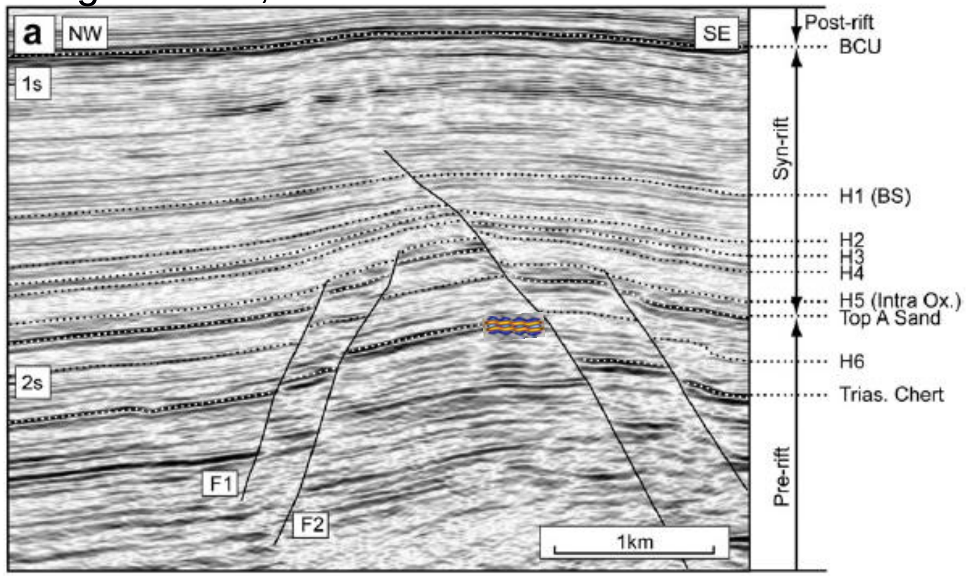
Long & Imber, 2010



Example of exploration scale interpretation

Exploration interpretation

Long & Imber, 2010



Example of exploration scale interpretation

Exploration interpretation

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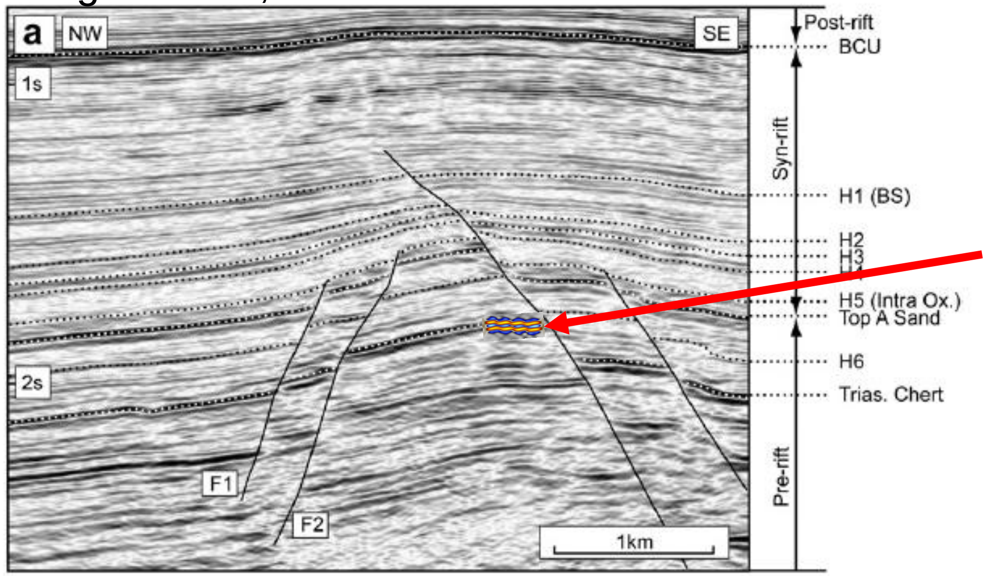

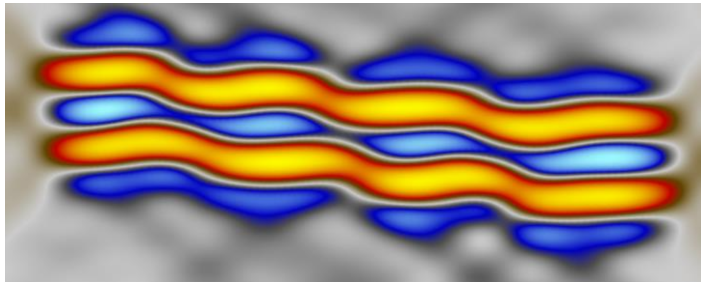

400m

H=V

Example of exploration scale interpretation, with local synthetic seismic

Synthetic seismic

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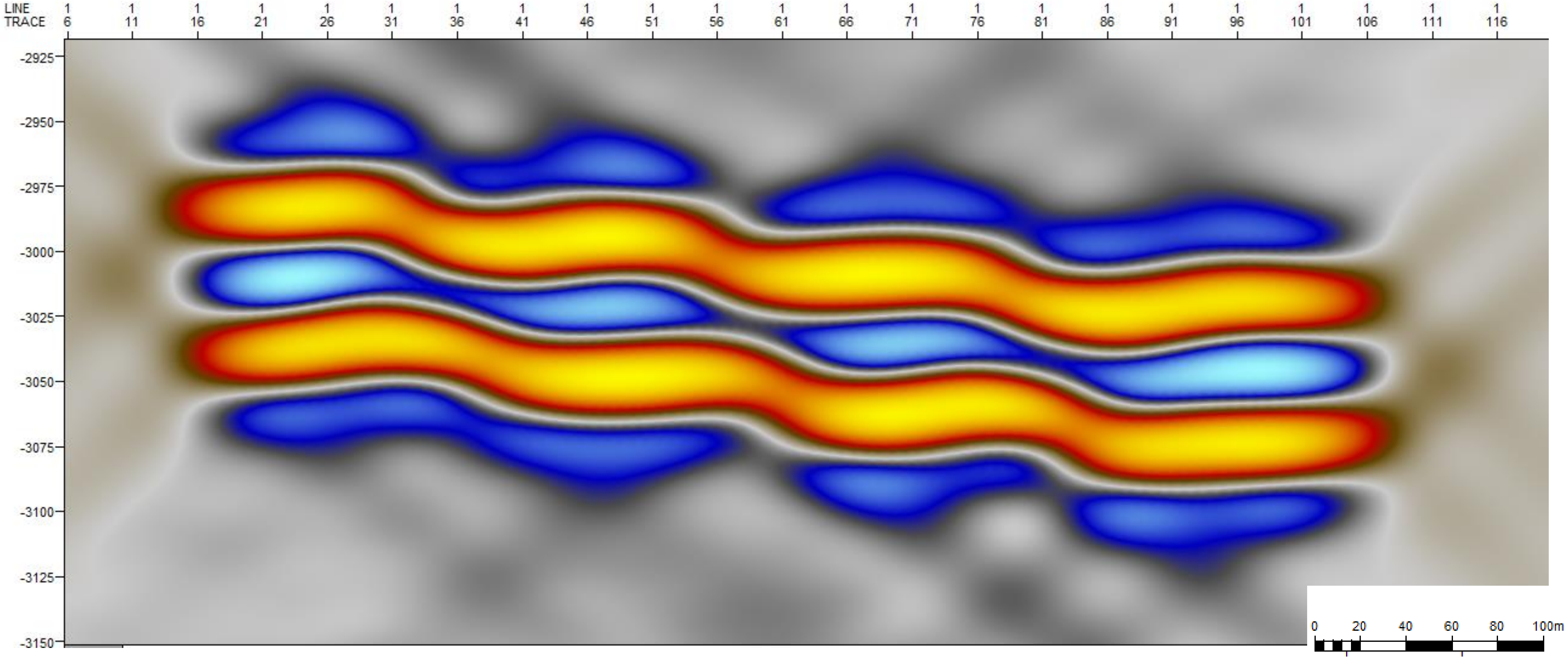
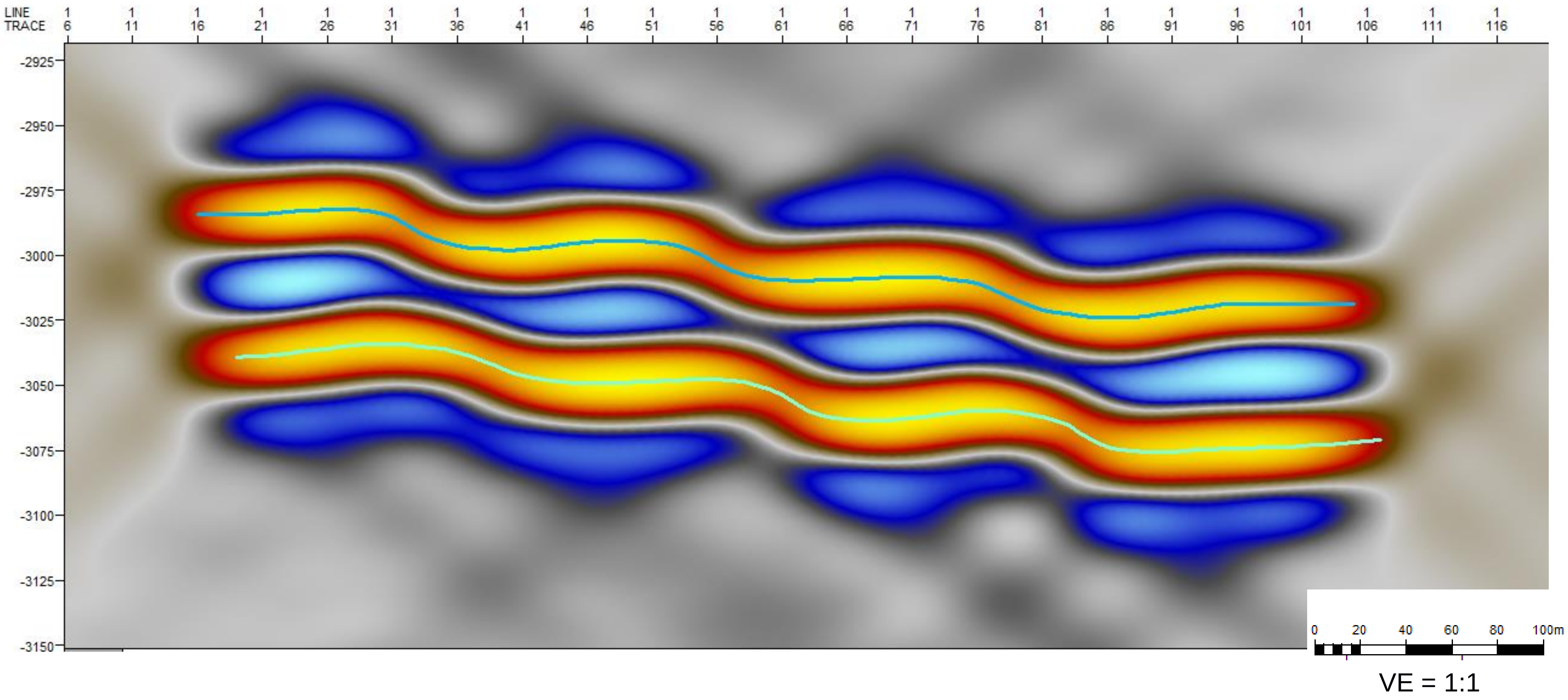


Synthetic seismic – interpreted



Blue lines = Autotracked horizon from reflections

Synthetic seismic – input

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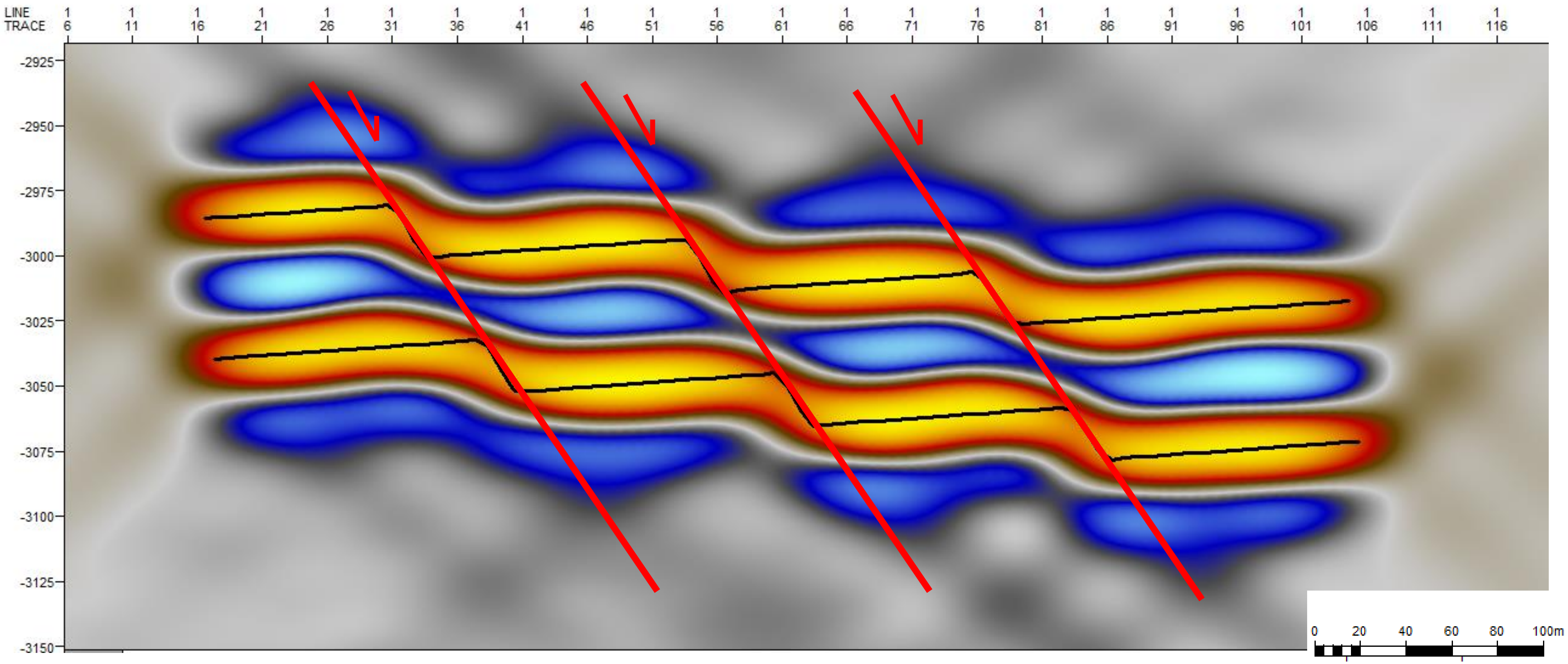

VE = 1:1

Black lines = Faulted input geometry of reflectors

Synthetic seismic – actual vs interpreted

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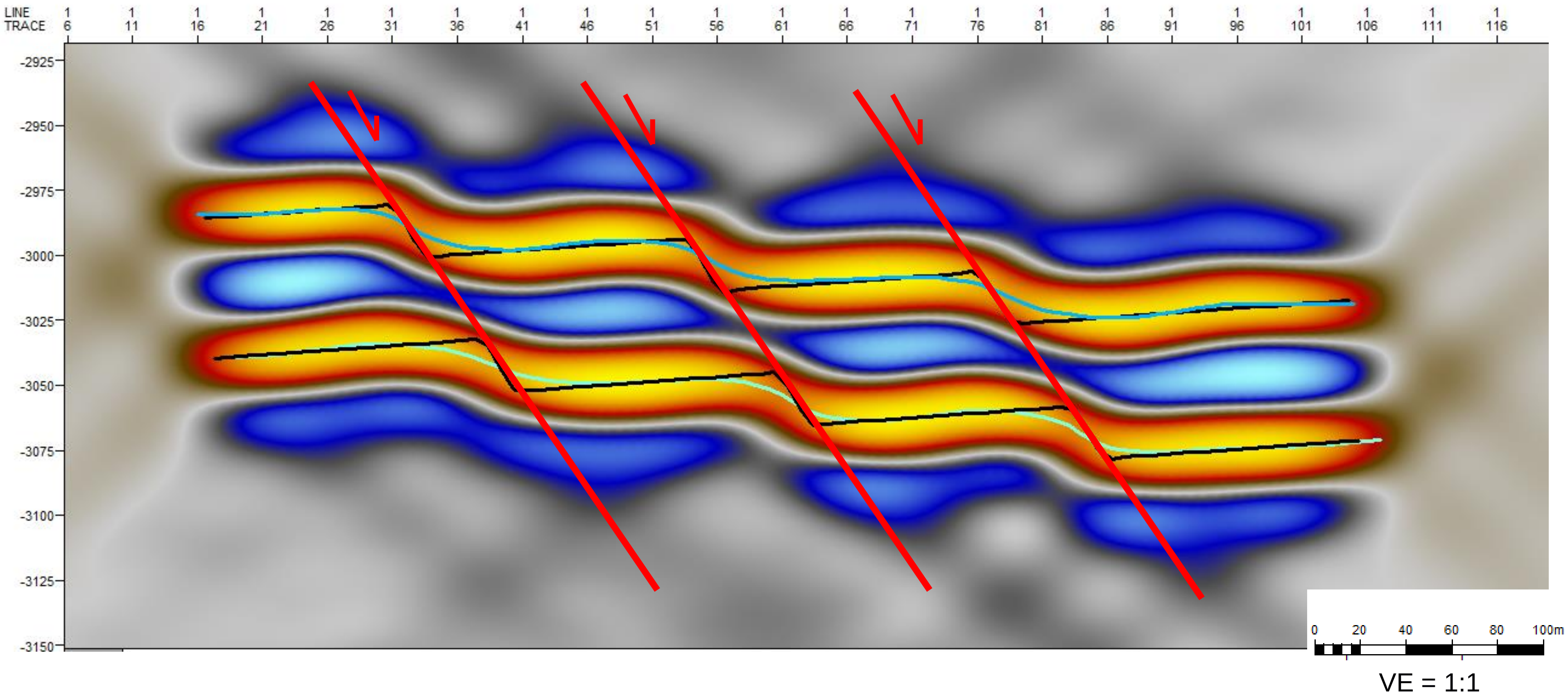
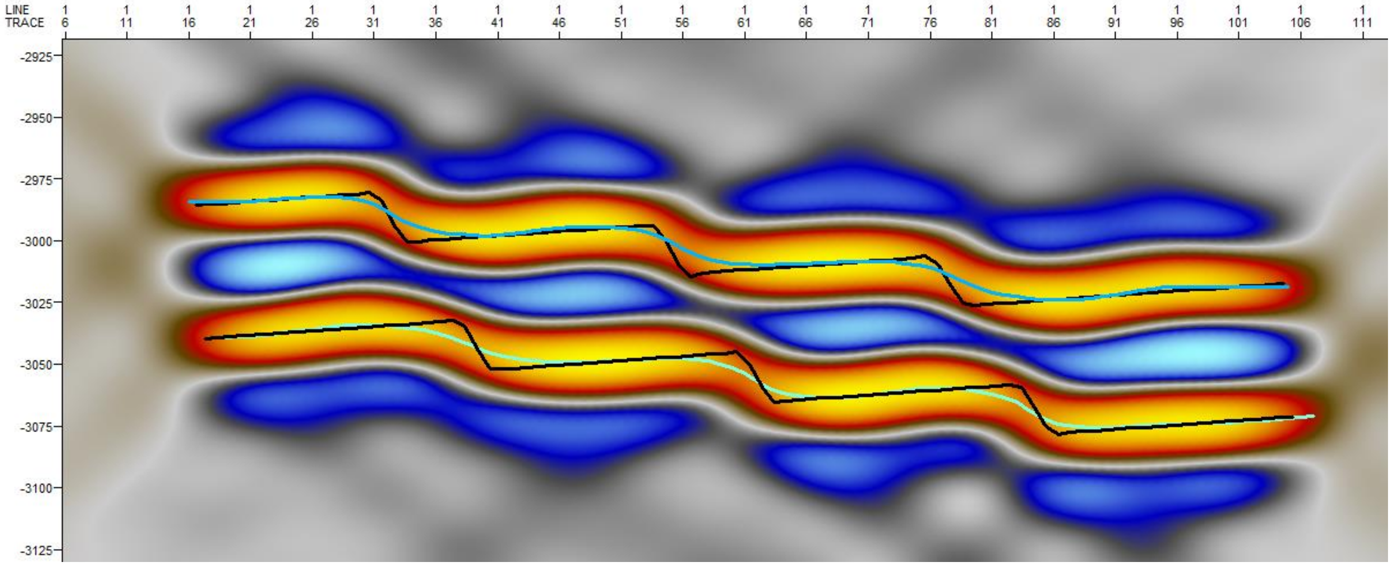


Alternate valid models for interpretation, especially when approaching resolution limits

The premise



- Exploration stage interpretation – unlikely to interpret small-scale faulting
- Dynamic data will illustrate true controls on flow
- Reservoir geometry defines gross rock volume – a sensitive topic
- How are these features considered in modelling?

Common modelling strategies

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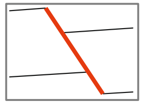
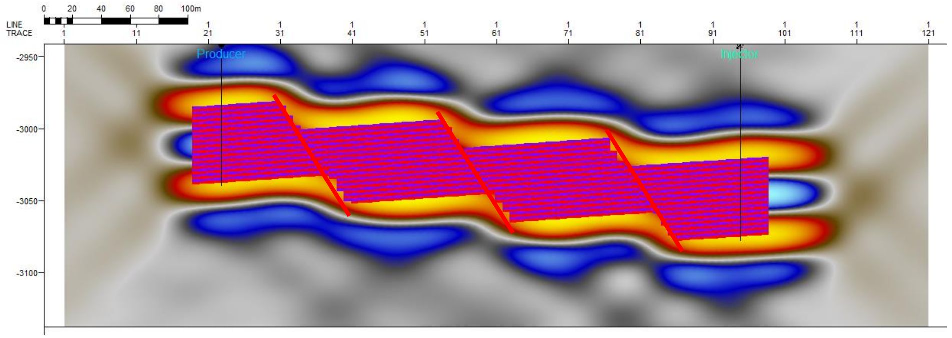
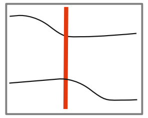
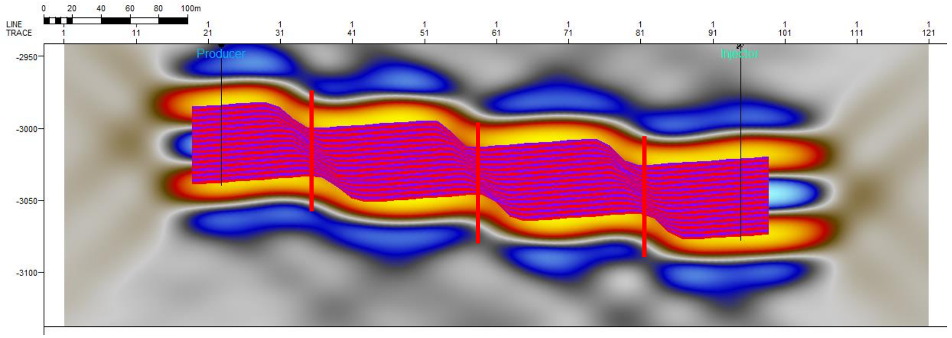
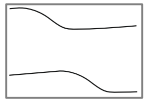
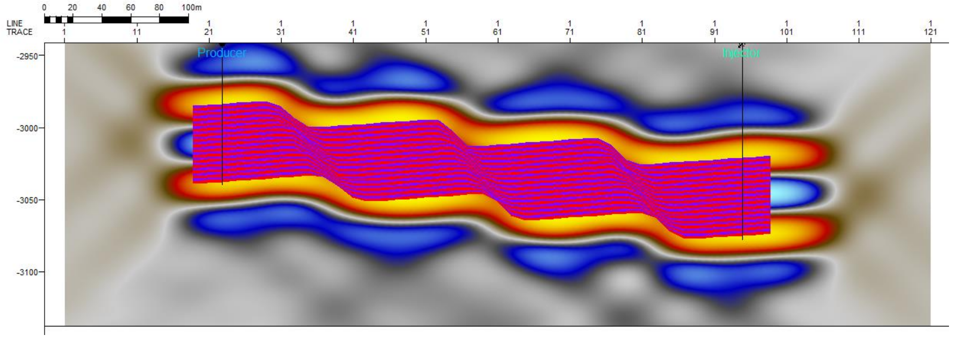
Strategy	Parameters	
Faulted 	Juxtaposition TM Bulk perm	
Simulation faults 	TM Bulk perm	
Unfaulted 	Bulk perm	

Common modelling strategies

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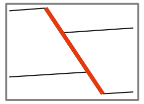
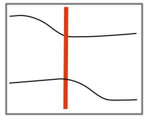
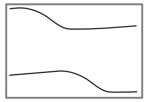
Strategy	Parameters
Faulted 	Juxtaposition TM Bulk perm
Simulation faults 	TM Bulk perm
Unfaulted 	Bulk perm

Matrix permeability

Matrix permeability = 200mD

Equivalent to consolidated sands with a porosity of 15-18%

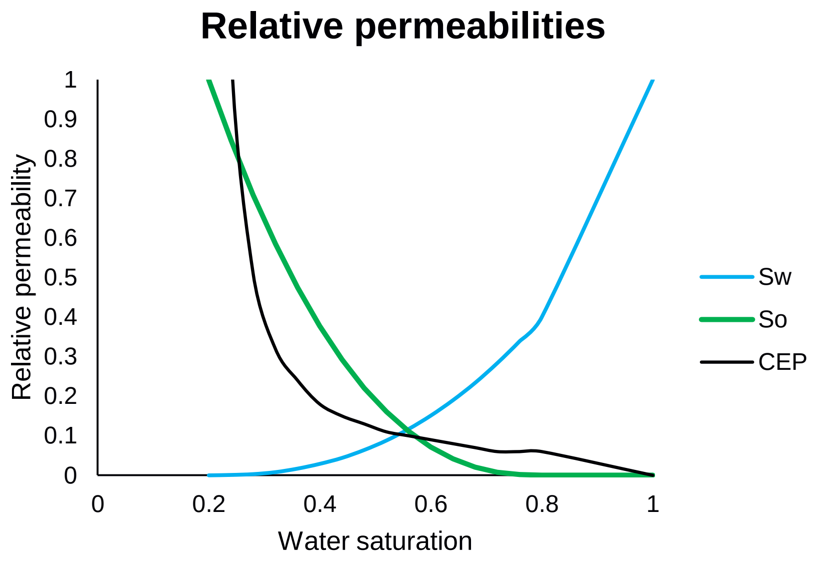
Transmissibility multipliers (TM)

Base TM = 0.4

Fault throw = 15m

Fault thickness = 0.2m

Simulated production strategy



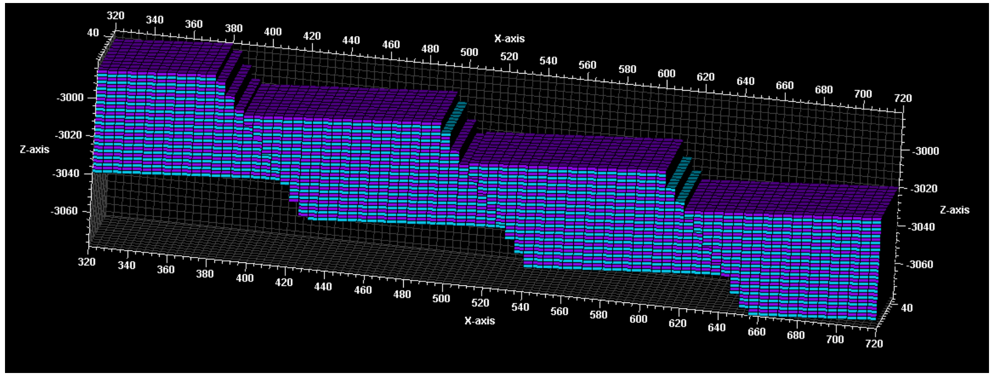
Fixed injection volume

20 reservoir cubic metres/day

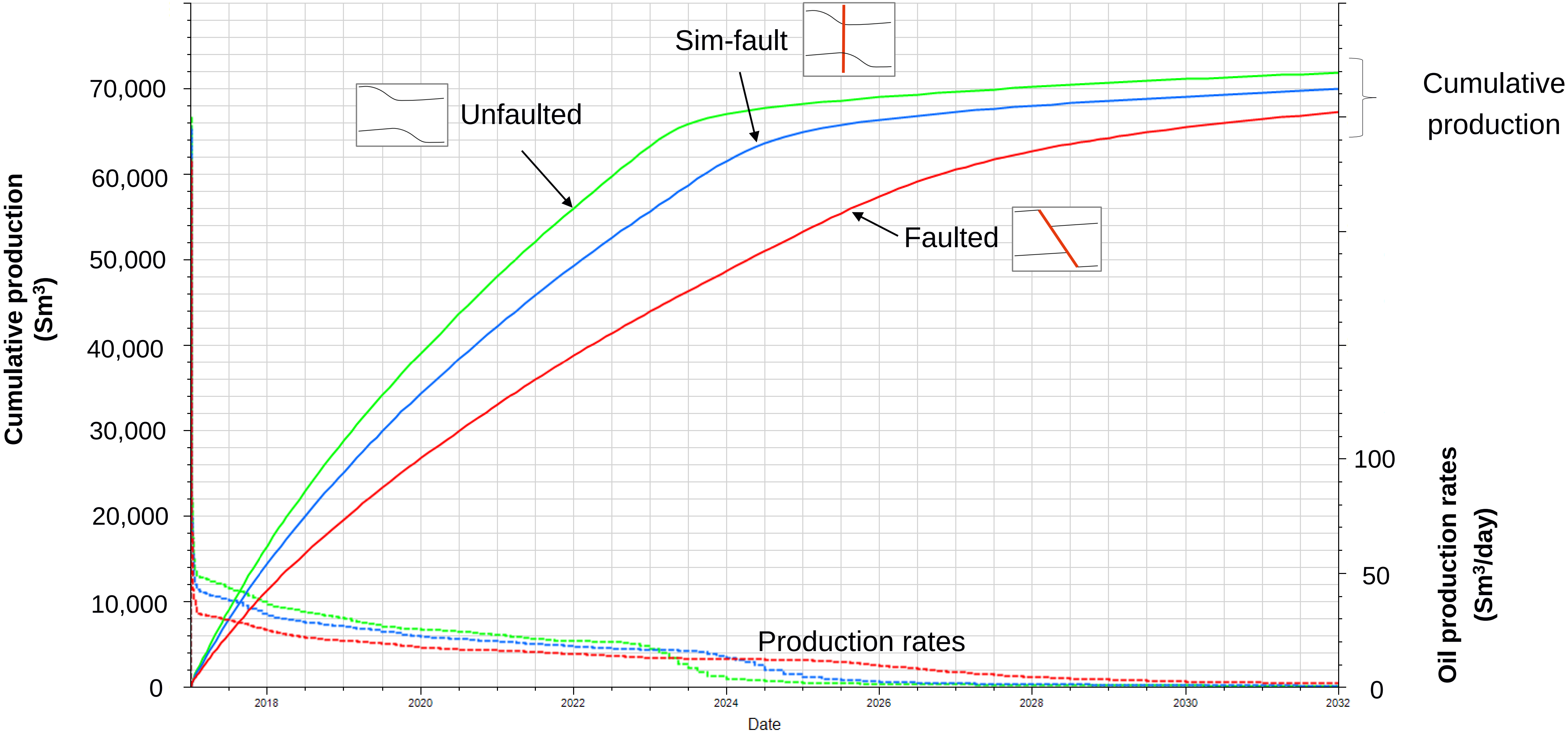
Fixed injection pressure

Focuses analysis on reservoir geometry

Modelling parameters	Value
Dimensions	400 x 50 x 50m
Wells	Injector/Producer pair
Production strategy	Waterflood
Aquifer support	None
Run time	15 years



Base cases – Fixed injector pressure



Injector BHP fixed at 400psi – illustrates reservoir response

Base cases – Fixed injector pressure

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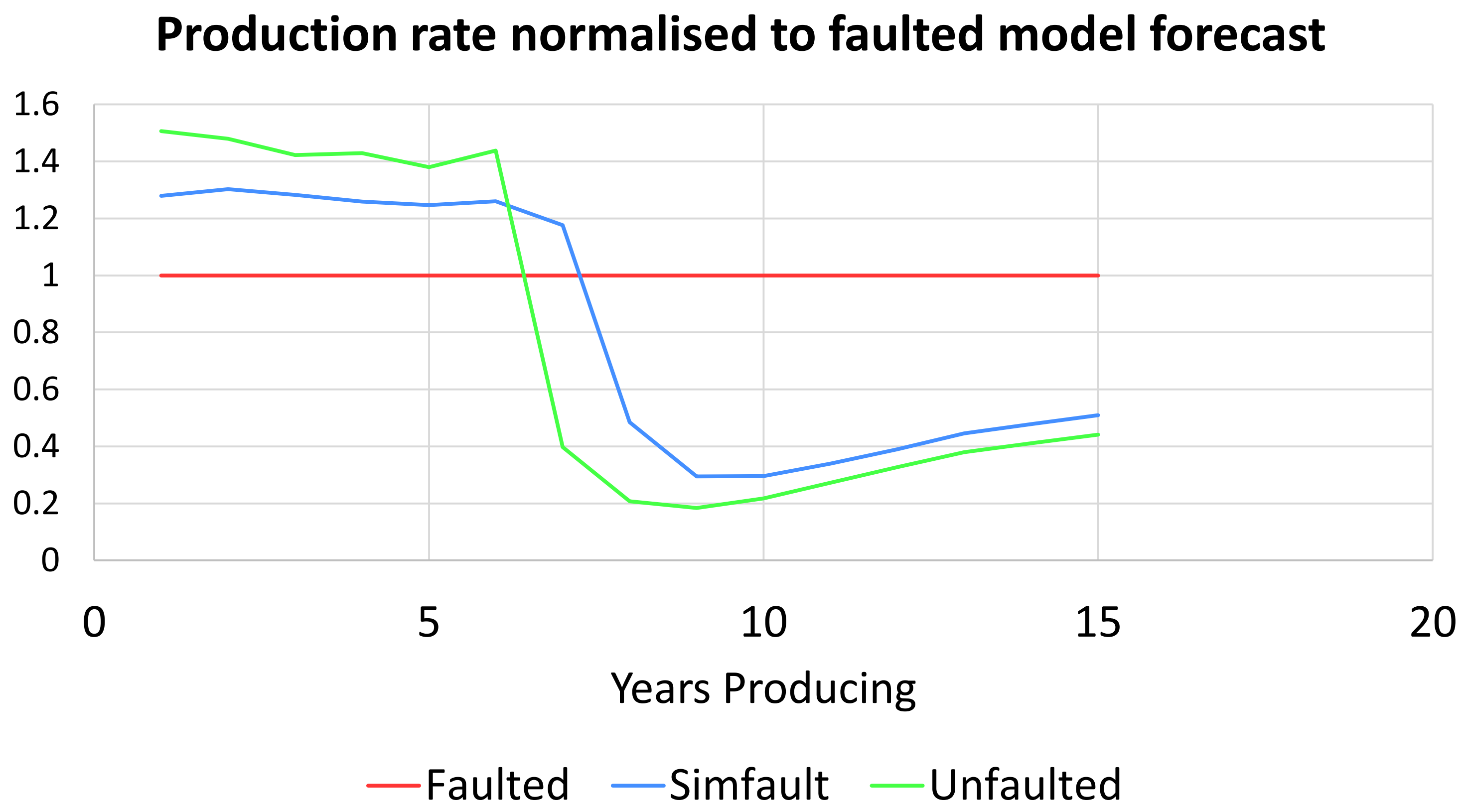
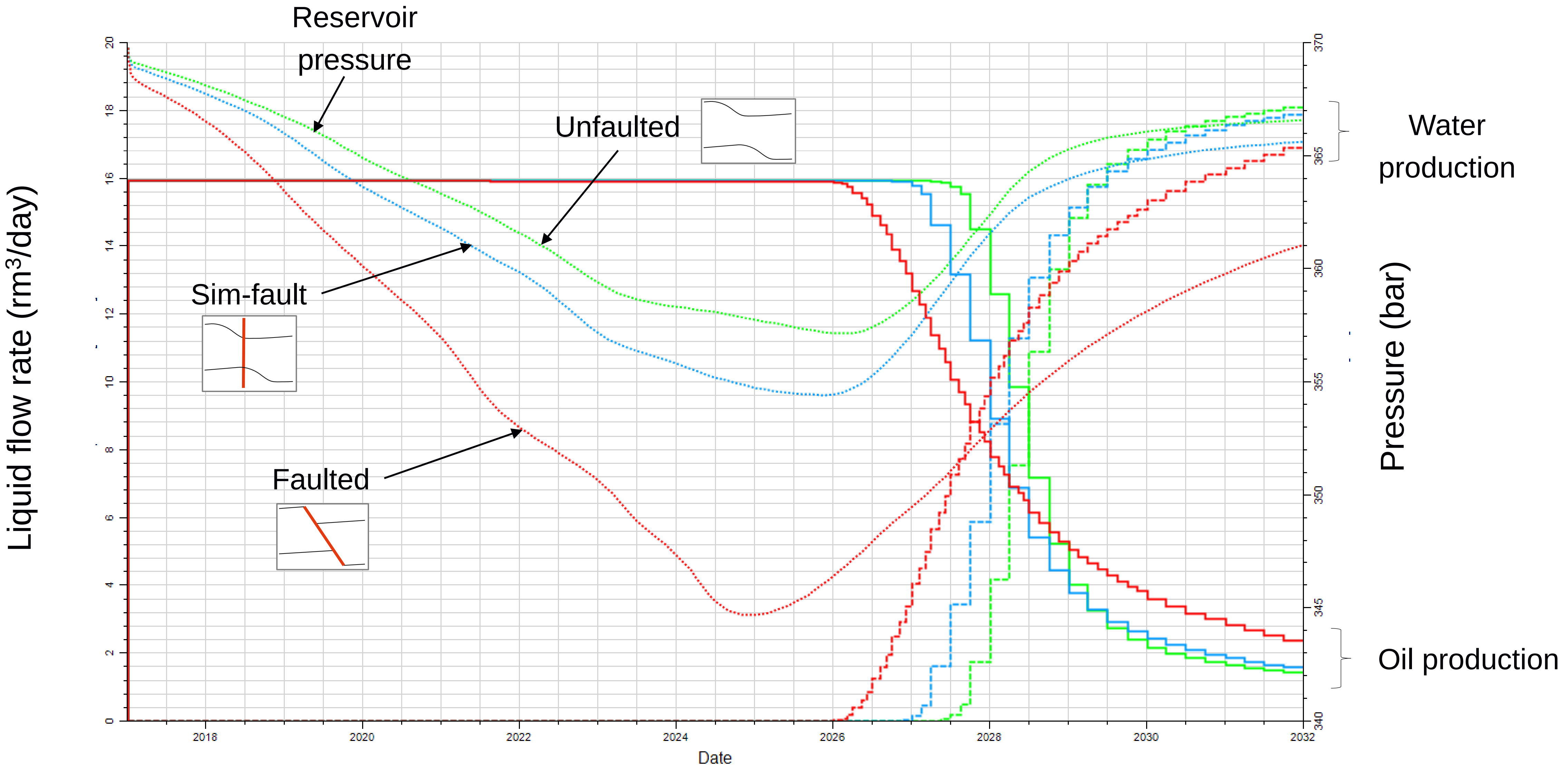


EUR12	**Volume (Sm^3)**	**Norm. to faulted model**
Faulted	65,381.8	
Simfault	69,081.5	1.06
Unfaulted	71,109.7	1.09

Significant affect on Net Present Value dependent on discount rate and costing model

Base cases – Fixed volume production rate



Injection rate fixed at 20 rm³/day, illustrating reservoir response

Reservoir modelling strategies

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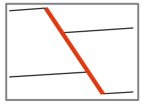
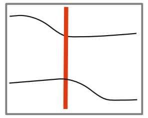
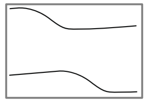
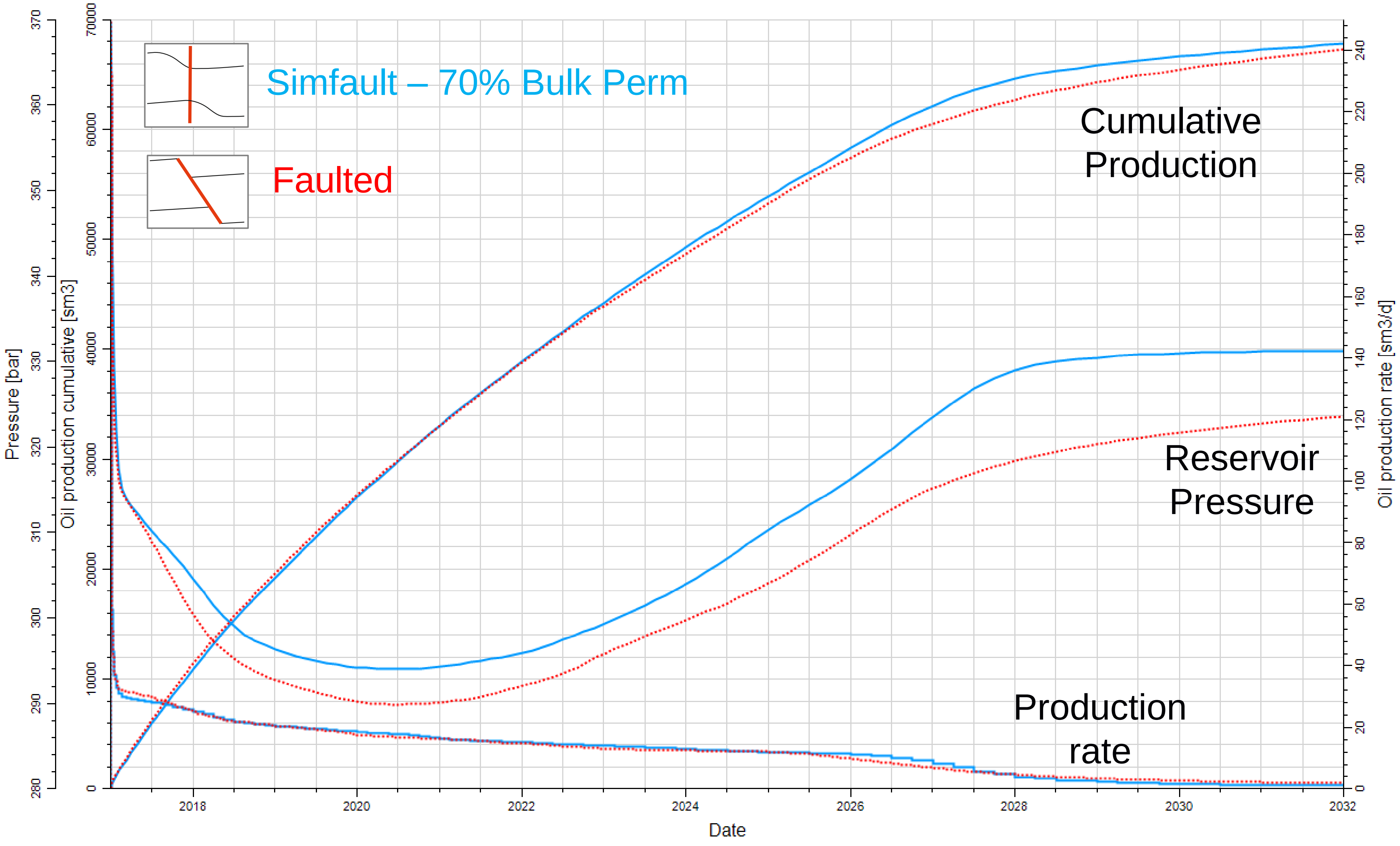
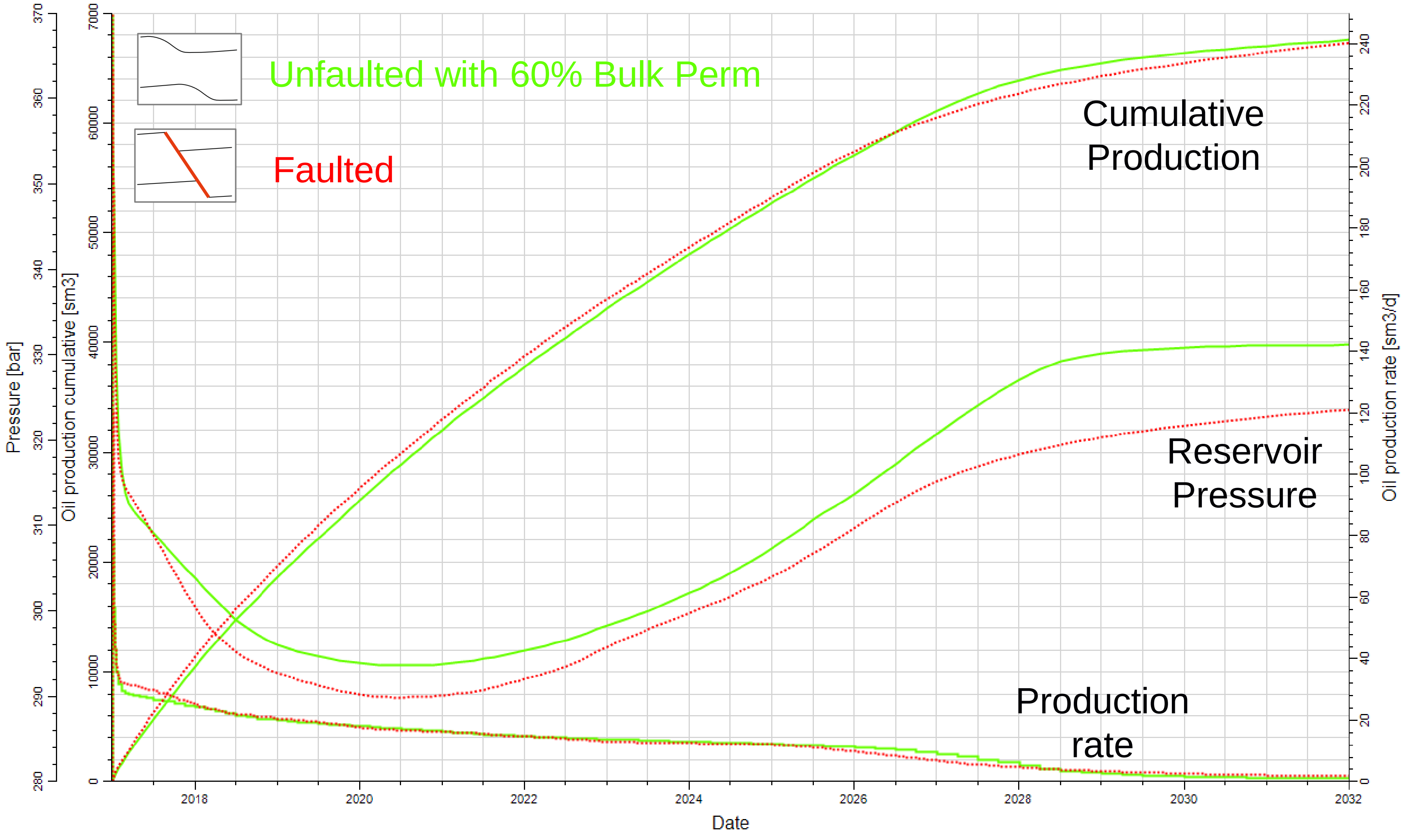
Strategy	Parameters	Observations
Faulted 	Juxtaposition TM Bulk perm	- Significant pressure draw-down - Earlier water breakthrough, slower increase in water cut - Fault geometry necking of reservoir
Simulation faults 	TM Bulk perm	- Moderate pressure draw-down
Unfaulted 	Bulk perm	- Moderate pressure draw-down

Matching for geological equivalence



Matching for geological equivalence



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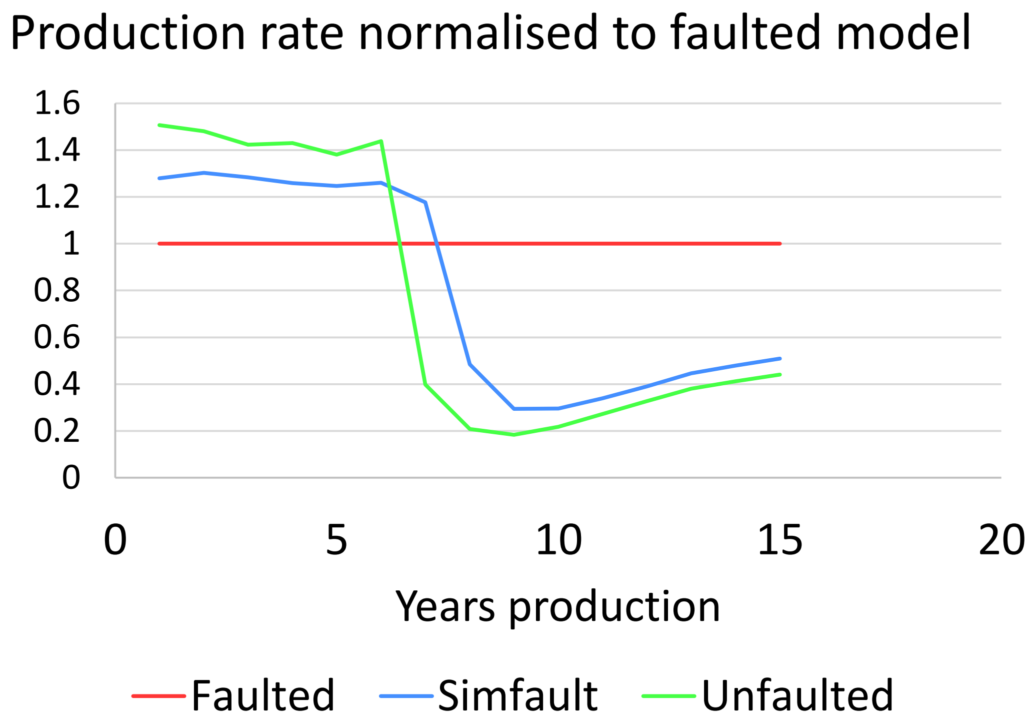
Conclusions

- Modelling strategy choice is significant
- In the absence of dynamic data; geological rigour is critical
- Sufficient dynamic data may allow decision making with simulation or unfaulted models
- Bottom hole pressure data required
- Sensitivity testing is critical
- Care must be taken with relative permeability and capillary effects
- Faults non-orthogonal to flow are likely exacerbate variance between these models



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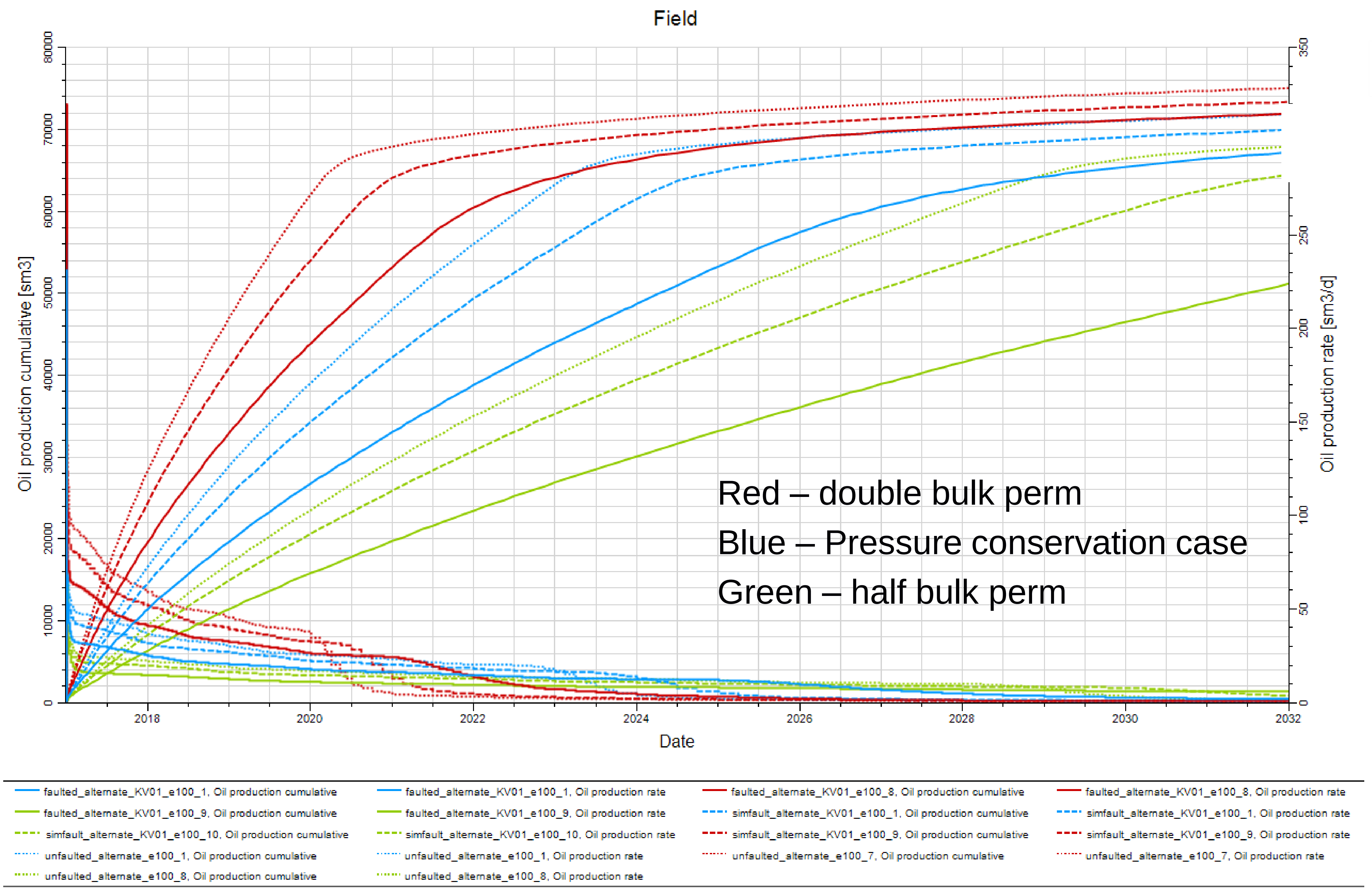

Field
Oil production cumulative [sm3]
Oil production rate [sm3/d]
Date
Red – double bulk perm
Blue – Pressure conservation case
Green – half bulk perm
faulted_alternate_KV01_e100_1, Oil production cumulative
faulted_alternate_KV01_e100_1, Oil production rate
faulted_alternate_KV01_e100_8, Oil production cumulative
faulted_alternate_KV01_e100_8, Oil production rate
faulted_alternate_KV01_e100_9, Oil production cumulative
faulted_alternate_KV01_e100_9, Oil production rate
simfault_alternate_KV01_e100_1, Oil production cumulative
simfault_alternate_KV01_e100_1, Oil production rate
simfault_alternate_KV01_e100_10, Oil production cumulative
simfault_alternate_KV01_e100_10, Oil production rate
simfault_alternate_KV01_e100_9, Oil production cumulative
simfault_alternate_KV01_e100_9, Oil production rate
unfaulted_alternate_e100_1, Oil production cumulative
unfaulted_alternate_e100_1, Oil production rate
unfaulted_alternate_e100_7, Oil production cumulative
unfaulted_alternate_e100_7, Oil production rate
unfaulted_alternate_e100_8, Oil production cumulative
unfaulted_alternate_e100_8, Oil production rate