Basin Structure Group
INSTITUTE OF APPLIED GEOSCIENCE

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Reservoir compartmentalisation and seismic interpretation uncertainty: Insights from seismic forward modelling

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Why forward model?

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Looks pretty

Intuitively; it tells us something

Sounds clever

Bias towards quantitative methods

Strategies for useful seismic forward modelling:

- **Comparing** potential geometries
- **Testing** analytical methods
- **Understanding** imaging constraint

See also; Chamberlin (1965), Tversky and Kahneman (1974) and Bond (2015)

Seismic imaging quality

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Resolution

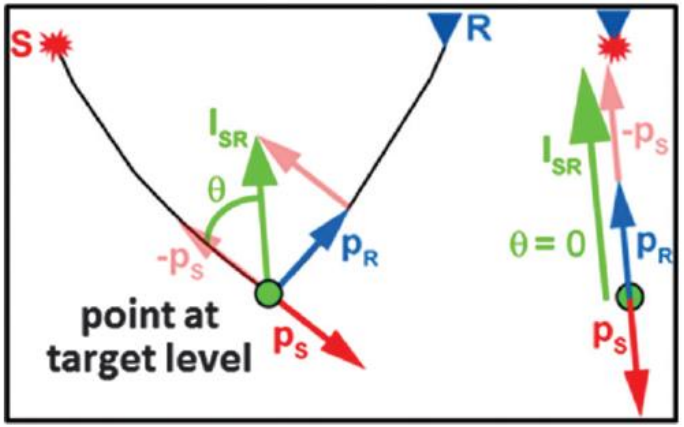
Frequency and velocity dependent

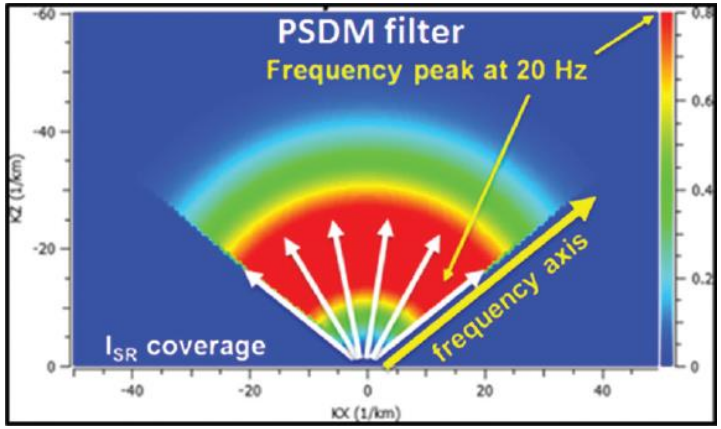
Detectability

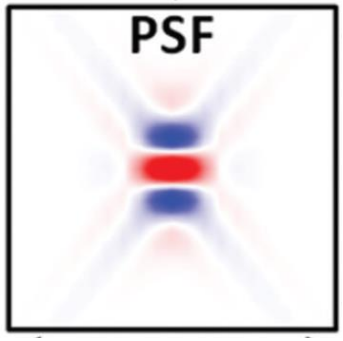
Signal to noise ratio

See Kallweit & Wood (1982)

Illumination







After Lecomte et al. (2015)

Multiple interpretations

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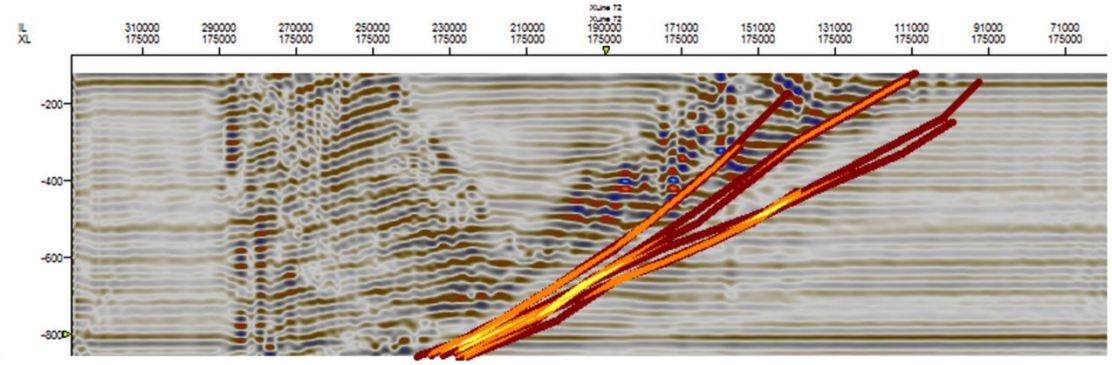
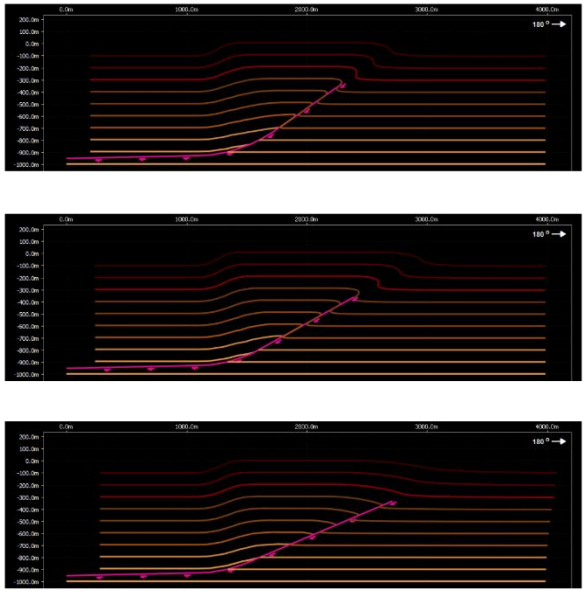
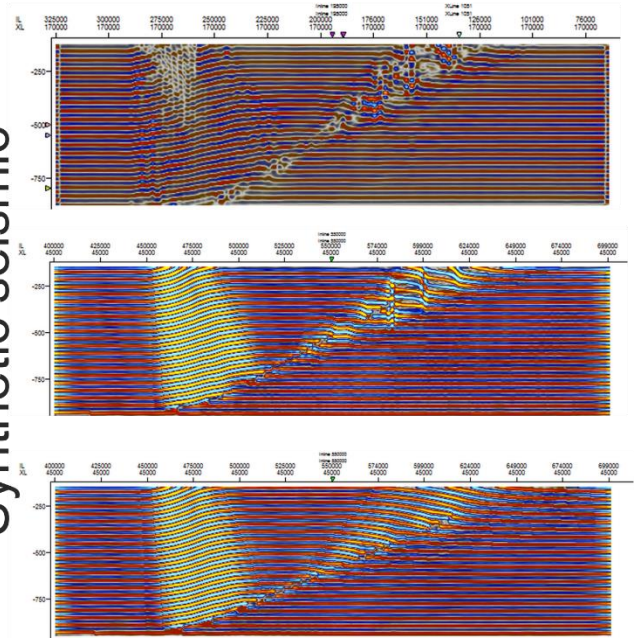


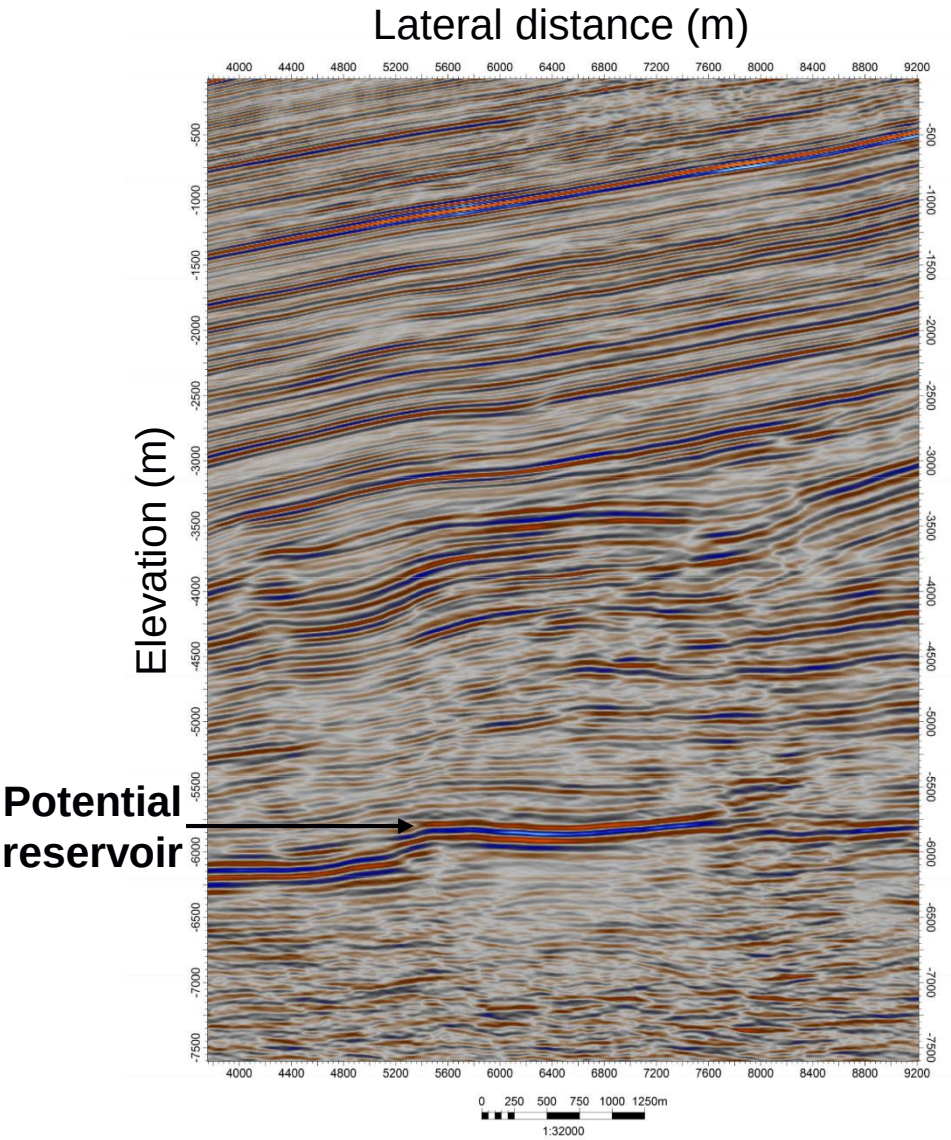
Kinematic models



Synthetic seismic



Interpretation



Frontal ranges of the Eastern Cordillera, Colombia

Compressional structures at surface

Structural inversion observed along trend

Alternative interpretations

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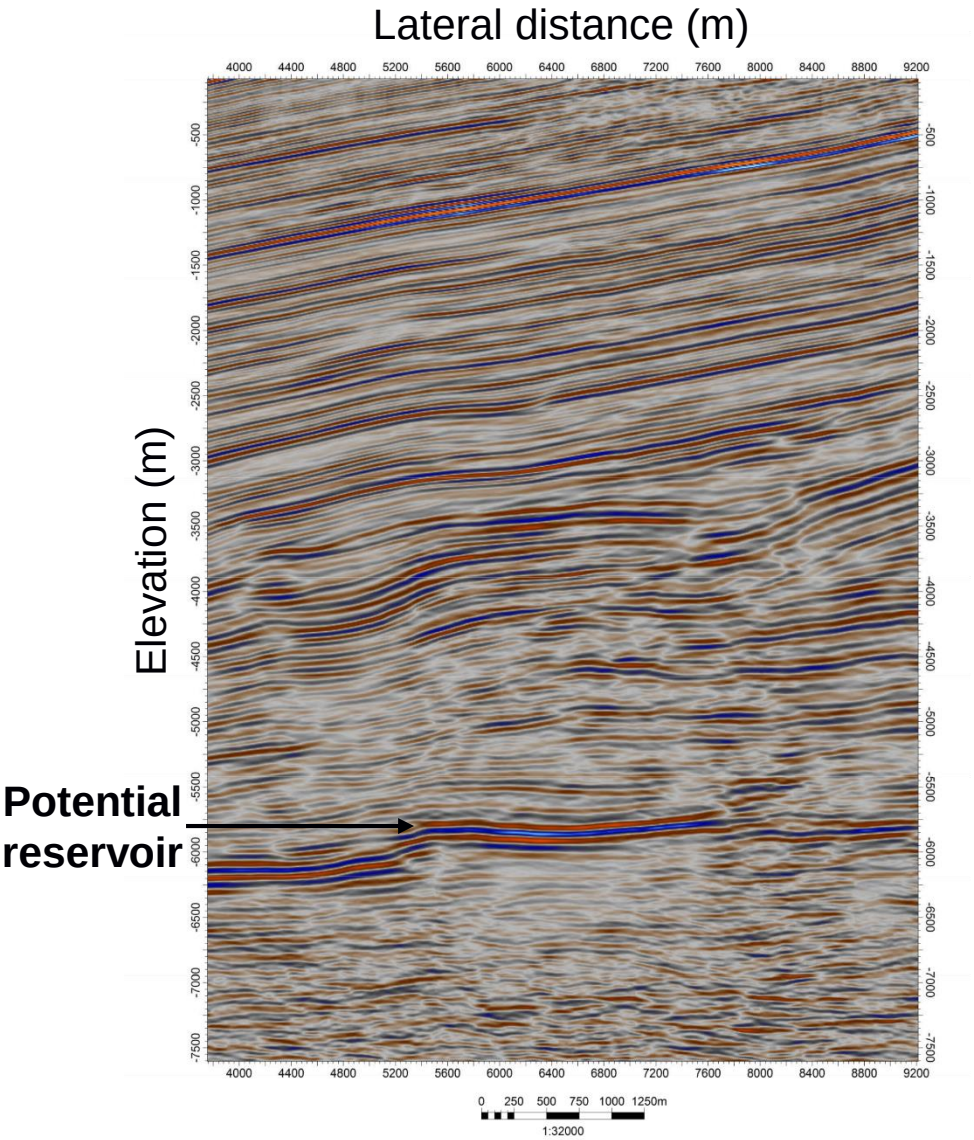
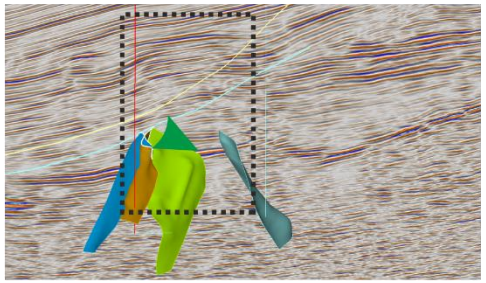
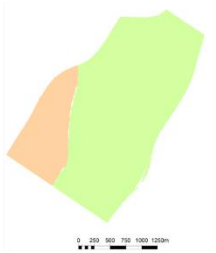
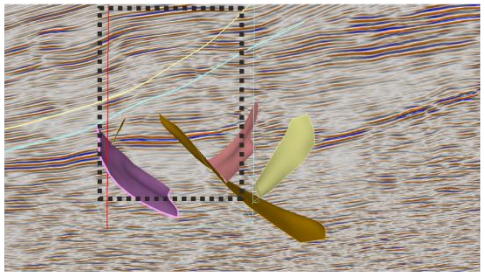
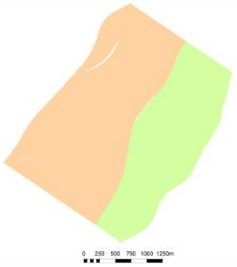




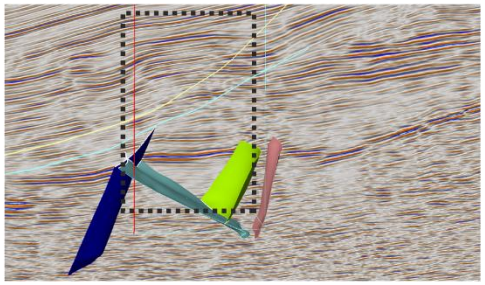


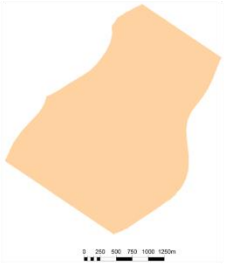
Extensional 500m H=V



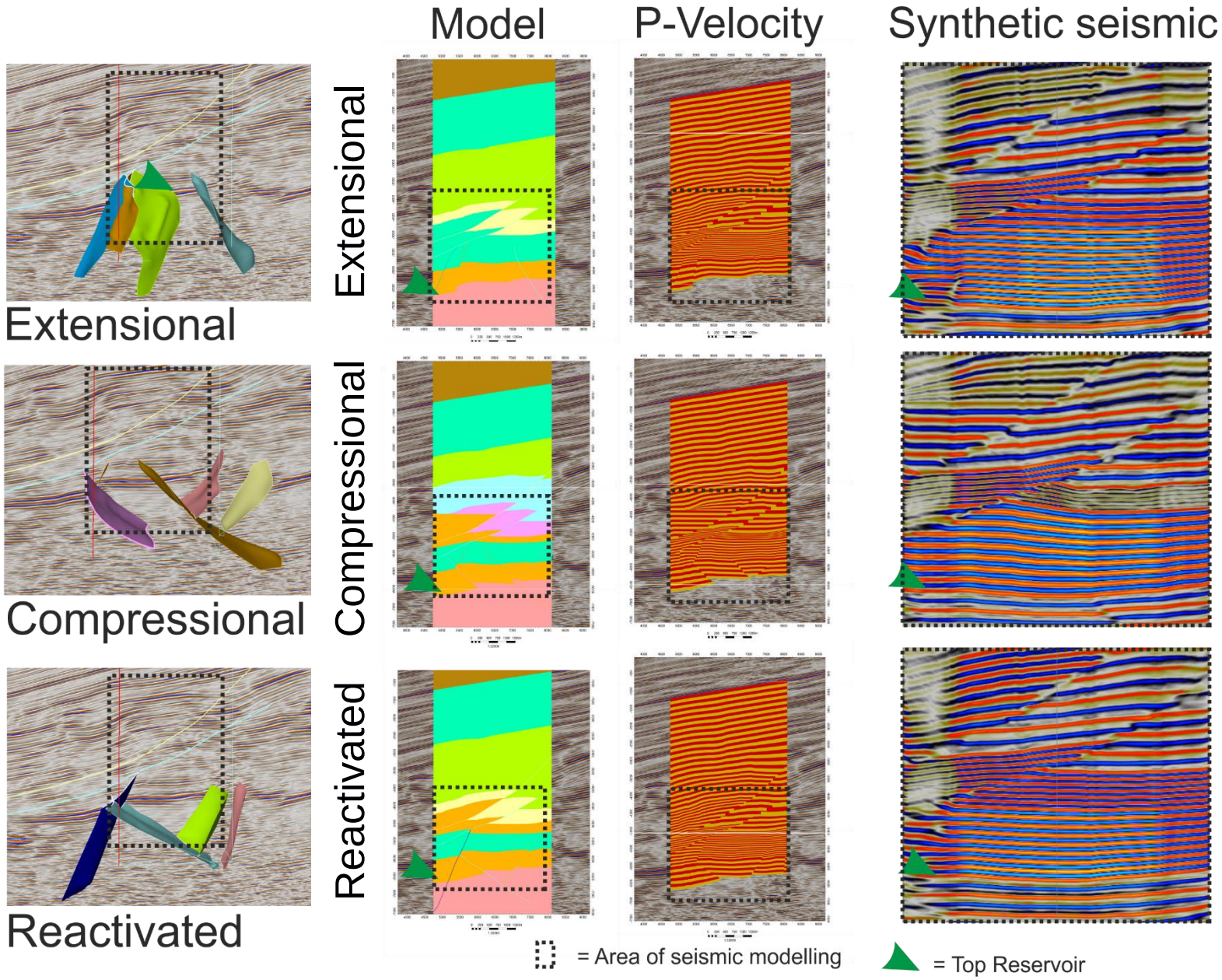


Compressional 500m H=V





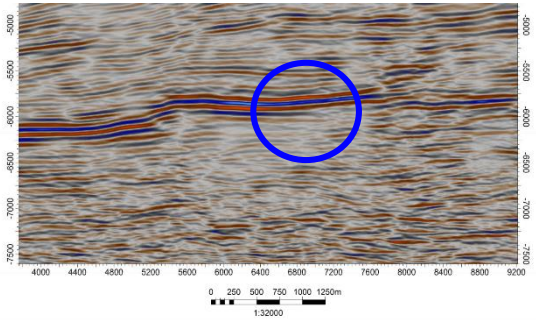
Reactivated 500m H=V

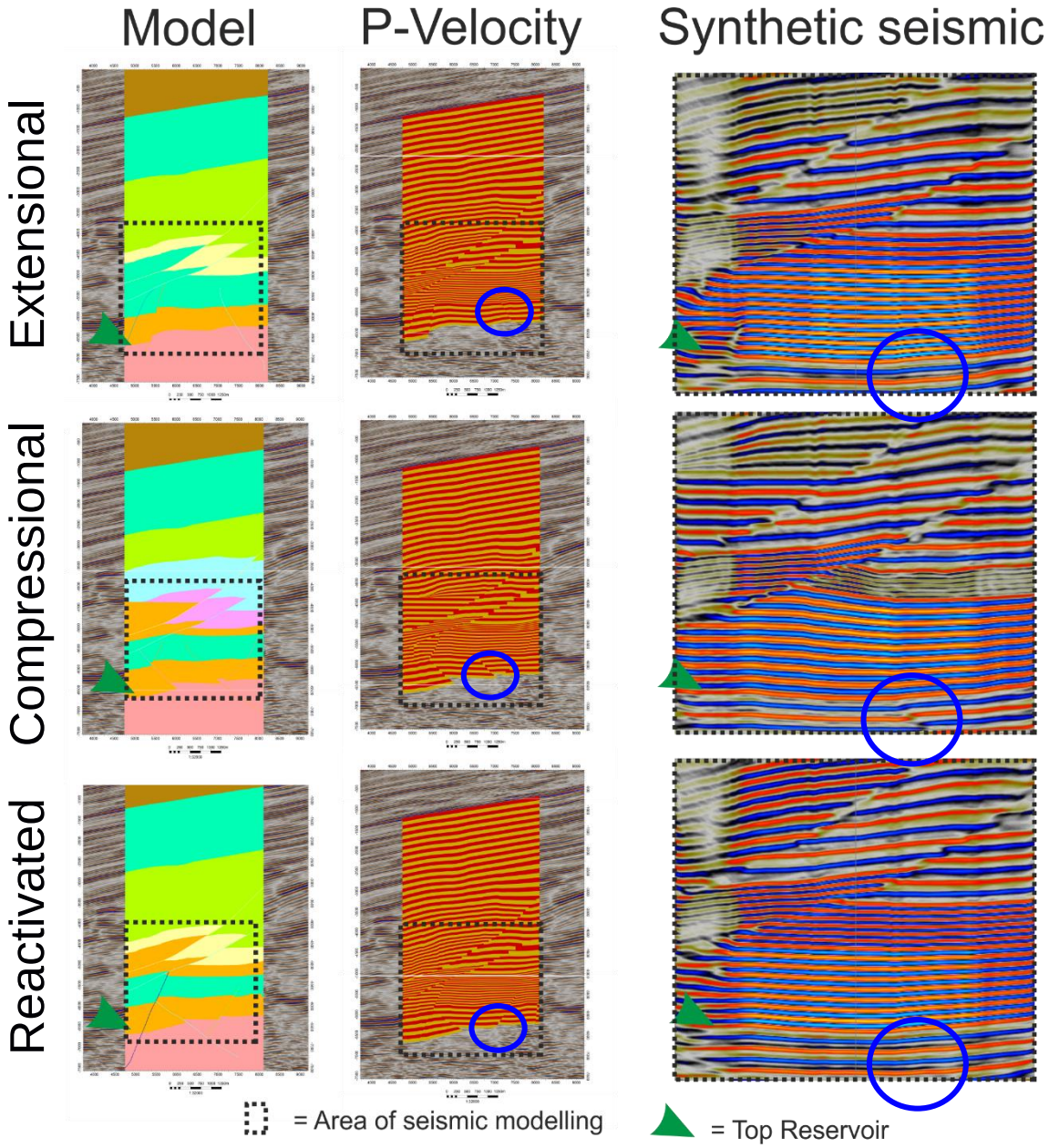

Model
P-Velocity
Synthetic seismic
Extensional
Compressional
Reactivated
Extensional
Compressional
Reactivated
= Area of seismic modelling
= Top Reservoir

Synthetic seismic

Comparison of he synthetic datasets may inform interpretation

Relative likelihood of scenarios defined





Volume calculation

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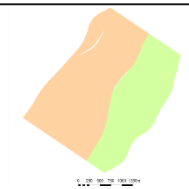
	Extensional		Compressional		Reactivated
					
Area	**Ext A**	**Ext B**	**Comp A**	**Comp B**	**React A**
Area (km^2)	1065.5	4420.7	4566.0	2951.6	6516.9
Mean Thickness (m)	56.0	72.4	63.9	96.5	75.8
Gross rock volume (m^3)	59.6 $x10^6$	320.2 $x10^6$	291.6 $x10^6$	284.8 $x10^6$	494.1 $x10^6$
Assuming: average porosity 0.22, average water saturation 0.6					
HCIIP (m^3)	5.2 $x10^6$	28.2 $x10^6$	25.7 $x10^6$	25.1 $x10^6$	43.5 $x10^6$
HCIIP (MMbbls)	33.0	177.2	161.4	157.6	273.5
Assuming: formation volume factor 1.2, recovery factor 0.6					
Recoverable HC (MMbbls)	23.8	127.6	116.2	113.5	196.9
Prospect totals (MMbbls)	151.4		229.7		196.9

Case	Likelihood	Justification
Extensional	0.4	Known passive margin history, normal offset faults visible.
Compressional	0.2	Synthetic suggest compressional features would be visible if present. Limited features identified with certainty.
Reactivated	0.4	Known passive margin history, normal offset faults visible.

Risked volumes

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Decision tree risk analysis

Interpretation case		COS		Fault seal		Total probability	Potential volume	Risked volume
0.4	Extensional	0.42	Success, p(B)	0.5	Fault open	0.084	151.4	12.7
				0.5	Fault closed	0.084	127.6	10.7
		0.58	Failure			0.232	0	0
0.2	Compressional	0.42	Success, p(A)	0.5	Fault open	0.042	229.7	9.6
				0.5	Fault closed	0.042	116.2	4.9
		0.58	Failure			0.116	0	0
0.4	Reactivated	0.42	Success, p(A)			0.168	196.9	33.1
		0.58	Failure			0.232	0	0

Recoverable volumes (MMbbls)

Total risked volume: 71.0 MMbbl

Assumptions:

- Risked for a single well development
- Faults taken to be fully open or sealing (50:50)
- Drilling to target largest segment
- COS by personal estimate (T: 0.75, S: 0.7, R: 0.8)

Conclusions

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Risk model	Interpretation	COS	Fault seal	Risked recoverable volume (MMbbls)
Best guess	Reactivated	0.42	N/A	82.7
Multi-deterministic	Multiple	0.42	0.5	71.0

- 16% difference in risked recoverable volume
- Highlights importance of considering multiple models
- Seismic forward modelling may inform interpretation
- Potential to build understanding of relative probability of models

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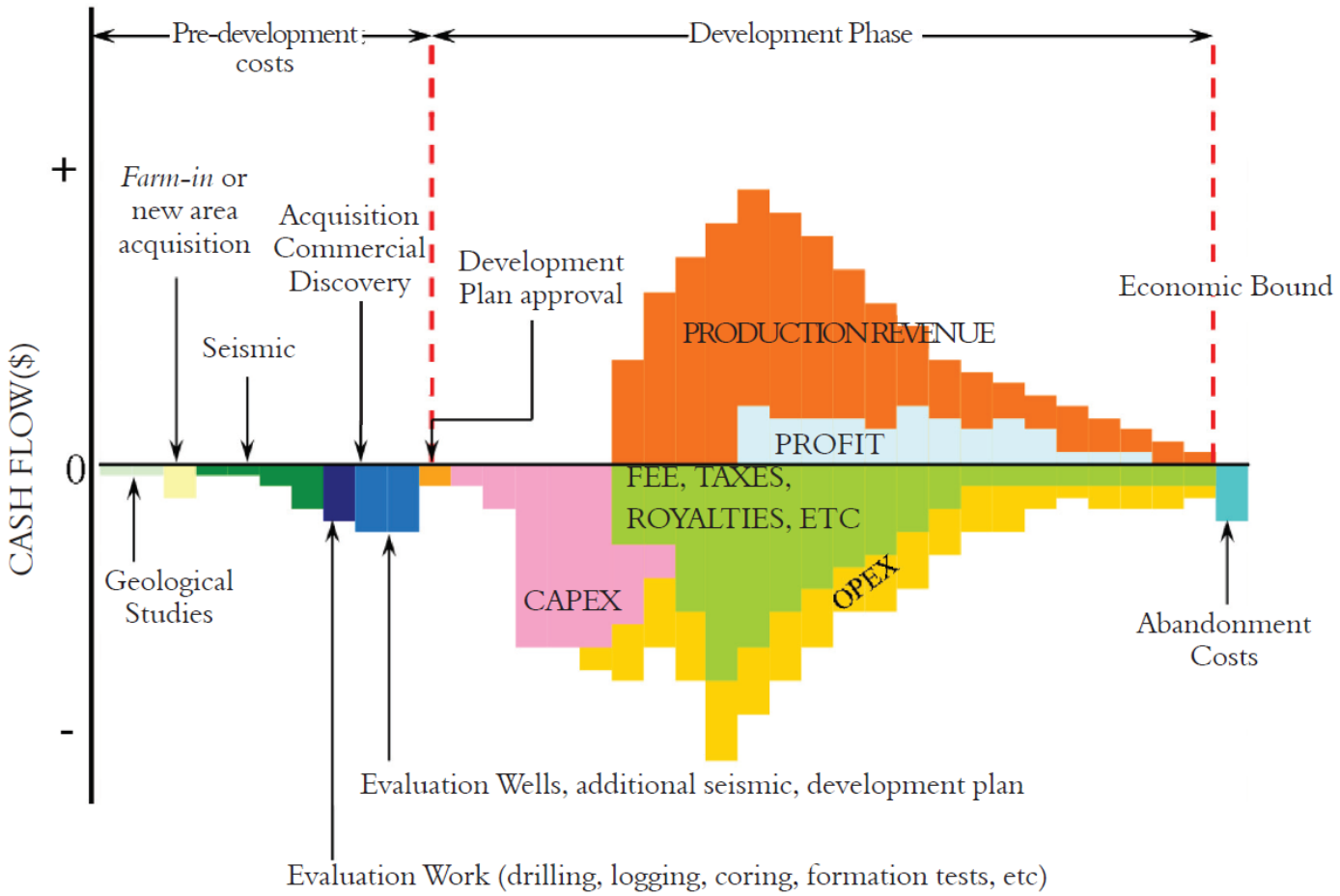

Suslick et al 2009

Exploration interpretation

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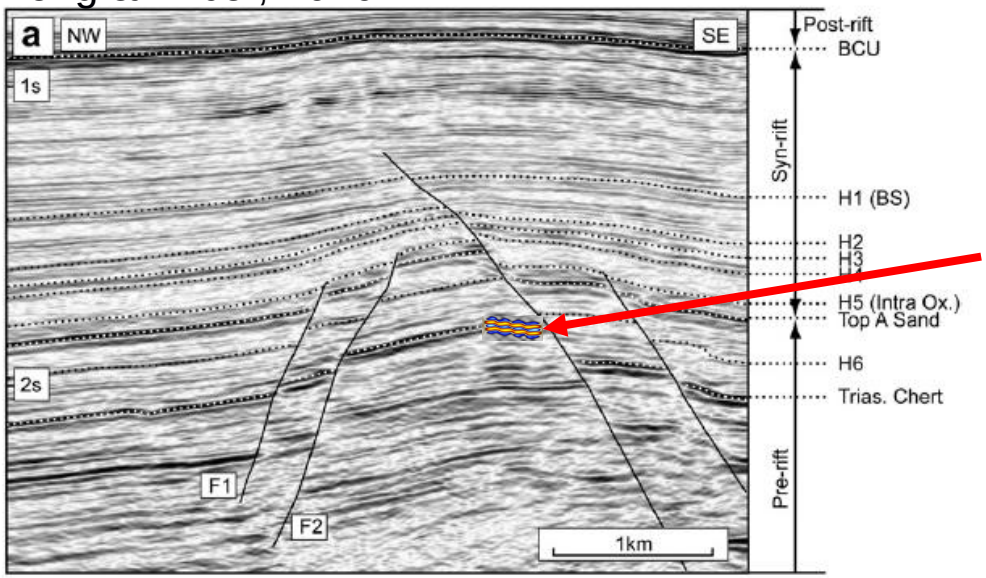
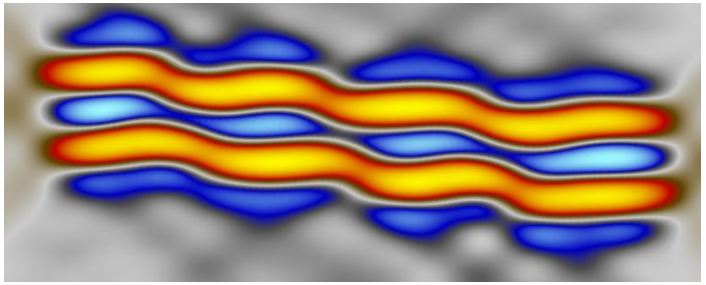
Long & Imber, 2010





400m

H=V

Example of exploration scale interpretation, with local synthetic seismic

Alternate models from identical seismic

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