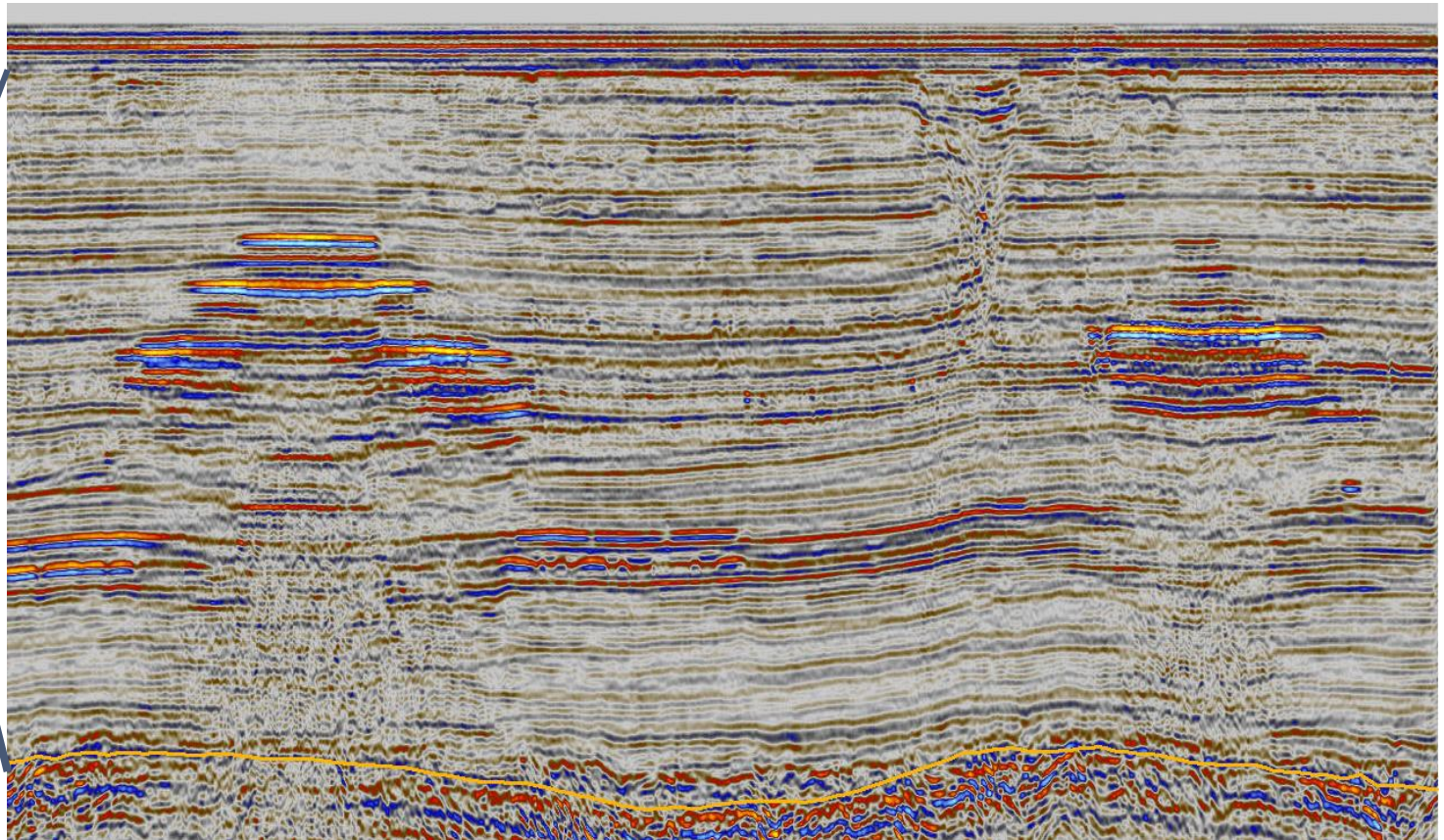


# Seismic Characterisation of Shallow Gas in The Netherlands

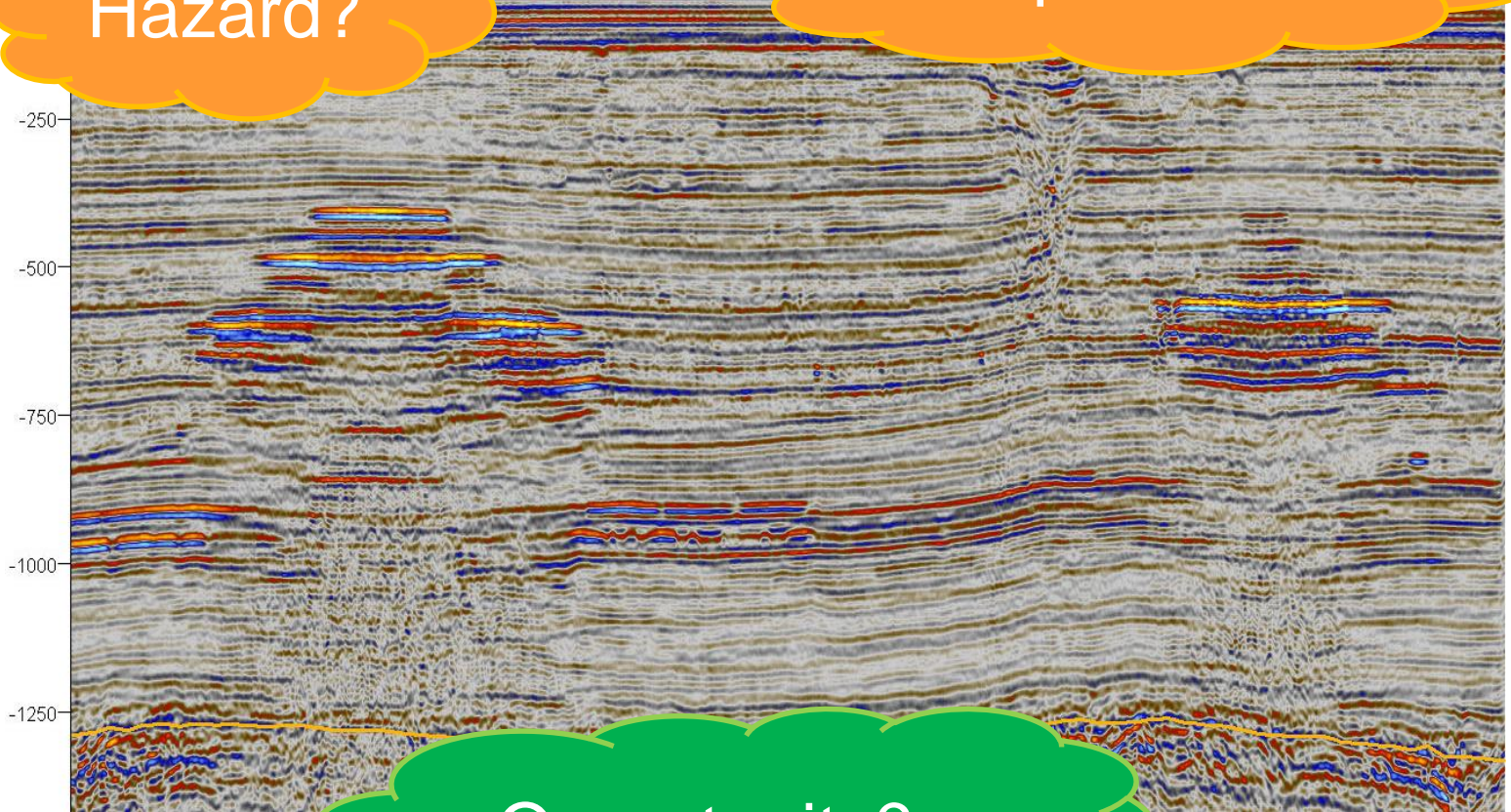
Cenozoic	Quaternary	Holocene	
		Pleistocene	
	Tertiary	Neogene	Pliocene
			Miocene
			Oligocene
		Paleogene	Eocene
Paleocene			
Mesozoic	Cretaceous	Late	
		Early	
		Late	
	Jurassic	Middle	
		Early	
		Late	
Triassic	Middle		
	Early		
	Early		
Paleozoic	Permian	Late	
		Early	
	Pennsylvanian		
		Mississippian	
	Devonian	Late	
		Middle	
Early			
Silurian	Late		
	Early		
Ordovician	Late		
	Middle		
	Early		
Cambrian	D		
	C		
	B		
	A		



Mijke van den Boogaard & Guido Hoetz (EBN)

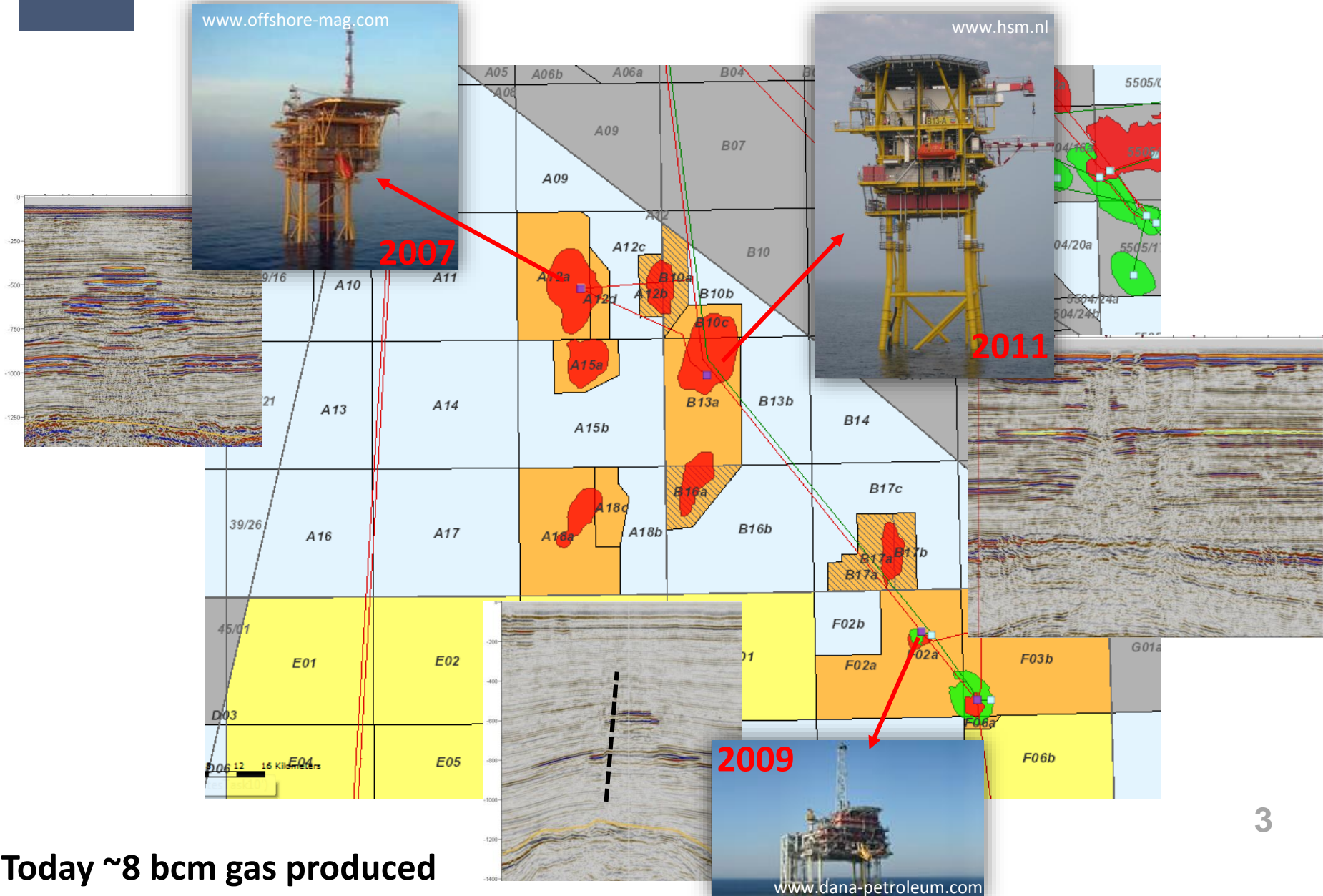
Hazard?

Deep source?

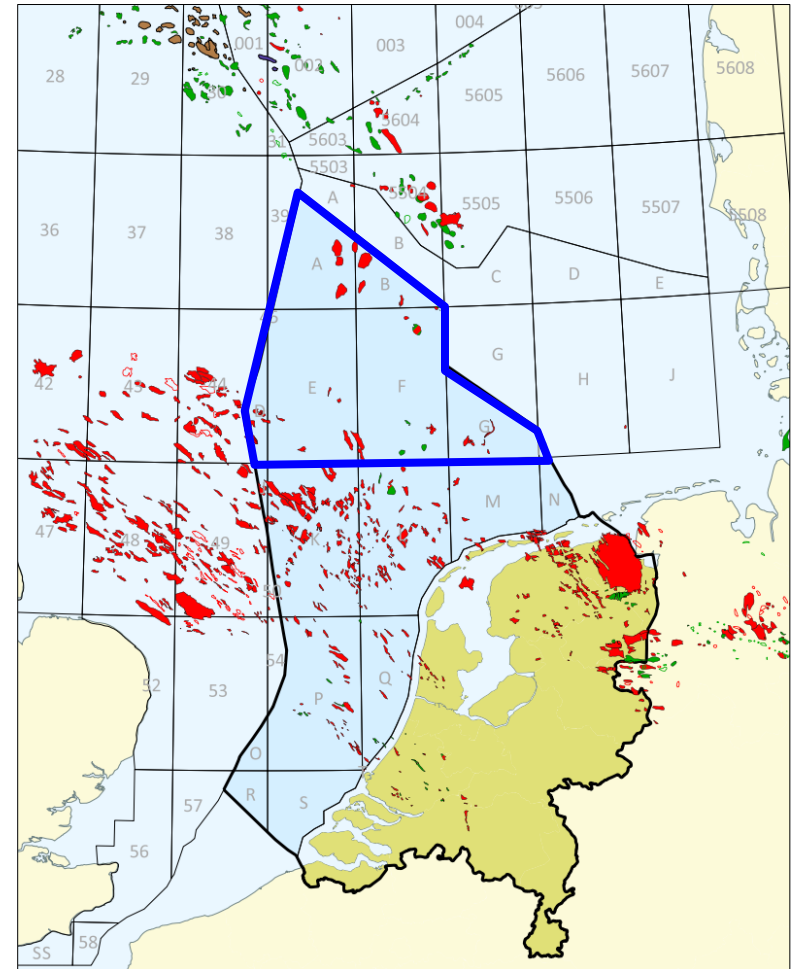


Opportunity?

# Shallow Gas Pays Off!

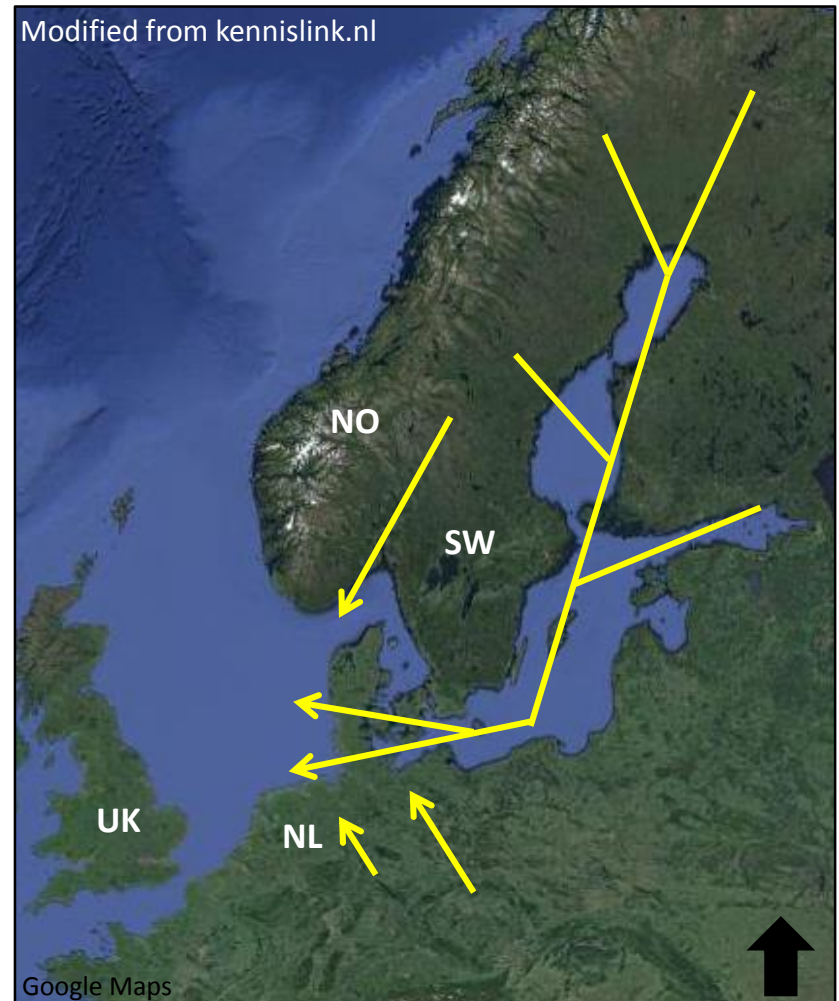
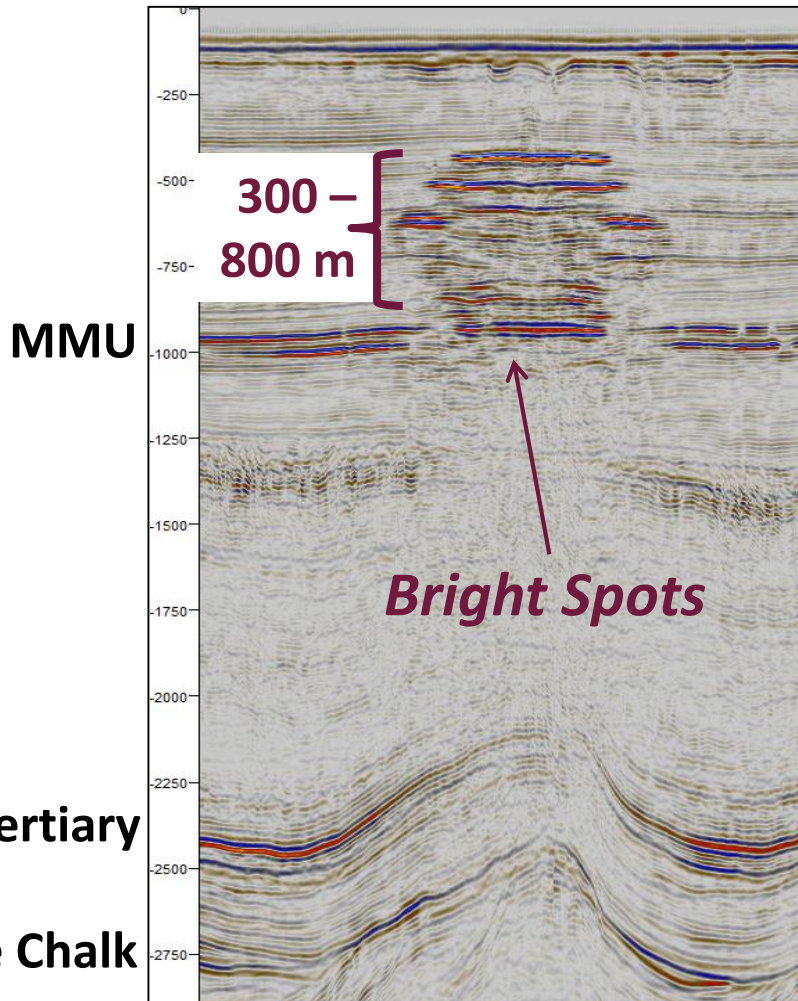


1. Introduction
2. New play rather than hazard
3. Seismic characterisation
4. Summary

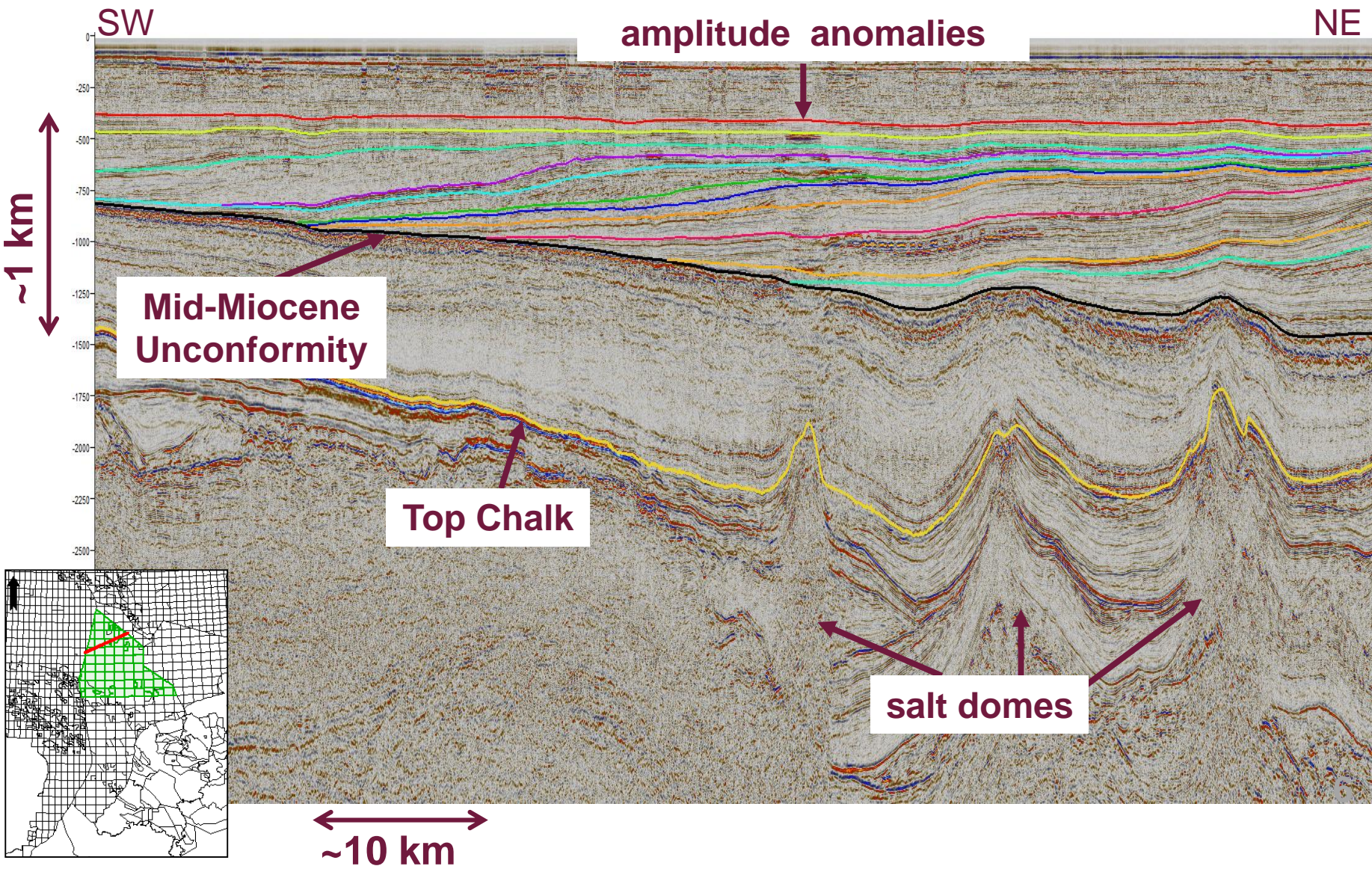


# Geological Setting

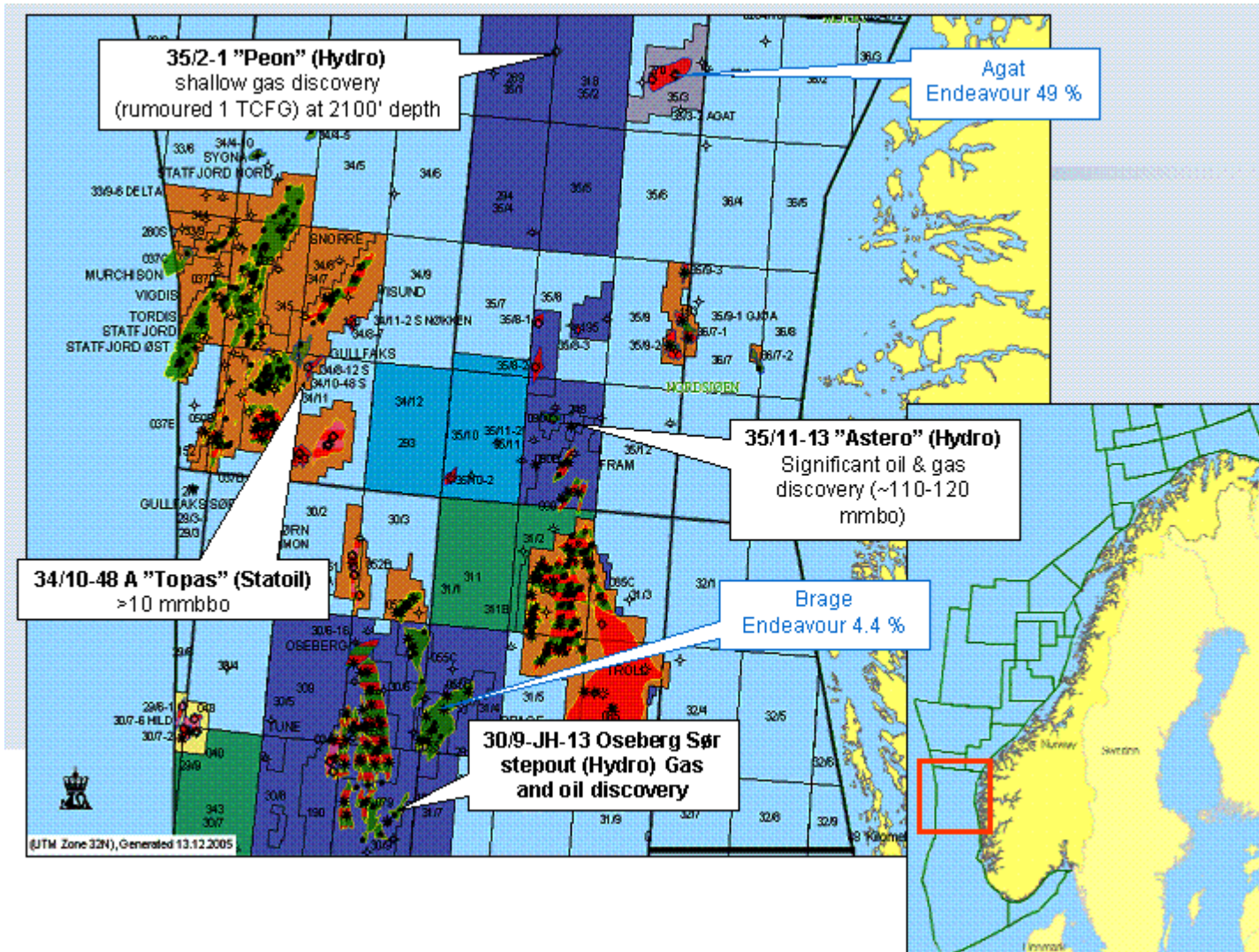
Shallow Gas (**SG**) = gas in unconsolidated, Miocene-Pleistocene sands



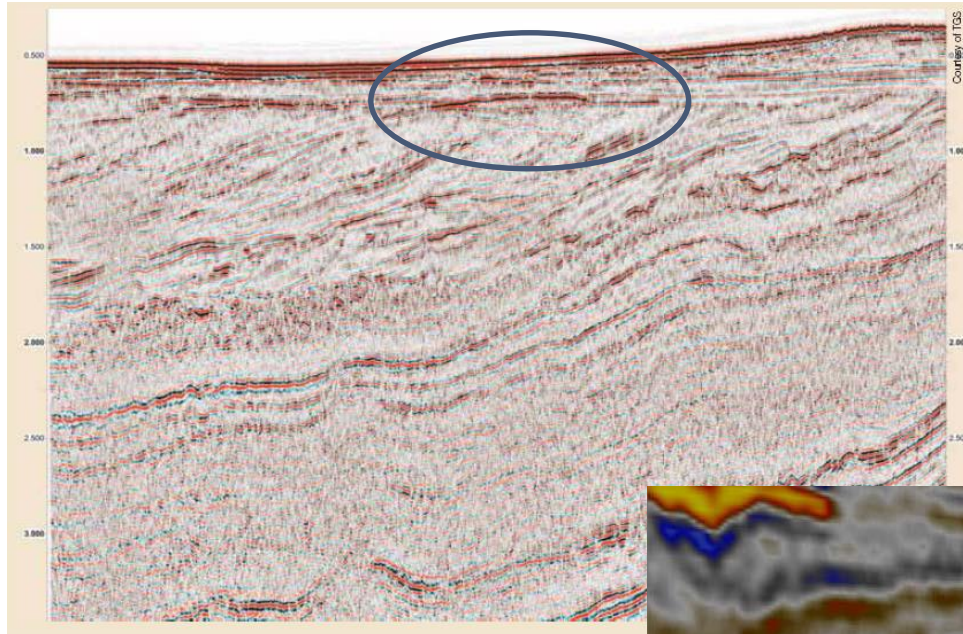
# Geological Setting



# Shallow Gas in Norway

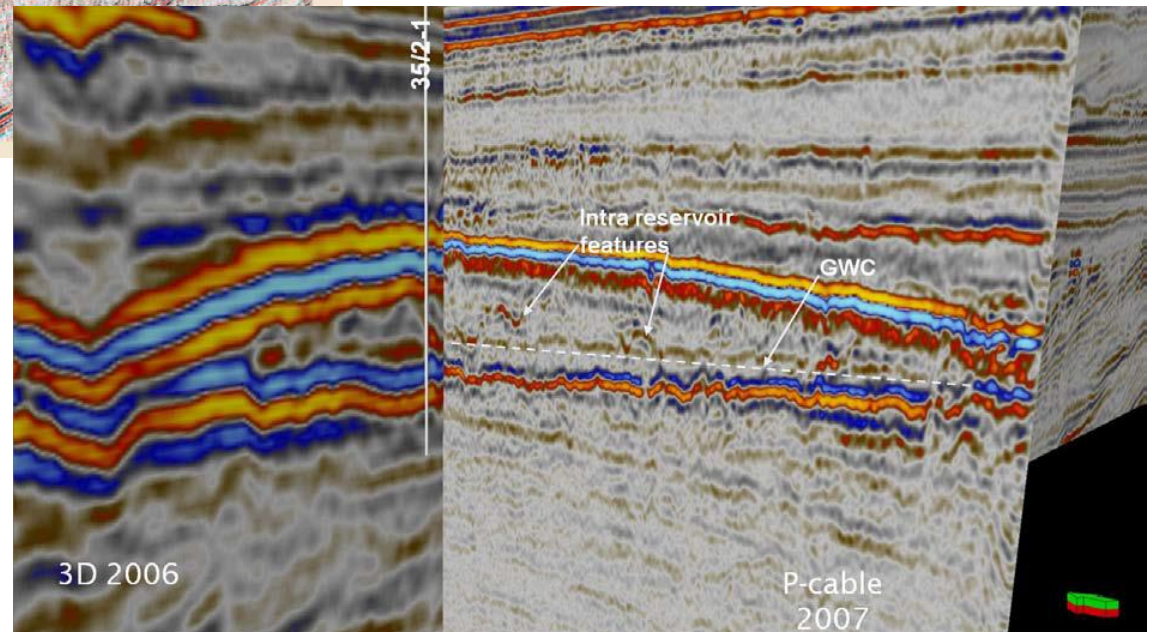


# Shallow Gas in Norway



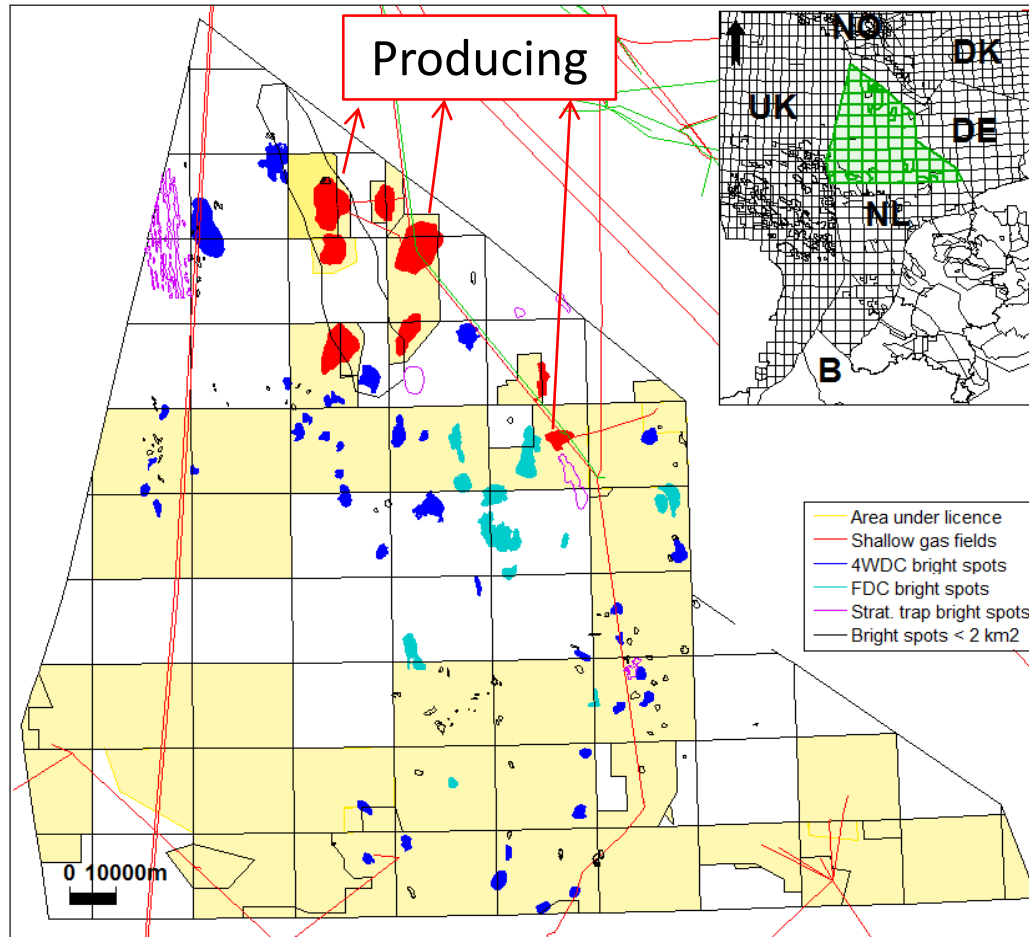
- 2005 Gas discovery
- Clean unconsolidated sands
- Pleistocene glaciofluvial / marine
- Nordland Gp sediments
- Top @ 574m

- 18.7 m gas column
- 99.5% methane
- $\Phi = 0.33$
- $N/G = 0.99$
- $SG = 0.88$



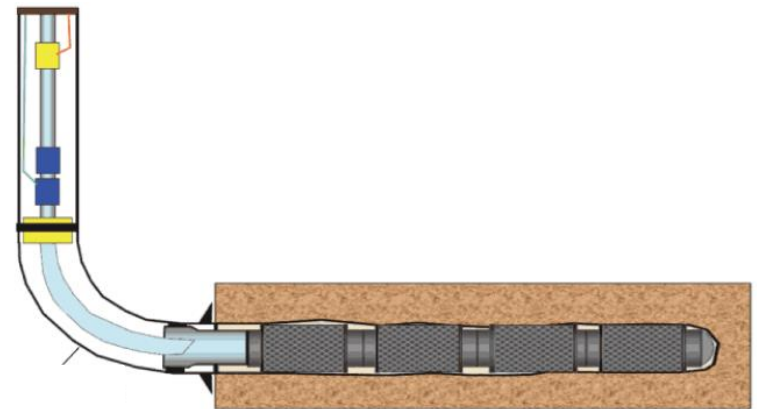


# Shallow Gas Portfolio

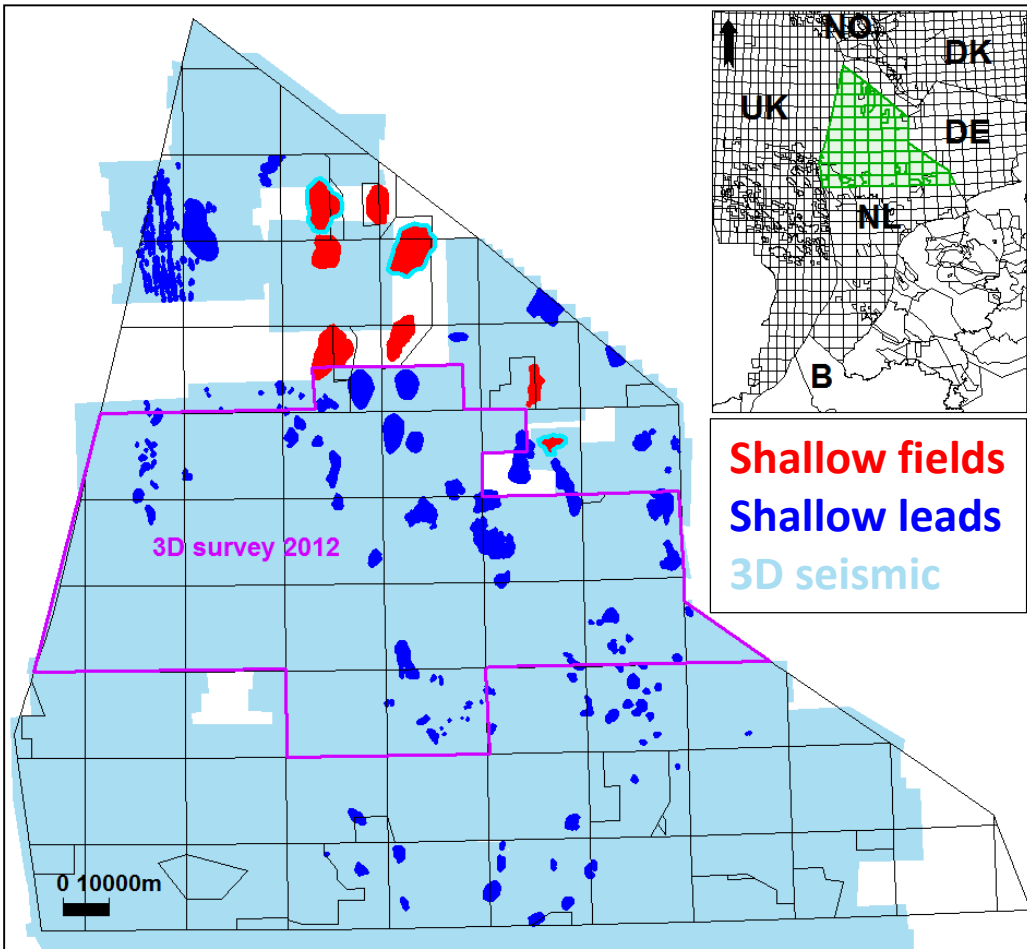


# Shallow Gas Production

- Presence shallow gas known since 70's
- Early water breakthrough & sand production expected  
→ fields not developed
- Currently 3 successfully producing fields:
  - A12-FA (2007)
  - F02a-B-Pliocene (2009)
  - B13-FA (2011)
- Technical breakthrough  
(e.g. sand control in horizontal wells)



# Shallow Gas: new play rather than drilling hazard



1. New technology proven successful for SG developments
2. New 3D seismic points to more opportunities
3. Small field tax incentive applicable

# Seismic Characterisation Shallow Gas

## SG portfolio



- *Bright Spots* identified (RMS ampl. scanning)
- 150 leads

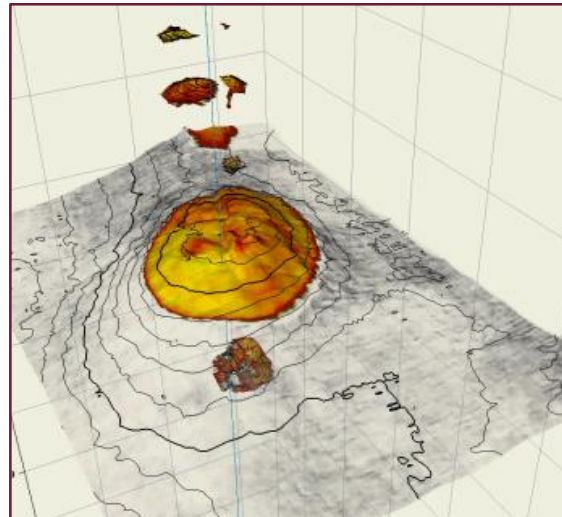
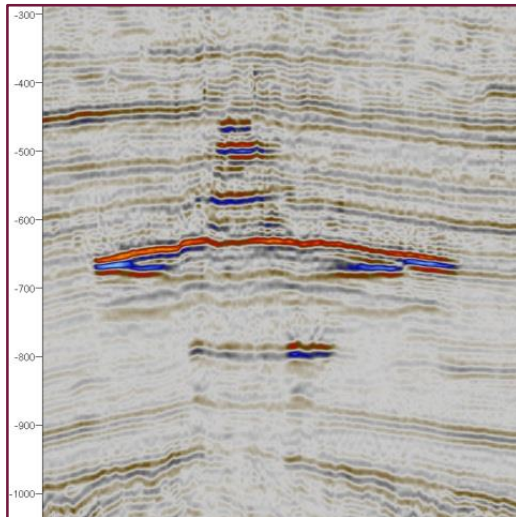
## *Bright Spot* ranking



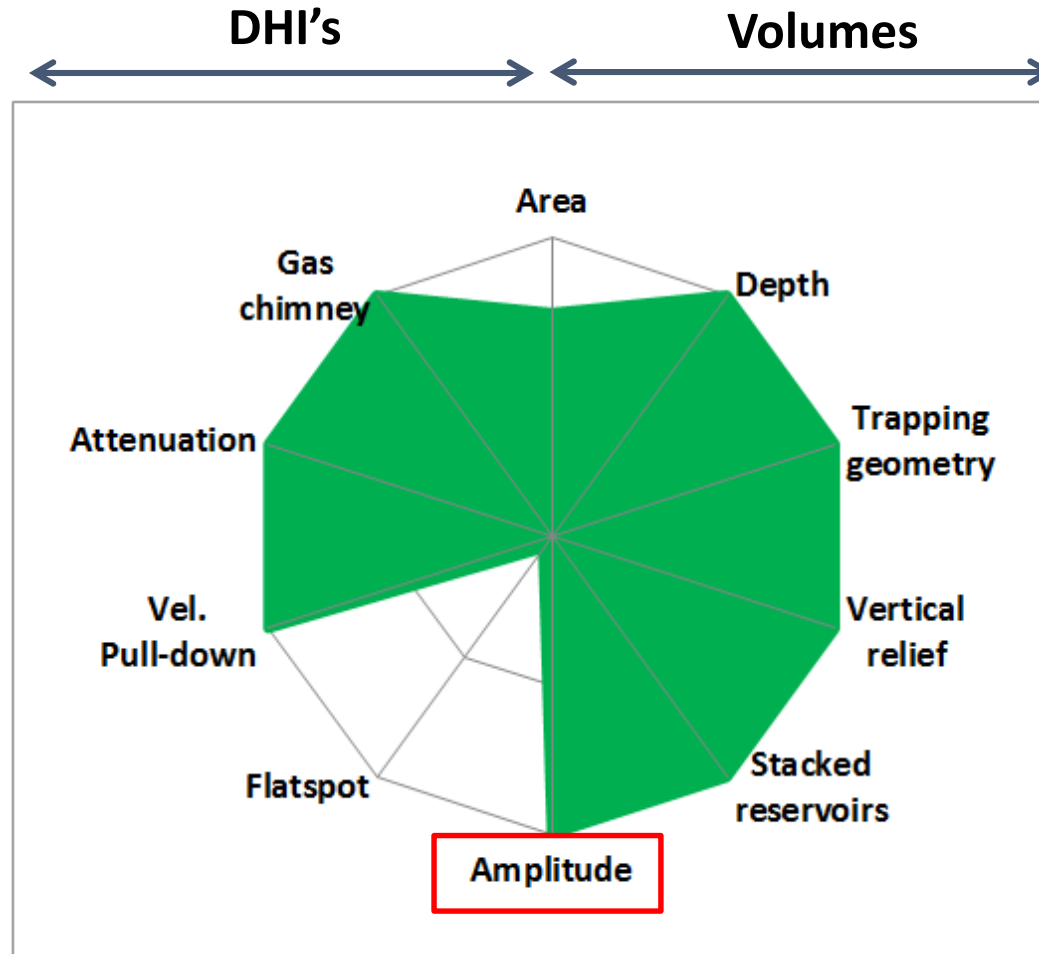
- Geometrical Characterisation
- Seismic Characterisation

## Highest ranking *Bright Spots*:

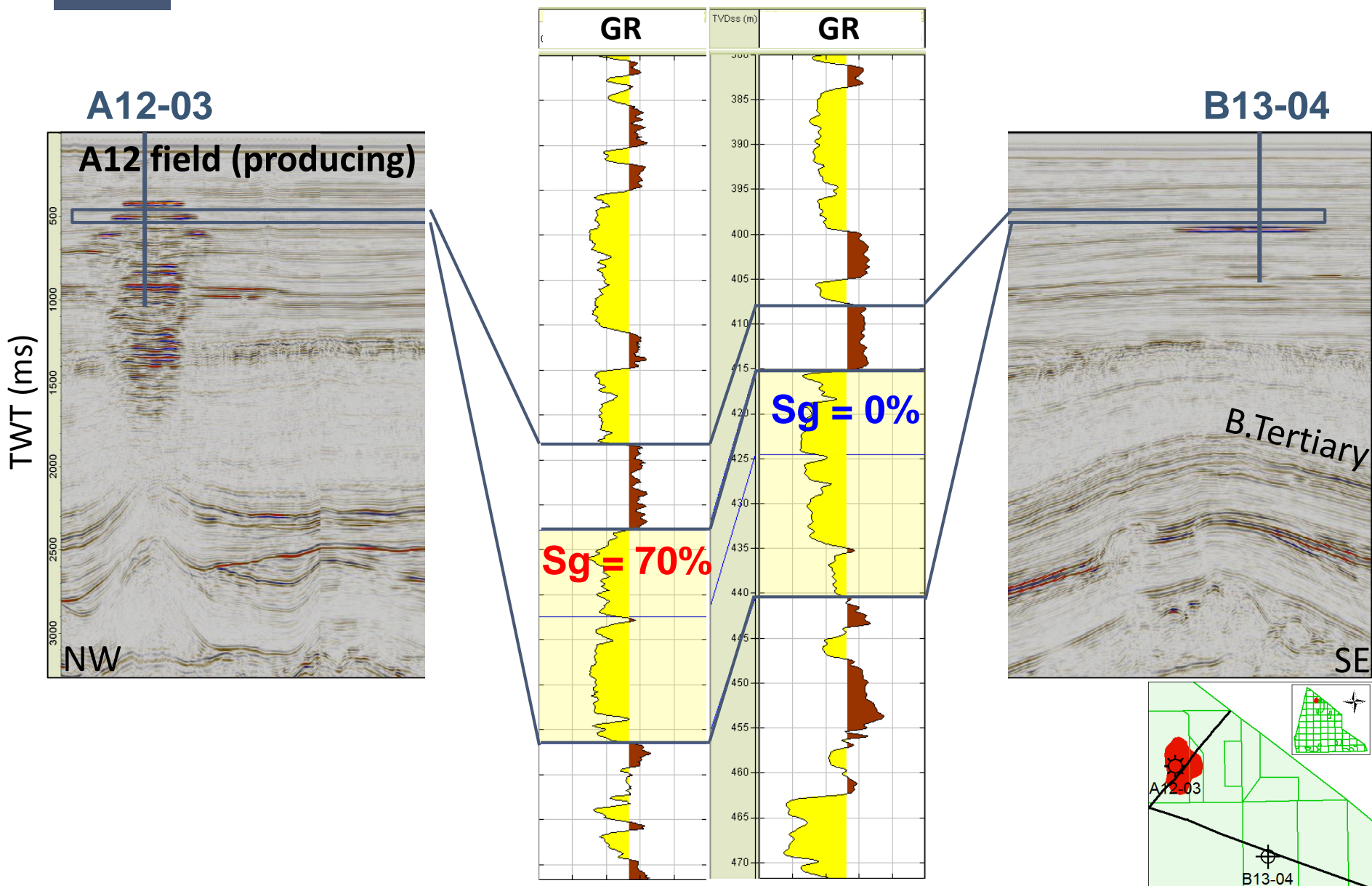
- 3D reservoir model
- Volumes



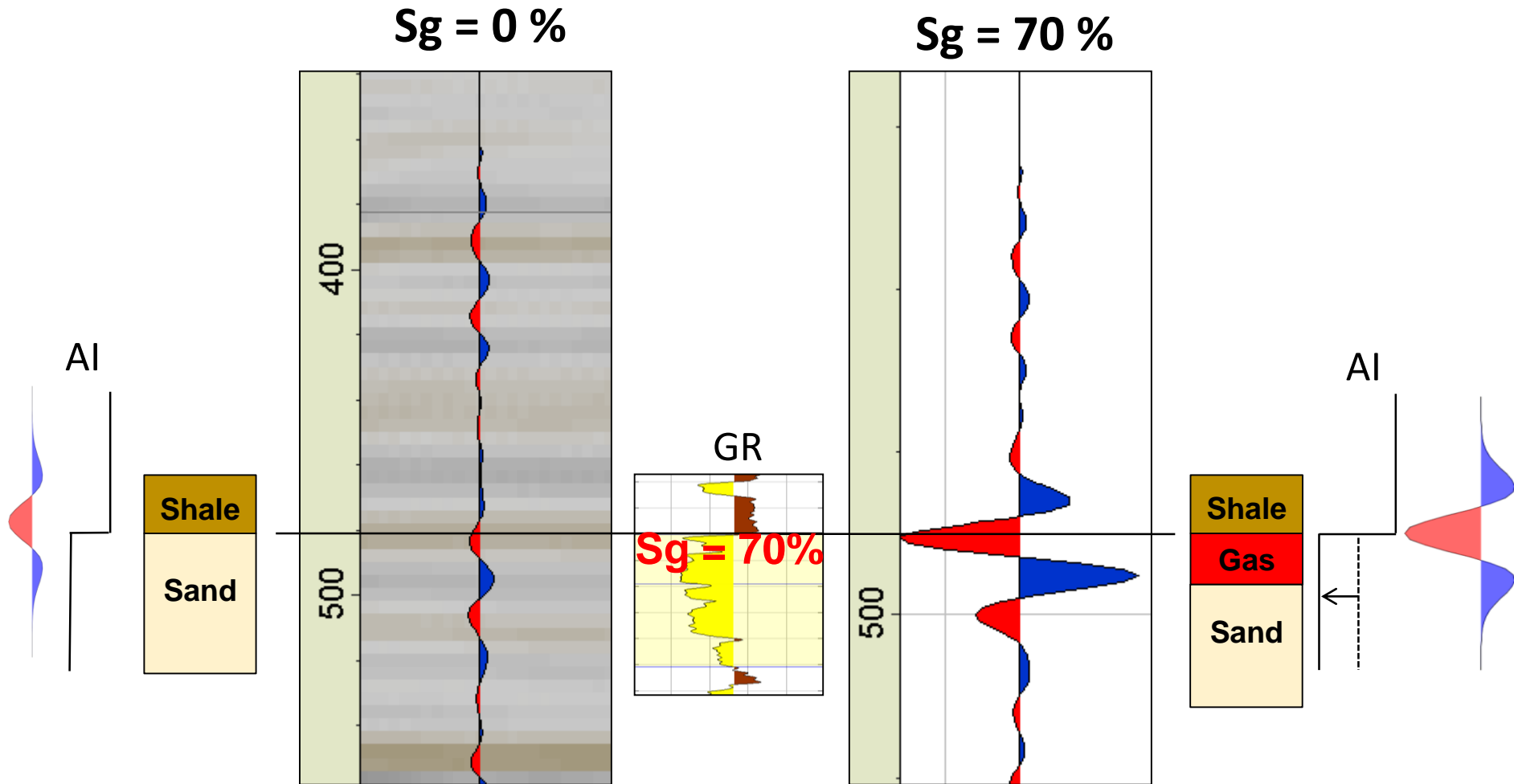
# Seismic Characterisation Shallow Gas



# Seismic Characterisation - Amplitude

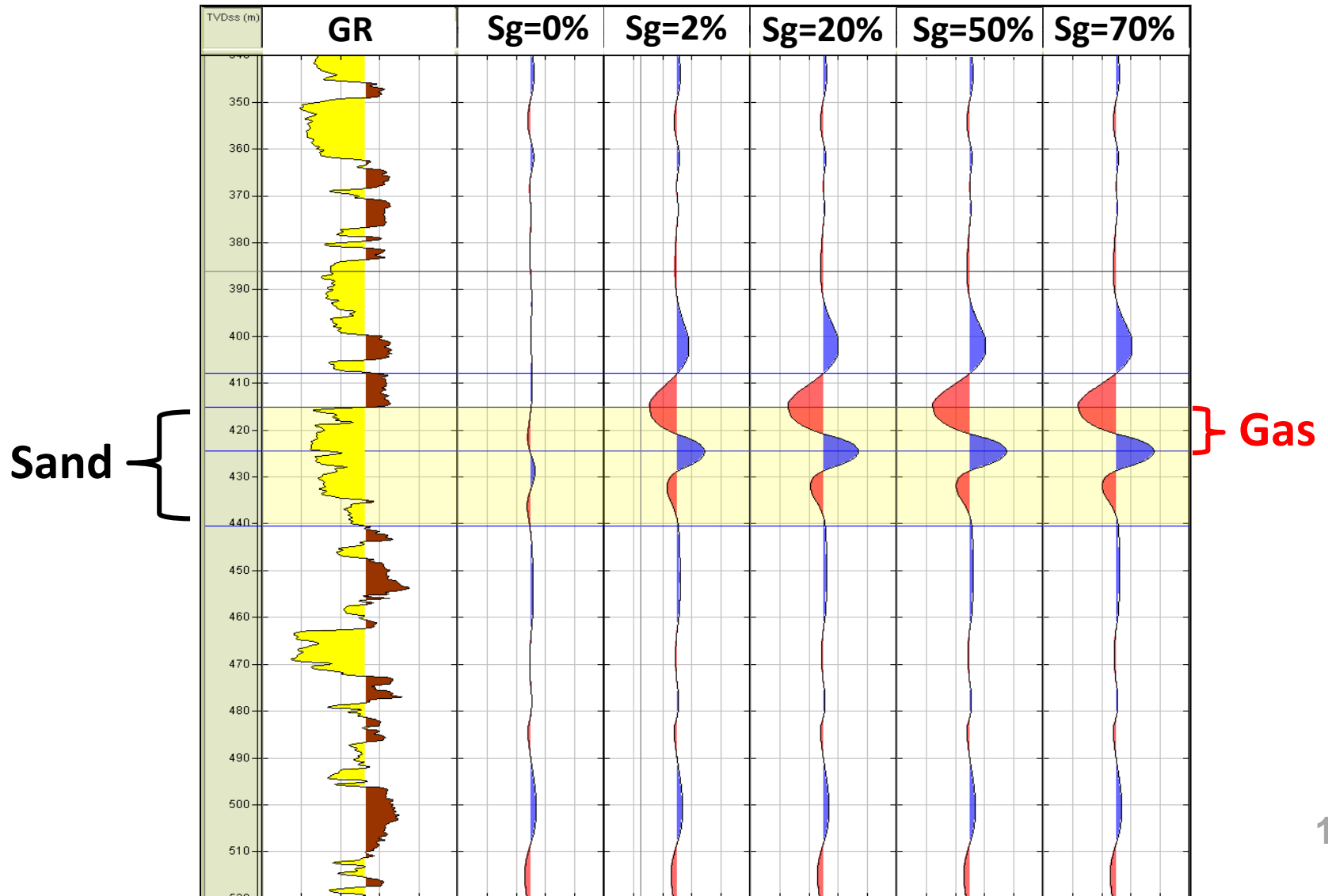


# Seismic Characterisation - *Amplitude*



**Gassmann fluid substitution approximately valid**

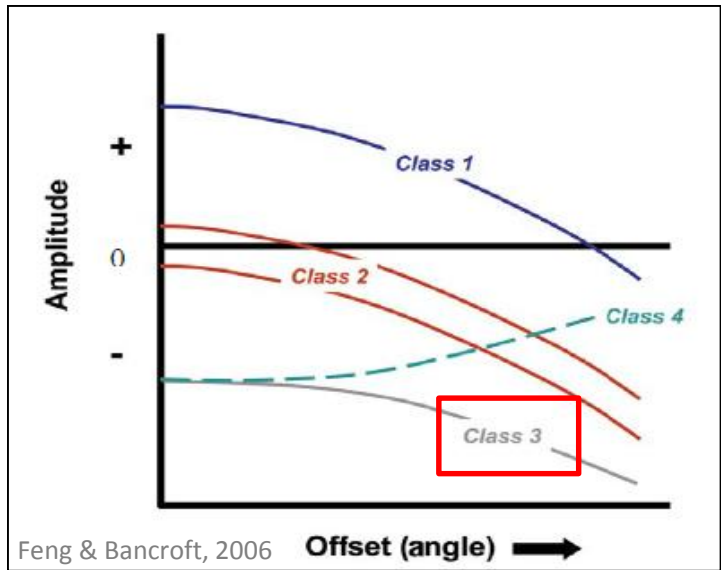
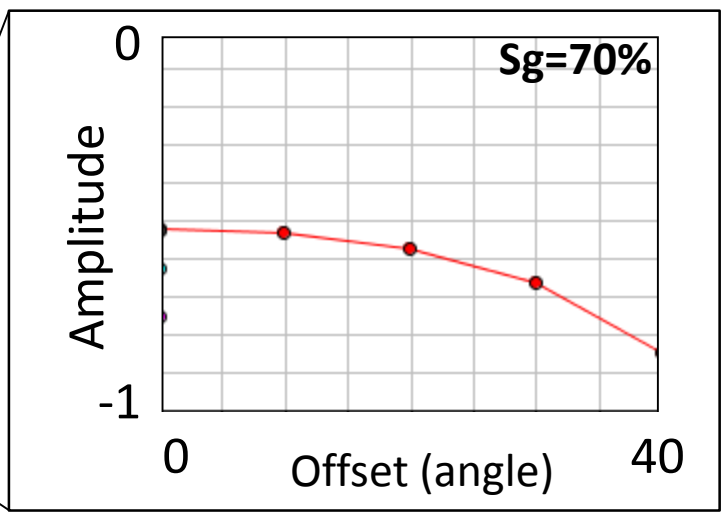
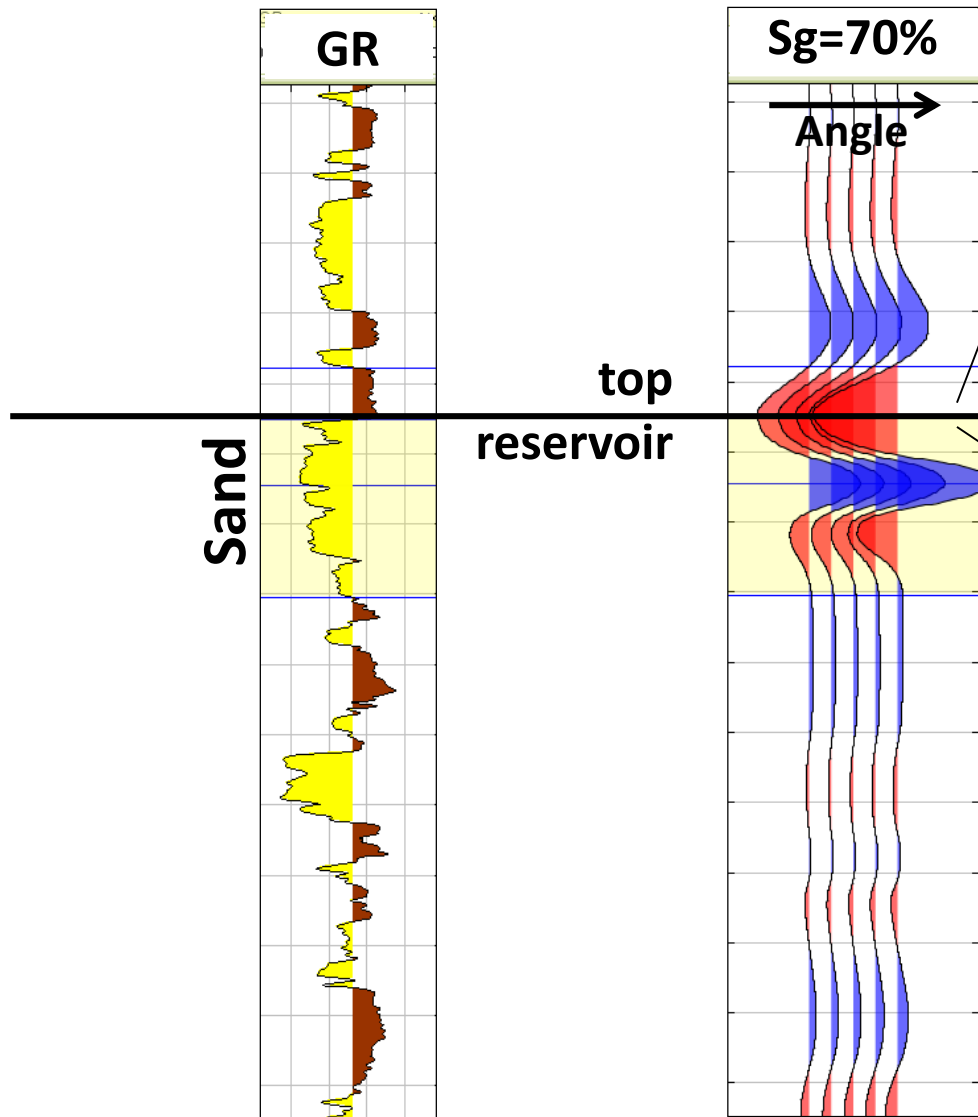
# Seismic Characterisation - *Amplitude*



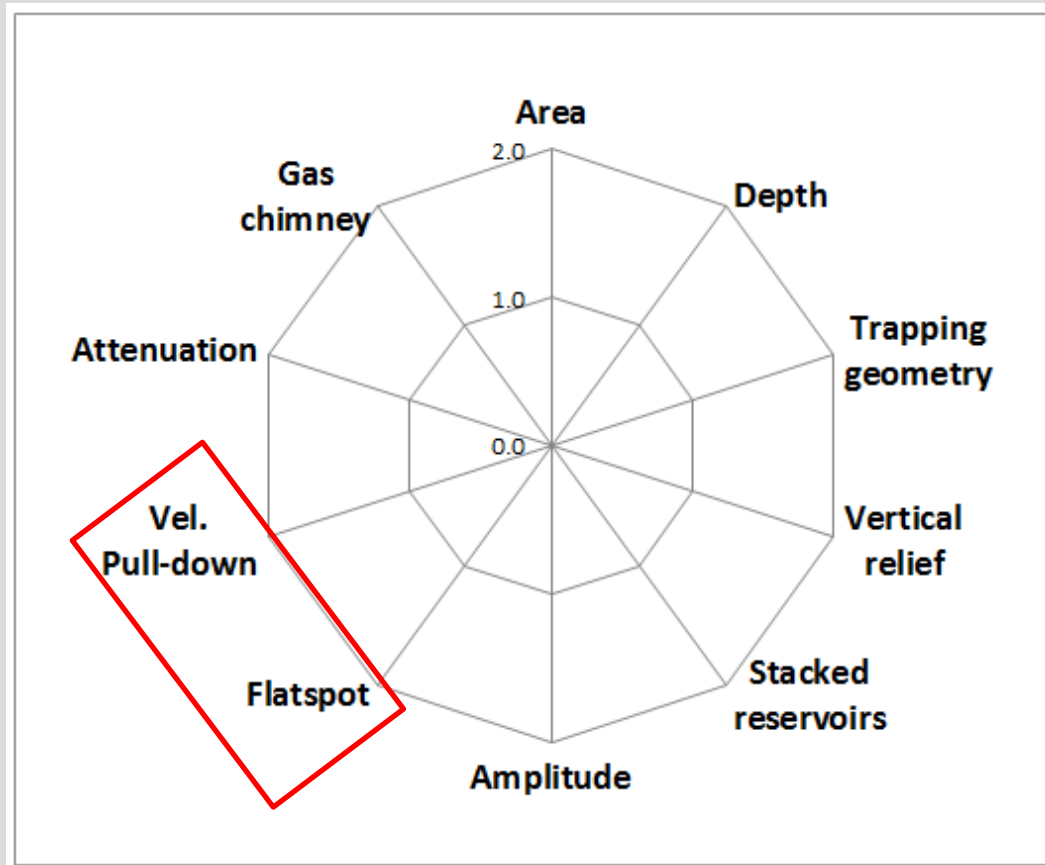


# Seismic Characterisation – Amplitude

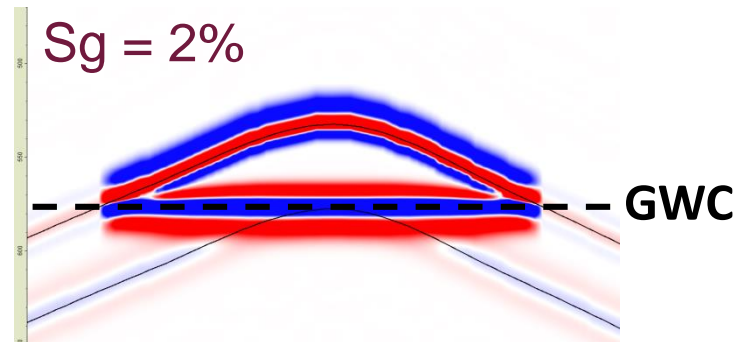
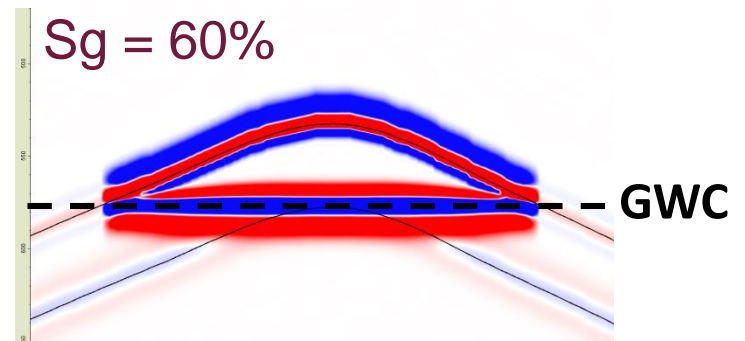
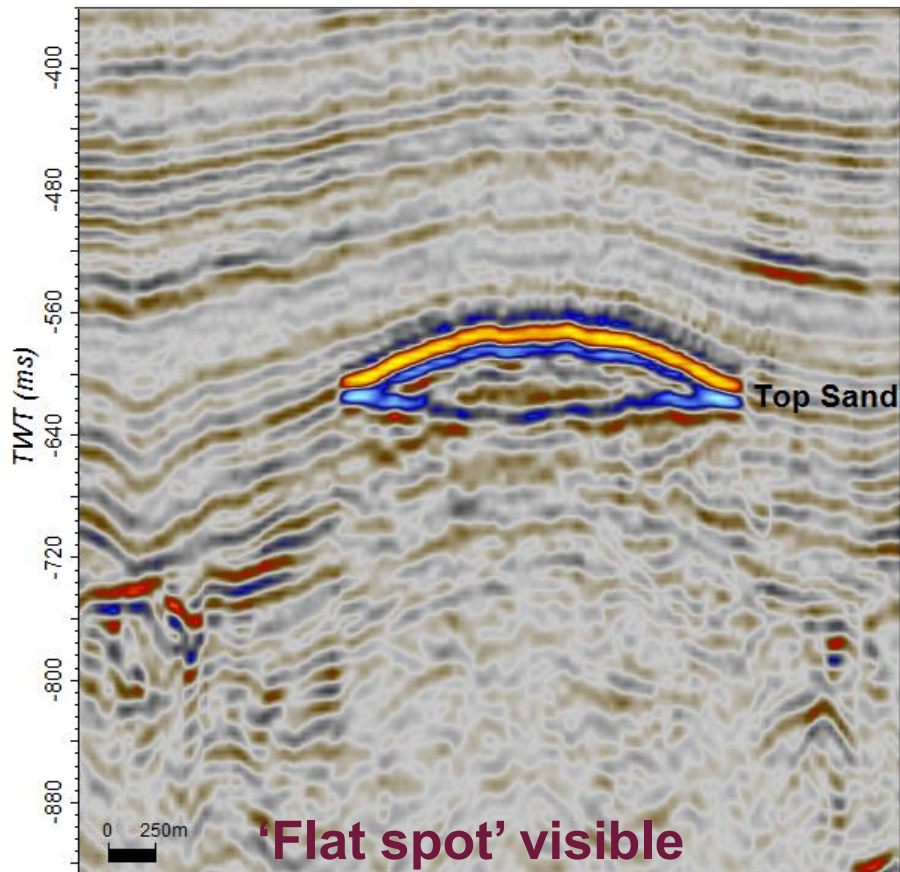
## Can AVO help?



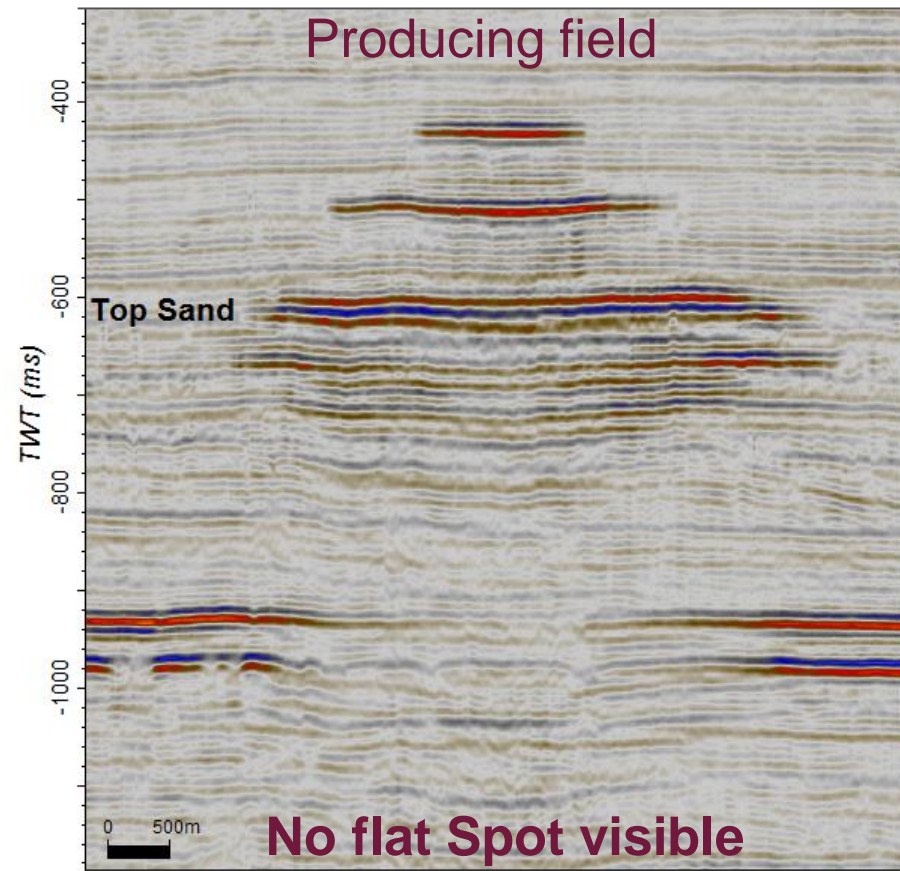
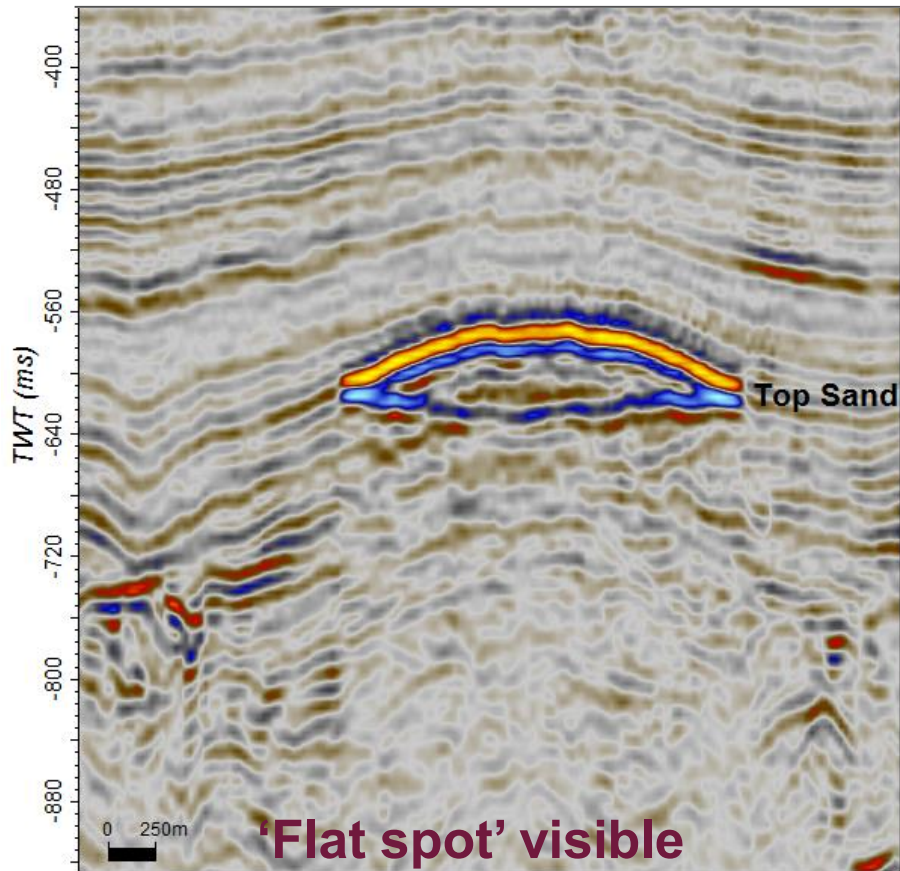
# Seismic Characterisation Shallow Gas



# Seismic Characterisation - *Flat Spot*



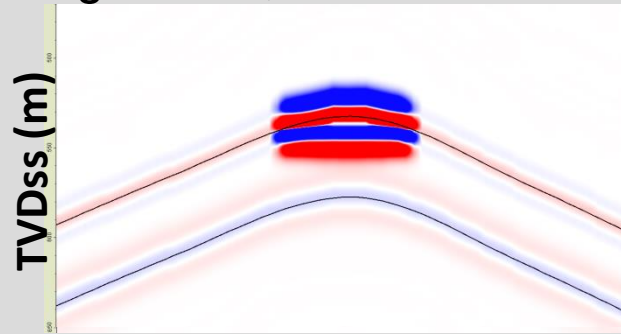
# Seismic Characterisation - *Flat Spot*



# Seismic Characterisation - *Flat Spot*

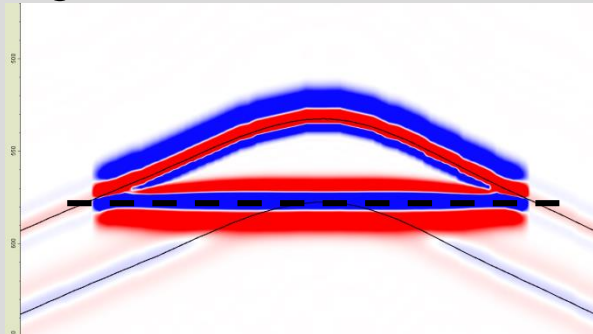
Reservoir = 50m

Sg = 60%, Column = 10m



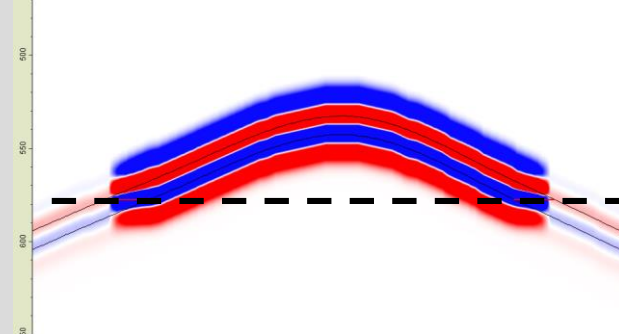
Reservoir = 50m

Sg = 60%, Column = 50m



Reservoir = 10m

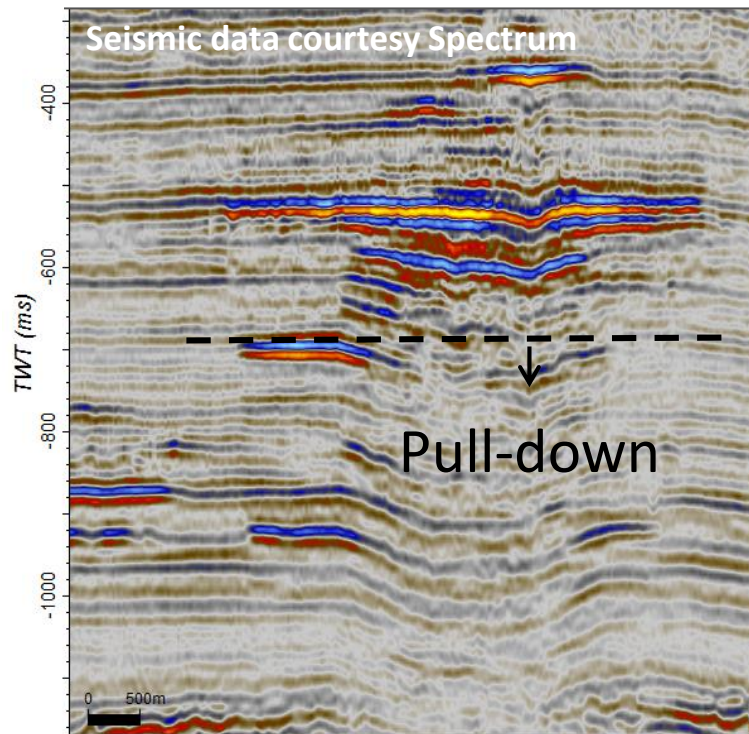
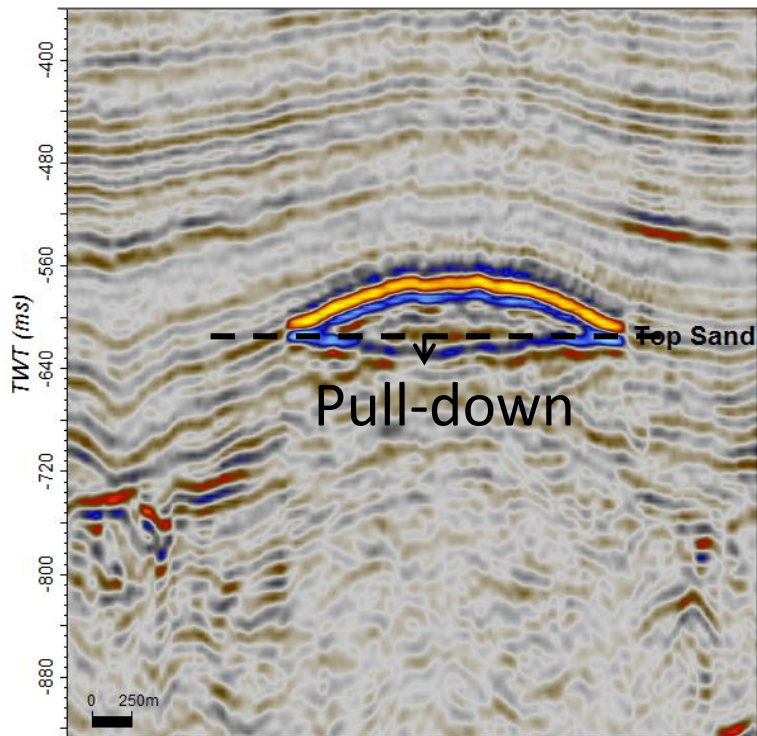
Sg = 60%, Column = 50m



Visibility of flat spot dependent on:

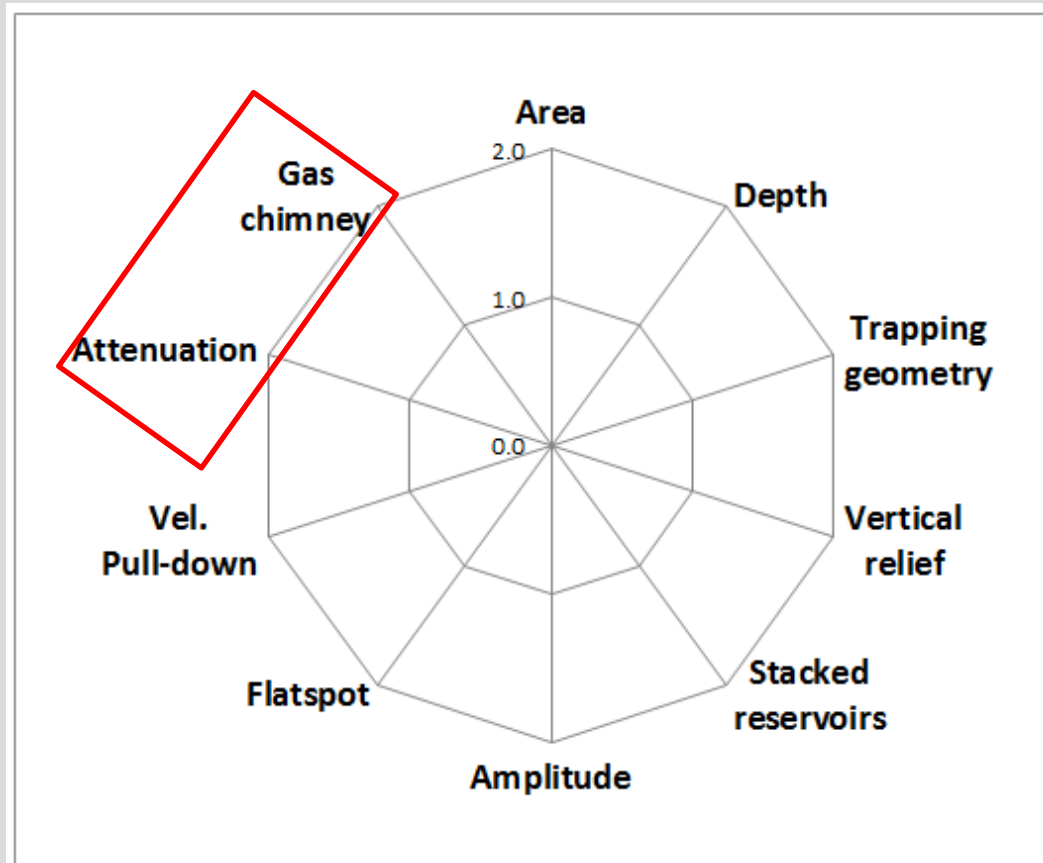
- Dip of reflectors
- Reservoir thickness
- Column height

**Flat spot indicates reservoir thickness & HC column, not saturation**



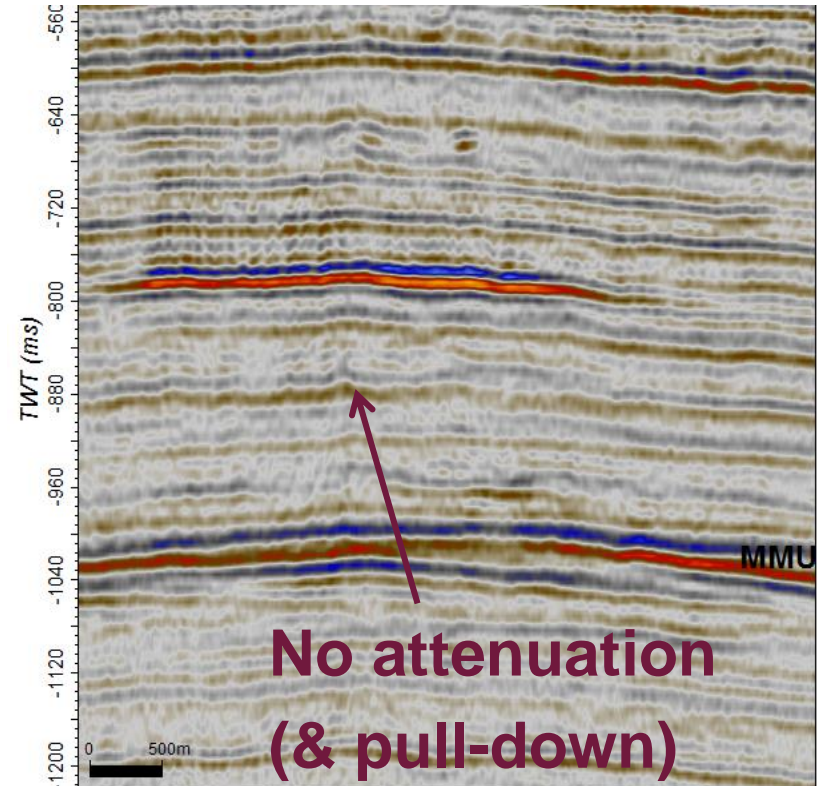
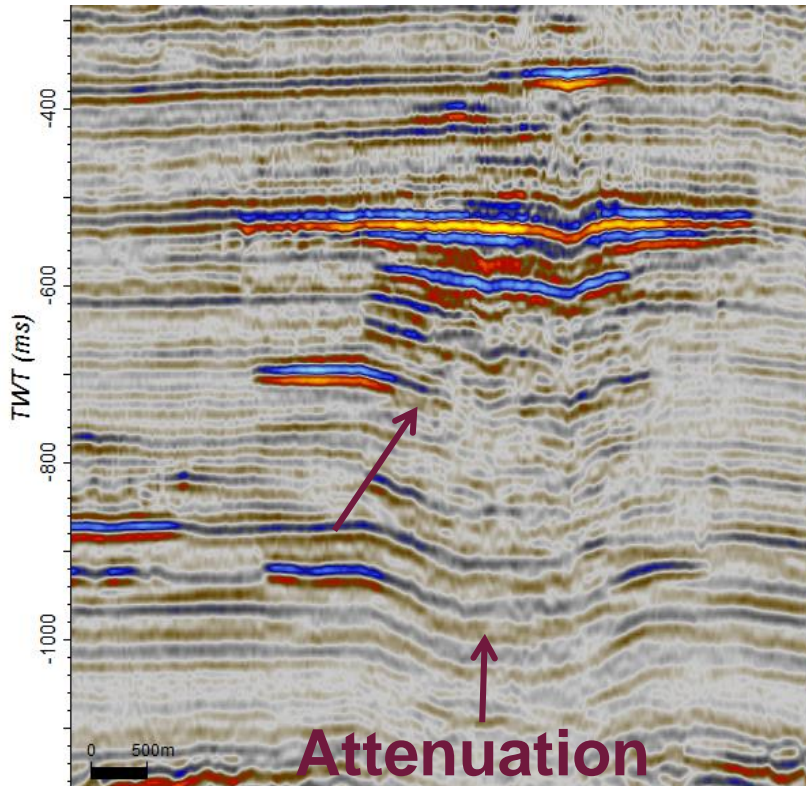
- **Pull-down indicates (total) HC column**
- **Absence pull-down indicates very low saturation**

# Seismic Characterisation Shallow Gas



# Seismic Characterisation - *Attenuation*

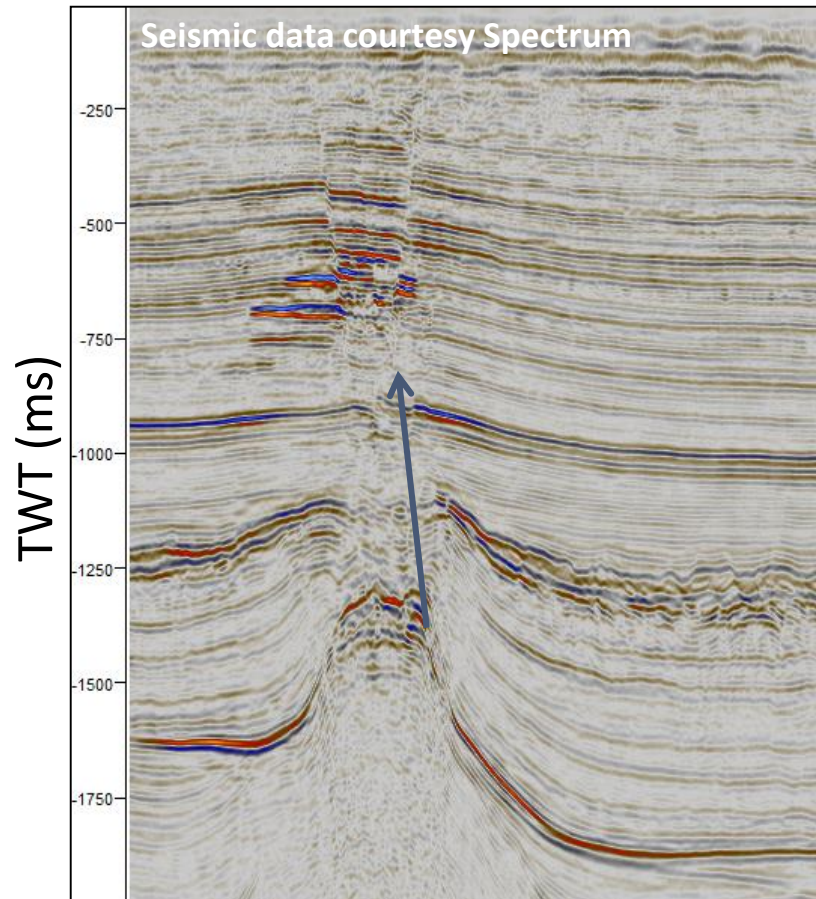
Seismic data courtesy Spectrum



→ Absence attenuation indicates very low saturation

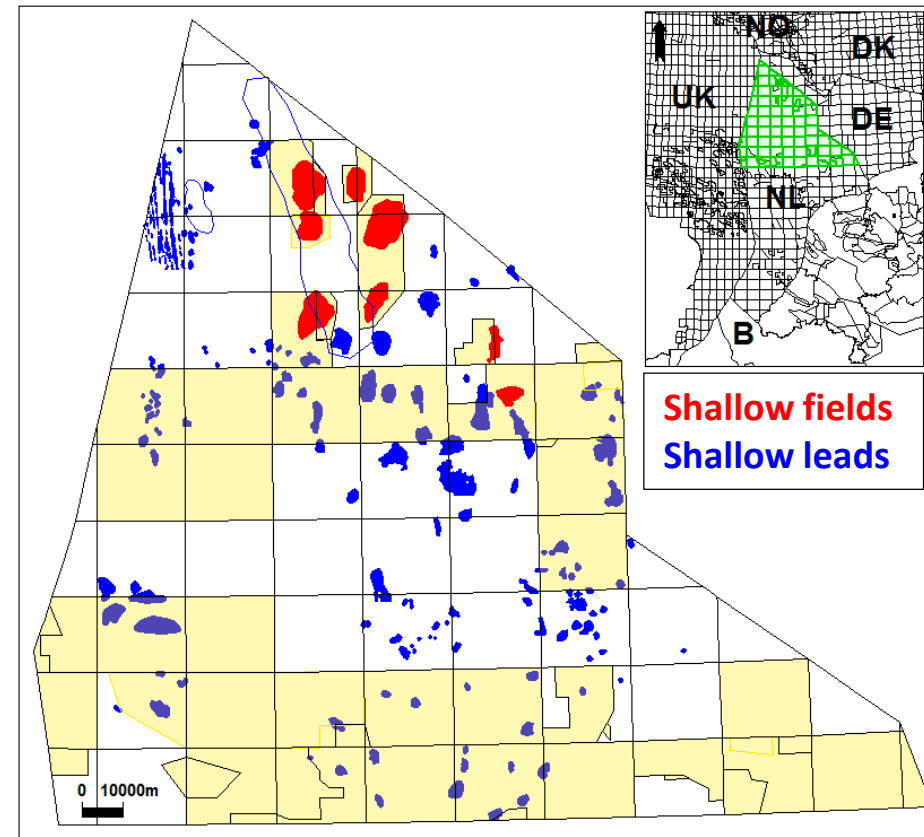


# Seismic Characterisation - *Gas Chimney*



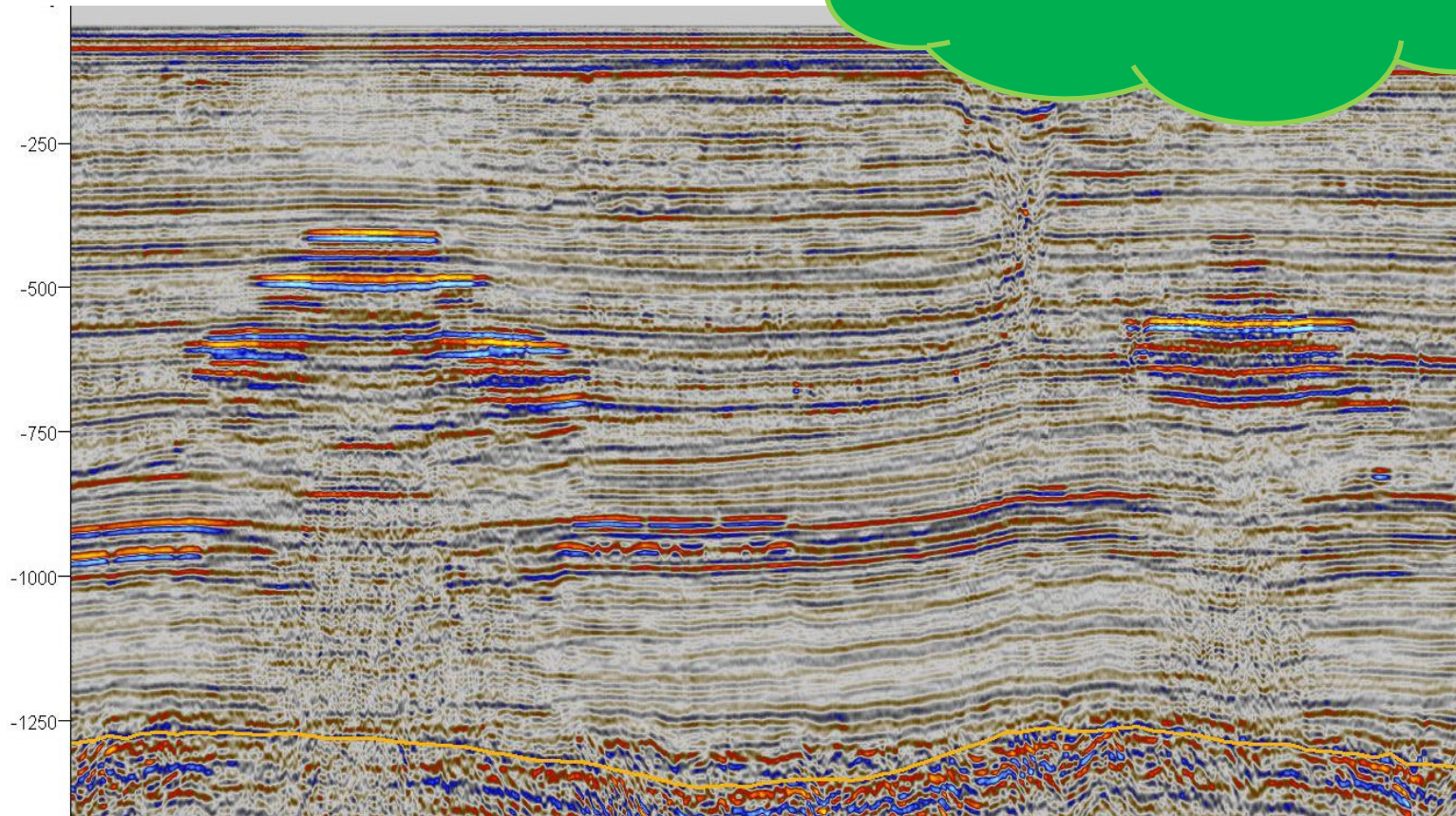
**Gas chimney indicator for gas**

- 8 fields (wells)
- > 150 leads (seismic data)
- Semi-quantitative seismic characterization useful for first order ranking
- AVO analysis ongoing
- Ultimate derisking requires the bit?



→ Find cost efficient solutions

# Opportunities



[www.nlog.nl](http://www.nlog.nl) (public seismic & well data)

- Spectrum, seismic data courtesy
- TNO
- Ikon Science
- Petrogas (E. Campbell, K. Borowski)
- EBN B.V. (B. Scheffers, E. Rosendaal)

Questions to [mijke.boogaard-van-den@ebn.nl](mailto:mijke.boogaard-van-den@ebn.nl)