North Sea Transition Authority

# Advancing our understanding of the Southern North Sea (SNS) Bunter

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Seismic 2023 conference

# Changing SNS landscape

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## NSTA responsibility?

Manage Hydrocarbon & Carbon Storage (CS) licences

## Why refresh SNS?

Carbon Storage, Exploration, Appraisal, Production and Co-Location

## SNS reservoirs?

Focus on Bunter Sandstone Fm (Triassic)
Mostly water wet
Relatively under-appraised

## Vast Subsurface Database, Patchy Knowledge

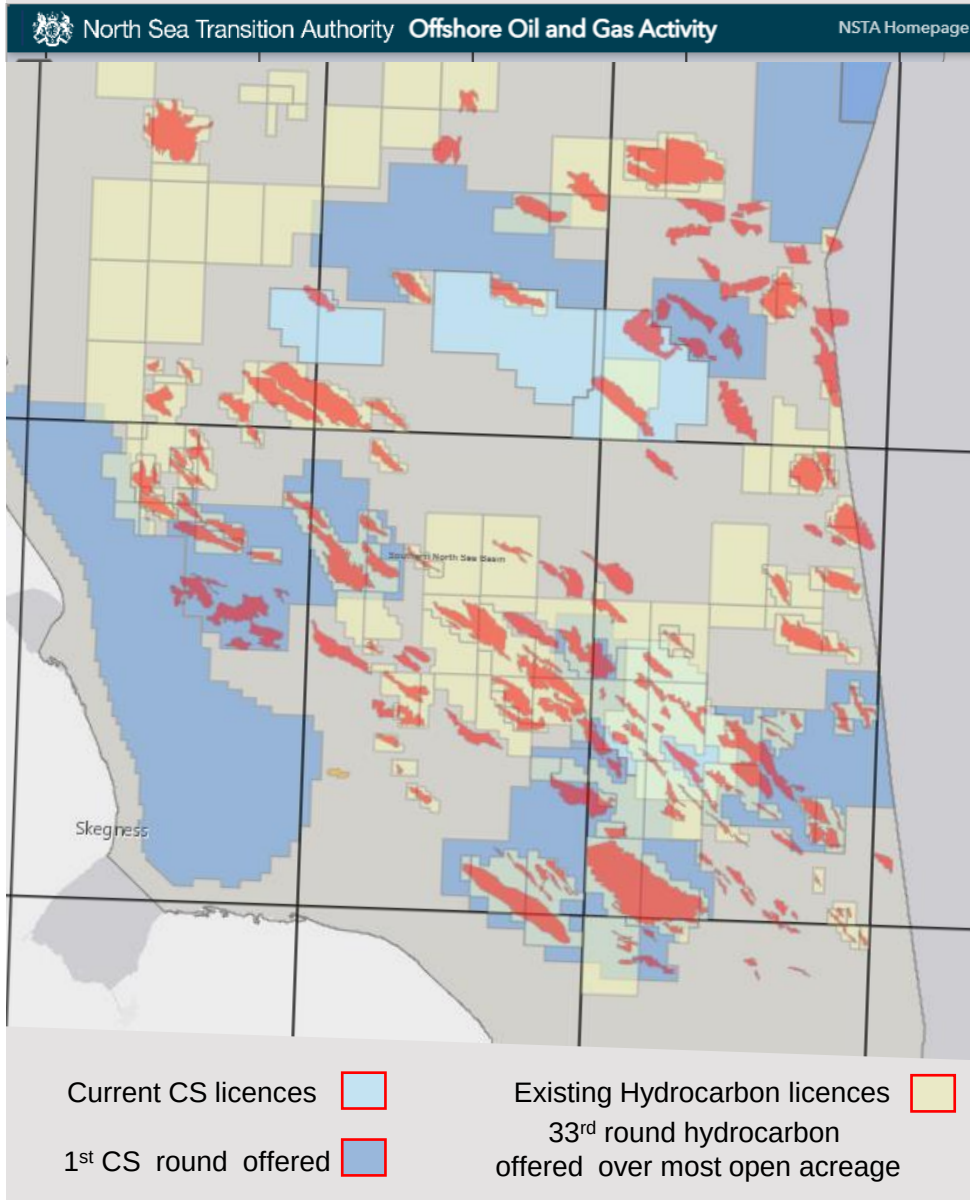
## What can we do?

Consolidate regional understanding

Spot the gaps

Influence work programmes

### NSTA Activity web map



# Extensive Wells Database

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## Extensive, freely downloadable offshore database

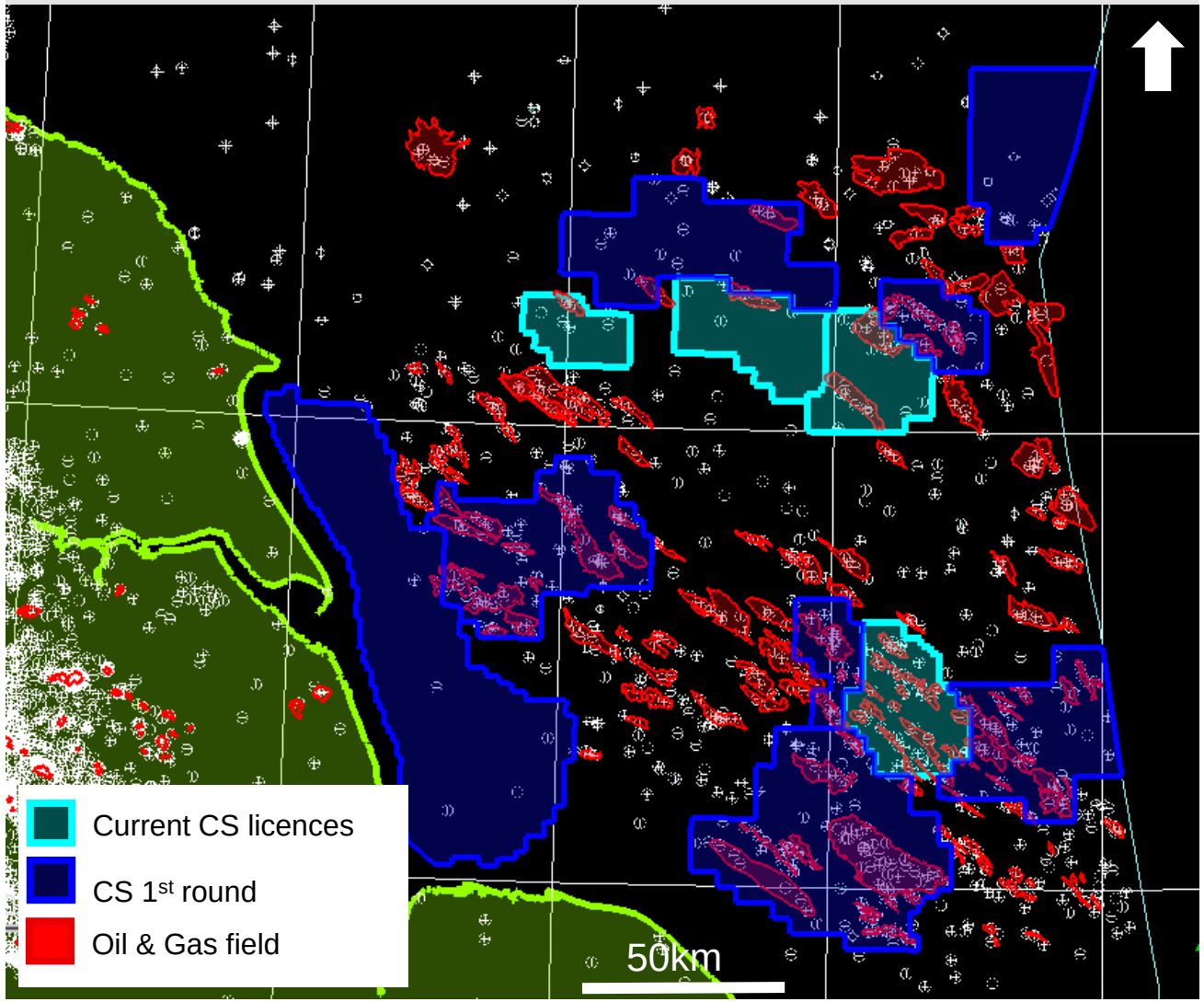
UK National Data Repository

## Accessible Onshore wells

UK Onshore Geophysical Library

British Geological Survey

**Well Distribution map**



# SNS Core

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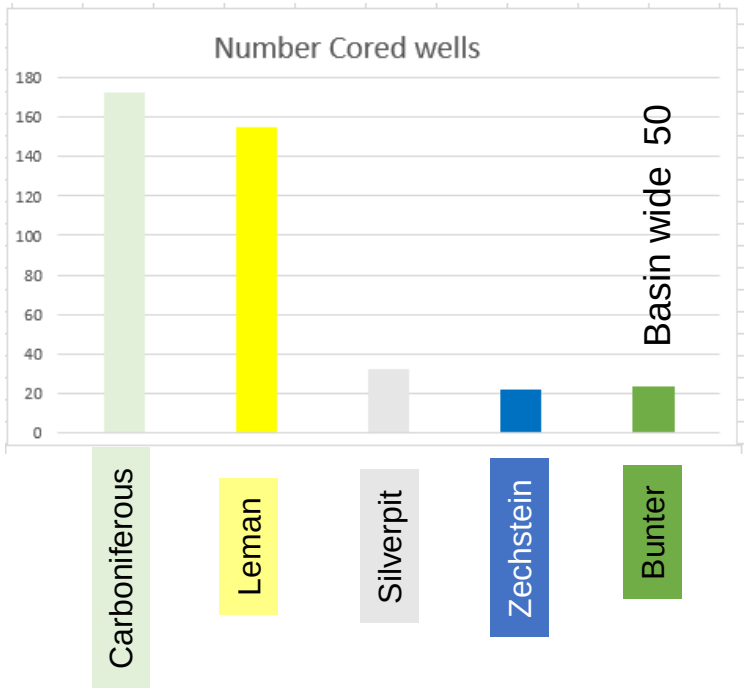


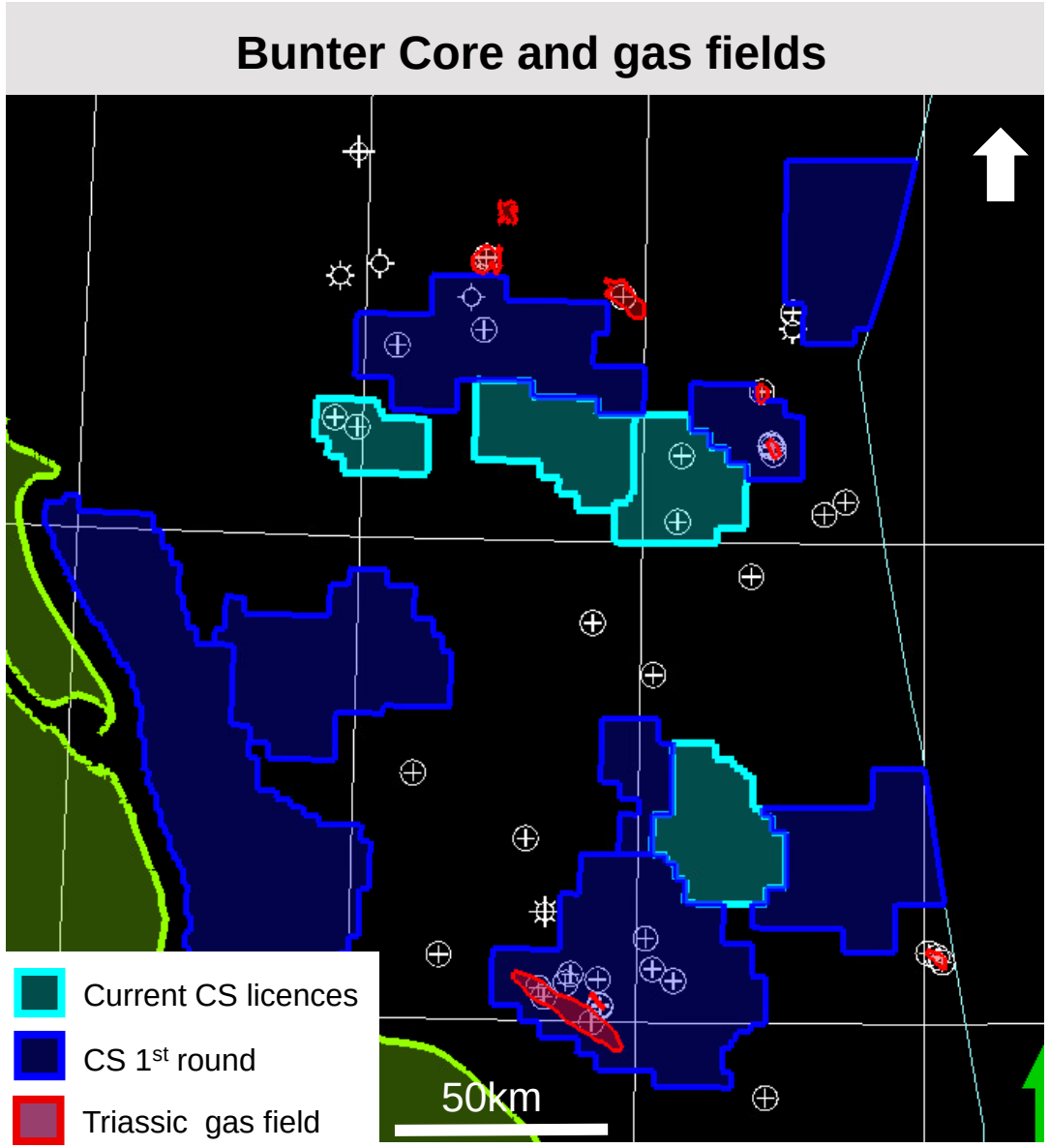


**Leman & Carboniferous well understood**

**Regionally under appraised Bunter**

- **Gas fields on basin margins**
- **Very Low number of Cores**
  - **Almost none near & on shore**
  - **~ 2 in overlying top seal**

# SNS Well tests

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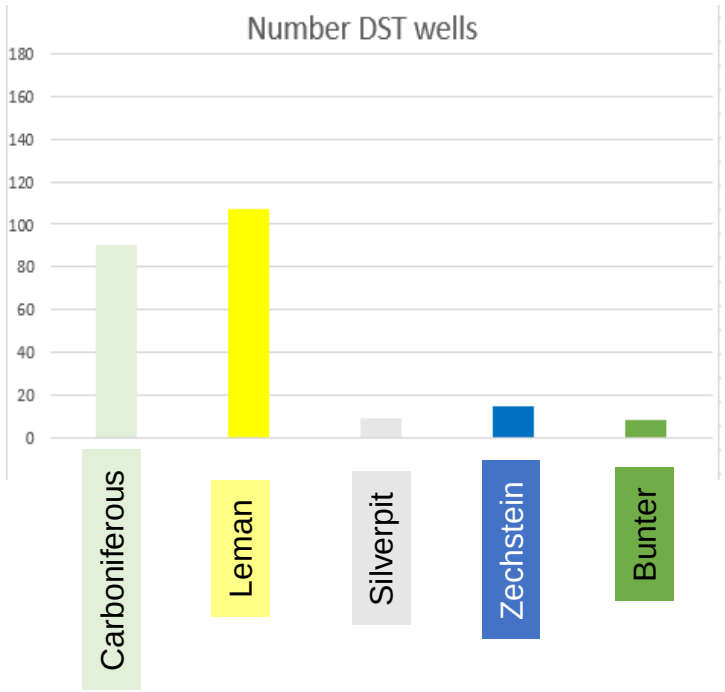
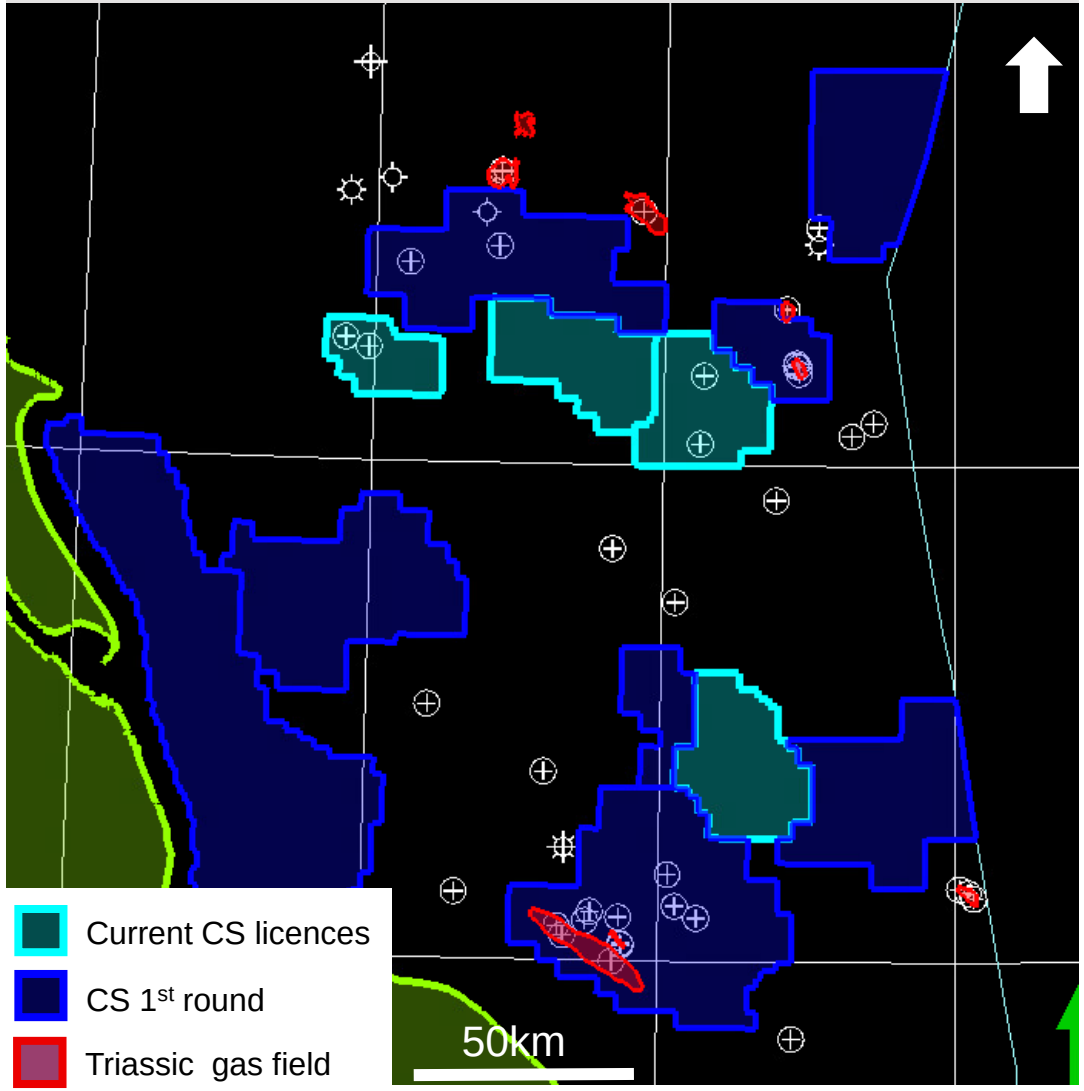



## Bunter Core and gas fields




**Regionally under appraised Bunter**

- **Sparse Density Neutron logs**
- **Rare pressure and fluid samples**
- **Almost no well tests**

# Seismic Database

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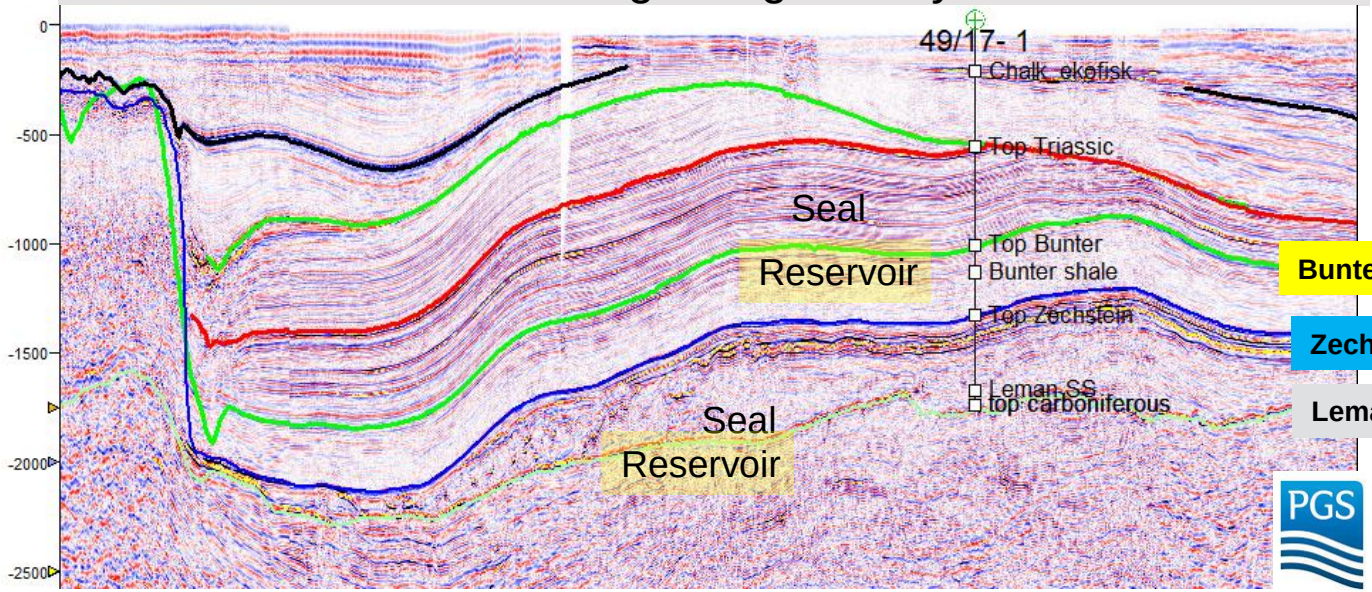
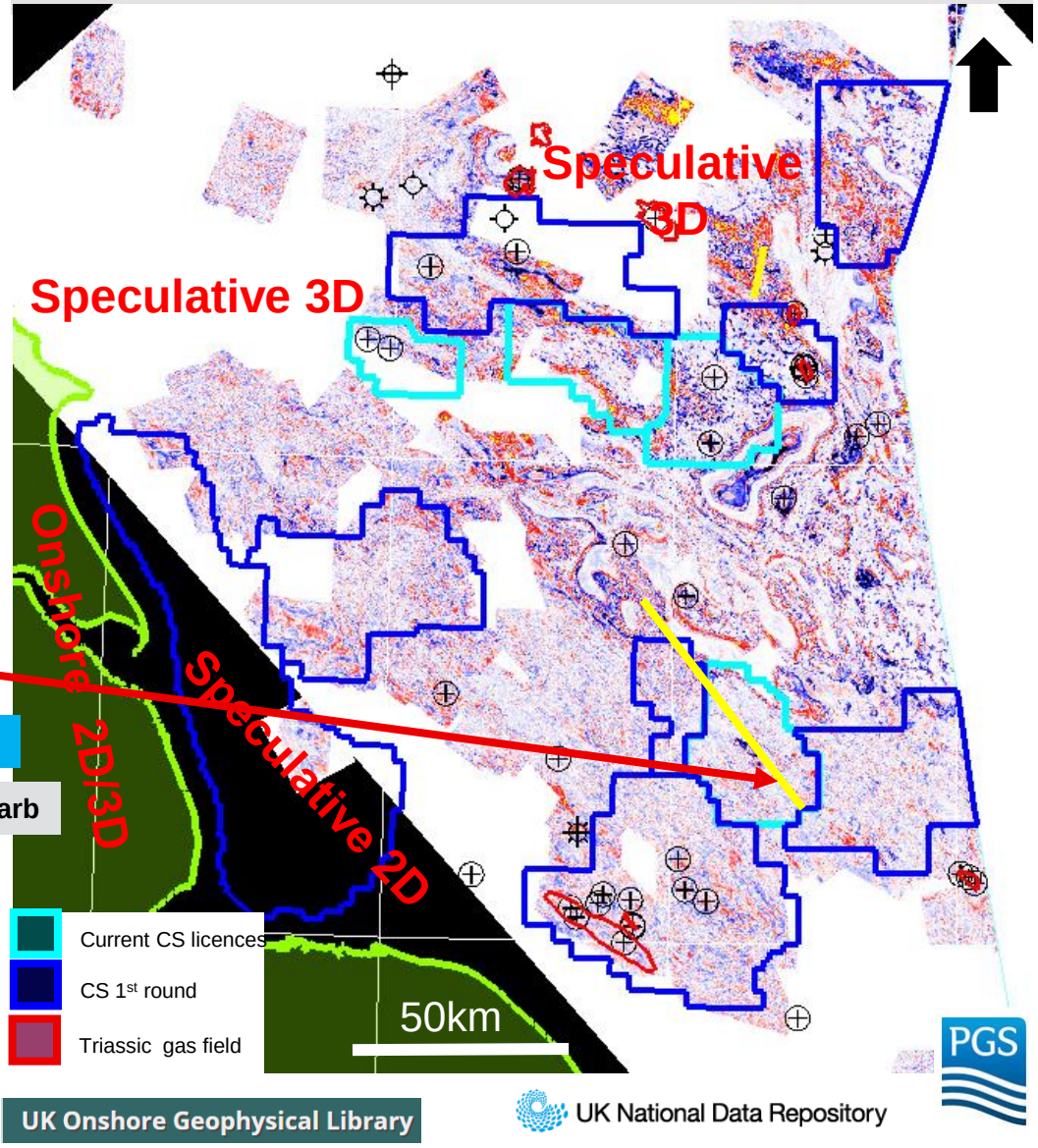
## Complete offshore 3D. 2D nearshore / onshore

- **Extensive freely downloadable offshore 2D & 3D**
- **Speculative 2D & 3D seismic vendors**
- **Onshore 2D & limited 3D**

Inline through Megasurvey




Released 3D time slice




UK Onshore Geophysical Library

UK National Data Repository

# Extensive Detailed mapping

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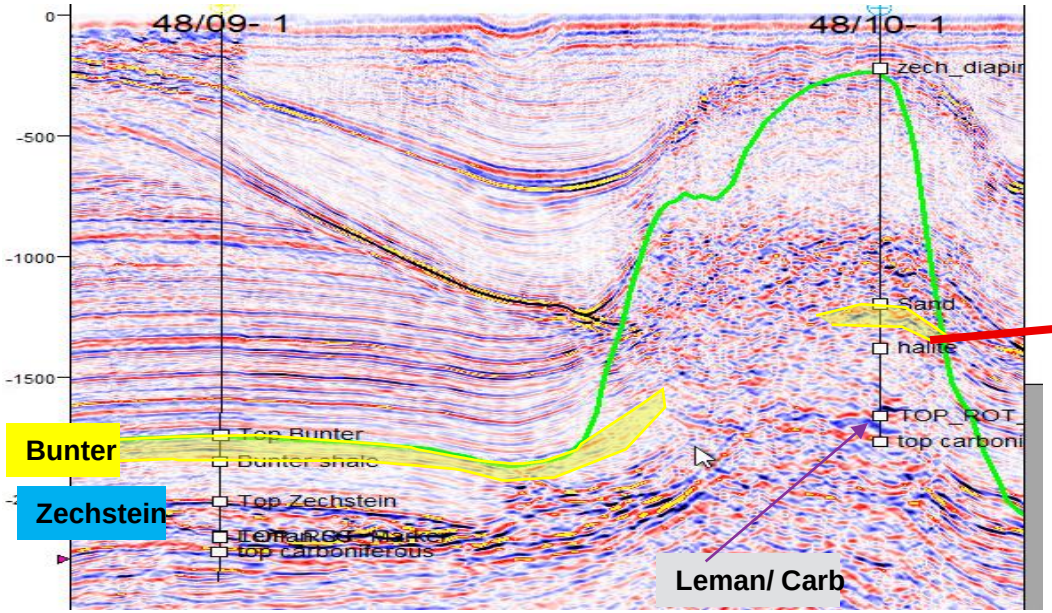
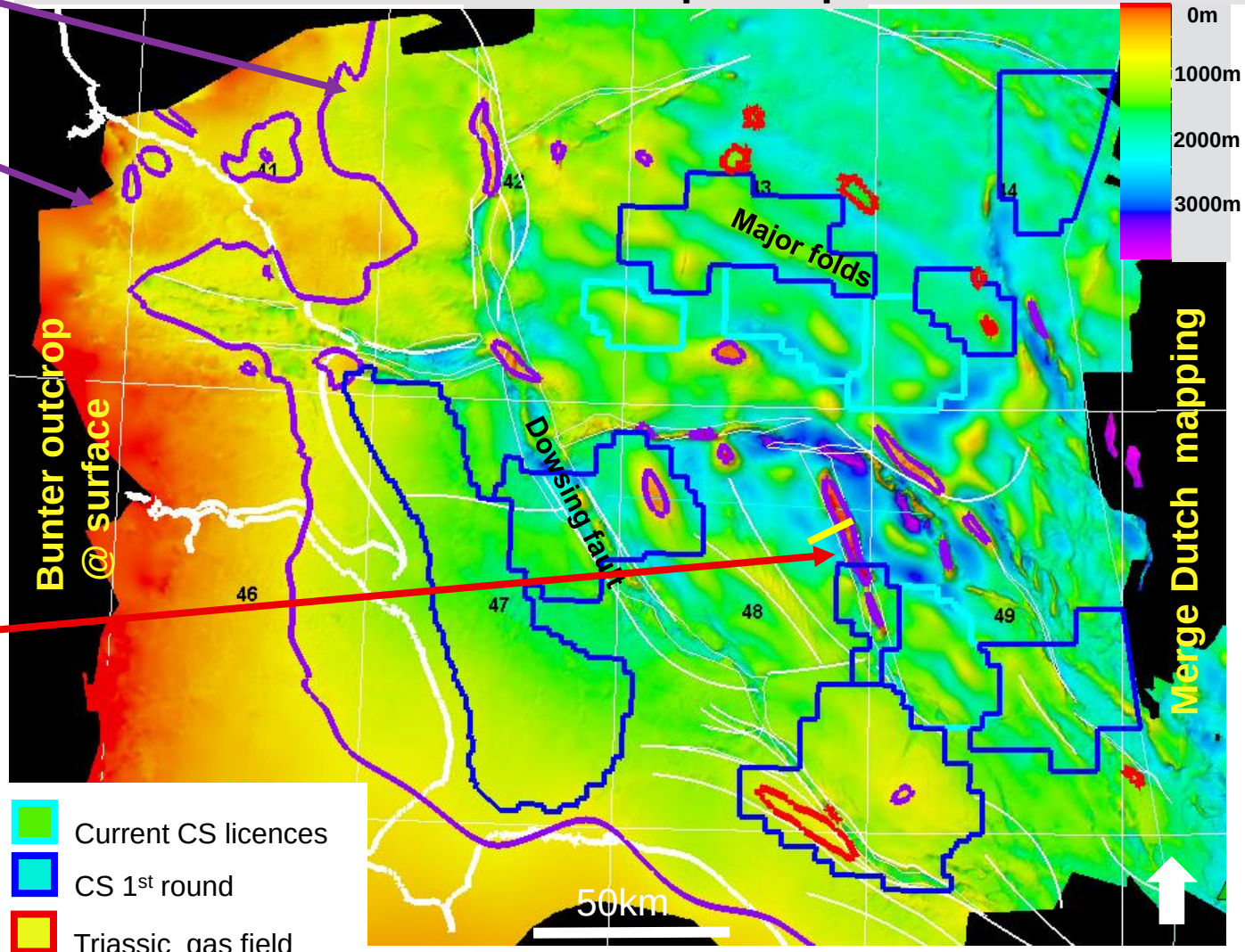
- 800m depth $CO_2$ supercritical phase
- Bunter outcrops in west
- Numerous structural closures
  - Zechstein salt controlled
  - Some complex overhangs
- Variable seismic imaging




Bunter depth map




Current CS licences

CS 1st round

Triassic gas field

UK Onshore Geophysical Library

CGG PGS slb TGS

NLOG Dutch Oil and Gas portal

# Resultant Bunter closures

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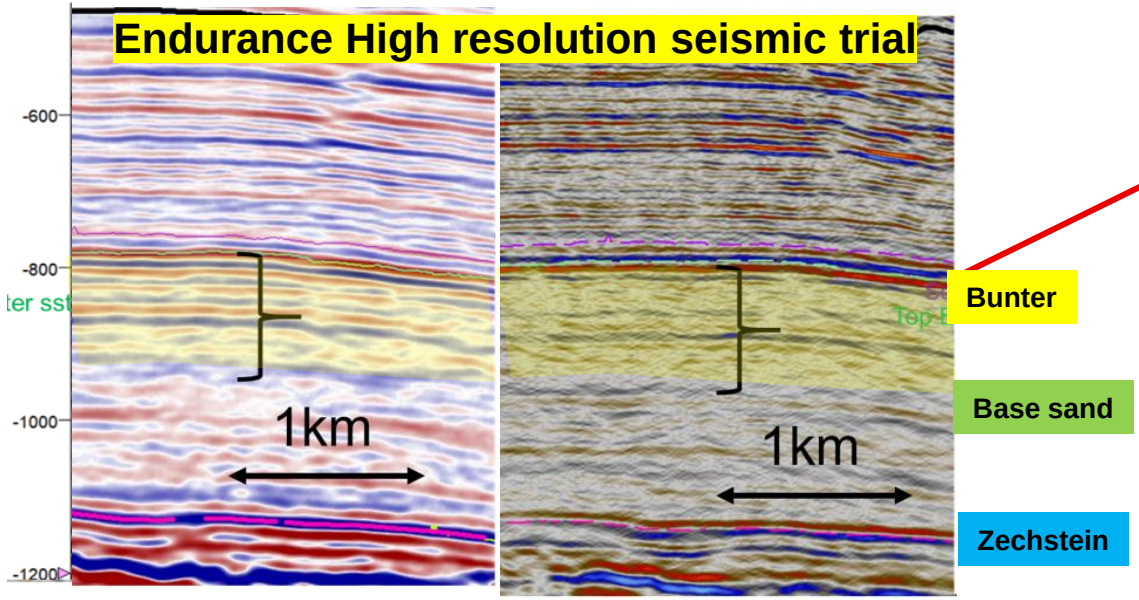
**Many structural culminations**

- **Great interest for carbon storage**
- **Mostly water wet**

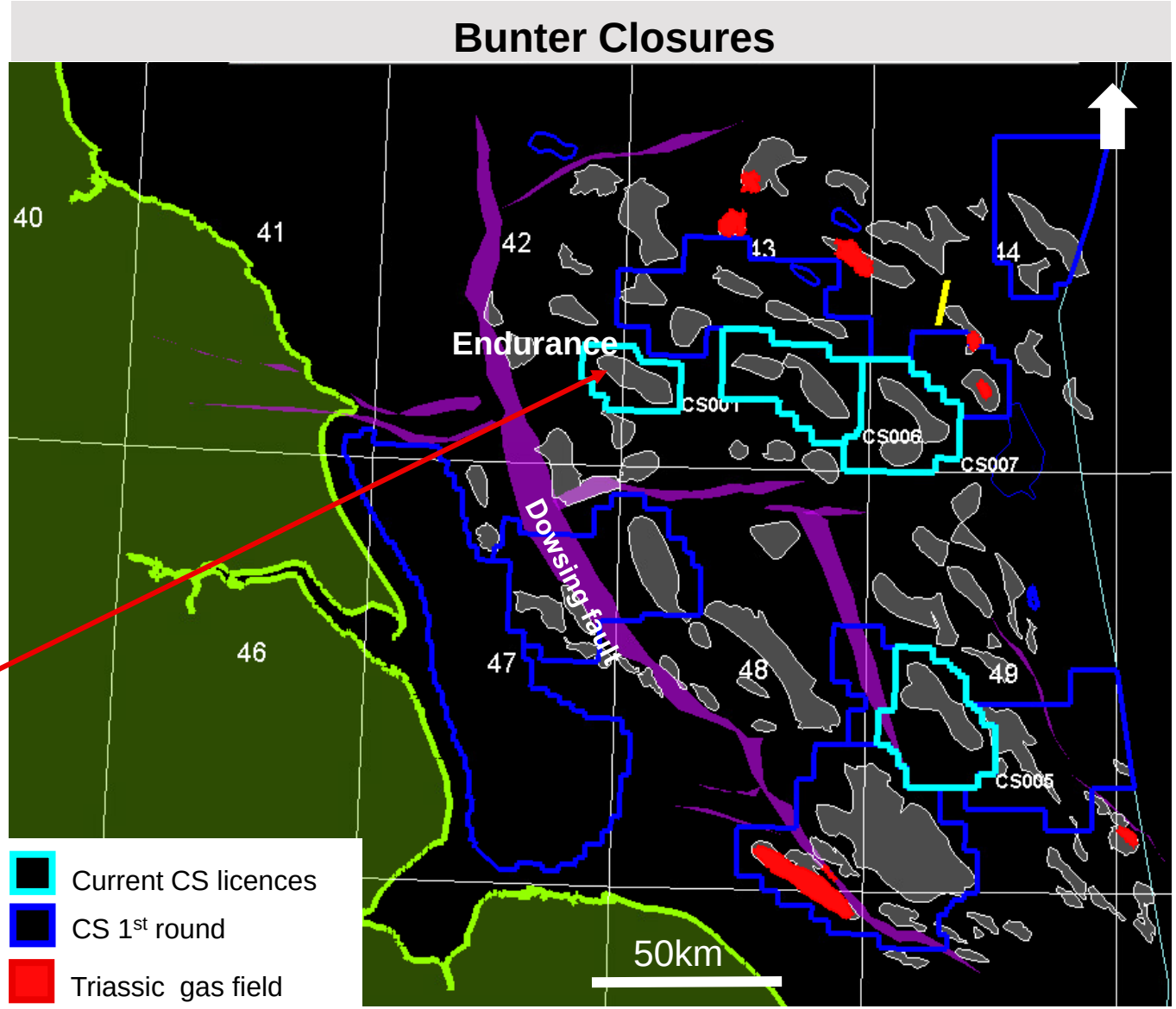
**Gas only at basin margin**

- **Underfilled structures**
- **No solid explanation for gas migration**

**Shallow reservoir amenable to HR 3D**




Courtesy Fiona Sutherland/ NEP, Leading edge Jan 2022



# Bunter Sand thickness

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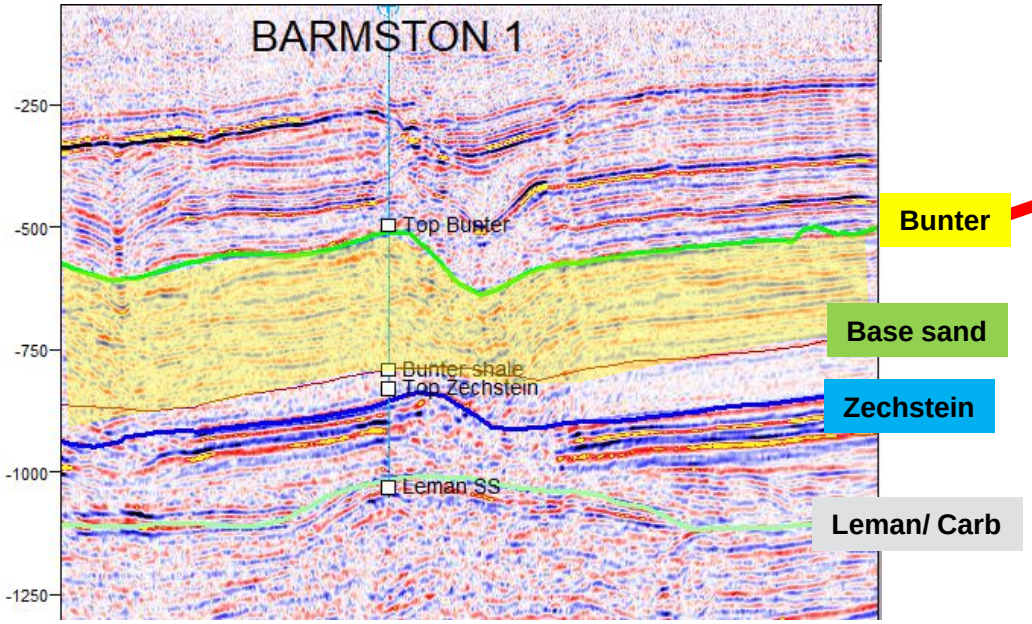
**Typically >200m within CS areas**

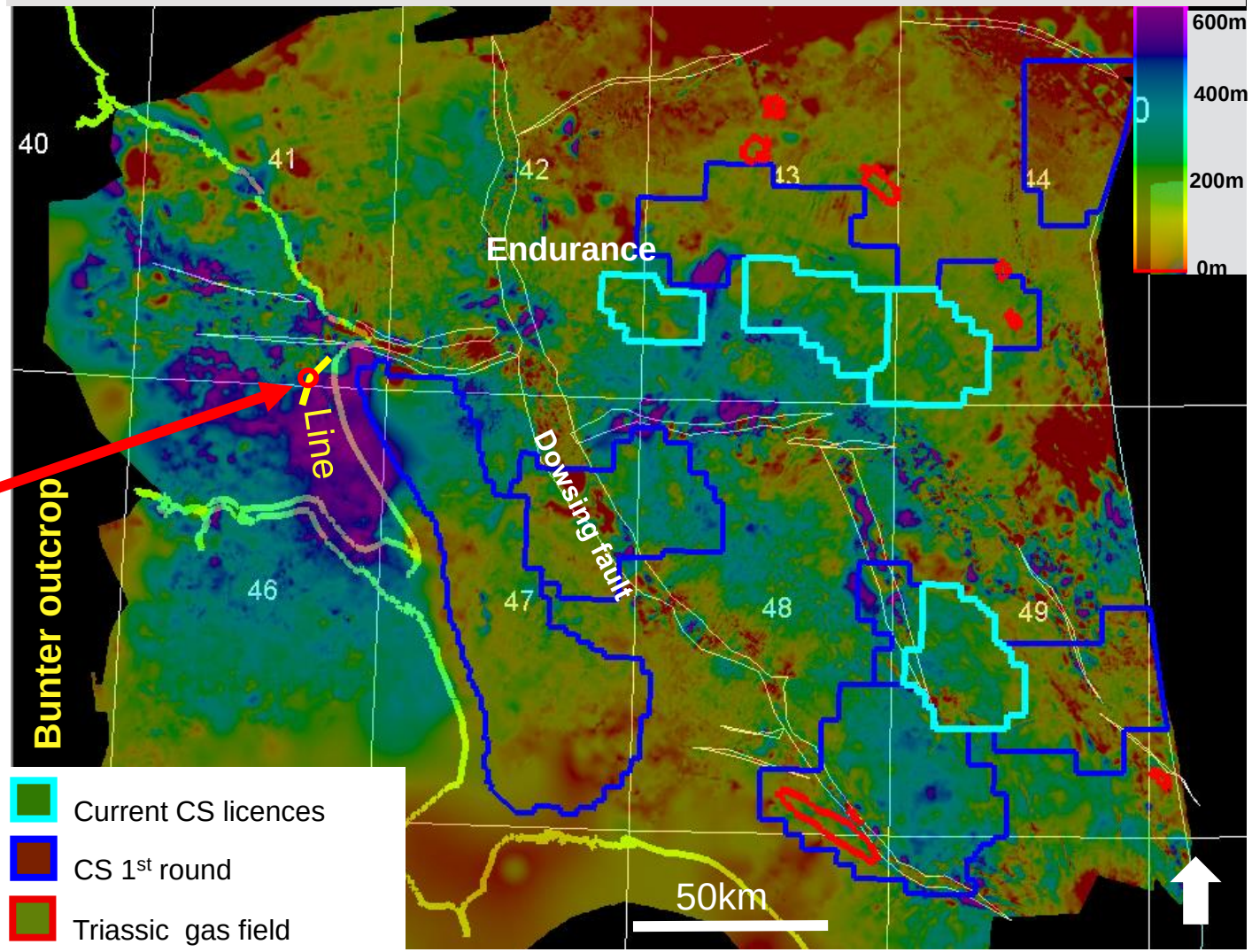
- **Eroded/ non-deposition margins**
- **Thins/ faulted out @ salt ridges**
- **Thickest  in west / onshore**




UK Onshore Geophysical Library

British Geological Survey

**Bunter Sand isopach**




UK Onshore Geophysical Library

CGG PGS slb TGS

# Endurance area porosity

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## Endurance large 4-way closure

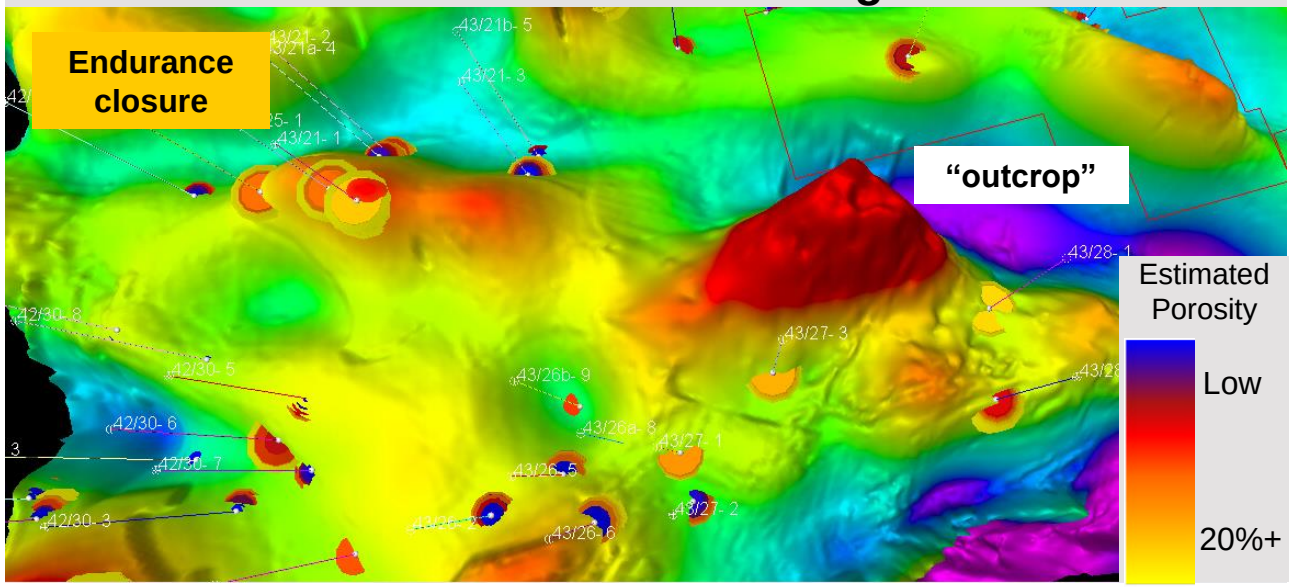
- 3 water wet wells
- Unusually high porosity top

## Widespread cemented & low porosity

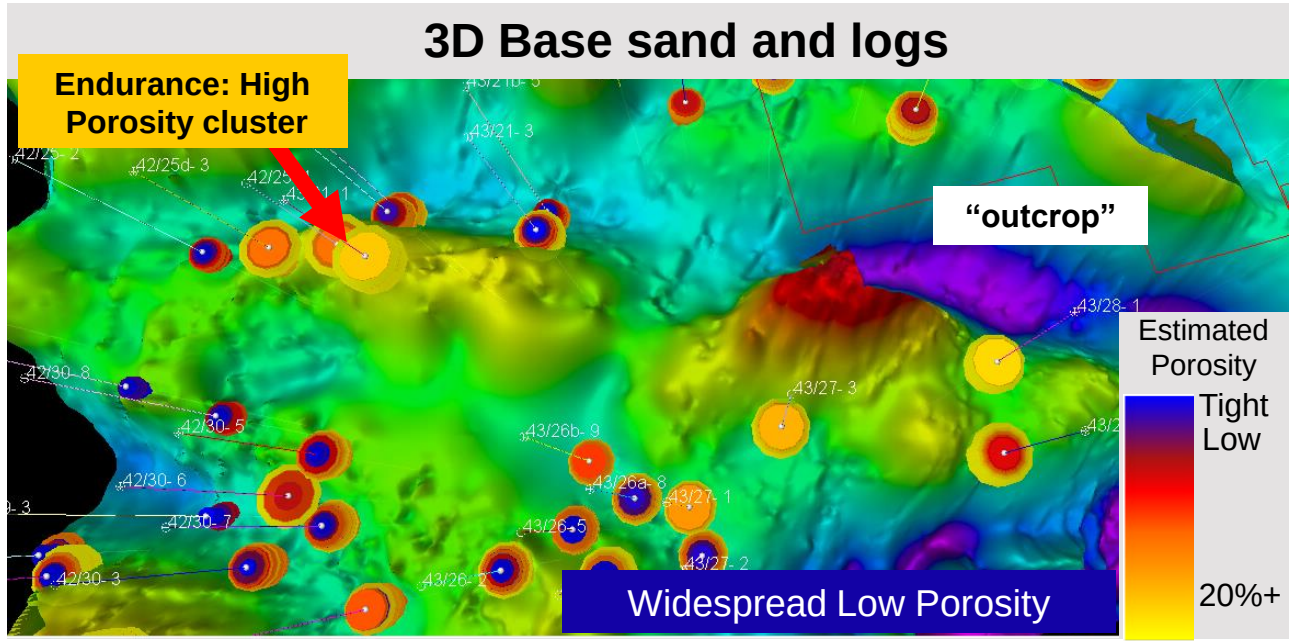
## Impairs:

- Effective net volume
- Injectivity
- $CO_2$ distribution

### 3D Bunter and logs




### 3D Base sand and logs



# Well porosity and seismic polarity

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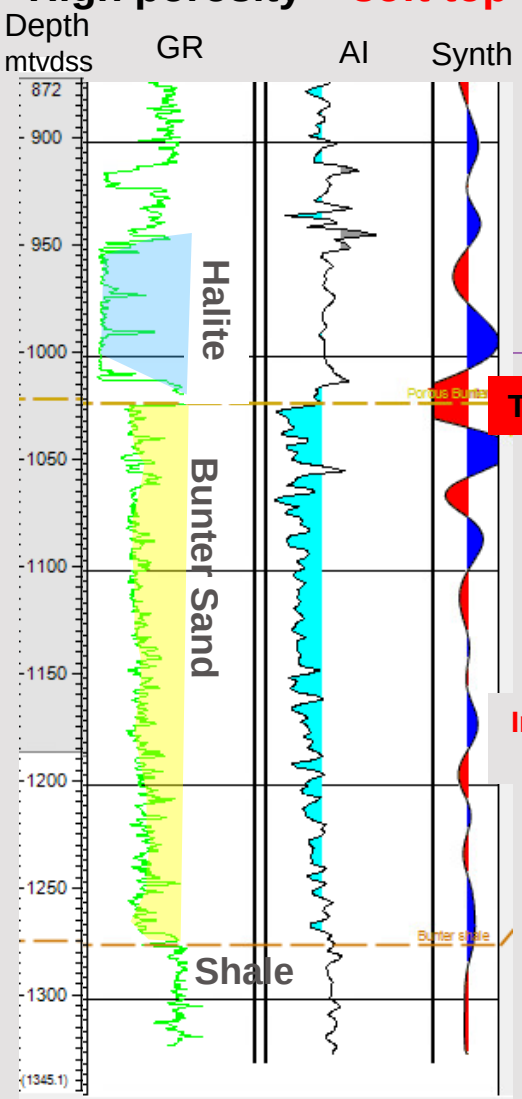
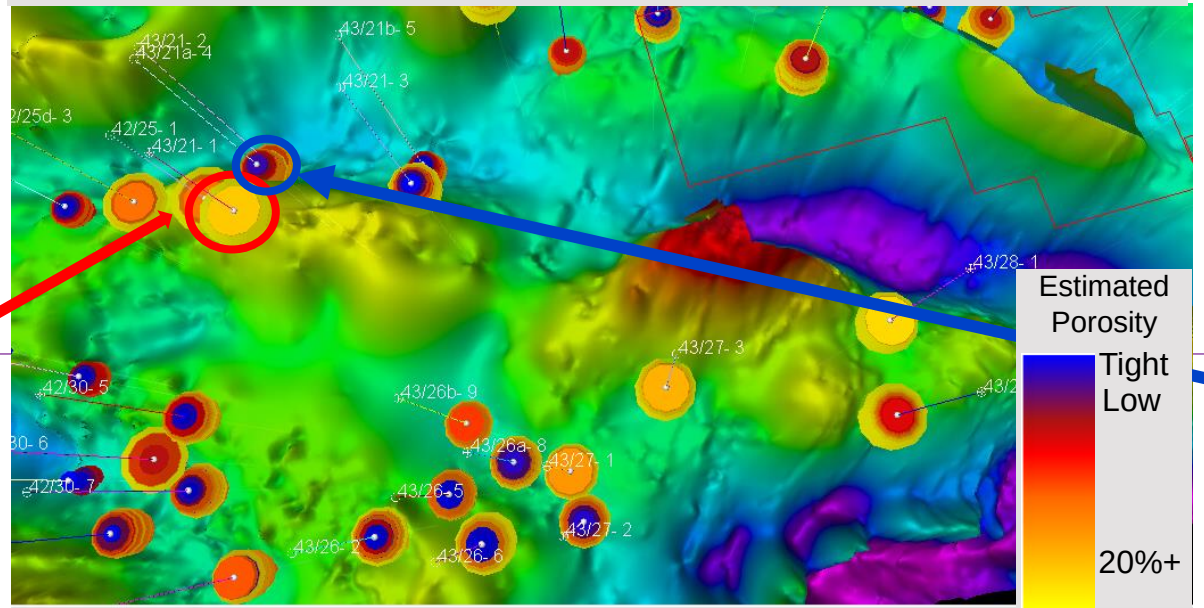
## Endurance
## High porosity = soft top




TROUGH

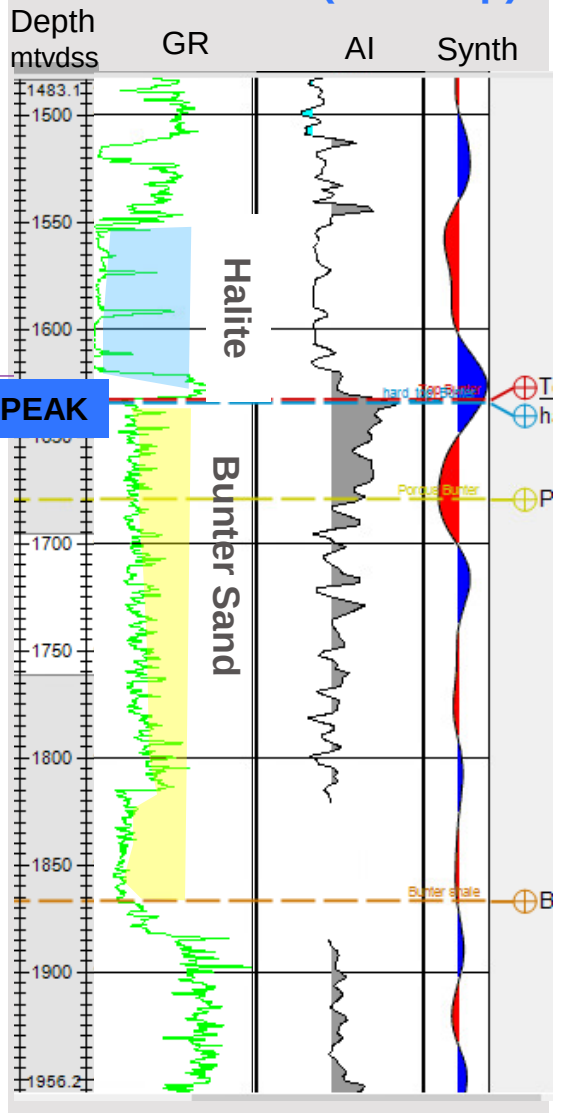
Intra- reservoir reflector

## Contrast 2 neighbouring wells




PEAK

## North of Endurance
## Cemented = (hard top)




**Bunter is not a thick, homogeneous tank of sand!**

- **Large impedance change & seismic polarity flips**
- **Subtle intra-reservoir reflectivity = porosity change?**

# Bunter is not an opaque canvas

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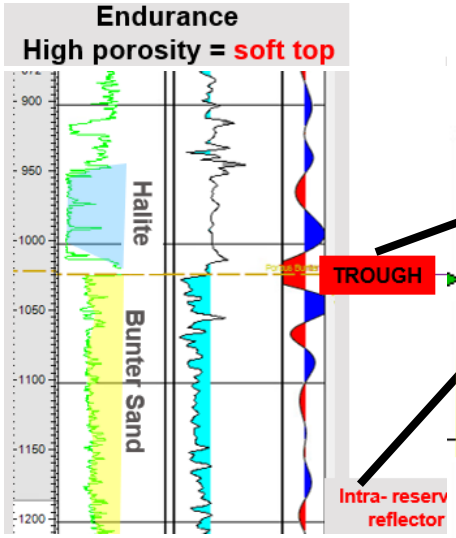


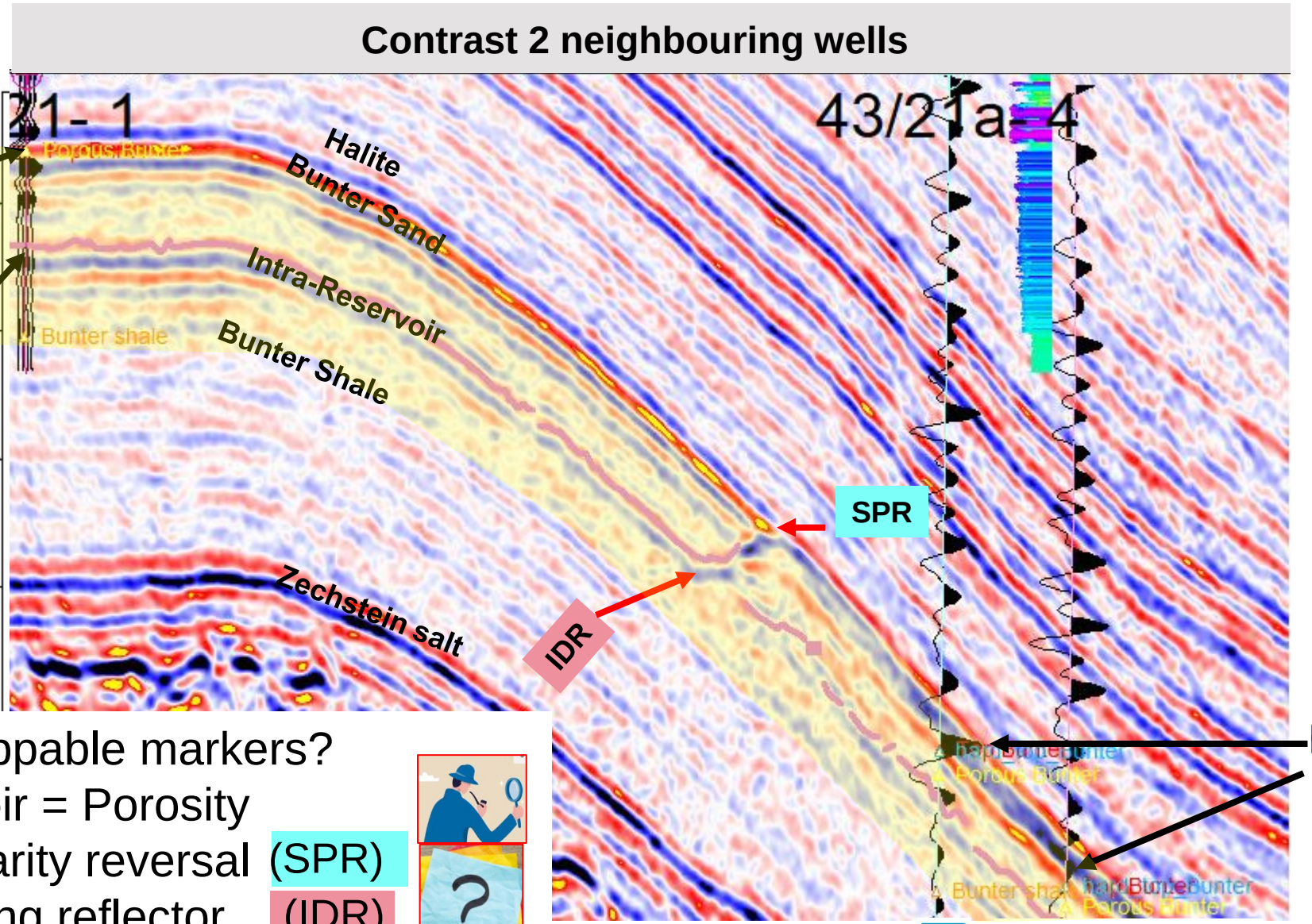


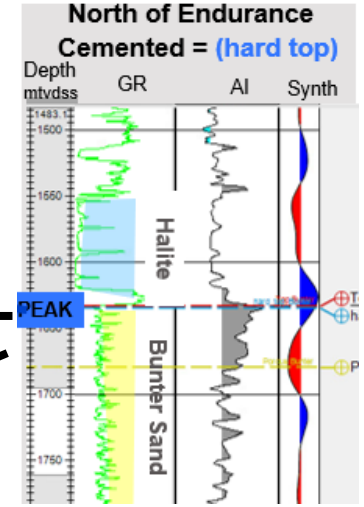


Mysterious mappable markers?

- Intra reservoir = Porosity
- Seismic Polarity reversal (SPR)
- Inward dipping reflector (IDR)



PGS

UK National Data Repository

# Bunter Amplitude & Dipping reflector

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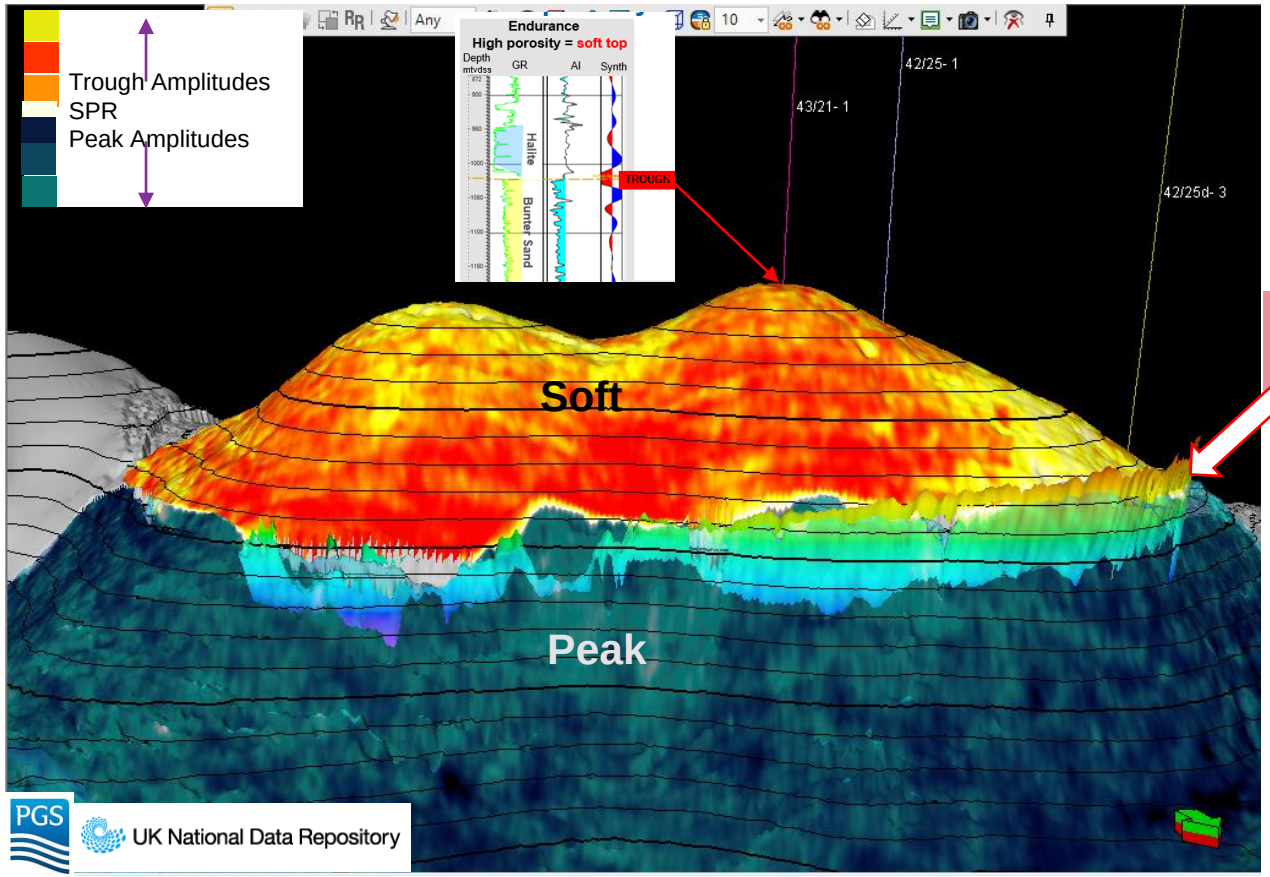
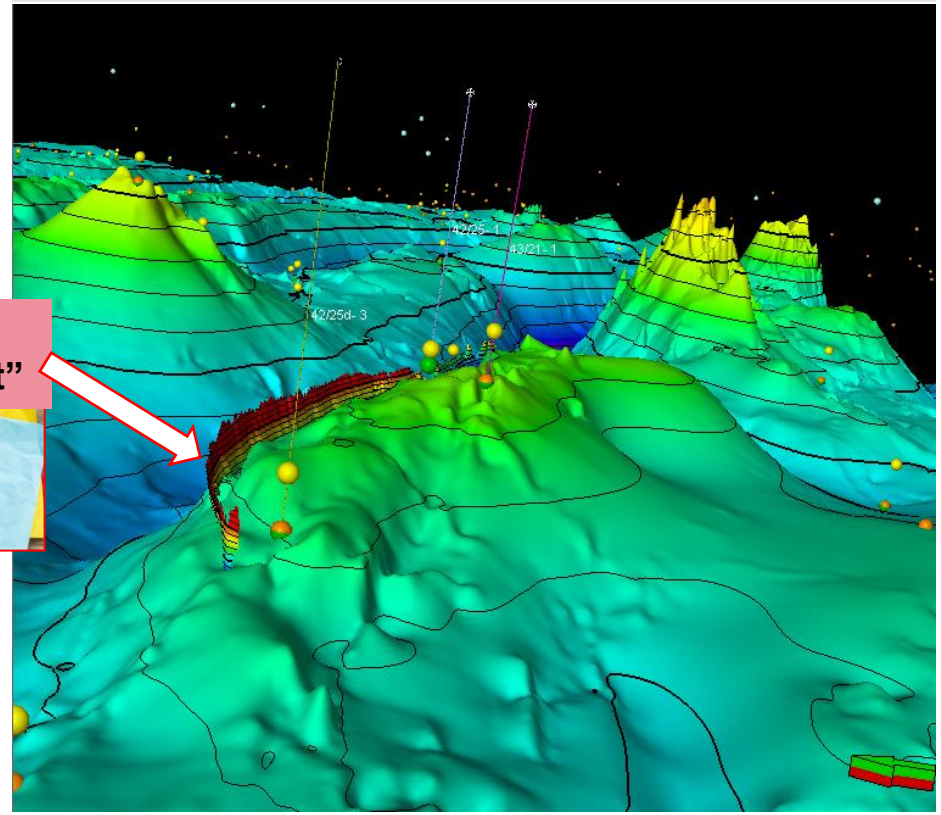
## Polarity & amplitude switching




## Inward Dipping reflector (IDR) & Base Bunter sand




IDR "skirt"

Abrupt amplitude/ polarity change -> porosity decrease?

Structural reconstruction required?

# Chase the detail: Bunter facies attribute?

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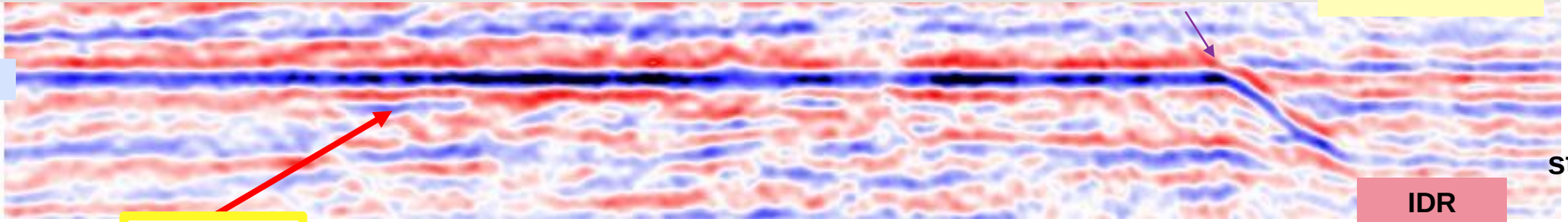
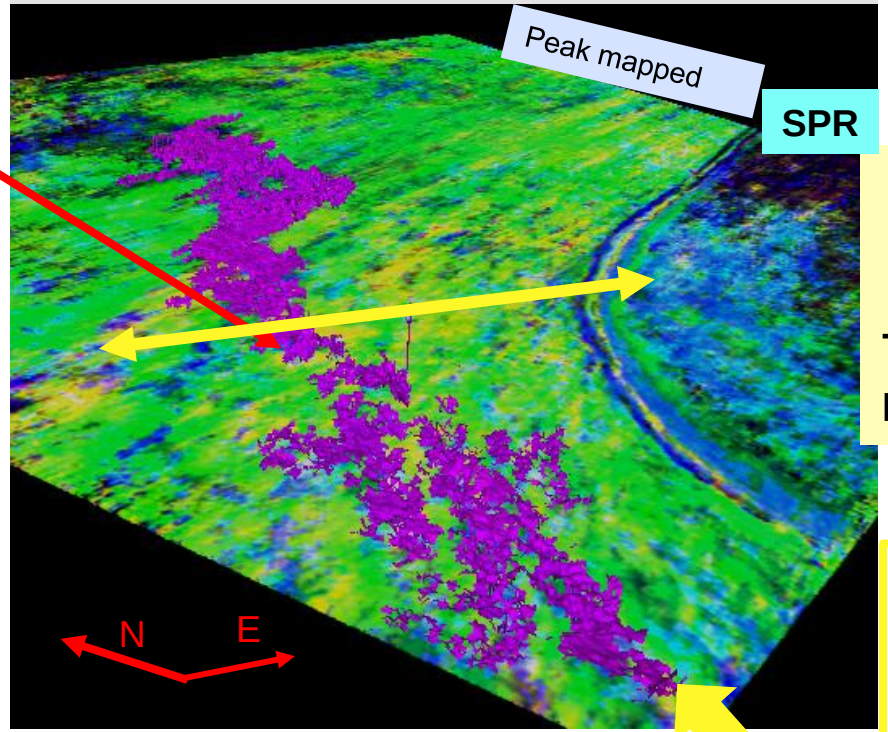
**Flattened Bunter seismic**




Fluvial system?

**Bunter Amplitude & fluvial channel**




Palaeogeography: Predominantly Fluvial "Some contribution from UK in west"

# Regional spectral decomposition

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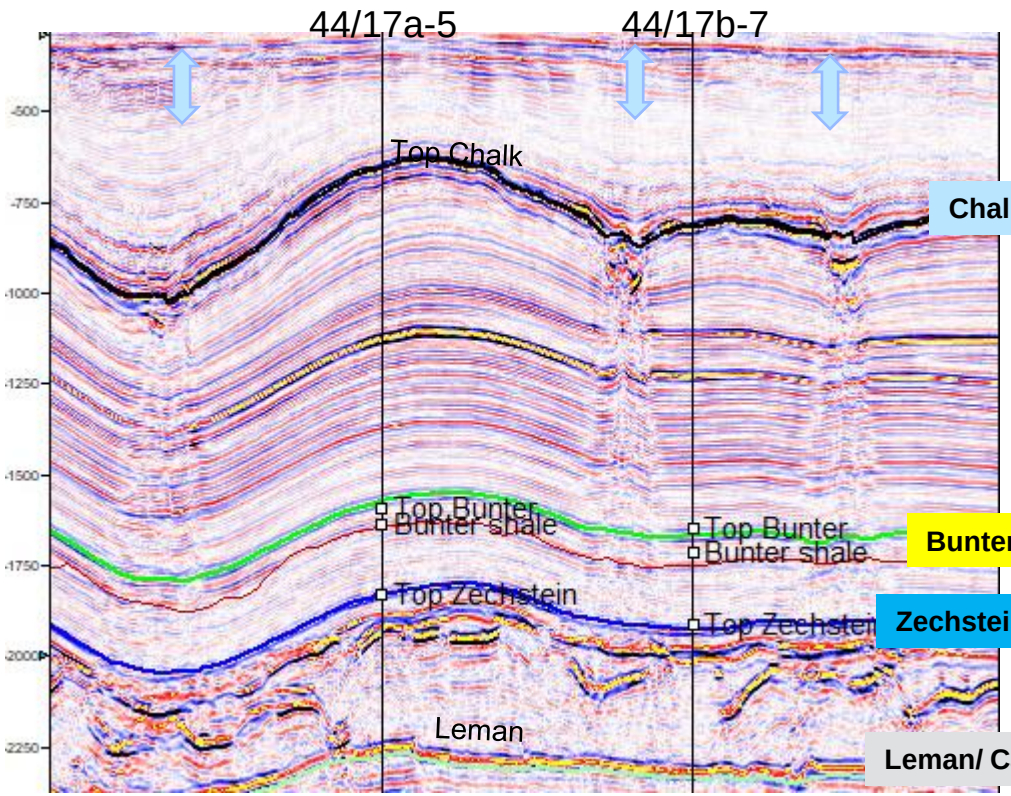
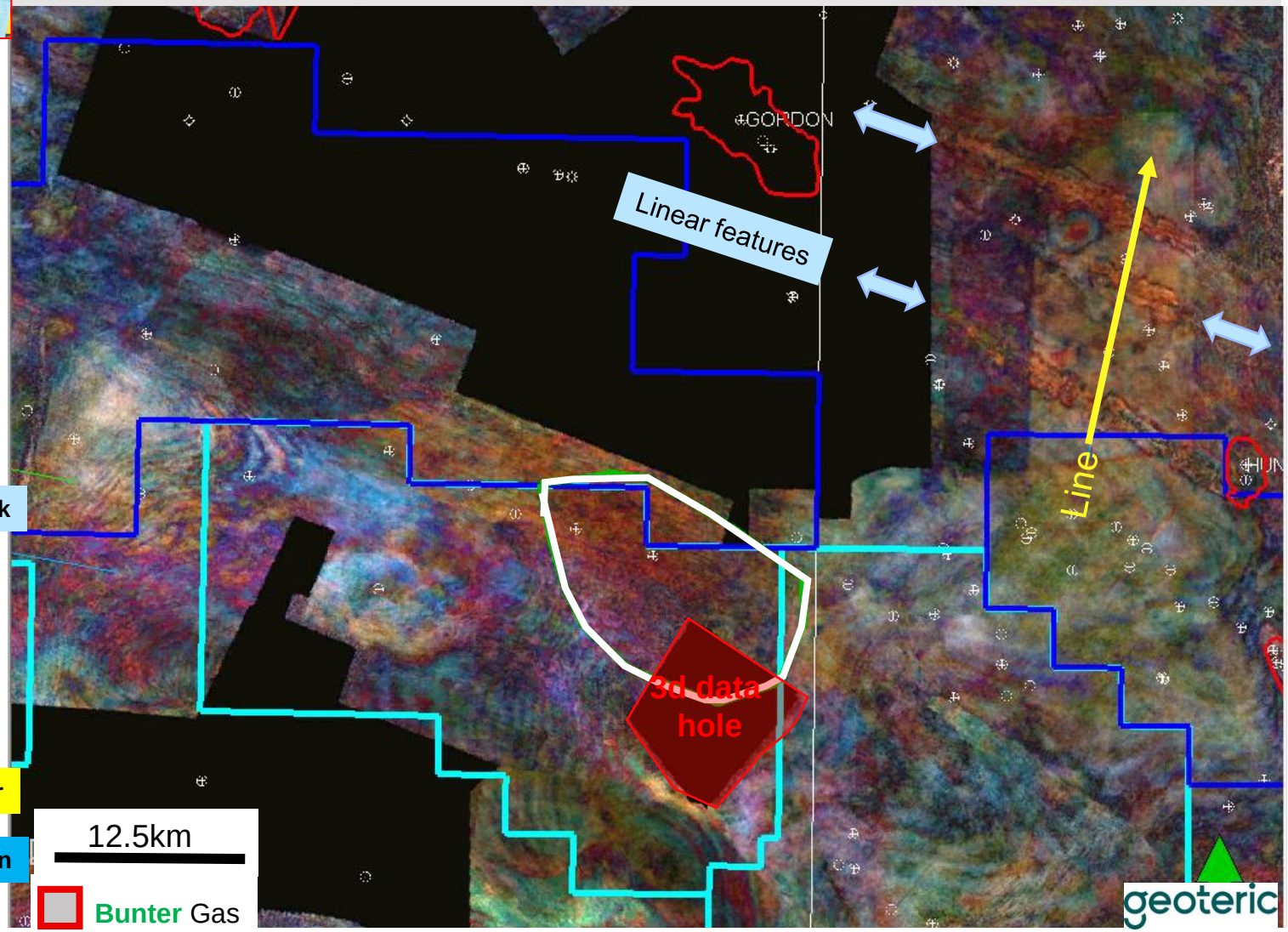
**Linear features in Bunter -> Channels?**
**= Vertical wipe-out -> Survey edges?**




## Bunter regional spectral decomposition



# Igneous dykes?

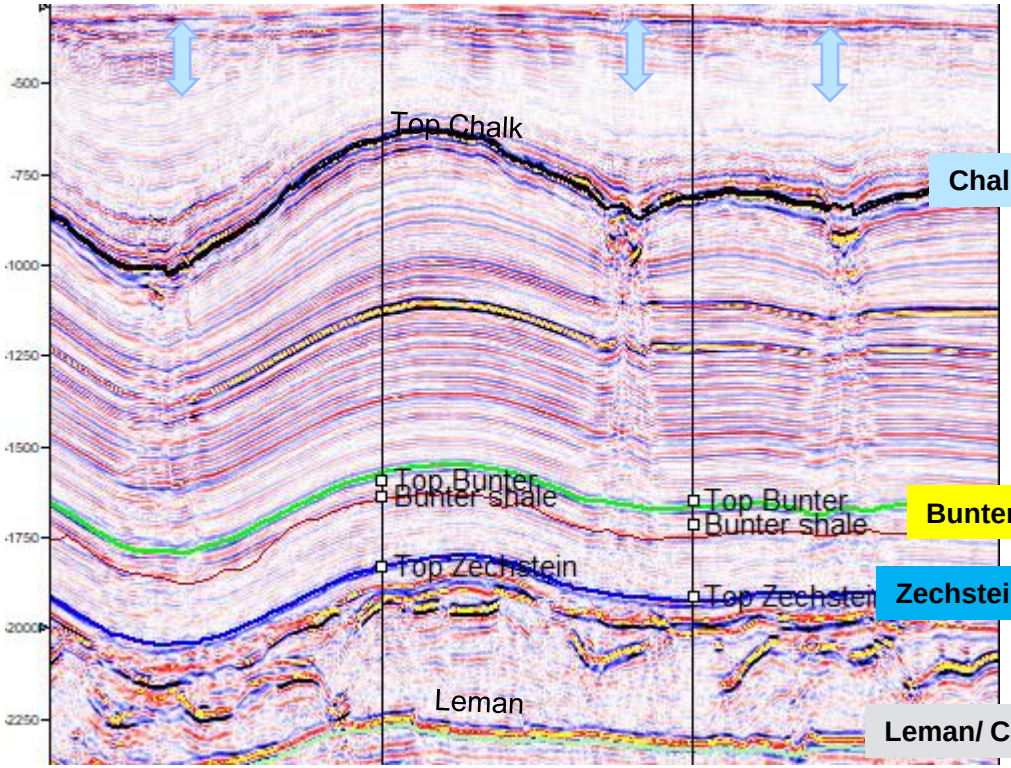
~~Linear features in Bunter -> Channels?~~

~~= Vertical wipe-out -> Survey edges?~~

**Align with magnetic anomalies? Dykes?**

**Small circular feature: DHI?**

**Note Undisrupted Larger Circle**

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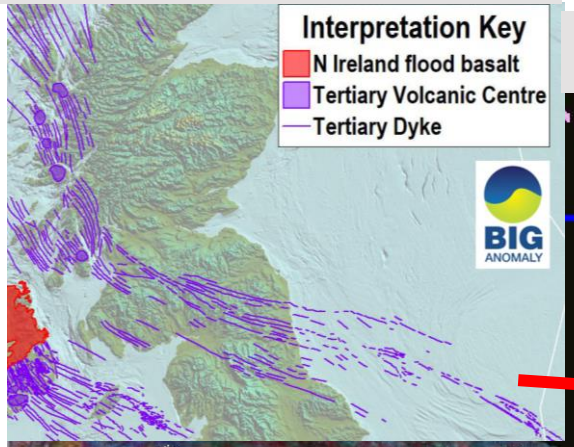
## Integrated magnetics




## Intrusives interpretation

# Dykes within the bigger picture

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~~Linear features in Bunter -> Channels?~~

~~= Vertical wipe-out -> Survey edges?~~

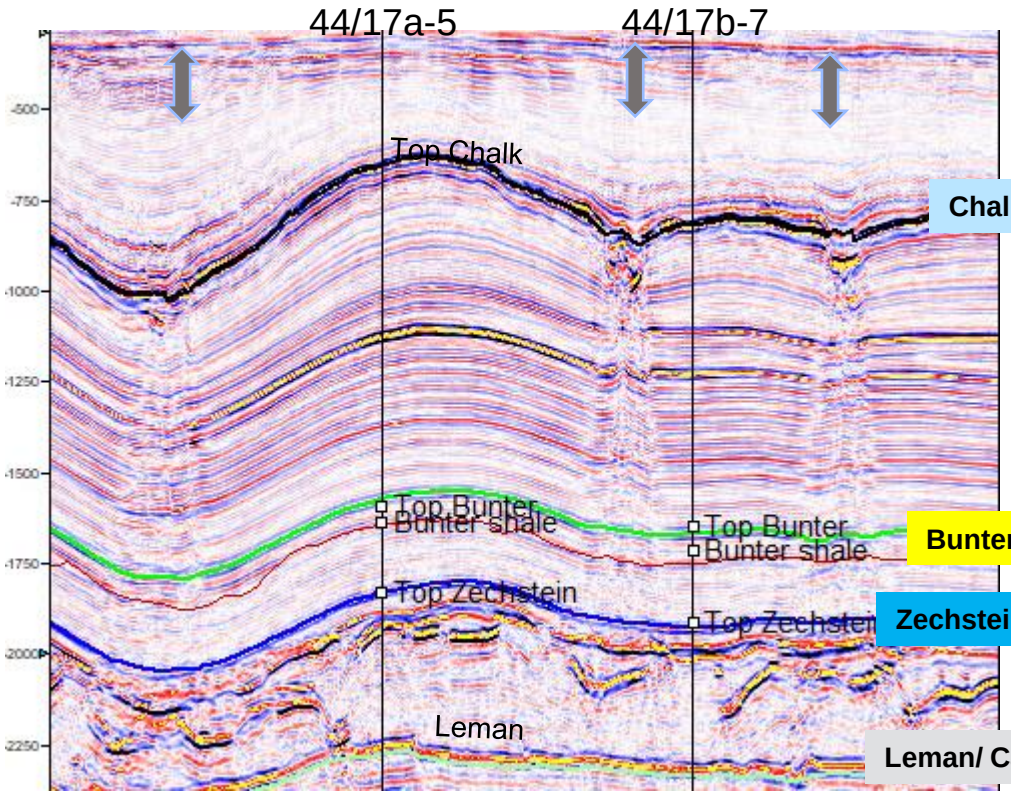
~~Align with magnetic anomalies?~~ **Dykes?**

**Align with structural grain?**

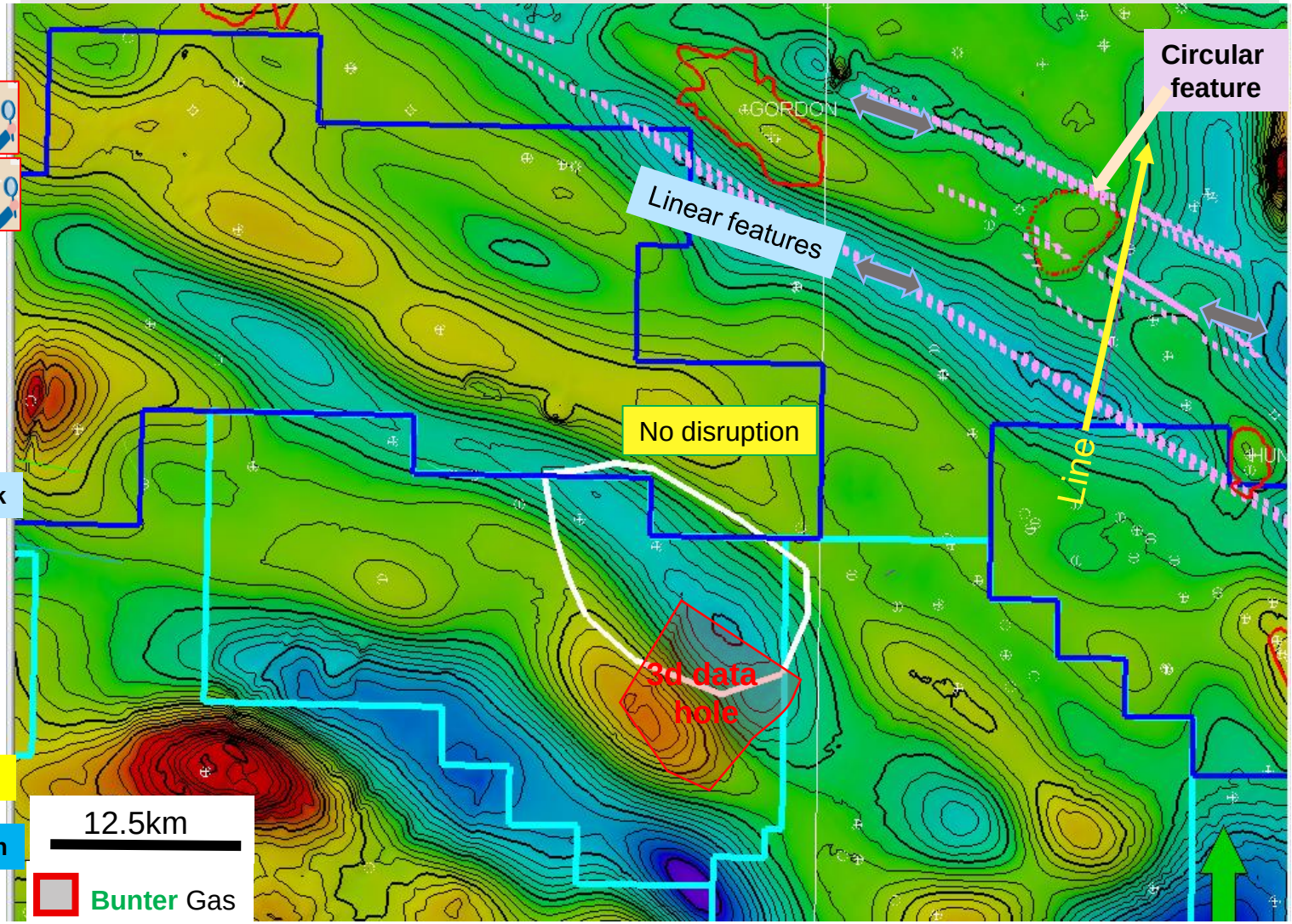
**Influence methane charge & high $CO_2$?**

**Small circular feature: DHI Conformance**

**Undisrupted Larger Circle in syncline**




## Intrusives and Bunter depth structure



# Sole Pit “Meteorite Crater?”

## Pros & Cons

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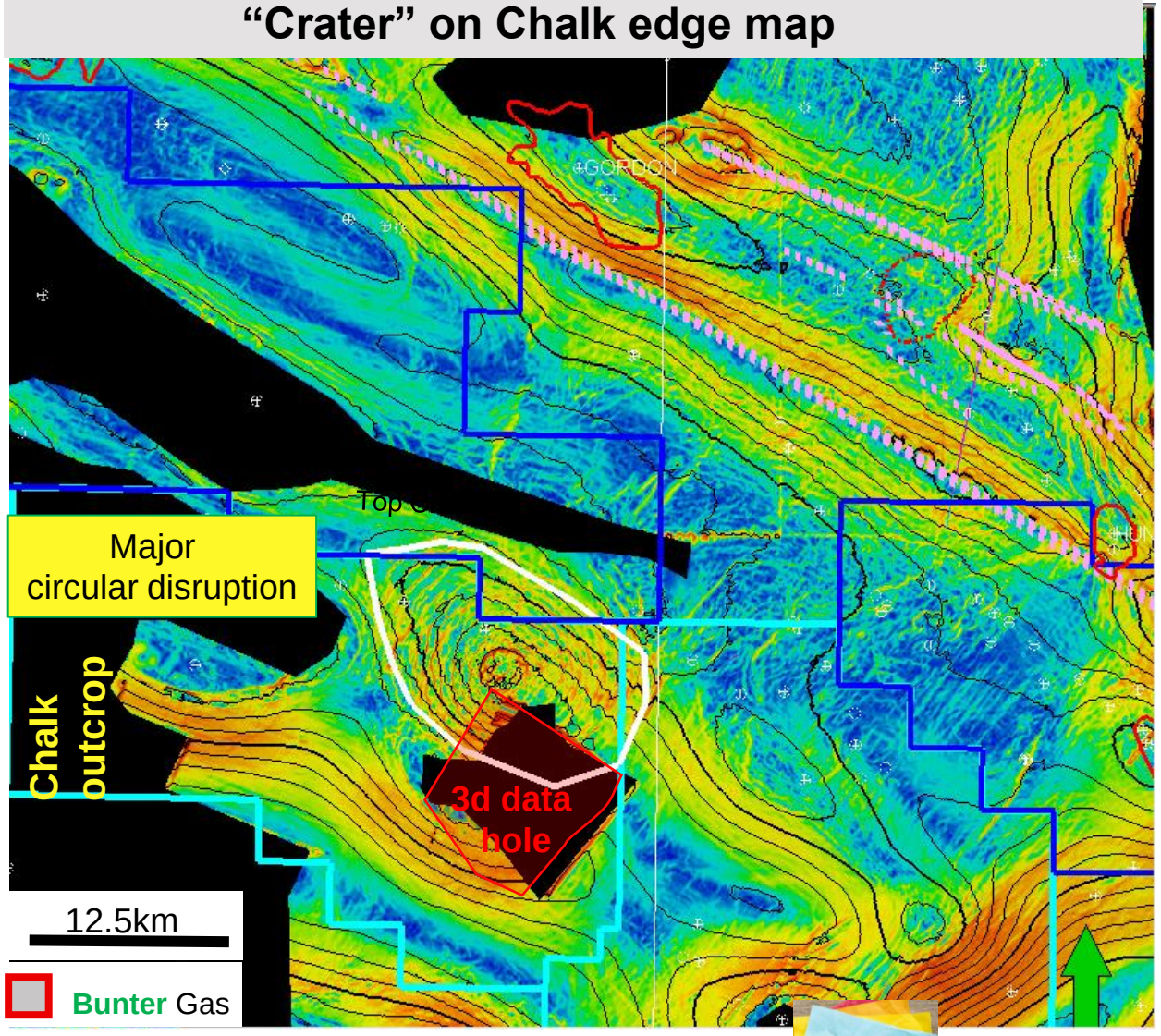
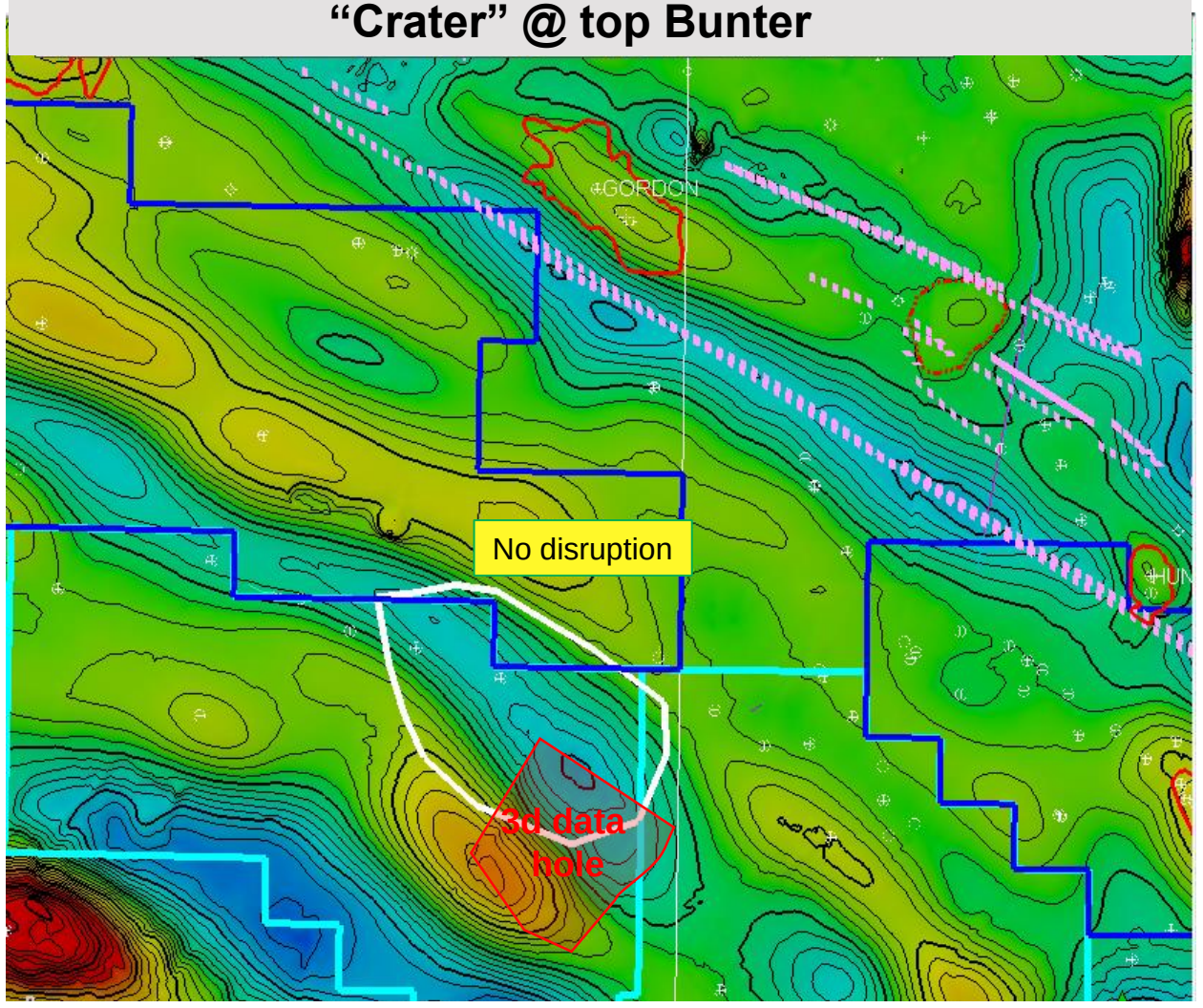
### “Crater” on Chalk edge map




### “Crater” @ top Bunter




**Circular Disruption**

**Multi survey merge & Data hole**

- **But, Off-centre 2D line mimics faulting pattern**

**Coincident: Bunter syncline & Zechstein thin**

# Sole Pit “Meteorite Crater?”

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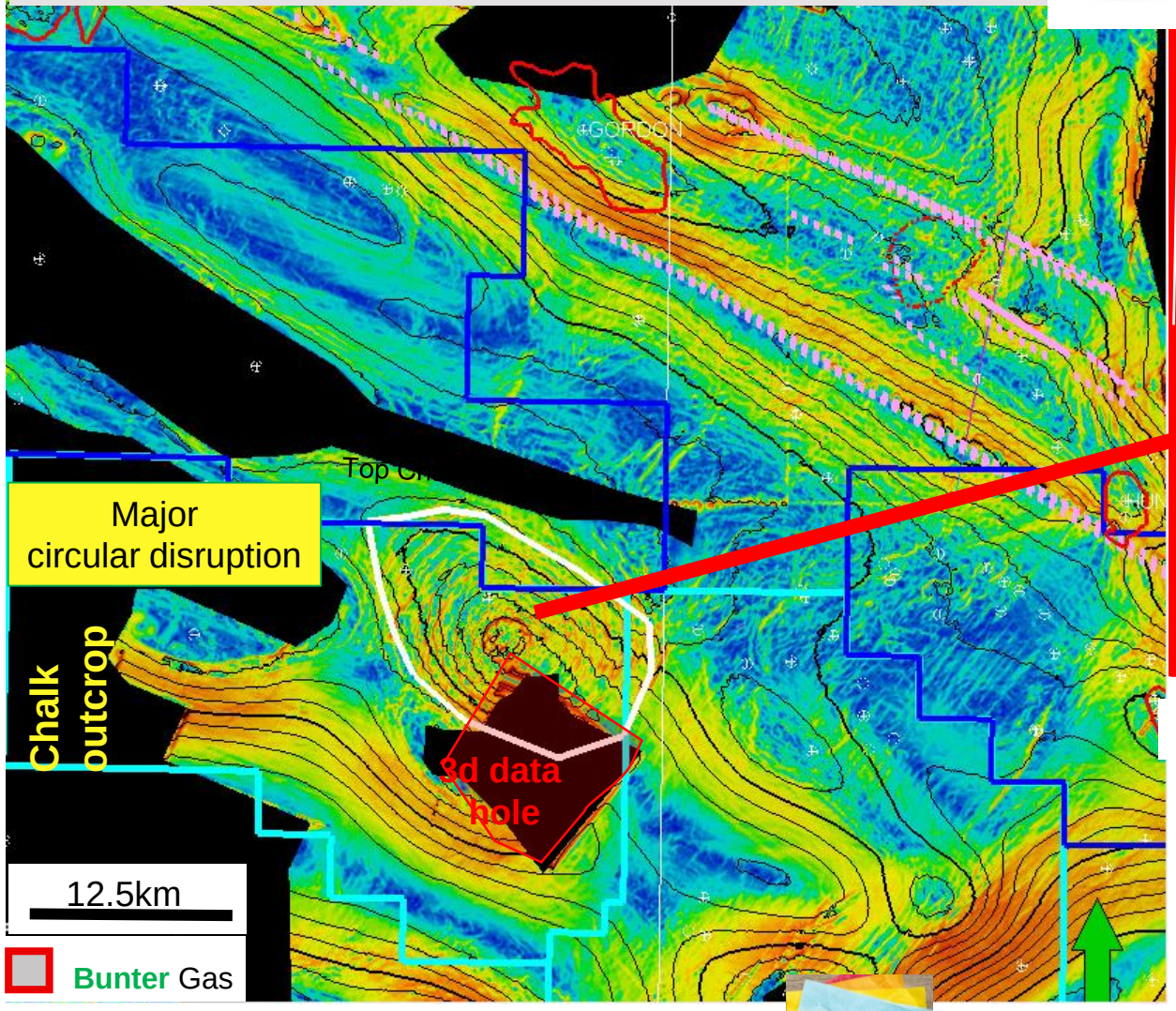
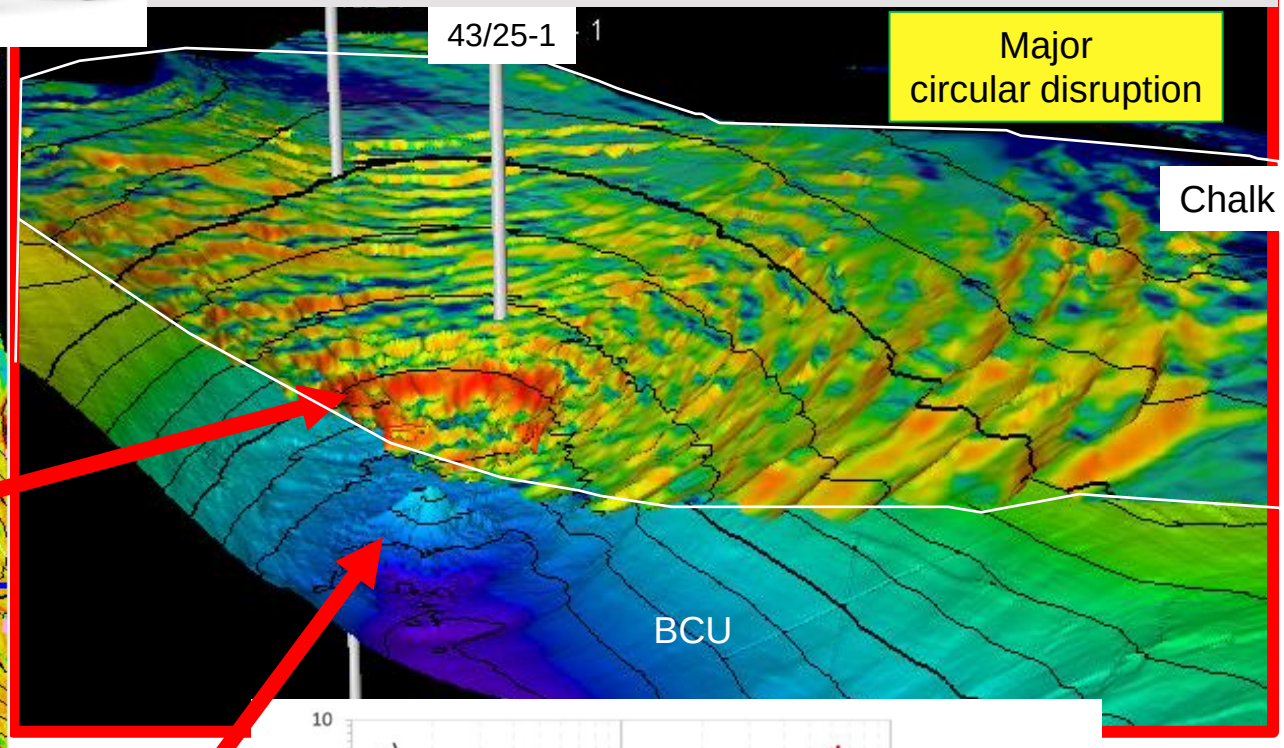
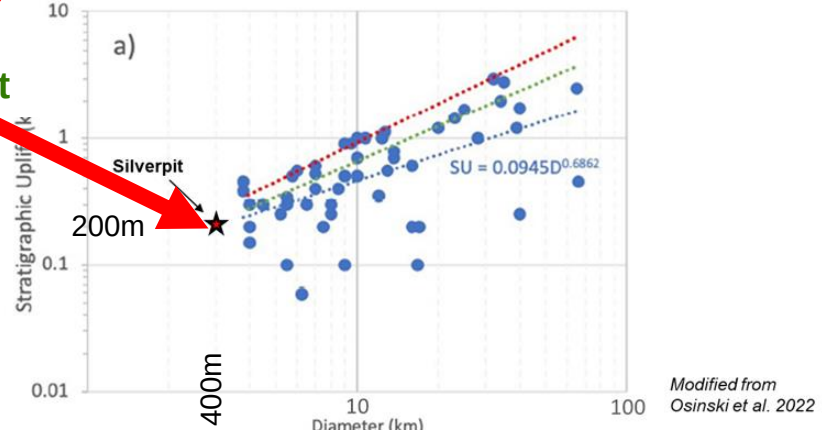
## “Crater” on Chalk edge map




## 3D “Crater” @ Chalk edge & BCU




Domal uplift




## Circular Disruption

## Diameter vs uplift fits on global crater trend

# Sole Pit "Meteorite Crater?"

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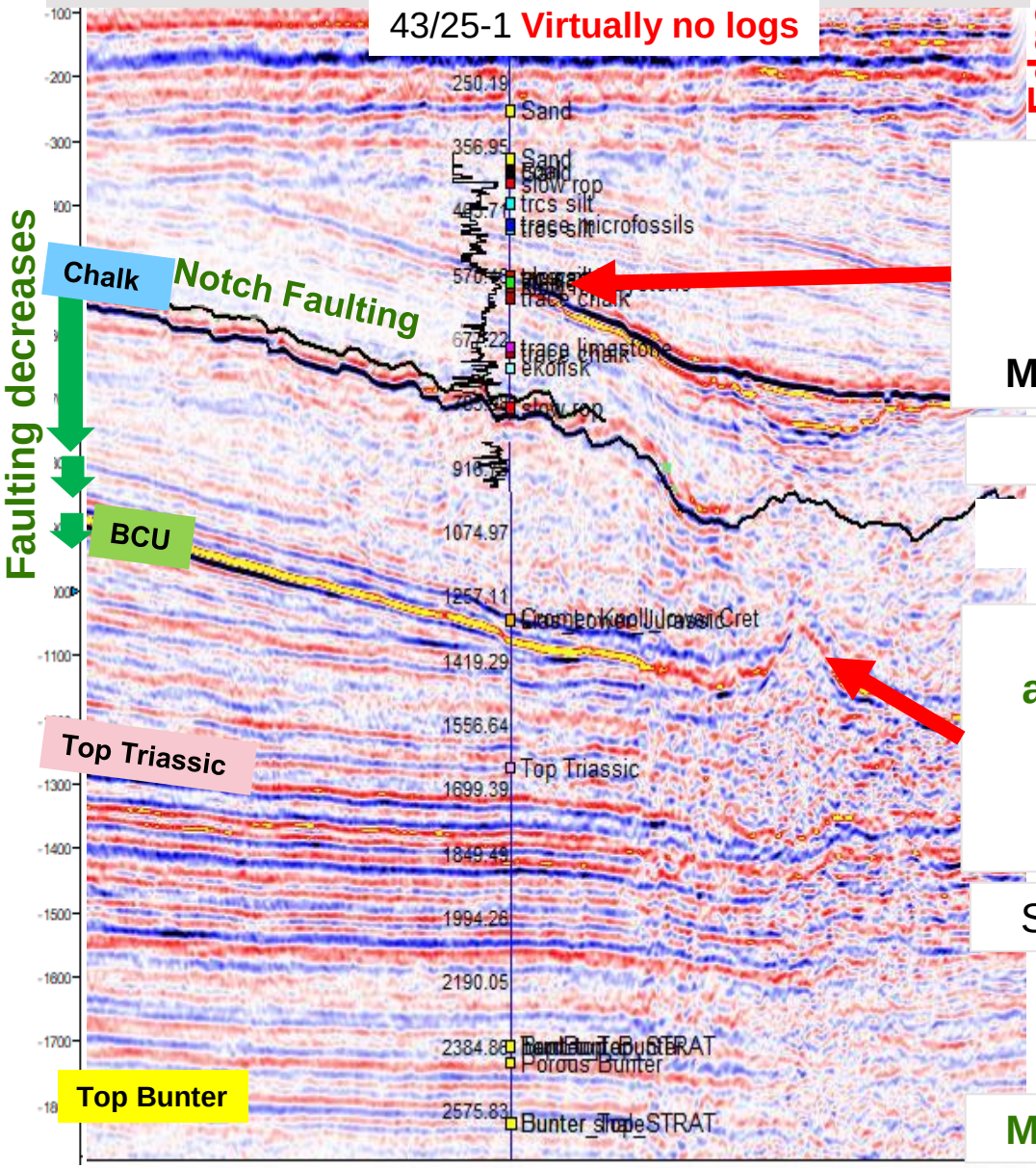
## 3D line through "crater"




Hardband = Slow ROP & lithified claystone
Meteorite floor?

Thickening

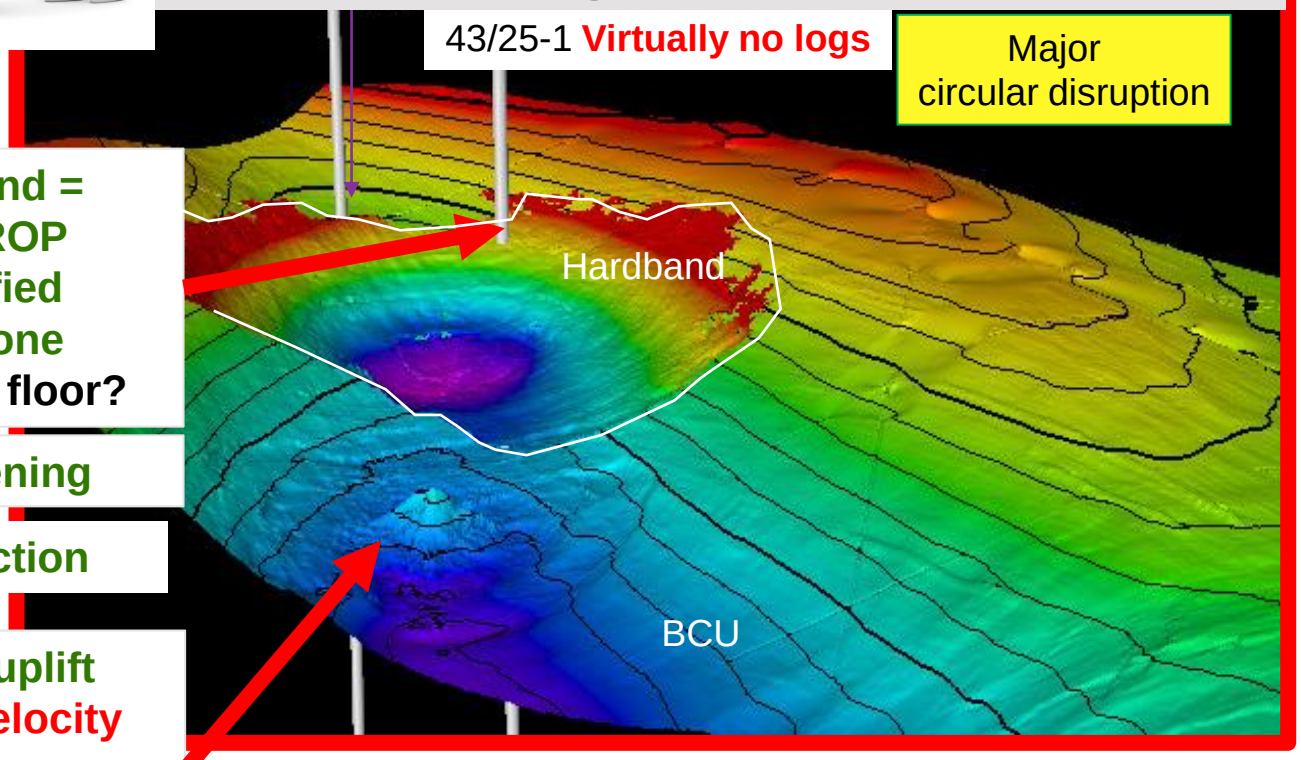
Destruction

Domal uplift and/or velocity pull up
Or migration swing

Sag /Push down

Minor Scattering

## 3D "Crater" @ Hardband & BCU




**You choose?!**

# Reflections on Changing CS landscape

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## Bunter is (mostly) a great regional CS play

- Very thick & extensive and good reservoir
- Good top seal
- Multiple culminations/ Very large storage capacity
- BUT.....geologically under-appraised

## Let's work the details & understand "mysteries"

- 1990s imaging inadequate/ Reprocessing promising
- New acquisition  beneficial
- Are we geophysically up-to-date?

## Co-location will be increasingly problematic

- Acquisition options for  3D static or targeted 4D

### NSTA Activity web map