Structural and kinematic analysis of the Slyne Basin:
Exploring the links between structural evolution and traps

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European Union
European Regional Development Fund
Science Foundation Ireland sfi For what's next
PIP Petroleum Infrastructure Programme

Research Aims

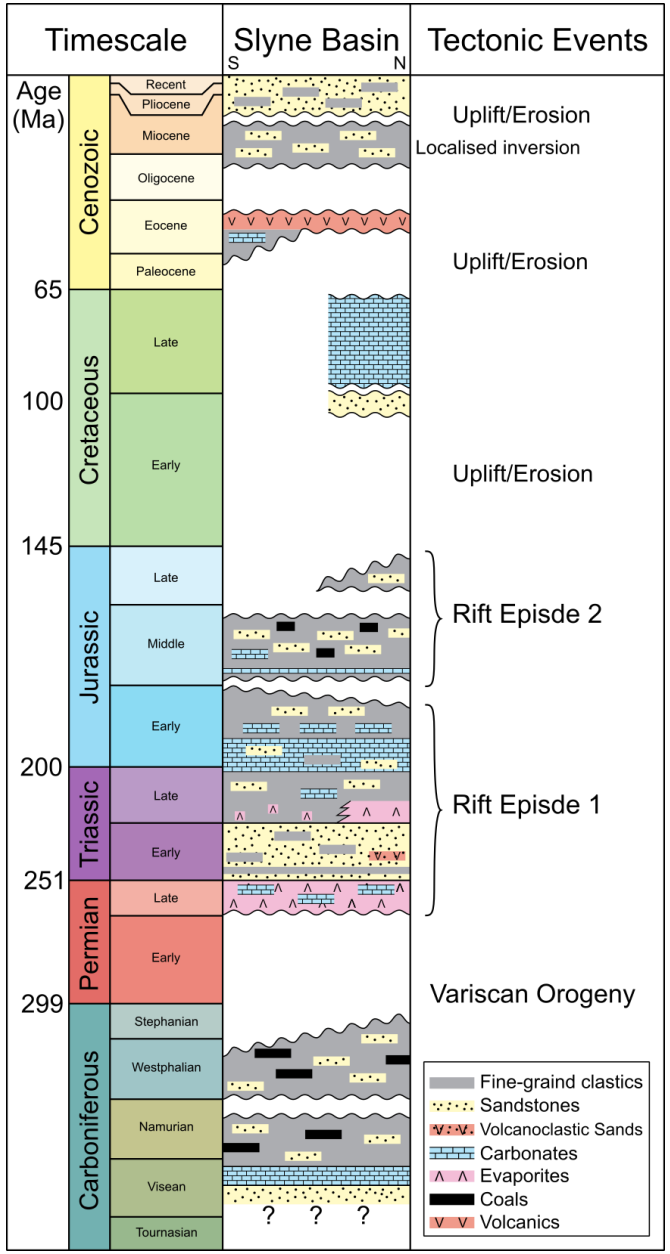
- Develop a robust model for the structural evolution of the Slyne and Erris Basins
- Additionally investigate:
  - The role of salt
  - Transfer zones between sub-basins
  - Hanging-wall structures

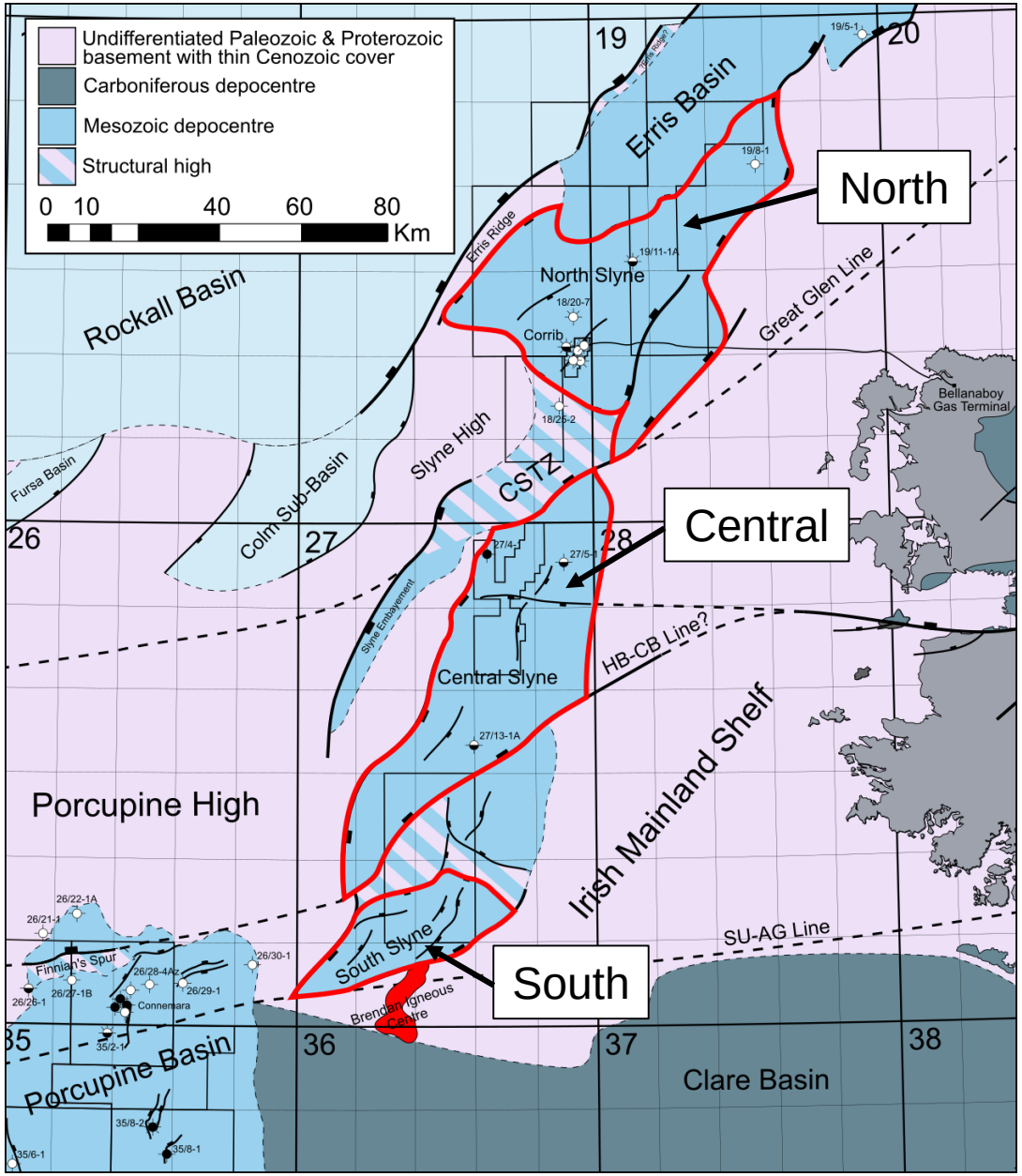
Presentation Outline

- Introduction
- Transfer Zones
- Salt Tectonics
- Early Findings

The Slyne Basin

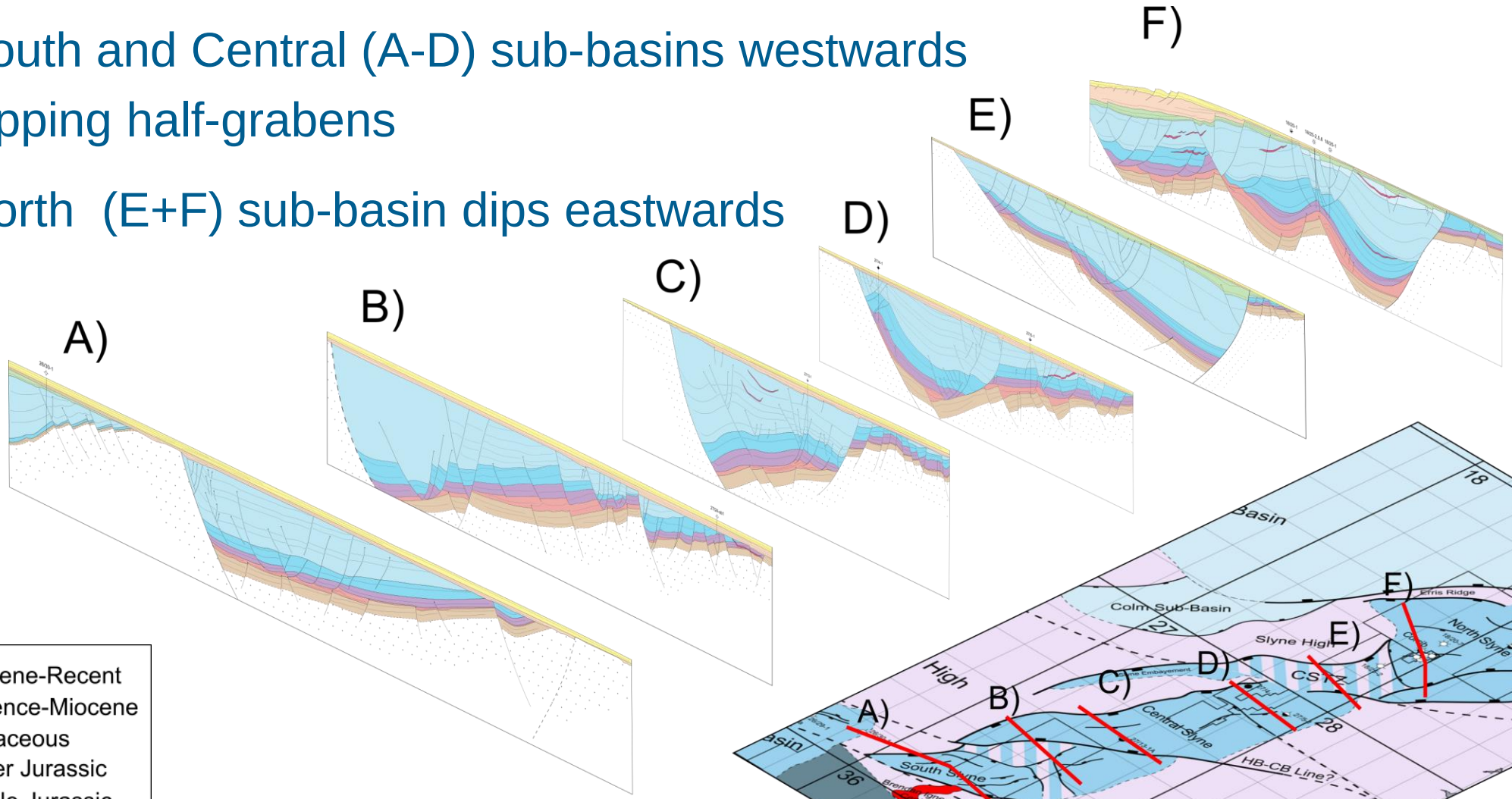
- Narrow elongate rift-basin
- Two phases of rifting
  - Permian to Early Jurassic
  - Middle to Late Jurassic
- Divided into three-sub-basins





Along-strike structural variability

- South and Central (A-D) sub-basins westwards dipping half-grabens
- North (E+F) sub-basin dips eastwards



- Miocene-Recent
- Eocence-Miocene
- Cretaceous
- Upper Jurassic
- Middle Jurassic
- Lower Jurassic
- Triassic
- Permian
- Carboniferous

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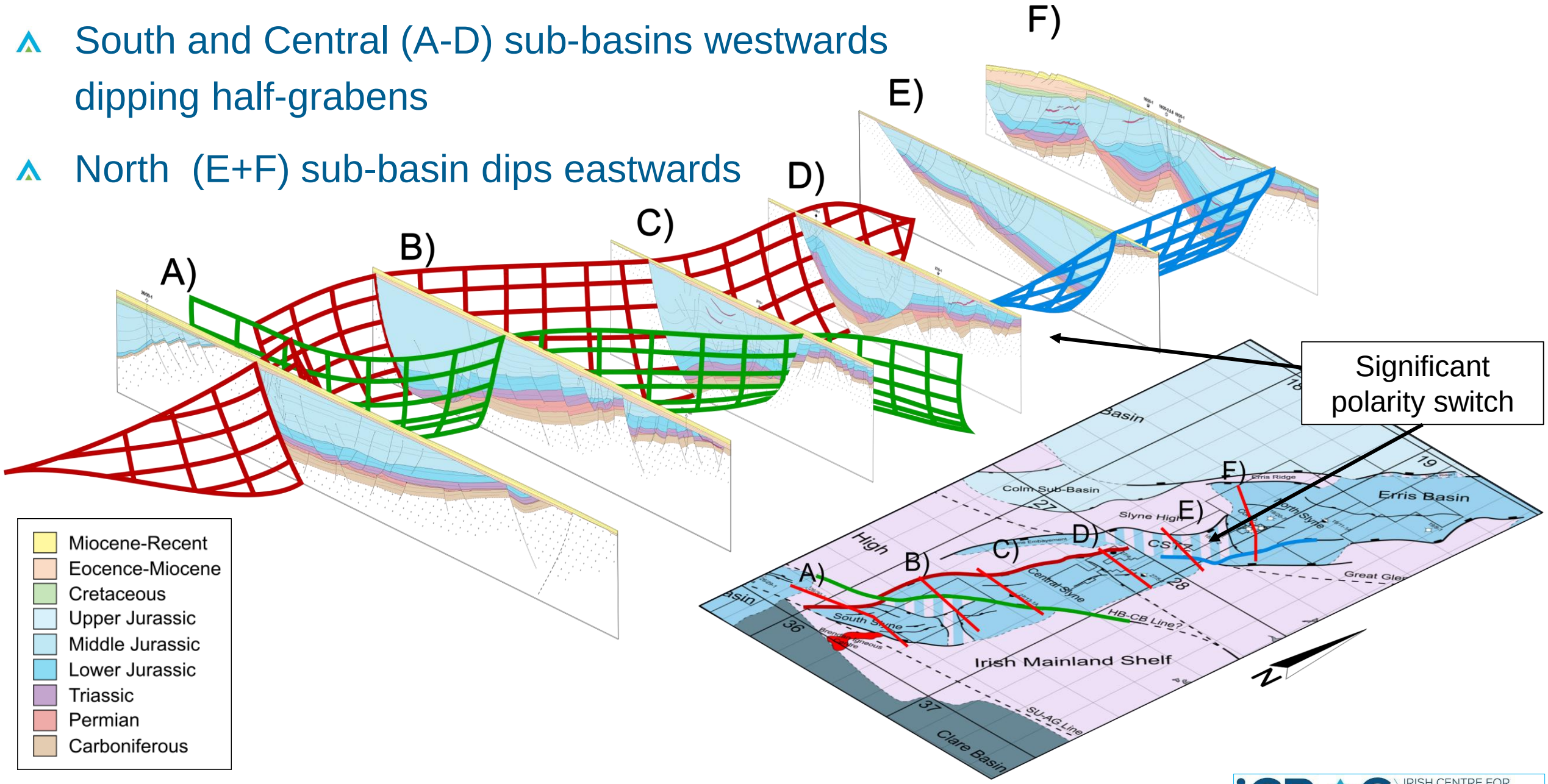

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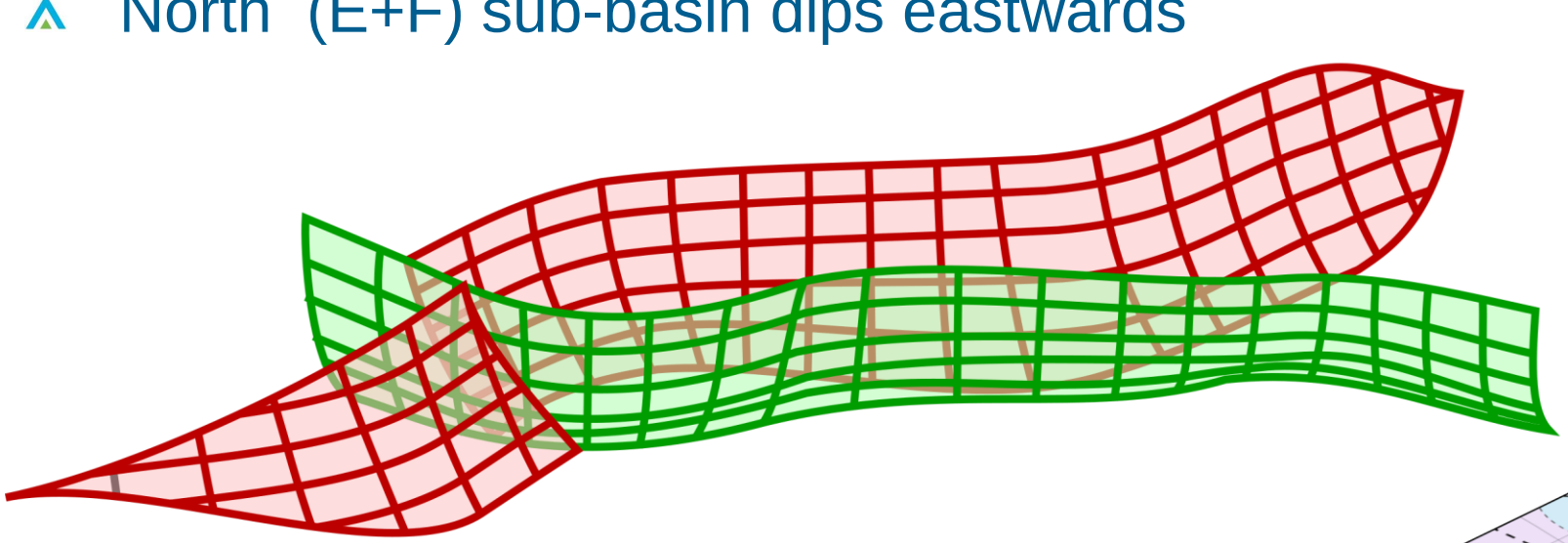

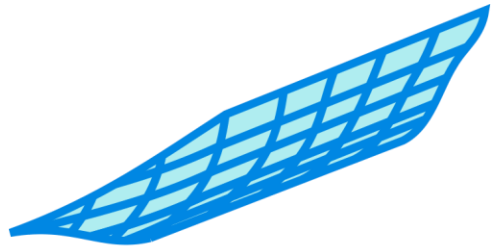

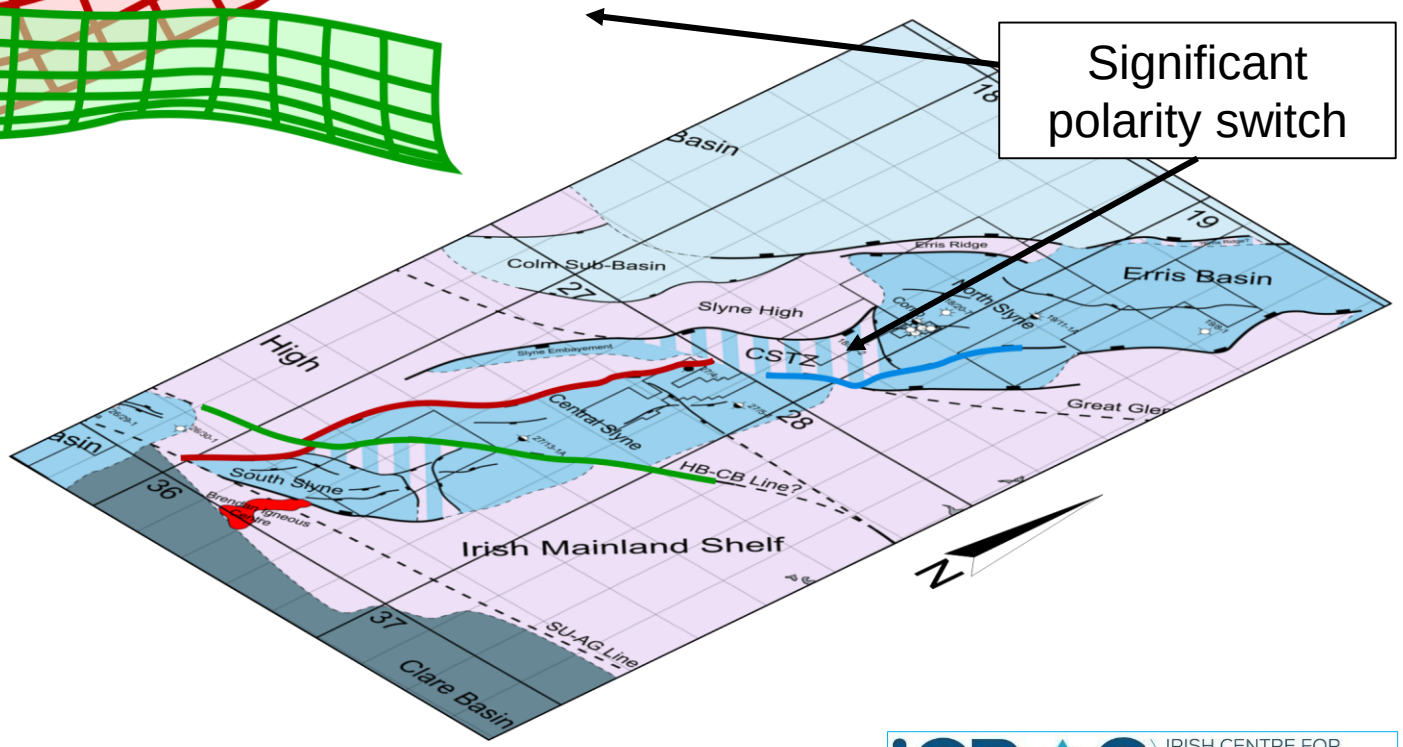

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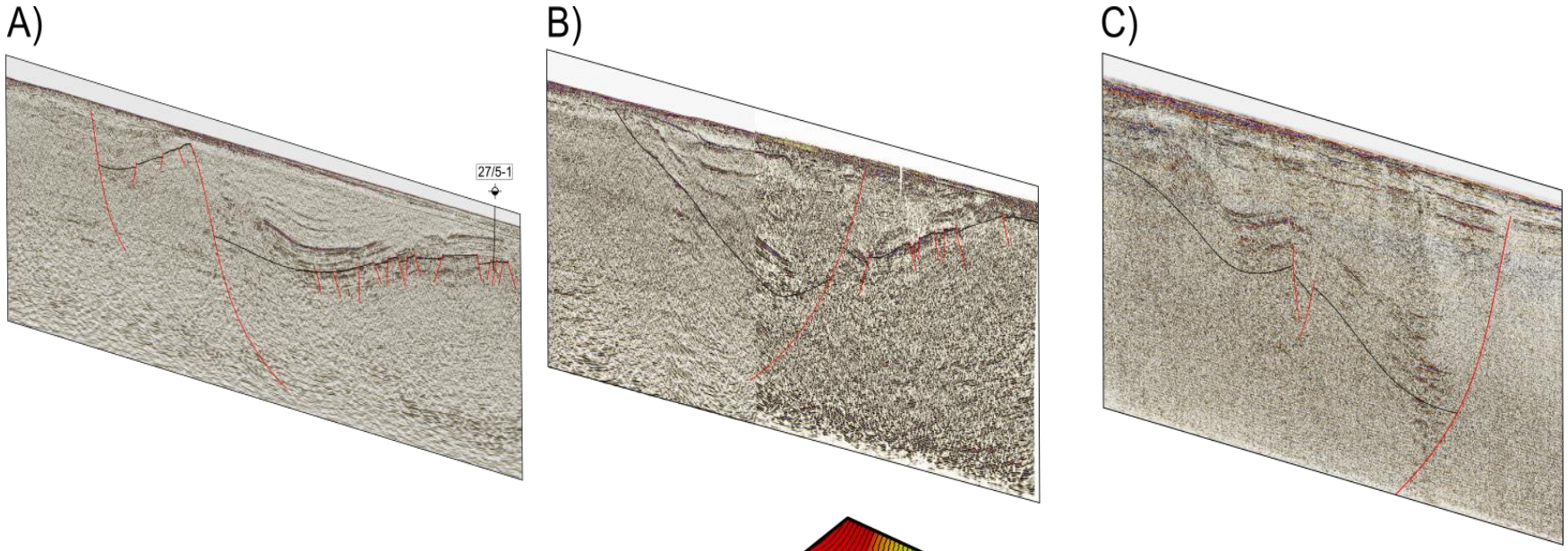
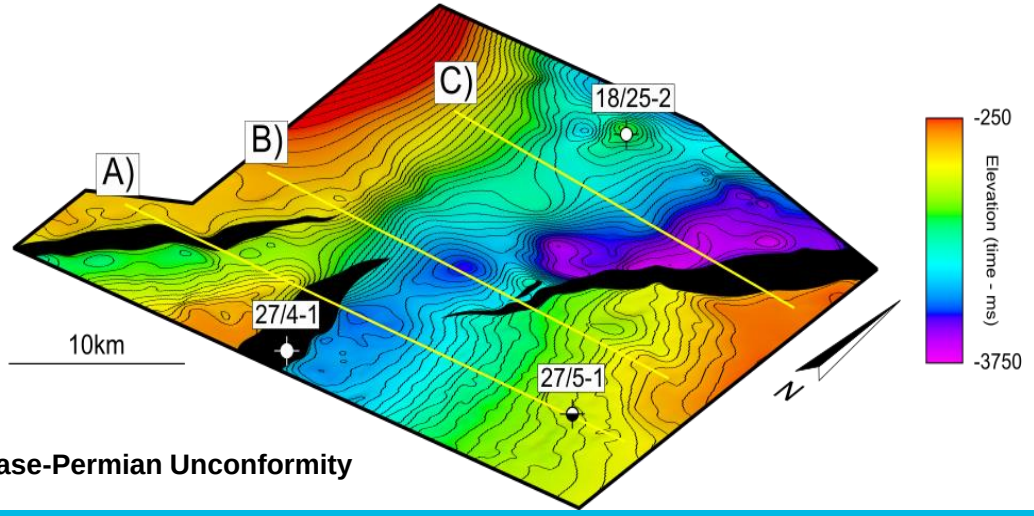
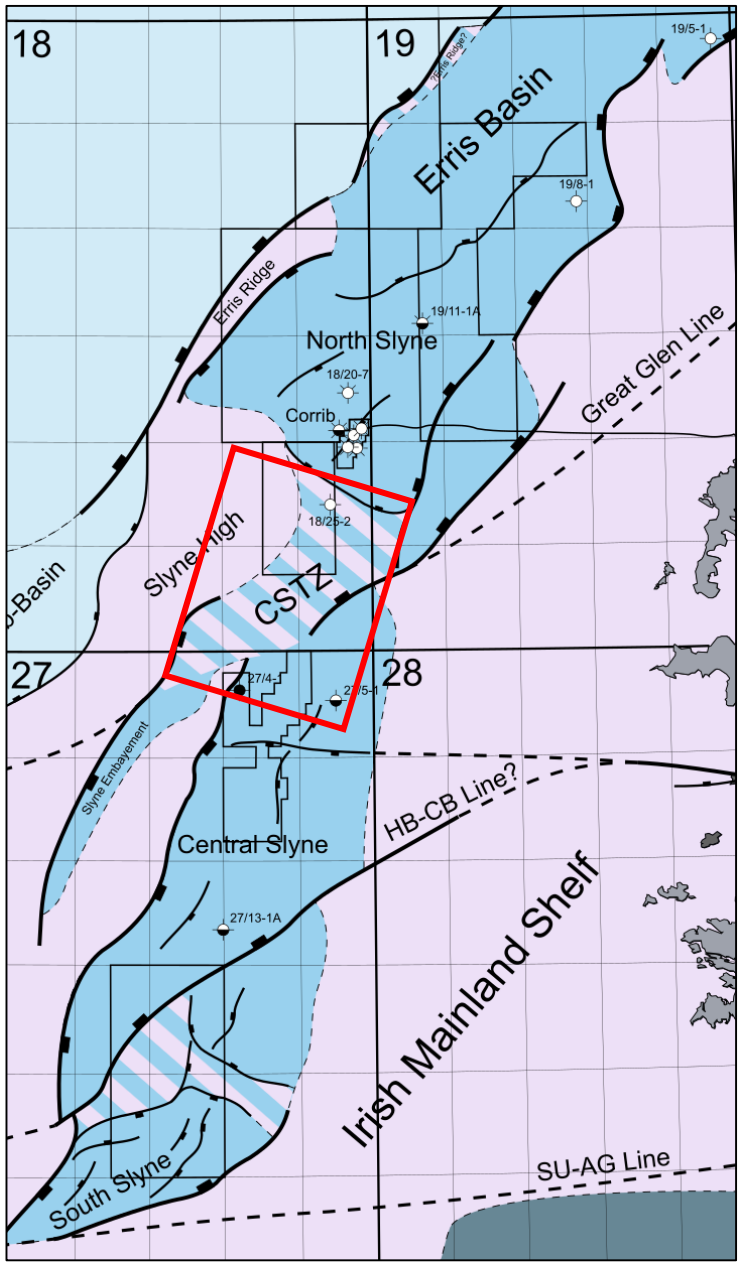
Central Slyne Transfer Zone (CSTZ)

- Rapid switch in polarity of multi-kilometre scale basin-bounding faults over 10-15km

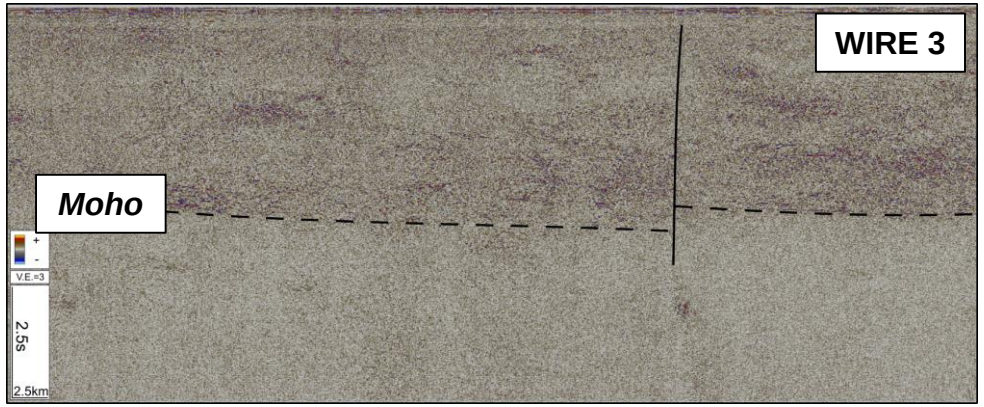


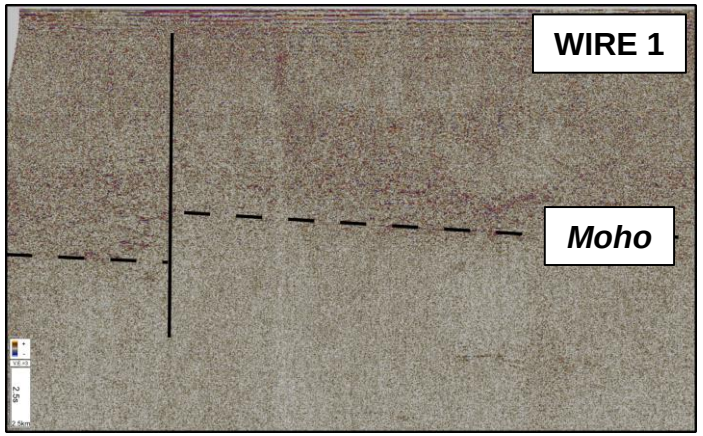


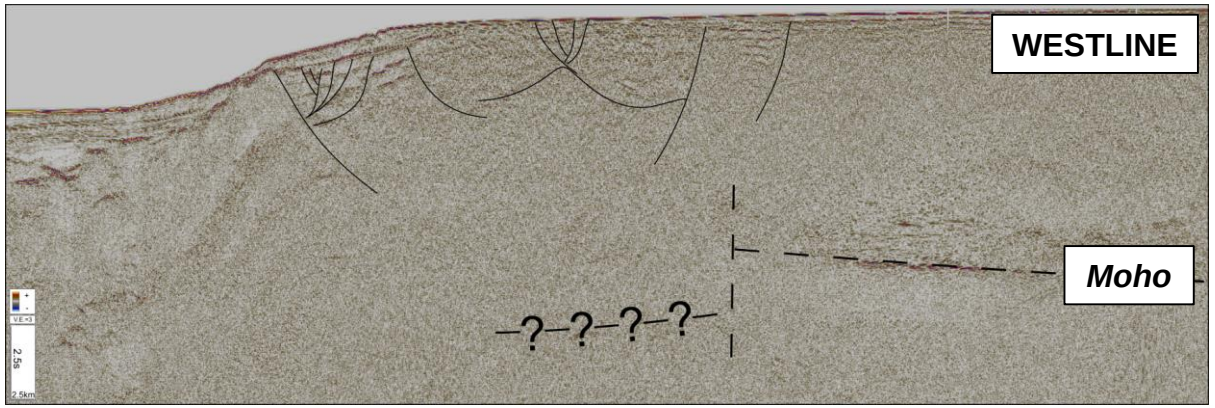
Time-structure map Base-Permian Unconformity

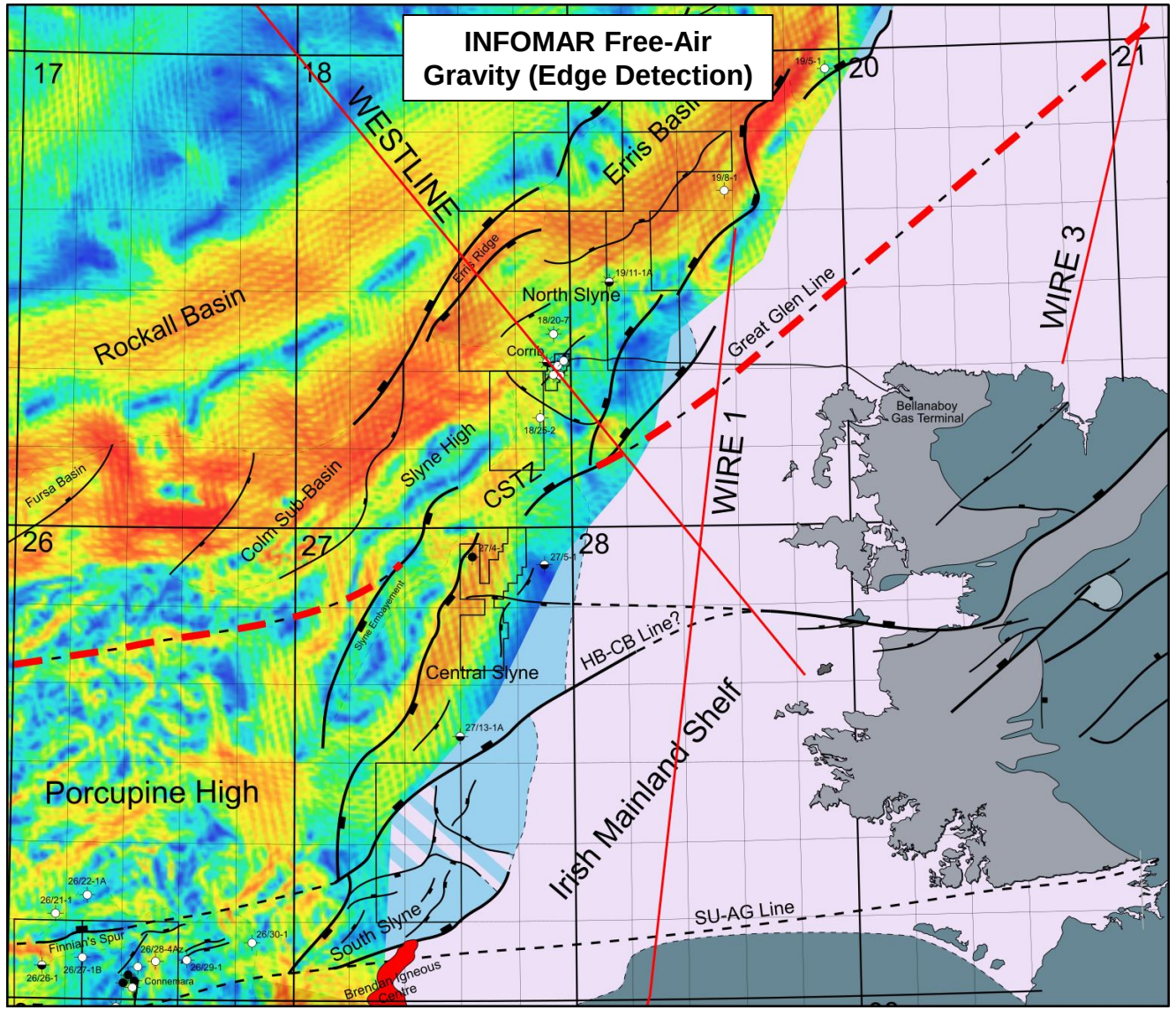


The Great Glen Fault Offshore Ireland





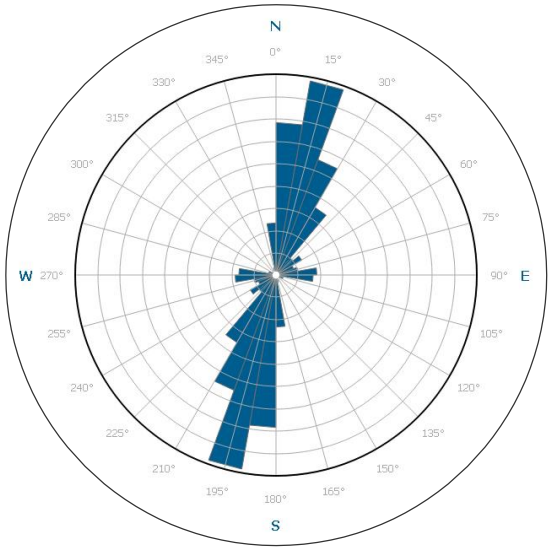




Transfer Zone Influence

Central Slyne:

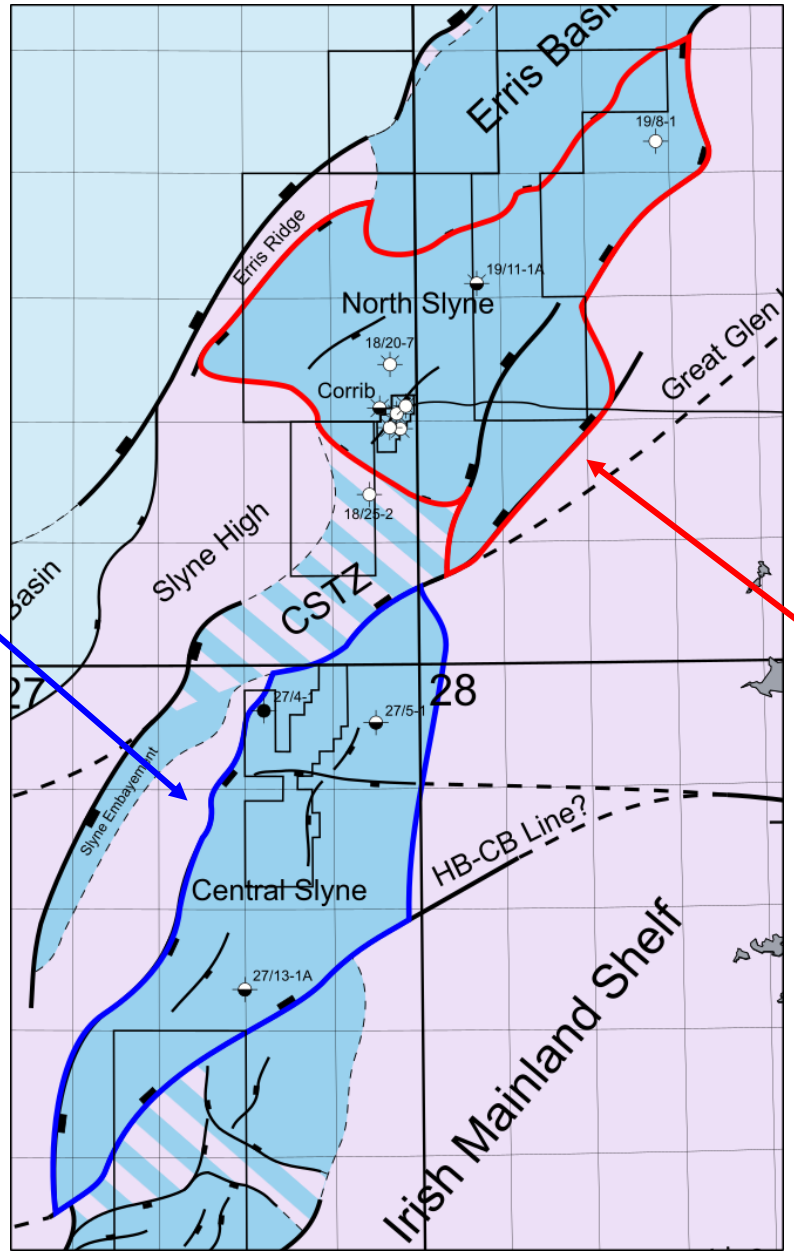
- **Westward** dipping
- **NNE-SSW** structural orientation
- **Oil**-prone
- Cretaceous **absent**
- Triassic **mudstone**



NNE

SSW

Fault-strike Rose Diagram – Central sub-basin

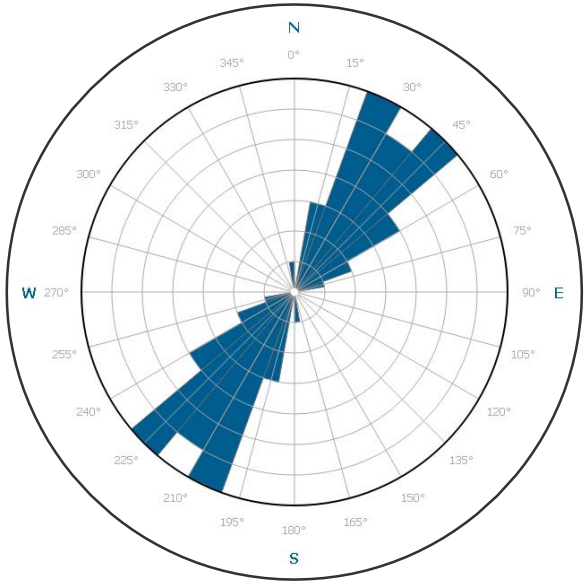


Northern Slyne:

- **Eastwards** dipping
- **NE-SW** structural orientation
- **Gas**- and **oil**-prone
- Cretaceous **preserved**
- Triassic **halite**

NE

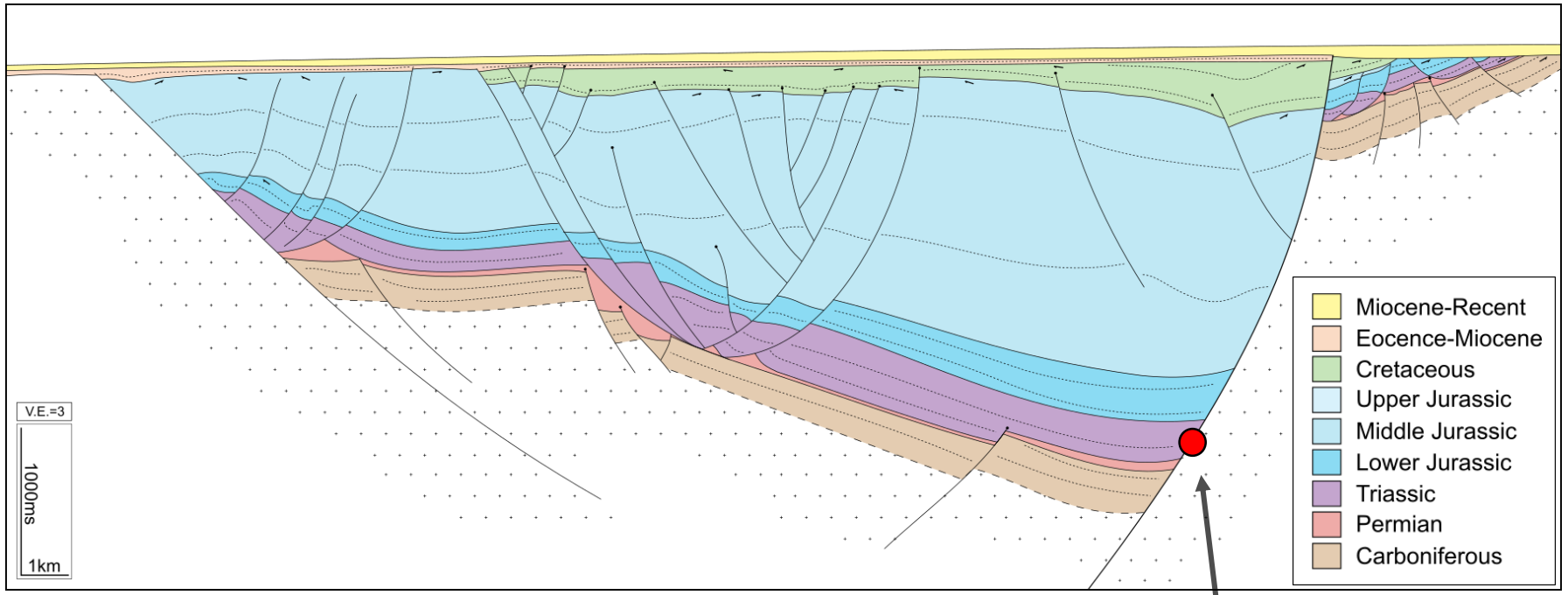
SW

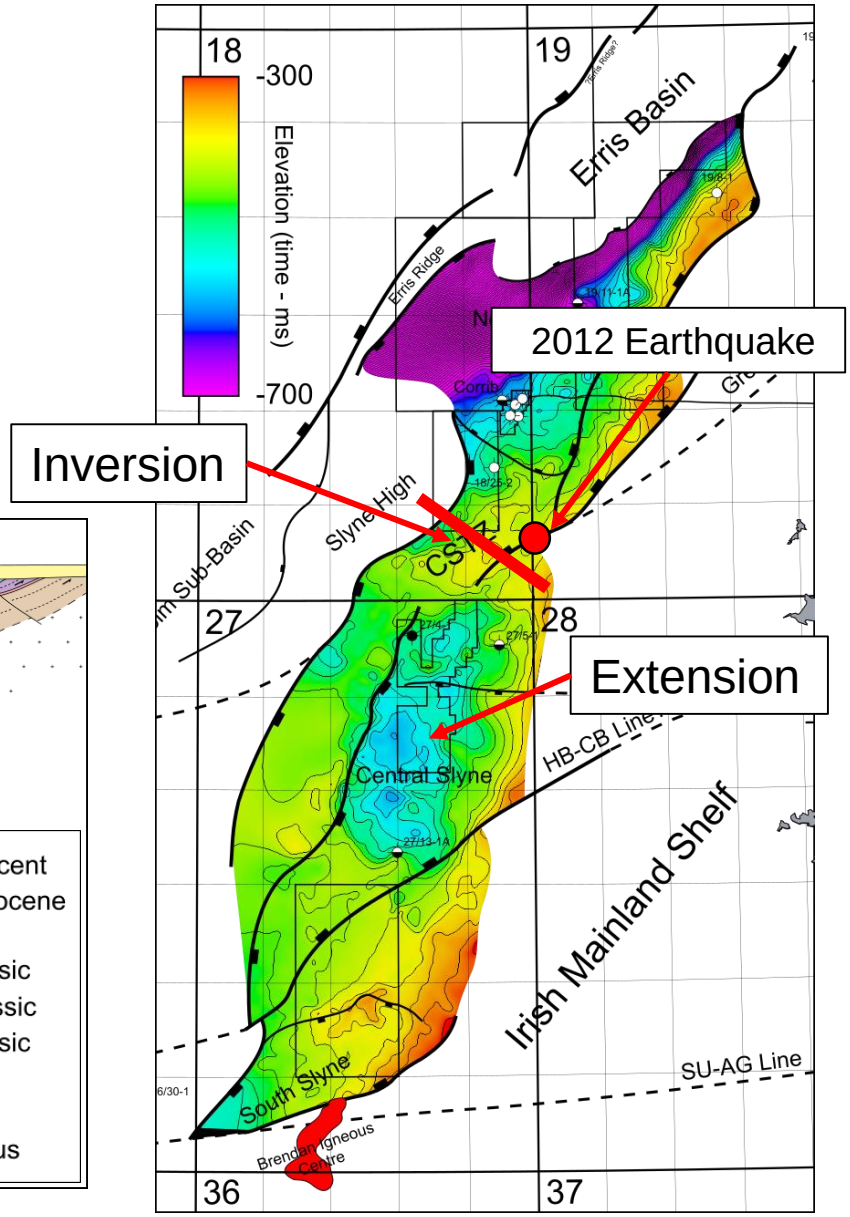


Fault-strike Rose Diagram – Northern sub-basin

Continued Influence Post-Rift

- Inversion in CSTZ
- Extension in Central sub-basin

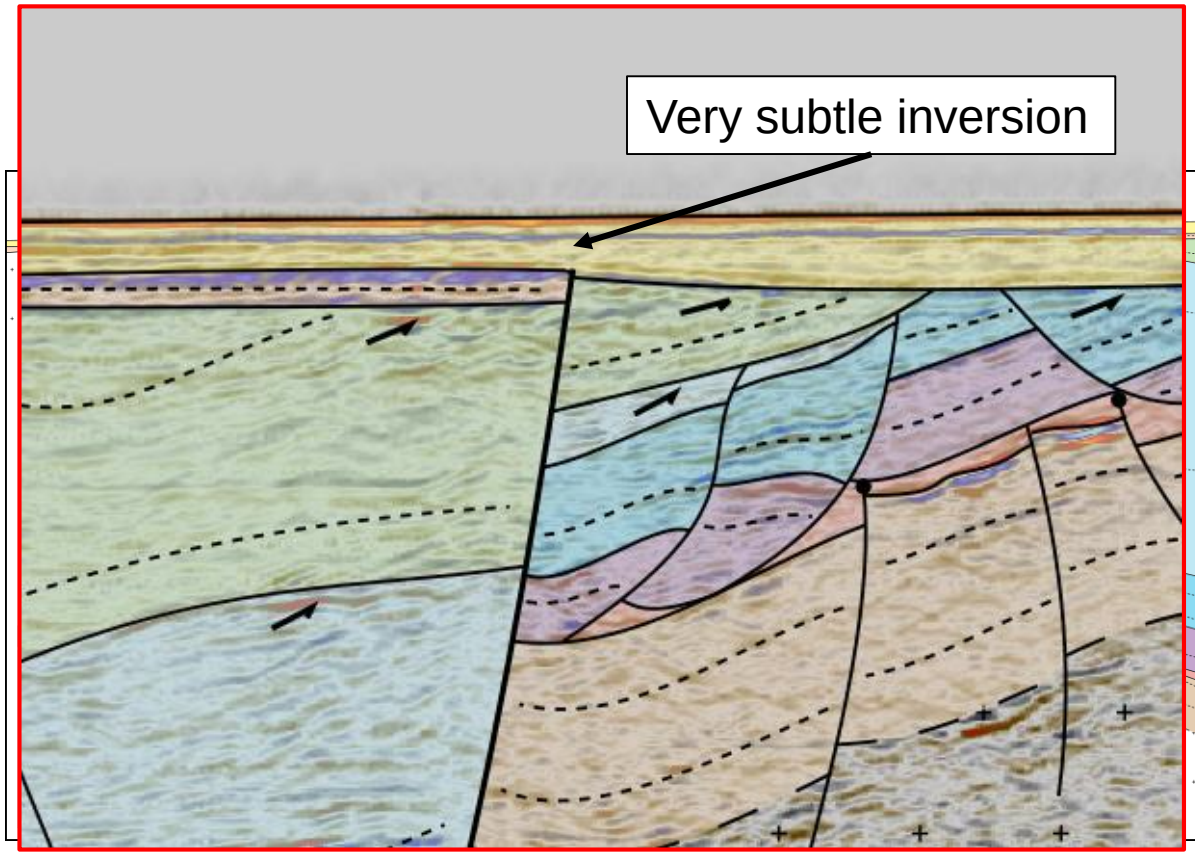


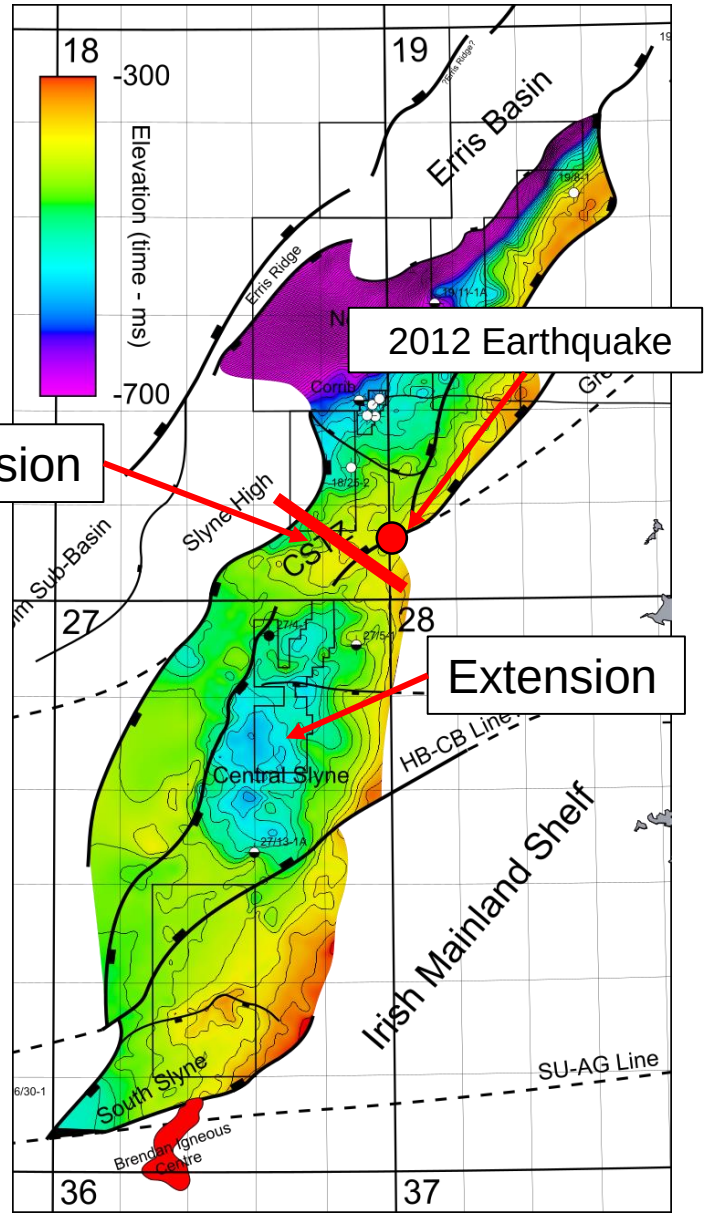


Base-Cenozoic Unconformity Time Structure Map

Continued Influence Post-Rift

- Inversion in CSTZ
- Extension in Central sub-basin

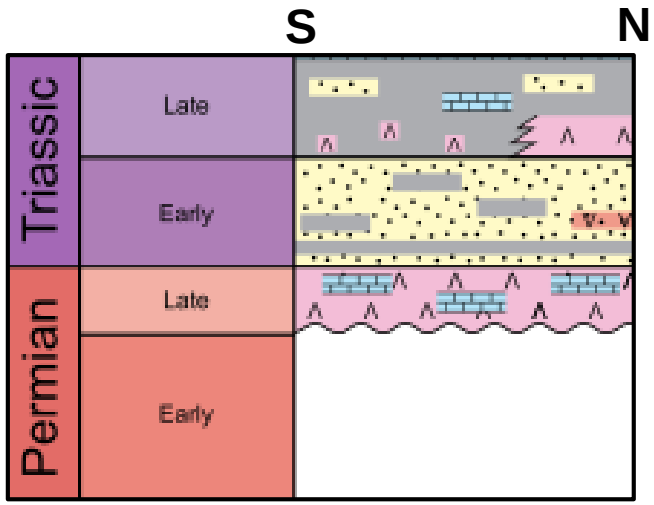




Base-Cenozoic Unconformity Time Structure Map

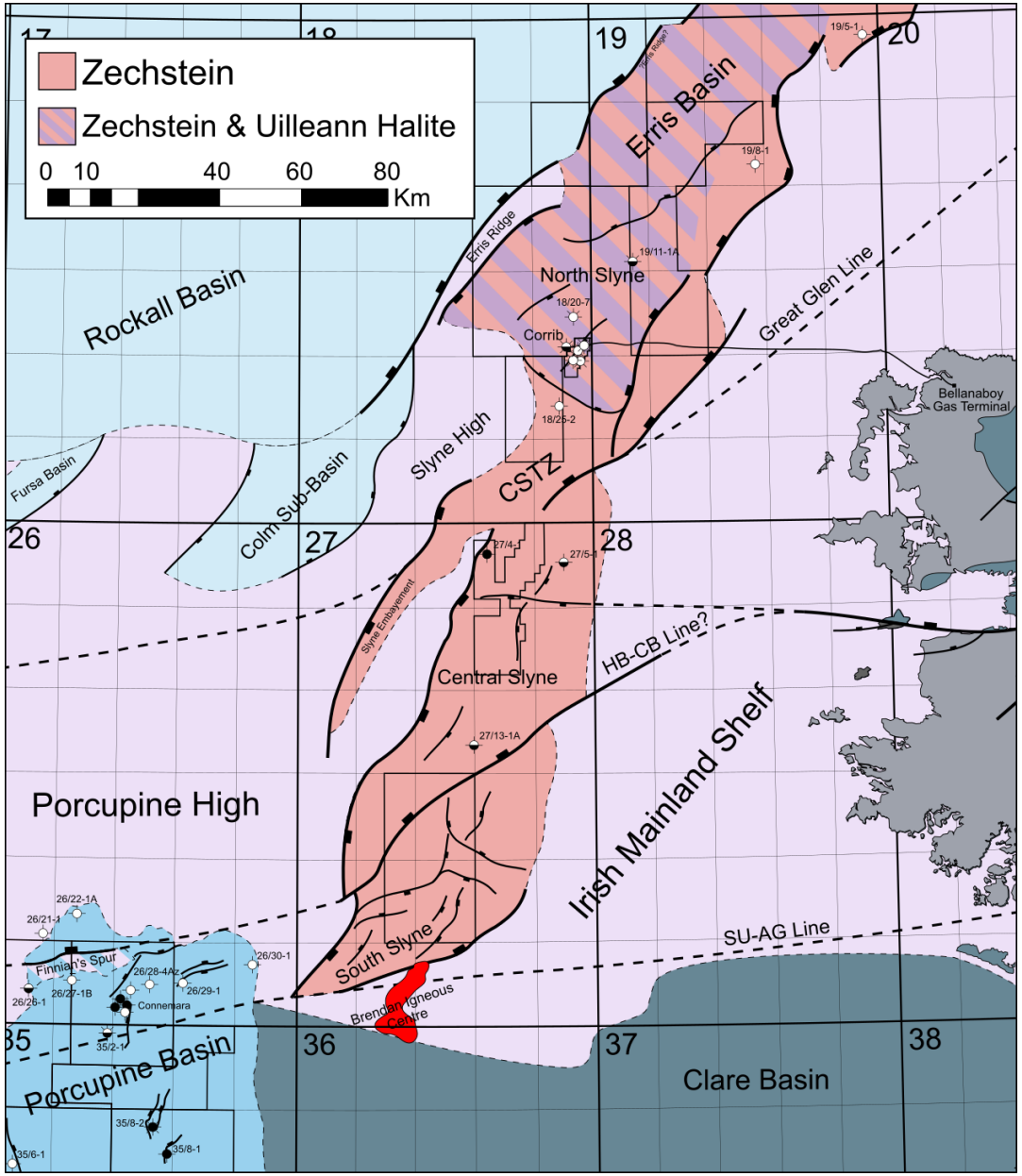
Salt in the Slyne Basin

- Permian **Zechstein** Group
  - Found throughout the Slyne Basin
- Upper Triassic **Uilleann Halite**
  - Only developed in **North Slyne**



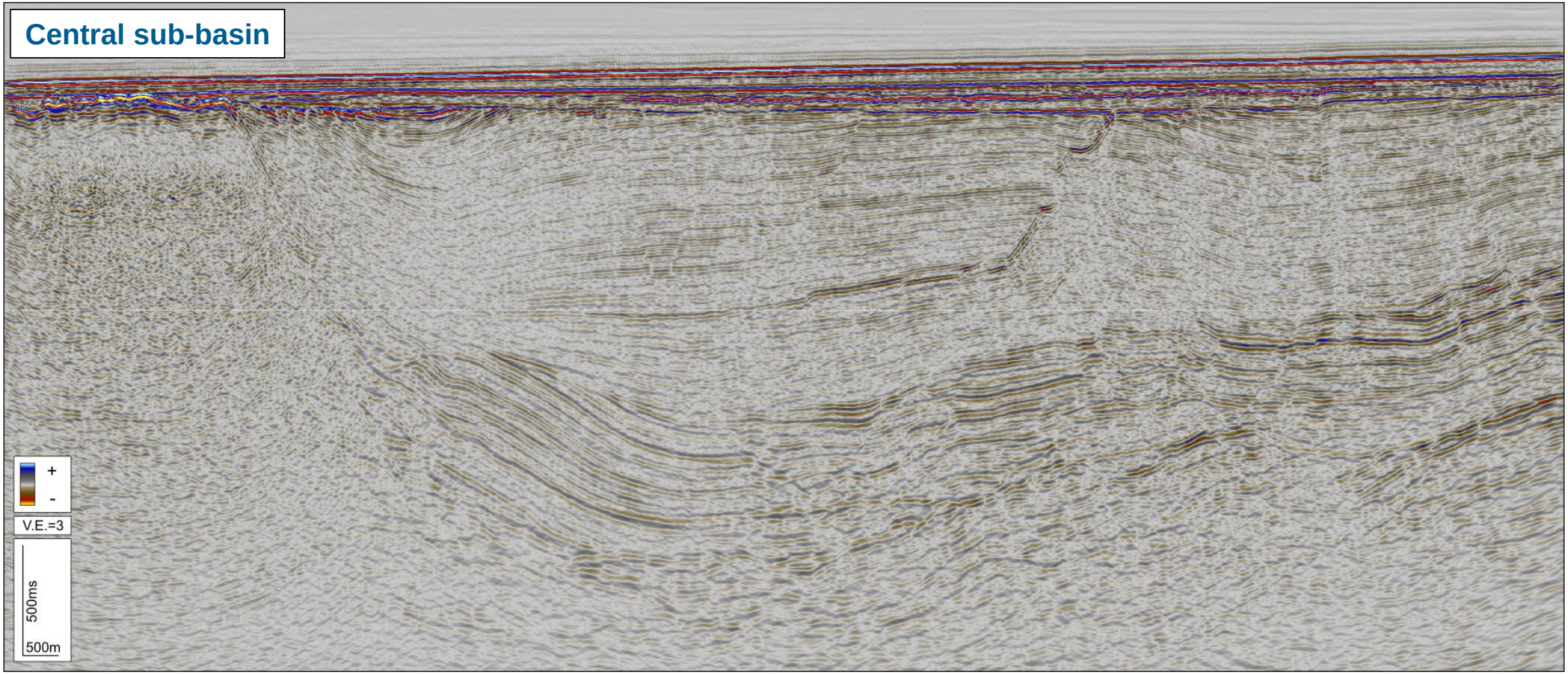
Uilleann Halite Member

Zechstein Group



Mechanical Detachment

- Salt mechanically detaches Mesozoic section from Palaeozoic basement
- Post-salt faulting is listric, soling out in salt layers
- Salt-welds provide secondary migration route



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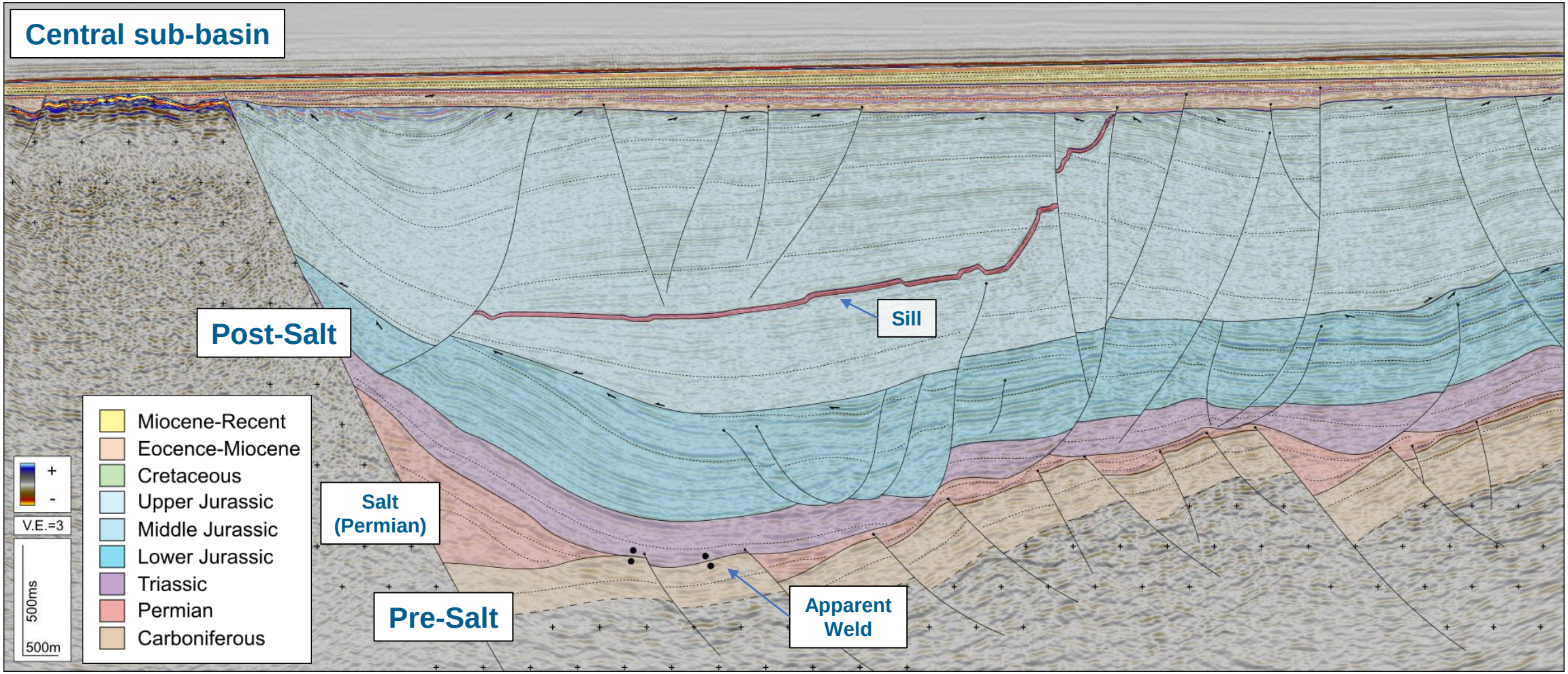


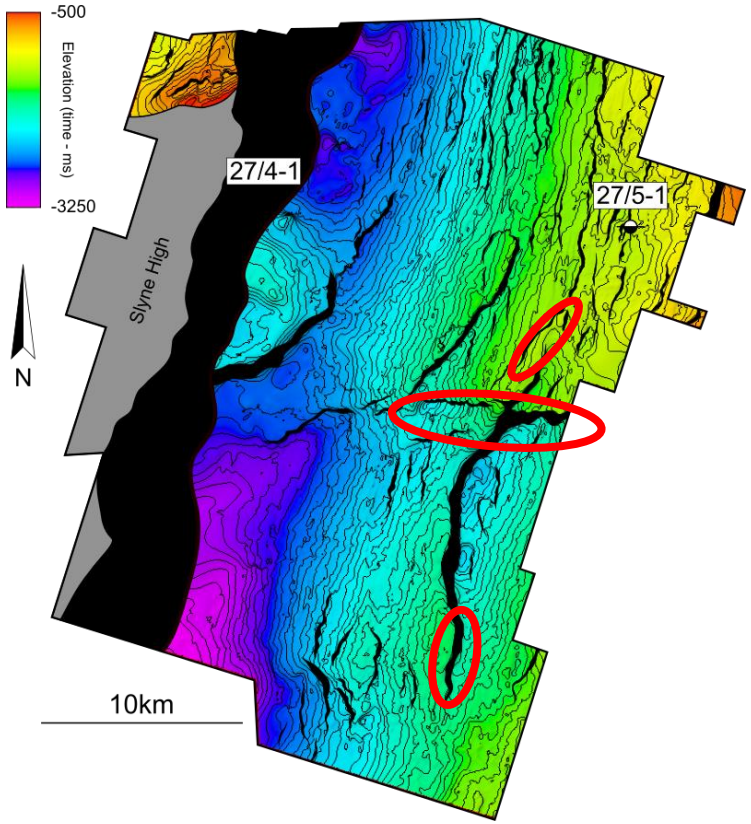
A little salt goes a long way…

188 faults interpreted

Only **3** through-going

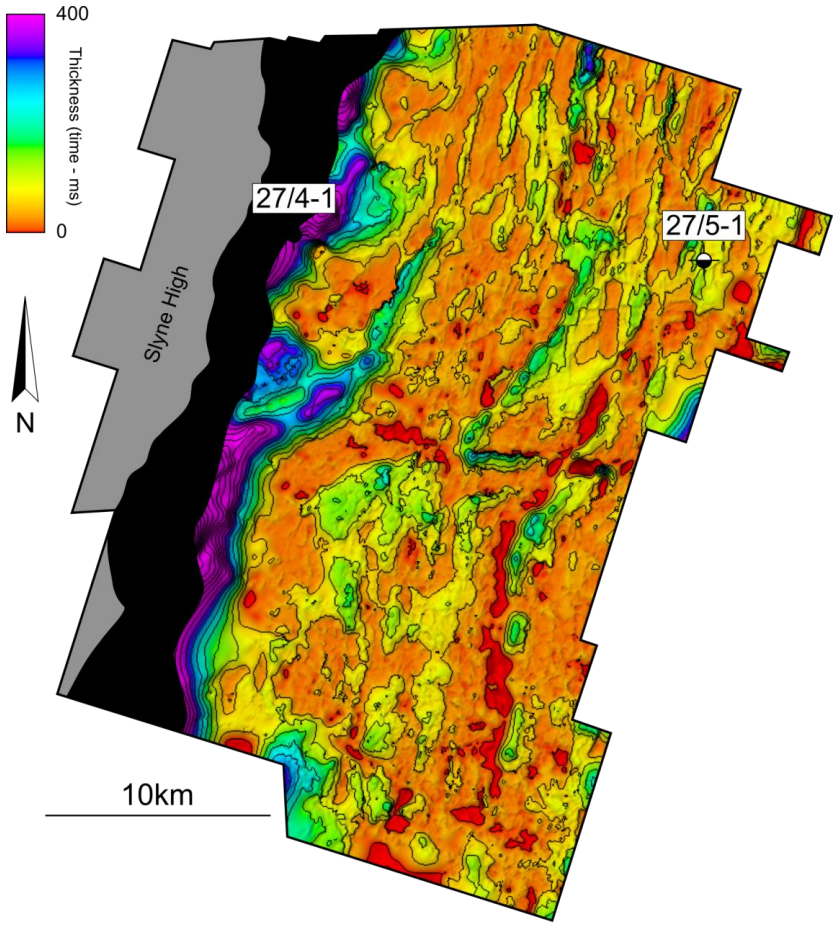
Pre-Salt

Base-Permian Unconformity Time Structure Map



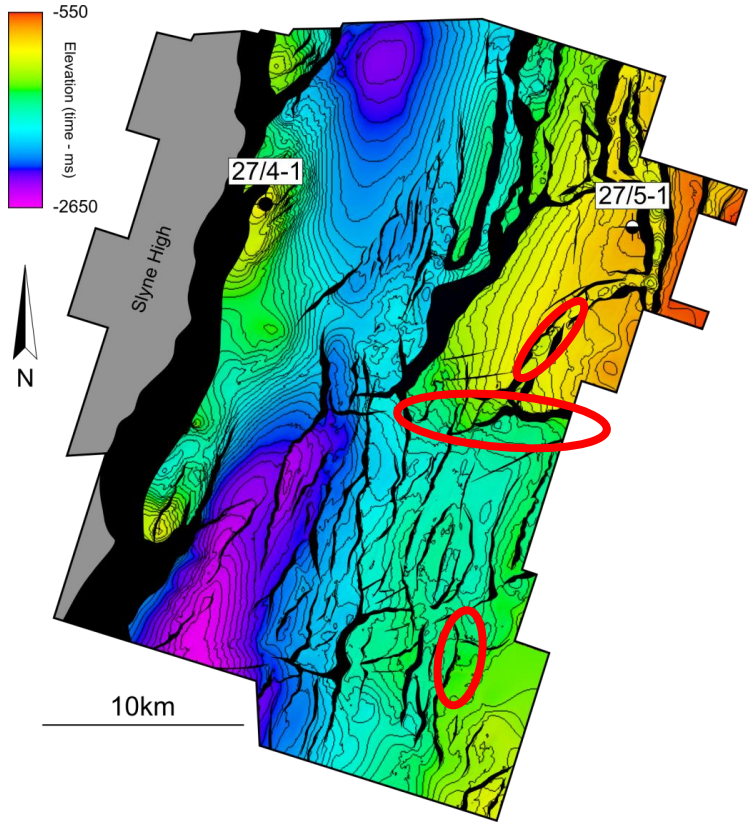
Salt

Zechstein Group Isochron Thickness

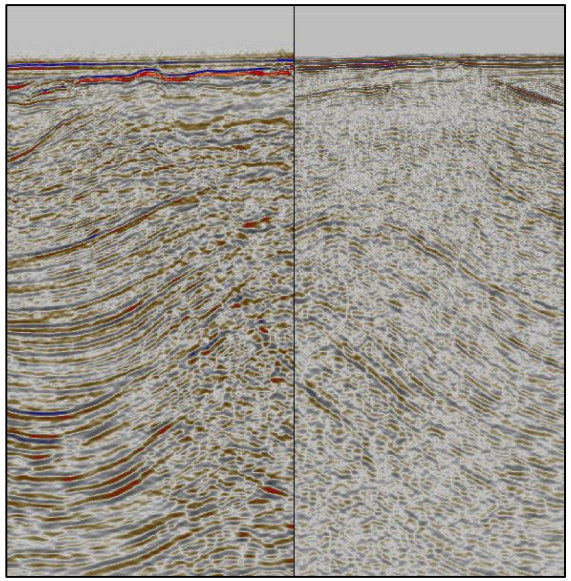


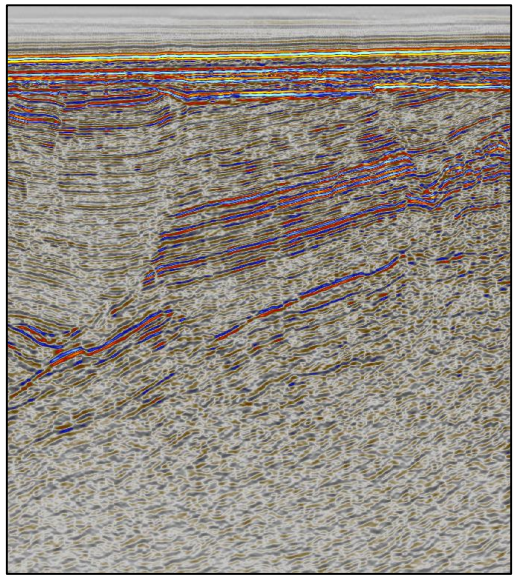
Post-Salt

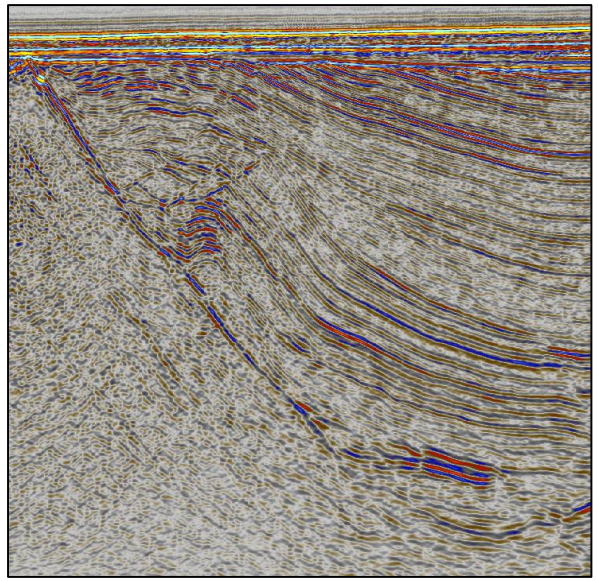
Penarth Group Time Structure Map

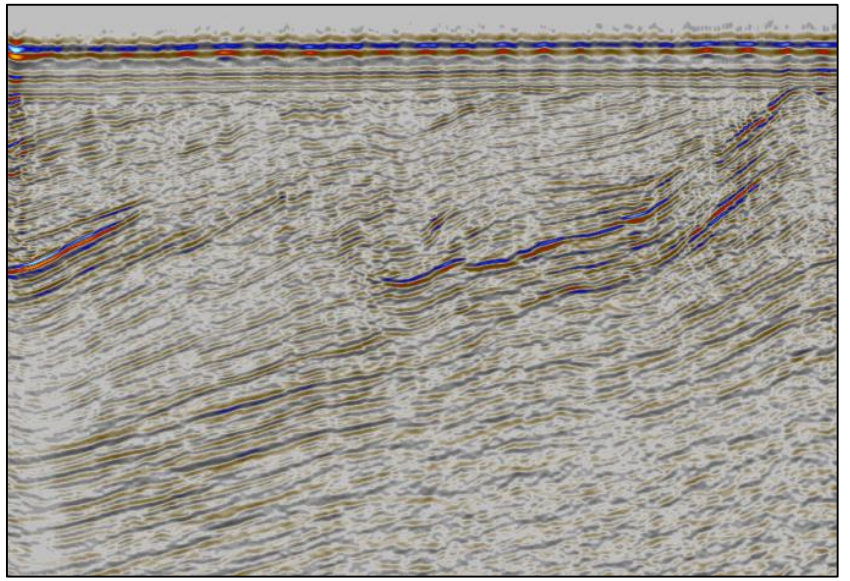


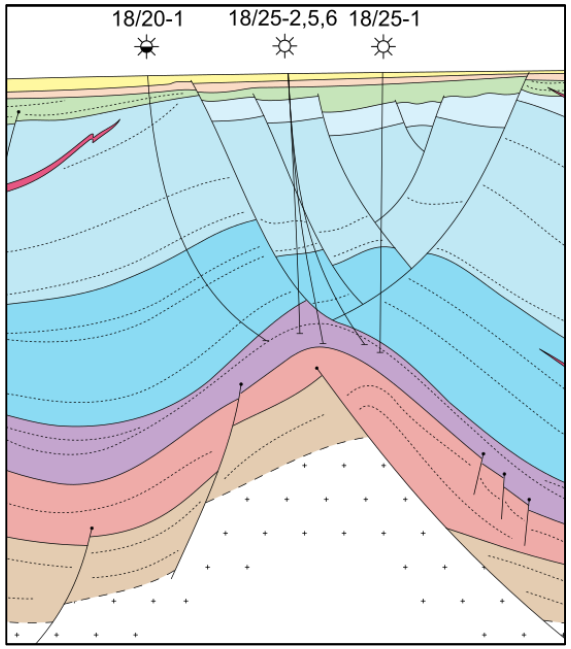
Structural traps in the Slyne Basin

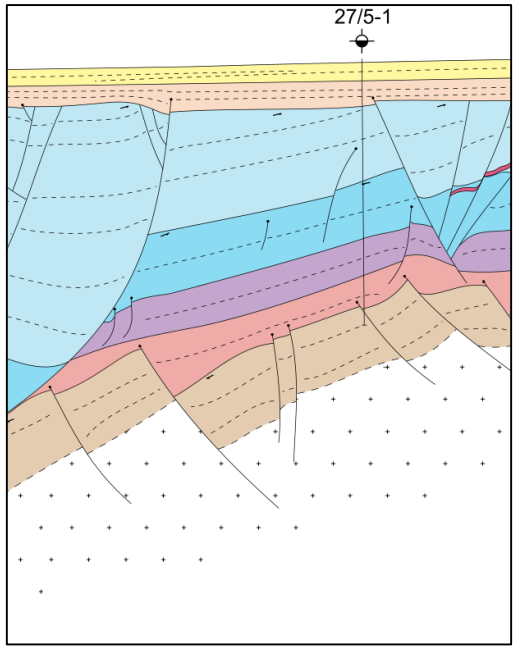


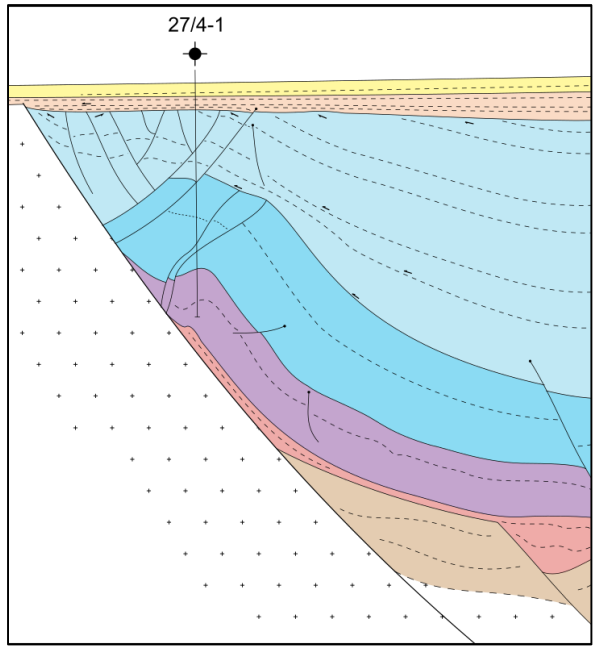


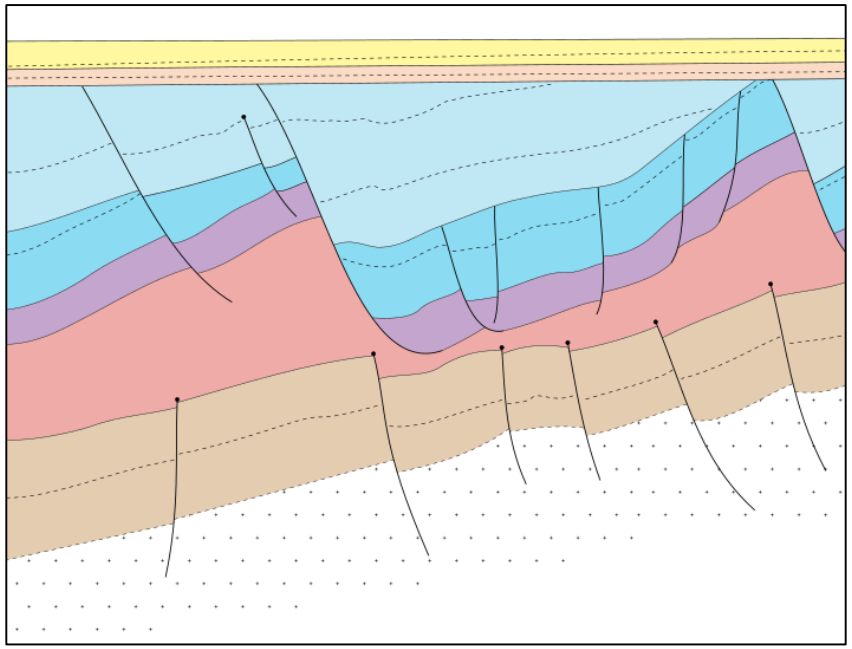




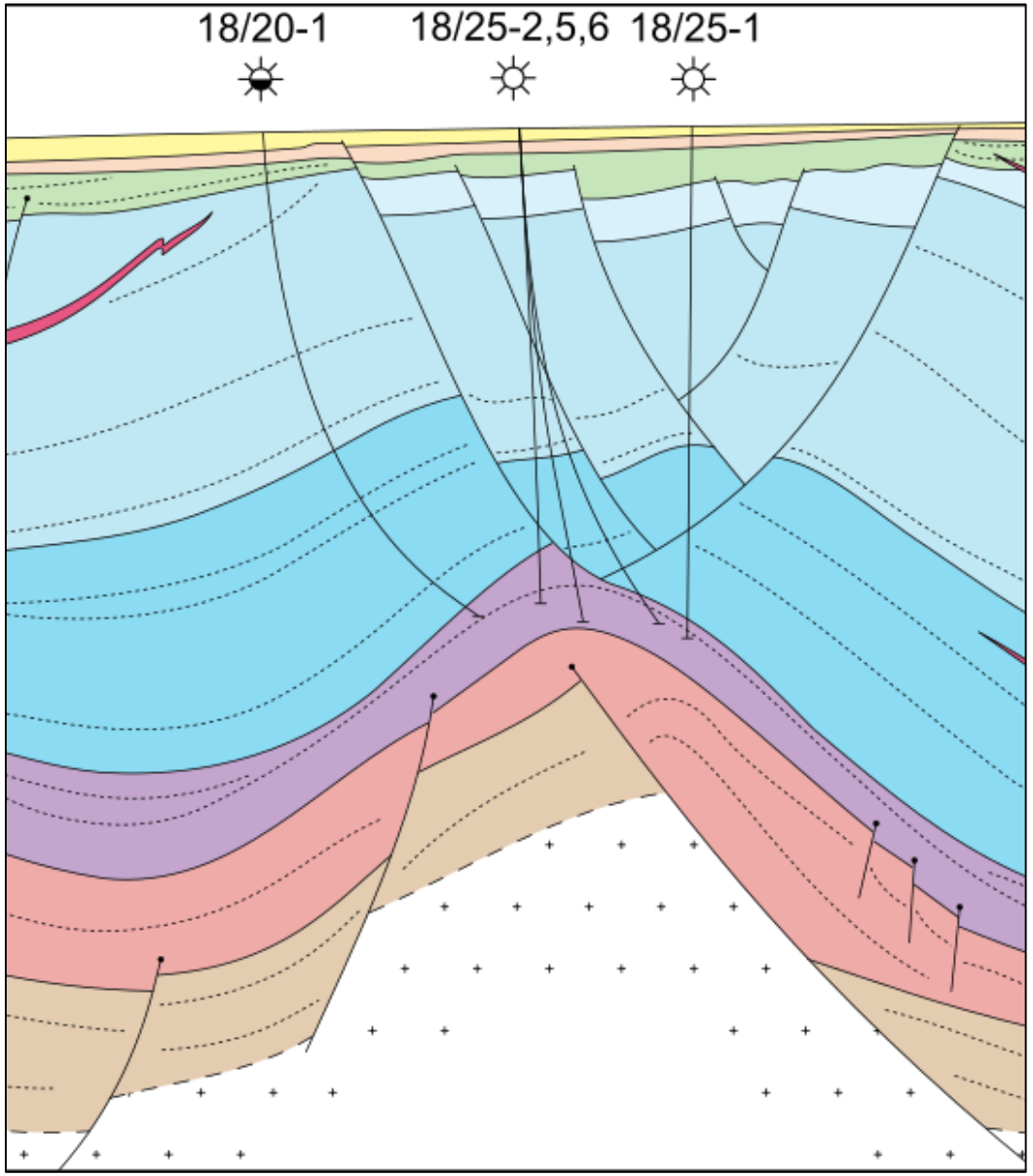


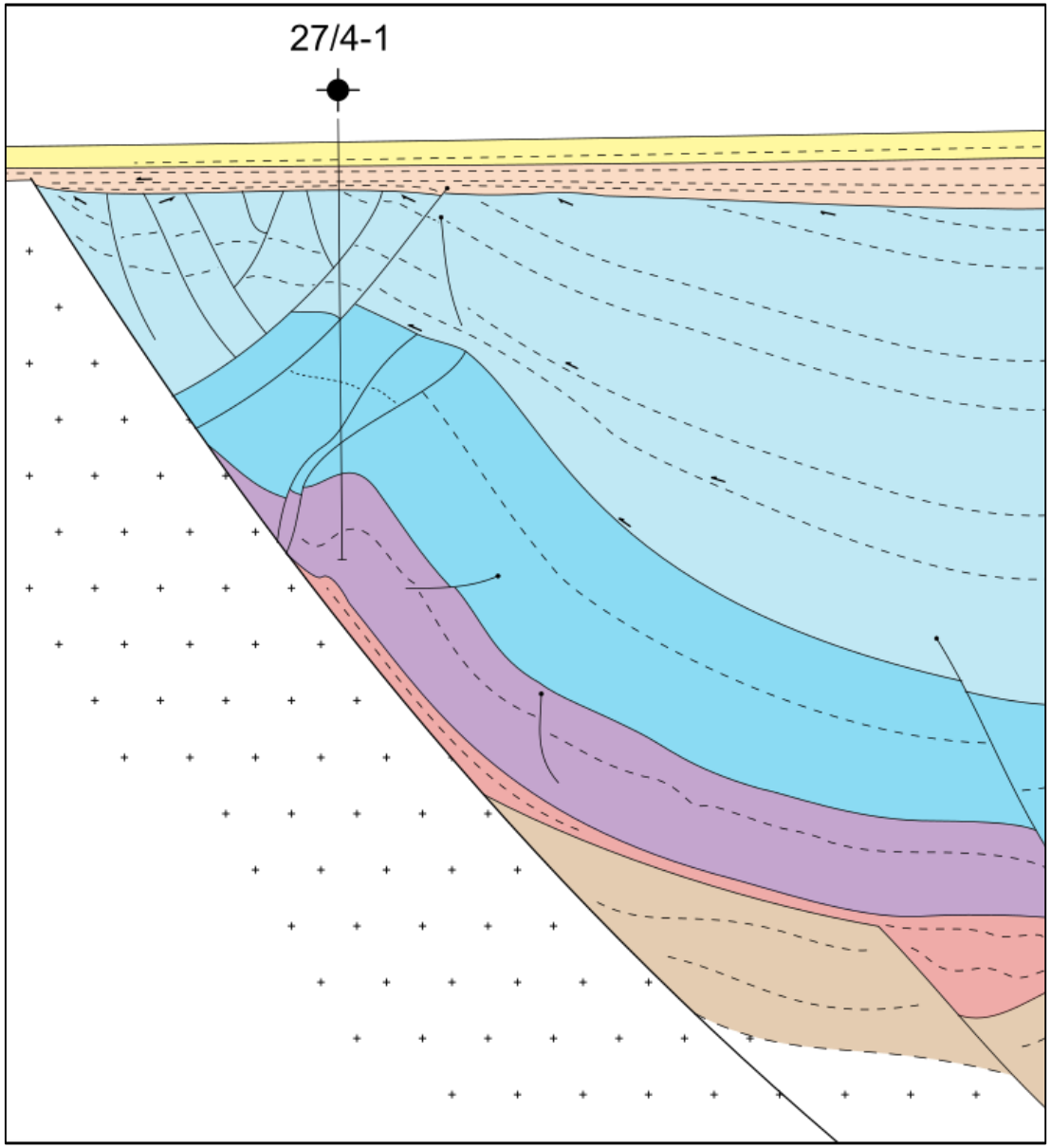




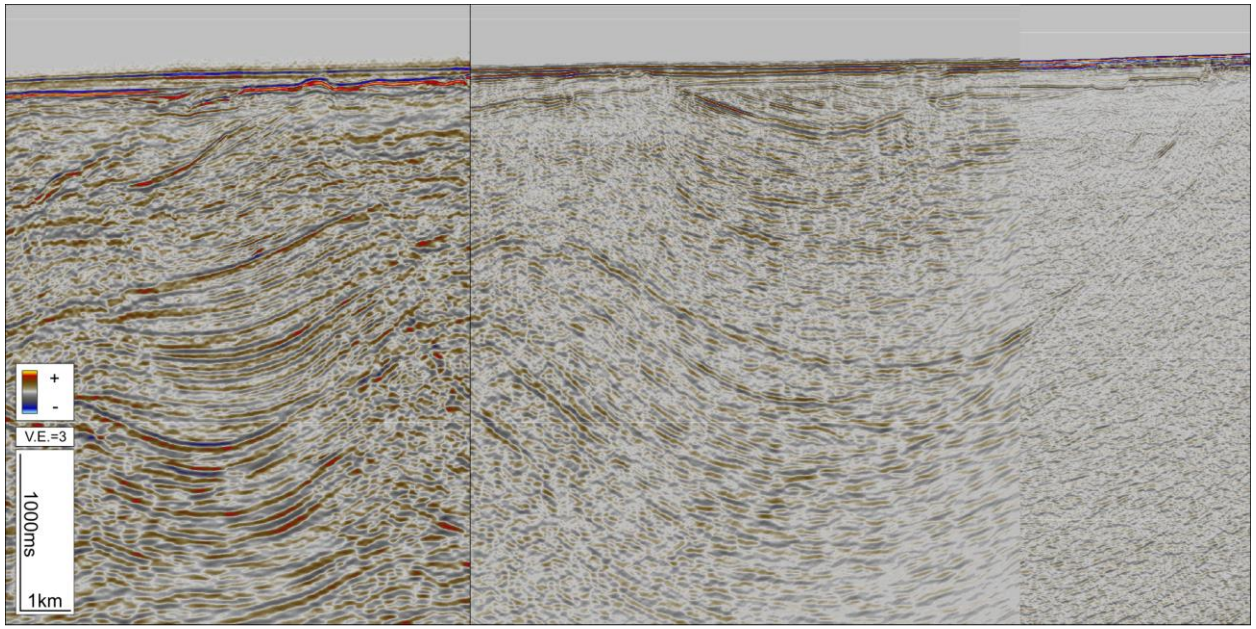


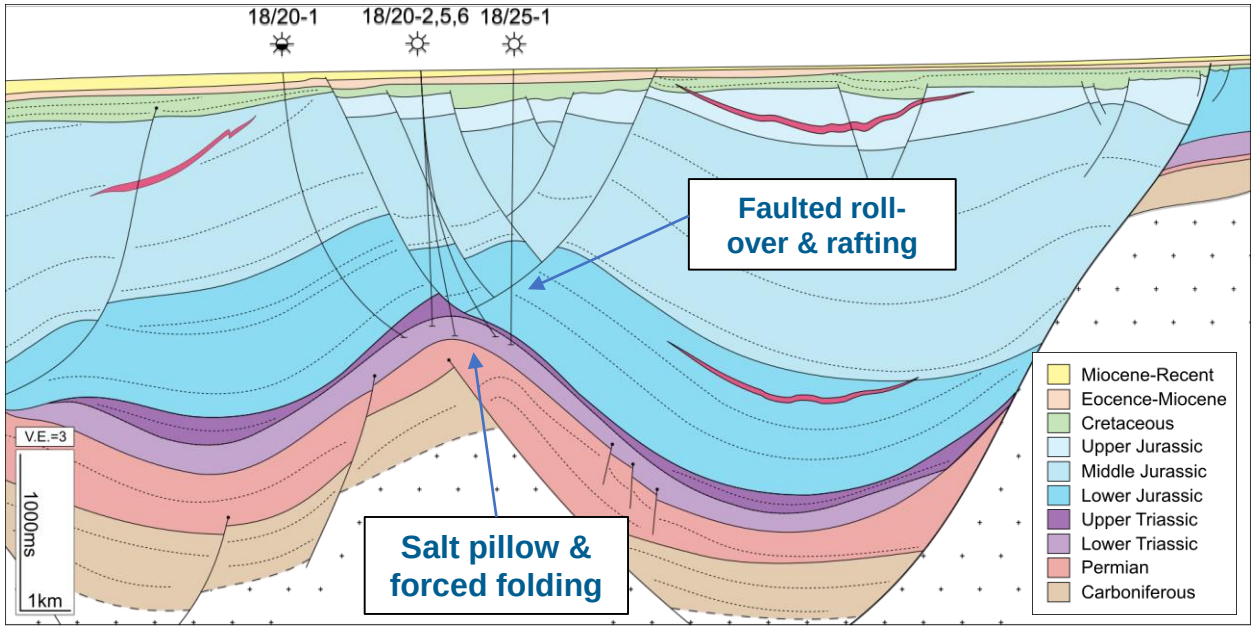
Structural traps in the Slyne Basin





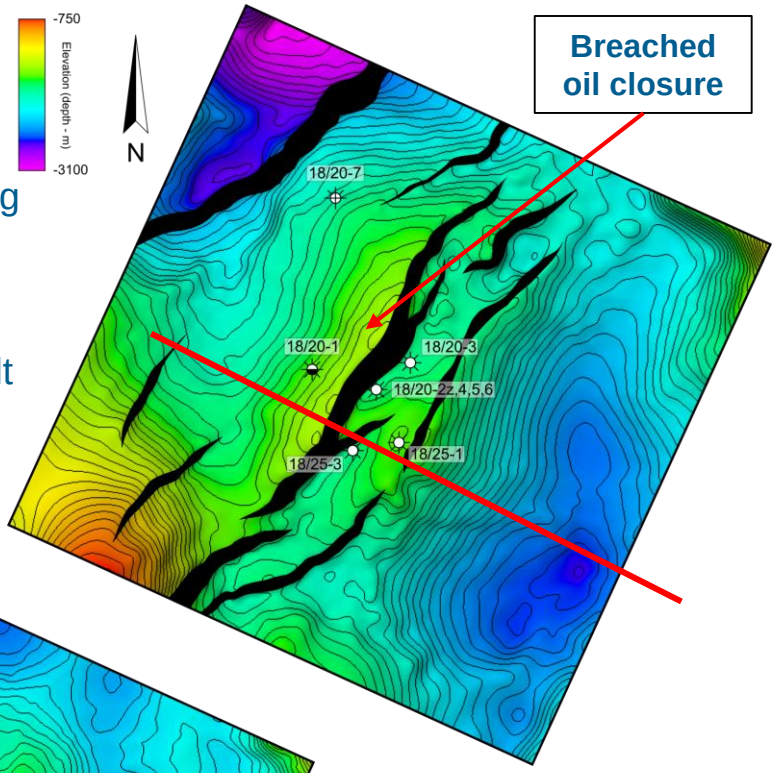
Corrib Gas Field – Double-Decker Salt Tectonics

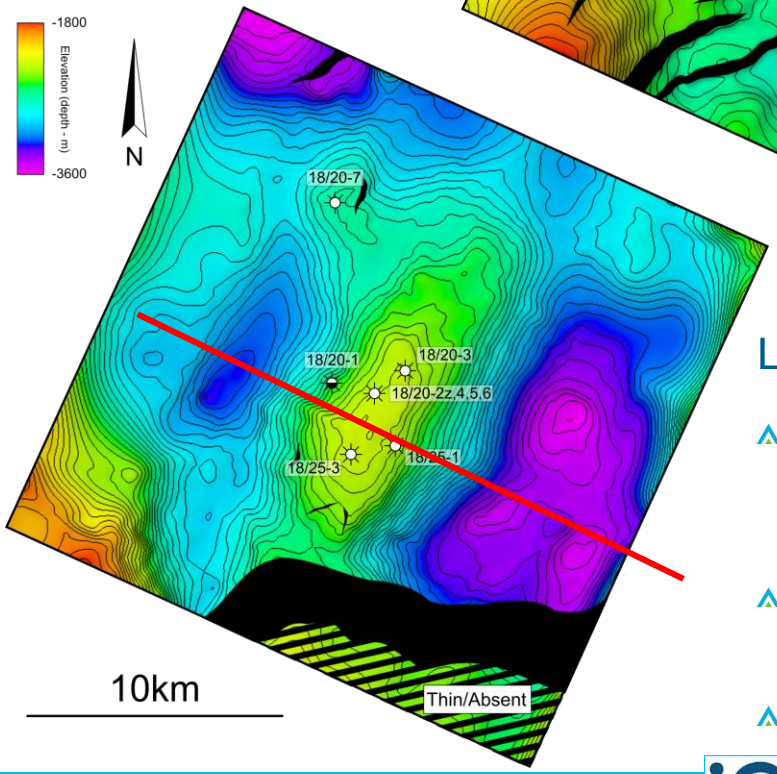




Middle Jurassic:

- 3-way dip closed tilted-fault block with bounding listric fault
- Evidence for post-rift movement on listric fault
- Breached oil column



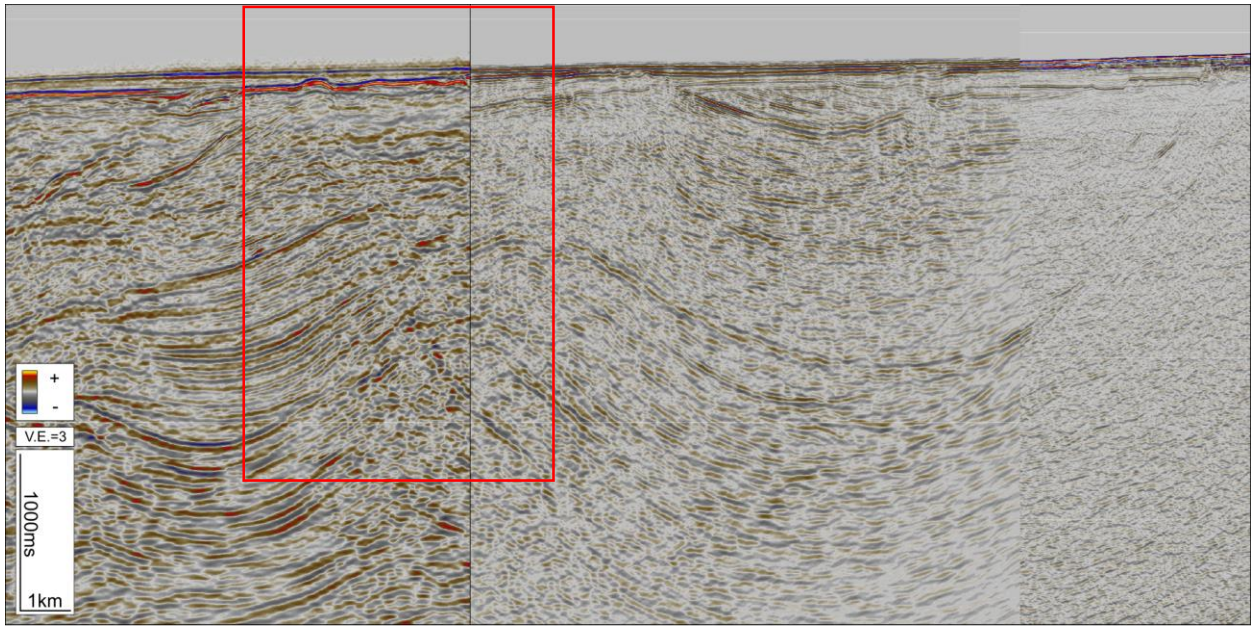


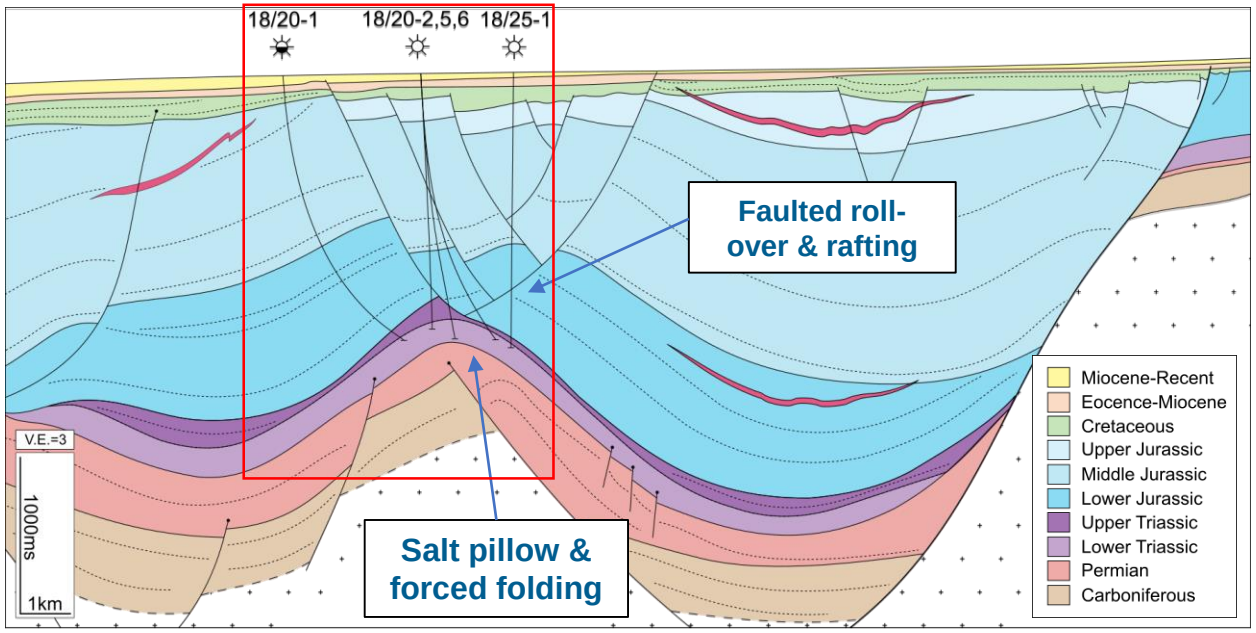
Lower Triassic:

- Sits between two salt layers (Permian and Upper Triassic)
- Simple 4-way dip closed anticline
- Gas charged structure

Corcoran & Mecklenburgh, 2005; Dancer et al., 2005

Corrib Gas Field – Double-Decker Salt Tectonics





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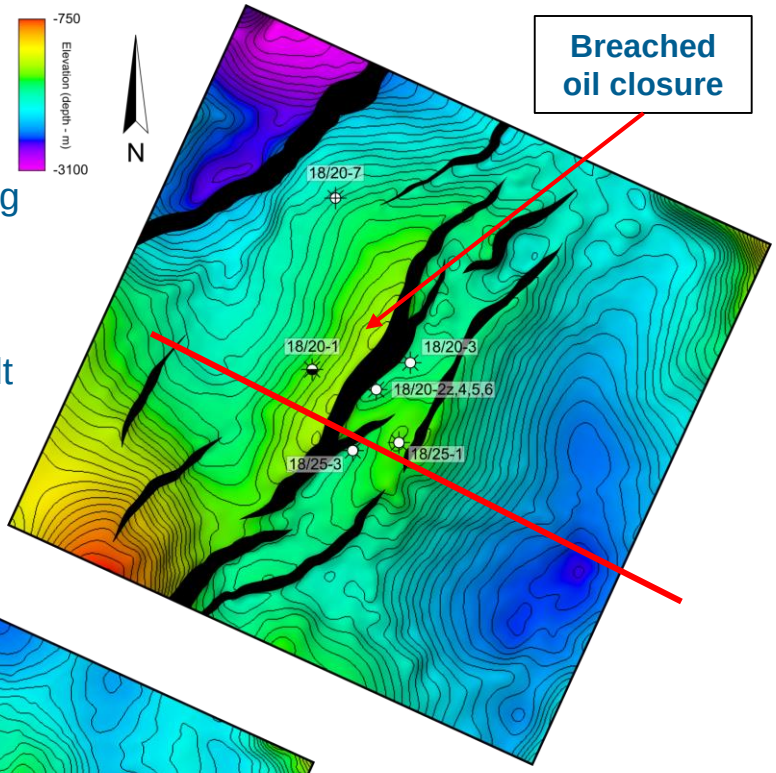

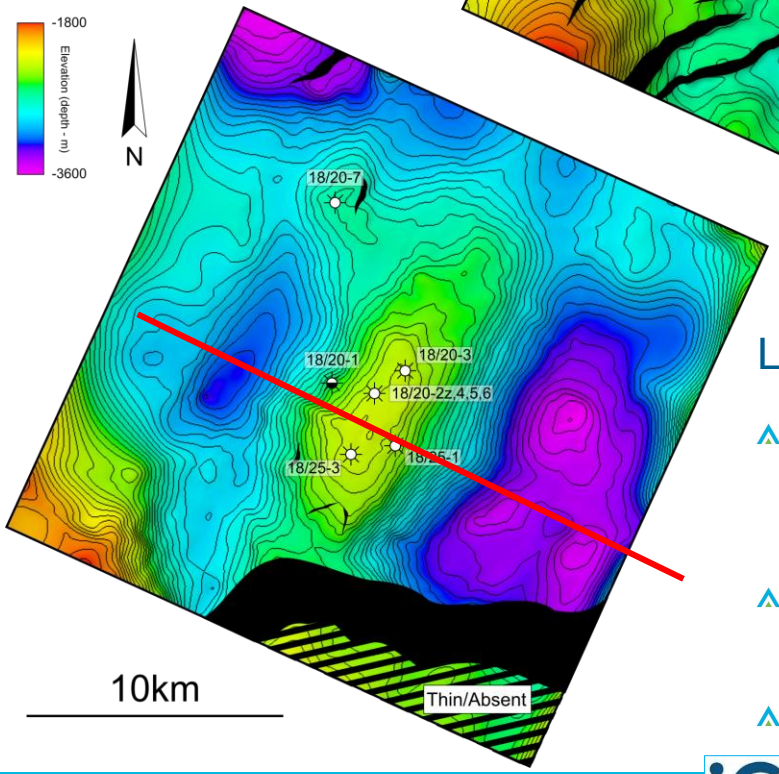

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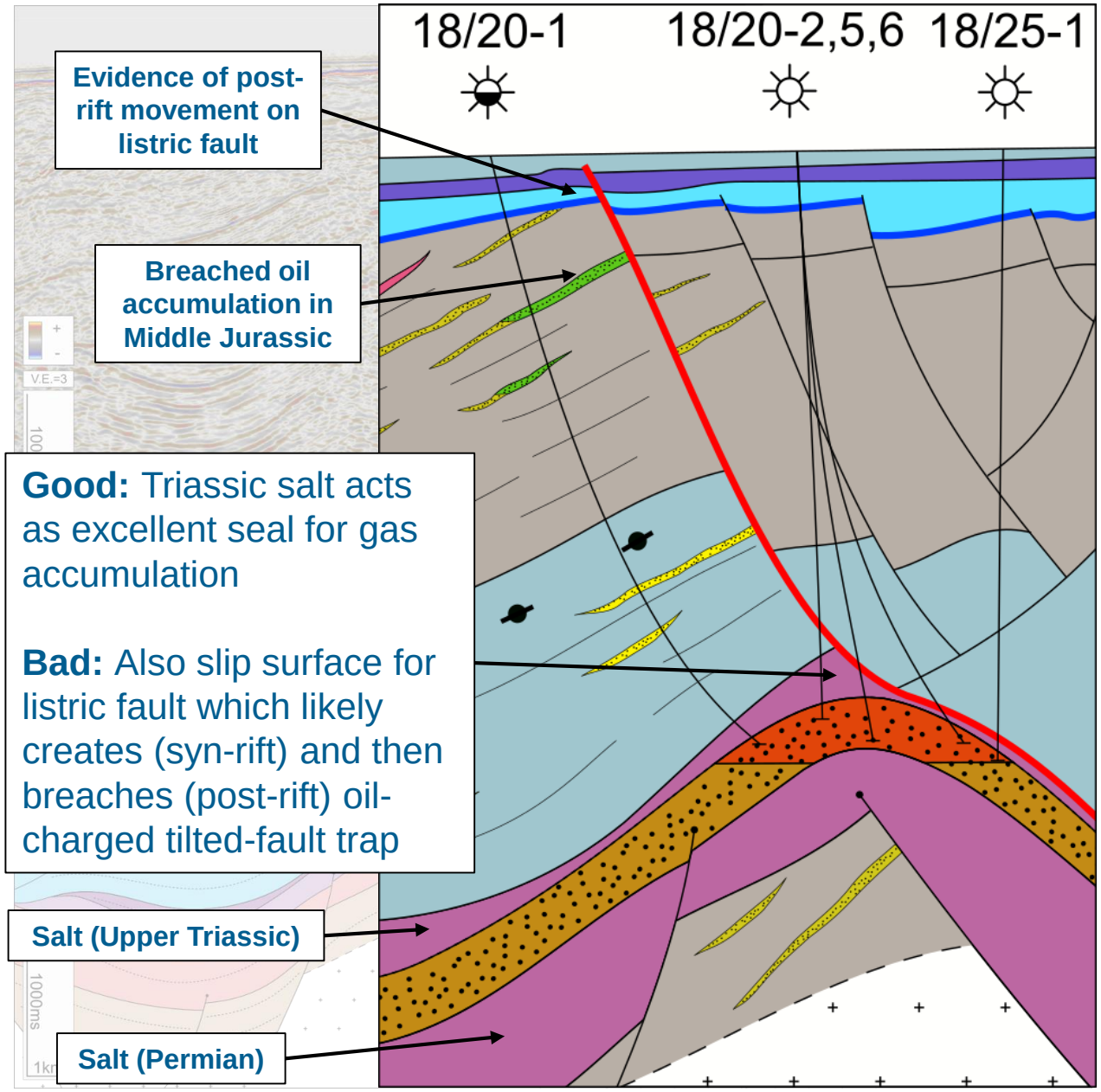

Good: Triassic salt acts as excellent seal for gas accumulation

Bad: Also slip surface for listric fault which likely creates (syn-rift) and then breaches (post-rift) oil-charged tilted-fault trap

Middle Jurassic:

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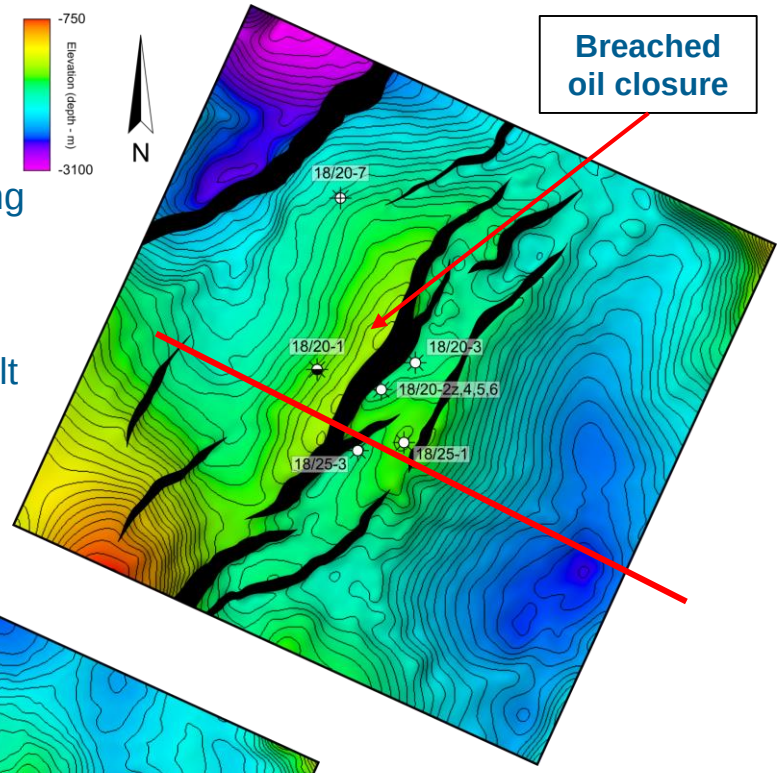
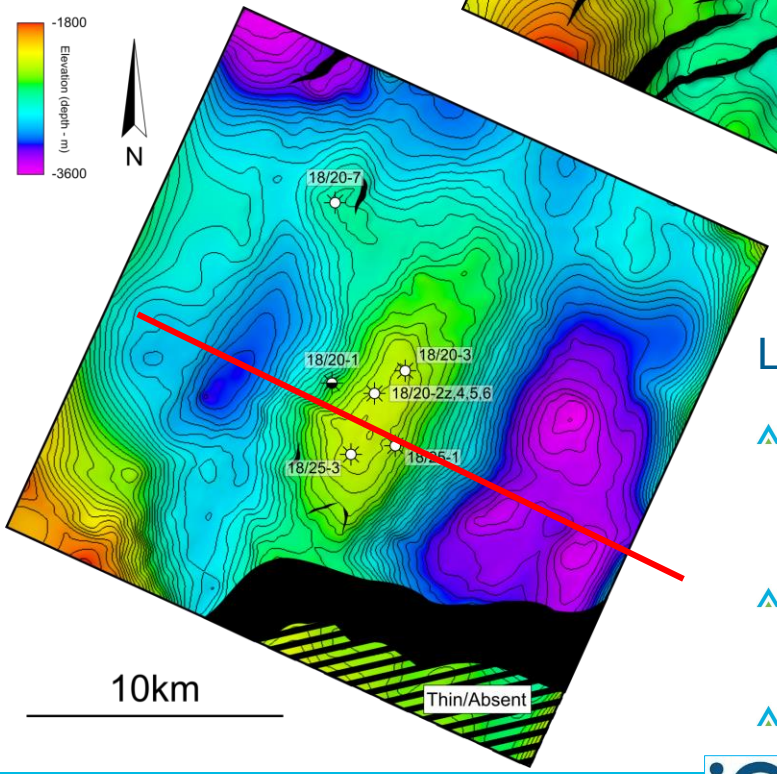
- Evidence for post-rift movement on listric fault
- Breached oil column





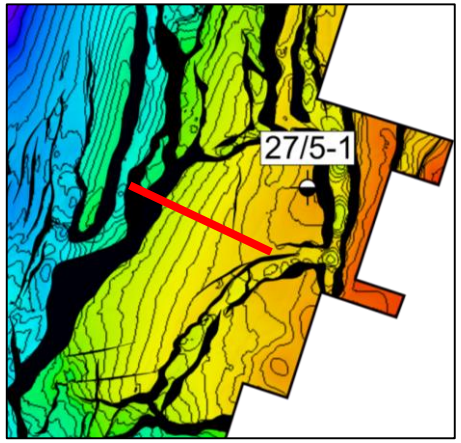
Lower Triassic:

- Sits between two salt layers (Permian and Upper Triassic)
- Simple 4-way dip closed anticline
- Gas charged structure

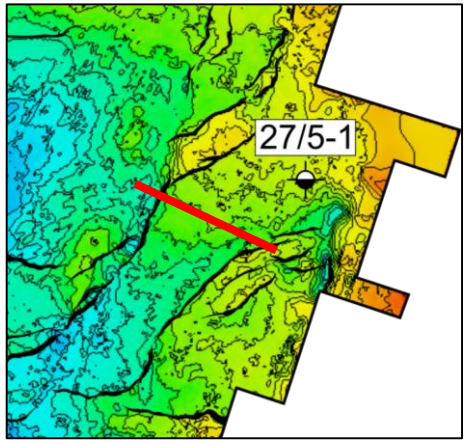
Post-rift listric fault movement

- Post-rift movement can breach traps
  - Both normal and reverse movements
  - Cross-fault juxtaposition

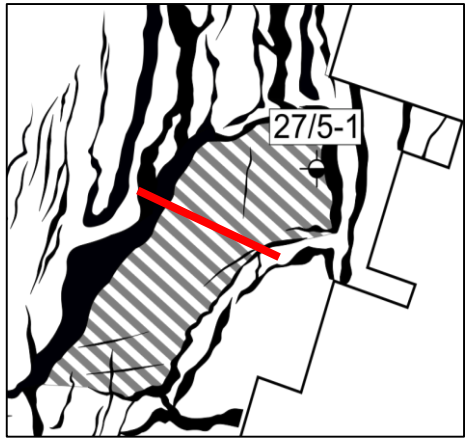
Lower Jurassic Structure Map



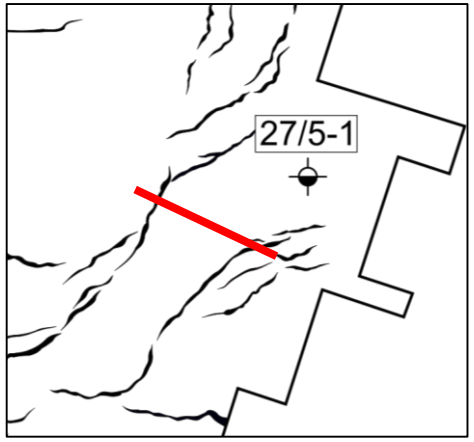
Base-Cenozoic Structure Map

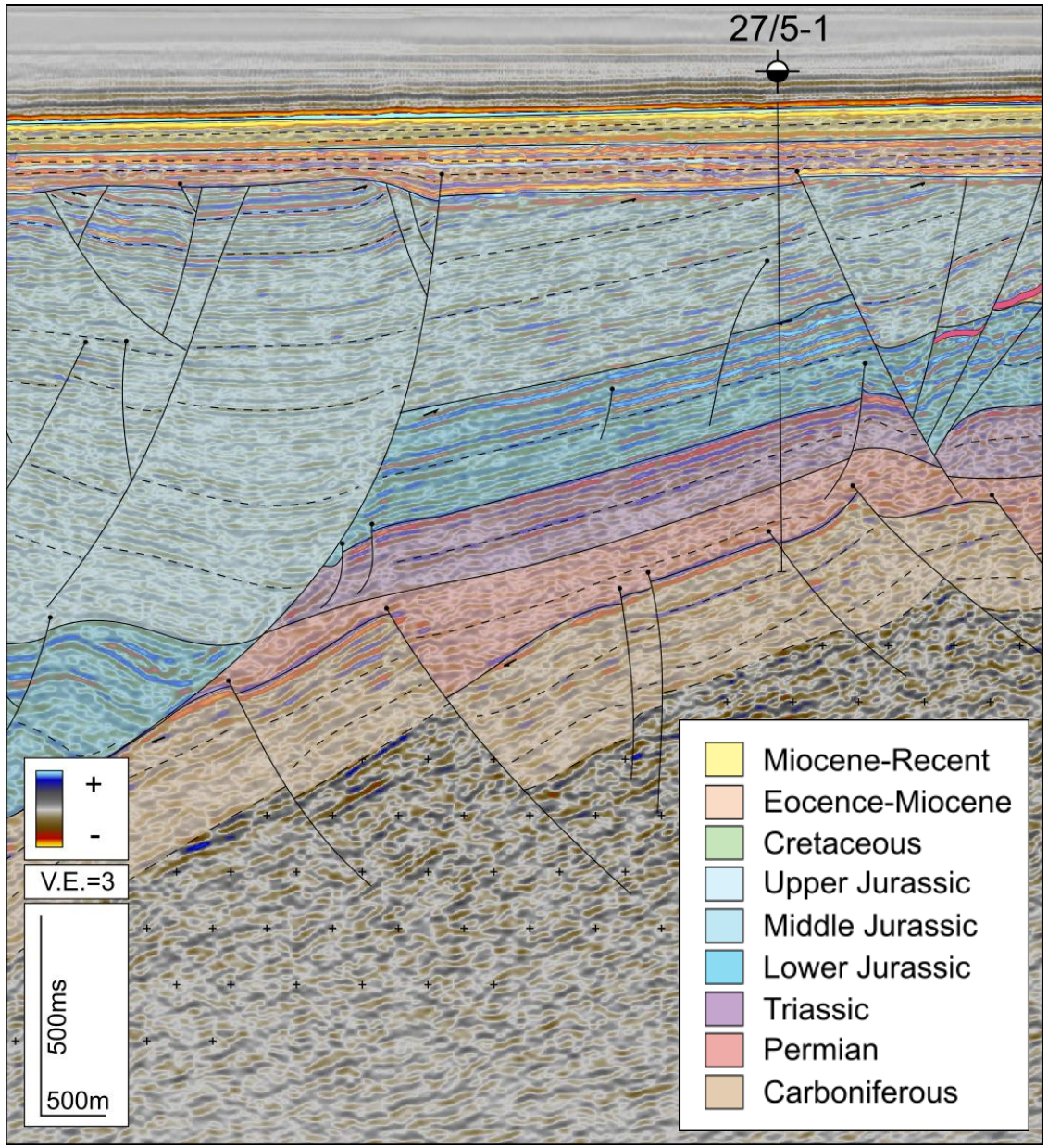


Lower Jurassic Fault Map



Base-Cenozoic Fault Map

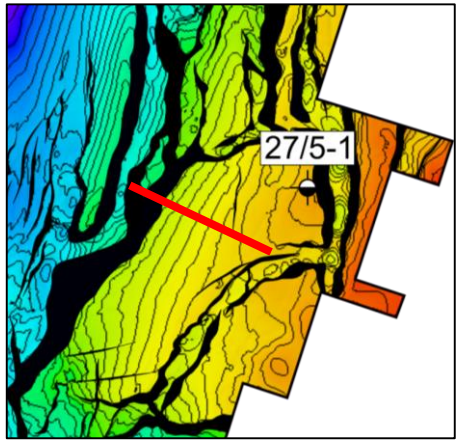




Post-rift listric fault movement

- Post-rift movement can breach traps
  - Both normal and reverse movements
  - Cross-fault juxtaposition

Lower Jurassic Structure Map



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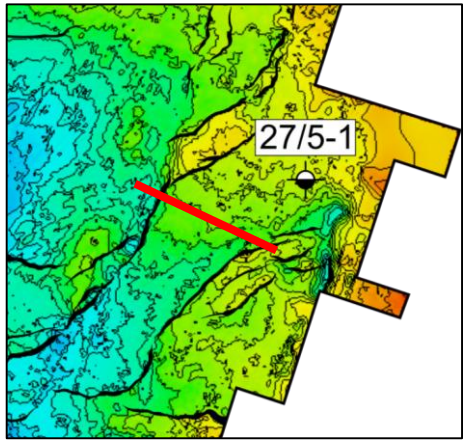

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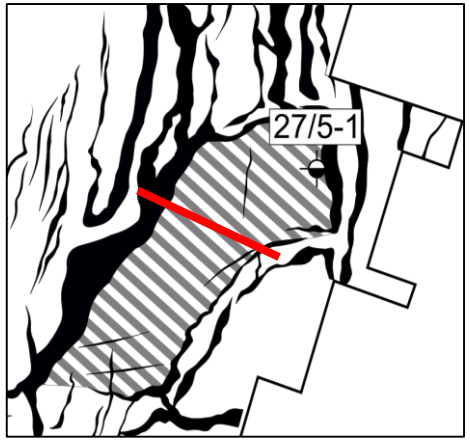

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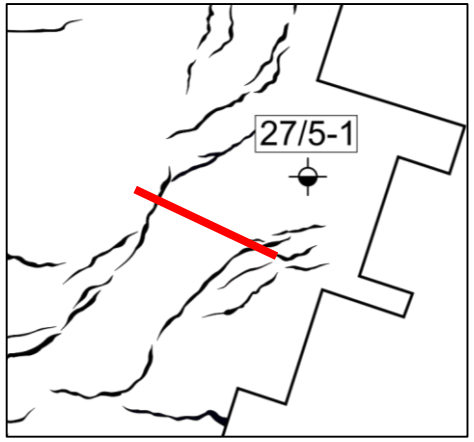

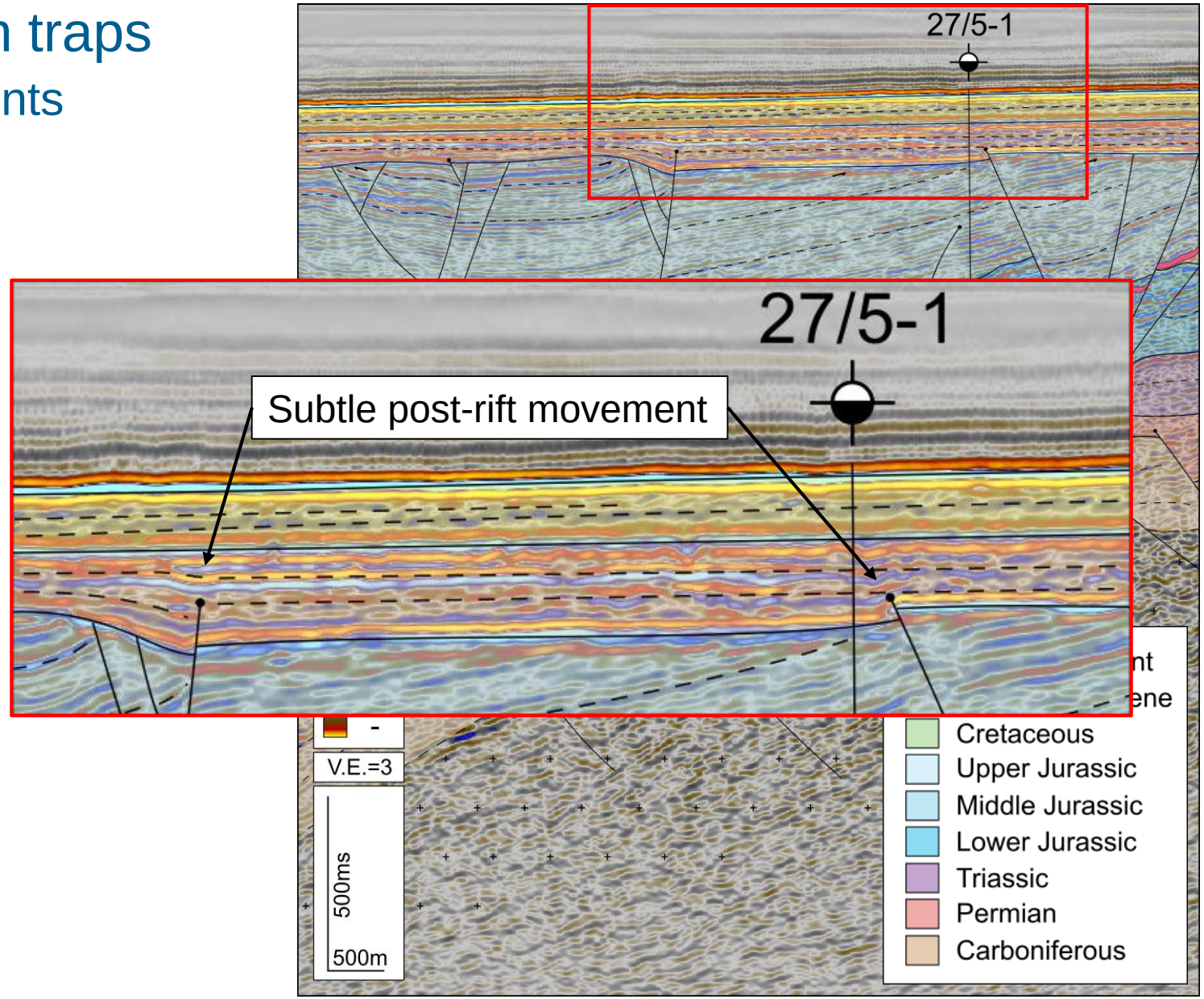

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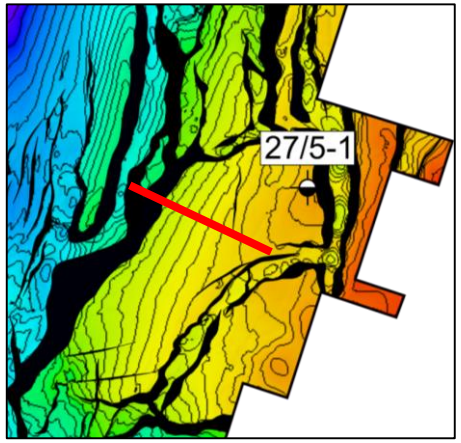
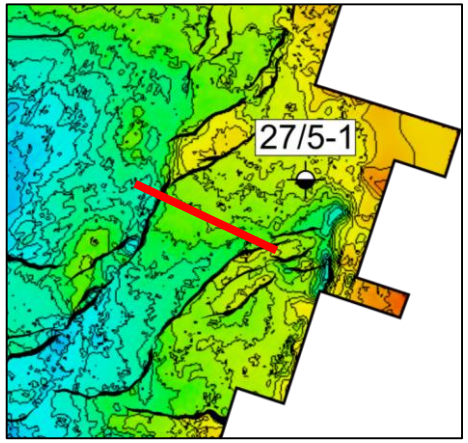
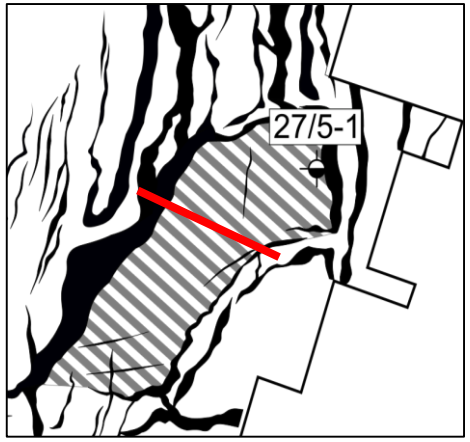


Base-Cenozoic Structure Map



Lower Jurassic Fault Map



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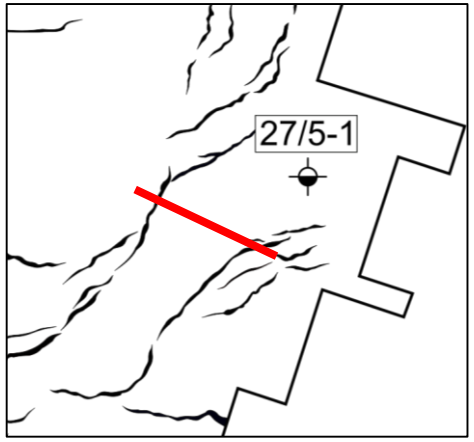
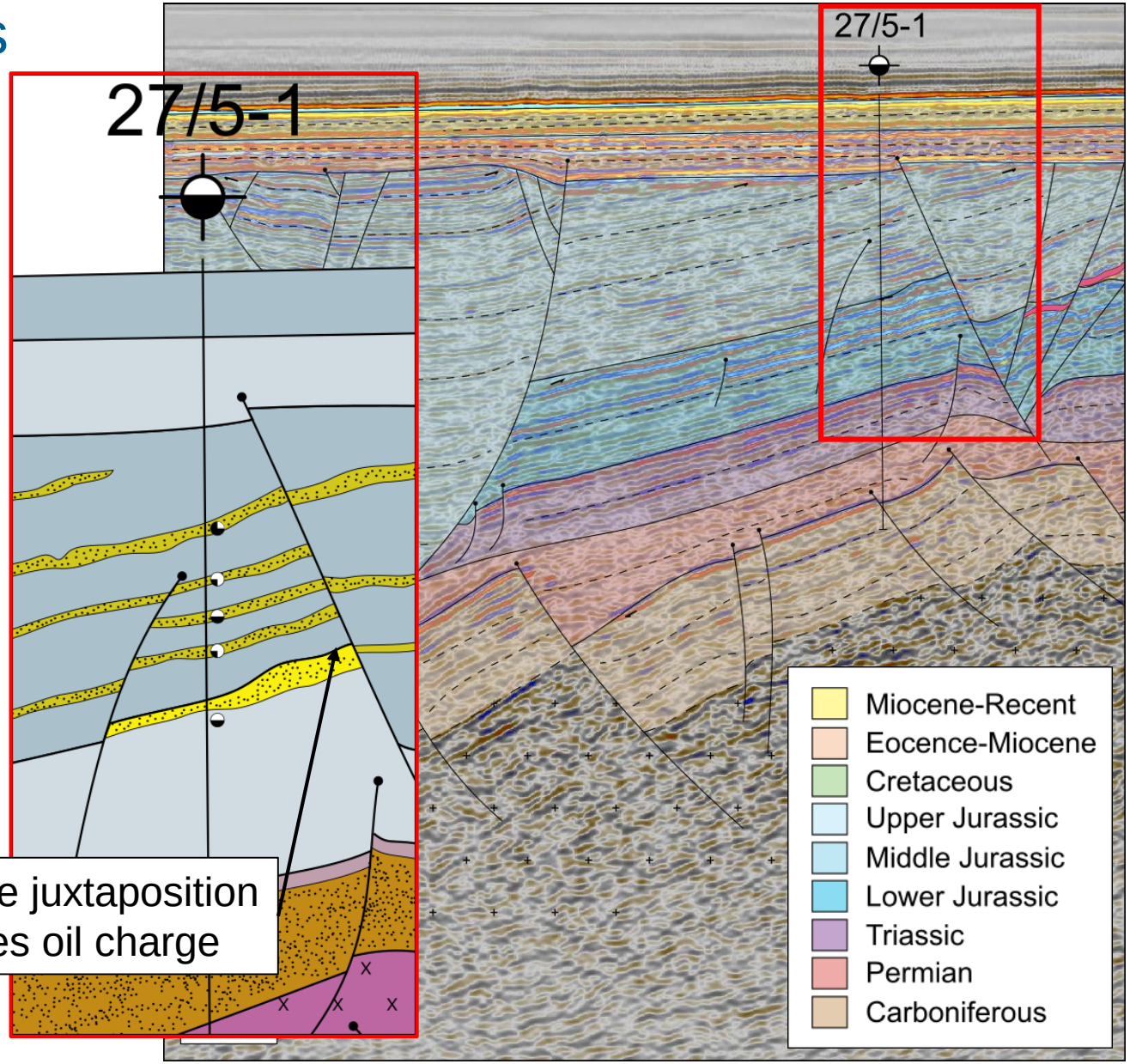
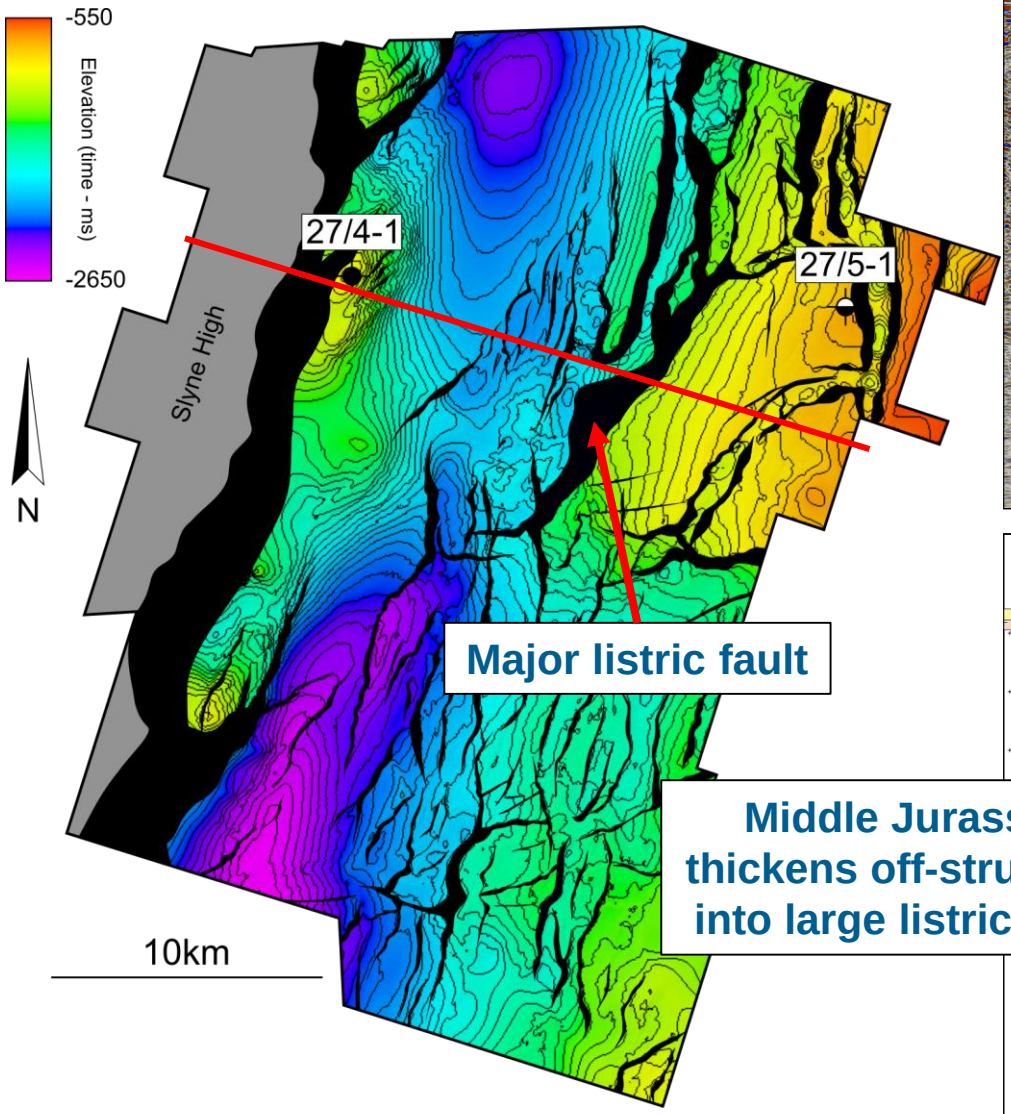
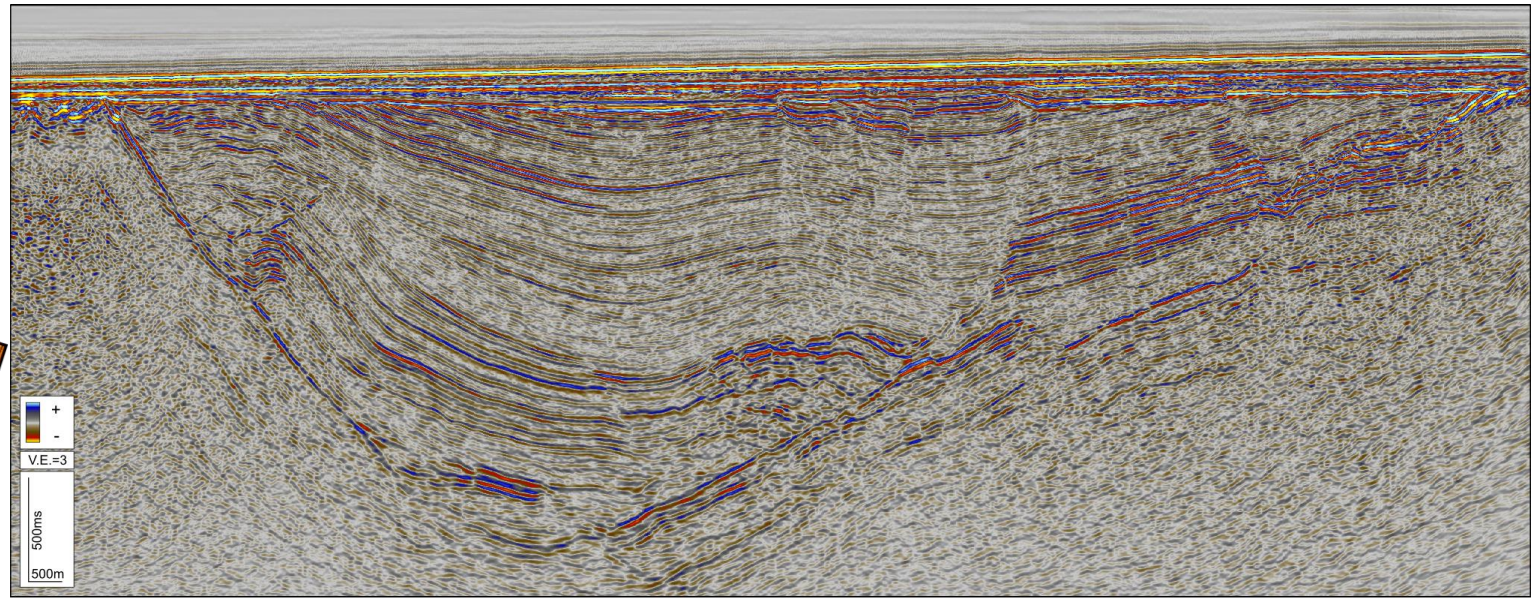


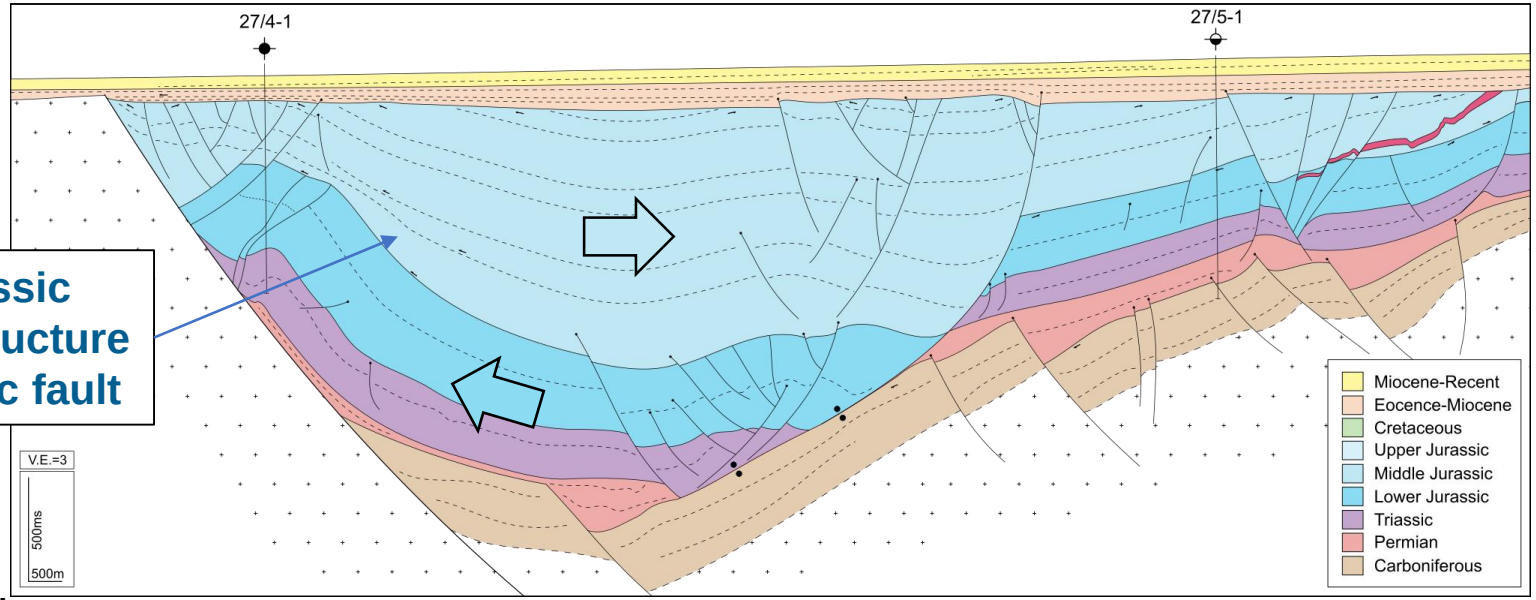


Bandon Oil Discovery



Time-structure map Lower Jurassic 'Hettangian Limestone Marker'





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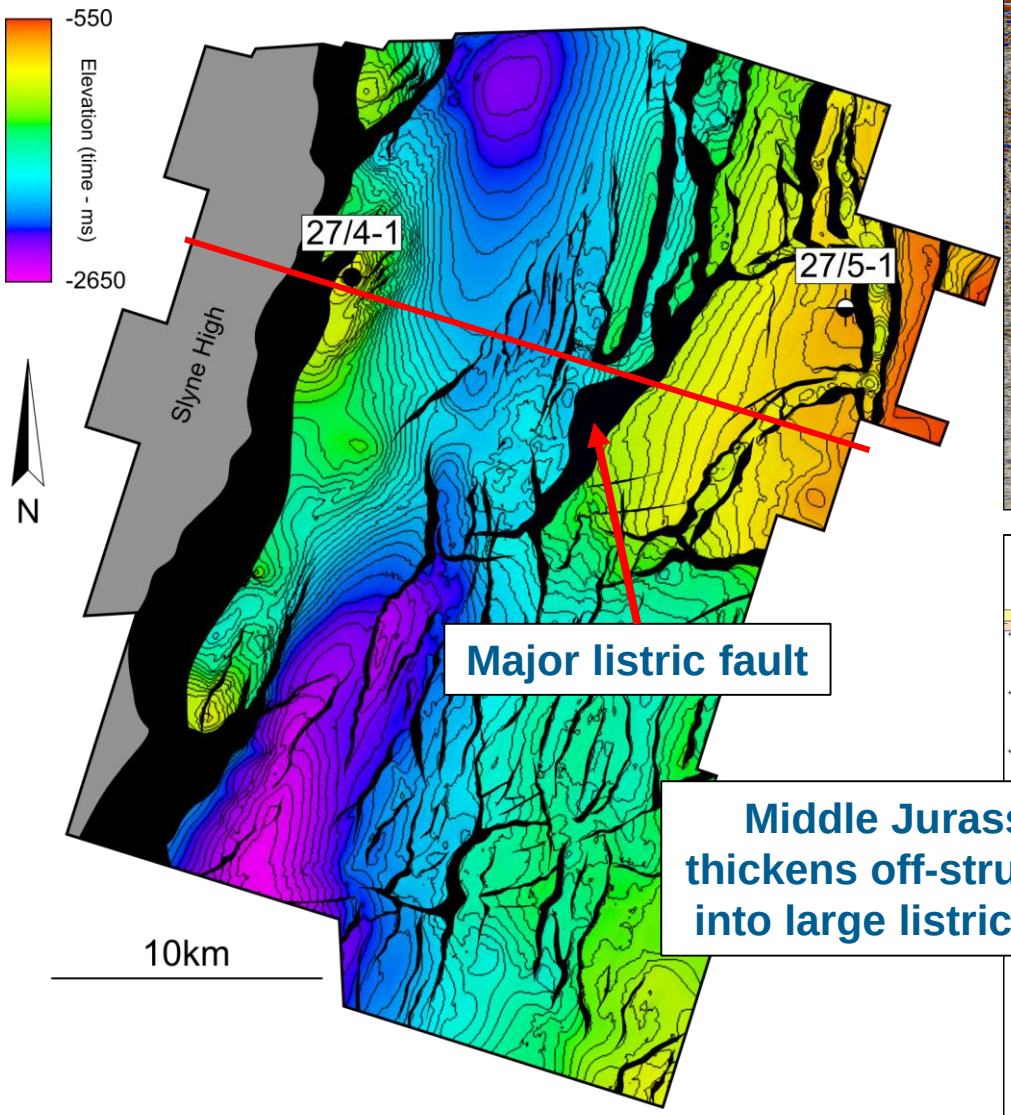

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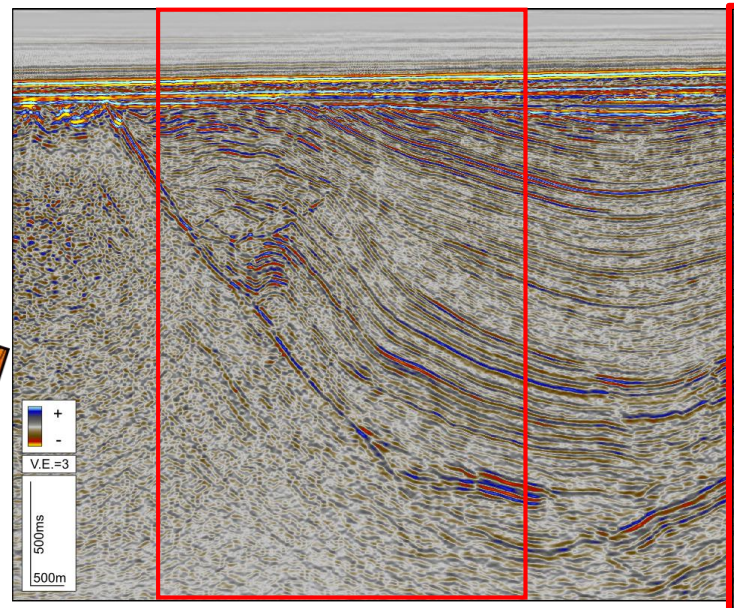
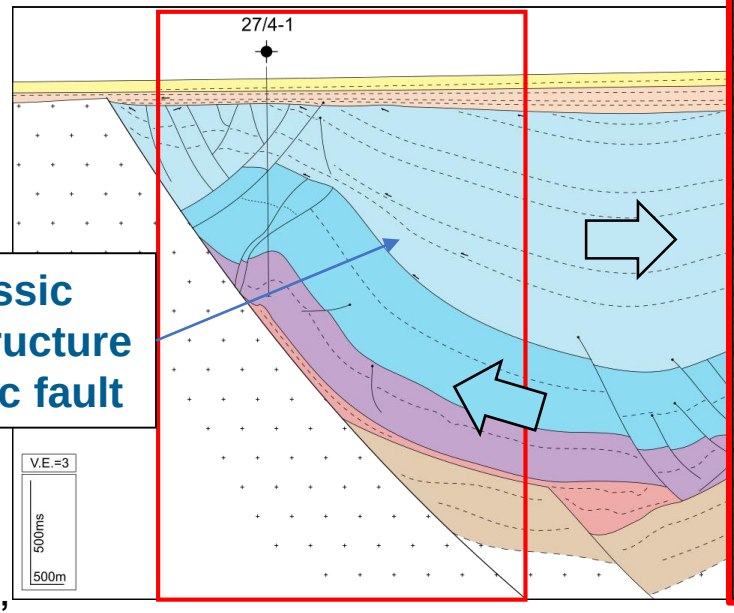
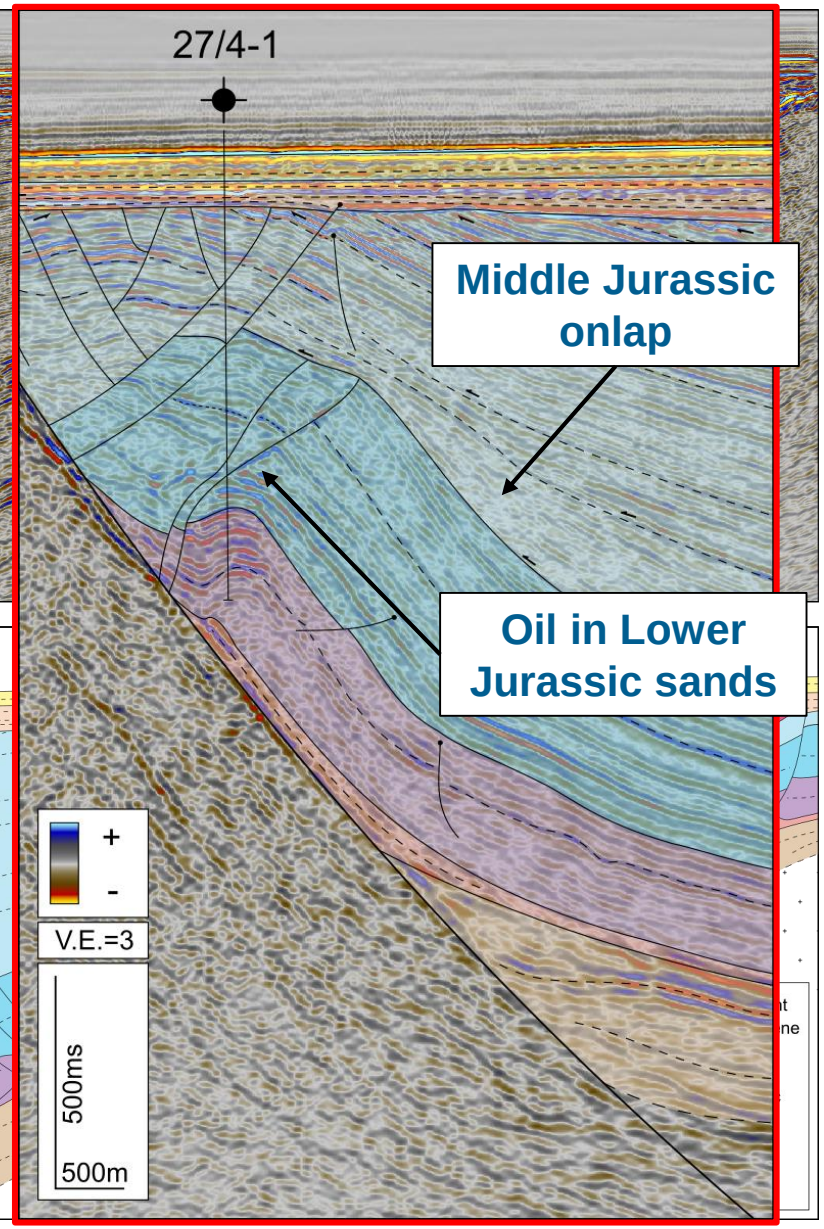
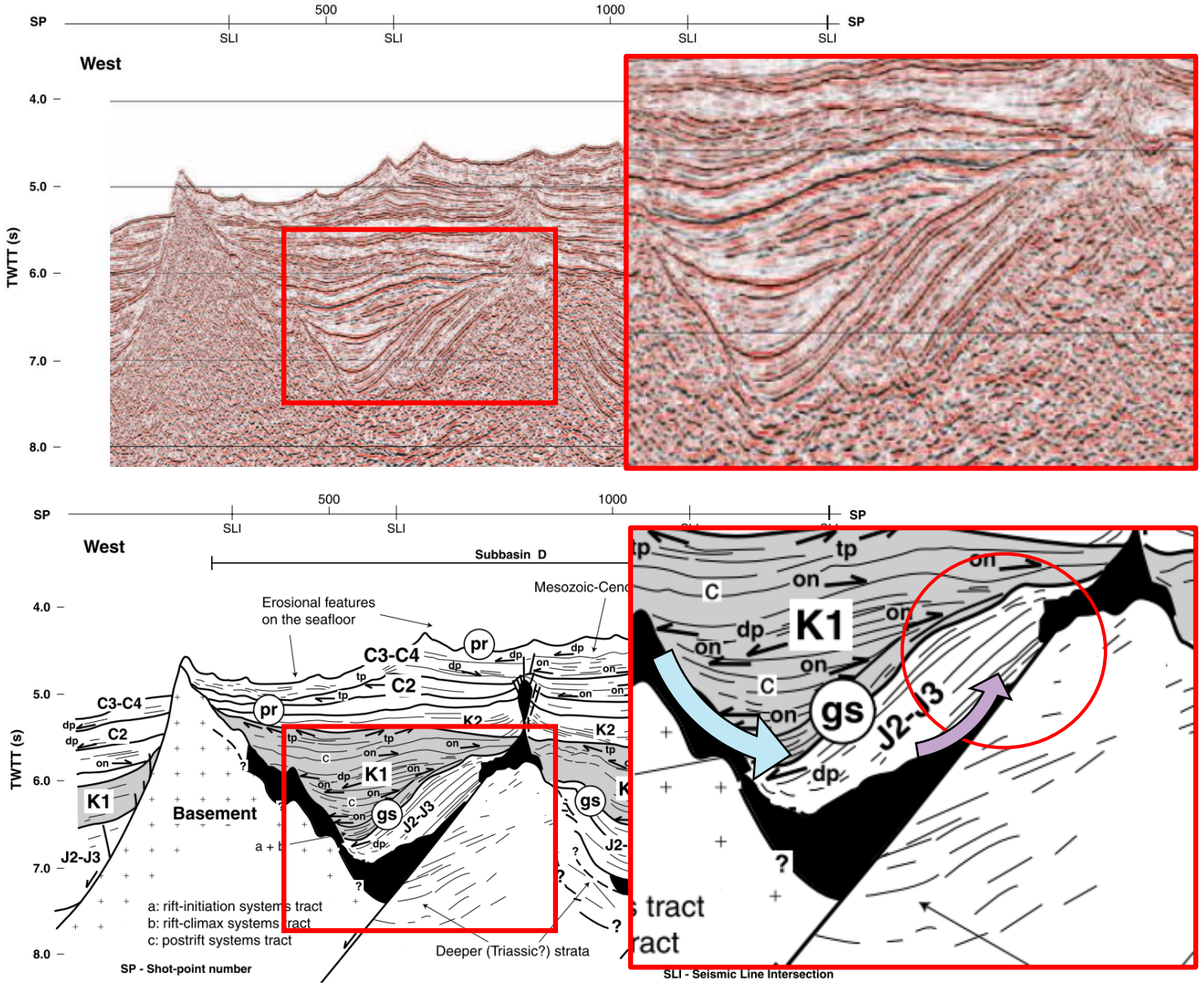
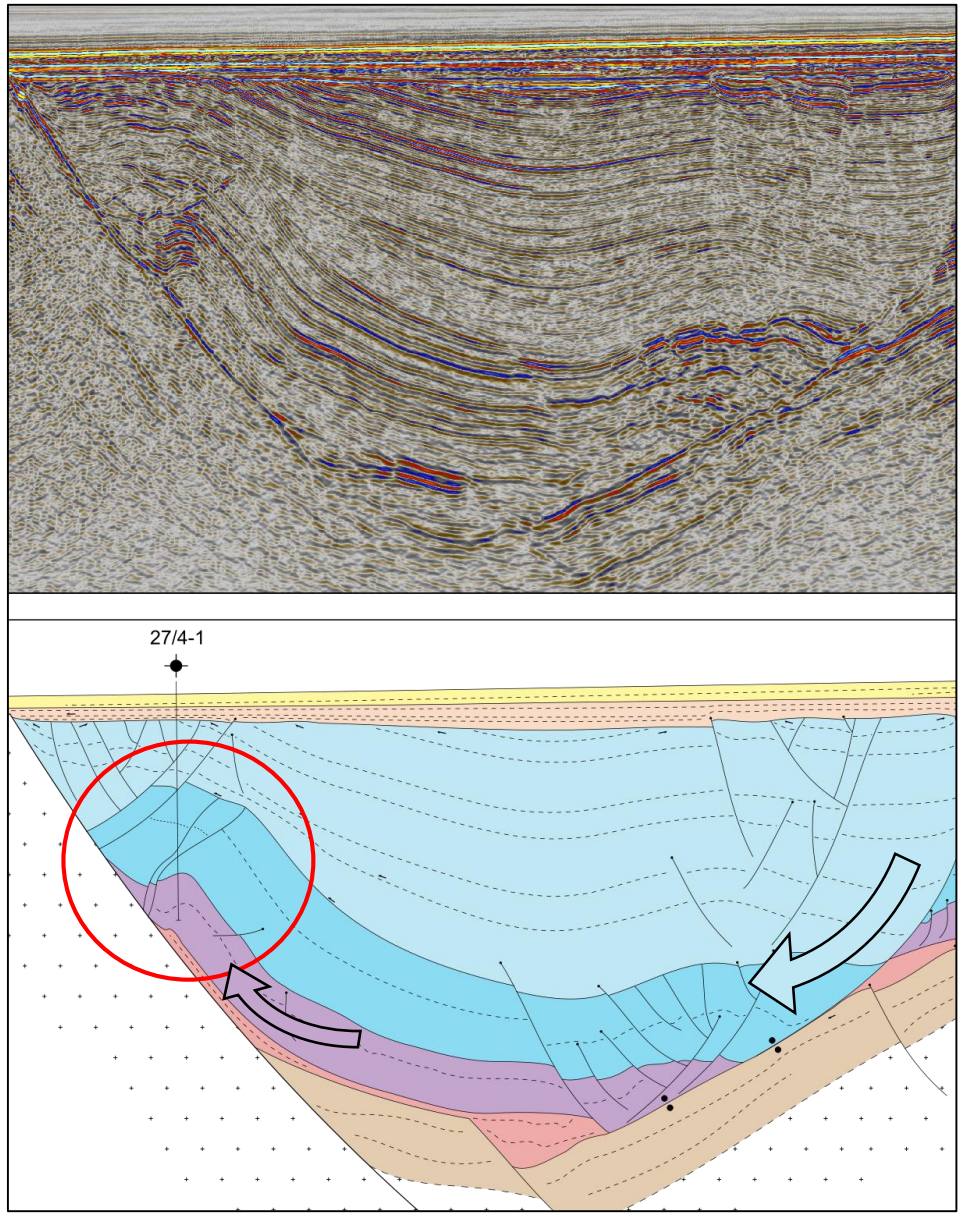






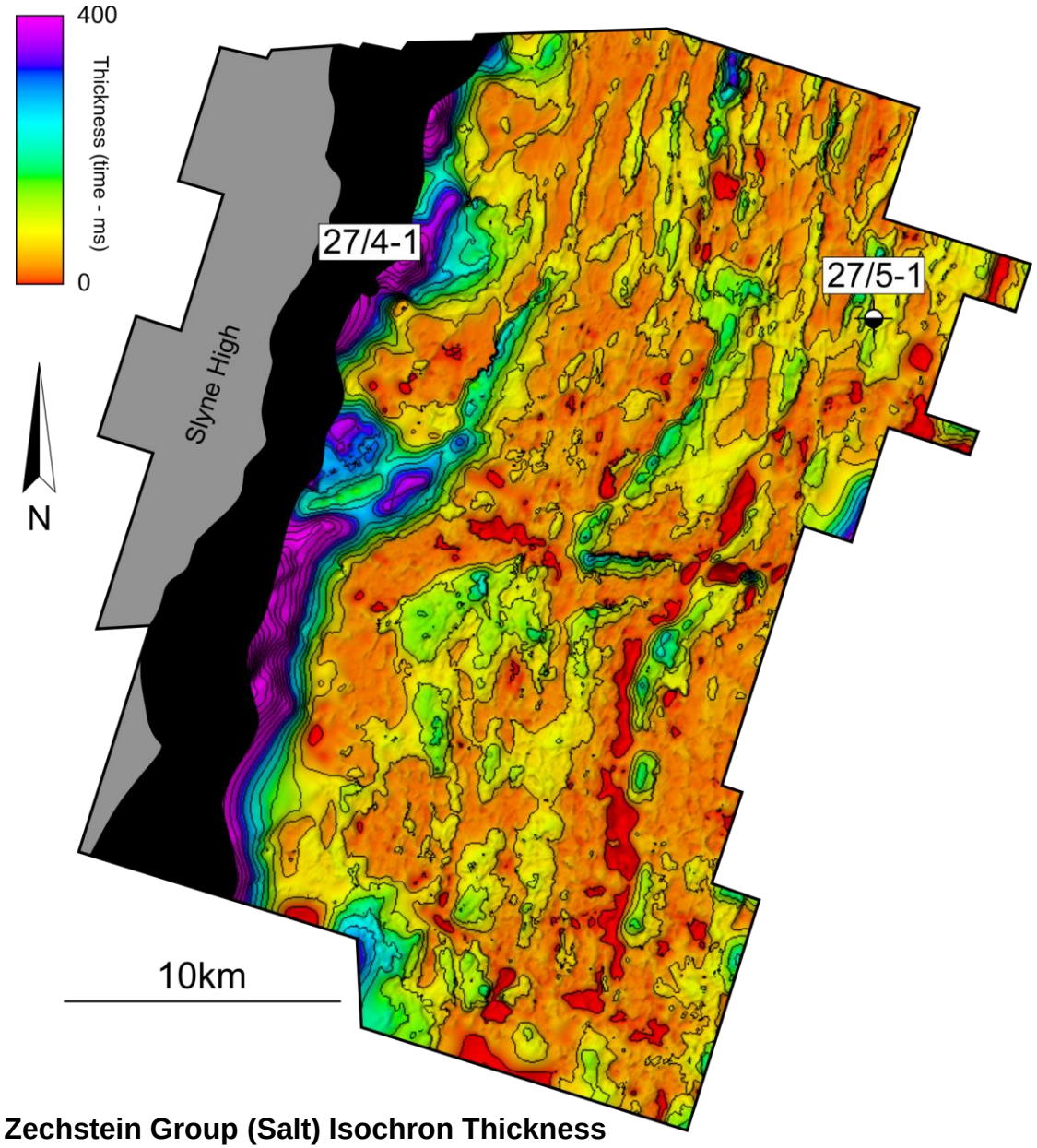
Analogues from the Portuguese Atlantic Margin





Alves et al., 2006

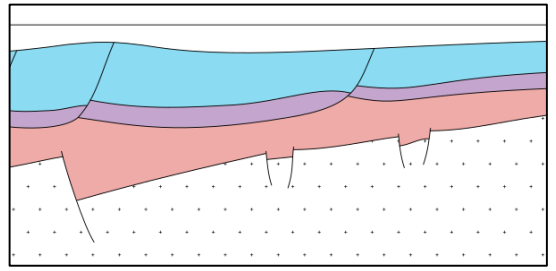
Salt withdrawal in the Slyne Basin



Zechstein Group (Salt) Isochron Thickness

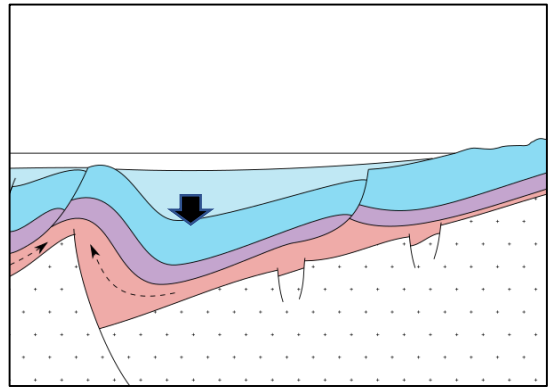
Lower Jurassic:

- Significantly thicker salt than present day



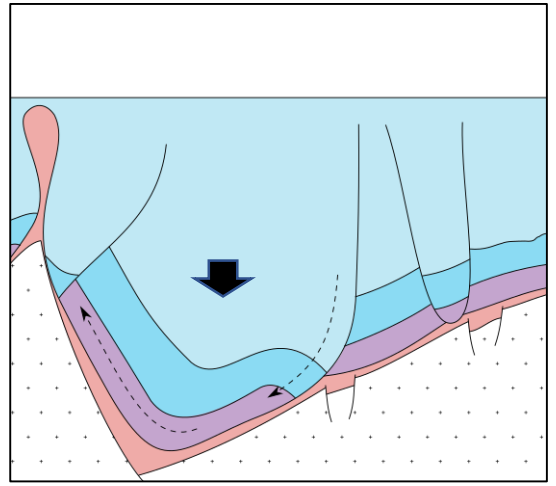
Middle Jurassic:

- Salt doming and withdrawal up basin-bounding faults

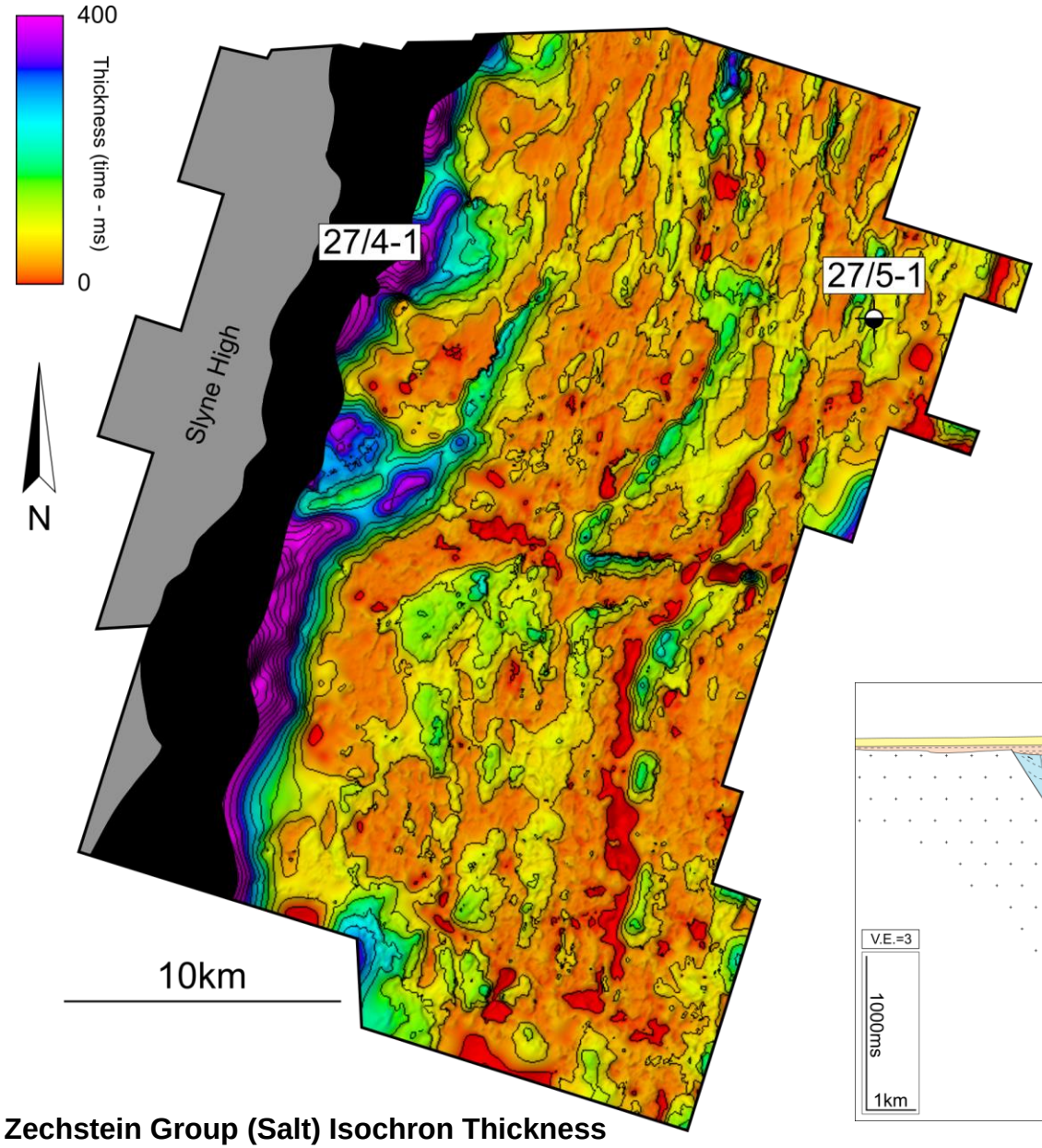


Middle-Late Jurassic:

- Further withdrawal causes salt to thin and weld
- Salt thickens against bounding fault as it evacuates



Salt withdrawal in the Slyne Basin



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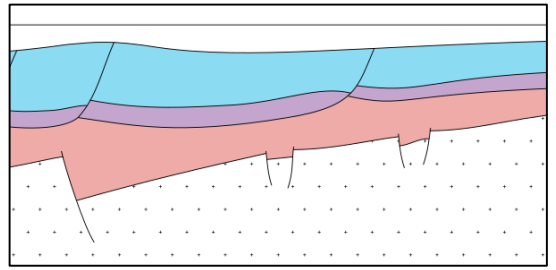

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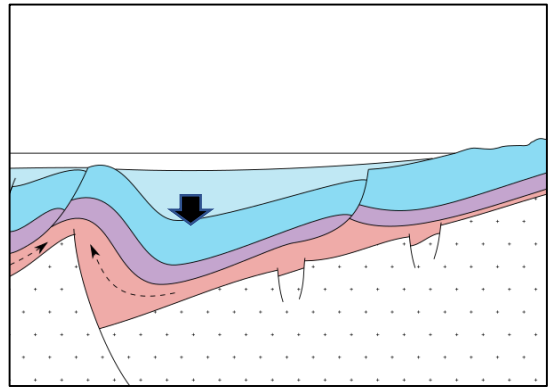
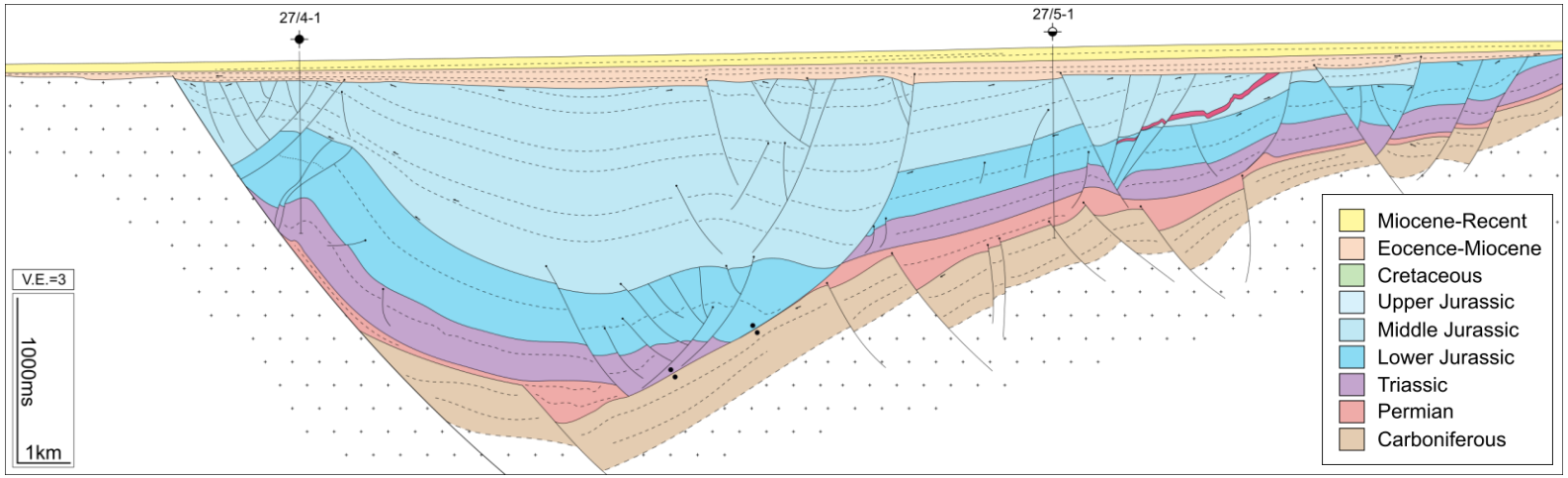
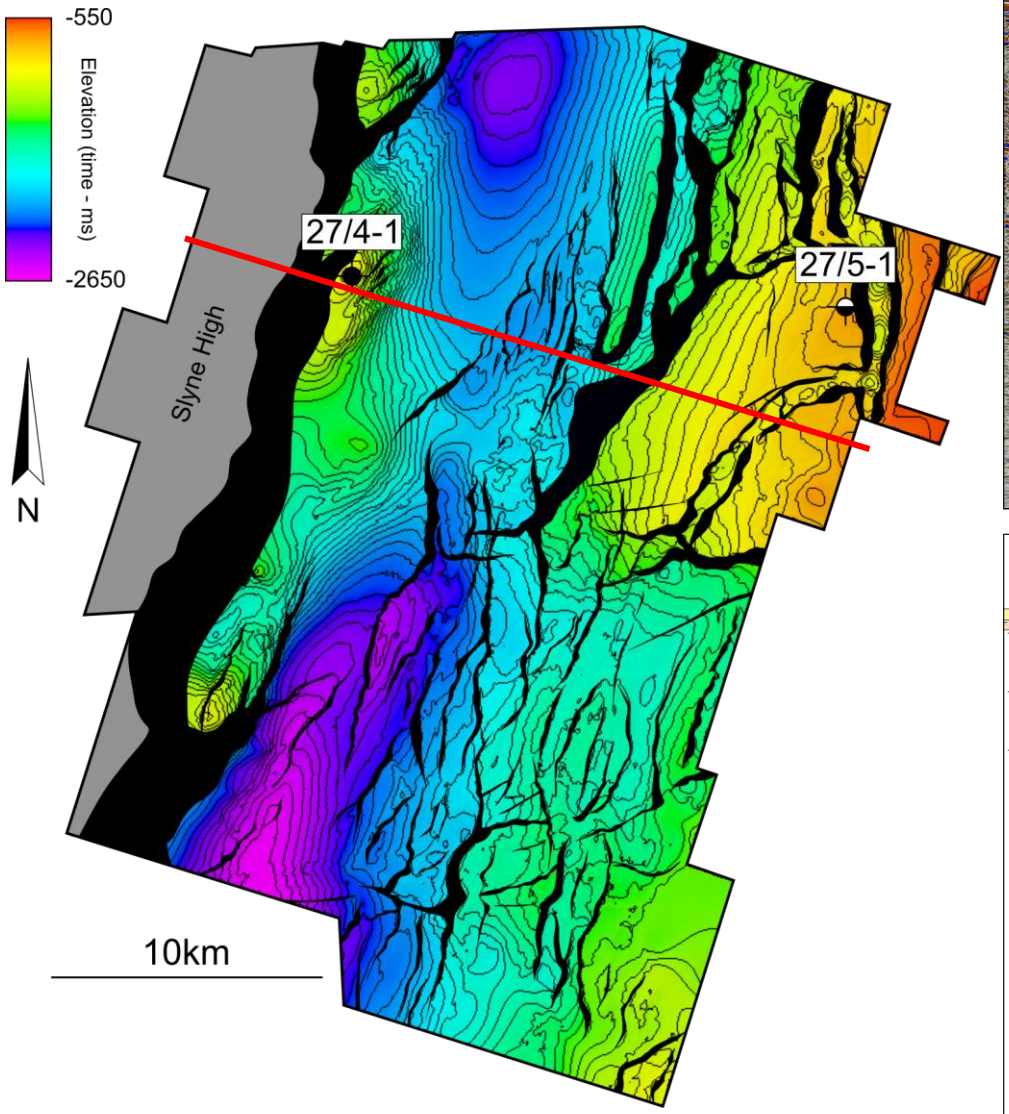
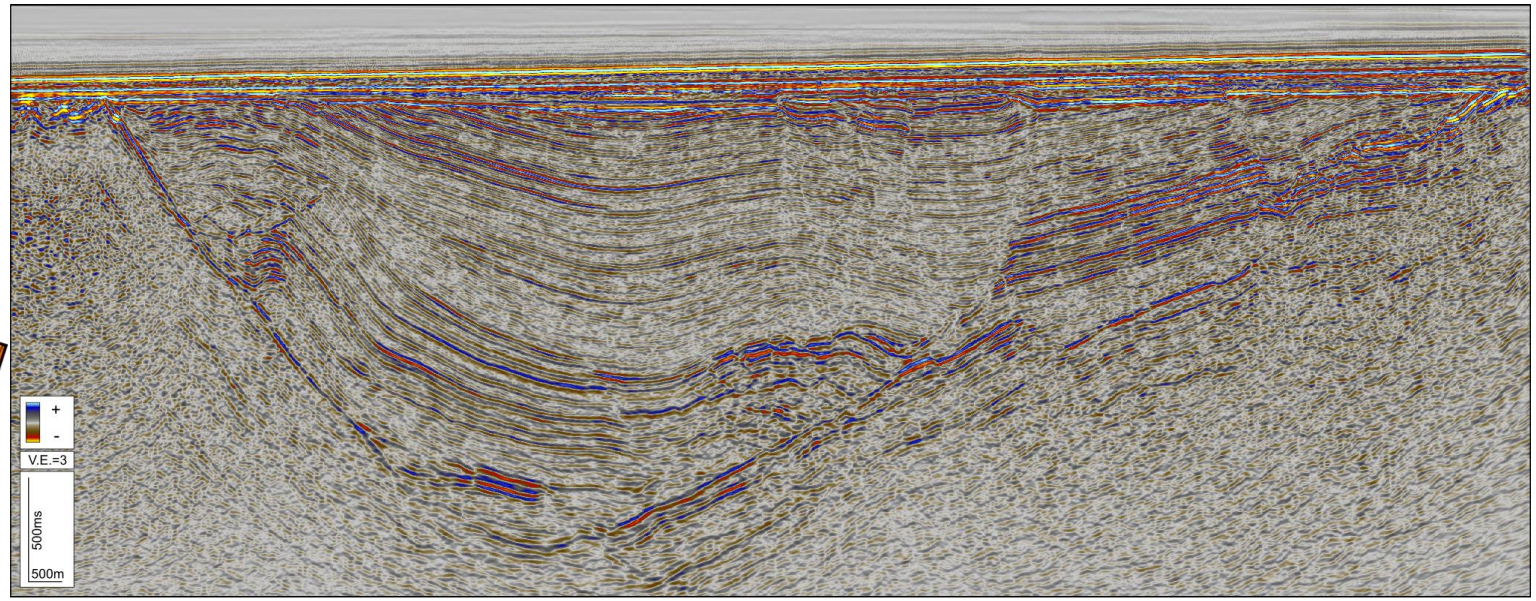


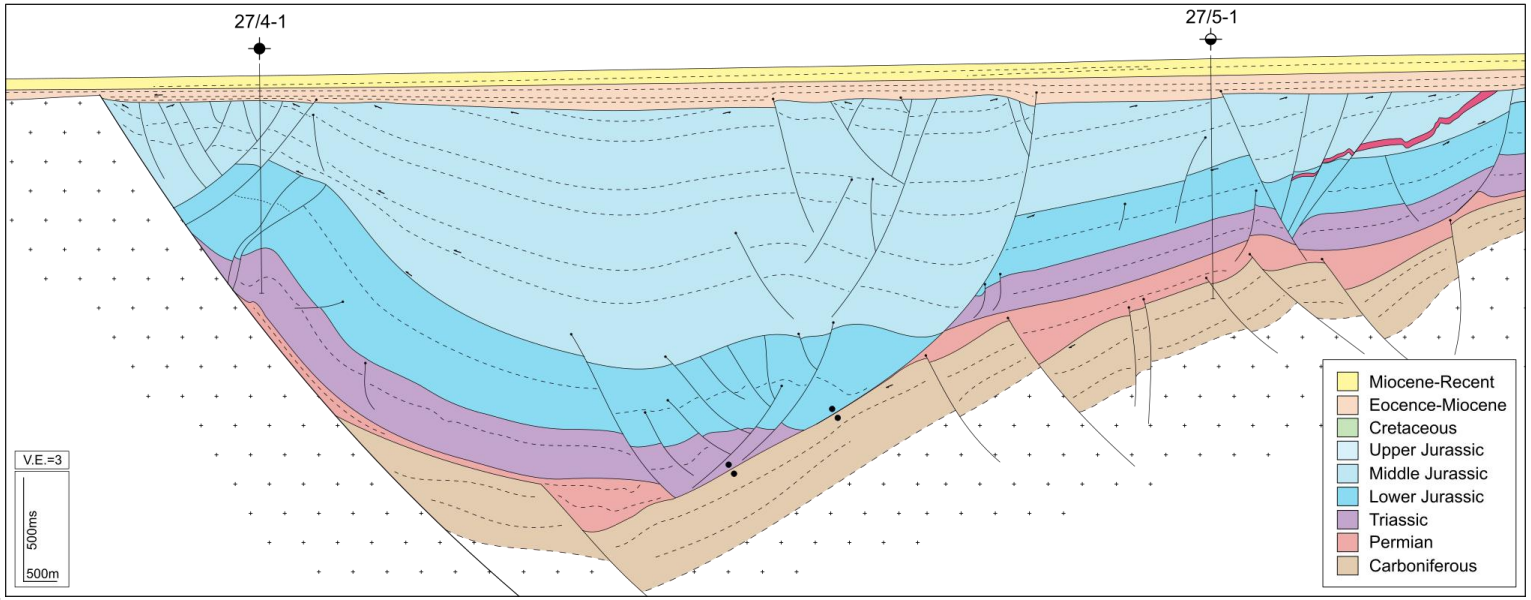


Base-Middle Jurassic Erosion



Time-structure map Lower Jurassic 'Hettangian Limestone Marker'





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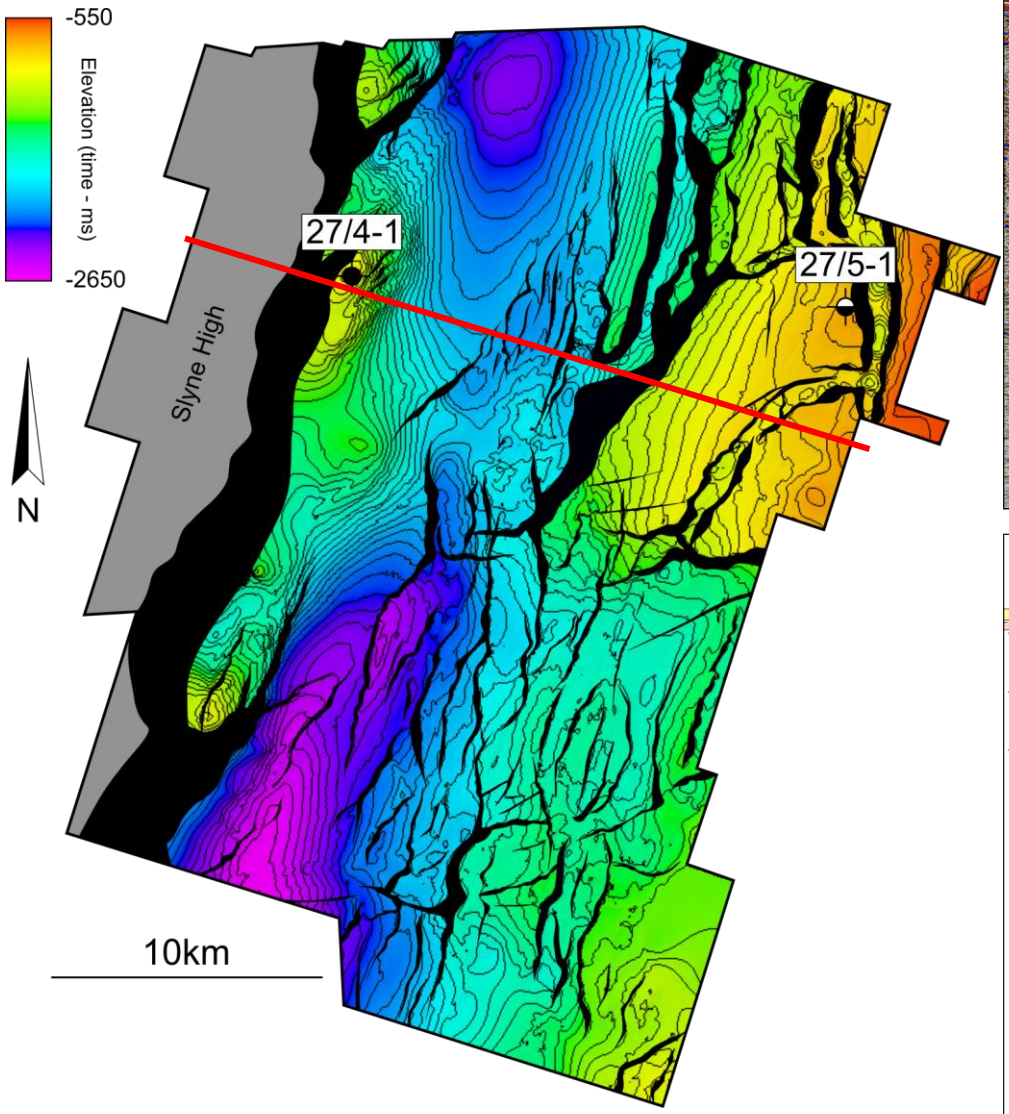

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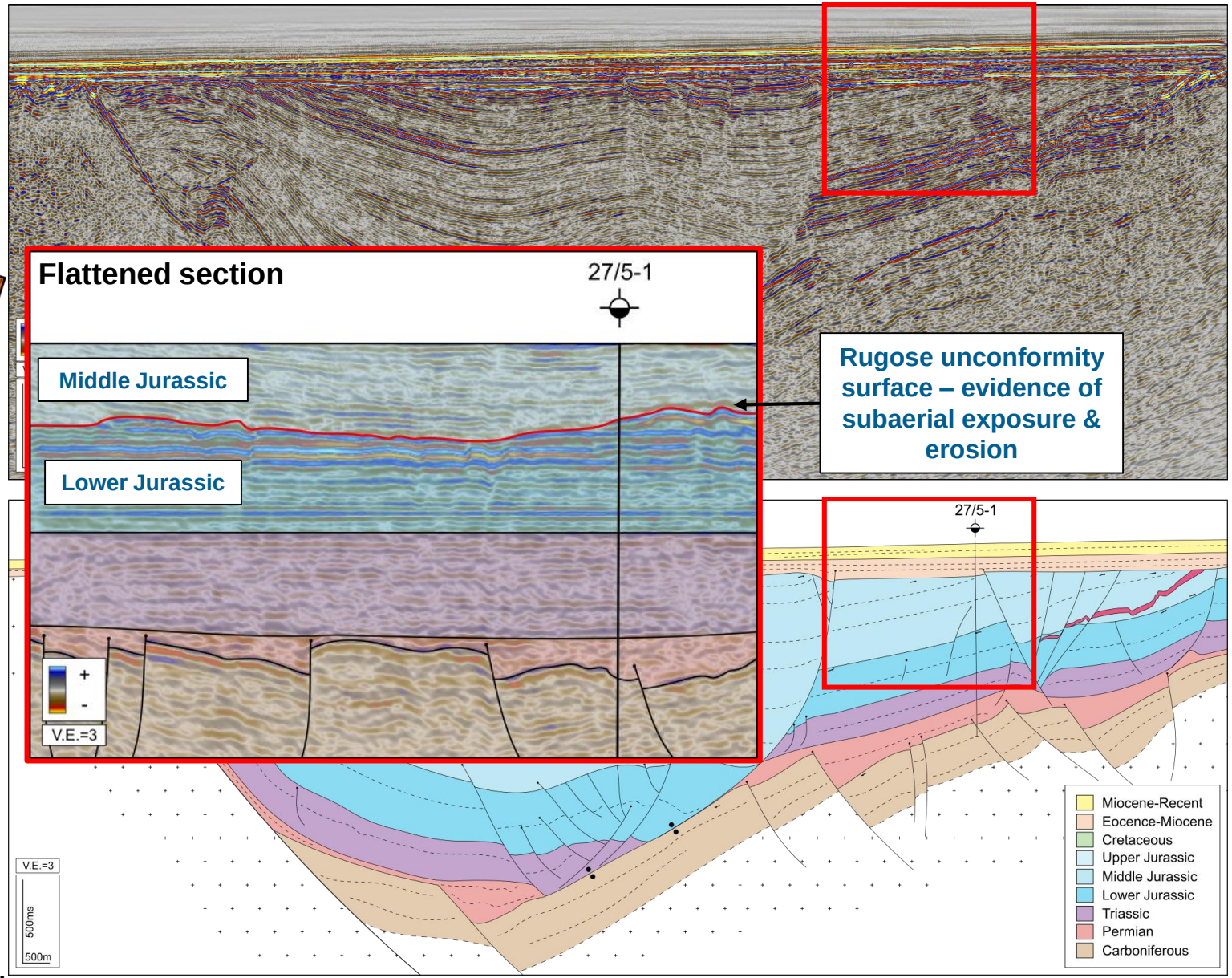

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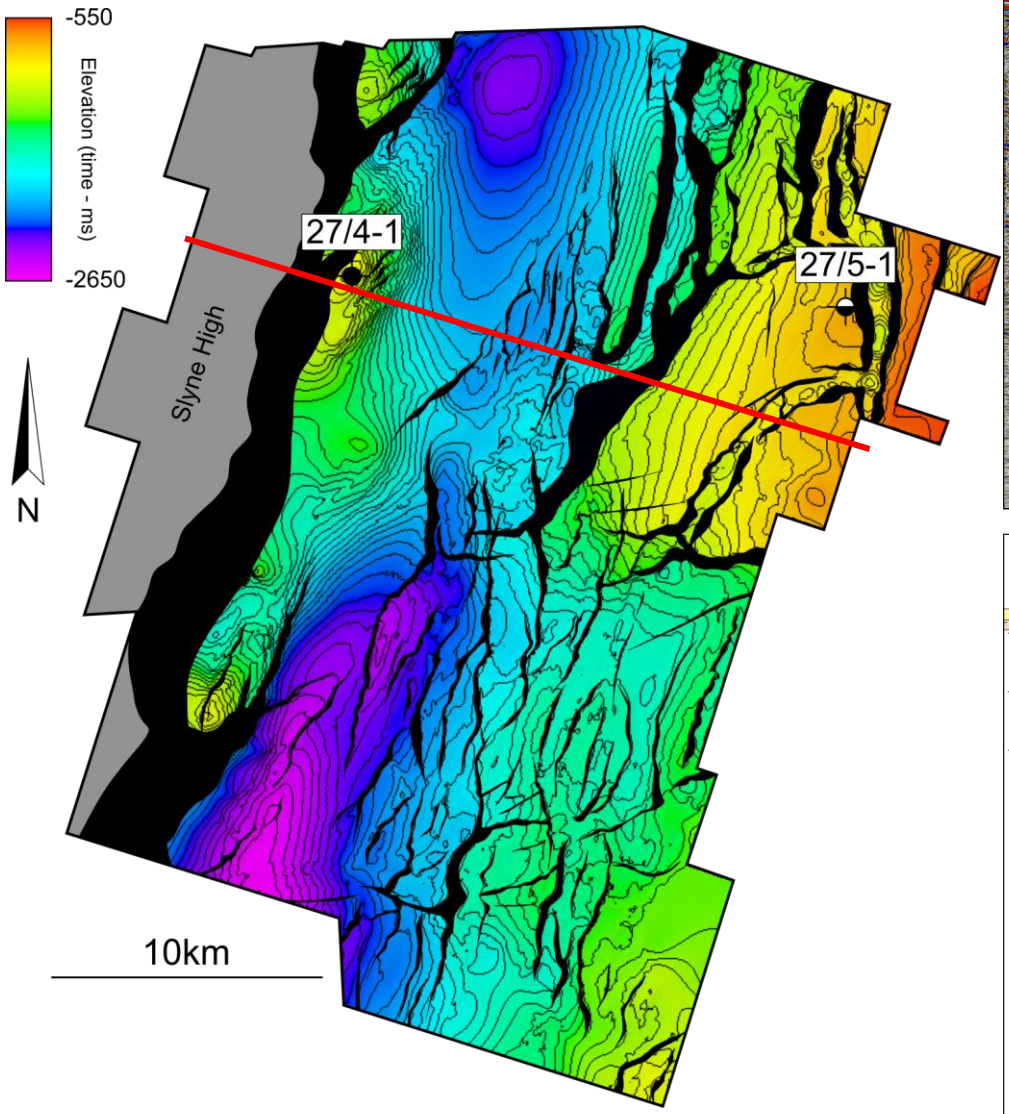

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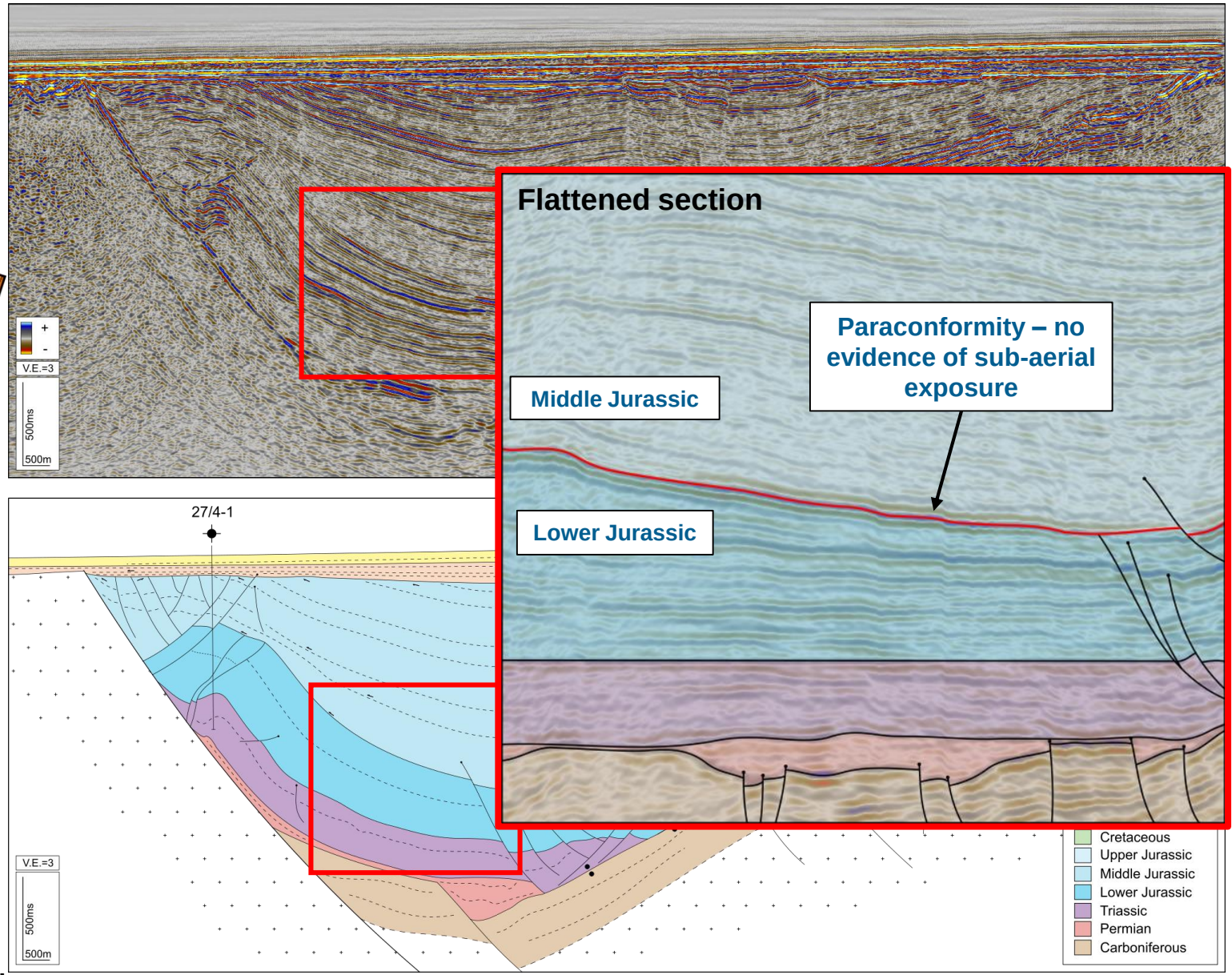

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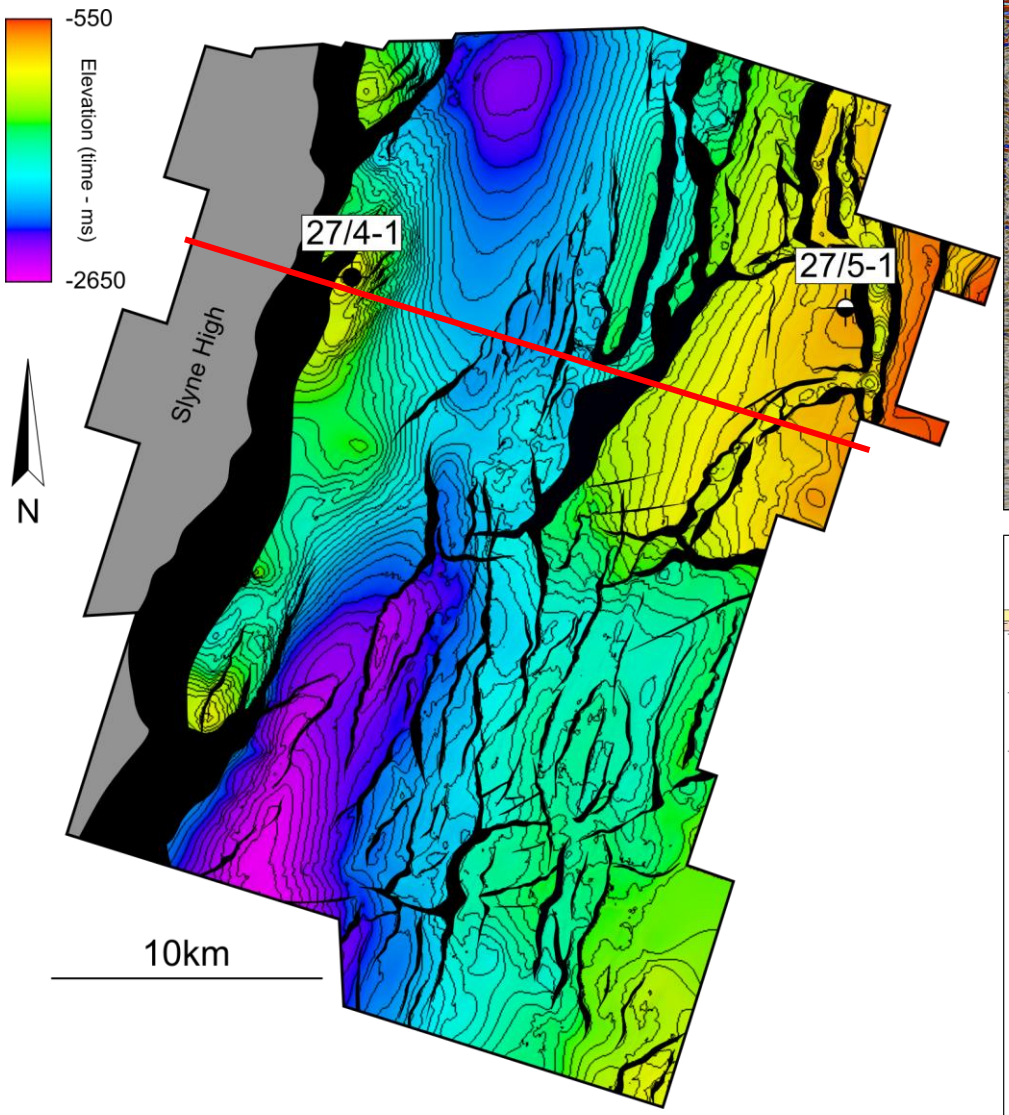

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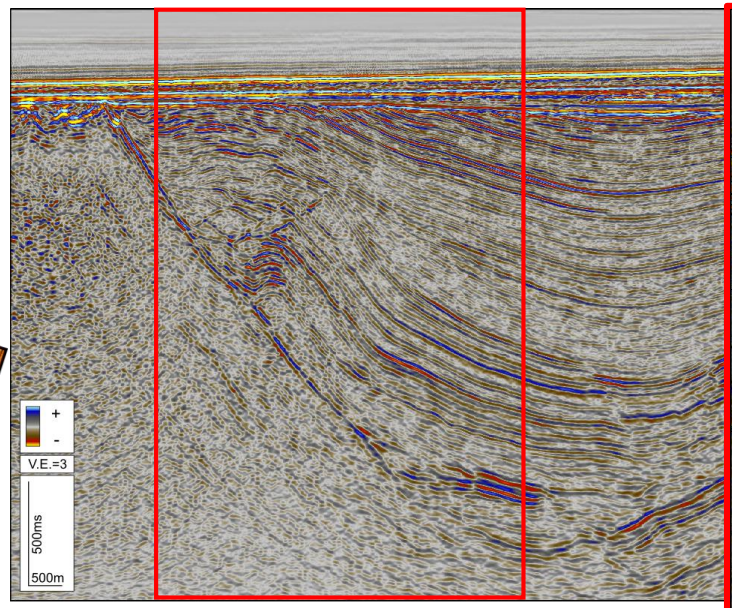
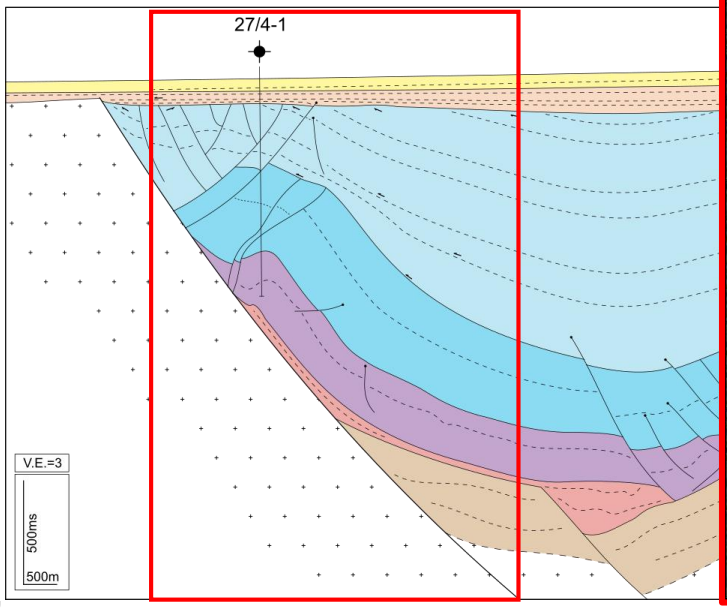
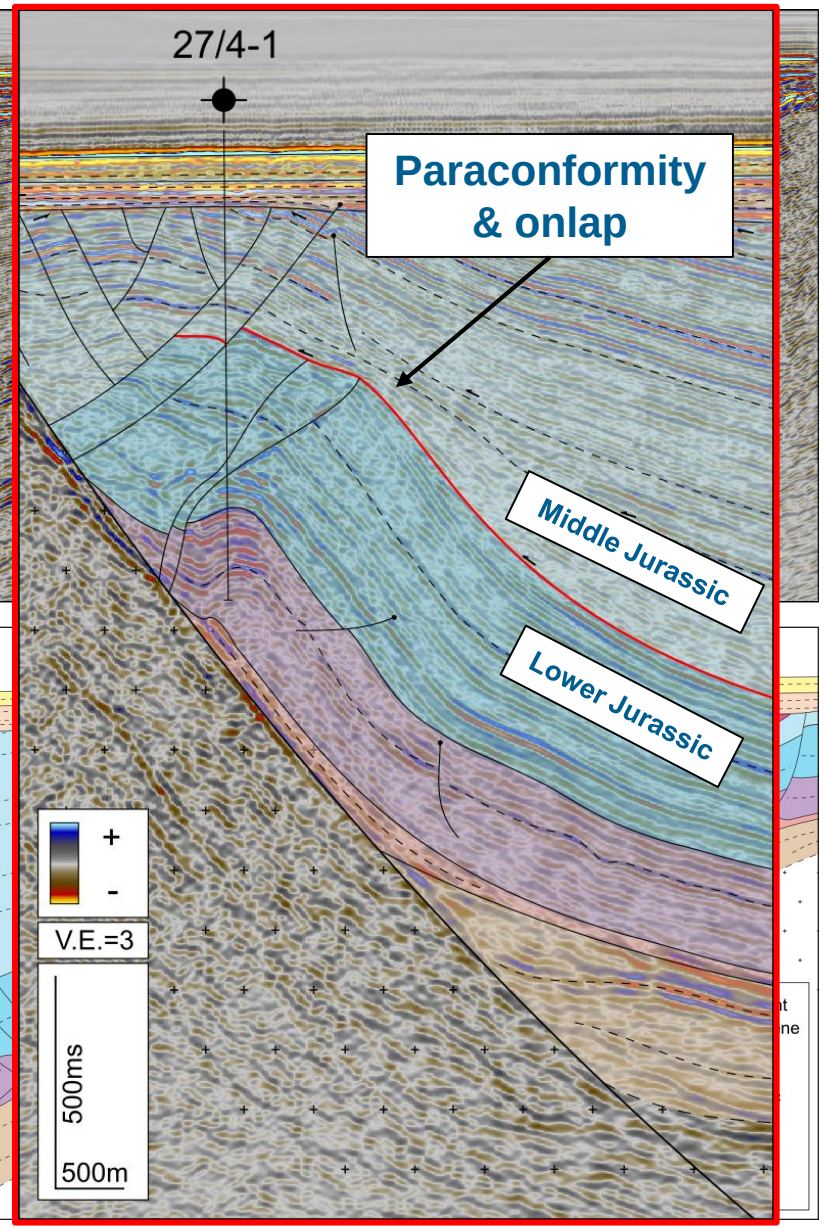
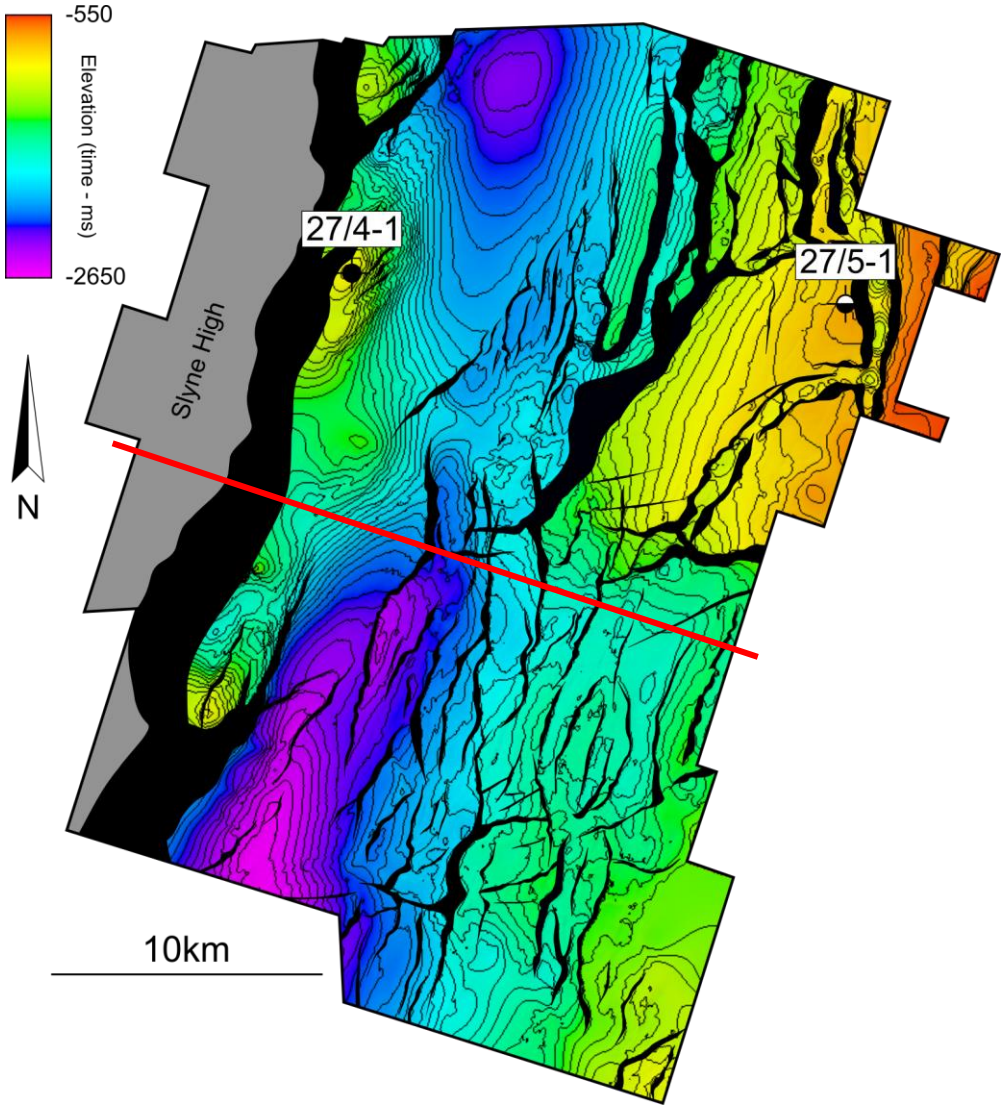






Erosion on high-strain side of half-graben



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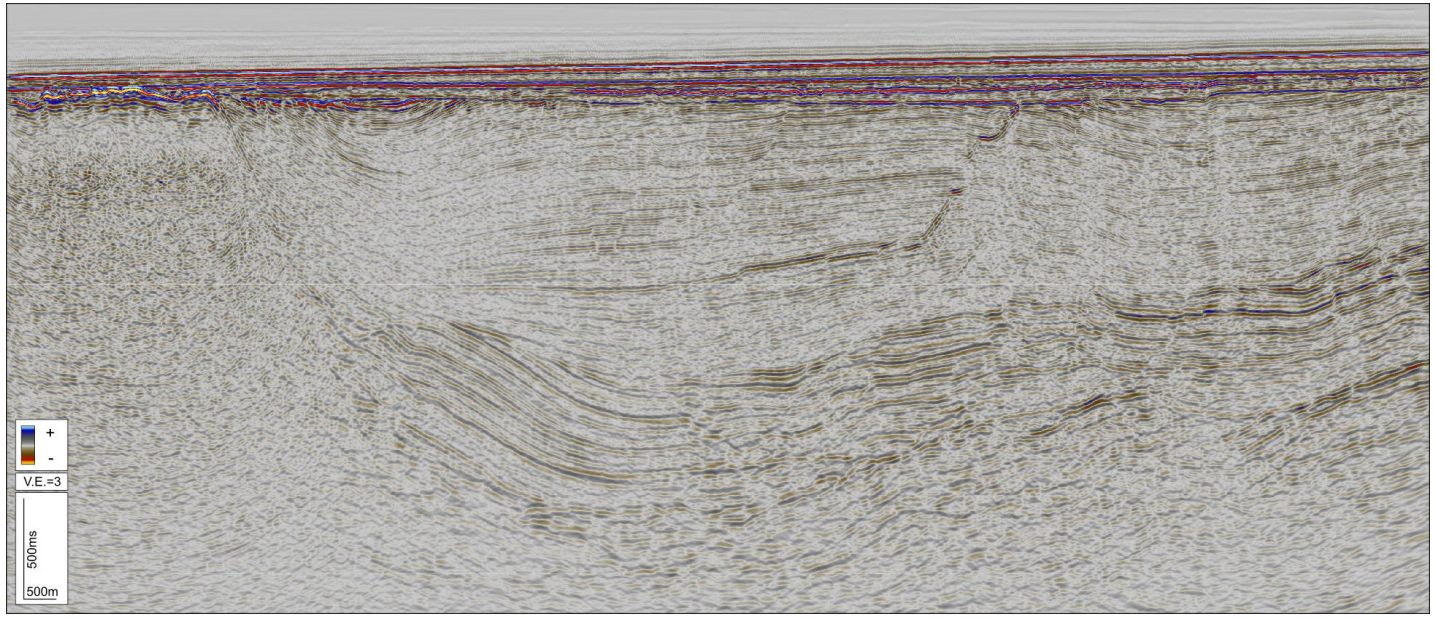
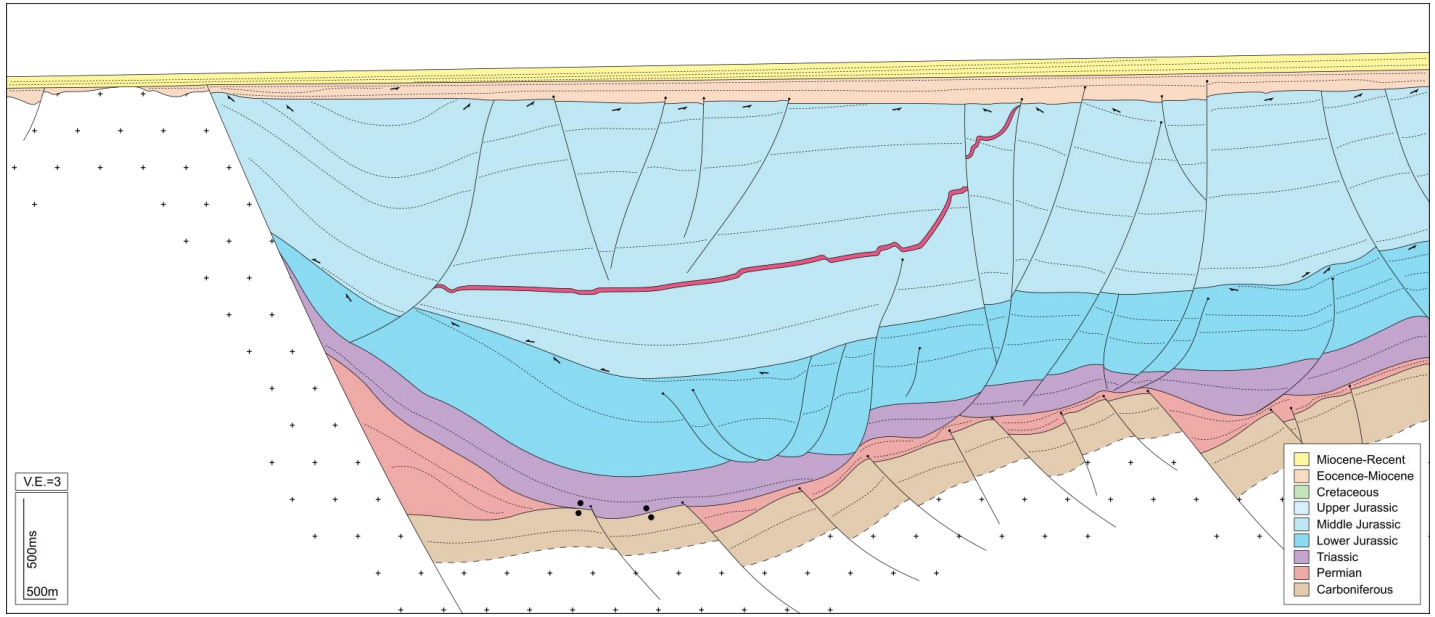
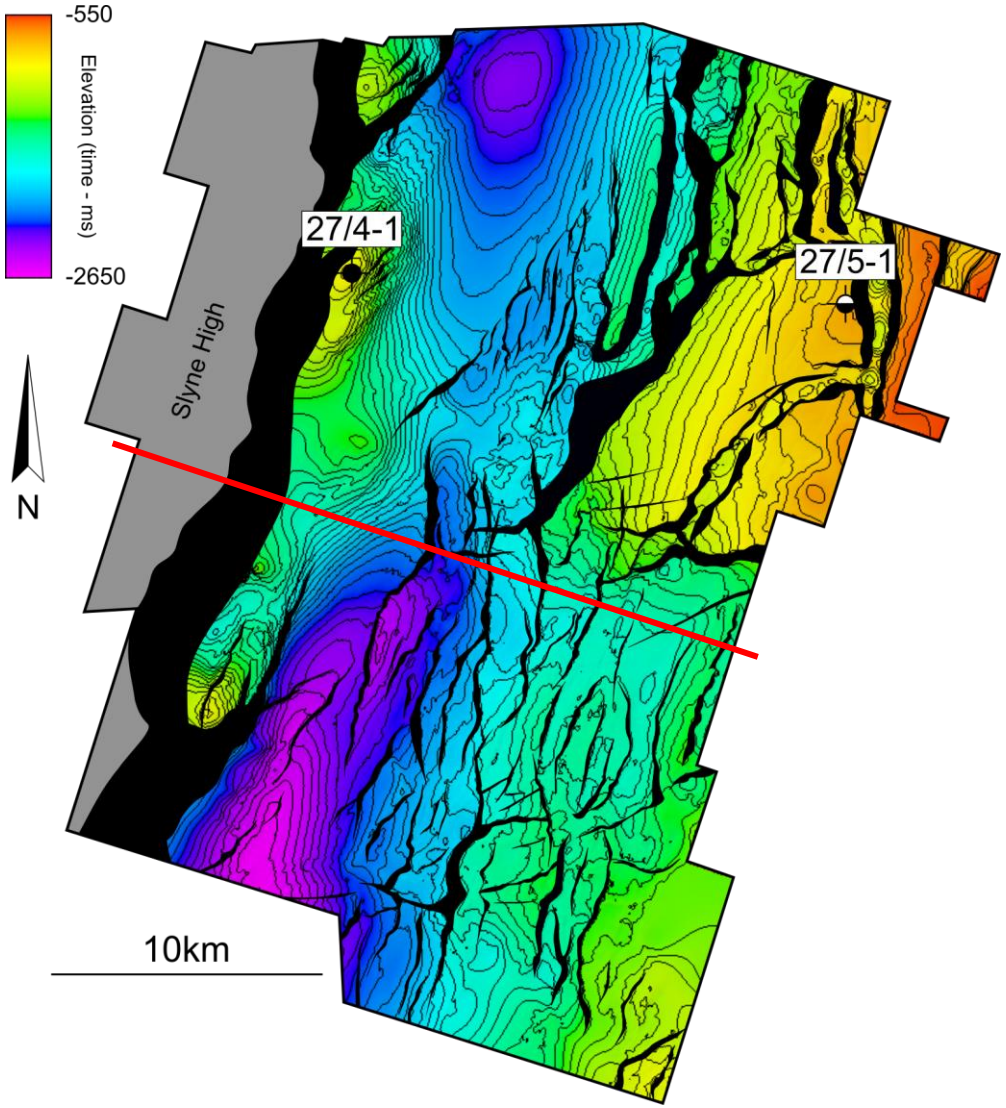




Erosion on high-strain side of half-graben



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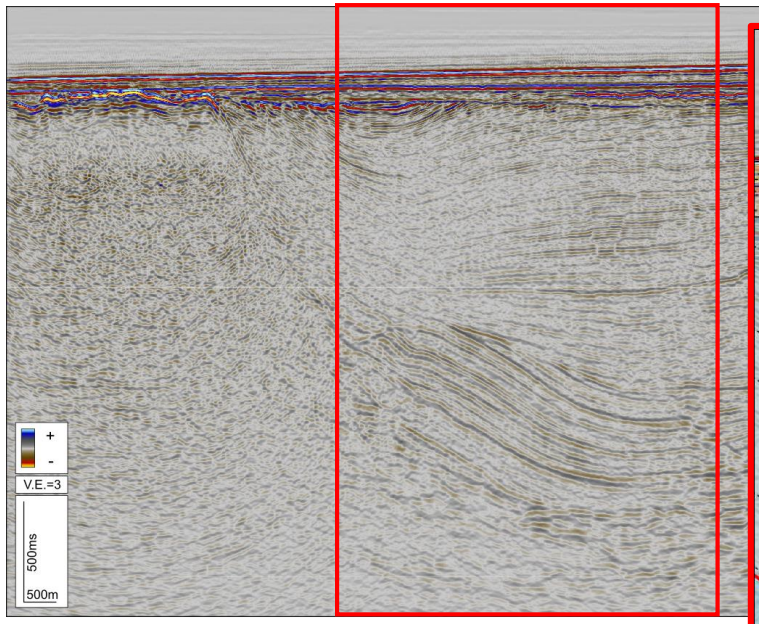
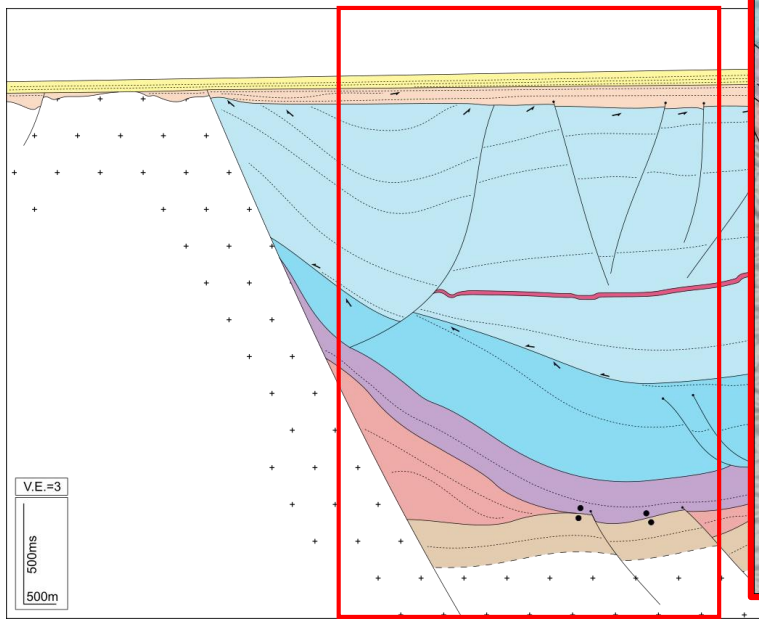
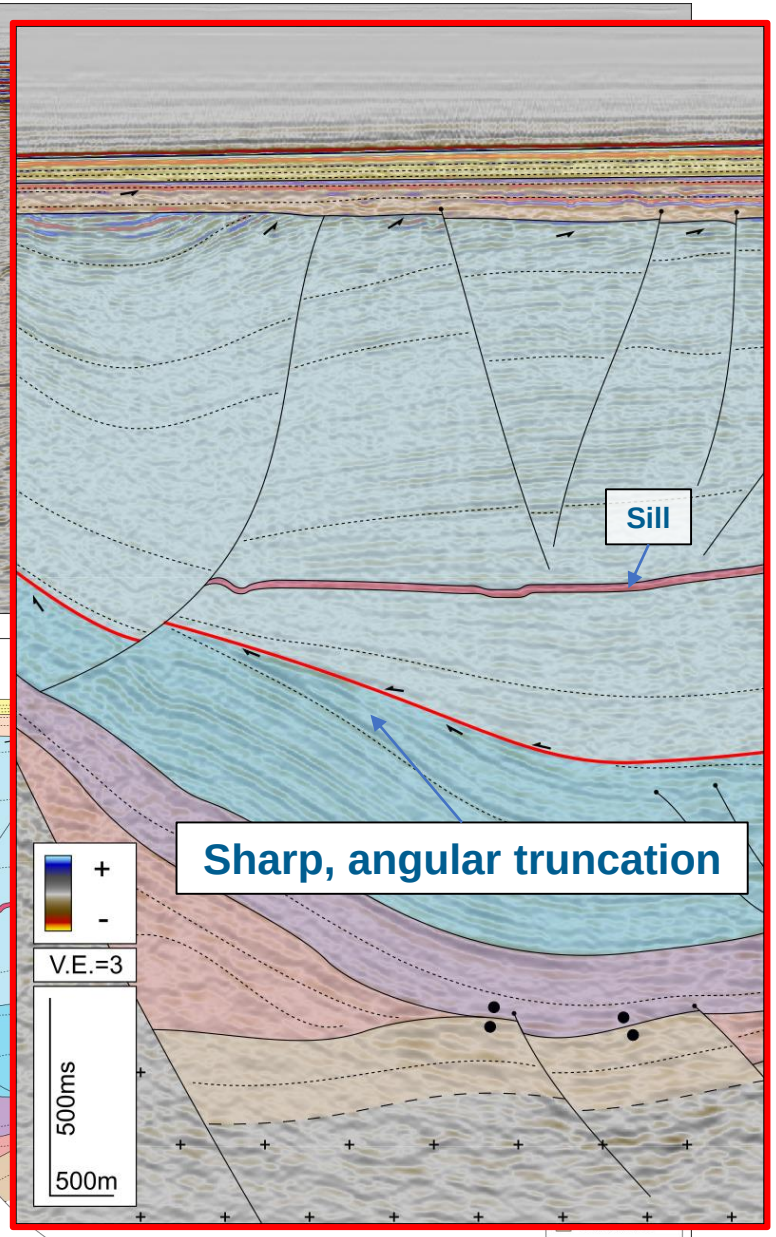
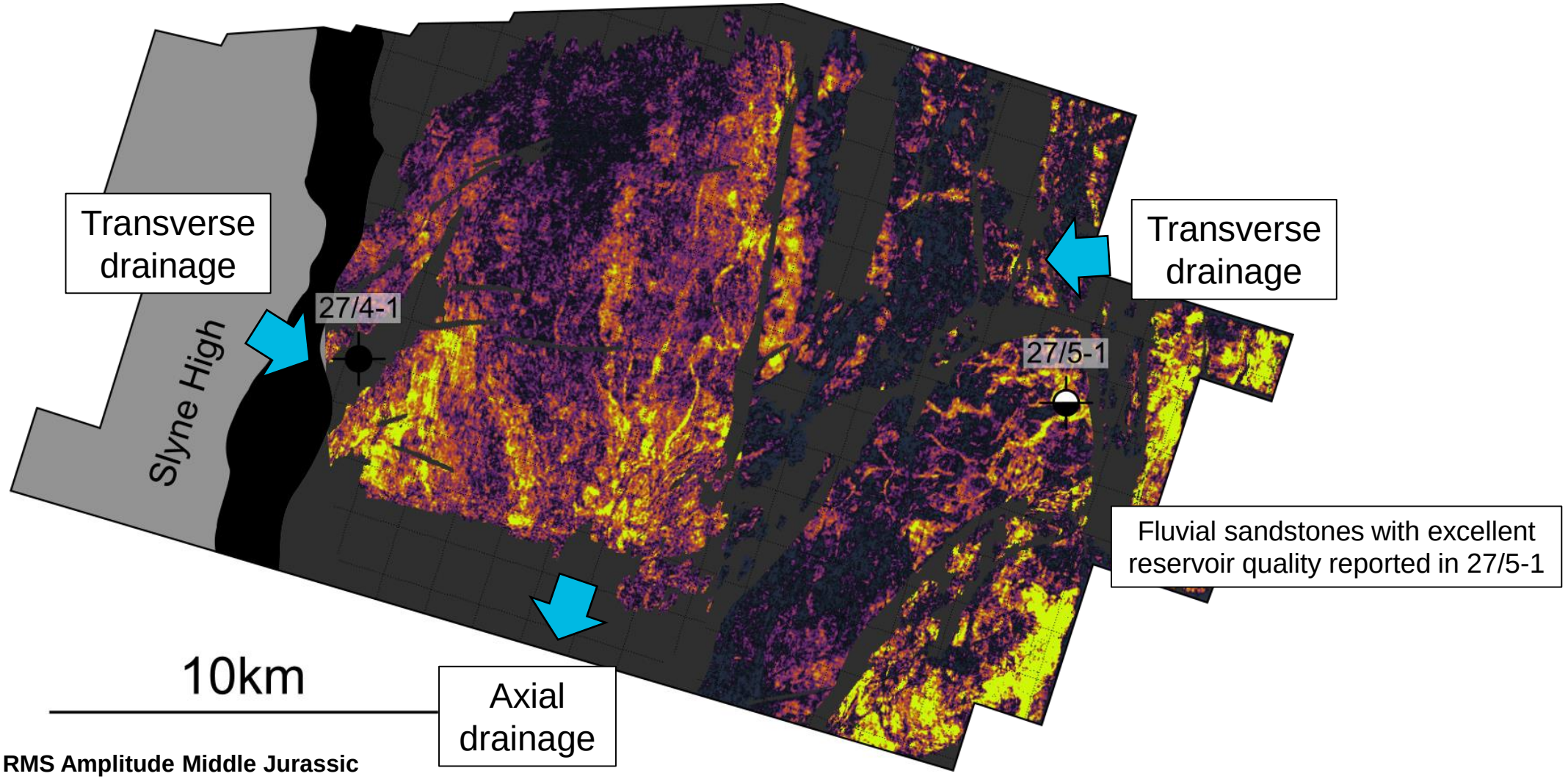






Salt control on Middle Jurassic Palaeogeography

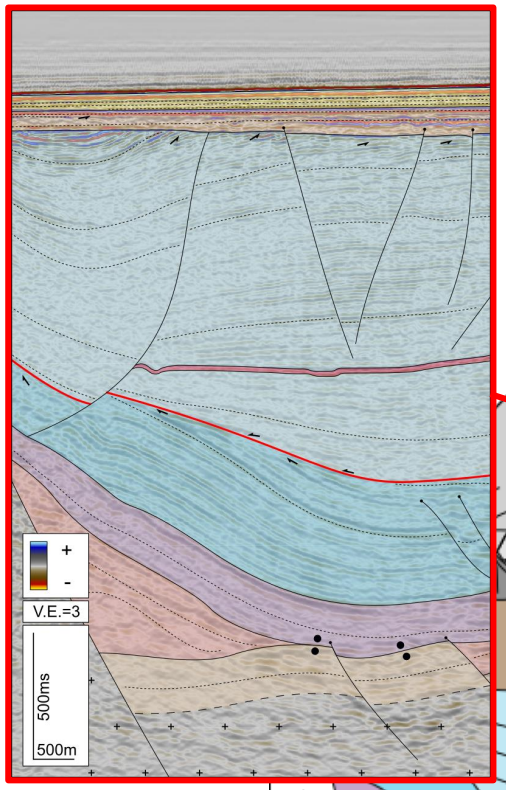
- Salt-controlled topography influences fluvial system direction
- Axial drainage in mini-basin centre, transverse at mini-basin margins

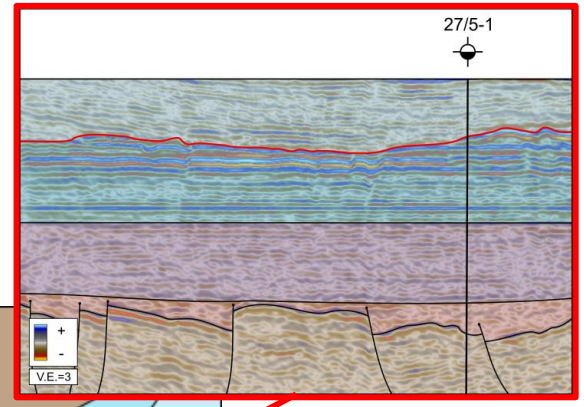


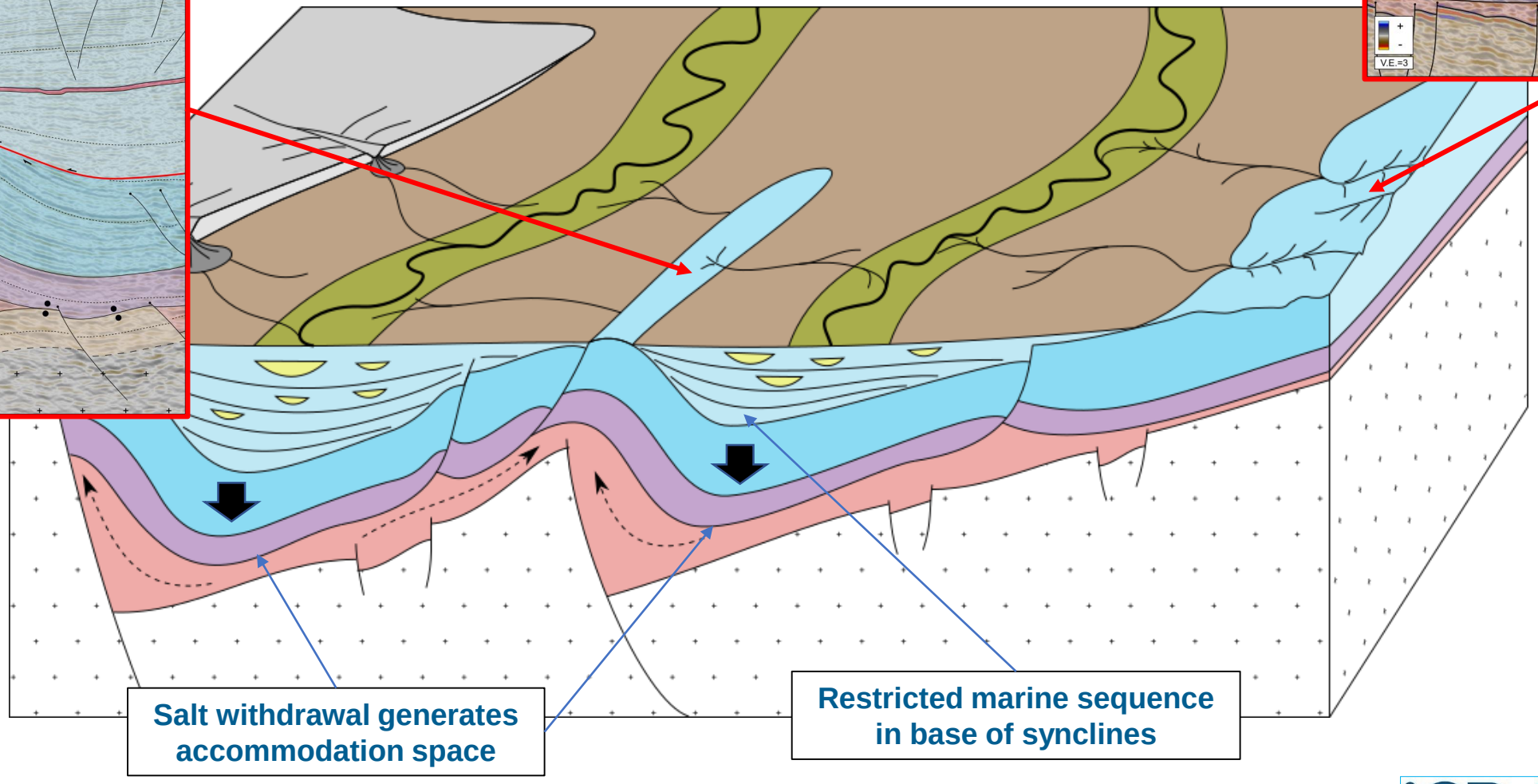
RMS Amplitude Middle Jurassic

Middle Jurassic Palaeogeography

Sub-aerial erosion on low-strain margins of half-grabens and exposed crests of withdrawal structures

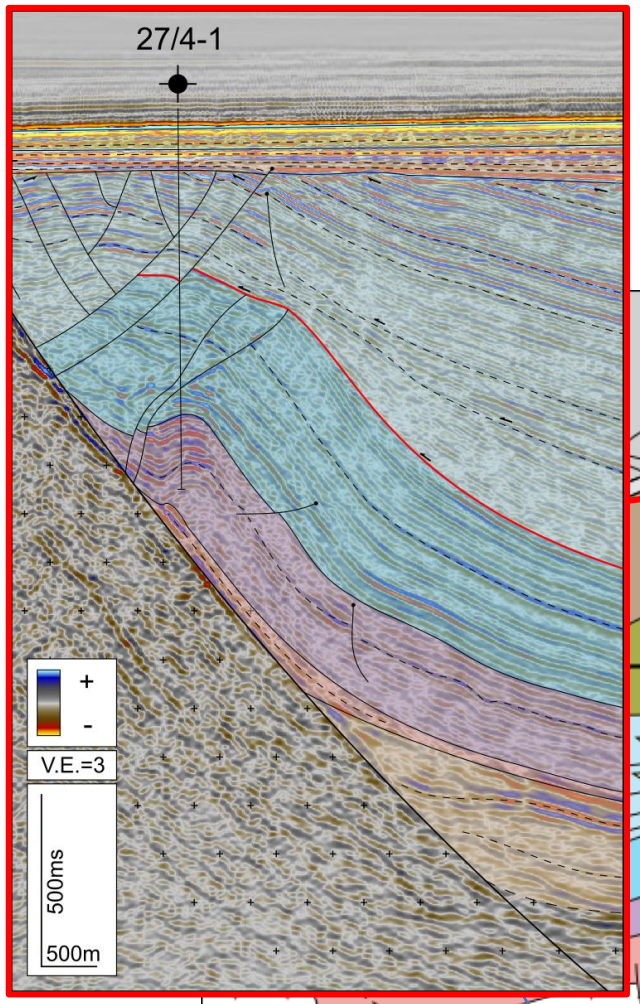


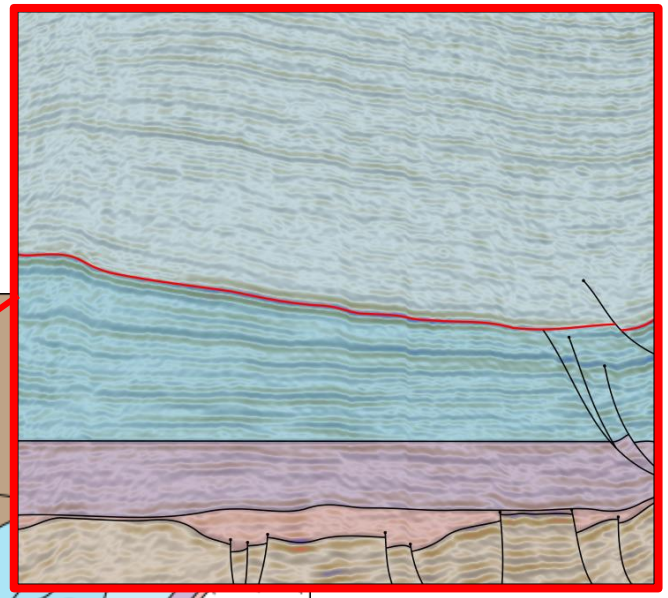


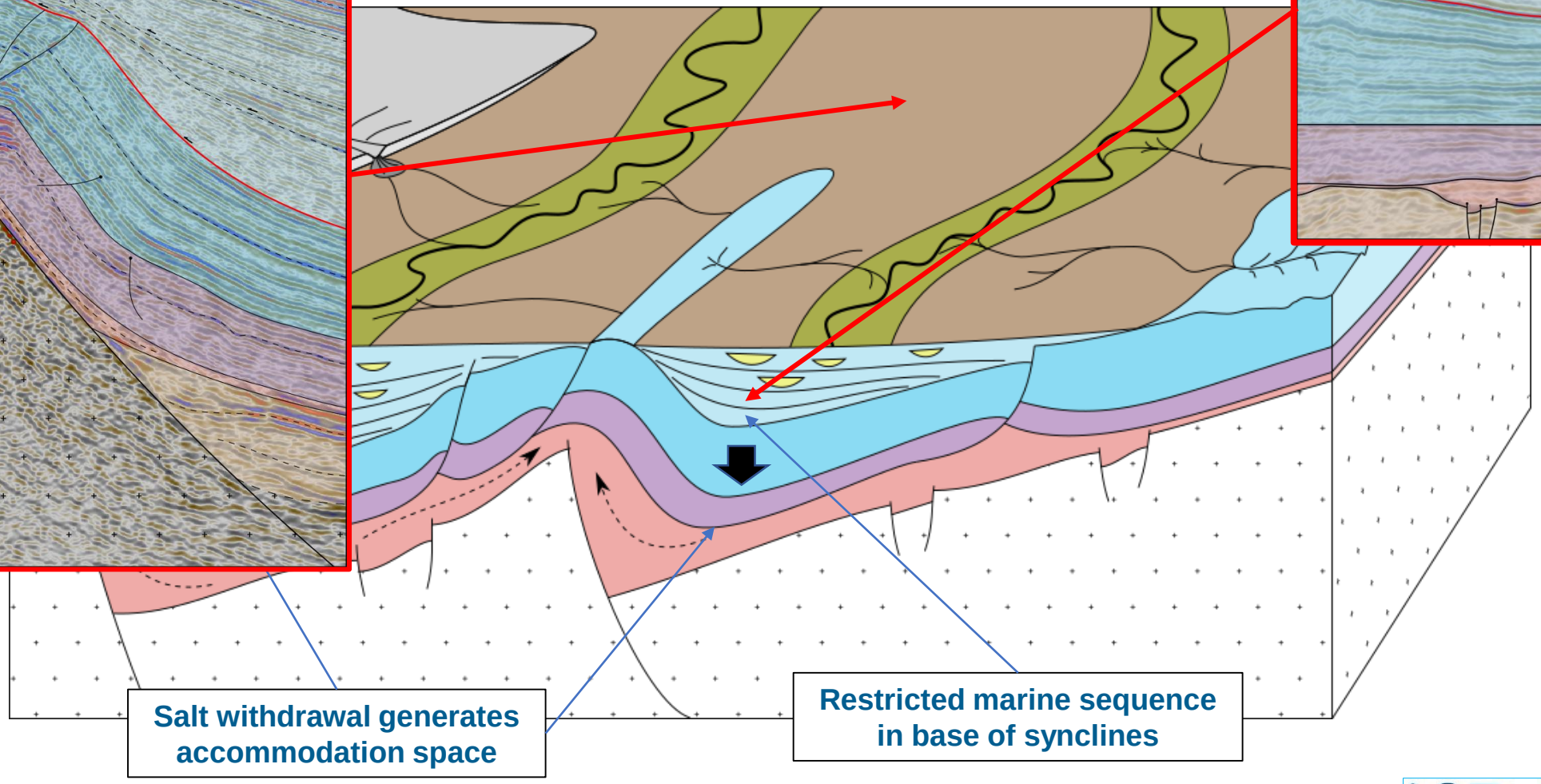


Middle Jurassic Palaeogeography

No sub-aerial erosion in submerged areas – centre of mini-basins and submerged withdrawal structures





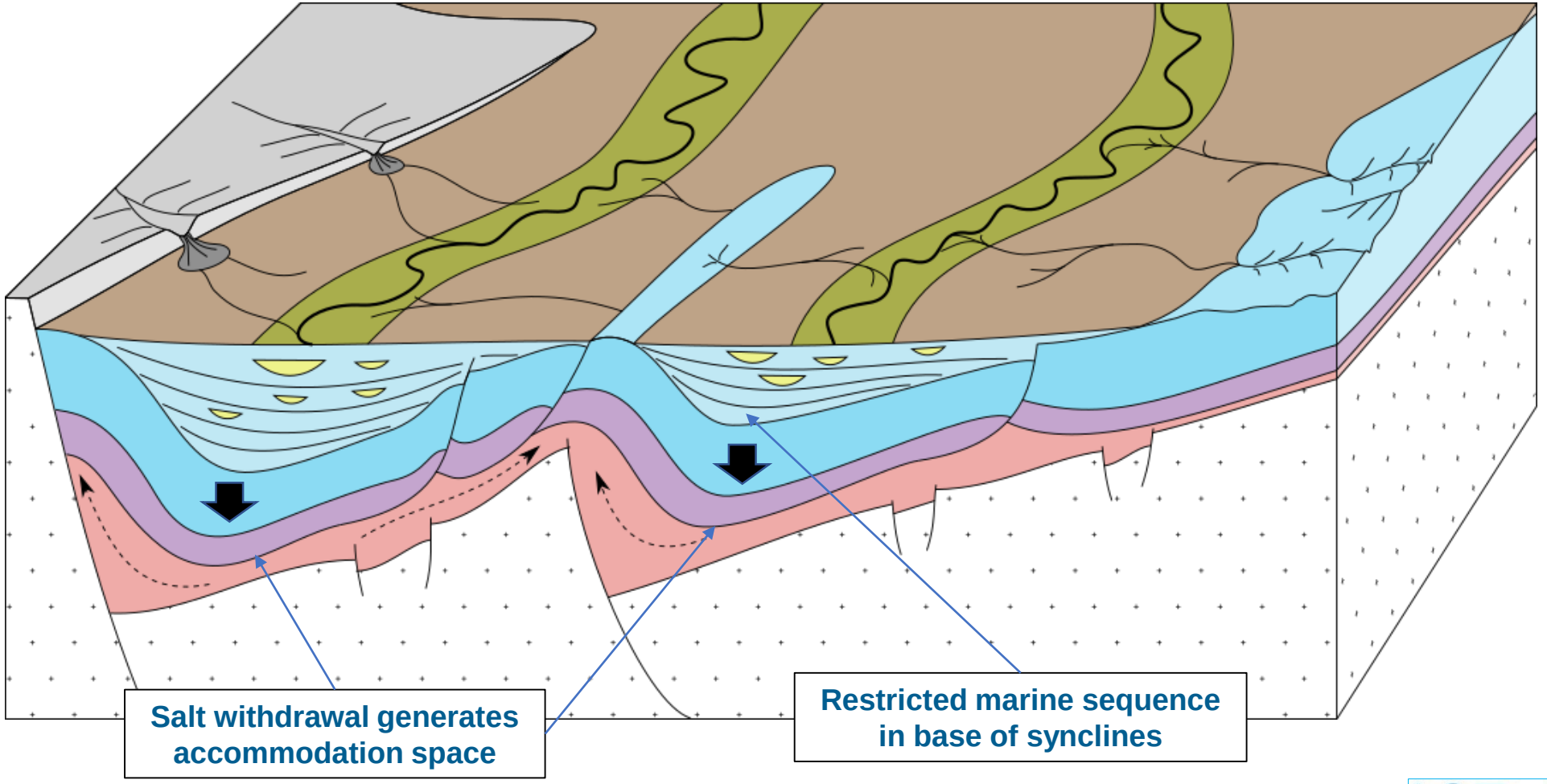


Salt withdrawal generates accommodation space

Restricted marine sequence in base of synclines

Middle Jurassic Palaeogeography

- Salt withdrawal:
  - Creates structural traps & accommodation space
  - Can bring Lower Jurassic oil-prone source rocks into generation window
  - Controls distribution of Middle Jurassic fluvial reservoir sandstones



Early Findings

Transfer Zones

- Deep-seated structures exert long-lived control on basin development (not just Slyne)

Salt Tectonics

- Salt controls geometry and style of most structural traps in the Slyne Basin
- Post-rift reactivation is a key risk for trap longevity
- Similar structures in neighbouring Porcupine, Erris basins – can we apply the same logic?
- Salt withdrawal has significant impact on basin development

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