Salt-Influenced Rift Basins: Structural Style, Syn-Rift Stratigraphic Response and New Models

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PGS

FORCE Salt Tectonics Seminar
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Rift Structure and Stratigraphy

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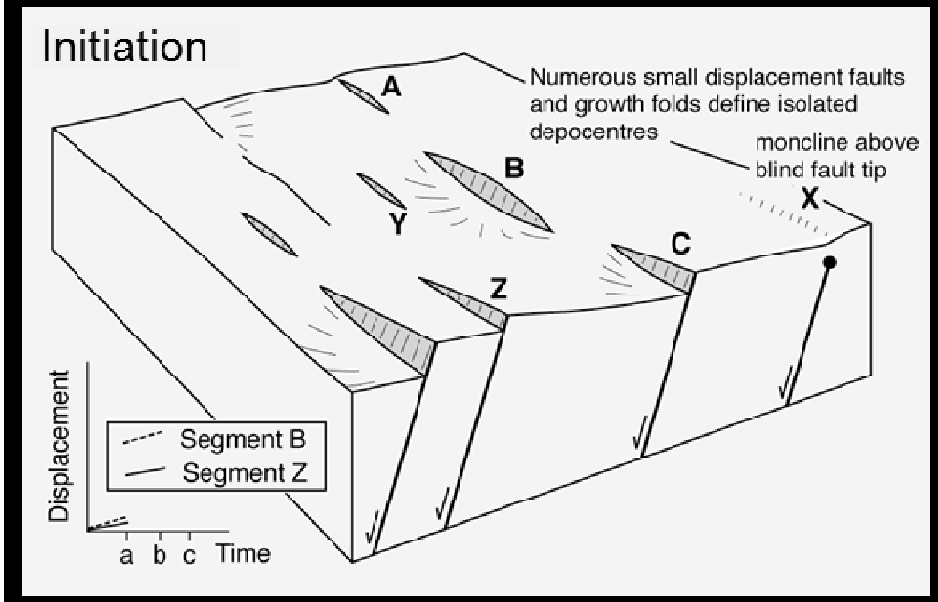

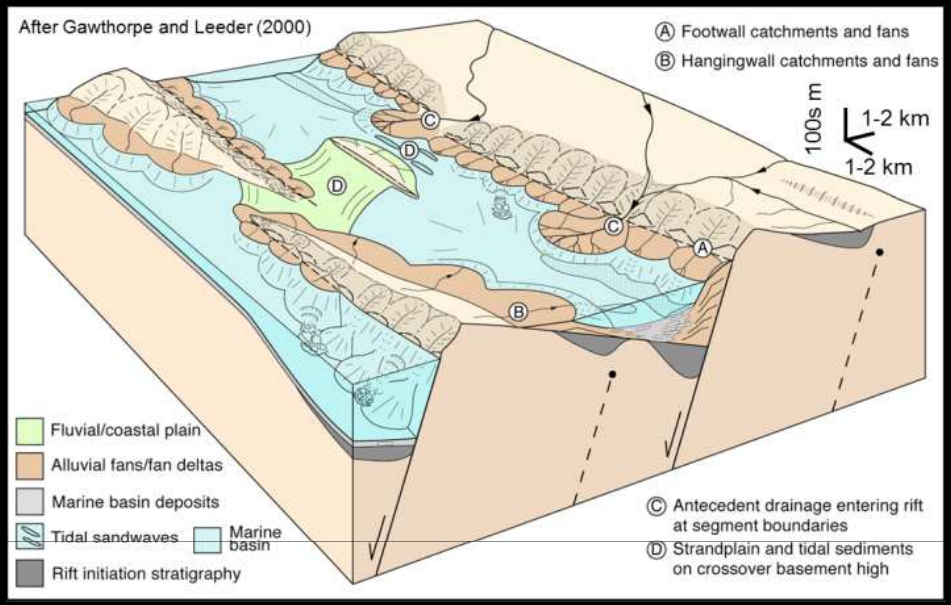

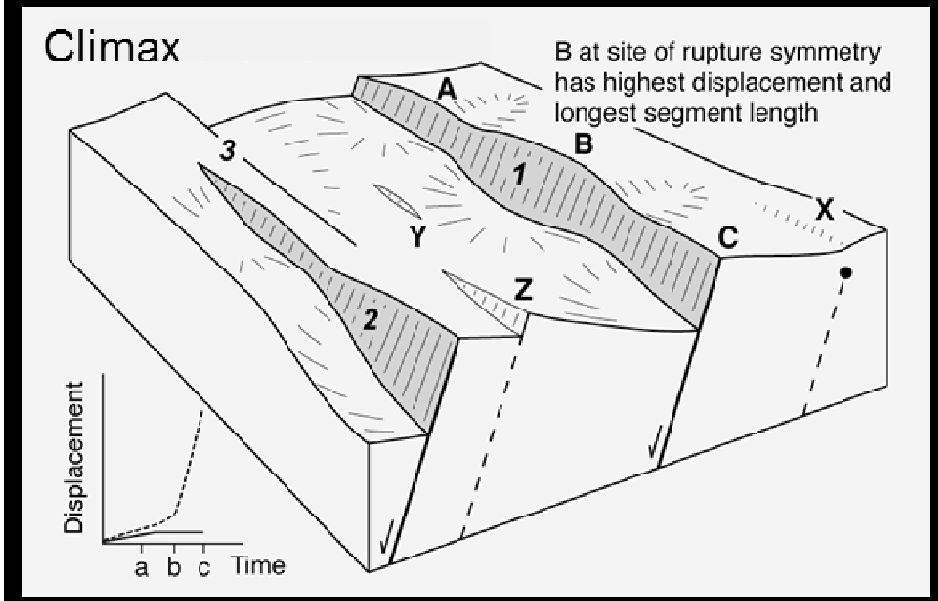

- Existing models based on observations from regions characterised by ‘homogeneous’, ‘brittle’ crust
- Fault growth by segment linkage
- Strain localisation (initiation>climax) and development of half-graben
- Temporal and spatial variations in subsidence and uplift
- Complex syn-rift depositional systems

Talk Outline

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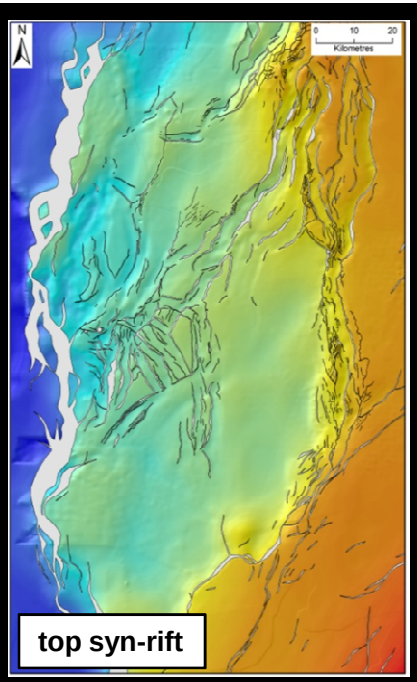

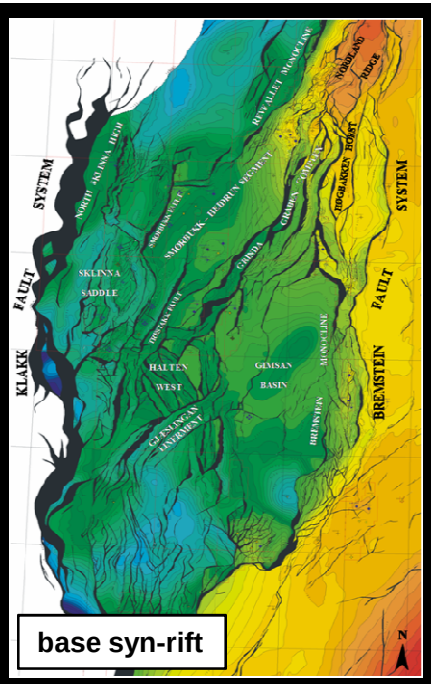

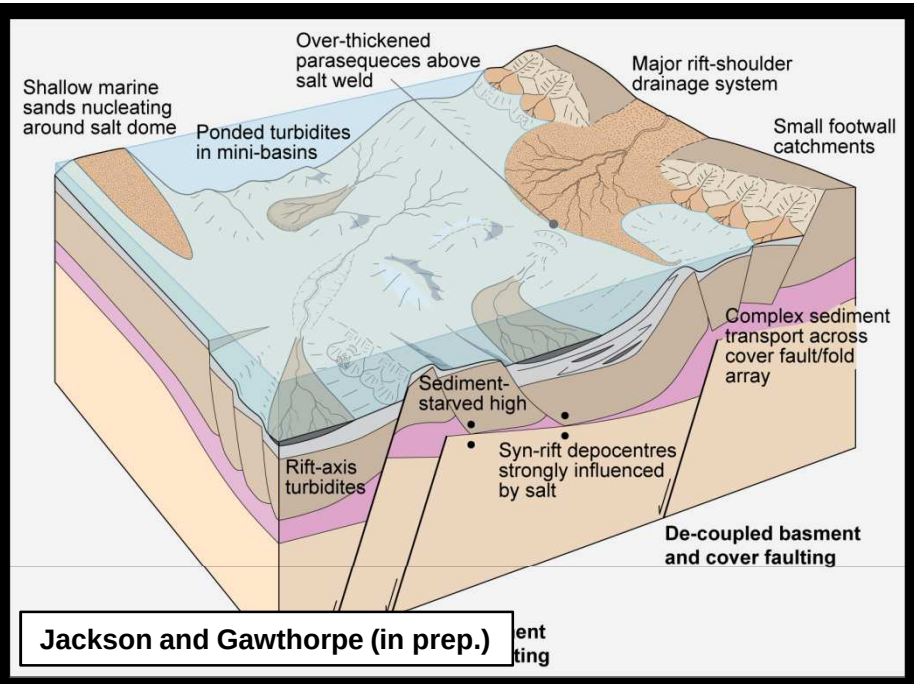

- Does salt impact the structural style of rift basins?
- Does salt impact size and location of sediment source areas, sediment dispersal and stratigraphic architecture?
- How does salt influenced hydrocarbon prospectivity in SIRBs?:
- Do existing rift tectono-stratigraphic models rifts apply to SIRBs?
- Examples from offshore Norway: (1) Danish Central Graben; (2) Egersund Basin; (3) Halten Terrace; and (4) South Viking Graben

Structural Style Variability

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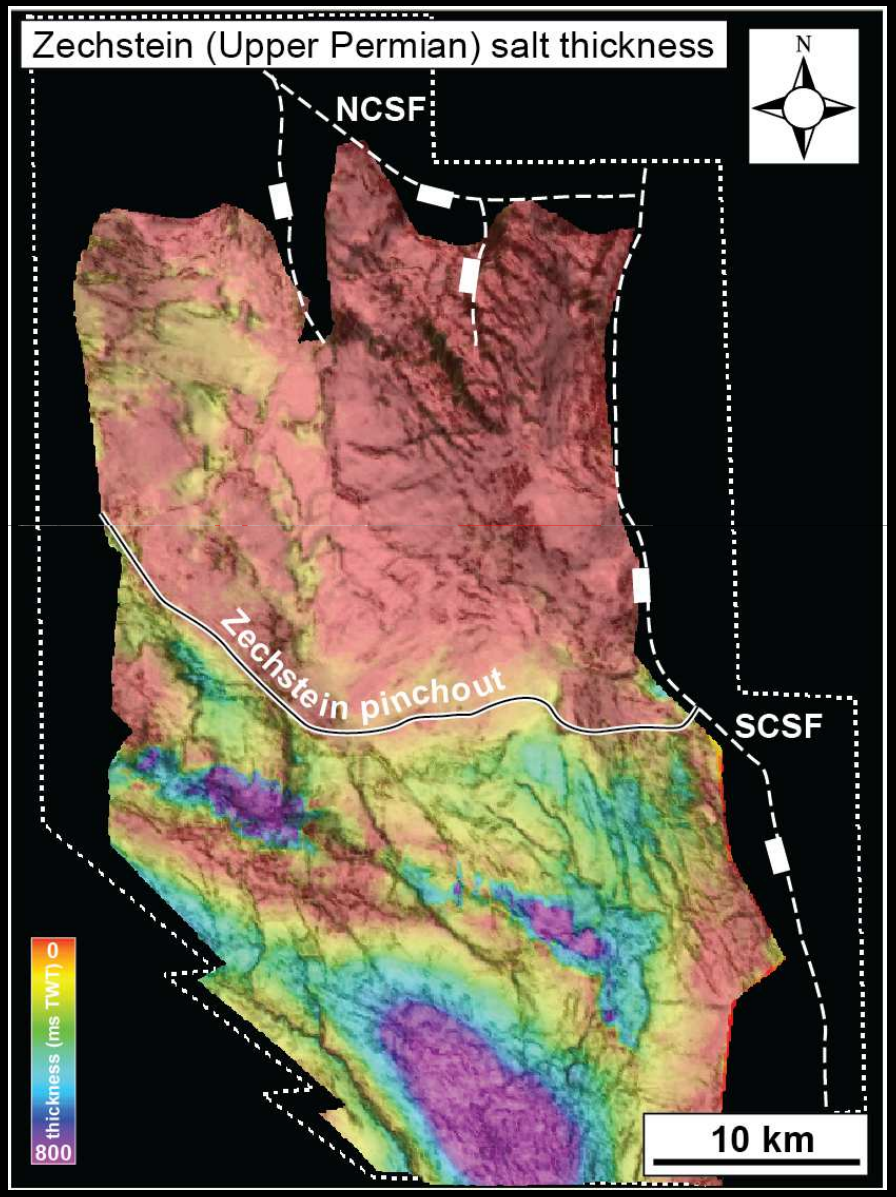

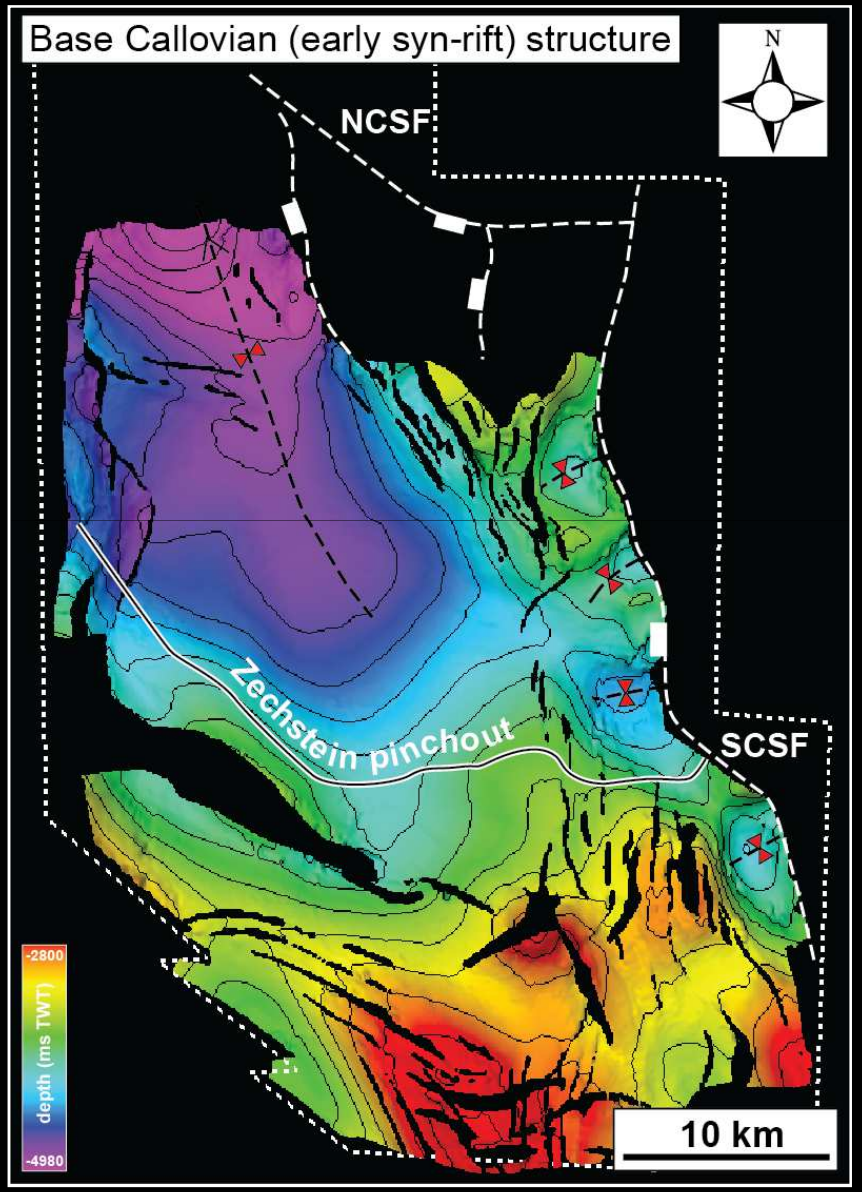

Structural Style Variability

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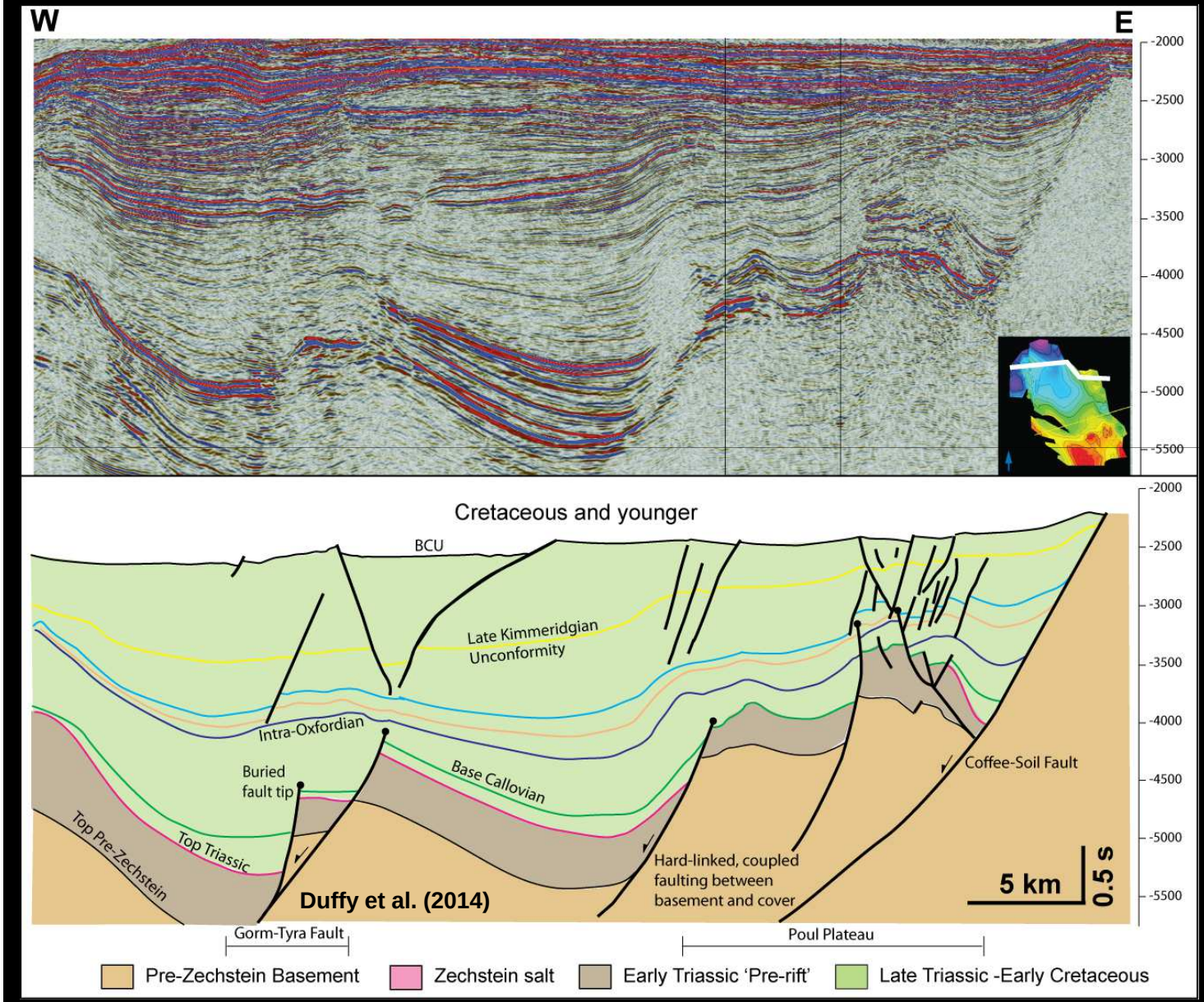

- Basement-involved normal faulting; simple half-graben
- Folding related to fault-propagation, frictional (normal) drag and post-rift inversion
- **Brittle, rift-related structural styles beyond salt pinchout**

Structural Style Variability

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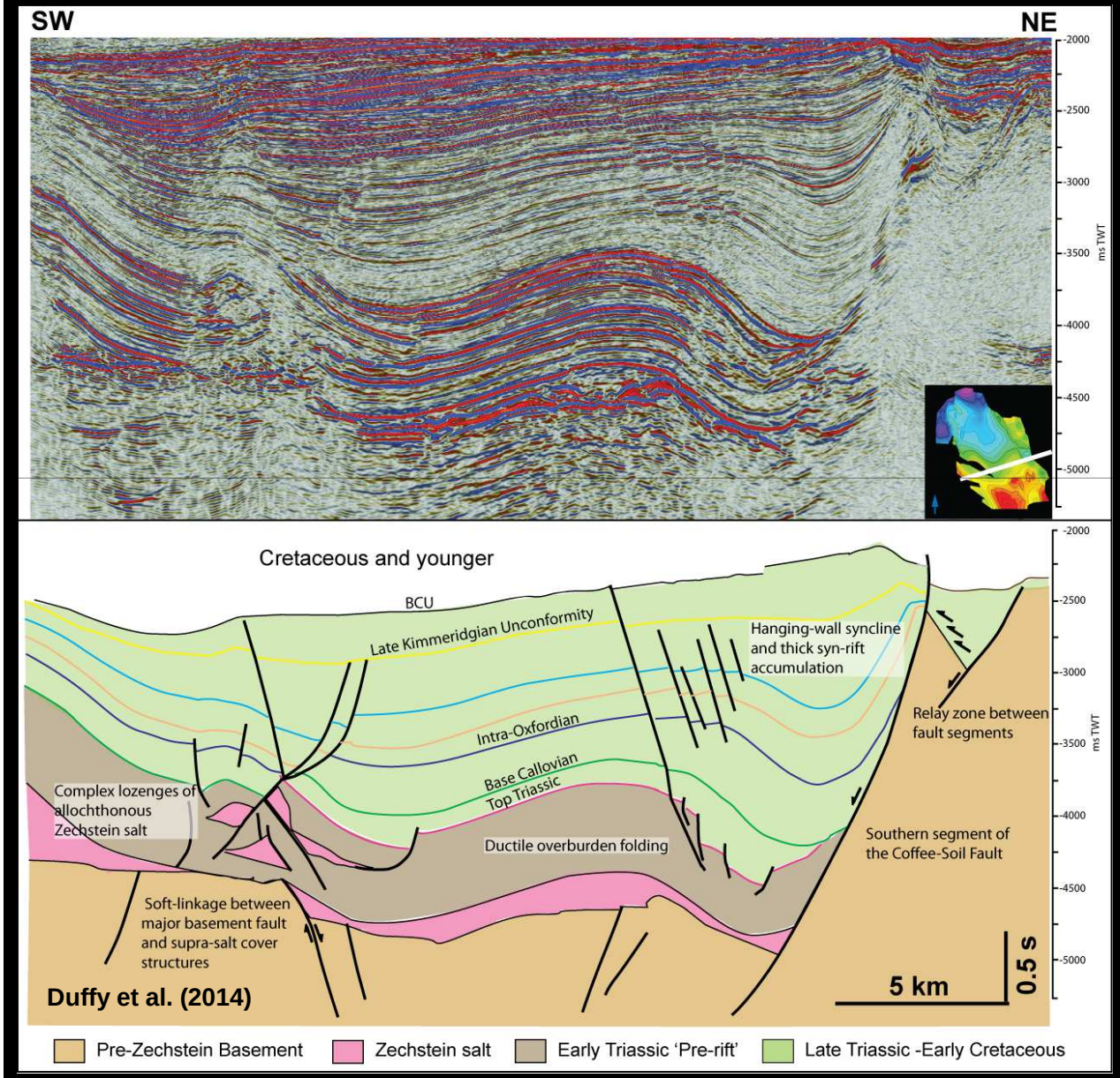

- Basement-involved normal faulting restricted to basin margin; complex half-graben
- Sub-salt-restricted, supra-salt-restricted, and thick-skinned faulting
- Salt-related folding superimposed on half-graben geometry
- **Ductile-brittle structural styles inboard of salt pinchout**

Structural Style Variability

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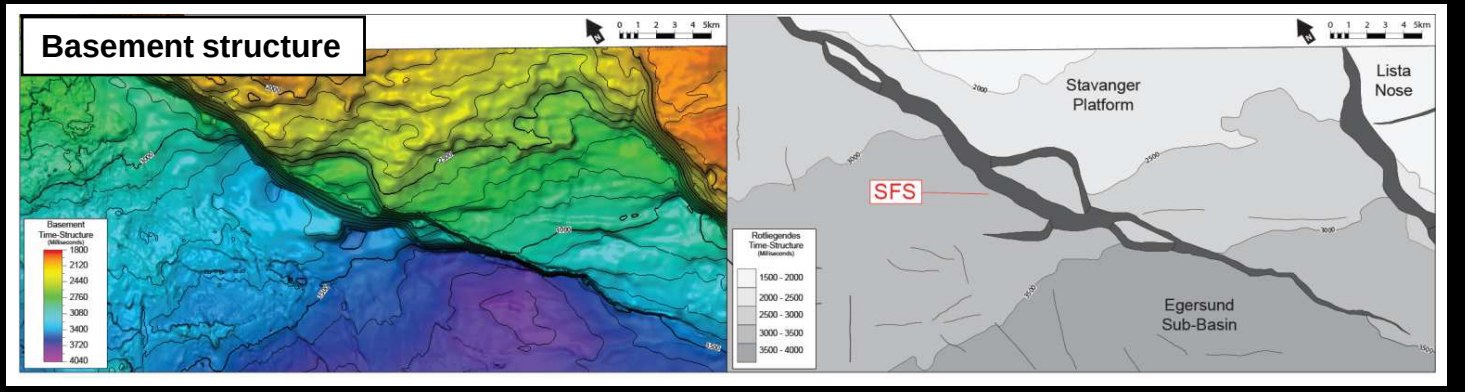
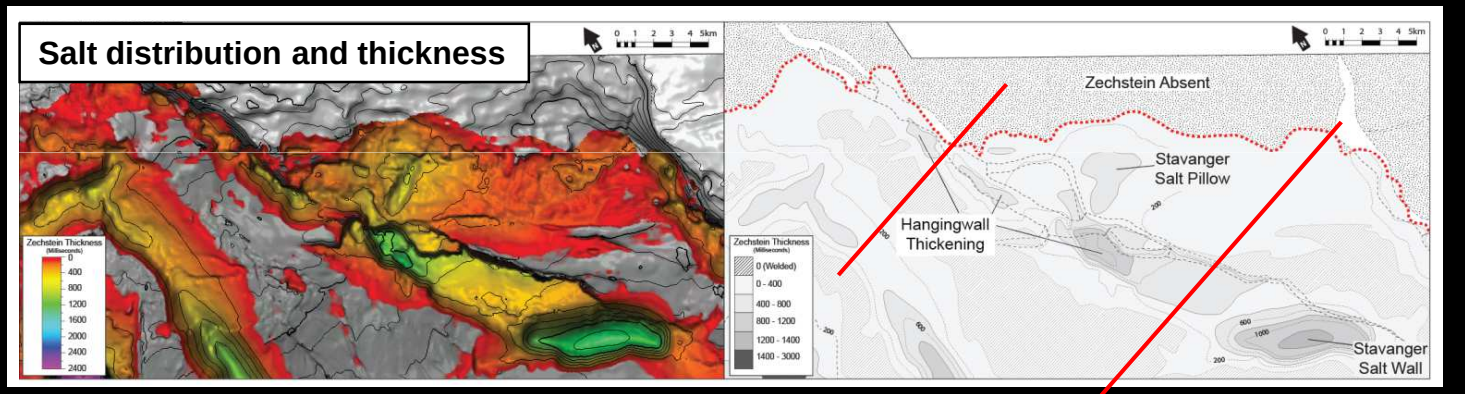
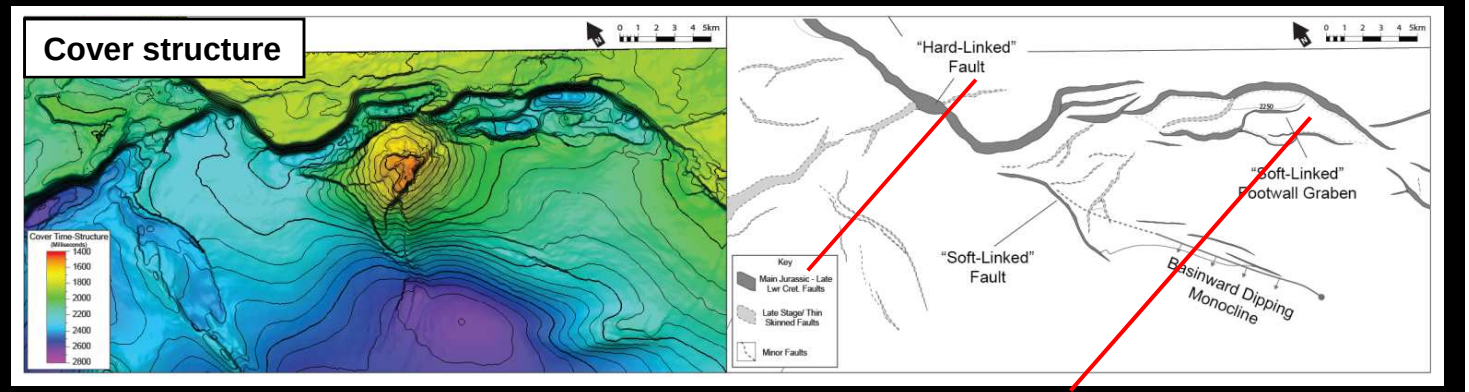
- Egersund Basin
- Margin of ZSG salt basin
- Along-strike variations in coupling of sub- and supra-salt structural styles
- Salt structures and related folding superimposed on half-graben geometry







Lewis et al. (2013)

Structural Style Variability

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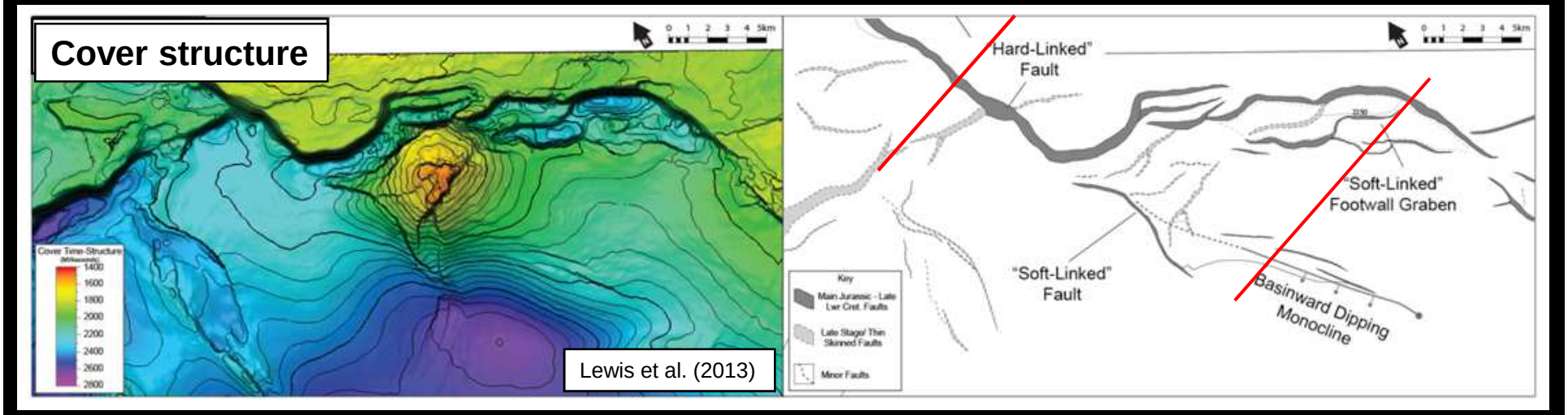

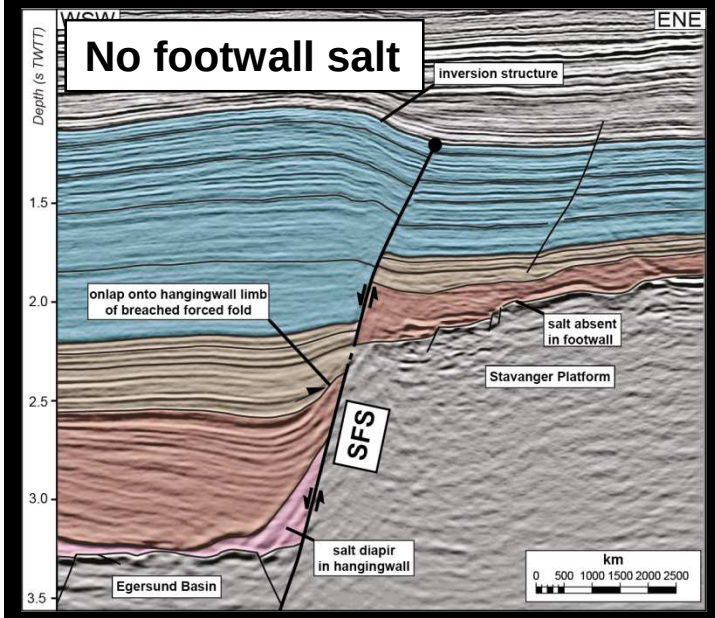

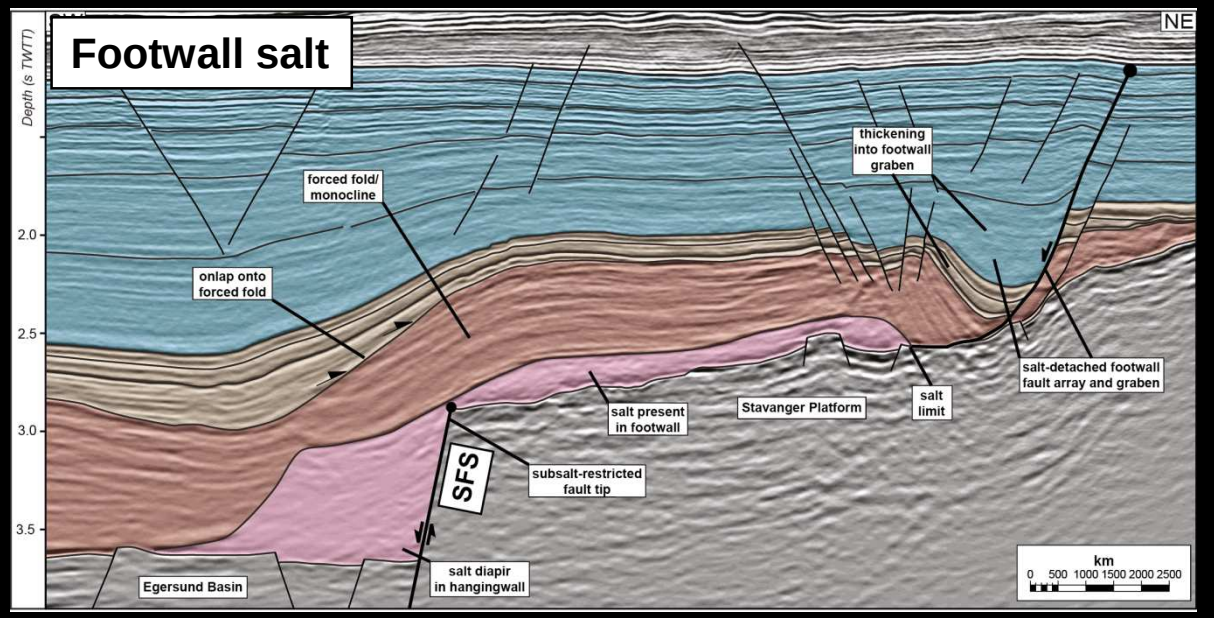

Structural Style Variability

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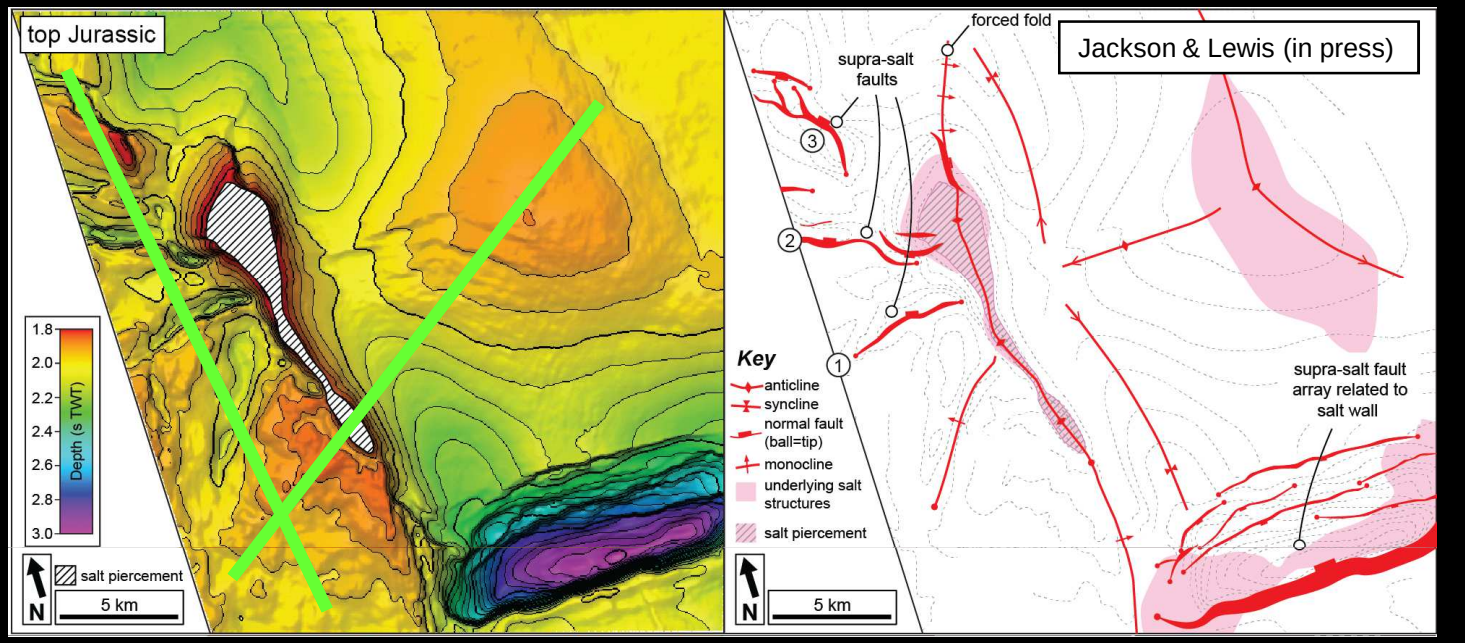
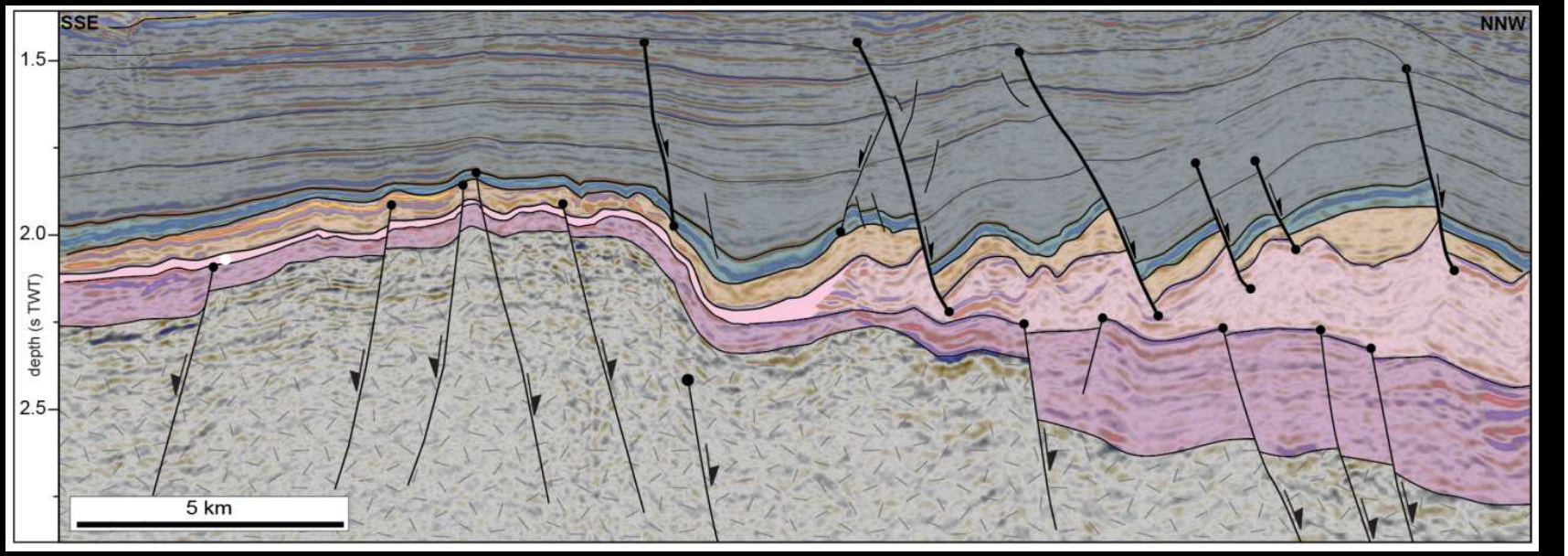
- Sele High, Egersund Basin
- ZSG impact on cover deformation





Structural Style Variability

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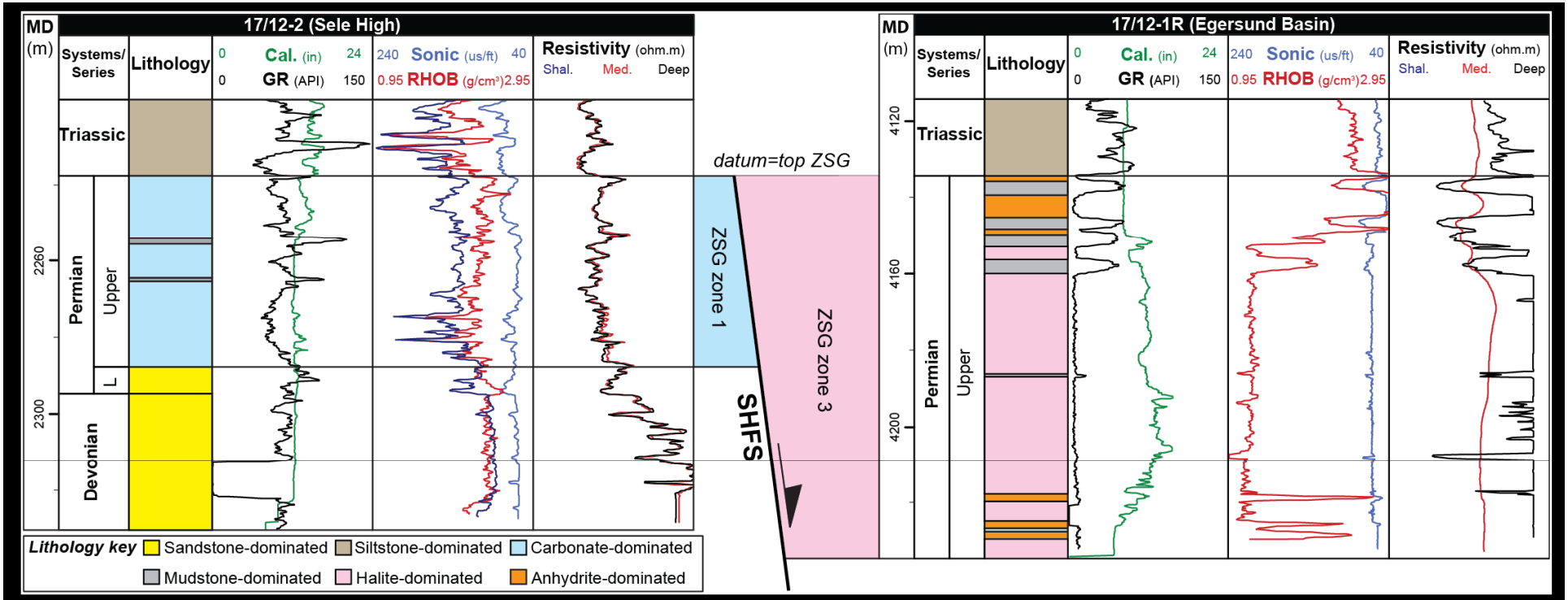

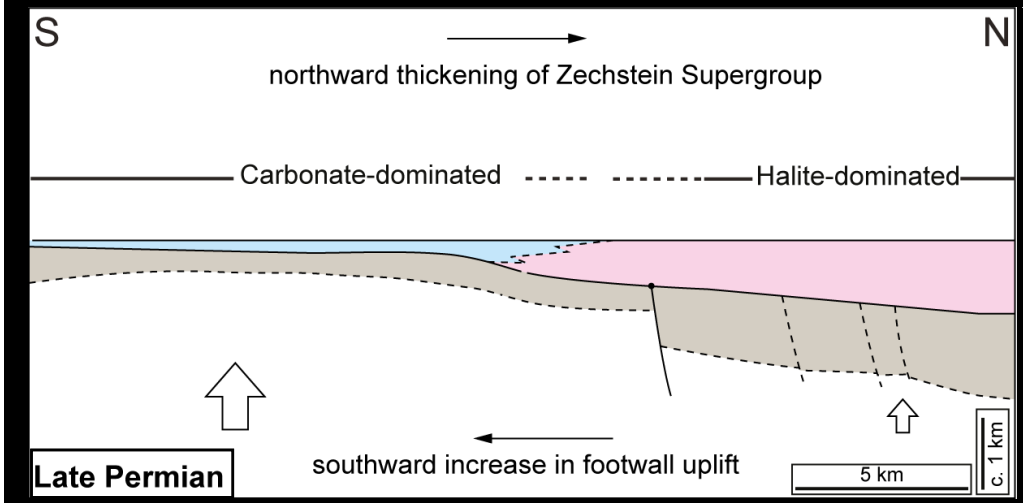

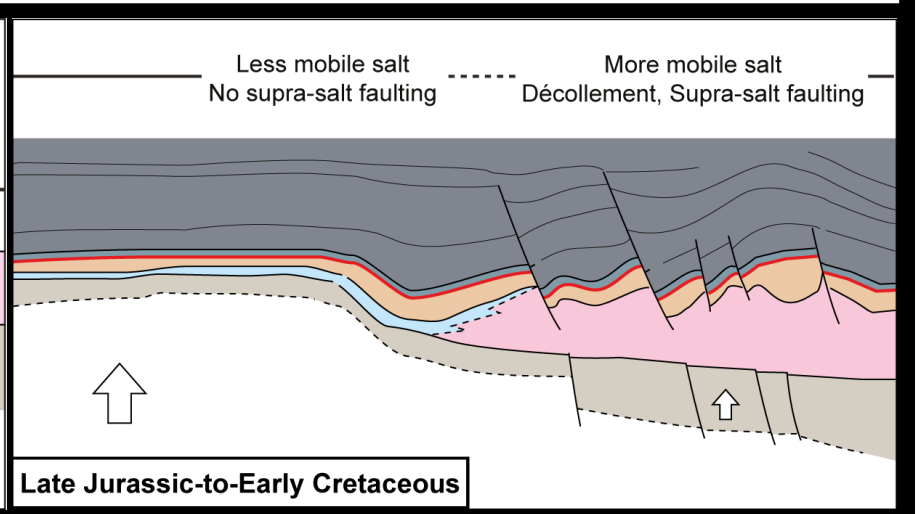

Thin-Skinned Tectono-Stratigraphic Styles

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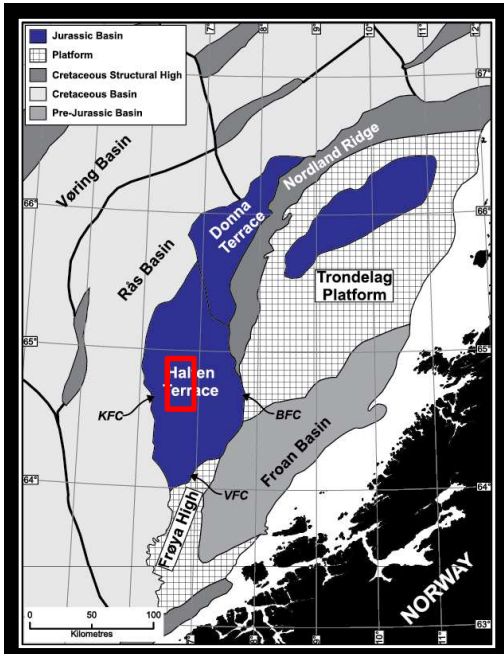
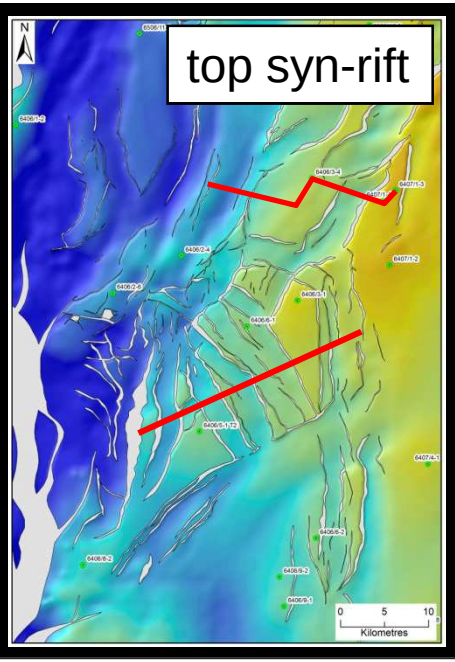
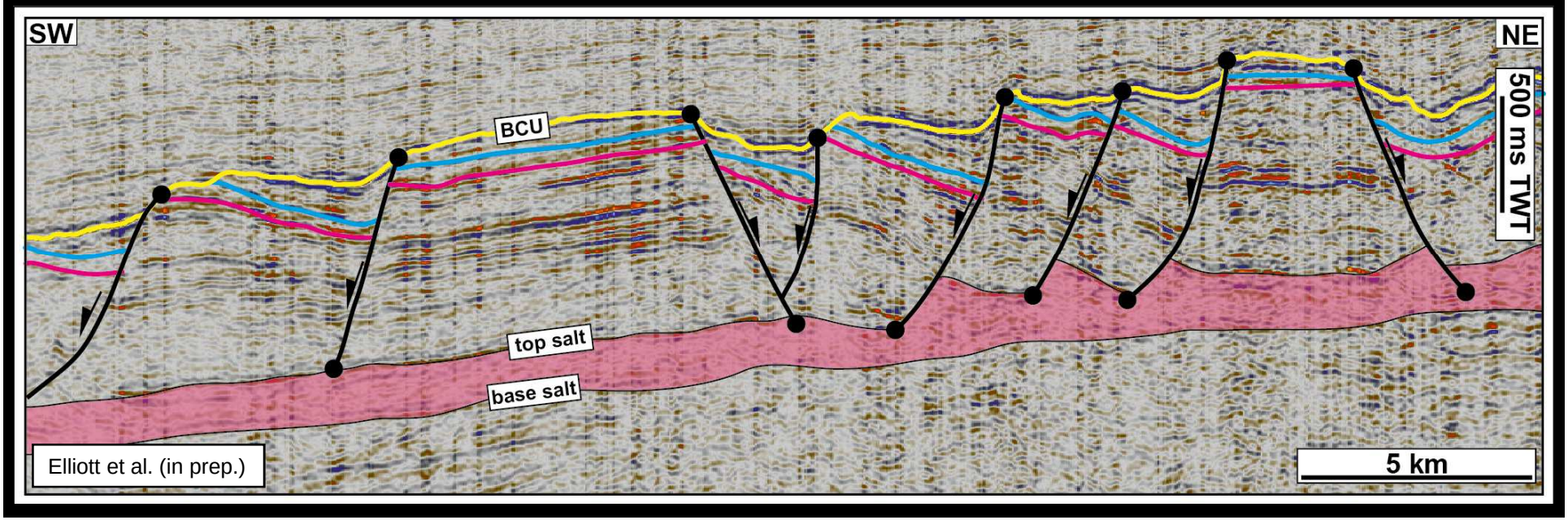




- Halten Terrace, offshore mid-Norway
- Thin-skinned extension on Triassic salt
- Listric faults, rafts and inter-raft depocentres
- Exploration focused on structural closures at raft crests
- Moderate erosion of raft blocks



Thin-Skinned Tectono-Stratigraphic Styles

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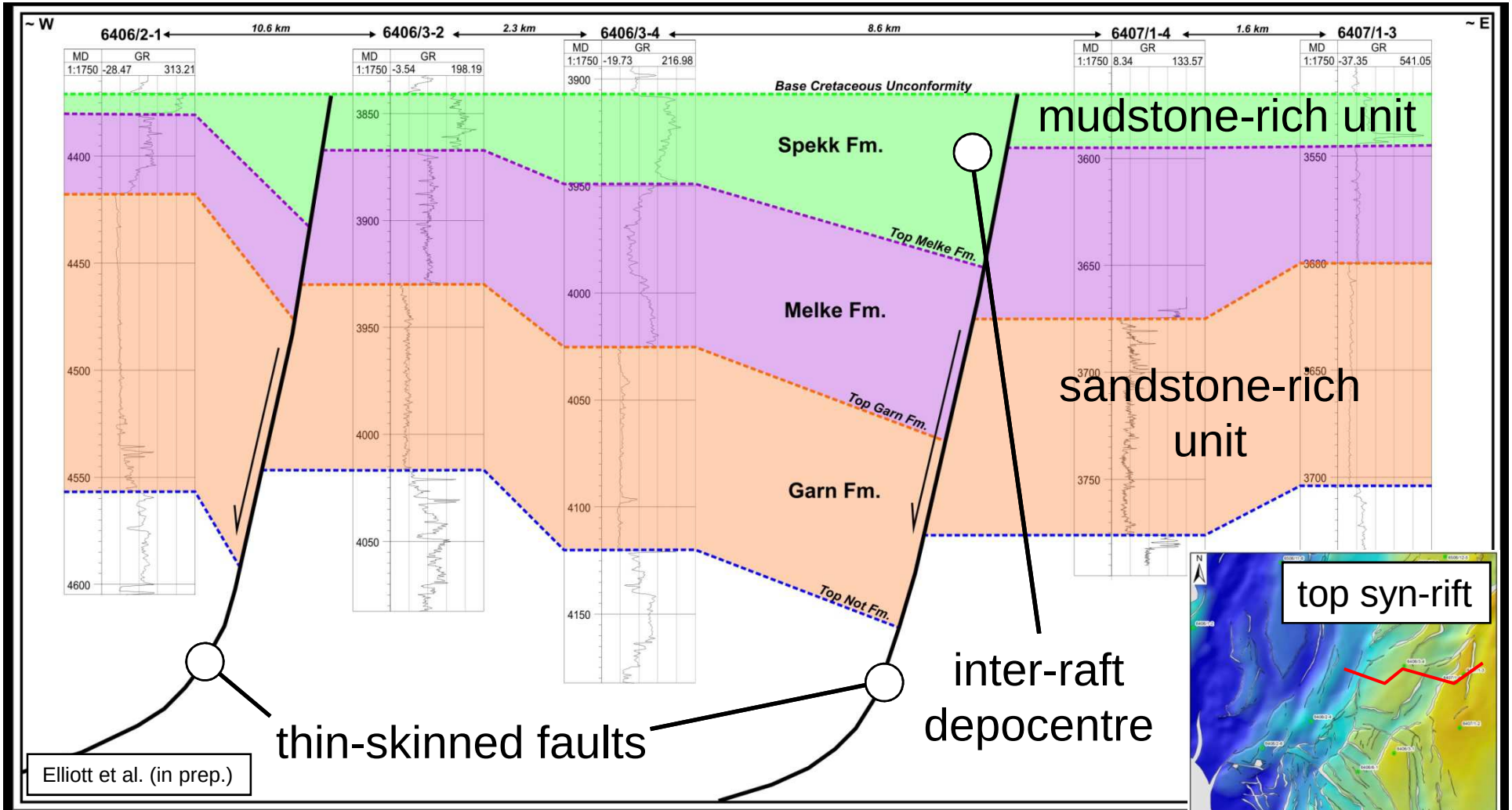

- Rafts capped by mudstone-dominated syn-kinematic succession
- Limited footwall uplift = minimal erosion of rafts = limited potential for reservoir deposition in inter-raft depocentres

Thin-Skinned Tectono-Stratigraphic Styles

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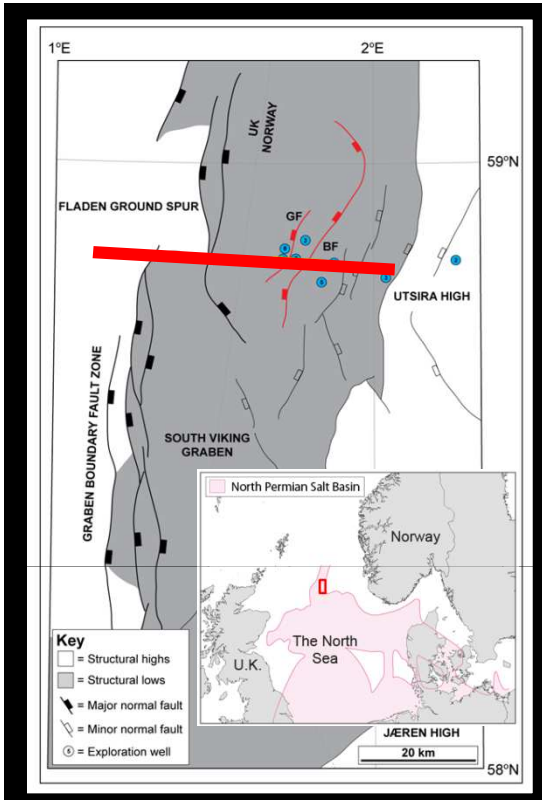
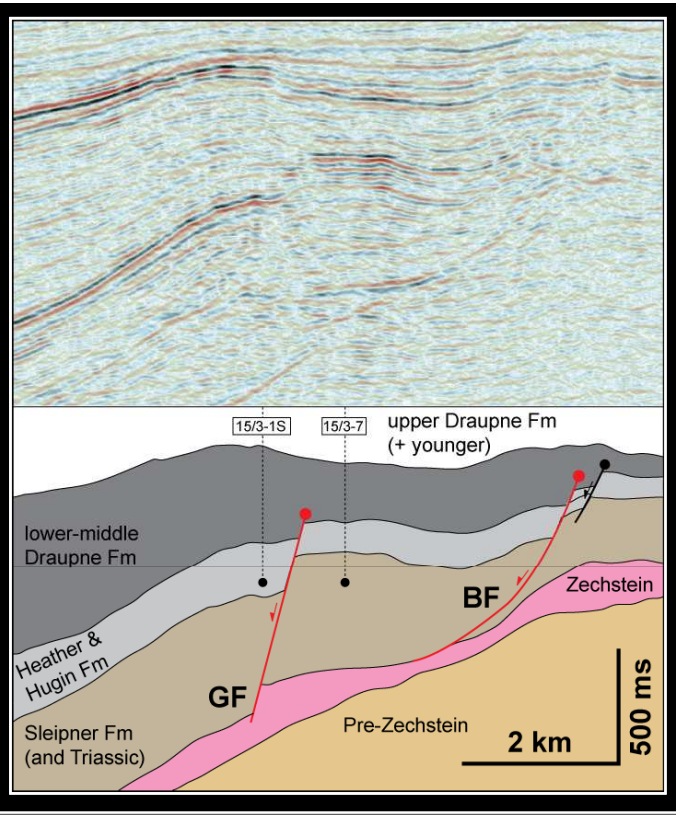
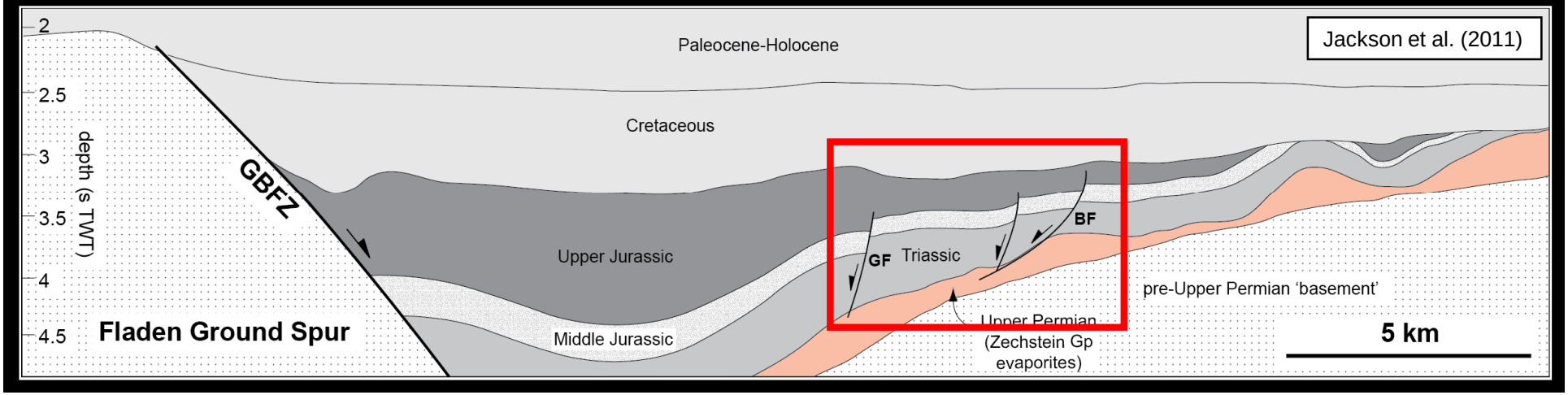




- South Viking Graben
- Thin-skinned extension above Zechstein salt
- Listric faults, rafts and inter-raft depocentres on hangingwall dipslope (i.e. intra-slope accommodation)
- Limited uplift, rotation and erosion of rafts



Thin-Skinned Tectono-Stratigraphic Styles

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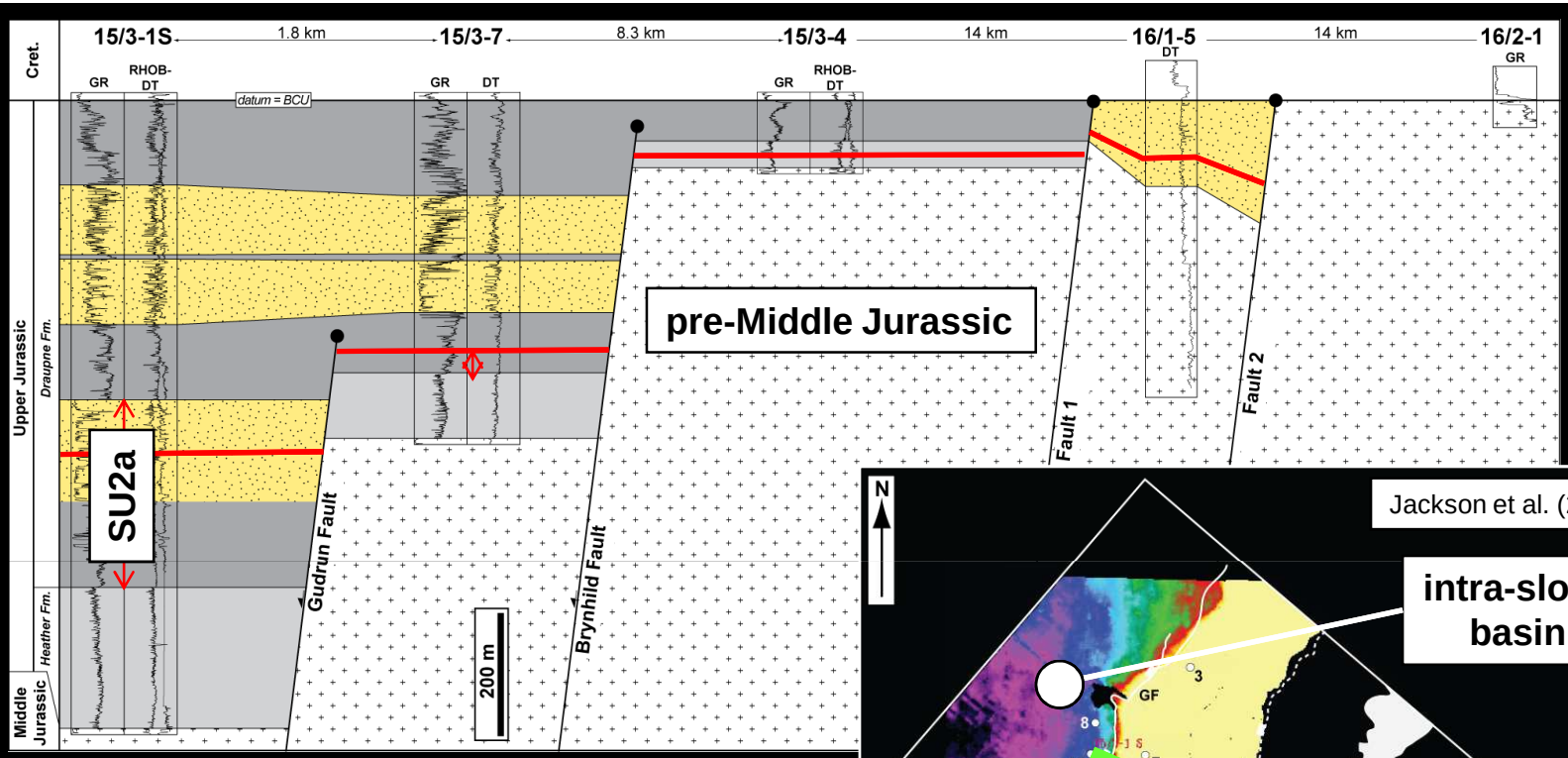
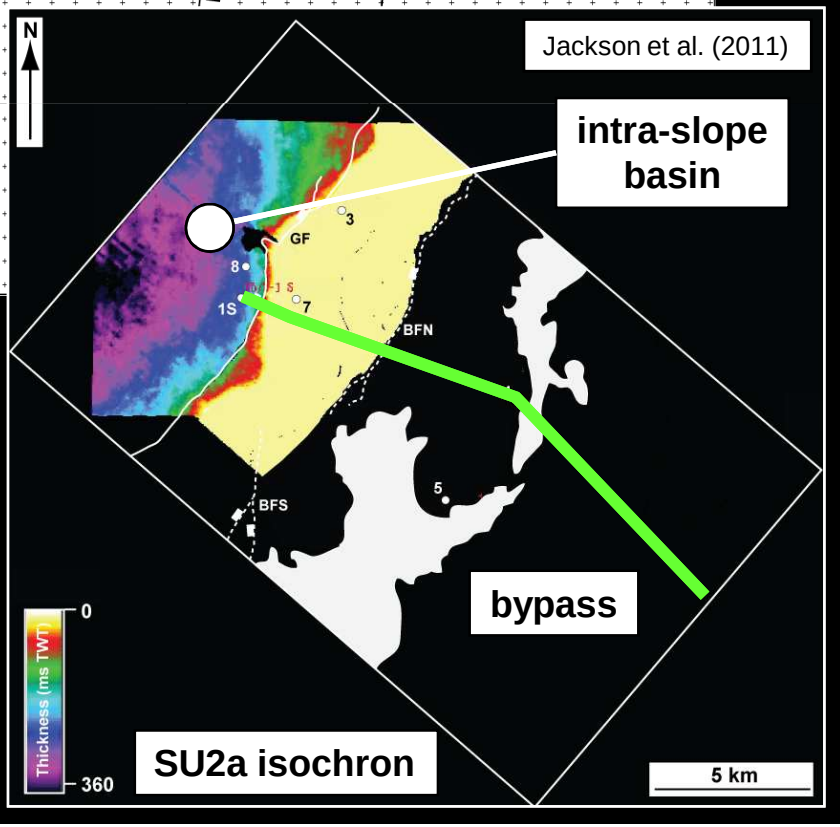
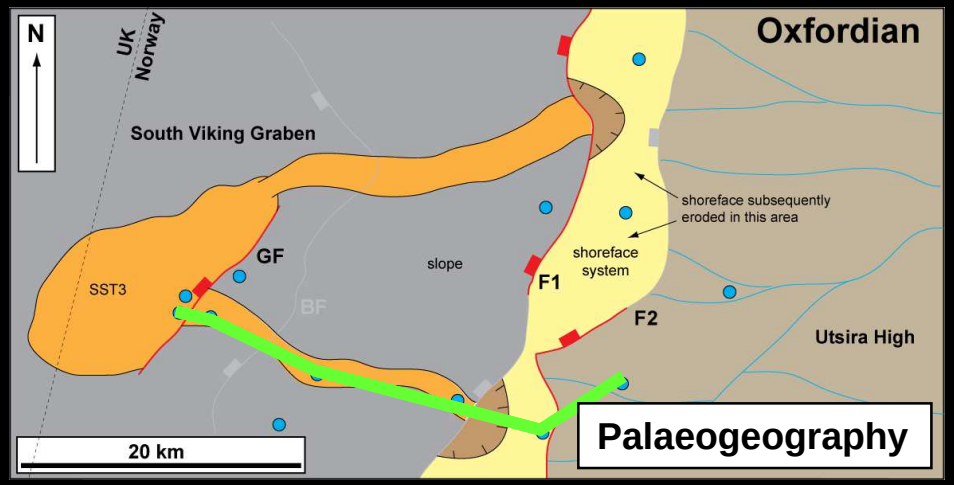
T1)

Upper Jurassic







Thin-Skinned Tectono-Stratigraphic Styles

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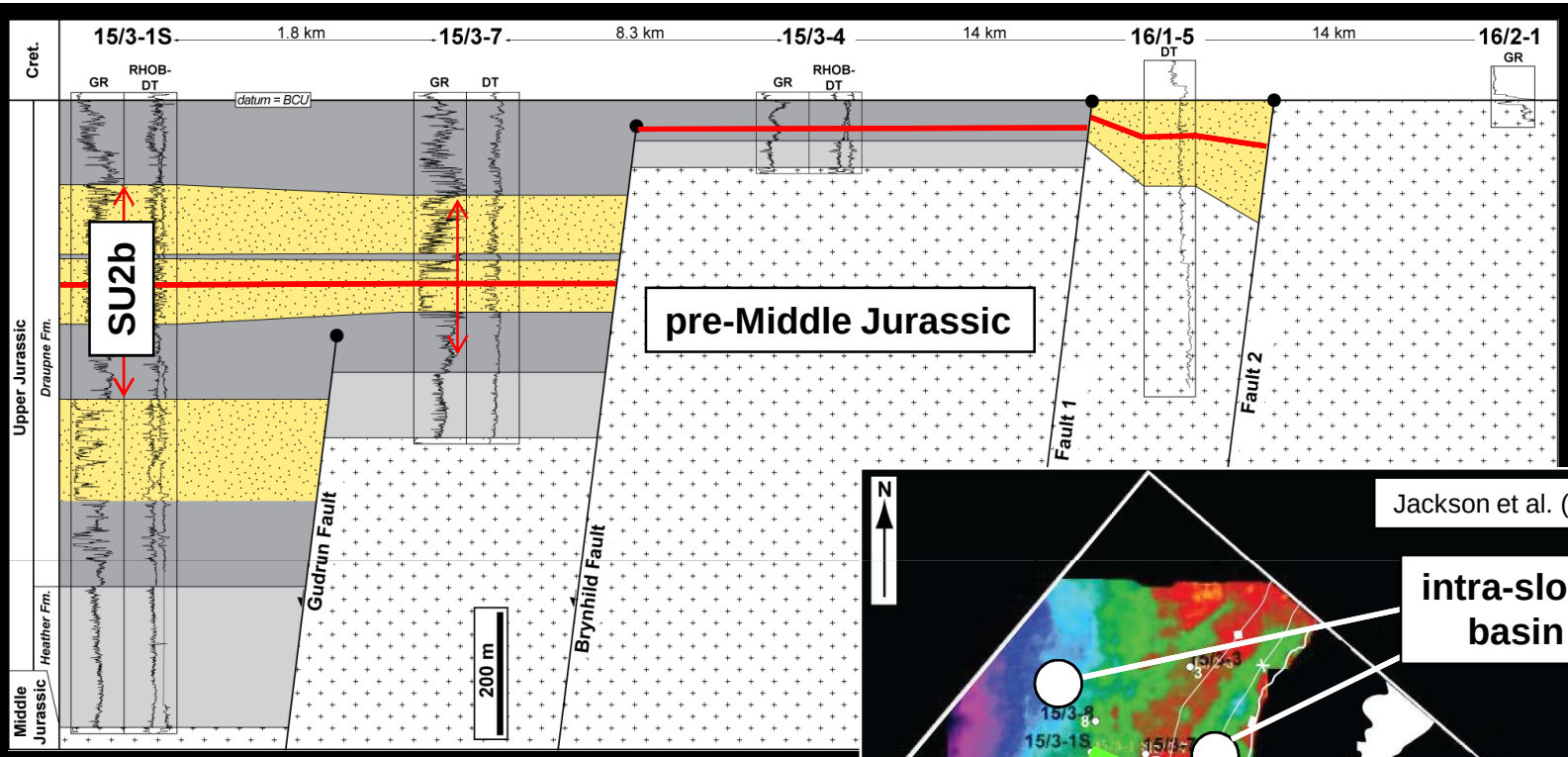
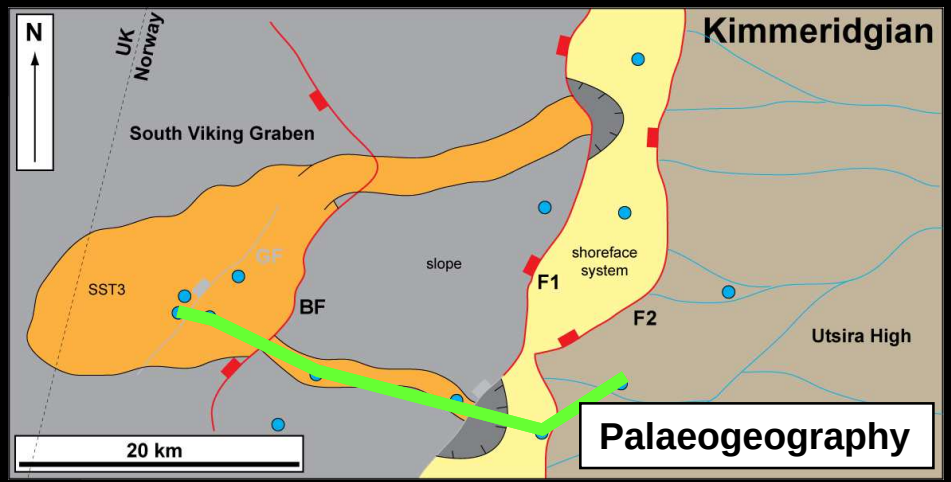
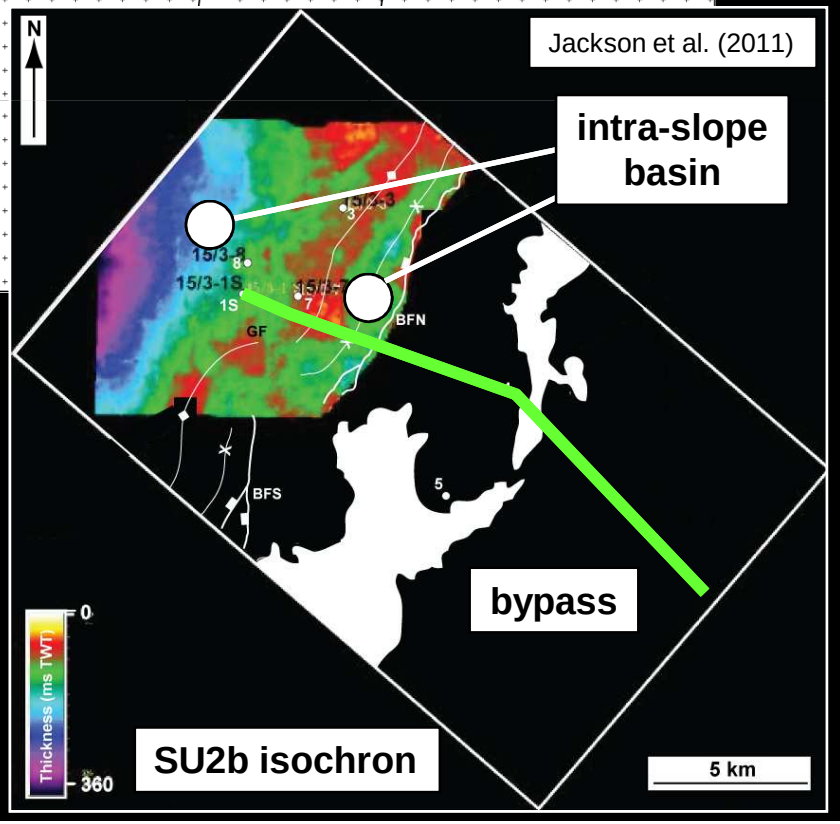
T2)

Upper Jurassic







‘Salt-Dominated’ Structural Styles

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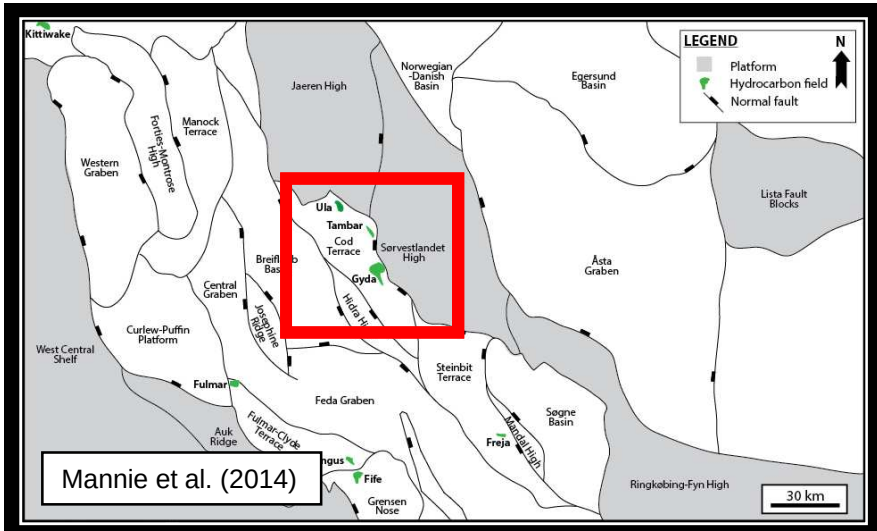

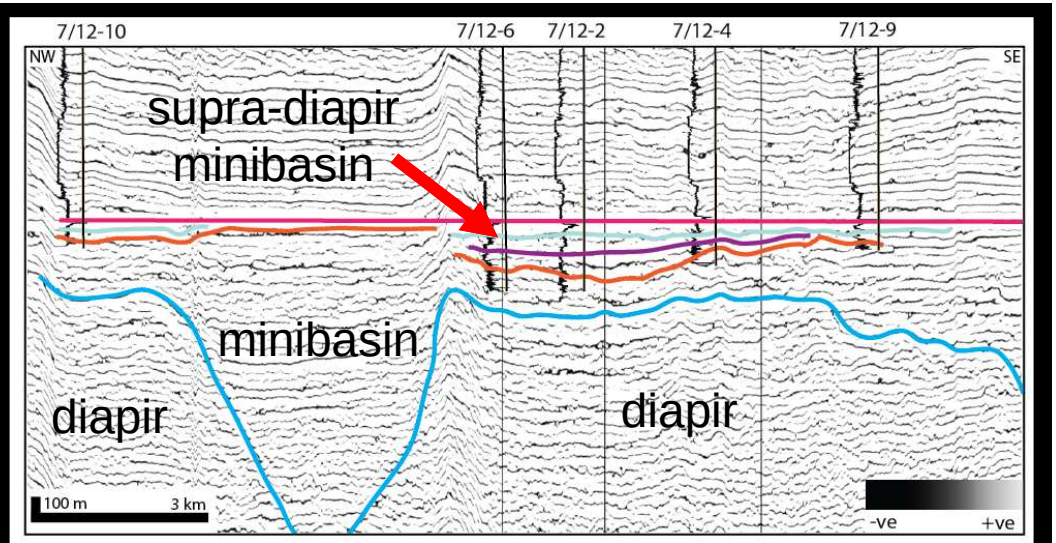

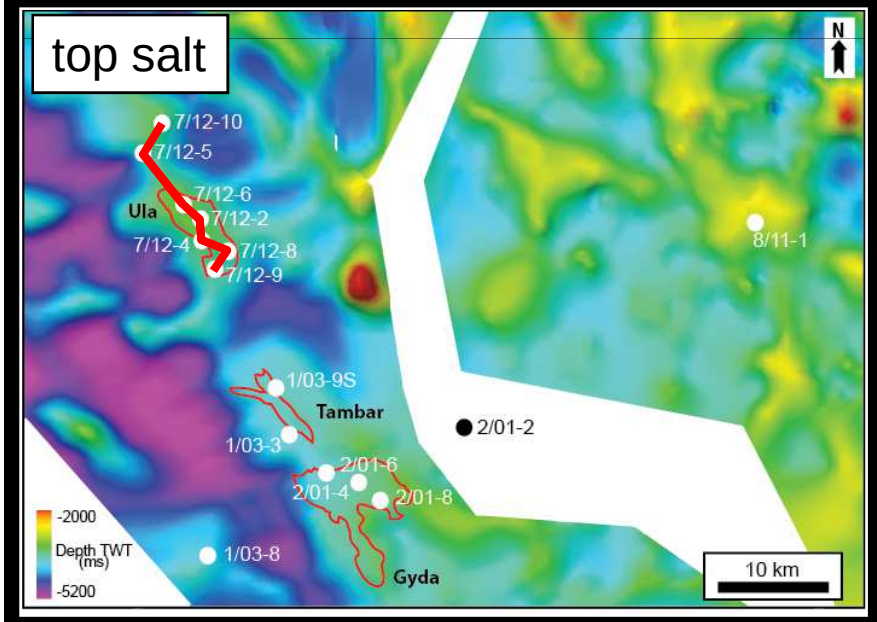

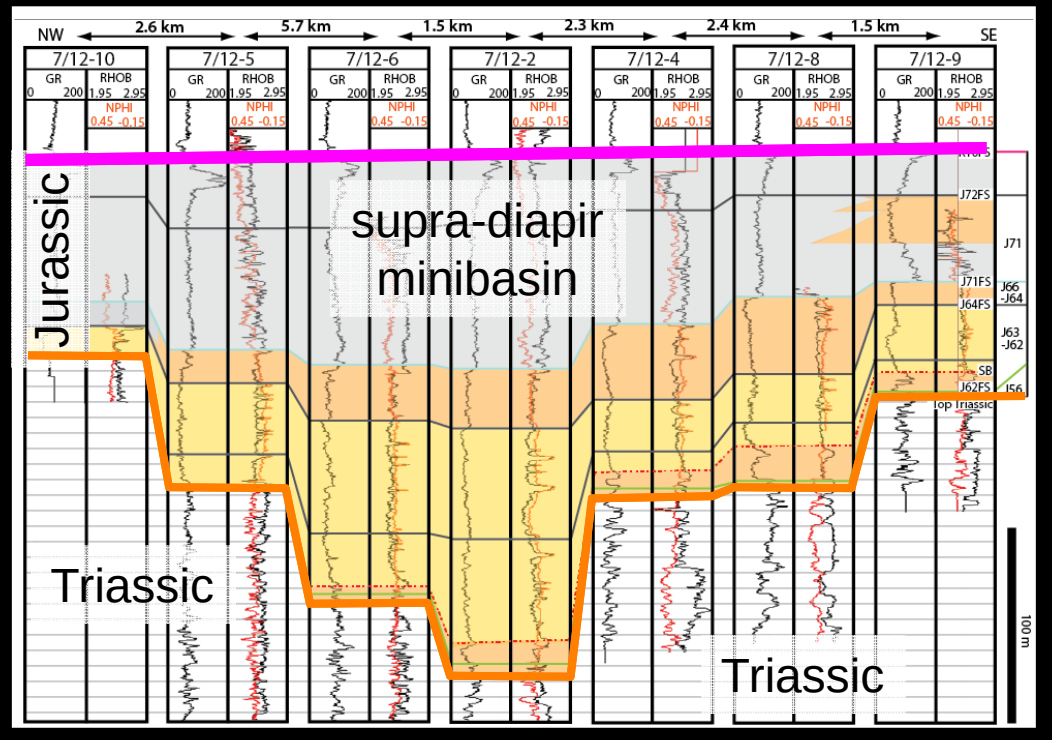

- Cod Terrace

‘Salt-Dominated’ Structural Styles

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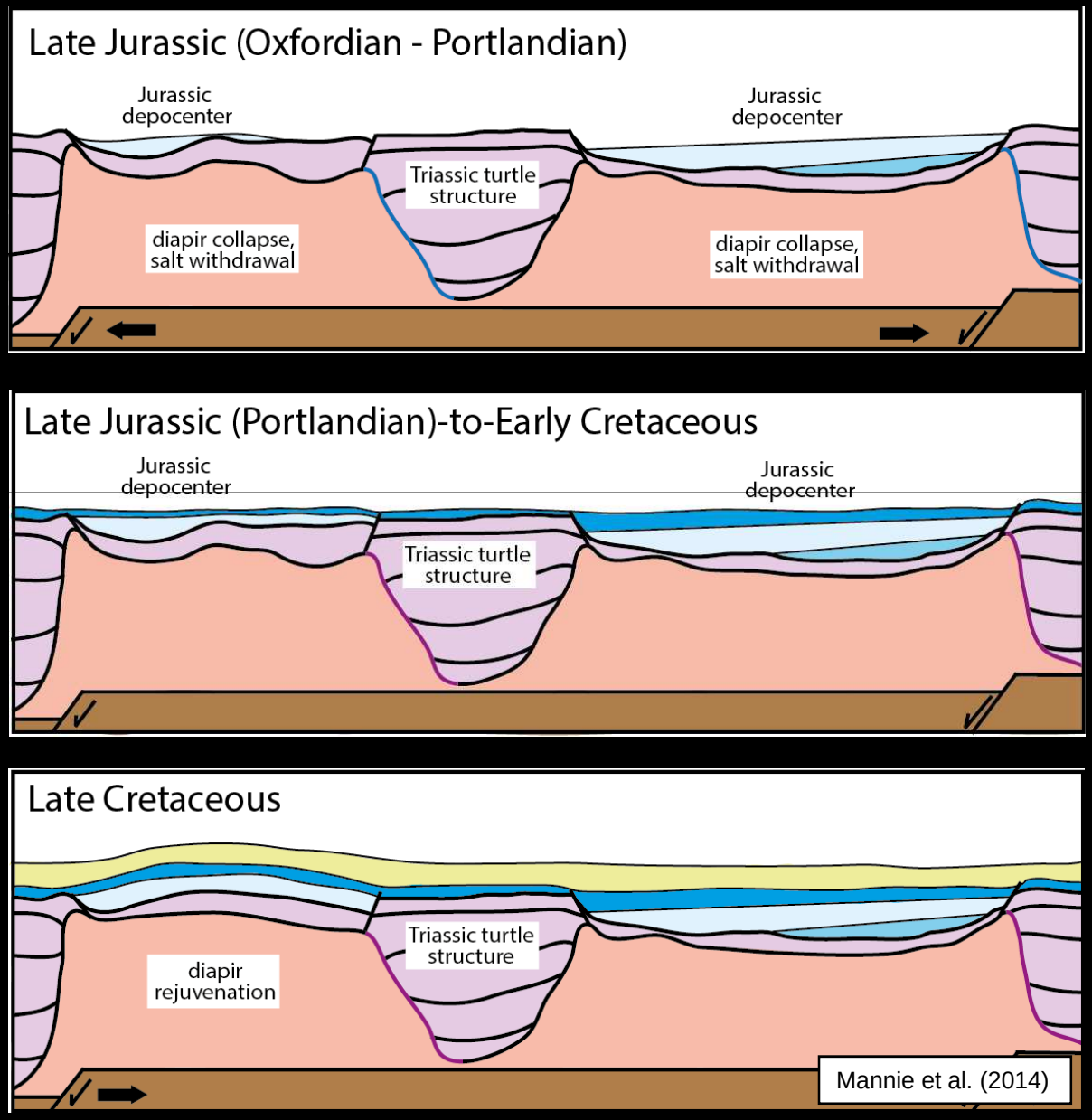

- **Stage 1 (Triassic-Middle Jurassic)** – Diapir growth (not shown)
- **Stage 2 (Oxfordian-Volgian)** – Basement and cover extension; diapir collapse and supra-diapir minibasin formation
- **Stage 3 – (latest Volgian-Early Cretaceous)** – Continued basement and cover extension, diapir collapse and supra-diapir minibasin subsidence
- **Stage 4 – (Late Cretaceous)** – Regional shortening, diapir squeezing and trap formation

SIRB Physiography I

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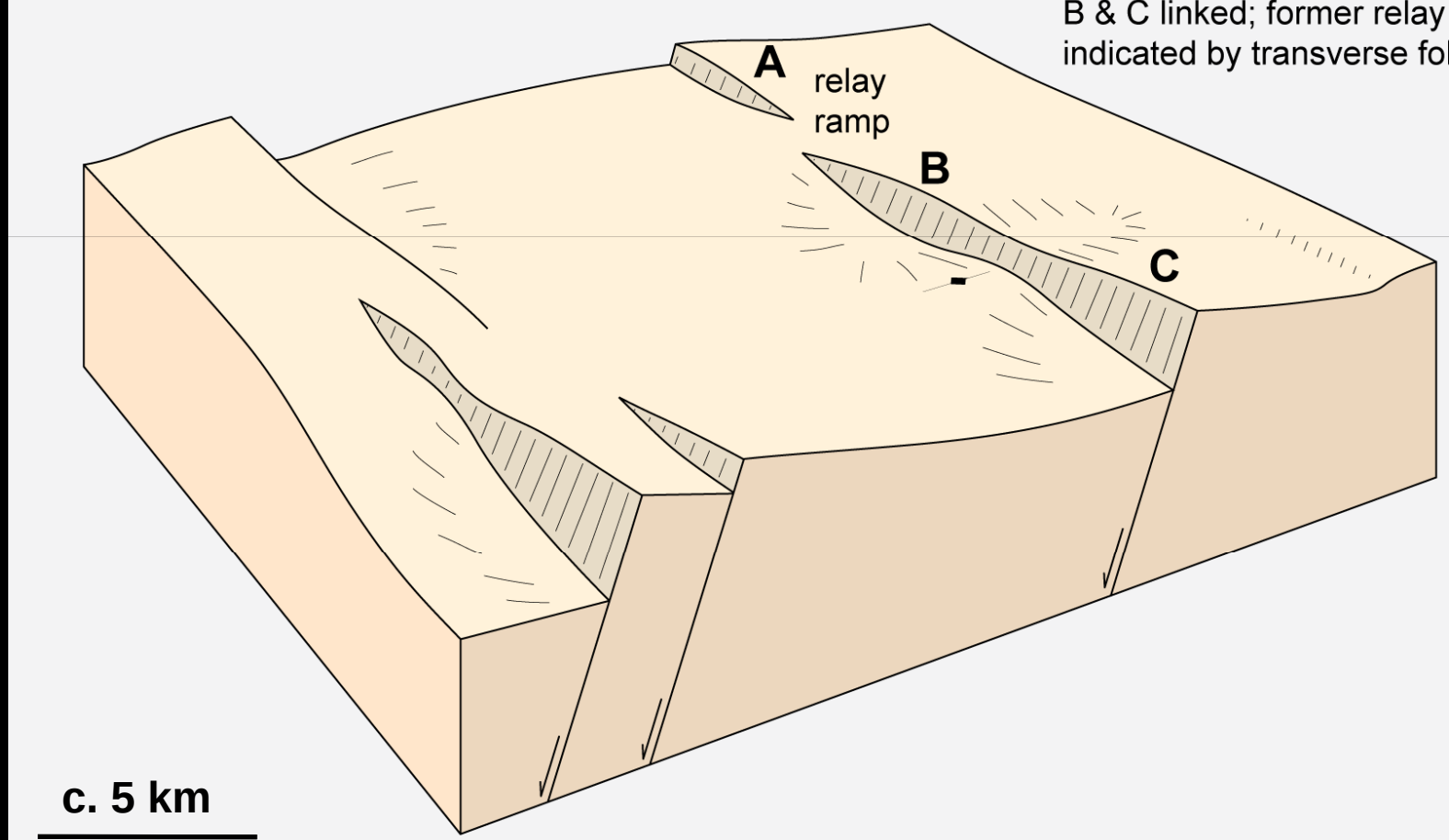
Basement Fault Geometry



SIRB Physiography II

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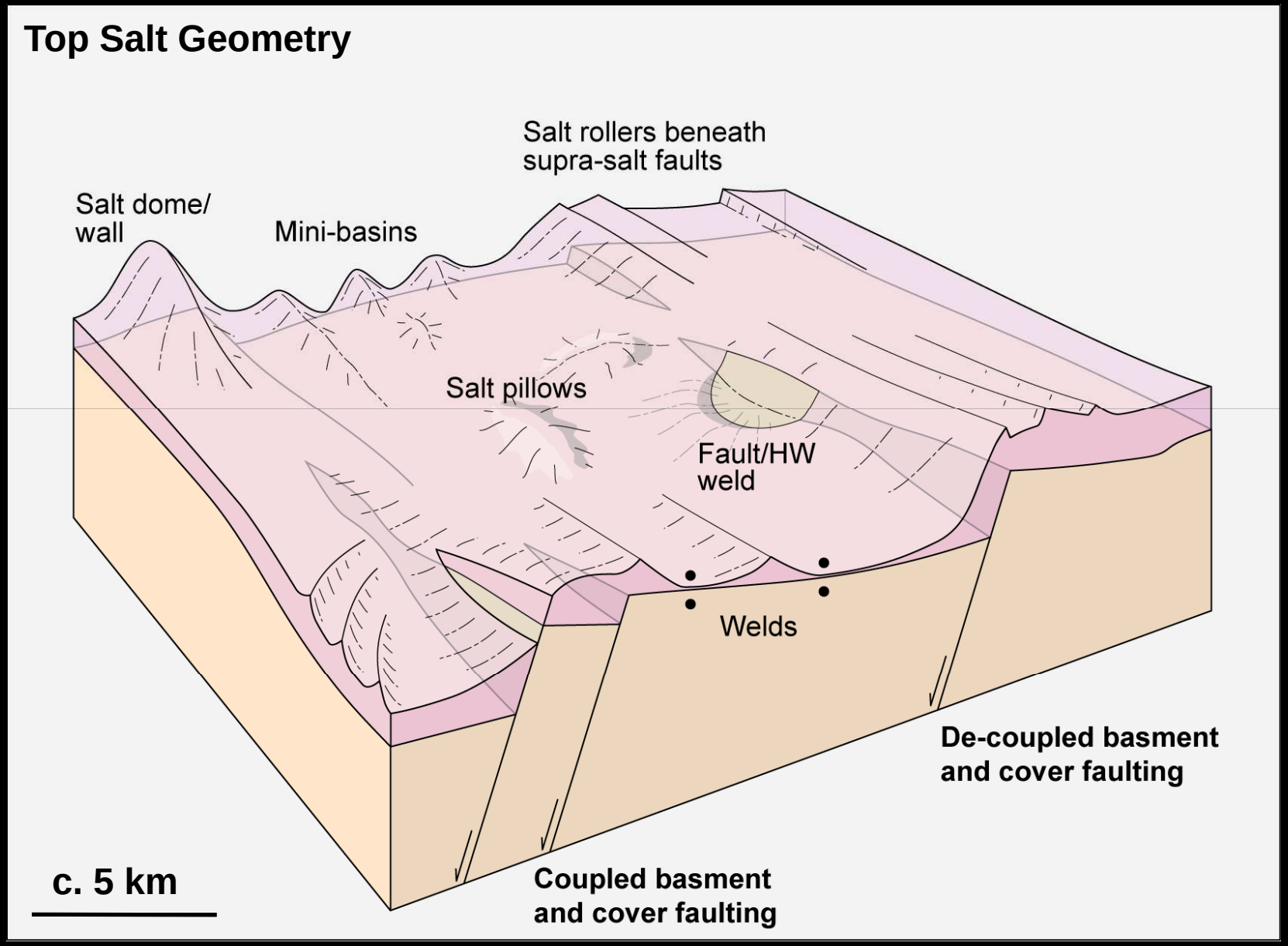

SIRB Physiography III

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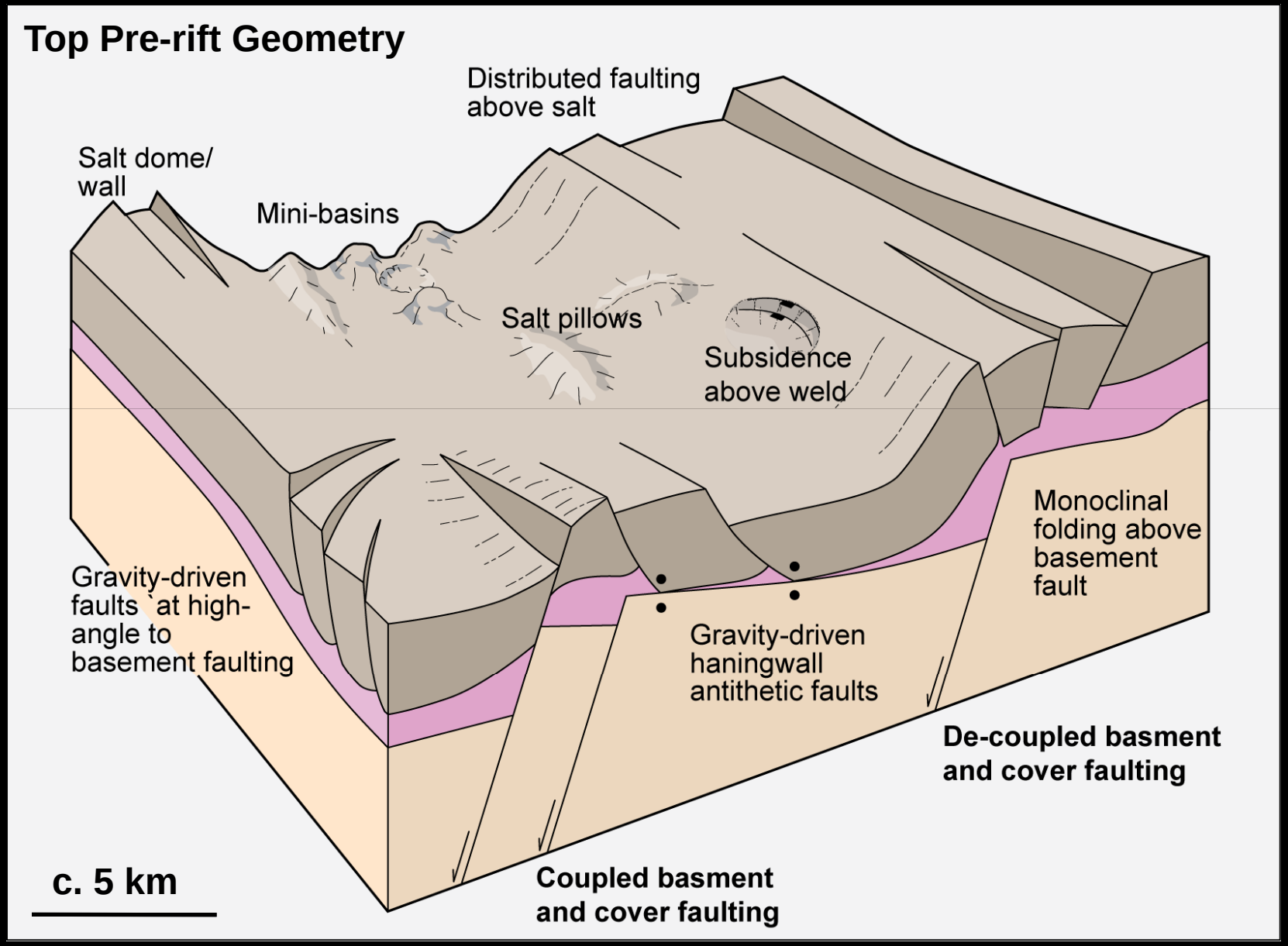

SIRB Depositional Systems

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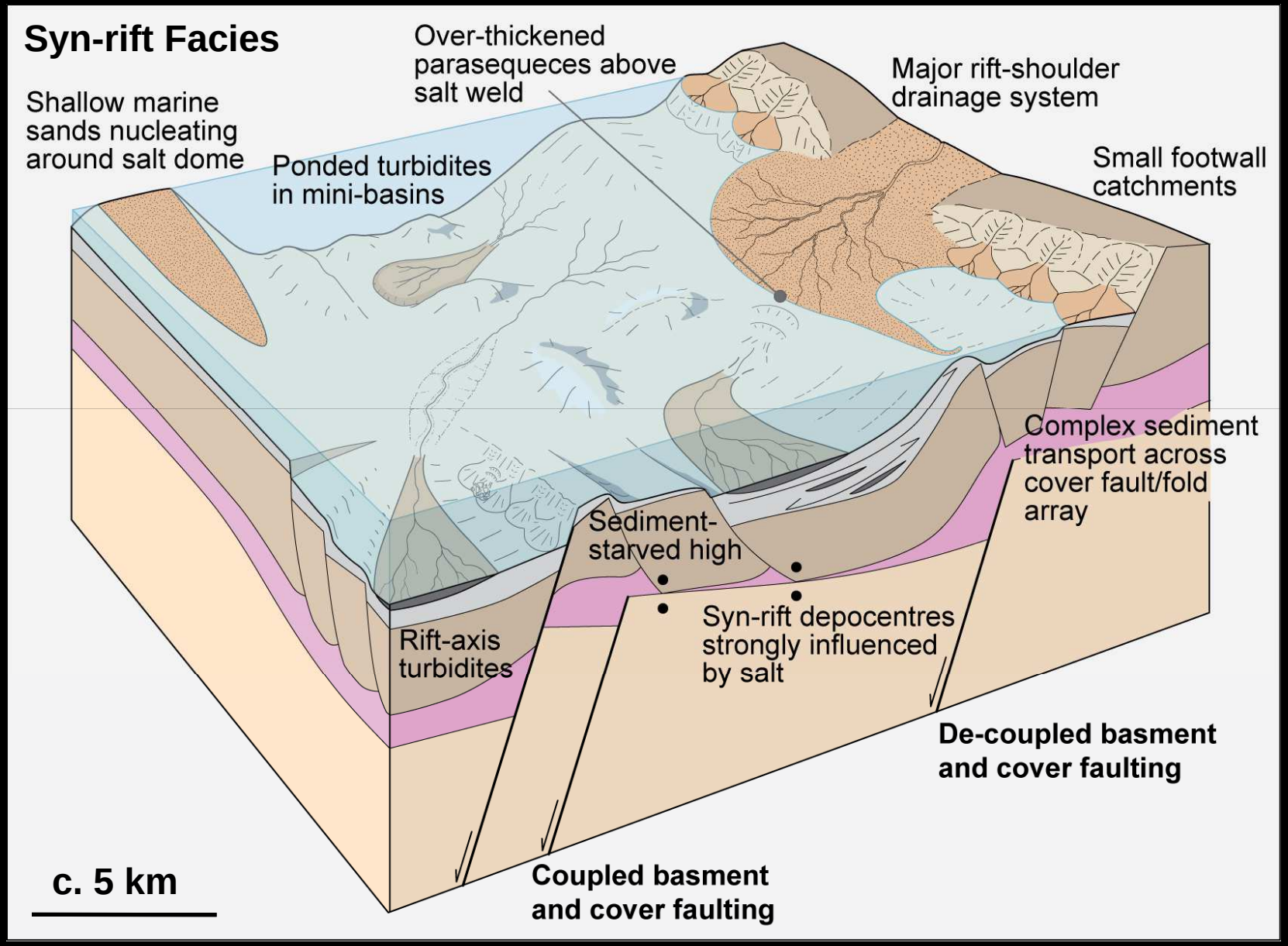

Accommodation Development

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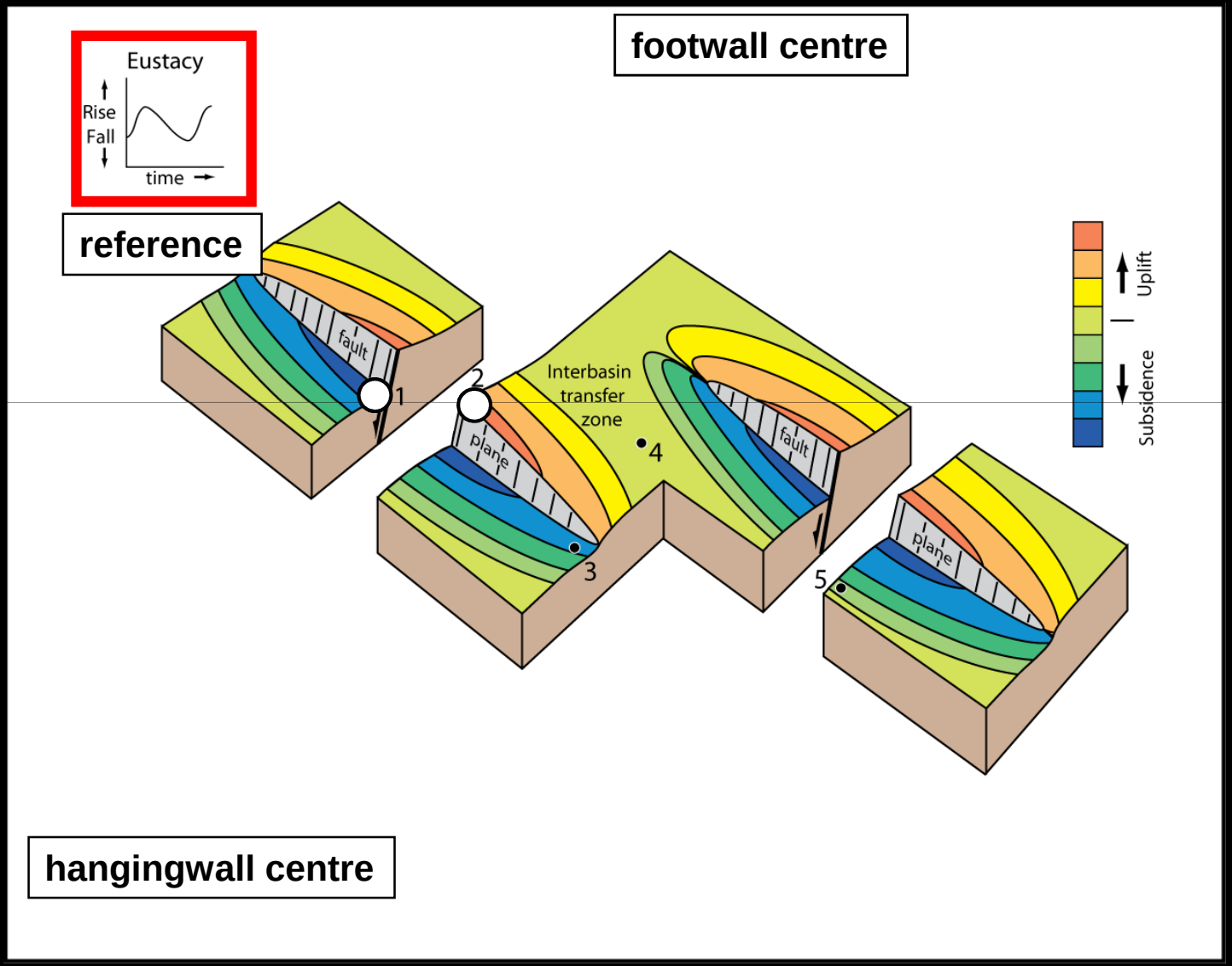
Salt-free rift



Gawthorpe et al. (1994)

Accommodation Development

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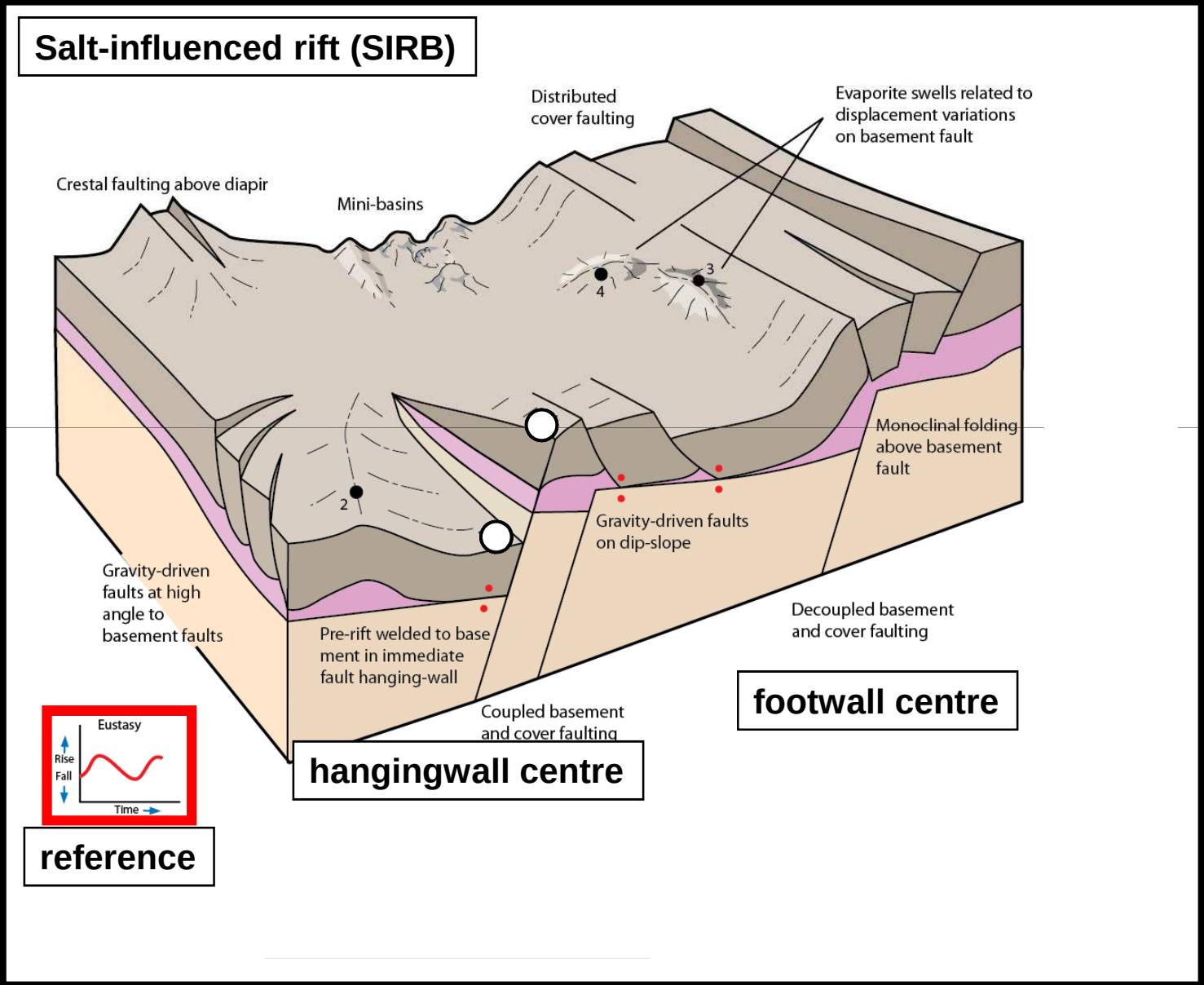

SIRB Structural Styles and Traps

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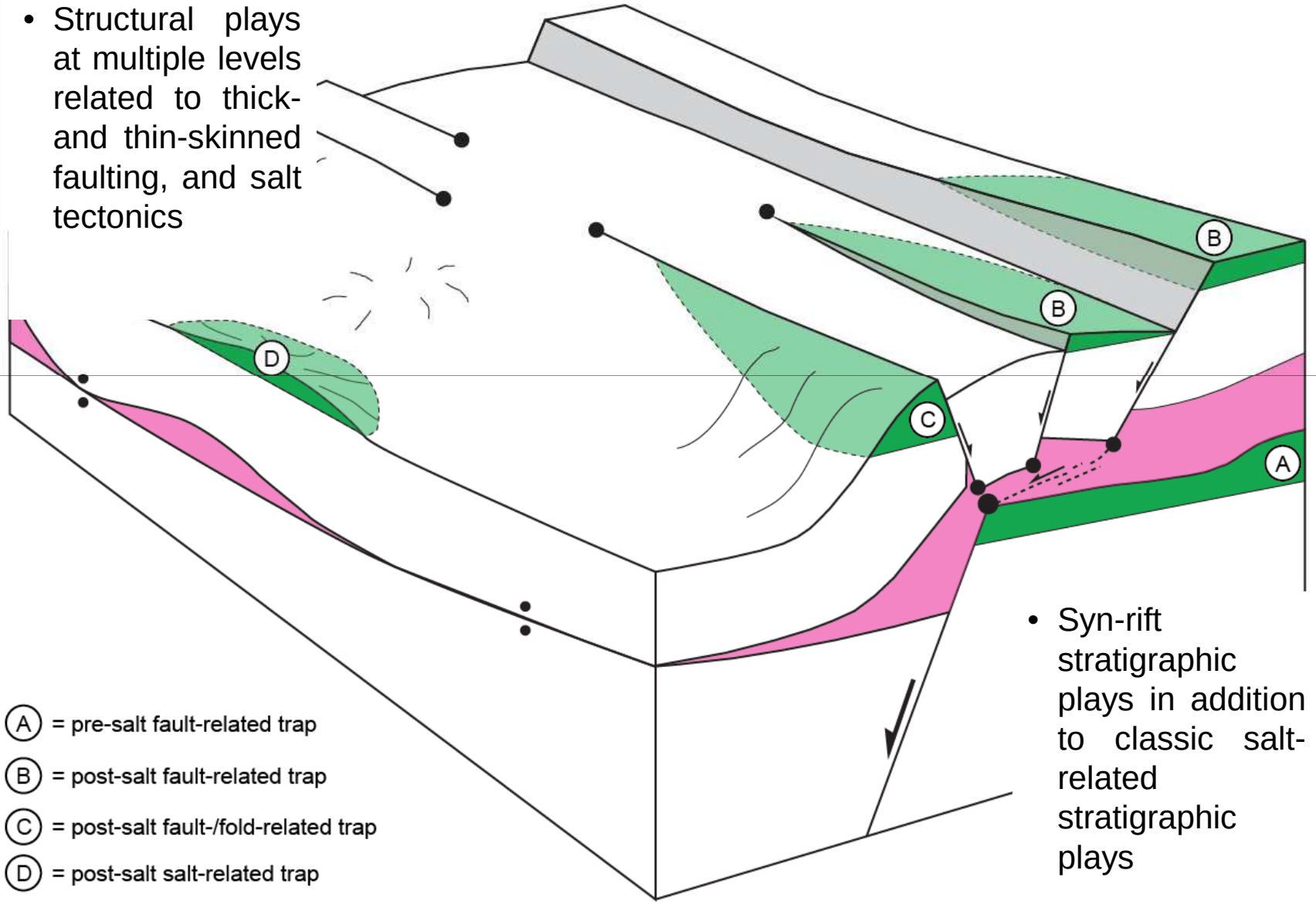
- Structural plays at multiple levels related to thick- and thin-skinned faulting, and salt tectonics



- Syn-rift stratigraphic plays in addition to classic salt-related stratigraphic plays

Conclusions

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- **Does salt impact the structural style of rift basins?**
  - More folding and distributed cover (thin-skinned) faulting
  - Variable coupling of basement and cover structural styles
  - Structures associated solely with halokinesis
  - Lack of simple half-graben and segmented normal faults
  - Modified fault populations
- **Does salt impact size and location of sediment source areas, sediment dispersal and stratigraphic architecture?**
  - Complex depocentres
  - Sediment source area size and location linked to degree of structural coupling
  - Complex sediment supply pathways
  - Megasequences hard to recognize due to salt flow
- **How does salt influenced hydrocarbon prospectivity in SIRBs?:**
  - Fault- and fold-related trapping styles
  - Smaller/compartmenalised traps in cover
- **Are existing tectono-stratigraphic models applicable to SIRBs?**
  - No. Bespoke models incorporating the above aspects should be used…

Fault Growth and Linkage

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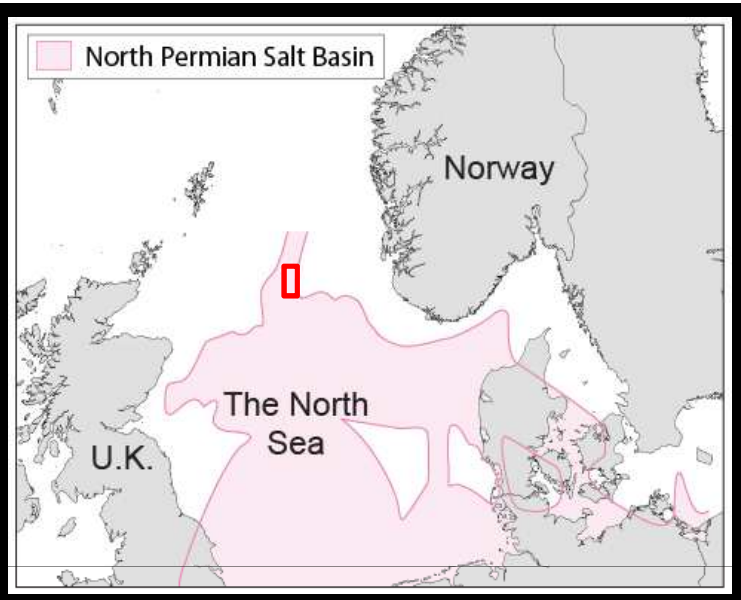
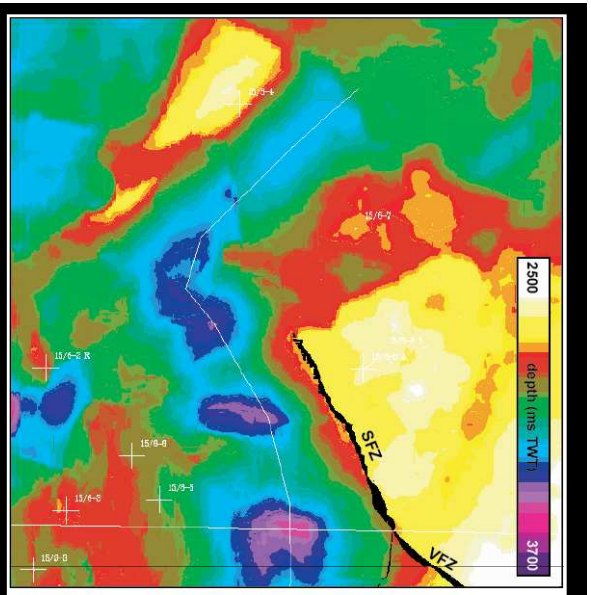
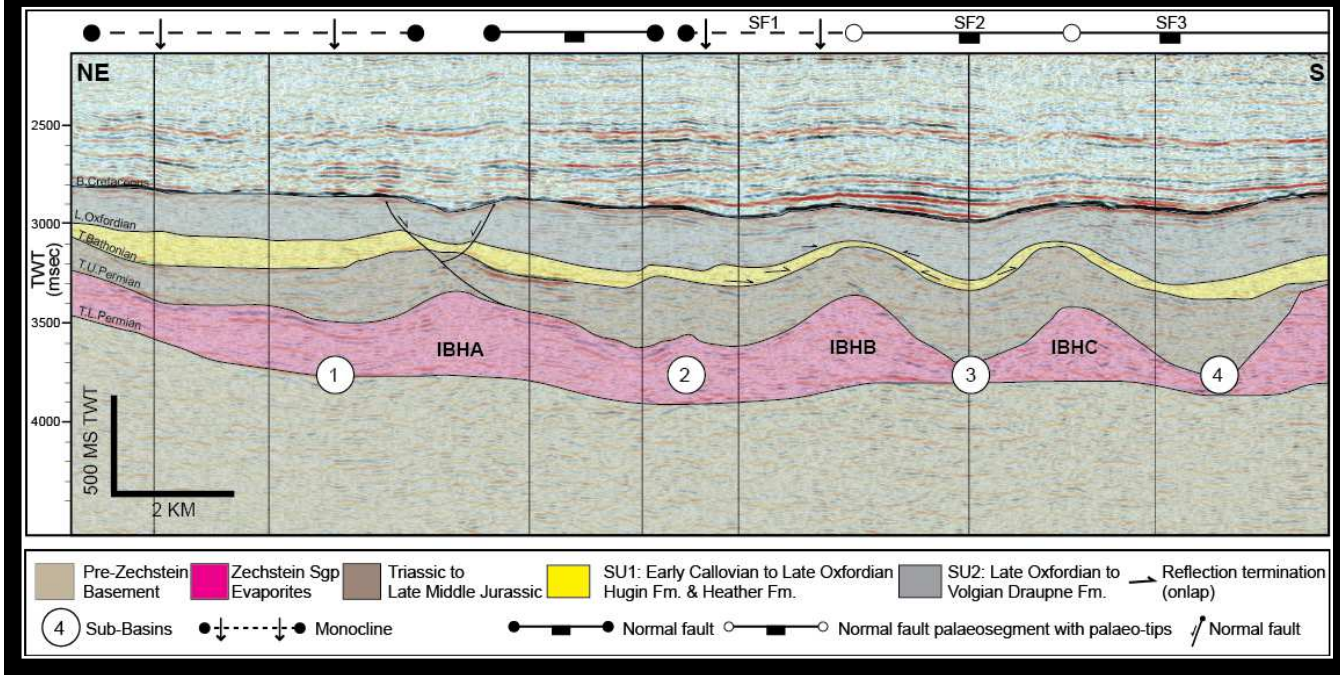
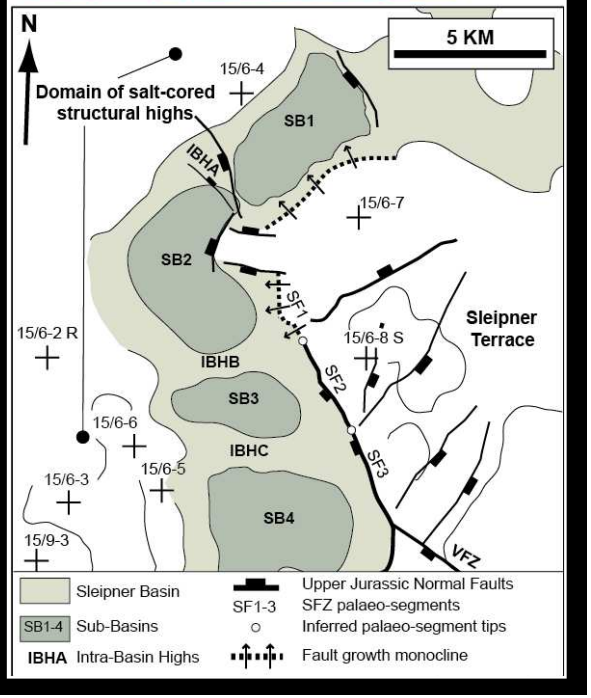
- South Viking Graben, offshore Norway
- Rifting initiated across a complex, salt-related structural template
- Along-strike variations in throw on basin-bounding faults
- Fault-related salt mobility and salt-related folding
- Complex half-graben geometries

Kane et al. (2010)









Fault Growth and Linkage

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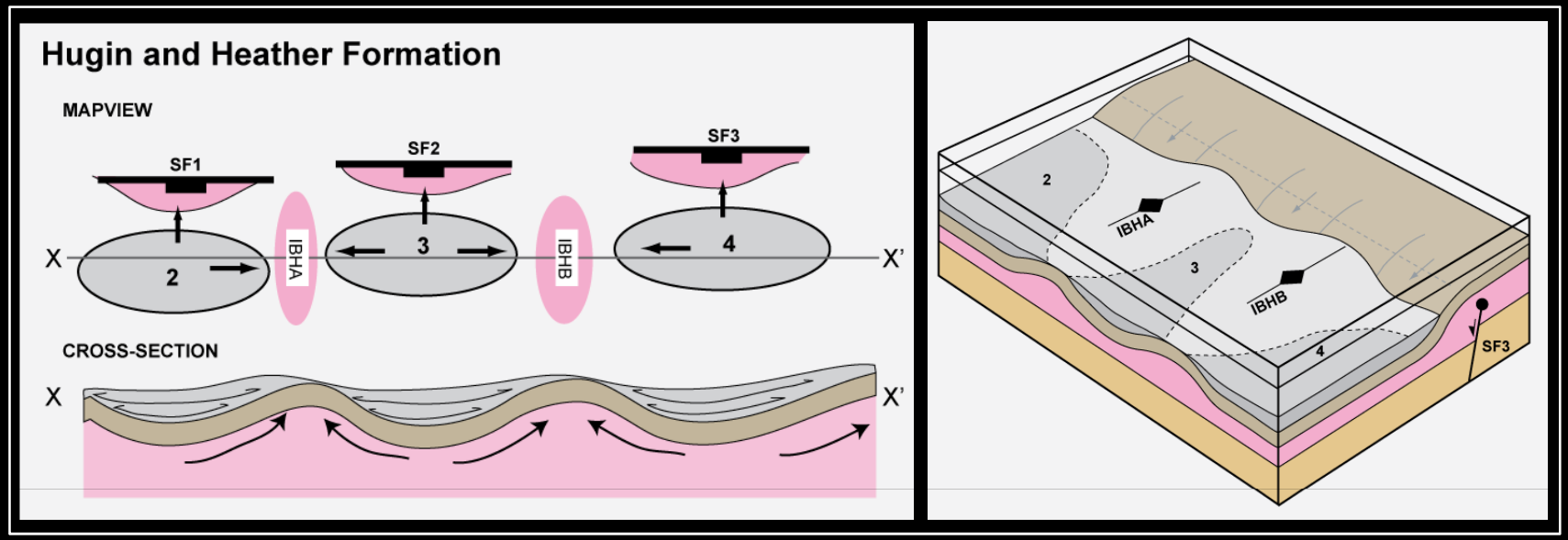

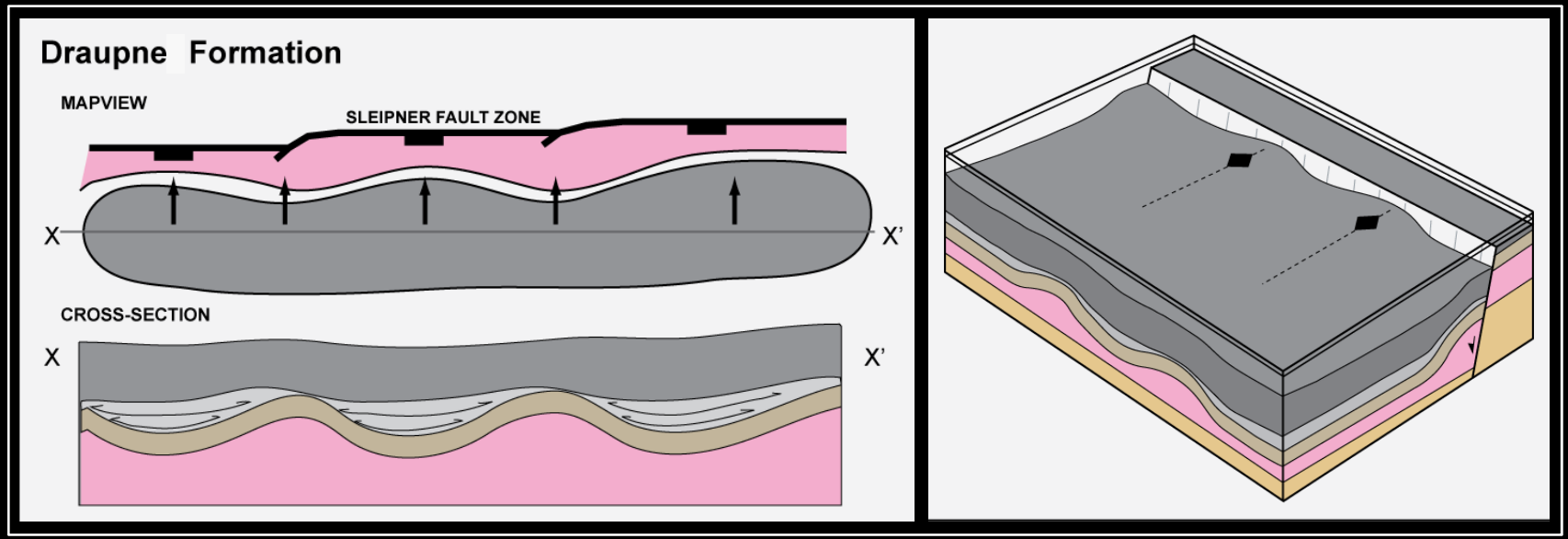

Kane et al. (2010)

Salt-Dominated Structural Styles

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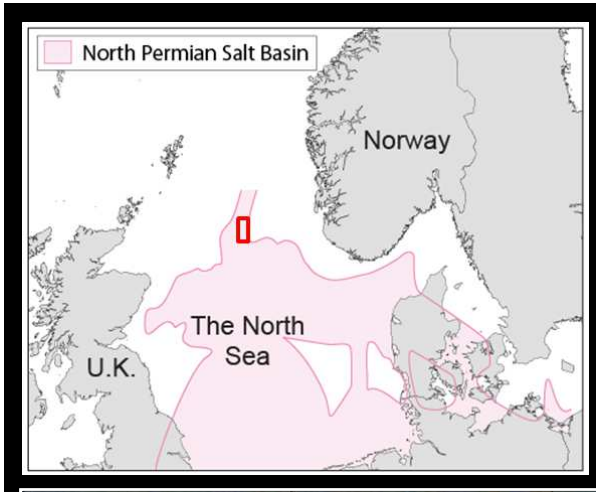
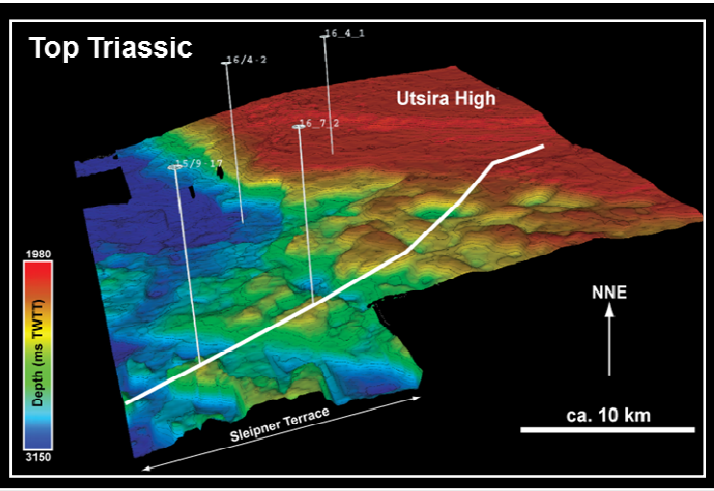
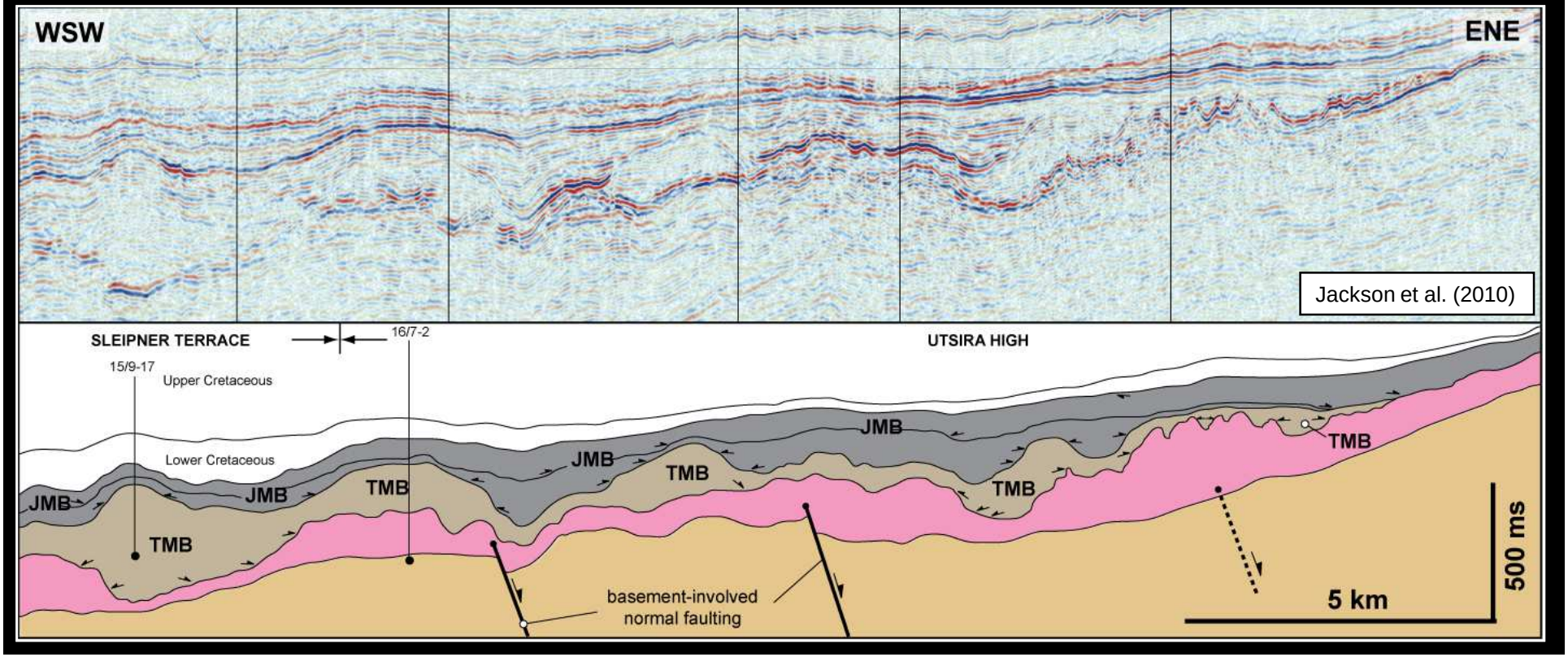




- South Viking Graben
- Sub-salt faults and complex thickness patterns related to salt flow
- Trigger uncertain…



Summary

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