wintershall

Shaping the future.

Salt invasion in a Triassic reservoir

A case study from the Southern North Sea

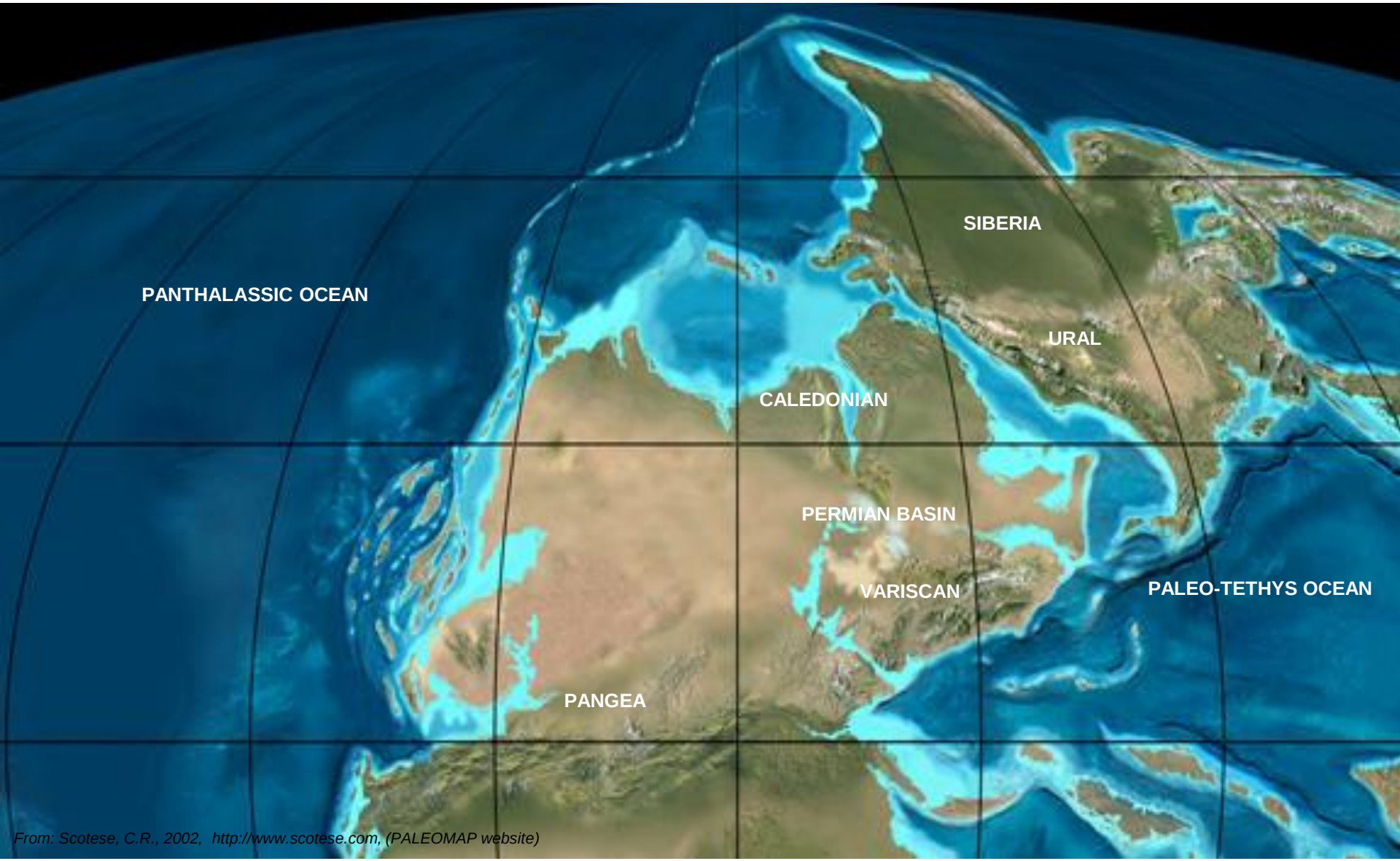
Agenda

- Regional setting
- Triassic gas play
- Statistical investigation
- Seismic attribute analysis
- Conclusions & further study

Acknowledgements

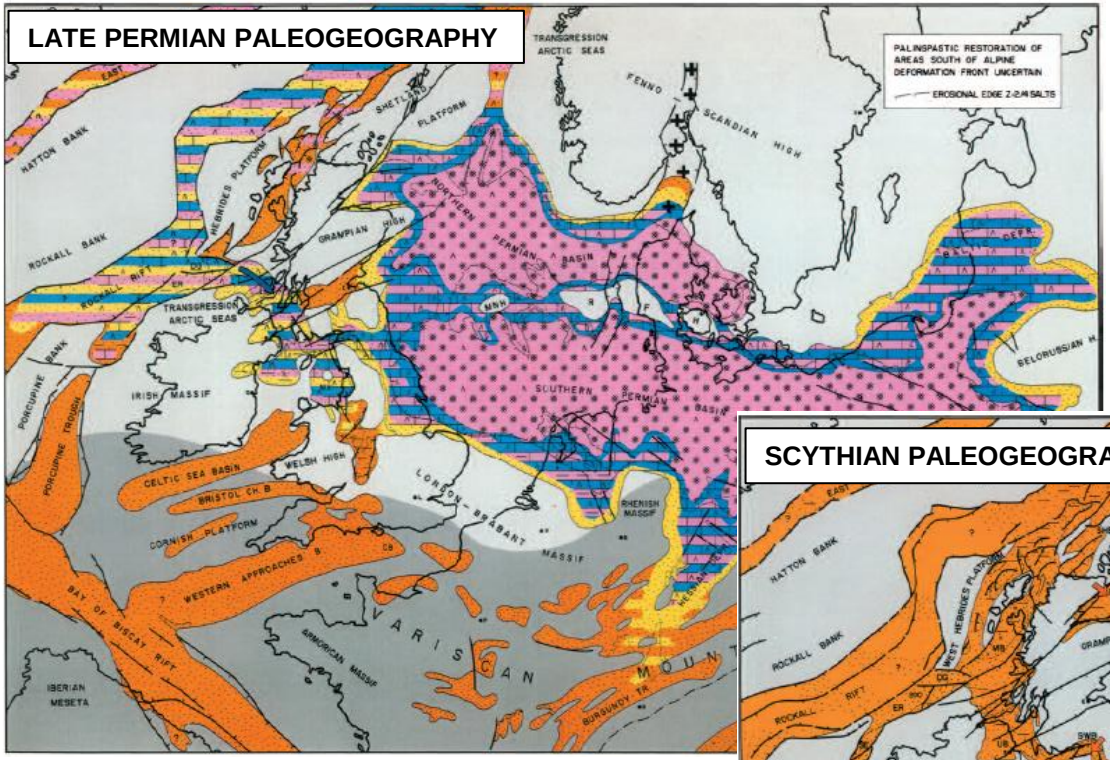
Data presented with permission from EBN B.V., Dana Petroleum Netherlands B.V. and Wintershall Noordzee B.V.

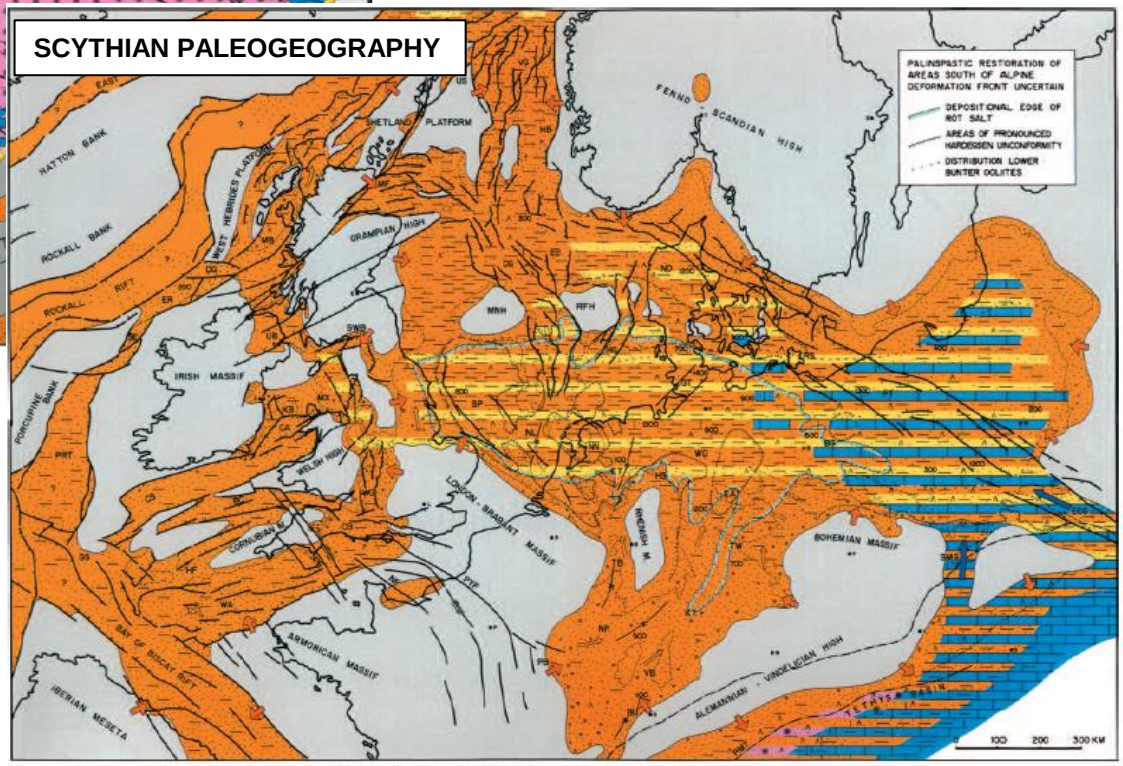
Plate Tectonic Reconstruction
Late Permian - Early Triassic



From: Scotese, C.R., 2002, http://www.scotese.com, (PALEOMAP website)

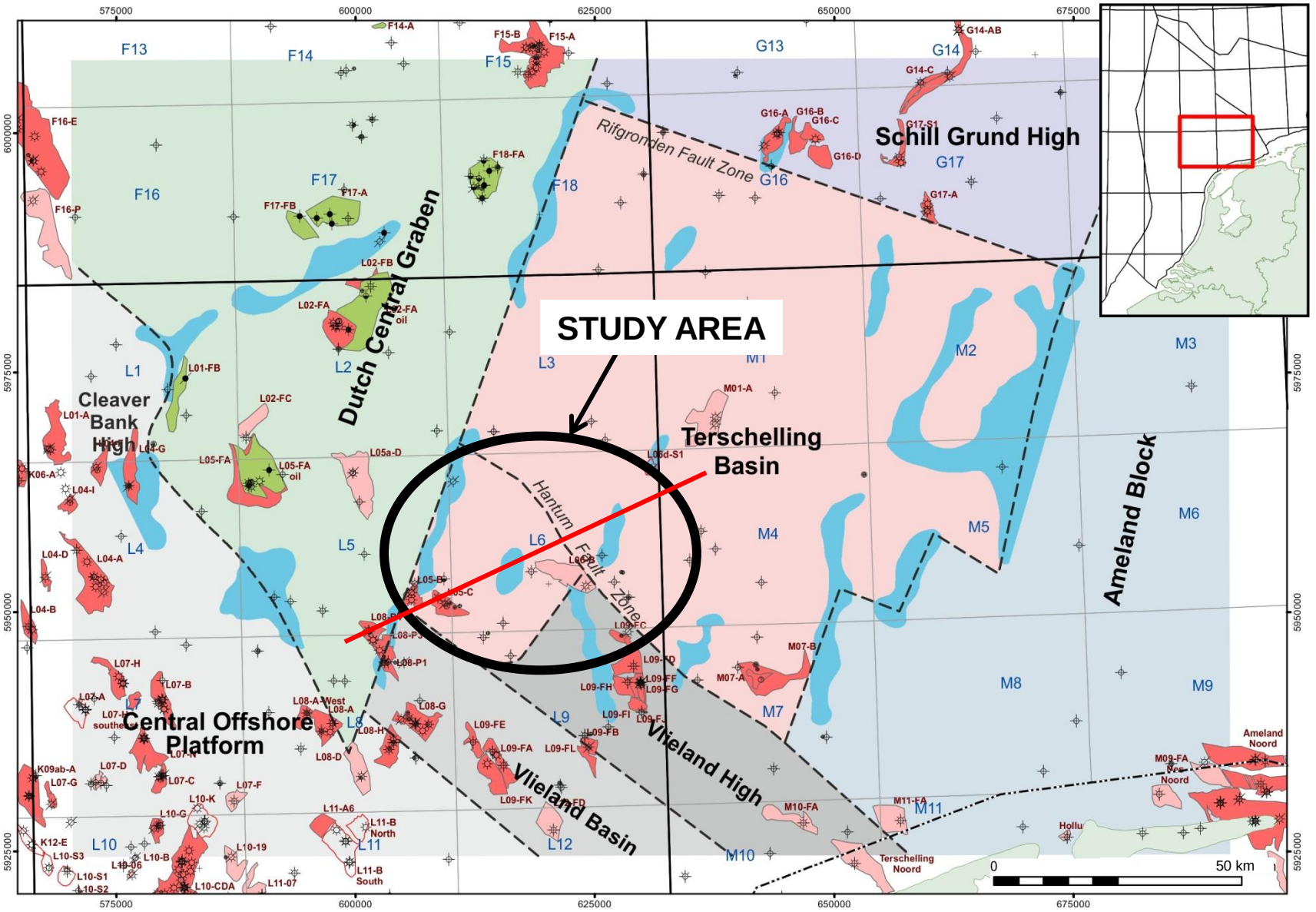
Regional Setting





From: Ziegler (2005)

Regional Setting



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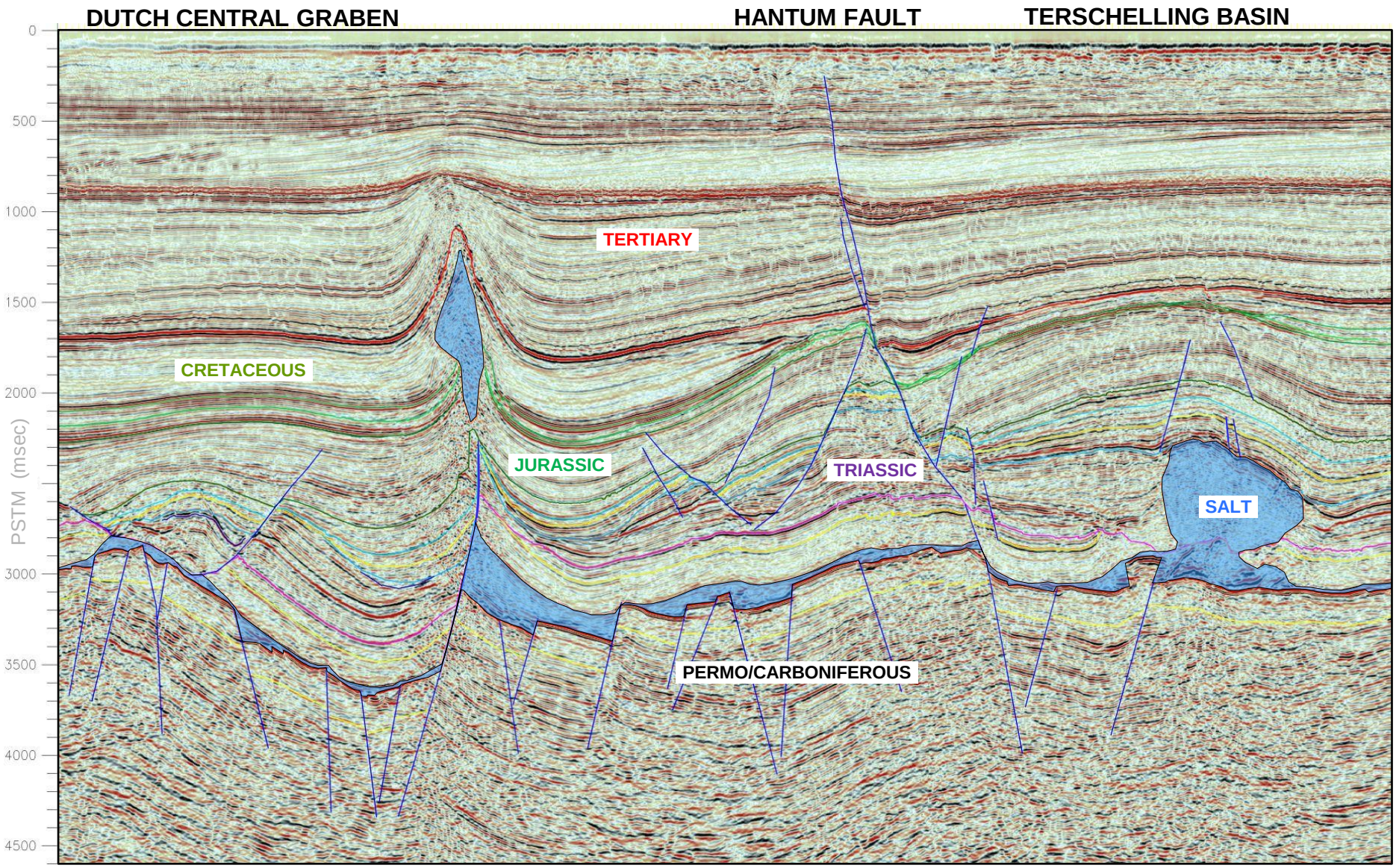

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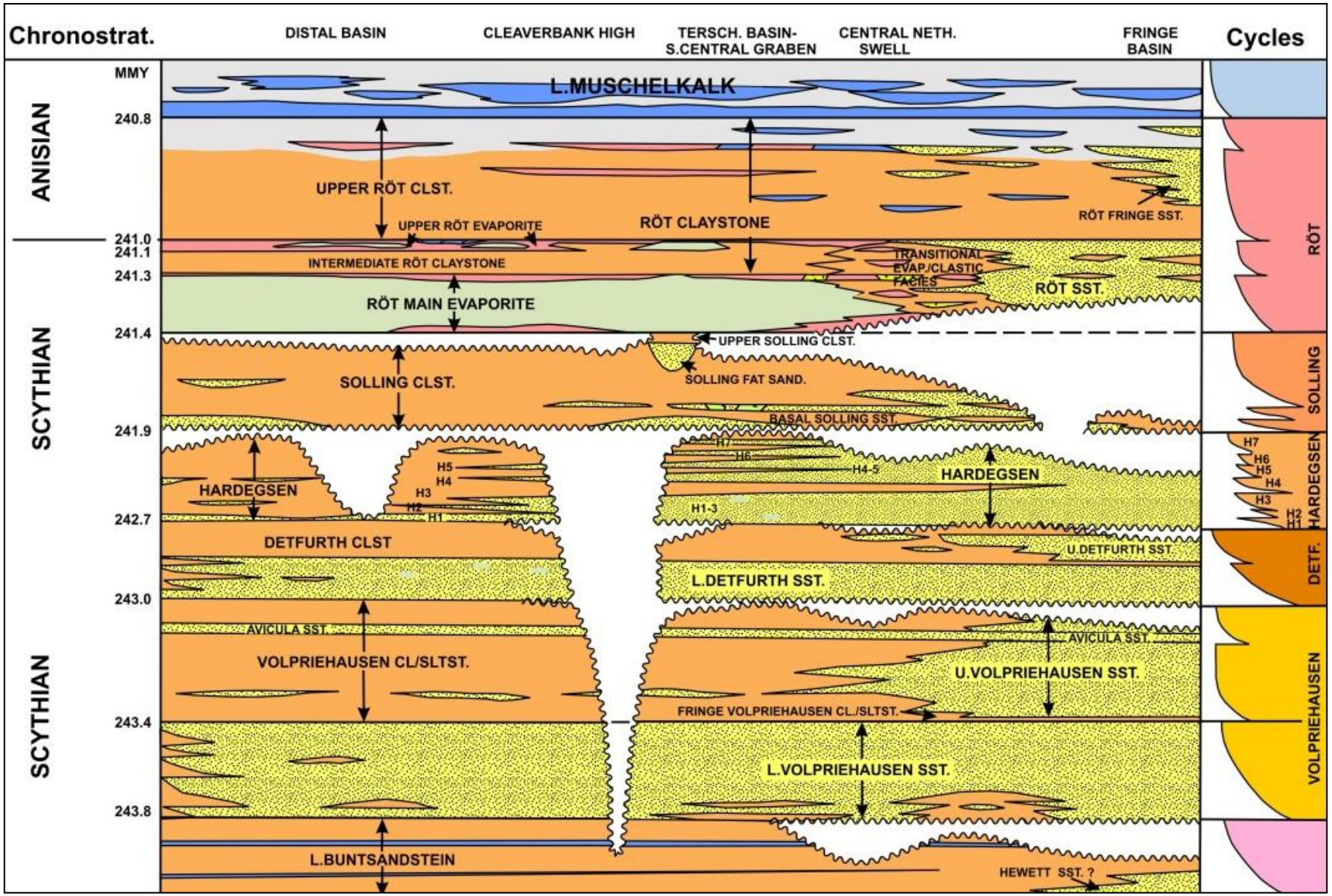
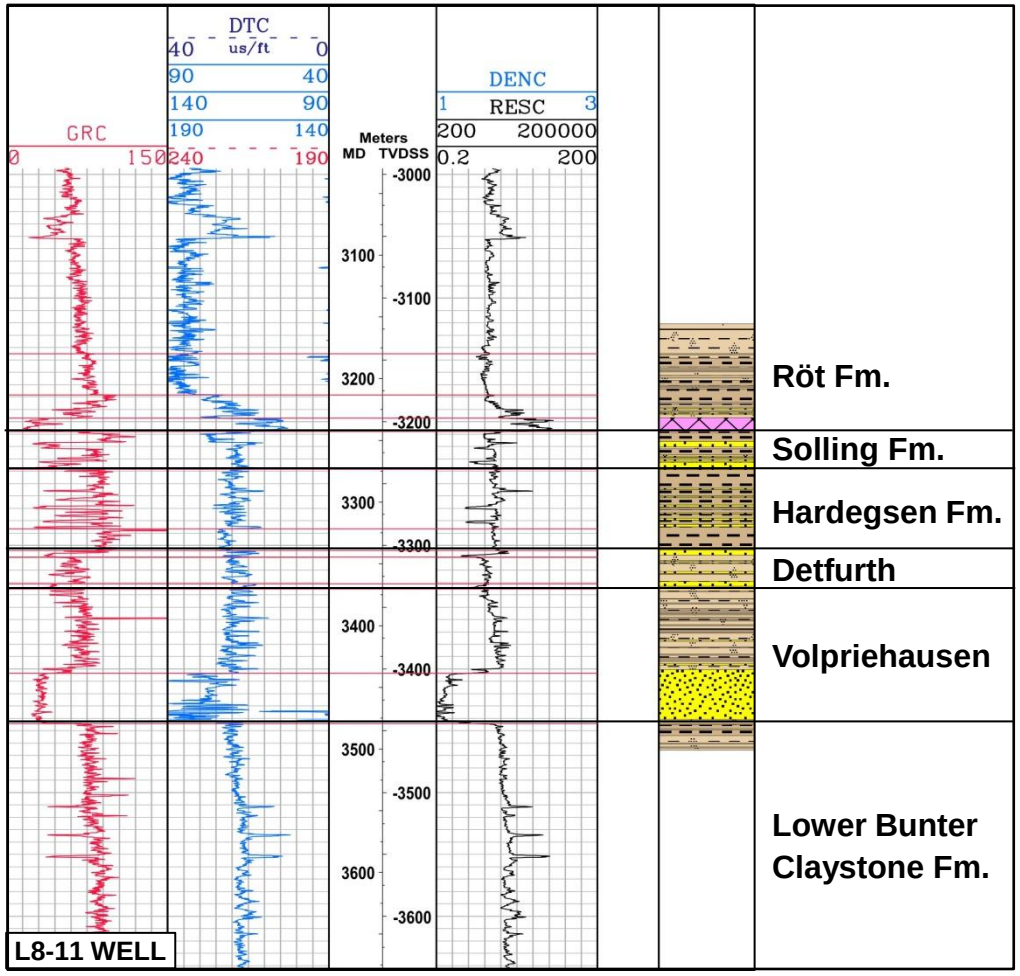
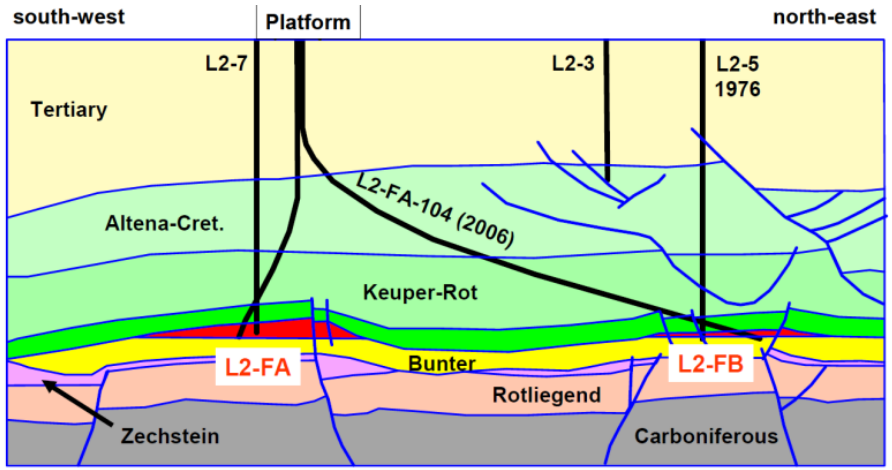


Triassic Gas Play
Reservoir & Top-Seal



- Volpriehausen Sandstone is main reservoir in study area
  - Thickness: 25-50 m
  - Net/Gross: 80-100 %
  - Average porosity: 9-15 %
  - Average permeability: 10-200 mD
- Depositional environment is continental under semi-arid conditions (eolian and fluvial sandstones with playa lake claystones)
- Röt Formation (with evaporites) is ultimate top seal
  - In some cases Hardegsen or Volpriehausen Claystone can also be sealing

Triassic Gas Play
Trapping Mechanisms & Charge



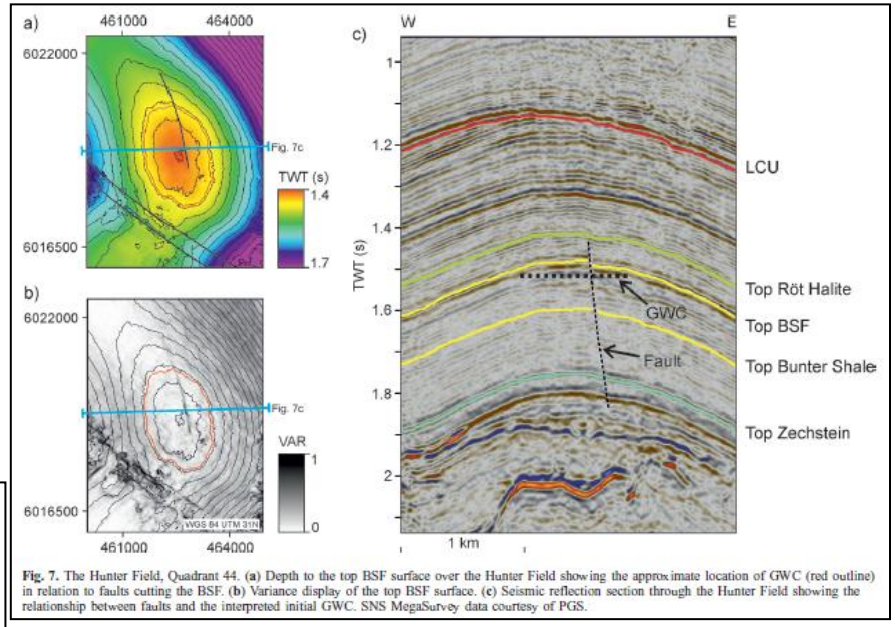
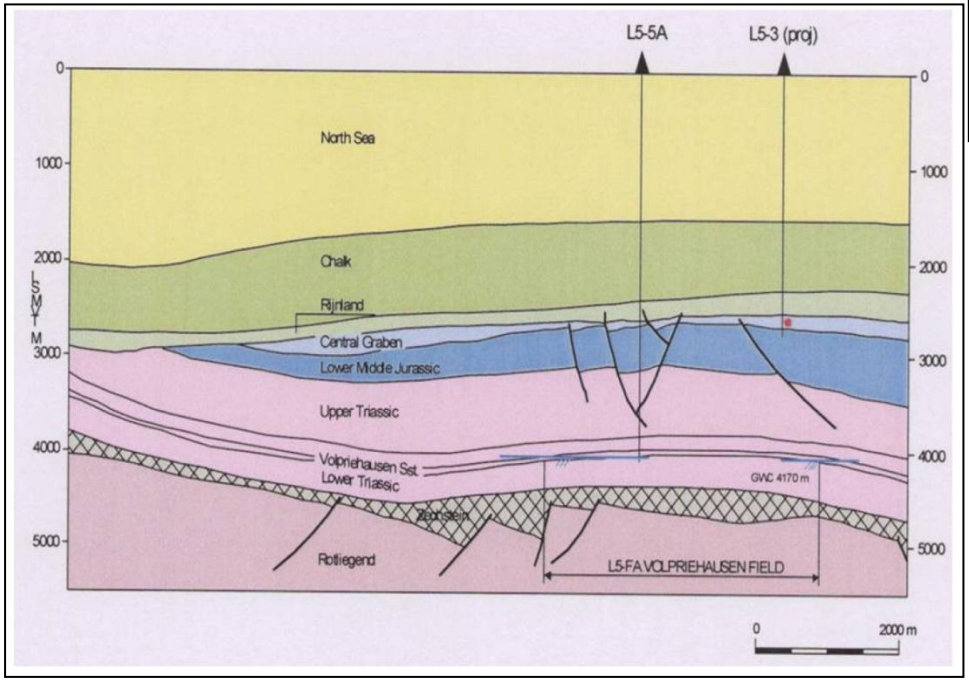
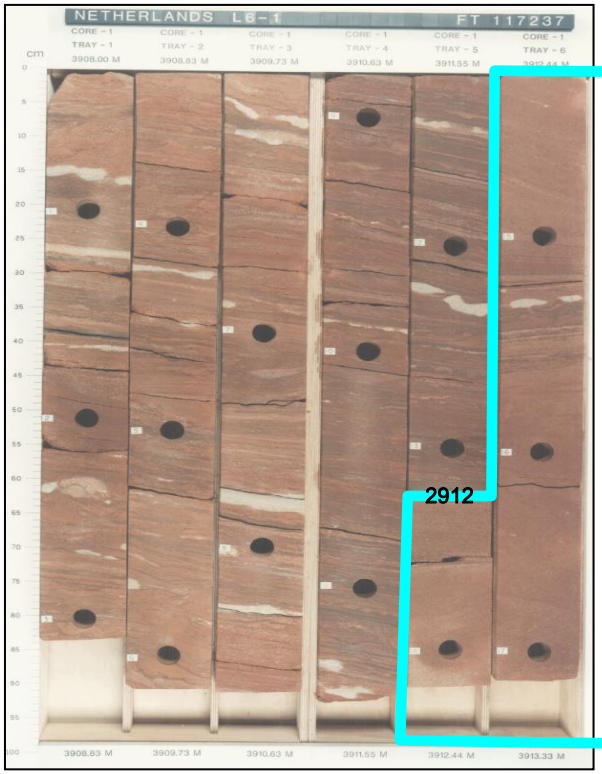


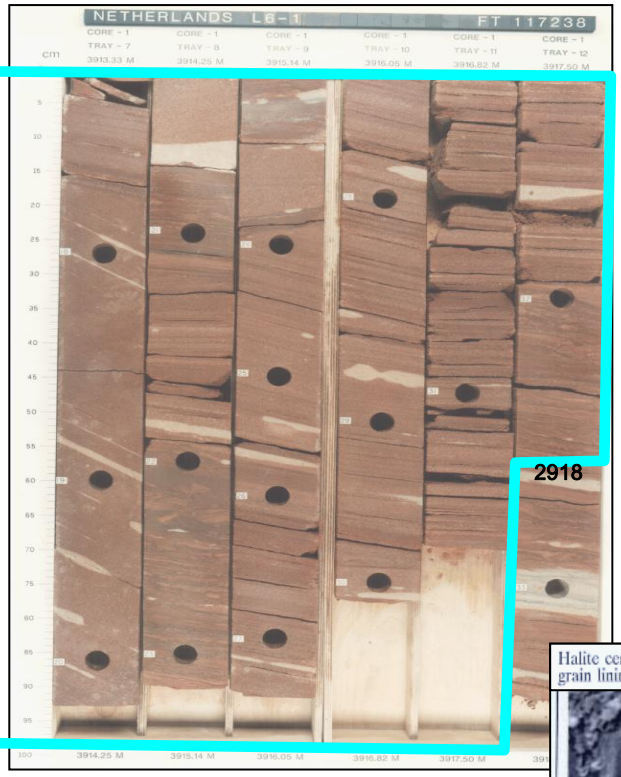
Fig. 7. The Hunter Field, Quadrant 44. (a) Depth to the top BSF surface over the Hunter Field showing the approximate location of GWC (red outline) in relation to faults cutting the BSF. (b) Variance display of the top BSF surface. (c) Seismic reflection section through the Hunter Field showing the relationship between faults and the interpreted initial GWC. SNS MegaSurvey data courtesy of PGS.

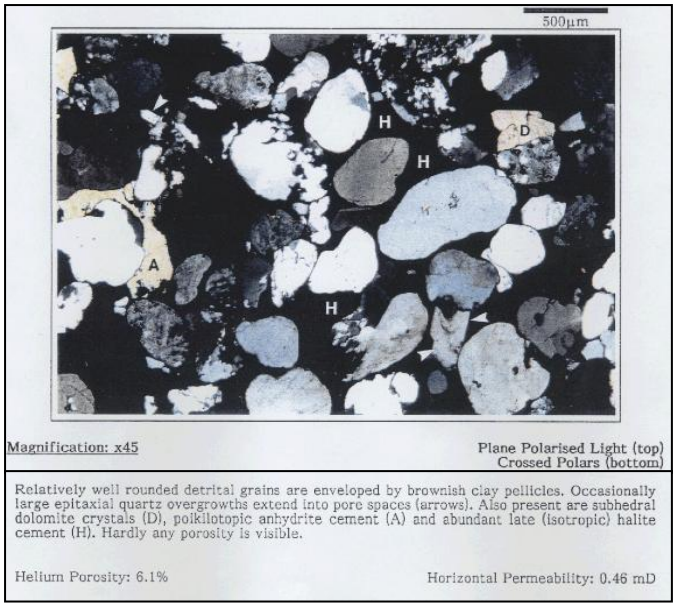


- Triassic structures are generally 4-way dip closures and gentle anticlines with only minor faulting, conformable with Top Salt
- Relying on windows through Salt for charge from Carboniferous coals
- Carboniferous mature at present day

Triassic Gas Play
Reservoir Effectiveness







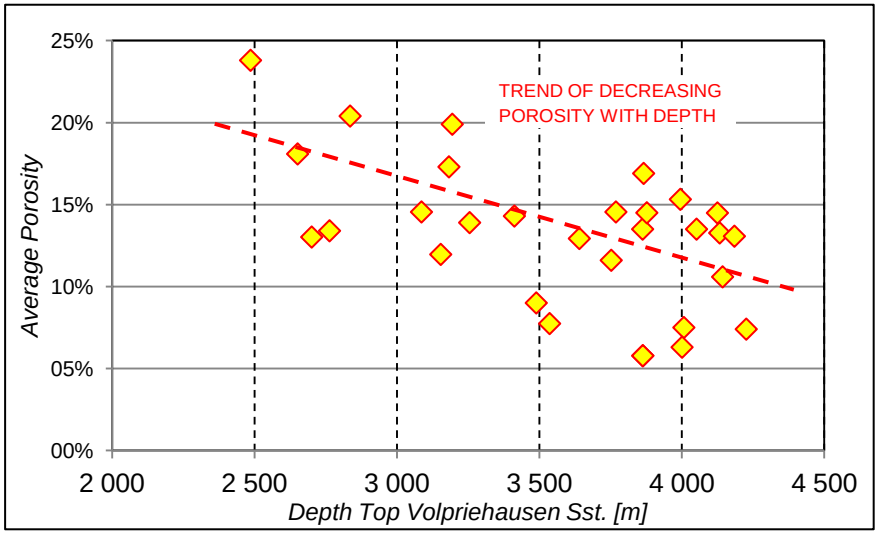
- Halite cement hardly visible on macro scale
- Dissolves in water-based drilling mud
- Often destroys all remaining porosity except micro-porosity in clay minerals

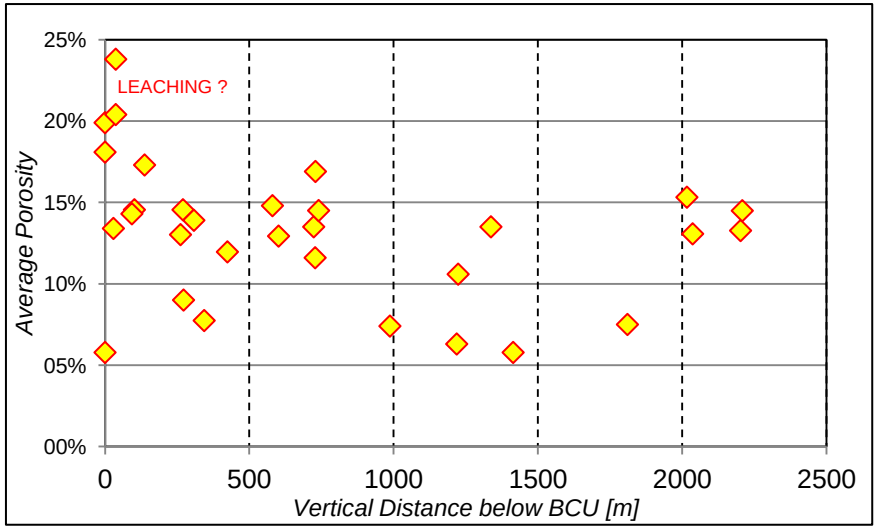
Statistical Investigation

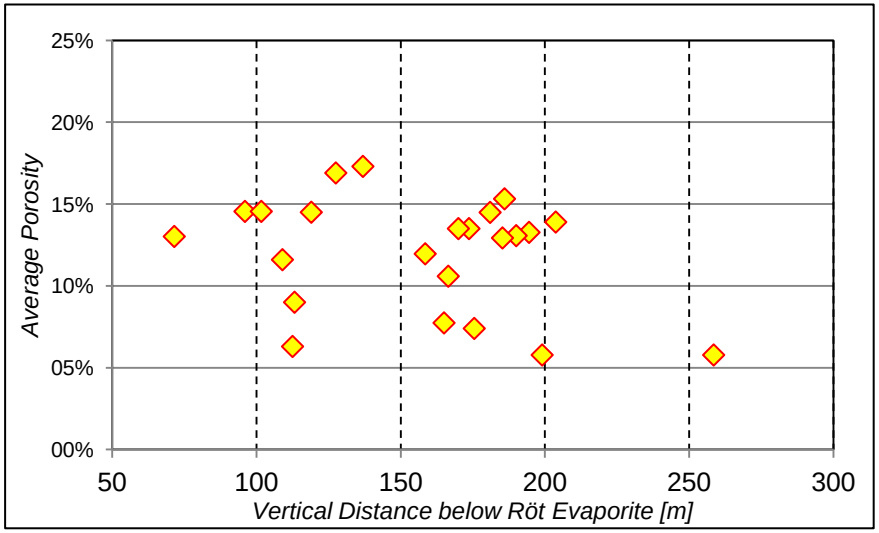
Possible causes for salt plugging in Triassic

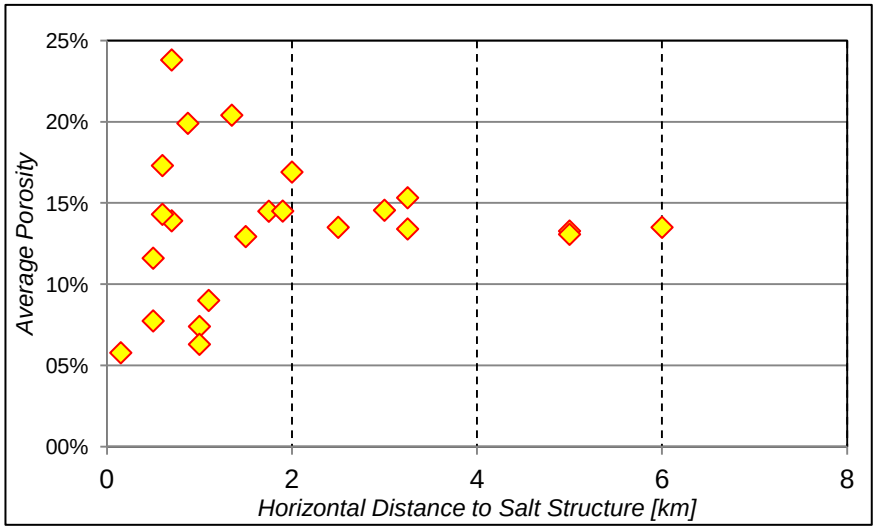
- Authigenic cement present in sediments
- Infiltration from Röt Formation above
- Infiltration from Zechstein below
- Lateral invasion from pierced salt domes
- Precipitation from brine when uplifted (thermogenic)
- Combinations of all of the above

Statistical Investigation

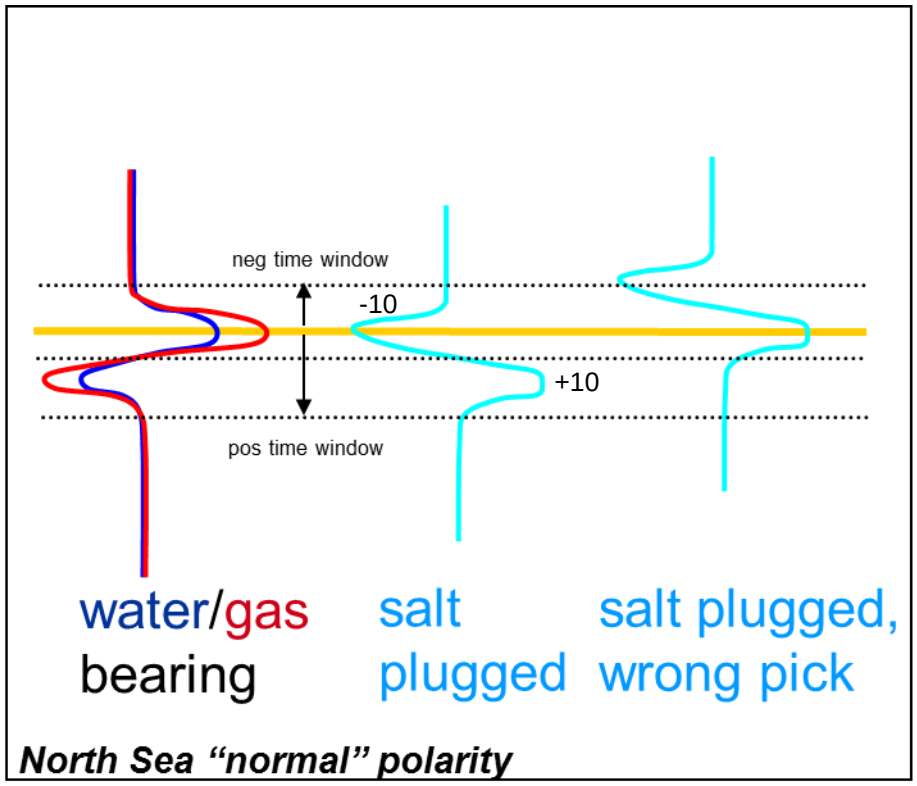








Seismic Attribute Analysis

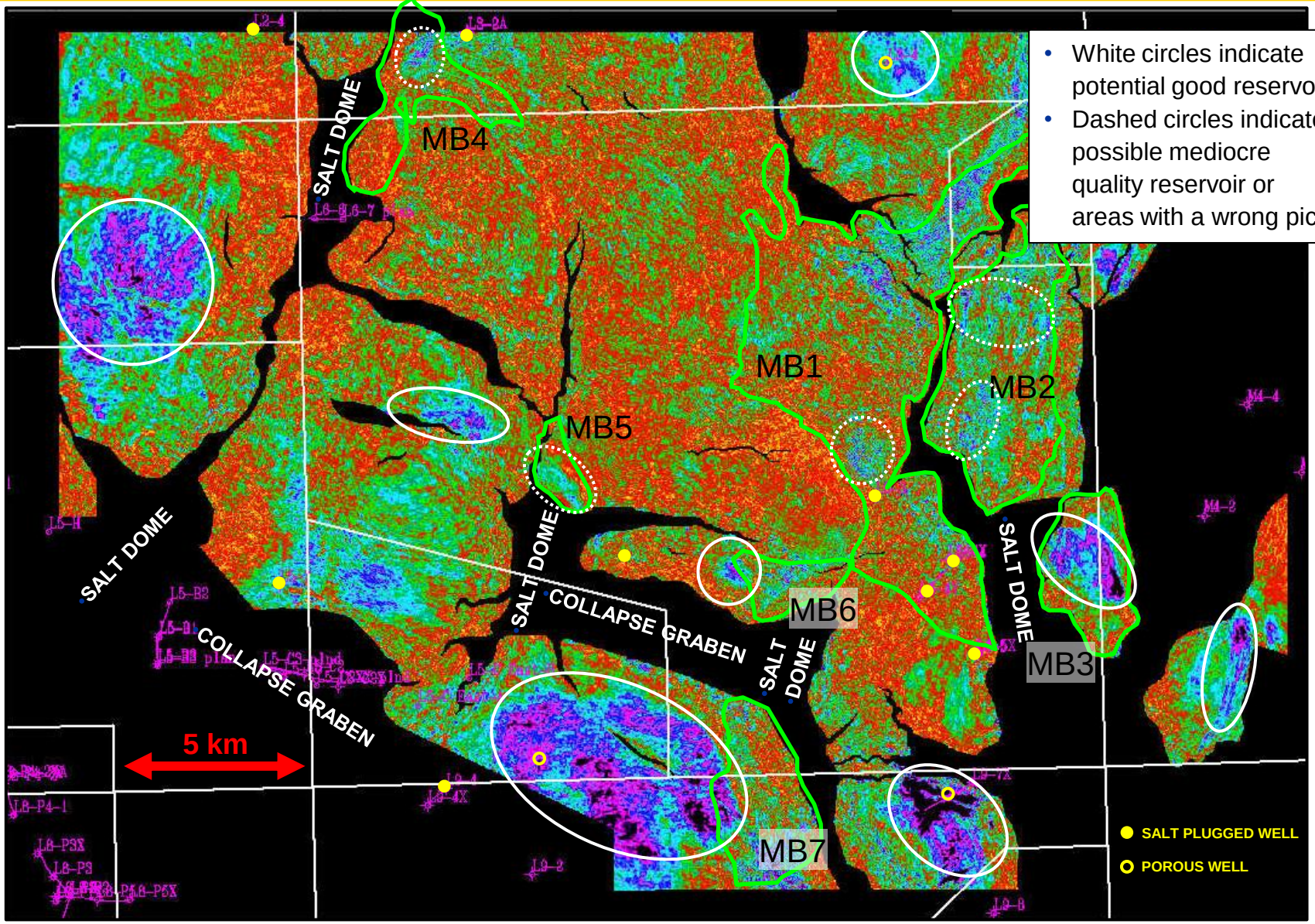


Lowest amplitude in lower time window minus the highest amplitude in upper time window:

Normal porosity	= - 10 - +10 = - 20
Salt plugged, good pick	= + 0 - - 0 = ~ 0
Salt plugged, wrong pick	= 0 - +10 = - 10

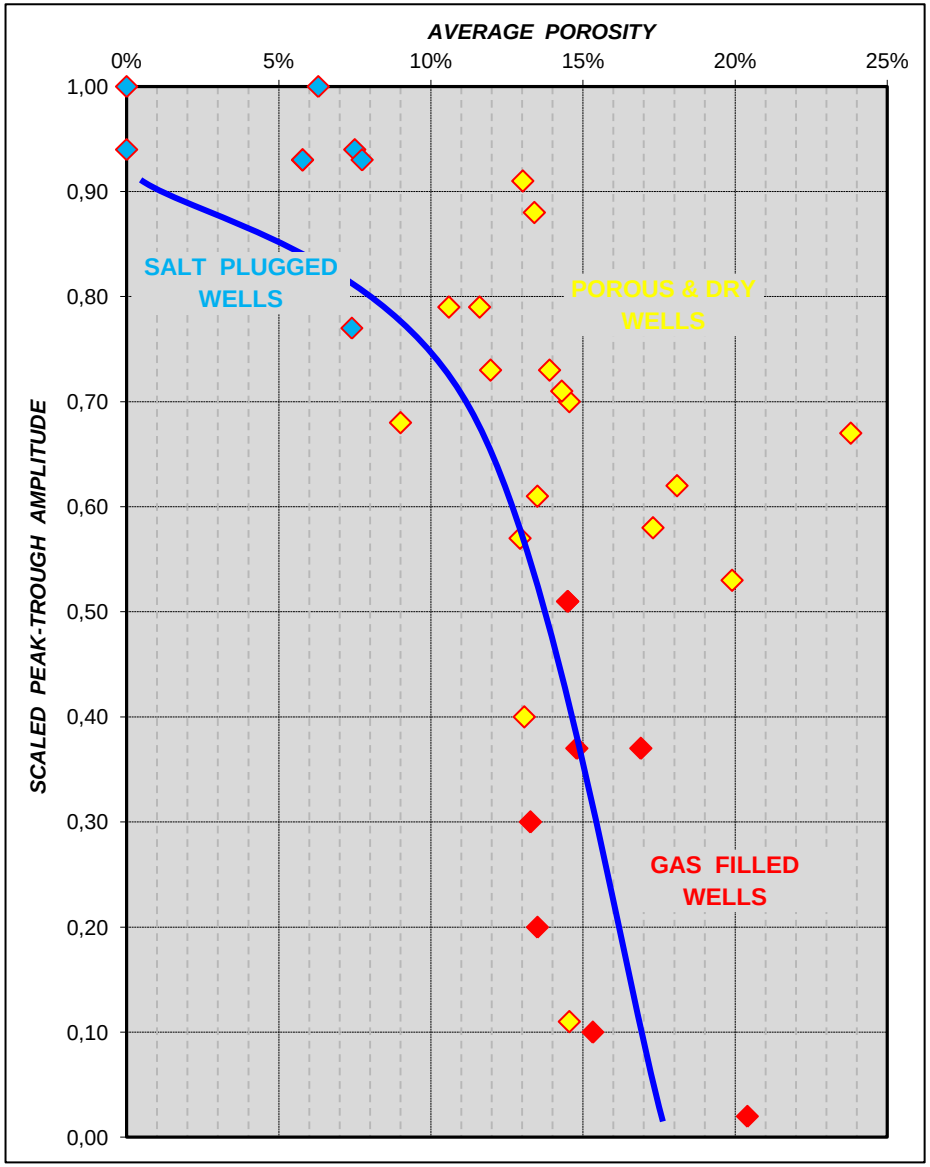
- If porous and water/gas bearing, Top Volpriehausen is a peak, followed by a clear trough
- Presence of gas causes a brightening
- If salt-plugged, Top Volpriehausen is a trough, followed by a clear peak
- If a salt-plugged Volpriehausen is incorrectly picked, Top Volpriehausen is a clear peak, followed by low-amplitude events
- Supported by forward modelling
- Amplitude difference scaled to factor between 0 and 1

Seismic Attribute Analysis
Scaled Amplitude Difference



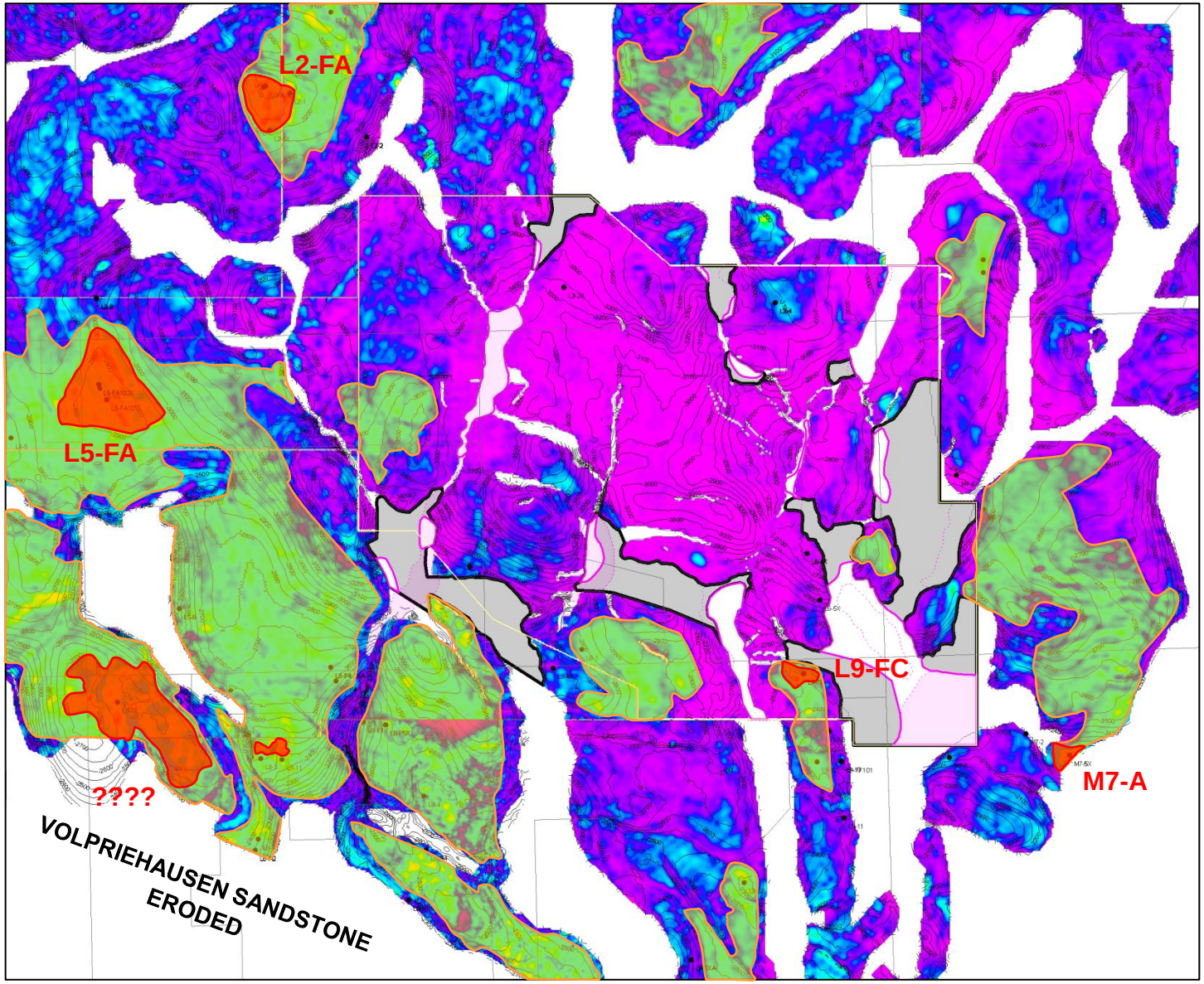
- White circles indicate potential good reservoir
- Dashed circles indicate possible mediocre quality reservoir or areas with a wrong pick

Seismic Attribute Analysis
Calibration to Wells

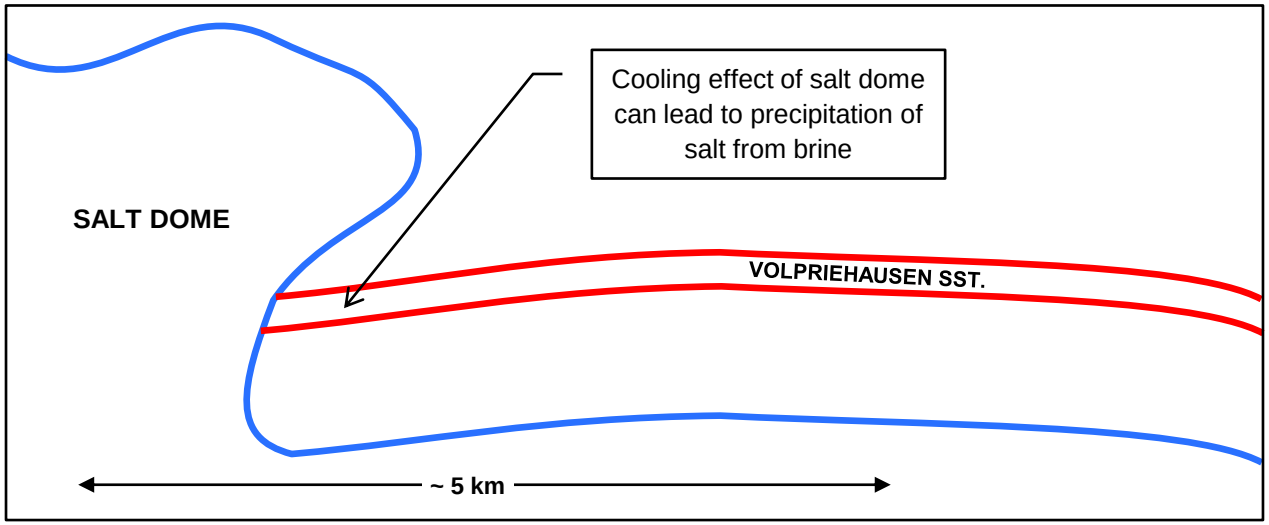


- Salt plugged wells (porosity < 10%) have high scaled amplitude values
- Porous wells (porosity > 10%) have medium to low scaled amplitude values
- Gas filled wells have low scaled amplitude values

Seismic Attribute Analysis
Scaled Amplitude Difference



Possible Mechanism



- High thermal conductivity of salt results in cooling effect near salt dome
- Lateral temperature differences of up to 6 ºC measured
- Cooling of saturated brine results in salt precipitation
- Modelling study in preparation

Conclusions

- Salt plugging in Triassic reservoirs occurs pervasively over large areas or in rims (0.5 – 2 km) around salt domes or former halokinetic structures (collapse grabens)
- Seismic attributes can help to identify areas of salt plugging and gas fill
- Salt cement was leached during the Early Cretaceous when the reservoir was close to the surface, probably by invasion of meteoric waters

Further Study

- Can salt cementation result in a lateral side-seal, creating “stratigraphic” traps?
- Apply this tool to identify Triassic gas fields in other areas
- Are there any low-porosity Triassic gas fields?
- Test the method on other plays

Ready for some new technology?