

The Evolution of the Rotliegend Play in the Permian Basin (NW Europe) Through Geological Time and Industry Wisdom*

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Abstract

The Permian palaeogeography of the Southern North Sea, or Southern Permian Basin (SPB), and the distribution and variability of the depositional environments of the Rotliegend Group have been of continuing interest for the last 55 years, since the discovery of the Groningen Gas Field. In the early ages, hydrocarbon exploration in the Rotliegend sandstone was based on the pioneering sedimentological work of Glennie (1972) followed by Ziegler's tectonic and paleogeographic reconstructions (1975, 1978). These maps initially identified broad depositional realms of aeolian, fluvial, and playa environments, distributed in a concentric spatial pattern to form a broadly saucer-shaped basin. These early maps, associated with the good reservoir properties of thick aeolian sandstones, led industry to develop the 40-years-long wisdom of considering the Rotliegend reservoir as a laterally homogenous sandbox, easily represented by layer-cake architecture. This conceptual geological model persisted over the years, although Ziegler's maps published between the mid 80's to early 90's provided an updated, more detailed understanding of tectonics and palaeogeography. Over the last 10 years, exploration has moved away from the aeolian sandstone fairway, either towards the center or the margin of the SPB. New discoveries have been enabled by implementing better techniques for seismic acquisition and processing and logging tools (e.g. high-resolution borehole images). This led to an improved understanding of reservoir geology and especially of the geometry of m-scale features, such as small dunes and/or sheetflood sandstones (good reservoir) interbedded within interdune or playa deposits (poor and non reservoir), and their lateral correlatability. Recent evidence also highlights the stratigraphic variability in certain basin areas, thus challenging the old wisdom of layer-cake stratigraphy and proving that tectonics played an important role in defining the resulting reservoir

architecture. Similarly, Ziegler's suggestion of the occurrence of large fluvial systems, entering the SPB from both southern and northern margins, provided crucial information to locate the best dune reservoirs. This has been recently demonstrated by extensive field observations on modern depositional environments, which identify a strong dependency of dune-field development upon the location of fluvial systems, which supply sand to the wind, and upon topographic slope. These examples demonstrate the importance of Ziegler's maps, which, besides guiding a multitude of geologists working in the SPB region, at an early stage offered a series of original intuitions at both basin and local scale that are now being recognised, years after their first publication. Ziegler's insightful research concepts foreshadowed the modern developments in our understanding of the SPB petroleum geology.

Selected References

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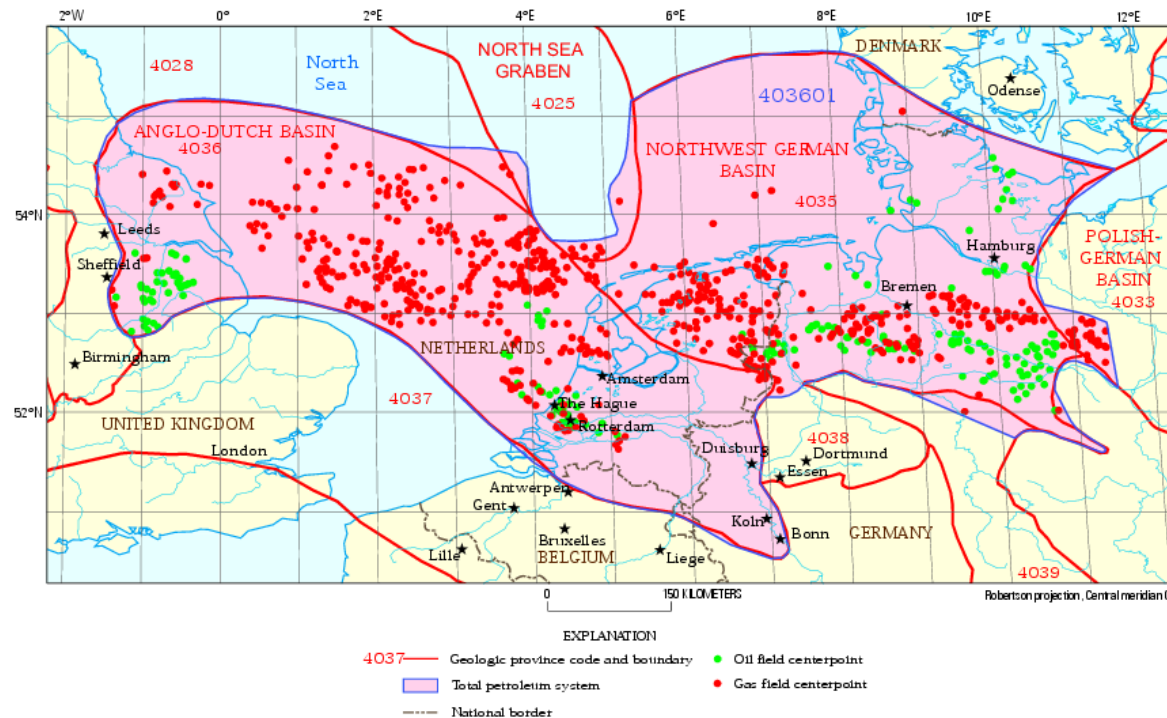
The evolution of the Rotliegend play in the Permian Basin (NW Europe) through geological time and industry wisdom.

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University of Geneva

Southern North Sea

- Gas province in production since 1965, the SNS has long been perceived as a **mature play** with very few new opportunities.
- Despite production has remained stable, several operators have been forced to either leave or look outside of the productive fairways and other areas to find additional reserves.
- New exploration success are continuously reported suggesting the Permian Gas Basin potential has not yet ended.

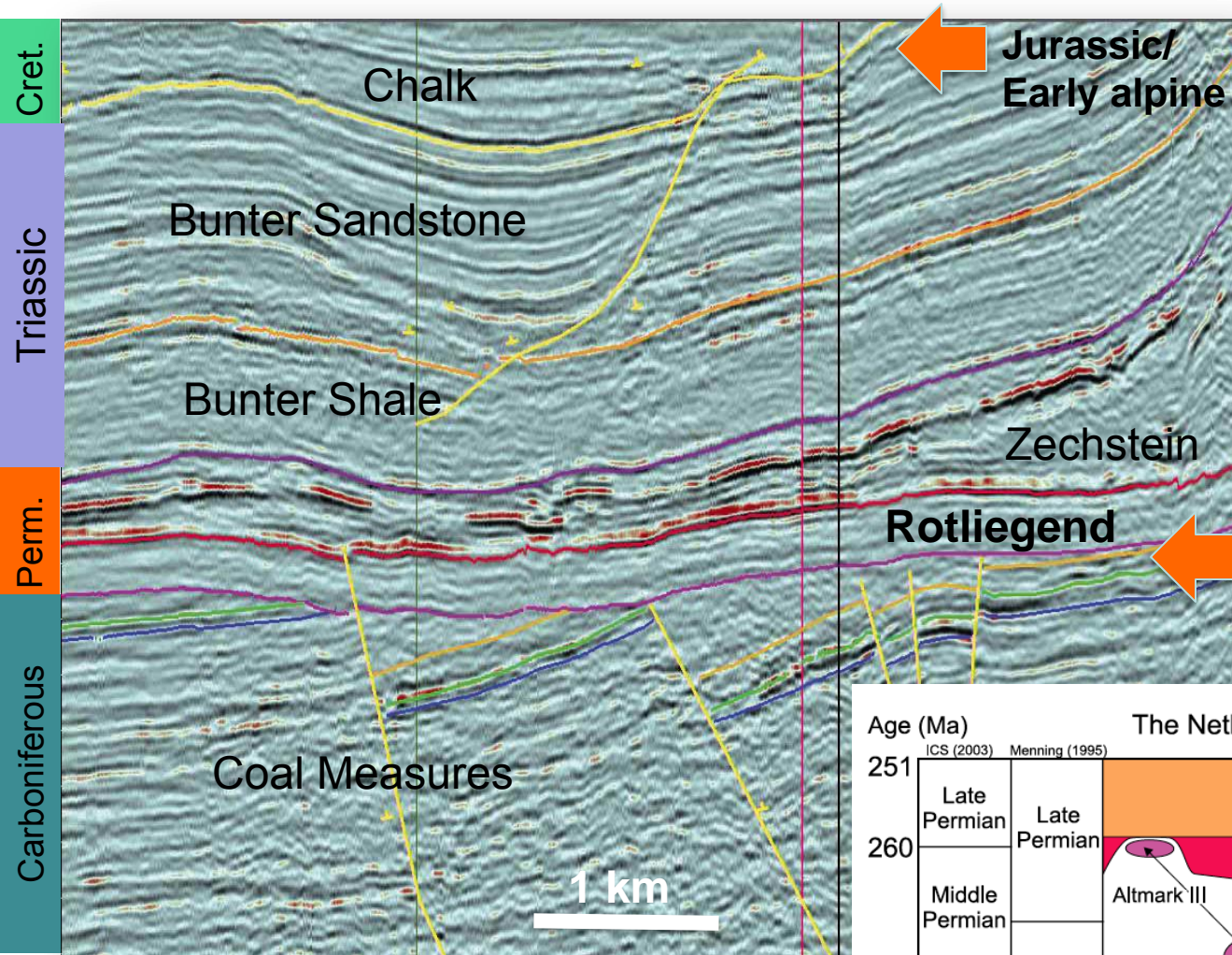


Source: USGS

Purpose

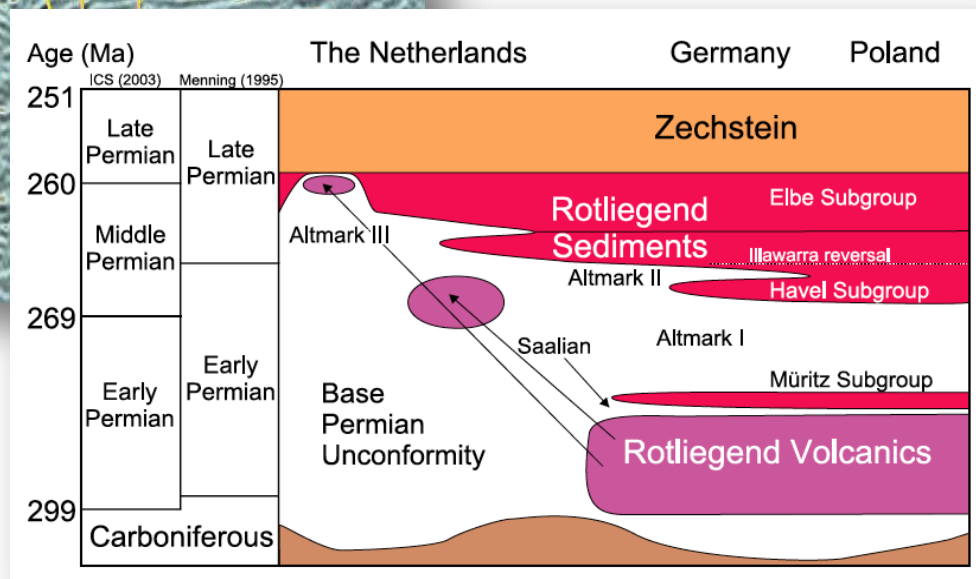
- How the work of early geoscientists has been inspirational to generation of geologists working the SNS Permian Basin area.
- Despite serendipity has been certainly a good companion of the industry since early days, the careful and diligent work of reconstructing the complex subsurface puzzle can yet pay back by driving the identification and definition of new opportunities at earlier stage.
 - Don't wait to happen...

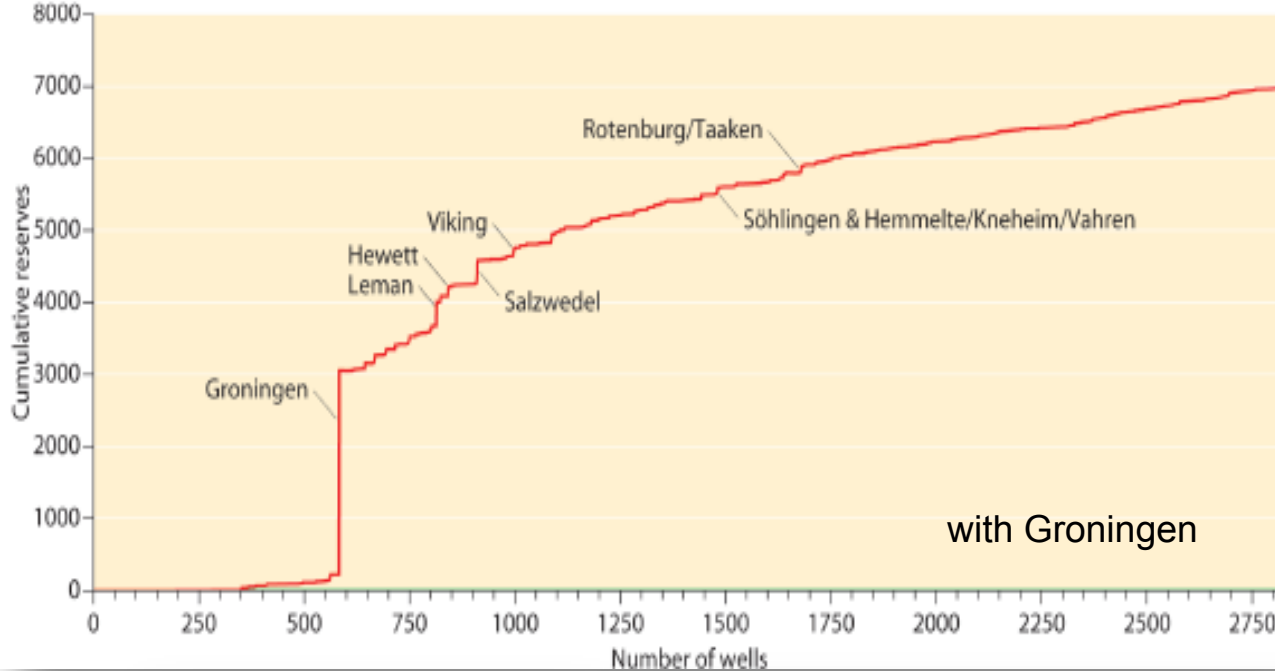




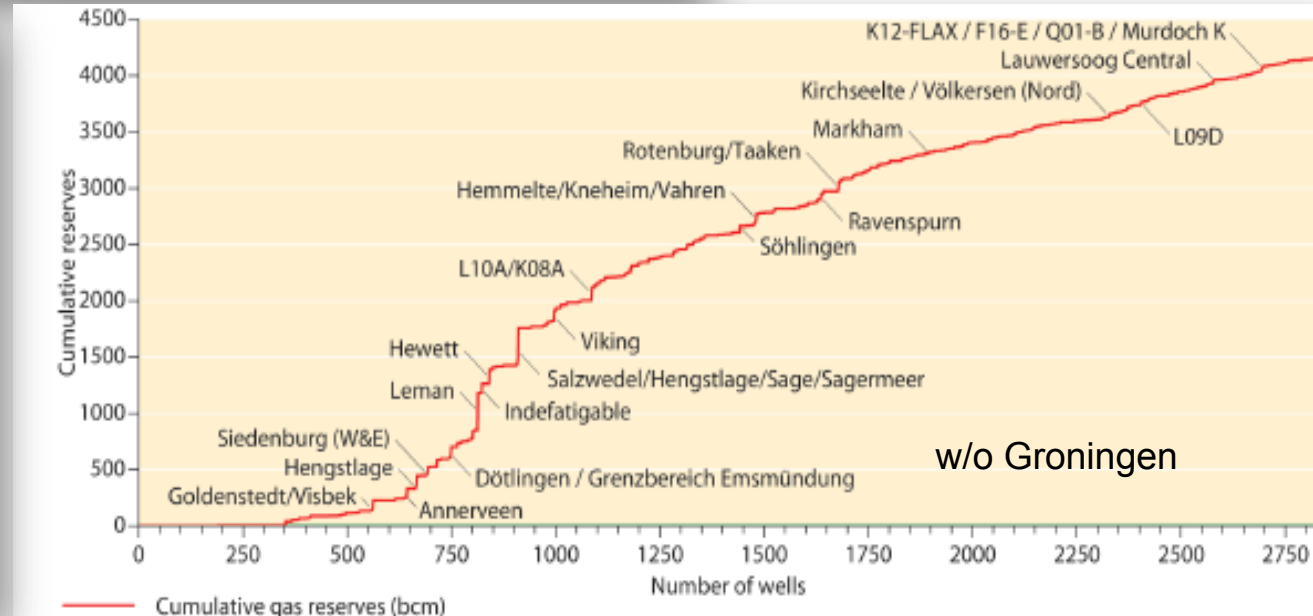
Source: Tullow Oil

Wong et al., 2007

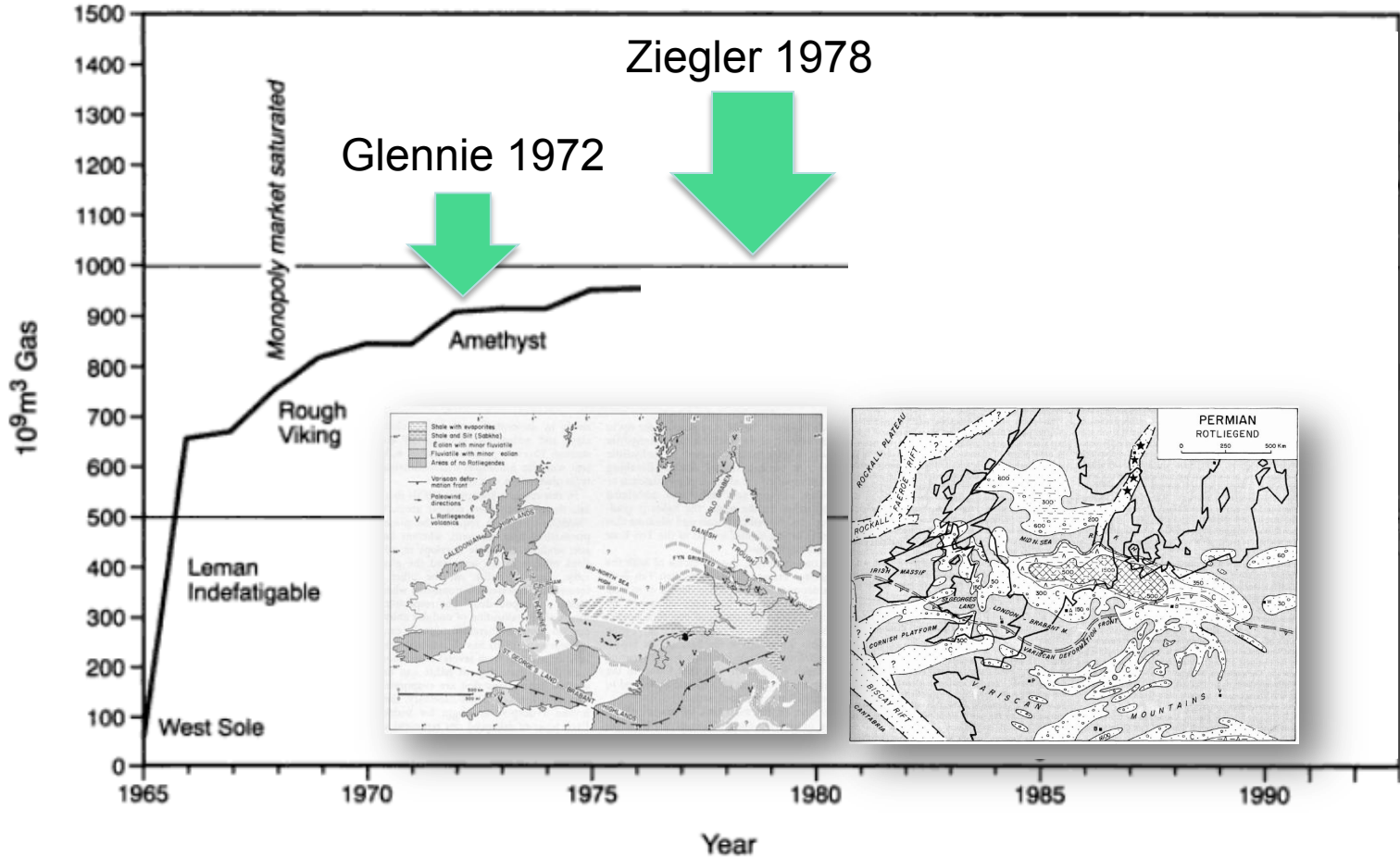


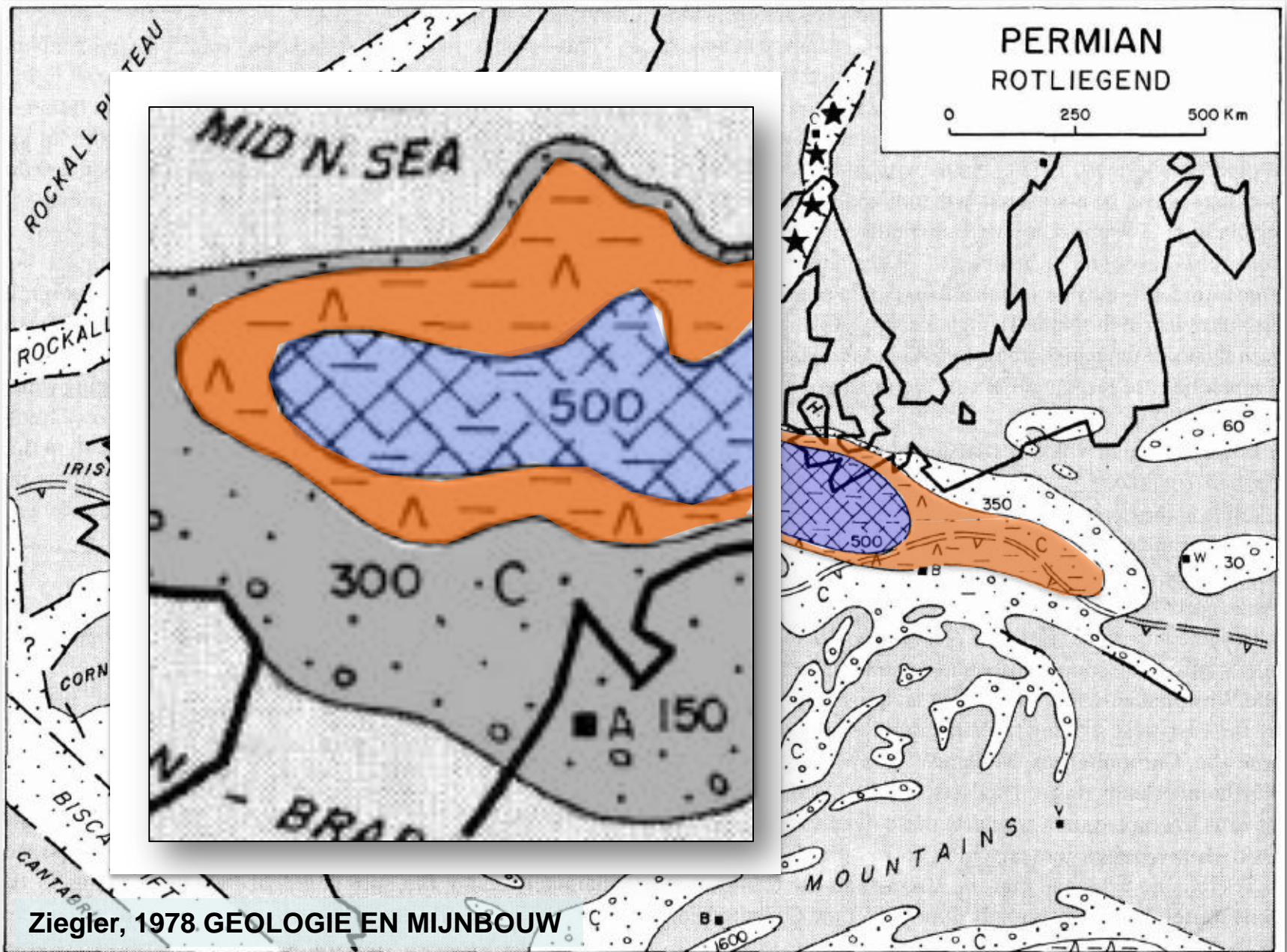


Creaming curve for the Anglo-Dutch and North German basins petroleum province

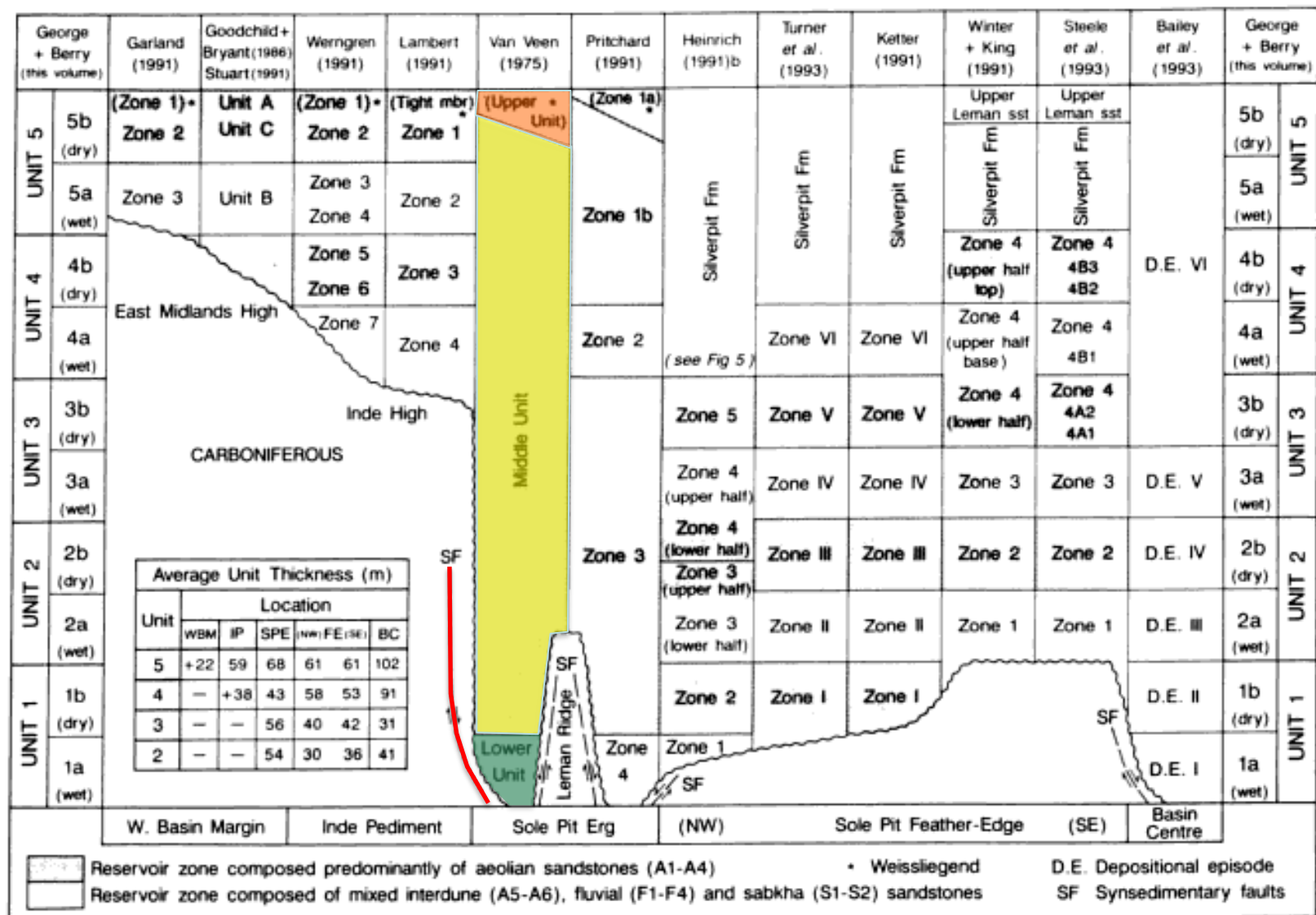


From PBGA, 2010



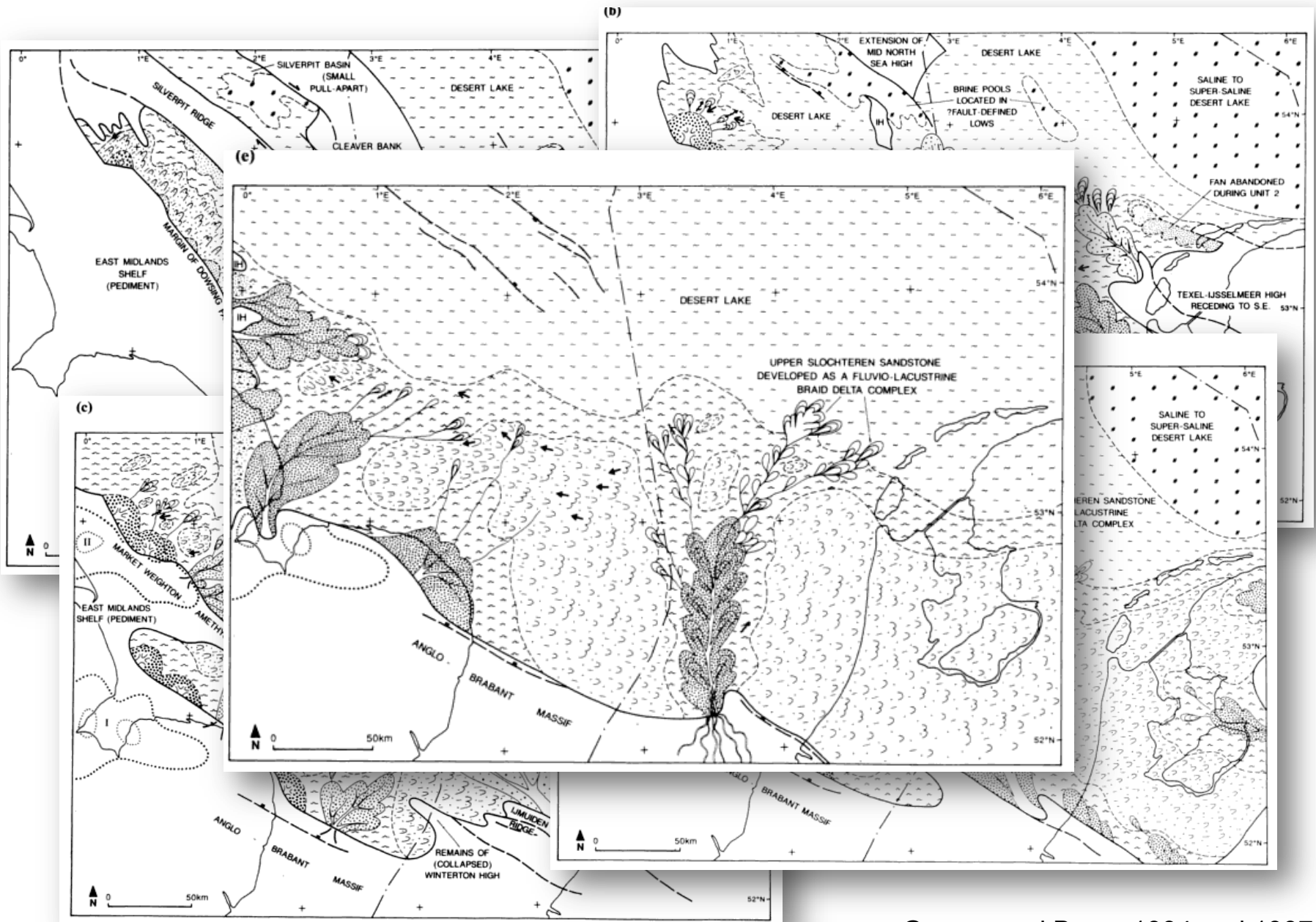


Ziegler, 1978 GEOLOGIE EN MIJNBOW



George and Berry, 1994 and 1997

Compilation of Rotliegend stratigraphy in the SNS Permian Basin

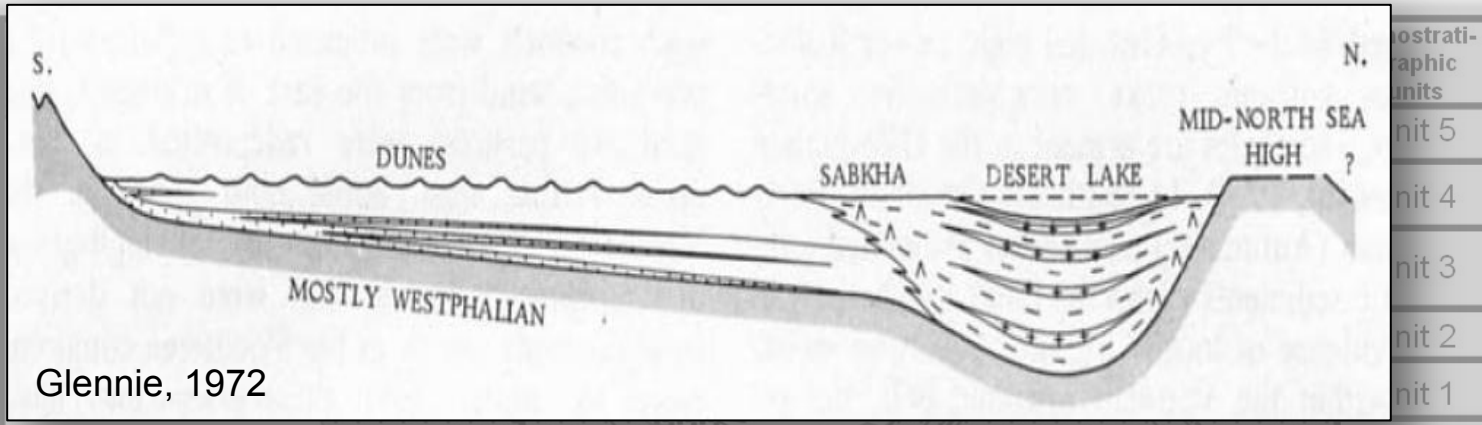


George and Berry, 1994 and 1997

East Midlands

SOLE PIT BASIN

Silver Pit Basin



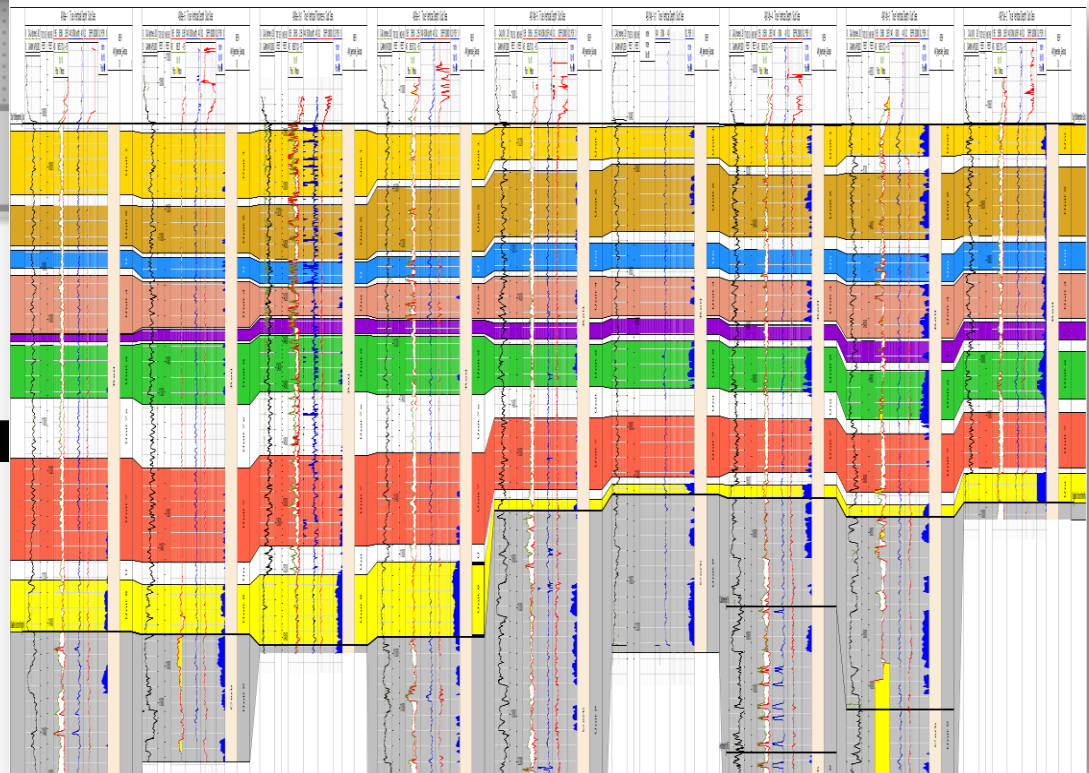
proximal

Modified after George & Berry (1993)

From concept to reality:
The Cutter Field (UK)

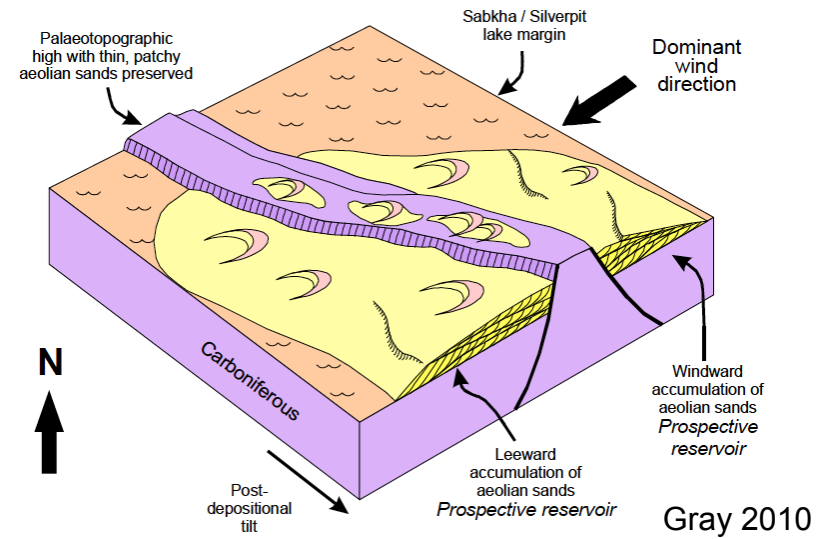
1972 → 1997 → 2006

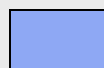
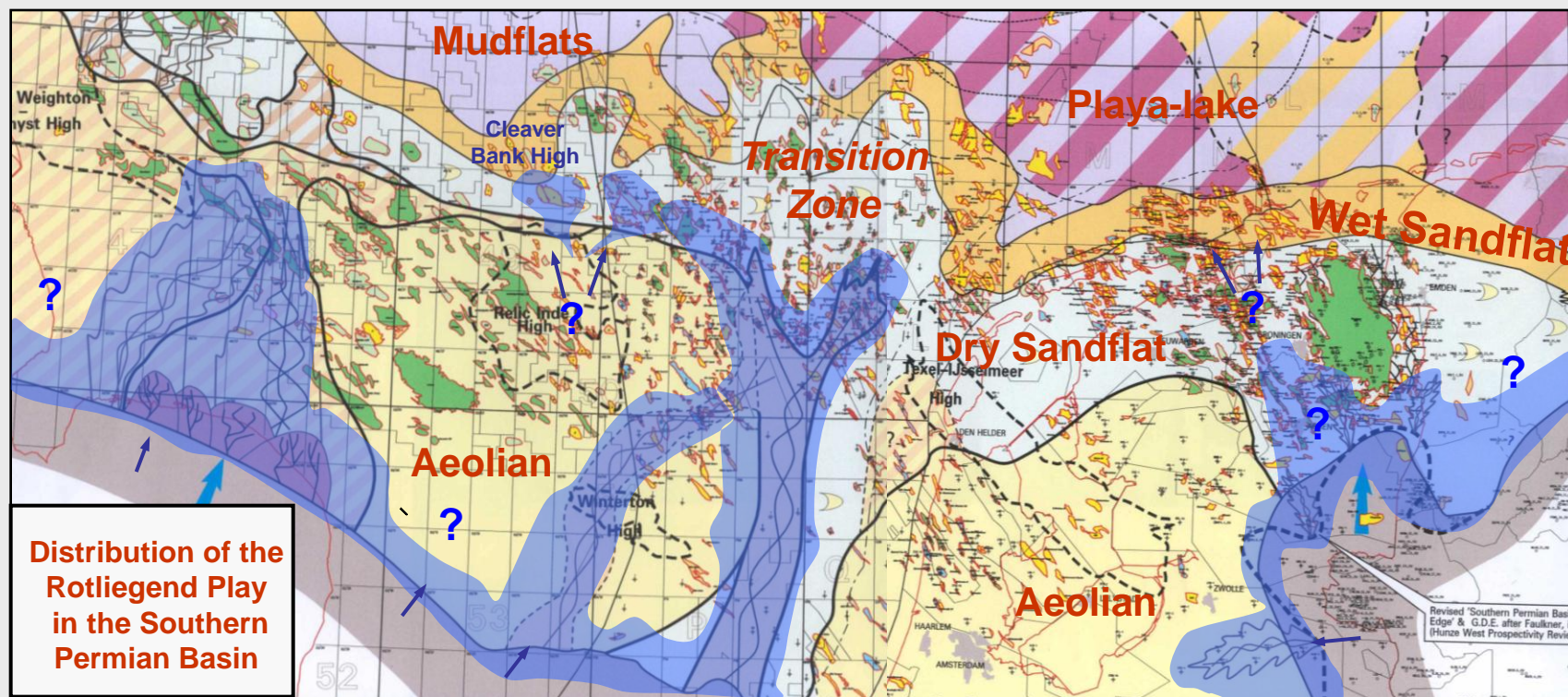
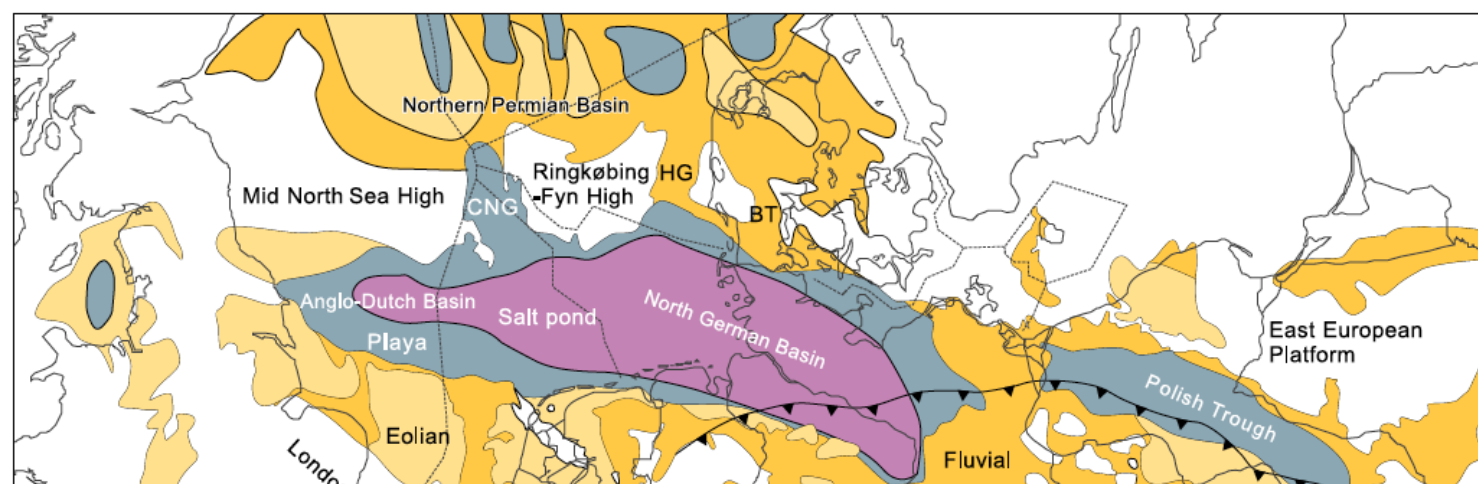
(Glennie, 1972;
Van Veen 1975; Ziegler, 1978;
George and Berry, 1997)





Fryberger et al, 2011



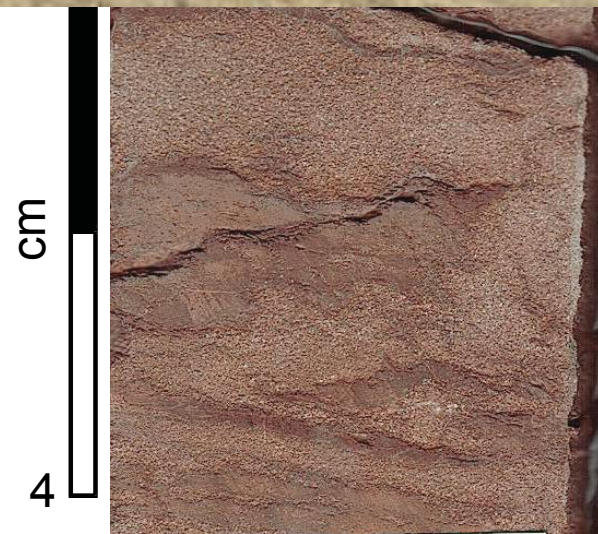
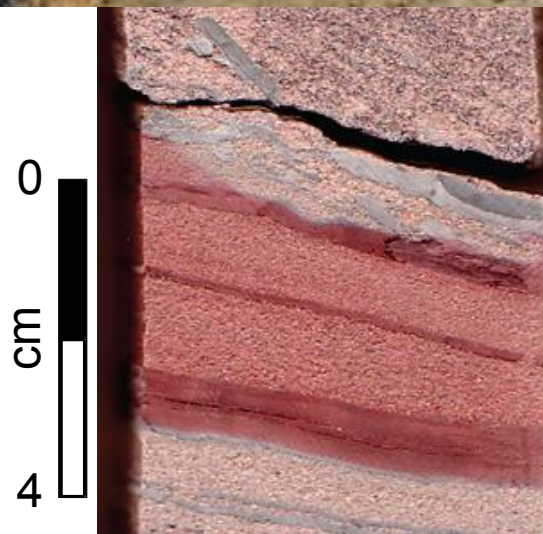
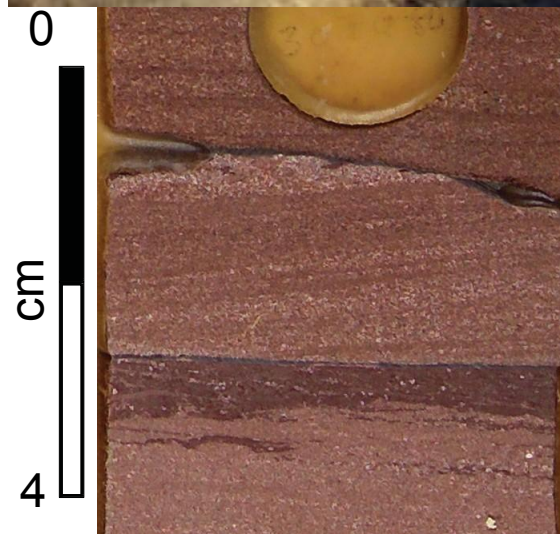


Basin margin and fluvial fans facies

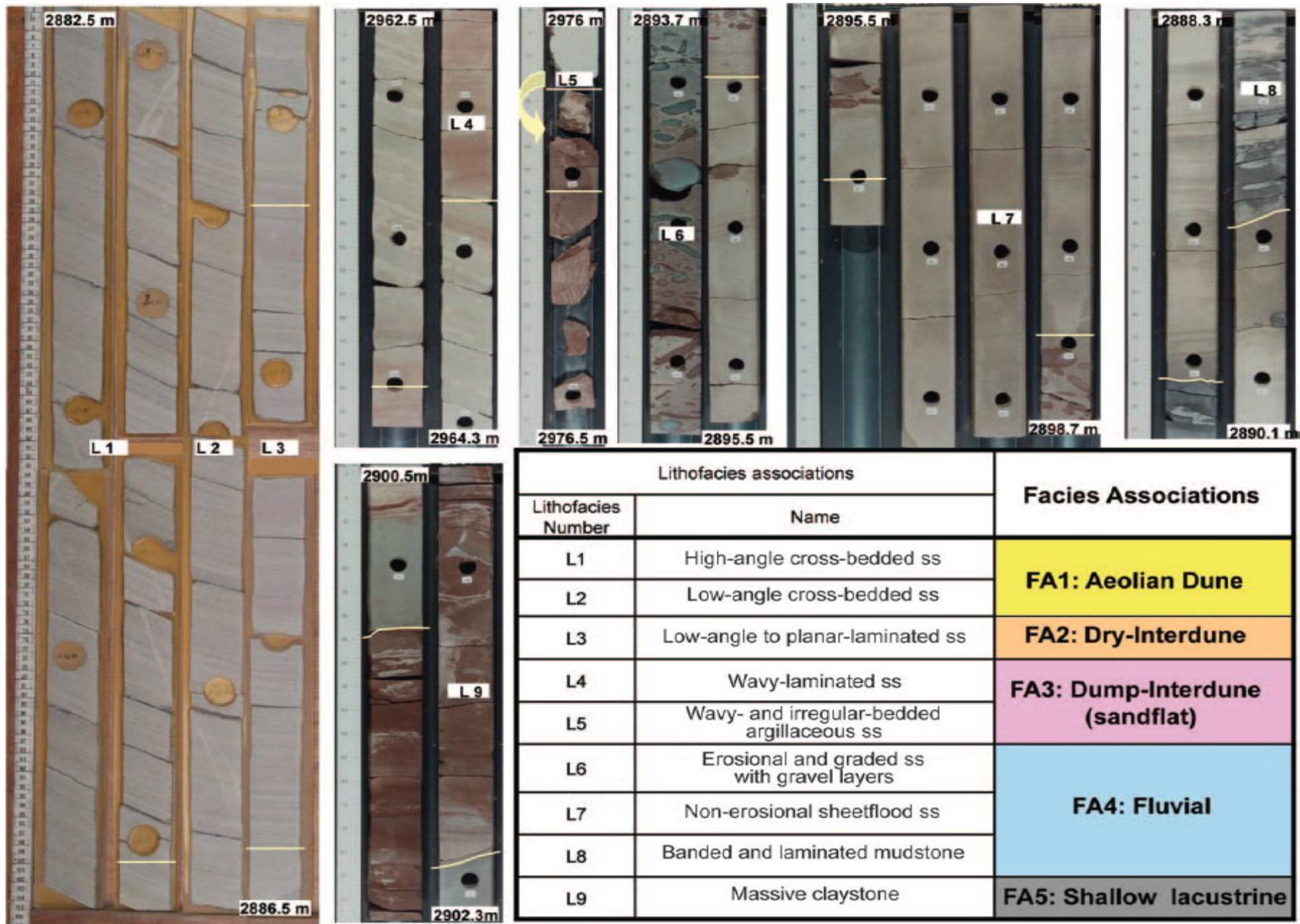


Point of fluvial input

Fluvial vs Aeolian facies

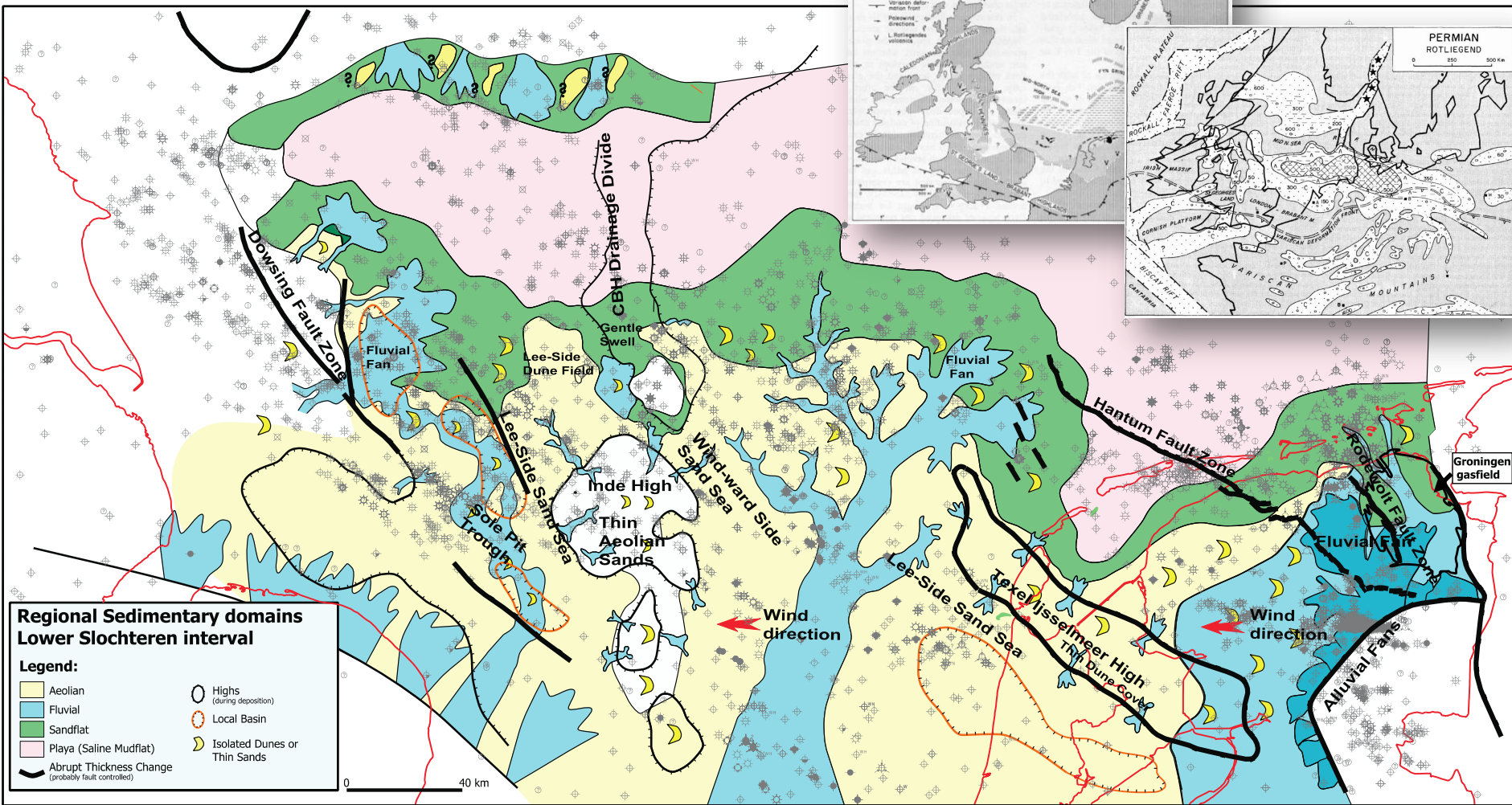


Fryberger, Knight, Hern, Moscariello and Kable, 2011

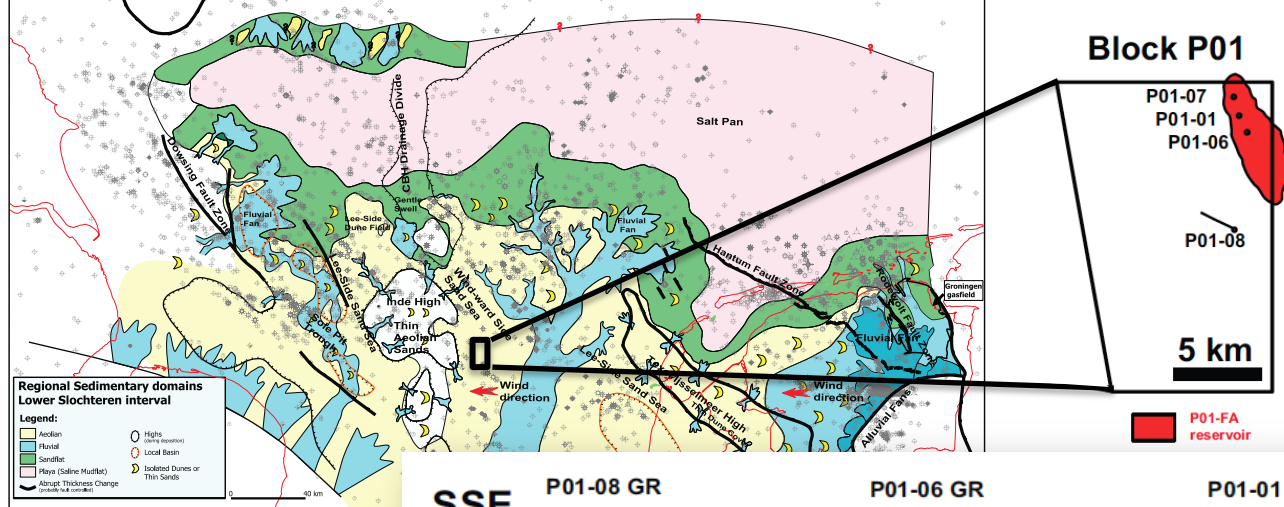


Moscariello, 2011

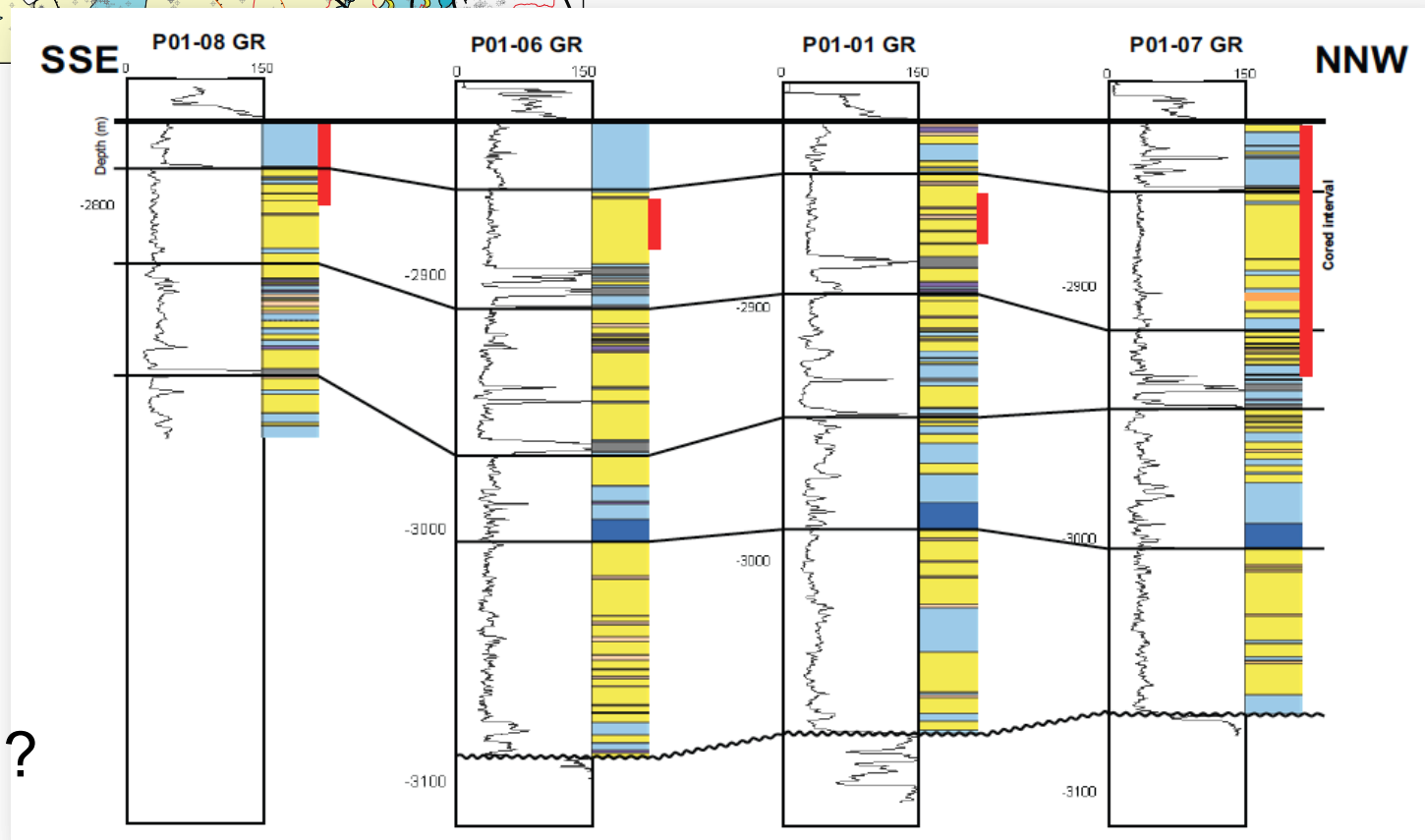
Facies map of Lower Rotliegend ands in the U.K. and the Netherlands



Fryberger, Knight, Hern, Moscariello and Kable, 2011



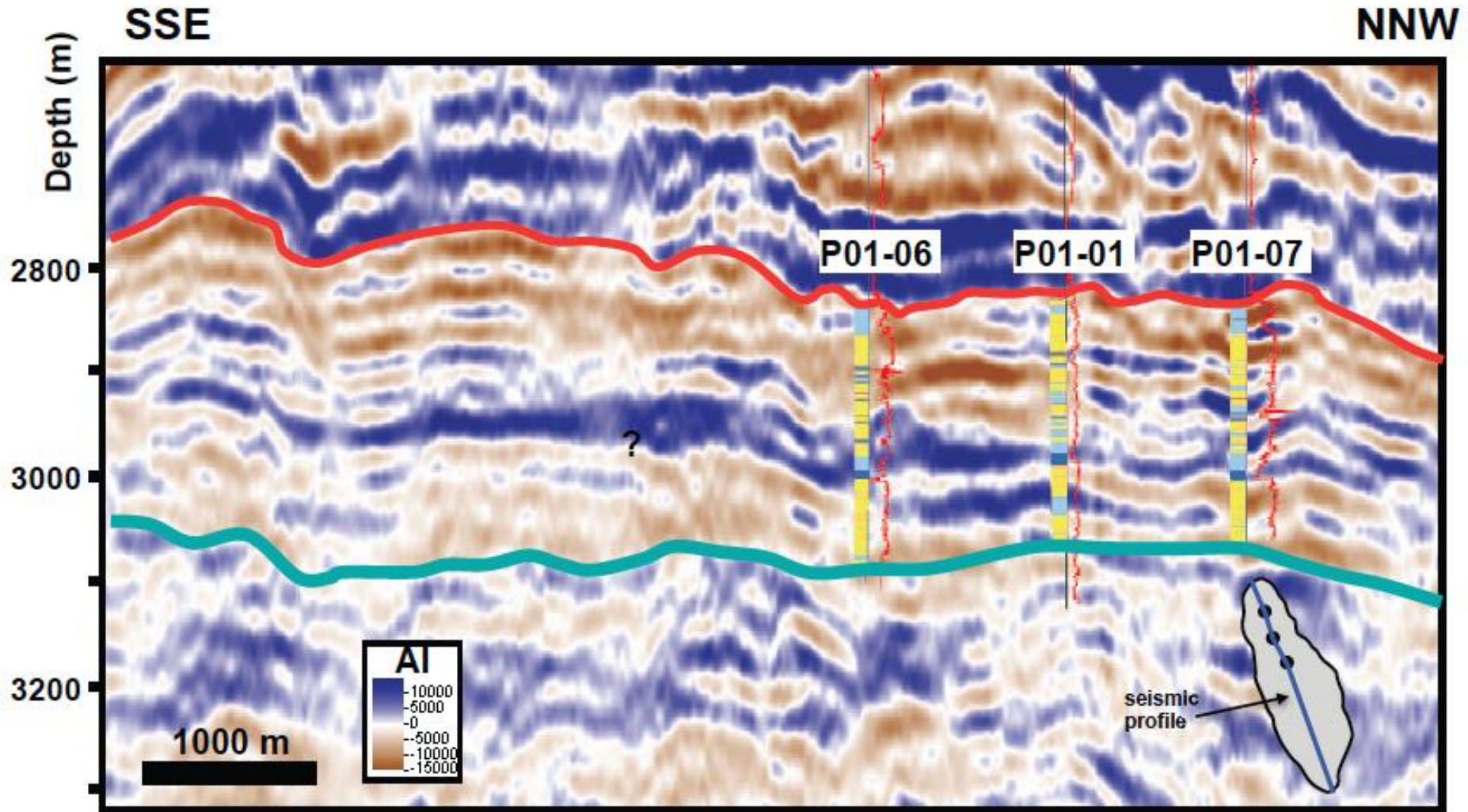
What about the 'aeolian' sand box ?



Aeolian
Reservoir:
Layer-cake
stratigraphy ?

Moscariello, 2011

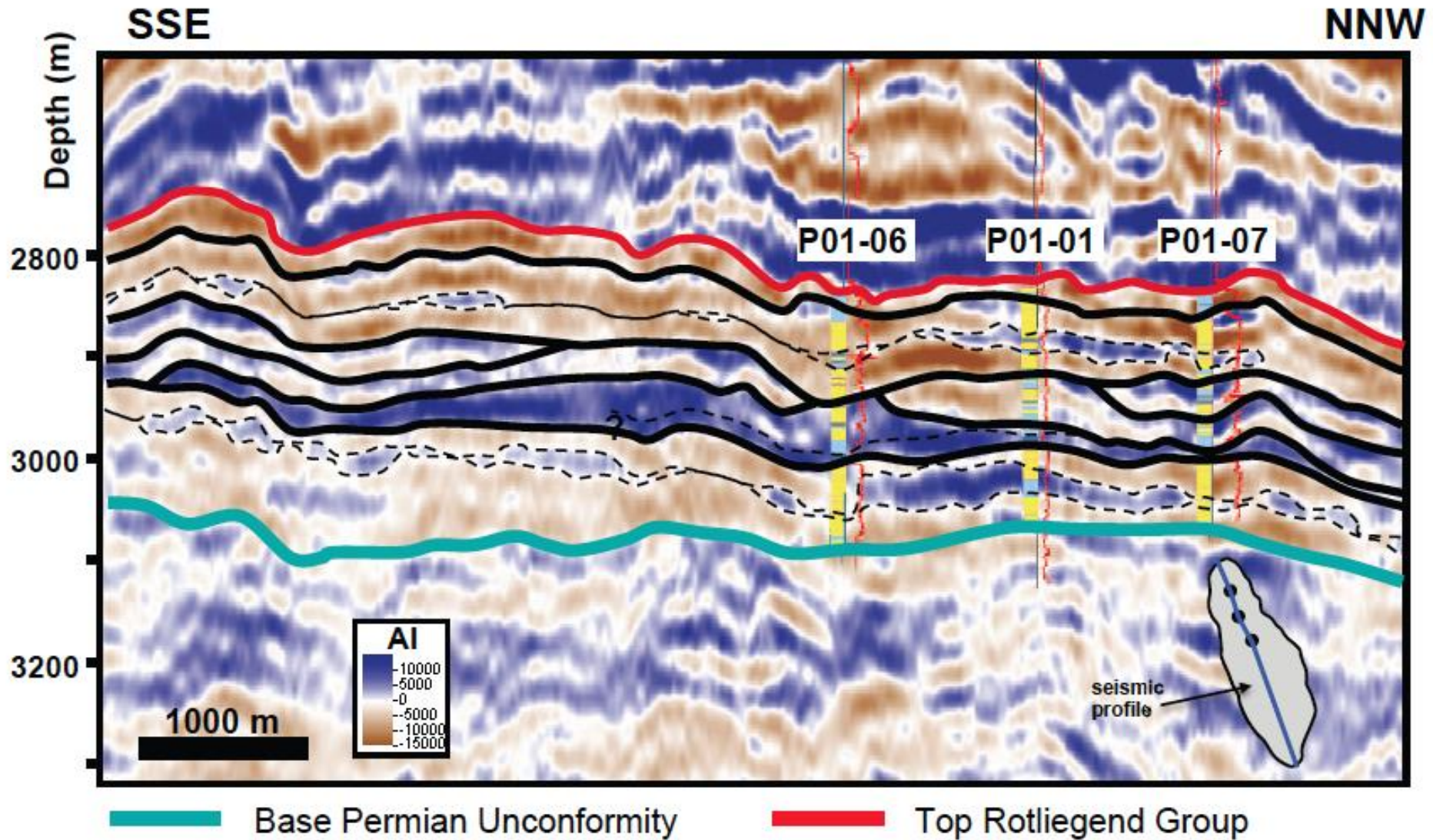
Challenging the myth of layer-cake stratigraphy



P-Impedance inversion volume

Moscariello, 2011

Challenging the myth of layer-cake stratigraphy



P-Impedance inversion volume

Moscariello, 2011

Conclusions

- Early understanding of the Permian Basin depositional model represented a solid and inspirational basis for the following work.
 - The ‘age’ of wisdom setters
- Further developments and several wells after and new technology, allows to define better important play details at both basin and reservoir scale.
 - The layer-cake myth...
- Some observations made at very early stage in the SNS petroleum play definition, were not followed up immediately, leaving behind a number of viable opportunities in the subsurface.
 - Geological concepts goes faster then industry -
- Serendipity is of great help, still listening to the geoscientists may make the difference...



Acknowledgments

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