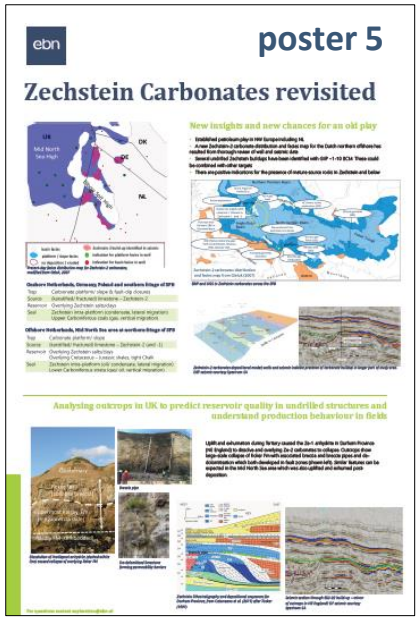
Zechstein Carbonates revisited

new insights and new changes for an old play

- Established petroleum play in NW Europe including NL
- A new Zechstein-2 carbonate distribution and facies map for the Dutch northern offshore has resulted from a review of well and seismic data
- Several undrilled Zechstein buildups have been identified, combine with other targets
- There are positive indications for the presence of mature source rocks in Zechstein and below
- Analysing outcrops in UK and NL production data helps in predicting reservoir quality and productivity in undrilled structures



- MSc research at EBN by Jan Schneider (‘13-’14) and Sjoerd Tolsma (‘12-’13)
- Prospectivity screening by EBN, excursion to outcrops (’13-’15)
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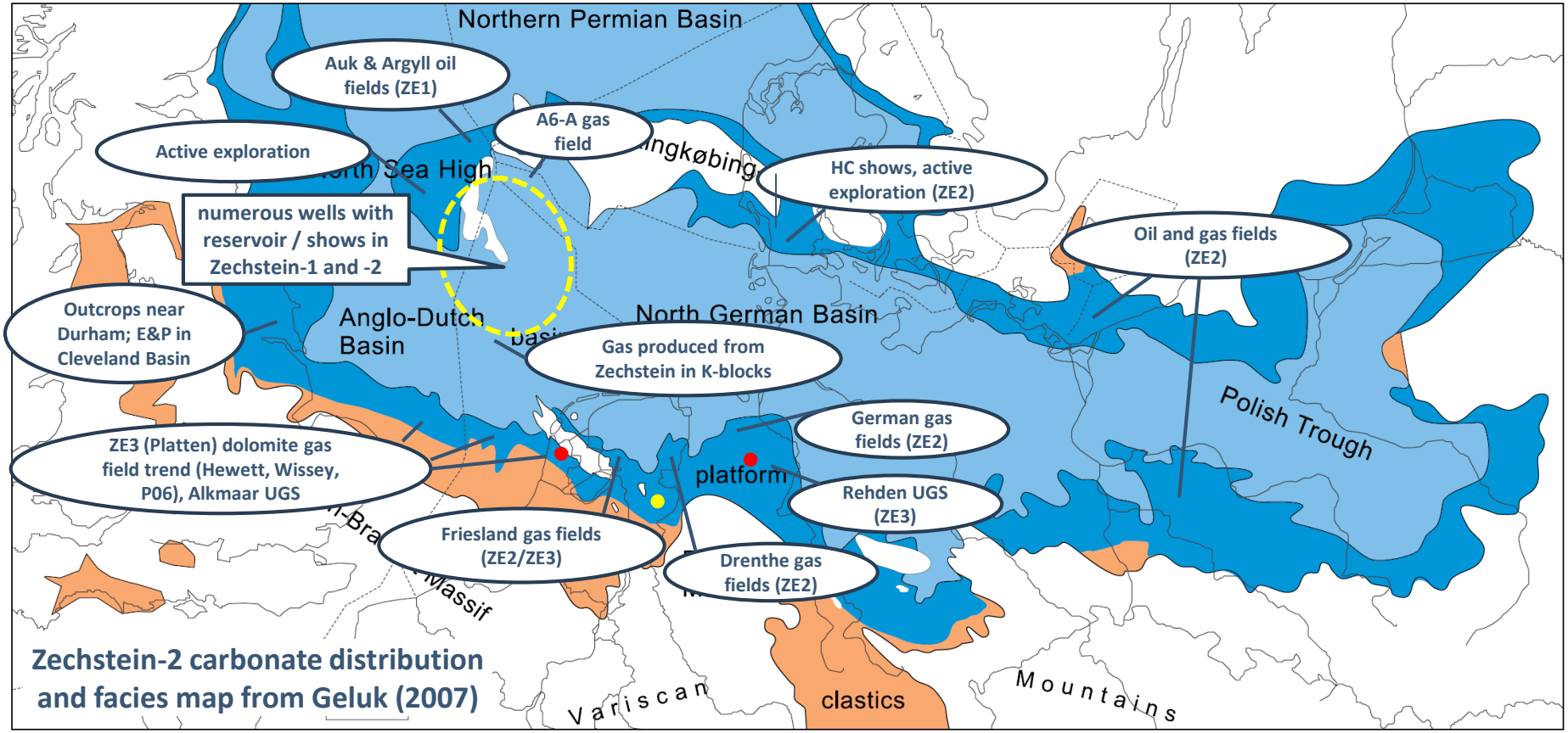
Zechstein carbonates in the Southern Permian Basin

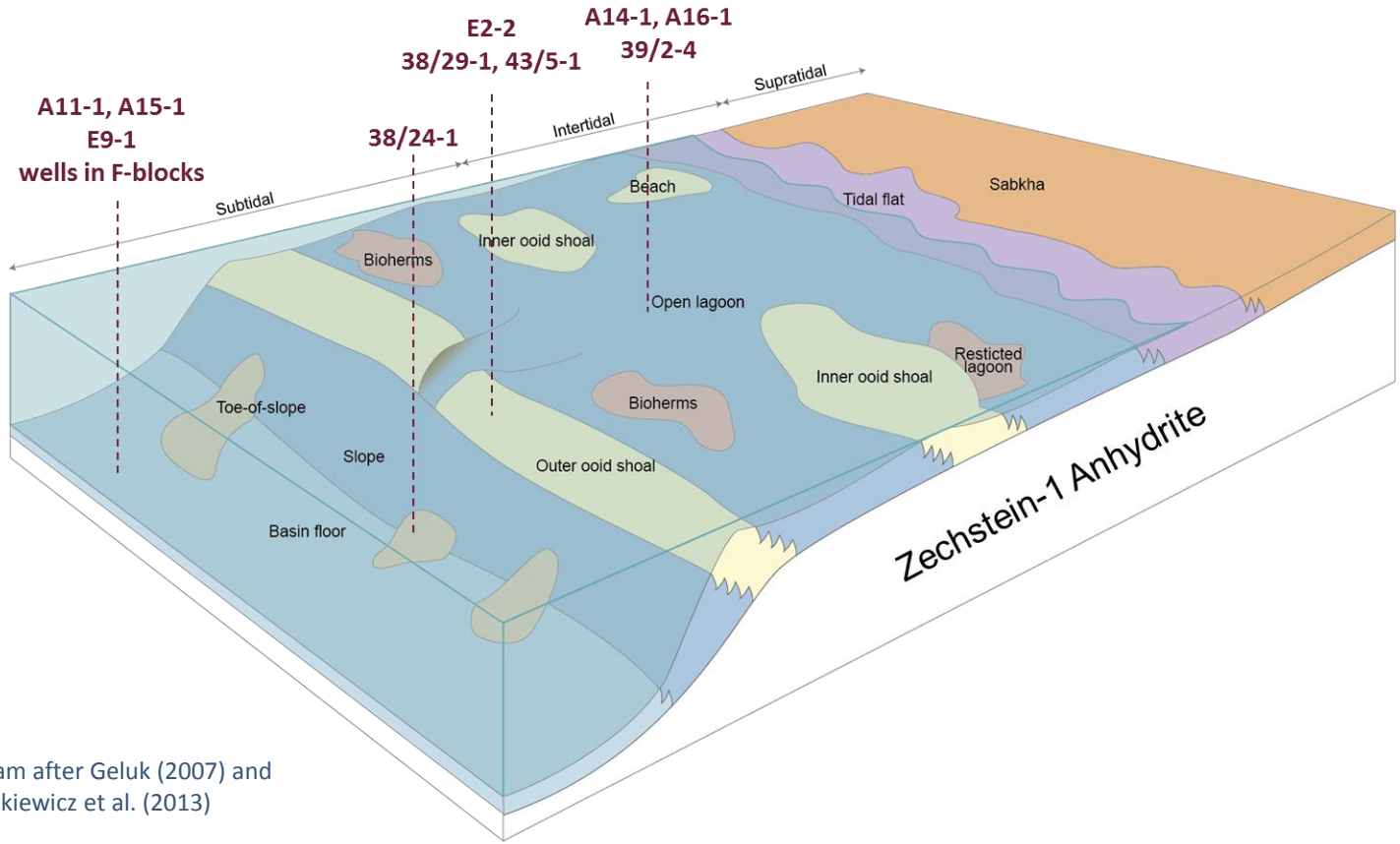
E&P and UGS in these reservoirs across / around the basin



Zechstein-2 carbonate distribution and facies map from Geluk (2007)

Zechstein-2 carbonates depositional model

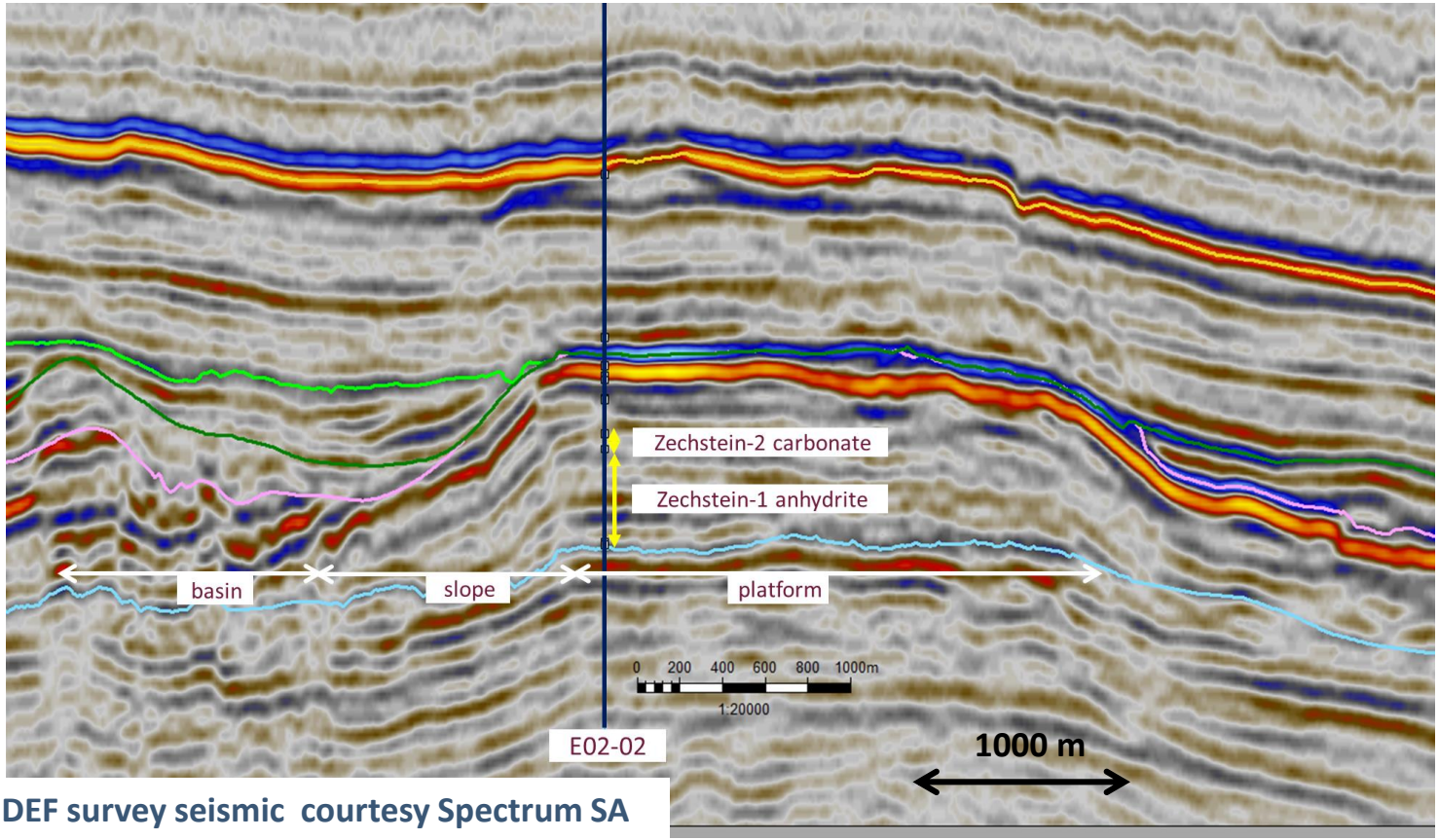
wells indicate presence of carbonate buildup in large part of study area



Daigram after Geluk (2007) and Słowakiewicz et al. (2013)

Zechstein in seismic – E02-02 buildup

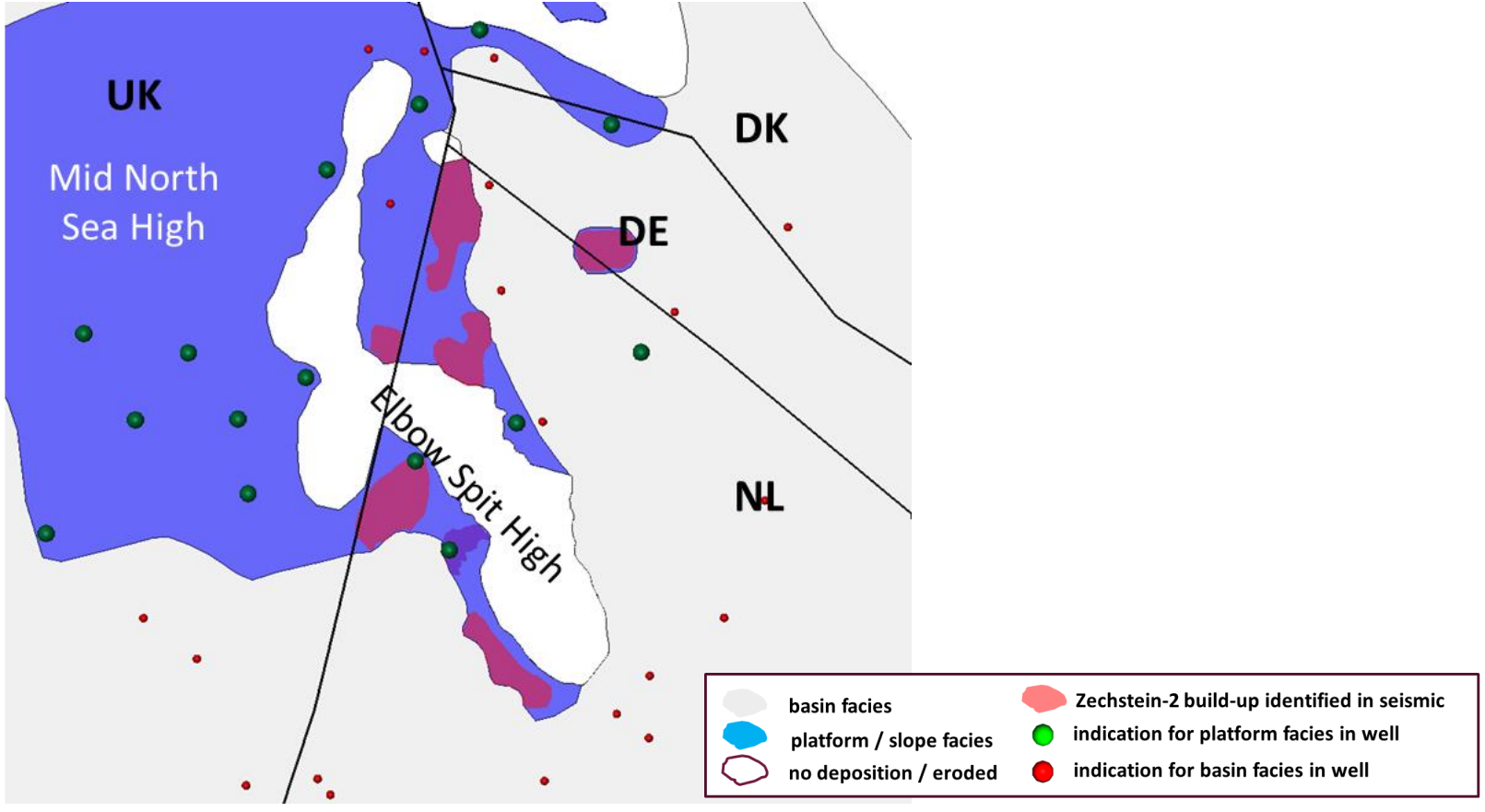
presence of several carbonate buildups in DEFAB area confirmed in seismic



DEF survey seismic courtesy Spectrum SA

New map for Zechstein-2 carbonates distribution

as a result of integrating well review and seismic interpretation

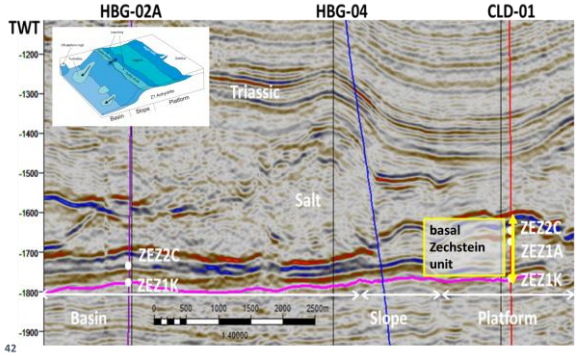


Time to explore – petroleum play elements

focus on Zechstein-2 carbonates – differences between areas

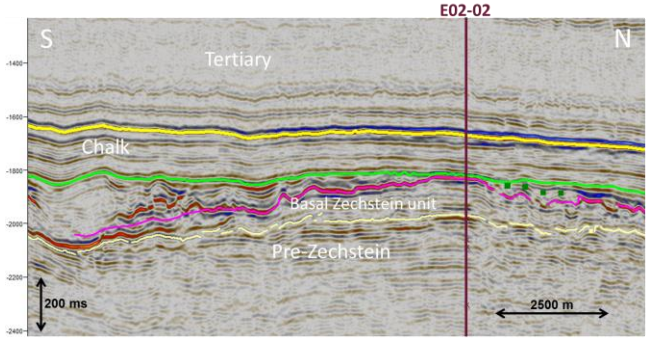
Onshore Netherlands, Germany, Poland at southern fringe of SPB

Trap	carbonate platform / slope & fault-dip closures
Reservoir	(karstified / fractured) limestone - Zechstein-2
Seal	overlying Zechstein salts / clays
Source	Zechstein intra-platform (condensate, lateral migration) Upper Carboniferous coals (gas, vertical migration)



Offshore Netherlands, Mid North Sea area at northern fringe of SPB

Trap	carbonate platform / slope
Reservoir	(karstified / fractured) limestone - Zechstein-2 (and -1)
Seal	overlying Zechstein salts / clays overlying Cretaceous - Jurassic shales, tight Chalk
Source	Zechstein intra-platform (oil / condensate, lateral migration) Lower Carboniferous strata (gas / oil, vertical migration)



Zechstein carbonates

petroleum play elements in the Mid North Sea area - reservoir

Trap	carbonate platform / slope
Reservoir	(karstified / fractured) limestone - Zechstein-2 (and -1)
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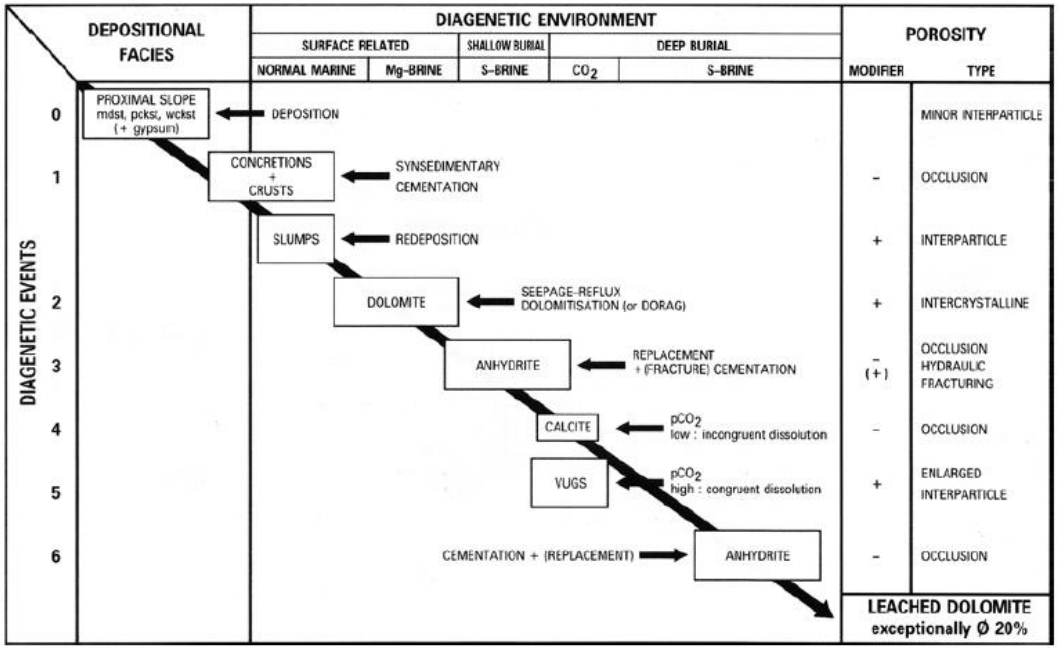
Source	Zechstein intra-platform (oil / condensate, lateral migration) Lower Carboniferous strata (gas / oil, vertical migration)

When lacking well data…

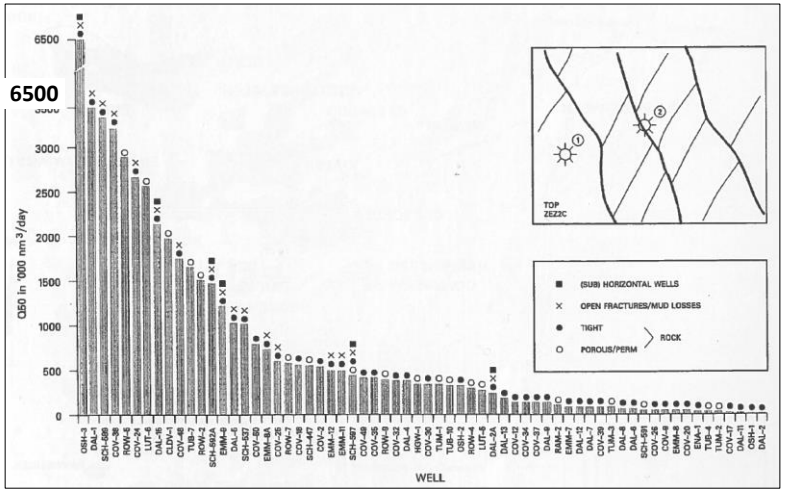
- Look at analogues in literature
- Look at relevant outcrops

Reservoir quality – many controlling factors…

Diagenesis & fractures – examples from producing Drenthe area (onshore NL)



Diagenetic model for proximal slope Zechstein-2 carbonates, from Reijers (2012)



Productivities of Drenthe ZeZ2C wells (Q50 test at 50 bar drawdown), from Frikken (1999)

EBN MSc thesis research on relation between productivity and fractures & facies ongoing, Coen Paulides (TUD)

Recent work on nearby similar german fields presented by Schoenherr et al. (2014)

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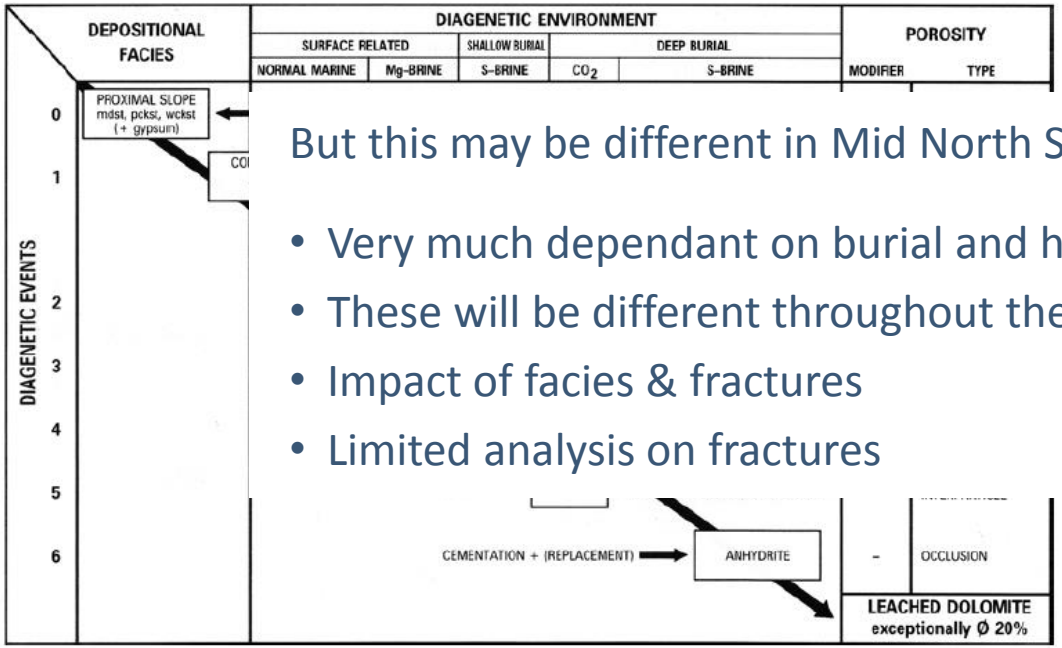
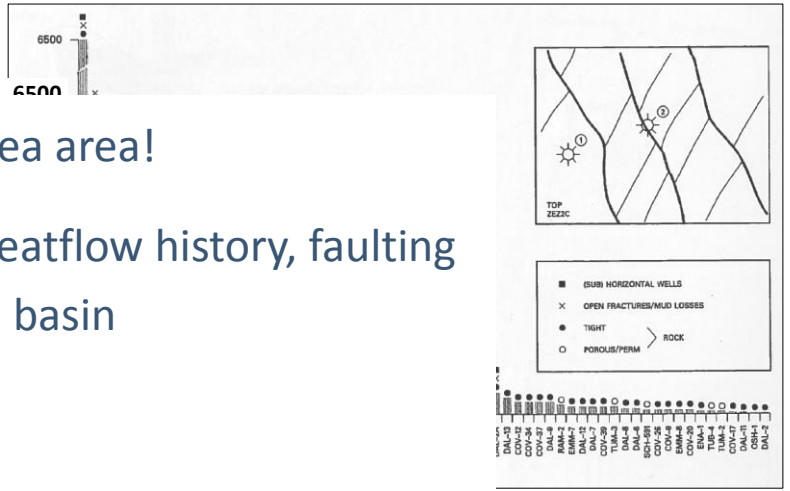


Diagenetic model for proximal slope Zechstein-2 carbonates, from Reijers (2012)

But this may be different in Mid North Sea area!

- Very much dependant on burial and heatflow history, faulting
- These will be different throughout the basin
- Impact of facies & fractures
- Limited analysis on fractures



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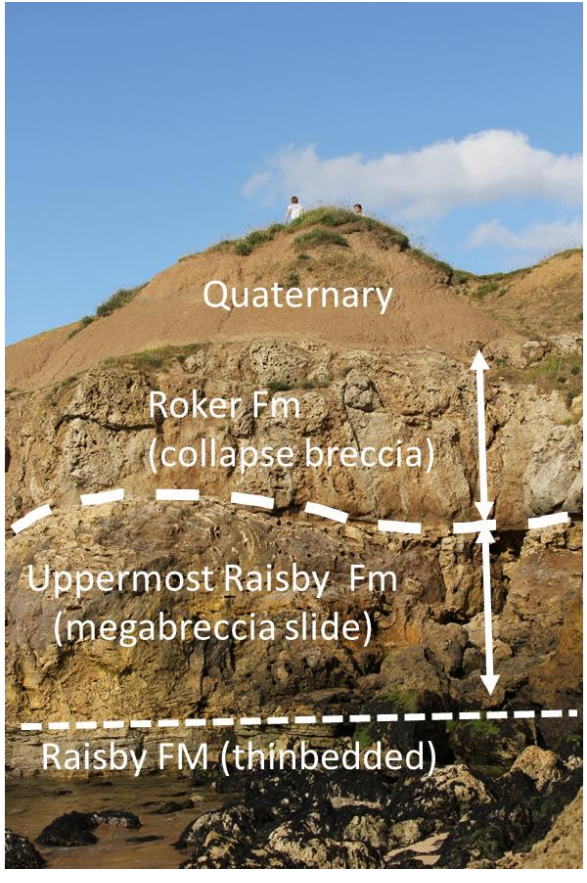
Little fieldtrip to Durham Province (NE England)

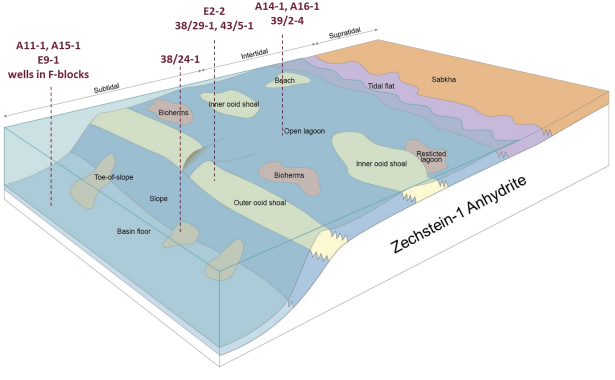
outcrops show diagenetic features impacting reservoir quality



Tertiary uplift and exhumation caused Ze-1 anhydrite to dissolve, overlying Ze-2 carbonates collapsed. Outcrops show large-scale collapse of Roker Fm, forming breccia.

residue Hartlepool Anhydrite (cm's)
Trow Point Bed (microbial, 10 cm)

slide plane



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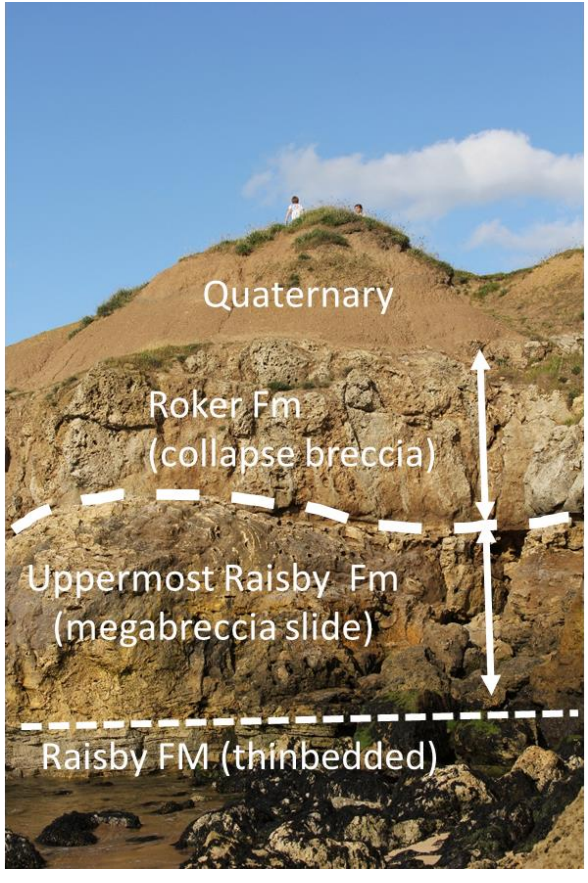
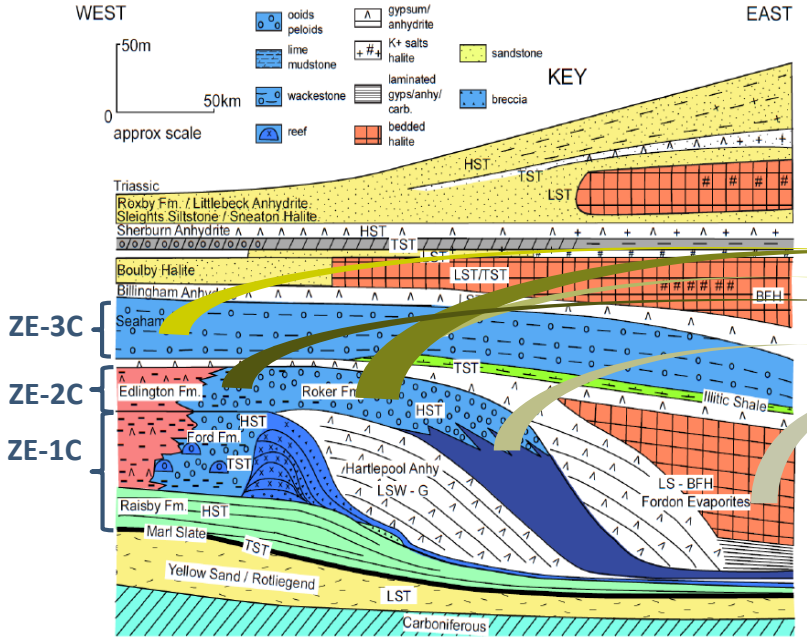
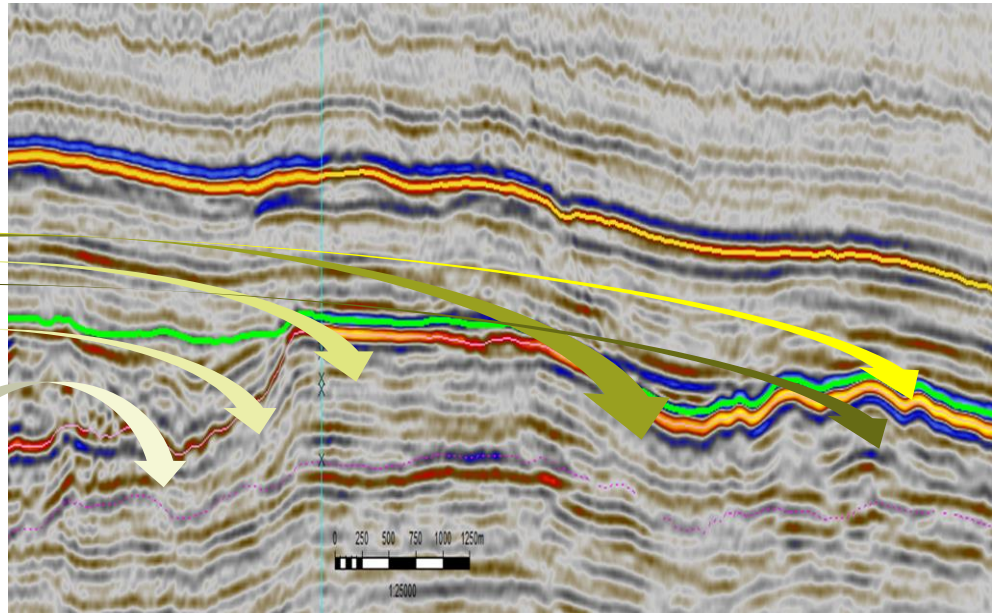


Tertiary uplift and exhumation caused Ze-1 anhydrite to dissolve, overlying Ze-2 carbonates collapsed. Outcrops show large-scale collapse of Roker Fm, forming breccia.

Breccia pipes and de-dolomitisation developed in fault zones.

Similar processes and effects may be expected in the MNS area which was also uplifted and exhumed after deposition





Zechstein lithostratigraphy and depositional sequences for Durham Province, from Catuneanu et al. (2011) after Tucker (1991)

Seismic section through E02-02 build-up

DEF seismic courtesy Spectrum SA

Zechstein carbonates

petroleum play elements in the Mid North Sea area – source & charge

Trap	carbonate platform / slope
Reservoir	(karstified / fractured) limestone - Zechstein-2 (and -1)
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Source	Zechstein intra-platform (oil / condensate, lateral migration) Lower Carboniferous strata (gas / oil, vertical migration)

- Positive indications for source rock potential and recent charge, see presentation *Source rock potential of the Dutch northern offshore*
- Zechstein intra-platform source rock potential:
  - Zechstein-2 carbonate proven SR for oil and condensate in SPB
  - Facies determines SR potential; seafloor, lower slope, lagoonal facies. See Slowaciewickz (2013)
  - Location in the basin matters; for instance salinity, oxygen, tidal activity impact SR (preservation) potential

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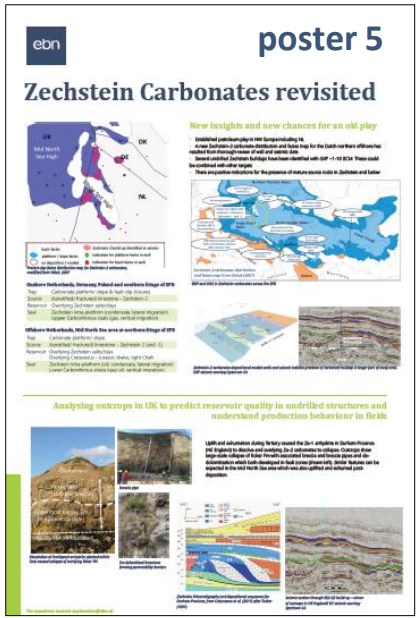

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