# Zechstein Carbonates revisited

## New Insights and New Chances for an Old Play

**Bastiaan Jaarsma* (EBN), Kees Geel (TNO) and Walter Eikelenboom (EBN)**

Marsden Bay (just South of Newcastle)

TNO innovation for life

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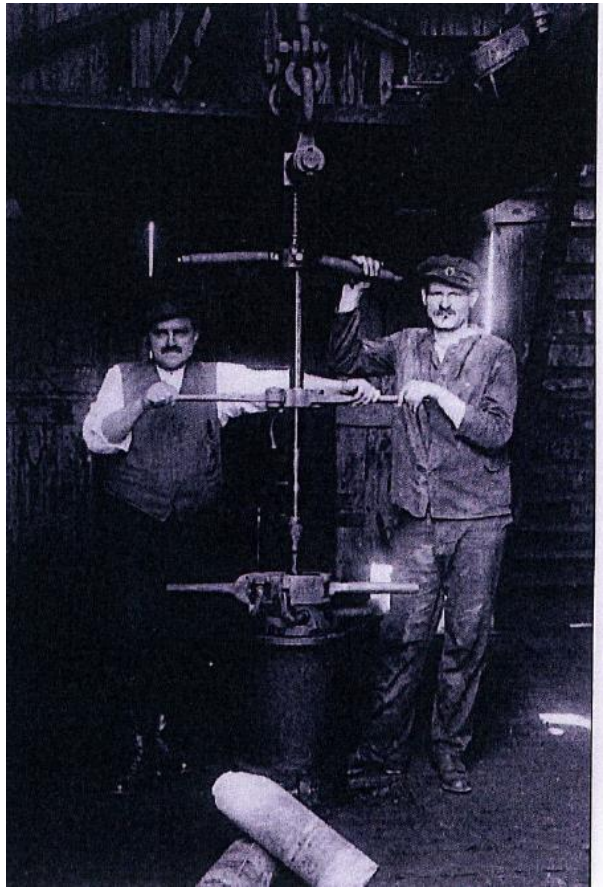
# It started a while ago…

## First discovery ever in The Netherlands in Zechstein in 1923 – well Corle-1



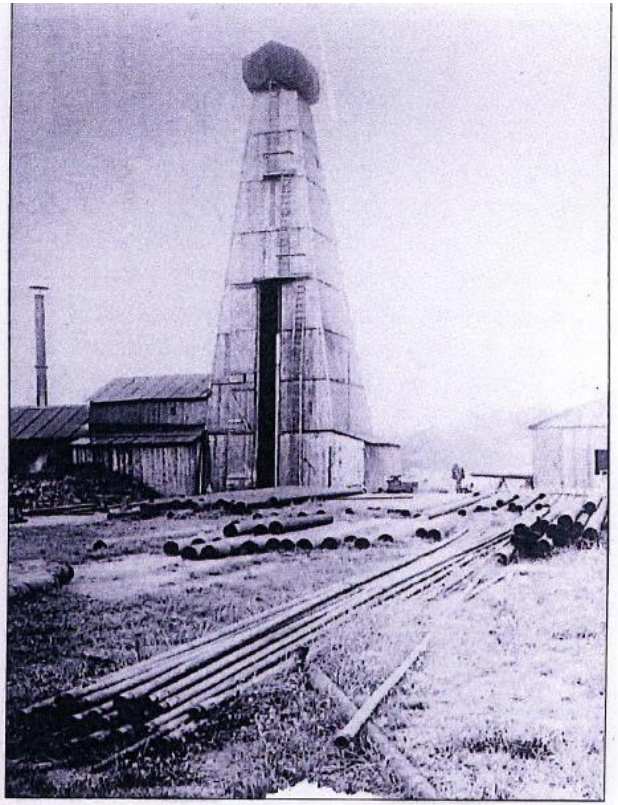


Fig. 6.1.-3 In 1923 the first discovery well in The Netherlands was drilled: Corle-1. The photo shows the rig at its location in the east of The Netherlands

DE GRA

DERDE BLAD.

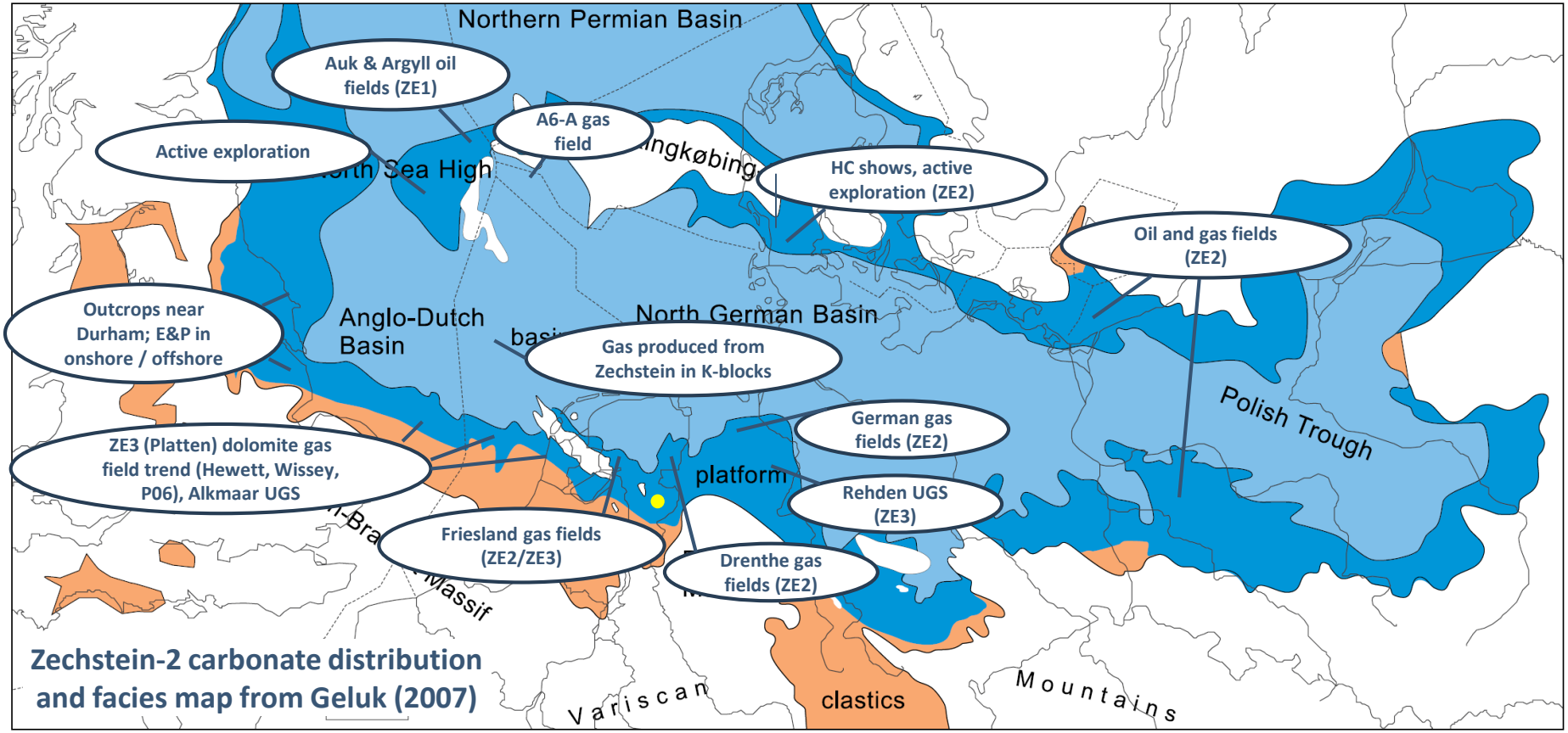
No 44 Vrijdag 29 Februari 1924.

Aardolie in Corle bij Winterswijk.

„Zaterdagmiddag, 23 Febr. j.l., is uit het boorgat van den boortoren „Rijksopsporing van delfstoffen" te Corle bij Winterswijk een stroom, groen geldkurde, lichte, ruwe aardolie gevloeid. In ongeveer een kwartier tijds werd 80 Liter gewonnen. Het gat werd weer gesloten, doch gistermiddag weer geopend. Toen is 150 liter gewonnen.

# Zechstein carbonates in the Southern Permian Basin

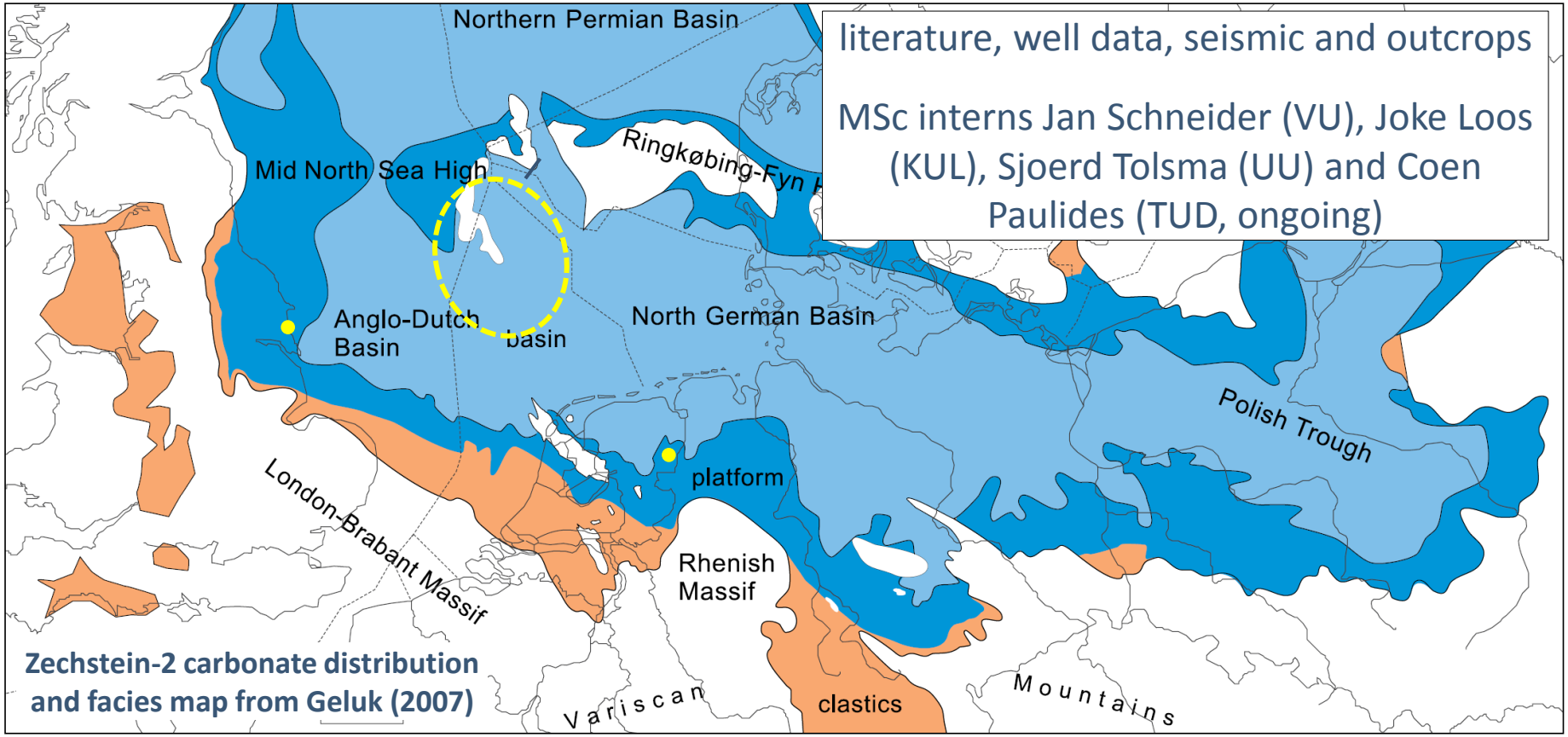
## E&P and UGS in Zechstein carbonates across the basin at present




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

# Zechstein carbonates in the Southern Permian Basin

## review by EBN and TNO to revise map in dutch northern offshore

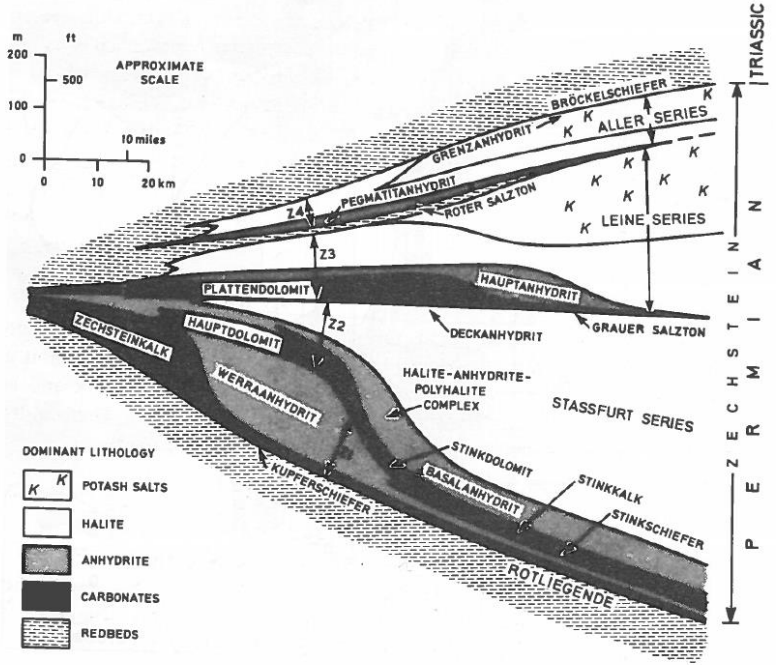



literature, well data, seismic and outcrops

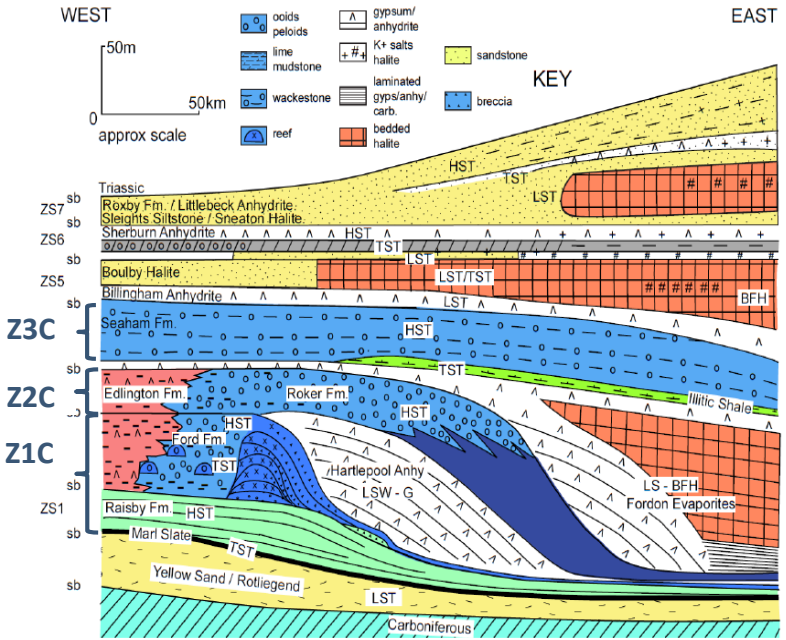
MSc interns Jan Schneider (VU), Joke Loos (KUL), Sjoerd Tolsma (UU) and Coen Paulides (TUD, ongoing)

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

# SPB Zechstein stratigraphy and sequences




Zechstein shelf-basin profile in SPB from Taylor (1984) in Glennie (1990)

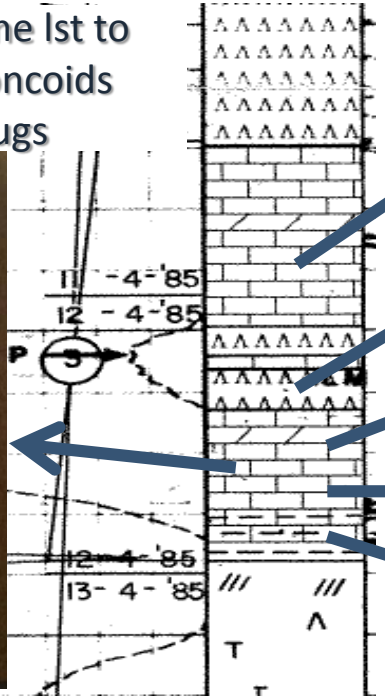



Zechstein lithostratigraphy and depositional sequences for Durham Province, from Catuneanu et al. (2011) after Tucker (1991)

# Reviewing Zechstein-1 carbonates distribution

## core material and reports from 5 wells – idealized Z1 sequence shown below

Transition from shallow marine lst to algal mat facies consists of oncoids high-perm streak with vugs




Z2 Stinkschiefer (basinal facies)

Z1 Anhydrite nodules

Z1 Algal mats

Z1 Shallow marine lst

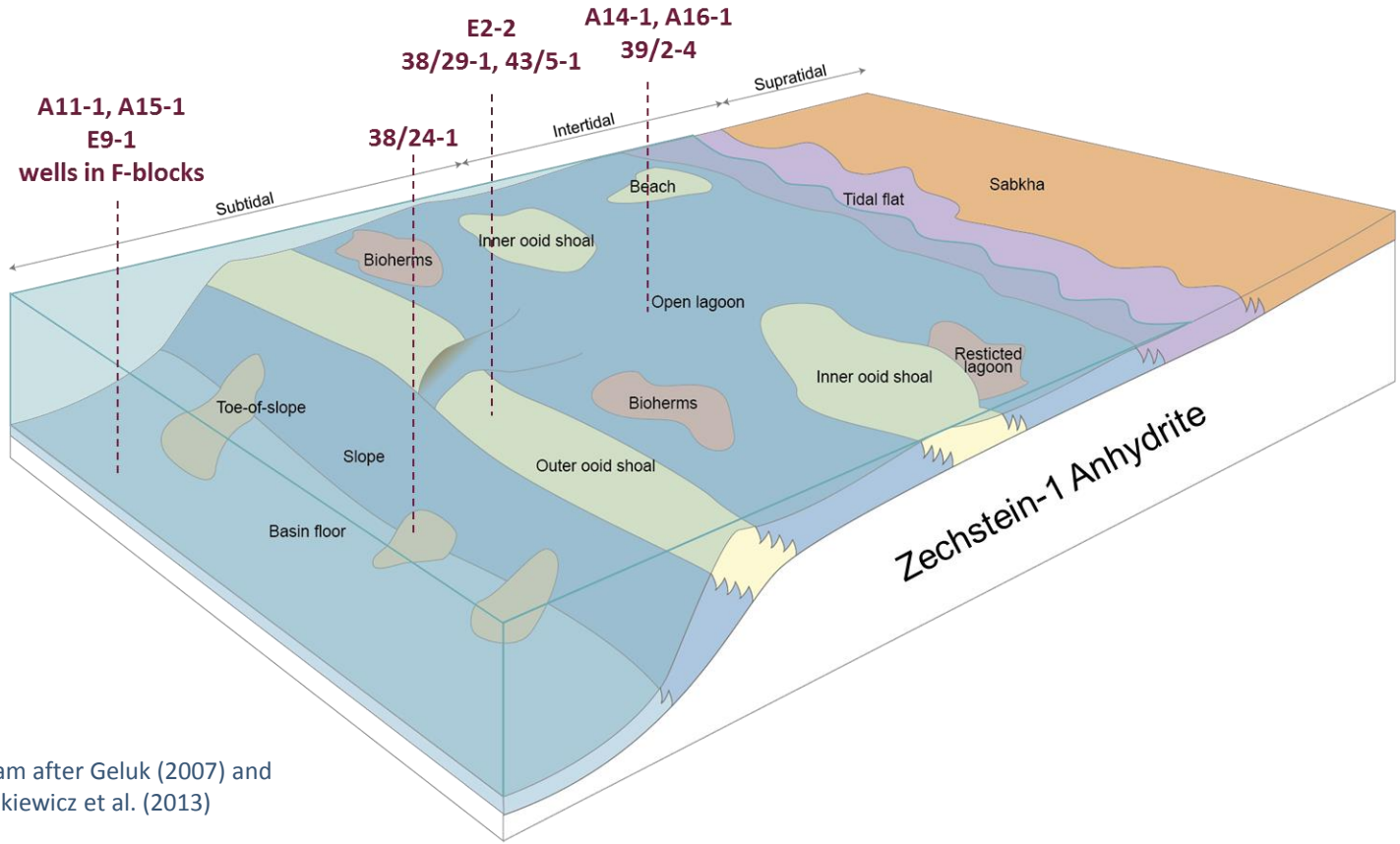
Z1 Kupferschiefer

The Z1C in the Cleaver bank area deposited on a platform, with potential for a good reservoir rock

TNO innovation for life

# Zechstein-2 carbonates depositional model

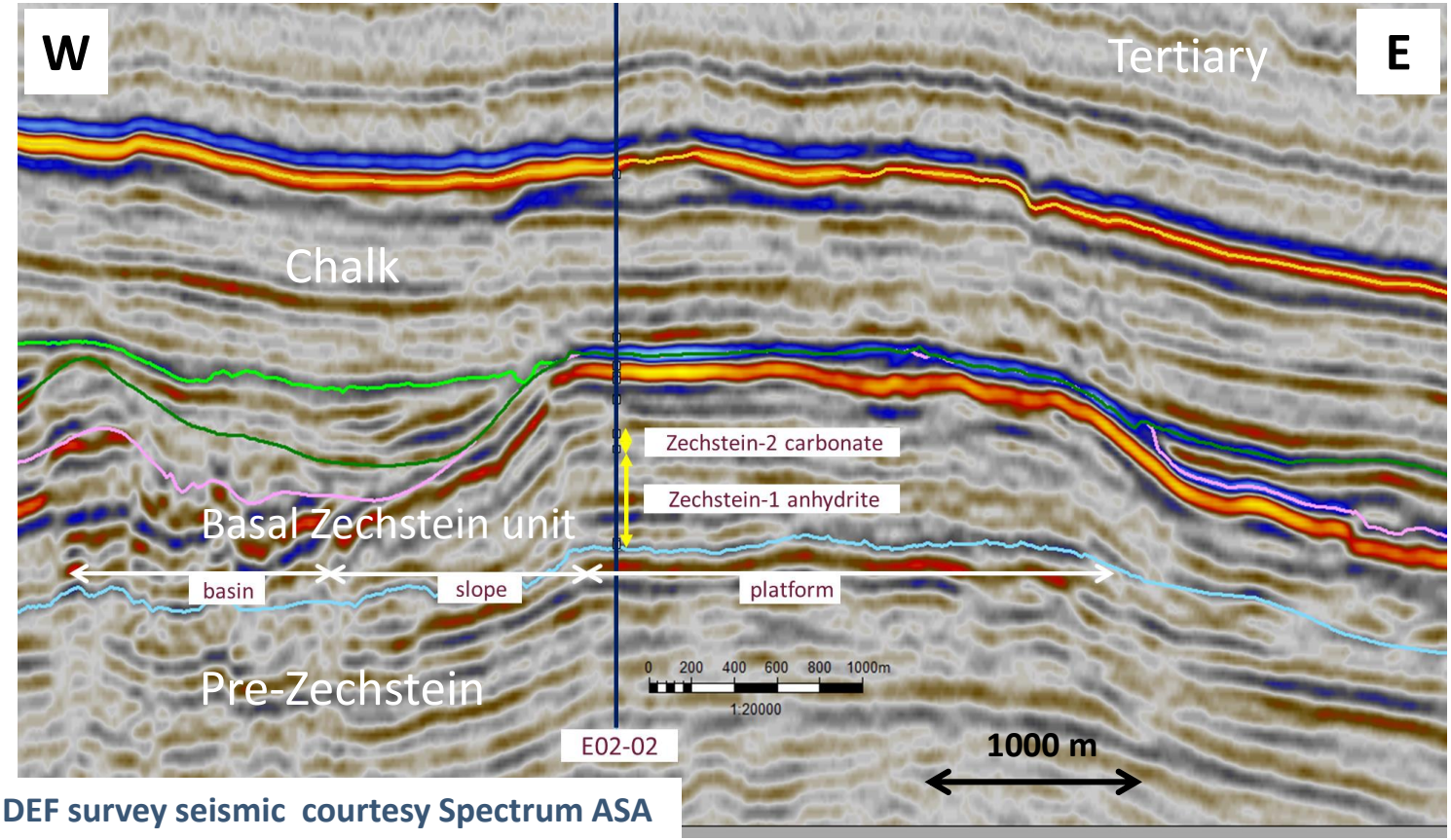
## wells indicate presence of carbonate buildup in large part of study area




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

# Zechstein in seismic – E02-02 buildup

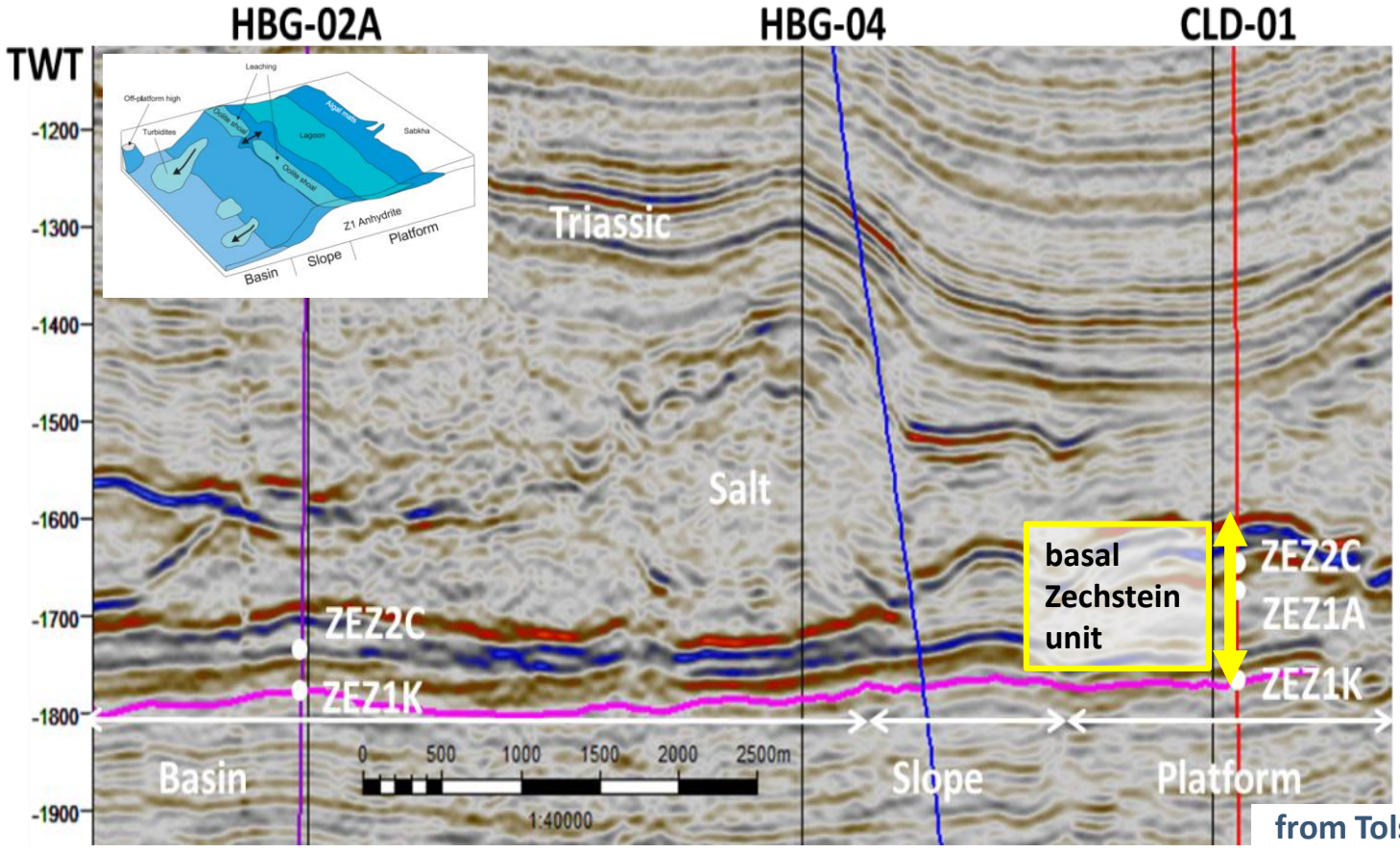
## presence of carbonate buildups in study area confirmed in new seismic




DEF survey seismic courtesy Spectrum ASA

# Zechstein in seismic – wells onshore NL

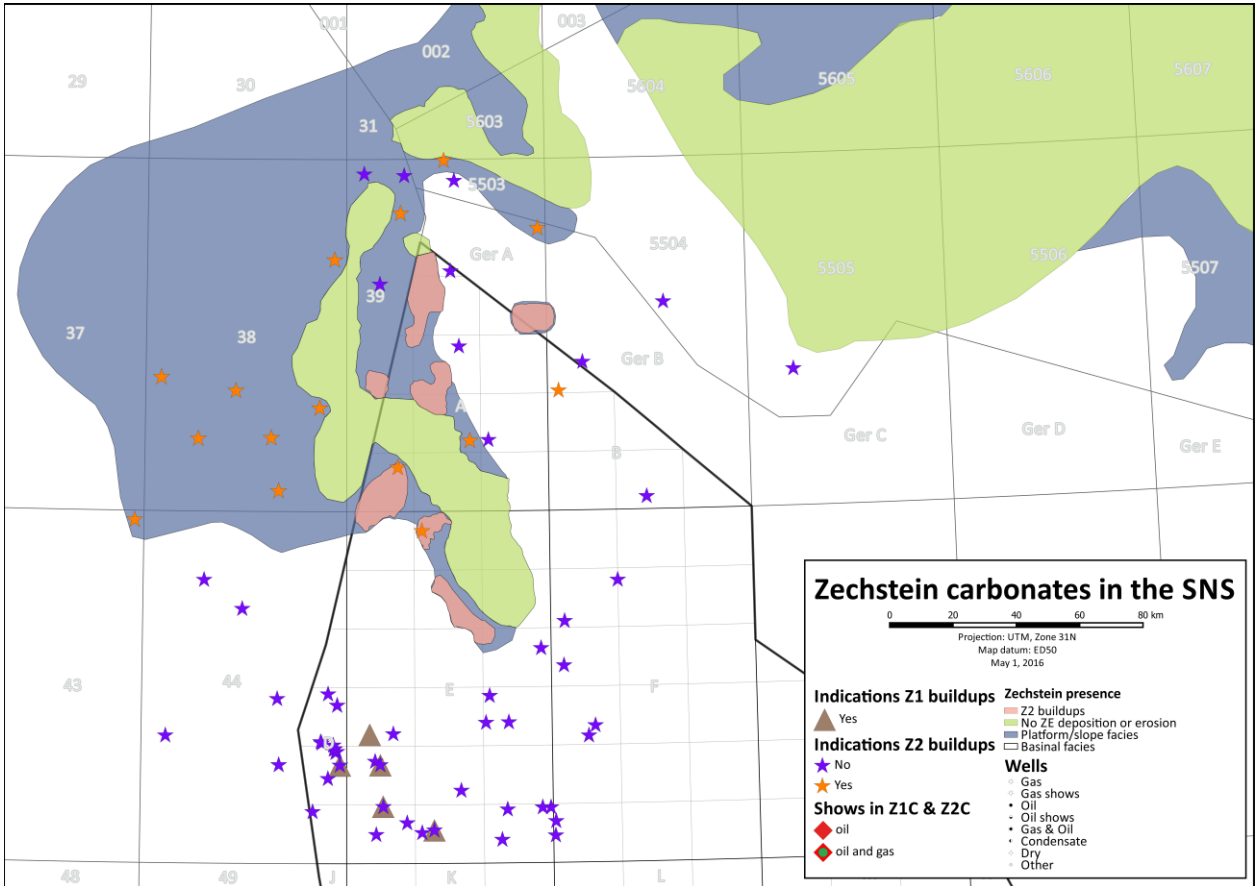
## platform – slope – basin transition in wells and seismic




from Tolsma (2014)

# New map for Zechstein carbonates distribution

## as a result of integrating well review and seismic interpretation



# Time to explore – petroleum play elements

## Offshore Netherlands in Mid North Sea area

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

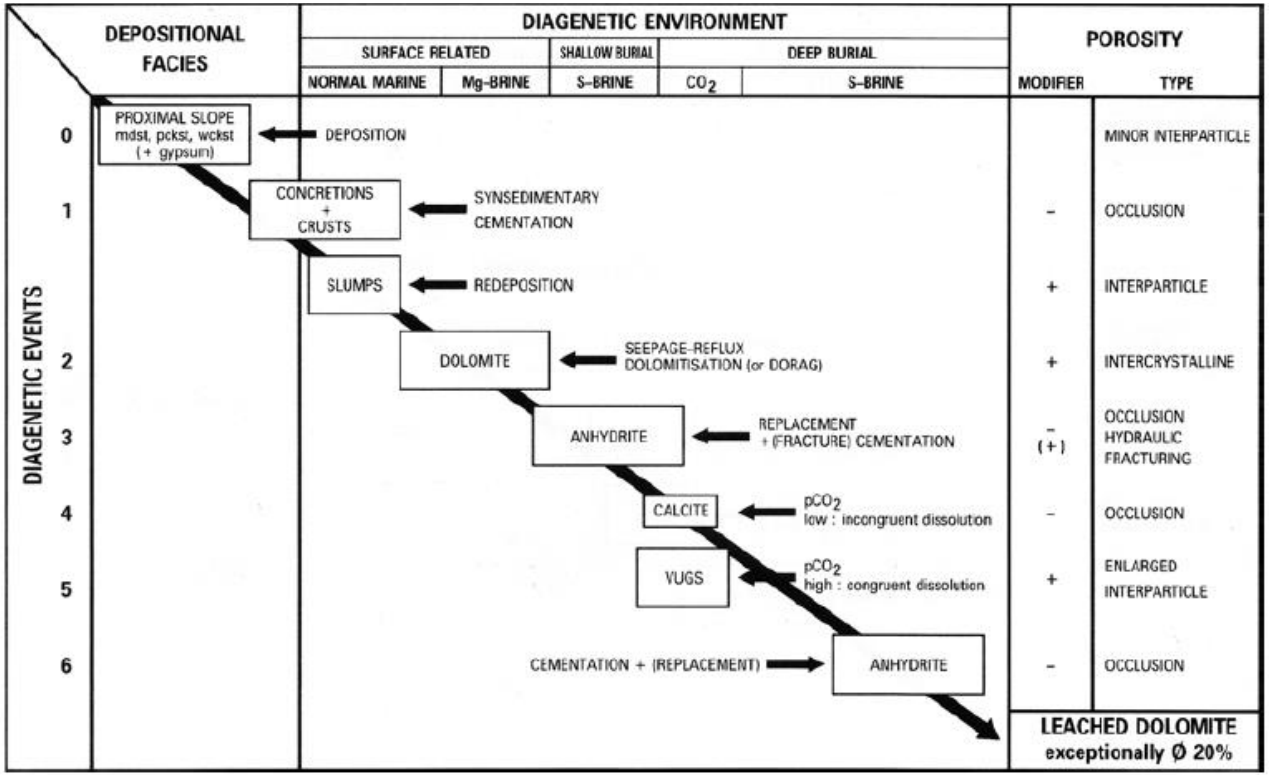
| | DST | PP avg ϕ (MS, CU 0.05) |
|---|---|---|
| **39/02-04** | | 0,13 |
| **43/05-01** | | 0,14 |
| **A06-03** | producing reservoir | |
| **A14-01** | no flow | |
| **A15-01** | "strong blow, weak burning" | 0,13 |
| **A16-01** | "no productivity" | 0,07 |
| **E02-02** | none | 0,16 |
| **E09-01** | 300 Mm3/d (85% N2) | |
| **E17-01** | 220 bbls/d (brine) | |

Not a lot of well data in the study area

Look at analogues, literature and outcrops

# Reservoir quality – many controlling factors

## Diagenesis – example from producing Zechstein-2 carbonates, onshore NL

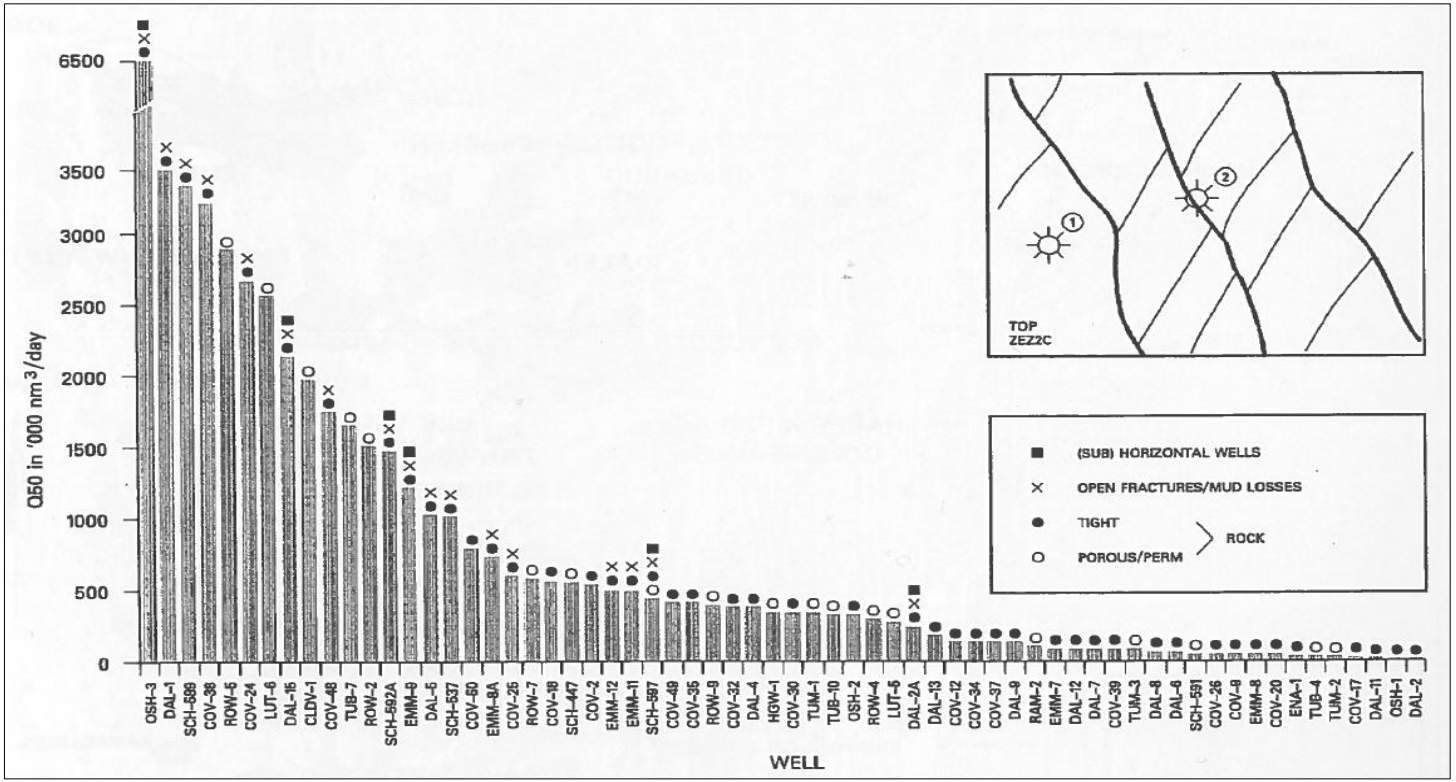



Diagenetic model for proximal slope Zechstein-2 carbonates, from Reijers (2012), based on numerous wells

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

# Reservoir quality – many controlling factors

## Fractures – example from producing Zechstein-2 carbonates, onshore NL

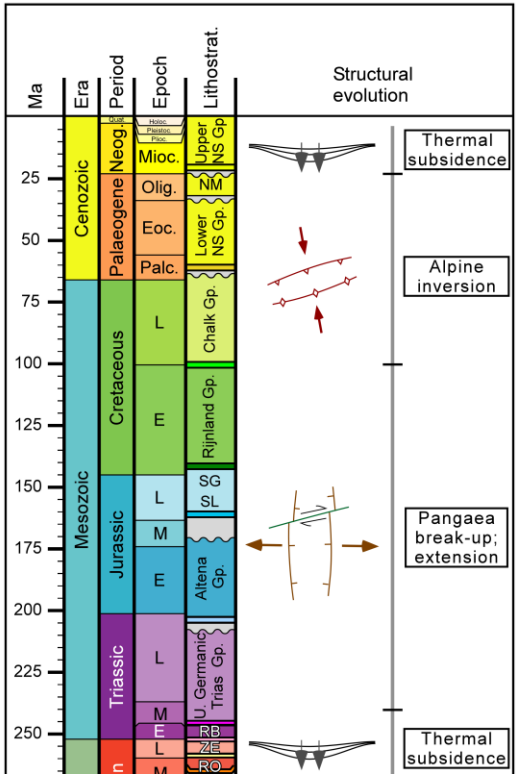



Productivities of Drenthe Zechstein-2 carbonates in production wells, from Frikken (1999)

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

# Reservoir quality – many controlling factors

## Diagenesis – different burial and heatflow history in MNS area




burial

(minor) inversion

burial

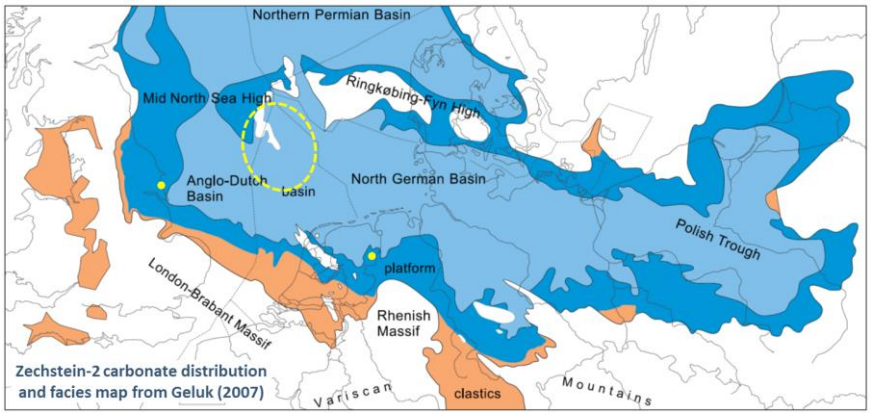
doming / uplift

burial

deposition

Reservoir thickness and quality may be different in Mid North Sea area or elsewhere in the basin!

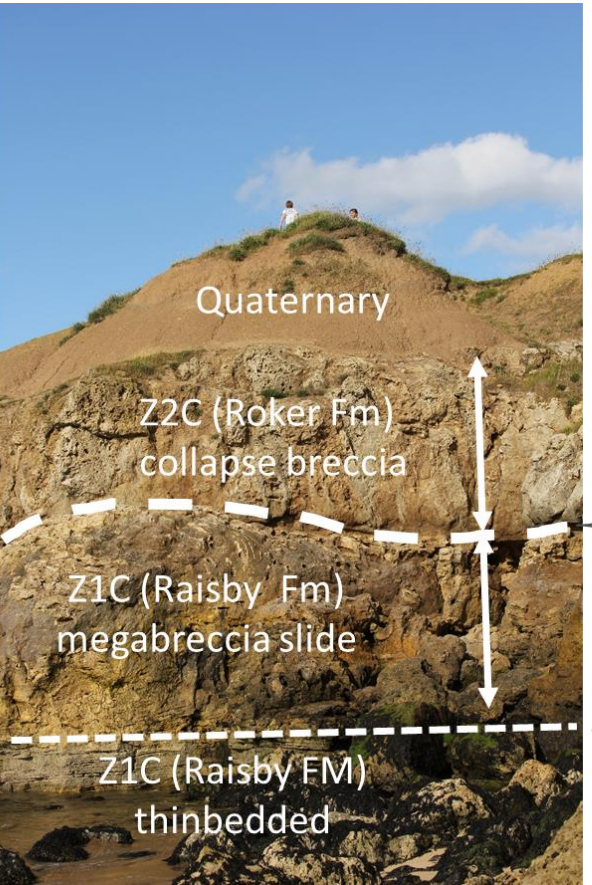
- Different conditions during deposition
- Different burial and heatflow history
- Different faulting and fractures




**Stratigraphic / event chart from ter Borgh et al. (poster session day one)**
**"A structural framework for the Mid North Sea area, Paleozoic to present"**

# Little fieldtrip to Durham Province (NE England)

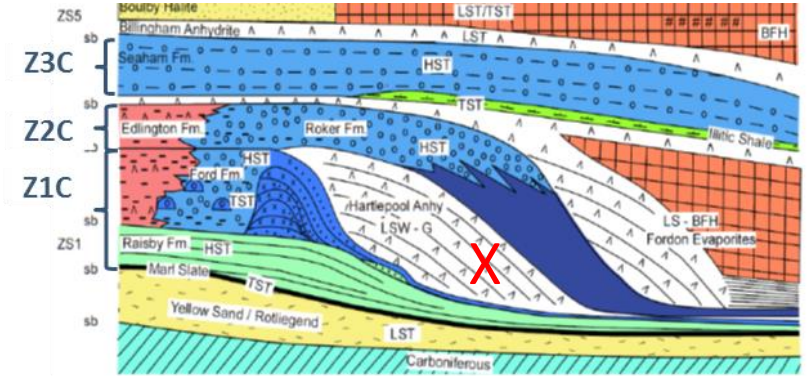
## outcrops show diagenetic features impacting reservoir quality




*residue dissolved Z1A*
*Z1C microbial*

*slide plane*

Tertiary uplift and exhumation caused Ze-1 anhydrite to dissolve, overlying Ze-2 carbonates collapsed




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

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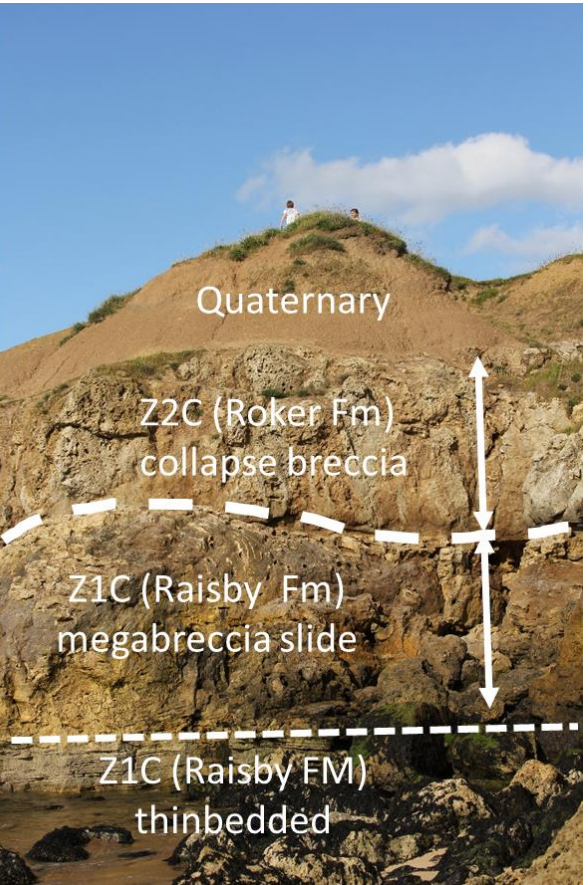
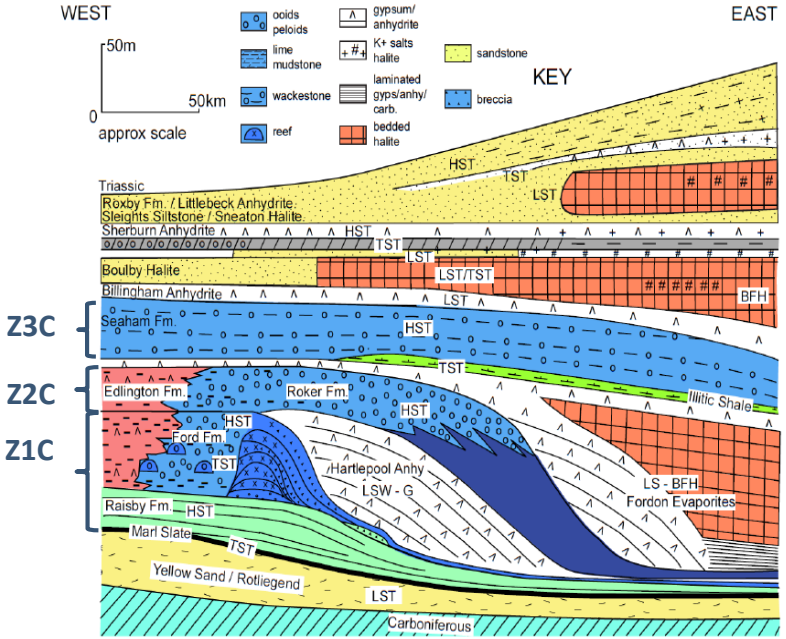



Tertiary uplift and exhumation caused Ze-1 anhydrite to dissolve, overlying Ze-2 carbonates collapsed

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

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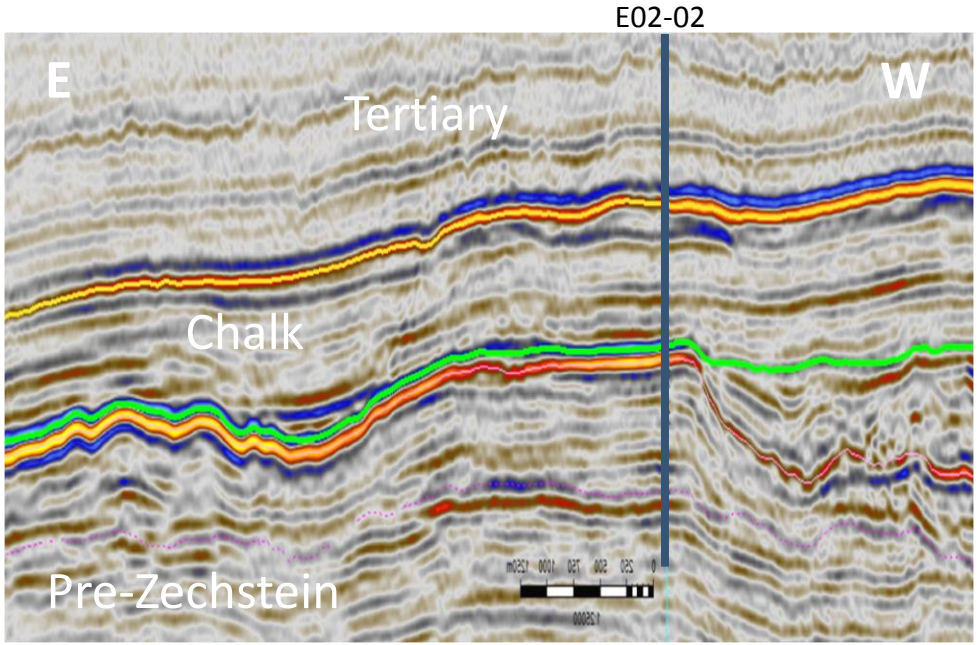


Seismic section through E02-02 build-up

DEF seismic courtesy Spectrum ASA

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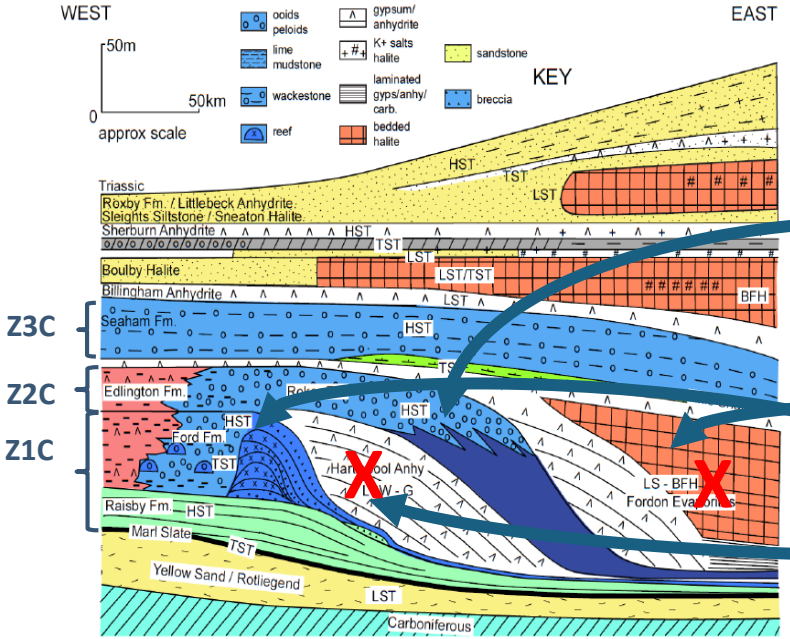


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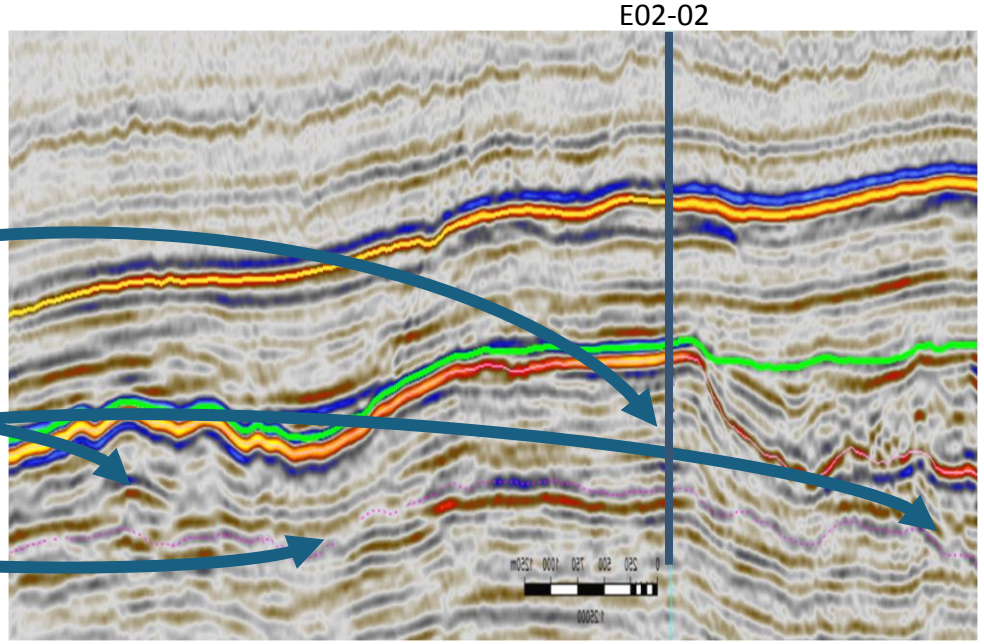
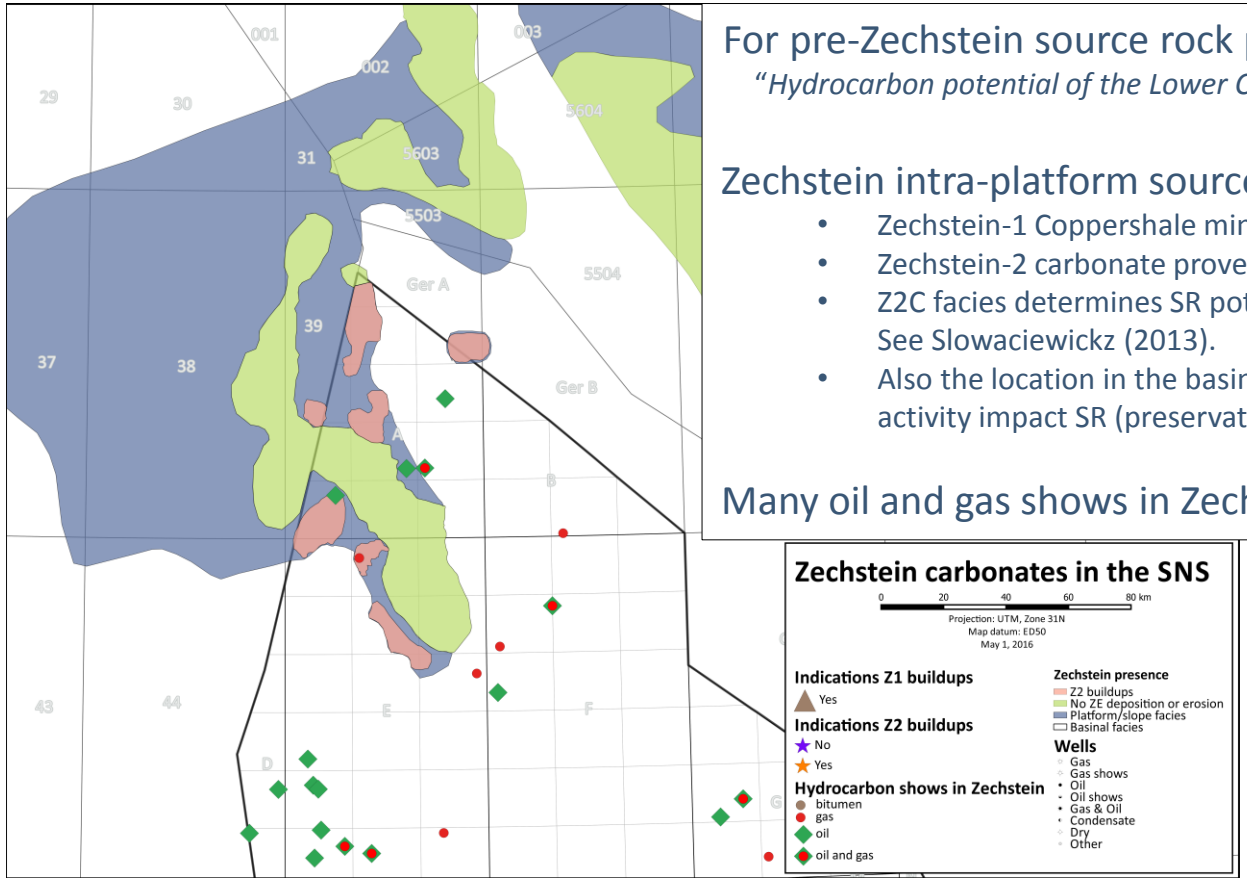



Seismic section through E02-02 build-up

DEF seismic courtesy Spectrum ASA

# Zechstein carbonates petroleum play

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




For pre-Zechstein source rock potential see Ter Borgh et al. (2016)

*"Hydrocarbon potential of the Lower Carboniferous in the Dutch northern offshore"*

Zechstein intra-platform source rock potential:

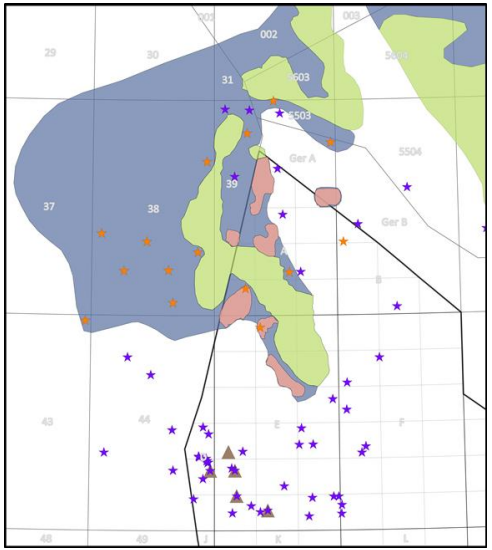
- Zechstein-1 Coppershale minor contribution
- Zechstein-2 carbonate proven SR for oil and condensate in SPB
- Z2C facies determines SR potential; seafloor, lower slope, lagoonal facies. See Slowaciewickz (2013).
- Also the location in the basin matters; for instance salinity, oxygen, tidal activity impact SR (preservation) potential

Many oil and gas shows in Zechstein carbonates

# Further work

- Advanced seismic interpretation / attributes (geometries, diagenesis, faults)
- Structural evaluation (paleotopography, burial history, fault trends)
- Core / samples (SR potential, diagenesis, fractures)
- Prospect evaluation

- Cross-border

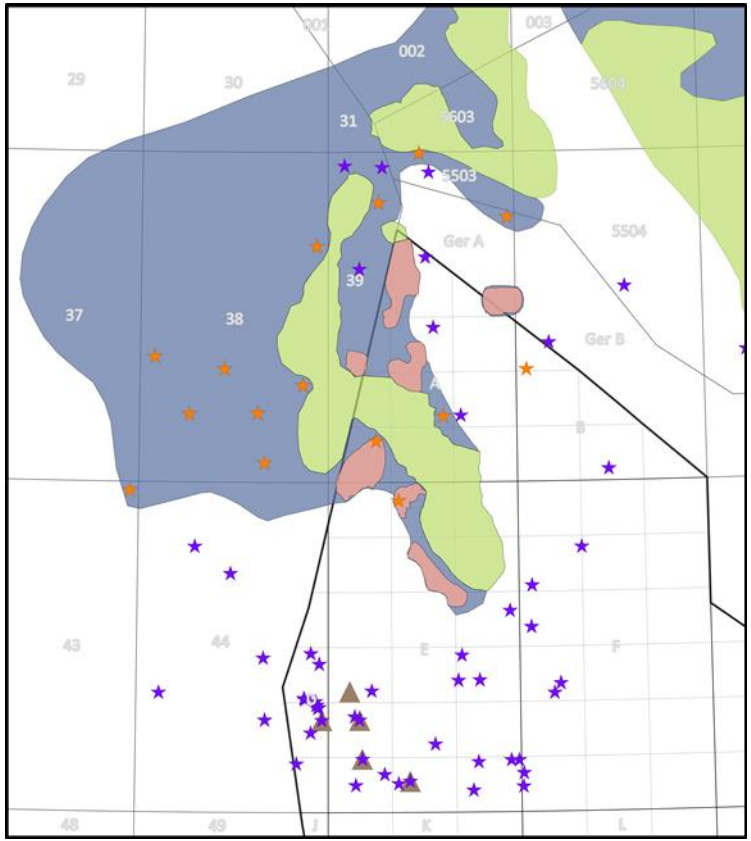


# Key messages of this presentation

- Established petroleum play in NW Europe, producing HC's for decades
- Results of reviews of well and seismic data:
  - a revised Zechstein-2 carbonate distribution and facies map for the Dutch northern offshore and mapping of several undrilled Zechstein buildups, mostly in currently unlicensed area
  - insight that Zechstein-1 carbonates in the same area were locally deposited on a platform rather than in a basinal setting and have potential for good reservoir quality
- Analysing outcrops in the UK and production data from the NL helps in predicting reservoir distribution and quality beyond well control
- There are clear positive indications for the presence of mature source rocks in Zechstein and older strata

# Zechstein Carbonates revisited

## New Insights and New Chances for an Old Play




Thanks for your attention! For more information, contact us:

bastiaan.jaarsma@ebn.nl kees.geel@tno.nl
walter.eikelenboom@ebn.nl

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Colleagues and university supervisors for their input
Rader Abdul Fattah (TNO) for basin modelling

TNO innovation for life

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