Zechstein Carbonates revisited
New Insights and New Chances for an Old Play

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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.
Zechstein carbonates in the Southern Permian Basin

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

Zechstein 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)
SPB Zechstein stratigraphy and sequences


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

The Z1C in the Cleaver bank area deposited on a platform, with potential for a good reservoir rock
Zechstein-2 carbonates depositional model
wells indicate presence of carbonate buildup in large part of study area

Diagram 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
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**

<table>
<thead>
<tr>
<th>Trap</th>
<th>carbonate platform / slope</th>
</tr>
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<tbody>
<tr>
<td>Reservoir</td>
<td>(karstified / fractured) limestone - Zechstein-2 (and -1)</td>
</tr>
</tbody>
</table>
| 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) |

<table>
<thead>
<tr>
<th>DST</th>
<th>PP avg φ (MS, CU 0.05)</th>
</tr>
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<tbody>
<tr>
<td>39/02-04</td>
<td>0,13</td>
</tr>
<tr>
<td>43/05-01</td>
<td>0,14</td>
</tr>
<tr>
<td>A06-03</td>
<td>producing reservoir</td>
</tr>
<tr>
<td>A14-01</td>
<td>no flow</td>
</tr>
<tr>
<td>A15-01</td>
<td>&quot;strong blow, weak burning&quot; 0,13</td>
</tr>
<tr>
<td>A16-01</td>
<td>&quot;no productivity&quot; 0,07</td>
</tr>
<tr>
<td>E02-02</td>
<td>none 0,16</td>
</tr>
<tr>
<td>E09-01</td>
<td>300 Mm3/d (85% N2)</td>
</tr>
<tr>
<td>E17-01</td>
<td>220 bbls/d (brine)</td>
</tr>
</tbody>
</table>

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

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

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

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