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Petroleum Plays of the Netherlands

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SUMMARY

A summary of petroleum exploration plays in the Netherlands is made to estimate remaining hydrocarbon potential in the country. The last 15 years the main exploration focus has been on drilling Rotliegendes and Triassic prospects. The exploration success of these plays makes it likely that more wells will be drilled to these targets. The viability of other plays in the country will be discussed.

Introduction

Aging infrastructure at the Dutch offshore causes the window of opportunity for hydrocarbon exploration slowly to close. In particular the viability of smaller hydrocarbon prospects is very dependent on the vicinity of the aging facilities.
Systematic exploration in the Netherlands started 100 years ago and got an enormous boost 50 years ago, following the giant Groningen Rotliegend gas field discovery. Conventional plays are still successful. These successes can not stem the production decline, both onshore and offshore. Before the disappearance of existing infrastructure, it is critical to investigate all remaining exploration potential. Purpose of this presentation is to review current knowledge of geological controls on hydrocarbon occurrences and plays in the Netherlands.

Some oil discoveries in the Netherlands go back to the years before or immediately after World War II. It was not until the discovery of Groningen when it was realized that gas generated in the shales and coals of Carboniferous age form the most important petroleum system of the country. There are only a few fields with oil and gas of other sources. The most widely found oil source bed is the Posidonia shale of Jurassic age. Over 250 oil and gas fields have been discovered, in formations ranging from Carboniferous to Cretaceous age (see figure). Exploration in this mature area, does not indicate a hyperbolic flattening ('creaming') when compared with the number of exploration wells (Breunese *et al.* 2005).
This is mainly due to continuous, gas discoveries in The Permian Rotliegendes and Triassic Bunter reservoir sands. Less than 10 percent of new discoveries are found in other formations like sands of Carboniferous age.

The success of the old plays is partly due to new solutions for old problems in particular a better grip on the complicated structuration in the Dutch subsurface.

New techniques make a difference for the discoveries:

- Improved subsurface imaging, through 3D seismic and PSDM
- Computer technology not only for seismic processing but also for amplitude studies and inversion studies
- Improved computer technology for improved maturation modeling, 3D geological modeling.

A brief summary of the countries play areas will be given with emphasis on less conventional plays. They are grouped in ten lithological intervals covering the whole stratigraphic column from the Caledonian unconformity (Devonian) up to the Quaternary.

1. Pre-Westphalian leads – A new frontier?

The Devonian and Lower Carboniferous plays are regarded as speculative and are unproven in the Netherlands. There are major uncertainties surrounding these plays. Large Lower Carboniferous age reefal structures were discovered recently and renewed interest in these very deep carbonates. Improved seismic acquisition and processing has made it possible to detect structures and stratigraphic details of this carbonate section which were unknown until recently.

These recent seismic interpretations have indicated massive Mississippian carbonate build-ups far below conventional petroleum exploration targets in the Netherlands.
There are no known oil or gas fields in the vicinity of the Netherlands in pre Silesian reservoirs.
The most prospective reservoir facies for the carbonate margin play are the rimmed shelf complexes comprising grainstone shoals and buildups.
Other Pre-Westphalian leads have been suggested in clastics, like Namurian sands.

2. Westphalian plays – More than a subcrop play?

There is gas production from the Westphalian but considering the thickness of the Westphalian age sediments and the fact it is present underneath almost the whole country this production is very limited. Prediction of sandy Westphalian age intervals is often difficult but has been successful. Fluvial sandstones occur at distinct stratigraphic levels A subcrop play has found gas onshore and offshore. An important question is if there is a viable intra Westphalian play.

3. Permian Rotliegend plays – Bread and butter of Dutch Exploration

The Rotliegend Play is the most successful play in the Netherlands and several sub plays and play areas can be distinguished. The excellent reservoir quality of Rotliegend sands combined with good seal of Permian Zechstein evaporites and gas generation in the underlying Carboniferous coal layers provides excellent gas reservoirs.
The success relies mainly on good structural definition with good 3D and often extensive seismic processing. The improved visibility of these seismic markers, defines more and more drillable structures.

4. Permian Zechstein Plays – Mature or underexplored?

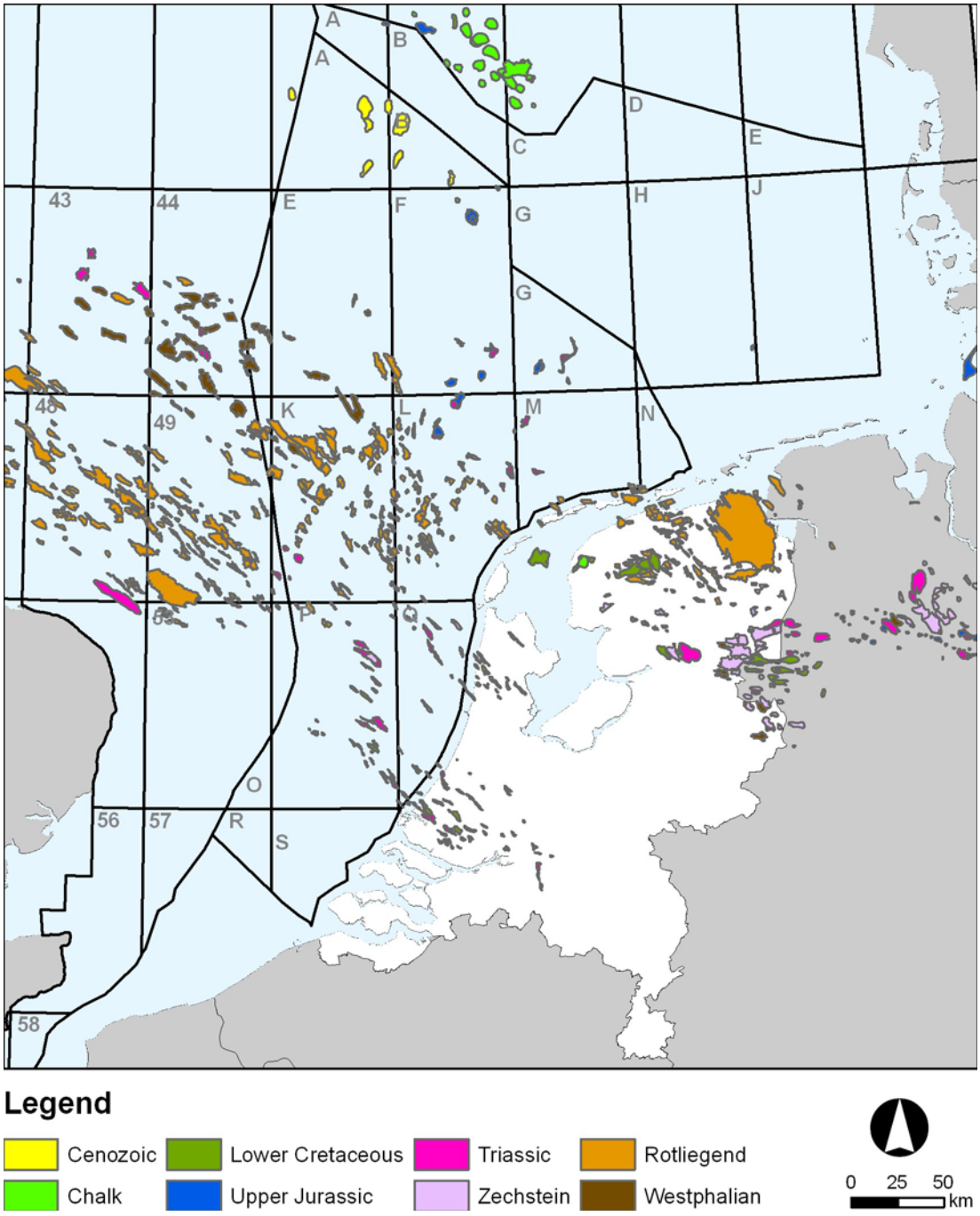
In 1948 the first Dutch successful Zechstein well Coevorden-1 is drilled to the Zechstein –2. The main play area is still concentrated there in SE Drenthe. It has resulted in mostly sour gas fields. The main Zechstein uncertainty is the reservoir quality, especially the carbonate porosity and the permeability. The wealth of geological and geochemical data which has been collected in the Zechstein fields has led to detailed depositional and diagenetic models for the Zechstein-2 carbonates. Interpretation of the extensive 3D seismic coverage as well as results of detailed fracture studies have added to the knowledge.

5. Triassic plays – Alive and kicking

Triassic reservoirs that contain significant gas fields are the mid Triassic Bunter sands. These fluviatile desert sands display good reservoir quality but locally the reservoir can be impaired. A major risk is salt plugging. Mostly the reservoirs are filled by the same Carboniferous gas as is found in the Rotliegend but the charging can be complex because of sealing of the underlying salt Zechstein evaporites. Another risk is a seal failure.

Some special Triassic reservoirs:

- Rogenstein oolites form gas reservoir in De Wijk gas field.
- Röt sands at basin fringe in the south form major reservoirs (Waalwijk gas field).
- Solling sands in rim synclines (Fatsand) close to salt domes.



Map of the Netherlands illustrating the gas and oil fields in the country, onshore and offshore and fields in the adjacent areas in the UK, Germany and Denmark (colors indicate producing reservoirs).

6. Upper Triassic and Lower Jurassic – More than source rock?

The most wide spread oil source rock, the Posidonia shale is present in the shales of Lower Jurassic age. Reservoirs of minor importance have been described in the upper Triassic (i.e. Muschelkalk) but are not seen as attractive.

7. Upper Jurassic plays – Do we know enough?

The Upper Jurassic age reservoirs have found oil and gas in a number of fields in the Dutch Central Graben. There have been a few new studies performed on these sometimes complex plays.

The new ideas have not been translated in increased drilling.

8. Lower Cretaceous plays – Out of favour?

Sands of lower Cretaceous age have yielded many oil and gas fields in the north, east and the southwestern part of the country. The geography of the Vlieland sands is not fully understood. It is likely there is undrilled potential not recognized on older seismic.

9. Chalk plays – Is drilling of all structures enough?

Compared to Denmark the Upper Cretaceous Chalk in the Netherlands has yielded hardly results that have led to development of fields. One gas and one oil field has been discovered.
Chalk is present over large parts of the country and has good well control. Most wells drilled into valid Chalk structure are dry. Seal collapse and lack of charge are major risks.

10. Cenozoic plays – Lots of gas. More than a drilling risk?

Shallow gas in sands of Tertiary age can often be seen on seismic as amplitude anomaly. However the Tertiary section has not been a popular exploration target for oil companies. Also research of non-commercial institutes is limited (Wong *et al*. 2007)
Shallow (biogenic) gas can be expected in the various sands of the Tertiary. In the IJsselmonde structure small amounts of gas have been tested from the Eocene age Dongen sands (Wong *et al*. 2007). In other areas is production is reported from the Dongen tuffite (De Wijk). Subsidence complications make production onshore of such reservoirs undesirable.
In the northern offshore the first production from shallow reservoirs, belonging to the Late Tertiary Eridanos delta, started in 2007. Salt domes combined with the shallow marine deltaic sands create gas accumulations. These accumulations show up as DHI's, phase reversals and seismic pull-downs. The Pliocene-Pleistocene marine shelf sands can be viable exploration target as soon more certainty is obtained about the production potential. Production problems are expected because of the unconsolidated nature of the sands

Discussion and conclusions

The last few years, exploration drilling in the Netherlands has been focused on Permian Rotliegend and Triassic Bunter. Other plays were unsuccessful or not attractive. This overview shows that there are many more prospective horizons which warrant a closer look before exploration will halt because of aging of infrastructure in the foreseeable future.

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