



Upper Jurassic shallow marine sandstones in the northern offshore

Dutch Exploration Day 2017
23 november 2017

ebn

Summary

- Two potential new reservoirs identified in northern Dutch offshore.
- Lead identified on new 3D seismics: F08-Ventoux.
- More information on the posters on display today.

Reservoir potential of the Upper Jurassic

Upper Jurassic shallow marine sandstones in the northern Dutch offshore

- Three fields with Upper Jurassic shallow marine sandstone reservoirs, 30 km from Dutch border: F16G, F6B10 (UK), A6-A (DE) (Fig. 1).
- Kimmeridgian to Volgian (Late Jurassic) shallow marine sandstones that form the reservoir of the UK Fife field are underexplored in the Netherlands.
- Fife-equivalent sandstones are likely to be present along the edges of the Central Graben. In the Netherlands these are part of the Noordvaarder Member.
- Sandstones from this interval with favourable reservoir characteristics have been encountered in at least two Dutch wells (figs. 1-4).
- A petrophysical analysis of the interval in Dutch well B13-02 shows a N/G of 0.93 and an average porosity of 21% (Fig. 3).
- Core plug measurements show permeabilities of up to 150 mD (Fig. 4).

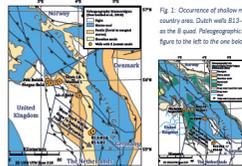


Fig. 1. Occurrence of shallow marine Kimmeridgian-Volgian sandstone reservoirs in the five country area. Dutch wells B13-02 and B14-02 show that these sands are present as far east as the Fife level. Petrographic reconstructions of their reservoirs very significantly compare the figure to the left to the one below.

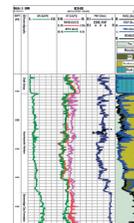


Fig. 3. Petrophysical analysis of the Noordvaarder Member interval in NL well B13-02.

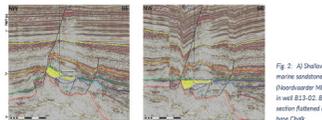
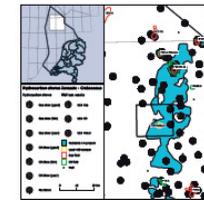


Fig. 2. A) Shallow marine sandstones (Noordvaarder Member) in well B13-02. B) section flattened at base Chalk.

Fig. 4. Core plug measurements from the Noordvaarder Member in NL well B13-02.

The Late Jurassic in the Central Graben

Further prospectivity in a proven play



The Late Jurassic play: 11 Late Jurassic oil & gas fields in the Dutch Central Graben, including the 125 MMbbl STOIP & 21 bcm GIIP F03-FB field.

- Reservoir sands in F03-FB consist of regionally deposited sandstones in a fluvio-deltaic (Lower Graben Fm) to shallow marine (Upper Graben Fm) environment.
- Faults in F03-FB seal for sand/shale juxtaposition and are non-sealing for sand/sand juxtaposition.

The Middle Graben shales are sealing for oil, but not for gas. The Kimmeridge Clay is an excellent regional seal.

- Oil and gas sourced from the Lower Jurassic Poldervaart Fm. Multiple other stratigraphic intervals have source rock potential as well.
- Oil migration started in the latest Jurassic and gas charge occurred in the Tertiary.

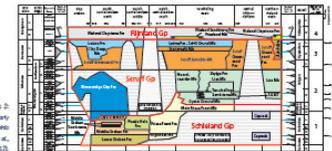


Fig. 2. Postulated Middle Jurassic-Early Cretaceous stratigraphic framework (Kamsteeg et al., 2012).

Lead: F08-Ventoux

- Block F08 has only recently been covered by 3D seismic (DEF seismic survey).
- Multiple Late Jurassic targets that can be tested with one exploration well.
- Fault/dip closure formed during the Latest/Early K; Up-dip well F08-02 has oil & gas shows in the Lower Graben Fm and Middle Jurassic sands. Shallow seismic anomalies visible.

Block	STOIIP (mm3)	GIIP (bcm)	Other oil
Block F08	125	21	None
Upper Graben Fm	100	200	Deep
Middle Jurassic	100	200	Deep
Shallow	100	200	Deep

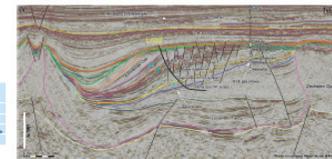


Fig. 3. Dip line through the lead showing complex faulting is both related to deeper extension faulting. Unlikely: Pinch-out and truncation (leading possibly to the west of lead).

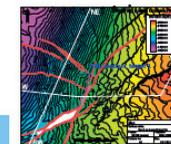


Fig. 4. Lower Graben Fm (fluvio-deltaic).

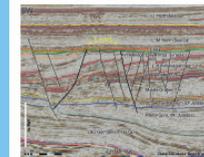


Fig. 5. Upper Graben Fm, grading up-dip into delta plain sediments of the Lower Graben Fm.

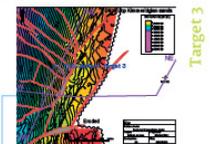


Fig. 6. Kimmeridgian sandstones: increased seismic amplitudes below the reflection could be an indicator of the presence of sand during a regression period (Fig. 8).

- To de-risk the lead it is recommended to:
 - PSDM re-process the seismic to improve the imaging of the complex faulting, increase resolution and to reduce the multiples at the J-K boundary
 - Investigate DHI's and AVO behaviour of the reservoir intervals
 - Further investigate timing/movement of faulting and fault juxtaposition

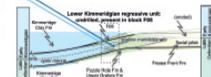
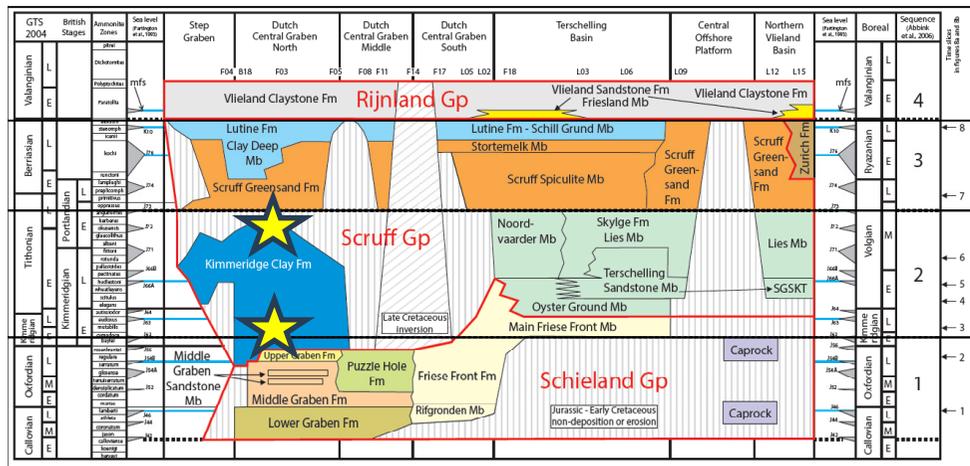


Fig. 8. Correlation (shallow) interval of Lower Kimmeridgian sands: the stratigraphic interval has not been affected in the area, but the seismic signature suggests this is a regressive unit that may well contain sands.

Fig. 7. 2014-NE Line through lead F08-Ventoux.

Jurassic stratigraphy

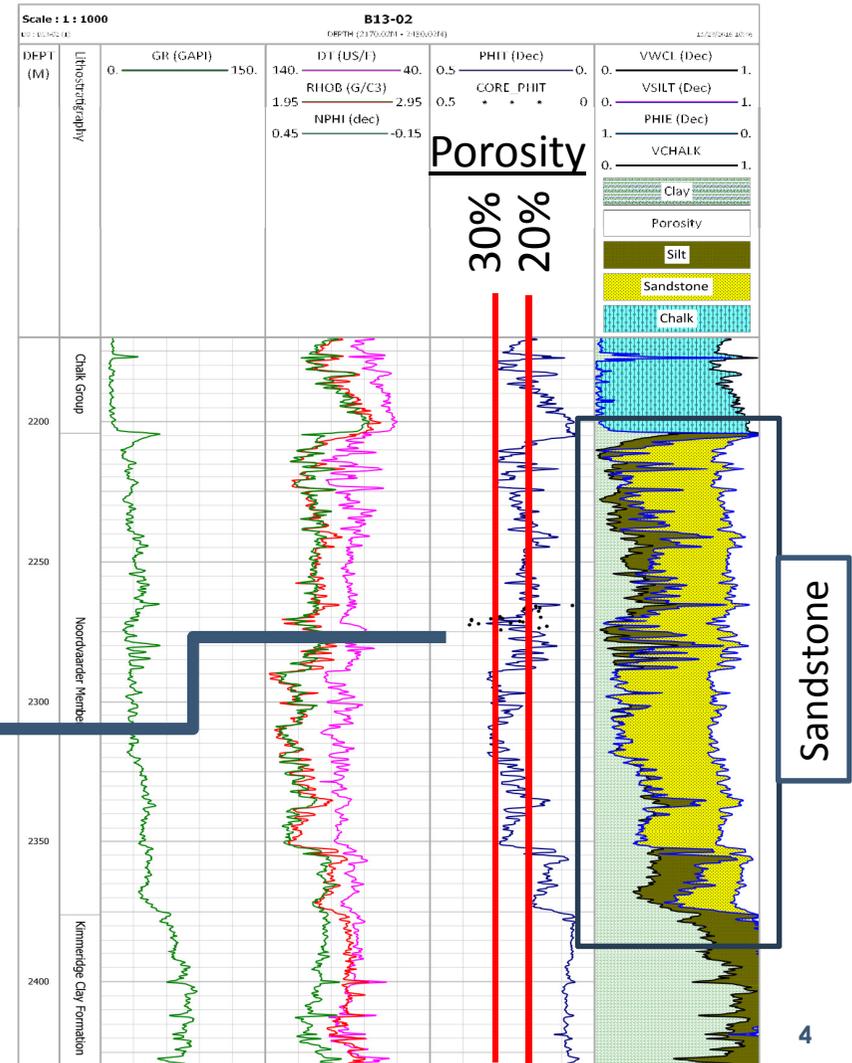
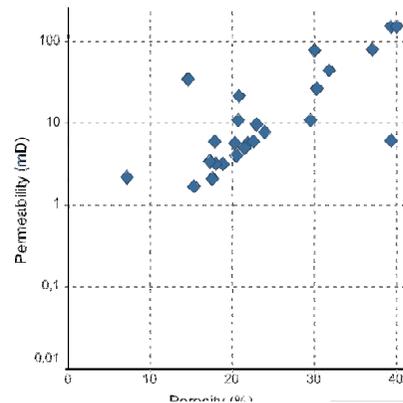


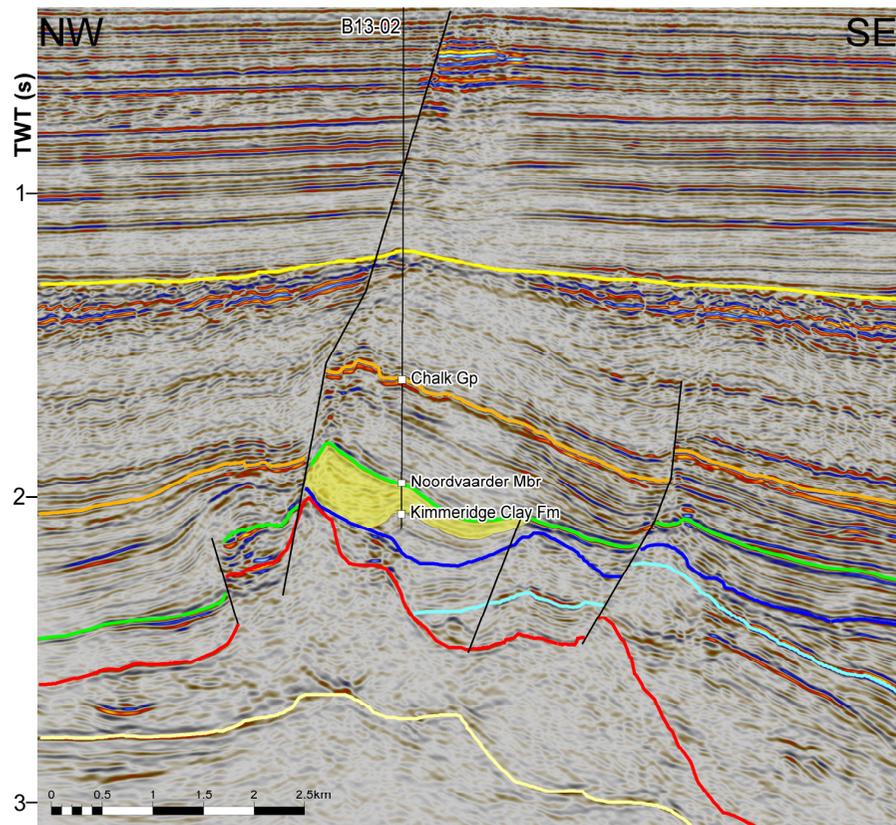
Munsterman et al. (2012)

- Is rather complex...
- ... but not just of academic interest.
- Where to expect reservoirs?
- Focus on two stratigraphic intervals with reservoir potential.

B13-02: high N/G sands

- Net-to-gross: 0.93 (160 m net).
- Average porosity: 21%
- Permeabilities up to 150 mD.
- Well logs show even cleaner sands outside cored interval.



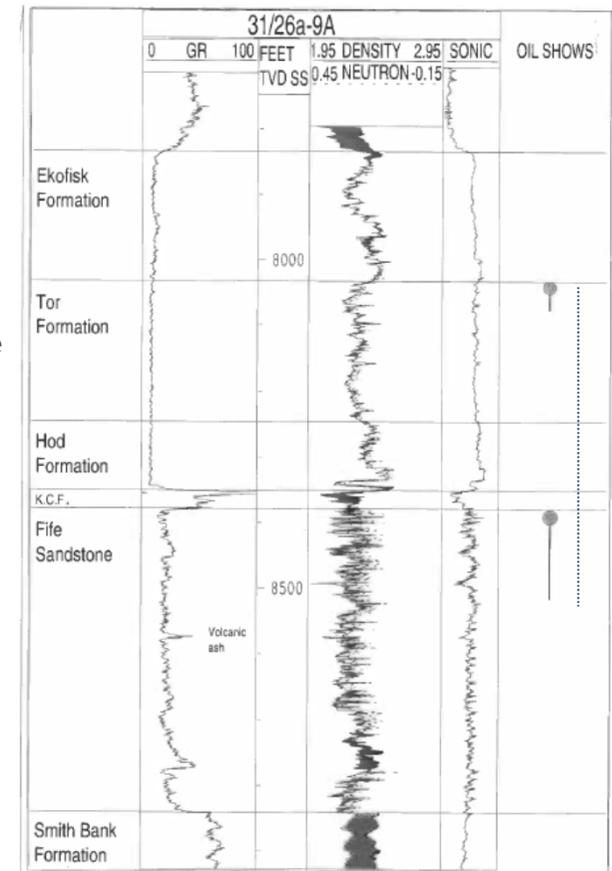
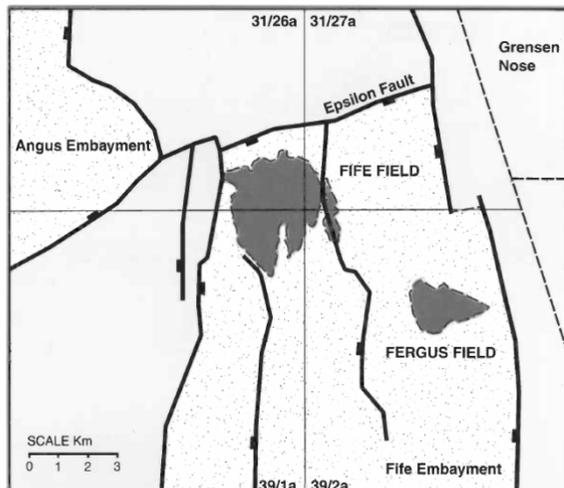


B13-02

- Drilled down-dip. No hydrocarbon shows in Jurassic.
- Likely cause of failure: lack of top and cross-fault seal, although up-dip potential can not be ruled out.
- Note: undrilled bright spot in Neogene!
- Questions:
 - Similar sands in traps?
 - How does this fit in the regional context?

Fife Field (UK)

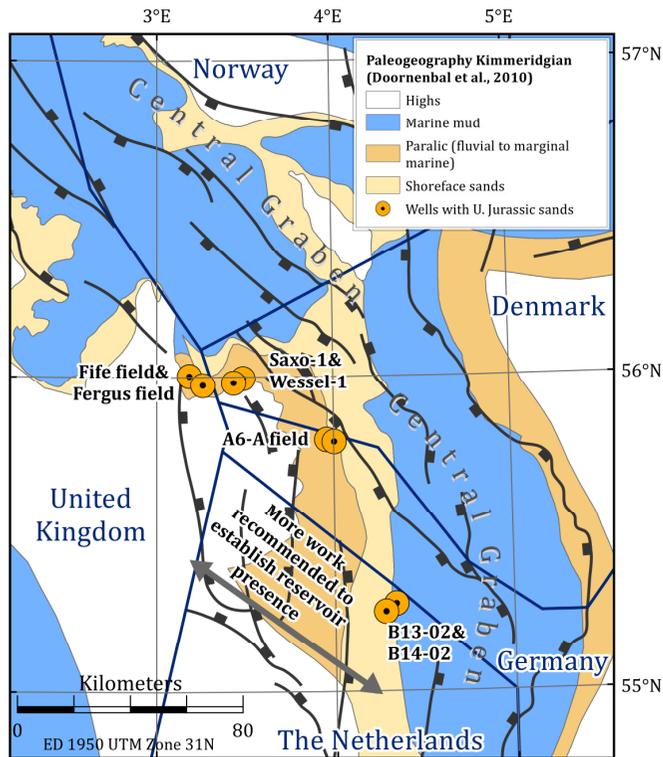
- Fife and Fergus field (132 MMBBL and 16.3 MMBBL STOIP).
- Fife sandstone: shallow marine shelf sst of Kimmeridgian-Volgian age (~Seq 2-3). Similar to B13-02 sandstones.
- Reservoir deposited locally, in the Fife embayment.
- Structure: 4-way dip, formed during inversion.



Source: The Fife and Fergus fields – Shephard 2003

The regional picture

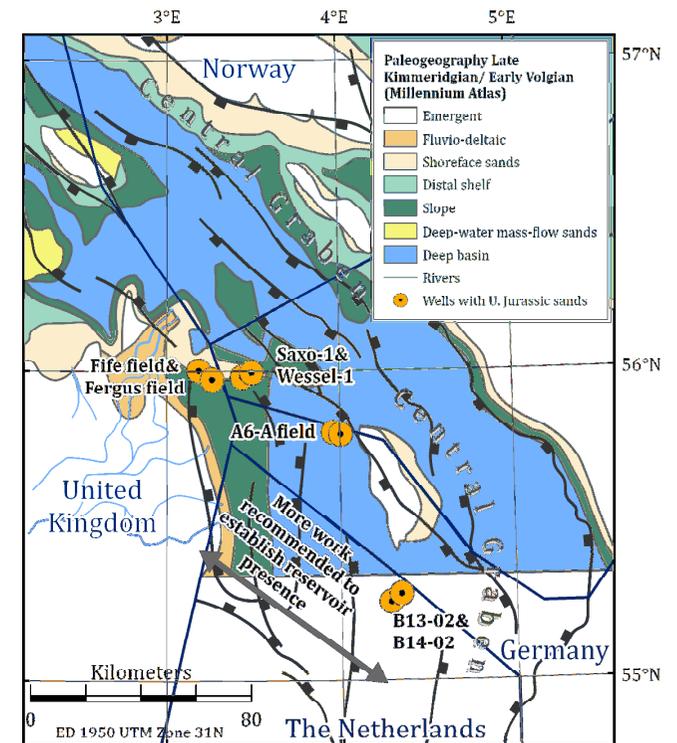
Southern Permian Basin Atlas



- B13/B14 sandstones equivalent to Fife field reservoir, “Outer Rough Sands” in Danish wells.
- Two maps, roughly the same time interval.
- Position of coast line varies.
- Which one is true?
- **Maybe both.**

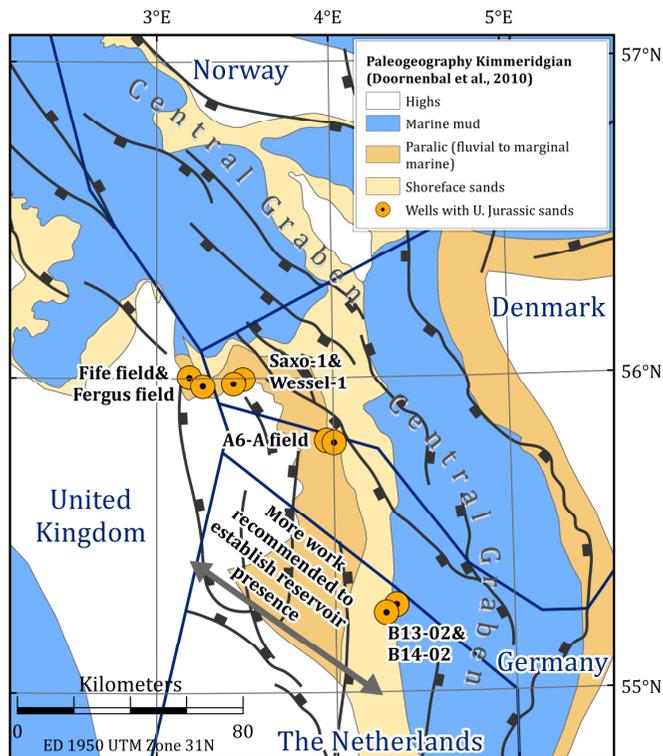


Millennium Atlas



The regional picture

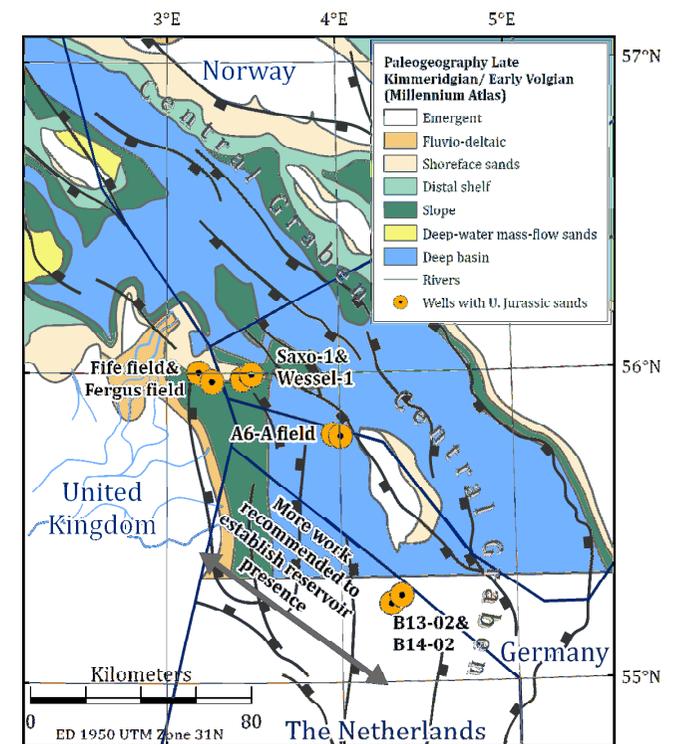
Southern Permian Basin Atlas:
Lowstand?



- Multiple relative sea level fluctuations expected.
- Lowstand situation would look like SPBA, highstand like Mil. Atlas.
- Lowstand/transgression: sandstones.
- Highstand: shales.
- **Potential for stratigraphic traps.**



Millennium Atlas:
Highstand?



Where to expect these reservoirs?

- In minor lows (embayments) on platforms adjacent to the Central Graben.
For instance: parts of the Step Graben.

What type of traps?

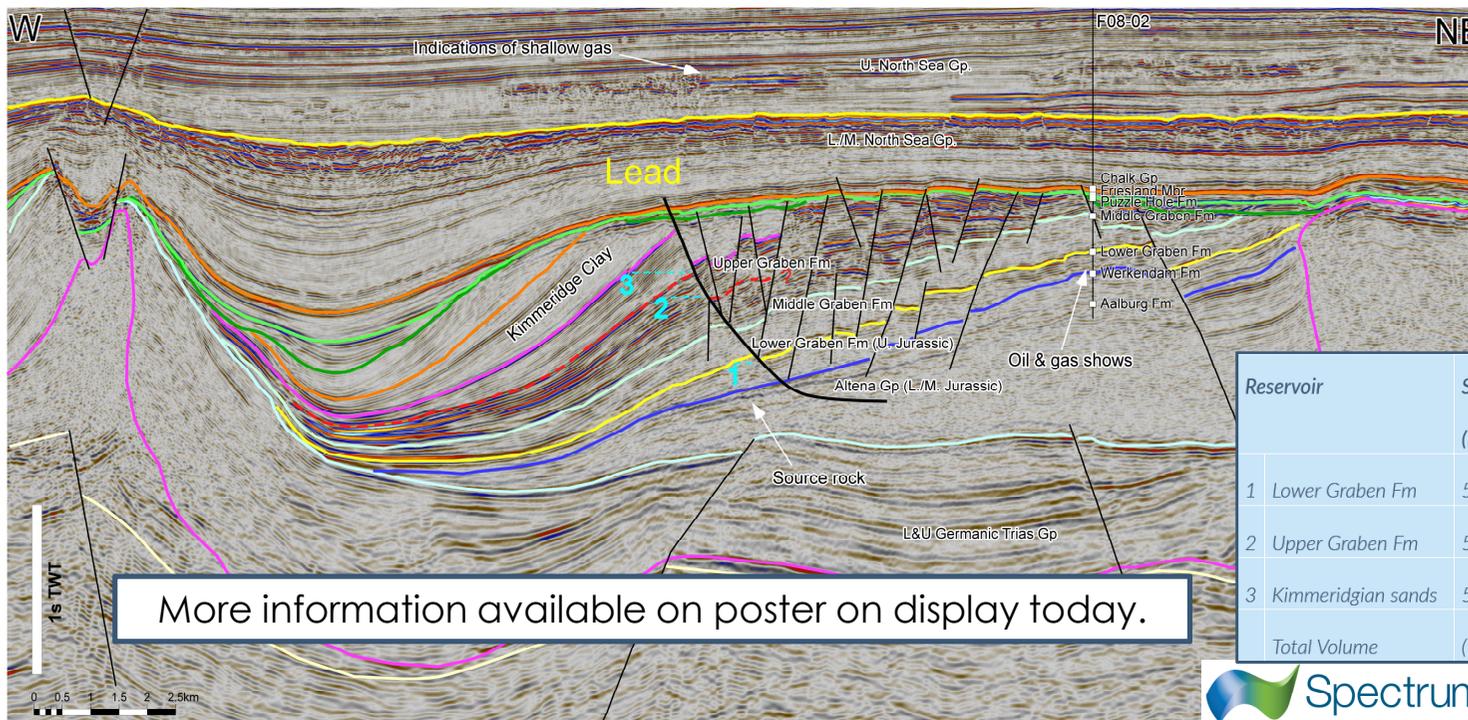
- Both structural and stratigraphic traps are to be expected.

And the source rock?

- See the poster on source rock potential and hydrocarbon shows.

Jurassic Lead: F08-Ventoux

- Block F08 only recently covered by 3D Seismics
- Lead with multiple Jurassic targets, can be tested with one well.



Reservoir	STOIIP range (MMbbl)	Geol. POS	Critical risk
1 Lower Graben Fm	5-15	35%	Trap
2 Upper Graben Fm	5-20	28%	Charge
3 Kimmeridgian sands	5-30	21%	Charge & Reservoir
Total Volume	(15-65)		

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- Kimmeridgian to Volgian (Late Jurassic) shallow marine sandstones that form the reservoir of the UK Fife field are underexplored in the Netherlands.
- Fine-equivalent sandstones are likely to be present along the edges of the Central Graben. In the Netherlands these are part of the Noordvaarder Member.
- Sandstones from this interval with favourable reservoir characteristics have been encountered in at least two Dutch wells (figs. 1-4).
- A petrophysical analysis of the interval in Dutch well B13-02 shows a N/G of 0.93 and an average porosity of 21% (Fig. 3).
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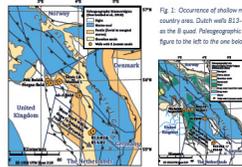


Fig. 1. Occurrence of shallow marine Kimmeridgian-Volgian sandstone reservoirs in the five quality areas. Dutch wells B13-02 and B14-02 show that these sands are present as far east as the E land. Petrographic reconstructions of their extent vary significantly, compare the figure to the left to the one below.

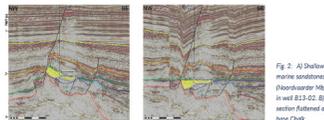


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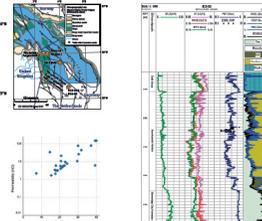
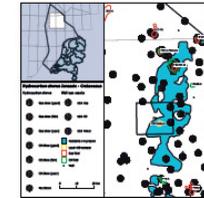


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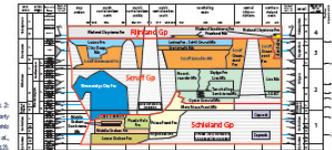


Fig. 5. Poldervaart Middle Jurassic (early) Continuous stratigraphic correlation (Kamsteeg et al., 2012)

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- Fault-dip closure formed during the Latest J/Early K; Up-dip well F08-02 has oil & gas shows in the Lower Graben Fm and Middle Jurassic sands. Shallow seismic anomalies visible.

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3	100	200	Shale
4	100	200	Shale
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8	100	200	Shale
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11	100	200	Shale
12	100	200	Shale
13	100	200	Shale
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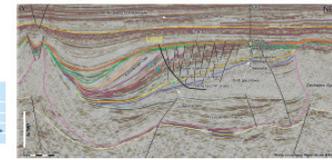


Fig. 3. Dip line through the lead showing complex faulting is both-basal to deeper extension faulting. Unstable Pitch-out and truncation resulting possible to the west of lead.

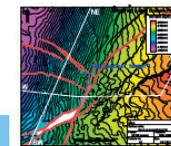


Fig. 4. Lower Graben Fm (Fluvio-deltaic).

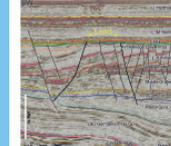


Fig. 5. Upper Graben Fm, gridding up-dip into delta plain sediments of the Noordvaarder Fm.

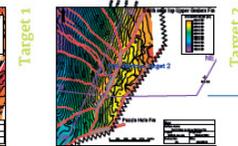


Fig. 6. Kimmeridgian sandstones, increased seismic amplitudes below the reflection indicate the presence of sand during a regional period (Fig. 6).

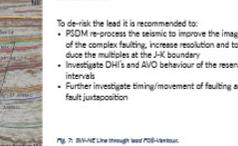


Fig. 7. 2014-NE Line through lead F08-Ventoux.

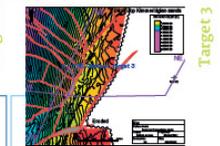


Fig. 8. Lower Kimmeridgian reservoir unit, possible present in block F08.

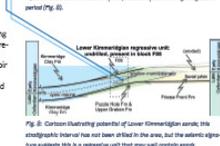


Fig. 9. Current faulting orientation of Lower Kimmeridgian sands, the stratigraphic interval has not been affected in the area, but the seismic signature suggests this is a reservoir unit that may well contain gas.

- To de-risk the lead it is recommended to:
 - PSDM re-process the seismic to improve the imaging of the complex faulting, increase resolution and to reduce the multiples at the J-K boundary
 - Investigate DHIs and AVO behaviour of the reservoir intervals
 - Further investigate timing/movement of faulting and fault juxtaposition

For questions contact exploration@ebn.nl

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