

DISPLAY B4

Production from Muschelkalk carbonates (Triassic, NE Netherlands) – Unique play or overlooked opportunity?

Michael Pöppelreiter (Shell, U.S.A) & Ravi Borkhataria & Thomas Aigner (University of Tübingen, Germany) & Koos Pipping (NAM, The Netherlands)

The Triassic Muschelkalk carbonates are a unique play in NW Europe producing hydrocarbons onshore the Netherlands. This paper aims at comprehensively describing these relatively unknown reservoirs and speculating on additional play potential outside of the current production areas.

The Muschelkalk formation consists of partially porous Lower and Upper Muschelkalk carbonates separated by tight Middle Muschelkalk evaporites. The 100 meter thick Lower Muschelkalk holds 1.9 bcm gas in the De Wijk field. The reservoir is a limestone-dolomite-marl succession producing from several decimetres thick calcisilicic dolo-mudstones encased in tight lime-mudstones. The reservoir shows a layer-cake-type architecture composed of sixteen cycles with thin, but laterally continuous porous units. Good reservoir facies is concentrated in the upper third of these cycles. Porosities vary from 6 to 27 %, (average of 12 %) and permeabilities range from 0.01 to 32 mD (average 0.06 mD). The reservoir rocks represent inner ramp sediments of a storm-dominated epeiric ramp. The 50 metres thick Upper Muschelkalk contains 0.8 bcm gas in the Coevorden Muschelkalk field. The reservoir consists of decimeters thick peloidal-oolitic dolo-grain- to packstones of good permeability interbedded with lower permeable dolo-mudstones to wackestones. Porosity varies from 5 to 29 % (average 15 %) and permeability ranges from 0.01 to 57 mD (av. 1 mD). The permeable dolo-grainstones occur chiefly around peak transgression and early regression of the Upper Muschelkalk. The producing Upper Muschelkalk deposits represent the inner ramp section of a storm-dominated homoclinal ramp.

Numerous gas shows in the Lower and Upper Muschelkalk, scattered over the onshore territory of the Netherlands, suggest missed-pay and possible upside potential. The highest reservoir potential occurs in grainy dolomitic inner ramp deposits. In Holland these are likely located close to the existing fields. Additional, currently unrecognized potential could be present in Southern Germany and Eastern Poland.

Plate A

Well: Netherlands Coevorden-46 Interval: 1378.75 m - 1381 m

Upper Muschelkalk description:

Core slabs shows all 5 lithofacies composing the Upper Muschelkalk arranged in one continuous depositional cycle:

- Peloidal-ooolitic packstones to grainstones (Facies 1),
- Bioturbated mudstones to wackestones (Facies 2)
- Intraclast packstones to grainstones (Facies 3)
- Scoured argillaceous mudstones to wackestones (Facies 4)
- Heterolithic mudstones to wackestones (Facies 5)

Facies description:

Facies 1: Peloidal-ooolitic packstones to grainstones.

Consists of amalgamated storm beds with angular intraclasts, low-angle lamination and oscillation ripples covered by bioturbated mudstones. Facies 1 shows the best reservoir quality with permeabilities up to 57 mD. The facies is interpreted as shoal/backshoal deposits.

Facies 2: Bioturbated mudstones to wackestones.

Consists of intensely bioturbated wackestones with Rhizocorallium burrow testifying open marine conditions in these deposits. The facies is interpreted as open lagoon deposits.

Facies 3: Intraclast packstones to grainstones.

consists of several stacked intraclastic layers, including bored intraclasts. The facies is interpreted as amalgamated storm beds during maximum wave energy in an interval of low net sediment accumulation.

Facies 4: Scoured argillaceous mudstones to wackestones.

Consists of scoured thin graded beds in places with small intraclasts interbedded with muddy beds and irregular, crinkly lamination probably related to algal lamination. The facies is interpreted as lagoonal to mudflat deposits.

Facies 5: Heterolithic mudstones to wackestones:

Consists of thinly interbedded scoured and crinkly laminated layers with desiccation cracks filled with early anhydrite. The facies is interpreted as sabkha deposits.

Plate B

Well: Netherlands Wijk-5B Interval: 1409.74 m - 1417.49 m

Lower Muschelkalk - Description:

Core slabs shows all 6 lithofacies composing the Lower Muschelkalk arranged in one continuous depositional cycle:

- Bioturbated lime-mudstones (Facies 1)
- Graded lime-mudstones (Facies 2)
- Bioclastic lime-packstones – to grainstones (Facies 3)
- Graded dolo-mudstones (Facies 4)
- Algal-laminated mudstones (Facies 5)
- Coloured marls and shales (Facies 6)

Facies description:

Facies 1: Bioturbated lime-mudstones:

composed of dark bioturbated lime-mudstones with a few preserved graded laminae. Facies is interpreted as low energy inner-ramp deposits.

Facies 2: Graded lime-mudstones.

composed of millimeter thick graded beds composed chiefly of peloids. These beds show a sharp erosive base, sometimes covered by intraclasts, low angle-lamination in places followed by oscillation ripples. The facies is interpreted as micro-tempestites deposited on the inner ramp.

Facies 3: Bioclastic lime-pack – to grainstones.

Composed of shells from only a few brachiopod and bivalve species and occurs stratigraphically confined to maximum transgression in the Lower Muschelkalk. Together with intraclast packstones to grainstones this facies forms tempestite sheets. Facies is interpreted as high-energy inner ramp deposits.

Facies 4: Graded dolo-mudstones.

Similar to facies 3 but composed of dolomite, finer grained and intercalated with algal-laminated facies. Facies is composed of millimeter thick graded beds made up of peloids. Graded beds show sharp erosive base, sometimes covered by intraclasts, low angle-lamination and oscillation ripples. Facies is finer-grained than

The facies is interpreted as distal micro-tempestites deposited on the proximal inner ramp.

Facies 5: Algal-laminated mudstones.

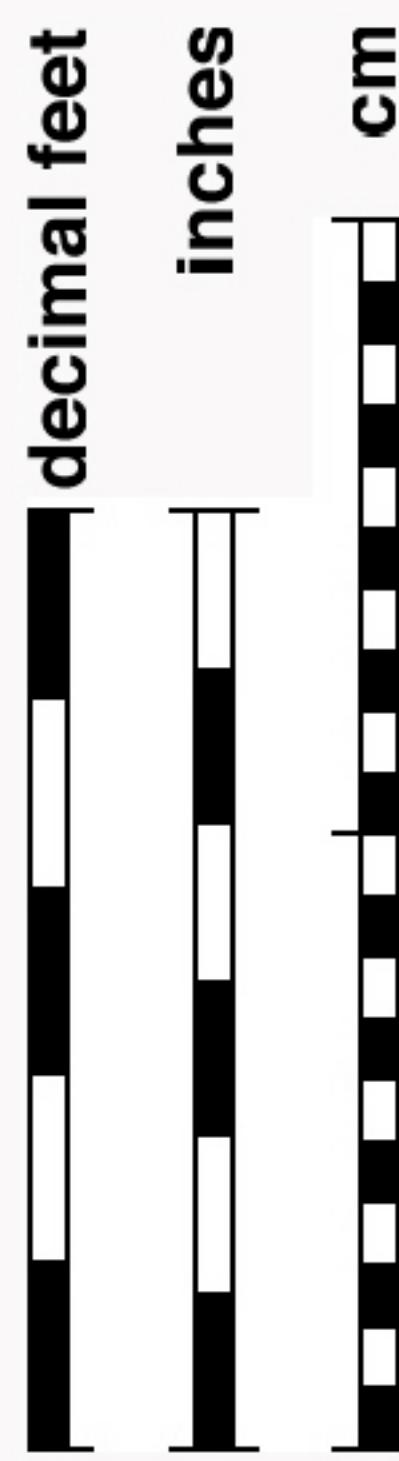
Comprised of thinly interbedded storm-generated scour surfaces and algal-generated crinkly laminated layers with mudcracks. Facies 5 is interpreted as sabkha deposits.

Facies 6: Coloured marls and shales.

composed of olive-green to purple coloured dolo-marls and shales. The presence of floating grains, intense mottling and grains with micro fractures and possible rhizoco-brecciation, points to pedogenic processes. The facies is interpreted as immature paleosoil.

Display B4 Plate A

Well Netherlands Coevorden-46 (COV-46)

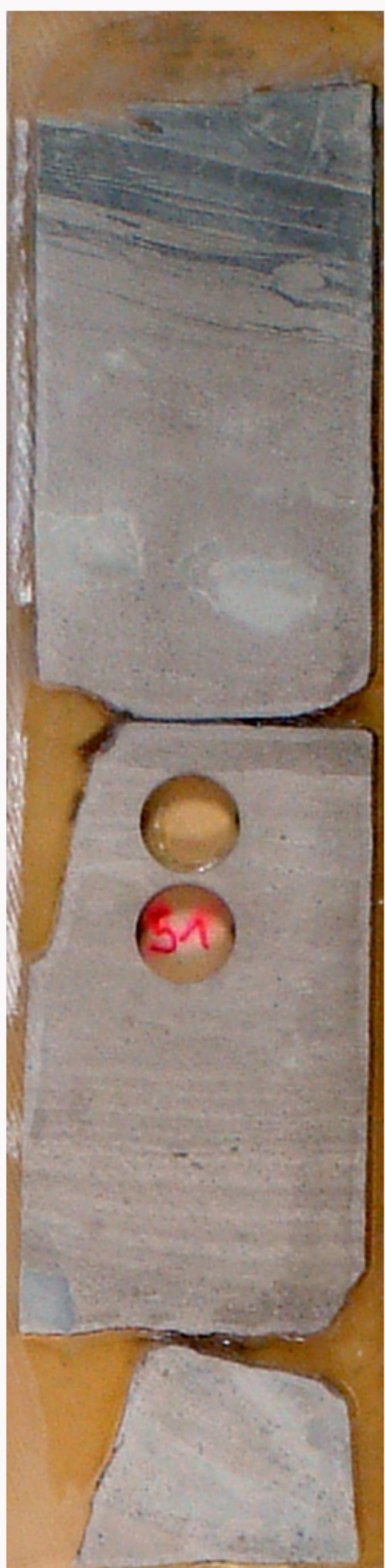


Core photography and digital processing by
Robert Leppard ([Leppard Sedimentology Ltd](#))
and
Colin Oakman ([Colin Oakman Associates](#))

1378.75 m



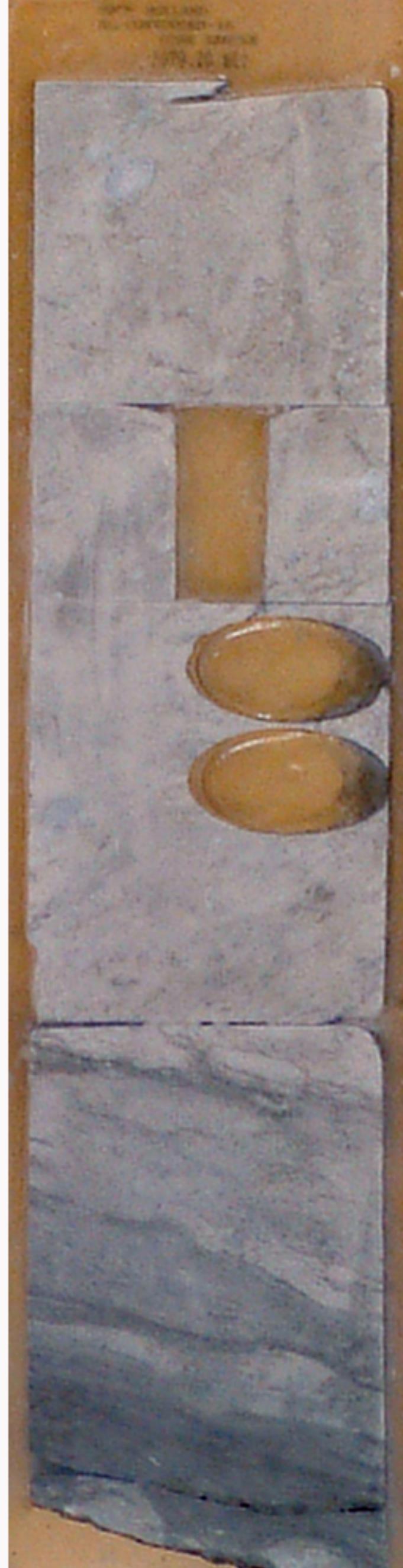
1380.10 m



1379.65 m



1379.20 m



1380.50 m



1381.00 m

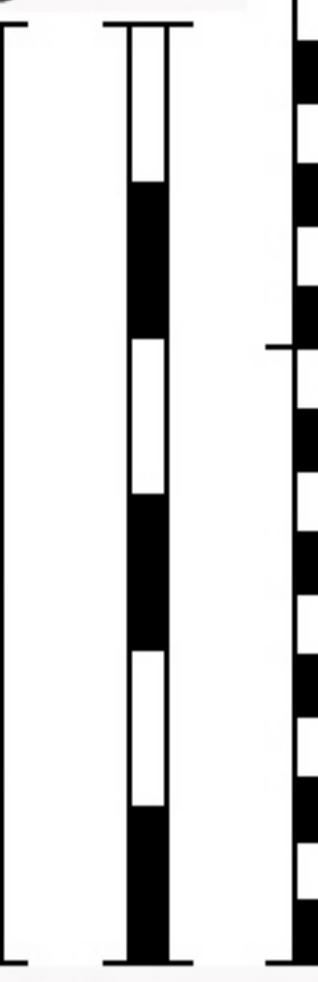
Display B4 Plate B

Well Netherlands Wijk-5B

1409.74 1410.34 1411.44 1412.26 1413.01 1413.91 1414.80 1415.70 1416.59

Depths
in
metres

decimal feet
inches



Core photography and digital processing by
Robert Leppard (Leppard Sedimentology Ltd)
and
Colin Oakman (Colin Oakman Associates)

