RESERVOIR PROPERTIES REVISITED

Results of data mining in the Dutch Oil & Gas portal www.nlog.nl |

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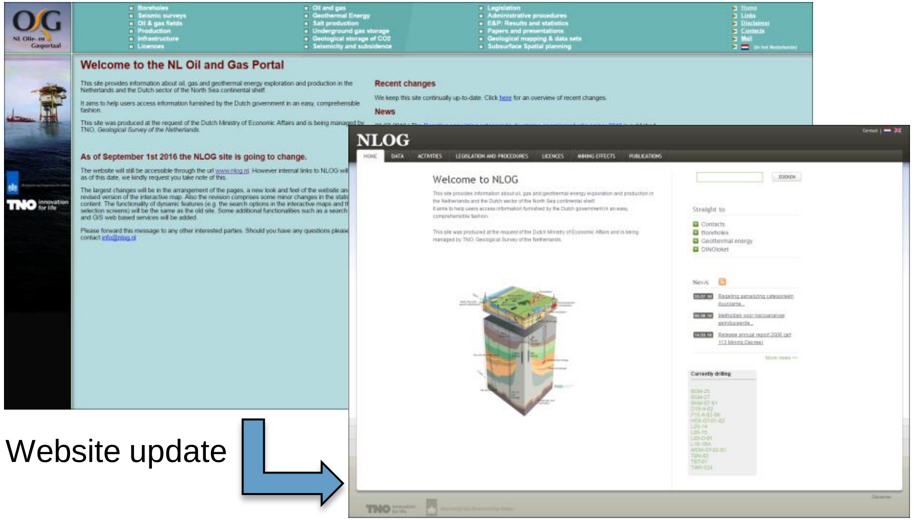
OVERVIEW

- Data mining from the Dutch Oil & Gas portal: www.nlog.nl

- Results from data mining: reservoir properties of the Lower Volpriehausen Sandstone
  - Porosity-permeability relation
  - Porosity-depth relation (2 methods):
    1. Based on well data
    2. Based on grain density
       - Method repeatability and applicability

- Conclusions

WWW.NLOG.NL → THE ULTIMATE PUBLIC DOMAIN PLAYGROUND FOR GEOLOGICAL DATA MINING



Website update

Some examples:

- > 200.000 routine core measurements.
- Litho-stratigraphic subdivision for almost all wells.
- Reservoir properties from petrophysical analyses.
- Petrographical data and reports.
- Regional reports on the Dutch geology.
- Etc…

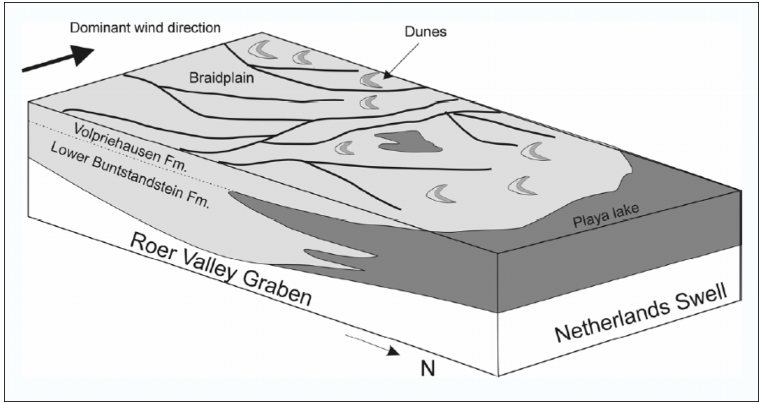
Usage:

- Gather and evaluate large data sets.
- Revealing well-known reservoir property trends on regional to sub-regional scale.

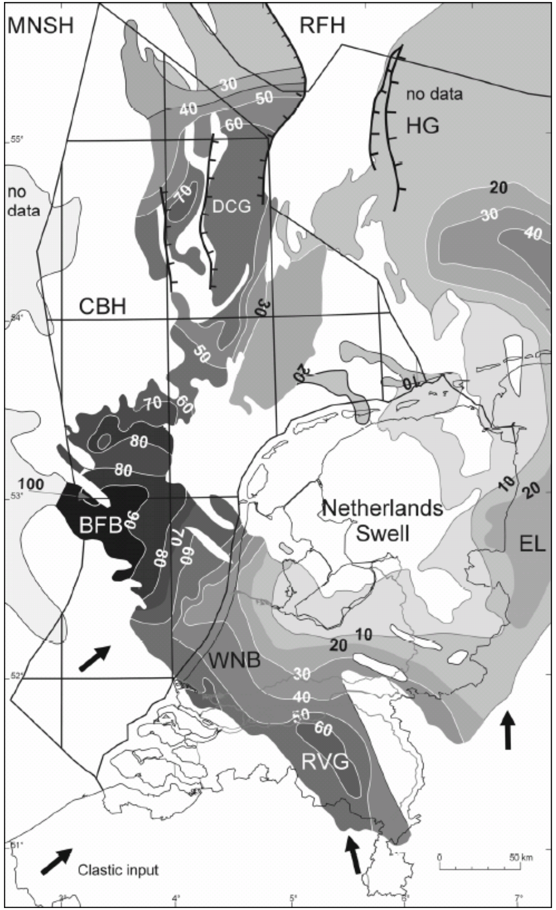
Solid reference framework for local reservoir quality analysis

EXAMPLE: LOWER VOLPRIEHAUSEN SANDSTONE (RBMVL)

- Age: Scythian (252 – 247 Ma), Early Triassic
- Oldest member of the Main Buntsandstein Subgroup
- Fine to medium grained, light-coloured arkosic sandstone.
- Often highly cemented base.
- Fluviatile sediments in the South, aeolian in the North.



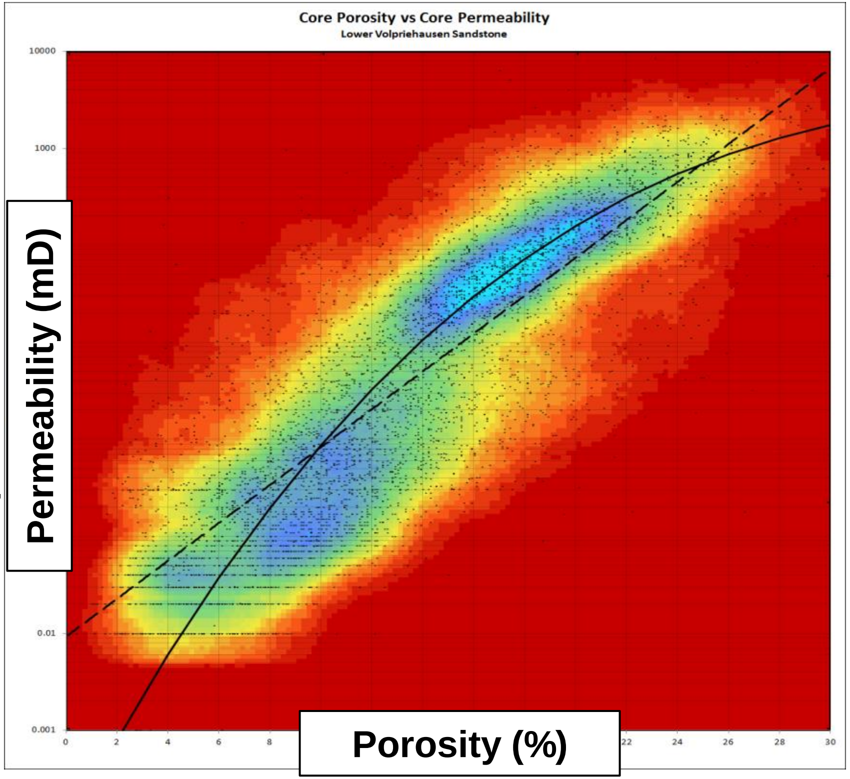
(Geluk, 2005)



POROSITY - PERMEABILITY RELATION

Lower Volpriehausen Sandstone Member

- > 5000 core plugs from 75 Dutch wells.
- Coloured background shows contoured density of data points (with Isatis).
- Note the curved nature of the data cloud.
- Often exponential poro-perm relations on log-normal plot are used. These do not honour the data adequately.
- Better to use curved or bilinear relation on log-normal plot.



POROSITY - DEPTH RELATION

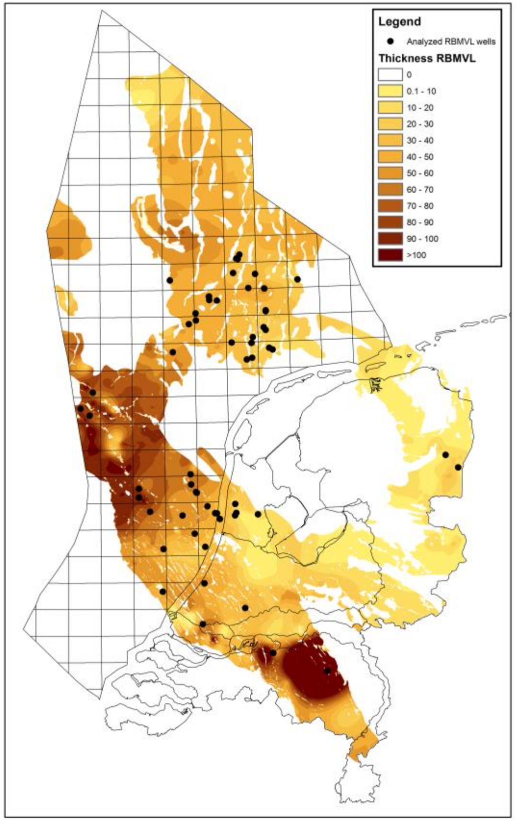
Lower Volpriehausen Sandstone Member

- Data collecting:
  - 80 wells
  - ± 7000 porosity core measurements

- Exclusion of data:
  - Wells with restricted sample selection (<10 samples)
  - Wells with restricted reservoir coverage (<25%)

- Remaining data set:
  - 59 wells
  - ± 5500 core measurements

Thickness map of the Lower Volpriehausen Sandstone Member

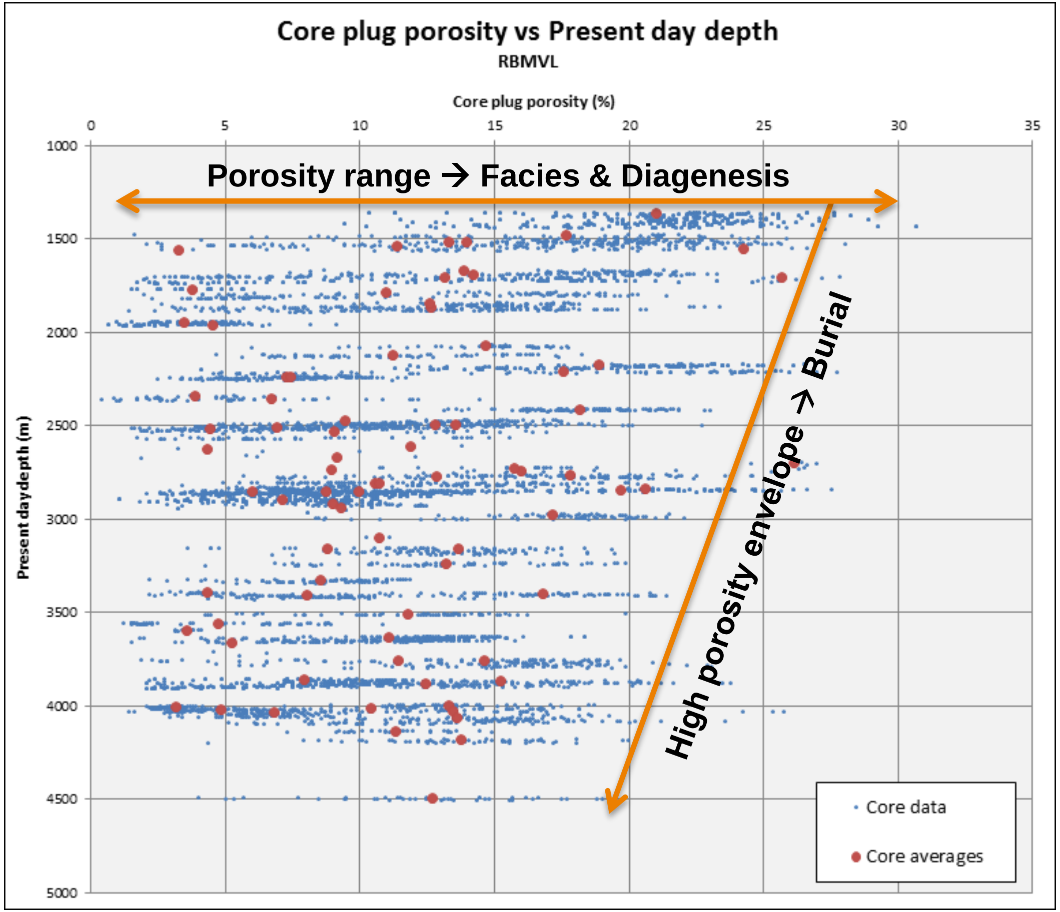


DATA FOR ANALYSIS

- Data points show high degree of scatter.
- Variation in porosity due to facies differences and diagenesis.
- High porosity envelope visible, caused by burial of sediments.

Be aware: some data from wells in inverted basins present

  - Conversion to maximum burial depth required.



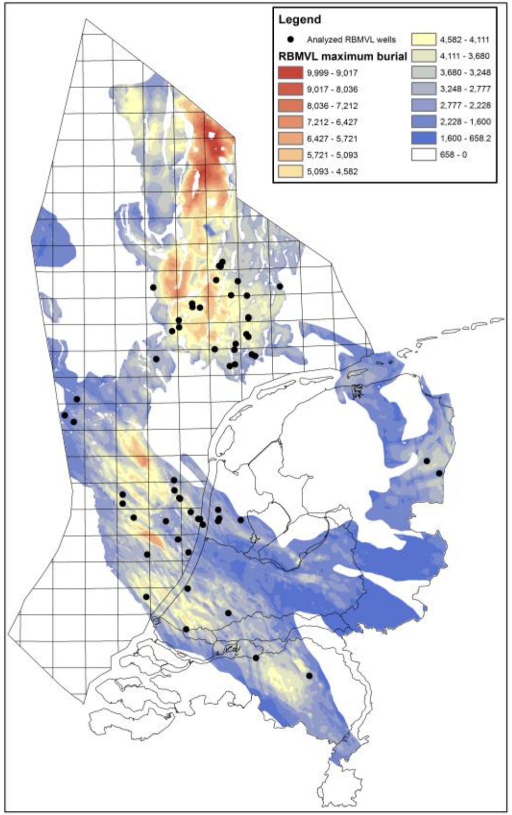
BURIAL HISTORY STUDIES

- Maximum burial depth of core measurements determined using the maximum burial map on the right:

- Maximum burial map based on results of Nelskamp & Verwey (2012):
  - Maximum burial depth of the RBMVL calculated using basin modelling.

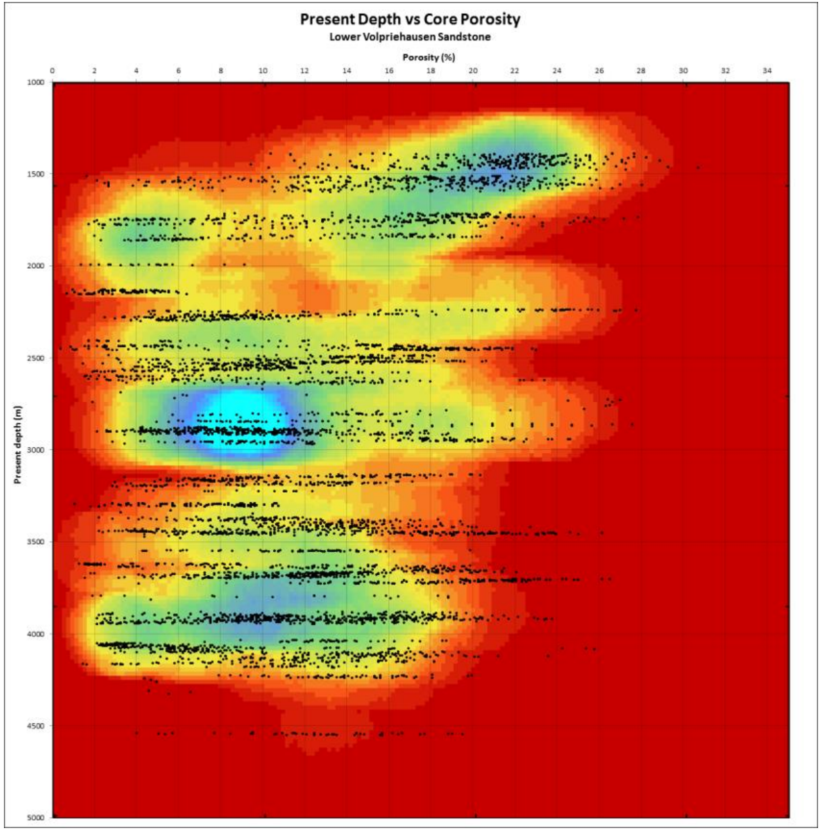
- Several studies on Dutch burial history:
  - Nelskamp & Verwey (2012)
  - Luijendijk et al. (2011)
  - Van Dalfsen et al. (2005)

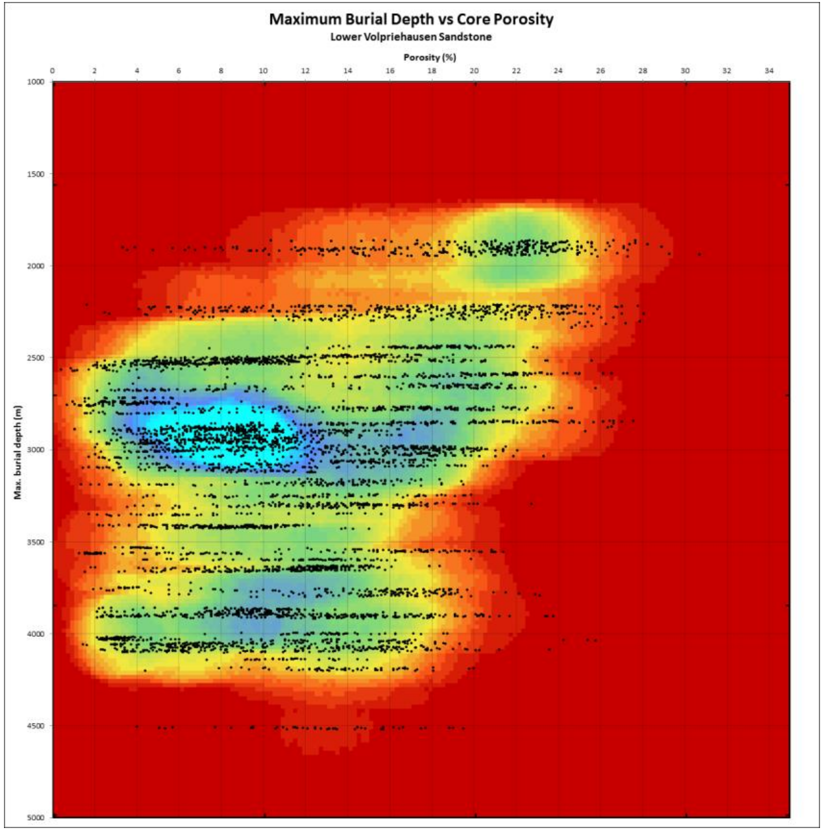
Maximum burial map of the Lower Volpriehausen Sandstone Member



PRESENT DEPTH TO MAXIMUM BURIAL DEPTH

Present day depth → Maximum burial depth





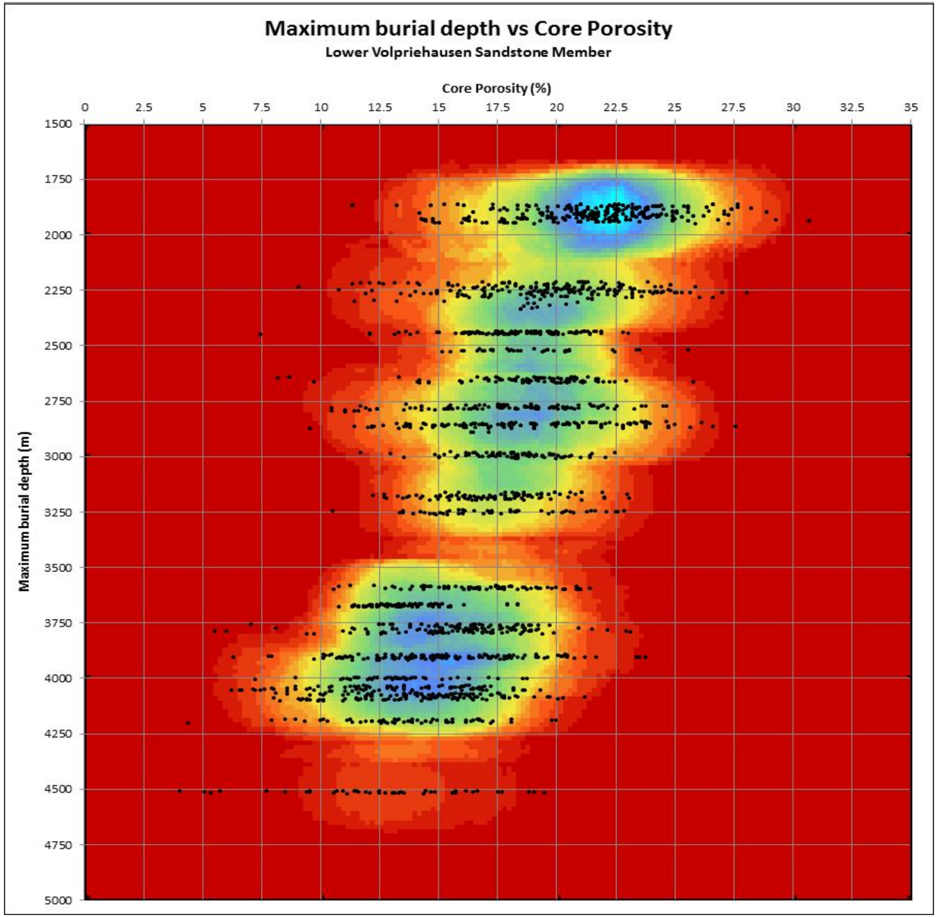
POROSITY – DEPTH RELATION

1. Based on well data

- Collecting well data:
  - Composite well logs, digital logs, core reports/descriptions, petrography/ sedimentology/petrophysics reports etc.

- Quick look petrophysical analysis:
  - Clay volume & porosity calculations

- Combine data to determine effects on porosity other than burial and assign attributes:
  - Diagenesis (mineral type)
  - Facies type (clay volume, grain size etc.)



POROSITY – DEPTH RELATION

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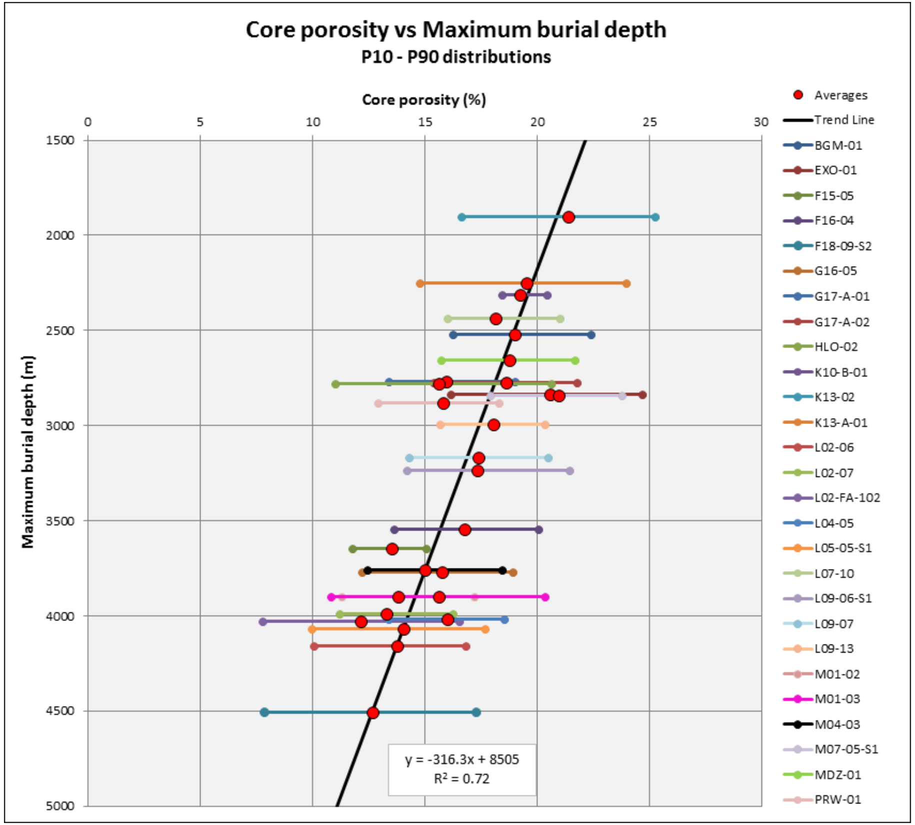
1. Based on well data

- P10 – P90 distributions, as well as average porosity of "reservoir quality" data plotted per well.
- Trend line through averages gives poro-depth relation for intervals with reservoir quality.
- Interesting how poro-depth relation develops with increasing clay volume and diagenesis.



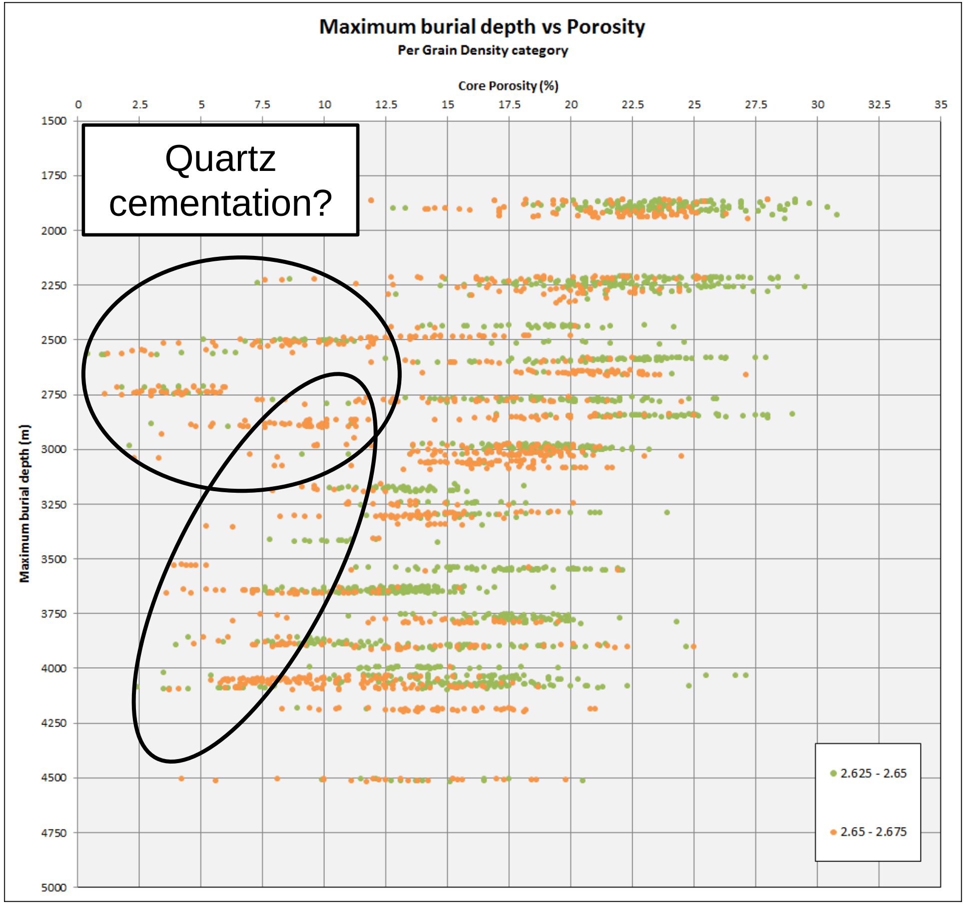
POROSITY – DEPTH RELATION

2. Based on grain density

- Grain density (GD) is a good porosity indicator:
  - Clay often has higher GD than quartz.
  - Common pore cements have high GD like:
    - Dolomite: 2.85 g/cm^3
    - Anhydrite: 2.98 g/cm^3
  - Halite has low GD

- Poro-depth trend clear in GD range: 2.625 – 2.675 g/cm^3

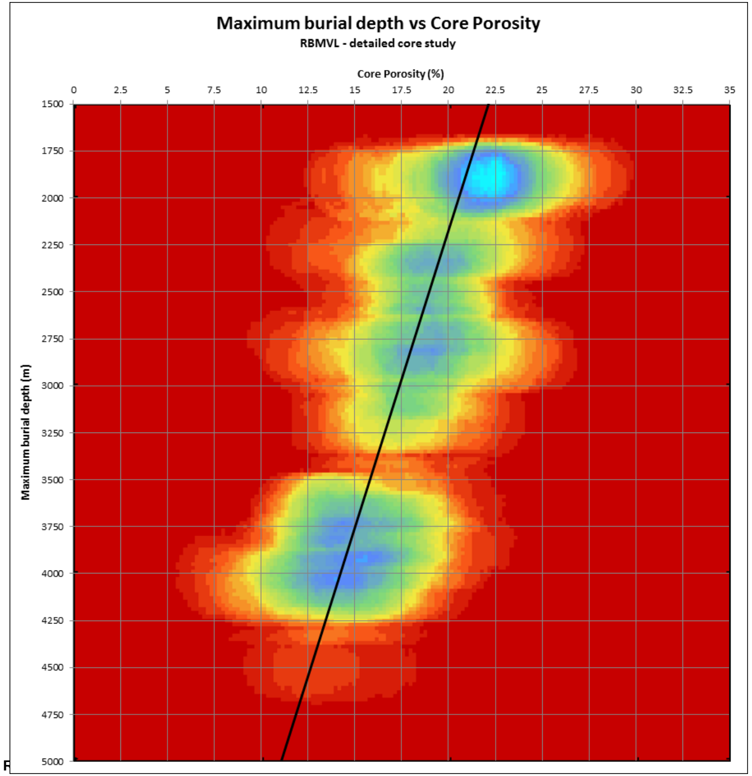
Note: quartz cement is problematic for this analysis.



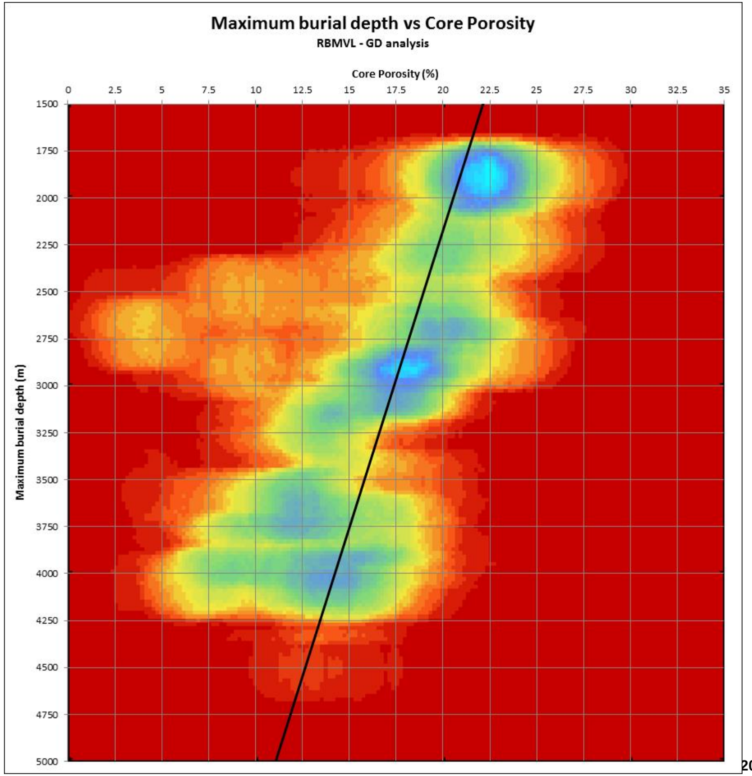
COMPARISON OF RESULTS

Similar porosity-depth trend derived from two different methods.

1. Based on well data



2. Based on grain density



POROSITY – DEPTH RELATION PER GD CLASS

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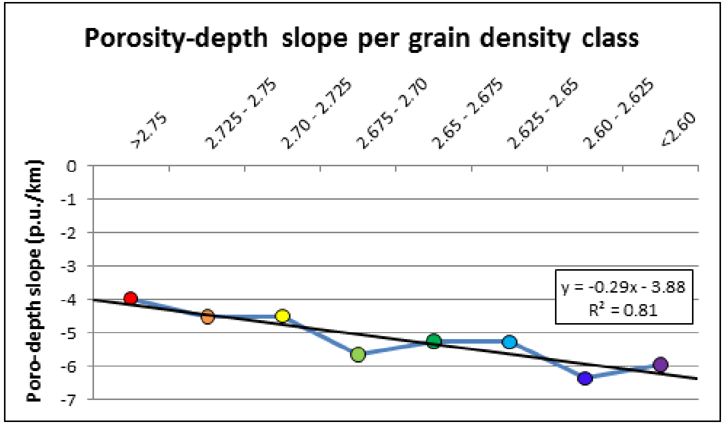
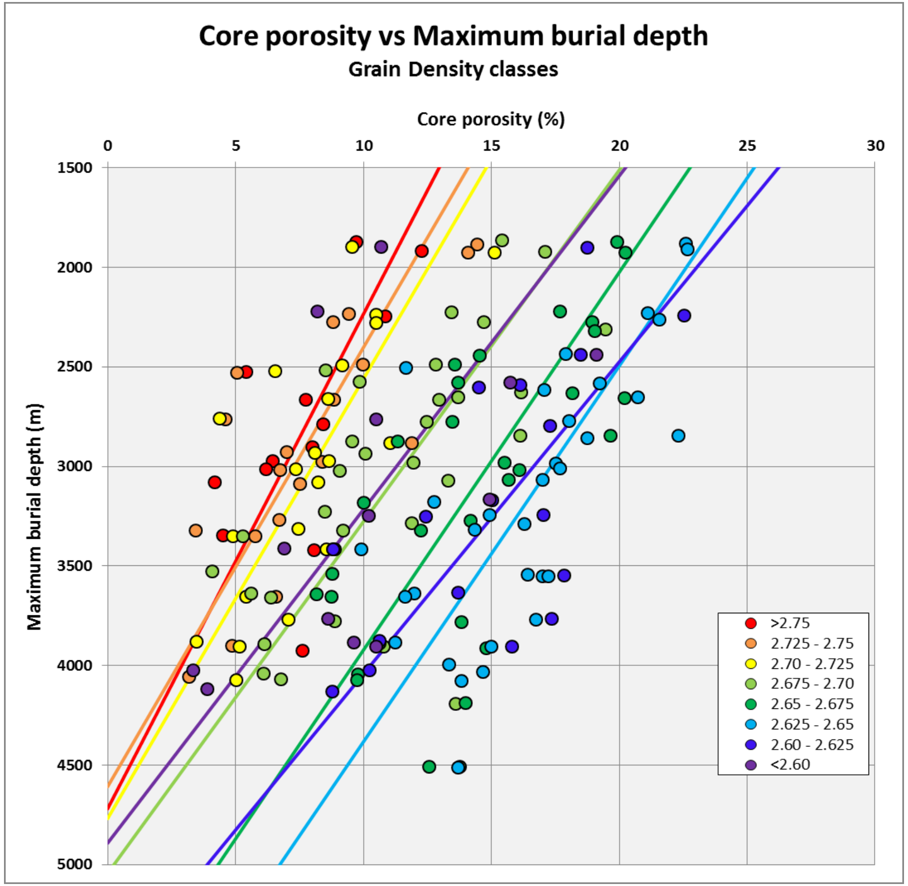
<u>Methodology</u>

- GD classes defined (colour scale).
- Upscaling: average porosity per 50m depth interval, for each GD class.
- Averages plotted versus mid of depth interval.

<u>Results</u>

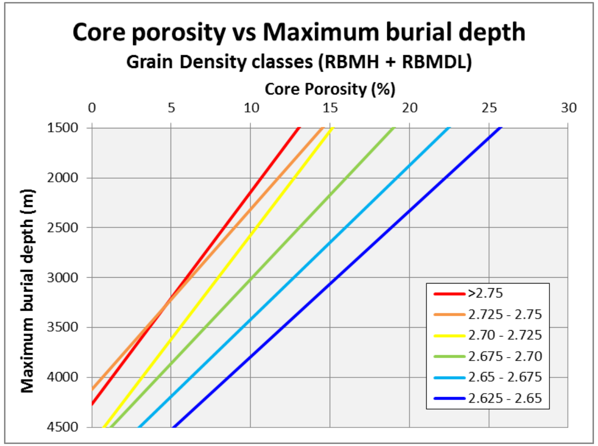
- Gradual increase in porosity with decreasing GD.
- Decreasing porosity with depth visible in each class.
- But, slope of porosity-depth trend varies per class.

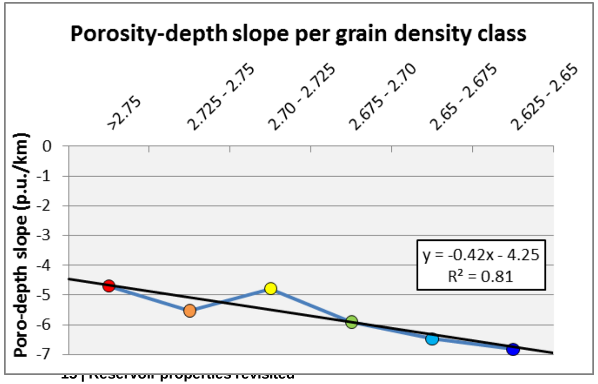




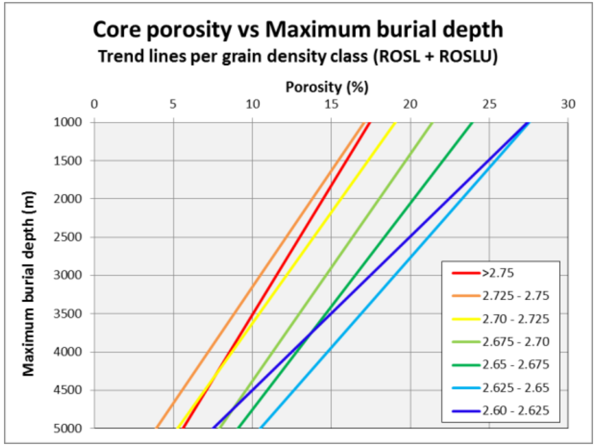
Method is repeatable for other lithological units

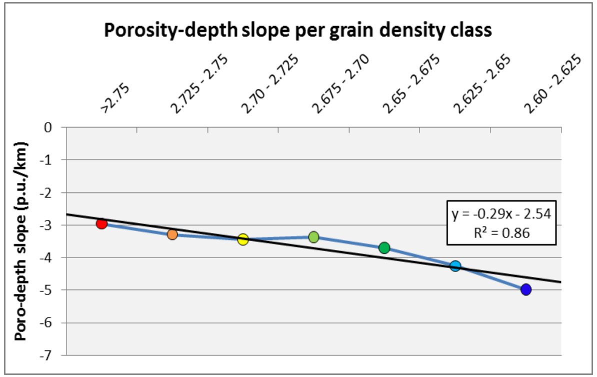
Hardegsen & Detfurth Sst. (Triassic)



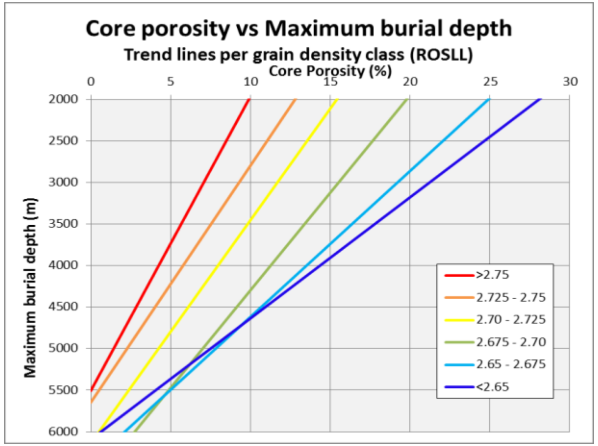


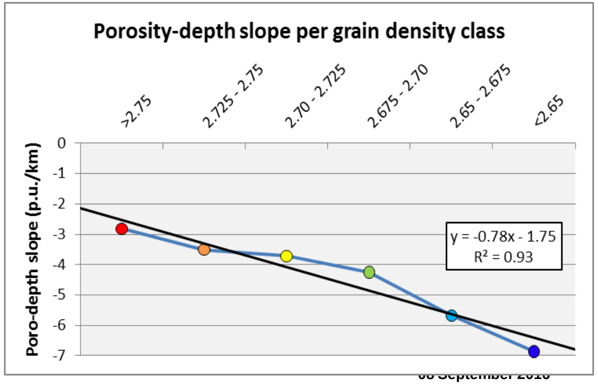
Upper Slochteren Sst. (Permian)





Lower Slochteren Sst. (Permian)



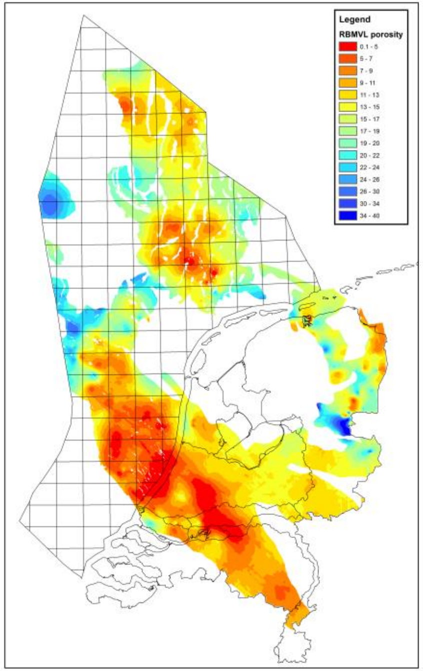


EXAMPLE OF APPLICABILITY

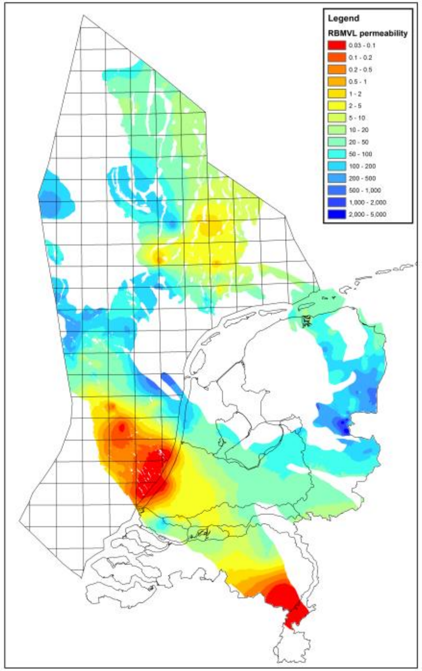
- Resulting porosity-depth relations used for generation of regional property maps (porosity, permeability, etc.) of important reservoir units in the Netherlands.

- Maps are based on well data. Relations are used for the interpolation process.

Porosity map of the Lower Volpriehausen Sandstone Member



Permeability map of the Lower Volpriehausen Sandstone Member



CONCLUSIONS

- Data mining and analysis of large data sets support generally known trends and provide an excellent reference framework for more detailed reservoir property analyses.

- Porosity-permeability relations are often defined by straight lines. However, the data proves in most cases that the relation is better described by curved functions on a log-normal plot.

- Porosity-depth relations in core data are revealed when correcting for maximum burial depth and other factors like cementation and facies differences.

- Porosity-depth relations in core data can be defined per grain density class. A decrease in porosity reduction with depth, with increasing grain density, is shown in the data.

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