

# Dinantian Carbonates

target for UltraDeep Geothermal in the Netherlands

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GREEN DEAL



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# UDG Program



## Take Away

- Government supported studies using existing and new data with expert project teams yielded many insights for exploring the geothermal potential of Dinantian Carbonates – input for UDG analyses and InterReg DGE-ROLLOUT, and “shallow” exploration
- Many results useful for geothermal exploration in reservoirs above the Dinantian
- Results shared and made available, see also [www.nlog.nl](http://www.nlog.nl) and [www.scanaardwarmte.nl](http://www.scanaardwarmte.nl)
- Large uncertainties in UDG doublet power estimations - hampering analysis of business cases
- Uncertainties caused by lack of data and large variations in reservoir quality of the Dinantian Carbonates at small scale - requires new subsurface data from seismic and drilling

A photograph of a massive, layered rock cliff face. The rock is primarily tan and brown with some greyish-white patches. A dark, irregularly shaped cave entrance is visible in the lower-middle section of the cliff. At the base of the cliff, two people are standing on a grassy slope, looking towards the cave. The overall scene is brightly lit, suggesting a sunny day.

## Definition of UDG in this program and presentation

- Reservoir is Dinantian carbonates (Lower Carboniferous)
- Depth > 4 km and Temperature > 120 degrees

# Ultra Deep Geothermal Program in the NL



- **'Green Deal UDG'** signed in 2017 by TNO, EBN, 2 ministries and 7 consortia in the Netherlands (light industry and heating), continued as **'Programma UDG'** since 2020
- Objective: assess the feasibility of UDG for heat in the Netherlands
- *"develop a play, not a single project"* & *"safe and sustainable"*
  - Share knowledge and data - technical and non-technical
  - Joint Exploration Work Program
  - Join forces in communication and stakeholder management
  - Government support
- Results and data public



# UDG Exploration Work Program



## A lot of new data and insights

- 12 large-scale / generic studies conducted by project teams in period Q4 2018 – Q2 2020
- using seismic, gravity and magnetic, well logs, cores, well reports, expertise, ...
- A lot of new data and insights on many aspects of the Dinantian carbonates in the Dutch subsurface
  - New maps for depth and facies
  - Reservoir quality taking into account diagenetic processes
  - Temperature model and factors effecting temperature distribution (presentation by Hans Veldkamp)
  - Subsurface stress field
  - Potential power estimations and uncertainty
  - Operational - Induced seismicity risks and drilling hazard register
- These are input for studies focused on a region or a single project  
Also input to InterReg DGE-ROLLOUT studies
- Seismic acquisition and (re-)processing – still ongoing, combined with the SCAN acquisition (see also [www.scanaardwarmte.nl](http://www.scanaardwarmte.nl))



# SCAN Dinantien project teams

Combining skills and expertise from many organizations

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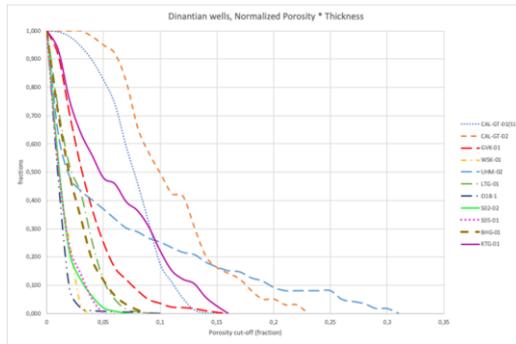
plus 8 independent consultant experts

The following slides comprise snapshots from various studies – a complete overview is not possible in 30 minutes

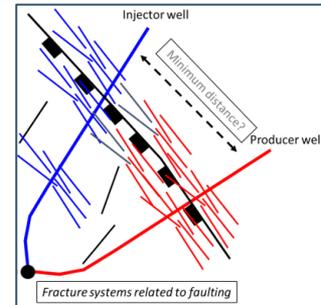
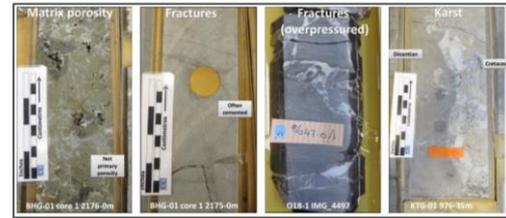
# Reservoir quality – petrophysics and fractures

Using logs, cores, well reports and literature

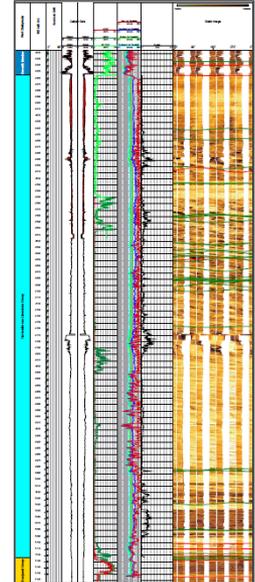
- PP evaluation of 13 wells, link to geology, resulting in consistent database available for public use
- Inventory of well observations on temperature, fluid composition, well tests and pressures
- Review of techniques and importance of fracture characterization, incl. FMI-analysis - **Lack of data!**



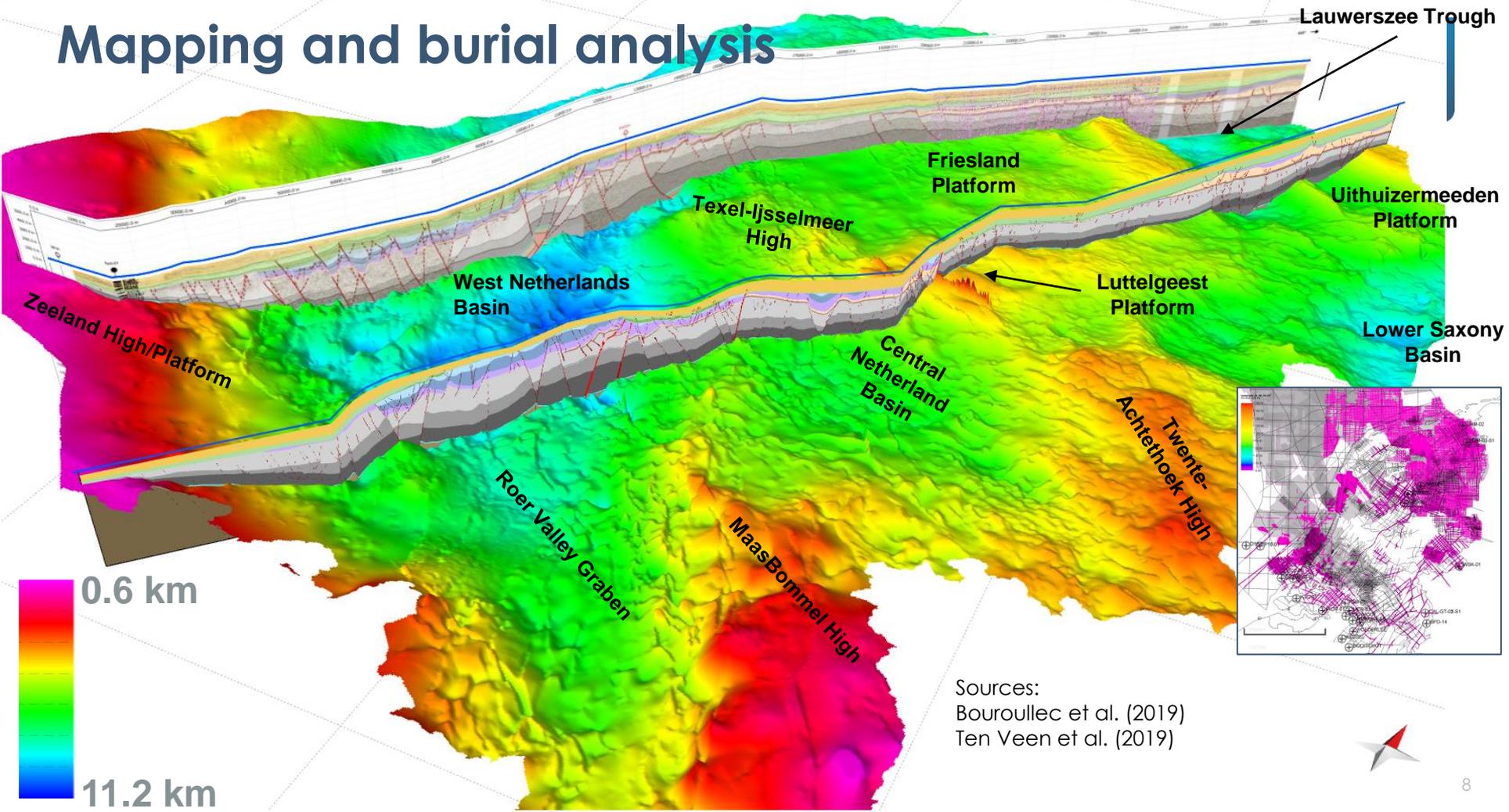
From: Carlson (2019)



From: Van Leverink & Geel (2019)



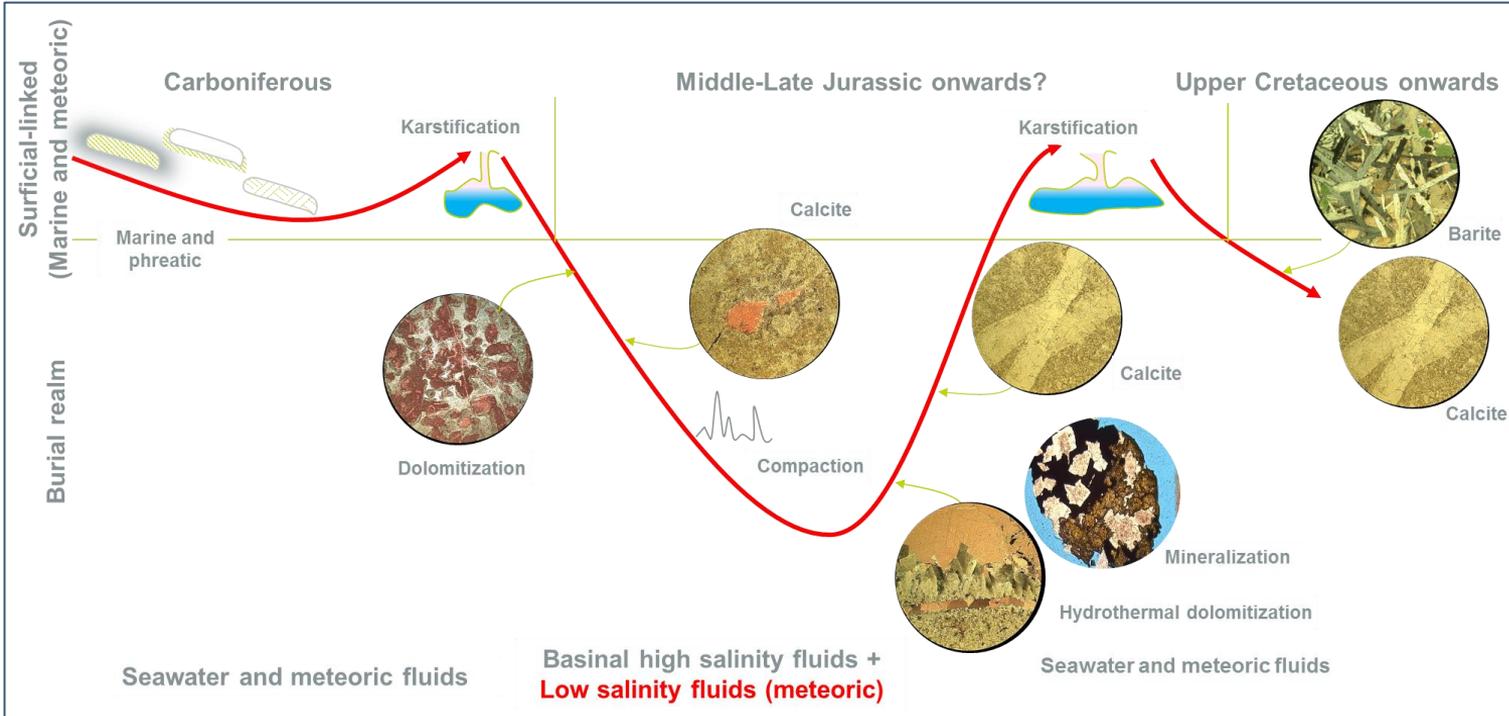
# Mapping and burial analysis



Sources:  
Bouroullec et al. (2019)  
Ten Veen et al. (2019)

# combining burial history and diagenetic sequence in wells

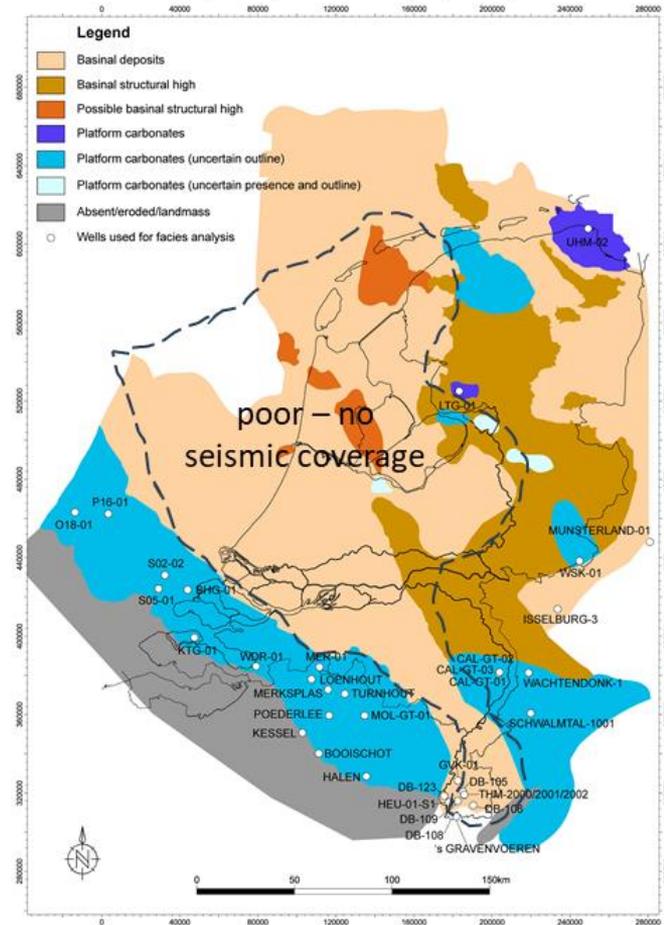
Still a challenge to predict RQ in areas with little well and seismic data



# Facies maps

- Will change with new seismic and wells
- Input for InterReg

Moliniacian-Livian (Sequence 2) and Warnantian (Sequence 3) facies distribution



from: Mozafari et al. (2019), maps prepared by Mozafari & Ten Veen

# Productivity & Injectivity

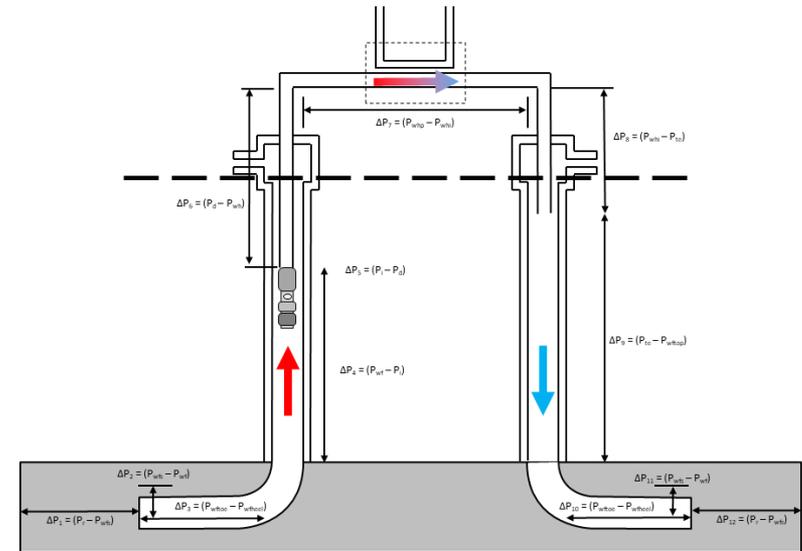
## Large uncertainties in power estimates

In-house tool used to estimate geothermal power for fractured reservoirs

Uncertainties in reservoir parameters and completion design result in wide range of estimated power

Fracture characteristics most uncertain while having the largest impact on performance

Expected overpressures have a negative impact on the doublet performance

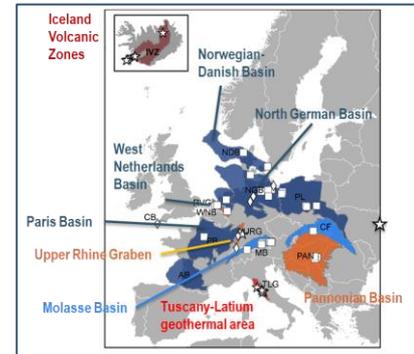


From Bruijnen, 2019

# Risks of induced seismicity

## 2 studies by TNO as part of SCAN / UDG

- Worldwide review of geothermal projects with / without seismicity and the relevance for Dutch geothermal - Buijze et al., 2019
  - “Dutch geothermal projects producing from permeable reservoirs, away from active fault zones will generally have low risks for induced seismicity. This has to be verified for every project.”
- Review of projects (possibly) analogue to Dinantian geothermal and workflows for seismicity monitoring and risk analysis - Ter Heege et al., 2020
  - Including review of Cal-GT (NL), Balmatt (B) and Molasse (D)



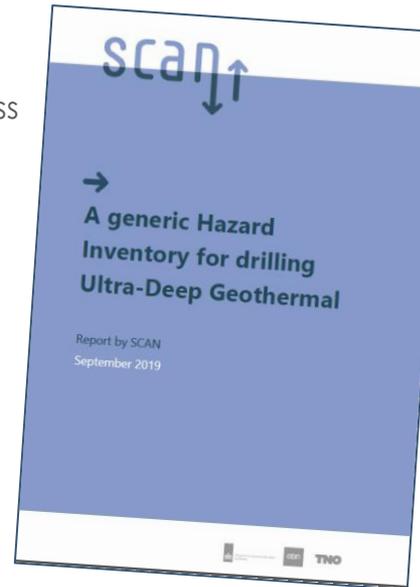
From Buijze et al., 2019

# Hazard Inventory for Drilling UDG



“everything is different when drilling deep wells”

- HAZID methodology adjusted from DAGO system
- few Dutch reference wells, more wells abroad
- main findings
  - location choice has large impact
  - possible presence of H<sub>2</sub>S
  - uncertainty reservoir depth and thickness
  - pressure management reservoir section



Participants in HAZID workshop  
> 200 years experience, mainly from oil industry

# UDG Program



## Take Away & Way Forward

- Government supported studies using existing and new data with expert project teams yielded many insights for exploring the geothermal potential of Dinantian Carbonates – input for UDG analyses and InterReg DGE-ROLLOUT, and “shallow” exploration
- Many results useful for geothermal exploration at geological levels above Dinantian
- Results shared and made available, see also [www.nlog.nl](http://www.nlog.nl) and [www.scanaardwarmte.nl](http://www.scanaardwarmte.nl)
  
- Large uncertainties in UDG doublet power estimations mainly because caused by lack of data and large variations in reservoir quality of the Dinantian Carbonates at small scale - hampers analysis of business cases
- UDG can therefore not be considered a mature renewable technology and new data from seismic and wells is required
  
- Seismic acquisition and (re-)processing will continue (combined with SCAN)
- UDG partners will identify the most appropriate location for a pilot project and prepare a well proposal looking at safety, reservoir quality and the repeat potential

# Thanks for your attention!

↓ [www.nlog.nl/scan](http://www.nlog.nl/scan) & [www.scanaardwarmte.nl](http://www.scanaardwarmte.nl)

✉ [info@scanaardwarmte.nl](mailto:info@scanaardwarmte.nl)



# References to the SCAN Dinantien reports



- ❖ Ten Veen, J.H., de Haan, H.B., de Bruin, G., Holleman, N., Schöler, W. (2019) - *Seismic Interpretation and Depth Conversion of the Dinantian carbonates in the Dutch subsurface (SCAN)*
  - ❖ Bouroullec, R., Nelskamp, S., Kloppenburg, A., Abdul Fattah, R., Foeken, J.P.T., ten Veen, J.H., Geel, C.R., Debacker, T., Smit, J. (2019) - *Burial and Structural Analysis of the Dinantian Carbonates in the Dutch Subsurface (SCAN)*
  - ❖ Van Leeuwen, W. (2019)- *Electromagnetic geothermal exploration in the Netherlands review of the CSEM and MT methods (SCAN)*
  - ❖ Van Heiningen, P.S. (2020) - *Gravity and magnetic interpretation and modelling of the Dinantian carbonates in the Dutch subsurface*
  - ❖ Mozafari, M., Gutteridge, P., Riva, A., Geel, C. R., Garland, J., and Dewit, J. (2019) - *Facies analysis and diagenetic evolution of the Dinantian carbonates in the Dutch subsurface (SCAN)*
  - ❖ Van Leverink, D.J. and Geel, C.R. (2019) - *Fracture Characterization of the Dinantian Carbonates in the Dutch Subsurface (SCAN)*
  - ❖ Carlson, T. (2019) - *Petrophysical Report of the Dinantian Carbonates in the Dutch Subsurface (SCAN)*
  - ❖ Osinga, S. and Buik, N. (2019) - *Stress field characterization of the Dinantian Carbonates in the Dutch Subsurface (SCAN)*
  - ❖ Buijze, L., van Bijsterveldt, L., Cremer, H., Paap, B., Veldkamp, H., Wassing, B., van Wees, J.-D. and ter Heege, J. (2019) - *Review of worldwide geothermal project mechanisms and occurrence of induced seismicity*
  - ❖ Ter Heege, J., van Bijsterveldt, J., Wassing, B., Osinga, S., Paap, B., Kraaijpoel, D. (2020) - *Induced seismicity potential for geothermal projects targeting Dinantian carbonates in the Netherlands*
  - ❖ Veldkamp, H. and Hegen, D. (2019) - *Temperature modelling of the Dutch subsurface at the depth of the Dinantian (SCAN)*
  - ❖ Bruinen, P.M. (2019) - *Estimating geothermal power of ultra-deep Dinantian carbonates in the Dutch subsurface (SCAN)*
  - ❖ Middelburg, M. and Drenth, D. (2019) - *A generic Hazard Inventory for drilling Ultra-Deep Geothermal Wells (SCAN)*
- **All downloadable from [www.nlog.nl](http://www.nlog.nl) with a lot of additional well data, maps, cross sections, scanned thin sections etc.**

