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WP1 Unlocking shallow geothermal reservoirs: Key insights for optimal exploitation of geothermal energy from medium depths (500-1500 m)

12-6-2025, Lies Peters, Nora Heijnen

Mede mogelijk gemaakt door: TKI Nieuw Gas Topsector Energie

WP 1 overview

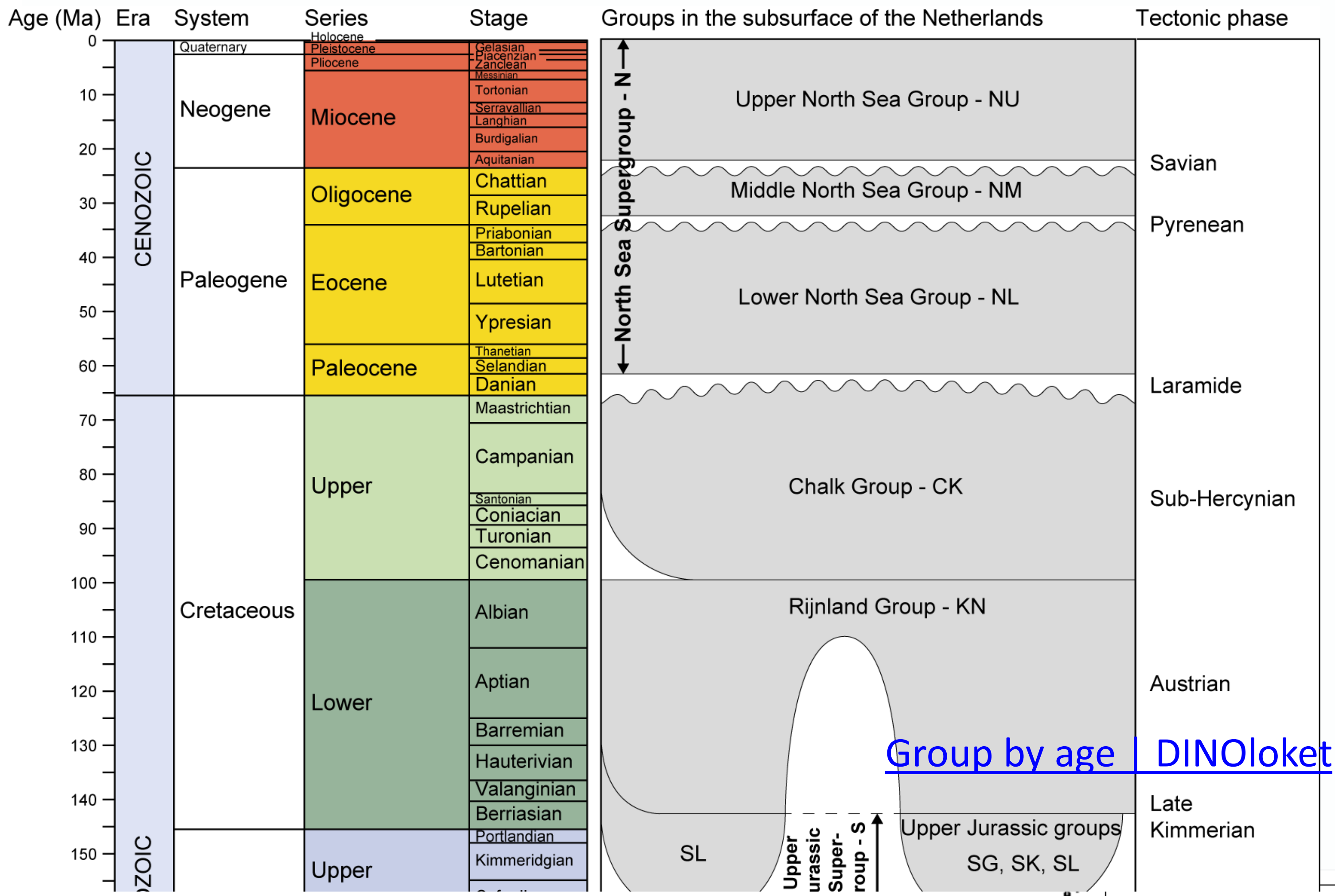
- WP goal
  - Bringing together knowledge from different perspectives (oil, gas and geothermal exploration and production) and outlining key factors and parameters that require further attention for optimal exploitation and development of the shallow geothermal depth domain.
- Approach
  - Collecting data relating to the development of unconsolidated reservoirs in the mid-depth range
  - from oil and gas fields in the Netherlands and Zevenbergen geothermal doublet
- Deliverables
  - report and xlsx database of available information
  - Recommendations for research to fill the identified knowledge gaps
  - Summary paper EAGE GET

Not included:

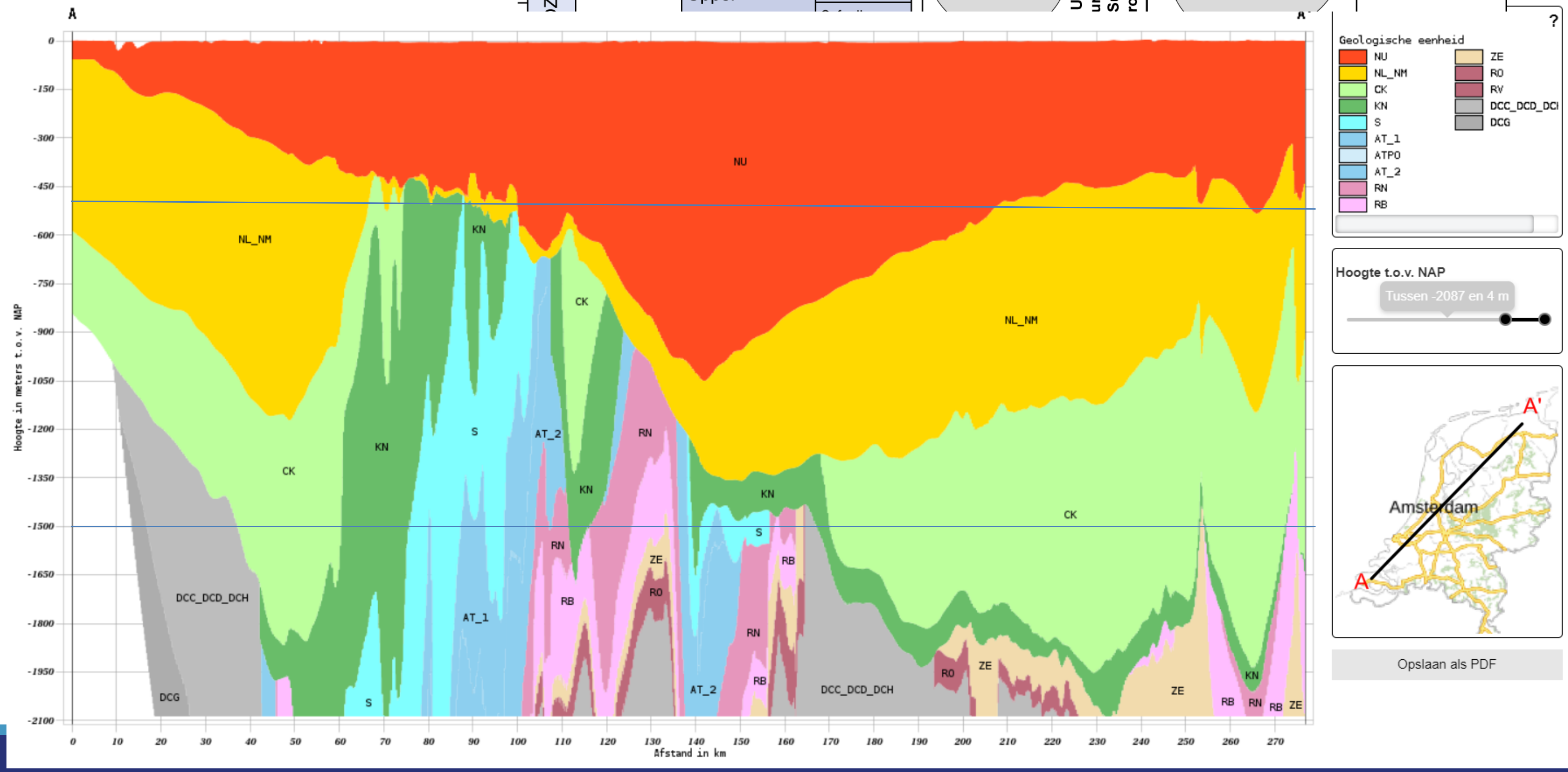
- impact of low temperature on use of the heat and heat pumps
- Integration in heat networks

Target formations

- Depth range: 500-1500 m; focus on 500 to 1000 m
- Poorly or partially consolidated formations
- Many of these formations are fine grained
- Target formations:
  - Upper North Sea Group (Breda Sg)
  - Middle and Lower North Sea Group (Brussels Sand and in Roer Valley Graben)
  - Rijnland Group (local)
  - Nieuwerkerk Formation (Delft and mainly Alblasserdam)



[Group by age | DINOloket]



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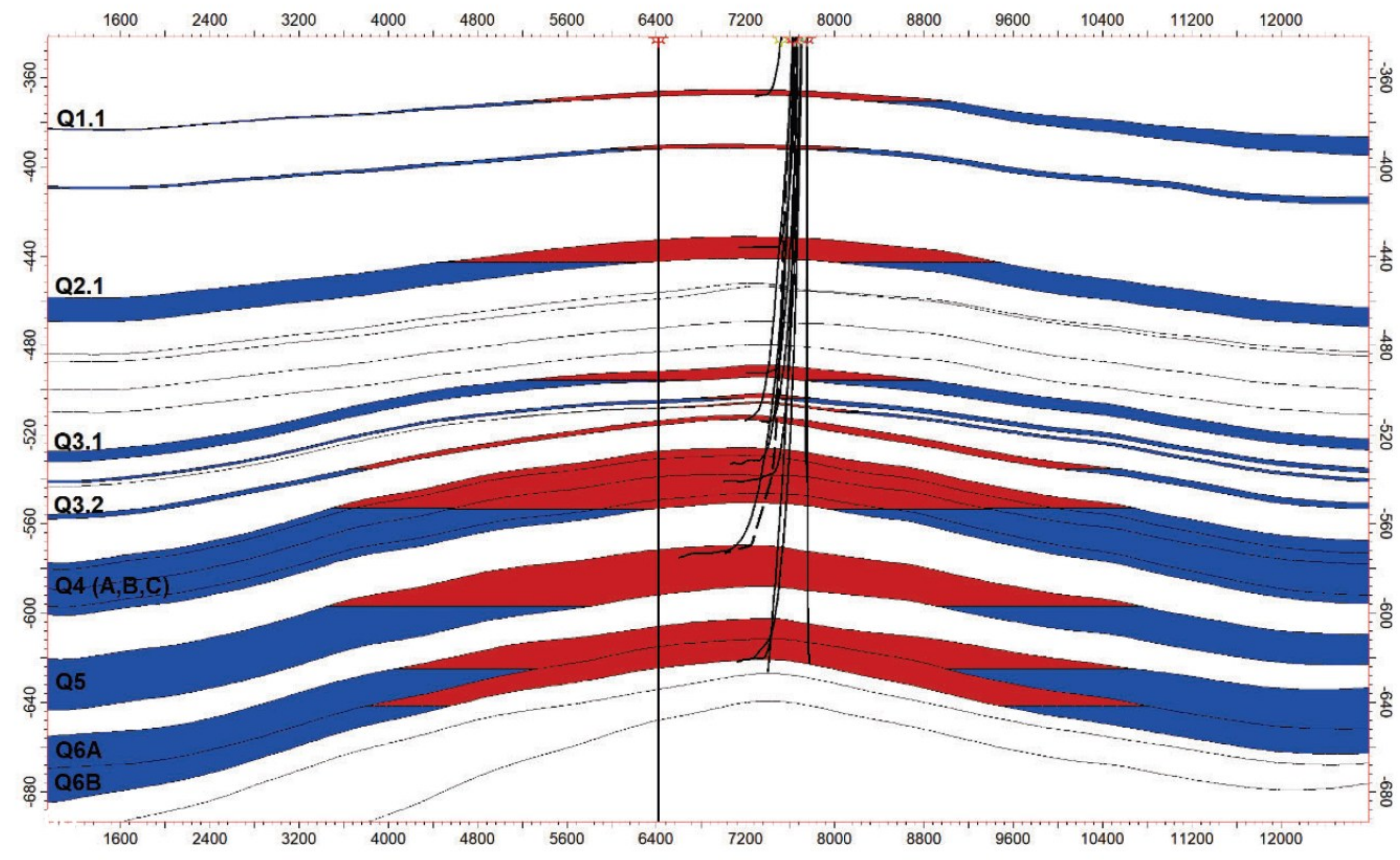
First workshop on 12 February

- Collect info on developing projects in shallow domain (technical perspective):
  - Drilling & completions
  - Production phase
  - how do the subsurface conditions/characteristics influence the choices made in the drilling, completions and production
- Data collection by: Shell geothermal, EBN, HP Wellscreen, IF Technology, TNO
- Discussion and support from: HVC, Geothermie Nederland, TUDelft

Information collected from:

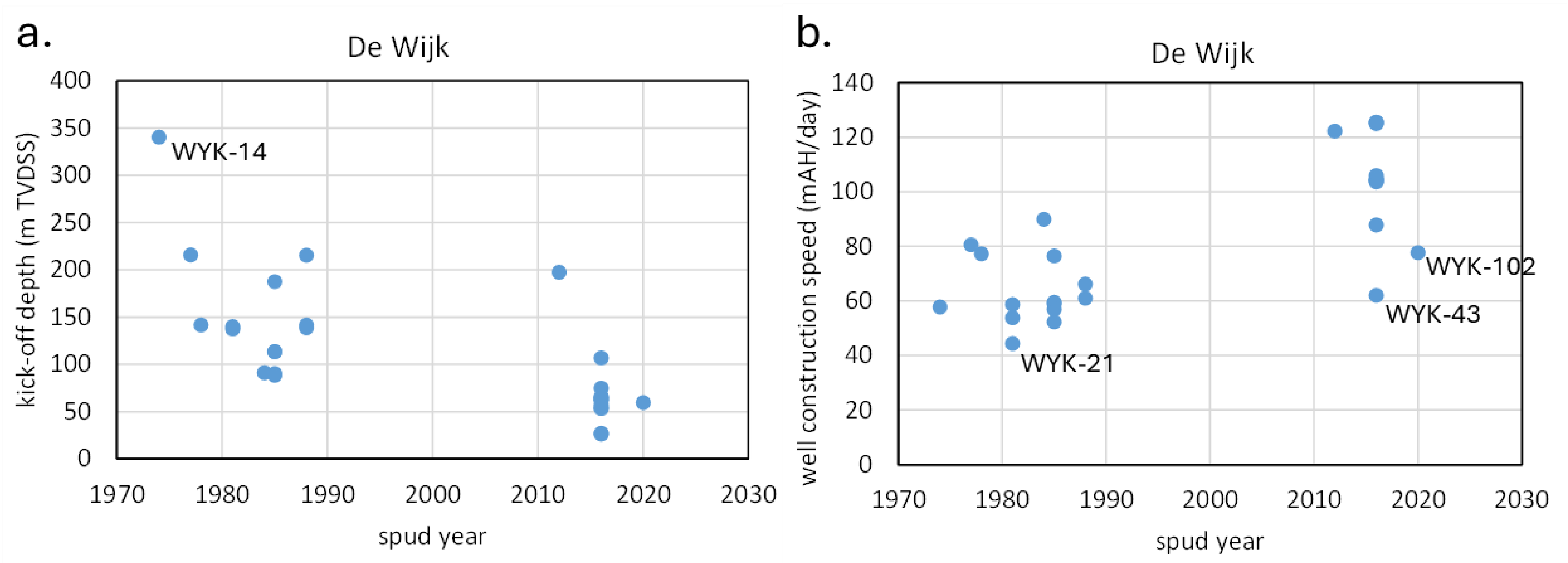
- Oil & gas:
  - De Wijk (on-shore): De Wijk Mb (was Basal Dongen Tuffite) at around 500 m depth
  - Schoonebeek (on-shore) in Bentheim Sst at around 700 to 900 m depth
  - Several field in the A/B blocks (offshore): Upper North Sea Group at depth of around 500 m
- Geothermal:
  - Zevenbergen in Brussels Sand Mb
- Other:
  - Salt production wells, e.g. BAS-03
  - Literature

Cross-section from A12 (Source: field development plan 2024)

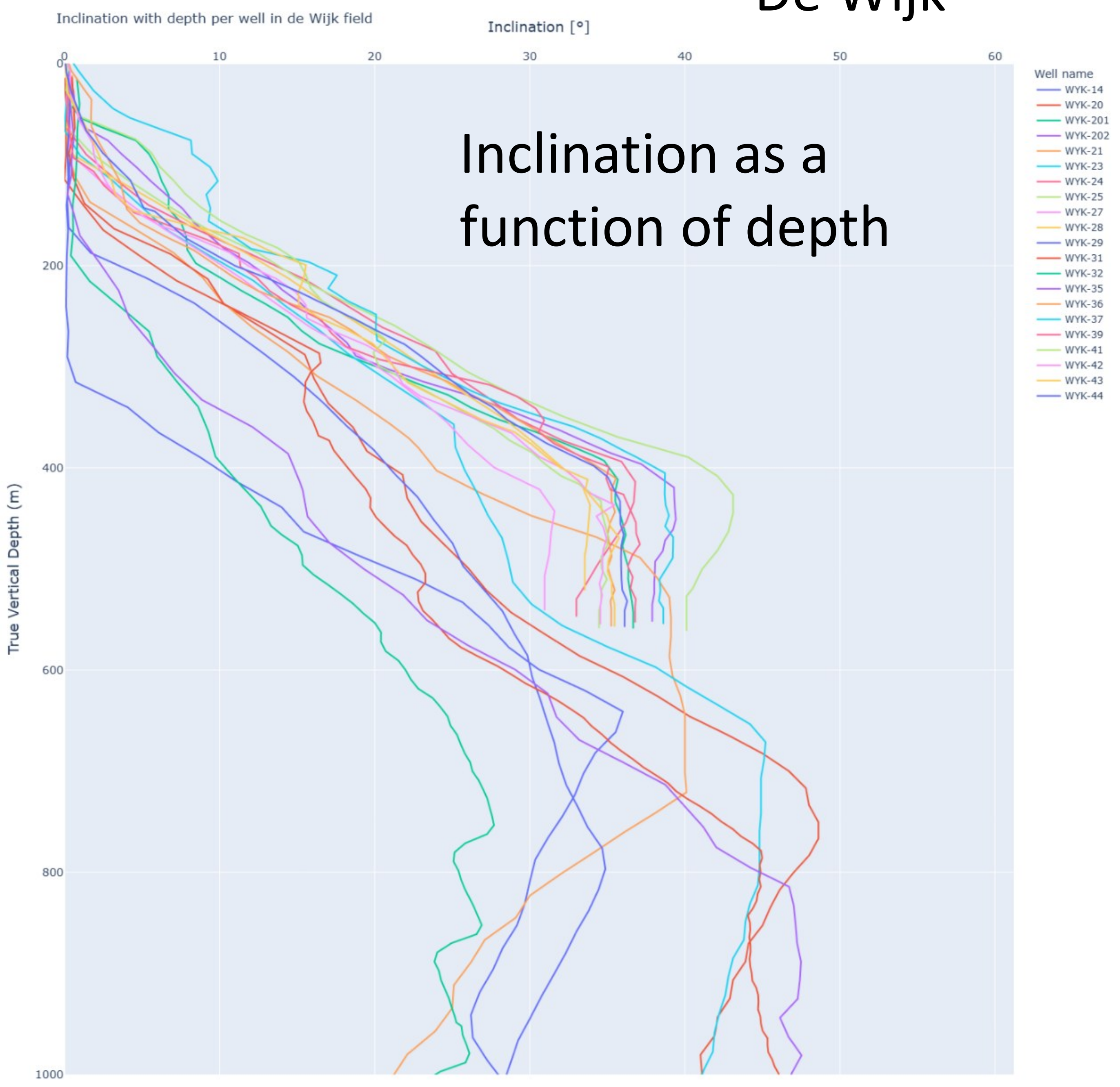


Kick-off depth and build rate

- Example De Wijk

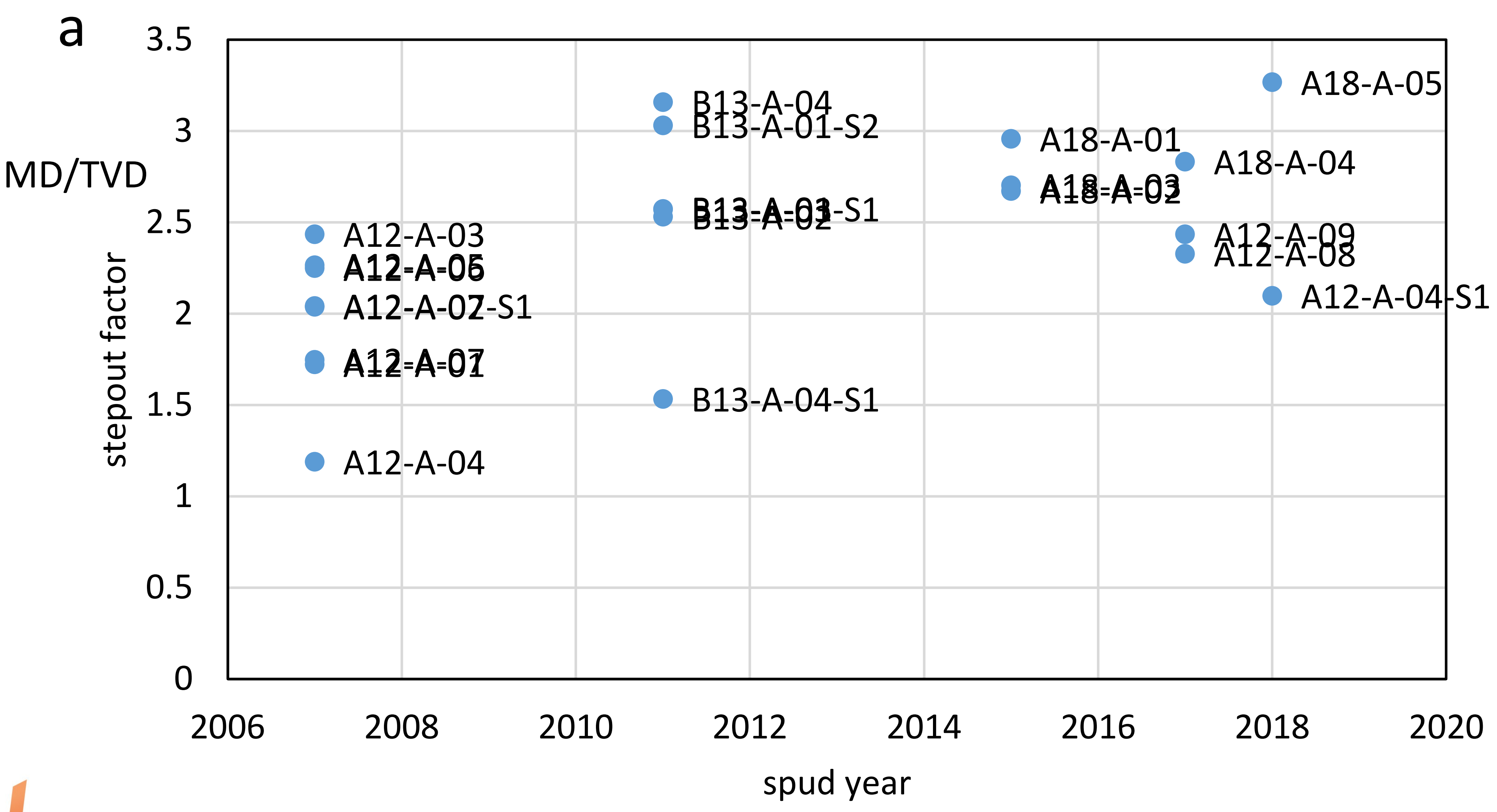


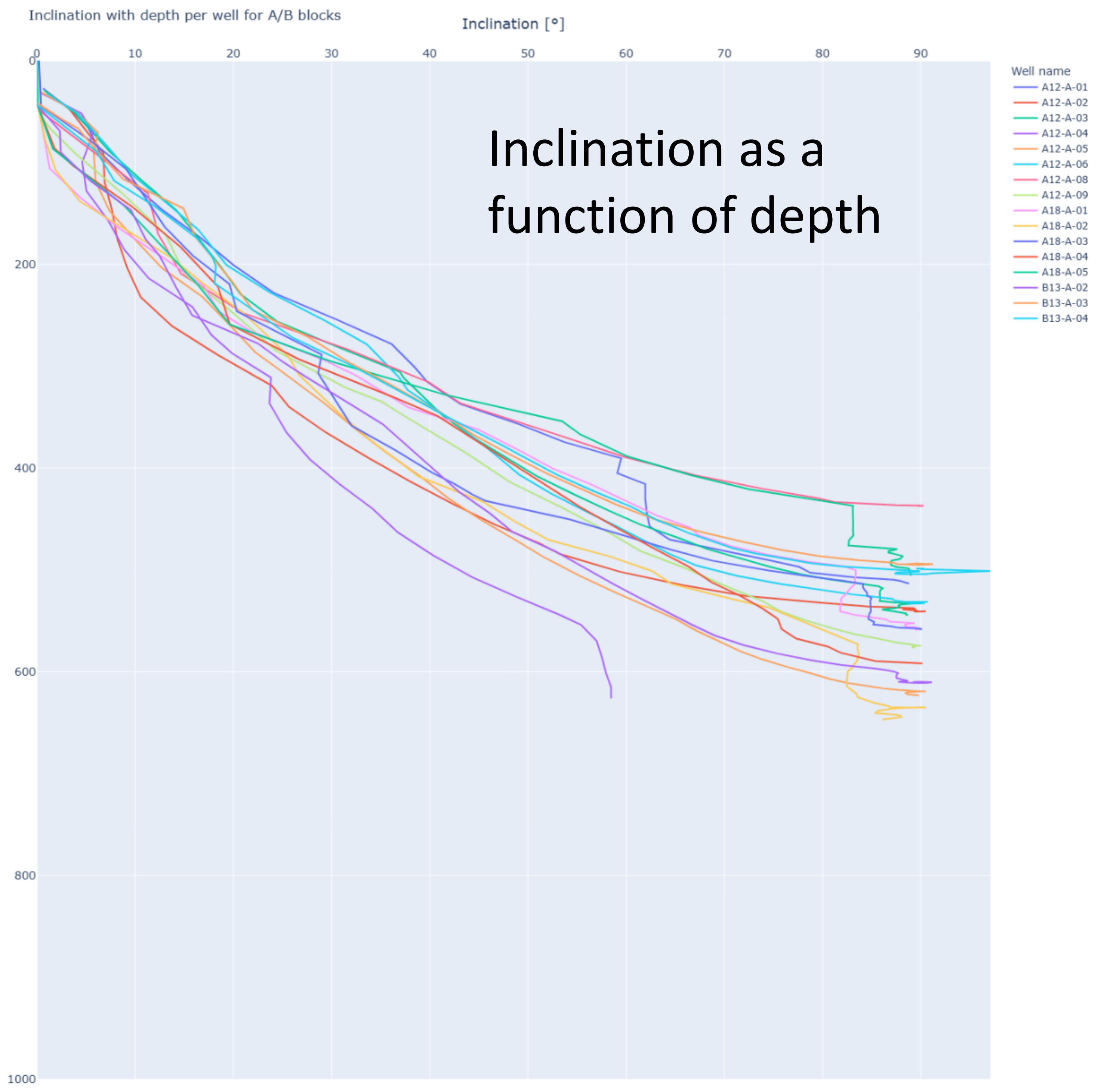
De Wijk



Kick-off depth and build rate

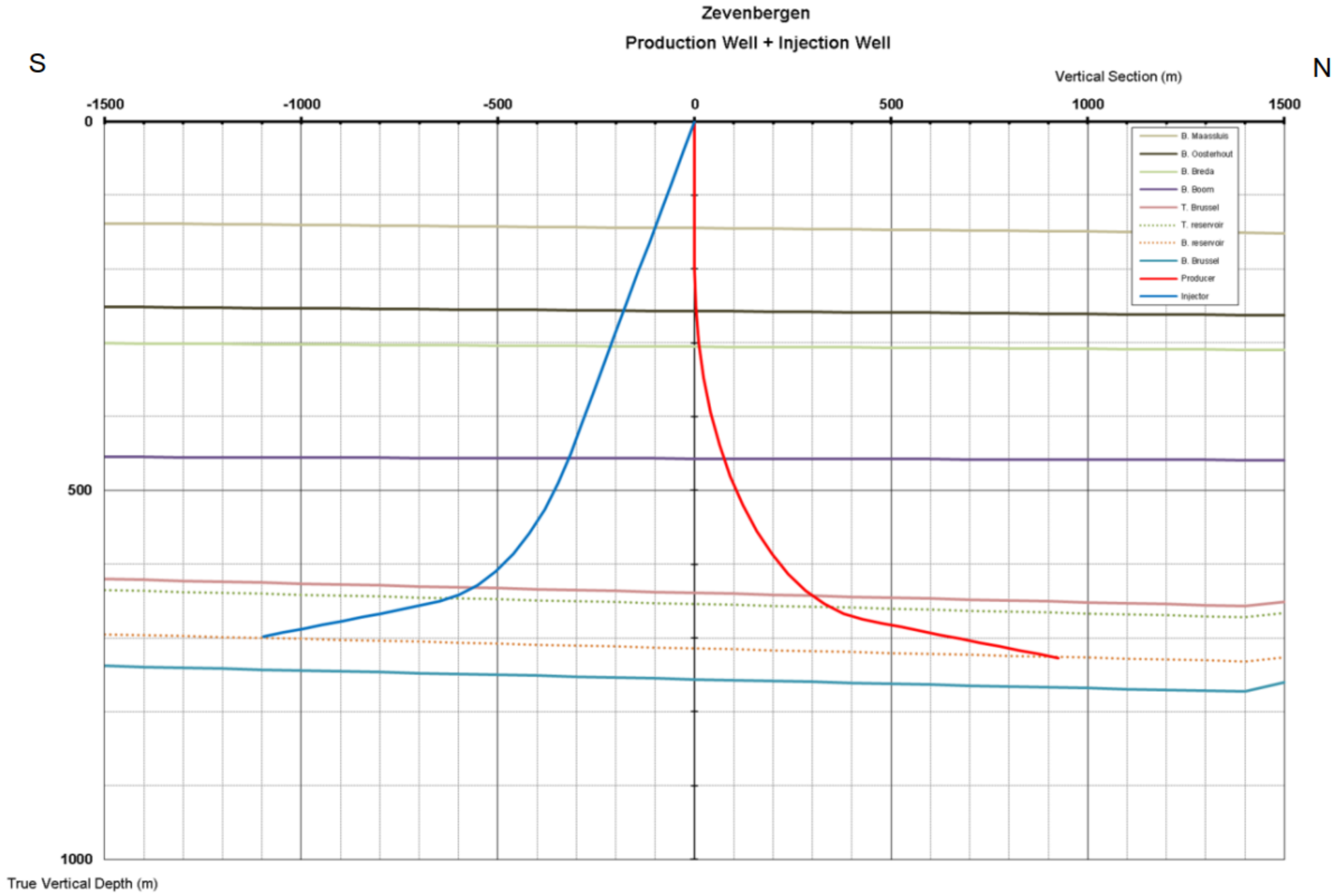
- Example A/B blocks





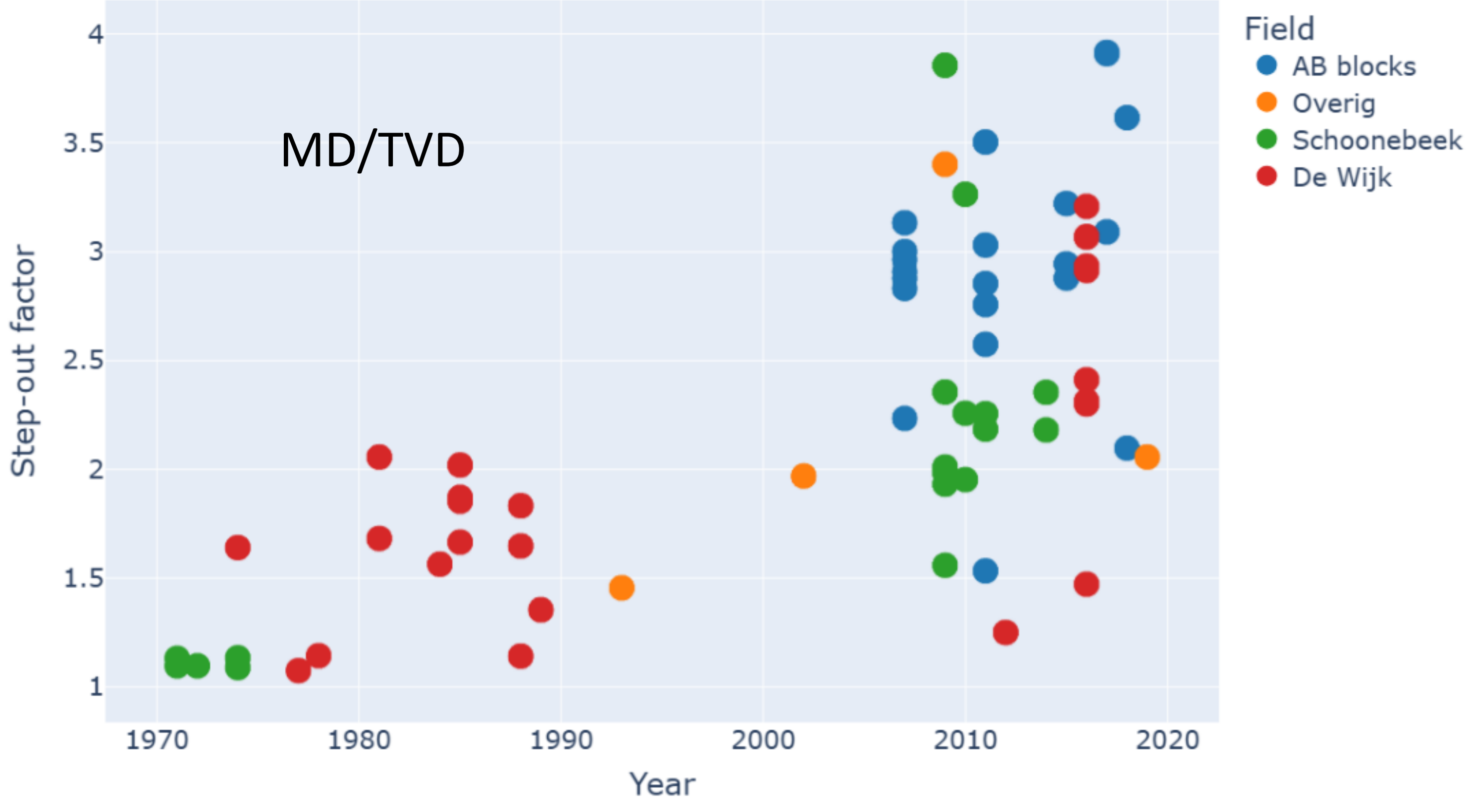
Zevenbergen

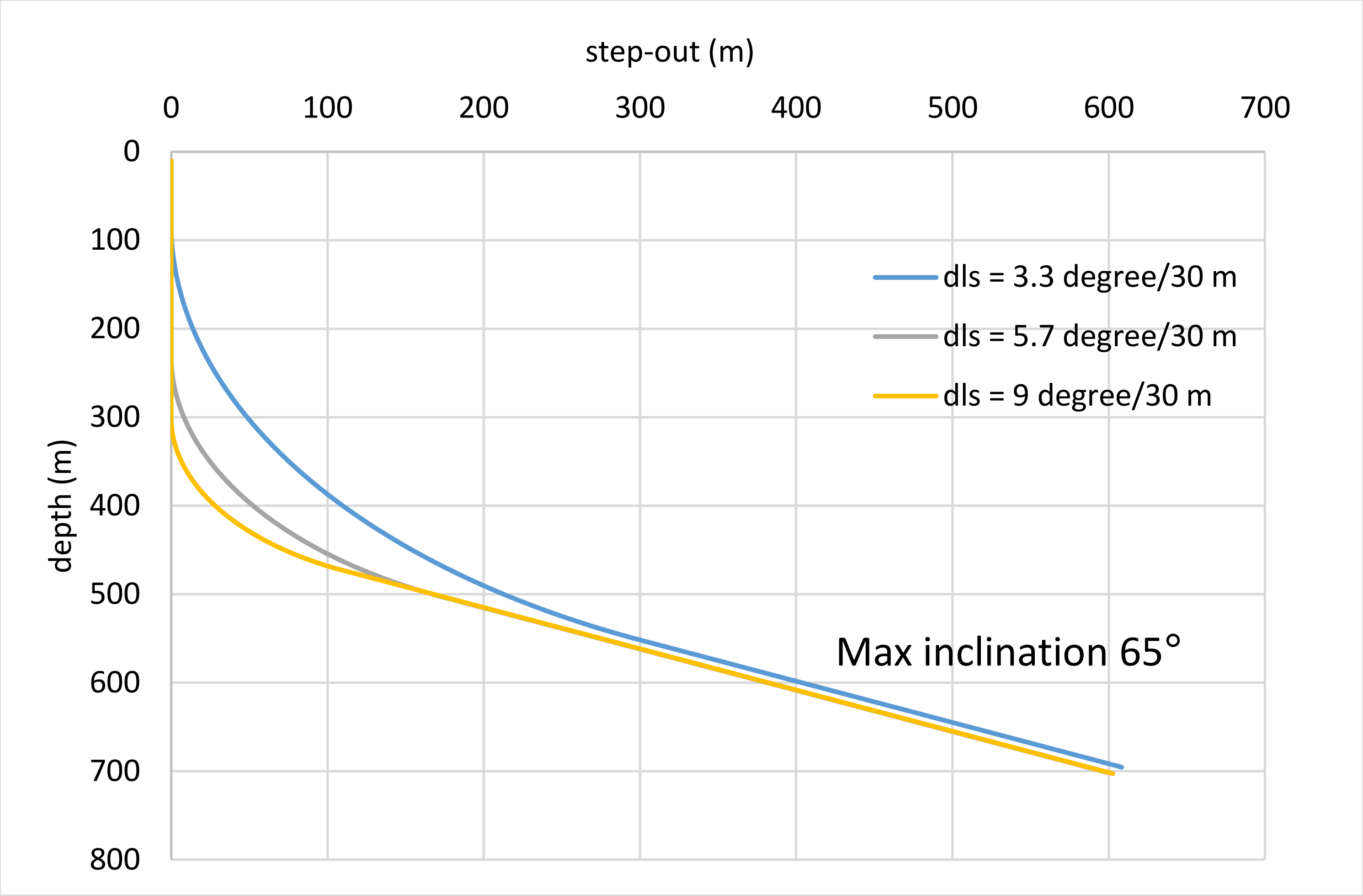
- Derisking the subsurface via a pilot well
- Issue during drilling: high angle (~85°) through consolidated stringers/streaks
- Choice of bit adjusted for better penetration rate.



Conclusion drilling

- Current technology to drill the required step-out wells for LTG is quite mature
- Long horizontals as in A/B blocks might not be necessary
- Critical success factors largely organisational
- Main issue is cost
- Cost reduction and drilling reliability achieved in oil and gas via:
  - Careful planning; continuous learning curve; "know the subsurface" → Concept select
  - Campaign drilling
  - Slimhole drilling





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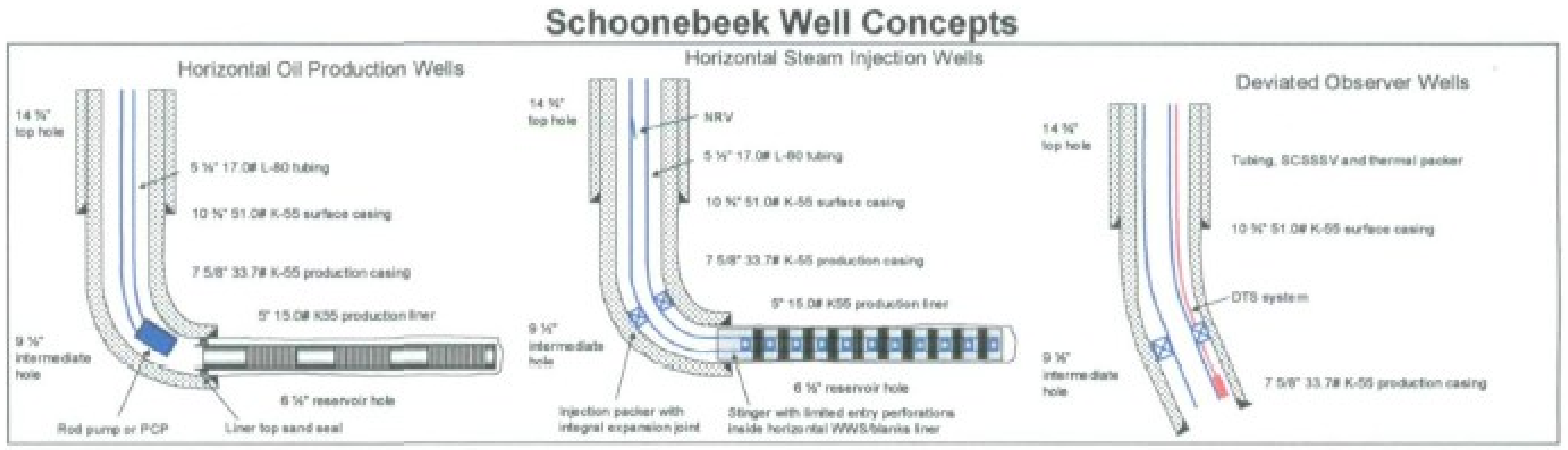
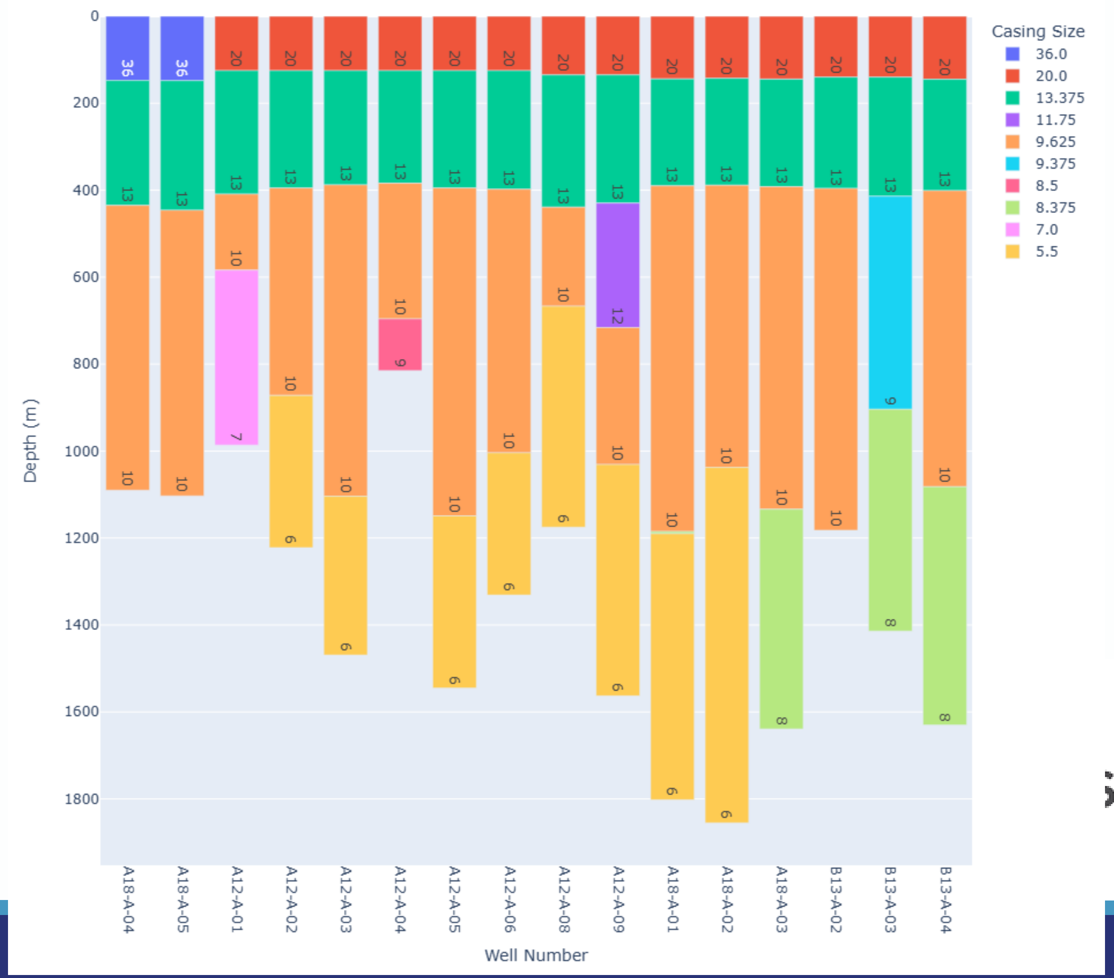
Completions & Operations

- A/B blocks
  - Long horizontals with Expandable Screens
- Schoonebeek:
  - Long horizontals with wire-wrapped screens
- De Wijk:
  - Deviated wells (max 40 – 50°) with perforated casing
- All:
  - Different fluids (gas/oil)
  - Lower rates (typically water/oil 10 to 15 m^3/h)
  - Limited drawdown (few bar)
- Shallow (< 500 m):
  - generally too conservative (WarmingUP report)



Source: Field development Plan

Casing size with depth per well for wells in A/B blocks



Conclusions completions & operations

- Completion options available, but application of those needs to be tested

- Operations: least experience
- Zevenbergen production decline over following years:
  - Cause not known but possible processes are: cleaning not fully effective, movement of fines resulting in clogging or (introduced) microbiological growth

- Both: uncertainty in relevant subsurface characeristics: fluid characteristics, dissolved gas, particle sizes and shapes, chemical composition (e.g which types of clay), geomechanical properties

Overview draft

On going research   Partially addressed   Not addressed (yet)

Topic	What knowledge is missing?	Possible Approach
Drilling	How to safely reduce cost?	Compact well control development → Diameter
		Collection of information for (e.g. shallow gas) and cases with compact well control (e.g. SCAN wells)
		Lighter rig options
		Alternative development options, like slim hole wells combined with storage; vertical wells Diameter
		Well materials (corrosion, pressure rating) → Bodemlus project
		Optimization of logging → vertical wells only Deltares (S)GR, NMR (e.g. Warming^{UP}*GOO*) + Diameter
	Business case: What is the maximum LCOH to let LTG fly? What can then be achieved in cost reduction by technological developments?	Desktop study →(Schepers et al. 2019); Rhodes, 2021) ; (WEP, 2022); (Boon et al., 2022)
Completions	Performance of different options for completions in LTG?	Combination of experiments + pilots →Diameter
	Erosion limits completions and ESP (currently too conservative?)?	Model studies + experiments →Diameter
	Impact of long, vertical completions (e.g. Breda Sg) or stacked (e.g. Alblasserdam)	Model studies + pilots → Diameter

Overview draft (cont.)

Topic	What knowledge is missing?	Approach
Operations	What is the maximum safe velocity at sand face for fines migration / sand transport?	Fundamental understanding (1D flow experiments + modelling) + application (3D flow experiments with relevant completions) → for vertical HTO wells TKI project 3B-HTO (KWR/Deltares/IF); impact T, HTO experiments in WarmingUP(GOO); Diameter Missing: deviated/horizontal; relevant completions; relevant formation characteristics
	What is max. drawdown / injection pressure?	Max. drawdown → (see above) Max injection pressure: investigation of sealing clay layers (properties and modelling)→Diameter
	What are guidelines for operational procedures (shut-in, start-up, cleaning etc)?	Diameter (n=2)
All topics	Subsurface information (what is needed depends on the depth range and location)?	Processing available data → Warming^{UP}*GOO*, ThermoGIS
		Drilling of research wells, collection of downhole material and measuring required properties → Diameter, some SCAN wells
	How to effectively share learnings?	

Discussion

- Which topics do you see as most urgent?

1. Drilling
2. Completion
3. Operations
4. Subsurface

Further ideas, questions or remarks?
Mail to: lies.peters@tno.nl

Discussion step 2

- Drilling: rig, design, materials
- Completions: performance different options, erosion limits completions & ESP, impact long completions vd stacked
- Operations: max velocity onset of fines migration, max drawdown/injection pressure, operational guidelines (and opex)
- Subsurface: all data is already known, site specific data is necessary for optimum design, all data is missing

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- Any missing future research questions?

- Other questions?

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