



TNO innovation
for life

› **RISE OF 3D/4D GEOLOGICAL MODELLING
AND PREDICTIVE GEOSCIENCE**

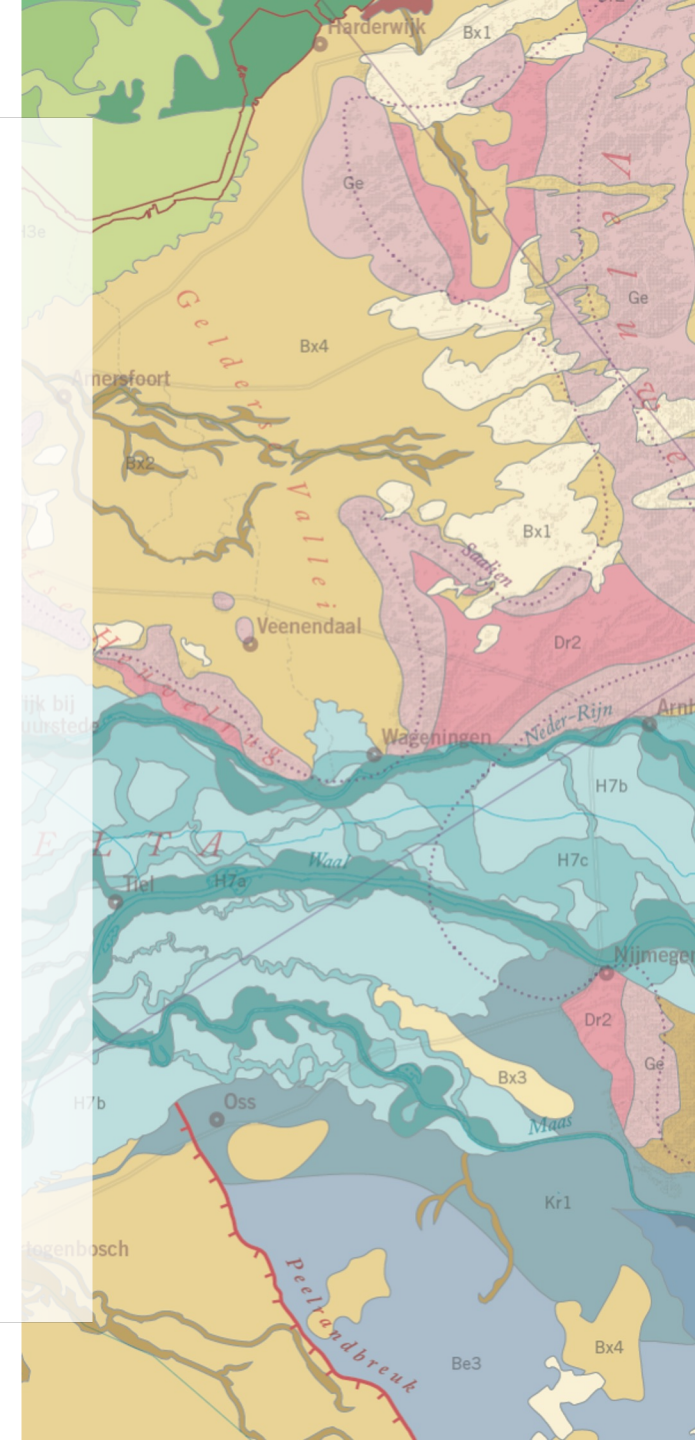
MICHIEL VAN DER MEULEN

GEOSPATIAL WORLD FORUM 2023 | ROTTERDAM, MAY 4, 2023

A model is an approximation of reality
created for the purpose of solving a problem

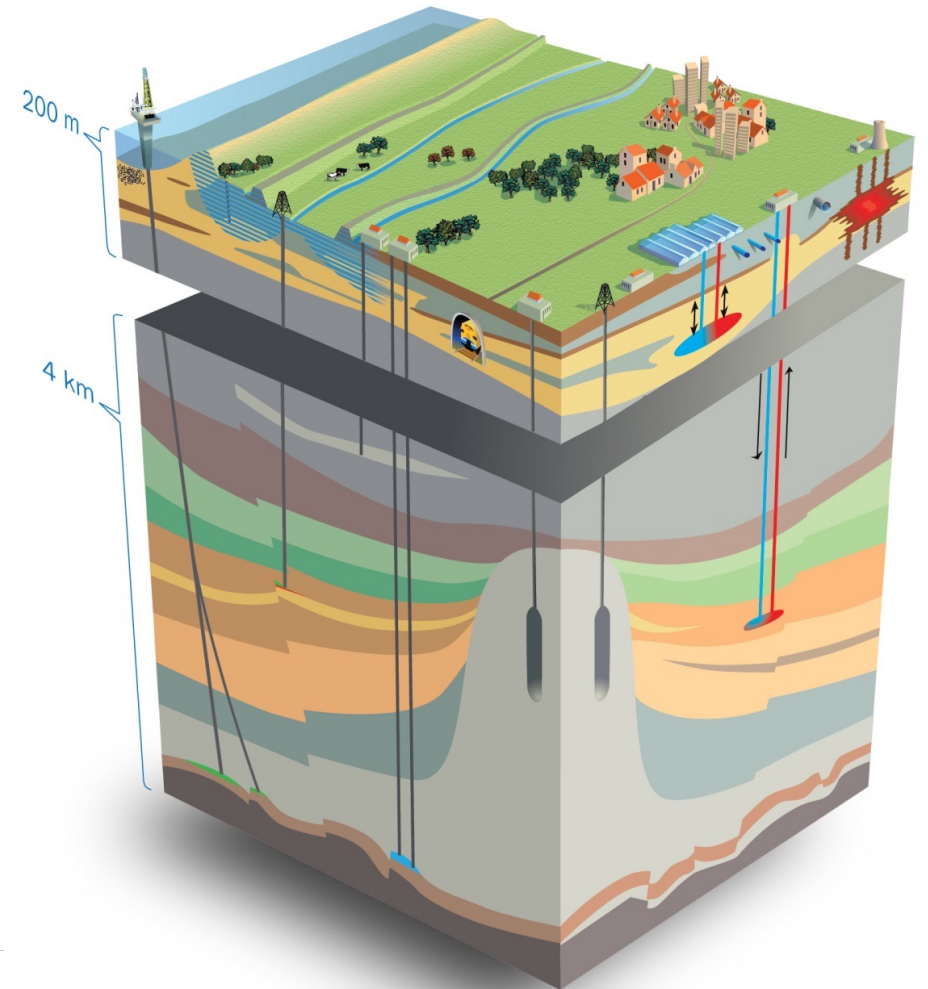
› WHAT PROBLEMS DO GEOLOGICAL SURVEYS SOLVE?

- › Shedding light on geological resources and hazards
- › Big job
- › Systematic approach
- › Institutionalization is a prerequisite
- › Anticipating on ever-changing information needs



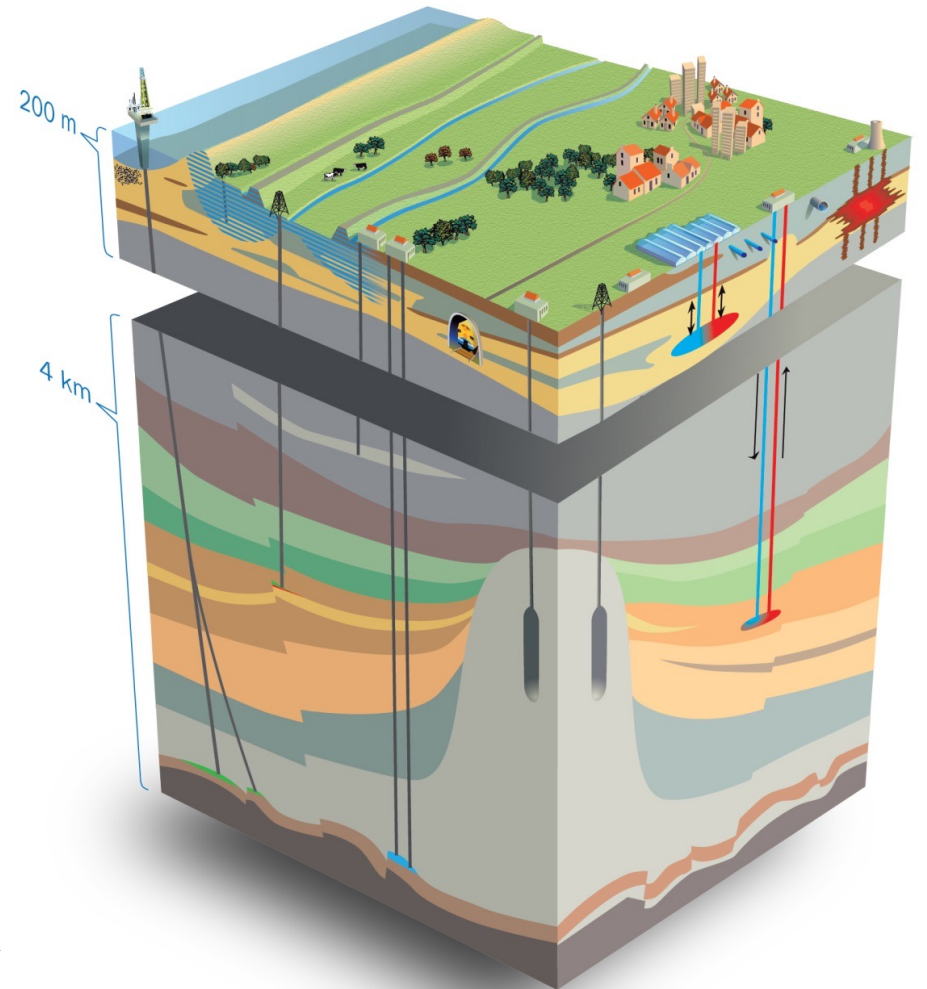
› GEOLOGICAL SURVEY OF THE NETHERLANDS

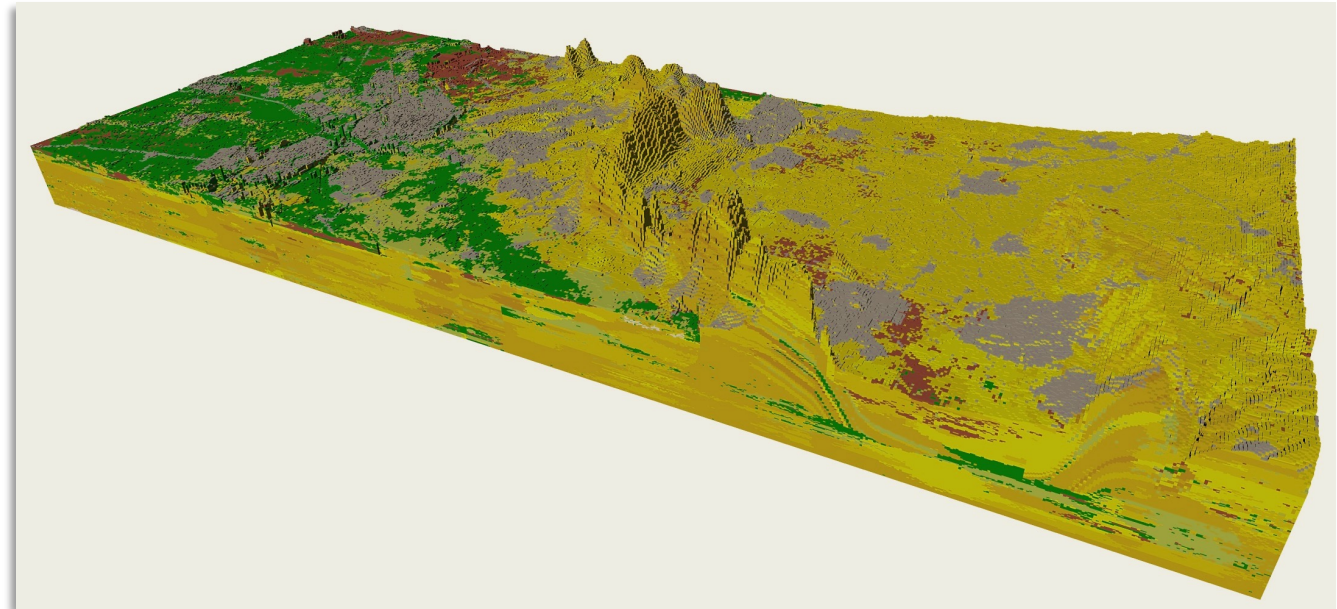
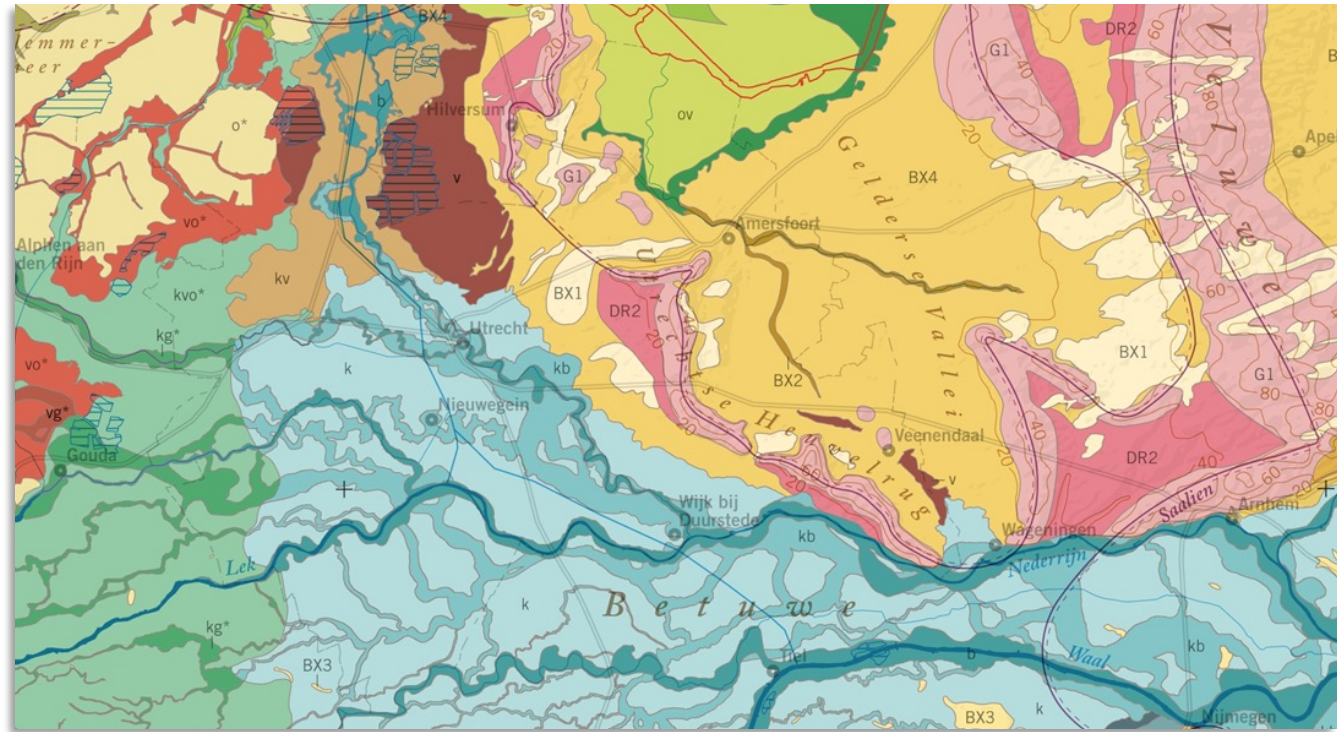
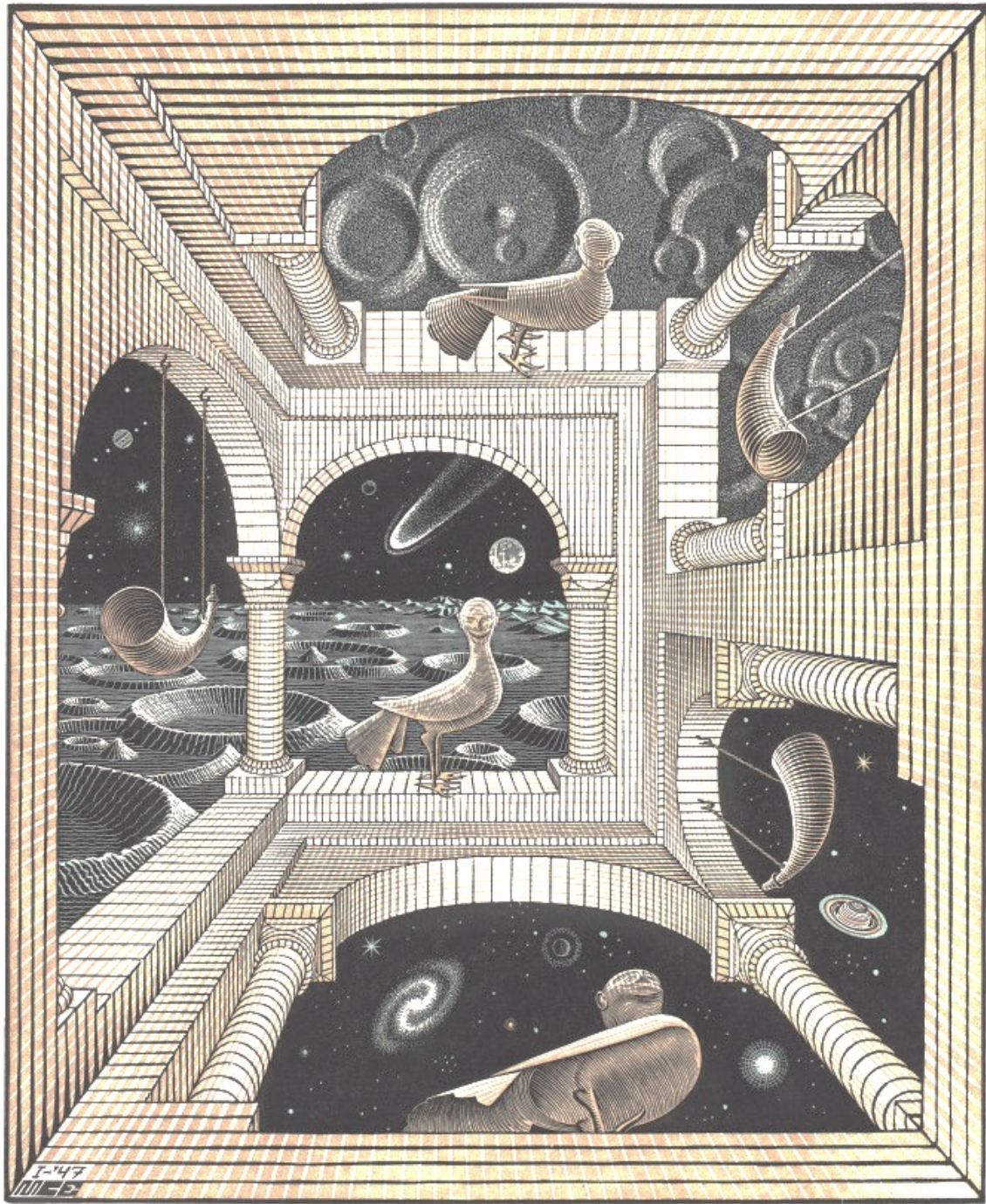
- › Application domains
 - › Built environment
 - › Groundwater
 - › Energy/mining
- › Leading GSO
 - › 3D modelling
 - › Geodata & IT



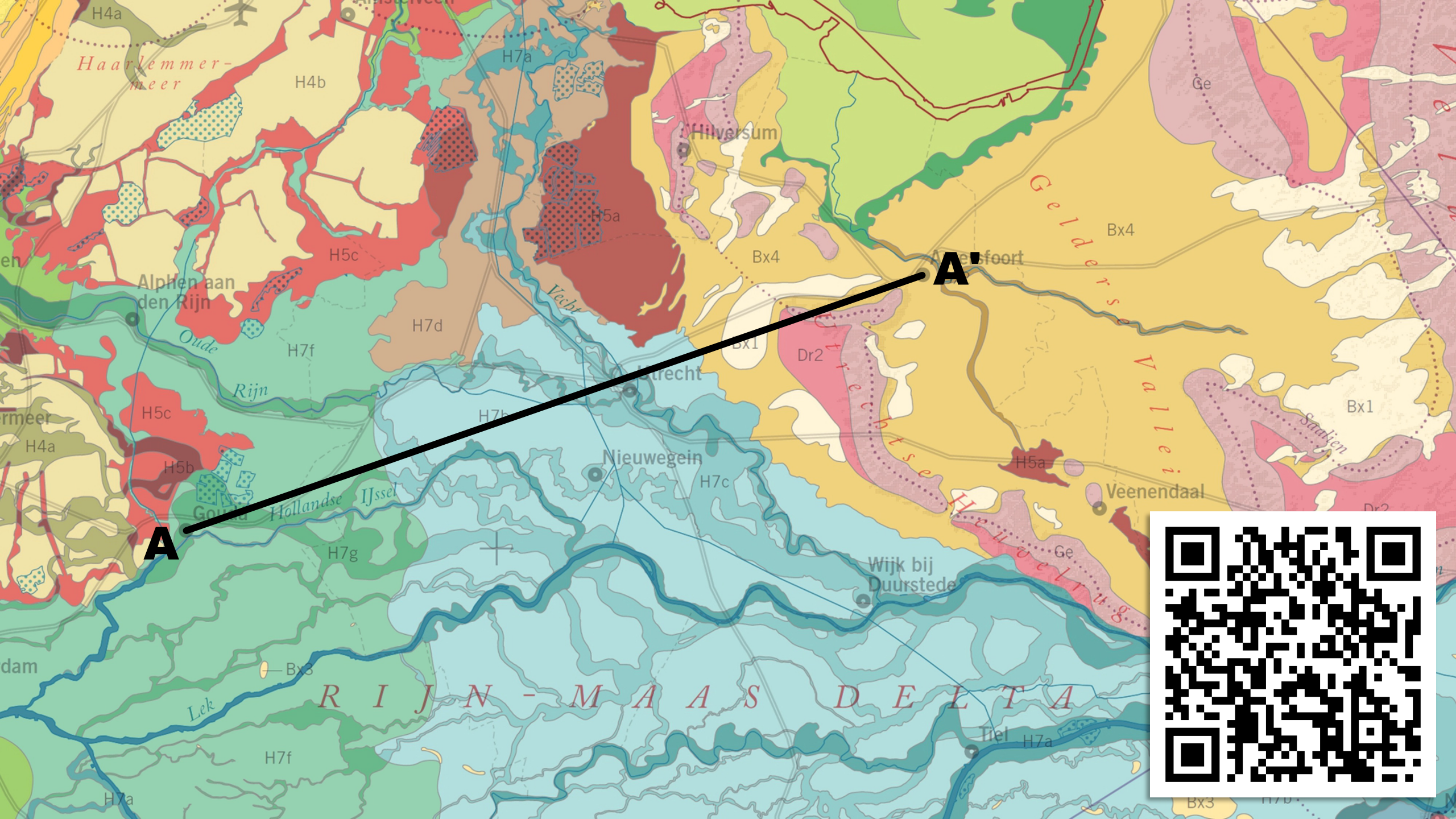
› GRAND CHALLENGES IN A SMALL COUNTRY

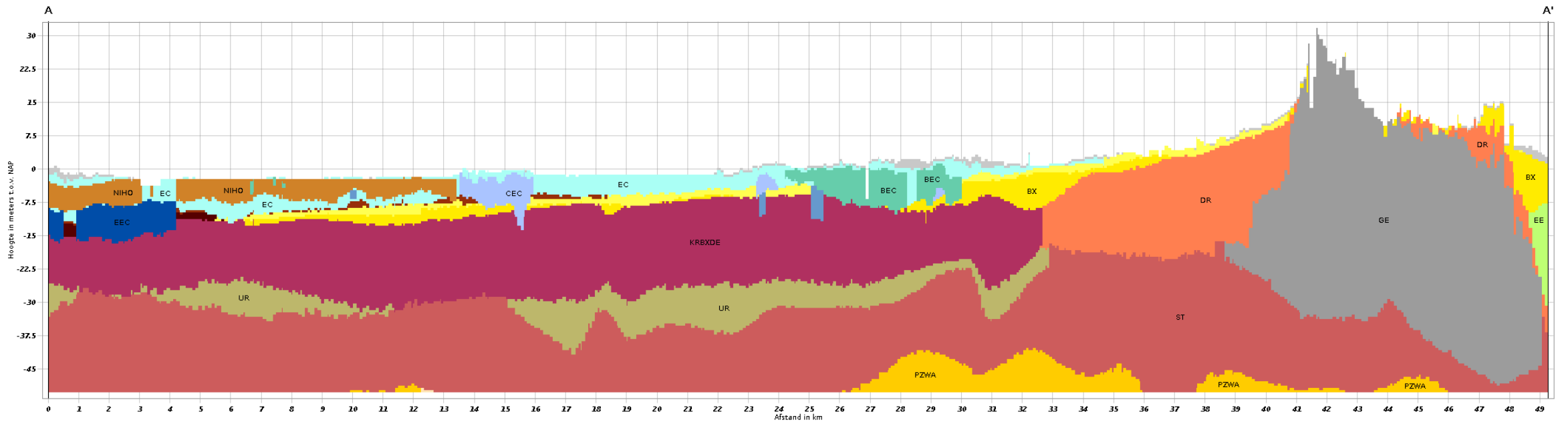
- › Built environment
 - › housing shortage
 - › subsidence
 - › long-term habitation of the Dutch lowlands
- › Groundwater
 - › management and protection
 - › draught, strategic reserves
- › Energy
 - › ...transition
 - › conflicts of use





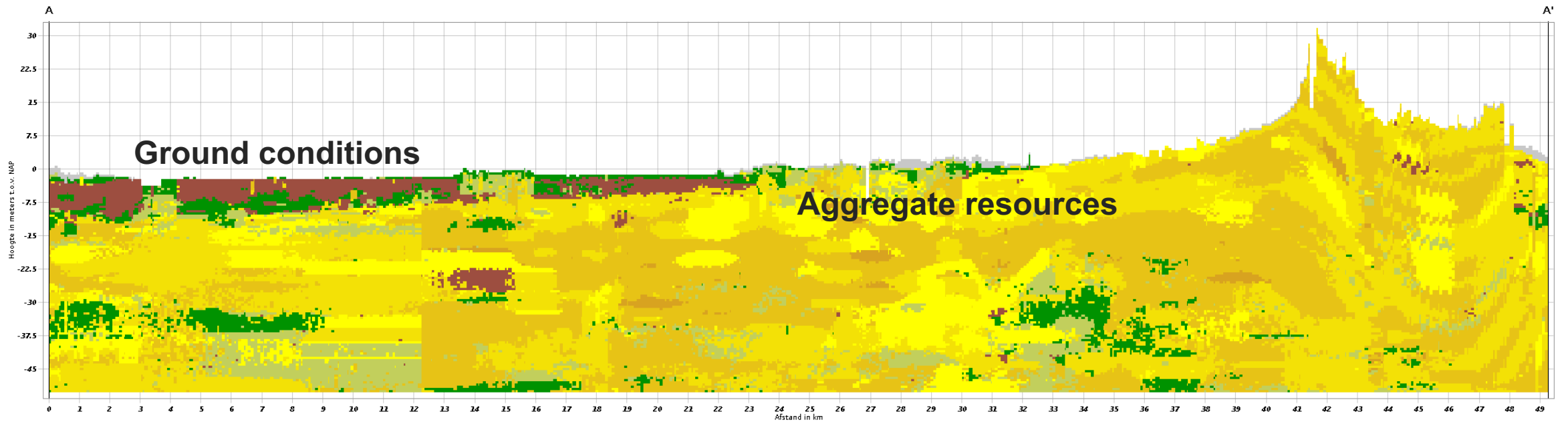
A proper three-dimensional geological model is four-dimensional





GeoTOP (upper 10s): geology

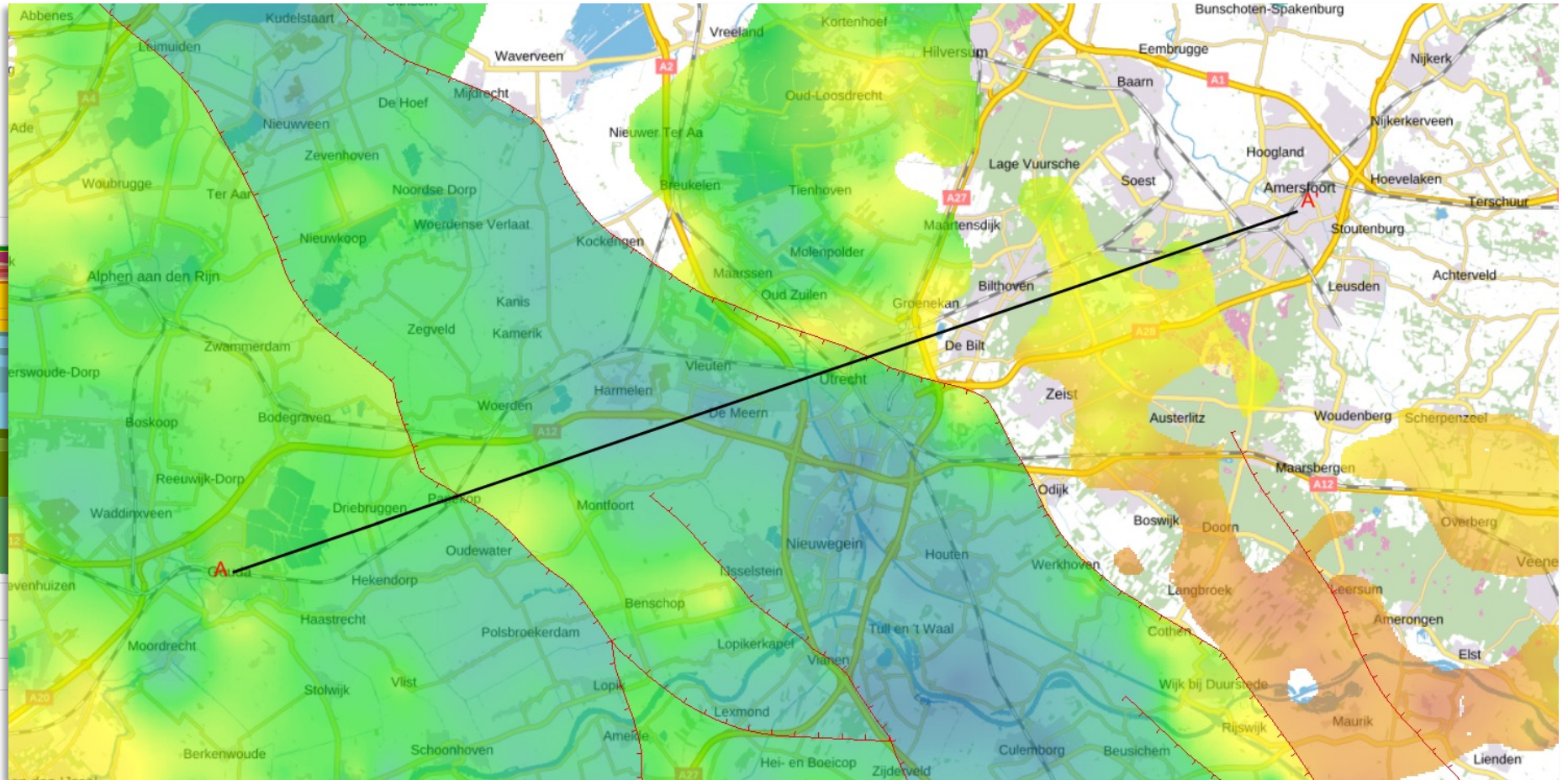
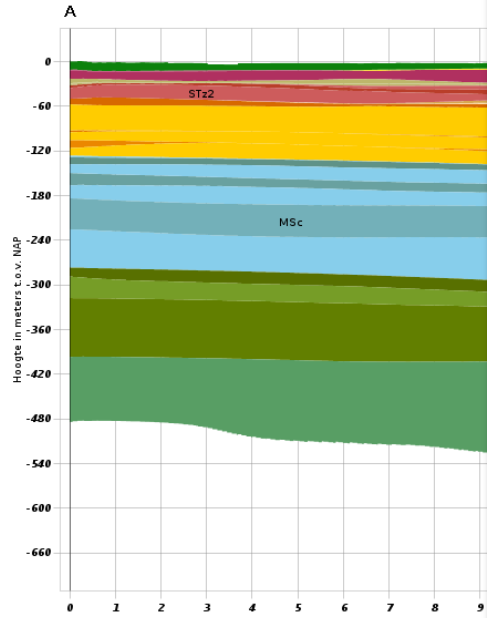




GeoTOP (upper 10s): lithology

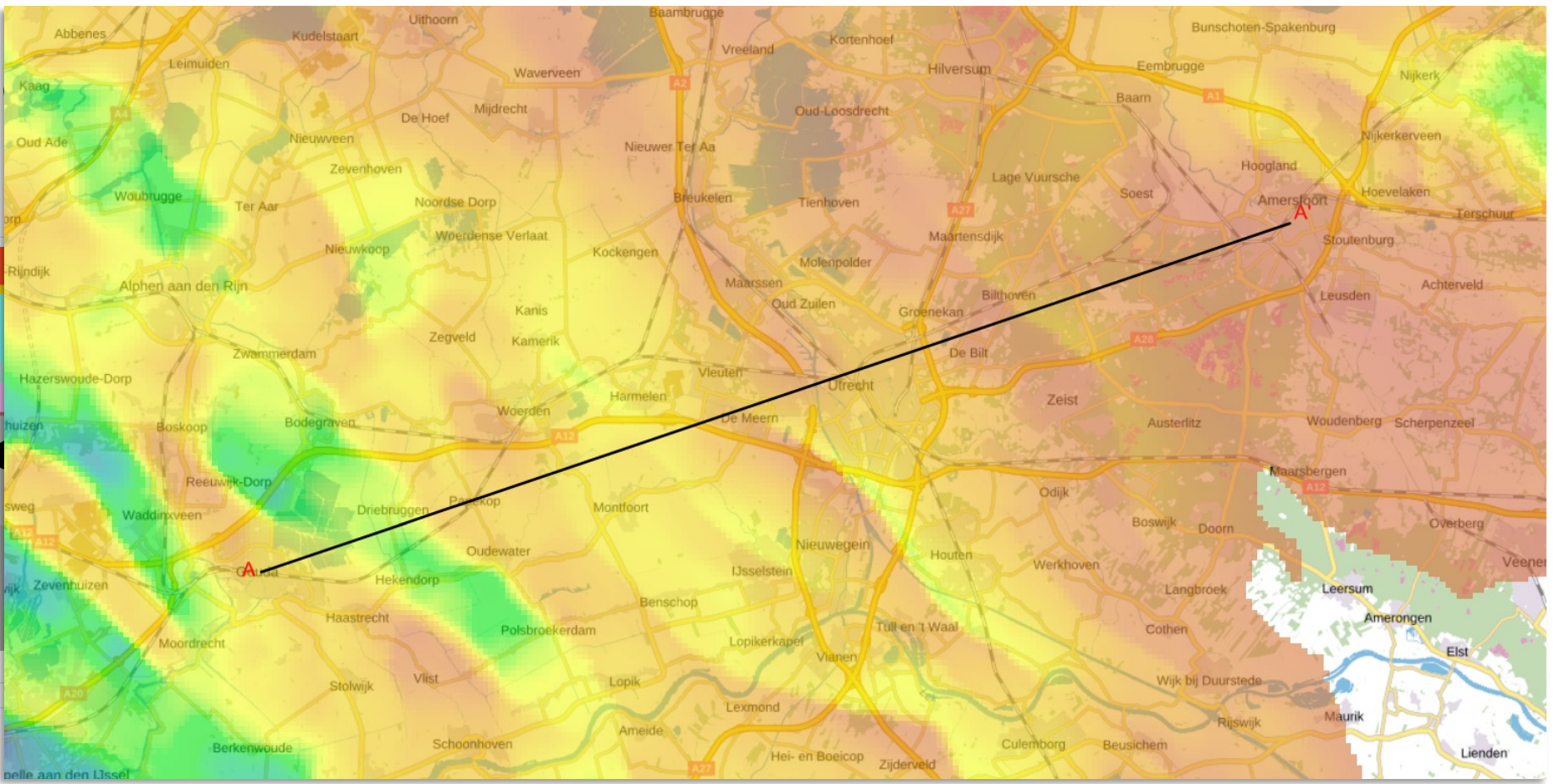
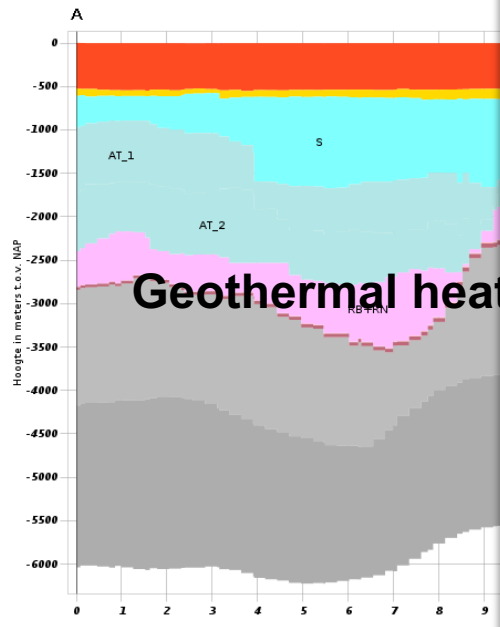


DGM / REGIS II



R I J N - M A A S D E L T A

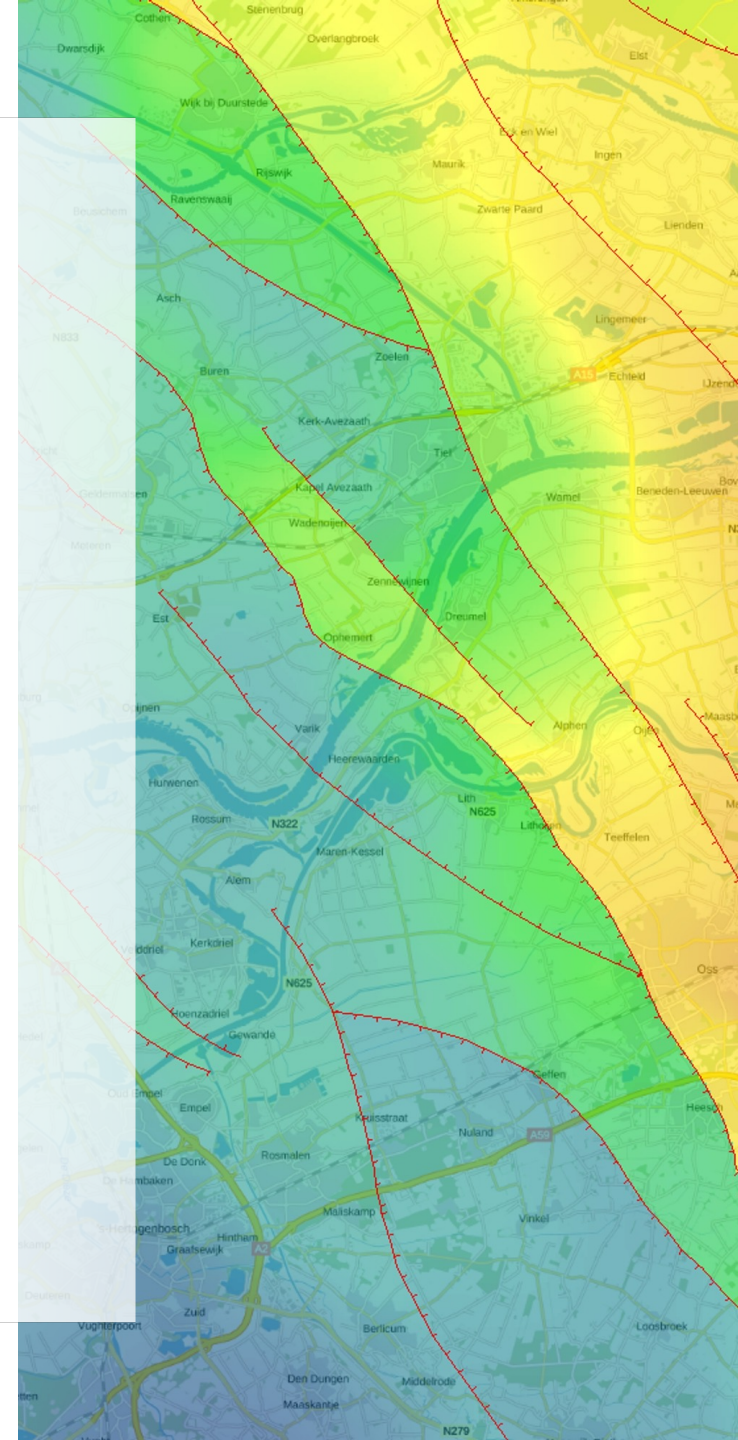
DGM deep (upp



R I J N - M A A S D E L T A

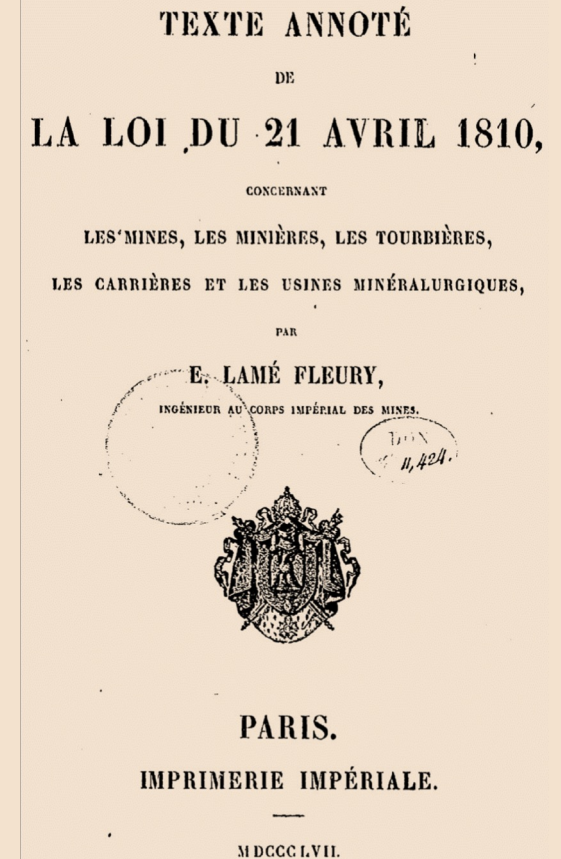
KEY STEPS

- › 1980s and 1990s:
 - › Digitisation of data
 - › First subsurface mapping efforts
 - › Surface mapping terminated
- › 2000s
 - › Systematic subsurface mapping
 - › Workflow digitisation
 - › Integration
- › 2010s
 - › Professionalisation
 - › QC, versioning
 - › New law

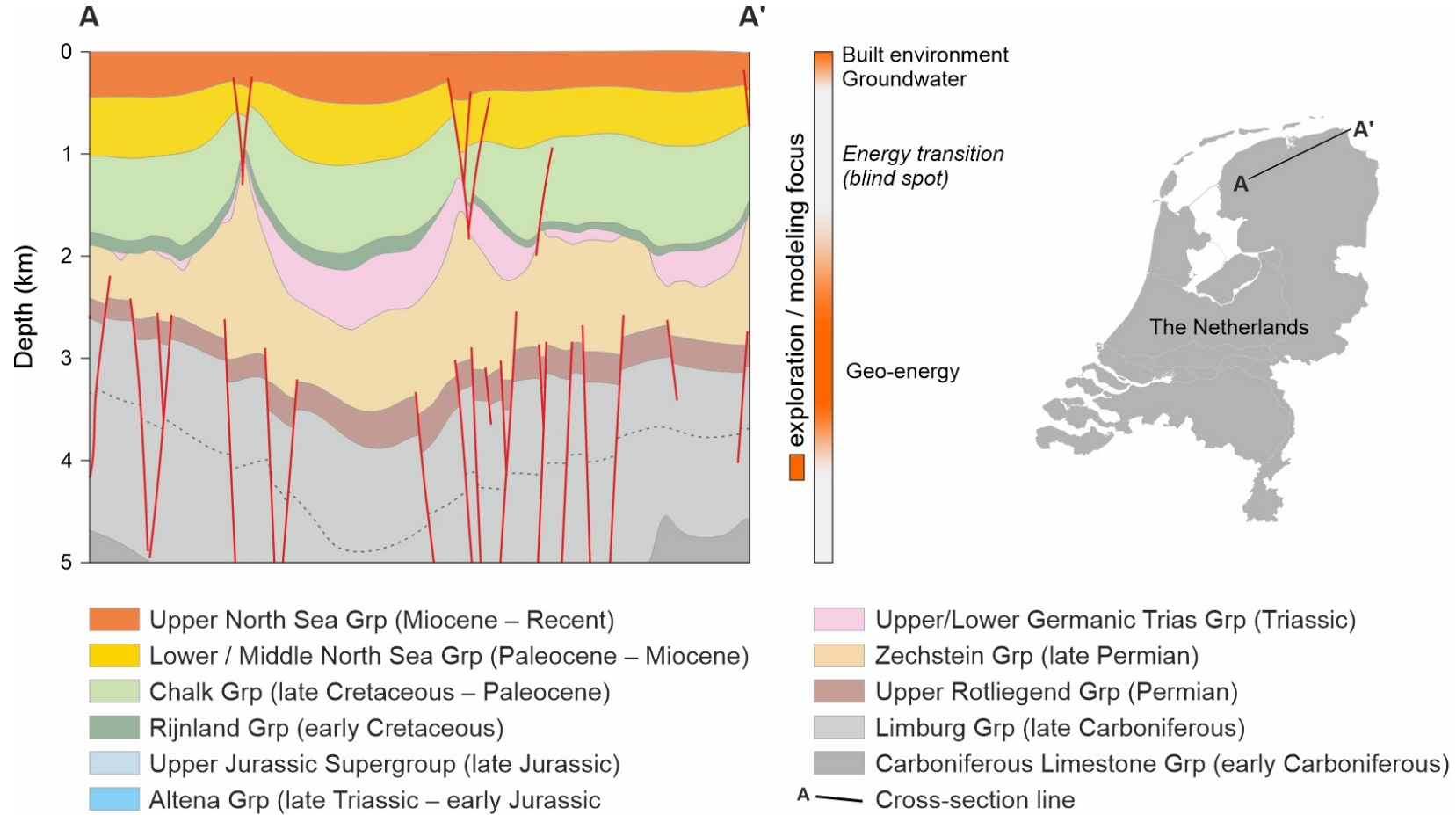


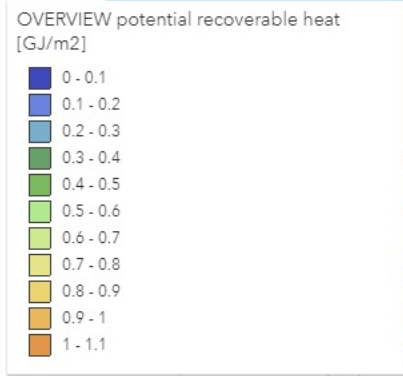
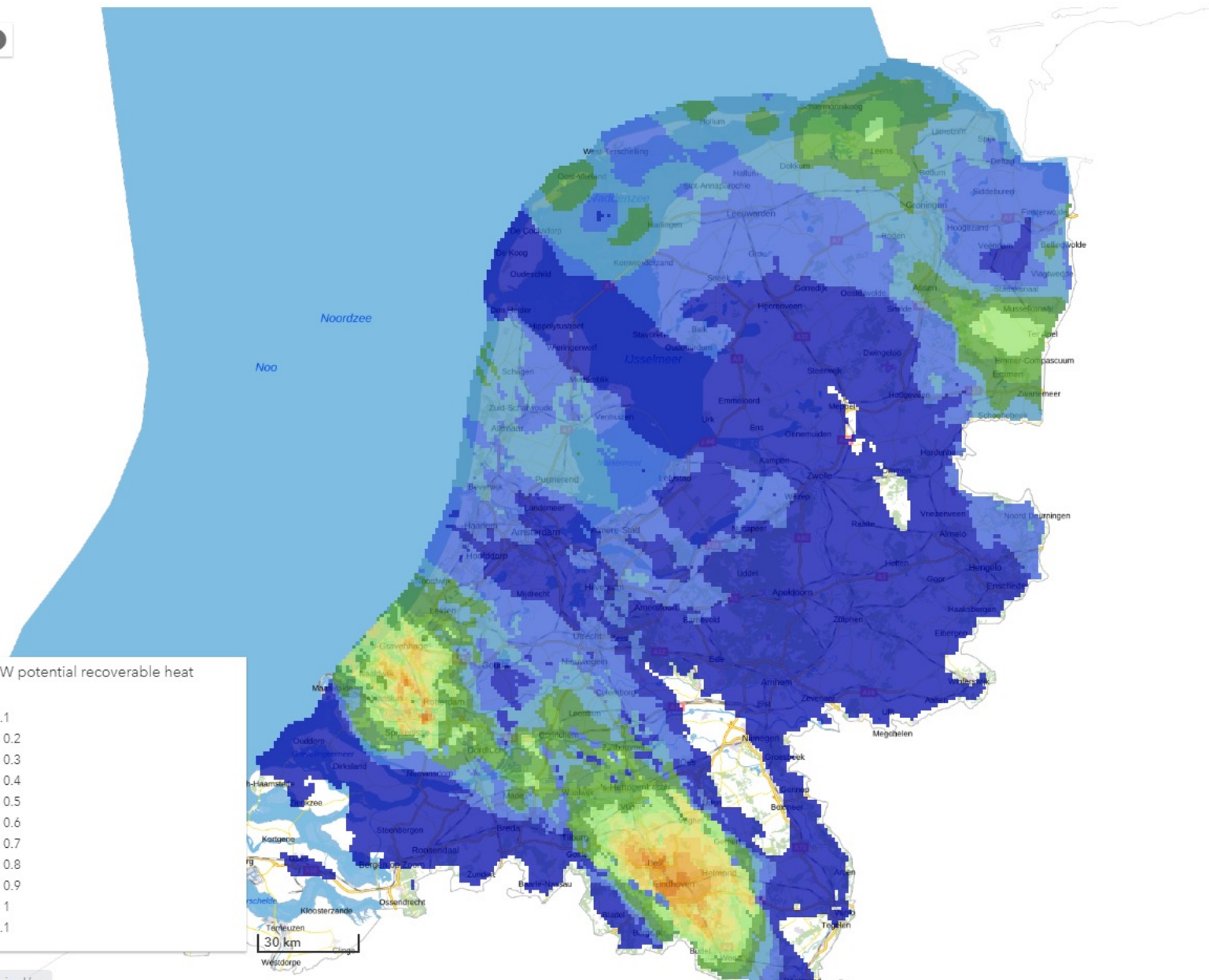
› LEGAL FRAMEWORK

- › Mining Act (... originally Napoleonic)
 - › Deep subsurface
 - › Data from licensed exploration and production
 - › Private data → public data
- › Key Registry for the Subsurface Act (2015)
 - › Shallow subsurface
 - › Public data and models in single registry
- › Geological data acquisition is a national effort
- › Model use is regulated



› NEXT STEPS





Overview Detailed Thematic

Selection Calculation

View general maps for the entire Netherlands.

▼ **Property: Potential recoverable heat**

Scenario: Well stimulation Heat pump

Probability: P90 P50 P10

"White spots"

Economic potential

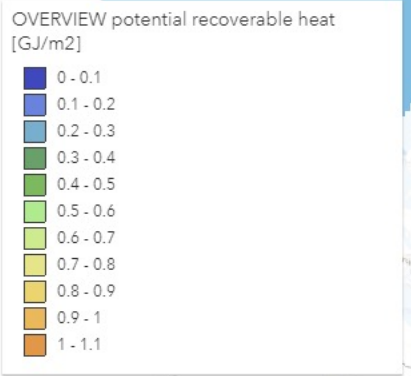
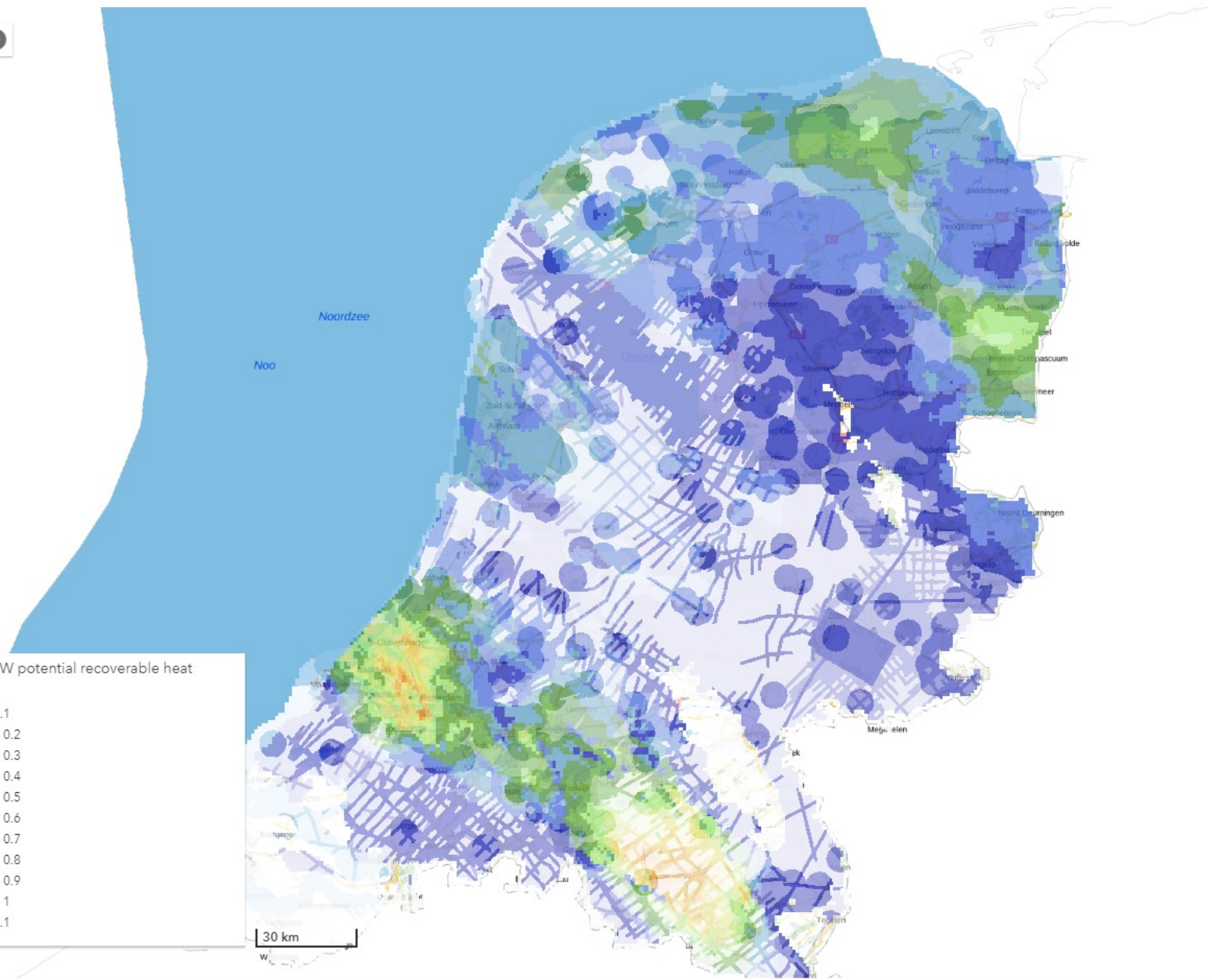
Technical potential

Power

Potential recoverable heat

Heat in place

Lat: 52.8271 Long: 8.6247



Overview Detailed Thematic

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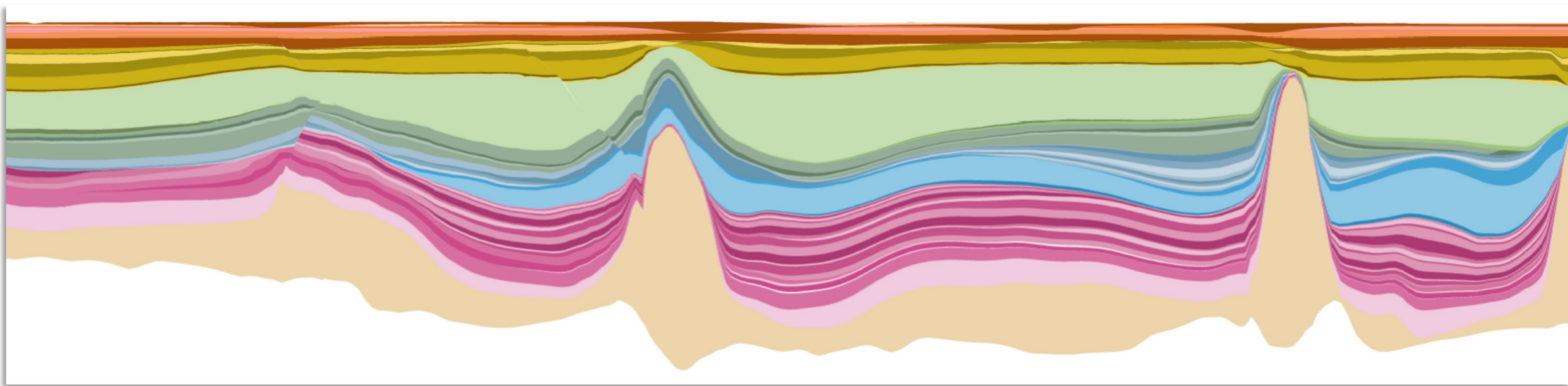
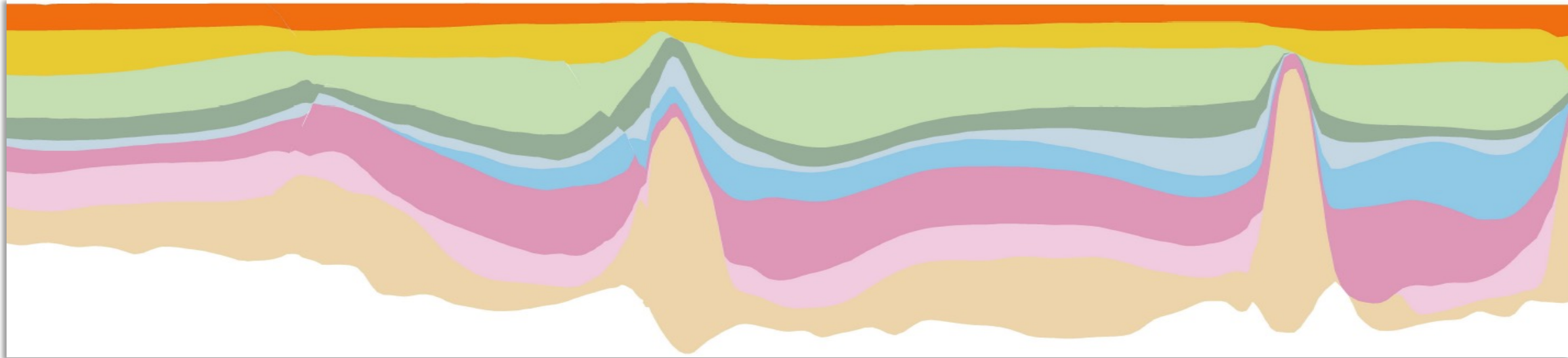
Power

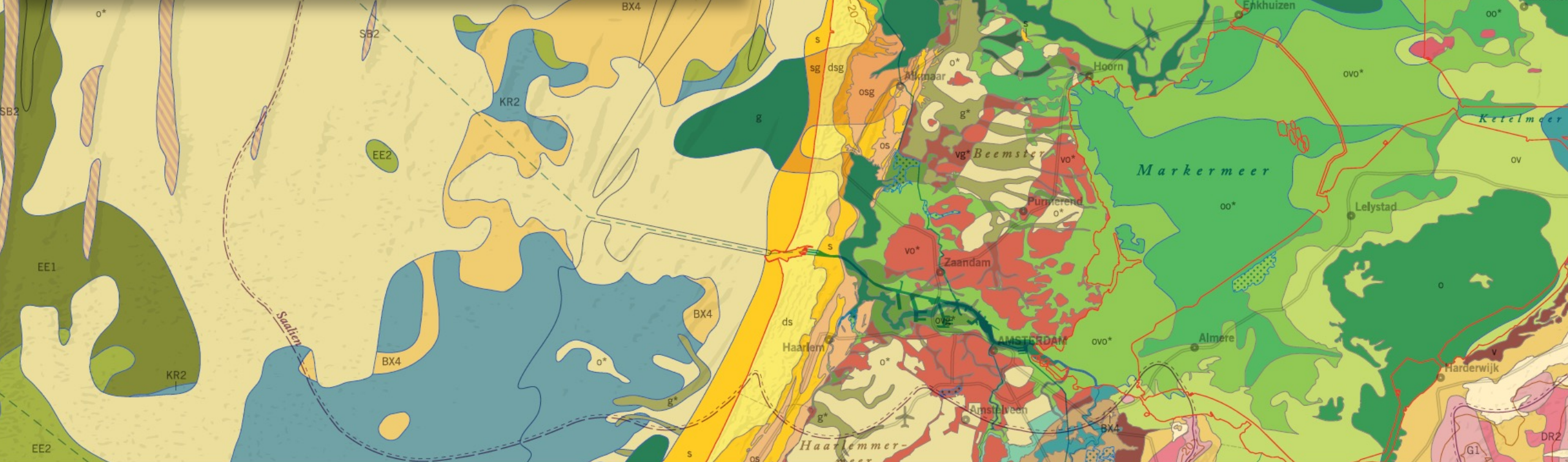
Potential recoverable heat

Heat in place

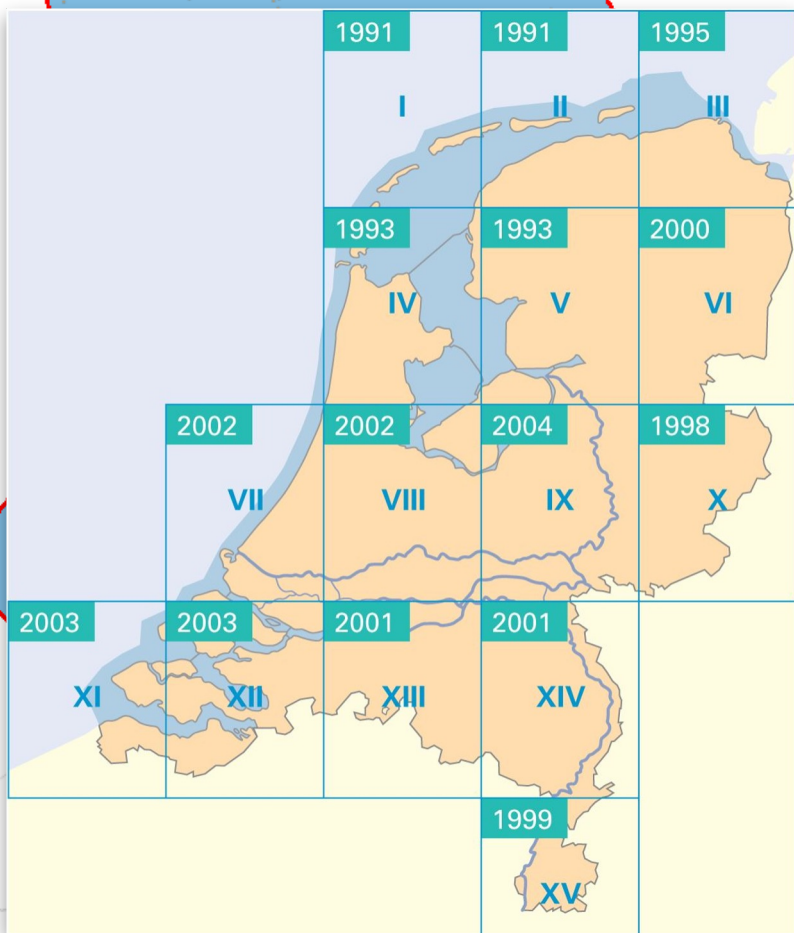
4 km

1 km





DGM-Deep



DGM
REGIS-II

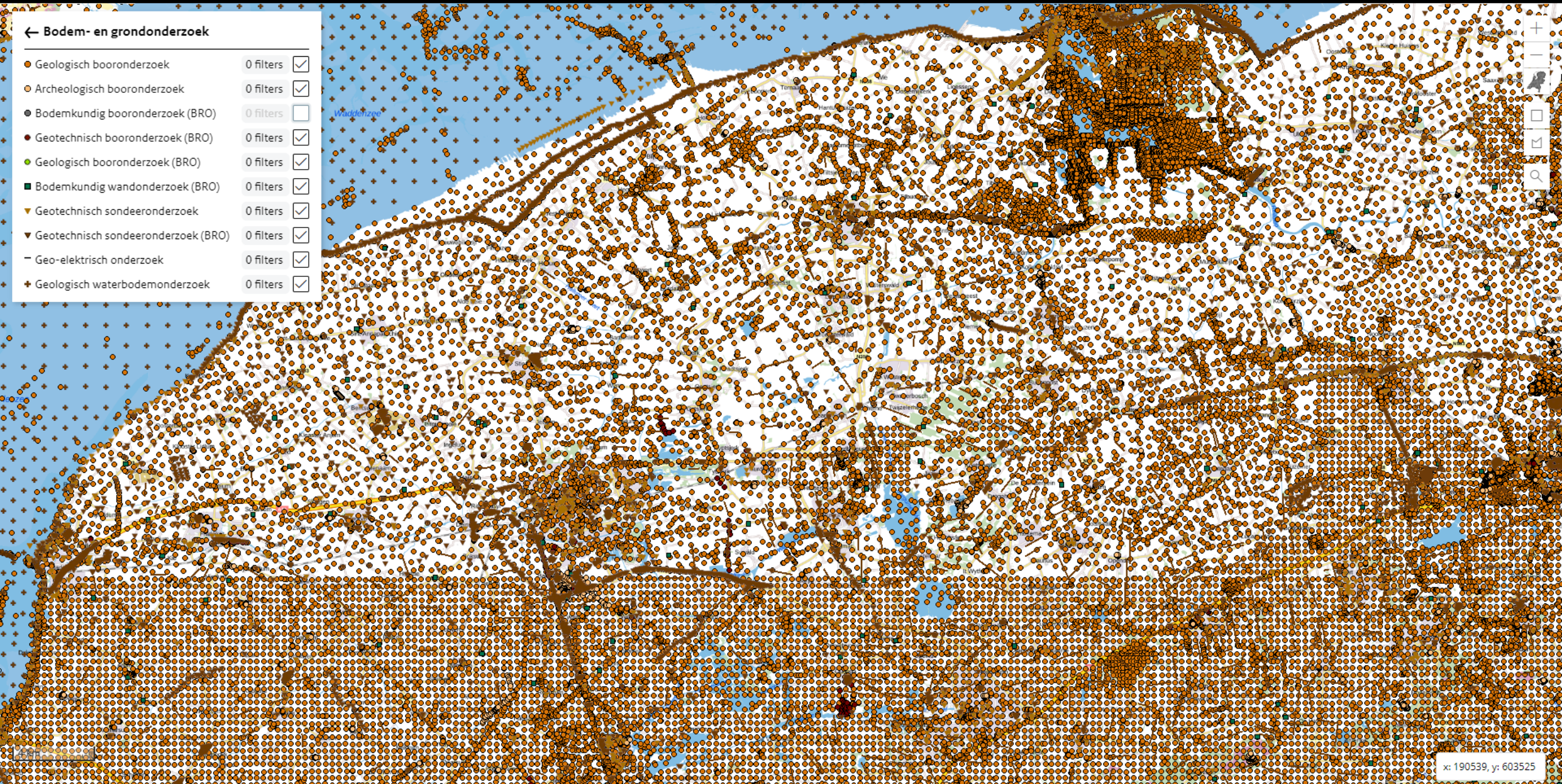


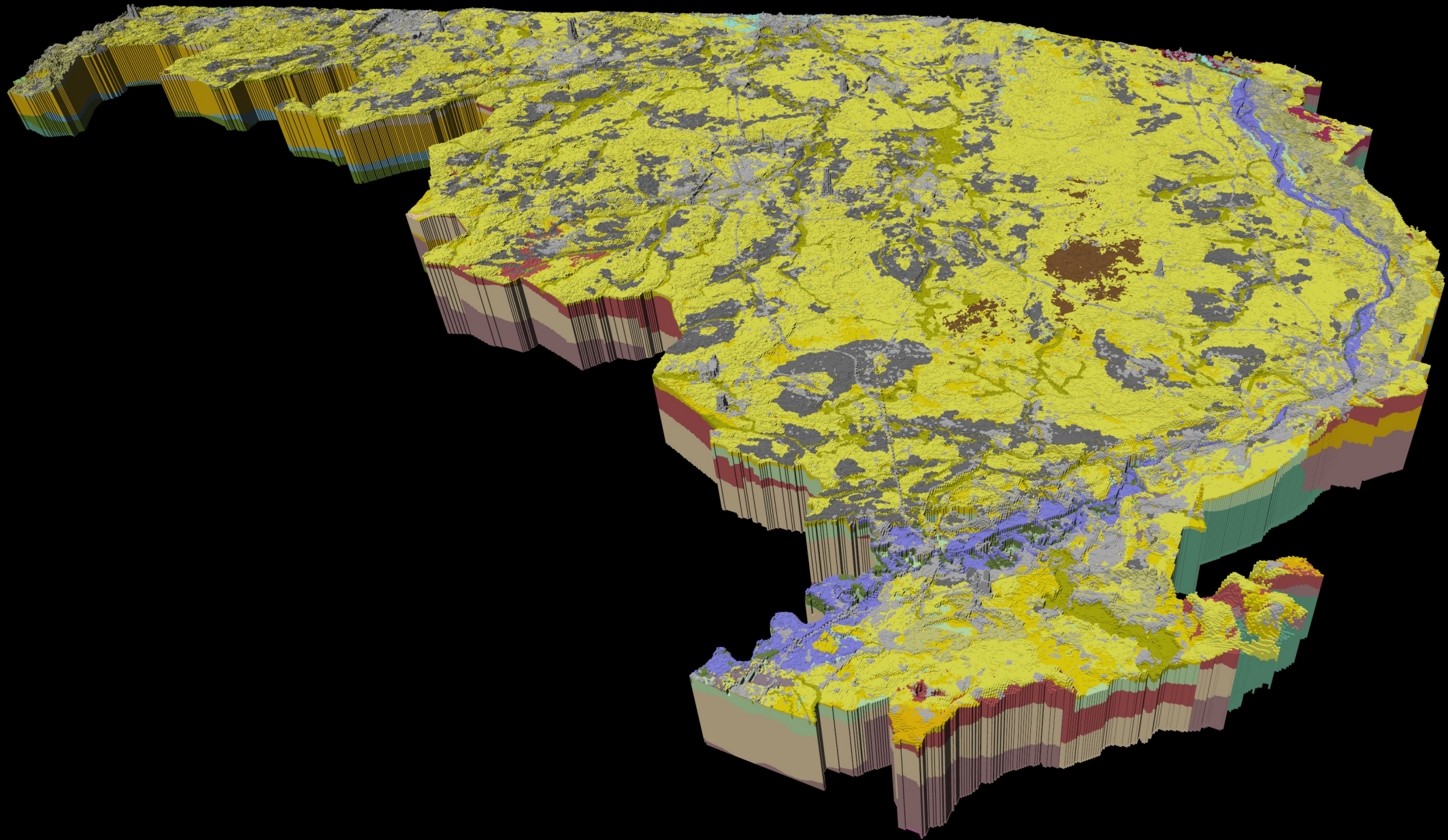
GeoTOP



← Bodem- en grondonderzoek

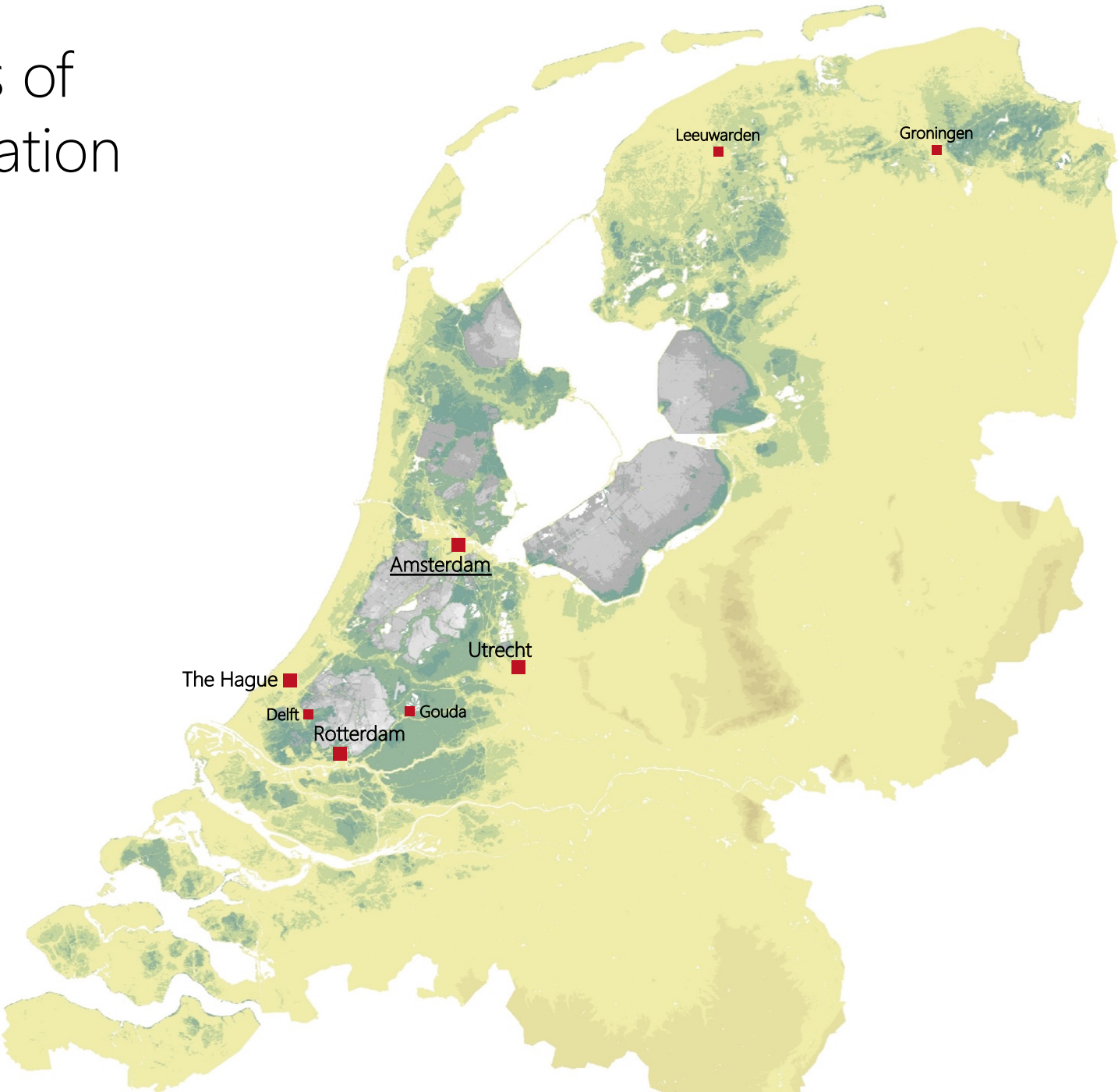
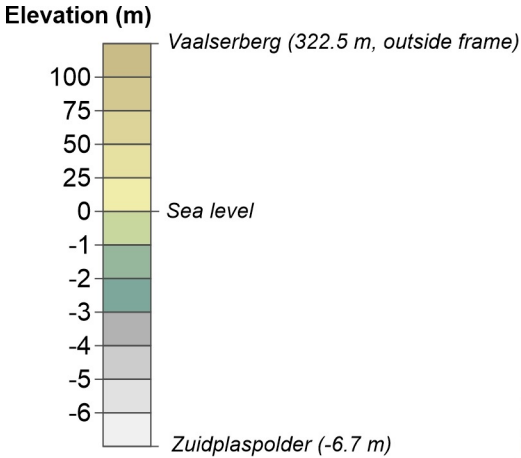
- Geologisch booronderzoek 0 filters
- Archeologisch booronderzoek 0 filters
- Bodemkundig booronderzoek (BRO) 0 filters
- Geotechnisch booronderzoek (BRO) 0 filters
- Geologisch booronderzoek (BRO) 0 filters
- Bodemkundig wandonderzoek (BRO) 0 filters
- Geotechnisch sondeeronderzoek 0 filters
- Geotechnisch sondeeronderzoek (BRO) 0 filters
- Geo-elektrisch onderzoek 0 filters
- Geologisch waterbodemonderzoek 0 filters







Subsidence due to 1,000 years of Dutch coastal peatlands cultivation



The theoretical end-product of current water management practices





From considering time to representing it;
towards proper predictive geoscience.

Applied Multidimensional Geological Modeling

*Informing sustainable
human interactions with
the shallow subsurface*

Edited by
*Alan Keith Turner
Holger Kessler
Michiel J. van der Meulen*



WILEY Blackwell

