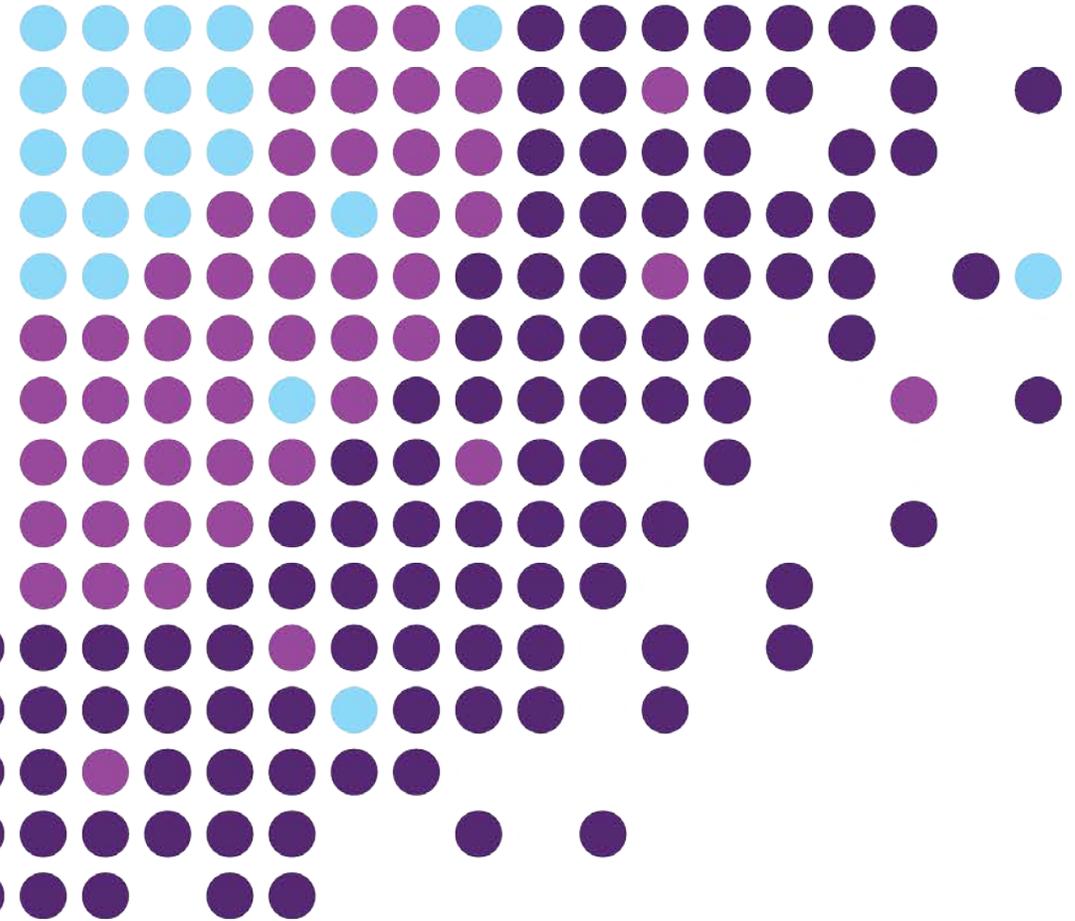


VoGERA



sck cen
Belgian Nuclear Research Centre

Koen Beerten, Alberto Casillas-Trasvina, and VOGERA team members - 23/06/2020

Groundwater at the receiving end: taking into account deep subsurface activities

VoGERA

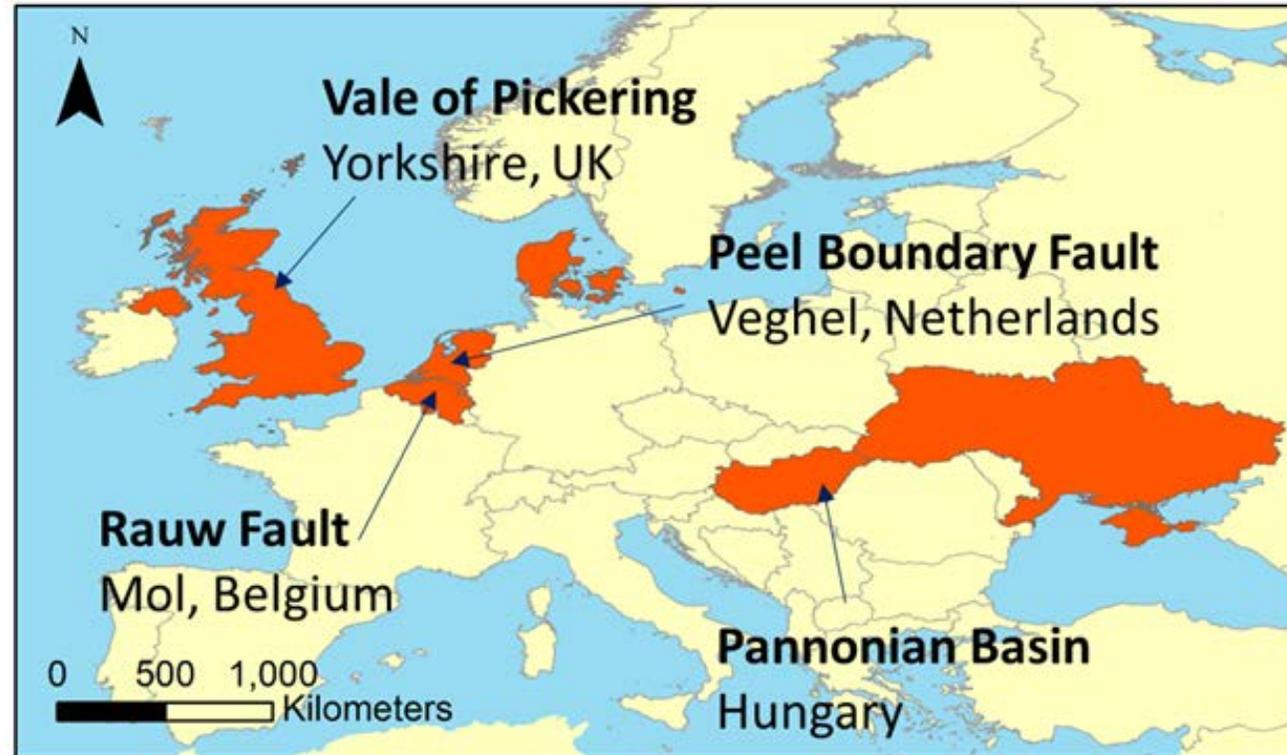
Vulnerability Of shallow Groundwater resources to deep sub-surface Energy Related Activities

Aims

- Improve scientific understanding of the vulnerability of shallow groundwater (e.g. potable water, water for other human uses and water supporting ecosystems) from deep sub-surface industrial energy-related activities.
- Develop a consistent approach to assessing a range of sub-surface energy activities including:
 - Conventional oil and gas
 - Geothermal energy
 - Unconventional oil and gas
 - Storage (e.g., energy, gas)
 - Waste disposal

Project partners and pilot sites

- BGS (UKRI) - UK
- TNO - NL
- VMM - B
- SCK CEN - B
- MBFSZ - H
- Geoinform - UA
- GUES - DK



Total budget: € 433782

Approach

- (1) Develop conceptual models of the sub-surface activities with possible pathways of contamination to groundwater
- (2) Use evidence to assess possible pathways (e.g. fault zones/abandoned wells) at pilot locations such as:
 - Stable isotopes
 - Dating/residence time indicators
 - Temperature
 - Hydraulic head
 - Groundwater flow data
 - 3D geological models
- (3) Develop framework for assessing vulnerability of shallow groundwater from the energy-related activities:
 - That can be applied across a range of European hydrogeological settings
 - Than can be used as a tool for regulators and decision makers
- (4) Test vulnerability framework at pilot sites and modify according to results

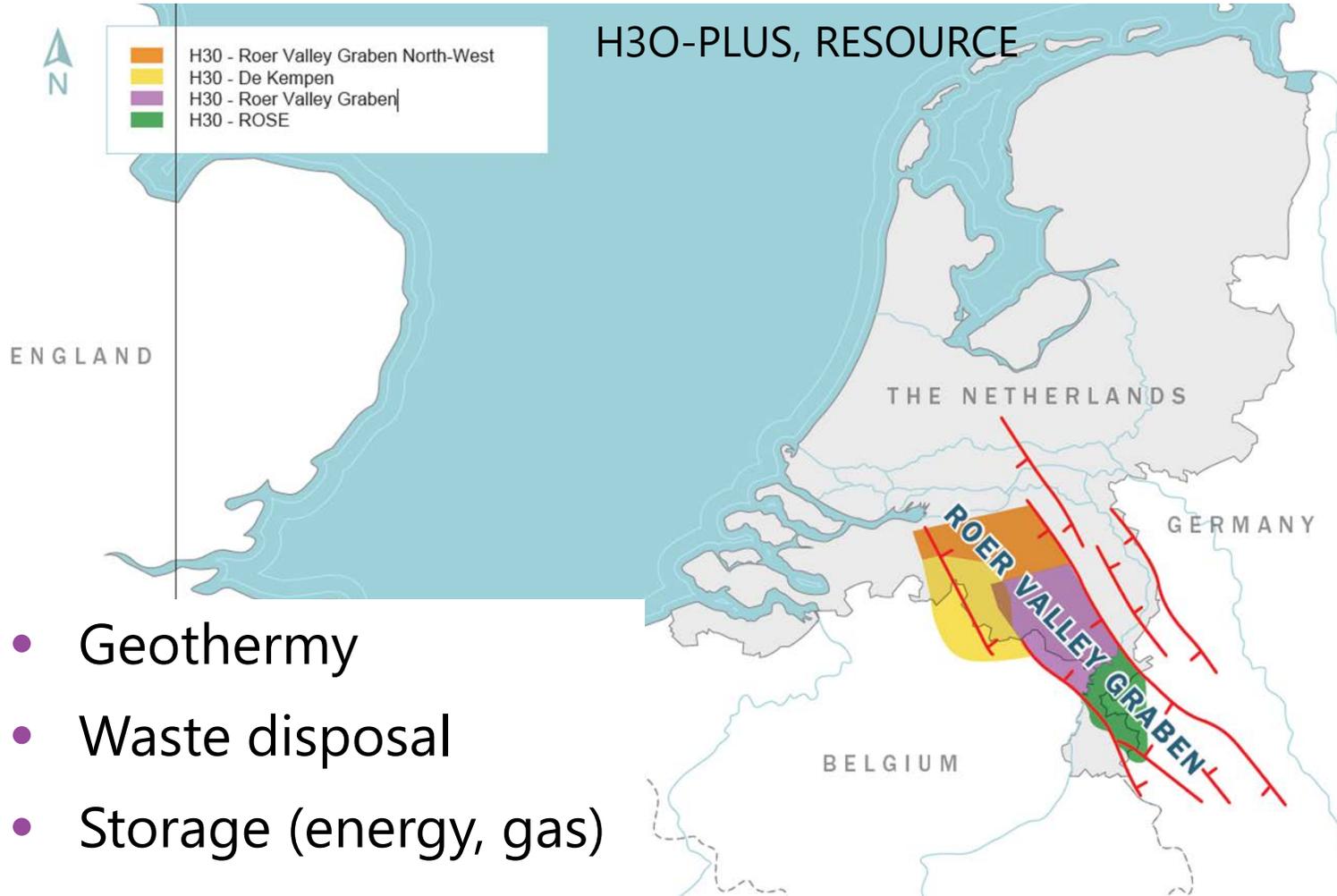


Expected outcomes

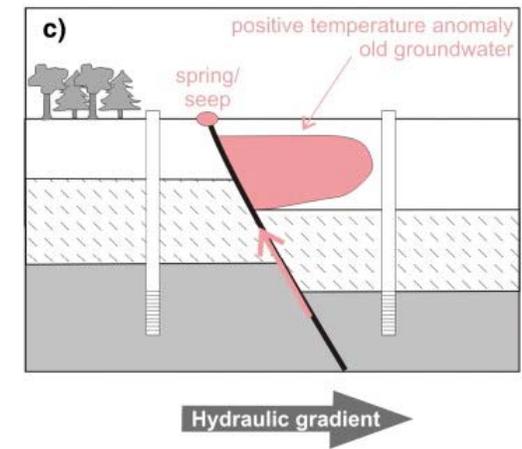
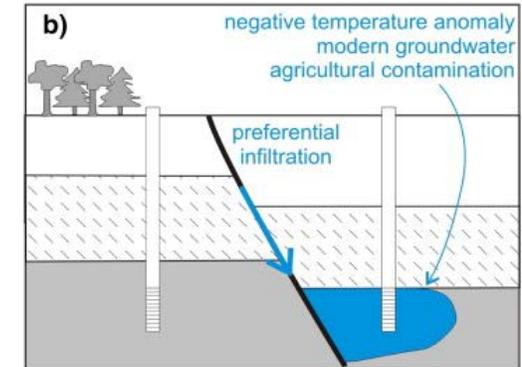
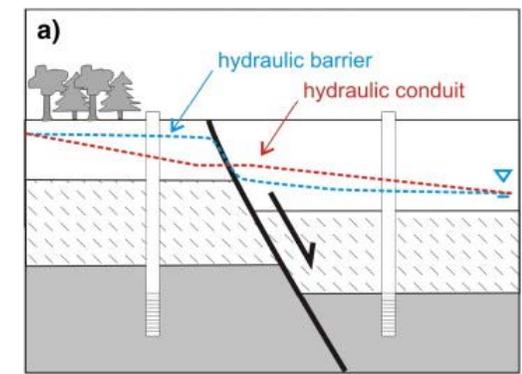
- Improved understanding of groundwater vulnerability to a range of energy related activities
- Improved sub-surface spatial planning and decision making
- Consistent approach for assessing groundwater vulnerability across Europe



Pilot sites: Roer Valley Graben faults



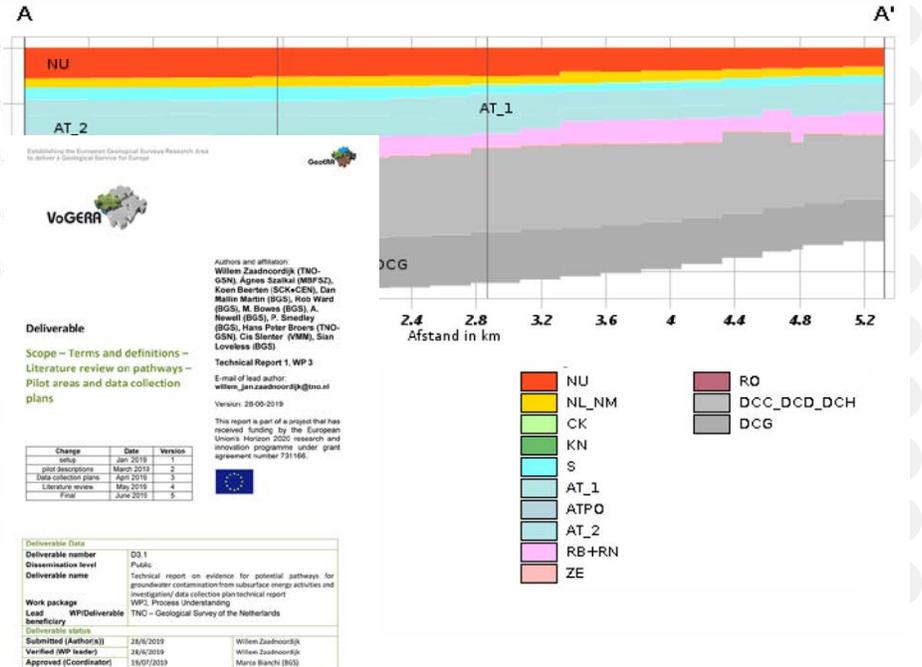
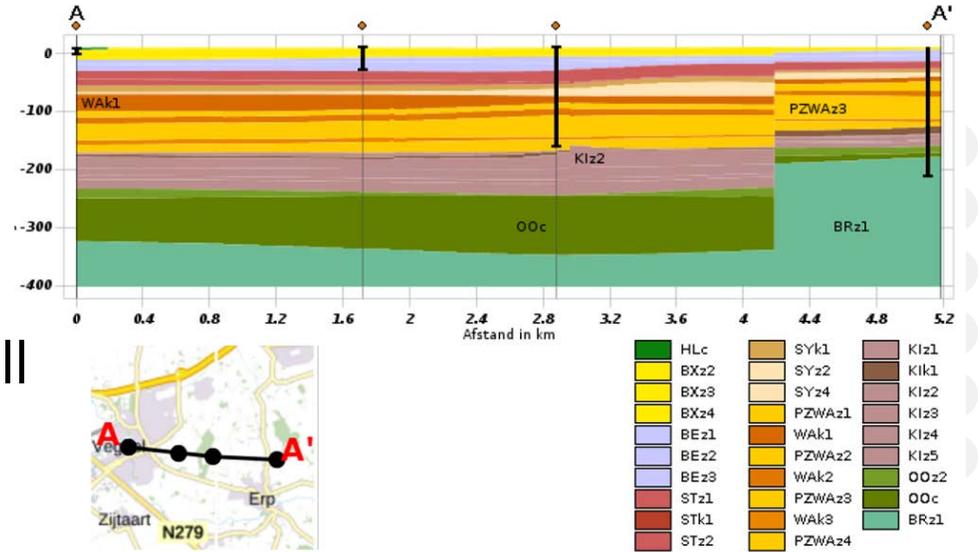
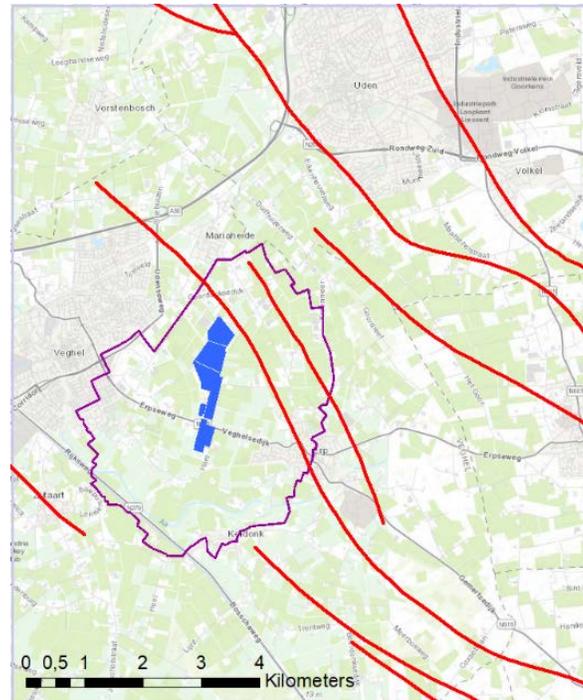
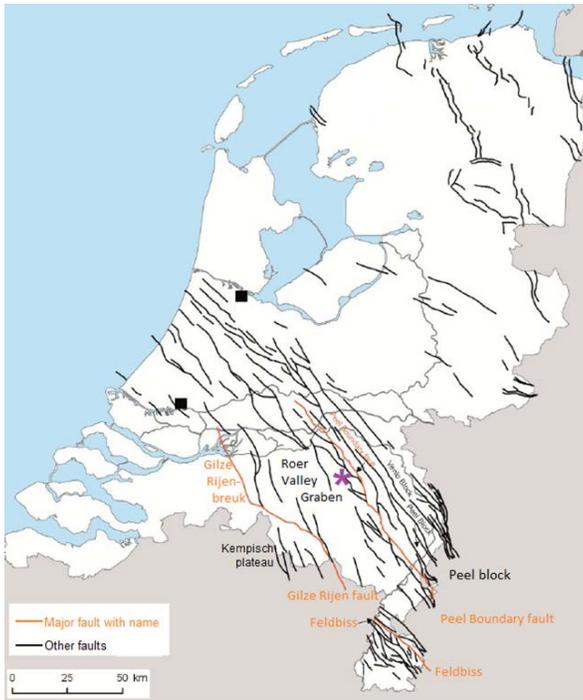
- Geothermy
- Waste disposal
- Storage (energy, gas)



Bense et al. Earth Science Reviews 2013

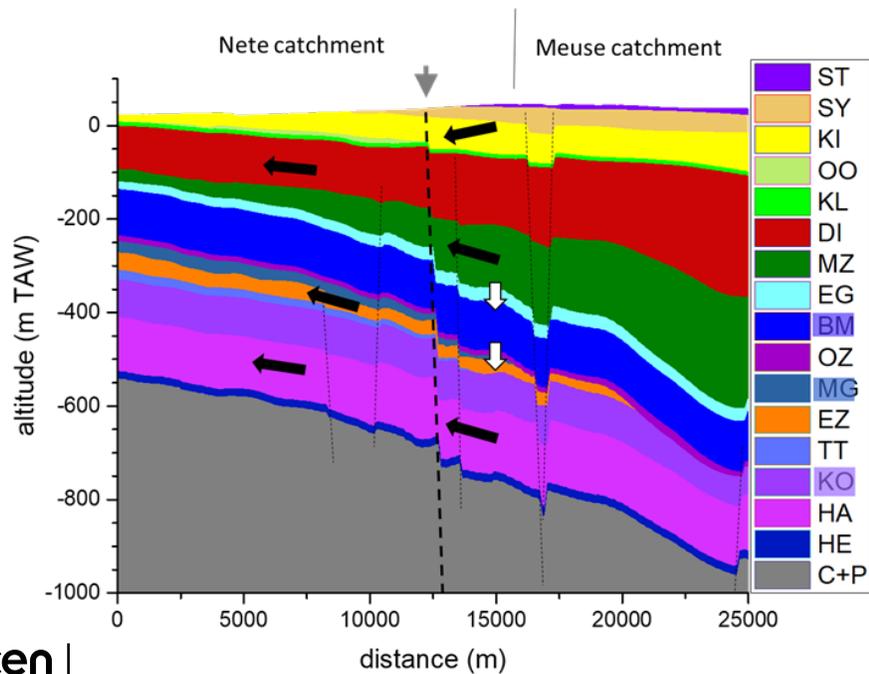
Peel Boundary Fault near Veghel (NL)

- Currently no deep subsurface activities
- One abandoned hydrocarbon exploration well
- Drinking water abstraction



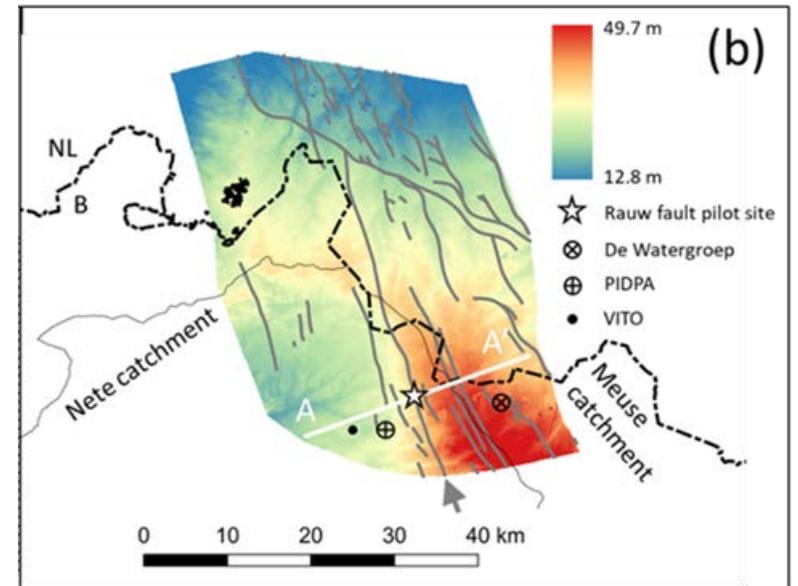
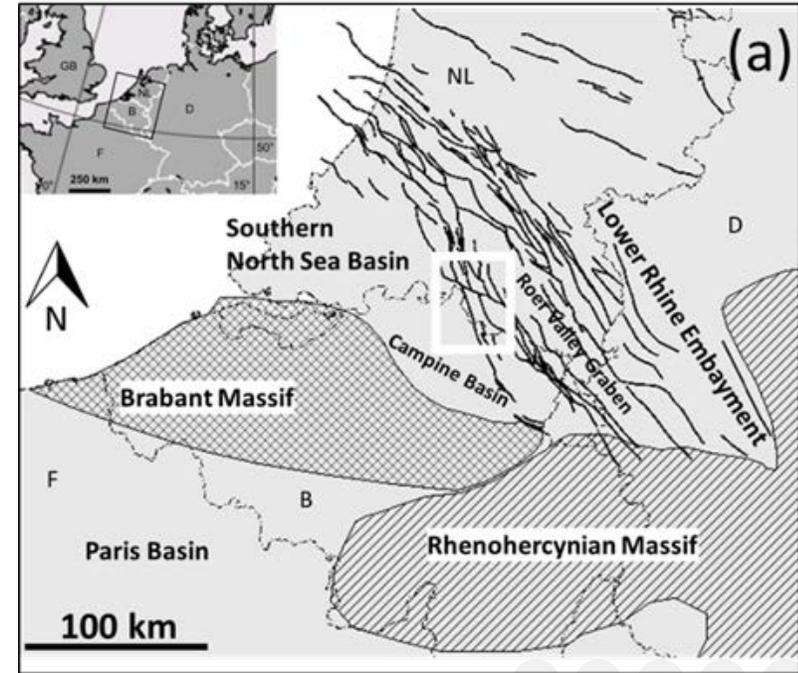
The Rauw Fault near Mol (B)

- Geothermal well
- Planned activities
- Drinking water abstraction

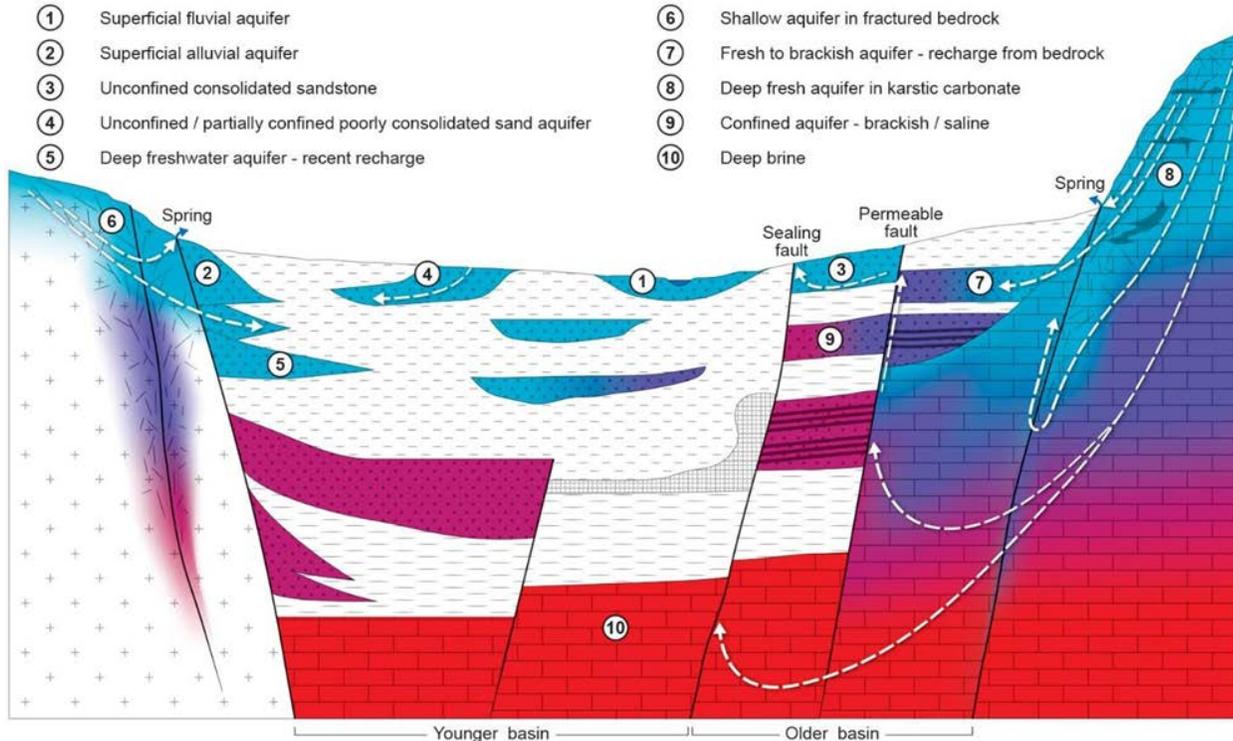


Water flow direction in the aquifers

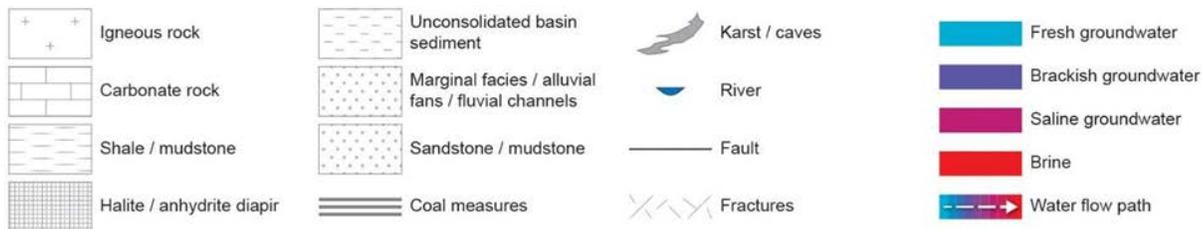
Direction of pressure gradient through the Boom Clay aquitard



Pathways and receptors



- ① Superficial fluvial aquifer
- ② Superficial alluvial aquifer
- ③ Unconfined consolidated sandstone
- ④ Unconfined / partially confined poorly consolidated sand aquifer
- ⑤ Deep freshwater aquifer - recent recharge
- ⑥ Shallow aquifer in fractured bedrock
- ⑦ Fresh to brackish aquifer - recharge from bedrock
- ⑧ Deep fresh aquifer in karstic carbonate
- ⑨ Confined aquifer - brackish / saline
- ⑩ Deep brine



Deliverable

D4.1 Expanded diagrams of conceptual models identifying potential pathways for energy activity in the deep sub-surface and shallow groundwater vulnerability

Authors and affiliation:
Sian Loveless (BGS), Dan-Mallin-Martin (BGS), Ágnes Szalkai (MBFSZ), Willem Zaadnoordijk (TNO-GSN), Cis Slenter (VMM), Koen Beerten (SCK•CEN), Rob Ward (BGS)

Report 1, WP 4

E-mail of lead author:
sian@bgs.ac.uk

Version: 10-07-2019

Change	Date	Version
Final v1	10/07/2019	1

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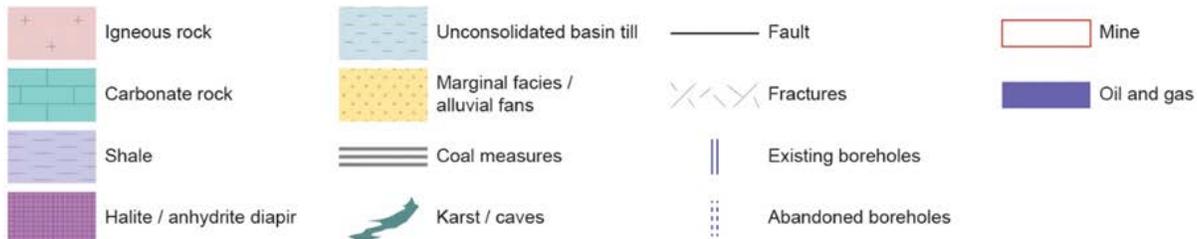
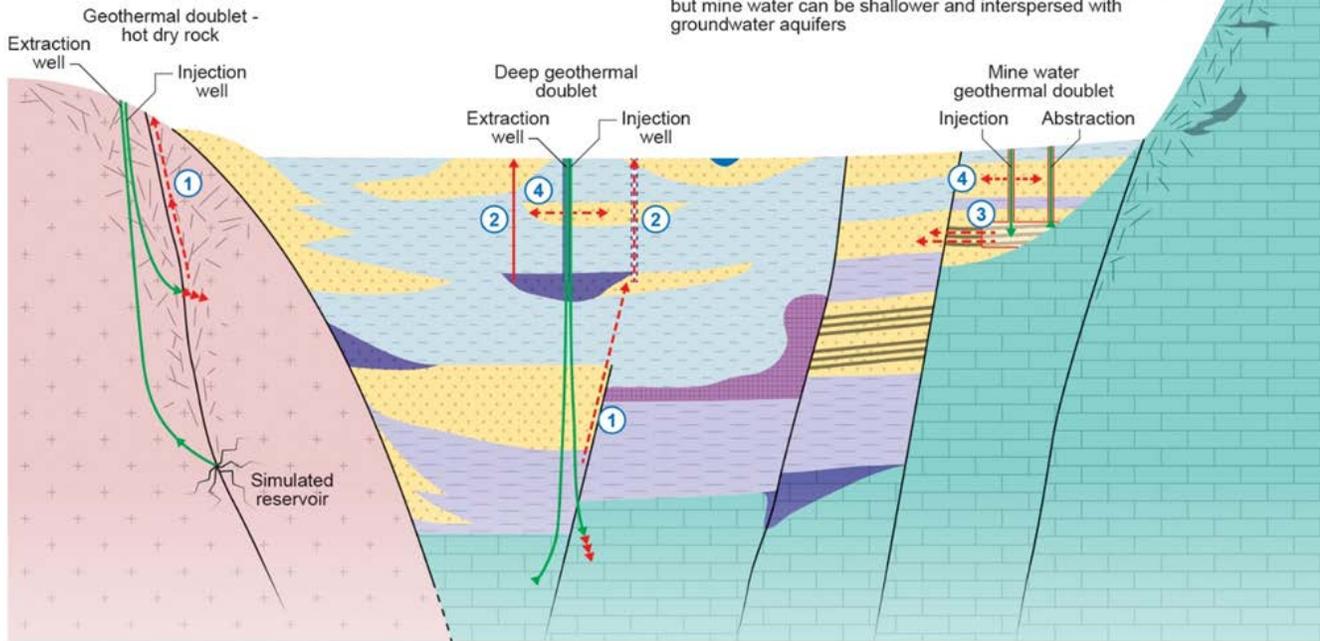


Geothermal energy

- ① Injection into permeable zone. Upwards pressure, could cause transport along fracture zone
- ② Mobilised / released contaminants travel along leaky boreholes into groundwater

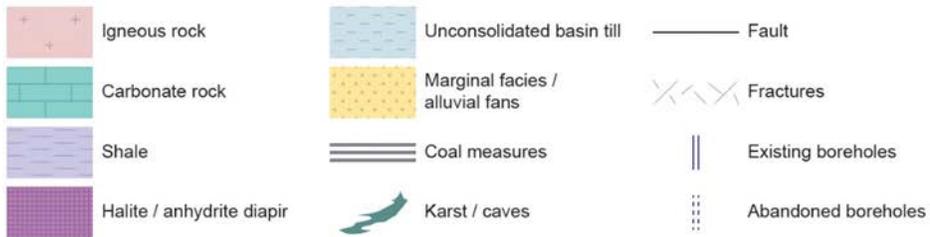
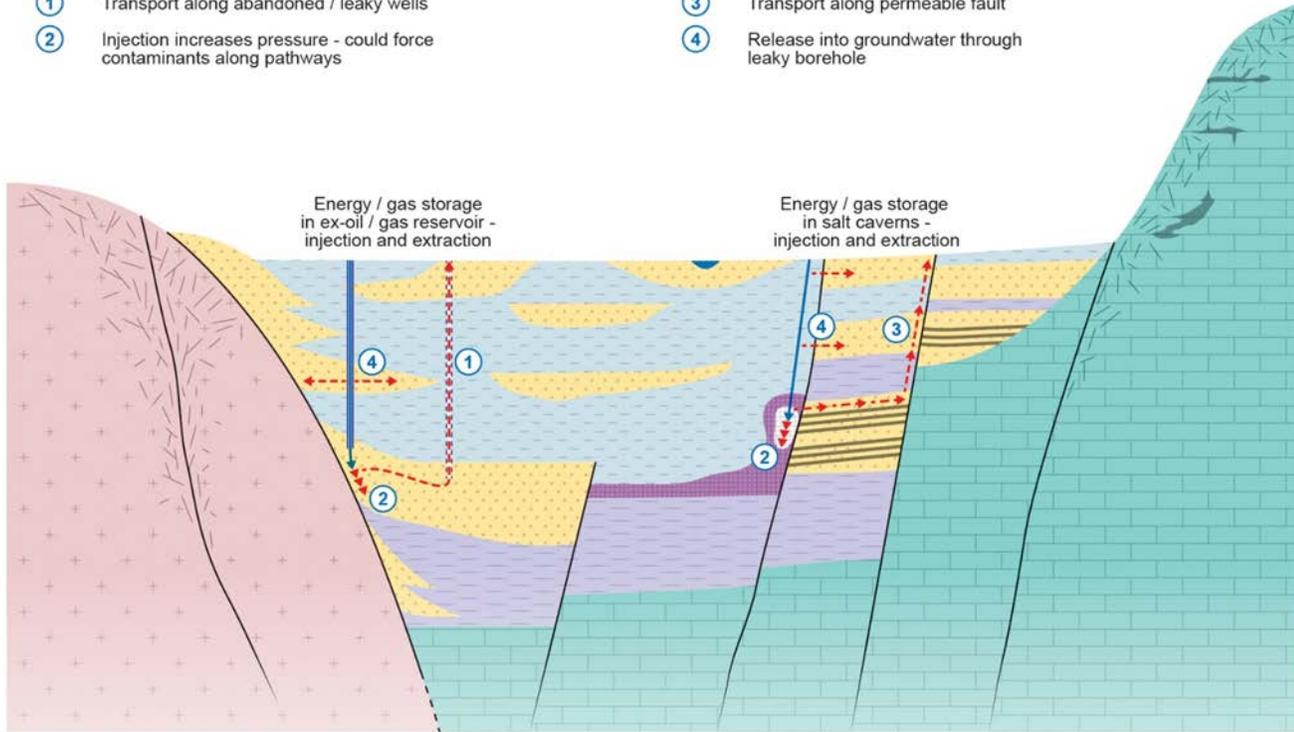
- ③ Transport through mine infrastructure
- ④ Release into groundwater through borehole

Due to need to get higher temperatures, geothermal generally at depths > 2 kilometres - well separated from groundwater, but mine water can be shallower and interspersed with groundwater aquifers

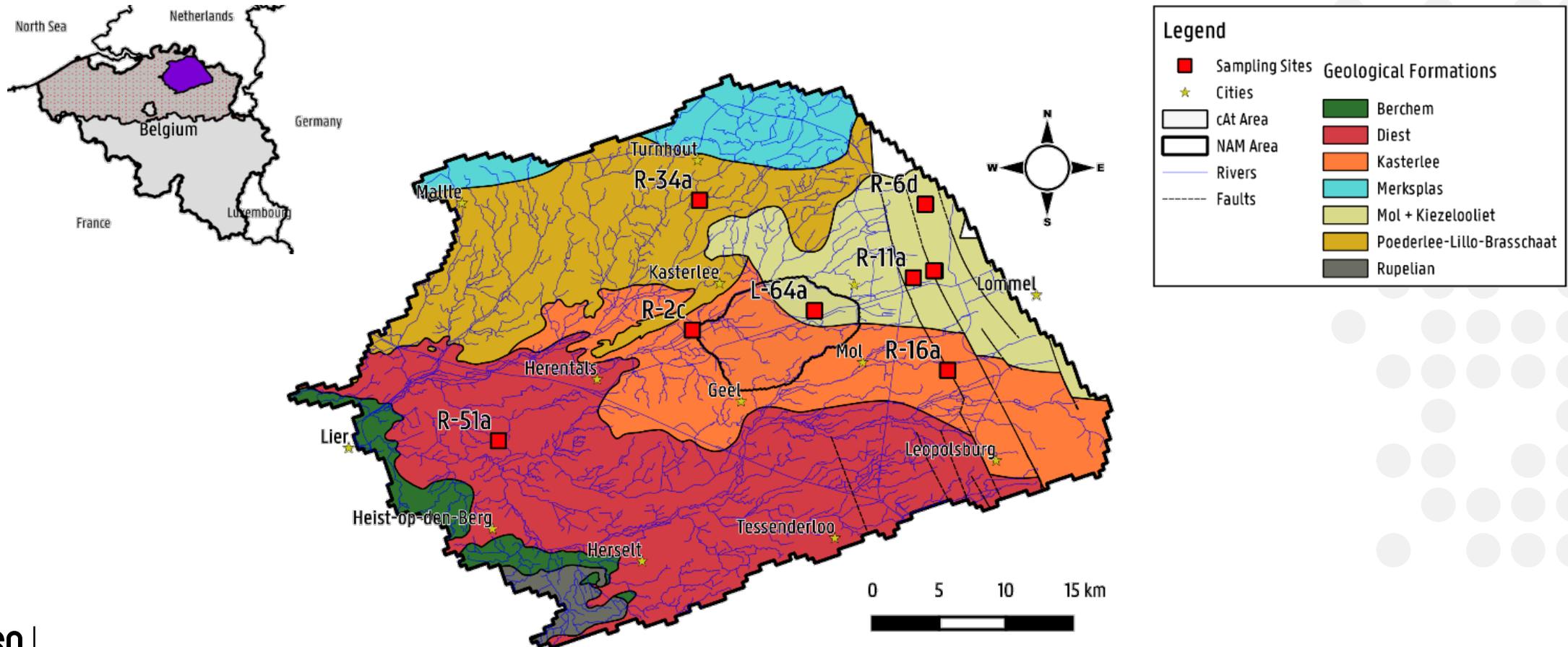


Energy (and gas) storage

- ① Transport along abandoned / leaky wells
- ② Injection increases pressure - could force contaminants along pathways
- ③ Transport along permeable fault
- ④ Release into groundwater through leaky borehole

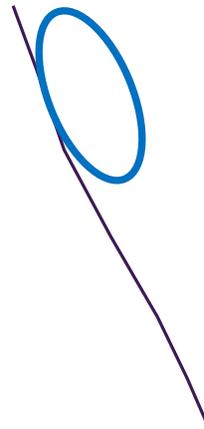


Assessment of Rauw Fault impact on local and regional hydrogeology using the Neogene Aquifer Model (NAM)



NAM modelled heads *without* Horizontal Flow Boundary (HFB)

Residual Obs = modelled minus measured

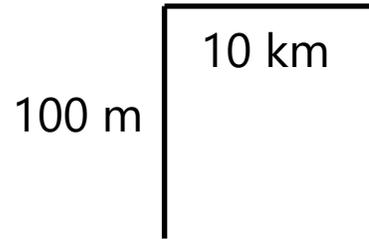


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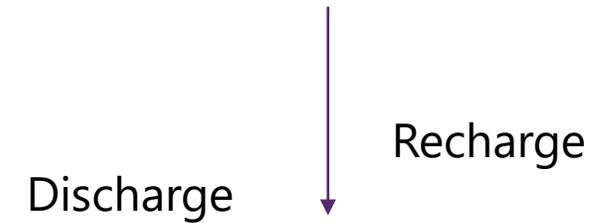
Mod < Meas

NAM modelled heads *with* Horizontal Flow Boundary (HFB)

Particle tracking



- Rauw fault causes upward flow
- Only the Rauw Fault acts as a HFB
- In modelling terms: only the K-value of the Rauw Fault proved to be sensitive



Summary

- Rauw Fault above Boom Clay is a horizontal flow boundary / hydraulic barrier
- In accordance with previous observations along the Roer Valley Graben
- Needs to be confirmed by transport model (He-4 and C-14)
- Not clear yet whether the fault also acts as a vertical conduit
- Vulnerability assessment tool to be tested at this pilot site

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Registered Office: Avenue Herrmann-Debrouxlaan 40 – BE-1160 BRUSSELS

Operational Office: Boeretang 200 – BE-2400 MOL