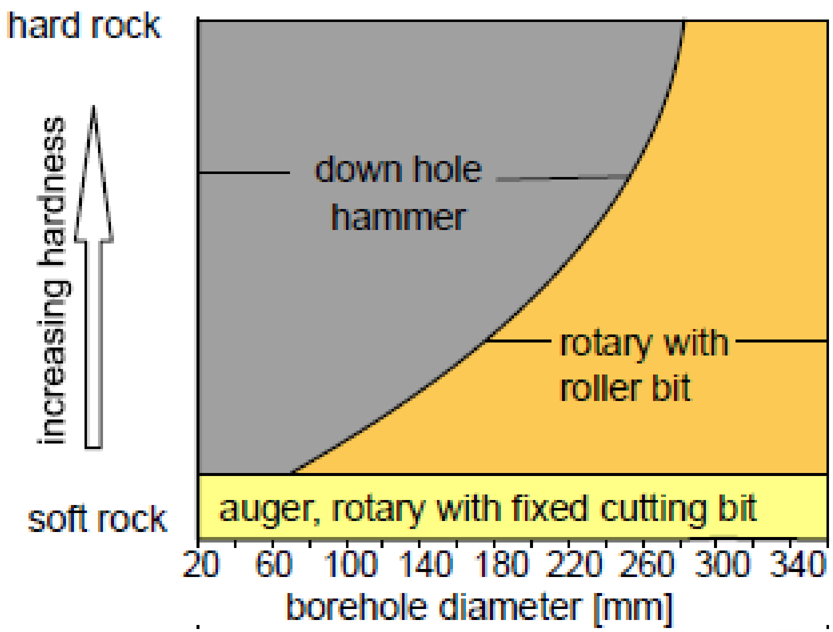
2. BEST DRILLING AND INSTALLATION TECHNIQUES

- ✓ **auger** (a screw-type drill removing soil from the hole while rotating, the way standard drills for wood and metal work)
- ✓ **the rotary system** with a fluid flushing the borehole (with different tools for cutting)
- ✓ **various hammer systems** (including cable-tool drilling)



after data from Hytti (1987)

Choosing elements:

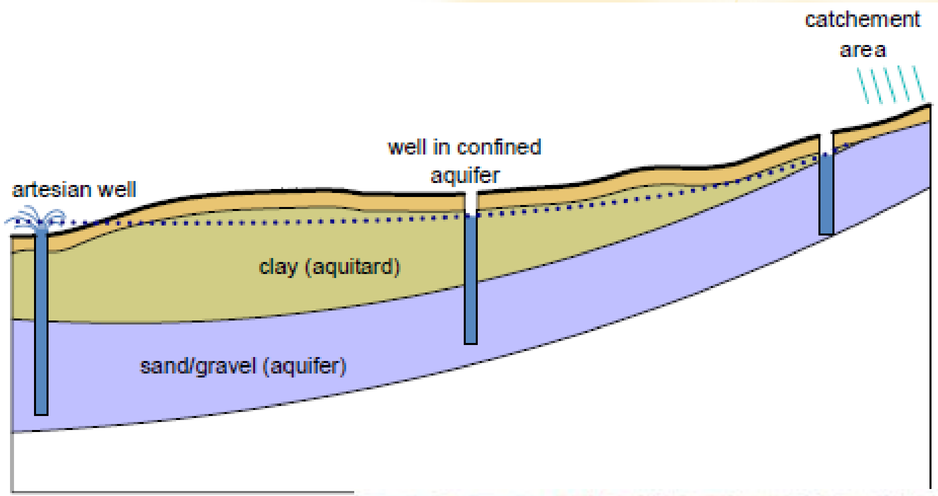
1. **Rock hardness**
2. **Presence of aquifers**
3. **Hole stability**

2. BEST DRILLING AND INSTALLATION TECHNIQUES

The pressure of the groundwater controls the water table in a well

+ in layers where the catchment area is higher than the drilling site

+ where layers with low permeability cover the aquifer



→ groundwater pressure level > physical upper boundary of the aquifer

→water in the well will rise

It is better to not to install a BHE in an artesian aquifer

2. BEST DRILLING AND INSTALLATION TECHNIQUES

Auger drilling

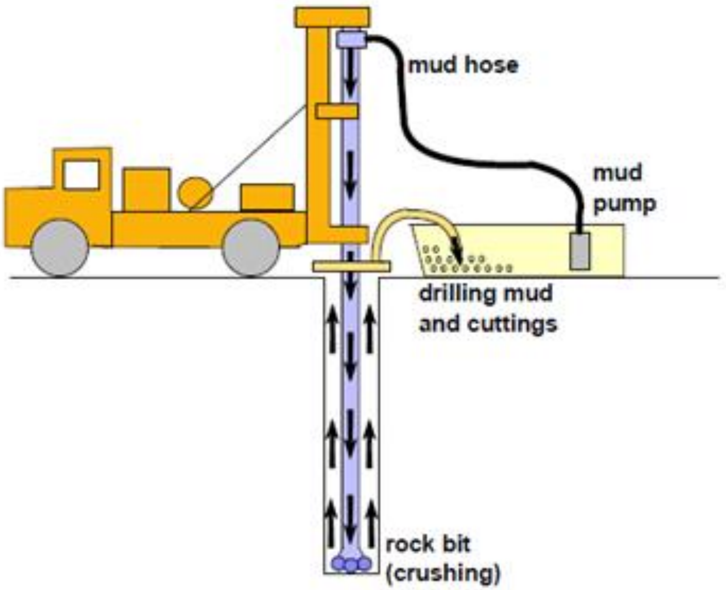
The drill cuttings are transported to the surface by a rotating auger

→ Augers are available at various diameters and with either a solid rod in the centre or a tube

Ø: 63-350 mm
depth: 15-20m MAX

→ used in soft, but sufficiently stable ground

2. BEST DRILLING AND INSTALLATION TECHNIQUES



Rotary drilling technique

by rotating a **drill bit** (tricone or chevron bit) to cut or crush the rock and the sediments, and flushing the hole

The drill cuttings are carried to the surface by a drilling fluid (water or mud/bentonite) pumped down through the hollow drill string

Ø: 89 - 300 mm
depth: 100 - 200 m

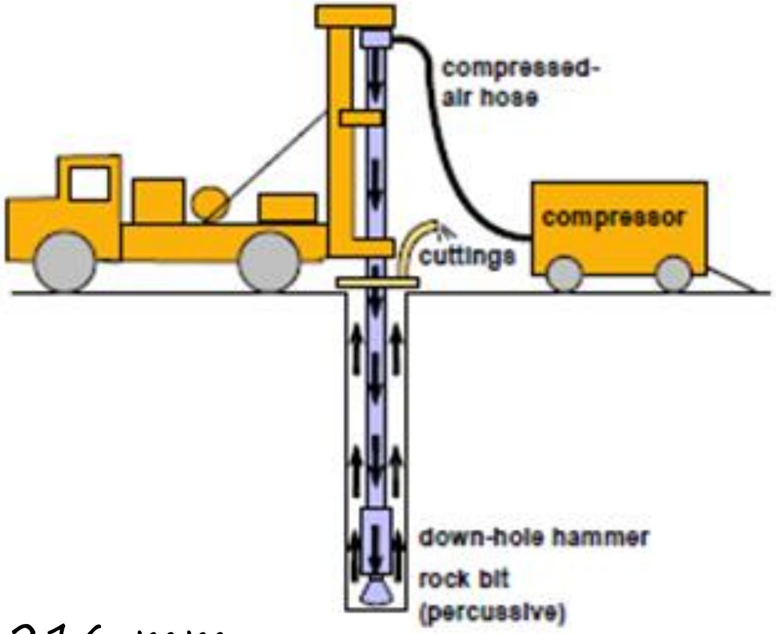
→ wide amounts of water supply + equipment for mud handling
→ additional space

→ in sediments as well as in medium to hard rock
→ quite fast only in loose sediments, always relatively slow in the other cases
→ In loose sediment requires casing

2. BEST DRILLING AND INSTALLATION TECHNIQUES

Down-hole hammer drilling

combines rotation and percussion



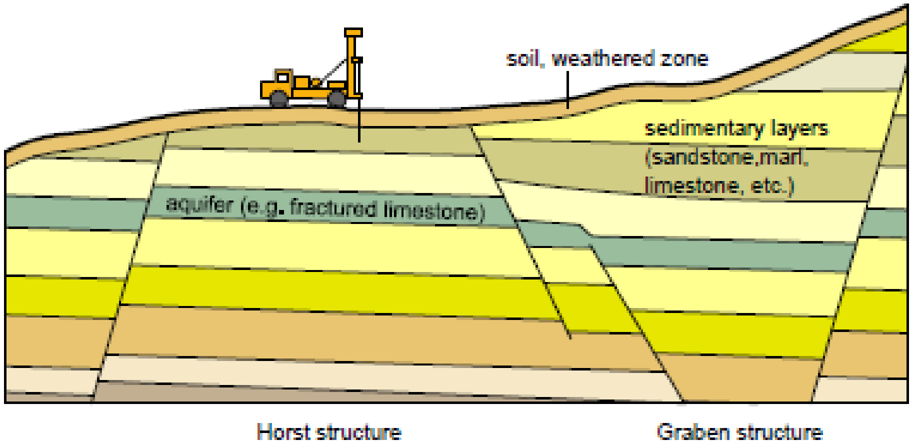
Compressed air is used for operating the hammer and for transporting the cuttings to the surface
→ powerful compressor
→ higher costs (use of the compressor) + consumed fuel

Ø: 100-216 mm
length: > 100 -150 m

→ relatively high drilling velocity in medium hard to very hard rock
→ if presence of loose sediments in the stratigraphic succession→ casing required, thus elongating the drilling time and costs

2. BEST DRILLING AND INSTALLATION TECHNIQUES

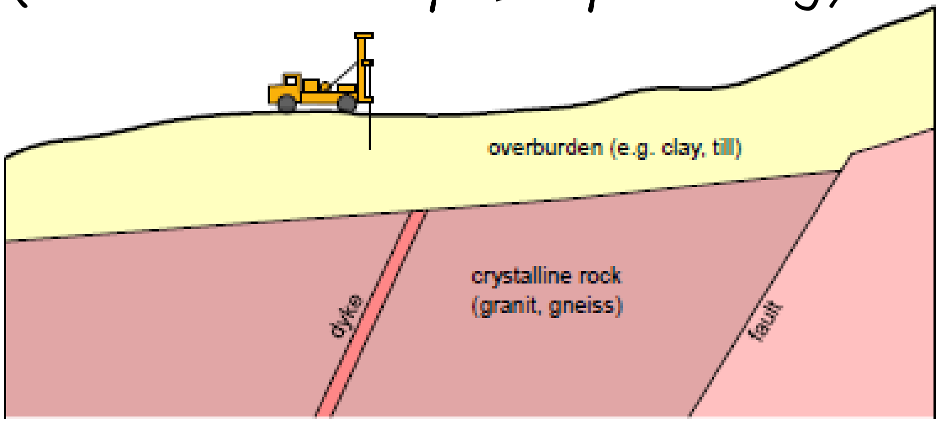
The drilling technology suitable on a given site is mainly dictated by the geological and hydrogeological conditions



1). <u>Hard rock under a softer layer of sediments</u> (from less than 1m to tens of m)

drilling with casing through the overburden depositional cover and open hole in rock (BHE mostly not grouted)

(Northern Europe, Alps Valley)



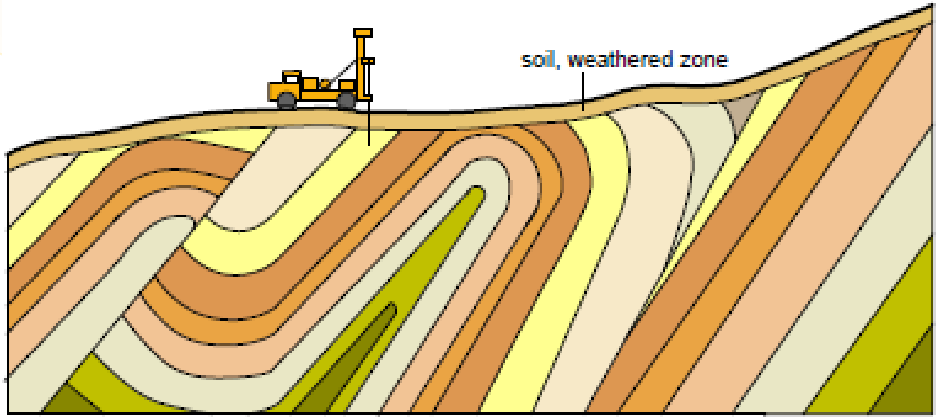
2) <u>Mesozoic sediments resting sub-horizontal or titled, often intersected by faults</u>.

Risk for confined or artesian aquifers

Drilling technique depends on rock hardness

BHE needs to be grouted

2. BEST DRILLING AND INSTALLATION TECHNIQUES



Saddle structure

3) <u>Sedimentary rock strata folded and faulted, often metamorphosed</u>

Groundwater can be found in fissures and fractures

Drilling mostly with DTH, sometimes rotary

Grouting always required

(Pyrenees, Alps, Carpathians)

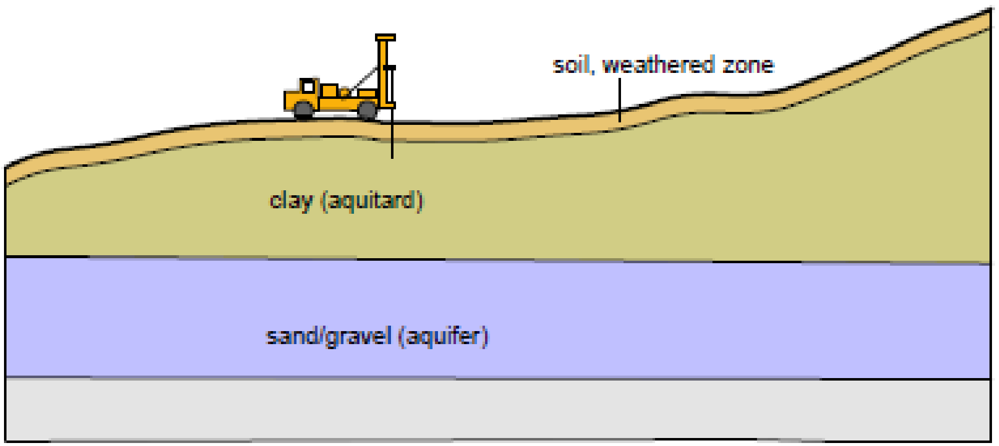
4) <u>Mostly unconsolidated sediments stacked on each other</u>

Risk of confined or artesian groundwater

Drilling mostly with auger or rotary rigs, often using casing to stabilize the hole

BHE needs to be grouted

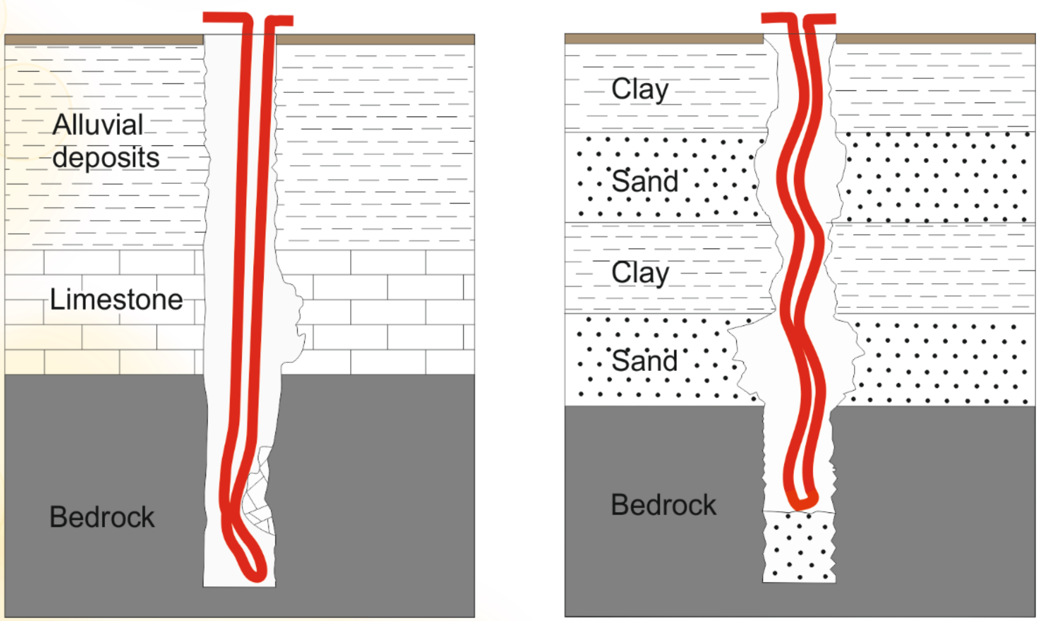
(sedimentary basins)



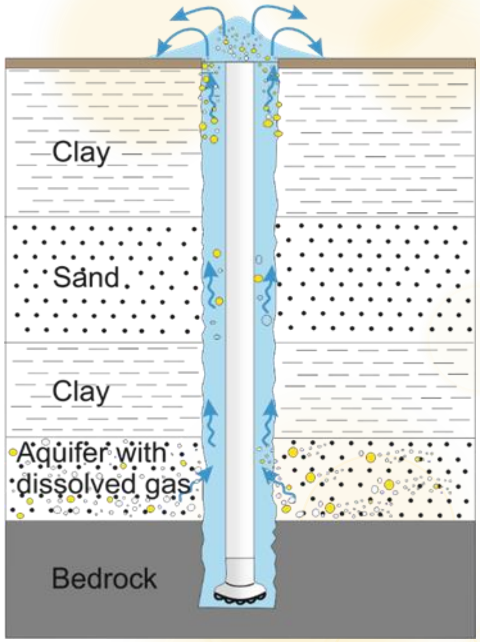
2. BEST DRILLING AND INSTALLATION TECHNIQUES

Uncorrect installations due to geological occurrences

partial collapse of the material into the well



high groundwater pressure



GEOLOGICAL AND HYDROGEOLOGICAL CHARACTERIZATION OF THE SITE

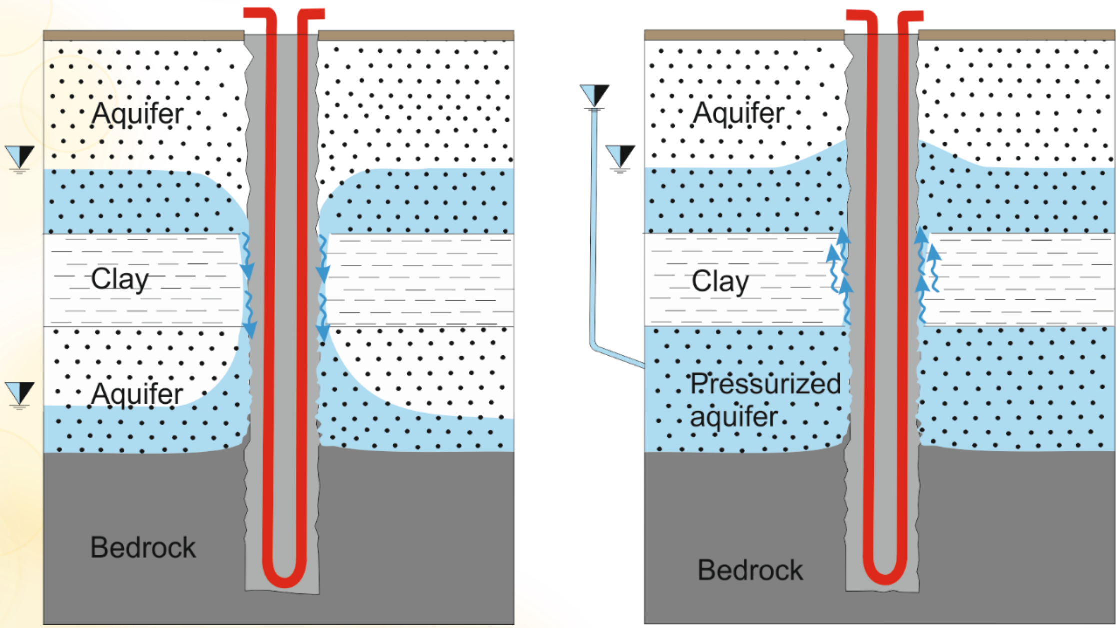
→environmental issues and regulatory constraints

1. Protection areas for hydrogeological reason: presence of drinkable water aquifers
2. Protection areas for presence of extraction water wells for drinkable water → imposed distances
3. Area of superficial pollution (contaminated sites)
4. Areas where the BHE are forbidden due to the presence of particular geological configuration (ex. Germany)
5. Thermal alteration induced in the ground
6. Possible thermal interactions with other geo-exchange systems

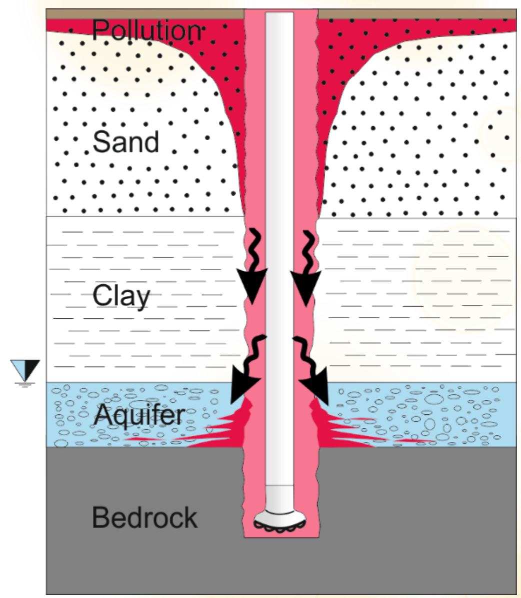
3.ENVIRONMENTAL AND REGULATORY CONSTRAINTS

Hazards related to particular geological sequences

interconnection between aquifers previously separated



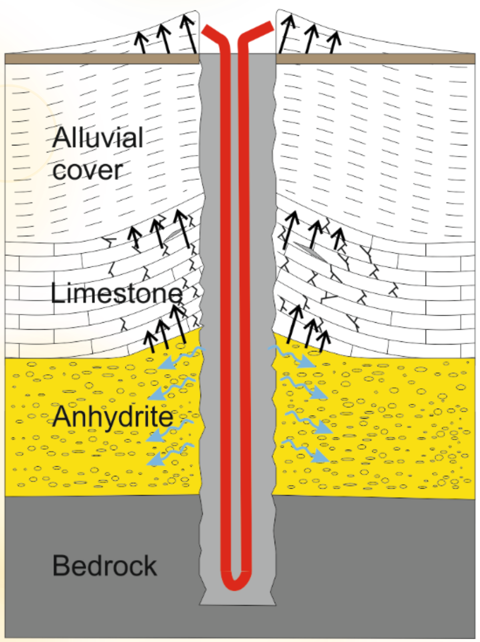
penetration of the superficial pollution underground



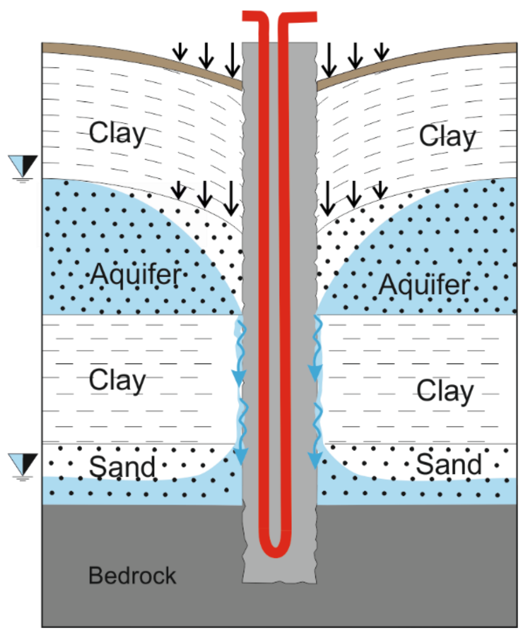
3.ENVIRONMENTAL AND REGULATORY CONSTRAINTS

Hazards related to particular geological formations

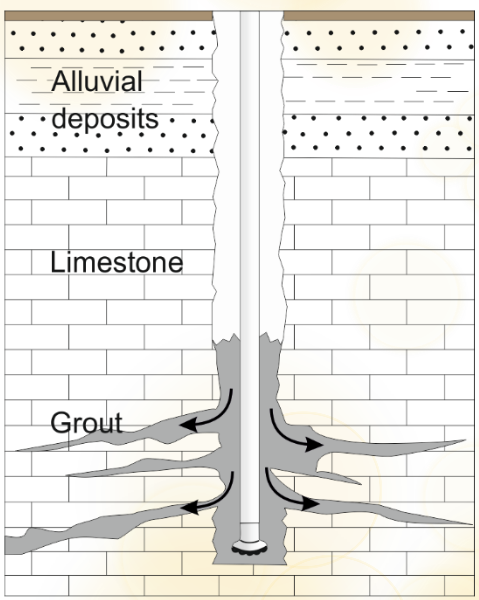
Anhydrite deposits (water free) → high volume increase if in contact with water



drainage of aquifers possibly resulting in land subsidence



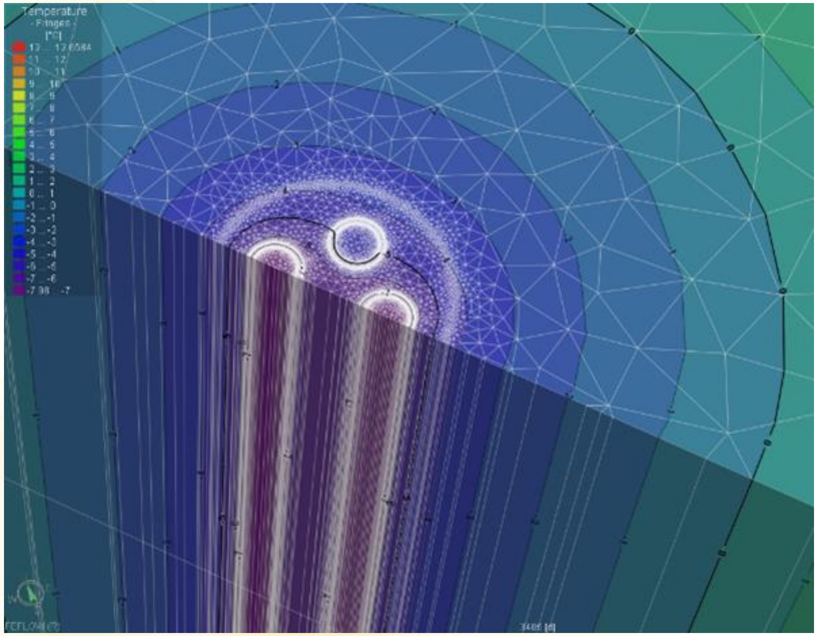
grout loss into fissures in the underground (karstic cavities in limestone areas)



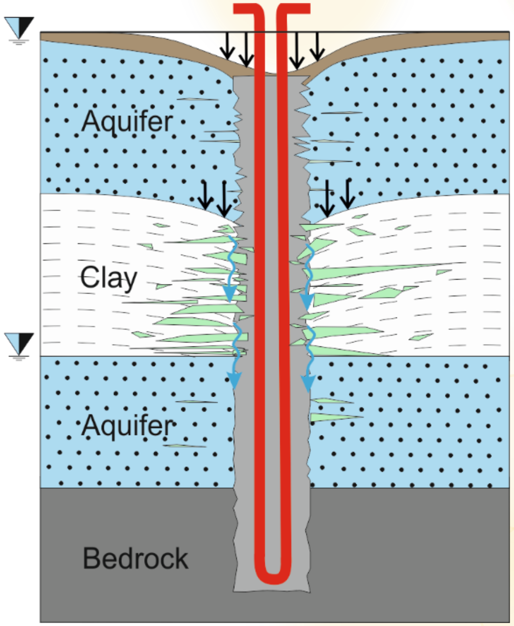
3.ENVIRONMENTAL AND REGULATORY CONSTRAINTS

Hazards related to high induced heat alteration

evaluation of the thermal alterations induced in the ground



Freeze-thaw cycles induced in cohesive sediments around the BHE → deformations of the ground level + change in the permeability + alteration of the thermal exchange and energetic performances



3.ENVIRONMENTAL AND REGULATORY CONSTRAINTS

Boundary conditions and initial conditions (temperature/hydro)

- ✓ air temperature
- ✓ geothermal flux
- ✓ initial temperature
- ✓ piezometric setting

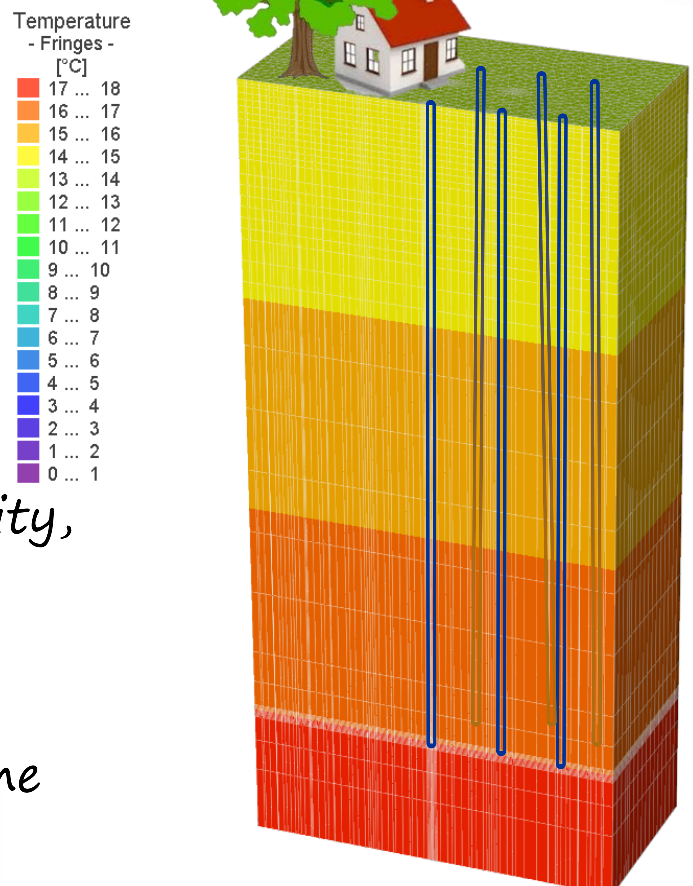
- software FEM
- hydro-thermal transport in porous media

→ evaluation of the thermal alteration induced in the ground

→ ground properties (porosity, permeability, thermal properties,..)

→ borefield geometry

→ BHE functioning over time (Q+power / Q+T)



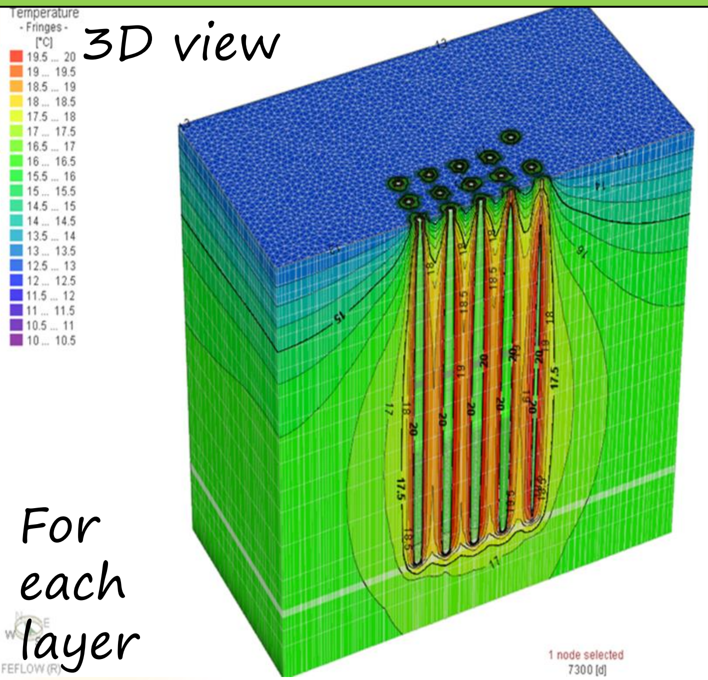
TO CHECK:

*** THERMAL GRADIENT in the ground**

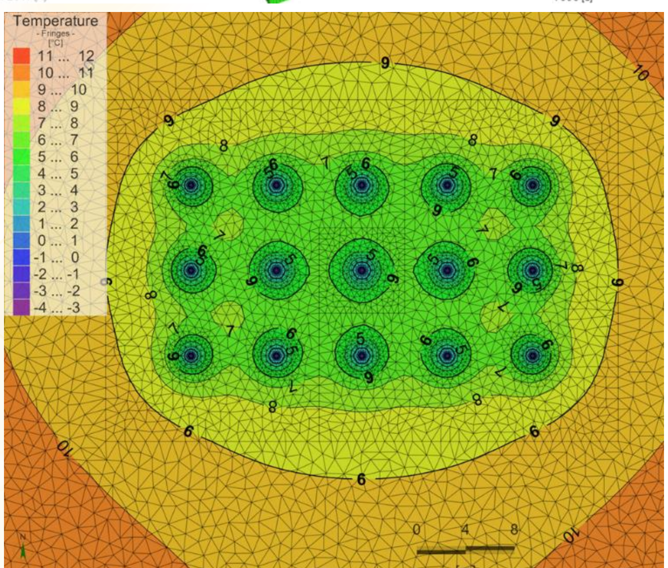
*** heat carrier FLUID TEMPERATURE**

3.ENVIRONMENTAL AND REGULATORY CONSTRAINTS

3D view



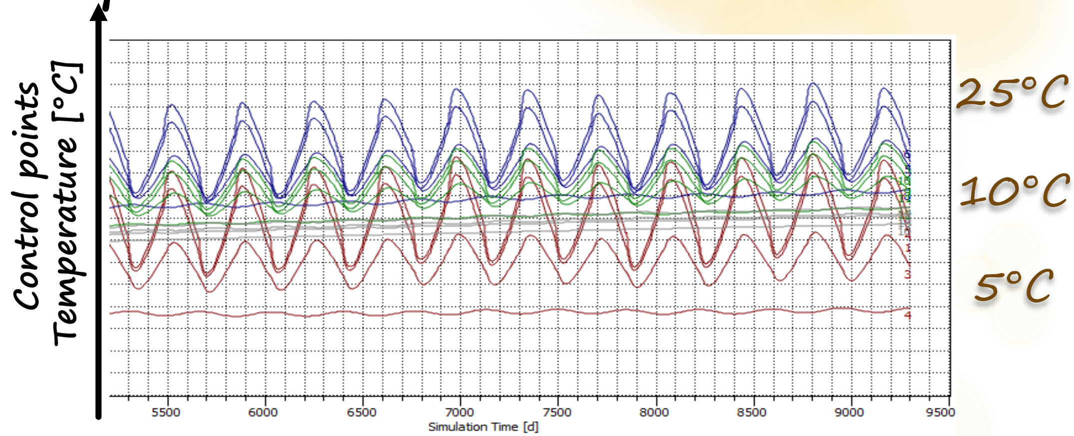
For each layer



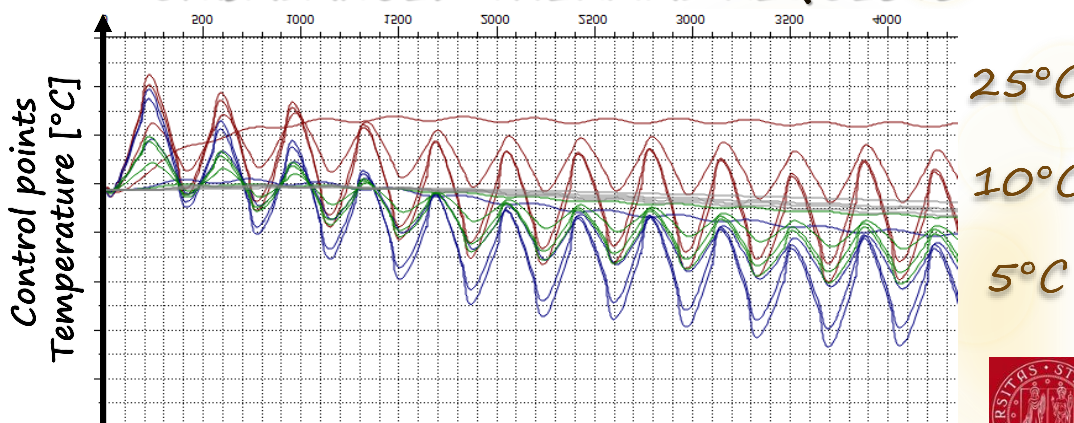
OUTPUTS: temperature induced in the underground

→ check the thermal alteration

Importance of the LOAD BALANCE

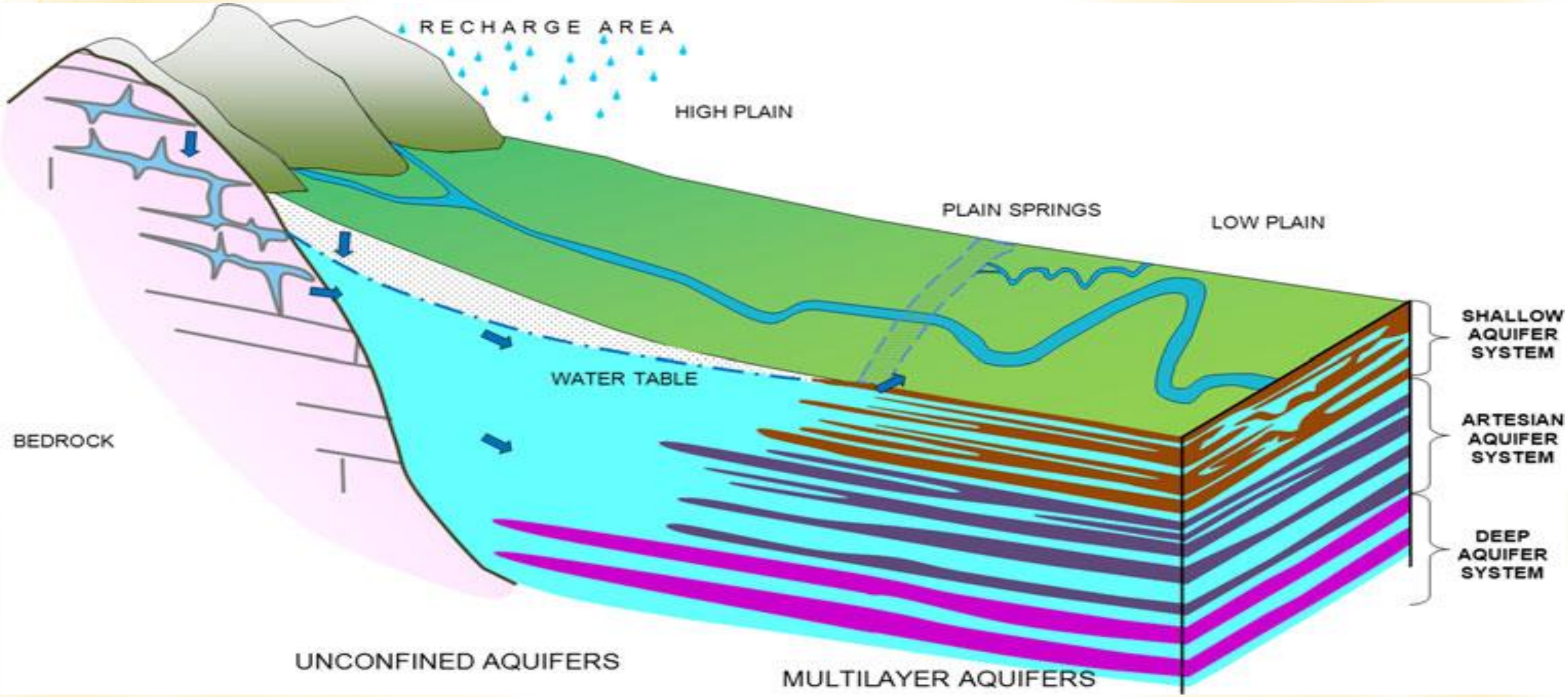


UNBALANCED THERMAL REQUESTS



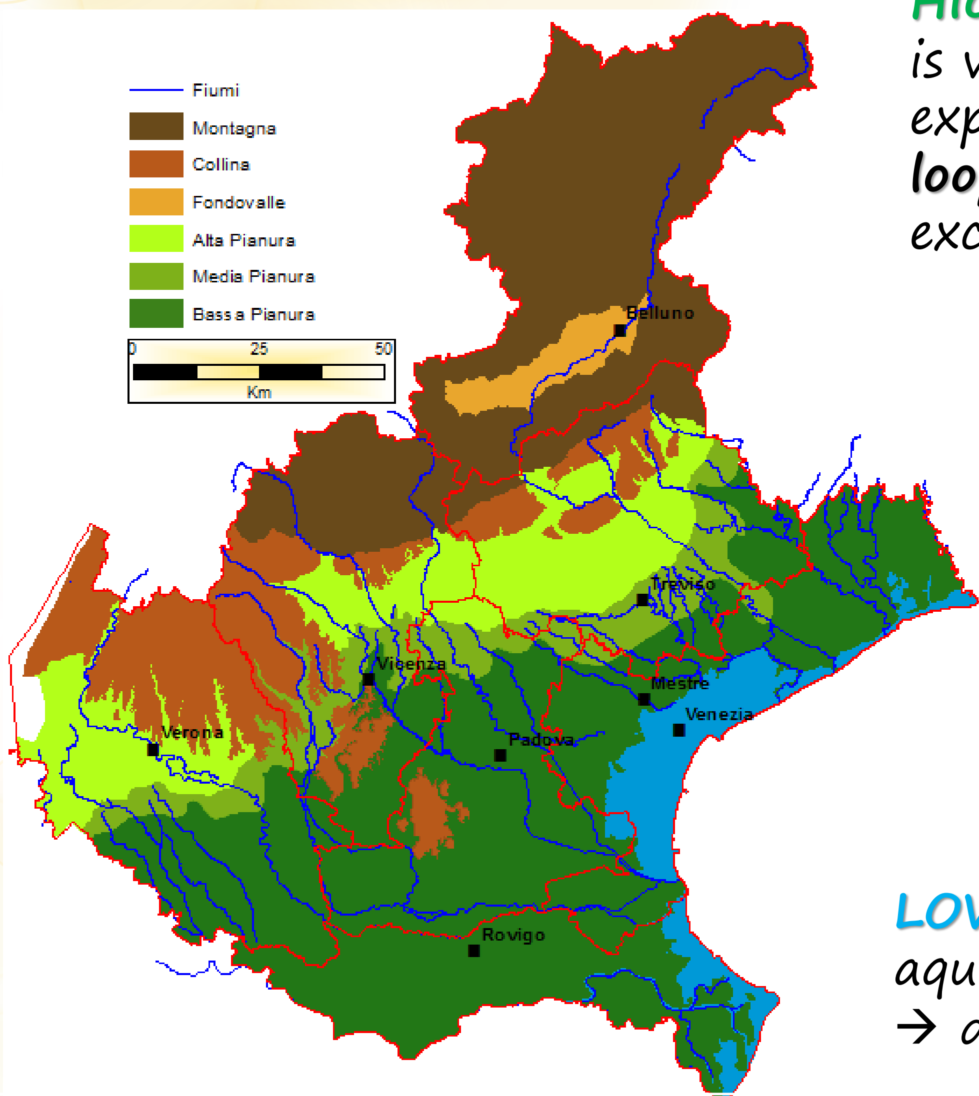
IDENTIFICATION OF THE BEST GHE

Depending on the local geological setting..



IDENTIFICATION OF THE BEST GHE

Depending on the local geological setting..



HIGH PLAIN AREAS: the water table is very low→ open loop systems are expensive and not effective / **closed loop** are higly efficient, high thermal exchange due to high groundwaterflow

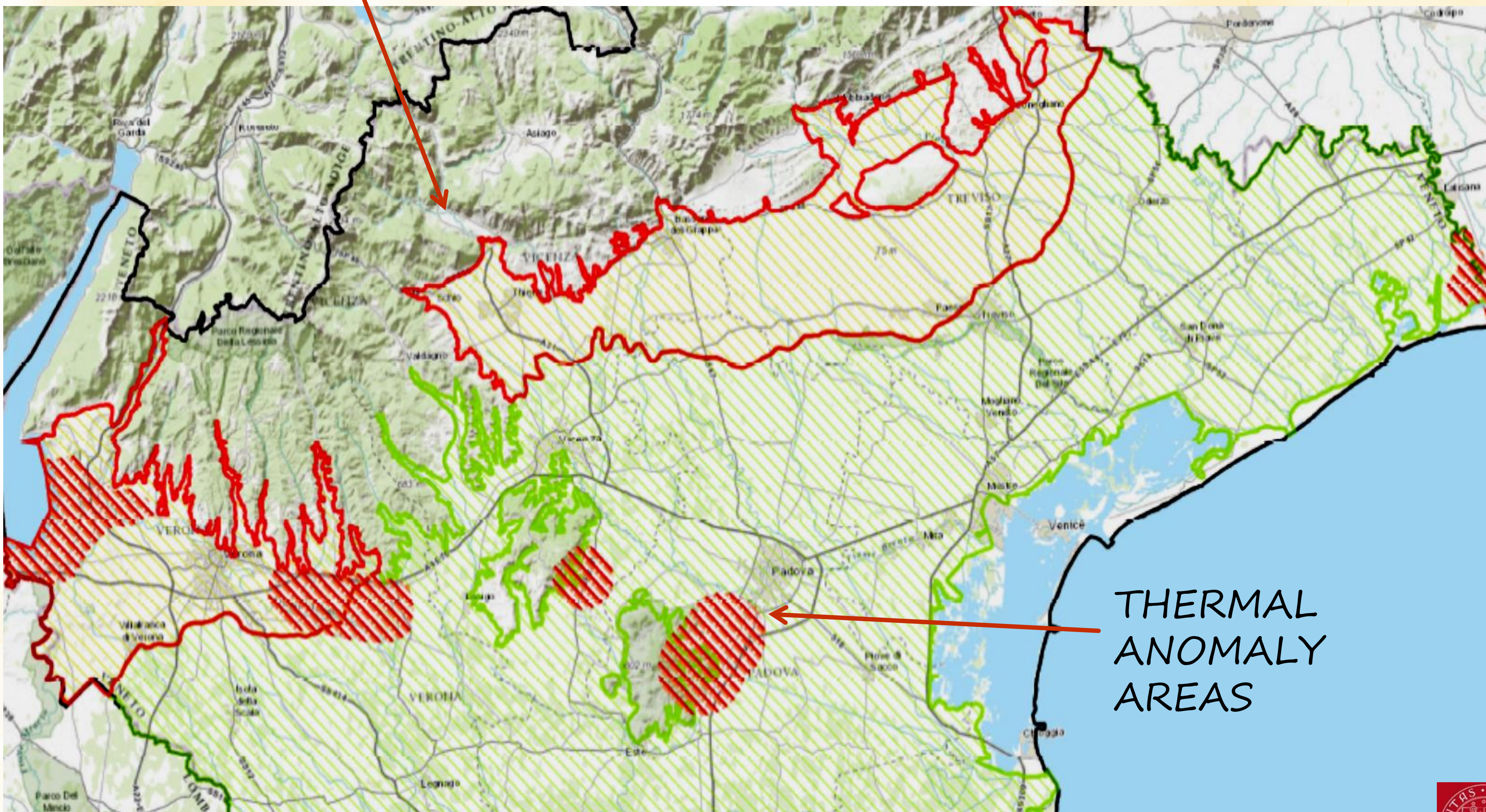
MIDDLE PLAIN AREAS: **Open loop systems** with highenergetic performances BUT presence of SPRINGS→ <u>HYDROGELOGY PROTECTION AREAS →</u> necessary to respect Q and distances from the caption wells + evaluation of the thermal plume

LOW PLAIN AREAS: pressurized aquifers, medium-low permeability → difficult renijection **closed loop**

IDENTIFICATION OF THE BEST GHE

Depending on the local geological setting..

HYDROGEOLOGICAL PROTECTION AREAS



IDENTIFICATION OF THE BEST GHE

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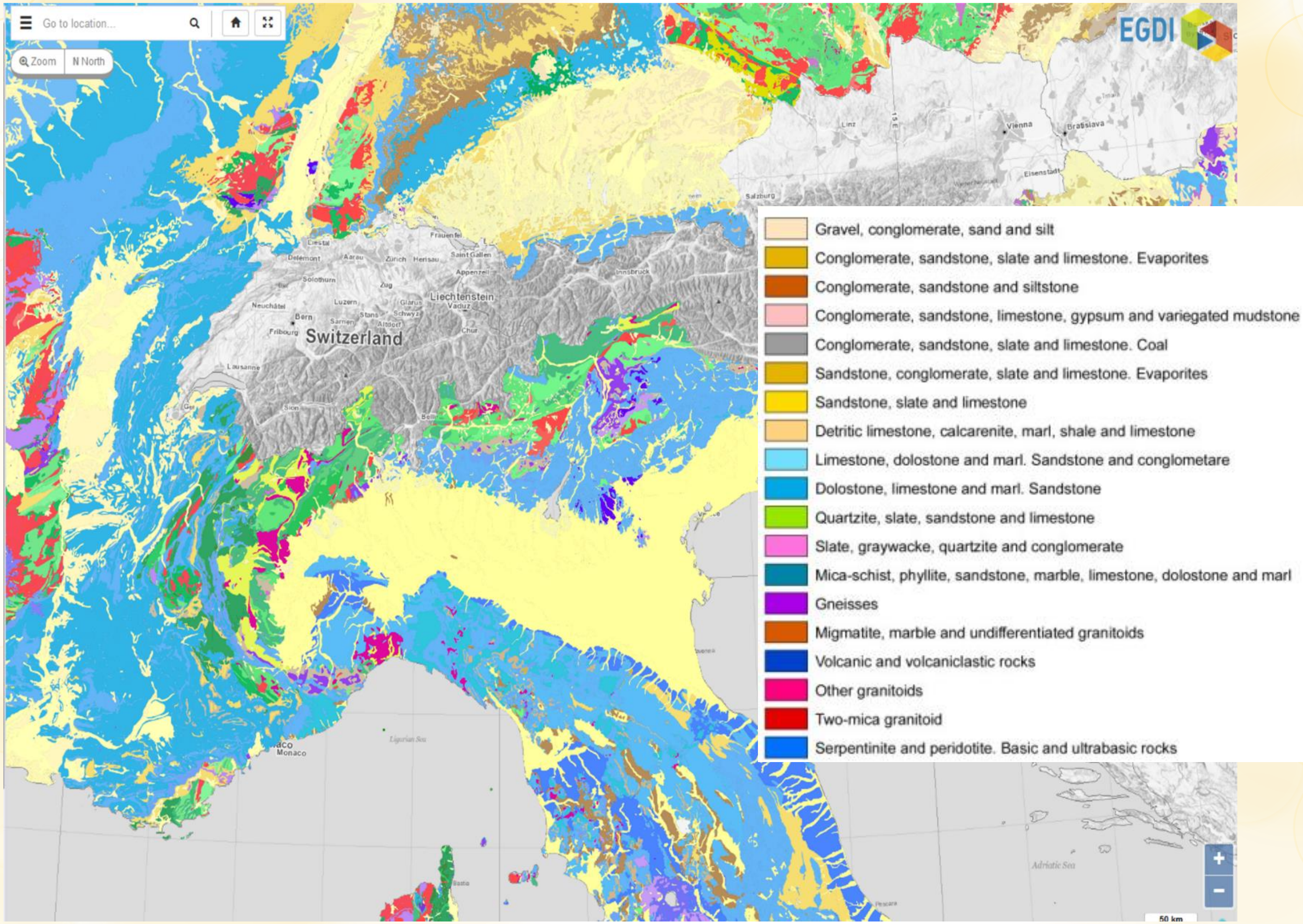

IDENTIFICATION OF THE BEST GHE

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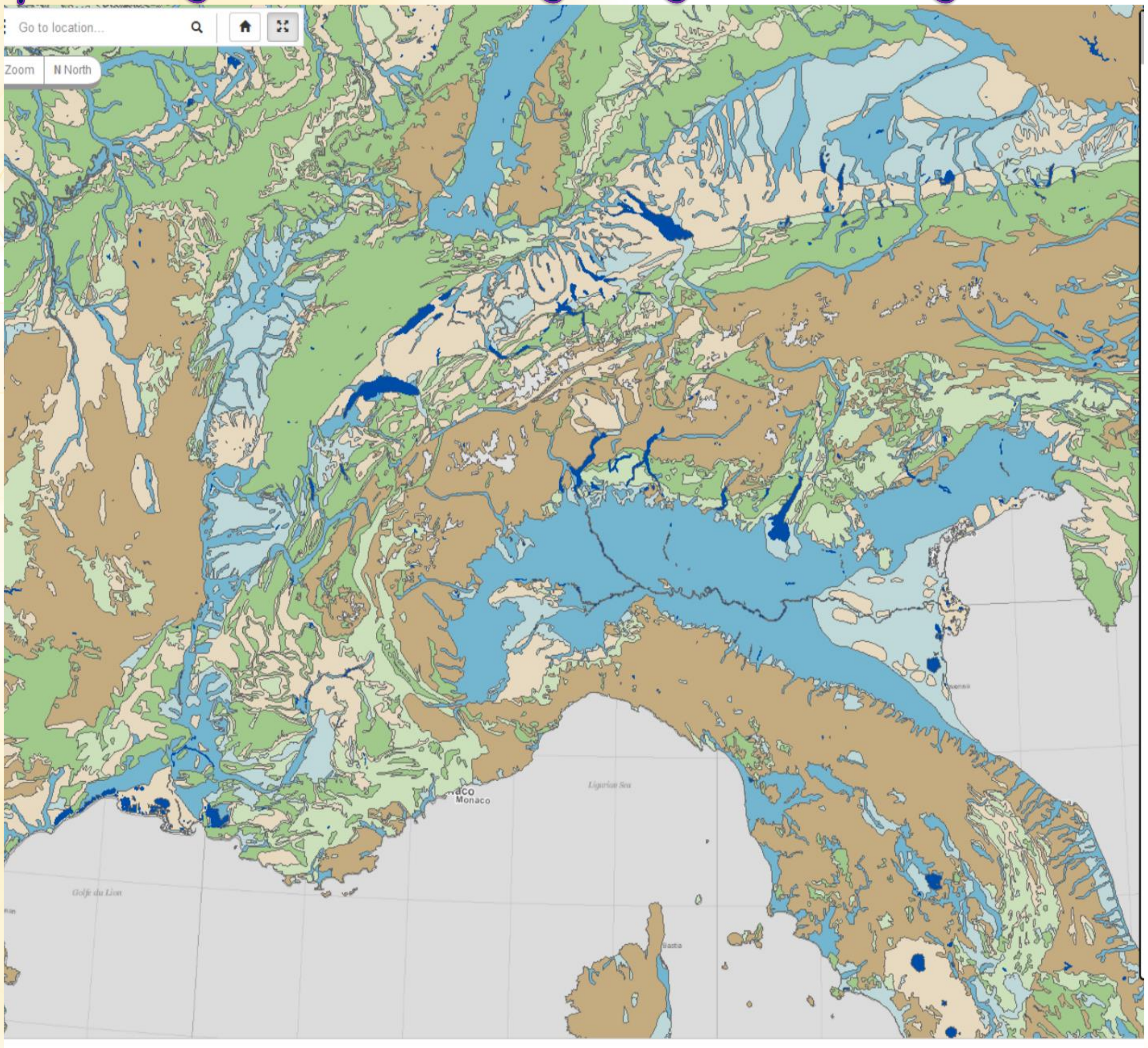

- *Highly productive porous aquifers*
- *Low and moderately productive porous aquifers*
- *Highly productive fissured aquifers (including karstified rocks)*
- *Low and moderately productive fissured aquifers (including karstified rocks)*
- *Locally aquiferous rocks, porous or fissured*
- *Practically non-aquiferous rocks, porous or fissured*
- *Inland water*