Multiple uses of the deep subsurface: foreseeable interactions

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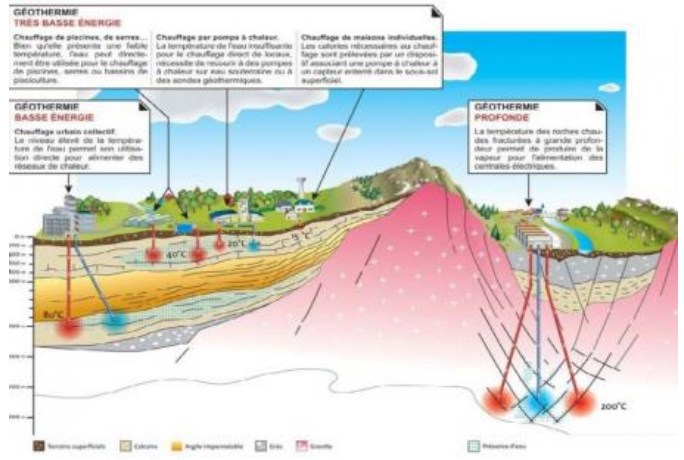
GeoConnect³d is funded under the GeoEnergy theme of GeoERA. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731166.

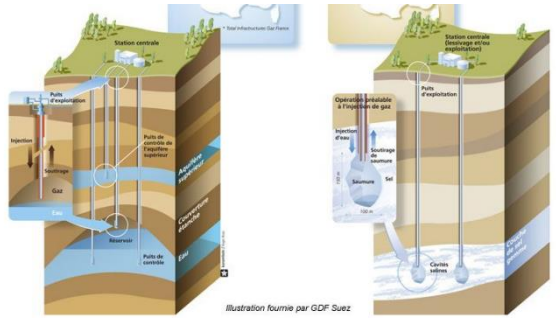
Important role of subsurface

- **Paramount importance subsurface for human life on Earth surface**
  - **Multiple uses of the subsurface**
  - **In the past or at present time**
  - **In the future for energy transition**
- **Extractive uses : exploiting resources from the underground**
  - **Mining : coal, ore**
  - **Oil and gas exploitation**
  - **Water**
  - **Geothermal activity**
  - **Etc.**



Geothermal uses ©ADEME-BRGM

- **Storage uses : exploiting the underground space and particular conditions (P, T, isolation)**
  - **Natural gas storage (in aquifer or in salt cavern)**
  - **CAES**
  - **CO_2 storage**
  - **Waste disposal**
  - **Etc.**



Gas storage in aquifer and in salt cavern
Source: GDF Suez

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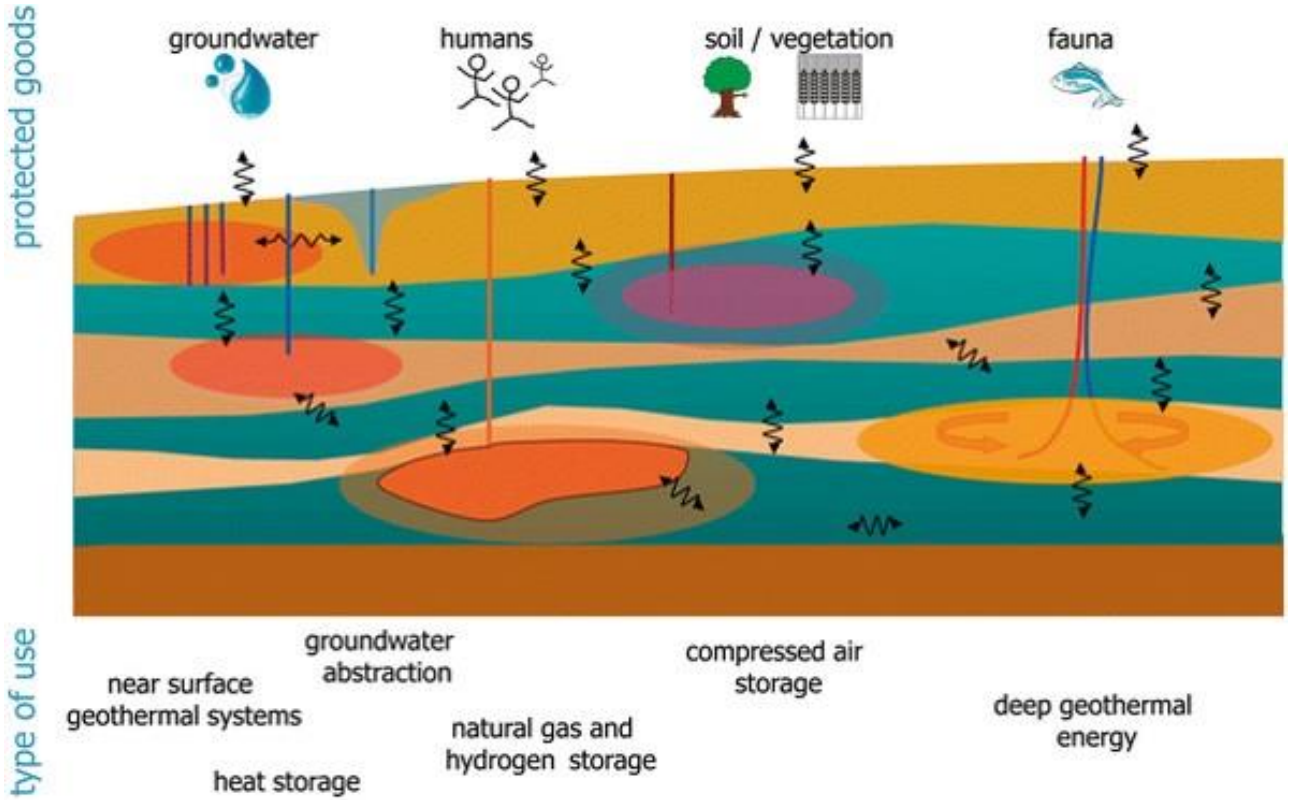
The subsurface management issue



- **Increased use** of subsurface in the last decades
- Foreseable increased use of subsurface **in the future** also (prospective uses for energy transition, etc.)

→ **interactions** between applications
→ **competition** for the same geological setting

From Bauer et al., *Impacts of the use of the geological subsurface for energy storage: an investigation concept*, Environmental Earth Sciences (2013) 70:3935-3943, DOI: https://doi.org/10.1007/s12665-013-2883-0

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Conflicts of use

- There is a conflict of use when the interactions between two subsurface uses are **negative interactions**, i.e. one application prevents the settlement of the other or its economic running.
- The conflict of use does not necessarily concern **simultaneous operations**: the setting up of a particular subsurface use can prevent **future utilisation** of the area for another subsurface use.
- **Direct** conflict of use
  - 2 subsurface uses target the same underground volume, but for different applications.
  - Planning and permitting stage → choice of one of the possible uses
- **Indirect** conflict of use
  - When the influence radius of a subsurface activity reaches the influence area of another subsurface activity.
  - For example, in pore-space applications, a pressure impact can reach another subsurface activity
  - The conflict of use may be unidirectional when one of the applications is more sensitive to being influenced

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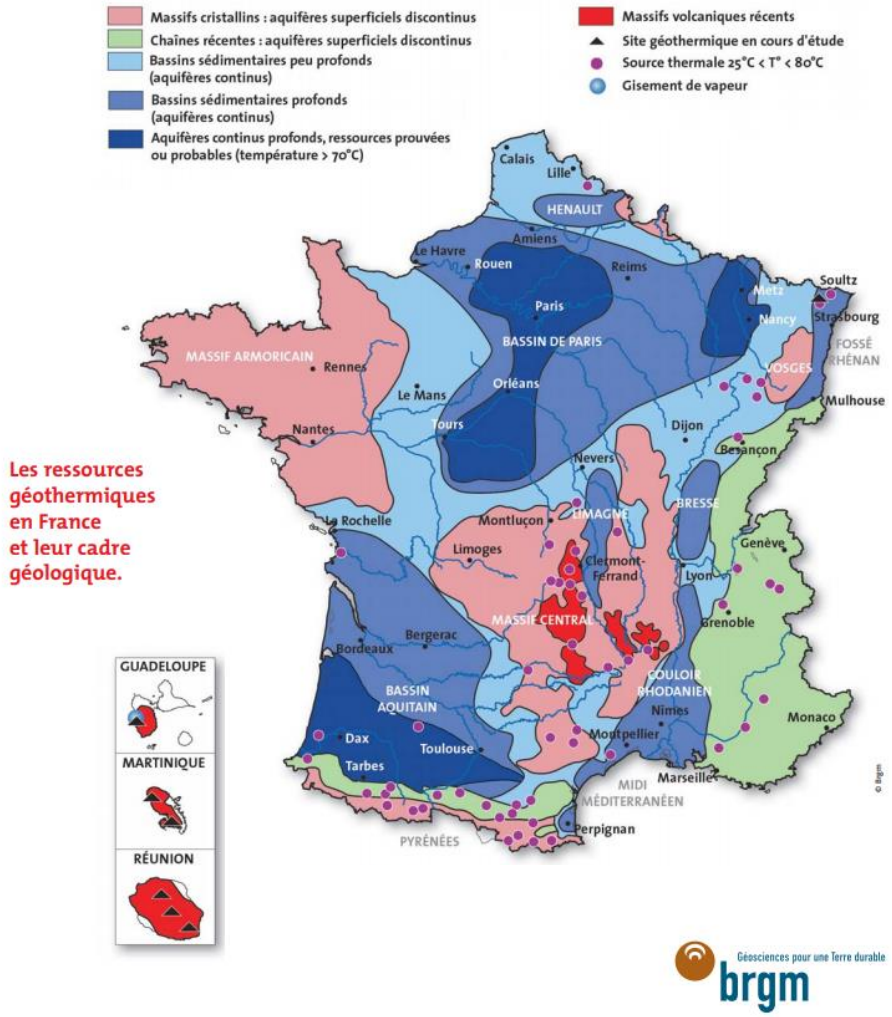
Deep saline aquifers



- Map: geothermal potential in France
- **Deep saline aquifers** in sedimentary basins
  - Potential for **deep geothermal** activity : continuous aquifers, temperature > 70°C
  - Potential for **CO_2 storage**

Geothermal vs CO_2 storage:
both type of subsurface use target the **same geological fomations**

→ **Direct conflict** at permitting and planning stage

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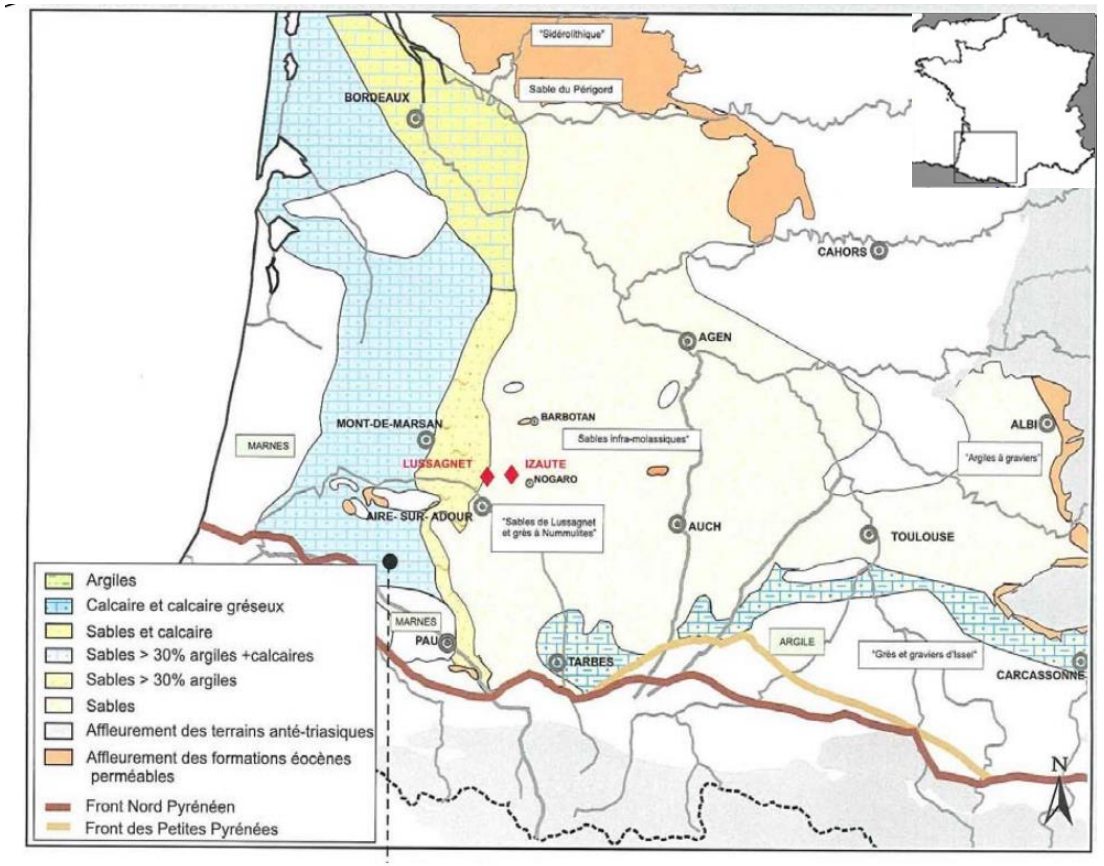
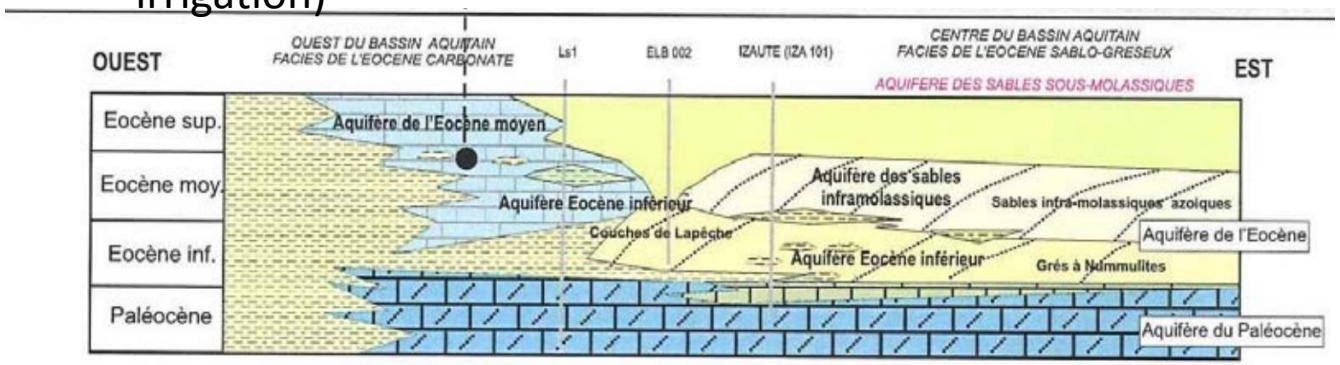
Case study: Lussagnet and Izaute gas storage site

- **Natural gas storage** operated by Terega
- Located in the **Aquitain sedimentary basin** (SW of France)
- 2 reservoirs in the « Infra-Molassic Sands Aquifer » (**Eocene sands aquifer**):
  - Lussagnet: 500m depth
  - Izaute: 900m depth
- Overburden : « Aquitain molasse » plastic clay and carbonate beds (up to 500m thick)
- Eocene sands aquifer is used by a **large variety of economic sectors** (potable water, thermal water, industrial water catchments, geothermal activities, irrigation)



Faciès, structure, lithostratigraphie de l'Eocène [*annexe VII Demande d'augmentation de la capacité Lussagnet - Total Fina Elf Gaz de France et AQUILA Conseil, 2001*]



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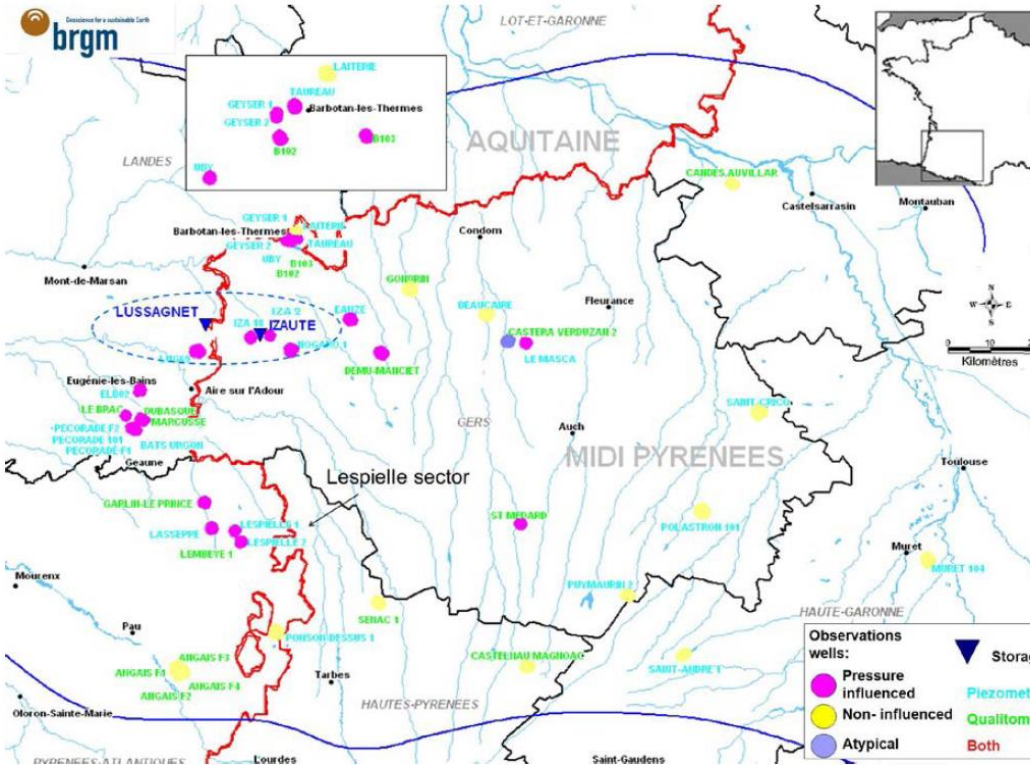
Case study: Lussagnet and Izaute gas storage site

- Gas storage operations generate **seasonal pressure variations in the aquifer**.

- A **pressure impact** is observed in wells several tens of kilometers away
  - ➢ **thermal stations** (20km away from the storage site) have spring rate decrease (no chemical impact).
  - ➢ **water exploitation** for drinking or irrigation also present a pressure impact → pumping installations.



Pressure impact around natural gas storages (Izautes and Lussagnet, south of France)
(IEAGHG 2011 from David, 2010)

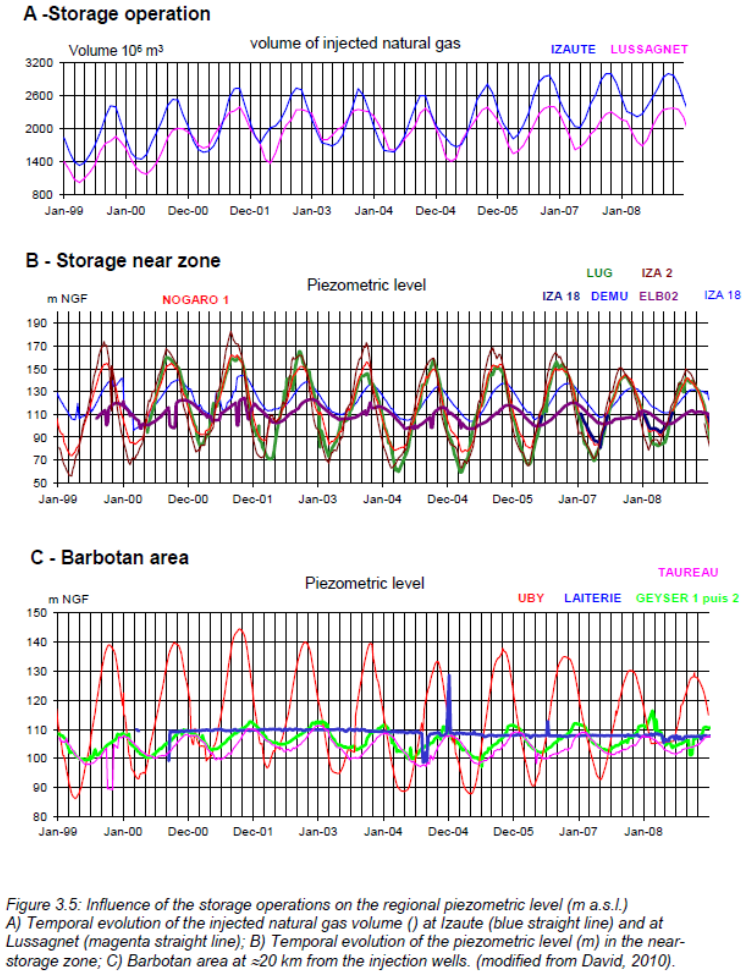


Figure 3.5: Influence of the storage operations on the regional piezometric level (m a.s.l.) A) Temporal evolution of the injected natural gas volume () at Izaute (blue straight line) and at Lussagnet (magenta straight line); B) Temporal evolution of the piezometric level (m) in the near-storage zone; C) Barbotan area at ≈20 km from the injection wells. (modified from David, 2010).

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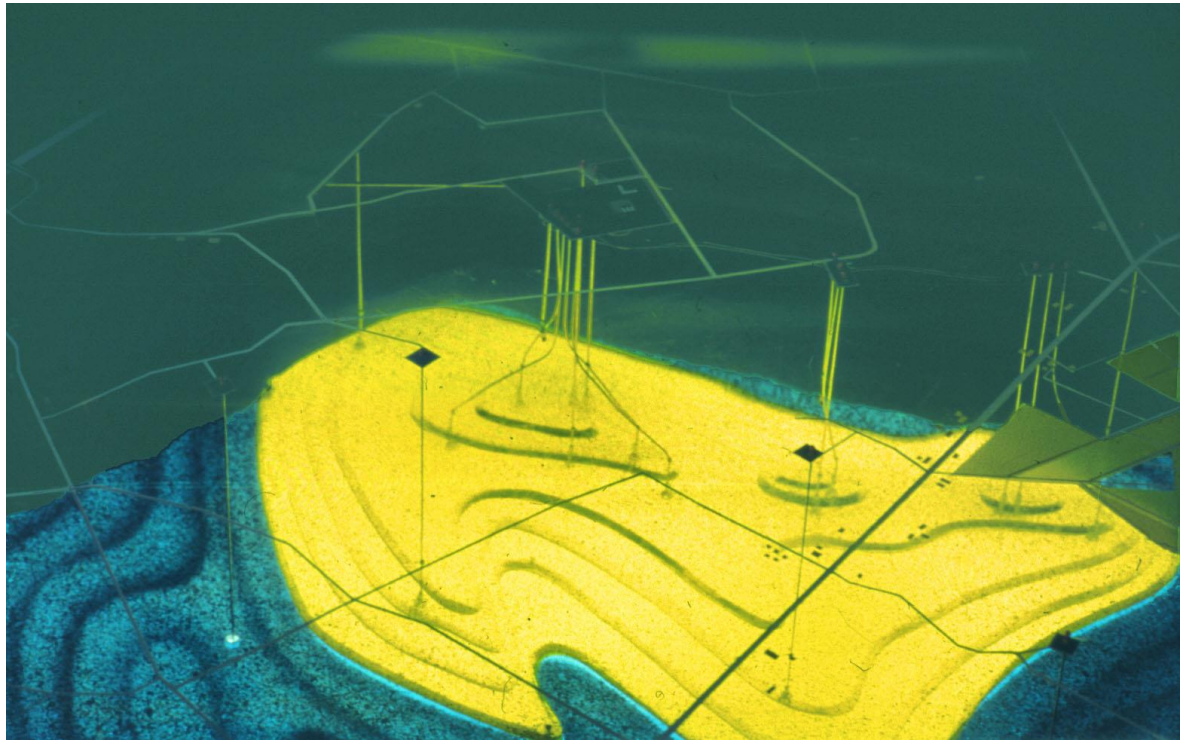
Case study : Loenhout (Belgium)

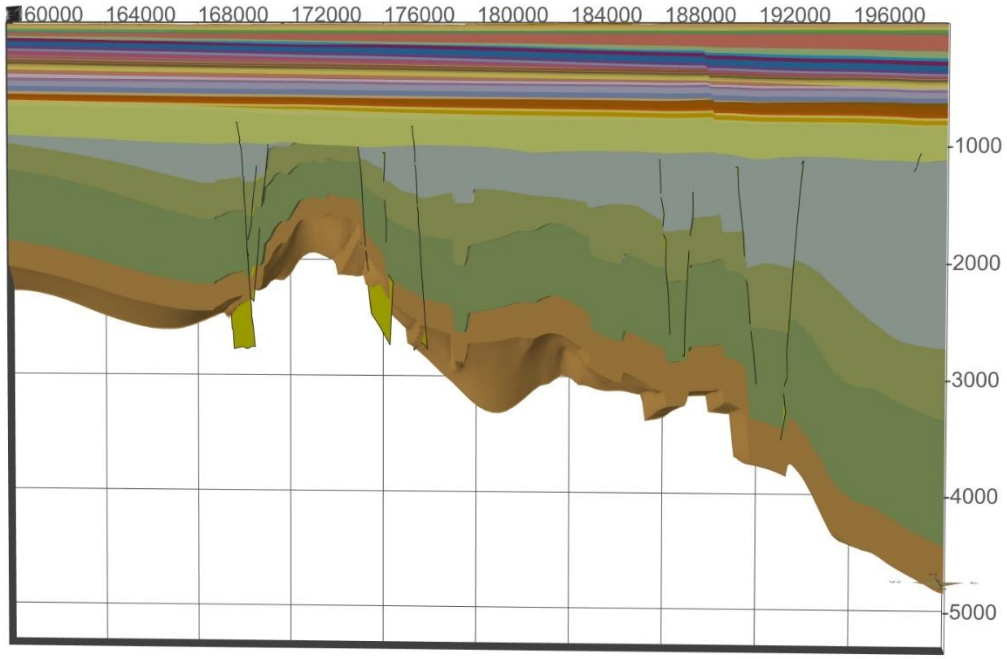
- Limestone aquifer (Dinantian) overlain by mudstones
- **Gas storage reservoir** located in a dome structure, good storage properties due to karstification

→ **Pressure waves** from seasonal injection/production could be observed in the aquifer

- **Deep geothermal projects** in the same aquifer, outside the dome stucture

→ **Mutual interferences** might occur.





⇦ EW profile through the Loenhout dome.
(Height exaggeration 5x, grid is in meter)
Source: Geologisch 3D Model van Vlaanderen, versie 3, Databank Ondergrond Vlaanderen.

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Case study : Loenhout (Belgium)

For the same aquifer, **two adjacent license areas** for gas storage and deep geothermal exploration fall under **different competence**.

- The gas storage falls under federal law and has been active since 1985.

- The deep geothermal project falls under Flemish competence and will soon start.

→ **Regulatory issue** for subsurface management

→ Need for regulation of **subsurface as a whole**

Reuse and synergies

- Two different kinds of subsurface uses can be **complementary** to each other, i.e. the interactions between them are **positive interactions**
- **Reuse**: the later activity uses the effects of a former one
  - salt caverns left after salt production
  - depleted hydrocarbons reservoirs for storage purposes
  - use of old mine shafts for pumped hydropower installations
  - Etc.
- **Synergies**: 2 projects in underground space are complementary simultaneously
  - waste acid gases are re-injected into a hydrocarbon's trap to sustain the exploitation pressure
  - heat energy is recovered from production water
  - Etc.

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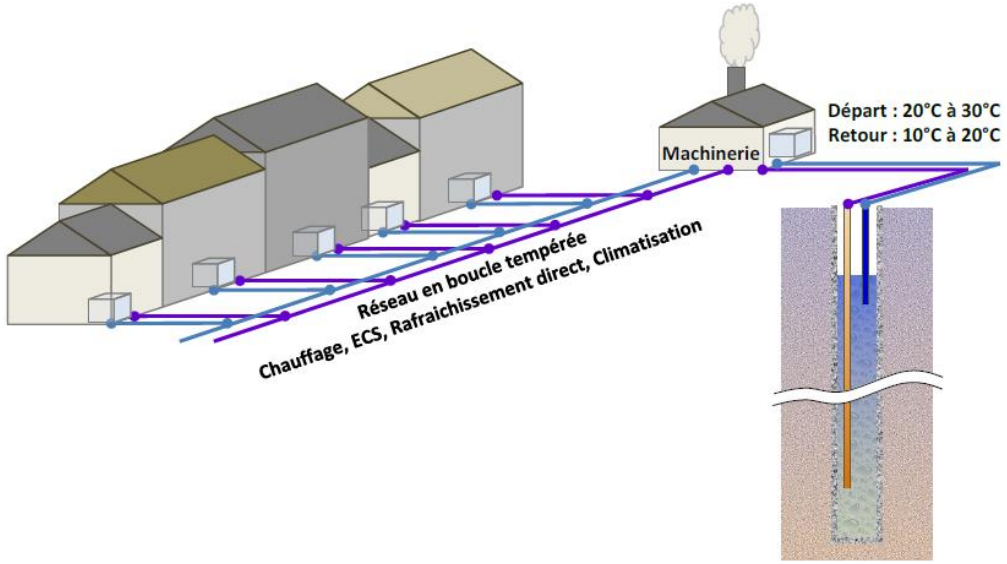
Reuse synergy in Gardanne (France)

Gardanne abandoned mine
(Bouches-du-Rhône, south of France)

- Exploiting the mine waters potential for heating/cooling of an eco-district.
- In a well of the abandoned mine (1100m deep; 10m large)
- Heat storage in the mine waters is also under consideration.



From Lesueur, 2016 (BRGM/RP-65723-FR)

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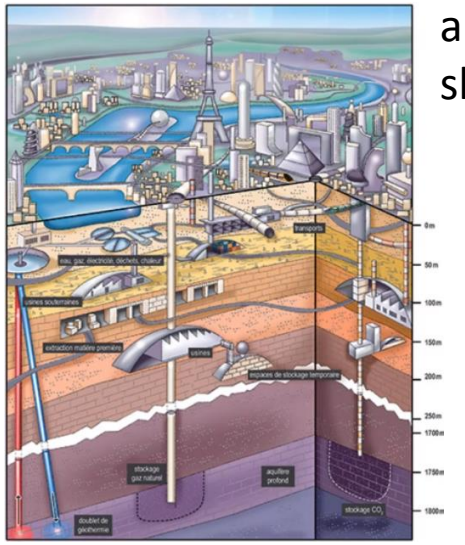
Need for subsurface management

- **Optimise** the use of subsurface:
  at the same time **avoid conflicts** and look for potential **synergies**

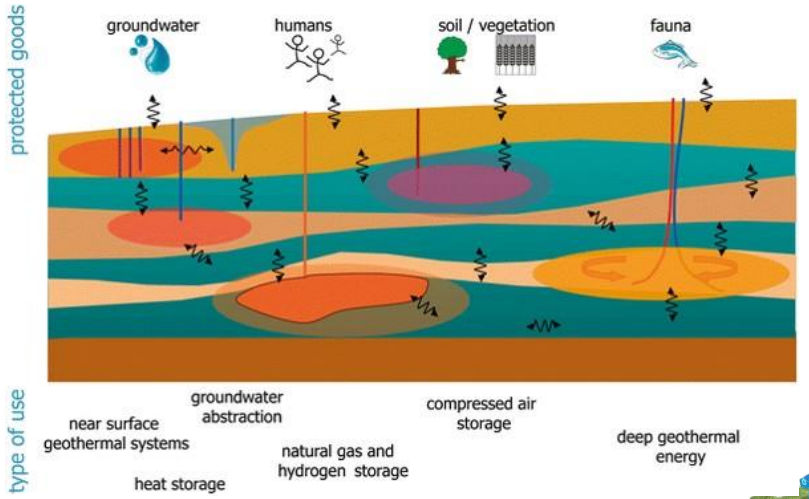
- Importance of **temporality**:
  - Synergies by **reusing** abandoned cavities
  - **Long term** management: address future uses of the subsurface as well as the current ones

- The subsurface management issue:



already identified in urban and shallow context

rising issue in deep subsurface context



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Regulatory framework in Europe

- **National level**:
  - **Diversity of authorities** and competence inside countries
  - Differences in organisation between countries → **no single pattern** of managing the underground space
  - None has incoporated the subsurface management issue in a legal system
  - **Inconsistencies** in regulations → lack or overlapping of competences
- **At EU level**:
  - regulations related to subsurface uses are **dispersed in various directives** or decisions
  - Need for regulation of subsurface **as a whole**
  - Not only for urban areas but also **deeper subsurface**

Ackowledgments to Monika Konieczynska & PGI team

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Concluding remarks

- On-going work in GeoConnect3d project
- Forthcoming report “State of the art of subsurface planning and management” by PGI (Polish Geological Institute)
- One of the objectives of GeoConnect3d: draw generic lessons on subsurface management from the case studies (Roer-to-Rhine, Pannonian Basin)

→ Need feedback from stakeholders

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THANK YOU FOR YOUR ATTENTION

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