

Simulation of groundwater and heat transfer for the geothermal use of flooded abandoned old-mines

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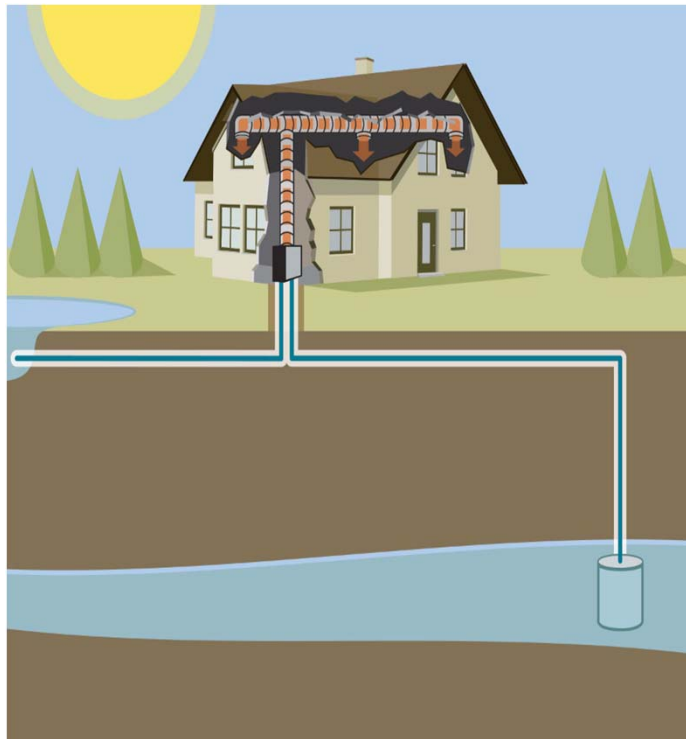
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* Now at ABO Group

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The underground... a source of energy

Low temperature geothermal energy is one of the source of green energy for cooling and heating systems.



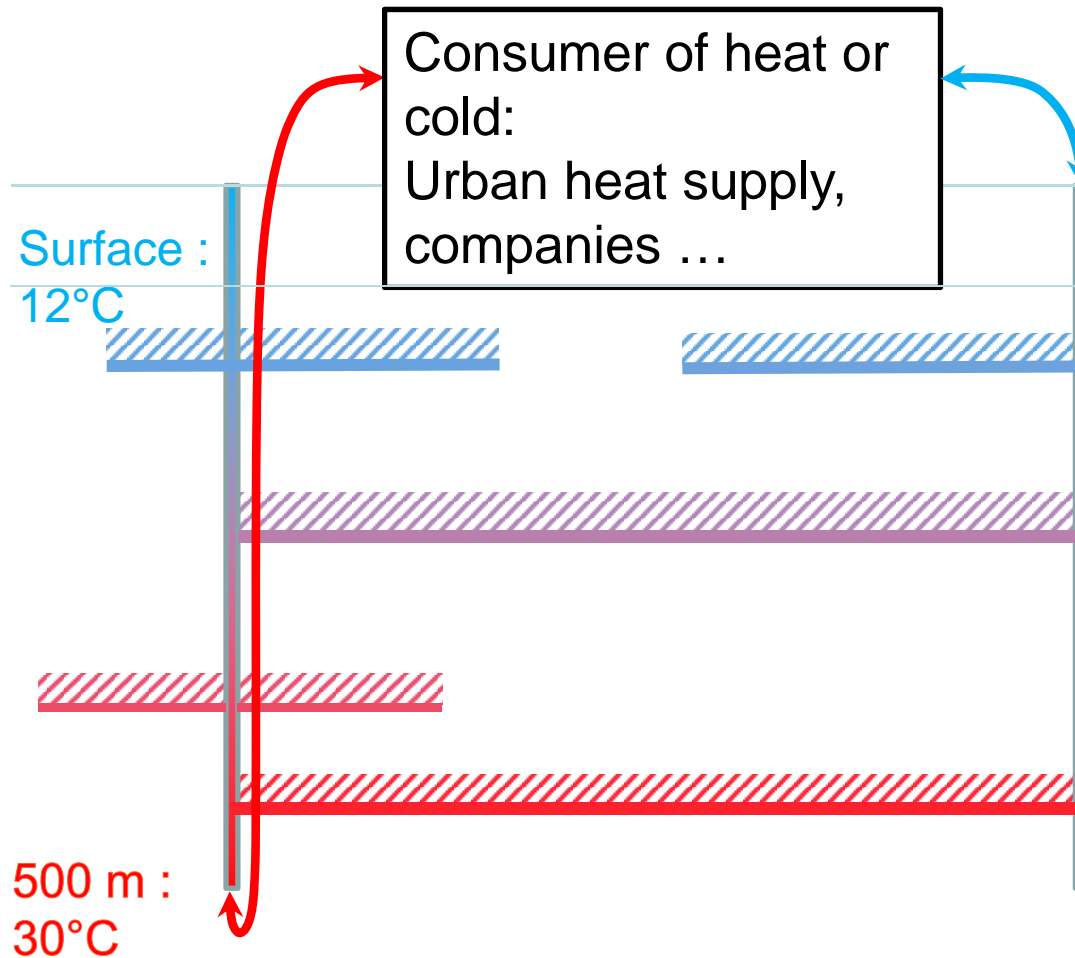
Rick Gilberts Geothermal Specialist, consulted in 2018 <https://geoproman.com/faqs>

Open loop geothermy

- High heat capacity of water
→ nice for high power demand
- P proportional to the water flow
→ large pumping rate needed

BUT needs an aquifer, at best not used for public water supply

Old flooded mines: a good candidate



Large voids

→ Possible to pump
with high flow rate

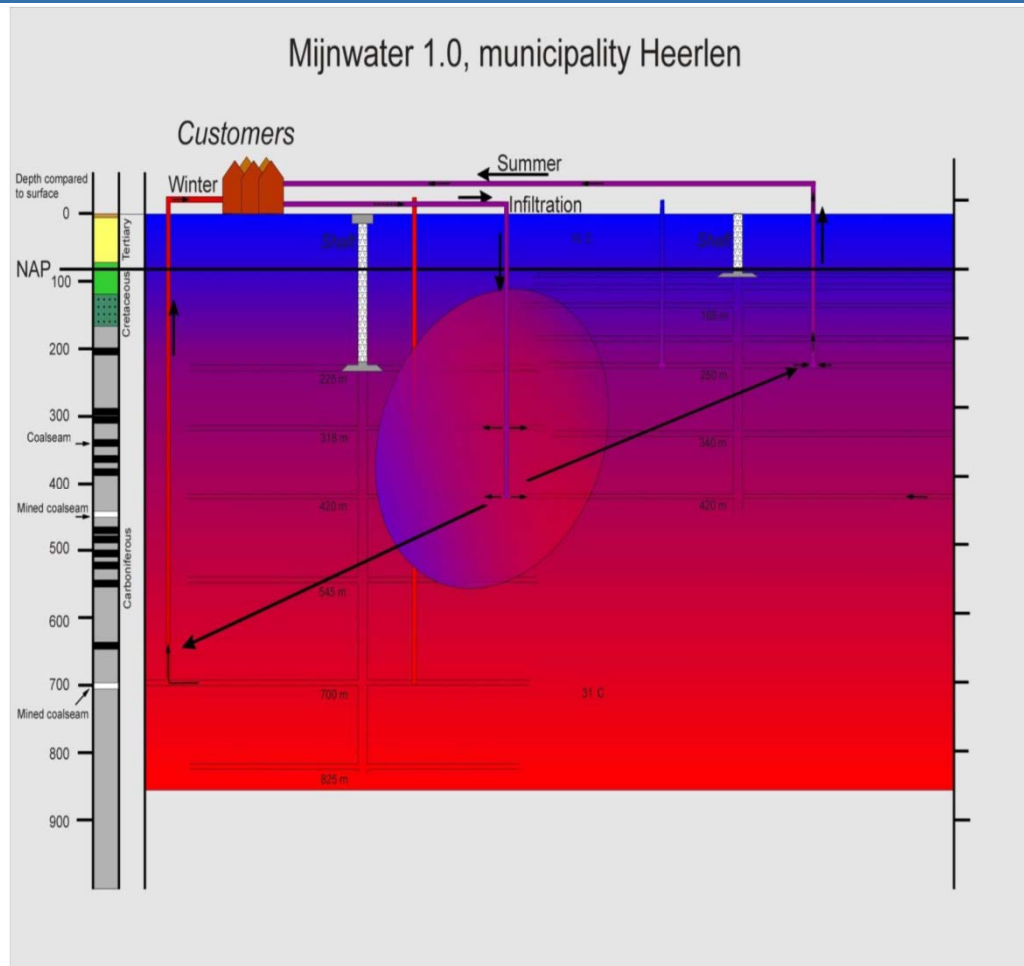
- Geothermal
gradient

→ warm and cold
water

- Old coal mines

→ Groundwater of
poor quality, few
conflicts with other
uses

Old flooded mines: a good candidate ... but a dynamic system requiring a challenging management



Verhoeven et al. 2012

Need of appropriate modelling tools to design and manage open loop systems in abandoned flooded mines

Challenges for modelling

We want to find a solution:

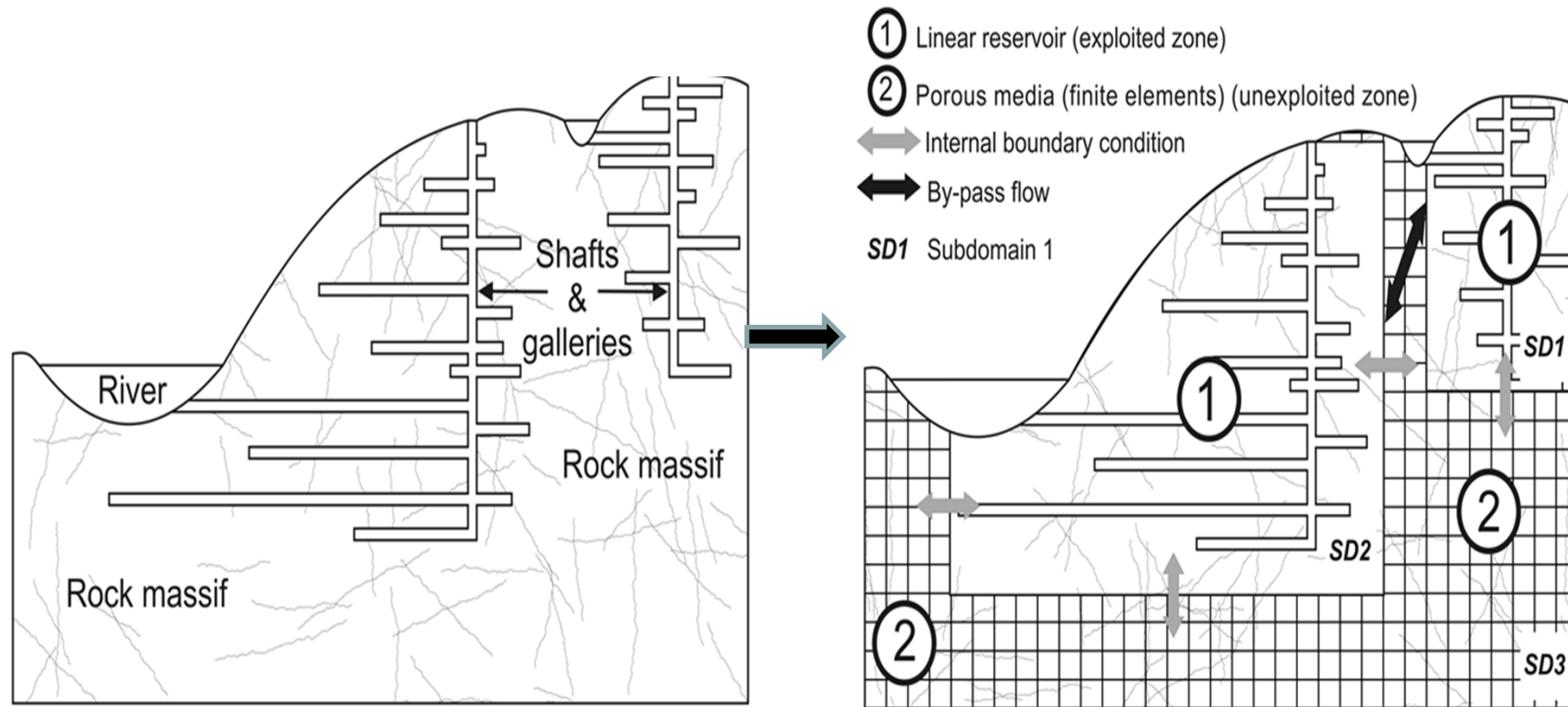
- Minimizing interaction between cold and warm water
- Giving the highest exploitable flow with coolest / warmest temperature

We have:

- Few data
- A large and complex domain to model
- High differences of porosity, of flow speed and thus of flow laws
- Domains with very different shapes and orientations (galleries, wells, damaged zones, hard rock...)

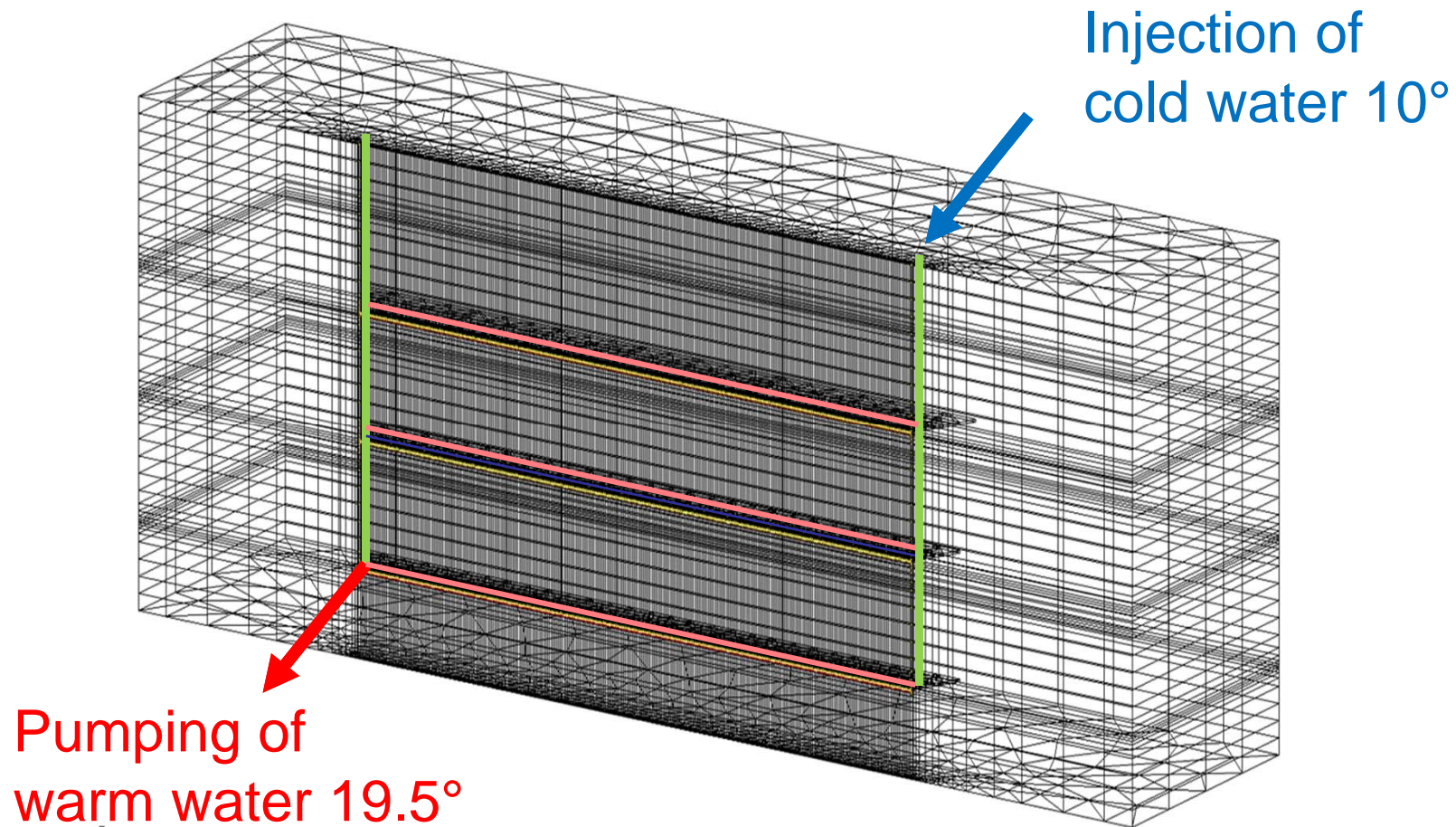
Classical modelling tools are not appropriate in such conditions

Solution : The hybrid Finite Element Mixing Cell Approach



Brouyère et al, 2009, Mine water and the environment.

Application : Based on the Werister abandoned coal mine (Belgium)

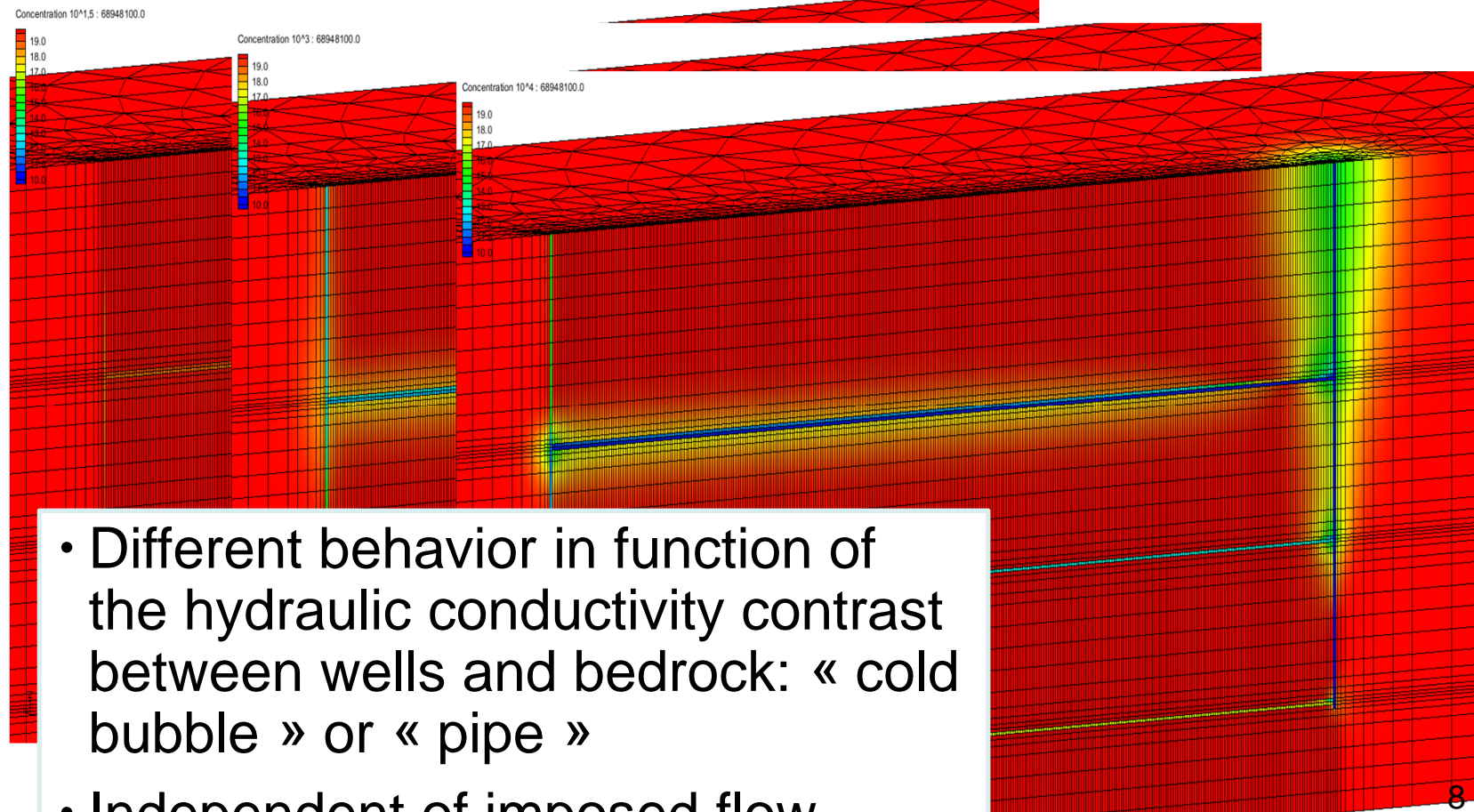


Application : Sensitivity analysis

$$\frac{K_{wells}}{K_{bedrock}} = 10^{1,5}$$

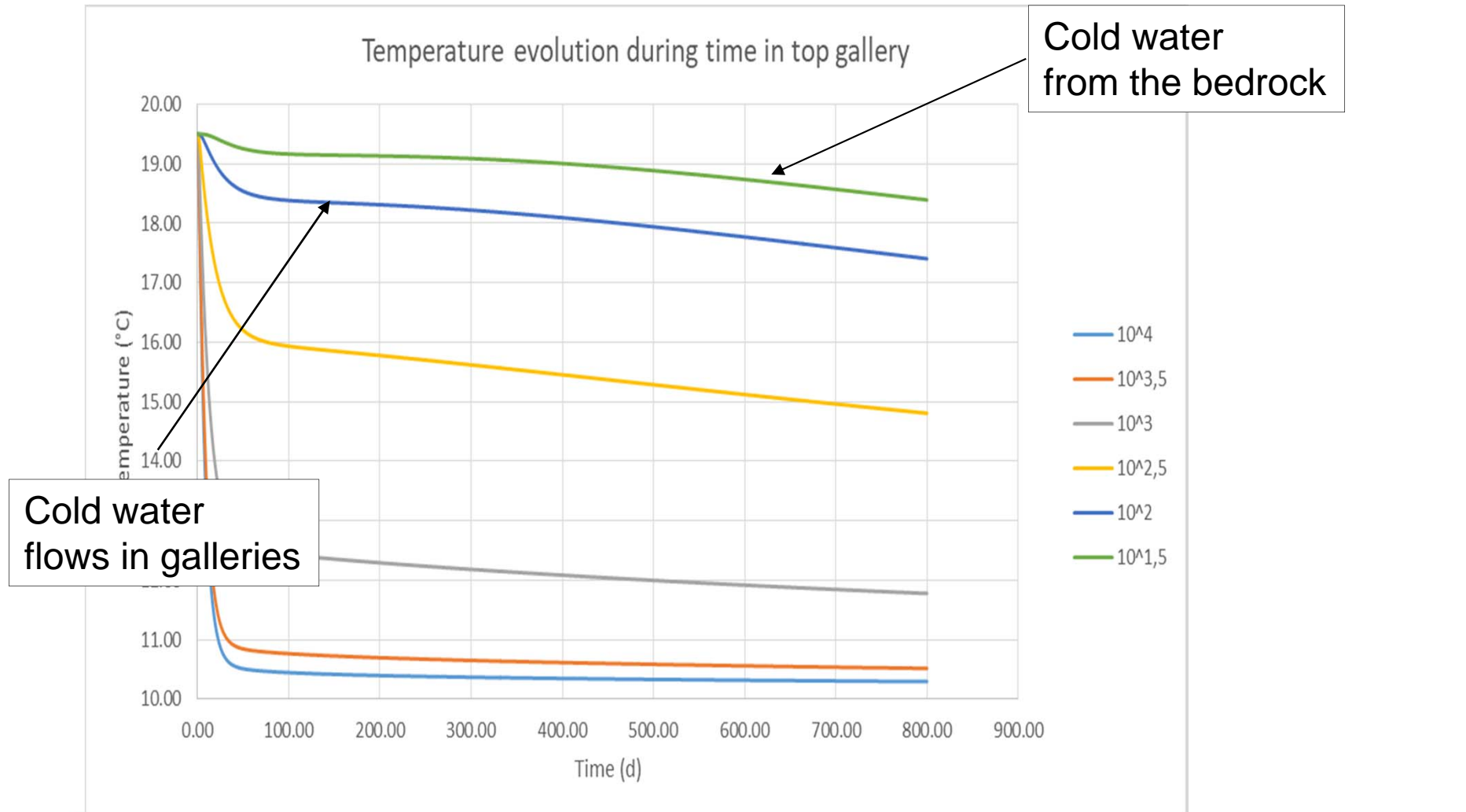
$$\frac{K_{wells}}{K_{bedrock}} = 10^3$$

$$\frac{K_{wells}}{K_{bedrock}} = 10^4$$

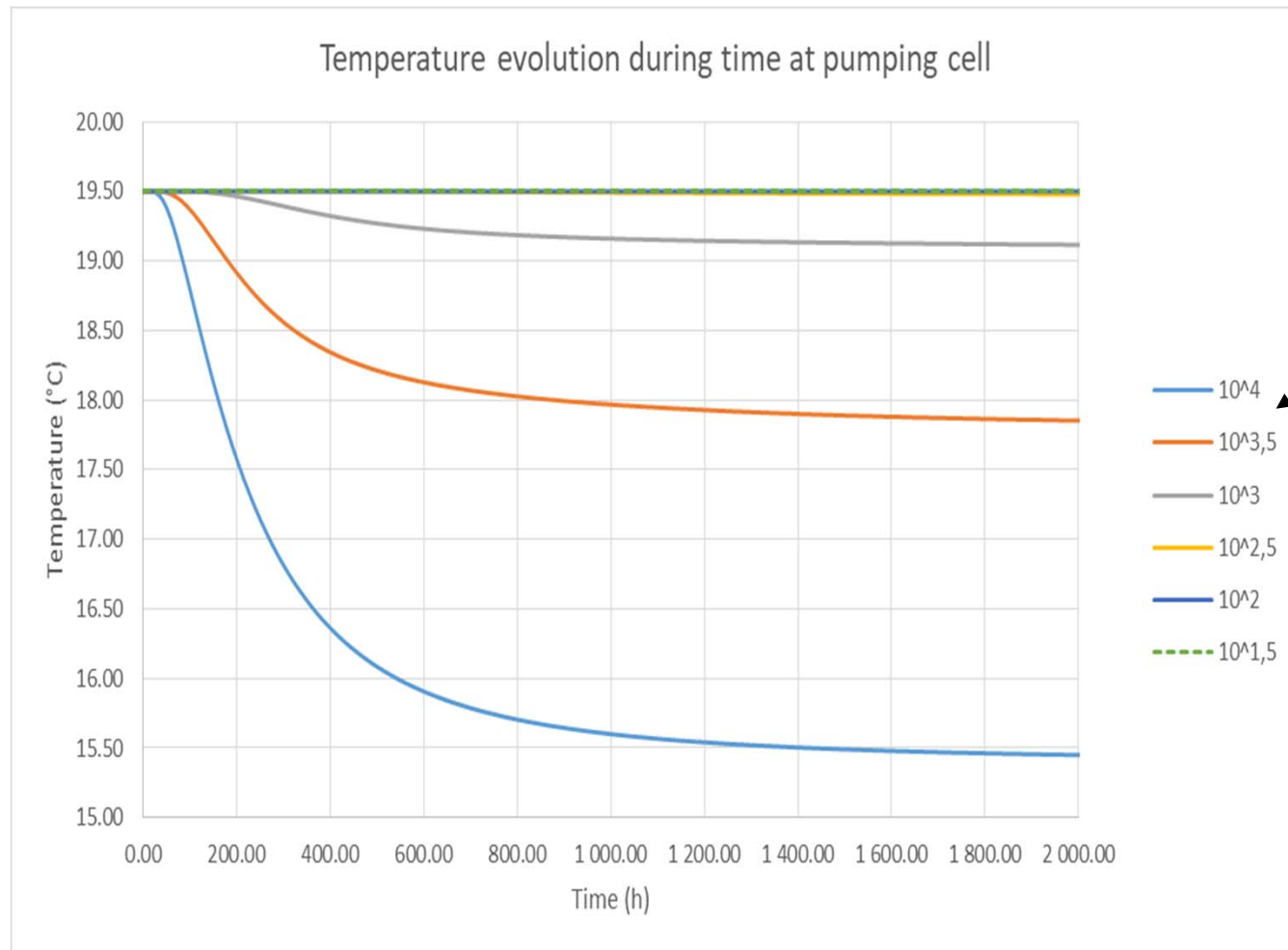


- Different behavior in function of the hydraulic conductivity contrast between wells and bedrock: « cold bubble » or « pipe »
- Independent of imposed flow

Application : Impact of the bed-rock on the temperature evolution



Application : Temperature evolution at the pumping location



Contrasts of conductivity:
 $\frac{K_{well}}{K_{bedrock}}$

Conclusions

- Flooded abandoned old mines can be good candidates for open-loop geothermal systems
- Open loop systems have to be correctly designed and managed to ensure their efficiency
- Galleries - Bed-Rock interactions can play a key-role
- Appropriate modelling tools adapted to mine have to be used to design such open loop systems

Any questions?



Groundwater Quality 2019

Groundwater Quality 2019

The next IAHS conference on Groundwater Quality (**GQ 2019**) will be held in Liège (Belgium) on 9-12 September 2019 !

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More information : aimontefiore.org/GQ2019

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