GEOTHERMAL USE OF OLD FLOODED MINES: FROM A RISKY TRIAL-AND-ERROR APPROACH TOWARDS CHALLENGING PREDICTIVE SIMULATIONS

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In urban areas, flooded abandoned mines could be used for shallow geothermal purposes. Such aquifer thermal energy storage (ATES) systems, using heat-pumps and an open loop with a groundwater pumping and re-injection doublet, are highly challenging and uncertain with risks undermining the ultimate feasibility. The true geometry of the interconnected network made of old open galleries and shafts can be highly complex and partially unknown/forgotten. Indeed, high-velocity water flow is expected in this network, while low-velocity groundwater flow occurs in less permeable fractured and porous rock massif. For the latter, hydraulic conductivity values have been significantly increased by mining exploitation. Logically, hot water is pumped in the deep parts of the open network, and cold water can be re-injected in the shallower parts (i.e. in shallower galleries or fractured rocks). A seasonal inversion could be planned for building cooling during the hot season.

So far, those who have successfully moved to such a heat production have adopted a risky strategy that can be qualified as a trial-and-error procedure. Indeed, after some time, a cold water breakthrough is observed as mixing with the pumped deep hot waters. In fact, this strategy needs to continually adapt the project by integrating several pumping/injection wells, seasonal variations, and even a further integration of other renewable energy sources in a local smart grid. This ends up with very significant investments that are rarely planned at the beginning of the project.

Another approach could be to involve more accurate hydrogeological characterization of the old mined zones for detailed simulations of the groundwater flow and the associated temperature evolution in pumping zones. The challenge is huge because characterization and numerical issues are to be solved. Added to the often unknown complexity/heterogeneity of the galleries network conjugated to those of the mined geological formations, variable density water flow and coupled heat transport must be taken into account using a dedicated software allowing to simulate a combination of high-velocity 'pipe-like' water flows (in the galleries) and porous/fractured groundwater flow (in the rock matrix). An example of a simplified but realistic situation is given showing numerical results with the differentiated temperatures as a consequence of heat/cold propagation in the galleries, shafts and the fractured rocks. This kind of numerical simulations allow to anticipate the temperature changes affecting the future (short-, mid-, and long-term) efficiency of the geothermal system as well as possible environmental impacts.

Real cases in relation with future projects, should ideally be simulated using such detailed approach, but numerical simulation with true data will surely not be an easy way. However, it is only on the basis of accurate predictions (i.e., about long term efficiency and possible expected impacts) that the financial risk could be assessed for decisions.

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