Investigating the key controls on mine-water heat in legacy flooded coal mines in the UK: What is the thermal footprint of past mining activities?

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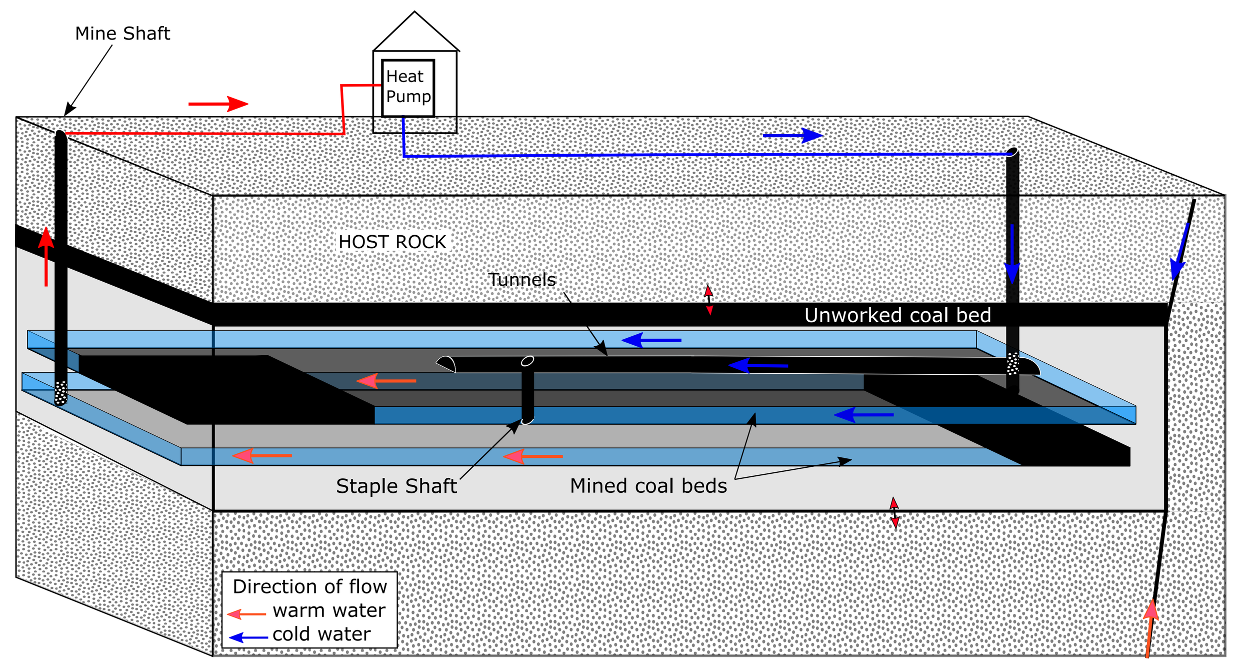
I - Introduction:

- Residential heating : ~50% of the energy consumption & ~20% of the GHG emissions in the UK.
- 9% of the population lives in formed mine areas; today, all underground coal mines are closed.
- Water rebound in abandoned mines is either in progress or completed; pumping implemented by the Coal Authority at some locations to avoid mine-water discharge at the surface.
- Recovering heat from mine-water using GSHP can provide local population with low-carbon heating (e.g. Dawdon mine-water heating project).

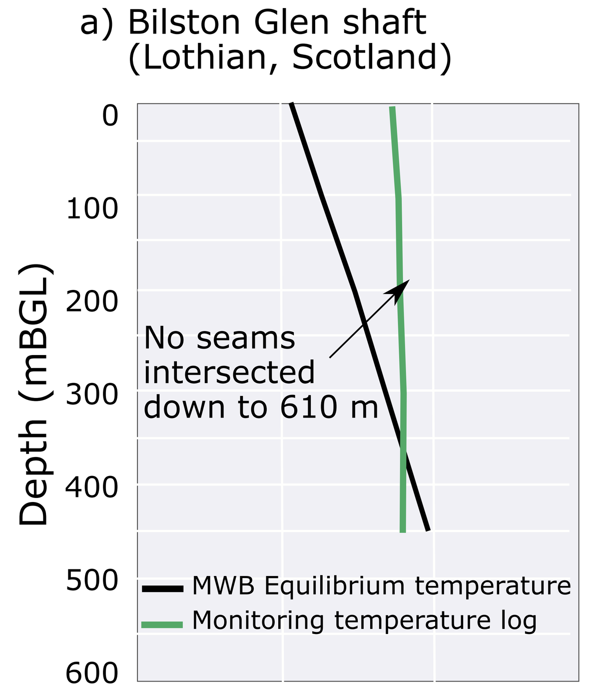
Problematic: Data revealed a lack of correlation between local equilibrium temperature in the mine-water block (MWB) and temperature profiles measured in mine shafts (Farr et al., 2020).

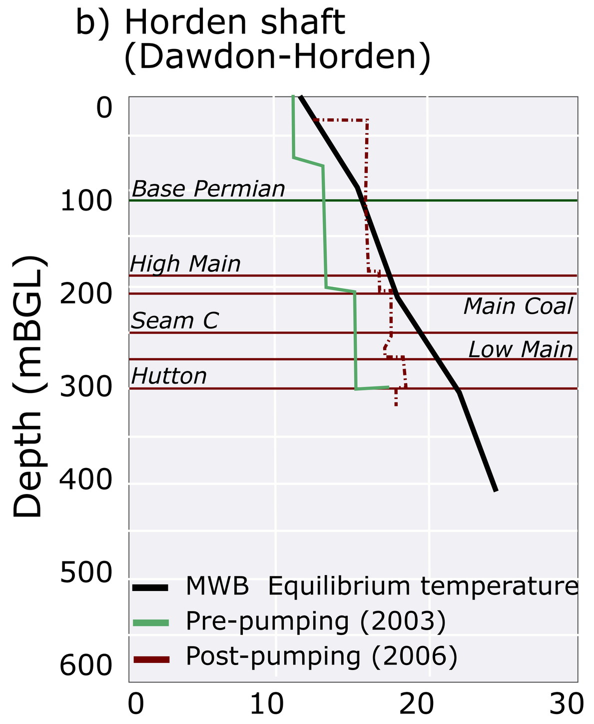
Objective: Investigate the long-term impact of pumping activities during mining on the temperature distribution in mines after water rebound to explain those discrepancies.

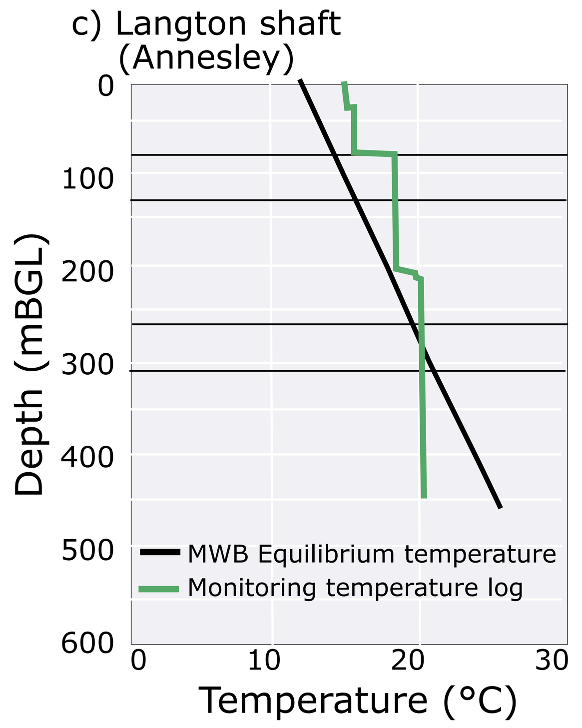
Key Message: We demonstrate the potential existence of new geothermal gradients in flooded mines. This suggests the importance of considering past mining activities & flooding history when performing geothermal potential assessments.

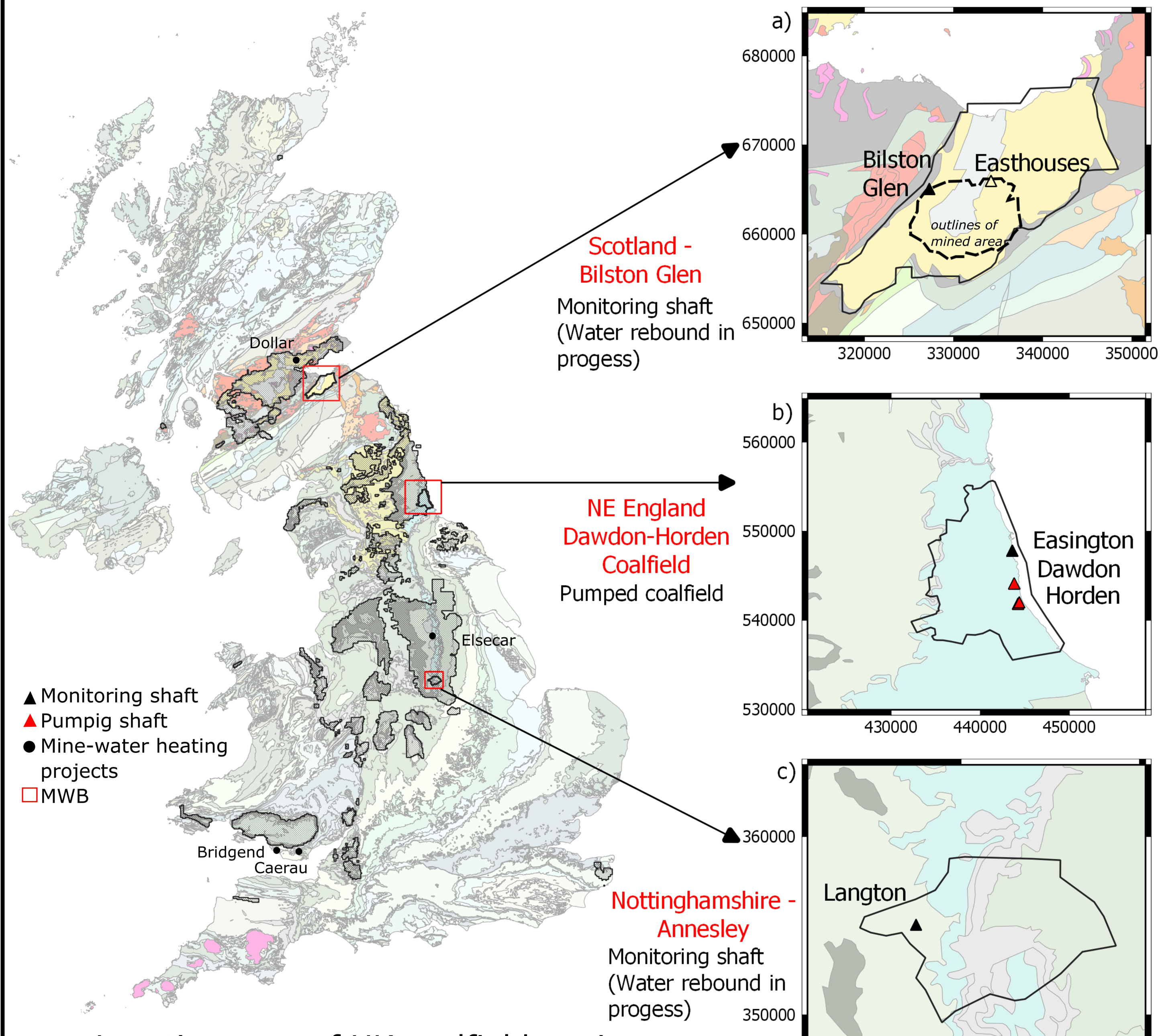


Conceptual model of coal mine working and Ground-Source Heat Pump (GSHP) system with direction of groundwater flow





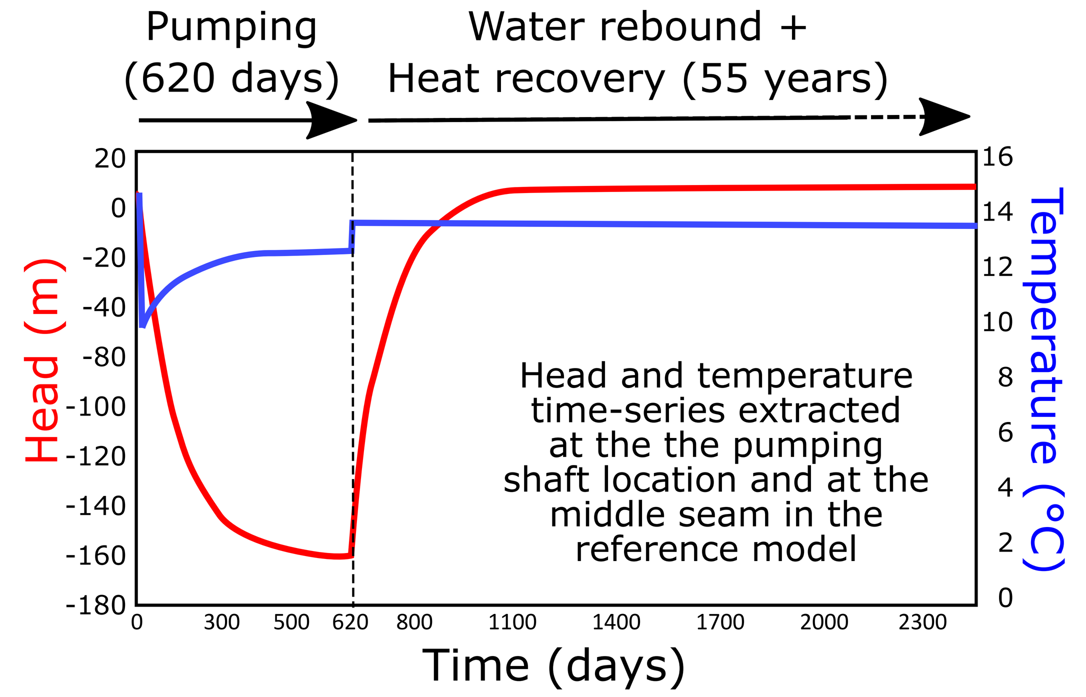


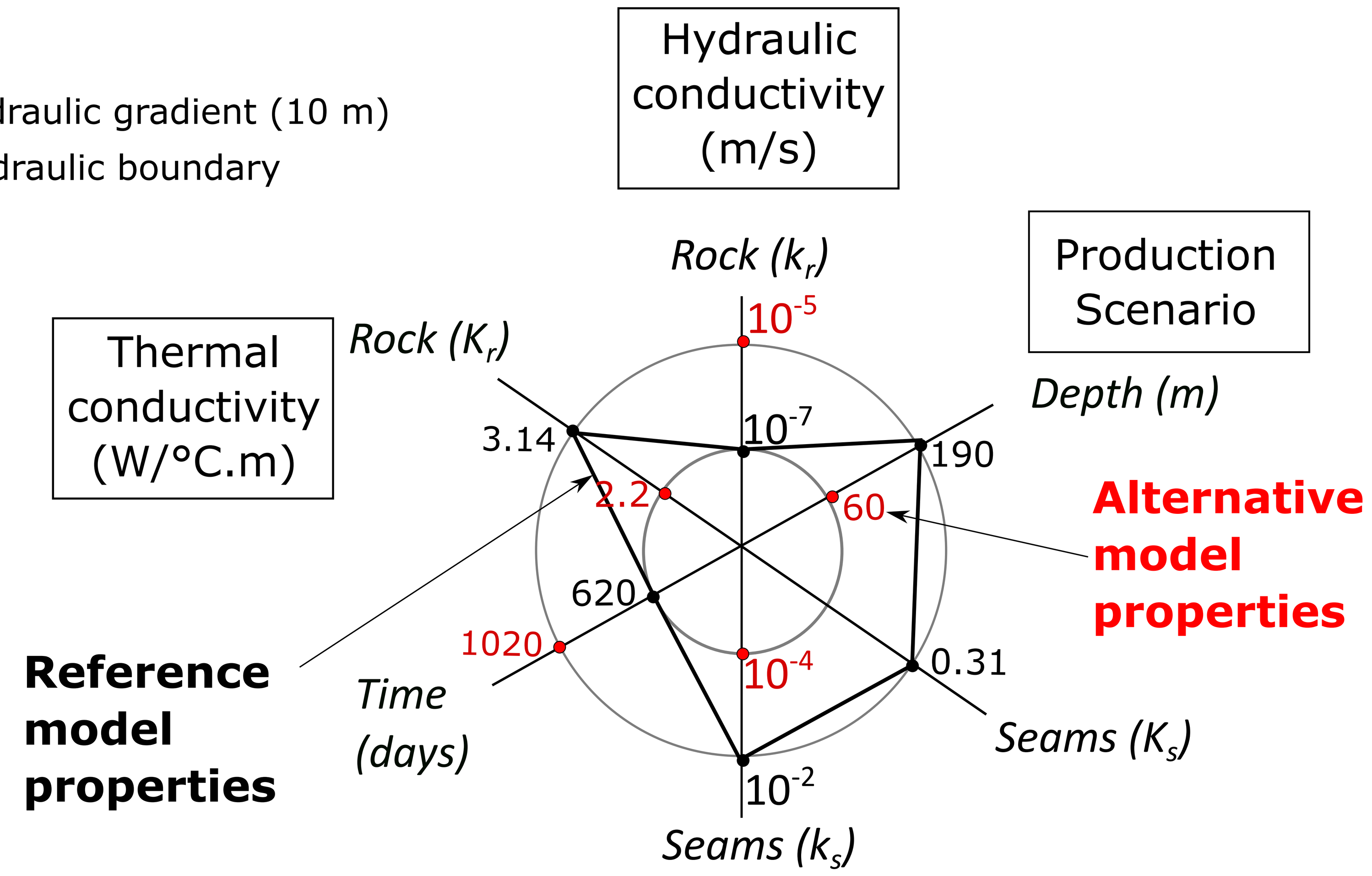


Location map of UK coalfields, mine-water blocs (MWB) and shafts where temperature profiles are available.

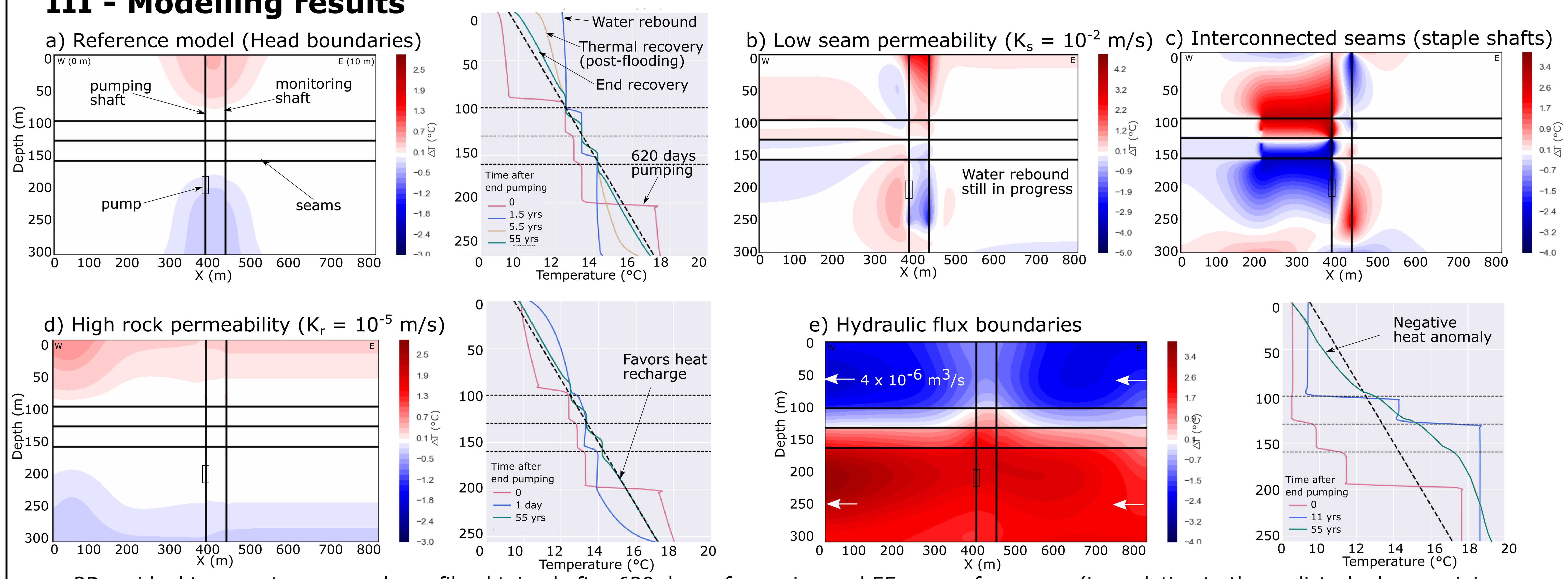
II - Methods

- Finite-element hydro-thermal modelling using OpenGeoSys
- Reference model (a): 2D Mine of simple geometry with westward regional hydraulic gradient (10 m)
- Sensitivity analysis on the effects of rock properties, production scenario, hydraulic boundary conditions and seams interconnectivity on the residual temperature anomaly.





III - Modelling results



2D residual temperature anomaly profile obtained after 620 days of pumping and 55 years of recovery (i.e. relative to the undisturbed pre-mining temperature distribution) and 1D temperature profiles extracted in the pumping shaft during water and heat recovery

IV - Key outcomes:

- Long-term perturbations of the geothermal gradient around shafts resulting from mine-water advection in highly permeable mining voids (i.e. convective heat flow) and mixing.
- Residual temperature anomaly depend on the k_r, k_s, the nature of hydraulic recharge during rebound and the seam interconnectivity.
- In our scenario, new temperature steady-state reached after ~50 years from the end of mining

V - Next step:

- Evaluation of the time to return to equilibrium considering a realistic mining history (i.e. duration, ventilation, hydraulic recharge)
- Investigation of the impact of the mine geometry on the long-term heat potential of flooded mines
- Calibration and validation of models based on data from the Dawdon-Horden coalfield

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References: Farr, G. et al., 2020. The temperature of Britain's coalfield. doi: 10.1144/qjegh2020-109