

A preliminary reactive transport approach to quantify swelling of clay-sulfate rocks

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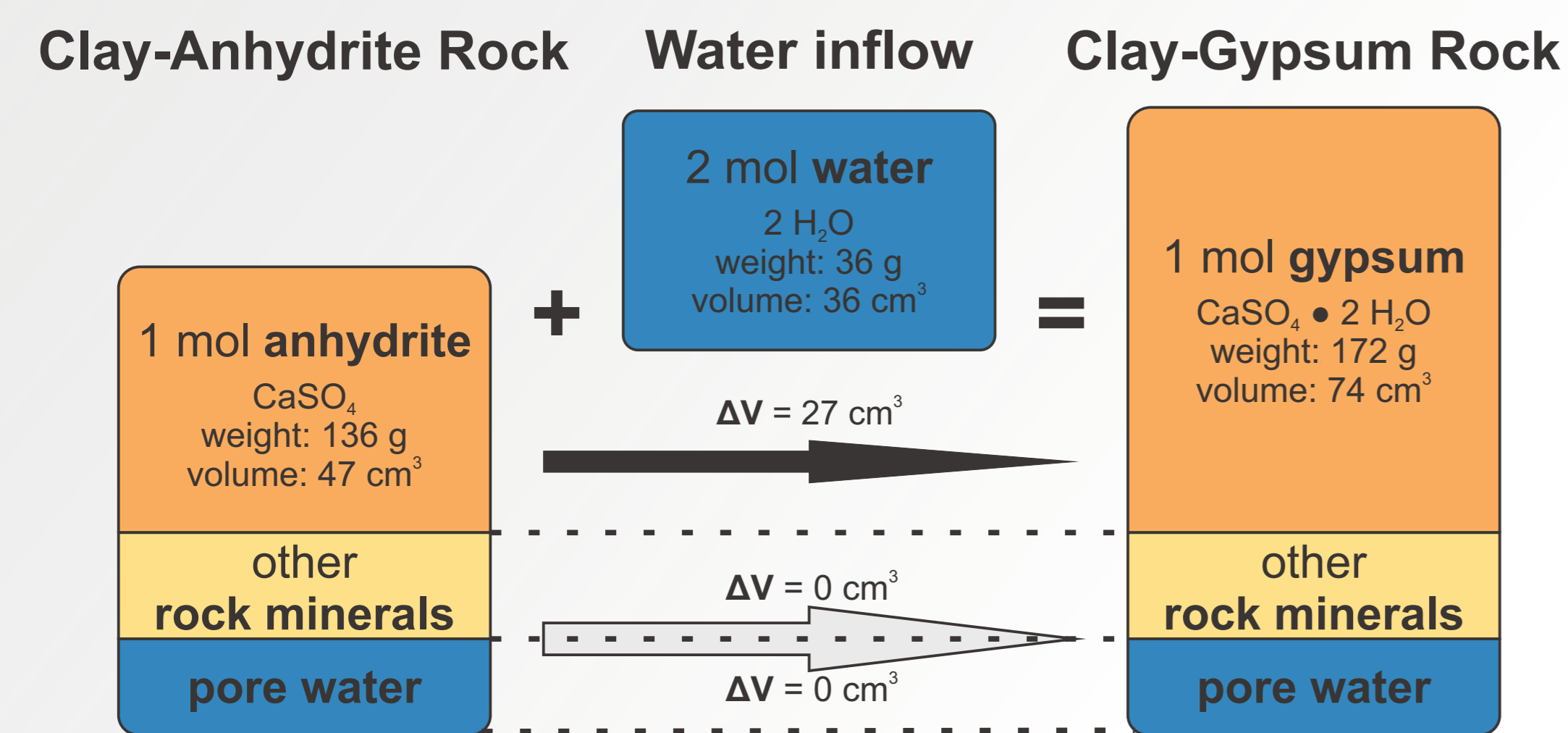
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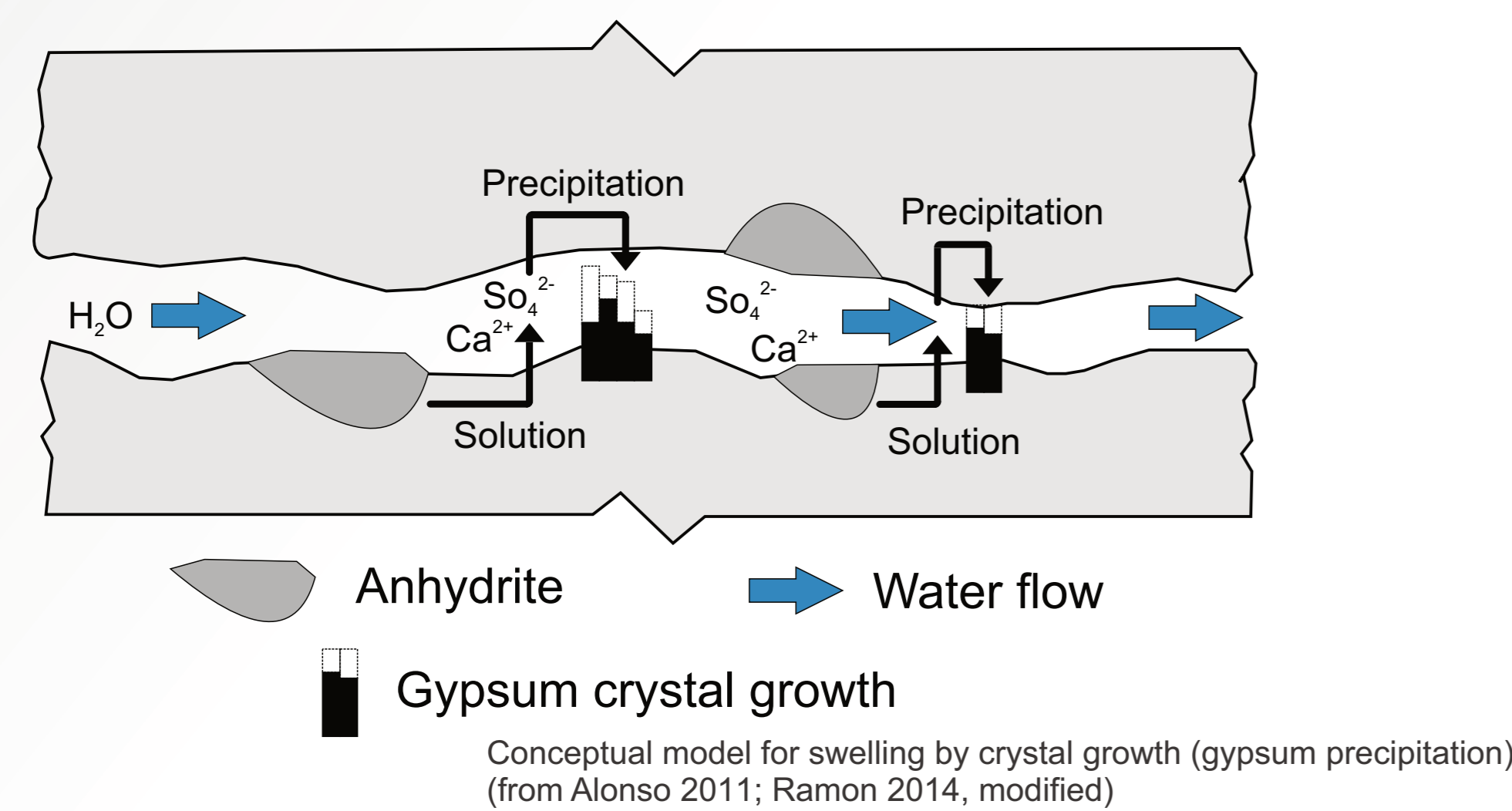
Staufen im Breisgrau, damaged houses as a result of ground heave after thermal drillings.

① Background

The transformation of anhydrite into gypsum as a result of water influx is considered to be the main mechanism contributing to the swelling process of clay-sulfate rocks, leading to an increase in volume of up to 60 %.



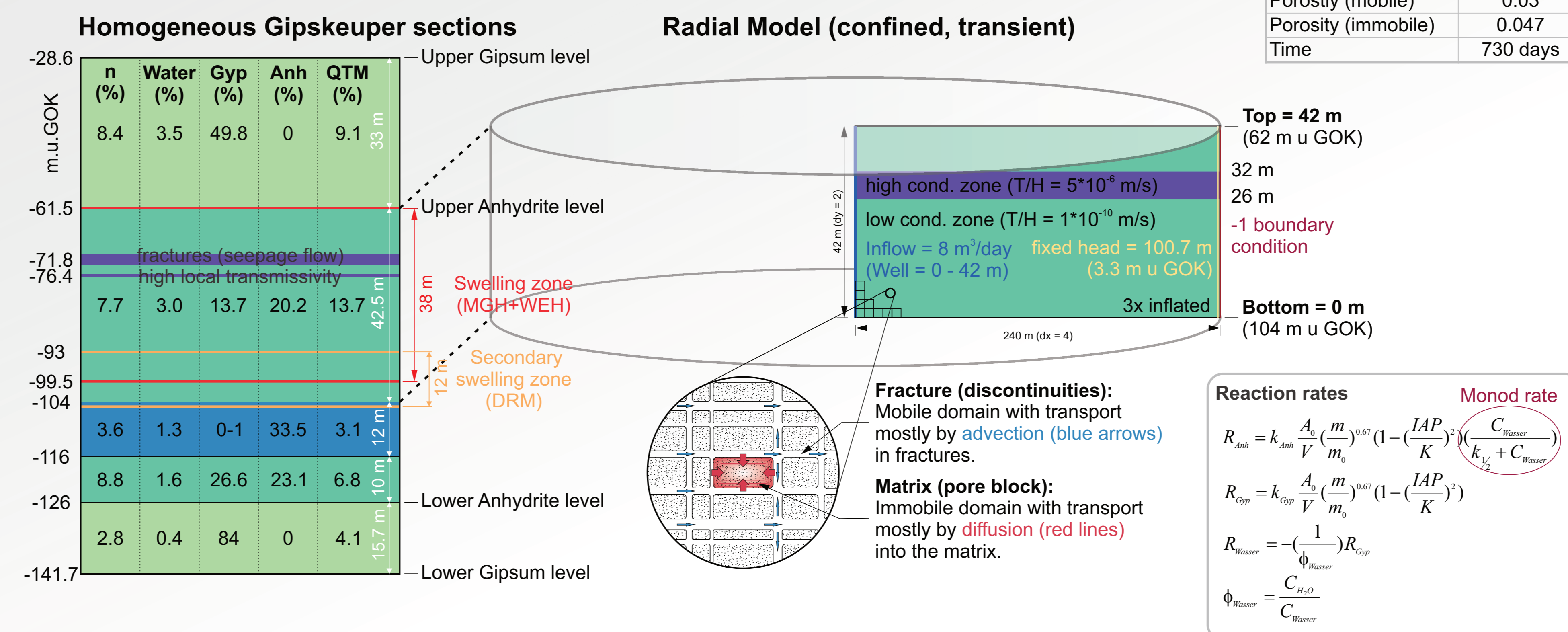
Groundwater flow and its flow pattern together with geochemical conditions are key factors controlling dissolution and precipitation of sulfate minerals in clay-sulfate rocks, and thus swelling.



② Hypotheses

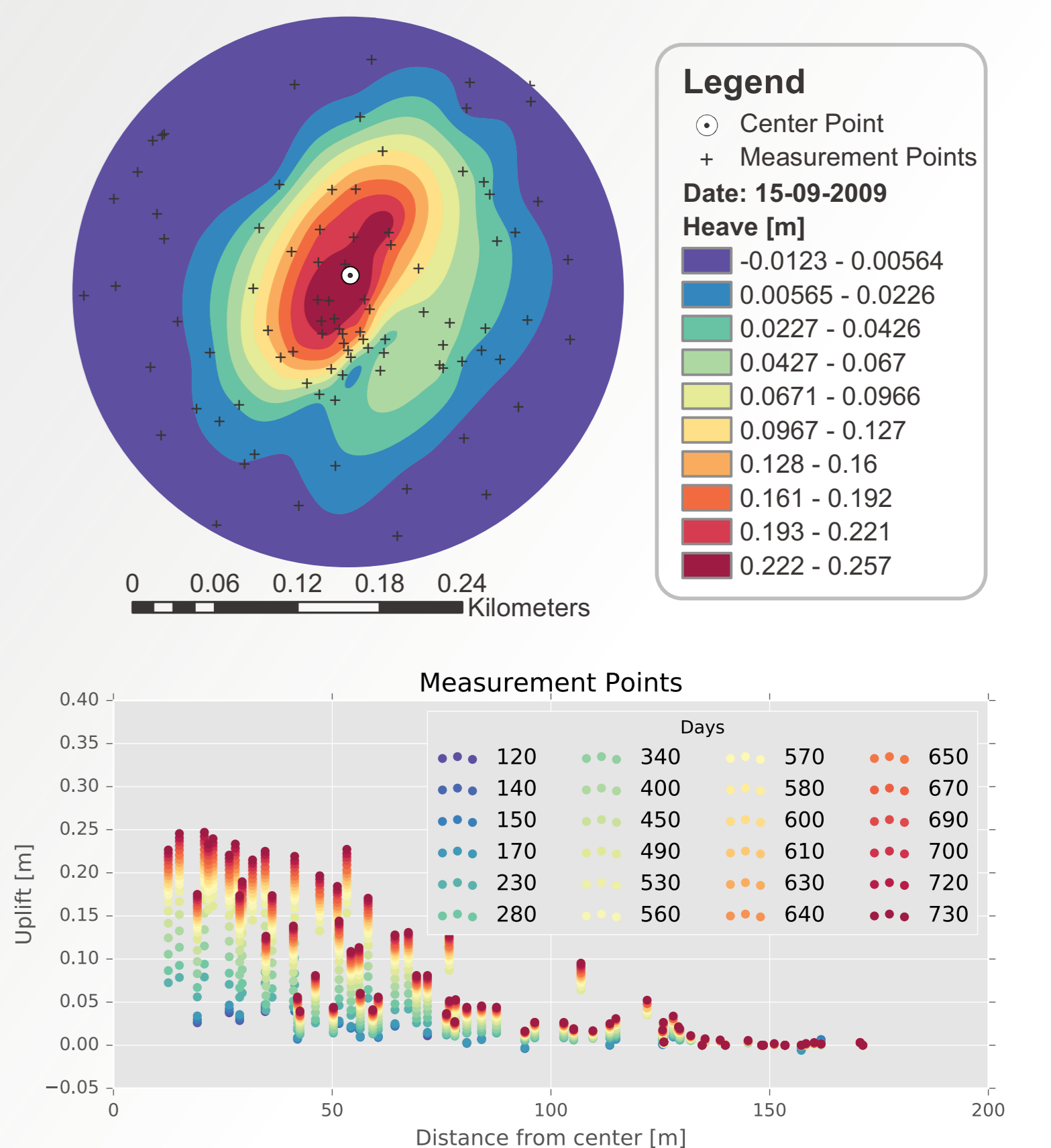
- Swelling of clay-sulfate rock is mainly controlled by anhydrite dissolution and gypsum precipitation.
- Changes in hydraulic conditions by human activities can lead to geochemical changes in sulfate rocks, triggering swelling.
- Field scale swelling reaction rates may differ from those determined in the laboratory.
- A quantitative description of groundwater flow and reactive transport can explain and possibly predict the swelling phenomena.

③ Reactive Transport Model



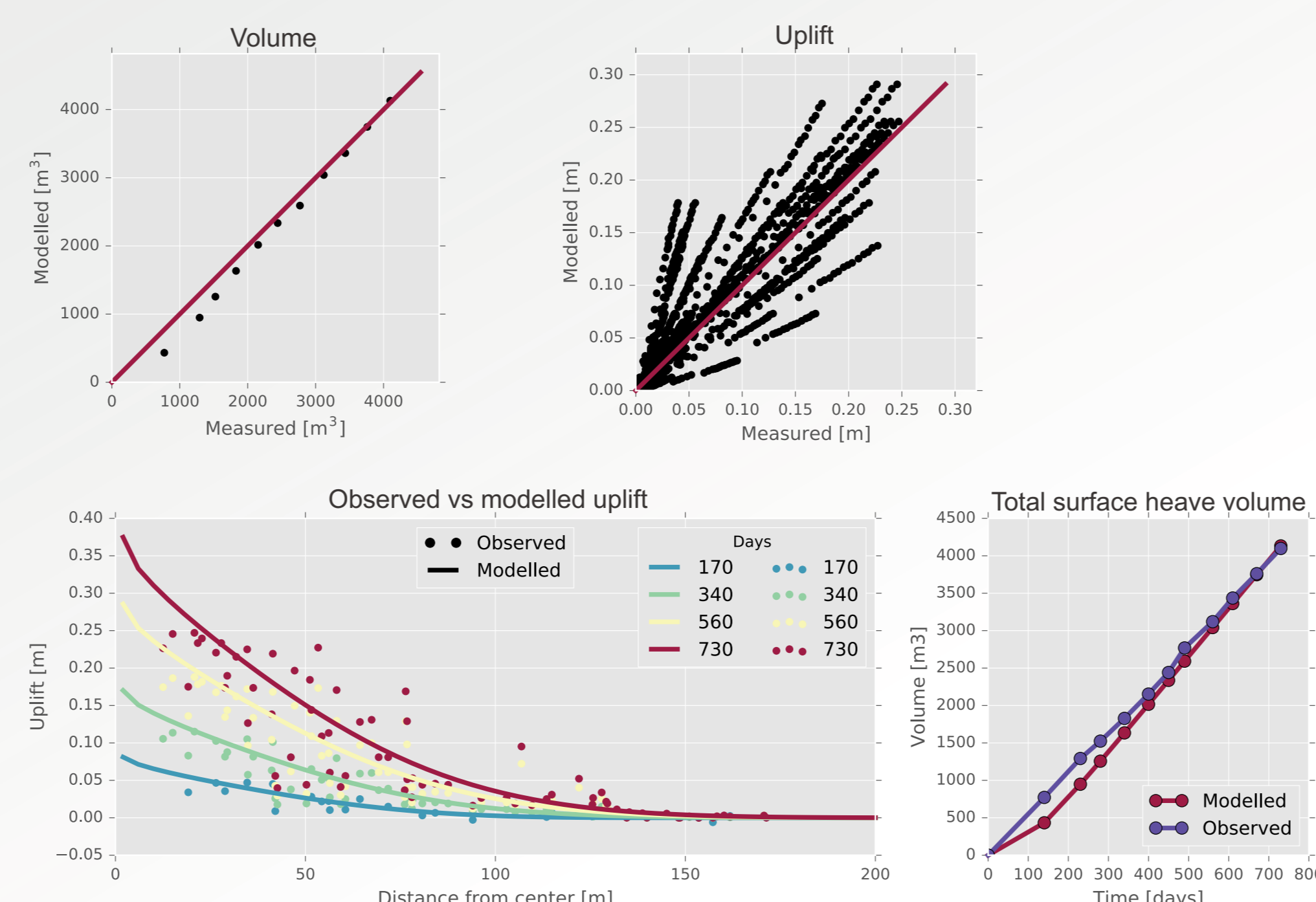
④ Measured Data

The model is calibrated against heave and uplift data obtained from a dense network of measurement points on site.



⑤ Parameter Estimation (PEST)

- PEST:
- 11 Estimated parameters
 - 1505 Observations of volume and uplift over a period of 730 days
 - Apply Tikhonov regularization to cope with non-unique solutions



⑥ Outlook

- Validate the calibrated model against an extended period of time (t=1500 days) with additional available volume and uplift data.
- Investigate whether our model can predict the continuous uplift due to water remaining in the system, after shutting down water inflow.

⑦ References

- Alonso E. E., 2011. Crystal growth and geotechnics. Paper presented at the Arrigo Croce Lecture, Rome, Italy, 15 Dec 2011, pp 46.
- Ramon A., 2014. Expansion mechanisms in sulphated rocks and soils. PhD thesis, Universitat Politècnica de Catalunya, Barcelona.
- Butscher, C., Mutschler, T. & Blum, P., 2016. Swelling of Clay-Sulfate Rocks: A Review of Processes and Controls. Rock Mech Rock Eng 49: 1533.