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Validation of multicomponent geothermometer with sensitivity analysis in basaltic geothermal setting

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Motivation

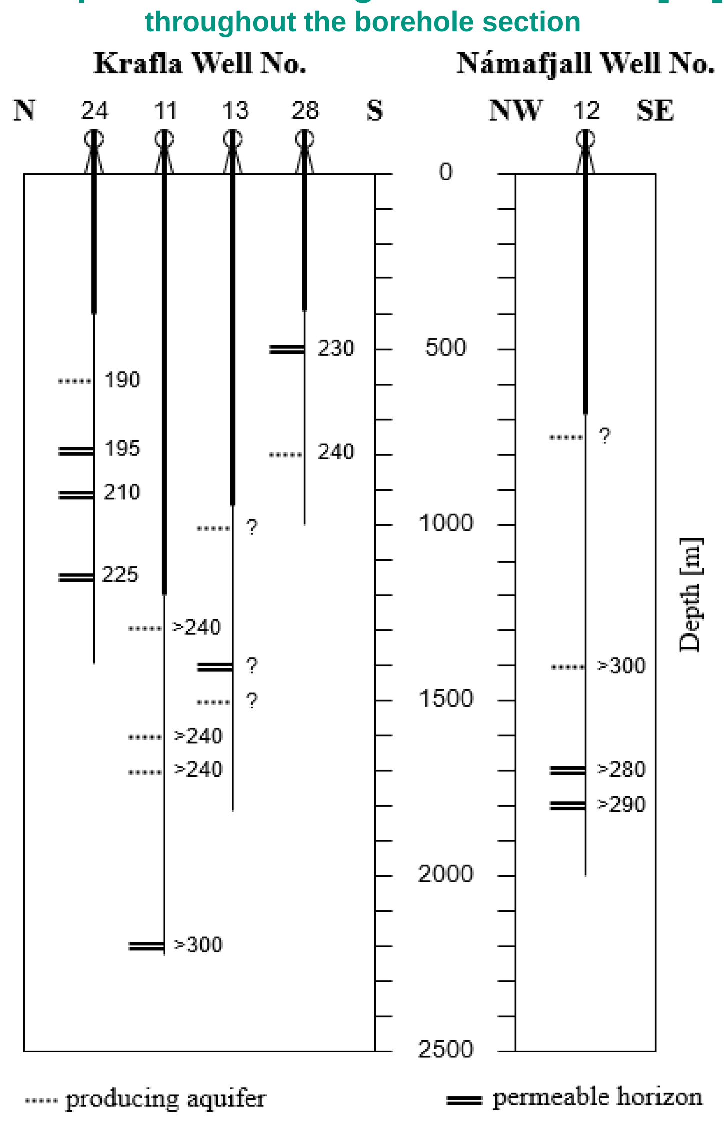
- Create an economical exploration tool by using multicomponent geothermometry to estimate reservoir temperatures
- Apply a sensitivity analysis (Nitschke et al. (2017)) for more robust and better temperature estimation
- Define and calibrate a specific mineral set for basaltic rock

Conclusion and outlook

- The estimated reservoir temperature matches the measured temperature with an error of ±5%
- The developed and calibrated tool can be applied on natural spring water with same results
- Future implementation of new mineral sets to adapt the tool to different geothermal settings

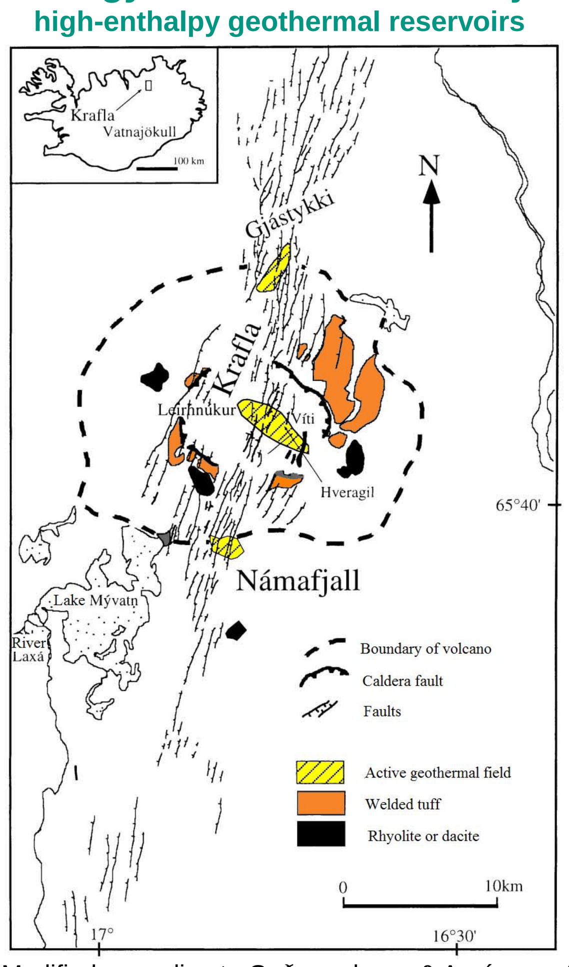
Geothermal fields Krafla and Námafjall

Temperature of the geothermal fluid [°C]
throughout the borehole section



Modified according to Guðmundsson & Arnórsson (2002)

Geology of Krafla and Námafjall
high-enthalpy geothermal reservoirs



Modified according to Guðmundsson & Arnórsson (2002)

- Krafla and Námafjall are high-enthalpy geothermal reservoirs up to 350°C at a depth of 2000 m

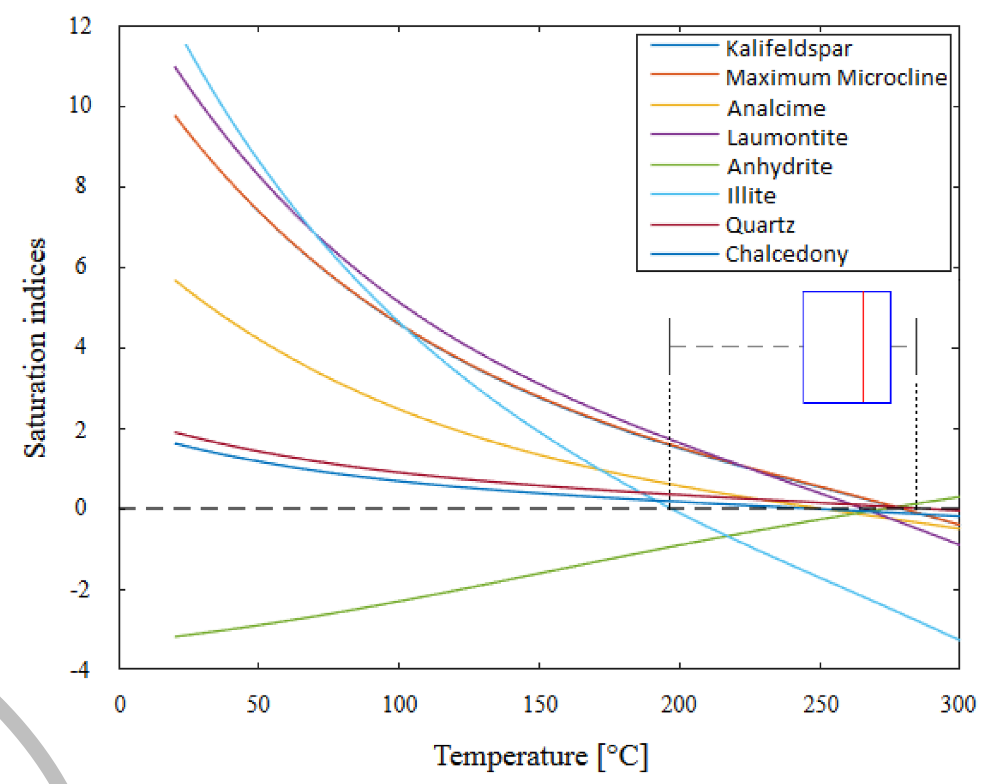
Saturation indices and mineral set

- Temperature estimation is given by the geochemical equilibrium between mineral phases and the reservoir rock
- Therefore the saturation indices of the mineral phases are serving as geothermometers
- The mineral set is based on secondary mineralizations in geothermal systems:

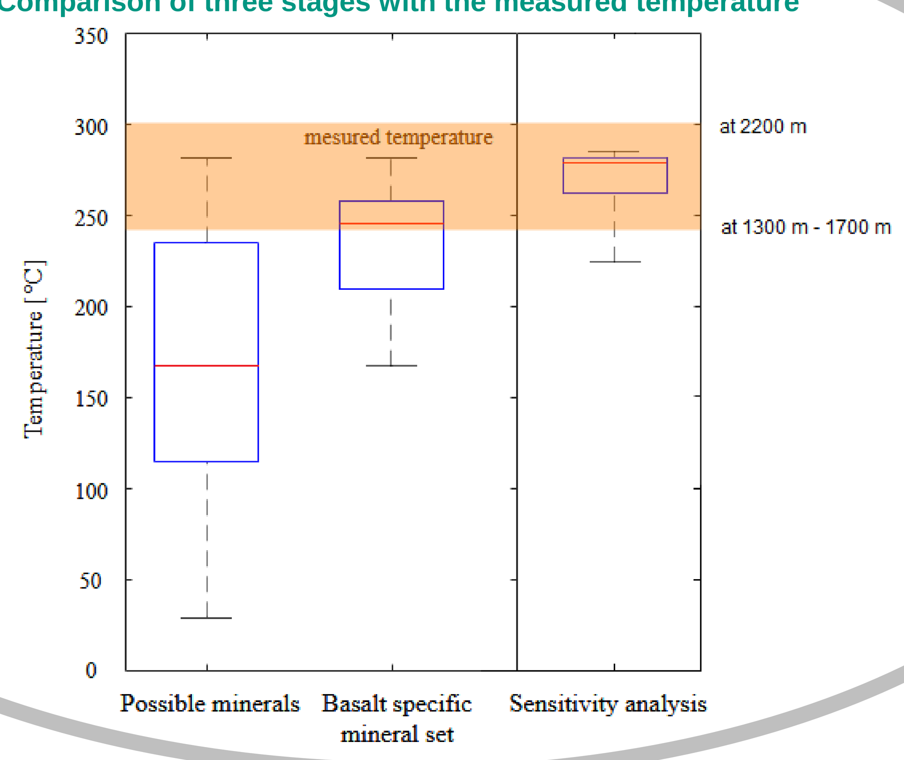
Calibrated basalt specific mineral set

low albite	fluorite
microcline	smectite
k-feldspar	clinochlore
epidote	illite
analcime	quartz
laumontite	chalcedony
wairakite	pyrite
calcite	marcasite
aragonite	pyrrhotite
anhydrite	goethite

Equilibrium of the mineral phases
used for the temperature estimation of the reservoir



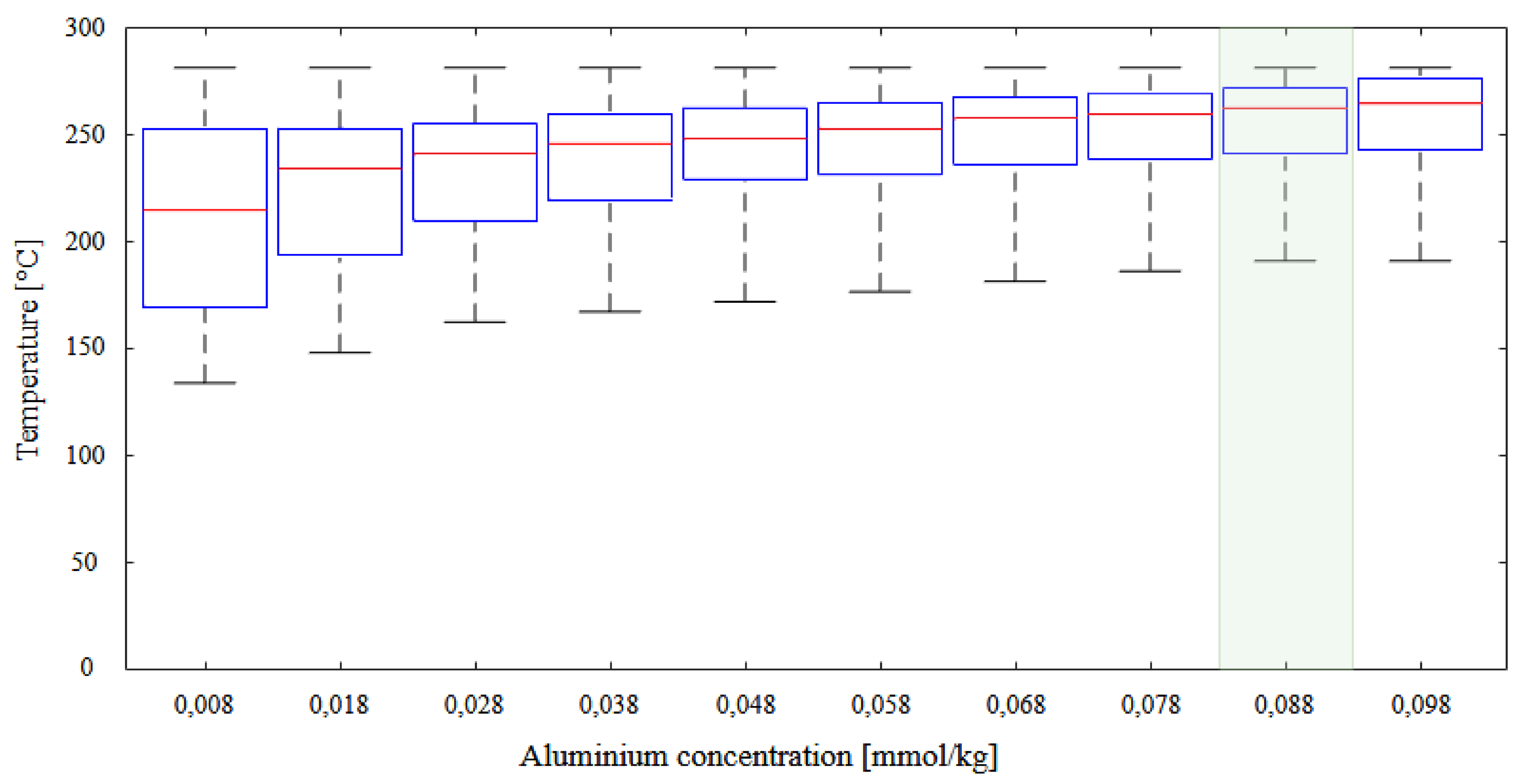
Temperature estimation
Comparison of three stages with the measured temperature



Sensitivity analysis

- Basic assumption of a chemical equilibrium
- Improvement of the estimated reservoir temperature by minimization of the boxplot spread
- Variation of the value yield of sensitive geochemical parameters: pH, aluminium concentration and redox potential

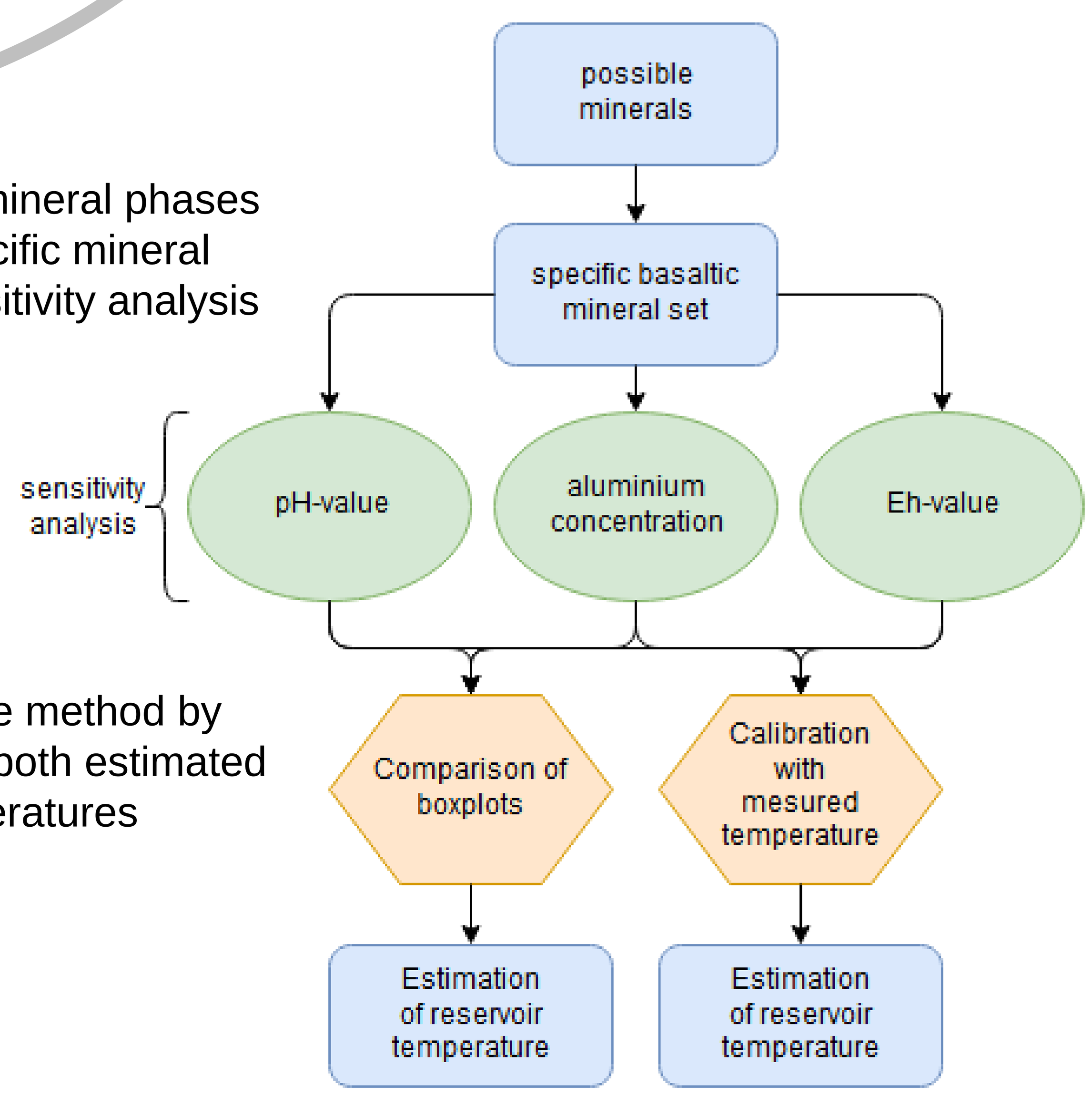
Example of the sensitivity analysis
for the best fit aluminium concentration



Workflow of the validation

Flowchart of the workflow

- Reducing the mineral phases to a basalt specific mineral set for the sensitivity analysis
- Validation of the method by comparison of both estimated reservoir temperatures



Publication of major contribution

Nitschke, F.; Held, S.; Villalon, I.; Neumann, T.; Kohl, T. (2017): Assessment of performance and parameter sensitivity of multicomponent geothermometry applied to a medium enthalpy geothermal system. In: Geotherm Energy 5 (1)
Guðmundsson, B. T.; Arnórsson, S. (2002): Geochemical monitoring of the Krafla and Námafjall geothermal areas, N-Iceland. In: Geothermics 31 (2), p. 195–243.