Adjusting Solute Geothermometry - Methods to Constrain Subsurface Temperature Estimation

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Being a key parameter for the assessment of the economic efficiency of future reservoirs, the knowledge of the reservoir temperature is of outstanding importance for geothermal exploration. Since decades, it is a common practice to use natural geothermal springs as a window to the subsurface, deducing an equilibrium temperature for the discharged fluids from their composition. Though, great efforts have been made to improve the methods, solute geothermometry is still subject to large uncertainties, leading to unreliable spreads of resulting temperatures, which frequently exceed 100 K.

The presented study assesses the performance of classical solute geothermometers and the numerical approach of multicomponent geothermometry. Applied to a data set of natural fluid samples and to fluids from laboratory equilibration experiments the uncertainties of both methods were quantified and the most sensitive interfering factors were identified. It is shown that, with regard to a number of parameters, the fluid composition at discharge do not reflect the in-situ conditions of the reservoir. During ascent re-equilibration, degassing, boiling and dilution change fluid composition significantly.

We propose methods to adjust the measured data aiming to reconstruct the original in-situ fluid composition which enables the estimation of true reservoir temperatures. An anthropogenic tracer based mixing model is used to quantify possible dilution with superficial waters. Reservoir rock dependent differences of equilibration behaviour are deduced from laboratory experiments and transferred to natural samples using strontium isotope measurements. Boiling and steam-loss processes can be identified by measuring stable water isotopes. The in-situ pH and the original aluminium concentrations are determined using numerical modelling techniques.

It is shown that, for both methods, classical solute and multicomponent geothermometry, the data adjustment leads to strongly converging calculated temperature with significantly low uncertainties of $\Delta T > 20$ K.