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Geothermometrical modelling of a carbonate-evaporitic thermal system

Blasco, M.[1], Auqué, L.[1], Gimeno, M.J.[1]

[1] Earth Sciences Department, University of Zaragoza. C/ Pedro Cerbuna, 12, 50009, Zaragoza, Spain.
monicabc@unizar.es

Most of the classical chemical geothermometers have been calibrated for their application to high temperature systems (e.g. [1]) and, therefore, they usually present problems when applied to low temperature geothermal systems hosted in carbonate evaporitic materials. In those cases, as it will be shown here for the Arnedillo geothermal system, a useful technique is the geothermometrical modelling.

This system is located in La Rioja (Spain) in the contact between the Cameros Range, mainly constituted by Mesozoic materials, and the Ebro basin, which consists of Tertiary sediments [2]. The thermal waters are of chloride-sodium type and emerge at a temperature of nearly 50 °C, being the aquifer the carbonate formations of the Lower Jurassic in contact with the Keuper facies [2].

The geothermometrical modelling has been carried out using PHREEQC [3] and the LLNL thermodynamic database distributed with it. This methodology consists of simulating a heating of the waters in order to find a range of temperatures in which a set of minerals (assumed to be in the reservoir) converge to equilibrium.

Calcite and dolomite, presumably in equilibrium with the groundwaters in the reservoir, do not converge to the equilibrium in the same range as the rest of the considered minerals. This fact could be due to a CO_2 outgassing process during their ascent to surface causing a variation in the saturation state of the waters with respect to these phases. In order to check this hypothesis, a theoretical simulation has been performed increasing the total dissolved inorganic carbon to reach the convergence of these minerals at the same range of temperature as the others.

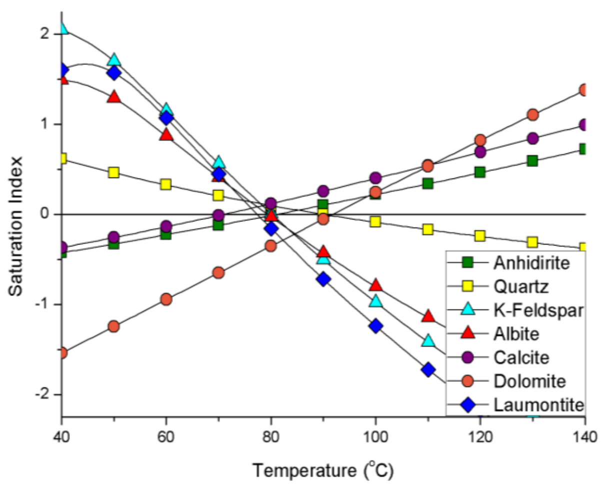

Figure 1: Saturation indices vs. temperature

Figure 1 shows the obtained result. A temperature of 80 ± 10 °C is proposed for these waters in the reservoir, which is acceptable since the uncertainty range normally admitted in these determinations is of ± 20 °C [4]. The mineral assemblage in equilibrium at the predicted temperature would be anhydrite, quartz, k-feldspar, albite, dolomite, calcite, and also different aluminosilicates (laumontite is shown as representative). It is a quite reliable set since they display different thermodynamic behaviour and sensitivity to secondary processes during the ascent of the waters.

Another interesting result is that, despite the usual problems, the application of different chemical geothermometers (SiO_2-quartz, Na-K, K-Mg and Na-K-Mg) to this geothermal system has given a temperature in clear agreement with the one predicted by the geothermometrical modelling.

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