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A Reactive Lateral Flow Model in Deep Limestone of the Acoculco Geothermal System, México

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Reactive Transport Modelling is a well-known approach to assess energy transfer coupled with chemical reactions in geoenergy or geothermal systems. In Earth sciences, it is applied to the study of geochemical processes such as geological carbon storage, hydrothermal flow, acid mine drainage remediation, and groundwater quality. A preliminary reactive transport model to study major geochemical signatures in the Acoculco Geothermal System (AGS), Puebla, México is reported in this study. This geothermal system is characterised by active hydrothermal alteration, cold springs with acid fluids, and cold gas emissions (CO2, H2S, radon and other trace gases) with near surface temperatures. Based on an early exploration programme conducted by the Mexican Federal Commission of Electricity, high-temperature gradients (between 280 and 300°C) with low permeability rocks were measured, from which the AGS was classified as a hidden or Hot-Dry Rock system. A new geochemical prospection of this geothermal system was carried out by Santos-Raga et al. (2022). These authors found a bimodal distribution of pH in cold and hot spring waters with a clear dilution pattern from acid to neutral waters, and a deep preferential flow path from the inner (IC) to the outer (OC) caldera zones. These geochemical signatures are in full agreement with the concentration patterns of Rare Earth Elements (REE) found in water and rock samples. The AGS evidences a high-temperature rock reservoir with pH mineral buffers and temperatures ranging from 200 °C to 300 °C. These REE concentrations seem to dominate with a preferential transport path from a deep heat source at the IC to shallow geothermal manifestations at the OC characterised by hot spring waters (up to 54 ◦C). By considering such geochemical features, a lateral flow model based on a reactive transport approach is proposed to support the existence of a deep geothermal system in the IC zone. The model was defined under the assumption of 1D radial geometry and was implemented in TOUGHREACT. The model has been successfully applied to evaluate the deep lateral fluid flow pathways, the main kinetic mineral-water reactions, and some fractionation processes of trace elements under a set of initial and boundary conditions.