RENE-5: Fallas y circulación de geofluídos en la corteza: Sistemas activos y fósiles

Constraining groundwater source and fluid flow pathways at the Lonquimay-Tolhuaca Volcanic Complex, Southern Chile

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The Lonquimay-Tolhuaca area in southern Chile (~38ºS) hosts several geothermal surface manifestations, including fumaroles, thermal springs, and bubbling pools. Within this area, thermal waters generally occur in close spatial relationship with two major tectonic features: the NNE to NE-trending Liquiñe-Ofqui Fault System, and the WNW-striking Andean Transverse Faults (ATF). Previous studies have shown that these fault systems exert an important control on the chemical composition of thermal springs in the area [1, 2, 3]. However, fundamental questions such as the source of water recharge, fluid flow pathways, subsurface mixing processes, and their rates are still poorly understood. In the present study, we combine geochemical, stable isotope, and environmental tracer data of thermal and groundwater outflowing at different localities to better understand the hydrogeochemical dynamics of this geothermal area. Conservative element ratios (e.g., B/Cl) show a marked difference between NW-oriented thermal springs, aligned with the trace of the ATF, and other samples in the study area. This difference is attributed to a deep magmatic vapor contribution related to the Tolhuaca volcano geothermal system. Stable isotope data (δ^2H, $\delta^{18}O$, and $\delta^{13}C_{DIC}$) show a predominantly meteoric water recharge component, with a more prominent magmatic influence at a central Tolhuaca system upflow. Anthropogenic tracers including chlorofluorocarbons (CFC-11, CFC-12, CFC-113) and sulfur hexafluoride (SF_6), allow us to infer different mixing patterns between CFC-free fluids and modern (post-1940) groundwater. Modern water fraction in thermal springs ranges from 1% to ~15%, pointing to rapid ascent along high vertical permeability networks, with little to no mixing with present-day groundwater. Results from this study confirm that the interplay between different fault systems in the area exerts a first-order control on the ascent rate and residence time of thermal waters, significantly impacting their hydrogeochemical and isotopic composition. Additionally, our results show that the combined use of conventional hydrogeochemical data with novel environmental tracers, including anthropogenic CFC and SF_6, is a powerful tool to better understand the dynamics of geothermal systems in southern Chile. **References** [1] Sánchez *et al.* (2013) *Int. Geol. Rev.* **55**, 1384–1400. [2] Tardani *et al*. (2016) Geochim. Cosmochim. Acta **184**, 193–211. [3] Wrage *et al*. (2017) *Chem Geol* **466,** 545–561.