Advanced geochemical techniques to characterize geothermal fluid circulation patterns

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Exploitation of geothermal energy depends on the productivity of the resource and hence mainly on stored temperature and fluid availability. Fluid circulation in the geothermal reservoir occur mainly on a fault and fracture systems, thus controlled by the tectonic regime but also by the lithology and the lithological response to the tectonic stress.

The research area around the Villarrica Volcano in the Andean Cordillera of Southern Chile is governed by a prominent lithological contrast between plutonic and volcano-sedimentary formations. The study investigates the impact of the lithological transition on geothermal fluid circulation. 15 hot springs were sampled and analyzed for hydrochemical composition. Additionally an extended methodology is applied by measuring chlorofluorocarbon species (CFC-11, CFC-12, CFC-113) concentrations, strontium isotopy and oxygen isotope fractionation of the sulfate-water system (used as a geothermometer). Fluid composition is investigated in comparison with potential reservoir rocks. Therefore 31 rocks samples were collected covering all possible reservoir rocks.

The selected methodology allows a characterization of the lithological impact on the two-parted circulation system. Strontium isotopy trace the lithological transition and allow a reservoir rock deduction. CFC concentration based mixing modeling determine the degree of subsurface dilution while reservoir temperature could be constrainted to a small temperature range by the fractionation of oxygen isotopes. A strong impact of the lithology on fluid circulation is revealed as fluid flow is concentrated on distinct faults in the plutonic rocks, while in the volcano-sedimentary formation a more disperse, ramified fluid circulation prevail.