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Fluid Flow Modeling using Geochemistry to Characterize the Songwe Medium Temperature Geothermal System - Tanzania

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A geothermal area with only bicarbonate thermal water discharges at medium temperature requires a more integrated analysis than used in classical geochemical exploration. This signature is typical for steam-heated water, which commonly occurs at the margins of a geothermal system. However, these waters can also rise from carbonate rich layers in the central part of the field. Our study shows that fluid flow modeling can identify the exact source, flow pathways and temperatures of reservoir fluids based on water-rock interaction. For the first time, we present a conceptual geothermal fluid flow model based on geochemical data for the Songwe geothermal system in Tanzania.

Thermal springs discharge along NW-SE fracture zones in two separate areas: the central Songwe graben (Iyola, Main springs, Rambo and Kaguri) and eastern Songwe graben (Ikumbi). The discharge temperatures of springs range between 37 and 85 °C with Na-HCO₃ type, and carbonate deposits surrounding most of the springs. We estimated fluid temperatures for a depth of 2.5km by applying K-Mg and Na-K-Ca (Mg correction) geothermometers, suggesting that reservoir fluids reach temperatures between 125 and 148 °C. We reconstructed reservoir fluid characteristics for that temperatures and propose oversaturated minerals (volcanics, clays, carbonates, apatites, weathered metamorphics and hydrothermal minerals) as a model result of interaction between the deep fluids and certain lithologies. Comparison between the modeled oversaturated minerals with minerals in the springs (calcite, aragonite, analcime, muscovite, and smectite) suggests that Kaguri spring water is a result of interaction between deep reservoir fluids with all lithologies, passed on the way to the surface (Metamorphics, Karoo group and Red Sandstone). The fluid signature of Kaguri springs suggest an upflow zone of the geothermal system. Further, our model with oversaturated minerals shows that the thermal water from the reservoir flows laterally along the Red Sandstone layer to the eastern part of study area. It appears as Rambo springs, south of Kaguri springs, and as Main springs and Iyola to the west. The outflow zone might be continuing towards Ikumbi springs, where the fluids also interact with volcanic units. The proposed model shows that carbonate dissolution from the Red sandstone layer is the most common water-rock interaction. The carbonate is embedded in pores and fractures and occurs as matrix in the sandstone. The water-rock interaction is dominated by HCO₃⁻ and Na and seen in carbonate

depositions at all springs.