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Groundwater dynamics in the complex aquifer system of Gidabo River Basin, southern Main Ethiopian Rift: Evidences from hydrochemistry and isotope hydrology

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Located in the tectonically active Main Ethiopian Rift system, the Gidabo River Basin in Ethiopia has a complex hydrogeological setting. The strong physiographic variation from highland to rift floor, variability in volcanic structures and disruption of lithologies by cross-cutting faults contribute for their complex nature of hydrogeology in the area. Until now, the groundwater dynamics and the impact of the tectonic setting on groundwater flow in this region are not well understood, though the local population heavily depends on groundwater as the major water supply. A combined approach based on hydrochemical and isotopic data was applied to investigate the regional flow dynamics of the groundwater and the impact of tectonic setting.

Groundwater evolves from slightly mineralized Ca–Mg–HCO_3 on the highland to highly mineralized Na–HCO_3 dominating type in the deep rift floor aquifers. δ18O and δD composition of groundwater show a general progressive enrichment from the highland to the rift floor, except in thermal and deep rift floor aquifers. Relatively the thermal and deep rift floor aquifers are depleted and show similar signature to the groundwaters of highland, indicating groundwater inflow from the highland. Correspondingly, rising HCO_3 and increasingly enriched signatures of δ 13C points to hydrochemical evolution of DIC and diffuse influx of mantle CO_2 into the groundwater system. Thermal springs gushing out along some of the fault zones, specifically in the vicinity of Dilla town, display clear influence of mantle CO_2 and are an indication of the role of the faults acting as a conduit for deep circulating thermal water to the surface. By considering the known geological structures of the rift, hydrochemical and isotopic data we propose a conceptual groundwater flow model by characterizing flow paths to the main rift axis. The connection between groundwater flow and the impact of faults make this model applicable to other active rift systems with similar tectonic settings.