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Groundwater dynamics in Gidabo River Basin, southern Main Ethiopian Rift

DEGU, A.[1], BIRK, S.[1], DIETZEL, M.[2], LEIS, A.[3], WINKLER, G.[1], MOGESSIE, A.[1]

[1] University of Graz, Institute of Earth Sciences, NAWI Graz, Heinrichstraße 26, 8010 Graz, Austria
email: abraham.degu@edu.uni-graz.at
[2] University of Technology, Institute of Applied Geosciences, NAWI Graz, Rechbauerstraße 12, 8010 Graz, Austria
[3] Joanneum Research, Resources – Institute for Water, Energy and Sustainability, Elisabethstraße 18/II, 8010 Graz, Austria

Groundwater has been described as a perennial source of water, a much needed buffer during times of drought, and a resource that can be developed for localized use at relatively low cost. Despite these positive and potential attributes groundwater resources play only a relatively limited role in the water supply for Gidabo basin, southern Main Ethiopian Rift. Groundwater utilization has been limited to community water supply using shallow hand dug wells and unprotected springs. The use of deep boreholes taping groundwater from deeper aquifers for irrigation is almost non-existent. The reason for such modest groundwater use is partly related to the complex hydrogeologic setting due to the strong physiographic variation from highland to rift floor, variability in volcanic structures, and disruption of lithologies by cross-cutting faults. The groundwater dynamics and the impact of the tectonic setting on groundwater flow in this region are not well understood. The objectives of this study therefore are to characterize the regional groundwater flow dynamics, including the role of geological structures and the hydrochemical evolution. A combined approach based on geological and structural mapping, acquisition and analysis of spring discharge and water level data as well as hydrochemical and isotope data was applied to investigate the regional flow dynamics of the groundwater and the impact of the tectonic setting.

Groundwater evolves from slightly mineralized Ca–Mg–HCO_3 on the highland to highly mineralized Na–HCO_3 dominating water type in the deep rift floor aquifers. Likewise, there is a progressive increase in temperature and electrical conductivity starting from the highland to the Rift floor with local anomalies related to the thermal systems. Groundwater temperature in the Rift floor aquifers is higher than the local air temperature suggesting the connection of these waters to deep regional groundwater circulation. In the vicinity of thermal springs and wells, cold springs and shallow wells can also be observed which indicates the occurrence of two major flow systems in the Rift floor. The $\delta^{18}O$ and δD values of the groundwater also show a general increase from the highland to the rift floor, except in thermal and deep rift floor aquifers. The thermal and deep rift floor aquifers show a stable isotope signature similar to that of the groundwater of the highland. The tritium isotope result suggests that the majority of the aquifers contain recent groundwater and don't show a distinct ageing trend towards to the Rift floor. However, at a few localities a regional flow component originating from the highland has been identified, particularly in deep thermal groundwaters. Rising HCO_3 content and increasing $\delta^{13}C$ values point to hydrochemical evolution of dissolved inorganic carbon (DIC) and diffuse influx of mantle CO_2 into the groundwater system. By combining hydrogeological, hydrochemical, isotopic data and knowledge of the structural geology of the rift, we propose a conceptual hydrogeological model characterizing the flow paths to the main rift axis. The water levels, hydrochemical evolution and isotopic composition show that there is groundwater movement from the recharge area on the highland and upper escarpment into the deep Rift floor aquifers. However, the aquifers are laterally disrupted by major fault systems. The rift boundary fault plays a major role in the occurrence of springs and drains the highland groundwater into the Rift floor aquifers. Series of marginal grabens, which characterize the rift floor, are considered as barriers for the regional flow and drain the groundwater parallel and sub-parallel to the axis of the rift. The proposed model is potentially useful as a basic source of information to site exploratory wells during groundwater investigations.