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Sources of Groundwater Geochemistry in the Karoo Basin, South Africa

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The Karoo Basin in South Africa is targeted for shale gas extraction in the near future. Groundwater in the Karoo Basin is the primary source of both drinking and agricultural irrigation but there is limited understanding of the connections between shallow and deep groundwater in the region. We sampled twenty-two springs and groundwater boreholes from eight areas with known geothermal, salt- and gas-rich springs and conducted a pre-drill assessment of groundwater geochemistry and quality in the critically water-restricted Karoo Basin, South Africa. The geochemical data identified three end-members: deep, saline groundwater with a sodium-chloride composition, old, fresh groundwater with a sodium-bicarbonate-chloride composition and shallow, calcium-bicarbonate freshwater. In a subset of shallow wells, we observed direct mixing of the saline formation water into the shallow aquifers. Stable water isotopes (oxygen and hydrogen) indicate that the chemistry in the shallow freshwater end-member is controlled by evaporation in modern, arid conditions, while the older, fresh and saline waters were recharged earlier, during wetter climatic conditions. Methane concentrations exceeding 14 ccSTP/kg were found only in the sodium-chloride water located near dolerite intrusions. The geochemical (Br/Cl, Na/Cl) and isotopic (oxygen, hydrogen, strontium, boron) data, in combination with elevated helium levels, suggest that exogenous fluids are the source of the gas-rich, saline groundwater and originated from remnant seawater prior to dilution by old meteoric water and further modification by water-rock interactions. The Karoo dolerites likely provide a preferential pathway for vertical migration of deeply-sourced hydrocarbon-rich saline waters to the surface. This baseline evaluation highlights that natural migration of methane-rich and salt-rich waters impacts shallow aquifers prior to shale-gas development in the Karoo.