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Baseline assessment of groundwater quality in the Karoo Basin, South Africa

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Global energy demand has led to worldwide exploration for natural gas. To develop guidelines for evaluating baseline groundwater quality prior to gas extraction, an assessment was performed in the Karoo Basin of South Africa where prospecting within the gas-rich Ecca Group is now underway. We collected dissolved gas and water samples from deep (2,490 to 3,500 mbls) and shallow groundwater wells (5 to 169 mbls) throughout the Karoo Basin. The hydrocarbon molecular and isotopic compositions and carbon-14 were interpreted along with the major and minor ionic chemistry and isotopic compositions of water, strontium, sulfate, inorganic carbon, uranium, thorium, and radium. Hydrogeochemical differences were observed in the southwest (faulted Cape Fold Belt region) compared to other regions. Samples from the southwest appeared to contain a greater proportion of older water and/or carbonate dissolution, as indicated by more positive $\delta^{13}C$ of dissolved inorganic carbon and lower carbon-14. These samples also had higher $^{87}Sr/^{86}Sr$ ratios indicating water-rock interactions with volcanic rocks. Deeper wells had a mixture of brine and infiltration of younger, more modern meteoric demonstrated by moderate concentrations of chloride (208 to 10,918 mg/L) and sodium (107 to 2798 mg/L) and $\delta^{2}H\text{-}H_2O$ and $\delta^{18}O\text{-}H_2O$ isotopic compositions consistent with the local meteoric water line. For the samples containing sufficient hydrocarbon concentrations for isotopic analyses: one contained fermentation-derived biogenic gas. Three contained biogenic gas from carbon dioxide reduction. One contained thermogenic gas, and one contained both biogenic and thermogenic gas. Five deep wells across the Karoo Basin contained geothermal gas as evidenced by heavier $\delta^{13}C\text{-}CH_4$ (> -30.4 ‰) and isotopic reversals. The dissolved gas in one shallow well showed isotopic evidence of deep gas migration into a shallow aquifer. The isotopic reversals observed in the deep wells are likely a result of increased thermal stress on sedimentary organic matter or thermogenic gas caused by intrusion of dolerite dykes and sills. This indicates baseline assessments of groundwater quality and monitoring thereafter when prospecting for gas in the Karoo Basin need to consider how the legacy wells and dolerite dykes and sills could allow for large scale gas migration into shallower units.