Noble gas characteristics in groundwaters near selected oil fields from the San Joaquin Basin, USA

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Noble gases are useful tracers for determining groundwater (GW) ages and recharge conditions. GW noble gas values relative to air-saturated water (ASW) can also potentially be used to discern the presence of fluids from oil and gas development, production, and/or waste disposal activities. Noble gases are among the many constituents analyzed in GW and produced water samples collected as part of the California State Water Resources Control Board's Oil and Gas Regional GW Monitoring Program.

We present GW noble gas isotope data (n=36) from areas overyling or adjacent to the Fruitvale, Lost Hills and South Belridge oil fields; noble gas samples from five additional wells with bladder pumps or large gas bubbles could not be collected or analyzed. Thermogenic or mixed thermogenic/biogenic methane was detected in several samples, with concentrations ranging from 0.05 to 1.30 cm^3STP/gH_2O. Helium isotopes ($^3He/^4He$) in Fruitvale samples (n=16) span from radiogenic (0.48 relative to the air value [R_A]) to 1.85 R_A. South Belridge (n=11) $^3He/^4He$ values range from 0.26 to 0.99 R_A. Lost Hills (n=9) values range from 0.06 to 0.42 R_A, suggesting these are the oldest waters.

Large air-derived noble gas excesses are apparent in several Fruitvale samples, whereas Lost Hills and Belridge samples are typically in the predicted equilibrium solubility range. One of the Fruitvale samples with the highest $^3He/^4He$ values had low, but detectable mixed thermogenic/biogenic methane concentrations. These samples also have elevated ^{20}Ne and ^{36}Ar concentrations, consistent with rapid infiltration from the Kern River and associated managed recharge ponds, the predominant recharge sources in the Fruitvale area. These and other samples from relatively long-screened production wells are likely to include mixtures of water from different depth zones. We explore a series of models used to explain the observed air-derived excesses in Fruitvale, as well as the smaller variations throughout Lost Hills and Belridge.