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Characterization of produced water from the Fruitvale, Lost Hills, North Belridge, and South Belridge oil fields, California, USA

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Isotopic and chemical analyses of produced waters and gases from oil wells, injection sites, and disposal ponds provide a means to characterize and distinguish fluids from oil and gas bearing formations, mixtures of formation fluids with injected water and steam, and wastewater managed at the surface. Such data, when combined with similar analyses of nearby groundwaters, provide a means of distinguishing possible sources and pathways of constituents from oil and gas development activities, into groundwater.

For this study, samples were collected from the Fruitvale, Lost Hills, North Belridge, and South Belrige oil fields in the San Joaquin Valley, California, USA, as part of the California State Water Resource Control Board's Oil and Gas Regional Groundwater Monitoring Program.

Produced waters from the Lost Hills and North Belridge oil fields had $CH_4/C_2H_6 < 54$ and $\delta^{13}C\text{-}CH_4 > -45$ per mil (‰), indicating thermogenic CH_4 origin, while produced water samples from Fruitvale had $CH_4/C_2H_6 > 500$ and $\delta^{13}C\text{-}CH_4 > -44$ ‰, identifying mixing with microbial methane. Some groundwater wells near Lost Hills and Fruitvale had $CH_4/C_2H_6 < 50$ and $\delta^{13}C\text{-}CH_4$ from -72 to -53 ‰, suggesting the presence of thermogenic CH_4 from subsurface pathways in places in the aquifers.

δD and $\delta^{18}O$ of produced waters from Fruitvale and North Belridge indicate an unevaporated meteoric-water source. In contrast, Lost Hills and South Belridge samples' δD and $\delta^{18}O$ indicate evaporation, consistent with withdrawal and reinjection of produced waters in these fields. Lost Hills δD and $\delta^{18}O$ were up to -10 and 5.7 ‰, respectively, while from the South Belridge oil well δD and $\delta^{18}O$ were -54 and -5.7 ‰, respectively. A groundwater sample collected from a plume associated with a produced water disposal pond near South Belridge had specific conductance (> 17,000 µS/cm), δD, and $\delta^{18}O$ similar to South Belridge produced water.

Specific conductance of produced water samples ranged from 6,090 to 52,250 µS/cm, relecting variations in hydrogeologic setting and oil field management across the San Joaquin Valley. These chemical and isotopic variations need to be characterized to better understand interactions of fluids from oil fields and with adjacent groundwater.