Geochemical evidence for fugitive gas contamination and associted water quality changes in nearby drinking-water wells

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Several studies have suggested that unconventional energy development can lead to fugitive gas contamination in some drinking-water wells near drill sites, while others suggest that methane is naturally occurring and unrelated to shale gas development. Thus, a direct link between elevated hydrocarbon gas levels in drinking-water wells and shale gas exploration remains controversial. Our previous studies in shallow aquifers examined molecular hydrocarbon ratios (e.g., C_2+/C_1), carbon isotopes of methane (i.e., $\delta^{13}C$-C_1), noble gases (He, Ne, Ar), and chloride in shallow aquifers to distinguish wells with stray gas contamination from the majority of wells that contained naturally-occurring hydrocarbon gases. Here, we broaden our analysis in the Appalachian and Dallas Fort-Worth Basins by conducting a comprehensive geochemical evaluation of drinking-water wells including major ions (e.g., Na, Ca, DIC, Cl, Br, SO_4), the isotopic composition of DIC ($\delta^{13}C$-DIC), water, boron ($\delta^{11}B$), and strontium ($^{87}Sr/^{86}Sr$), the molecular composition of major gases (C_1-C_6+, N_2, H_2S, CO_2), the isotopic composition of hydrocarbon gases and N_2 ($\delta^{13}C$-C_1, δ^2H-C_1, $\delta^{13}C$-C_2, and $\delta^{15}N$-N_2), and noble gases (e.g., $^3He/^4He$, $^4He/^{20}Ne$, $^{20}Ne/^{36}Ar$). We use this data to address 3 critical questions: 1) Do comprehensive geochemical analyses support previous conclusions of fugitive gas contamination in these study areas?; 2) Is there evidence for upward brine (or hydraulic fracturing fluid) migration associated with fugitive gas contamination?; and 3) Does fugitive gas contamination lead to secondary changes in water quality, such as the generation of H_2S or the redox/base exchange controlled release of salts or oxyanions (e.g., As, Fe, Mn) from the aquifer rocks via secondary reactions?