LETTER

Reply to Saba and Orzechowski and Schon: Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing

Two letters by Saba and Orzechowski (1) and Schon (2) address our research linking elevated methane and ethane concentrations to shale-gas drilling and hydraulic fracturing (3). We respond briefly here and point readers to a supplementary document for more details (4).

An assertion, and misconception, in both letters is that, because we found small amounts of mixed biogenic and thermogenic gas in 85% of groundwater samples, the thermogenic gas we observed near shale-gas wells occurred naturally. What we showed instead (figures 3 and 4 of ref. 3) was that drinking water was more likely to have high methane and ethane concentrations when homeowners lived within 1 km of a gas well. We also showed that the isotopic signatures for both $\delta^{13}C$ and $\delta^{2}H$ of methane found in high concentrations in private water wells closely matched the signatures of methane coming out of gas wells, and that the ratios of methane to ethane and propane were different [figure 4b (3)]. Furthermore, the methane present in high concentrations in water wells was more thermogenic in both its ^{13}C and ^{2}H signatures than background values more than 1 km from a gas well. There are indeed low concentrations of thermogenic methane found across the region. That methane does not, however, look like the methane found in drinking water near gas wells.

Saba and Orzechowski (1) first state that, because average methane concentrations in nonactive water wells in the Genesee were higher than in active wells (1.5 mg L^{-1} vs. 0.3 mg L^{-1}), "the correlation is opposite of what we concluded." That comparison is essentially meaningless. We sampled one active water well in the Genesee, supplemented with additional samples in nonactive water wells, primarily to provide a baseline for future sampling after horizontal drilling and hydraulic fracturing occur. The one active sample simply shows no evidence of contamination.

They also raise separate issues about our Catskill and Lockhaven data. Saba and Orzechowski (1) suggest, for instance, that, because we did not analyze for ethane isotopes, we could not "conclusively determine" that the methane in Catskill samples is related to gas extraction. We respectfully disagree. Figures 3 and 4 in our study (3) demonstrate the spatial relationship between dissolved gas in the Catskill aquifer and gas extraction wells and the more thermogenic nature of the gas found near gas wells. They also show the pronounced differences in gas concentrations between active and nonactive areas.

For the Lockhaven data, Saba and Orzechowski (1) cite unpublished Department of Environmental Protection (DEP) correspondence (without graphs, maps, or data on gas-well proximity and hydrogeology) to assert that the presence of thermogenic methane in Mainesburg, PA, in Tioga County is unrelated to gas extraction operations (1). There are serious problems with this assertion. Extensive areas of Tioga County, which is outside our initial study area, have been used for commercial underground gas storage, leading to documented leaks into well water (5). The DEP correspondence they cite also states quite clearly that "we do suspect that one of these gas wells could be leaking and plan to pursue additional testing this spring." The limited data provided cannot rule out an effect of natural gas operations.

Because the same DEP correspondence included data from a methane seep in Tioga County where the gas appears to be thermogenic, we tested this idea in our study area with new data collected in June 2011. We sampled the nearest natural methane seep to our study sites, the Salt Springs State Park in the Catskill formation of Pennsylvania (41°54′50″N 75°51′59″W). The isotopic signatures of its methane were indeed thermogenic (−45.9‰ $\delta^{13}C\text{-}CH_4$ and −242‰ $\delta^{2}H\text{-}CH_4$). However, there was zero overlap isotopically between this gas and our active Catskill samples (figure 4 of ref. 3). In contrast, the gas did overlap with our nonactive, background Catskill samples (3). Not all "thermogenic" methane is the same.

Finally, Saba and Orzechowski (1) argue that approximately 20‰ variation in $\delta^{13}C\text{-}CH_4$ for Lockhaven samples is surprising if the gas in the shallow zone came from shale-gas extraction (1). This may be true if the produced gas comes from a single source. However, gas collected from the Middle Devonian section in the northern Appalachian basin has been interpreted as migrating from other parts of the basin and can easily span a range of approximately 20‰ (6–8), overlapping the range of $\delta^{13}C$ values from our shallow Lockhaven groundwater samples.

Schon (2) states that our data "do not support the interpretation put forth that shale-gas development is leading to methane migration" yet offers no alternative to explain the differences in chemistry and gas concentrations we observed. He also notes "industry best practices… ensure that the region's substantial shale-gas resources can be developed safely and environmentally responsibly." The increased standards he refers to in Pennsylvania were implemented in February 2011. As a scientist, surely he would want to test the effectiveness of the new regulations before concluding that they "ensure success." The Pennsylvania DEP apparently thinks additional safeguards are desirable; they proposed strengthening the Oil and Gas Act again in June 2011 to expand the presumptive liability distance from 1,000 ft to 2,500 ft, consistent with our recommendation (9).

Finally, we agree with the writers of both letters that more data will be helpful and that an ideal experiment would be to randomly sample homes with predrilling data. As we outlined previously (9), industry has thousands of archived predrilling estimates of water quality in Pennsylvania. Working with

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industry, the Pennsylvania DEP, and homeowners, we have proposed to randomly select and resample 100 to 200 homeowner water wells from the predrilling database. We hope that industry and the Pennsylvania DEP will work with us to make this experiment happen, providing exactly the kind of data that they, and the authors of the PNAS letters, have called for.

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