TESTIMONY OF DONALD I. SIEGEL
TO THE COMMITTEE OF SCIENCE, SPACE, AND TECHNOLOGY OF THE U.S. HOUSE OF REPRESENTATIVES

"Hydraulic Fracturing: Banning Proven Technologies on Possibilities Instead of Probabilities"

Thursday April 23, 2015
Rayburn House Office Building

Mr. Chairman and Members of the Committee, I am Donald I. Siegel, Professor and Chair of Earth Sciences at Syracuse University, New York. I present this testimony on whether hydraulic fracturing of rock for gas and oil, found thousands of feet deep, can *systemically* degrade the quality of groundwater found in shallow aquifers. I offer this testimony entirely on my own behalf.

For over 30 years I have studied how natural gas and dissolved substances form and move in wetlands, soils, and rocks. My research on these topics has been mostly funded by the National Science Foundation. Most recently, I have been funded by Chesapeake Energy Corporation to do basic research and synthesize tens of thousands of chemical analyses of shallow ground water that Chesapeake collected in Pennsylvania and nearby states as part of its pre-drilling program for natural gas in the deep Marcellus and Utica Shales in the Appalachian region. From this unprecendented large data set, I hope to help resolve important questions regarding migration of natural gas and other dissolved substances from deep in the subsurface toward the land surface before, during and after drillling for natural gas and oil.

INTRODUCTION

Petroleum engineers and water well drillers use hydraulic fractured (fracking) to fracture rocks and allow oil, gas and water to flow more easily to wells. In the case of oil and gas, fracking involves briefly injecting water, sand, emulsifiers and anti-scaling agents and bacterial inhibitors under high pressure to create paper-thin fractures in shale and other rock.

Fracking has been around decades. When I worked for Amerada Hess from 1972-1974, I supervised the drilling and fracking of an oil well about 9,000 feet deep in Utah. Then, however, oil and gas wells consisted of only vertical pipes, in what has been called “conventional” drilling. Today “unconventional drilling” allows drillers to turn pipes horizontally directly through the middle of the hydrocarbon-bearing rock, much like a flexible soda straw. The horizontally fracked zone now can be a mile or more long, which allows for more of the rock to release the oil and gas.

Everyone at this hearing knows about the controversies on fracking that have been extensively reported by the media, adversarial websites on both sides of the issue, films, and blogs. These controversies range from legitimate philosphical concerns over climate disruption to potential life style changes and to economic inequities in small communities that might welcome the oil and gas industry.

The most visible contention on whether fracking might compromise drinking water quality in shallow ground water located thousands of feet above the zone where the fracking occurs. I speak only to *this* issue—whether fracking will *systemically* lead to drinking water contamination.

My answer is no.

THE SCIENTIFIC ISSUES RELATED TO GROUNDWATER CONTAMINATION BY FRACKING

There are two kinds of contamination possible from fracking which hypothetically could contaminate shallow ground water from drilling and subsequent development of oil and gas deposits: produced salty water and natural gas itself.

1. Produced salty water

Very salty water, called produced water, returns with the oil and gas in production wells. This water, locked in the subsurface for millions of years, naturally occurs everywhere where oil and gas are commercially produced (e.g. Feth, 1970, 1981). Because salt water weighs more than the drinkable water above it, it cannot move easily upward. Fundamental laws of physics preclude this. Where produced salt water has been stored temporarily in ponds at the land surface, occasional breaches lead to locally contaminated ground water. In contrast, there has been no evidence (e.g. Brantley et, al, 2014; Vidic et al, 2013; Kresse et al., 2012) that shallow ground water has been *broadly* contaminated by produced water, despite occasional spills and accidents.

2. Migration of Dissolved and Bubbling Natural Gas

People have become even more concerned about potable ground water being contaminated by natural gas leaking from drilling operations or failed wells. This natural gas can be invisible, dissolved in the ground water or transported as bubbles, much as carbon dioxide bubbles moving upward in an opened soda bottle.

In oil and gas producing regions, natural gas can occur almost everywhere in the rocks from the land surface to thousands of feet deep. For example, in the Appalachian Basin, with which I am most familiar, natural gas occurs in shale and other rocks that provide drinking water (e.g. Kappel and Nystrom, 2012). The U.S. Geological Survey found natural gas in virtually every sample of domestic water it recently sampled in the southern part of the New York State in the Appalachian Basin (Heisig and Scott, 2013).

The concern over natural gas escaping from gas wells has been highlighted by two papers published by Duke University in 2011 and 2012. Researchers sampled 141 domestic water wells in northeastern Pennsylvania and adjacent New York and published a graph showing more dissolved natural gas in drinking water that was closer to gas wells. From this they concluded: "Our results show evidence for natural gas contamination of shallow drinking-water systems in at least three areas of the region and suggest important environmental risks accompanying shale-gas exploration worldwide." (Osborn et al, 2011) and "Dissolved natural gas was detected in the drinking water of 82% of the houses sampled (115 of 141). Natural gas concentrations in drinking water wells of homes <1 km from natural gas wells (59 of 141) were six times higher on average than concentrations for homes farther away." Jackson et al. 2013).

When I read these papers, 141 samples seemed too few to make such a sweeping conclusion. I also saw that the Duke scientists sampled a cluster of about a dozen home wells at Dimock, Pennsylvania, where gas wells clearly failed. This cluster of samples, as well as others, suggests to me that the authors chose a sampling design that was skewed, rather than randomly sampled, to avoid sampling bias inherent in such a small sample of wells, given the large numbers of domestic wells available to sample. In my own comparable program at Syracuse University, my colleagues and I characterize natural gas concentrations and other water quality parameters in southern New York by using random sampling to maintain statistical rigor--even where pre-existing gas wells might be known to occur ((http://swift.syr.edu/; Lautz et al., 2014).

Sampling domestic water near gas wells *known* to have failed cannot address the general issue if more natural gas occurs in ground water near gas and oil wells. Common sense dictates that there will be more natural gas in drinking water near known failed gas wells, much as there has to be more smoke near known burning buildings. Vidic et al. (2012) ad Brantley et al. (2014) have clearly documented that less than ½ of 1 percent of unconventional wells in Pennsylvania have caused more natural gas in domestic ground water. But could there be more well failures than those reported by State agencies?

THE CHESAPEAKE ENERGY CORPORATION PRE-DRILLING GROUNDWATER DATA SET

About three years ago, I was approached by Chesapeake Energy Corporation (herein termed "Chesapeake") to assist them to do basic science on an enormous data set of background water quality in Pennsylvania and adjacent states. Chesapeake collected these data between June 2009 through November 2011 as part of its voluntary pre-drilling characterization of native groundwater prior to drilling unconventional gas wells in the Marcellus Formation, and oil and gas in the Utica Formation. This data set, over 34,000 individual samples in its entirety, constitutes the largest data set of its kind in the United States, exceeding in number those I worked with when I was employed by the USGS as a groundwater quality expert before I joined Syracuse University.

Chesapeake hired me to head up this project to test specifically whether drilling operations have, in fact, led to contamination of ground water. This data set statistically captures, , all domestic wells in two multiple county-sized regions centered in northeastern Pennsylvania and western Pennsylvania. My colleagues and I will be mining this data set for years to come, because it affords a unique opportunity to do so.

We published our first paper from this project in April, 2015 in *Environmental Science and Technology* (Siegel et al., 2015).

CRITICISM OF THE PAPER BY THE MEDIA

Immediately after publication of our paper, certain media (e.g. http://insideclimatenews.org/news/06042015/fracking-study-water-contamination-under-ethics-review) challenged whether we met the ethical necessity of divulging our associations and possible payment by Chesapeake Energy Corporation. I found this accusation unusual, insofar as the reviewers of the paper, the associate editor handling it, and the editor found no fault and accepted the paper for publication. I have served as associate editor of many professional journals over my career. I fully understand disclosure issues. The journal asked my colleagues and me to expand on our disclosure, which we have done and the revised paper as been, not surprisingly, accepted.

In its pre-drilling groundwater evaluation program, Chesapeake chose to use the standard protocols accepted by the EPA and the Pennsylvania State Department of Environmental Protection for sampling and measuring natural gas and identifying potential contamination problems. Chesapeake's choice seems obvious to me: regulatory agencies recommend the sampling approaches they will accept and dictate the kind of analytical work done in applied science of this kind.

However, we also were challenged about using data from these protocols because the USGS, in its basic research program, uses a different method to sample for natural gas (http://insideclimatenews.org/news/06042015/fracking-study-water-contamination-under-ethics-review).

Why does the USGS use a different approach than regulatory agencies?

It may be possible for some dissolved natural gas to be lost in the regulatory method when concentrations of gas are very high, at the level where the water cannot hold any more dissolved natural gas without it bubbling out (called "saturation"). Sometimes, the decrease of water pressure as water flows out of the water pipes leads to bubbles of natural gas previously dissolved in the water (e.g. Coleman and Coleman, 2013).

However, there is no problem if this happened in the Chesapeake data collection because of the nature of the question we wanted to answer in our paper: Do concentrations of dissolved methane get higher in ground water the closer the sample is to a gas well? The absolute amount at the high end makes no difference once saturation occurs.

Let me make an analogy. Bathroom scales top out at 500 pounds. If someone stood on a scale and weighed 500 pounds, everyone would agree that the person is overweight. If the person weighed 600 or 700 pounds, the scale would still only read 500 pounds because that weight is as high as the scale can read. But the person will still be overweight!

High dissolved concentations of natural gas will will always be high during sampling, even if some bubbles of it escape during sampling.

OUR RESULTS

To see if we could replicate the Duke results, we determined if concentrations of dissolved natural gas in ground water from 11,300 domestic wells would be higher relative to proximity to 661 gas wells within Bradford and adjacent counties in northeastern Pennsylvania. We could not replicate the Duke studies. Both high and low concentrations of natural gas occur close to *and* far away from gas wells, with no discernable pattern to the eye, nor when we used four rigorous statistical tests. We suggested in our paper that the Duke studies had an insufficient number of samples to adequately reflect reality; although perhaps *how* they sampled also led to their erroneous results.

We also understand that gas wells can fail; but the Pennsylvania experience suggests these situations happen rarely. If gas wells *do* fail, natural gas will bubble vigorously out of nearby domestic water wells that previously had had no bubbling natural gas. Dissolved natural gas concentrations cannot effectively be used as a forensic tool because natural gas concentrations vary so much in nature.

Our study points to the necessity of not jumping to conclusions about contamination of any kind, without sufficient numbers of samples and a sampling program designed to truly characterize the problem. In future papers, we will address other kinds of contamination that could be related to oil and gas production; how to best characterize naturally poor water quality; the daily and seasonal variability of natural gas concentrations in native ground water; and the geologic and geochemical controls over natural gas concentrations within the Appalachian Basin.

References Cited

Brantley, L.S.; Yoxtheime, R, D.; Arjmand, S., Grieve, P.; Vidic, R.; Pollak, P.; Llewellyn, G.T.; Abad, J.; and C. Simon, 2014, Water resource impacts during unconventional shale gas development: The Pennsylvania experience, International Journal of Coal Geology, vol. 126, p.140–156.

Coleman, D.D. and T.M. Coleman 2013, Collecting Water Samples for the Determination of Dissolved Gas Concentrations, Presentation GWPC, September 2013, St. Louis MO.

http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB4QFjAA&url=http%3A%2F%2Fwww.gwpc.org%2Fsites%2Fdefault%2Ffiles%2Fevent-sessions%2FColeman_DennisFinal.pdf&ei=zTM0Vb-cEoi8ggThqoHYDg&usg=AFQjCNFvUcWi1ZjqTnIbONOIqmy-P081EA&bvm=bv.91071109,d.eXY; accessed 4-19-15)

Feth, J. H., 1970. Saline Groundwater Resources of the Conterminous United States, Water Resources Research, Vol. 6, , p.1454-1457

Feth, J. H., 1981, Chloride in Natural Continental Water-A Review: U.S. Geological Survey Water-Supply Paper 2176, 30 p.

Heisig, P. M. and Scott, T. M., 2013. Occurrence of Methane in Groundwater of South-Central New York State, 2012—Systematic Evaluation of a Glaciated Region by Hydrogeologic Setting. USGS Scientific Investigations Report 2013-5190.

Jackson, R. B.; Vengosh, A.; Darrah, T. H.; Warner, N. R.; Down, A.; Poredac, R. J.; Osborn, S. G.; Zhao, K.; Karra, J. D., 2013, Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction. Proc. Natl. Acad. Sci. U. S. A., vol. 110, p. 11250−11255.

Kappel, W. M., and Nystrom, E. A., September 2012. Dissolved Methane in New York Groundwater. USGS Open File Report 2012-1162.

Kresse, T.M.; Warner, N.R.; Hays, P.D.;Down, A.; Vengosh, A.; Jackson, R.B., 2012, Shallow Groundwater Quality and Geochemistry in the Fayetteville Shale Gas-Production Area, North-Central Arkansas, 2011, USGS Scientific Investigations Report 2012-5273.

Lautz, L.K.; Hoke, G.D.; Lu, Z.; Siegel, D.I.; Christian, K.; Kessler, J.D. and N.G., Teale, 2014, Using Discriminant Analysis to Determine Sources of Salinity in Shallow Groundwater Prior to Hydraulic Fracturing, Environmental Science and Technology, vol. dx.doi.org/10.1021/es502244v

Osborn, S. G.; Vengosh, A.; Warner, N. R.; Jackson, R. B., 2011, Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing, Proc. Natl. Acad. Sci. U. S. A., vol. 108, p. 8172−8176.

Siegel, D.I.; Azzolina, N.A.; Smith. B.J.; Perry, A.E. and R.K. Bothun, 2015, Methane Concentrations in Water Wells Unrelated to Proximity to Existing Oil and Gas Wells in Northeastern Pennsylvania, Environmental Science and Technology. http://pubs.acs.org/doi/abs/10.1021/es505775c).

Vidic, R. D.; Brantley, S. L.; Vandenbossche, J. M.; Yoxtheimer, D. and Abad, J. D., 2013. Impact of Shale Gas Development on Regional Water Quality. Science, Vol. 340 no. 6134 DOI: 10.1126/science.1235009.