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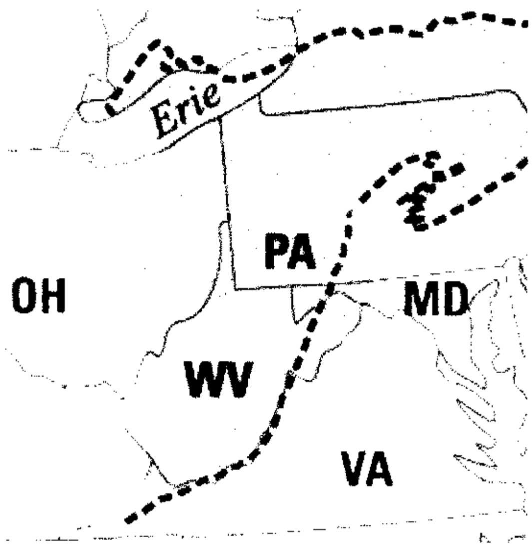
Hydrofracking in the Marcellus Shale: How a Pressure Bulb is Created

by Bob and Ruth Haag July 1, 2011



Distribution of the Marcellus shale

Source: USGS Fact Sheet 2009-3032

An environment vs. energy debate has been heating up over the extraction of natural gas from the Marcellus shale in Western Pennsylvania. Eventually, we expect the debate to arrive in eastern Ohio. The debate is mostly about a practice called "hydrofracking," or just "fracking." Fracking involves injecting water ("hydro") into the shale to cause it to fracture ("frac"). This opens up pores that were previously tightly closed, and allows natural gas to migrate into wells.

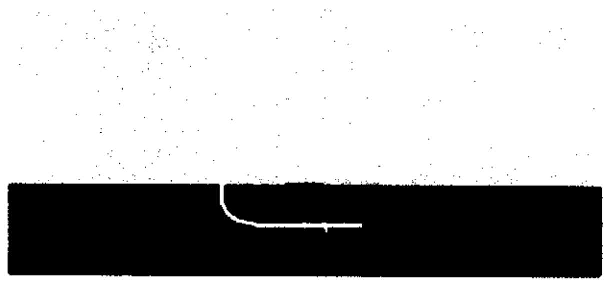
Flowback Water

Many have a concern about petroleum additives in the fracking water, along with natural radionuclides that enter the water at depth. Typically, as much as 4 million gallons of water may be injected to frack a well, and about 15-20% (up to 600,000 gallons) of that water comes back to the surface. Different fracking-water disposal methods have been tried, but the most prevalent at this time is to truck the water to deepwell injection sites (http://www.epa.state.oh.us/shale.aspx). So, whatever doesn't stay in the ground where it is injected, gets injected somewhere else.

Concerns over fracking fluids reaching shallow groundwater

The 600,000 gallons of flowback water has been the main focus lately, but some wise person also asked, "Where does the rest of the 4 million gallons go, once it gets down there?" The big concern is that the fracking water will get into groundwater wells. When questions about this used fracking water are asked, the response is to point out that the shale is 1-2 miles deep, and groundwater supplies come from less than 300 feet deep, so what could be the problem? The same debate has occurred many times, with regard to (1) EPA permitted deep hazardous waste injection wells, (2) injection/solution mining, and (3) deep burial of nuclear wastes. When we look at problem scenarios from those three past issues, we find that the argument that the fracking fluids won't reach drinking water wells can be a case of "telling the truth in such a way that lying is unnecessary."

What to <u>really</u> worry about: secondary effects of pressure



Pressure bulb above a hydrofracking zone. Illustration: Sandusky Bay Journal

While it is true that the fracking fluid will most likely not reach the groundwater, what we need to examine are the secondary effects on drinking water wells, caused by a fracking induced "pressure bulb". When you apply pressure to soil or rock, the pressure doesn't just stop at the surface you are pushing on; the pressure spreads and dissipates through the surrounding soil or rock. In hydro-fracking, the pressure applied is enormous. In order to crack the rock down deep, the injected pressure has to be in the same ballpark as the weight of the soil and rock overhead. For a rough rule of thumb, we can estimate that the pressure due to the weight of overlying strata is about 1 pound per square inch (psi), for every foot of depth. By this estimate, the pressure a mile down (5,280 feet down) would be about 5,280 psi. Due to internal friction within soil or rock, the sideways pressure is only about 1/3 of the vertical pressure, so one might only have to push outward at 1500 to 2000 psi in order to get shale to fracture a mile down.

That 1500 to 2000 psi will dissipate through the rock and soil above the shale. Pressure is also called "stress," and the movement that occurs in response to stress is called "strain." So, imagine throughout the stress bulb above the hydrofracking zone, there is a corresponding strain bulb. Imagine that all of the rock and soil above the frack moves, just a little bit. This little bit of movement can be measured at the ground surface, by a sensitive device called an inclinometer.

Let's consider an example from salt mining. In 1993, the Ohio Department of Natural Resources (ODNR) issued a report entitled "Investigation of Active and Abandoned Class III Salt Solution Mining Projects in Ohio." ODNR documented a solution-mining operation near Barberton, Ohio, that began in 1899 and continued until the 1980s. At this facility, 36 solution mining wells were drilled into the salt-bearing Salina formation, which was tapped at depths ranging from 2721-3208 feet below the land surface (BLS). Pressure was induced into the subsurface, both to bring brine to the surface, and in some low-pressure attempts at hydrofracking. ODNR made two observations that are key to understanding the effects of fracking:

1. "...faults are conduits for migration, and the migration of petroleum, gas, or water in a fault plane can take place, up or down ...
2. Numerous oil and gas wells surrounding the Barberton solution salt mines had fluid flowback at the surface.

Now, let's put the entire picture together for hydrofracking. High pressure is injected at a depth of a mile or more. This creates a pressure bulb above the injection location, which slightly lifts all of the strata above the injection location. In the immediate vicinity of the injection, cracks open in the shale layer, and a sand "proppant" is injected to keep the cracks open and allow the gas to flow. Further up in the profile, there are tiny shifts along existing fractures, and permeability of the overlying rocks is increased. The existing fluids in the overlying rocks are pushed up by the injected fracking fluids. We never expect the fracking fluids themselves to enter shallow groundwater aquifers, nearly a mile above the shale. However, the fracking fluids may be expected to push naturally salty water up into the freshwater zone near the surface.

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