Residual hydraulic fracturing water not a risk to groundwater, study says

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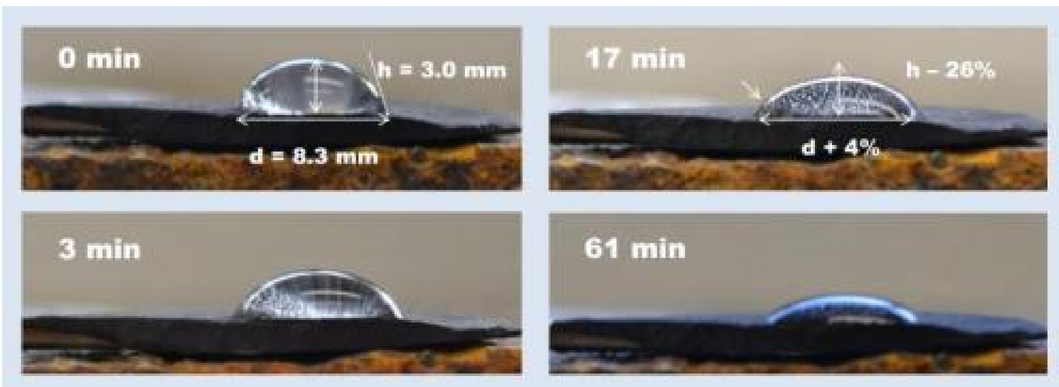

Sixty-one minutes of imbibition and evaporation of a 154 microliter bead of tap water on a 2.3 gram chip of the Union Springs Member of the Marcellus Formation. The drop disappeared in approximately 100 minutes. The photograph labeled 0 min was taken about 10 seconds after the bead was dropped on the Marcellus chip. Counter-current imbibition is indicated by methane bubbles floating up into the water bead from the Marcellus chip, starting on the left side of the bead at time = 0 min. This experiment was started 5 days after receiving fresh cuttings of the Union Springs from a horizontal well in PA. Credit: Engelder, Penn State

Hydraulic fracturing—fracking or hydrofracturing—raises many concerns about potential environmental impacts, especially water contamination. Currently, data show that the majority of water injected into wells stays underground, triggering fears that it might find its way into groundwater. New research by a team of scientists should help allay those fears.

In a paper published in the current issue of the *Journal of Unconventional Oil and Gas Resources*, Terry Engelder, professor of geosciences, Penn State; Lawrence Cathles, professor of earth and atmospheric sciences, Cornell University; and Taras Bryndzia, geologist, Shell International Exploration and Production Inc., report that injected water that remains underground is sequestered in the rock formation and therefore does not pose a serious risk to water supplies.

Hydraulic fracturing is a drilling technique commonly used to extract gas from previously inaccessible "tight" gas reserves, including gas trapped in shale formations such as the Marcellus. During this technique between 1.2 and 5 million gallons of water mixed with sand and chemical additives are injected at high pressure into each well to fracture the rock and release the gas.

Typically less than half of the injected water returns to the surface as "flowback" or, later, production brine, and in many cases recovery is less than 30 percent. In addition to the chemical additives, flowback water contains natural components of the gas shale including salt, some metals, and radionuclides and could impair water quality if released without proper treatment. While flowback water can be managed and treated at the surface, the fate of the water left in place, called residual treatment water or RTW, was previously uncertain.

Some have suggested that RTW may be able to flow upward along natural pathways, mainly fractures and faults, and contaminate overlying groundwater. Others have proposed that natural leakage of the Marcellus is occurring without human assistance through high-permeability fractures connecting the Marcellus directly to the water table and that hydraulic fracturing could worsen this situation.

The researchers report that ground water contamination is not likely because contaminant delivery rate would be too small even if leakage were possible, but more importantly, upward migration of RTW is not plausible due to capillary and osmotic forces that propel RTW into, not out of, the shale. Their study indicates that RTW will be stably retained within the shale formation due to multiphase capillary phenomena.

"Capillary forces and coupled diffusion–osmosis processes are the reasons the brines and the RTW are not free to escape from gas shale," said Engelder. "The most direct evidence of these forces is the observation that more than half the treatment waters are not recovered. Introducing treatment water causes gas shale to act like a sponge based on the principles of imbibition.

"Imbibition into gas shale is made possible by the high capillary suction that a fine-grained, water-wet shale matrix can exert on water. As water is wicked into gas shale, the natural gas in the shale is pushed out. The capillary forces that suck the RTW into the gas shale keep it there."

Estimating imbibition is complicated, but simple experiments conducted by the researchers show that water can be readily imbibed into gas shale in quantities fully capable of sequestering RTW. The researchers demonstrated this process in a series of experiments on cuttings recovered from the Union Springs Member of the Marcellus gas shale in Pennsylvania and on core plugs of Haynesville gas shale from NW Louisiana.

"The hydraulic fracturing fluid consists mostly of very low-salinity surface water, while the shale contains high concentrations of water soluble inorganic cations and anions," said Engelder. "During hydraulic fracturing water is lost to the formation while inorganic cations and anions are transferred from the formation to the hydraulic fracture. Diffusion osmosis assists the rapid imbibition of water by the shale and diffusion of ions into the treatment water causing the high salinities observed in flowback fluids. The point to be emphasized here is that this osmotic pressure pushes the hydraulic fracture fluids into the shale matrix, expelling gas and cations to make high-salinity flowback in the process."

The researchers believe that in addition to there not being enough water in the shale to contaminate groundwater, the most important point of their work is that multiphase capillary phenomena must be considered in cases where a non-aqueous fluid is present in the subsurface pore space. The vadose zone—the area from the surface to the groundwater—and oil and gas migration cannot be understood using single-phase, porous-media flow methods, and any policy insights or prescriptions based on single-phase considerations will be fatally flawed, they argue.

"The practical implication is that hydrofracture fluids will be locked into the same 'permeability jail' that sequestered overpressured gas for over 200 million years," said Engelder. "If one wants to dispose of fracking waters, one could probably not choose a safer way to do so than to inject them into a gas shale."

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