Received 1/30/2019 3:02:18 PM Supreme Court Middle District

IN THE SUPREME COURT OF PENNSYLVANIA
MIDDLE DISTRICT

Southwestern Energy Production Company, Appellant	:	
v.	:	No. 63 MAP 2018
Adam Briggs, Paula Briggs, his wife, Joshua Briggs and Sarah Briggs, Appellees	:	

Appeal from the opinion and order of the Superior Court of Pennsylvania filed April 2, 2018, reargument denied June 8, 2018, reversing the order entered August 8, 2017, in the Court of Common Pleas of Susquehanna County, Civil Division, at Docket No. 2015-01253

BRIEF OF *AMICUS CURIAE* PROF. TERRY ENGELDER

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January 30, 2019

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I. STATEMENT OF INTEREST

I, Terry Engelder, am an amicus petitioner with an office at the Pennsylvania State University. My academic research career of 51 years took place at four institutions of higher learning: Yale (1968-1970), Texas A&M (1970-1973), Columbia University (1973-1985), and the Pennsylvania State University (1985 to present). During this research career, I wrote a book on the relationship between hydraulic fracturing and earth stress[1] plus over 160 research papers with a cumulative citation index of over 11,000 according to Google Scholar as of January 2019. The geology and geophysics of gas shale is the focus of a large number of these research papers. Selected subjects include:

Stress Regimes in the Lithosphere[2]

Rock fracture[3]

Fracture by explosion[4]

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[1] Engelder, T., 1993, Stress Regimes in the Lithosphere, Princeton, New Jersey, Princeton Press.

[2] *Ibid*: Engelder, T., 1993.

[3] Engelder, T., 1987, Joints and shear fractures in rock, *in* Atkinson, B. K., ed., Fracture Mechanics of Rock: London, Acad. Press, p. 27-69; Engelder, T., and Fischer, M. P., 1996, Loading configurations and driving mechanisms for joints based on the Griffith energy-balance concept: Tectonophysics, v. 256, no. 1-4, p. 253-277.

[4] Engelder, T., and Zevenbergen, J. F., 2018, Analysis of a gas explosion in Dimock PA (USA) during fracking operations in the Marcellus gas shale: Process Safety and Environmental Protection, v. 117, p. 61-66.

Artificial hydraulic fracturing[5]

Natural hydraulic fracturing[6]

Natural fractures within the Marcellus gas shale[7]

Natural fractures within gas shale other than the Marcellus[8]

Rock permeability[9]

Hydrology of Appalachian Basin[10]

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[5] Evans, K. F., Engelder, T., and Plumb, R. A., 1989, Appalachian stress study; 1, A detailed description of in situ stress variations in Devonian shales of the Appalachian Plateau: Journal of Geophysical Research, v. 94, no. B6, p. 7129-7154; Zhou, Y., Nikoosokhan, S., Tan, Y., Johnston, T., and Engelder, T., 2018, The correlation between low tectonic stress and the Appalachian Basin Quiet Zone: Tectonophysics, v. 745, p. 95-116.

[6] Engelder, T., and Lacazette, A., 1990, Natural hydraulic fracturing: Rock joints: Rotterdam, AA Balkema, p. 35-44; Savalli, L., and Engelder, T., 2005, Mechanisms controlling rupture shape during subcritical growth of joints in layered rocks: Geological Society of America Bulletin, v. 117, no. 3-4, p. 436-449.

[7] Engelder, T., and Geiser, P., 1980, On the use of regional joint sets as trajectories of paleostress fields during the development of the Appalachian Plateau, New York: Journal of Geophysical Research, v. 85, no. B11, p. 6319-6341; Engelder, T., Lash, G. G., and Uzcátegui, R. S., 2009, Joint sets that enhance production from Middle and Upper Devonian gas shales of the Appalachian Basin: AAPG Bulletin, v. 93, no. 7, p. 857-889.

[8] Lash, G. G., and Engelder, T., 2005, An analysis of horizontal microcracking during catagenesis: Example from the Catskill delta complex: AAPG bulletin, v. 89, no. 11, p. 1433-1449; Lash, G. G., Loewy, S., and Engelder, T., 2004, Preferential jointing of Upper Devonian black shale, Appalachian Plateau, USA: evidence supporting hydrocarbon generation as a joint-driving mechanism, *in* J., C., and T., E., eds., The initiation, propagation, and arrest of joints and other fractures: London, Geological Society Special Publications 231, p. 129-151.

[9] Engelder, T., and Scholz, C. H., 1981, Fluid flow along very smooth joints at effective pressures up to 200 megapascals, *in* N. L. Carter, M. Friedman, J. M. Logan, and Stearns, D. W., eds., Mechanical behavior of crustal rocks: the Handin volume, American Geophysical Union Monograph 25, p. 147-152; Kranz, R. L., Frankel, A. D., Engelder, T., and Scholz, C. H., 1979, Permeability of whole and jointed Barre granite: Int. J. Rock Mech. Min. Sci. Geomech. Abstr. ; Vol/Issue: 16, p. Pages: 225-234.

[10] Woda, J., Wen, T., Oakley, D., Yoxtheimer, D., Engelder, T., Castro, M. C., and Brantley, S. L., 2018, Detecting and explaining why aquifers occasionally become degraded near

Microseismic analysis of the Marcellus gas shale[11]

Stratigraphy of the Marcellus gas shale Electric log analysis[12]

Pore pressure analysis of the Marcellus gas shale[13]

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In submitting this amicus brief I am acting as a friend of the court, although I presently serve the Commonwealth of Pennsylvania as a representative from academia on a statute-mandated committee, the Pennsylvania Grade Crude Development Advisory Committee. My work on this brief is pro bono as no person

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hydraulically fractured shale gas wells: Proceedings of the National Academy of Sciences, v. 115, no. 49, p. 12349-12358.

[11] Tan, Y., Chai, C., and Engelder, T., 2014, Use of S-wave attenuation from perforation shots to map the growth of the stimulated reservoir volume in the Marcellus gas shale: The Leading Edge, v. 33, no. 10, p. 1090-1096; Tan, Y., and Engelder, T., 2016, Further testing of the bedding-plane-slip model for hydraulic-fracture opening using moment-tensor inversions: Geophysics, v. 81, no. 5, p. KS159-KS168.

[12] Kohl, D., Slingerland, R., Arthur, M. A., Bracht, R., and Engelder, T., 2014, Sequence Stratigraphy and Depositional Environments of the Shamokin (Union Springs) Mbr., Marcellus Fm. and Associated Strata in the Middle Appalachian Basin: American Association of Petroleum Geologists Bulletin, v. 98, no. 3, p. 483-513; Lash, G. G., and Engelder, T., 2011, Thickness trends and sequence stratigraphy of the Middle Devonian Marcellus Formation, Appalachian Basin: Implications for Acadian foreland basin evolution: AAPG Bulletin, v. 95, no. 1, p. 61-103.

[13] Zhou, Y., Nikoosokhan, S., and Engelder, T., 2017, Sonic properties as a signature of overpressure in the Marcellus gas shale of the Appalachian Basin: Geophysics, v. 82, no. 4, p. 1-15.

[14] Engelder, T., Cathles, L. M., and Bryndzia, L. T., 2014, The fate of residual treatment water in gas shale: Journal of Unconventional Oil and Gas Resources, v. 7, p. 33-48.

[15] Engelder, T., 2009, Marcellus 2008: Report card on the breakout year for gas production in the Appalachian Basin: Fort Worth Basin Oil and Gas Magazine, v. August 2009, p. 18-22.

or entity paid in whole or in part for the preparation of this brief or authored in whole or in part this brief. However, my previous research on the Marcellus was supported by a combination of governments and industry. Southwestern was one of more than twenty operators that supported my research at one time or another. My research support ended two years ago by university regulation with my retirement as an active faculty member at the Pennsylvania State University. Although I am using Pennsylvania State University facilities, including an office and library services to prepare this report, I am solely responsible for the contents of this brief.

II. ARGUMENT

A. Introduction: Fracturing of rock.

In my opinion as a former instructor of petroleum and natural gas geology at the Pennsylvania State University, one of the more fundamental concepts within Pennsylvania's oil and gas law is that of a **well** as established in the ***Oil and Gas Conservation Law (Act 1961-359)***. The author of that legislation wrote, "Well" means a bore hole or excavation for the purpose of producing oil or gas, or both. It is a well-known and widely accepted fact that "excavation" of rock cannot be accomplished without cracking and fracturing rock to split and break it apart.

Universities like Penn State offer a battery of courses including petroleum engineering, rock mechanics, and fracture mechanics to further reinforce a student's understanding of the many nuances of rock fracture.

Breaking or fracturing rock requires energy applied by a mechanical device, a practice dating back to the stone age. The Egyptians used mechanical devices (i.e., a wedge and feather) in excavating rock for their famous granite monuments.[16] In the 19th century oil and gas industry of Appalachia, the original technique for breaking (a/k/a excavating) oil bearing formations involved mashing rocks under a weight which was later named a drill bit. When the Drake well was drilled in 1859, the technique was to repeatedly drop a weight onto the bottom of the borehole to crush a layer of rock, fractions of an inch thick with each blow. The Chinese first developed this technique centuries ago. A modern equivalent is the jackhammer and, when scaled up by industry, it is known as an air-drill. Even to this day, drilling is not possible without breaking rock under the drill bit, albeit on a microscopic scale. More importantly, drilling causes petal-centerline fractures, each of which reaches out in the form of a crack from the borehole wall.[17] Examples of drilling induced petal-centerline fractures are common in the Marcellus of northeastern

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[16] *Ibid*: Engelder (1993).

[17] *Ibid*: Engelder (1993).

Pennsylvania.[18] Such drilling-induced fractures are distinguished from hydraulic fractures mainly by their presence before stimulation of the well. Another type of fracturing that occurs during drilling is the borehole breakout, again penetrating into the rock behind the borehole wall.[19]

Aside from drilling-induced fracturing, rock is commonly broken by expansion of a fluid (gas or liquid) in a confined space. With the help of mechanical devices, the expansion of a fluid can either be as fast as the shock wave of an explosion[20] or as slow as the pumping of a fluid, either a gas (i.e., nitrogen or foam) or a liquid (i.e., gasoline, diesel, water, or mixtures of liquids) into the rock[21]. Regardless of whether these fluids split the rock by a shock wave or by a much slower injection by pumping, the driving force of the process is a form of hydraulic fracturing[22,23]. The only instance a fluid is not pumped into the borehole to split or fracture rock is when a shock wave takes advantage of the fluid already present in

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[18] Wilkins, S., Mount, V., Mahon, K., Perry, A., and Koenig, J., 2014, Characterization and development of subsurface fractures observed in the Marcellus Formation, Appalachian Plateau, north-central Pennsylvania: AAPG Bulletin, v. 98, no. 11, p. 2301-2345.

[19] Plumb, R. A., and Cox, J. W., 1987, Stress directions in eastern North America determined to 4.5 km from borehole elongation measurements: Journal of Geophysical Research, v. 92, no. B6, p. 4805-4816.

[20] *Ibid*: Engelder and Zevenbergen (2018).

[21] *Ibid*: Evans et al. (1989).

[22] *Ibid*: Engelder and Fischer (1996).

[23] The adjective, hydraulic, in hydraulic fracturing is not restricted to water but rather is the general term conjuring up a fluid of any sort from air or nitrogen (gasses) to diesel or water (liquids).

the borehole. Regardless of the technique for applying energy to split the rock, it is broken to some distance away from the point of application of the energy just like drilling induced petal-centerline fractures and borehole breakouts. This is the same principle that the Egyptians relied on to excavate granite using a wedge and feather technique.

Early on in the North American oil and gas industry, rock in a borehole was broken by the release of energy with the explosion of nitroglycerine (a rapid expansion of a fluid, a gas, as a shock wave) introduced into a borehole by a mechanical device called a torpedo.[24] This practice of 'stimulating' the borehole started just after the end of the Civil War and by the 1870s many wells throughout Appalachia were excavated or fractured by with the use of nitroglycerine charged torpedoes. The possibility of artificial fractures caused by drilling or by torpedoes crossing under permit boundaries at depth has been an integral part of the industry since the last quarter of the 19th century. In my opinion, any legislation or case law written in Pennsylvania after about 1870, implicitly incorporated the fact that either drilling and/or stimulation caused fractures to travel some distance from the borehole. Concomitantly, migration and capture of oil and gas would have followed along these higher permeability channels. When writing case law in 1889, it is

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[24] Herrick, J. P., 1949, Empire Oil: The Story of Oil in New York State, New York, Dodd, Mead, 474 p.

reasonable to speculate that the authors of the decision for ***Westmoreland & Cambria Natural Gas Co. v De Witt (18 A. 724) (Pa. 1889)*** knew about the role of artificial fractures, either drilling induced or stimulated, in the recovery or 'capture' of oil and gas.

B. Background: Established engineering and geological principles as they may apply to Briggs v Southwestern.

According to the courts, the modern practice of hydraulic fracturing was introduced in the late 1940s as a safer and more predictable means of excavating (breaking or fracturing) reservoir rock than was the use of nitroglycerine.[25] However, in Pennsylvania the breaking of rock under high water pressure started before the Second World War with water flooding. That practice was not called hydraulic fracturing but operators, mainly without knowing it, were splitting or breaking rock by water pressure long before the name, hydraulic fracture, was adopted by the courts.[26] The important elements of hydraulic fracturing or earlier splitting rock by water flooding did not change the basic post-civil war practice of breaking rock by the application of energy using a mechanical device and concomitant expansion of a fluid (either a gas or a liquid) to break the rock, thus

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[25] ***N.Y. State Natural Gas Corp. v Swan -Finch Gas Development Corp.***, 173 F.Supp. 184 (W.D. Pa. 1959).

[26] Yuster, S., and Calhoun, J., 1945, Pressure parting of formations in water flood operations: Oil Weekly, v. 117, no. 2, p. 38-42.

making extraction more economic. The point is that breaking rock has always been an implicit element of oil and gas operations starting shortly after the Drake well was drilled. Breaking the rock is a mechanical process always requiring the introduction of a mechanical device.

The courts are often asked for interpretations of the law in cases where scientific terms are either made unnecessarily complicated by legislation or where complaints have inappropriately obfuscated scientific terms. This happens largely because state law often defers to public policy which may not reflect the reality presented by geology (i.e., science on the ground). In my opinion, the case of Briggs v. Southwestern is an example where both unnecessary complexity and obfuscation has added confusion to what should have otherwise been a straight forward judgment.

The following is a list of long standing scientific facts of a geological nature applicable in the case of Briggs v. Southwestern:

- Reservoir rocks including both sandstone and shale have a porosity that can be charged with one or a mixture of three types of geological fluids: petroleum, natural gas (CH_4, CO_2, H_2S, etc.), or water (fresh water, brackish water, or brine).[27]

[27] Hunt, J. M., 1996, Petroleum Geochemistry and Geology, 2nd edition, New York, W.H. Freeman and Company.

- All reservoir rocks including sandstone and shale have interconnected pore space which allows for a property that enables the movement of fluid called intrinsic permeability (i.e., permeability of small samples of rock without fractures).[28]

- The content of pores (i.e., petroleum, gas, and water) is fugacious while the pore space is fixed and, thus, does not move with the fugacious fluid.

- All reservoir rocks contain natural fractures and as long as they are not filled veins[29], natural fractures increase the bulk permeability of the rock (i.e., permeability of large samples of rock after tectonic forces introduce natural fractures).[30] The Naples field of western New York was a fractured Marcellus reservoir (pool) developed in 1880.[31]

- Both intrinsic and bulk permeability of sandstone is greater than the intrinsic and bulk permeability of shale.

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[28] Sakhaee-Pour, A., and Bryant, S., 2012, Gas permeability of shale: SPE Reservoir Evaluation & Engineering, v. 15, no. 04, p. 401-409.

[29] A vein is a natural cement like calcite or silica.

[30] *Ibid*: Kranz et al. (1979); Engelder et al. (2009).

[31] Van Tyne, A., 1983, Natural gas potential of the Devonian black shales of New York: Northeastern Geology and Environmental Sciences, v. 5, p. 209-216.

- The Appalachian Basin has as many as seven viable gas shale layers with the three most important by reservoir size being the Dunkirk-Huron, the Marcellus, and the Utica.[32]
- The first gas shale in the Appalachian Basin to be developed as a gas reservoir was the Dunkirk-Huron using vertical (Fredonia, NY, 1825) and horizontal (Big Sandy Field, KY, 1978) drilling techniques.[33]

C. Non-specific terms carrying an overtone of scientific fact in the case of Briggs v Southwestern.

In my opinion, there are three non-specific terms carrying an overtone of scientific fact which have been obfuscated by legislation to enact public policy. These are subjective notions and, thus, hard to defend in a court of law when held up as a holistic scientific concept.

1. **Pool**: In the ***Oil and Gas Conservation Law (Act 1961-359)*** *"Pool" means an underground reservoir containing a common accumulation or oil and gas, or both, not in communication laterally or vertically with any other accumulation of oil or gas*. Implicit in this definition is that accumulations are sealed from each other. As

[32] Ettensohn, F. R., 1994, Tectonic controls on formation and cyclicity of major Appalachian unconformities and associated stratigraphic sequences: SEPM Concepts in Sedimentology and Paleontology #4, Tectonic and Eustatic Controls on Sedimentary Cycles, p. 217-242.

[33] Yost II, A. B., Overbey, W. K., and Carden, R. S., 1987, Drilling a 2,000-ft Horizontal Well in the Devonian Shale, Paper SPE 16681 presented at Annual Technical Conference and Exhibition: Dallas, TX, 27-30 September.

both sandstone and shale have an intrinsic permeability, neither qualifies as a seal although much of the geological literature traditionally identifies a shale as a seal over a sandstone reservoir. In a recent peer-reviewed paper, I point out that a gas shale is sealed by capillary pressure at its boundary.[34] The internal portion of a gas shale is in communication just as any other reservoir and is, therefore, a common accumulation by Pennsylvania Law. Until a reservoir is entered by mechanical means (drilling and the fracturing that comes with drilling), the fugacious minerals remain static in both sandstone and shale, a property of conventional reservoirs.

2. **Unconventional formation**: The ***Oil and Gas Act (Act 13-Chapter 23)*** defines an unconventional formation as a *geological shale formation existing below the base of the Elk Sandstone or its geologic equivalent stratigraphic interval where natural gas generally cannot be produced at economic flow rates or in economic volumes except by vertical or horizontal well bores stimulated by hydraulic fracture treatments or by using multilateral well bores or other techniques to expose more of the formation to the well bore.* The fact is that several viable gas shales, including the Dunkirk-Huron shale, are above the base of the Elk sandstone and these require identical techniques (i.e., horizontal laterals and splitting of the shale with the application of energy via fluid under pressure) to enhance flow rates to the well bore. Act 13-Chapter 23 is a law that was written as political policy to protect small-scale oil and gas operators from impact fees levied on the large-scale operators. Act 13-Chapter 23 was not intended to make some distinction between the nature of gas recovery in conventional shale and unconventional shale. The fact is that all seven or more shale layers in Pennsylvania are conventional by definition of a pool in the ***Oil and Gas Conservation Law (Act 1961-359)***.

3. **Hydraulic fracture**: As stated above the courts have misunderstood hydraulic fracturing. Among other things, the courts have misidentified the date at which hydraulic fracturing first

[34] *Ibid*: Engelder et al. (2014).

occurred when pumping fluids into boreholes for the purpose of recovering oil. Further to the point, statutes have added confusion by suggesting that hydraulic fracturing is, somehow, different when used in conventional and unconventional formations. To add further confusion natural fractures and artificial hydraulic fractures are indistinguishable using modern techniques such as microseismic analysis. Because microseismic events are more often seismic noise created by slippage on natural fractures, the distribution of microseismic events is neither a measure of the true length of artificial fractures nor a measure of the extent to which frack fluid has invaded outward from the well bore.[35] Natural fractures are uniformly distributed in gas shale on the scale of a typical lease. Their presence makes it more likely that drainage from one property to another is as much a consequence of natural fractures and not artificial fractures caused by hydraulic fracturing. Finally, the presence of natural fractures means that it is impossible to know with certainty whether artificial fractures are to blame for enabling capture across property lines.

D. A geologist's view of Pennsylvania's Oil and Gas Law: A restatement of arguments A, B, and C.

Rock fracture by artificial means reaches beyond the well bore to help capture fugacious fluids by enhancing flow to the well bore. Artificial fracturing of rock has allowed oil and gas development to flourish for a period exceeding 150 years. Ever since the judgment in ***Westmoreland & Cambria Natural Gas Co. v De Witt (18 A. 724) (Pa. 1889)*** Pennsylvania courts have embraced the rule of capture and, implicitly, rock fracture which make that capture possible. Because the history of

[35] *Ibid*: Tan, Y., and Engelder, T. (2016).

artificial fracture predates ***Westmoreland***, any statue involving the rule of capture implicitly gives license to the use of artificial means including rock fracture to enhance that capture. This implicit sanction of using artificial means to capture oil and gas had real consequences when the ***Oil and Gas Conservation Law (Act 1961-359)*** was enacted. That law permitted non-conservation wells to snuggle up to lease boundaries as long as the Onondaga Formation had not been penetrated. ***Act 1961-359*** recognizes,

> that the uninterrupted exploration and development of Pennsylvania and Mississippian Systems and the Upper and Middle Devonian Geological Series, being sands and strata above the Onondaga Horizon, both of a primary and subsequent methods have been carried on exhaustively since the discovery of oil in the Drake Well in 1850 without regulatory restriction or control to such an extent that at the present stage of development it would be impractical and detrimental to the operation of such shallow horizons to impose regulations under this act, particularly in view of the facts that the production therefrom, whether of primary or secondary nature is carried on without appreciable waste and that the methods of exploration, discovery, development and production above the Onondaga Horizon and in shallow horizons at a depth of less than three thousand eight hundred feet differ from methods of exploration, discovery, development and production below the Onondaga Horizon or below three thousand eight hundred feet in cost, methods, operating problems, and other important characteristics.

The flaw in this statement is that, somehow, there is a difference between extraction above and below the Onondaga. Never-the-less, this act is close to an explicit sanction of the cross boundary propagation of artificial fracturing as can be found in Pennsylvania law for industry operating above the Onondaga. The term, hydraulic fracture, is found in the text of Act 1961-359 but without definition. It was a common practice dating back to the days of water flooding more than twenty years before Act 1961-359 was written. In a recent law review, Pierce writes, "Geologist William S. Lytle, in writing about hydraulic fracturing activities in Pennsylvania, noted that a sharp increase in fracturing deep productive gas zones occurred in 1954."36 Commenting on the state of the practice in 1965, Mr. Lytle reported that "most of the deep gas wells drilled since 1957 have been fractured." He also added that most of the shallow gas wells were being fractured. By 1961, the benefits of fracturing oil wells had been proven. Mr. Lytle summed up the Pennsylvania situation as it existed in 1965 stating: "The hydraulic fracturing boom is off to a good start." This provides clear evidence that legislators should have known about the role of hydraulic fracturing in draining pools when writing Act 1961-359. If they did not, they were asleep at the throttle because with Act 1961-359 legislators sanctioned a process which would later be obfuscated by trial lawyers arguing subsurface trespass by artificial means.

E. Comments on Superior Court's opinion for Briggs v Southwestern.

The following are examples of confusion arising from a misunderstanding of common engineering and geological principles when mixed together with non-

[36] Pierce, D. E., 2010, Developing a Common Law of Hydraulic Fracturing: U. Pitt. L. Rev., v. 72, p. 685.

specific terms carrying an overtone of scientific fact as cited by the Superior Court's opinion on ***Briggs v Southwestern*** filed April 2, 2018.

First, the court writes, "Appellants point to the differences between hydraulic fracturing and the 'conventional process of tapping into a pool or reservoir of fluids that flow according only to high and low pressure….' "

> Both parties to ***Briggs*** will agree with the Reply Brief of Mr. Kelly (December 23, 2017) that "oil or gas is fugacious, that is, capable of flowing or fleeing such as a wild animal." Of course, this was confirmed in ***Westmoreland & Cambria Natural Gas Co. v. De Witt,*** 18 A. 724 (Pa. 1889), where the Court noted that "unlike other minerals, [oil and gas] have the power and the tendency to escape without the volition of the owner." What is in dispute in ***Briggs*** is whether there is any difference in how gas flows out of the Marcellus relative to other reservoir rock, conventional or unconventional, in Pennsylvania.
>
> The fact is that both oil and gas leak by natural processes from reservoir rocks because it flows from high to low pressure. The presence of oil and gas seeps in North American prior to Columbus discovering America is evidence of this fact. The problem is that natural flow is not fast enough to meet commercial needs. Starting in 1859, wells in Pennsylvania are drilled to increase the pressure difference and, hence, flow rate of fugacious hydrocarbons. What should be in dispute in ***Briggs*** is whether there is any difference between natural flow of a fugacious mineral and drilling a well to increase a pressure differences (high to low) in a fugacious mineral.
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> Within five years of the Drake well, the operators discovered that paraffin from Pennsylvania grade crude clogged pore space and reduced flow to wells. The solution was to break through the paraffin clog by fracturing rock around the borehole by using nitroglycerine. Fracturing the rock further increased the distance that a fugacious hydrocarbon might 'flee like a wild animal'. Note that ***Westmoreland*** was a judgment that post-dates fracturing and the concomitant

possibility that fugacious hydrocarbons would escape without the volition of the owner.

Hydraulic fracturing was later introduced as a much safer and predictable technique for fracturing rock relative to the results obtained by employing nitroglycerine. Neither the physics of fugacious migration nor the properties of rocks was changed with the introduction of hydraulic fracturing. What should be in dispute in ***Briggs*** is whether there is any difference between drilling a well to increase a pressure differences (high to low) in a fugacious mineral and stimulating the well by hydraulic fracture to increase the pressure differences (high to low) in the same fugacious mineral. From the point of view of the physics of petroleum and gas migration, there is no difference between conditions present when nitroglycerine was introduced some time shortly after the civil war and conditions present during modern hydraulic fracturing. Both allow for the flow of a fugacious mineral from high pressure to low pressure as do drilling induced fractures present before stimulation of any sort.

Second, the court writes, "Appellants assert that, like the minerals in ***Young***,[37] natural gas contained in shale formations would remain trapped there forever if not for the 'forced extraction' through hydraulic fracturing."

One point is that the very act of drilling a well is unnatural and leads to a "forced extraction."

A second and more important point is that hydrocarbons do not remain trapped forever. If that were really the case, there would have been no leaks of natural gas and oil prior to the arrival of Columbus.

The implication is that the low permeability of the shale formation allows trapping "forever." Low permeability rock like the Marcellus leak naturally and should have lost all of its hydrocarbon charge. Here is where the subjective terms, conventional and unconventional

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[37] ***Young v Ethyl Corp.*** (521 F.2d 771) (8th Circuit).

reservoir, provide an element of confusion that has carried into the courts. All reservoirs including the Marcellus require a seal. Traditionally, conventional reservoirs have been characterized as a high permeability sandstone capped by a low permeability shale. What has been missed by this traditional picture from the industry is that it is capillary forces associated with pore throats in shale that make the formation seem like a seal.[38] Gas in an unconventional reservoir like the Marcellus is trapped in the same manner as that which holds conventional gas in place, a capillary seal.

Another point which is lost in the confusion created by an attempt to distinguish conventional and unconventional reservoirs is that gas shales like the Marcellus contain a network of cracks and fractures in the form of both joints and veins.[39] This network gives a gas shale a natural permeability that hydraulic fracturing seeks to tap into. This network knows no property boundaries but its presence gives natural pathways for fugacious hydrocarbons to flee across boundaries, particularly when connected by hydraulic fracturing.

Third, the court writes, "According to Appellants, it is possible to measure the source of natural gas obtained through hydraulic fracturing, and therefore, the rule of capture should not apply."

Industry measures gas flowing to a wellhead and distributes royalty checks according to the distribution of ownership within a given drilling unit. The industry disburses income in this manner because it does not know nor can it measure the exact amount of gas coming from beneath individual parcels of land. In fact, such a system of disbursement assumes that the rule of capture applies uniformly to all parcels in a drilling unit unless parcels in the drilling unit have elected to decline membership in that drilling unit.

Industry cannot control how and where hydraulic fractures interconnect with natural fractures. In a sense the very process of

[38] *Ibid*: Engelder et al. (2014).
[39] *Ibid*: Engelder et al. (2009); Wilkins et al. (2014).

> hydraulic fracture growth among natural fractures is a 'fleeting, flowing, wild process' which engineers like to think they have more control over than they really do. There is a general engineering model that is based on the premise that fractures grow outward in an elliptical, vertical plane from the perforations along a wellbore. In reality, this is rarely the case as indicated by microseismic surveys which show the fleeting, flowing, wild process that a hydraulic fracture stimulation really is.[40]

Fourth, the court writes, "Southwestern asserts that the rule of capture should be applied to natural gas obtained through hydraulic fracturing, which it describes as a 'mechanical method of increasing the permeability of rock, and, thus, increasing the amount of oil or gas produced from it....' "

> Southwestern's description of the hydraulic fracture process is accurate but the same statements can be applied to drilling back in 1859 with the introduction of drilling induced fractures next to the wellbore. Shortly after the Drake well nitroglycerine was used to fracture rock. As early as 1889 ***Westmoreland*** certified that the rule of capture applies when a well is drilled and the rock is fractured beyond natural fractures which are present before drilling. It is, in my opinion, splitting hairs to argue that there is a difference between intervention by drilling vertical wells and drilling horizontal wells. It is also splitting hairs to argue that there is a difference breaking rocks using nitroglycerine, nitrogen, diesel, water or any other artificial means.

Fifth, the court writes, "Appellants argue that hydraulic fracturing 'differs dramatically' from conventional gas drilling, and that the principles underlying the

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[40] Neuhaus, C. W., Williams-Stroud, S. C., Remington, C., Barker, W., Blair, K., Neshyba, G., and McCay, T., 2012, Integrated Microseismic Monitoring for Field Optimization in the Marcellus Shale-A Case Study, SPE 161965: SPE Canadian Unconventional Resources Conference.

common law rule of capture do not apply to natural gas obtained through the process of hydraulic fracturing."

> Here is a good example of confusion because fracturing was a common practice for 'conventional' production of oil and gas from the beginning. Hydraulic fracturing in the narrow sense was an important tool for the conventional industry since it was introduced in Pennsylvania in 1954. Fracturing rocks to obtain gas has been a common practice for as long as there was a demand for that commodity and the flow of gas to a well always involves the rule of capture, regardless of whether or not crossing a property boundary is involved in the flow of gas to the wellhead.

Sixth, in citing ***Butler v. Charles Powers Estate ex rel. Warren, 65 A.3d 885, 894 (Pa. 2013)*** the court quotes the case opinion that, "The pressure creates cracks in the rock that propagate along the azimuth of natural fault lines in an elongated elliptical pattern in opposite directions from the well." And, the court added from ***Butler***, "the hydraulic length, which is the distance the [hydraulic fracturing] fluid will travel, sometimes as far as 3,000 feet from the well . . . but virtually nothing can be done to control that direction; the fractures will follow Mother Nature's fault lines in the formation."

> This is an example where the courts are implicitly arguing that hydraulic fracturing should be treated much like *ferae naturae*. They can't be controlled and sometimes do travel more than 3,000 feet from a well, even if the operator does everything in his/her power to limit the length of the fracture.[41]

[41] https://www.post-gazette.com/business/powersource/2015/01/05/West-Virginia-judge-denies-chemical-company-s-second-challenge-to-fracking-operations/stories/201501050130 accessed January 29, 2019.

Seventh, in citing ***Coastal Oil & Gas Corp. v. Garza Energy Trust***, 268 S.W.3d 1 (Tex. 2008) the court writes, "Regarding the majority's four reasons 'not to change the rule of capture,' Justice Johnson stated that, although he disagreed with some of those reasons, his fundamental disagreement was that he believed the majority was, in fact, changing the rule of capture."

> No, the majority is not changing the rule of capture. It seems to me that Justice Johnson failed to understand the extent to which capture by fracturing was implicit in Pennsylvania case law prior to the opinion issued in 1889 for ***Westmorland***.

III. CONCLUSION

In my opinion, while the permeability of sandstone is greater than the permeability of shale, the legal principle of *ferae naturae* (i.e., there is no natural ownership of petroleum, natural gas, or water underground) should apply to minerals in the pore space of both sandstone and shale without prejudice. To argue that a reservoir of gas shale is not a pool or to argue that hydraulic fracturing is fundamentally different from any other technique for breaking rock or to argue that unconventional techniques for extracting oil and gas are fundamentally different from conventional techniques for extracting oil and gas might, in my opinion, be very, very difficult in a court of law. The major reason that these arguments might well fail is that there are no statutes precisely defining a reservoir, hydraulic fracturing, and unconventional extraction techniques, definitions that would have enabled a clear distinction between modern techniques and those practices for breaking rock and capturing oil or natural gas dating back to the 1870s in Pennsylvania. Finally, the presence of natural fractures makes it impossible to know with certainty whether artificial fractures are to blame for enabling capture of fluid (oil, natural gas, or water) held in pore space until intervention by artificial means. The principle of *ferae naturae* applies equally well to natural gas flowing in either natural or artificial fractures.

Respectfully submitted,

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January 30, 2019

CERTIFICATE OF COMPLIANCE

I certify that this filing complies with the provisions of the *Public Access Policy of the Unified Judicial System of Pennsylvania: Case Records of the Appellate and Trial Courts* that require filing confidential information and documents differently than non-confidential information and documents.

Terry Engelder

WORD-COUNT CERTIFICATION

I certify that the attached contains less than 7,000 words, excluding supplementary matter, as calculated by the word-count feature of Microsoft Word.

Terry Engelder

CERTIFICATE OF SERVICE

I certify that on January 30, 2019, I caused a copy of my Amicus Brief to be served through PACFile.

Terry Engelder