Debunking Durand

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Overview: Presentation's faulty premise forgets gravity and the weight of the earth

There's a highly publicized presentation available online by Marc Durand, a retired professor from the University of Quebec in Montreal (UQAM), that paints a frightful (and inaccurate) picture of what occurs during shale gas development. Through a cartoon of a "virtual cube" Durand describes in vivid colors and three-dimensional detail how hydraulic fracturing — a technology that has been safely used for many years in North America — will supposedly cause irreparable harm to the environment. The facts, however, tell a different story.

Durand is a soil-stability engineer with experience working near surface in particular for the Montreal subway and sewer systems. He has first hand knowledge and expertise with regard to Utica shale that he encountered at and near the surface. We agree that at the surface brittle rock like the Utica will chip, fissure and crack and act just the way Mr. Durand observed and explains in his presentations and videos.

Mr. Durand extrapolates his observations and he bases all of his theories on the premise that rock reacts the same at surface as it does two thousand metres under the earth. This is simply not the case and everything Mr. Durand hypothesizes is based on this faulty premise.

In his PowerPoint presentation, Durand shows pictures of the Utica Shale taken in the tunnels of the Montreal subway system where the rock has pieces chipping away. He shows water leaking through the rock. He even shows gas seeps that bubbled through the rock naturally decades ago. Mr. Durand then proposes this "impermeable" rock is not actually impermeable after all and that hydraulic fracturing will create permanent pathways to the surface.

A very rudimentary understanding of physics would show the errors in Durand's presumptions. There is layer upon layer of impermeable shale – in fact 1000 to 2000 metres of it – pressing down on top of the layer we hydraulically fracture. There are many many billions and billions of tonnes of rock that create huge confining pressures. Oil and gas geologists, geophysicists and engineers have an expertise gained over careers studying the rock from surface all the way to depths and how it reacts at various depths and in various geological settings.

We have to put steel casing in our wells to stop the weight of the rock from closing off and sealing the hole we drill.

We have to use fine sand in our hydraulic fractures is to keep the fissures open – the shale is under so much pressure that our millimetre-wide fissures would simply reseal immediately without the sand.

And the issue of fracing into a fault open to the surface? They don't work the way Mr. Durand pictures them. It is true that in nature, the tectonic forces that moved Quebec from the equator to where it is today, cause faults. In some circumstances the pressures can be tensional or pulling the earth apart. This can allow gas and even oil that is lighter than water to escape upwards. Water and fluids typically respect gravity and move downwards though there are exceptions.

It pays our industry to understand faults very well. The reality is we go out of our way to avoid faults such as this – because there is no high pressure natural gas there – it would have escaped long ago. The natural gas we have found in Quebec is high pressure which proves there are no open faults connected to surface.

In Mr. Durand's second video he makes the same mistake. He shows propane bottles under the ground. He says they are time bombs waiting to explode when the steel corrodes. Except with a few billion tonnes of rock above would the propane bottles explode? No they will collapse like pancakes.

Mr. Durand is no doubt an expert on soil stability from his experience working on the construction of the Montreal subway system. He is not an oil & gas geologist or engineer. He has no experience in the geomechanics of deep shale. He presents no independent research from oil & gas geology experts to support his hypothesis. His hypothesis rests on an assumption that is not correct and is not observed in the real world.

As one anonymous expert commented the theory is so obviously wrong it's not worth refuting.

What follows is a dissection of Mr. Durand's presentation, which includes most of his claims about what occurs when natural gas is produced from shale. Next to each claim is a description of why Mr. Durand is mistaken in his presentation, and what the facts really are.

Durand Presentation	Reality
1:01 – "The extraction of the gas in the Utica Shale cannot be done except by criss-crossing the whole plain with about 20,000 wells."	Wells do not "criss-cross." They are drilled in a carefully planned pattern, usually branching out from a central surface location. The use of multi-well drilling pads means much more gas can be produced safely with a significantly reduced surface impact. According to a report prepared for the U.S. Department of Energy, horizontal drilling (which is common in developing shale gas) "allows an area to be developed with substantially fewer wells than would be needed if vertical wells were used." In addition, advanced computer modeling is used to optimize spacing between the wells, both to maximize production and to avoid wells from being drilled into one another. As for the number of wells, it is currently unknown if any development will be economic in Quebec, and thus it's impossible to determine how many wells would ever be drilled. Currently, economic models have assumed a range of well scenarios, but most likely the number is around 8,000 wells.
1:16 – "One may expect recovery of 20 percent of methane contained in the gas deposit."	If the industry or anyone else knew what the recovery rate would be, it would save companies millions of dollars in exploration costs. The fact is there are no independent published estimates of what recoveries will be for the Utica Shale in Quebec, and experiences elsewhere show a broad spectrum of recoverability rates. The Fayetteville Shale in Arkansas, for example, has a technically recoverable resource base of 41.6 trillion cubic feet (tcf) out of a total gas in place of 52 tcf, or roughly 80 percent. The Woodford Shale in Oklahoma has a recovery rate of nearly 50 percent. Although most shales have recoverability rates well below these, these examples clearly demonstrate that Durand's claim of a 20 percent rate of recovery, based on zero data, is purely speculative. Again, it is unknown if development will be economic in Quebec, and part of that uncertainty stems from the fact that recovery rates are unknown. If recovery rates are extremely low, then development will not make sense.
1:29 – "At the end of the operation, it would be suitable to rename the formation the Fractured Utica".	This is a very elementary level misunderstanding of Utica geology. It is already the 'naturally fractured Utica'. The tectonic forces that moved Quebec from the equator 400 million years ago to its present position have naturally and repeatedly fractured the Utica. The Utica will also have been naturally hydraulically fractured in the process of creating natural gas. Kerogen takes up less space than the gas that it creates when heated at depth. This gas can hydraulically fracture the rock due to expansion. Over time these fractures naturally heal due to the weight of the rock and fluid flows that deposit minerals. Fractures that fill with natural gas can prevent the flow of other fluids. We encounter mostly healed fractures but also open ones in our work in the Utica. Over the last 400 million years both the natural gas and the salty water in lower zones have remained safely in place. When we hydraulically fracture the Utica we use seismic forces millions of times smaller than the natural tectonic forces. Forces equivalent to dropping a pail of water on the ground. We will have also fractured a very small fraction of the rock that has been fractured naturally. The fractures we create will heal just like natural ones. In fact they could heal faster because we will have removed the natural gas pressure.

Durand Presentation	Reality
1:31 – "All this [shale gas extraction] goes on in the depths, out of sight.	Although Mr. Durand appears to use this line as a means of scaring the audience about the unknown, this is actually an important point. Deep shale natural gas exploration (as would be required for the Utica Shale in Quebec) takes place hundreds or even thousands of metres below the surface, and hydraulic fracturing occurs at a depth far below all groundwater supplies. The producing formation is also separated from water aquifers by multiple layers of impermeable rock, which, along with gravity, prevent any fluid migration from the hydraulic fracturing zone into any drinking water supplies.
1:36 – "As it might be thought that only the rural areas are affected, I will now explain what a gas well is in three dimensions. And, in order to better visualize the scale, I will place it in the middle of the city.	They say a picture is worth a thousand words, and by superimposing his diagram onto Montreal, Mr. Durand is indeed generating a scary story. While he says this is done to "visualize the scale" of the operation, he could have chosen thousands of different representations (click here and go to page 14 to find a schematic of deep shale gas exploration, compared against the height of the CN Tower). Instead, he chose to make a highly populated area the backdrop for his presentation on the supposed risks of shale gas development, a decision motivated by more than just a point of comparison. In reality, oil and gas fields are developed largely in rural settings (as Durand notes in his presentation), and any representation of shale gas production would be more accurately placed in the setting in which it will actually occur.
2:26 – Hydraulic fracturing schematic shows the span of the fractures reaching almost 500 metres; the cube is one square kilometre, yet the fractures reach both sides from the middle of the cube.	Not only is this a misrepresentation of hydraulic fracturing, but it also leads to a significant misunderstanding about the total volume of rock that is stimulated and, in turn, the overall impact of the operation (more on that below). In an actual hydraulic fracturing operation, the length of each fracture would only be about 100 metres. As shown in Mr. Durand's presentation, the area of the rock that receives stimulation is more than five times larger than what it would be in an actual shale gas well. The virtual cube also fails to show even the most basic of geological layers that exist between the surface and the formation where hydraulic fracturing takes place. This leaves the viewer with the impression that only space separates the fracturing zone from ground water supplies, when in reality multiple layers of impermeable rock lie between the Utica Shale and the surface.
2:40 – Refers to "gas ore" that is "acquired at the staggering price of ten dollars per year."	First of all, "ore" is a solid rock containing minerals for extraction, typically metals. It has nothing to do with methane or the source rock from which natural gas is extracted in a shale well. Secondly, the price of natural gas is determined on the open market at a price per volume (typically dollars per cubic foot or cubic metre). The volume of the source rock (or the mass of that rock) has absolutely no influence on pricing, nor are prices determined on a per-year basis. Moreover, the cost of extracting natural gas from shale is based on drilling and completion practices and conditions specific to the areas in which the wells are drilled. According to Canada's National Energy Board, horizontal wells in the Utica Shale are projected to cost five to nine million dollars (although that figure is based only on early assumptions). Mr. Durand comments on the fiscal system of Quebec. Like Norway Quebec does not have an open auction system for permits. Like Norway the MNRF grants licenses to qualified applicants who present an accepted exploration program and commit to spending minimum amounts on their program with annual reports on progress. Unlike Norway, Quebec also charges a royalty on successful exploitation. We agree and expect that the MNRF – once there has been proven success and demand warrants will – increase its requirements. It could also change the system from the international system to one like Alberta with open auctions and no review of exploration programs or qualifications. Industry is satisfied to work under either system.

Durand Presentation	Reality

2:52 – "Let's now look at the same operations in the case when the horizontal drilling encounters a geologic fault..."

The presentation shows the drilling operation encountering a major, near-vertical fault. But before drilling ever begins, a complex surveying process takes place, including the use of advanced 3-D seismic testing and aero magnetic. These tests allow companies to locate major and even minor fault lines deep below the surface so they can avoid these areas.

Mr. Durand's presentation also shows a perfectly straight fault line without any layers of rock. This is a significant misrepresentation of geology, as each layer of rock acts as a restriction on fractures, and thus a single fault line can be naturally sealed due to the conditions of any or all of those layers.

Each layer of rock acts as a restriction on fractures. Imagine a wall of bricks. Mr. Durand shows all the bricks with no mortar and all lined up neatly. In real life the bricks are not lined up neatly and they are cemented. If you crack one brick at the bottom it won't crack the bricks at the top. Also if there is no mortar then there is no natural gas.

Industry also creates cartoons to try to make very complicated systems understandable. Mr. Durand's cartoon is just too simple and not representative of real geology.

The fault shown in the presentation is also either open or in tension, but we can all be assured that there will not be commercially recoverable natural gas near these types of faults. Any gas would have leaked away through that fault thousands or even millions of years ago.

3:11 – "It is possible only one drilling in ten or one in a hundred will cut through a fault. We don't know enough about their numbers and their distribution to be more precise. But what is certain is that drilling everywhere in the Utica there will be scores, indeed hundreds of problematic cases."

Contrary to Mr. Durand's assertion that we don't know much about geological fault lines, the truth is that geologists have studied this region for centuries. And with advanced seismic capabilities utilizing highly accurate 3-D computer modeling, companies can adjust their operations to avoid even minor fault lines deep below the surface, faults that are much smaller than the one Mr. Durand includes in this presentation.

Faults can be very small and there are faults of only a few centimetres easily seen in granite kitchen counter tops. So many faults are too small to map but obviously do not represent the problem shown by Mr. Durand.

As it happens the major fault systems in our area of interest have already been mapped by geologists and geophysicists staring with Logan in the mid 1800s. That's how we know the type of fault Mr. Durand shows in his cube are exceedingly rare. In response to the BAPE suggestion that major faults be mapped by the Government, industry shared its data and work through a recent peer reviewed study entitled the "stability of fault systems in the St Lawrence Lowlands"

In the extremely rare case that drilling encountered a fault line, the drilling company would know because constant pressure tests would indicate its presence. Hydraulic fracturing would never take place near these faults. For hydraulic fracturing to be successful there must be very high pressure in the rock formation, and fault lines reduce that pressure while also providing pathways for hydrocarbons away from the well bore. For this reason, carrying out hydraulic fracturing near a fault would also considerably reduce the recovery rate in the formation, which would make operations less economical.

Through the use of 3-D seismic and existing geological knowledge, industry has proven itself quite adept at finding and avoiding fault lines. For example, the Barnett Shale in north Texas (the second largest producing shale gas formation in the United States) contains many natural faults, yet operators there are able to recognize and avoid coming into contact with those faults (click here to see a very basic cross-section of the Utica Shale). Wells that intersect faults often cannot be stimulated or used for production because of the loss of pressure, so the industry has an enormous incentive not to spend millions of dollars on a well that intersects faults and thus cannot produce any gas.

Durand Presentation	Reality
3:46 – "Injection pressure is 300-400 times atmospheric pressure	We are glad to see that the author accurately described the pressure at which we hydraulically fracture. Two kilometres under the ground there is a great deal of pressure from just the weight of the trillions of tons of rock. Studying and understanding pressures is essential to our industry. The pressures exerted on geological formations are completely different kilometres deep than they are at surface. Petroleum engineers and petroleum geologists are specially trained and have extensive experience with in-situ (in-place) pressures, how to evaluate them, how they affect drilling and fracturing and how to mitigate risks associated with high pressures. Studying the rock properties of the Utica in our laboratories and at surface is just the first step to understanding the rock. Next petroleum geologists and petroleum engineers need to study the pressures exerted on the rock in-place in the formation to elaborate the design of the well and the computer modeling of the hydraulic fracturing stimulations. Our casings, cements, blow-out preventers, etc. etc. are all selected and designed with these pressures in mind. In fact, because shales have such low porosity and permeability, the pressures are usually consistent and are easier to deal with than many conventional reservoirs.
4:09 – "In this way, a path of communication between the depths and the surface is created. In forcing its opening, and in injecting sand with the fluid, communication has been enhanced in an irreversible fashion with the surface layer."	This would not happen. A fault encountered during drilling would be avoided during the hydraulic fracturing process. The region surrounding the fault would be isolated by what are called "packers" (essentially that portion of the well would be blocked off from hydraulic fracturing) and intentionally left unstimulated. In the rare case where a fault was accidentally stimulated, as soon as any fluid penetrated the fault the pressure drop would be noticed by the crew using real-time monitoring onsite. They would stop pumping fluid long before even a small communication pathway could be opened, much less before the creation of a large pathway spanning an entire kilometre as Mr. Durand suggests would be inevitable. The U.S. Department of Energy has found that faults tend to "divert the flow of fracture fluids" and have the effect of "reducing the volume of reservoir rock being fractured." This means less gas is produced, and a well operating in such a manner is far less economical.
4:24 – "What is most put in direct communication is the methane from the depths, now liberated by the hydraulic frac to the surface above."	This is physically impossible. There are no known instances in past hydraulic fracturing operations where a path for methane migration was opened that allowed it to travel one kilometre from depth to the surface. In addition, the various layers of impermeable rock that separate the fracturing zone from the surface serve as an additional barrier against such migration.
5:06 – "But the fissure plane on the other hand extends for some kilometers and its exact location itself is difficult to determine."	Again, fissures and faults are all mapped with seismic technology prior to the beginning of any actual drilling. You can find a cross-section representation of the Utica Shale by visiting the website of the National Energy Board. There is only a remote possibility that drilling operations would cross a fault, and if that occurred hydraulic fracturing would not be performed. The likelihood of encountering an unknown fissure plane is even less likely.

Durand Presentation	Reality
5:16 – "It is not only that gas can use this path to the surface, but also super-salinated water from the depths, where all subterranean flow will have been greatly disturbed by the new fractures."	This is a fundamental misunderstanding of gravity. The impermeable rock is stopping the fresh water from going down. The prime force here is gravity and as any farmer can tell you they have to pump the water out of their wells. Of course there are anomalies where pressure or heat can cause water to rise against the force of gravity to the surface. An artesian flow from depths like the Old Faith geyser Yellowstone National Park has not been observed in Quebec and if it did exist one can be sure there would be no gas. Because hydraulic fracturing is limited to the Utica Shale, there is little or no impact to "subterranean flow." The Utica has such low permeability and porosity that there is no water movement within this rock layer to be disturbed. Such low permeability also means that all activity in the Utica Shale will be limited to that formation and that formation only.
5:42 – "It is 50 or 100 or even 150 million cubic metres of rock which will now have an augmented permeability of several orders of magnitude."	Assuming a volume that is 1,000 metres long (the length of the horizontally drilled portion of the well as shown in the video) by 200 metres wide (the total span of the fractures from the well bore) and a height of 100 metres (typical height of fractures at this depth), the maximum rock volume that could be stimulated is 20 million cubic metres, less than half of the lowest end estimate that Mr. Durand projects. And even this assumes that all stages of the zone being hydraulically fractured are perfectly spaced, and that not a single cubic centimetre of rock within this rectangular "box" is left unstimulated. This is impossible. A more realistic expectation is that 20-25 percent of the 20 million-cubic-metre "box" would receive stimulation. Secondly, it makes no difference if the rock volume at this depth has an augmented permeability. Once commercial gas production has ended, the "enhanced reservoir," which is still isolated by hundreds of metres of impermeable rock from fresh water aquifers, will simply sit there (albeit at a slightly lower, and safer pressure), just as it has for millennia.
7:06 – "When the profitable production is over after a few years, there's still 80 percent of the methane in the shale…"	This once again assumes that only 20 percent of the gas can be recovered. There is still uncertainty about whether the Utica Shale will be economical, which hinges partially on what the recovery rate will be. Given that each formation has its own unique recovery rate, it is pure speculation to assume that after production, 80 percent of the gas in the Utica will remain in place.
8:11 – "But there are concentric shrinkage fissures, badly sealed spaces between the rock and the tube due to the grout being badly adapted to the local condition, insufficient cleaning of the drilling sludge, uncontrolled water seepage, fractures present in the rock in close proximity to the wall, and other causes explain the frequent problems of leaks in the exterior seal."	Mr. Durand is combining a series of rare issues with a poor understanding of the technology used of in situ pressures. It is important to remember why the casing is put in the hole. Due to the high pressures created by the weight of the rock the hole would collapse on itself. In a reasonably short time the hole would normally seal itself. We have well over 100 years of experience plugging wells. The oldest were plugged using technology and environmental regulations over 100 years old. There are not widespread problems with these 100 year old wells plugged with 100 year old technology though exceptions have been found. Modern cement is not concrete. It is a high tech product with an excellent track record. It is true that cementing jobs sometimes require more than one treatment. In a minority of cases follow up work is required to get a perfect seal. As an example in Quebec approximately 3 of 31 wells have required follow up work. Only one of these wells had a problem with natural gas migration outside the casing which is the problem Mr. Durand refers to. This rate will improve with additional experience in the Utica.

Durand Presentation

Reality

8:43 – "Even perfectly sealed, this conduit [the well after production] has a permeability many thousands of times greater than the rock within which it was drilled."

The reservoir is depleted at the time of abandonment, and so there is very little pressure 'pushing' on the steel casing and cement bridge plug used to seal off the well. It is more than capable of sealing the remaining methane in the reservoir. The video implies that the pressure will somehow recharge itself over time, but once the reservoir has been depleted there is no source from which this additional pressure could be generated. Moreover, due to the trillions of tons of rock above the formation, the weight of the earth will be working constantly to close off and seal the well.

9:35 – "With this new method of hydraulic fracturing, one should not act as it was done for other types of wells, which are not at all comparable."

Hydraulic fracturing is not a "new method." It is a technology that has been used more than 1.2 million times throughout North America. Its first commercial application was in the late 1940s.