The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Tech Talk - Future Bakken Production and Hydrofracking

Posted by Heading Out on February 15, 2013 - 5:48am

Before there were refrigerators folks kept drinks cool by putting them into clay jars that had been soaked in water. The evaporation of the water from the clay cooled the container and its contents, which today includes wine bottles. On the other hand, for many years artisans have taken clay in a slightly different form, shaped it and baked it and provided the teacups which keep the liquid inside until we drink it.

Two different forms of the same basic geological material, with two different behaviors and uses. Why bring this up? Well, there is a growing series of articles which continue to laud the volumes of oil and natural gas that the world can expect from the artificial fracturing of the layers of shale in which these hydrocarbons have been trapped for the past few million years. It has been suggested that there is no difference between this “unconventional” oil and the “conventional” oil that has been produced over the past century to power the global economy. And yet, despite the scientific detail which some of these critics discuss other issues, they seem unable to grasp the relatively simple geologic and temporal facts that make the reserves in such locations as the Marcellus Shale of Pennsylvania and the Bakken of North Dakota both unconventional and temporally transient. Let me therefore try again to explain why, despite the fact that the oil itself may be relatively similar, the recovery and economics of that oil are quite different from those economics involved in extracting conventional deposits.

But before getting to that, let’s first look at the current situation in North Dakota, using the information from the Department of Mineral Resources (DMR). According to the January Director’s Cut the rig count in the state has varied from 188 in October, through 186 in November, and 184 in December, to 181 at the time of the report. Why is this number important? Well, as I will explain in more detail later, the decline rate of an individual well in the region is very high, and thus the industry has to continue to drill wells at a rapid rate, just to replace the decline. (This is the “Red Queen” scenario that Rune Likvern has explained so well.) The DMR recognize this by showing the effect of several different scenarios as the number of rigs changes.

For example, they project that 170 rigs will be able to drill around 2,000 wells a year. At that level, and with some assumptions about the productivity of individual wells that I am not going to address here, but which Rune discussed, I would suggest that it is irrational to expect that new wells will continue to sustain existing first year levels as the wells move away from formation sweet spots. Yet, accepting their assumptions for now, DMR project that the 170 rigs will generate the following production from the state:

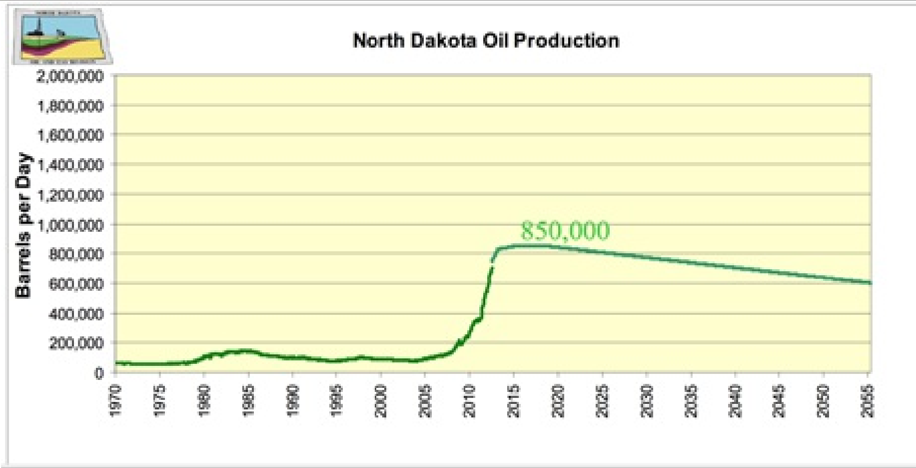

Figure 1. Achieved and projected North Dakota production when 170 rigs are used to continue to develop the field into the foreseeable future. ([ND DMR](#)).

The DMR plot also assumes that the wells are developed and brought into production in a timely manner. In October the state produced an average of 749 kbd of oil, which was through mid-January, [the current peak level of production](#). Currently it is estimated to cost $2 million to frack a well, and in January there were 410 wells waiting on that service.

In order to reach a higher level of production (and bear in mind that OPEC has been projecting significant further increases in production to make their anticipated supply and demand levels balance) the DMR looked at estimates of production if there were 225-250 rigs, and contrasted that with what would happen if the rig count fell almost immediately to 60.

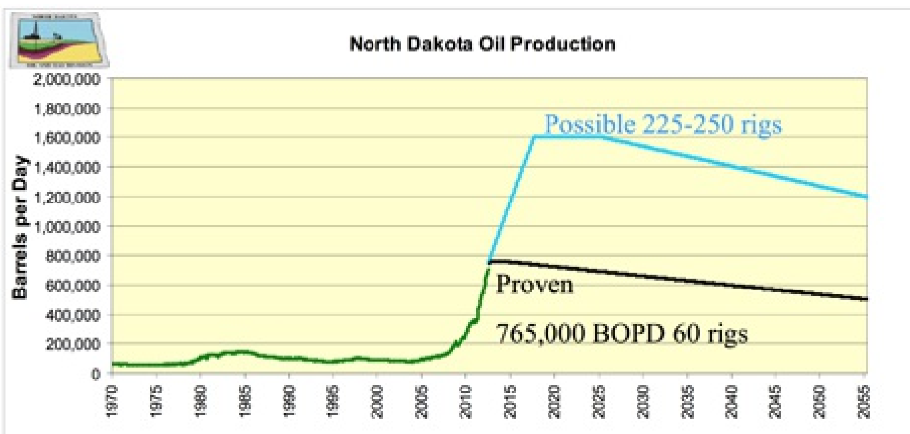

Figure 2. North Dakota oil production with either 225-250 rigs, or with 60. ([ND DMR](#))

Note that at 60 rigs, the state production goes into an immediate decline. Somewhere in between those two extremes lies the likely future, but with the Director noting a December price of $77.09 that future may be at the lower, rather than higher end of the scale. (Though in January it popped back up to $87.25).

To illustrate the sensitivity of these numbers consider that if the rig count fell from 170 to 100, then production would decline to 800 kbd but would still fall into decline in 2020, while at 200 rigs the production would rise to a peak of 1 mbd, although the peak interval might only be four years from the 2,400 new wells added each year.

The ferocity of the decline rates of these wells is part of the reason that they are called unconventional, since they do not behave in the same manner as a conventional well, nor can they be developed in a similar way.

To return to the geology of the deposits (and shale is a consolidated clay) the middle Bakken formation is made up of a combination of layers of shale, sandstone, siltstone and limestone. These are, in general, rocks that have a very low permeability, and that property was explained in more detail in an earlier post. Simplistically it is a measure of how easy it is for fluid to flow through the rock, and for most of the Bakken rock it is not easy at all. If it were then there would be no need to put in the crack paths that the oil uses to reach the well. Let me repeat a figure from that post:

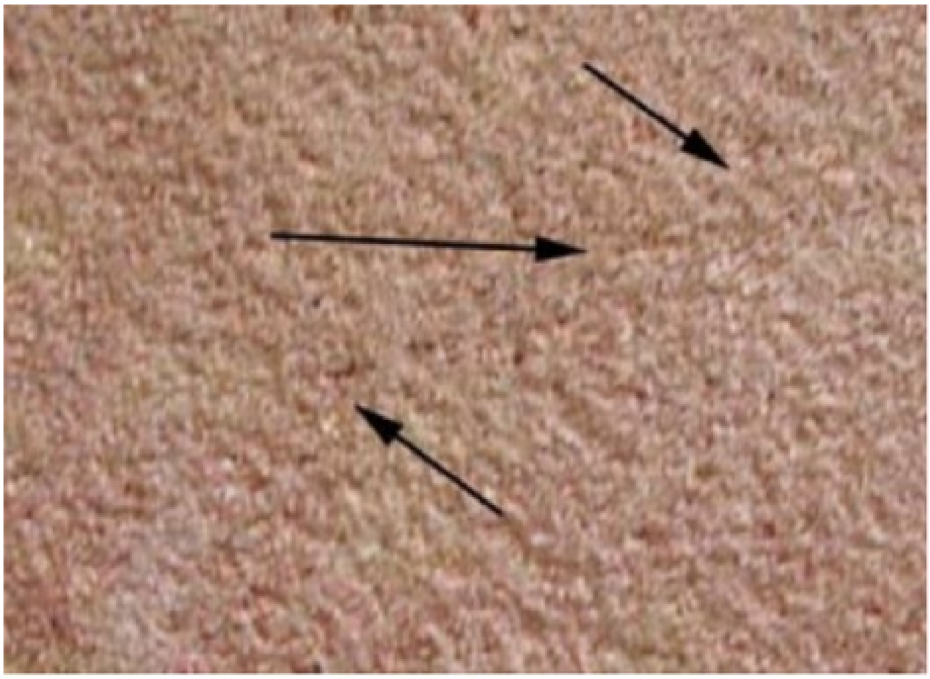

Figure 3. Block of sandstone with a crack in it (shown by the arrows).

I have been on a site where my hosts (a federal agency) had injected fluid that they were hoping would penetrate a layer of ground so that it would form an impermeable barrier. It had not, even though the ground was relatively easy for the fluid to penetrate. Instead it had all flowed into a crack no bigger than the one shown in the picture above, and the attempt was a failure.

Put that into reverse where you are trying to pull fluid out of the ground. There are two places where the fluid (oil or gas) is located, in the natural cracks and joints of the rock – which the hydrofrack is designed to cut across. And in the much lower permeability of the blocks of rock that are edged by these fractures, bedding planes and joints.

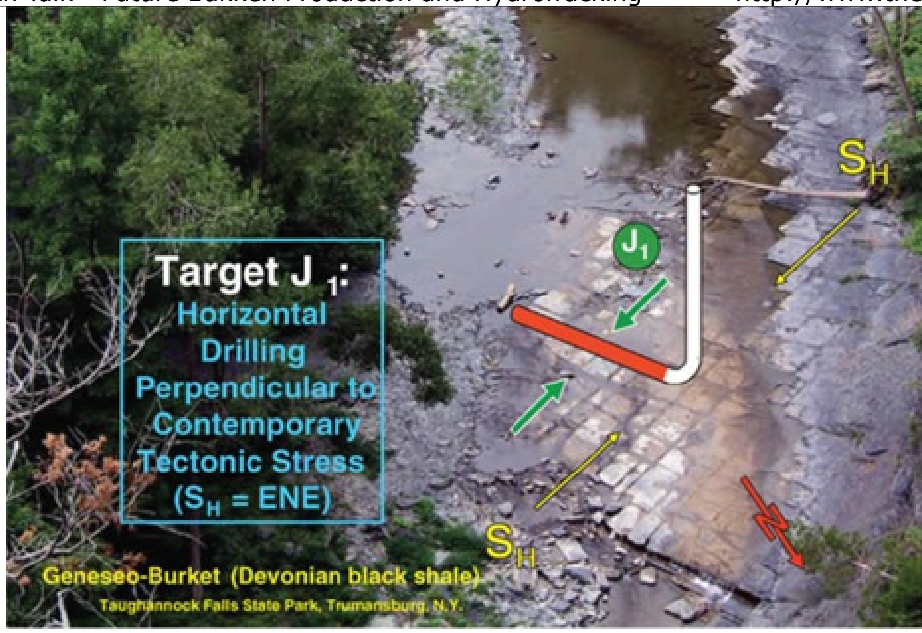

Figure 4. Representation of a horizontal well drilled in the Marcellus, shown against the natural fracture pattern (Source AAPG)

Over the millennia the oil/gas has migrated to those bedding planes and natural joints and fractures in the rock. When the well is first put in place, that fluid is more easily available to flow through the intersecting crack pattern to the well. But as those interstices empty out it is much more difficult to move the oil from the rock surrounding the natural cracks into that crack and thence to the well.

Most illustrations of hydraulic fracturing show a network of artificially induced cracks getting more numerous as they move away from the well. That actually is not the way it normally happens. The majority of the cracks that open are already there, and these are much easier to develop – as my unfortunate hosts learned – that it is to try and generate a multiplicity of new fractures, as I have previously explained here and here. The production, to go back to my initial metaphor, begins to move over that first year of production and then dramatically fall in yield, from relying on the permeability of the wine cooler part of the rock, to that of the teacup.