

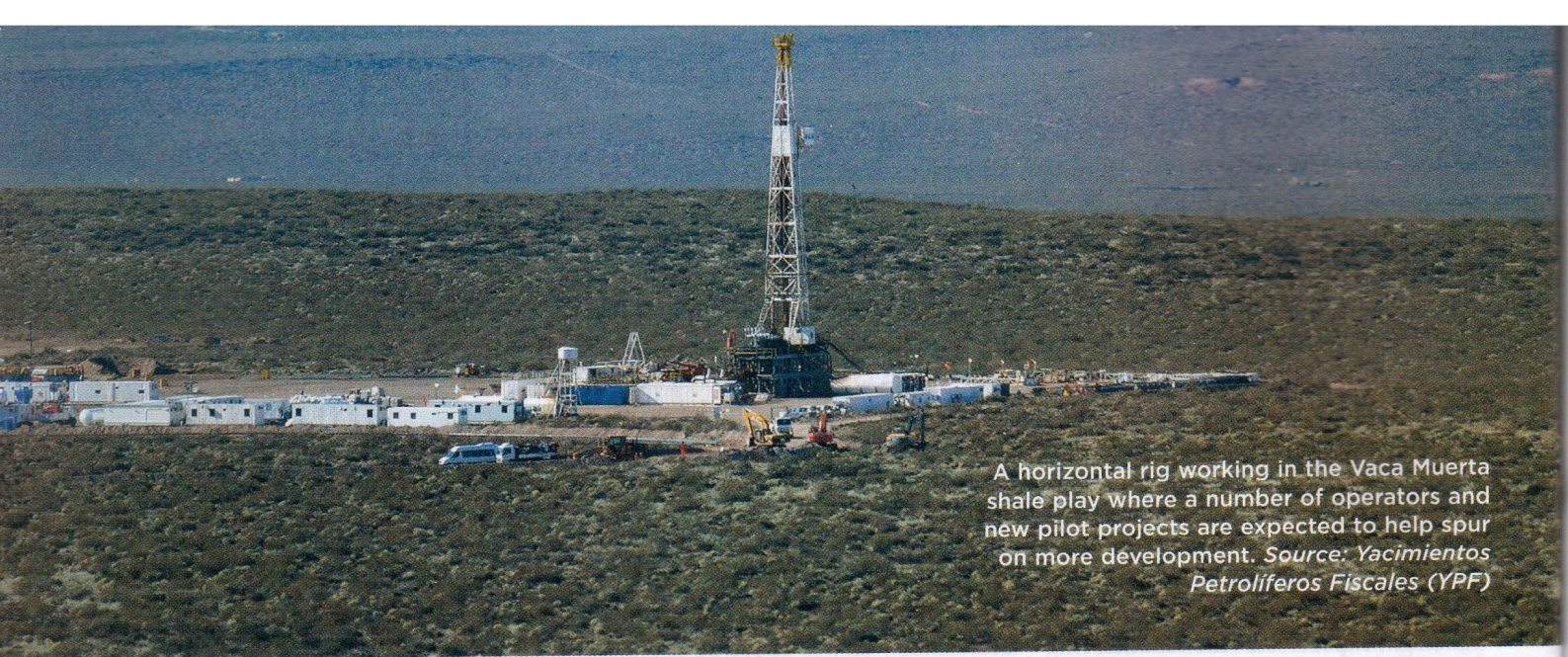
JPT

PROGRESS IN VACA MUERTA

DEEPWATER PROJECTS
INTELLIGENT FIELDS TECHNOLOGY
MULTILATERAL/EXTENDED-REACH WELLS
CEMENTING/ZONAL ISOLATION

FEATURES

Russia's Push for Growth
SPE President and Board Nominations
New Way to Look at Fracturing
India's Licensing Round



A horizontal rig working in the Vaca Muerta shale play where a number of operators and new pilot projects are expected to help spur on more development. *Source: Yacimientos Petrolíferos Fiscales (YPF)*

Optimism and Activity Rising in the Vaca Muerta

Trent Jacobs, *JPT* Digital Editor

Confidence in the geologic potential of Argentina's unconventional resource plays is higher than ever, which is turning the focus to how and when oil and gas producers there will ramp up commercial levels of production. At stake is whether the well-known Vaca Muerta formation will become a shale superpower—and the first outside of North America.

Its immense reserves, estimated to be 308 Tcf of gas and 16 billion bbl of oil, according to the US Energy Information Administration, and the work done so far to prove them has attracted commitments of billions of dollars from international majors BP, ExxonMobil, Shell, and Chevron.

But leading the pack is the domestic explorer and producer Yacimientos Petrolíferos Fiscales (YPF). The company's progress may offer a reasonable expectation of what the future holds.

Operating more than 540 shale wells in the Vaca Muerta and running 44 rigs at

the end of last year, YPF has been by far the most active shale operator in Argentina. Eighty of those wells are horizontals in the Loma Campana field, operated as a joint venture with Chevron.

The first were drilled and completed there in 2013, and the most recent have shown an average productivity increase of 25%, a figure based on 300 days of production data. In all, YPF drilled 56 horizontals last year, showing that it has picked up the pace compared with 2015 when 30 were drilled and the 2 years prior when a combined five were drilled.

The gas portion of the 62,300 BOED YPF is reporting in gross shale production (which includes areas outside Loma Campana) represents 22% of its total natural gas production. That will be an important piece of the pie chart to track going forward because the majority of YPF unconventional programs, and those of its competitors, have become increasingly focused on boosting Argentina's gas supplies.

This is a shift from the initial programs that targeted the oil window and is being driven by a newly elected government that is aiming to reverse the country's position as a net importer of gas.

Falling Well Costs

Speaking at the IHS Markit CERAWEEK conference in Houston earlier this year, Miguel Gutiérrez, the president of YPF, expressed a bullish tone for the future as he said horizontal well costs in the Loma Campana field have fallen from around USD 17 million in 2013 to USD 8 million at the end of last year.

He added that new horizontal wells are generating returns at USD 40/bbl and that drilling times have been slashed from 40 days to just 15—figures that are comparable to ones shared by some top US shale producers. These trend lines have Gutiérrez "totally convinced" that the Vaca Muerta can one day rival the output of the Permian Basin but "the first thing we had to do was reduce the costs."

However promising they may be, the Loma Campana results are not a representative sample. The programs that operators, including YPF, are running elsewhere in Argentina are in even earlier-stage exploration modes and have drilled dozens of horizontal wells, not hundreds.

Most firms have achieved two or three new horizontals a year so far, however, the hope is that these companies will be picking up the pace as YPF has in the Loma Campana. If so, there is reason to believe that a breakout of development-mode activity across the Vaca Muerta could come sometime early next decade.

Chevron's Subsurface Learning

In addition to being the most active unconventional field, YPF's Loma Campana program is benefiting from the collaboration of nonoperating partner Chevron, which is able to leverage its North American experience in the analysis of field data from Argentina.

Pablo Crespo has been involved with the project since the first well was drilled, initially for YPF and now as a senior reservoir engineer of unconventional resources with Chevron.

He described that in addition to the Loma Campana, Chevron is involved in an exploratory project in another Vaca Muerta block known as the Narambuena. There, engineers are deploying advanced diagnostic technologies to



YPF President Miguel Gutiérrez (left) and Shell Argentina President Teófilo Lacroze signing a new joint venture that will see the latter firm investing USD 300 million on a new unconventional pilot program in the Vaca Muerta. This deal is just one of 10 pilots that YPF is planning to launch in 2017. Source: YPF.

climb the learning curve and lower average well costs.

Studies completed so far have relied on microseismic surveys, oil and water tracers, permanent downhole gauges, and multiple types of logs. The data from this work have been built into static models which Chevron is now trying to link to dynamic models that can deliver even more insight into reservoir behavior. Once that step is completed, the aim is to begin using hydraulic fracturing models to improve completion designs.

Other models are helping determine best practices for producing horizon-

tal wells. Crespo said this work involves optimizing production through choke management techniques to protect the conductivity of hydraulic fracture networks while also avoiding production delays.

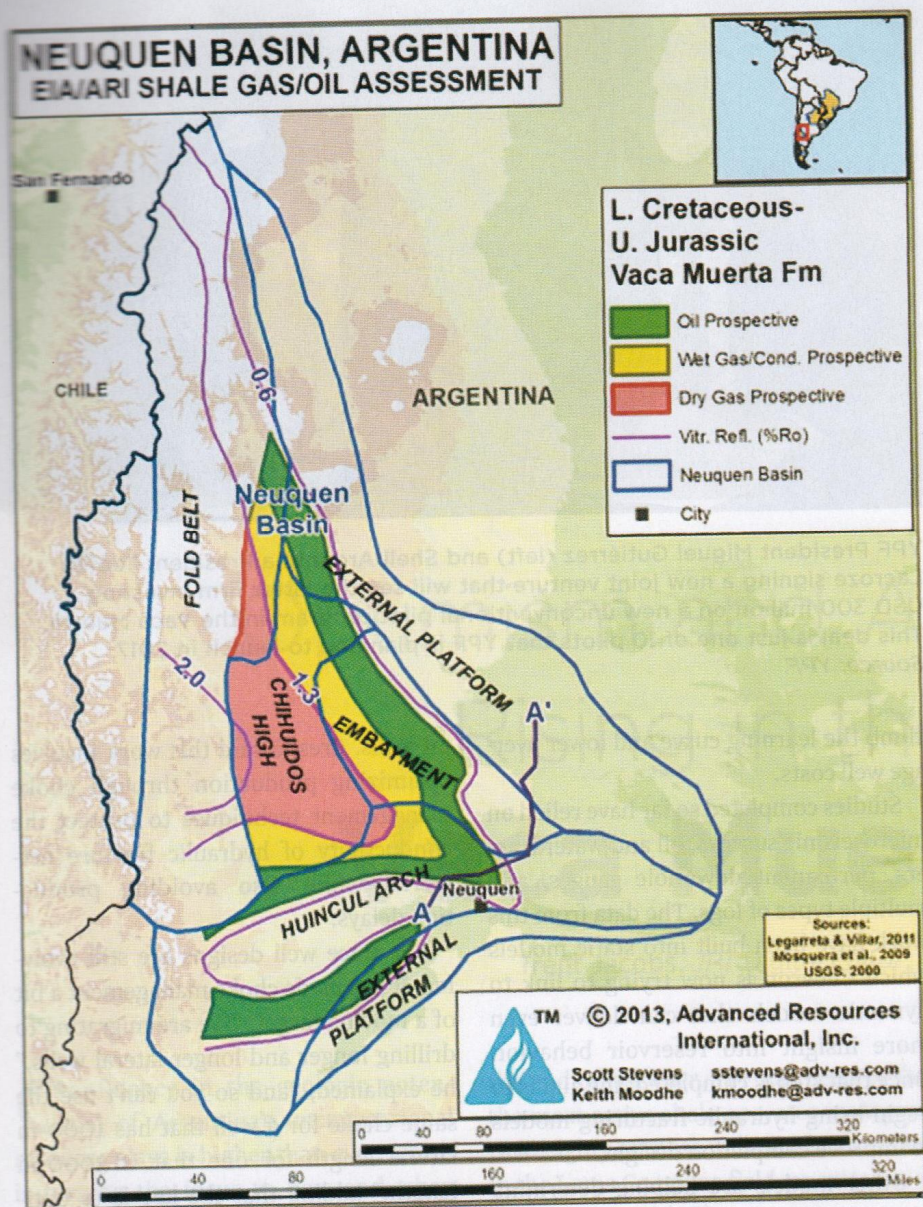
But since well designs are still evolving, it has made choke management a bit of a moving target. "We are migrating to drilling longer and longer lateral wells," he explained, "and so you can't use the same choke for a well that has 1000-m lateral length for one that is 3000-m length," adding that the key is to optimize the drawdown.



The palace of the Argentine National Congress. Source: Getty.

To encourage extraction efforts, the federal government has enacted some of the largest industry-focused measures in years, including setting a subsidized price floor of USD 7.50 per MMBtu of domestically produced gas that will expire at the end of 2020.

Agreements are also in place to reform tax laws, relax labor union rules, and build a USD 1.2 billion railway for logistical support that will connect supply hubs in the capital Buenos Aires to the heart of the Vaca Muerta. For their part of the bargain, operators of government-awarded shale blocks have said they will invest around USD 5 billion this year—a sum that is expected to grow in subsequent years.



The Vaca Muerta shale formation is found in the remote Neuquén basin of Argentina. Unconventional activity began in the play's oil window in 2010 but the focus has since moved to the gas fields to help meet domestic demand. Source: US Energy Information Administration and Advanced Resources International.

The engineers and earth scientists working on this project are also trying to determine where the best landing zones are. Though there are several hydrocarbon-rich benches of the Vaca Muerta, not all have been proven. The use of microseismic and chemical tracer technologies should help narrow the target list down, said Sergio Cuervo, a geoscientist on Chevron's Vaca Muerta asset team.

The challenges in this come back to the relatively low number of wells that have been drilled thus far. "We are going to need a lot more wells to confirm our theories," said Cuervo. "If I identify a bench

that's a very good producer in this area, how can I extrapolate the knowledge to 5 or 10 km away from that well. That's part of the learning program."

Pan American Following Suit

Pan American Energy, BP's Argentine subsidiary, is among those companies working through many of the same challenges outlined by YPF and Chevron's experience.

After drilling about 90 vertical wells in a tight sand gas area of the Vaca Muerta, the company now has at least 10 horizontal wells completed there. Part of

the ongoing pilot effort is to use microseismic data to interpret the fracture heights and lengths—critical metrics for shale optimization.

Cristian Espina, the technical manager for unconventional at Pan American, said the company is confident that it has characterized its position in the Vaca Muerta from a static geologic point of view, and like its larger competitor, is now learning how to characterize its dynamic behavior to identify its production drivers.

"That is going to be the key to opening this play up, because if we understand the dynamics between the fracs, the wells, and the different landing zones, then we will be able determine if this play is economic," he said. Other technologies are being used here as well including tracers, rate-transient-analysis, and soon fiber-optics will be deployed to deliver real-time production data from inside the wells.

Stepping out lateral lengths is also a focus of Pan American which has in recent years moved from 800-m to 1000-m and recently, 1500-m wells. In the new lateral wells the number of frac stages has also been stepped up from 15 to between 21 and 25. This is driving the intensity of the fracturing jobs by requiring more sand and water. The next step is to move to 2000-m laterals.

But for all the progress being made in Argentina, most people involved in the projects there wish things could move faster. A factor seen as holding back the ramping up of activity is that the country has only six operators working on unconventional projects. "I don't think that's the best scenario to develop these kinds of plays," said Espina, who explained that with more companies would come more wells, which in turn would accelerate the learning curve on drilling, production techniques, and logistics.

If there were also more service companies and technology vendors, Espina said it would give operators even greater leverage to lower costs. "For example, the companies who provide sliding sleeves for fracturing, we only have a couple of them—while in the United States, you have many, many people working on that," he said.

EOR Project in the Vaca Muerta Shale Gives Water for Oil

Trent Jacobs, *JPT* Digital Editor

New research from Argentina is trying to see if the Vaca Muerta shale formation is a viable candidate for enhanced oil recovery (EOR). The laboratory and field experiments completed so far are promising, which in itself is a notable development since there have been very few breakthroughs on this front for the shale sector.

The companies leading this work, Buenos Aires-based VYP Consultores and InLab, are using a simple huff-and-puff approach to shale EOR that involves injecting produced water back into a well for a soaking period of 30 days. During this time, with the well shut in, the formation does most of the work through imbibition; i.e., the water goes into the formation, and exchanges places with hydrocarbons.

"If we can take advantage of these imbibition forces, then we can really change the way shales are looked at," said Fernando Tuero, the president of VYP, a firm that prior to this research has been known more for its work on secondary recovery projects in Argentina's mature oil fields. The company has been working jointly with InLab, a well-established petrophysics laboratory in Argentina, to validate its EOR approach.

Tuero said based on the lab experiments and modeling, it is thought that up to 15 huff-and-puff cycles could increase the hydrocarbon recovery by as much as 40% before diminishing returns kick in. Replicating anything near that figure in the real world would be quite extraordinary since most people peg primary shale recovery between 3 and 7%.

The potential to increase shale productivity by such margins would mean that oil and gas producers could not just benefit from higher long-term output, but they could also be more competitive with how they value prospective drilling locations.

The chance to prove these benefits attracted shale explorer Pan American Energy to the project last year through a joint venture with VYP. The operator, a subsidiary of BP, granted VYP access to a 4-year-old well in the Vaca Muerta where the most recent testing took place.

Tuero is withholding the details of that test, but indicated that the initial signs were positive. "What we can conclude is that imbibition was taking place, and was taking place very quickly," he said.

The full results will be presented in July at the SPE/AAPG/SEG Unconventional Resources Technology Conference being held in Austin, Texas. Perhaps the most important thing to be revealed is whether the improved recovery was worth the 30-day wait; in other words, will it be seen as a commercially viable EOR method?

Tuero said the research team has gone through a series of validation exercises in the lab and the field that were completed prior to this latest experiment, all of

which showed that multiple sections of Vaca Muerta reservoir rock are prone to imbibition. In fact, Tuero believes the lab tests may represent the first time crude oil was effectively extracted from shale purely through an imbibition process.

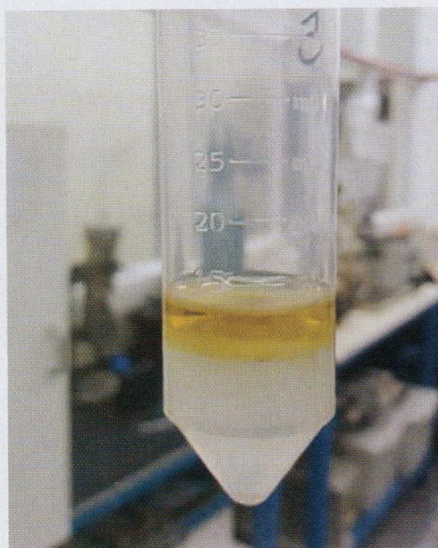
There are a couple of important factors at play here, one of them being that there may be many areas of the Vaca Muerta that are water-wet as opposed to oil-wet. This means when more water is introduced, the formation will naturally allow it to be absorbed into the matrix. "And what comes out when the water goes in has to be oil or gas," Tuero explained. "That process is done at a ratio of 1:1—so it's very effective."

The other critical enabler for EOR in this case is the strength of the capillary forces that are understood to be a strong influencer of how shale formations produce oil and gas.

This capillary dominance is the result of the extremely tight permeability of shale rocks, and importantly, Tuero said, in certain circumstances it is a more powerful force than the typical drivers of conventional reservoirs—the viscosity of the hydrocarbons and gravity.

And though this effect is something that has been studied for years by petrophysics academics, capillarity is rarely cited as a production driver by operators. Tuero said the topic is worthy of greater investigation since so many operators in Argentina and North America routinely observe only small fractions of the water used in hydraulic fracturing treatments returning to the surface.

"That was the first anecdotal evidence that nobody could explain," he said, noting that some people have argued that the stimulation water is just going into fractures very far from the well. However, in the early days, "Very few people mentioned capillarity as a reason for the water disappearing." **JPT**



The light crude shown in this sample is thought by researchers in Argentina to be the first oil extracted from a tight shale rock via imbibition. Source: VYP Consultores/InLab.