Challenges in Vaca Muerta: Tecpetrol Experience in the Exploration and Appraisal of the Play*

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Abstract

The presentation will cover Tecpetrol’s exploration and appraisal strategy for Vaca Muerta. The first step was to define an acreage position strategy for Tecpetrol to become a major player in Vaca Muerta. Two key elements were taken into account. The first was having a portfolio of assets diversified in all fluid windows (but with the focus in the gas window). The second was acquiring good quality acreage. Following this strategy, Tecpetrol acquired blocks in 2014 and 2015 and now has a position of around 200,000 net acres in Vaca Muerta distributed in five blocks. An exploration and appraisal strategy was defined for the evaluation of Vaca Muerta, which includes vertical wells to characterize the entire Vaca Muerta interval and to select the potential landing zones and horizontal wells to evaluate the productivity and potential of these rocks. In the areas where the results of the evaluation are successful, an appraisal plan will be carried out to complete the evaluation of the zone and to define the optimum parameters for the development of the area (well spacing, completion strategies, frac designs, etc). Tecpetrol started a drilling campaign in June 2016 with two vertical and seven horizontal wells for the exploration and evaluation of its blocks in this play.
Moving toward the Prediction of Unconventional Plays: Lessons Learned from Tight and Shale Reservoirs in the Neuquén Basin
Challenges in Vaca Muerta: Tecpetrol Experience in the Exploration and Appraisal of the Play

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Tecpetrol
Stages of Involvement in Vaca Muerta Project

1. Initial Assessment
   - Understanding of the regional context
   - Understanding overall aspects of the basin
   - Analysis of performance potential

2. Positioning
   - Purchase of participation of GyP in Fortin de Piedra
   - Acquisition of Loma Ancha Block
   - Acquisition of Apasa (Americas Petrogas)

3. Appraisal & Pilots
   - Drilling of evaluation wells
   - Drilling of appraisal pilots
   - Acquisition of 3D seismic
   - Temporary facilities

4. Full Development
   - Construction of facilities
   - Initiation of full development plan
   - Startup

Current stage
Stage 1- Initial Assessment

A) Understanding of the regional context
   Drilling & Completion best practices
   Service availability
   Infrastructure
   Regulatory framework
   Understanding of the Argentinean market and energy balance

B) Understanding of the overall aspects of the basin (G&G)
   Richness maps
   Maturity Windows
   Vaca Muerta Model
   Definition of areas of interest

C) Analysis of performance potential
   Productivity per window
   Type wells
   Potential landing zones
a) Understanding of the regional context
Argentina Gas Demand & Production Forecast

Shale gas resources are key to supply the projected demand
a) Understanding of the regional context
Vaca Muerta Forecasts vs US plays
b) Understanding of the overall aspects of the basin
Neuquen Basin – Regional Screening

Average Porosity Map

Thickness Map (TOC > 2%)

Richness Map Vaca Muerta

Areas with
- Thick VM
- High TOC
- High PHIE
- Low Sw
- Over P

NetPay [m] (TOC > 2%)

Average PHIE

0.04 - 0.05
0.06 - 0.07
0.08 - 0.09
0.10 - 0.11

PHIE * (1-Sw) * H
b) Understanding of the overall aspects of the basin
Vaca Muerta Fluid Windows

Objective
- Diversification
- Gas as a priority
c) Analysis of performance potential

Productivity – Type Wells

Oil and Gas Type Wells (1500m lateral - 15 fracs)

- Type wells estimated using public VM production data.
- Production calibrated for lateral length and number of stages.
- Validated with volumetric analysis. Unknown parameters (drainage area, recovery factor) assumed from US analogs.

![Graph showing productivity over time](image)

- $Q_{gi}$: 9 MMcfd
- EUR: 5 bcf
Stage 2 - Positioning

- Purchase of participation of GyP in Fortin de Piedra
- Acquisition of Loma Ancha Block
- Acquisition of Apasa (Americas Petrogas)

**Tecpetrol acreage through time**

**Acreage according to type of HC**

- Dry Gas
- Wet Gas
- Oil
## Positioning Tecpetrol’s Blocks in Vaca Muerta

<table>
<thead>
<tr>
<th>Block</th>
<th>WI %</th>
<th>Total Area (km²)</th>
<th>Type of HC</th>
<th>%</th>
<th>Gross (km²)</th>
<th>Net (km²)</th>
<th>Gross (10^3 acres)</th>
<th>Net (10^3 acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fortín de Piedra</td>
<td>100</td>
<td>250</td>
<td>Dry Gas</td>
<td>46</td>
<td>114</td>
<td>114</td>
<td>28</td>
<td>28</td>
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<tr>
<td></td>
<td>100</td>
<td></td>
<td>Wet Gas</td>
<td>54</td>
<td>136</td>
<td>136</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Los Toldos I</td>
<td>45</td>
<td>398</td>
<td>Dry Gas</td>
<td>19</td>
<td>74</td>
<td>33</td>
<td>18</td>
<td>8</td>
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<tr>
<td></td>
<td>45</td>
<td></td>
<td>Wet Gas</td>
<td>81</td>
<td>324</td>
<td>146</td>
<td>80</td>
<td>36</td>
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<tr>
<td>Los Toldos II</td>
<td>45</td>
<td>156</td>
<td>Oil</td>
<td>100</td>
<td>156</td>
<td>70</td>
<td>38</td>
<td>17</td>
</tr>
<tr>
<td>Loma Ancha</td>
<td>95</td>
<td>143</td>
<td>Dry Gas</td>
<td>100</td>
<td>143</td>
<td>136</td>
<td>35</td>
<td>33</td>
</tr>
<tr>
<td>Loma Ranqueles</td>
<td>90</td>
<td>135</td>
<td>Dry Gas</td>
<td>100</td>
<td>135</td>
<td>121</td>
<td>33</td>
<td>30</td>
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<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>1080</strong></td>
<td><strong>756</strong></td>
<td><strong>267</strong></td>
<td><strong>187</strong></td>
</tr>
</tbody>
</table>

Diversified portfolio of high quality blocks for Vaca Muerta
Positioning
Tecpetrol’s Blocks in Vaca Muerta

- Diversified Portfolio: Presence in the Dry Gas, Gas-Condensate and Black Oil HC Windows.

- Blocks situated in good quality VM areas: Thick Interval, High TOC, High PHIE, Low Sw, Over-P
Stage 3 - Appraisal / Pilot Projects

• Vertical evaluation wells (frac’d and tested) to characterize the entire Vaca Muerta interval and select potential landing zones.

• Horizontal evaluation wells to evaluate productivity of Vaca Muerta.

• Vertical pilots to adjust the structural model (geosteering) and to refine the characterization of Vaca Muerta throughout the blocks.

• Appraisal pilots to optimize development strategy (lateral length, well spacing, completions, landing zones).

• Acquisition of 3D seismic.

• Early Production Facilities
Appraisal / Pilot Projects
2016 - 2017 Activity

- Vertical well
- Horizontal well
- Prior VM vertical well
- 3D seismic

Tecpetrol
GTW Argentina 2016
FP.x-1003 Competition Program

- Intervals selection with log data, cutting analysis and mudlog.
Appraisal / Pilot Projects
Workflow Fortin de Piedra – FPx-1003

Gas (Mcfd), Water (bpd), Pb (psi), Choke (mm)

2mm x 3mm. Increase in flow and pressure.

3mm x 4mm. Increase in flow: 1.6 MMcfd to 3 MMcfd Gas (no change in wellhead pressure, constant at 5400 psi).
Appraisal / Pilot Projects
Workflow Fortin de Piedra – Landing Zone Selection

- Lower VM is the main target to be evaluated in the appraisal campaign.
- Additional potential landing zones in Upper VM.
Appraisal / Pilot Projects
Workflow Fortin de Piedra – Evaluation Wells

• Vertical evaluation wells (frac’d and tested) to characterize the entire Vaca Muerta interval and select potential landing zones.

• Horizontal evaluation wells to evaluate productivity of Vaca Muerta.
Appraisal / Pilot Projects
Workflow Fortin de Piedra – Pilots

- Vertical pilots for structural model and characterization of Vaca Muerta.
- Appraisal pilots to optimize development strategy (lateral length, well spacing, completions, landing zones).

16 km² Module
One vertical pilot well in each module
One vertical tested well every four modules
Stage 4 - Development

Below Ground Factors

• Size of Potential Reserves
• Productivity
• Well optimization

Above Ground Factors

• Fiscal Regime – Prices
• Land Access / operability
• Workforce
• Service Sector
• Distribution network
• Market
Development Phase
Drilling Activity Fortin de Piedra

Multiwell Pad Development
- 80 acre spacing
- 500 wells
- 8 wells pads
Development Phase
Facilities Fortin de Piedra

10 Modular Batteries
- Gathering & Separation
- Dehydration
- Compression

Batteries
PADS (8 wells)
Tecpetrol’s Experience in Vaca Muerta
Conclusions

Assessment
• Regional studies to understand overall aspects of the basin.

Positioning
• 187,000 net acres with 250 to 350 m of Net pay (TOC>2%) => Diversified Portfolio (Gas, condensate, oil) in good quality blocks.

Appraisal
• Moving fast in the appraisal stage with the drilling of vertical and horizontal wells to evaluate the productivity and the potential of the blocks.

Development
• Multiwell pad development will be started after successful results of the appraisal stage.