Loma Negra Complex
Slanted Well Project

Slanted well technique performance in multilayer reservoirs

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April 2006

Curriculum:

Oscar Lista: Geologist (UNC), Post graduated Petroleum Engineer (1978), Post graduated Reservoir Engineer (2004), 25 years in the oil Industry. 10 years in Exploration Department SAN JORGE SA. 5 years Production Geologist and Team Leader Subsurface Team in CHEVRON.

Matias Romero: Petroleum Engineer (ITBA). 1 year Planing in TOTAL, 3 years Production and Reservoir Engineer in CHEVRON.

Abstract:

This presentation refers to the convenience of drilling a slanted well in a multilayer reservoir where the lateral continuity was difficult to determine.

The Loma Negra Oil Field was discovered by Petrolera Argentina San Jorge in 1996. The field is located in the western part of Argentina and the oil production is coming from 3 different reservoirs, Punta Rosada Fm, Lajas Fm and Pre-Cuyo Fm at depths of 8200 ft, 9200 ft and 10200 ft respectively.

With the objective of developing the Pre-Cuyo reserves (represent 48% of the total P1 undeveloped reserves) an extensive study have been performed to analyze different alternatives to be applied in multilayer reservoirs as the case of Pre-Cuyo fm.

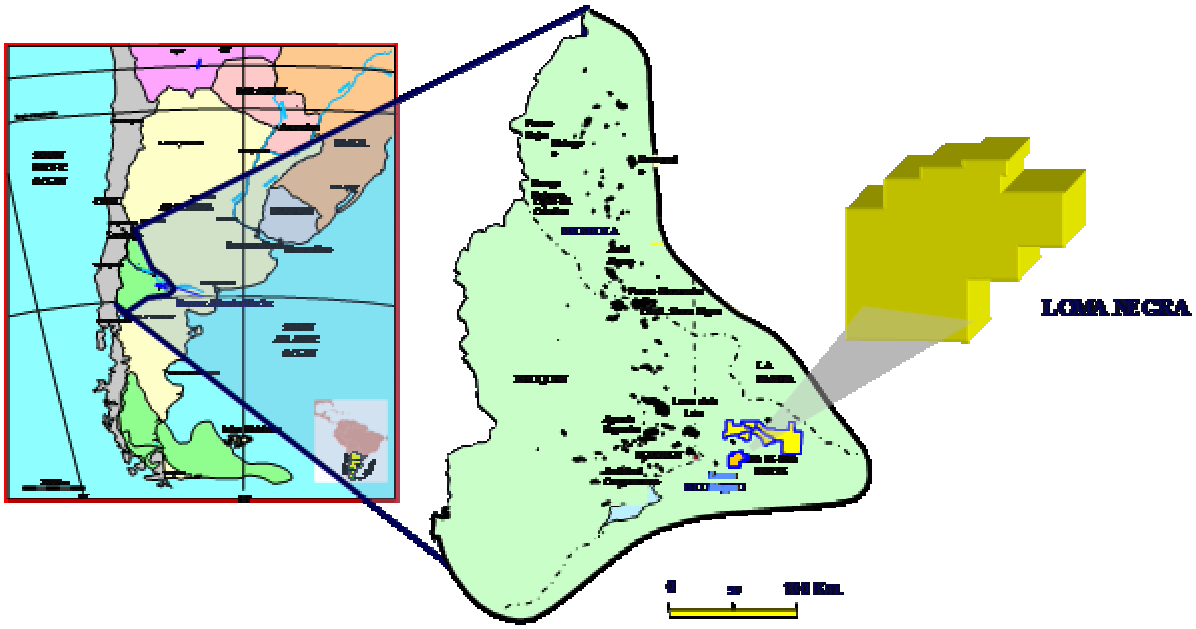
The Pre-Cuyano sediments are alluvial fan deposits. The reservoir is formed by conglomerates and sandstones with individual beds about 7 to 15 feet thick showing a total net pay of 65 feet. The lateral continuity of these bodies is extremely difficult to define. This lack of continuity and the oil characteristics (undersatured 28 °API with a GOR of 80 SCF/STB) most likely causes well production rates to decline rapidly in the first year of production.

The development of this formation was based on vertical wells which only accumulate 57,000 bbl on average. Due to the high drilling costs and the low production obtained, they were not economic.

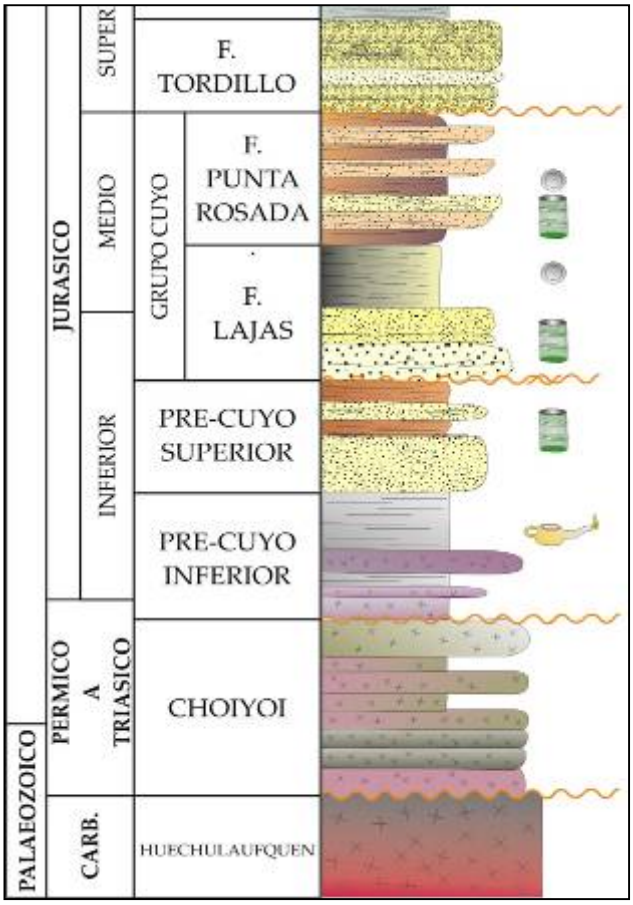
The recommendation of the study team was to drill a pilot high deviated well (slanted) in order to add as many layers as possible increasing the net pay per well.

Introduction

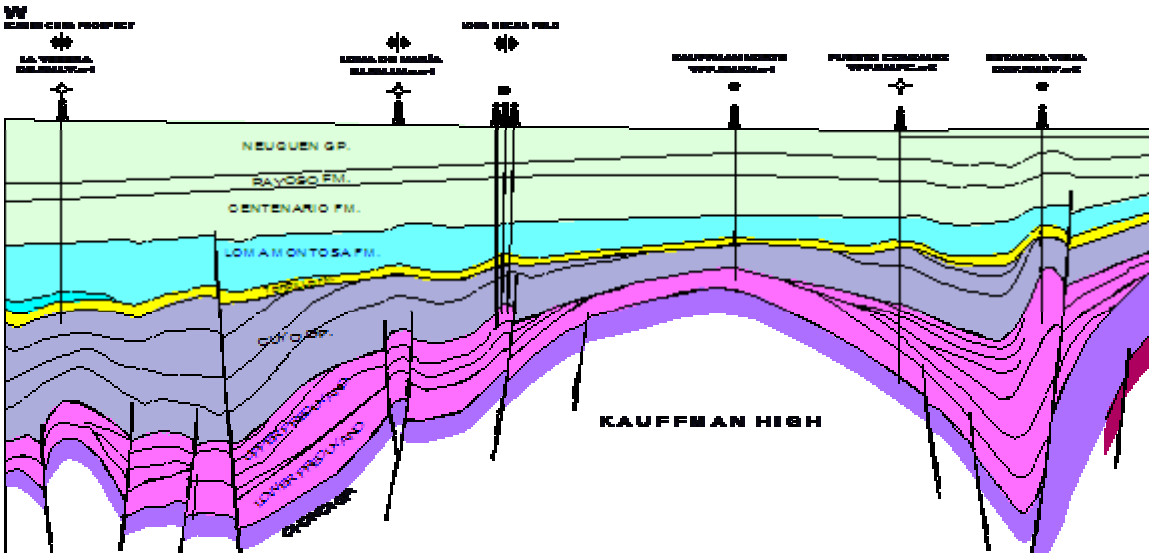
The Loma Negra Oil Field was discovered by CSJ in 1996. The field is located in the Neuquen Basin of ***Argentina***.



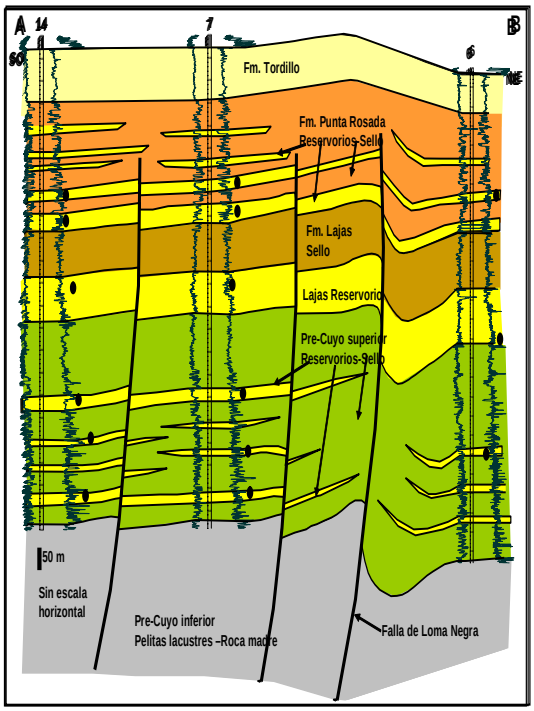
Oil production was tested from 3 different reservoirs, Punta Rosada Fm, Lajas Fm and ***Pre-Cuyo***.



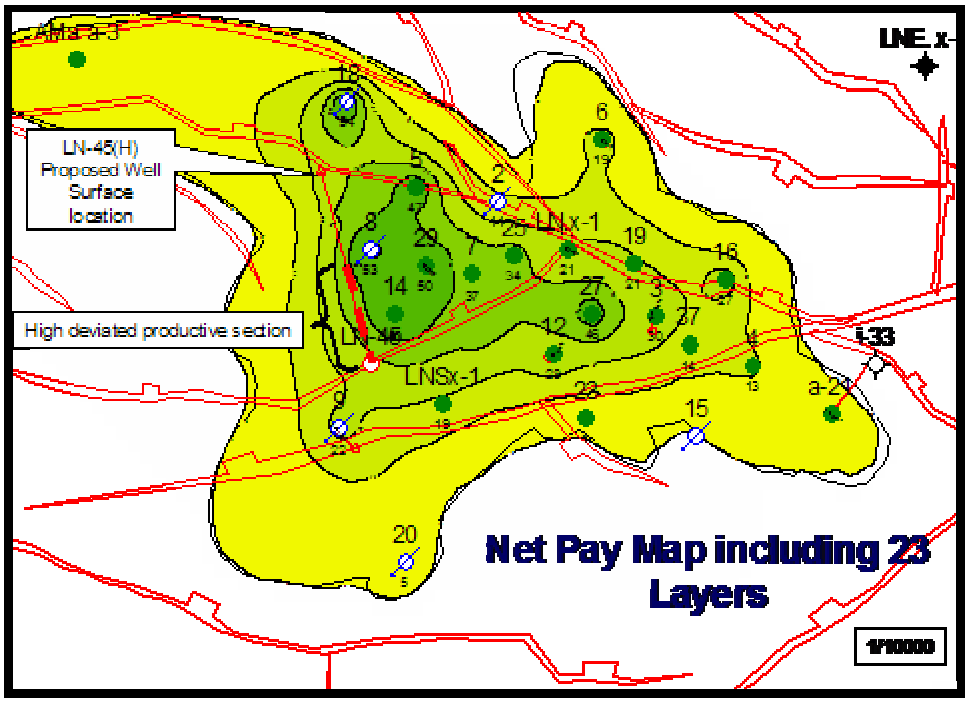
The last one is the deepest ***multilayer reservoir*** deposited in an ***alluvial fan environment***, developed in a hemigraben which was related to basement extensional faults.

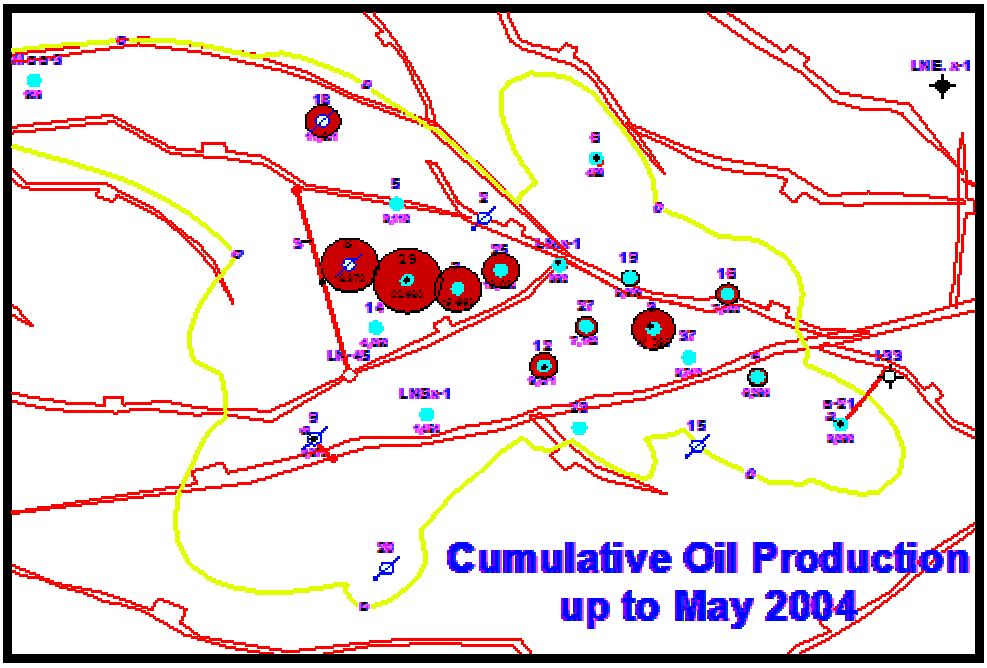


The reservoir is formed by ***conglomerates and sandstones*** with individual beds about ***7 to 15 feet thick*** showing a ***total net pay of 65 to 90 feet***. The ***lateral continuity*** of this bodies is ***extremely difficult*** to define. This behavior most likely was caused by the lack of continuity and the oil characteristics (***undersatured 28° API, GOR: 80 SCF/STB***).



Up to May 2004 the Pre-Cuyo oil production from ***20 vertical wells*** have not had a good performance since they had ***high initial production but strong decline rate***.

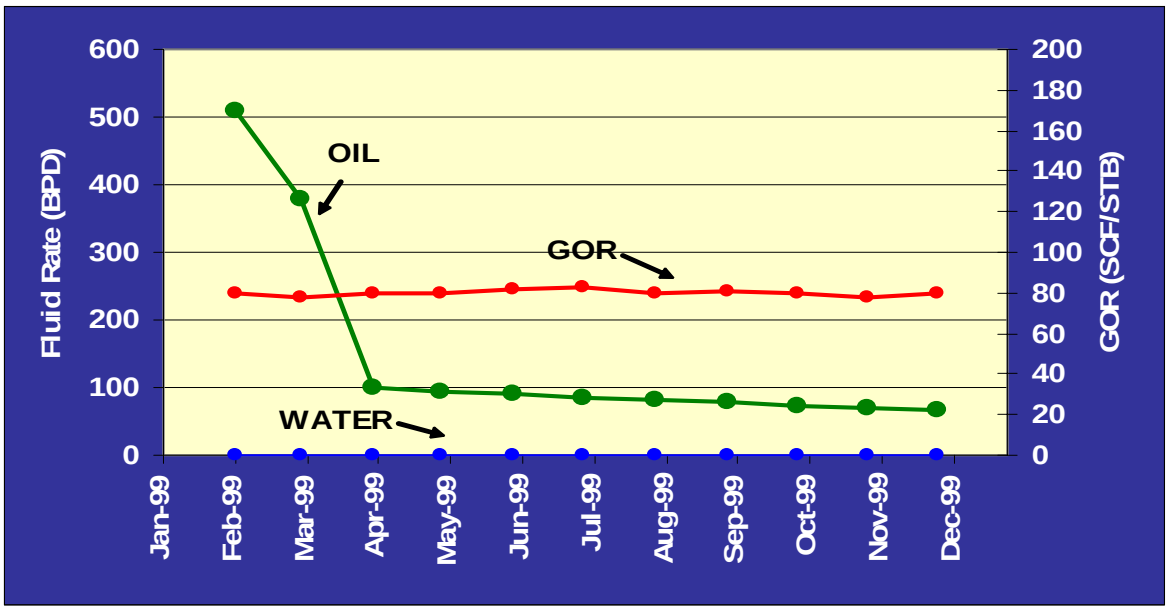


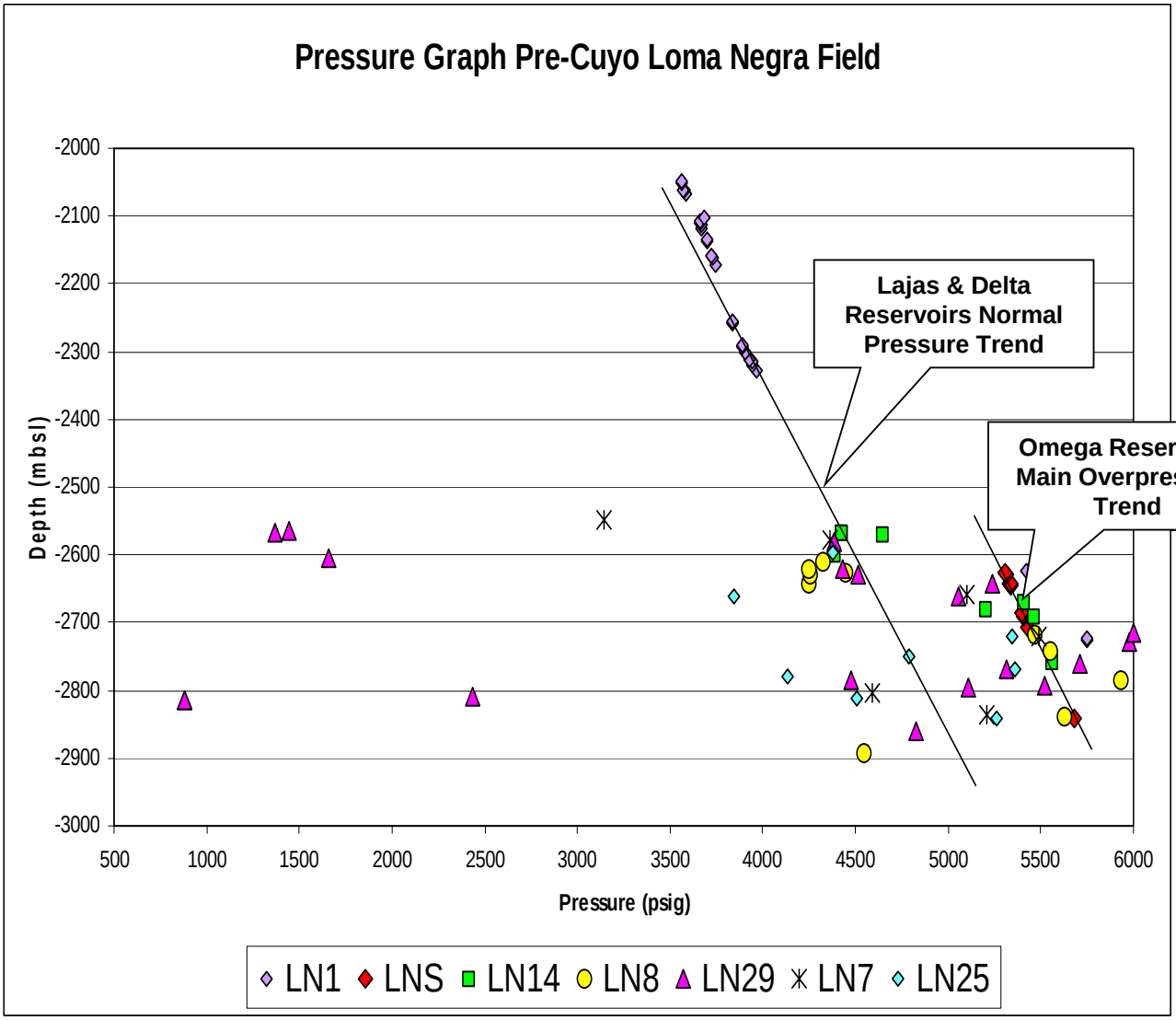


This behavior most likely was caused by the lack of continuity and the oil characteristics (***undersatured 28° API, GOR: 80 SCF/STB***).

Reservoir Properties	
Reservoir Temperature, °F	190
Permeability (avg), mD	50
Vertical Permeability (avg), mD	1.85
Porosity %	/ 18.53
Depletion Mechanism	Fluid & Rock expansion
Average Depth, ft	10,800
Average Net/Gross	0.1
Average Net Pay, ft	65
Average Net Pay per Layer. ft	7 to 15

Fluid Properties	
Oil Gravity, °API	28
SP gas gravity	0.76
Initial Water Saturation, %	20
GOR, SCF/STB	80



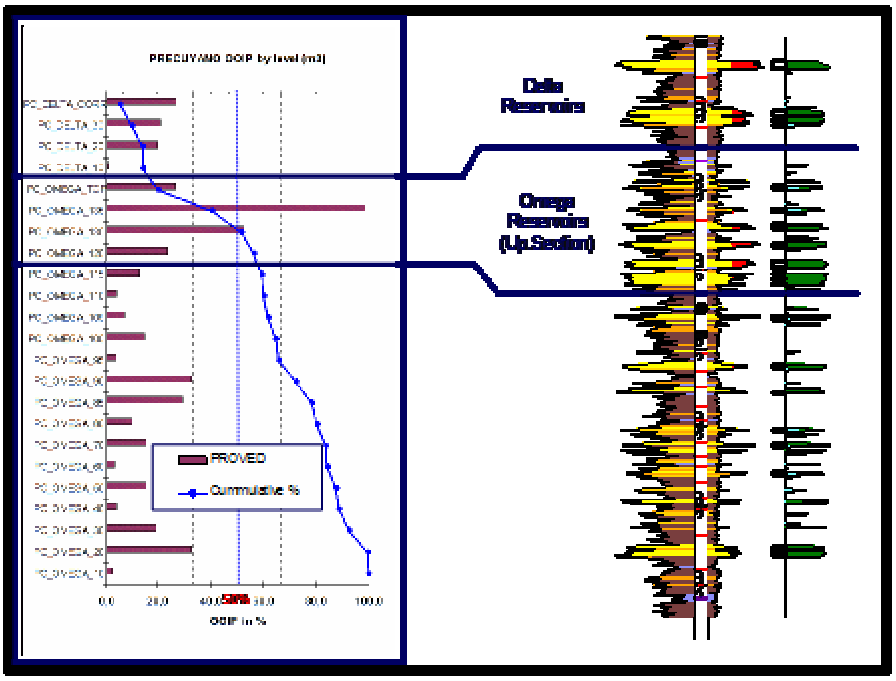


- Each Pre-Cuyo reservoir showed a different depletion while drilling campaing (1996-2004).
- The most significant OOIP were allocated in moderate to low depleted layers.
- An average of 3000 psi was assumed for production forecast in MBAL & Prosper model (P50).

Such as near ***50% of the Proved Oil Reserves*** are placed in the Pre-Cuyo reservoirs, new drilling and completion techniques were evaluated looking for a better economic development.

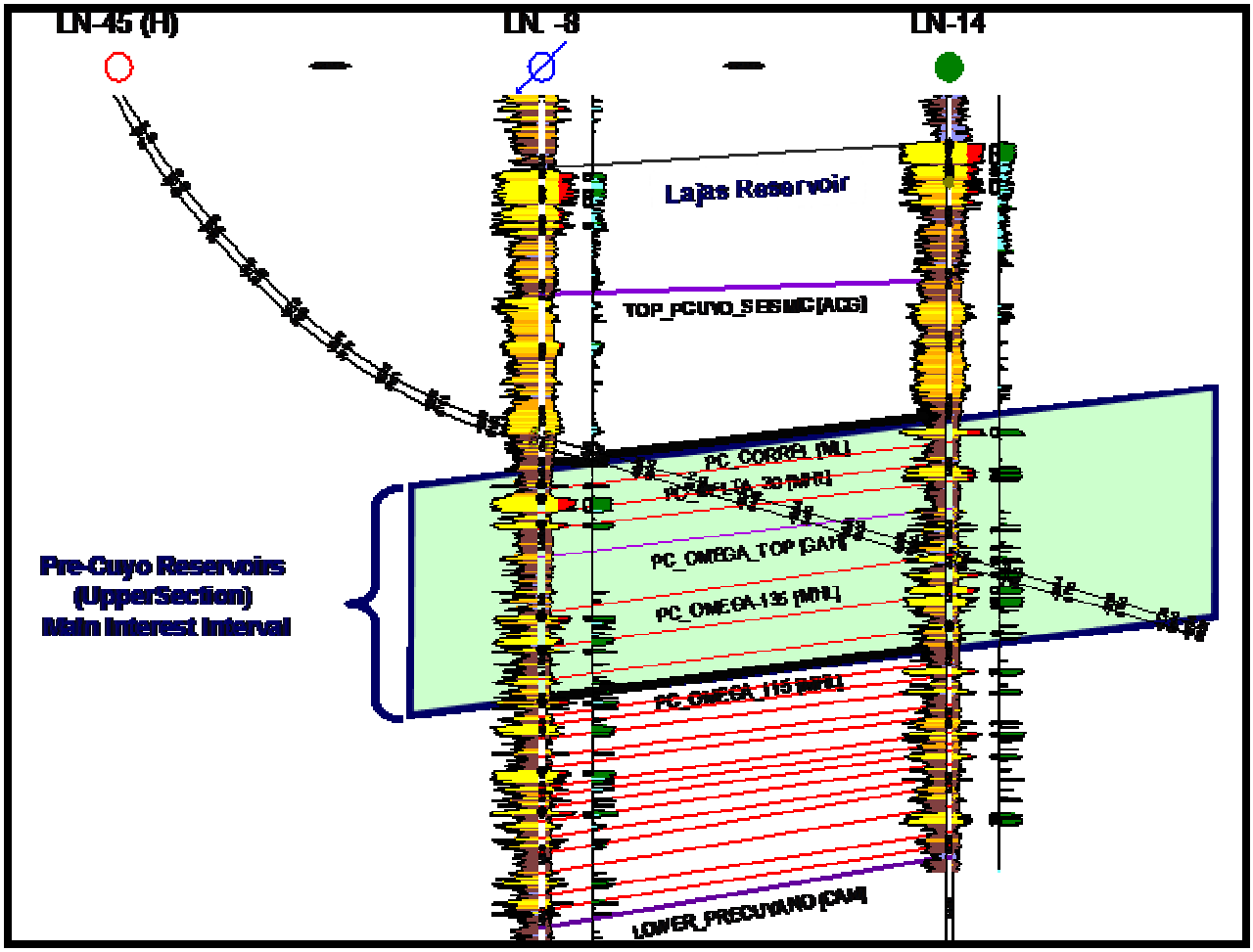
RESERVES	
	Pre-Cuyo Contribution
P1 Dev	4%
P1 Undev	48%
P2	24%
P3	51%

After a G & G reevaluation, a target area was selected for a ***pilot "slanted well"*** due to the reservoir characteristics and distribution. The main concern was the reservoir pressure, therefore ***Petroleum Experts Tools*** (MBAL & Prosper) were used to forecast the production.



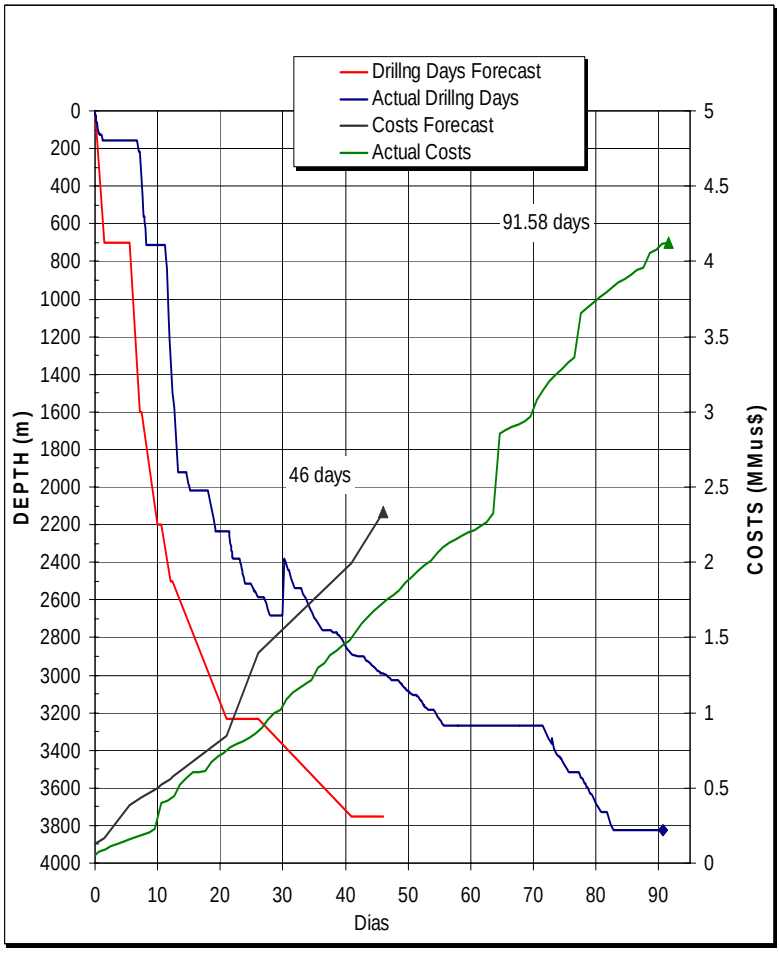
Project Development

The ***well*** was drilled with a ***high deviated angle (76°)*** to include the main Pre-Cuyo layers ***increasing four times the apparent net pay*** (360 ft from logs evaluation) in the ***1650 ft of the slanted section***. To prevent borehole breakouts and induced fractures a feasibility evaluation for an open hole completion was made. A ***wellbore stability*** (HASA) and a ***mechanical rock properties*** (Baker) ***analysis*** were accomplished. A ***water base mud*** (Baroid) with polymers, NaCl and SrCO3 for density was selected.



The well was drilled and completed from October 2004 to February 2005. As consequence of being the first experiences in this kind of wells several issues have increased costs and drilling time.

The ***drilling*** stage took ***92 days*** (46 days longer than forecast) due to several problems like union conflicts, rig's crew accident and mud motor performance (side track). Further, the need for sliding was more than expected and insufficient bit hydraulic caused poor wellbore cleaning, high tool dragging, well closing and hole tortuosity.



After casing with 9 5/8 to the top of Pre-Cuyo Gp, the multilayer reservoirs target was completed by ***open hole with a 7" slotted liner***.

No RFT pressure data were obtained from LN-45H due to the wells problems mentioned above. The maximum pressure estimated 6,200 psi, was from the 11.6 ppg mud weight needed to control the well. This indicated an overpressure reservoir
After ***1 year of production*** the results of the first slanted well show that the forecast was achieved and current cumulative oil production ***(200,000 BBl)*** is better than any existing vertical well.

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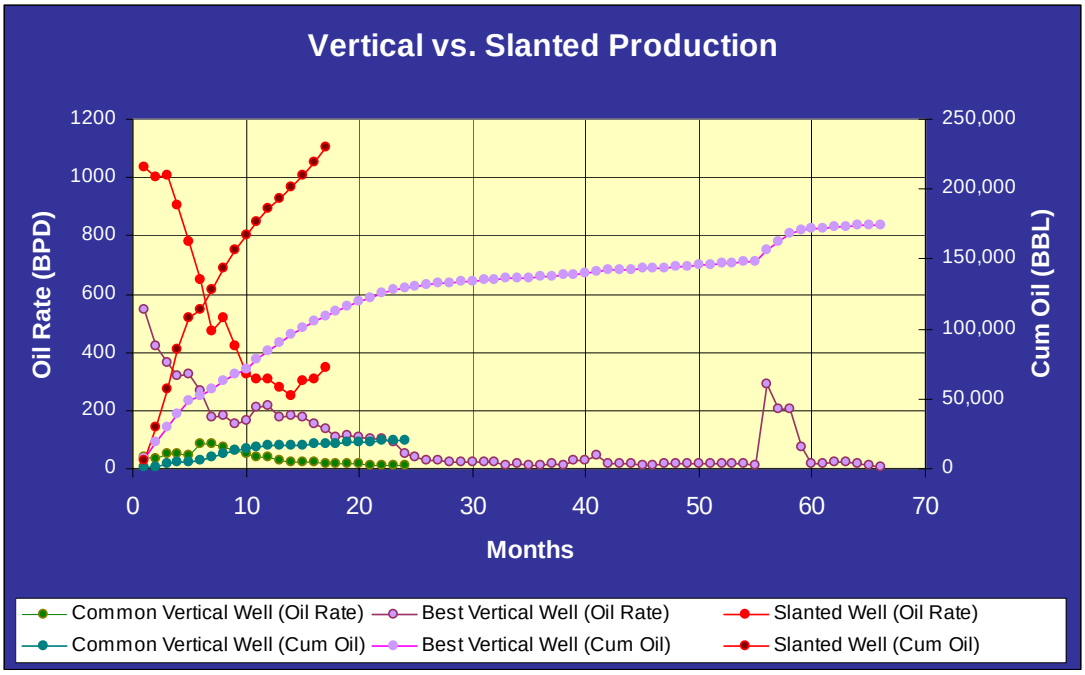

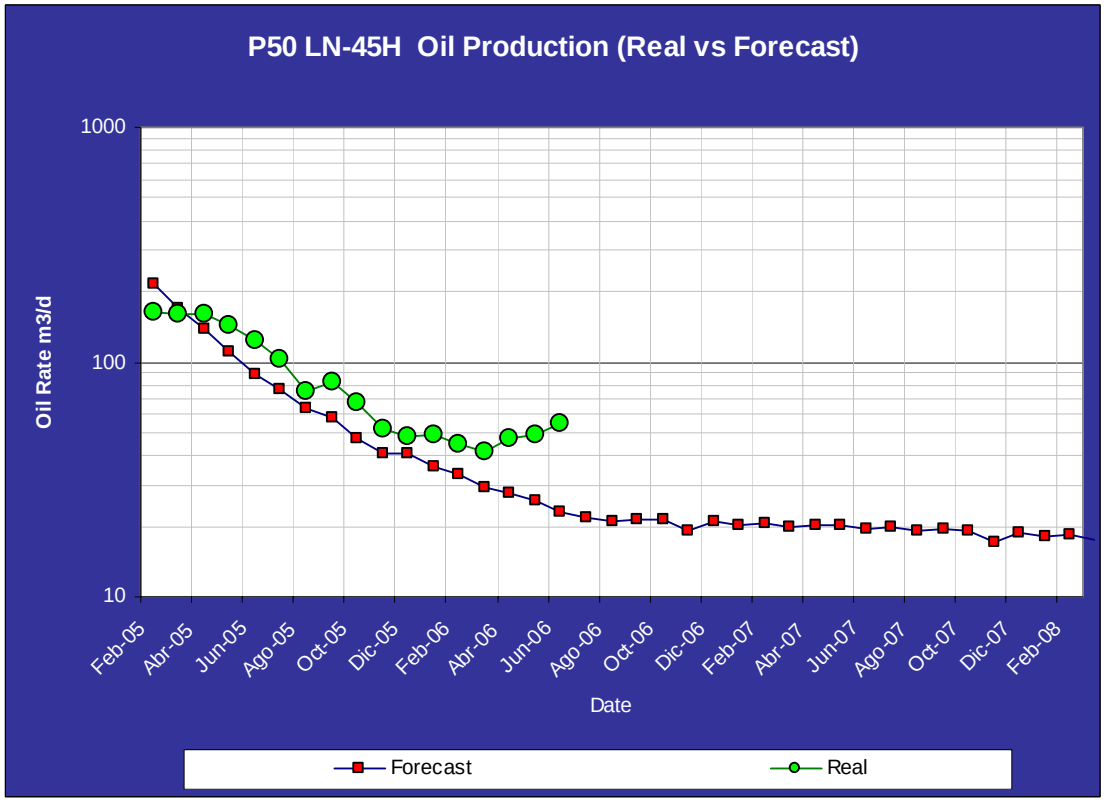

Conclusions

Lessons Learned

- Better initial oil rate and decline rate than the vertical wells have been observed.
- Slotted liner in multilayer reservoirs with non sanding issues can be an option in case of having collapse risks.
- Ultimate directional drilling tools must be applied in order to reduce time and costs.
- Pilot well to assess geology and define producer trajectory could be a good alternative.
- Use clean brines in the hole for installation of 7” slotted liner in order to protect the ESP.
- Team Work is essential.

Best Practices applied

- Use of slanted/horizontal wells technology in multilayer reservoirs allow a better production performance and a higher final recovery factor than a vertical well.
- Geomechanic and drilling mud studies are necessary to select the best well orientation and to reduce collapse risks.
- Use of Petroleum Expert Tools (IPM) to forecast the well performance.
- Sensitivity cases are needed in order to reduce uncertainties in the well production forecasting.

Challenges face on the project.

- Lateral sandstone continuity.
- Lack of static pressure data by layer.
- Find a methodology to economically produce the huge P1 reserves of Pre-Cuyo formation.
- Achieve the proposed trajectory of the well, taking into consideration that this was the first well with these characteristics in the area.

Acknowledgement

The authors wishes to express their thanks to Chevron San Jorge for the permission to publish this work.

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