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Simposio de Recursos No Convencionales: Hacia una Nueva Convención

ON THE PATH TO A COMMERCIAL UNCONVENTIONAL PLAY IN ARGENTINA: NEUQUEN BASIN, A CASE STUDY

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RESUMEN

En el camino hacia un *play* no convencional comercial en Argentina: Cuenca Neuquina, un caso de estudio

Los recursos no convencionales dependen económicamente de la reducción de los costos de desarrollo a la vez que se maximizan la recuperación de hidrocarburos. La baja actividad de perforación y lenta tasa de aprendizaje comparado con los activos de norte américa obstaculiza el control de los costos en un porfolio internacional. En Argentina, Shell administró los costos a partir de escalar y planificar su paso de aprendizaje y así reducir las incertidumbres de sus áreas operadas (Sierras Blancas y Cruz de Lorena) de forma eficiente. Los resultados hasta hoy muestran lo importante que es integrar el conocimiento multidisciplinario para fijar la estrategia de adquisición de información, reducción de incertidumbres de reservorio y producción, y planear la administración del reservorio.

La estrategia de maduración de los bloques se hizo alrededor de los centros de conocimiento – áreas puntuales donde se intensifica la adquisición de datos estáticos y dinámicos en 1 a 3 pozos), incluye perfiles, geomecánica, geoquímica, coronas, PLT, microsismica, trazadores químicos, trazadores no radiactivos (NTR) en el agente sostén e información de presión, entre otras. El objetivo es facilitar el entendimiento de las propiedades del reservorio en la vertical, entender barreras de fracturas y el volumen estimulado (SRV). Los futuros centros de conocimiento incorporarán fibra óptica para investigar el espaciamiento vertical - horizontal y la eficiencia de los diseños de fractura.

La integración de esta información a partir de los centros de conocimiento ayudó a entender la importancia de las zonas de aterrizaje, las barreras de fractura, y las dimensiones de la zona estimulada (SRV). La integración e interpretación de los datos de pozo y sísmica soportan un potencial desarrollo dual. Dado los resultados prometedores, se va a perforar una extensión de 4-6 PADs en las cercanías con los siguientes objetivos: 1) testear incertidumbres claves a partir de la ejecución de diferentes diseños de pozo, 2) demostrar progreso en la reducción de costos, y 3) ganar confianza en la capacidad de ejecutar pozos, de forma repetitiva y con la misma performance.

El punto de inicio es el aprendizaje continuo de la estratigrafía, el análisis de las facies de roca y la predicción de las propiedades de la roca entre los bloques. Al integrar todo esto con datos de producción a modelos dinámicos y geomecánicas de reservorio ha sido un gran avance para avanzar en entender el desarrollo de la Formación Vaca Muerta. Esto a abierto la posibilidad de un desarrollo dual.

INTRODUCTION

The Neuquén Basin is the most prolific onshore basin in Argentina with significant conventional activity since the first oil discovery a century ago. The Vaca Muerta Formation is a self-sourced, liquid rich unconventional play that requires horizontal wells and hydraulic fracture stimulation to achieve material well recoveries. The recovery mechanism is pressure depletion of the stimulated rock volume. Even though the basin is a well-established oil producing area, unconventional exploration and production is in early stages and there is, to date, a relatively limited number of horizontal wells targeting unconventional production. Over the last few years, a lot of de-risking activity has been achieved in the basin and now pilots drilling followed by development activity is picking up.

Unconventional projects exhibit many unique features that differentiate them from most conventional fields. Key aspects of these plays are large geographical areas, variable well productivity and capital and operationally intensive multi-year drilling and stimulation programs. These issues need to be adequately addressed to optimize profitability and therefore warrant a dedicated, stage gated approach to opportunity realization and hydrocarbon maturation. A typical stage progression goes from Exploration to Appraisal, Pilot and then Development, with increasing play understanding and corresponding reduction of risk, but also increasing levels of capital exposure.

This paper elaborates on how this strategy was implemented for the Sierra Blanca's (SB) and Cruz de Lorena (CDL) blocks and integration of knowledge hub concept for the appraisal and pilot phase of the project, with economical evaluation towards a sustainable development.

METHODOLOGY

1. Concept

The path to commercial play through proper exploration, appraisal and de-risking can be achieved byan End to End delivery process1 for an unconventional play as shown in Fig1. The stage gate approach can be defined as consisting of three phases: Examine (Exploration and Appraisal), Measure (Appraisal and Pilot) and Harvest (Development). During the early exploration phase a combination of short lateral wells with vertical pilot were drilled with extensive static data acquisition. This consisted of getting whole cores, sidewall cores, and full sets of logs including image logs through the production section.

Entering the Appraisal/Pilot stage requires sufficient data to confidently delineate an area with top tier profitability, that is competitive in a company's portfolio and has an actionable risk mitigation plan. This phase involves defining and optimizing landing zones, understanding frac barriers, rock mechanics and potential well-to-well interaction (interference). The appraisal

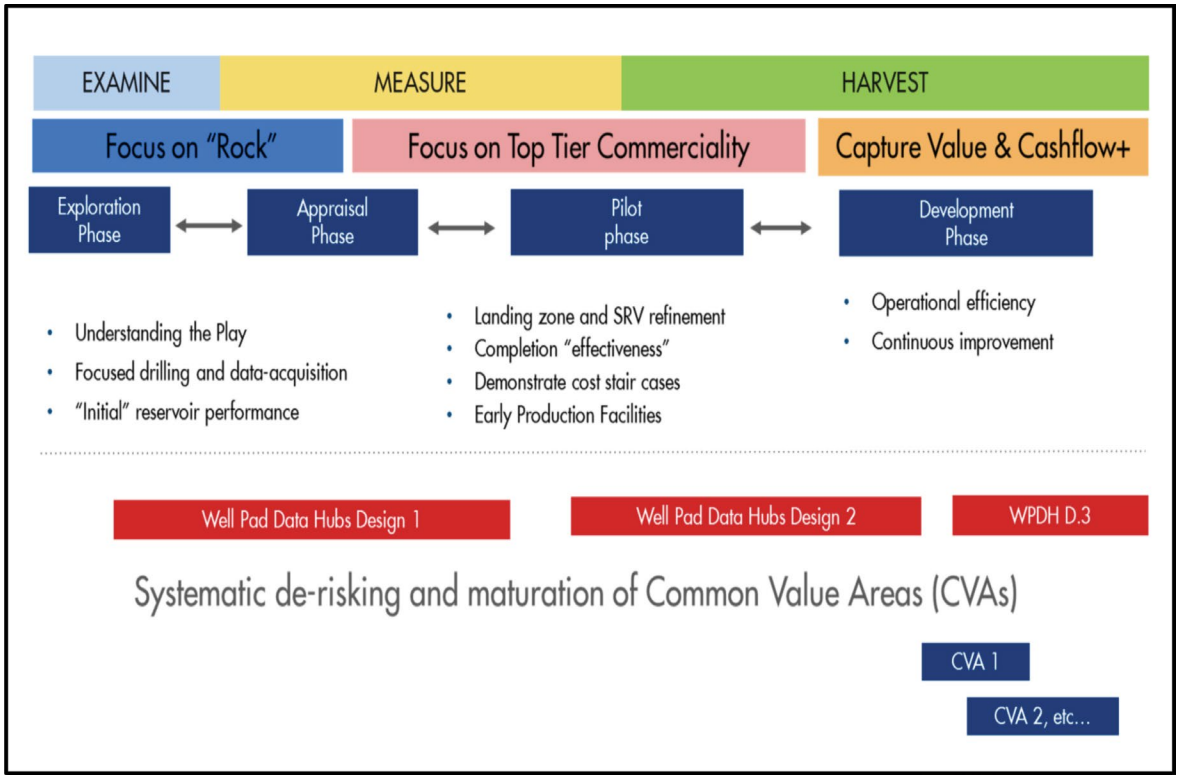

Figure 1. End to End hydrocarbon maturation work flow

phase is also more about assessing the production potential of the reservoir. During this phase, 2 knowledge hub pads were drilled for data acquisition and multi-disciplinary integrated learning in the Sierras Blancas (SB) and Cruz de Lorena(CDL) blocks. The concept of knowledge hub is integration and synergy of data acquisition, since doing more in one area adds exponentially against spreading out the data collection over a larger area. Knowledge pads gave us more confidence on how we understand the subsurface and are key to derisk and faster mature Vaca Muerta play. They are used to further integrate the subsurface understanding into reservoir deliverability. Careful choice of technologies was used to answer specific questions in these pads and along with qualified decisions, to justify the surveillance data collection.

2. Multi -disciplinary Approach

Sierras Blancas and Cruz de Lorena are in the oil window of the formation with potential for two layer development. The learnings of an integrated cross discipline approach for optimized field development which was developed in North American plays has been very useful and applied to Vaca Muerta play. An unconventional integrated cross-discipline approach (Fig 2) developed for Permian Asset of Shell has been modified to achieve deep technical understanding and optimum field development in Vaca Muerta Fm. In this cross-discipline work flow, the geological

structure, depositional thickness and extent, and petrophysical evaluation of individual units, such as SoPhiH (and other properties) are combined with engineering and dynamic data, such as completion information, production analysis, PVT, and water cut, to optimize the Vaca Muerta development, therefore improving profitability and maximizing the value.

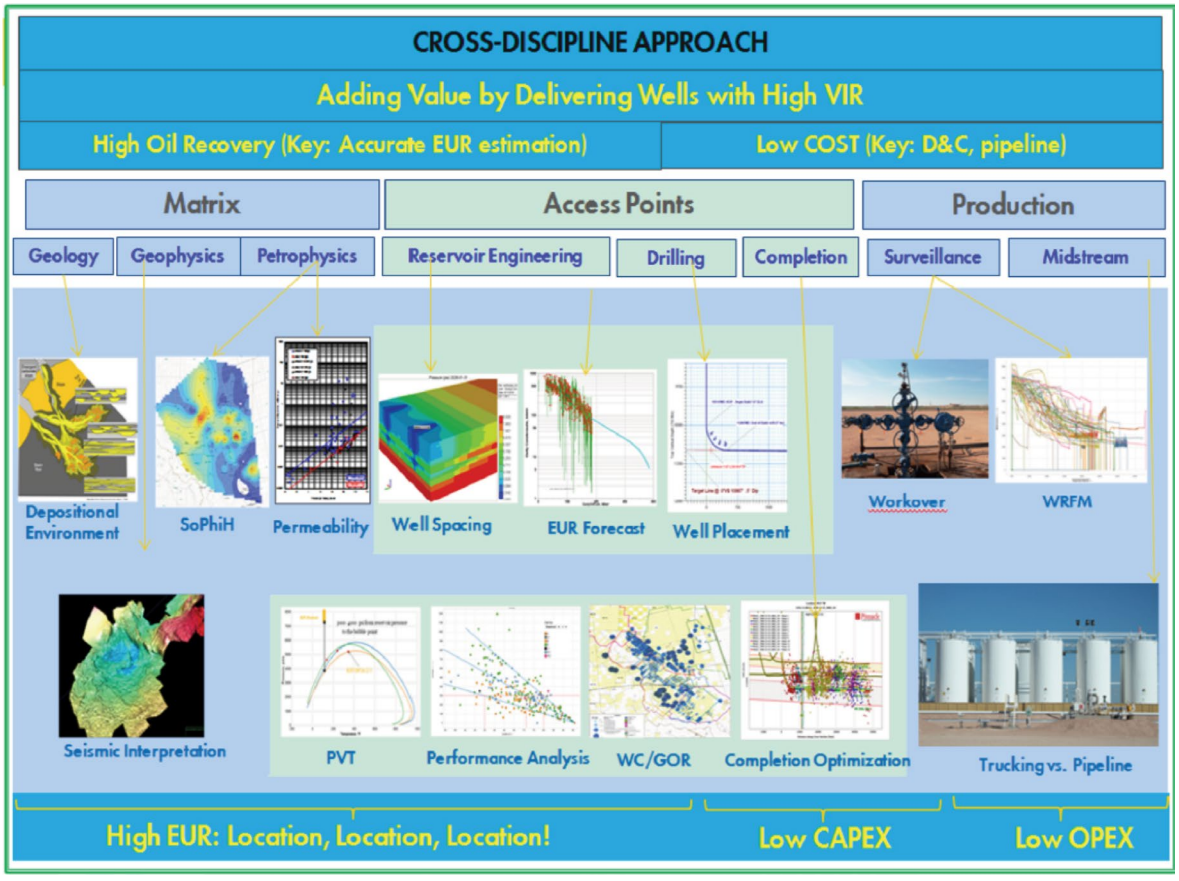

Figure 2. Diagram of Integrated Cross Discpline Knowledge HubApproach(Caoet al, 2016).

An integrated cross-discipline "Knowledge Hub"approach has been developed to apply Shell's experience and ability to achieve deep technical understanding and more accurate prediction of EURs.

In 2015, the first knowledge hub (multi-well pad) with the objective to assess dual layer development was drilled in SB block (Fig3). The pad included two horizontal wells landed in the two high Porosity/high TOC targets for Sequence 1 and 2 and one slant well traversing the entire Vaca Muerta pay section at a three-degree angle. A legacy well served as the pad's pilot. The bulk of the data acquisition took place in the slant well including a full suite of wireline logs, microseismic, oil and water-based tracers, pressures, a production log and geochemical fingerprinting amongst others. The CDL x-3/CDL x-4 knowledge hub (Fig3) was drilled to understand fracbarriers and

vertical extant of hydraulic fractures, SRV. The data acquisition, included NRT (non-radioactive tracer) proppant, Logs: sonic dipole, Tracers (oil and water soluable), PLT, Geochemical fingerprinting, and Microseismic.

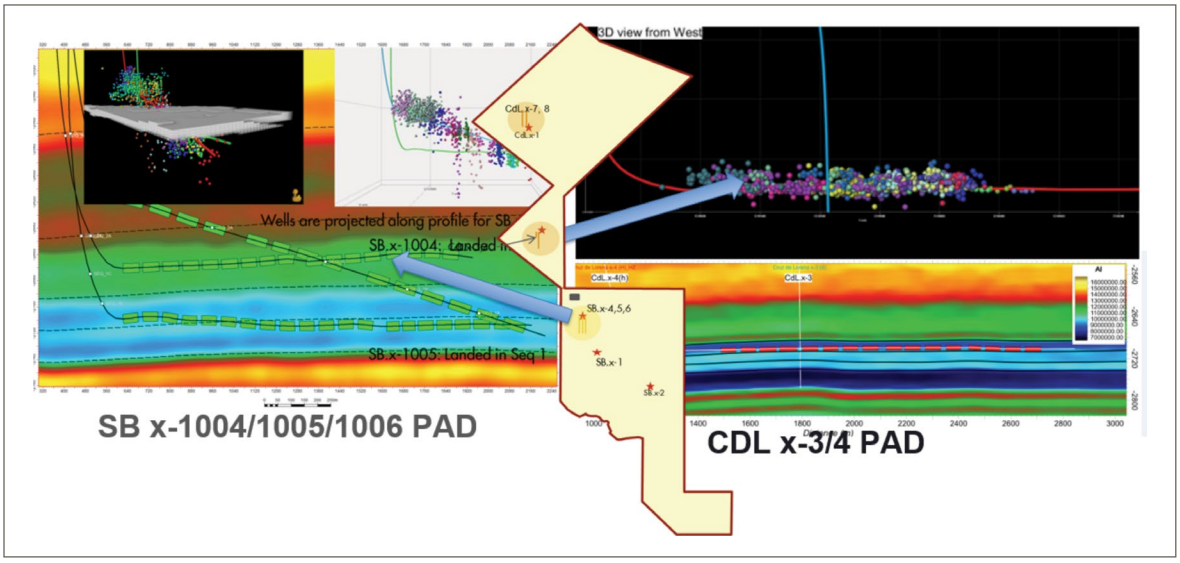

Figure 3. SB and CDL knowledge hubs with data acquisition to support multi-disciplinary integrated approach.

Consistent well and infrastructure operation are required to deliver cash flow. Development concepts are optimized (e.g. well placement, well spacing, frac and infrastructure design) and project value created and increased by leveraging economies of scale to reduce cost and improve performance of wells and field. Because unconventional fields are developed with many densely drilled horizontal producers, determination of the optimum horizontal and, in the case of multi-layer development, vertical inter-well spacing is critical to define a commercially sound development plan. "Optimum" well spacing can be defined as a function of limiting production interference versus minimizing "unstimulated" reservoir, and meeting company specific economic and strategic criteria. The well spacing parameter is usually one of the last variables to be understood, as the earlier efforts are focused on establishing commercial production rates from individual, typically single wells (no neighboring producers), and defining optimal landing zone targets, completion designs, and lateral length. To understand these uncertainties and optimizing the development, we are planning on a 3rd Knowledge hub data pad in SB block. The layout of the pad is shown in Figure 4 and it consists of 4 wells in a pad with the objectives of understanding lateral well spacing, dual layer development, completion efficiency and design optimization as a function of well spacing. The proposed data acquisition strategy includes fibre optics,microseismic, chemical tracers, bottom-hole pressure gauge and geochemical fingerprinting.

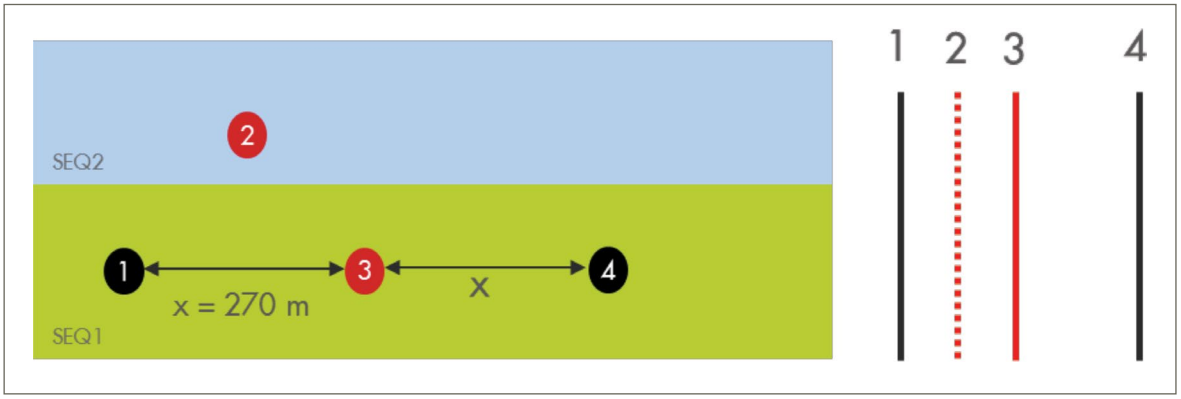

Figure 4. Future SB knowledge hub with objective of optimizing well spacing, dual layer development and completion optimization understanding.

Determining well spacing requires drilling and completing multi-well pads and associated higher capital exposure (when compared to single well tests). Therefore, well spacing gets addressed typically only after single well production has been proven to be commercially viable. Proceeding with a development with too tightly spaced wells leads to significant over capitalization, whereas under drilling leaves resources behind. Both scenarios result in, potentially significant, value erosion of the field (Fig 5).

Typical NPV Well Spacing Implication

Over Cap vs NPV Risk ($MM)		Right Spaced		
		4 wps	6 wps	10 wps
		400 m	270 m	160 m
Actual Spaced	400 m	$0	-$96	-$500
	270 m	-$513	$0	-$227
	160 m	-$1,521	-$1,008	$0

NPV Risk from Under-Development of Resource

Over-Capitalization Risk

Figure 5. Typical NPV Well Spacing Implications.

Well spacing and completions design are intimately linked to development parameters that cannot be effectively addressed independent from each other.The process of well spacing optimization provides guidance on how to manage interaction between the wells and landing zones. Selection of spacing for unconventional wells can often require evaluation of competing

objectives i.e Maximize value, reduce capital exposure in area, accelerate payout and improve the internal rate of returns.

RESULTS

1. Economics Evaluation

The targeted landing zones,Seq 1 and Seq 2for both blocks are identified through detailed mapping and well correlation in the blocks. We have been using directional drilling technology together with experiences from North American assets, which includes well design to drill and land the well within 5 -10 m tolerance in landing zone and very limited tortuosity. Adopting the integrated approach developed in North American assets, we have observed significant drilling cost reduction in Vaca Muerta Formation. with fever wells drilled (Fig 6.)

There are two aspects to maximizing value of blocks: One is to determine well location in the petrophysical property "sweet spot" and landing zone (or "sweet zone") that correspond to high EUR (Estimated Ultimate Recovery), the other is to deliver wells with low cost, including drilling and completion (CAPEX) and operations (OPEX).Fig 6 shows the significant Capex reduction achieved in Vaca Muerta Formation. with less number of wells by integrating the learning, thus enhancing value of the asset.

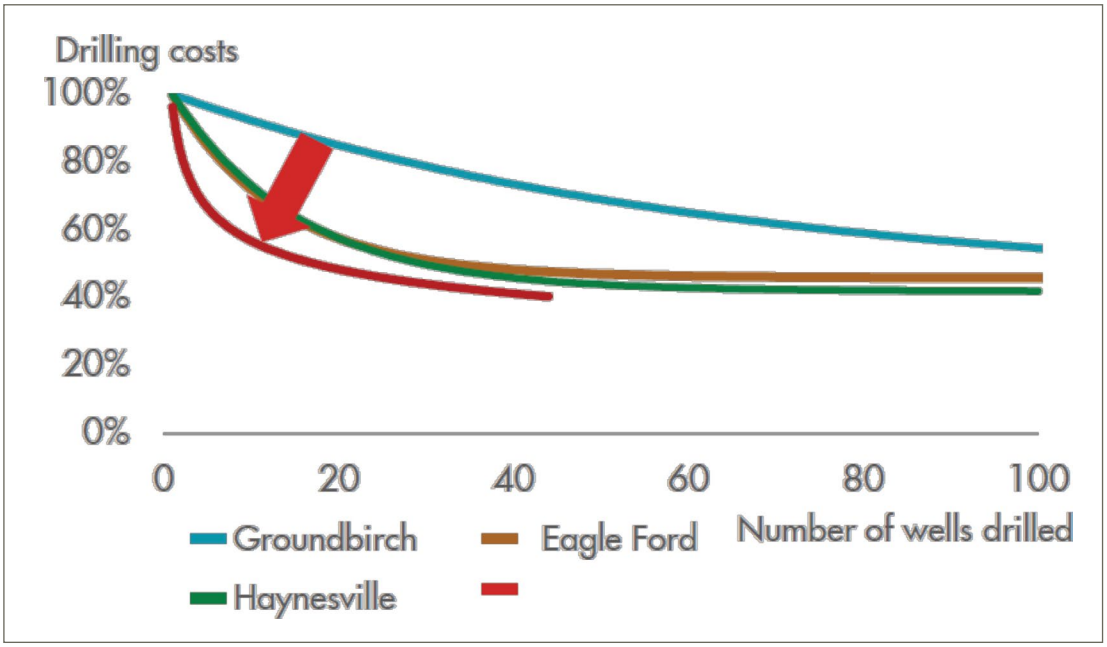

Figure 6. Drilling performance at each basin with number of wells

CONCLUSION

An integrated cross-discipline approach together with Knowledge Hub concept is used for Vaca Muerta development leveraging Shell's experience and ability to achieve deep technical understanding and more accurate prediction of future EURs. In this multi-disciplinary approach, best practices from North American Shell assets were adopted to develop integrated work flows. Integration of data from geological structure, fault interpretation, turbidite sand depositional trend mapping, and petrophysical evaluation combined with completion design, production analysis, water cut and PVT was used to optimize the development strategy for profitability and maximizing value. This approach has allowed us to take expediteddecision on Cruz de Lorena, and Sierras Blancas blocks. Finally, the learnings of an integrated cross discipline approach for optimized field development can be very useful and applied to other blocks in Vaca Muerta Formation.

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