Incised Valley and Submarine Canyons (Aalenian-Bajocian) in Lajas Formation, Cuyo Group, Neuquen Basin: Advances in the Knowledge of Exploratory Play*

Facundo Pagan1, Karina Mykietiuk1, Francisco Fernandez Bell Fano1, and Rodolfo Guerello1

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1Exploration Department, YPF S.A., Buenos Aires, Argentina (facundo.j.pagan@ypf.com)

Abstract

The Cuyo Group reservoirs have been extensively studied in subsurface and outcrops, and their commercial exploitations proven in traps with a conspicuous structural component. In low deformed areas and / or paleo-structures, stratigraphic traps type become relevant. In order to define new potential exploratory plays, interpretation was focused on the Middle Jurassic slope area of the Neuquén Basin. In particular on the incised valleys and submarine canyons, identified in 3D seismic, in order to characterize them as stratigraphic traps. These morphological features were recognized along a strip of more than 100 km long and 30 km wide in the central-western area of the basin in the middle and upper sections of the Lajas Formation.

The depositional model, highly progradational for the Cuyo Group in the central area of the Neuquén Basin, is interrupted by cycles of relative sea level fall and rise generating the alternation of negative and positive accommodation spaces, that result in the platform exposure, erosion and flooding with basinward displacement of non-marine depositional environments.

The high rates of sedimentary supply could have generated unstable slopes, favorable for the generation and evolution of submarine canyons. These, in turn, during their development towards the platform break could have captured the incised valleys developed on the platform even with small relative sea level variations.

Some of these interpreted eroded features and their sedimentary fill reach up to 10 km in length, 5 km in width, and 200 m in thickness, being the average of about 7 km - 2.5 km - 150 m, respectively. In areas with high concentration of incisions, the stacking of different canyons and incised valleys can reach an area of about 400 km² and a thickness of 600 m. The purely stratigraphic character of this type of entrapment (cut and fill) makes it dependent on petrophysics and lateral and vertical variation. Seal efficiency is the critical factor of this play.
References Cited


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F. Pagán¹, K. Mykietiuk¹, F. Fernandez Bell Fano¹, R. Guerello¹.

1 Exploration Department YPF S.A., Buenos Aires, Argentina

INTRODUCTION AND AIM

✓ The Neuquen Basin is located in the central western part of Argentina and is the main producing basin in the country.
✓ Cuyo Group is composed of clastic rocks deposited in distal marine environments (Los Molles Fm), coastal (Lajas Fm), non-marine (Challacó Fm and Punta Rosada Fm) and evaporitic deposits (Tábanos Fm). It is the first expression of the filling of the basin.
✓ The reservoirs have been extensively studied in subsurface and outcrops, and their commercial exploitations proven in traps with a conspicuous structural component. In low structured areas, stratigraphic traps type become relevant. In order to define new potential exploratory plays, interpretation was focused on the Middle Jurassic slope area of the Neuquén basin.
✓ The aim of this work is to contribute to the knowledge of Cuyo Group looking for stratigraphic traps and the occurrence of potential reservoir facies in depositional environments associated with lowstand systems tract in gas window (Los Molles Fm source rock).

METHODOLOGY

The Cuyo Group stratigraphic succession’s was studied through seismic geomorphology and seismic facies analysis within the framework of sequence stratigraphy.

The seismic interpretation began with the identification of seismic patterns and the definition of key surfaces (downlap, onlap and truncation surfaces).

Seismic facies were characterized by their geometry, lateral continuity, seismic amplitude and frequency. They were used in the interpretation of depositional environment, sequence limits and sedimentary tract.

2-A. PSTM arbitrary seismic strike line flattened to Lotena Fm.

2-B. The stacking pattern makes it possible to identify discontinuities due to large-scale erosions, reaching up to 200 m of vertical incision and a range of 3 to 5 km in the horizontal. Despite the high concentration of incisions interpreted in the region, it is possible to work with their temporality.

PSTM seismic cube Horizon slice flattened to top Lotena Fm

3-A. Horizon slice below datum (+300 ms). We recognize V shape geoforms (incisions)

3-B. Interpretation of horizon slice: discontinuities due to different stages of erosion, younger toward the norwest (basin ward). It is possible to differentiate the shelf and the slope.
Paleoenvironmental interpretation on the shelf-slope areas correlates with what is observed landward (southwest of the area of study), where 3D seismic data was calibrated with deep wells and could be observed alternating high and low amalgamation system tracks (Catuneanu, O., 2019) in more than 1000 m of non-marine sediments. These variations in accommodation space rate were interpreted as a relative sea level fall and their correlative expression to landward.

Comparing outcrops with seismic resolution scale. Out1: deltas and hummocks deposits (inner shelf); Out2: turbiditic deposits (slope zone); Out3 turbiditic deposits (outer slope/abyssal plain)
Many hydrocarbon accumulations in deep marine environments are associated with a stacking of sinuous channel systems. There are 3 accepted models for channel migration in deep marine environment:
- Continuous Lateral Accretion;
- Meandering to Aggrading Terraces
- Time punctuated Channel Avulsion.

The first two require continuous and stable flows (fluvial systems), while the remainder can be explained by short-lived, non-continuous flows (turbiditic flows). (White, C.J., et al 2018)

Zones with a high stacking of incision were recognized within a 100 km long belt. The thickness was estimated in more than 600 m of sediments associated to the filling of different sectors of platform-slope-deep basin.

Deposits in submarine canyons could be divided into at least 2 groups. The first is associated with Upper Canyon, where high frequency of sedimentation, coarse grain and materials transported from shelf environments dominates. It is characterized by stages of sediment storage and release. The second group is associated with Lower Canyon, where the low frequency of sedimentation dominates and sand is the most relevant fraction. It is characterized by deposits that run through the entire length of the canyon and are linked to catastrophic events such as high-magnitude earthquakes, intense storms, slumps. (Nieminsky, N.M., et al 2018)
DISCUSSIONS

Conceptual geological model for a dip section. Low Sea Systems Tract (LST-FSST) are proposed as candidates with better preservation of the original petrophysical characteristics.

Composite image on a satelital view with the Cuyo Group outcrops, the interpreted incisions (Bajocian-Aalenian time), and the migration of the shelf edge. With the use of 3D seismic these incisions were recognized over an area of 100 km long and 25 km wide. Including the incisions described in outcrops, this belt could exceed 200 km long. The red colored line is the interpreted regional lineament that might control the distribution of incisions in Cuyo Group. It seems to have been active during the deposition of Tordillo Fm (orange line) and Vaca Muerta Fm (purple line).

CONCLUSIONS

- Cuyo Group: progradational to aggradational trend interrupted by erosive discontinuities at the shelf edge. Stratigraphic traps can be expected.
- The seismic facies interpreted as incision fills were related with high energy deposits.
- Deep canyons and incision valleys characterization. Composite geoforms of deep canyons and incised valleys (type 1) are more efficient for sediment transport toward deep waters.
- Seal is the critical factor of this play. Each sequence boundary has its own seal and could be recognized by the interpretation of the coastal line migration.
- There is a SO-NE regional lineament interpreted (~100 km) with a possible depositional control over the Cuyo Group-VM sedimentary record.

REFERENCES


