Depositional Patterns in the Lacustrine Cuyana Basin, Argentina*

Yolanda Ruiz¹ and Octavian Catuneanu²

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¹YPF S.A., Buenos Aires, Argentina (yolanda.ruiz@ypf.com)
²University of Alberta, Edmonton, Alberta, Canada

Abstract

Rocks associated with lakes account for more than 20% of the current worldwide hydrocarbon production, and lacustrine organic-rich rocks are significant sources of these hydrocarbons. Lacustrine sources and reservoirs are important in many areas of current and future exploration opportunities, including Africa, South America, southeast Asia, and China. Numerous studies of modern lakes and ancient lacustrine basins reveal that lakes are not just small oceans, and that there are significant differences from the known patterns in the oceans. These differences influence the occurrence, distribution and character of hydrocarbon source, reservoir and seal play elements. Some of these differences are due to the smaller volumes of sediment and water in the lakes, which make the lacustrine systems much more sensitive to accommodation and climate, as the lake level can fluctuate much more rapidly than the global sea level. Another difference is that the lake level and sediment supply are directly linked in lacustrine systems, in contrast to the marine systems where the sea level and sediment supply are only weakly linked, or with no linkage at all. There are also similarities between lacustrine and marine environments, in the sense that the same types of stacking patterns can be observed. For example, lake shorelines can move basinward either by progradation driven by sediment supply (i.e., normal regression) or by the simple withdrawal of water (i.e., forced regression), both leaving different patterns in the stratigraphic record. The evolution of a lake is fundamentally controlled by the relative rates of accommodation and sedimentation. Accommodation in excess of sedimentation leads to underfilled basins that experience water deepening. Sedimentation in excess of accommodation leads to water shallowing and the eventual shift to overfilled conditions. The Cuyana Basin in Argentina provides a case study of a lacustrine basin with high rates of oil production, which evolved from underfilled to overfilled stages of basin development. The most productive reservoirs of the Cuyana Basin are of late Jurassic and Cretaceous age, but the basin also has Triassic reservoirs, with much more complex patterns associated with syn-depositional tectonic activity. The relationship between the various elements of the petroleum system (i.e., reservoirs, source rocks, seals, and charge) can be analyzed within a sequence stratigraphic framework. Notably, due to the variety of lacustrine basins in terms of local accommodation and sedimentation conditions, lacustrine models are basin specific, and one model is not applicable to all lake-basin types. The case study of the Cuyana Basin provides an example of how sequence stratigraphy can be used to understand and predict the patterns of a lacustrine petroleum system, and to guide the future petroleum exploration.
Selected References


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Stratigraphic column for the Cuyana Basin. Kokogian et al. (1993) and Irigoyen et al. (2002)

**Triassic Deposits Potrerillos Formation**

- **Lacustrine Source Rock** (Cacheuta FM = Organic Shale)
- **Lacustrine Coastal Systems** (Sands & Shales)
- **Lower Energy Fluvial** (Sands / Tuffs / Shales)
- **Potrerillos Formation**
- **Higher Energy Fluvial** (Sands / Tuffs / Shales)
- **Las Cabras Alluvial Fans** (Sands / Tuffs / Conglomerates)
**TRIASSIC DEPOSITS**

**POTRERILLOS FORMATION**

- **LACUSTRINE SOURCE ROCK**
  - (CACHEUTA FM = ORGANIC SHALE)

- **LACUSTRINE COASTAL SYSTEMS**
  - (SANDS & SHALES)

- **LOWER ENERGY FLUVIAL**
  - (SANDS / TUFFS / SHALES)

- **POTRERILLOS FORMATION**

- **HIGHER ENERGY FLUVIAL**
  - (SANDS / TUFFS / SHALES)

- **LAS CABRAS ALLUVIAL FANS**
  - (SANDS / TUFFS / CONGLOMERATES)
TRIASSIC DEPOSITS
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HIGHER ENERGY FLUVIAL
(SANDS / TUFFS / SHALES)

LAS CABRAS ALLUVIAL FANS
(SANDS / TUFFS / CONGLOMERATES)
INFORMATION AVAILABLE

- BASIN MODEL
- SEISMIC
- OUTCROPS
- CORES
- PETROGRAPHY
- SEDIMENTOLOGY
- WELL LOGS
- PALINOGNOLOGY
PRODUCTION TO PRESENT DAY
(From January 1973)
10,000 km³ Oil
SYNRIFT I
LAS CABRAS
SYNRIFT II
POTRERILLOS FM
SEISMIC FLATTENED TO CACHEUTA TOP

PRODUCTIVE FIELD
BASE OF SYNRIFT
PRODUCTIVE FIELD
PRODUCTIVE FIELD
PRODUCTIVE FIELD
SEQUENCE STRATIGRAPHY MODEL

Las Cabras Fm

Maximum Regressive Surface

Maximum Flooding Surface

Wave Ravinement Surface

Cacheuta Fm

Upper Potrerillos

Middle Potrerillos

Lower Potrerillos

PROGRADING STAGE

SE

NW

100 m

100 m
PROGRADING STAGE: OUTCROPS

Lower Potrerillos: crude cross-stratification

Potrerillos: gravel-bed braided

SE PROGRADING STAGE NW

MRS

100 m
PROGRADING STAGE. 3D SEISMIC LINE

Well 1

PRODUCIVE FIELDS

MRS

100 m
SEQUENCE STRATIGRAPHY MODEL

Potrerillos Model

- Maximum Regressive Surface
- Maximum Flooding Surface
- Wave Ravinement Surface

1. The numbers indicate the sequence coast lines

RETOGRADING STAGE

- Cacheuta Fm
- Upper Potrerillos
- Middle Potrerillos
- Lower Potrerillos

10 m

MFS

MRS
Well 1
CONCLUSIONS

❖ The Potrerillos Formation consists of three genetic units: a fluvial prograding system (Lower Potrerillos), a fluvial transgressive system (Middle Potrerillos), and a coastal transgressive system (Upper Potrerillos).

❖ Each of the 3 genetic units has an age-equivalent lacustrine system (i.e., Cacheuta facies) towards the depocenter of the basin (downdip).

❖ The limits between reservoirs (Potrerillos facies) and source rocks (Cacheuta facies) are diachronous.

❖ The transgression of the Cacheuta lake resulted in the formation of a regional diachronous unconformity (i.e., a wave-ravinement surface) at the limit between the Middle and the Upper Potrerillos.

❖ The long-term transgression of the Cacheuta coastline was punctuated by higher frequency stages of progradation, visible at well-log scales but below the resolution of the seismic data.

❖ The sequence stratigraphy model, helps to predict new prospects in this continental basin.
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QUESTIONS?