Bolivian Petroleum Systems: Paradigm Shifts*

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Abstract

The petroleum systems of the Bolivian basins have been revised under the light of a fully integrated regional study. The stratigraphic review, including biostratigraphy, sedimentological core description, and seismo-stratigraphic investigations led to new consistent tectono-sedimentary models and allowed the identification of several conceptual plays. The geochemical synthesis coupled with the stratigraphic study allowed a better definition of the potential source rocks. The thermal calibration of the temperature and maturity data is only possible by taking into account an increase of the heat flow during Triassic-Jurassic times. Two main phases of hydrocarbon expulsion are calculated. The first began in Triassic-Jurassic time and the second was contemporaneous with Andean deformation and associated foreland basin. During the Andean phase, the hydrocarbon charge of the sub-Andean traps was controlled by expulsion in the synclines and in the anticlines. Mechanical expulsion related to burial is the main expulsion mechanism in the synclines sometime associated with increase of maturity. In the case of anticlines, expulsion occurred due to the hydrocarbons’ volume expansion during uplift.
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- (1) Beicip-Franlab, (2) YPFB
**Introduction**

**ECATE Project**
- 3.5 years joint exploration project between YPFB and Beicip-Franlab.
- Petroleum system assessment of Bolivia (Altiplano, Madre de Dios, Beni and Chaco Plains, Northern and Southern Sub-Andean, Boomerang hills and Foothills).
- >50 Exploration Projects
- Full access to the country dataset (CNIH)

**Schedule**
- Source Rocks (Southern Bolivia)
- Thermal Calibration and Expulsion
- Trap Charge (Sub-Andean)
Stratigraphy

- 470 wells: Core description and Electric log analysis
- Outcrops
- Analysis of the existing bio-stratigraphy
- Revision of the chrono-litho-stratigraphy
- Sedimentary models
Devonian

- Eifelian Huamampampa and Emsian Huamampampa
- Heterogeneous distribution of Source Rocks
Lochkovian (GDE 1)
Pragian (GDE 2)
New data base (>5800 analysis)
- Type II-III / Type III
- Each mega-sequence has SR potential
- Heterogeneous spatial distribution
Thermal gradient and Heat Flow

(378 wells)

(127 wells)

(20 km below sediments)
Late Triassic Thermal Event

- High maturity gradient in Devonian
- \(\rightarrow\) Past Thermal Event (Regional)

- Volcanism at Trias-Jurassic boundary:

<table>
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<td>Camiri</td>
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</tbody>
</table>

- Plutons: Cordillera Real (Trias-Jurassic)
- ZFT SN > 223+/−32,3 \((XR\text{-Petroandina, 2013})\)
- AFT SS > Late Jurassic \((Geotrack-BGB, 2016)\)
Thermal gradient and Heat Flow

(94 wells)

(20 km below sediments)
Maturity

Los Monos: Oil Window

Icla: Condensate / Gas Window
SR - Fluids

- Rio Seco Gas sourced by Icla
- Huayco Gas sourced by Silurian
2 Expulsion pulses

Los Monos: Oil Window
Icla: Wet Gas Window
Kirusillas: Dry Gas Window

Oil in Iquiri
Expulsion

Syncline

- Maturity
- Mechanical Compaction

Los Monos
Huamampampa
Icla
Santa Rosa
Tarabuco
Kirusillas

Anticline

- Decompression

Key Parameters

- Syncline
  - Sedimentation syn- and post tectonics
- Anticline
  - Amount of Uplift
Charge = FA * SPI (Age) * PSY

Fetch Área

Eifelian: 2500-1540 km$^2$
Pragian: 3980-2200 km$^2$
Mean PSY: 21% ($\sigma = 12\% ; n = 11$)

PSY: 25%

PSY: 15%

PSY: 8%
**Charge – Filling Factor**

Age: 4.5 Ma  →  SPI 0.13 t HC / m²
PSY: 21%  →  Total gas 3.9 Tcf (mean)
Tank: 4.1 Tcf  →  Filling Factor: 89%

Charge (mean 3.9 Tcf)  Tank (mean 4.1 Tcf)  Filling Factor (mean 89%)  \( P (FF < 99\%) = 55\% \)
Conclusions

**Present**
- Los Monos is not the unique source rocks of Bolivia
- Two major expulsion pulses
- Compact petroleum system during the Andean pulse with expulsion due to:
  - Compaction and Maturity in syncline
  - Depressurization in anticline
- Quick and Efficient calculus of trap charge in the sub-Andean

**Future**
- Looking for new plays such as:
  - Paleozoic pinch-out
  - Carboniferous stratigraphic traps
  - Unconventional
Oral – Poster - Booth

- **(Oral) Chaco Plain**: Future exploration potential associated with glaciogenic carboniferous series in Bolivian Sub Andean Chaco Foreland system.
- **(Poster) Boomerang**: Probabilistic attribute derived from Pre-stack seismic inversion and characterization for prospect identification into Boomerang area
- **(Poster) Boomerang**: Petroleum Systems Modeling and Hydrocarbon Charge Assessment in Pie de Monte Boomerang Province, Bolivia
- **(Poster) Madre de Dios**: Stratigraphic and sedimentary processes simulation to explore the Silurian and Devonian sequence in the Madre de Dios basin
- **(Poster) Sub-Andean**: A New Kinematic Tool for Petroleum System Modeling in Complex Structural Settings: Application to the Andean Foothills
Acknowledgements

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