Hydrocarbon Potential of the Bolivian Santa Cruz-Tarija Foreland Basin*

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Abstract

The Santa Cruz-Tarija Foreland Basin, located in the southeastern part of Bolivia is, from an exploration point of view, an intermediate sub-Andean basin (1800 sq km). A complete stratigraphic revision has been carried out which suggests some changes in the historical sedimentary models. In particular, the intimate stratigraphic architecture of glaciogenic Carboniferous series has been partially resolved at the basin scale. The results allow distinguishing an extremely strong intrinsic architectural complexity relying on the glaciogenic nature of deposits as well as the occurrence of numerous undrilled stratigraphic traps. The geochemical study indicates existence of various Silurian to Devonian source rocks with influence of continental-marine environments, in which a Pridoli shale sequence below the El Carmen Formation and the Lochkovian Boomerang Shale Member of the Robore Formation could be good candidates for unconventional exploration.

To evaluate the hydrocarbon potential of the basin, a 3D dynamic model has been built. The thermal calibration of the temperature and maturity data is only possible considering an increase of the heat flow during Triassic-Jurassic time. Therefore, most of the hydrocarbons are expelled before Cretaceous times by the identified kitchen. The remaining were expelled between the Oligocene and present time. Lateral long-distance migration through the Silurian and Devonian carrier beds occurred before Andean deformation. Silurian or Devonian pinch out against the Brazilian craton were then filled during the first expulsion phase. The Mesozoic and Cenozoic plays were then charged by vertical and lateral migration. The Andean deformation resulted in enhancing the structural closures and vertical migration. At present day, the regional study allowed identifying more than 60 leads and prospects in the Boomerang area, and close to 85 leads in the Chaco Plain. The average in-place yet to find, evaluated by combining basin modeling results and creaming curve analysis, is 16 Tcf of gas and 470 MMbbl of oil for the Boomerang area, while it is 30 Tcf of gas and 900 MMbbl of oil for the Chaco Plain.

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BeicipFranlab

YPFB
La fuerza que transforma Bolivia

Introduction

Project ECATE

3.5 years joint project (2015-2018) carried out by Beicip-Franlab and YPFB

7 Regional Studies (Altiplano, Madre de Dios, Llanura Beniana, Llanura Chaqueña, Subandino Norte y Sur, Piedemonte y Boomerang)

47 Exploration Projects

Results

Potencial of Bolivia (Yet to Find): 136 Tcf gas & 17 Bbbl oil.

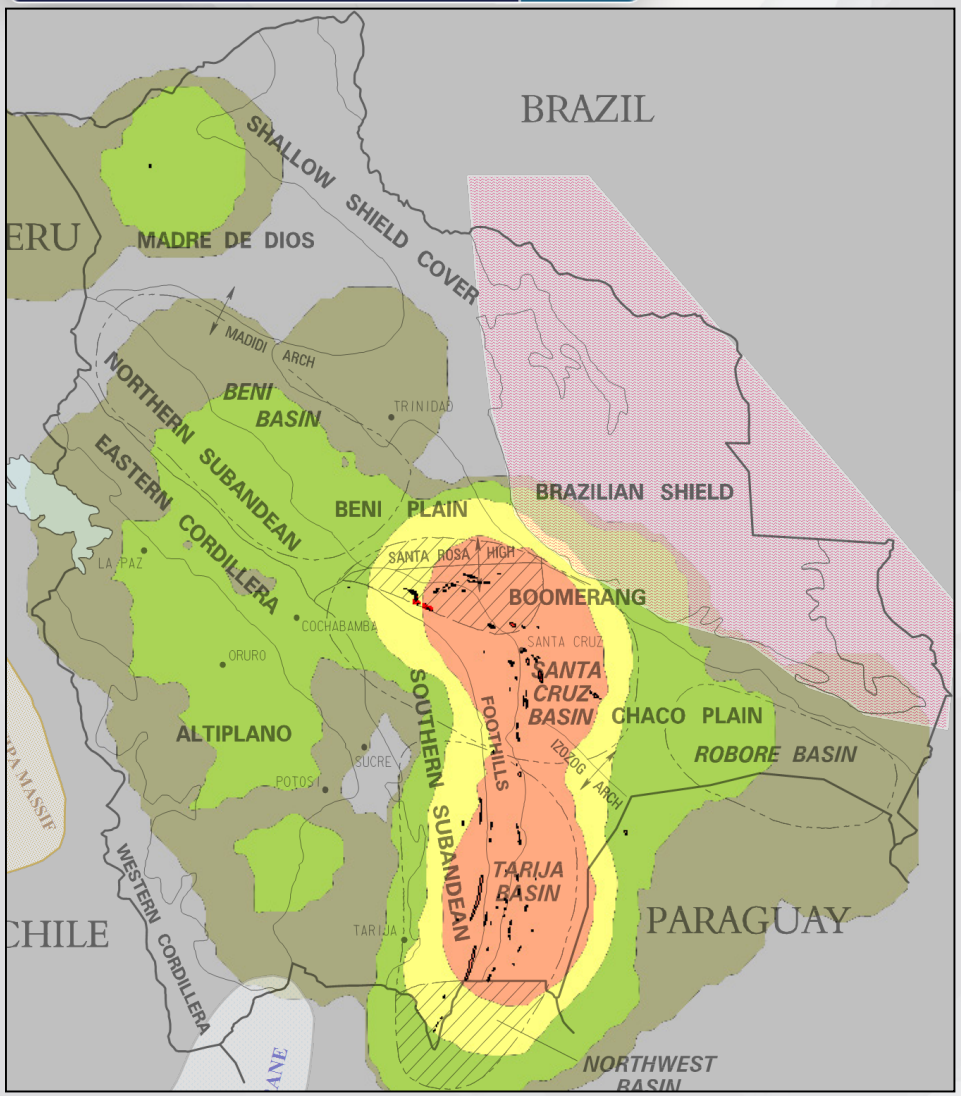
Portafolio: ~10 New Plays, >250 leads, ~20 prospects , 6 drilling projects.

Prospective Resources: 34 Tcf gas & 0,8 Bbbl oil.

Risked P.R.: 9 Tcf & 115 MMbbl oil

Yet to Find and Prospective Resources are mean in situ, which does not include unconventional accumulations

Santa Cruz – Tarija Basin

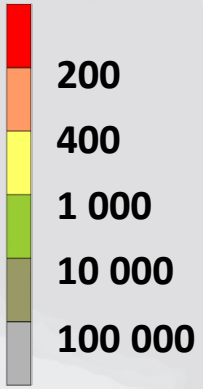


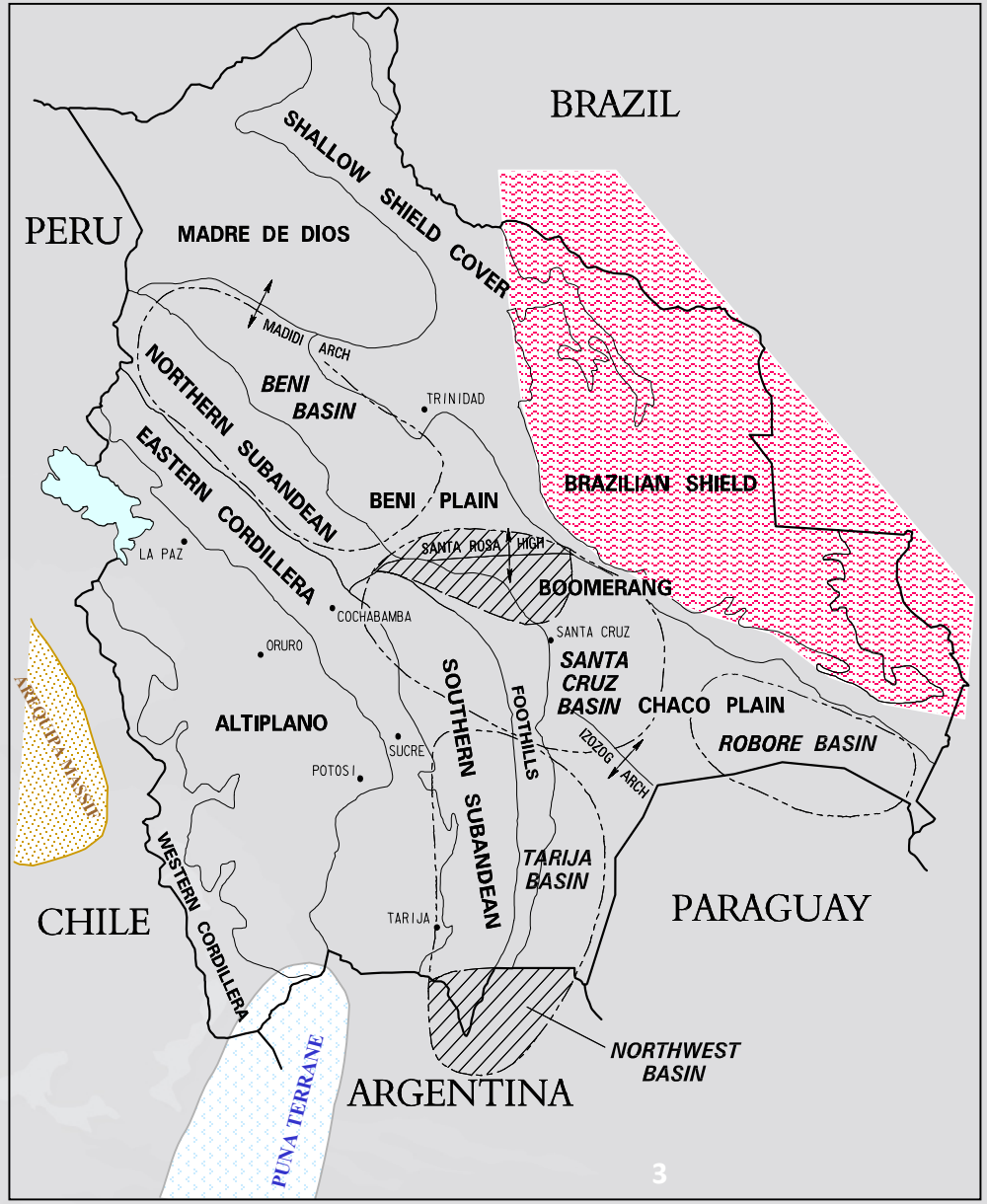
(Grid 5 km x 5 km, R: 125 km)

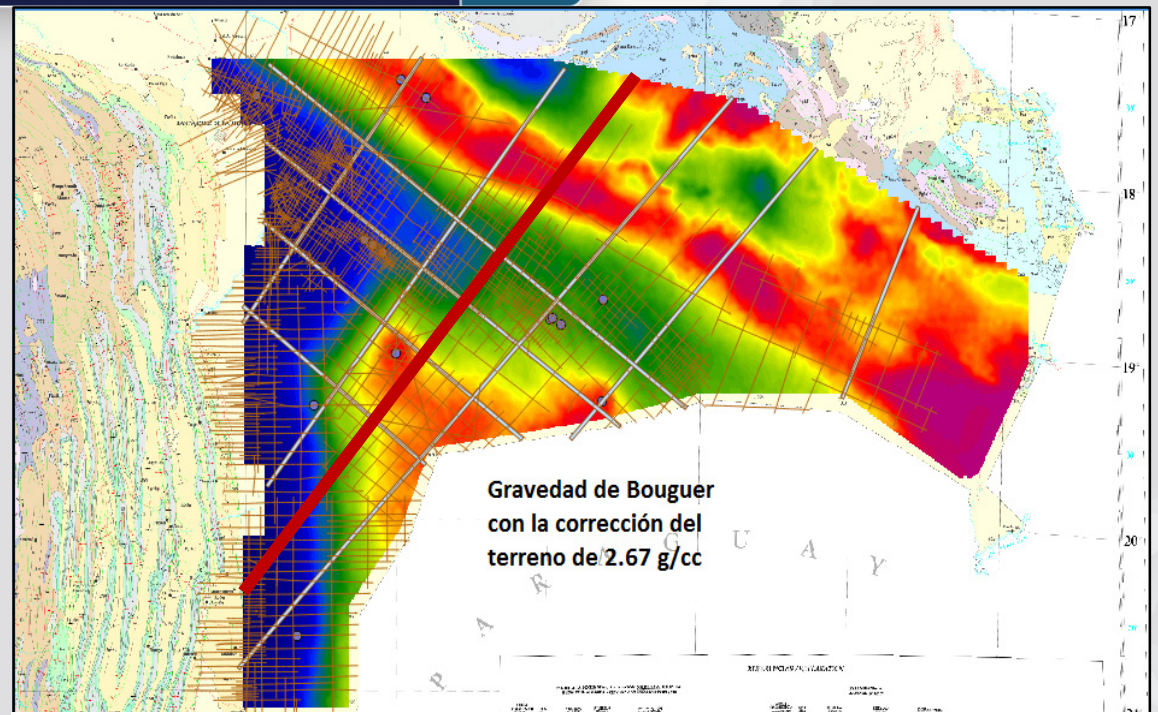
Basins:
- Santa Cruz
- Tarija
- Robore

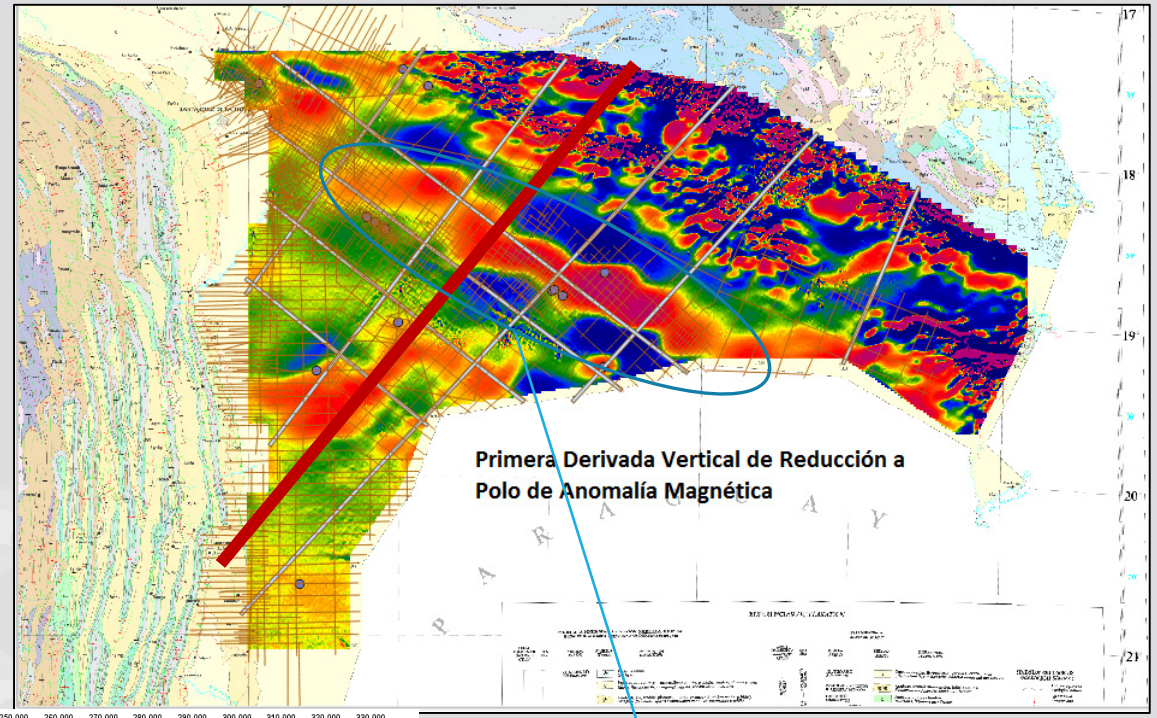
Structural Provinces:
- Foothills
- S. Subandean
- Chaco plain
- Boomerang

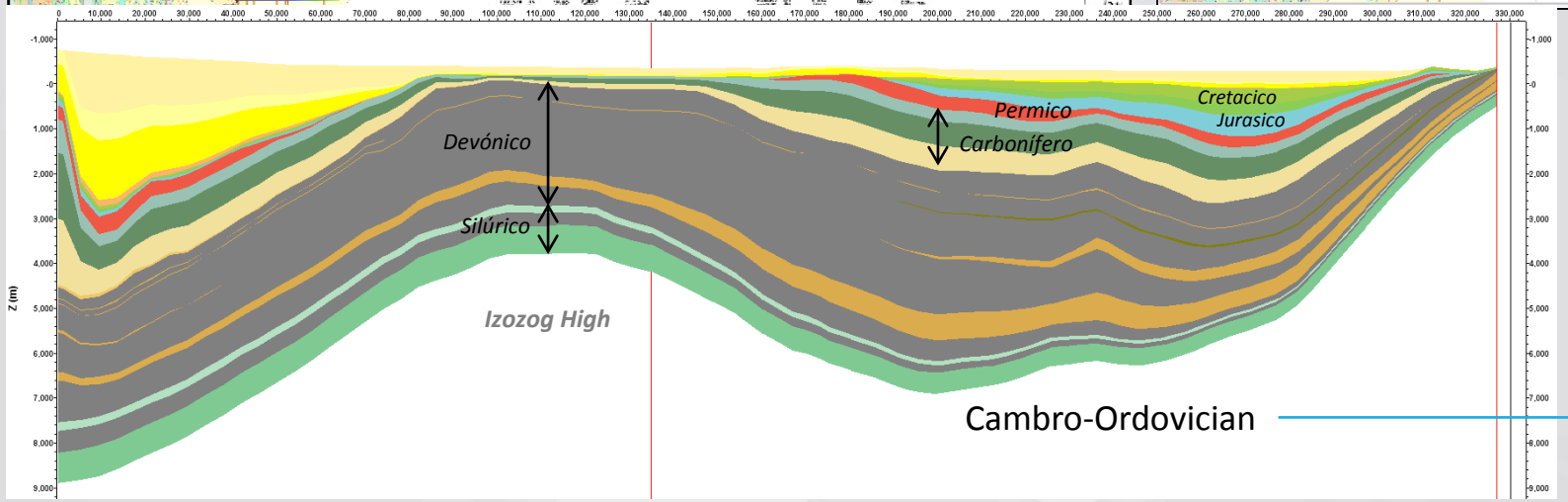
Well density (km^2/well)



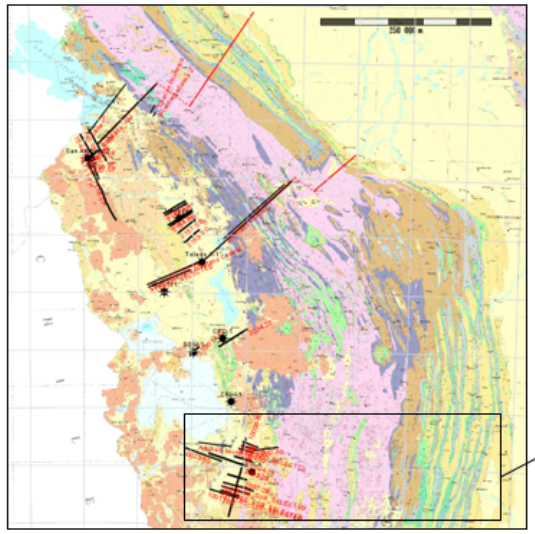


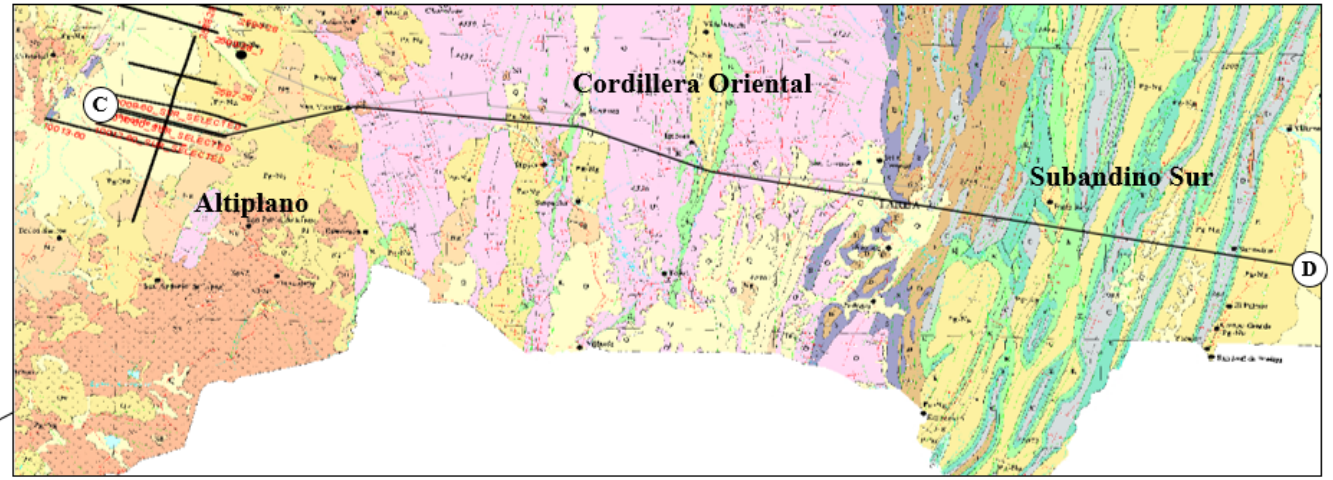






Cambro-Ordovician → Aborted rift ?

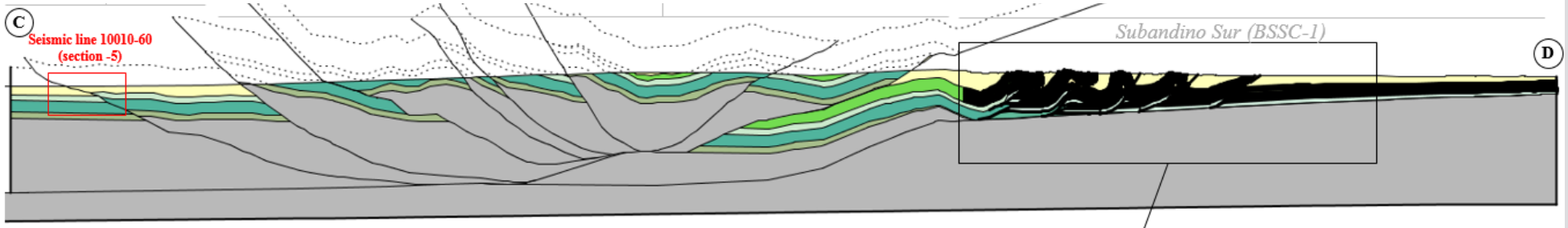


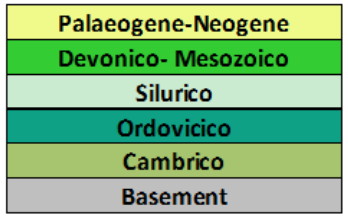


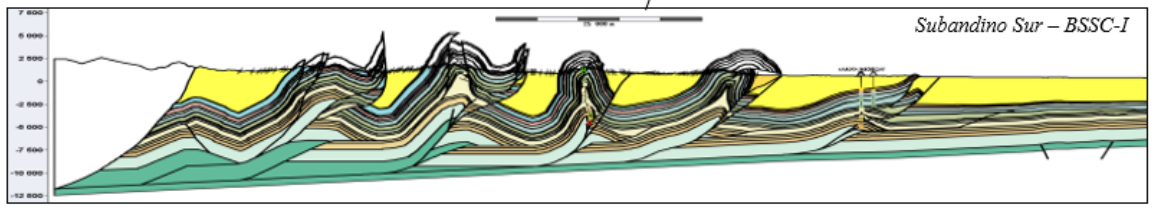
Altiplano

Eastern Cordillera

Southern Sub Andean







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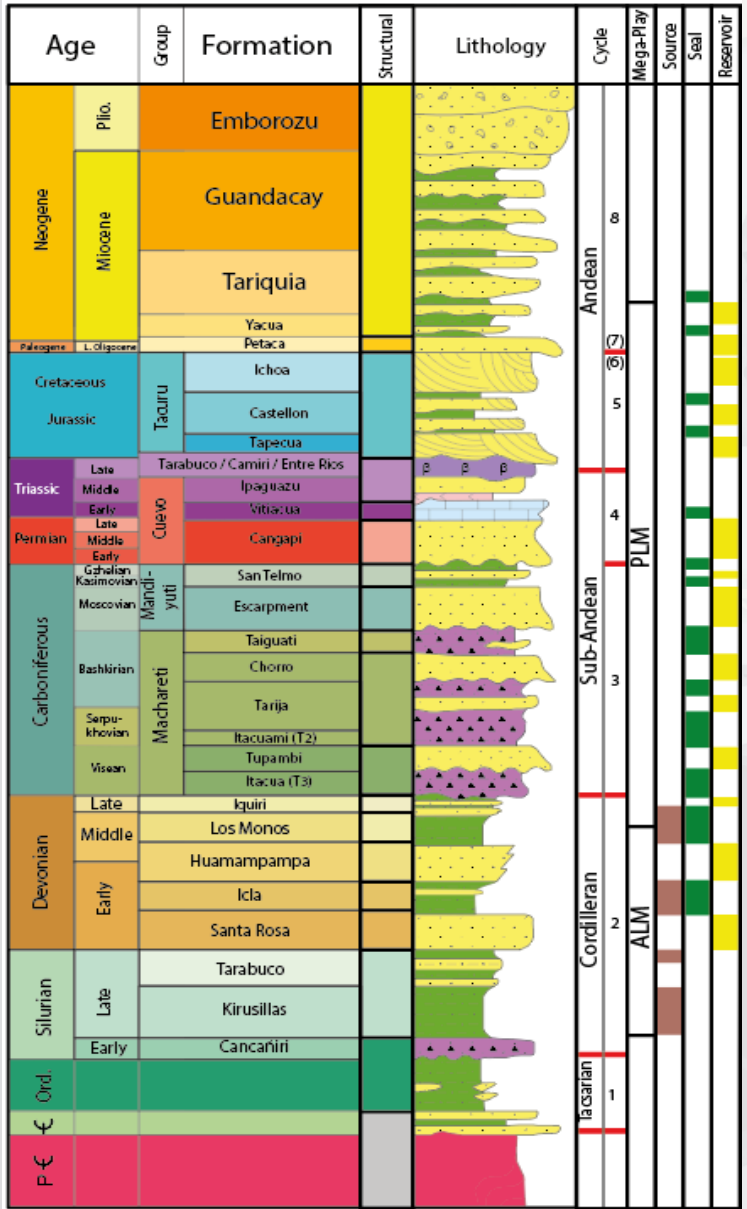
AAPG 27-30 August Buenos Aires, Argentina

Petroleum Systems



Total in place: 48,7 Tcf

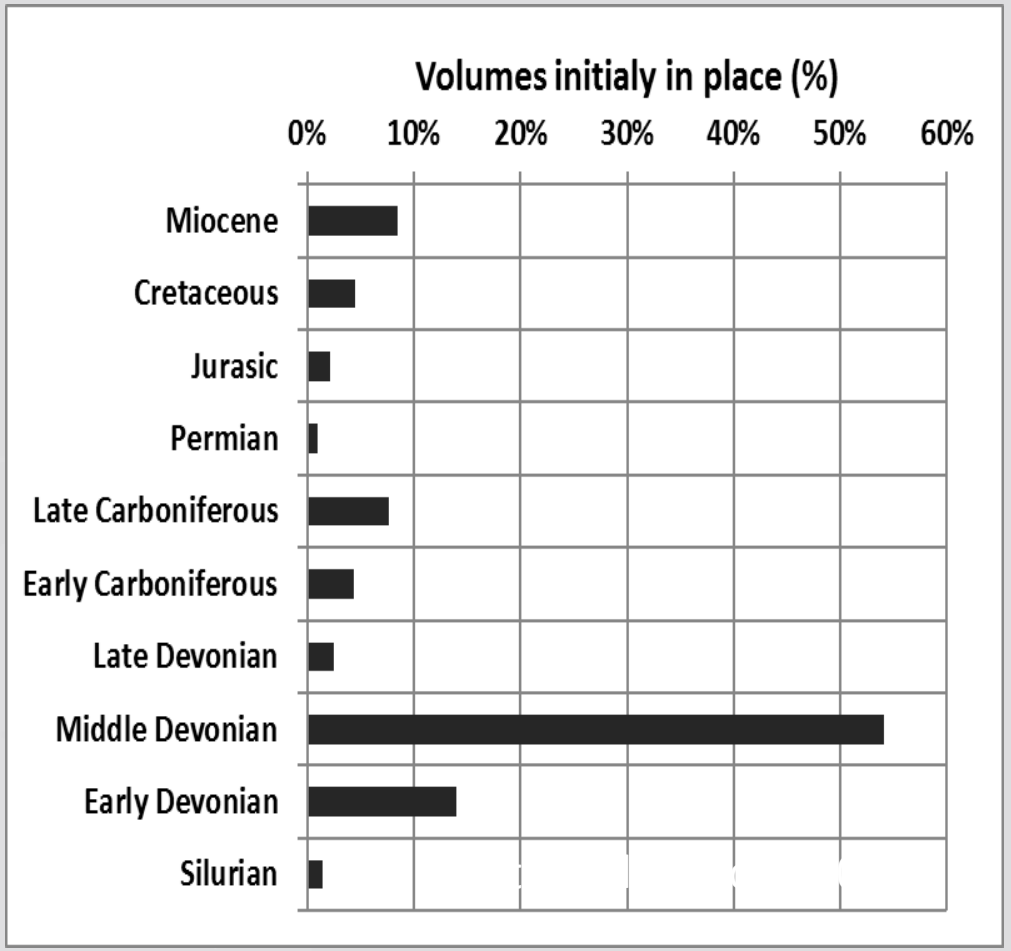
Total Recoverable: 28.4 Tcf

(Ryder Scott, 2009)

22% PLM

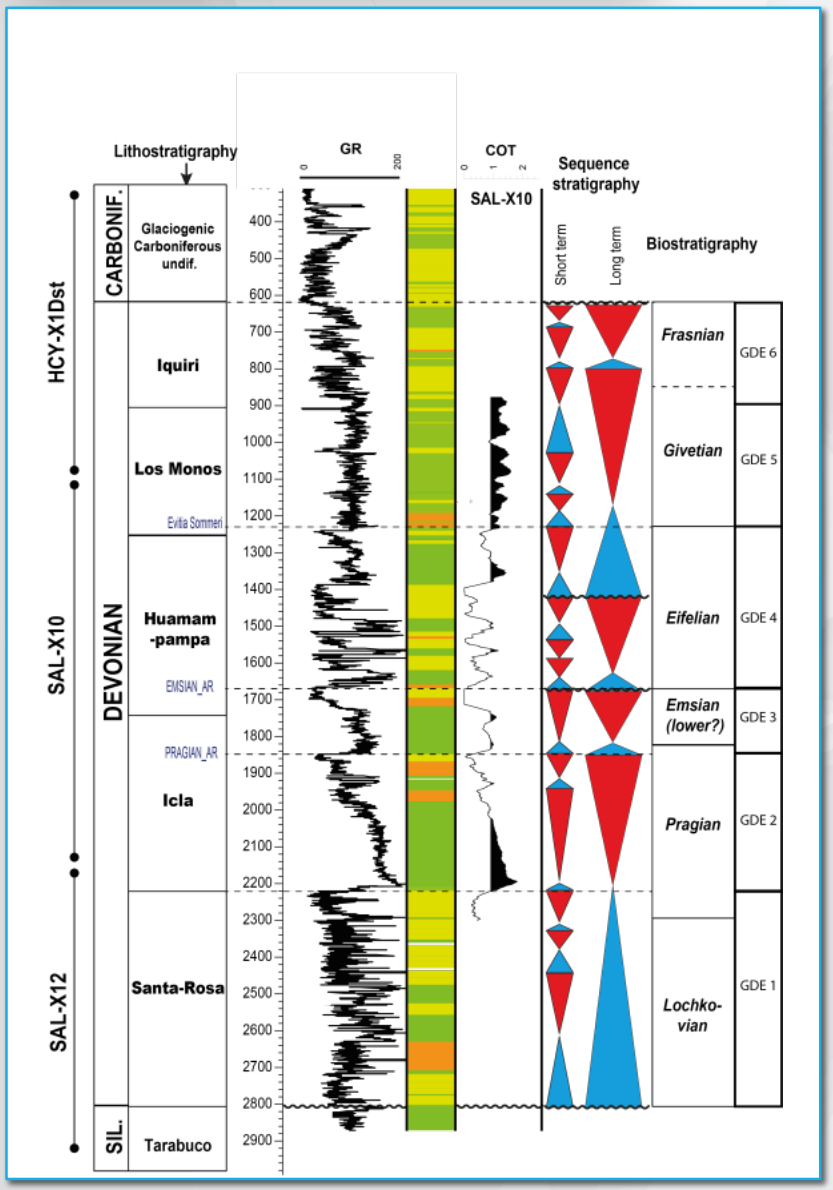
78% ALM

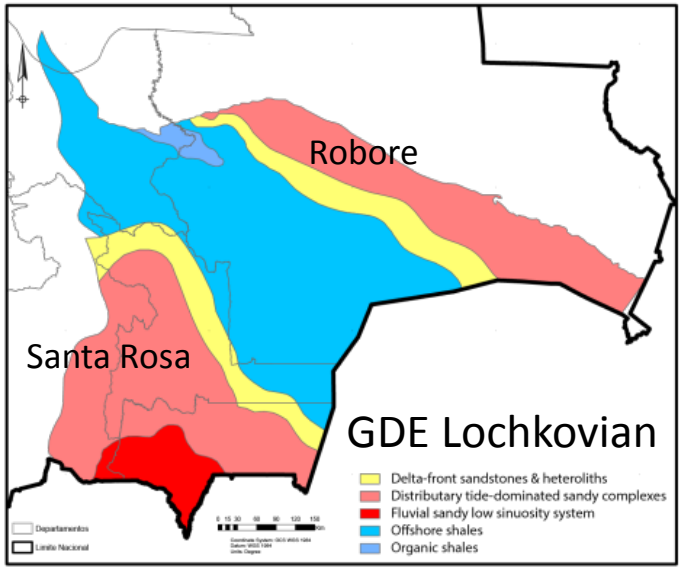
(53 % Huamampampa)

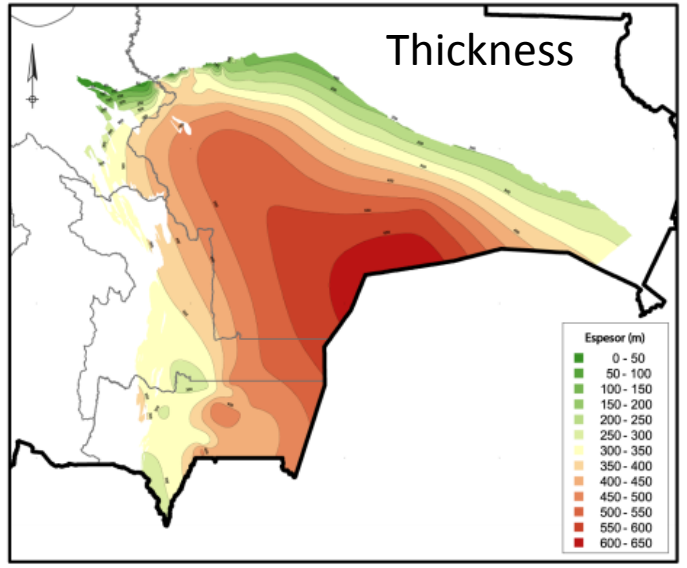


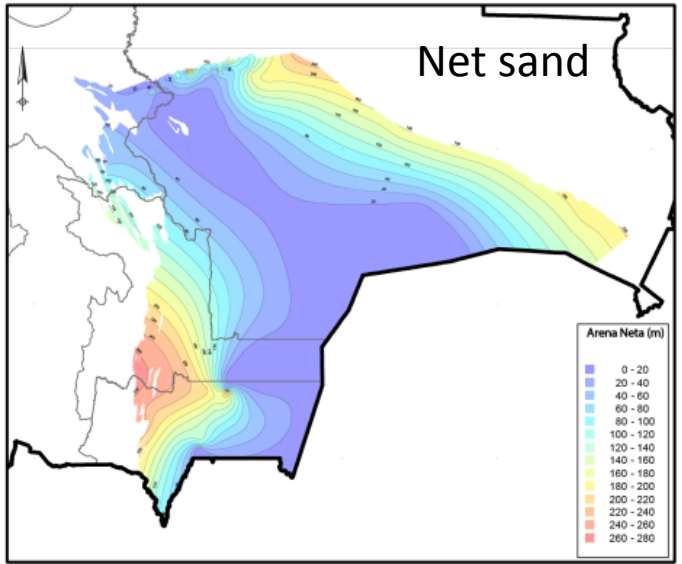
2 Mega-Plays: Ante Los Monos (ALM) y Post Los Monos (PLM)

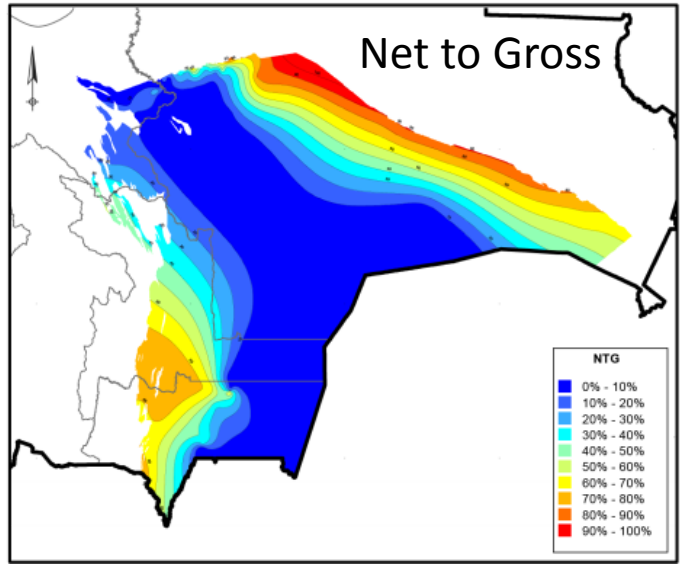
Stratigraphy



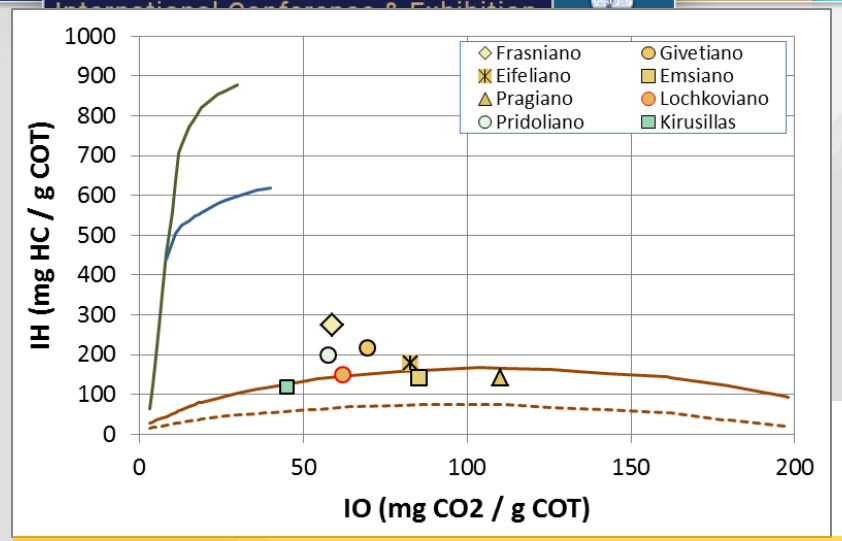


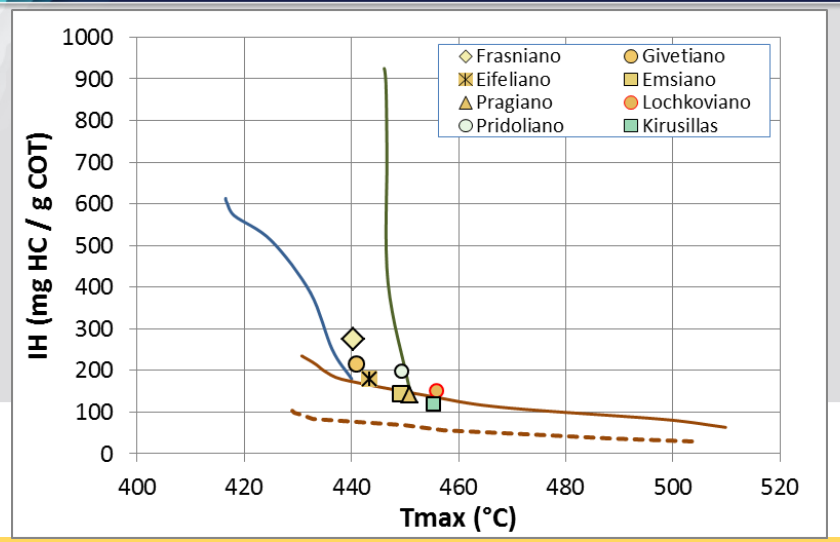


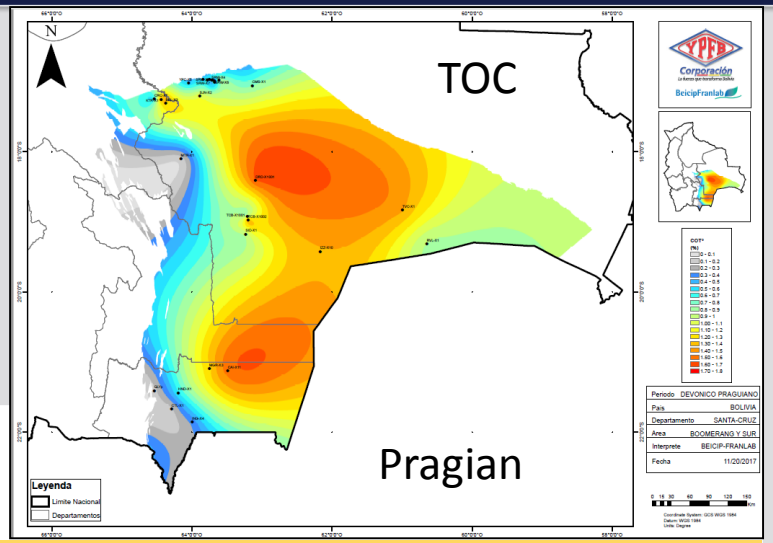




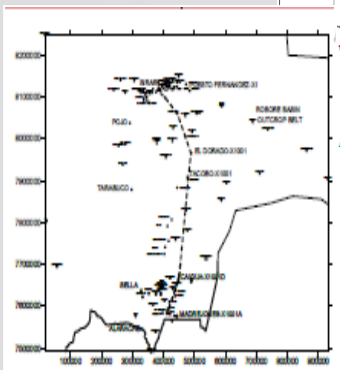
Silurian and Devonian Source Rocks

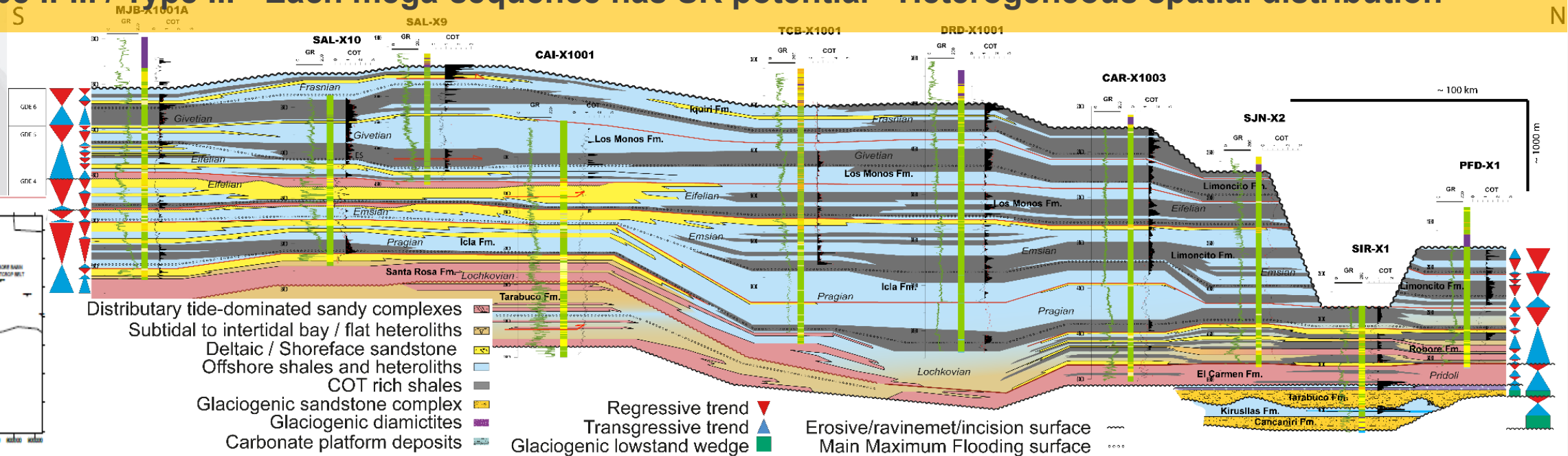




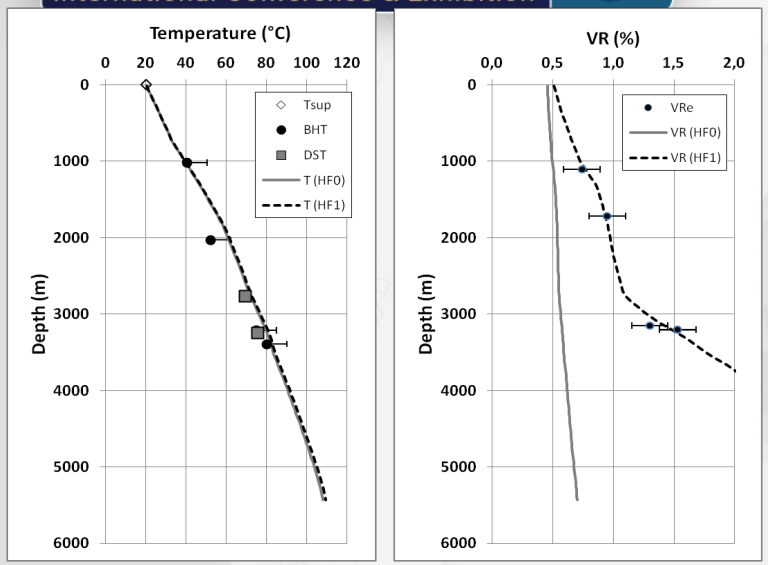


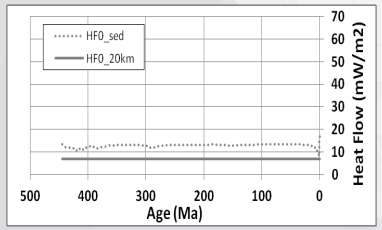
Type II-III / Type III - Each mega-sequence has SR potential - Heterogeneous spatial distribution

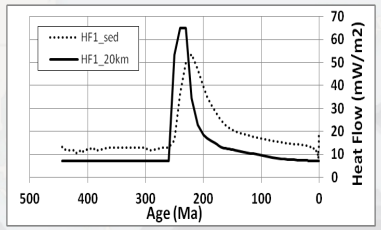


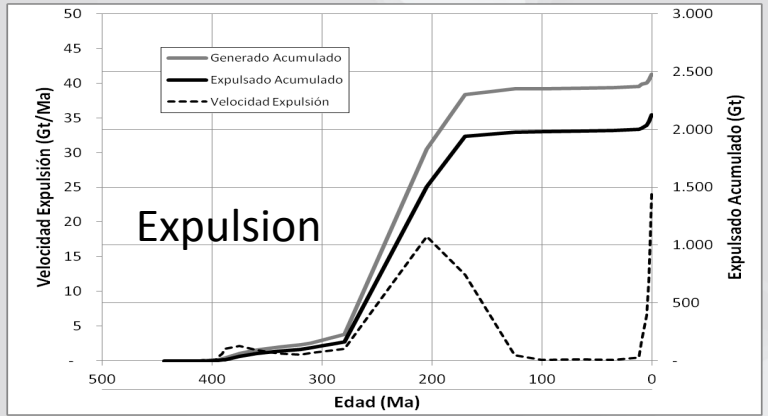


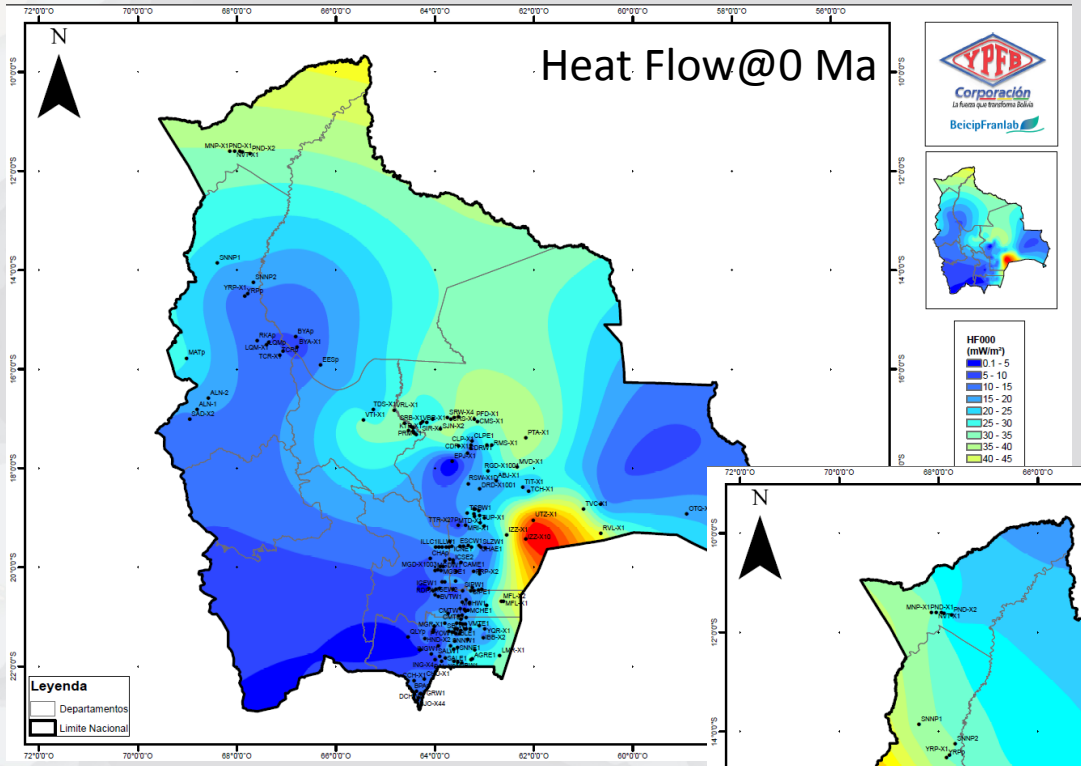
Thermal gradient and Heat Flow

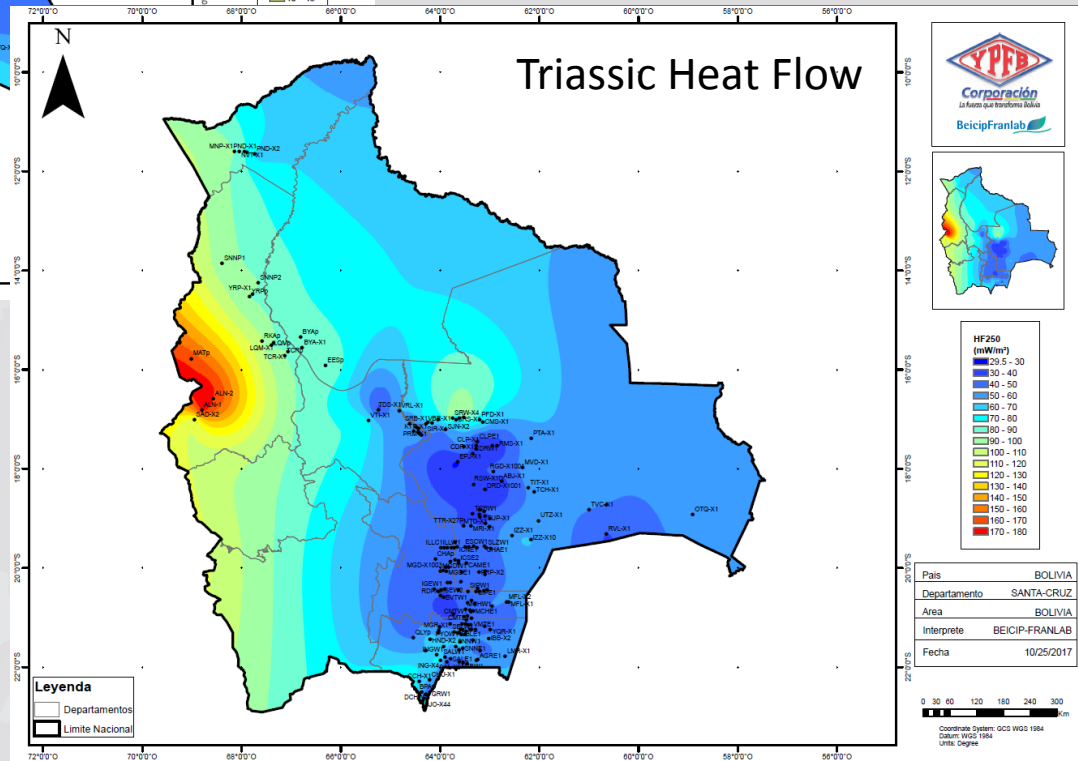










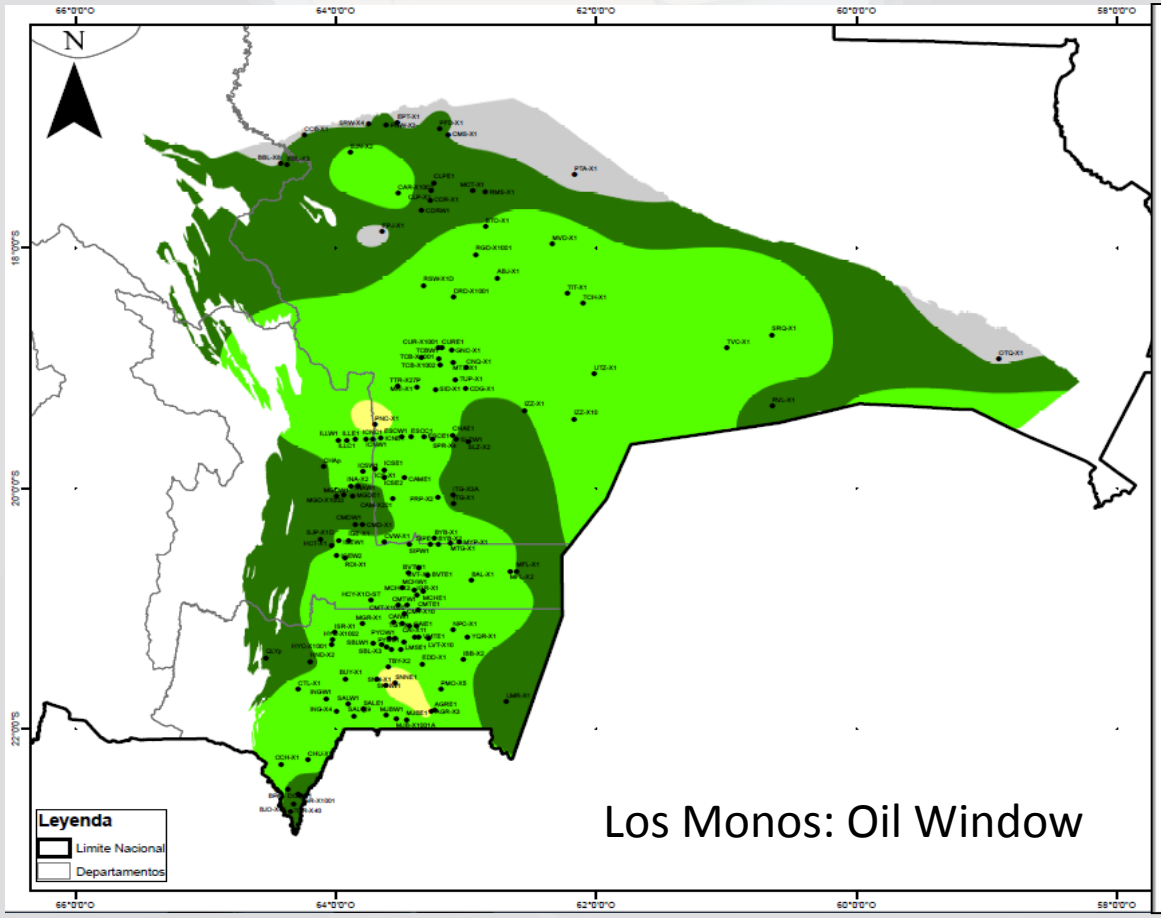


Temperature and maturity calibration is reached considering a Triassic thermal event

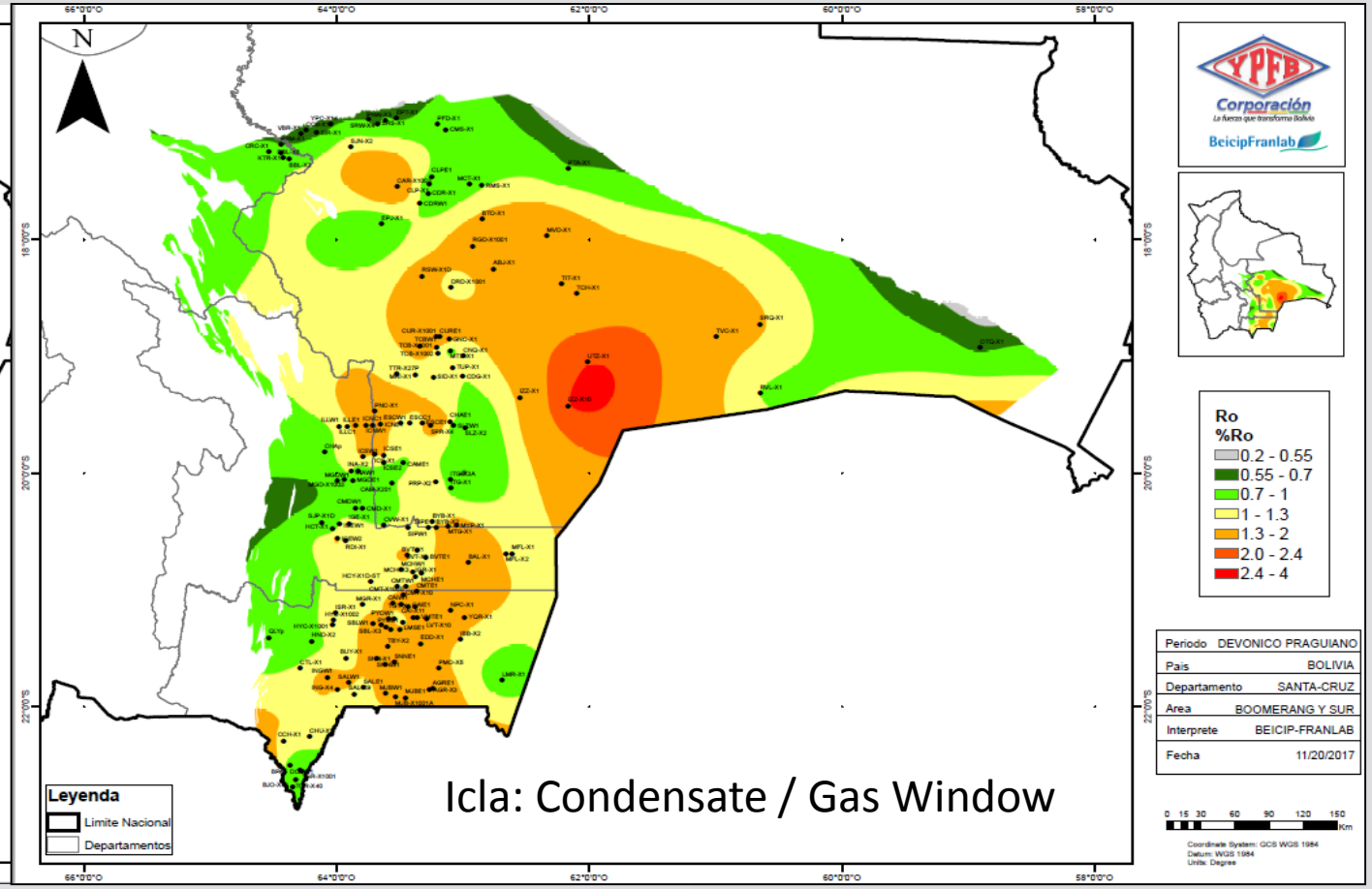
Most of the expulsion occurred before Cretaceous

A second phase of expulsion is associated to the Andean phase

Maturity



Los Monos: Oil Window

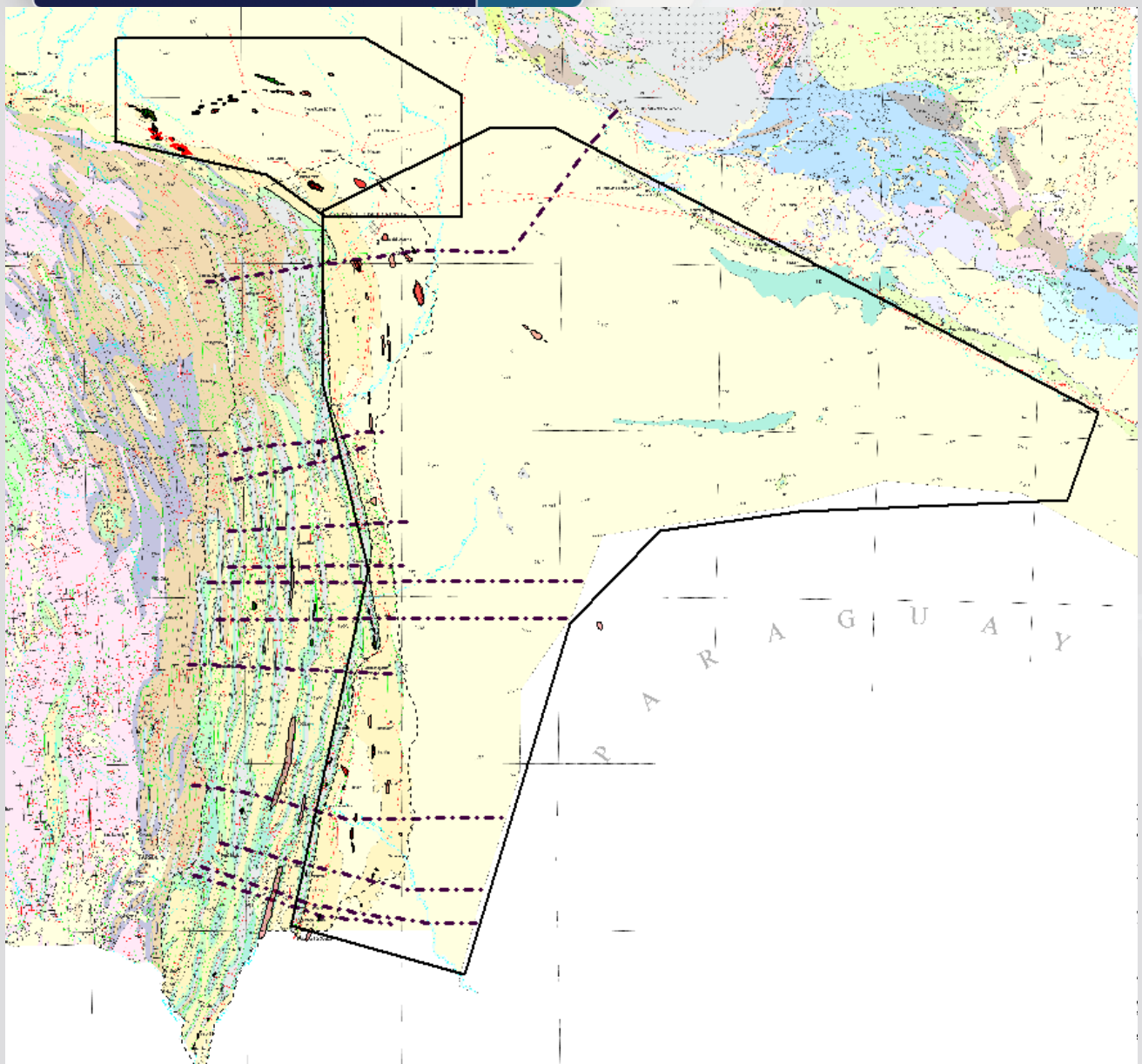


Icla: Condensate / Gas Window

Not the source of Huamampampa gas !

Better candidate for Huamampampa gas !

Methodology



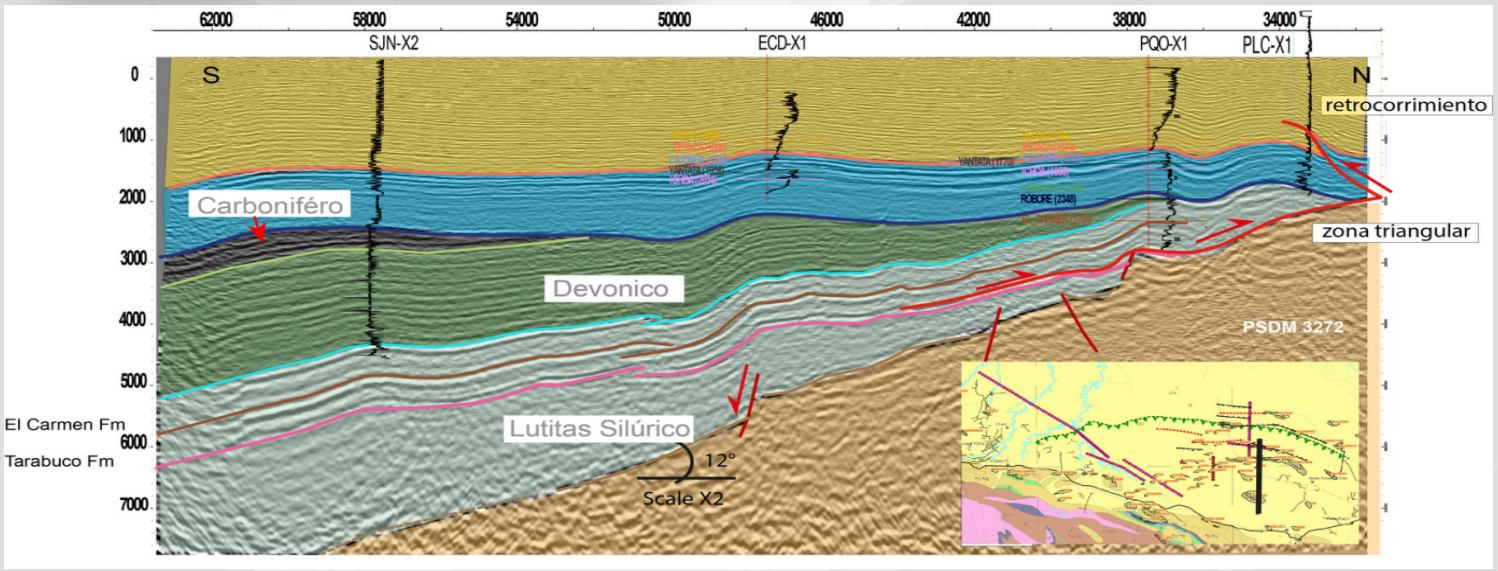
Regional synthesis: Stratigraphy, Sedimentology and Organic Geochemistry

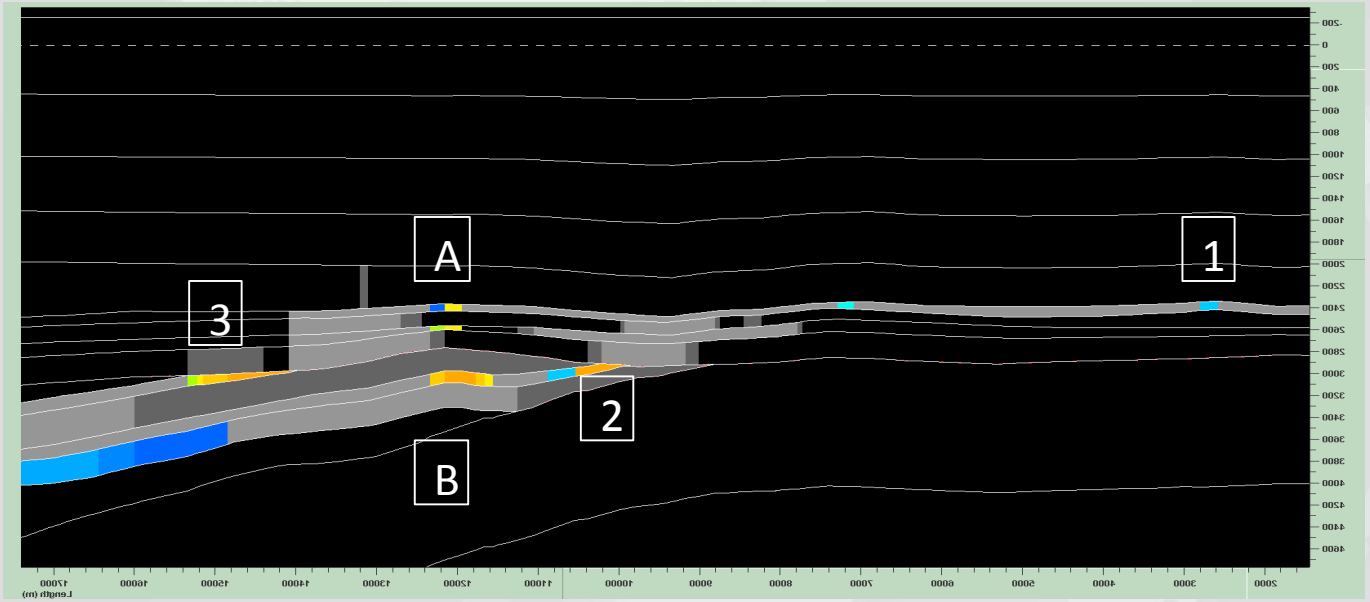
Boomerang (mature)
- Structural maps
- 3D basin modeling
- Creaming curve

Chaco Plain (frontier)
- Structural maps
- 3D basin modeling

Southern sub Andean and Foothills (mature)
- Structural sections
- 1D basin modeling and fetch area
- Creaming curves

Boomerang





Proven plays

A: Andean structure in Petaca and Yantata Fms

B: Andean structure in Silurian and Devonian

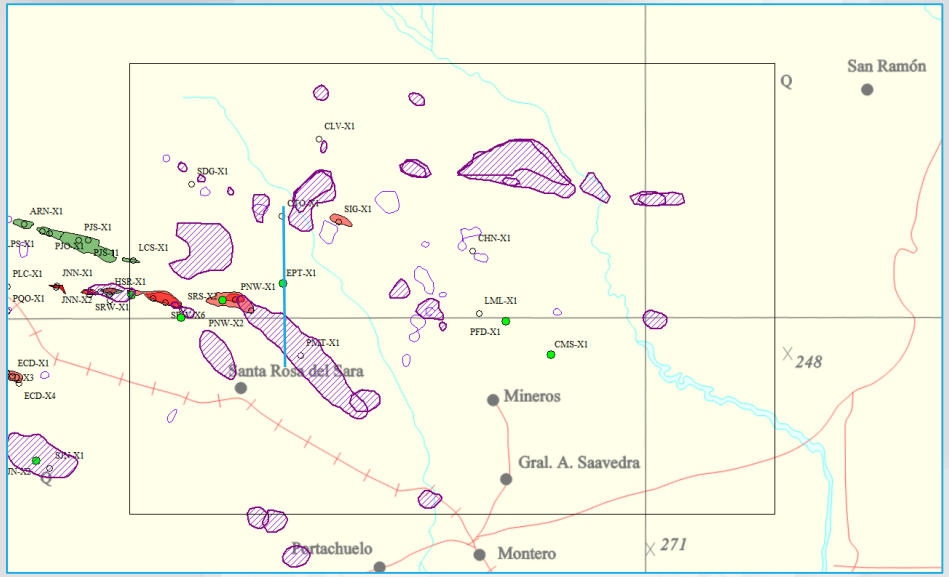
Conceptual plays

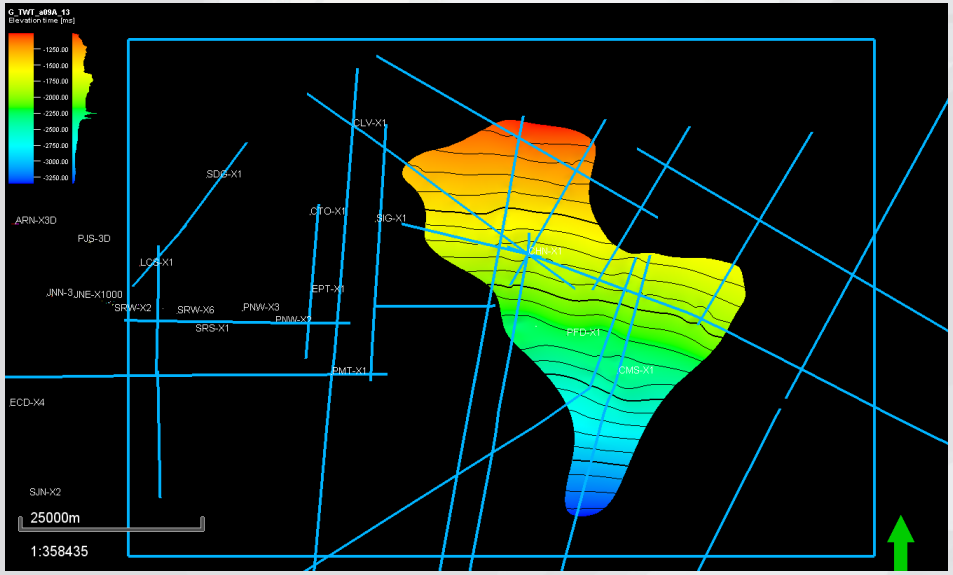
1: Long range migration in Petaca Fm toward the N - NE

2: Stratigraphic in Silurian

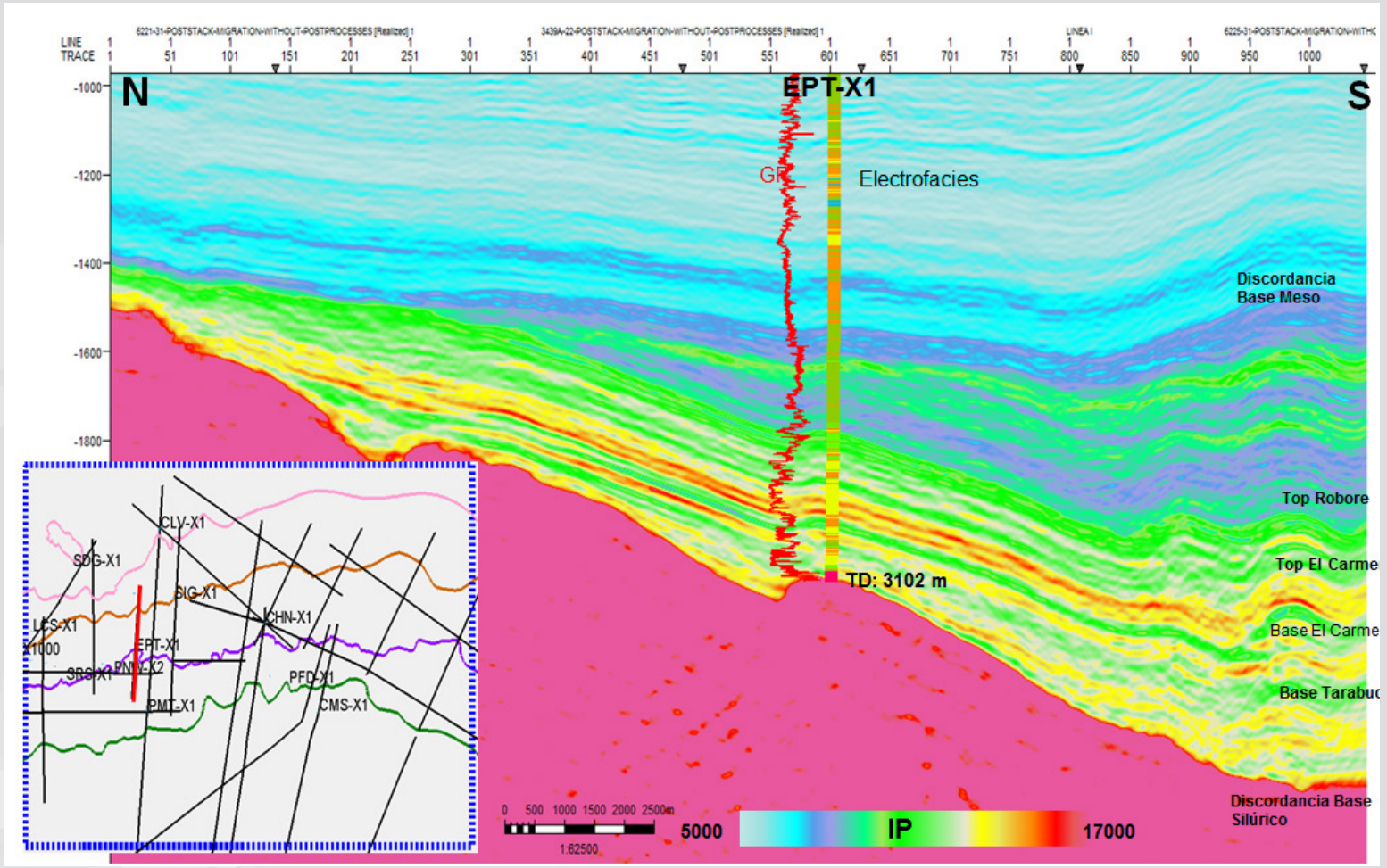
3: Stratigraphic in Devonian

Boomerang Paleozoic pinch out

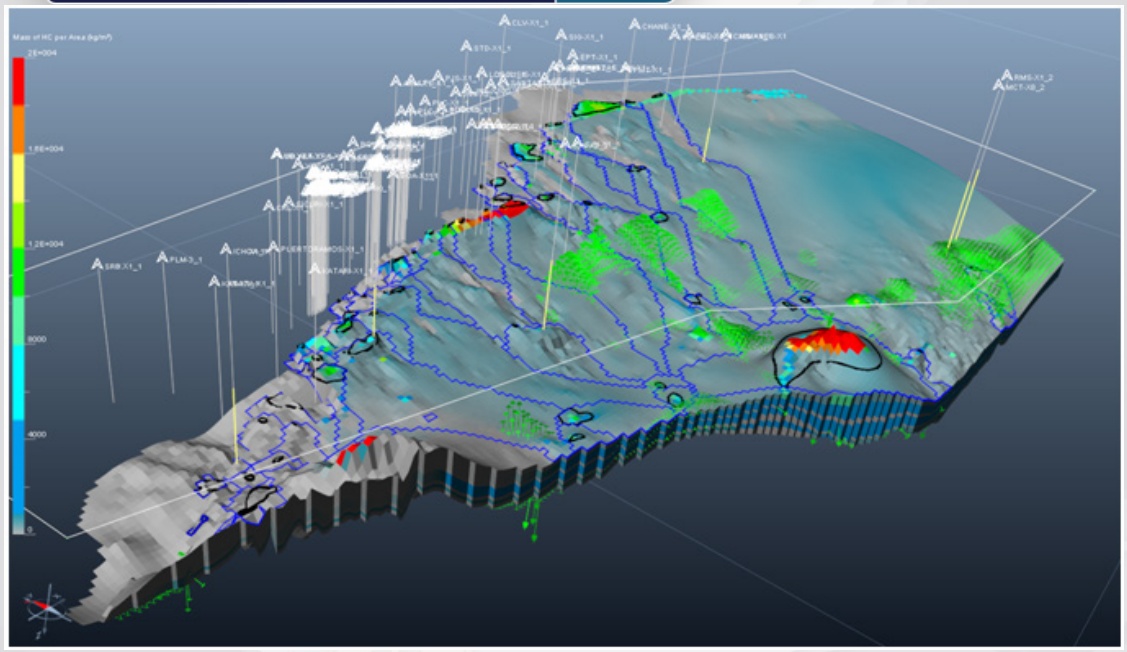




Acoustic inversion



3D basin modeling and balance

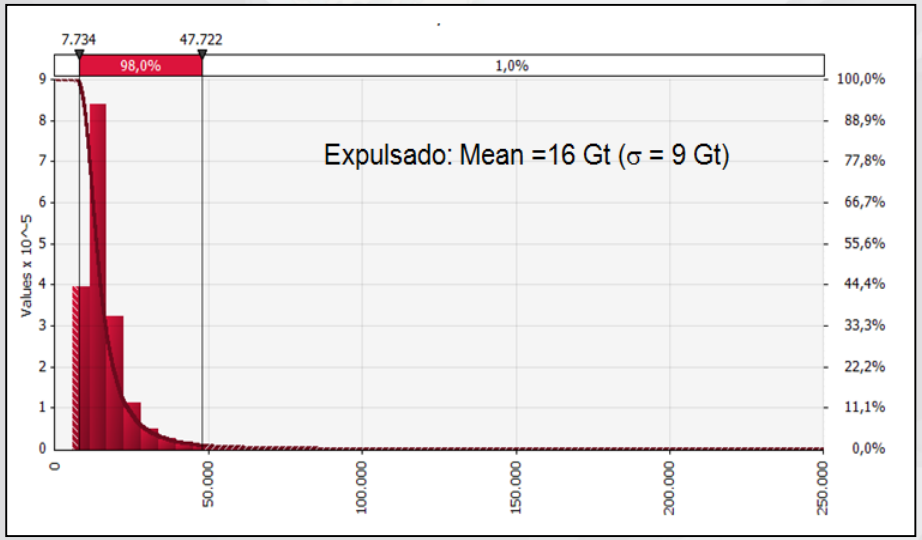


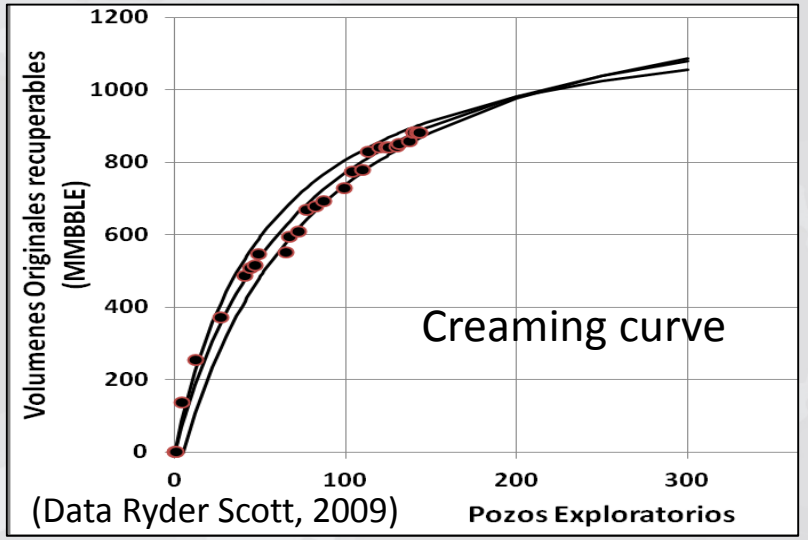
Discovered 880 MMBBLE (2009) PSY: 1,3 % (P99)

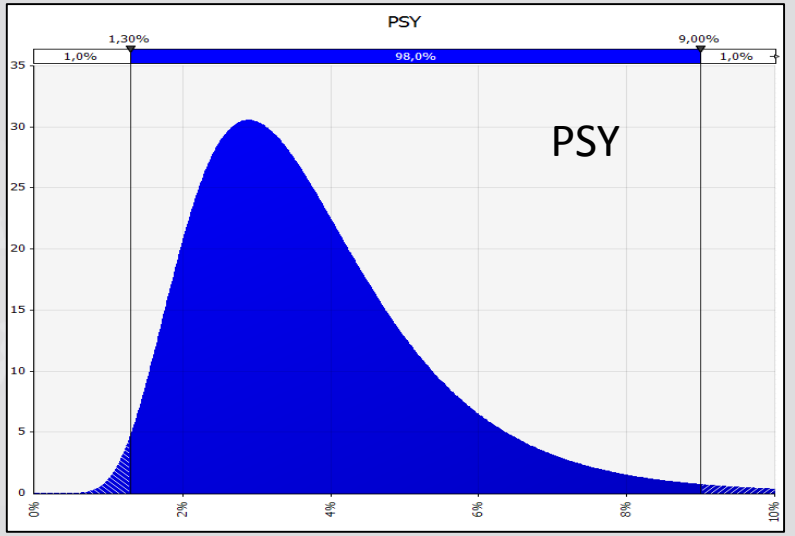
Creaming curve asymptote: 1250-1400 MMBBLE PSY: 2 %
→YTF: 370-520 MMBBLE (without new plays)

3D basin modeling:
- **Expelled 135 GBBLE (mean)**
- **Trapped: 12 GBBLE (mean)** PSY: 9 % (P01)

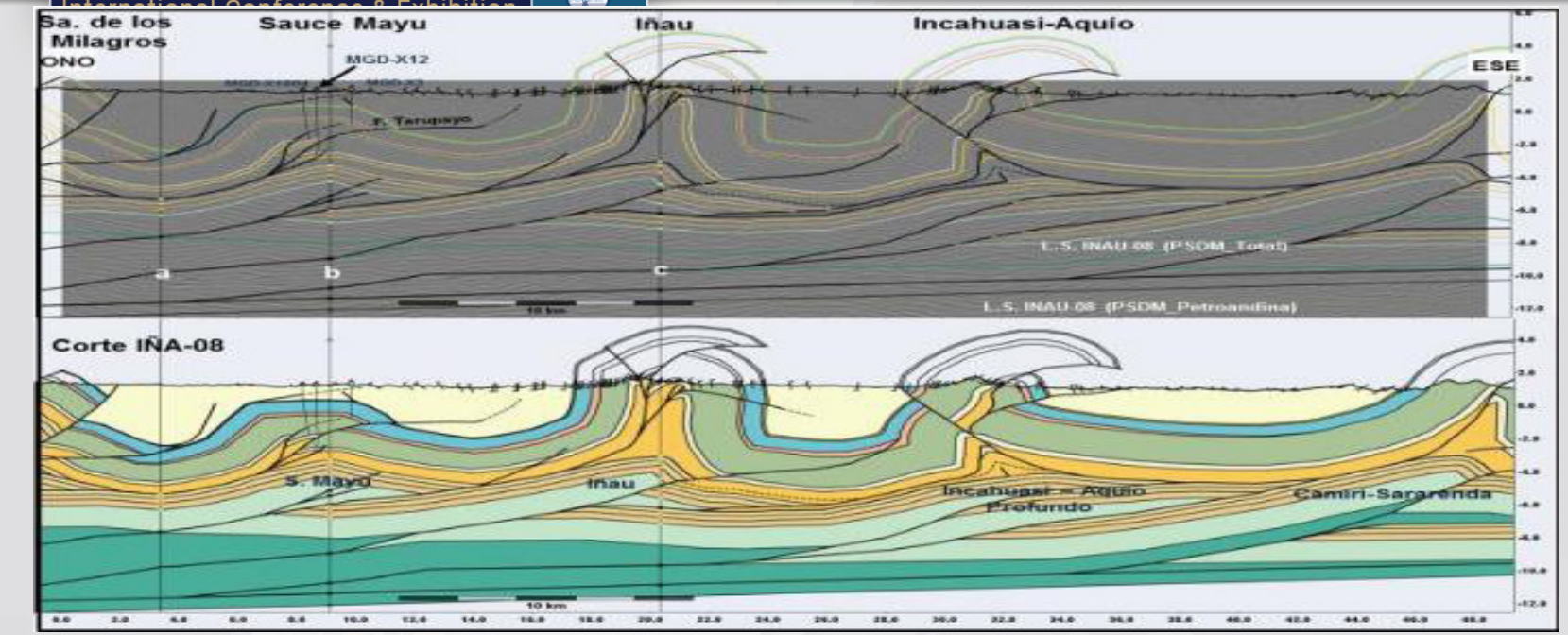
PSY (mean): 3.7 %
→ YTF: 3,2 GBBLE in place (470 MMbbl oil y 16 Tcf gas)

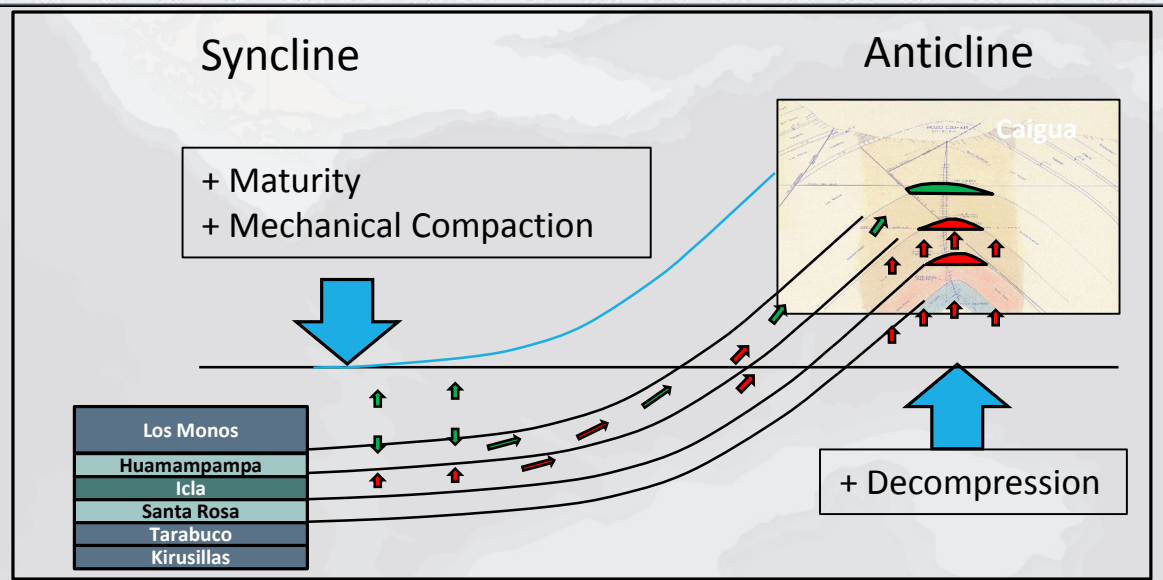


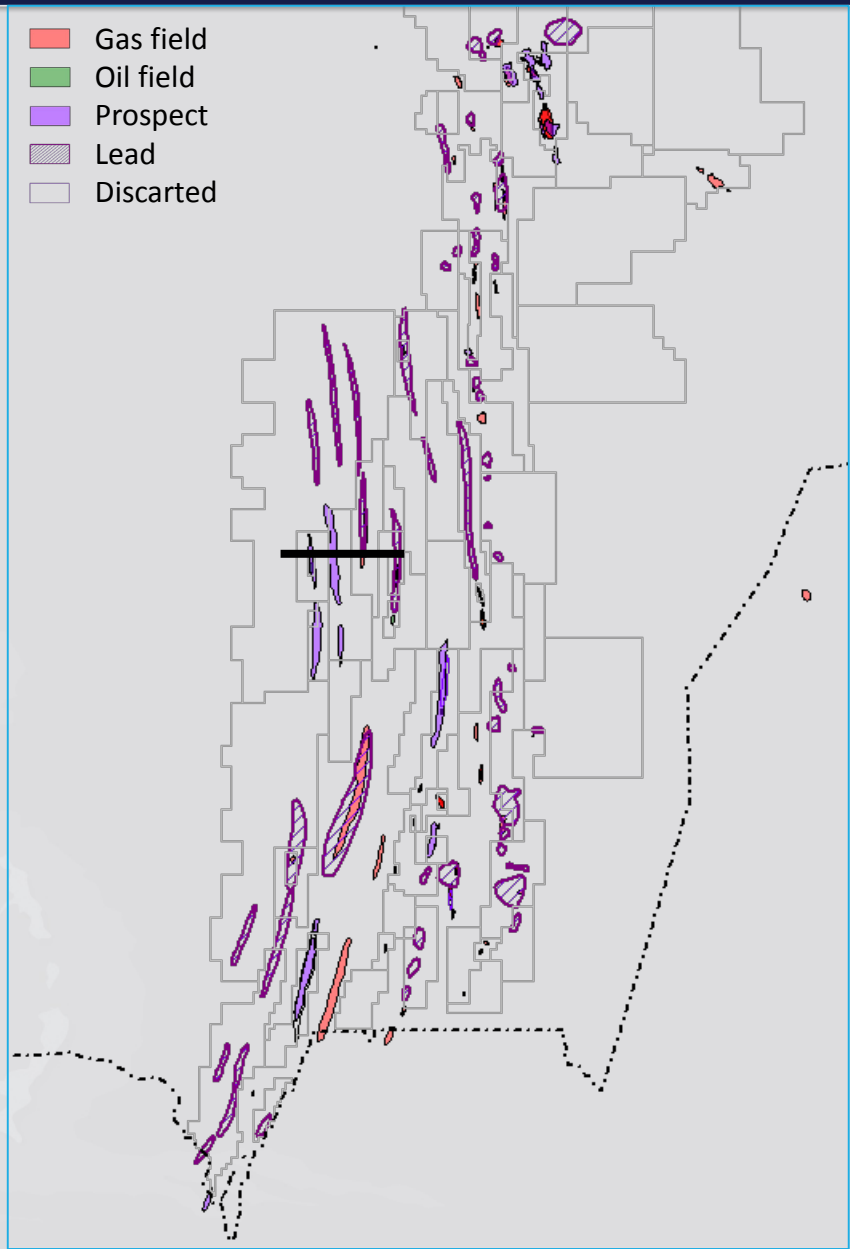




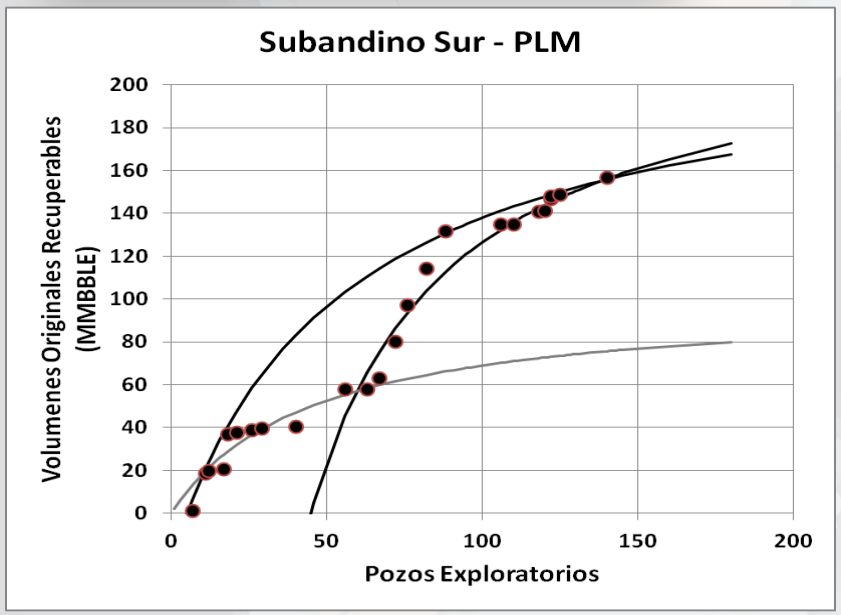
Southern Sub Andean and foothills





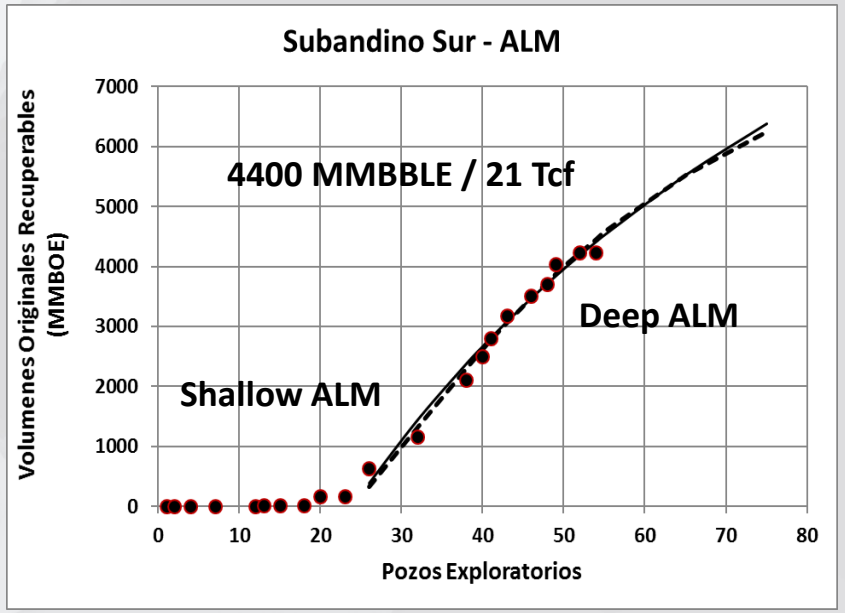


Creaming curves: Yet to Find



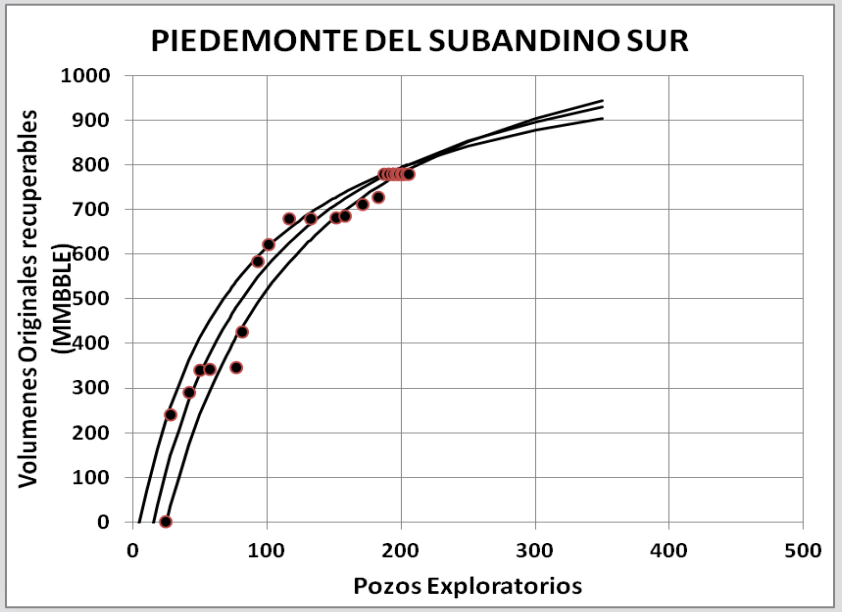
157 MMBBLE (2009)

Asymtote: 225-230 MMBBLE
→YTF: 68-73 MMBBLE



4400 MMBLE (2009)

Asymptote: 11400 - 17500 MMBBLE
→YTF: 7000-13100 MMBBLE



780 MMBBLE (2009)

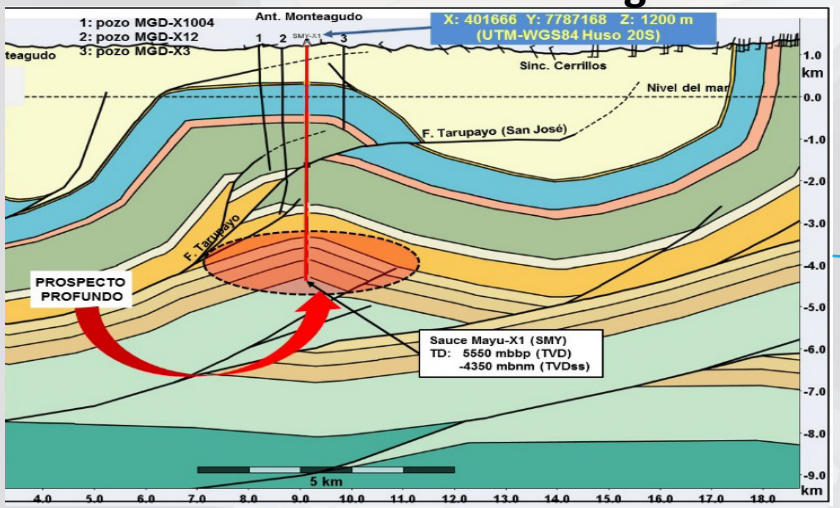
Asíntota: 1100 - 1250 MMBBLE
→YTF: 320-470 MMBBLE

Yet To Find : 74 Tcf (mean) in place (without new play)

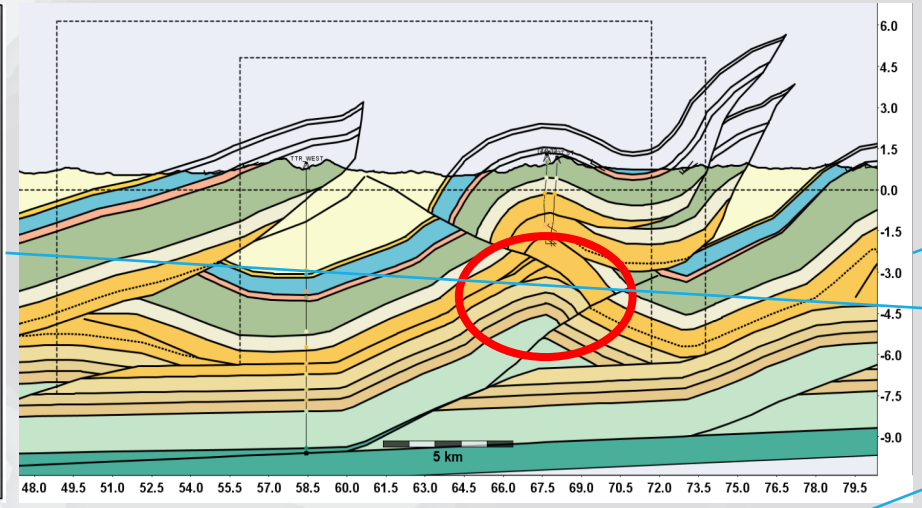
(Data Ryder Scott, 2009)

Prospective resources

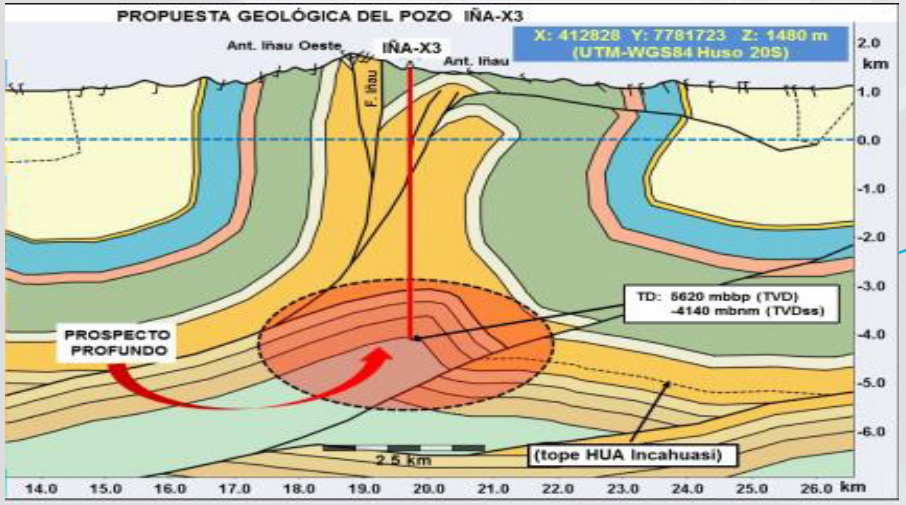
Monteagudo ALM



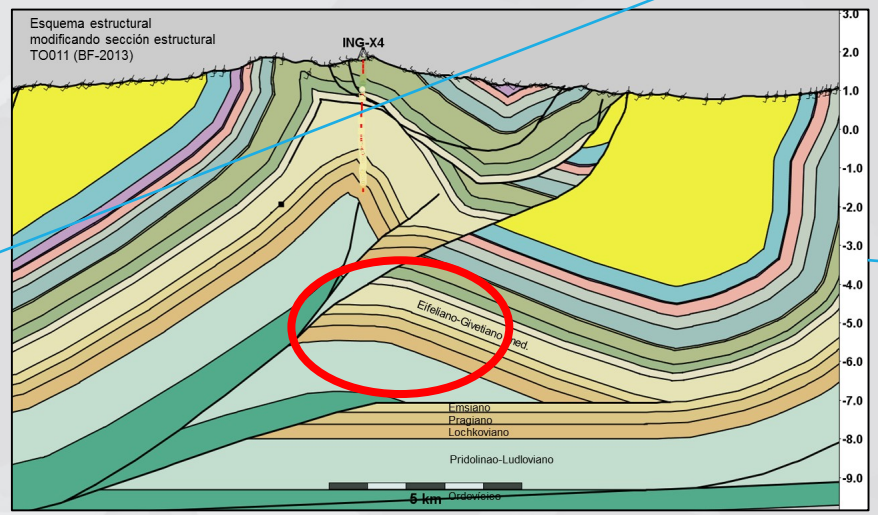
Tatarenda ALM

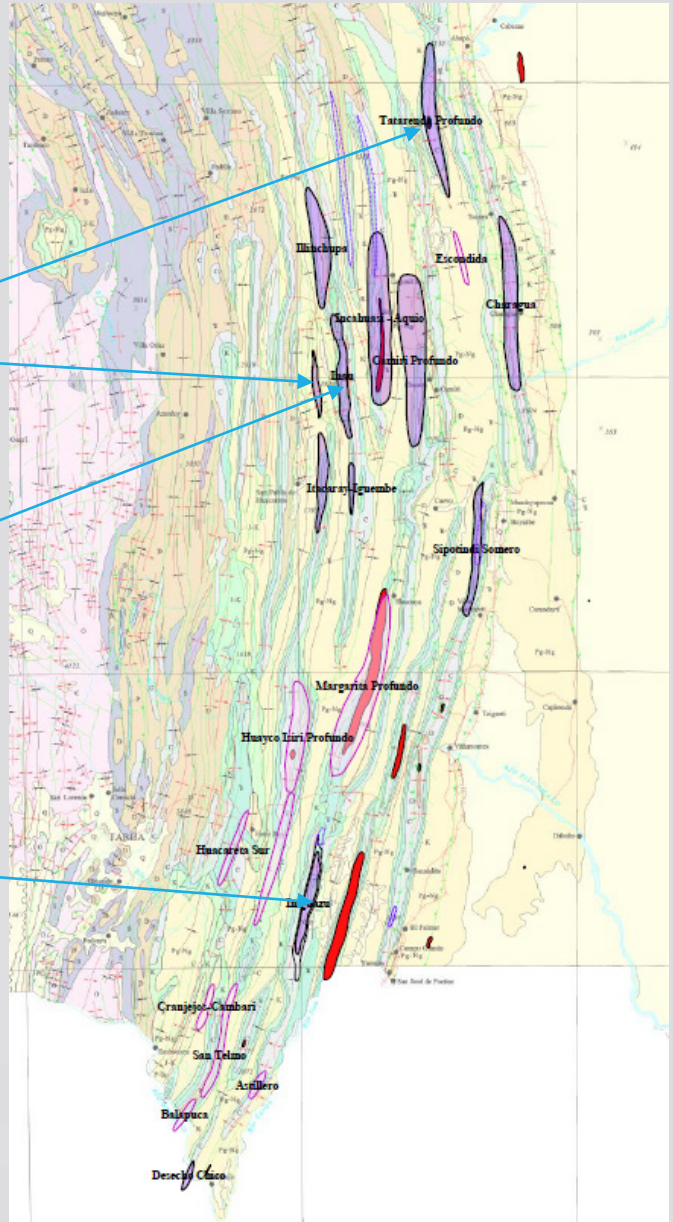


Inau ALM



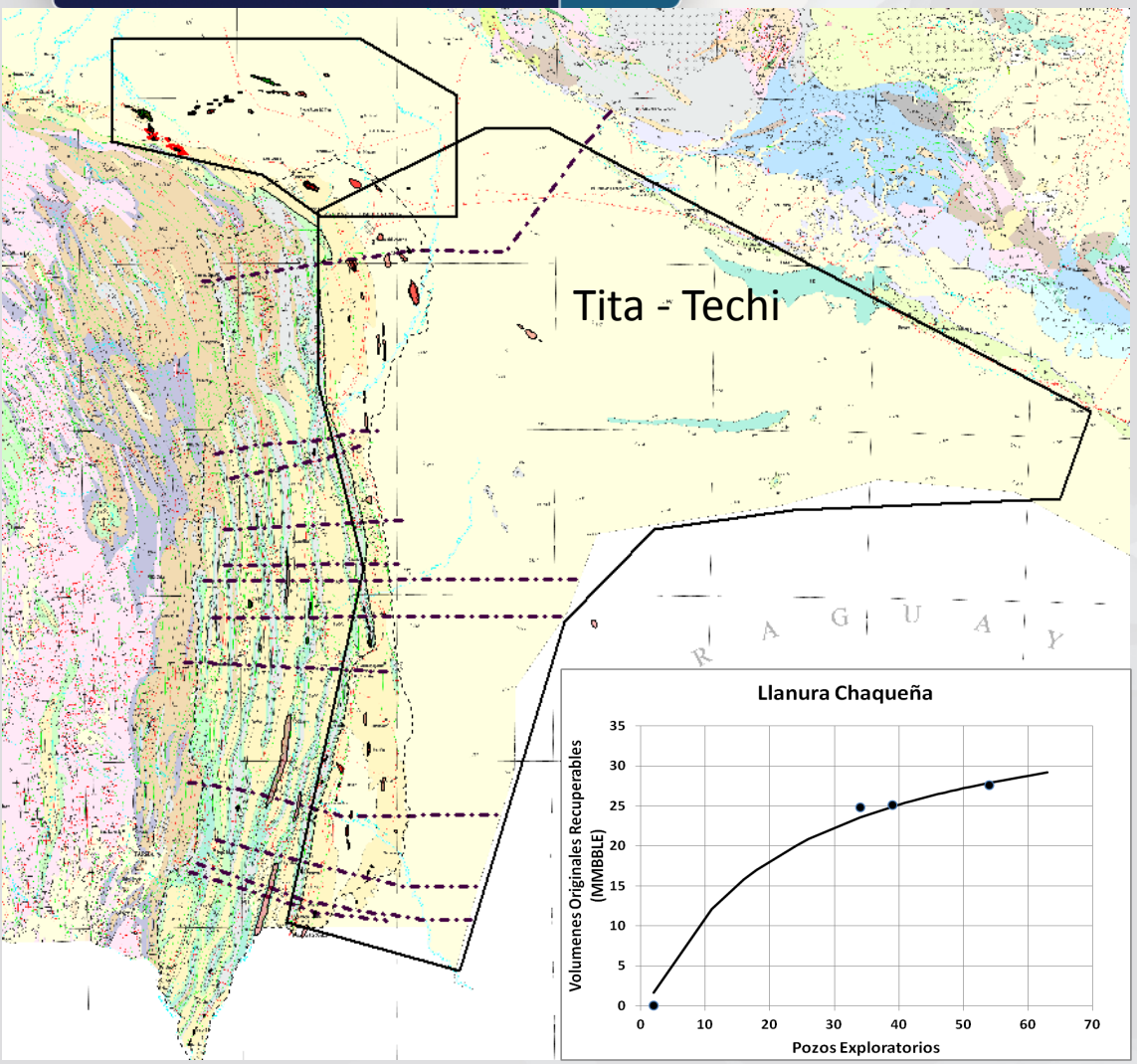
Iniguazu ALM

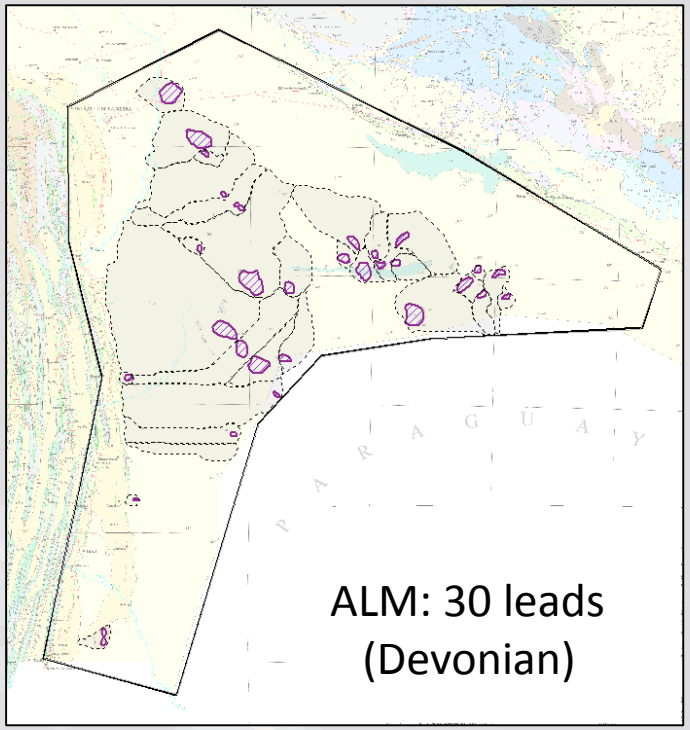


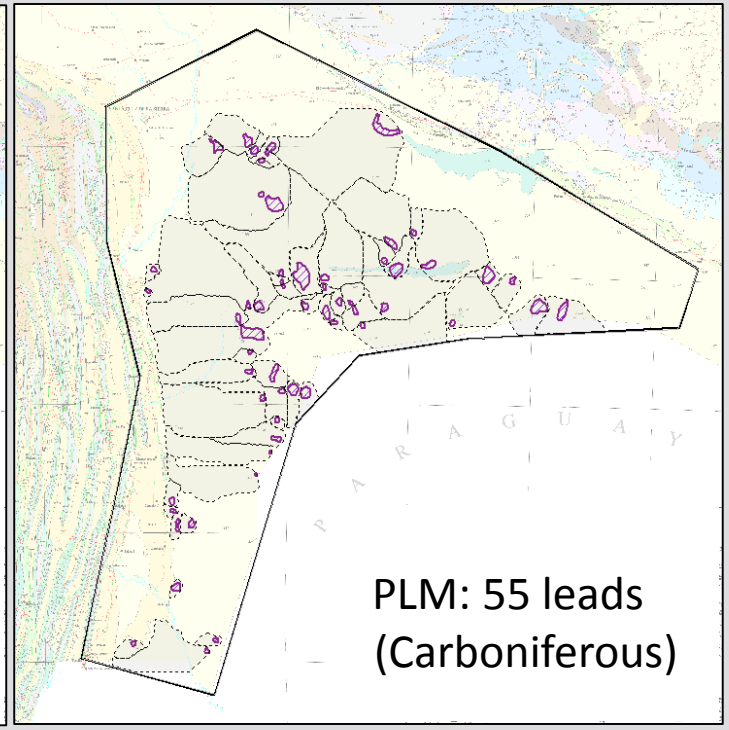


14 Prospects→ Prospective Resources: 34 Tcf (mean)

Chaco Plain







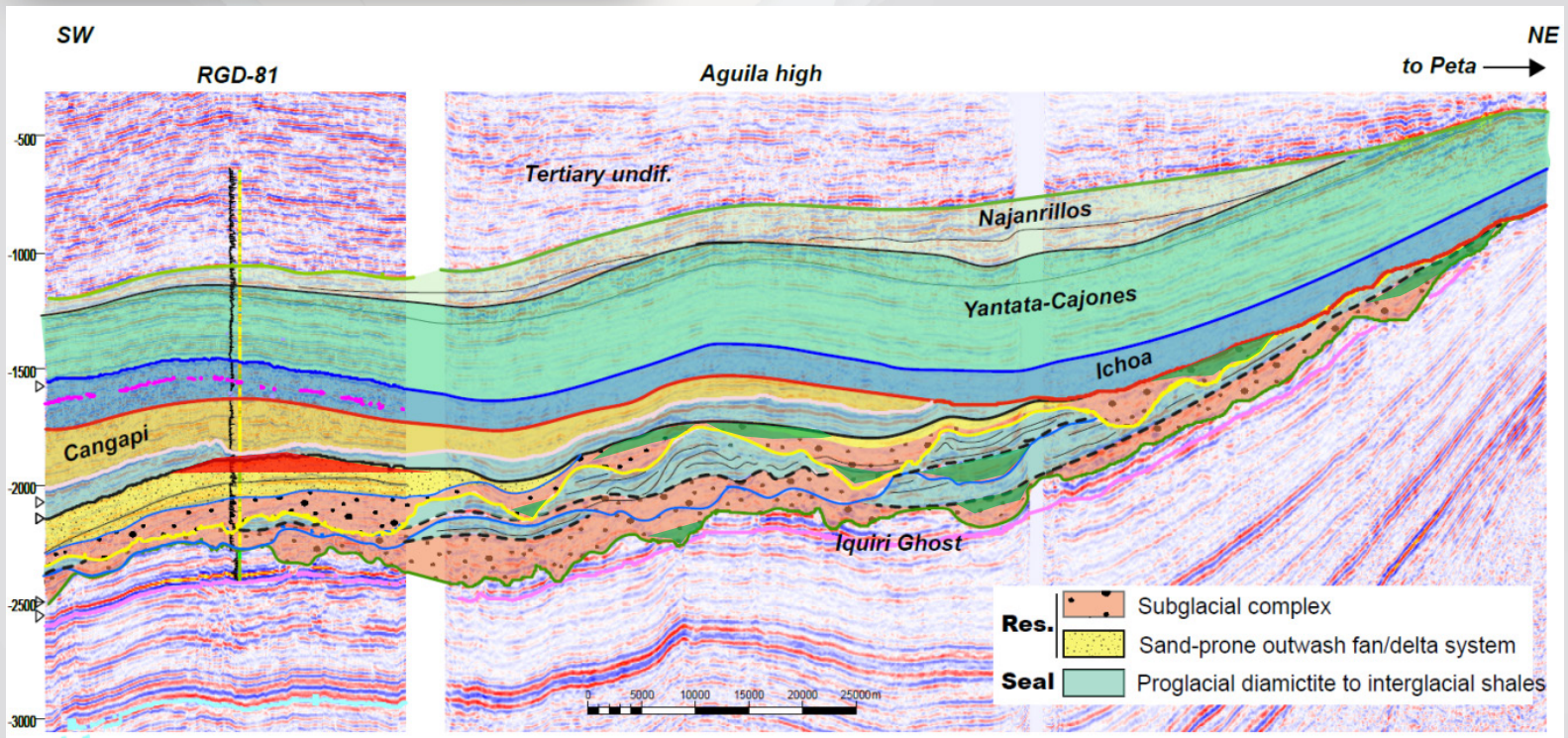
3D basin modeling

→*Yet to find:* 0,9 Bbbl petróleo y 30 Tcf Gas

29 MMBBLE (2009)

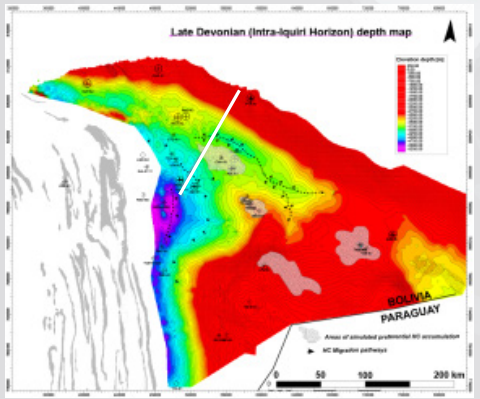
Asymptote: 40 MMBBLE (3 fields!) → YTF: 11 MMBBLE

Carboniferous Plays



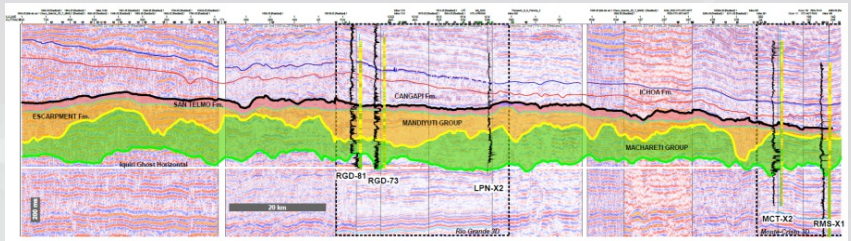
Glaciogenic plays

Mainly erosively based valley-shaped geobodies as reservoir plays;

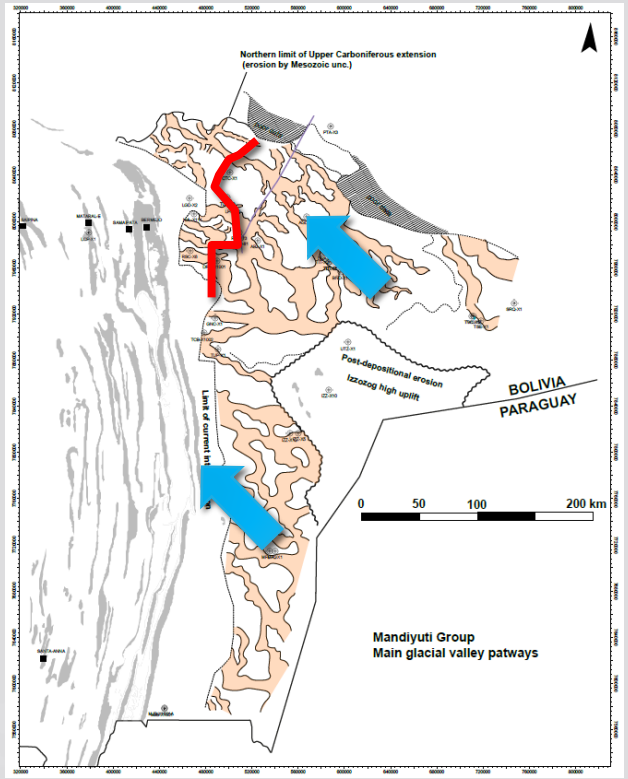


Gas accumulations (proven)

Potential HC accumulations (leads)



Mandiyuti



Hydrocarbon Potential

- **Proven conventional plays**
  - ALM (deep) Play has the higher short-term potential

- **Conceptual conventional plays**
  - Paleozoic pinch out
  - Stratigraphic Carboniferous
  - Pre-Andean tectonic(s)

- **Conceptual unconventional plays**
  - Boomerang
  - Chaco Plain

First expulsion pulse (80-90 %)

Portfolio:

222 leads and 15 Prospects

Yet to Find: 120 TCF gas 8 Bbbl oil

Prospective Resources: 34 Tcf and 0,8 Bbbl oil