

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.



AAPG
Latin America & Caribbean Region

BOLIVIA 2018
Geosciences Technology Workshop

Bolivian Petroleum Systems: Paradigm Shifts

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Introduction

ECATE Project

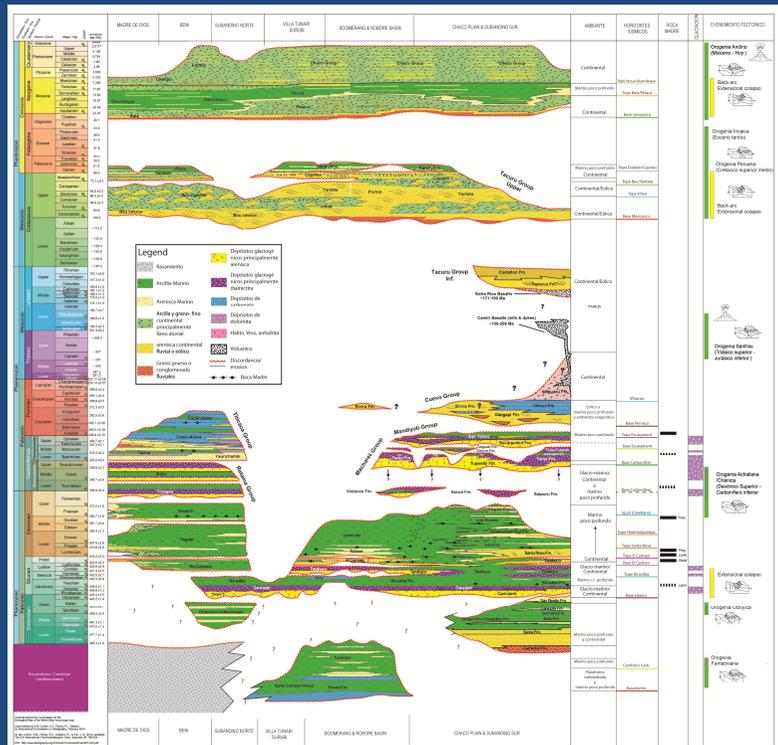
- 3.5 years joint exploration project between YPFB and Beicip-Franlab.
- Petroleum system assessment of Bolivia (Altiplano, Madre de Dios, Beni and Chaco Plains, Northern and Southern Sub-Andean, Boomerang hills and Foothills).
- >50 Exploration Projects
- Full access to the country dataset (CNIH)

Schedule

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



Stratigraphy

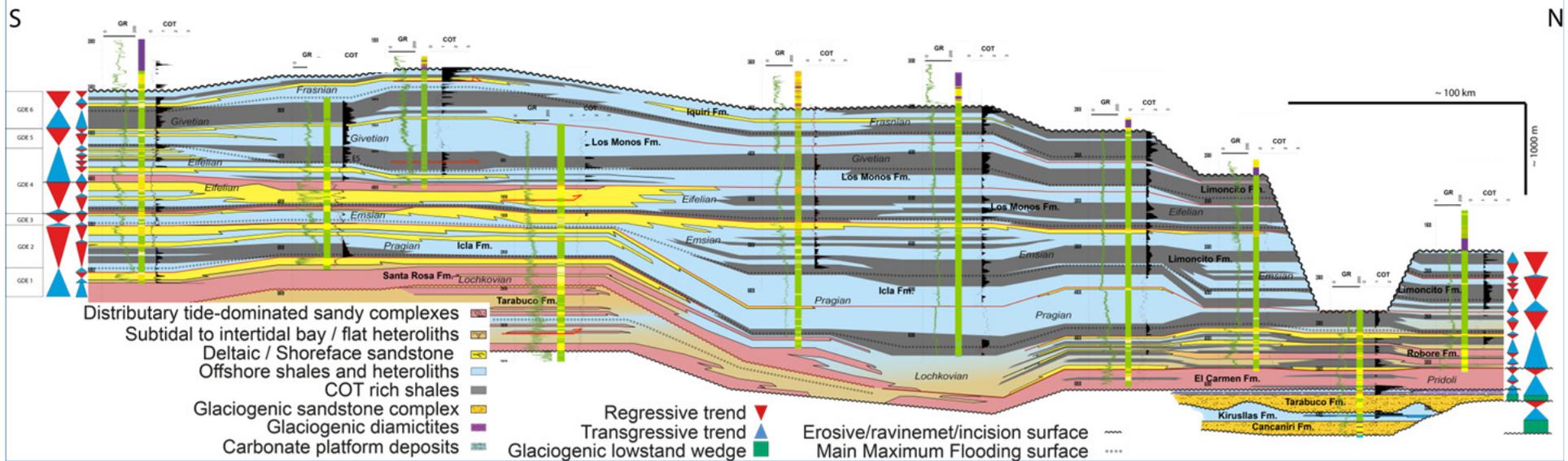


- 470 wells: Core description and Electric log analysis
- Outcrops
- Analysis of the existing bio-stratigraphy
- Revision of the chrono-litho-stratigraphy
- Sedimentary models



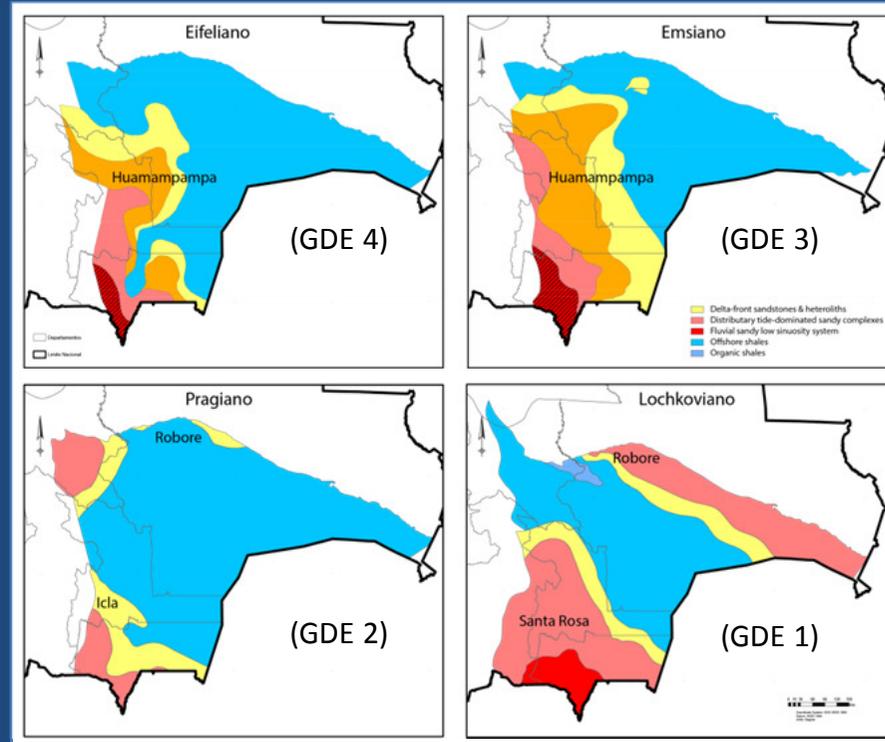
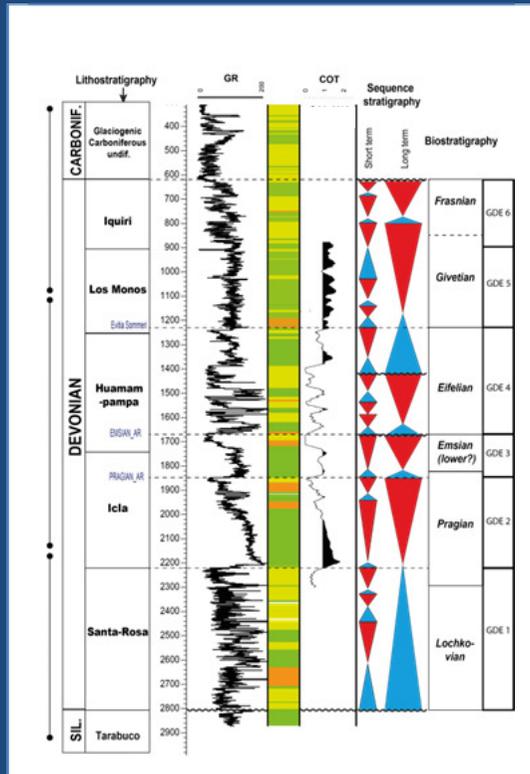
Devonian

- Eifelian Huamampampa and Emsian Huamampampa
- Heterogeneous distribution of Source Rocks



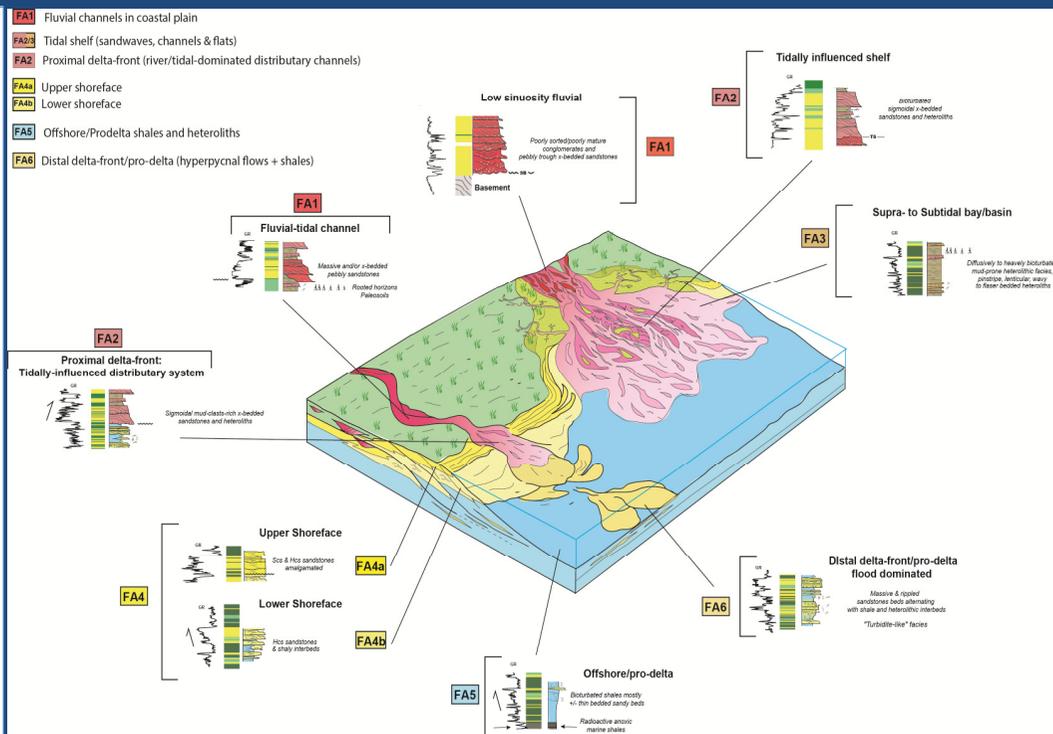
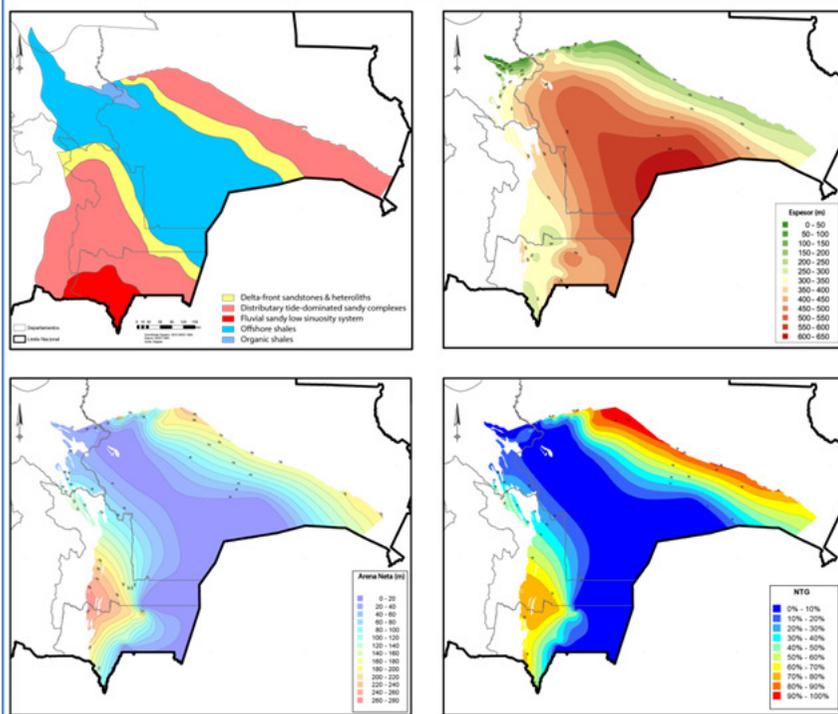


Devonian



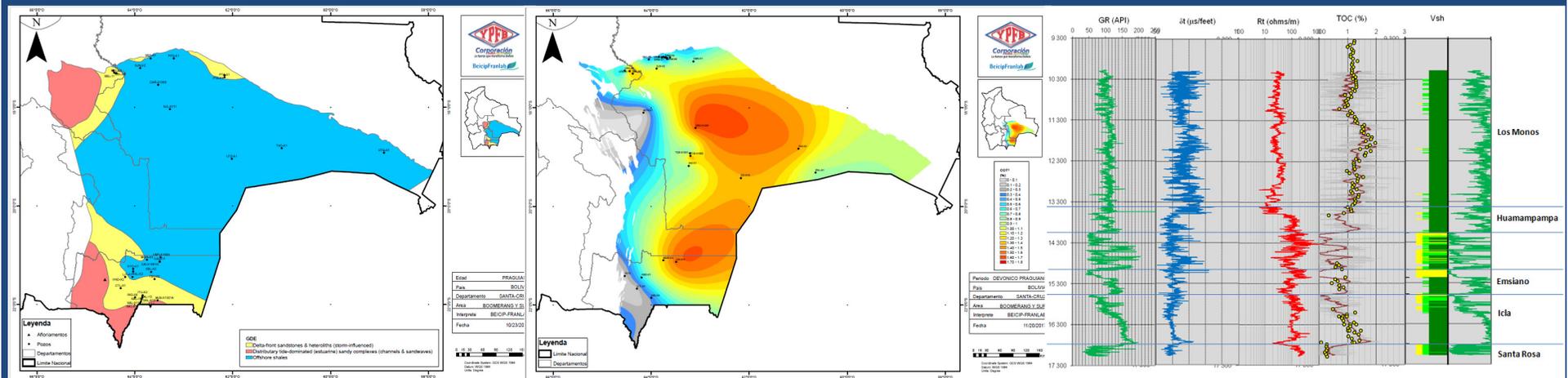


Lochkovian (GDE 1)



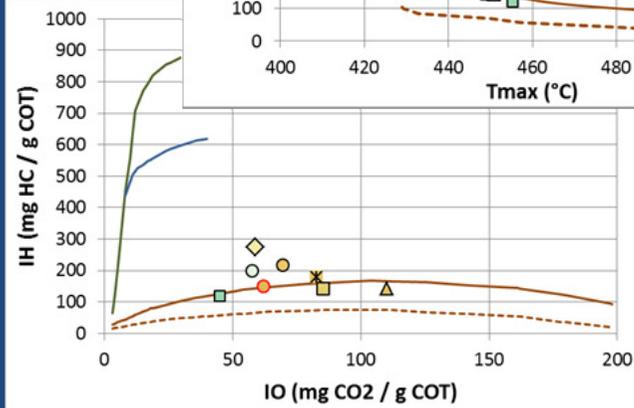
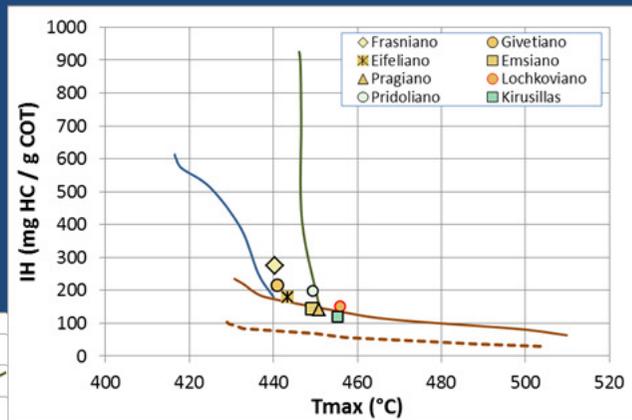


Pragian (GDE 2)





SR Geochemistry

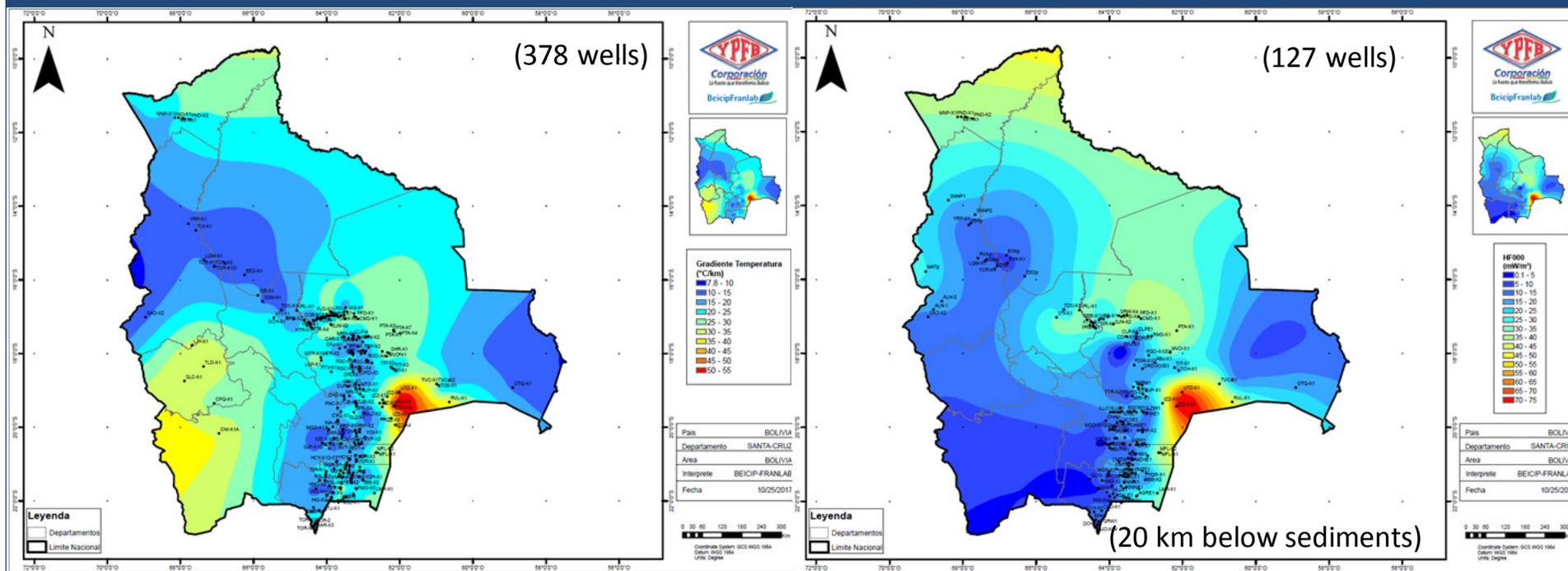


	Frasniano	Givetiano	Eifeliano	Emsiano	Pragiano	Lochkoviano	Pridoliano	Kirusillas
Sitios	39	63	42	29	26	32	17	4
Datos	299	1692	392	388	316	211	58	22
COT (%)	0,93	0,87	0,74	0,78	0,89	0,99	1,18	1,25
IH (mg HC/g COT)	274	216	178	143	141	151	199	119
IO (mg CO2/g COT)	59	70	83	85	110	62	58	45
Tmax (°C)	440	441	443	449	451	456	449	455
Ro (%)	0,68	0,78	0,91	1,03	1,05	1,10	1,02	1,21
COT* (%)	0,93	0,87	0,85	0,85	0,95	1,06	1,30	1,32
IH* (mg HC/g COT)	278	227	235	206	203	238	250	169
Hsr (m)	100	200	200	150	250	150	150	150
SPI (t/m2)	0,6	0,9	1,0	0,6	1,2	0,9	1,2	0,8

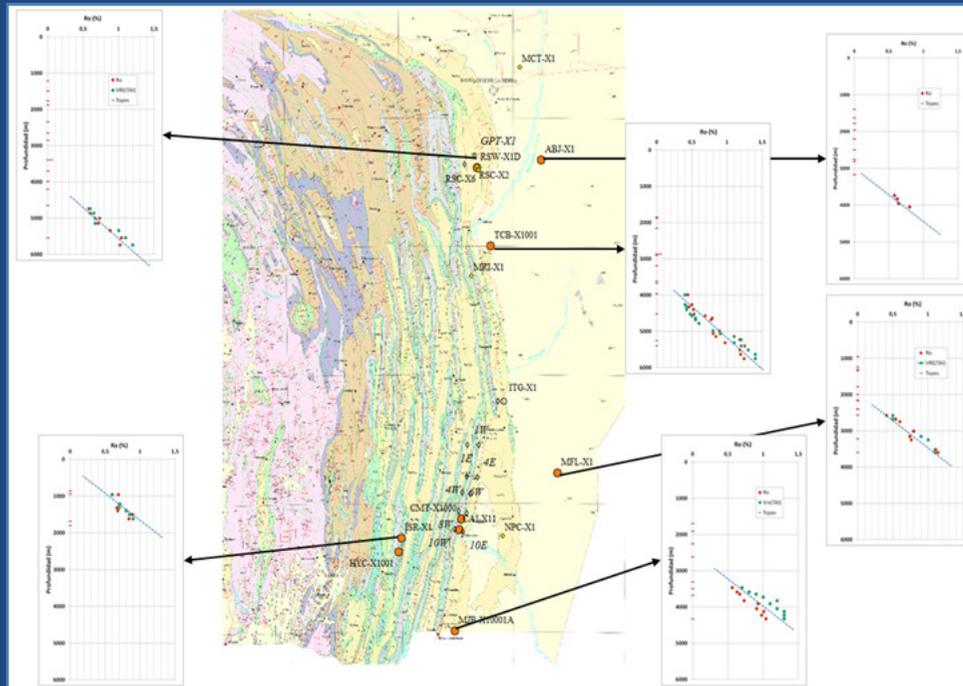
- New data base (>5800 analysis)
- Type II-III / Type III
- Each mega-sequence has SR potential
- Heterogeneous spatial distribution



Thermal gradient and Heat Flow



Late Triassic Thermal Event



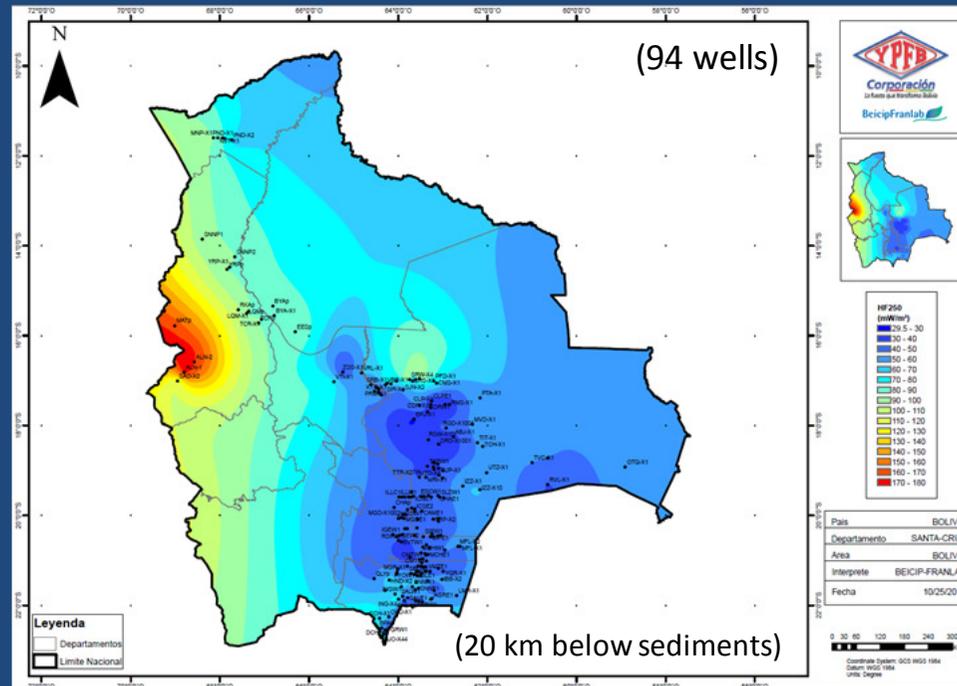
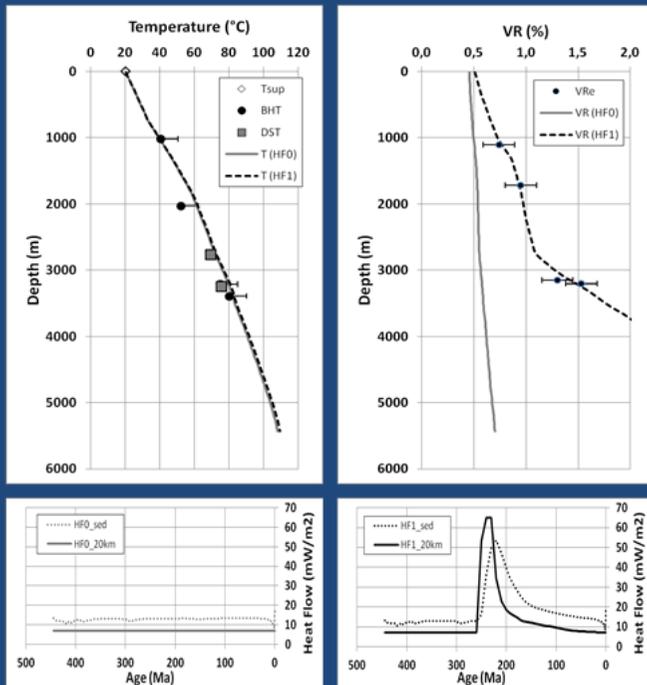
- High maturity gradient in Devonian
- → Past Thermal Event (Regional)
- Volcanism at Trias-Jurassic boundary:

	Sempere et al (1992)	Bertrand et al (2005)	Kusiak (2009)	Bertrand et al (2014)
	K/Ar	40Ar/39Ar	40Ar/39Ar	40Ar/39Ar
Tarabuco	171,4 ±4,2	196,1 ±1,5		198,1 ±1,5
Entre Rios			181,5 ±0,9	
Camiri		203,7±4,1	204,3 ±1,4	199,2 ±2,2

- Plutons: Cordillera Real (Trias-Jurassic)
- ZFT SN > 223+/-32,3 (XR-Petroandina, 2013)
- AFT SS > Late Jurassic (Geotrack-BGB, 2016)

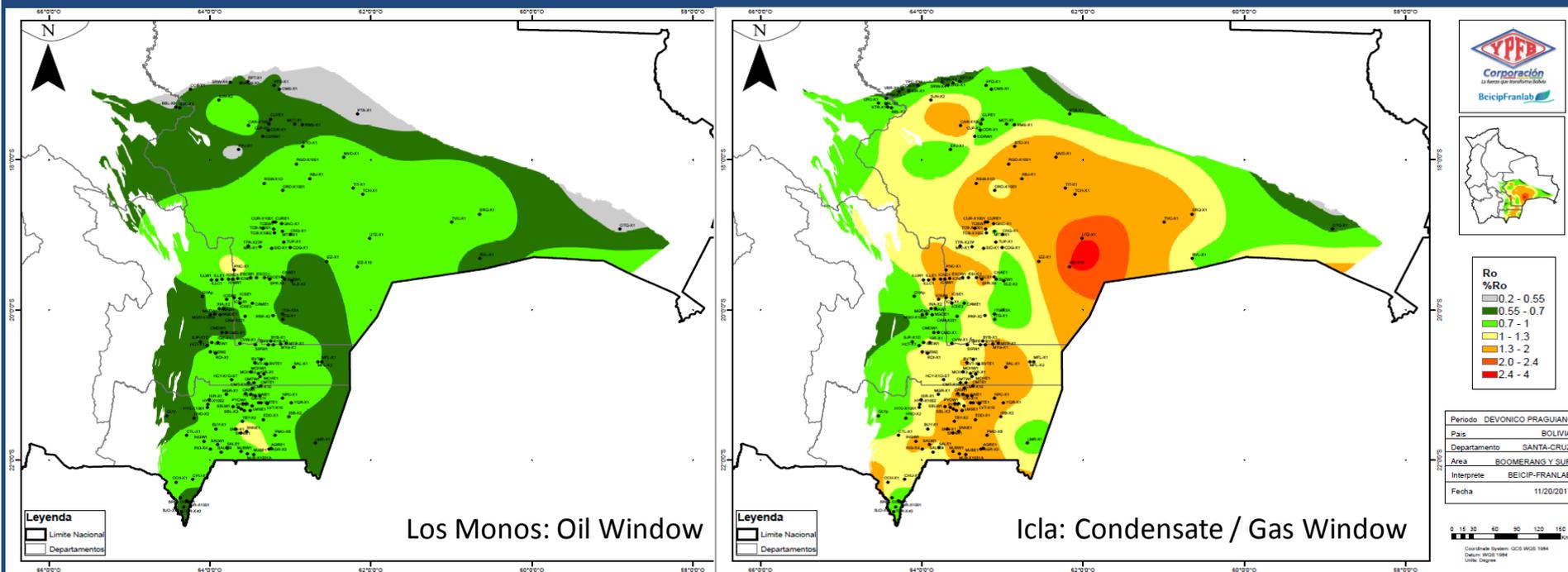


Thermal gradient and Heat Flow

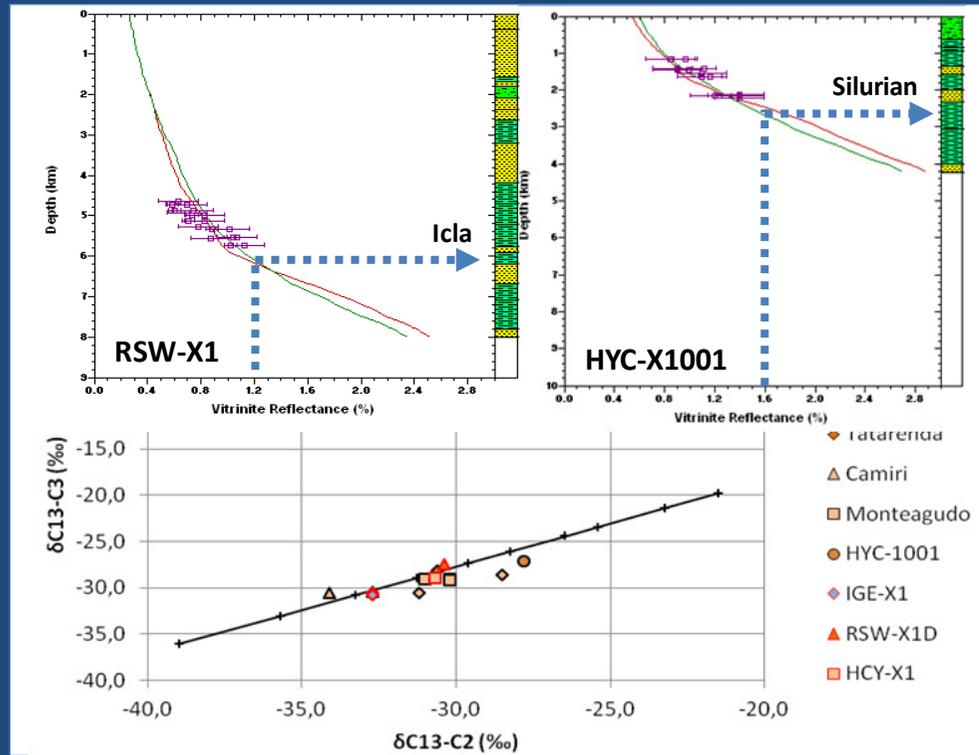




Maturity



SR - Fluids

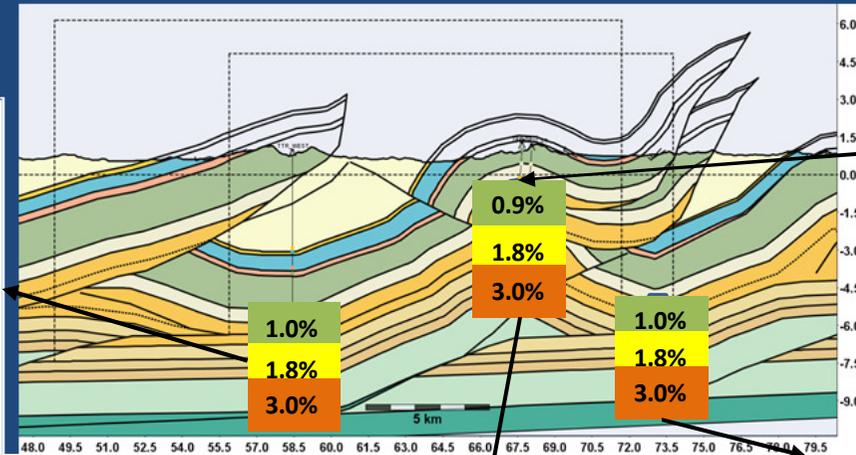
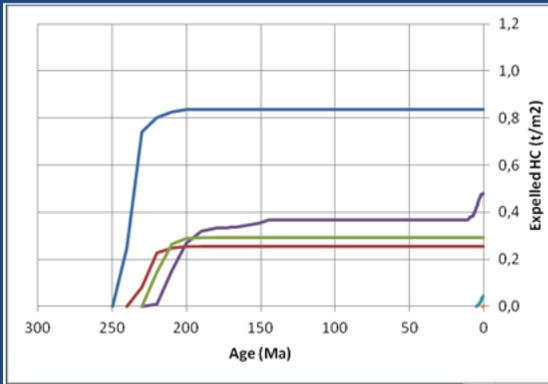


- Rio Seco Gas sourced by Icla
- Huayco Gas sourced by Silurian



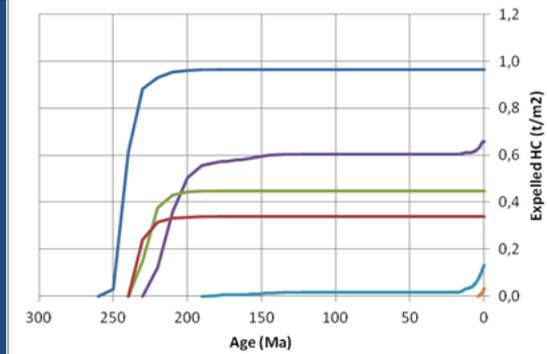
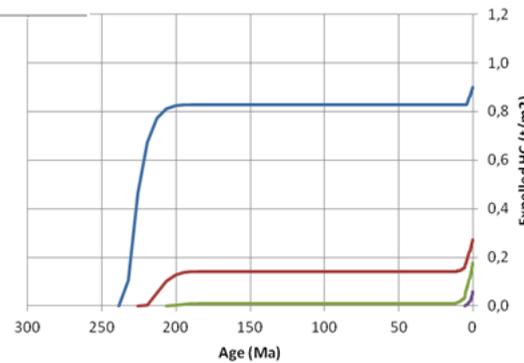
2 Expulsion pulses

- Frasniano
- Givetiano
- Eifeliano
- Emsiano
- Pragiano
- Lochkoviano
- Pridoliano
- Kirusillas



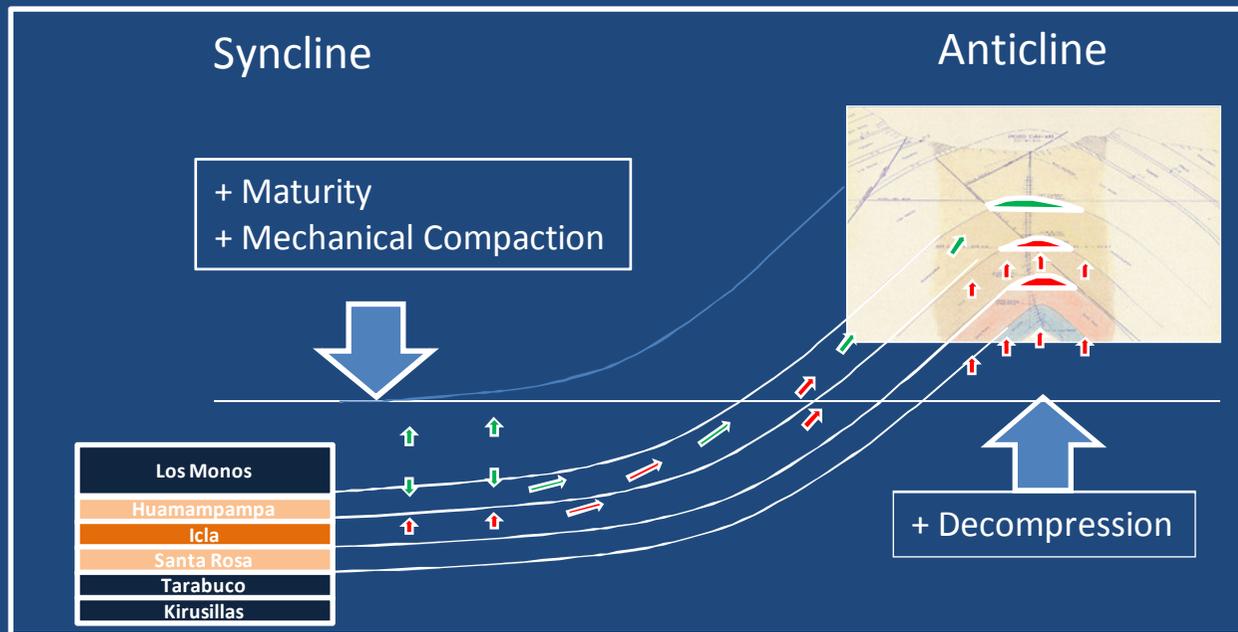
Oil in Iquiri

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



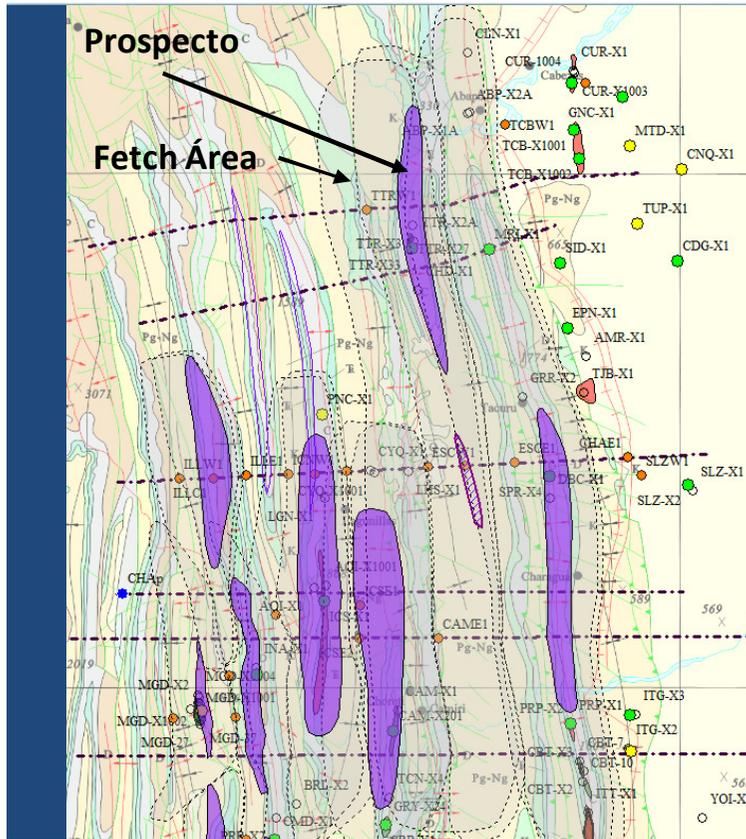


Expulsion

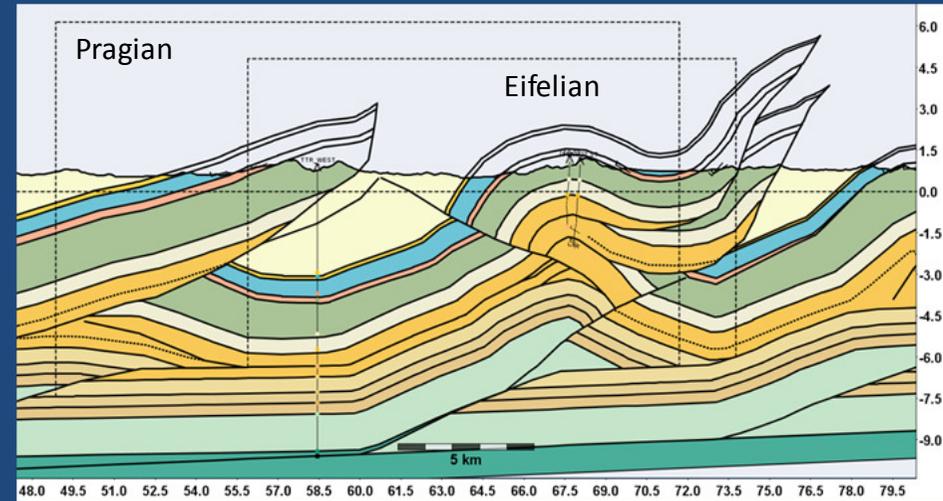


Key Parameters

- **Syncline**
 - Sedimentation syn- and post tectonics
- **Anticline**
 - Amount of Uplift



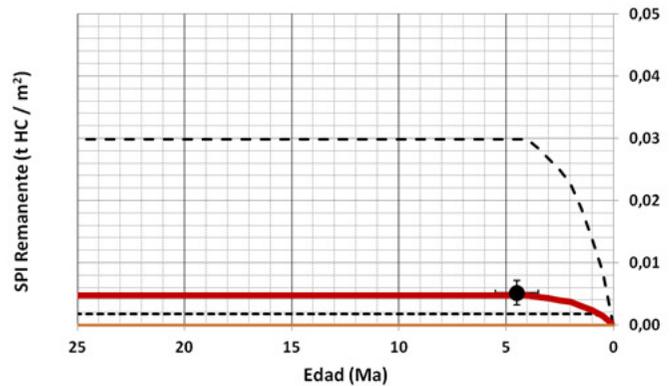
$$\text{Charge} = \text{FA} * \text{SPI (Age)} * \text{PSY}$$



	<u>Fetch Área</u>
Eifelian:	2500-1540 km ²
Pragian:	3980-2200 km ²

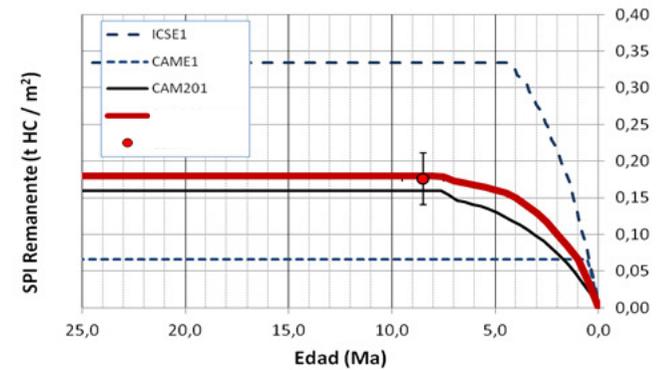
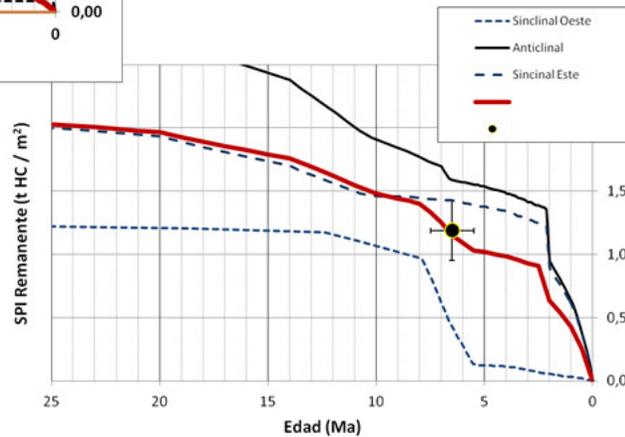


Mean PSY: 21 % ($\sigma = 12$ %; $n = 11$)



PSY: 25%

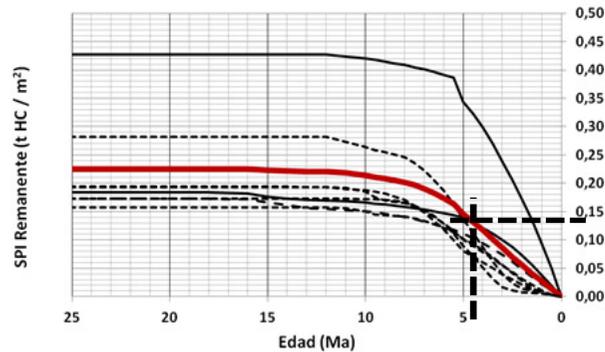
PSY: 15%



PSY: 8%

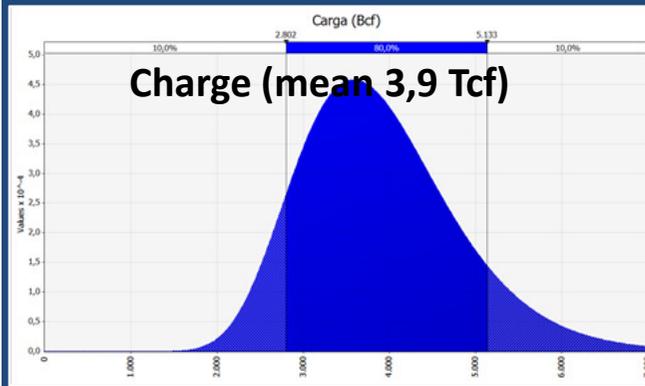


Charge – Filling Factor

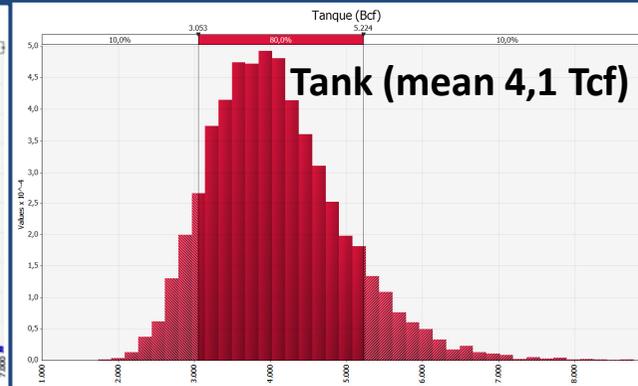


Age: 4.5 Ma
PSY: 21%
Tank: 4.1 Tcf

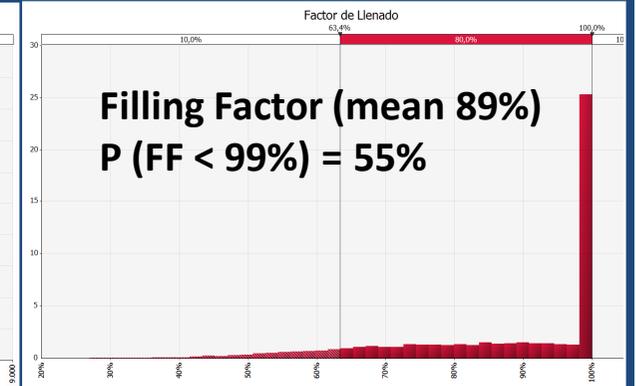
→ SPI 0.13 t HC / m²
→ Total gas 3.9 Tcf (mean)
→ Filling Factor: 89%



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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