[PS]Petroleum Systems Modeling and Hydrocarbon Charge Assessment in Pie De Monte Boomerang Province, Bolivia*

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Abstract

An active petroleum system is recognized by producing fields in Boomerang Pie de Monte foreland basin in stratigraphic up-dip and structural traps of Silurian-Devonian and Cretaceous formations. The area is considered as one of the most prolific gas provinces in Bolivia. However, the timing of hydrocarbon expulsion and migration versus trap formation remains unclear as confirmed by dry wells showing low gas shows of residual by-passed hydrocarbons. To reduce this uncertainty, we built a basin model that honors seismic structural interpretation and well data to simulate burial history, temperature, source rock maturity and pressure regimes through geological time. Hydrocarbon expulsion from source-rocks and further HC migration was simulated using 3D basin fluid flow modeling based on Darcy flow equation, followed by a map-based fetch area trap charge assessment. The main source rock units correspond to Silurian-Devonian sequences with influence of continental-marine environments (kerogen Type II/III). Maturity trend increases from north to south due to higher burial. Two phases of hydrocarbon expulsion were recognized: one early expulsion phase from Silurian source rocks during Late Triassic and a second expulsion phase from Early Devonian source rocks during Late Jurassic-Early-Cretaceous times. Lateral long distance up-dip migration through Robore Formation occurred before Andean deformation, following a northward fill and spill trap charge accumulating below Late Jurassic erosive unconformity. The Cretaceous plays were charged by vertical and lateral migration above the unconformity. The Andean deformation resulted in enhancing the structural closures and vertical migration towards Cretaceous plays. The results of this study provided to YPFB a model-based approach to predict yet to find volumes in place for undrilled prospects and leads and a proposition for a future drilling strategy.

Petroleum Systems Modeling and Hydrocarbon Charge Assessment in Pie de Monte, Boomerang Province, Bolivia

AAPG BOLIVIA 2018 Geosciences Technology Workshop — Latin America & Caribbean Region

BeicipFranlab — An IFP group company

YPFB

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1. OBJECTIVE

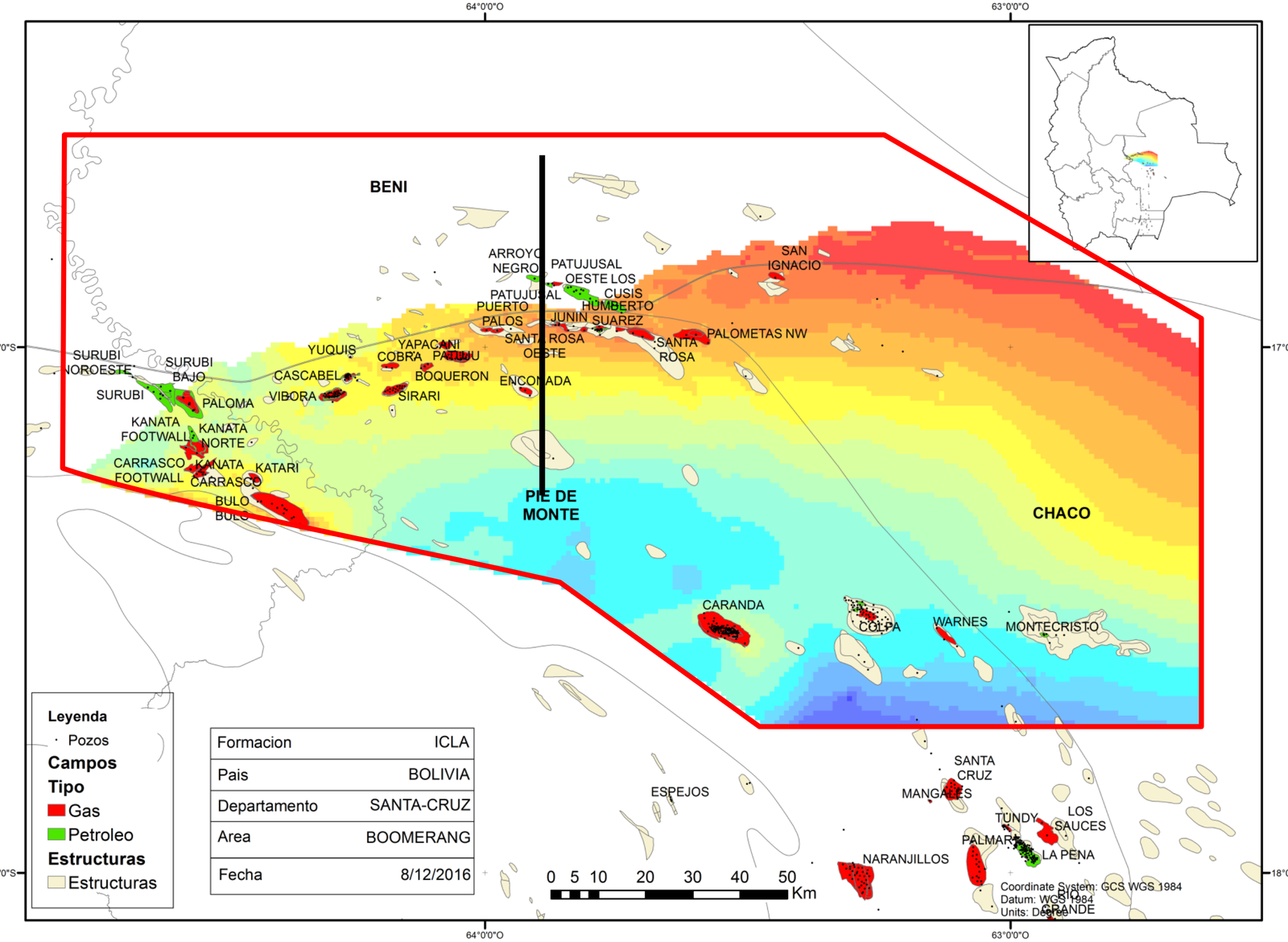
The objective of this study was to evaluate the petroleum systems and petroleum potential of Boomerang Province in order to assess:

- Source rock potential
- Expulsed HC quantities
- Timing of migration mechanisms and trap charge
- Definition of leads and prospects
- Yet To Find

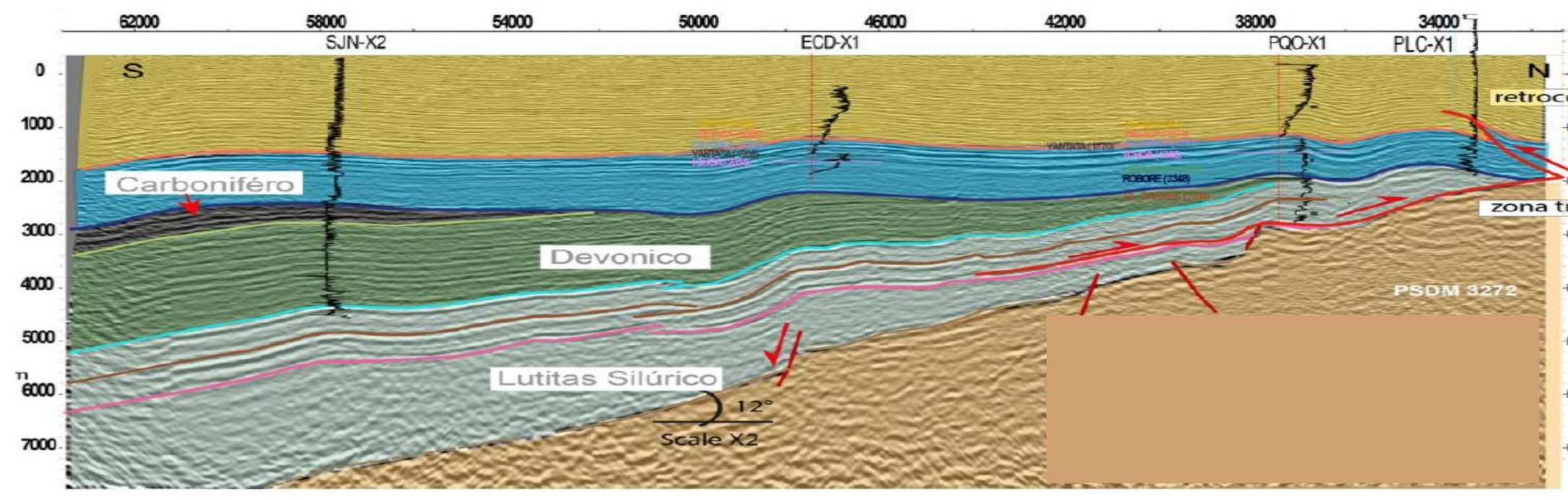
Workflow integrates available E&P data from YPFB in collaboration with Beicip-Franlab from ECATE Project into a 3D Basin Model for structural, sedimentary depositional model and geochemical analysis.

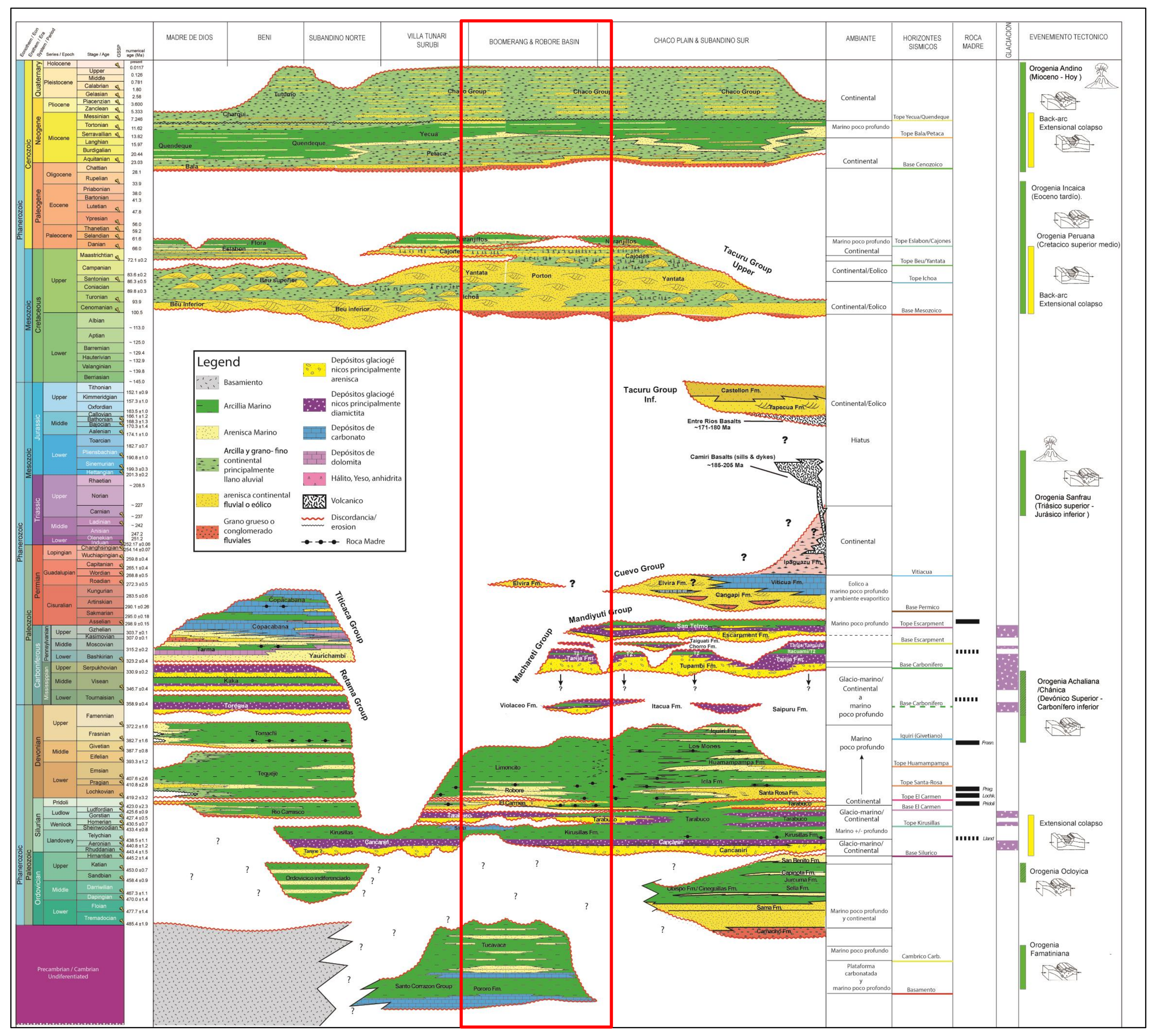
2. GEOLOGICAL SETTINGS

The Boomerang Pie de Monte foreland basin, is characterized by a Paleozoic sedimentary wedge developed during Ordovician-Carboniferous age, thinning northward onto the Precambrian Brazilian shield. Paleozoic mega sequence (Silurian-Devonian) corresponds to deep marine, coastal, fluvio-deltaic deposits (0-6000 m) with an erosive unconformity in the north created during Triassic-Jurassic orogeny. Main reservoirs are Robore and El Carmen Fm.



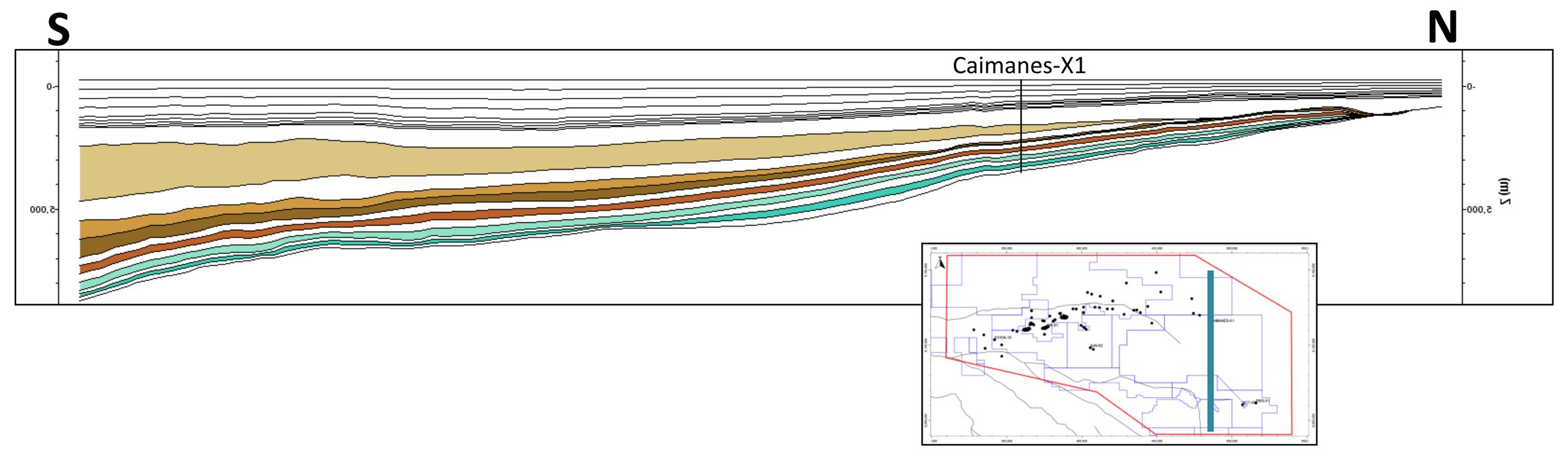
Mesozoic Cenozoic mega sequence overlaps erosive unconformity and consists of fluvio-deltaic continental deposits. Main reservoirs are Yantata and Petaca Fm (1000-4000 m).

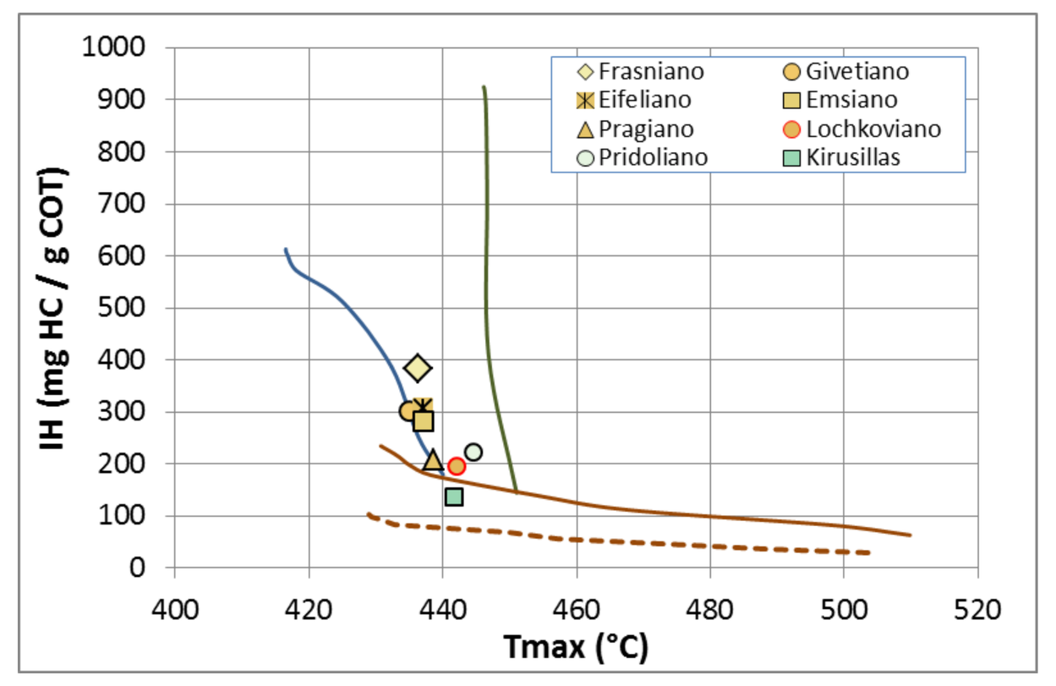




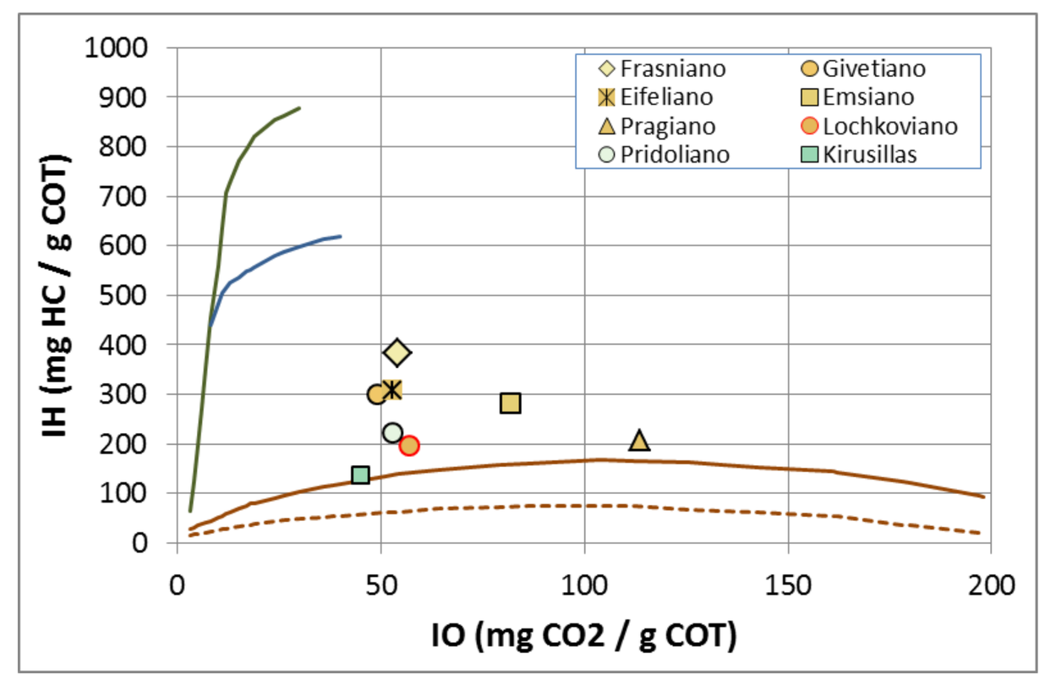
3. GEOCHEMICAL ASSESSMENT

Geochemical source rock characterization was carried out in order to identify the source rock initial potential and kerogen type. The main source rock units correspond to Silurian-Devonian sequences with influence of terrigenous wax-poor and marine siliciclastic environments (kerogen Type III and II/III).



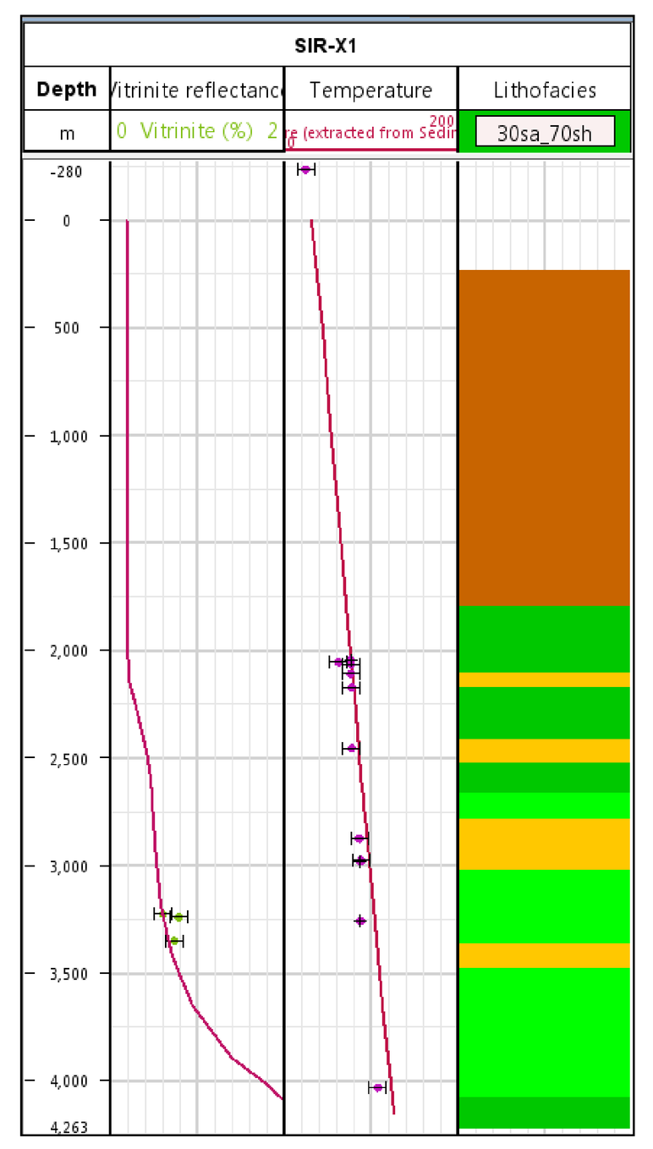


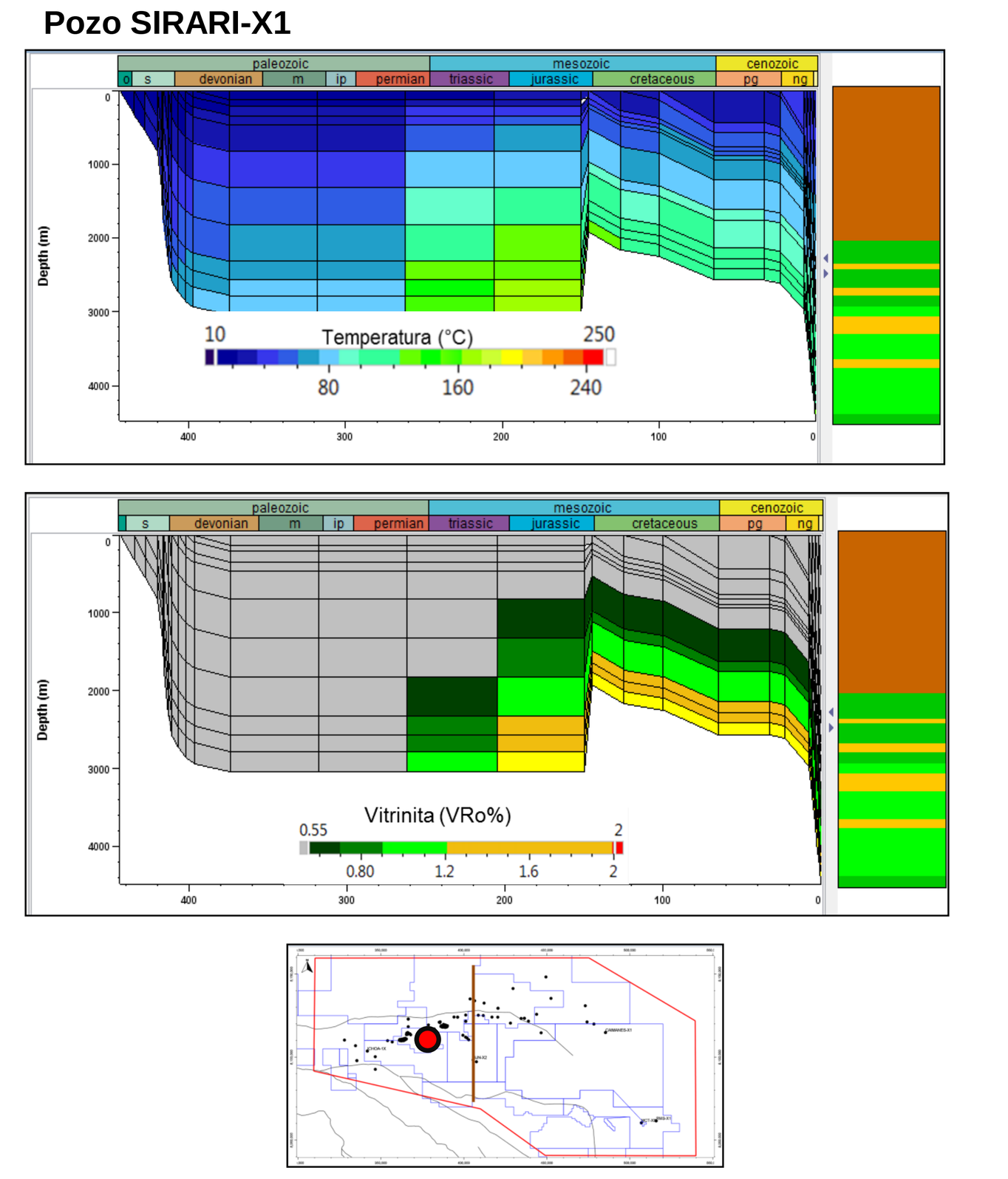
	Frasniano	Givetiano	Eifeliano	Emsiano	Pragiano	Lochkoviano	Pridoliano	Kirusillas
Sitios	3	4	4	4	11	20	13	3
Datos	11	24	22	60	41	122	48	19
COT (%)	1,17	0,96	0,88	0,86	0,96	1,00	1,32	1,37
IH (mg HC/g COT)	384	301	308	281	208	196	222	138
IO (mg CO2/g COT)	54	49	53	82	114	57	53	45
Tmax (°C)	436	435	437	437	439	442	445	442
Ro (%)	0,60	0,63	0,69	0,72	0,77	0,85	0,91	0,95
COT° (%)	1,17	0,96	0,91	0,86	0,97	1,03	1,36	1,43
IH° (mg HC/g COT)	385	304	322	289	223	217	252	173

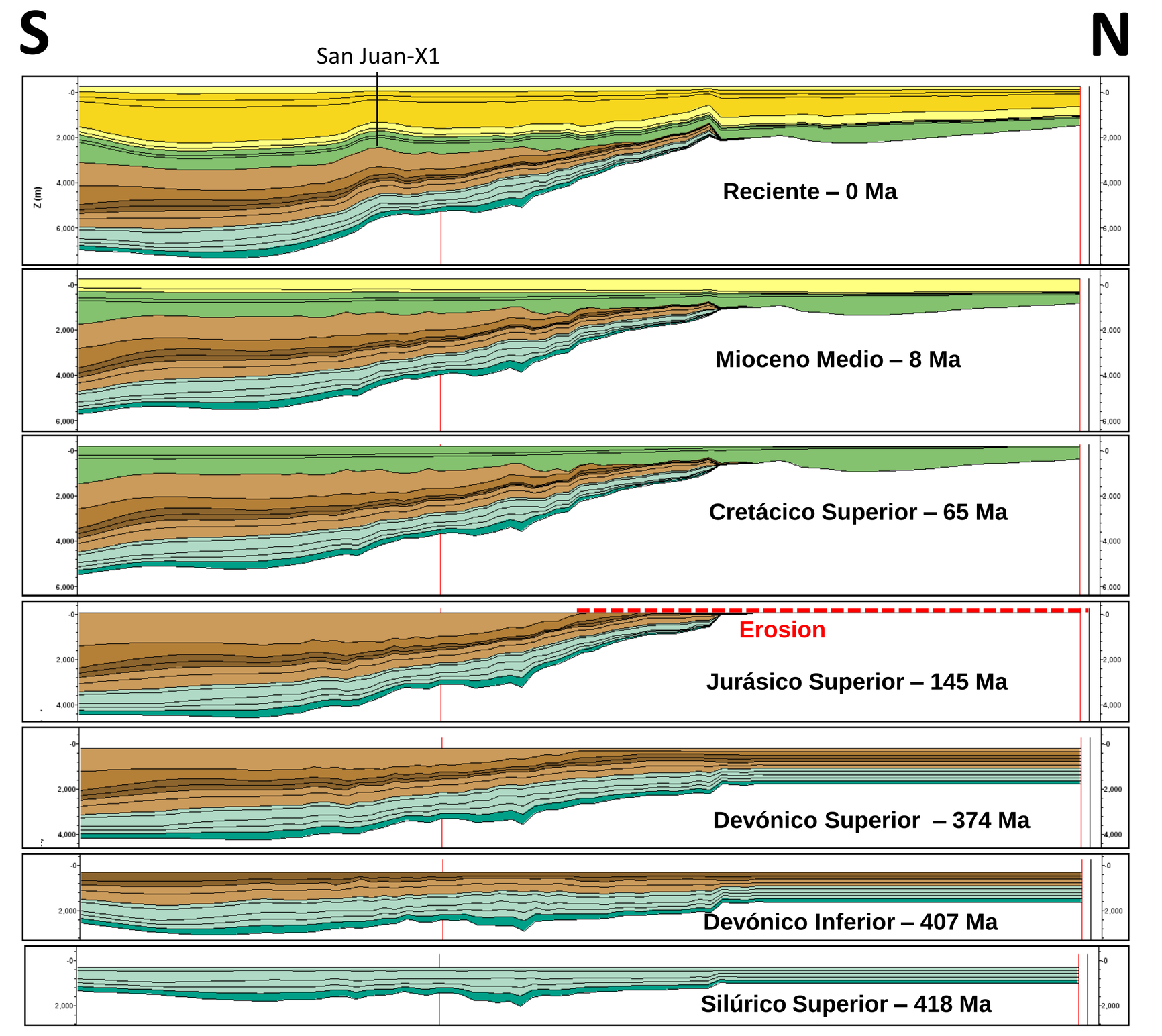


4. THERMAL BURIAL HISTORY

Well temperature and maturity indicators were used to calibrate present day geothermal gradients and constrain paleo-temperature thermal gradients for maturity trend. Maximal burial of source rocks was reached before Triassic-Jurassic orogeny erosion event giving place to major thermal gradients and maturity expulsion peak.







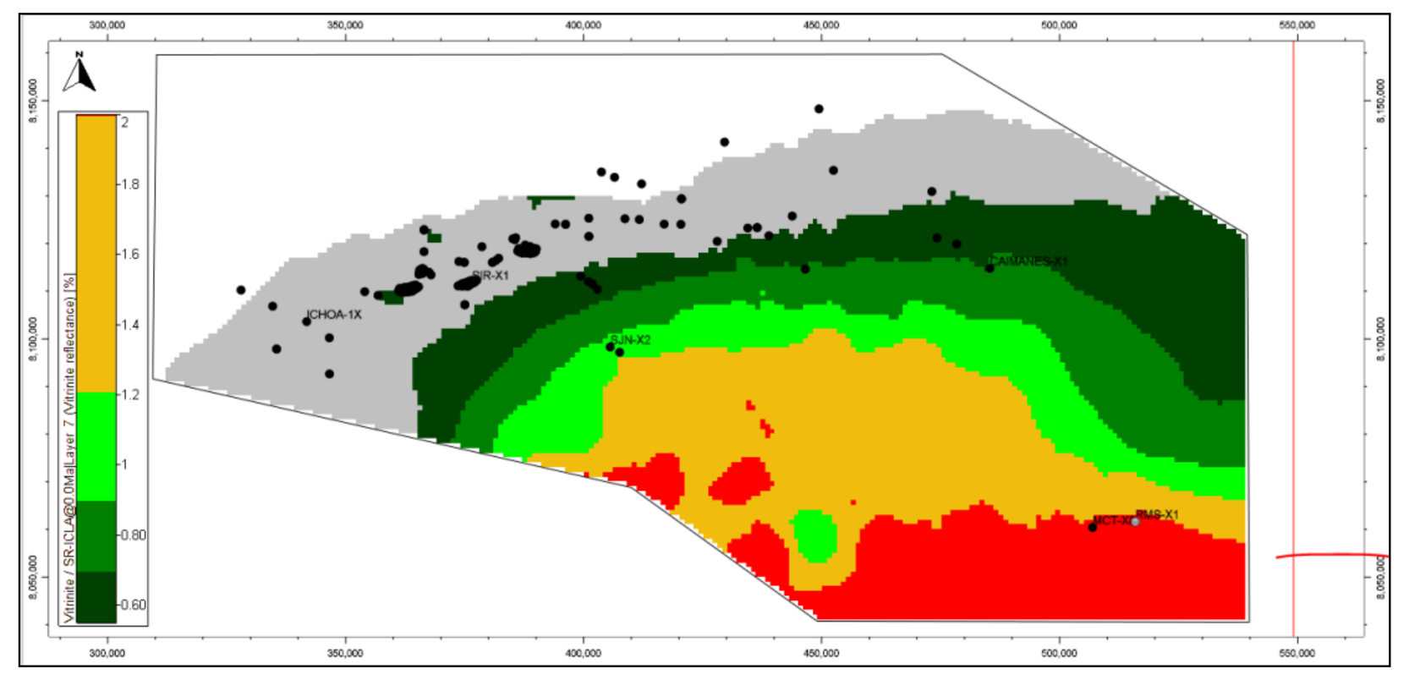
5. HYDROCARBON EXPULSION, MIGRATION & CHARGE

Maturity trend increases from north to south where higher burial occurs, from dry gas areas in the south to oil window in the northern erosive front. Two phases of hydrocarbon expulsion were identified:

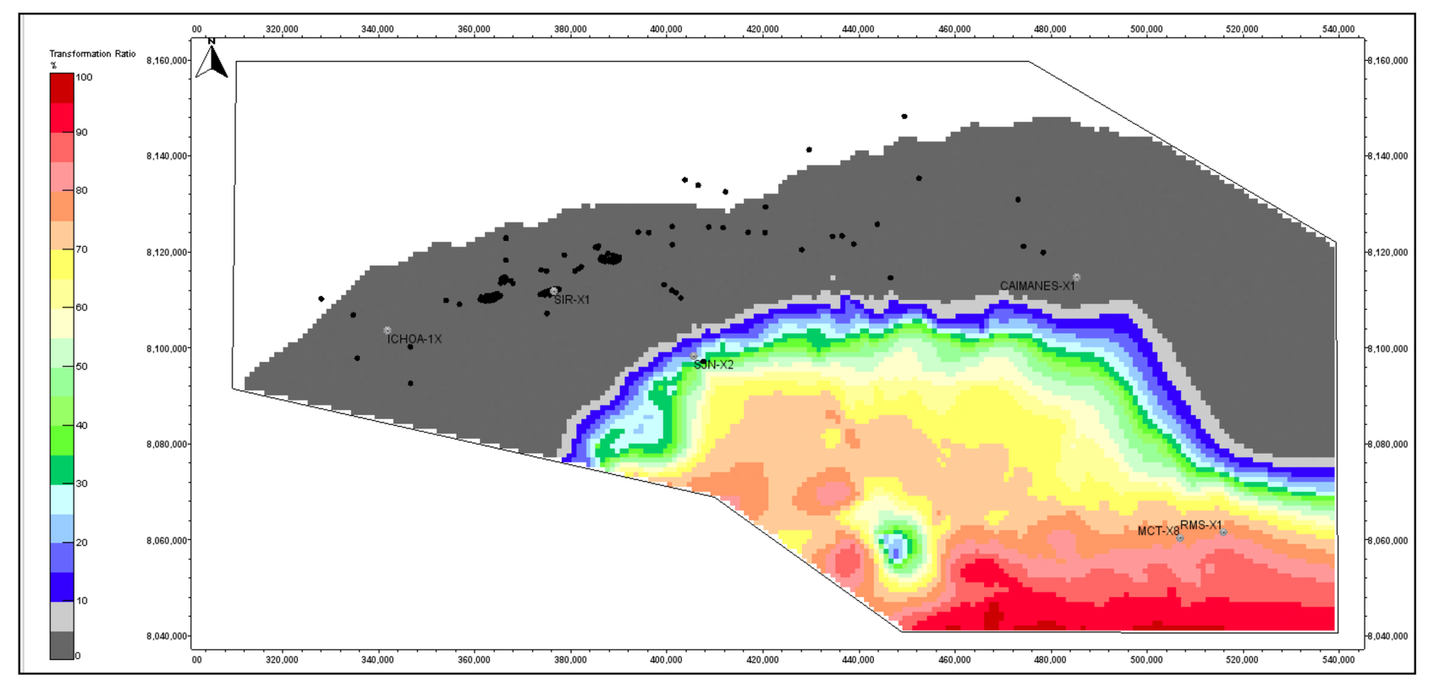
- one early expulsion phase from Silurian source rocks (Pridolian and Kirusillas) during Late Triassic.
- and a second phase from Lower Devonian source rocks (Givetian to Lochkovian) during Late Jurassic-Early-Cretaceous times.

Upper Devonian source rocks remain in the heavy oil window bellow peak of oil expulsion.

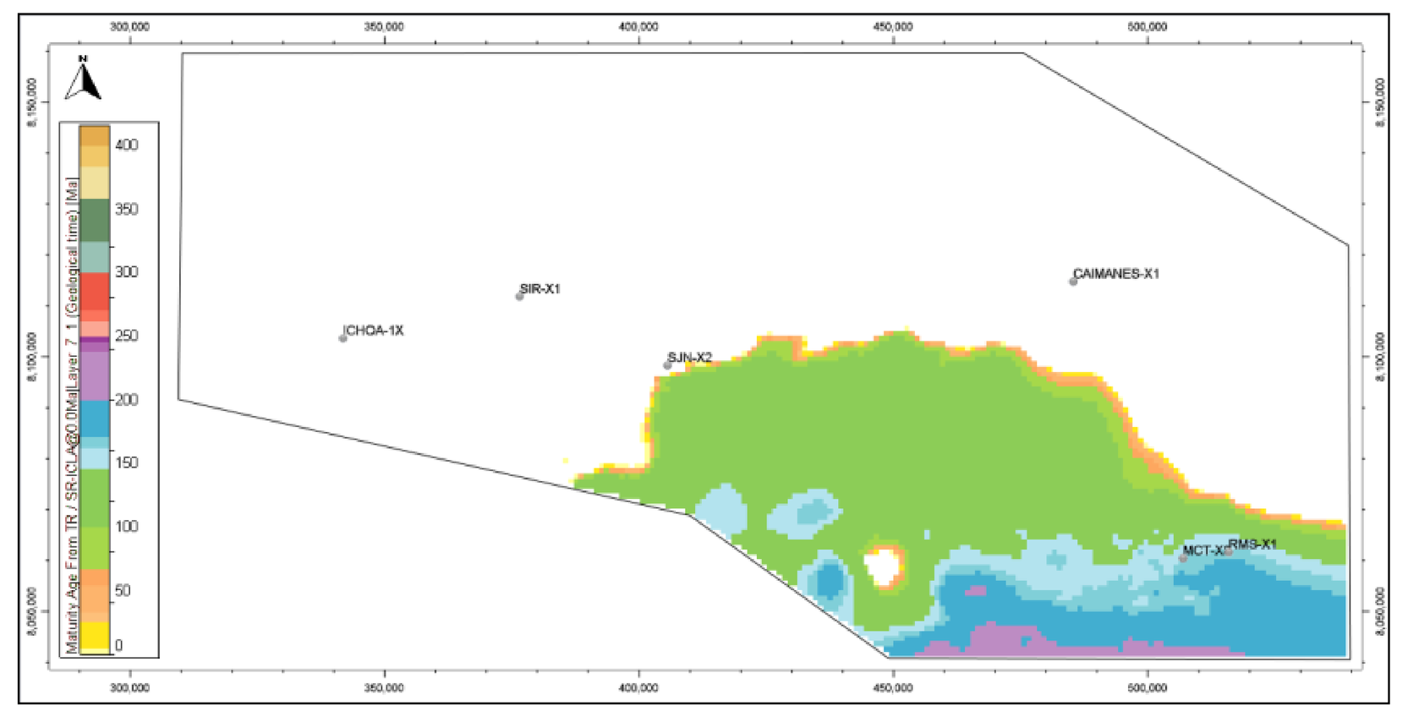
Vitrinite Reflectance % - Praginan SR



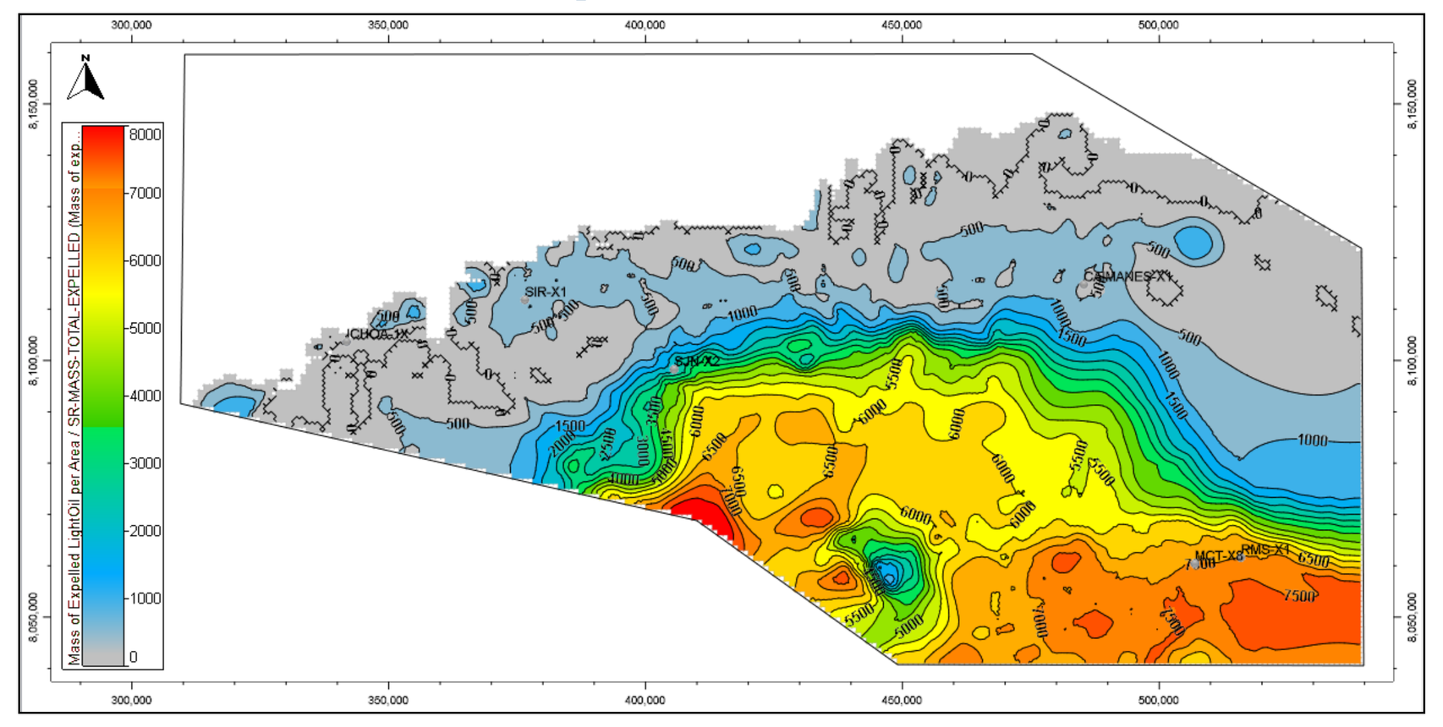
Transformation Ratio % - Praginan SR



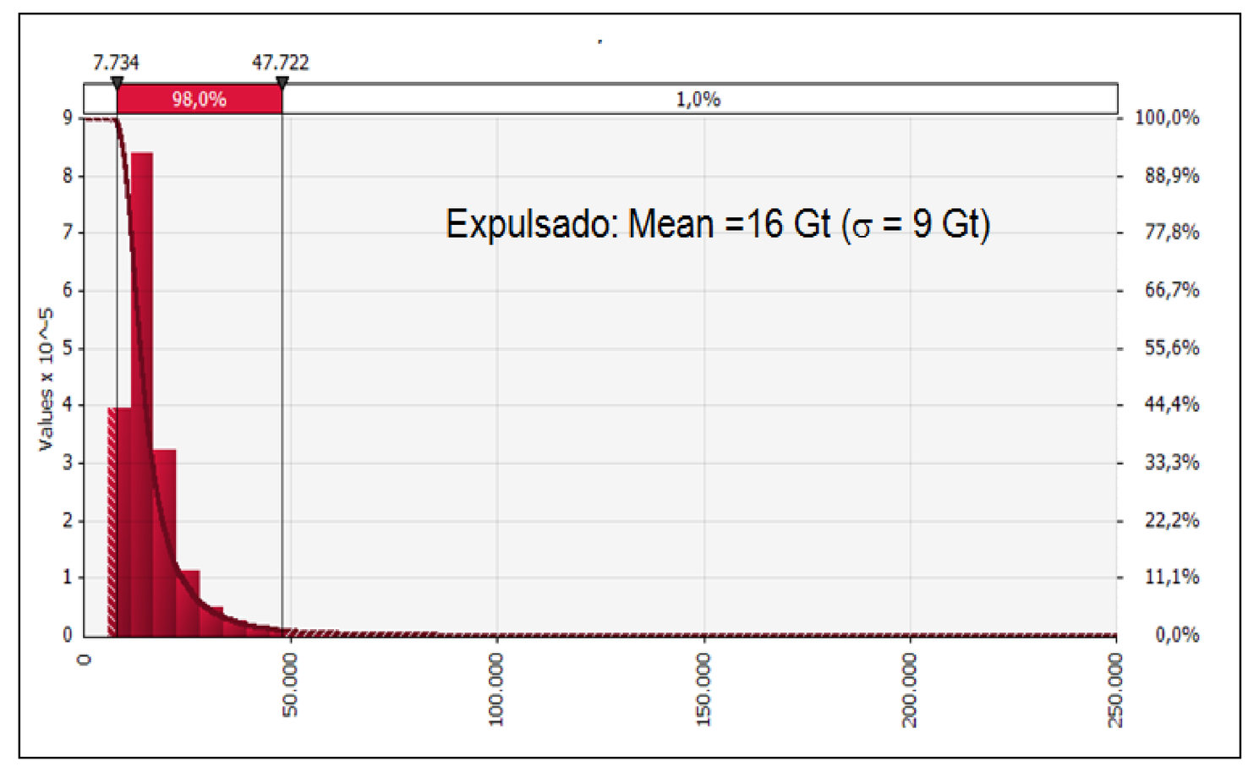
Age of Peak Expulsion (Ma) - Praginan SR



Total Mass of Expulsed HC - All SR

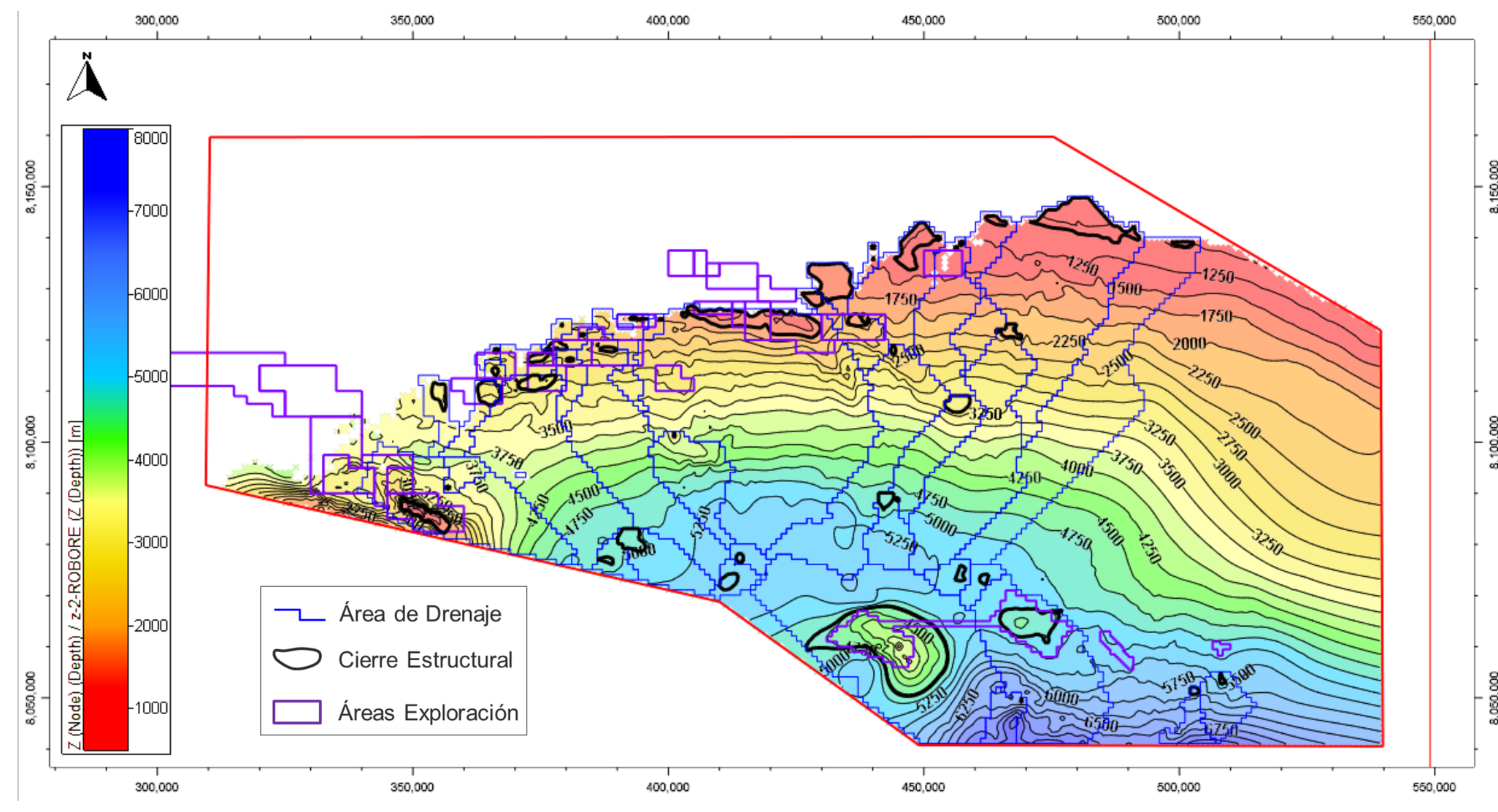


- Main quantities of expulsed hydrocarbons come from Lower Devonian Preginian source rock given the high initial source rock potential and the high thermal maturity.
- Mean expulsed total HC masses from Devonian and Silurian source rocks is 16 Gt.
- Given the nature of the gas prone kerogen and the higher expulsed quantities from mature areas, fluid composition and type in fields ranges from gas condensate and wet-dry gas, with some liquid phase oil fields due to

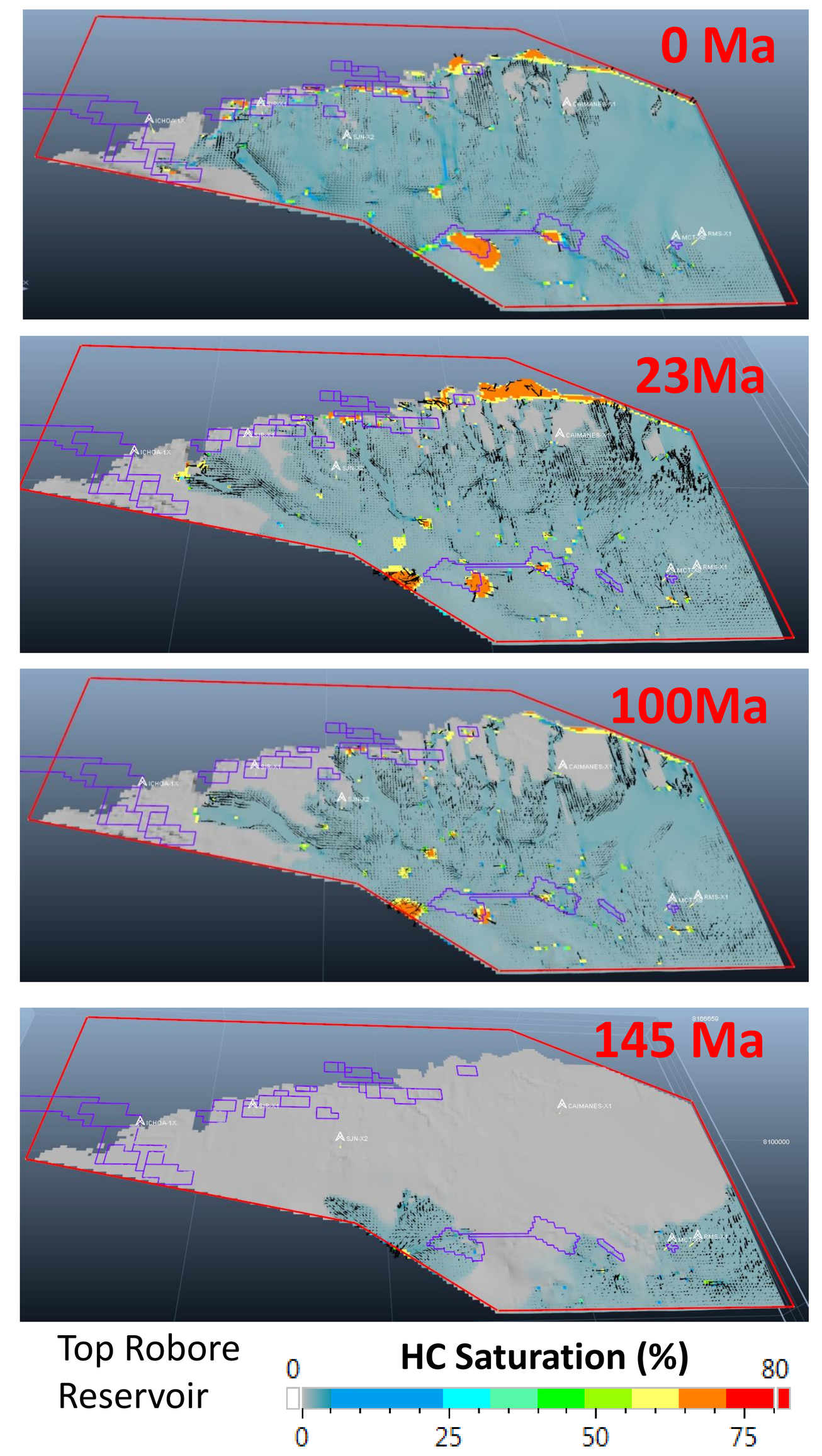


- Lateral, long distance up-dip migration through the Robore formation occurred during Early Cretaceous before the Andean deformation, following a northward fill and spill trap charge accumulating below the Late Jurassic erosive unconformity.
- Lateral migration was controlled by paleo-fetch drainage areas evolving through time. Structures in the central area were charged during early expulsion phase and leaked during late second expulsion phase by-passed hydrocarbons
- The Cretaceous-Tertiary reservoirs were charged by vertical and lateral migration above the unconformity. The Andean deformation resulted in enhancing the structural closures and the vertical migration towards the Cretaceous plays.
- Oil field occurs due to: 1) Early migration of up-dip low pressure below pressure saturation hydrocarbons trapped before Andean orogeny (Arrollo Negro Field); 2) Small drainage area structures with source rock in oil window (Surubi Field)

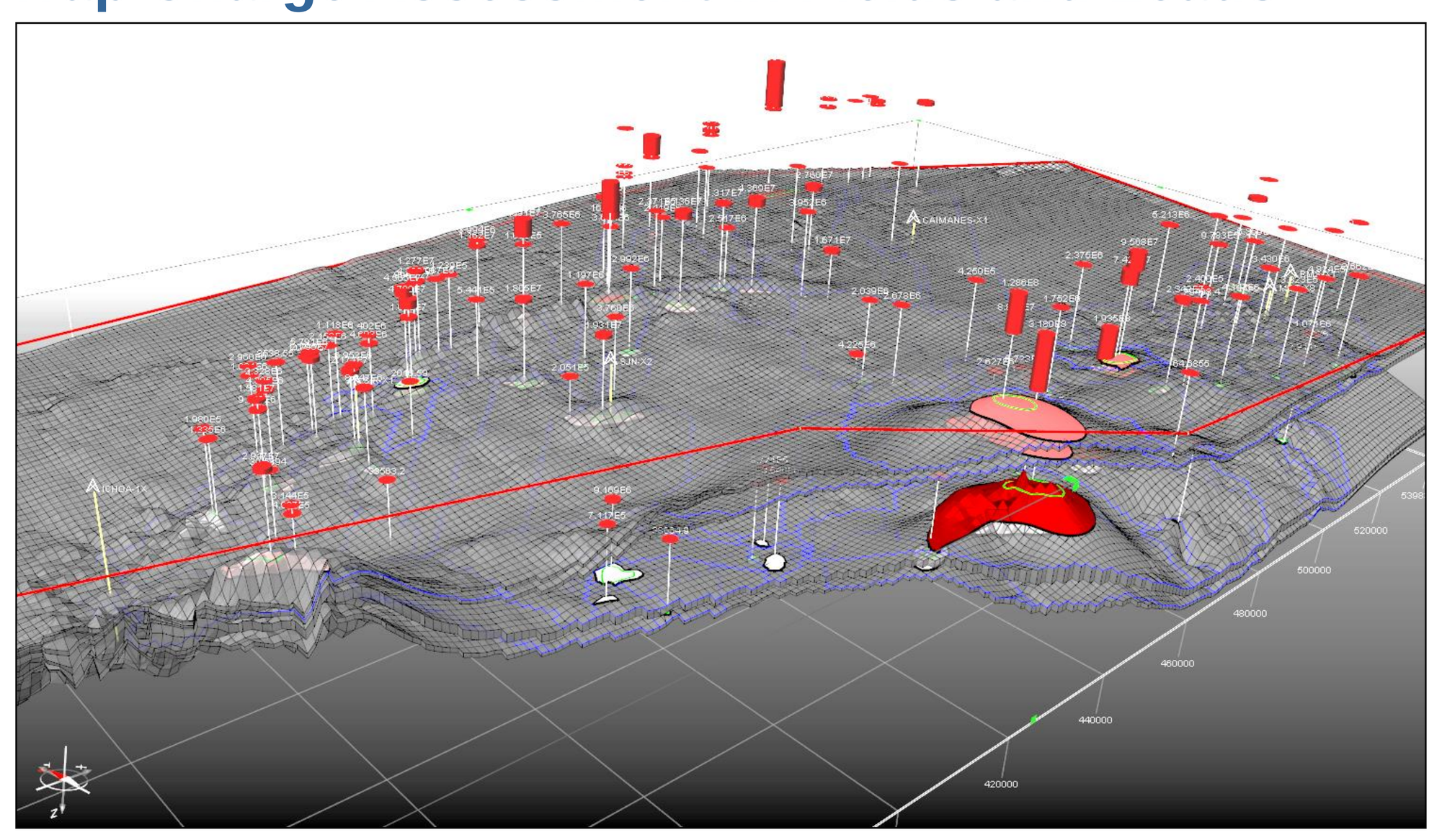
Drainage area (Fetch area) – Robore Reservoir



HC Migration and Charge



Trap Charge Assessment in Fields and Leads



6. CONCLUSIONS

The results of this study provide a petroleum systems understanding in HC migration mechanisms, charge and synchrony of events.

The results of this study provided YPFB with a model based approach predicting yet to find volumes in place for undrilled prospects and leads, allowing to delineate a future drilling strategy.

Main recommendations are to focus in less explored Northeastern area which encompasses favorable timing of hydrocarbon expulsion and migration versus trap formation in stratigraphic wedge bellow erosive unconformity.