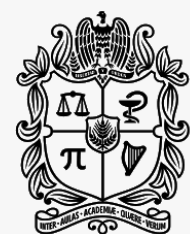


COLOMBIA ROUND 2021



UNIVERSIDAD
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ACOGGP
ASOCIACIÓN COLOMBIANA DE GEÓLOGOS Y GEOFÍSICOS DEL PETRÓLEO



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ANH
AGENCIA NACIONAL DE HIDROCARBUROS



El futuro
es de todos

Minenergía

CAGUÁN SUB-BASIN

Geological Integration, Evaluation of Oil Systems and Prospectivity

2021-07-02

Work Team – *Kurt Bayer*

Regional Geological Framework / Chronostratigraphic Sections / Gross
Depositional Environments – Gatsby López, *Luis Vergara**

Petrophysics, Reservoirs and Seals – Helman Bonilla, *Luis Vergara**

Structural sections / Plays, prospects and leads – Catherine Jaimes,
*Andres Mesa**

Petroleum System / Yet to Find – *Cesar Mora*

*Speaker

Work Team

- Project Director *Kurt Bayer*
- UPTC Coordinator *Carlos Julio Rodríguez*
- Stratigraphy Advisor *Luis Vergara*
- Structural Geology Advisor *Andrés Mesa*
- Petroleum Systems Modeling *Cesar Mora*
- Geologist support in Stratigraphy *Gatsby López*
- Petrophysics Advisor *Helman Bonilla*
- ☐ Seismic Interpretation *Catherine Jaimes*
- Yet to Find *Juan Guarín*
- Support Geologist at MSP *Leady Caro*
- GIS Specialist *Aldemar Cardozo*

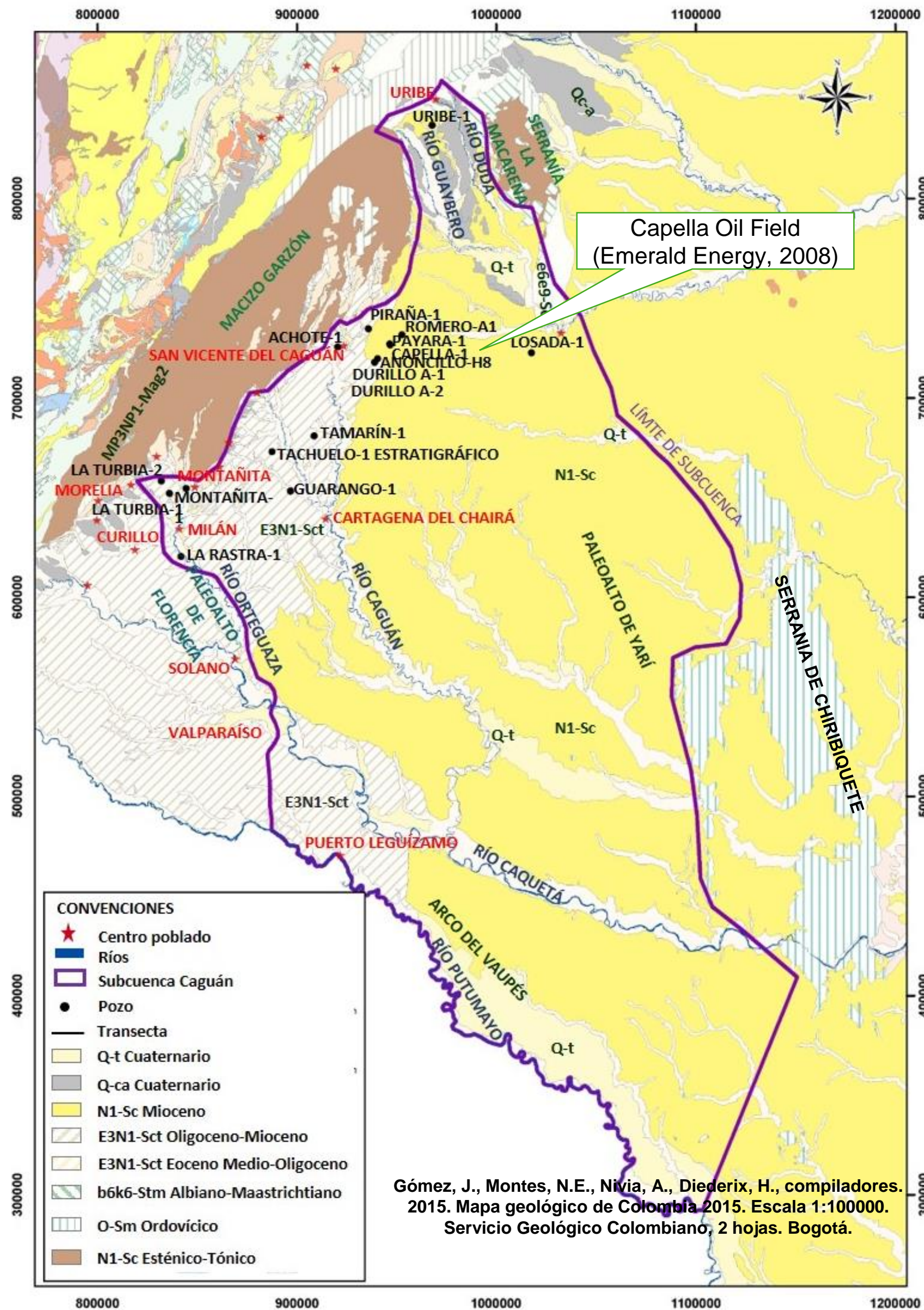
11
Professionals

Geological Framework Chronostratigraphic Sections Gross Depositional Environments

GATSBY E. LOPEZ / LUIS VERGARA

GEOLOGICAL FRAMEWORK

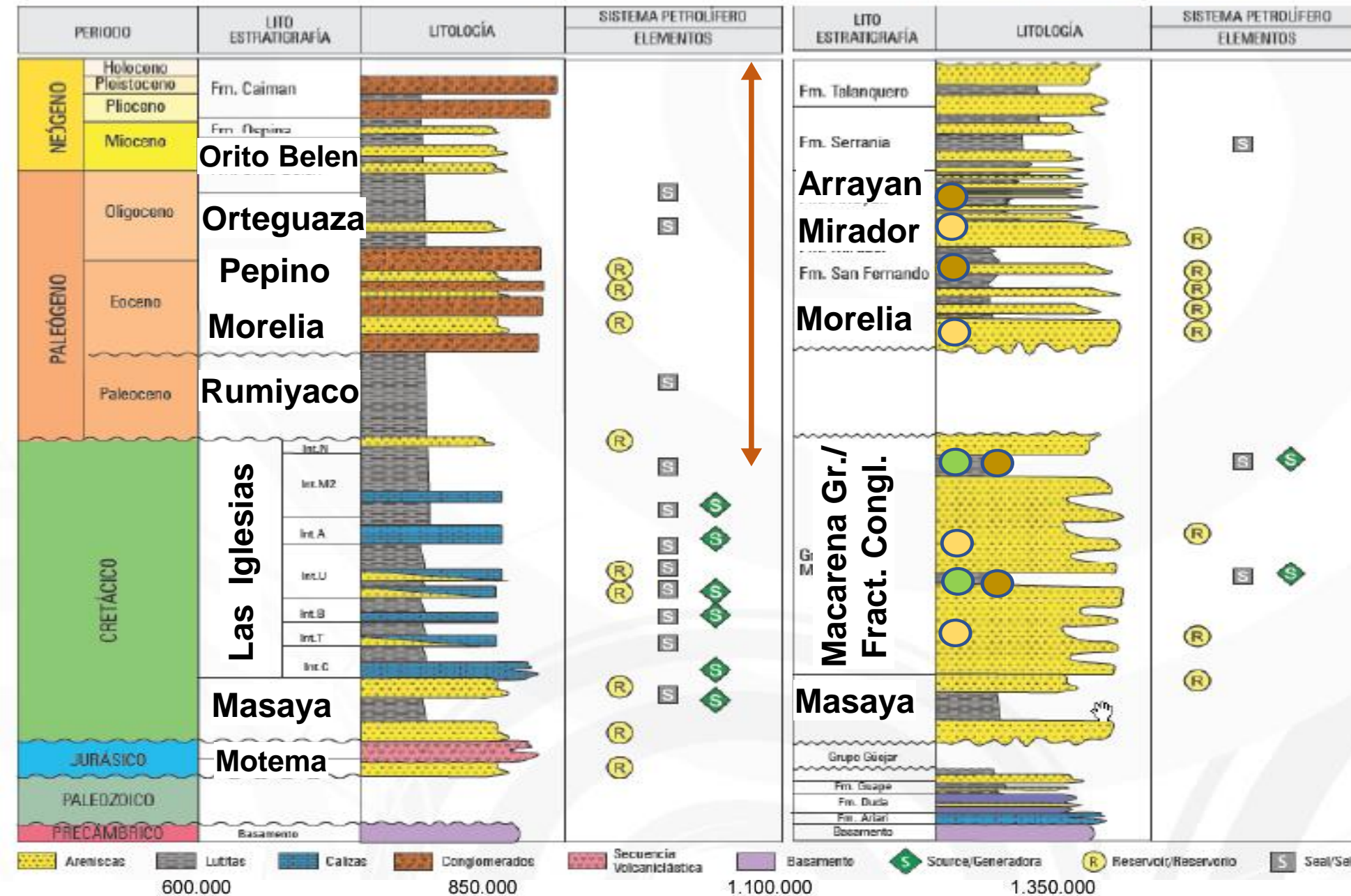
Geologic Map



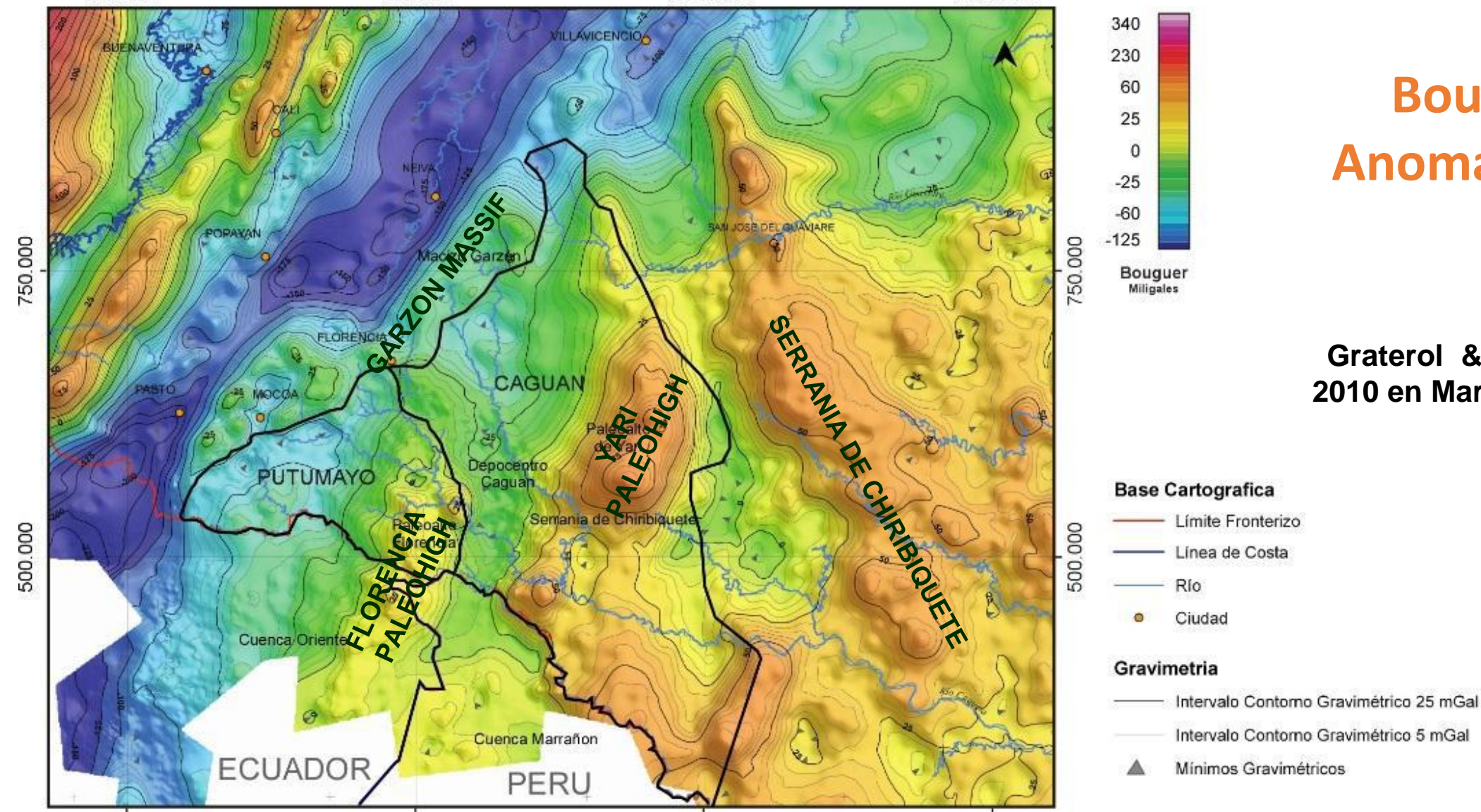
Caguan S / Putumayo N
Mora et al (1998)



Caguan N



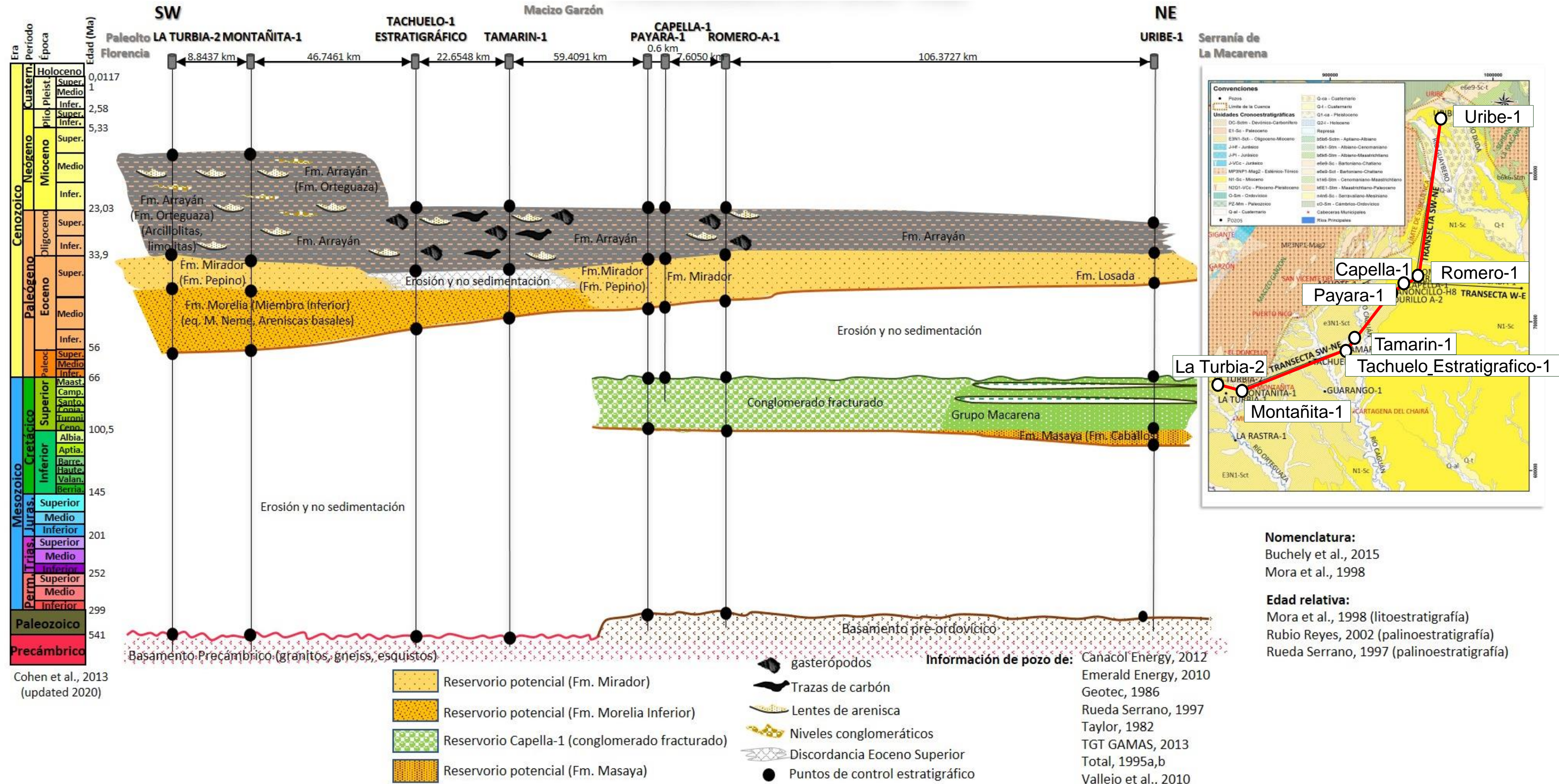
Stratigraphy



Bouguer Anomaly Map

Graterol & Vargas Gómez, 2010 en Martínez et al., 2014.

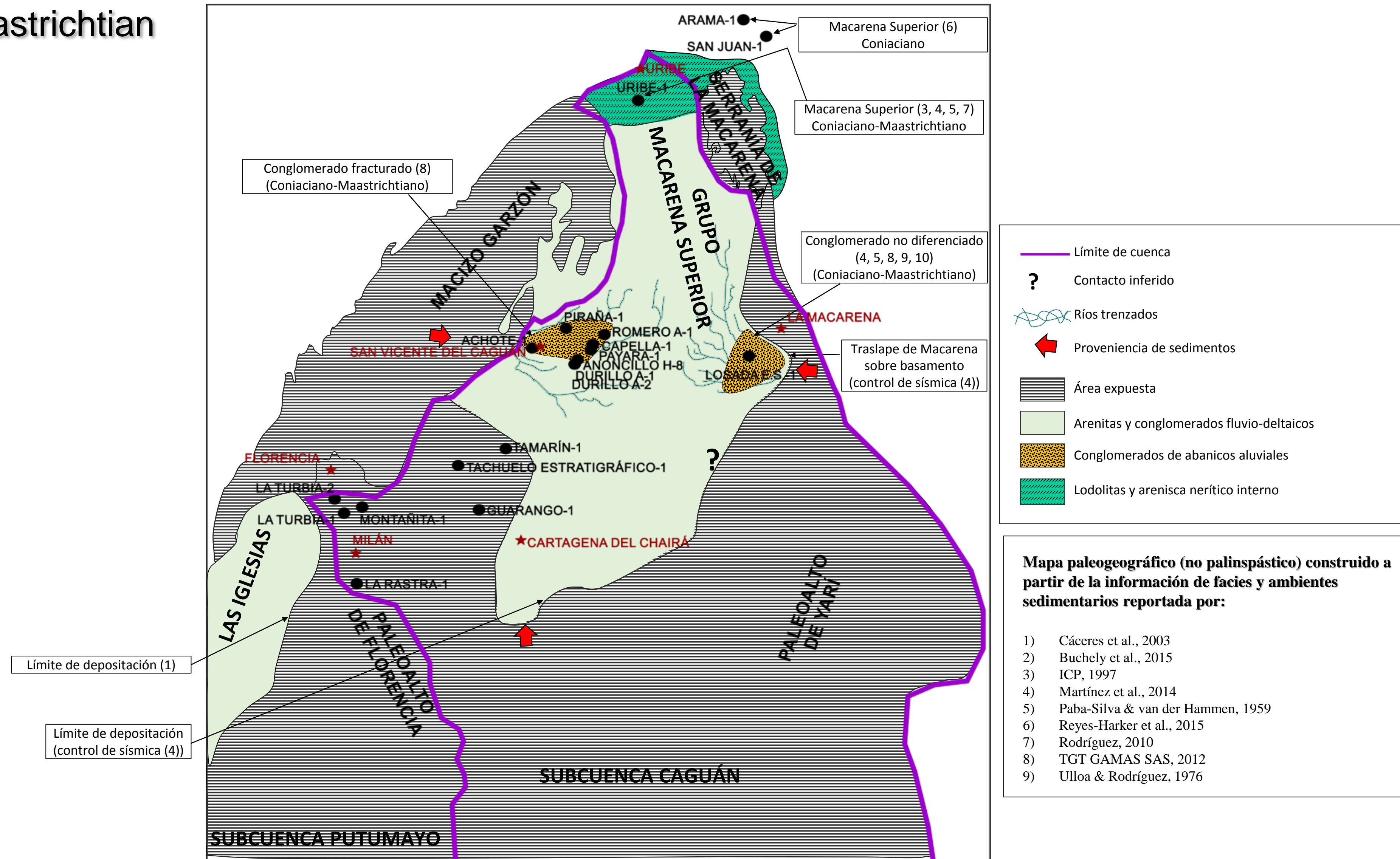
CHRONOSTRATIGRAPHIC SECTION I



Cohen et al., 2013 (updated 2020)

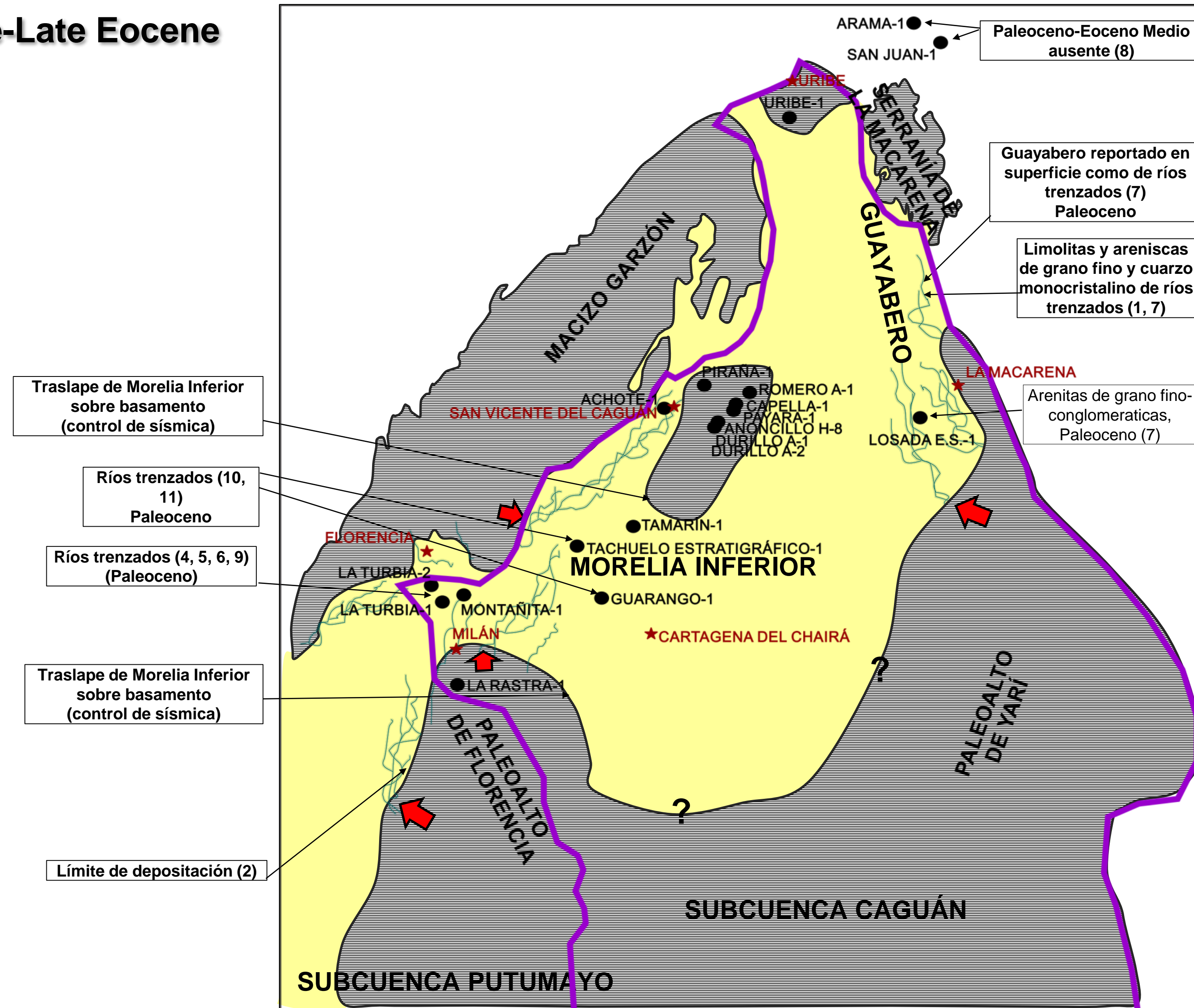
GROSS DEPOSITIONAL ENVIRONMENTS

Coniacian-Maastrichtian



GROSS DEPOSITIONAL ENVIRONMENTS

Paleocene-Late Eocene



Legend:

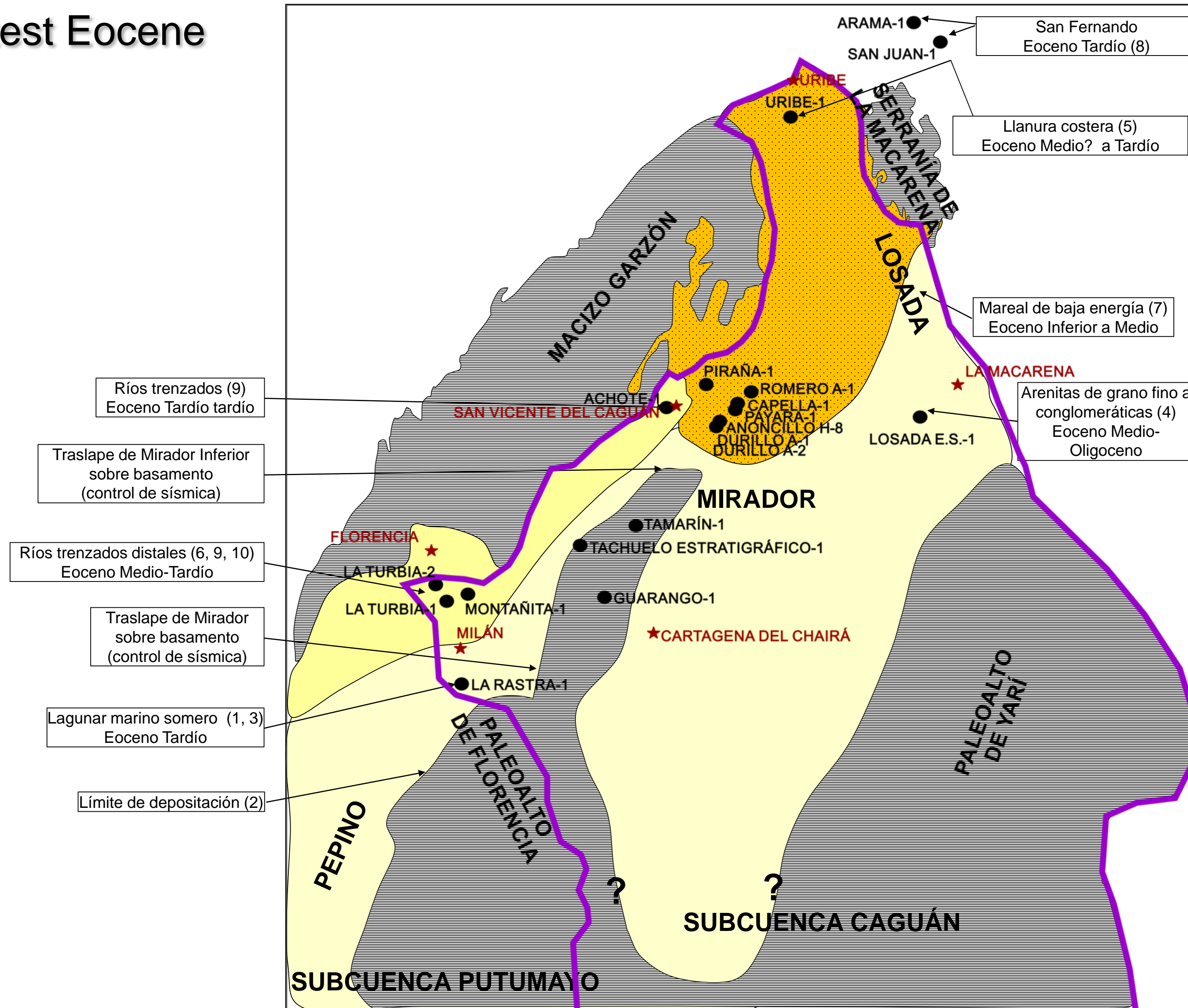
- Límite de cuenca
- ? Contacto inferido: sin control de pozo ni sísmica
- ~ Ríos trezados
- ➔ Proveniencia de sedimentos
- ▨ Área expuesta
- Depósitos de ríos trezados

Mapa paleogeográfico (no palinspástico) construido a partir de la información de facies y ambientes sedimentarios reportada por:

- 1) Buchely et al., 2015
- 2) Cáceres et al., 2003
- 3) Gómez et al. (2015)
- 4) Kendall, 1982
- 5) Martínez et al., 2014
- 6) Mora et al., 1998
- 7) Navarrete, 1995
- 8) Reyes-Harker et al., 2015
- 9) Rodríguez, 2010
- 10) TGT GAMAS SAS, 2012
- 11) TGT GAMAS SAS, 2013

GROSS DEPOSITIONAL ENVIRONMENTS

Latest Eocene



— Límite de cuenca
? Contacto inferido: sin control de pozo ni sísmica
 Ríos trezados
 Proveniencia de sedimentos
 Área expuesta
 Depósitos de ríos trezados
 Arenitas de llanura mareal (*sand-flat*)
 Arenitas costero-mareal

Mapa paleogeográfico (no palinspástico) construido a partir de la información de facies y ambientes sedimentarios reportada por:

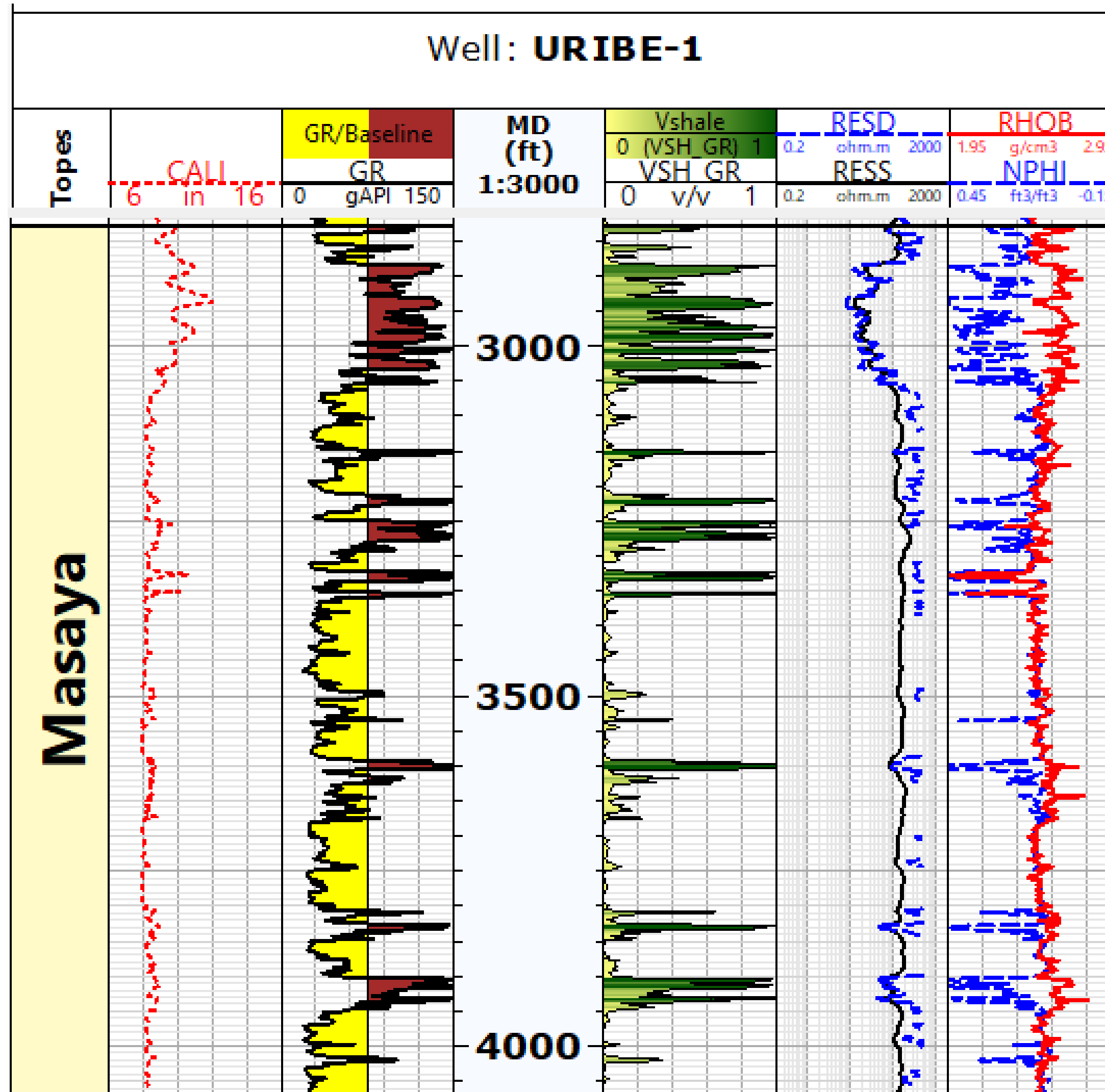
- 1) BLOSS LTDA, *n.d.*
- 2) Cáceres et al., 2003
- 3) Data Log, 2011
- 4) Gómez et al., 2015
- 5) ICP, 1997
- 6) Kendall, 1982
- 7) Paba-Silva & van der Hammen, 1959
- 8) Reyes-Harker et al., 2015
- 9) Sarmiento Pérez, 2013
- 10) Vallejo et al., 2010

Petrophysical Evaluation Reservoirs and Seals

HELMAN BONILLA / LUIS VERGARA

RESERVOIR EVALUATION

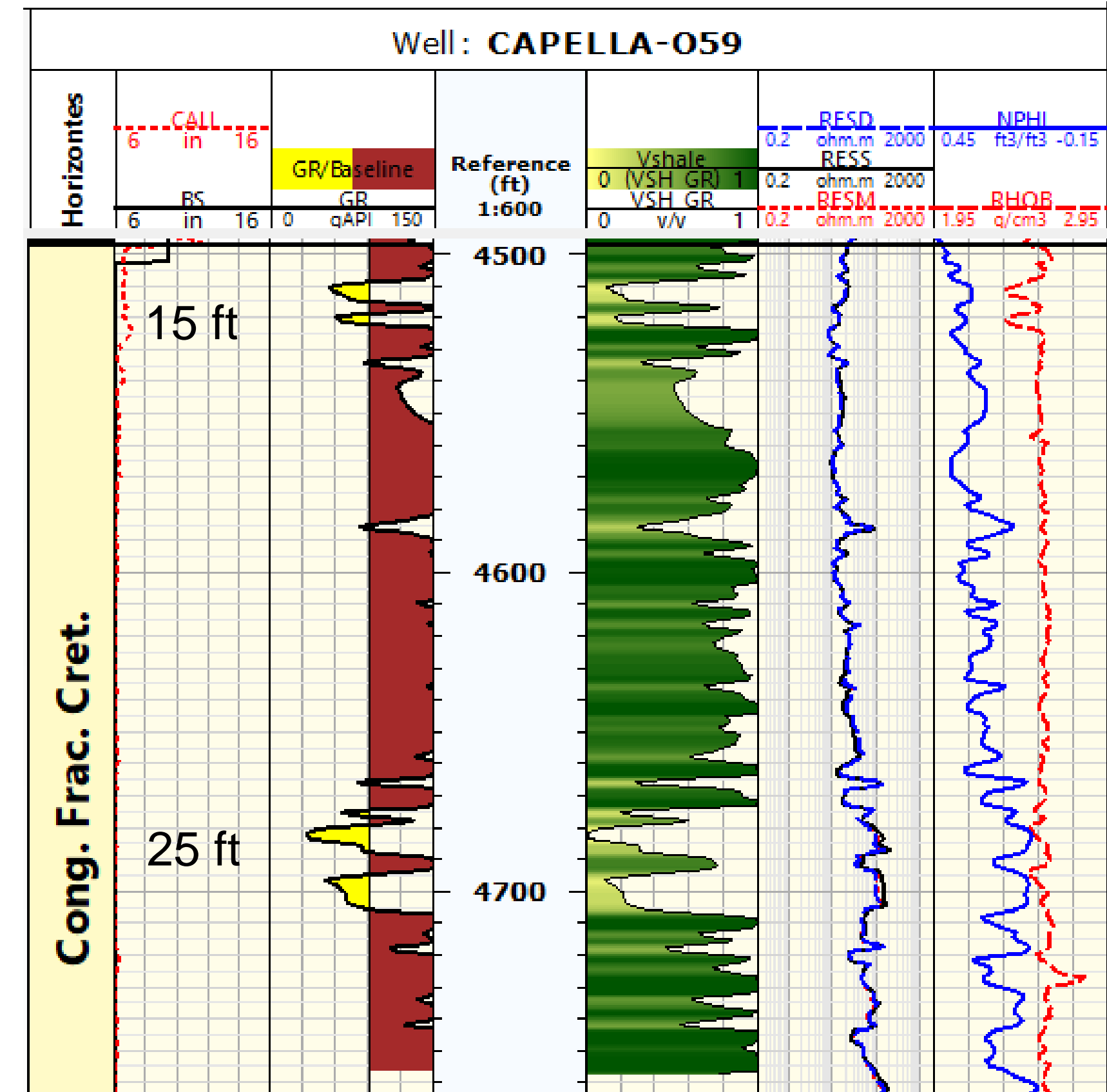
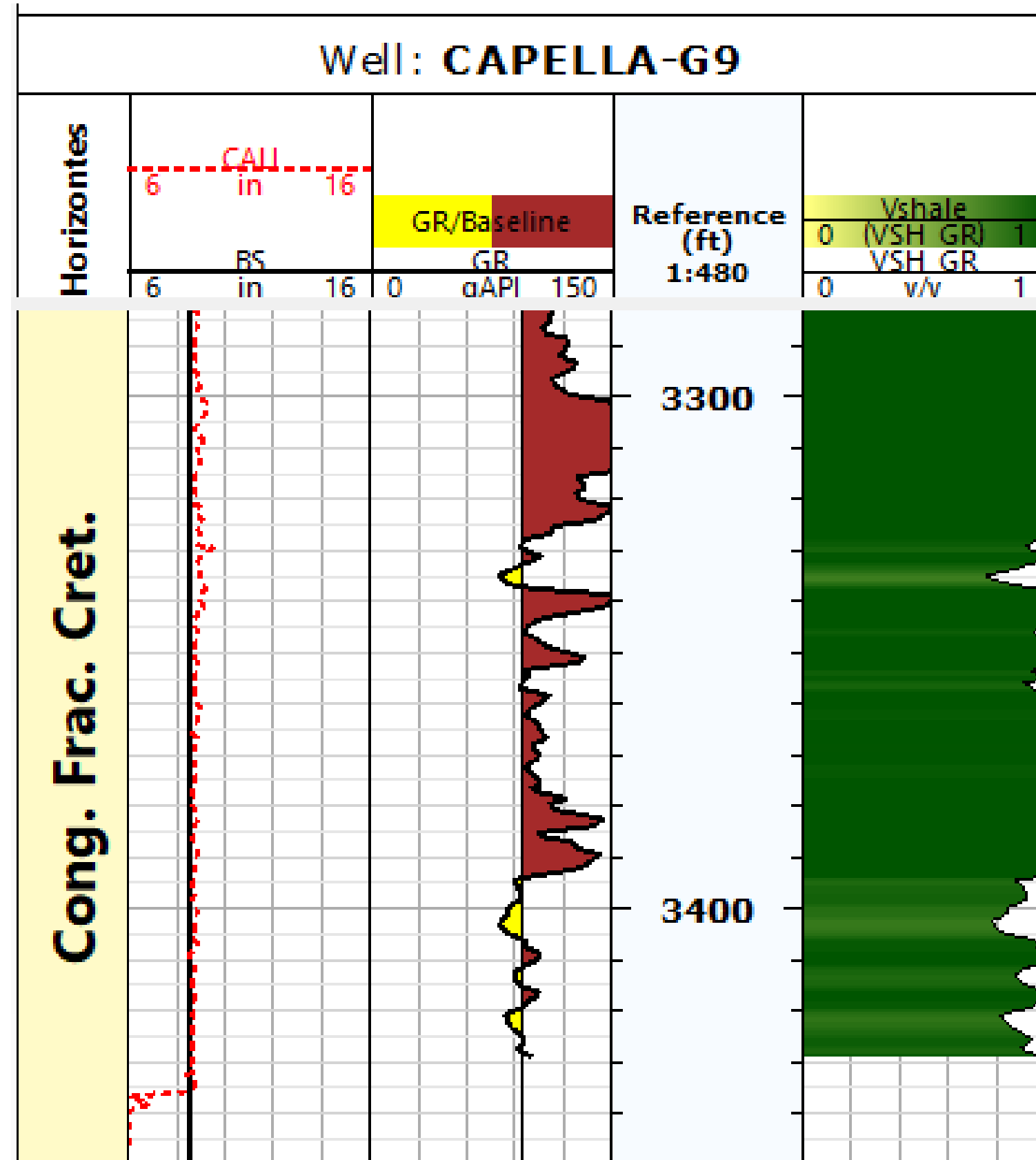
Masaya Formation



- Clay zones towards the top, otherwise clean sandstones with GR 30-70 API and Vclay of 10% average.
- High resistivity with possible fluid mobility
- Low Permeabilites of about 2 mD.
- Oil shows and favorable lithology indicate potential storage capacity

RESERVOIR EVALUATION

“Fractured Conglomerate”



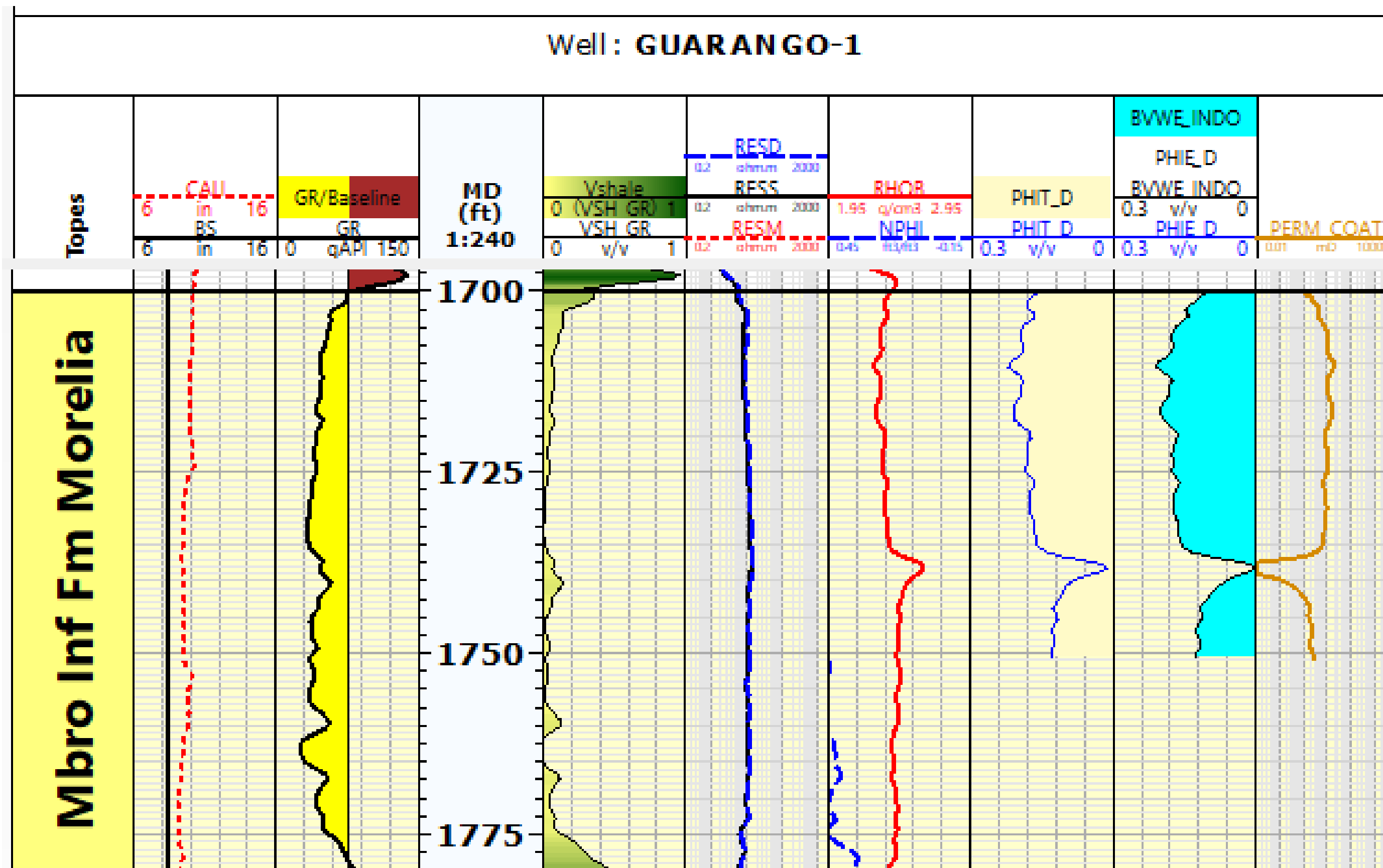
- Conglomerates with sandstone interbeds, 150 ft thick
- Main components are quartz fragments, pebbles, igneous and metamorphic lithics

- Predominantly clay interval 100 ft thick
- Sandy zones with GR 55-70 API and Vclay ~ 12-18% have reservoir potential

- Presence of fractures may affect porosity calculations, up to 25% ϕ possible

RESERVOIR EVALUATION

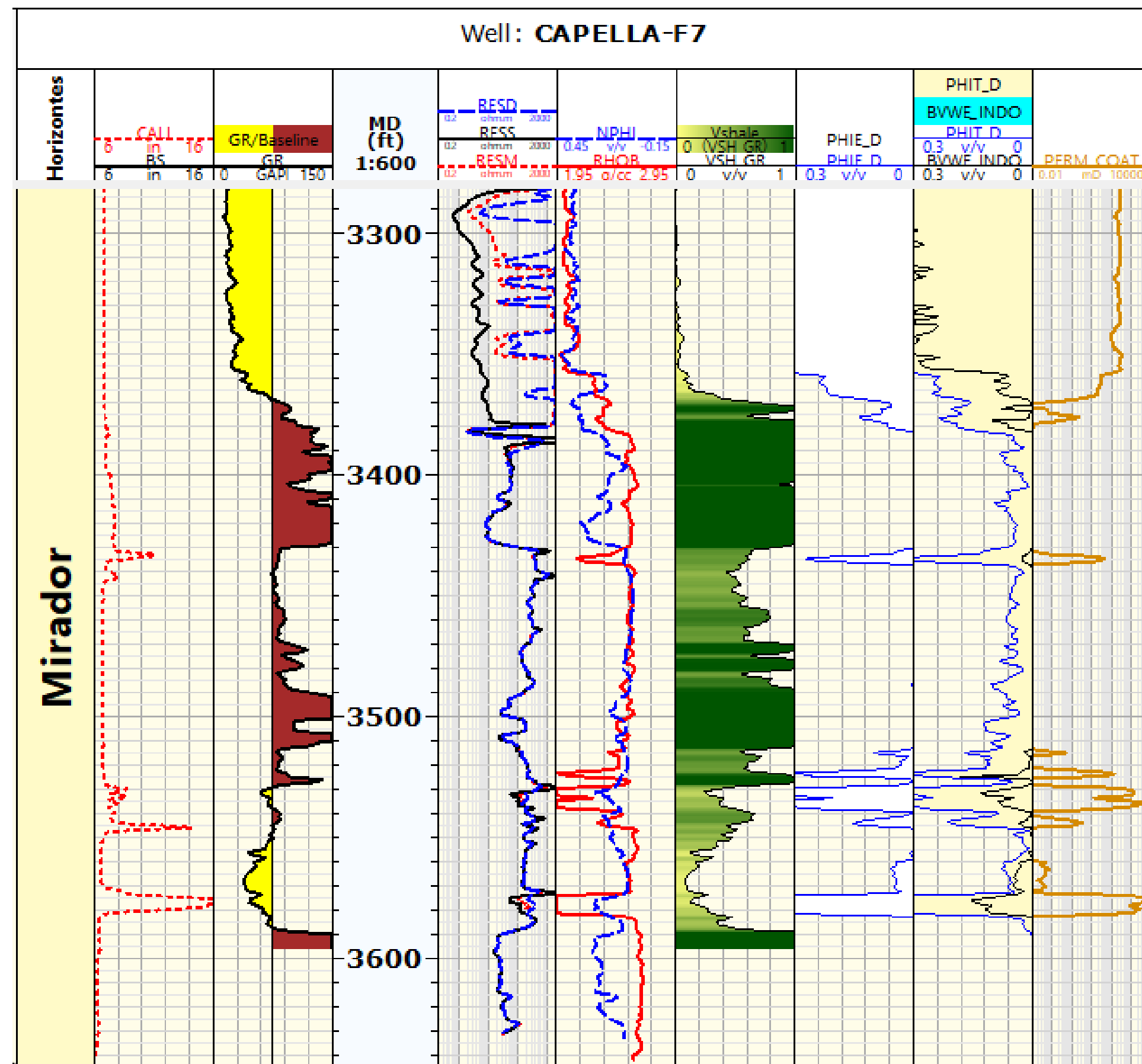
Lower Morelia Formation ("Basal Sandstones")



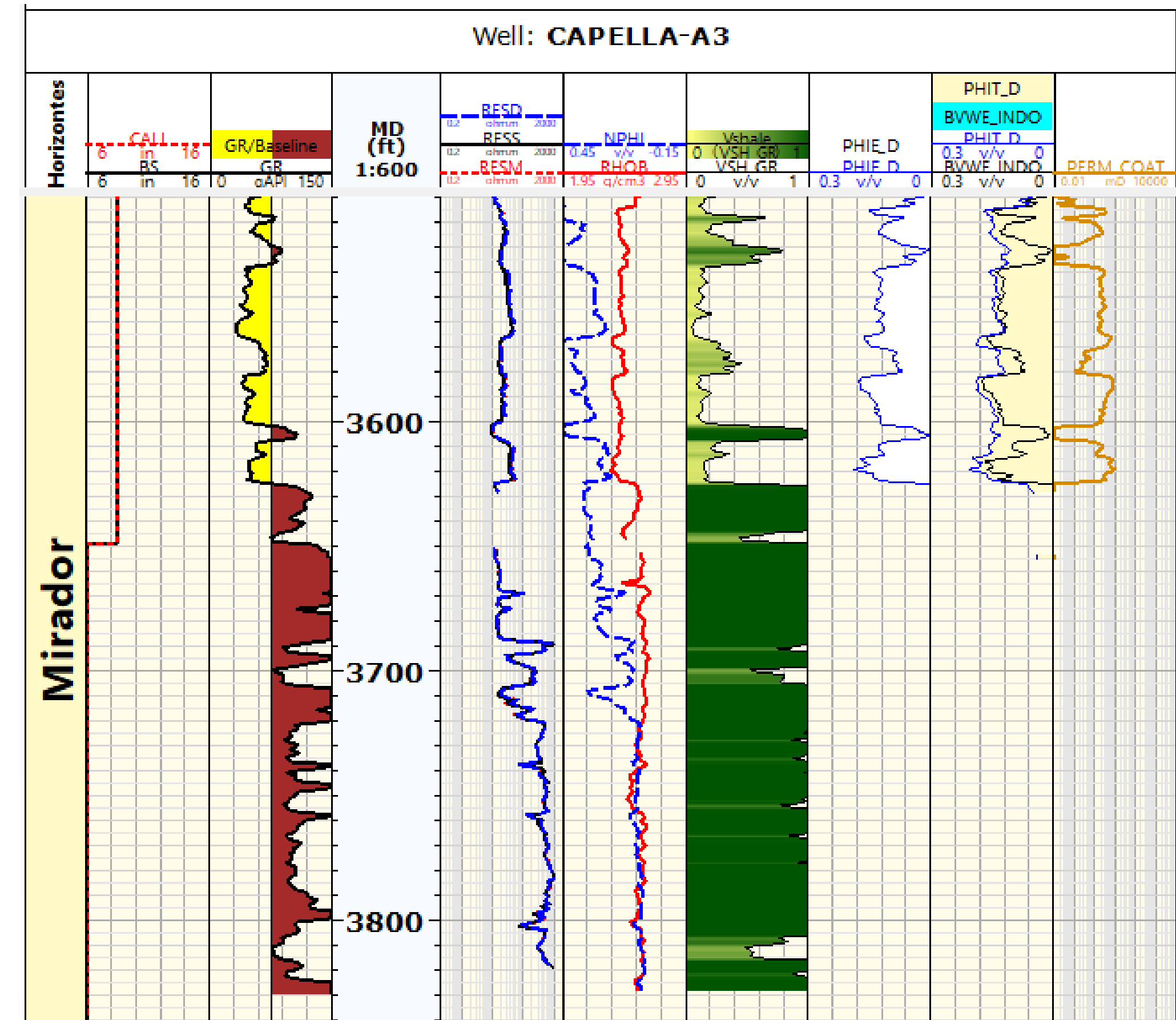
- Clean lithology
- GR values 30 - 70 API
- Vclay < 10%
- Low resistivity values and deflection indicate poor mobilities
- Average Porosity 16%
- Low Permeability 8 mD.

RESERVOIR EVALUATION

Mirador Formation



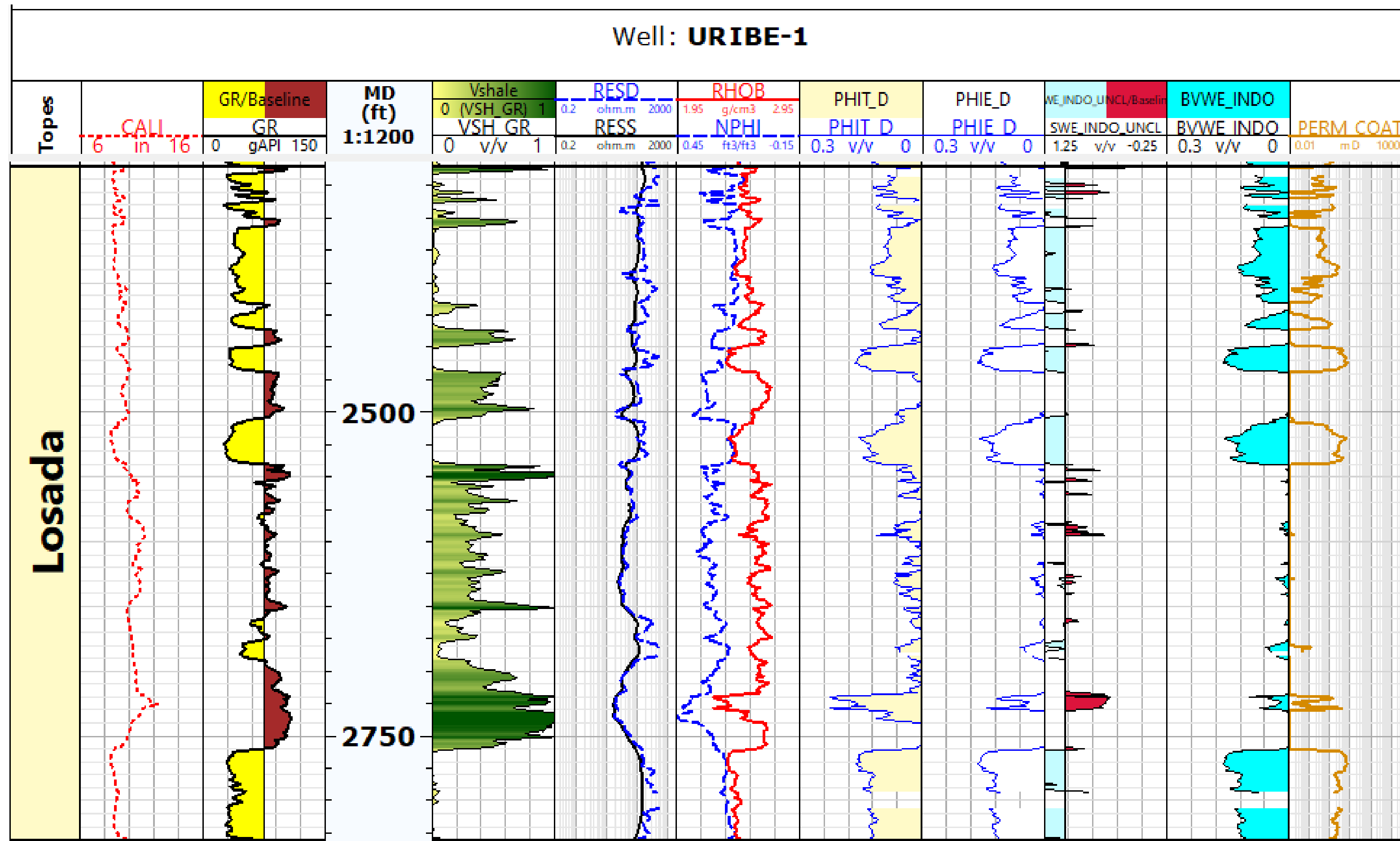
- Upper interval shows good reservoir potential
- Average porosity 35%, water saturated (D-N logs)
- Average Permeability of 1000 mD allows mobility (Resistivity logs)



- Average porosity around under 15%.
- Permeability around 100 mD, fluid mobility

RESERVOIR EVALUATION

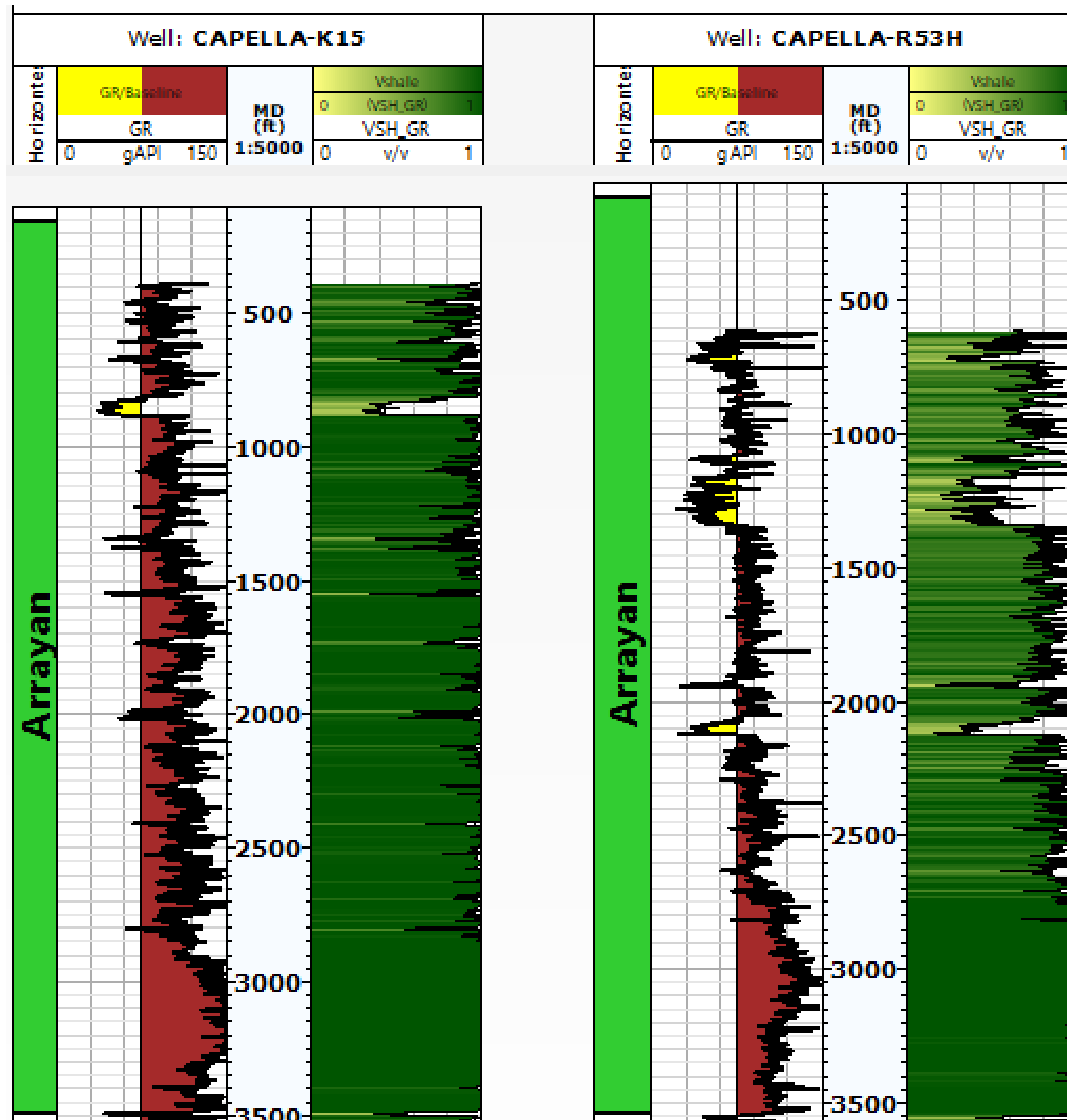
Losada Formation (Mirador eq.)



- GR 30-70 API shows Res zones with clean sandstones
- Vclay < 10%.
- High resistivity and deflection support possible fluid mobility
- Maximum porosity of 15%
- Permeability about 5 mD.
- Potential reservoir unit

SEAL EVALUATION

Arrayán Formation

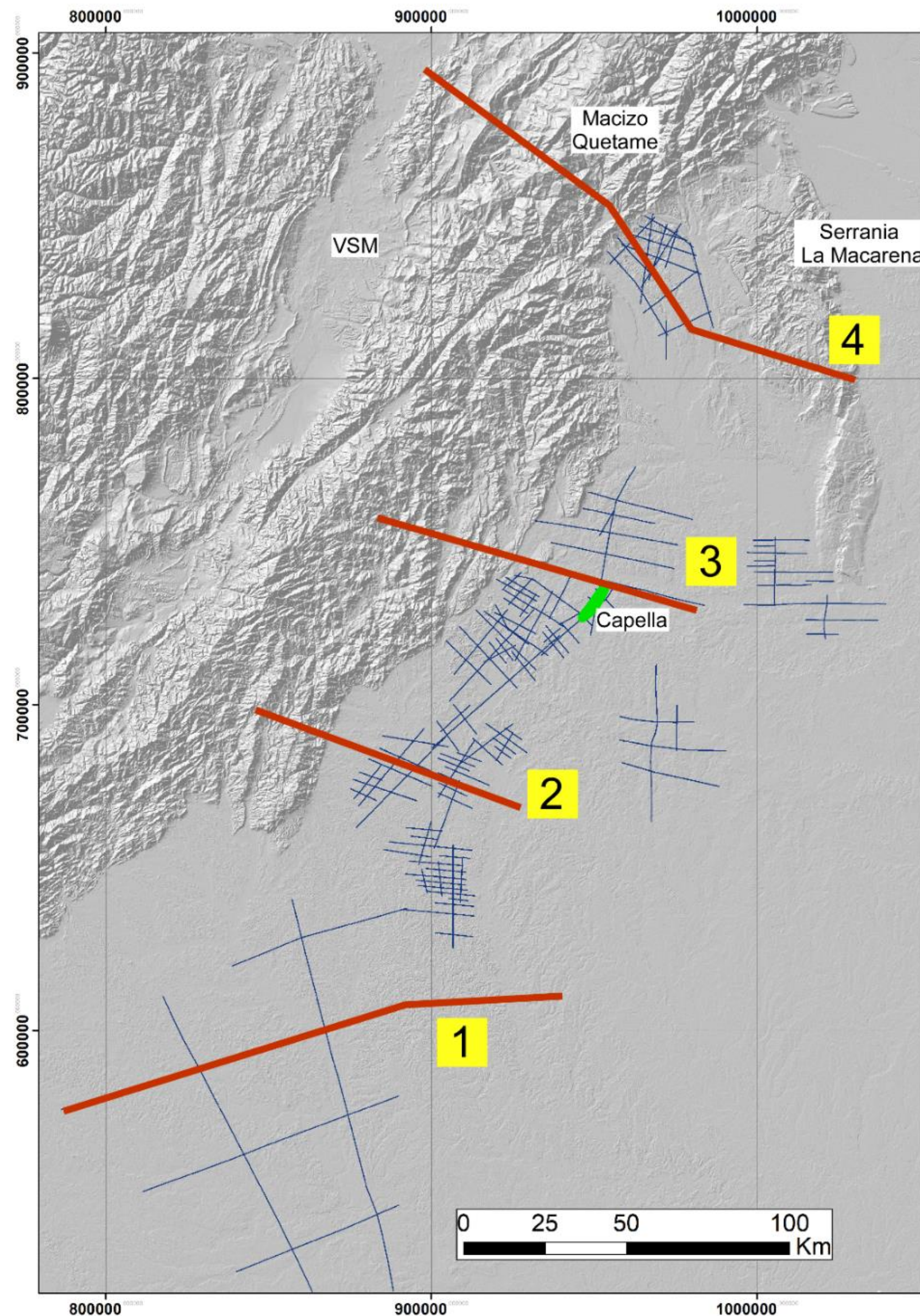


- Regional ultimate seal composed of massive claystones 3000 ft + thick
- Incomplete set of logs acquired this unit, only studied in Capella wells
- GR values vary from 65-90 API
- Vclay 65%-80%
- Sandstone intercalations with Vclay under 35% and reservoir potential occur towards the top

Structural sections / Plays, prospects and leads

CATHERINE JAIMES - ANDRES MESA

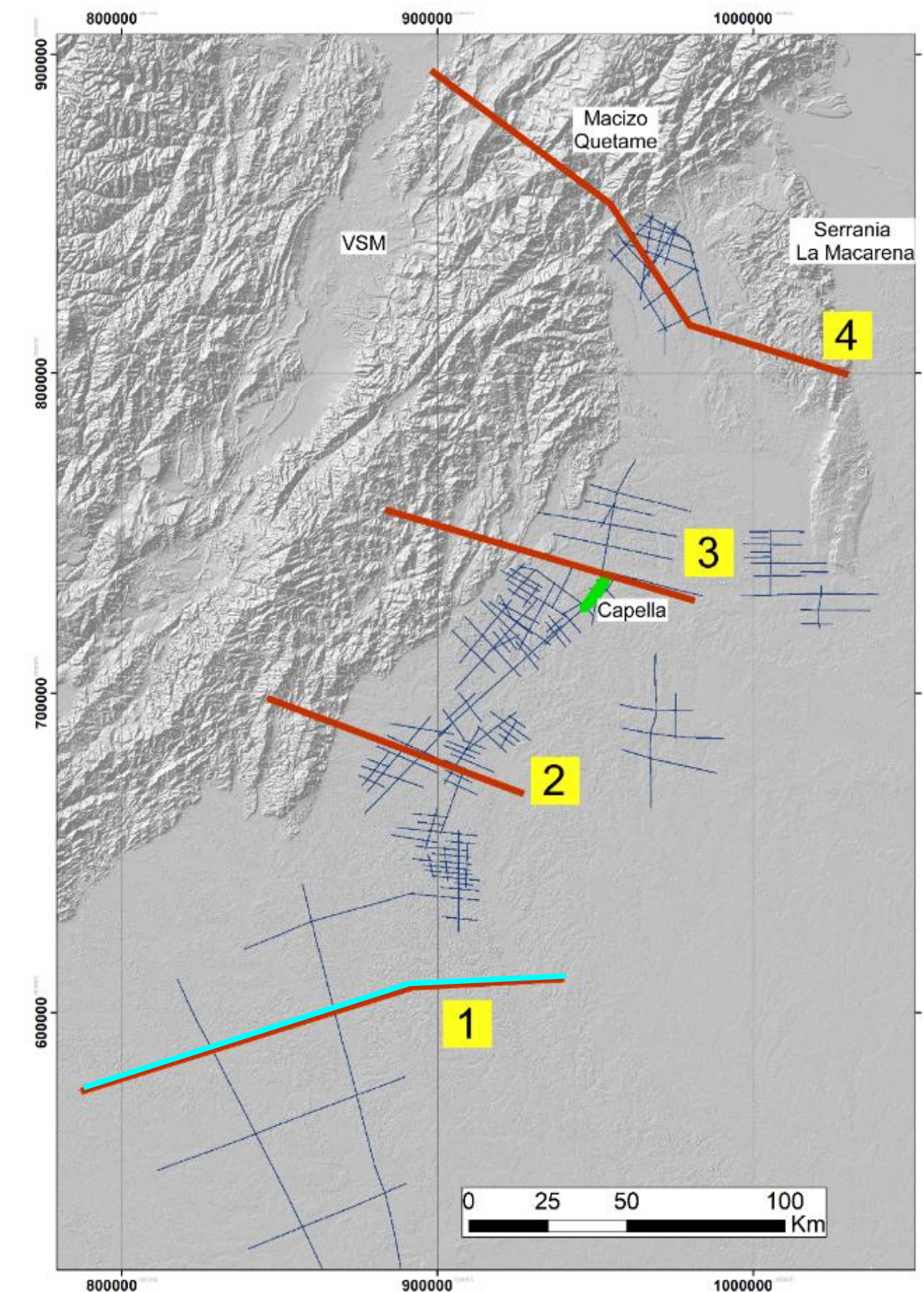
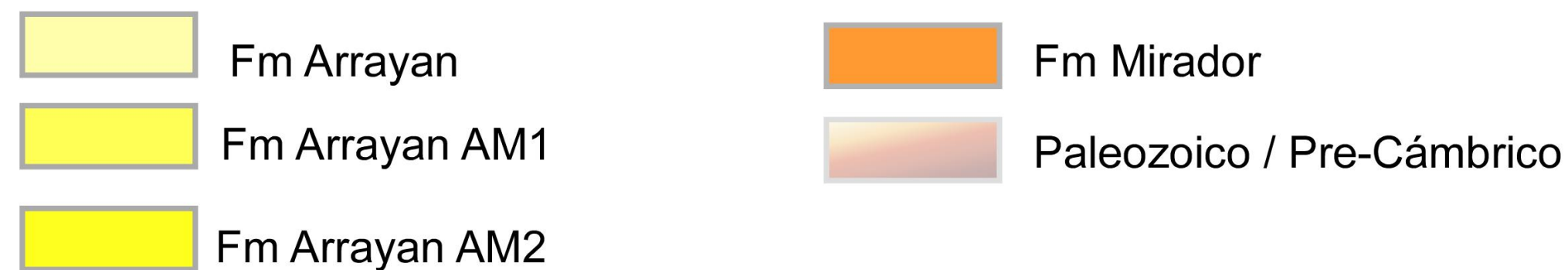
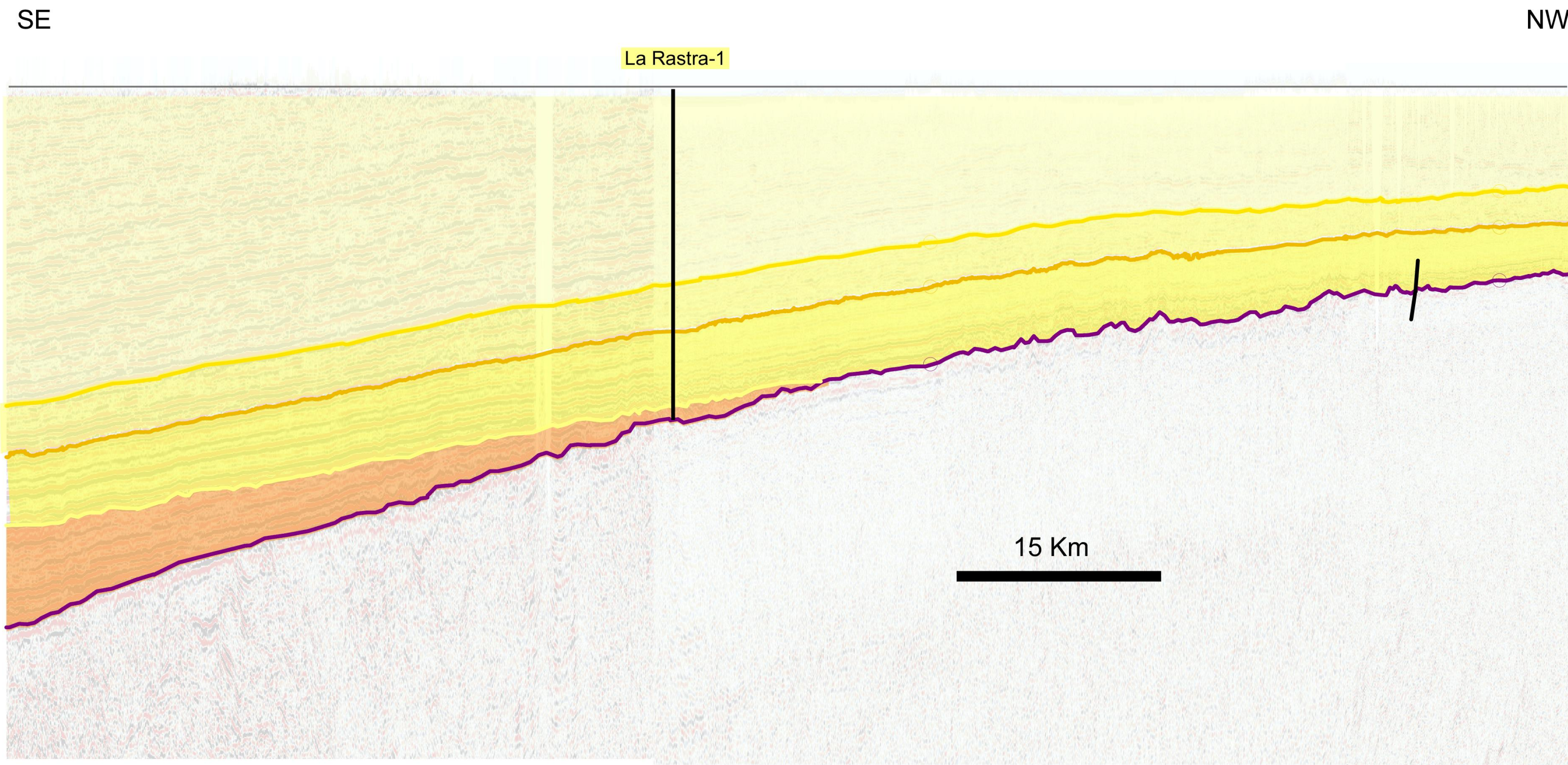
STRUCTURAL FRAMEWORK



- Seismic data base of 3.000 km 2D seismic
- Four transects were done to show the regional structural framework

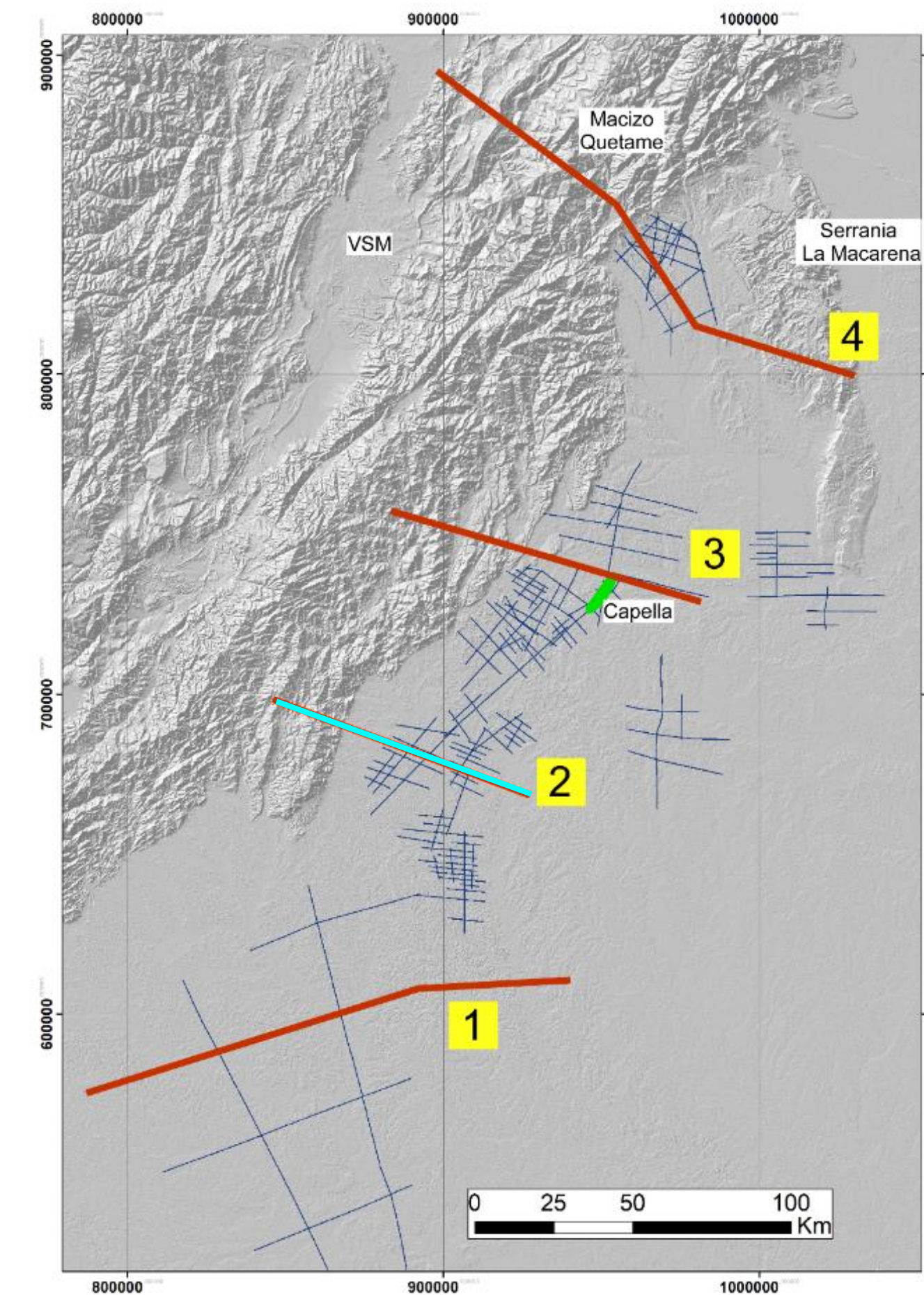
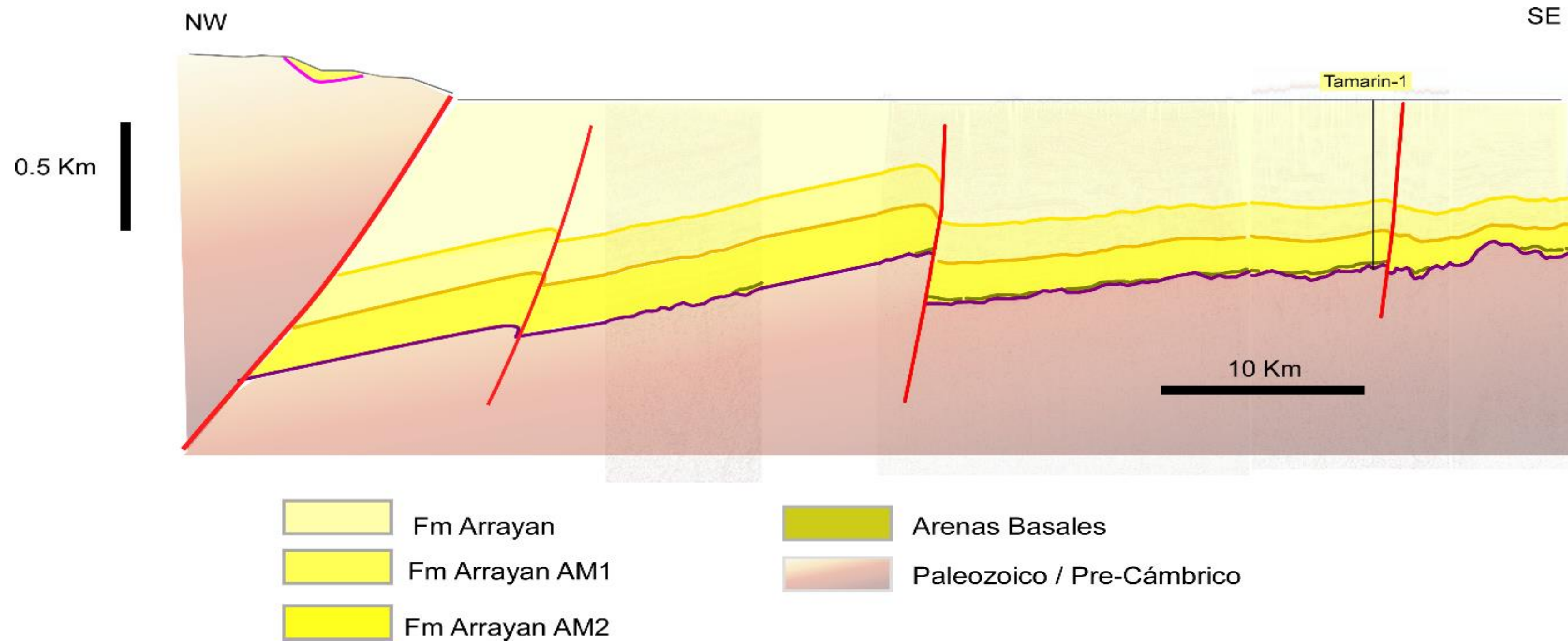
TRANSECT 1

- **Mirador Fm onlap** to the East
- Undeformed area



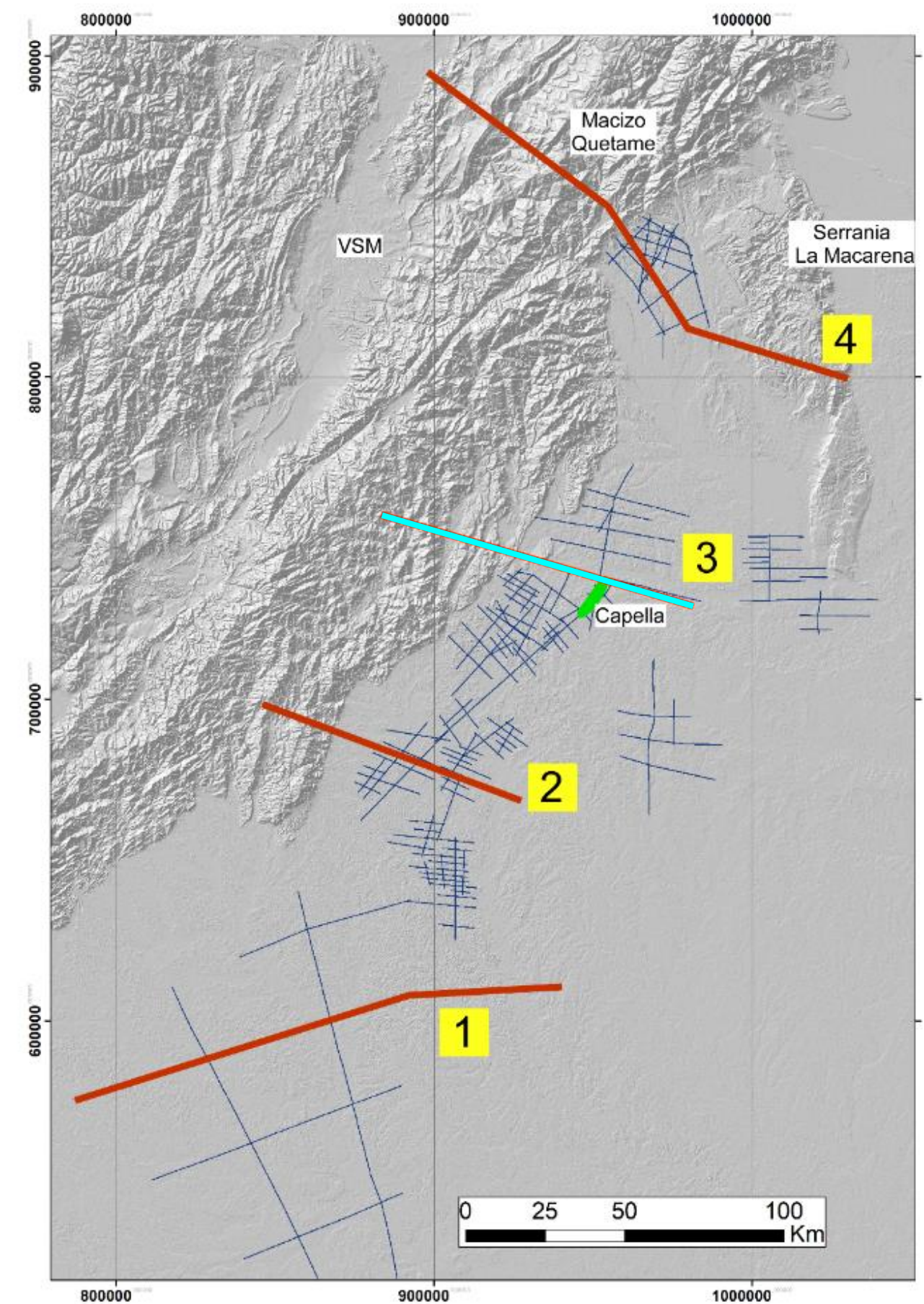
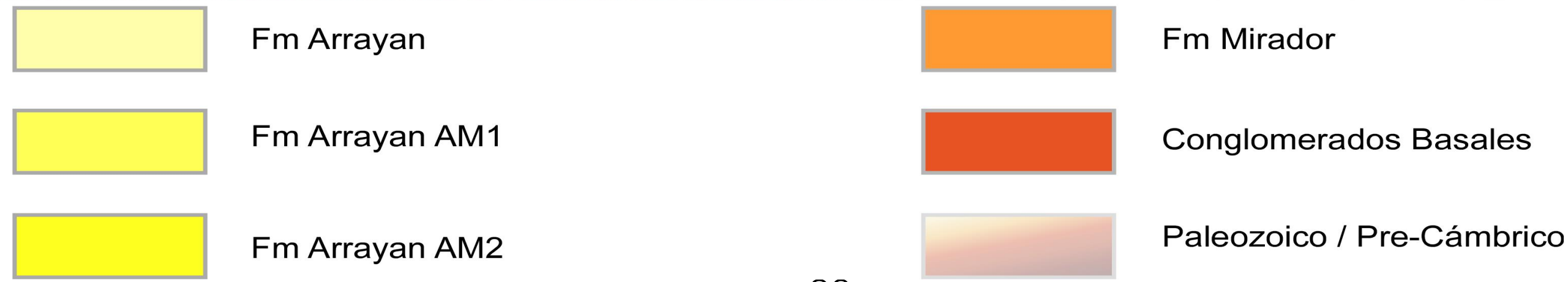
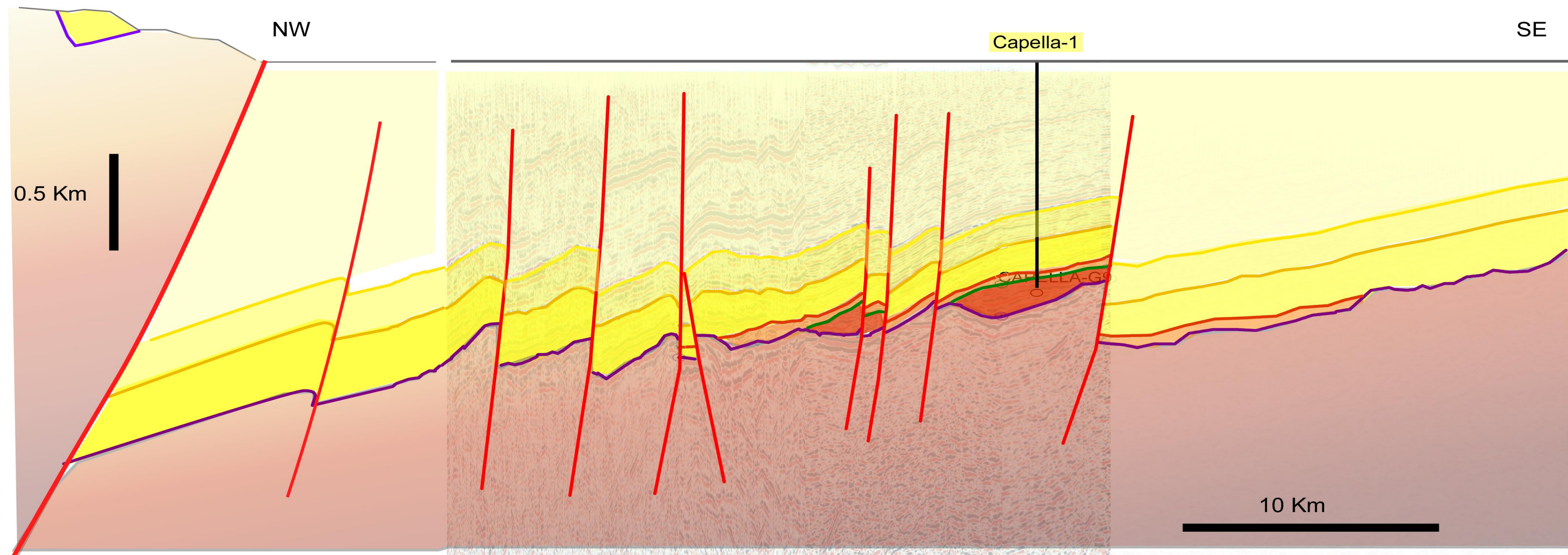
TRANSECT 2

- Low degree of deformation
- Paleo-topography filled with Morelia Fm. Sediments.

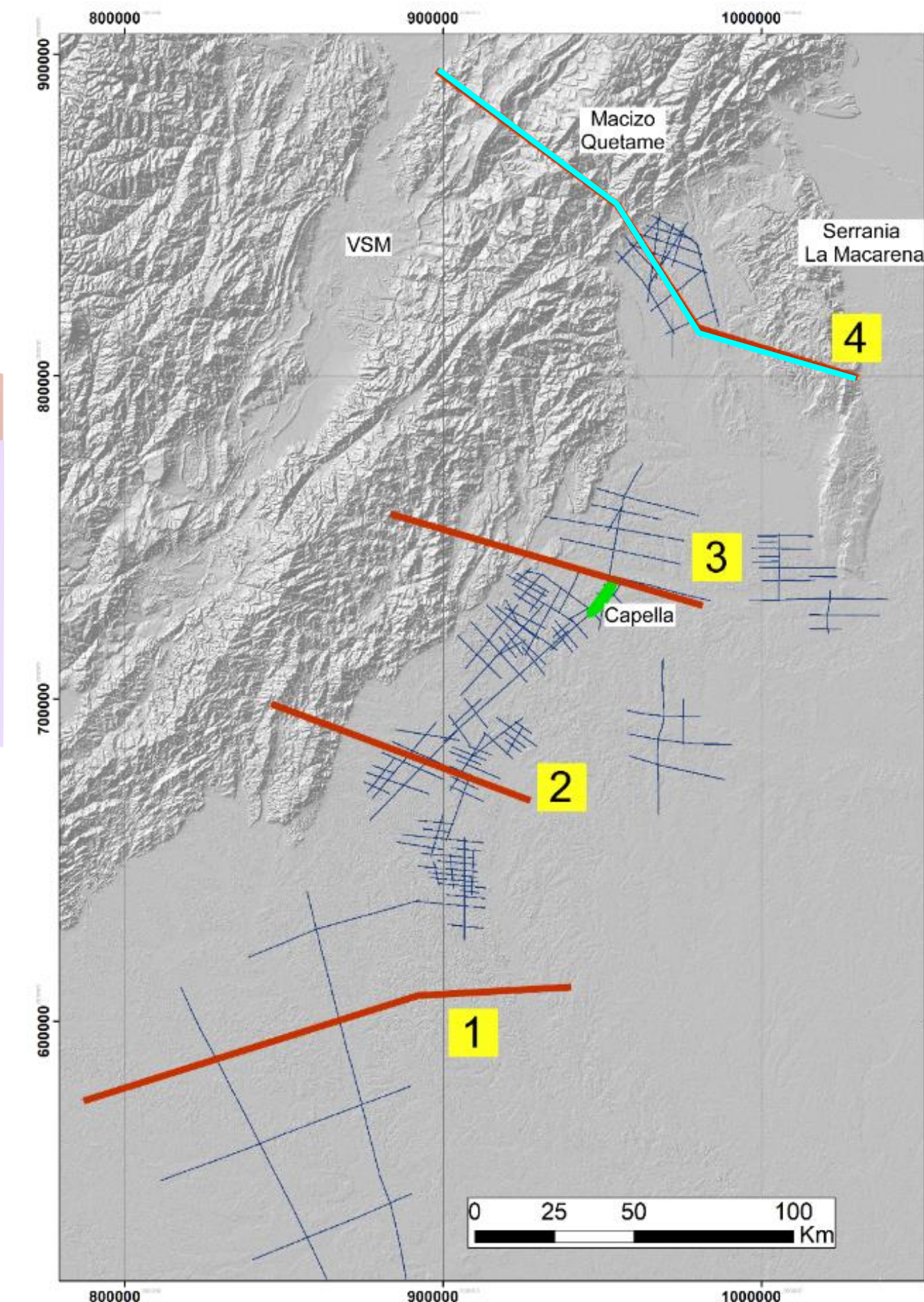
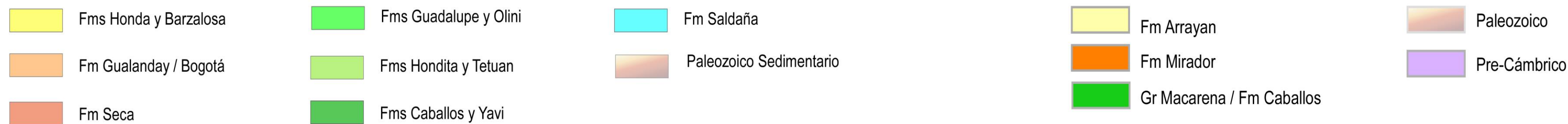
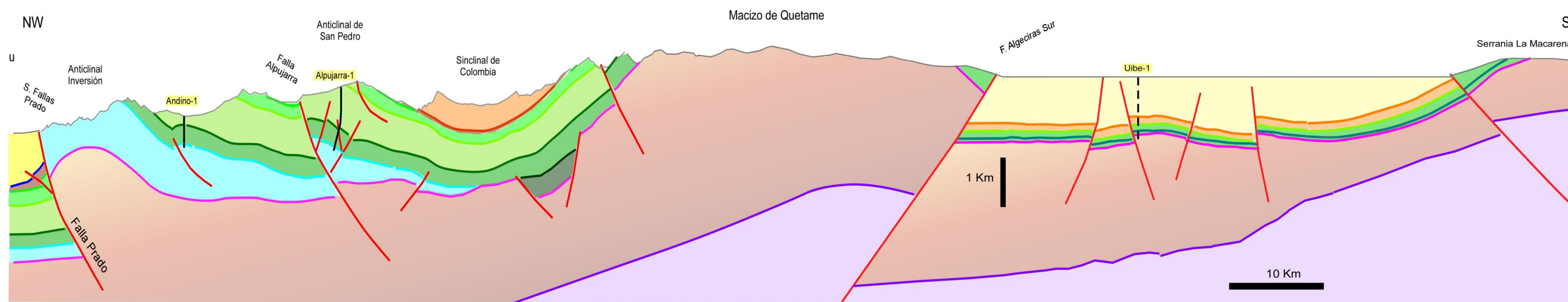


TRANSECT 3

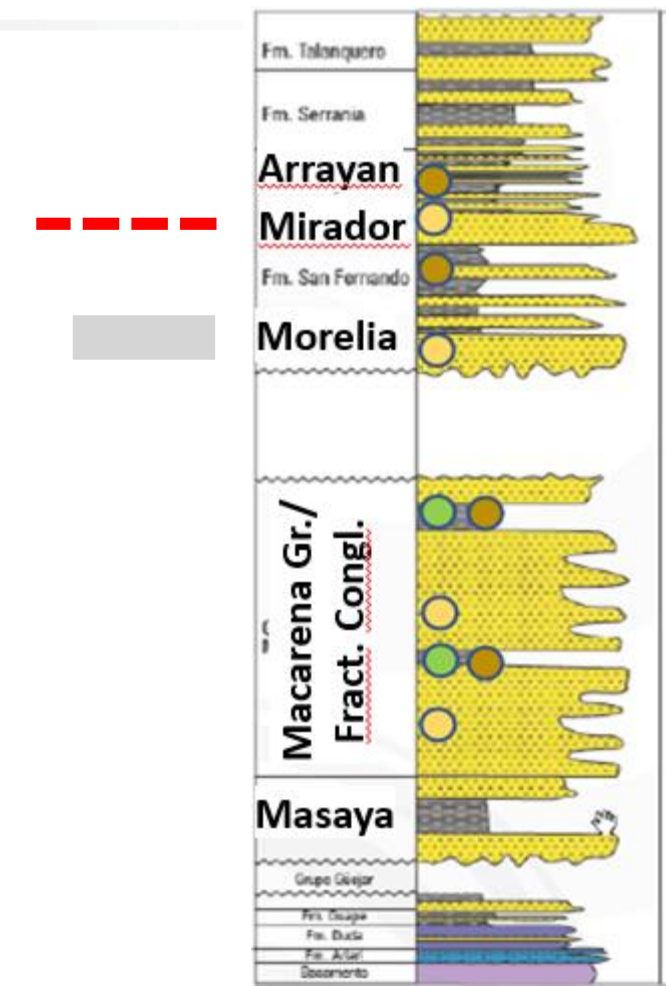
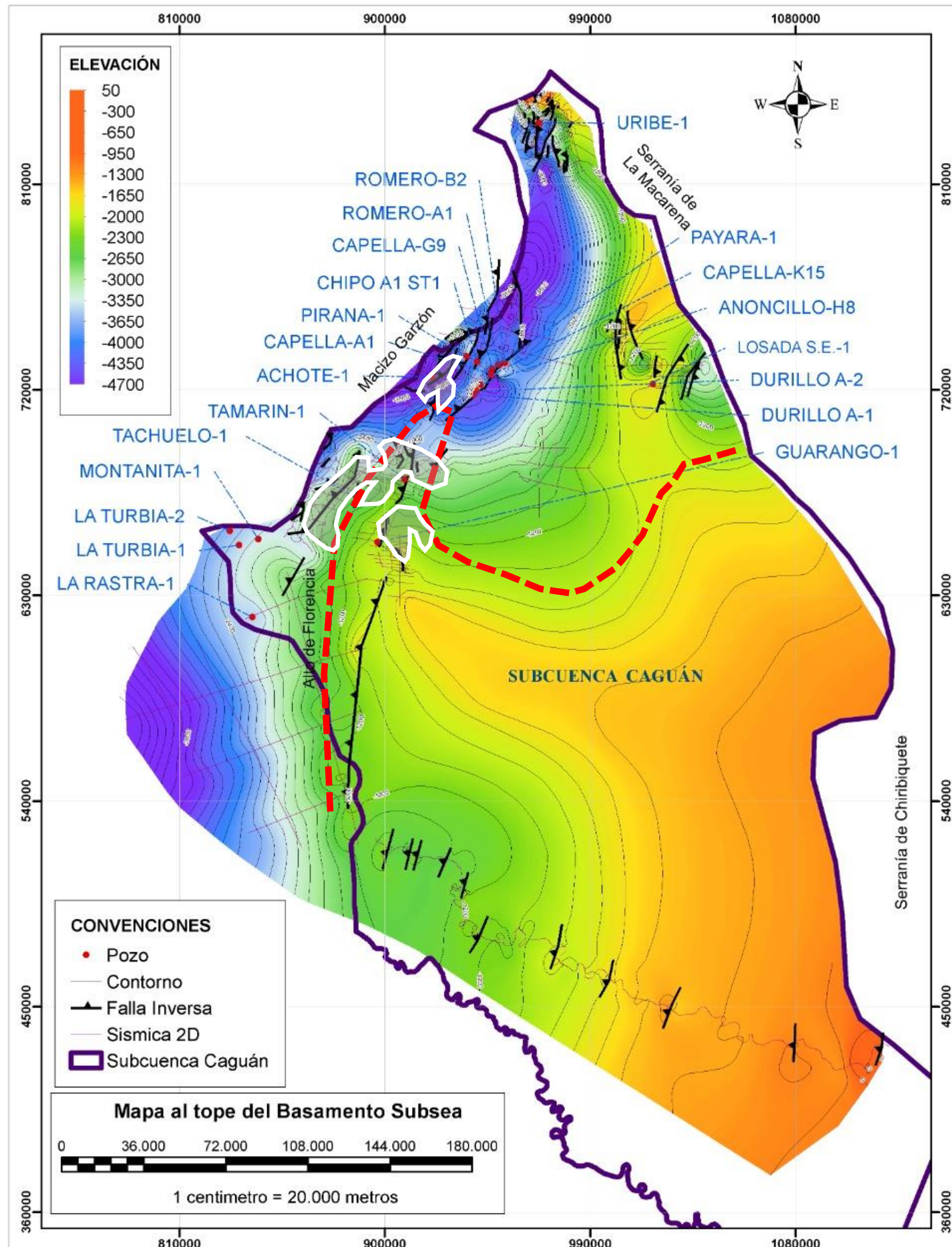
- Highly deformed area, where the **Capella oil field** was discovered.
- **Inverted faults** with presence of basal conglomerates in restricted areas.



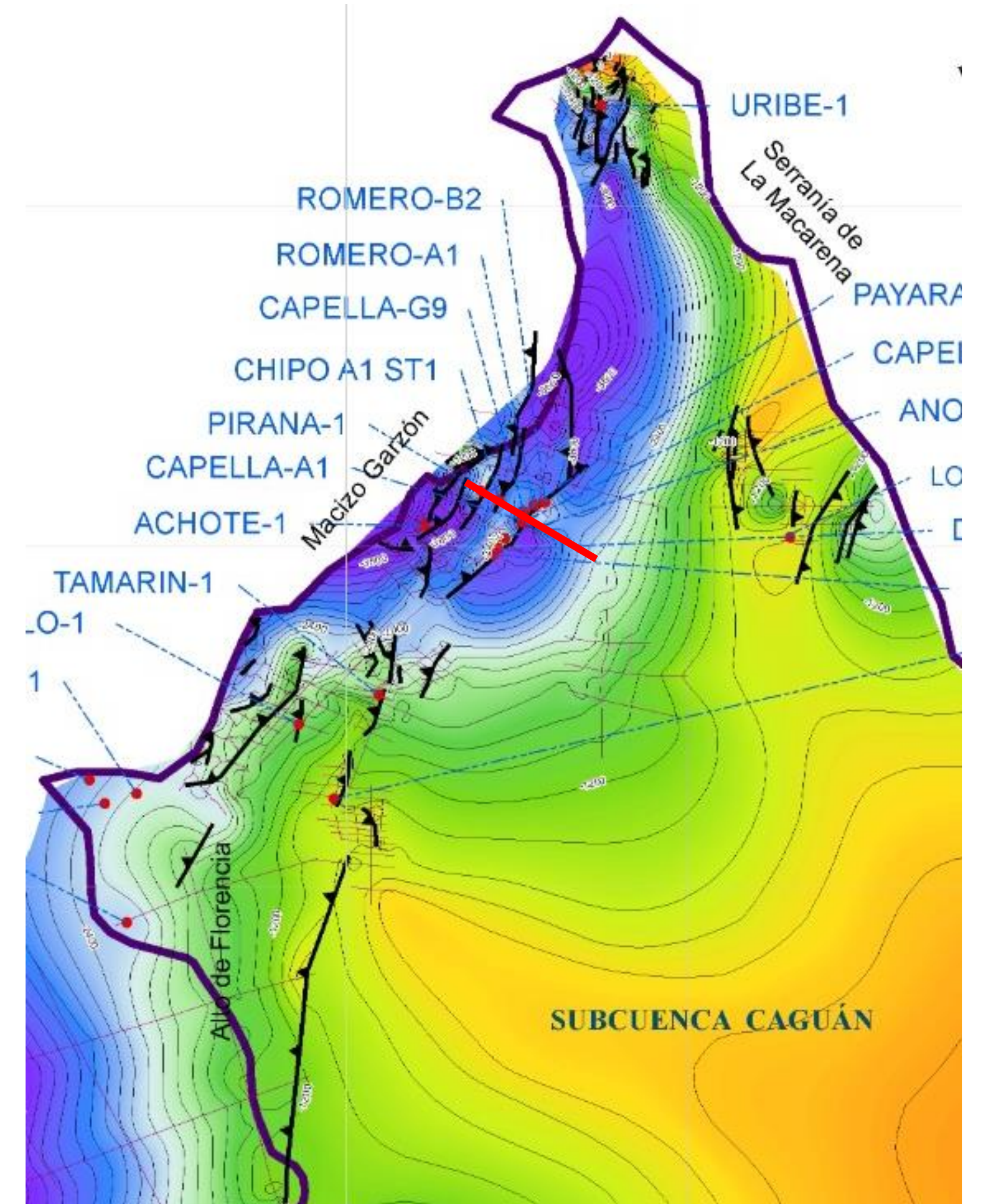
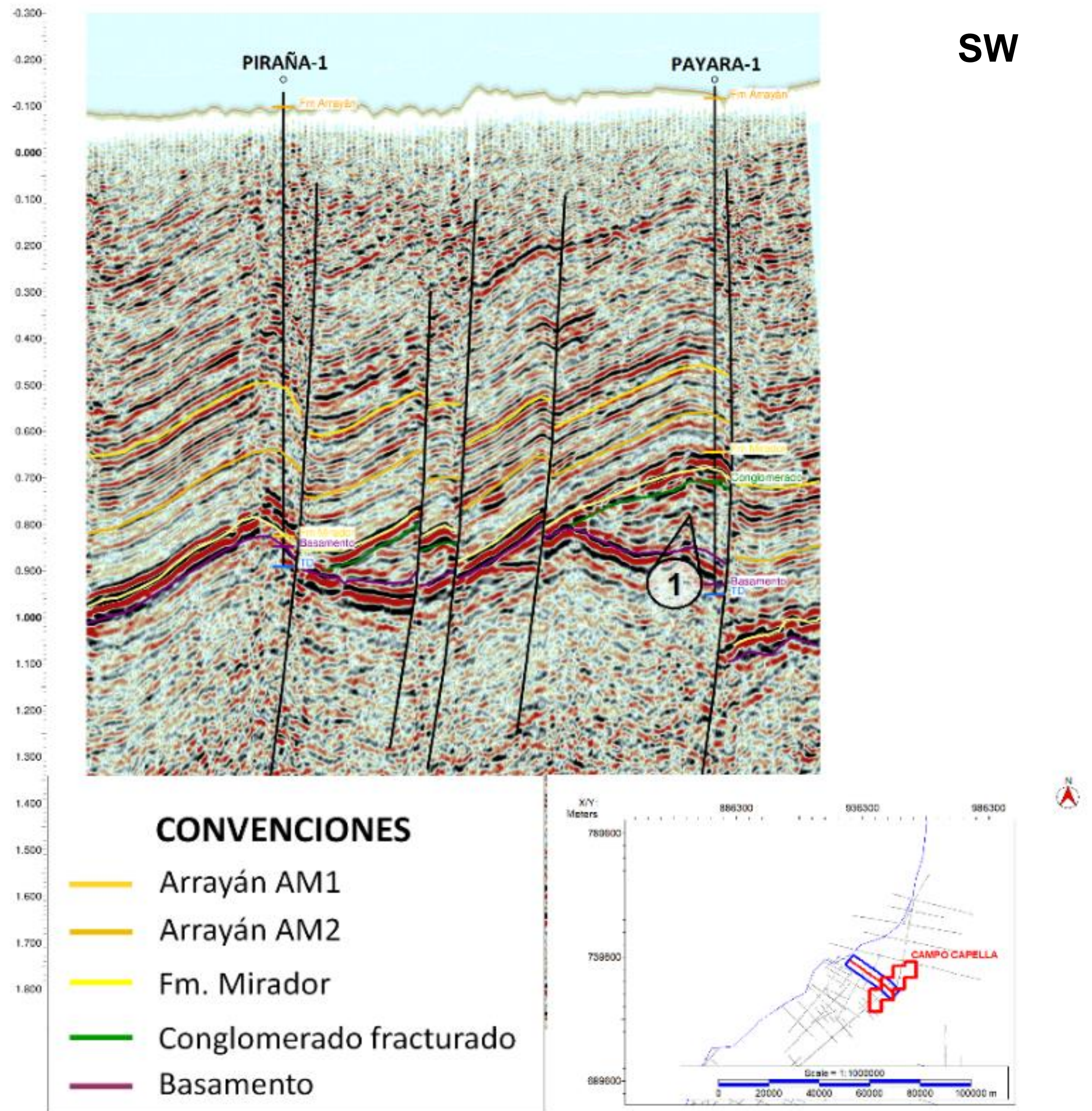
- Cretaceous presence in the hanging wall of the major Algeciras Fault, proves the **connection between Caguan and Eastern Cordillera**
- **Steep inverse faults** are present in the northern part of Caguan, also affected by the uplift of La Macarena.

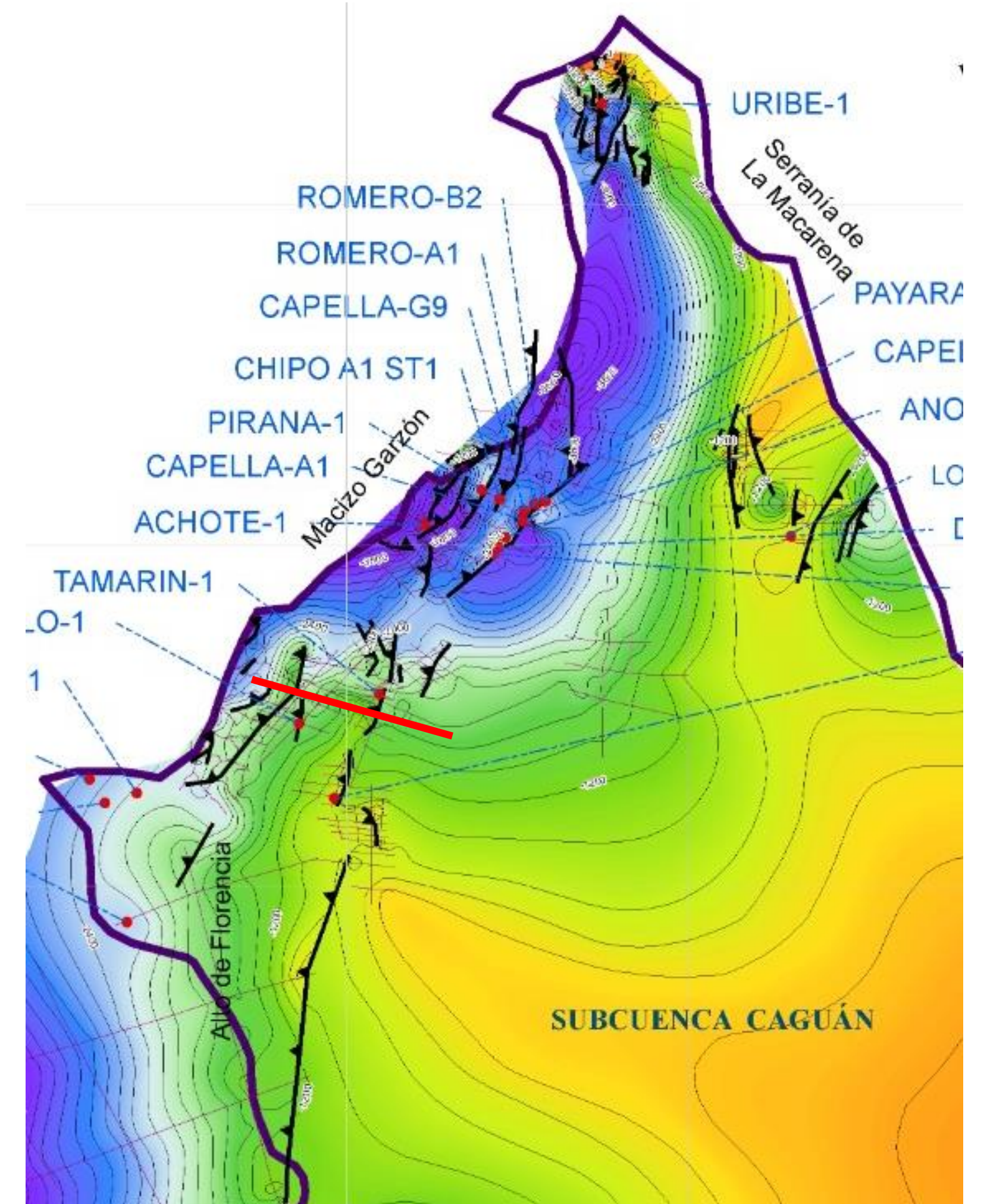
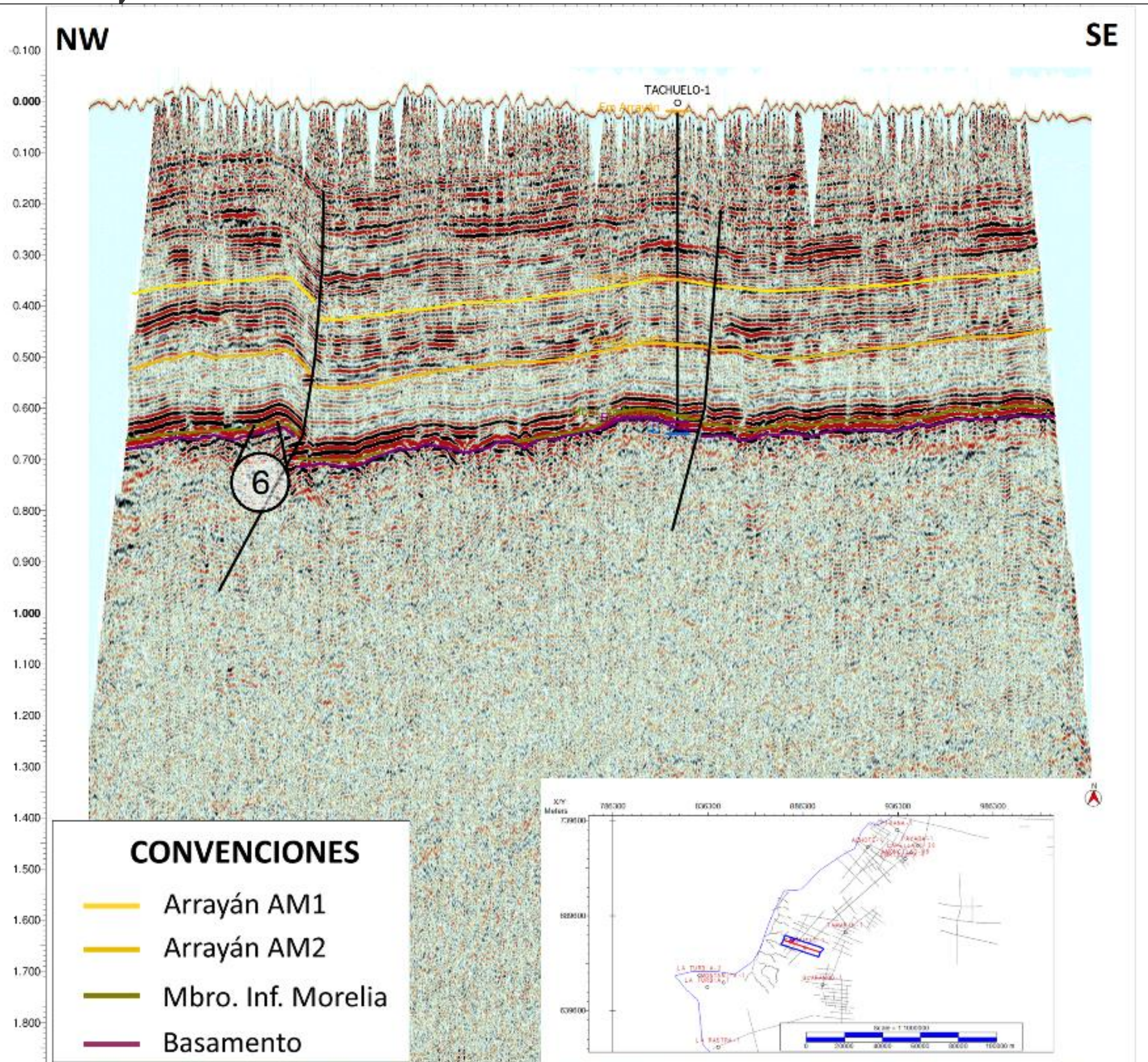


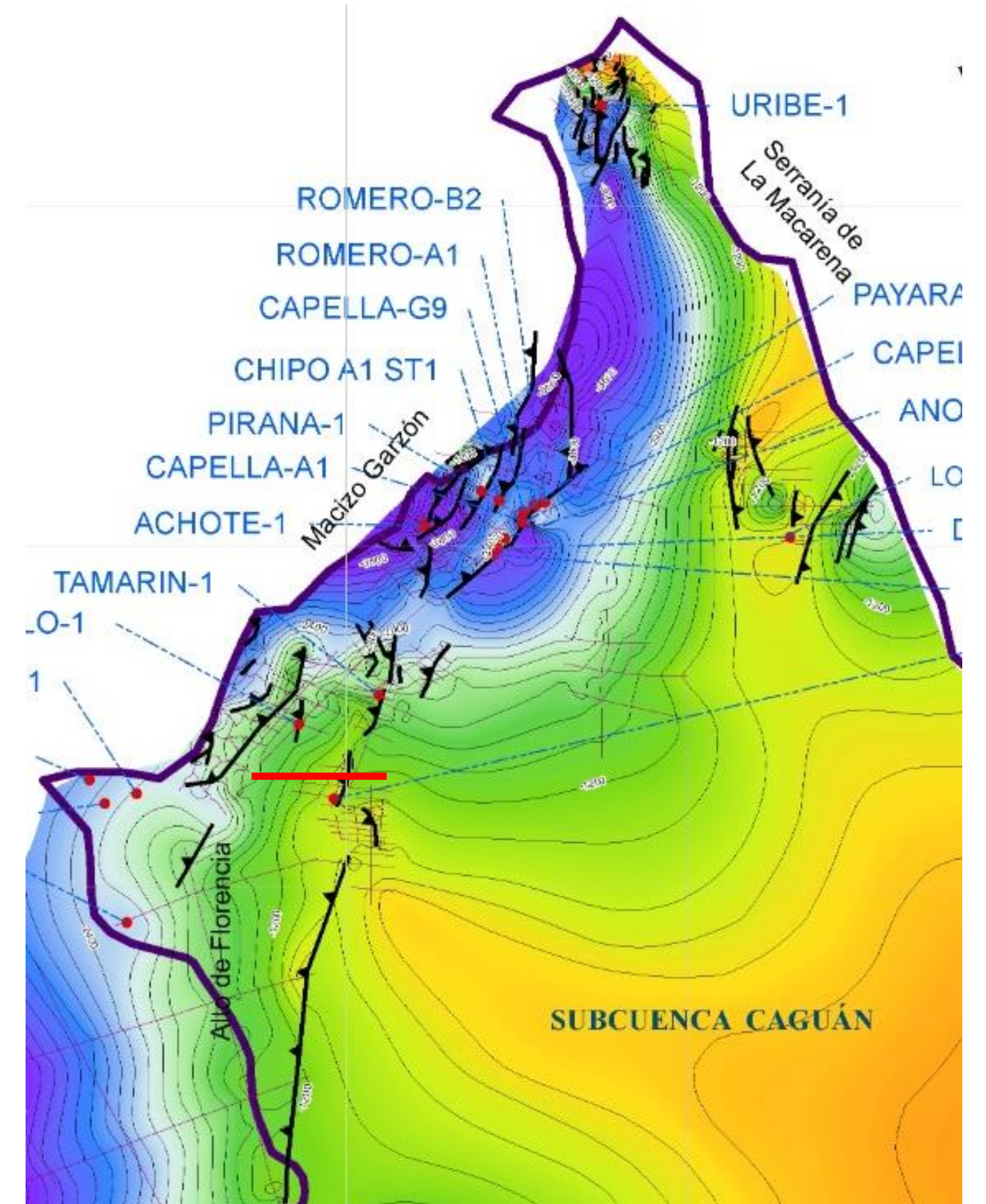
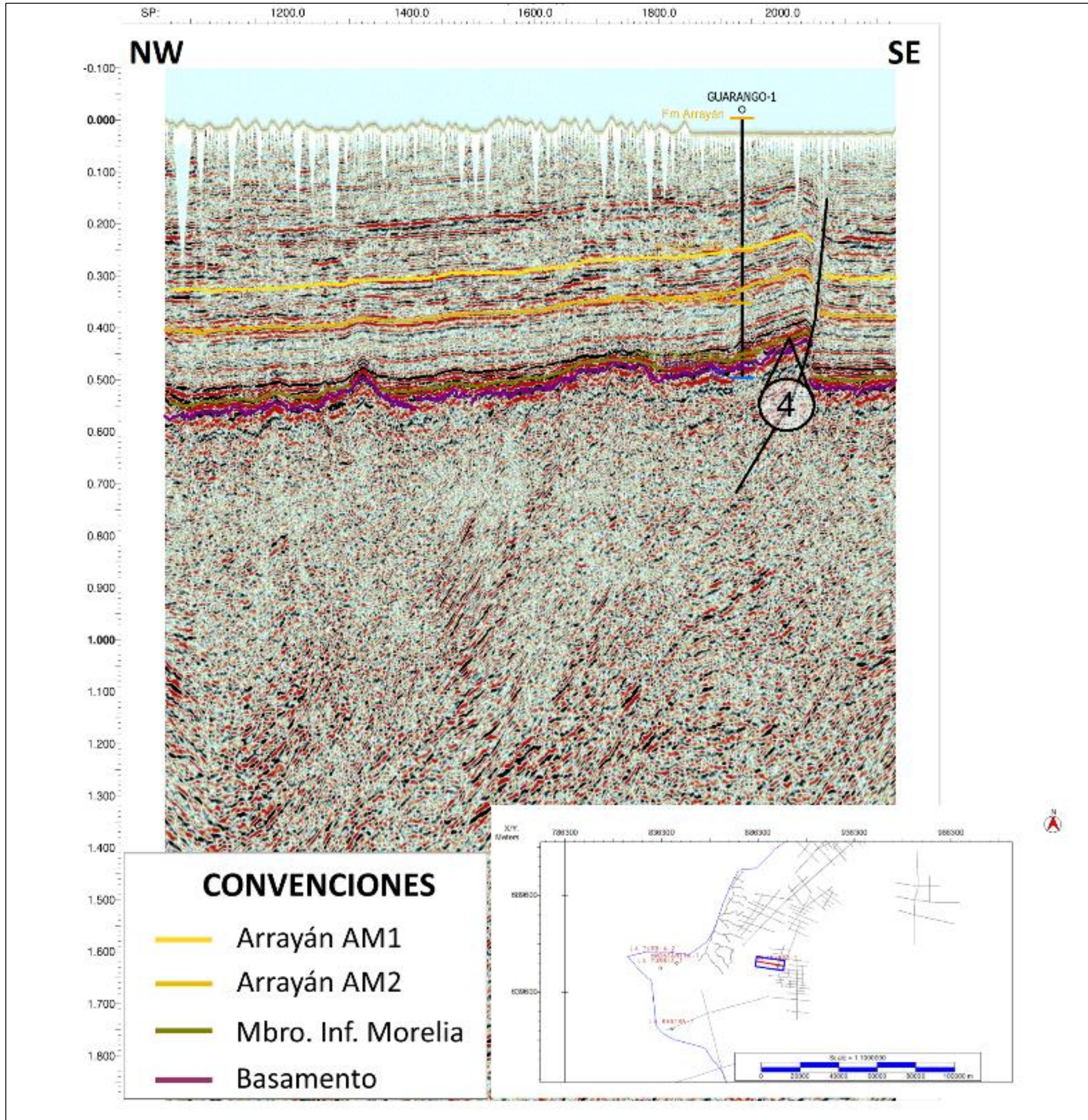
BASEMENT MAP

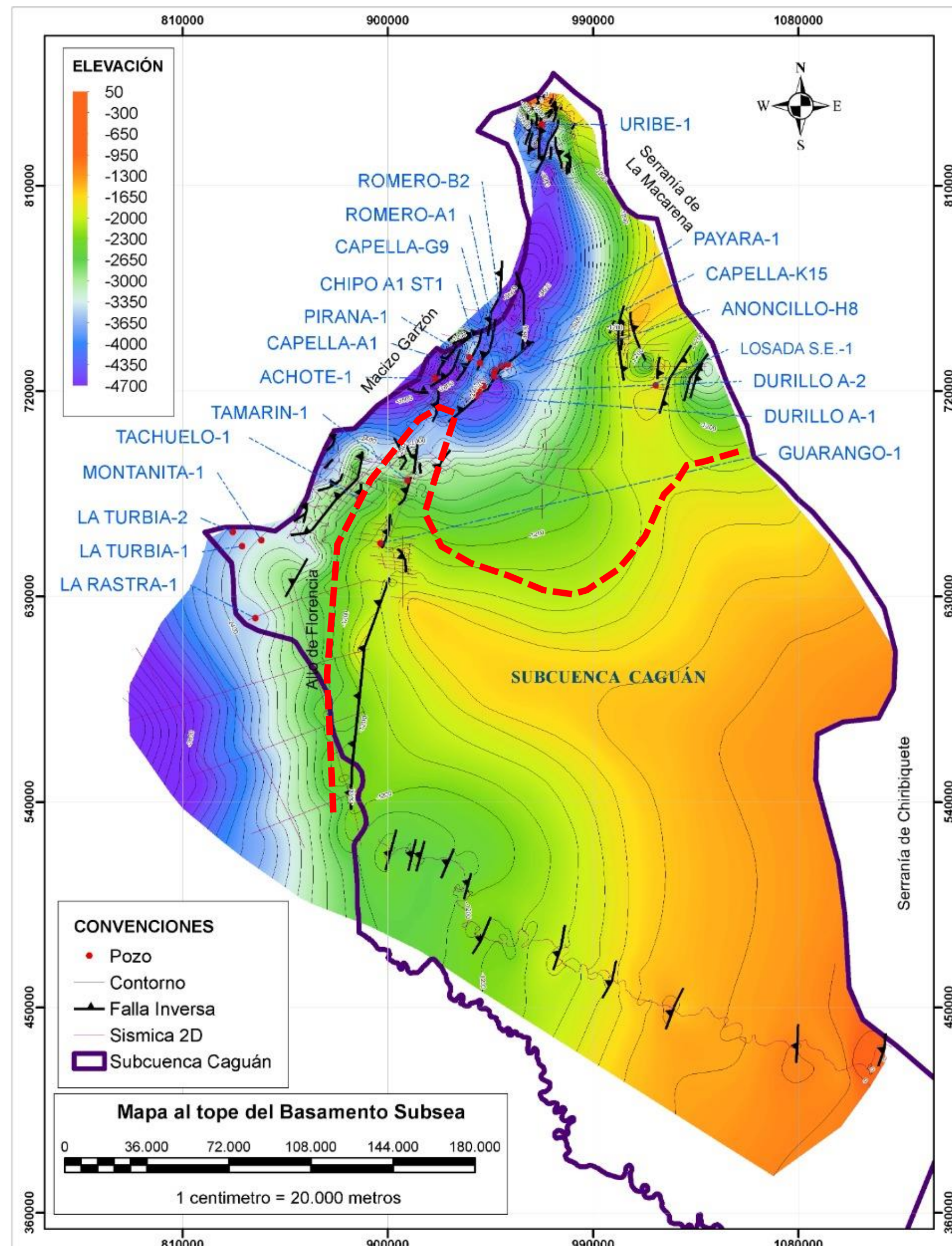


- **Foreland basin** dipping to the West.
- **Deformation** of the basin is higher in the areas **close to the Eastern Cordillera** foothills and La Macarena high.
- Basement **paleo-topography** restricted the presence of reservoirs **Mirador and Morelia formations**.









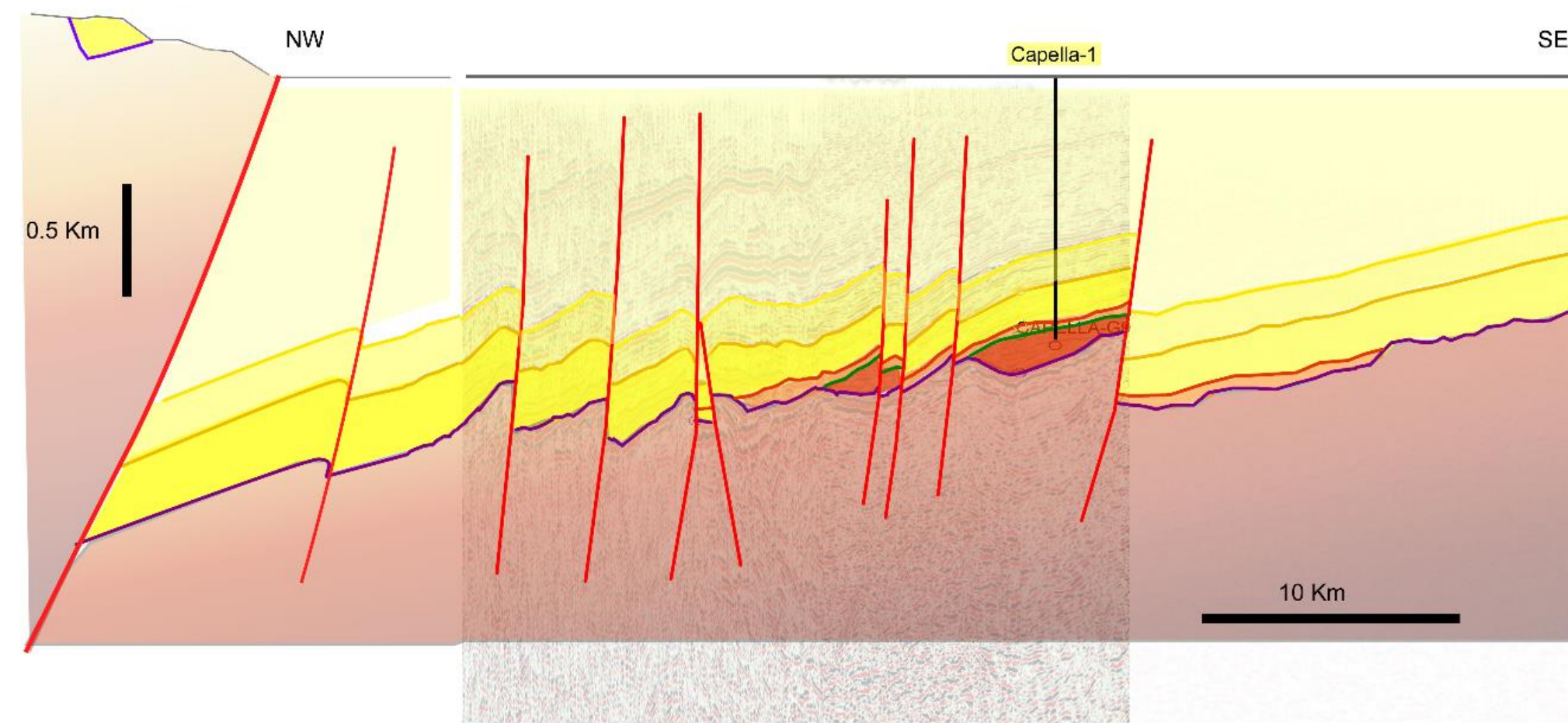
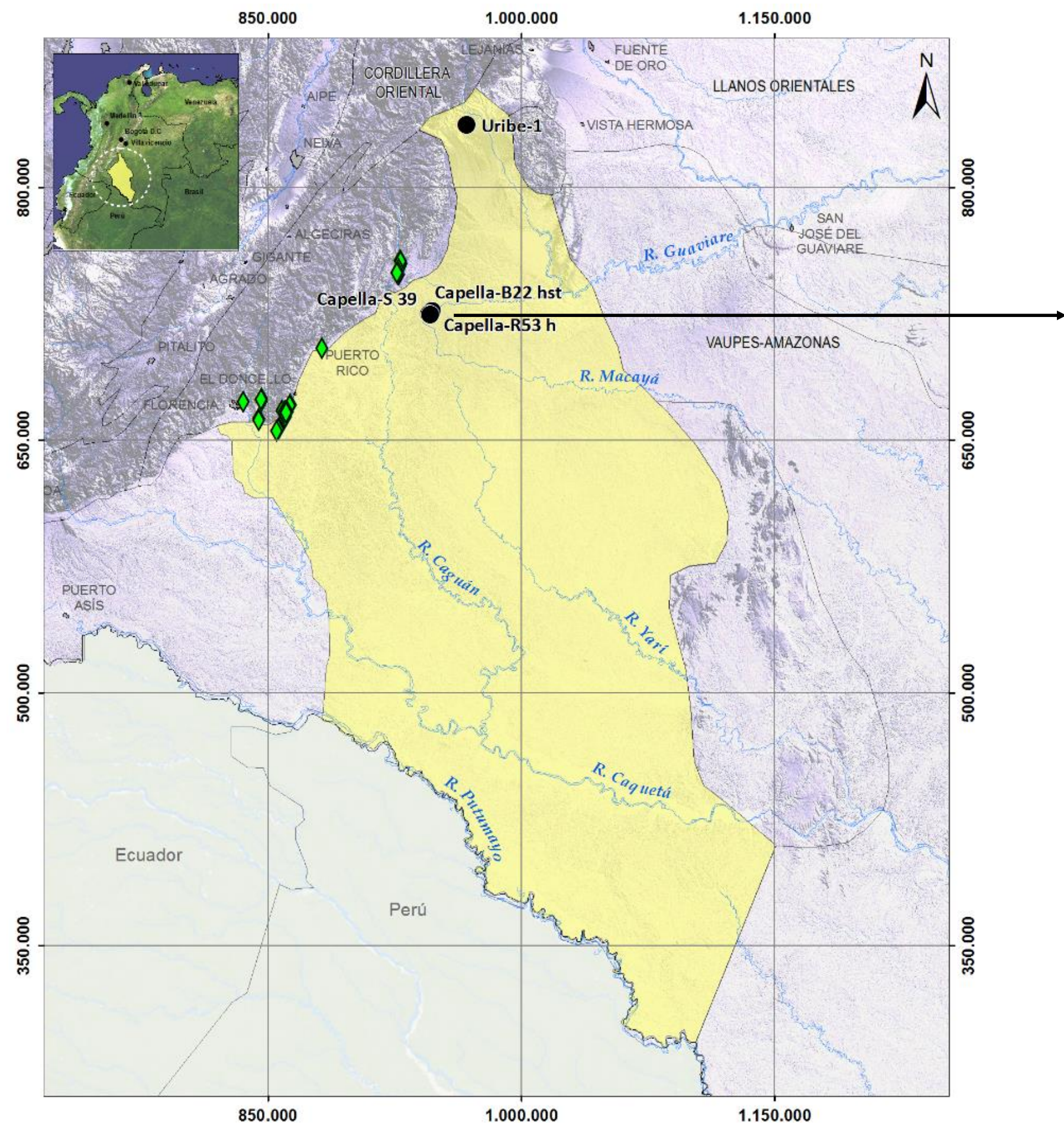
- The **basin deformation is low**, focused on the areas close to the Eastern Cordillera
- There is a strip of **inverse faults in the Northeast** part of the basin, where the Capella field was discovered
- **Stratigraphic play** along the depositional limit of Mirador Fm, represents a major **underexplored** play that is extended to the Putumayo Basin

Petroleum System Yet to Find

CESAR MORA

PETROLEUM SYSTEM MODELING

Hydrocarbons Occurrence And Proven Plays



Structural Eocene and Cretaceous Field : Capella
OOIP : 0.3 Bboe
Reservoir: Mirador 9° API

Edad	Tipo De Play	Reservorio Principal	Reservorio Secundario	Nombre	Oil in Place	Campo
Eoceno Tardío	Estructural	Fm Mirador	NA	Play Estructural Eoceno Tardío Fm Mirador	300MMBP	Capella
Cretáceo Inferior	Estructural	NA	Fm "C"	Play Estructural Cretaceo Inferior Fm "C"		



0.3 Bboe

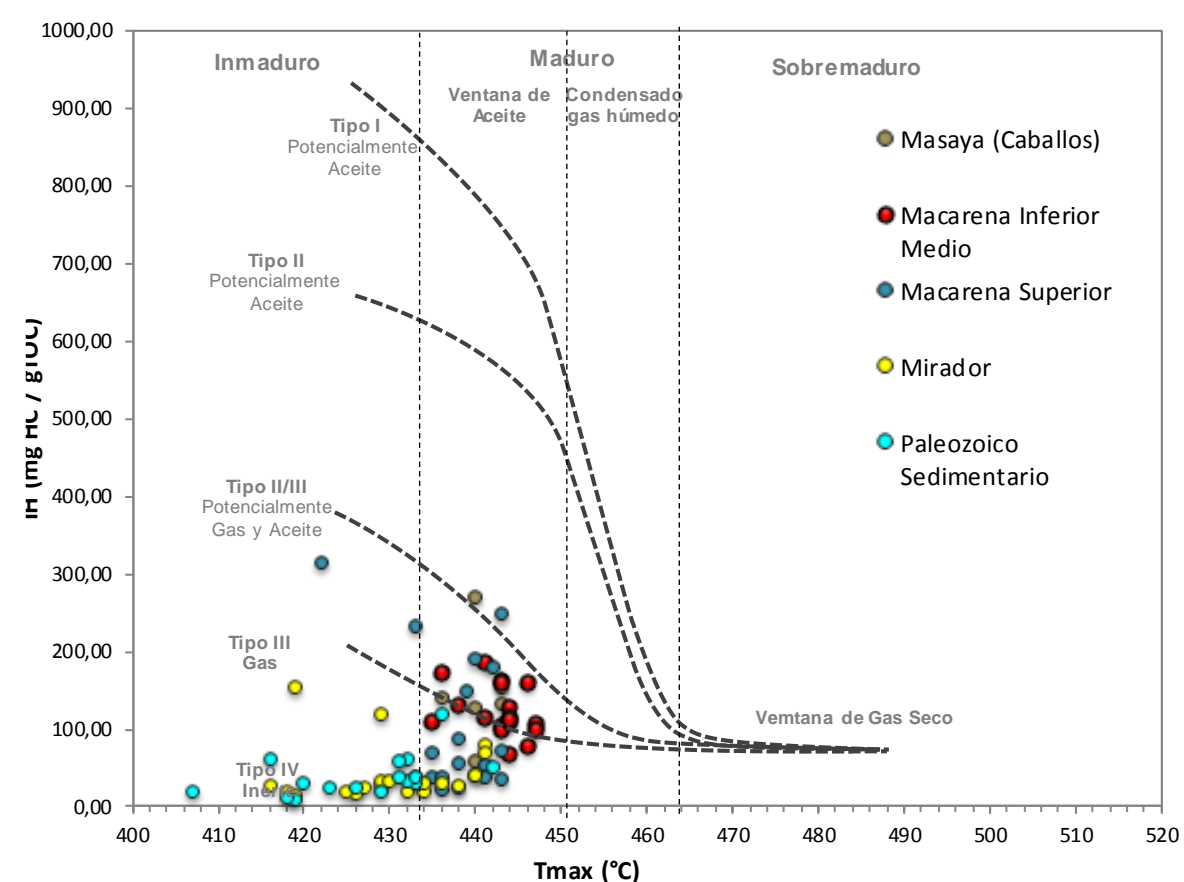


PETROLEUM SYSTEM MODELING

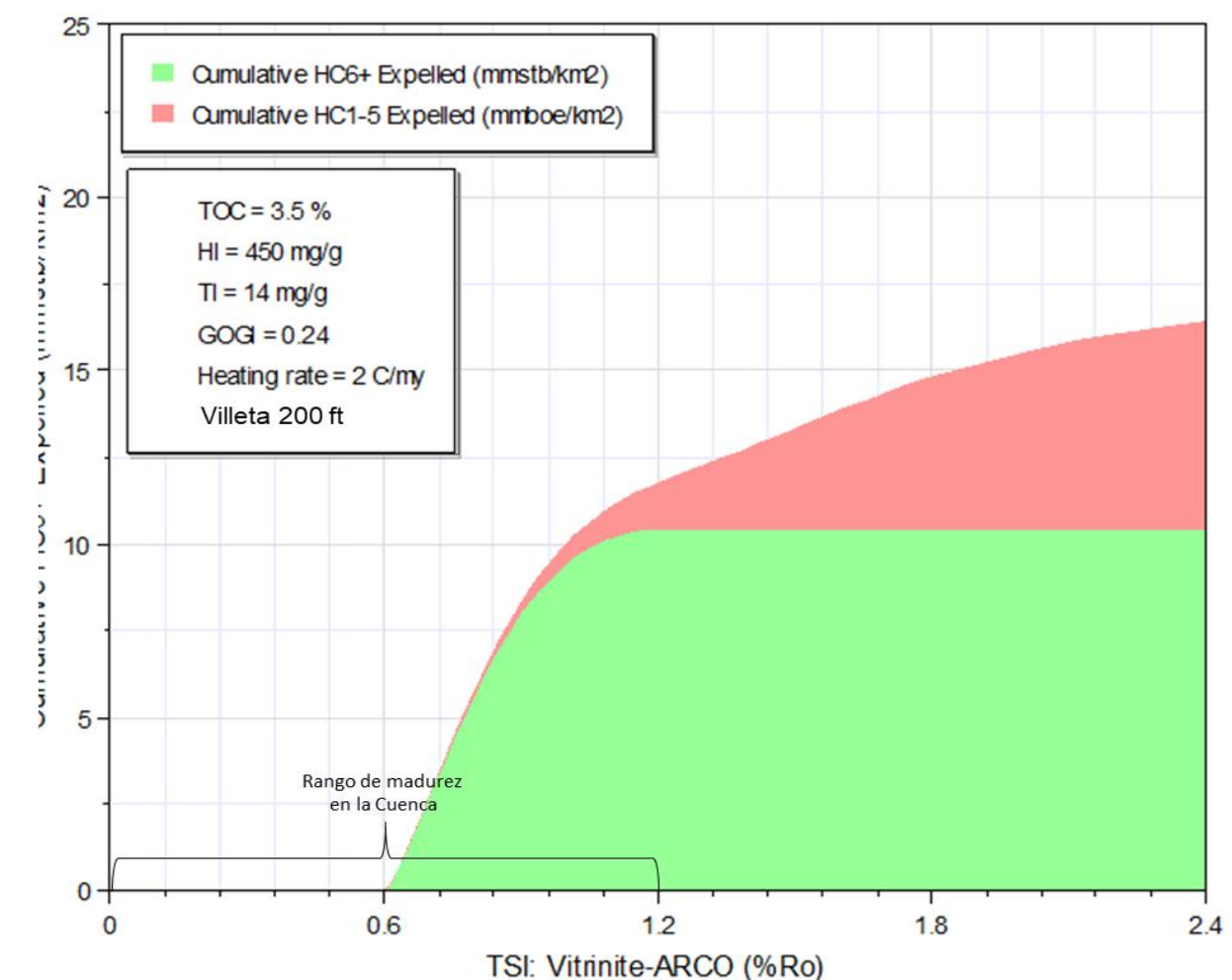
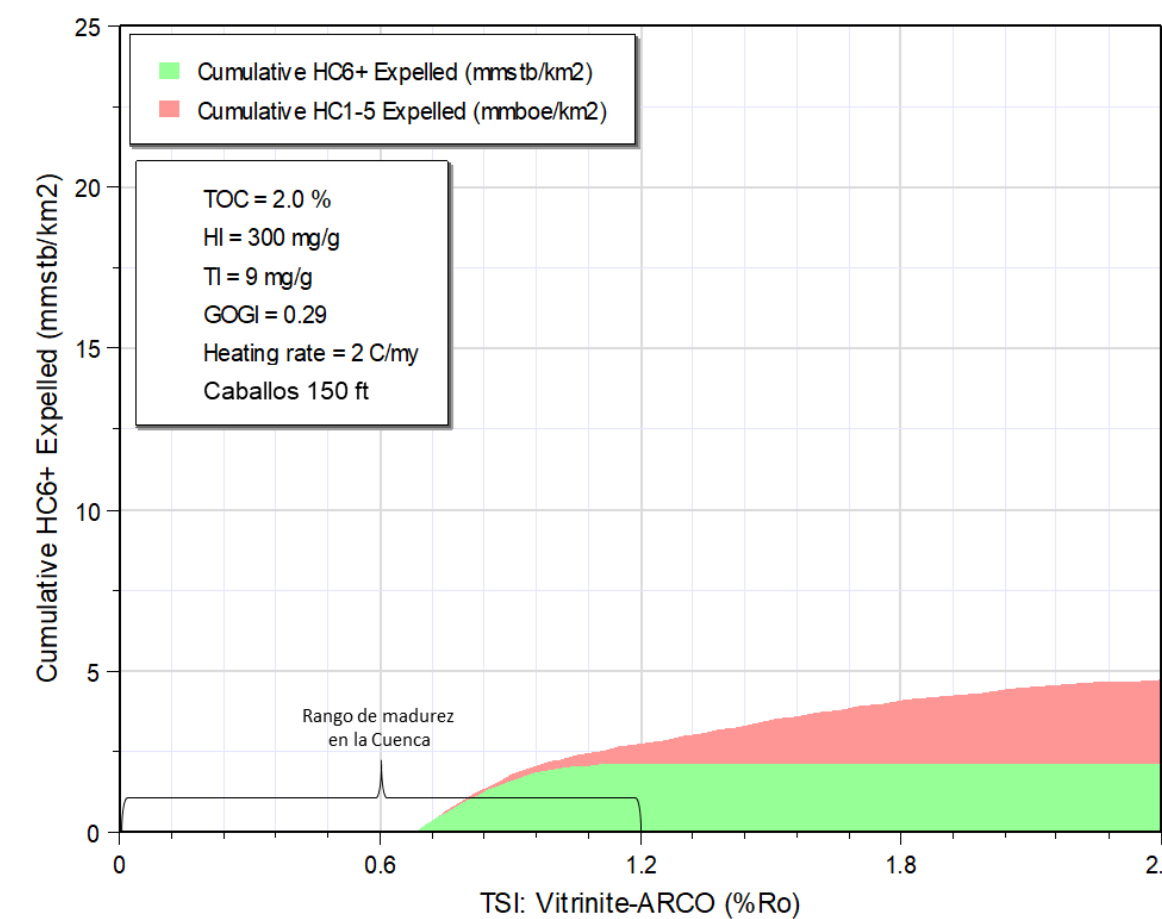
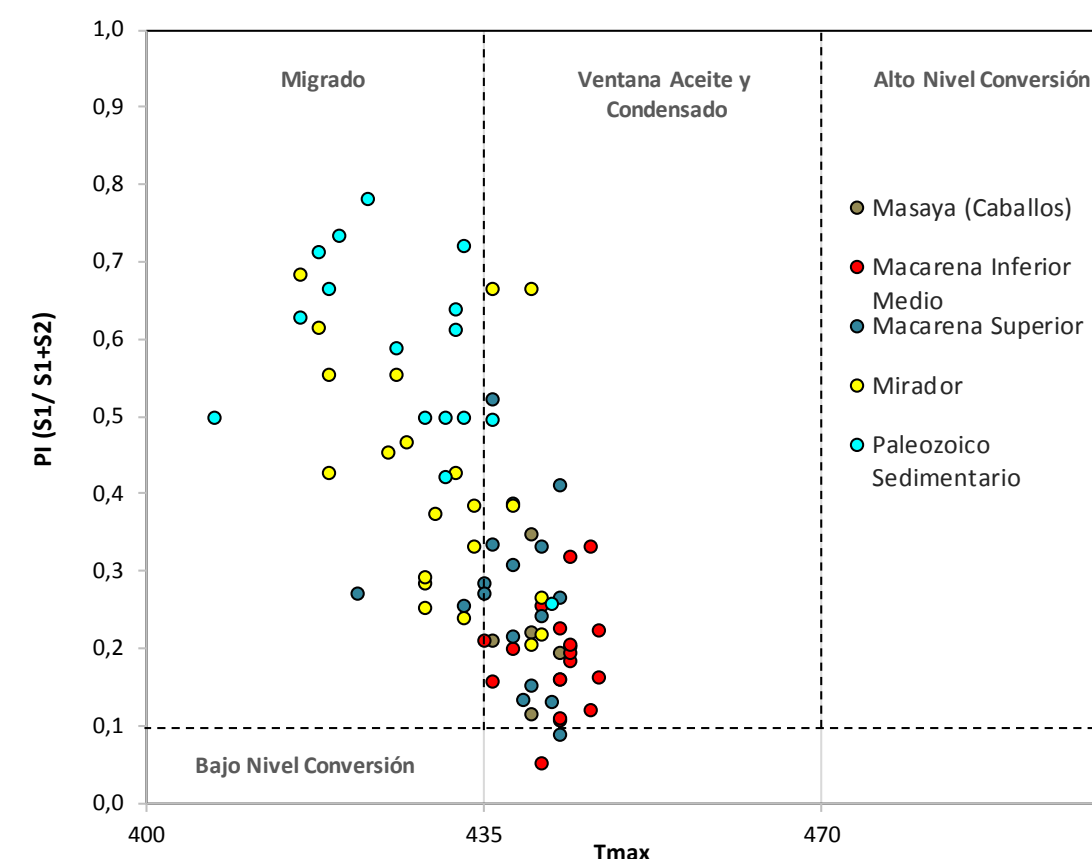
Hydrocarbon Potential

Cuenca	Formación	Ambiente Depósito	Facies Orgánicas	IH	TOC (%)	Espesor (pies)
Caguán	Villeta	Marino Plataforma	Marino Siliciclástica	450	3.5	200
	Masaya	Marino Plataforma	Marino Proximal	300	2.0	150

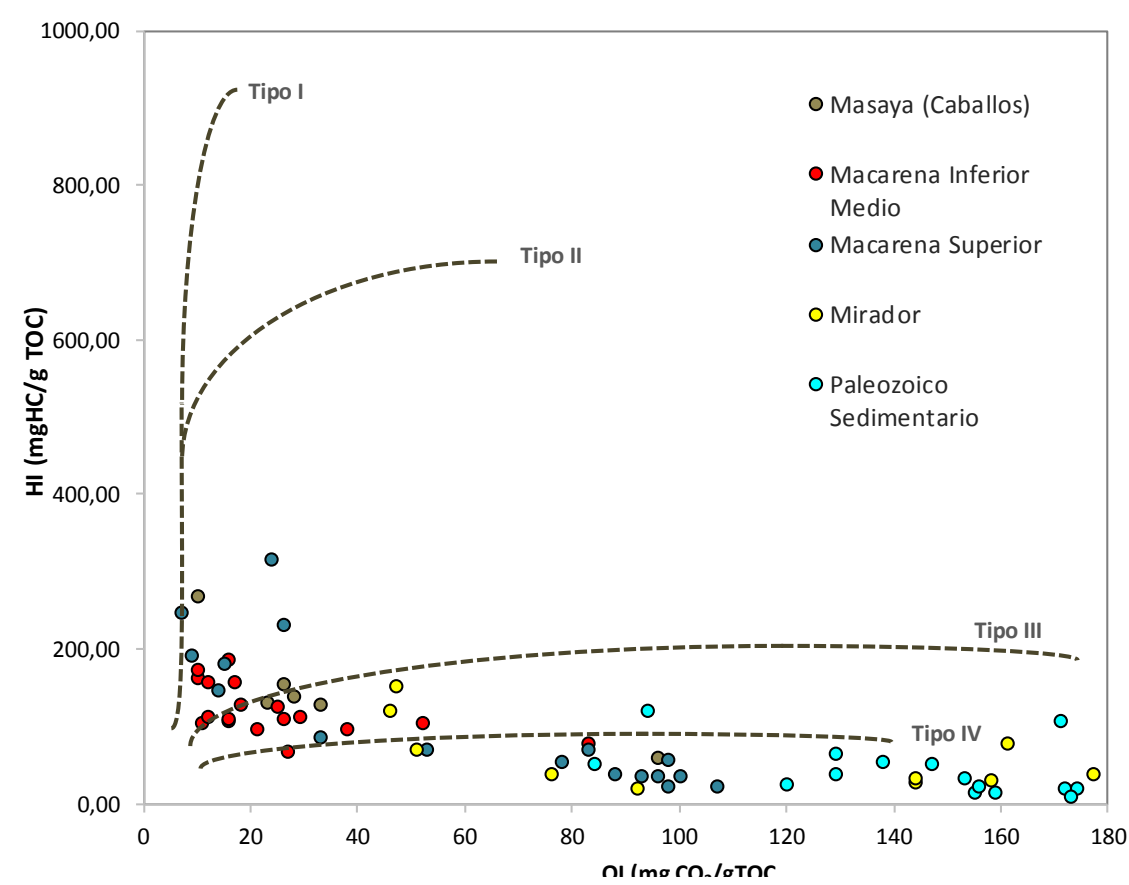
MADUREZ TÉRMICA



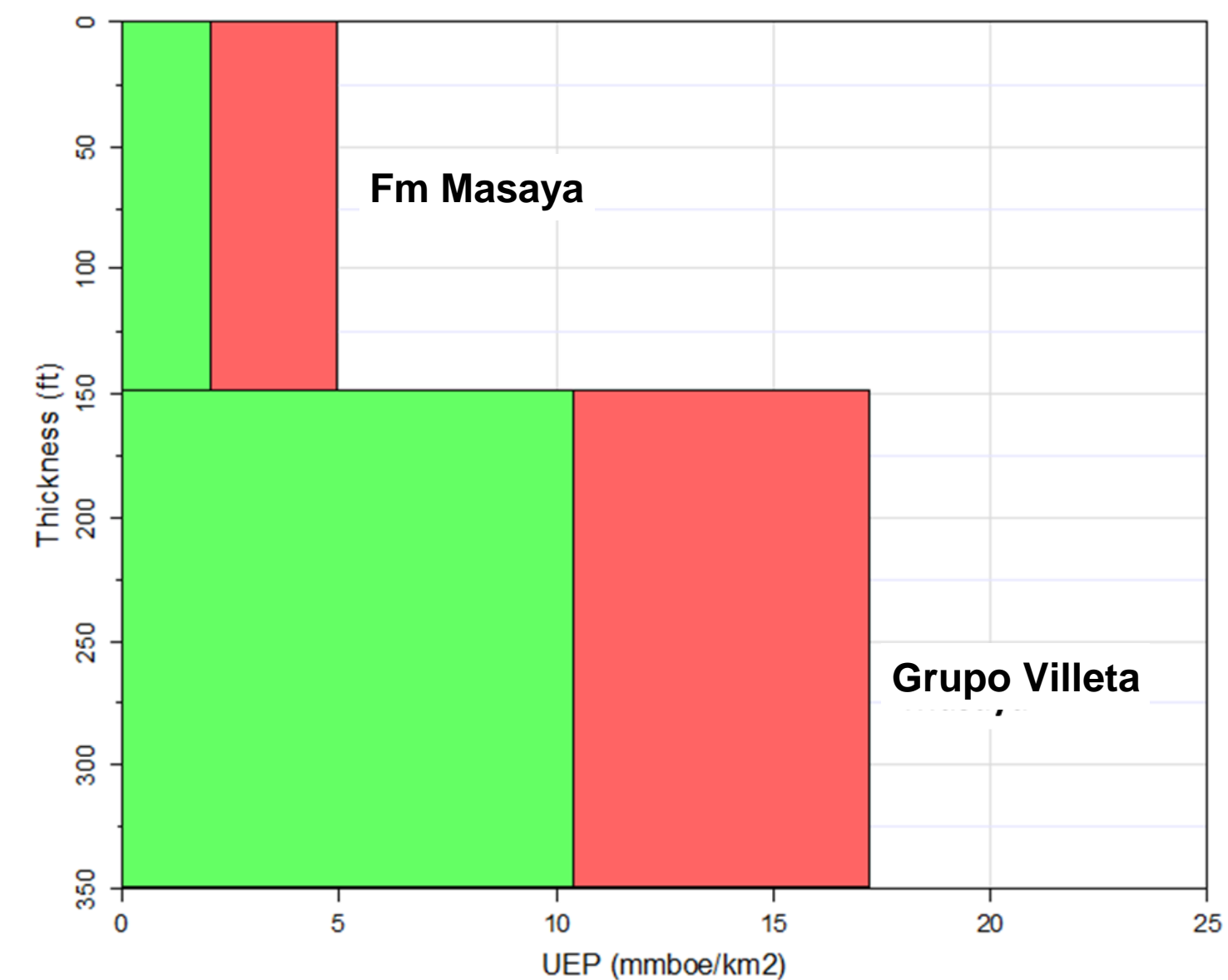
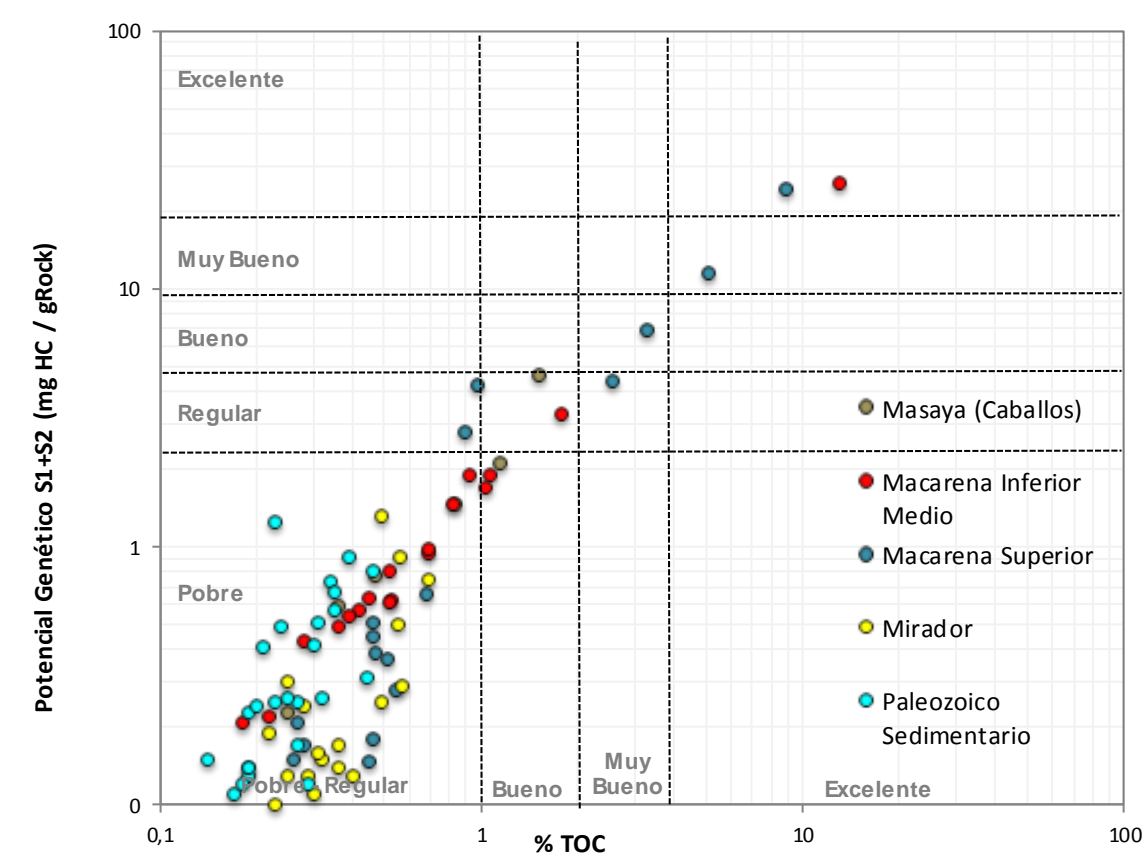
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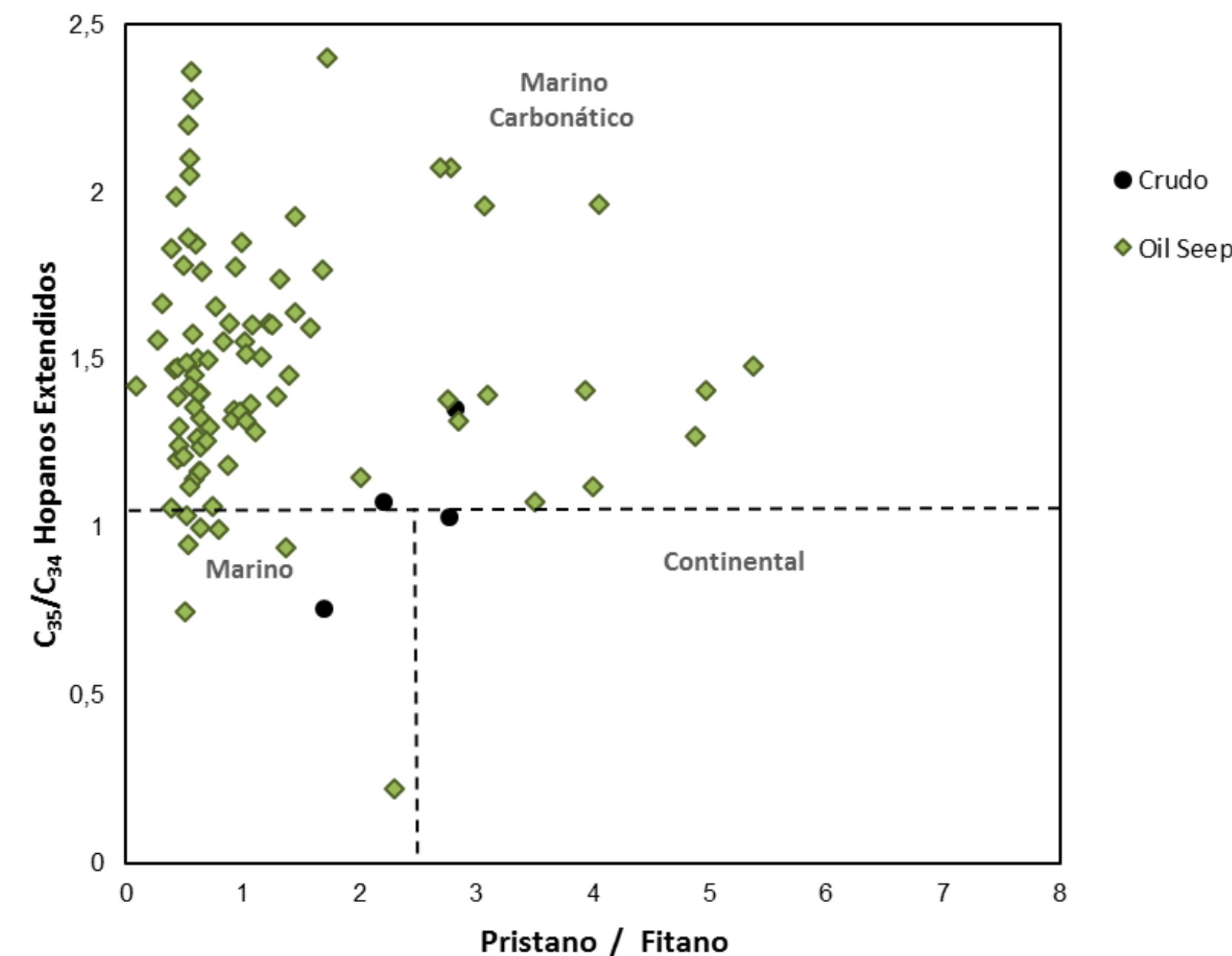
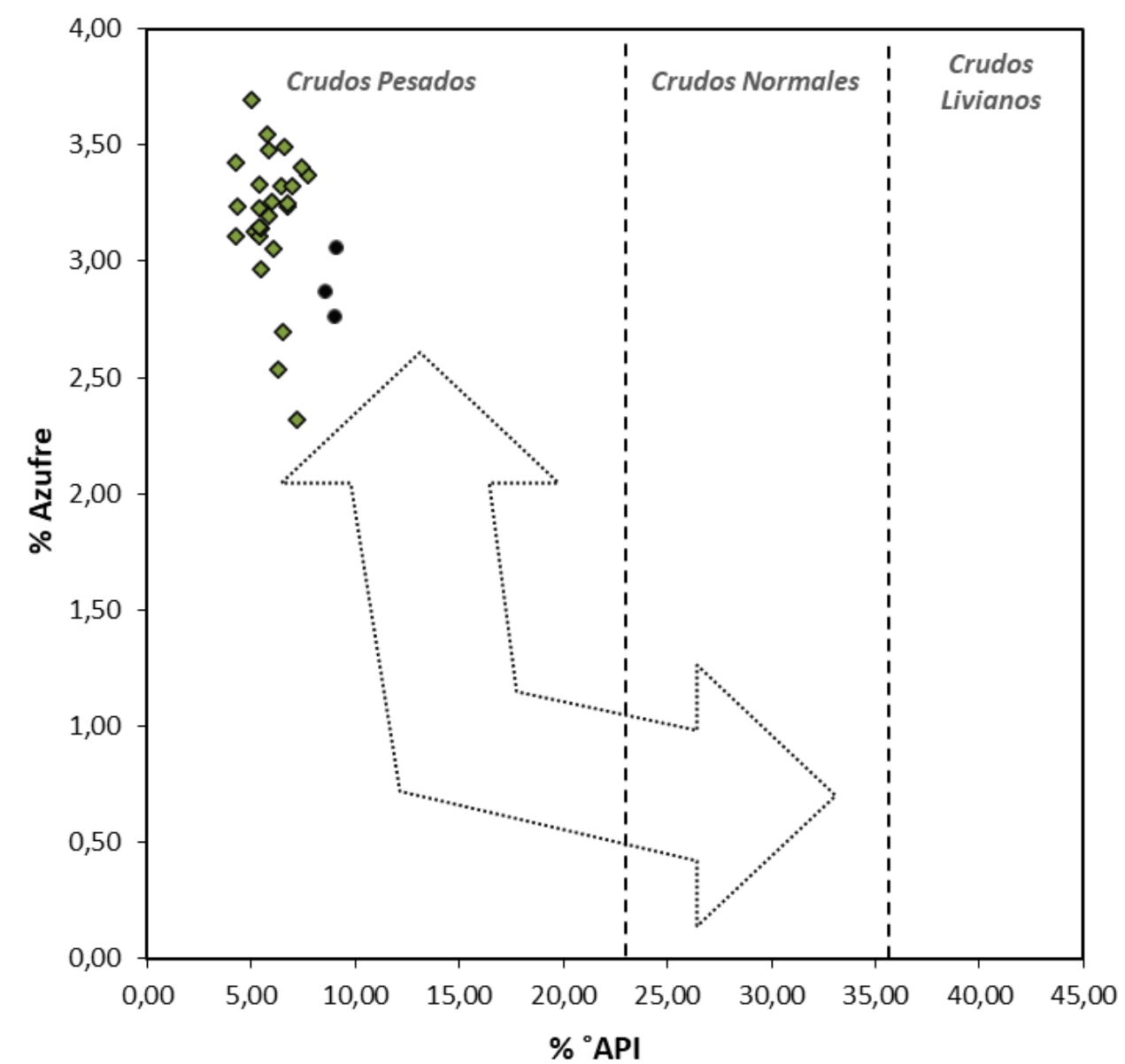
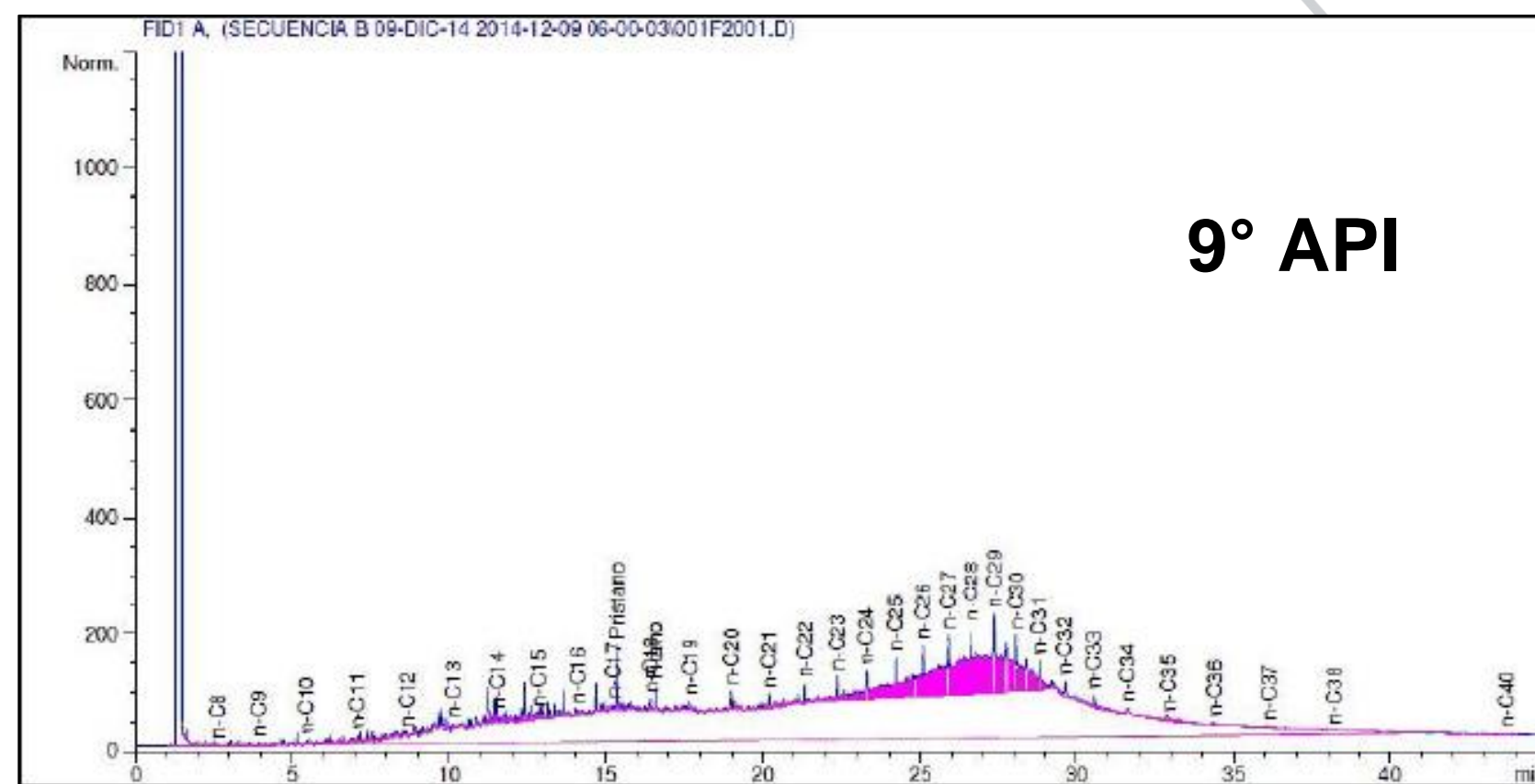
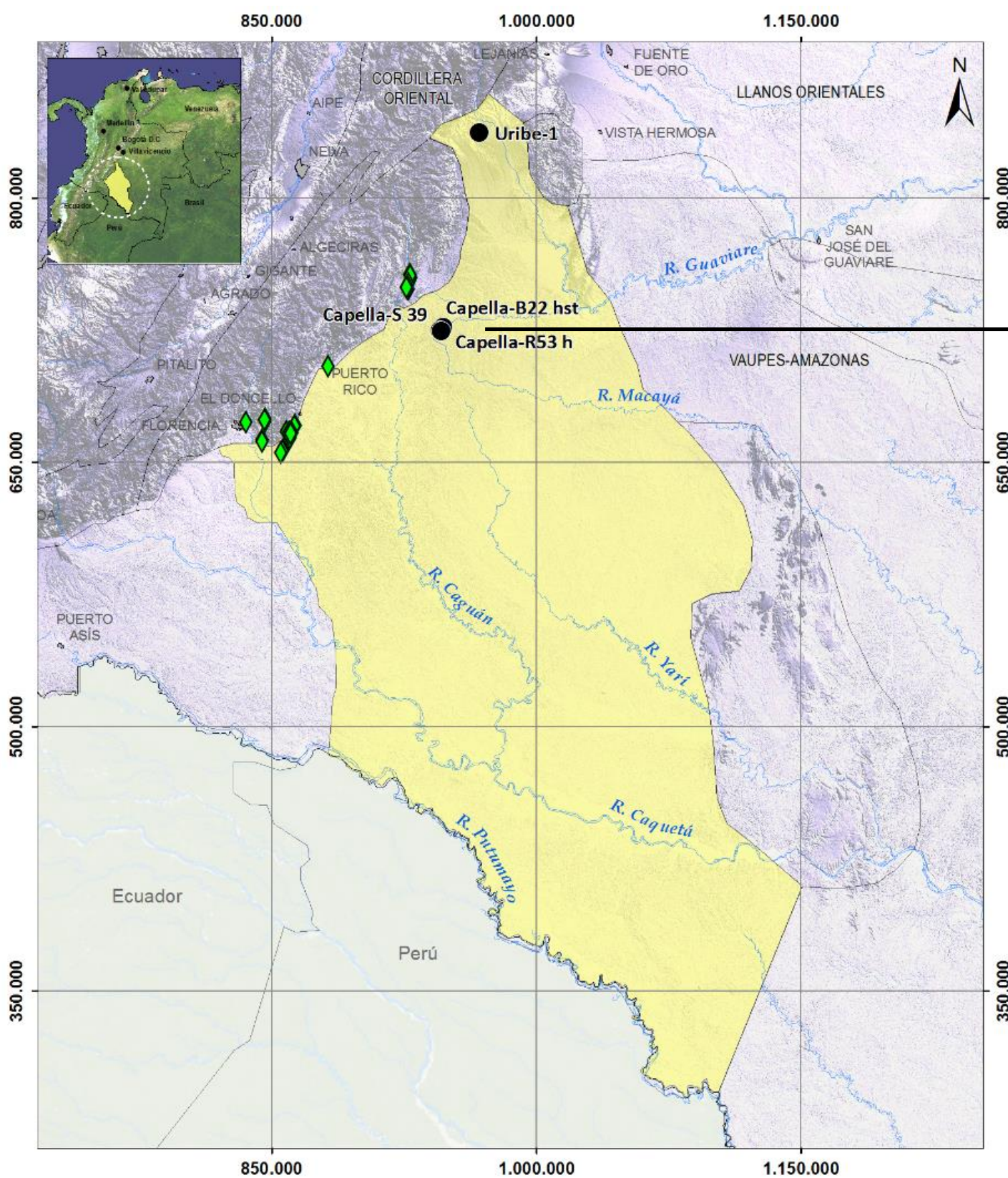


TIPO DE KERÓGENO



POTENCIAL GENERADOR (S1 + S2)

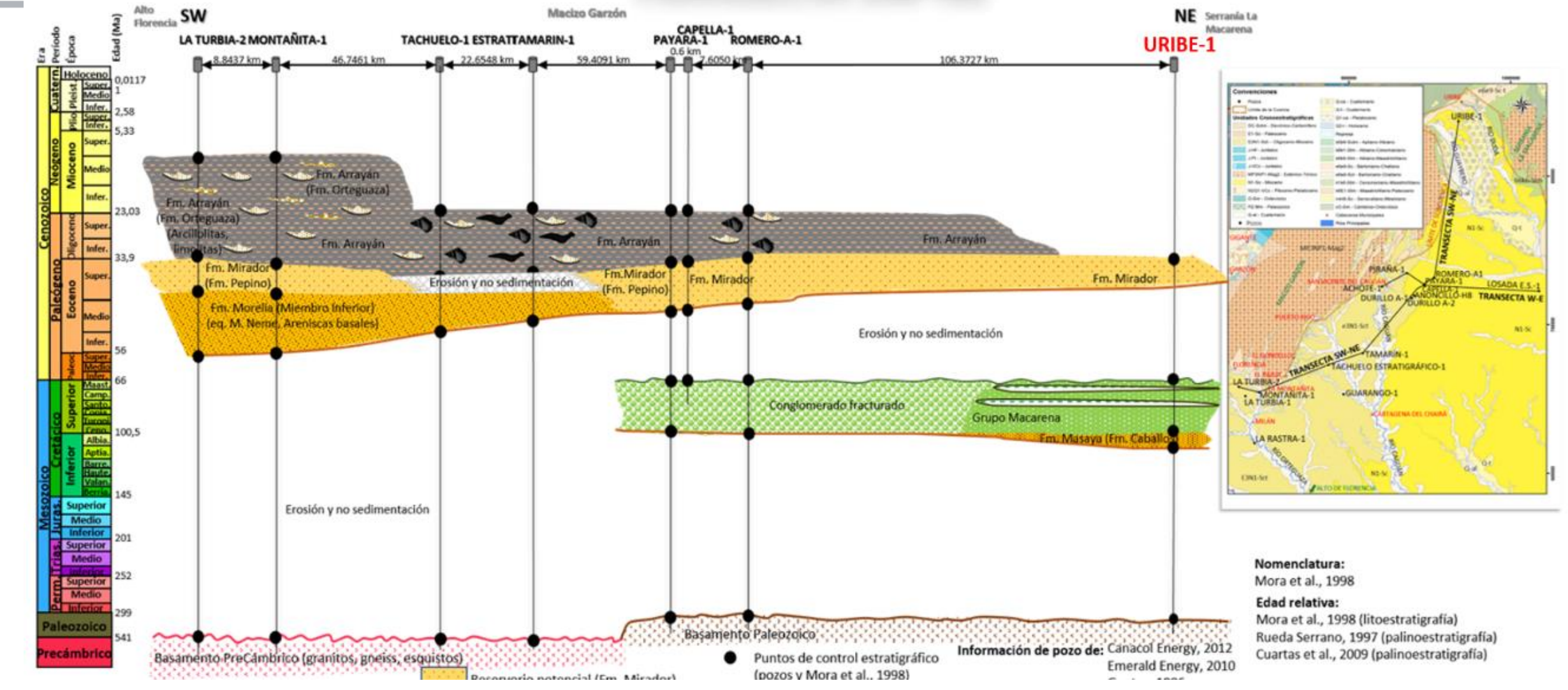
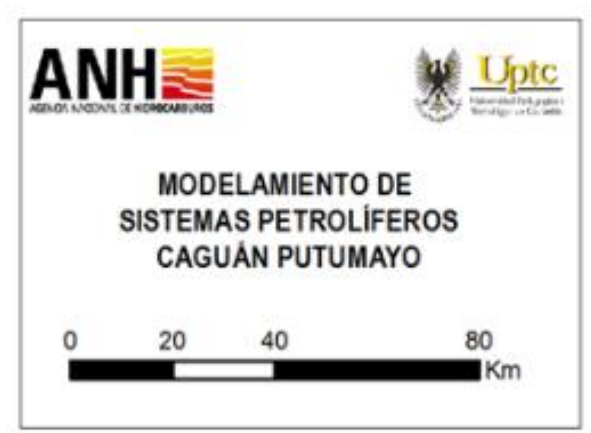
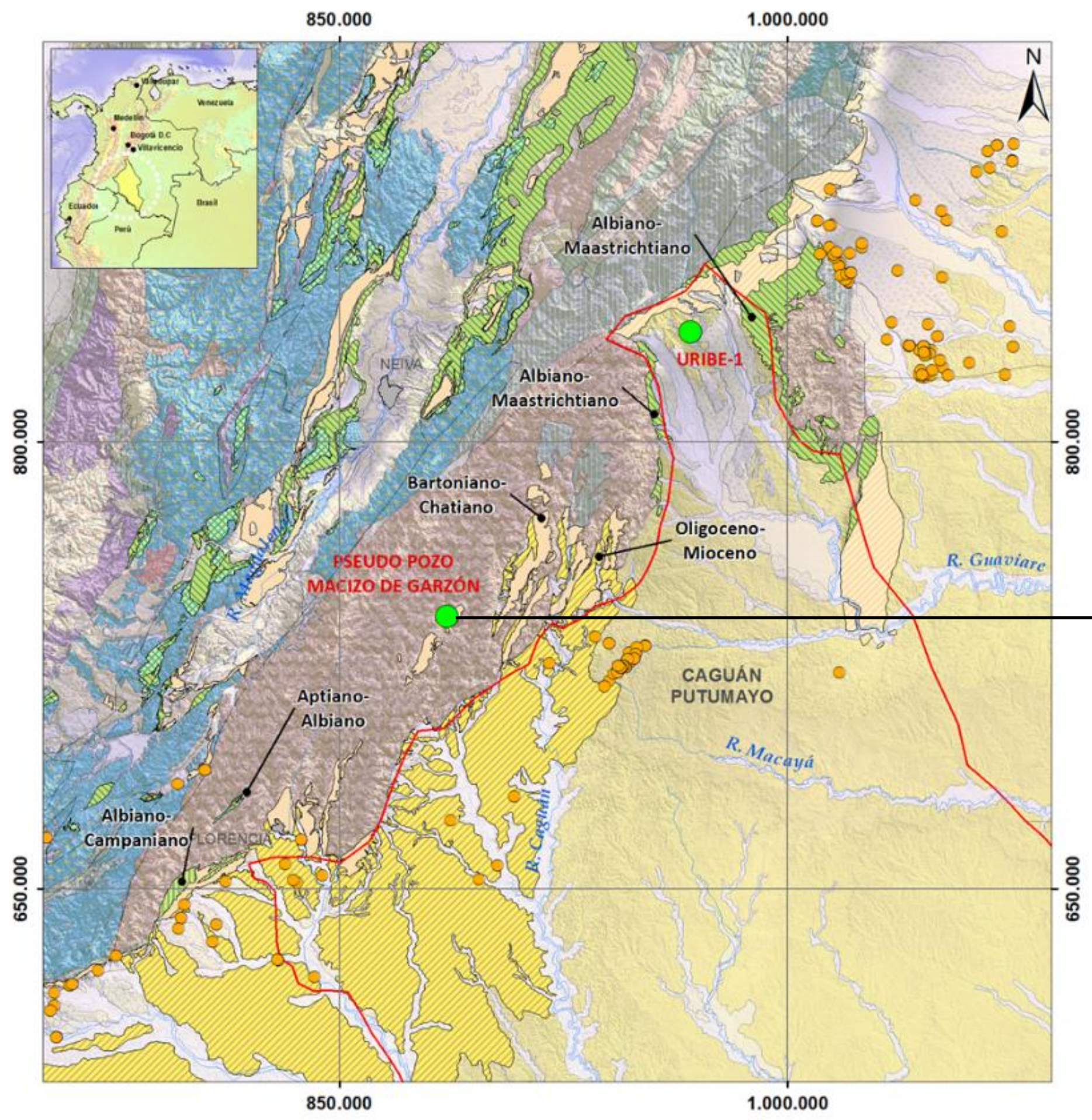




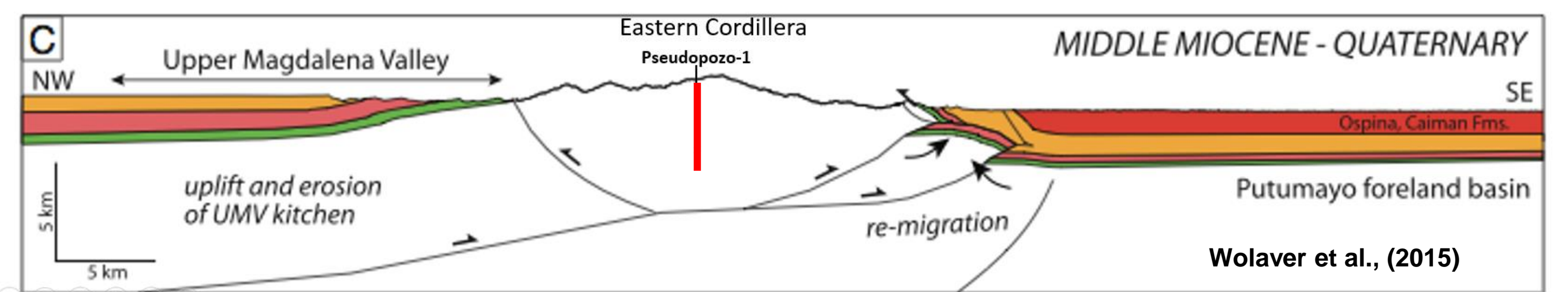
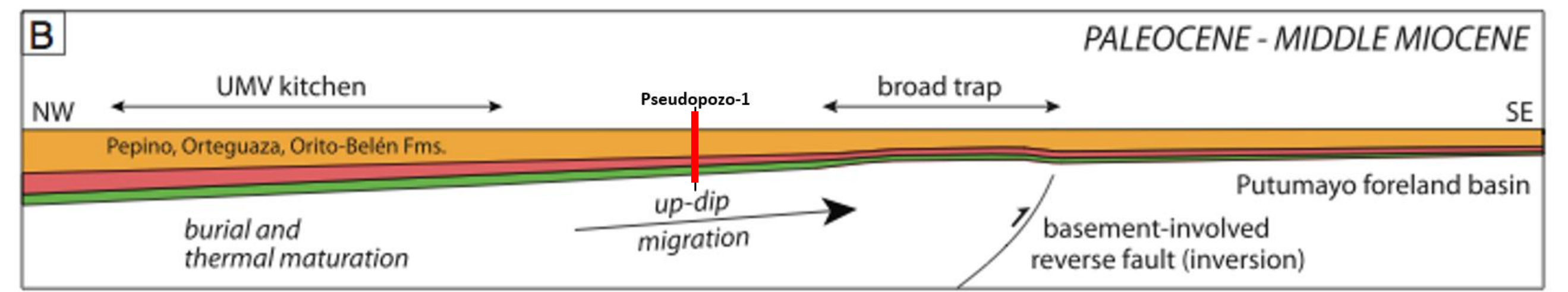
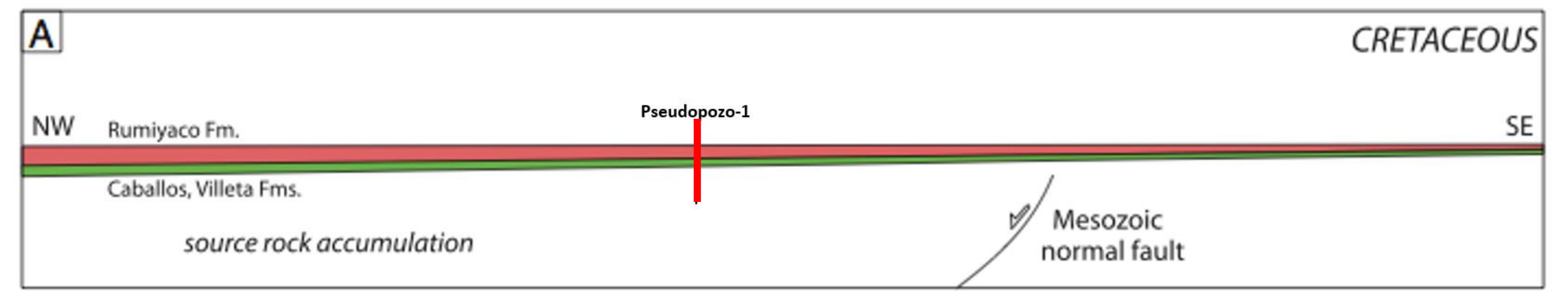
PETROLEUM SYSTEM MODELING

1D MODELING PSW Macizo Garzón

TRANSECTA SW-NE



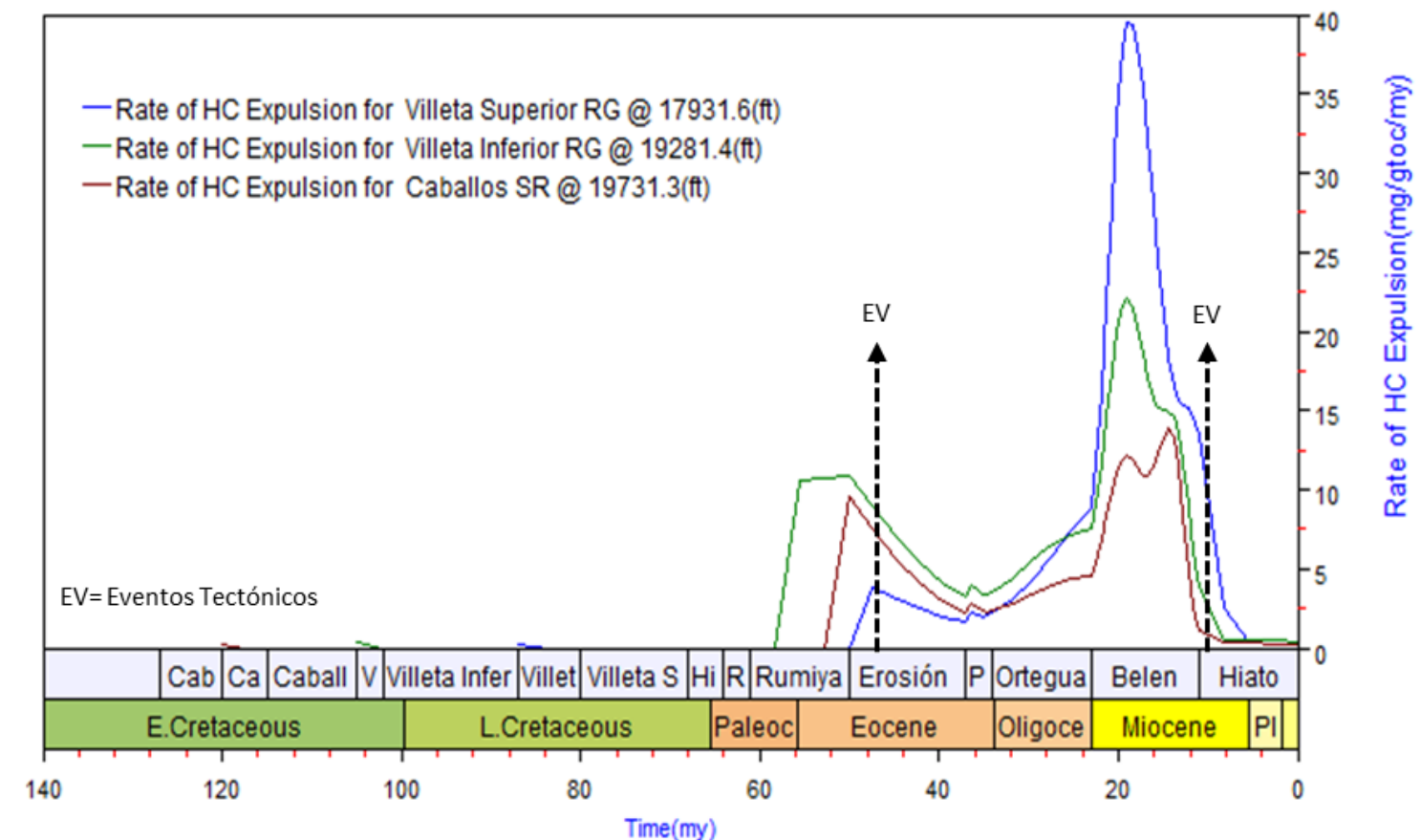
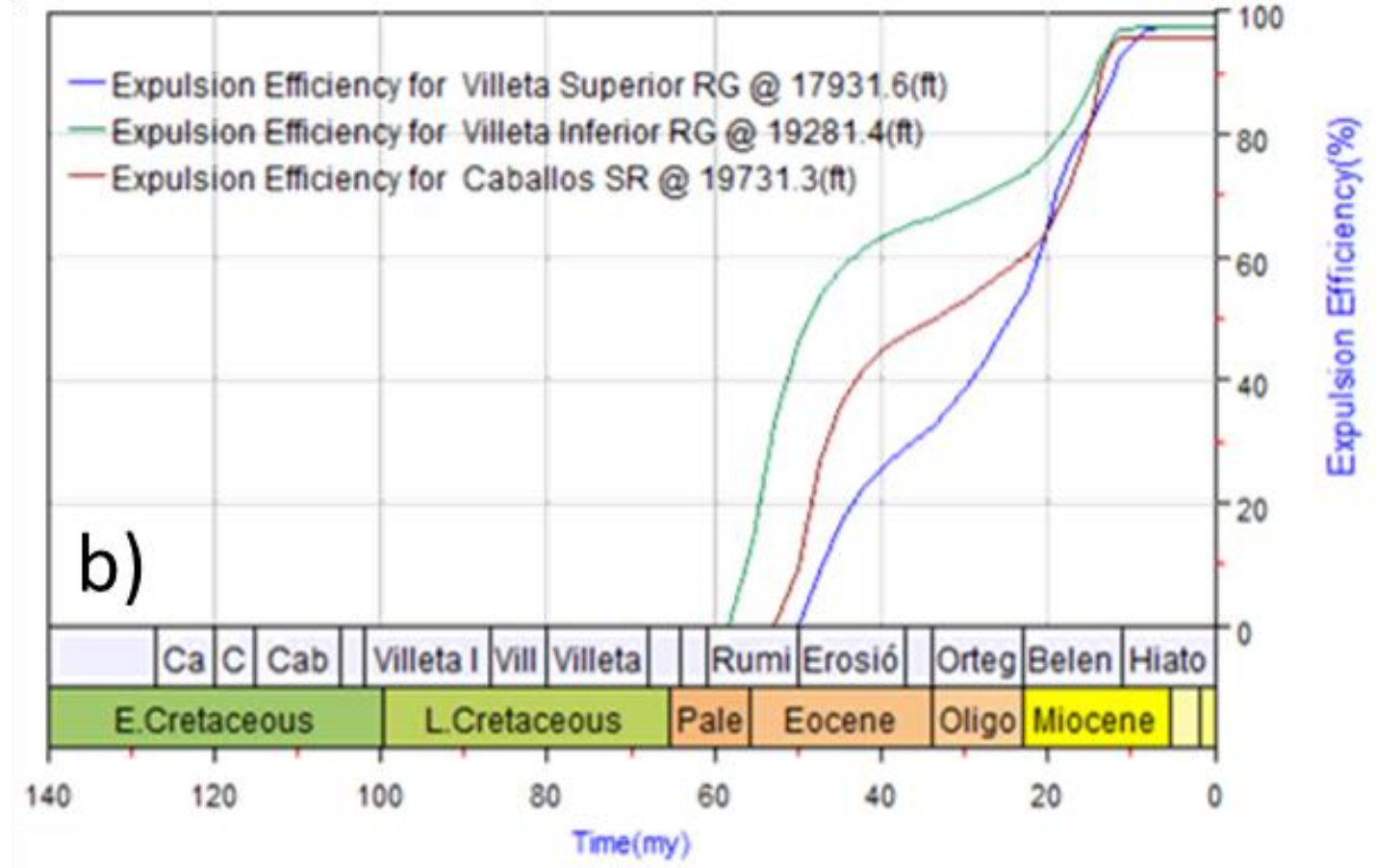
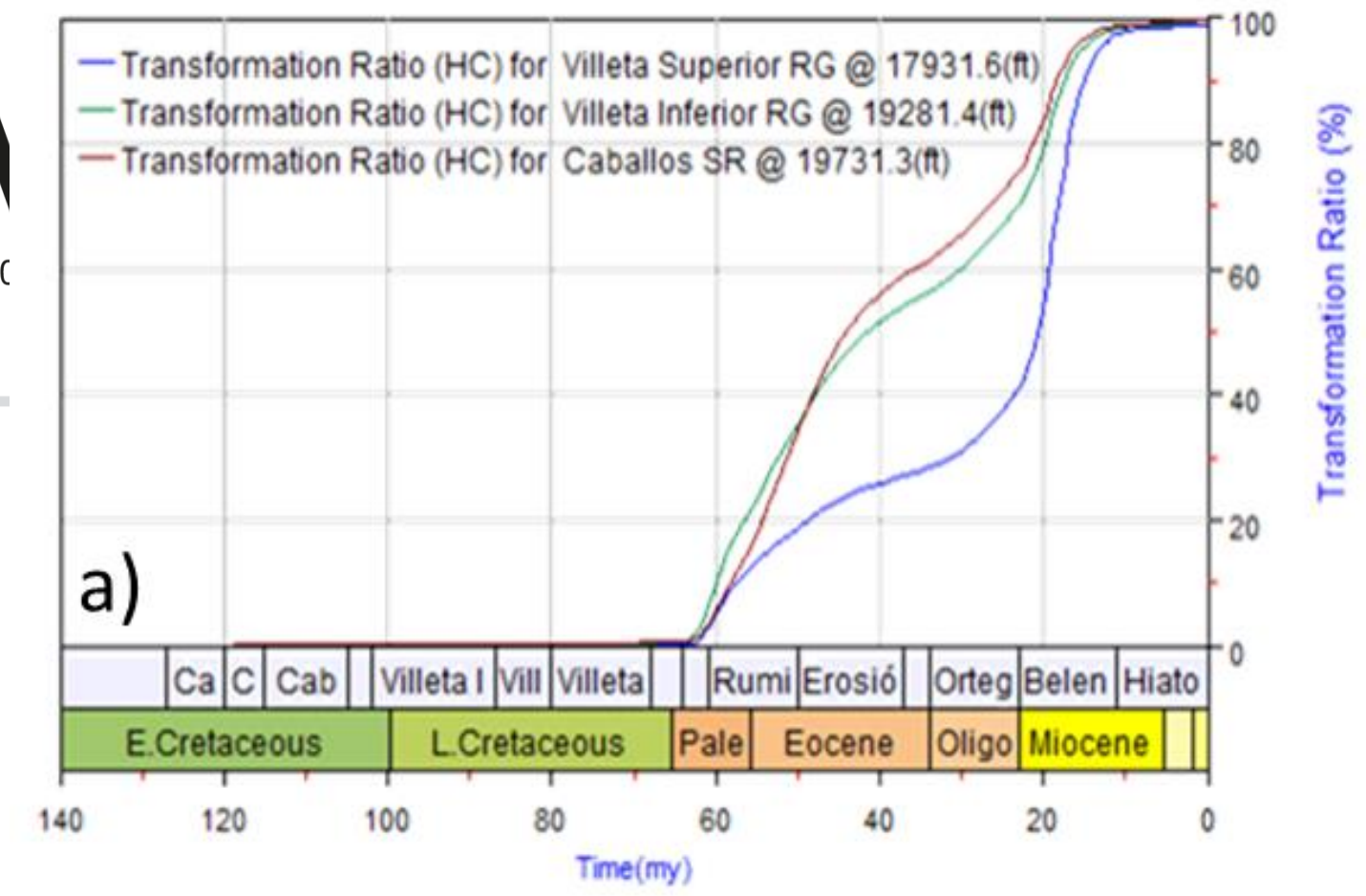
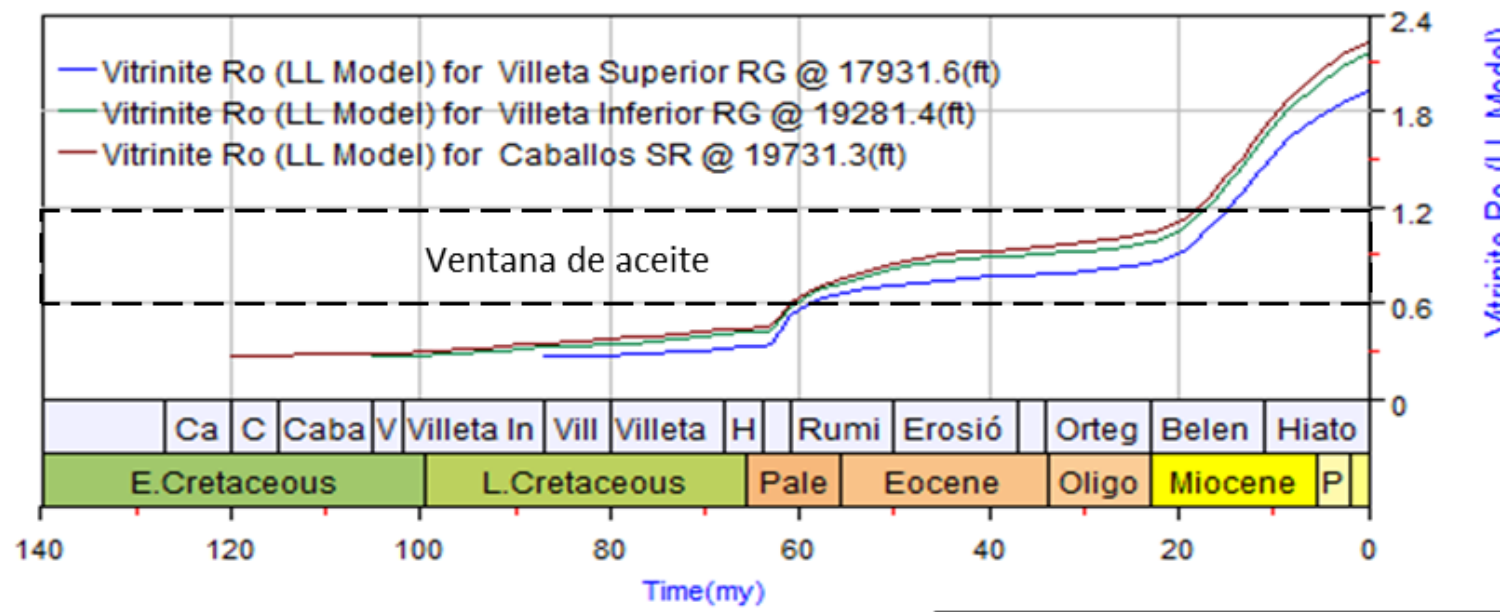
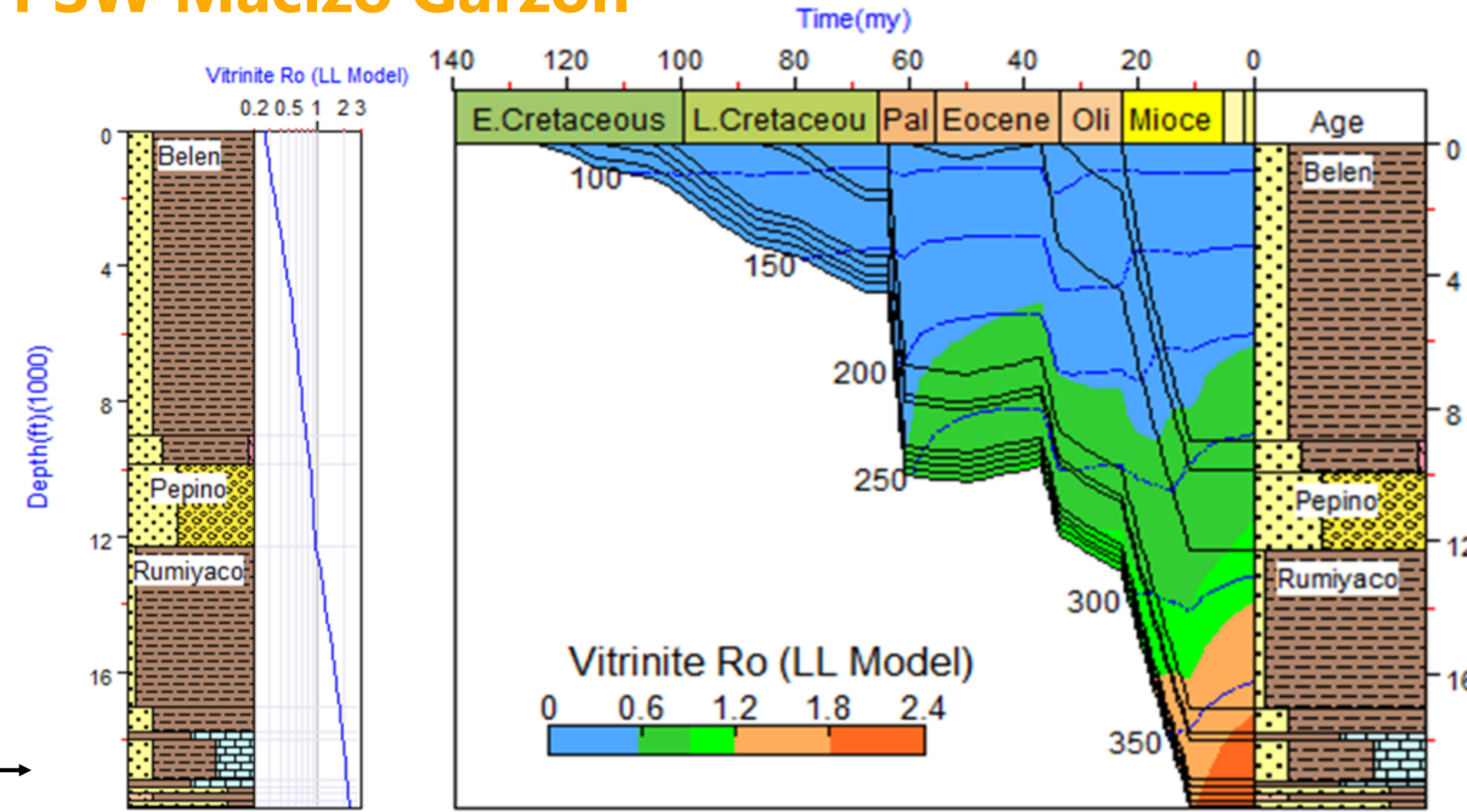
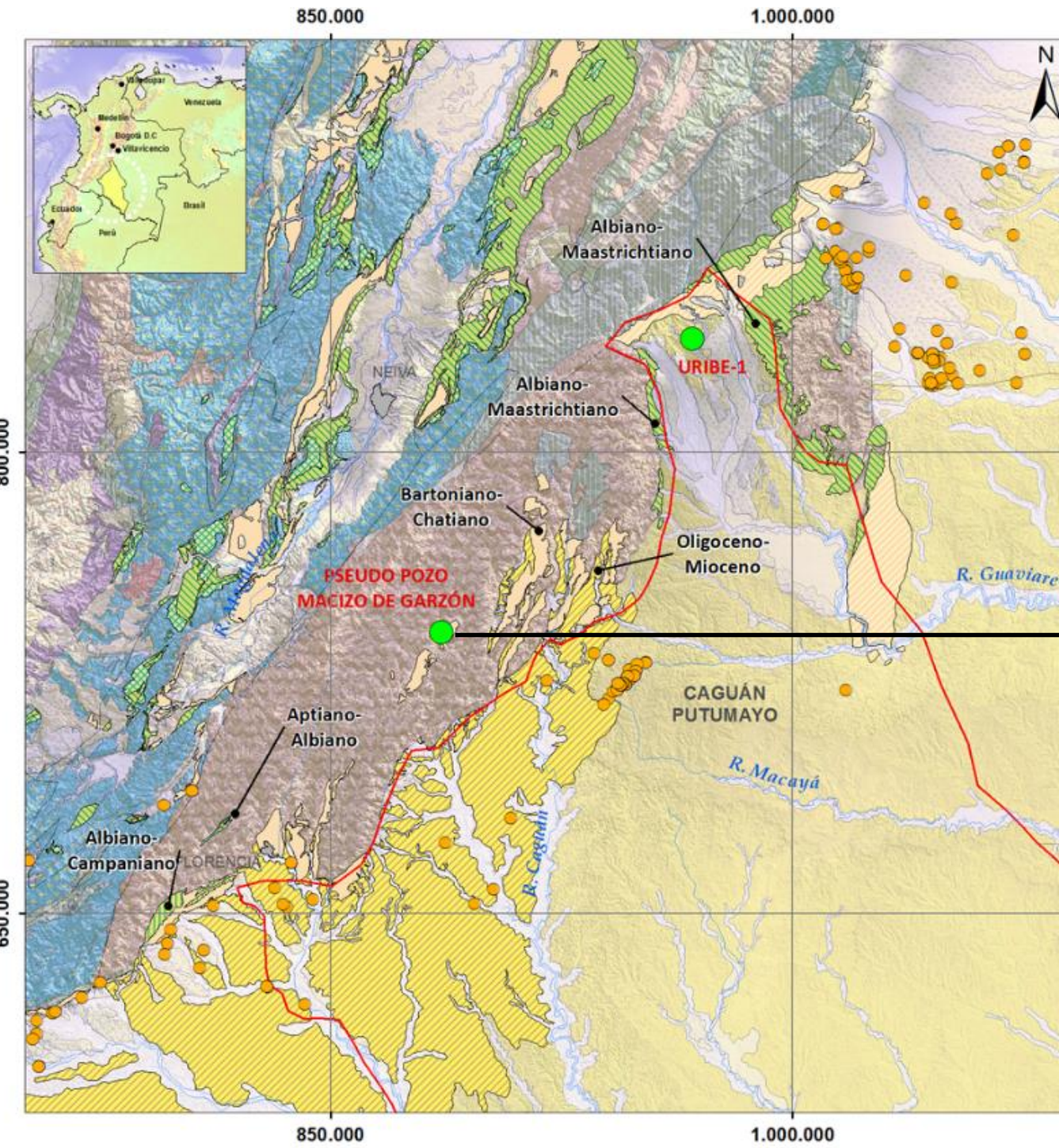
Nomenclatura:
Mora et al., 1998
Edad relativa:
Mora et al., 1998 (litoestratigrafía)
Rueda Serrano, 1997 (palinoestratigrafía)
Cuartas et al., 2009 (palinoestratigrafía)



Wolaver et al., (2015)

PETROLEUM SYSTEM MODELING

1D MODELING PSW Macizo Garzón



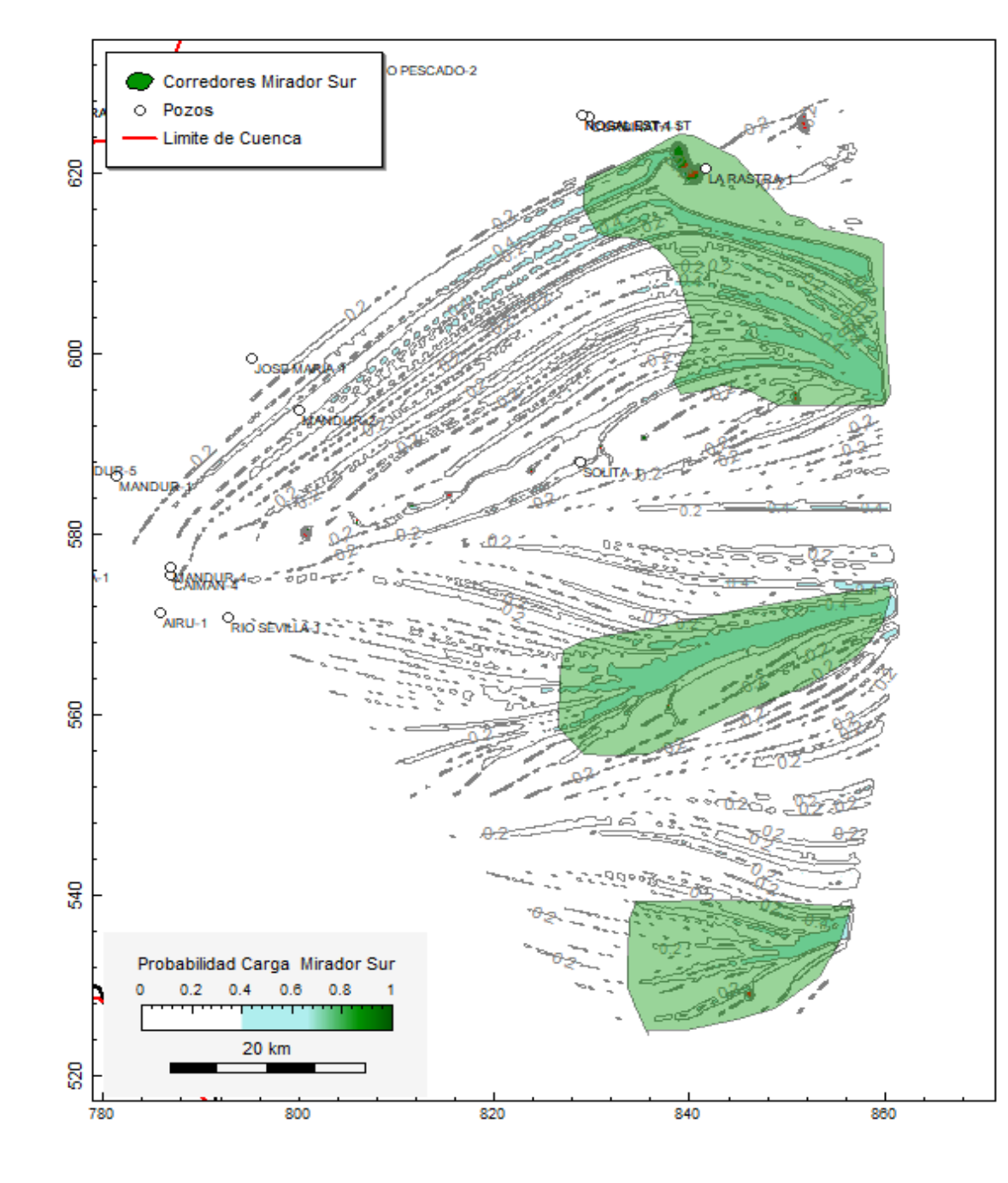
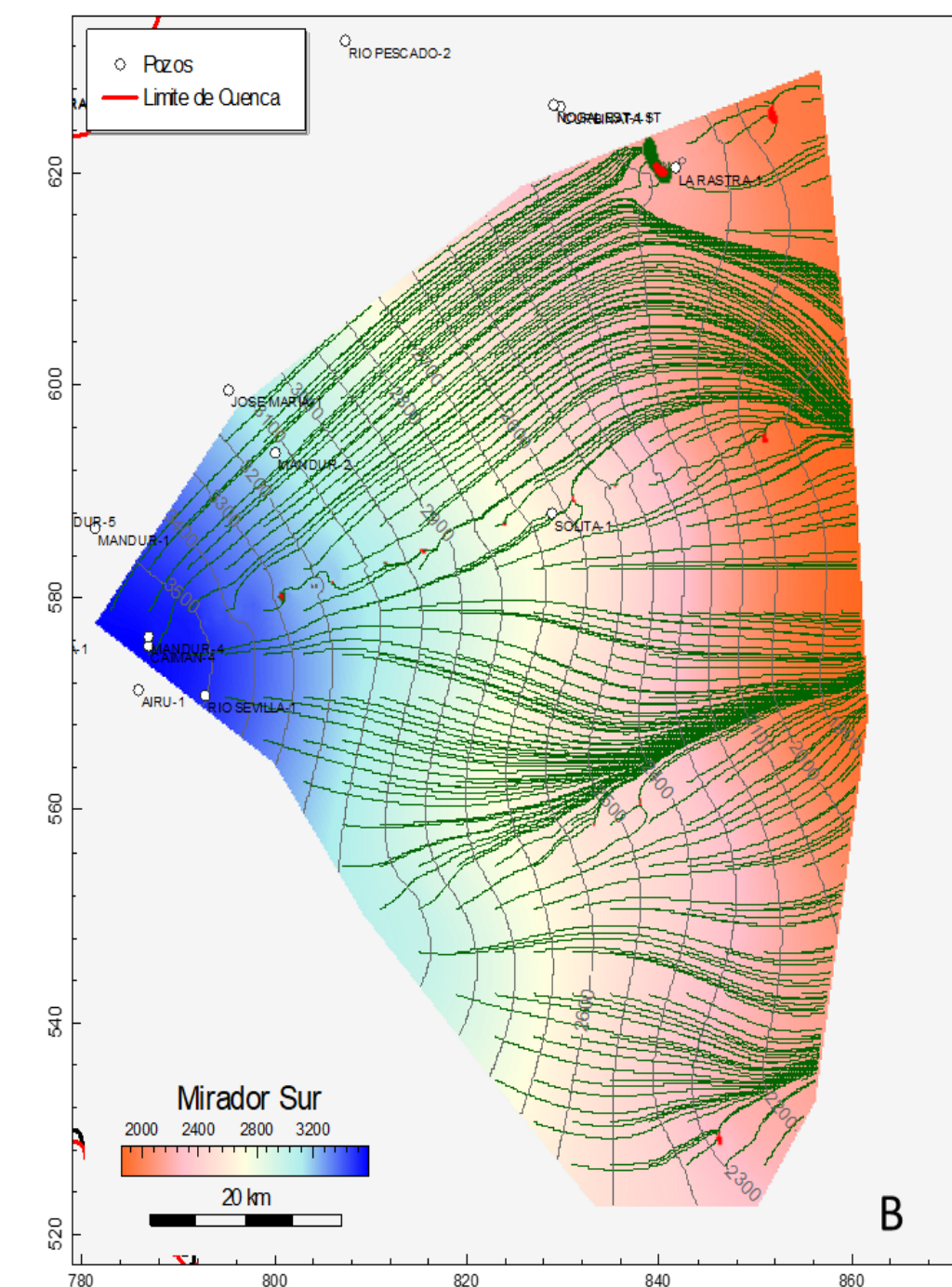
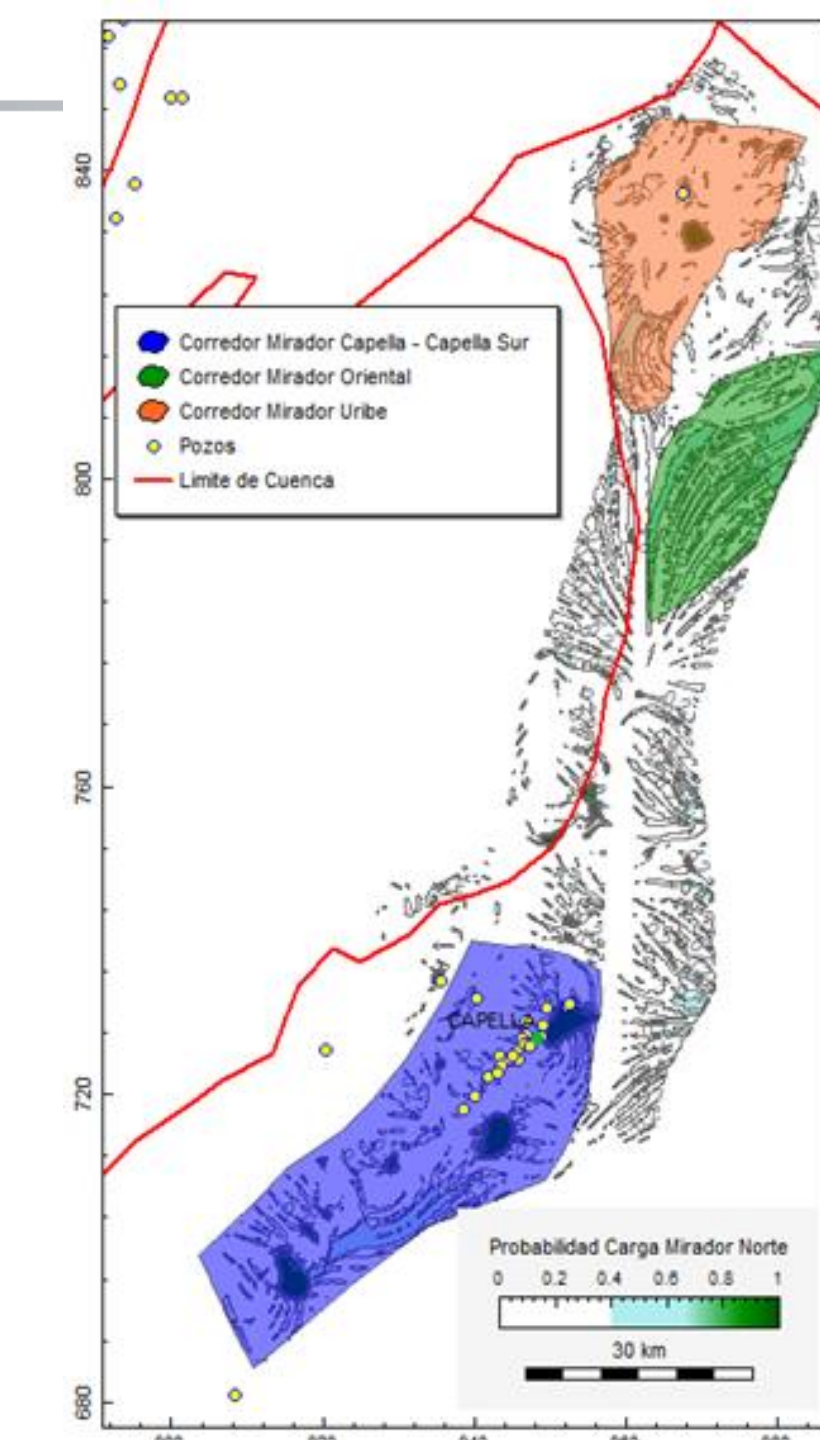
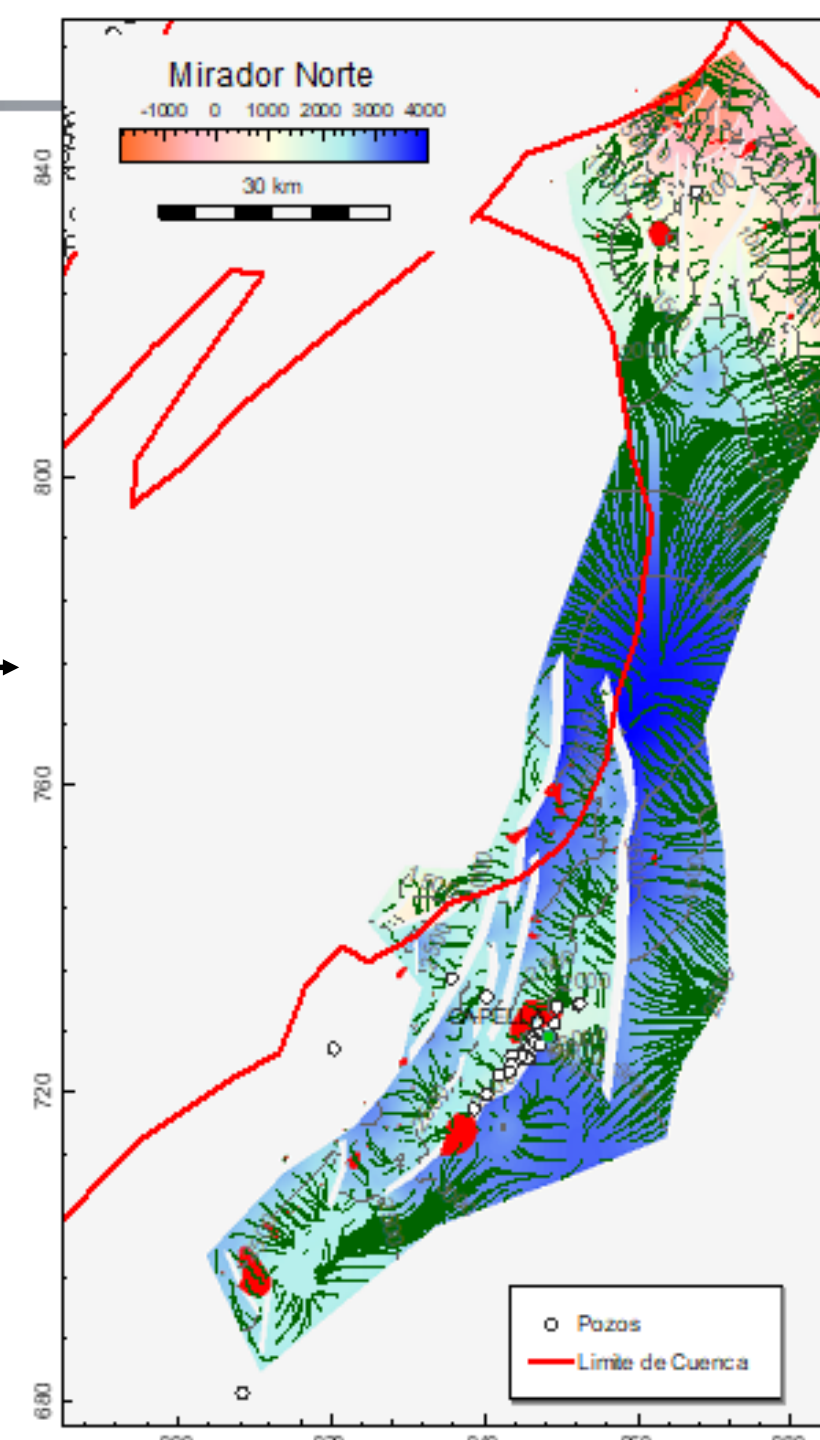
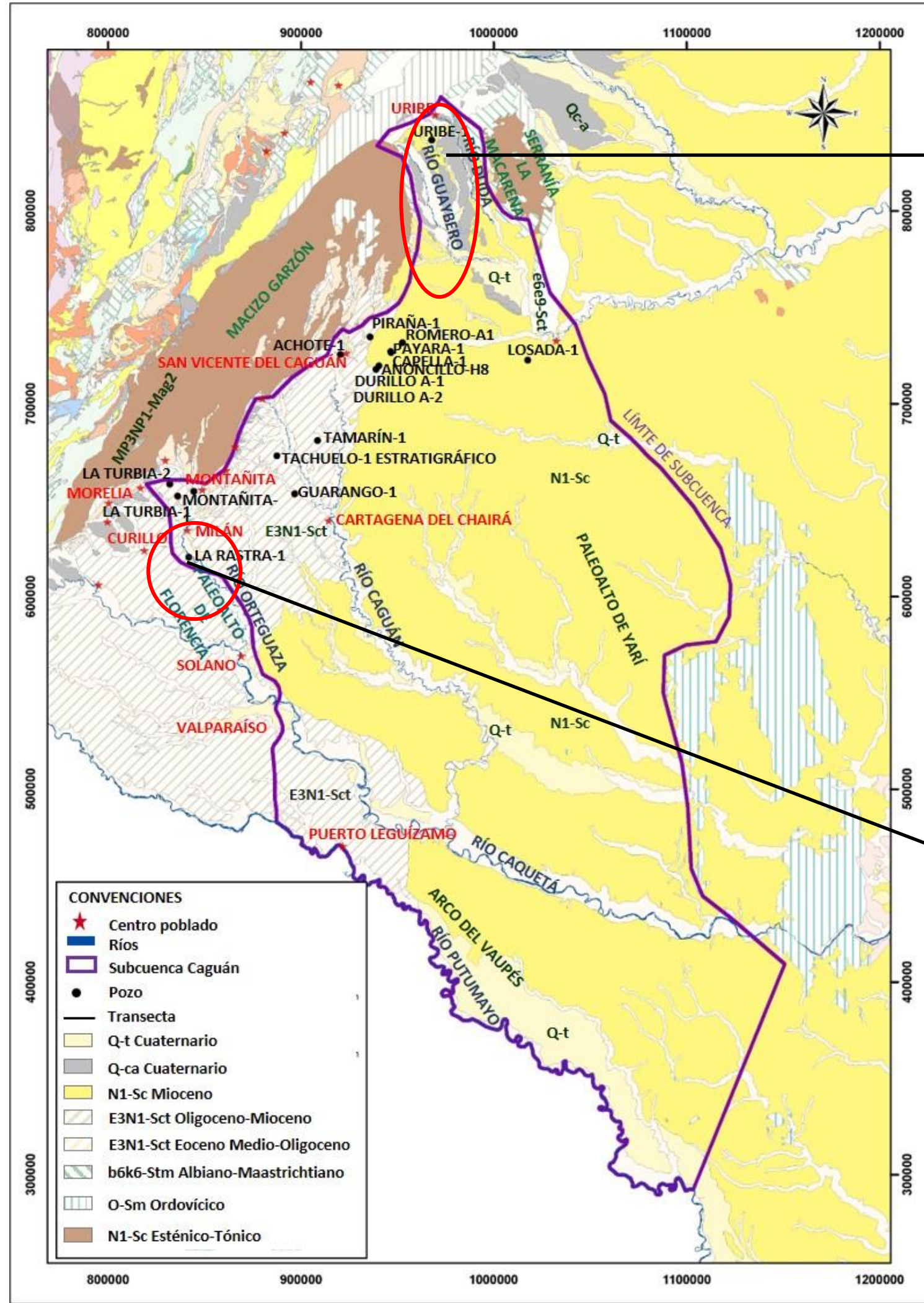
PLAY FAIRWAY MAPS

Uribe and La Rastra Área



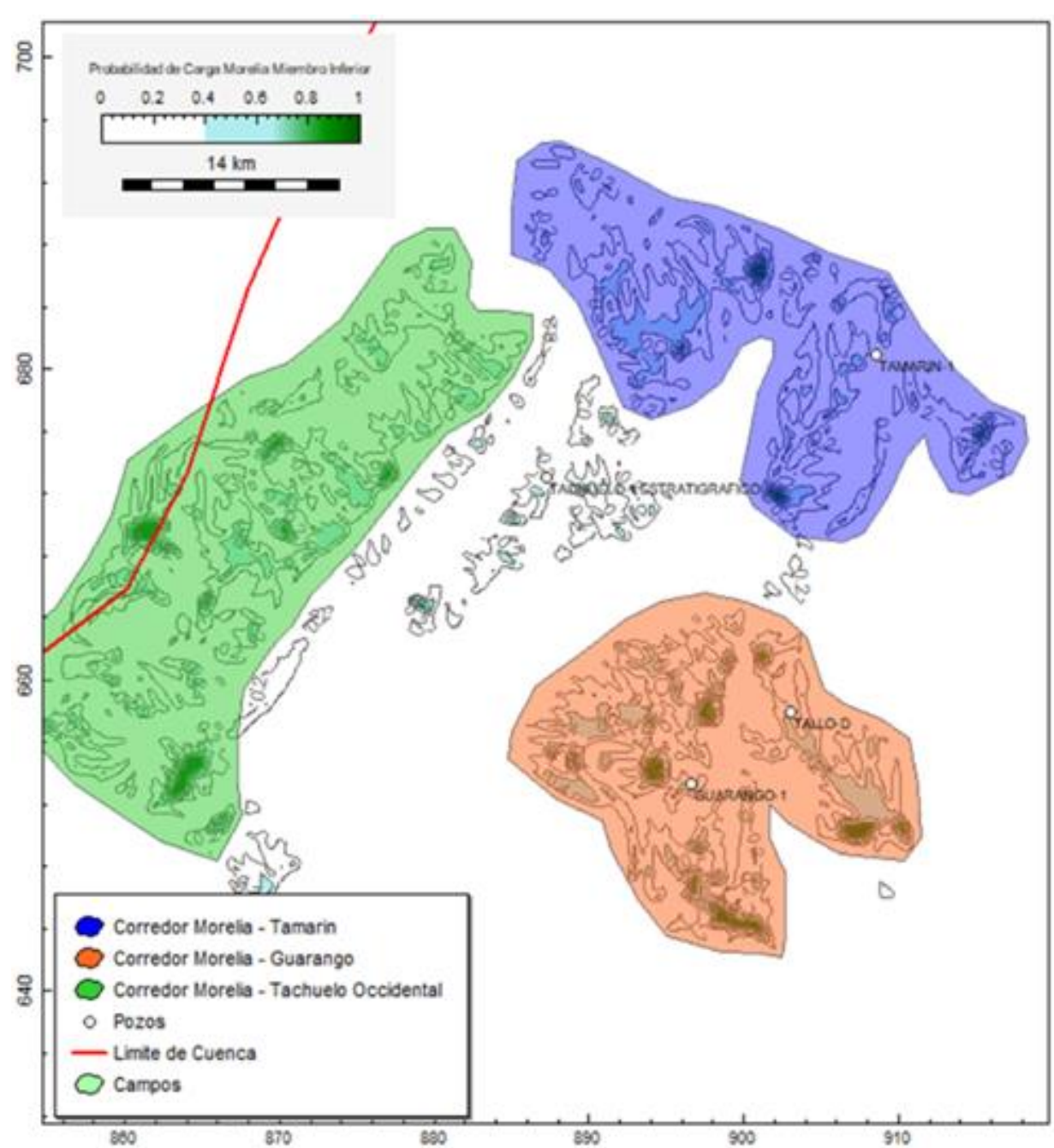
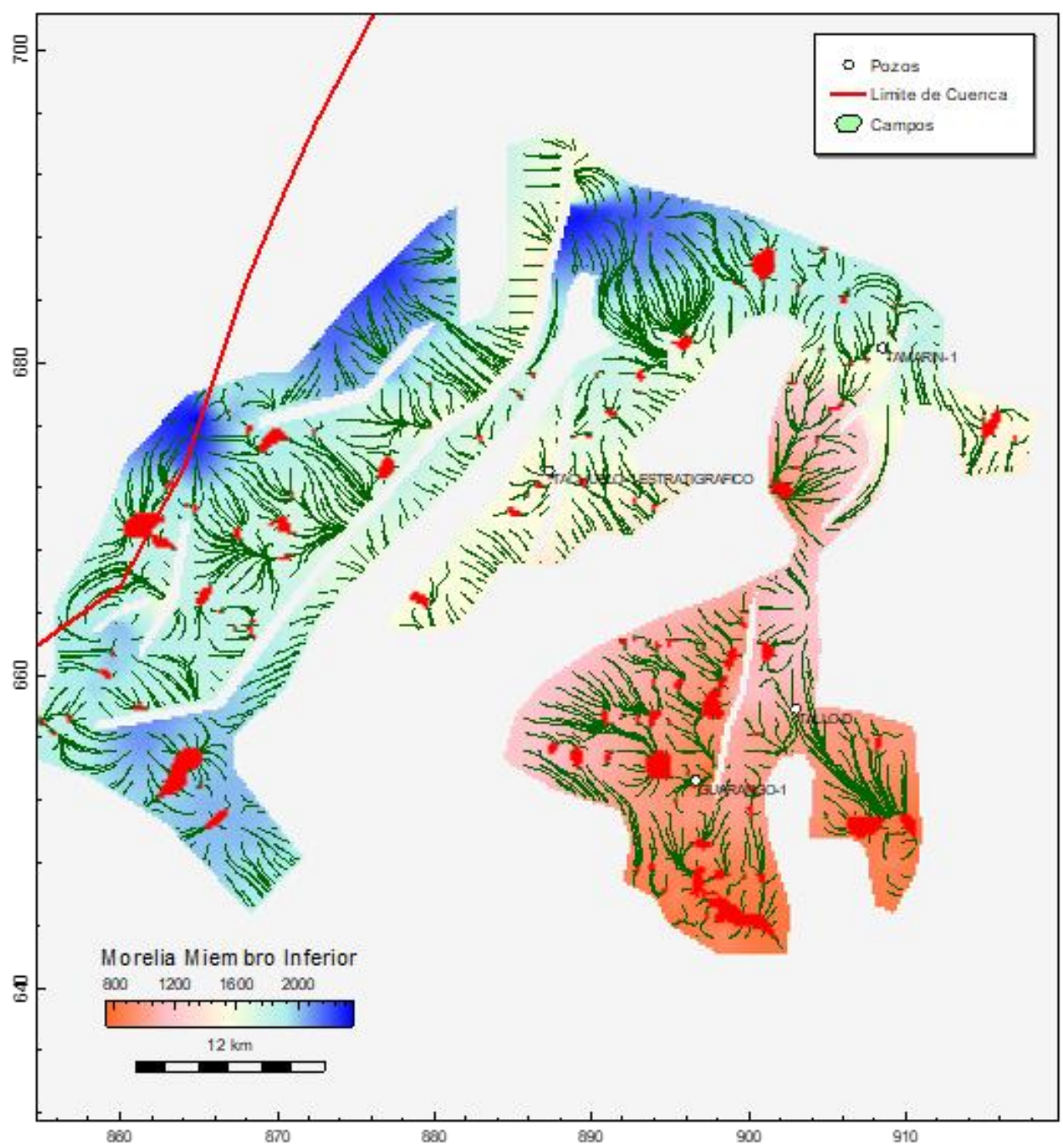
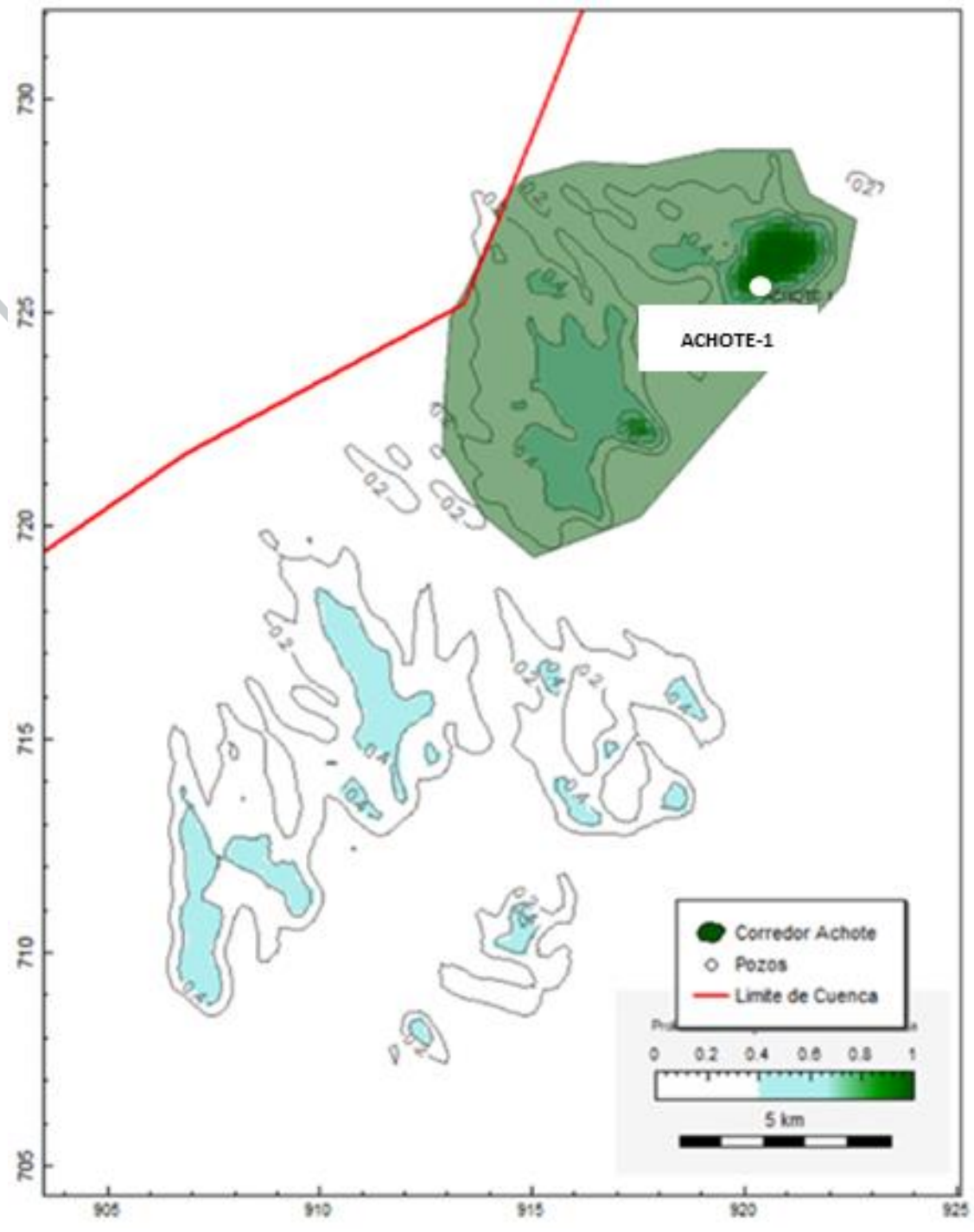
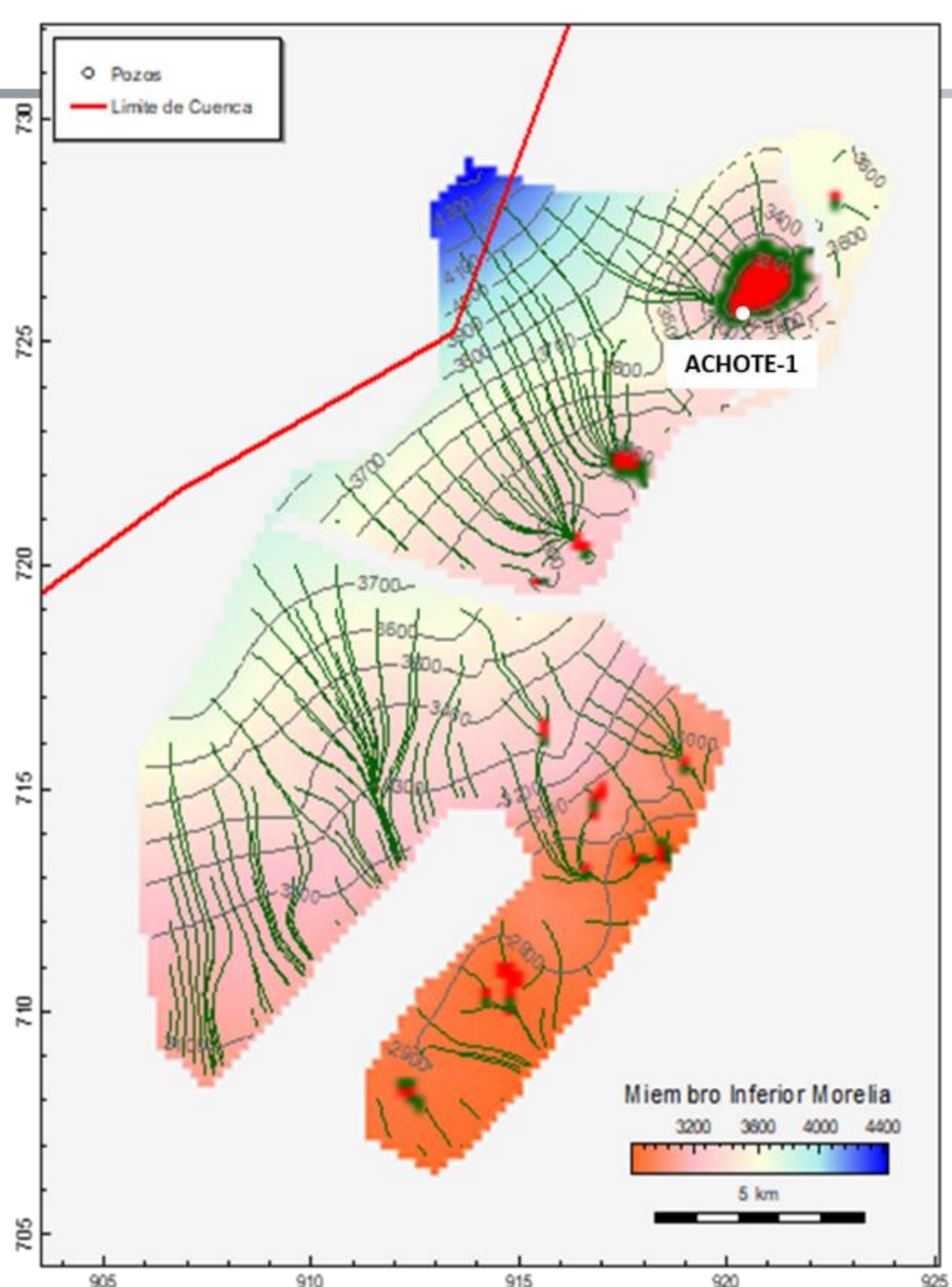
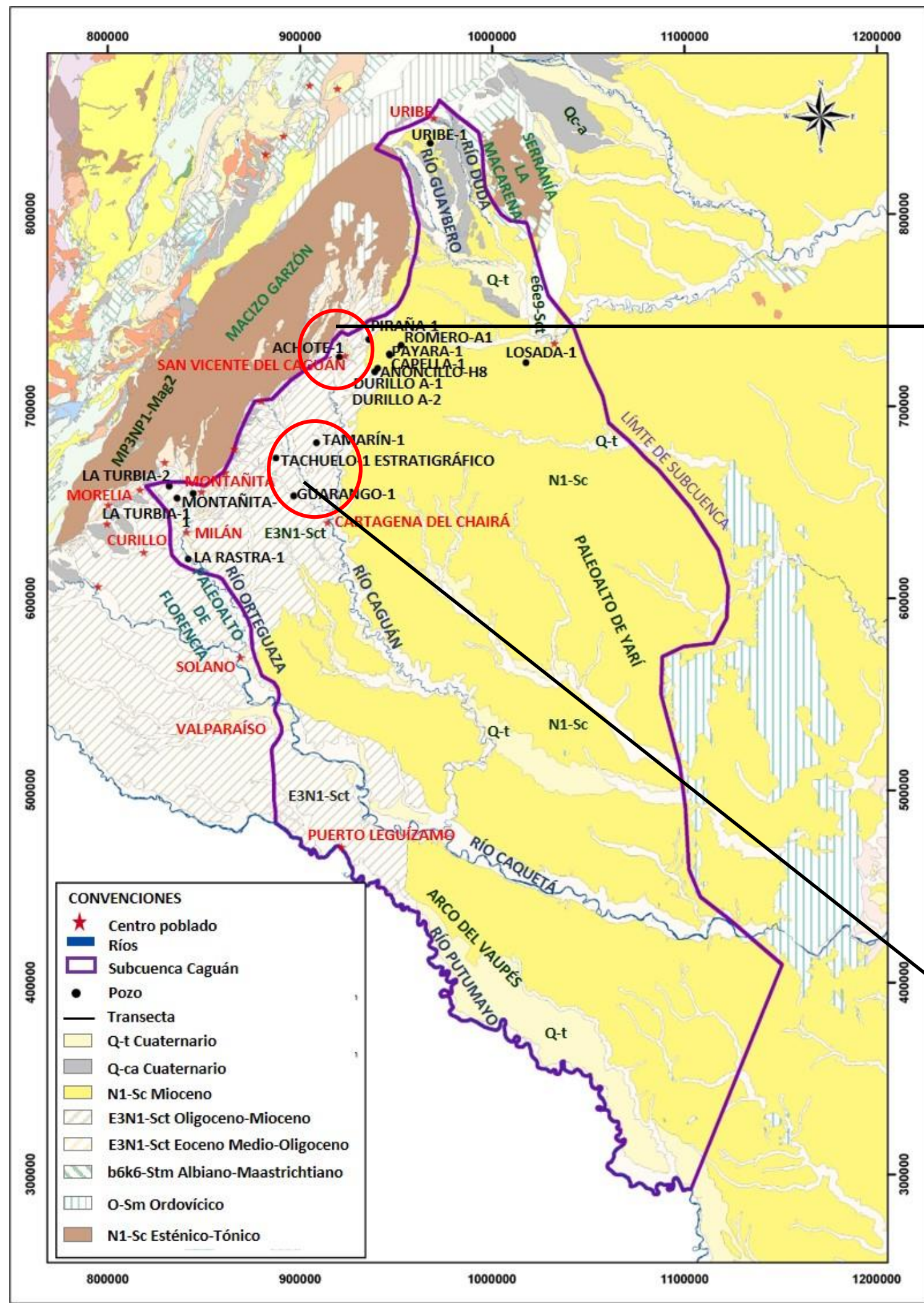
El futuro es de todos

Minenergía



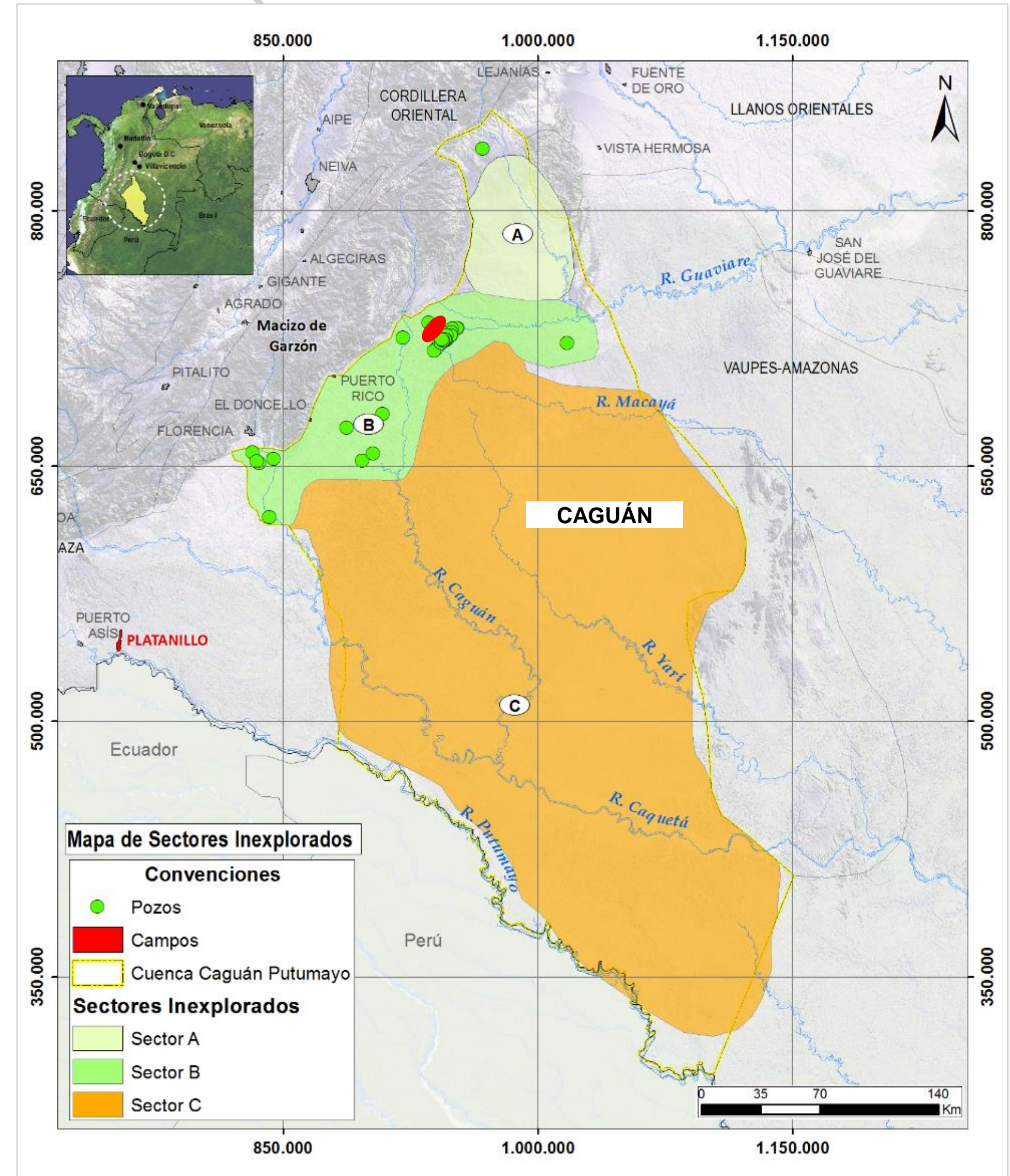
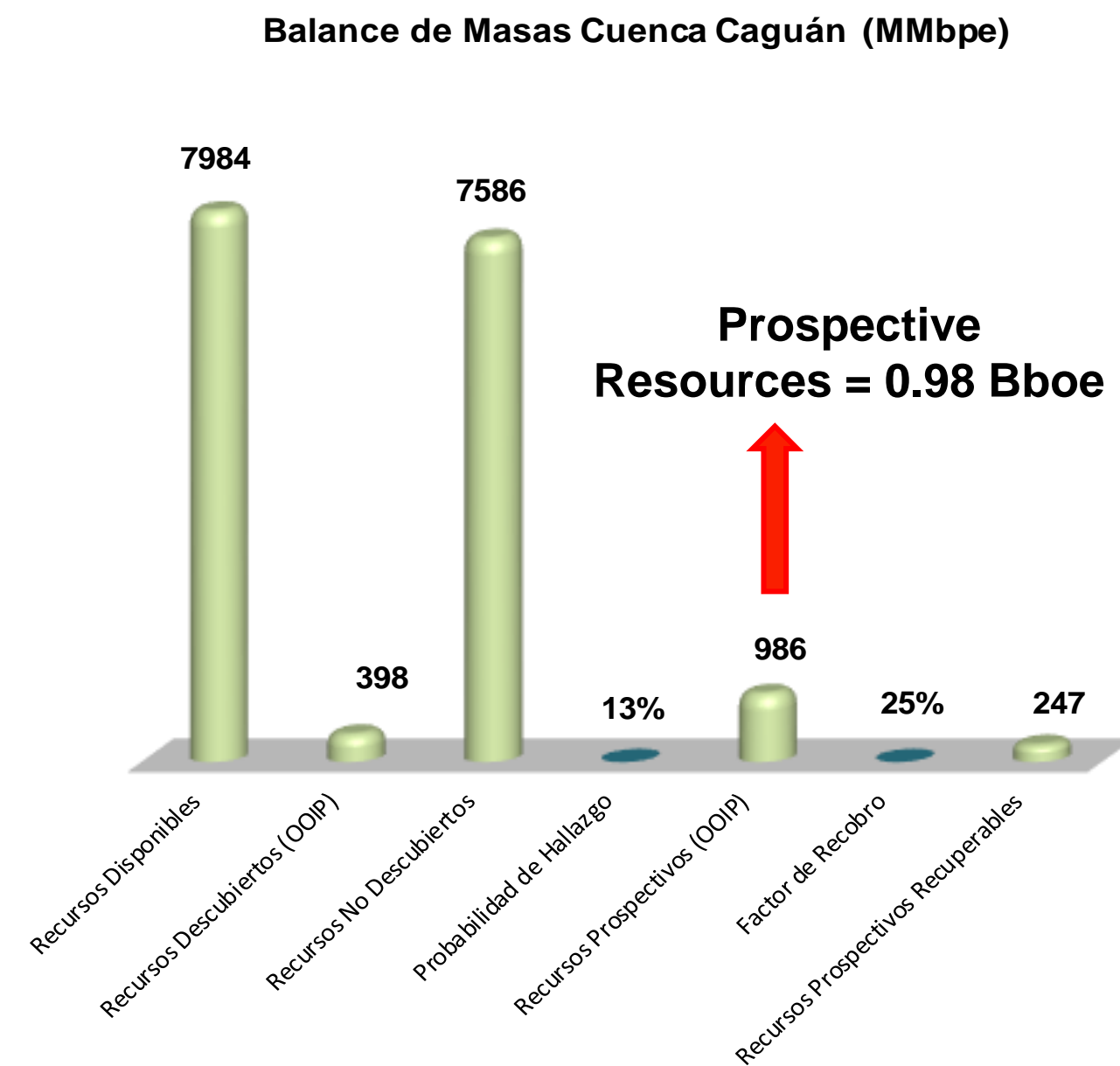
PLAY FAIRWAY MAPS Central Área

futuro de todos Minenergía



PARÁMETROS	UNIDADES	Caguan	TOTAL
		K Mz Garzon	
HC's Generados / Villeta Superior	MMbpe	41812	41812
HC's Disponibles / Villeta Superior	MMbpe	1840	1840
HC's Generados / Villeta Inferior	MMbpe	103315	103315
HC's Disponibles / Villeta Inferior	MMbpe	5078	5078
HC's Generados / Caballos	MMbpe	24224	24224
HC's Disponibles / Caballos	MMbpe	1066	1066
Total HC's Generados	MMbpe	169351	169351
Recursos Disponibles	MMbpe	7984	7984
Recursos Descubiertos (OOIP)	MMbpe	398	398
Recursos No Descubiertos	MMbpe	7586	7586
Probabilidad de Hallazgo	%	13%	13%
Recursos Prospectivos (OOIP)	MMbpe	986	986
Factor de Recobro	%	25%	25%
Recursos Prospectivos Recuperables	MMbpe	247	247

*FG= Foco Generador



Final Comments

- The Caguán Sub Basin as a Frontier Basin with oil production (Capella field) is a **great opportunity for visionaries**.
- Update and review confidentiality of the information to **increase the volume of data available** for this type of study, making the results more attractive to the Industry.
- Similar to USA, Canada, England and recently in Brazil, the seismic information, wells, surface geology, etc., could be **made public one year after being obtained**. It would be very useful for operators, investors and strategies of the ANH and the SGC.
- More volume and availability of geological and geophysical information stimulates **additional studies related to groundwater, minerals, infrastructure, construction, etc.**

Thanks

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