AREAS ADVERTISEMENT 2022

Middle Magdalena Valley Basin

Geological evaluation , petroleum systems and prospectivity of oil and gas in the southern middle Magdalena basin Magdalena (Phase II)

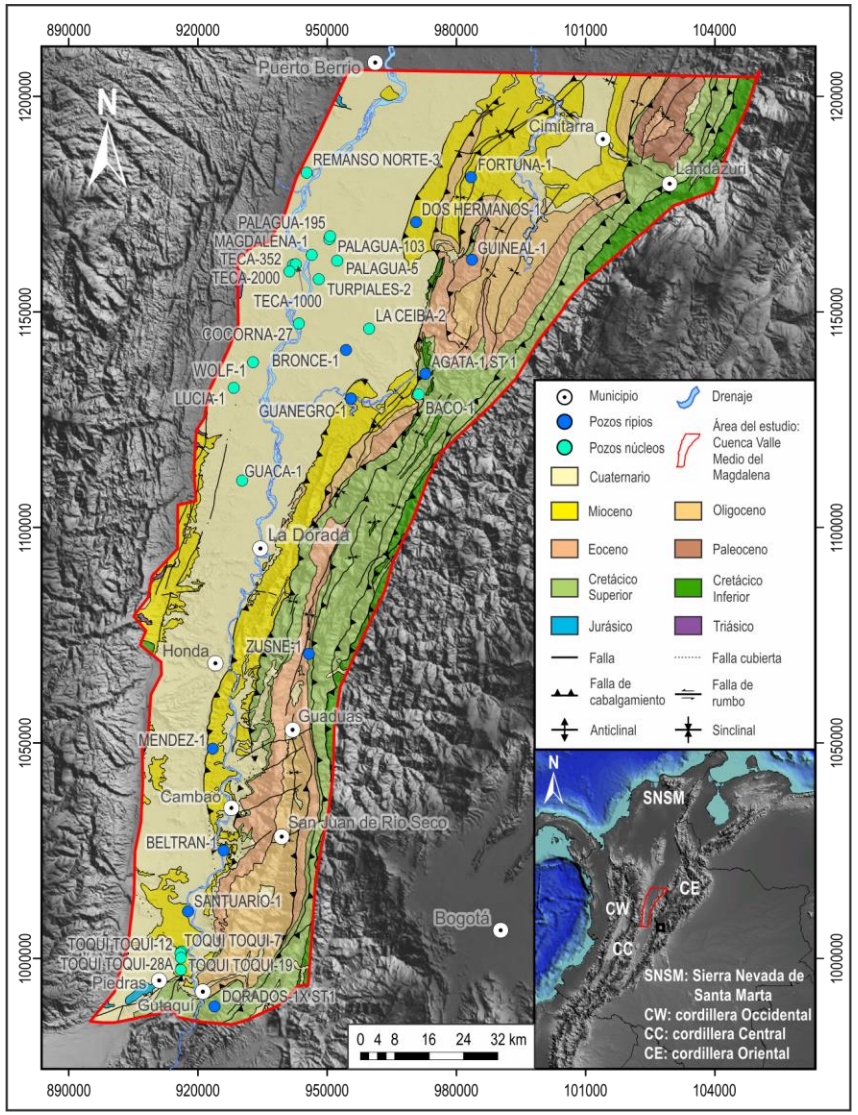
Presentation outline

08:00 – 08:05	Introduction. **E. Velásquez**
08:05 – 08:20	Stratigraphy. **A. Pardo**
08:20 – 08:35	Seismic Interpretation & Structural Framework. **L. Rendón/R. Linares**
08:35 – 08:55	Play Fairway maps and Yet to Find. **C. Mora**
08:55 – 09:00	Wrap up. **E. Velásquez**

Stratigraphy

- Sampling and description of cores, ditch cuttings and outcrops. Photographs.
- Stratigraphic logs and facies analysis.
- Chronostratigraphic chart of the area.
- Micropaleontological and ichnological analyses.
- Petrographic analysis.
- Paleogeographic maps (Maastrichtian, Paleocene, Eocene, Oligocene and Miocene).

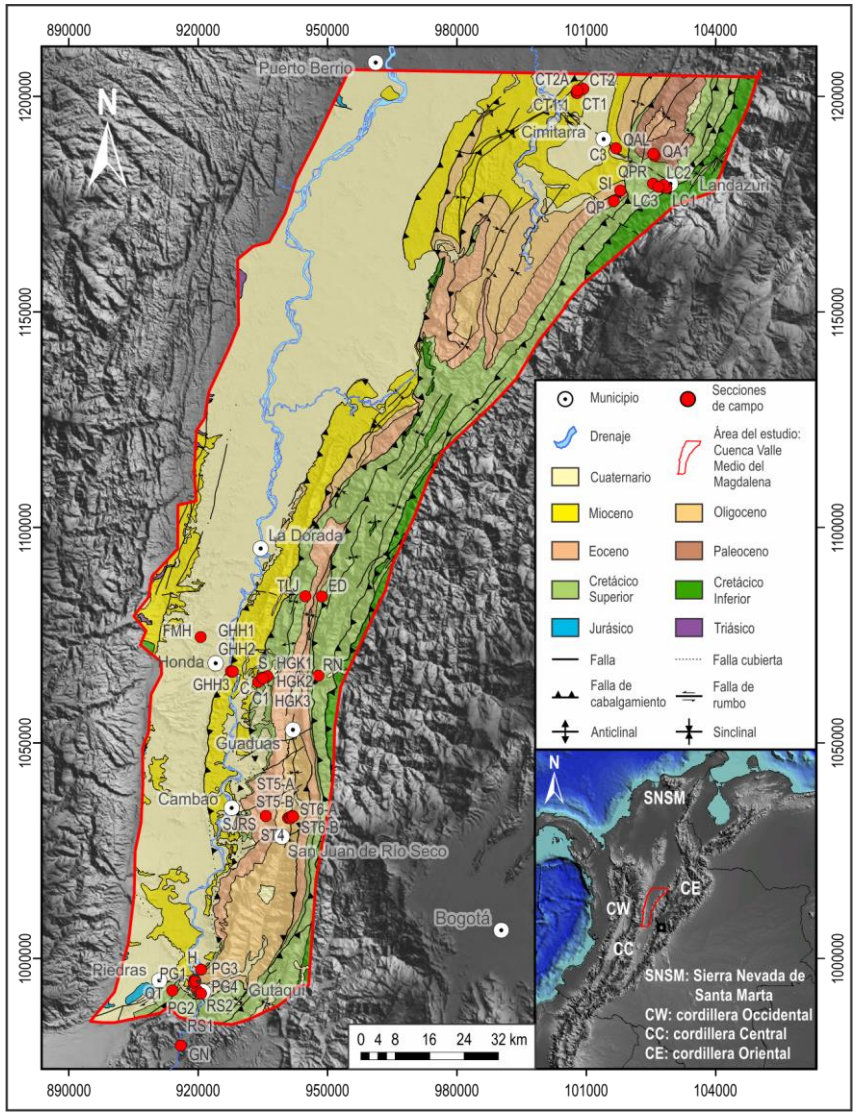
Wells



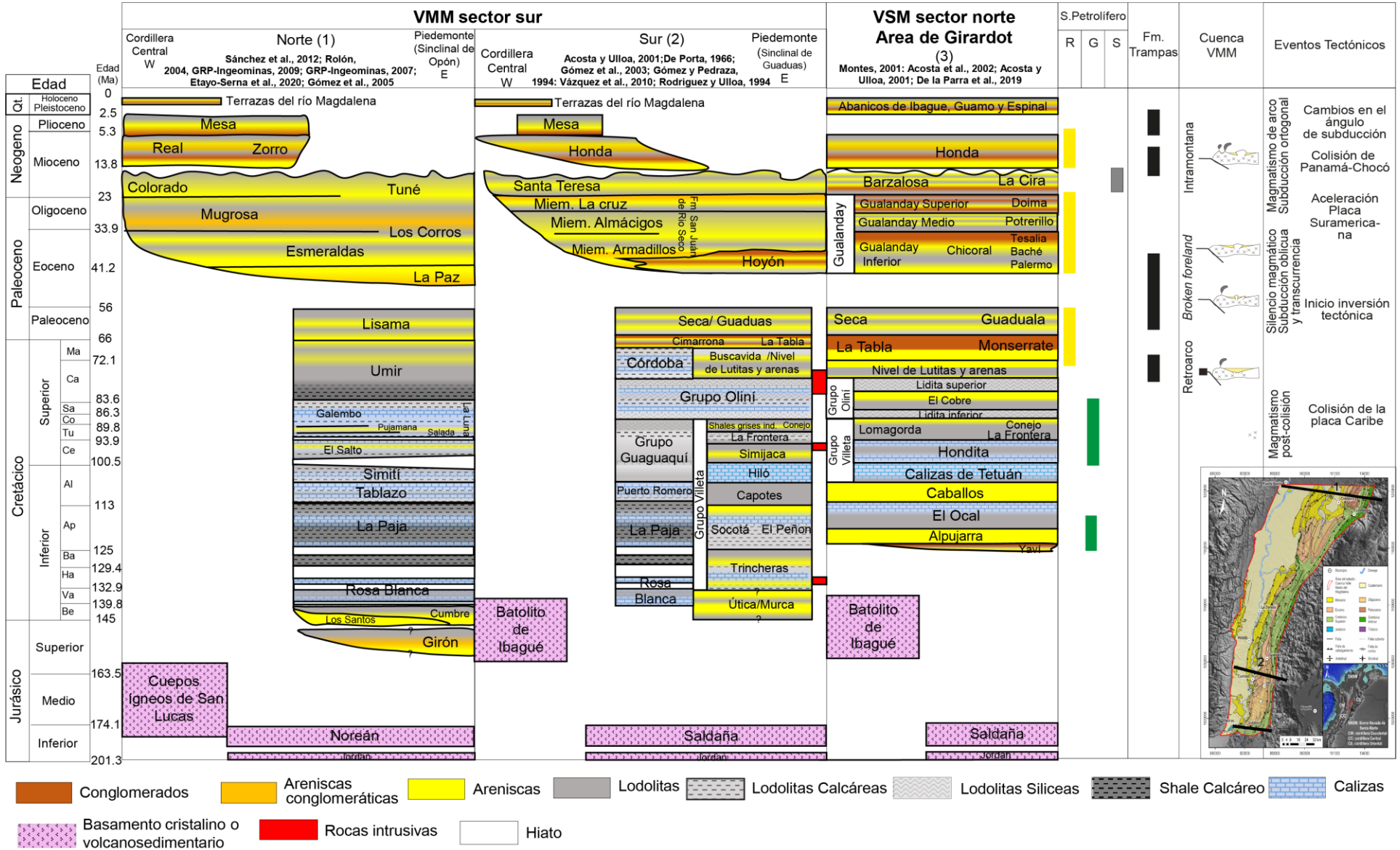
Outcrops
1802 m

Core wells
1100 m

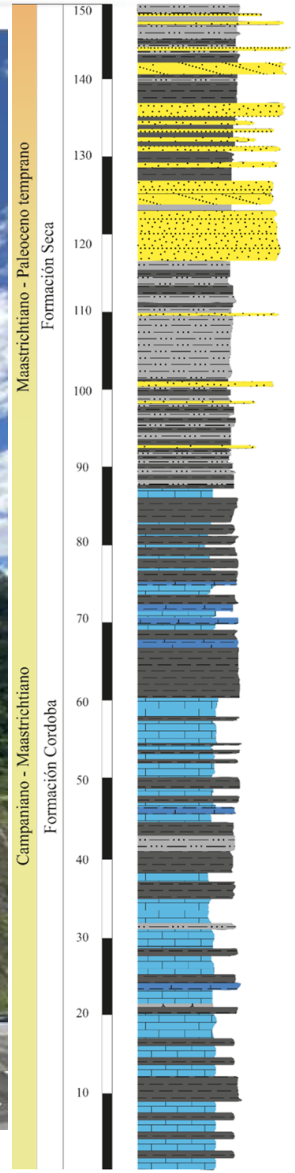
Outcrops



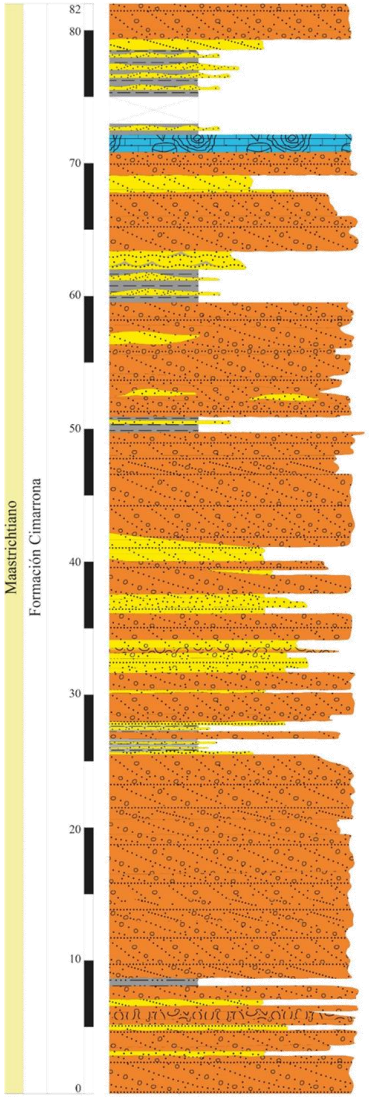
Stratigraphic chart



Túnel las Lajas (Córdoba, Seca formations). Source of hydrocarbons

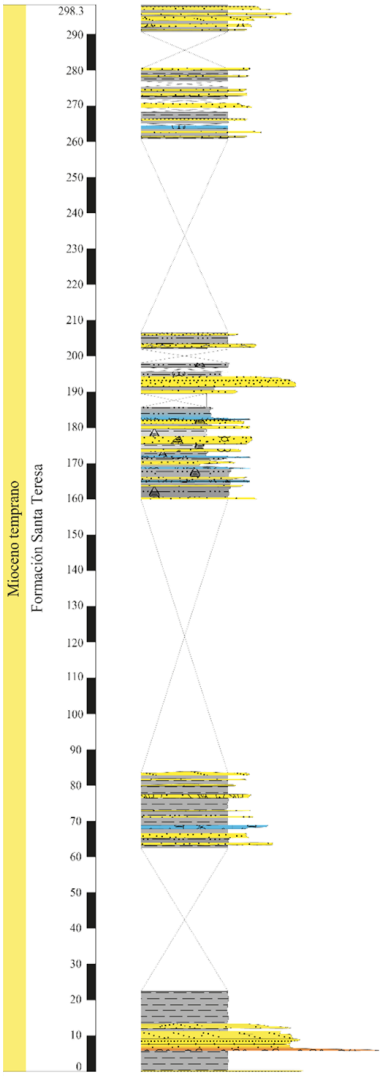


Honda-Guaduas (Cimarrona Fm.). Reservoir

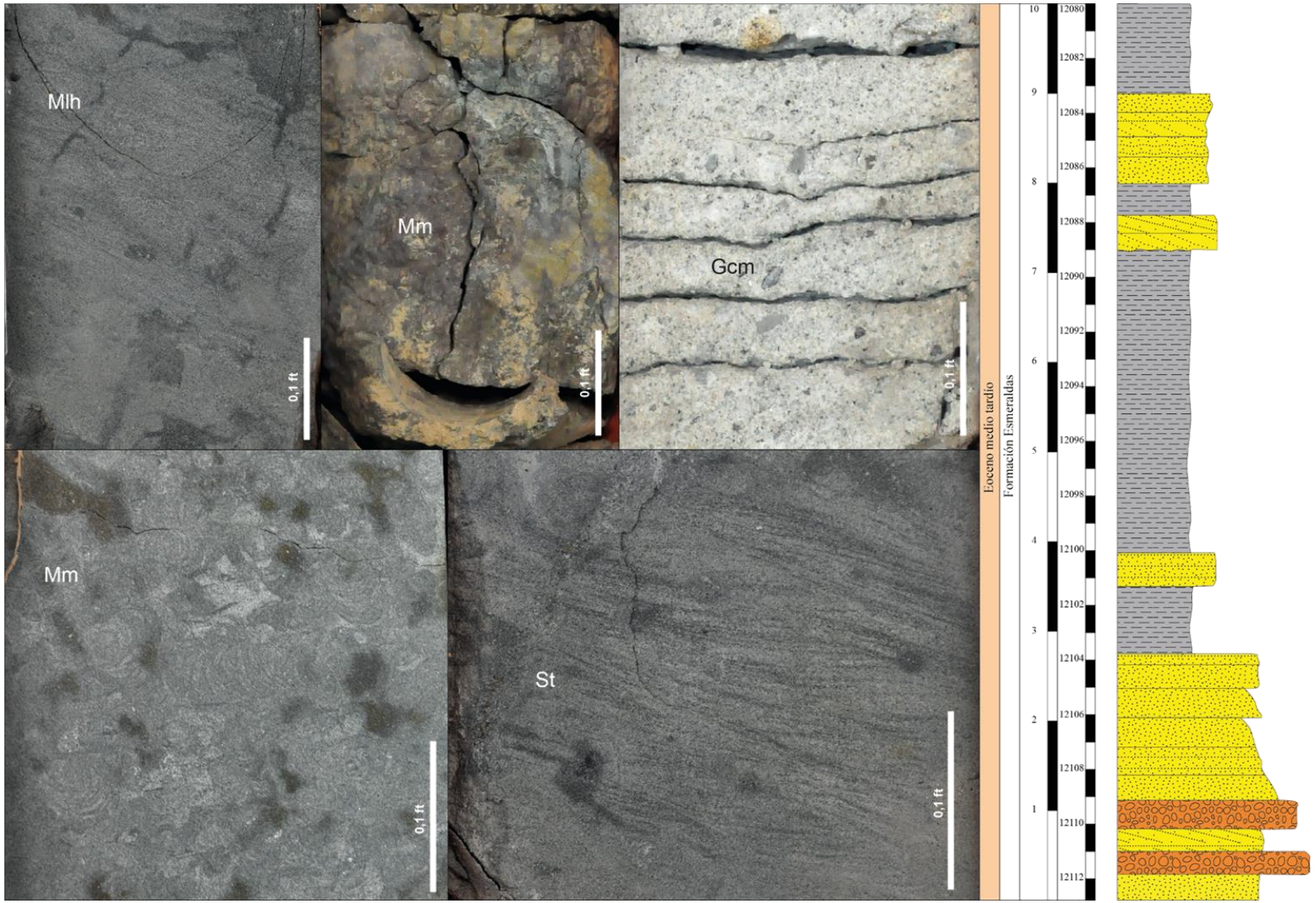


Guataquí-Piedras (San Juan de Río Seco Fm.). Reservoir

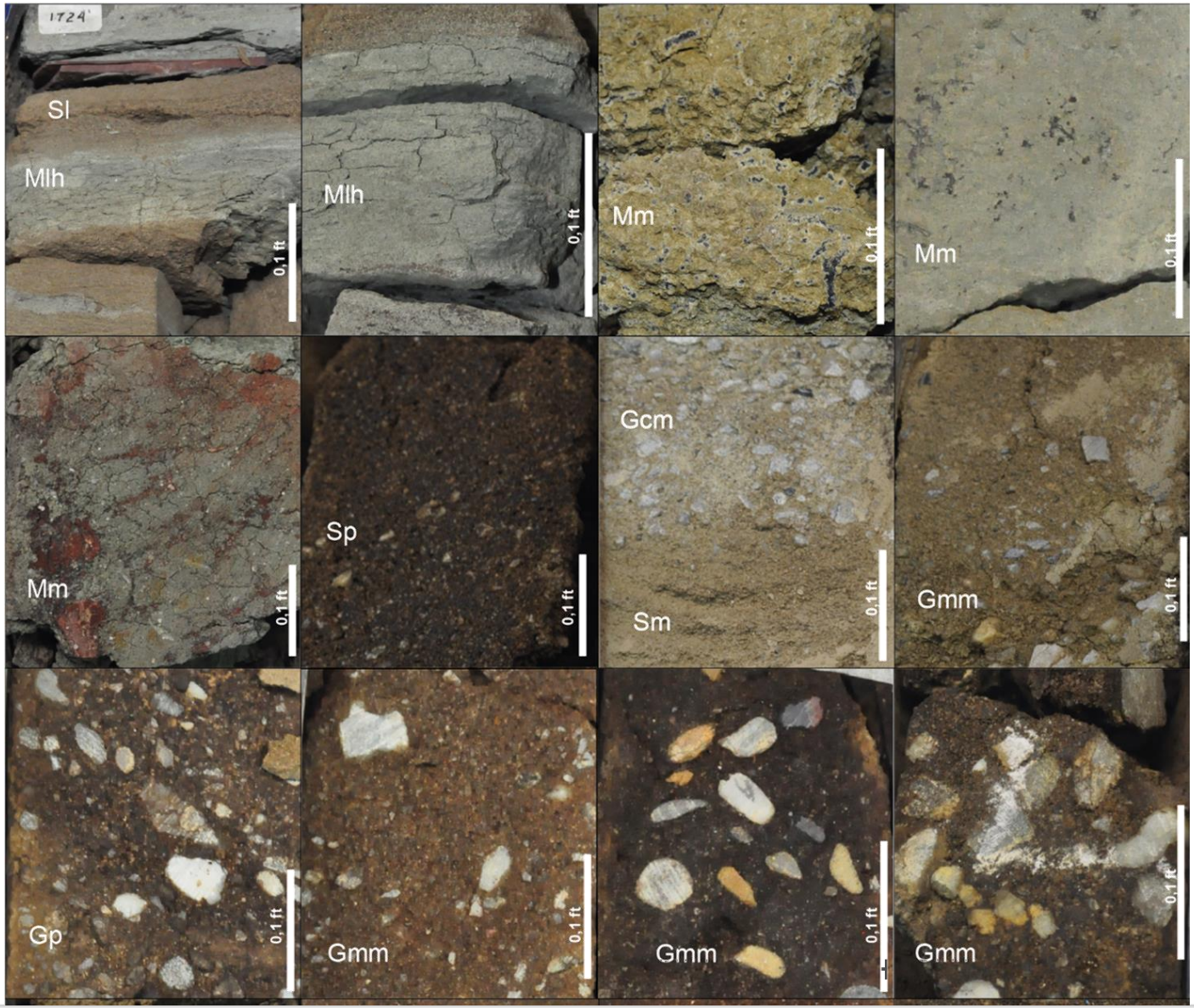
Santa Teresa Fm. (Regional seal)

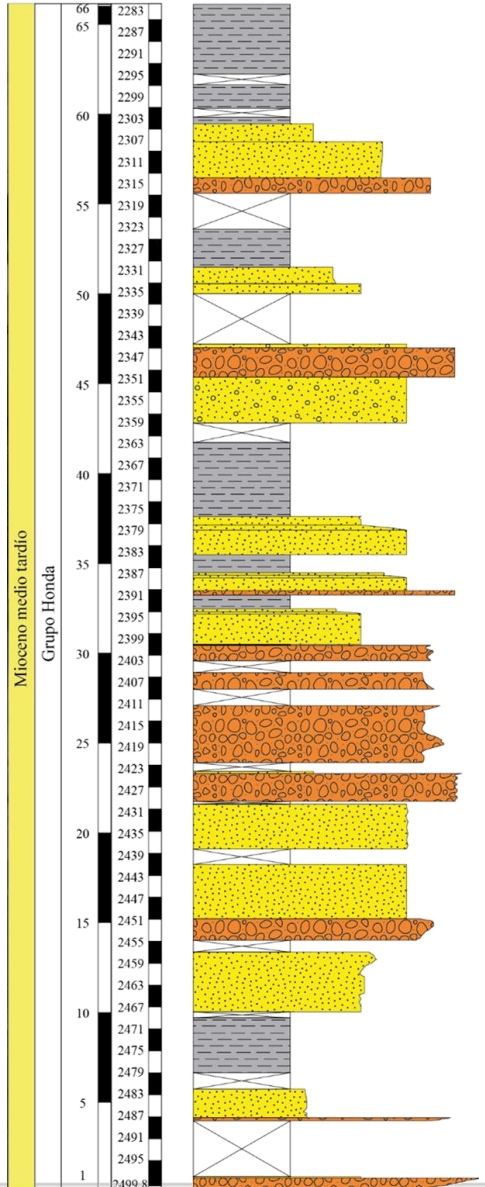


Baco-1 well. (Esmeraldas Fm.). Reservoir



Cocorná-27 well. (Honda Gp.). Reservoir





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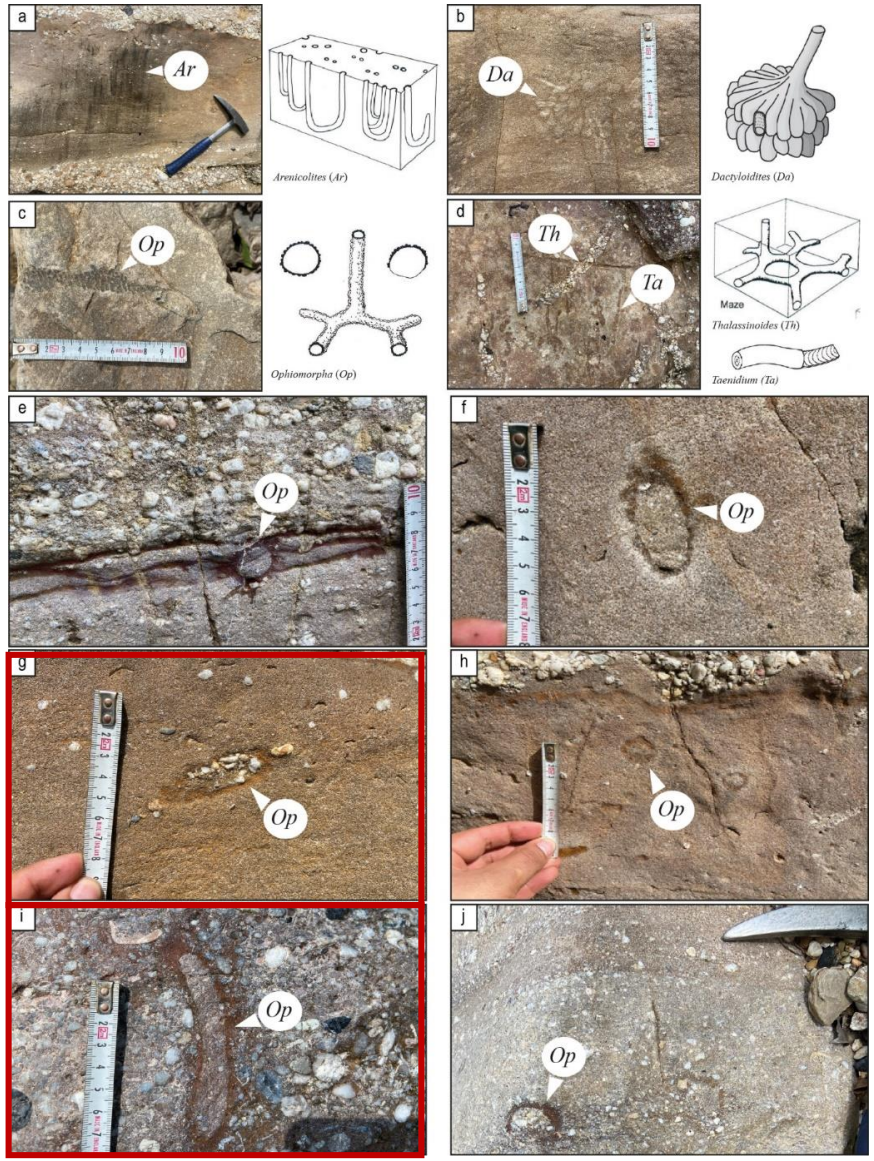
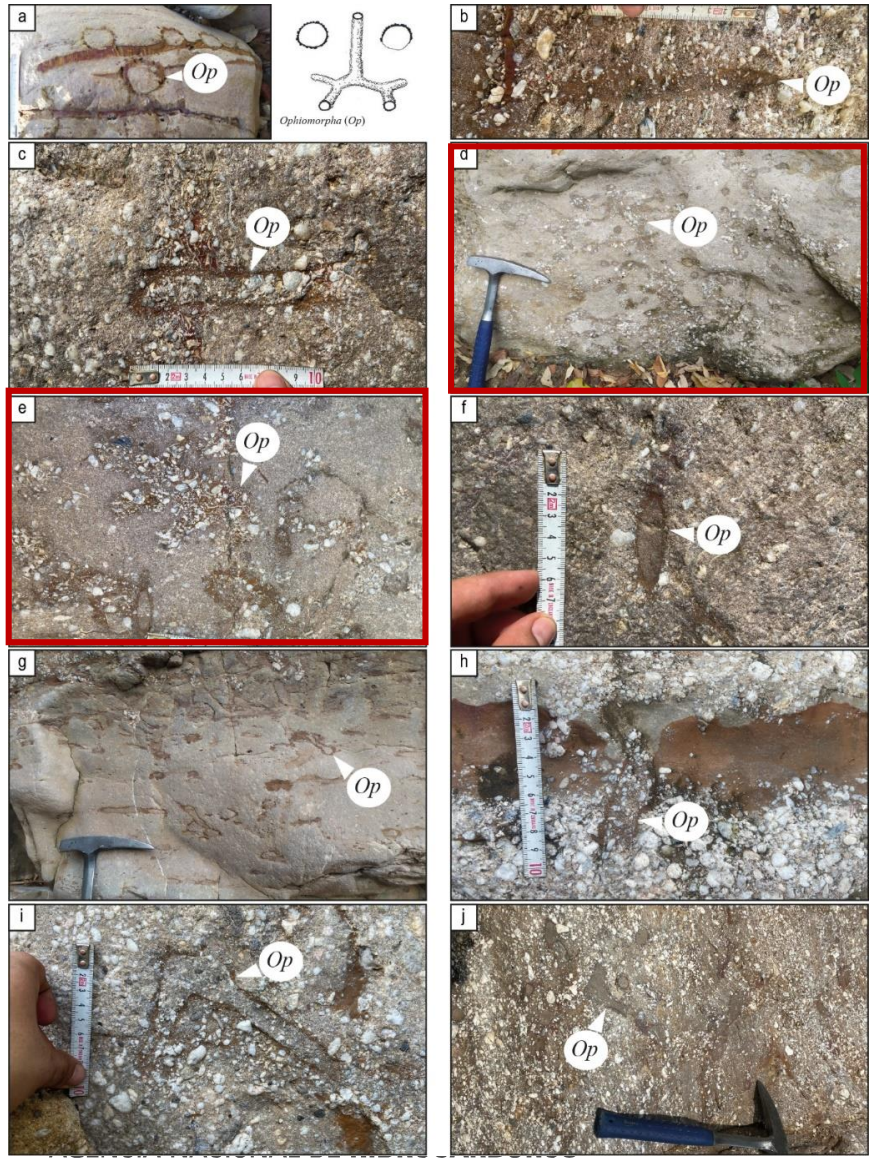
El futuro es de todos | Minenergía

Ichnology





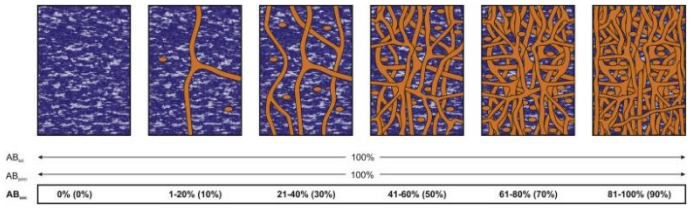
Cimarrona Fm.

Oxigenation ↑

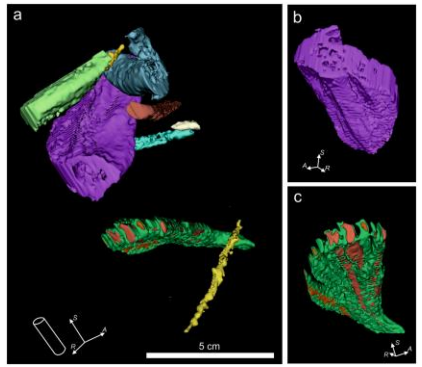
Nutrients ↓

Energy ↑

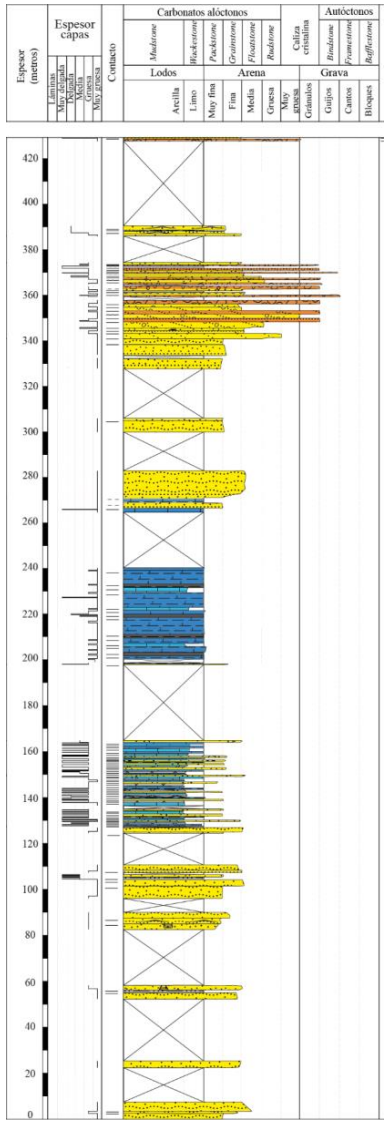
Sedimentation rate ↑

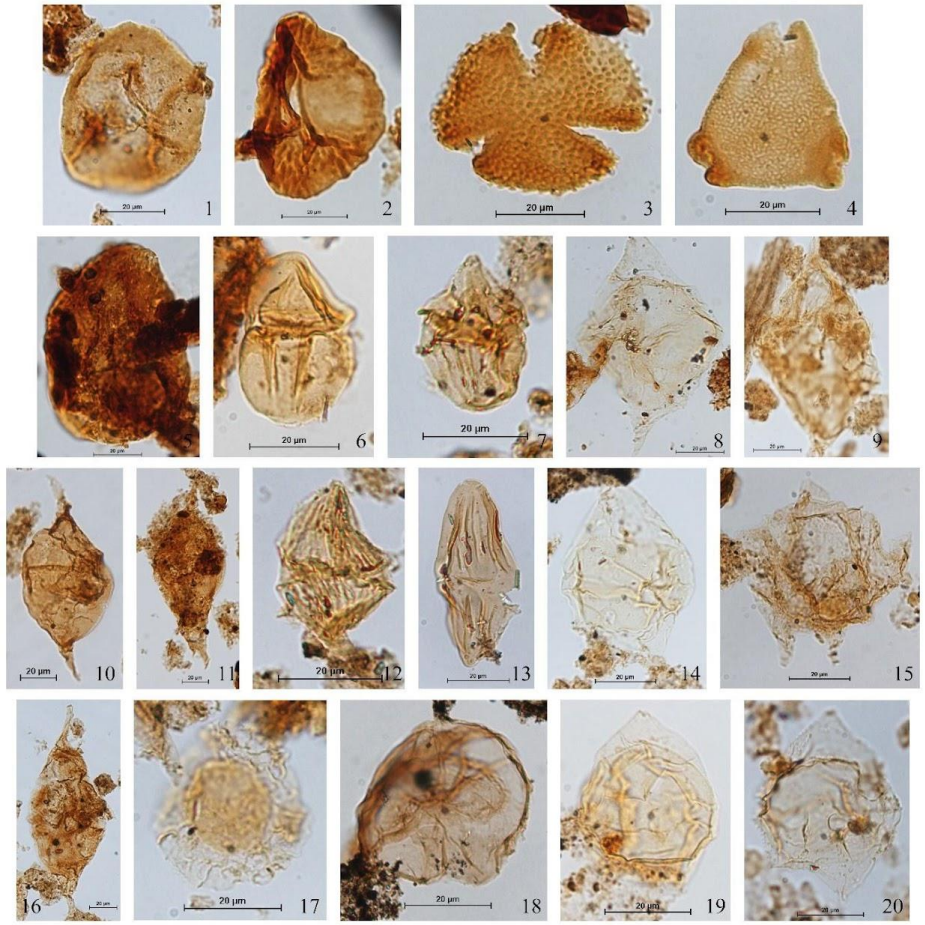


Knaust et al. (2020). *Marine and Petroleum Geology*.

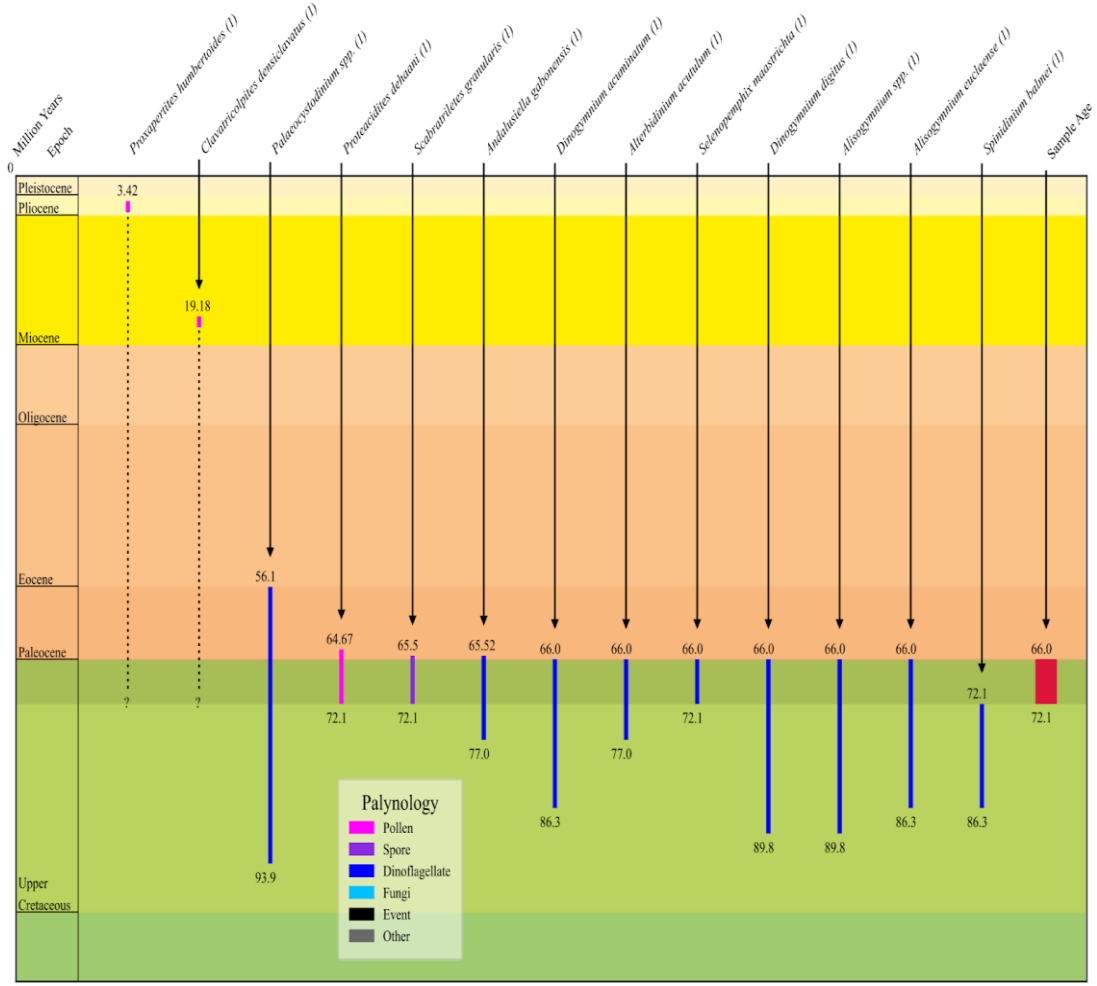


Talora creek (Palynology)





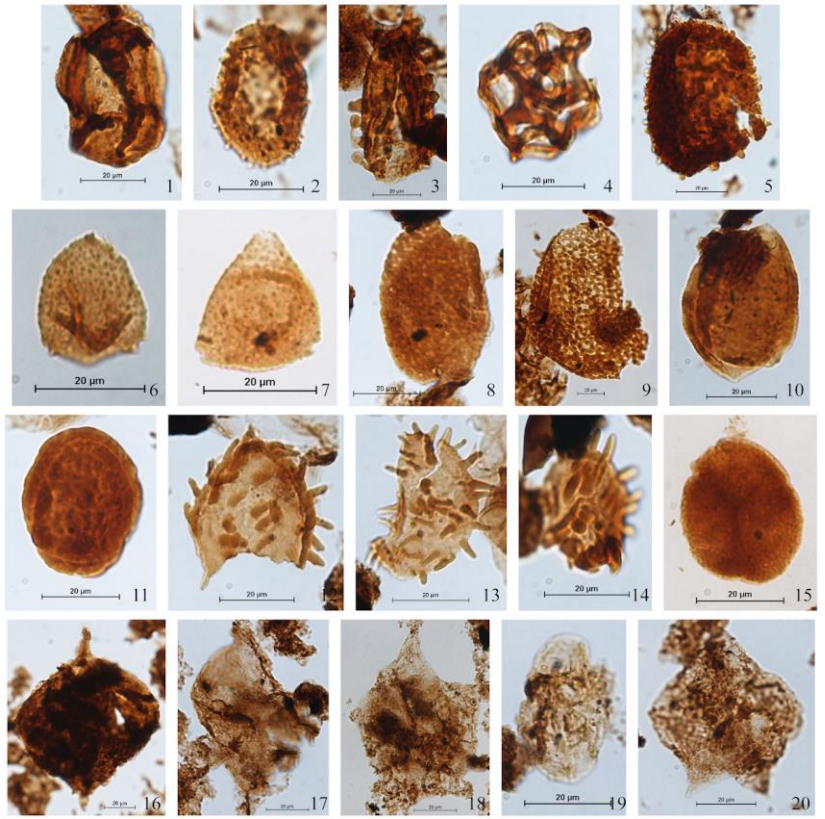
Stratigraphic distribution of selected species



CIMITARRA

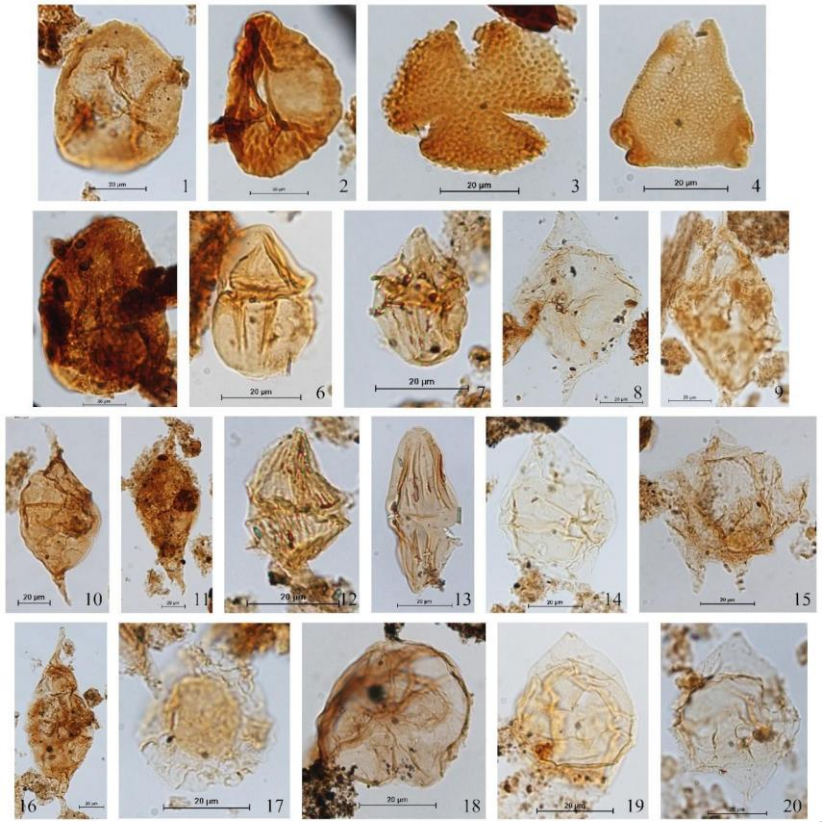
LC1 and LC2 Maastrichtian (Umir Fm.) Ro ~1.3-1.8%

HONDA-GUADUAS

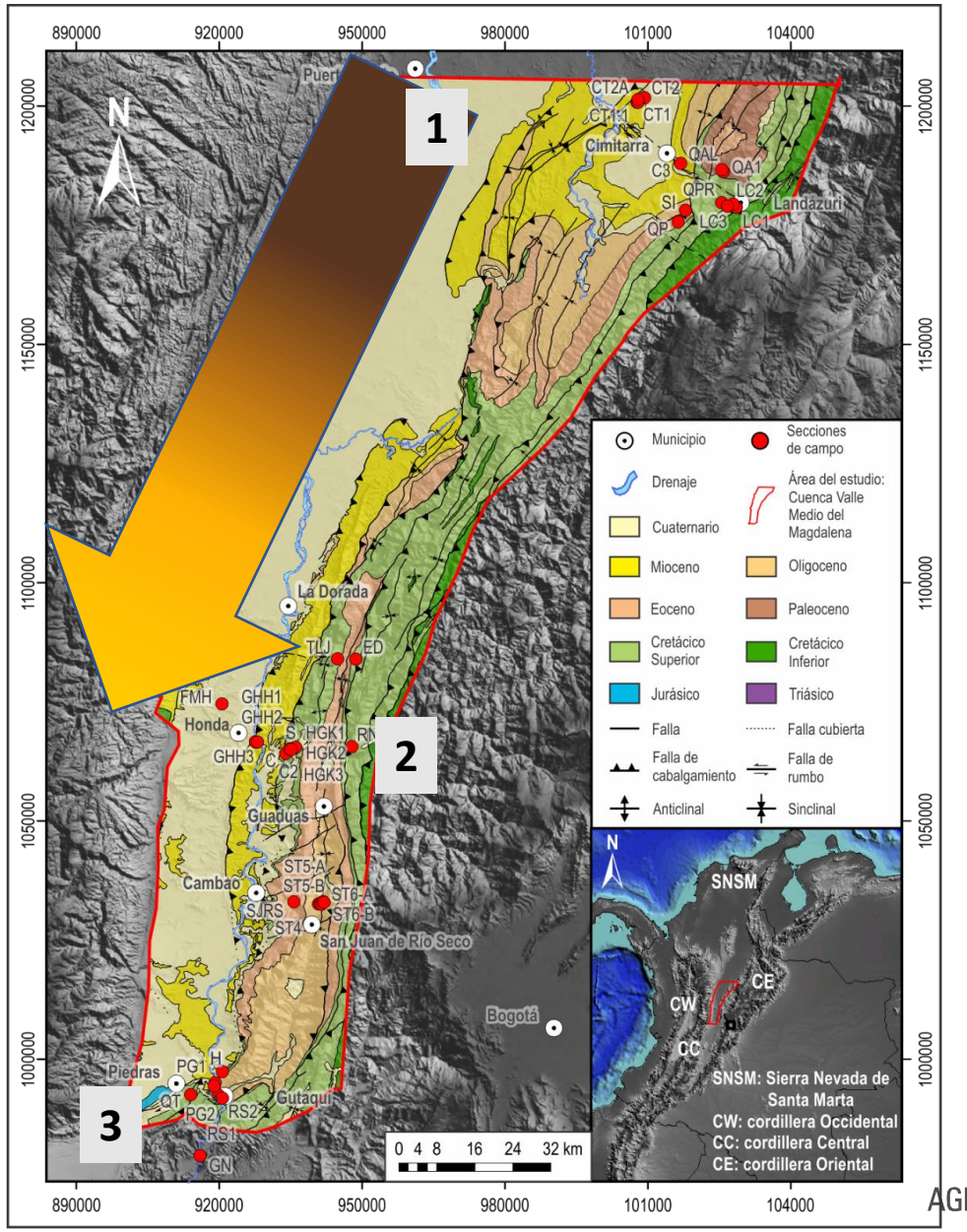


TLJ Maastrichtian (Córdoba Fm.) Ro ~0.4-0.6%

GUATAQUÍ-PIEDRAS



QT Campanian-Maastrichtian (Lidita Superior, Buscavida, La Tabla) Ro ~0.4-0.6%



1. CIMITARRA

LC1 Maastrichtian (Umir Fm.) Ro ~1.3-1.8%
LC2 Maastrichtian (Umir Fm.) Ro ~1.3-1.8%
LC3 Maastrichtian (Umir Fm.) Ro ~1.3-1.8%
QPR Maastrichtian (La Luna-Umir fms.) Ro ~1.0-1.3%
QA1 Maastrichtian (Umir Fm.) Ro ~0.8-1.2%
QAL Paleocene (Lisama Fm.) Ro ~ 0.8-1.2%

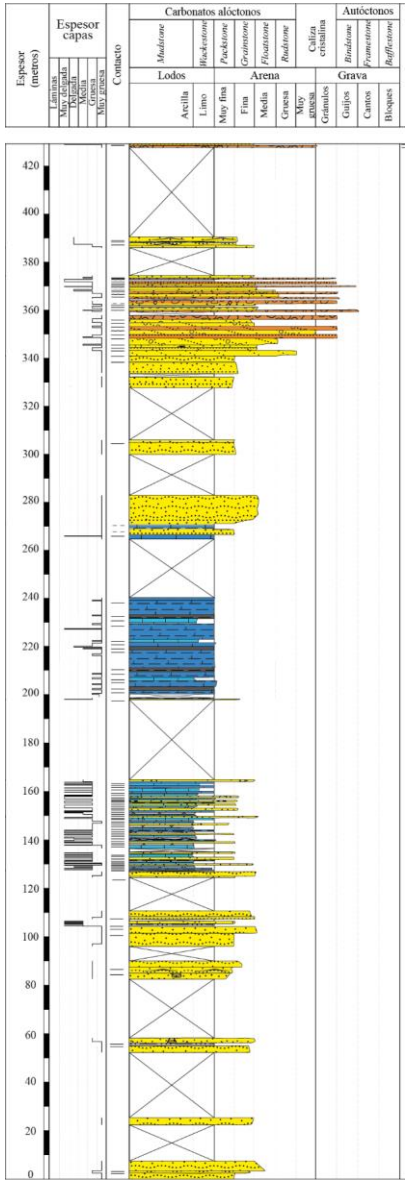
2. HONDA-GUADUAS

RN Coniacian-Maastrichtian? (Olini Gp.) Ro ~0.8-1.2%
TLJ Maastrichtian (Córdoba Fm.) Ro ~0.4-0.6%
HGK Maastrichtian (Umir) Ro ~0.4-0.6%

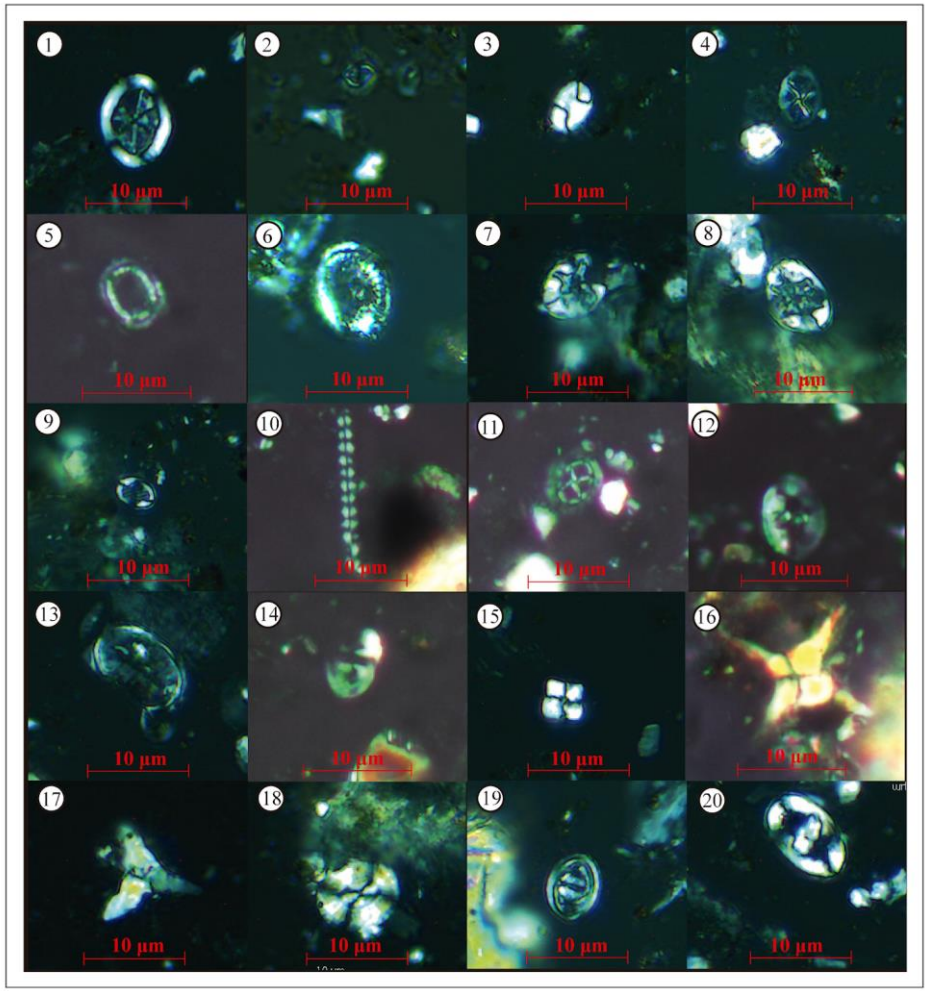
3. GUATAQUÍ-PIEDRAS

QT Campanian-Maastrichtian (Lidita Superior, Buscavida, La Tabla fms.) Ro ~0.4-0.6%

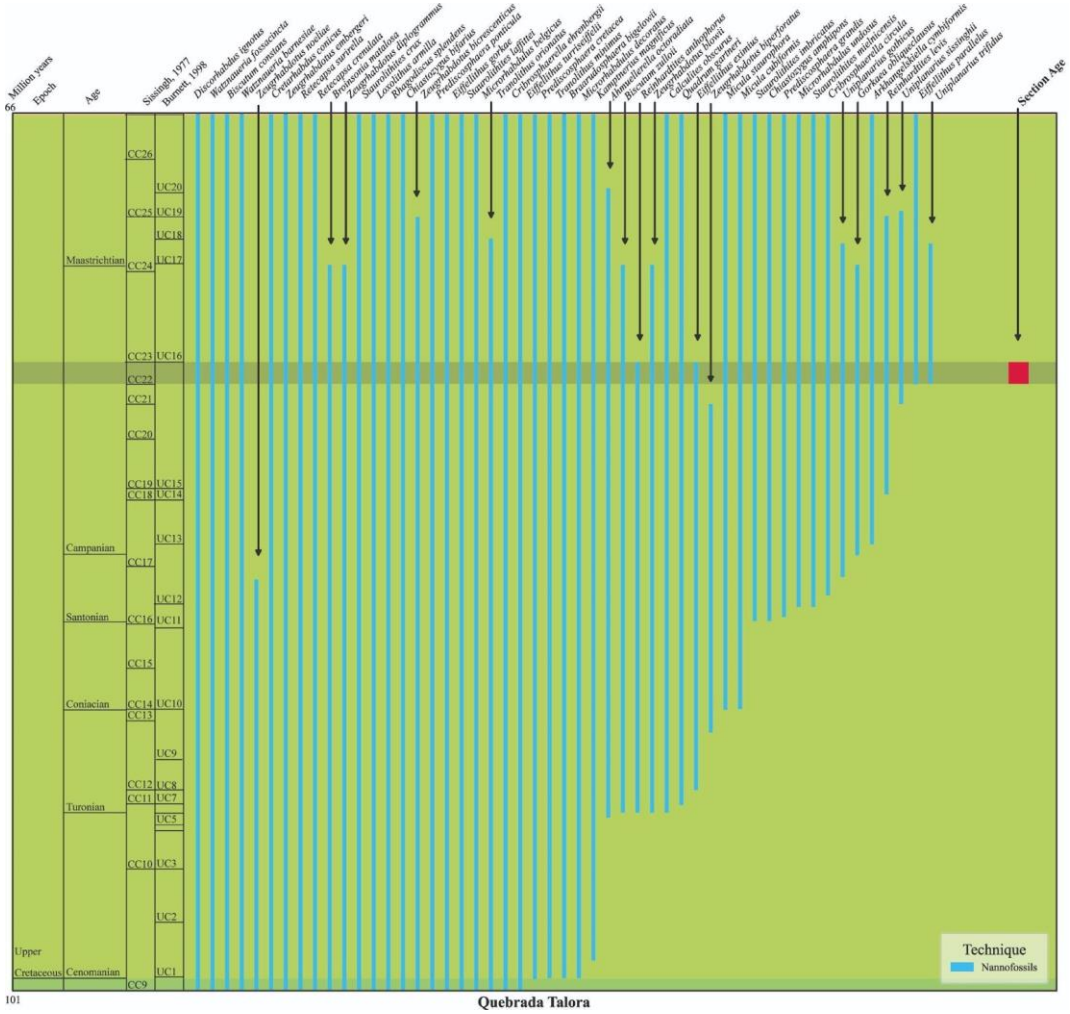
TAI Color

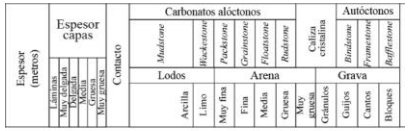


Talora creek (calcareous nanofossils)

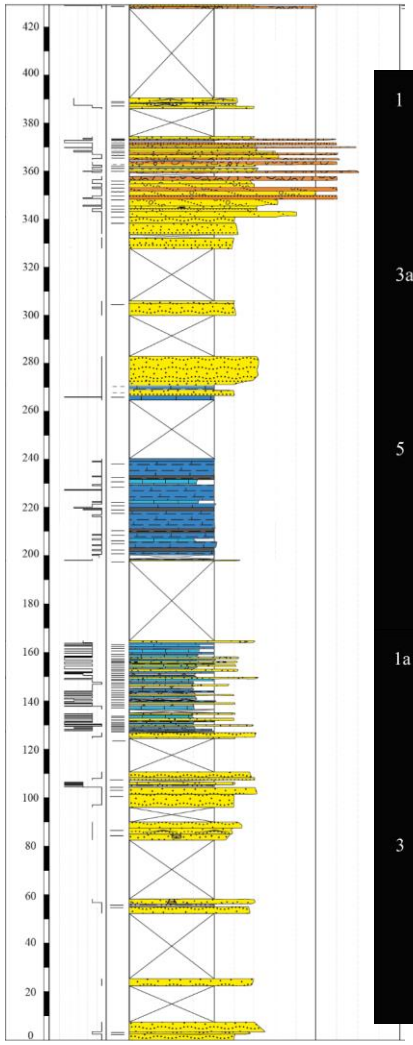


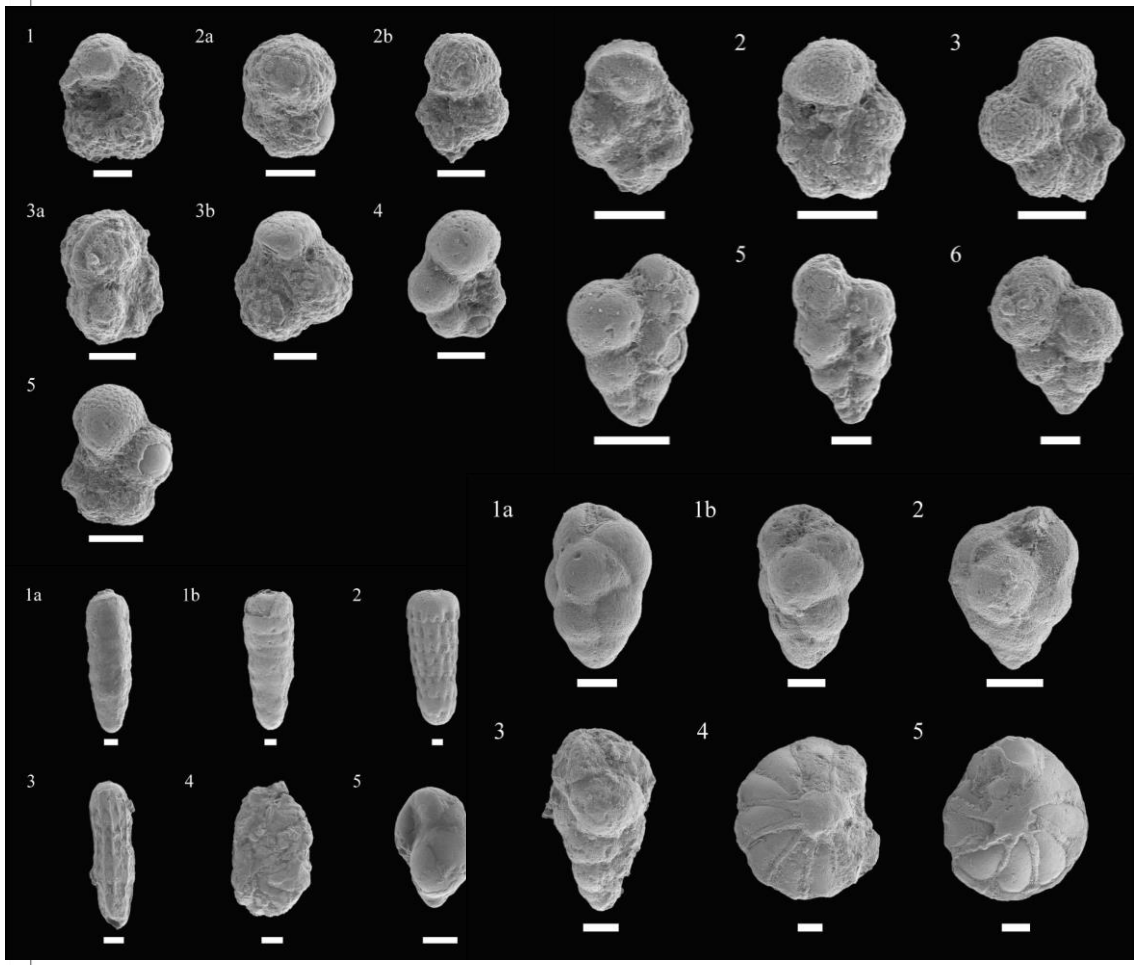
Stratigraphic distribution of selected species



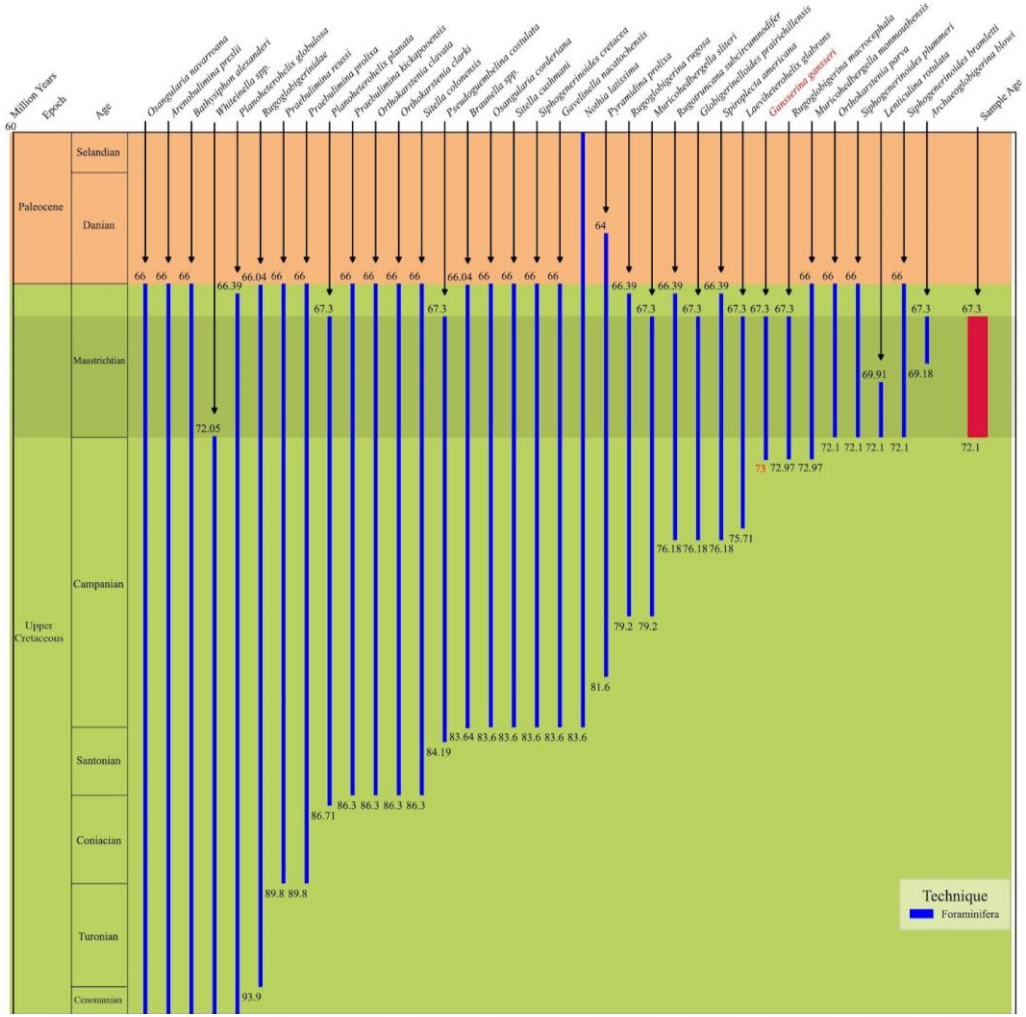


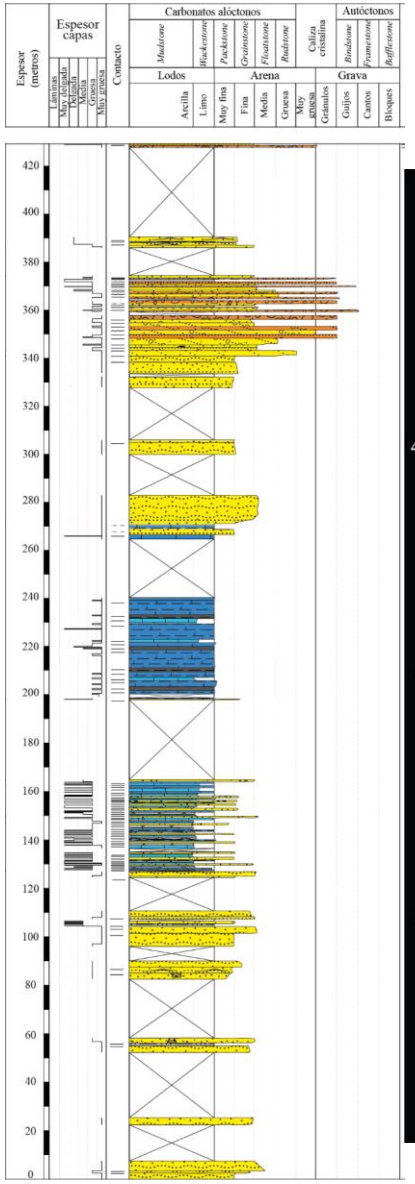
Talora creek (Foraminifers)



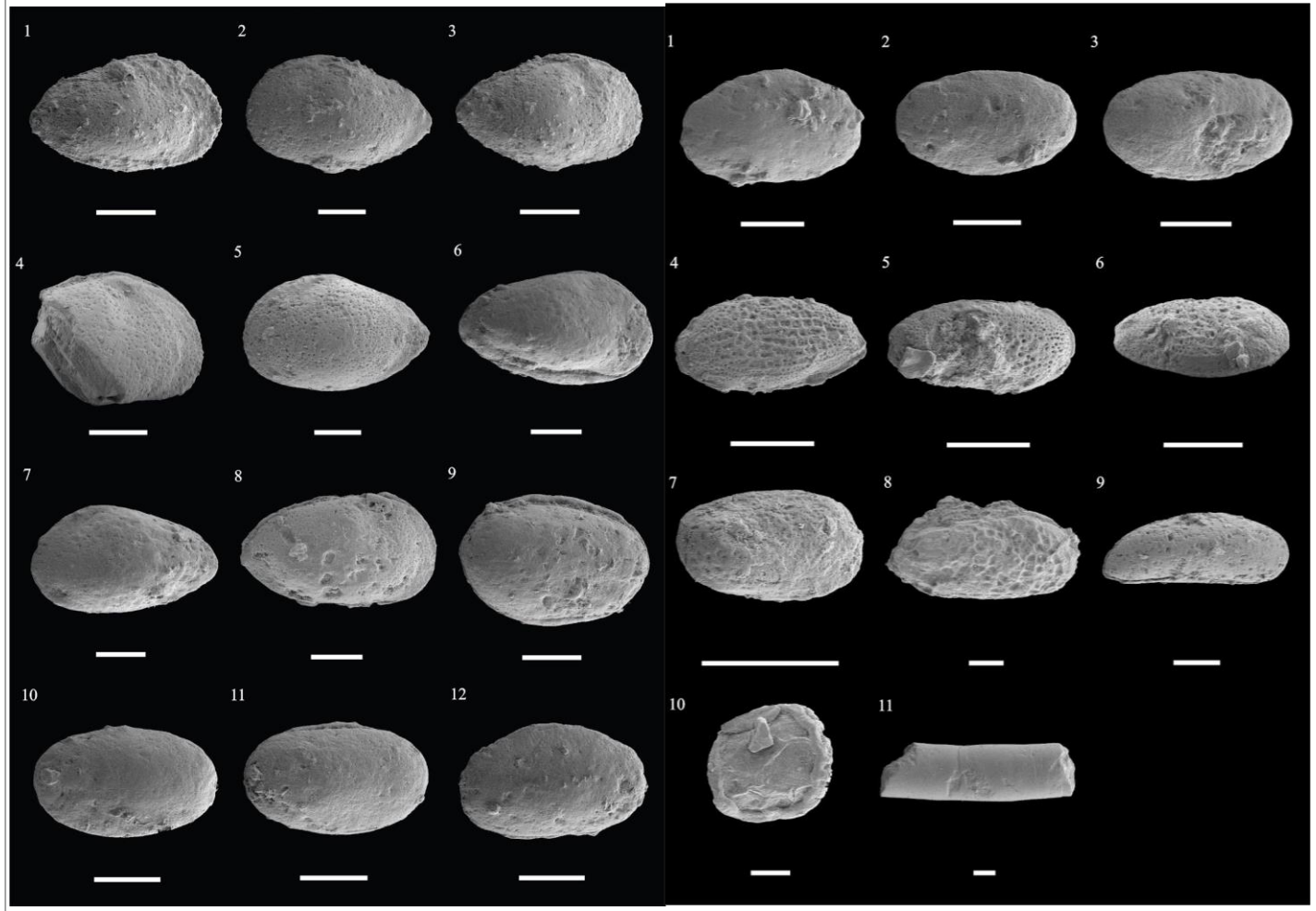


Stratigraphic distribution of selected species

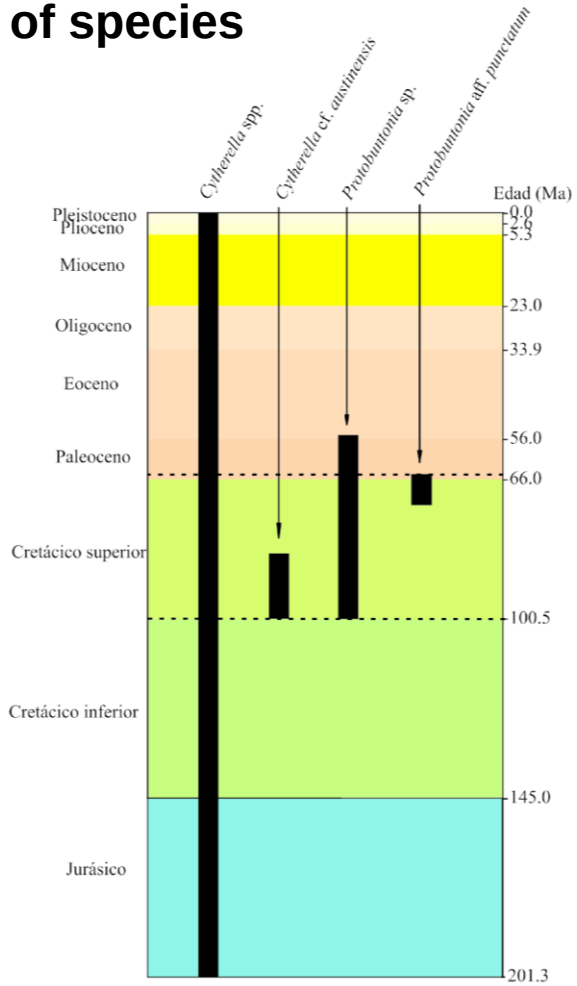




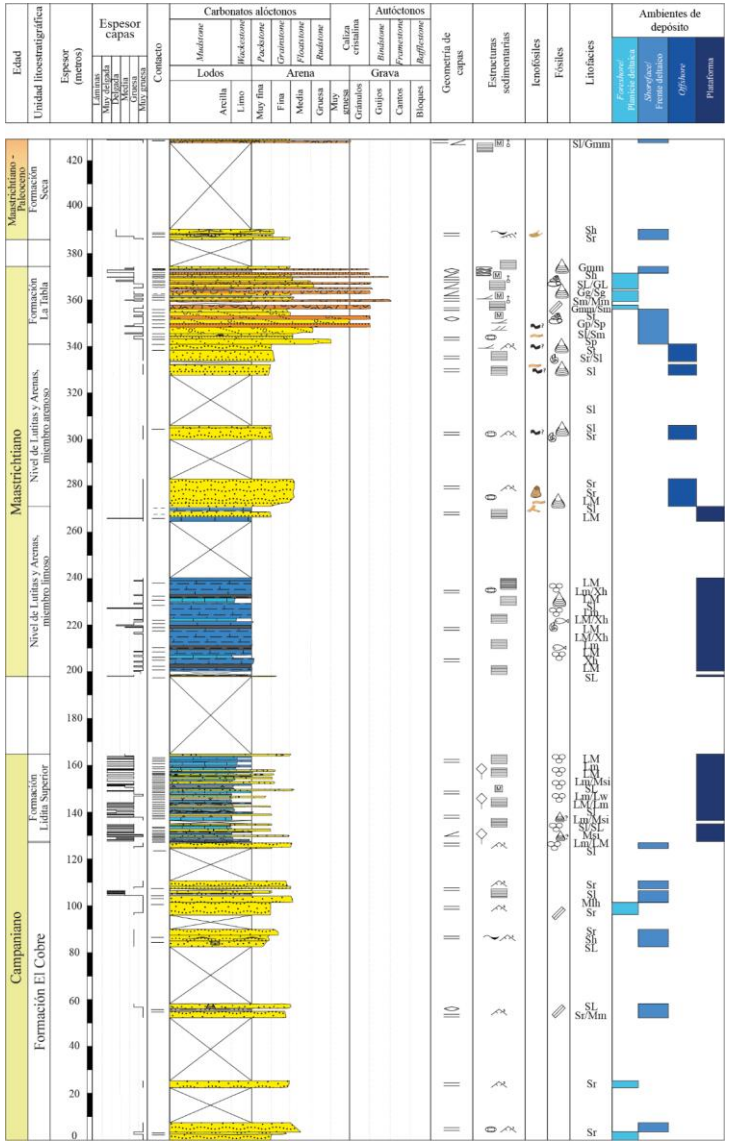
Talora creek (ostracods)

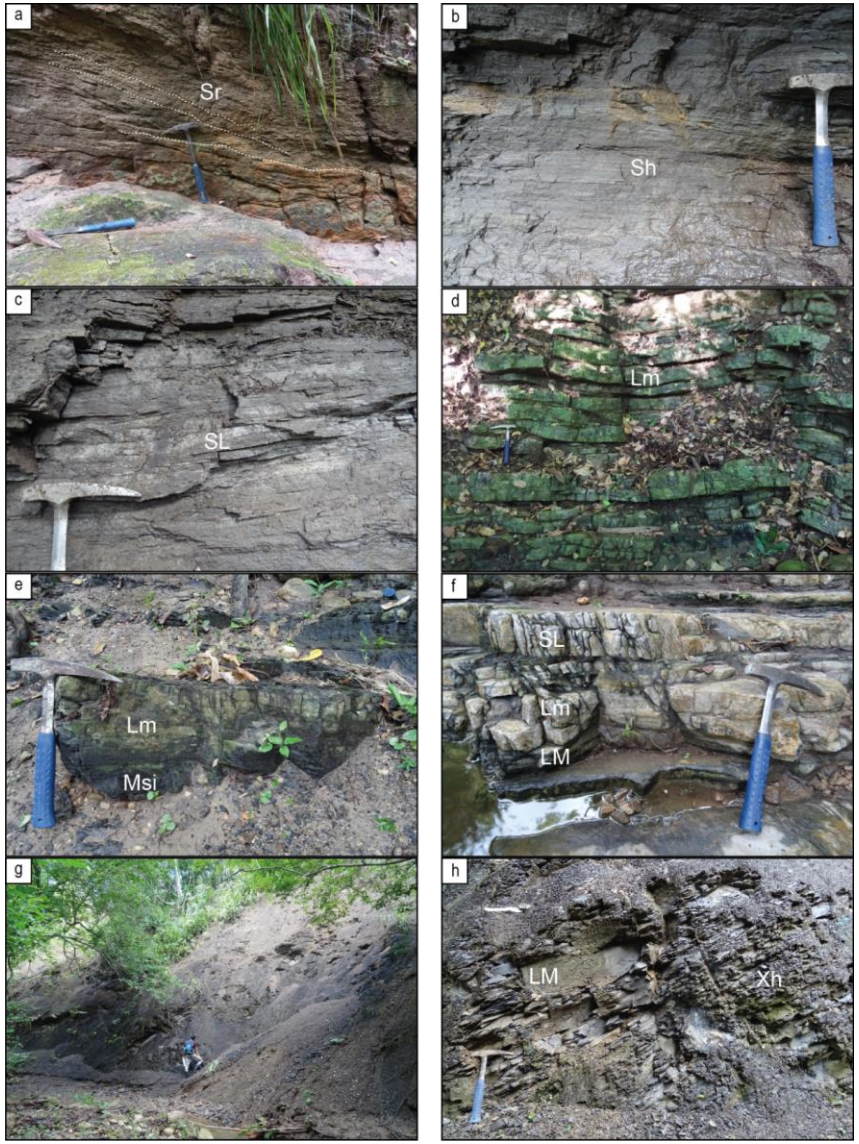


Stratigraphic distribution of species

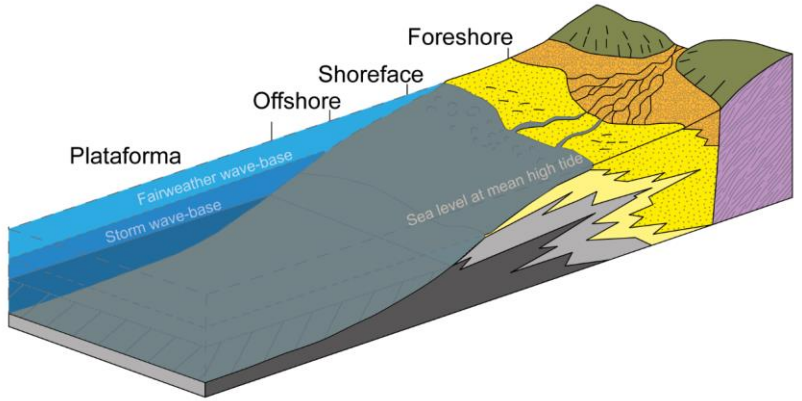


Facies (Talora creek)

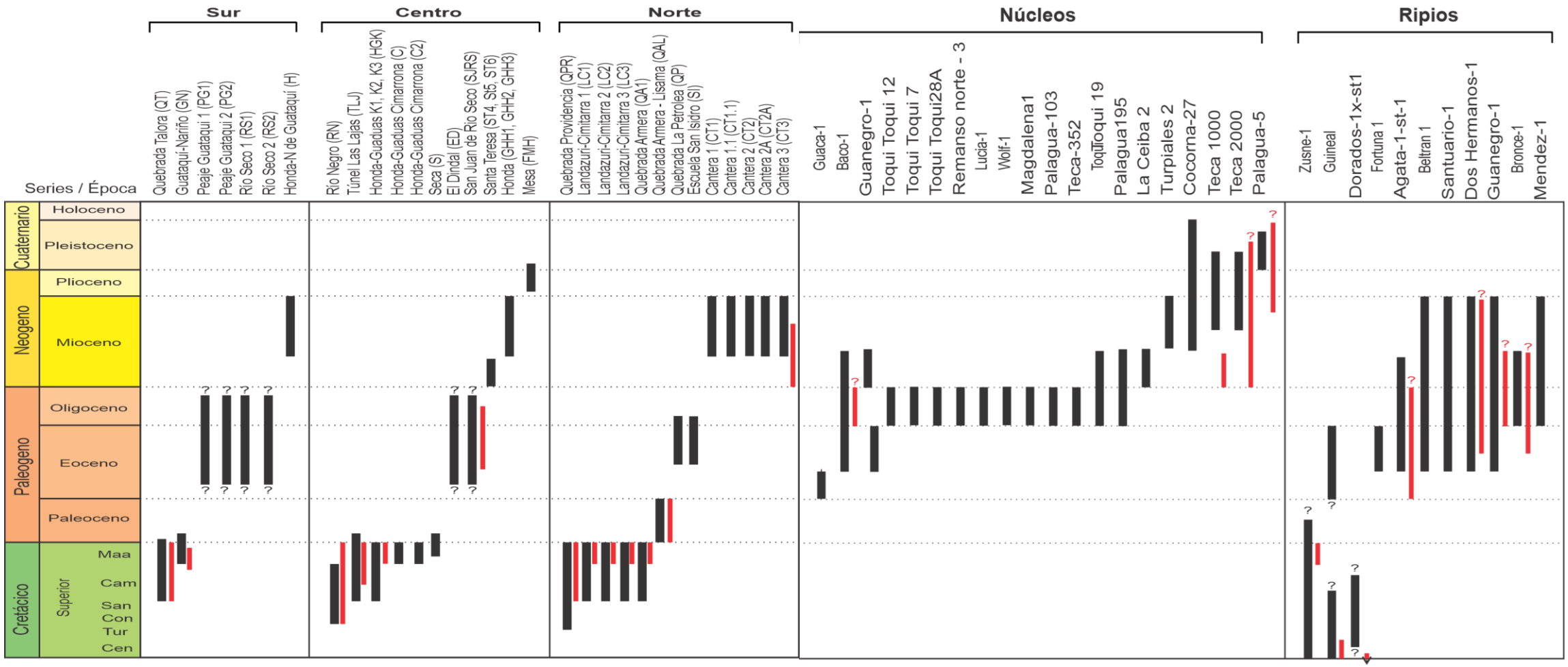




Paleoenvironmental interpretation



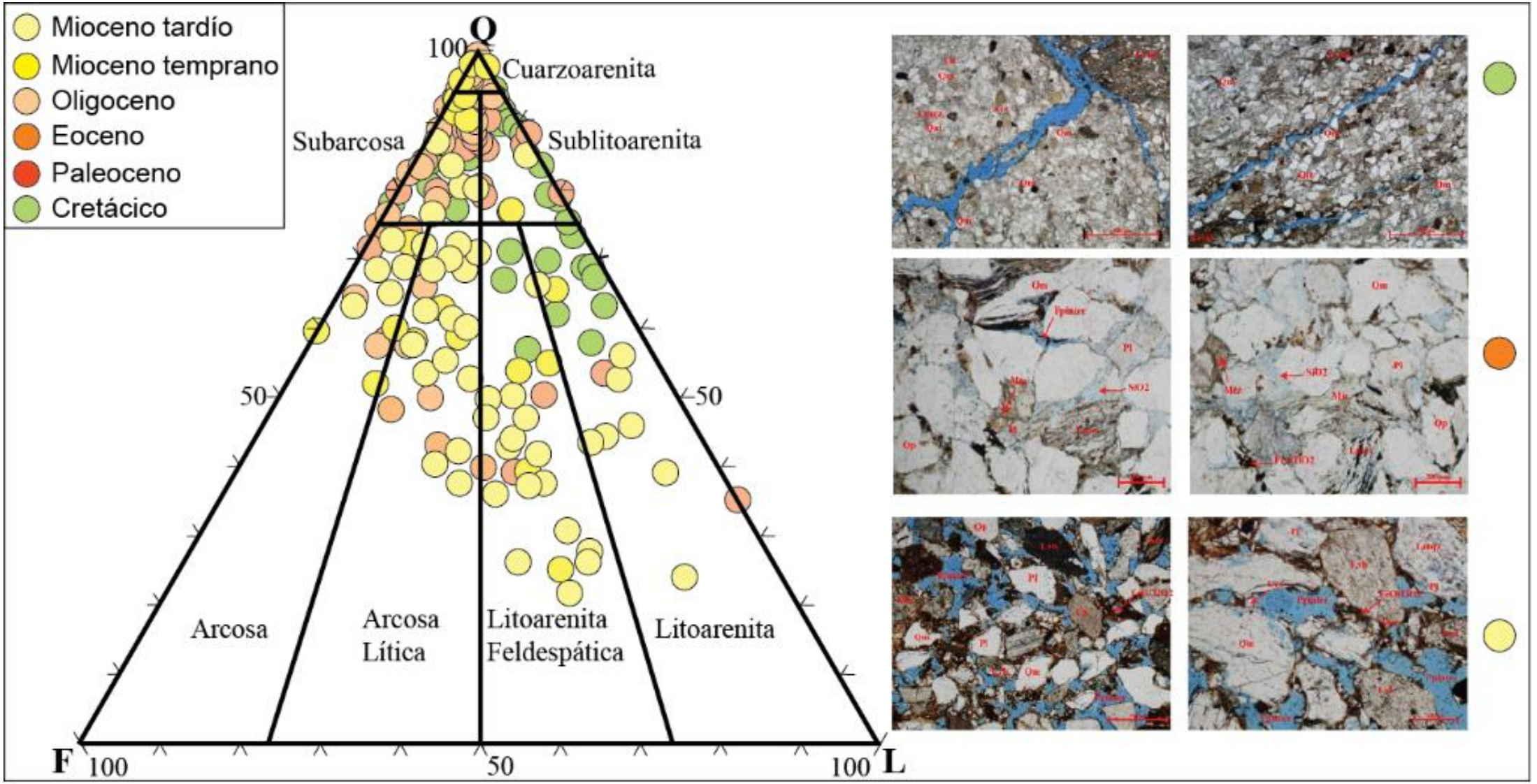
Micropaleontology (biostratigraphy)



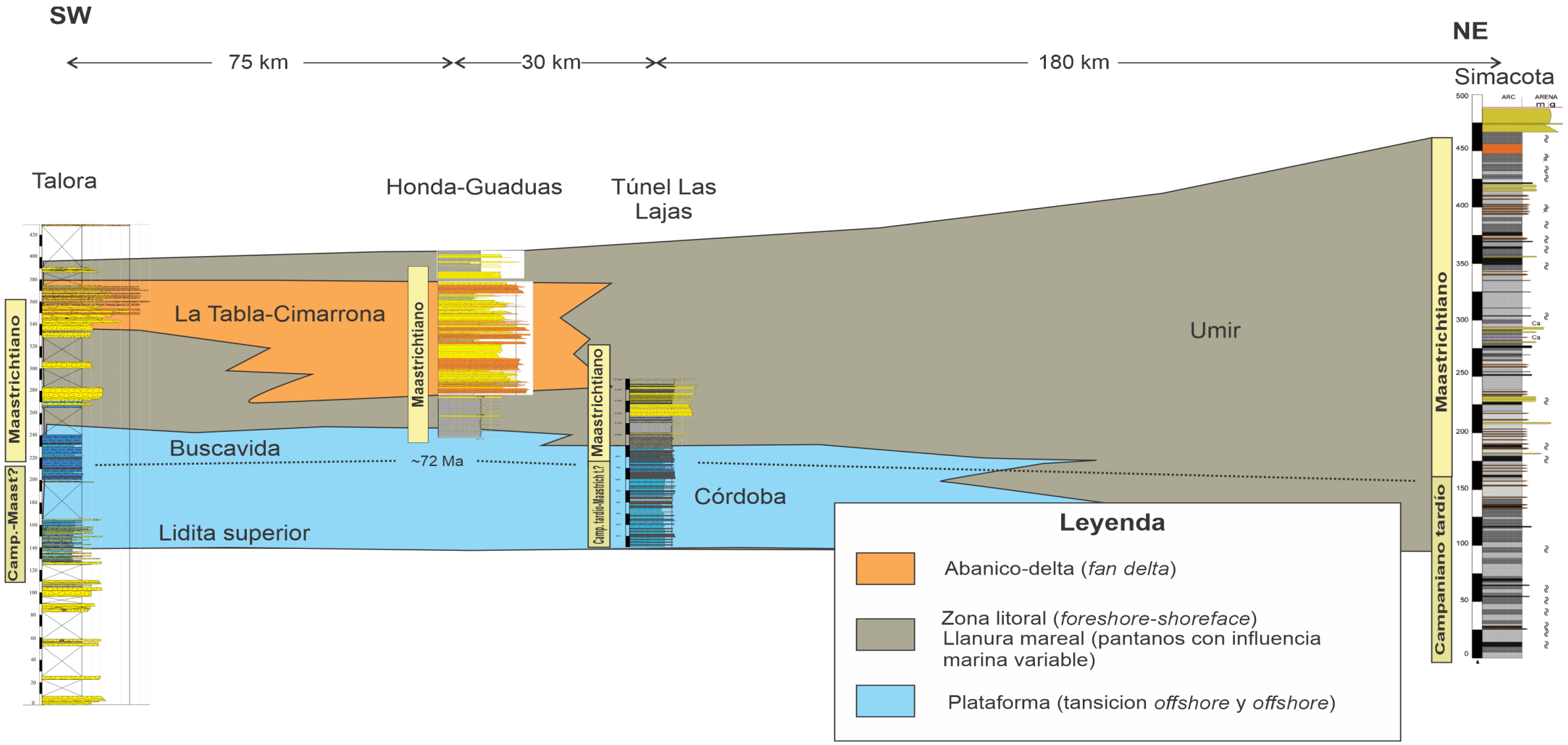
Edades reportadas en la literatura

Edades obtenidas en este proyecto

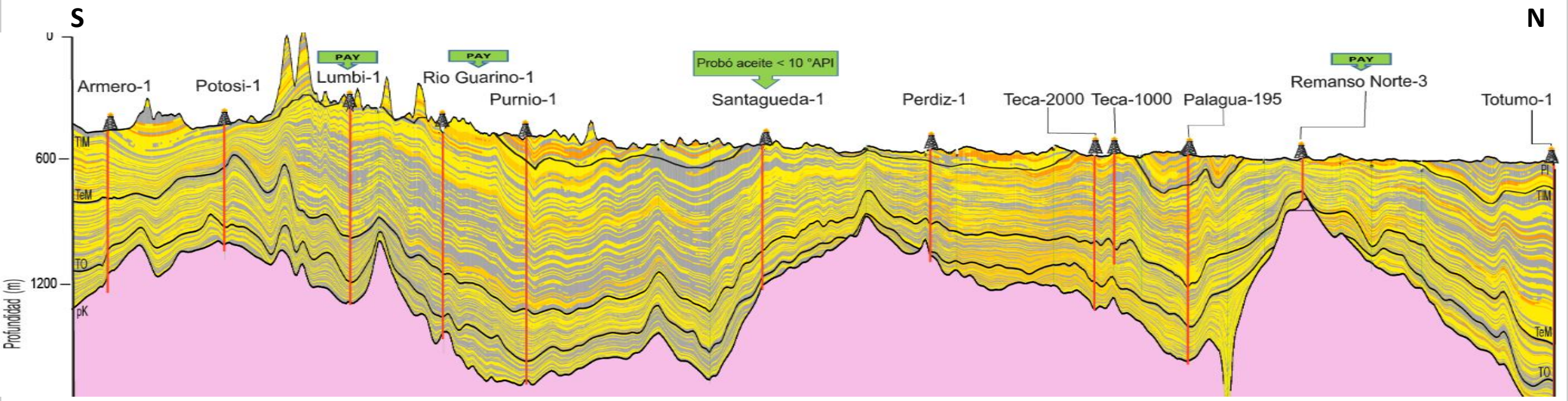
Sandstone petrography



Regional stratigraphic correlations



Regional stratigraphic correlations



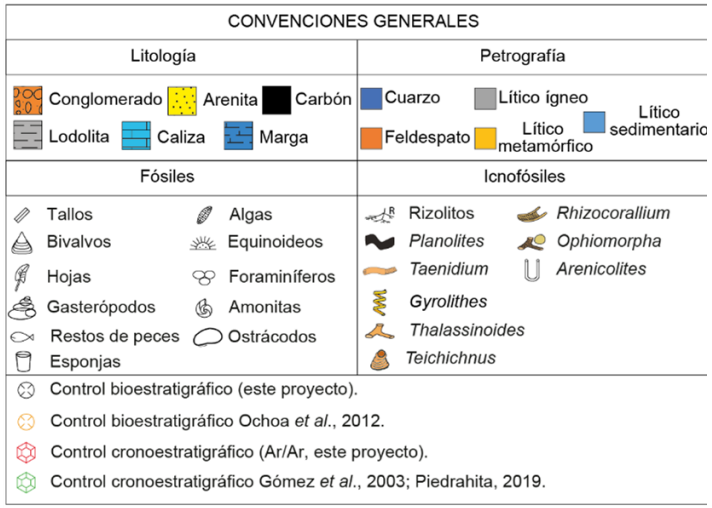
Economic basement

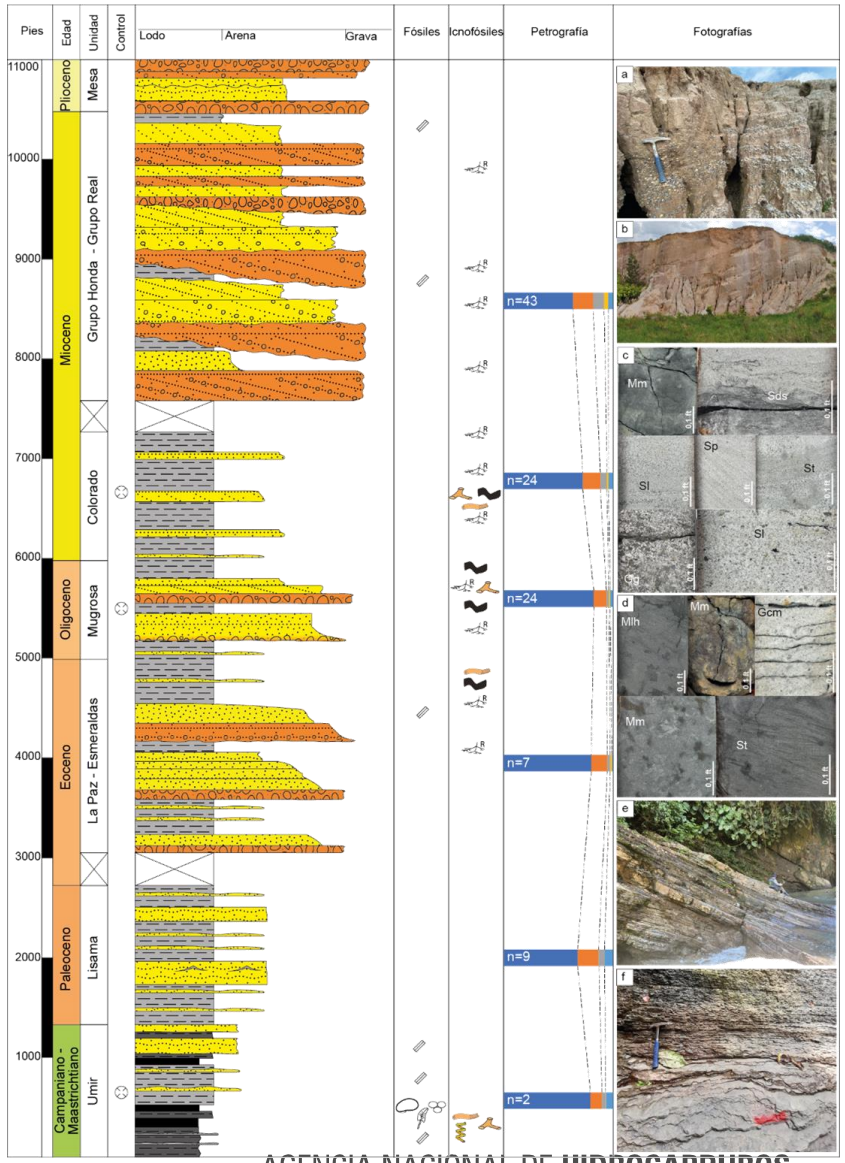
Mudstones

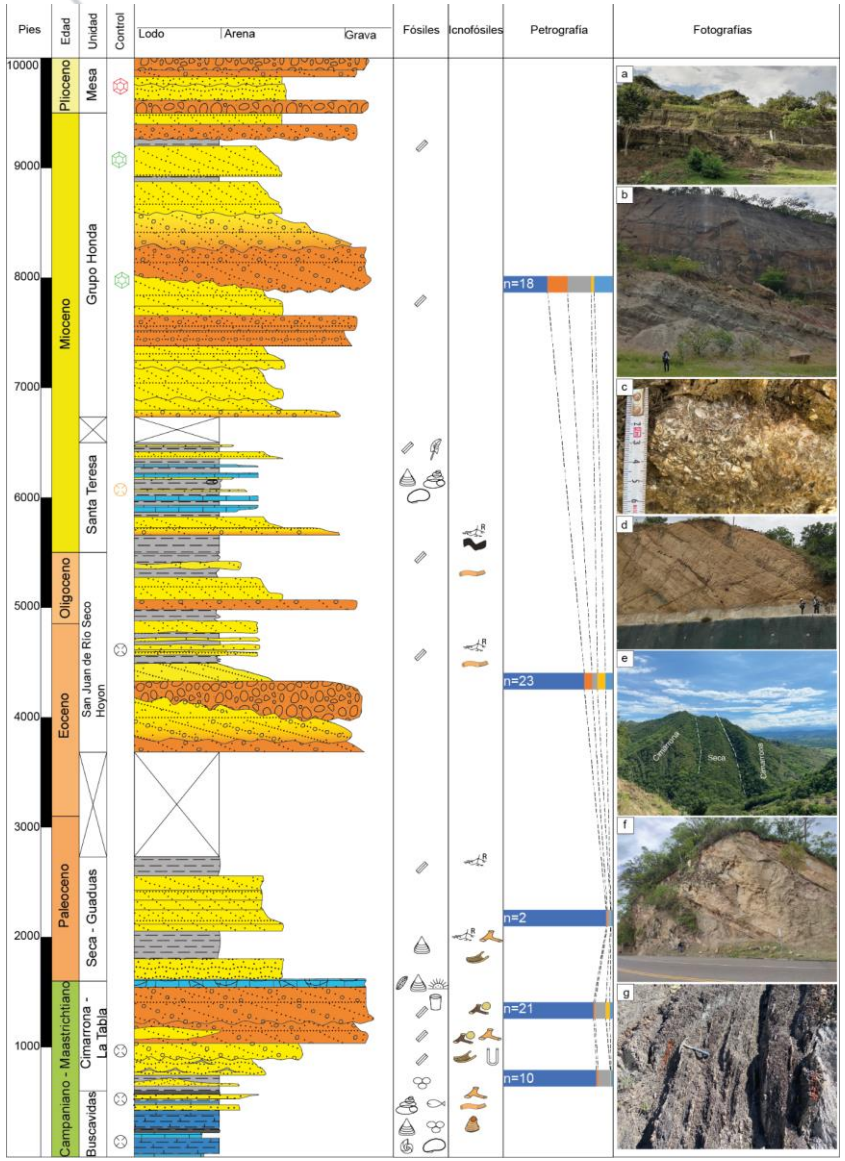
Sandstones

Conglomerates

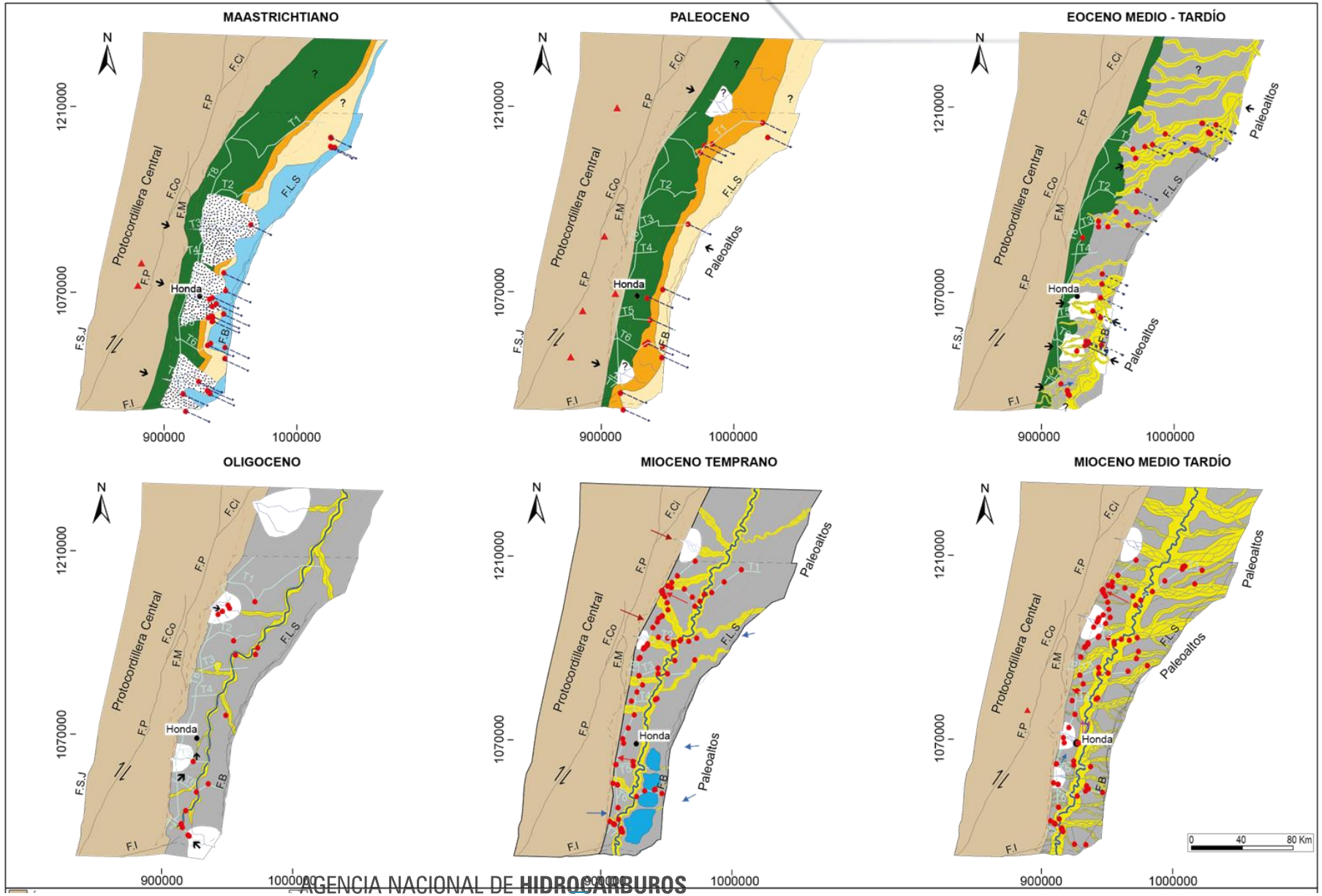
General stratigraphy (north-south)

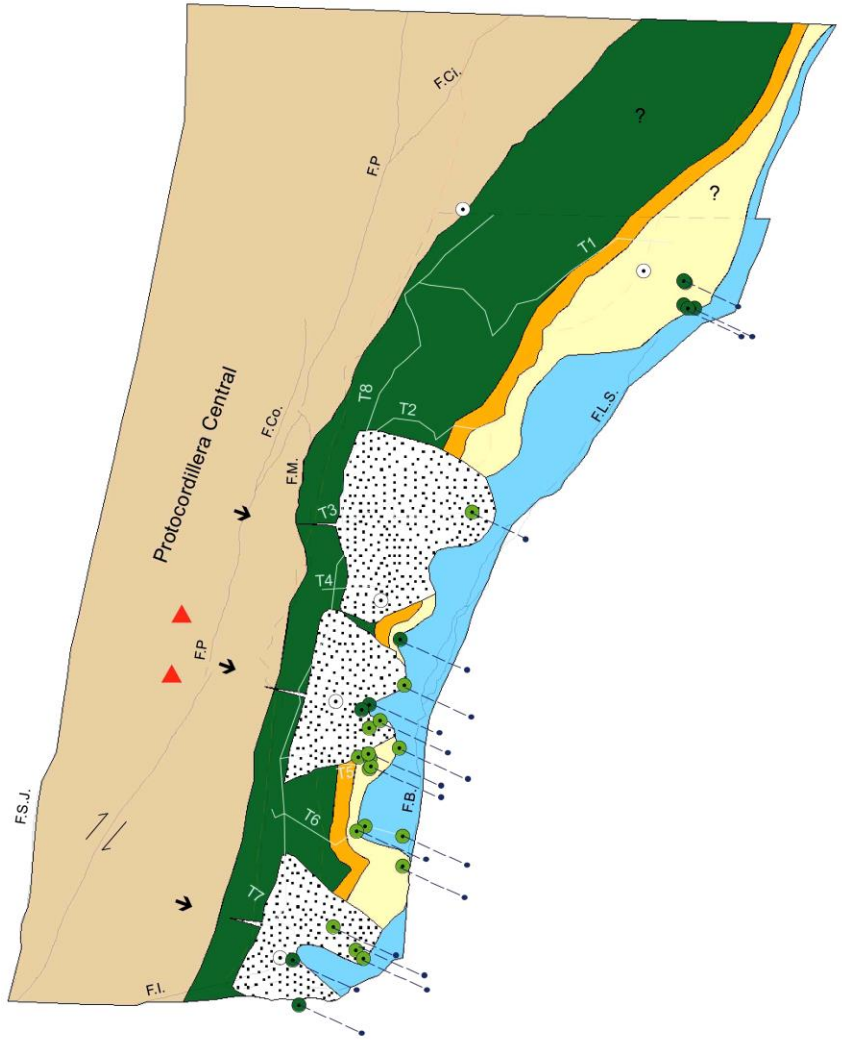




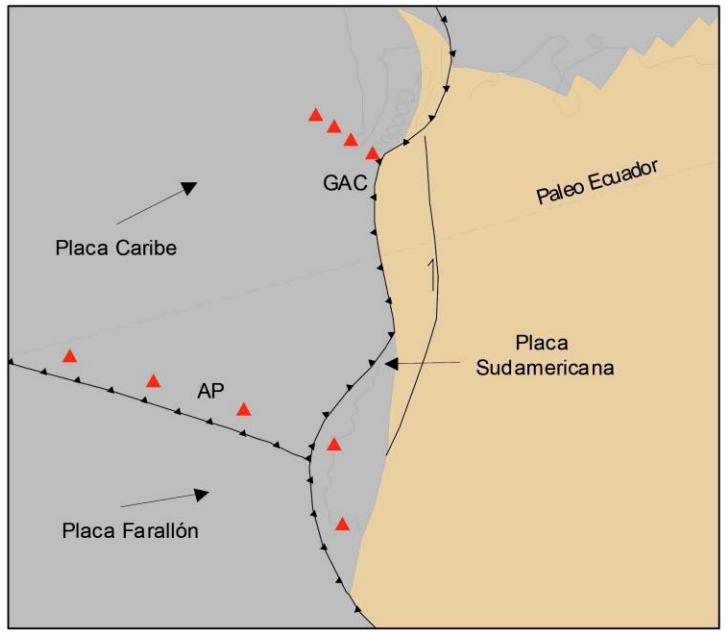


Paleogeographic maps (Maastrichtian-Miocene)





Maastrichtiano



Conventions

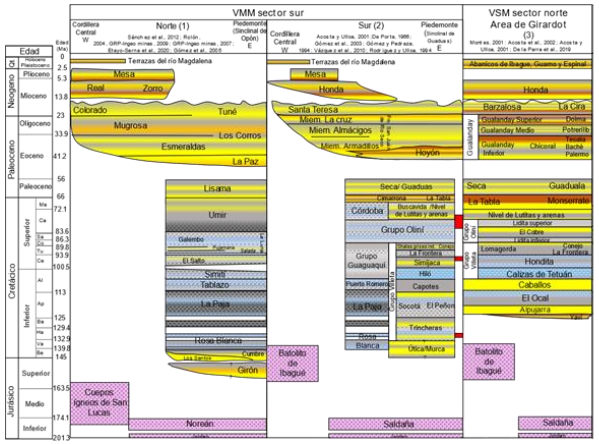
- Marino (plataforma)
- Coastal (bs, fs, sf)
- Lake
- Continental (alluvial)
- Fan delta
- Cretaceous sedimentary rocks
- Igneous-metamorphic (basement)

Seismic Interpretation

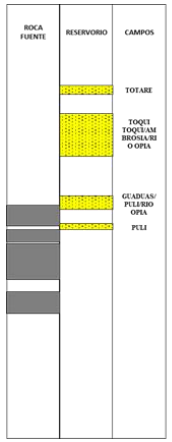
- It is a regional work where an appropriate structural model was used that allowed the continuous interpretation of horizons and the correlation of faults with a regional character.
- The surface and subsurface stratigraphic information obtained by the other project teams was integrated to the interpretation.
- The interpretation and mooring was carried out with 2D seismic information where priority was given to seismic events with regional continuity.
- The nomenclature used in the interpretation project (horizons / formation tops) follows the recommendations of the ANH.
- The generated maps are the main input to determine the trap geometry of the prospectivity fairways.

Seismic Interpretation

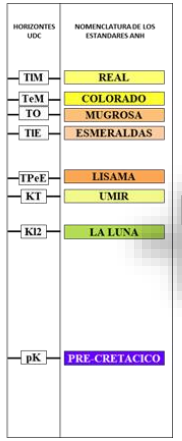
CHORNOSTRATIGRAPHIC CHART



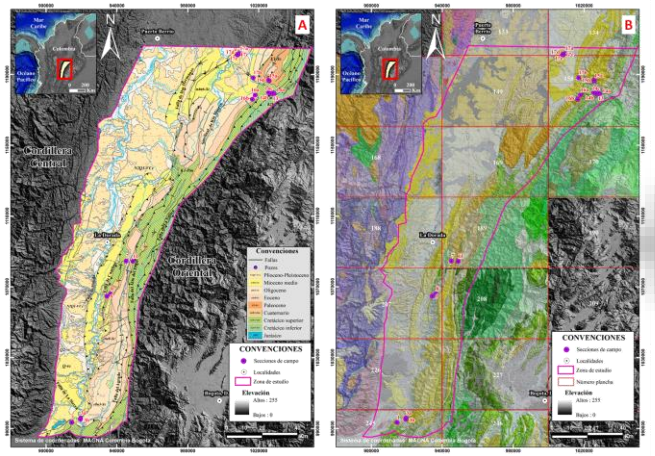
PETROLEUM SYSTEMS



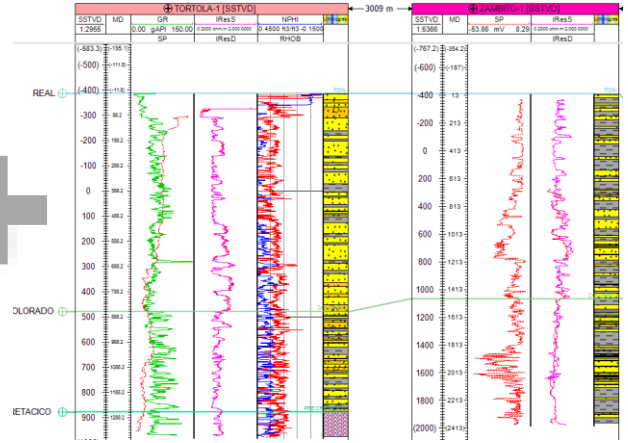
ANH NOMENCLATURE



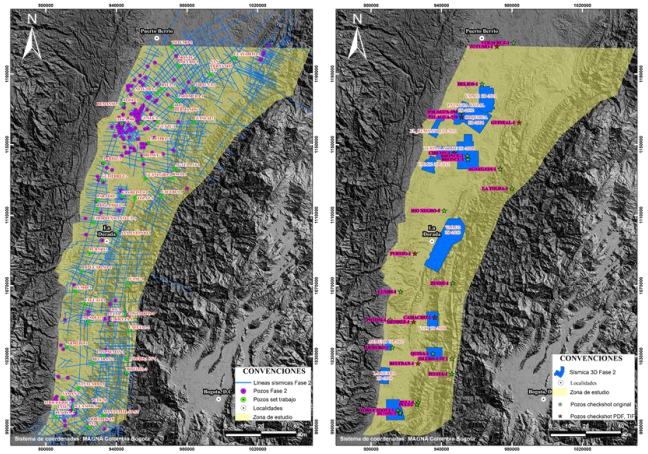
GEOLOGIC MAPS INTEGRATION



WELL ANALYSIS INTEGRATION



AVAILABLE INFORMATION



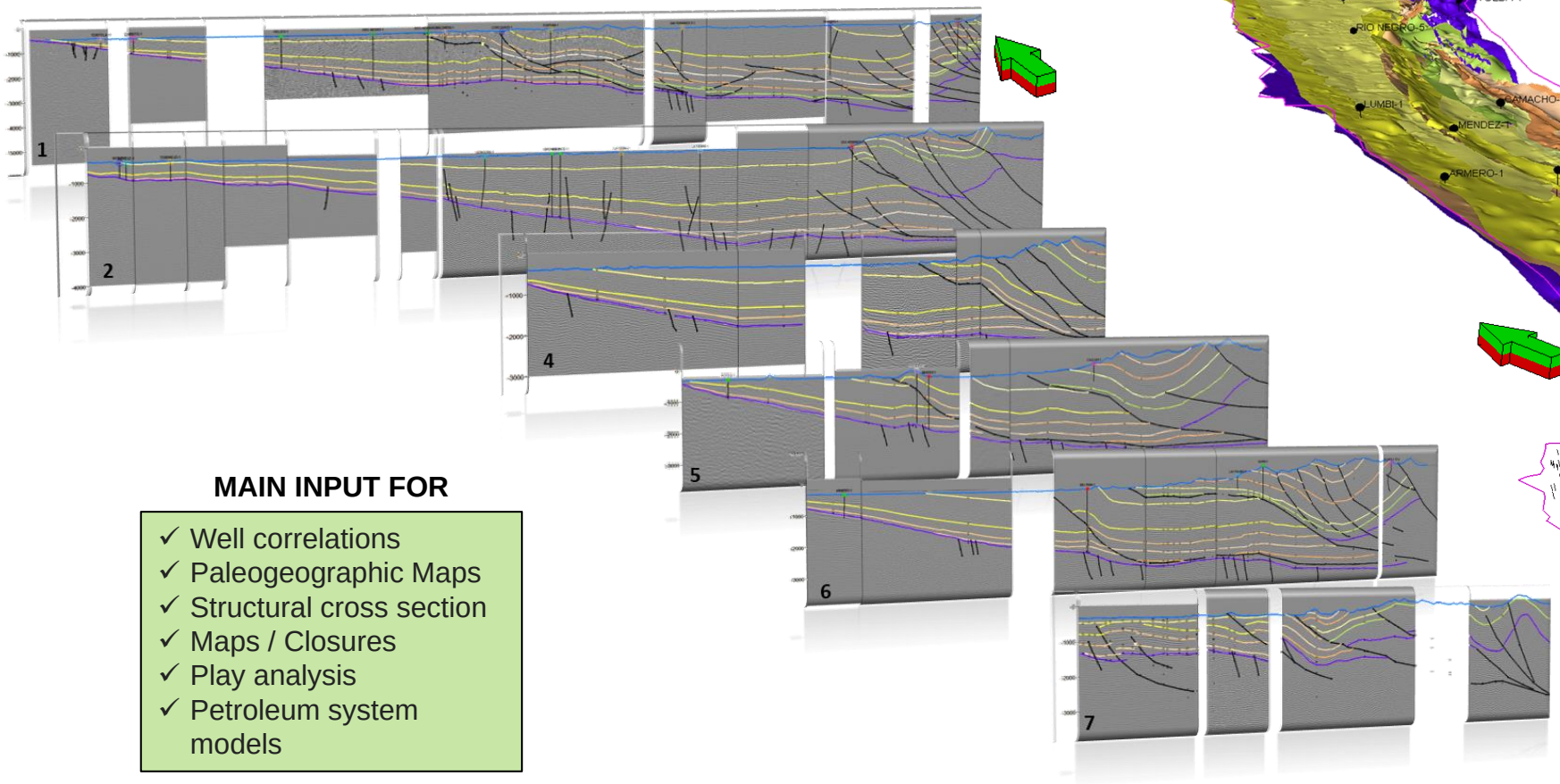
- ✓ 690 Seismic lines (9.143 km)
- ✓ 12 3D surveys (1.319 km^2)
- ✓ 103 Wells (33 *checkshot*)
- ✓ Gravimetry
- ✓ Field trips

INTERVAL DEFINITION

TIM	late Miocene	REAL	8 HORIZONS
TeM	early Miocene	COLORADO	
TO	Oligocene	MUGROSA	
TIE	late Eocene	ESMERALDAS	
TPeE	Paleocene-early Eocene	LISAMA	
KT	upper Cretaceous M	UMIR	
Kl2	upper Cretaceous S	LA LUNA	
pK	PRE-CRETACICO	PRE-CRETACICO	

Seismic Interpretation

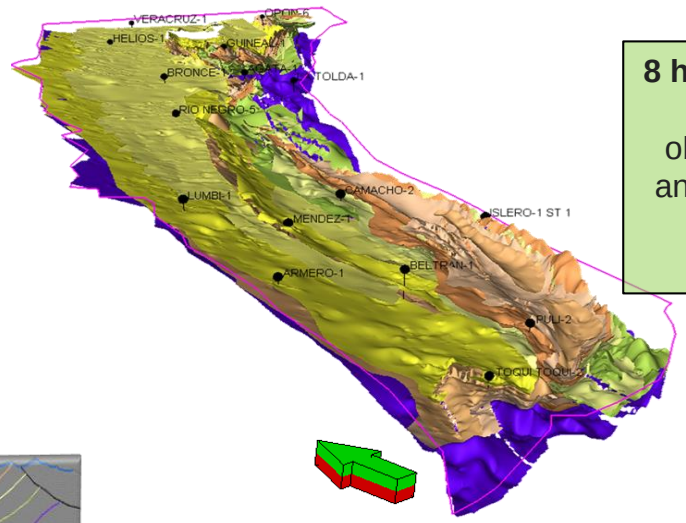
SEISMIC INTERPRETATION, G&G INTEGRATION



MAIN INPUT FOR

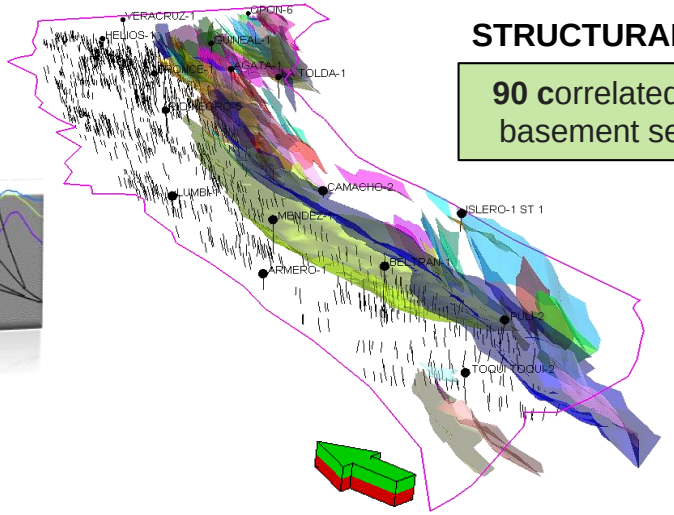
- ✓ Well correlations
- ✓ Paleogeographic Maps
- ✓ Structural cross section
- ✓ Maps / Closures
- ✓ Play analysis
- ✓ Petroleum system models

GEOLOGICAL MODEL



8 horizons separated according to the degree of deformation to observe the behavior of footwall and hanging wall blocks and their possible closures (where applicable)

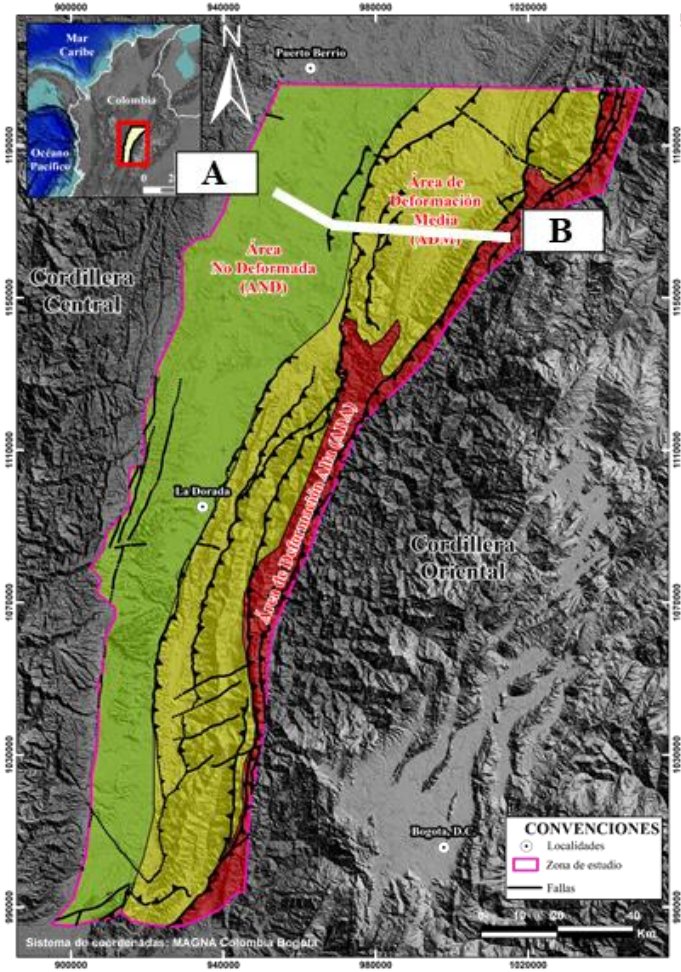
STRUCTURAL MODEL

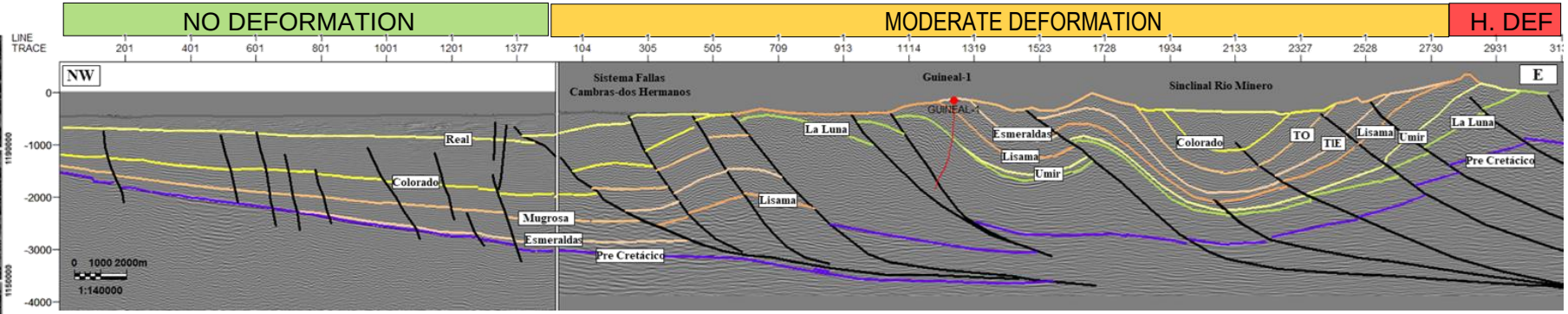


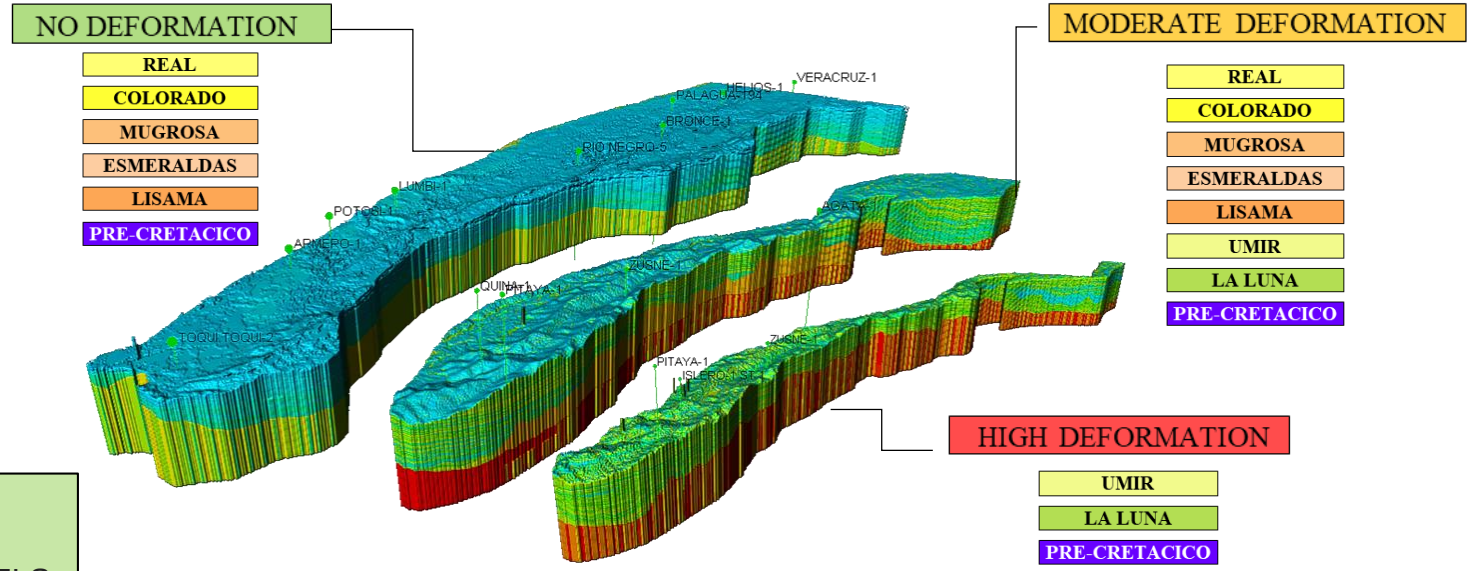
90 correlated faults + basement segments

Seismic Interpretation

DEFORMATION DOMAINS



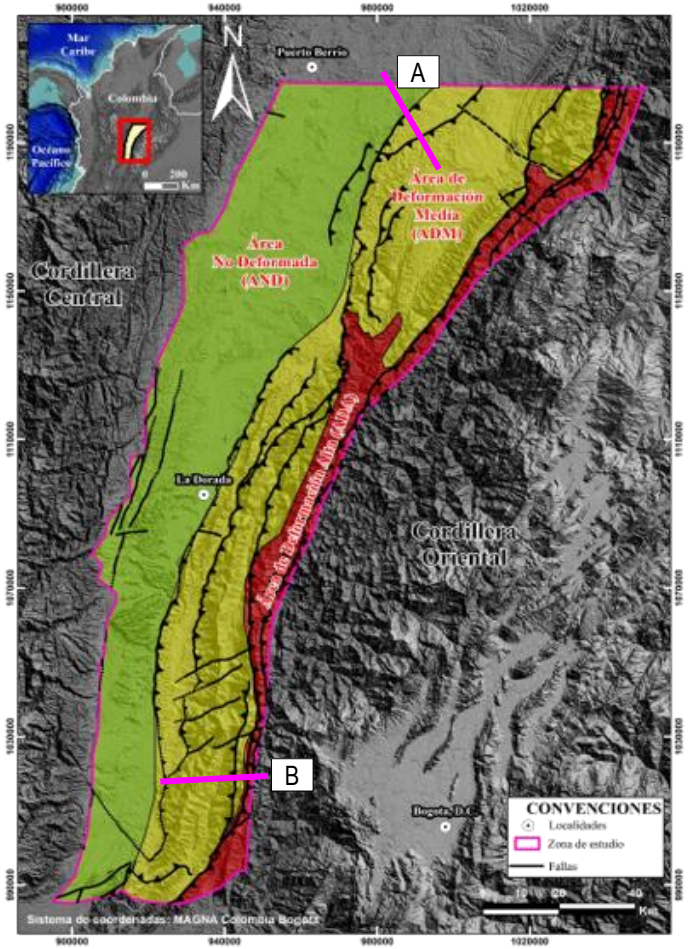




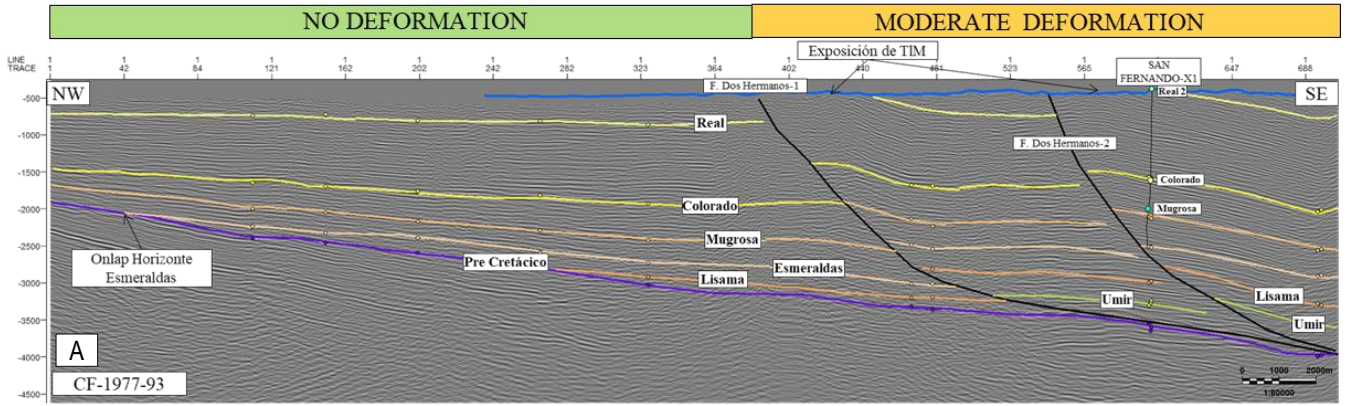
- ✓ HORIZONS
- ✓ MAPS
- ✓ VELOCITY MODELS

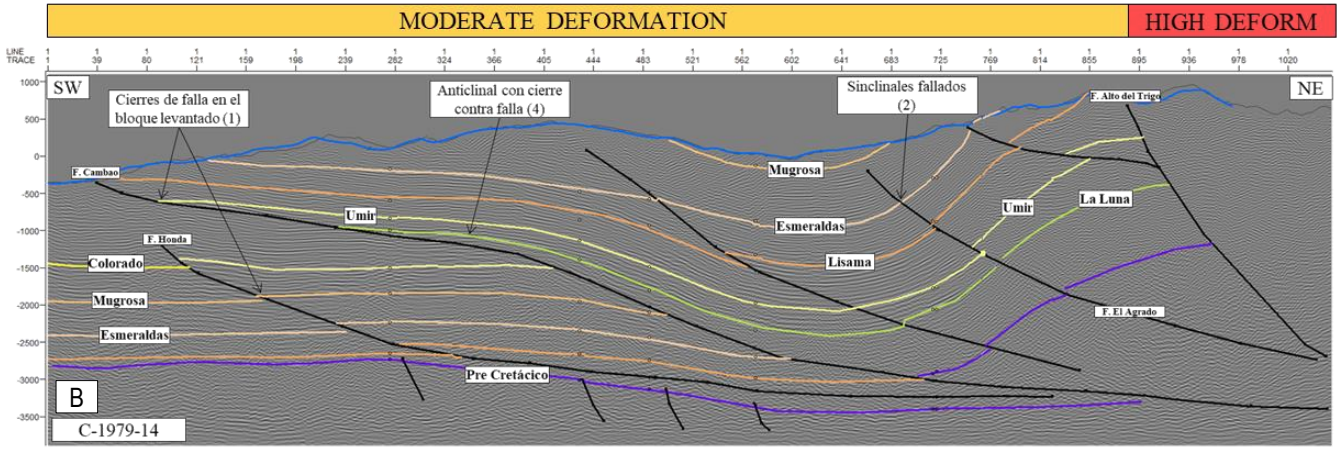
Seismic Interpretation

DEFORMATION DOMAINS



SEISMIC EXPRESSION DEFORMATION DOMAINS AND PLAYS





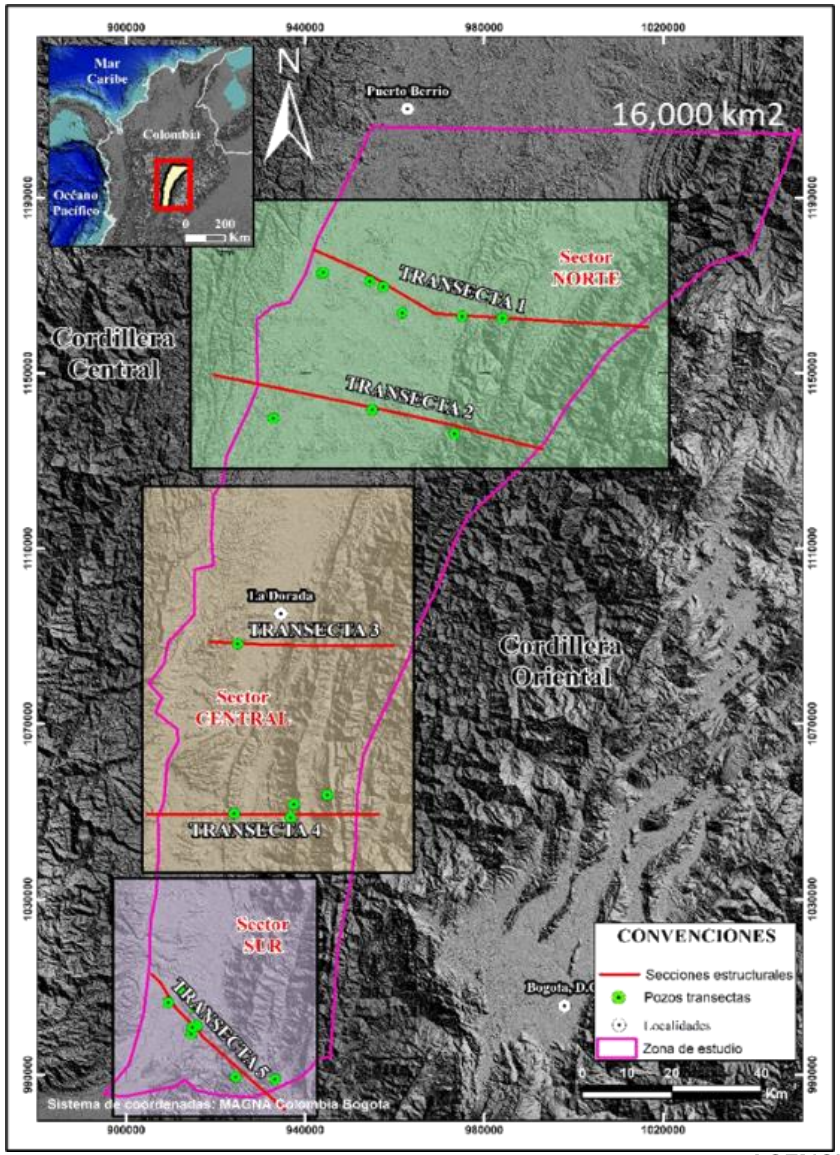
- Cenozoic sequences
- Low deformation
- Good preservations of sequences
- Sequences onlapping to the west – Stratigraphic plays
- Front deformation footwall closures – Structural plays

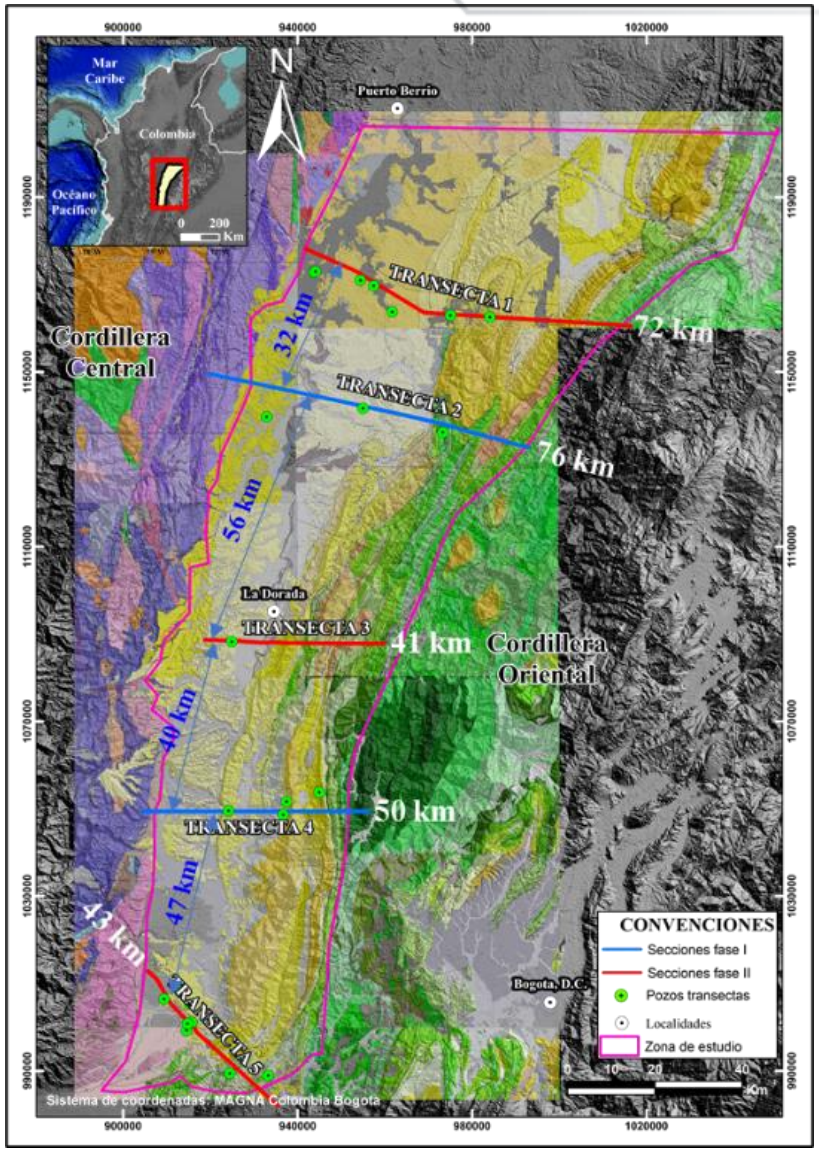
- Cretaceous - Cenozoic sequences
- Erosion of Cenozoic sequences
- Middle deformation
- Preservation of Paleocene/Cretaceous sequences mainly
- Footwall/hanging wall closures, (Anticline against fault, faulted synclines) – Structural plays

- Exposed Cretaceous and older sequences
- Hihgly faulted and deformed
- Low prospectivity

AREAS ADVERTISEMENT 2022

Structural Cross Sections Location

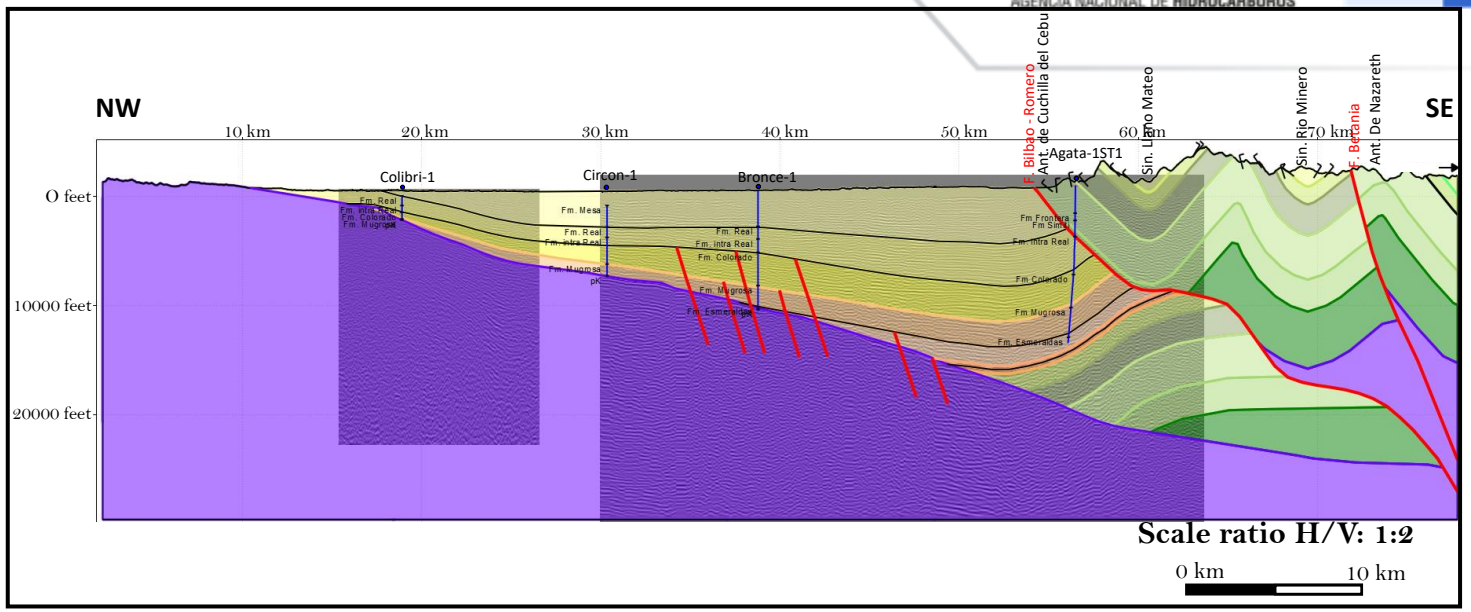




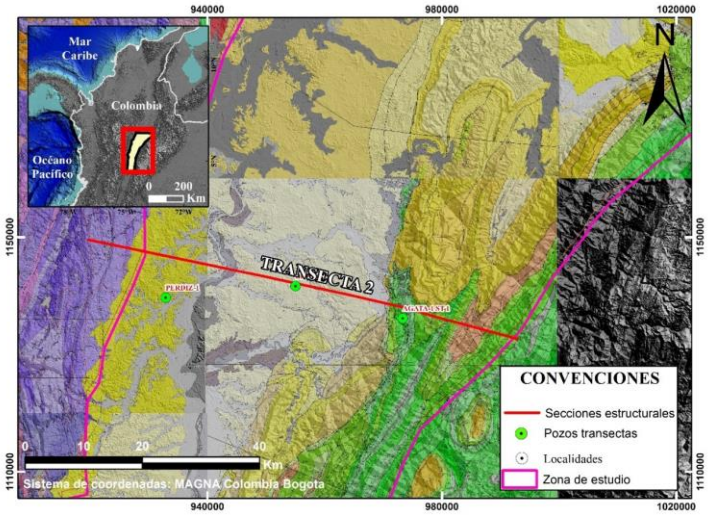
Structural Cross Sections No. 2

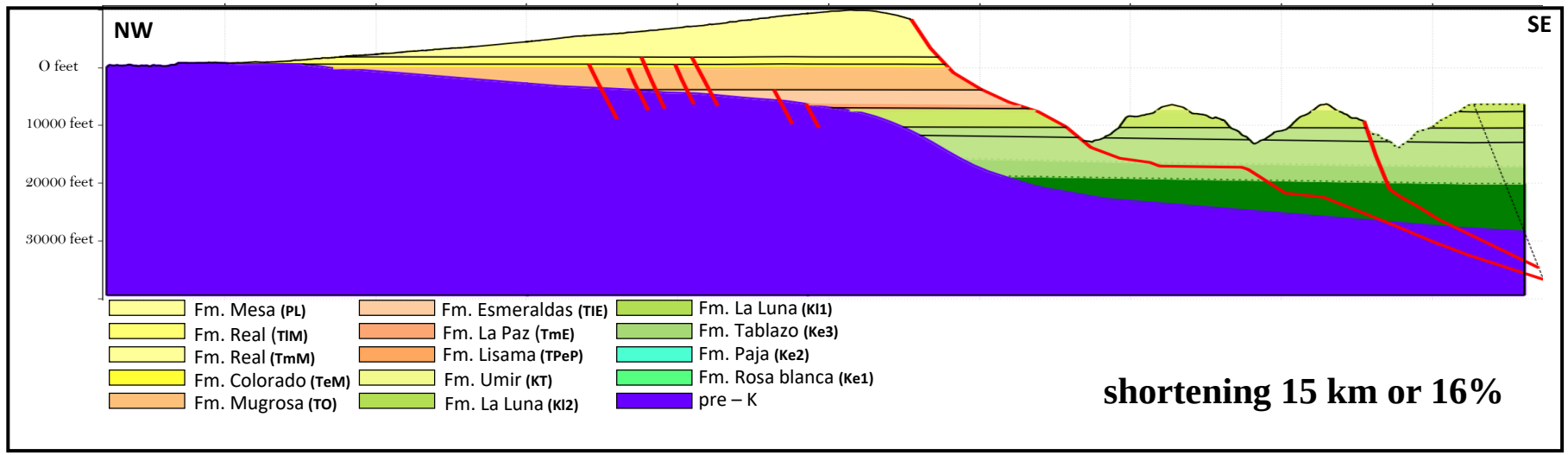
Length 76

CROSS SECTION 2	
Seismic profiles	L-1983-12
	TPB-1995-142
Wells	Colibrí-1
	Circon-1
	Bronce-1
	Agata-1ST



Balanced cross section





Restored cross section

Structural Cross Section No. 1

AREAS ADVERTISEMENT 2022

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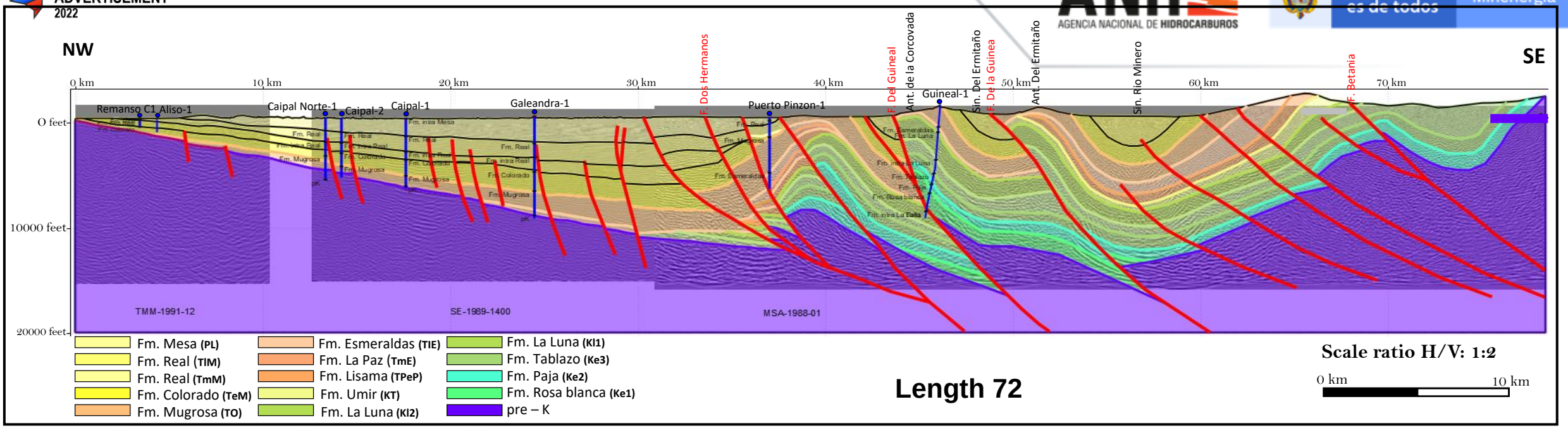
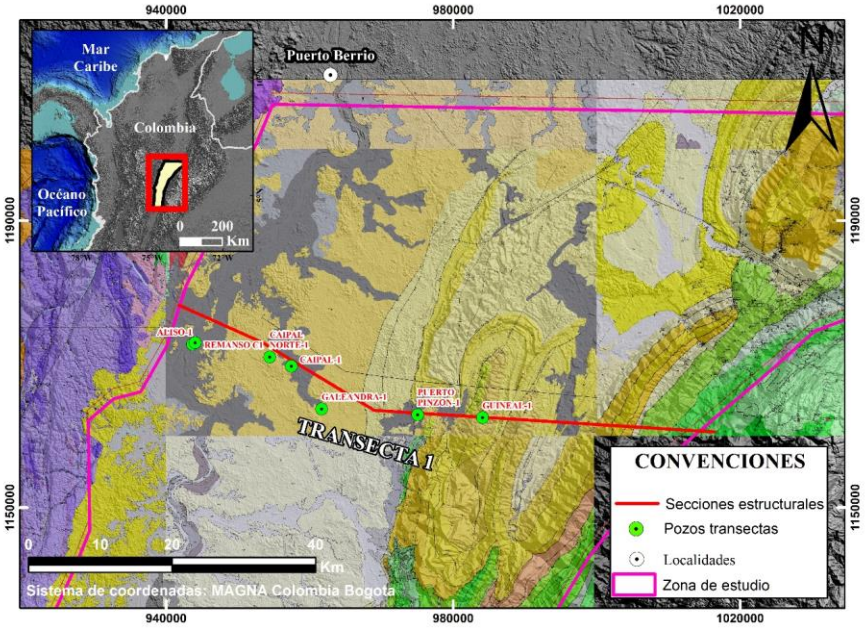


Length 72

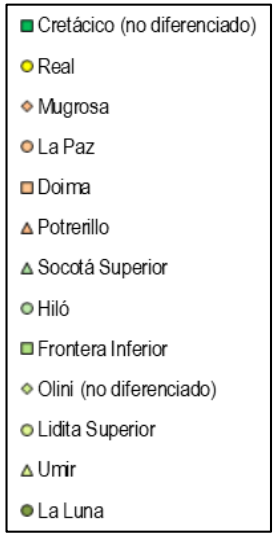
Scale ratio H/V: 1:2

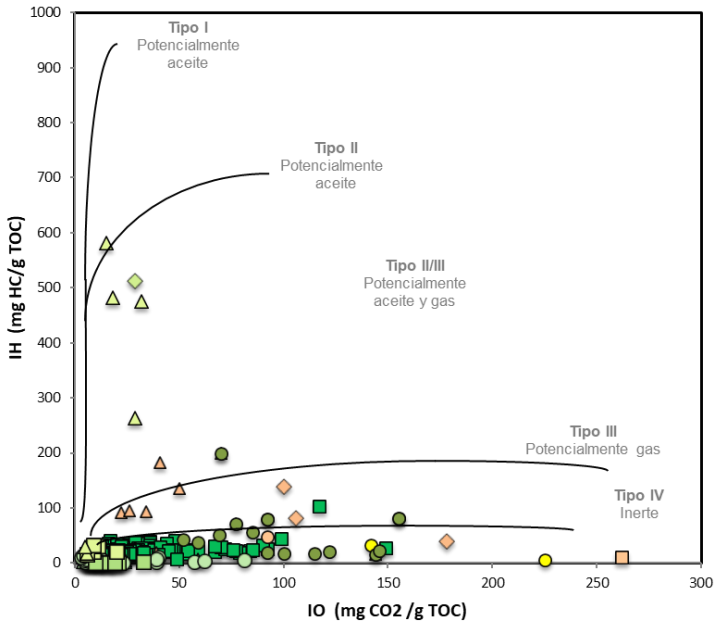
0 km — 10 km

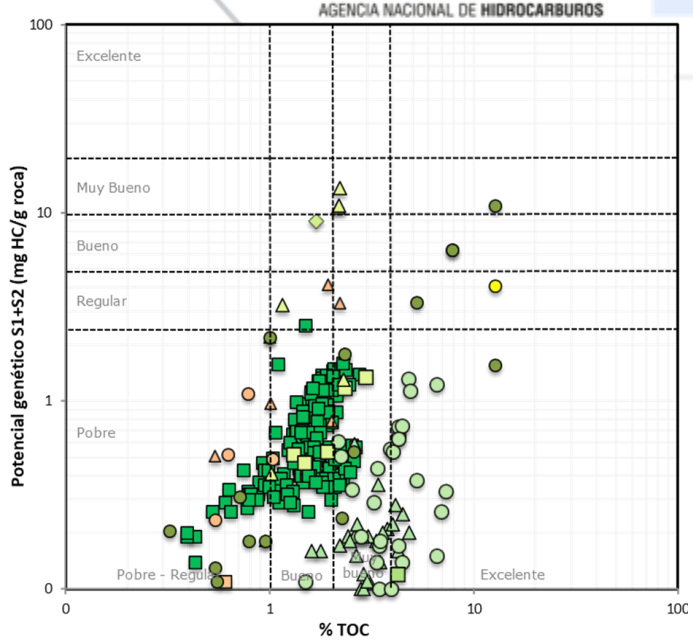


CROSS SECTION 1	
Seismic profile	SE-1989-1400
	MSA-1988-01
	TMM-1991-12
Wells	Remanso-C1
	Aliso-1
	Caipal Norte-1
	Caipal-1
	Galeandra-1
	Puerto Pinzon-1
	Guineal-1

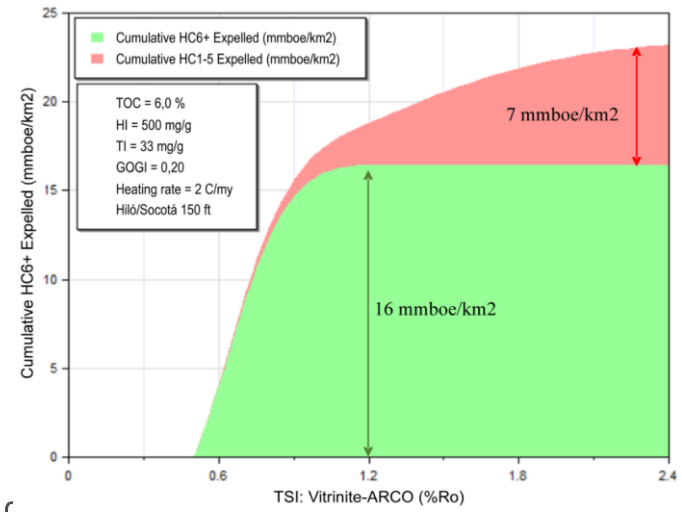
Rock geochemistry

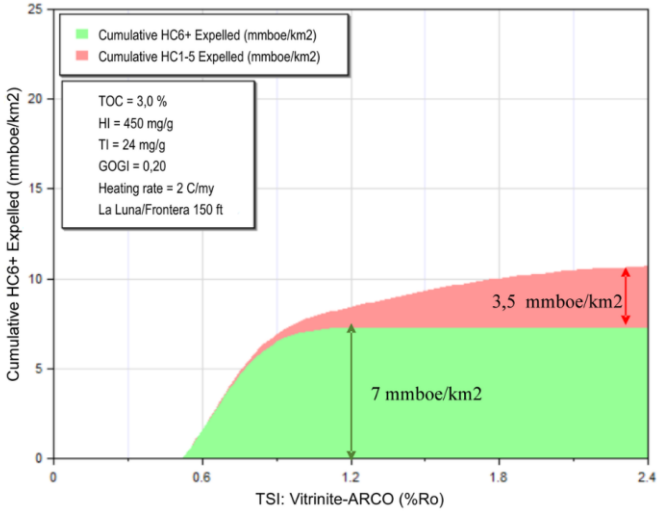




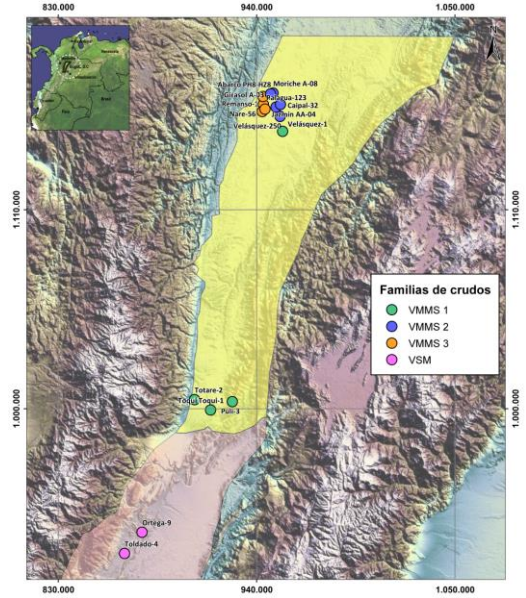


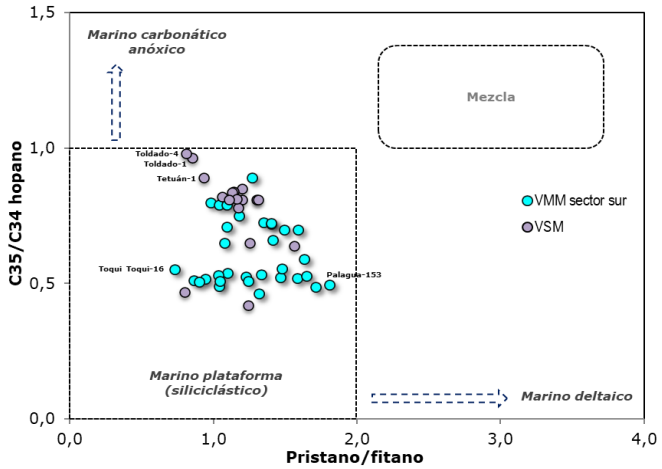
Intervalo generador	Datos de entrada				Resultados	
	TOC actual (%)	Tasa transformación (%)	IH actual (mg/gTOC)	S1 actual (mg/gRoca)	TOC original (%)	IH original (mg/gTOC)
Cretácico Tardío (La Luna/Frontera)	1,5	90	50	1,5	3	450
Cretácico Temprano (Hiló/Socotá)	4	95	40	0,5	6	500

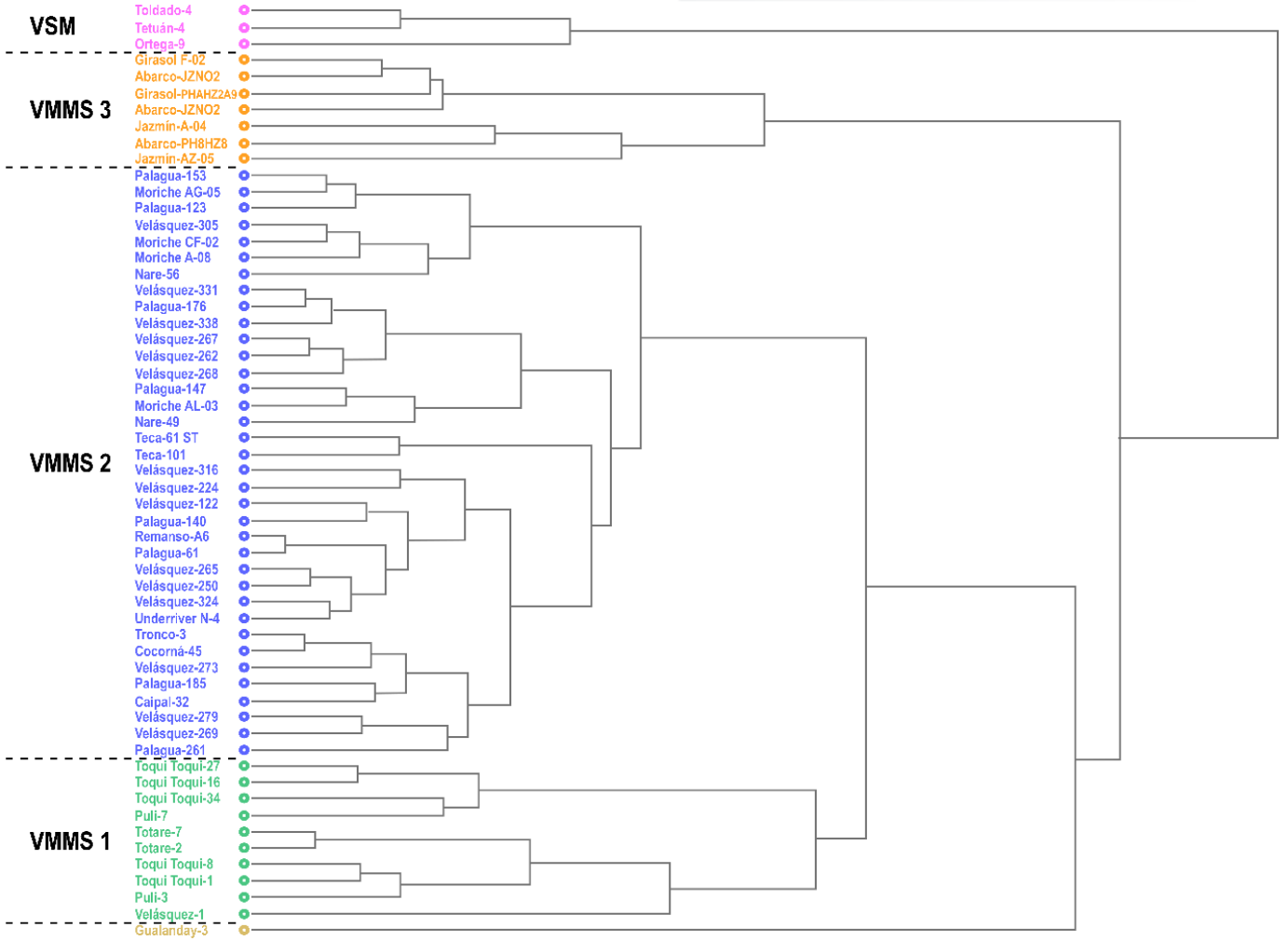




Crude oil geochemistry





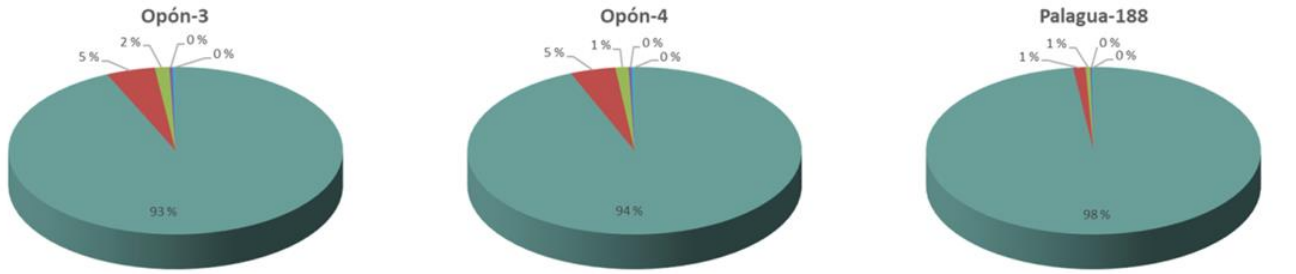


Sur ----------Biodegradación----------Norte

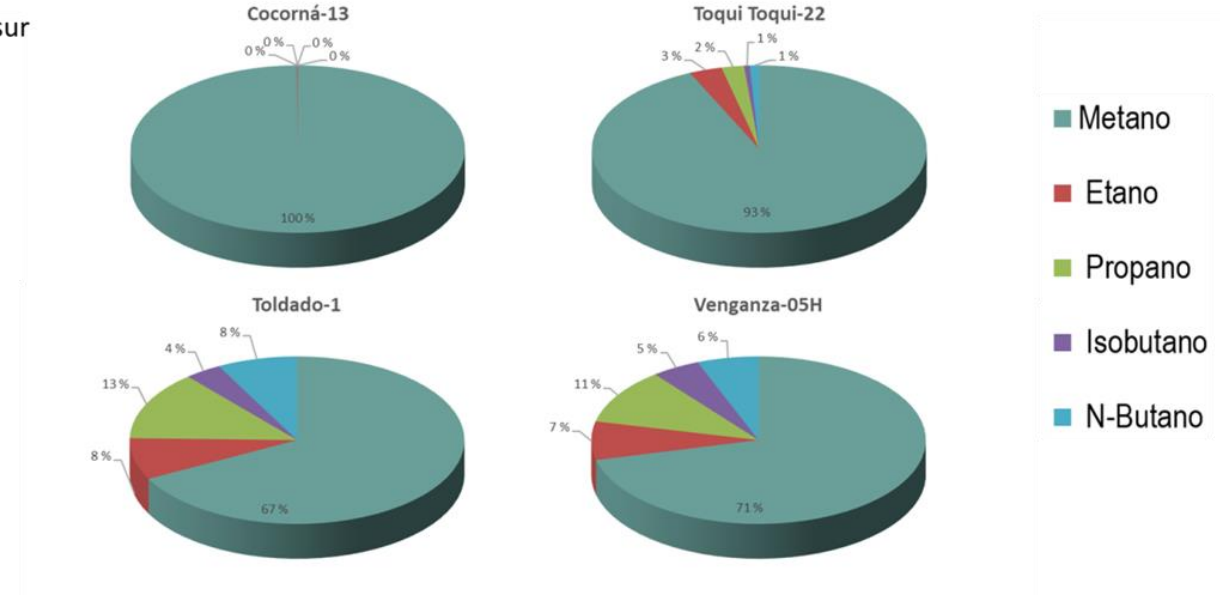
VSM	VMMS 1	VMMS 2	VMMS 3
Toldado-1 23 °API 25 norhopano/C30 hopano = 0,01	Crudos Mezclados -- Refreshing Pulí-3 33 °API 25 norhopano/C30 hopano = 0,17	Velásquez-269 18 °API 25 norhopano/C30 hopano = 0,17	Abarco-PH8HZ8 8 °API 25 norhopano/C30 hopano = 0,61
Ortega-9 25 °API 25 norhopano/C30 hopano = 0,01	Toqui Toqui-16 21 °API 25 norhopano/C30 hopano = 0,12	Palagua-176 18 °API 25 norhopano/C30 hopano = 0,21	Girasol A-03 7 °API 25 norhopano/C30 hopano = 0,62
Pacandé Sur-1 28 °API 25 norhopano/C30 hopano = 0,01	Totare-2 22 °API 25 norhopano/C30 hopano = 0,13	Moriche AG-05 17 °API 25 norhopano/C30 hopano = 0,22	Jazmín-AZ-05 9 °API 25 norhopano/C30 hopano = 0,62

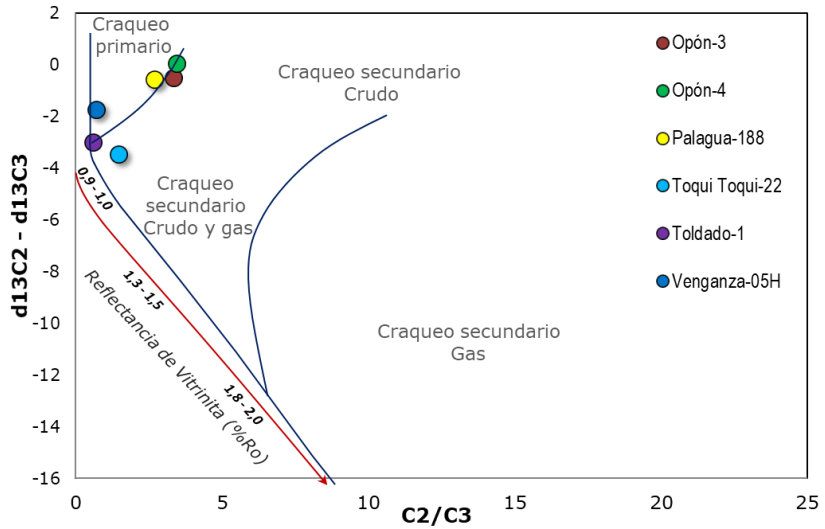
Gas geochemistry

VMM sector sur

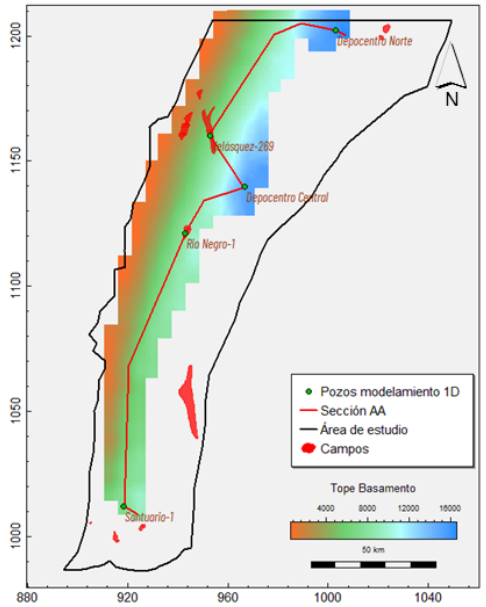


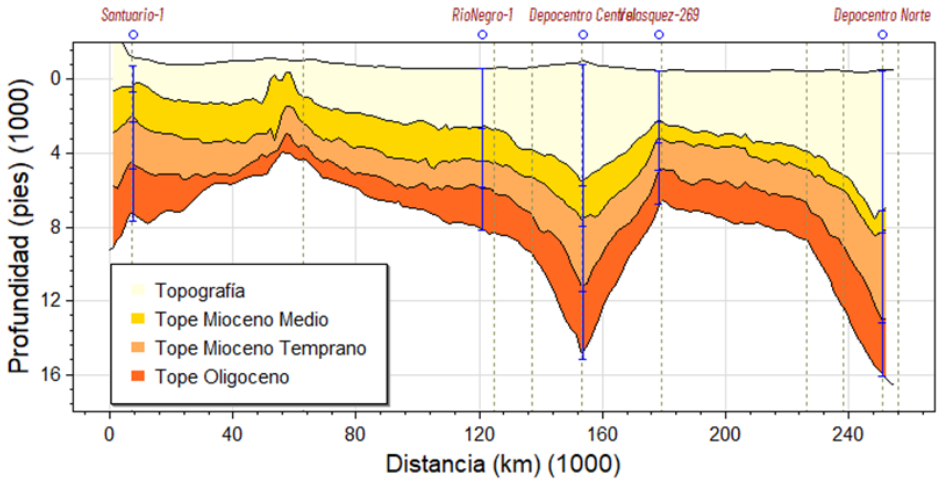
VSM

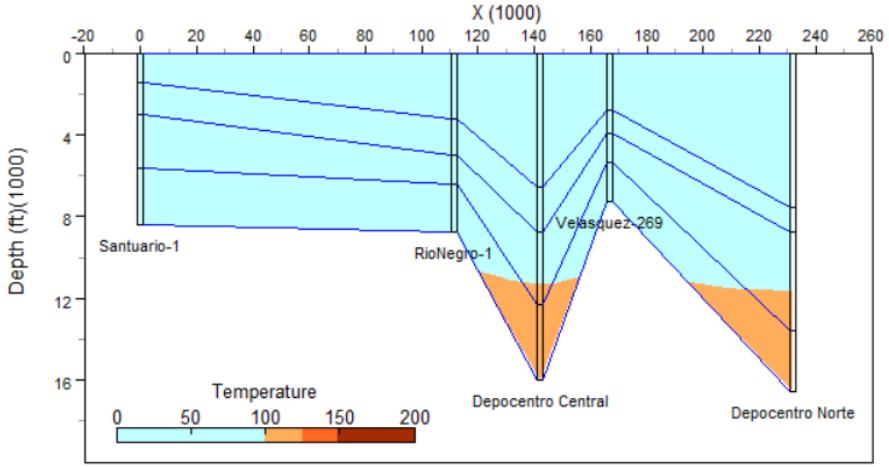


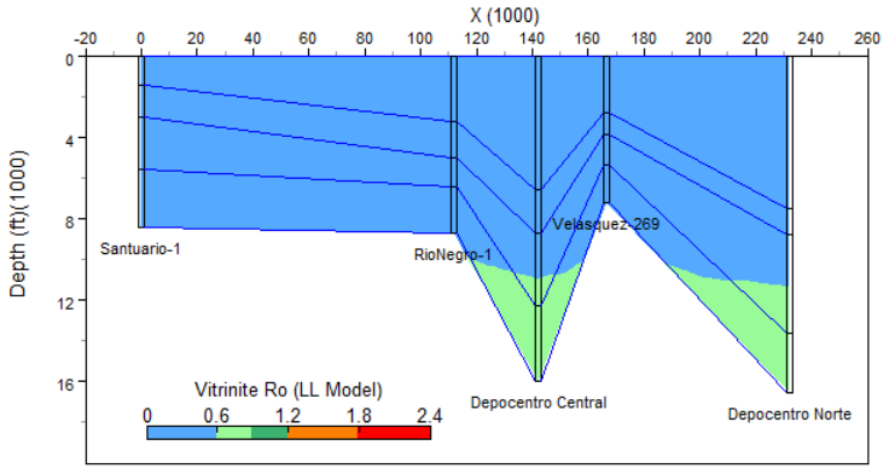


Modeling SP (1D)



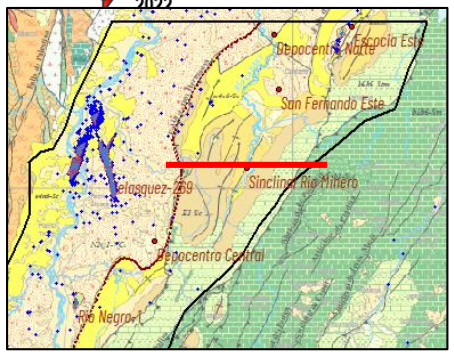


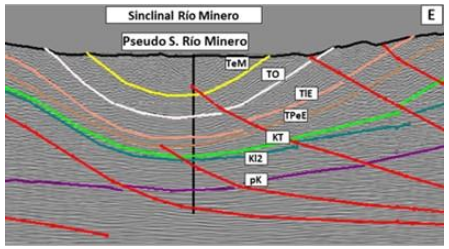


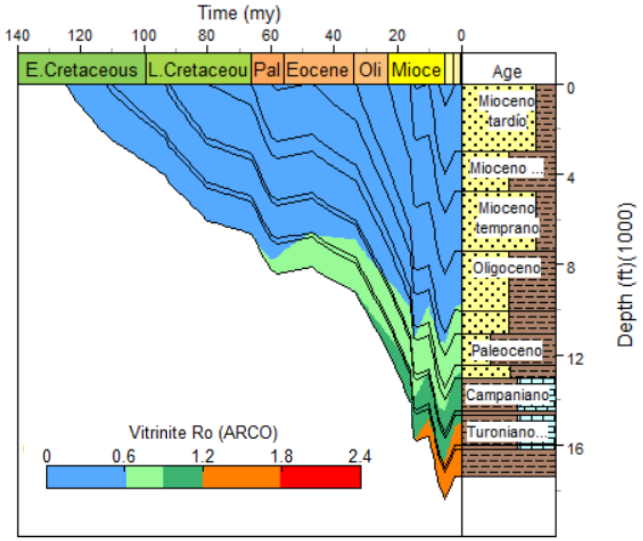


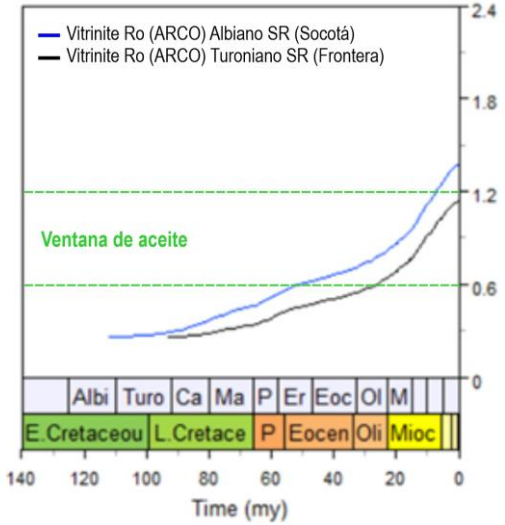
La correlación de la temperatura actual (°C) y la reflectancia de la vitrinita (% Ro) a lo largo de una sección de rumbo en la estructura monoclinal, muestra cómo solo en los depocentros la secuencia estratigráfica del Terciario alcanzó niveles de madurez térmica compatibles con la fase de generación temprana.

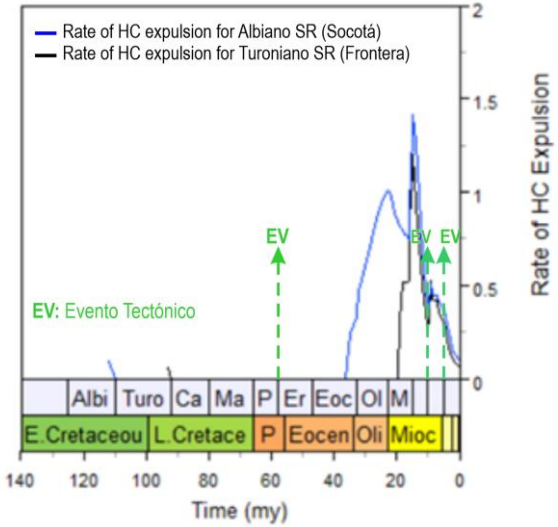
Variación de la temperatura actual y la madurez térmica a lo largo de una sección de rumbo.

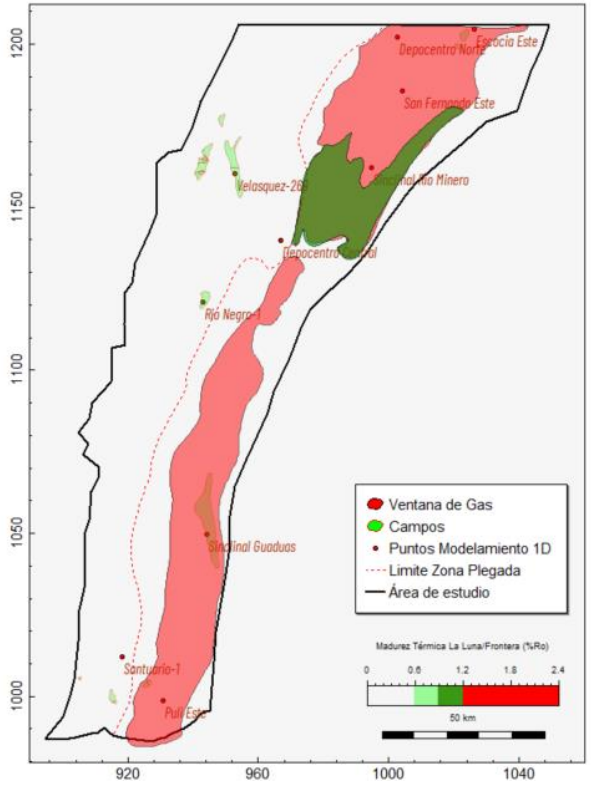


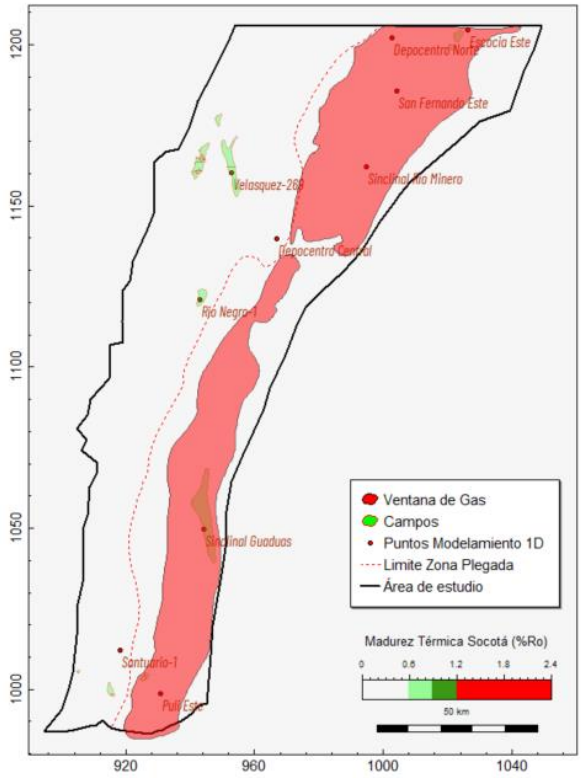






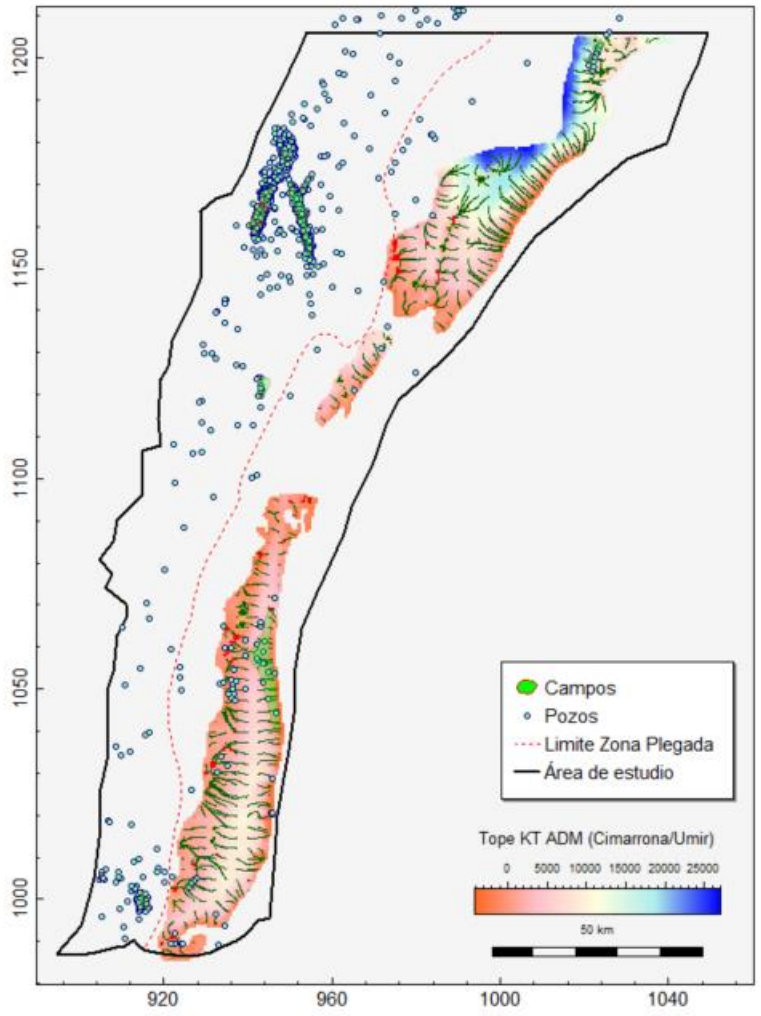


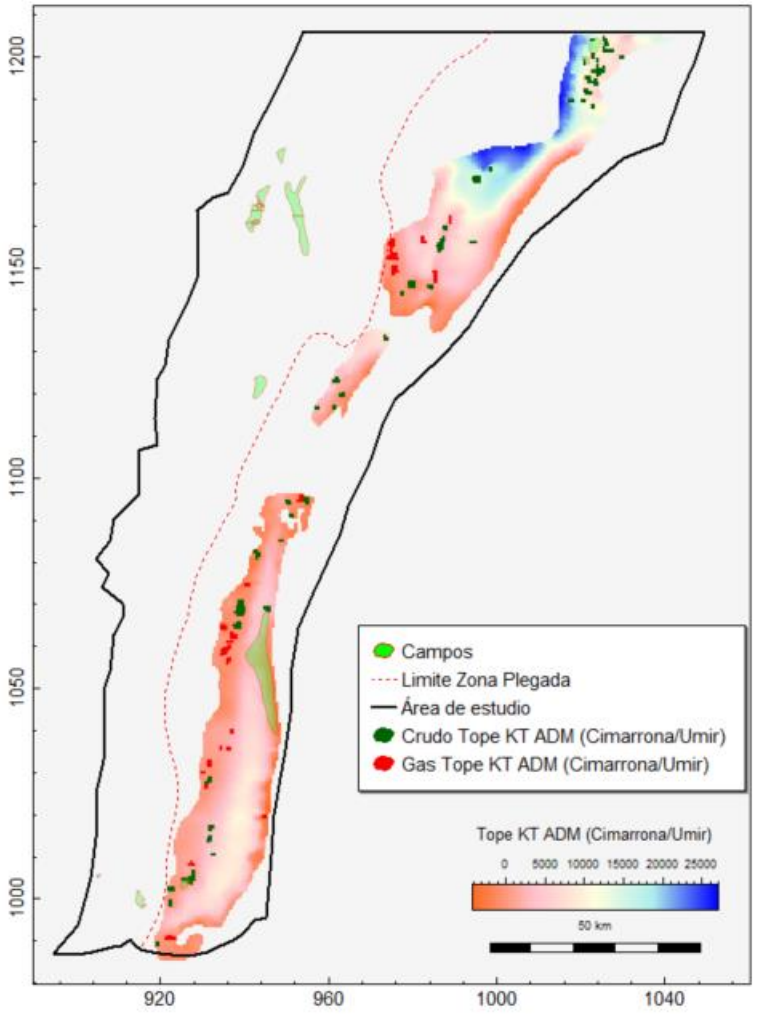


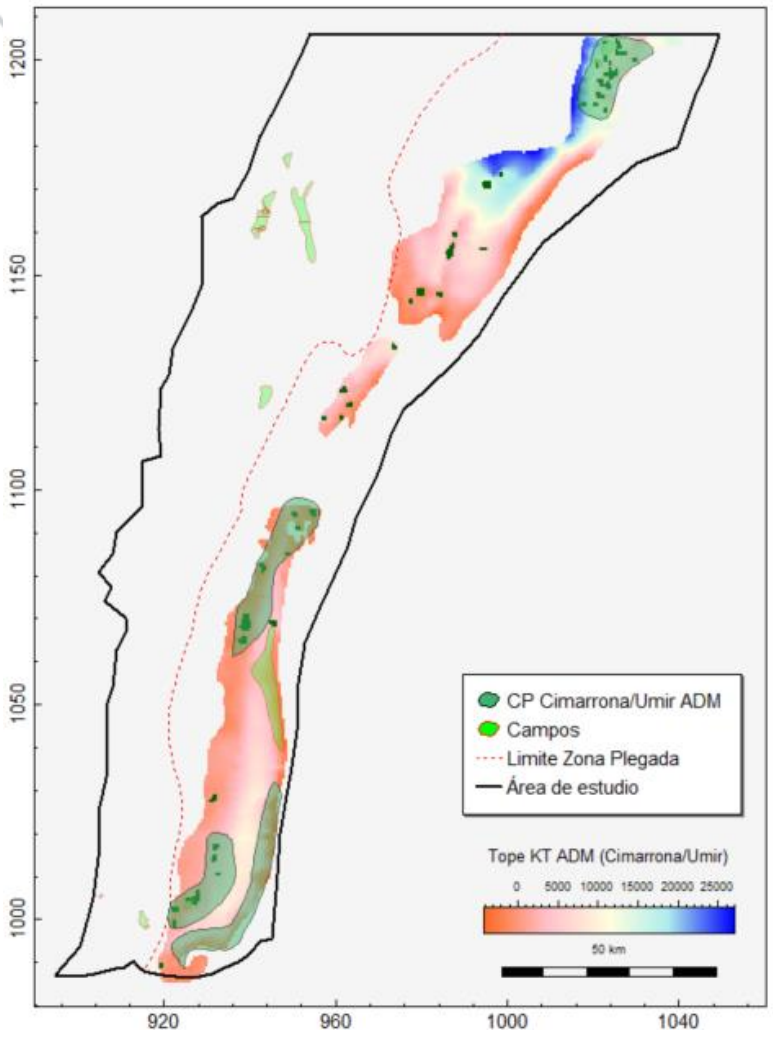


Modeling SP (1D) /Sinclinal Río Minero

Migration, HCs charge and play fairway / Cimarrona-Umir







AREAS ADVERTISEMENT 2022

Migration, HCs charge and play fairway / Cimarrona-Umir

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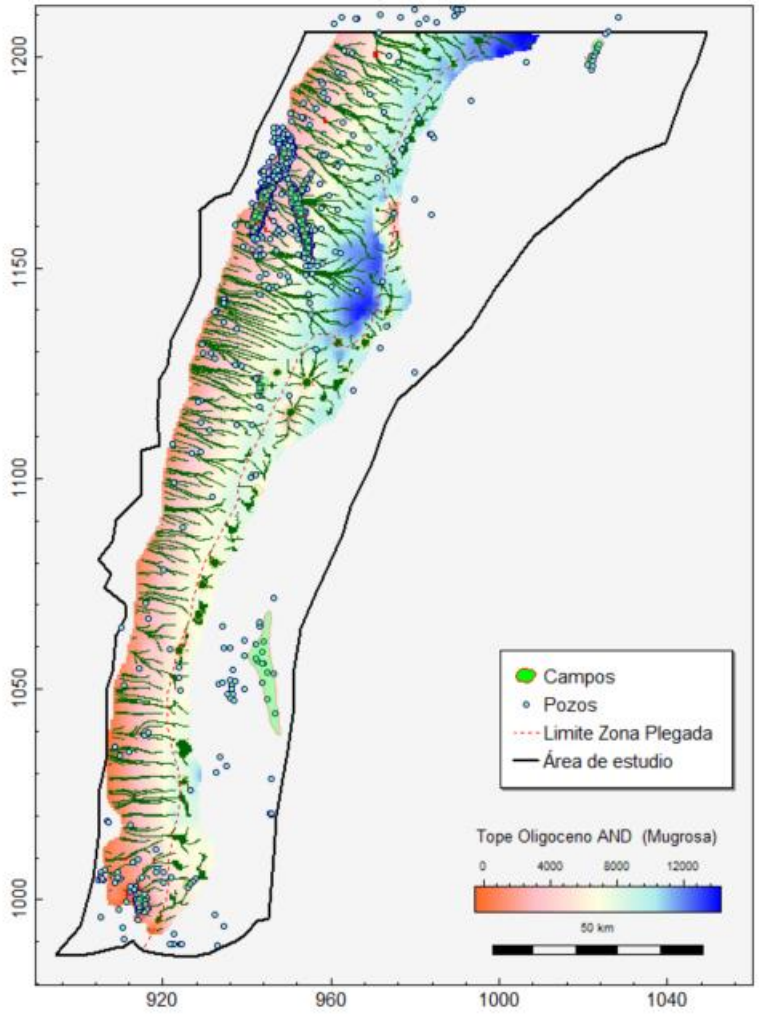
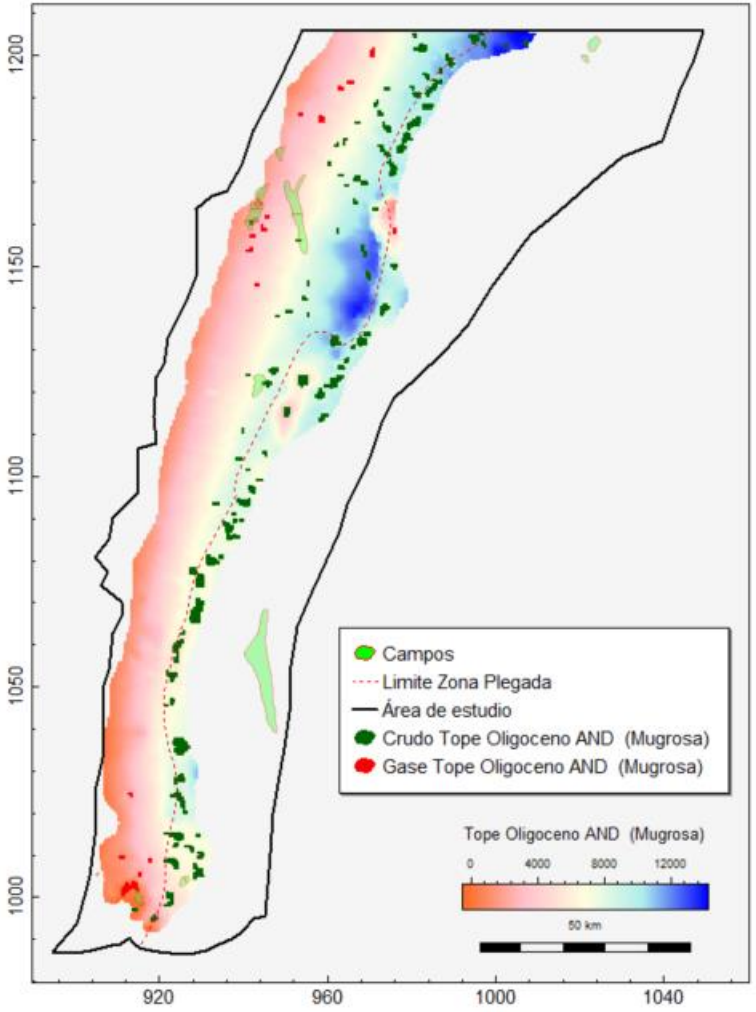
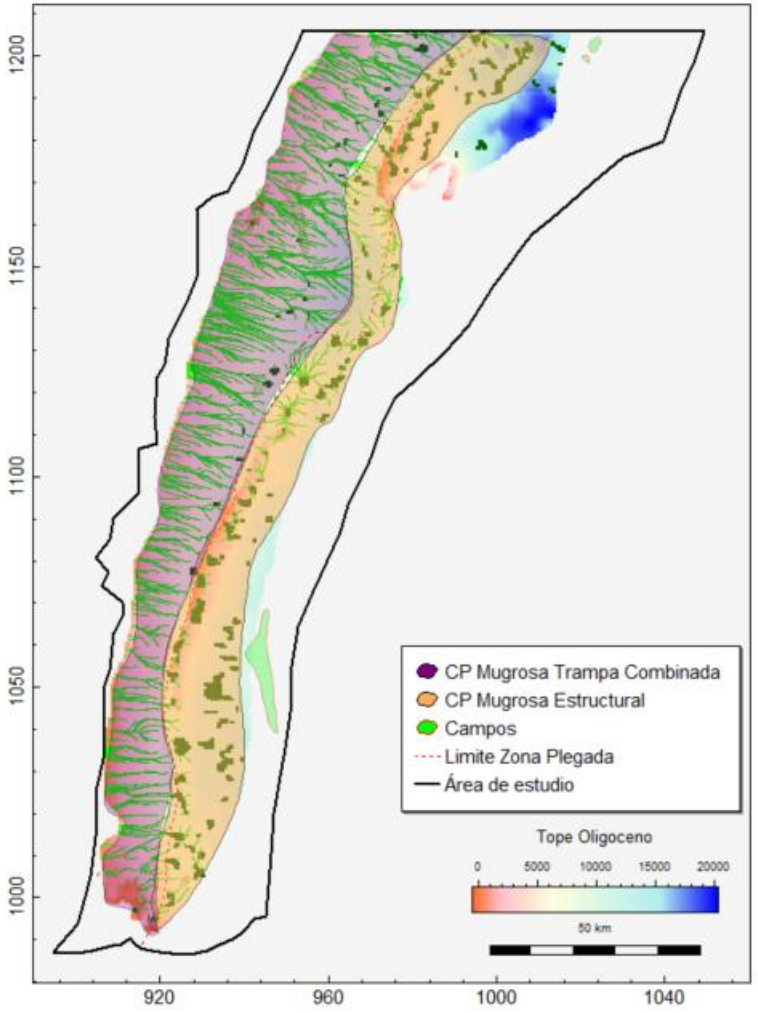


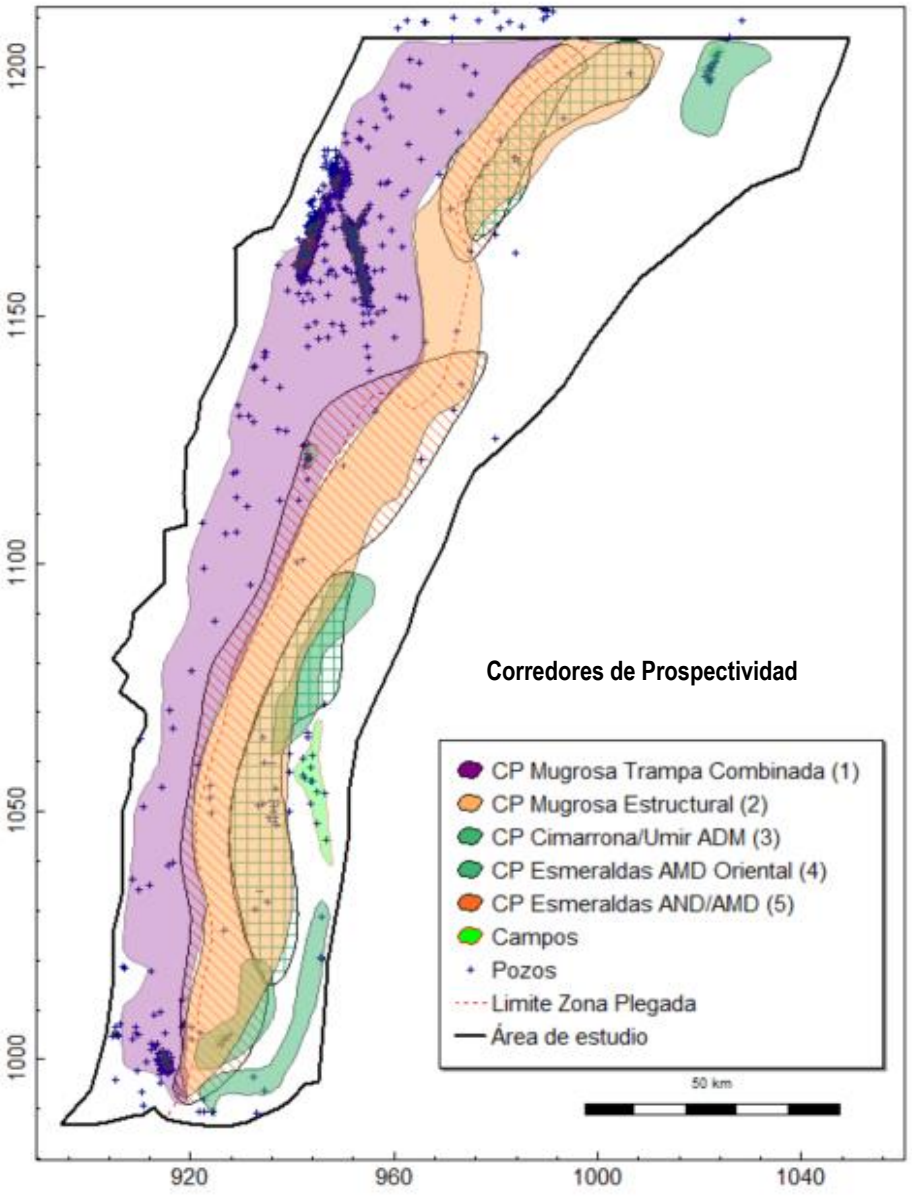


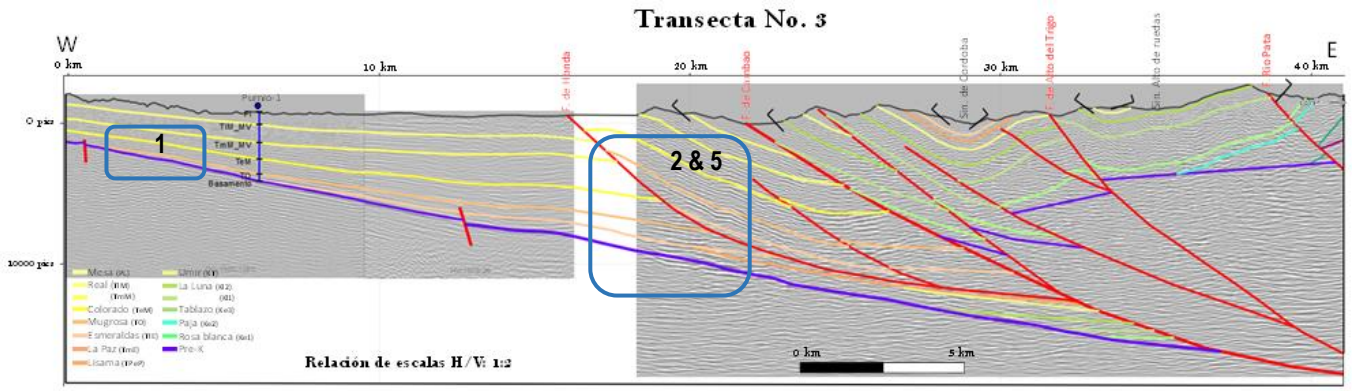


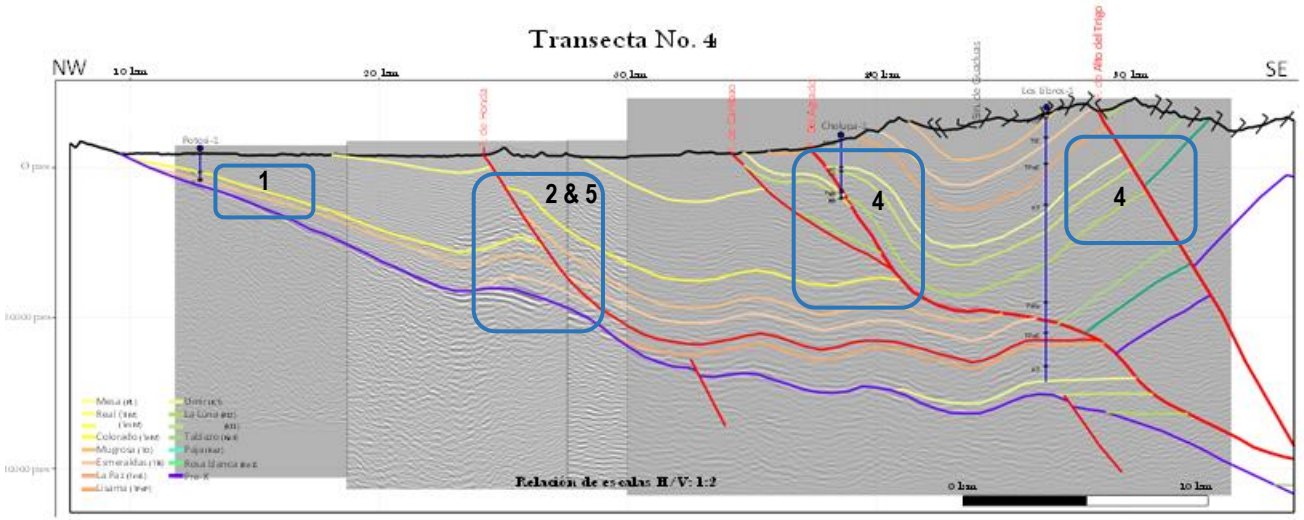
Modeling SP (3D)

AREAS ADVERTISEMENT

Play fairway







Recursos Prospectivos

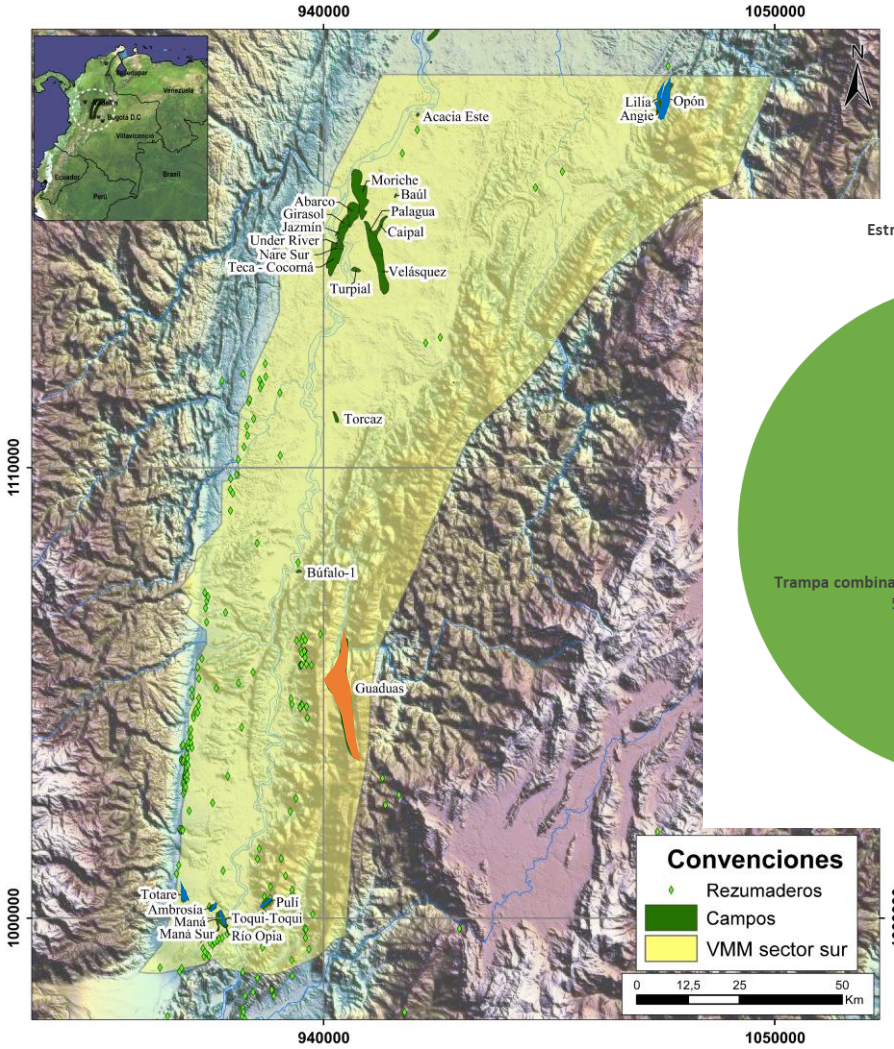
Creaming Curve

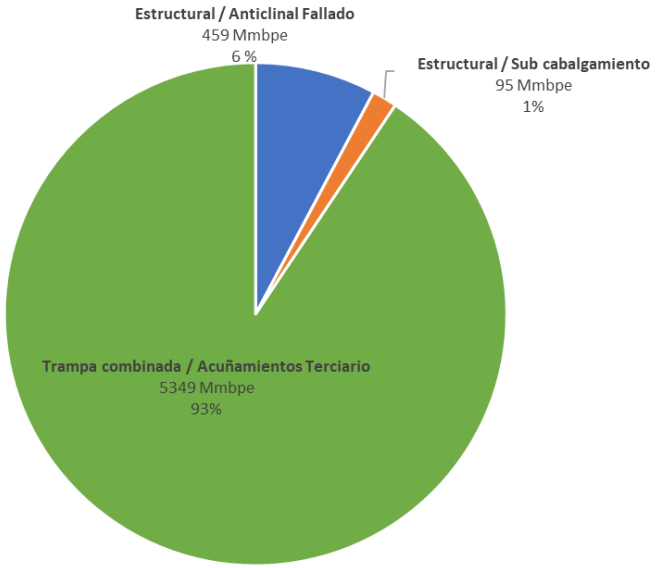
Análisis Fractal

Balance de Masas

Discriminación Crudo y Gas

Plays Probados



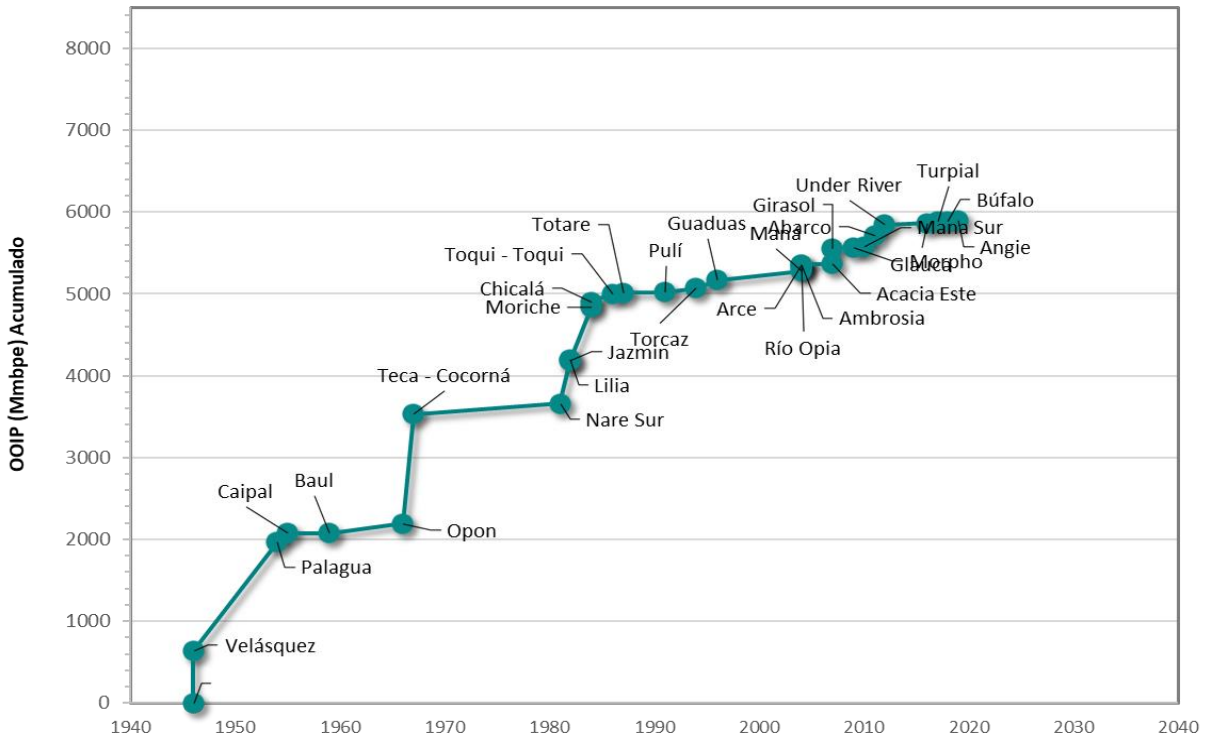


Mapa de localización de campos petrolíferos, sector Sur de la cuenca VMM.

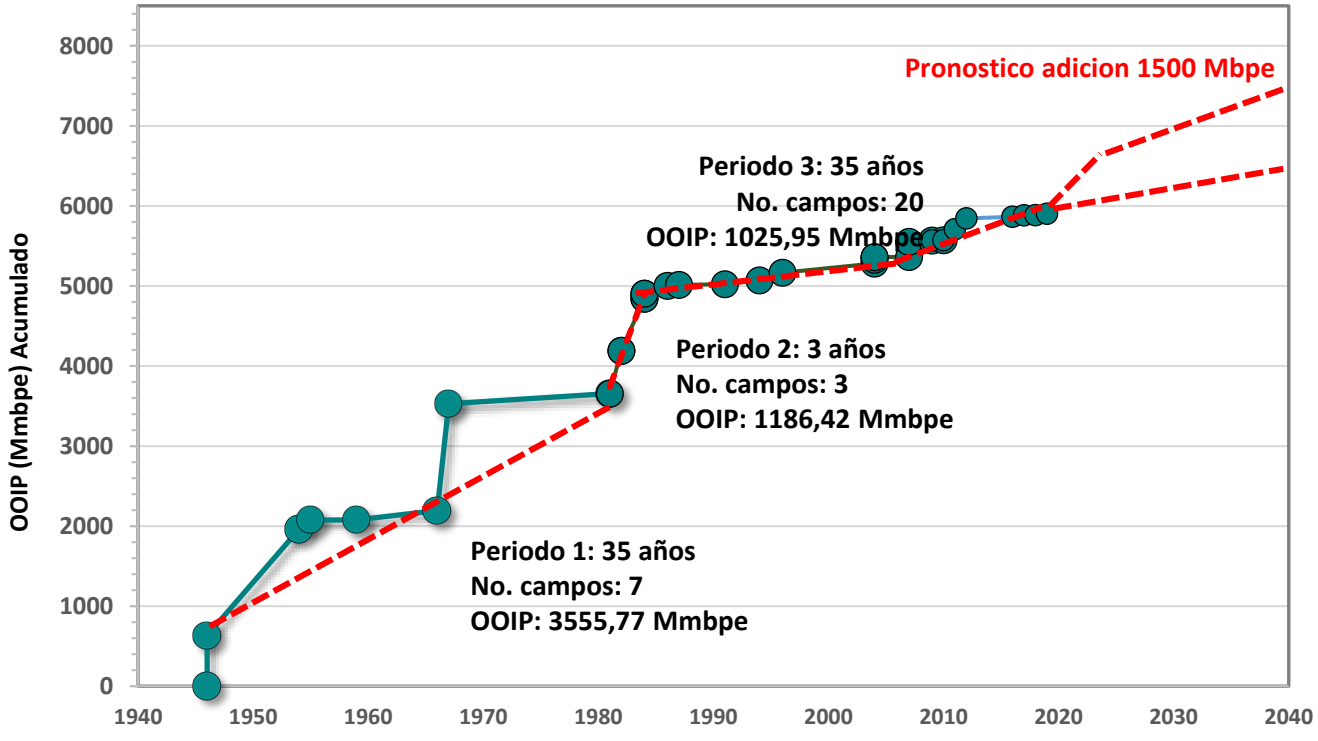
Campo	Año de descubrimiento	Tipo de Play	OOIP-ANH (Mmbpe-2020)
Velásquez	1946	Trampa combinada acuñamientos Terciario	634
Palagua	1954	Trampa combinada acuñamientos Terciario	1329
Caipal	1955	Trampa combinada acuñamientos Terciario	114
Baul	1959	Trampa combinada acuñamientos Terciario	1
Opon	1966	Estructural / Anticlinal Fallado	118
Teca - Cocorná	1967	Trampa combinada acuñamientos Terciario	1333
Nare Sur	1981	Trampa combinada acuñamientos Terciario	128
Jazmin	1982	Trampa combinada acuñamientos Terciario	534
Lilia	1982	Estructural / Anticlinal Fallado	1
Moriche	1984	Trampa combinada acuñamientos Terciario	651
Chicalá	1984	Trampa combinada acuñamientos Terciario	62
Toqui - Toqui	1986	Estructural / Anticlinal Fallado	99
Totare	1987	Trampa combinada acuñamientos Terciario	11
Pulí	1991	Estructural / Anticlinal Fallado	8
Torcaz	1994	Trampa combinada acuñamientos Terciario	49
Guaduas	1996	Estructural / Sub cabalgamiento	95
Maná	2004	Estructural / Anticlinal Fallado	115
Río Opia	2004	Estructural / Anticlinal Fallado	47
Ambrosia	2004	Estructural / Anticlinal Fallado	32
Arce	2004	Trampa combinada acuñamientos Terciario	1
Acacia Este	2007	Trampa combinada acuñamientos Terciario	2
Girasol	2007	Trampa combinada acuñamientos Terciario	190
Morpho	2009	Estructural / Anticlinal Fallado	16
Mana Sur	2010	Estructural / Anticlinal Fallado	4
Abarco	2011	Trampa combinada acuñamientos Terciario	136
Under River	2012	Trampa combinada acuñamientos Terciario	135
Glauca	2016	Trampa combinada acuñamientos Terciario	21
Turpial	2017	Trampa combinada acuñamientos Terciario	18
Búfalo	2018	Estructural / Anticlinal Fallado	1
Angie	2019	Estructural / Anticlinal Fallado	19
		Total	**5903**

Distribución del OOIP de acuerdo al tipo de *play* en el sector sur de la cuenca VMM

Recursos descubiertos – Creaming Curve

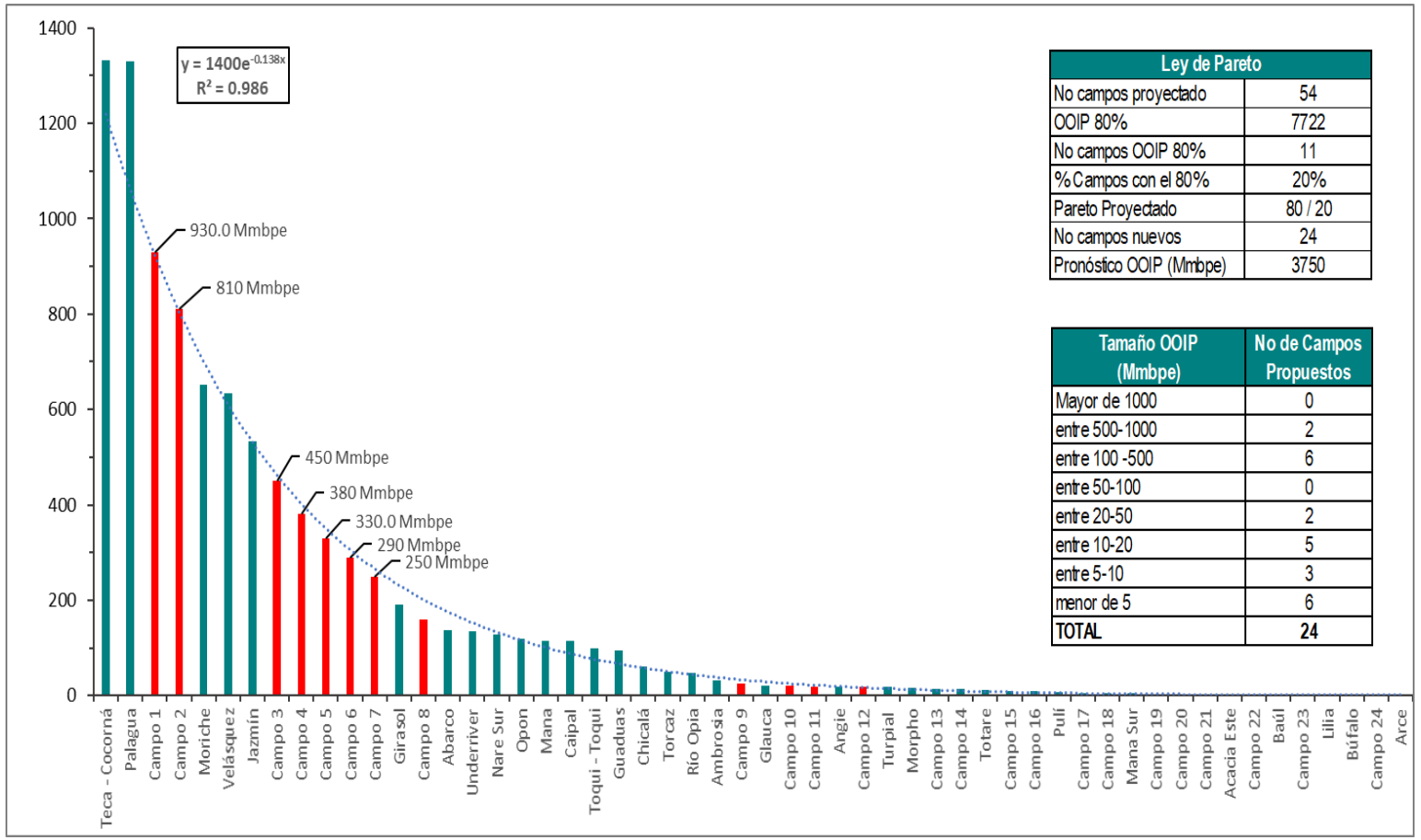


Recursos por descubrir – Creaming Curve



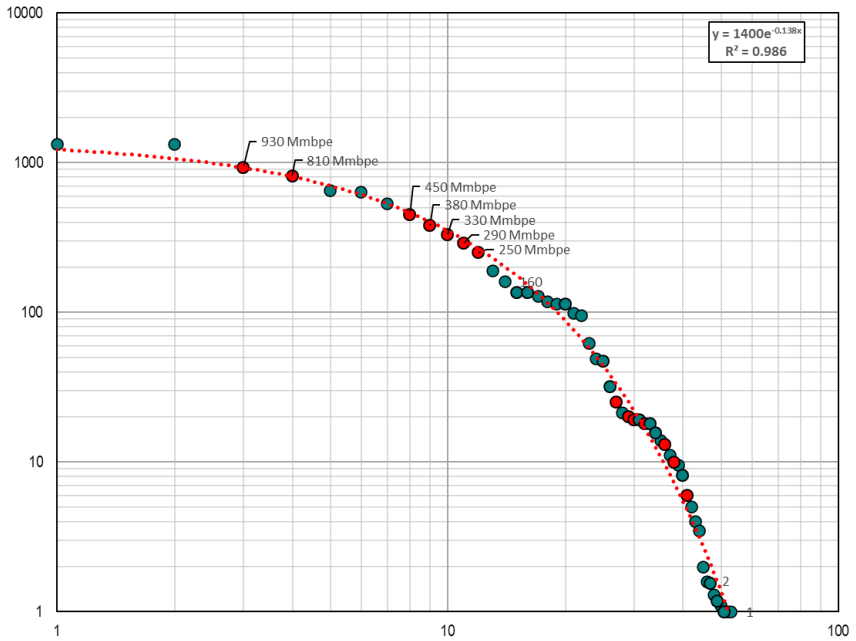
En el sector sur de la Cuenca VMM se han perforado más 3390 pozos, entre exploratorios y de desarrollo y se han descubierto 30 campos petrolíferos (ANH, 2020). Los campos de mayor tamaño se encuentran en la zona comprendida por los campos Teca-Nare con 1335 Mmbpe, Palagua con 1329 Mmbpe, Moriche con 651 Mmbpe, Los valores de *original oil in place* (OOIP) para toda la zona son 5903 Mmbpe.

Recursos por descubrir Análisis fractal pronóstico



Ley de Pareto	
No campos proyectado	54
OOIP 80%	7722
No campos OOIP 80%	11
% Campos con el 80%	20%
Pareto Proyectado	80 / 20
No campos nuevos	24
Pronóstico OOIP (Mmbpe)	3750

Tamaño OOIP (Mmbpe)	No de Campos Propuestos
Mayor de 1000	0
entre 500-1000	2
entre 100 -500	6
entre 50-100	0
entre 20-50	2
entre 10-20	5
entre 5-10	3
menor de 5	6
TOTAL	24



Distribución fractal pronóstico del sector norte de la Cuenca VMM en función del tamaño de los campos descubiertos y por descubrir.

Recursos por descubrir Análisis Fractal

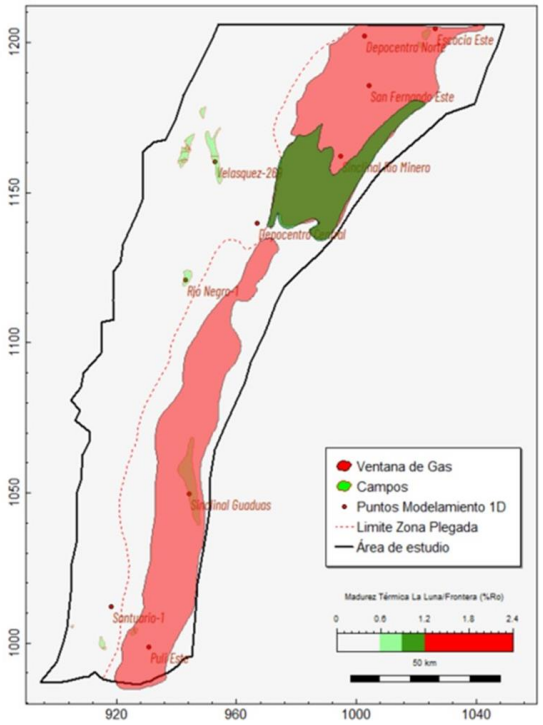
Tamaño OOIP (Mmbpe)	No. campos actuales	No. campos pronóstico	No. total campos
Mayor de 1000	2	0	2
Entre 500-1000	3	2	5
Entre 100 -500	6	6	12
Entre 50-100	3	0	3
Entre 20-50	4	2	6
Entre 10-20	5	5	10
Entre 5-10	1	3	4
Menor de 5	6	6	12
TOTAL	30	24	54

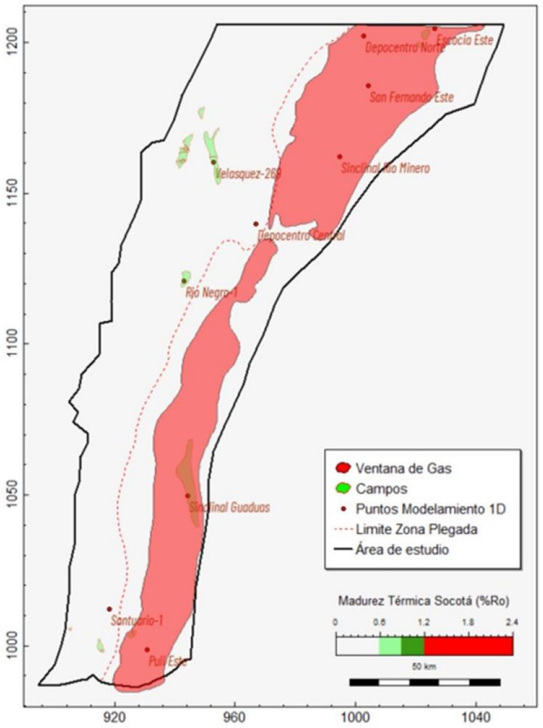
Se añaden un total de 24 campos nuevos, ocho (8) de los cuales tienen OOIP superior a los 500 Mmbpe .

Dos de los campos a encontrar tendría más de 800 Mmbpe, lo cual los ubicaría como el tercer y cuarto campo más grande de este sector de la cuenca.

Los descubrimientos adicionales en la cuenca sumarían 3750 Mmbpe (OOIP).

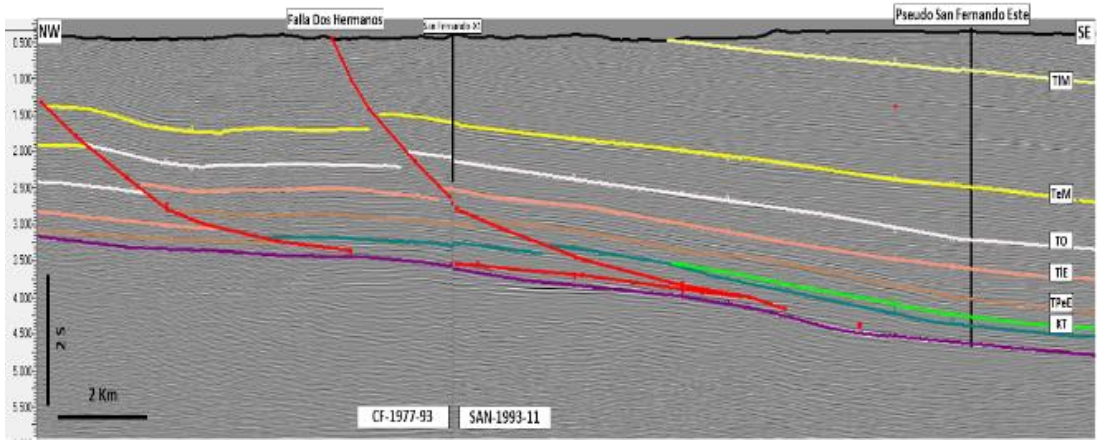
Recursos por descubrir Balance de Masas



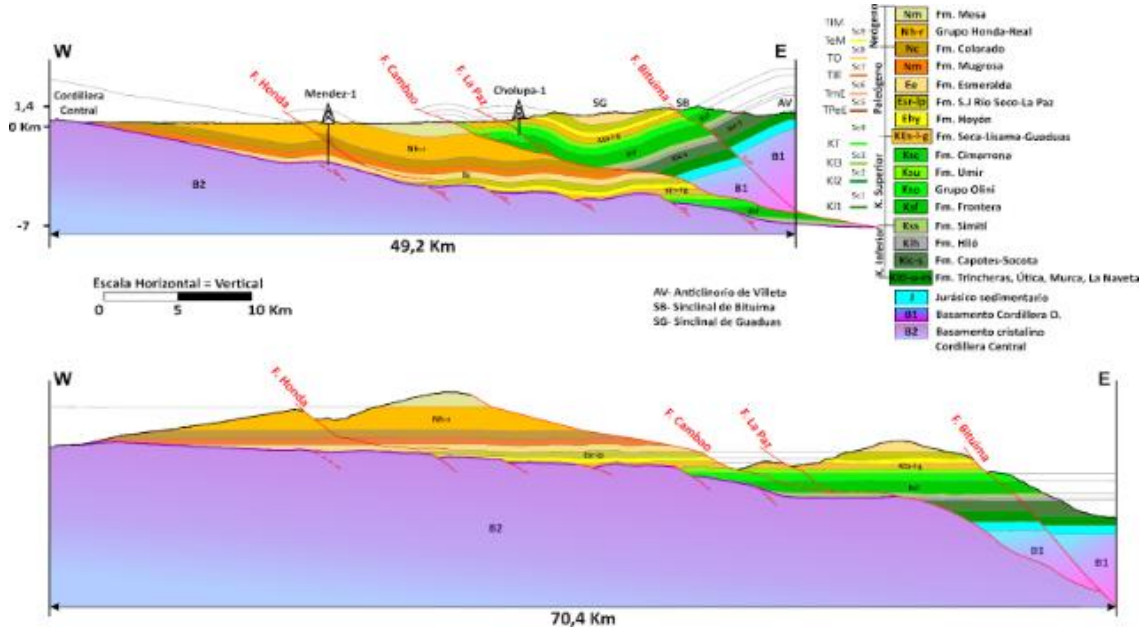


FM. LA LUNA - FRONTERA (Cretácico Superior)	
Poligono	**km2**
1. San Fernando	1346
2. Guaduas	1962
FM. HILÓ - SOCOTÁ (Cretácico Inferior)	
Poligono	**km2**
1. San Fernando	1495
2. Guaduas	2180

Foco Generación San Fernando



Foco Generación Guaduas



Recursos por descubrir Balance de Masas

PARÁMETROS	UNIDADES	CUENCA VMM SECTOR SUR		TOTAL
		FG San Fernando	FG Guaduas	
HC´s Generados / LA LUNA-FRONTERA	Mmbpe	25,601	37,321	62,921
Hc´s Disponibles / LA LUNA -FRONTERA	Mmbpe	4,800	6,998	11,798
HC´s Generados / HILÓ-SOCOTÁ	Mmbpe	68,079	99,253	167,332
Hc´s Disponibles / HILÓ-SOCOTÁ	Mmbpe	8,935	13,027	21,962
Total HC´s Generados	Mmbpe	93,680	136,574	230,253
Recursos Disponibles	Mmbpe	13,735	20,025	33,760
Recursos Descubiertos (OOIP)	Mmbpe	5,407	496	5,903
Recursos No Descubiertos	Mmbpe	8,328	19,529	27,857
Probabilidad de Hallazgo	%	16%	16%	16%
Recursos Prospectivos (OOIP)	Mmbpe	**1333**	**3125**	**4457**
Factor de Recobro	**%**	20%	20%	20%
Recursos Prospectivos Recuperables (FR = 20%)	Mmbpe	**267**	**625**	**891**

Discriminación de Recursos prospectivos por Descubrir Crudo y Gas

Parámetro		Unidades	SAN FERNANDO		GUADUAS		TOTAL
			Frontera	Socota	Frontera	Socota	
P.CALCULADOS	Aceite Expulsado/Km2	Mmbp/km2	15	33,6	17,7	17,7	
	Gas Expulsado/Km2	Gpc/km2	38,6	78,5	41,3	45,5	
	Total Hidrocarburos Expulsados/Km2	Mmbpe/km2	21,7	47,1	24,8	25,5	
RESULTADOS	Hidrocarburos Liquidos	%	69%	71%	71%	69%	
	Hidrocarburos Gaseosos	%	31%	29%	29%	31%	
	Hidrocarburos Disponibles Balance de Masas	Mmbpe	4800,1	8935,4	6997,6	13027	33760,1
	Hidrocarburos Líquidos Disponible	Mmbp	3318,1	6374,3	4994,3	9042,3	23728,9
	Hidrocarburos Gaseosos Disponibles	Mmbpe	1482,1	2561,1	2003,4	3984,7	10031,2
	Hidrocarburos Gaseosos Disponibles	Tpc	**8,9**	**15,4**	**12,1**	**24**	**60,4**
	Probabilidad de hallazgo	%	16%	16%	16%	16%	
	Recursos Prospectivos Gas	Tpc	**1,4**	**2,5**	**1,9**	**3,8**	**9,7**

1719 Mmbpe

Recursos por Descubrir OOIP Mmbpe

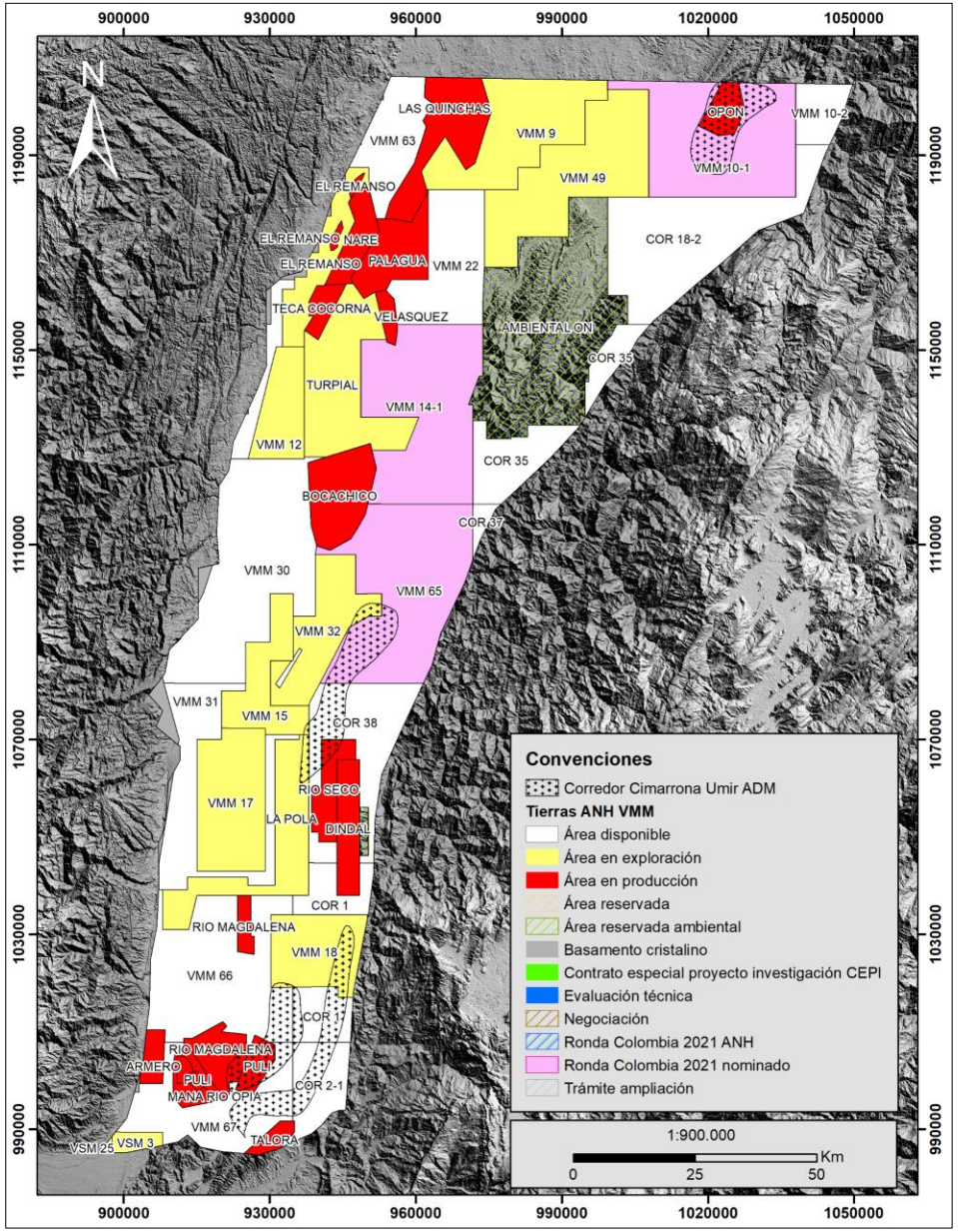
Recursos por Descubrir Método Creaming Curve. Escenario Mínimo
Proyección para los próximos 20 años con tendencia de descubrimiento promedio de los últimos años 1500 Mmbpe.

Recursos por Descubrir Método Fractales.
El pronóstico realizado cumpliendo ley de Pareto y un coeficiente de correlación del 98%.
Recursos por descubrir 3750 Mmbpe.

Recursos por Descubrir Método Balance de Masas.
Foco Generador Guaduas Formaciones Hiló-Socotá y La Luna-Frontera. 3125 Mmbpe
Foco Generador San Fernando Formaciones Hiló-Socotá y La Luna-Frontera. 1333 Mbpe
Total 4457 Mmbpe.
La discriminación de recursos de gas por descubrir a partir del balance de masas arroja un valor de 9,7 Tpc de gas (1719 Mmbpe)

AREAS ADVERTISEMENT 2022

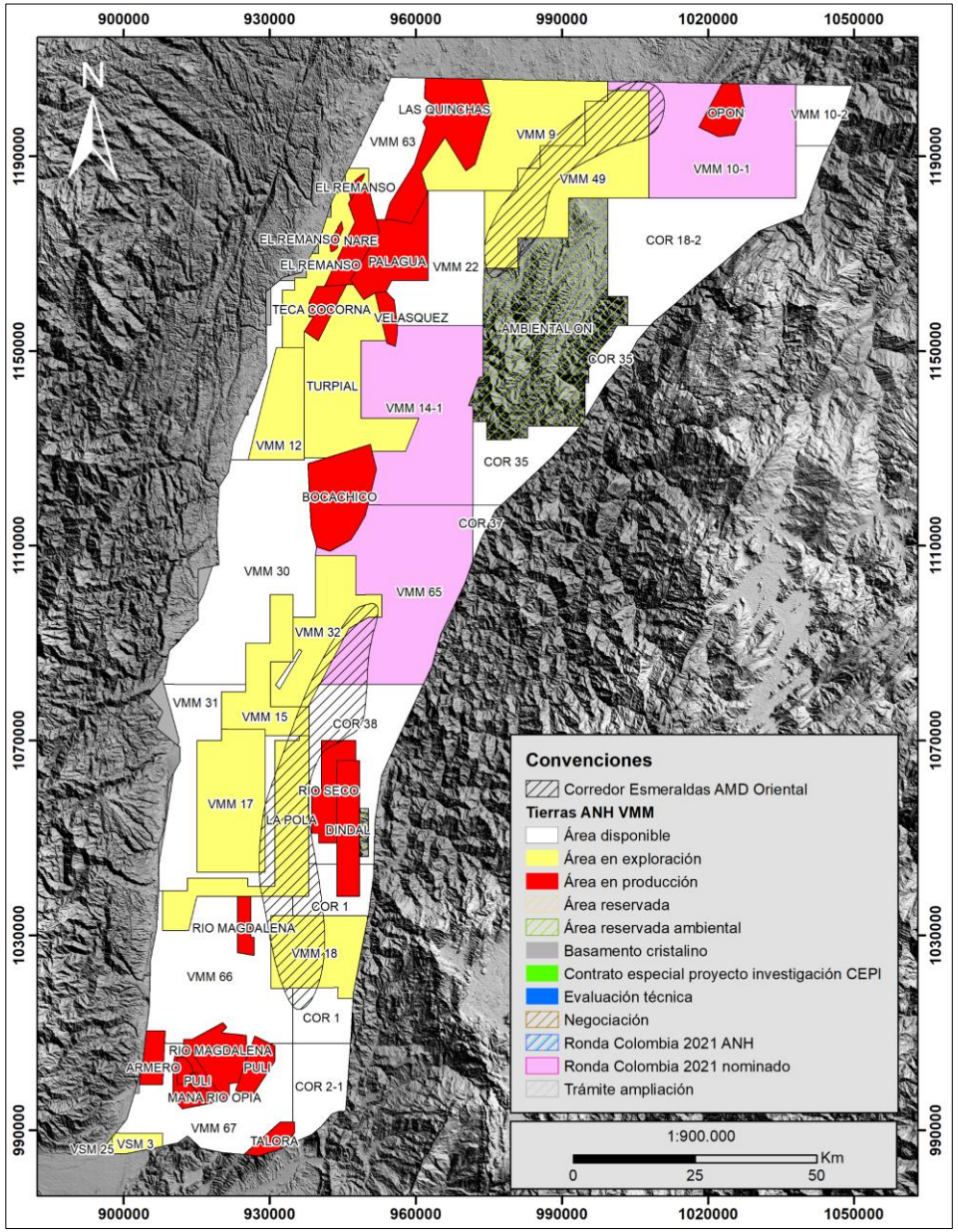
Cimarrona Umir ADM play fairway map



AGENCIA NACIONAL DE **HIDROCARBUROS**

AREAS ADVERTISEMENT 2022

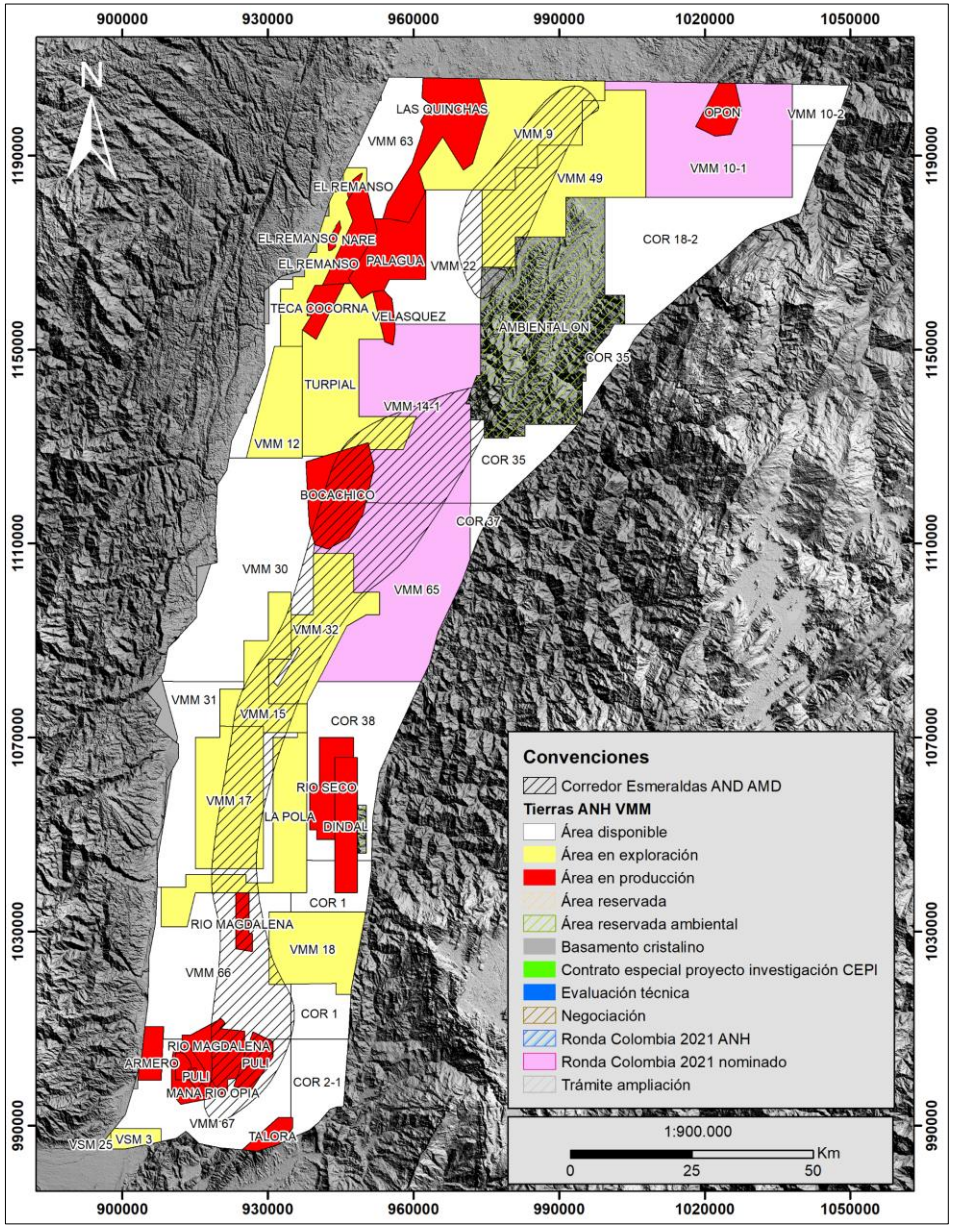
Esmeraldas AMD Oriental play fairway map



AGENCIA NACIONAL DE **HIDROCARBUROS**

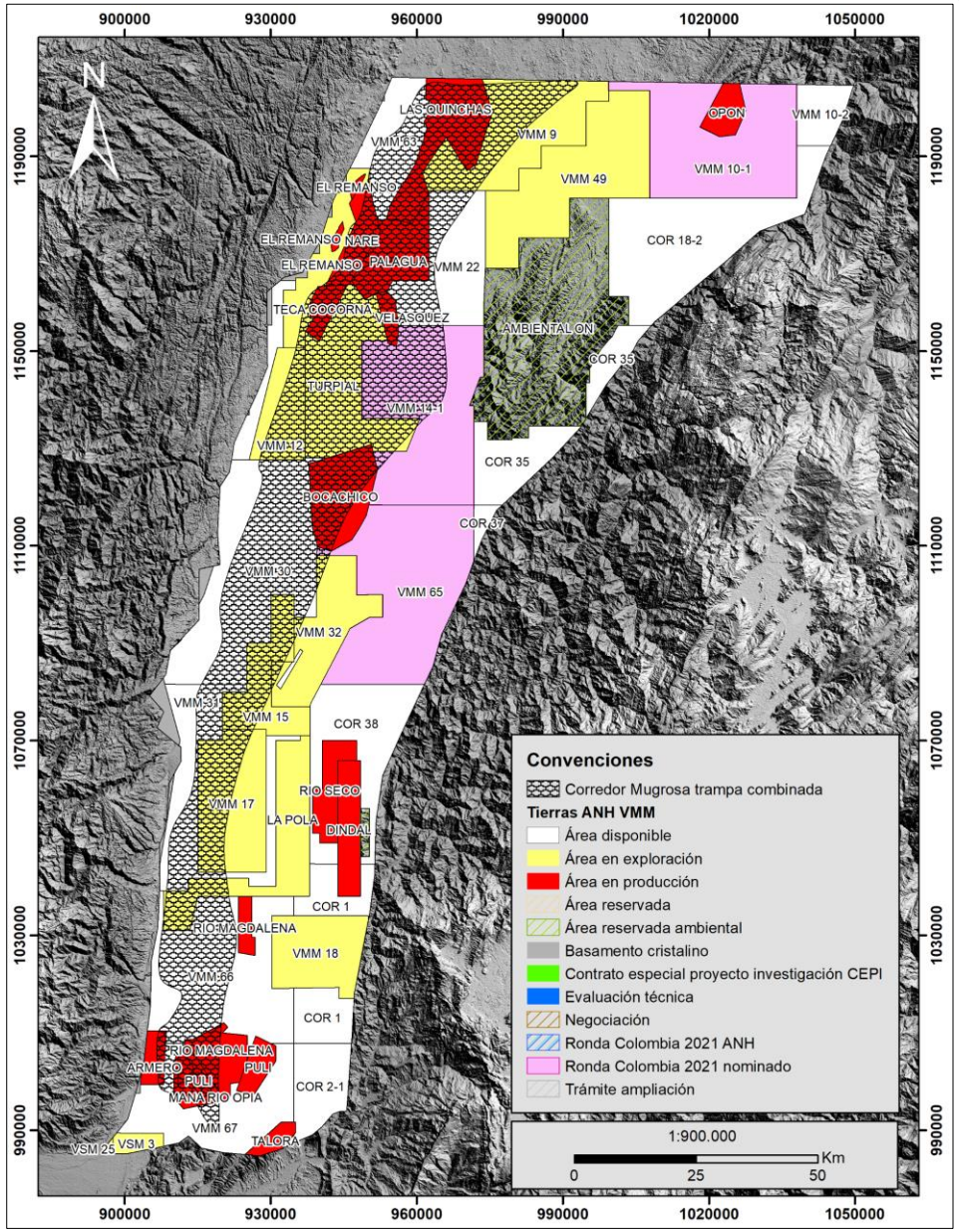
AREAS ADVERTISEMENT 2022

Esmeraldas and AMD play fairway map



AREAS ADVERTISEMENT 2022

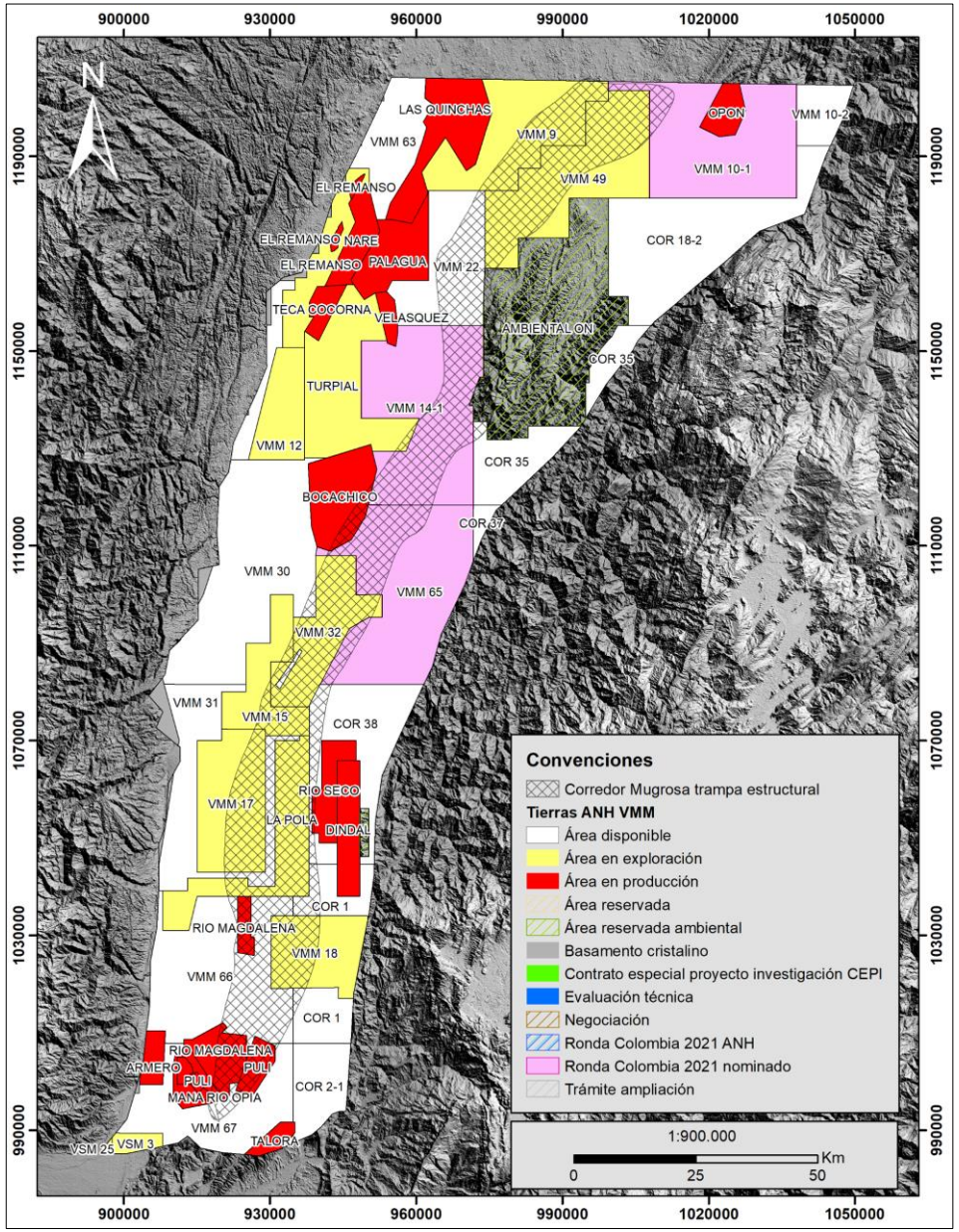
Mugrosa trap combined play fairway map



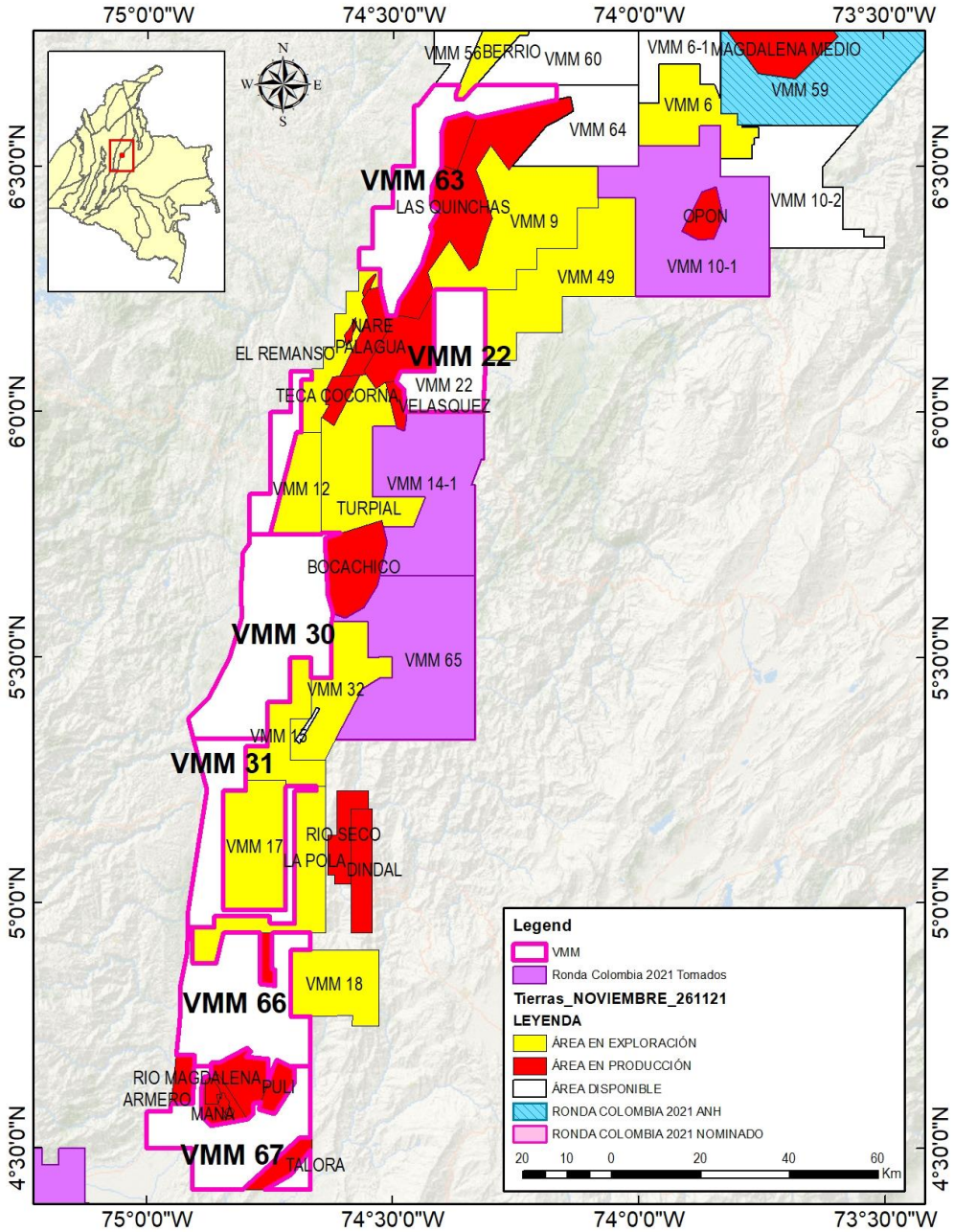
AGENCIA NACIONAL DE **HIDROCARBUROS**

AREAS ADVERTISEMENT 2022

Mugrosa trap structural play fairway map

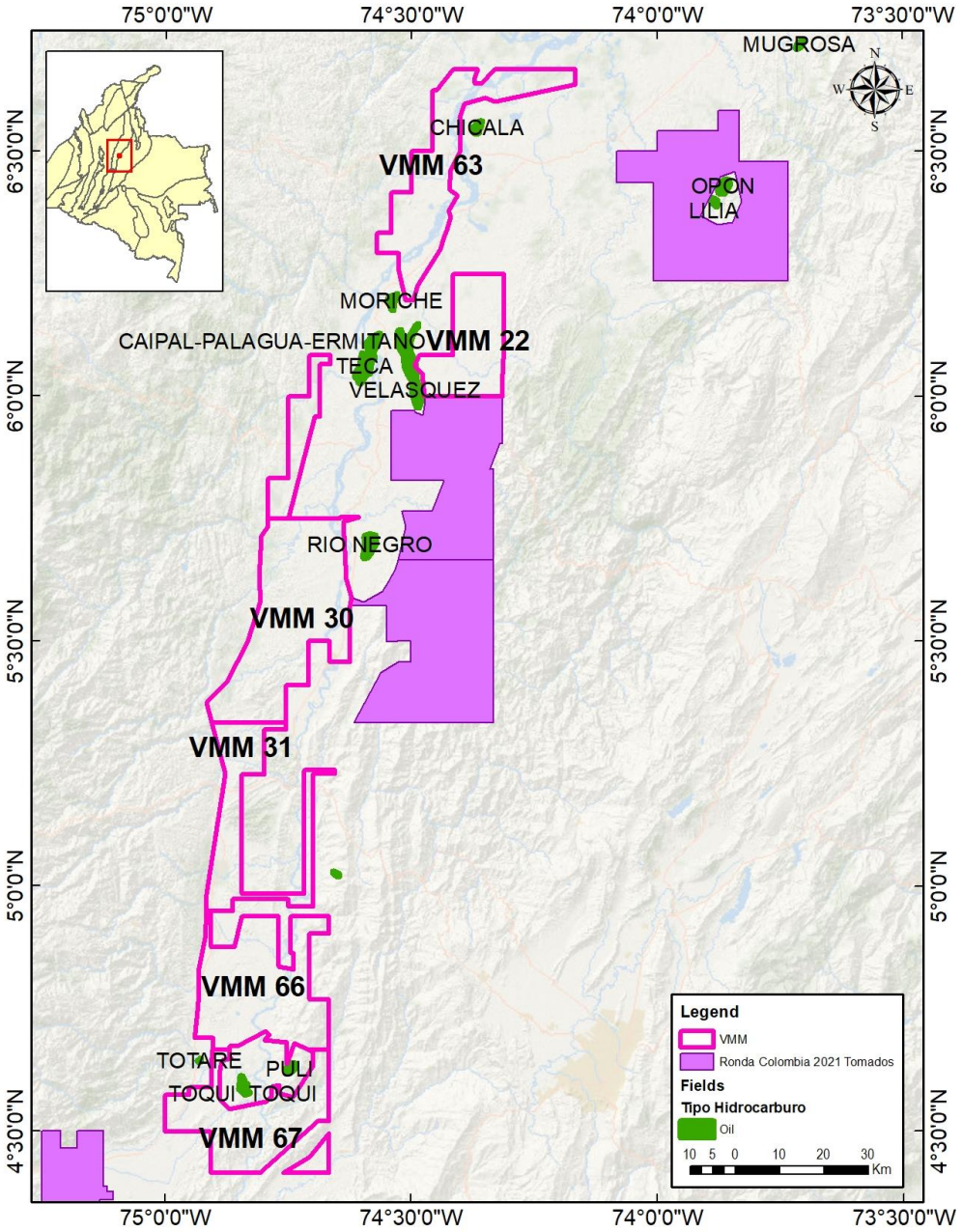


AGENCIA NACIONAL DE **HIDROCARBUROS**



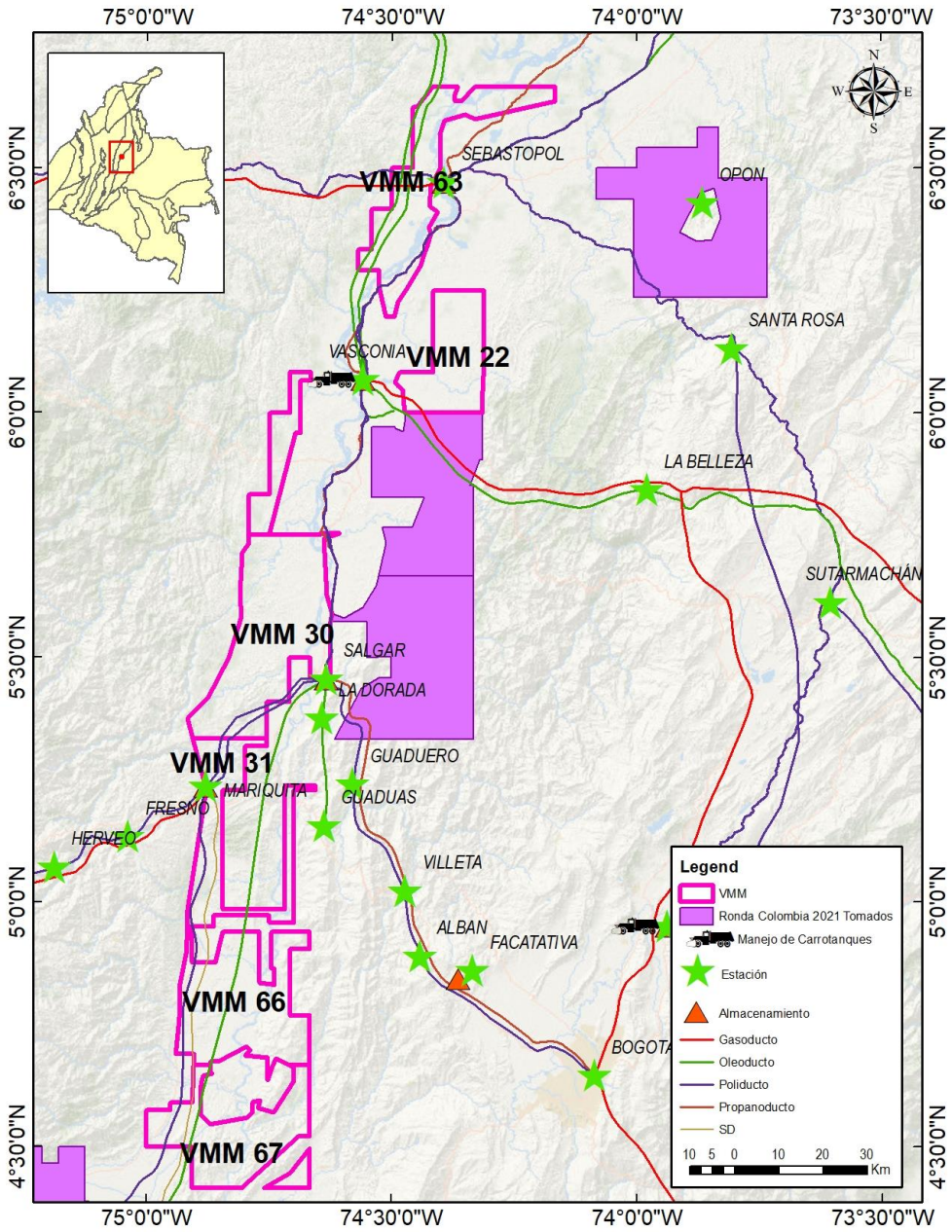
VMM 63 - VMM 22 - VMM 30
VMM 31 - VMM 66 - VMM 67

MAPA DE TIERRAS



VMM 63 - VMM 22 - VMM 30
VMM 31 - VMM 66 - VMM 67

CAMPOS



VMM 63 - VMM 22 - VMM 30 VMM 31
VMM 66 - VMM 67

INFRAESTRUCTURA PETROLERA