Overview of the Oil and Gas Basins of Colombia

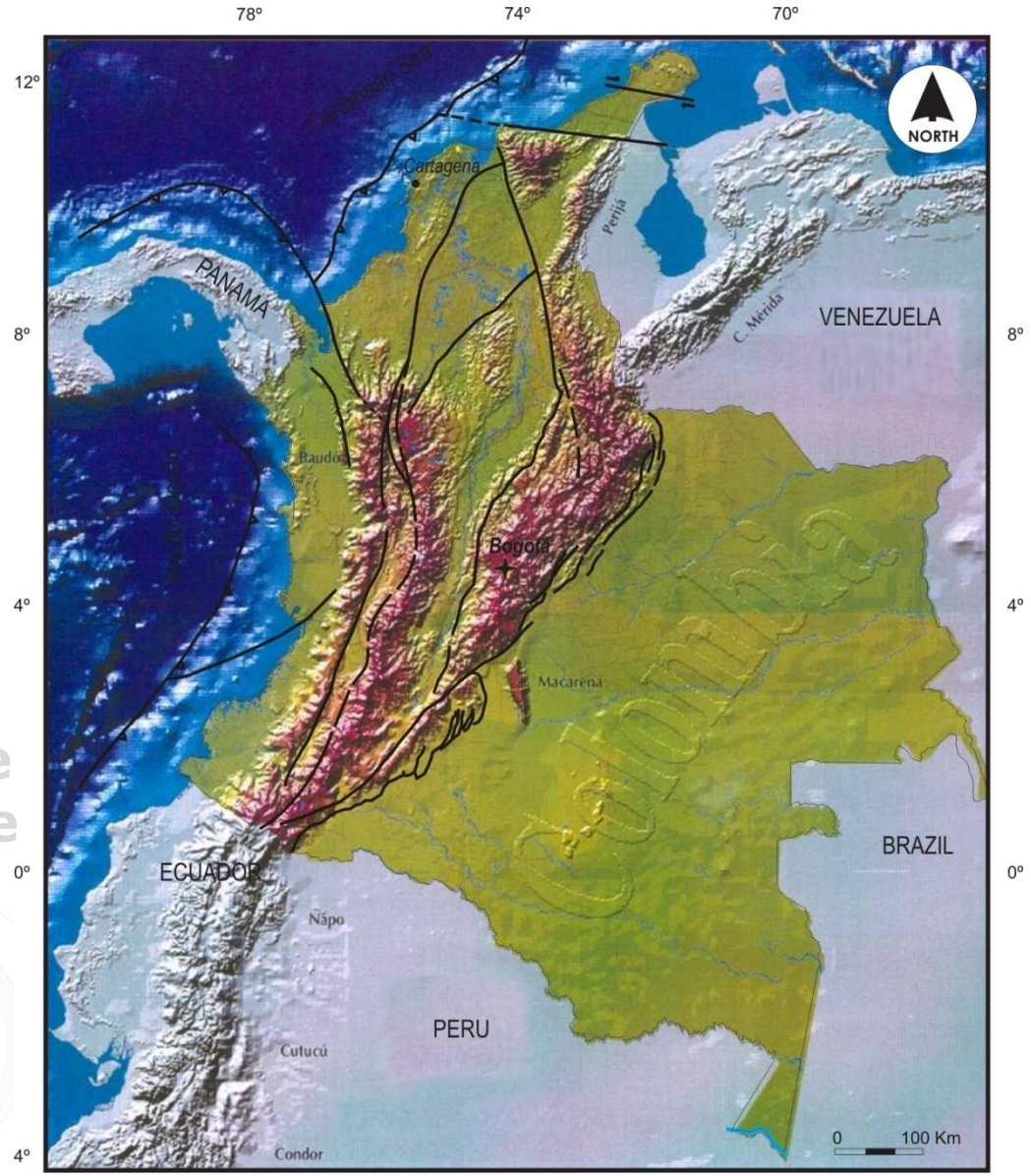
Presented by:

Jairo Mojica
Geologist, PhD.
Advisor – Technical Branch
National Hydrocarbons Agency (ANH)

Colombia

BASINS OF COLOMBIA

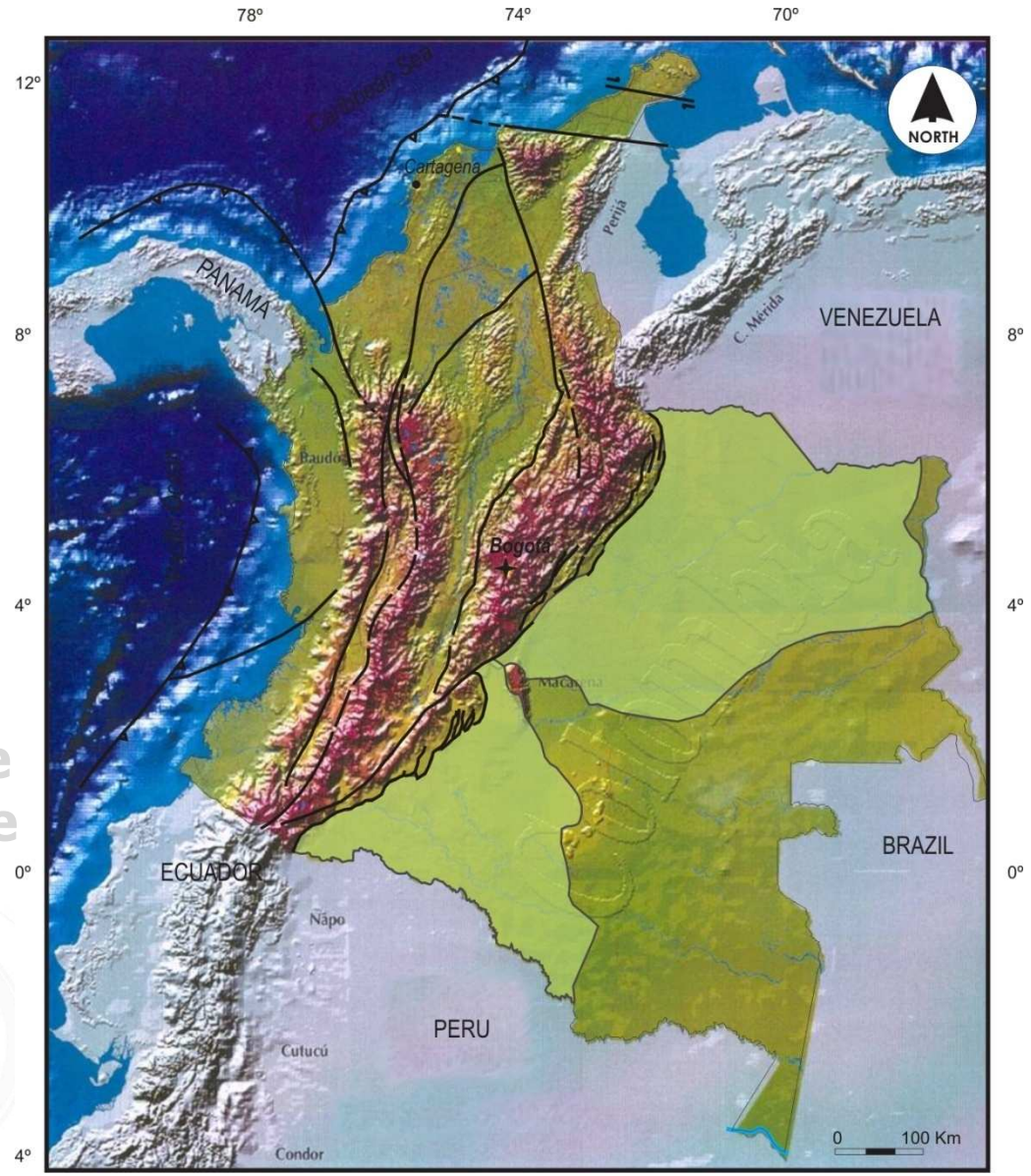
1. Pericratonic
2. Mountain and Intermountain
3. Coastal Onshore
4. Coastal Offshore



Colombia

BASINS OF COLOMBIA

1. **Pericratonic**
2. Mountain and Intermountain
3. Coastal Onshore
4. Coastal Offshore



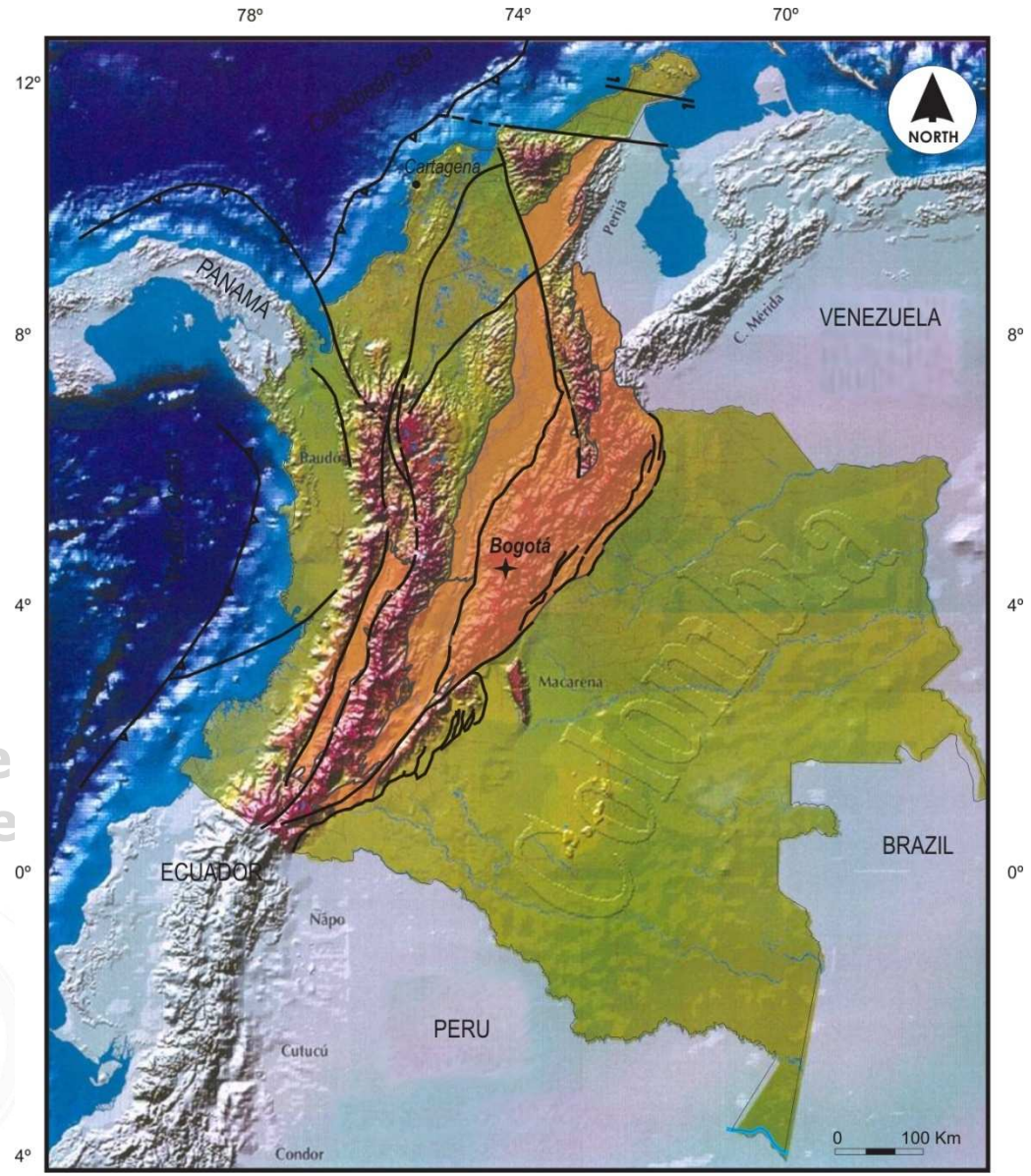
AGENCIA NACIONAL DE **HIDROCARBUROS**

Open Round COLOMBIA 2010

Colombia

BASINS OF COLOMBIA

1. Pericratonic
2. **Mountain and Intermountain**
3. Coastal Onshore
4. Coastal Offshore



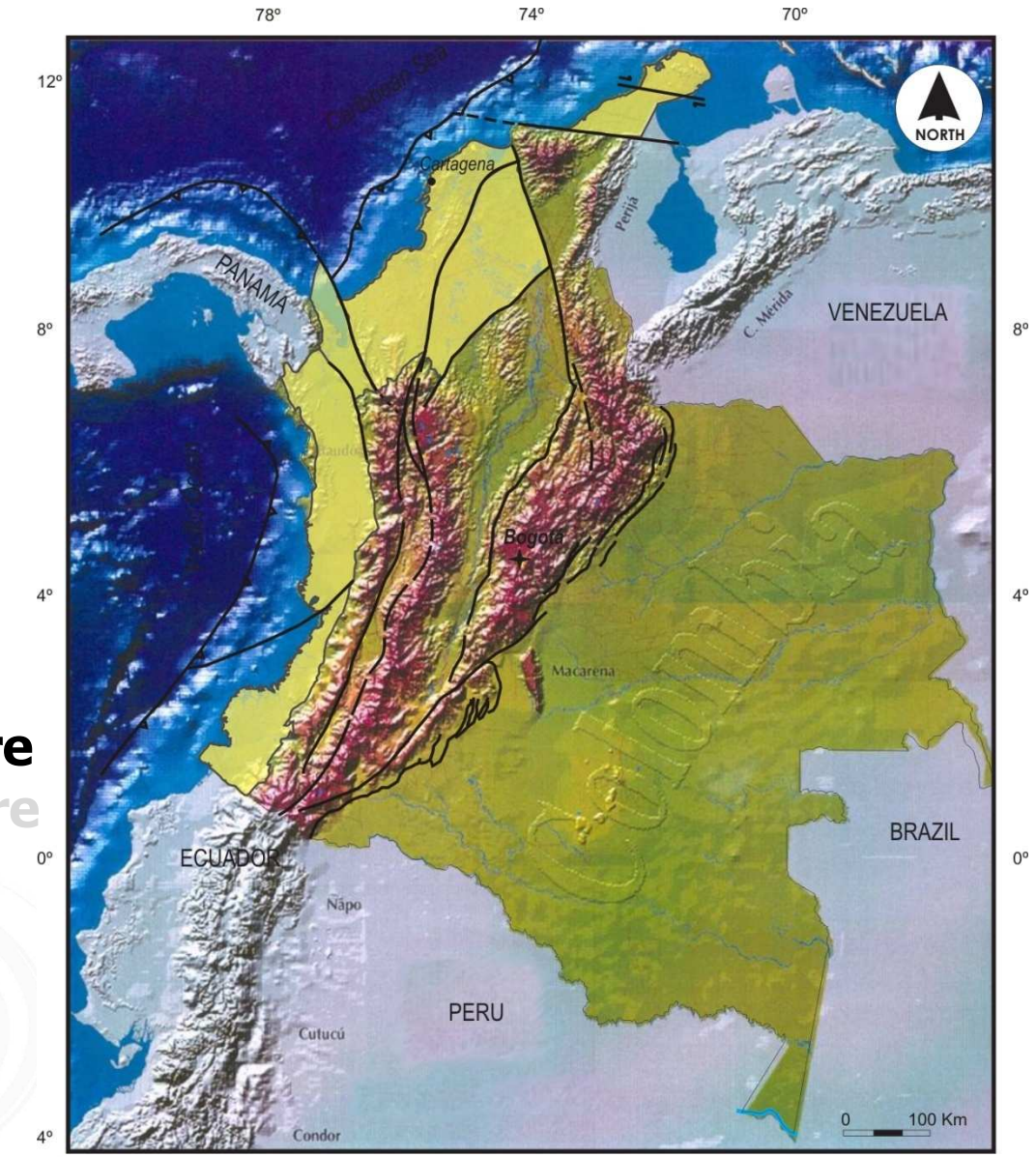
AGENCIA NACIONAL DE **HIDROCARBUROS**

Open Round COLOMBIA 2010

Colombia

BASINS OF COLOMBIA

1. Pericratonic
2. Mountain and Intermountain
3. **Coastal Onshore**
4. Coastal Offshore



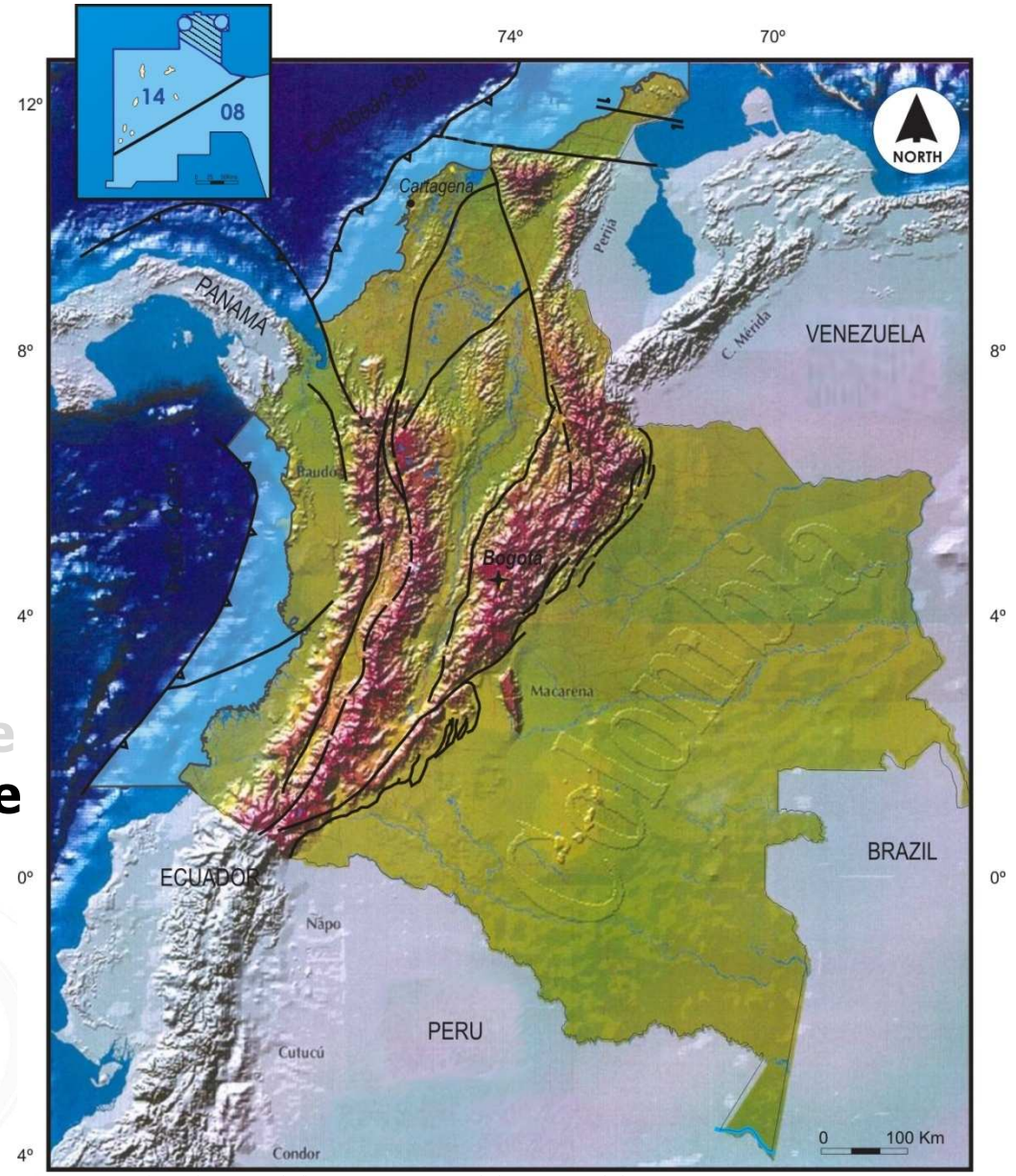
AGENCIA NACIONAL DE **HIDROCARBUROS**

Open Round COLOMBIA 2010

Colombia

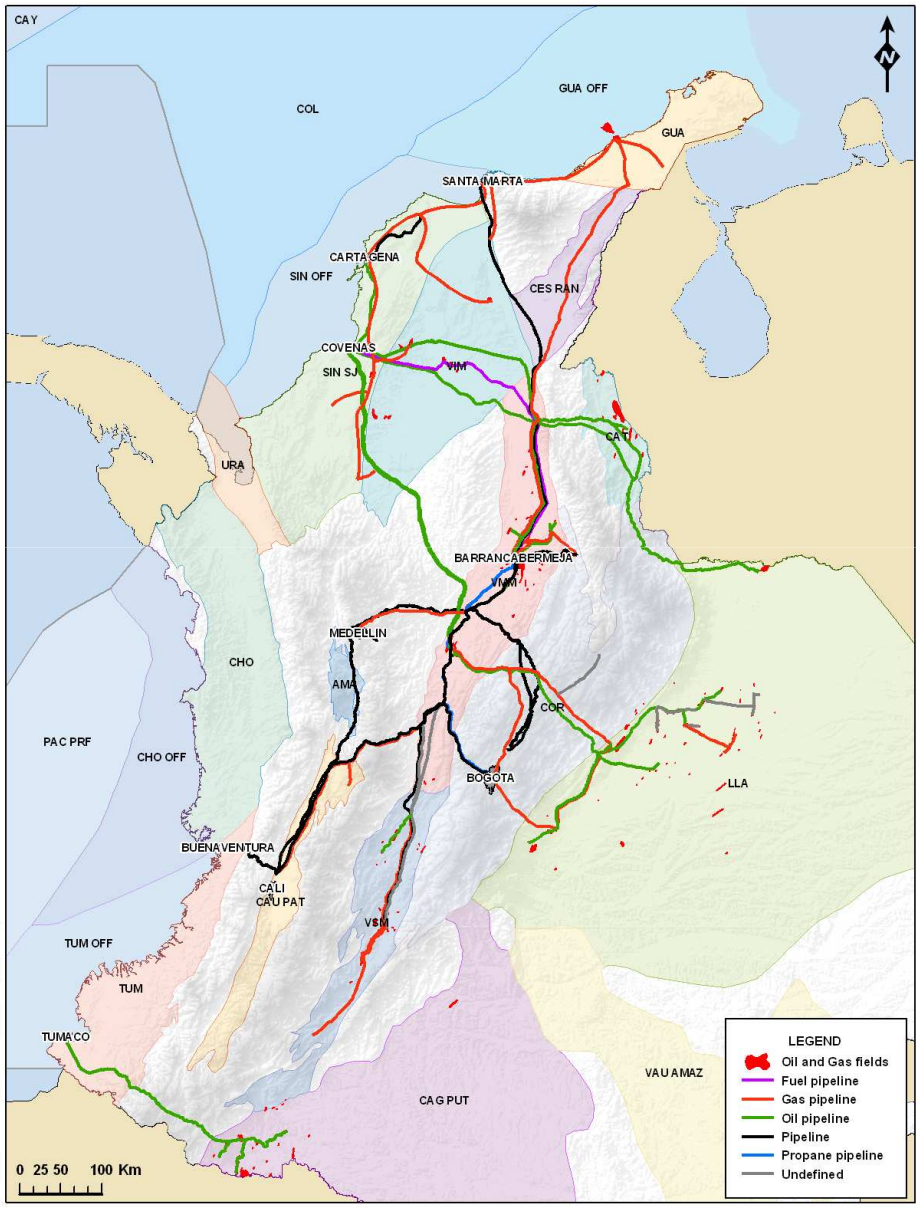
BASINS OF COLOMBIA

1. Pericratonic
2. Intermountain
3. Coastal Onshore
4. **Coastal Offshore**



Colombia

OIL AND GAS INFRASTRUCTURE



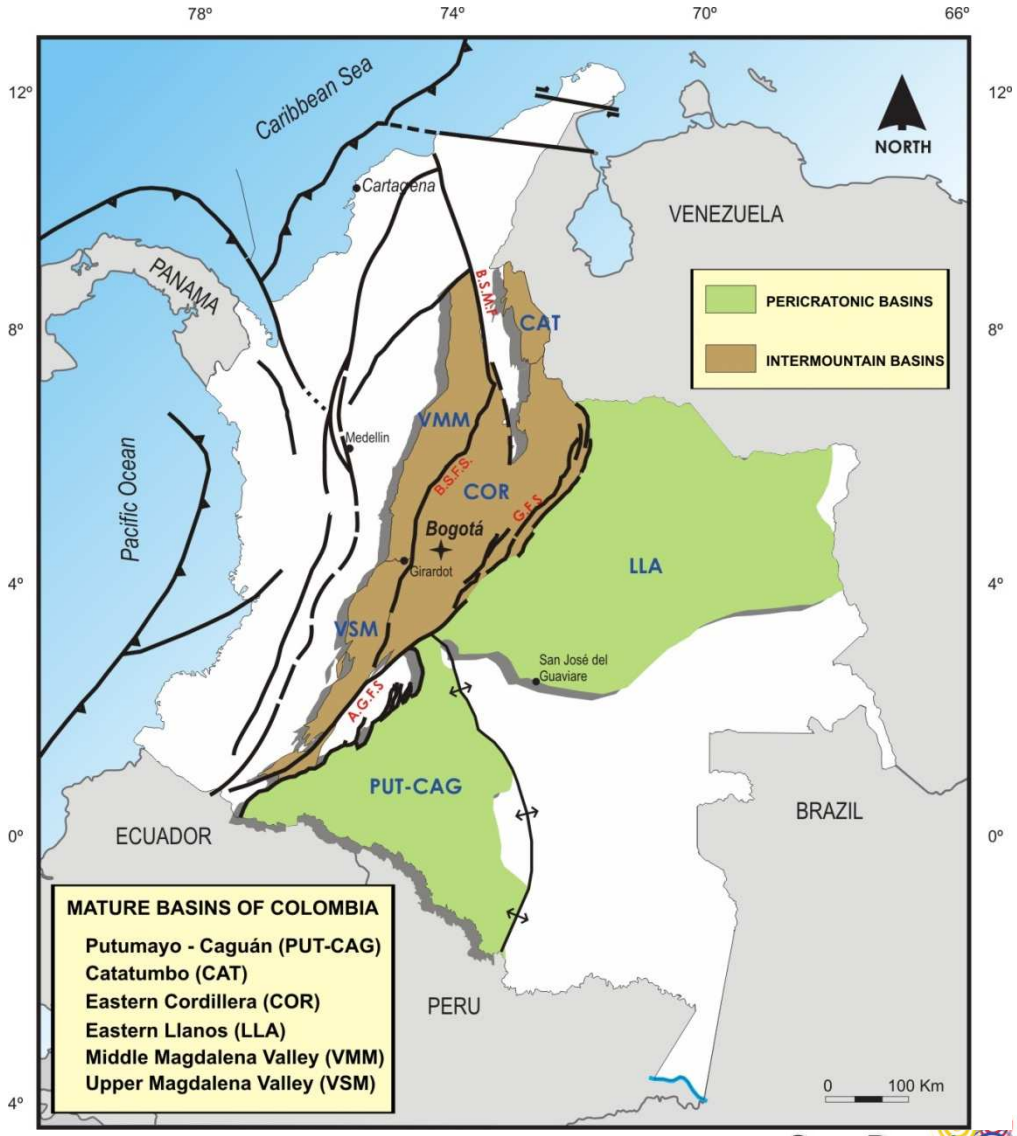
First Part
Mature Basins

Colombia
MATURE BASINS

Area of Mature Basins

BASIN	AREA (Km²)
EASTERN LLANOS (LLA)	225,603
PUTUMAYO-CAGUÁN (PUT - CAG)	110,304
MIDDLE MAGDALENA VALLEY (VMM)	32,949
UPPER MAGDALENA VALLEY (VSM)	21,513
CATATUMBO (CAT)	7,715
EASTERN CORDILLERA (COR)	71,766

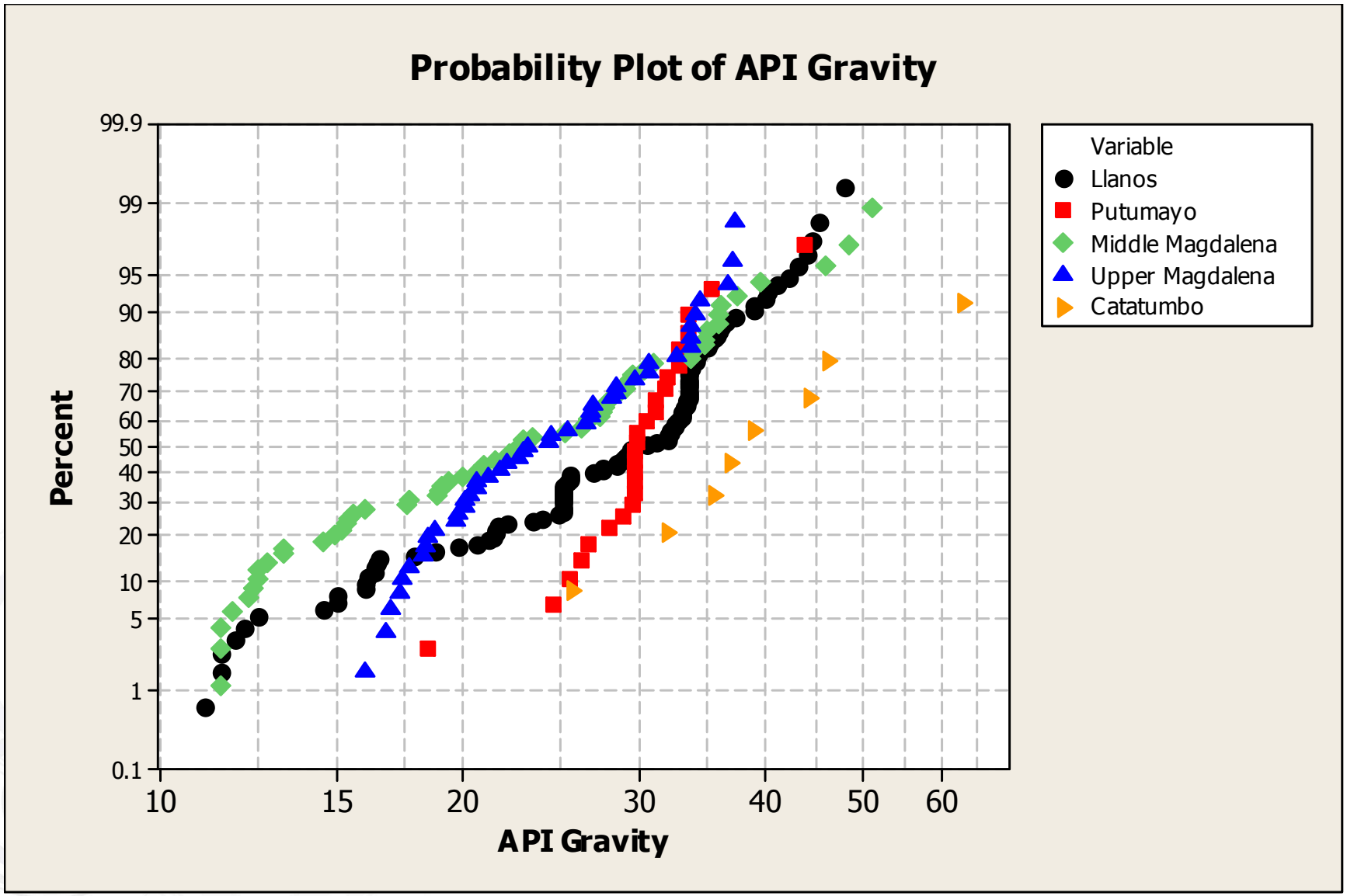
Colombian Mature Basins



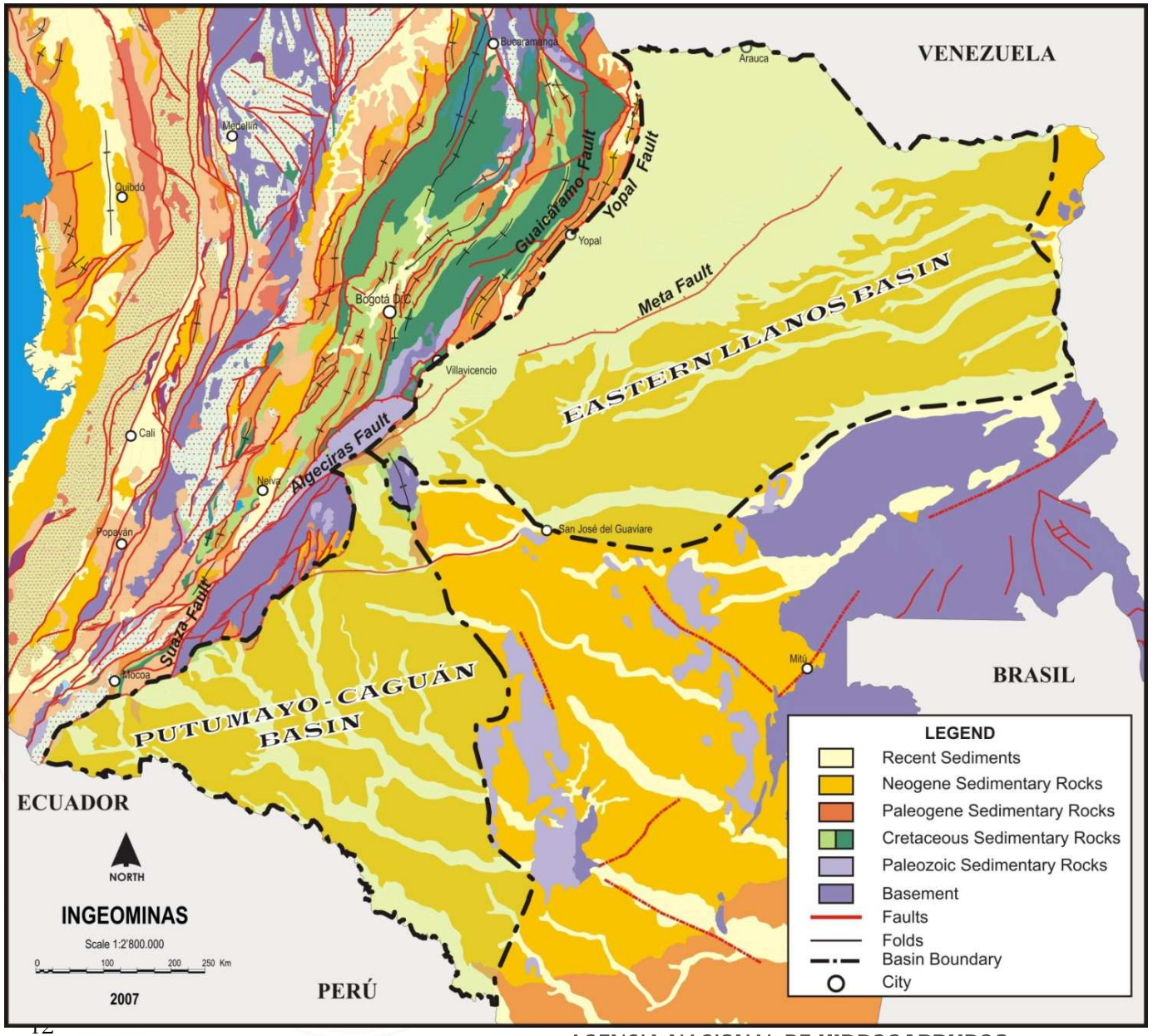
Oil production from Mature Basins

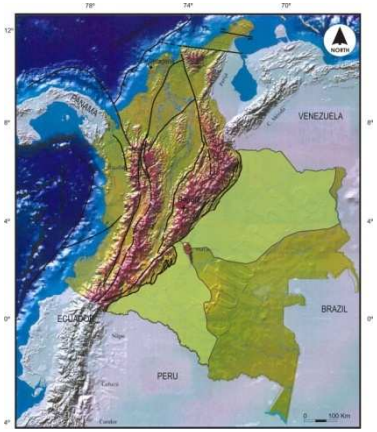
Basin	Current Production (BOPD)	Percent National Production	N. Fields	Light Oil	Medium Oil	Heavy Oil
Eastern Llanos	425,231	66.45%	118	50	33	35
Middle Magdalena Valley	98,687	15.42%	61	10	17	34
Upper Magdalena Valley	88,149	13.78%	44	11	16	17
Putumayo-Caguán	24,000	3.75%	26	8	17	1
Catatumbo	3,283	5.10%	6	5	1	0
Eastern Cordillera	79	1.00%	1	0	0	1
Total	**639,429**	**100%**	**256**	**84**	**84**	**88**

API gravity by basin



Pericratonic basins





Basins

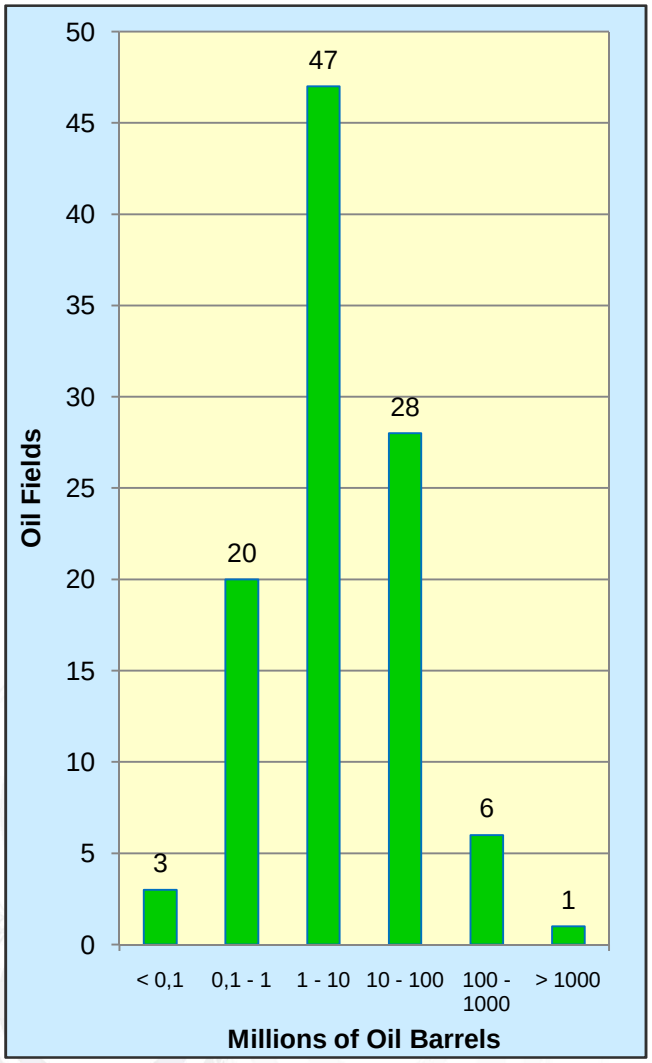
Eastern Llanos

Putumayo - Caguán

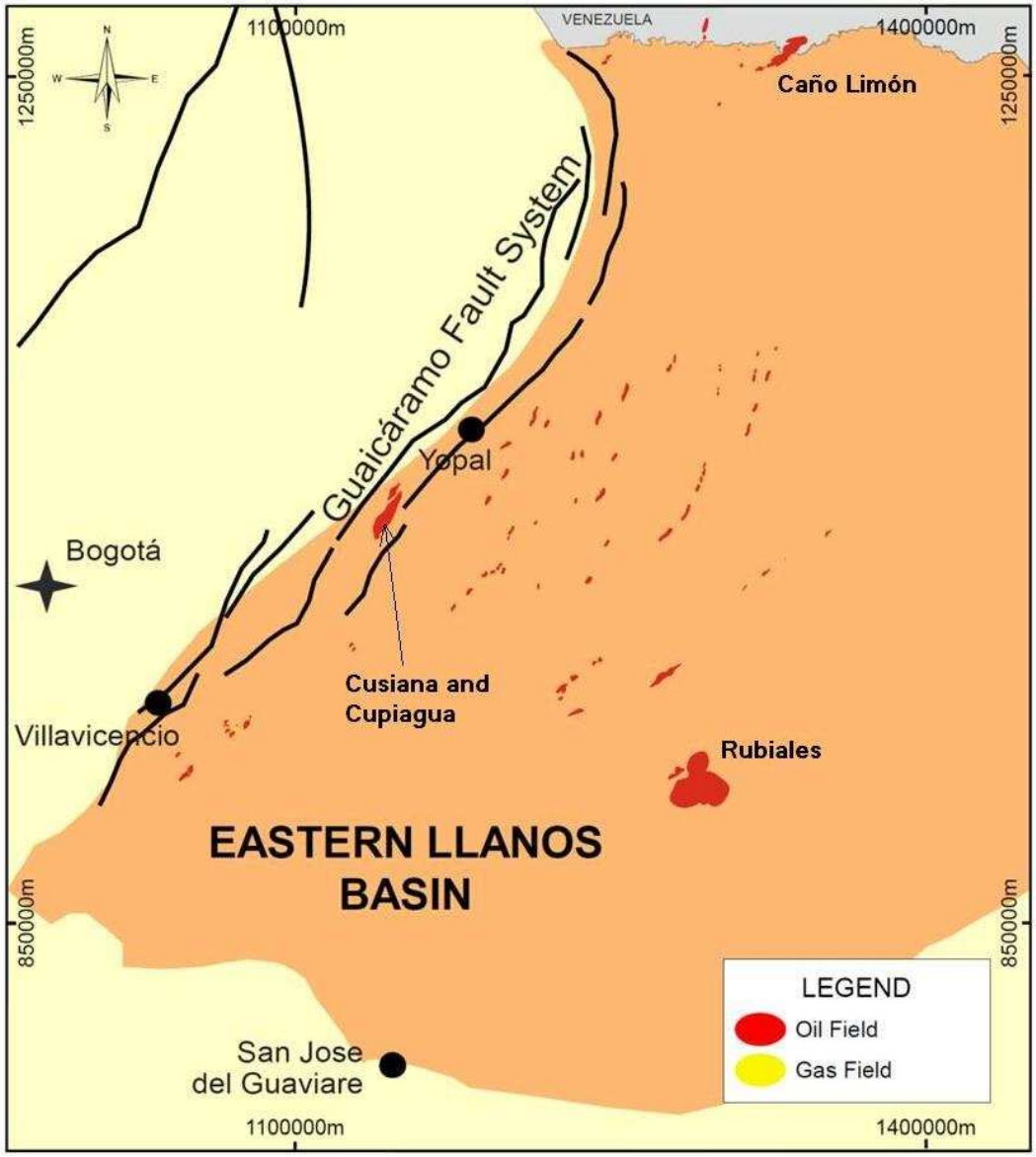
Eastern Llanos

Oil & gas fields

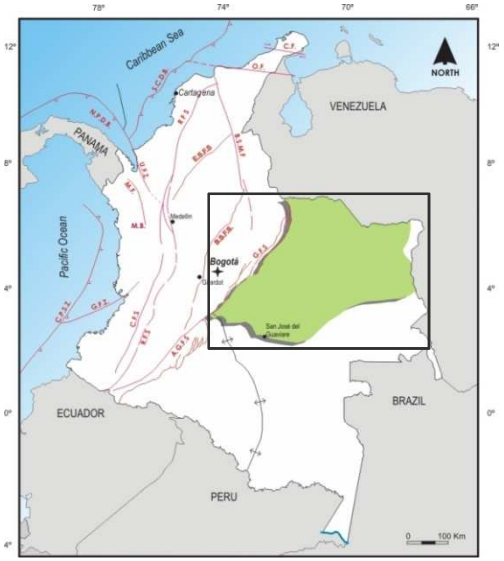
Oil Fields Size Distribution



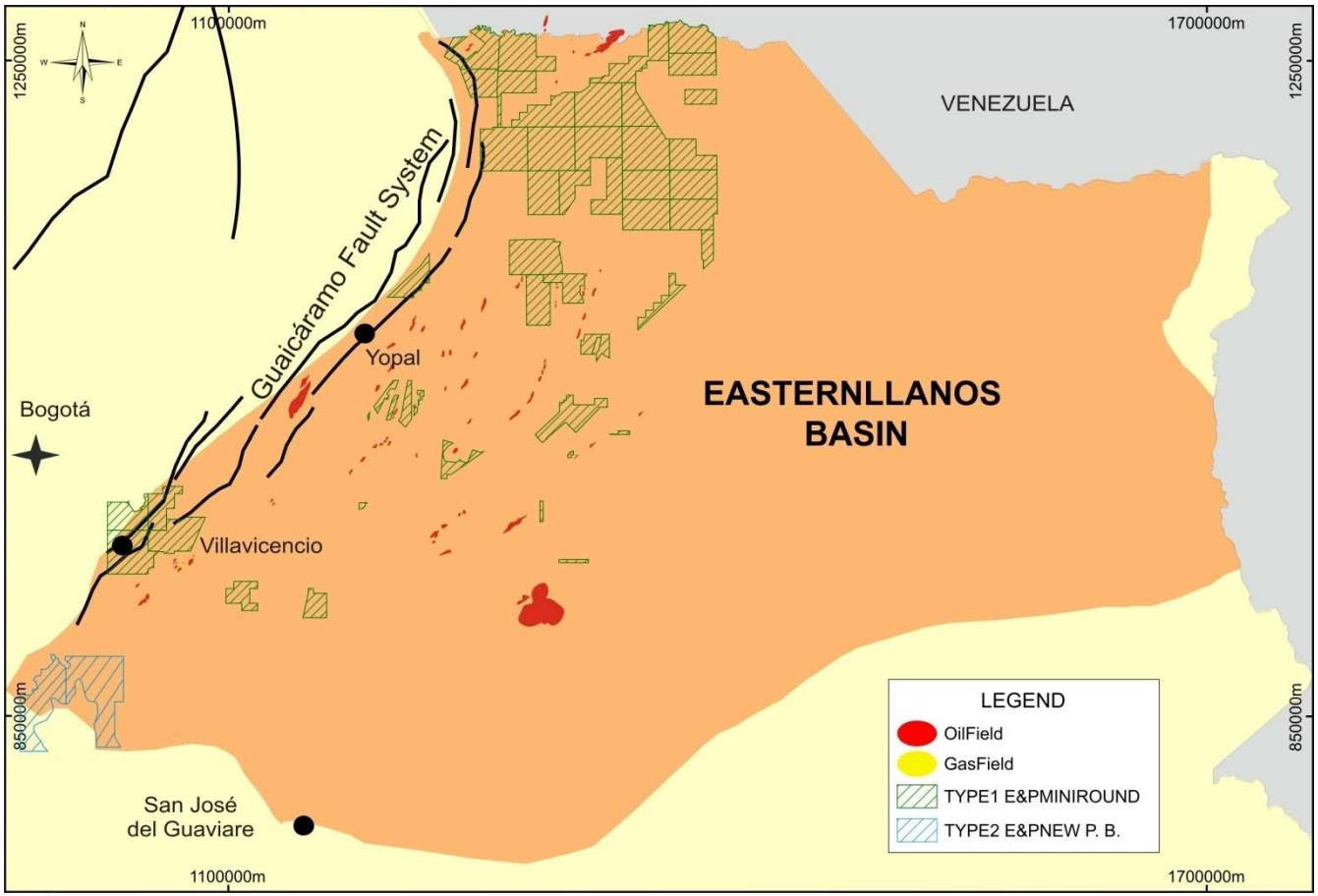
Statistics for 105 Oil Fields



Eastern llanos



Location map with the offered blocks



OPEN ROUND 2010 BLOCKS

Type 1: 52 Blocks
17,183 Km^2

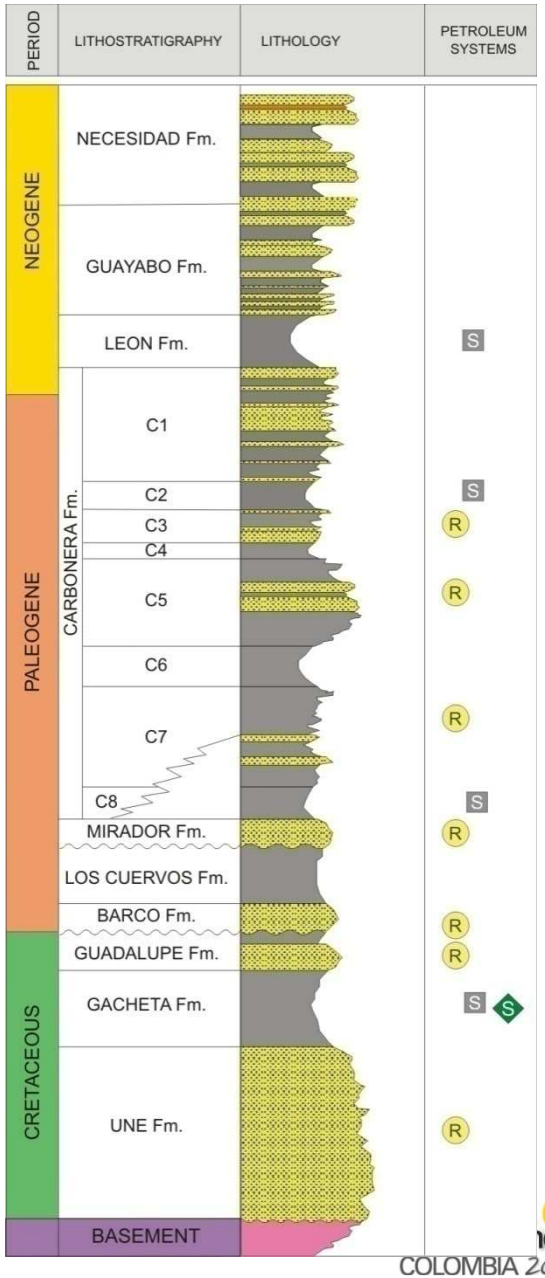
Type 2: 2 Blocks
2,004 Km^2

Eastern Llanos

Petroleum geology

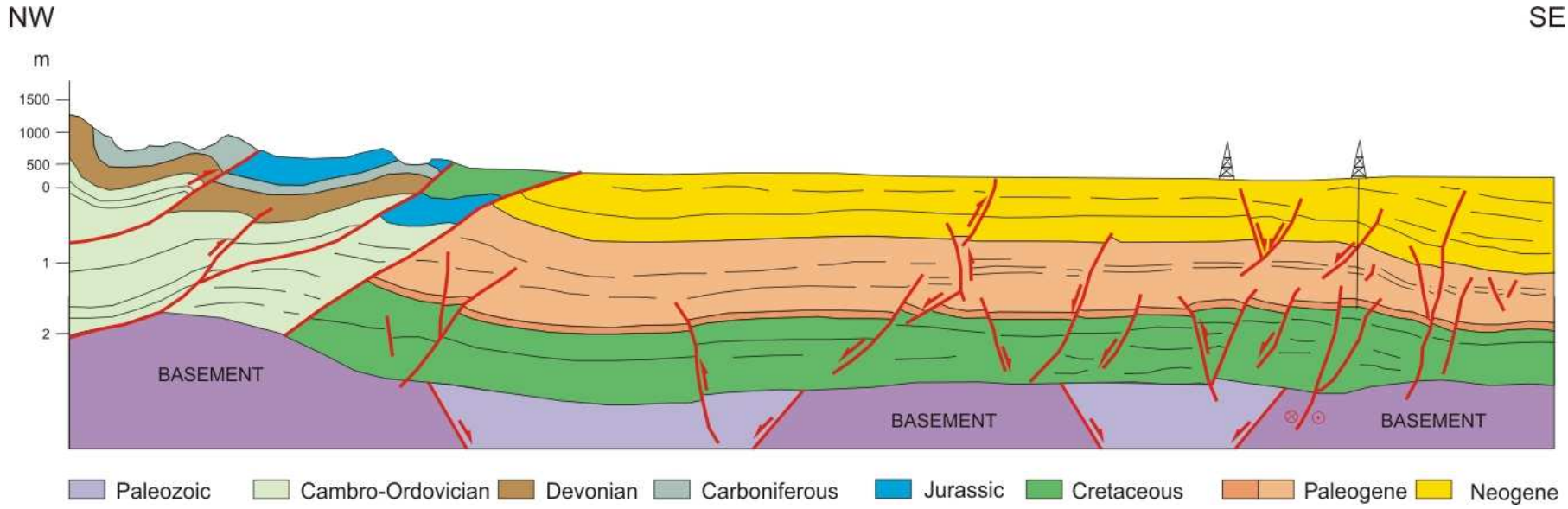
Source rock, reservoirs and seals

PETROLEUM SYSTEM ELEMENT	LITHOLOGIC UNIT	REMARKS
S Source	Gachetá Fm	TOC: 1.0 – 3.0%
R Reservoir	Carbonera Fm Mirador Fm Guadalupe Fm Une Fm	Sandstones Porosity: 10 – 30%
S Seal	León Fm* Carbonera Fm (C2, C4, C6 & C8 Zones) Interbedded shales in Guadalupe Fm & Gachetá Fm	*Regional Seal Local and intraformational shales



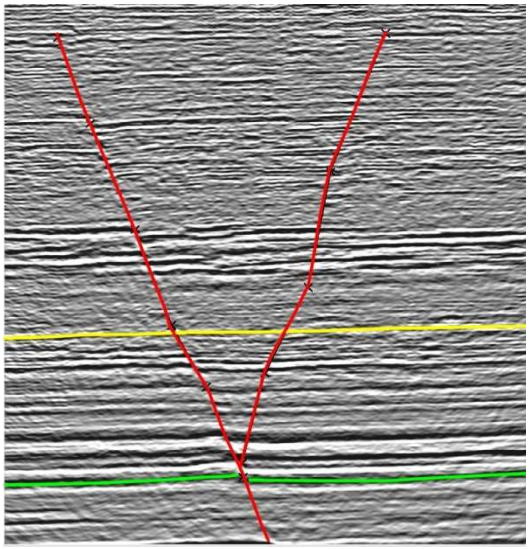
Eastern Llanos

Regional structural style



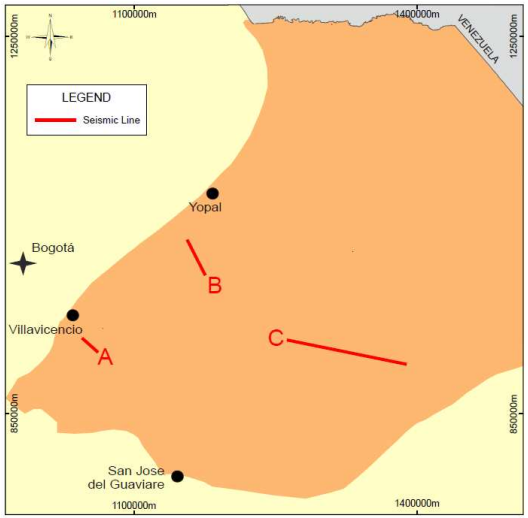
Trap styles within Llanos Basin

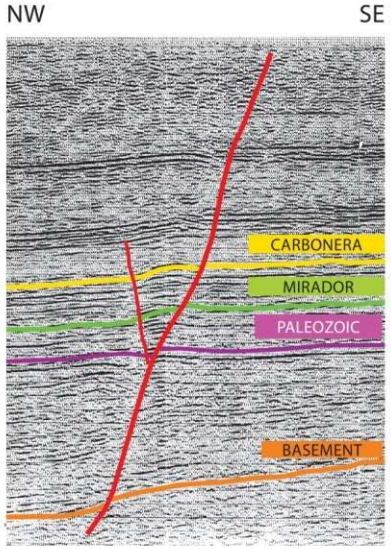
- **Antithetic normal faults**
- **Inversion structures**
- **Anticlines over inversion faults**
- **Stratigraphic traps**
- **Fault-propagation folds**
- **Potential Paleozoic structures**



Eastern Llanos

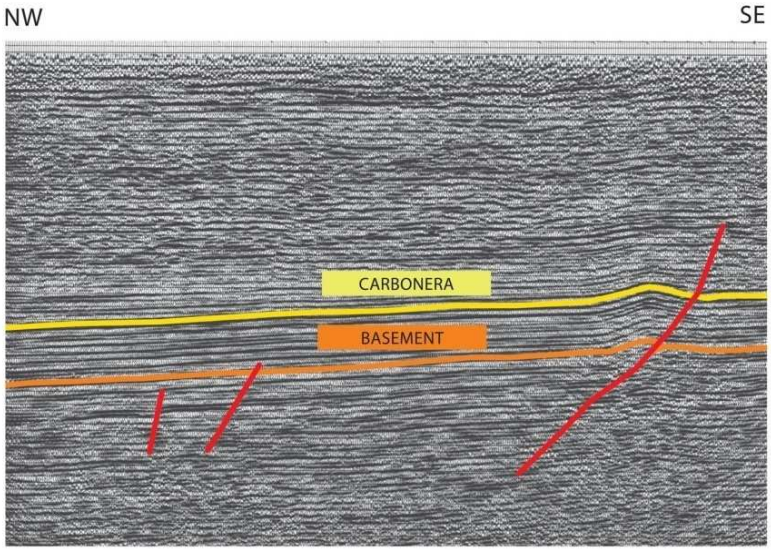
Examples of play types



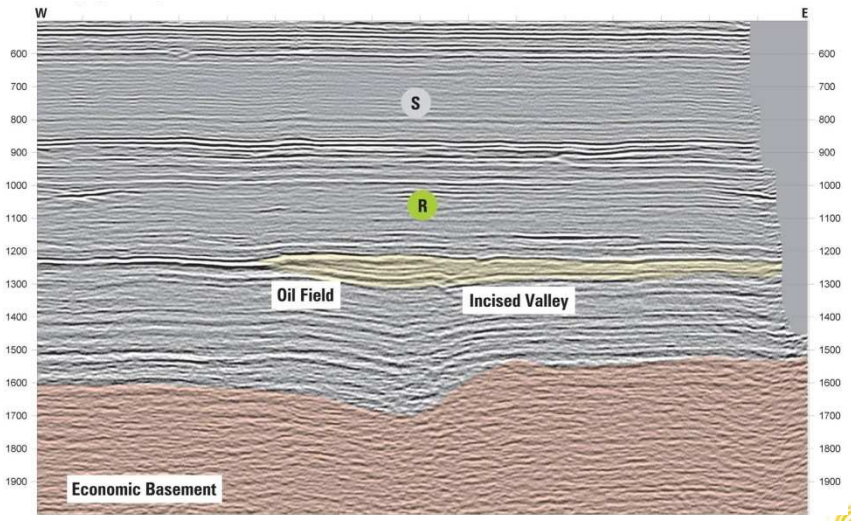


A) Roll-over anticline related to the mild inversion of a normal fault

B) Anticline related to a contractional fault. Carbonera Fm. over a basement high



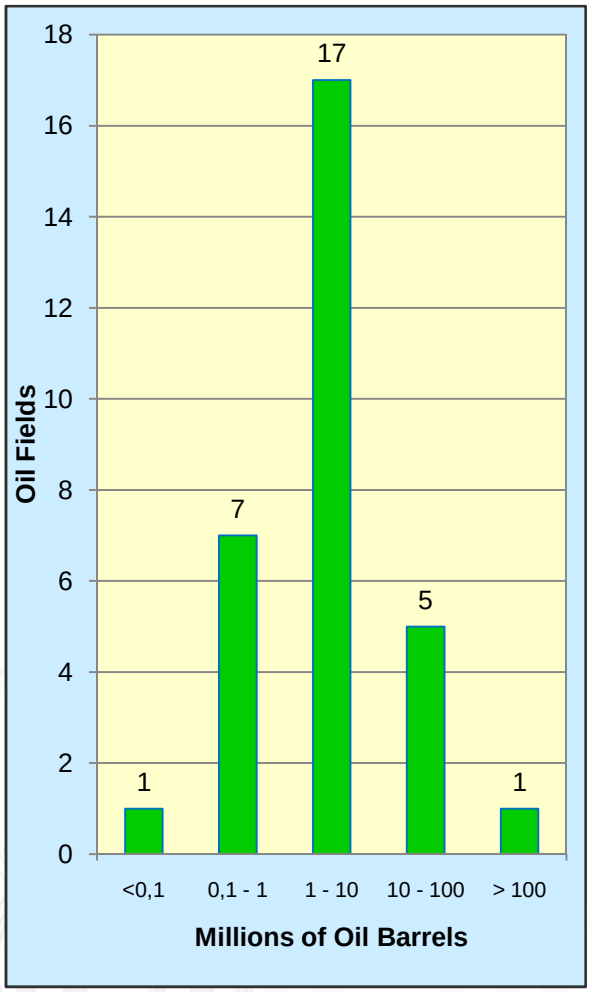
C) Stratigraphic Trap – Incised valley and lateral pinching out



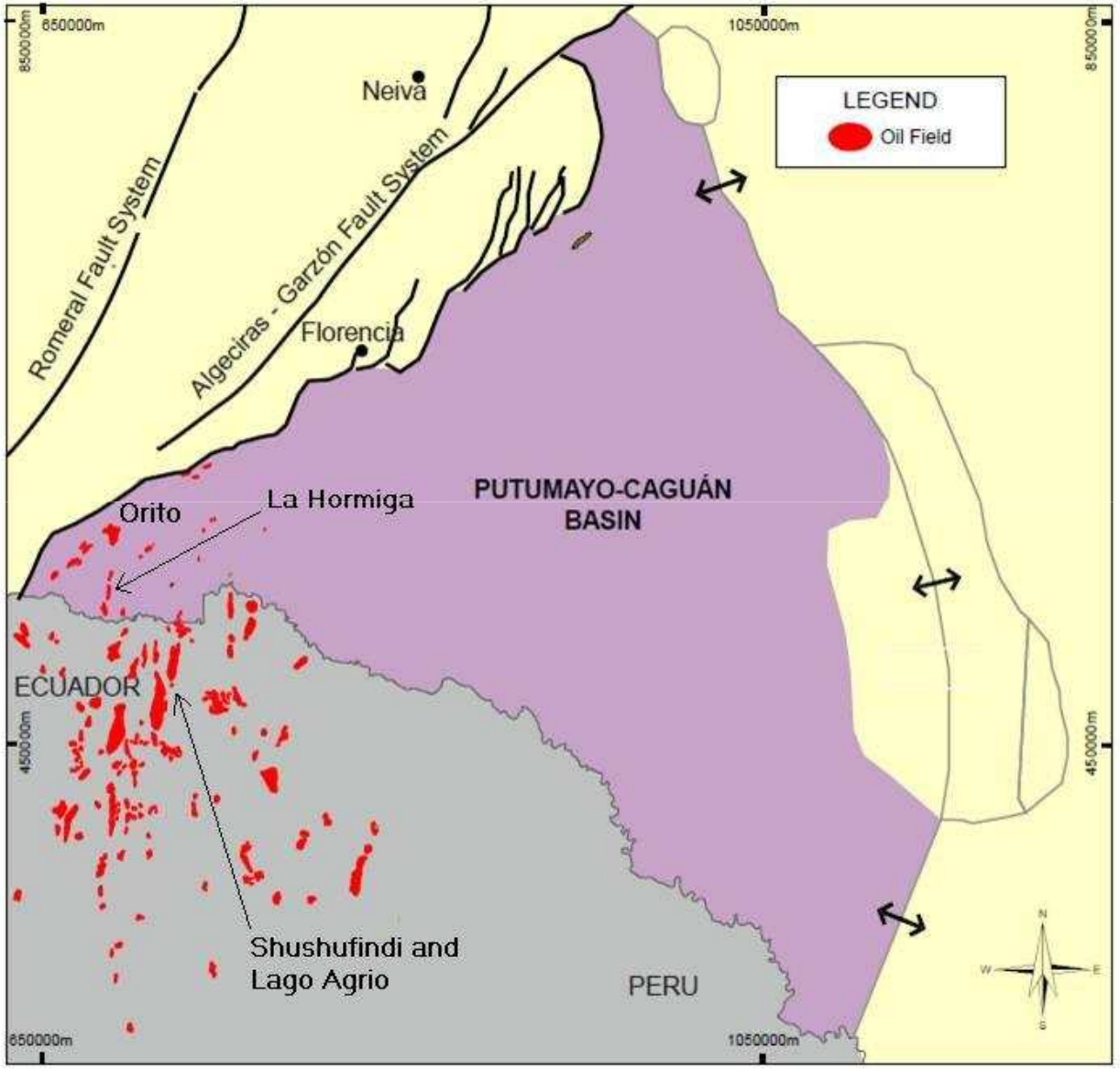
Putumayo - Caguán

Oil & gas fields

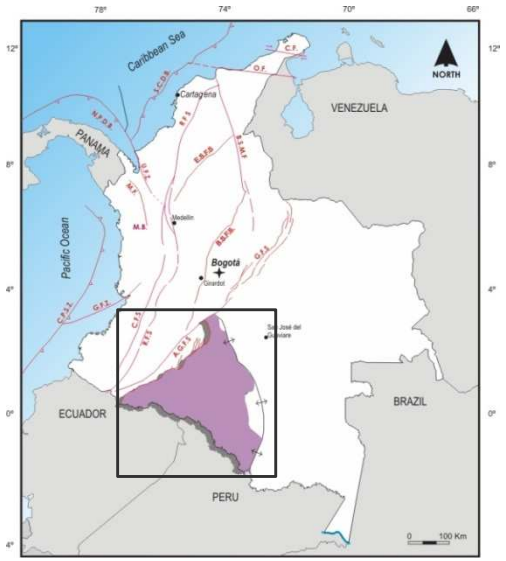
Oil Fields Size Distribution



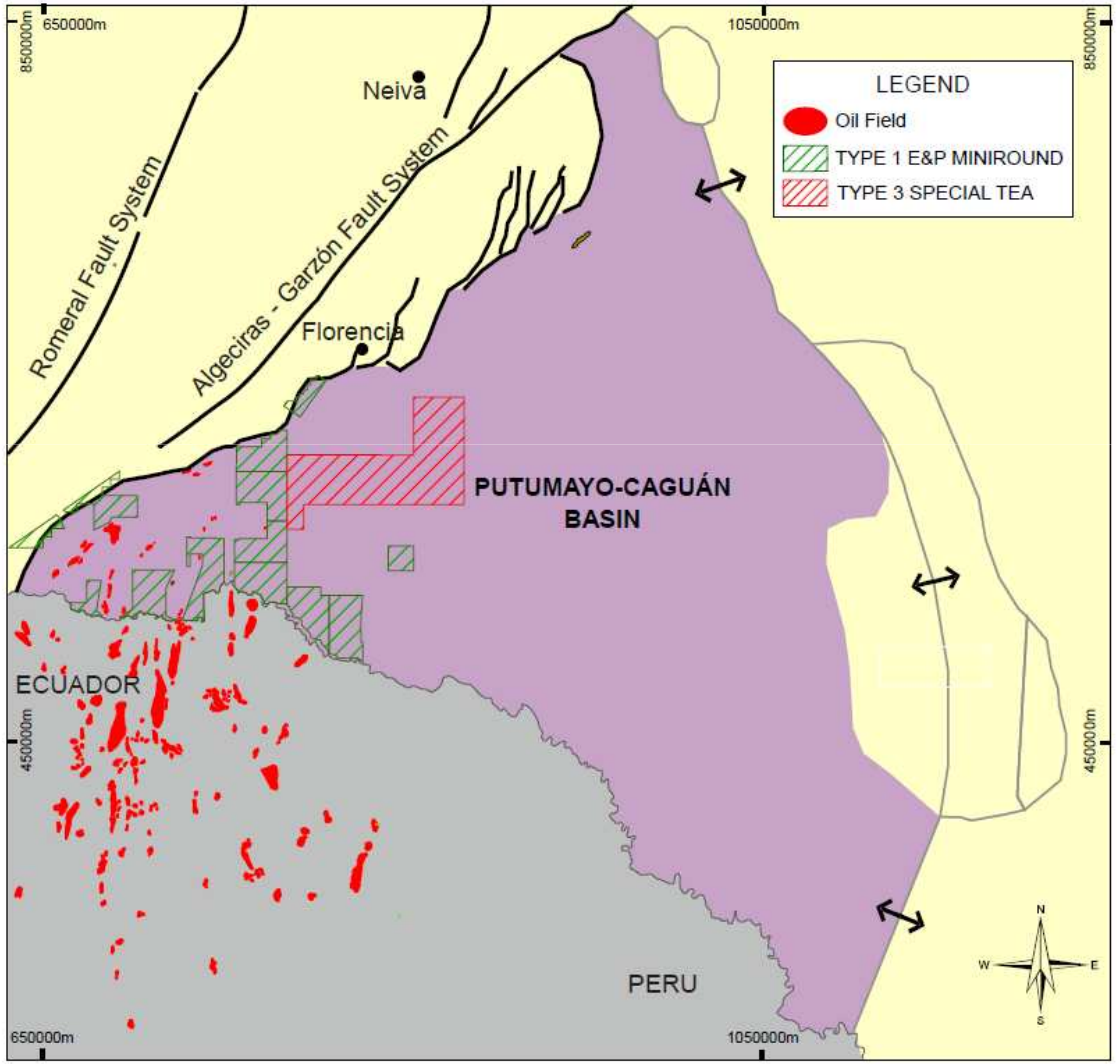
Statistics for 31 Oil Fields



Putumayo - Caguán



Location map with the offered blocks



OPEN ROUND 2010 BLOCKS

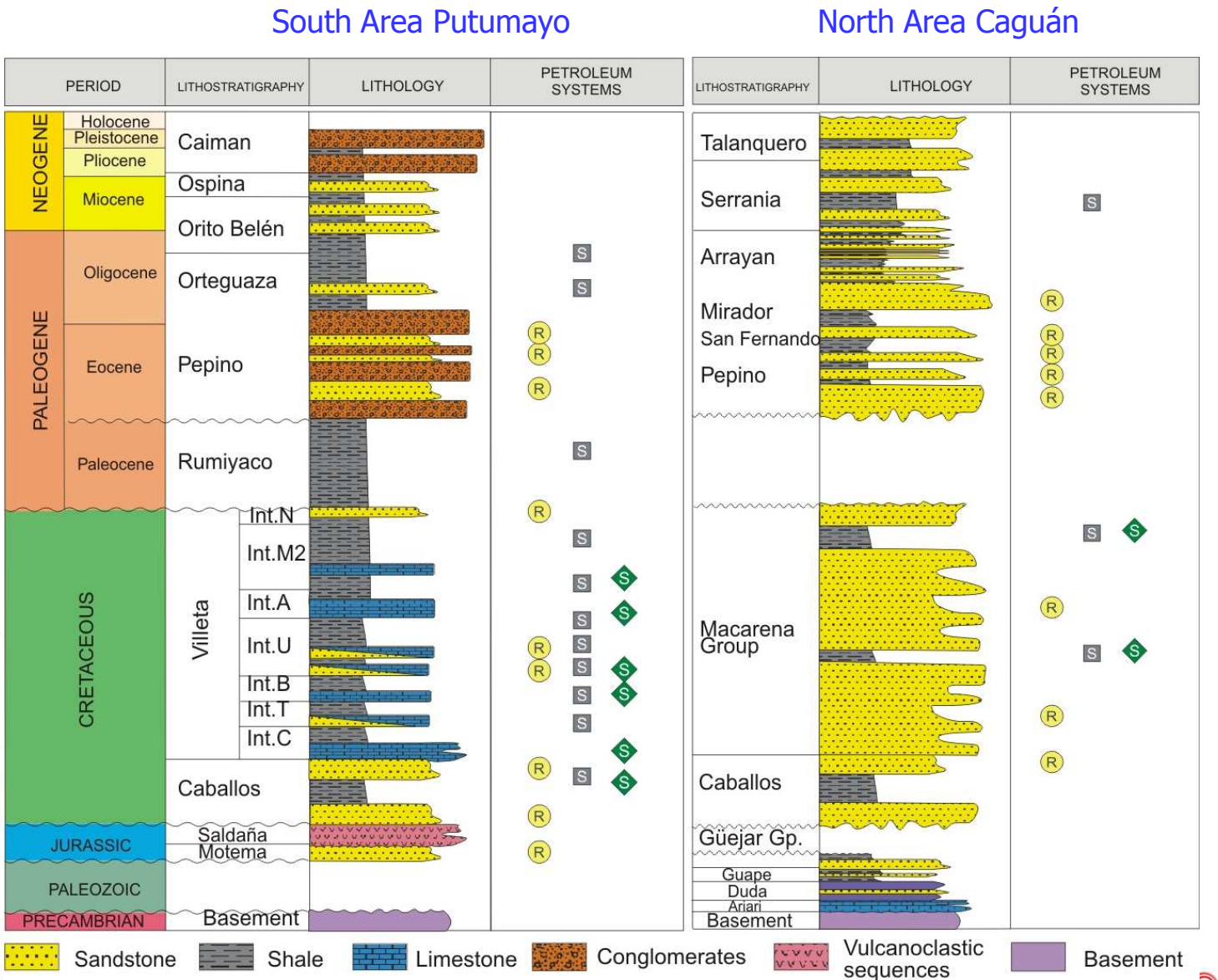
Type 1: 13 Blocks
5,615 Km^2

Type 3: 1 Block
3,720 Km^2

Putumayo - Caguán

Petroleum geology (I)

Stratigraphic chart showing source rocks, reservoirs and seals

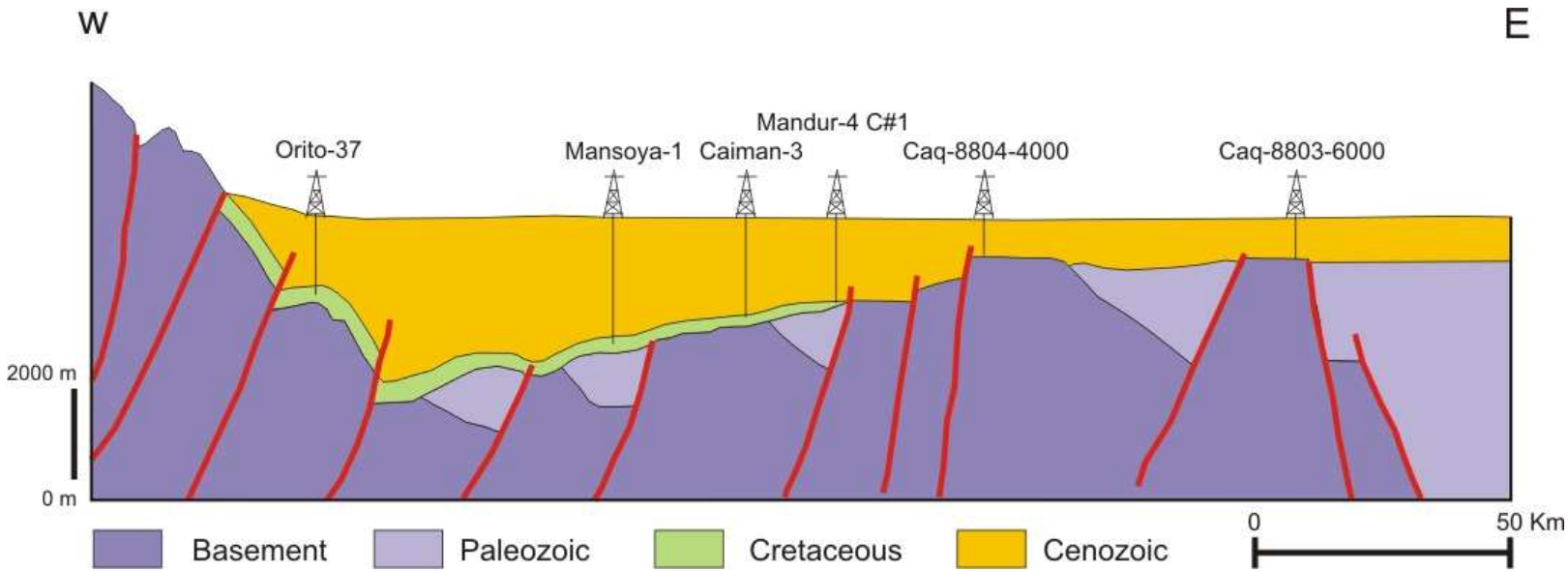


Source rocks, reservoirs and seals

PETROLEUM SYSTEM ELEMENT	LITHOLOGIC UNIT	REMARKS
S Source	Villeta Fm Caballos Fm (Middle interval)	Kerogen: Type II - III HI 100 – 500 mg HC/ g TOC
	Macarena Gp (Upper & middle intervals)	TOC: > 7.3% Kerogen: Type II
R Reservoir	Caballos Fm Villeta Fm (Limestones) Pepino Fm	Caballos Fm. Porosity: 10 – 16% Permeability: around 50 mD
	Caballos Fm Macarena Gp Cenozoic units	Transitional to fluvial sandstones
S Seal	Villeta Fm Cenozoic shales	In the foothills thrust faults may act as effective seals

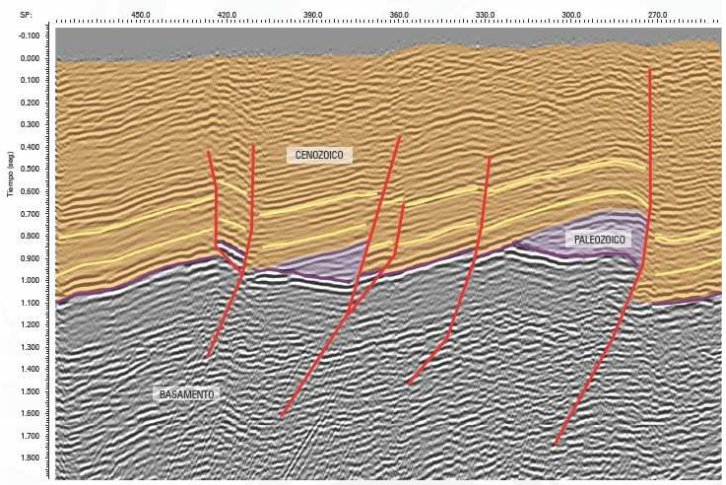
Putumayo - Caguán

Regional structural style



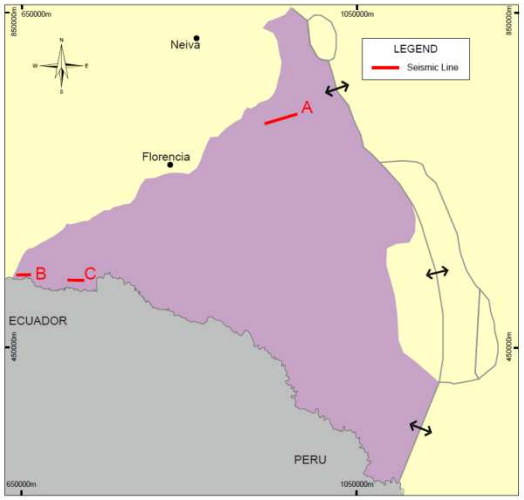
Trap styles within the Putumayo-Caguán Basin

- **Antithetic normal faults**
- **Inversion structures**
- **Anticlines over inversion faults**
- **Stratigraphic traps**
- **Fault-propagation folds**
- **Potential Paleozoic structures**

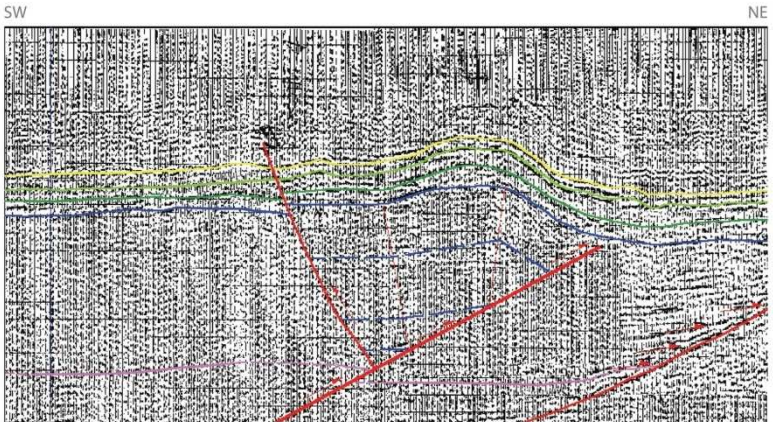


Putumayo - Caguán

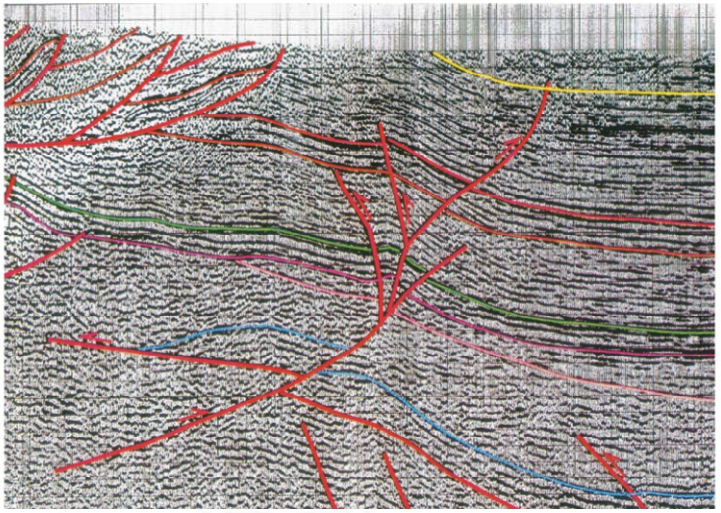
Examples of play types



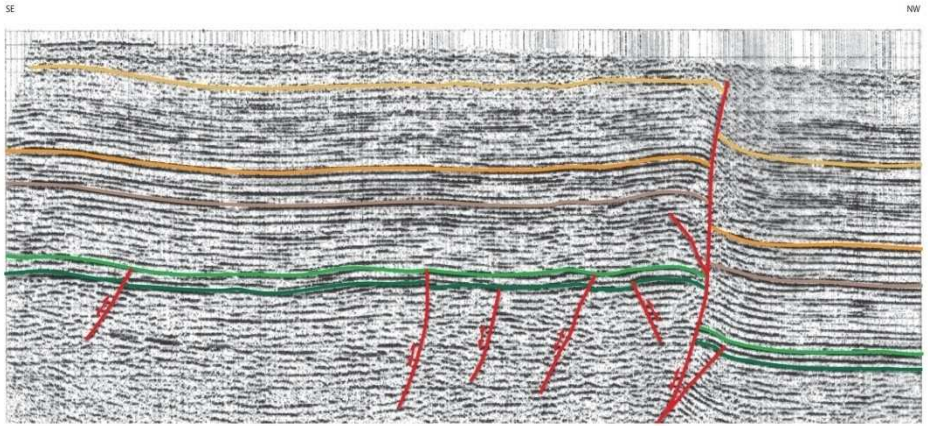
A) Wide anticline related to a reverse fault
Caguán Basin



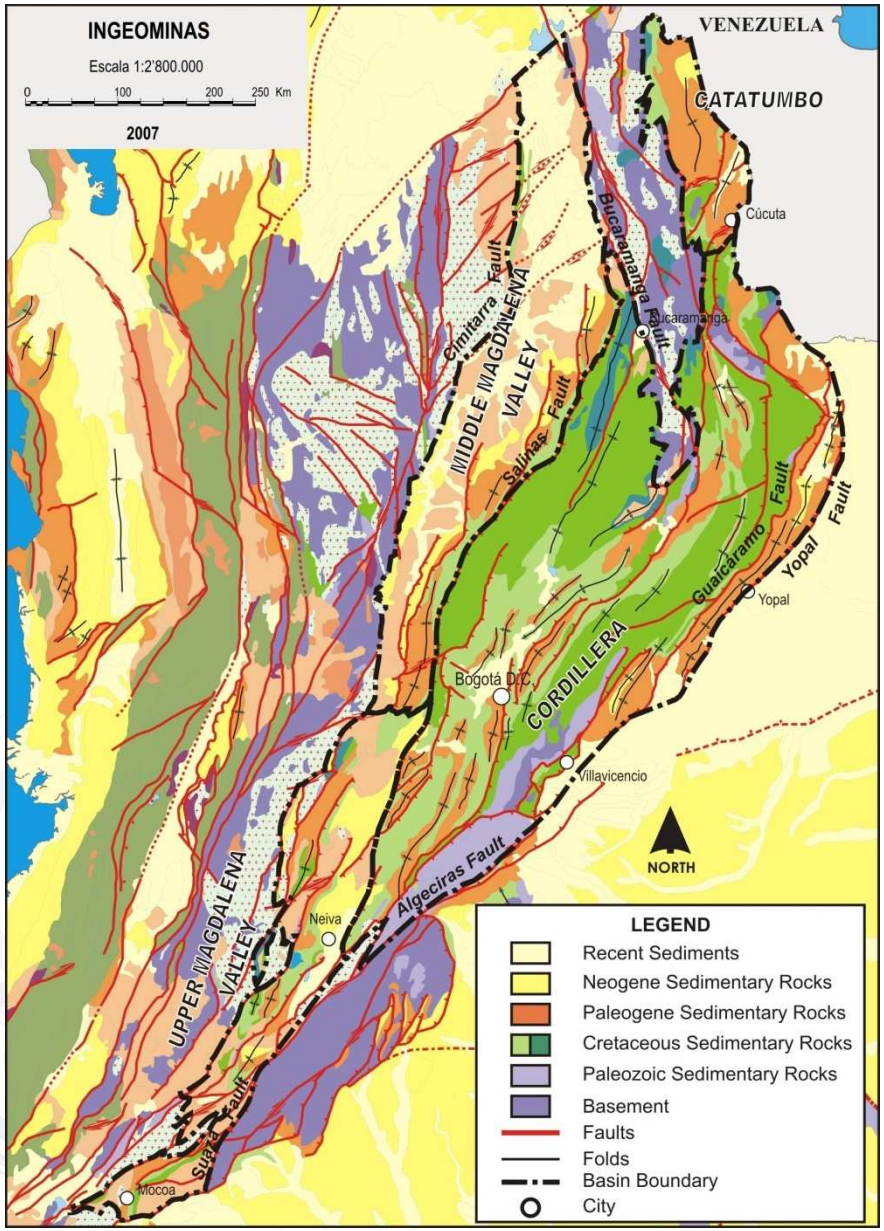
B) Anticline related to a branching reverse fault
Putumayo Basin

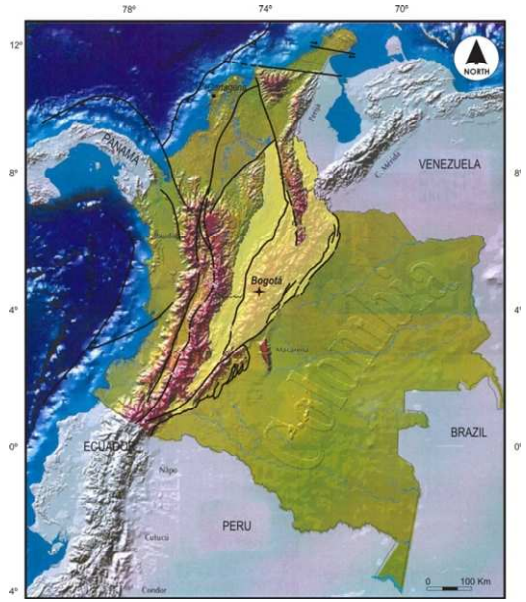


C) Drag folds in the limbs of an inverted fault
Putumayo Basin



Cordillera and intermountain basins





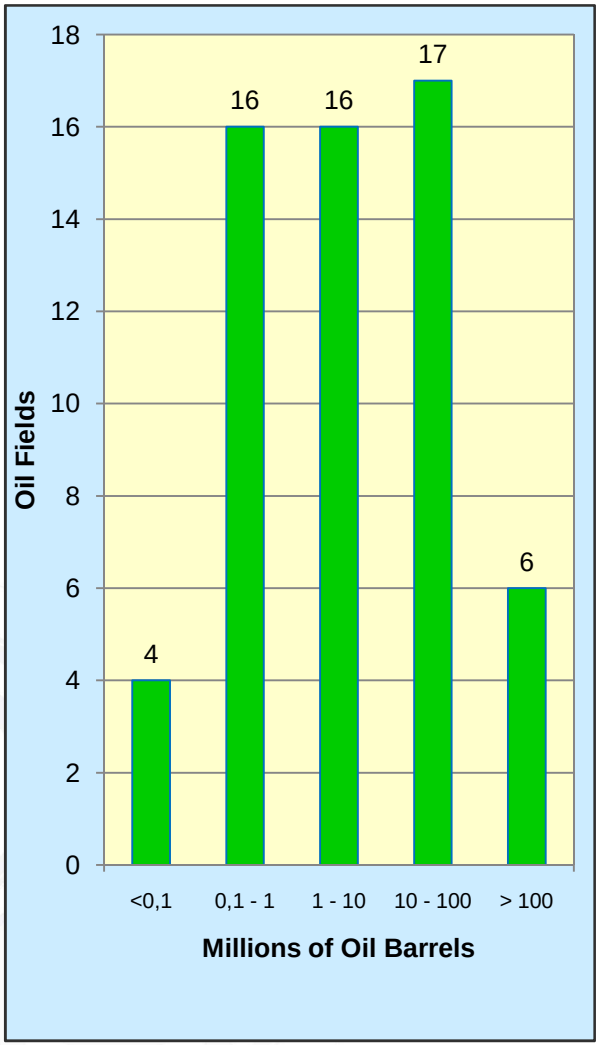
Basins

Middle Magdalena Valley
Upper Magdalena Valley
Catatumbo
Cordillera Oriental

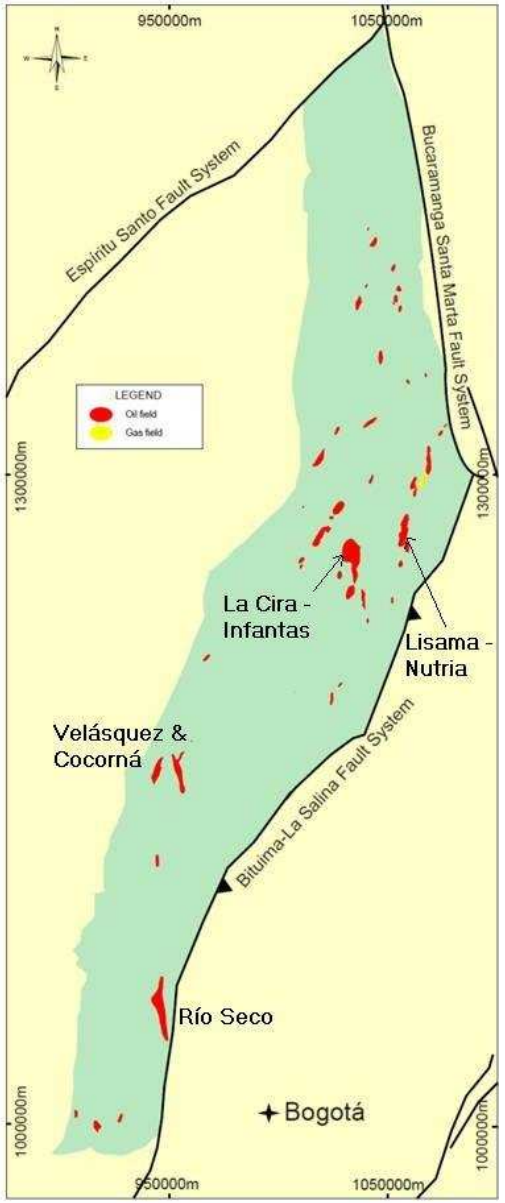
Middle Magdalena Valley

Oil & gas fields

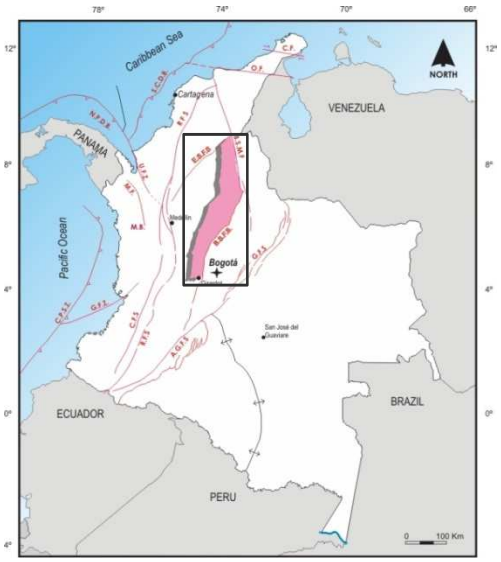
Oil Fields Size Distribution

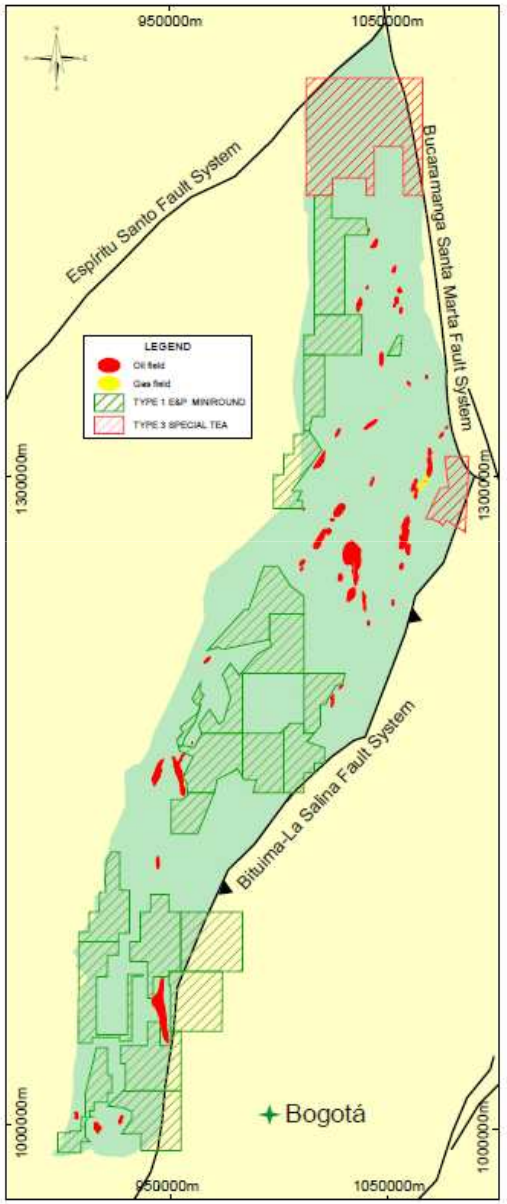


Statistics for 51 Oil Fields



Middle Magdalena Valley





Location map with the offered blocks

OPEN ROUND 2010 BLOCKS

Type 1: 20 Blocks
8,898 Km^2

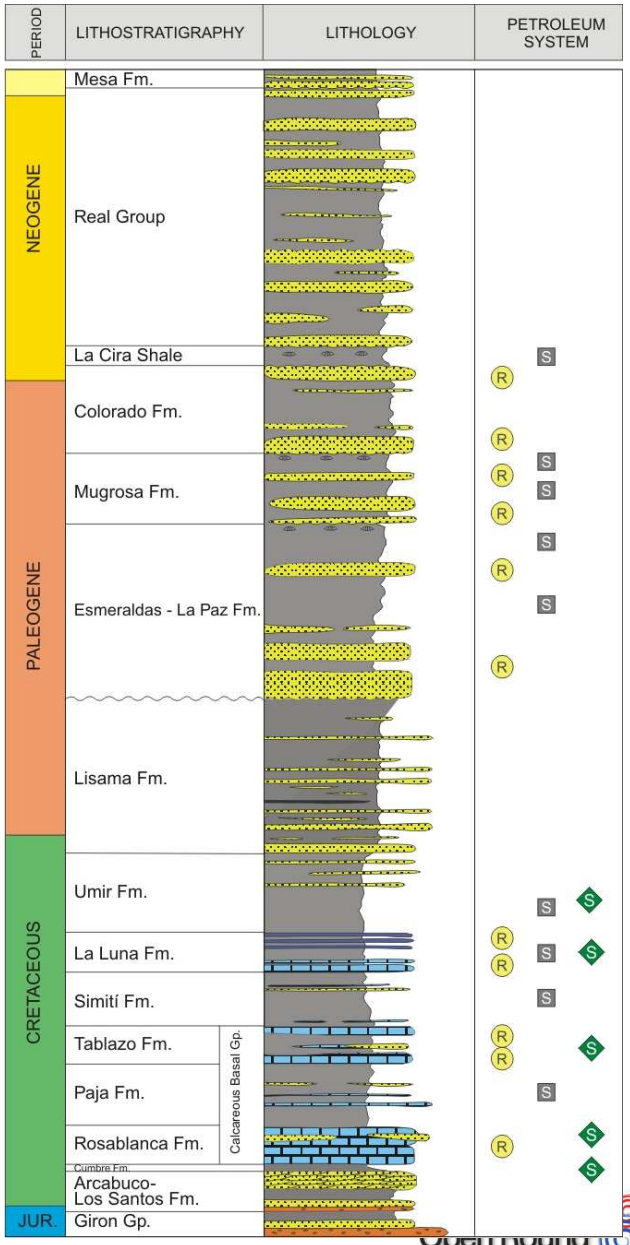
Type 3: 2 Blocks
2,996 Km^2

Middle Magdalena Valley

Petroleum geology

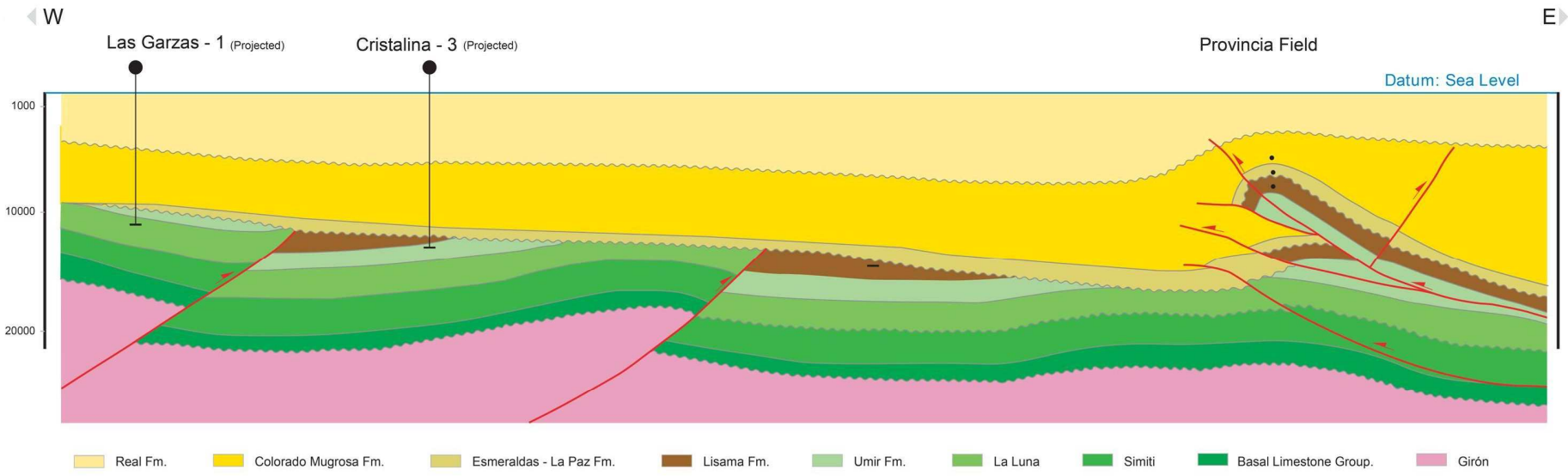
Source rocks, reservoirs and seals

PETROLEUM SYSTEM ELEMENT	LITHOLOGIC UNIT	REMARKS
S Source	La Luna Fm Simití Fm Tablazo Fm	TOC: 1.0 – 6.0% Kerogen: Type II %Ro: 1.1 – 1.2
R Reservoir	Colorado Fm Mugrosa Fm Esmeralda Fm La Paz Fm	Sandstones Porosity: 15 – 20% Permeability: 20 – 600 mD
R Reservoir	La Luna Fm Tablazo Fm Rosablanca Fm	Fractured limestones
S Seal	Colorado Fm(1) Esmeralda Fm(1) Umir Fm(2) Simití Fm(2)	(1) Cenozoic seals (2) Cretacous seals



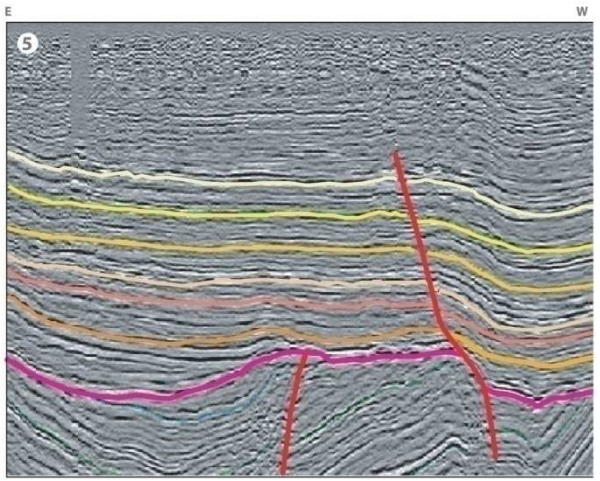
Middle Magdalena Valley

Regional structural style



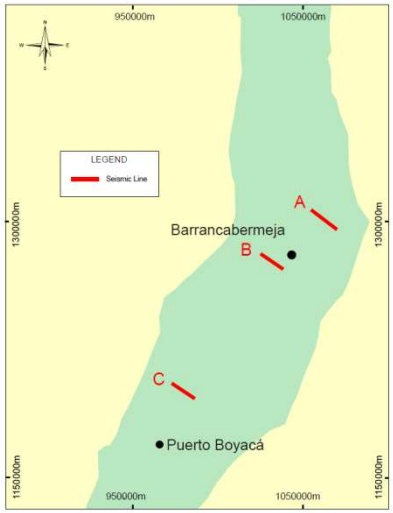
Trap styles within the Middle Magdalena Basin

- **Inversion structures**
- **Subthrust folds**
- **Duplex structures**
- **Fault seal traps**
- **Stratigraphic traps**

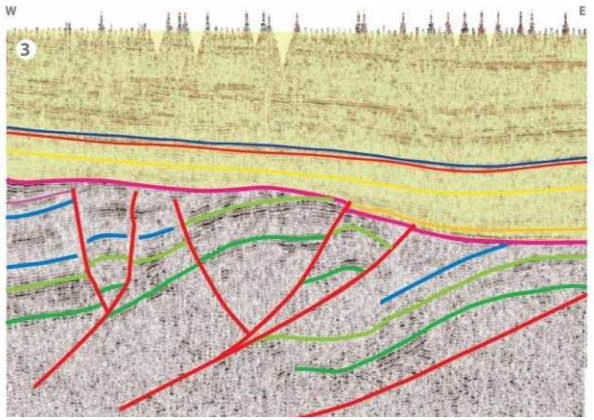


Middle Magdalena Valley

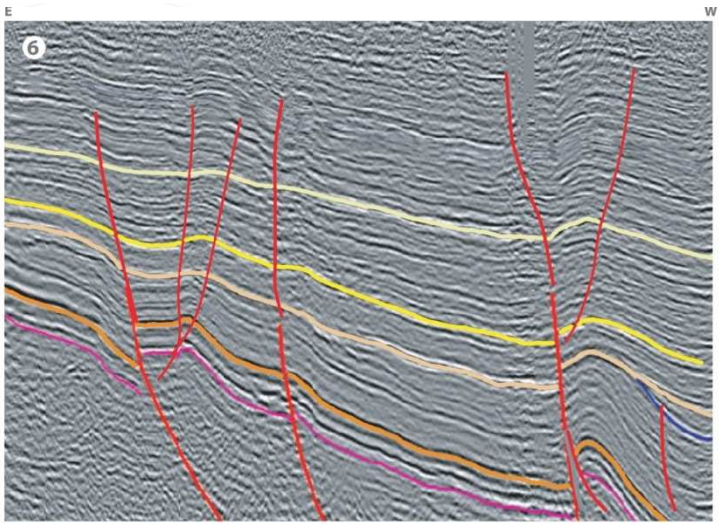
Examples of play types



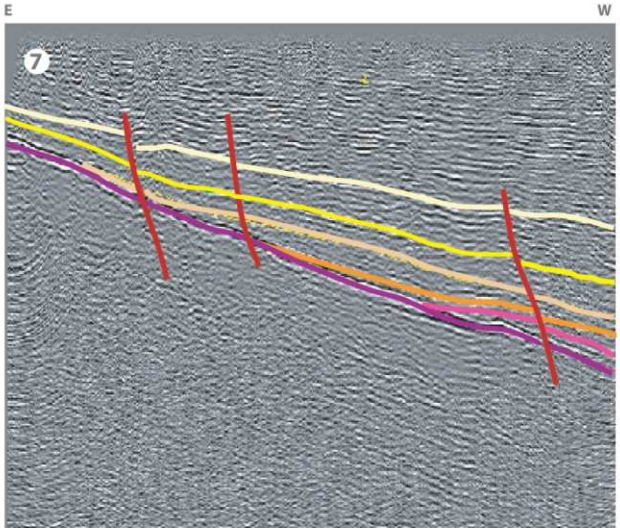
A) Cretaceous reservoirs – Anticlines related to reverse faults – Puntapiedra area



B) Cenozoic reservoirs – Anticlines related to wrench faults – Casabe area



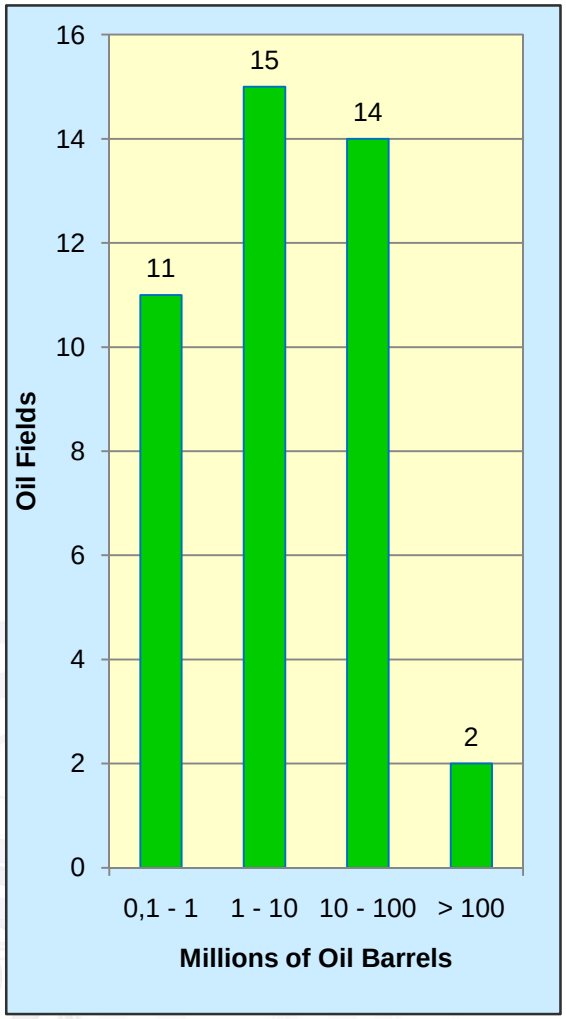
C) Stratigraphic trap – Onlap of Miocene reservoirs over the basement – Central area



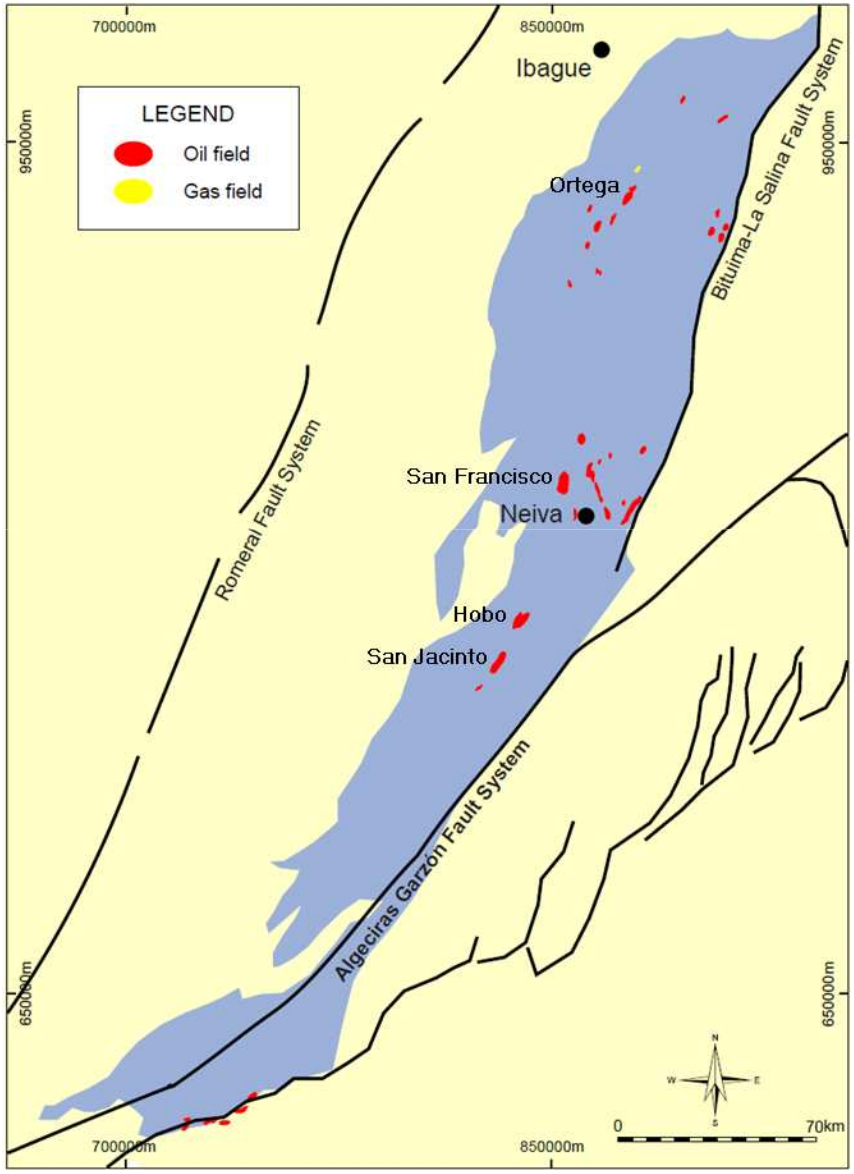
Upper Magdalena Valley

Oil & gas fields

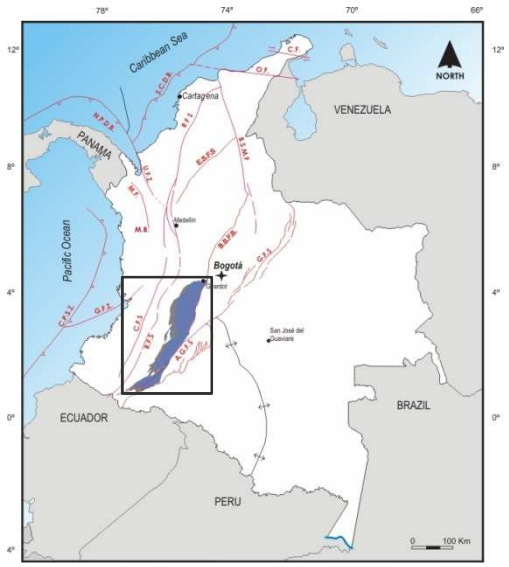
Oil Fields Size Distribution

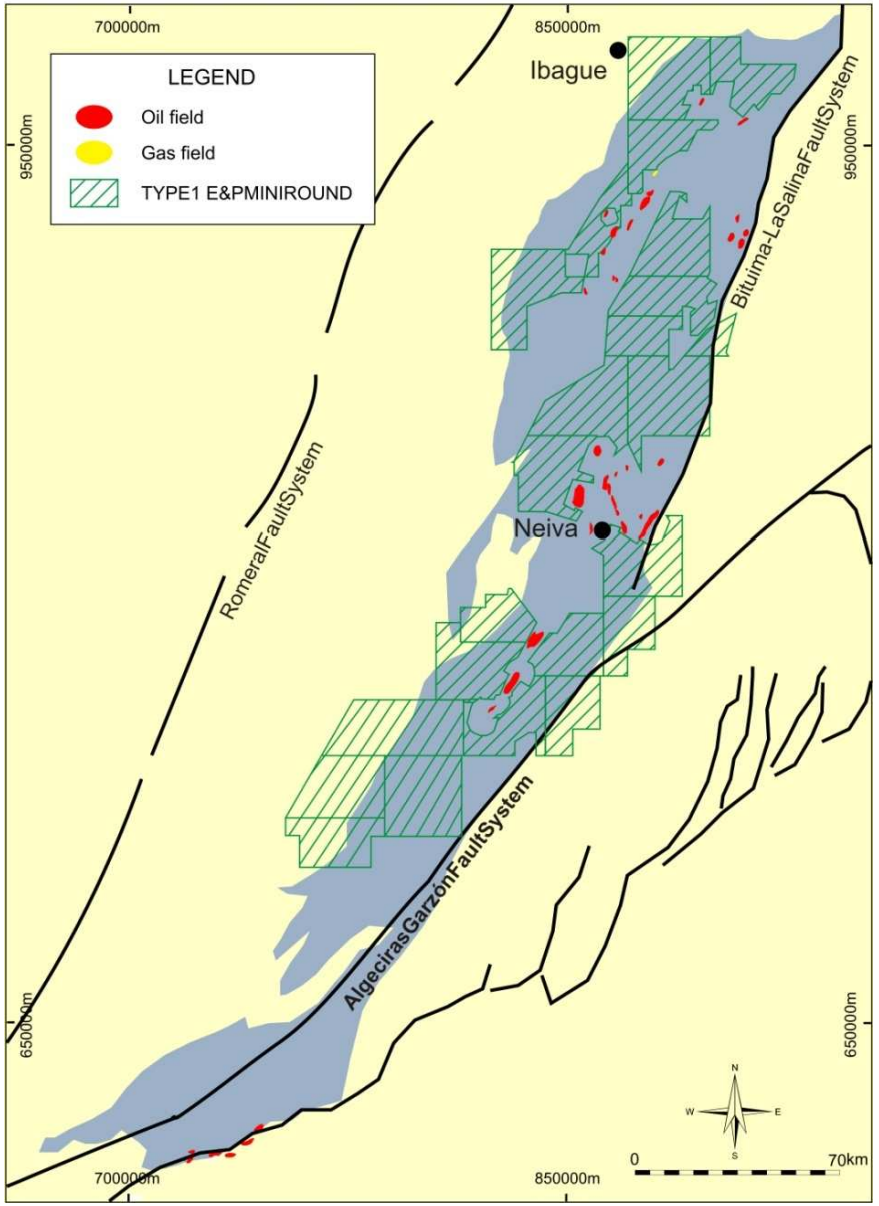


Statistics for 42 Oil Fields



Upper Magdalena Valley





Location map with the offered blocks

OPEN ROUND 2010 BLOCKS

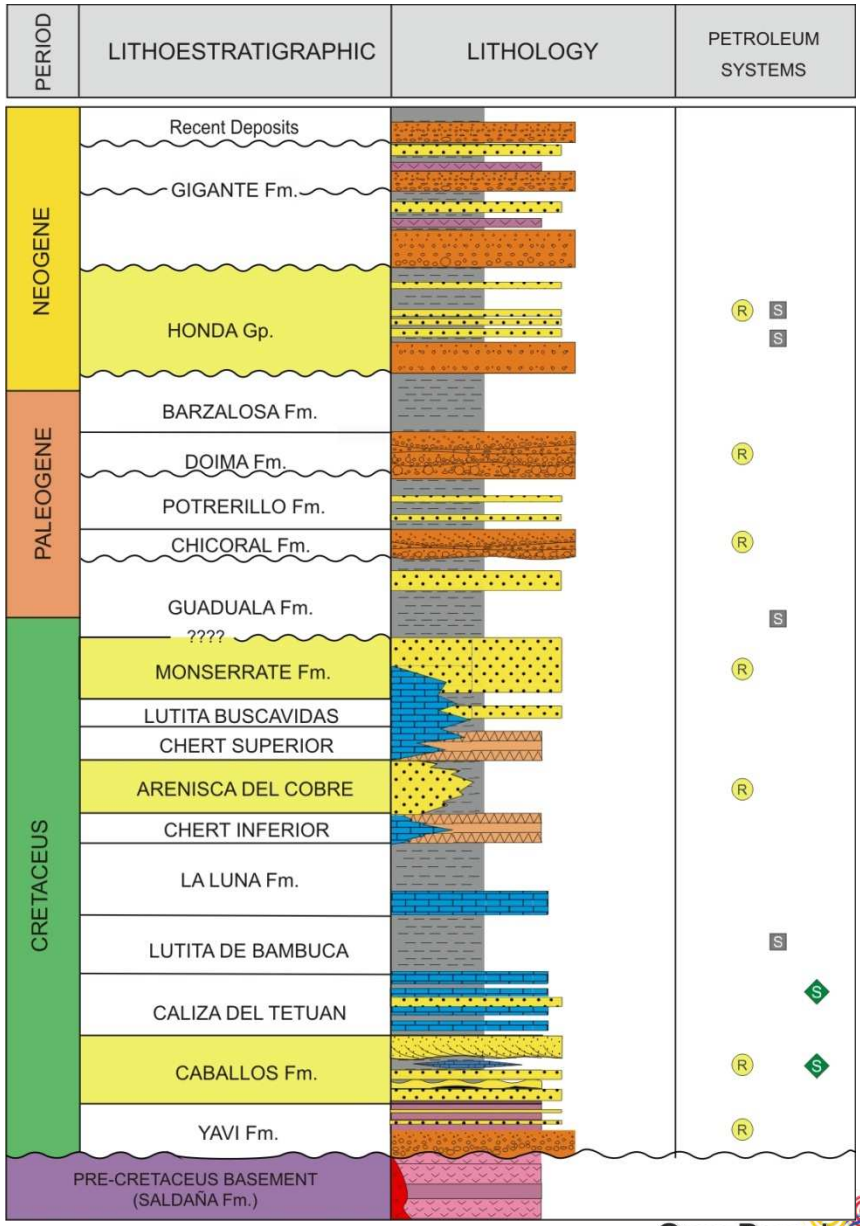
Type 1: 23 Blocks
9,846 Km^2

Upper Magdalena Valley

Petroleum geology

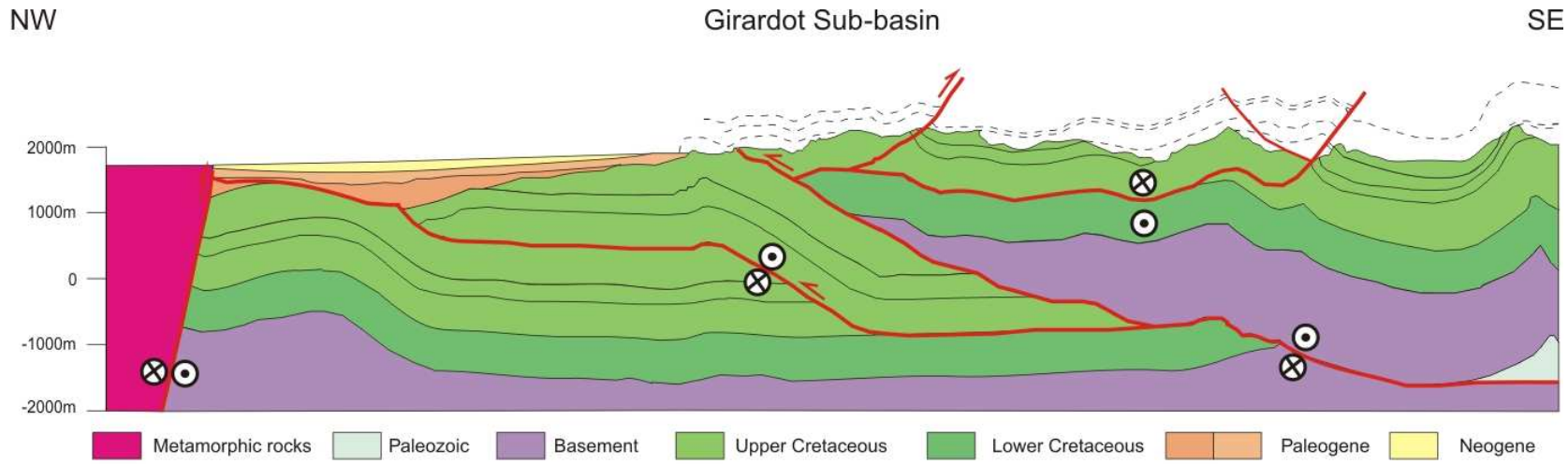
Source rocks, reservoirs and seals

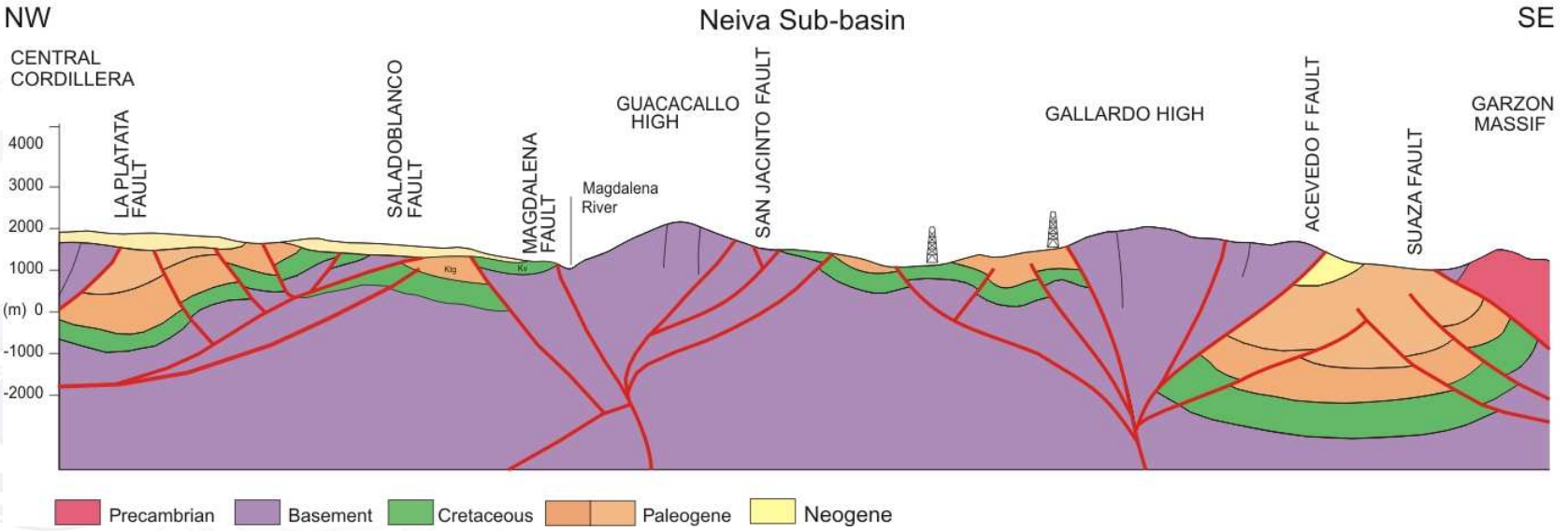
PETROLEUM SYSTEM ELEMENT	LITHOLOGIC UNIT	REMARKS
S Source	La Luna Fm Bambucá Fm Tetuán Fm	TOC: >5.0% Kerogen: Type II %Ro: 0.5 – 1.3 Tmax: 450°
R Reservoir	Honda Gp Monserrate Fm Caballos Fm	Sandstones Occasional limestone units
S Seal	Honda Gp Guaduala Fm Bambucá Fm	Regional Seals



Upper Magdalena Valley

Regional structural style

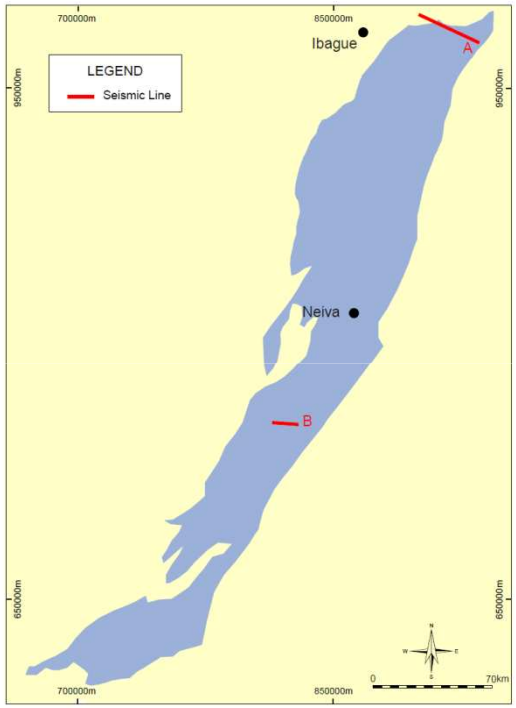


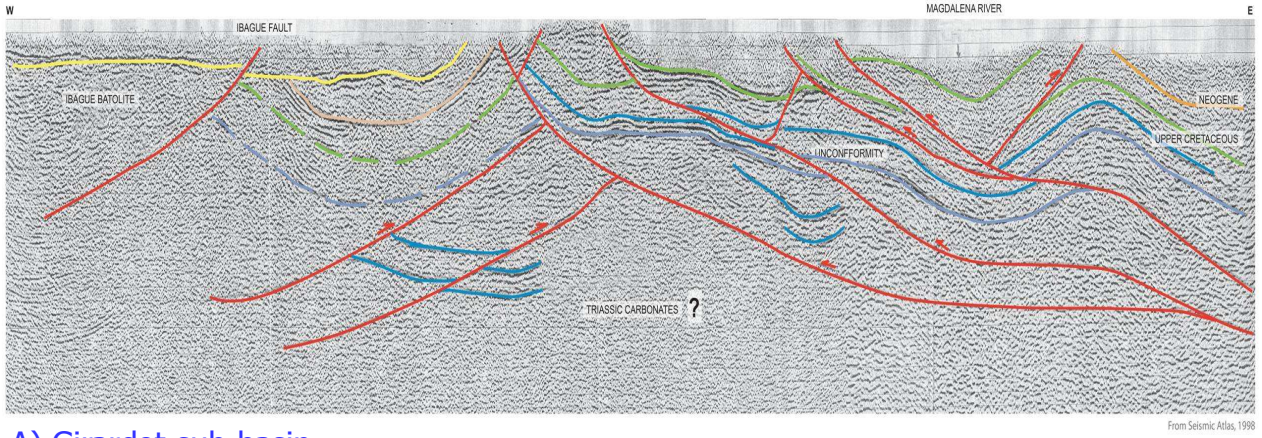


Upper Magdalena Valley

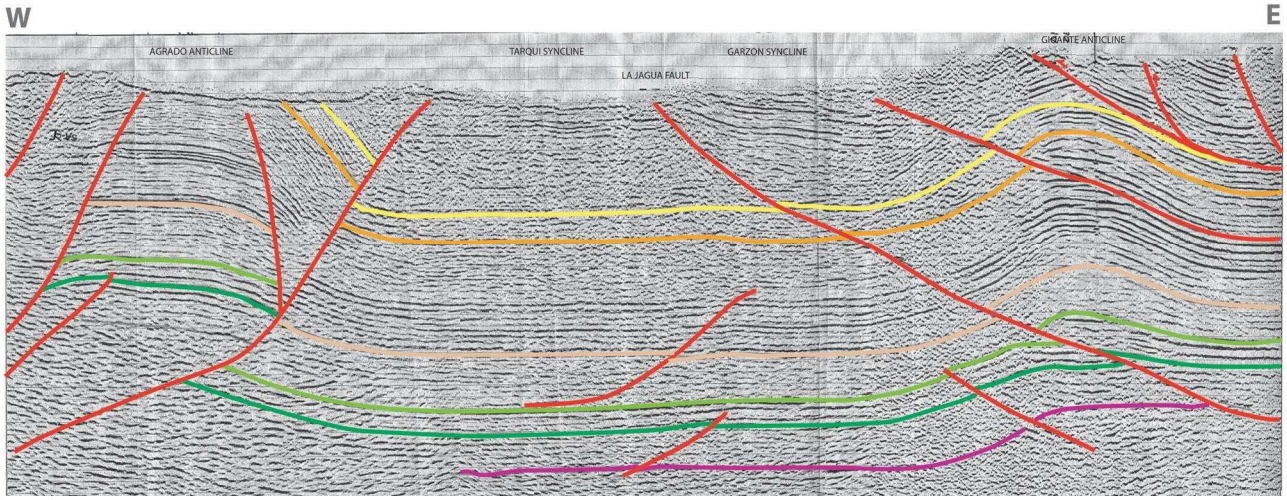
Examples of play types

Thrust and subthrust anticlinal traps
related to west-verging fault systems





A) Girardot sub-basin

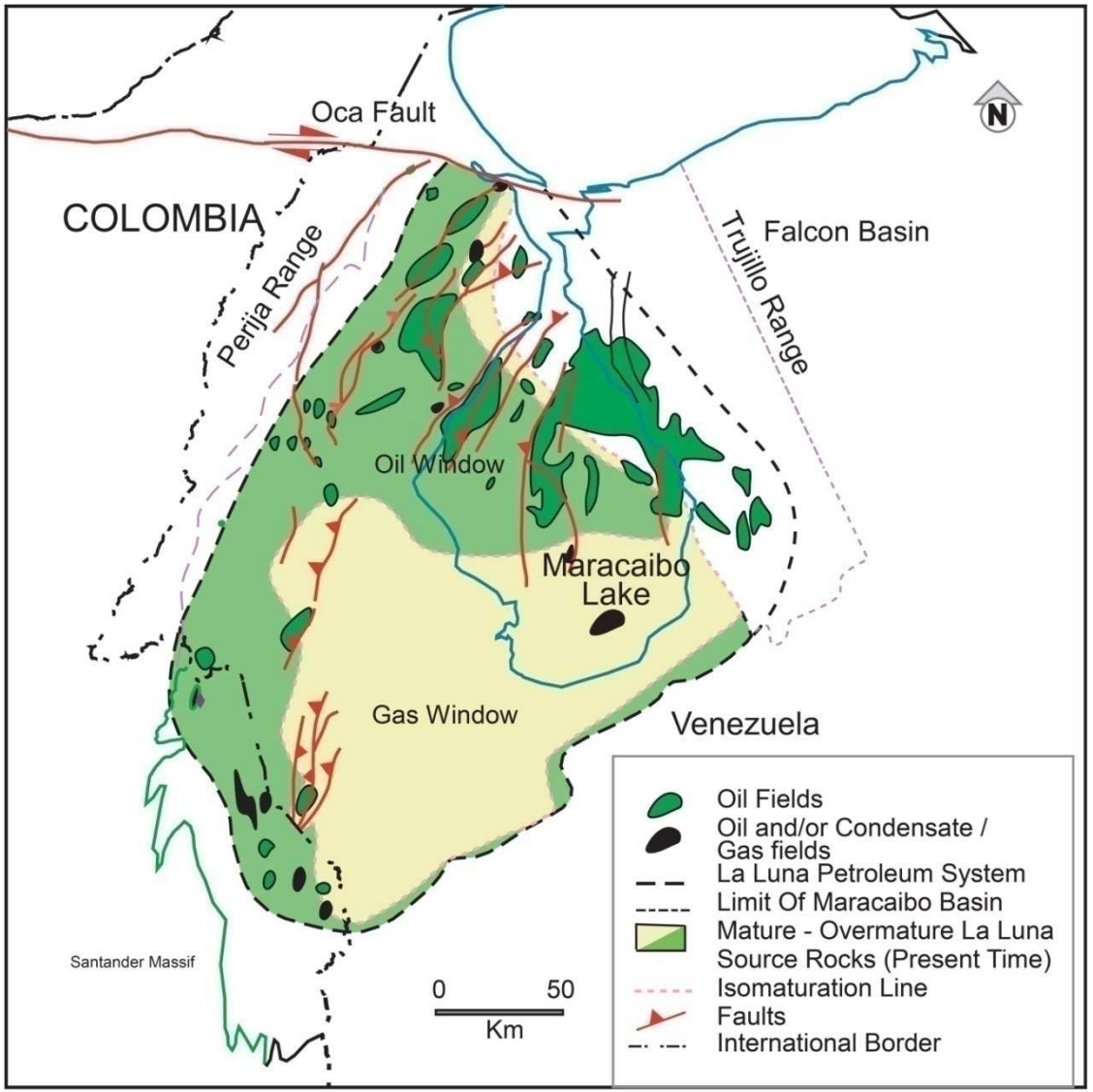


B) Neiva sub-basin

Catatumbo

Regional situation

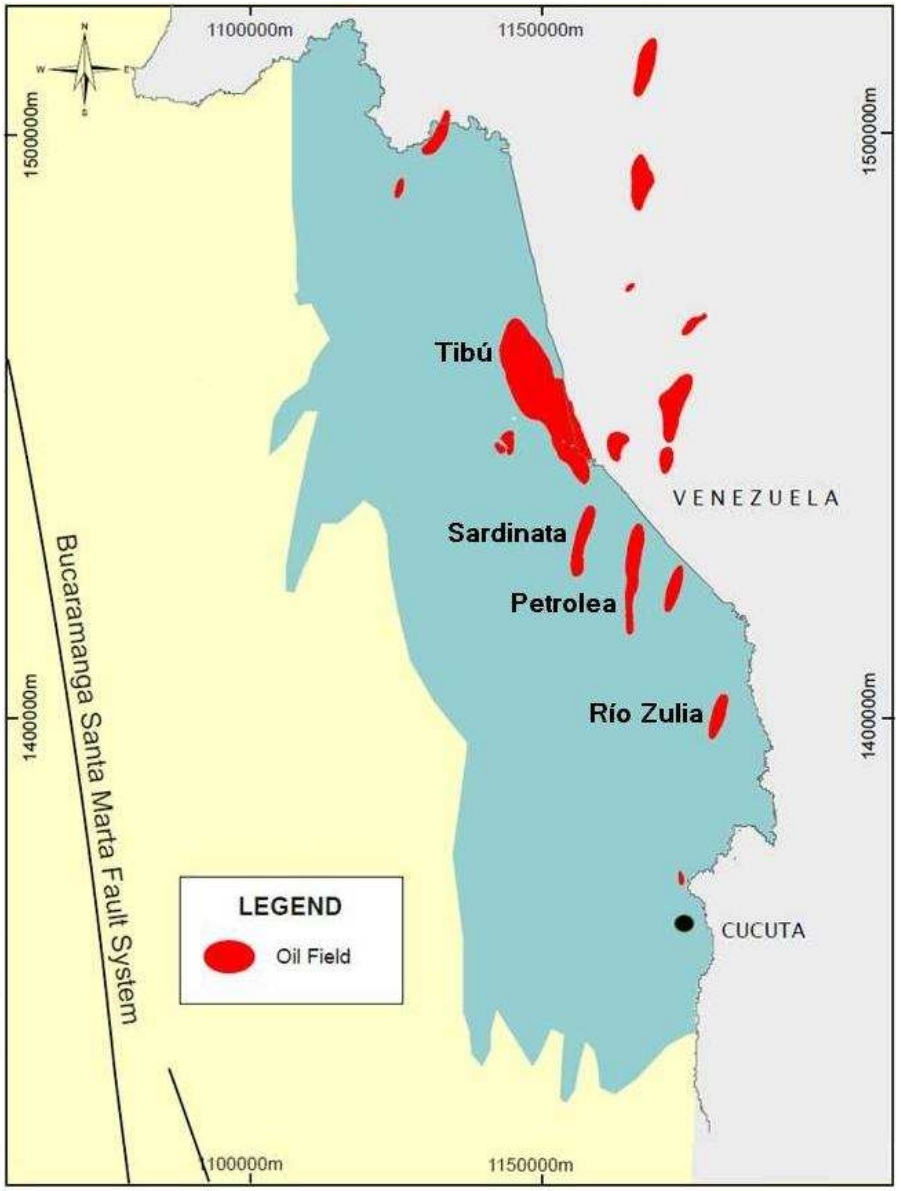
Catatumbo Basin
Southern portion of
Maracaibo Basin (Venezuela)



From Talukdar and Marcano, 1994

Catatumbo

Oil & gas fields



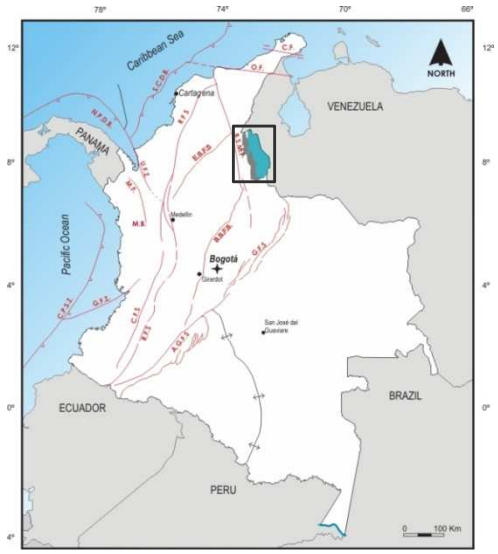
OIL FIELDS SIZE:

>100 MMBO: 2

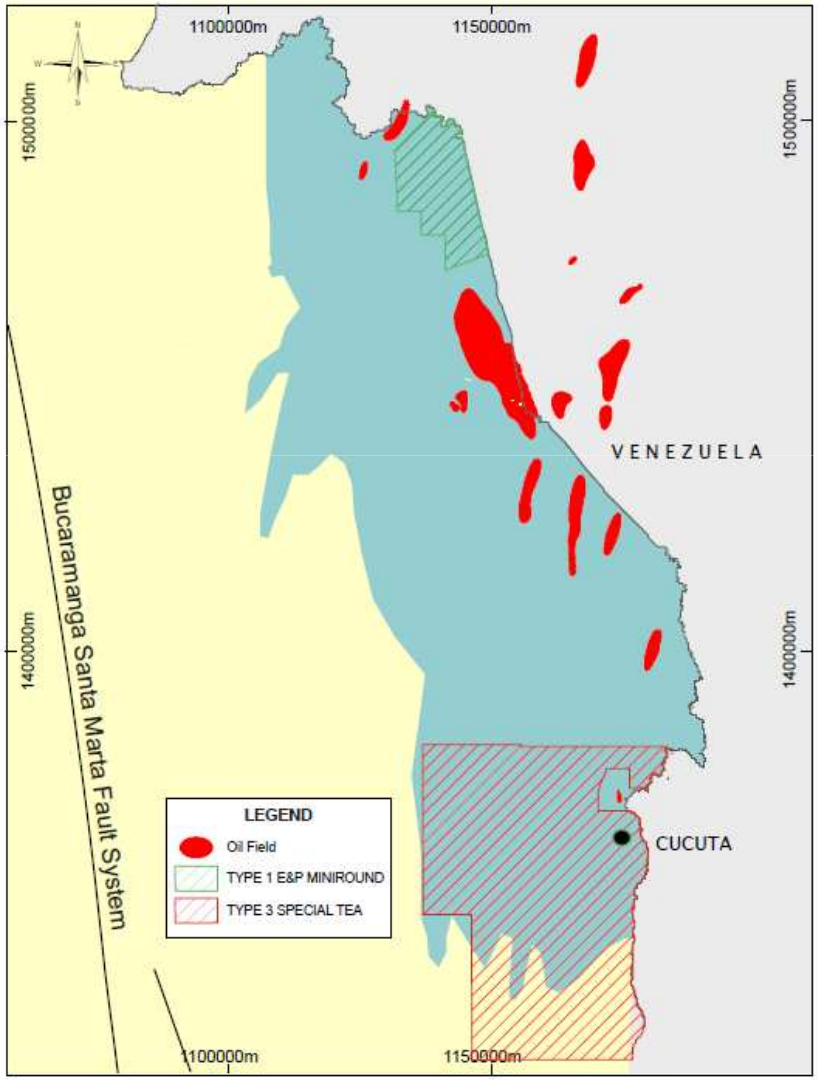
10 – 100 MMBO: 2

<1 MMBO: 2

Catatumbo



Location map with the offered blocks



OPEN ROUND 2010 BLOCKS

Type 1: 1 Block
315 Km^2

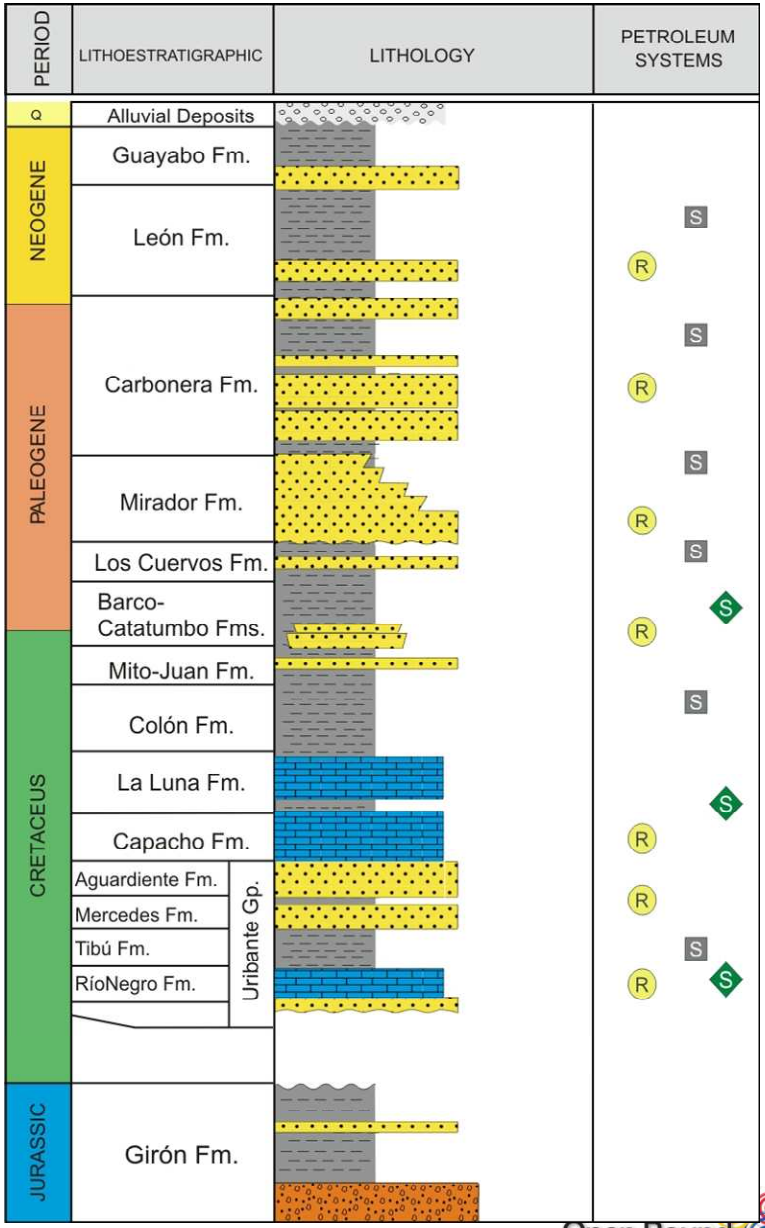
Type 3: 1 Block
2,157 Km^2

Catatumbo

Petroleum geology

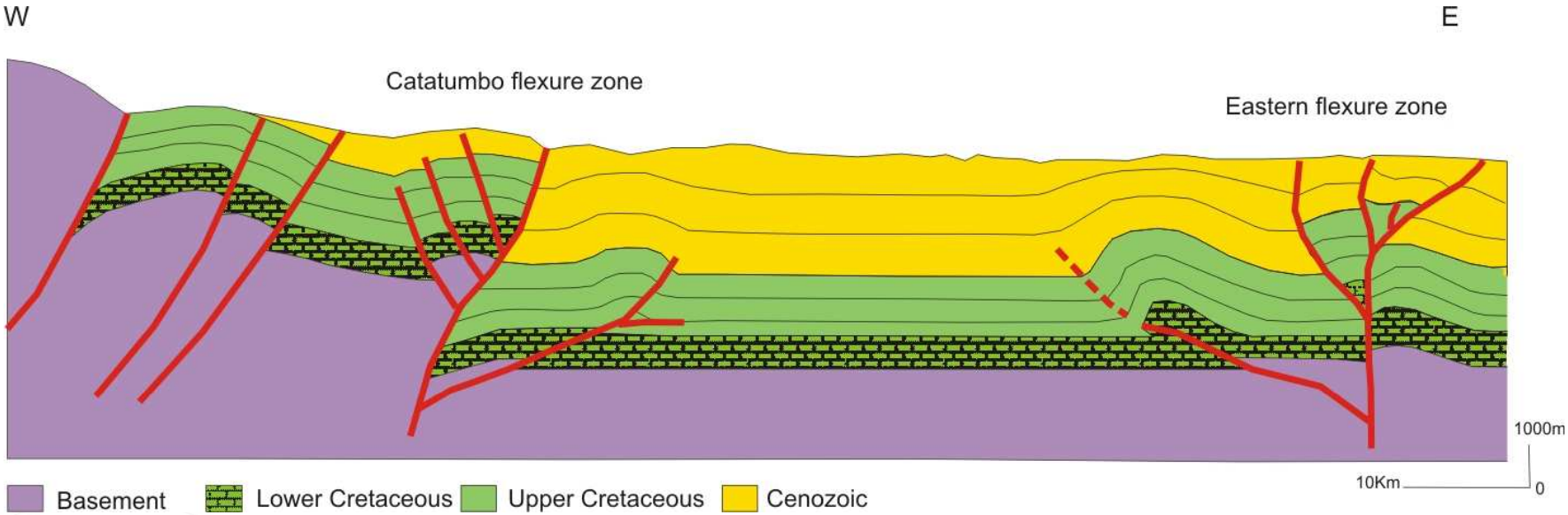
Source rocks, reservoirs and seals

PETROLEUM SYSTEM ELEMENT	LITHOLOGIC UNIT	REMARKS
S Source	La Luna Fm Capacho Fm Tibú Fm Mercedes Fm	La Luna Fm (principal source rock) TOC: 3.8%%
R Reservoir	Barco Fm Mirador Fm Carbonera Fm	Cenozoic sandstones
	Uribante Gp Capacho Fm	Fractured limestones
S Seal	Cenozoic and Cretaceous shales	León Fm (regional seal)



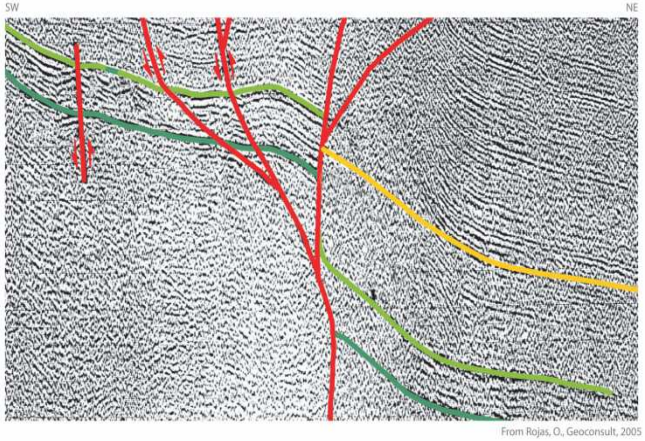
Catatumbo

Regional structural style



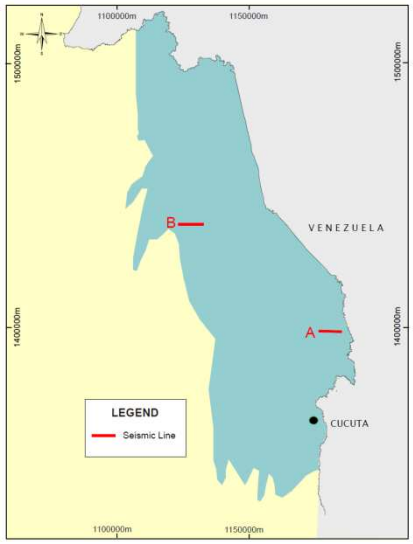
Trap styles within the Catatumbo Basin

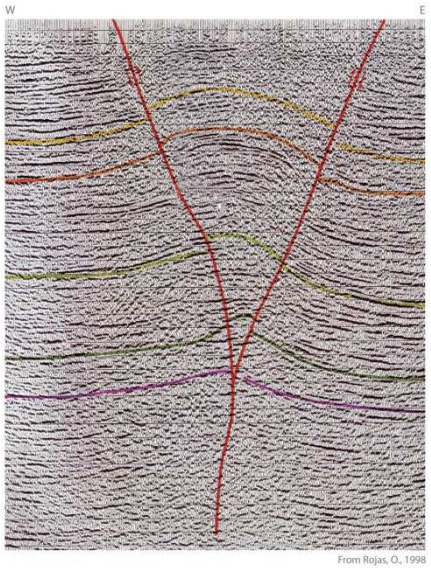
- **Inversion structures**
- **Strike-slip faults (east)**



Catatumbo

Examples of play types

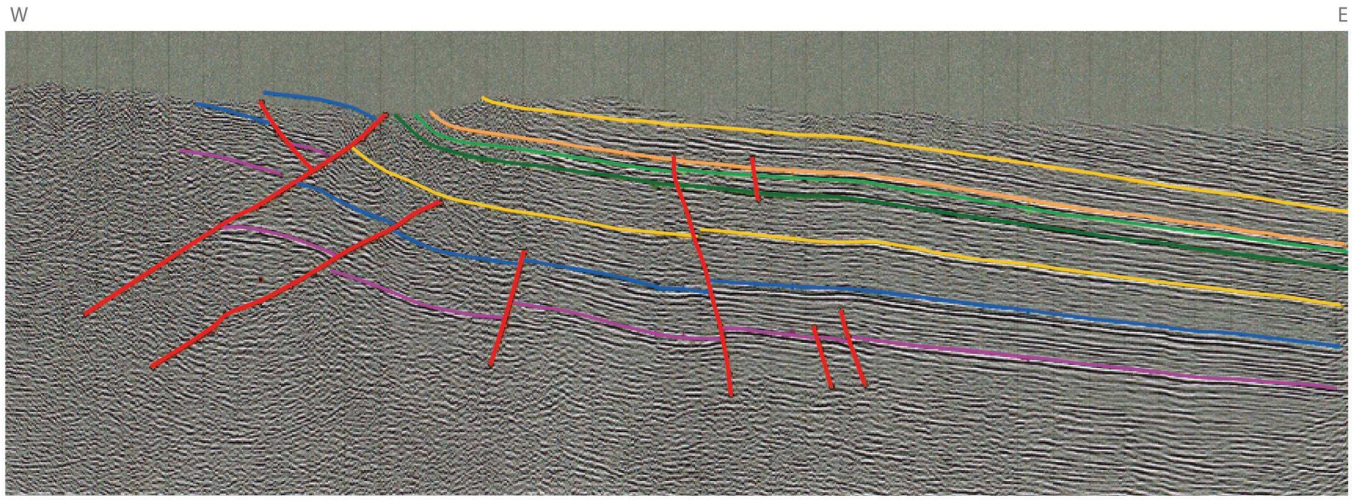




From Rojas, O., 1998

A) Anticline related to a wrench fault

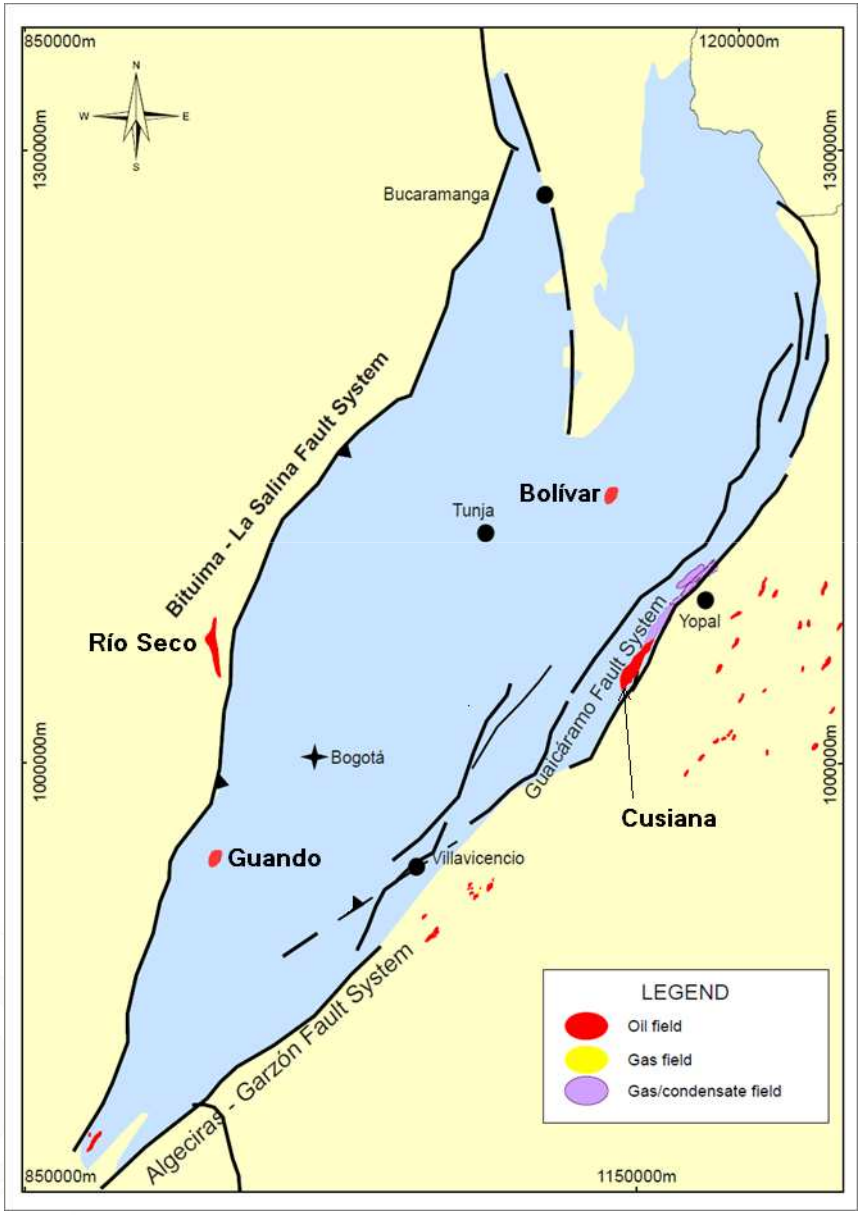
B) Subthrust trap in the western margin of the basin. High side closure in central part of the profile



From Barrero, D., 1998

Eastern Cordillera

Oil & gas fields



OIL FIELDS SIZE:

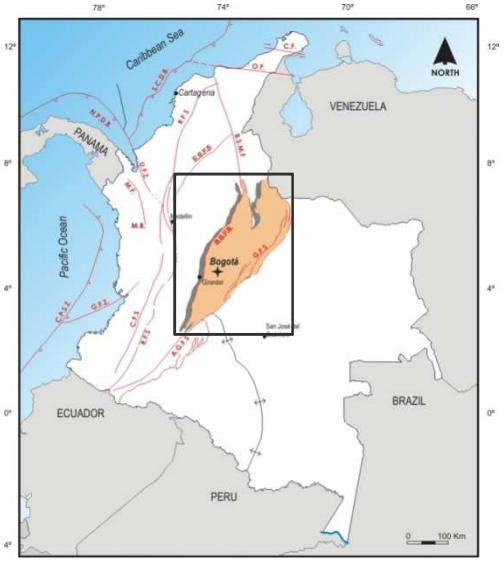
>100 MMBO: 1

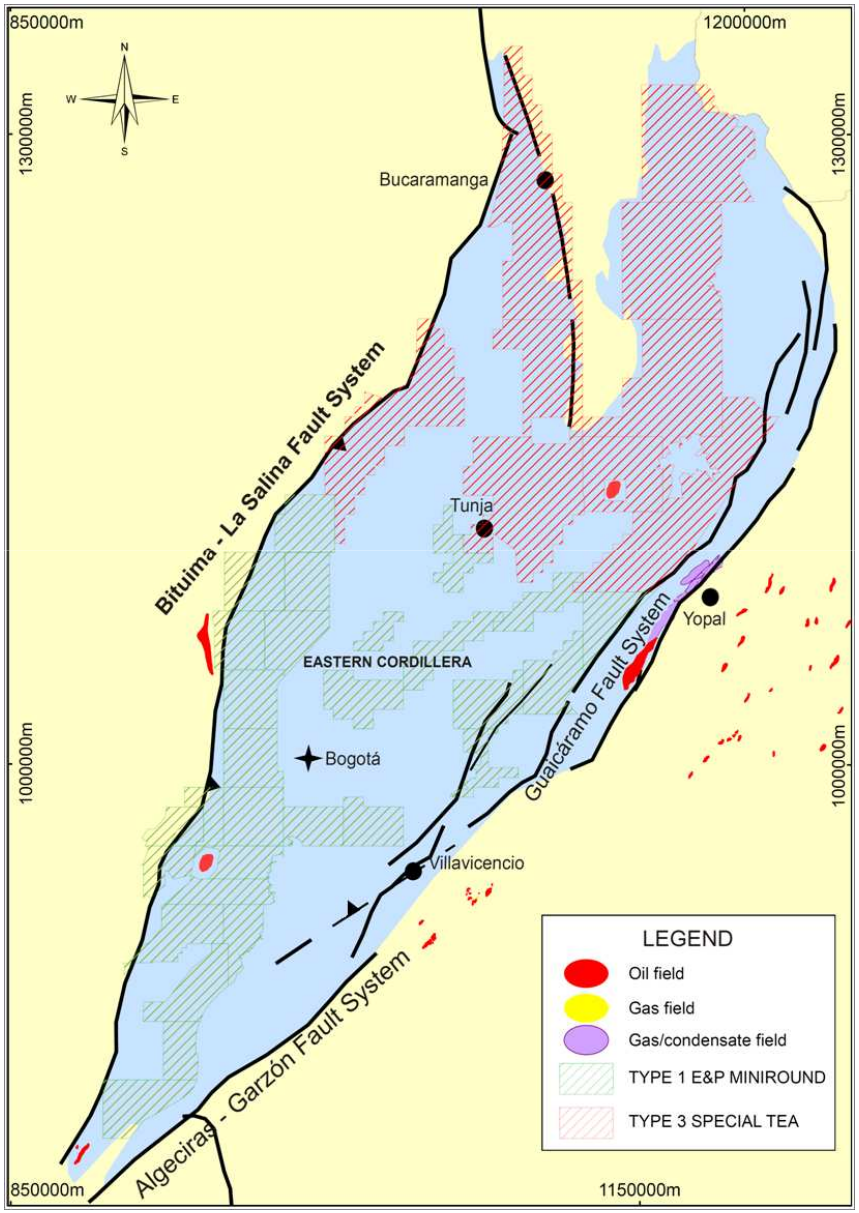
10 – 100 MMBO: 2

1 – 10 MMBO: 1

<1 MMBO: 1

Eastern Cordillera





Location map with the offered blocks

OPEN ROUND 2010 BLOCKS

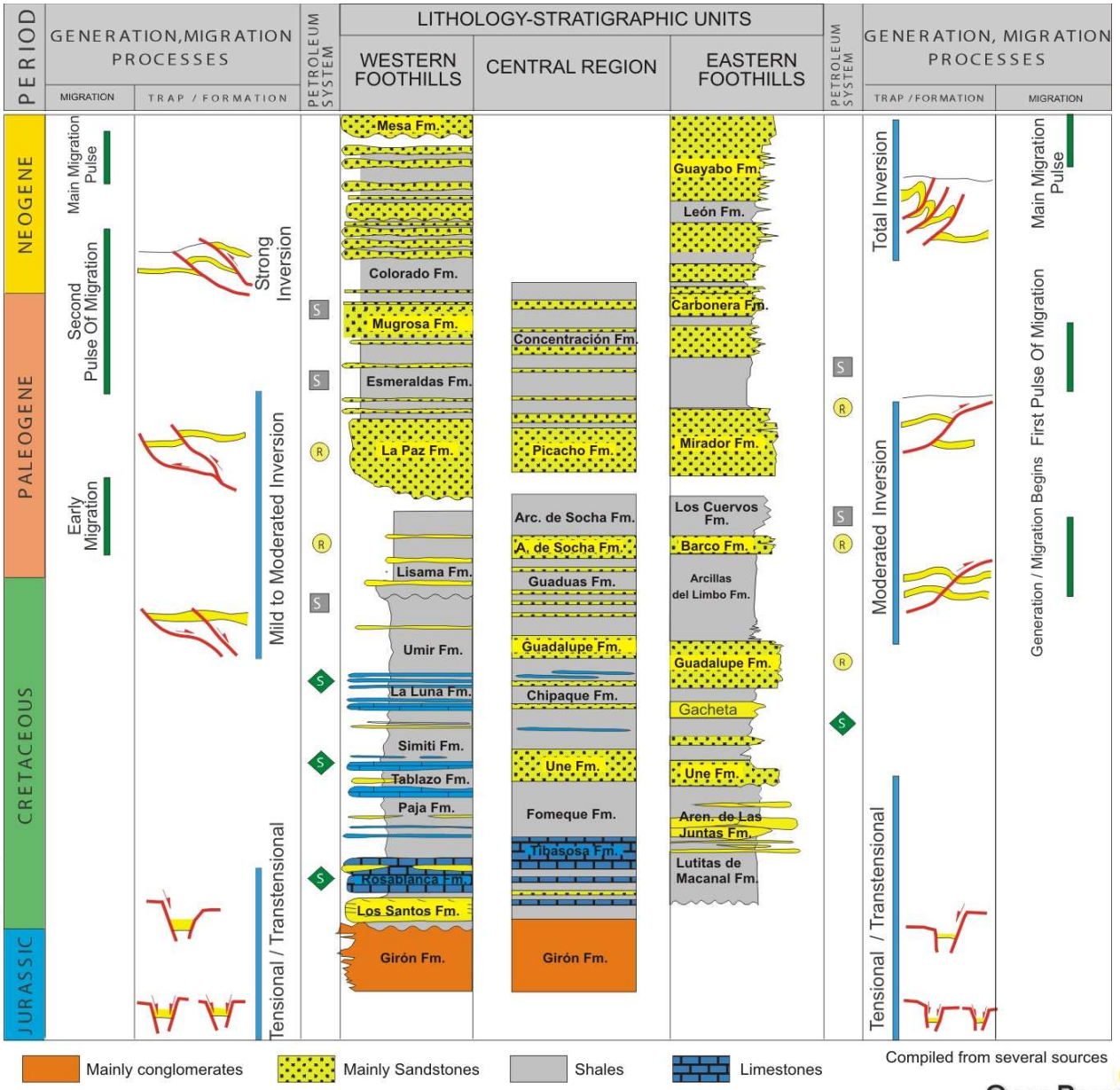
Type 1: 29 Blocks
16,648 Km^2

Type 3: 9 Blocks
21,216 Km^2

Eastern Cordillera

Petroleum geology (I)

Stratigraphic chart showing source rocks, reservoirs, s eals, and tectonic events



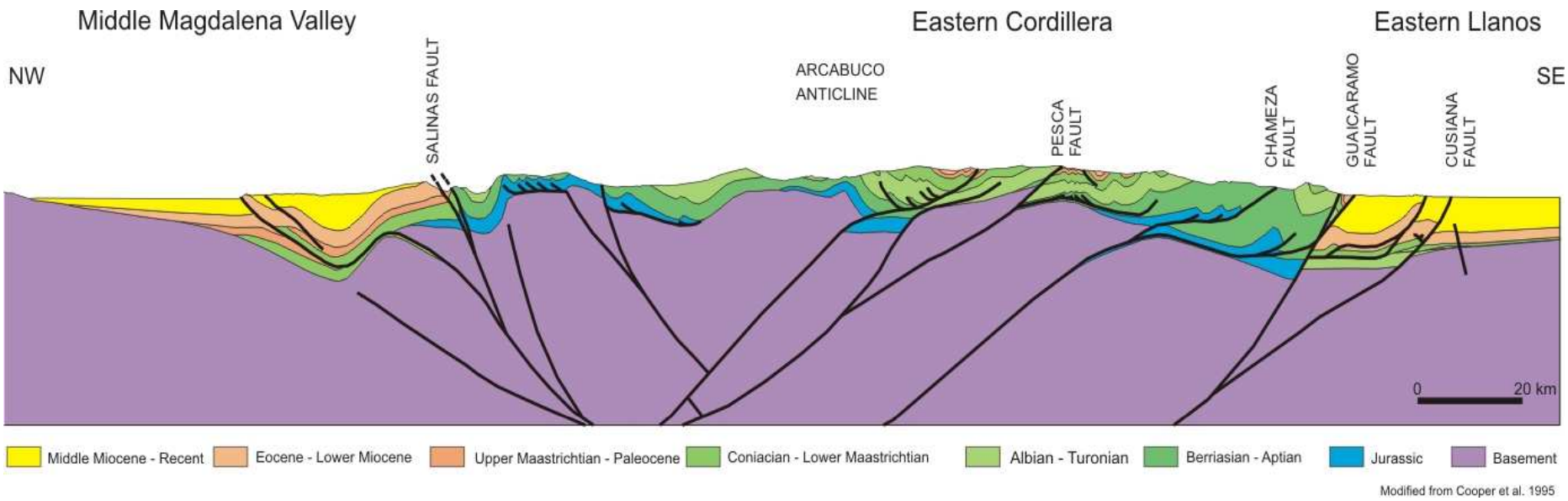
AGENCIA NACIONAL DE **HIDROCARBUROS**

Source rocks, reservoirs and seals

PETROLEUM SYSTEM ELEMENT	LITHOLOGIC UNIT	OBSERVATIONS
S Source	La Luna Fm (N) Simití Fm (N) Chipaque Fm (E) Fómeque Fm (E) Other Cretaceous shaly intervals	TOC: 1.0 – 3.0% Kerogen: Type I and II
R Reservoir	Une Fm Guadalupe Fm Picacho Fm Mirador Fm Lower Socha Fm	Sandstones Porosity: 5 – 10% Permeability: 4 - 100 mD
S Seal	Chipaque Fm Upper Socha Fm Other Cretaceous and Cenozoic shaly intervals	Chipaque Fm and Upper Socha Fm are regional seals

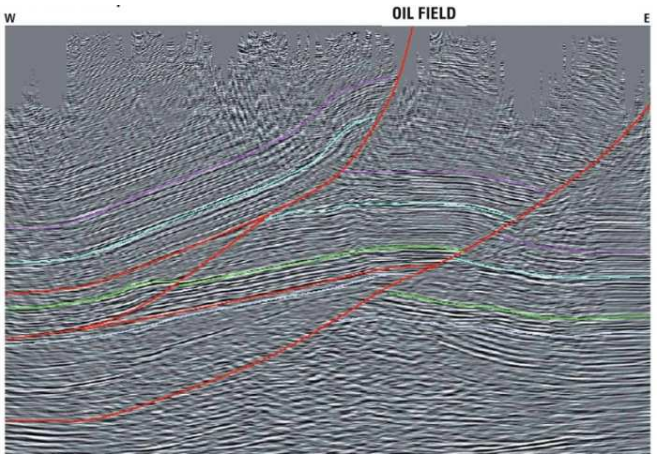
Eastern Cordillera

Regional structure



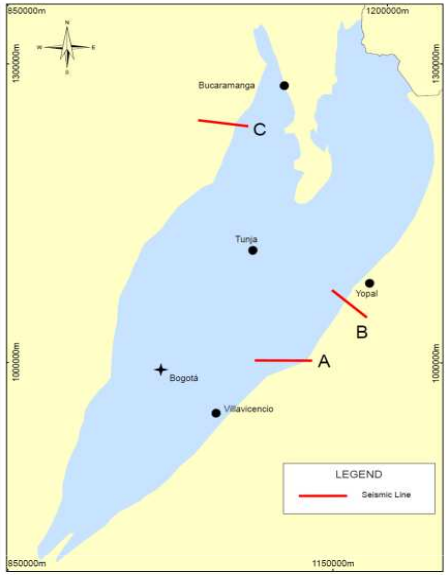
Trap styles within the Cordillera Oriental

- **Thrusts and Folds**
- **Imbricate Thrusts**
- **Duplex structures**
- **Subthrust structures**
- **Triangle zones**
- **Salt domes**

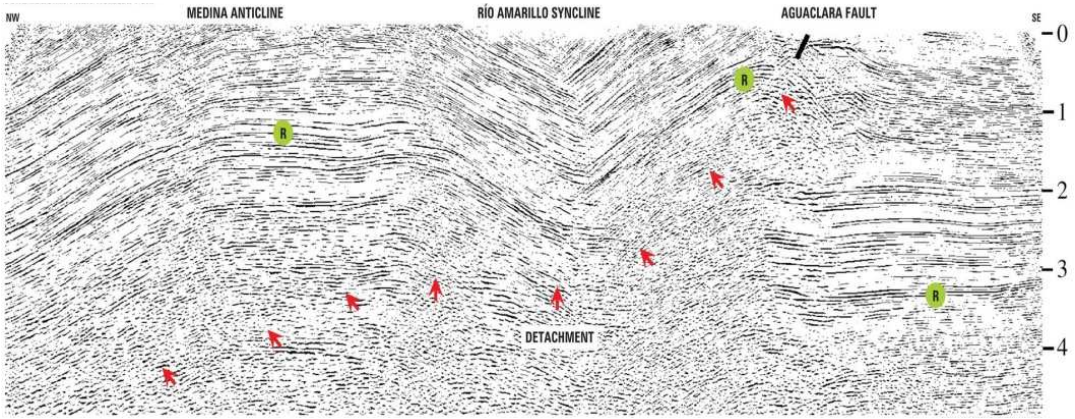


Eastern Cordillera

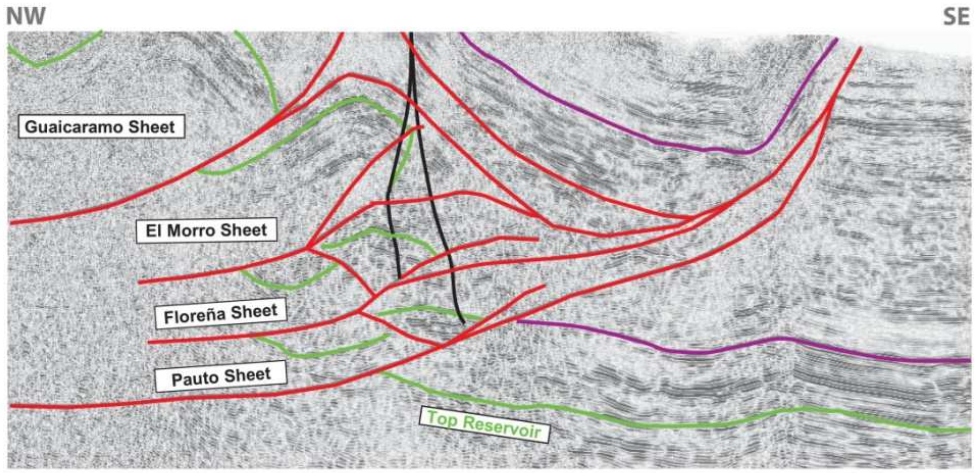
Examples of play types



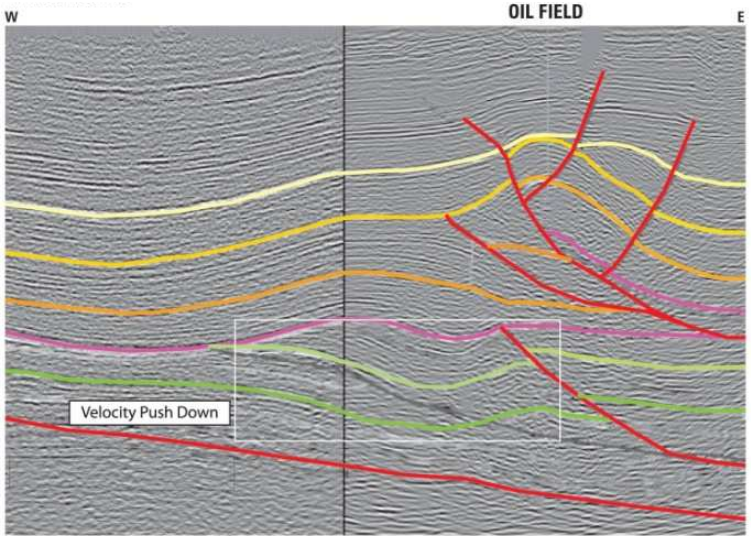
A) Wide anticline over detachement fault
Eastern foothills



B) Duplex structure – Floreña Area
Eastern foothills



C) Thrust anticline over detachement surface
Western foothills



Coffee Break!

Second Part
Emerging and Frontier Basins

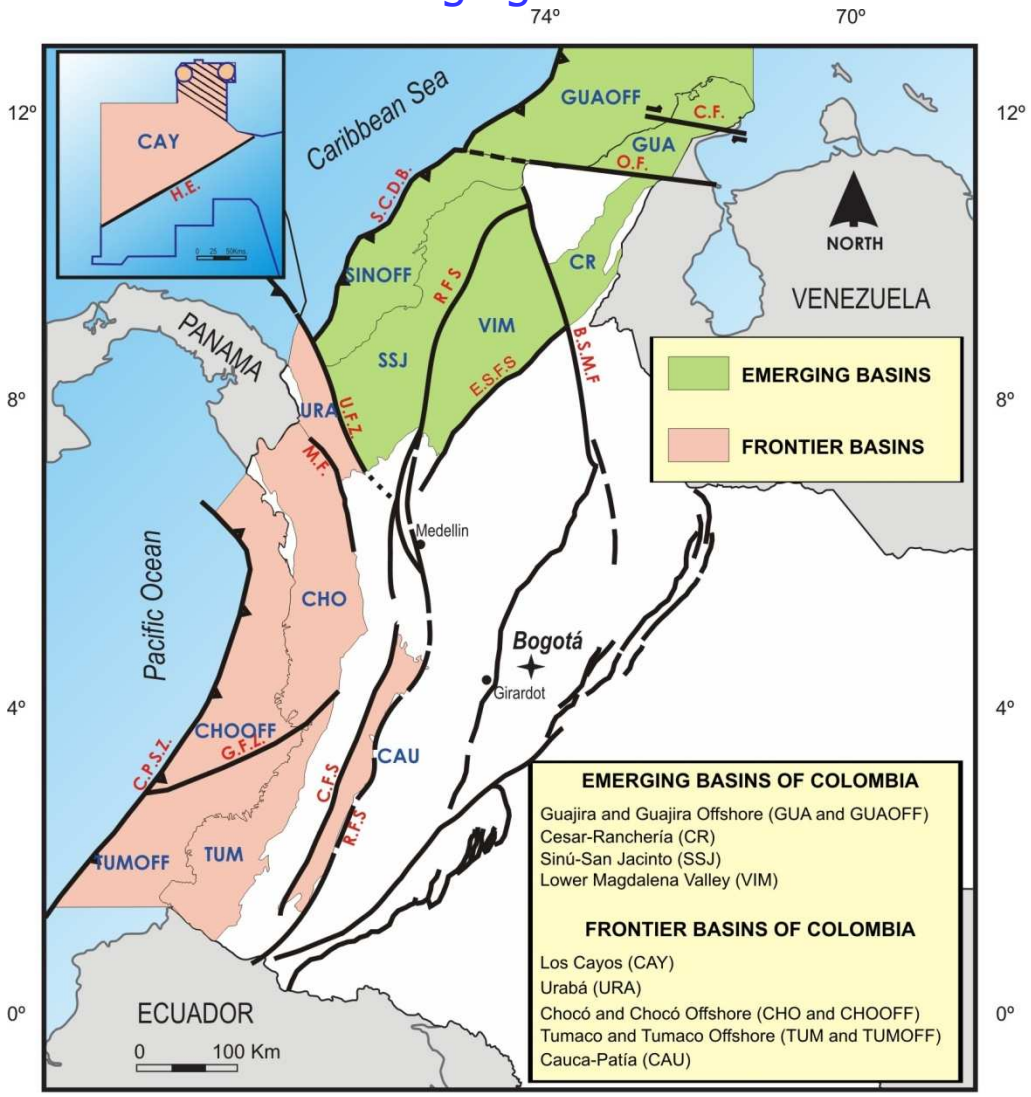
Colombia

Emerging and frontier basins

Area of Emerging and Frontier Basins

BASIN	AREA (Km²)
GUAJIRA (GUA) & GUAJIRA OFFSHORE (GUA OFF)	13,778 52,860
CESAR – RANCHERÍA (CR)	11,668
SINÚ – SAN JACINTO (SSJS) & SINÚ OFFSHORE (SIN OFF)	39,645 29,576
LOWER MAGDALENA VALLEY (VMM)	38,017
LOS CAYOS (CAY)	144,755
URABÁ (URA)	9,449
CHOCÓ (CHO) & CHOCÓ OFFSHORE (CHO OFF)	38,582 37,773
TUMACO (TUM) & TUMACO OFFSHORE (TUM OFF)	23,732 34,553
CAUCA – PATÍA (CAU)	12,823

Colombian Emerging and Frontier Basins



Emerging and frontier basins

Statistics

Emerging Basins

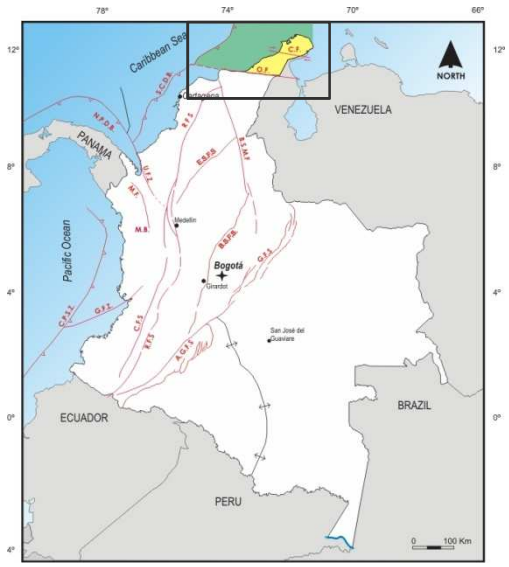
Basin	Basin Area (Km^2)	Production	Discoveries	Number of wells	2D seismic (Km)
Guajira and Guajira offshore	66,639	3.72 TCFG	5 gas	78	24,074
Cesar-Ranchería	11,668	ND	2 oil + 3 gas (NCP)	67	3,458
Sinú-San Jacinto	69,221	ND	3 gas	205	26,343
Lower Magdalena Valley	38,017	0.35 TCFG + 64.2 MBO	4 oil + 8 gas	273	16,704

Frontier Basins

Basin	Basin Area (Km^2)	Production	Oil & Gas Seeps	Wells with Shows	Number of wells	2D seismic (km)
Los Cayos	144,755	-		2 oil & gas	2	4,739
Urabá	9,449	-	✓	2 gas	5	4,665
Chocó and Chocó offshore	73,675	-	✓	1 oil & gas	5 (Atrato)	6,599
Tumaco and Tumaco offshore	58,285	-	✓	1 oil & 2 gas	5	9,452
Cauca-Patía	12,823	-	✓	1 gas	5	968

Basin Statistics as of July 2009

Guajira



OPEN ROUND 2010 BLOCKS

Onshore

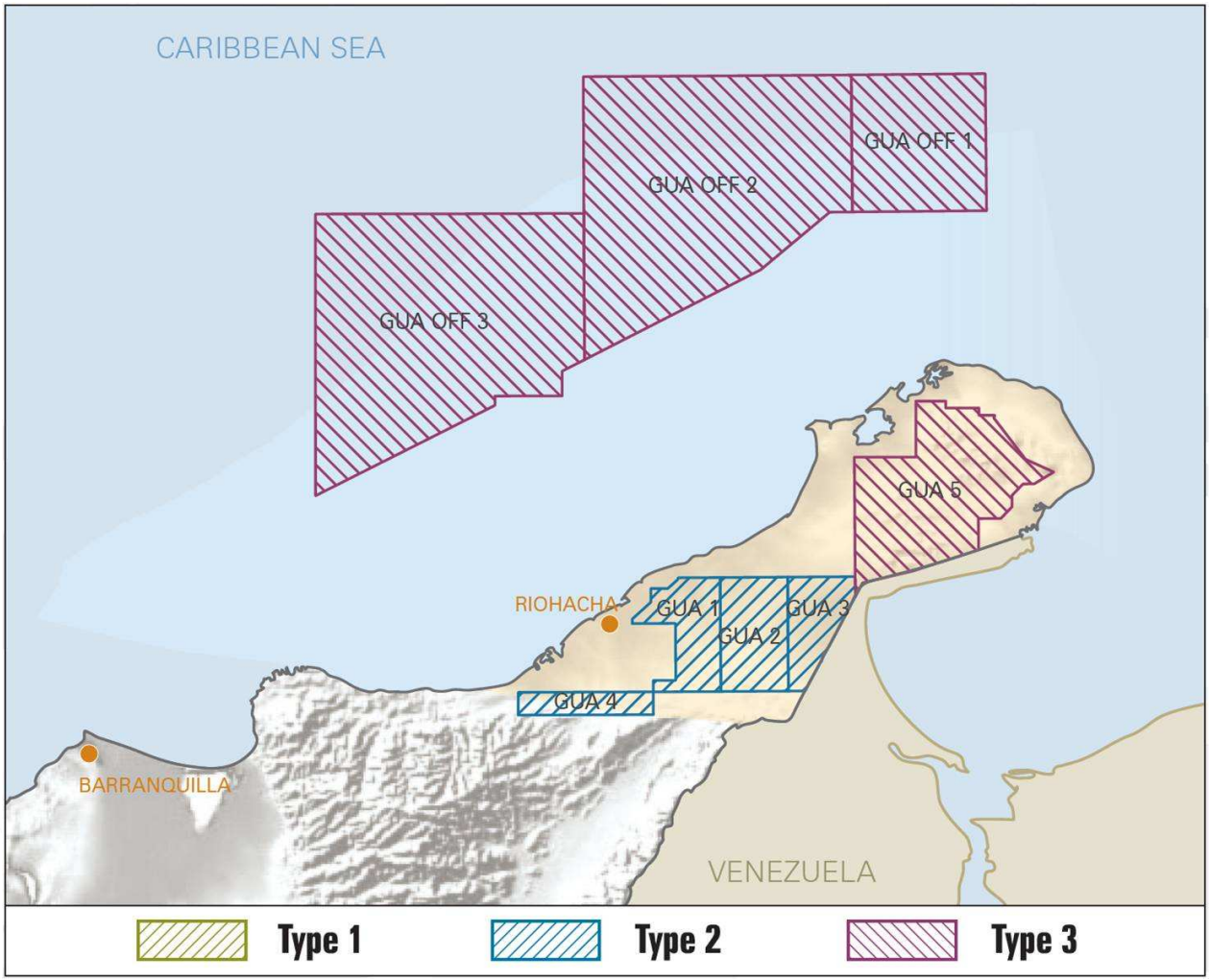
Type 2: 4 Blocks
3,691 Km^2

Type 3: 1 Block
3,461 Km^2

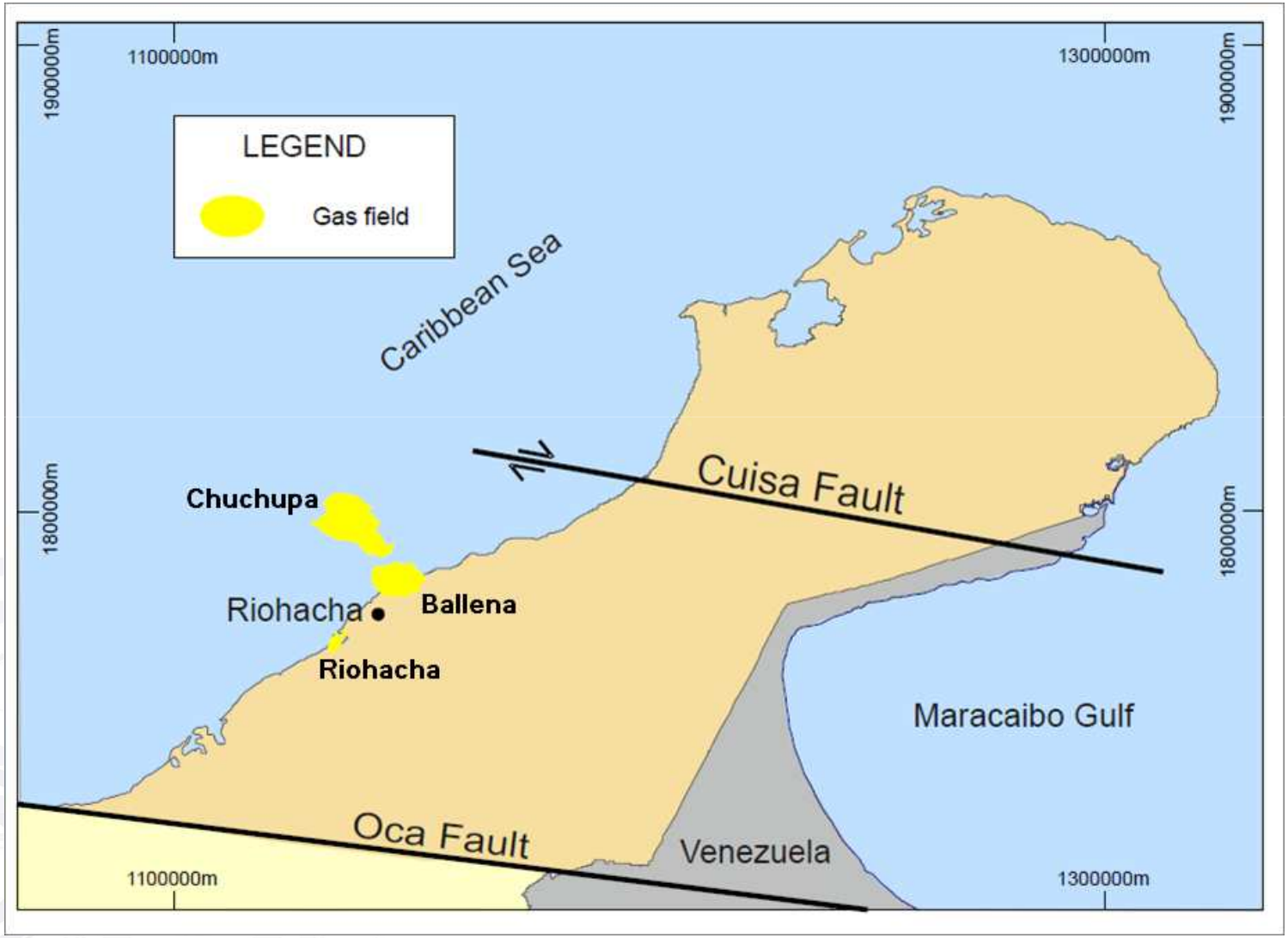
Offshore

Type 3: 3 Blocks
21,765 Km^2

Location map with the offered blocks



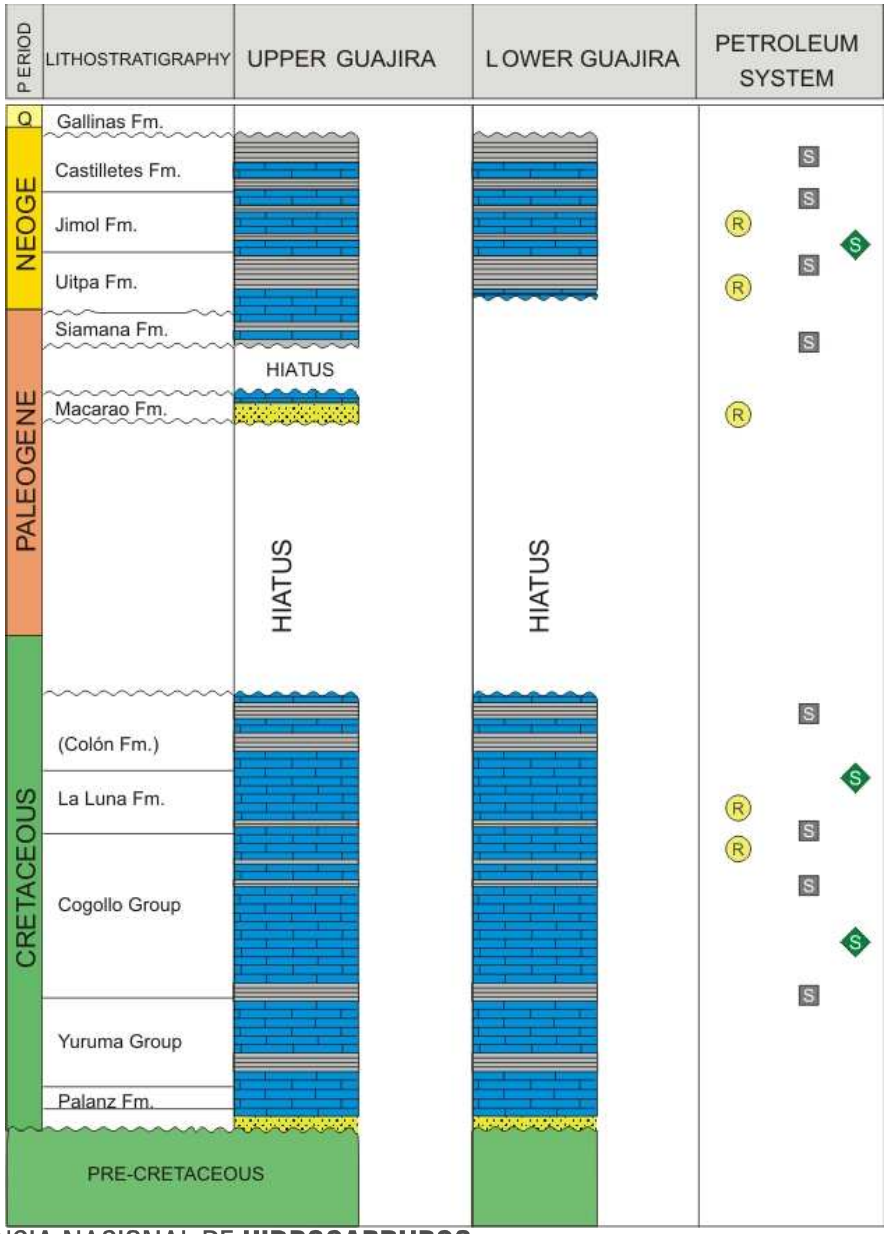
Guajira
Gas fields



Guajira

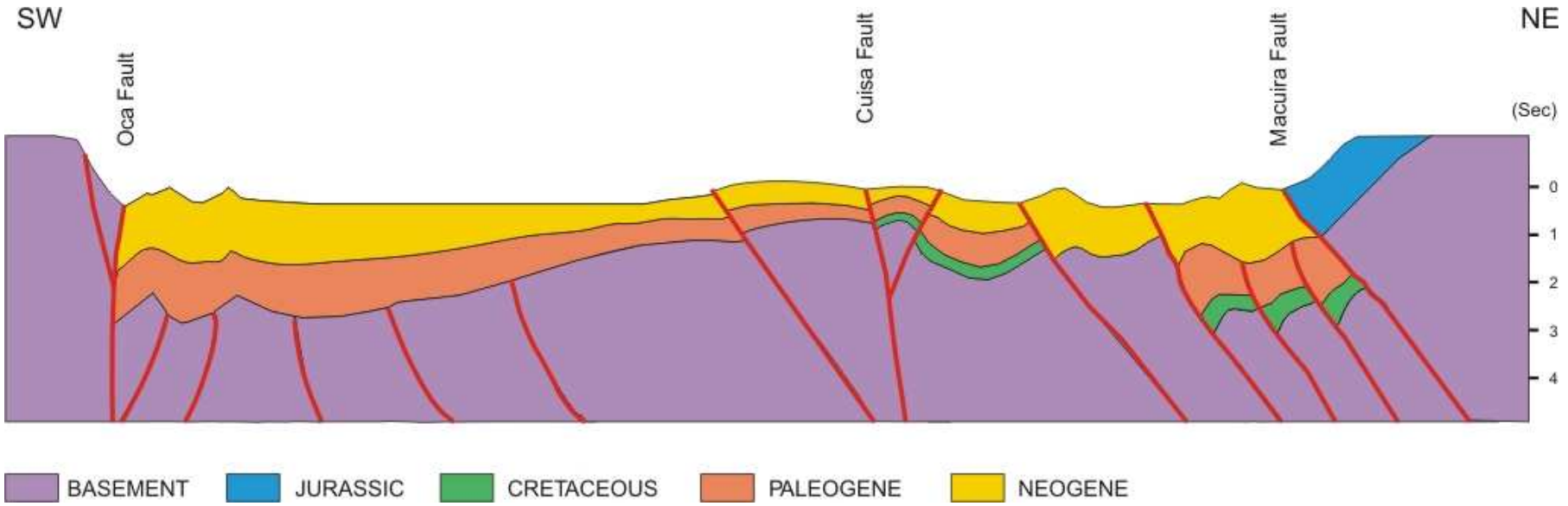
Petroleum geology

Stratigraphic colums of the Upper and Lower Guajira showing source rocks, reservoirs and seals



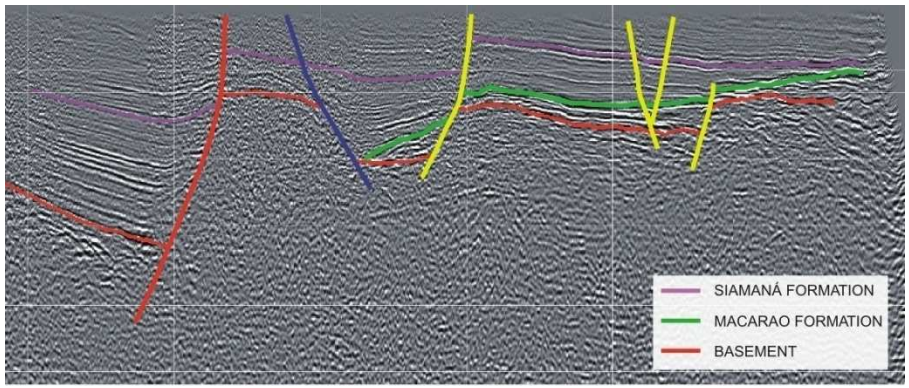
Guajira

Regional structural style



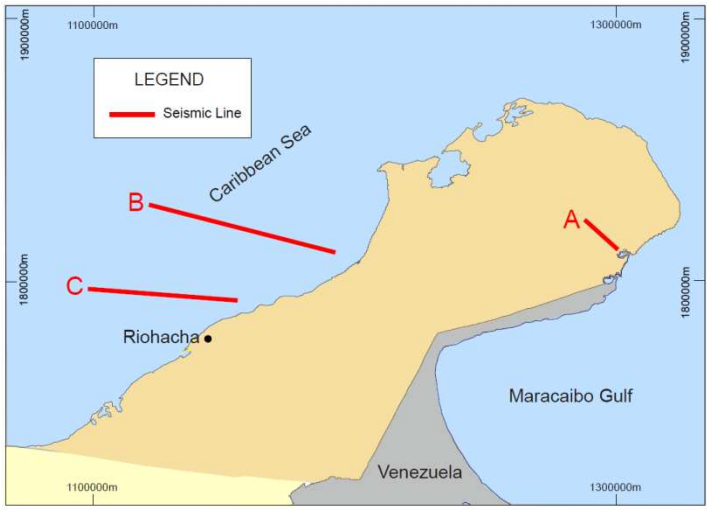
Trap types within Guajira basin:

- **Reverse and normal fault traps**
- **Flower structures**
- **Tectonic wedges**

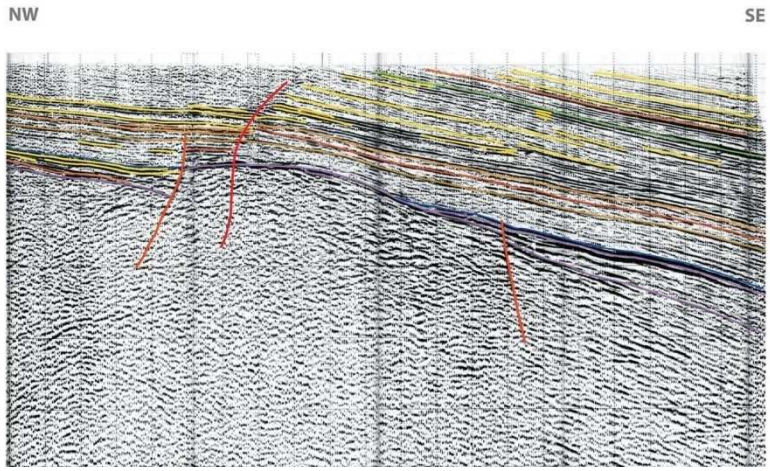


Guajira

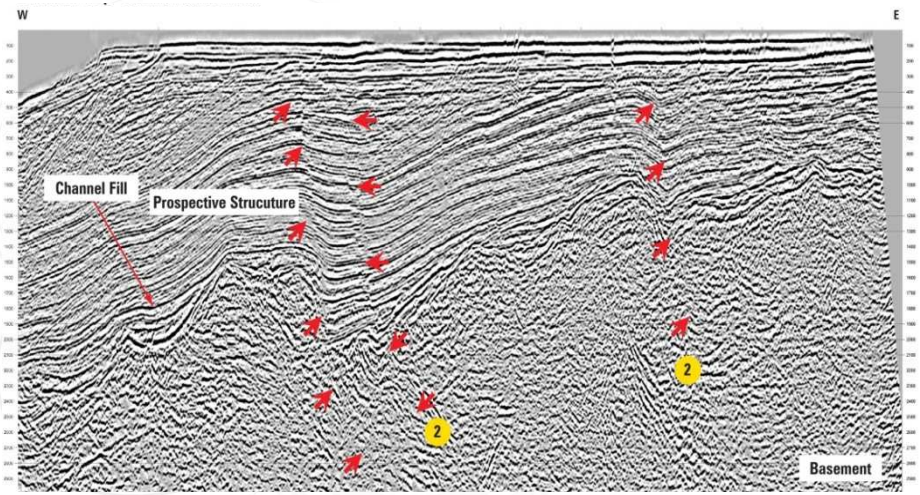
Examples of play types



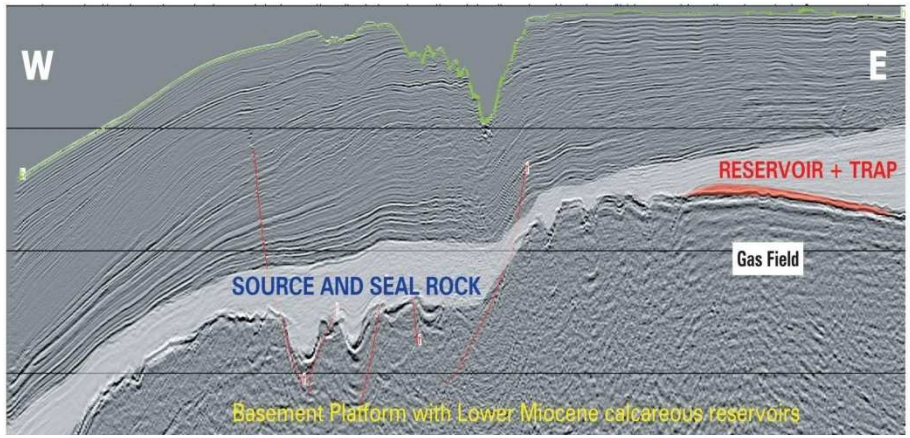
A. Onlapping over basement



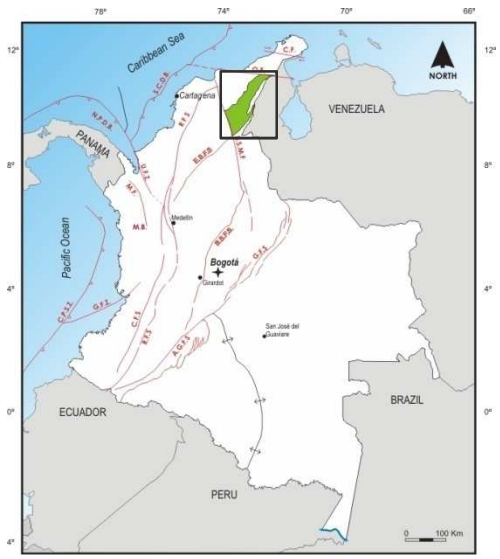
B. Positive structures related to planar normal faults

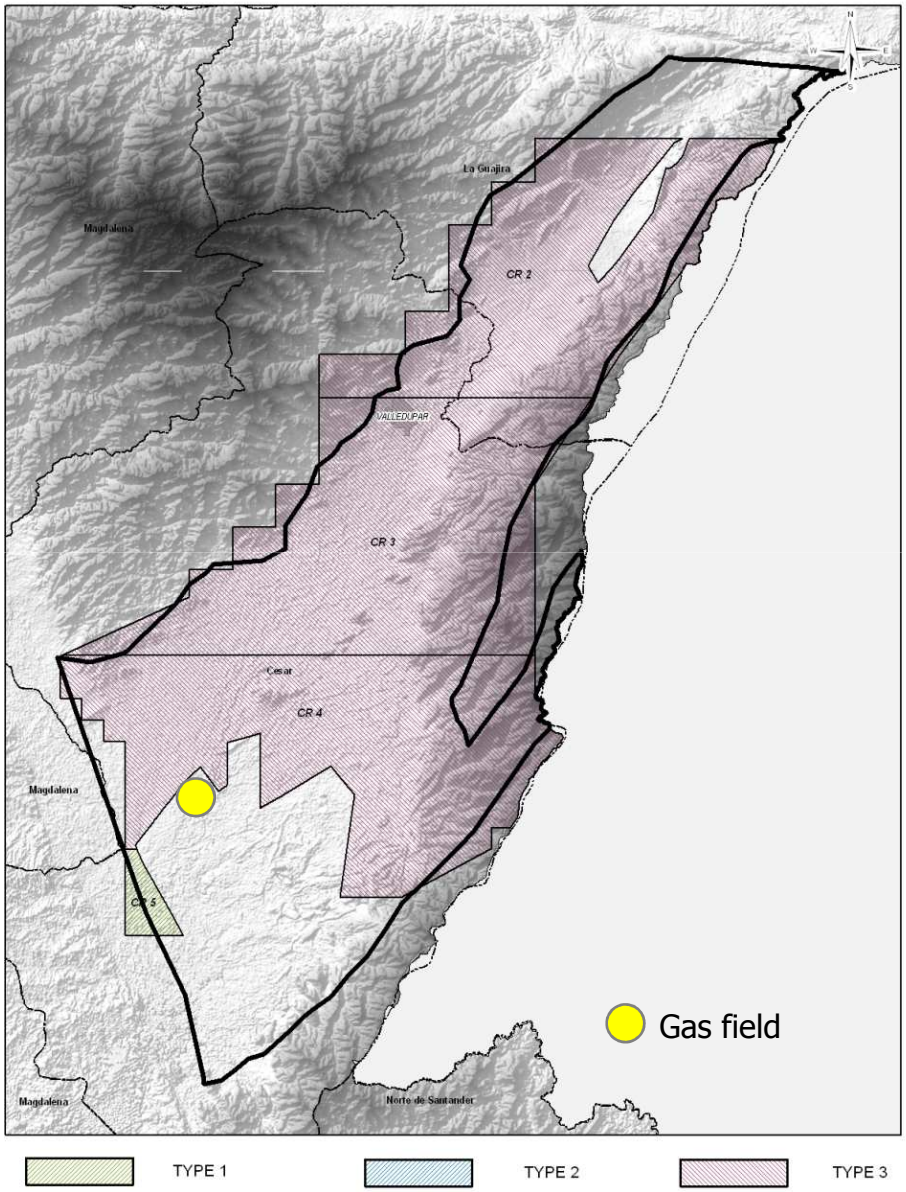


C. Combined structural - stratigraphic trap



Cesar - Ranchería





OPEN ROUND 2010 BLOCKS

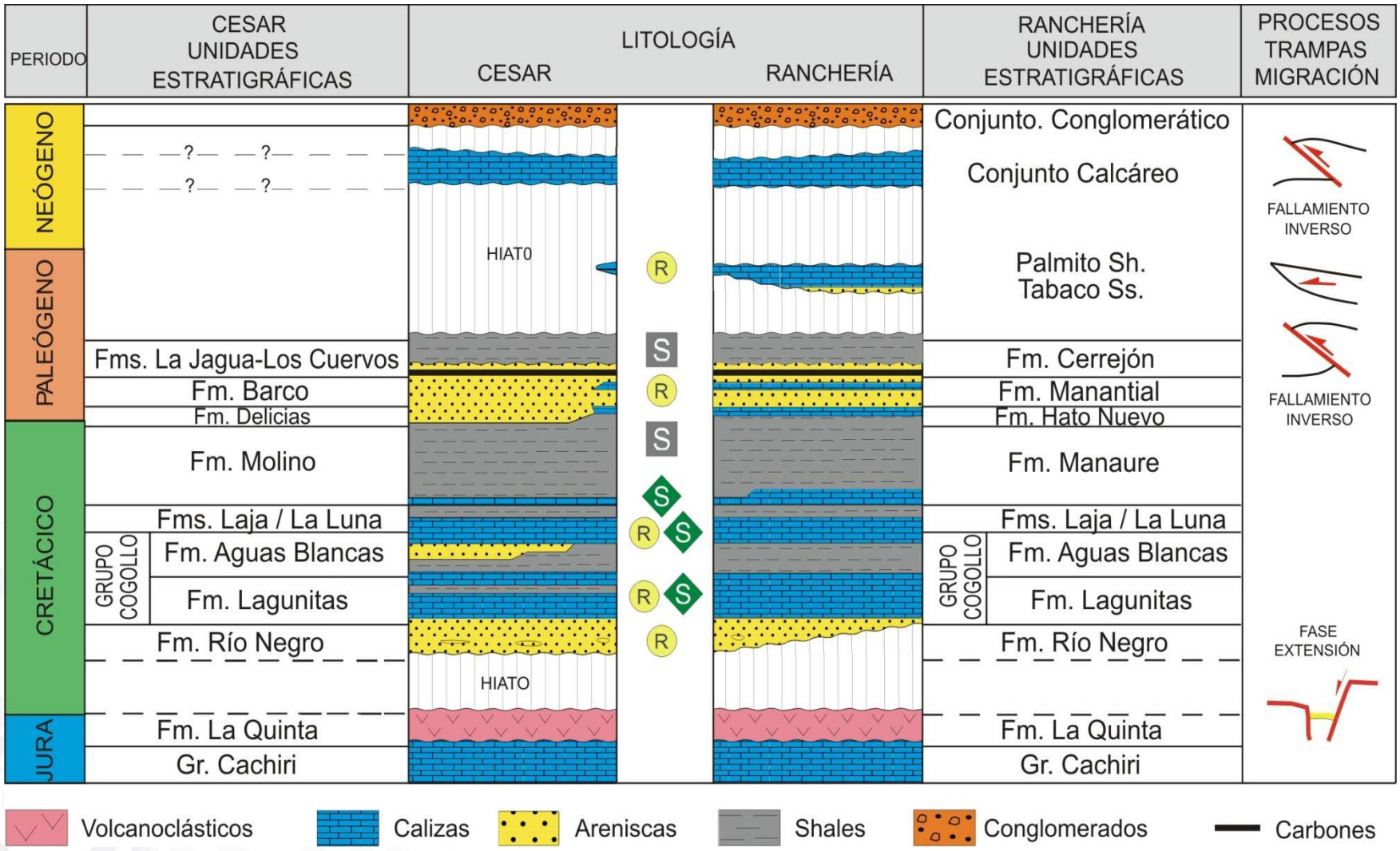
Type 1: 1 Block
135 Km^2

Type 3: 3 Blocks
9,591 Km^2

Location map with the offered blocks

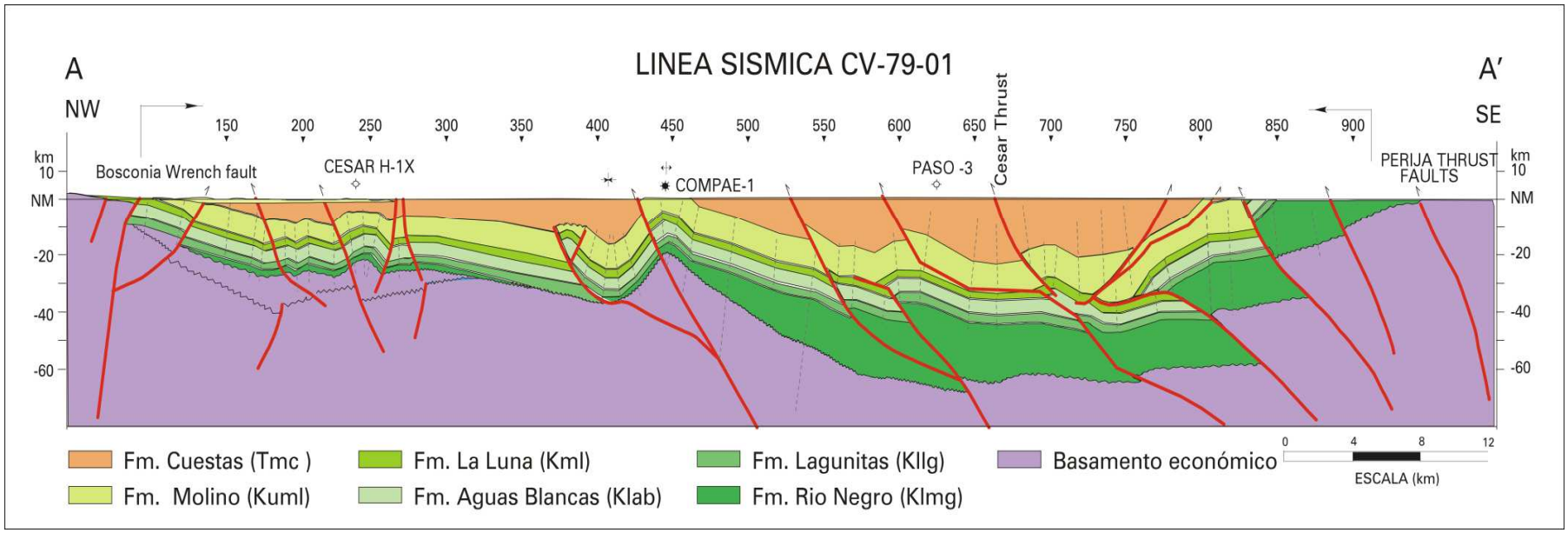
Cesar - Ranchería

Petroleum geology



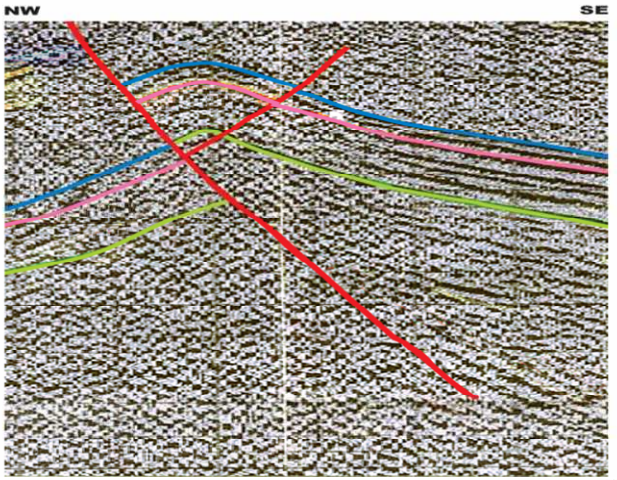
Cesar - Ranchería

Regional structural style

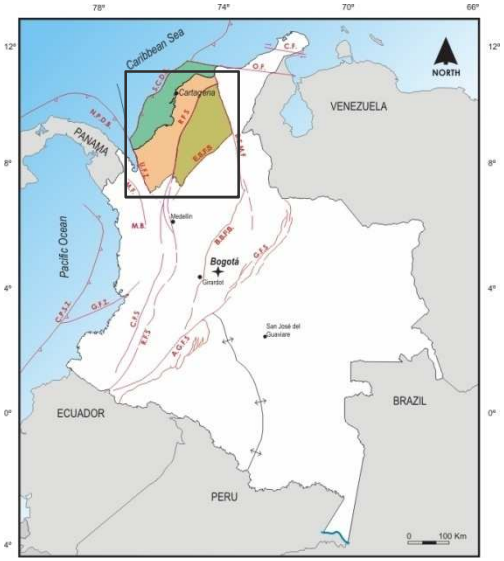


Traps within Cesar – Ranchería basin:

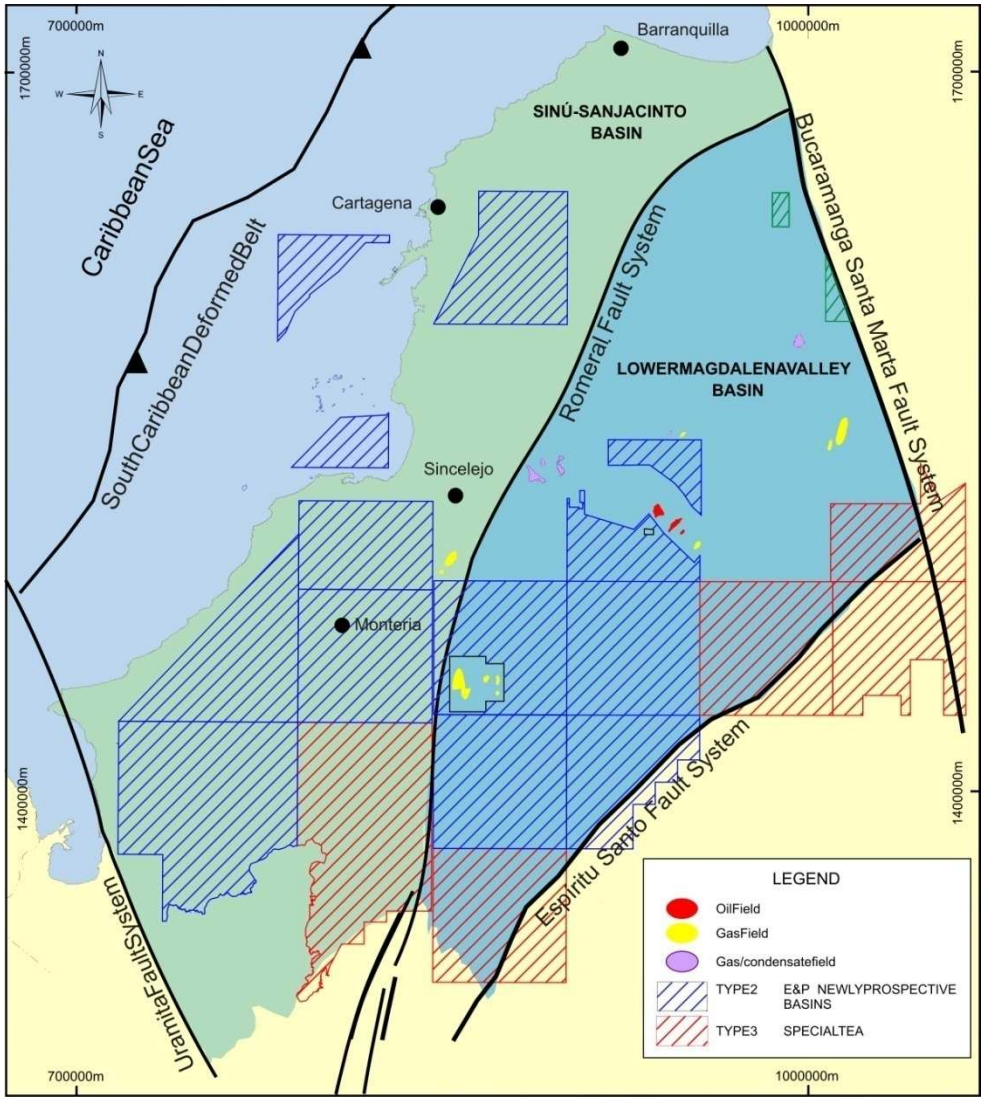
- **Thrust faults**
- **Regional unconformities at the base of the Cretaceous and the Cenozoic**



Sinú – San Jacinto – Lower Magdalena Valley (LMV)



Location map with the offered blocks

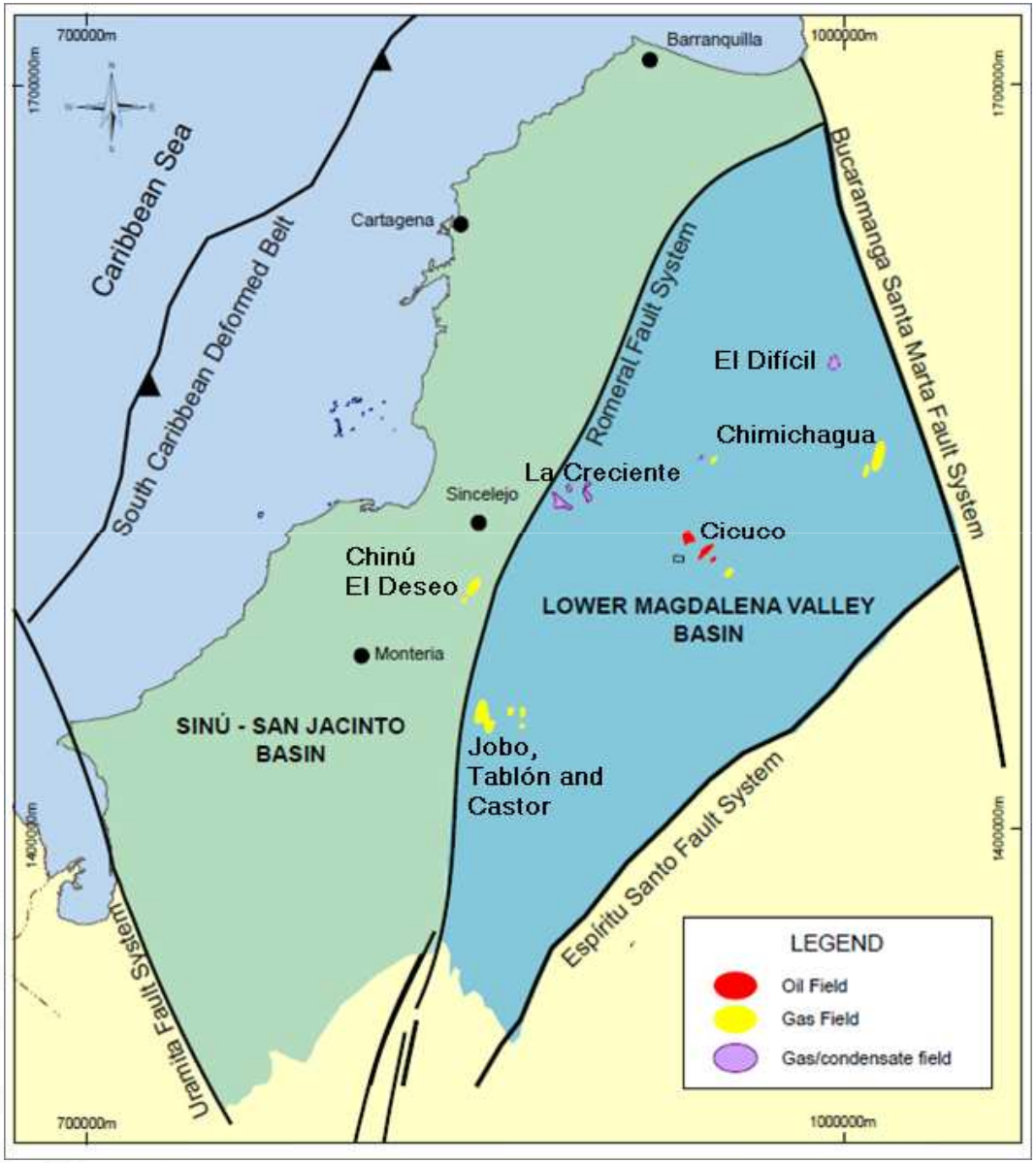


OPEN ROUND 2010 BLOCKS

Offshore	Onshore
Type 2: 2 Blocks 1,452 Km^2	Type 1: 2 Blocks 293 Km^2
	Type 2: 11 Blocks 27,874 Km^2
	Type 3: 4 Blocks 12,668 Km^2

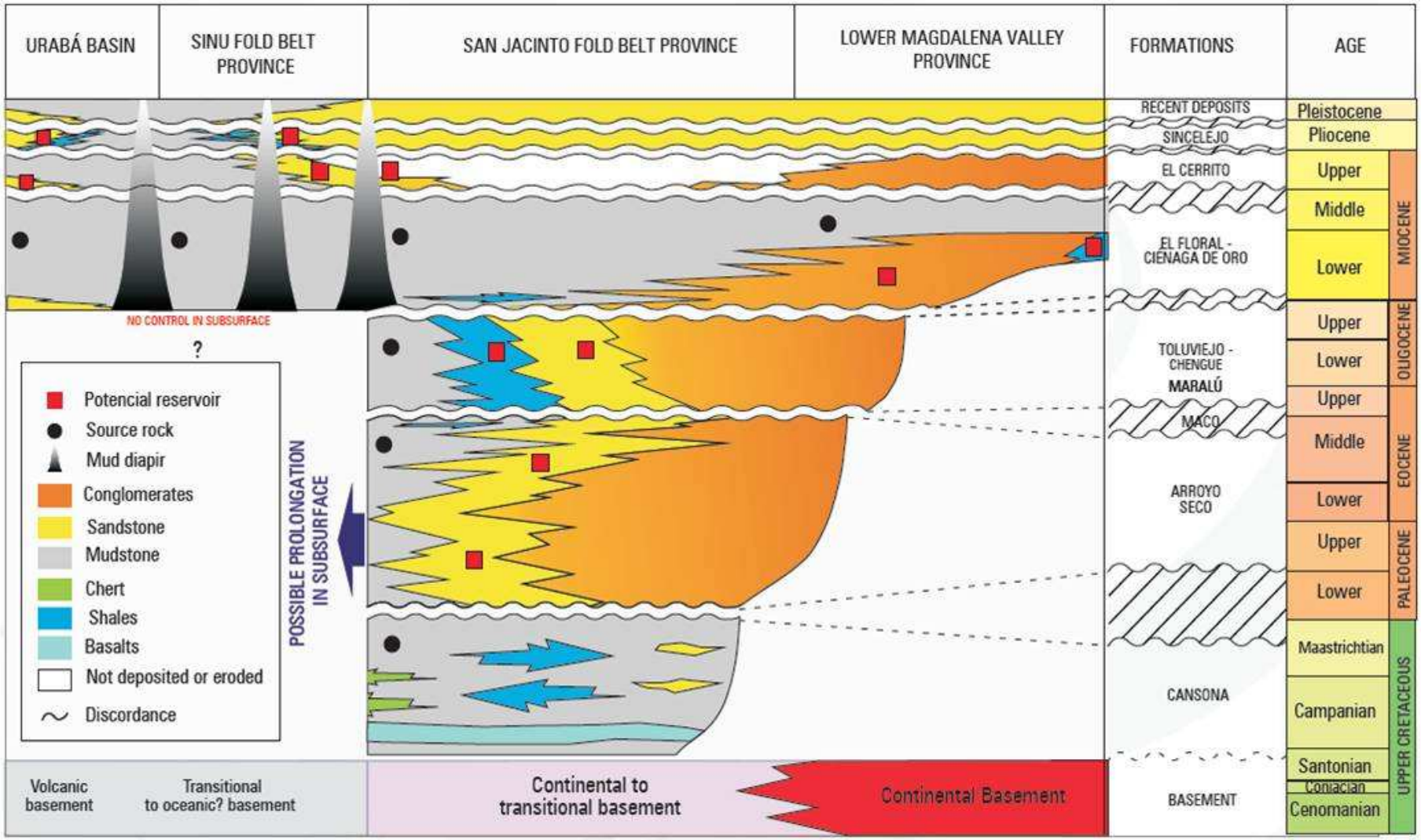
Sinú – San Jacinto – LMV

Oil & gas fields



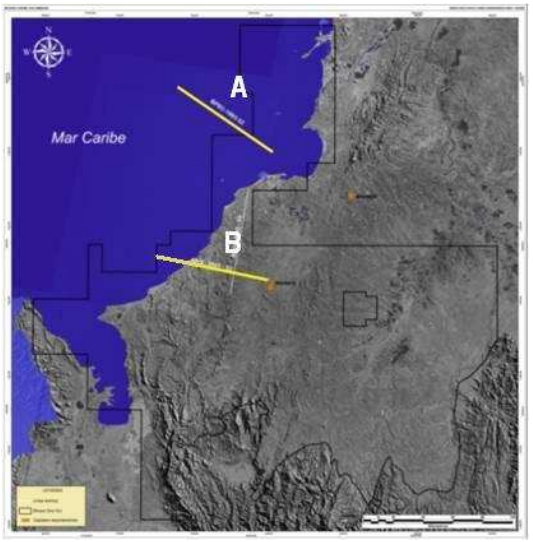
Sinú – San Jacinto – LMV

Petroleum geology

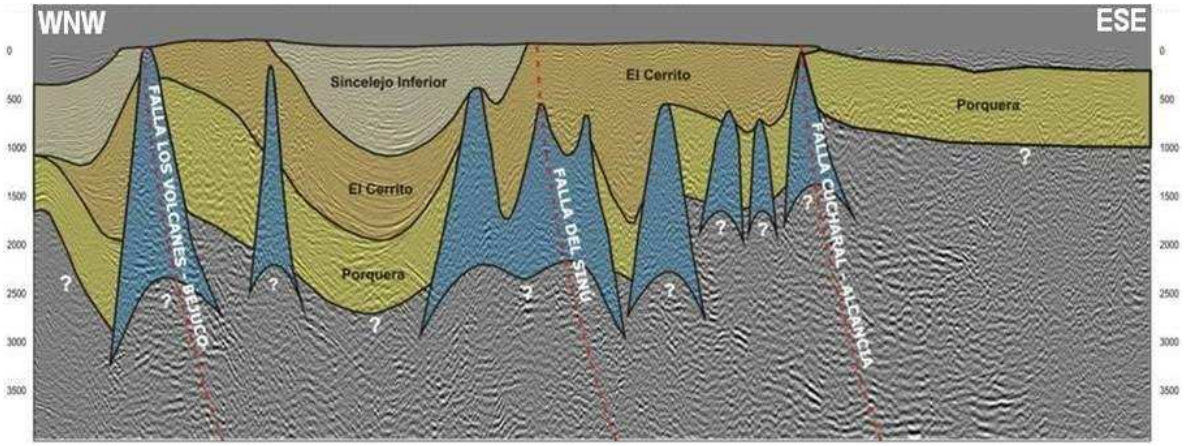


Sinú

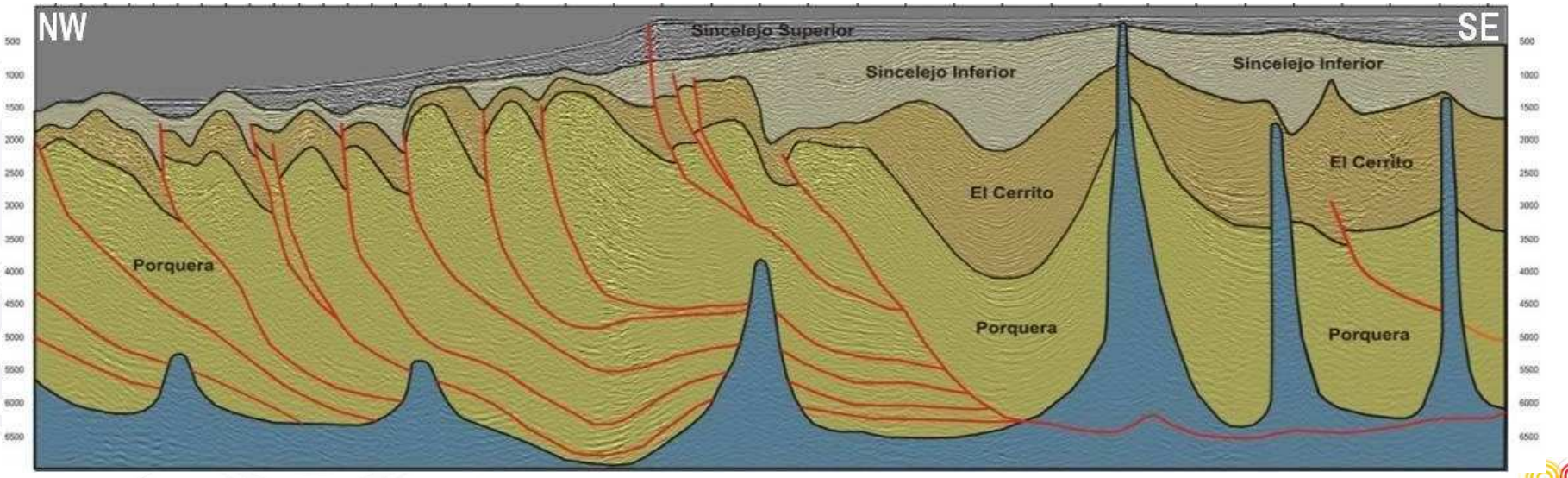
Structural style and play types



A) Traps flanking mud diapirs

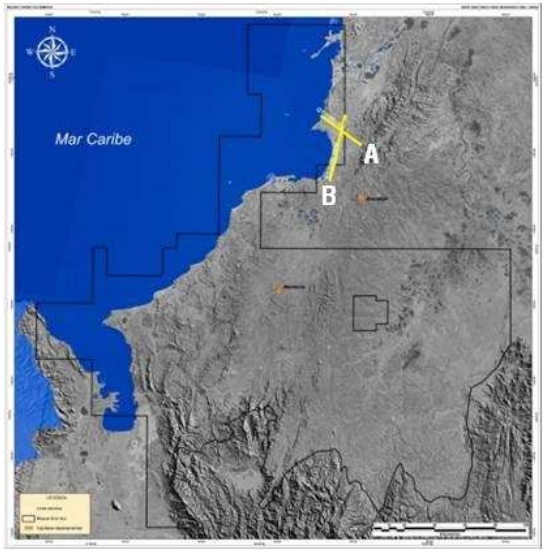


B) Traps related to reverse faults (NW) and mud diapirs (SE)

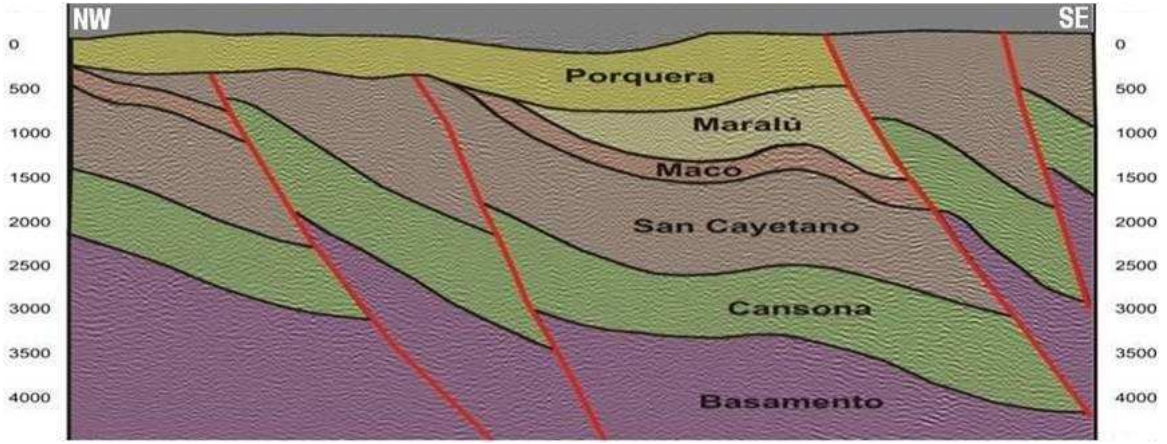


San Jacinto

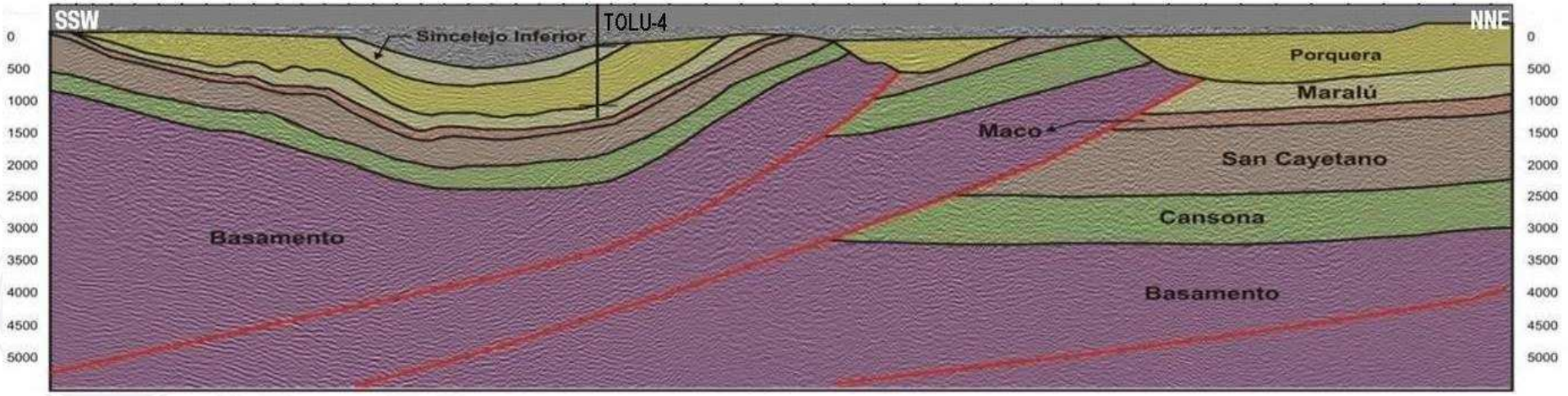
Structural style and play types



A) Folds related to west-verging reverse faults

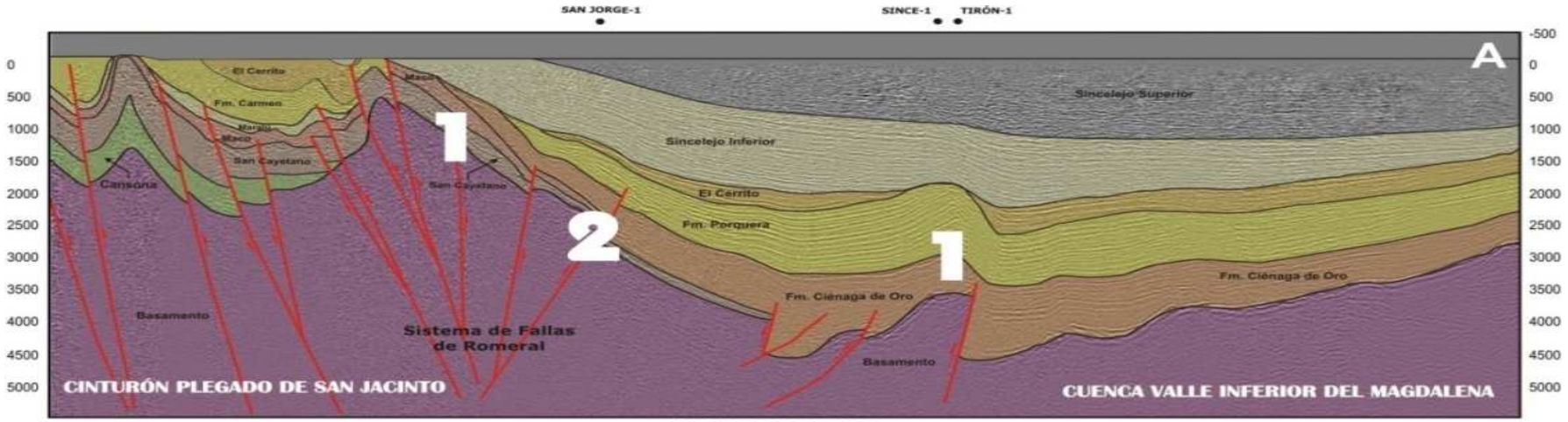


B) Stratigraphic traps associated to regional unconformities

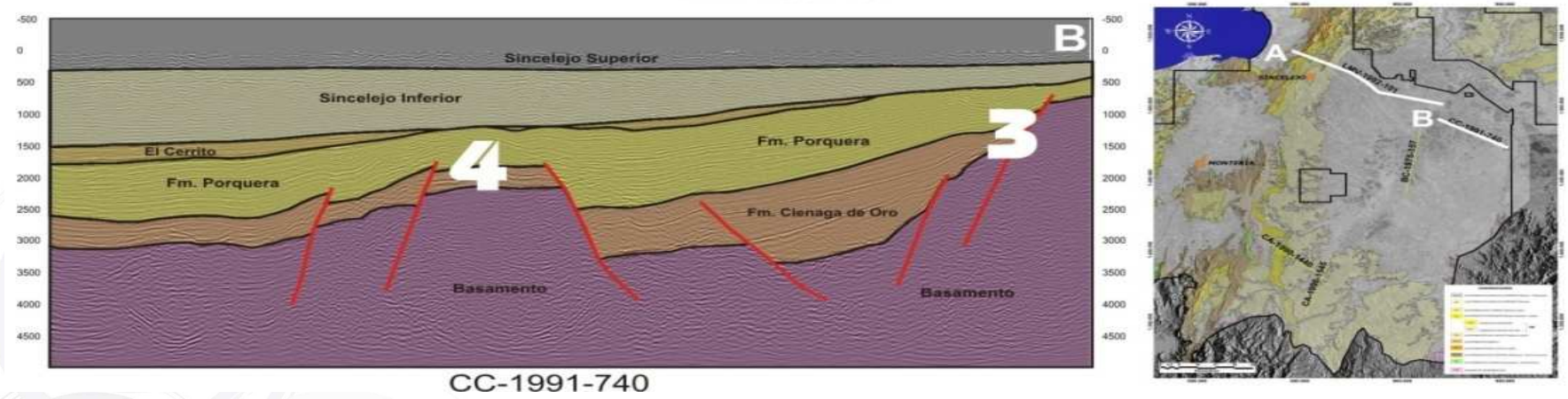


Lower Magdalena Valley

Structural style and play types



LMV-1992-101

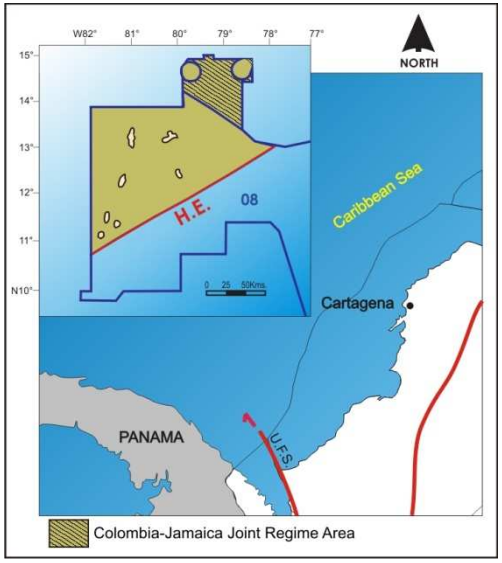


CC-1991-740

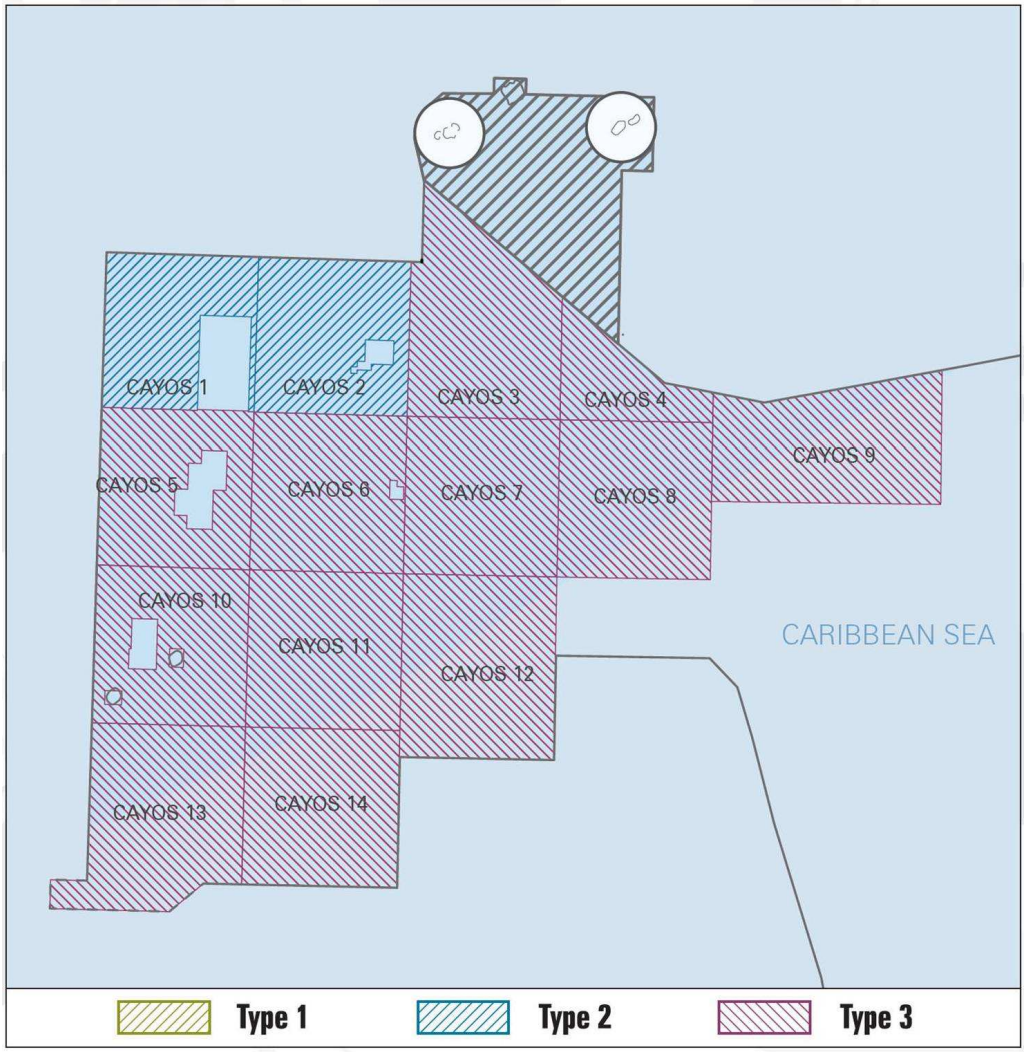
Trap Types within Lower Magdalena Valley:

1. **Anticlines related to reverse faults.**
2. **Extensional and compressive fault traps.**
3. **Onlapping over basement.**
4. **Basement highs.**

Los Cayos



Location map with the offered blocks



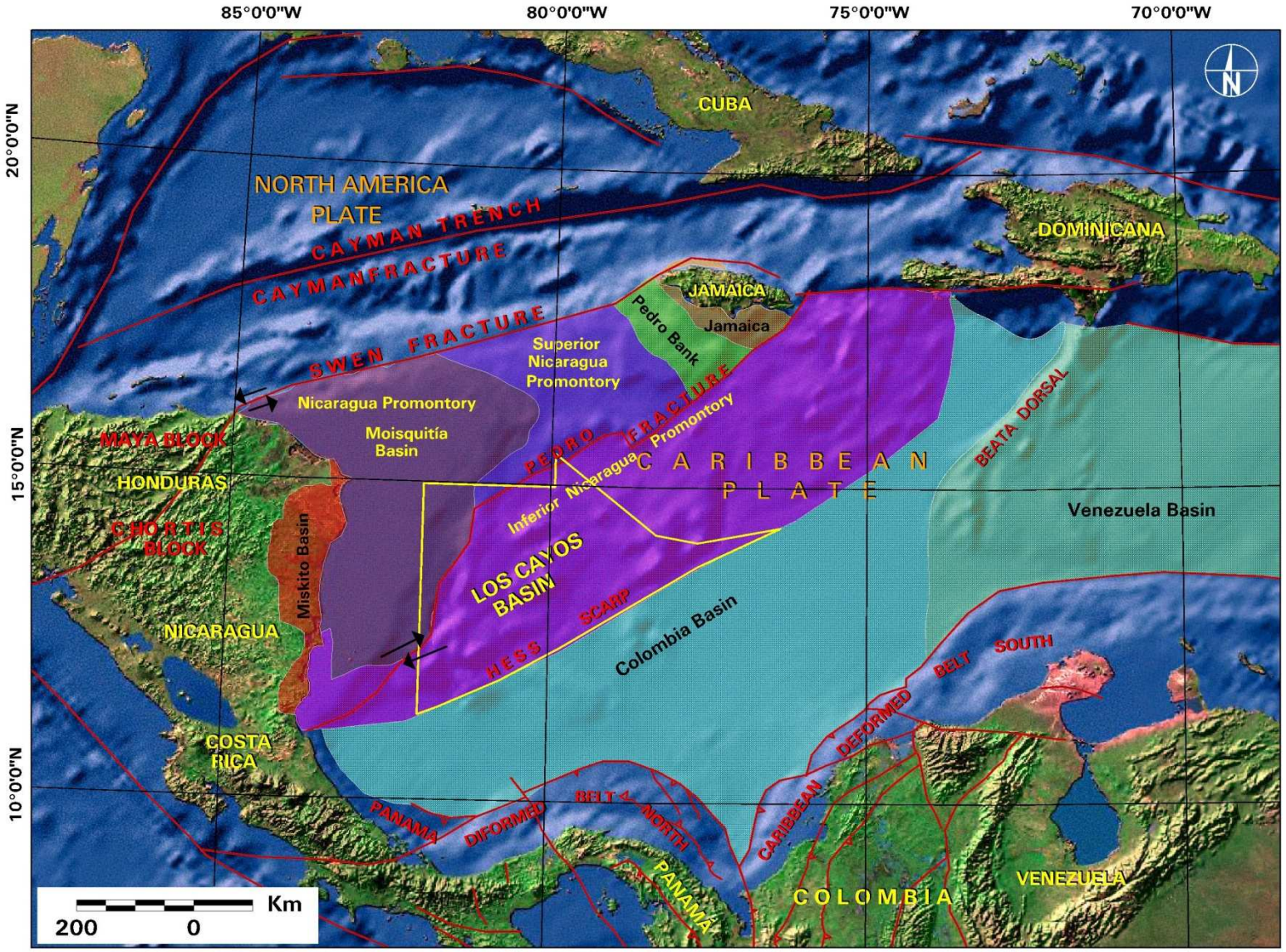
OPEN ROUND 2010 BLOCKS

Type 2: 2 Blocks
20,899 Km^2

Type 3: 12 Blocks
142,580 Km^2

Los Cayos

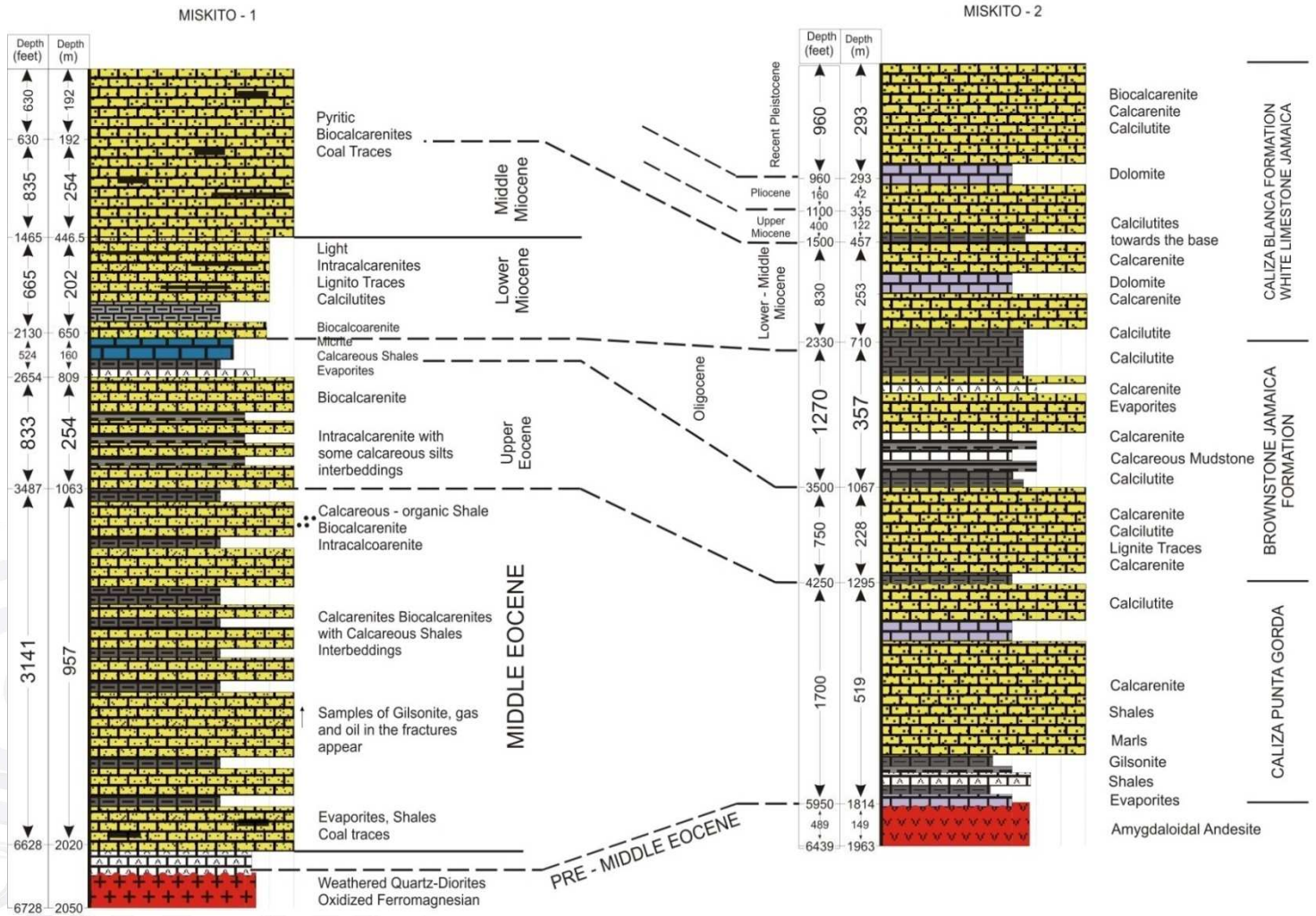
Regional tectonic setting



Los Cayos

Petroleum geology

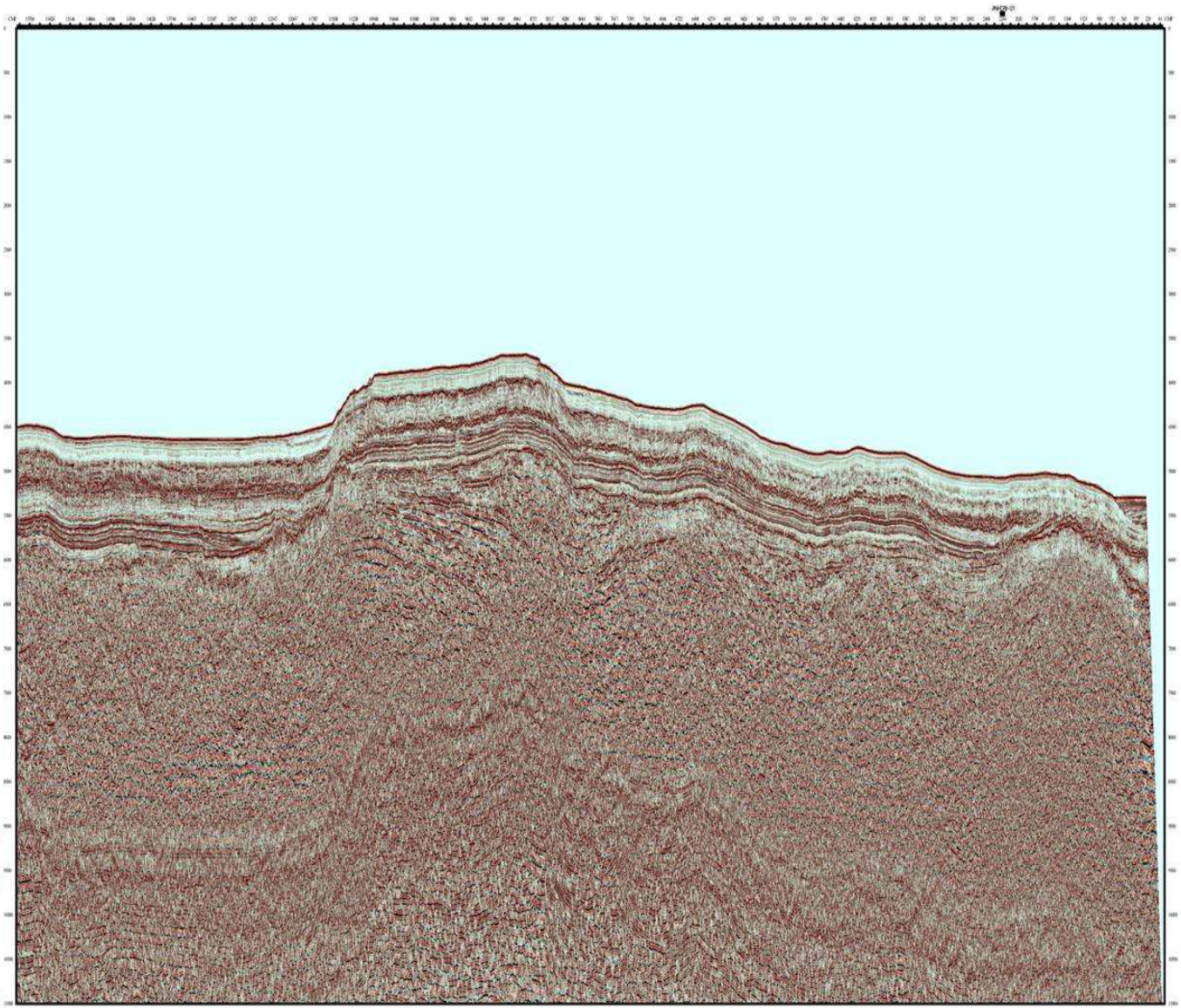
MISKITO-1 AND MISKITO-2 WELLS SCHEMATIC STRATIGRAPHIC COLUMNS CORRELATION



Reservoir Rock **Source Rock**

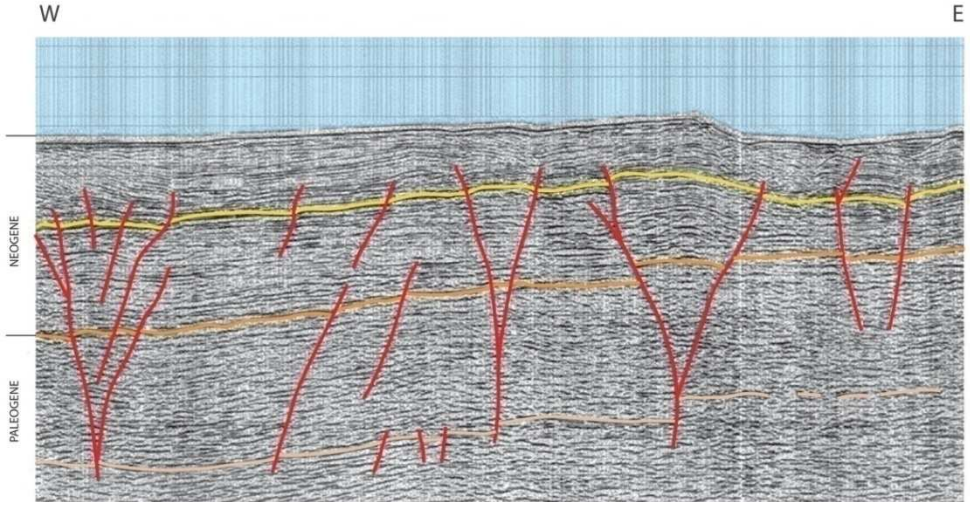
Los Cayos

Regional structure

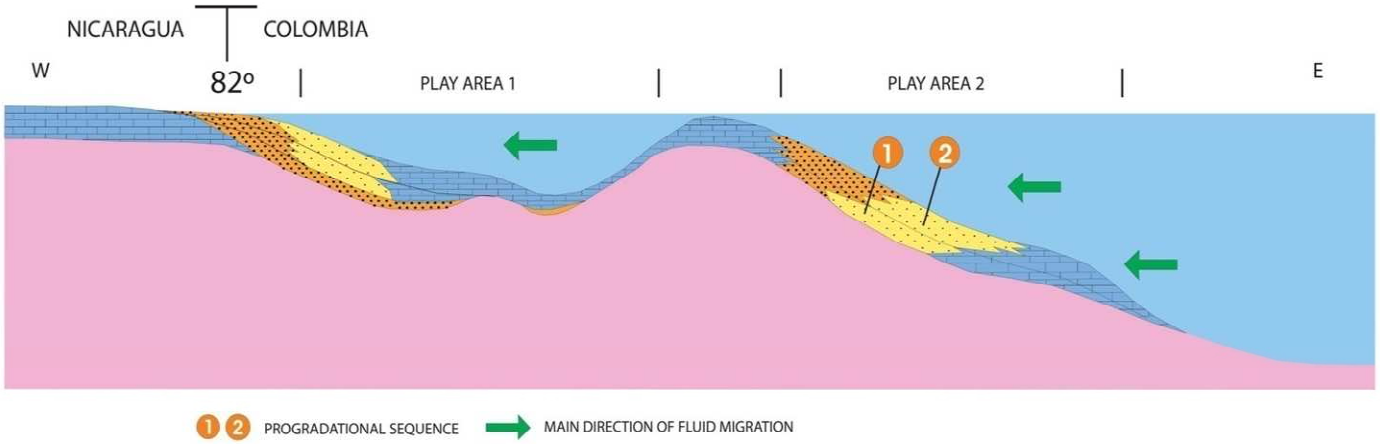


Los Cayos
Play types

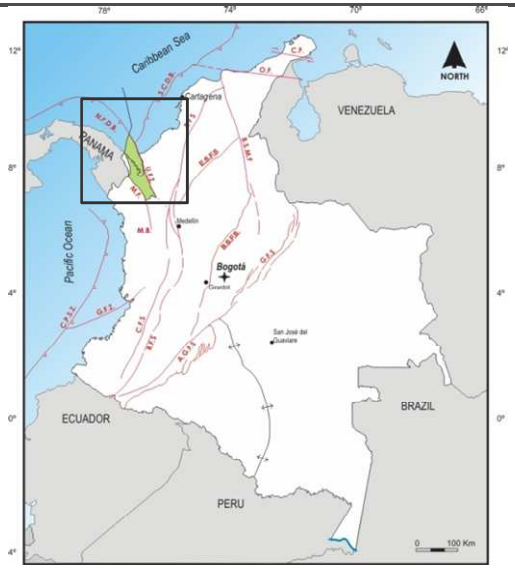
Structural traps
Gentle anticlines related to transpressive faults



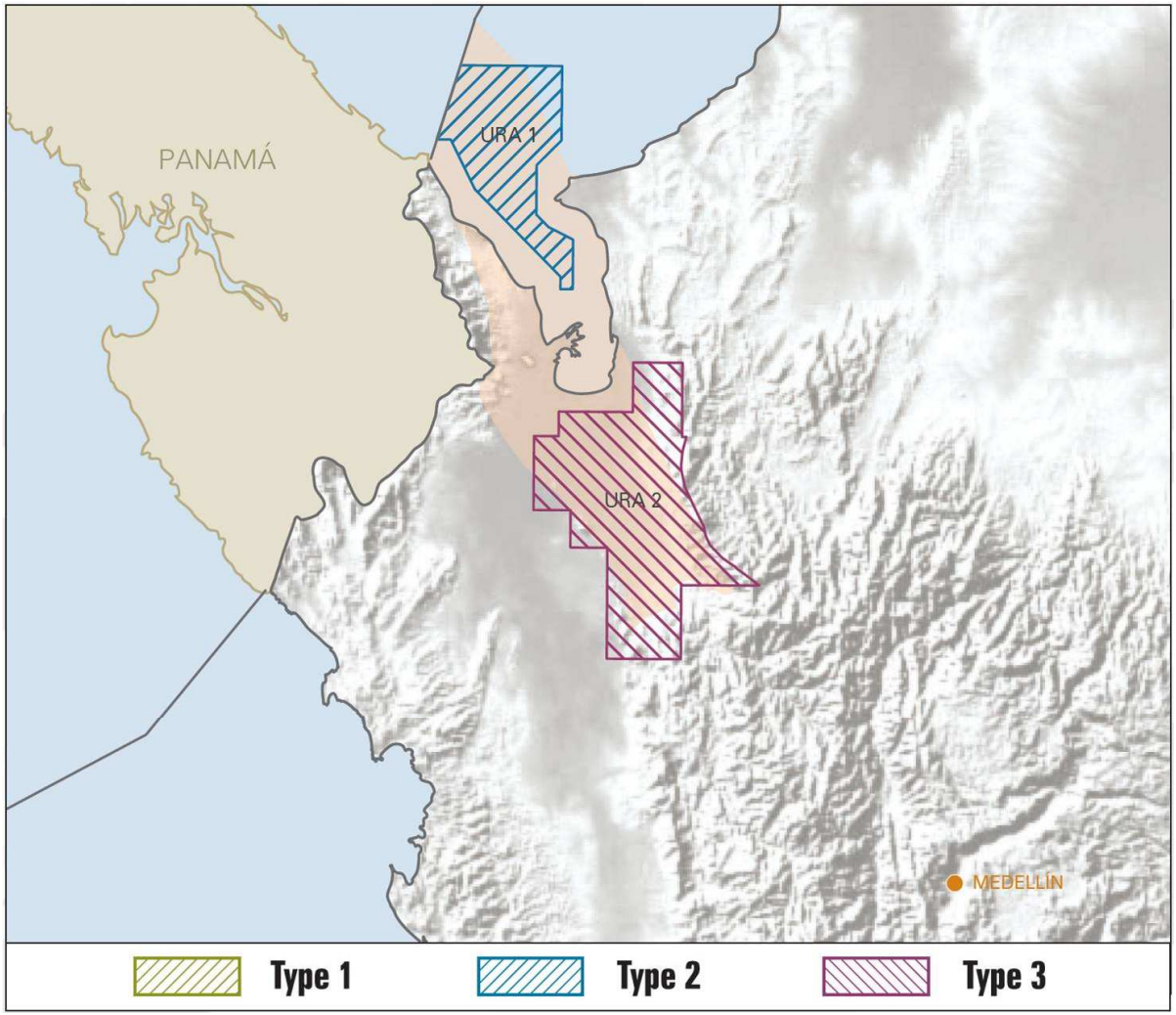
Stratigraphic traps
Prograding sequences



Urabá



Location map with the offered blocks



OPEN ROUND 2010 BLOCKS

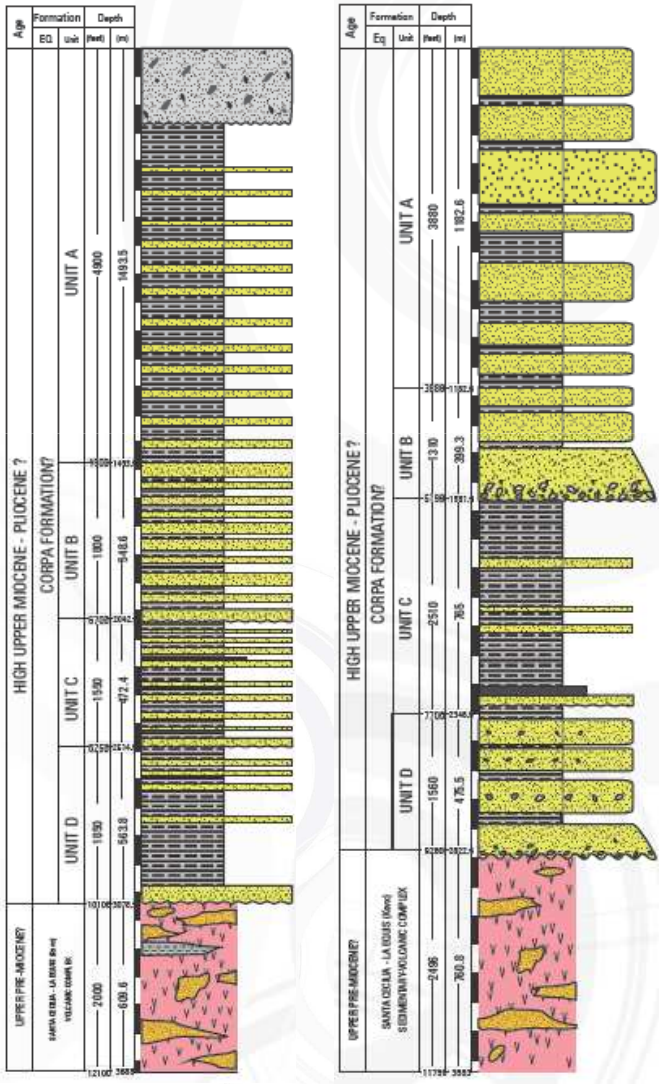
Type 2: 1 Block
2,206 Km^2

Type 3: 1 Block
4,441 Km^2

Urabá

Petroleum geology

Pozo Apartado-1 **Pozo Chigorodo-1**



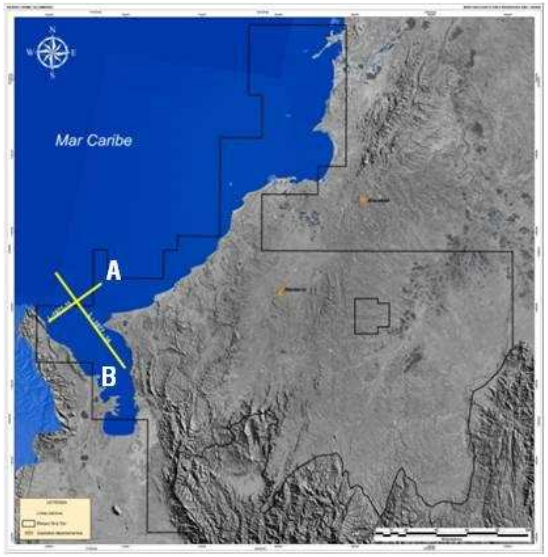
Exploration wells penetrate numerous potential sandstone reservoirs throughout the thick upper Miocene-Pliocene basin fill. Intercalated shales may be effective intraformational seals.

Trap styles include: structural-stratigraphic traps tied to known normal and reverse faults cutting the basin, and to stratigraphic pinchouts on basement in the southeast part of the basin.

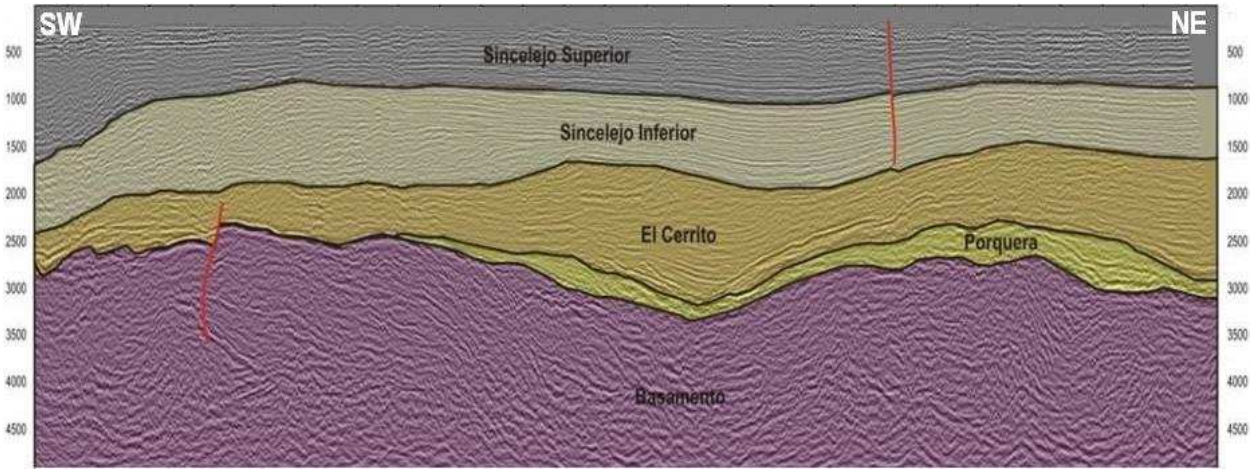
Biogenic gas is a strong possibility in this thick deltaic sedimentary section.

Urabá

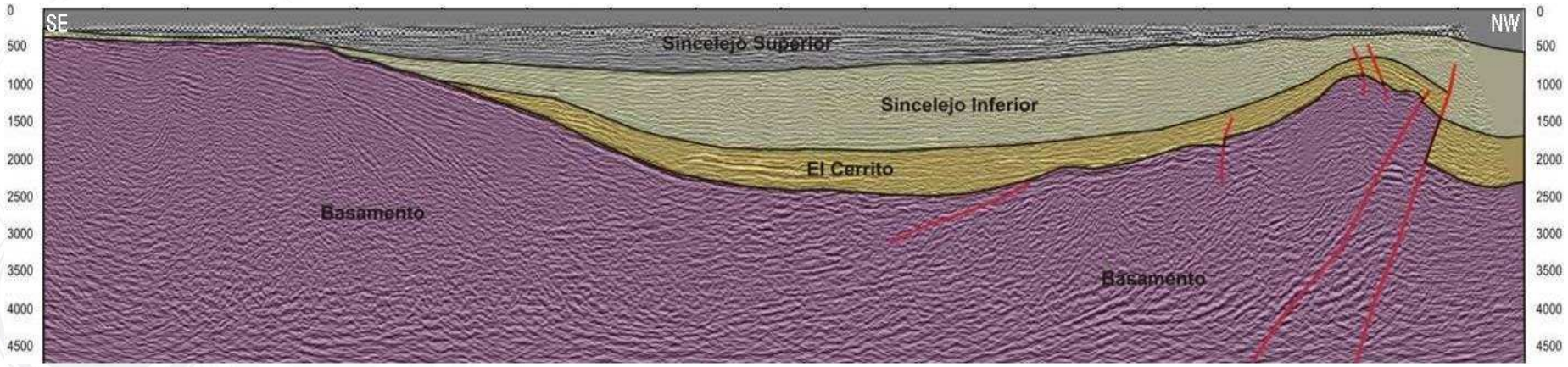
Structural style & play types



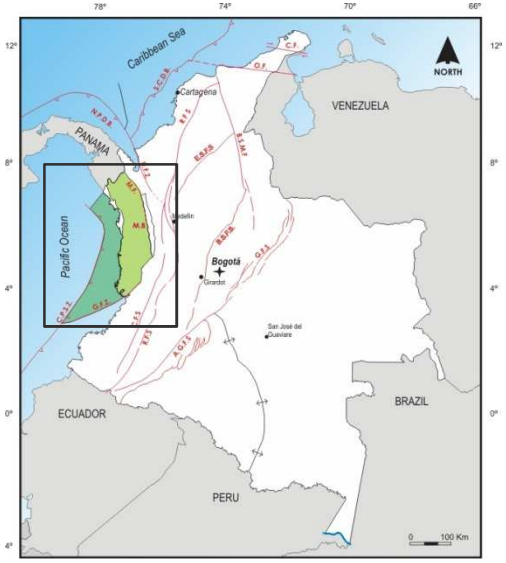
A) Pinch-outs and possible coral reefs against basement highs.



B) Syndepositional growth folds related to reverse faults.



Chocó



OPEN ROUND 2010 BLOCKS

Onshore

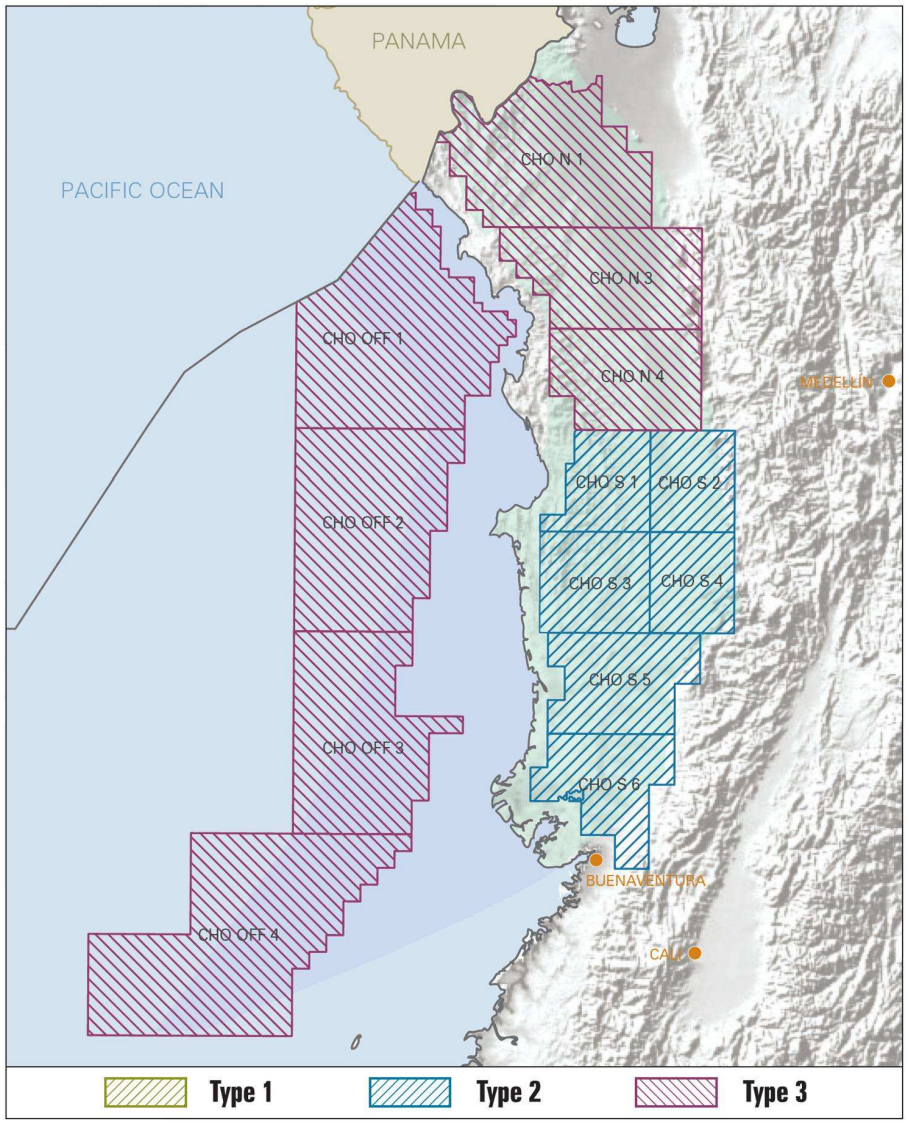
Type 2: 6 Blocks
18,690 Km^2

Type 3: 3 Blocks
16,783 Km^2

Offshore

Type 3: 4 Blocks
38,210 Km^2

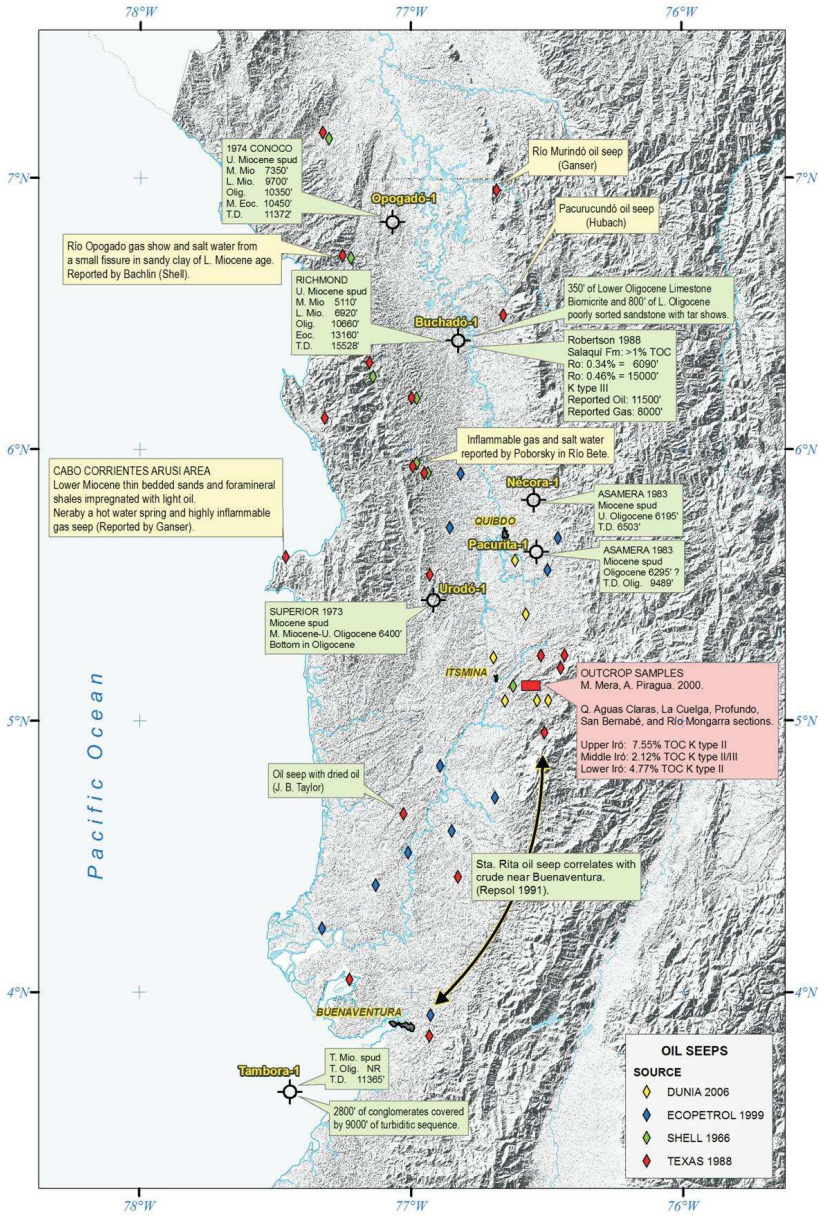
Location map with the offered blocks



Chocó

Oil seeps & wells

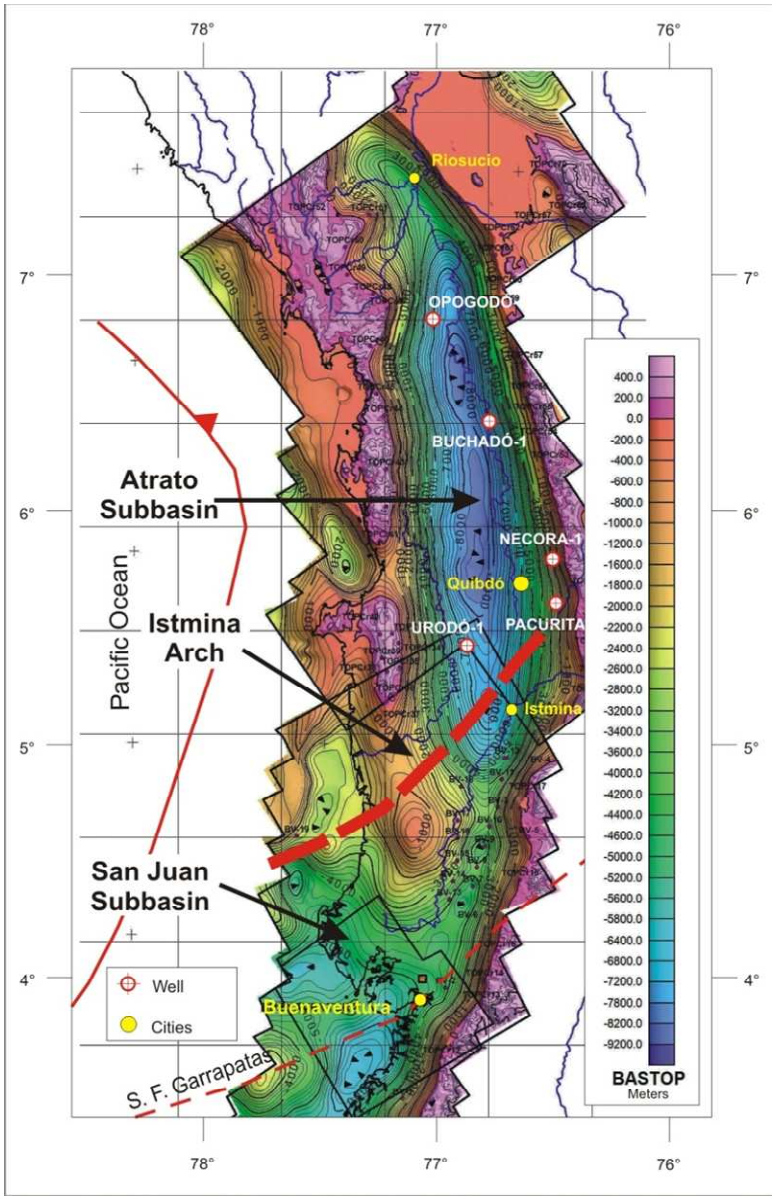
Location of Oil seeps and drilled wells along the Chocó basin



Chocó

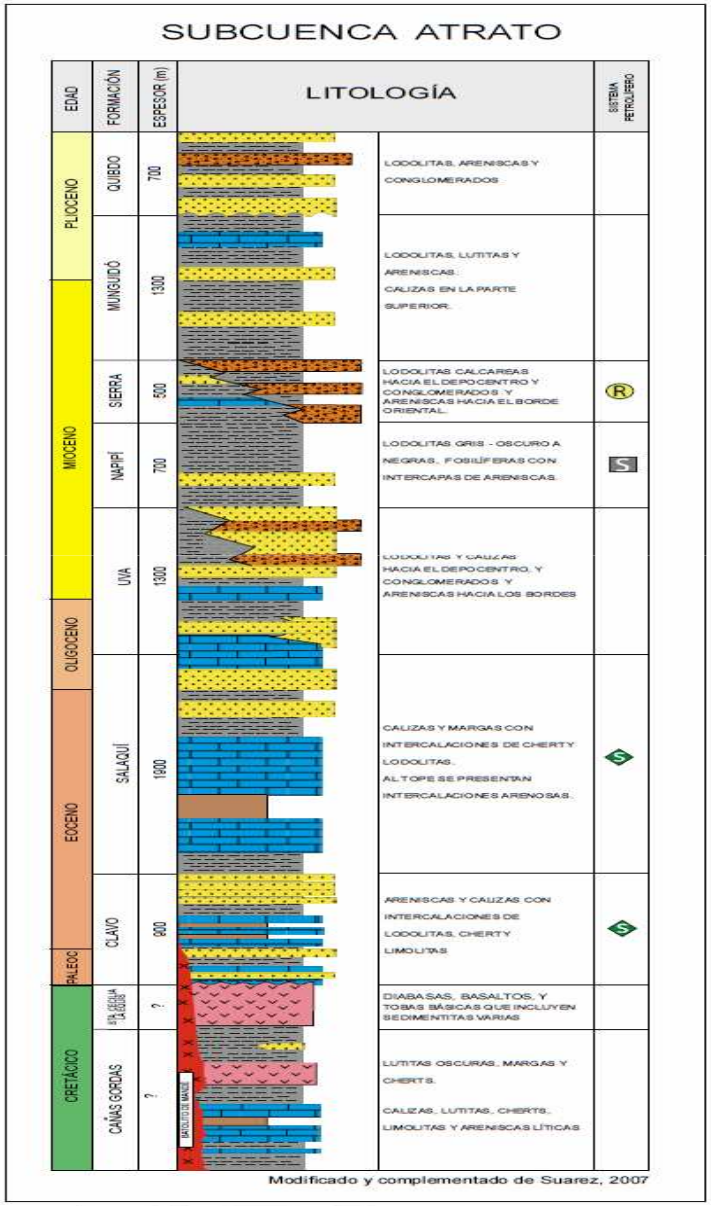
Structural provinces

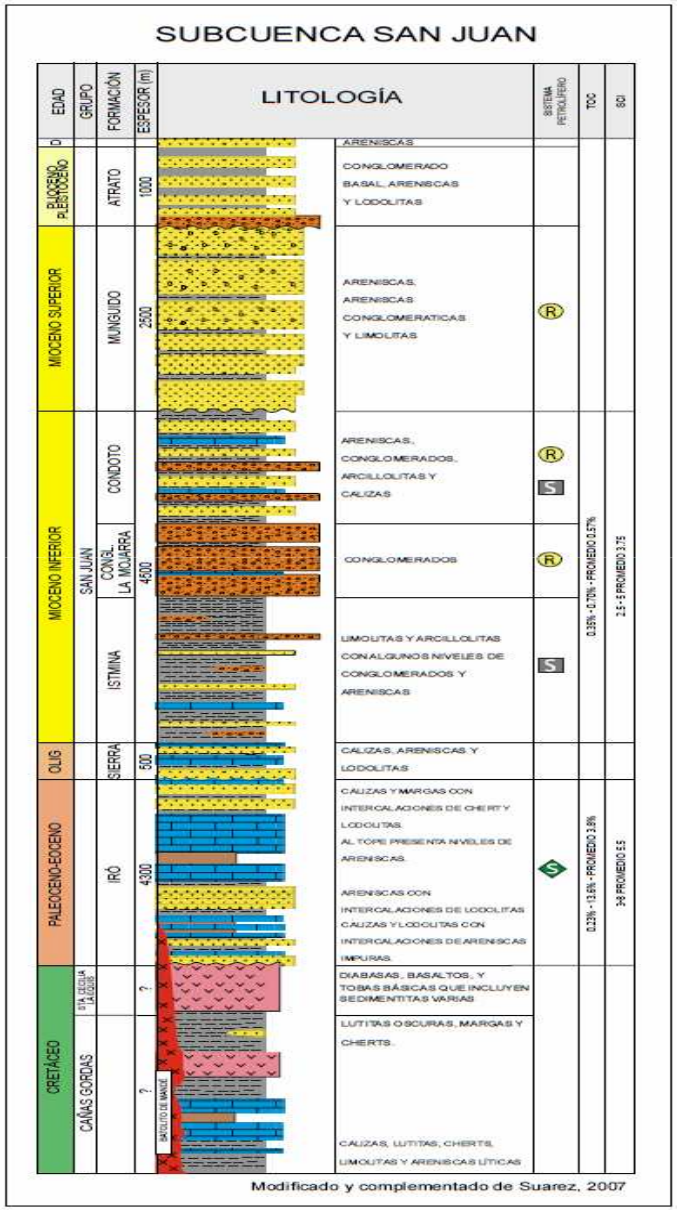
Basement depth contour map with the location of Atrato and San Juan sub-basins and Istmina Arch.



Chocó

Petroleum geology

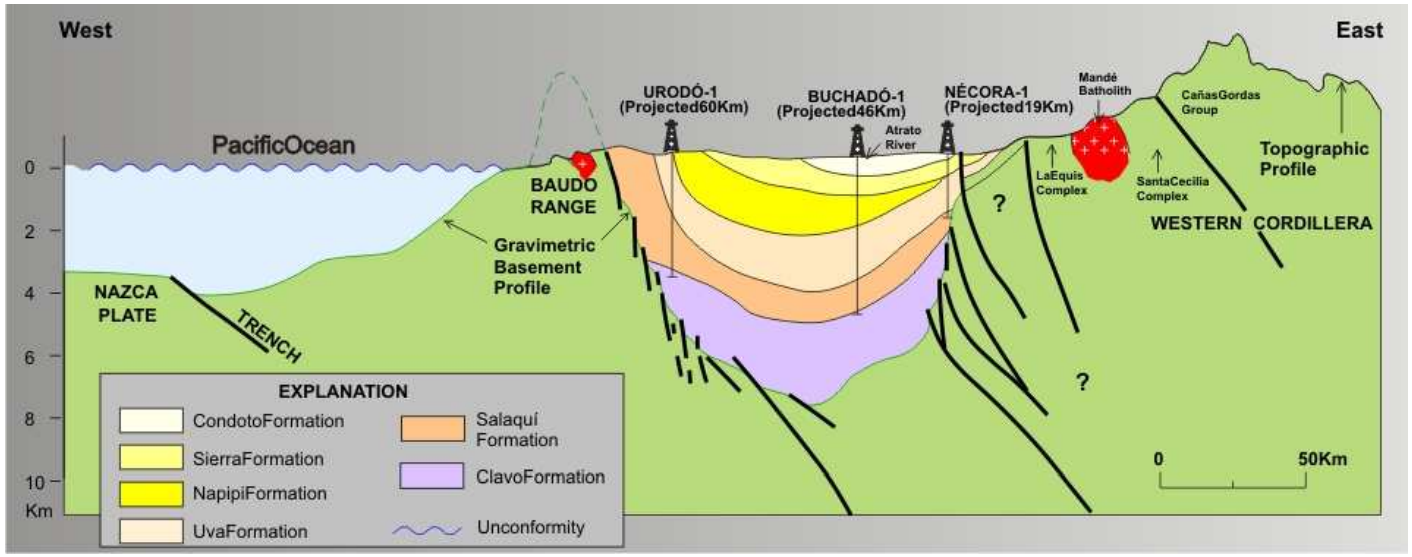




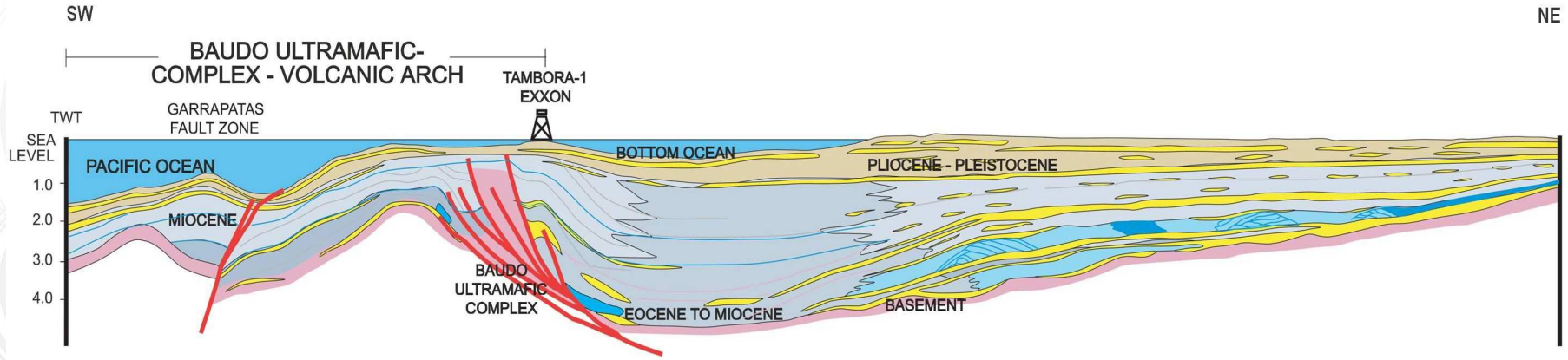
Chocó

Regional structural style

Transversal section of the Atrato sub-basin (6° N)

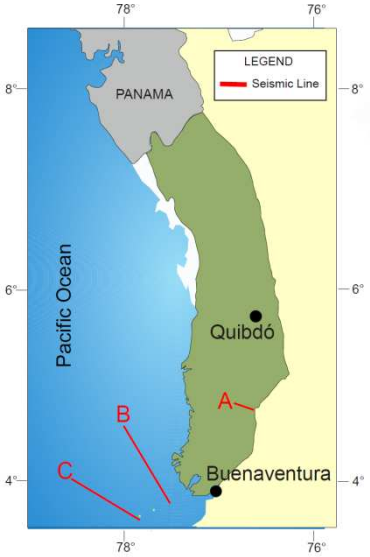


Longitudinal section of the San Juan Delta

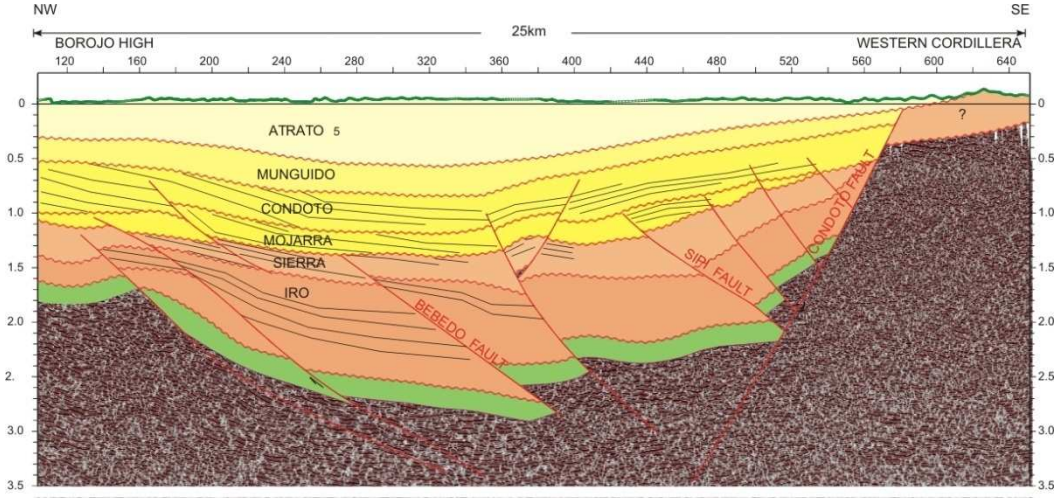


Chocó

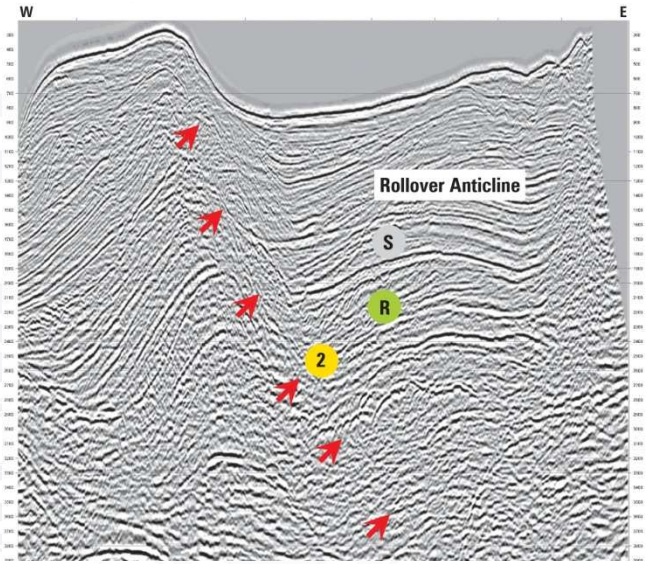
Examples of play types



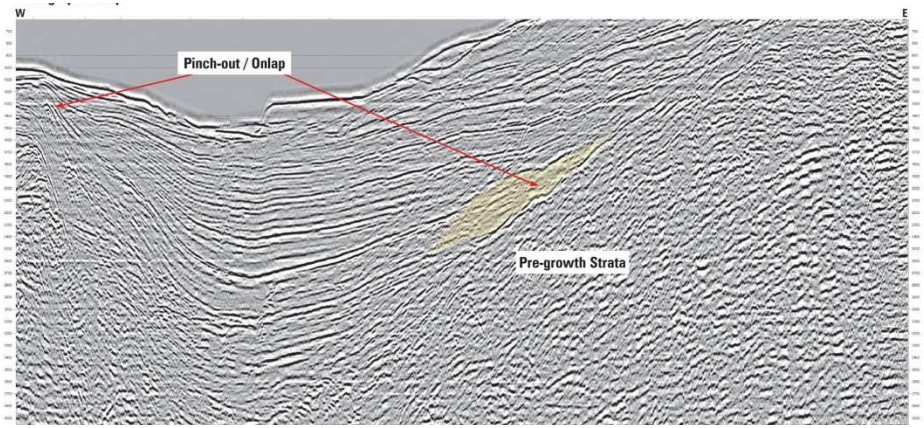
A) Positive structures related to inversion tectonics (Nóvita graben)



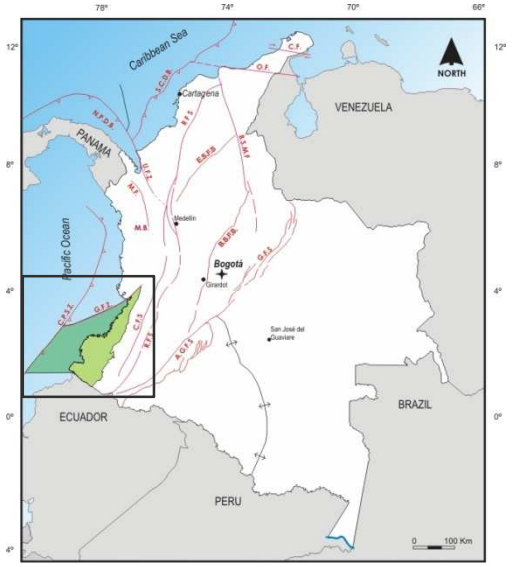
B) Roll-over anticline



C) Stratigraphic traps – pinch-out and onlap over the basement



Tumaco



OPEN ROUND 2010 BLOCKS

Onshore

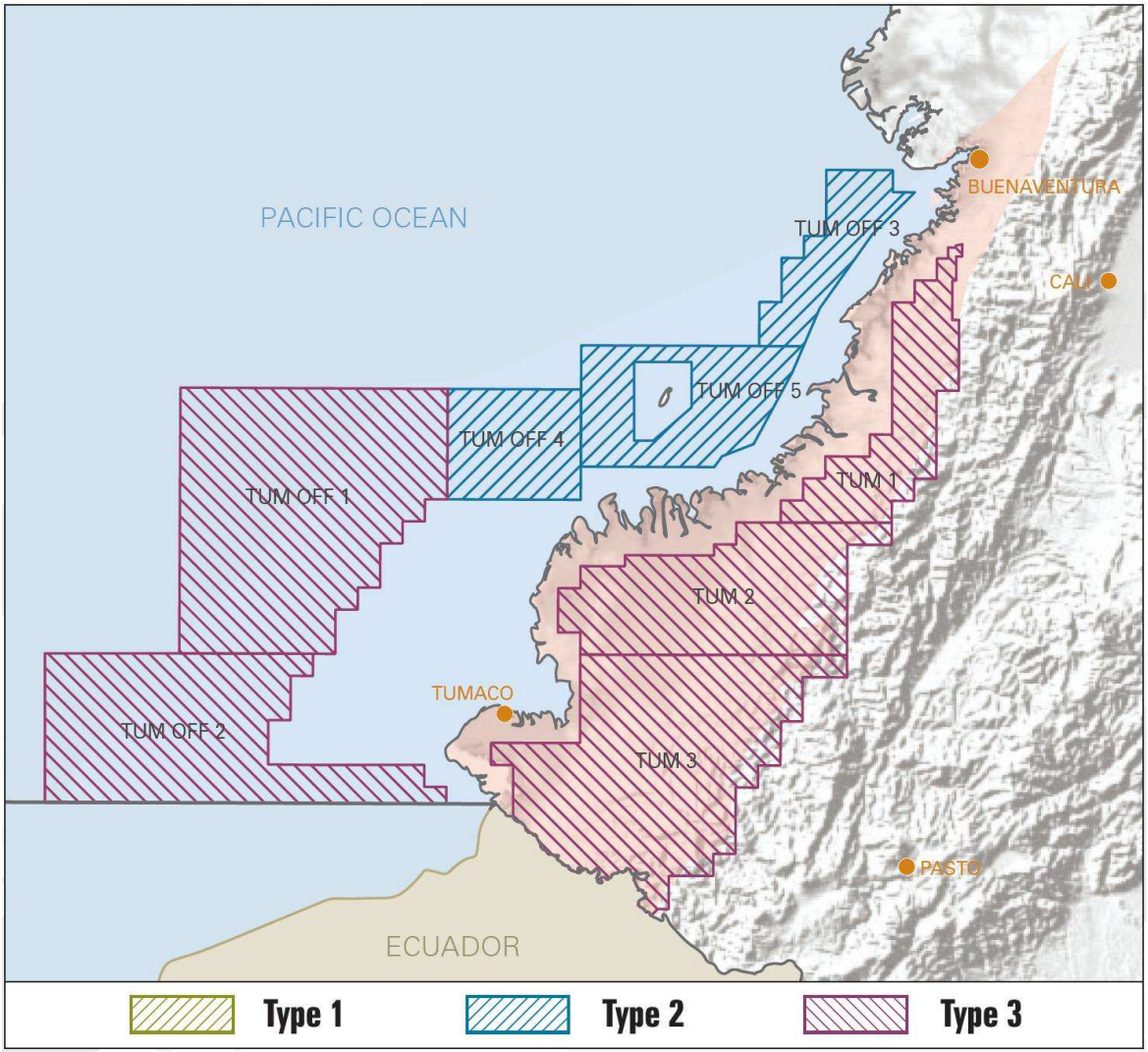
Type 3: 3 Blocks
17,443 Km^2

Offshore

Type 2: 3 Blocks
7,771 Km^2

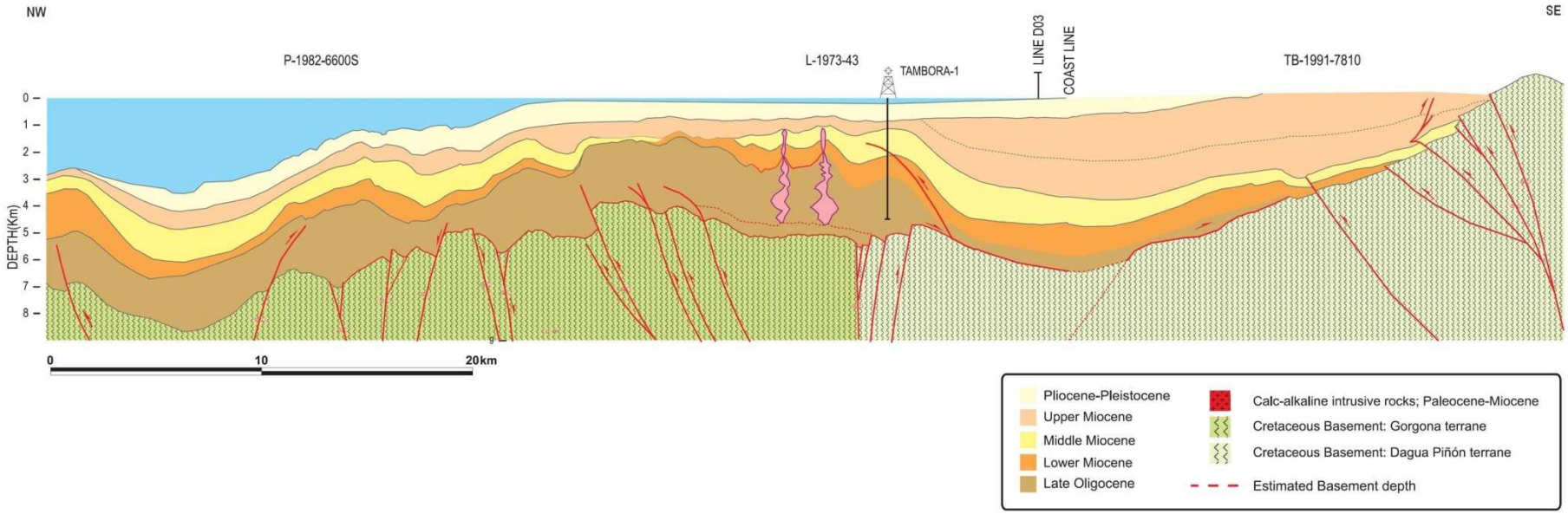
Type 3: 2 Blocks
17,729 Km^2

Location map with the offered blocks



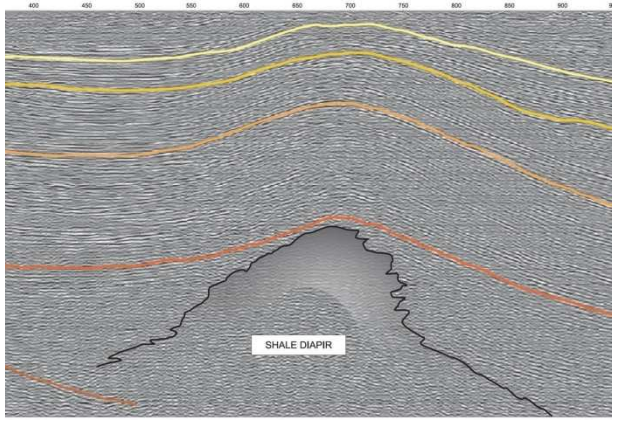
Tumaco

Regional structural style



Traps within Tumaco basin:

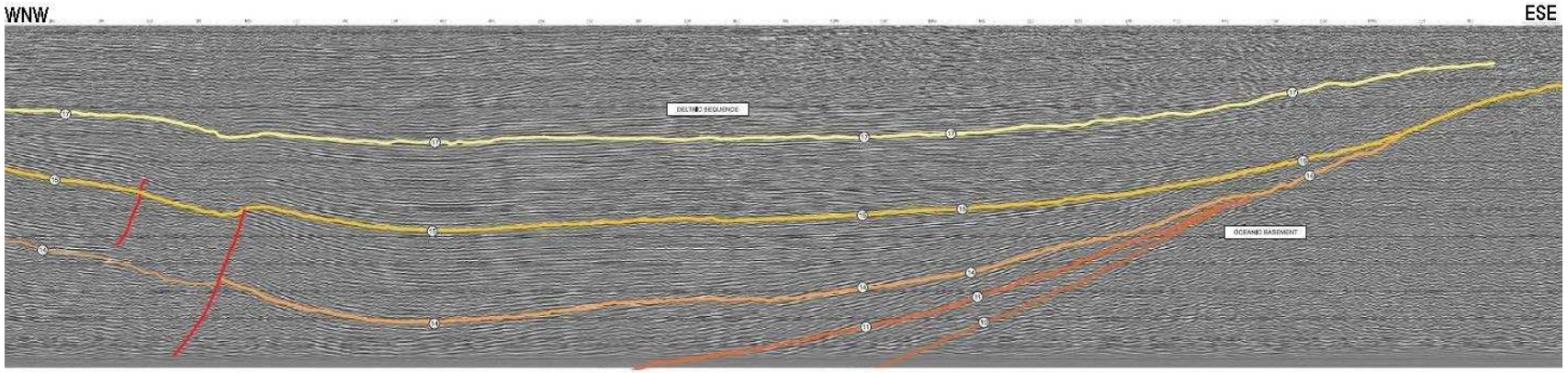
- **Anticlines associated to mud diapirs**
- **Roll-over folds related to normal faults.**
- **Fault-propagation folds**
- **Thrust related anticlines**
- **Stratigraphic traps**

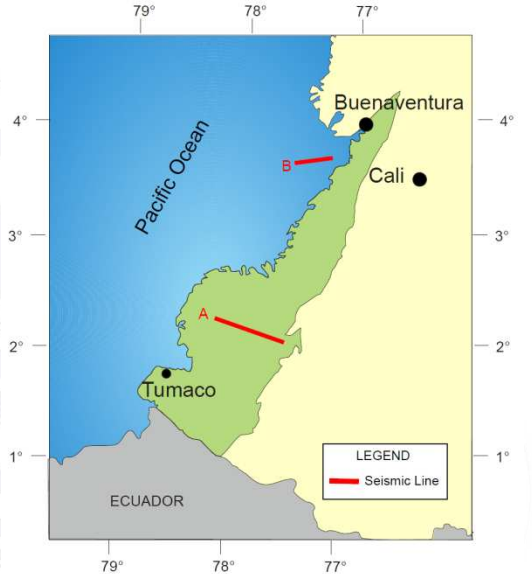


Tumaco

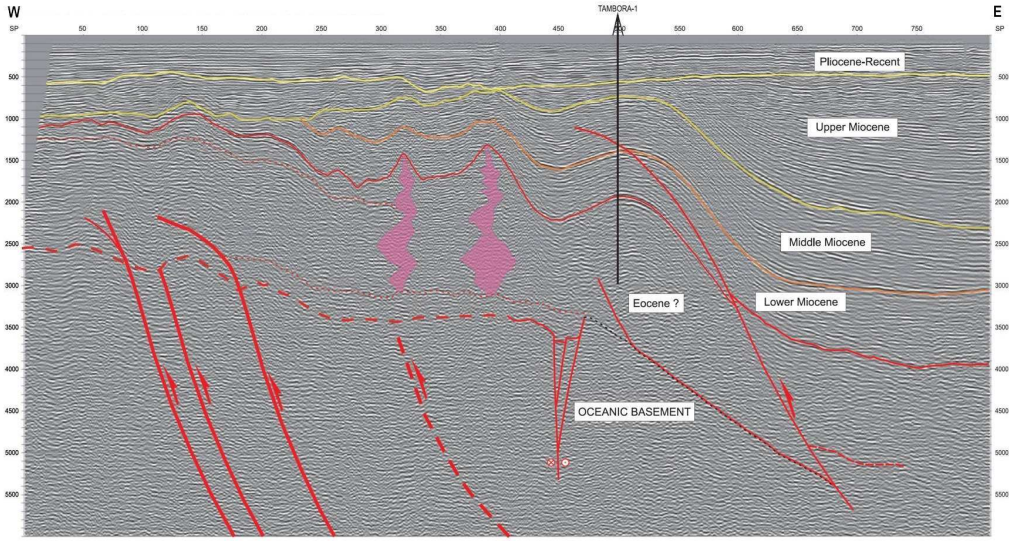
Examples of play types

A) Onlapping over the basement and roll-over folds associated to normal faults

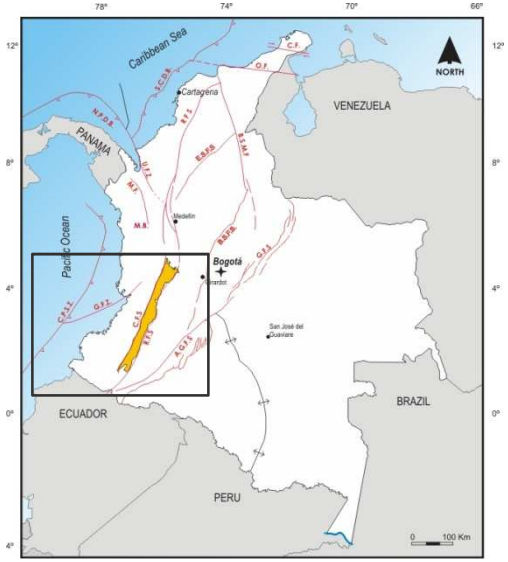




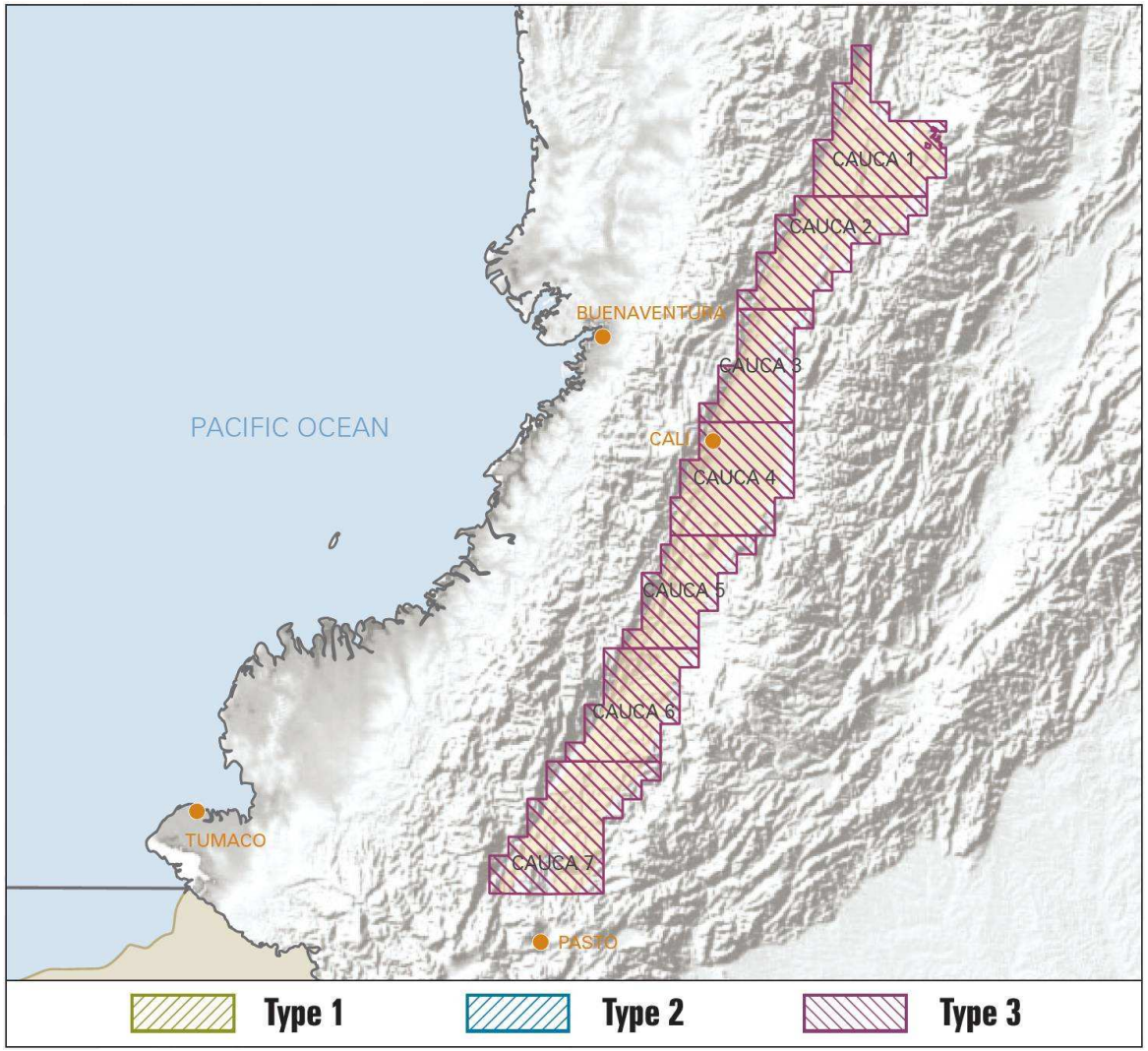
B) Fault-propagation folds related to high angle reverse faults



Cauca - Patía



Location map with the offered blocks

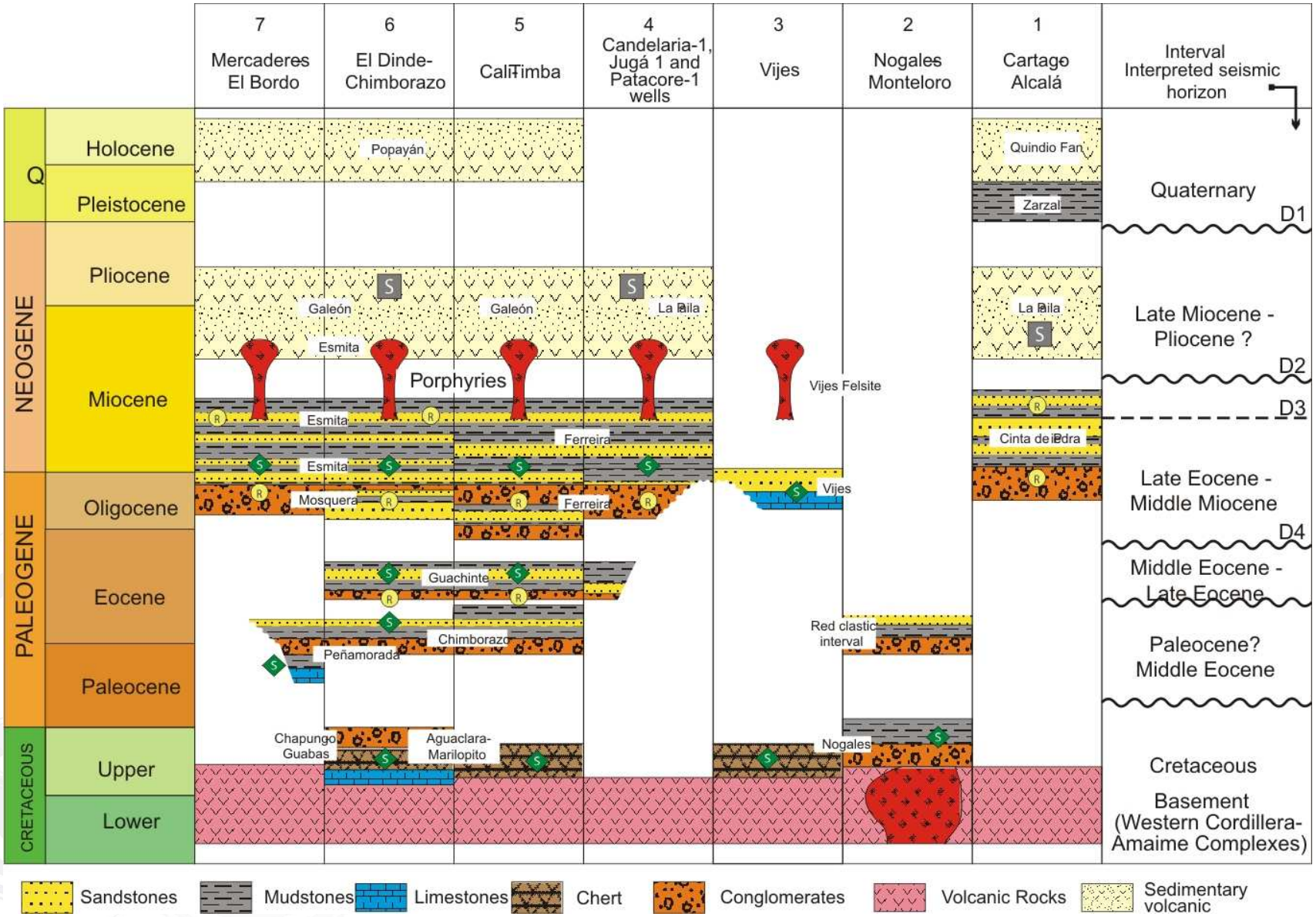


OPEN ROUND 2010 BLOCKS

Type 3: 7 Blocks
17,768 Km^2

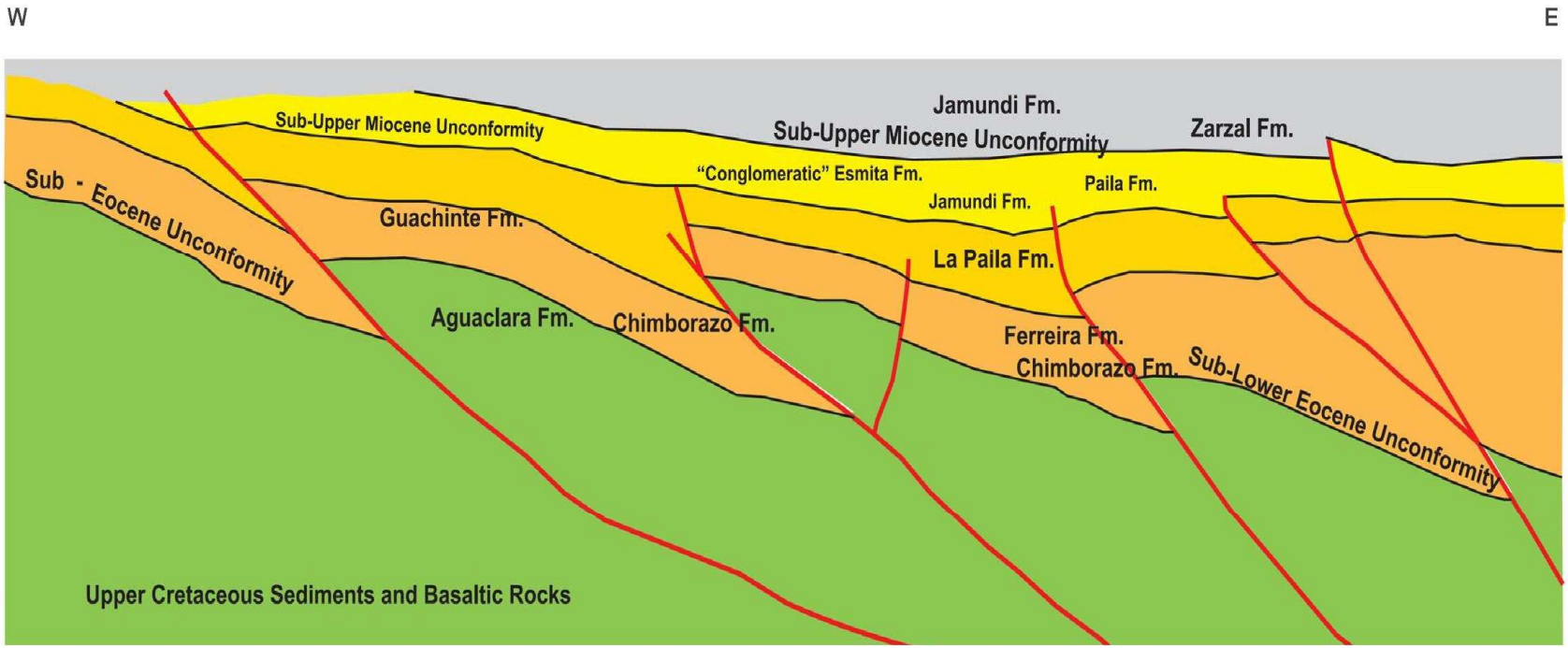
Cauca - Patía

Petroleum geology



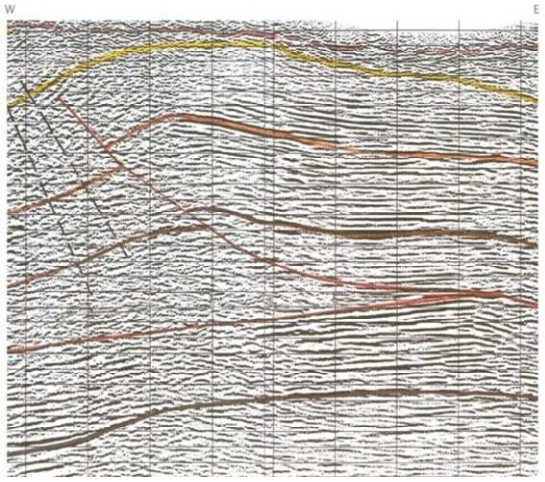
Cauca - Patía

Regional structural style



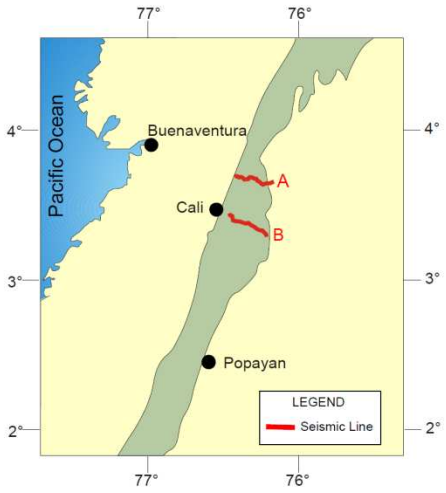
Trap styles within Cauca – Patía Basin

- **Fault-propagation folds**
- **Inversion structures**
- **Basement highs**

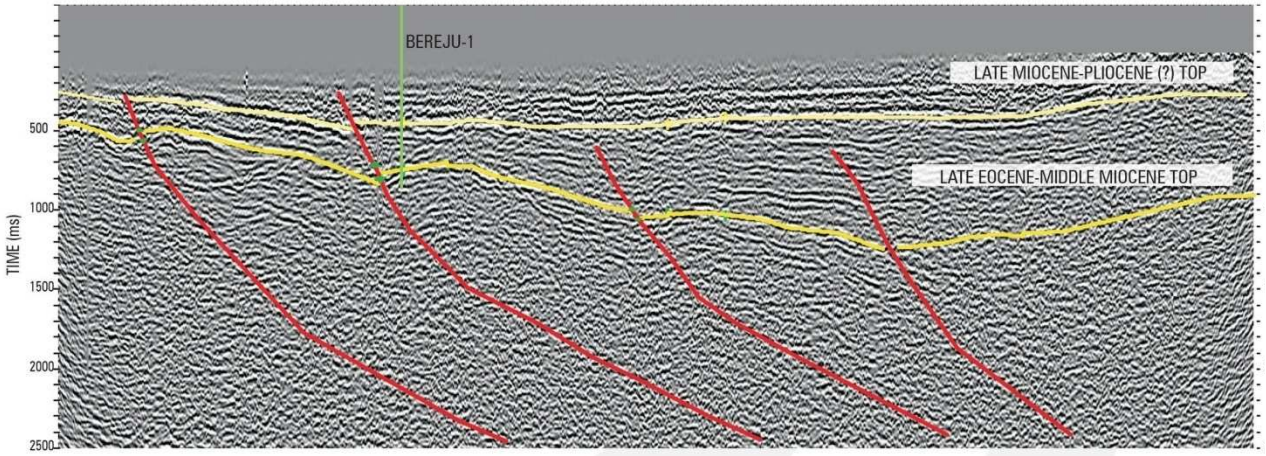


Cauca - Patía

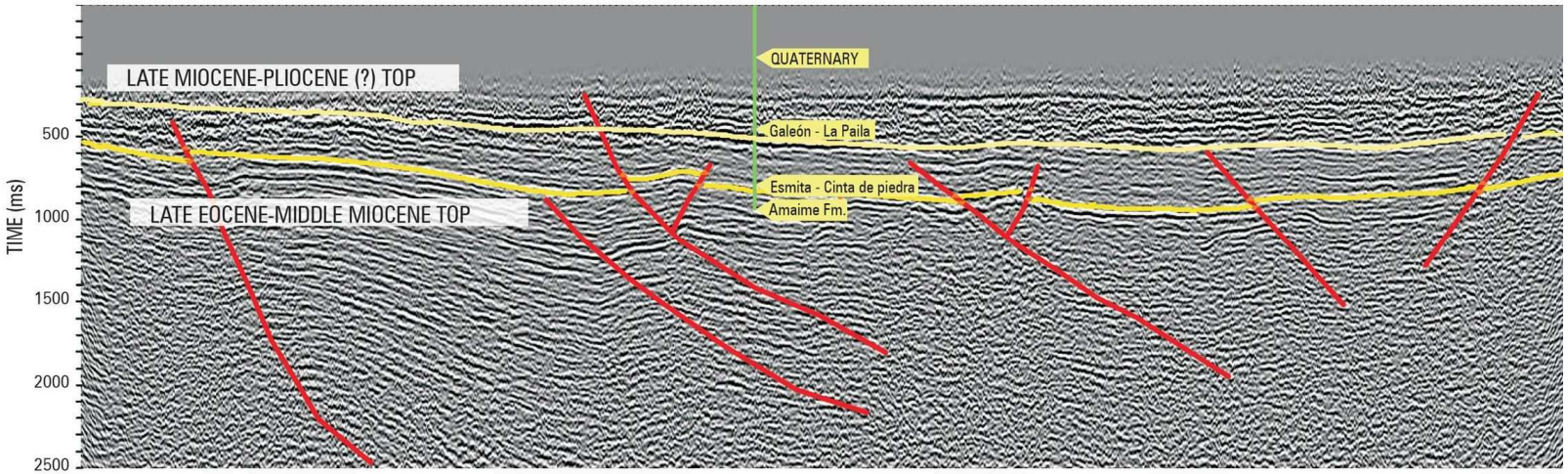
Examples of play types



A) Wide anticlines related to west-verging reverse faults



B) Anticlines related to reverse faults and associated back-thrusts




Thank you for your attention.
Come visit with us in Bogota.
www.anh.gov.co