



# **Overview of the Oil and Gas Basins of Colombia**

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# Contents



## **1. Introduction**

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## 3. Colombia Round 2012

### 3.1. Block Types

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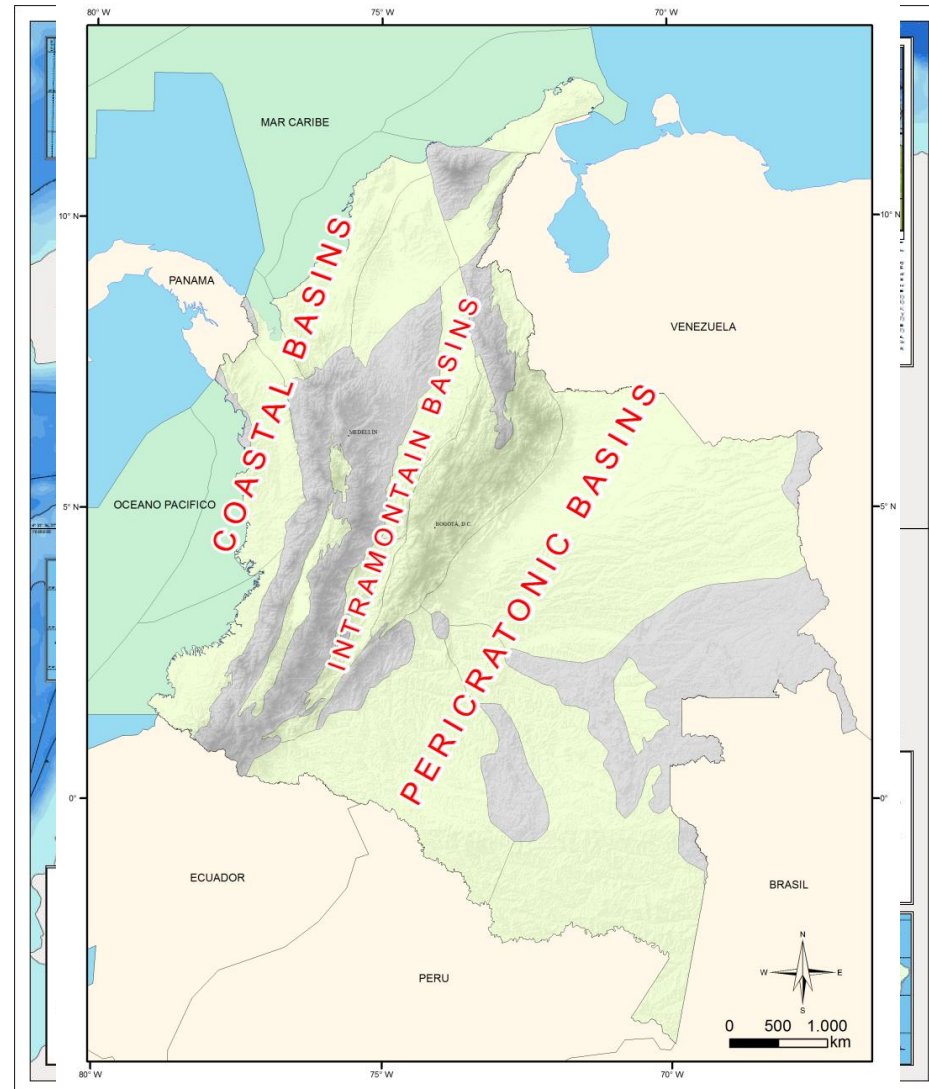
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## 4. Summary and Conclusions

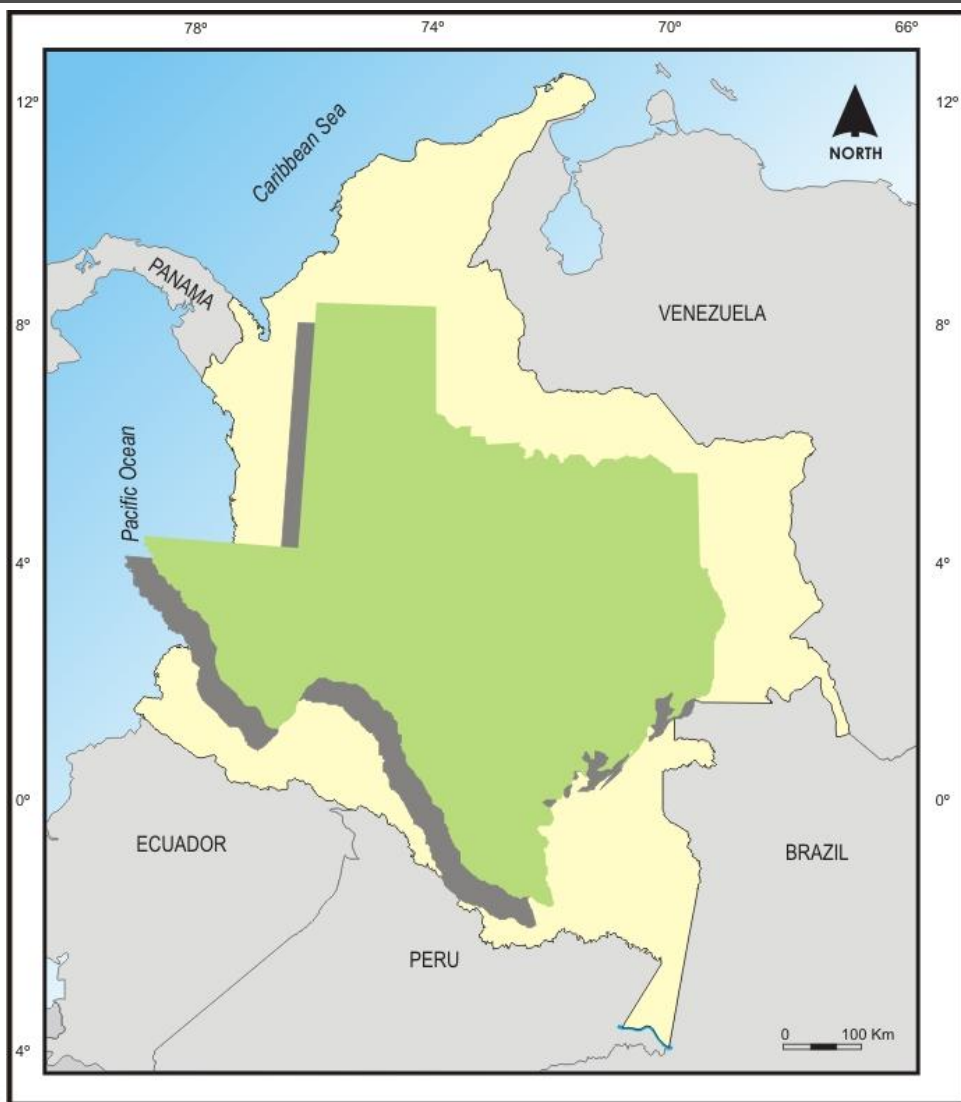
# Colombia

= *Diverse Geology*

= *Something For All Explorers!*



# Area Comparison



Texas is about  
60% of the size of  
Colombia

Colombia  
1,141,748 km<sup>2</sup>

Texas  
696,241 km<sup>2</sup>

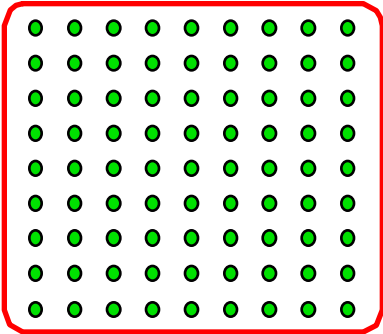
# Colombia – An Underexplored Country



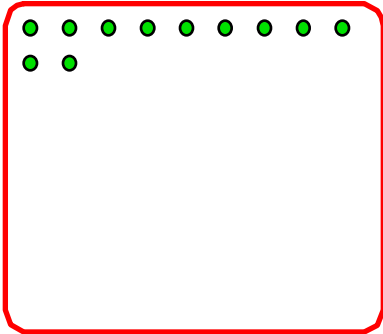
## Wells per 1,000 km<sup>2</sup>

UNITED STATES	—————>	83
CANADA	—————>	11
COLOMBIA	—————>	2

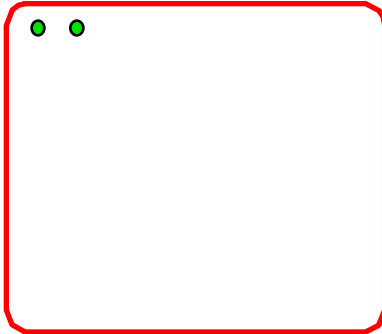
UNITED STATES



CANADA



COLOMBIA



# Colombia – An Underexplored Country



Western Sedimentary Basin of Canada

Approx. 525,000 wells  
1 well / 2.5 km<sup>2</sup>

Eastern Cordillera-Llanos-Putumayo  
2,026 wells  
1 well / 200 km<sup>2</sup>

*Colombia has room to explore!*

# Contents



## 1. Introduction

## **2. Colombian General Geological Framework and Basins Technical Aspects**

### 3. Colombia Round 2012

3.1. Technical Aspects of Basins

3.2. Block Types

3.3. Minimum Exploration Program (Conventional Blocks)

3.4. Unconventional Resources

3.5. Minimum Exploration Program (Unconventional Blocks)

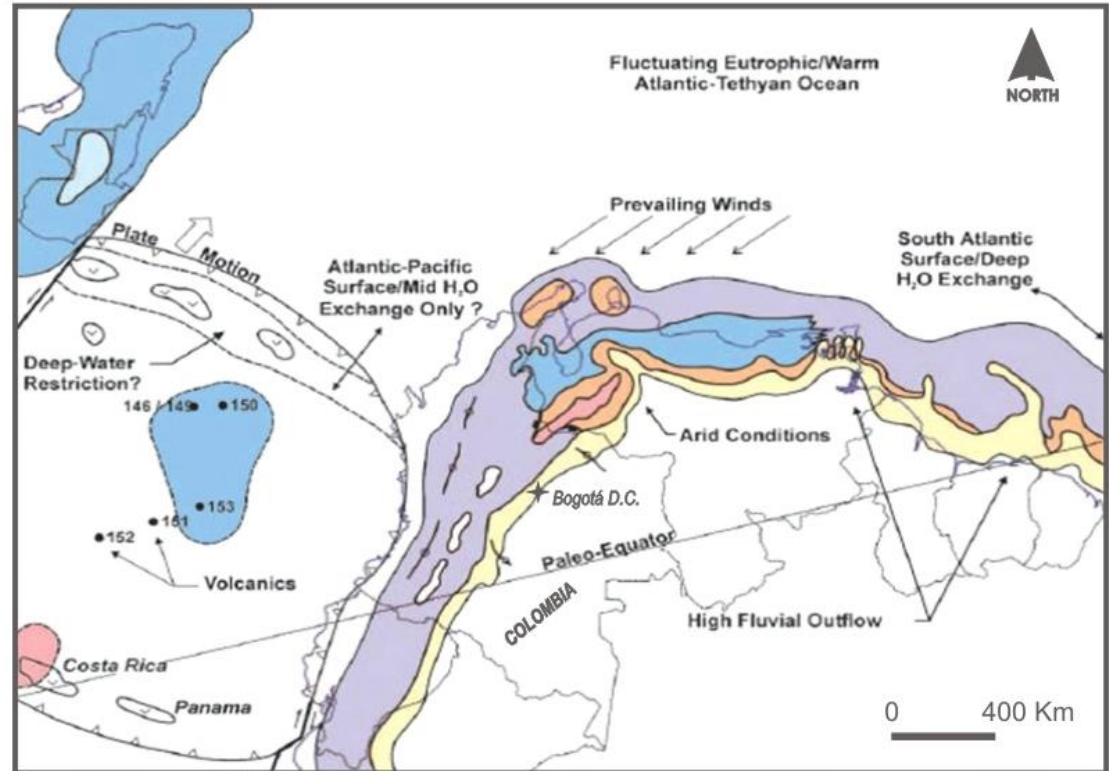
3.6. Database (EPIS)

## 4. Summary and Conclusions



# Colombia Has a World-Class Source Rock!

- ✓ Mid-Cretaceous La Luna / Gachetá, Villeta, Cansona – A rich, regional hydrocarbon source rock.
- ✓ Additionally, Tertiary carbonaceous shales and coals are also present.
- ✓ In the shallower basins, these rocks might have generated commercial quantities of biogenic methane.



From Villamil, 2003, AAPG

Late Cenomanian-Turonian paleogeography of NW South America. La Luna / Cansona deposition in purple and blue.

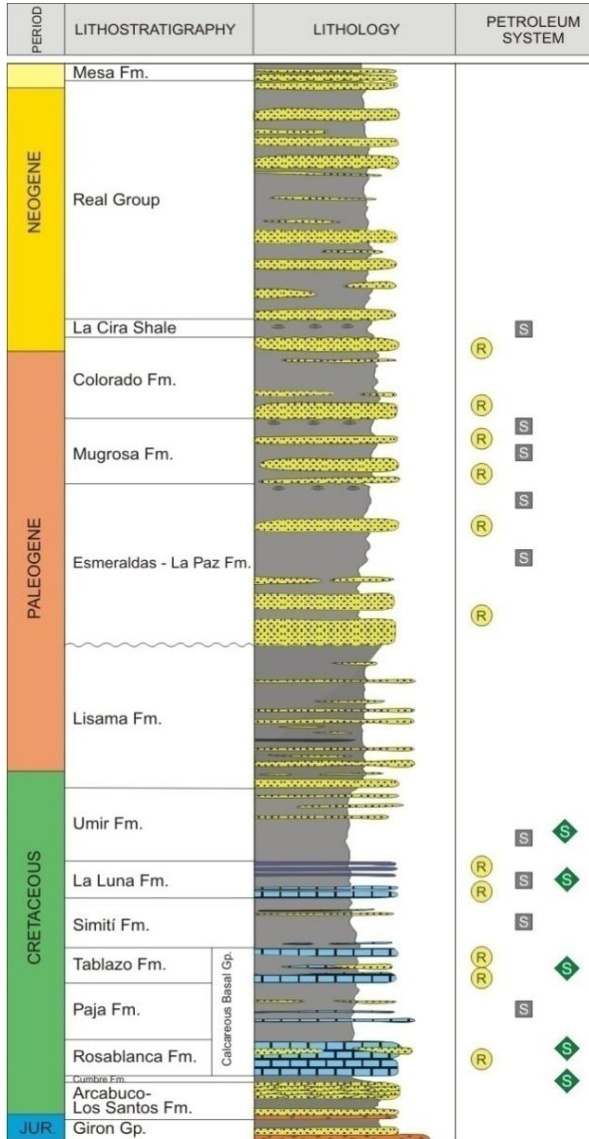
# Colombia Has Reservoirs!



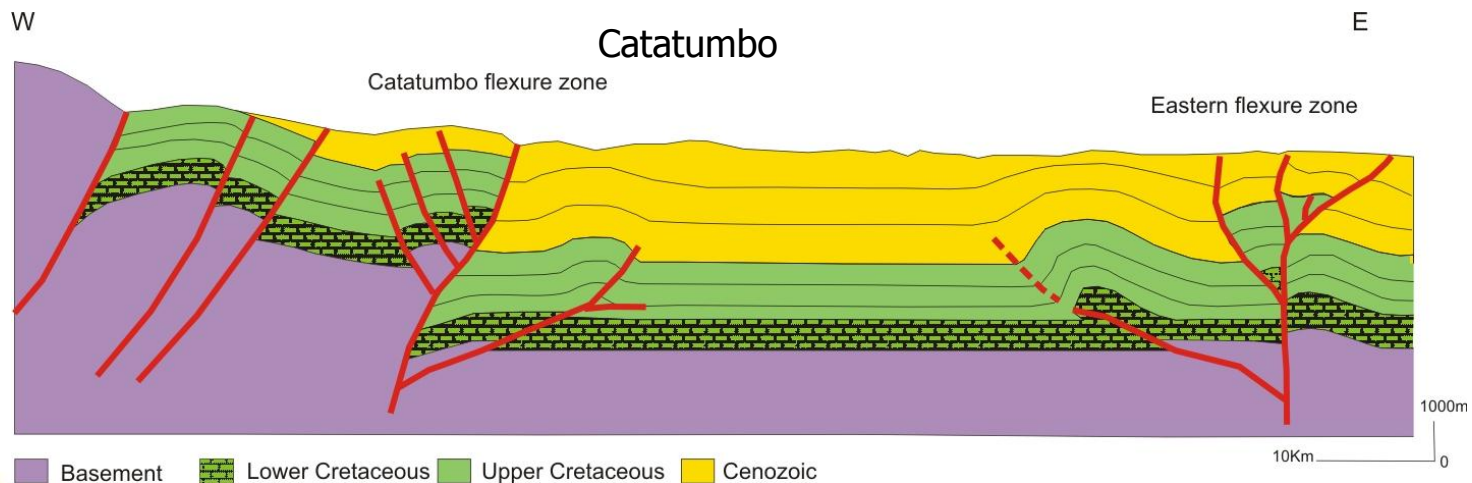
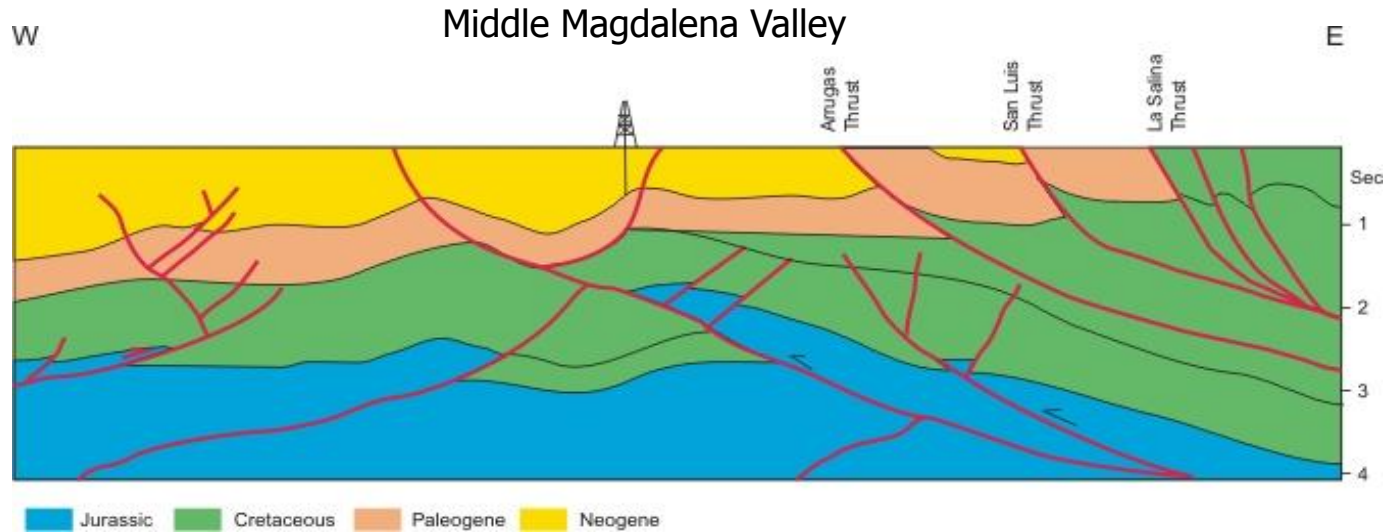
FOR CONVENTIONAL HC

## Middle Magdalena Basin Reservoirs

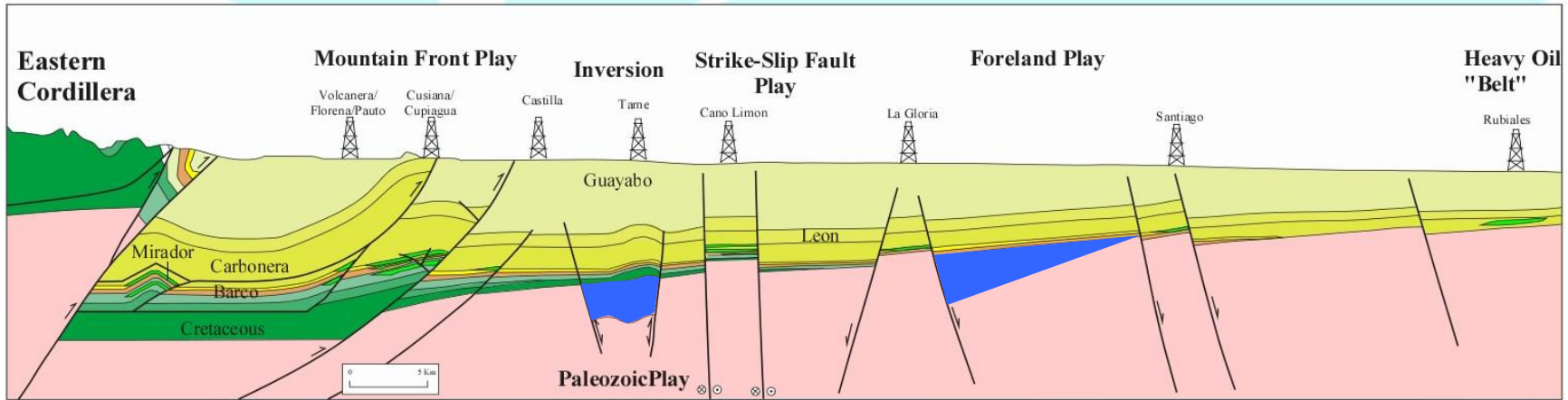
Colorado Fm. Mugrosa Fm. Esmeralda Fm. La Paz Fm. Lisama Fm.	Sandstones Porosity: 15 – 20% Permeability: 20 – 600 md
La Luna Fm. Tablazo Fm. Rosablanca Fm.	Fractured Limestone



# Colombia Has a Wide Variety of Structural Styles



# Colombia Has a Wide Variety of Structural Styles

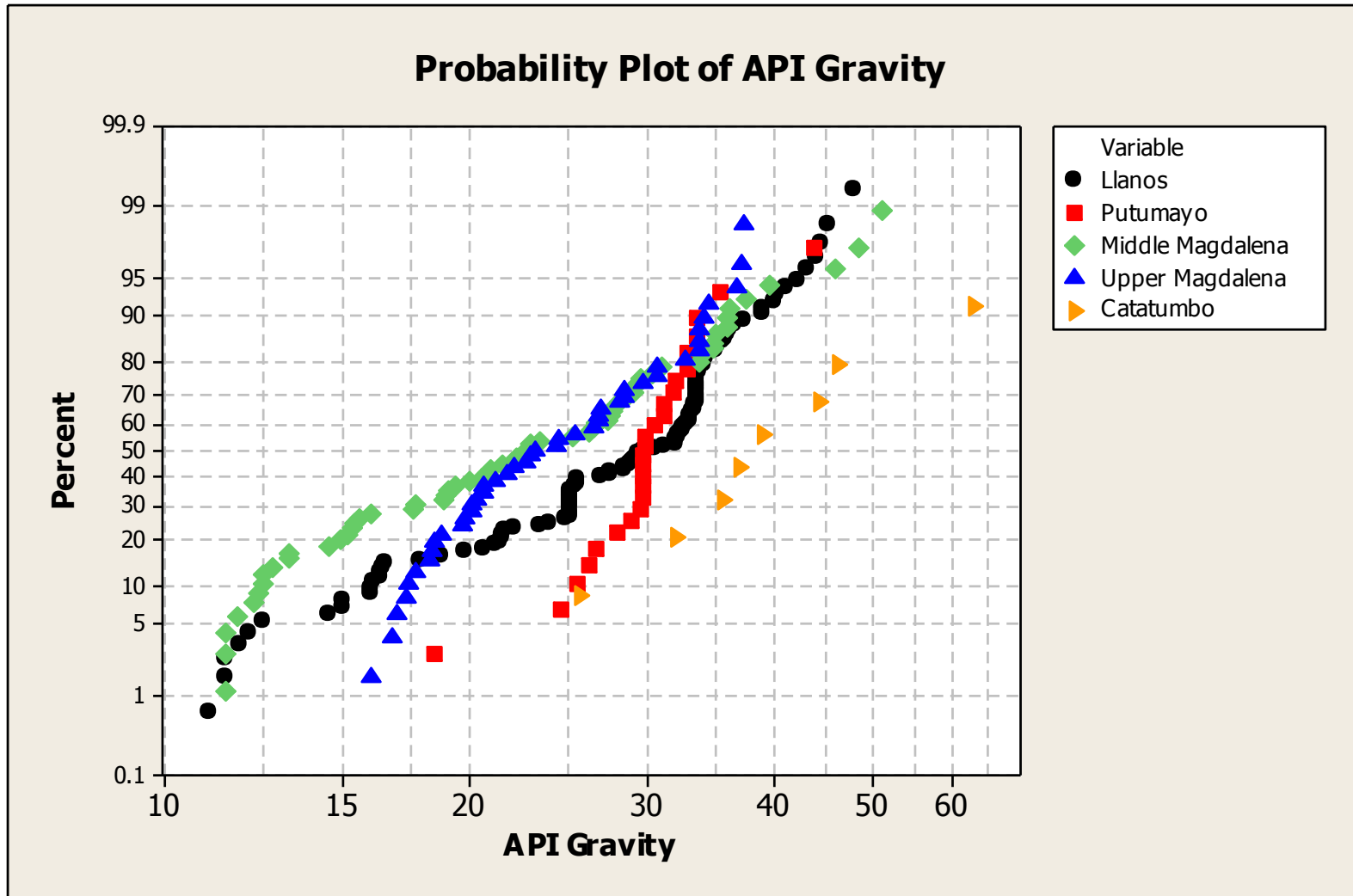


Generalized E-W Cross Section - Llanos Basin

## Trap styles within Llanos Basin

- ▶ Antithetic normal faults
- ▶ Inversion structures
- ▶ Thrust – related anticlines
- ▶ Stratigraphic traps
- ▶ Fault-propagation folds
- ▶ Similar traps anticipated in Pz rocks

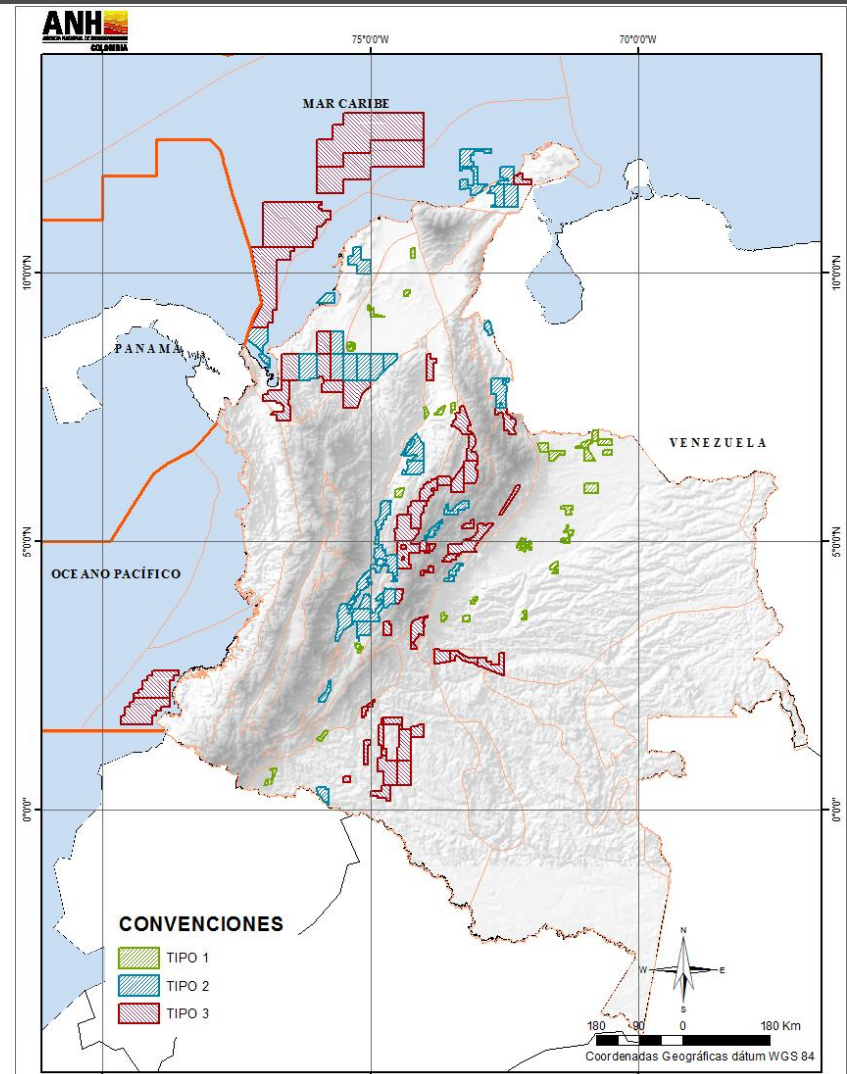
# Crude Oil Quality



# Colombia Round 2012

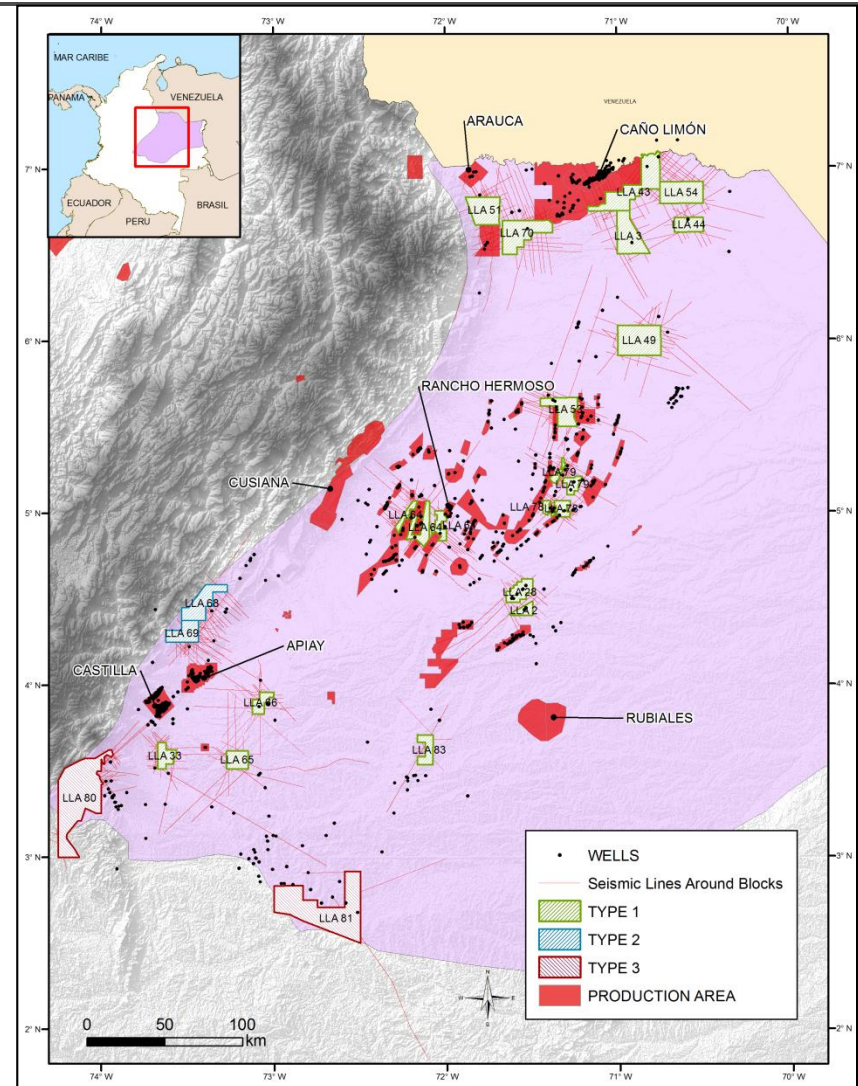
	Onshore	Offshore
Type 1 (Mature)	29	
Type 2 (Emerging)	29	5
Type 3 (Frontier)	40	6
<b>TOTAL</b>	<b>98</b>	<b>11</b>

Type	2D Seismic (km)	Number of wells	Total (km <sup>2</sup> )
Type 1	914	76	6,565
Type 2	1,644	186	35,913
Type 3	438	23	92,297
<b>TOTAL</b>	<b>2,996</b>	<b>285</b>	<b>134,775</b>

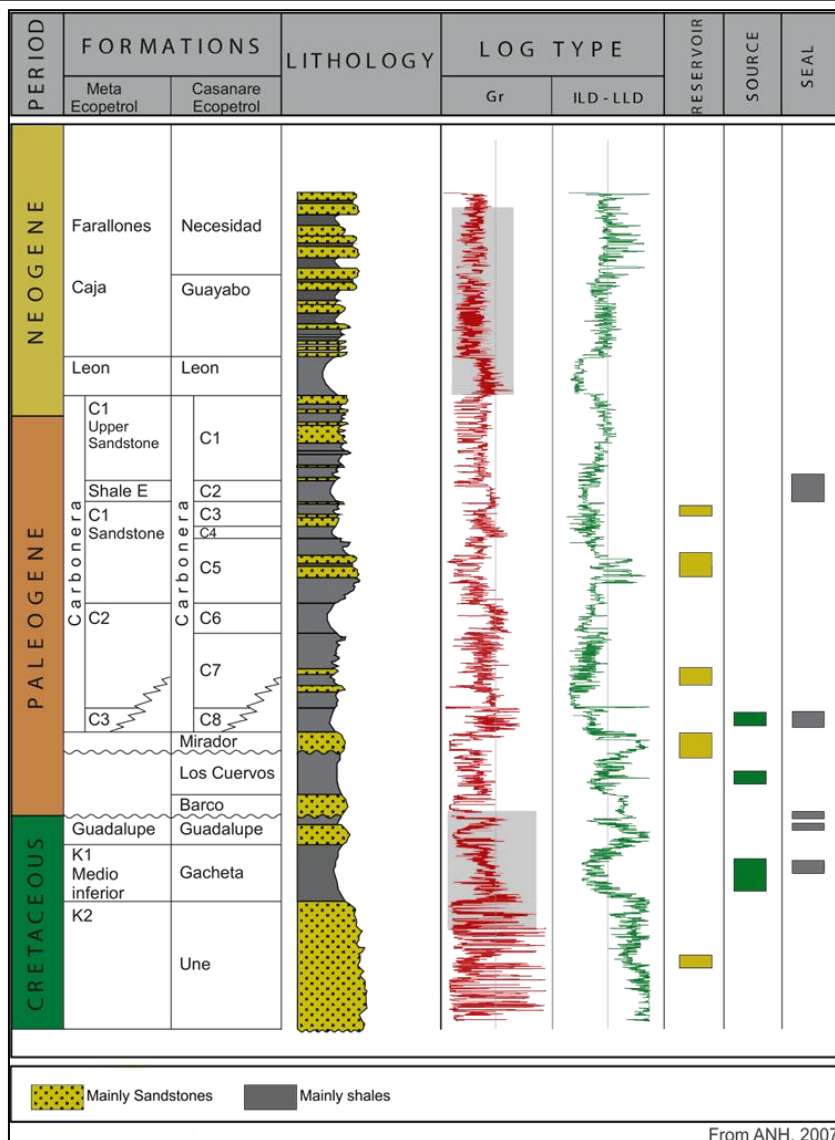


# Llanos Basin

- Mature in terms of exploration
- It is the country's most prolific basin.
- A preliminary assessment of hydrocarbon resources suggests that the basin is also prospective for *Shale Oil* and *Shale Gas*.



# Llanos Basin



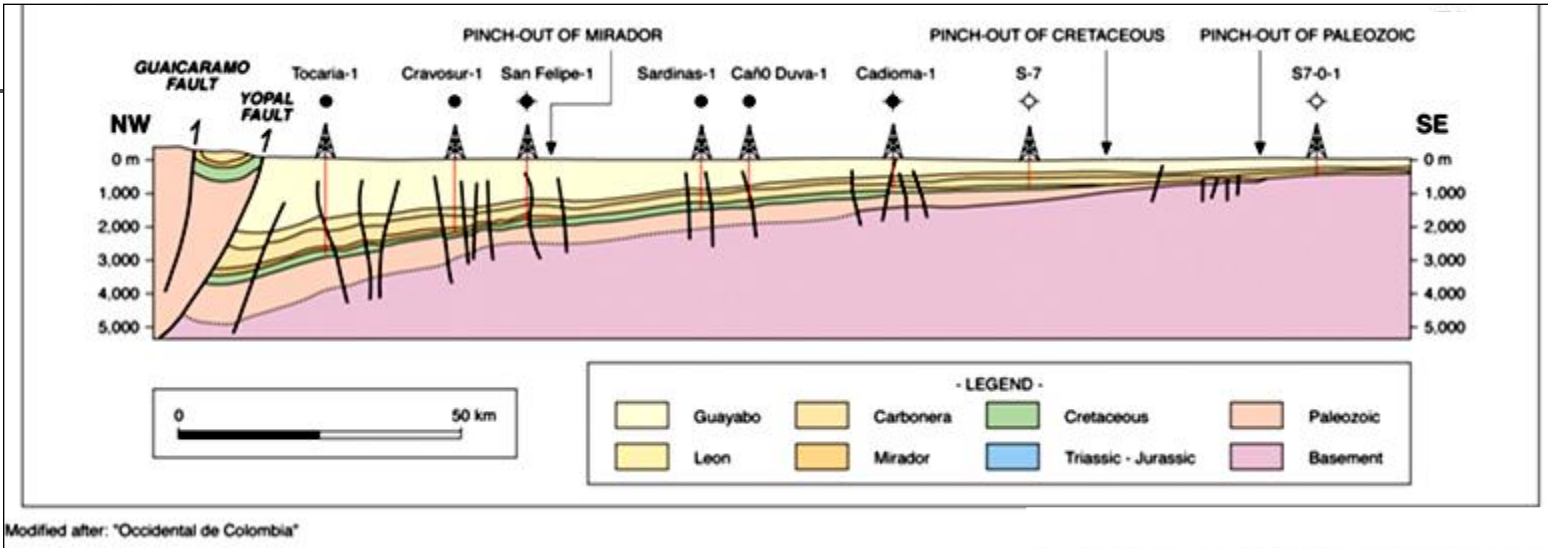
## PETROLEUM SYSTEM

**K** (Gacheta) – **K** (Une)

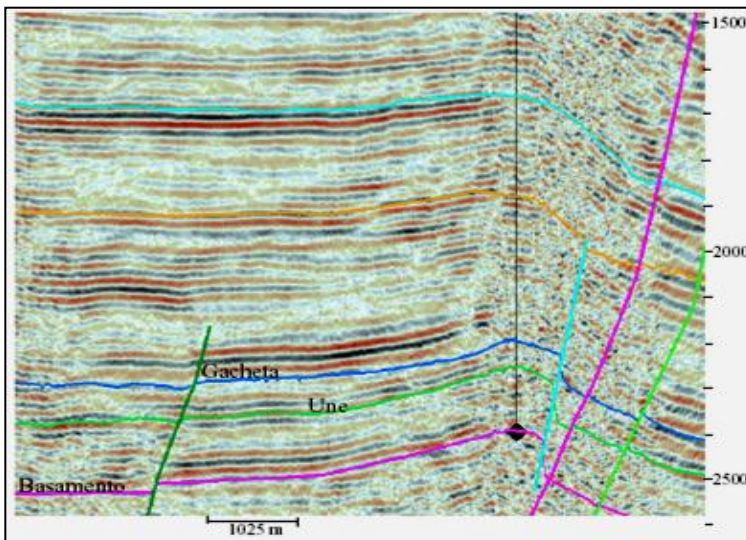
**K** (Gacheta) – **P** (Mirador - Carbonera)



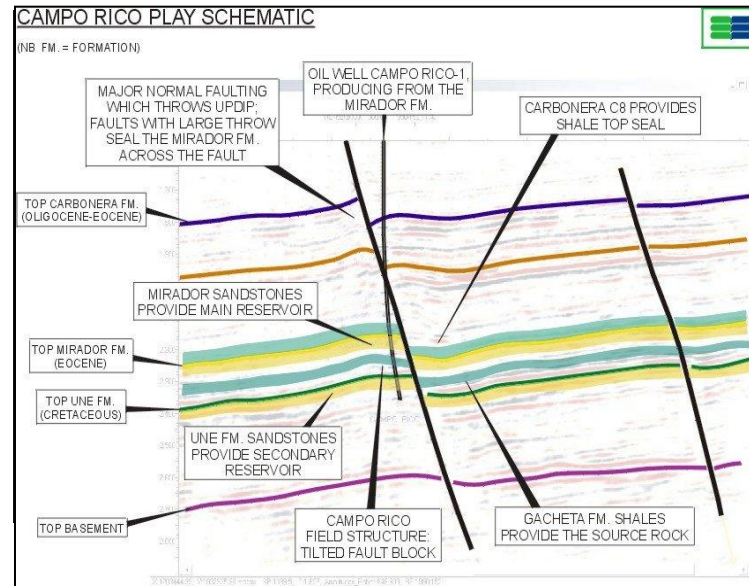
# Structural Styles



**Inversion structure**

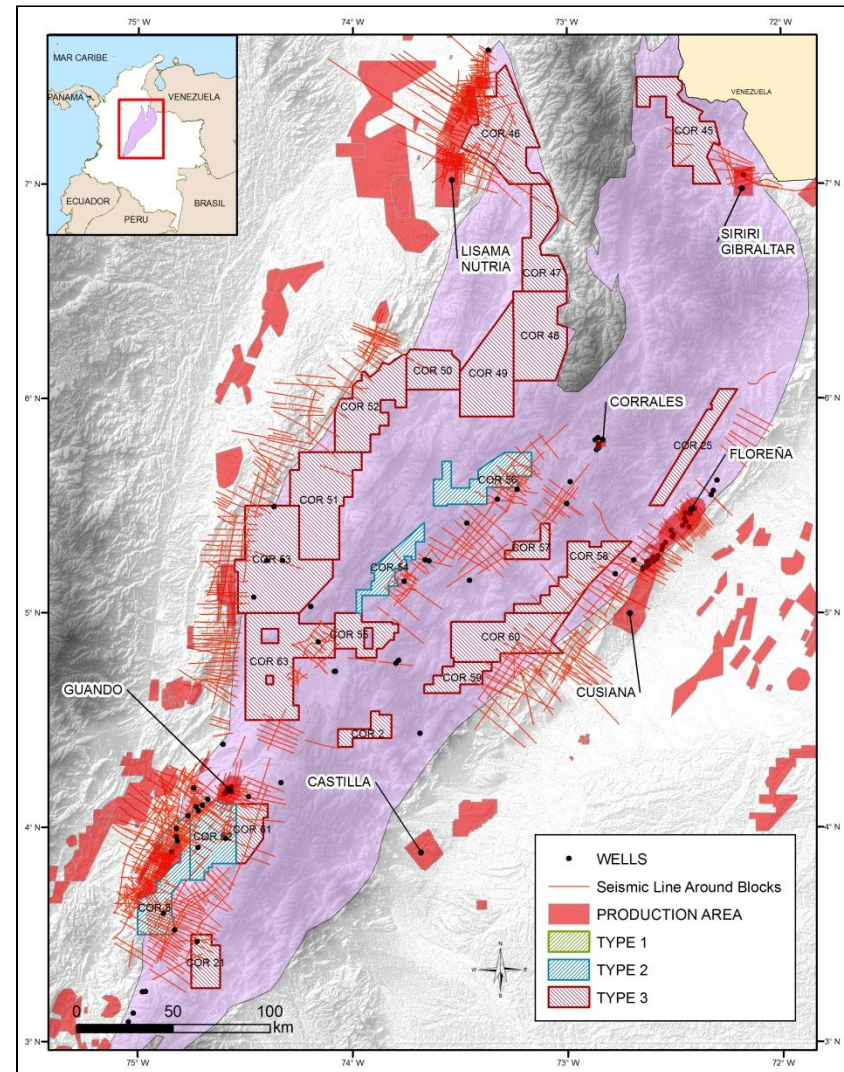


**Antithetic normal fault**

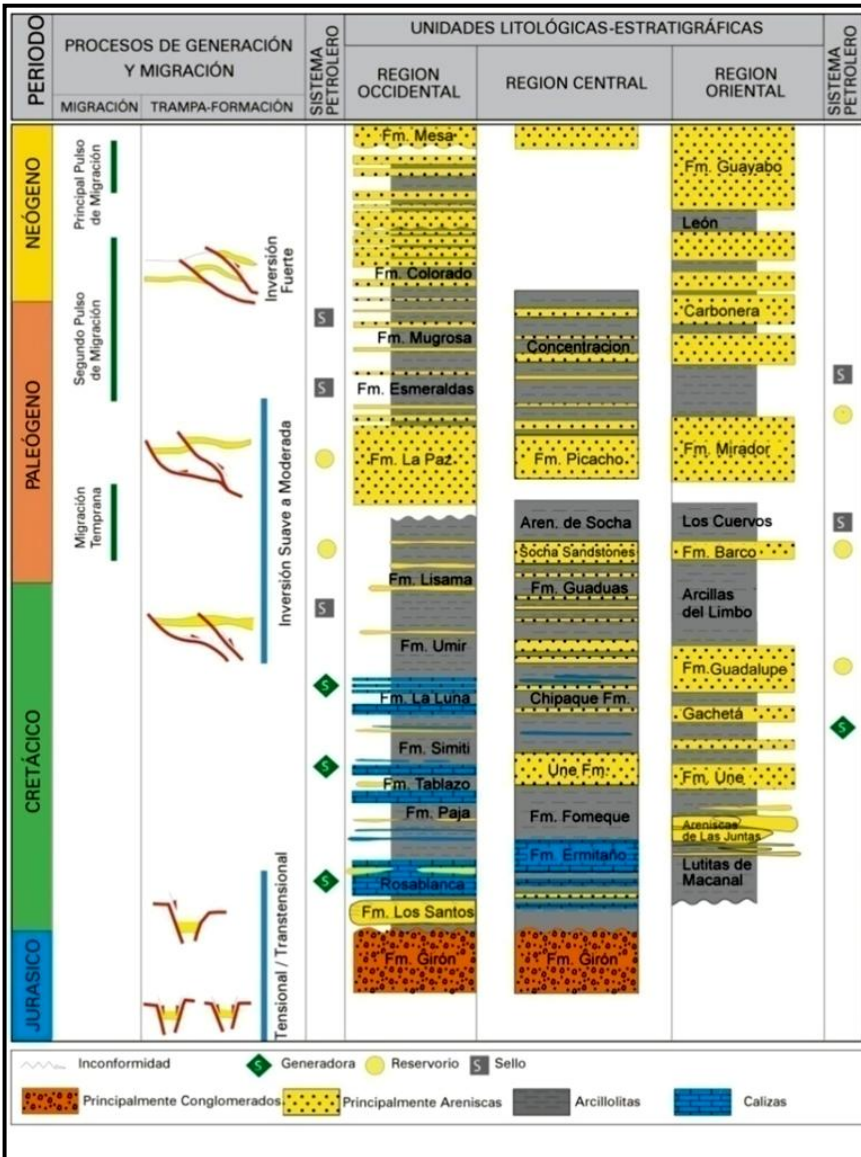


# Eastern Cordillera Basin

- Active petroleum system (Multiple seepage of liquid hydrocarbons)
- Excellent quality source rocks (Chipaque Fm= La Luna Fm)
- A preliminary assessment of the hydrocarbon resources suggests that the basin is also prospective for *Oil Shale* and *Shale Gas*.



# Eastern Cordillera Basin



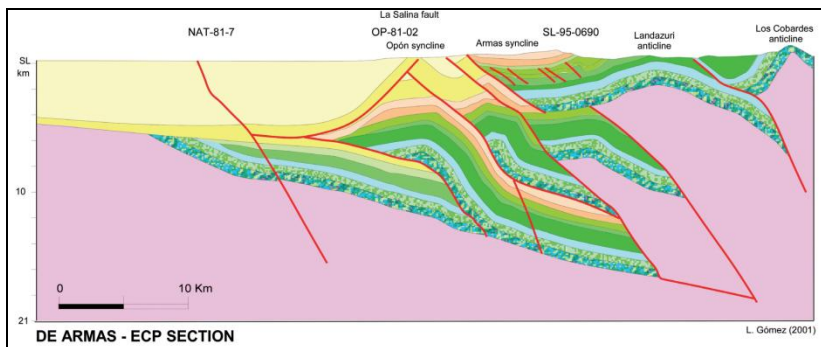
## PETROLEUM SYSTEM

**K** (Gacheta- La Luna) – **K** (Guadalupe)

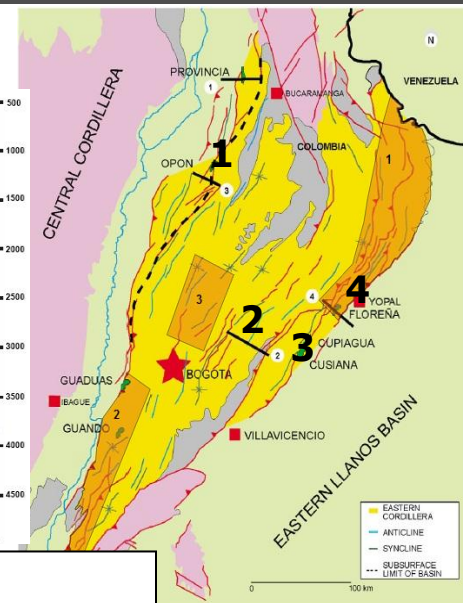
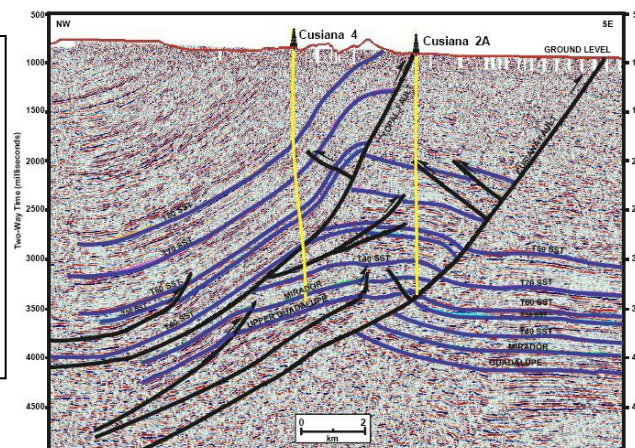
**K** (Gacheta- La Luna) – **P** (Barco-Mirador)

# Structural Styles

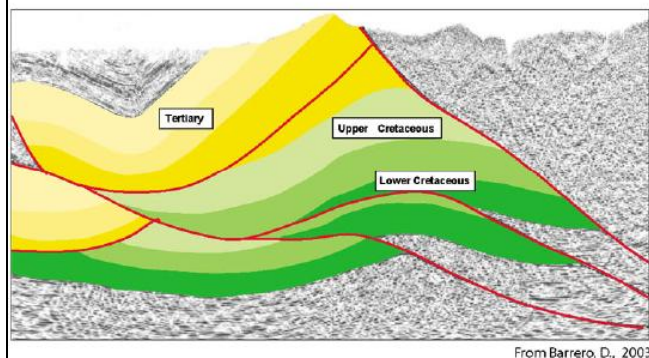
## 1. Sub thrust anticline



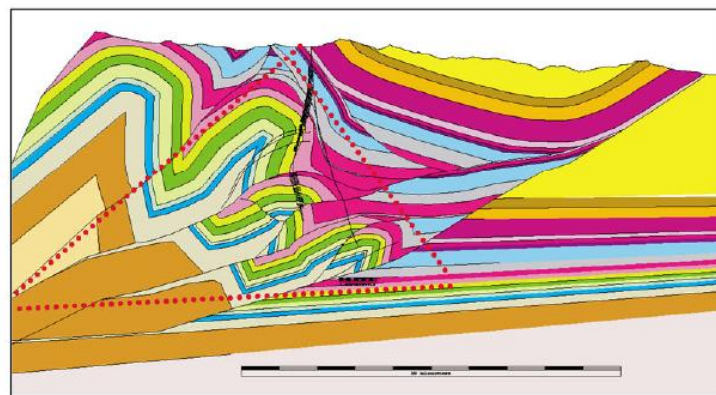
## 3. Cusiana field



## 2. Triangle zone – Río Horta

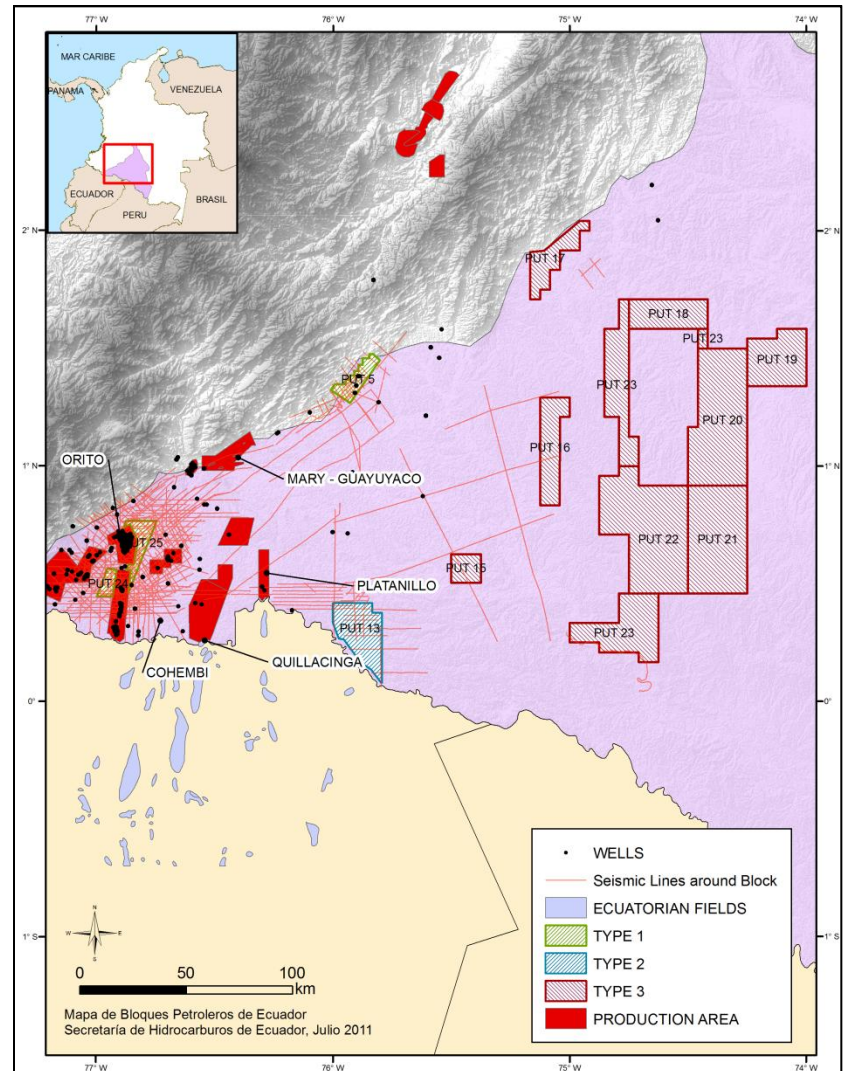


## 4. Duplex structure – Floreña area

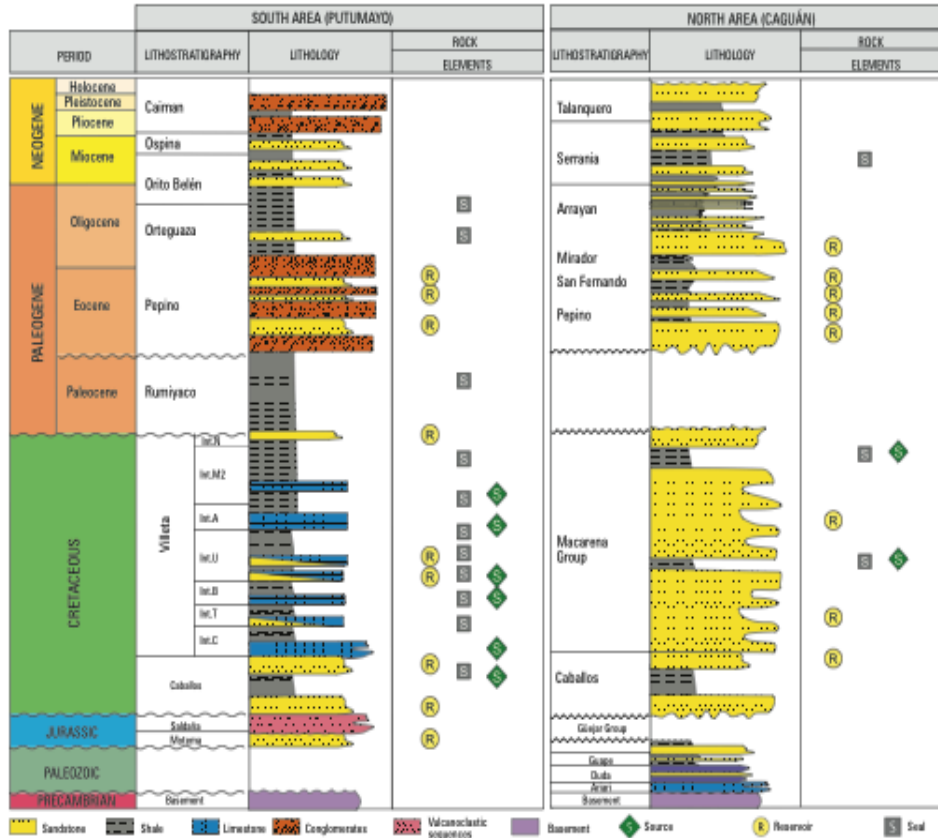


# Caguán–Putumayo Basin

- Possible extension of the Llanos basin heavy oil belt.
- Possible petroleum system associated with Paleozoic rocks (Caguán Sub-basin)
- Stratigraphic potential remains unexplored
- Excellent quality source rocks (Villeta Fm. and Caballos Fm.).



# Caguán–Putumayo Basin

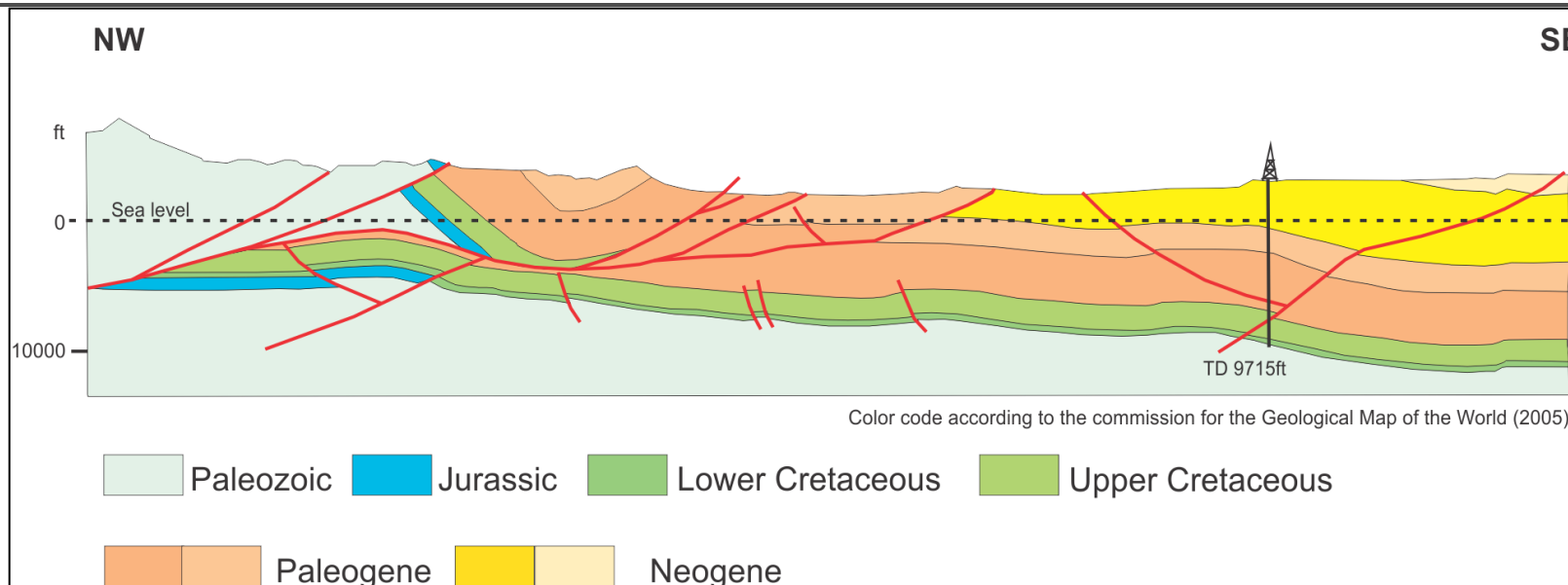


## PETROLEUM SYSTEM

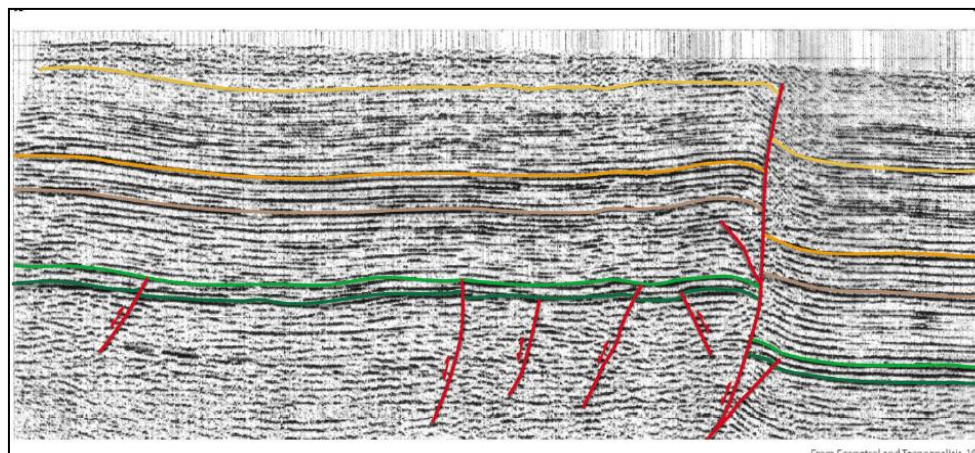
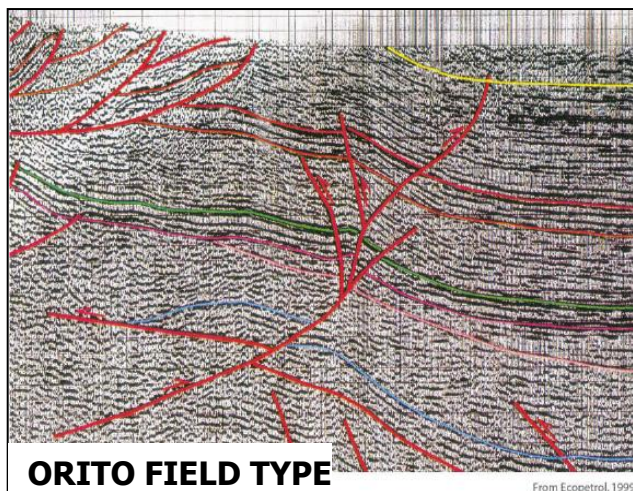
**K** (Caballos-Villeta) – **K** (Caballos-Villeta)

**K** (Caballos-Villeta) – **P** (Pepino)

# Structural Styles

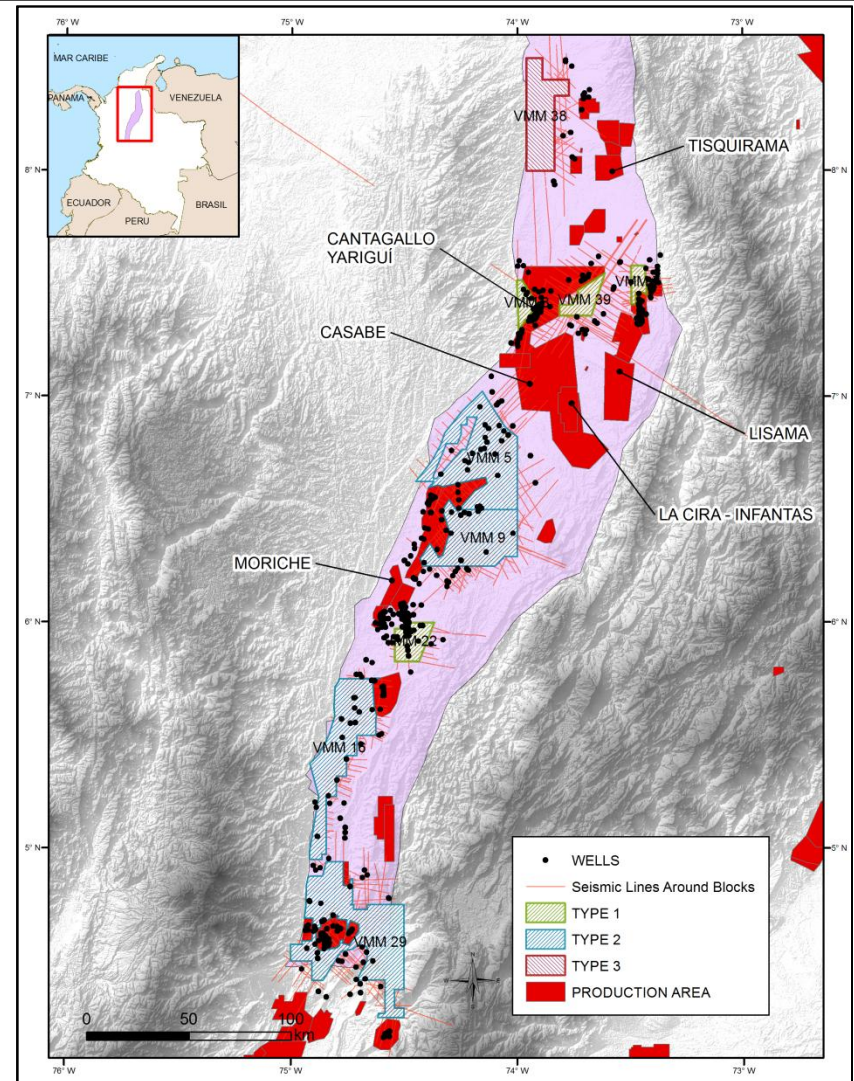


## Inversion structure



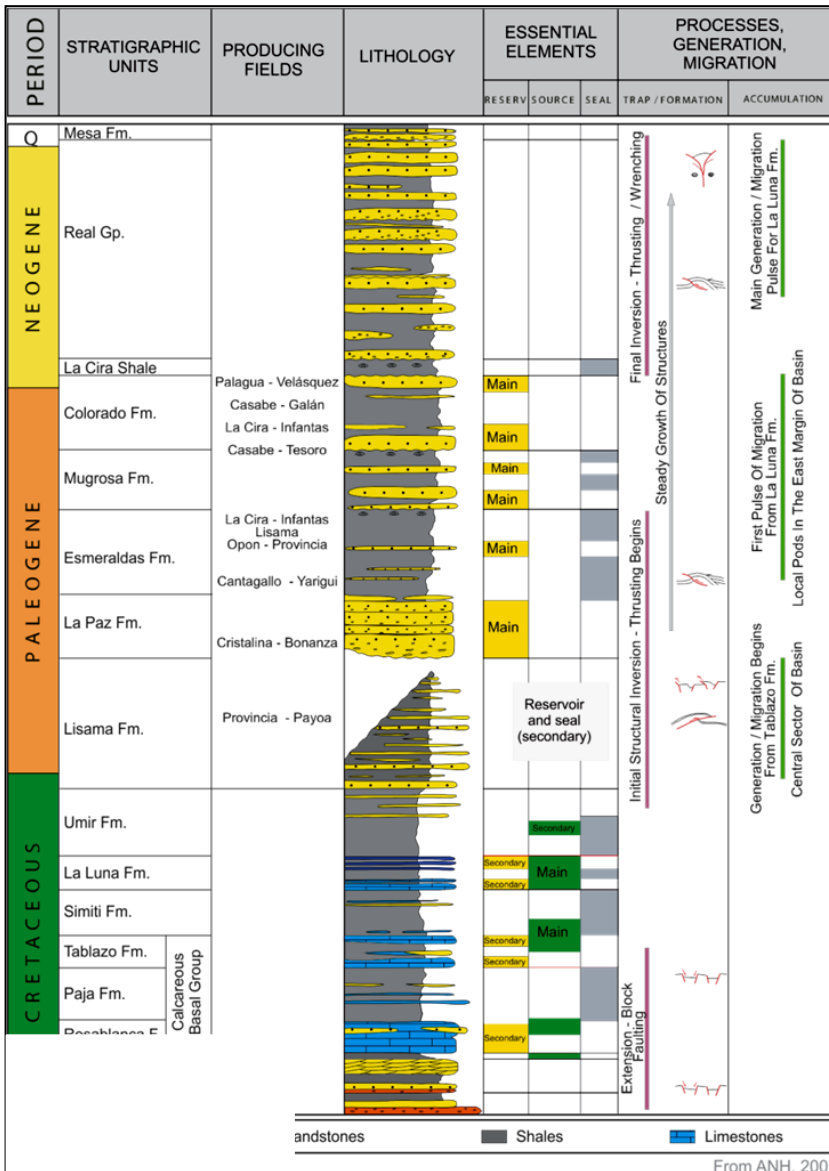
# Middle Magdalena Basin (VMM)

- It has additional exploration potential and is one of the most prolific basins in the country.
- Unexplored Cretaceous carbonates.
- A preliminary assessment of the hydrocarbon resources suggests that the basin is also prospective for *Oil Shale* and *Shale Gas*.





# Middle Magdalena Basin (VMM)

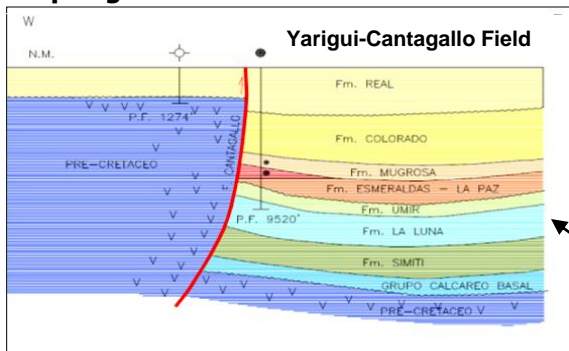


## PETROLEUM SYSTEM

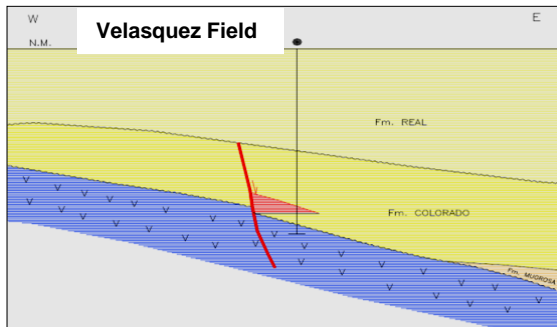
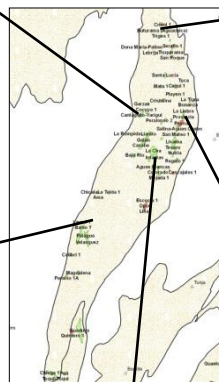
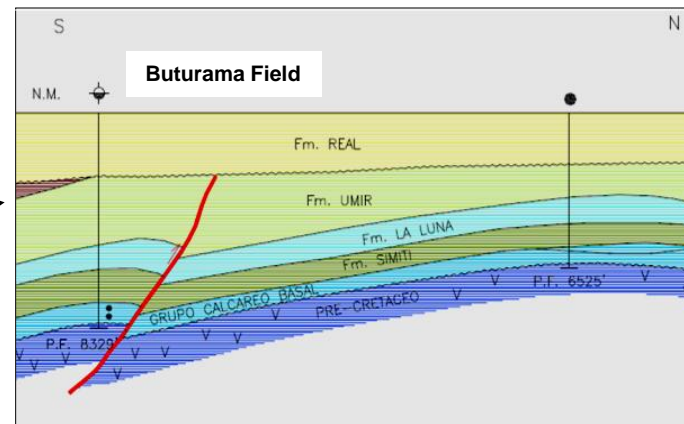
**K** (La Luna) – **P** (La Paz, Mugrosa, Colorado)

# Structural Styles

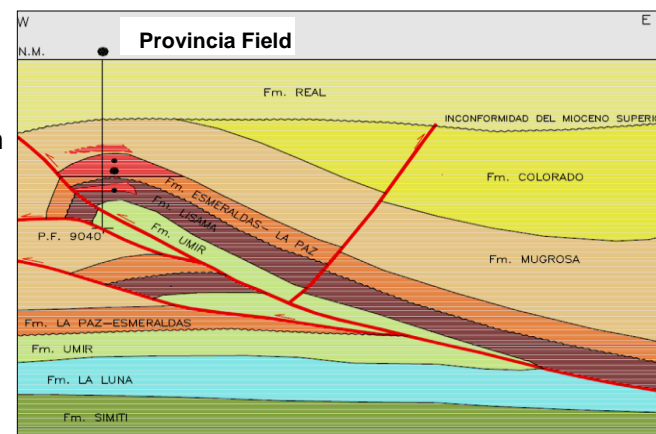
**Faulted traps against basement of the Central Cordillera**



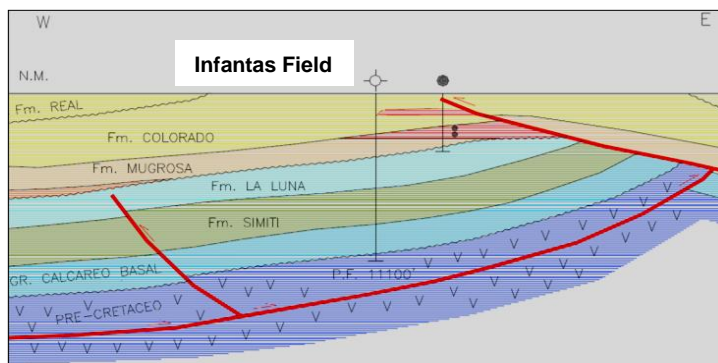
**Lower Cretaceous fractured limestones**



**Fold Propagation Fault**



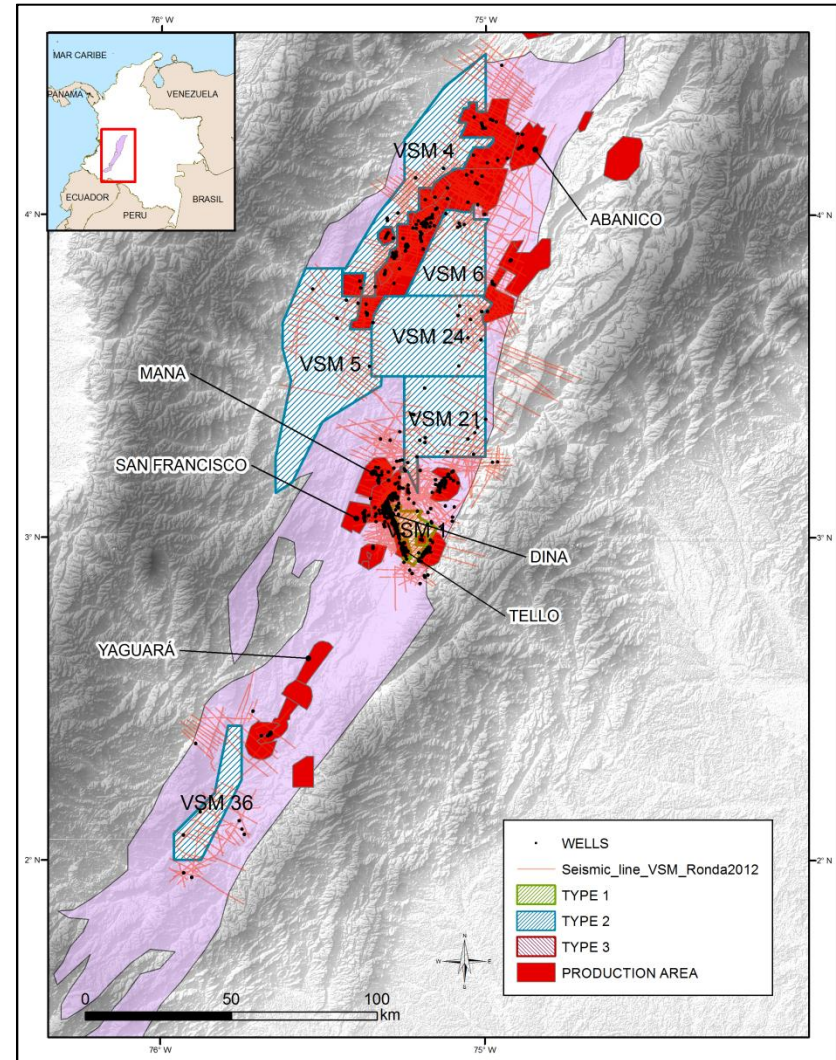
**Subthrusts structures associated to Andean deformation**



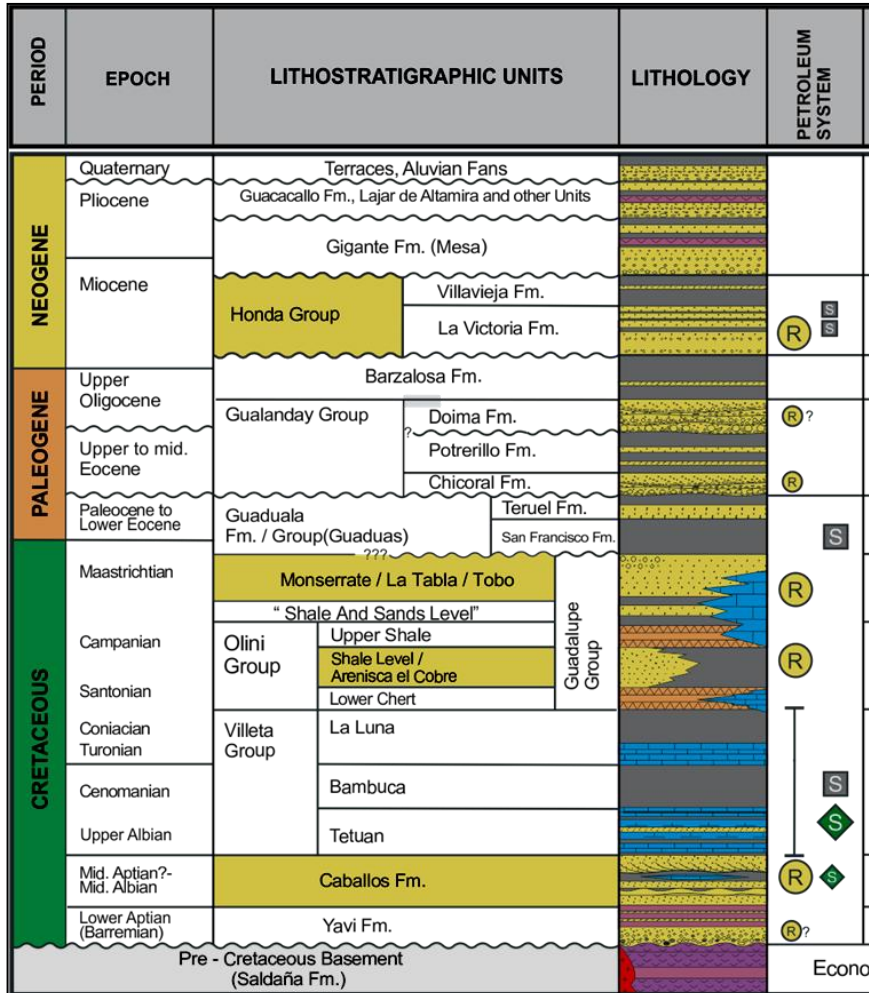
**Normal fault traps - eastward dipping monocline**

# Upper Magdalena Basin (VSM)

➤ A preliminary assessment on the hydrocarbon resources of the country suggests that the basin is also prospective for *Oil Shale* and *Shale Gas*.



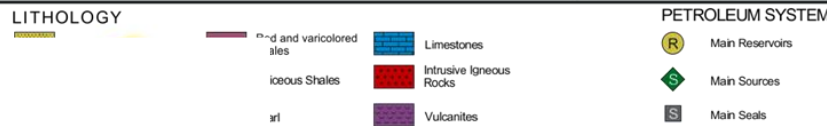
# Upper Magdalena Basin (VSM)



## PETROLEUM SYSTEM

**K** (Caballos-Tetuan) – **K** (Caballos-Guadalupe)

**K** (Caballos-Tetuan) – **P-N** (Gaulanday, Honda)

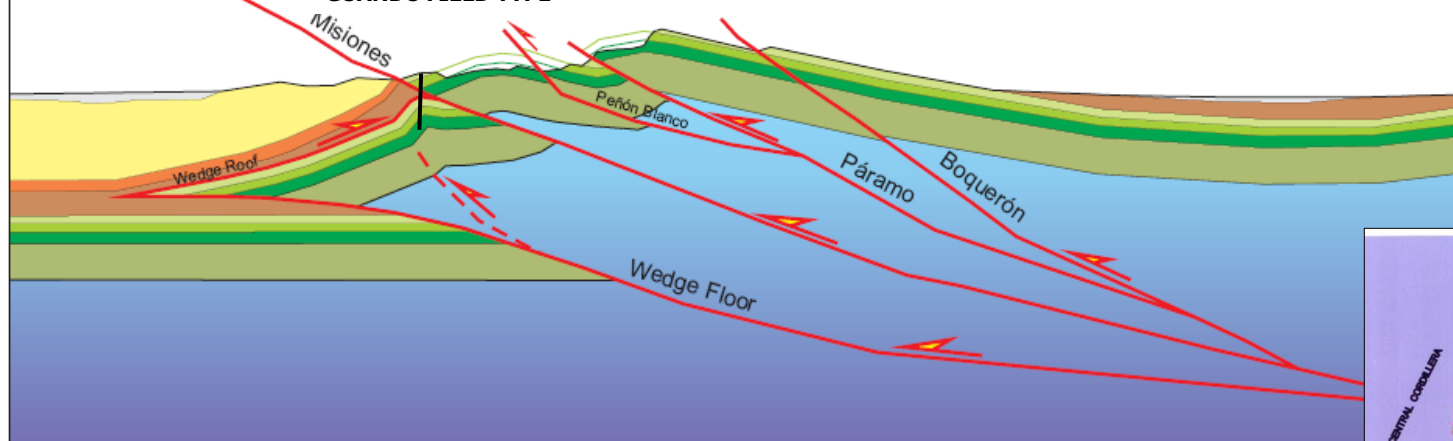


# Structural Styles

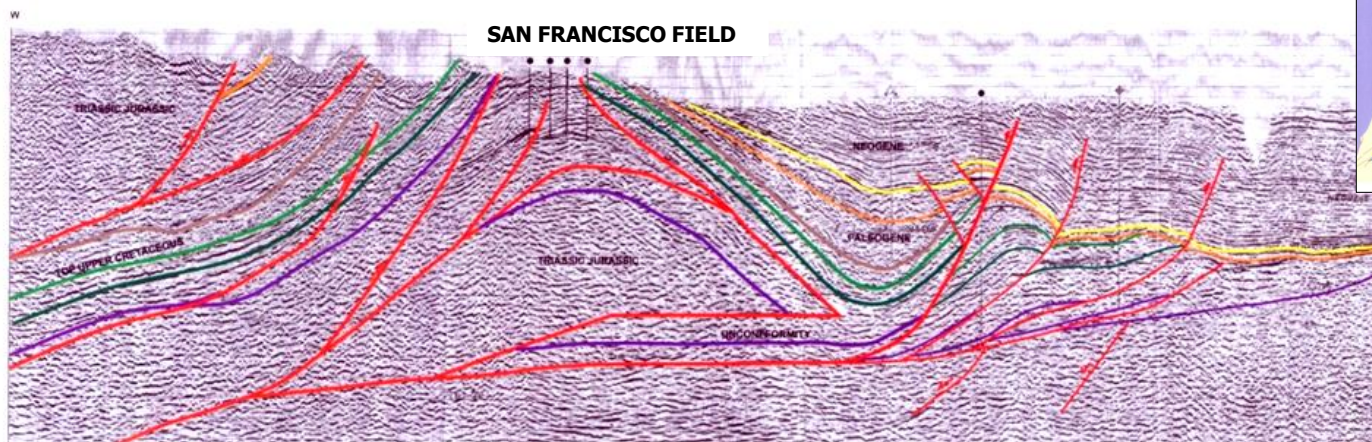
WNW

GUANDO FIELD TYPE

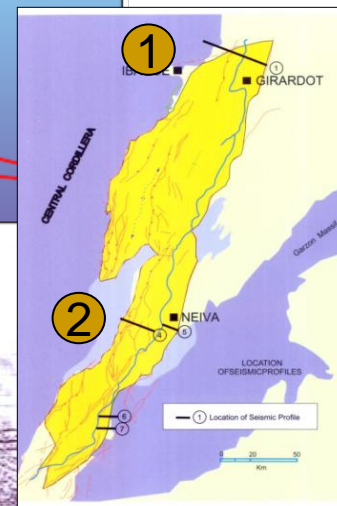
1- Sub-thrust and thrust anticlines



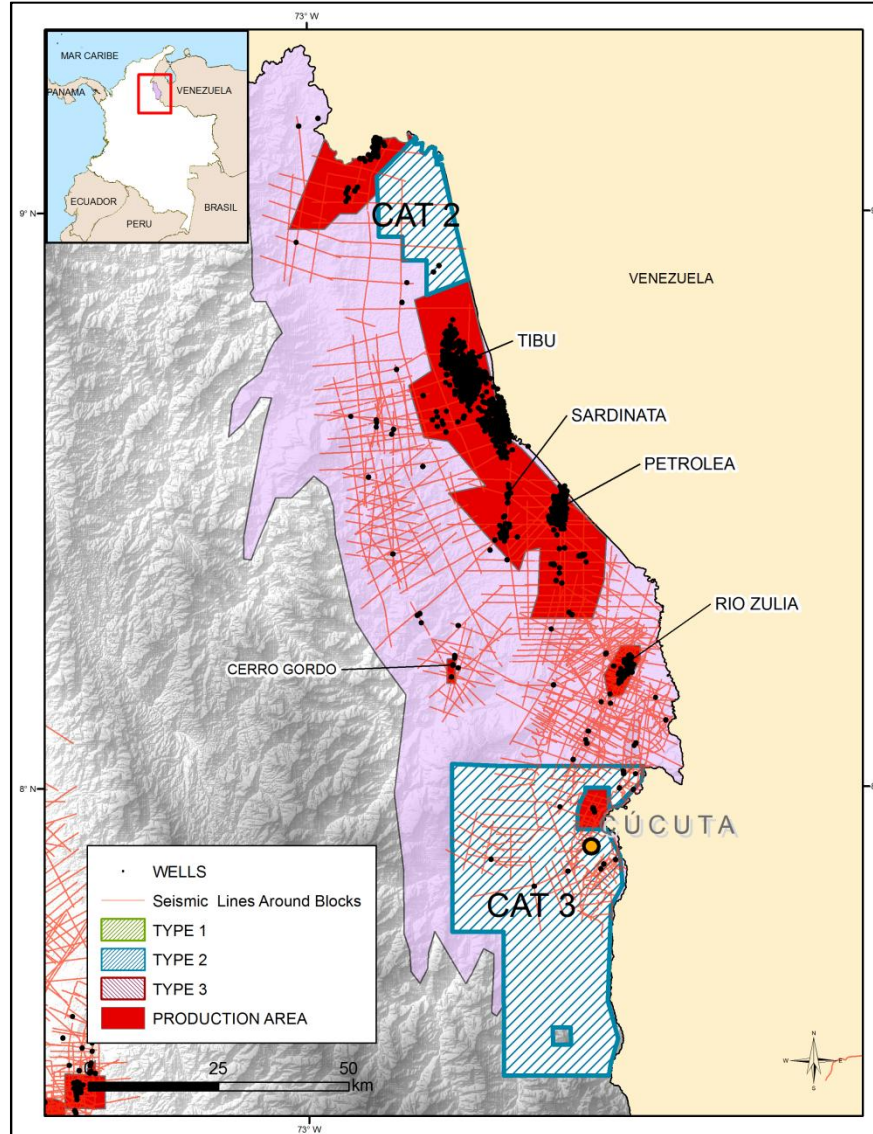
2- Fault Bend Fold and imbricate thrust fans



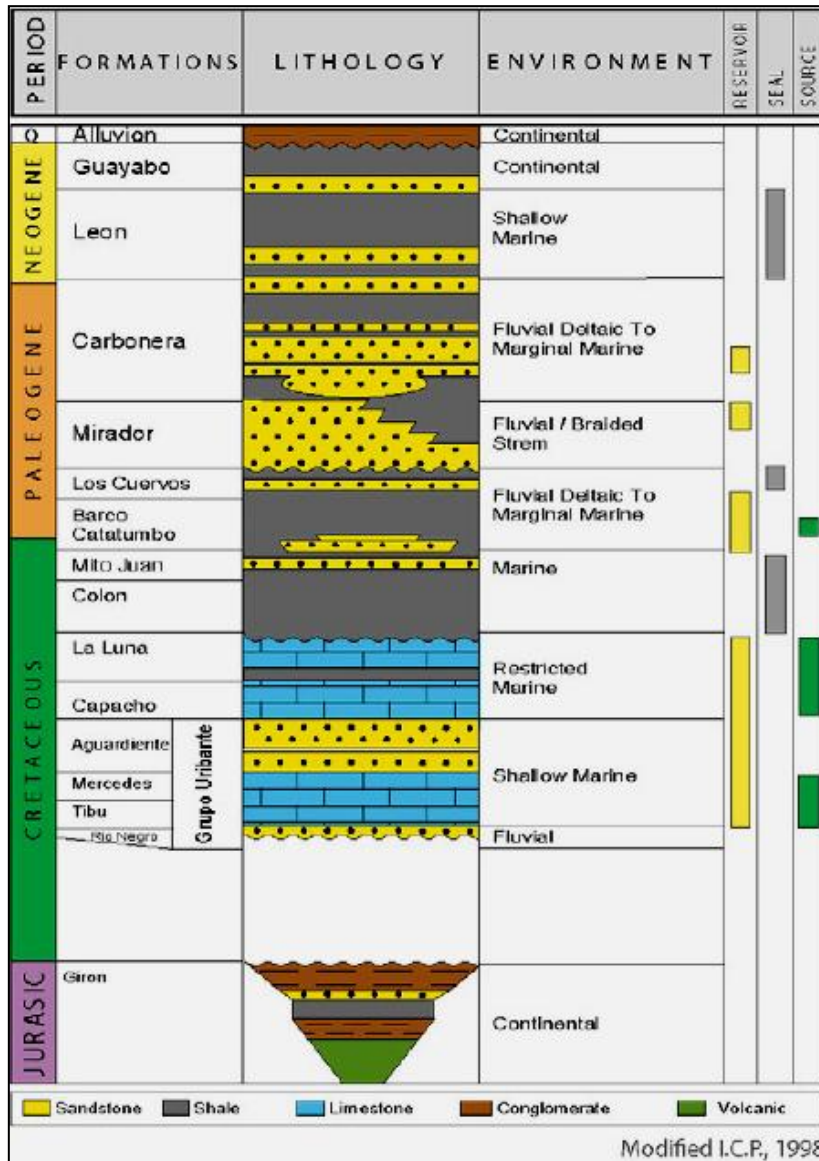
From Seismic Atlas, 1998



# Catatumbo Basin (CAT)



# Catatumbo Basin (CAT)



Modified I.C.P., 1998

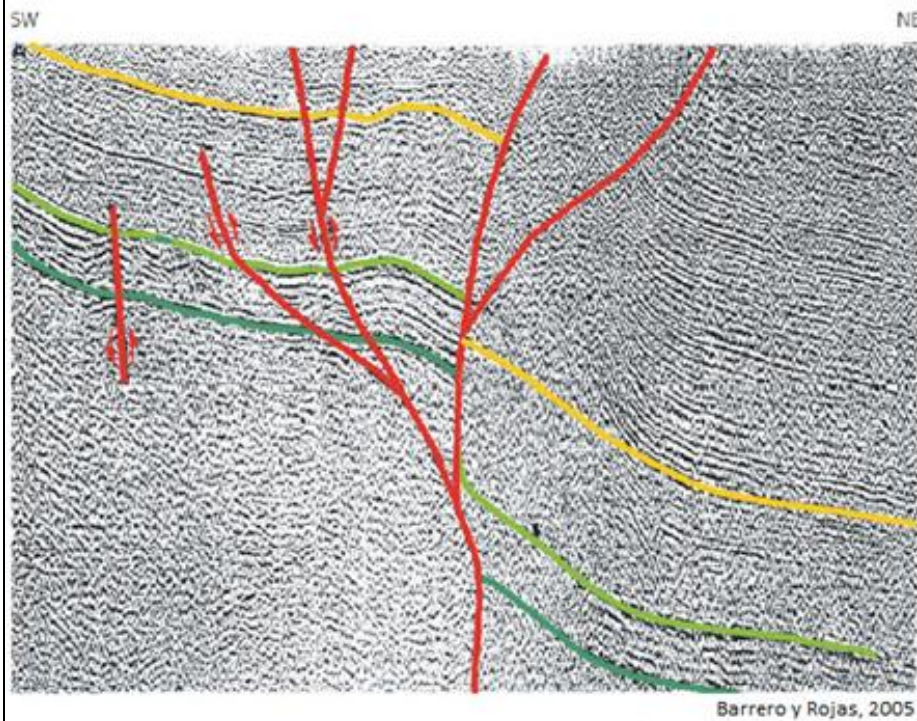
## PETROLEUM SYSTEM

**K** (Uribante, La Luna) – **K** (Uribante, La Luna)

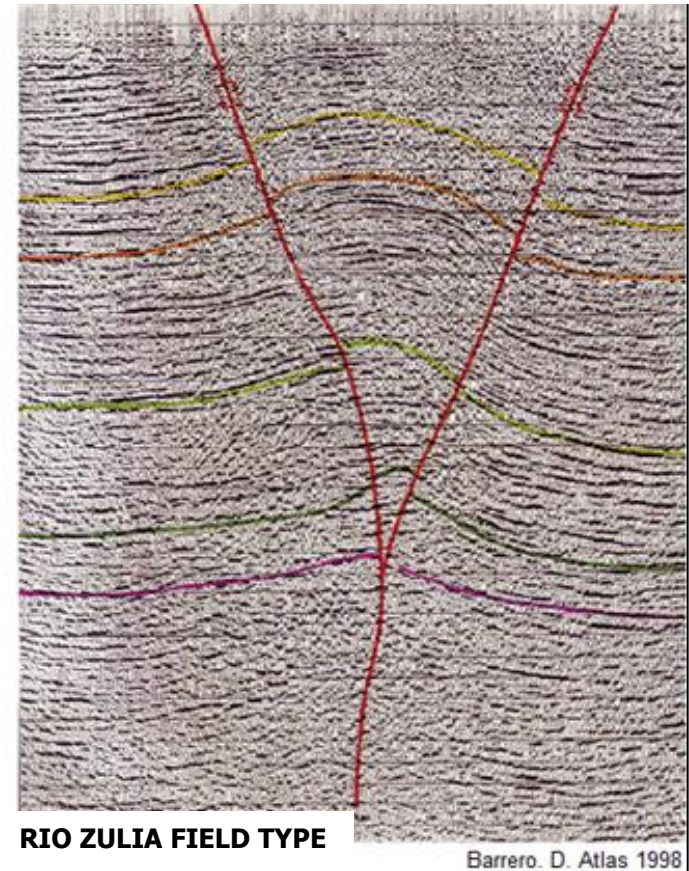
**K** (Uribante, La Luna) – **P** (Barco, Mirador , Carbonera)

# Structural Styles

1- Closures on both hanging-wall and foot-wall of faults developed under transpression

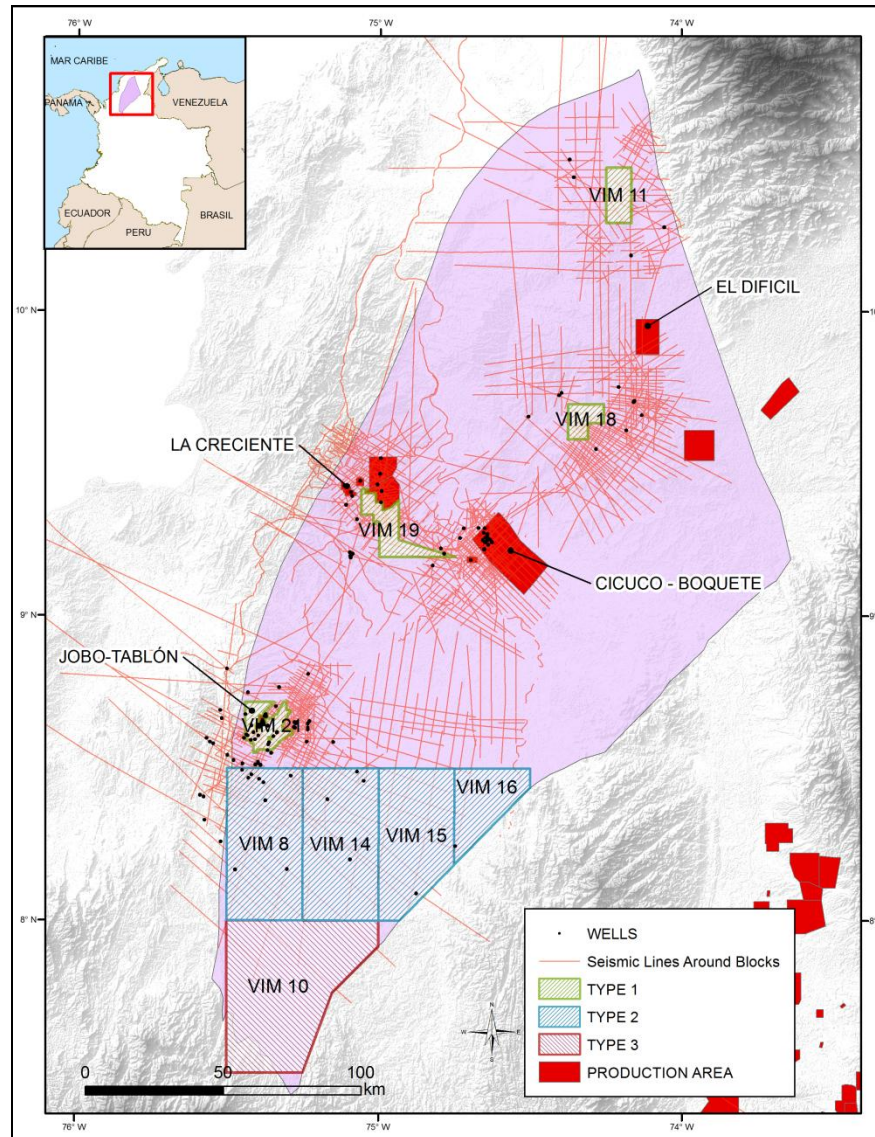


2- Anticline traps (Flower Structures) developed under wrenching conditions

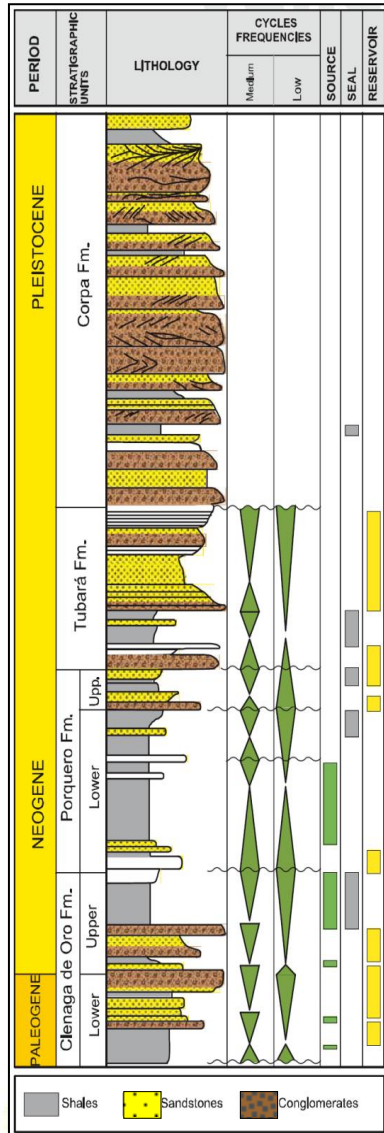




# Lower Magdalena Basin (VIM)



# Lower Magdalena Basin (VIM)



## PETROLEUM SYSTEM

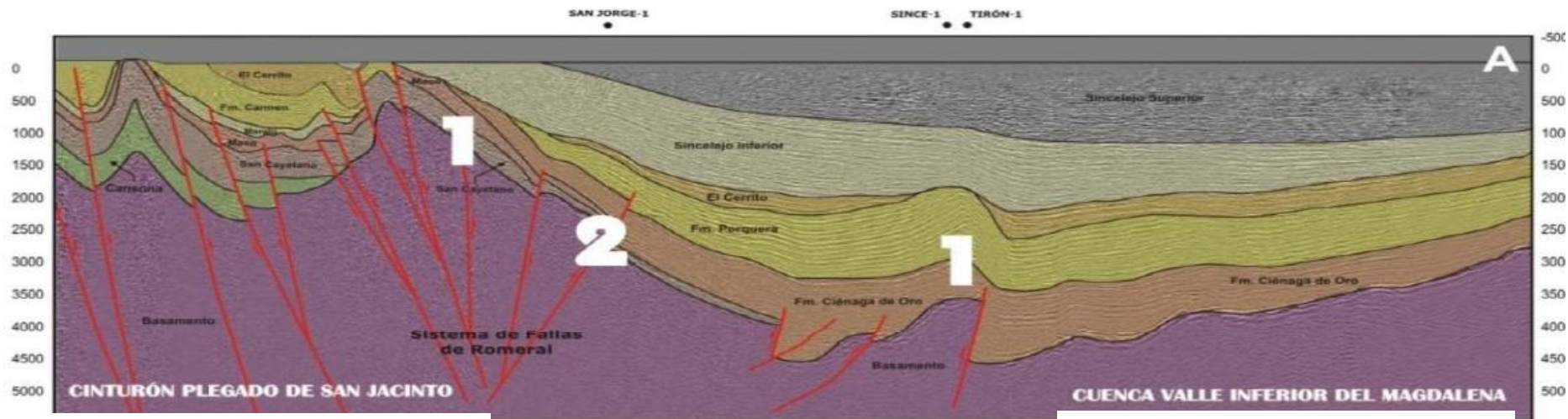
**P** (Ciénaga de Oro) – **N** (Ciénaga de Oro, Tubará)

**N** (Porquero) – **N** (Porquero, Tubará)

Barrero et al, 2008

# Structural Styles

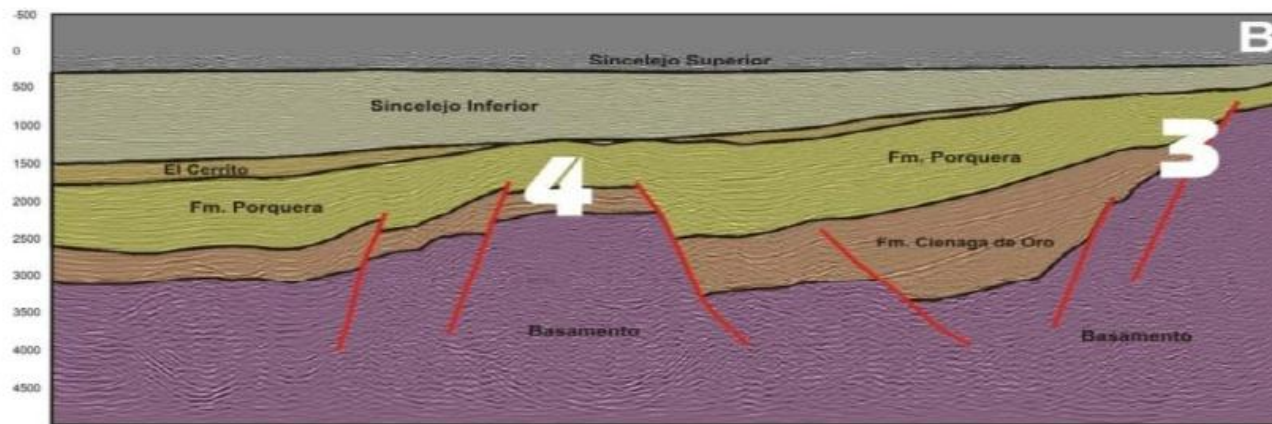
- 1- Inversion anticlines    2- Fault juxtaposition traps    3- Pinch-outs against basement    4- Basement High



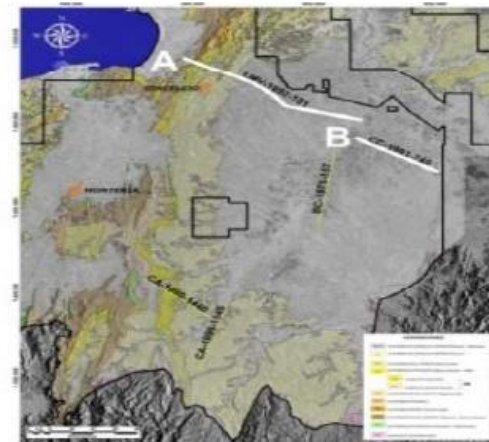
SAN JACINTO FOLD BELT

LMV-1992-101

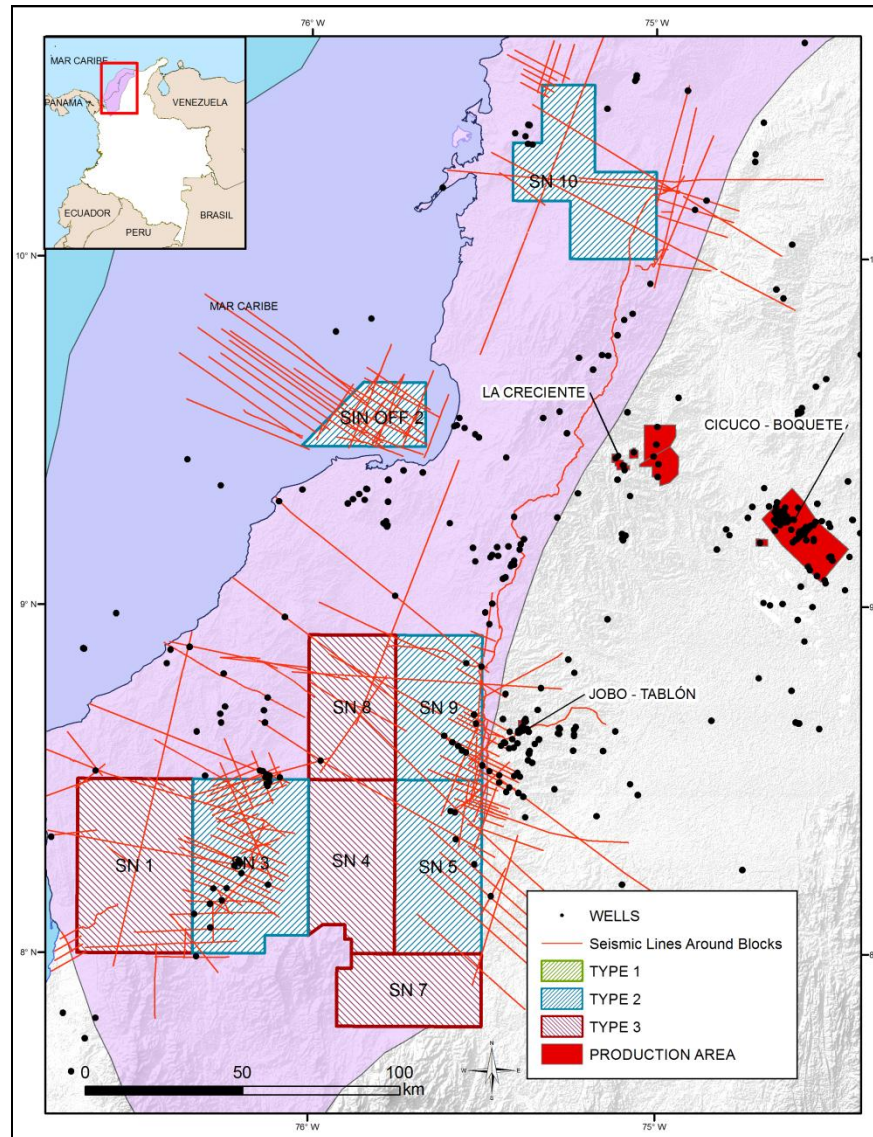
VIM BASIN



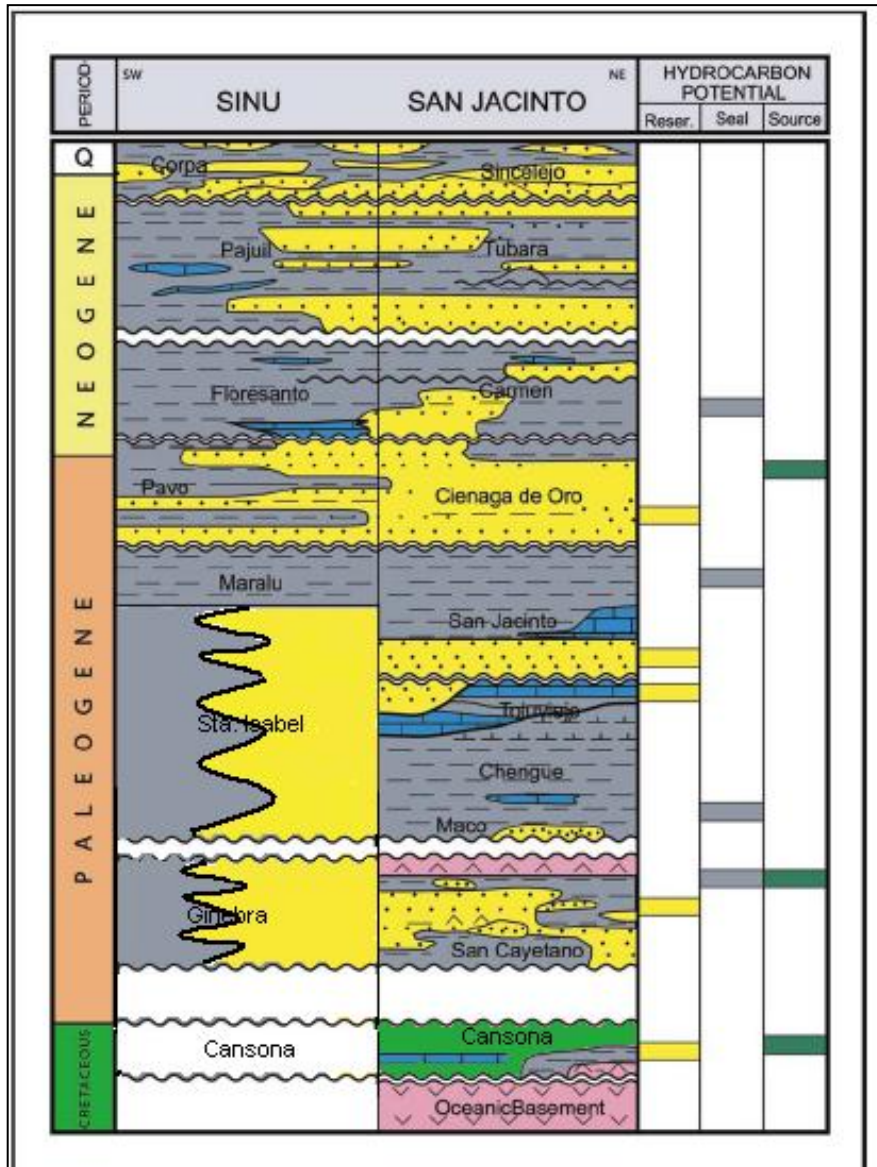
CC-1991-740



# Sinú–San Jacinto Onshore and Offshore Basins



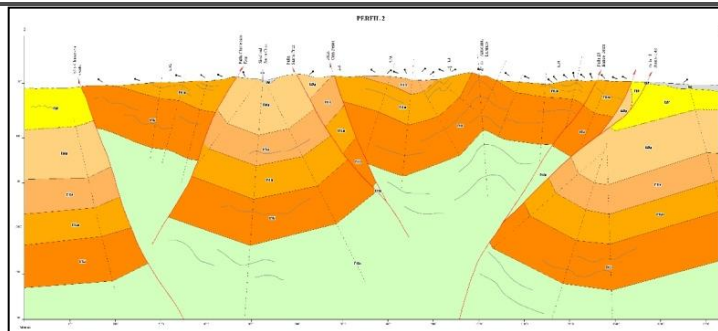
# Sinú– San Jacinto Onshore and Offshore Basins



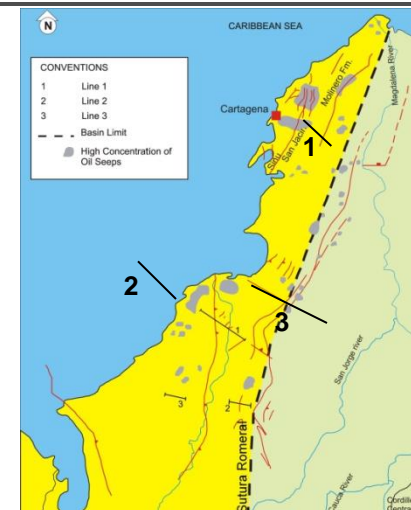
## PETROLEUM SYSTEM

**K?** (?Cansona) – **P** (San Cayetano, Ciénaga de Oro)

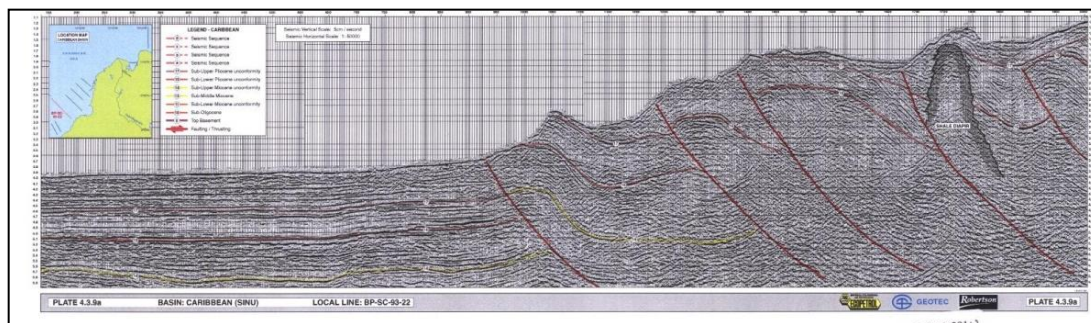
# Structural Styles



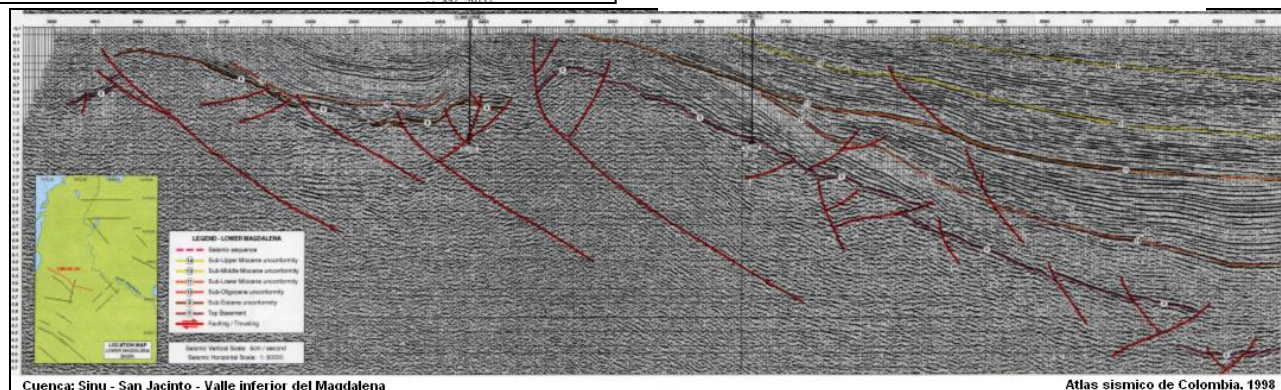
**1- Wrench structure – San Jacinto Fold Belt**



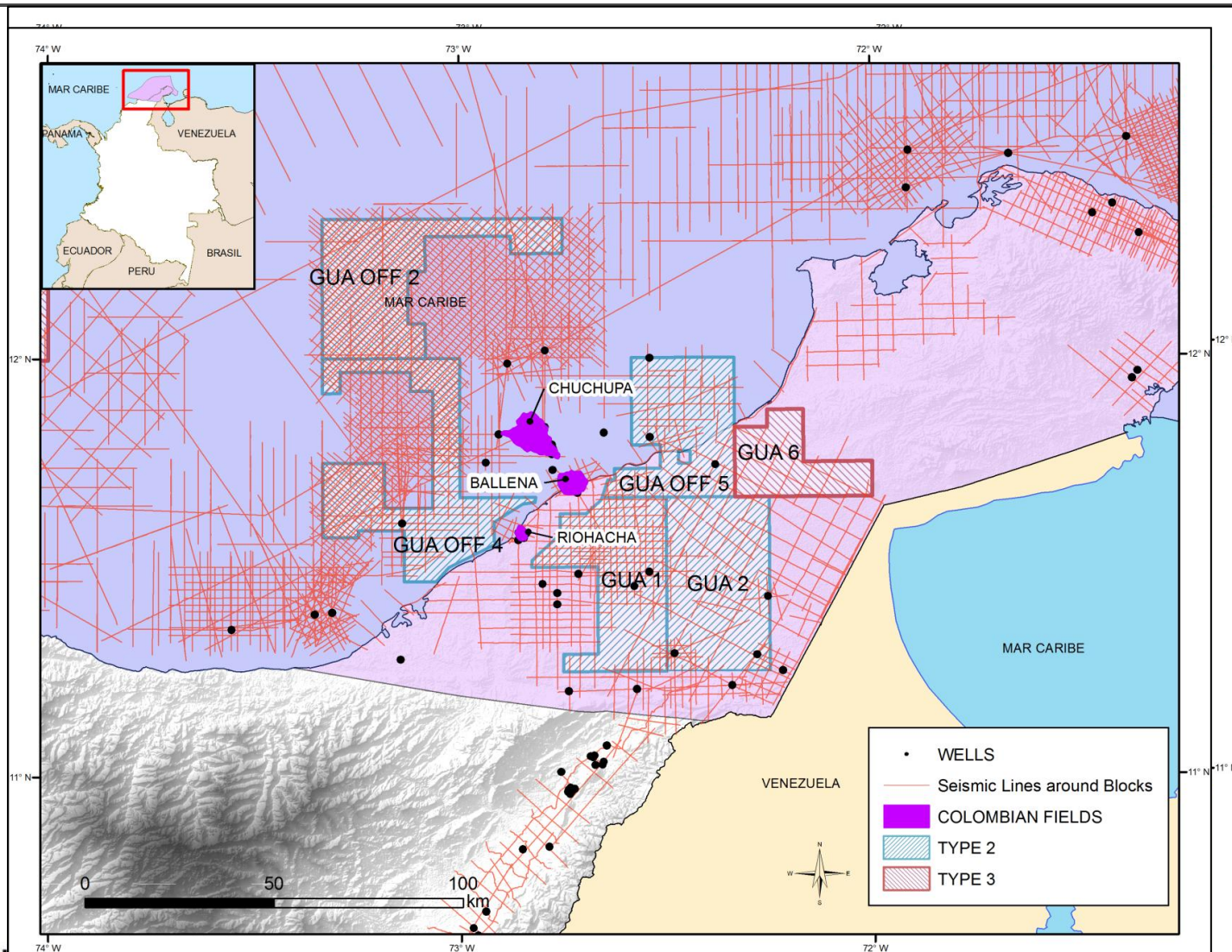
**2- Fold propagation fault and diapiric structures - Sinu Fold Belt -offshore**



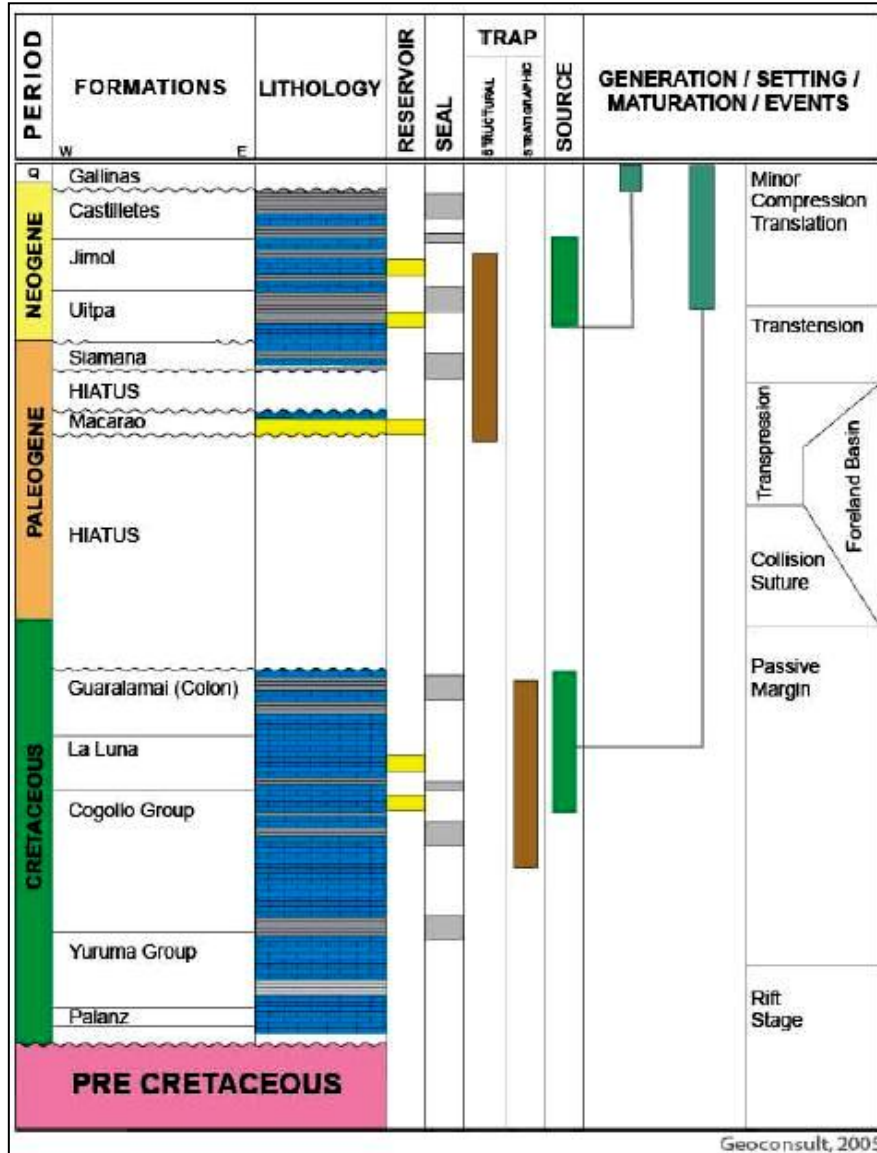
**3- Inversion structure - Romeral Fault System**



# Guajira Onshore and Offshore Basins



# Guajira Onshore and Offshore Basins



Geoconsult, 2005

## PETROLEUM SYSTEM

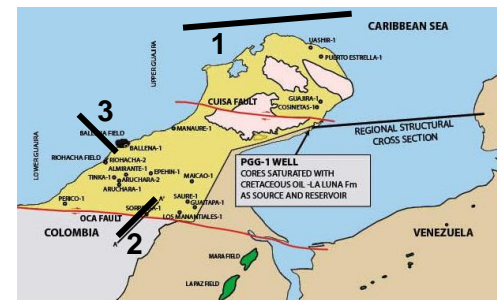
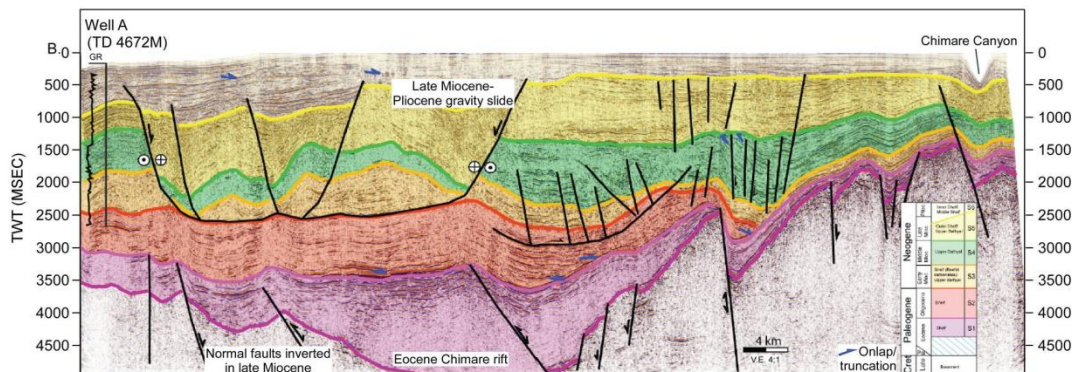
**K** (La Luna) – **K** (La Luna)

**K** (Uribante, La Luna) – **P-N** (Macarao, Uitpa)

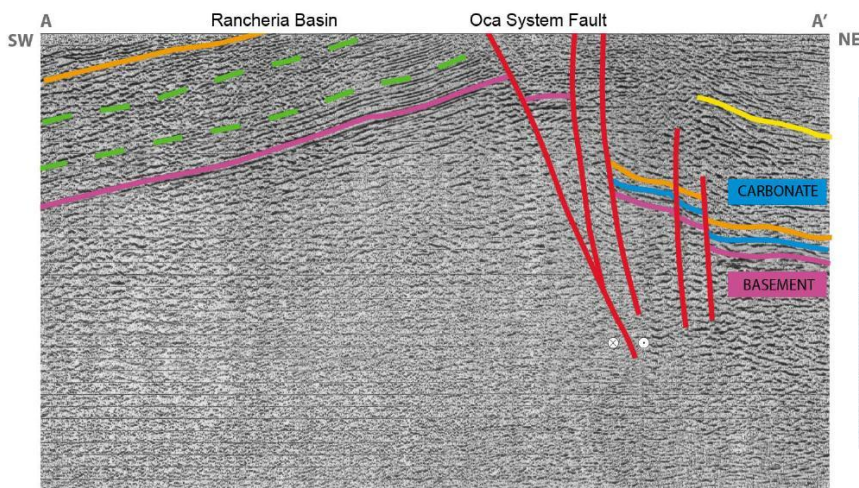


# Structural Styles

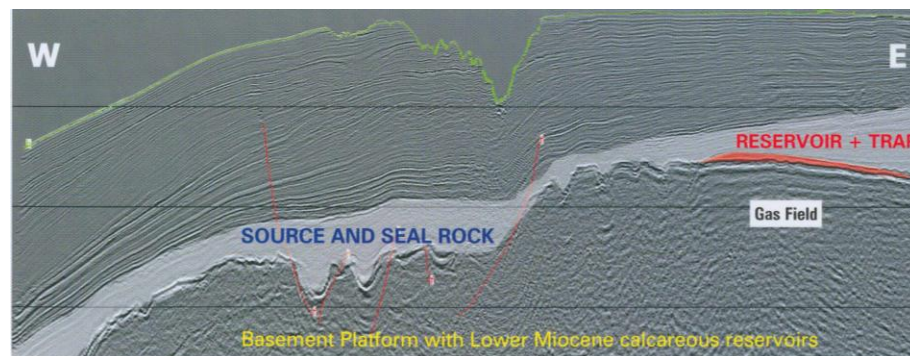
## 1- Normal Fault traps



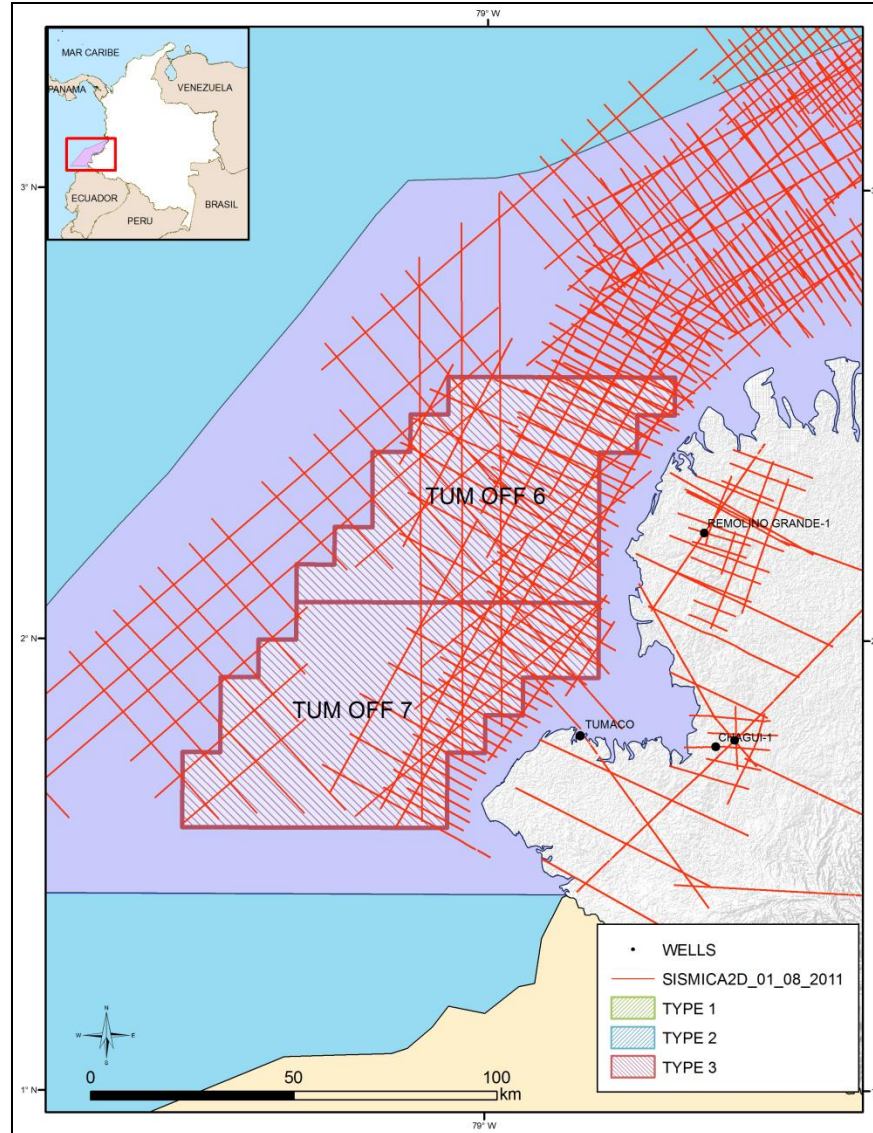
## 2- Oligocene carbonates strongly Fractured by the Oca Wrench System



## 3- Combined (structural and stratigraphic) traps

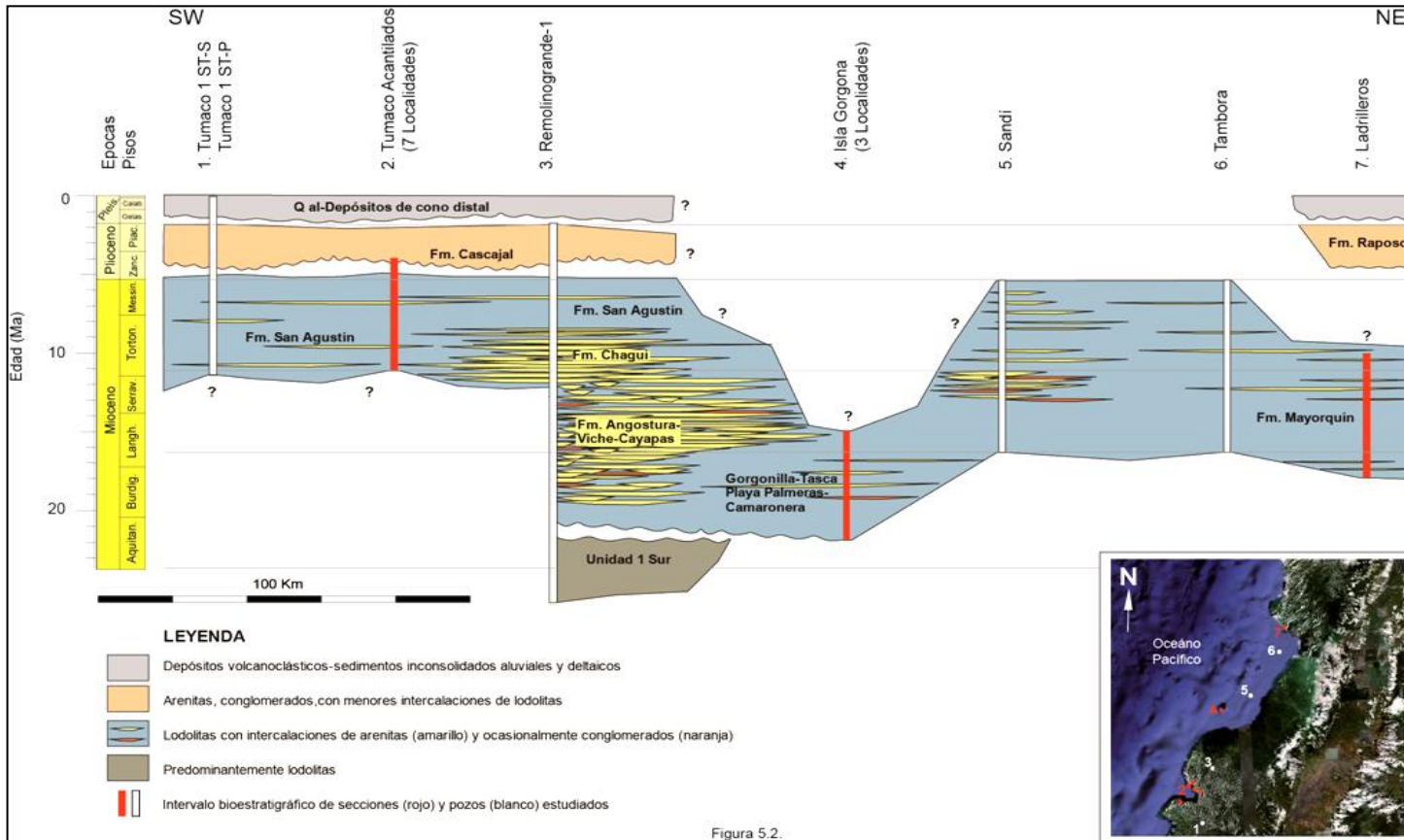


# Tumaco Basin Offshore (Tum)



# Tumaco Basin Offshore (Tum)

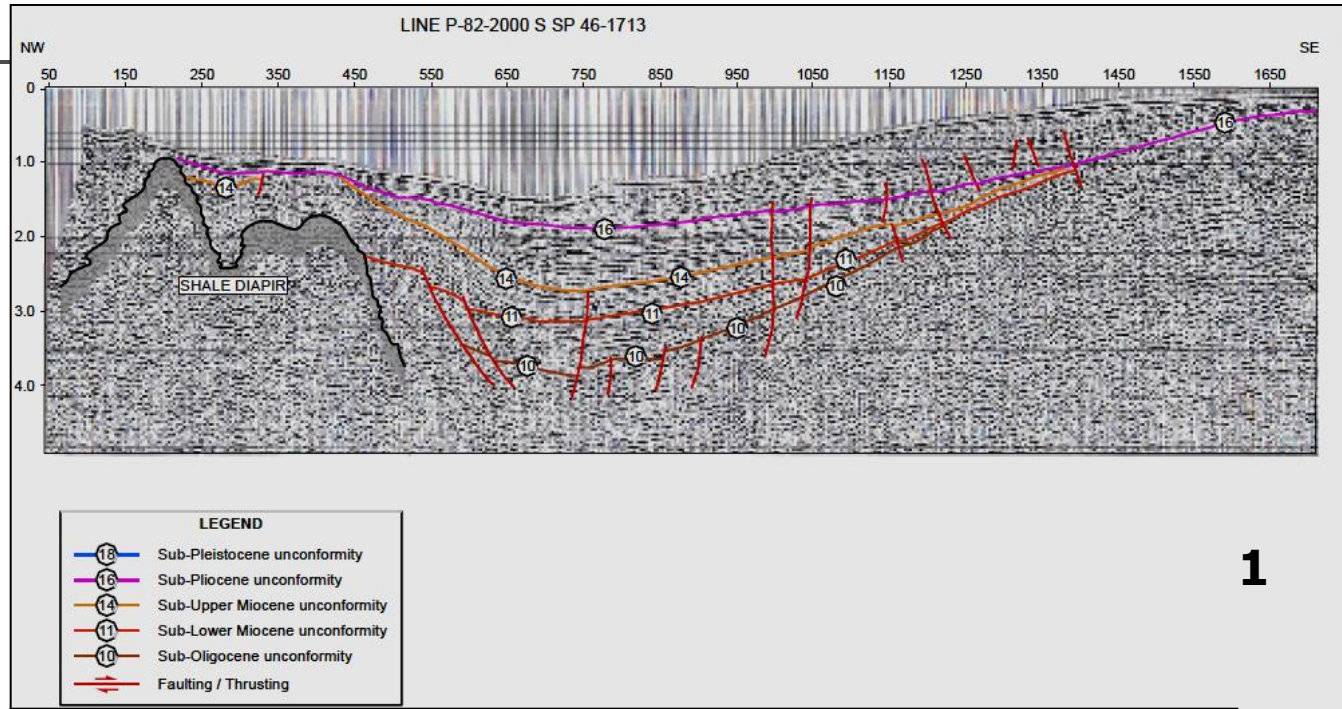
## Stratigraphic chart



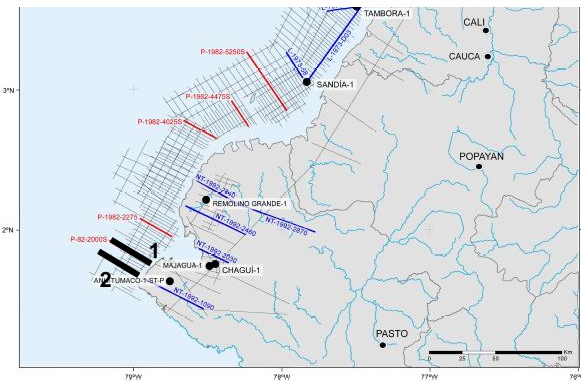
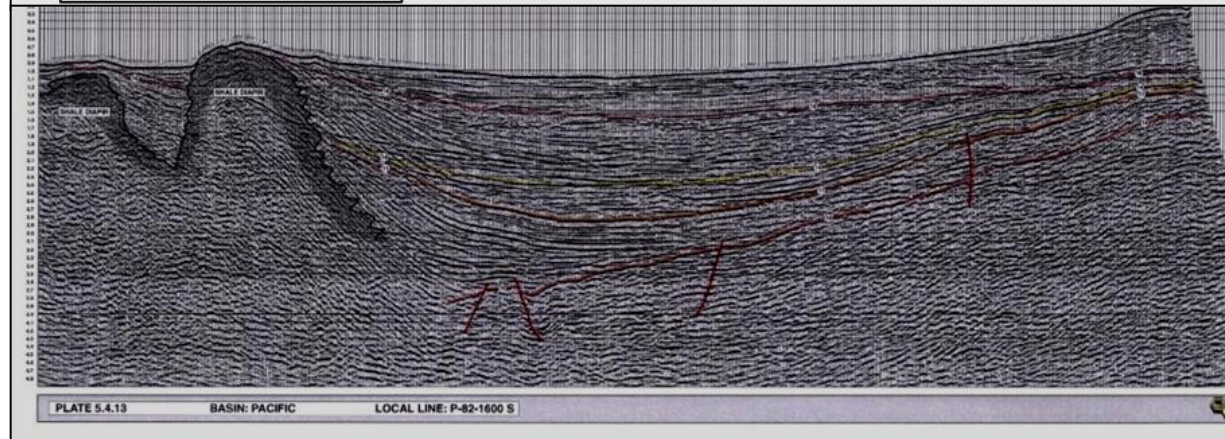
**PETROLEUM SYSTEM**

P? ( ) – N (Angostura -Cayapas)

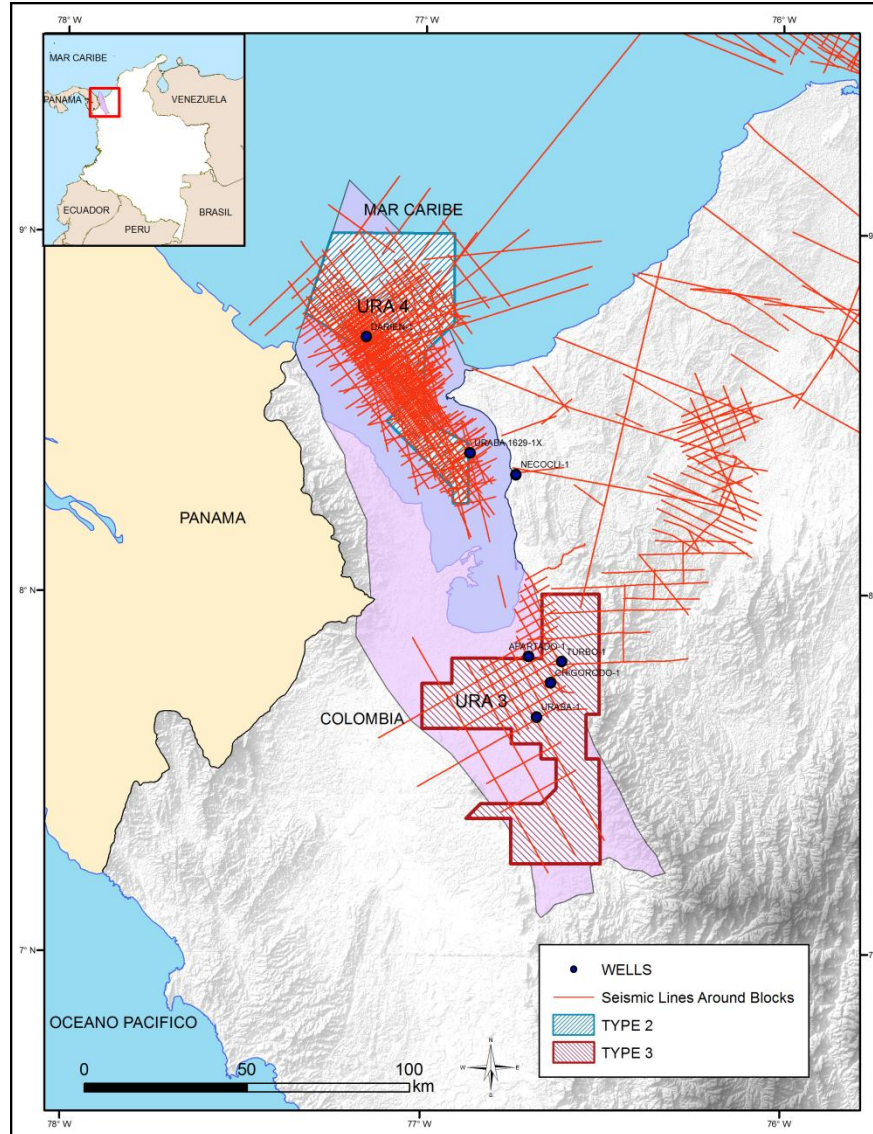
# Structural Styles



1- 2 Normal faults and stratigraphic traps, diapiric structures

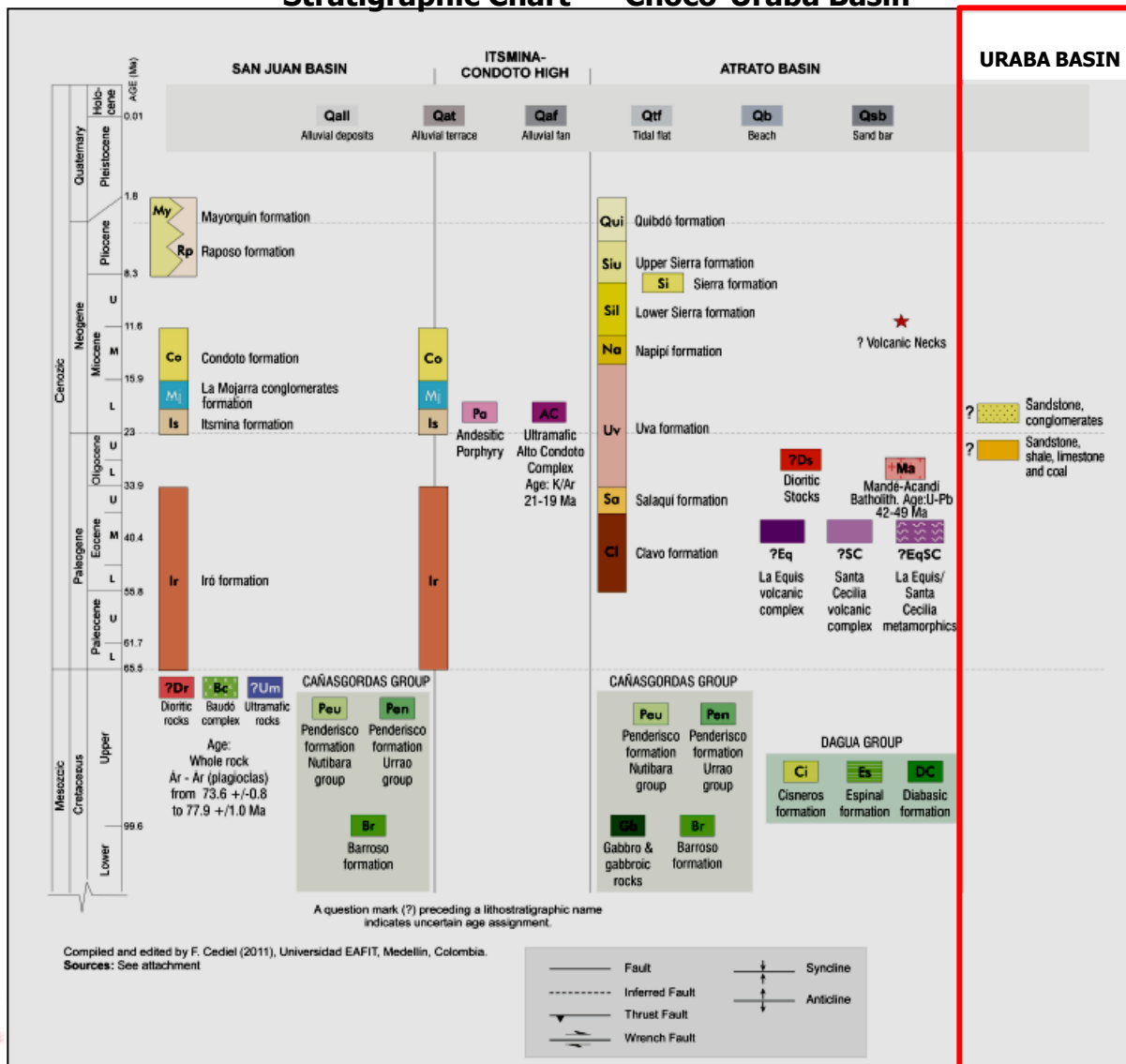


# Urabá Basin (Ura)

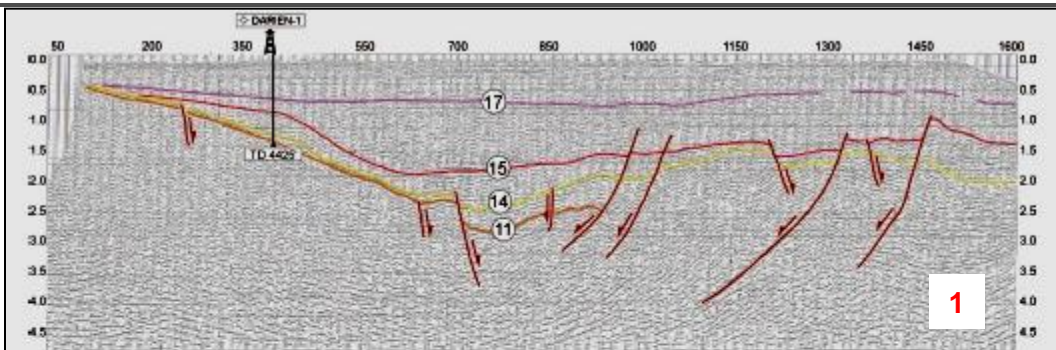


# Urabá Basin (Ura)

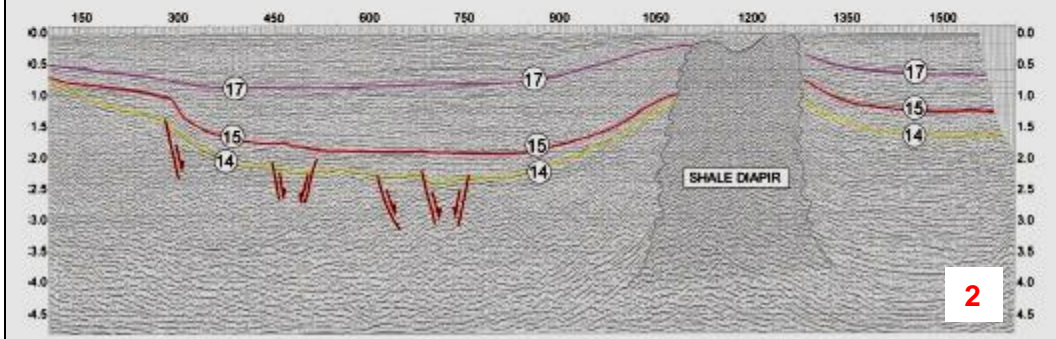
## Stratigraphic Chart – Chocó-Urabá Basin



# Structural Styles

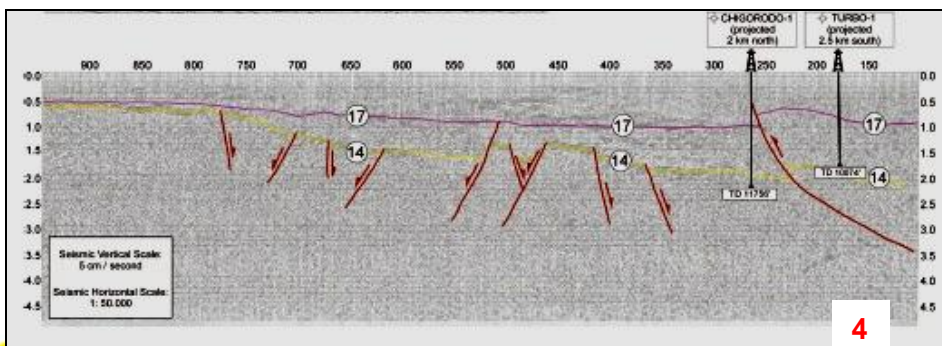
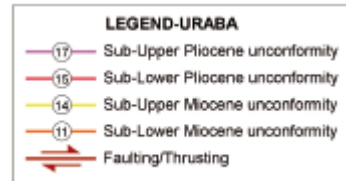
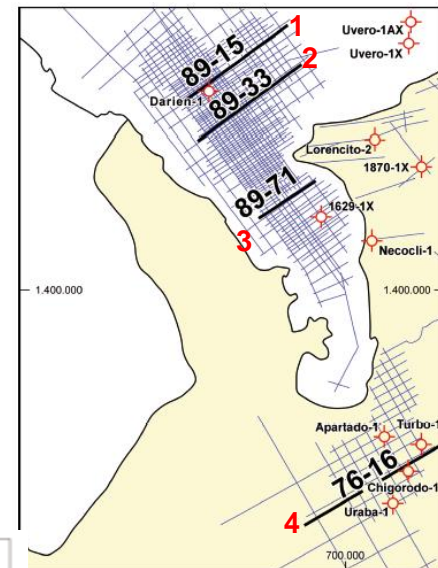


1

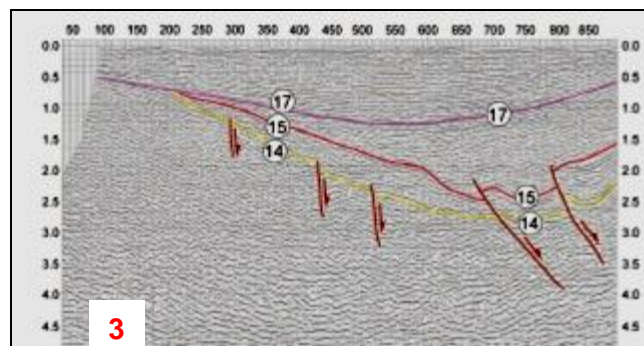


2

- 1-3 Normal fault and stratigraphic traps
- 2 Diapiric structures
- 4 inversion structures

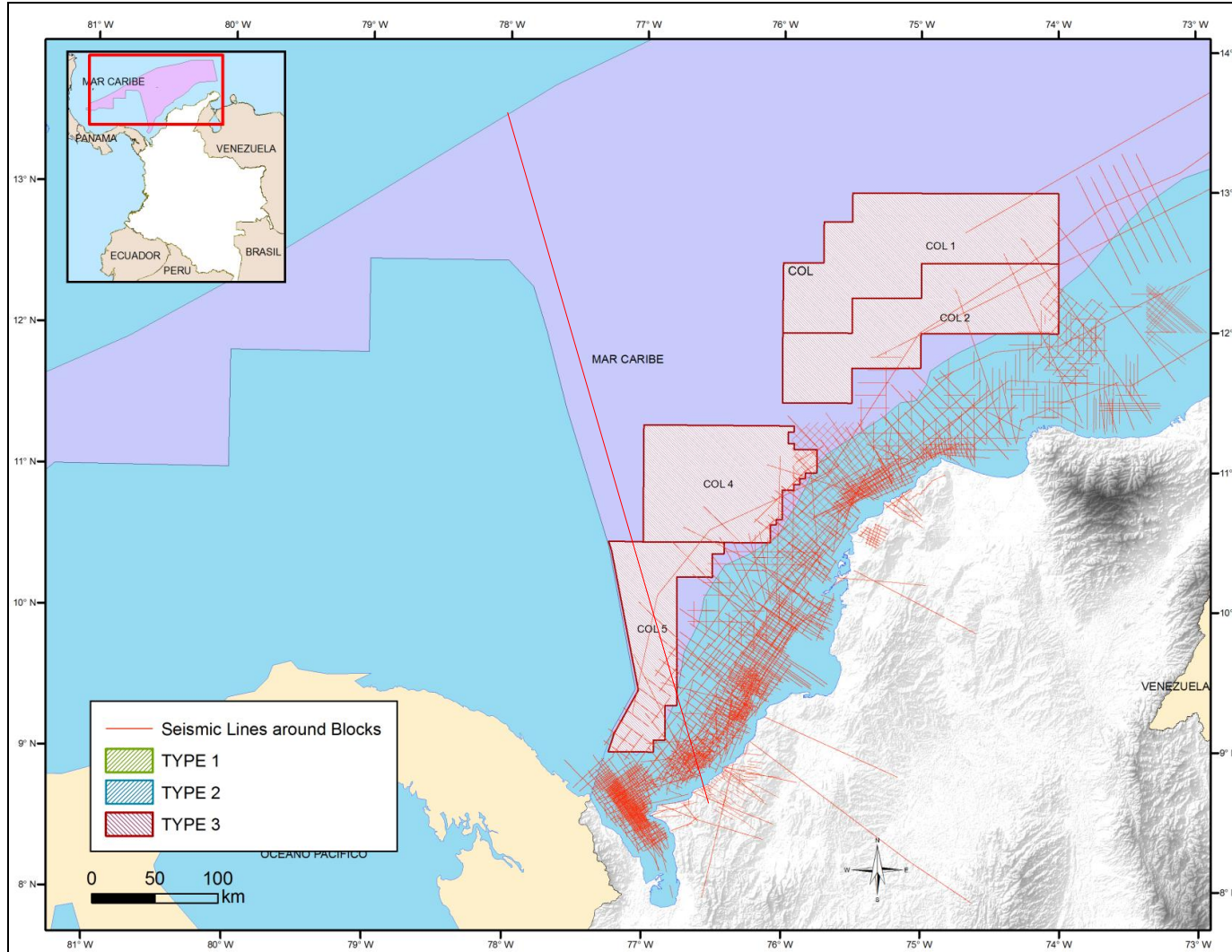


4



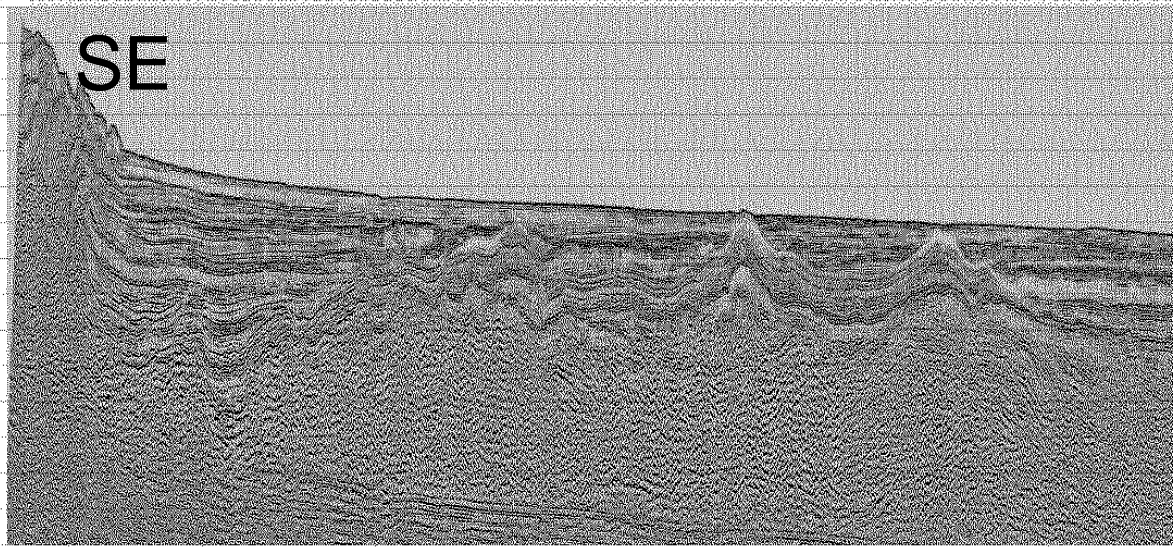
3

# Colombia Basin (Col)

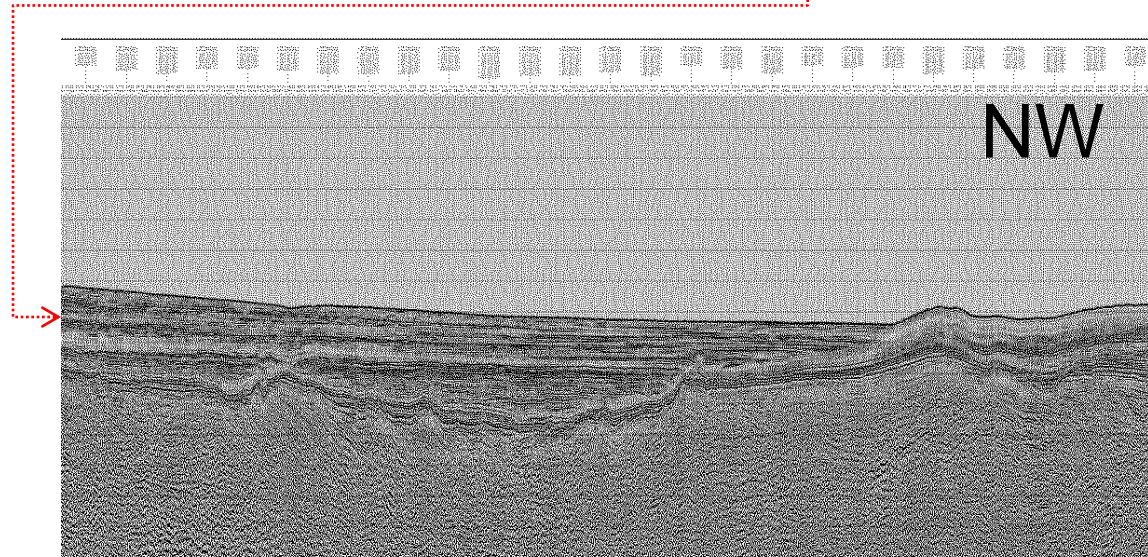




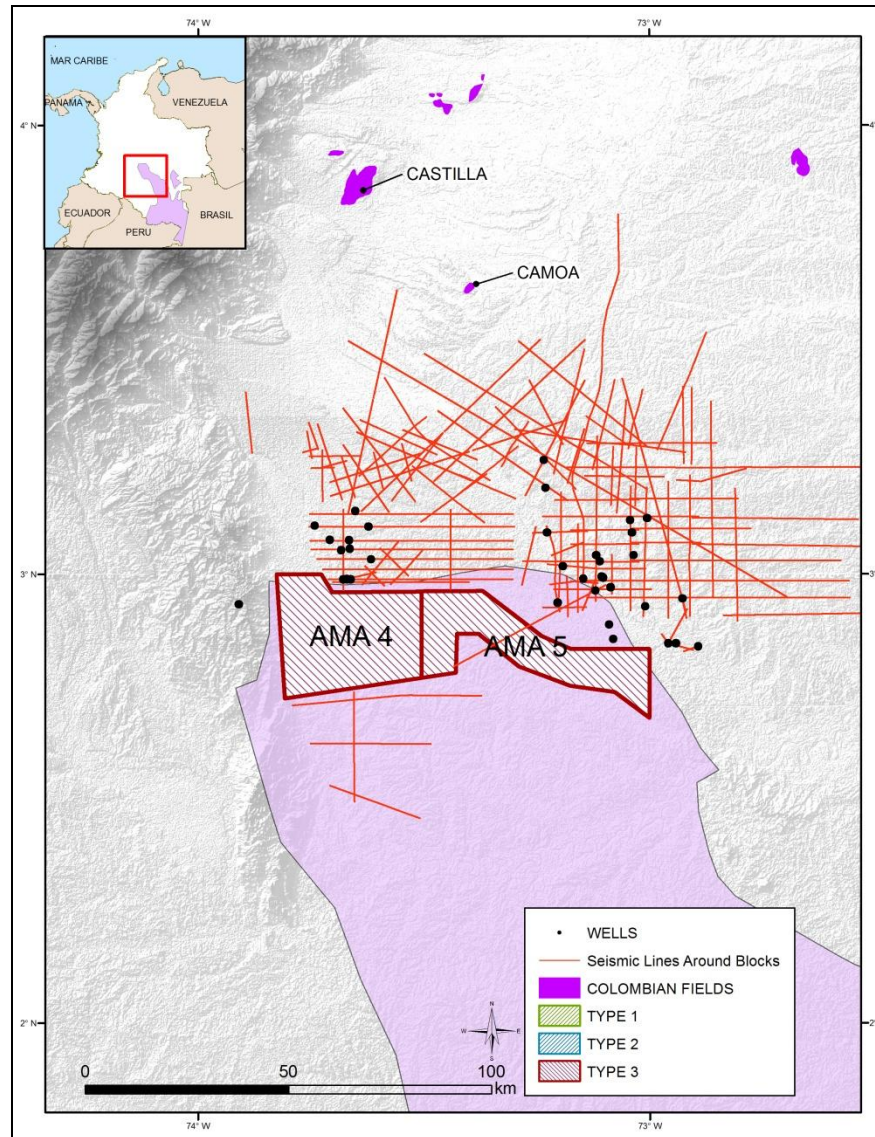
# Colombia Basin (Col)



Seismic Line Colombia Basin



# Vaupés-Amazonas Basin (Vau)





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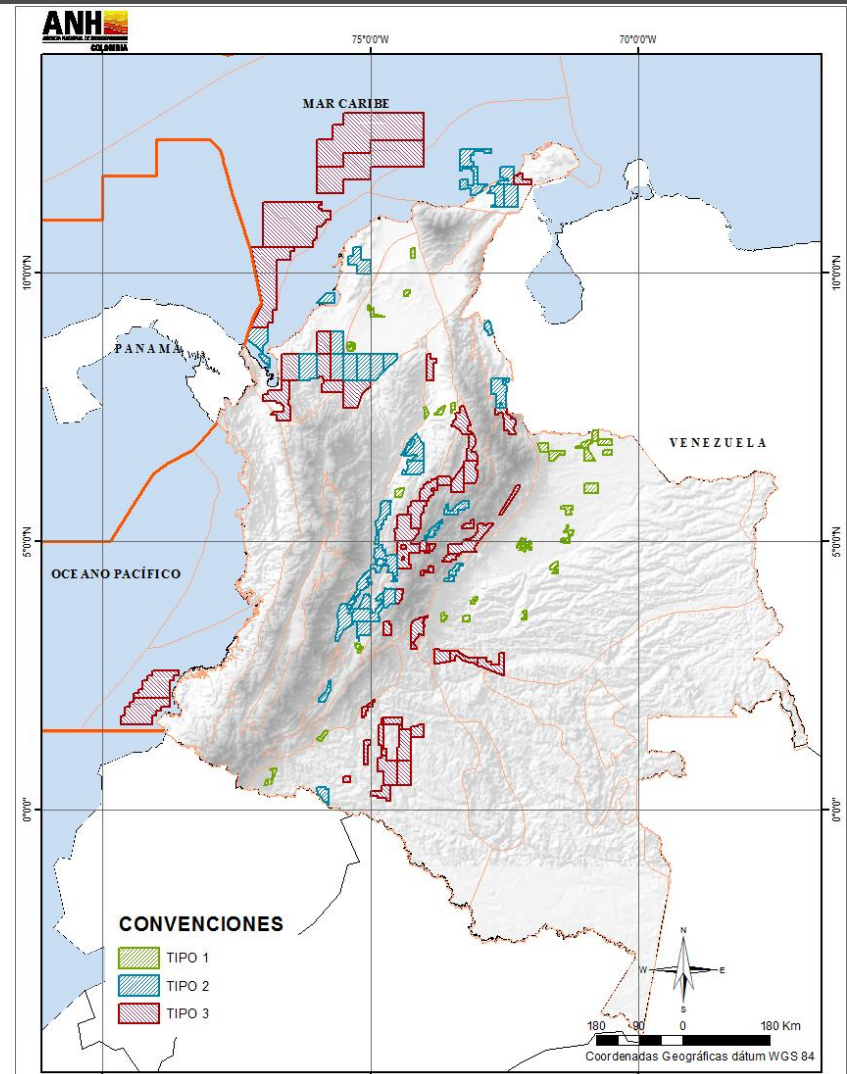


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# Colombia Round 2012

	Onshore	Offshore
Type 1	29	
Type 2	29	5
Type 3	40	6
<b>TOTAL</b>	<b>98</b>	<b>11</b>

Type	2D Seismic (km)	Number of wells	Total (km <sup>2</sup> )
Type 1	914	76	6,565
Type 2	1,644	186	35,913
Type 3	438	23	92,297
<b>TOTAL</b>	<b>2,996</b>	<b>285</b>	<b>134,775</b>



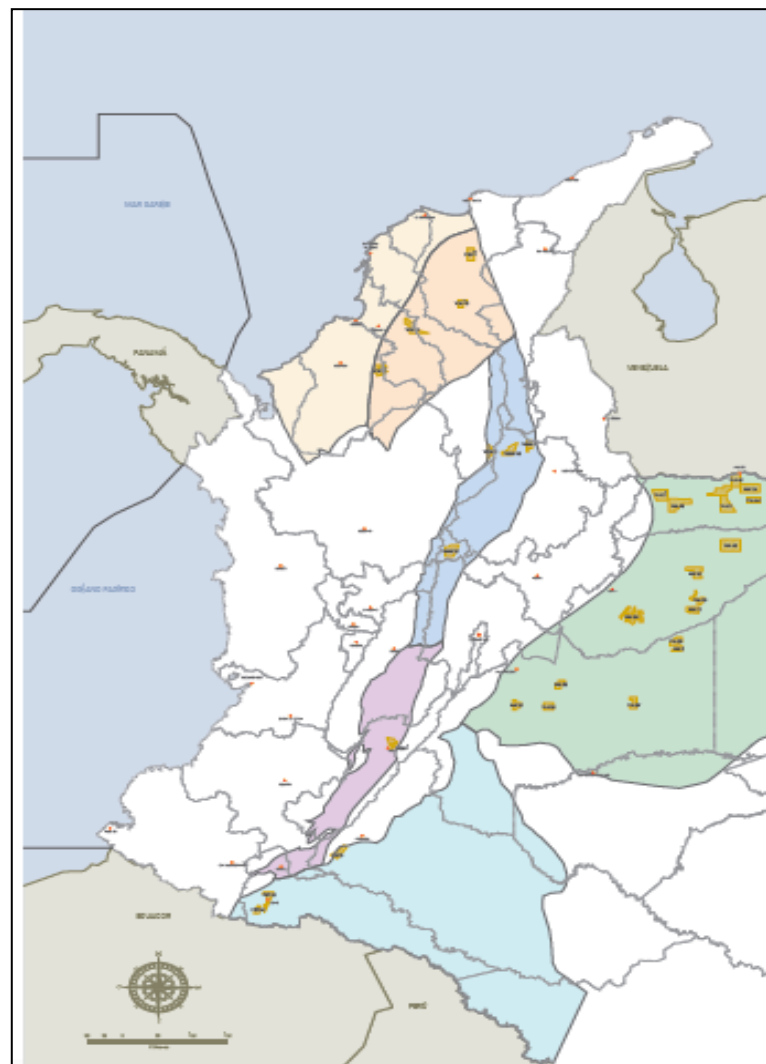
# Type 1 Blocks

- ✓ Blocks in mature areas.
- ✓ E&P contracts

Type 1		
Blocks	Total Area (km <sup>2</sup> )	Size Range (km <sup>2</sup> )
29	6,565	76 – 573

Seismic lines	Wells
Seismic 2D (km)	Number of wells
914	76

Basins (5)
<ul style="list-style-type: none"> <li>• Lower Magdalena</li> <li>• Middle Magdalena</li> <li>• Upper Magdalena</li> <li>• Caguán-Putumayo</li> <li>• Llanos</li> </ul>



# Type 2 Blocks

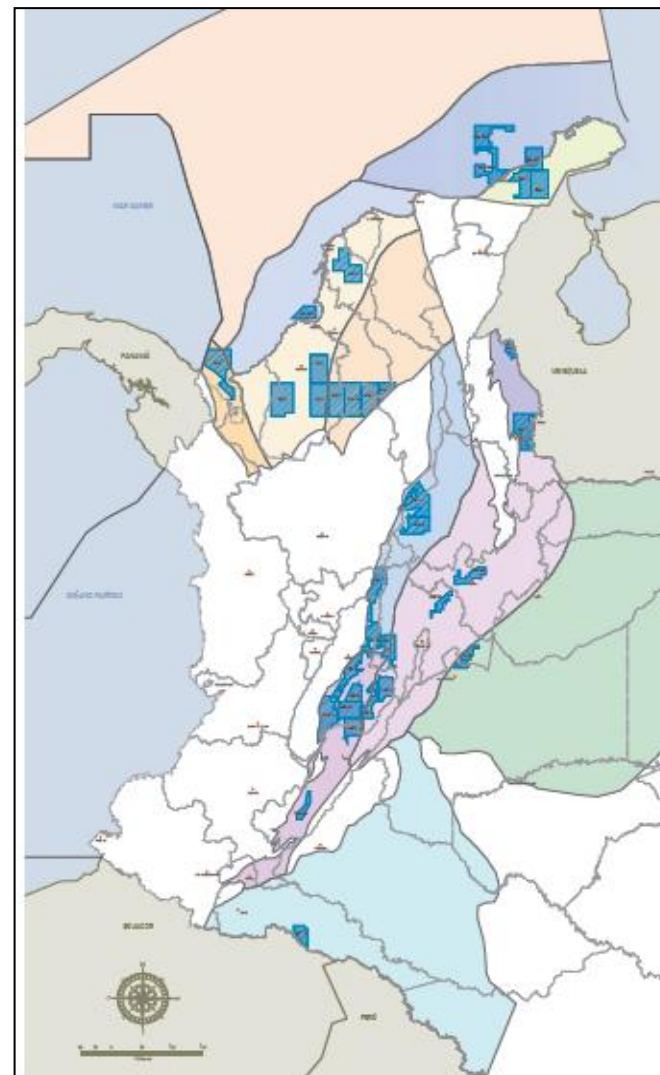
- ✓ Blocks in emerging areas.
- ✓ E&P contracts.

Type 2		
Blocks	Total Area (km <sup>2</sup> )	Size Range (km <sup>2</sup> )
34	35,913	227 – 1,954

Seismic Lines	Wells
Seismic 2D (km)	Number of wells
1,644	186

## Basins (12)

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>• Guajira</li> <li>• Guajira Offshore</li> <li>• Sinú Offshore</li> <li>• Urabá</li> <li>• Sinú-San Jacinto</li> <li>• Lower Magdalena Valley</li> </ul> | <ul style="list-style-type: none"> <li>• Middle Magdalena</li> <li>• Upper Magdalena</li> <li>• Caguán-Putumayo</li> <li>• Llanos</li> <li>• Eastern Cordillera</li> <li>• Catatumbo</li> </ul> |
|---|---|





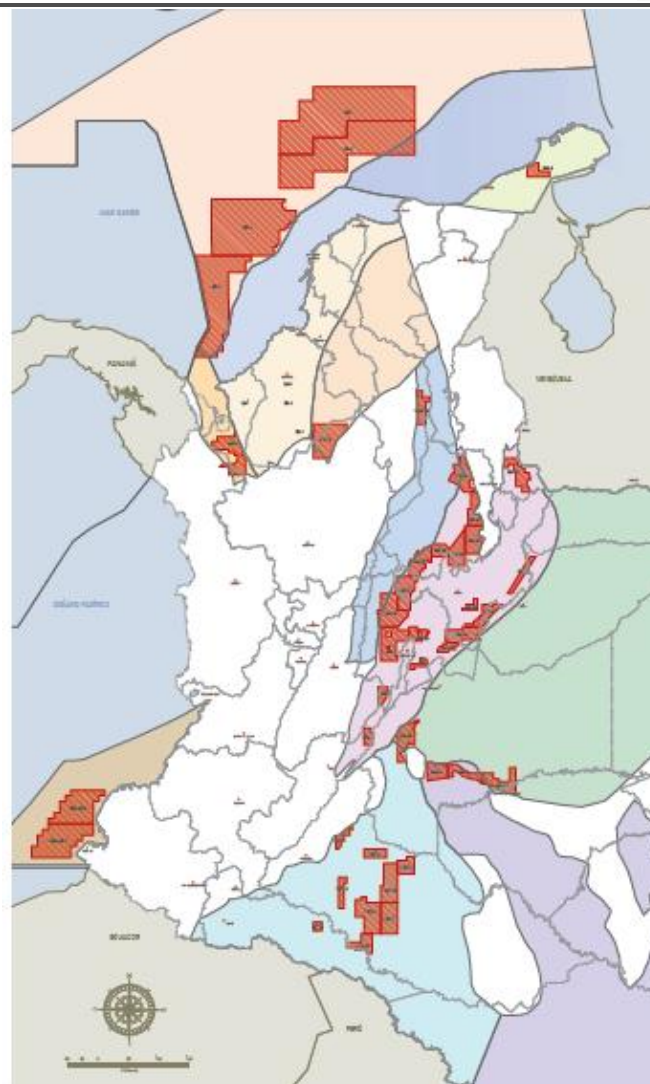
# Type 3 Blocks

✓ Exploration Blocks in frontier areas for Technical Evaluation Agreements (TEA)

Type 3		
Blocks	Total Area (km <sup>2</sup> )	Size Range (km <sup>2</sup> )
46	92,297	186 – 14,275

Seismic Lines	Wells
Seismic 2D (km)	Number of wells
438	23

Basins (10)	
<ul style="list-style-type: none"> <li>• Guajira</li> <li>• Colombia</li> <li>• Urabá</li> <li>• Lower Magdalena</li> <li>• Tumaco Offshore</li> </ul>	<ul style="list-style-type: none"> <li>• Vaupés-Amazonas</li> <li>• Middle Magdalena</li> <li>• Caguán-Putumayo</li> <li>• Llanos</li> <li>• Eastern Cordillera</li> </ul>



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# Minimum Exploration Program

## ***Blocks Type 1 & Type 2 Conventional Onshore***



<b>Phase I (3 years)</b>	<b>Phase II (3 years)</b>
✓ 2D Seismic, minimum 1km/5km <sup>2</sup> .	✓ 3D Seismic, minimum 1km <sup>2</sup> /10km <sup>2</sup> .
✓ 1 Exploratory well (drill the whole sedimentary sequence, or down to economic basement).	✓ 2 Exploratory wells (drill the whole sedimentary sequence, or down to economic basement).

# Minimum Exploration Program

## *Type 2 Conventional Offshore*



Phase I (3 years)	Phase II (3 years)
<ul style="list-style-type: none"><li>✓ 15 km<sup>2</sup> of 3D seismic / 200 km<sup>2</sup> of area.</li><li>✓ Collection of one (1) piston core / 200 km<sup>2</sup> of area.</li></ul>	<ul style="list-style-type: none"><li>✓ 1 (one) Exploratory well (the whole sedimentary sequence, or down to economic basement).</li></ul>

# Minimum Exploration Program

## **Type 3 Conventional Onshore and Offshore**



Onshore Unique Phase (3 years)	Offshore Unique Phase (3 years)
	✓ Piston Coring, 1 /10 km <sup>2</sup> .
✓ 2D Seismic, minimum 1km /10 km <sup>2</sup> .	✓ 2D Seismic, minimum 1km /10 km <sup>2</sup> .
✓ Regional analysis (i.e. mapping with remote sensing or airborne geophysical methods).	✓ Regional analysis (i.e. mapping with remote sensing or airborne geophysical methods).
✓ 1 (one) stratigraphic well, with physical and geochemical logs.	
	✓ 20 (twenty) km of bathymetric survey / 10 km <sup>2</sup> of area.

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# Area Comparison

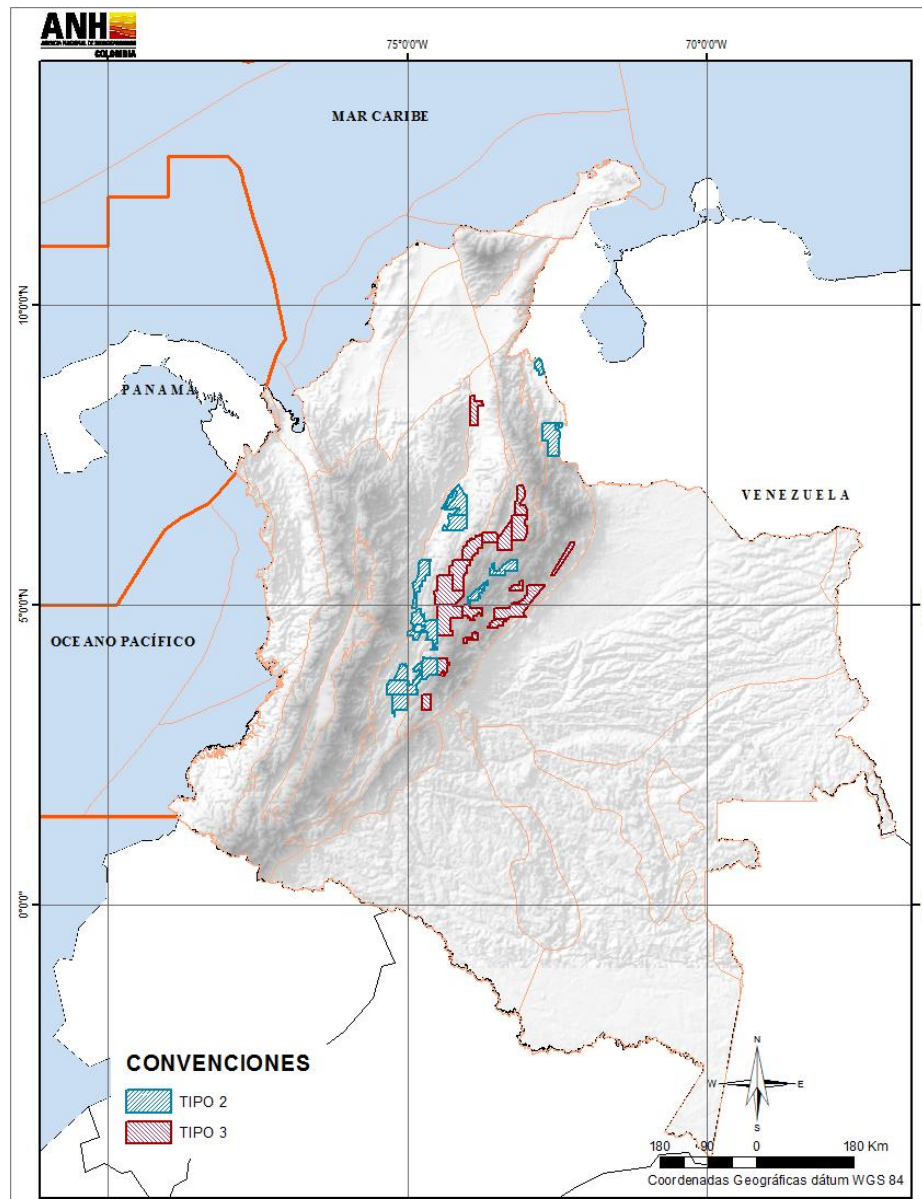


Texas is about  
60% of the size of  
Colombia

Colombia  
1,141,748 km<sup>2</sup>

Texas  
696,241 km<sup>2</sup>

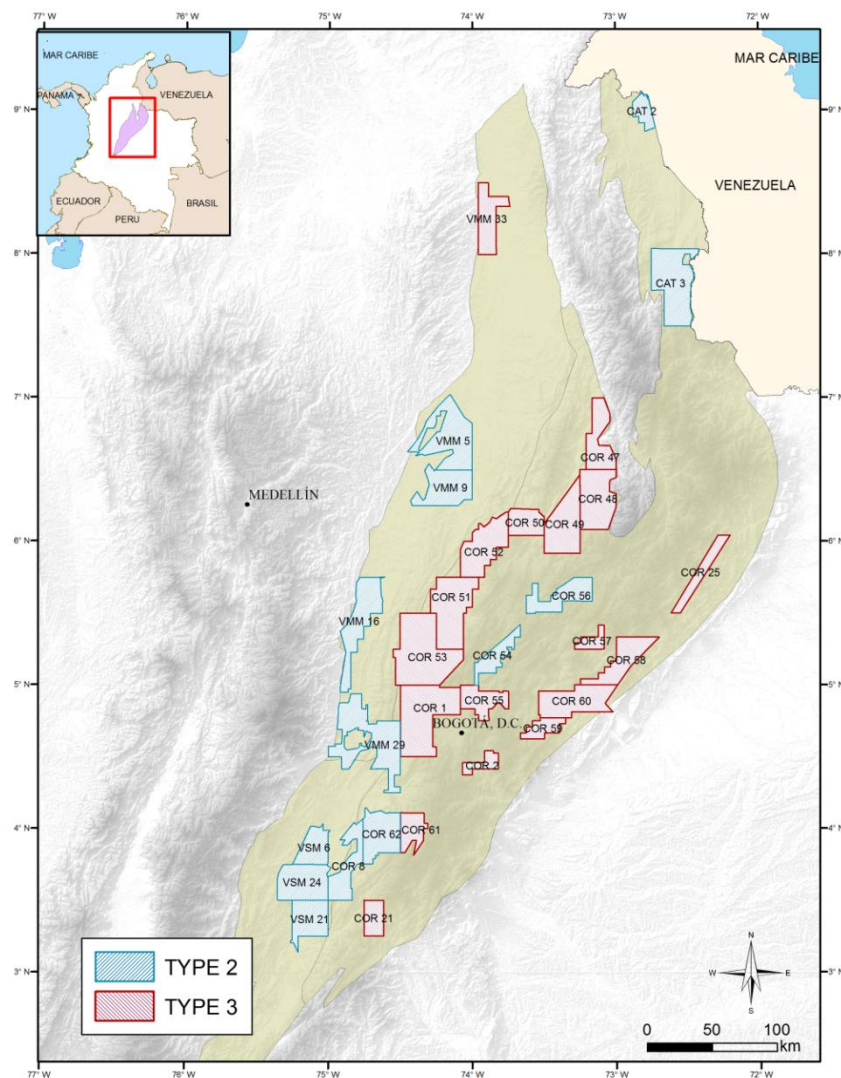
# Suggested Blocks for Unconventional Resources





# Prospective Areas for Unconventional Resources

Unconventional HC. Colombia Round 2012			
Blocks (Total)	Type I	Type II	Type III
21	0	11	10
10	0	2	8



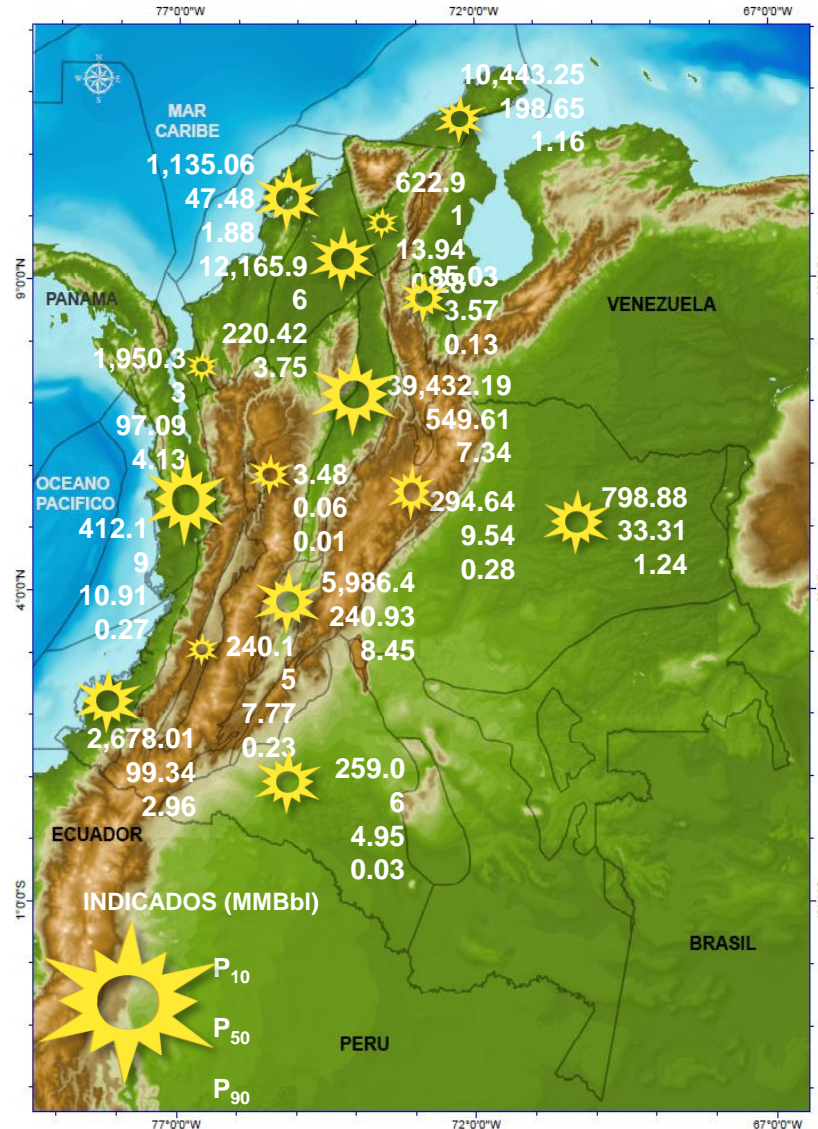
# Unconventional Resources (Preliminary Assesment, UNAL, 2011)



Resources	Results P10 - P90	Prospective Basins
Tar Sands	151,153.8 – 3,455.1 MMbbl	Middle Magdalena Valley Eastern Cordillera Eastern Llanos
Oil Shale	151,524 – 3,090.6 MMbbl	Eastern Cordillera Chocó Upper Magdalena Valley
Shale Gas	2,050.7 – 33.8 TCF	Eastern Cordillera Eastern Llanos Caguán - Putumayo
Tight Sands	43.7 – 1 TCF	Eastern Llanos Caguán - Putumayo Eastern Cordillera

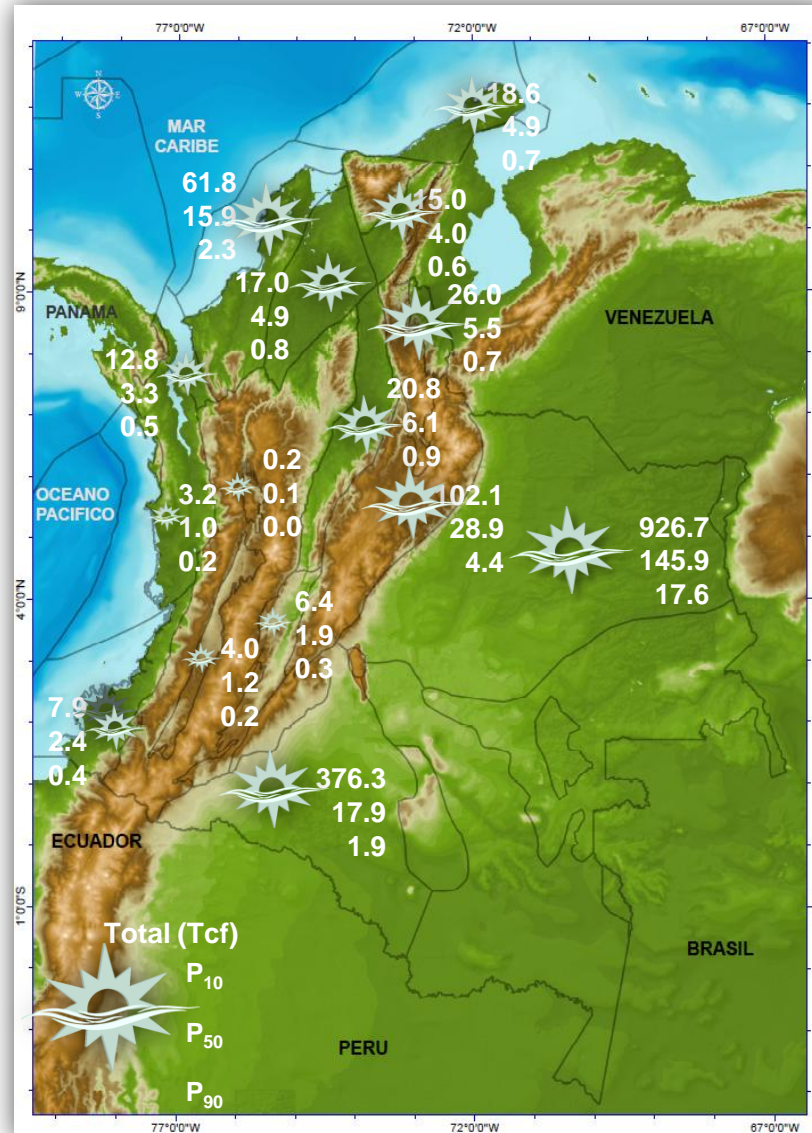
# Unconventional Resources

## Oil Shale in Colombia (Preliminary Assesment, UNAL, 2011)



# Unconventional Resources

## Shale Gas in Colombia (Preliminary Assesment, UNAL, 2011)



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# Minimum Exploration Program

## *Type 2 Unconventional*



Phase I (3 years)	Phase II (3 years)	Phase III (confirmation) (2 years)
✓ Geological mapping, scale 1:25.000 or higher, minimum 50% of the block area.		
✓ Surface geochemistry, minimum 1 km/5 km <sup>2</sup> of the block area.		
✓ 2D Seismic, minimum 1km/5km <sup>2</sup> .		
✓ 2 Stratigraphic wells, with physical and geochemical logs.	✓ 1 Stratigraphic well, with physical and geochemical logs.	
	✓ 2 Exploratory wells with physical and geochemical logs.	✓ 4 Exploratory wells with physical and geochemical logs.

# Minimum Exploration Program

## *Type 3 Unconventional*





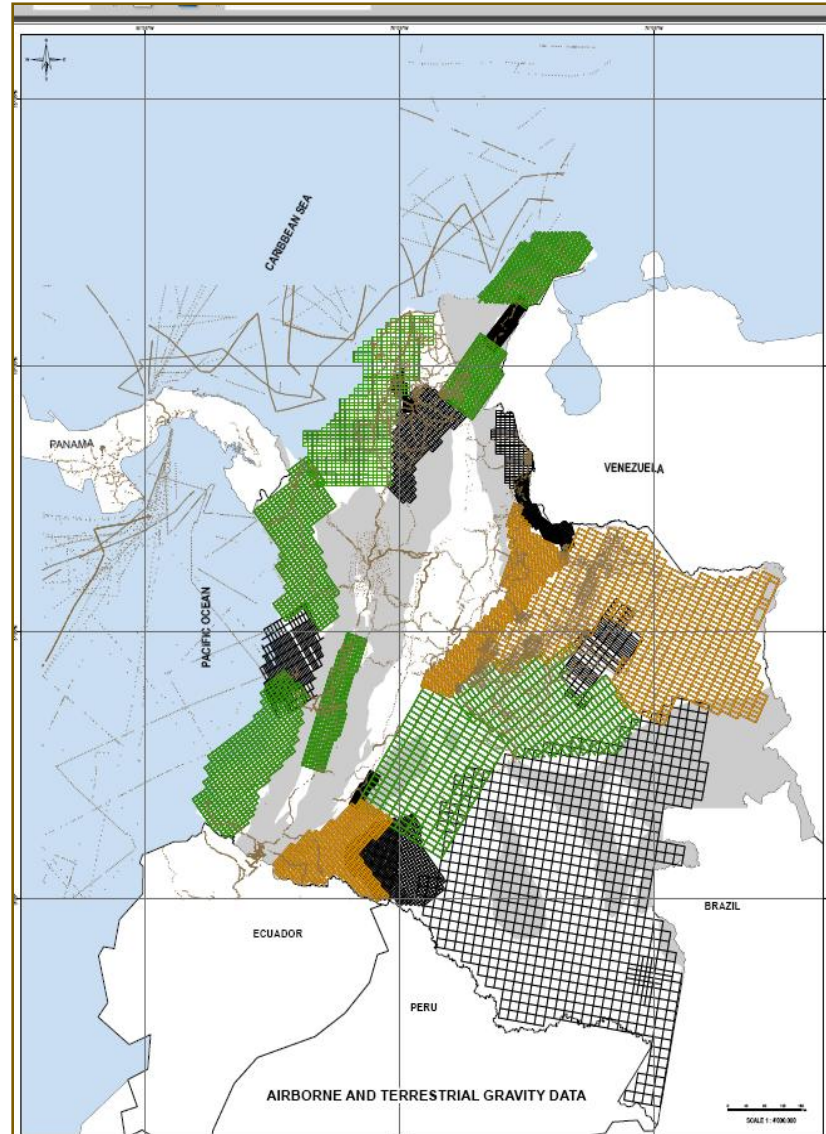
Onshore Unique Phase (3 years)
✓ Geological mapping, scale 1:25.000, or larger, minimum 50% of the block area.
✓ 2D Seismic, minimum 1km / 10 km <sup>2</sup> .
✓ Regional analysis (i.e. mapping with remote sensing or airborne geophysical methods).
✓ 2 (two) stratigraphic wells, with physical and geochemical logs.
✓ Geochemical sampling, 2 km / 10 km <sup>2</sup> .

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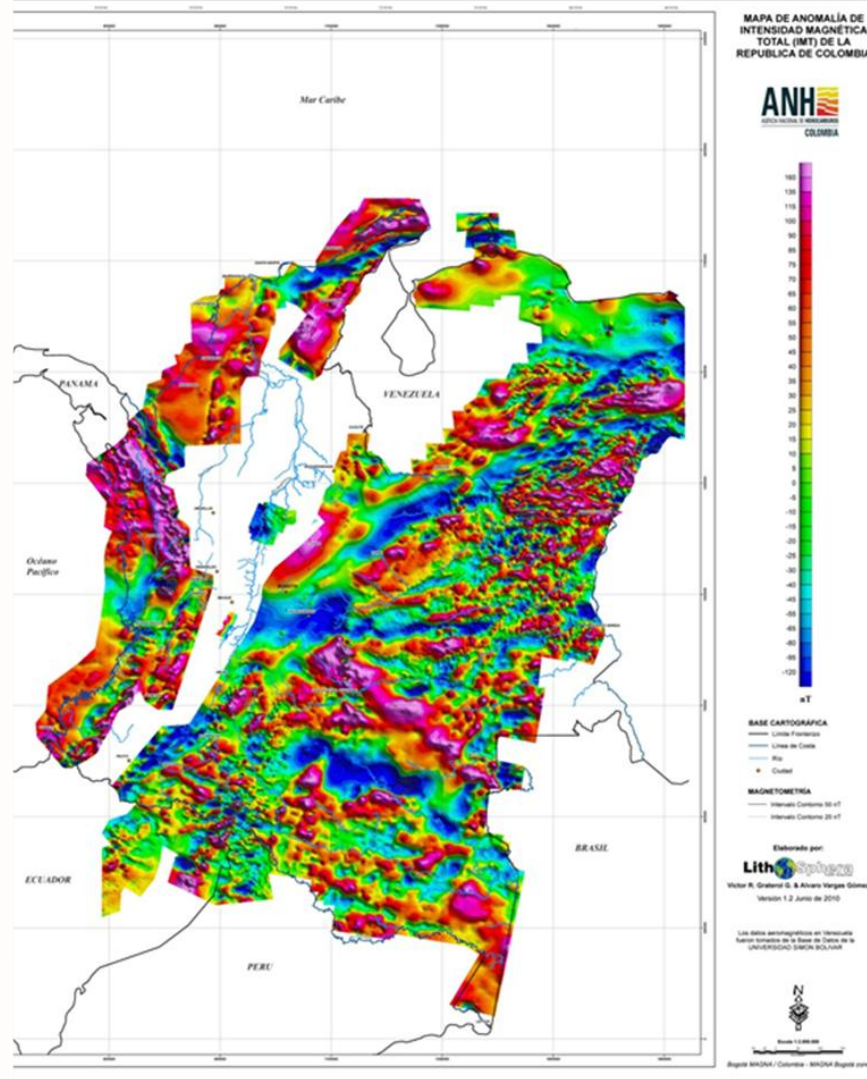
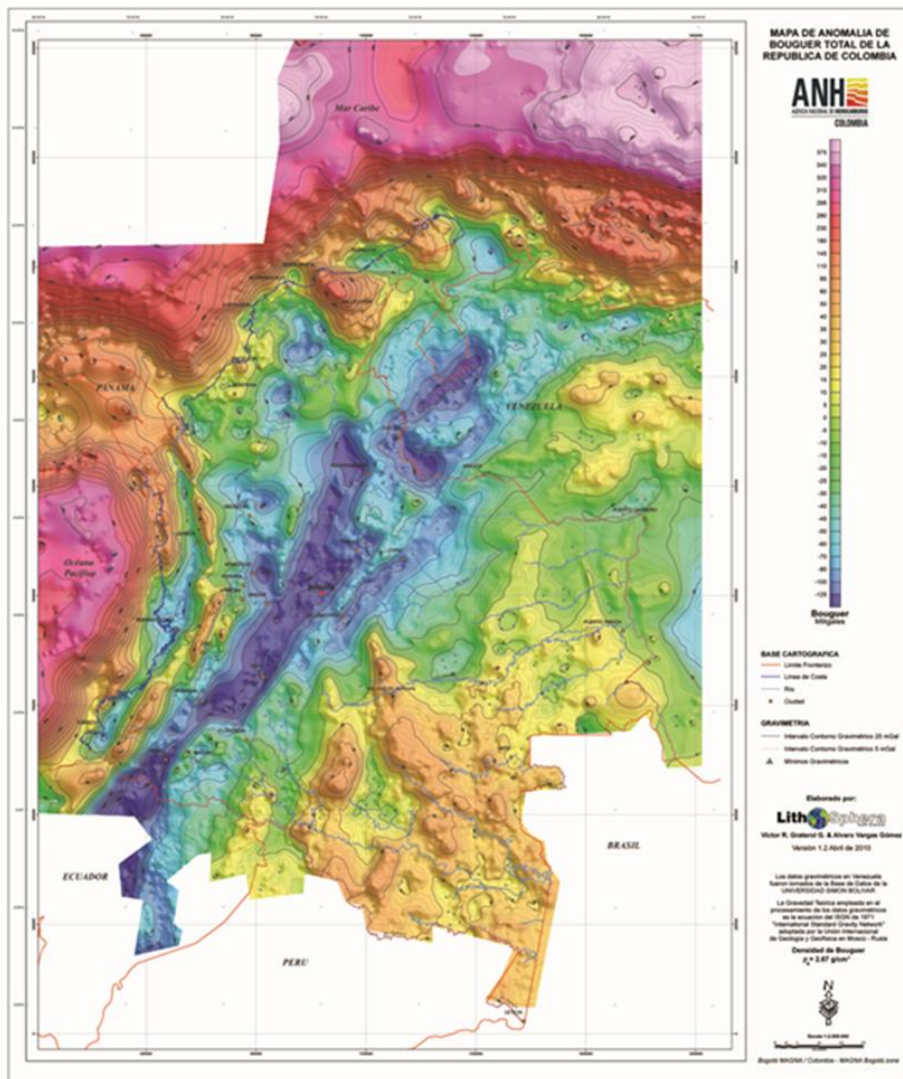


# Airborne Geophysical Coverage

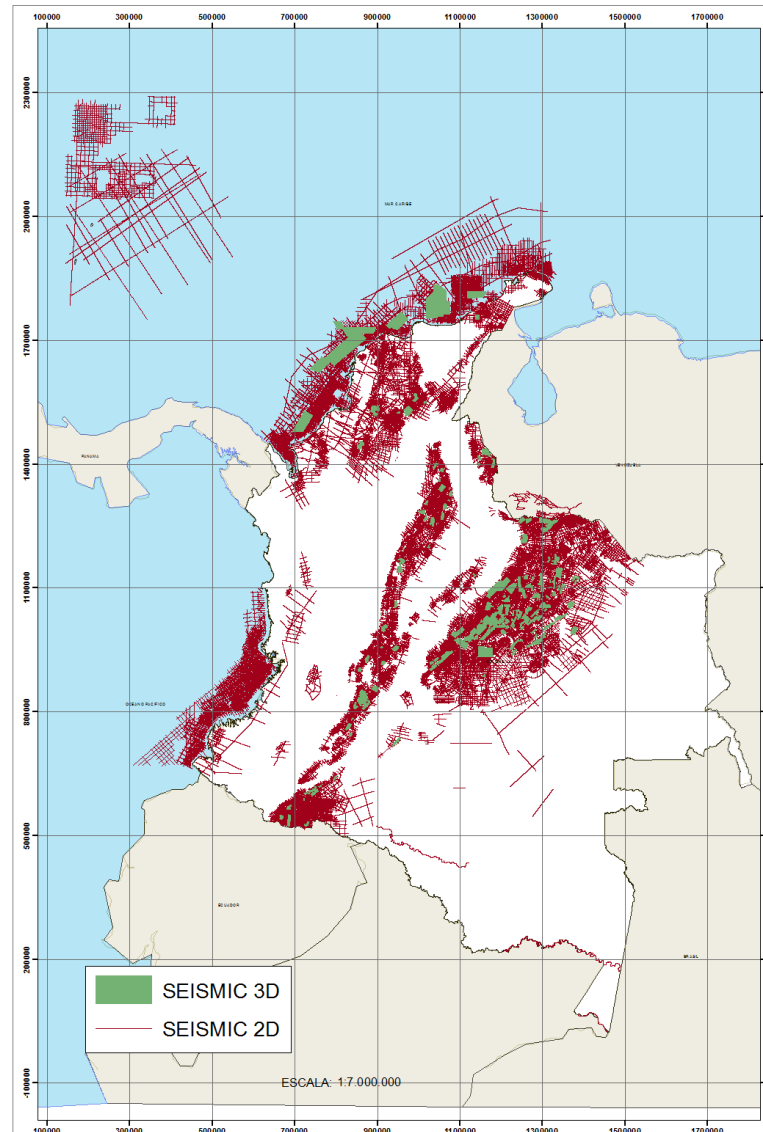
-  ANH 2005-2007
-  ANH 2008-2009



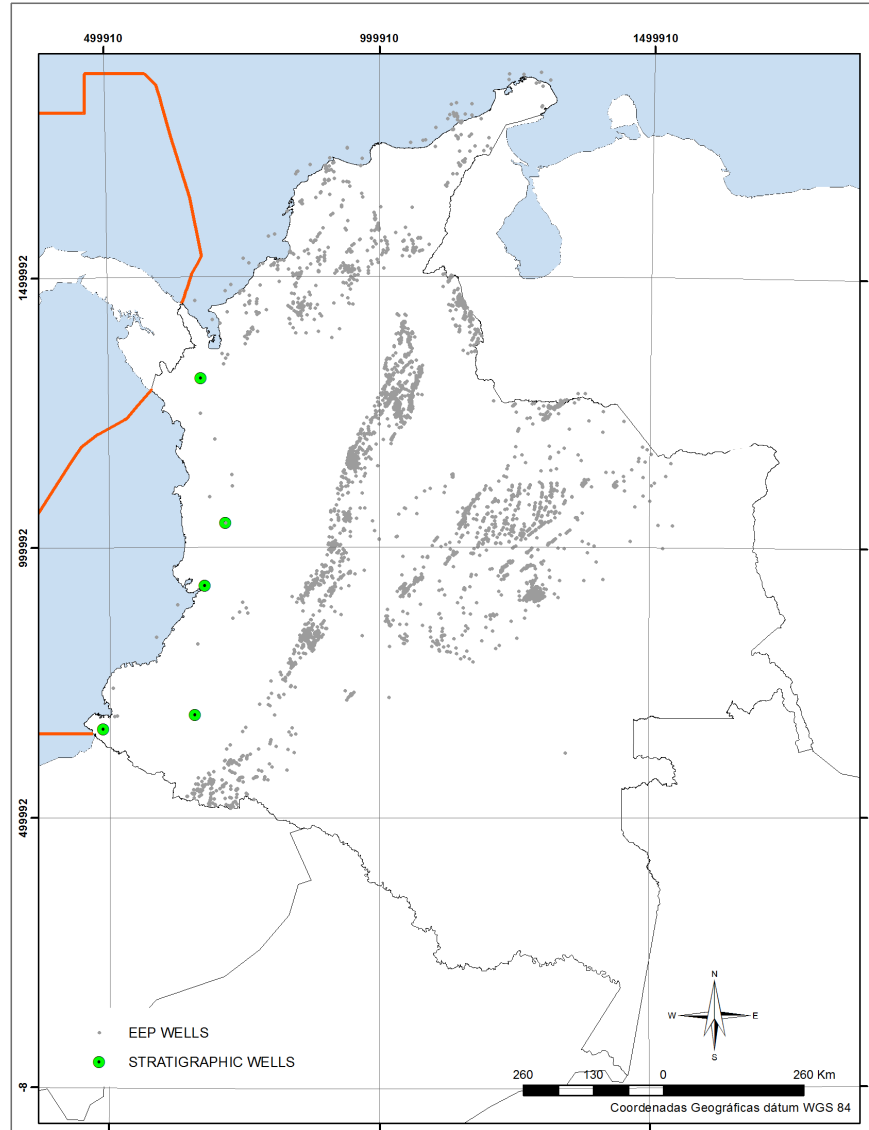
# Gravity and Magnetic Anomalies Maps



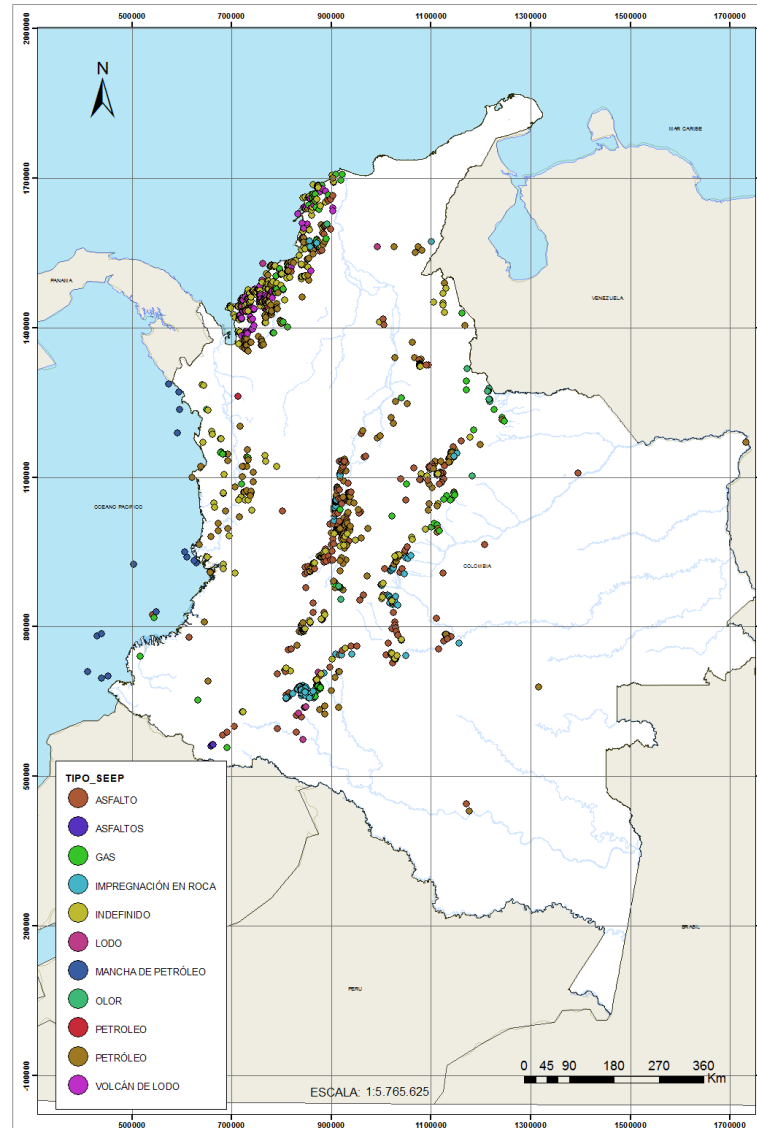
# 2D and 3D Seismic Coverage



# Exploration, Evaluation, Production and Stratigraphic Wells Map



# Oil and Gas Seeps



# Information Packages

CAG-PUT	27	131	1	11
CAT	13	106	0	13
COL	1	10	0	0
COR	41	201	0	8
GUA	21	187	0	6
GUA OFF	3	5	0	2
LLA	136	648	10	31
PAC-OFF	2	72	0	4
SIN OFF	4	38	0	0
SIN SJ	23	135	0	25
URA	8	126	0	4
VIM	33	170	4	36
VMM	94	561	2	79
VSM	94	601	3	66
<b>TOTAL</b>	<b>504</b>	<b>2,996</b>	<b>20</b>	<b>285</b>

# Information Packages



<http://www.anh.gov.co/>

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# Summary and Conclusions



## Colombia has.....

- World class petroleum systems.
- Significant underexplored areas.
- Significant upside potential for unconventional hydrocarbon resources.

Therefore, there are excellent exploration opportunities, on a global scale, in **mature**, **emerging** and **frontier** basins



***New Ideas + New Technologies  
+ New Licenses***

**=**



***Significant new discoveries***





*Thanks,  
See you in Colombia!*



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