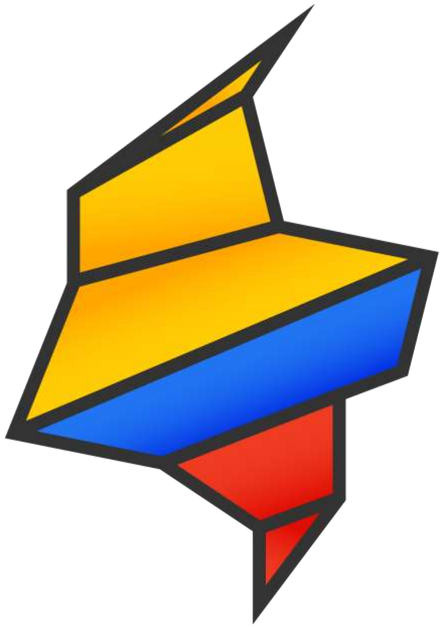

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A NEW TECTONIC PROVINCE PROPOSAL AND PROSPECTIVITY OF THE MIDDLE MAGDALENA VALLEY BASIN

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14/05/2021

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- Hocol (2 years)
- Pacific Rubiales (8 years)
- Mansarovar Energy (4 years)

Volunteering

- AAPG Latin America: Visiting Geologist
- ACGGP Colombia Visiting Geologist
- Bull Scout Colombia 2020 - Present
- ACGGP President 2010-2011
- Guest speaker in topics such as: Seismic Interpretation, Sequence Stratigraphy, Advanced Petroleum Geology in many Faculties of Latin America
- Author of the Lecture Series “Tour Sísmico por varias cuencas sedimentarias de Latinoamérica” (Seismic Tour by many sedimentary basins of Latin America)

Disclaimer

- Only public data was used with academic purposes
- The interpretations are regional and author responsibility
- Confidential data and reports that modify these interpretations could exist
- The main intention is making general statements and not exact locations of prospects

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AGENDA

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- Basin overview
  - Tectonic Provinces, Types of Plays, Petroleum Systems
- North Zone
  - From Buturama Field to Boranda
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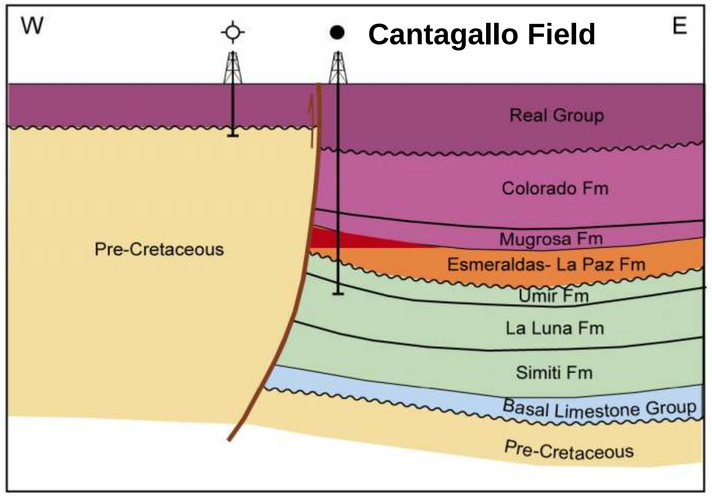
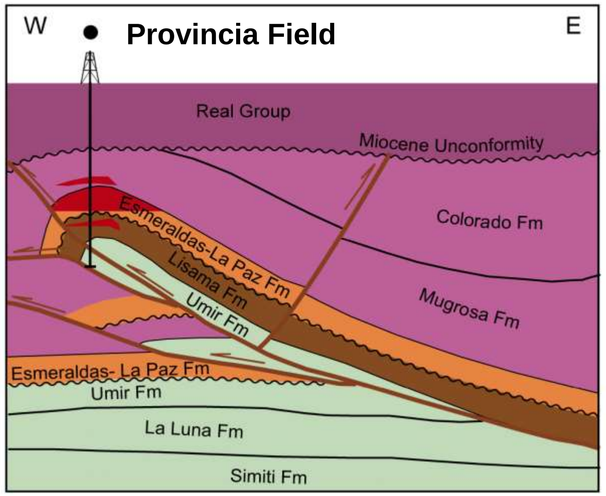
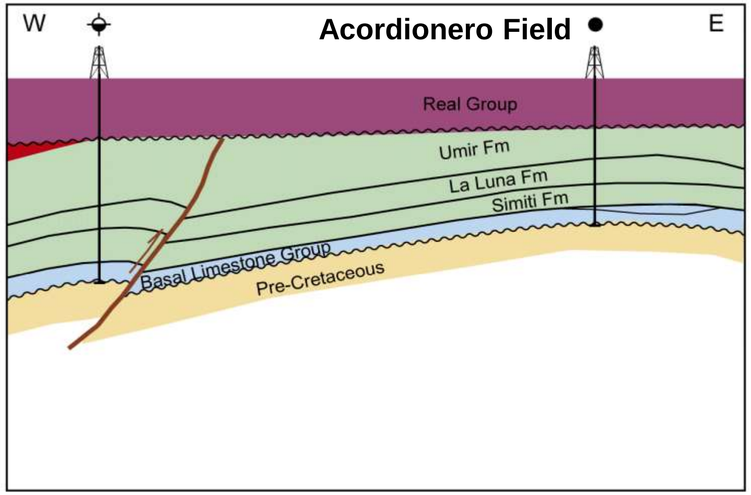
Play Types in the Middle Magdalena Basin

TERTIARY COMPRESSIONAL STRUCTURAL PLAYS

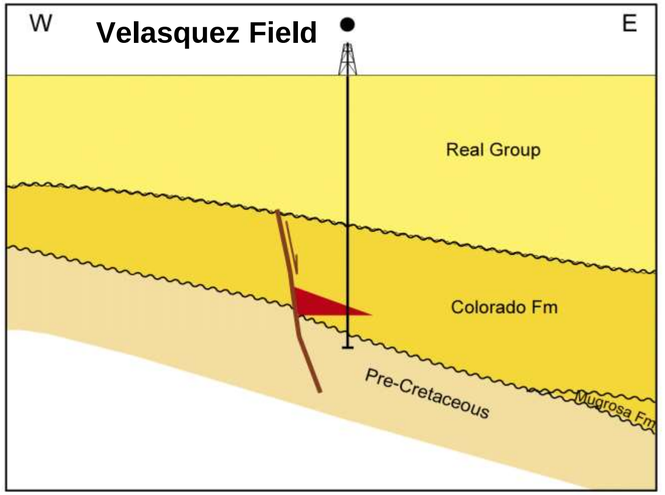




CRETACEOUS STRUCTURAL PLAY

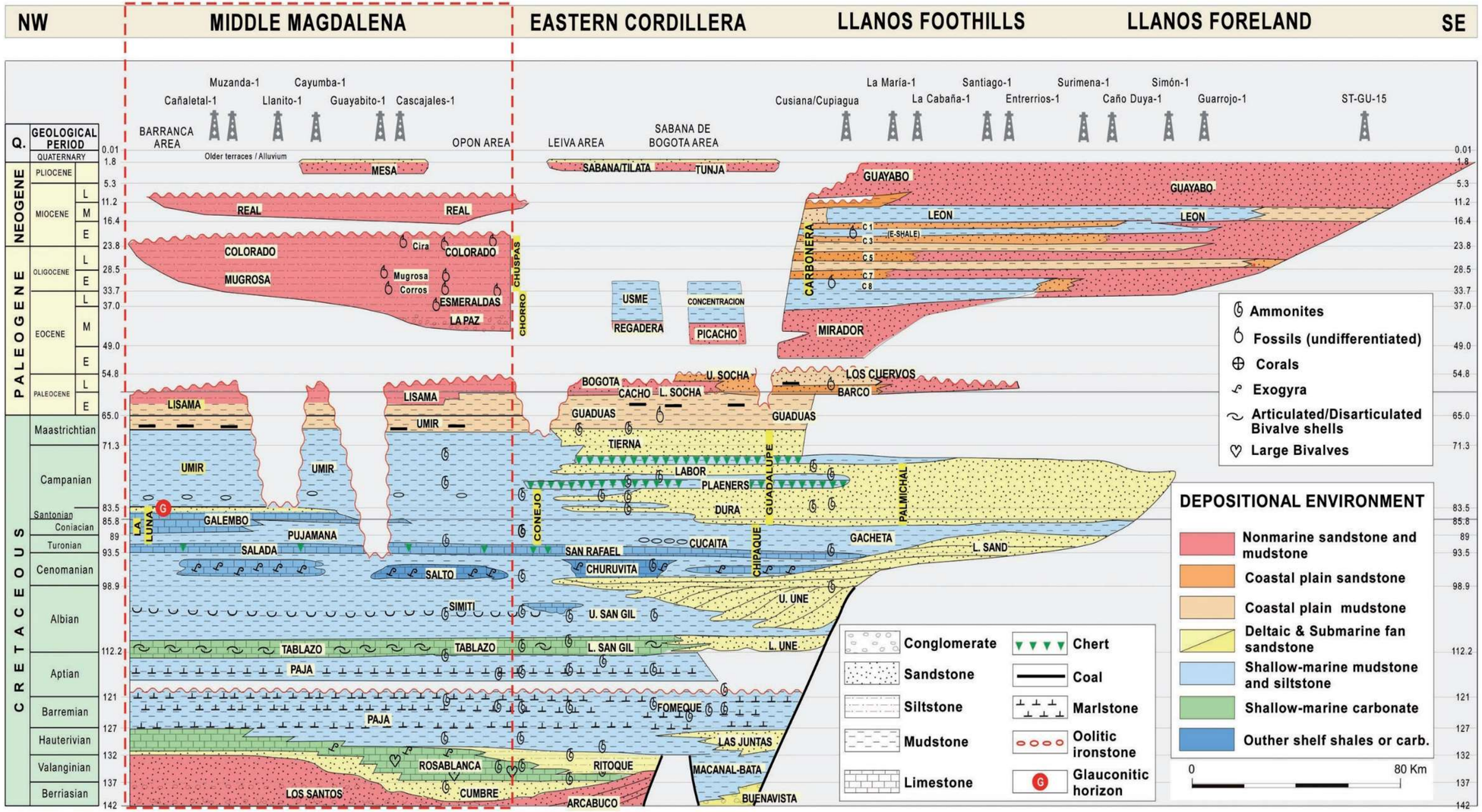


TERTIARY EXTENSIONAL STRUCTURAL PLAY



Source: IHS

Wheeler Diagram
Middle Magdalena Valley Basin



Compiled and modified after ETAYO, F. (1985,1994), GEOTEC (1992), COOPER, M. A. *et al.* (1995) and GOMEZ E. (1999)
Ecopetrol and Beicip (1995), Mora *et al.* (2010)

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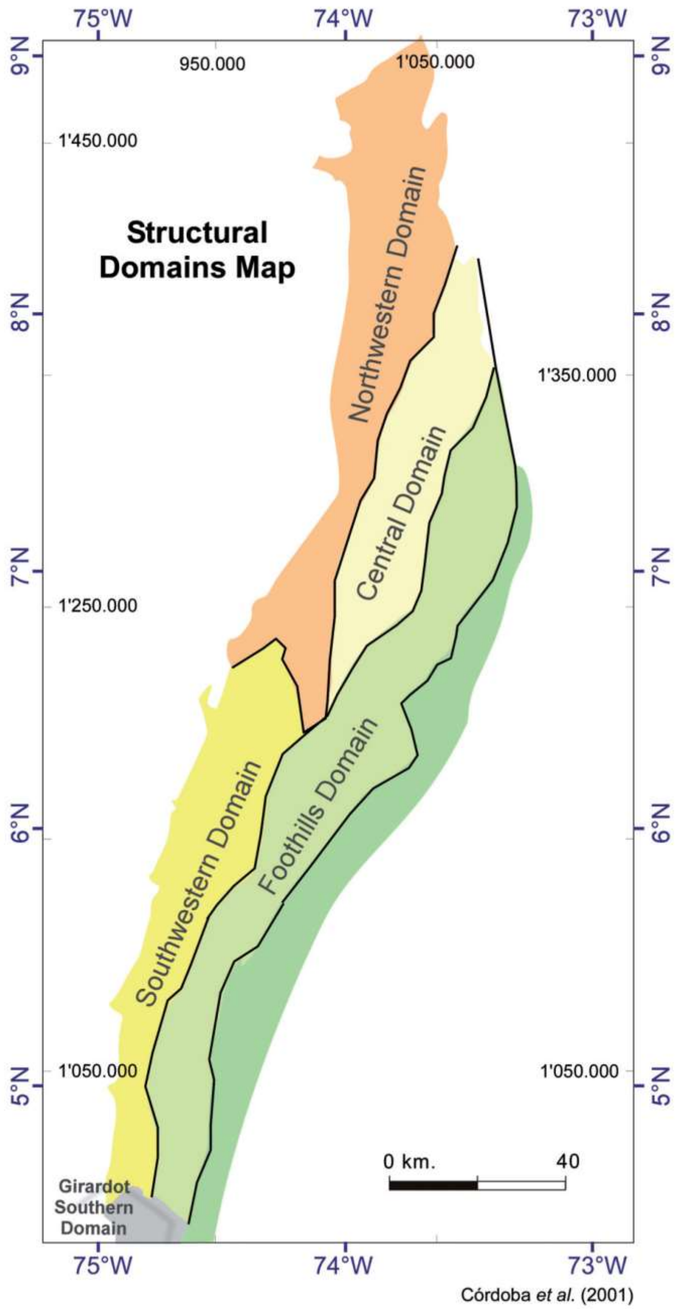
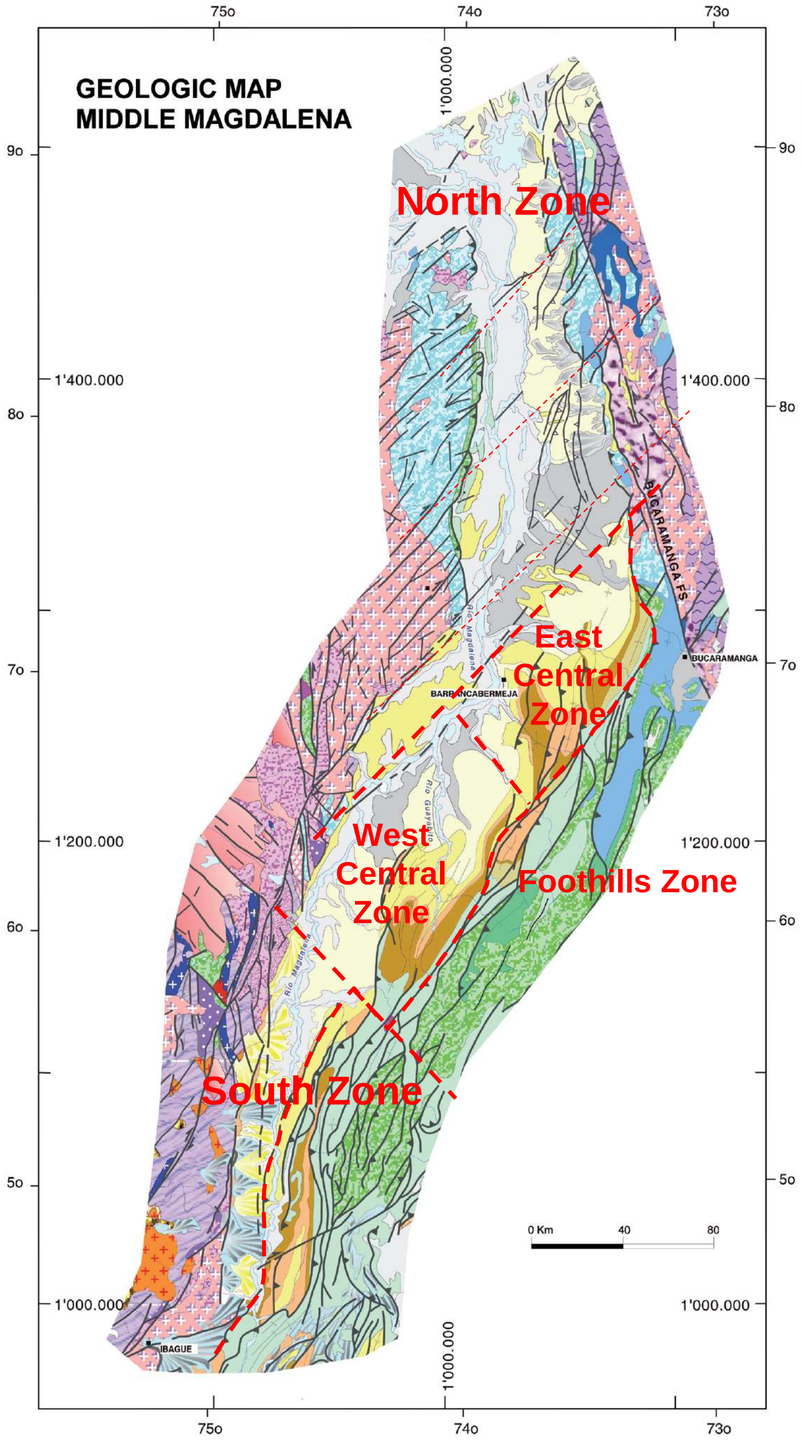
Tectonic Provinces of the Middle Magdalena Basin





Source ANH 2011

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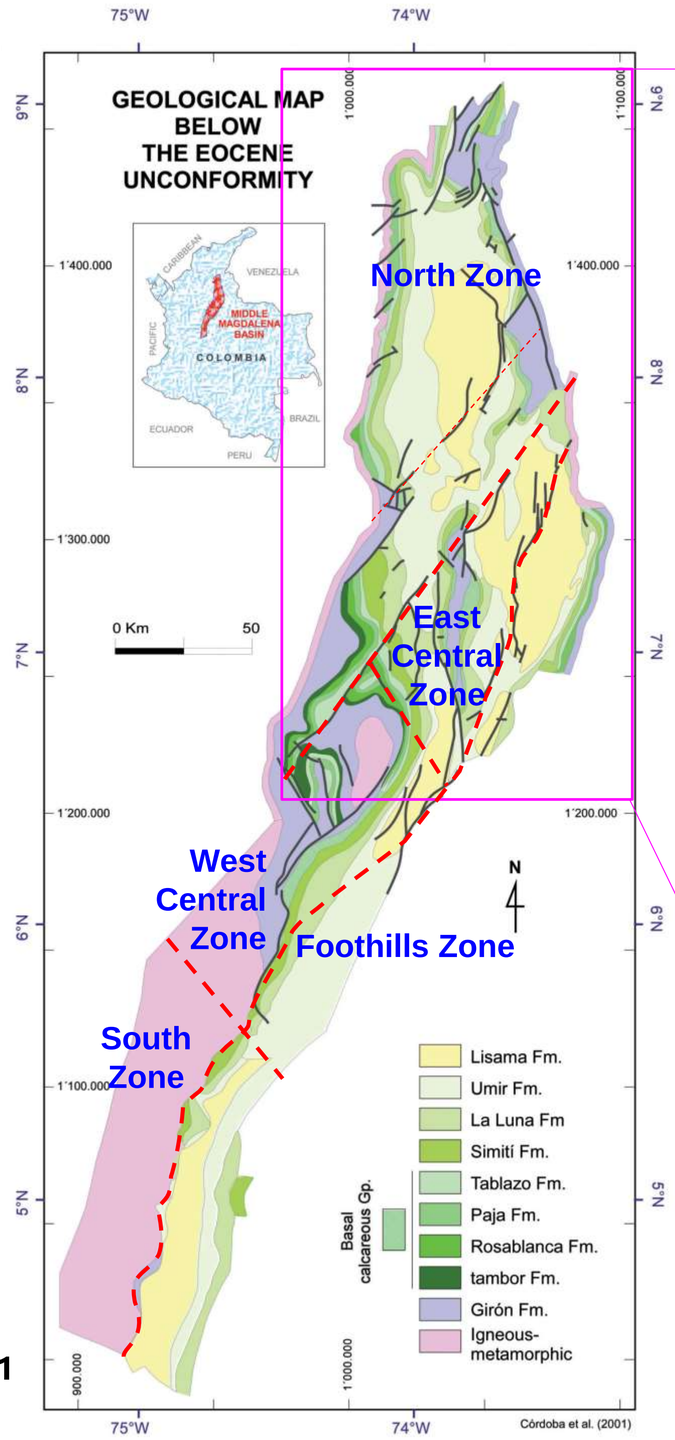
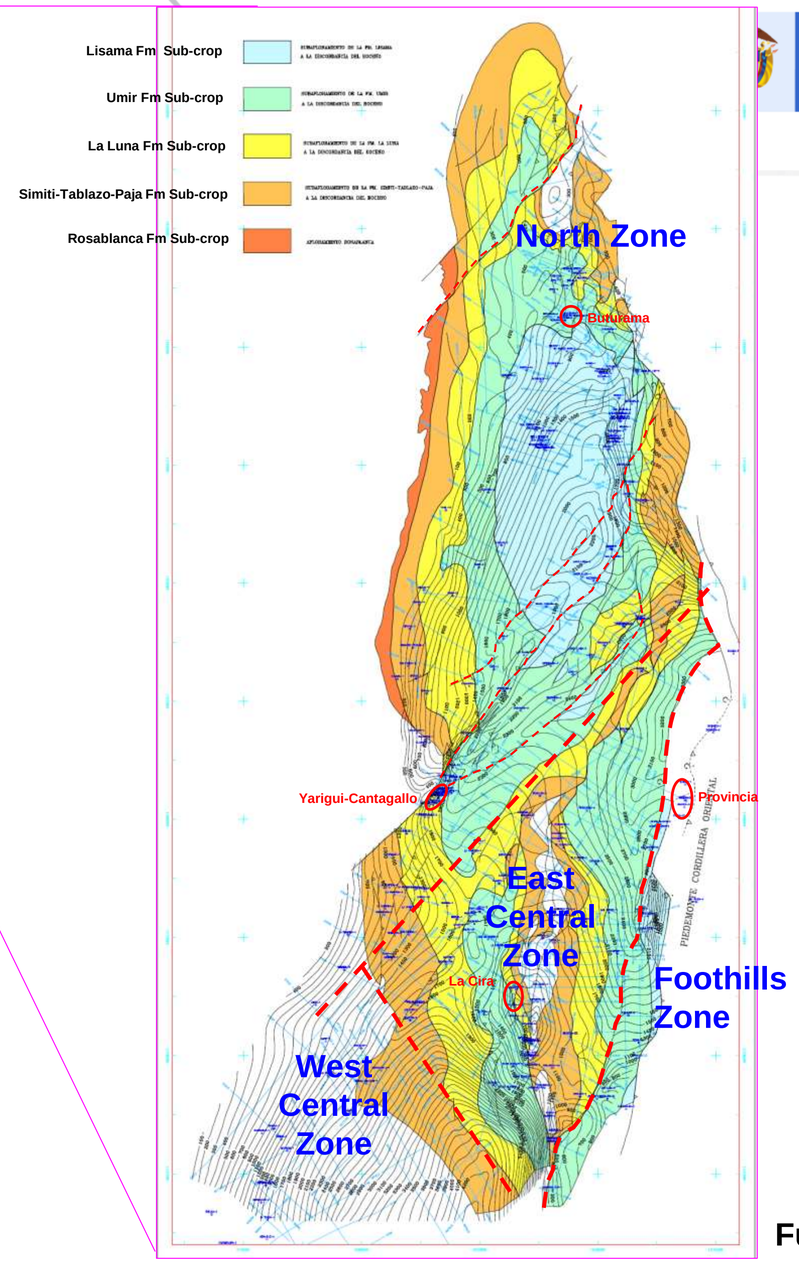
Subcrop Below the Eocene Discordance Map at the Middle Magdalena Valley Basin



Source ANH 2011



Fuente ICP 1998

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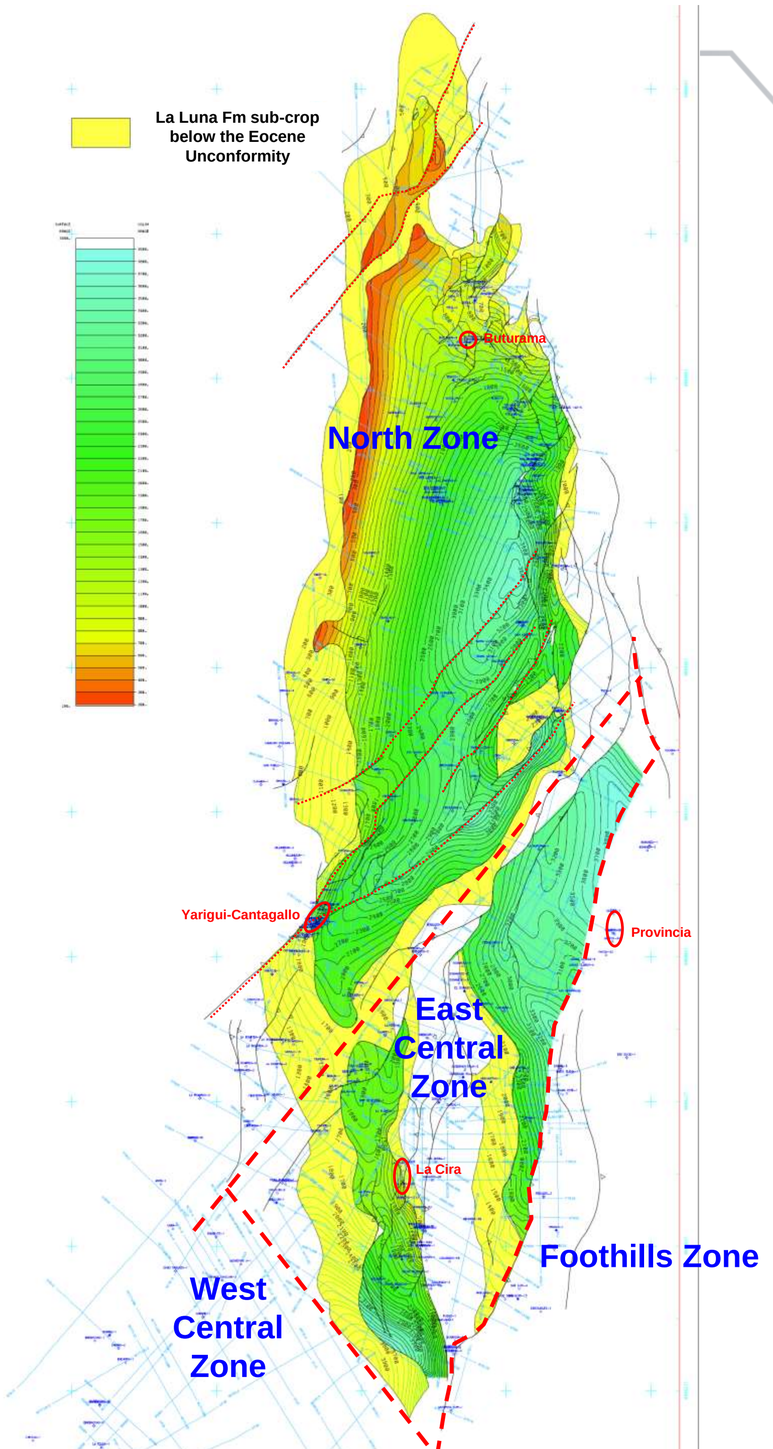
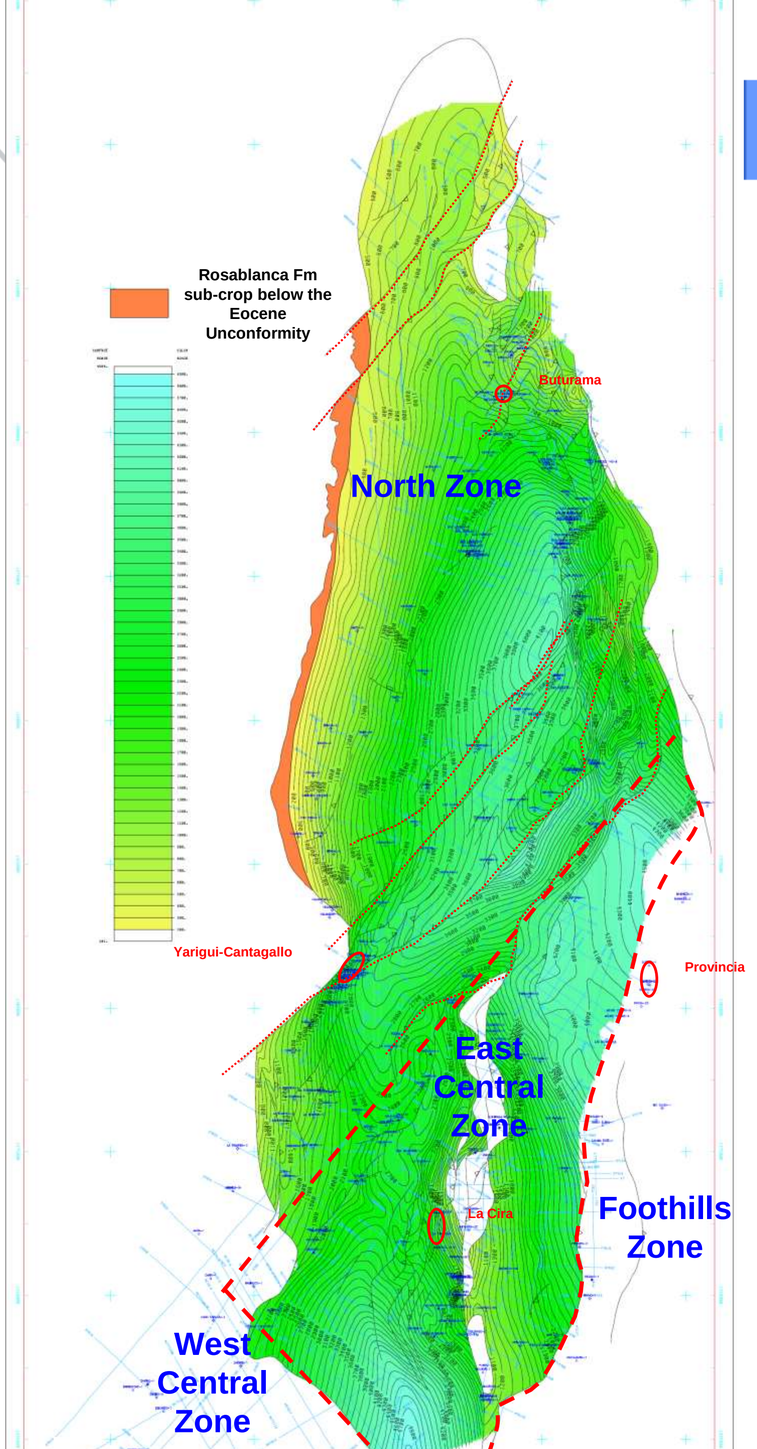
TWT Structural Maps at the Top of La Luna and Rosablanca Fms in the Middle Magdalena Basin





Source ICP 1998

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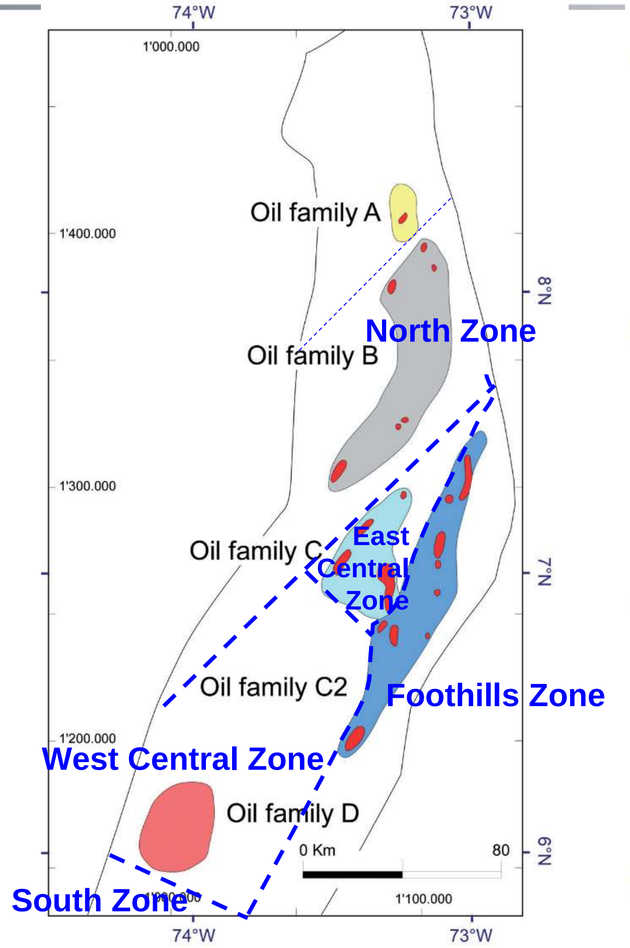
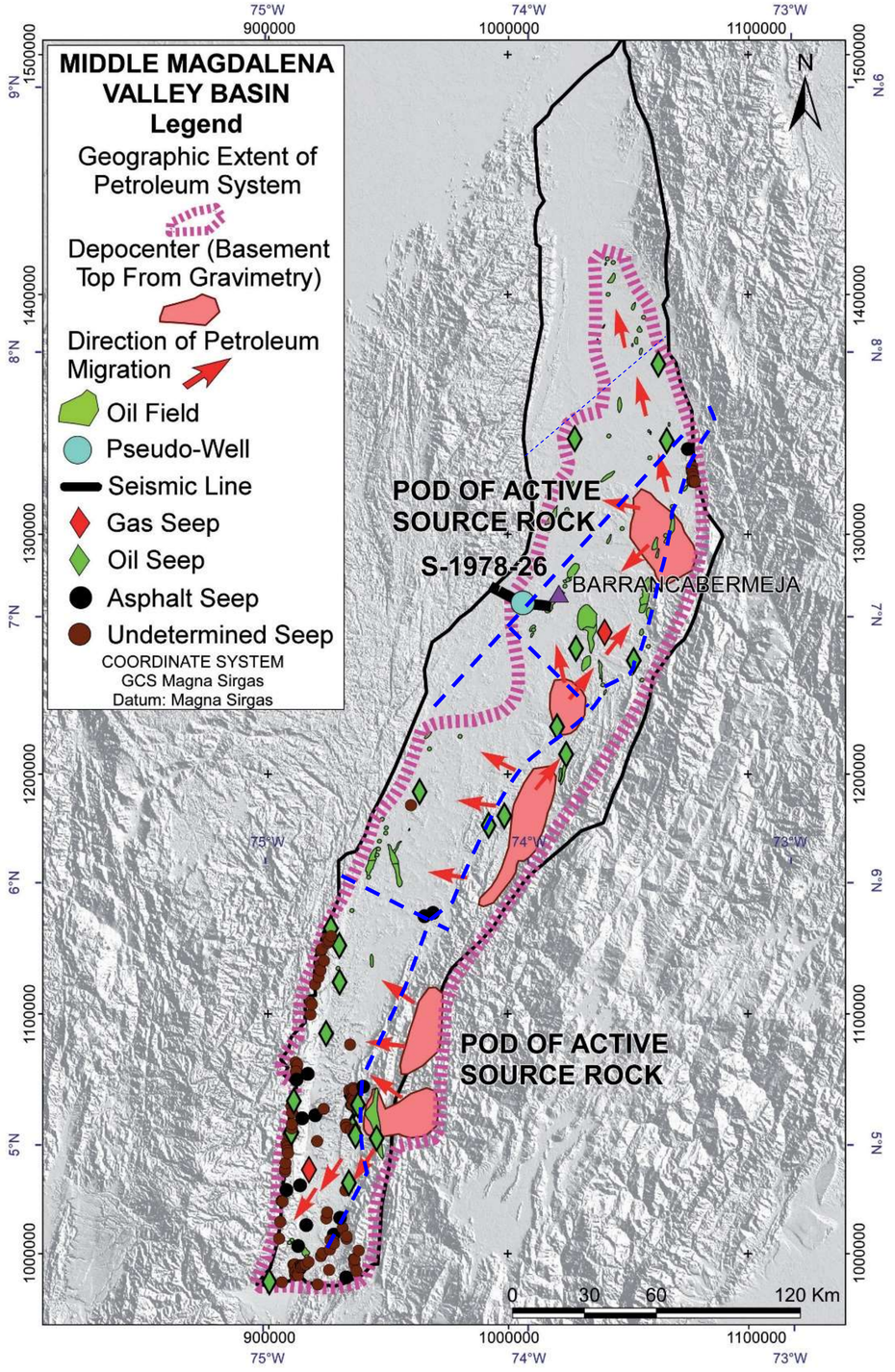
Petroleum Systems Map of the Middle Magdalena Basin

CHARACTERISTICS	F - A	F - B	F - C1	F - C2	F - D
API	35	23	22	35	28
% S	0.6	1.6	0.9	0.6	0.8
Pr / Ph	0.7	0.7	1.0	1.2	1.1
% < C 15	30	30	23	33	20
v	15	15	60	51	86
Ni	10	16	46	18	43
C15 Satured	- 25.8	- 28.5	- 27.3	- 27.5	- 27.91
C15 Aromatics	- 27.5	- 27.5	- 27.1	- 27.9	- 27.35
CPI	1.0	1.02		1.1	
Satured/Aromatics	1.3	0.9	1.2	2.1	1.6
Ts / Tm	4.9	0.28	0.71	0.78	1.02
C29 - C20S / R	0.8	0.7	0.73	0.79	0.7

Mora *et al.* (1996)



Source ANH 2011



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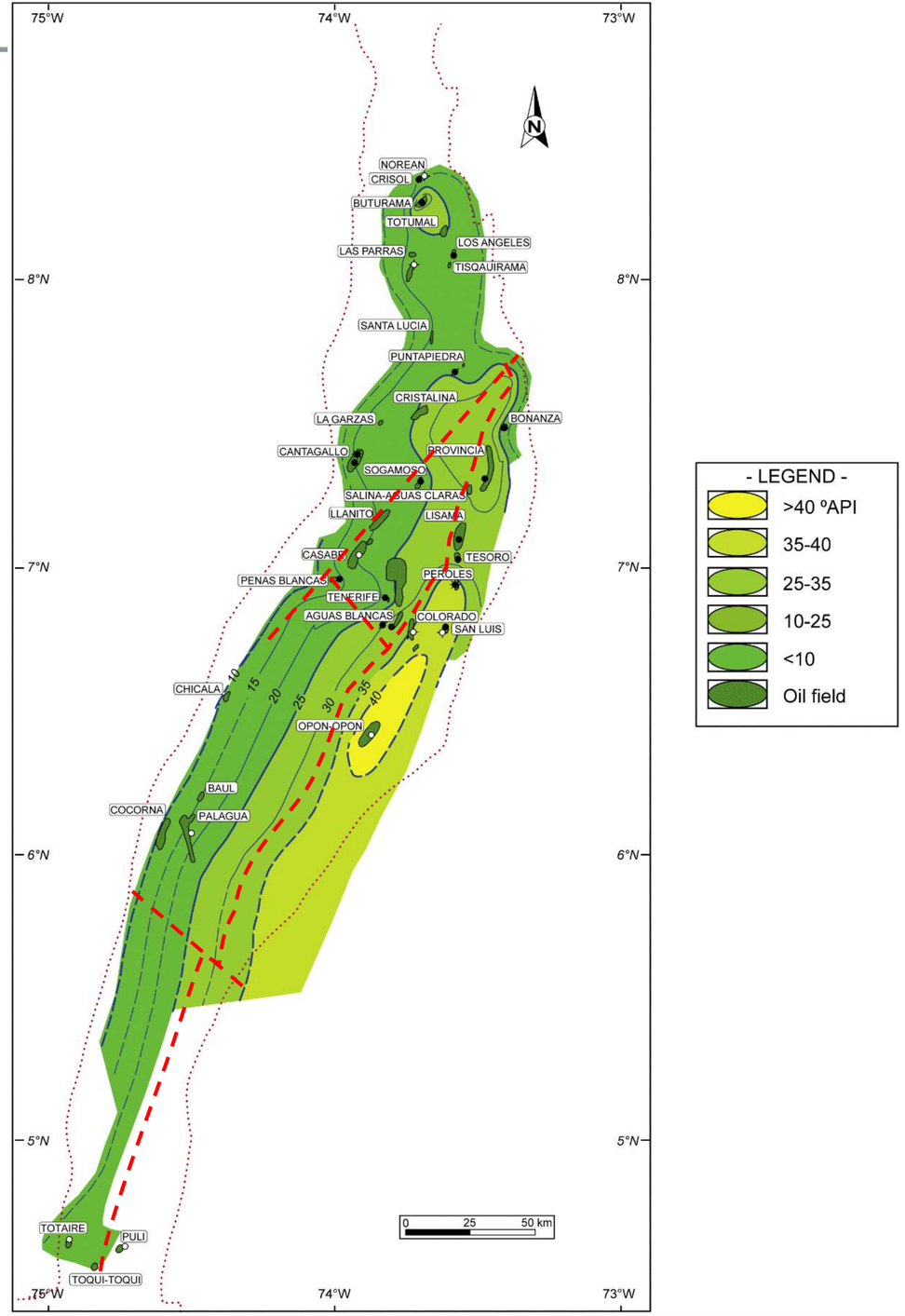
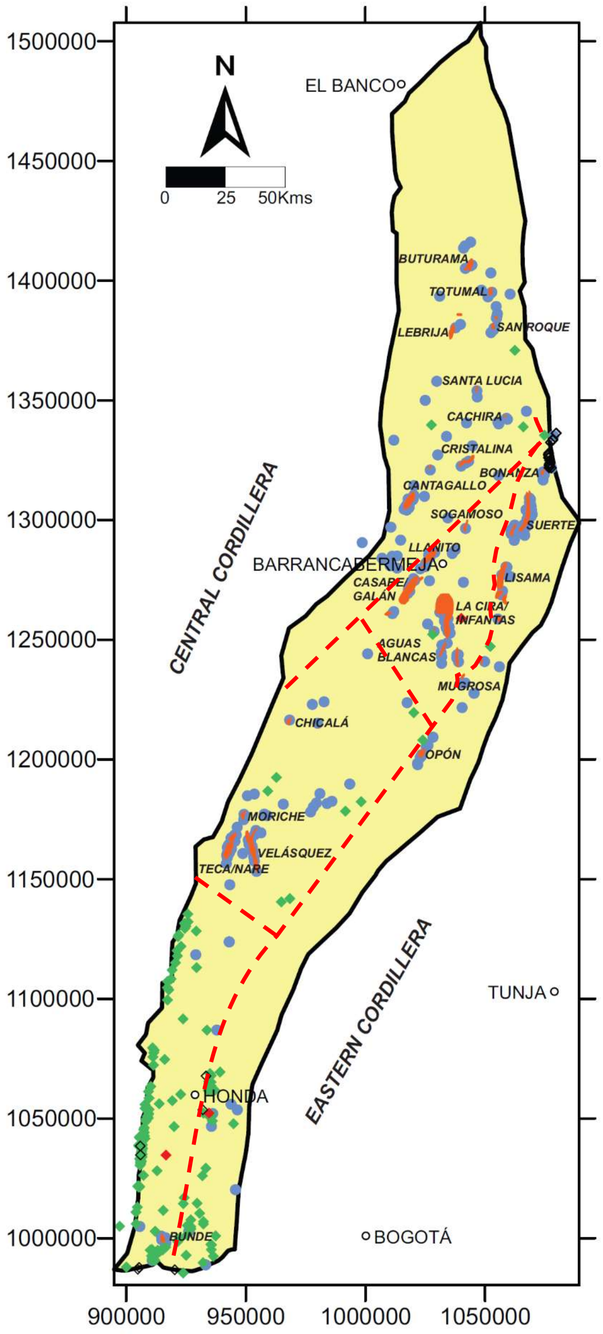
Isogravity Map of the Middle Magdalena Valley Basin



Source IHS

Wells and Seeps Map of the MMVB

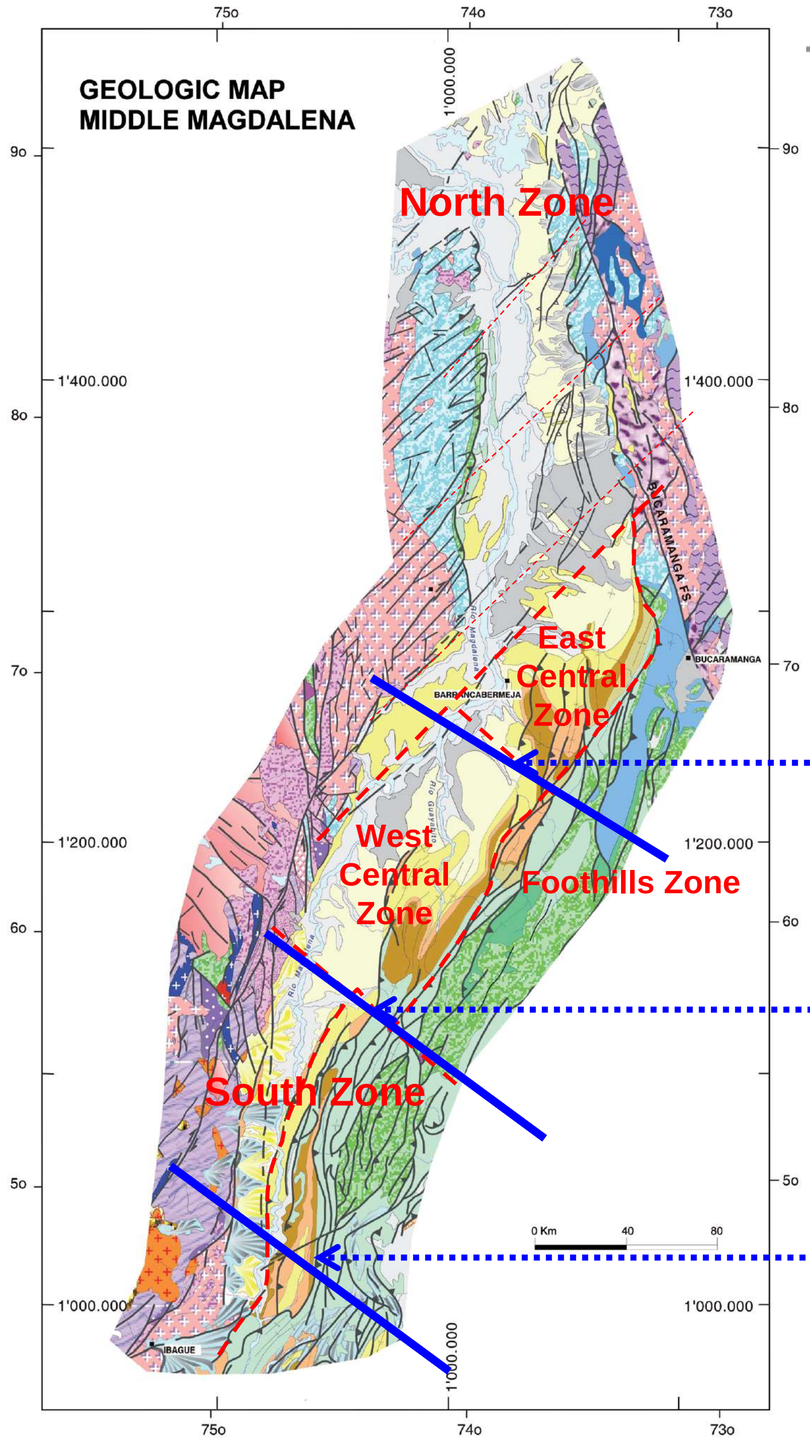


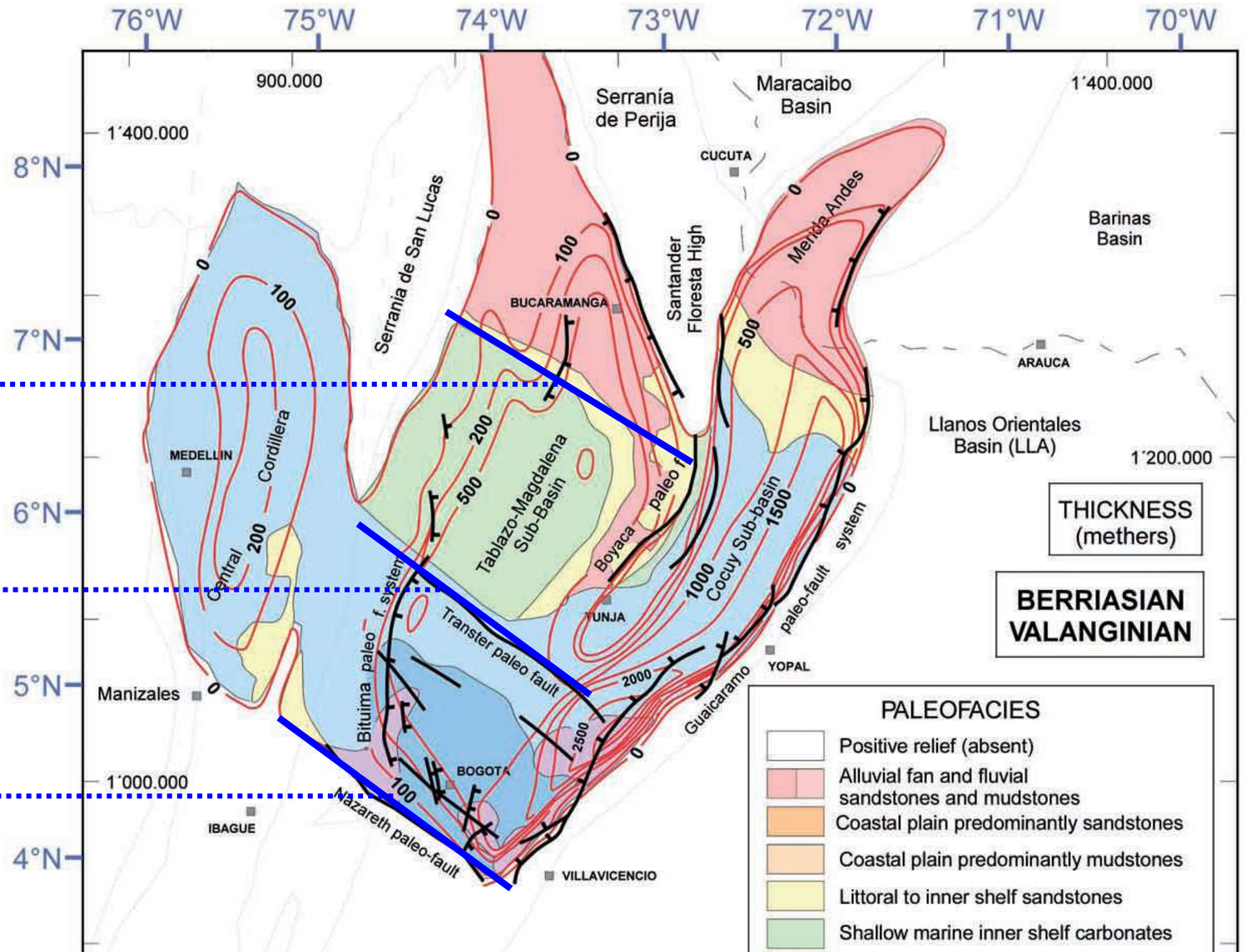
- Oil and gas fields
- Wells with geochemical information
- Oil seeps
- Gas seeps
- Undetermined seeps
- Cities/Towns

Source: ANH Atlas de Geoquímica (Geochemical Atlas), 2010

Geological Meaning of the identified Alignments

Source Sarmiento-Rojas, 2003





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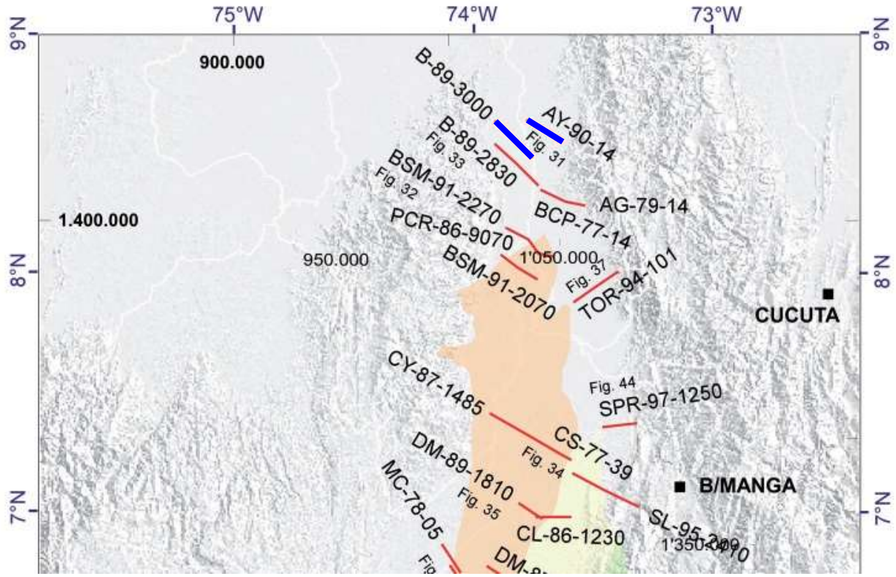
North Zone of the Middle Magdalena Valley Basin

Geotec, Robertson Research, Ecopetrol (1998)

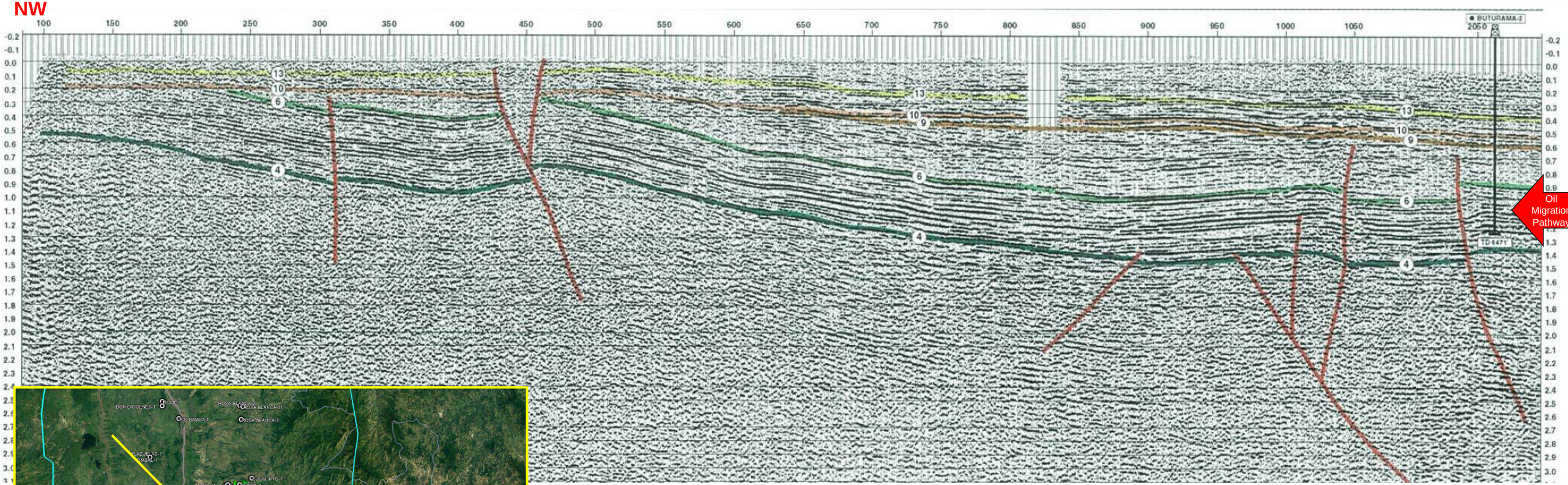


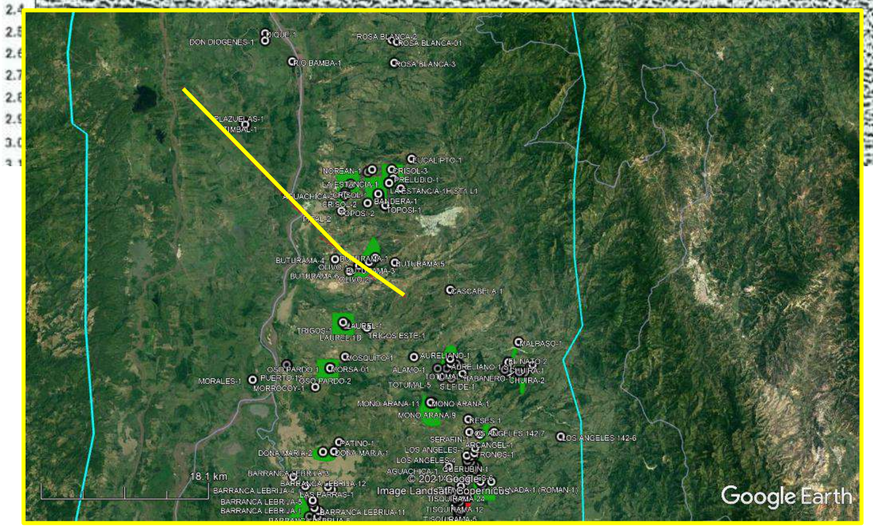
Source ANH, 2011

North Zone: Buturama Field in the Middle Magdalena Basin (Seismic Line BSM-1991-2690)

NW

SE



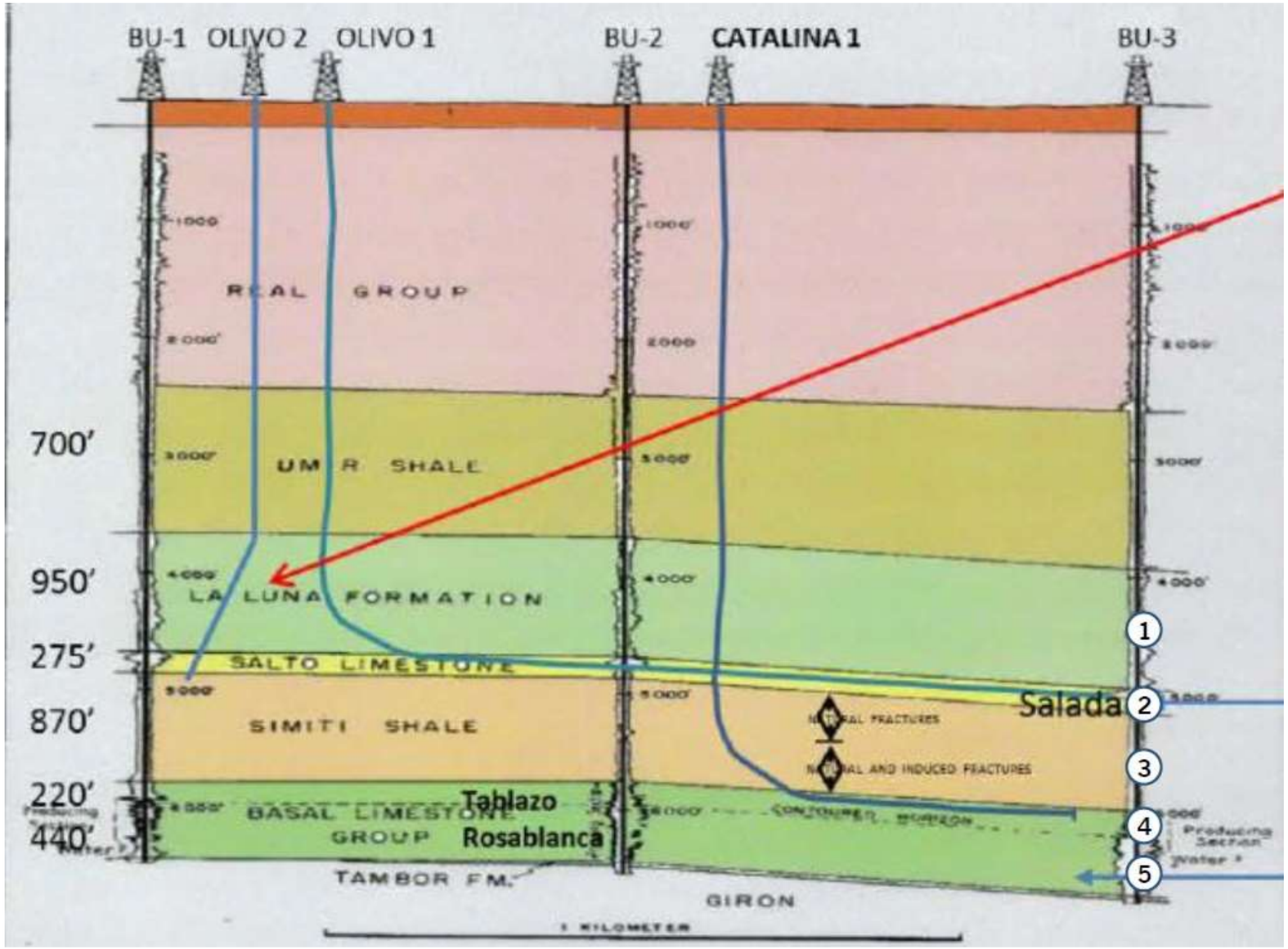


LEGEND - MIDDLE MAGDALENA

- 16 Sub-Pliocene unconformity
- b Seismic sequence
- a Seismic sequence
- 13 Sub-Middle Miocene unconformity
- 10 Sub-Oligocene unconformity
- 9 Sub-Eocene unconformity
- 6 Turonian MFS
- 4 Sub-Cretaceous unconformity
- Faulting / Thrusting

Source Seismic Atlas 1998

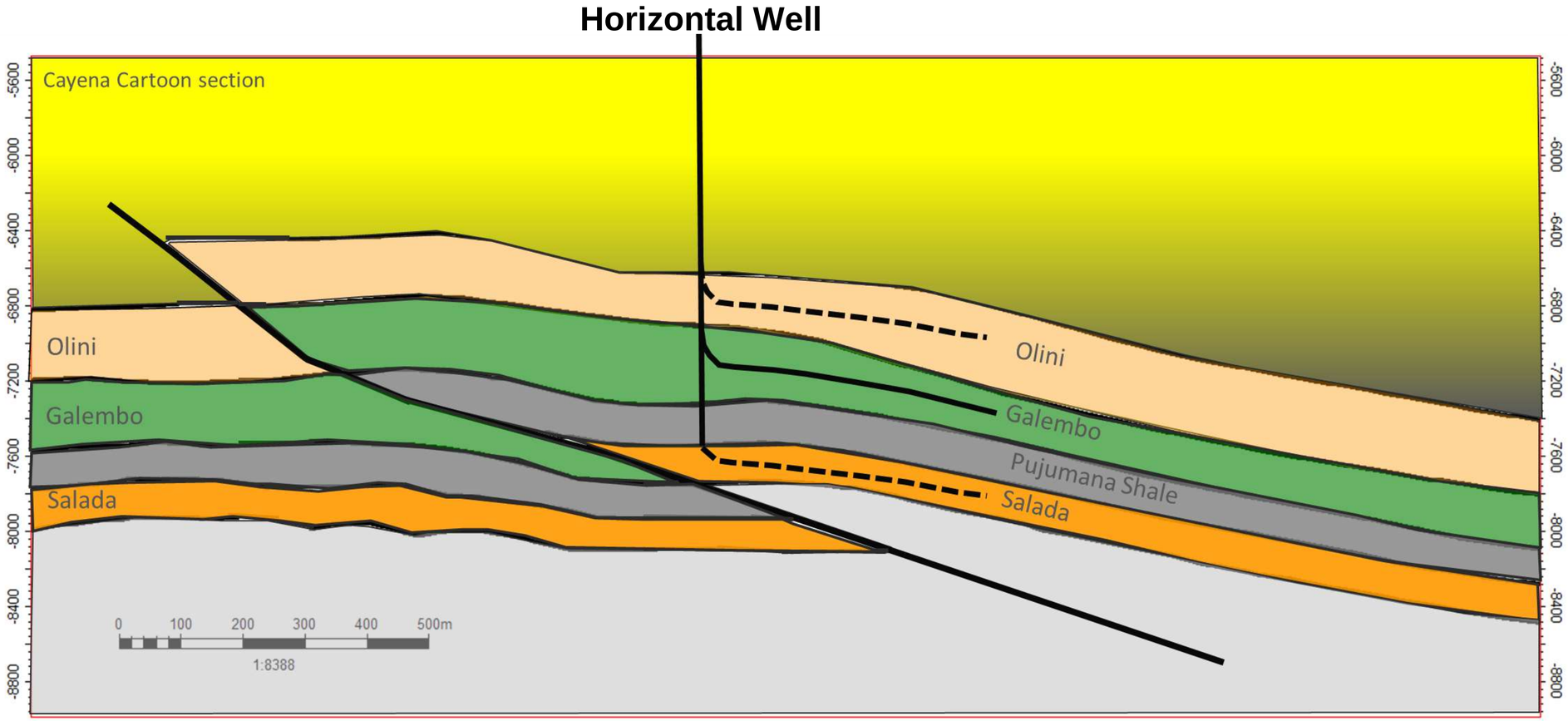
North Zone: Buturama, Olivo & Catalina Fields



1. **La Luna Shale (oil)**
2. **Salada Limestone (oil)**
3. **Simiti Shale (Gas + NGLs)**
4. **Tablazo Shale (light oil)**
5. **Rosa Blanca Limestone (light oil)**

- Olivo-1 Basal La Luna (Salto or Salada Limestone produced 14° oil from a horizontal section at an initial rate of **5,000 bopd** with a cumulative of 675,000 barrels)
- Catalina-1 “Basal Limestone” or Rosablanca produced 38° oil from a horizontal section at an initial rate of **7,500 bopd** with a cumulative of 600,000 barrels

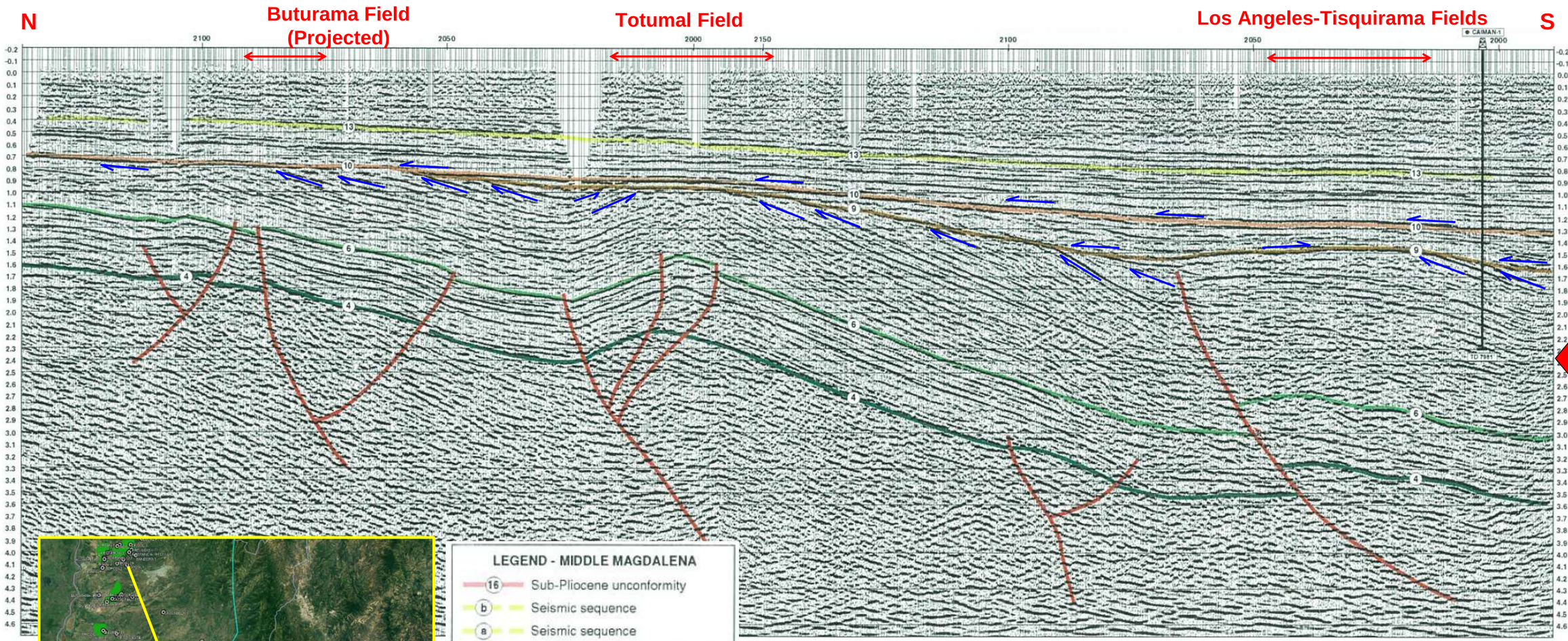
North Zone: Cayena Discovery (Fortuna Block) by Parex in the Middle Magdalena Basin



~ 242 bopd
>30ºAPI
BSW<1%

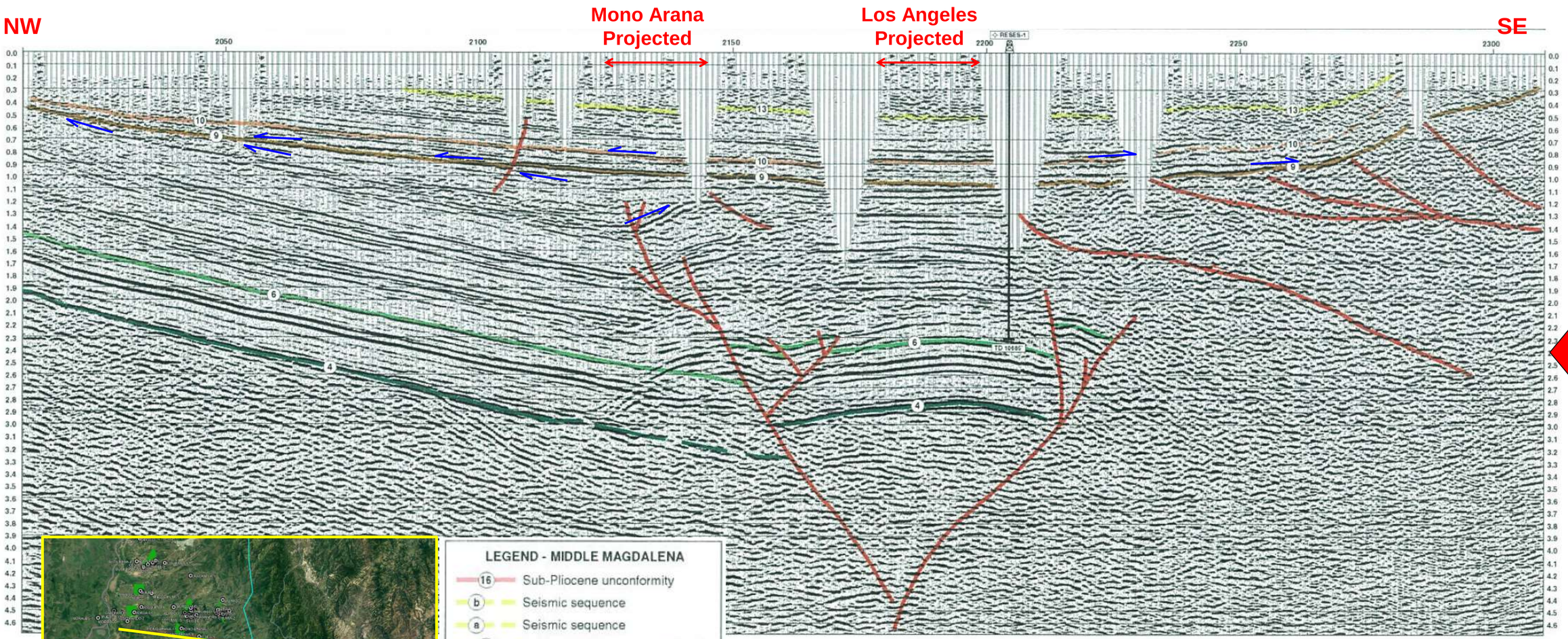
Source Parex Web Page

North Zone: Los Angeles & Tisquirama Fields
(Seismic Line MM 1976-01C&01D)



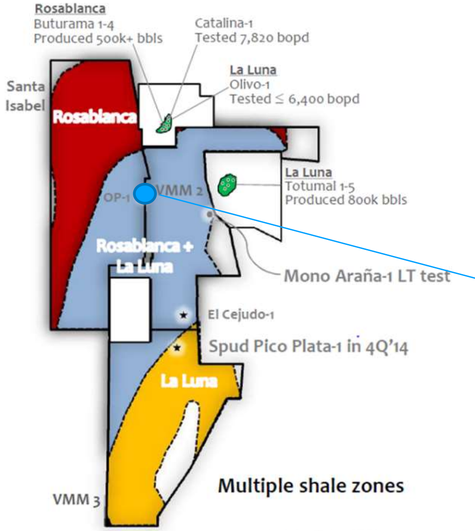
Source: Seismic Atlas, 1998

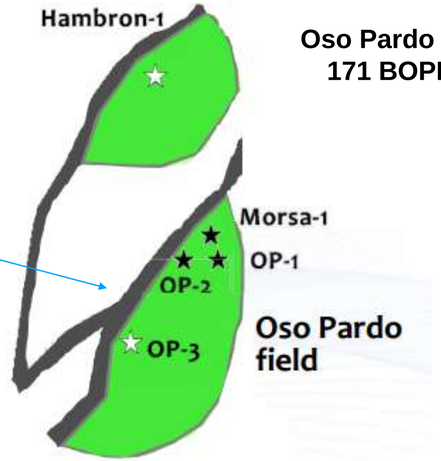
North Zone: Reses – 1 Well
(Seismic Line MM-1976-14)



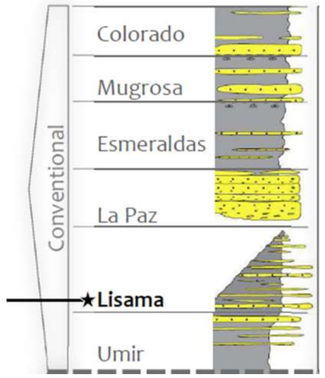
Source Seismic Atlas, 1998

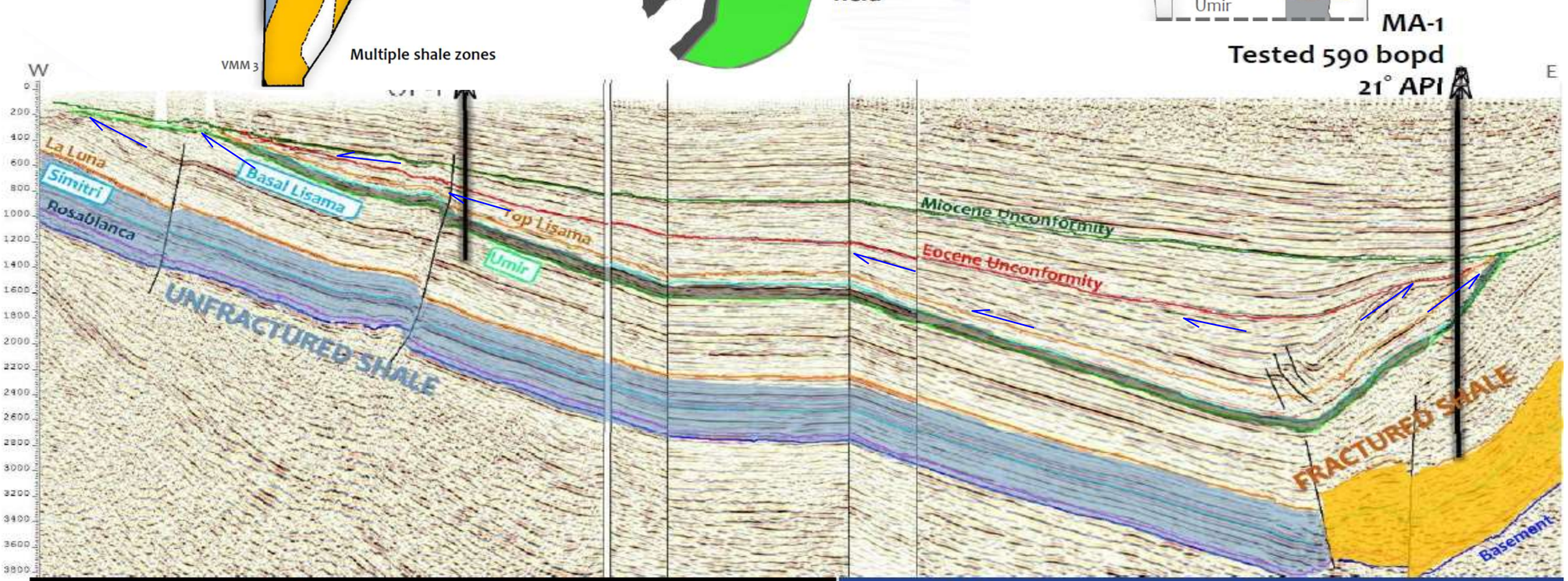
Oso Pardo – 1 Discovery (Lisama Fm Producer)





Oso Pardo Production: 171 BOPD (Jun/16)

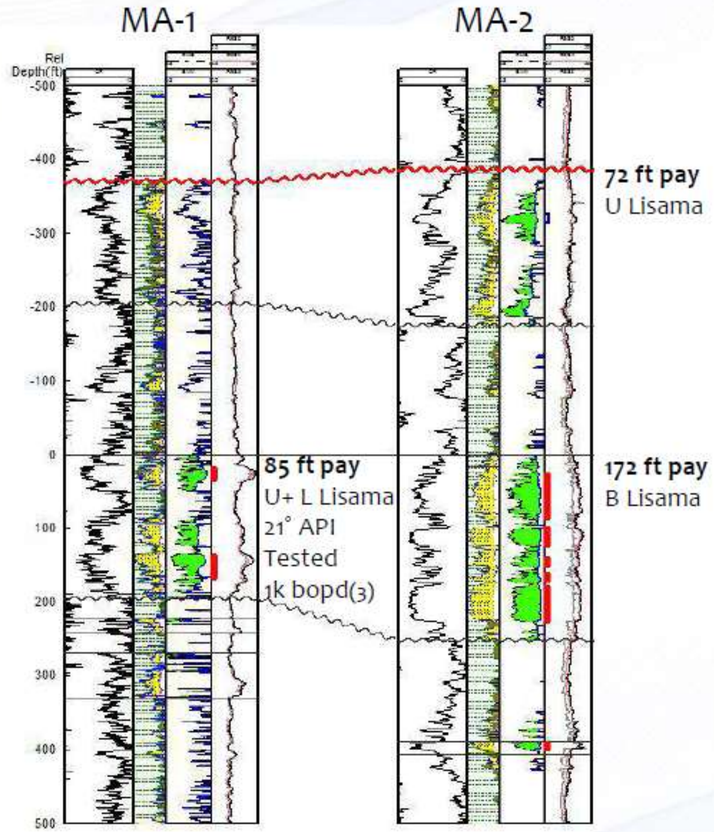


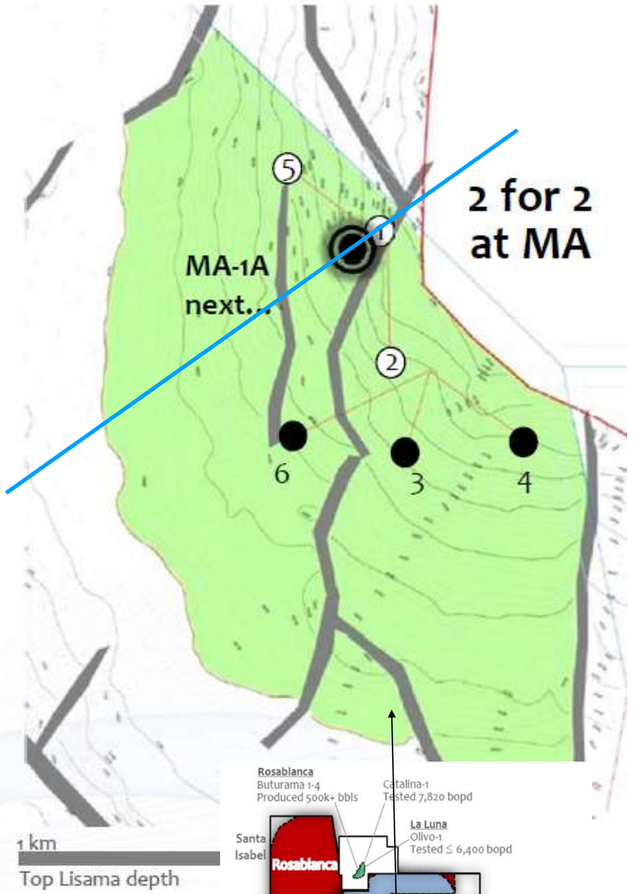


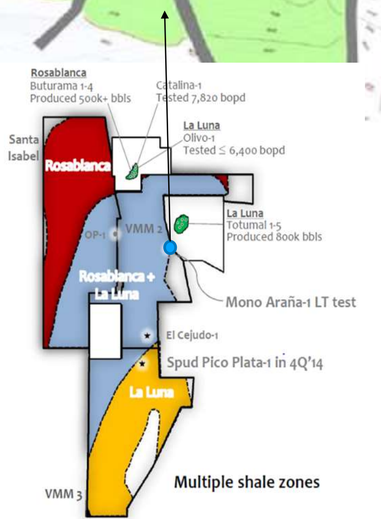
Santa Isabel discoveries (Lisama & Umir)

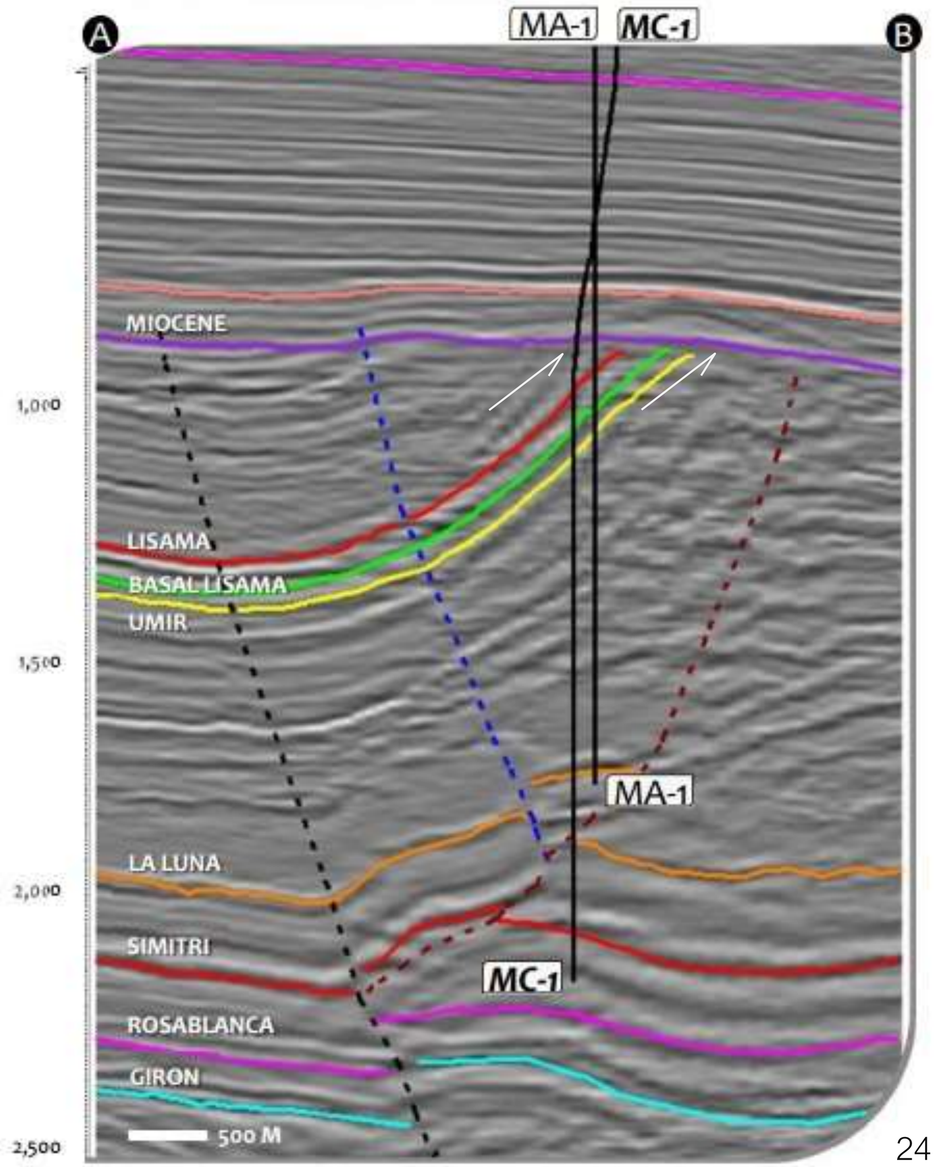
VMM 2 discoveries (Lisama & La Luna)

Mono Araña- 1&2 (Lisama Fm Producer)









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Recent Discoveries Map from the North Zone of the MMVB

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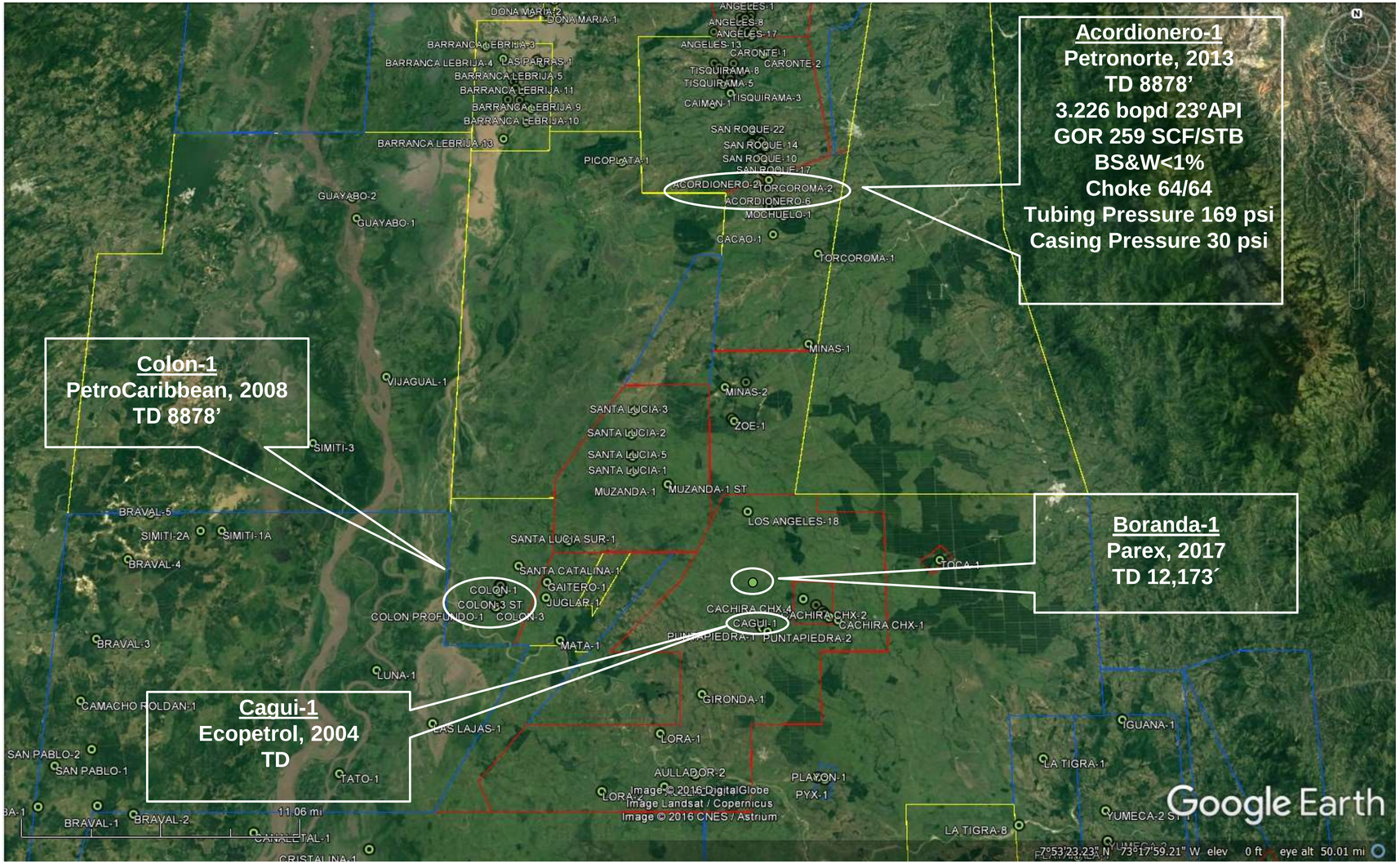
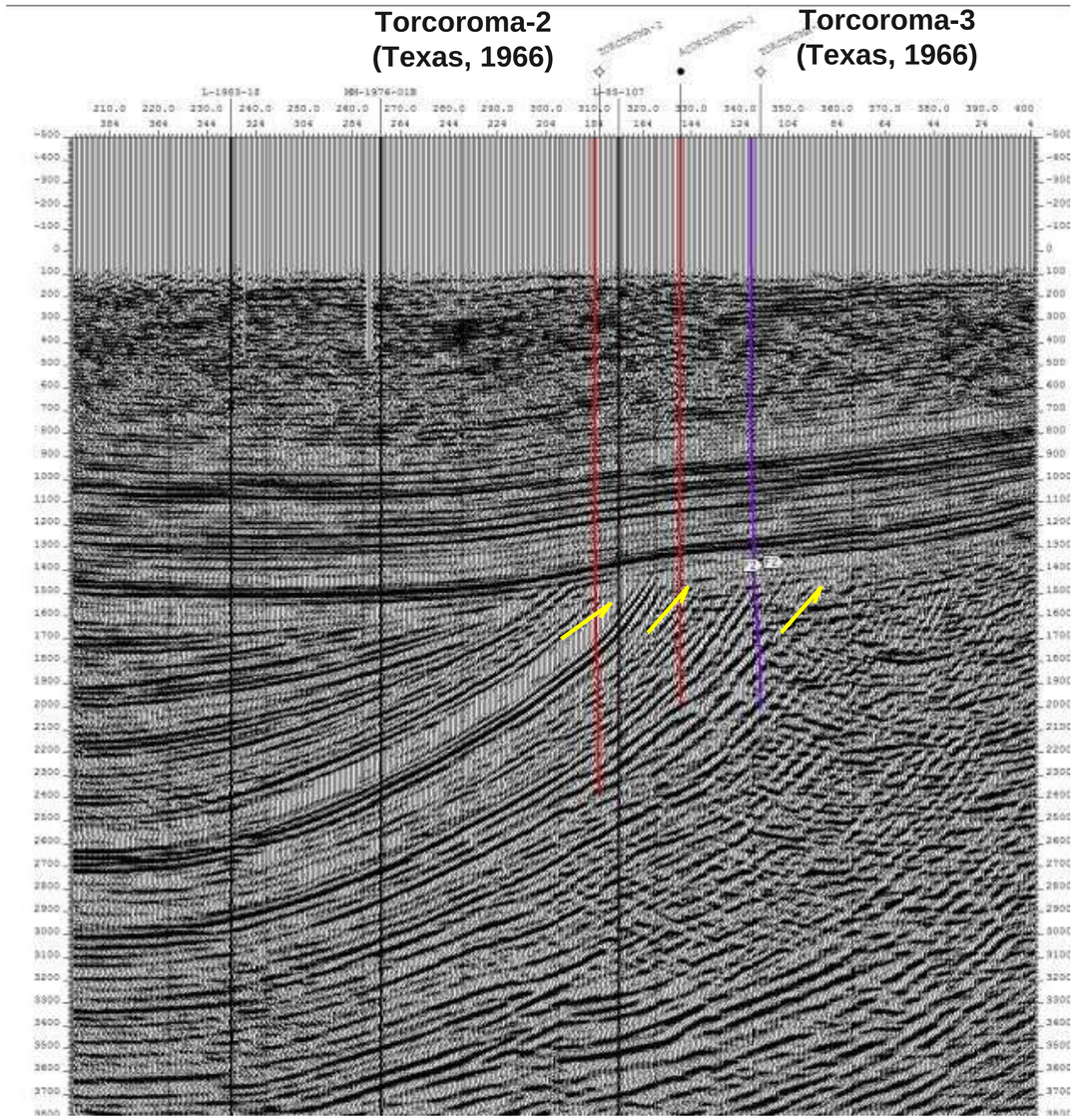


Acordionero-1 Discovery (Petrolatina, 2013)

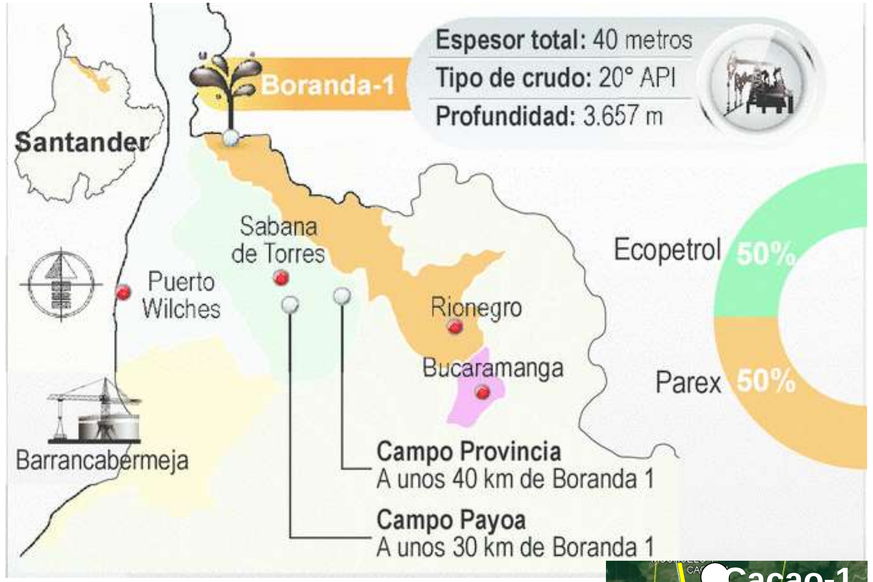
“An Unusual Large Stratigraphic Trap within the Paleocene Lisama Formation”

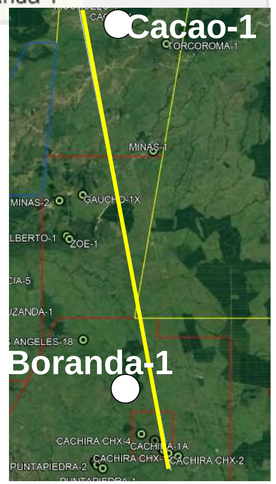
January of 2020: 14,709 bopd

From Prince et al, 2016

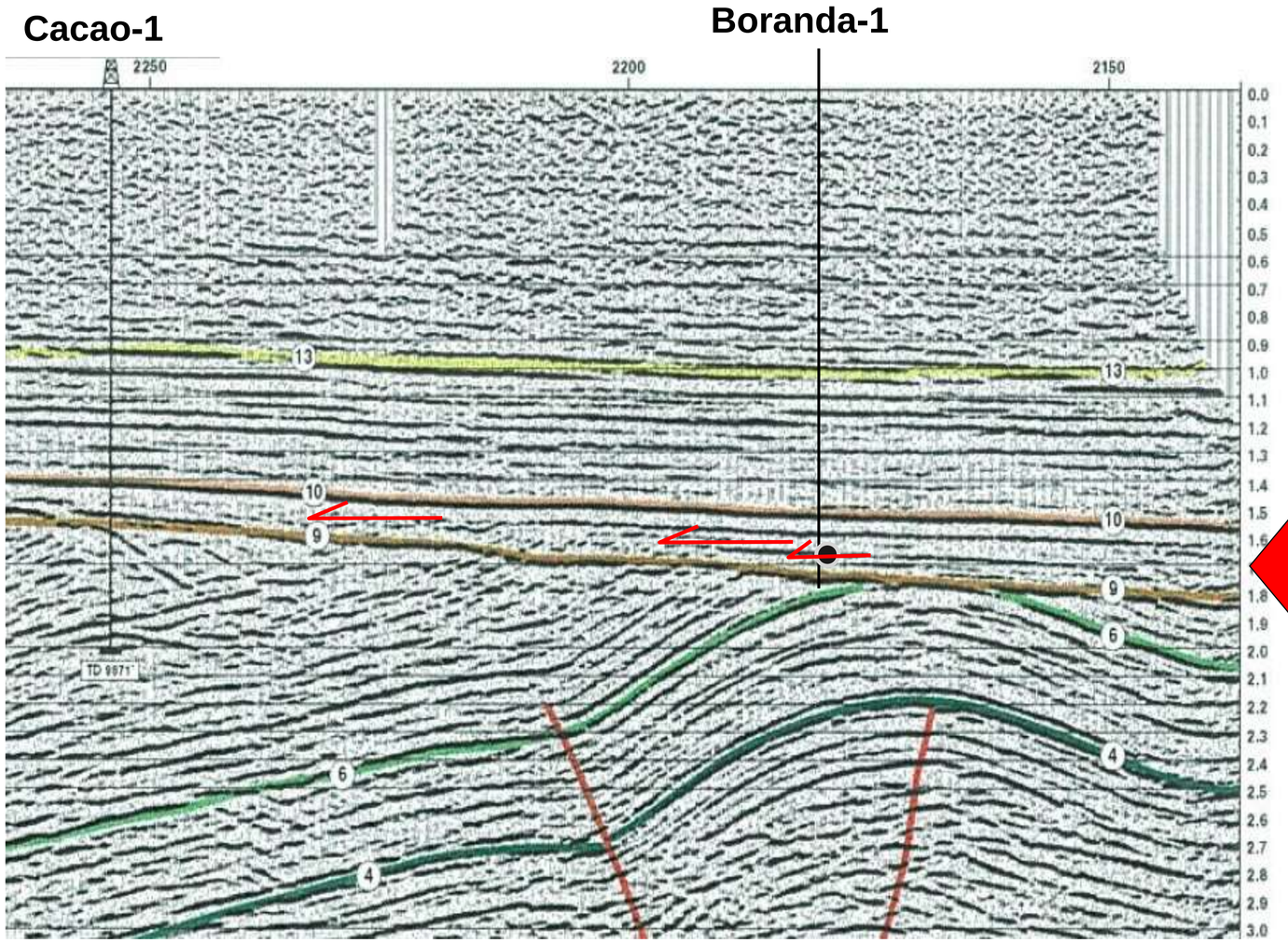


North Zone: Boranda-1 Discovery



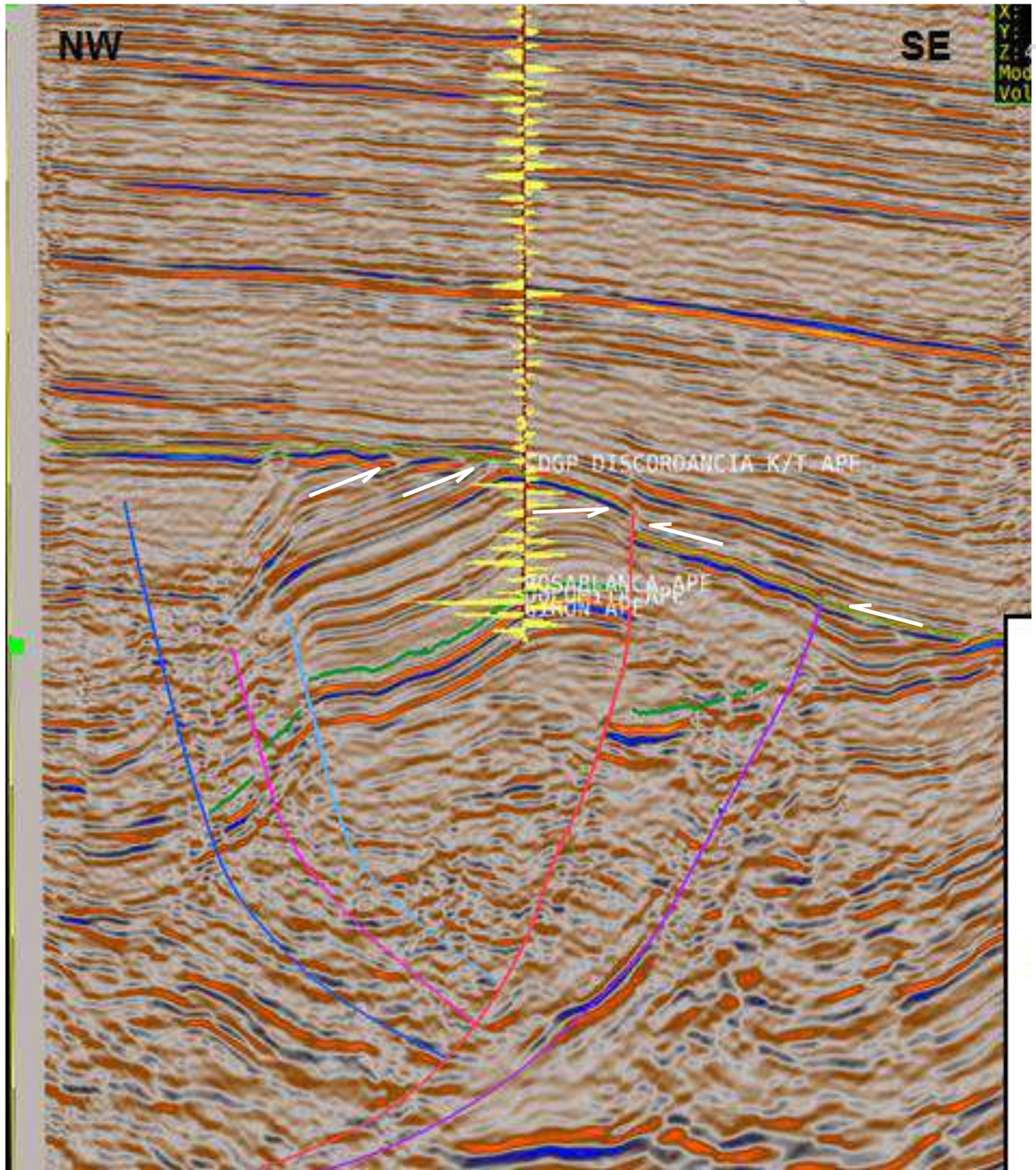


ECP WI 50%; PAREX 50%
Total depth of 12,173 feet
Objective: La Paz Formation
94 bopd of 20º API oil



Source: "Atlas Sísmico de Colombia" (Seismic Atlas of Colombia)

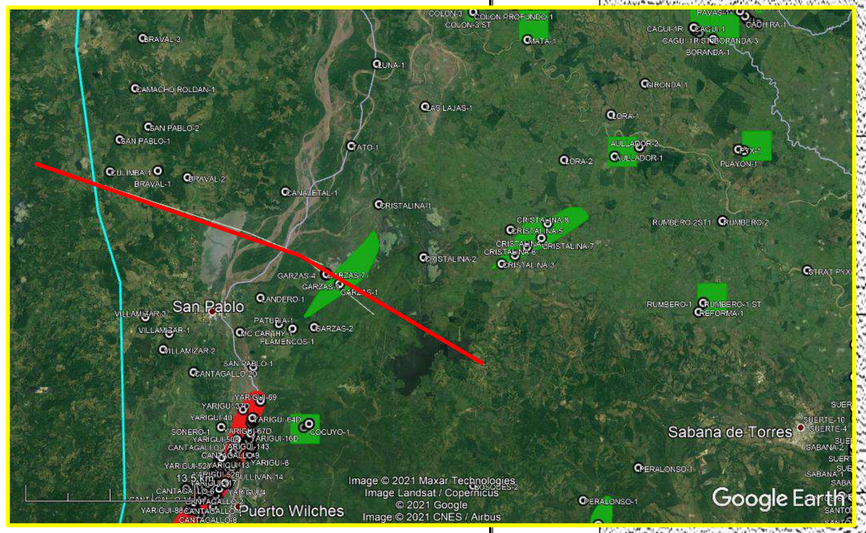
Cagui – 1 Well & Eocene Prospectivity

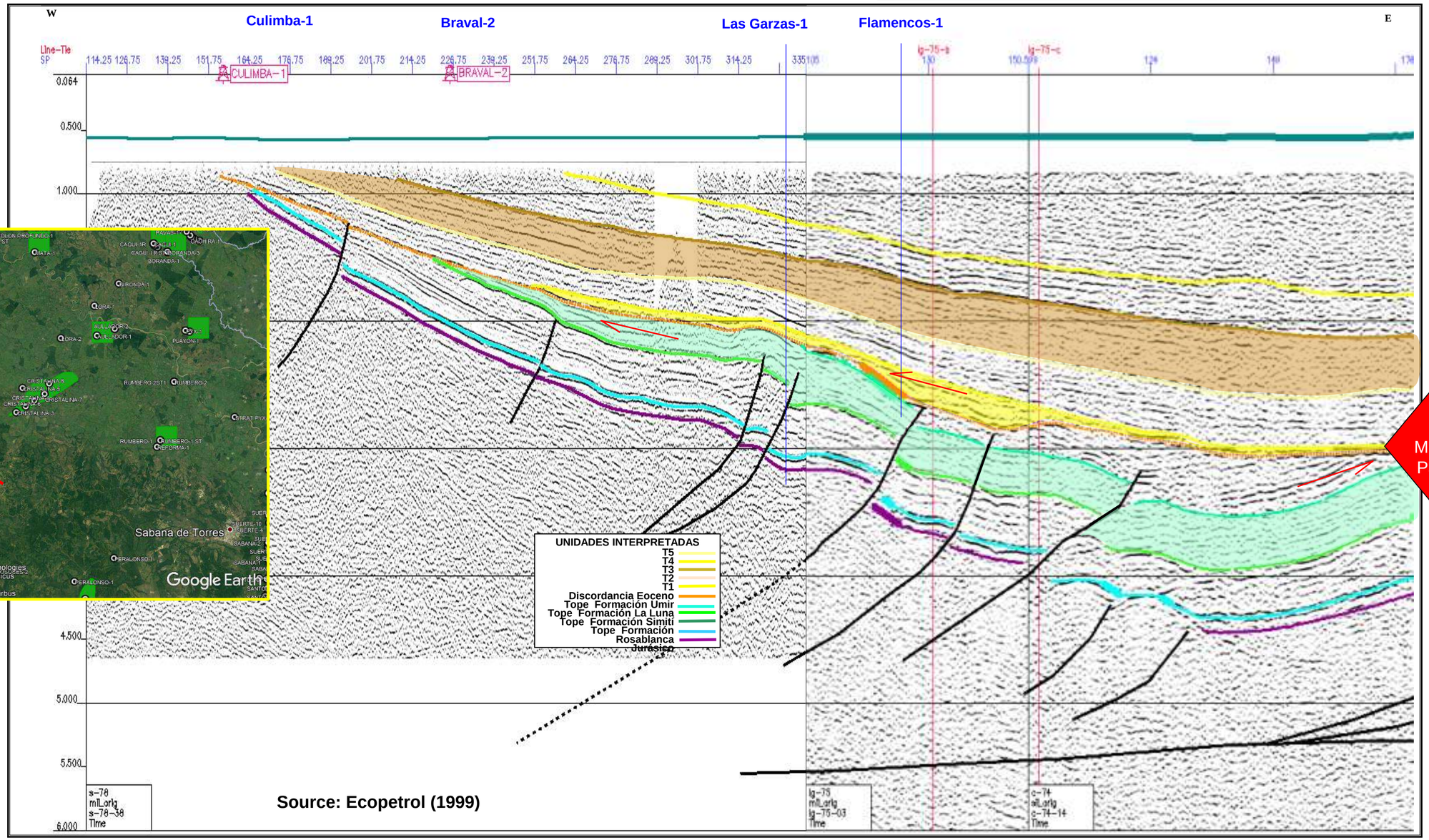


Oil Migration Pathway

Courtesy by Peña, Anderson

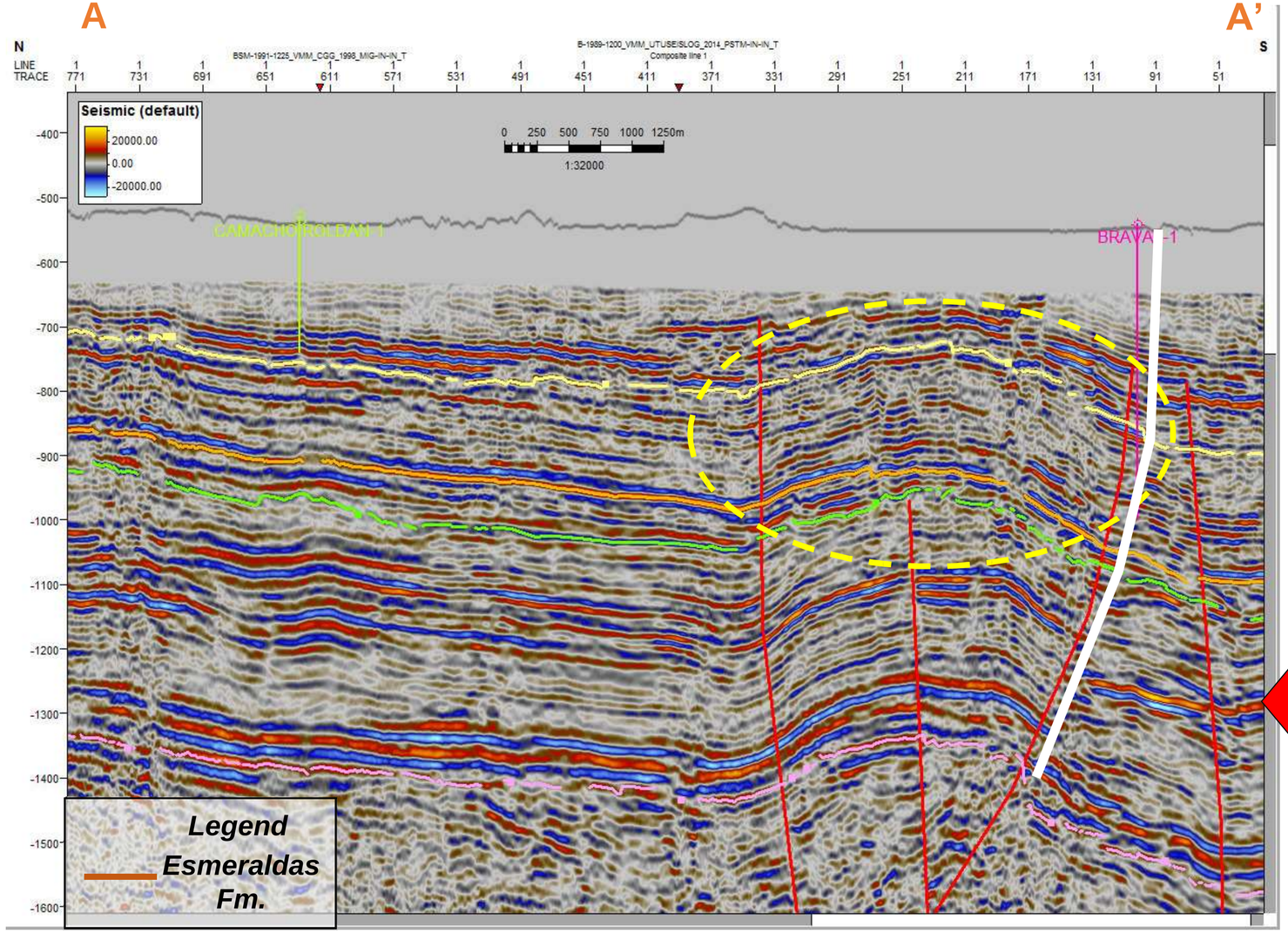
North Zone: Flamencos-1 Discovery



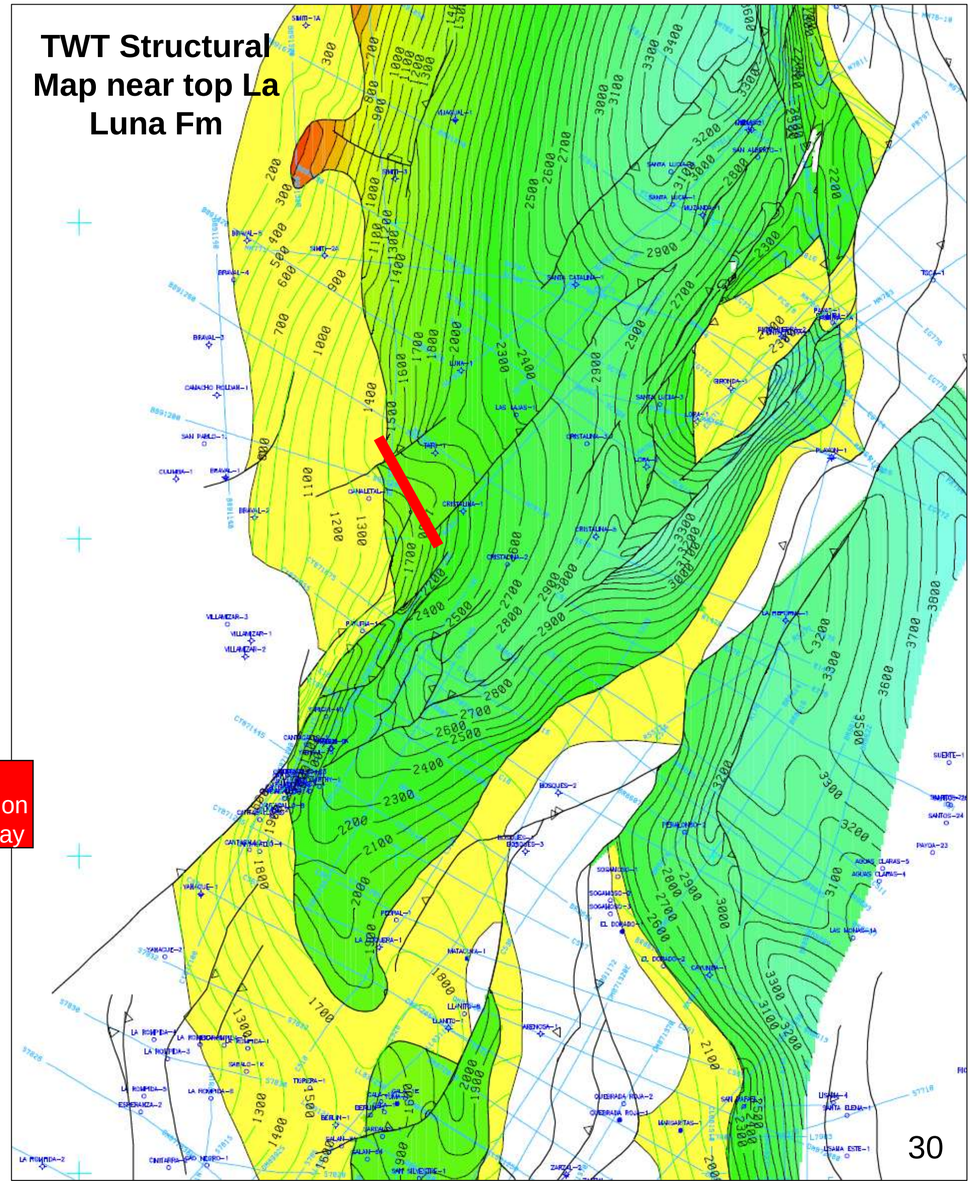


Source: Ecopetrol (1999)

North Zone: Block VMM-28-1 Additional Prospectivity



Oil Migration Pathway



Source Parex Web Page

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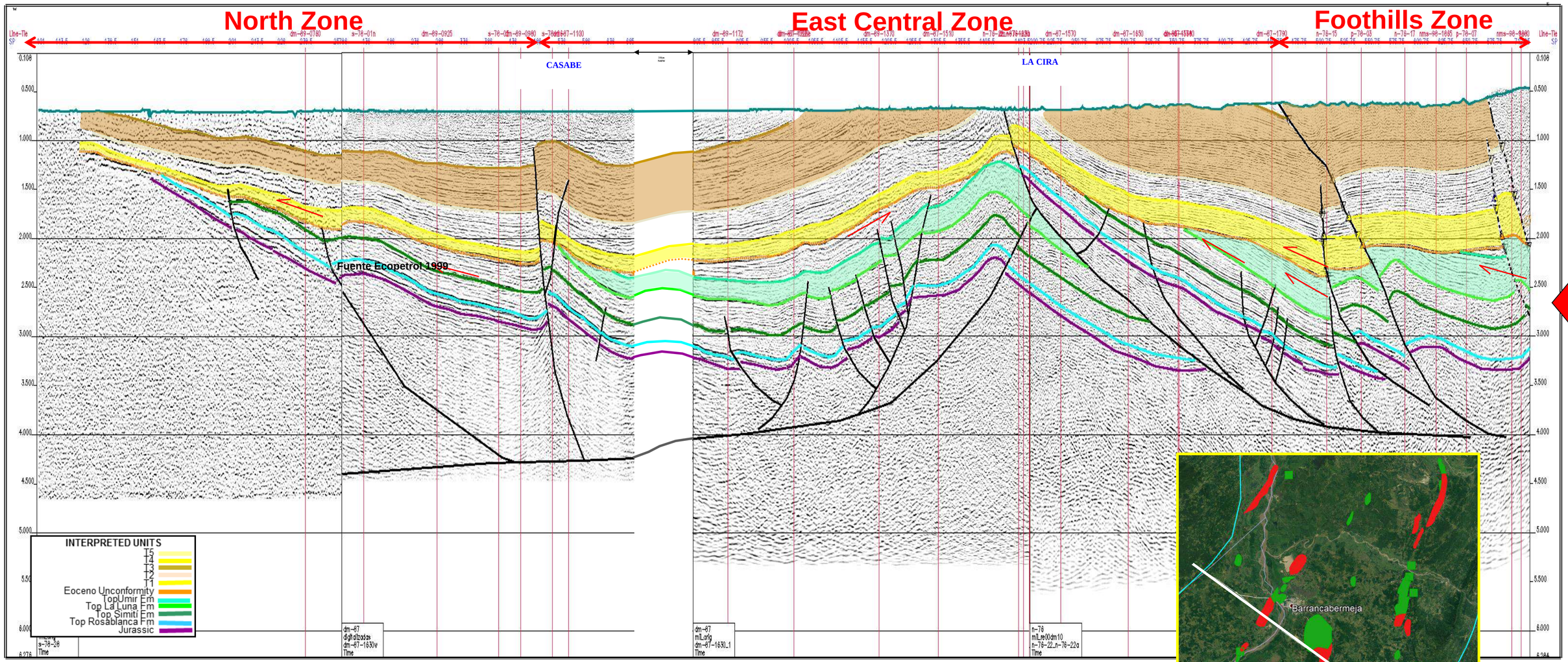
  - Fields Totare, Ambrosia, Rio Opia, Toqui Toqui and Puli

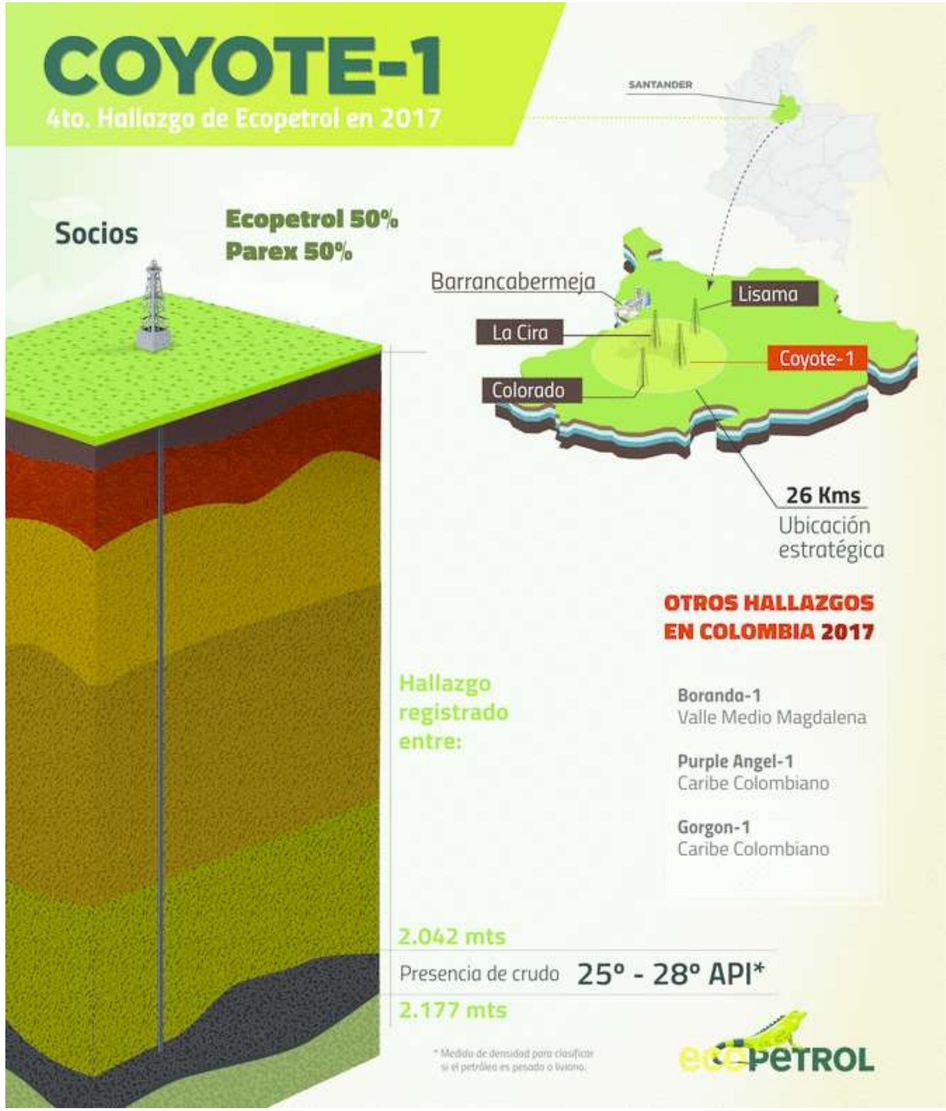
Composite Section Casabe - Peroles



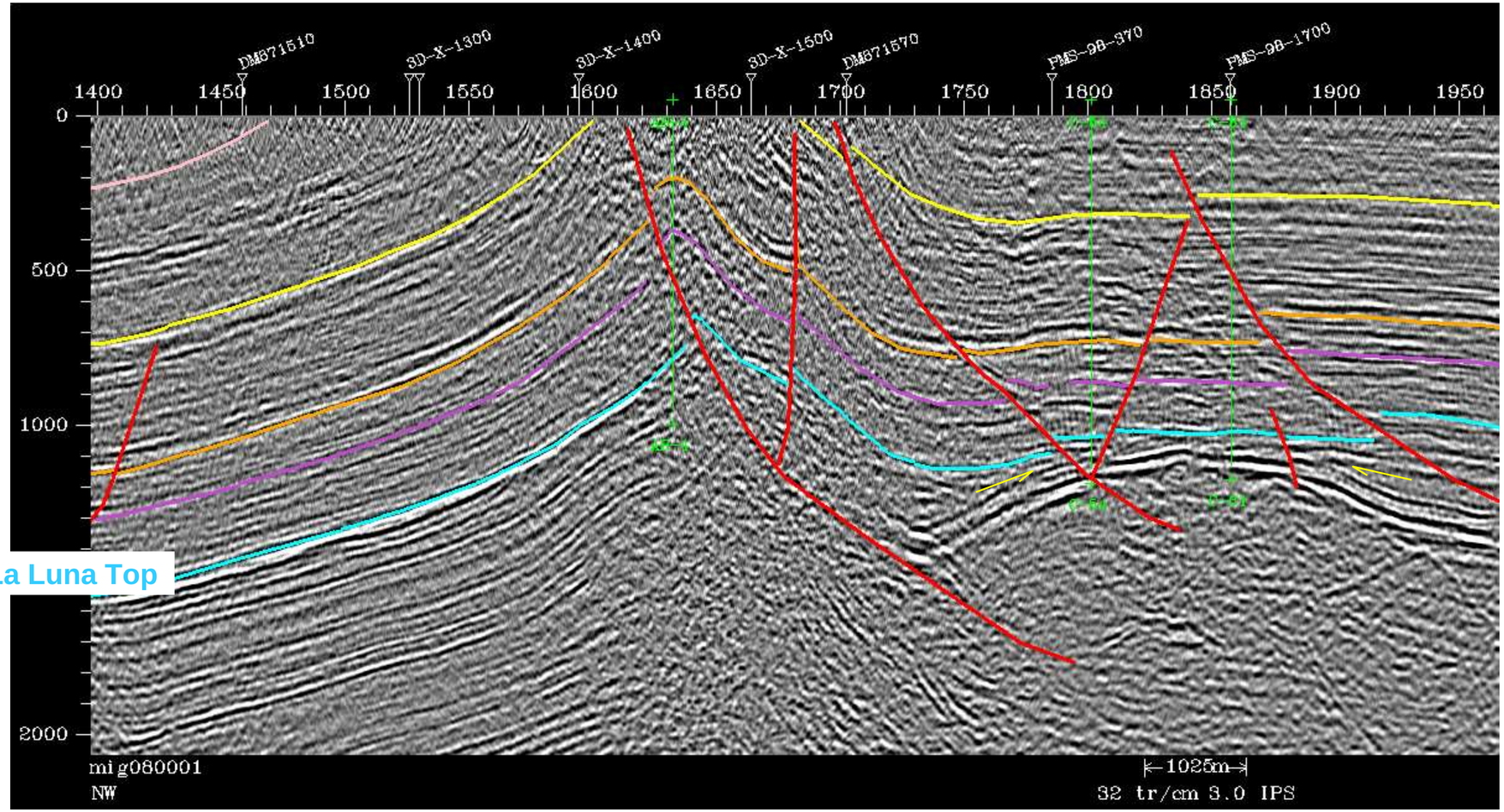
Oil Migration Pathway

Source: Ecopetrol (1999)

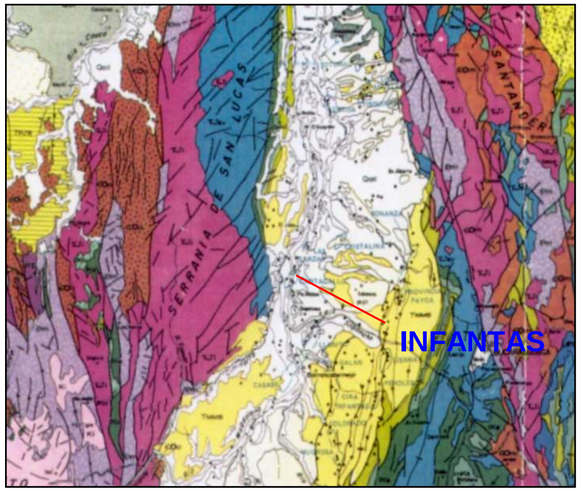
Recent Discoveries in the Esat Central Zone: Infantas Oriente & Coyote



Colorado Field: Compare prev-T Structures at Both Sides of the Fault



Aprox La Luna Top



Source: ICP 1997

COLOMBIA ROUND 2021

AGENDA

ANH AGENCIA NACIONAL DE HIDROCARBUROS

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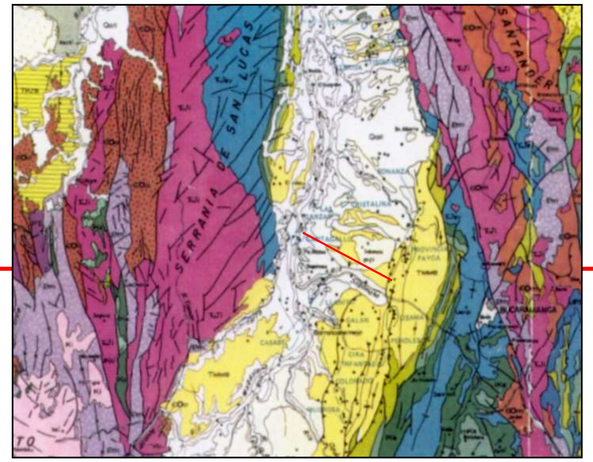
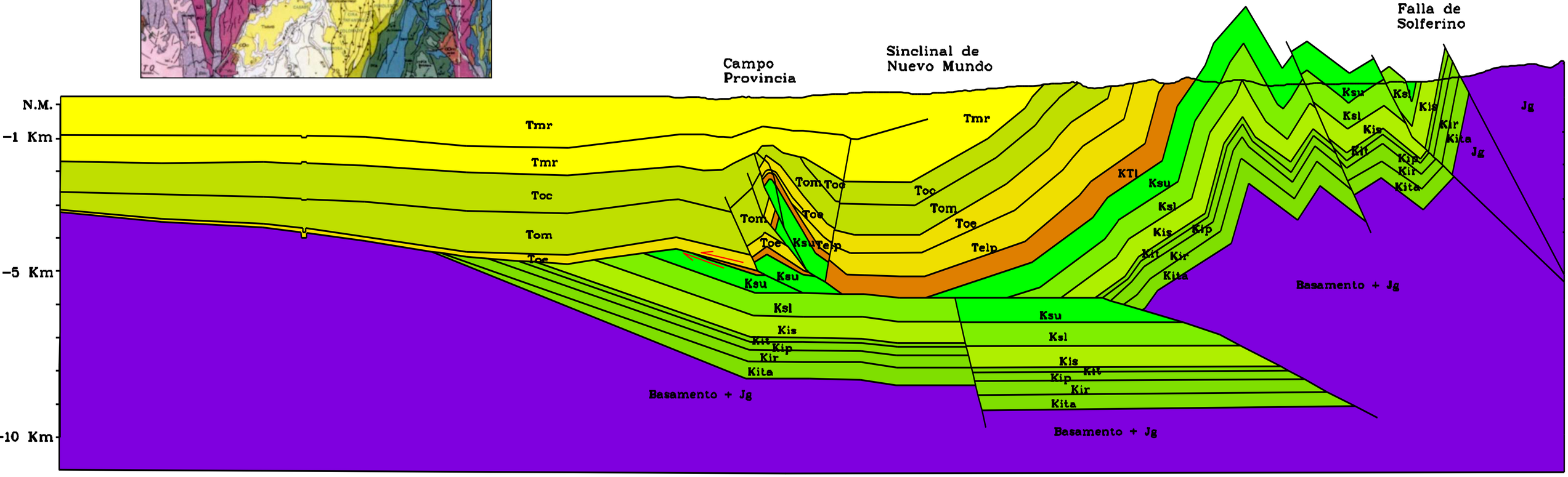
Foothills Zone: Provincia Field



East Central Zone

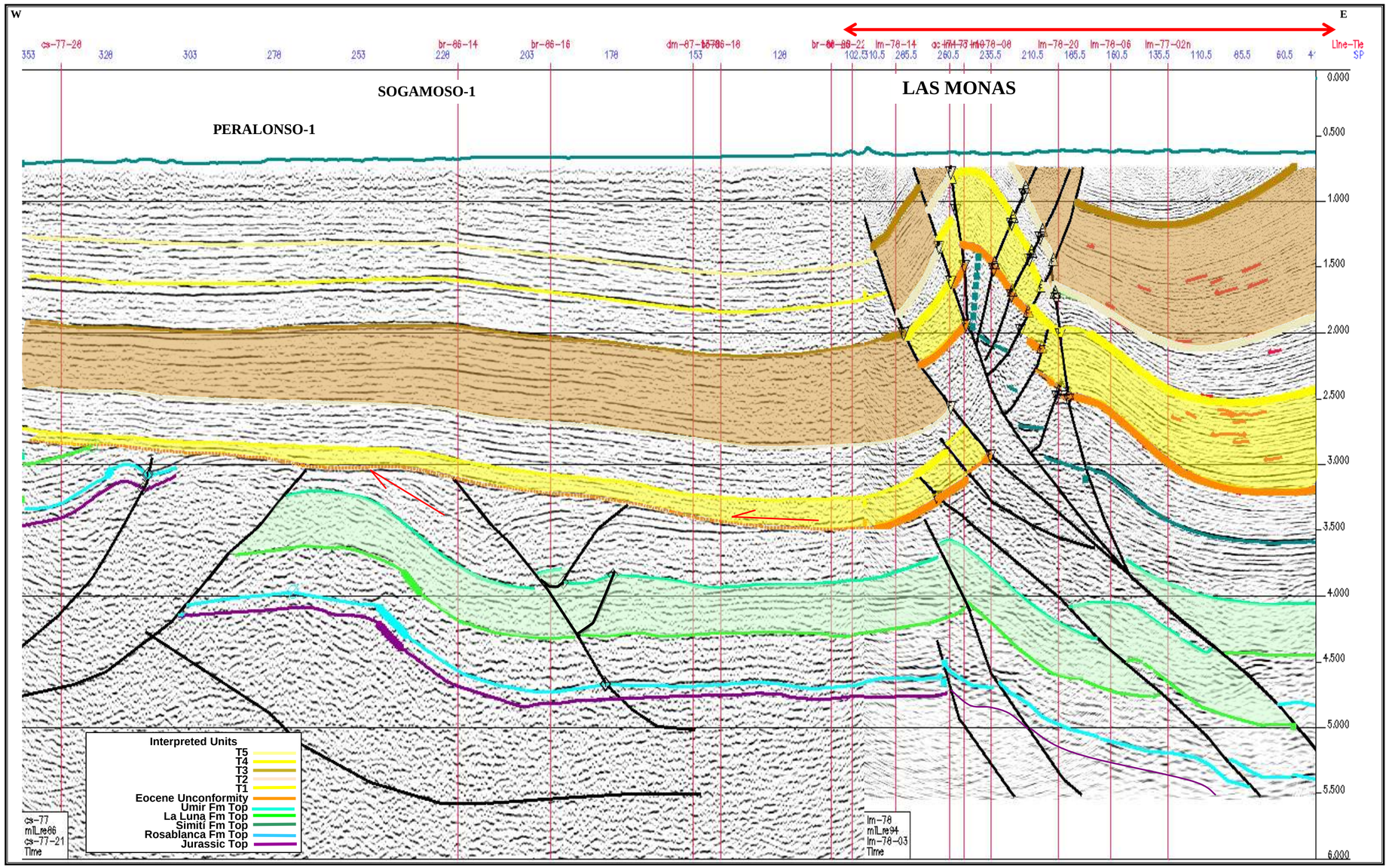
Foothills Zone



Source: Ecopetrol (1999)

Foothills Sector: Las Monas Field

Foothills Sector



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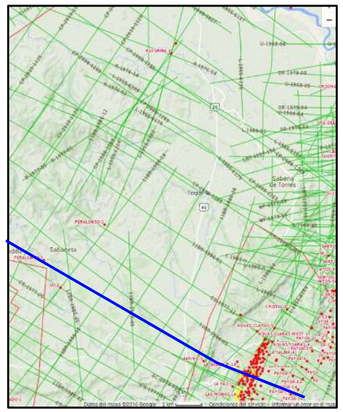

COLOMBIA ROUND 2021

Foothills Sector: Sequence Stratigraphy at Las Monas Field

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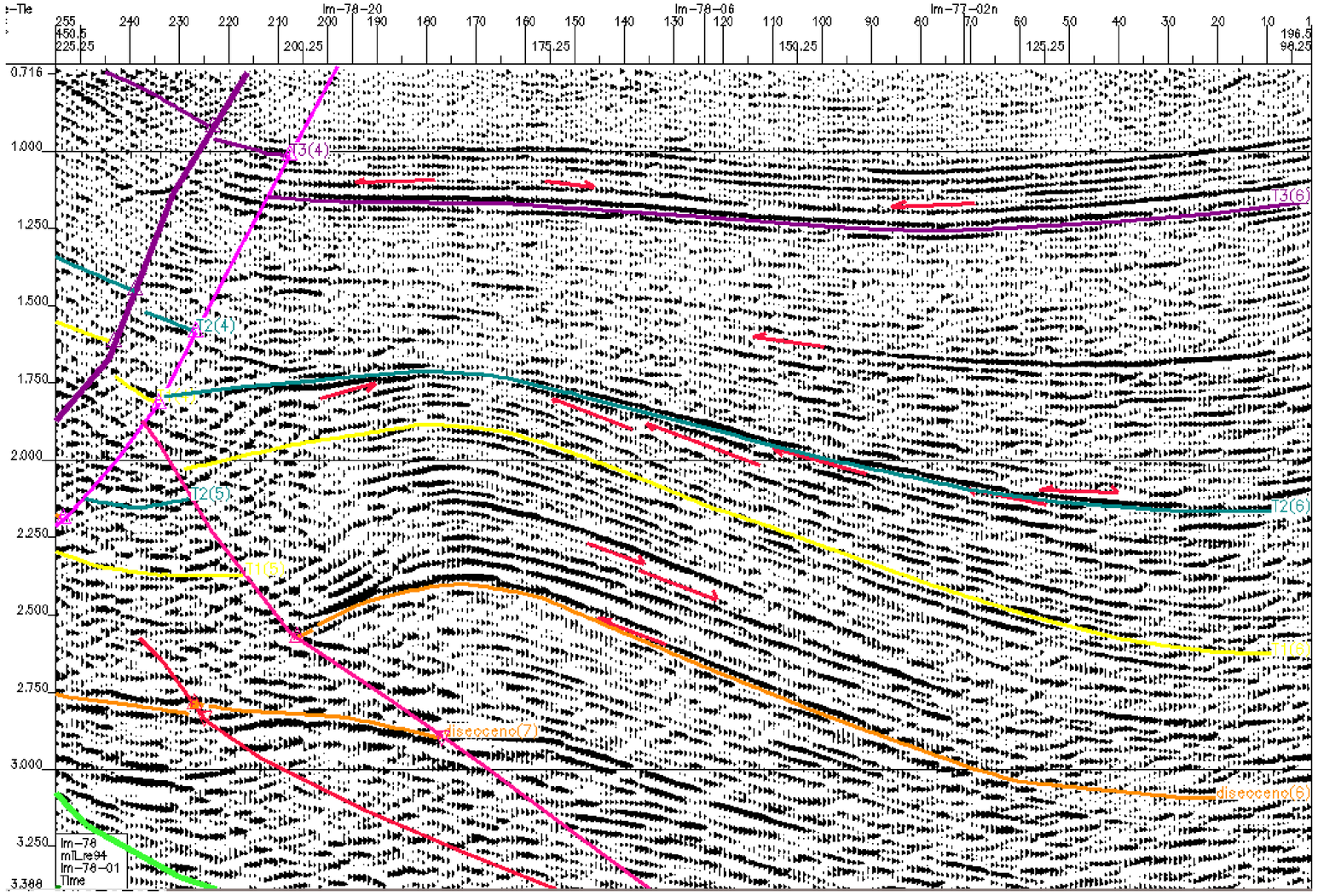
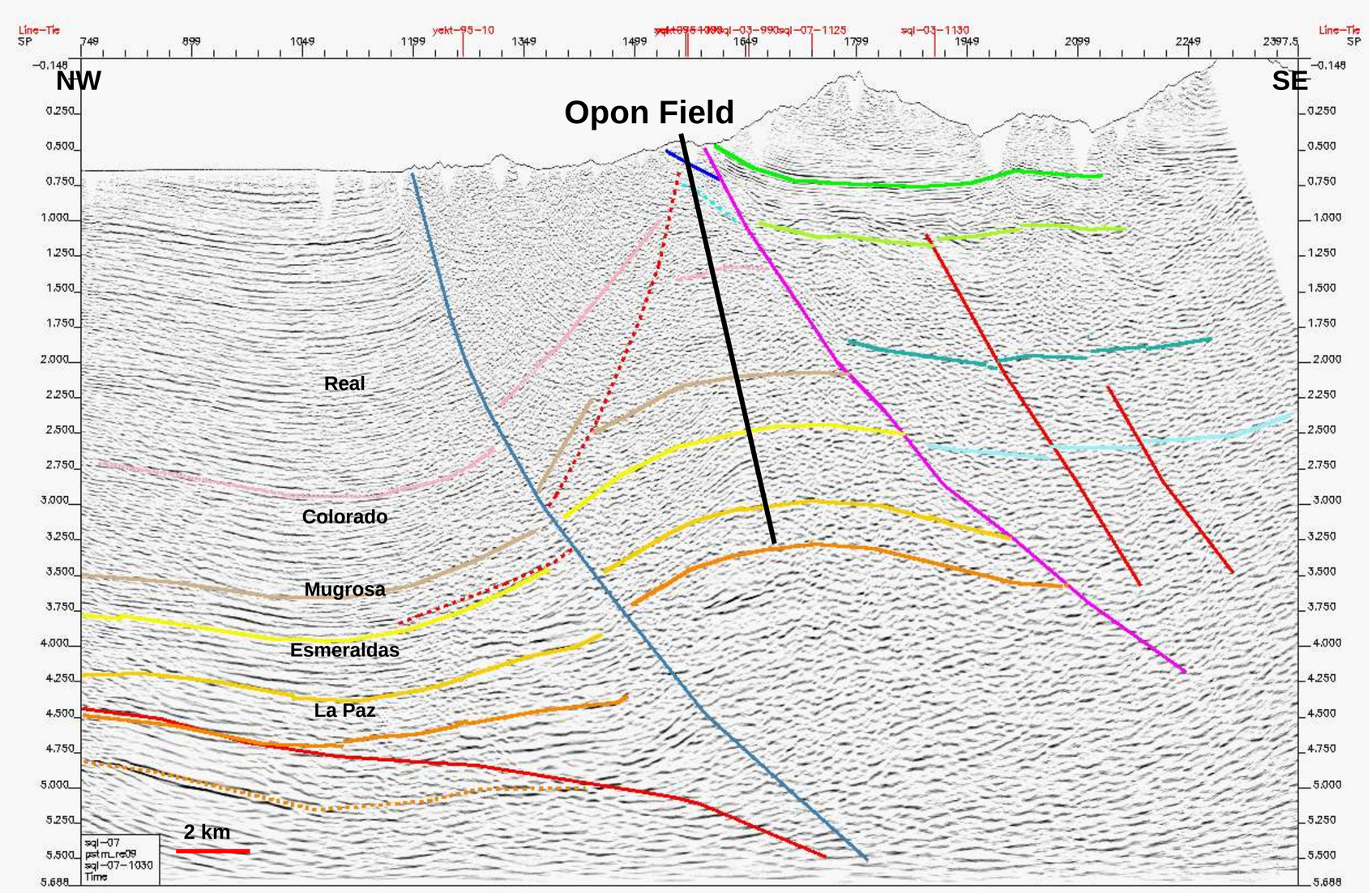
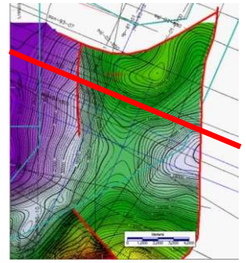
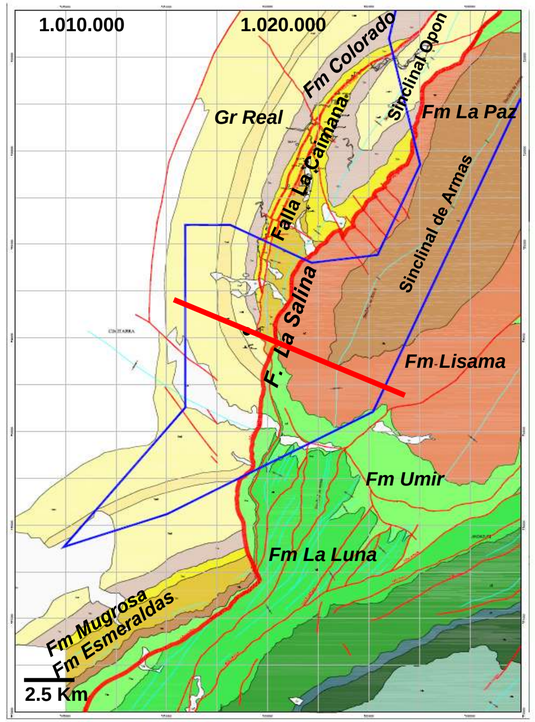


Opon Field Area: SQL-07-1030

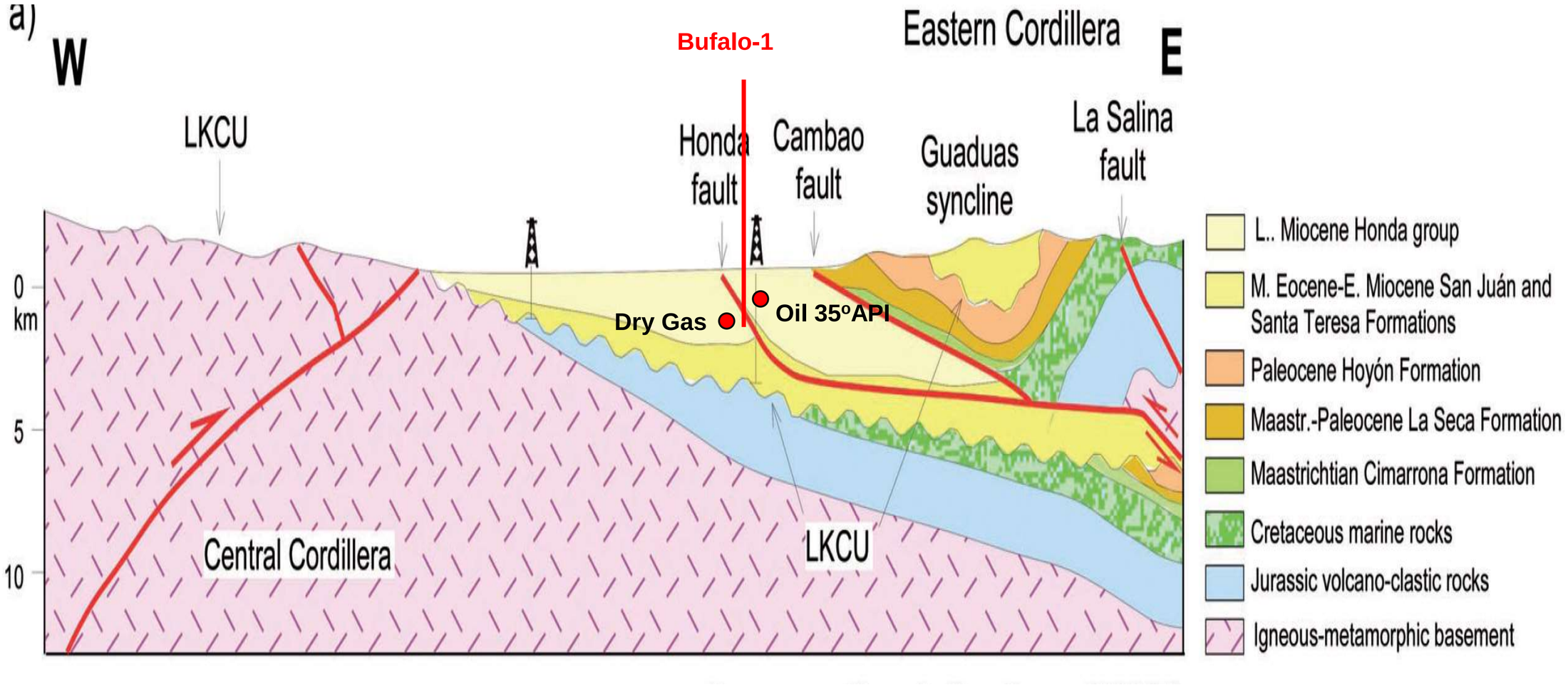






Búfalo-1 Discovery

Bufalo – 1 Discovery: Western Foothills of the Eastern Cordillera



Source ANH

COLOMBIA ROUND 2021

AGENDA

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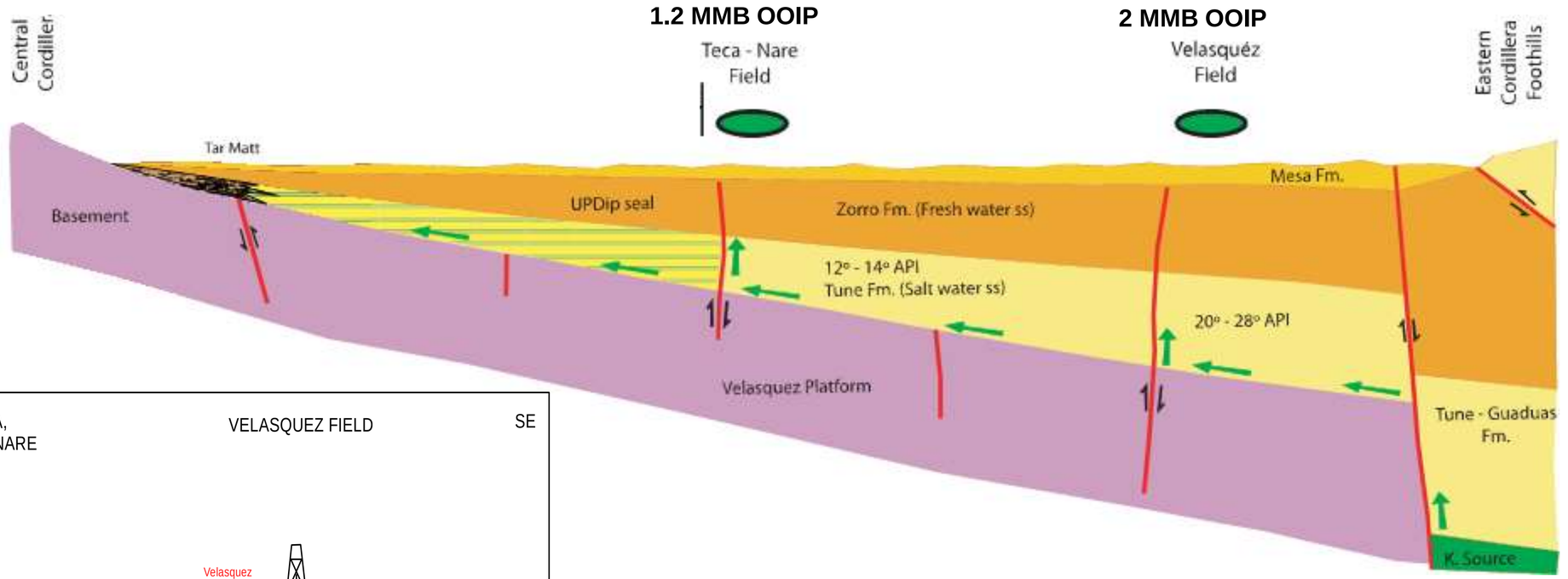
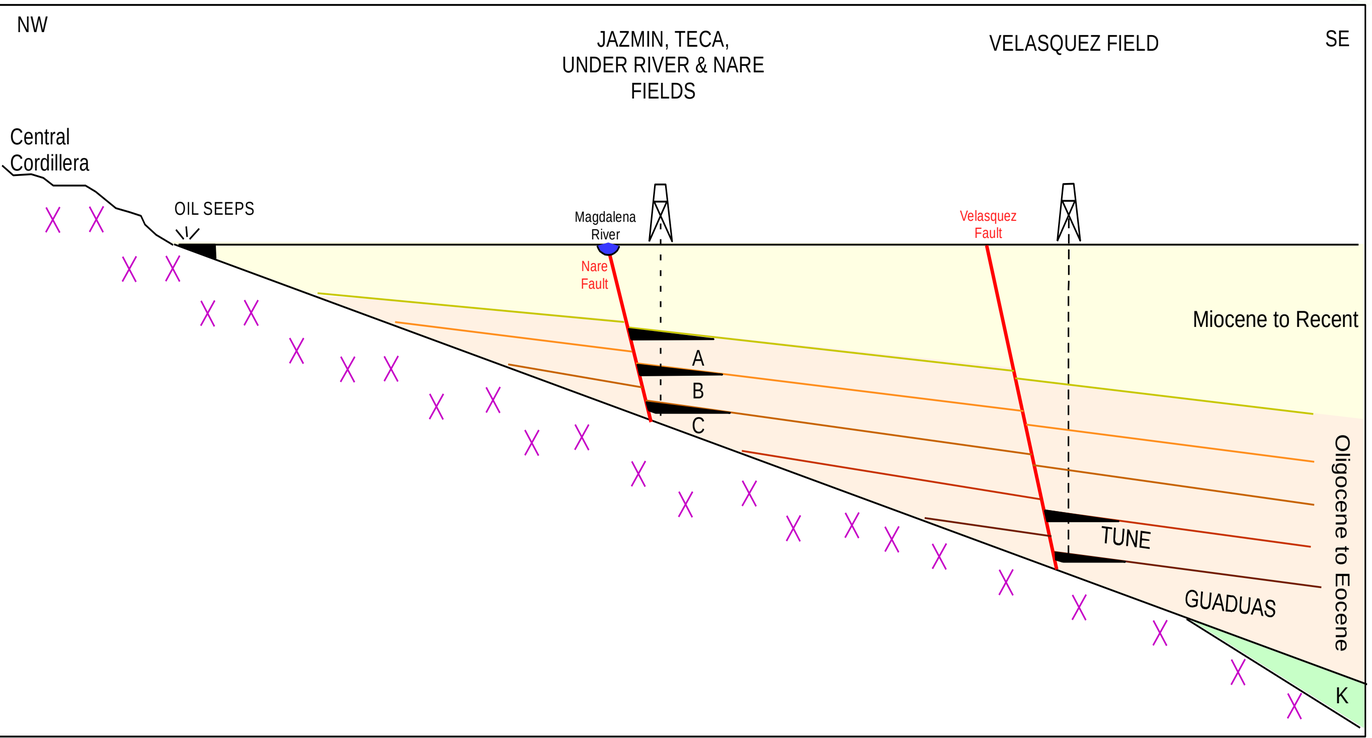
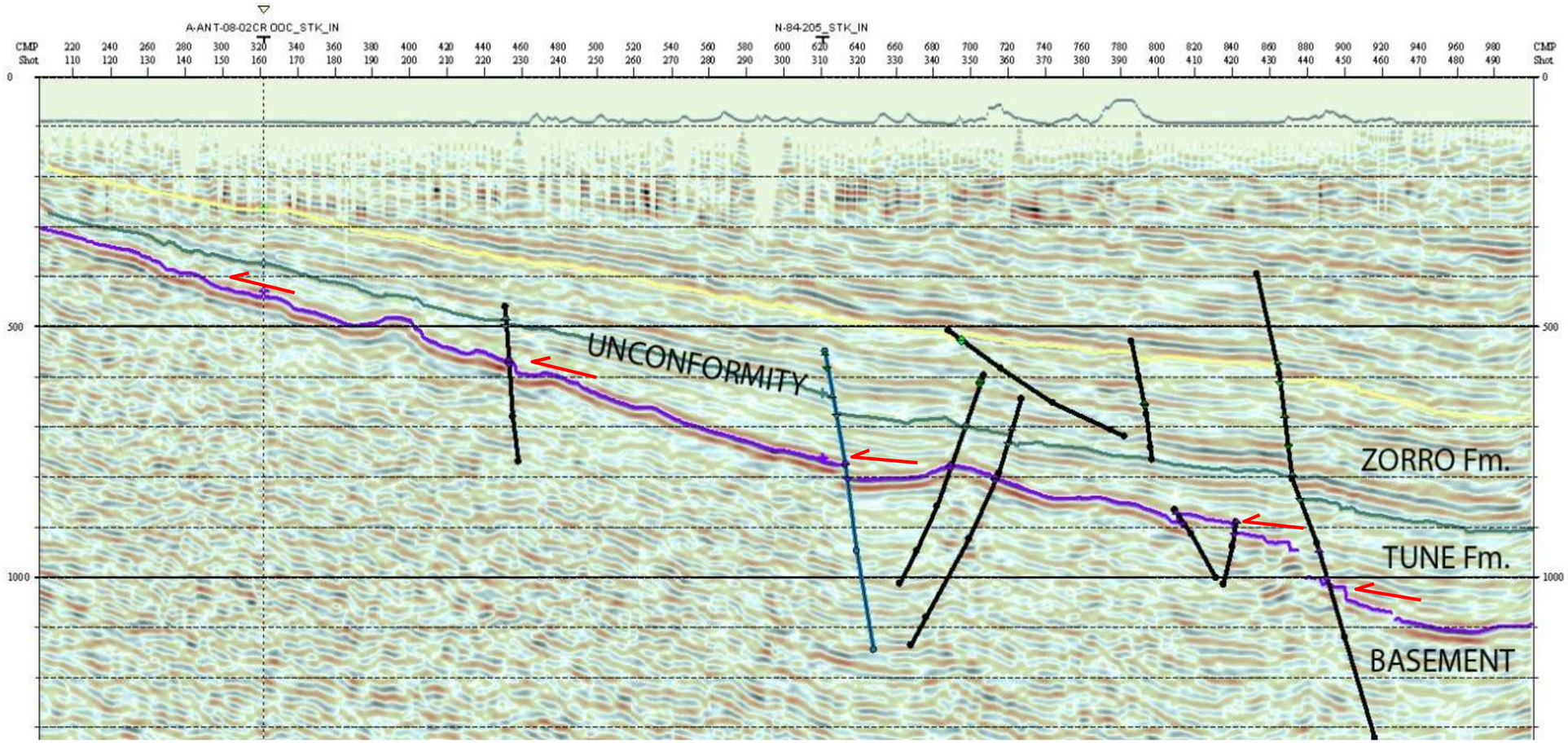
West – Central Zone of the MMVB Play Concept





West – Central Zone of the MMVB:
(Seismic Line L-1984-214)

Antorcha



COLOMBIA ROUND 2021

AGENDA

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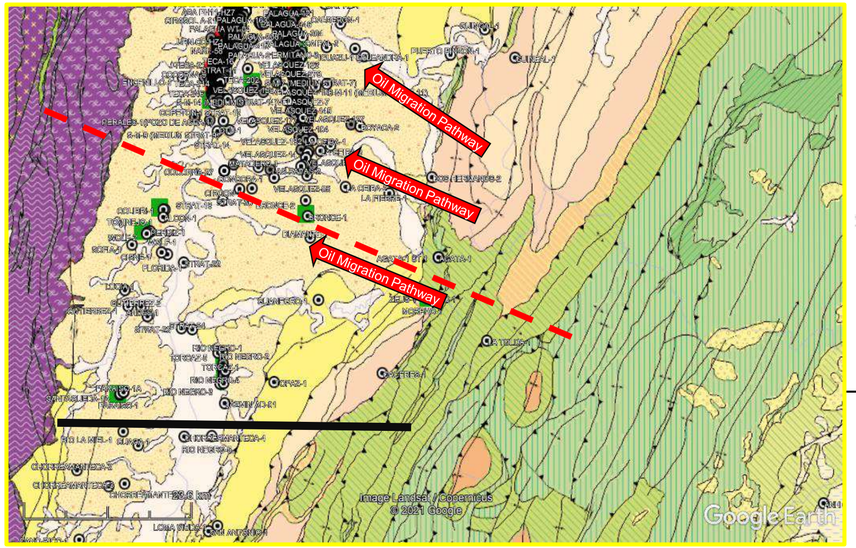
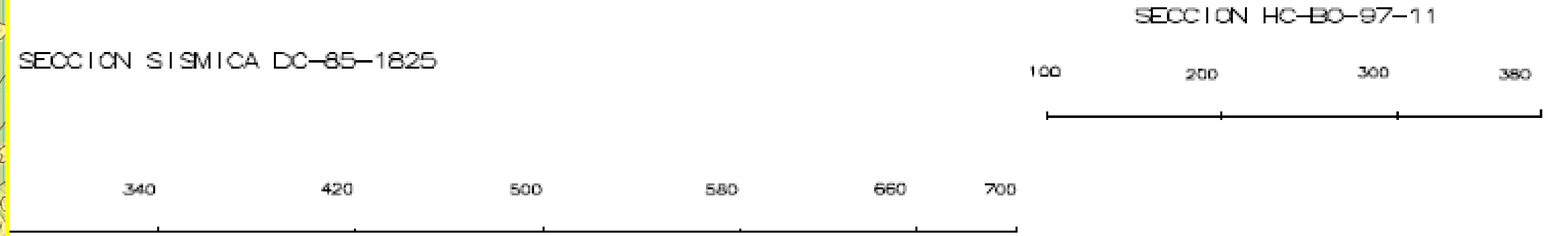
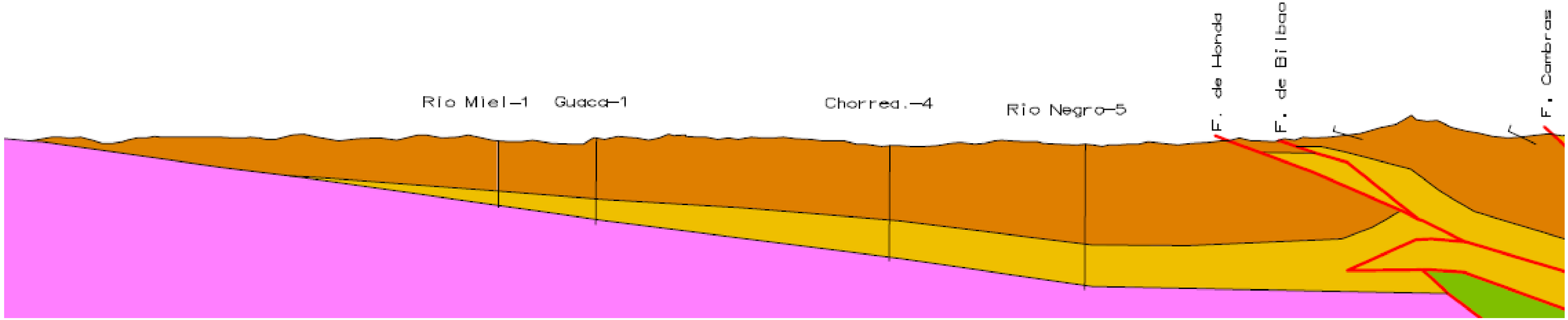
South Zone of the MMVB
Seismic Line DC-1985-1825



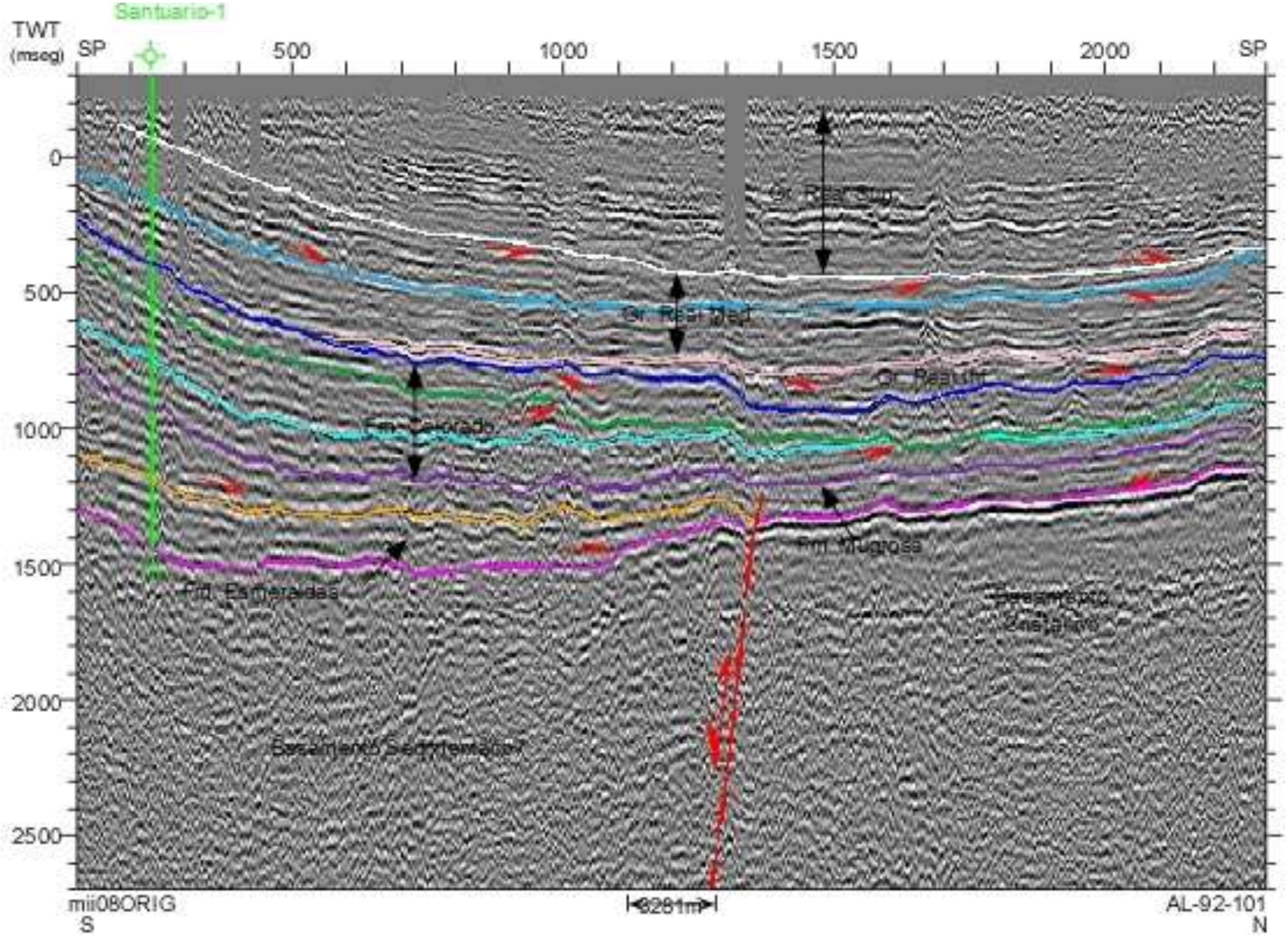




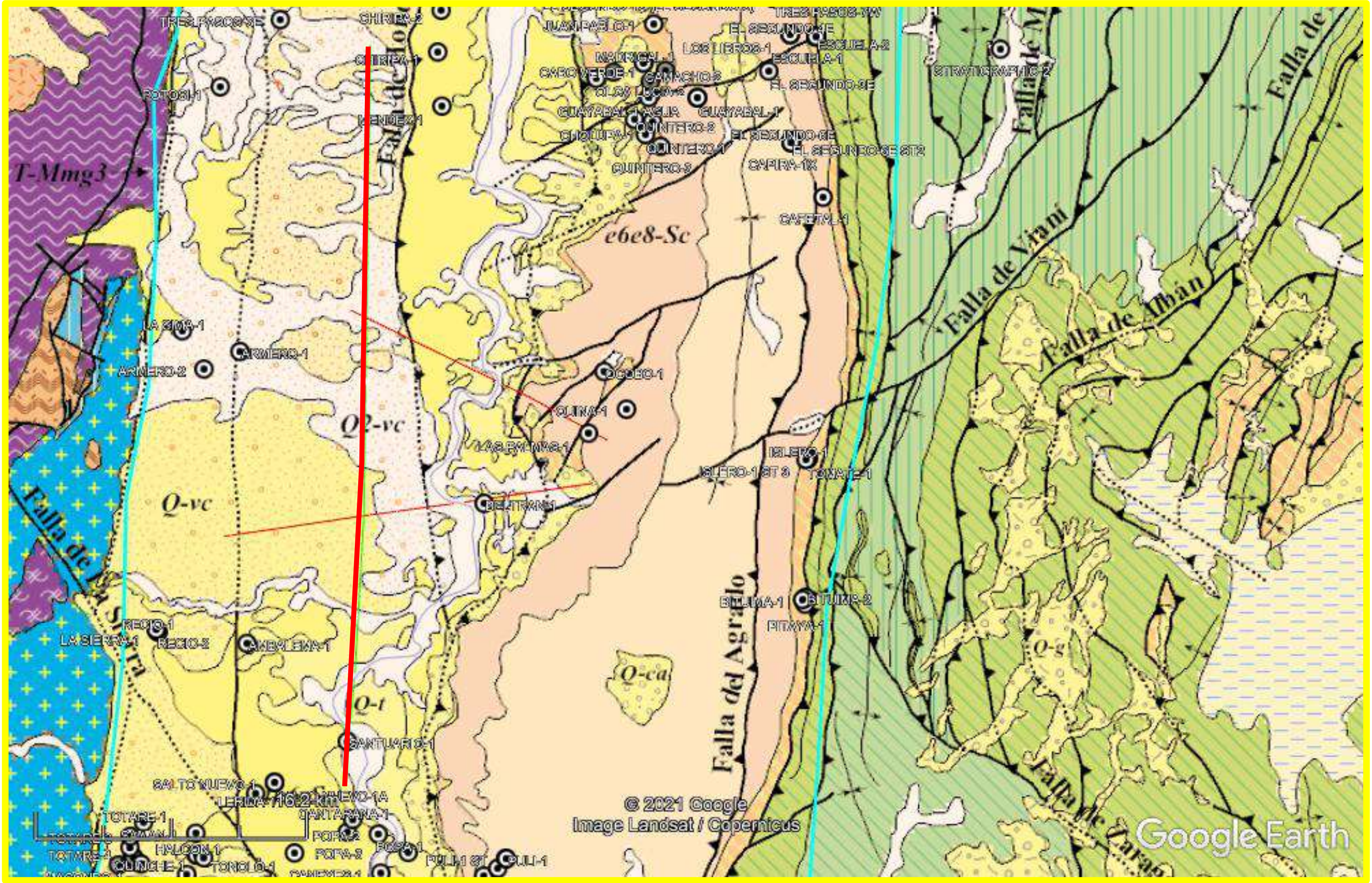
Source Linares, (1998)

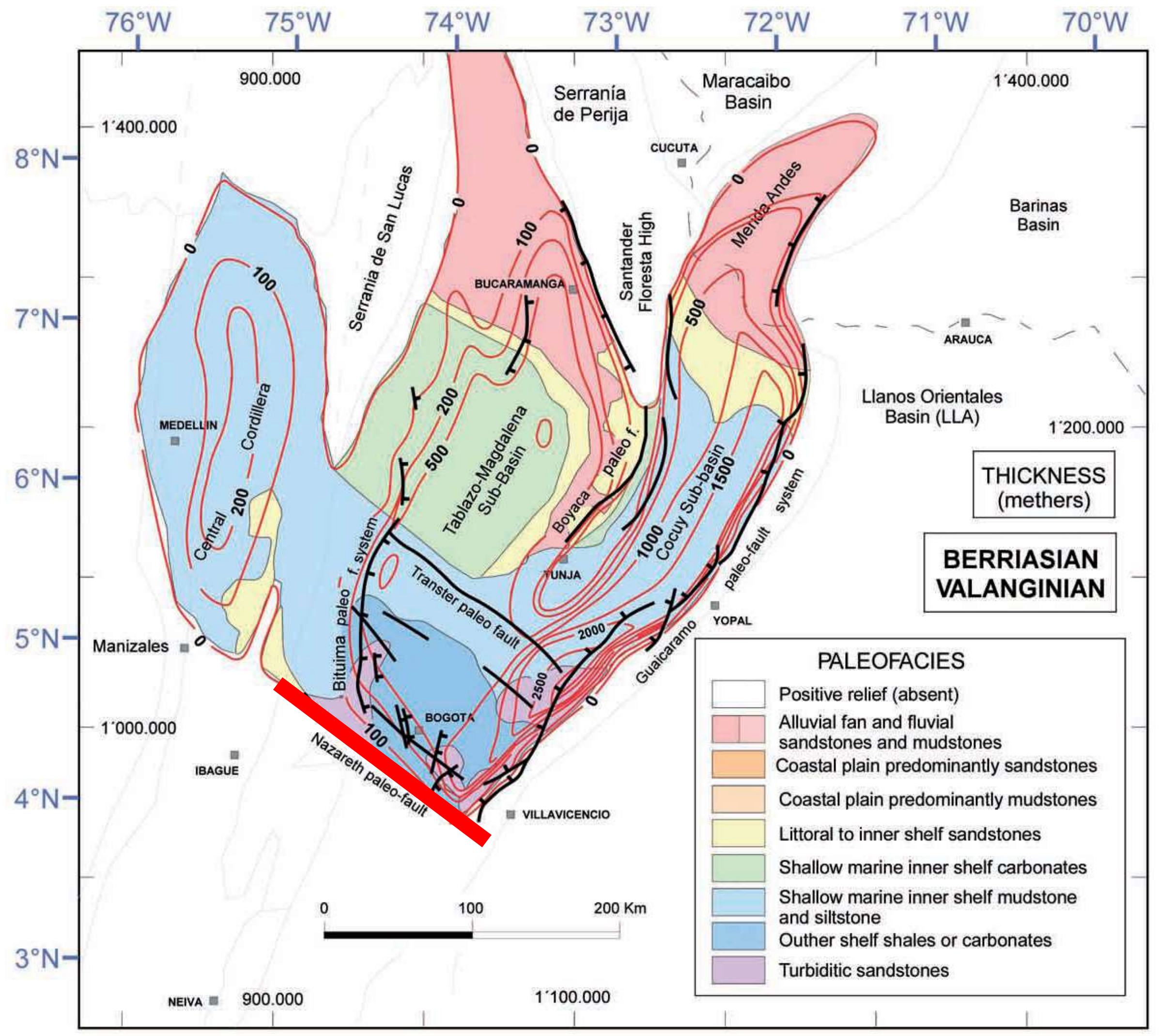
South Zone of the MMVB:

Seismic Line AL-1992-101

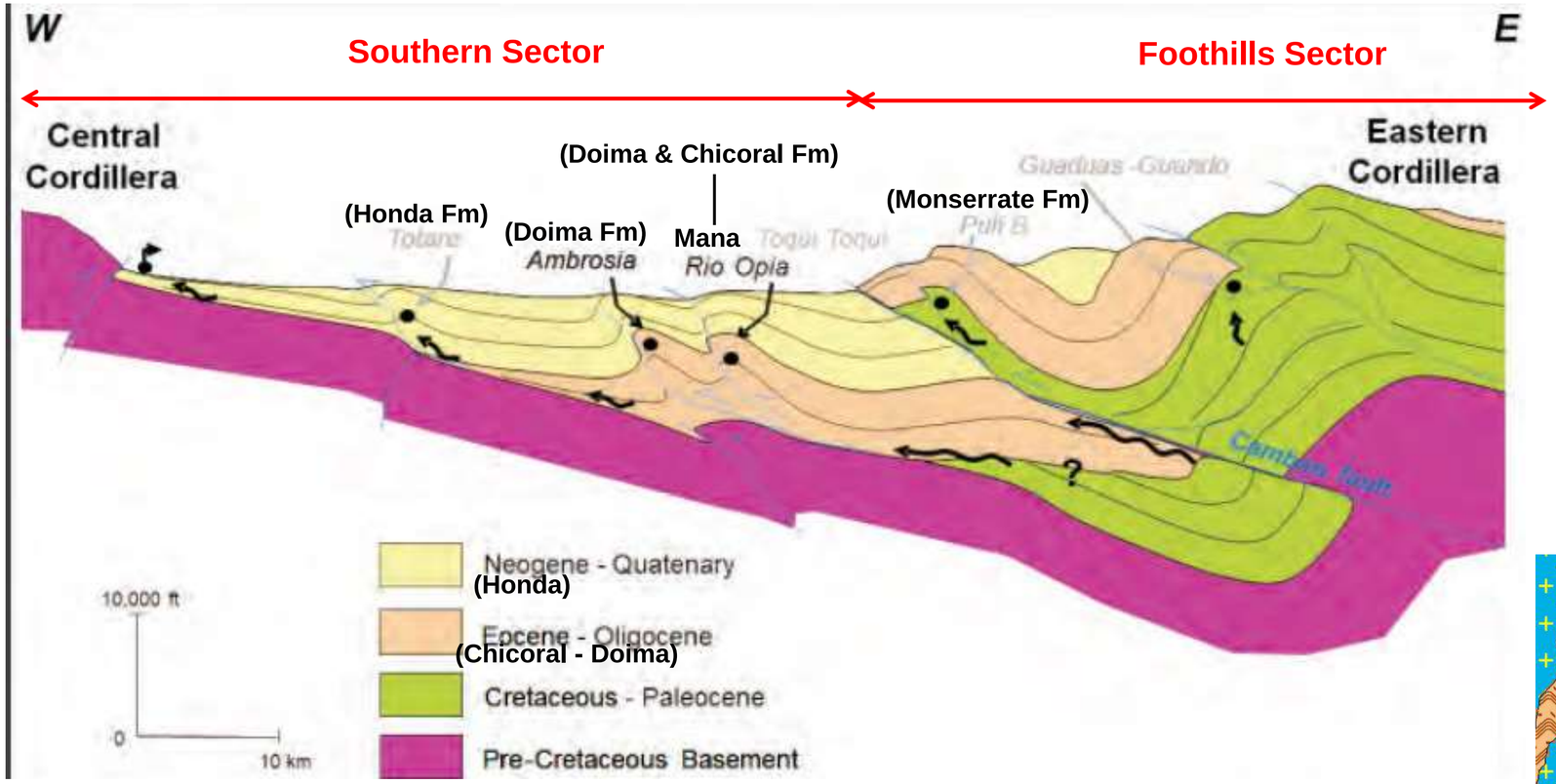


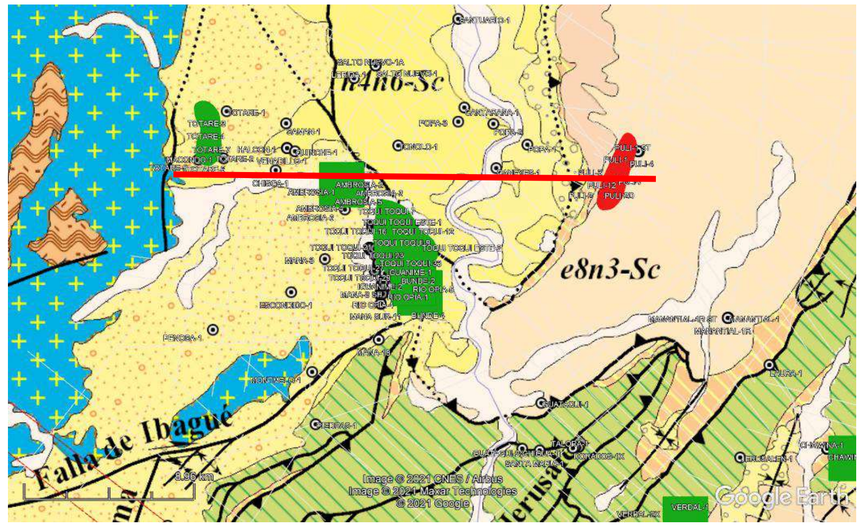
Source ICP (1998)





COLOMBIA ROUND 2021 South Zone of the MMVB:
Fields Totare, Ambrosia, Rio Opia, Toqui Toqui & Puli



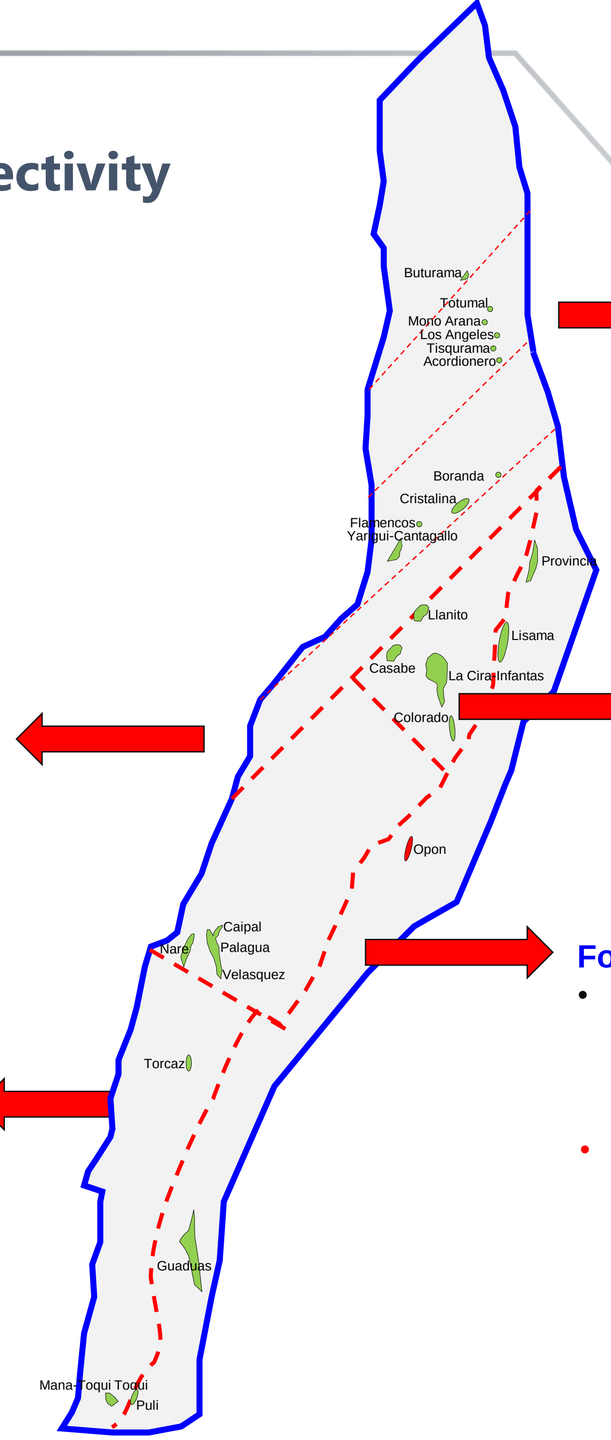


Source: ANH

Conclusions & Prospectivity

Conclusions & Prospectivity

- New ideas for Old Basins
- A new Tectonic Provinces Division is proposed
- The new proposal need additional multidisciplinary studies
- The new proposal has consequences in the hydrocarbon prospectivity:



North Zone

- Structural Traps:
  - In Cretaceous Limestones as in Buturama, Olivo, Cayena, etc.
  - In Upper Cretaceous & Paleocene as in Acordionero, Mono araña, etc.
- Stratigraphic Traps:
  - In Tertiary (mainly Eocene) as in Boranda, Flamencos, etc.

East Central Zone

- Structural Traps:
  - In Tertiary as in La Cira-Infantas, Aguas Blancas, Colorado, etc.
- New Plays
  - Structural Traps in Cretaceous & Paleocene
  - Stratigraphic Traps in Tertiary (3D required)

Foothills Zone

- Structural Traps:
  - In Tertiary as in Provincia, Opon, etc.
  - In Upper Cretaceous & Paleocene as in Lisama, La Tigra, etc.
- New plays:
  - Footwall of thrust as in Bufalo, etc.

West Central Zone

- Structural Traps:
  - In Tertiary as in Velasquez, Palagua, Caipal, Nare, etc.
- New Plays
  - Stratigraphic Traps in Tertiary (3D required)

South Zone

- Structural Traps:
  - In Tertiary as Mana, Toqui Toqui, etc.
  - In Upper Cretaceous & Paleocene as in Puli, etc.
- New Plays
  - Stratigraphic Traps in Tertiary (3D required)

Thanks

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14/05/2021