

Shale Gas Potential in the Eastern Cordillera of Colombia*

Mario Garcia-Gonzalez¹

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¹Geology, Universidad Industrial de Santander, Bucaramanga, Colombia mgarciag@uis.edu.co

Abstract

A preliminary estimation of the shale gas potential of the Eastern Cordillera reveals a gas resource of 37 TCF which was calculated on the basis of organic-rich shales, vitrinite reflectance, formation thickness and size of the large structures in the Cordillera. The Eastern Cordillera of Colombia contains a thick sedimentary sequence that ranges from Late Paleozoic to Middle Miocene in age, where the Cretaceous sequence contains siltstones, shales and mudstones with two organic rich levels that present excellent shale gas potential.

The main shale gas reservoirs are the Turonian-Coniacian sequence that correspond to the Luna and Chipaque formations. Gas potential of these formations is indicated by high TOC content that ranges from 1 to 8% with mean TOC value of 4.5% in the La Luna Formation and 2% in the Chipaque Formation. A predominance of Kerogen type II has been identified in the La Luna Formation, and a mixture of Kerogen II and III dominates in the Chipaque Formation. Thermal maturation of the La Luna and Chipaque formations changes regionally from 0.5% on the eastern and western boundaries of the Cordillera to 2% on the axis of the Eastern Cordillera.

Lateral facies changes are observed from east to west, exhibiting toward the east siltstone and sandy shales in the Chipaque Formation that change to mudstone. The La Luna Formation presents siltstone and mudstone facies, and outcrop mostly toward the west side of the Eastern Cordillera. The Villeta Formation of Albian to Cenomanian age also presents shale gas potential, which is indicated by high TOC values from 1 to 2%. The main shale gas potential is related to the relatively high vitrinite reflectance values that can reach up to 2.5% in the axis of the Cordillera, indicating that large quantities of thermal gas have been generated.

Major anticlinal structures with Lower Cretaceous organic-rich shale have been identified. These anticlines present organic-rich rocks in the nucleus and are covered by Upper Cretaceous shales that act as seals in these prospects. Other important structures for Cretaceous shale gas are monoclines associated with thrust faults, which are located in the axis and the west flank of the Cordillera.

Selected References

Sarmiento, R.L.F., 2002, Occurrence of submarine exhalative Pb-Zn ore deposits in Cretaceous sedimentary rocks of the Eastern Cordillera, Colombia: Boletín de Geología Bucaramanga, v. 24/39, p. 49-72.

Villamil, T., 1998, Chronology relative sea-level history and a new sequence stratigraphic model for basinal cretaceous facies of Colombia, *in* Paleogeographic Evolution and Non-Glacial Eustasy, Northern South America: SEPM Special Publication, v. 58, p. 161-216.

Etayo, S.F., de-P.N. Sole, J. de-Porta, and T. Gaona, 2003, The Bata Formation of Colombia is truly Cretaceous, not Jurassic: Journal of South American Earth Sciences, v. 16/3, p. 113-117.

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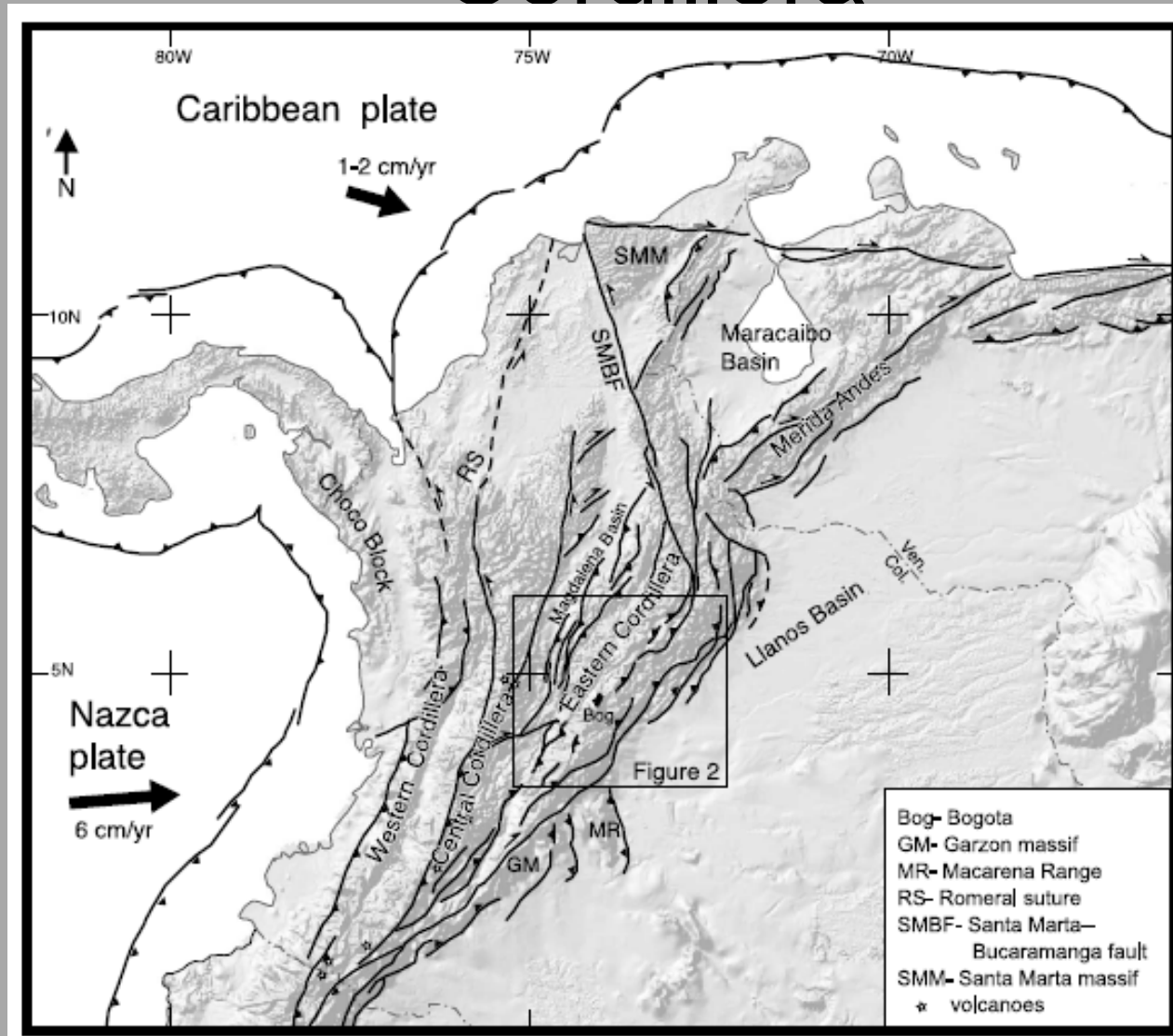
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Research Group on Hydrocarbon and Coal Geology

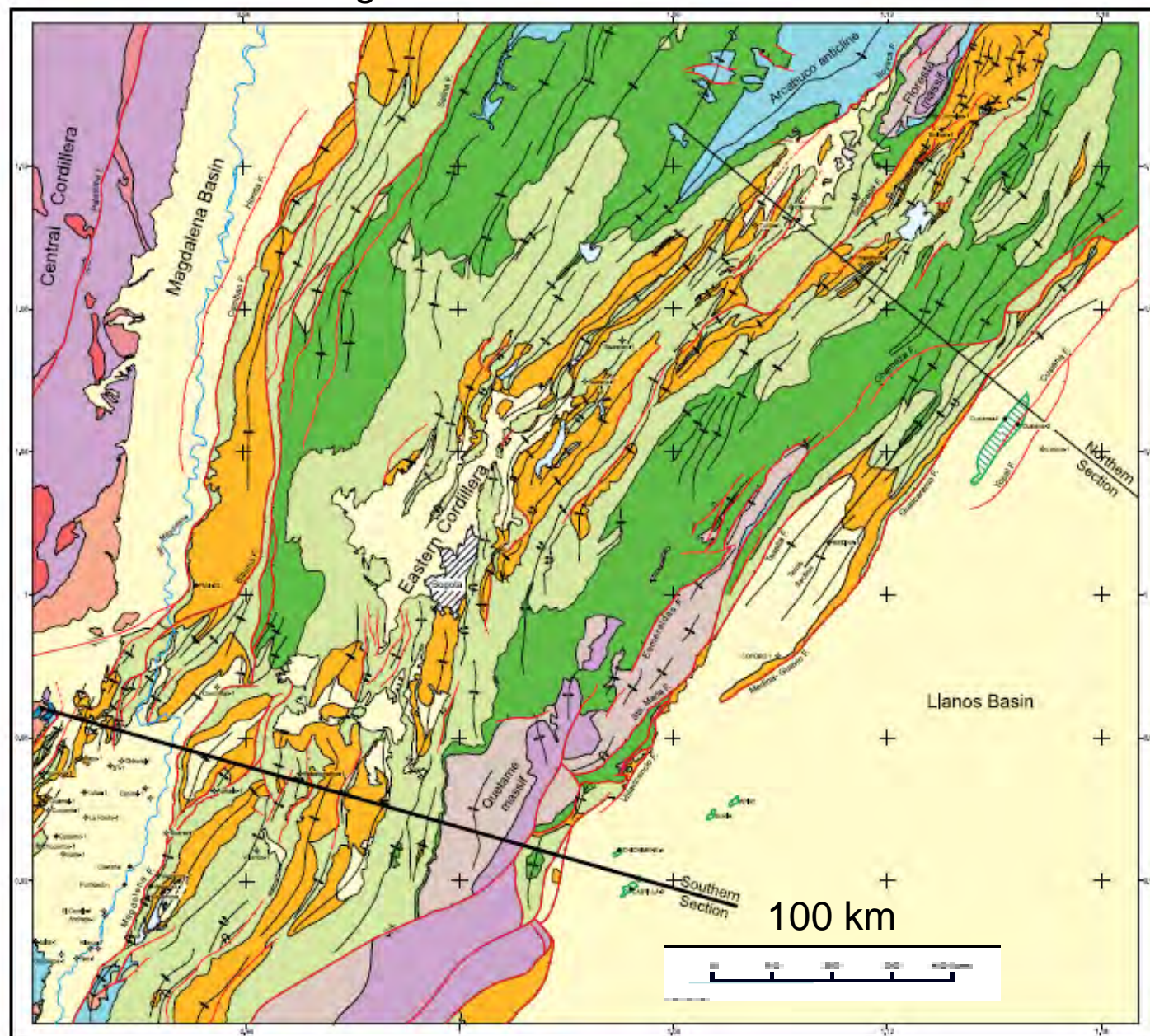
Universidad Industrial de Santander

AAPG International Conference & Exhibition Calgary September, 2010

Tectonic Setting of the Eastern Cordillera



Central region of the Eastern Cordillera



Sedimentary Rocks

- Neogene-Quaternary
- Paleogene
- Late Cretaceous
- Early Cretaceous
- Late Jurassic
- Triassic
- Paleozoic

Igneous and Metamorphic Rocks

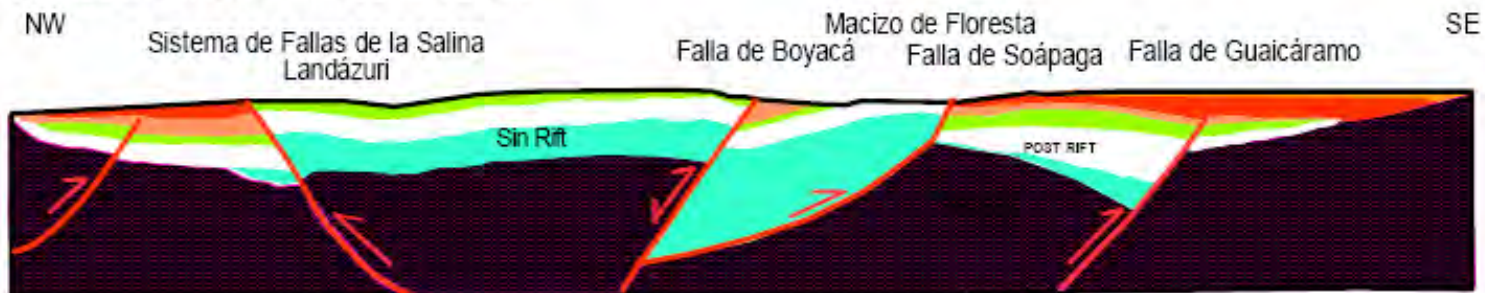
- Tertiary volcanic rocks
- Tertiary pluton
- Cretaceous pluton
- Jurassic pluton
- Paleozoic crystalline basement
- oil field (approx.)

Sedimentary Rocks

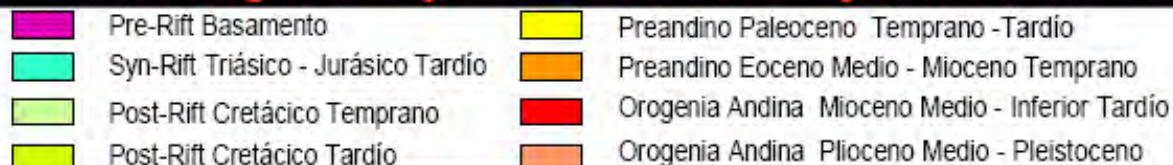
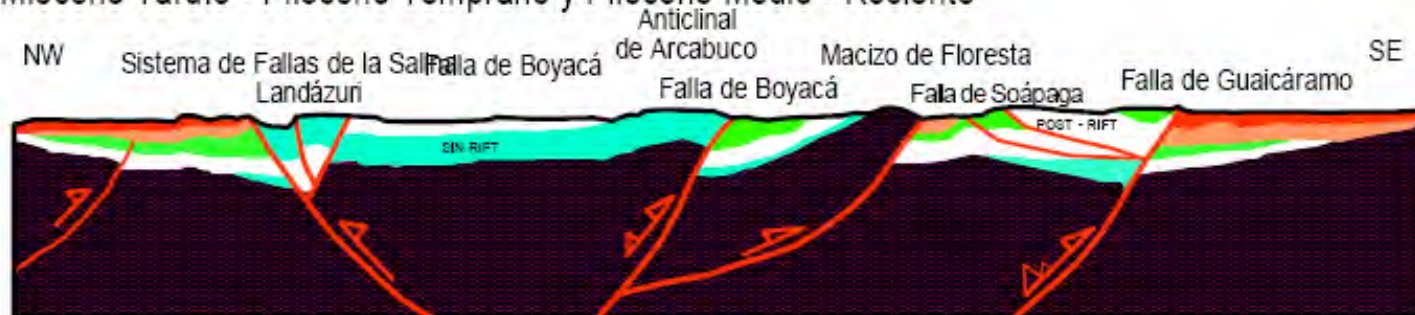
0 10 20 30 40 km

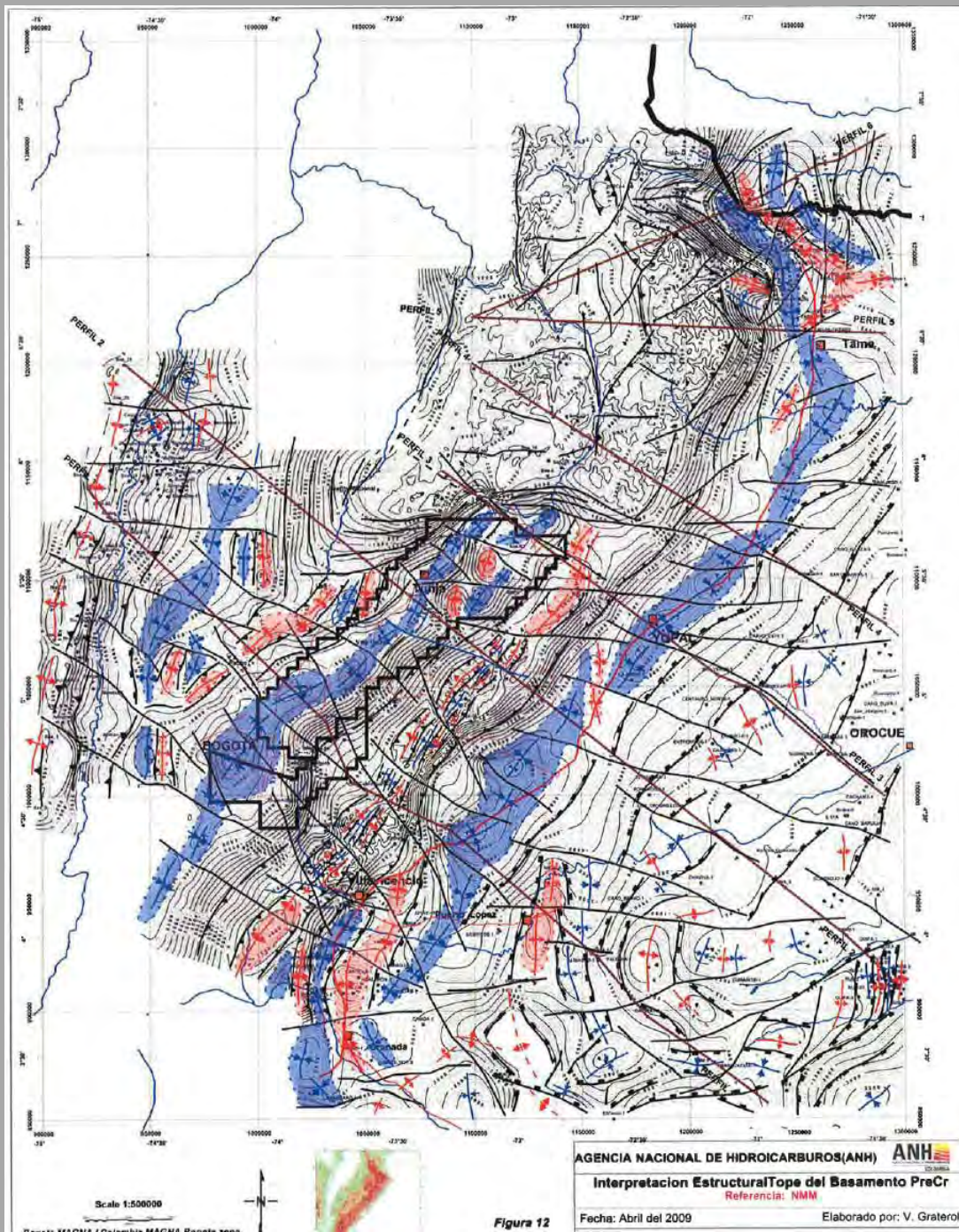
Structural Evolution of the Eastern Cordillera

E.Mioceno Medio - Mioceno Tardío



F.Mioceno Tardío - Plioceno Temprano y Plioceno Medio - Reciente





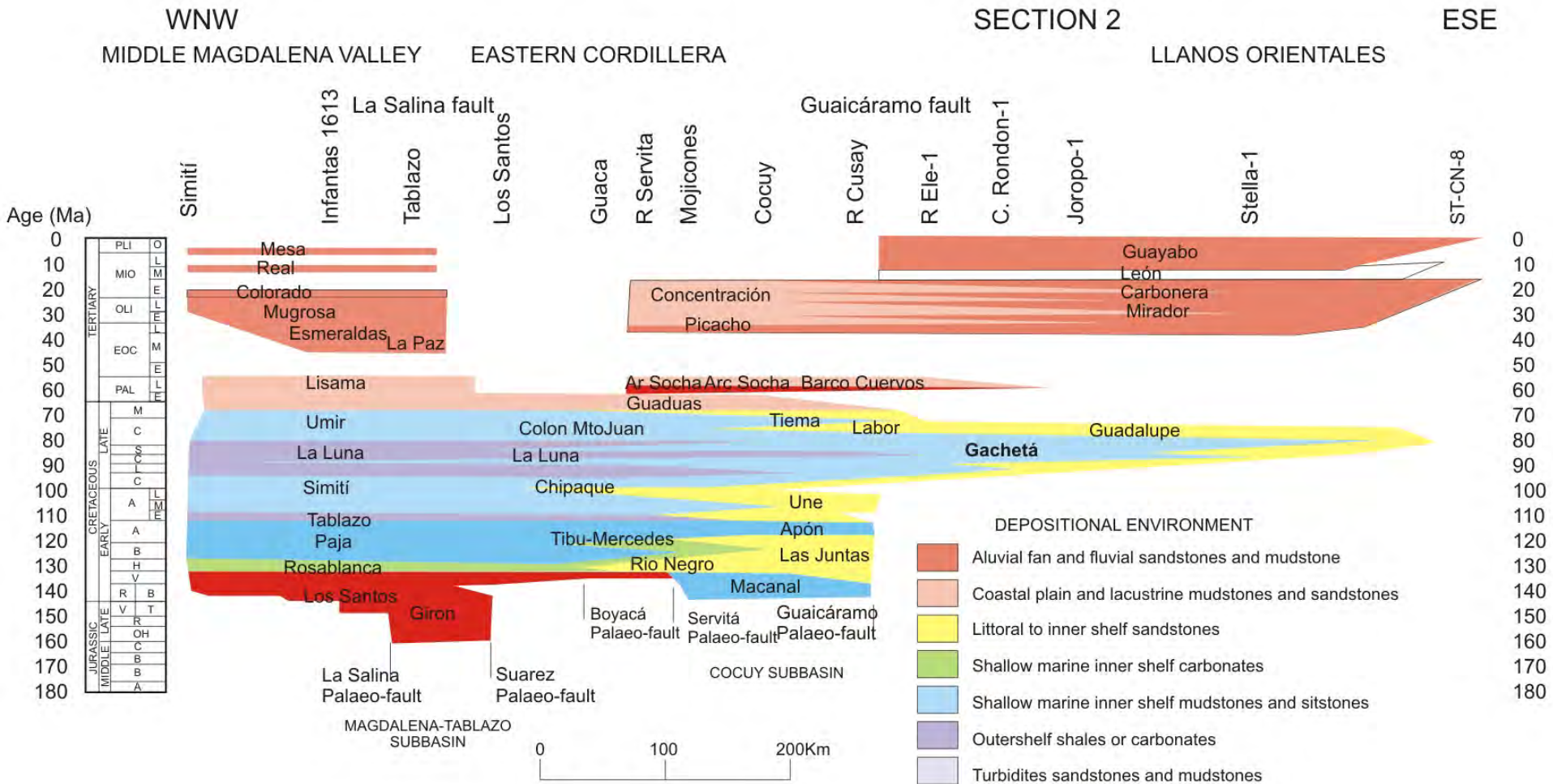
Structural contour map of the Pre – Cretaceous Top Eastern Cordillera.

- 1) Llanos Foothill sub-basin
- 2) Axis of the Eastern Cordillera
- 3) Guaduas Syncline

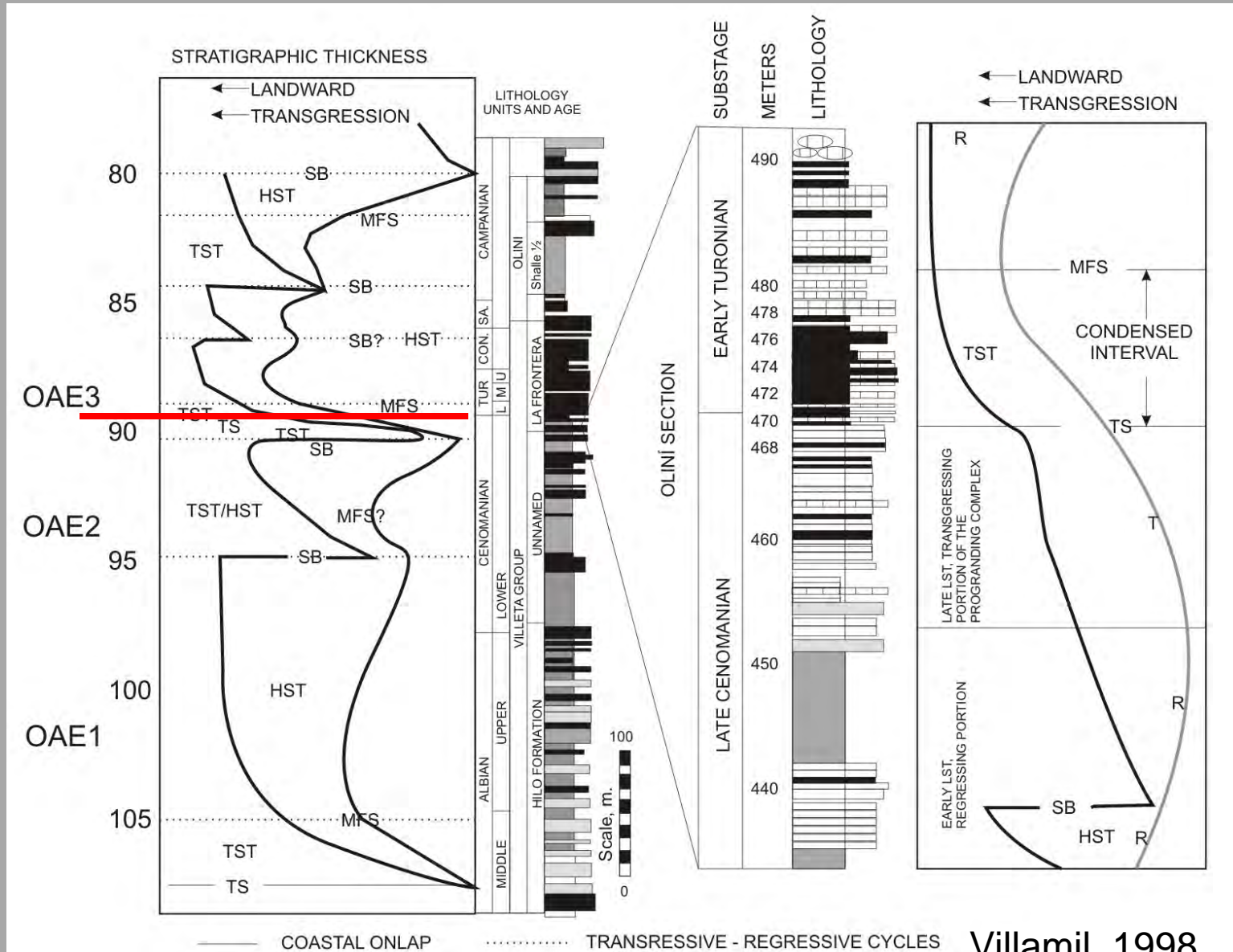
Sub-basins present Cretaceous Sequence 3 to 6 km thick

ANH (2009)

Stratigraphic Framework of the Eastern Cordillera Colombia



ORGANIC ANOXIC EVENT IDENTIFIED IN THE LA LUNA AND CHIPAQUE FORMATIONS ASSOCIATED TO HIGH TOC CONTENT



Villamil, 1998

Hydrocarbon source rocks with high TOC and HI contents

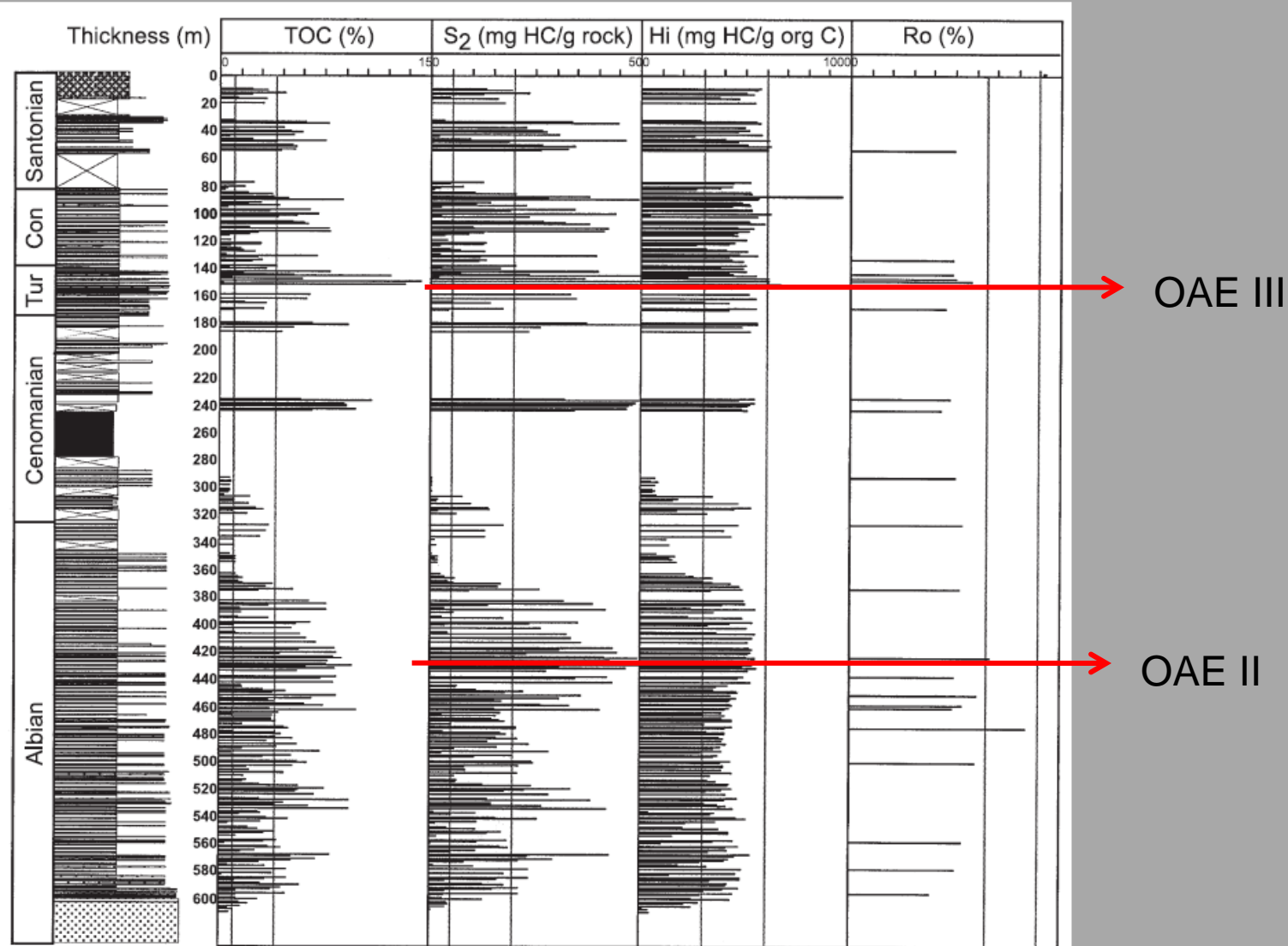
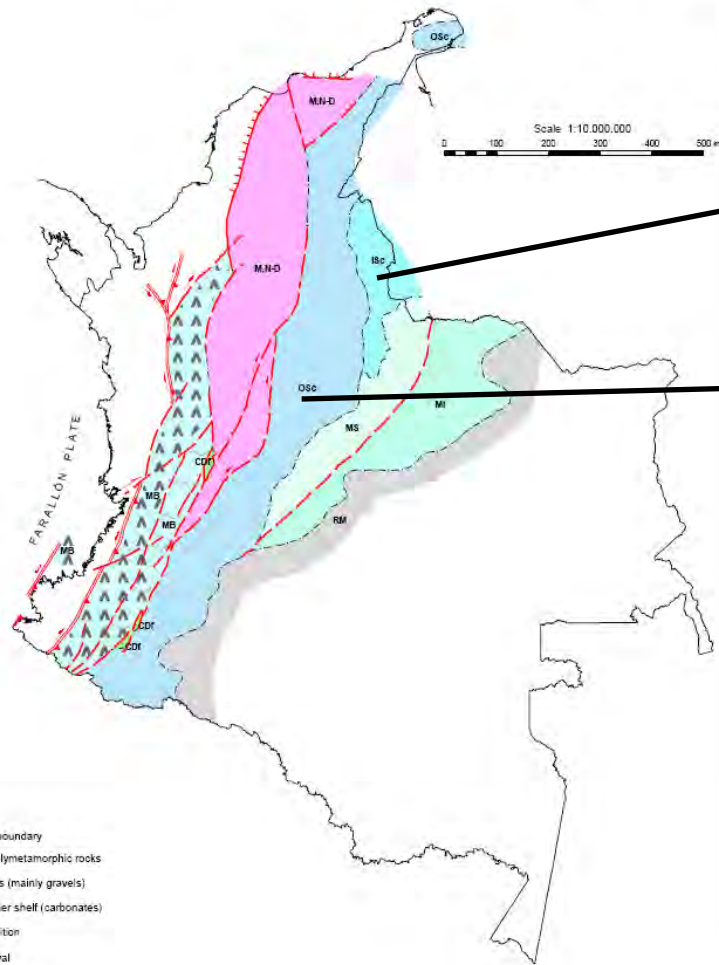


Figure 16. Geochemical profile (270 samples) of the Villeta Formation (La Luna Formation equivalent), Oliní reference section, Upper Magdalena Valley (see Figure 3). High TOC intervals within the Albian, Cenomanian, Turonian, and Coniacian suggest oxygen depletion and high rates of organic matter preservation, at least partially coincident with OAE II and OAE III.

Villamil, 1998

SEDIMENTARY FACIES DISTRIBUTION AND TECTONIC SETTING
OF COLOMBIA THROUGH THE PHANEROZOIC

MAP 10
TURONIAN



Distribution of

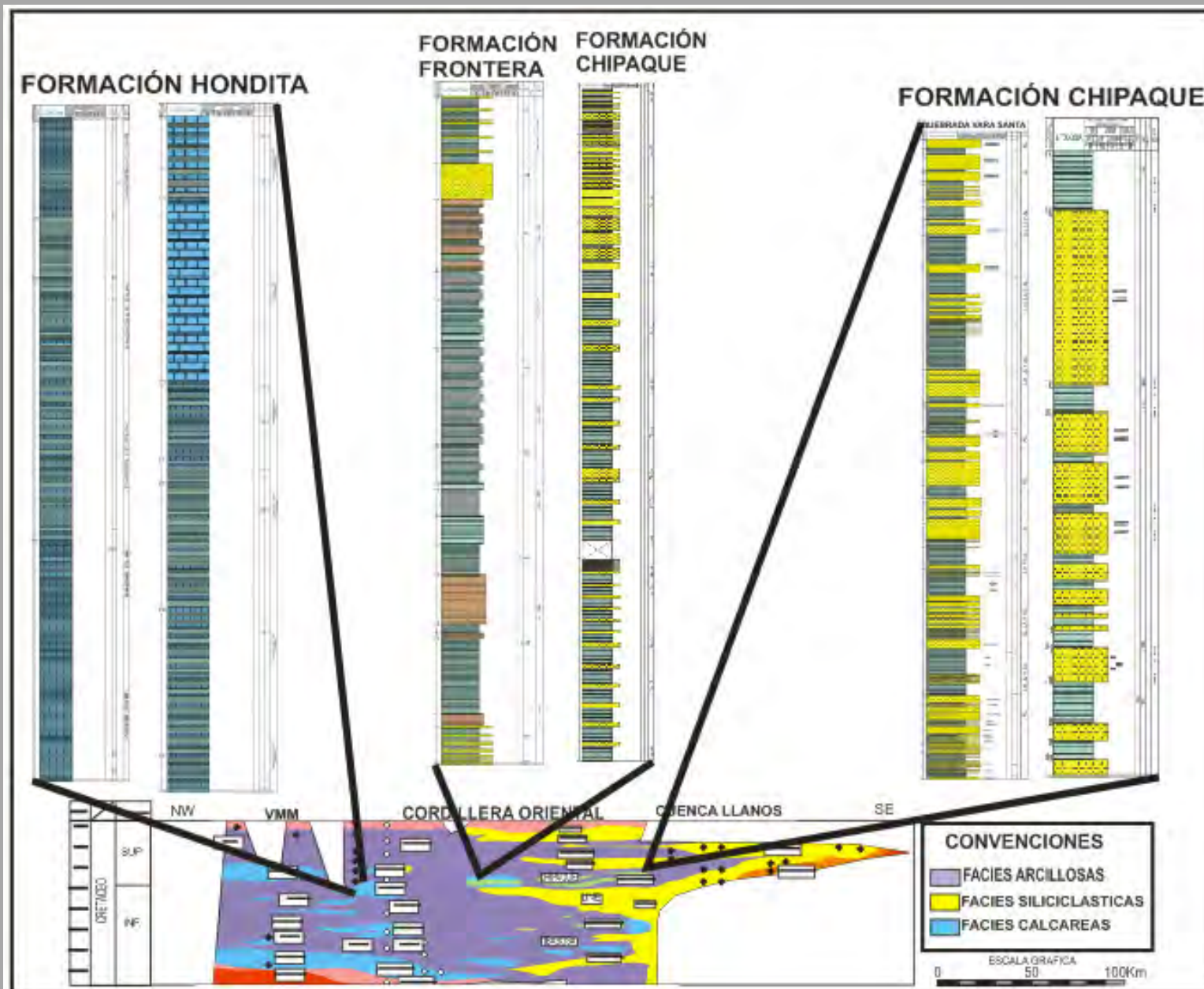
Shallow marine carbonates facies

Outer shelf carbonates facies

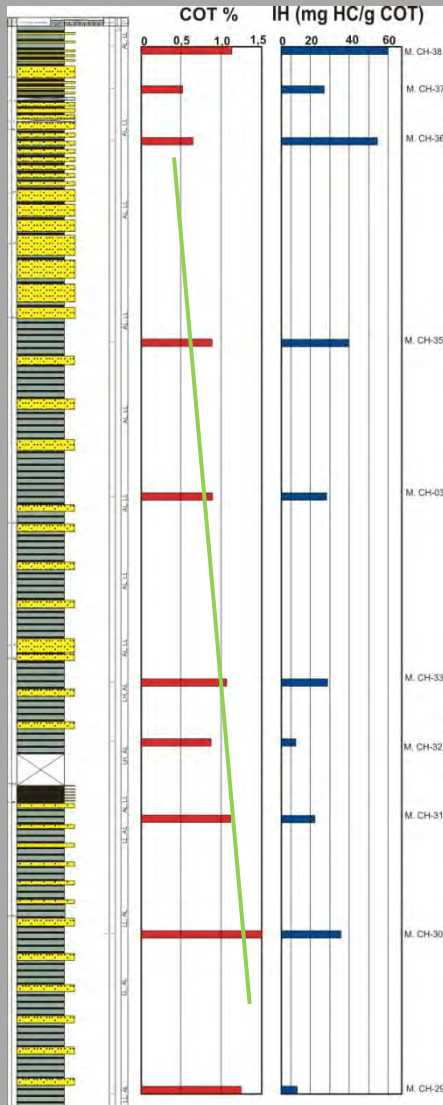
During Turonian

After Etayo et al., 2003

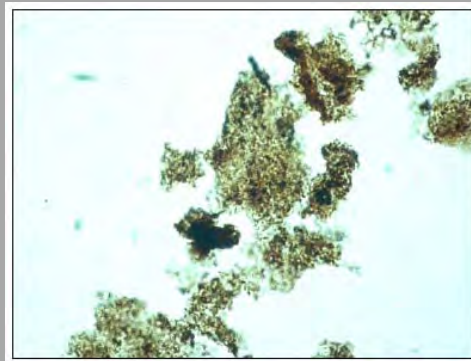
Lateral Facies variation across the Eastern Cordillera in Cenomanian-Turonian Stratigraphic sections



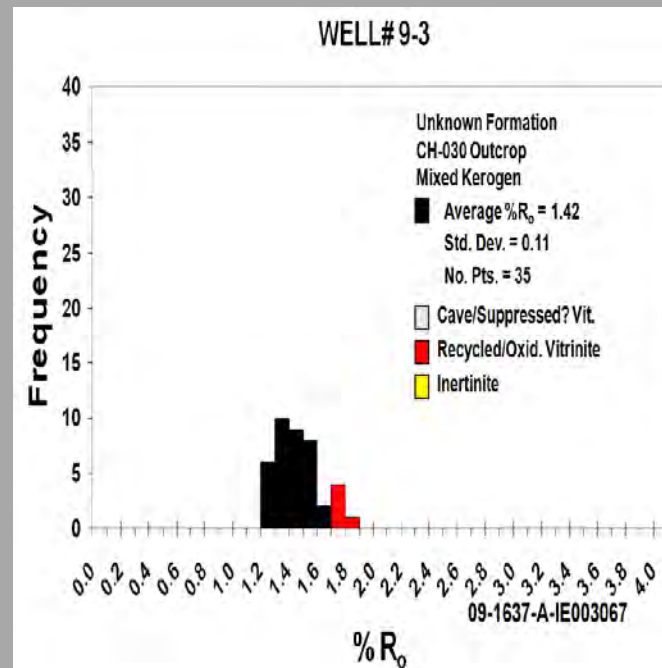
Chipaque Fm. Crucero section



TOC increases from top to base of the Fm

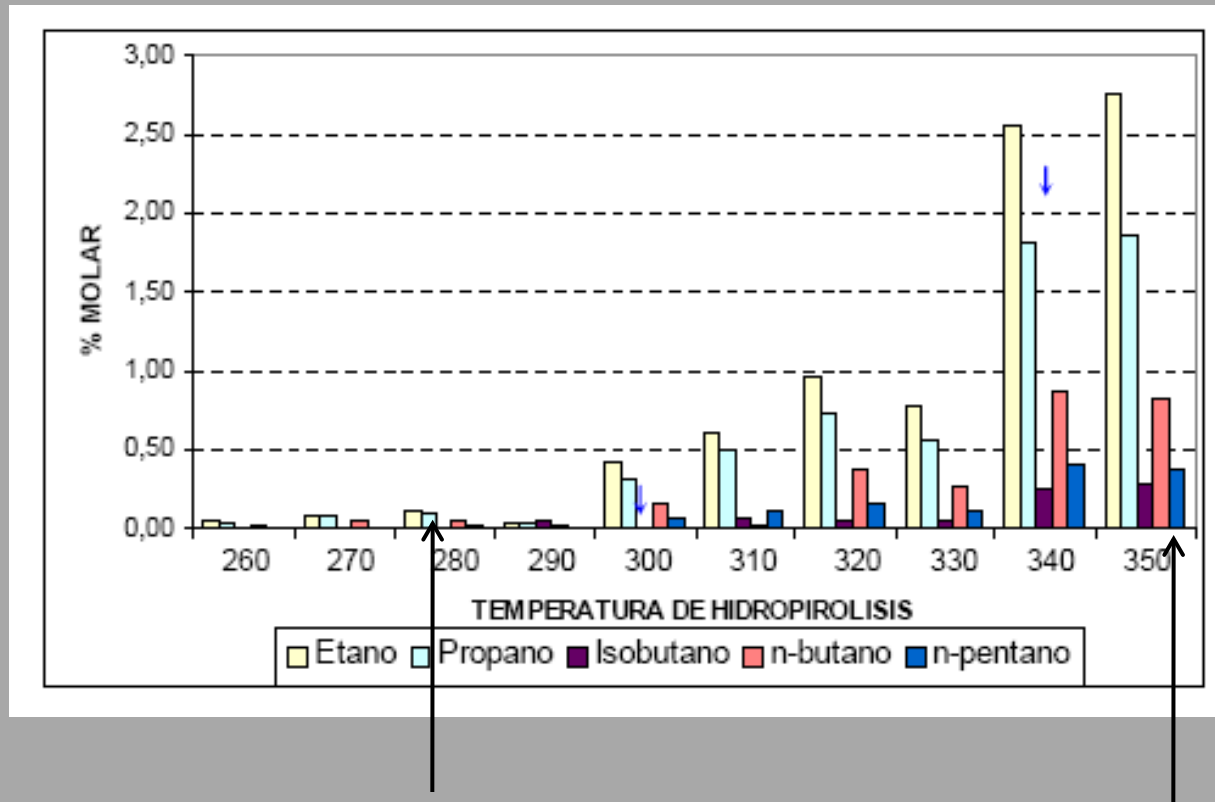


Kerogen II and III



Average Ro 1.4%

Generation of hydrocarbon gases from TOC rich shales of the Chipaue Fm during hydrous pyrolysis experiments



Ro = 0.5% 30 cft gas/Ton rock

Ro = 1.9%. 230 cft gas/Ton rock

Chipaque Formation at the Crucero section



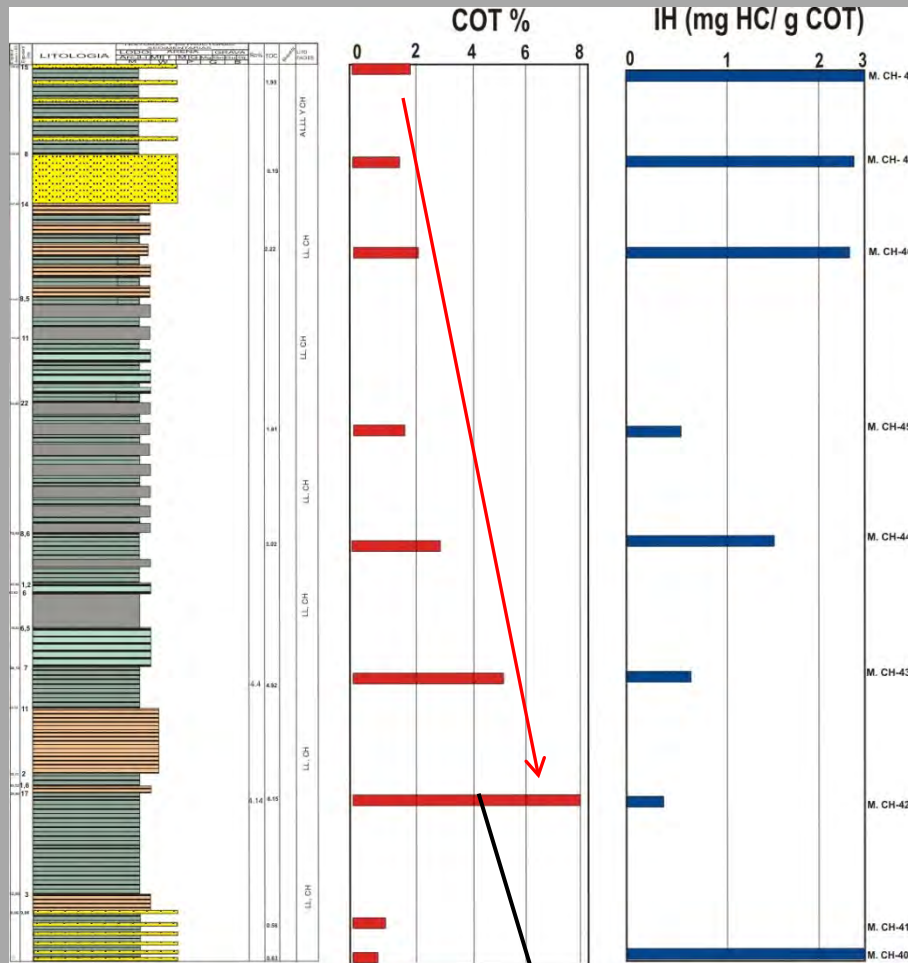
Facies:

Siltstones

Shales

Sandy shales

Chipaque Fm. Ubate section



TOC increases from top to base

TOC varies from 2 to 8%

Average Ro = 2.2%

The Ubate section presents
Predominance of Shale facies

TOC peak associated with OAE III

Shale Facies at the Ubate section. Chipaque Fm



TOC varies 2 – 8%
Ro = 1- 1.9%

Fractured chert of the Lidita Formation Reservoir overlaying the Chipaque Fm

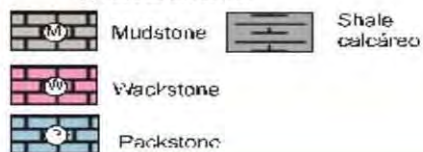


Stratigraphic section of the La Luna Formation MMB

[illegible]

CONVENCIONES

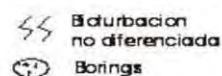
LITOLOGICAS



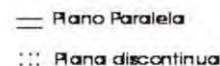
FOSILES



TECHNOLOGICAL



LAMINACION



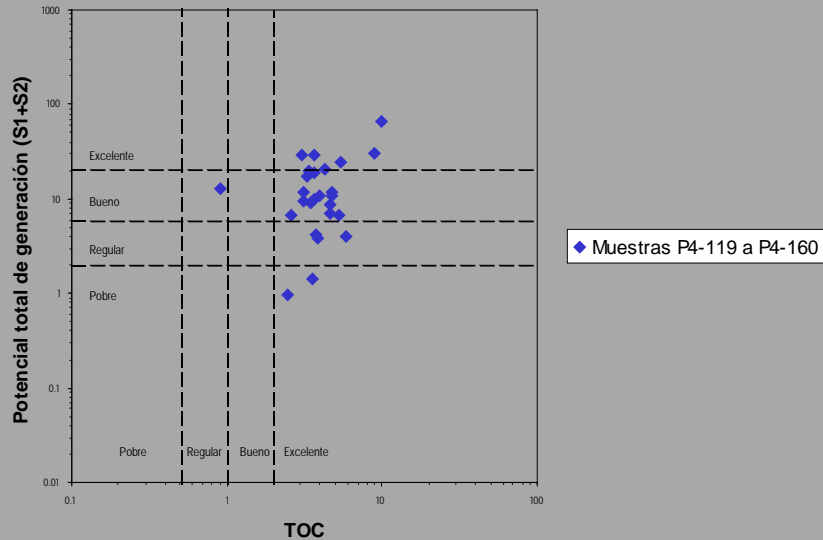
OTROS



Calcareous concretions and shales

La Luna Formation Eastern Cordillera

ROCA FUENTE VALLE MEDIO DEL MAGDALENA, FORMACIÓN LA LUNA,
MIEMBRO SALADA



Excellent source rocks
With high TOC values
2 – 10 %
But! low
 $R_o = 0.5 - 0.8\%$

South



The thickness section locates in the central region of the Eastern Cordillera

PRINCIPAL SOURCE ROCKS CENOMANIAN-SANTONIAN INTERVAL

La Frontera - Chipaque - Churuvita - Conejo Fms.
(Eastern Cordillera axial zone)

ORGANIC MATTER QUALITY

Predominantly type II, with some mixture of types II and III, associated to marine shelf and foreshore environments.

ORGANIC MATTER QUANTITY

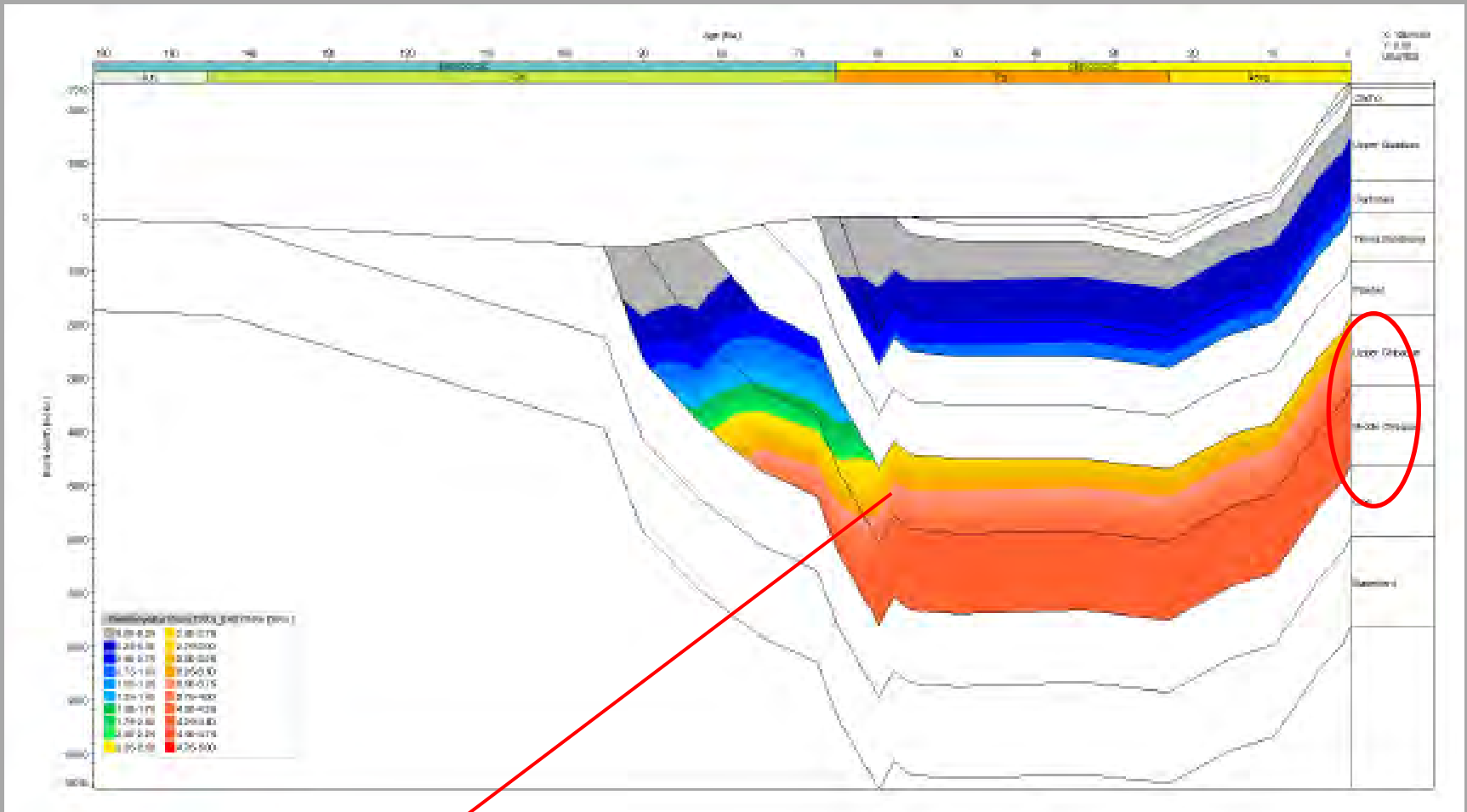
TOC 2.5%-3% Lo. Chipaque and Conejo Fms.
TOC <1% Upper Chipaque Fm.

THICKNESS OF THE SOURCE UNITS

Thickness Chipaque-Churuvita Fms. 250-500 m.
Generative thickness 100-200 m.
Thickness Conejo Fm. 350 m.

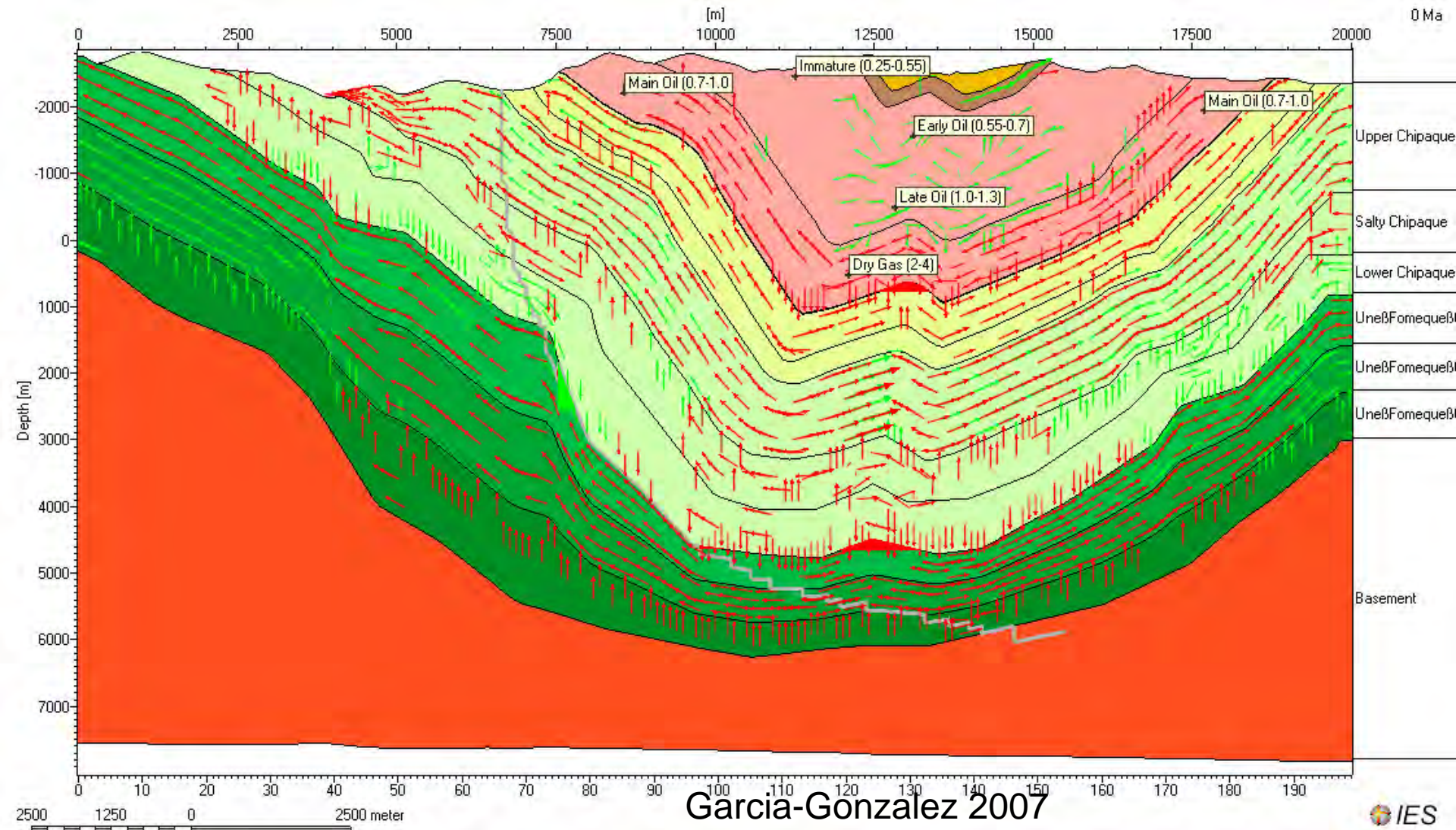
EASTERN CORDILLERA BASIN

1D Geochemical Modeling of the Checua Syncline

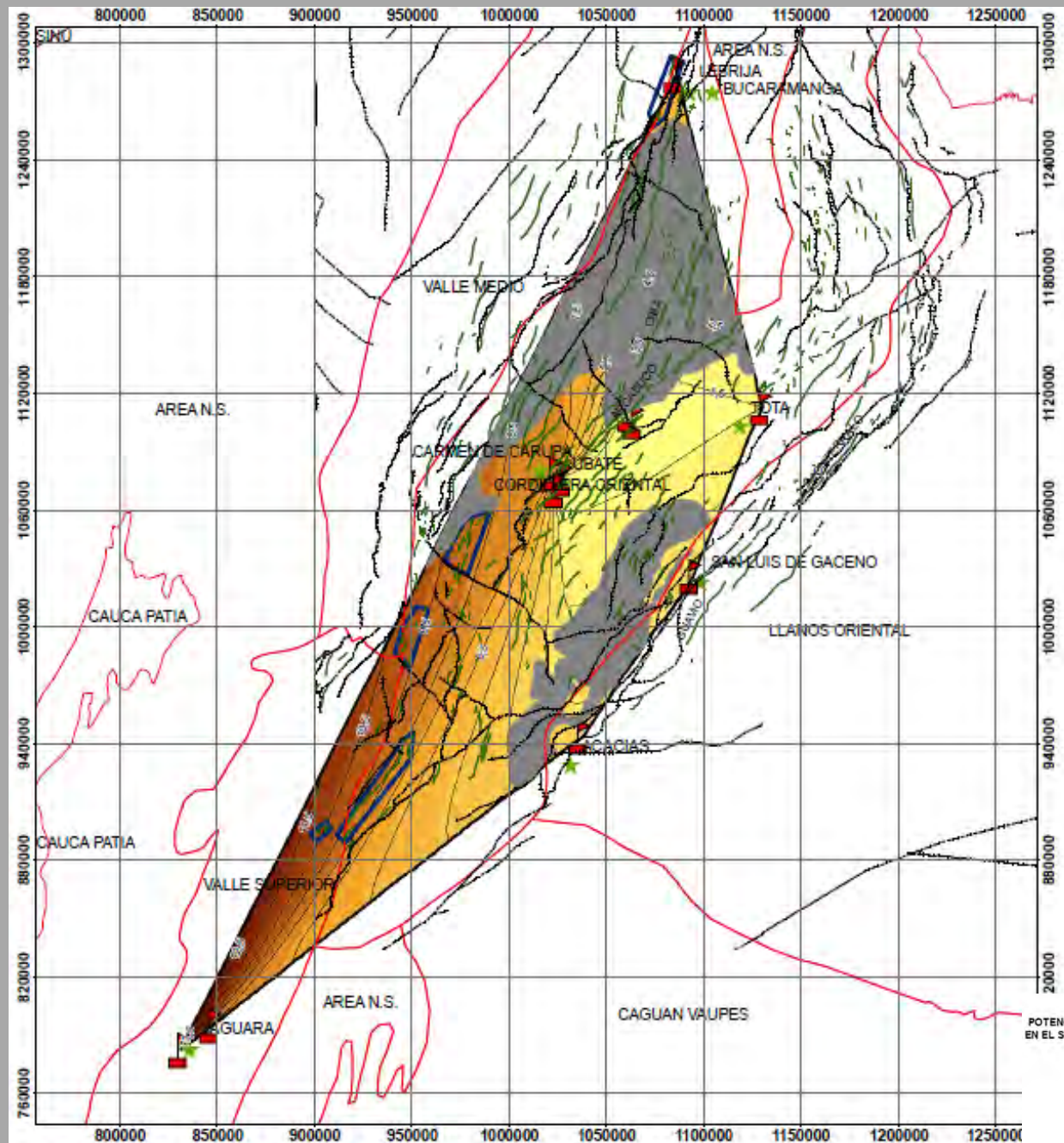


Chipaque Fm enter the Termal gas window in Late Cretaceous

2D Geochemical Modeling of the Checua Syncline



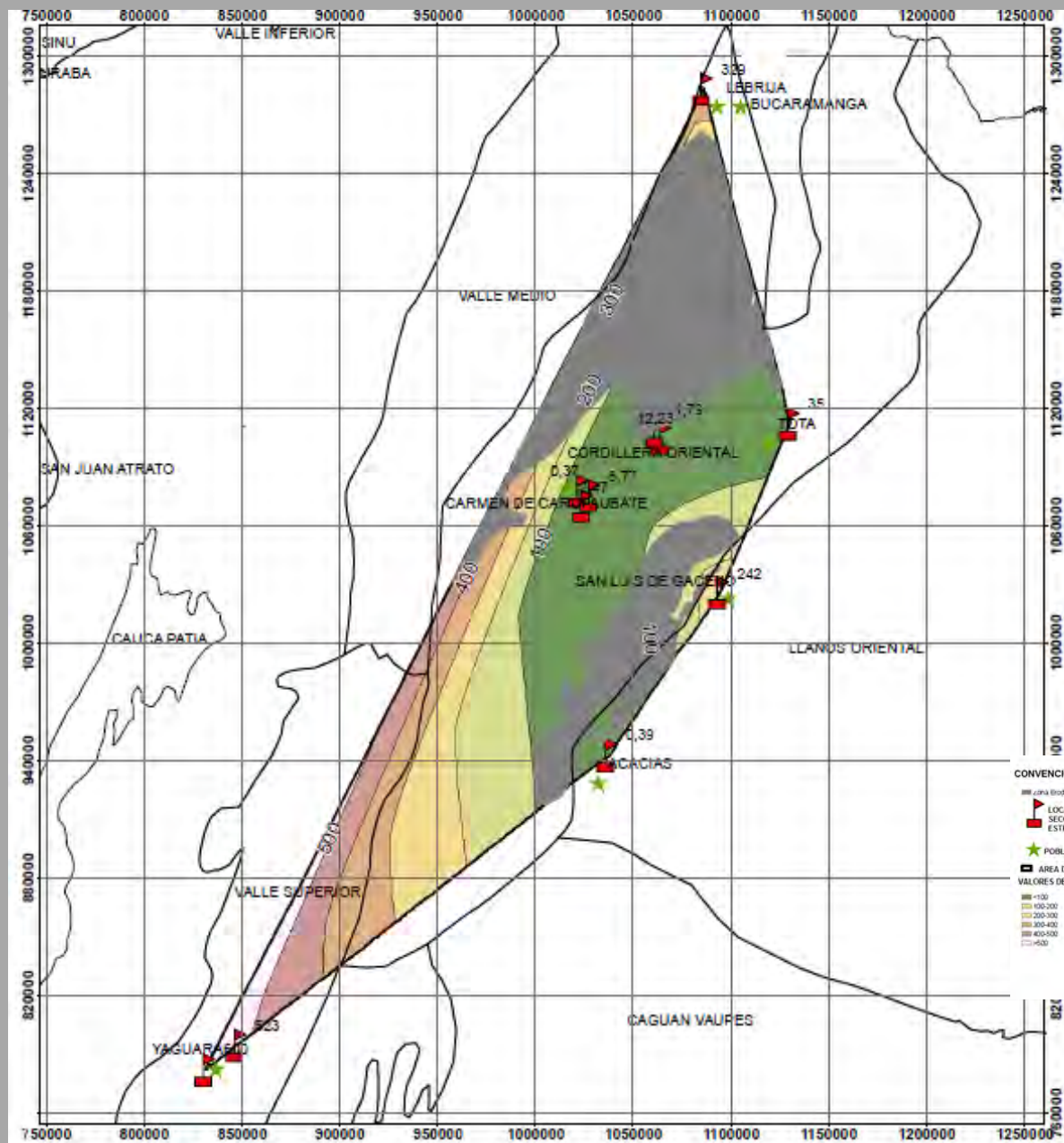
TOC distribution trends In the Eastern Cordillera



POTENCIAL GASÍFERO DE LAS LUTITAS DEL CRETÁCEO SUPERIOR
EN EL SECTOR MERIDIONAL Y NORTE DE LA CORDILLERA ORIENTAL.

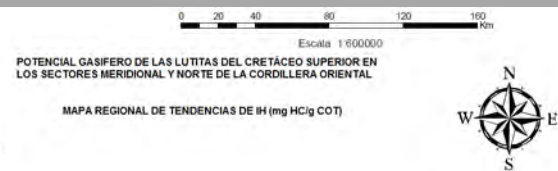
ÁREAS PROSPECTIVAS DE SHALE GAS



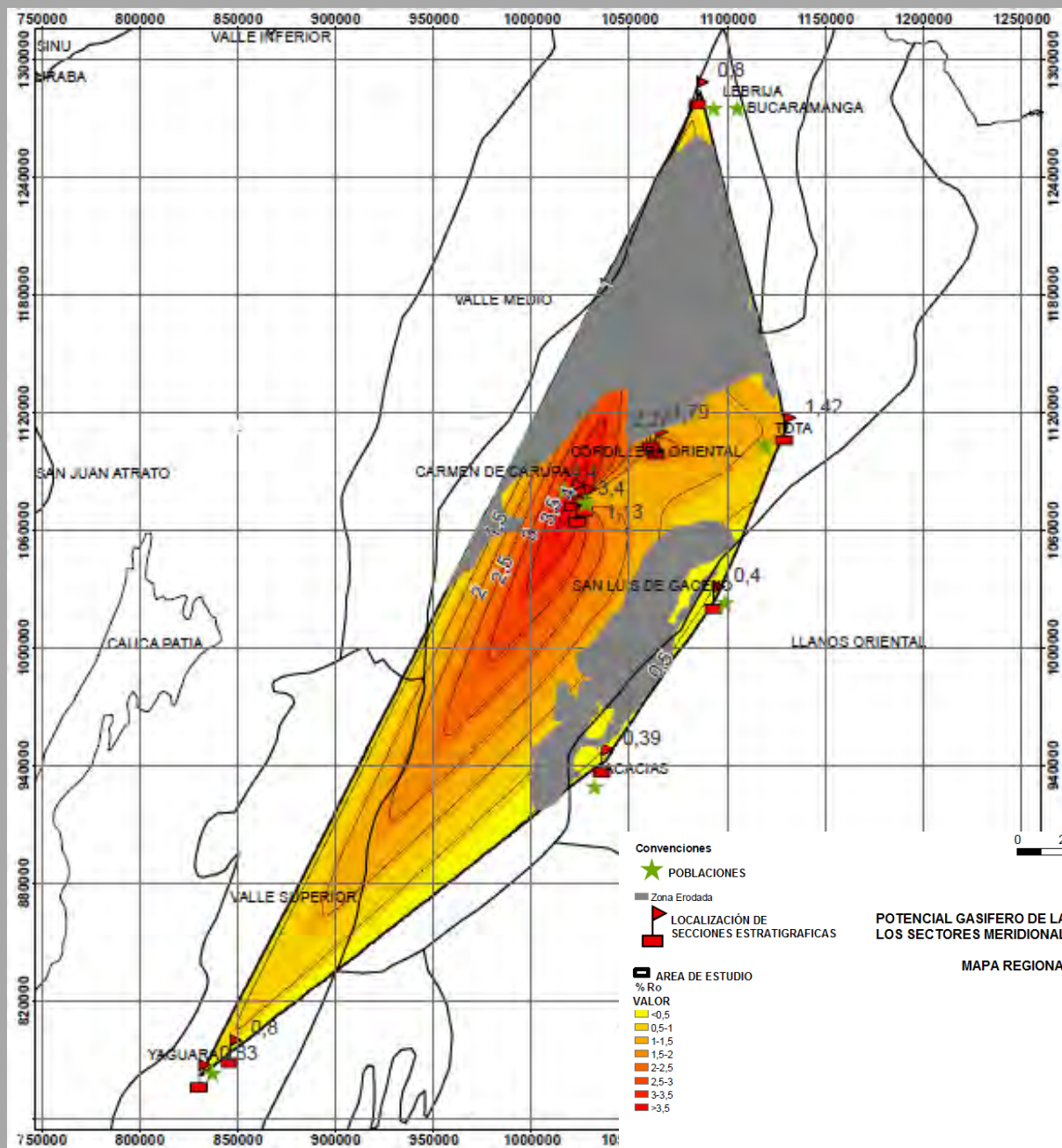


Hydrogen Index HI
distribution trends
in the
Eastern Cordillera

From <50 to >800 mgrHC



Autor
Mario A. Moreno Castellanos

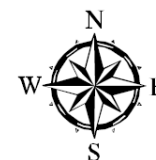


Ro distribution trends
In the Eastern Cordillera

From 0.5 % to 3%

POTENCIAL GASIFERO DE LAS LUTITAS DEL CRETACEO SUPERIOR EN
LOS SECTORES MERIDIONAL Y NORTE DE LA CORDILLERA ORIENTAL

MAPA REGIONAL DE TENDENCIAS DE %Ro



Autor
Mario A. Moreno Castellanos

Conclusions

- In the Eastern Cordillera of Colombia the shale gas plays are stratigraphically located in the Cenomanian Turonian Conician interval
- The Cenomanian Turonian presents the highest TOC values and it is associated with a MFS that correspond to shale gas plays.
- A general trend of east-west facies change from sandstone facies in the east to shale facies in the axis to a limestone facies in the west.
- A regional trend of TOC content increases from east to west. The highest TOC values are present in the west margin

Conclusions

- A regional Ro trend show that the highest Ro values (3%) are located in the axis of the Cordillera and the values decreases toward the borders.
- In the western flank La Luna Formation presents excellent TOC content. However Ro values are low for shale gas.
- The Lower and Upper and Cretaceous sequence shows its maximum thickness in the central area of the Eastern Cordillera making this area an excellent shale gas play.
- Hydrous pyrolysis experiments indicate that the Chipaque formation is a gas source capable to generate up to 230 cft gas / Ton of shale rock at 1.9% Ro.