



**PLAY CONCEPTS APPLIED TO
COLOMBIA CARIBBEAN BASIN**

TECHNICAL TEAM



Victor Orlando Ramirez C. vito_ramirez@yahoo.com

Technical Lead

Proyecto Corredores Exploratorios Caribe



Geólogo de la Universidad Nacional - Bogotá, 1993
Especialista en Geología Económica del ITC – Holanda, 1996
MSc en Geología Universidad de Alabama, 2007
Diplomado en Energías Renovables de la Escuela de Ingeniería Julio Garavito, 2021
Mas de 22 años de vinculación con Ecopetrol en exploración de hidrocarburos entre 1997 y 2020.
Interés principal en análisis de sistemas petrolíferos.
Aportes publicados en eventos y revistas internacionales sobre exploración y potencial de hidrocarburos en el Caribe colombiano.
Expresidente de ACGGP en 2008-2009 y 2018-2019,
Expresidente de AAPG para América Latina en 2013-2015
Miembro del Advisory Council de AAPG 2020-2023

Jorge Fabricio Combita

Senior Geologist

Proyecto Corredores Exploratorios Caribe



Geólogo de Universidad Nacional de Colombia con Diplomado en Geología del Petróleo de la ACGGP y Maestría en curso en la Universidad Nacional de Colombia.
Cuenta con más de 15 años de experiencia en Interpretación Sísmica 2D y 3D,
Construcción de modelos y transectas regionales, correlaciones, estudios geológicos regionales y detallados en bloques de exploración en las diferentes Cuencas Colombianas.
Ha trabajado en actividades de Interpretación en varias compañías como: PetroCol LTD., Petrotesting, Ramshorn International Limited, Vetra E & P Colombia, Emerald Energy y El Servicio Geológico Colombiano.
Hace parte del equipo de evaluación de Corredores Exploratorios de la Cuenca Caribe para El Servicio Geológico Colombiano – ANH.

Andrés Julián Lozano

Senior Geologist

Proyecto Corredores Exploratorios Caribe



Geólogo de la Universidad Industrial de Santander con 14 años de experiencia en proyectos de exploración y desarrollo relacionados con la industria de los Hidrocarburos convencionales y no convencionales en varias Cuencas Colombianas Onshore y Offshore.
Interpretación Sísmica 2D y 3D, extracción de atributos sísmicos, integración de información geológica de superficie y de pozo, elaboración de correlaciones estratigráficas y modelamiento de secciones estructurales, evaluación de riesgo, viabilidad de oportunidades y cálculos volumétricos preliminares de recursos prospectivos.
Experticia en el manejo de plataformas de interpretación sísmica, modelamiento estructural y datos de pozos, conocimientos en software de mapeo y dibujo.

Leonardo Enrique Moreno C.

Senior Geologist

Proyecto Corredores Exploratorios Caribe



Geólogo egresado de la Universidad Nacional de Colombia con más de 25 años de experiencia en actividades exploración y producción de Hidrocarburos.
Ha trabajado en actividades de Interpretación y Operaciones en varias compañías como: Canacol Energy, Vetra E & P Colombia, Chevron Petroleum Company, Agencia Nacional de Hidrocarburos, Unión Temporal Offshore y El Servicio Geológico Colombiano.
Tiene una especialización en SIG, conocimiento de la geología regional de Colombia y Ecuador, cartografía geológica de campo y preferencia por las cuencas frontera.
Ha realizado evaluación para certificación de Recursos y Reservas.
Hace parte del equipo de evaluación de Corredores Exploratorios de la Cuenca Caribe para El Servicio Geológico Colombiano – ANH.

TECHNICAL TEAM



Cesar Augusto Mora H.

Advisor – Petroleum Systems Expert

Proyecto Corredores Exploratorios Caribe

Geólogo de la Universidad Nacional de Colombia, sede Bogotá, 1987
MSc Universidad Federal de Río de Janeiro, 2021
Con más de 32 años de experiencia en la Industria en Colombia.
Gerente y líder de proyectos exploratorios para Ecopetrol (1987 - 2003) y Sipetrol (2003 - 2005)
Gerente en PGT (2004 - 2005), GEMS S.A. (2005 - 2014), Kuenka (2014 – Actual)
Actualmente se desempeña como consultor Senior en proyectos de Análisis de Cuencas, Geoquímica del Petróleo y Evaluación de Sistemas Petrolíferos.



Leidy Esperanza Ramírez O.

Advisor - GIS Expert

Proyecto Corredores Exploratorios Caribe

Ingeniera Topográfica de la Universidad Distrital Francisco José de Caldas con 4 años y medio de experiencia en el área SIG en empresa privada, generando productos SIG y Cartografía para el Instituto Geográfico Agustín Codazzi (IGAC). Actualmente desempeña labores como profesional SIG para El Servicio Geológico Colombiano en convenio con la ANH.



Juan Carlos Ramón

Technical Director

Proyecto Corredores Exploratorios Caribe

Geólogo de la Universidad Industrial de Santander, 1988
Especialista en Geofísica Colorado School of Mines, 1989
Ph. D. en Geología Colorado School of Mines, 1997
Con más de 30 años de experiencia en exploración y desarrollo de campos petroleros y comprobados éxitos exploratorios y en incremento de reservas en campos productores maduros.
Ha trabajado en todas las cuencas sedimentarias de Colombia y en algunas áreas de Latinoamérica (Ecuador, Argentina, Perú y Brasil).
Su experiencia técnica incluye análisis de cuencas, exploración sísmica 2D y 3D, caracterización de yacimientos y evaluación integrada (sísmica 3D, registros de pozo y datos de producción) de campos y de cuencas sedimentarias para definir prospectos.



Gabriel Steve Santana G.

Editing and Drawing

Proyecto Corredores Exploratorios Caribe

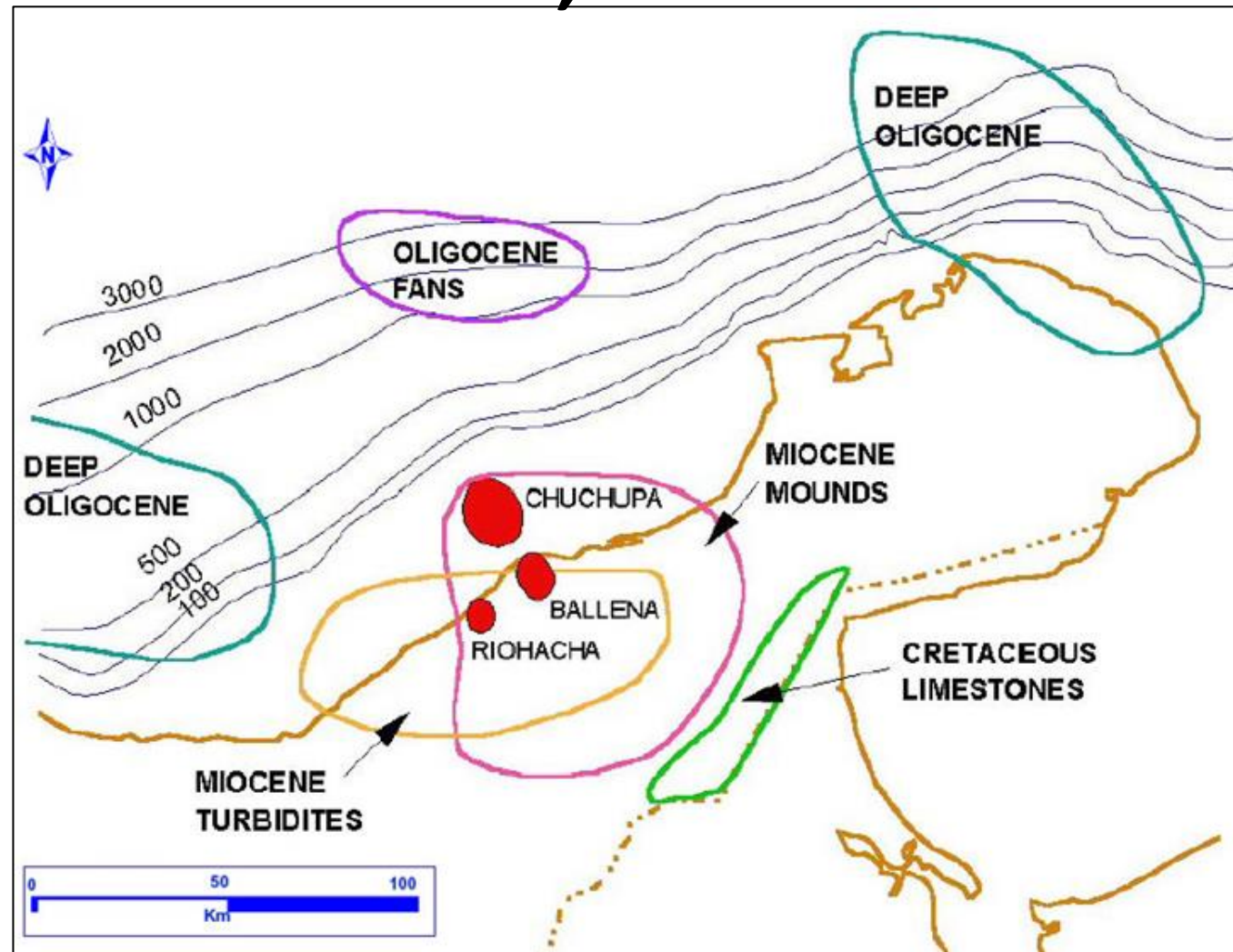
Dibujante e Ingeniero de Minas de la Fundación Universitaria del Área Andina con mas de 6 años de experiencia en el soporte y apoyo gráfico para el desarrollo de proyectos geológicos, geofísicos y mineros en la prospección, exploración y explotación de hidrocarburos y minerales.
Ha desempeñado labores en compañías como: Meridian Consulting, Inforpetrol, Paleosedes E.U., Synergy, Petroseis, Asesorías Técnicas Geológicas (ATG Ltda.), Cemex Colombia y El Servicio Geológico Colombiano.

ACKNOWLEDGMENTS TO: ANH María Rosa Cerón, Liliana Zuleta and Miguel de Armas, EPIS Personnel V. Amaris and H. Fuenzalida from SGC

PREVIOUS WORKS ON PLAY CONCEPTS APPLIED TO NORTHERN COLOMBIA

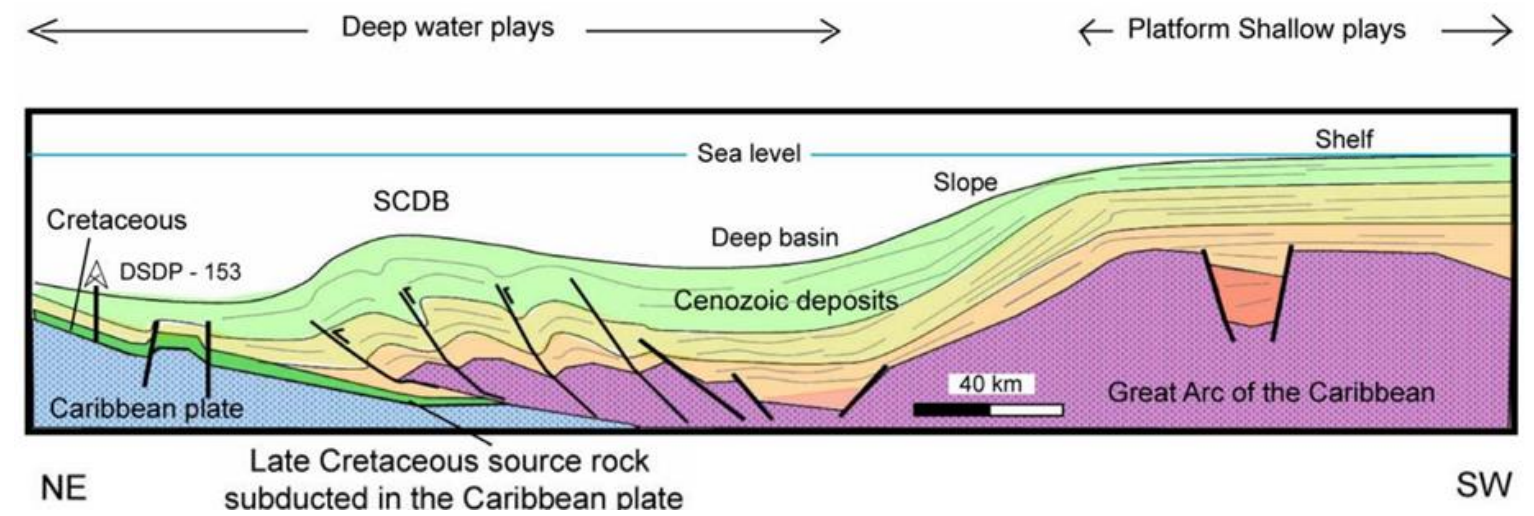
PLAY CONCEPTS IN THE CARIBBEAN

Ramirez, 2007



Plays associated to stratigraphic target

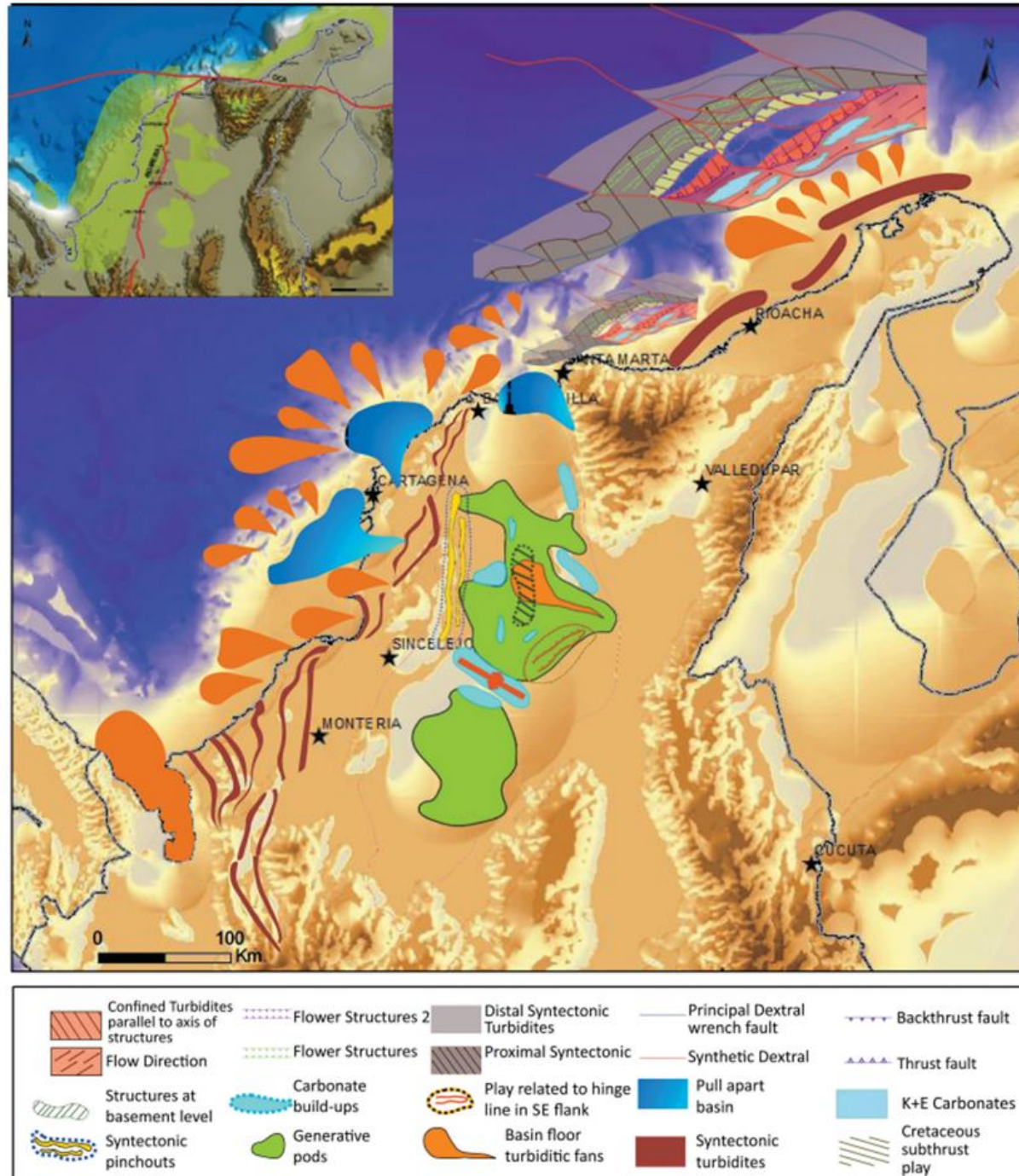
Vence, 2008



Plays associated to tectonic/geographic location

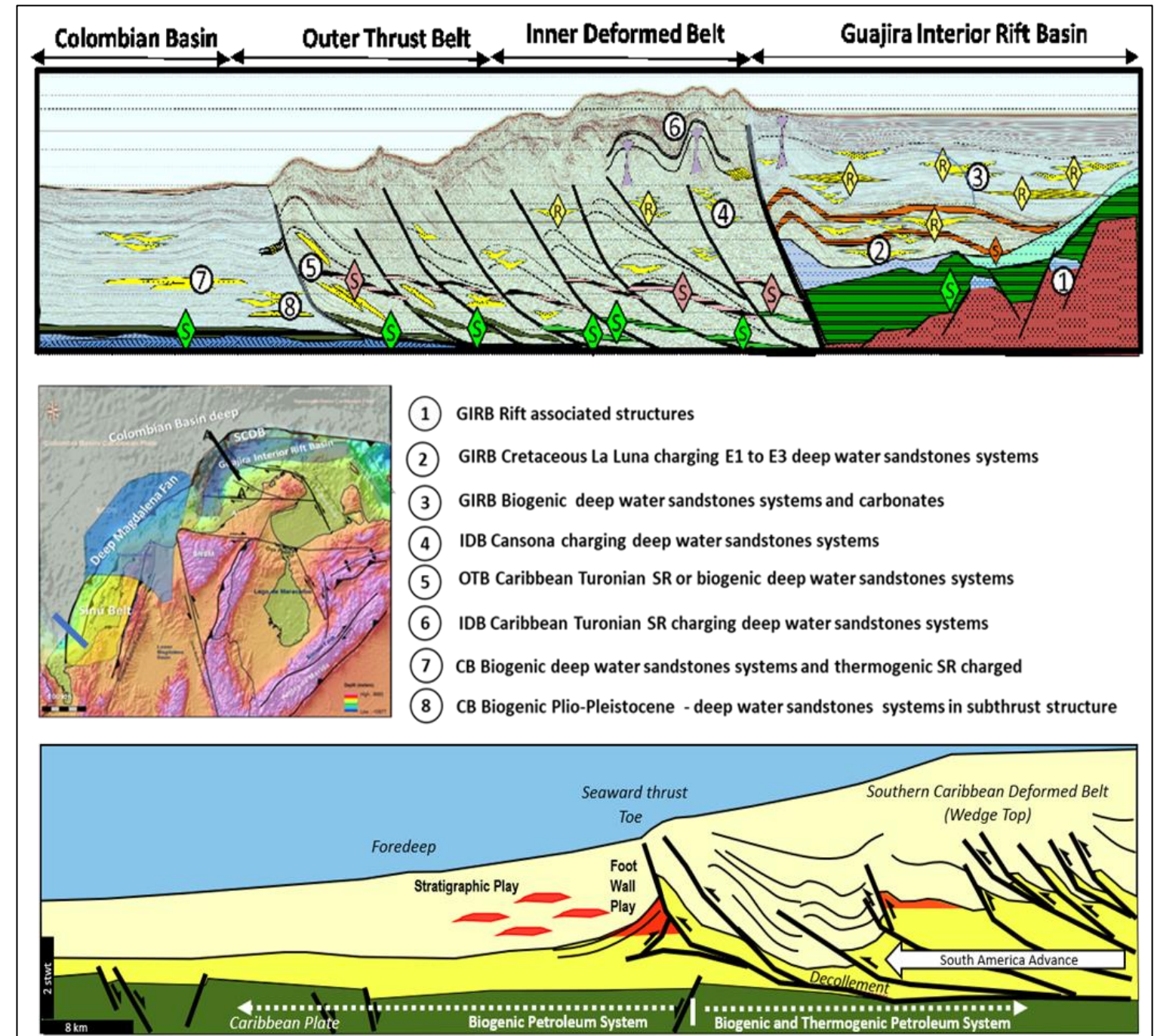
PLAY CONCEPTS IN THE CARIBBEAN

Ardila and Diaz, 2015



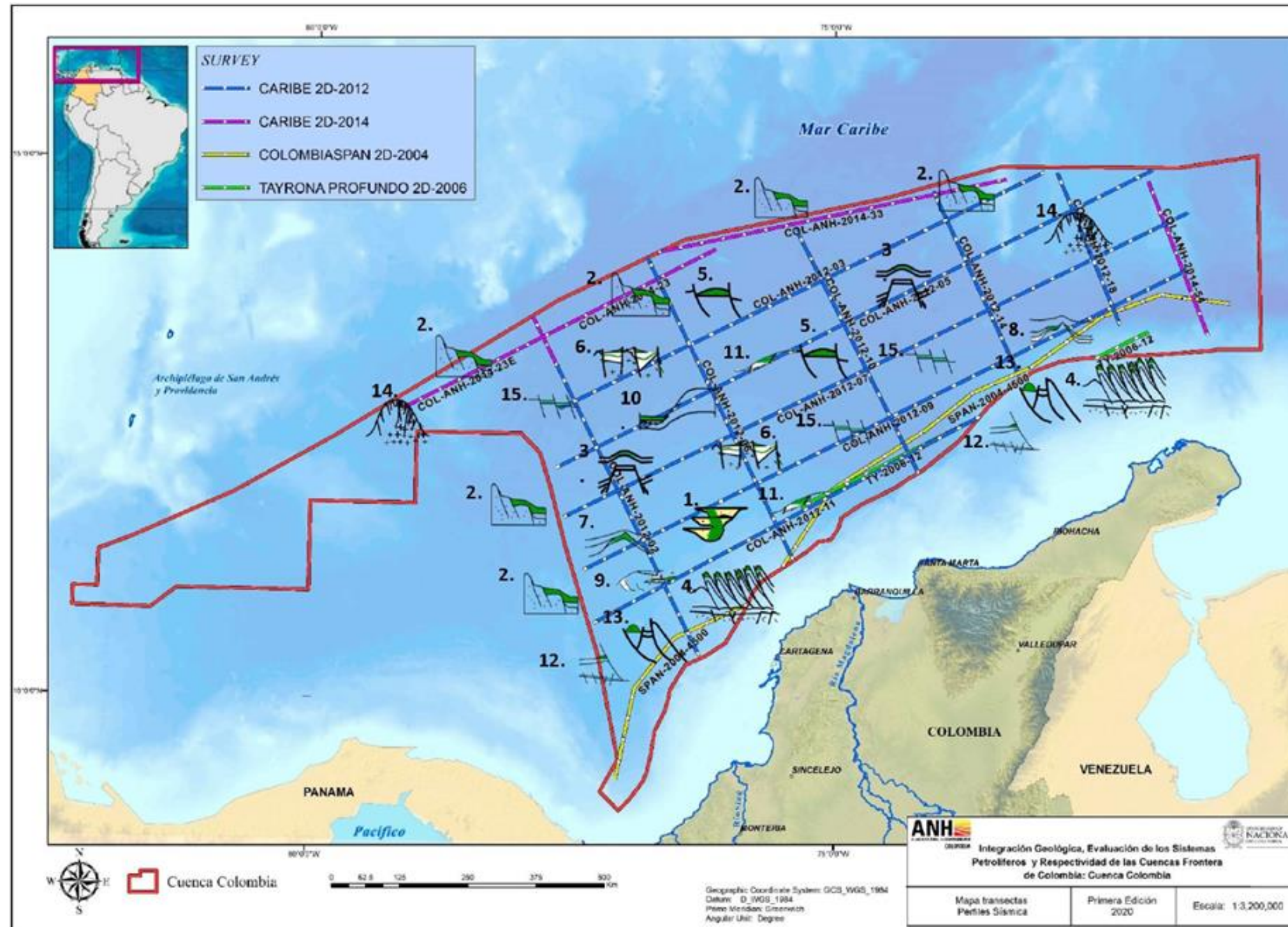
Regional plays based on regional observations

Ecopetrol, 2016



PLAY CONCEPTS IN THE CARIBBEAN

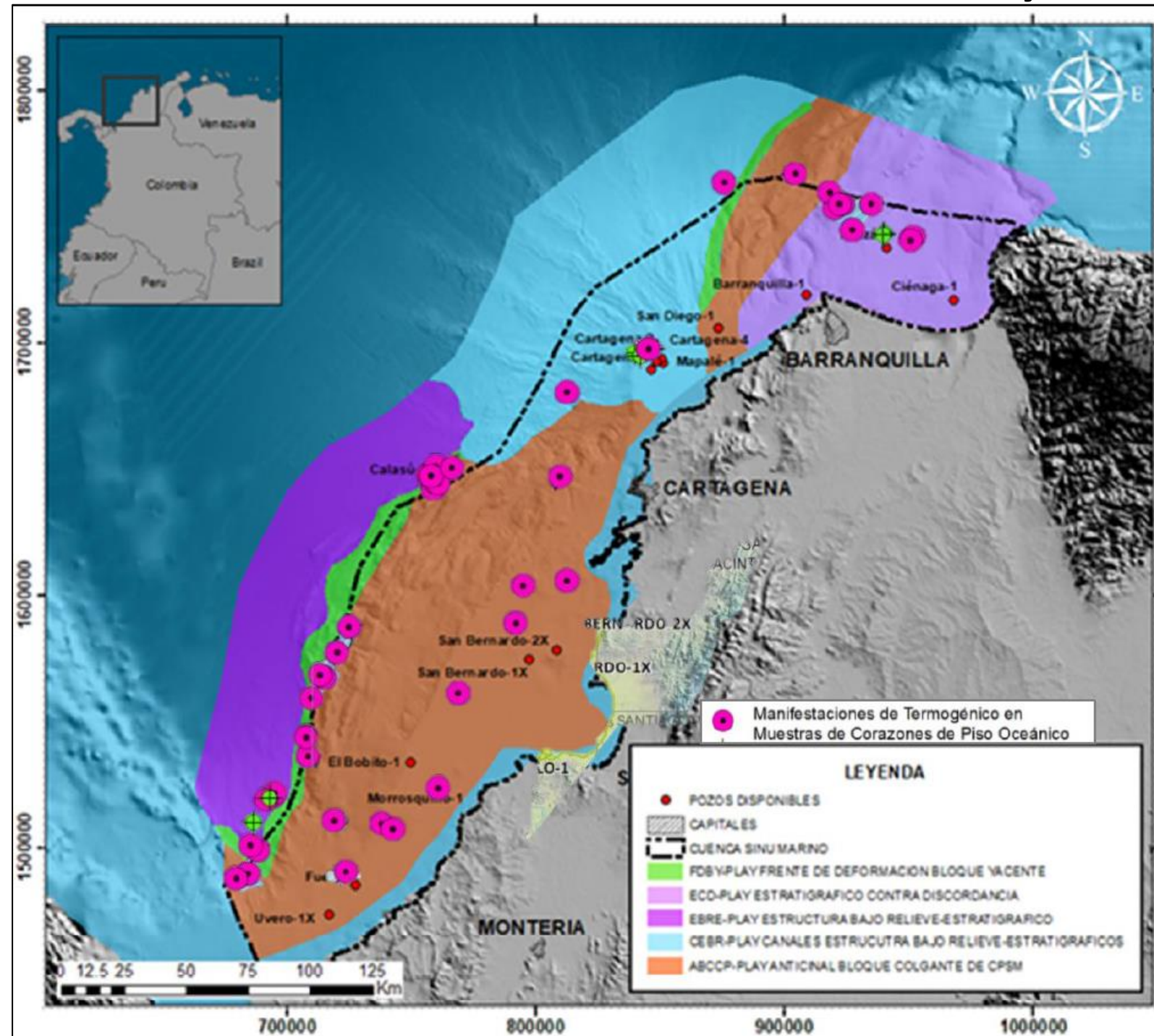
ANH – UNIVERSIDAD NACIONAL, 2020



Plays described based on trap geometry

PLAY CONCEPTS IN THE CARIBBEAN

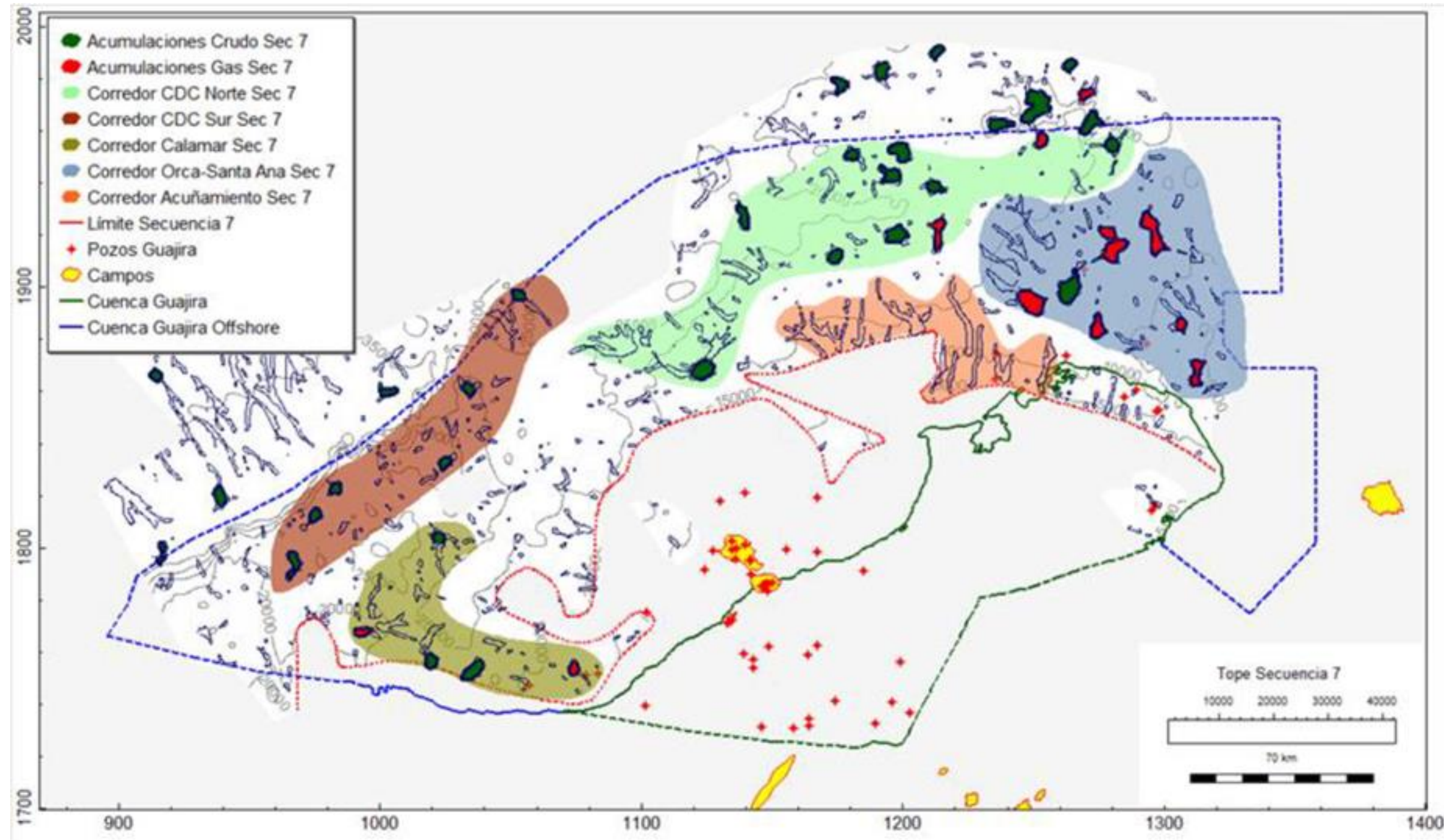
ANH – UNIVERSIDAD DE CALDAS, 2020



Plays described based on regional interpretation

PLAY CONCEPTS IN THE CARIBBEAN

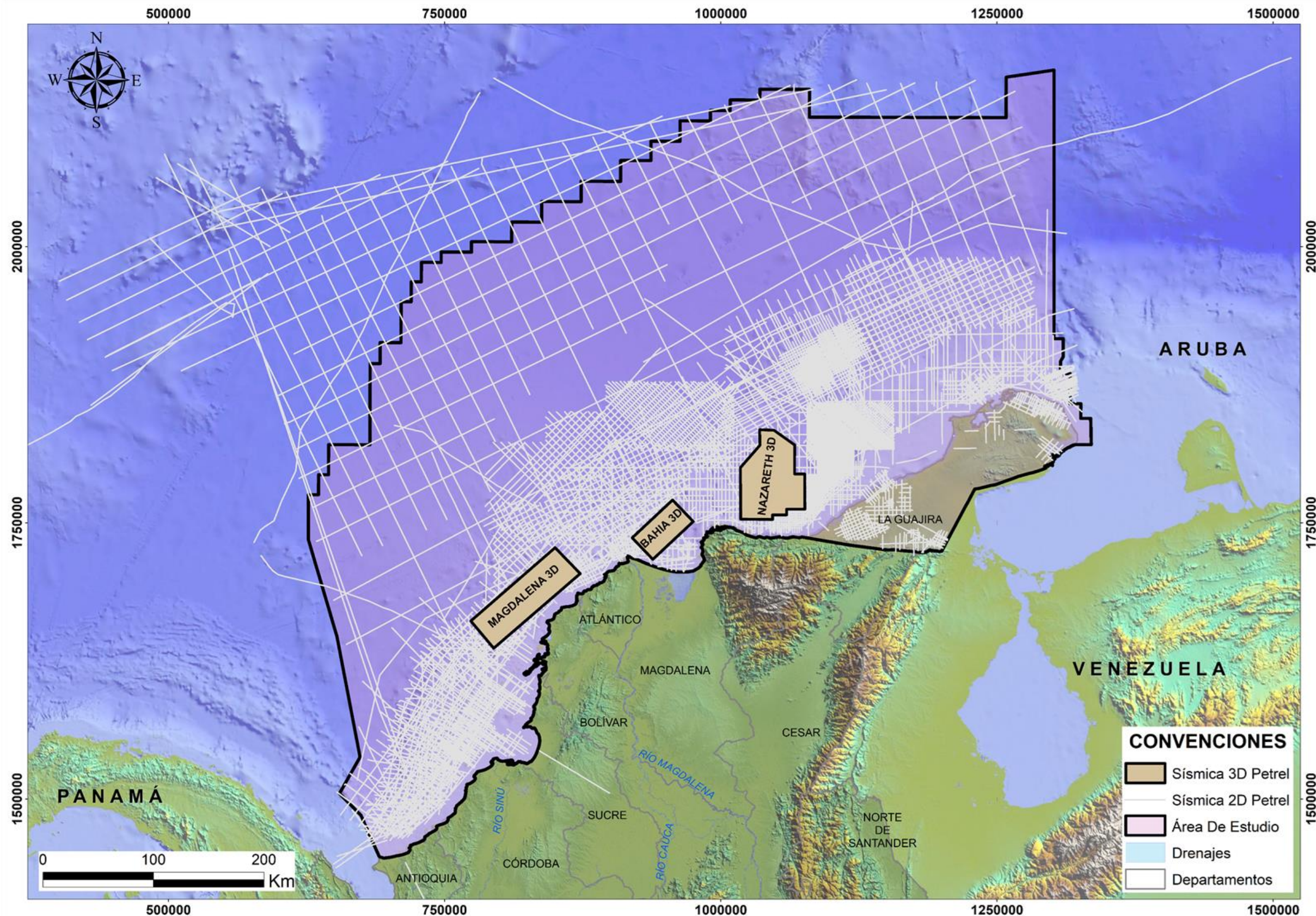
ANH – UNIVERSIDAD DE PAMPLONA, 2020



Plays described based on regional interpretation

REGIONAL INTERPRETATION

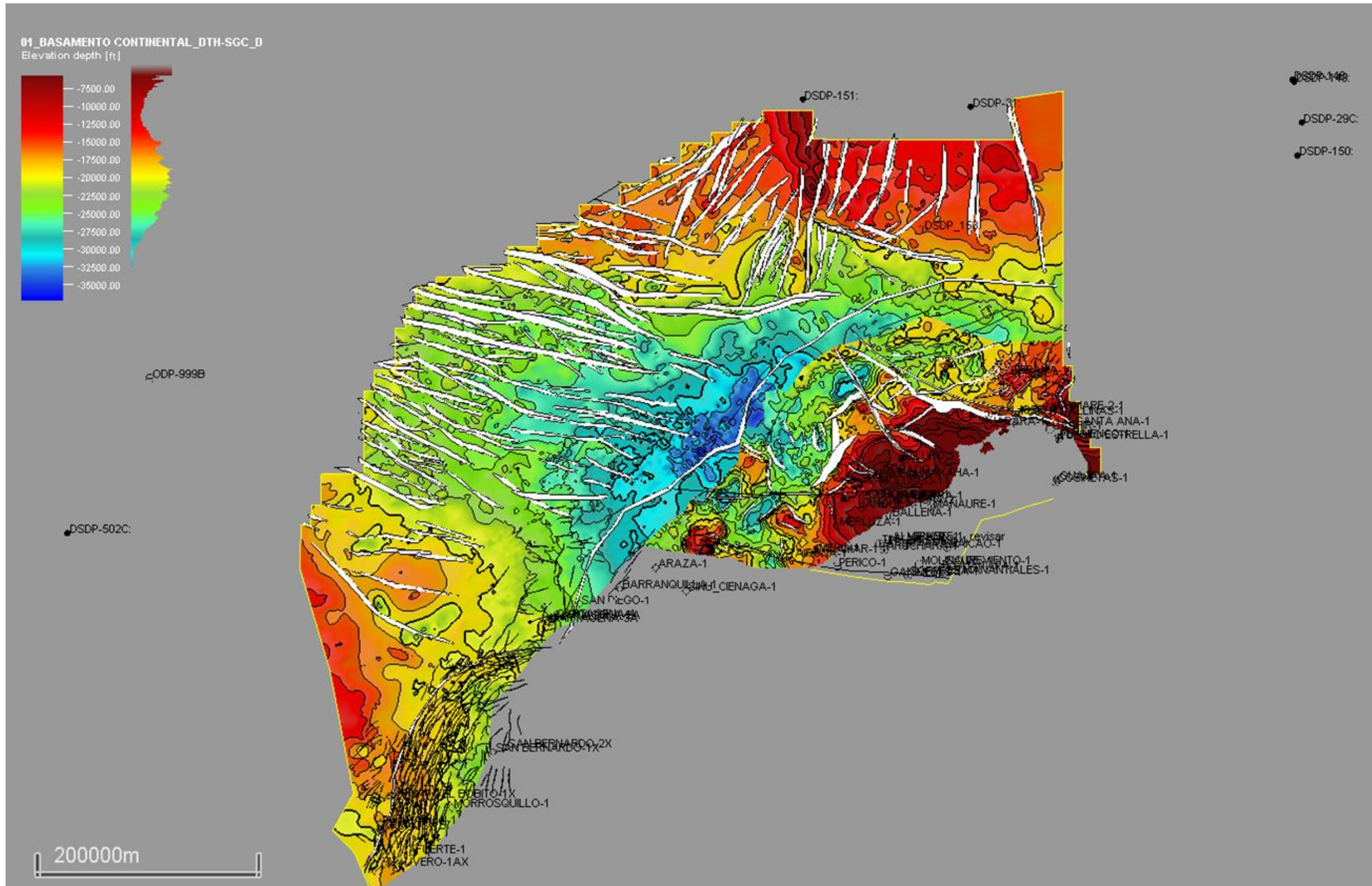
SUBSURFACE DATABASE



Study area of more than 250.000 km²

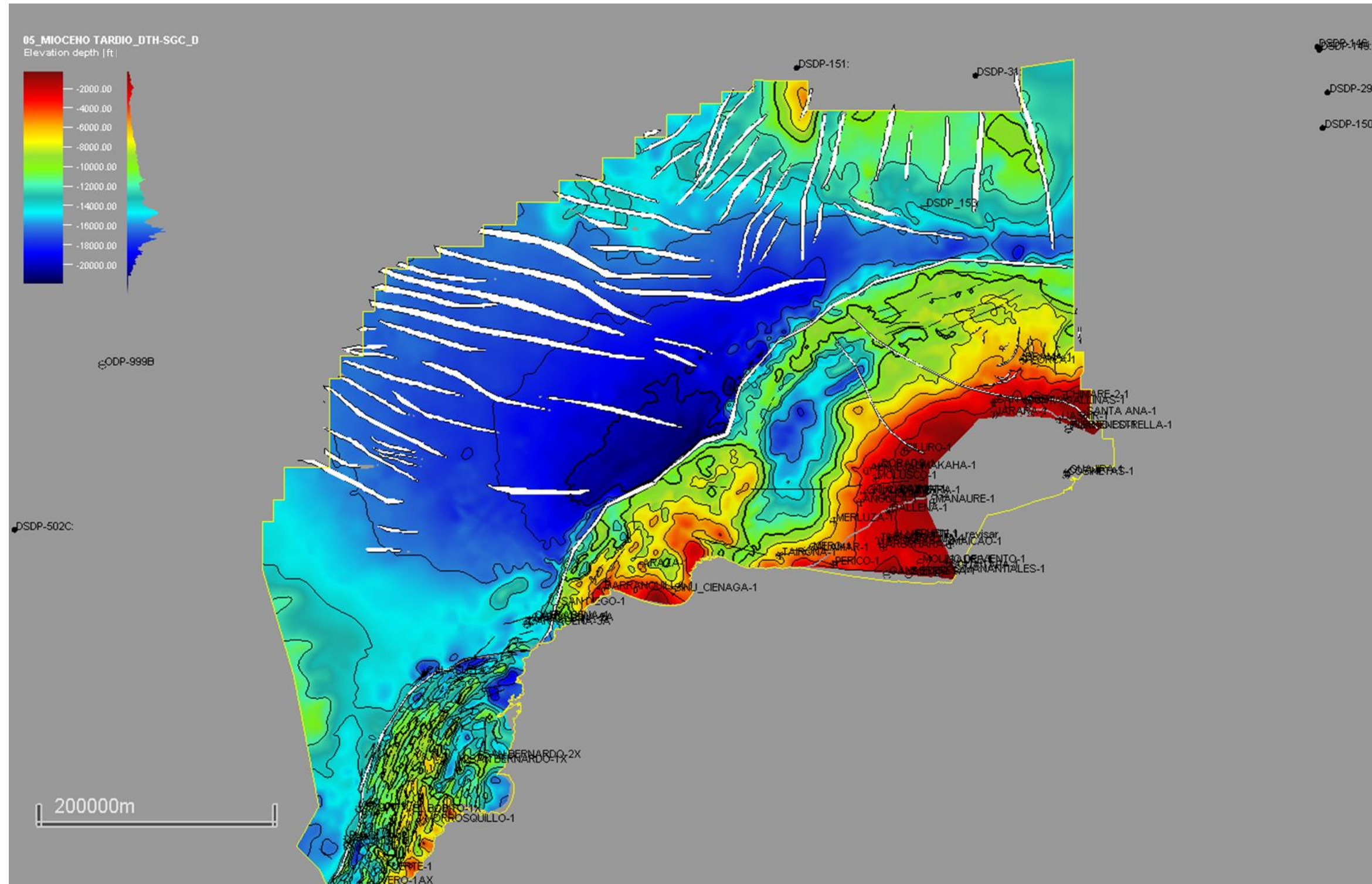
110.000 km of 2D seismics, about 6.000 km² of 3D and 66 Wells.

BASEMENT STRUCTURAL MAP



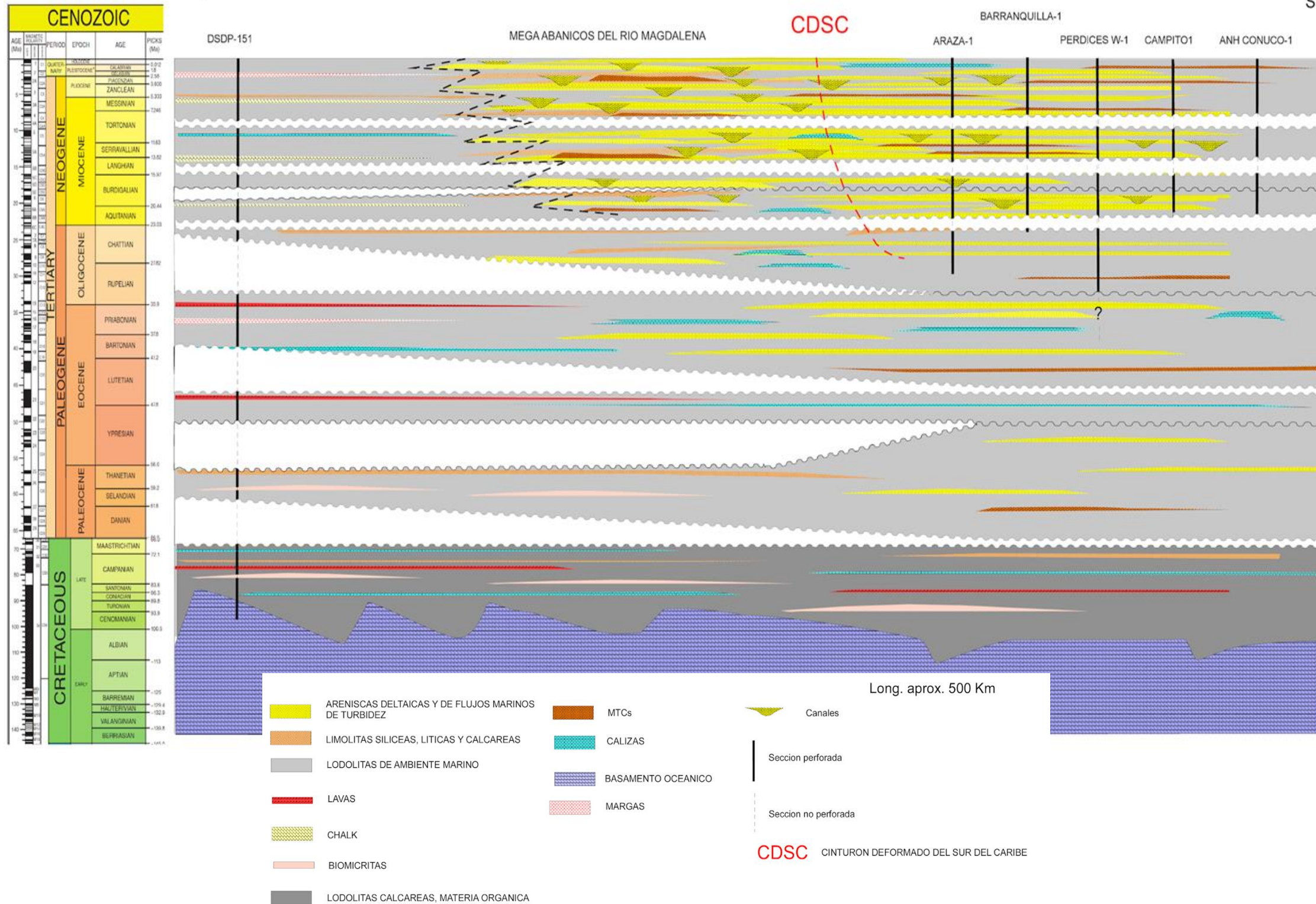
Time and depths maps prepared for Basement, Cretaceous, Oligocene, Late Miocene and sea bottom.

LATE MIOCENE STRUCTURAL MAP



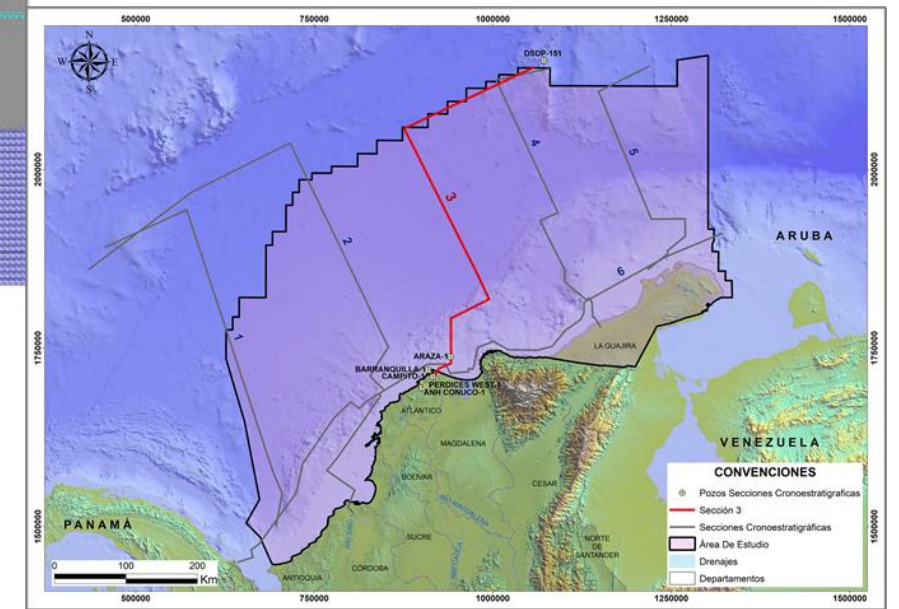
Trend of W-E faulting controlling main depocenter

CHRONOSTRATIGRAPHIC CHART

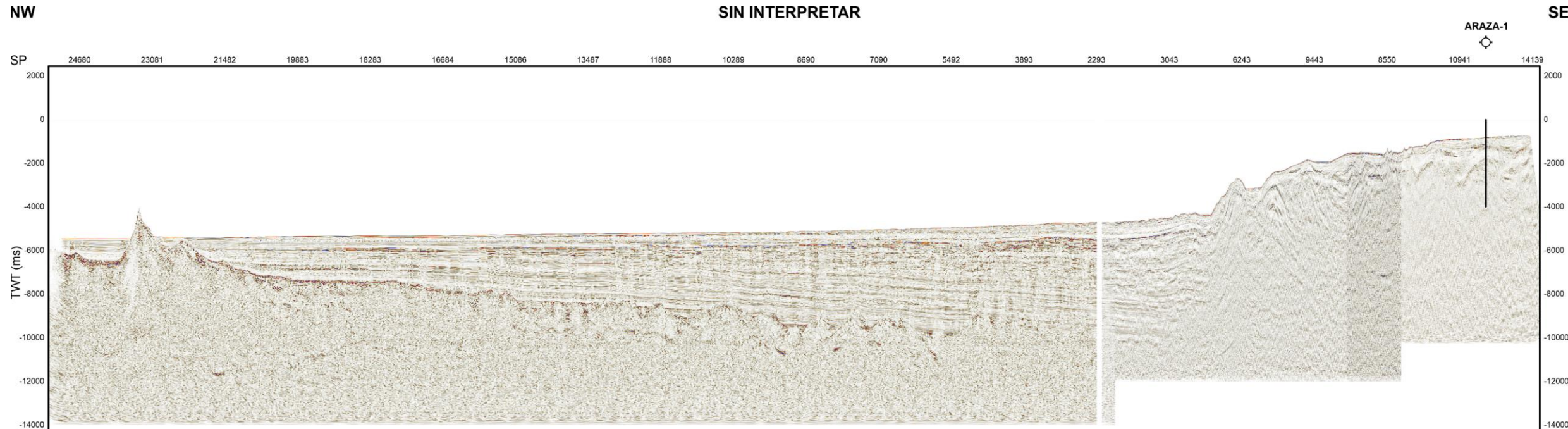


Six regional interpreted chrono charts

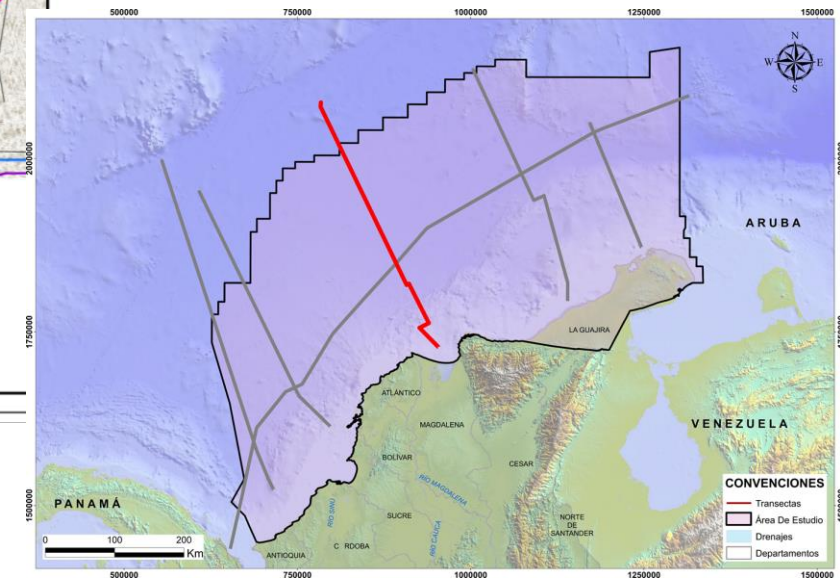
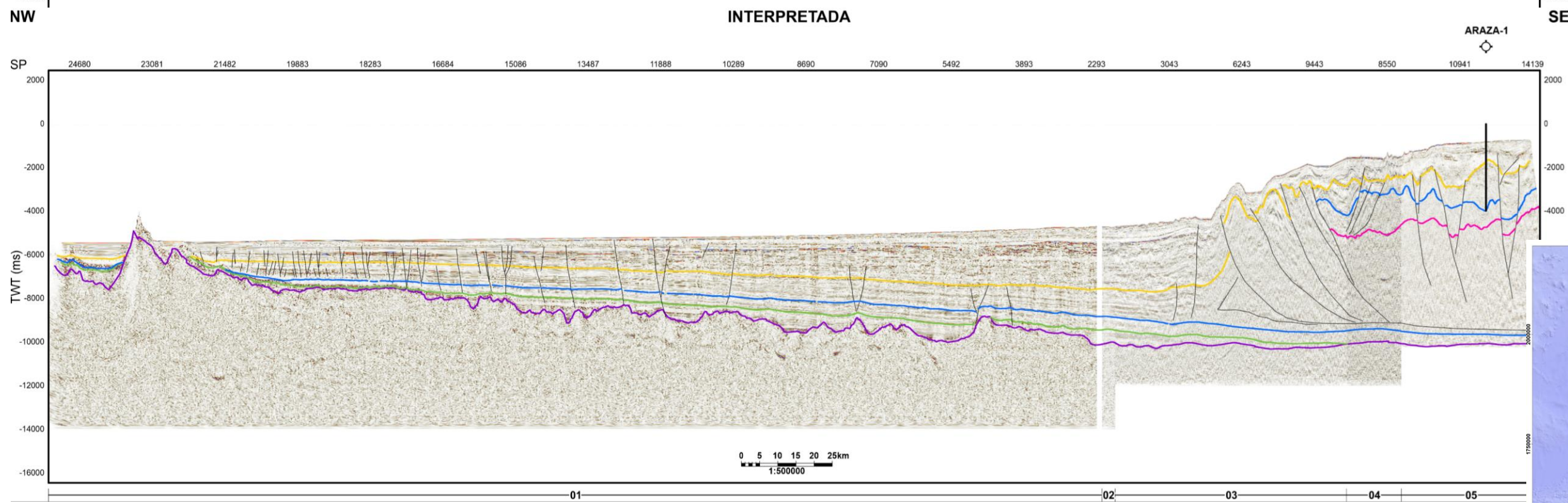
Horizontal scale stretched to display Magdalena Fan area



STRUCTURAL STYLES

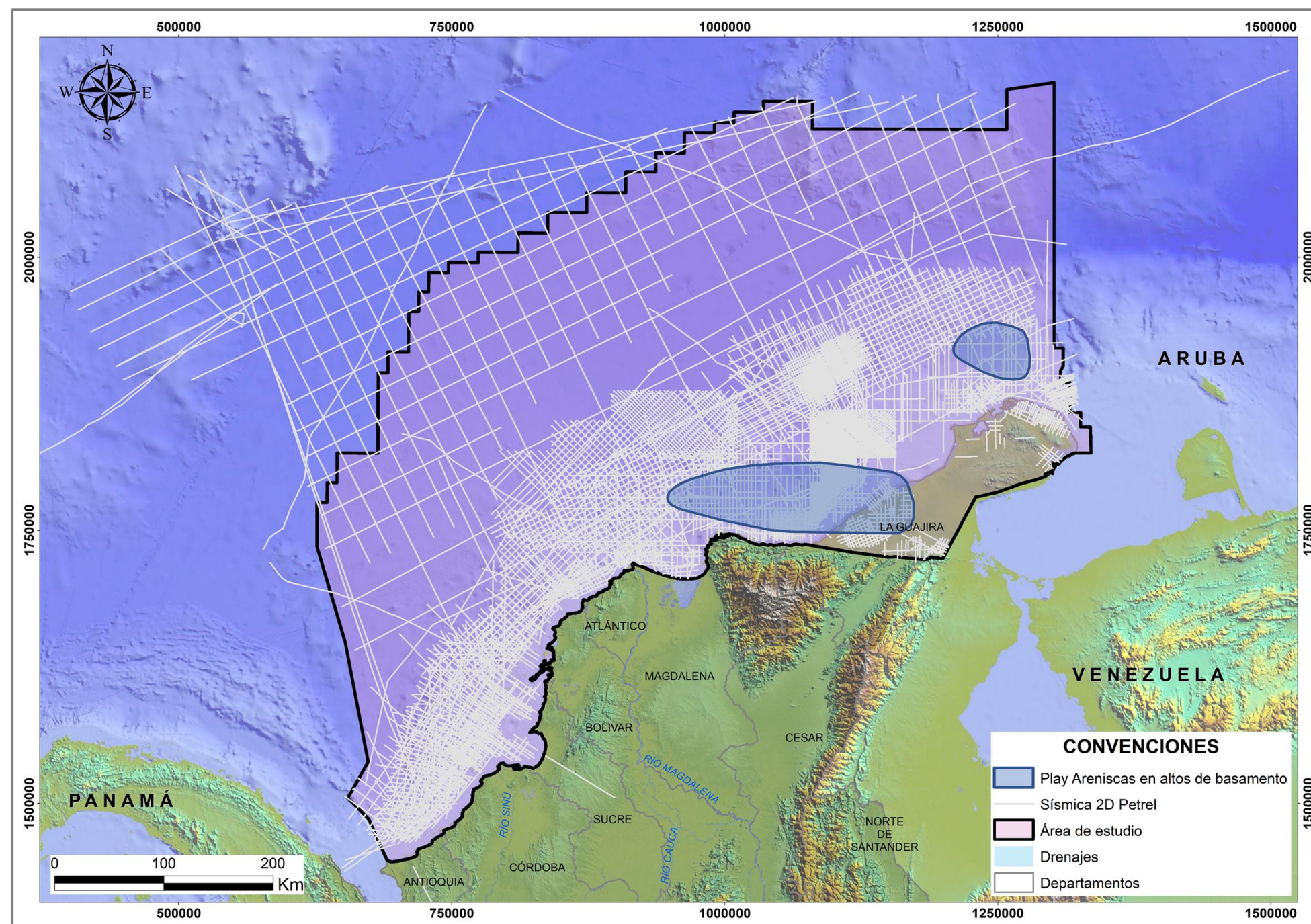


Six regional cross sections prepared along the basin

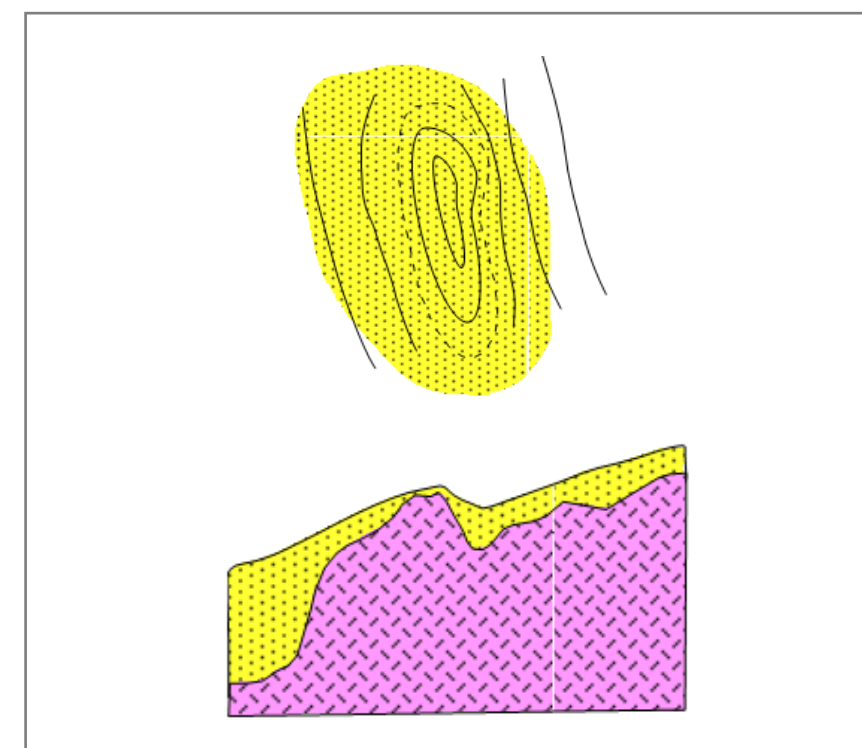


PLAY CONCEPTS IDENTIFIED IN THE CARIBBEAN OFFSHORE OF COLOMBIA

SANDSTONES ON BASEMENT HIGHS



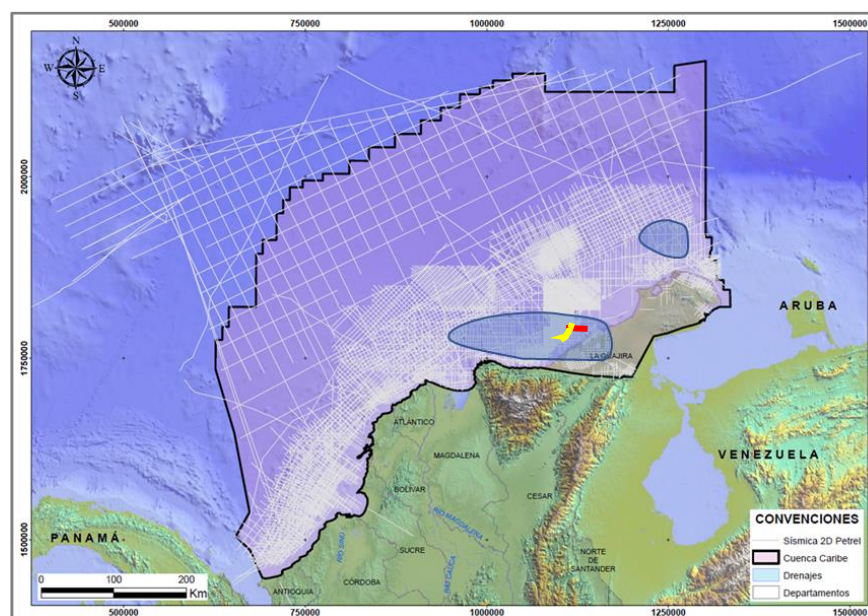
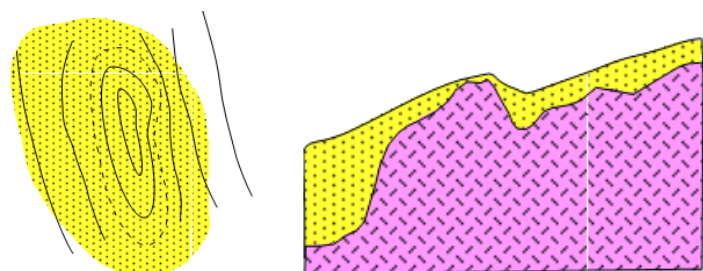
Late Oligocene to Early Miocene clastic reservoirs on regional basement highs



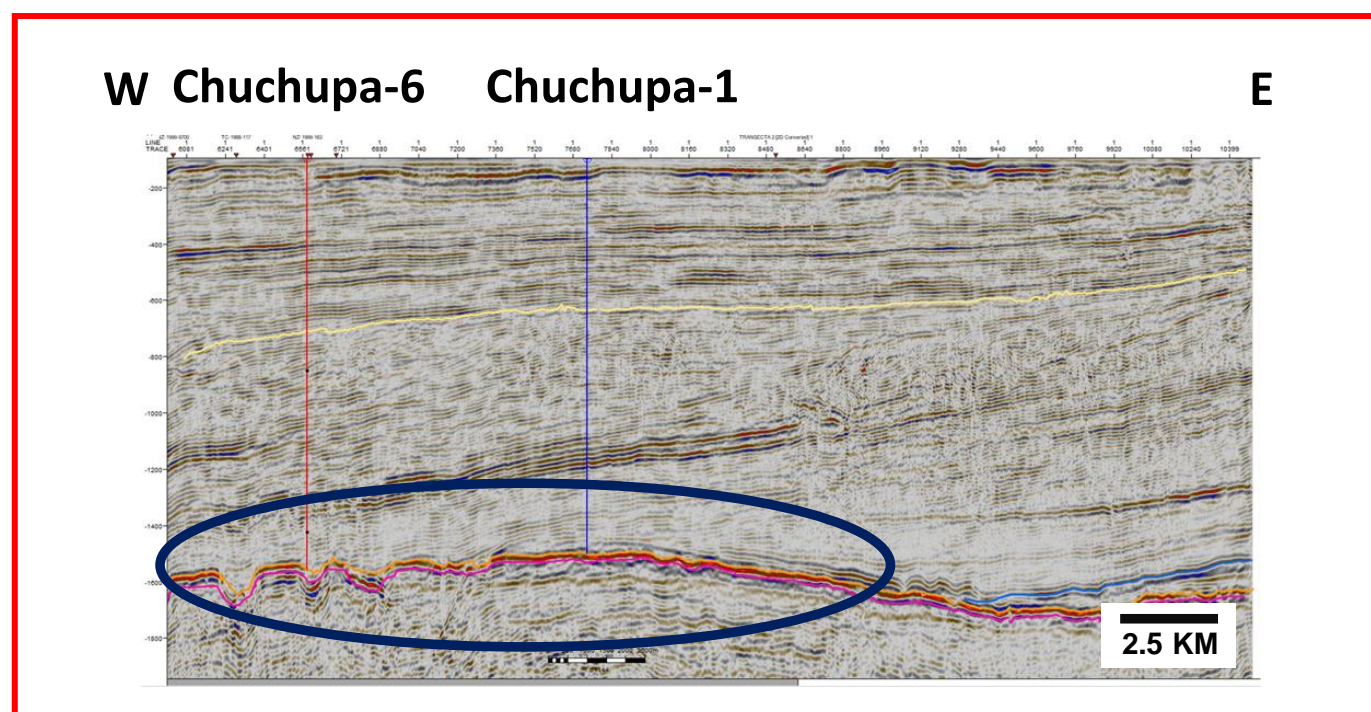
Play present in Guajira basin associated with paleo highs.

SANDSTONES ON BASEMENT HIGHS

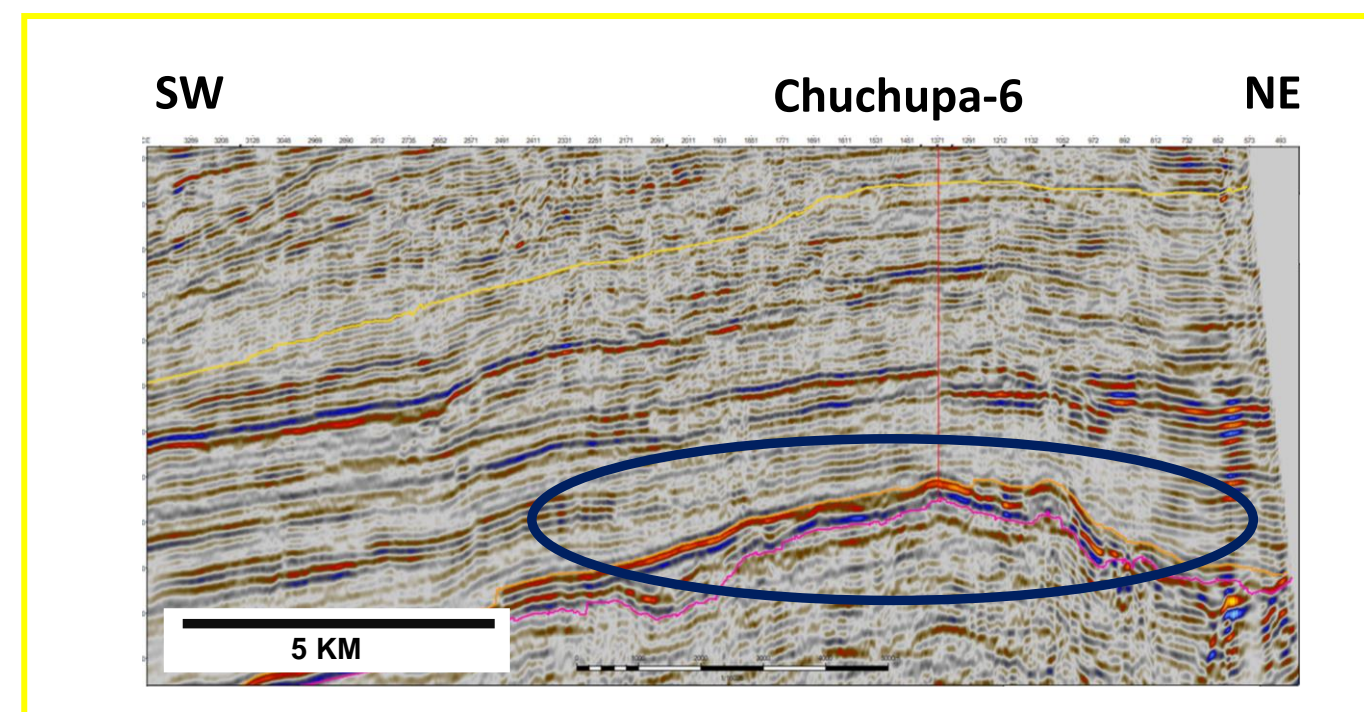
Play proven in Chuchupa field, and Orca-1.



To be tested in Tayrona depression and west of Chuchupa platform



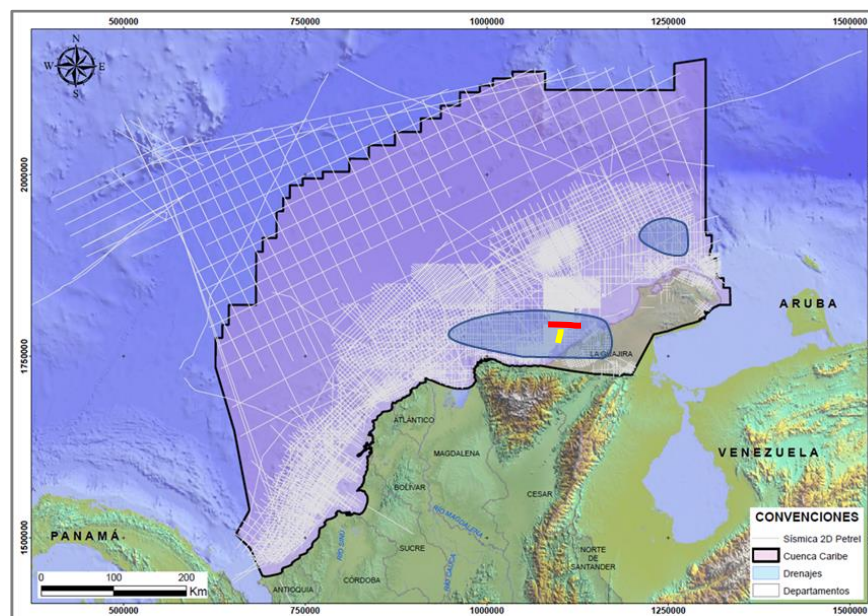
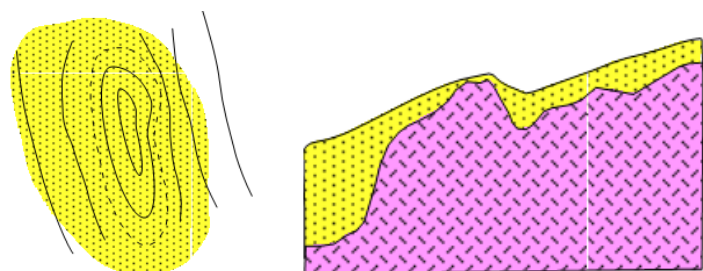
Line NZ-1999-9400



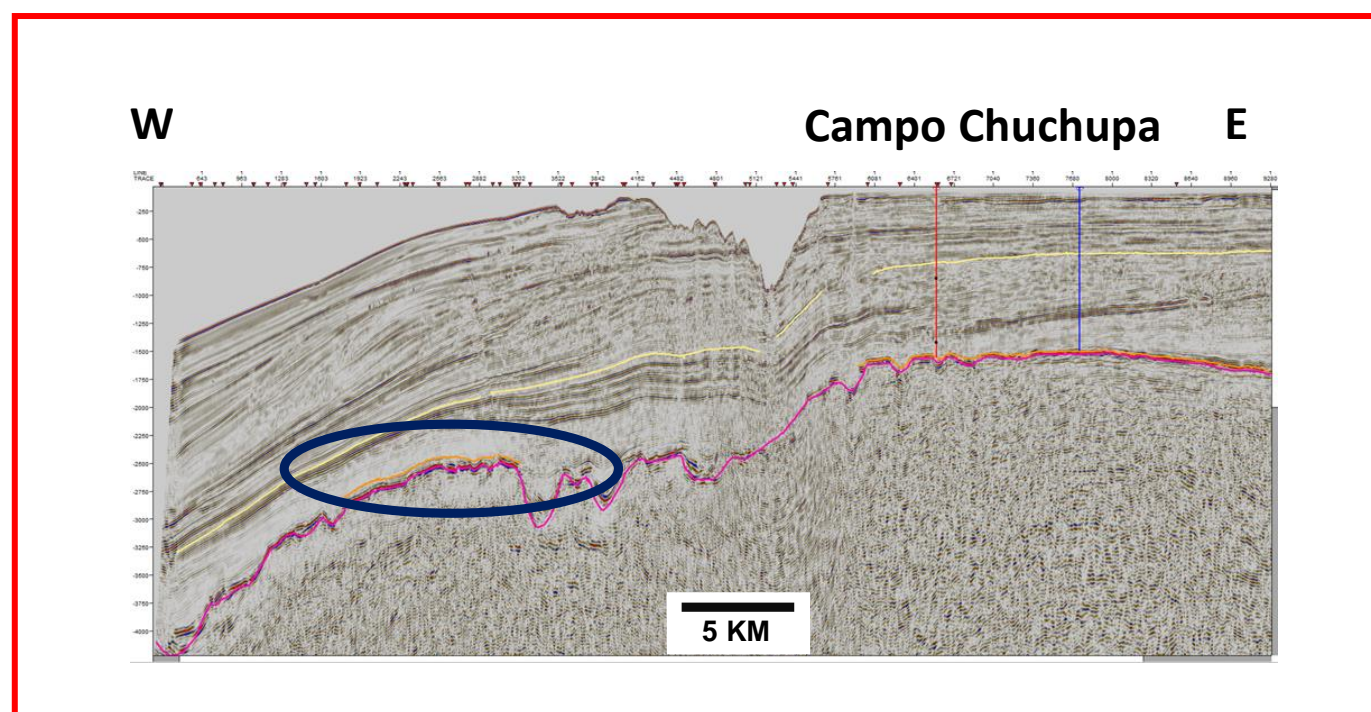
Line NZ-1999-114

SANDSTONES ON BASEMENT HIGHS

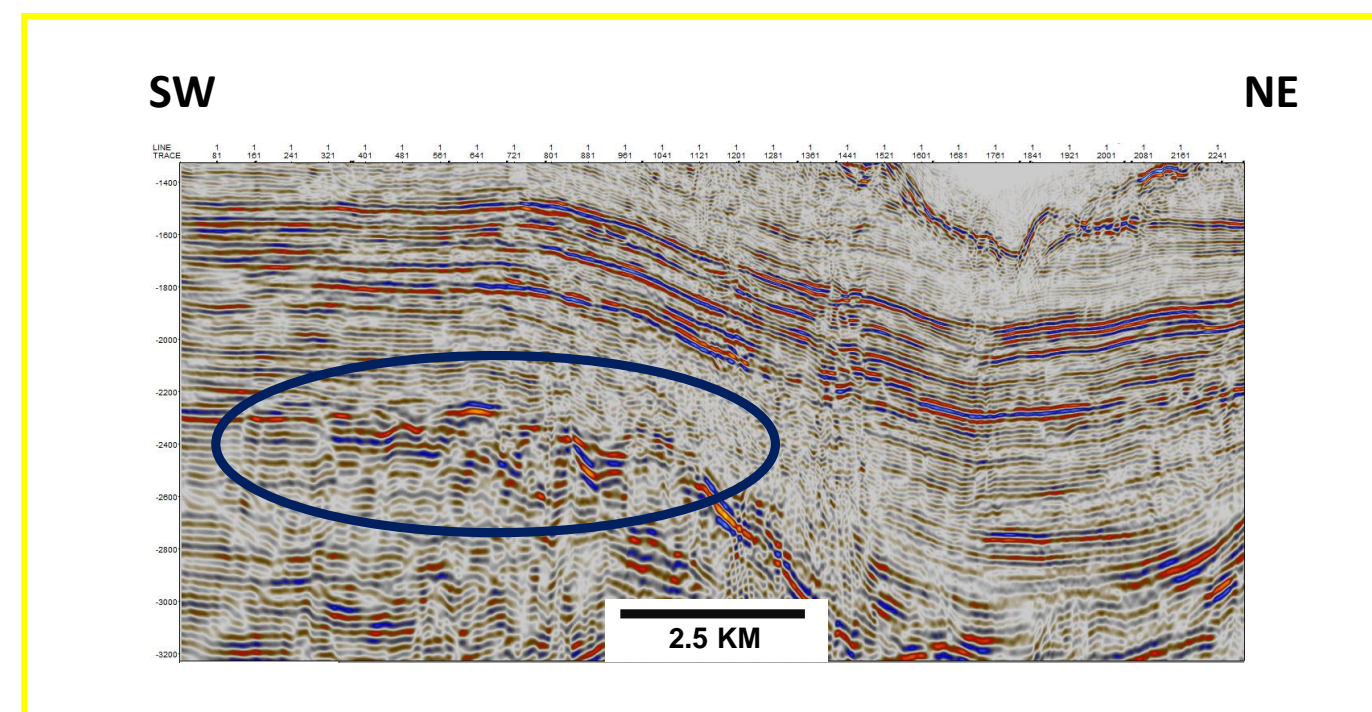
Play proven in Chuchupa field, and Orca-1.



To be tested in Tayrona depression and west of Chuchupa platform

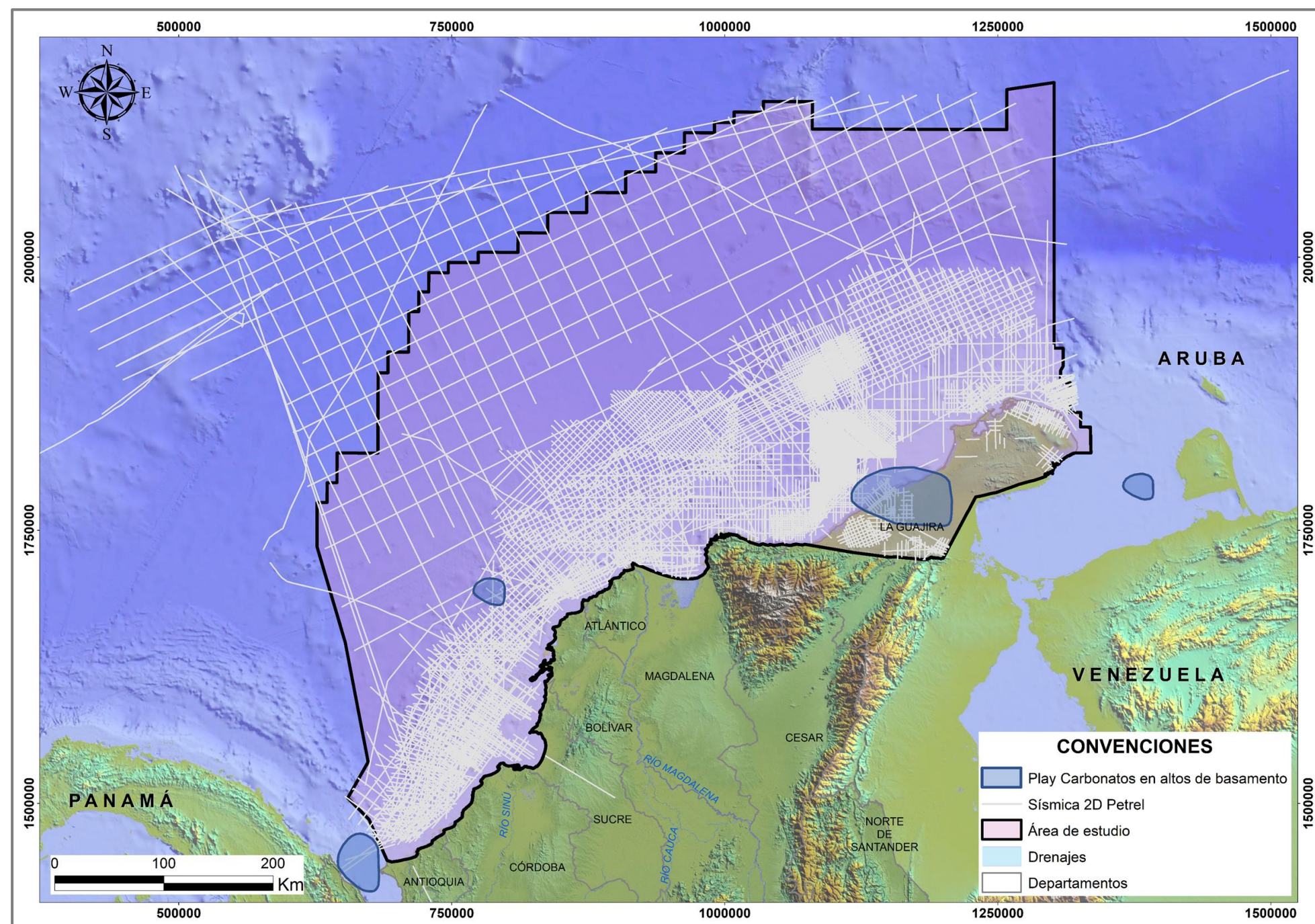


Line NZ-1999-9400

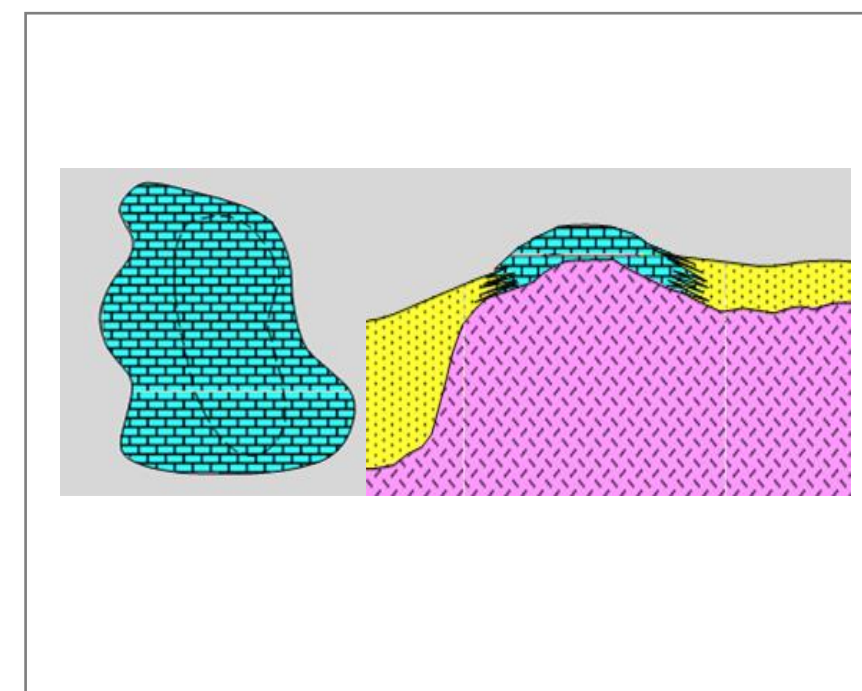


Line NZ-1999-159A

CARBONATES ON BASEMENT HIGHS



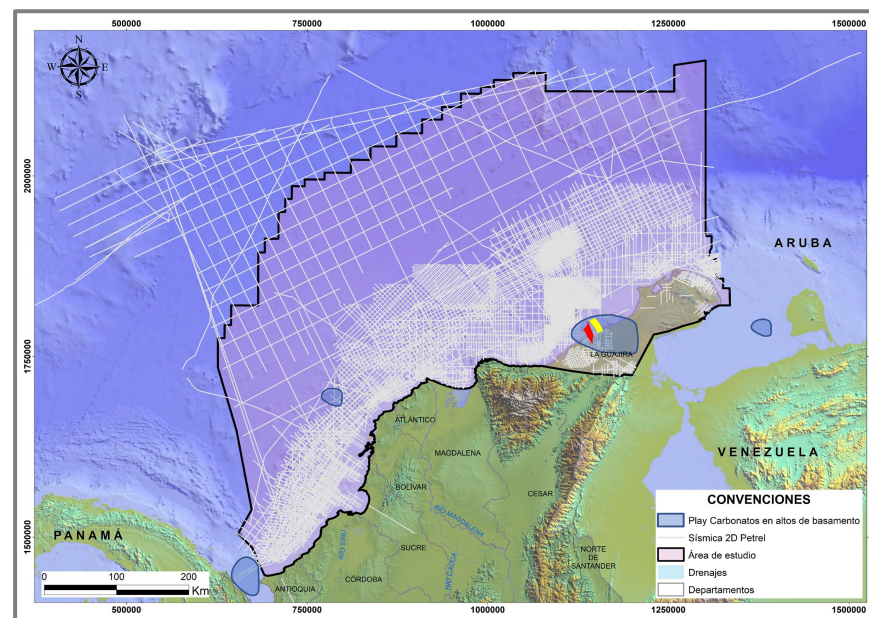
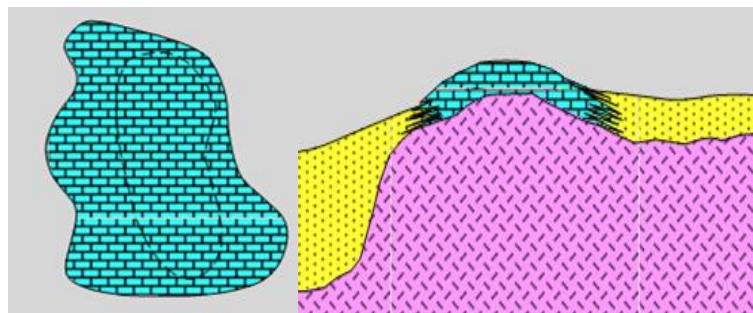
Late Oligocene to Early - Mid Miocene calcareous reservoirs on highs with shallow paleo bathymetry.



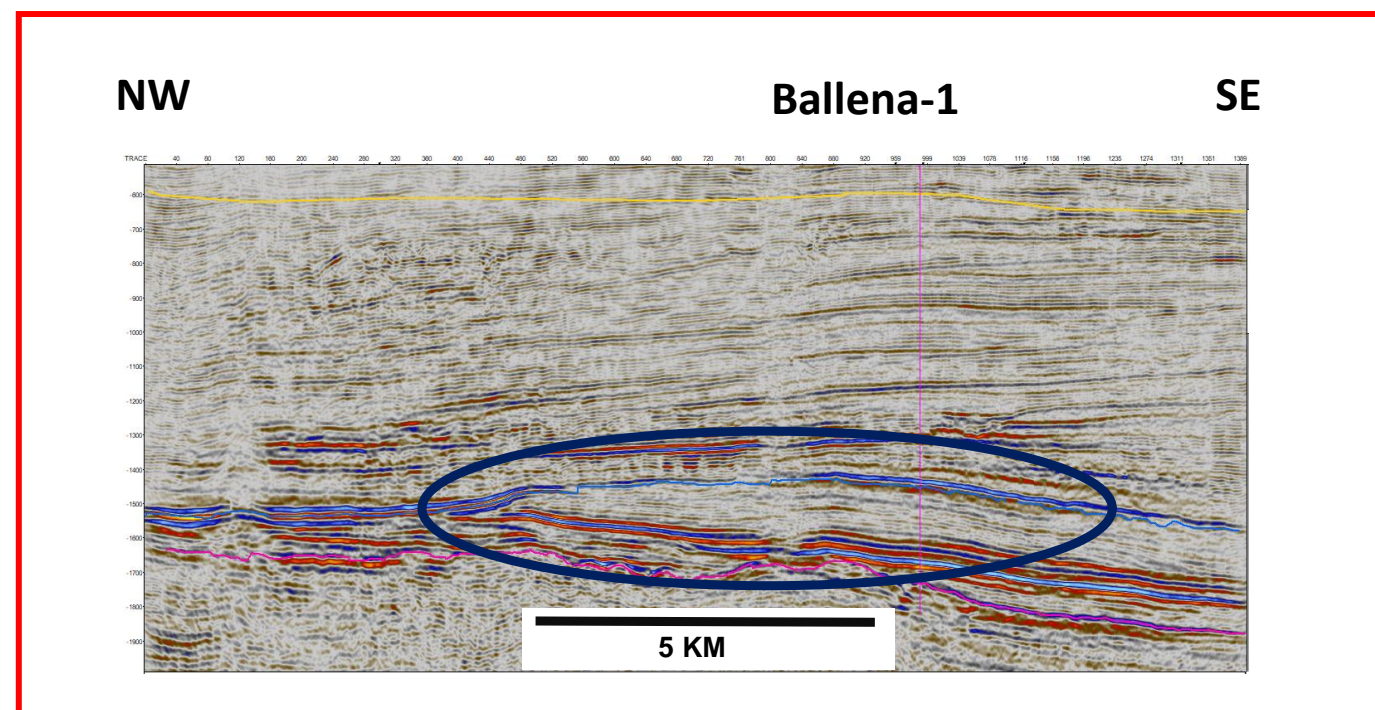
Play present in structures associated with paleo highs.

CARBONATES ON BASEMENT HIGHS

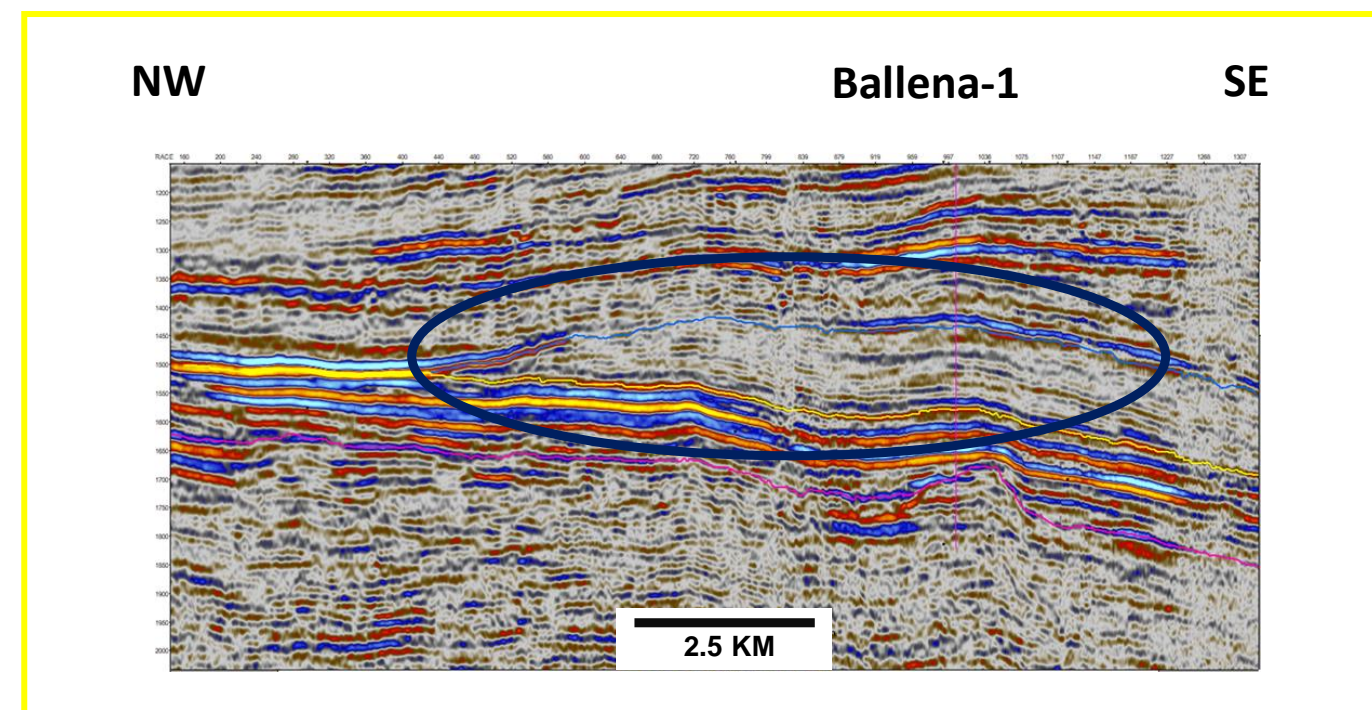
Play proven in Ballena field, Perla
Discovery in W Venezuela.



To be tested in basement
highs in the Caribbean.

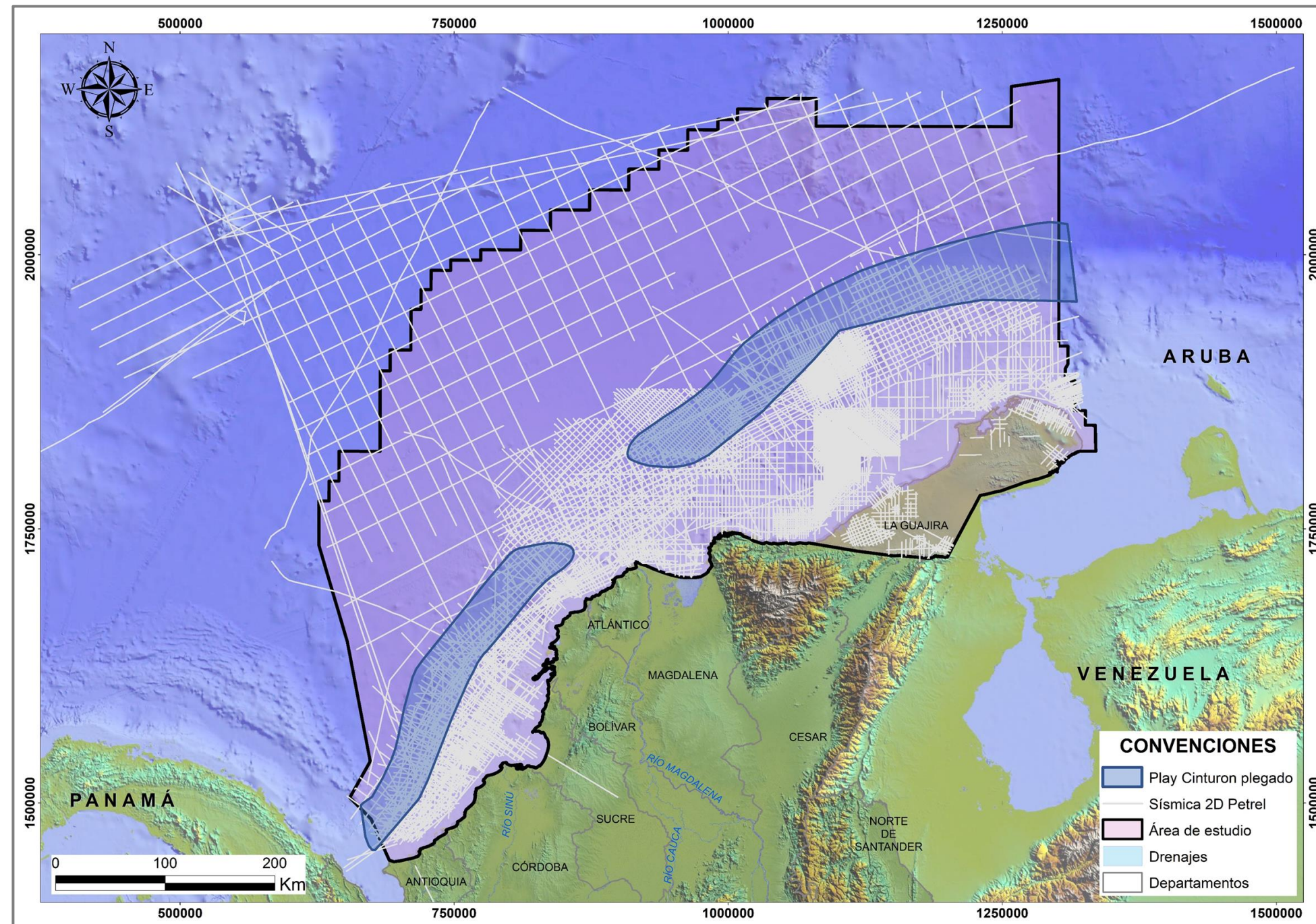


Line CG-2010-1113

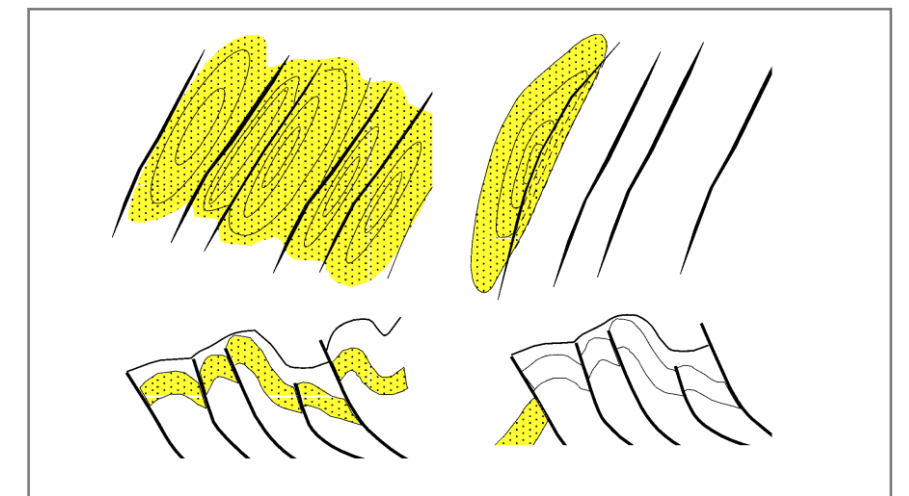


Line CG-2010-115

FOLD BELT STRUCTURES



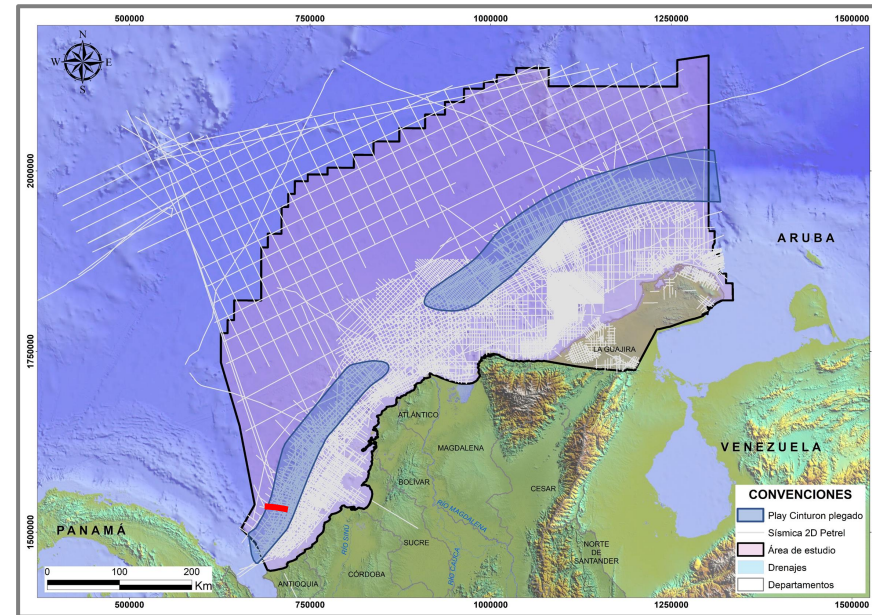
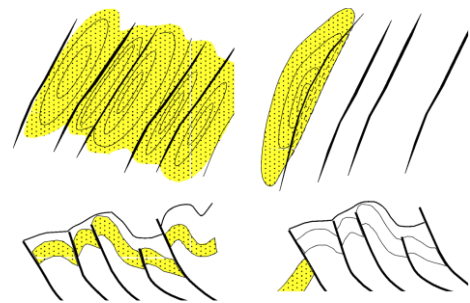
Anticline and monocline structural closures in the South Caribbean Deformed Belt, involving rocks from Late Oligocene up to Pleistocene.



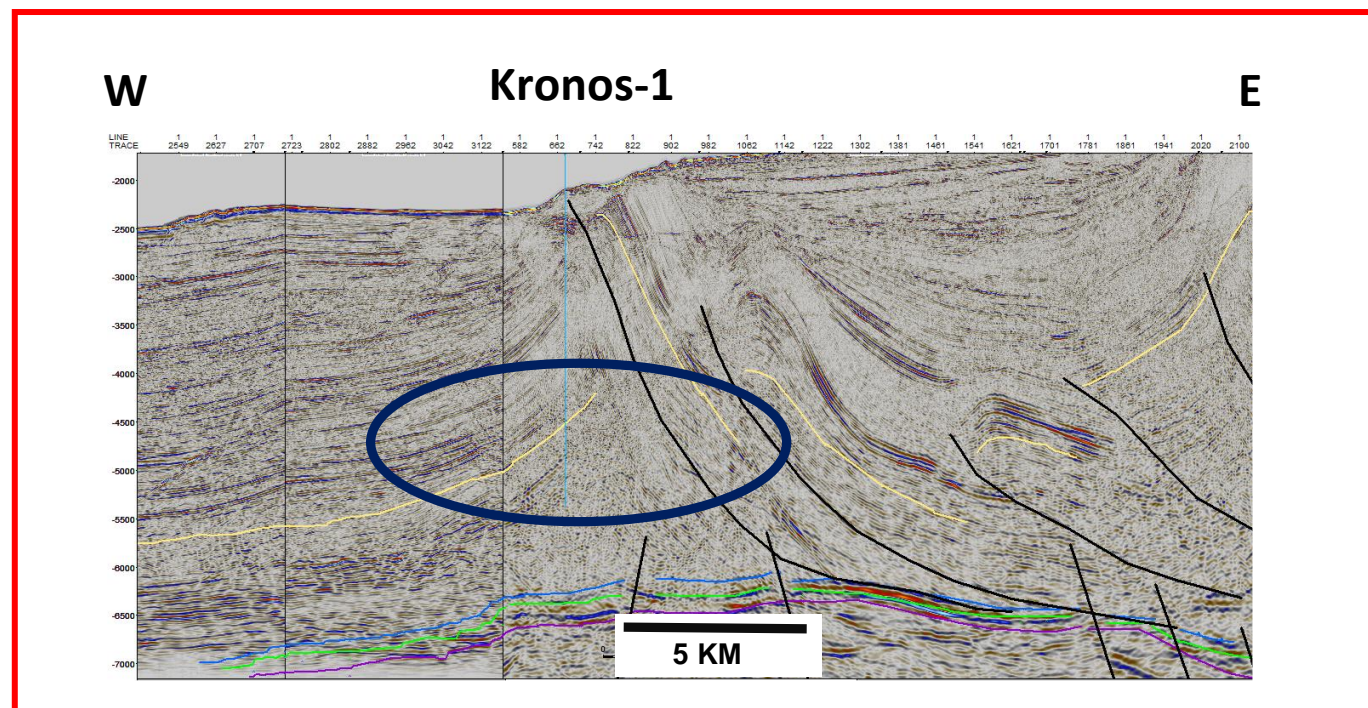
Play present in Guajira and Sinu offshore. Absent in Magdalena delta area.

FOLD BELT STRUCTURES

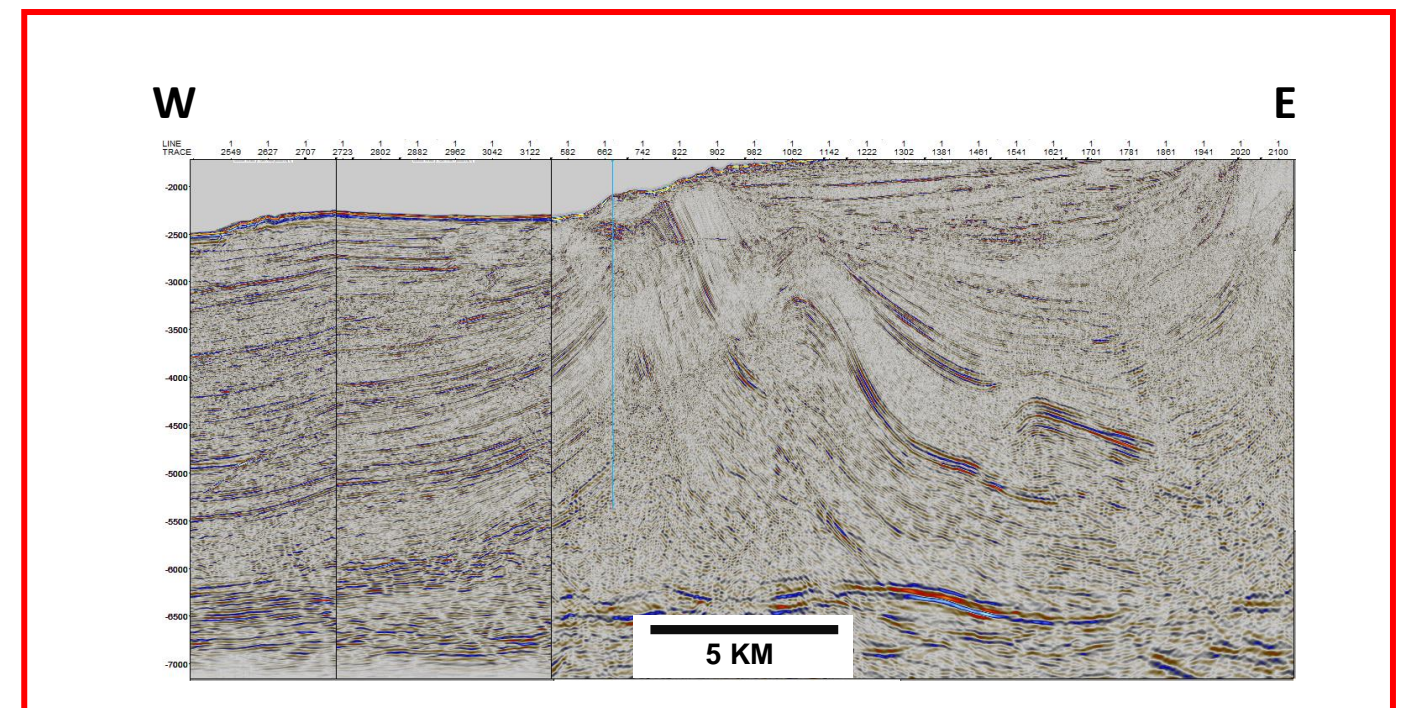
Proven in Kronos, Gorgon and Purple Angel wells.



To be tested in structures along the SCDB.



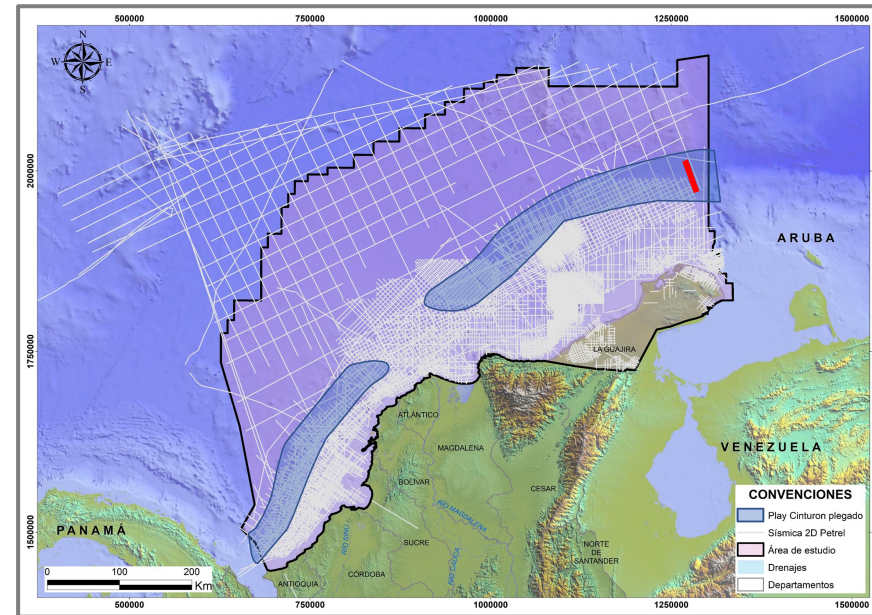
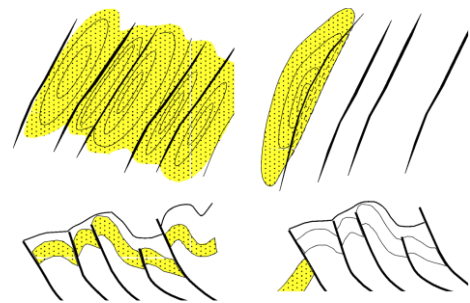
Interpreted Composite line



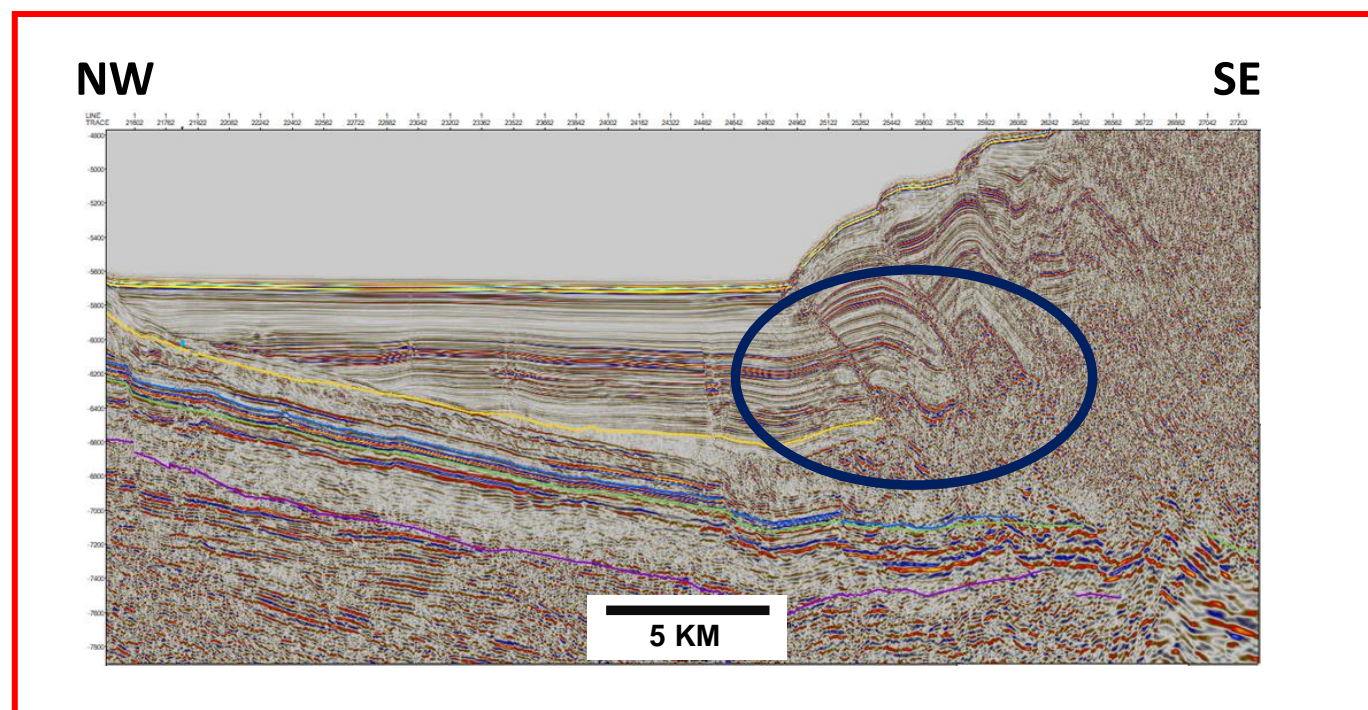
W-E Composite line

FOLD BELT STRUCTURES

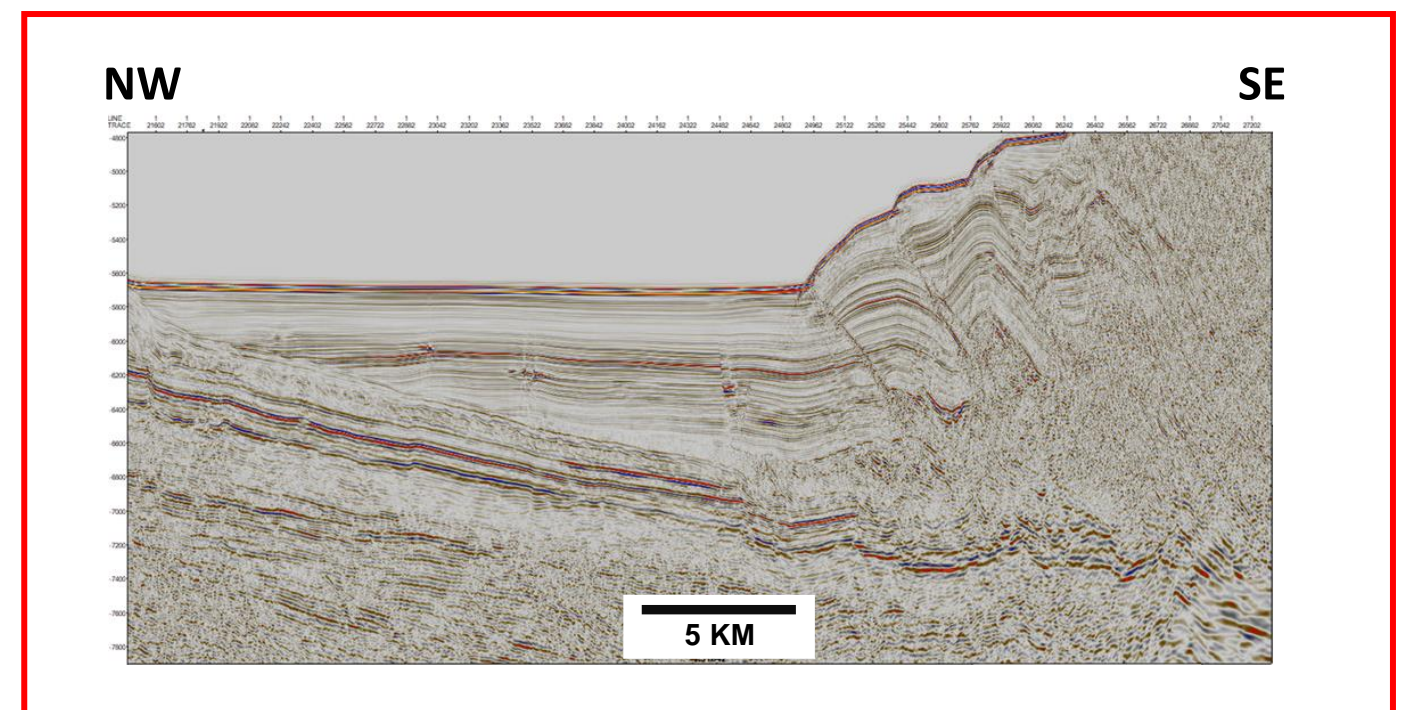
Proven in Kronos, Gorgon and Purple Angel wells.



To be tested in structures along the SCDB.



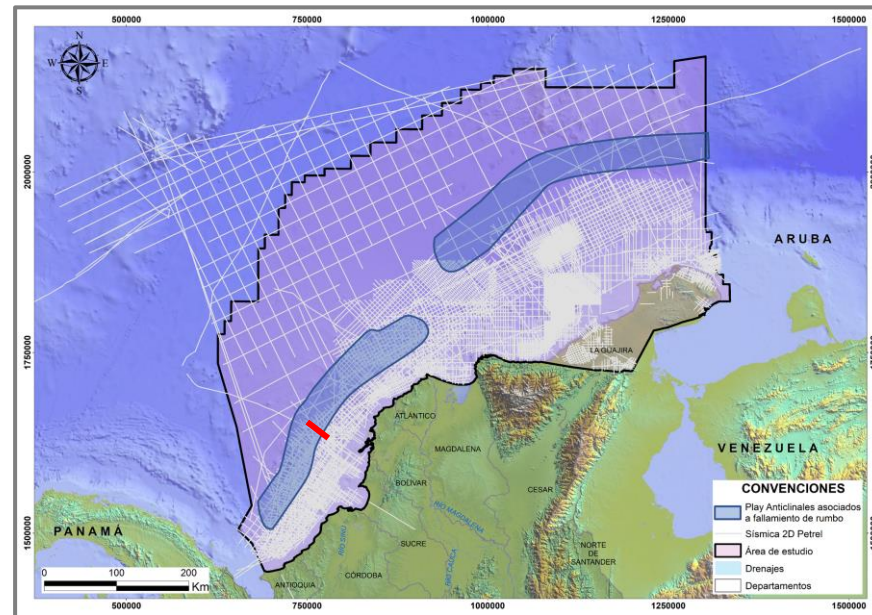
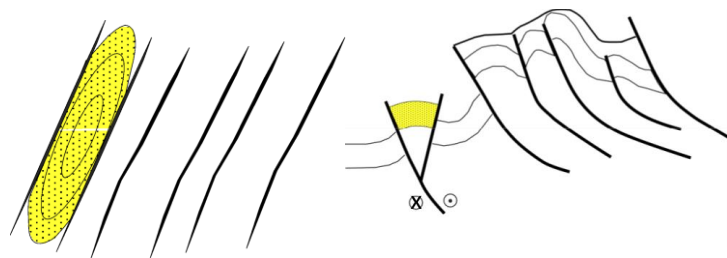
Line COL-ANH-2014-54



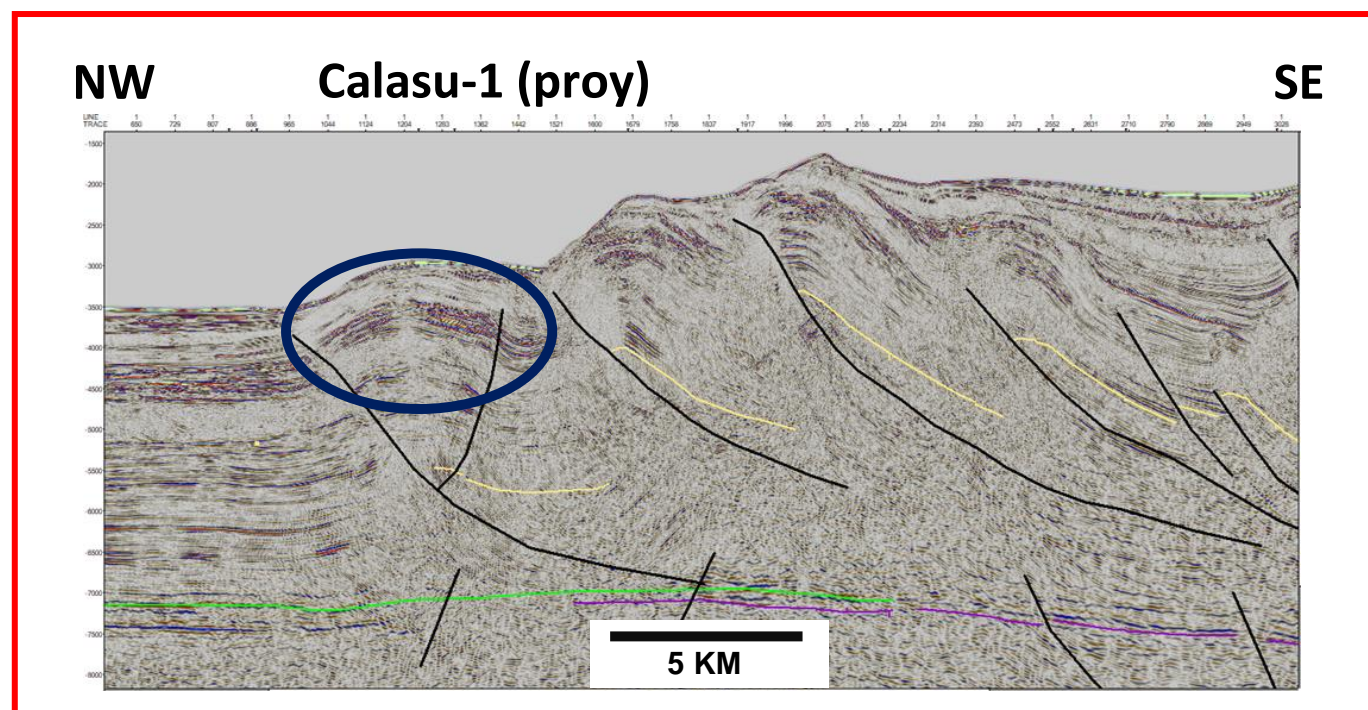
Line COL-ANH-2014-54

FOLD BELT (AND STRIKE SLIP) STRUCTURES

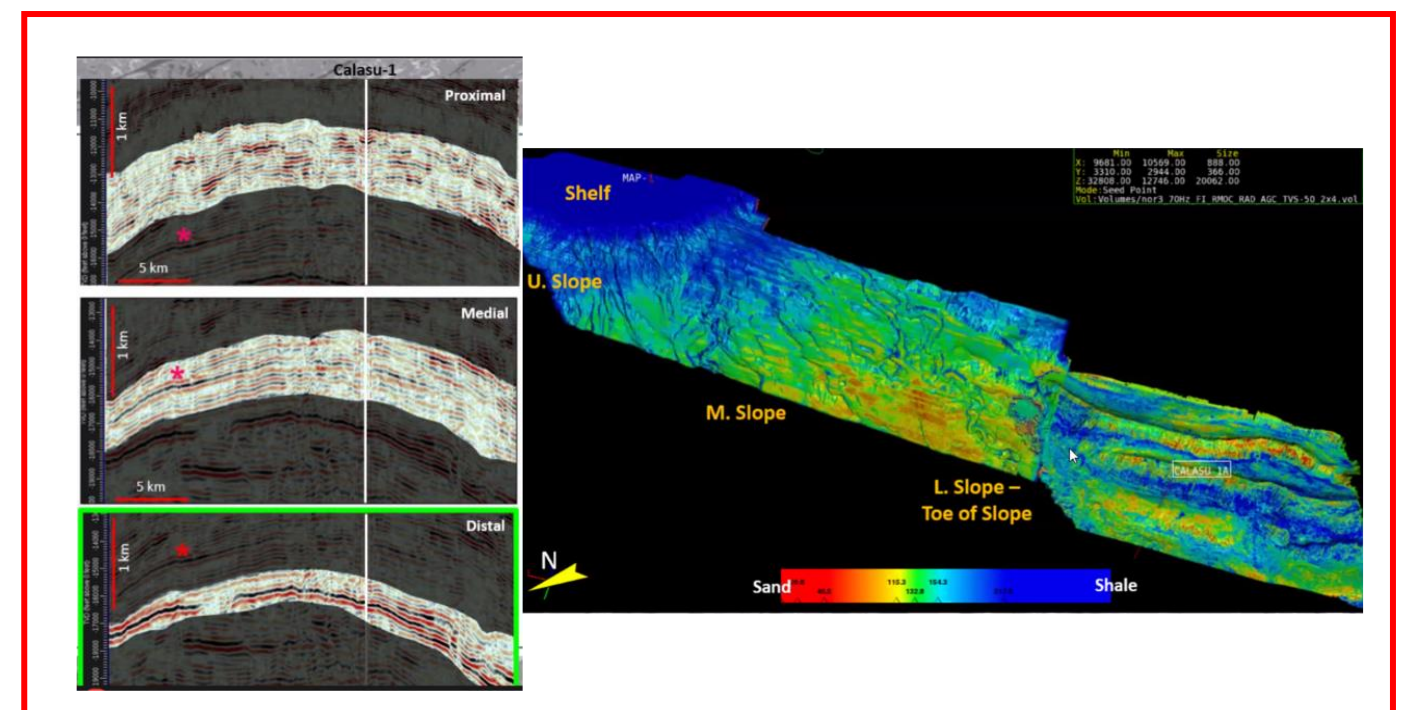
Along the SCDB, strike slip related structures are present, as proven in Calasu-1 well.



To be tested in structures along the outer most side of SCDB.

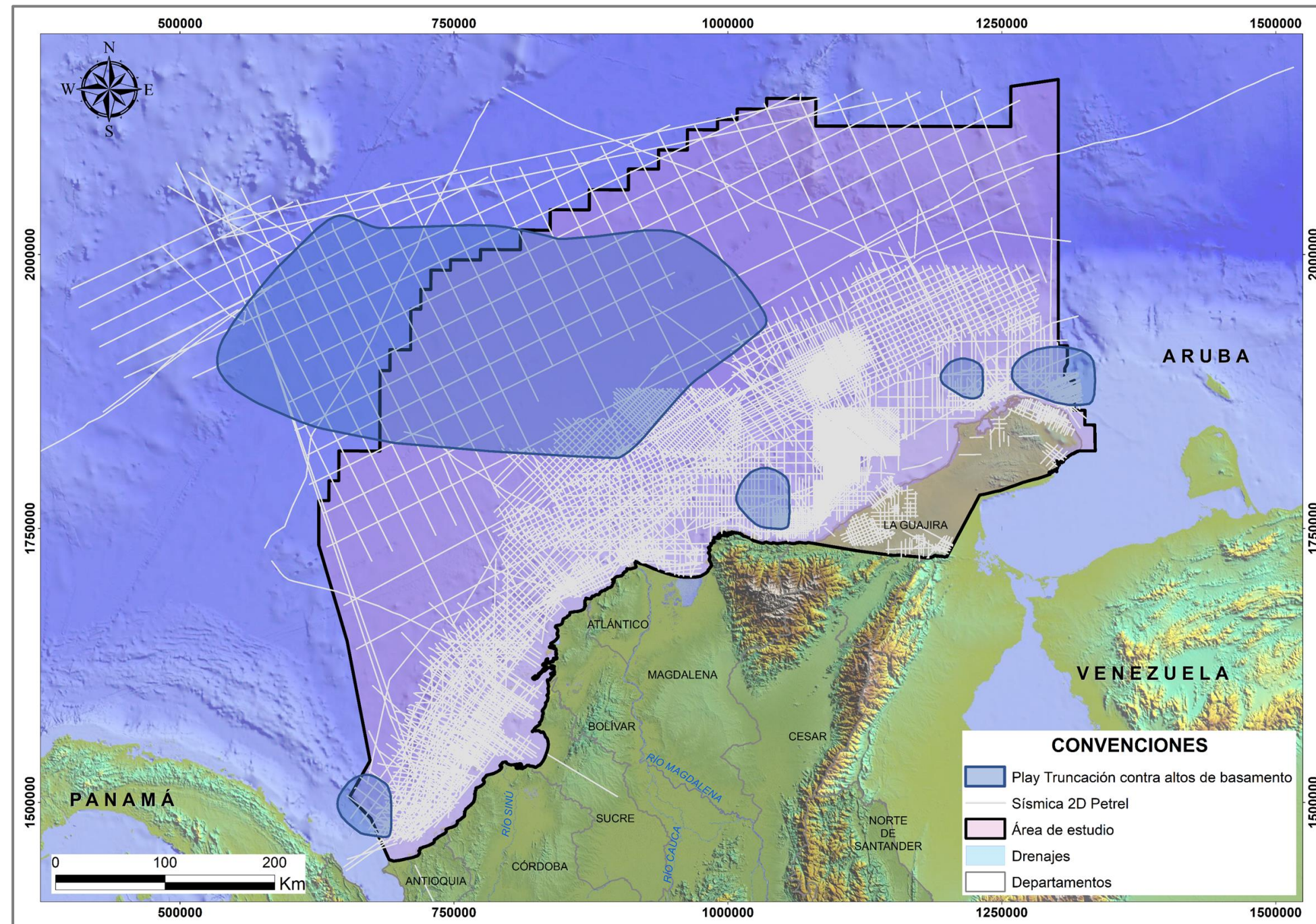


Line CF-2006-89

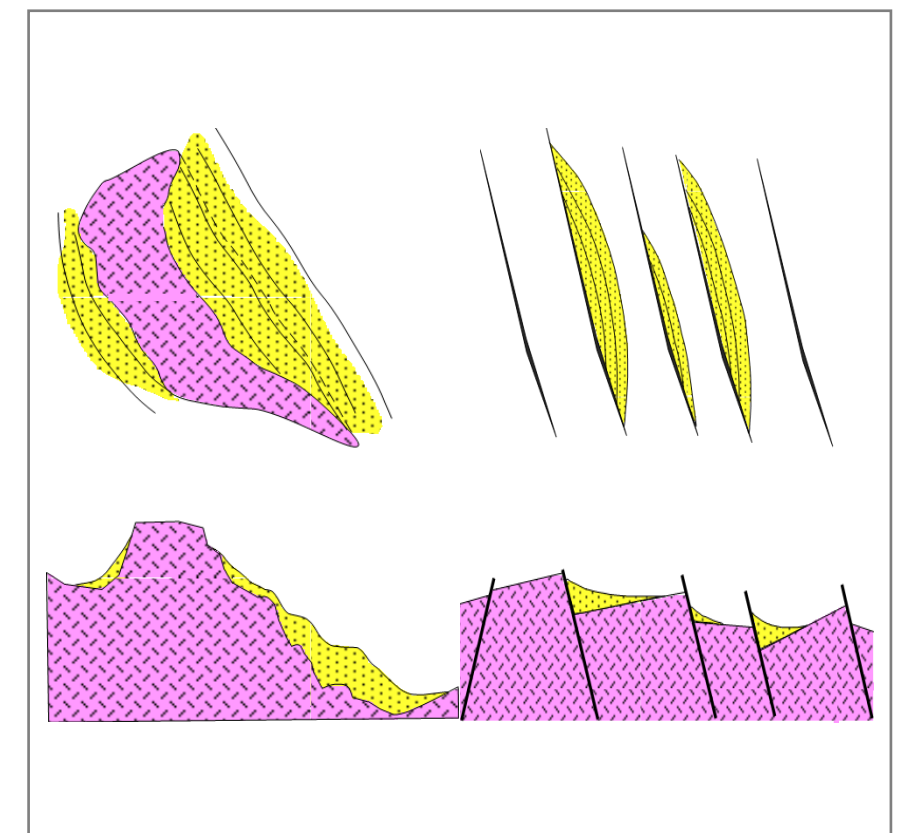


Llinas and Rendon, 2021. Prograding submarine fans in the SCDB

ONLAPS AGAINST BASEMENT HIGHS



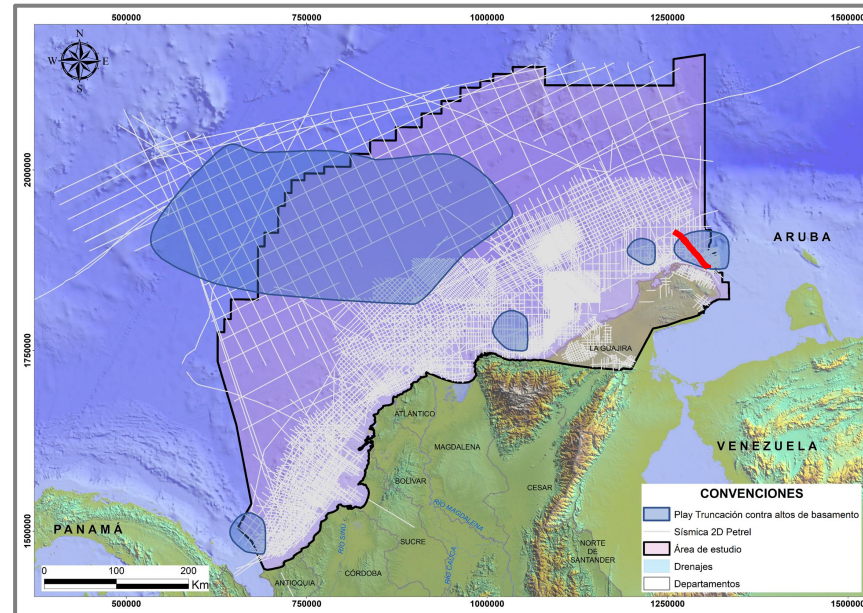
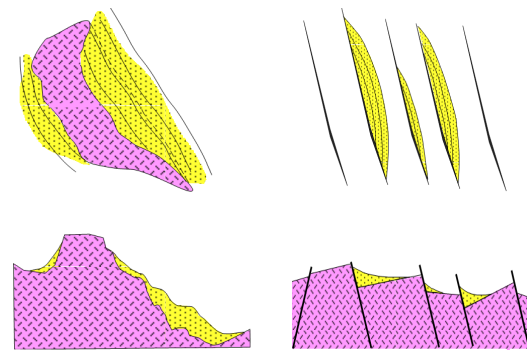
Onlap and structural terminations of Cretaceous and Tertiary sequences against basement highs.



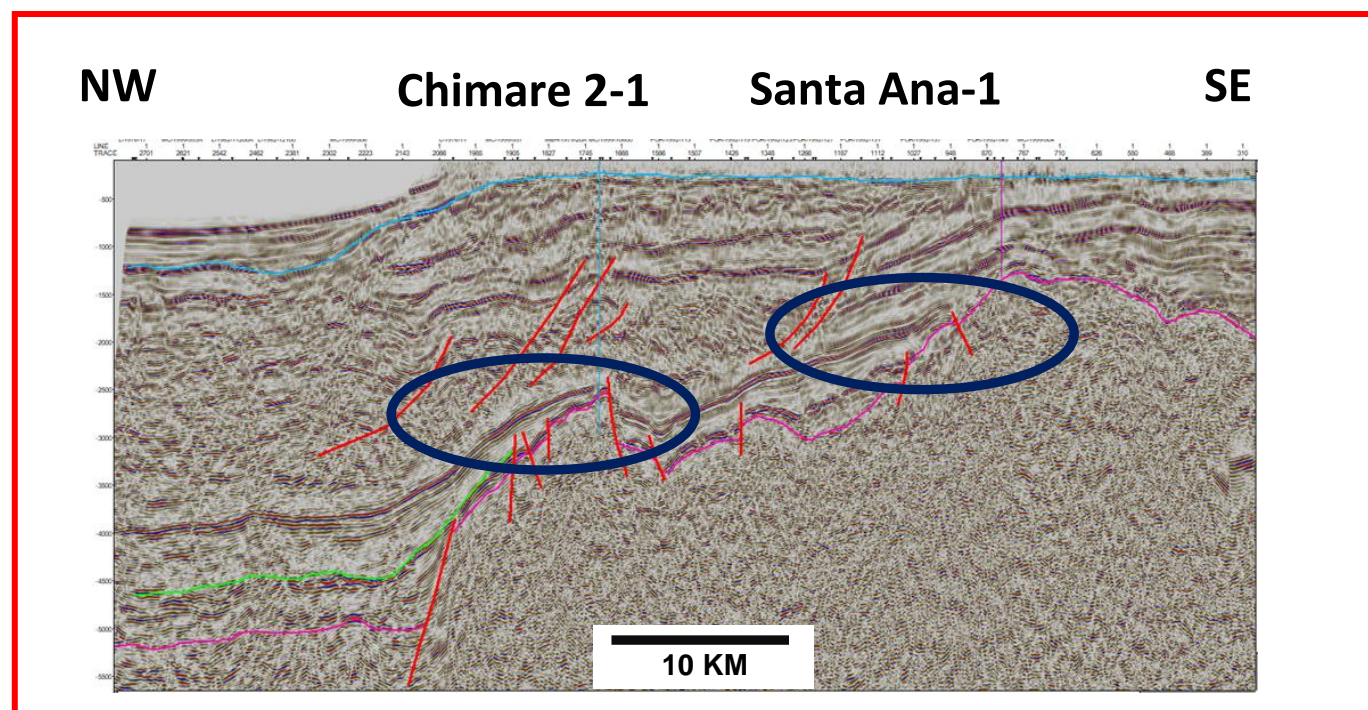
Play present in Guajira and Colombia Basin.

ONLAPS AGAINST BASEMENT HIGHS

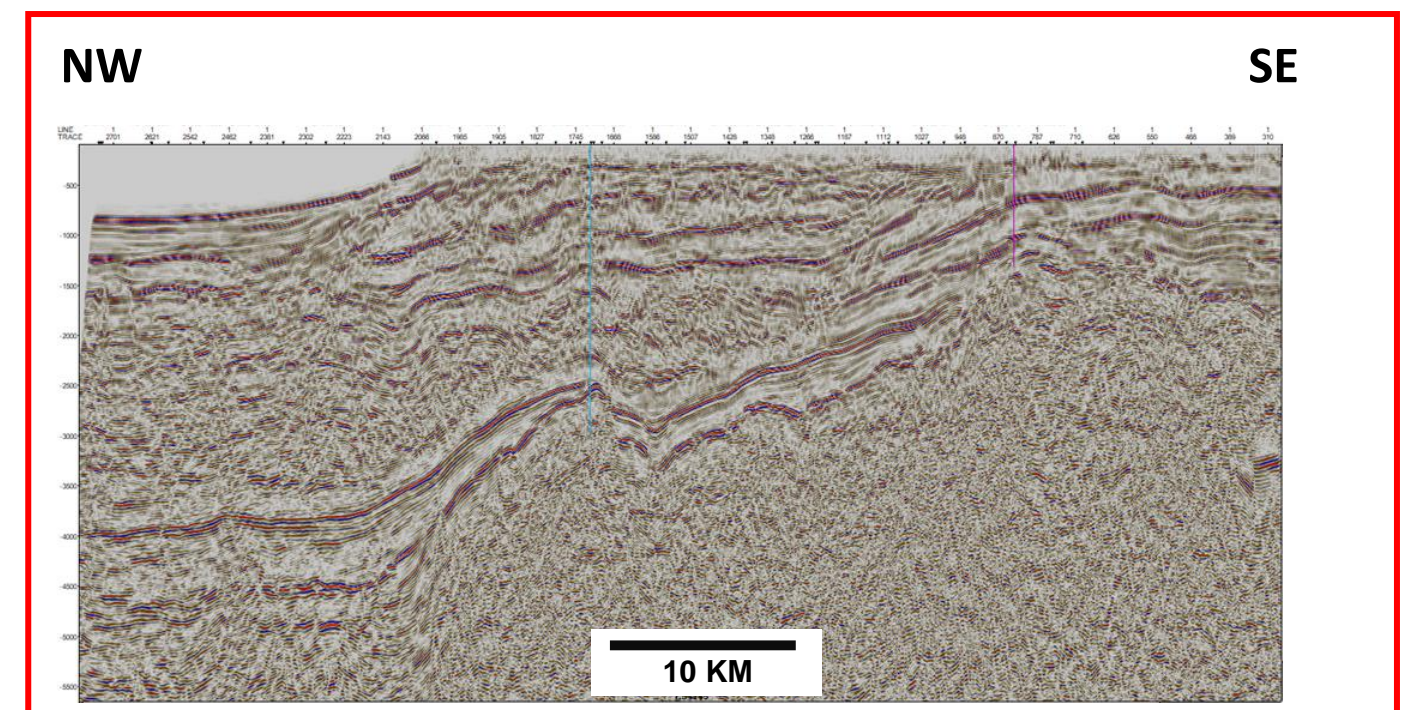
Proven in Santa Ana-1 and Chimare 2-1 wells.



To be tested in Tayrona Depression and Colombia Basin.



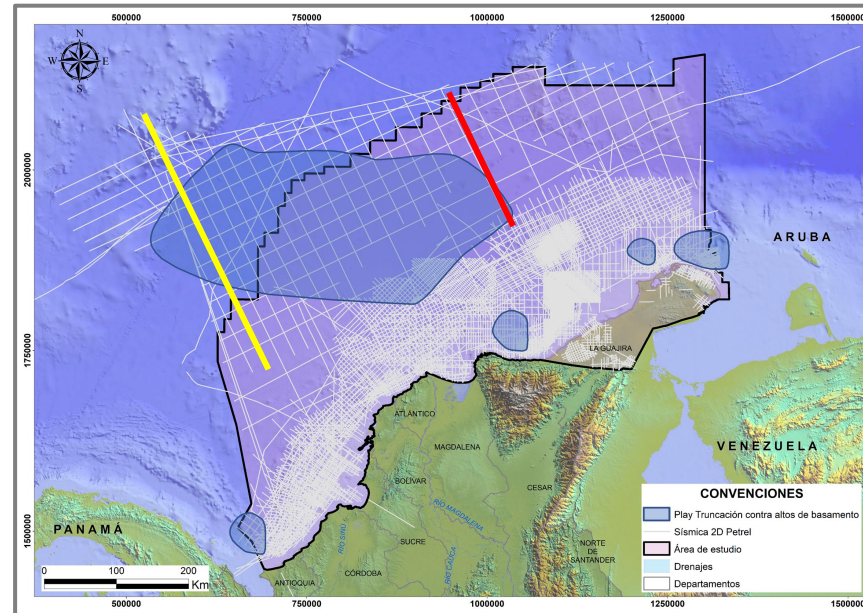
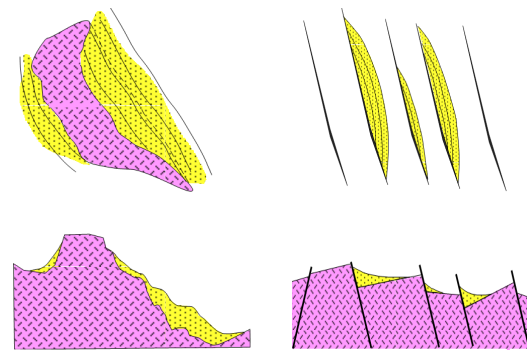
L-1976-04 504



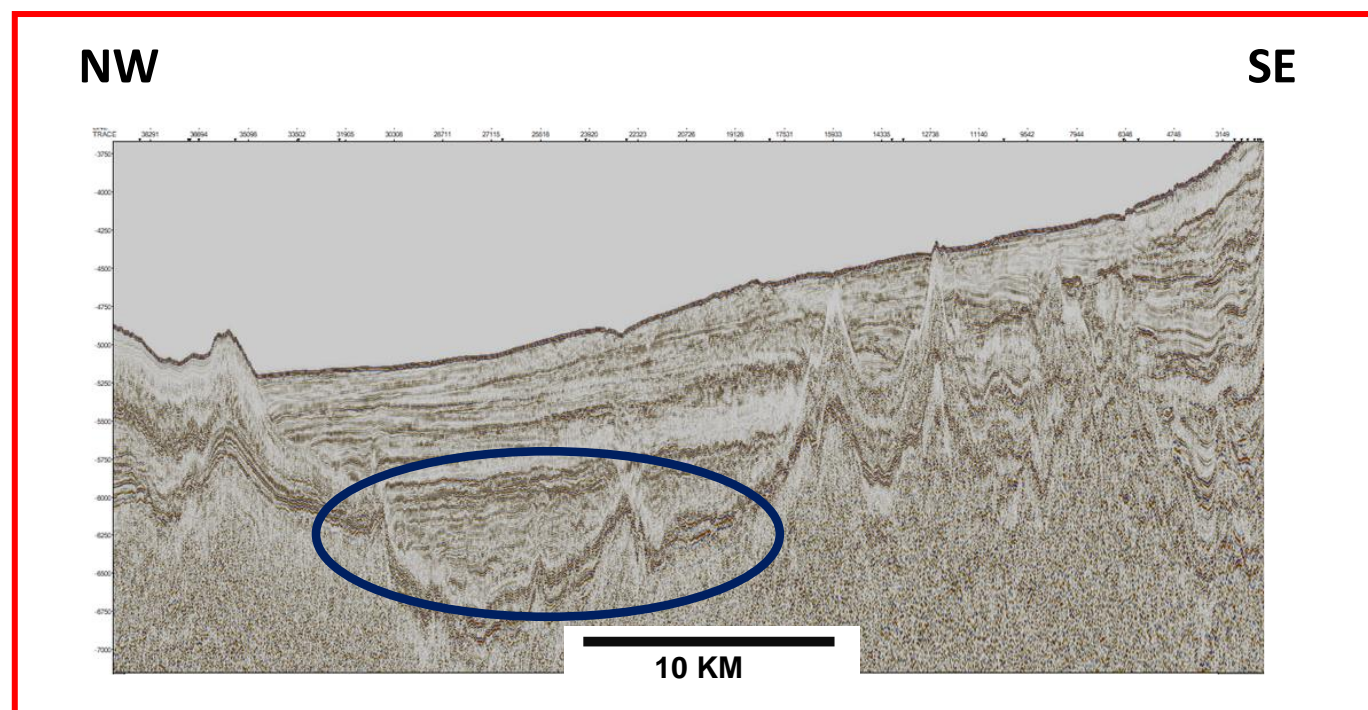
L-1976-04 504

ONLAPS AGAINST BASEMENT HIGHS

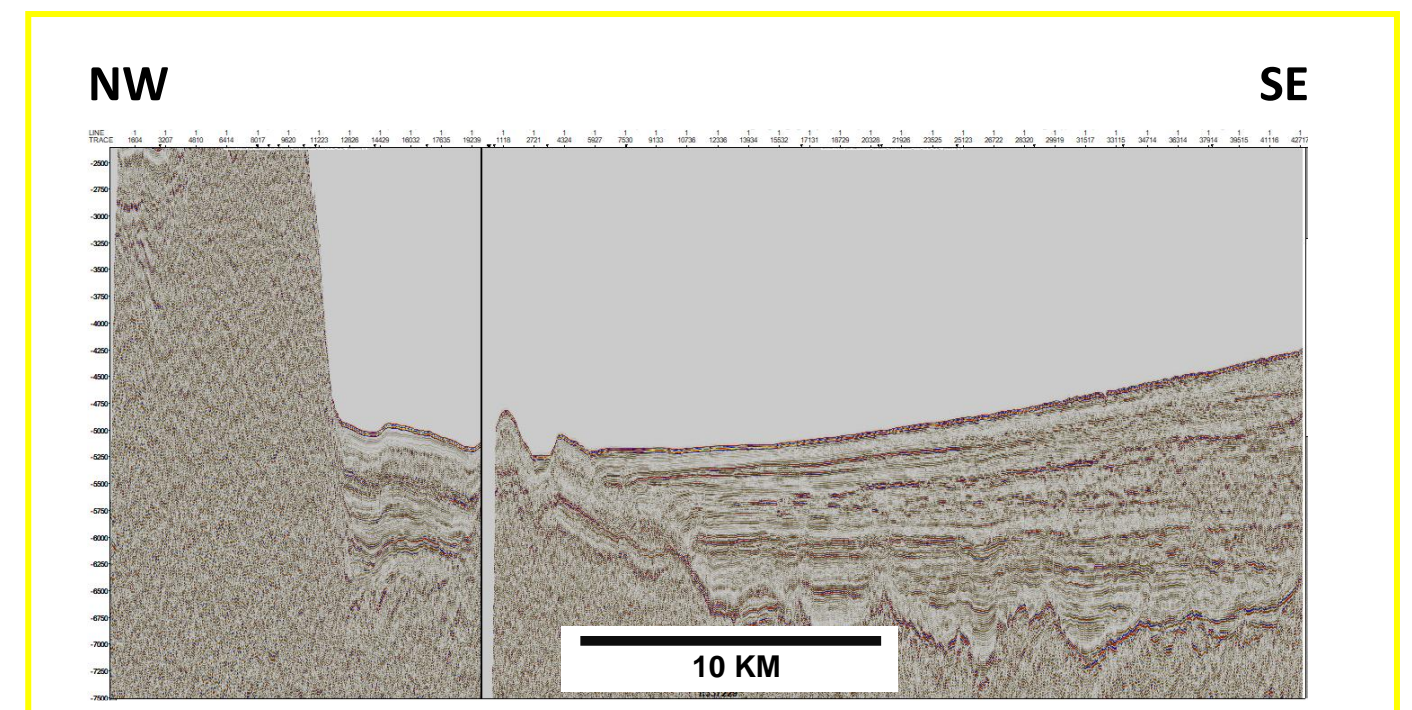
Proven in Santa Ana-1 and Chimare 2-1 wells.



To be tested in Tayrona Depression and Colombia Basin.

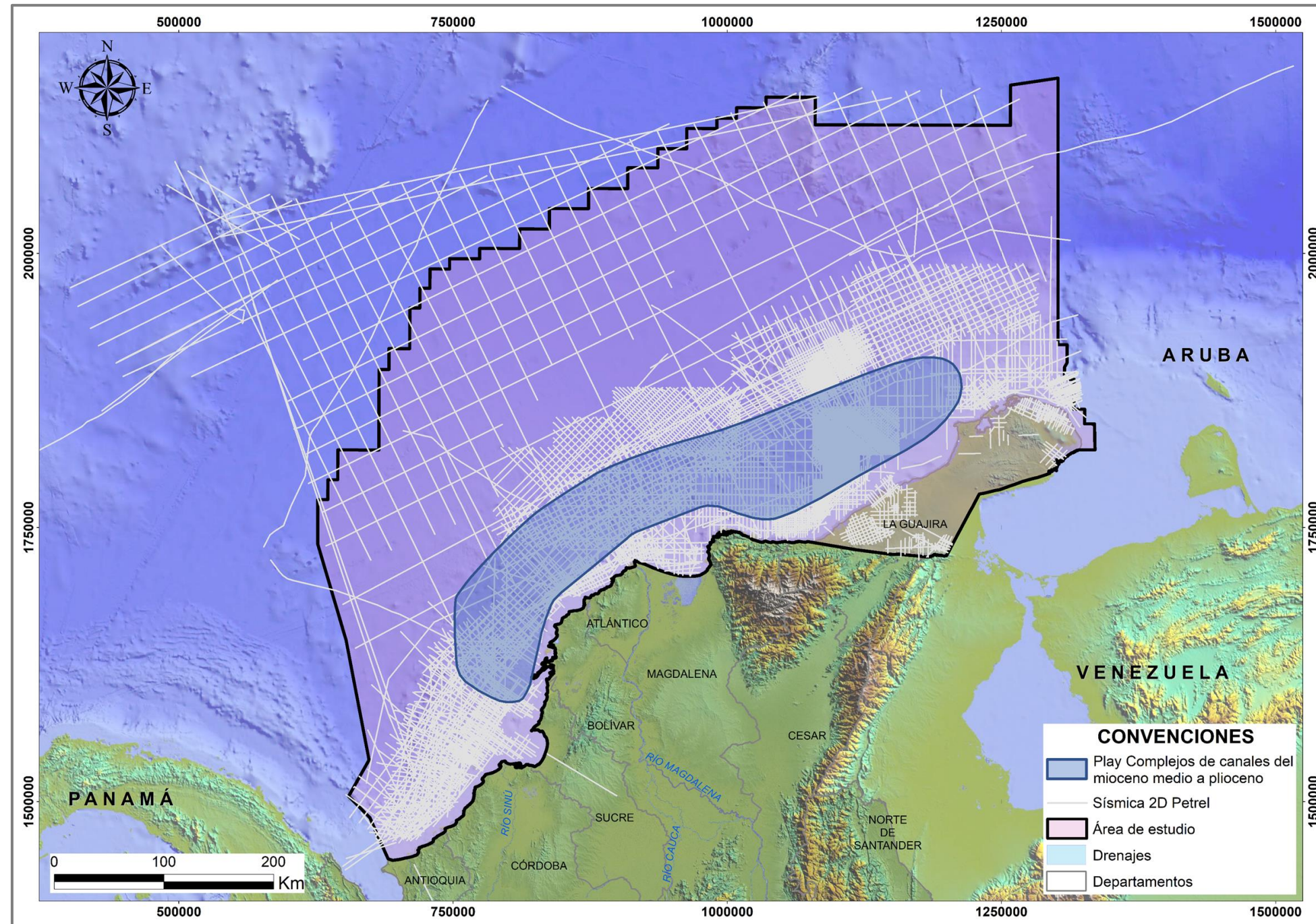


ANHCAY-2009-01

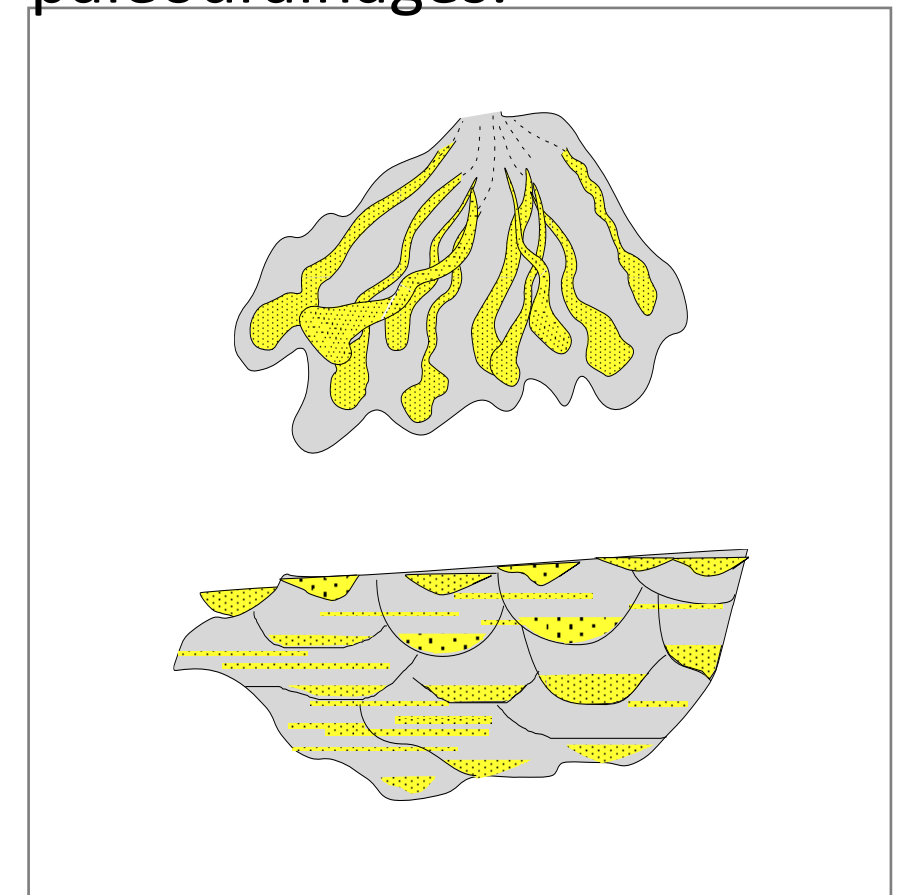


COL-ANH-2014-24E y 24

MIO-PLIOCENE CHANNEL COMPLEXES



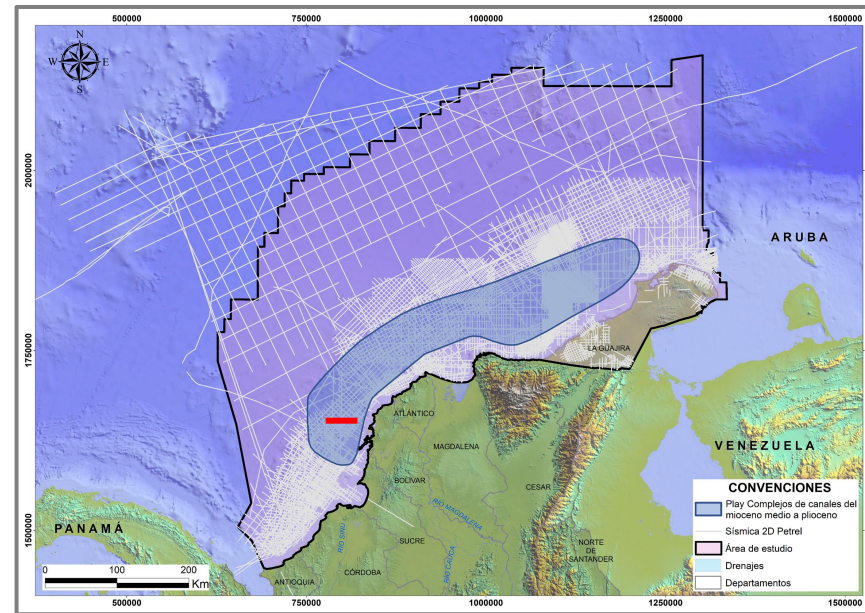
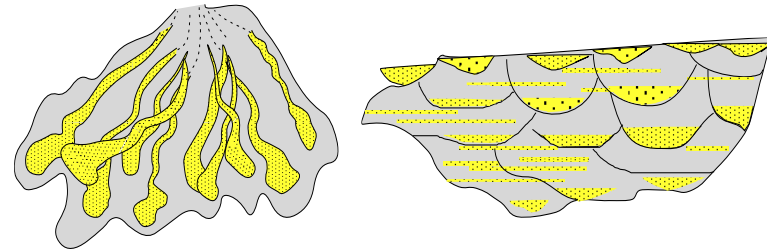
Clastic deposits from nearshore Magdalena fan and other Neogene paleodrainages.



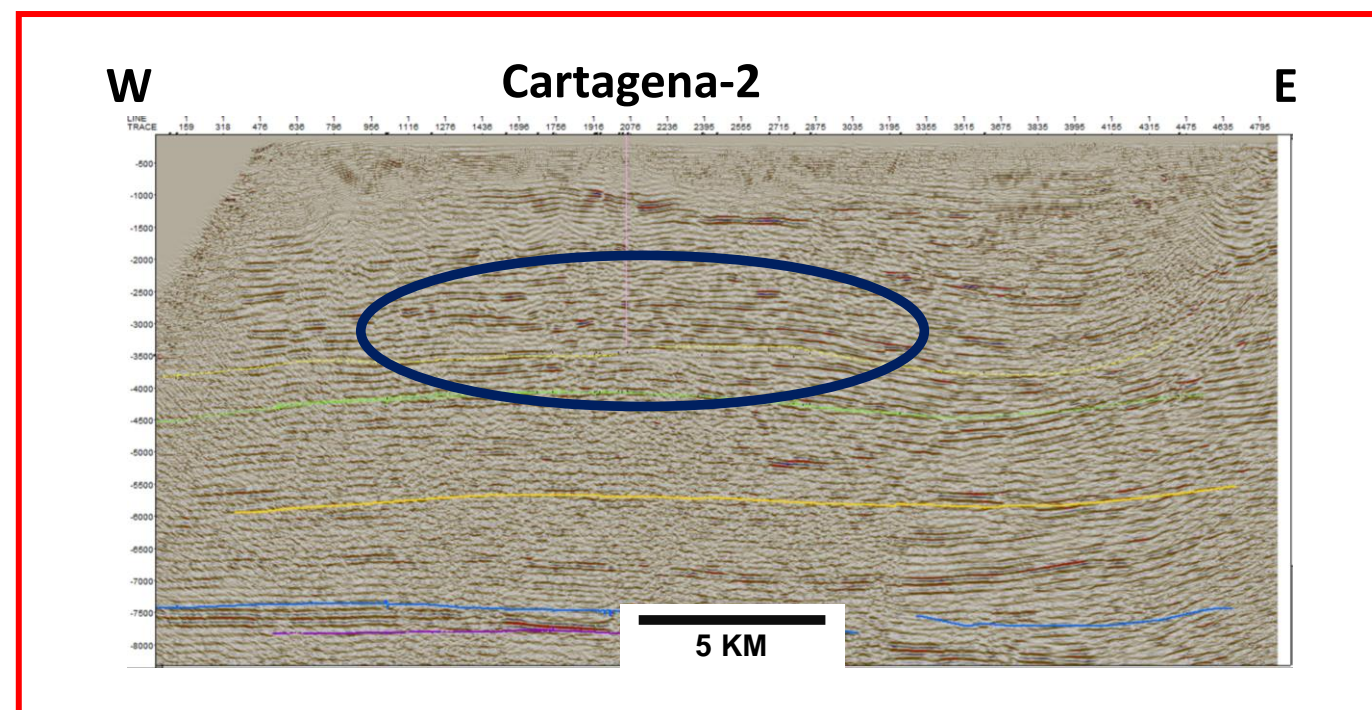
Play present in Guajira and Sinú offshore areas.

MIO-PLIOCENE CHANNEL COMPLEXES

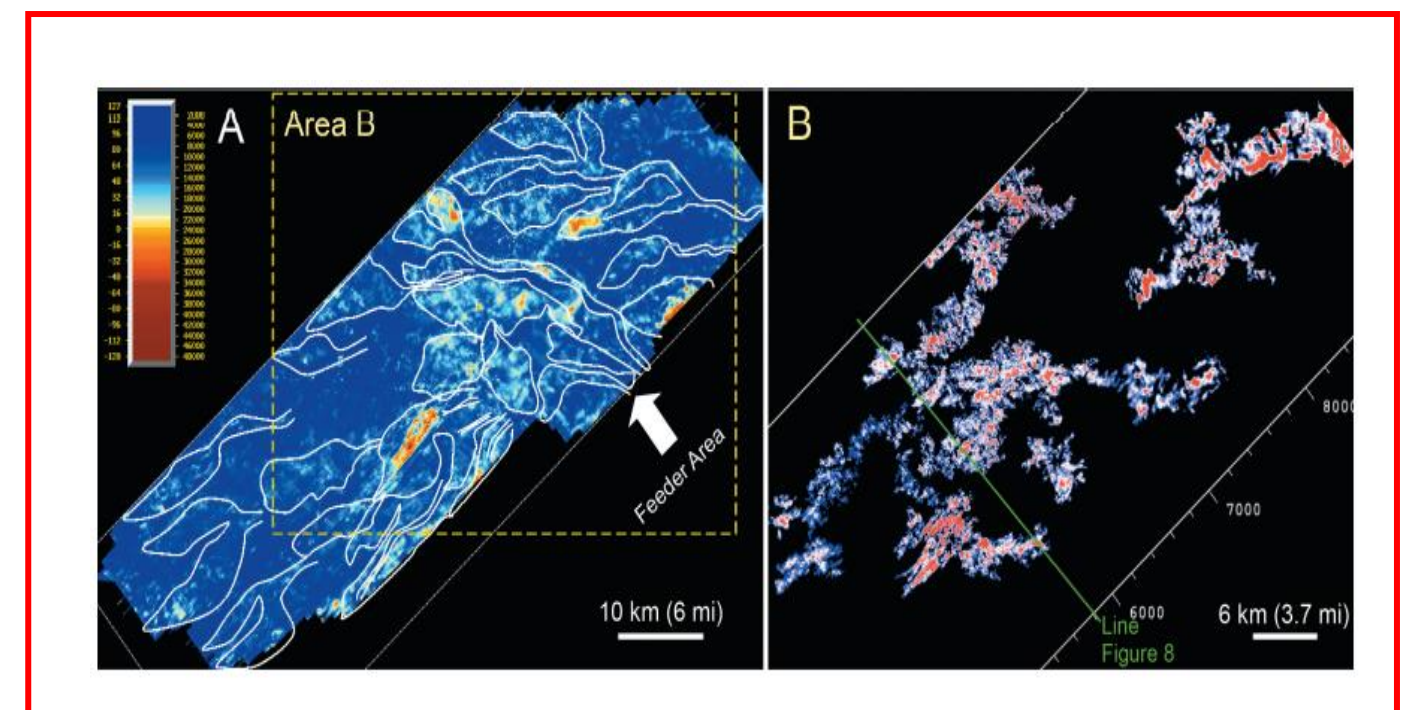
Proven in Cartagena-2 and Mapale-1 wells.



To be tested in offshore Guajira and Sinú.



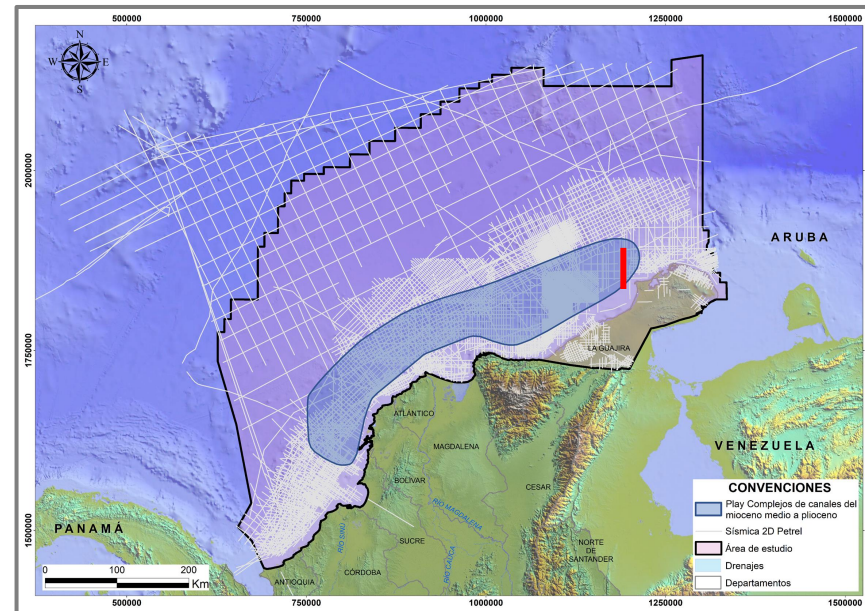
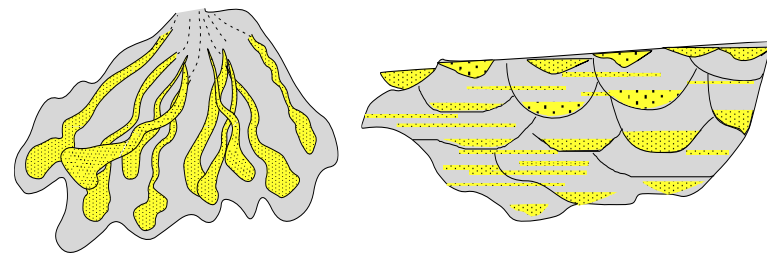
Seismic image of Magdalena Delta



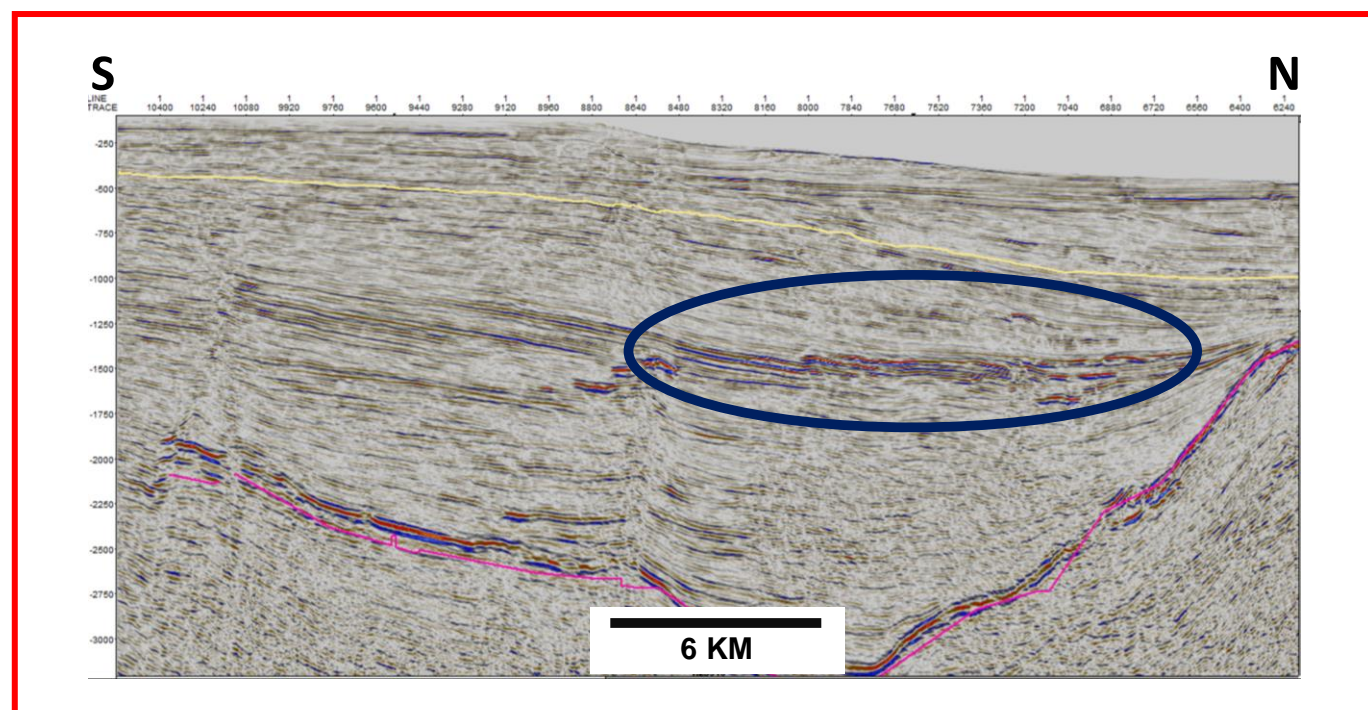
Channel complex observed in 3D seismic by Martinez et al (2015)

MIO-PLIOCENE CHANNEL COMPLEXES

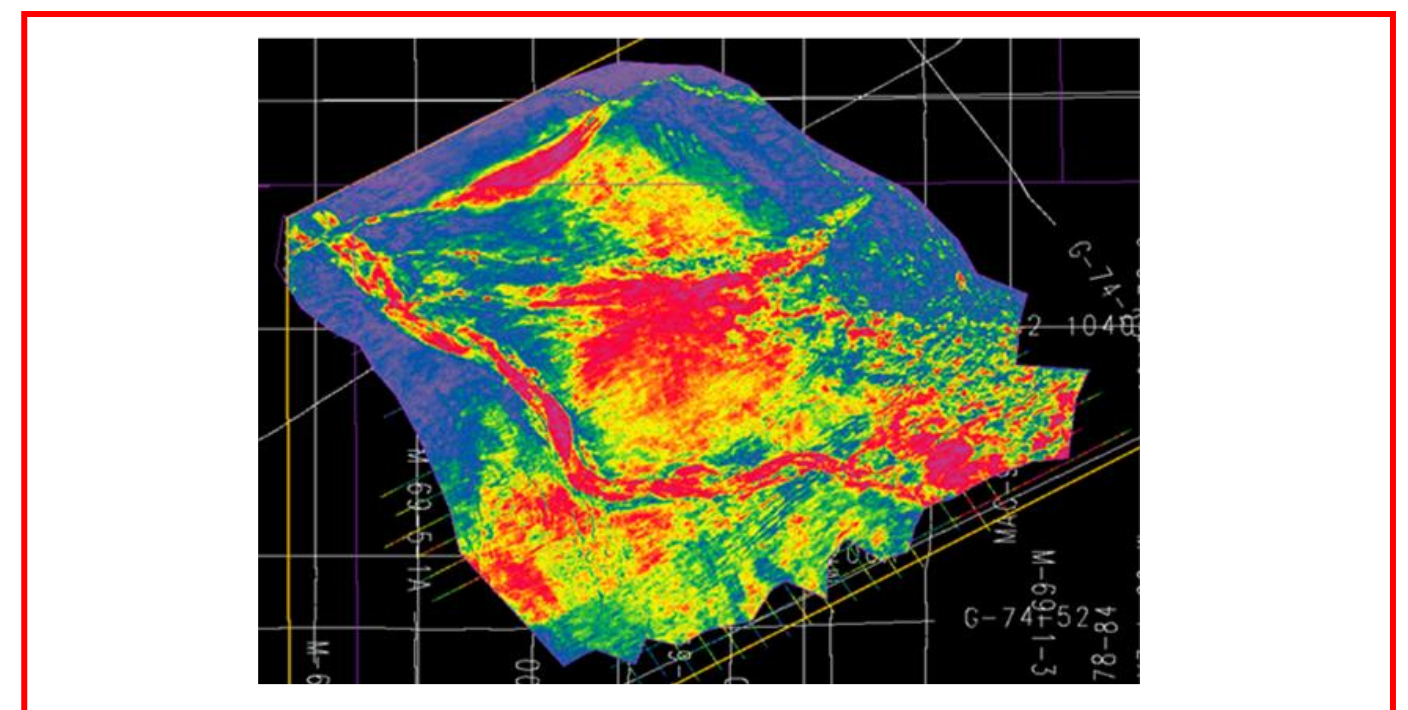
Proven in Cartagena-2 and
Mapale-1 wells.



To be tested in offshore
Guajira and Sinú.

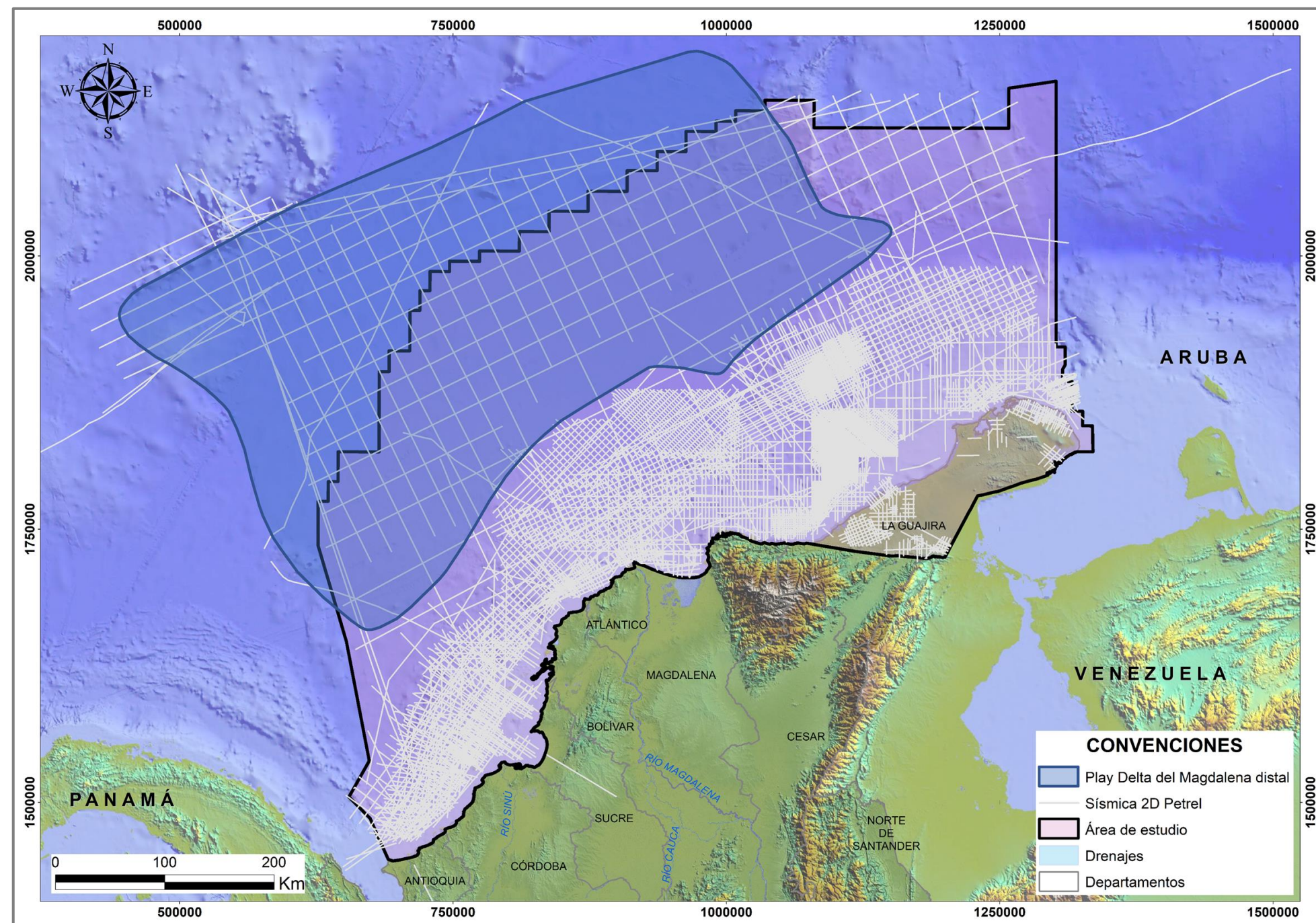


Seismic section west of Cabo de la Vela, Offshore Guajira

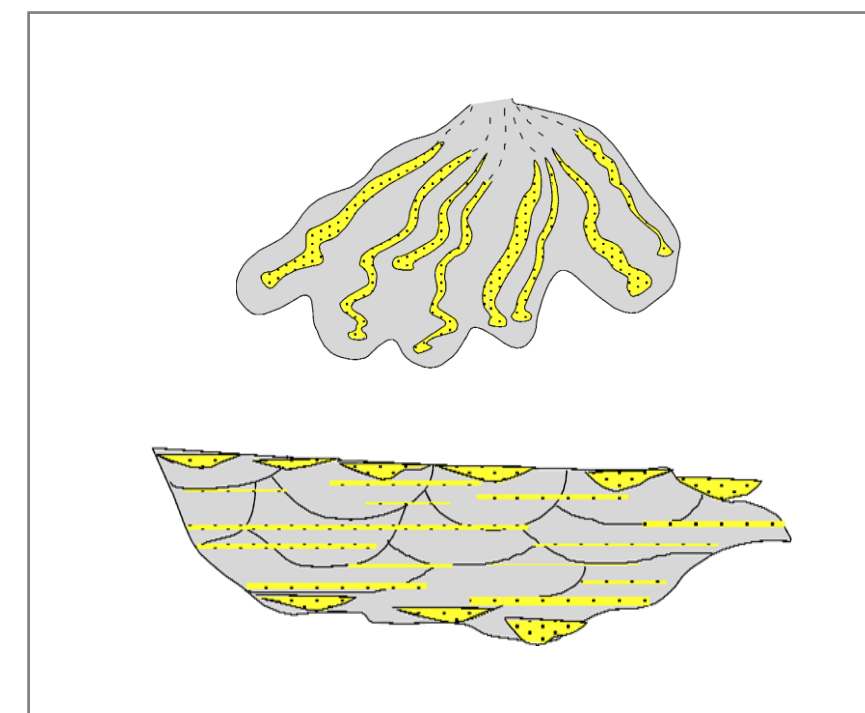


Channel complex observed in 3D seismic. Modified after Ecopetrol (2012)

DISTAL MAGDALENA FAN



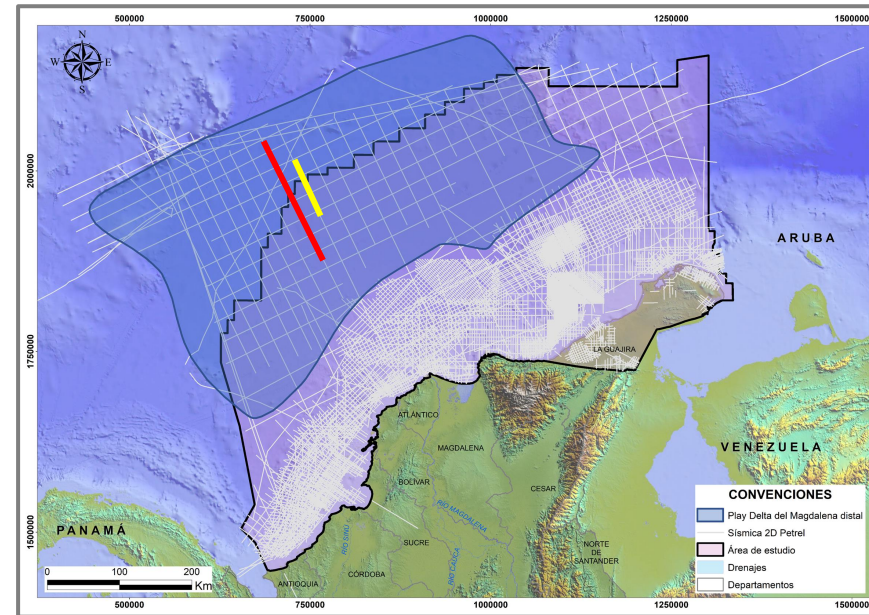
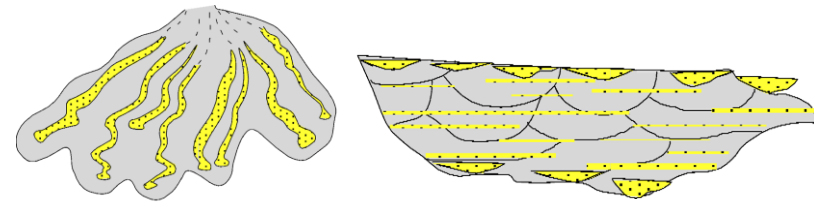
Mid to late Miocene clastic deposits from distal Magdalena fan, filling Colombia basin as far as Hess Scarpment.



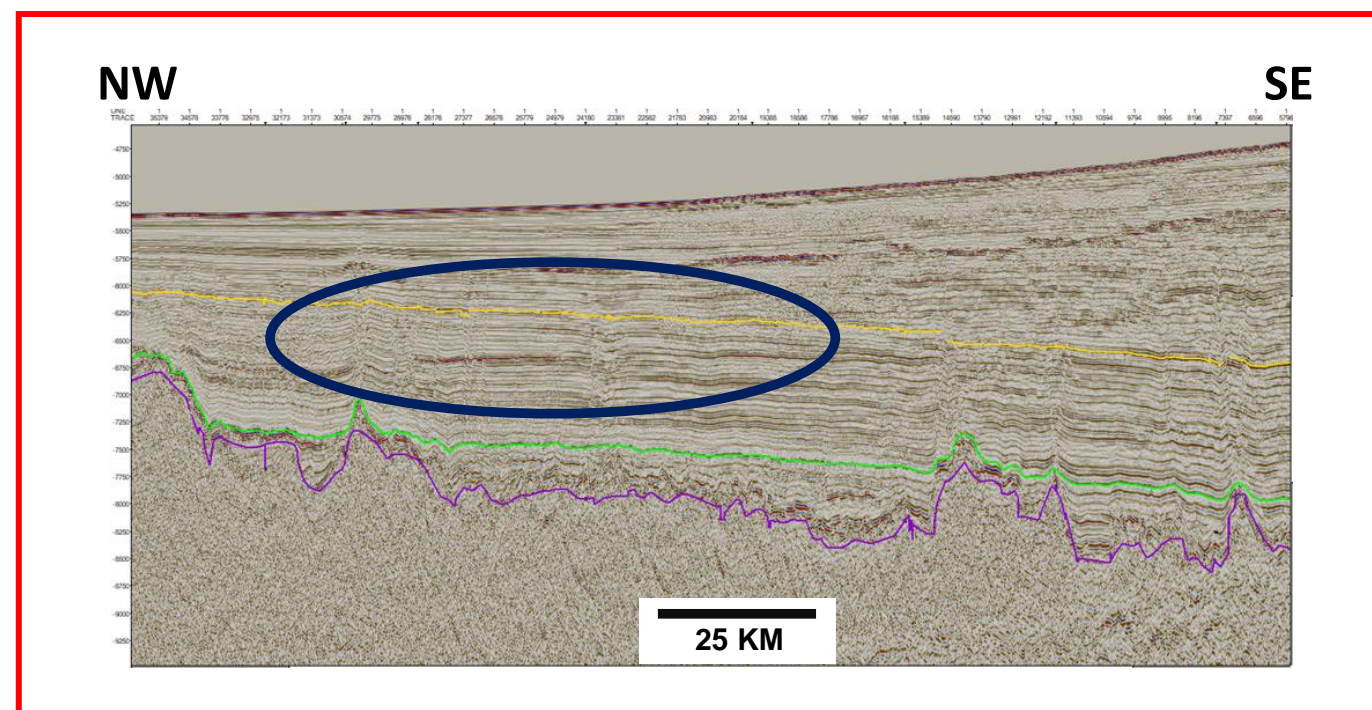
Play present in Colombia basin, likely fed from K source rocks.

DISTAL MAGDALENA FAN

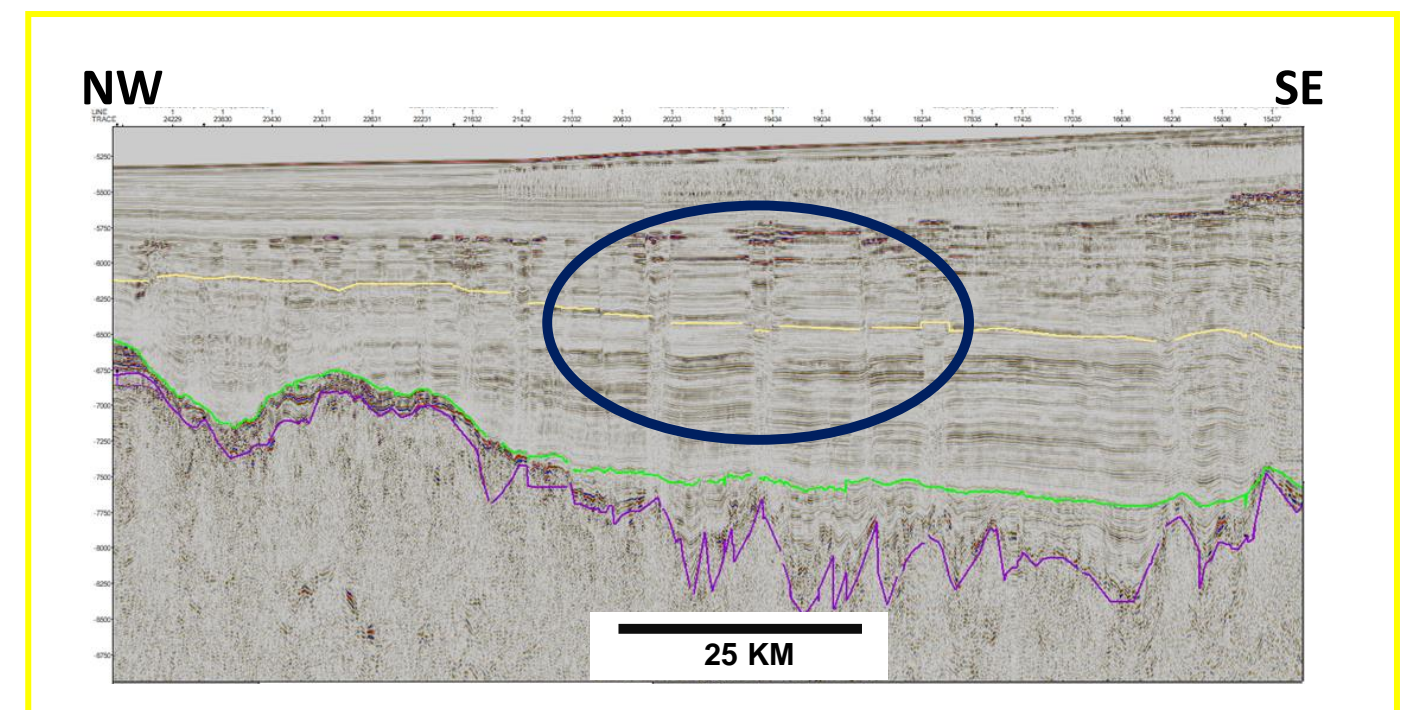
Magdalena fan infill models supported by Idarraga (2019) and Leslie and Mann (2020).



To be tested in Colombia basin, in several amplitude anomalies associated to vertical features representing posible migration paths.



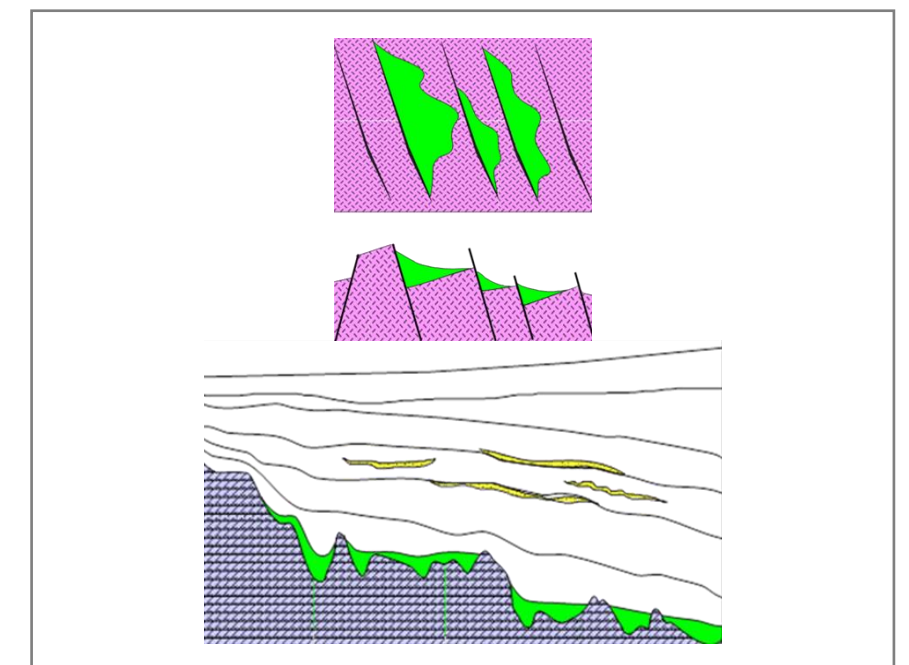
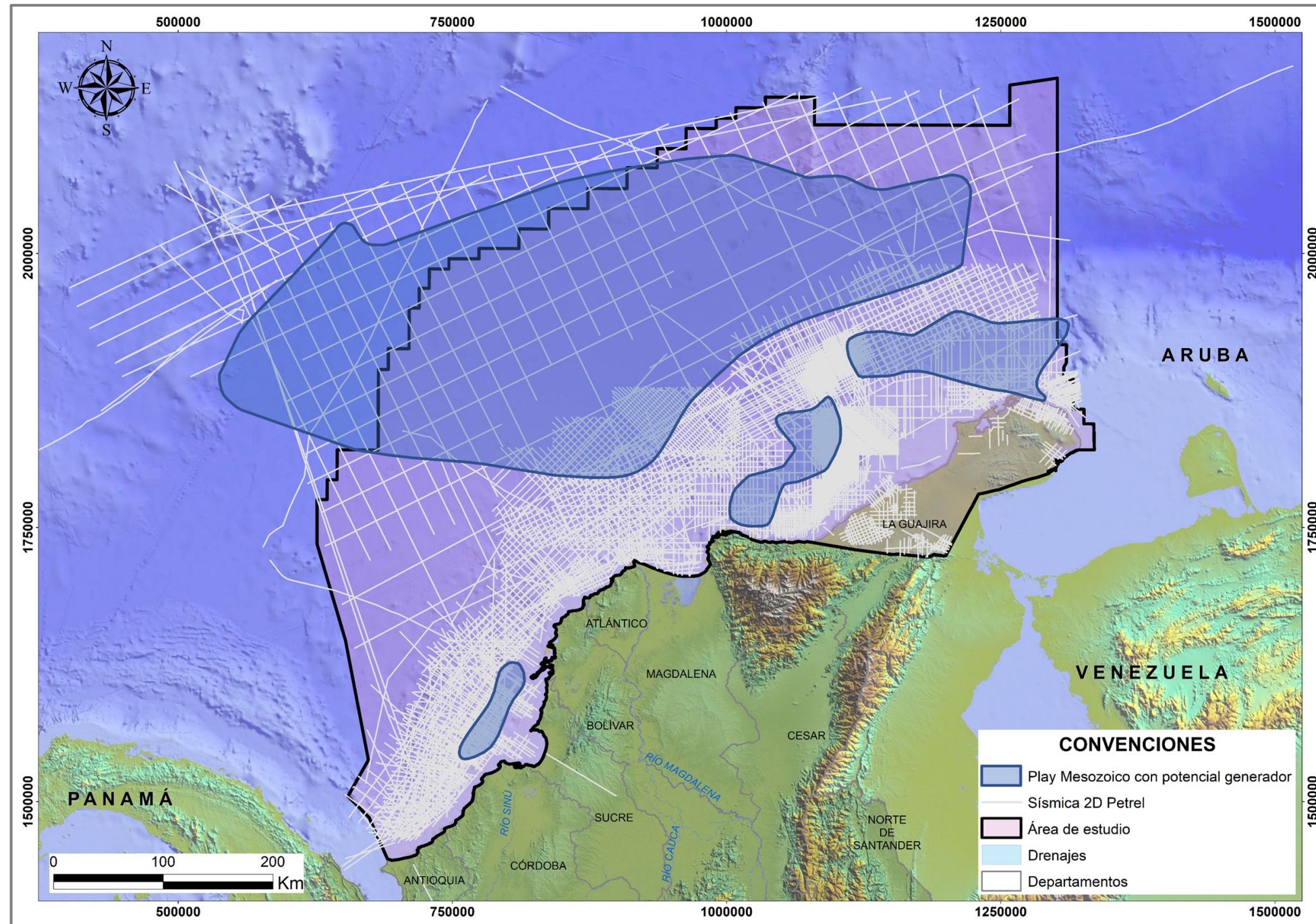
COL-ANH-2012-04



COL-ANH-2012-0

...WITH MESOZOIC SOURCE ROCKS

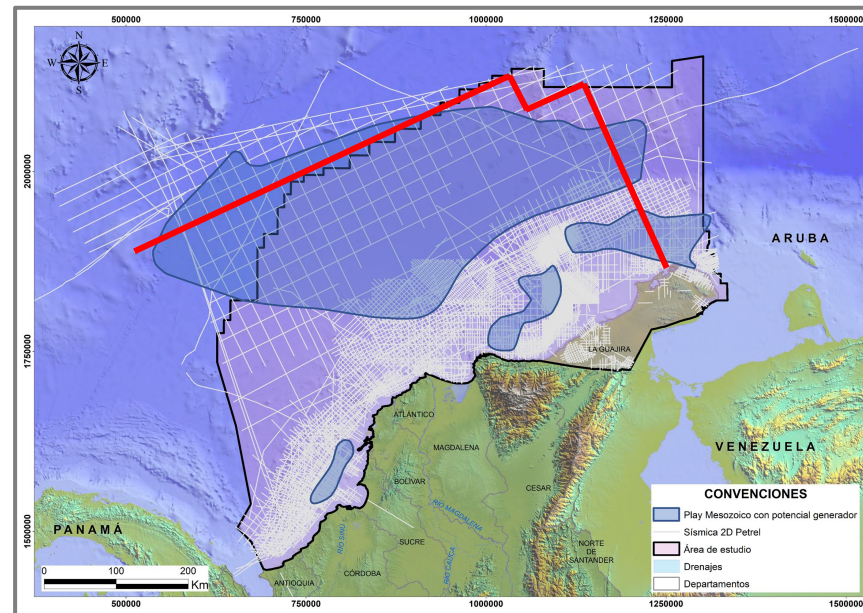
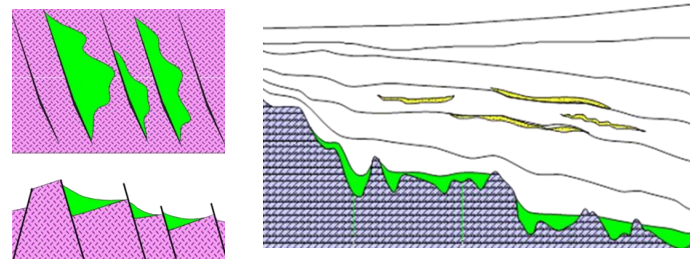
Late Cretaceous with fair to good TOC content and oil prone character. Likely preserved in hemigrabens in Colombia basin and some nearshore locations.



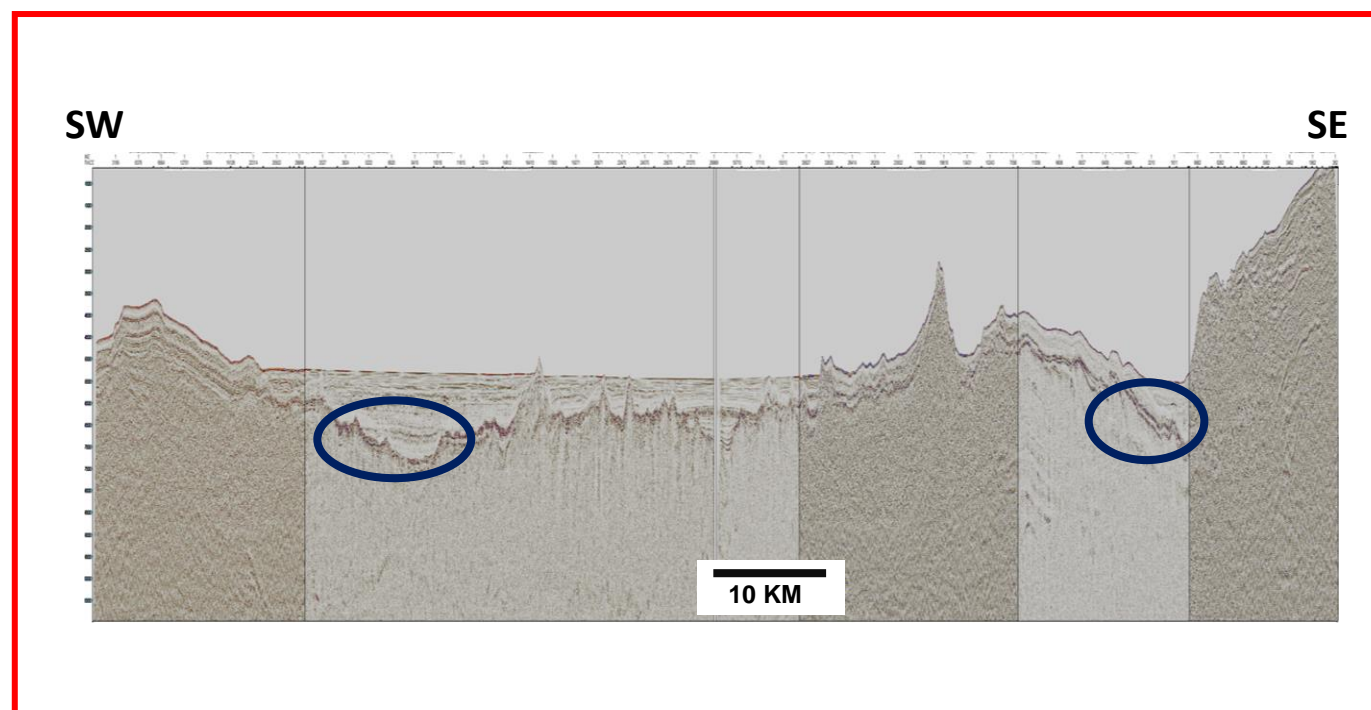
Interpreted in Colombia basin from seismic facies, wells and piston coring.

...WITH MESOZOIC SOURCE ROCKS

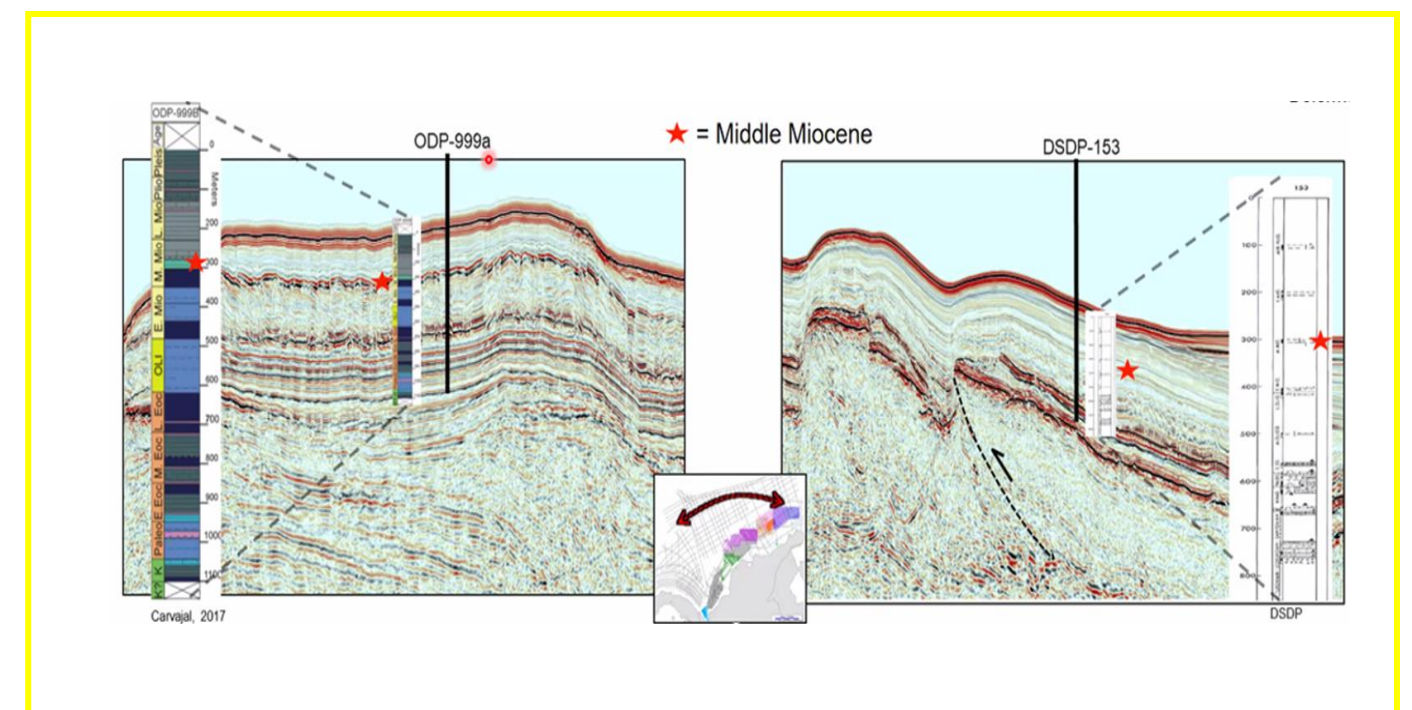
Colombia basin and local nearshore depocenters with remnants of Cretaceous source rocks.



To be tested in Colombia basin, as source rock for overlying amplitude anomalies.



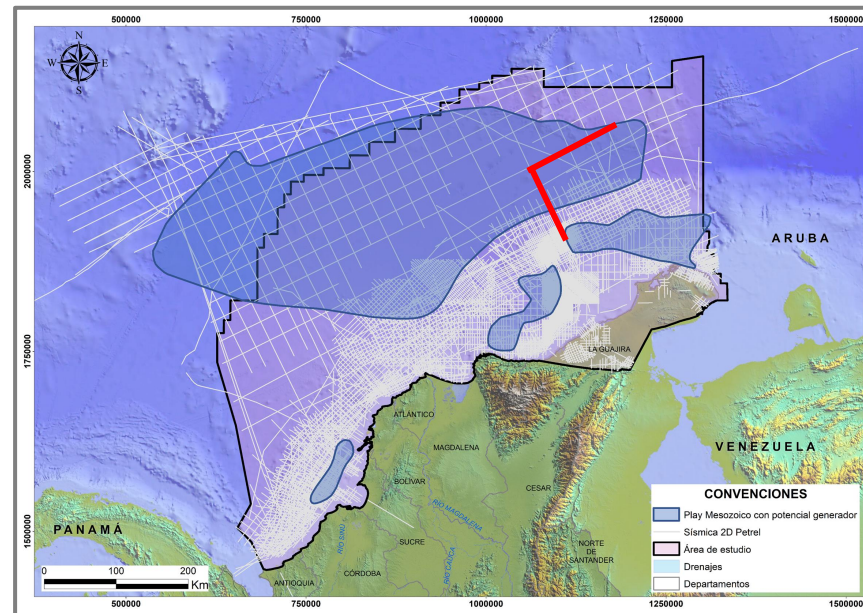
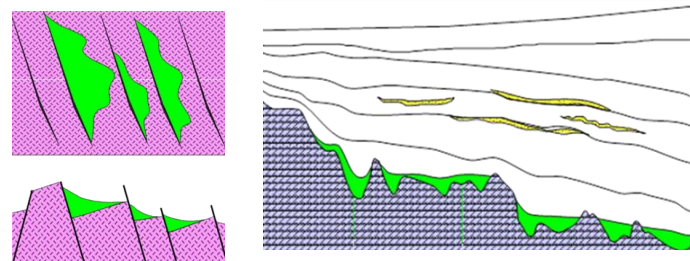
Seismic line from ODP 999a to DSDP 153



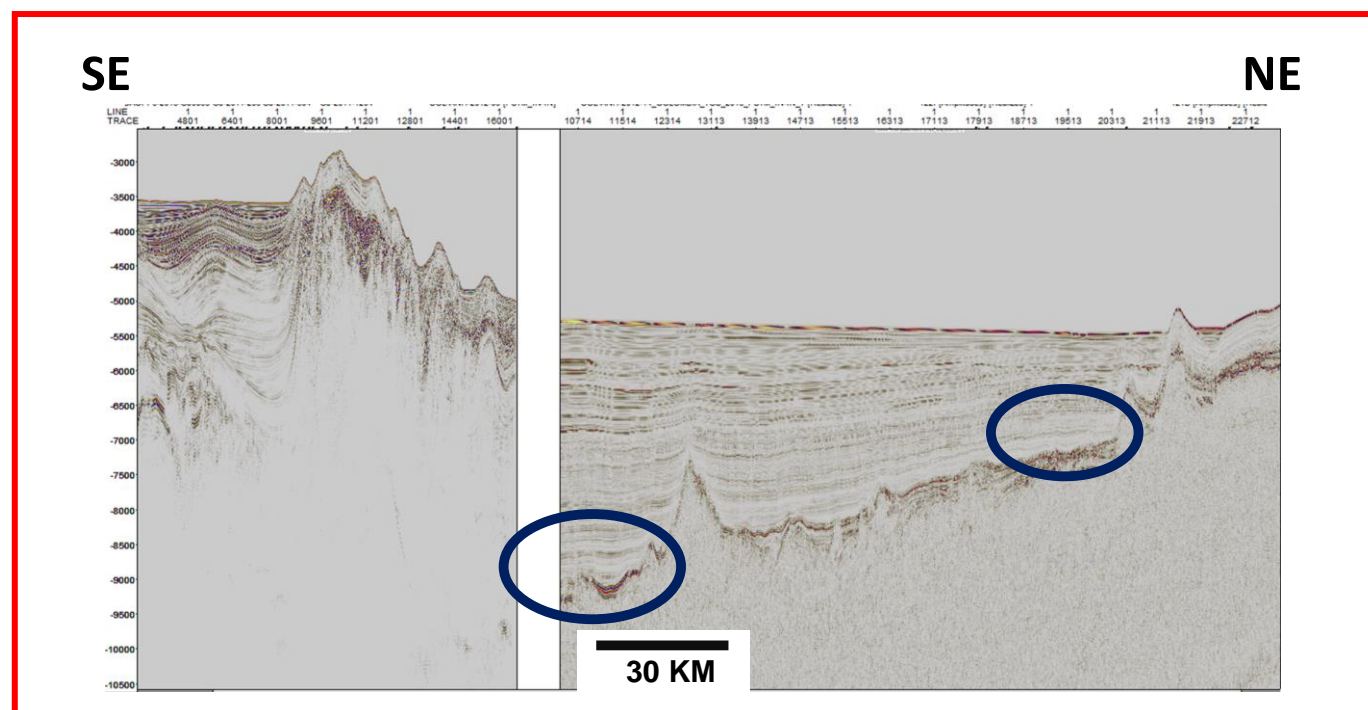
Record of Cretaceous sequence (from ION-ANH 2021)

...WITH MESOZOIC SOURCE ROCKS

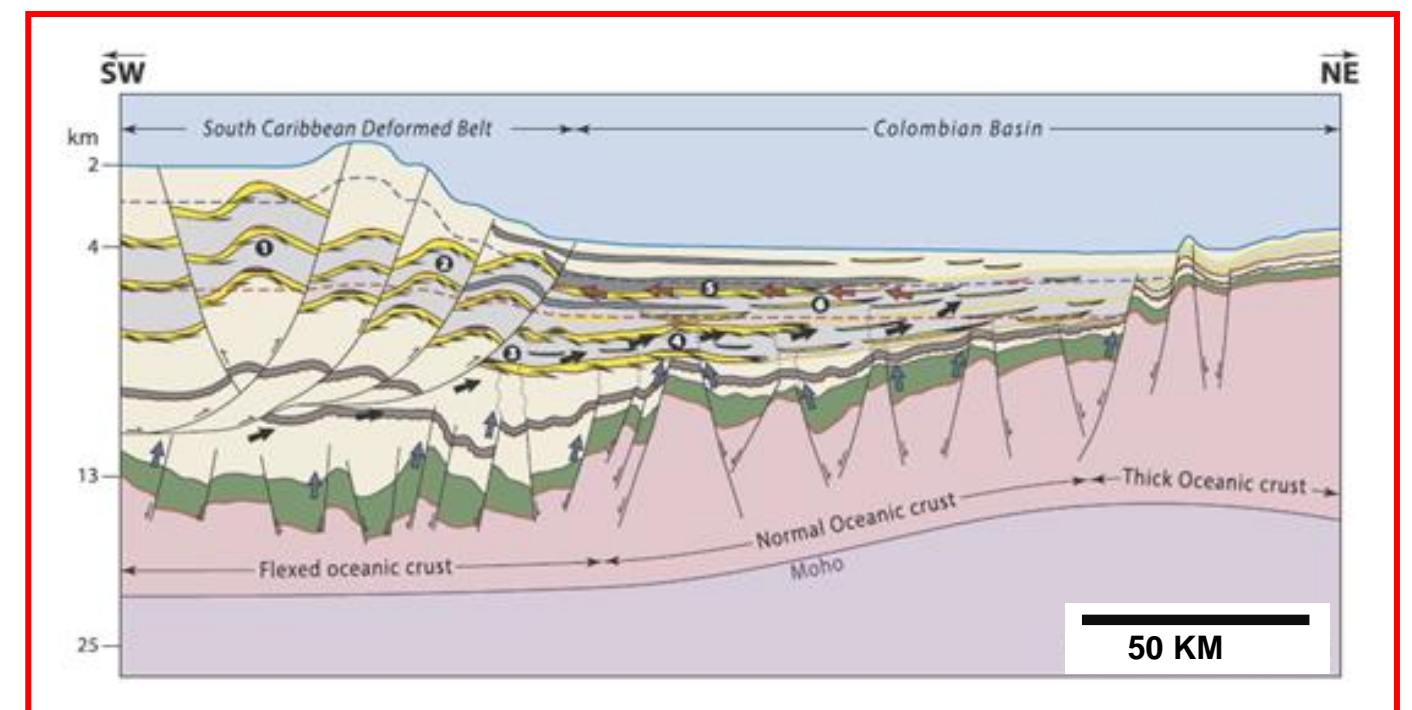
Colombia basin and local nearshore depocenters with remnants of Cretaceous source rocks.



To be tested in Colombia basin, as source rock for overlying amplitude anomalies.



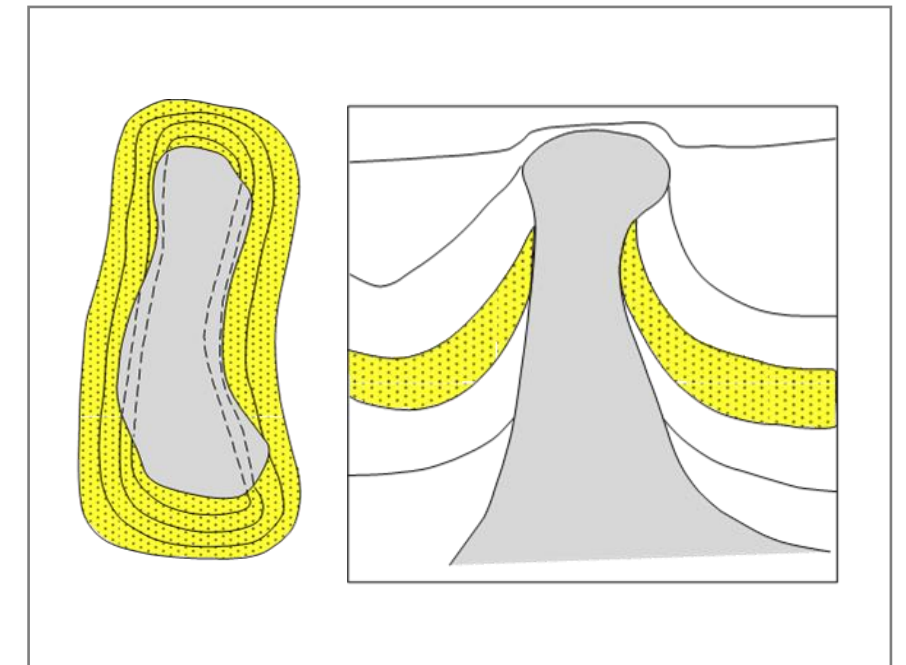
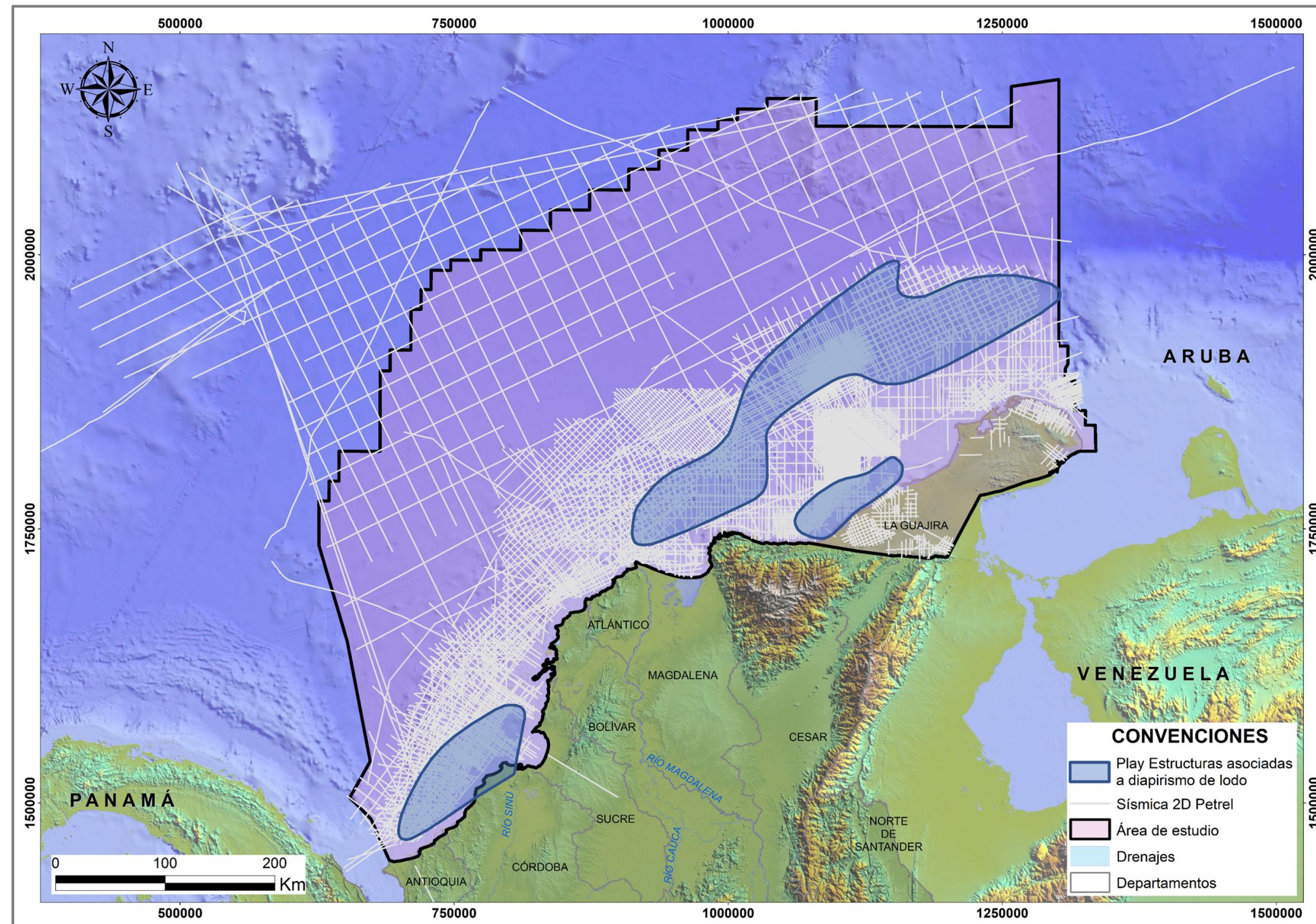
Section from SCDB to DSDP 153



Maturity model by Carvajal et al (2020)

MUD DIAPIRISM TRAPMENT FEATURES

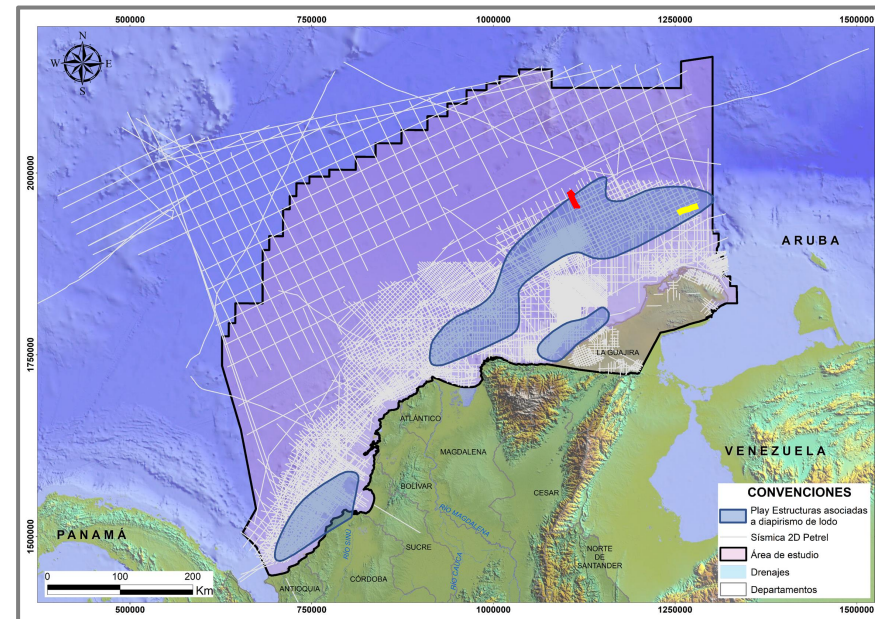
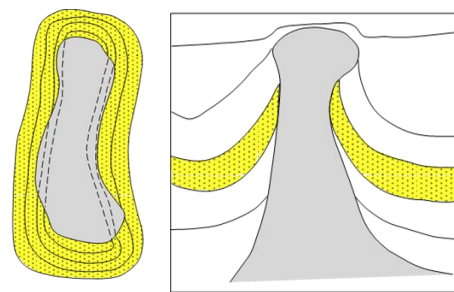
Mud tectonics associated structures, flanking and overlying diapirs. Commonly expressed in sea bottom as mud volcanoes.



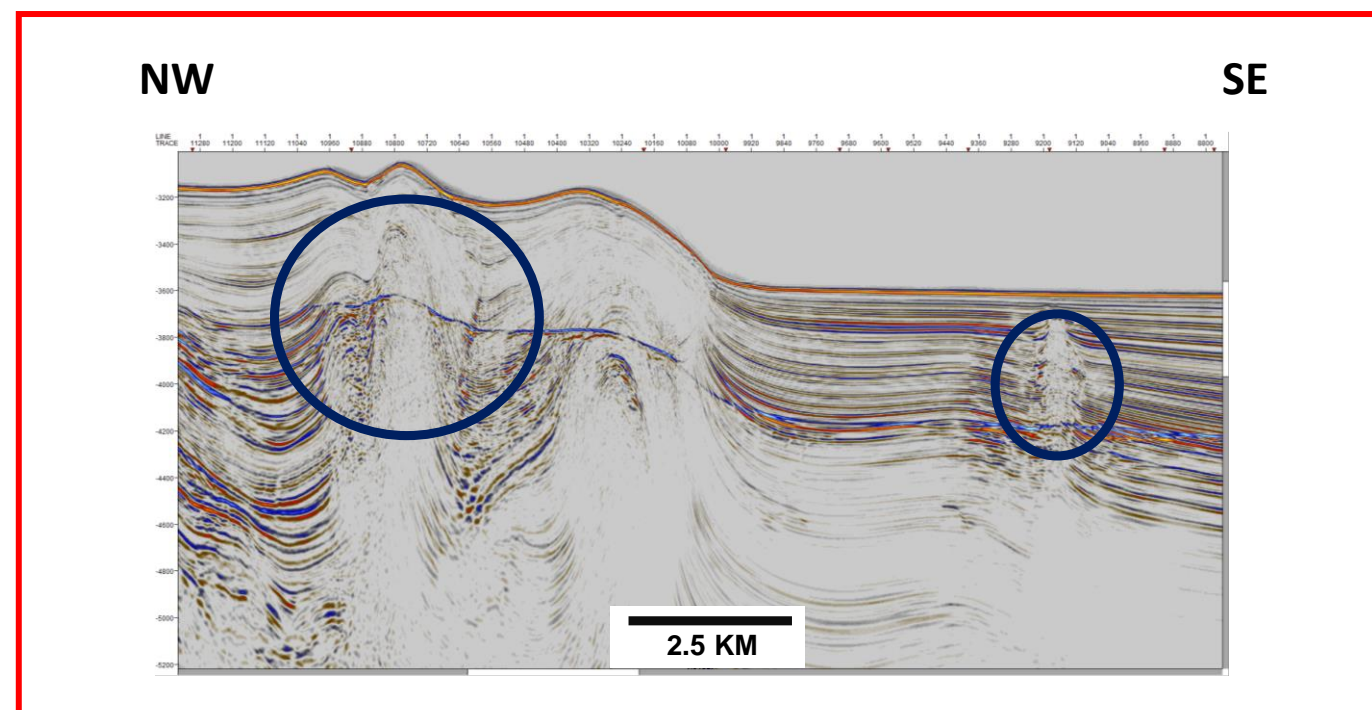
Interpreted as associated to anomalous pressure and densities, and methane hydrate presence.

MUD DIAPIRISM TRAPMENT FEATURES

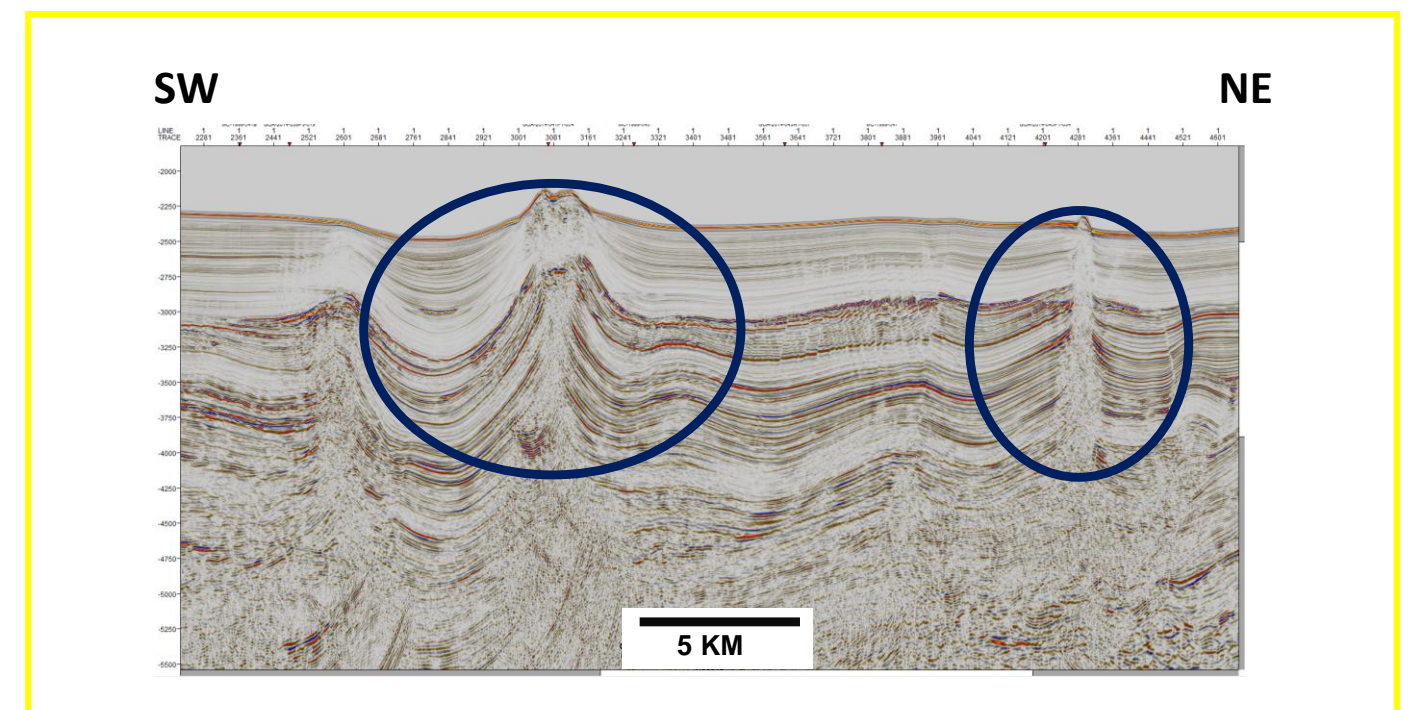
Features commonly associated with BSR, attesting the presence of gas hydrates.



Regional distribution, often breaking up thru the sea floor.

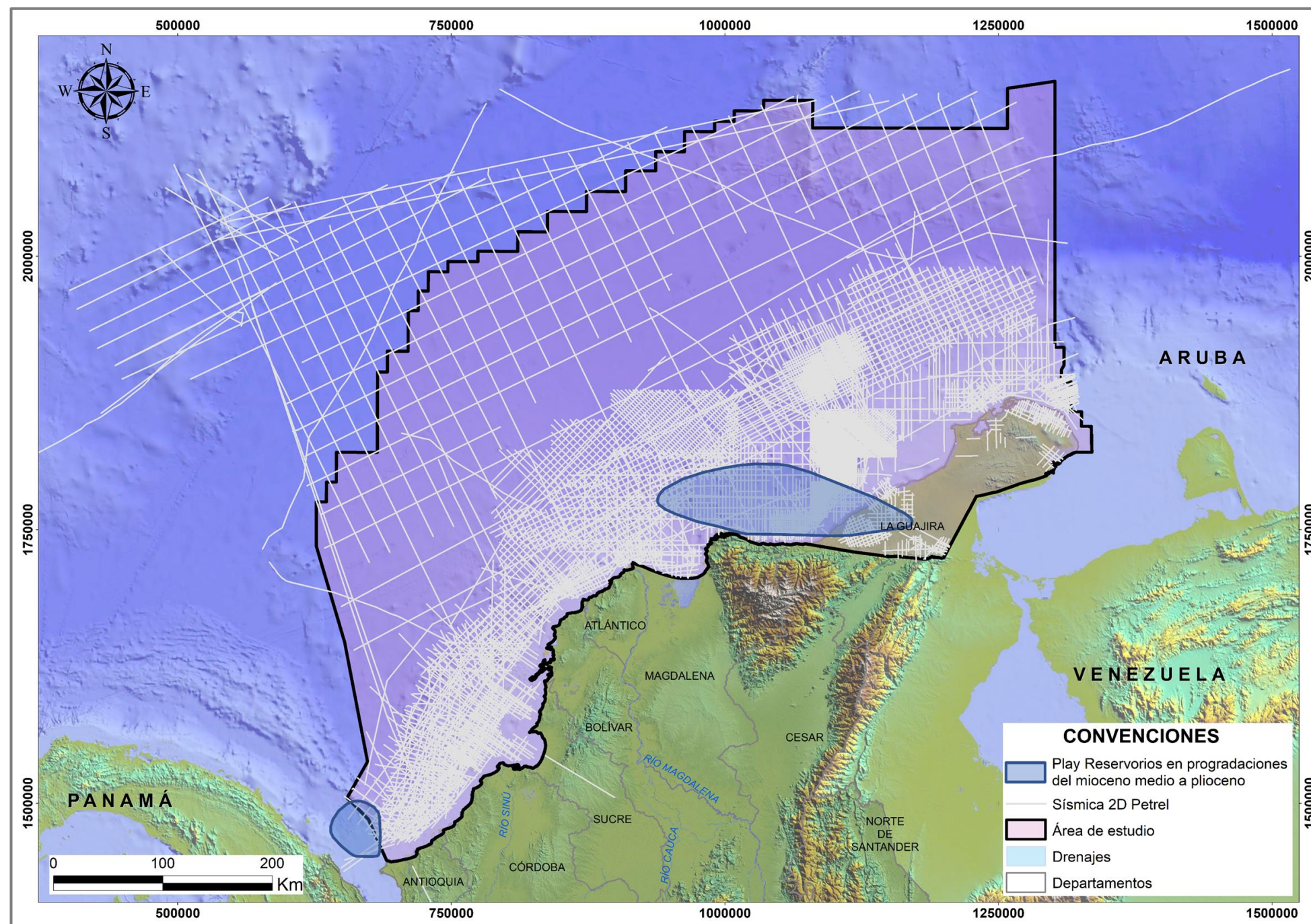


GJ-2011-235

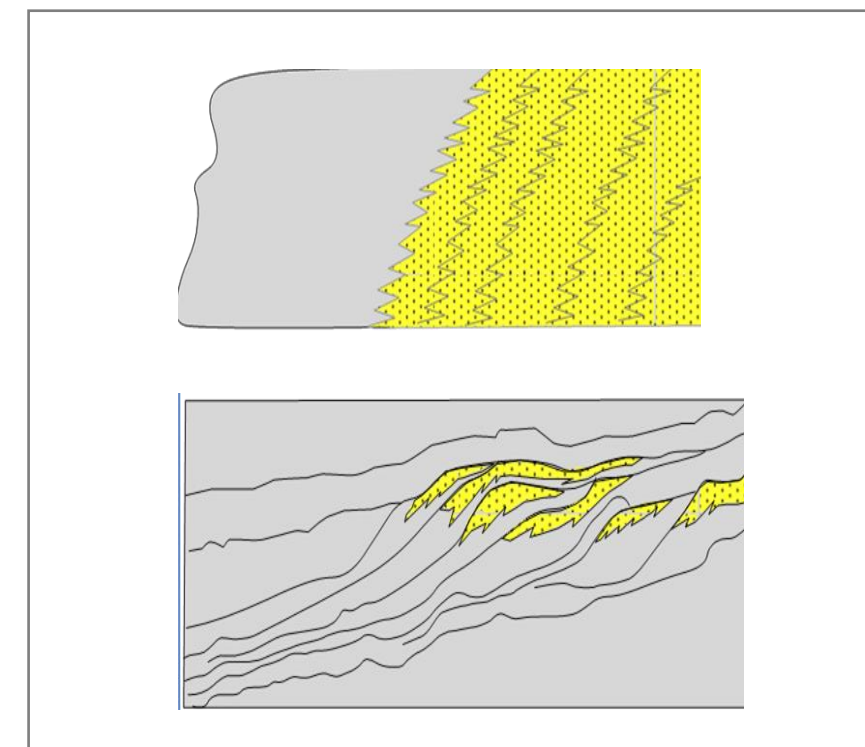


GUA-2014-14BP-018

MIO-PLIOCENE PROGRADDING SEQ.



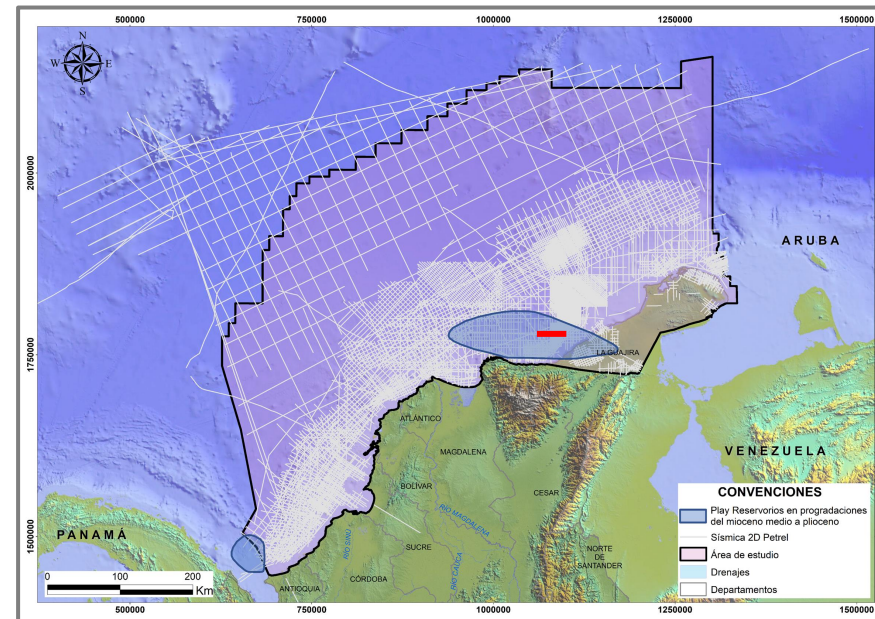
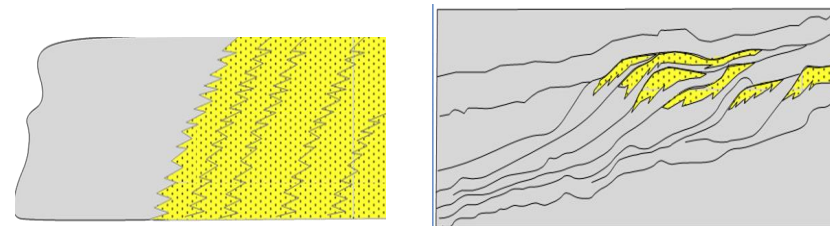
Stacked and prograding clastic developments towards the edge of the platform.



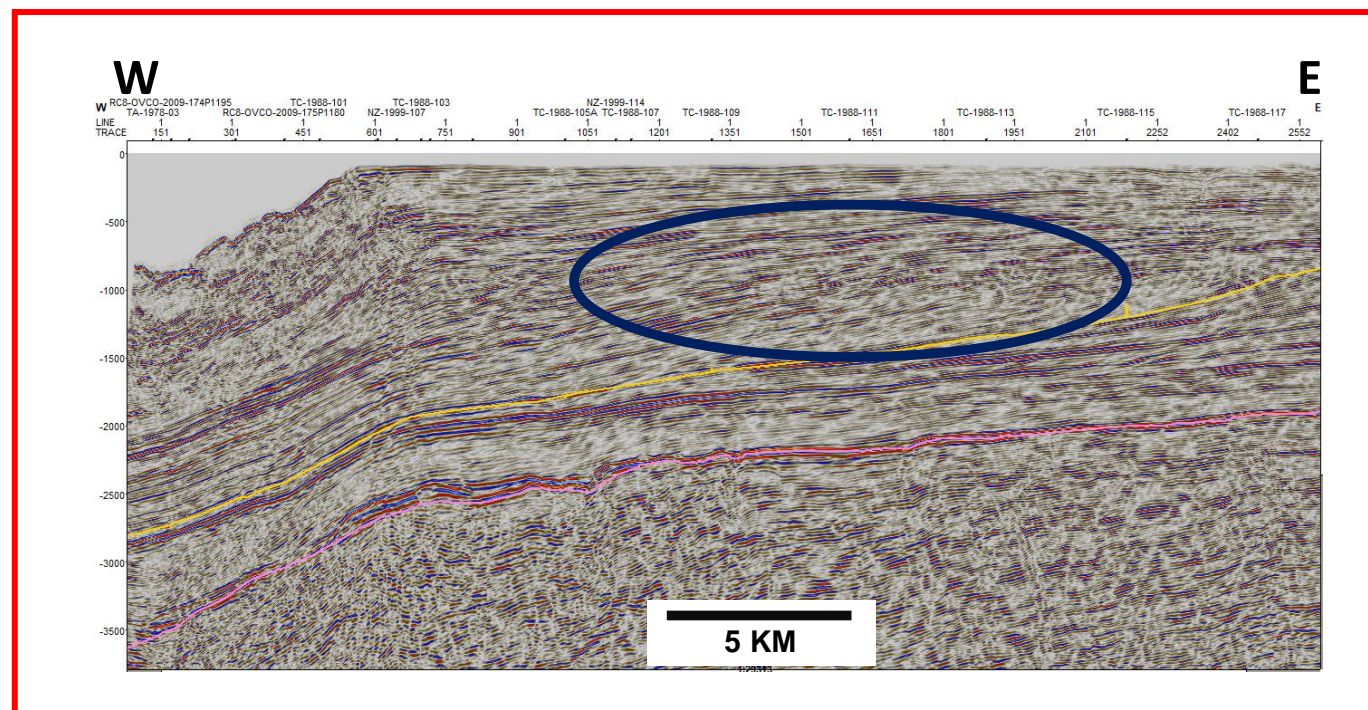
Identified in Mid Miocene to Pliocene sequences in Guajira and Uraba areas

MIO-PLIOCENE PROGRADING SEQ.

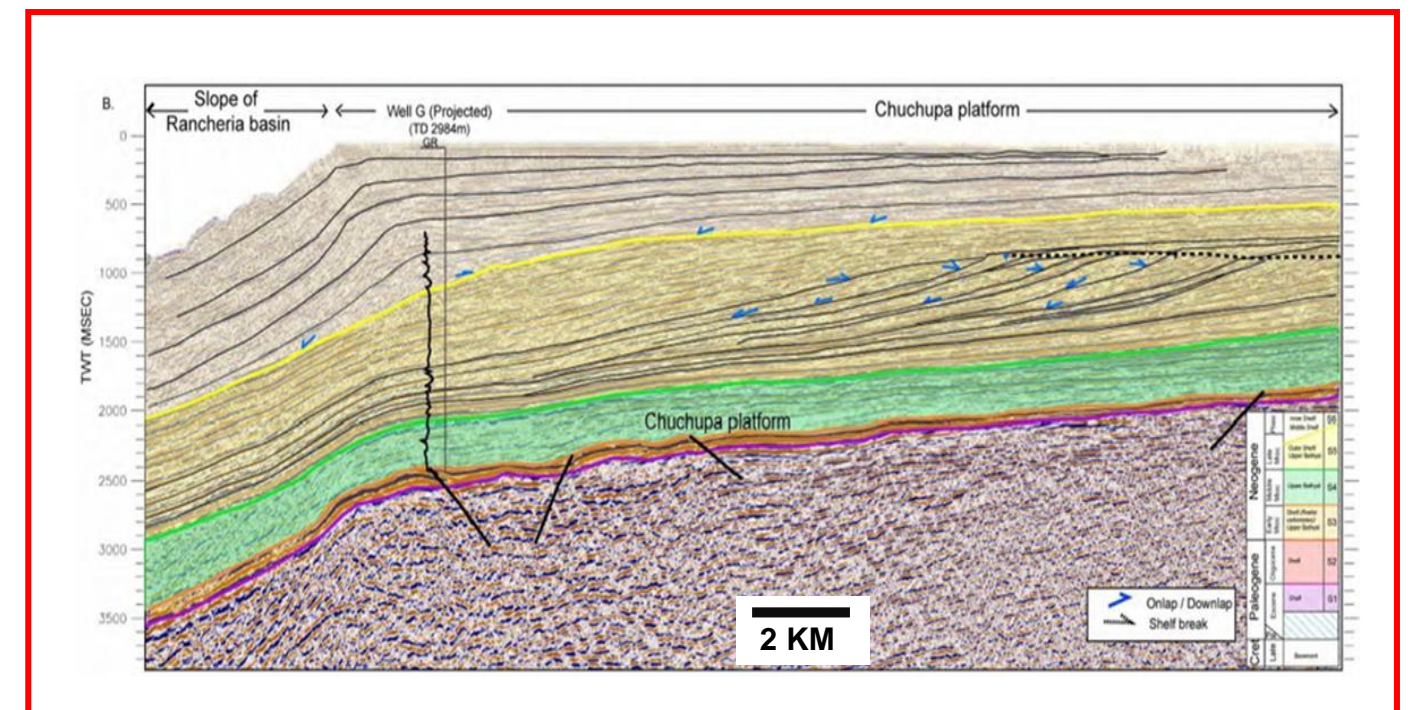
Mid to late Miocene reservoir and seal potential due to lateral facies changes.



Locally in Guajira Late Miocene prograding low stand and Pliocene aggrading high stand.

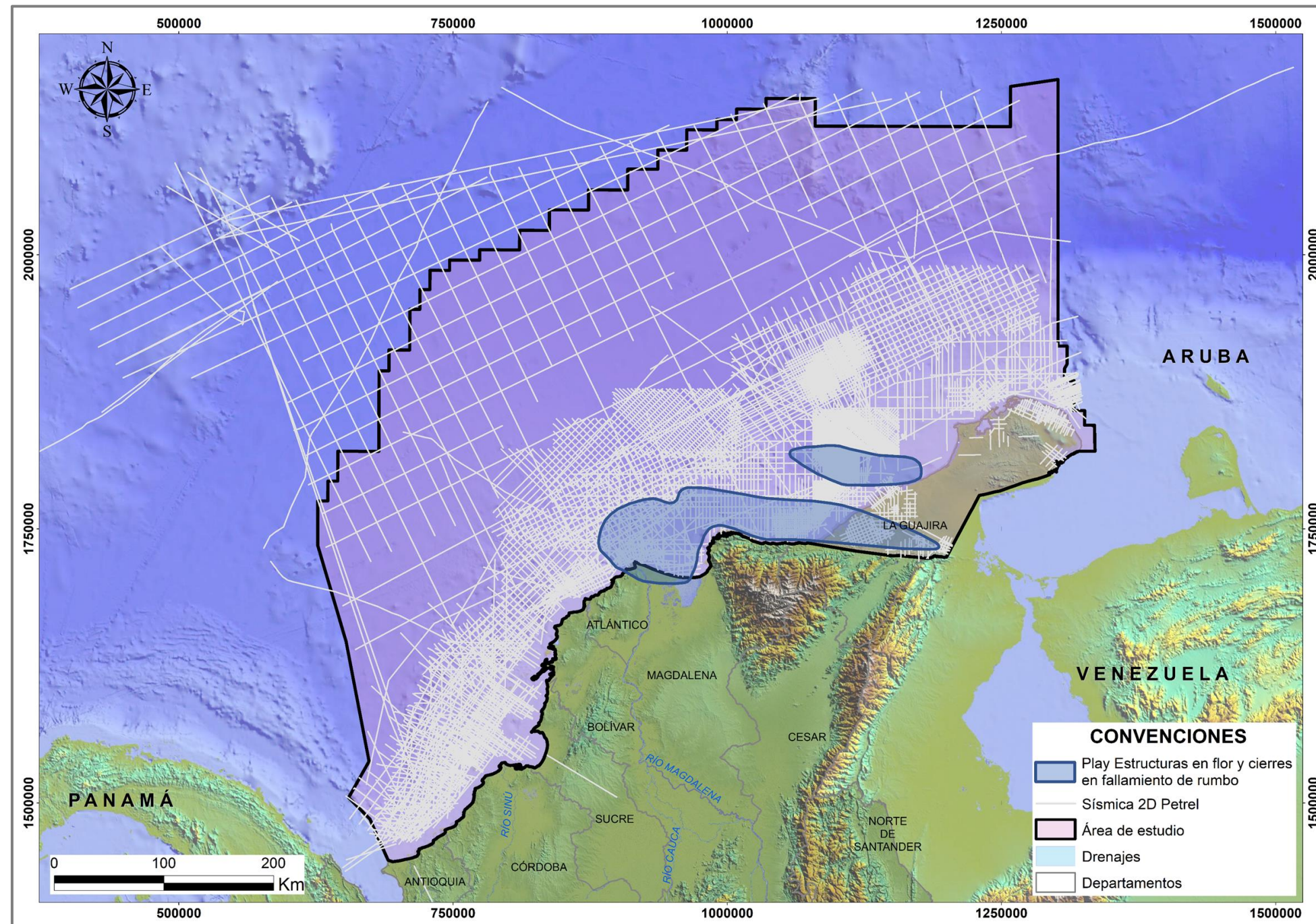


TC-1988-110

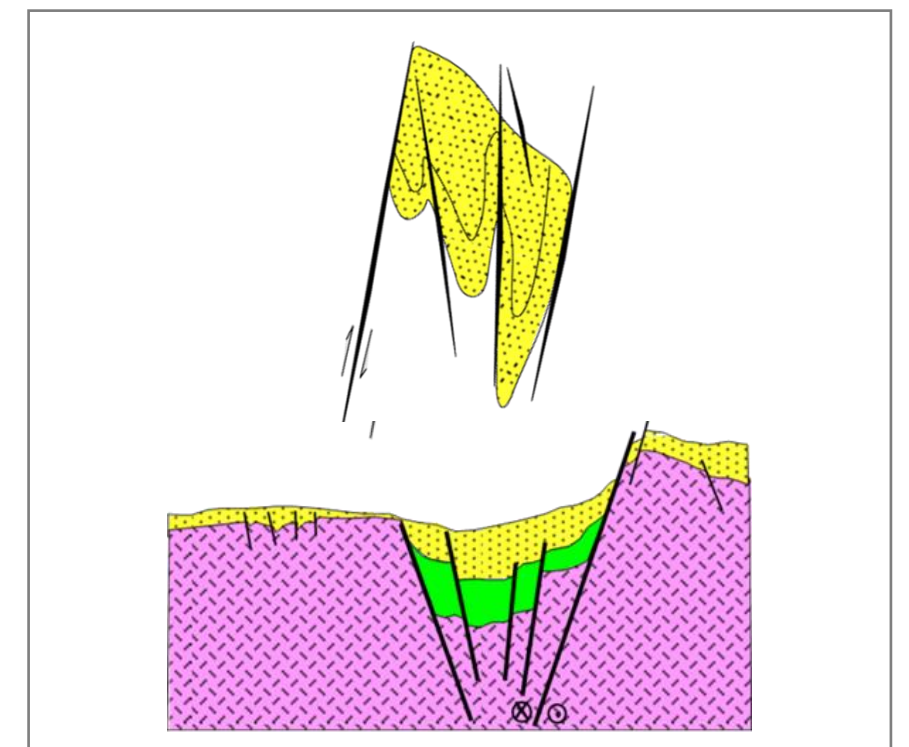


PLAY Model by Vence (2008), Vence and Mann (2020)

TRAPS IN FLOWER STRUCTURES



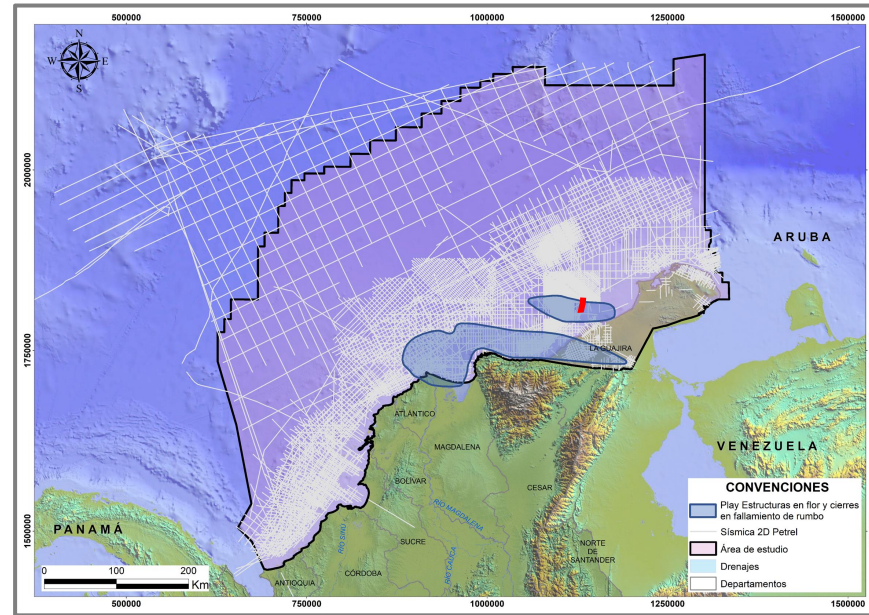
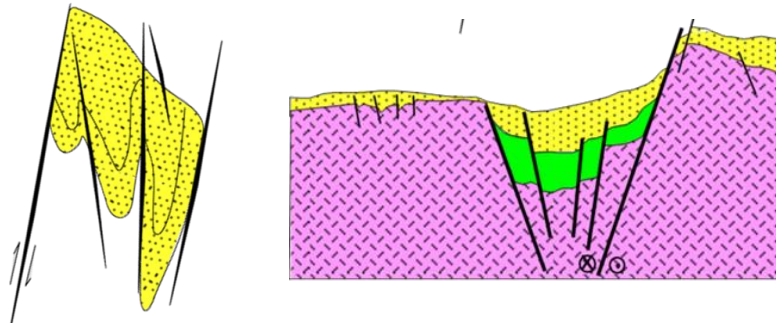
Pull apart structures and faulted blocks related to wrench tectonics.



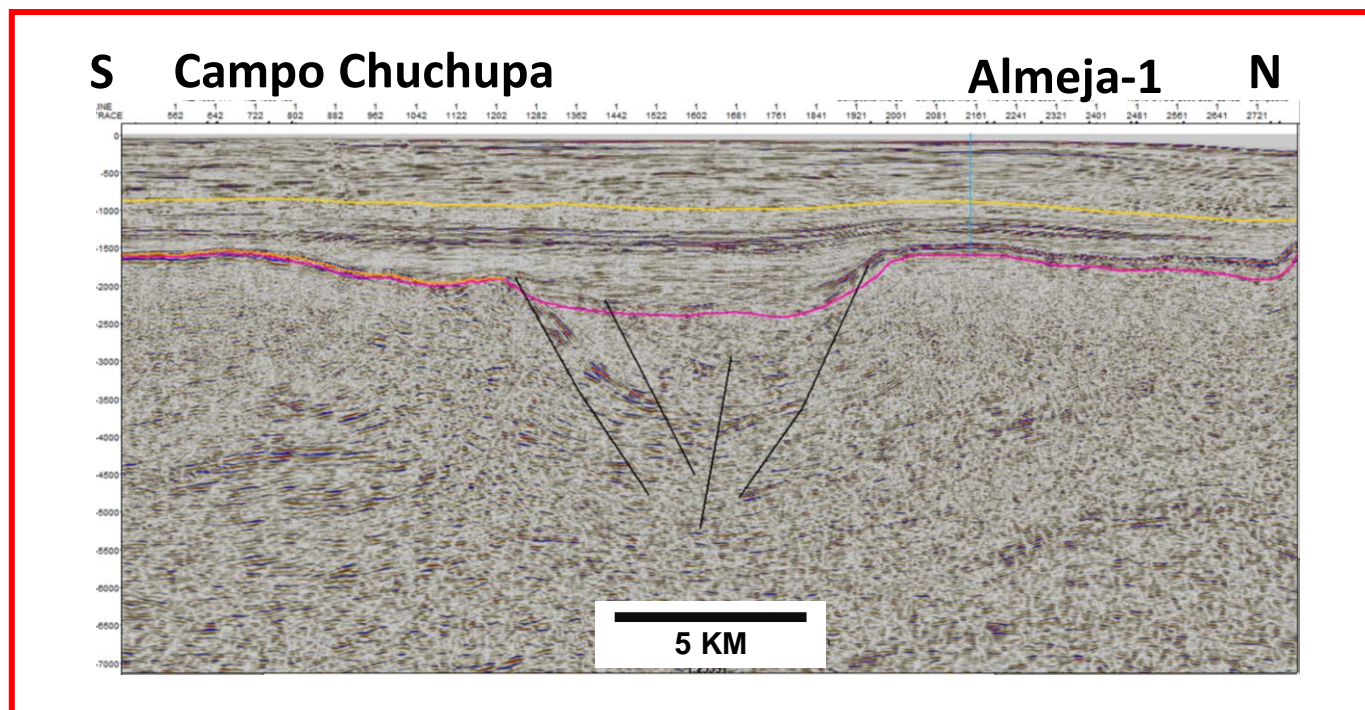
Geographically related to Oca, Cuisa and Santa Marta fault systems.

TRAPS IN FLOWER STRUCTURES

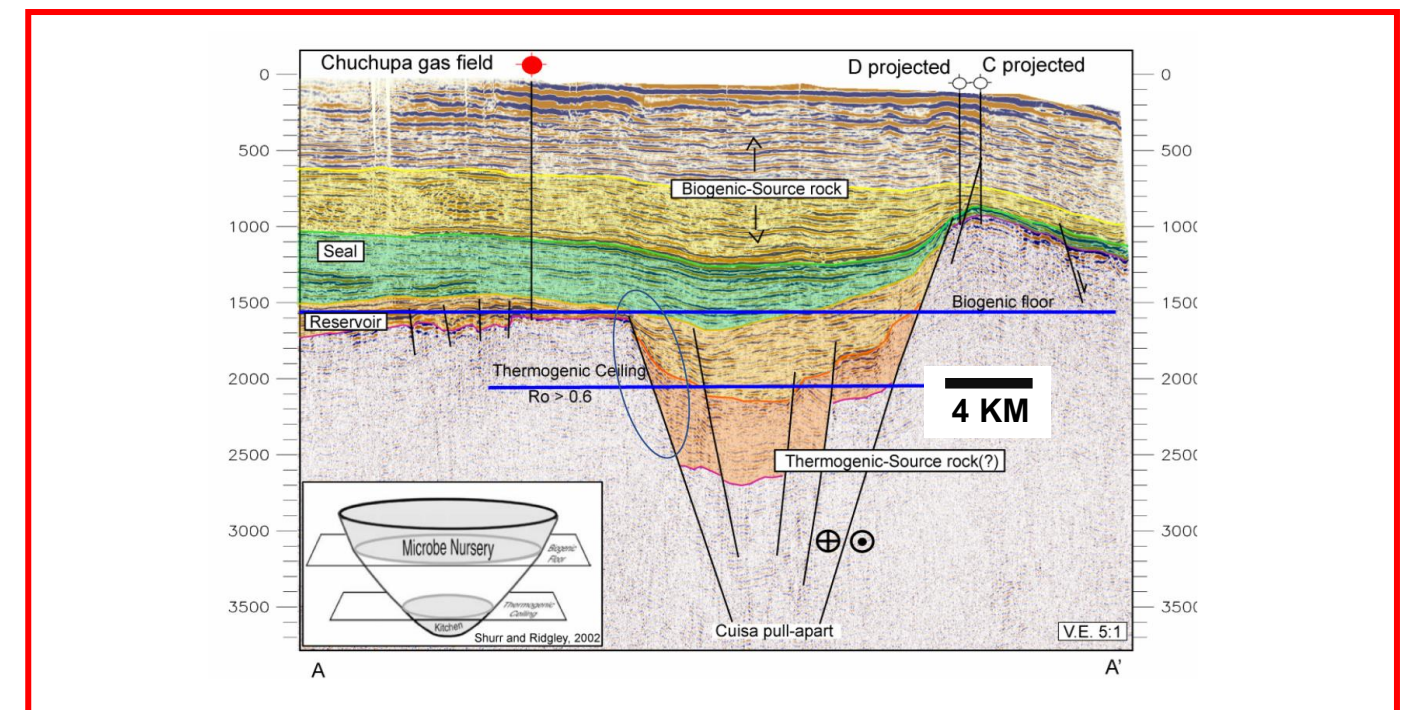
Pull apart basin dipping blocks, with likely connection to deep mature pre Miocene source rocks



Locally in Guajira and SNSM areas, as result of wrench tectonics in the región.



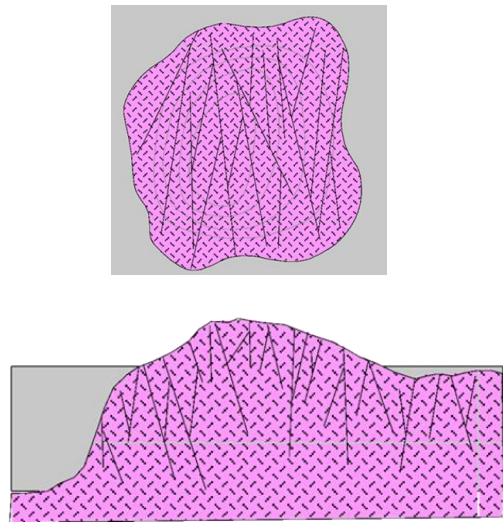
NZ-1999-109



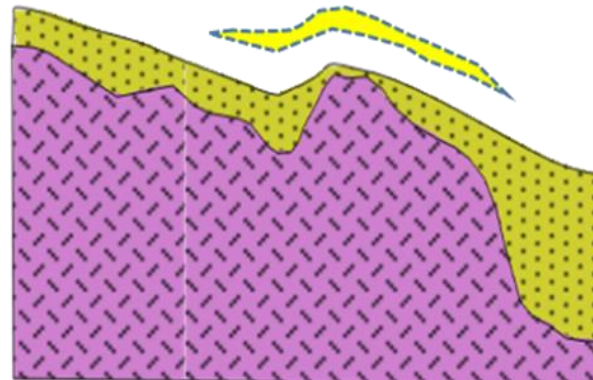
Maturity model by Vence (2008) in Cuisa pull apart basin

ADDITIONAL PLAYS

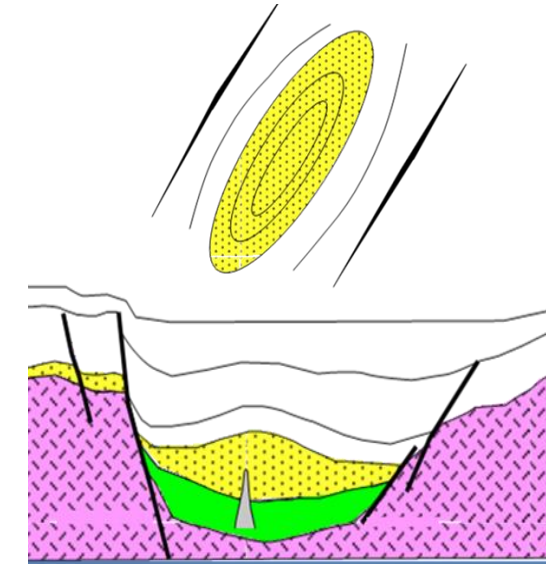
FRACTURED BASEMENT AS RESERVOIR



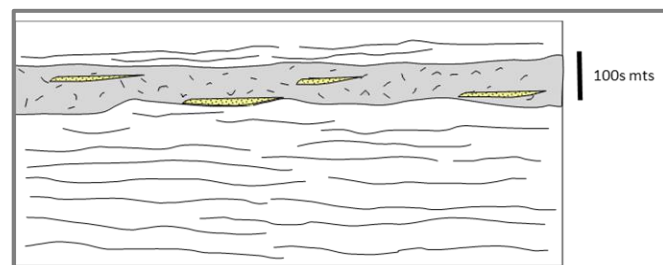
DIFFERENTIAL COMPACTION CLOSURES



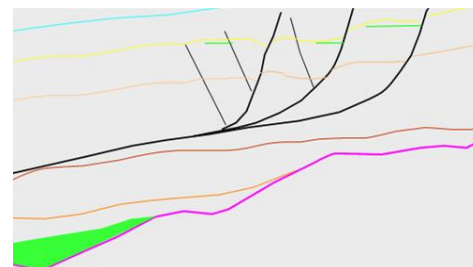
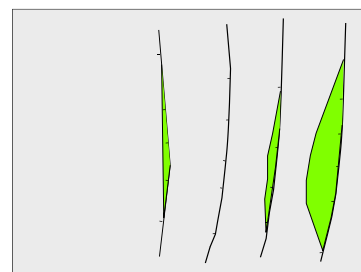
ANTICLINES ON EXTENSIONAL SETTINGS



MASS TRANSPORT COMPLEXES



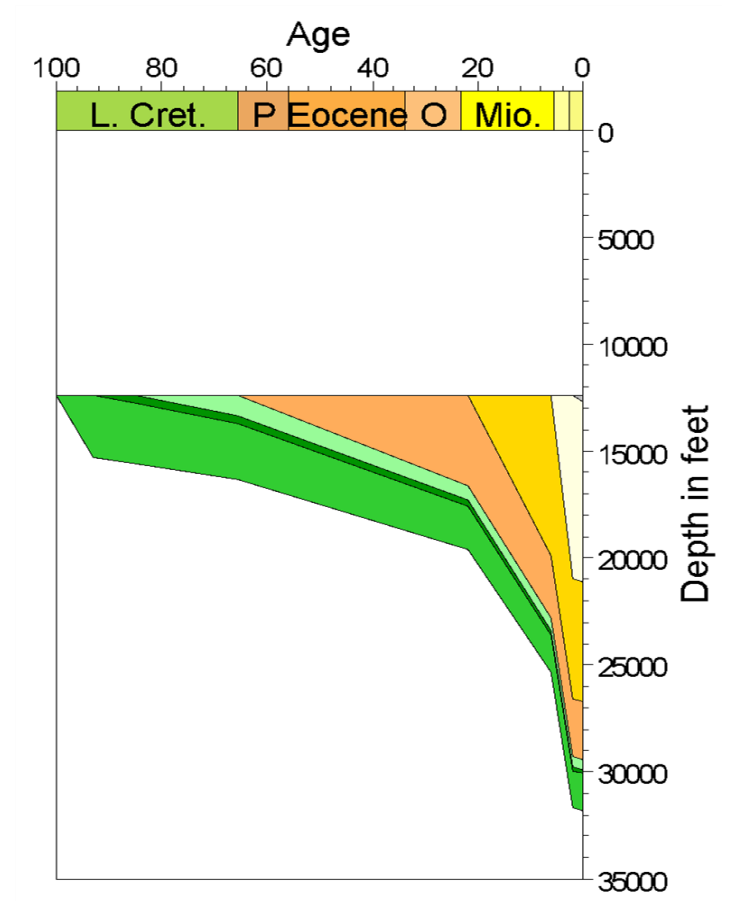
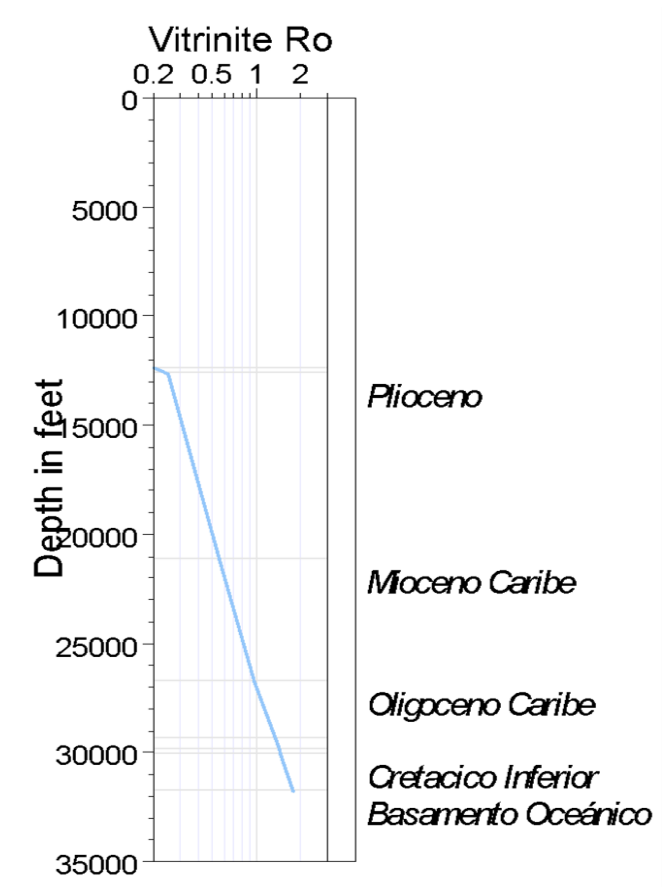
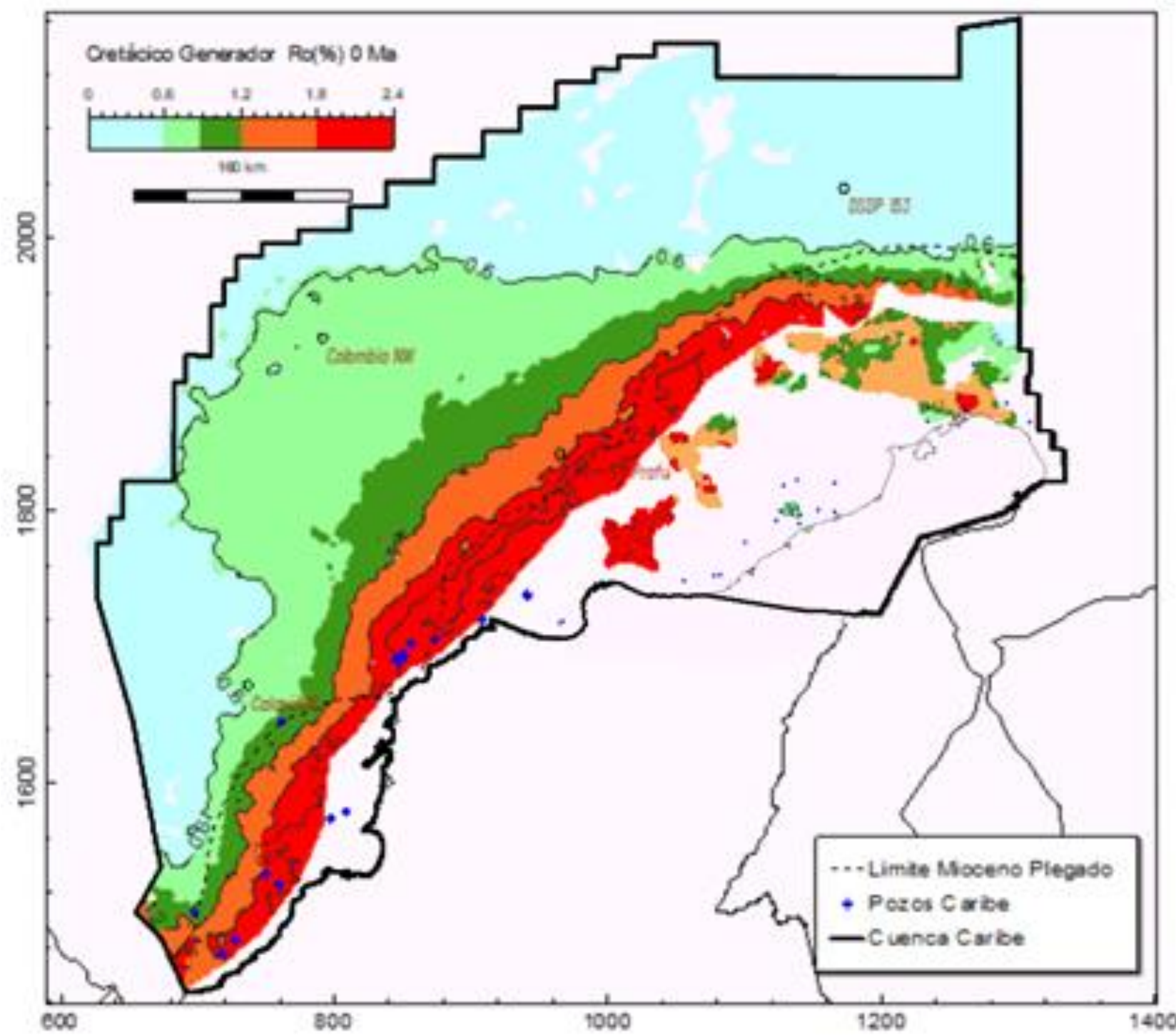
LISTRIC FAULTING RELATED CLOSURES



...These plays are also documented in the 2021 report (Atlas of Caribbean Play Fairways Maps)....

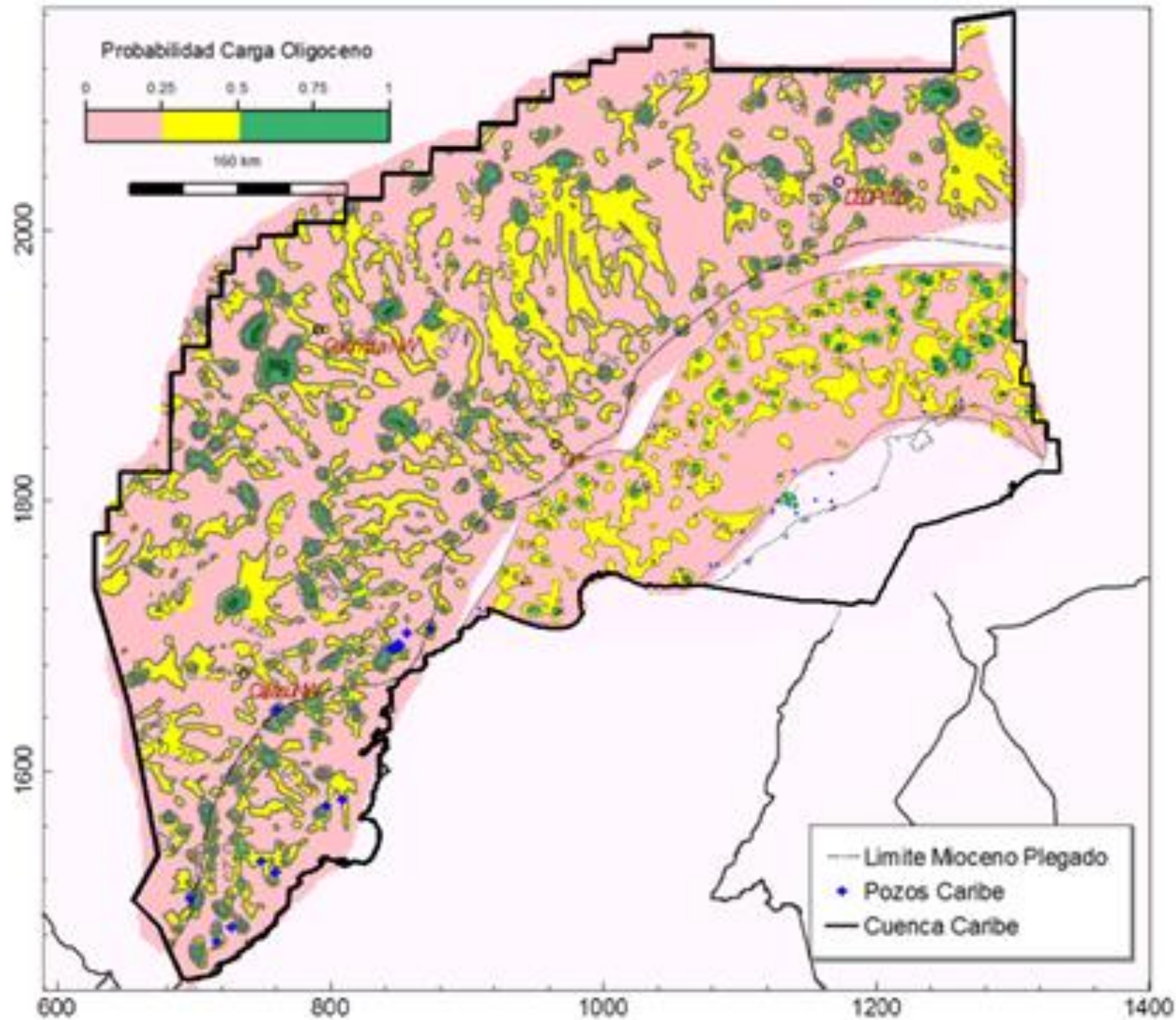
PETROLEUM SYSTEMS EVIDENCES AND MODELLING

CRETACEOUS MATURITY MODEL

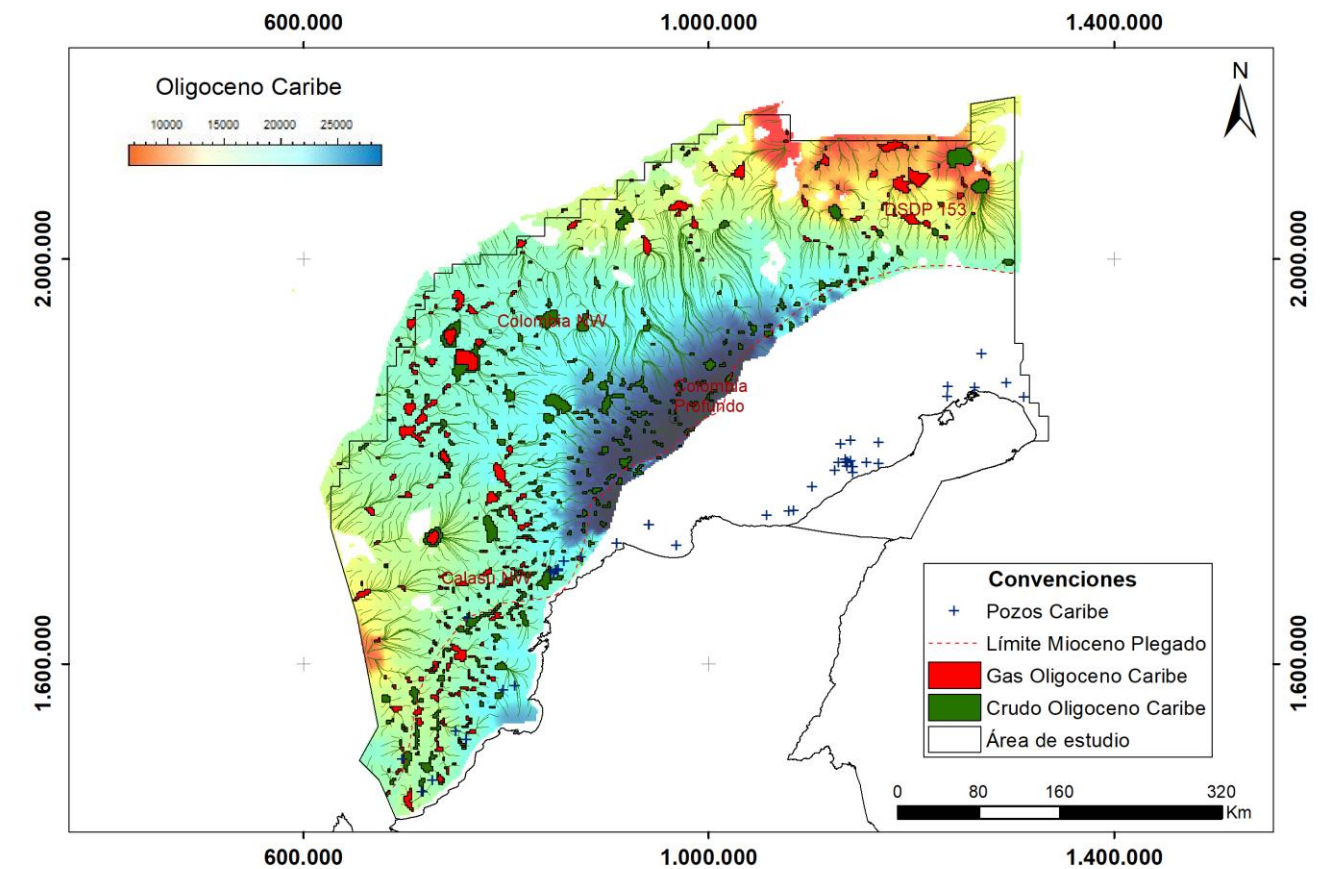


Model input from integrated structural map, 1D model in pseudowells. Thickness and SR quality from ODP and DSDP wells

OLIGOCENE CHARGE MODEL



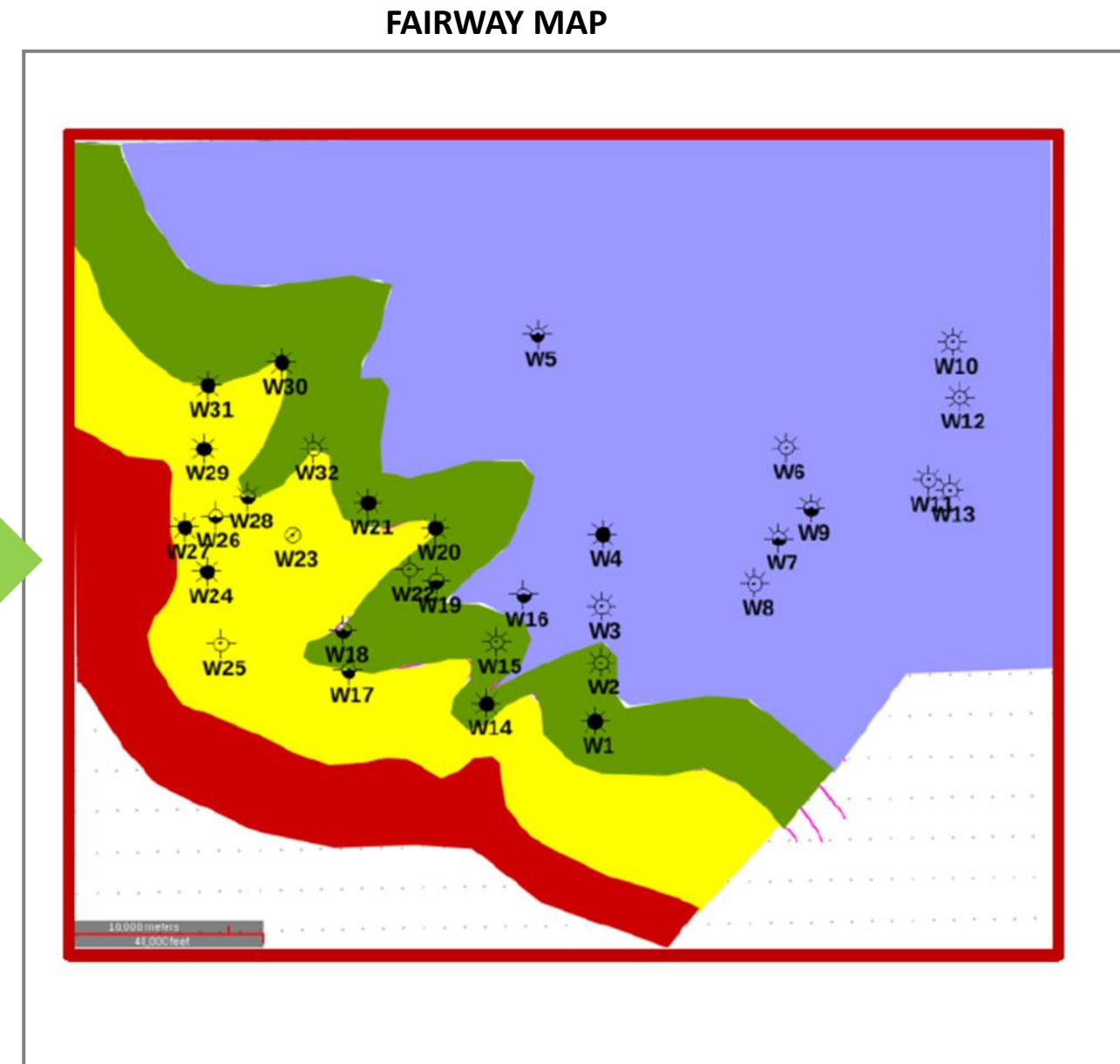
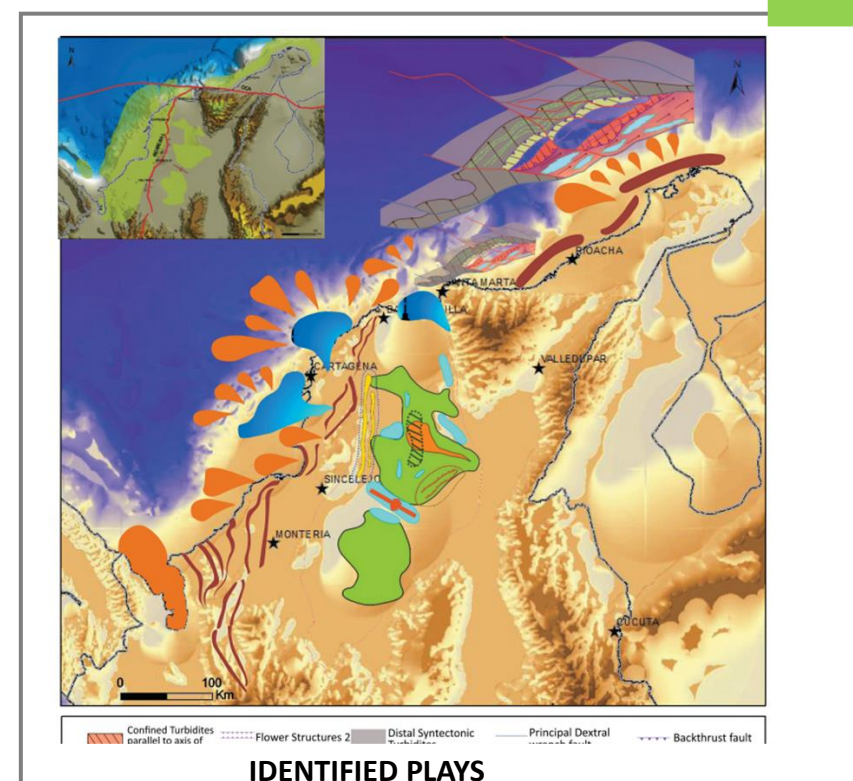
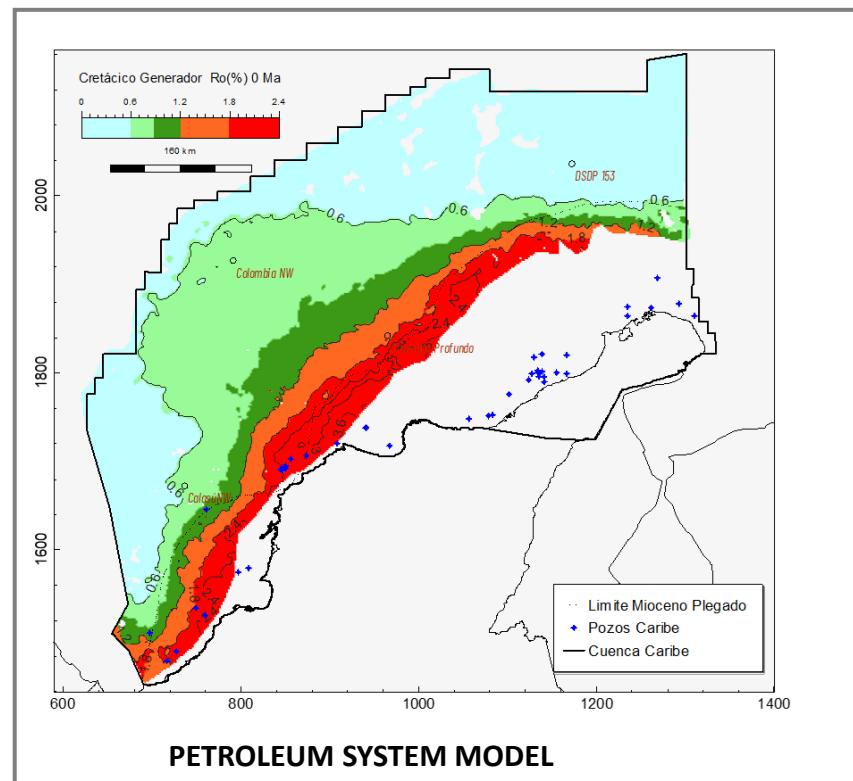
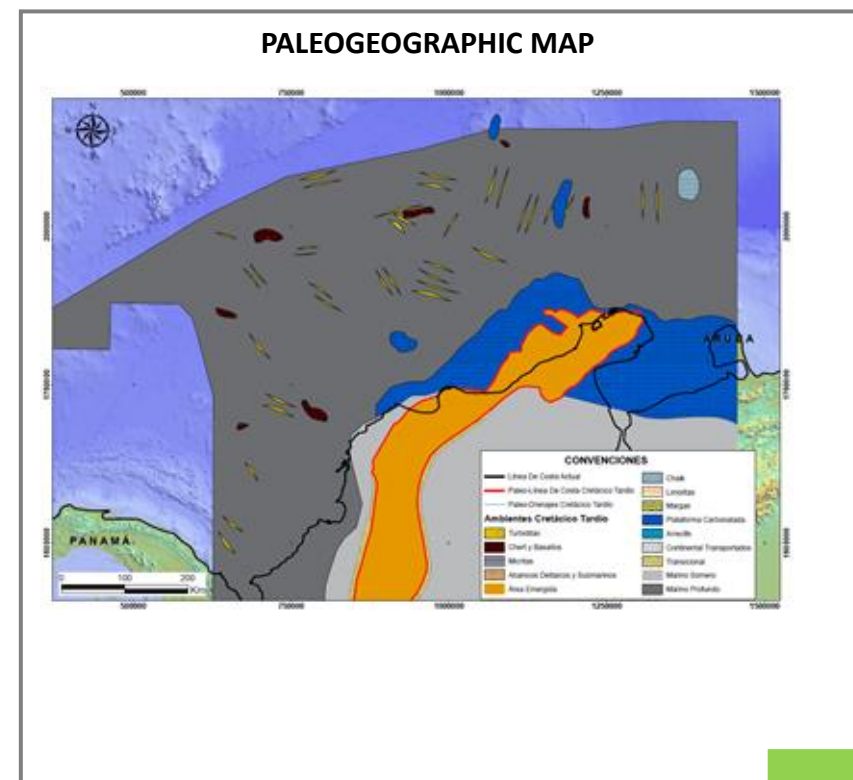
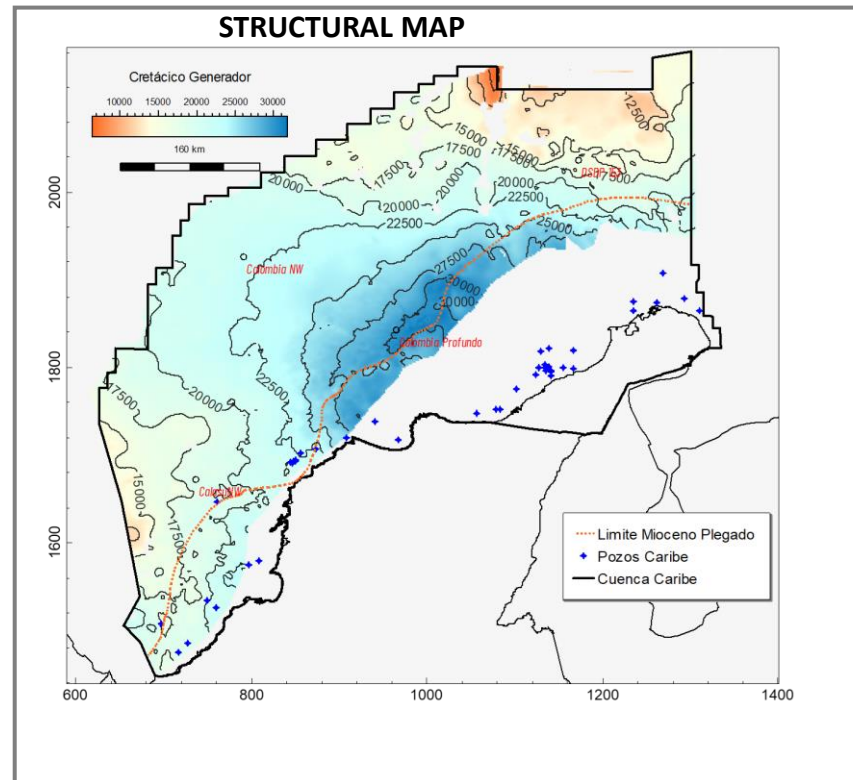
Short and long distance migration patterns identified.



Regionally, more oil vs gas occurrences are predicted by the model.

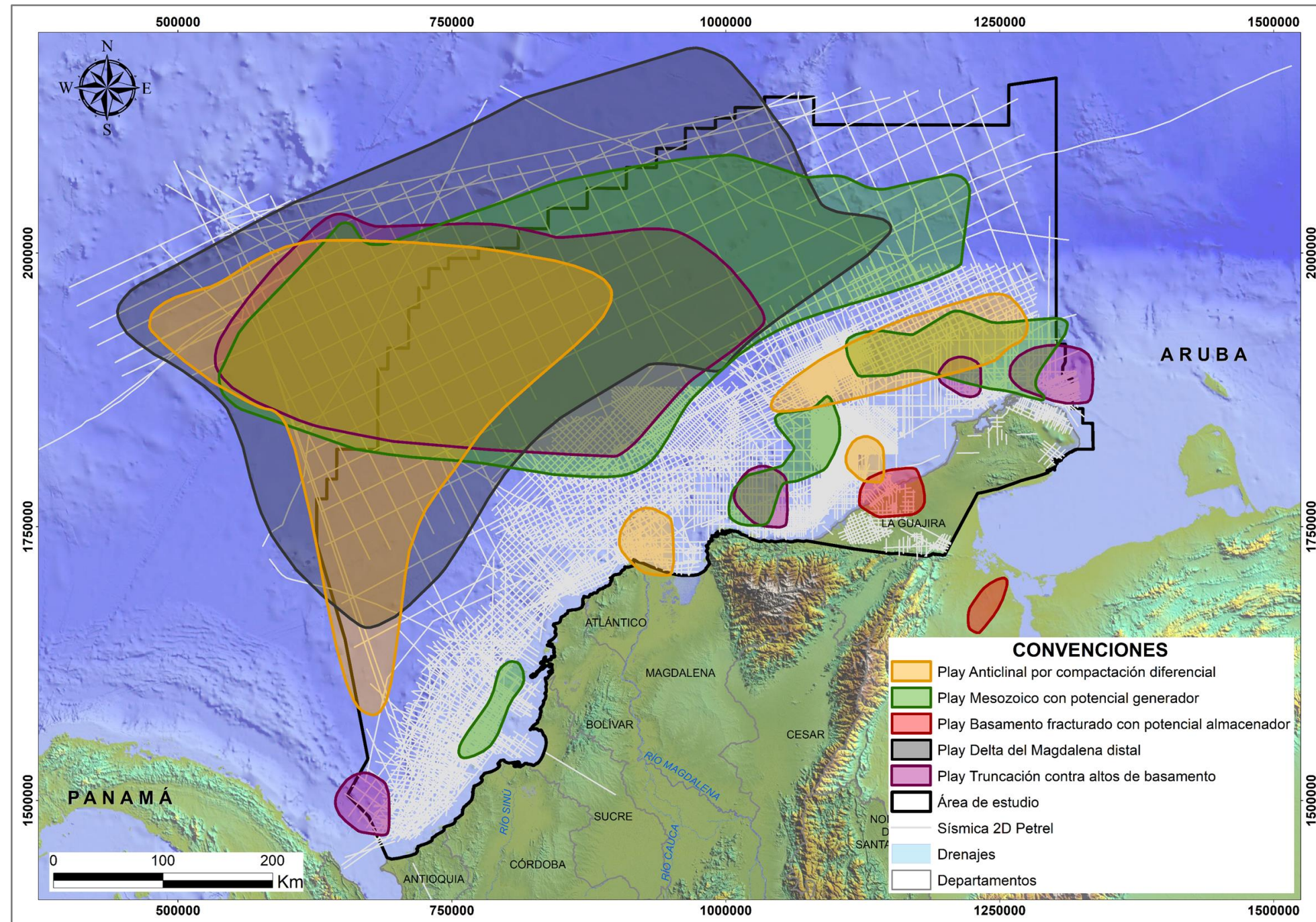
PLAY FAIRWAY MAPS

PLAY FAIRWAY MAPS



Methodology from Dahl et al, 2020

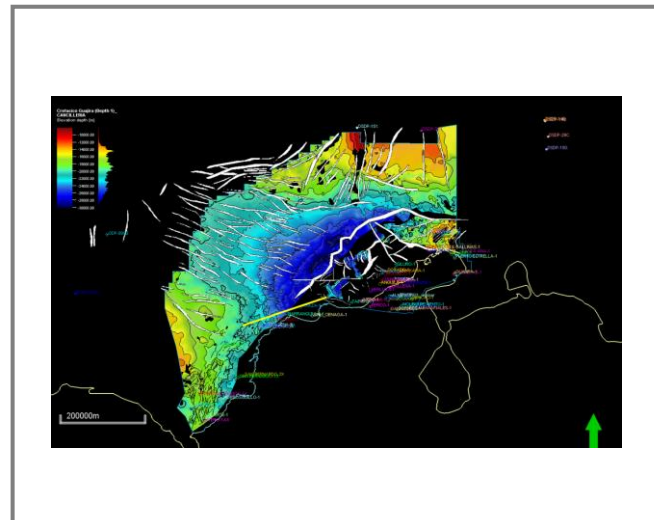
PLAY FAIRWAY MAPS



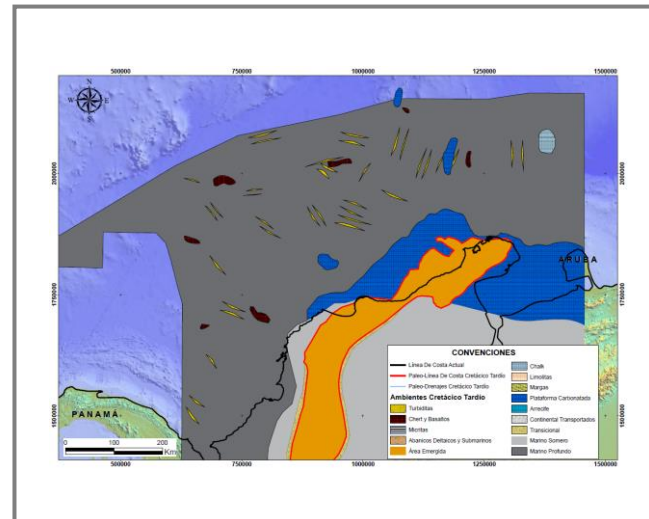
Cretaceous source rocks associated plays.

PLAY FAIRWAY MAPS

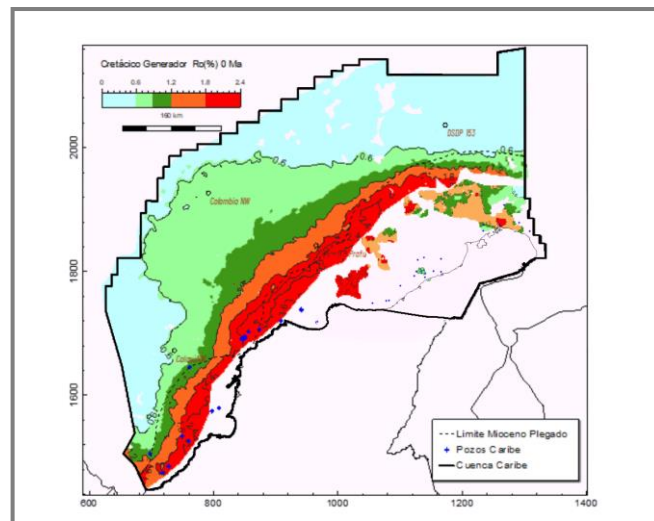
STRUCTURAL MAP



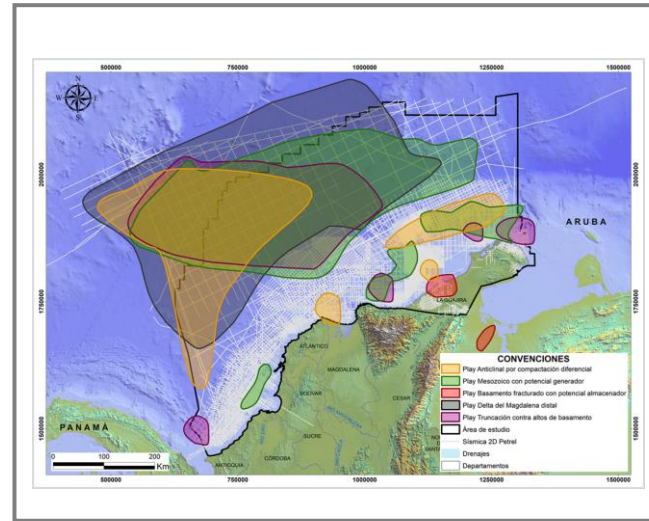
PALEOGEOGRAPHIC MAP



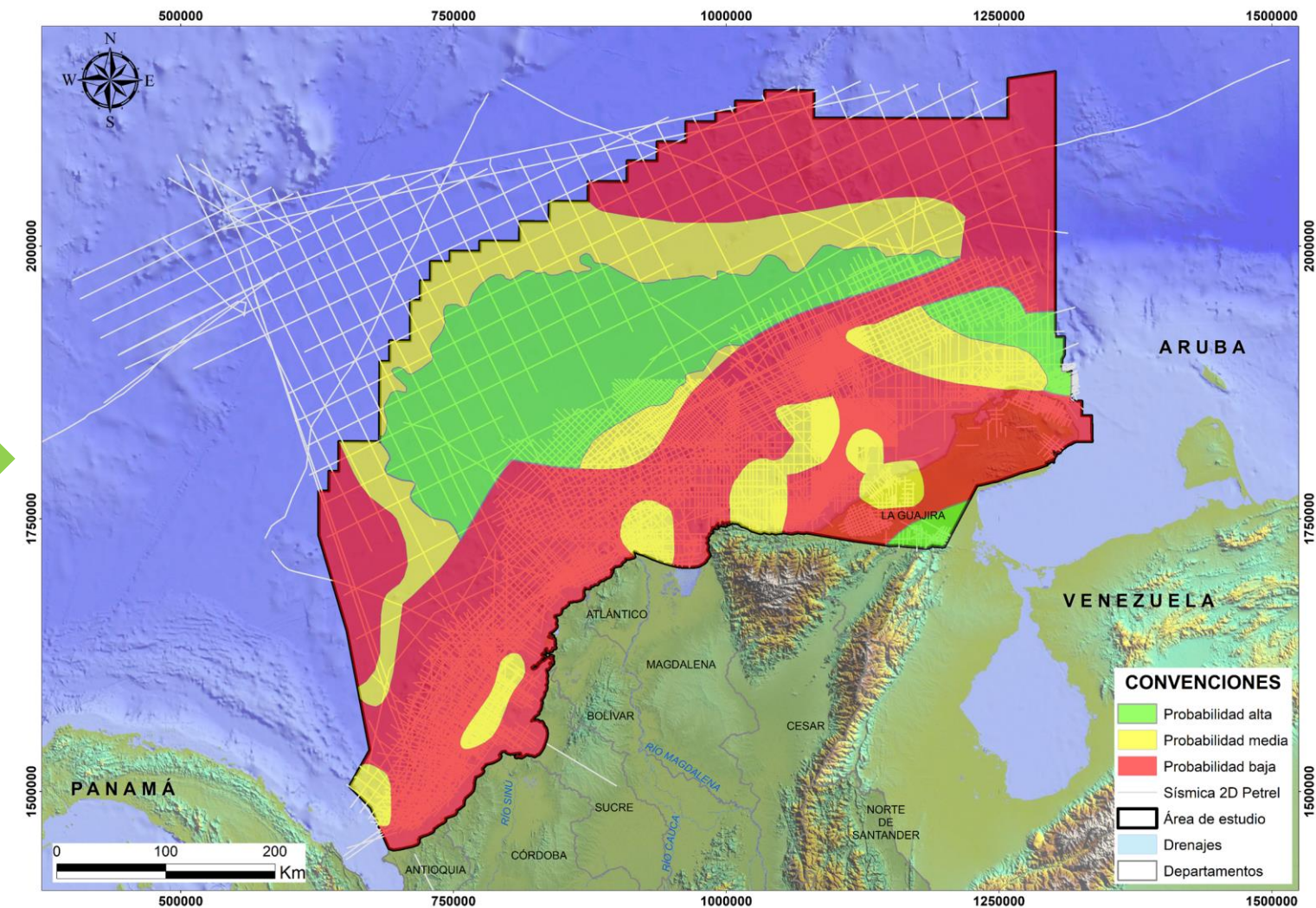
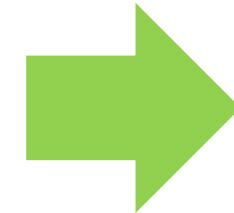
FAIRWAY MAP FOR CRETACEOUS RELATED PLAYS



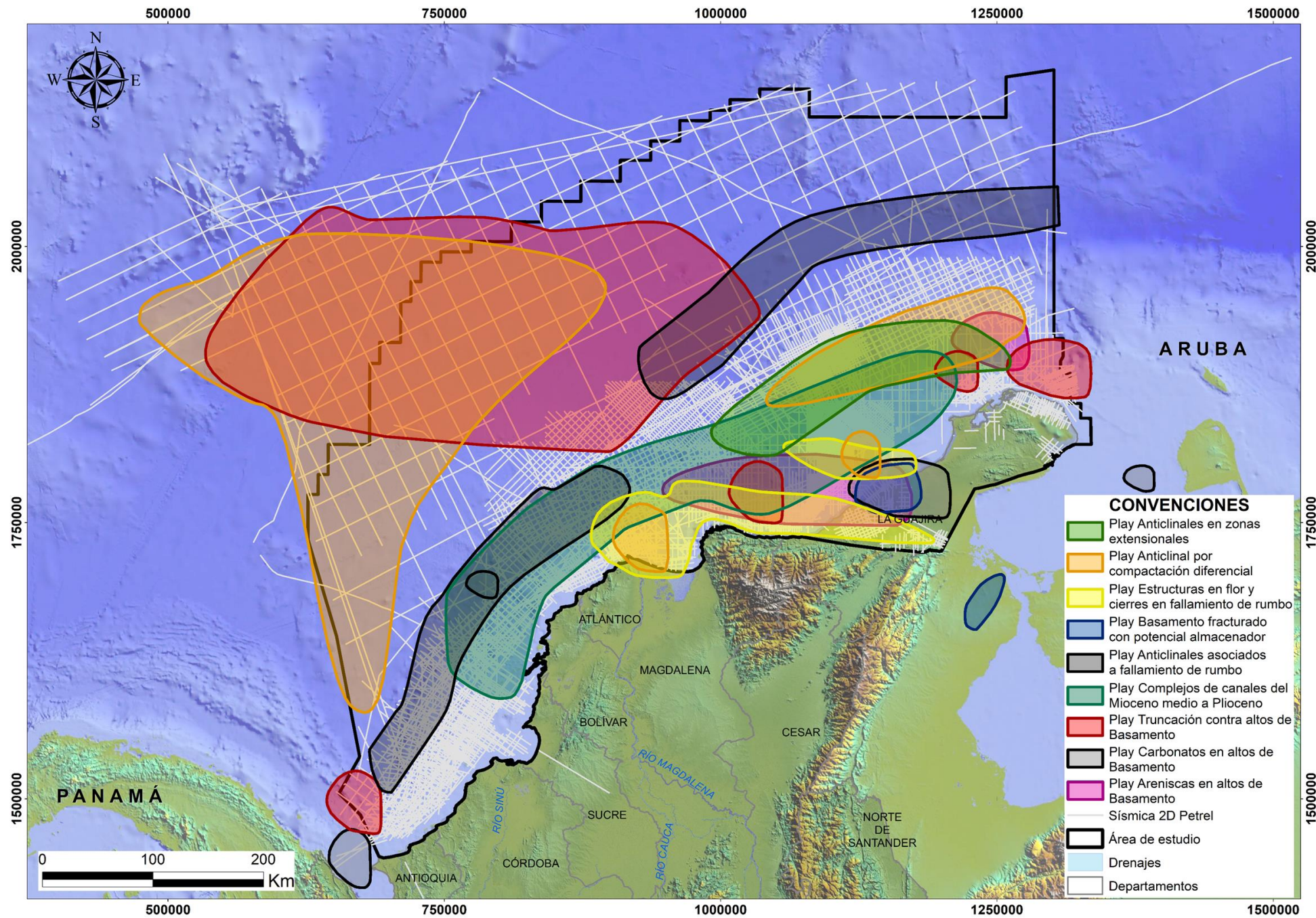
PETROLEUM SYSTEM MODEL



IDENTIFIED PLAYS



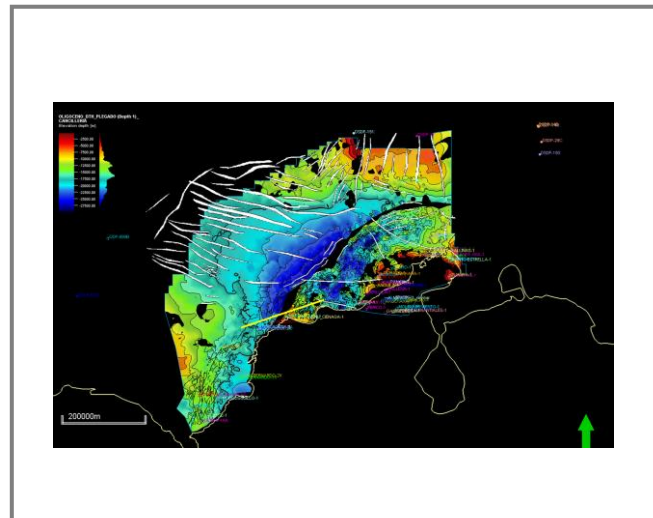
PLAY FAIRWAY MAPS



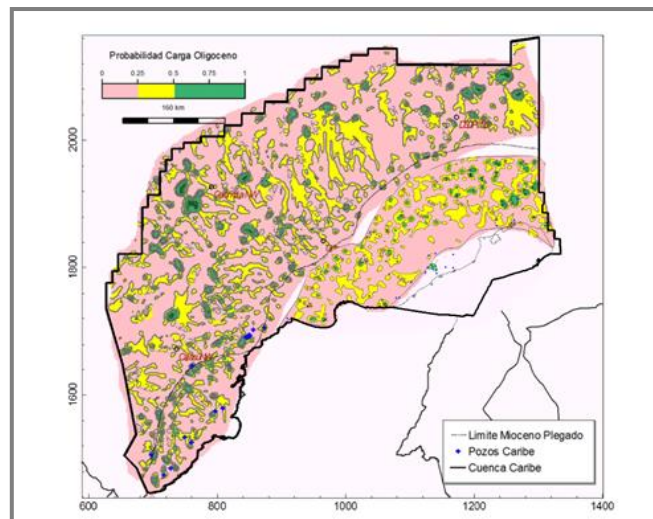
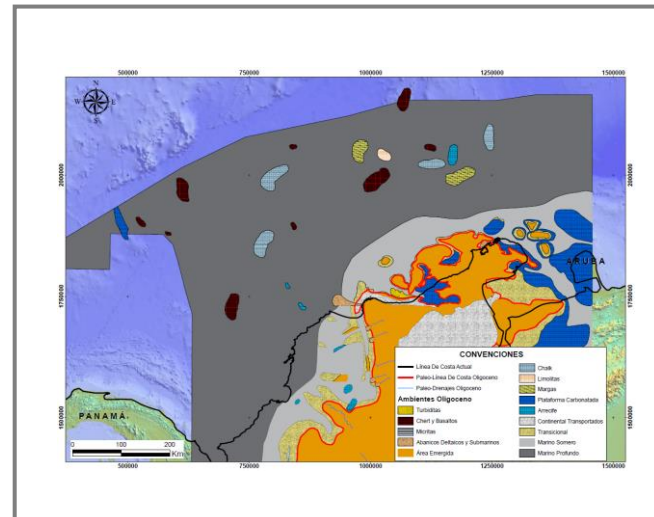
Plays associated to Oligocene to Early Miocene clastic and calcareous reservoir rocks.

PLAY FAIRWAY MAPS

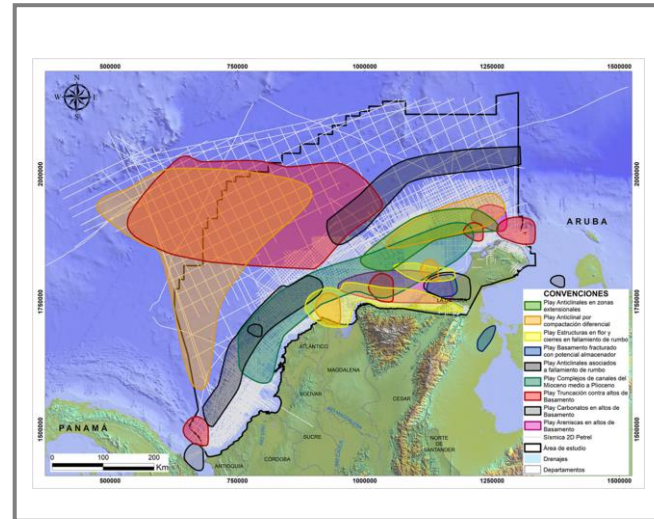
STRUCTURAL MAP



PALEOGEOGRAPHIC MAP

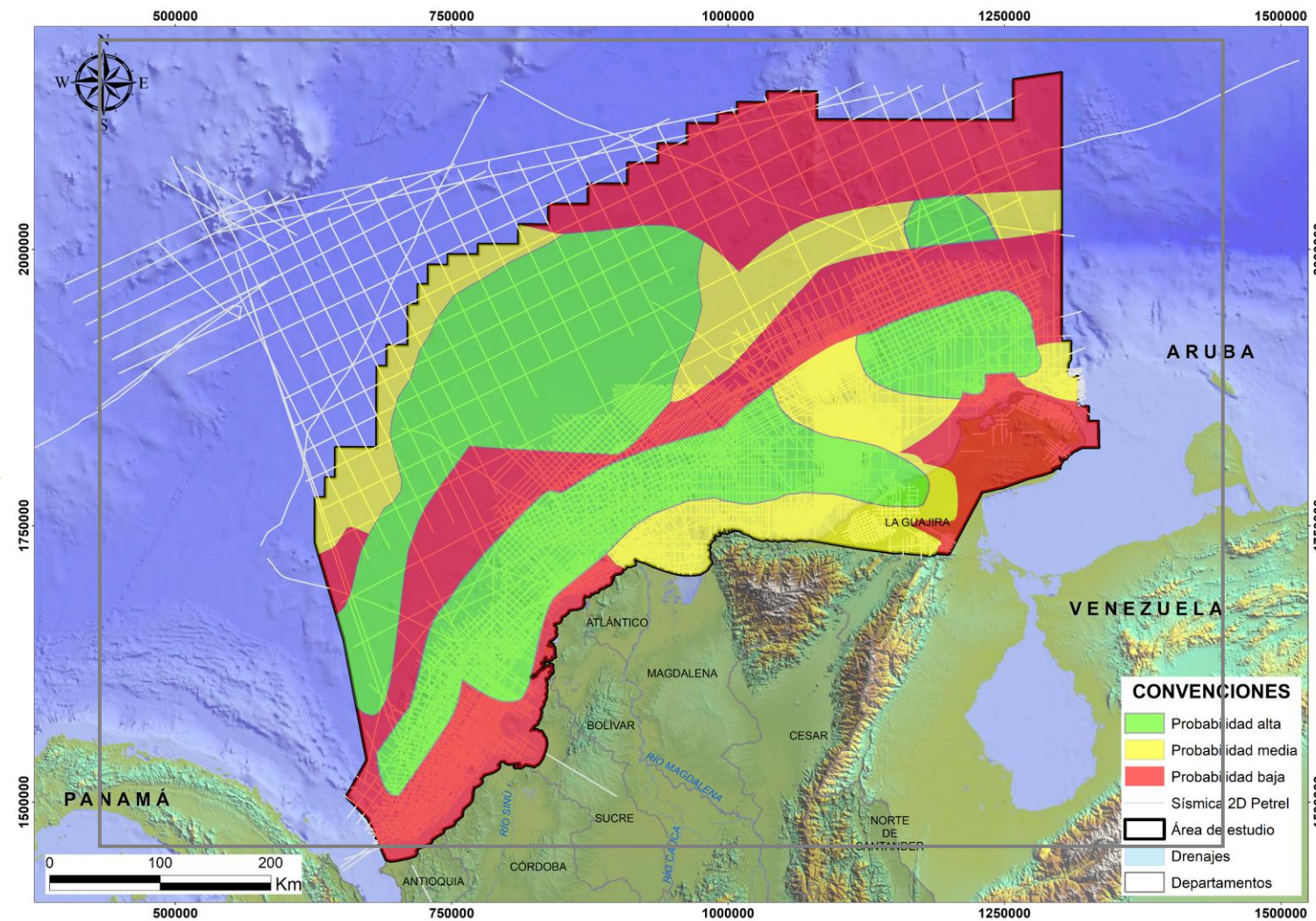
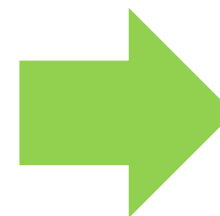


PETROLEUM SYSTEM MODEL

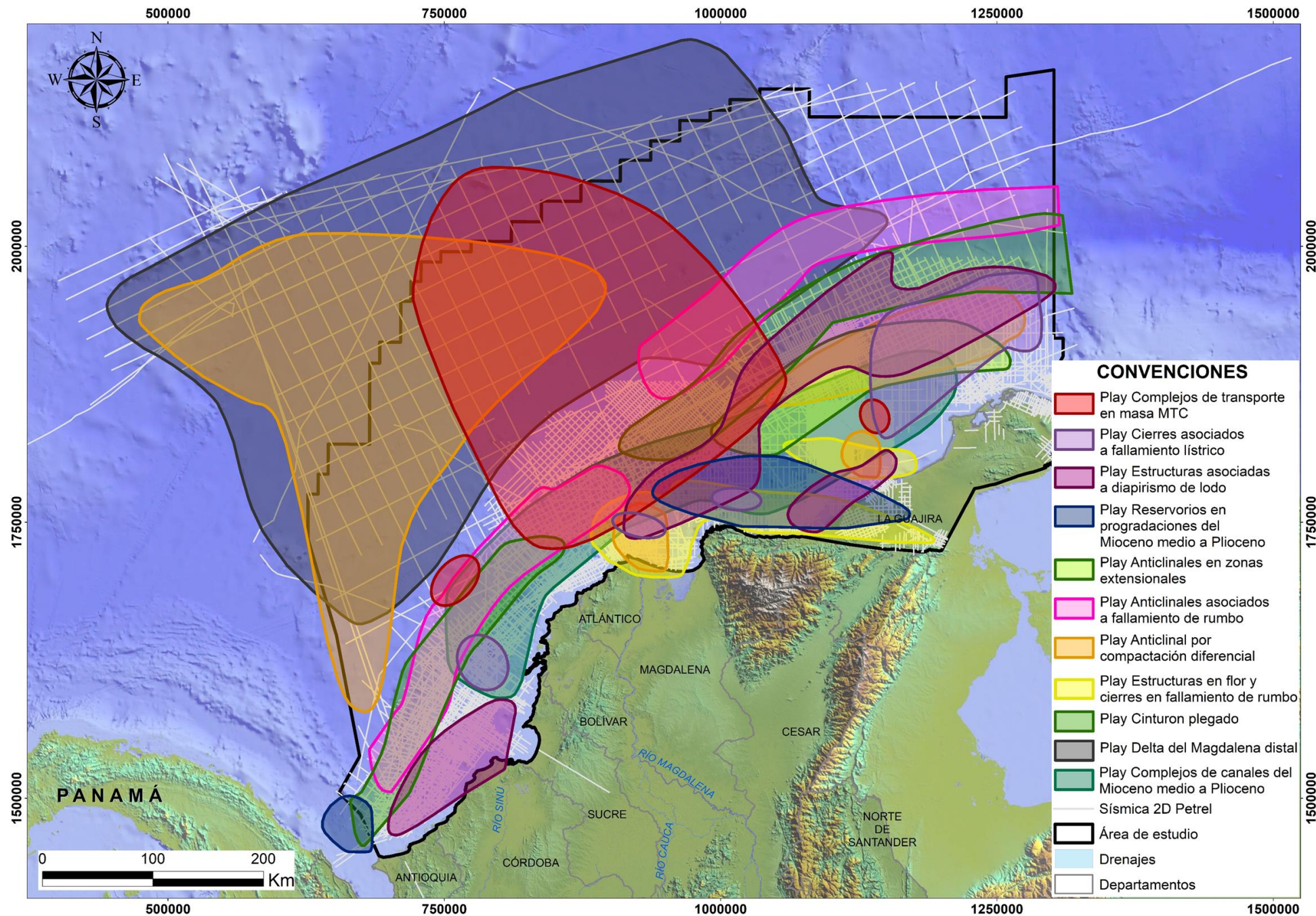


IDENTIFIED PLAYS

FAIRWAY MAP FOR OLIGOCENE – EARLY MIOCENE RELATED PLAYS



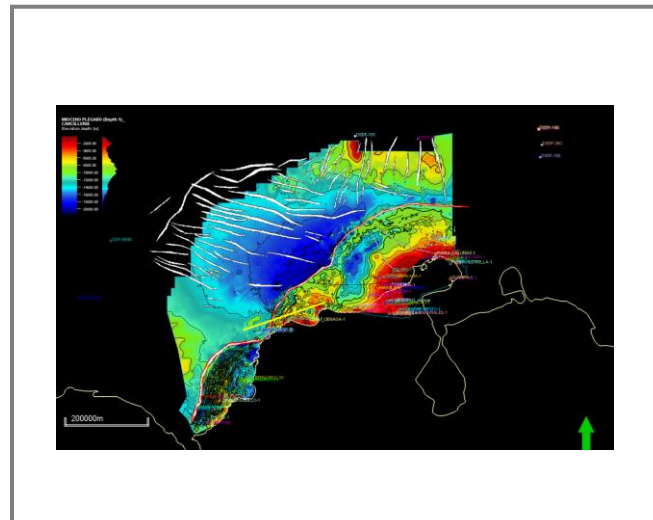
PLAY FAIRWAY MAPS



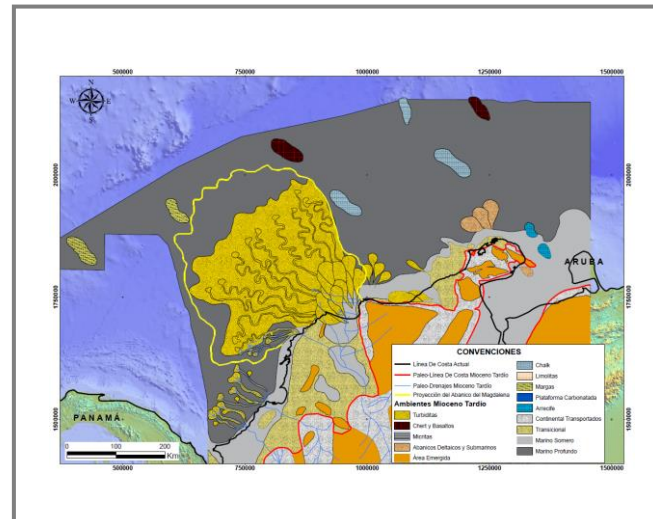
Plays associated to Mid Miocene to Pliocene clastic reservoir rocks (including turbidites).

PLAY FAIRWAY MAPS

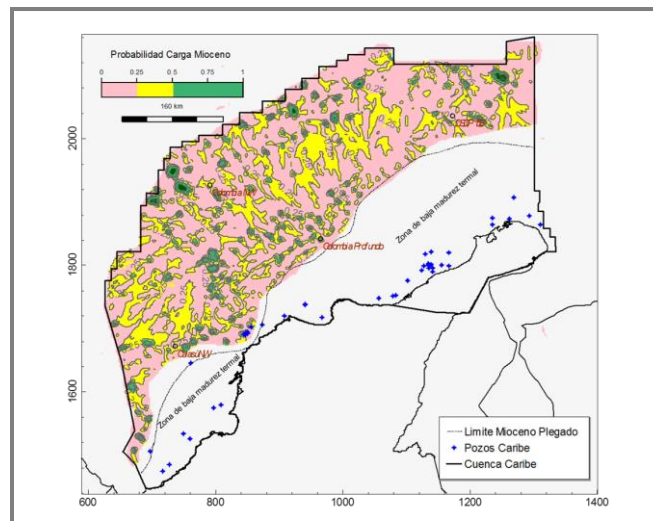
STRUCTURAL MAP



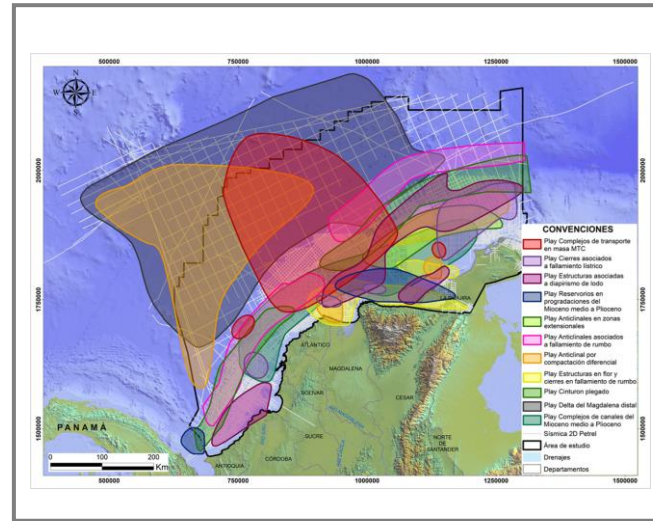
PALEOGEOGRAPHIC MAP



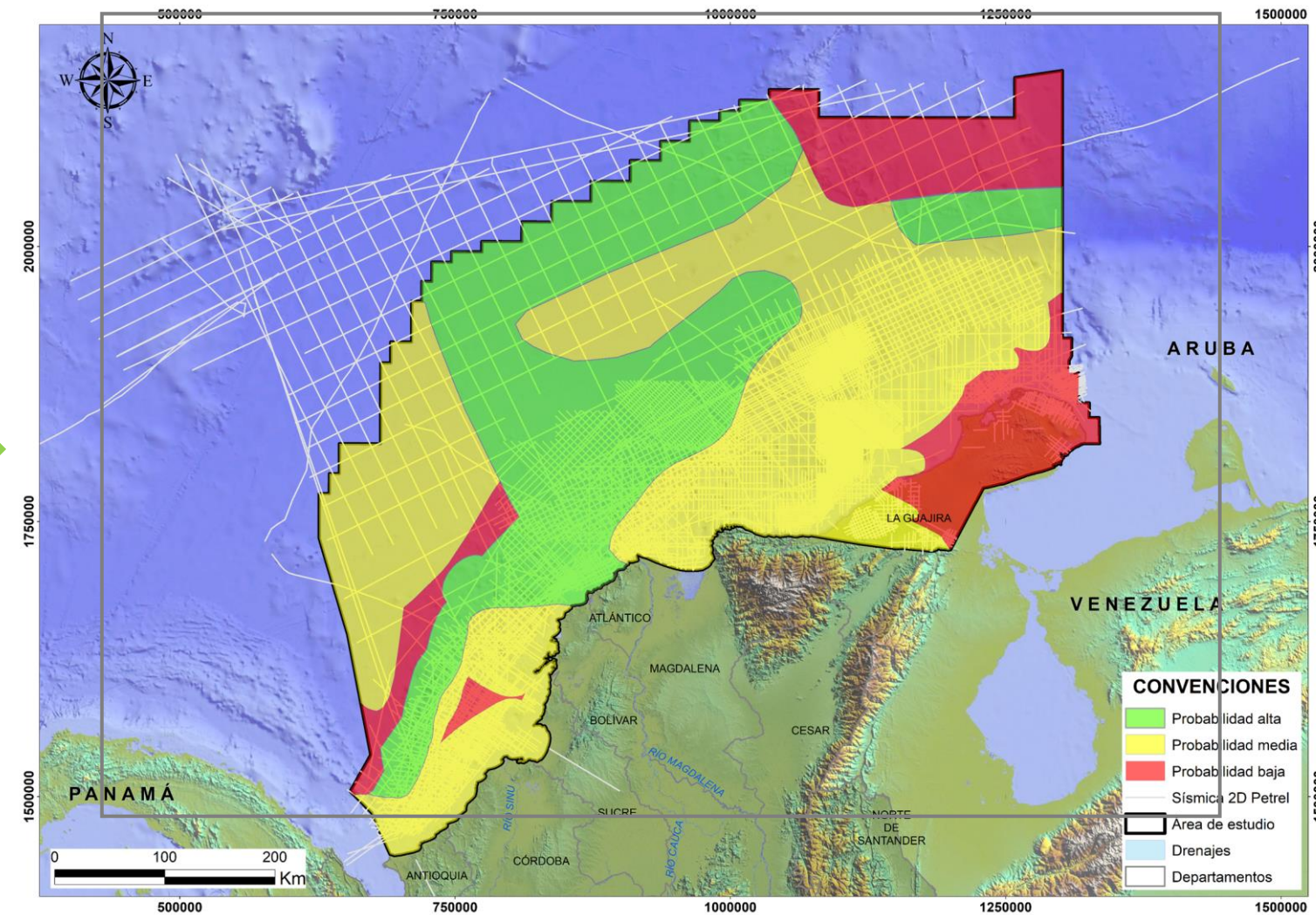
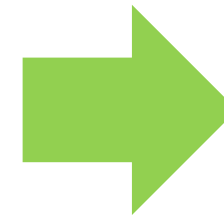
FAIRWAY MAP FOR MID MIOCENE – PLIOCENE RELATED PLAYS



PETROLEUM SYSTEM MODEL



IDENTIFIED PLAYS



MAIN CONCLUSIONS

MAIN CONCLUSIONS

Caribbean Offshore basin of Colombia, with an extension of more than 250.000 km² and considered a frontier province in northern South America, is becoming an exploratory emerging region. Encouraging results from seismics, piston coring, and drilling campaigns in the last decade indicate the presence of working petroleum systems, with a hydrocarbon potential in the level of 35 to 90 TCFG, and fair to good chances of finding liquid hydrocarbons. Two ongoing drilling operations would add valuable information on petroleum system elements in different provinces in the Caribbean.

Sixteen play types have been identified, with local and regional distribution. Stratigraphic character and thermogenic potential deserve further studies with 3D seismics and modern geochemical analyses.

Exploratory efforts in the Caribbean have been carried out during the 21st century in offshore Colombia, executed with state of the art concepts and technologies in a block by block (contract by contract) fashion.

This work presents the most recent efforts of Agencia Nacional de Hidrocarburos and the Dirección Técnica de Hidrocarburos –SGC- to use play based exploration approach to analyze the Caribbean Offshore in a single systematic project. Sixteen play concepts are reviewed, documented and updated. The summarized results, reported in an atlas format as play fairways maps, constitute a technical basis for fostering the exploration and investment in this promising province.

Play Based Exploration is a methodology that allows to put together petroleum systems and prospective geological features in a basin framework. By identifying geological features of exploratory interest under the concept of play, explorers, decision makers and investors can rank geographic areas into the particular basin and allocate proper time, technical efforts and economic resources to those projects where higher return and portfolio growth is expected.



QUESTIONS?

SERVICIO
GEOLOGICO
COLOMBIANO



ANH
AGENCIA NACIONAL DE HIDROCARBUROS