Hydrocarbon Migration and Charge Models for the Eastern Cuyana Basin Fields, Argentina*

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Abstract

The Cuyana Basin is a Triassic rift basin formed as a consequence of the Gondwana aperture at the early Mesozoic. For each hemigraben generated, several deposits such as fluvial, deltaic and lacustrine developed. The Triassic lacustrine deposits for this basin, named as the Cacheuta Formation, is the main source rock with excellent conditions for hydrocarbon generation. The main kitchen is located at the Tupungato depocenter at the west margin of the basin, although there are other Cacheuta depocenters with good conditions for the hydrocarbon generation, such as Tierras Blancas depocenter. In the basin there are two productive trends parallel to each other, with northwest to southeast direction. Since the oriental trend is the furthest away from the main kitchen it´s not easy to explain how the oil reached the big fields that produce large amounts of hydrocarbon at the present day. Several authors have demonstrated that the oil produced from the fields of the oriental trend, for the late Triassic, Jurassic, and Cretaceous reservoirs, have had long hydrocarbon migration from the Tupungato-Tierras Blancas depocenter (with Ro%>0.6), at about 20 to 70 km away. For these long migrations the Jurassic clastic deposits of the Barrancas Formation, which have a very constant distribution among the whole basin, is the known carrier bed. These authors also calculated the age of expulsion and migration starting from the age of 10 m.y. For the occidental trend productive fields, it´s easier to understand how the migration and charge took place, but for the oriental trend, assuming today´s structural configuration for the known carrier bed, the migration and charge of the eastern fields is not possible. Some ideas assume that the migration to the eastern fields of the basin, took place using the strike slip faults as carriers but at the moment there´s no modelling simulation for this possibility. In this work, several models will be shown, one of which is based on these strike slip faults, which have a huge participation in the hydrocarbon distribution in the oriental trend. It will be shown how at different moments of the basin history, these faults acted like a seal and also as a carrier. On the other hand, another model not fault dependent, is also proposed for the oriental trend migration and charge, assuming an expulsion and migration previous to the tertiary structuring, defined at the age of 5 m.y., with a fluid re-accommodation with the present topography of the reservoirs. Both models allow us to easy simulate the charge of the oriental trend fields (Rio Viejas, Vacas Muertas, Punta de las Bardas, Vizcacheras, Cañada Dura, etc.), and shows the huge effect of the stratigraphic seal configuration for some of these fields. This workflow is an essential tool that allows the identification of areas with high charge risk and also areas with new possibilities for the hydrocarbon exploration.

Selected References

Irigoyen, M.V., K.L. Buchan, M.E. Villeneuve, and R.L. Brown, 2002, Cronología y significado tectónico de los estratos sinorogénicos neógenos alforantes en la region de Cacheuta-Tupungato, Provincia de Mendoza: Revista de la Asociación Geológica Argentina, v. 57/11, p. 3-18.

Kokogian, D.A., F.F. Seveso, and A. Mosquera, 1993, Las secuencias sedimentarias tria ´sicas. 12° Congreso Geolo ´gico Argentino y 2° Congreso de Exploracio ´n de Hidrocarburos, Relatorio Geologı ´a y Recursos Naturales de Mendoza, v. 1/7, p. 65-78.

Zencich, S., H.J. Villar, and D. Boggetti, 2008, Sistema petrolero Cacheuta-Barrancas de la Cuenca Cuyana, Provincia de Mendoza, Argentina, in C.E. Cruz, J.F. Rodríguez, J.J. Hechem, and H.J. Villar (Eds.), Simposio de Sistemas Petroleros de las Cuencas Andinas: VII Congreso de Exploración y Desarrollo de Hidrocarburos, Buenos Aires, Argentina, IAPG, p. 109-134.

HYDROCARBON MIGRATION AND CHARGE MODELS FOR THE EASTERN CUYANA BASIN FIELDS, ARGENTINA

Yanina A Basile & Yolanda Ruiz

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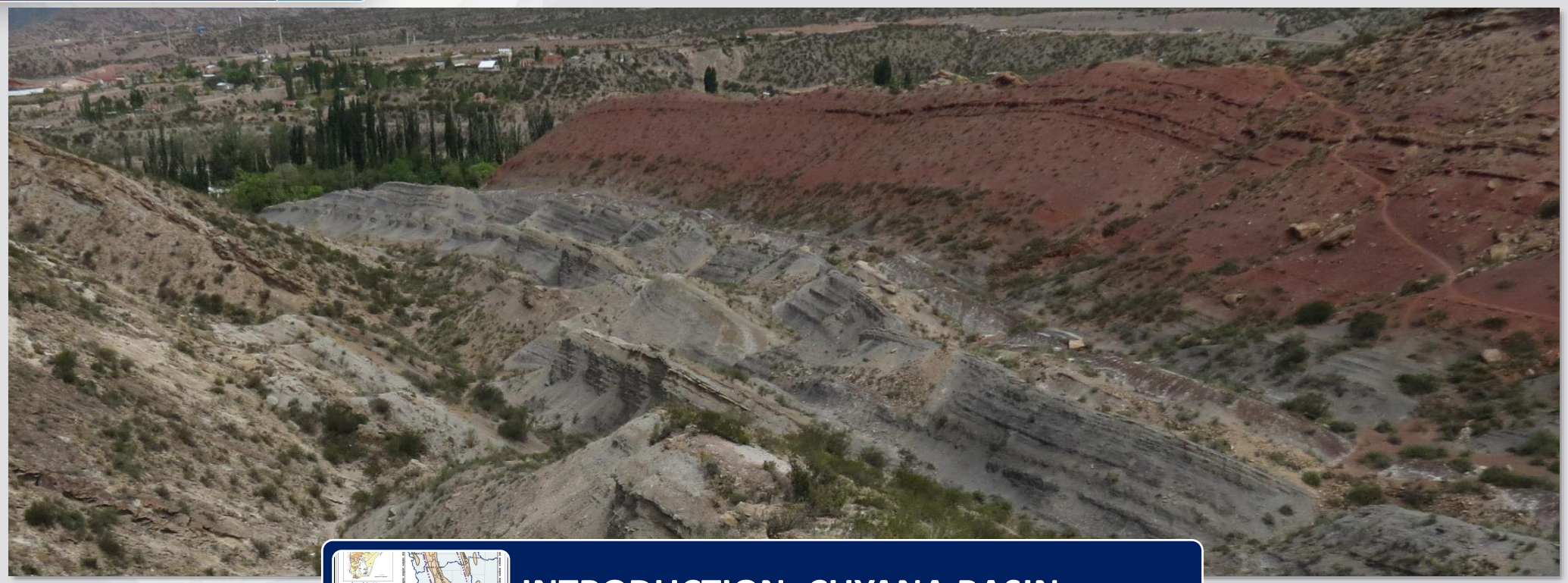
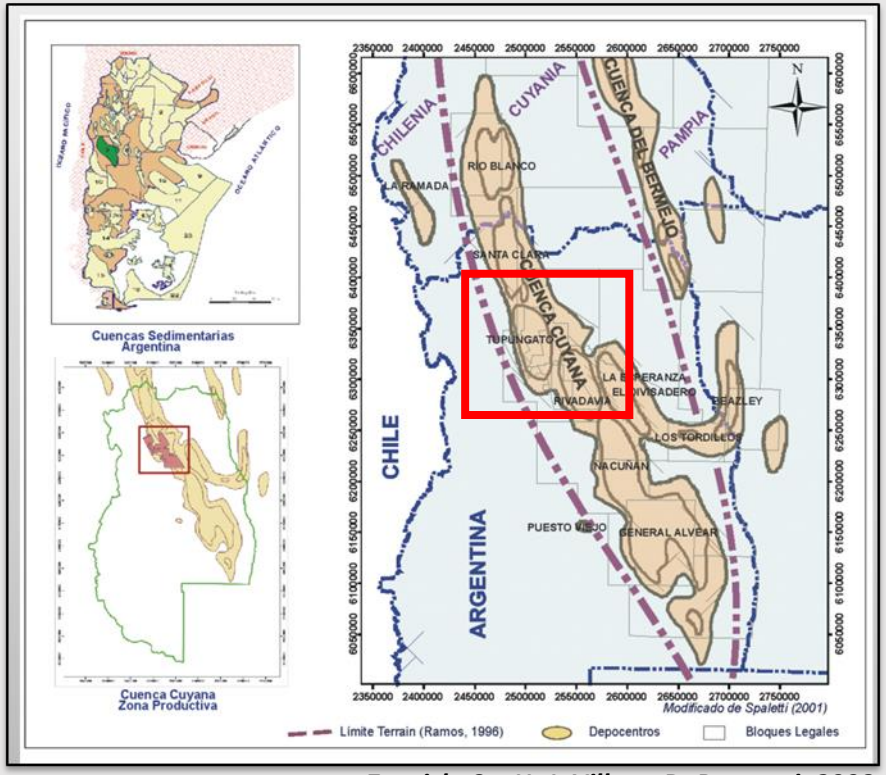


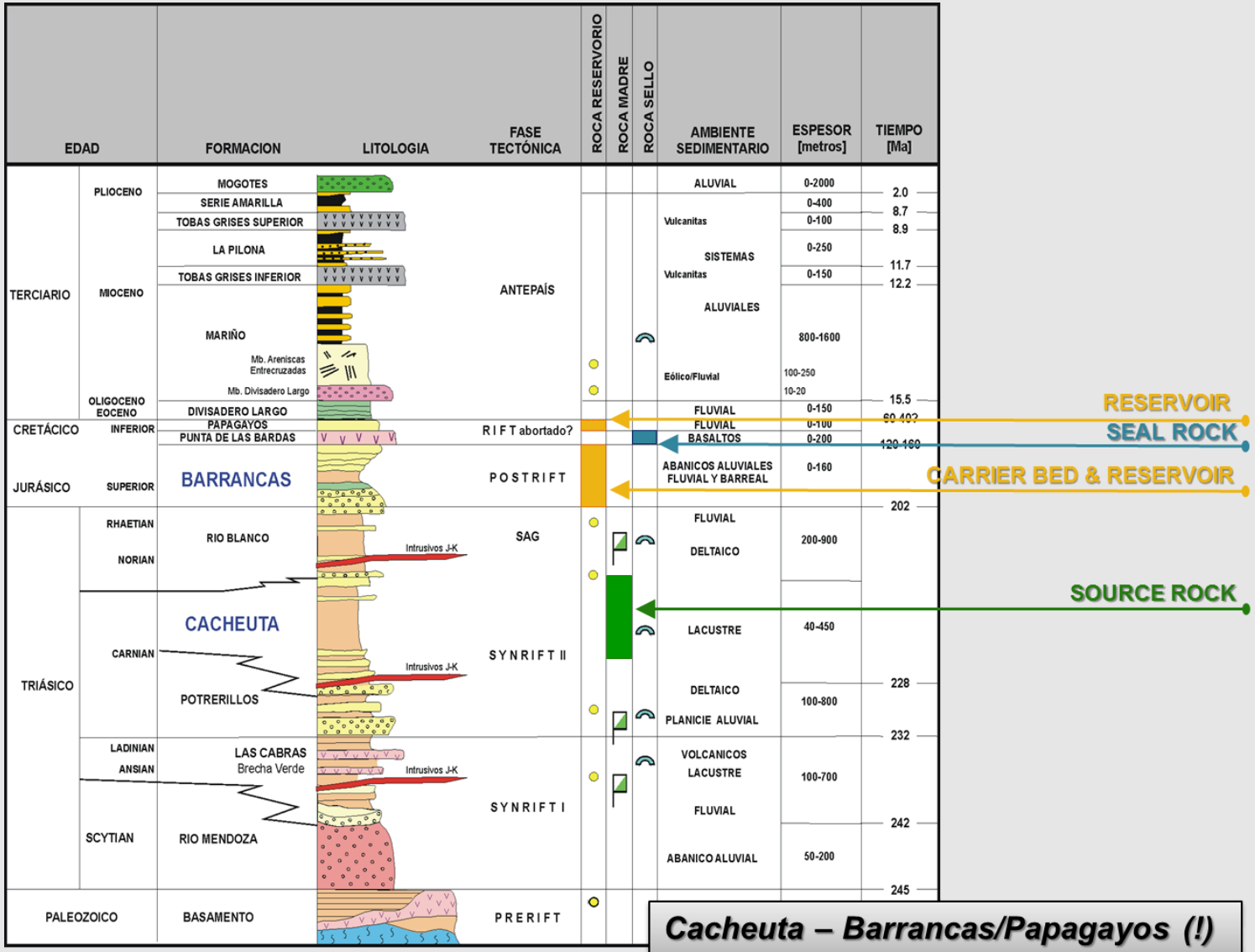
Cerro Cocodrilo, Mendoza Province

INTRODUCTION: LOCATION & STRAT. COLUMN



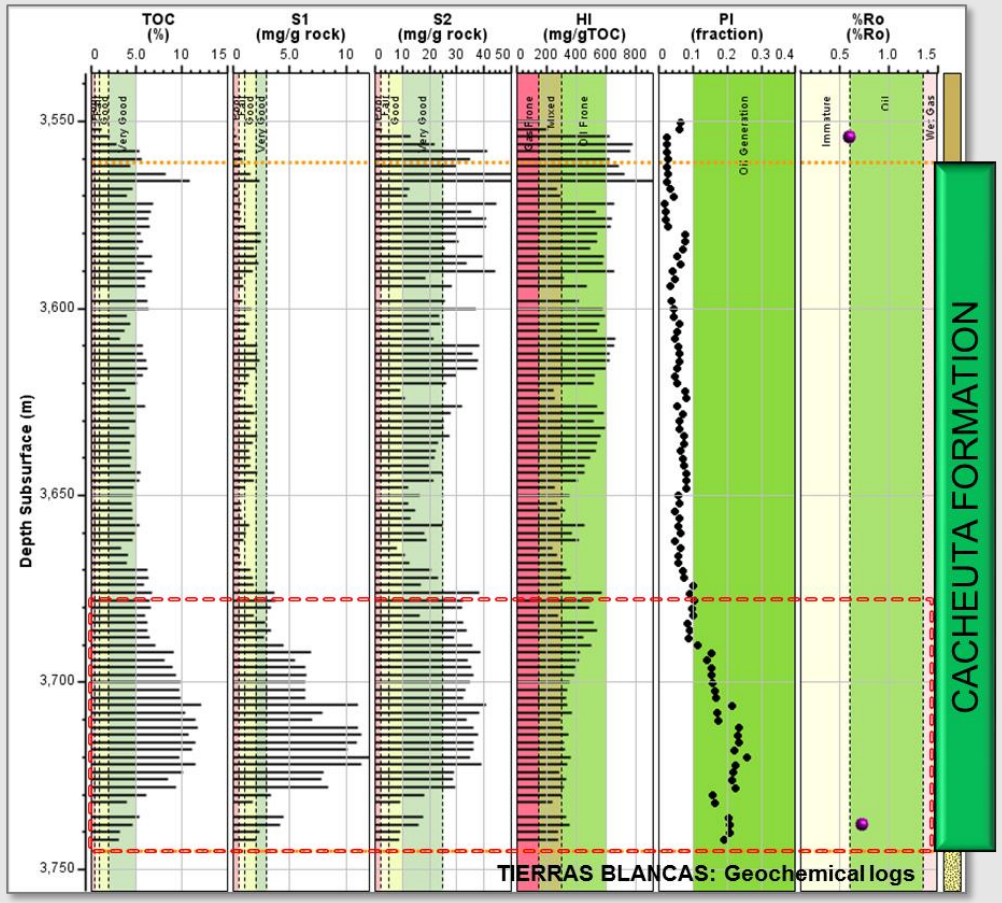
Zencich, S., H. J. Villar y D. Boggetti, 2008

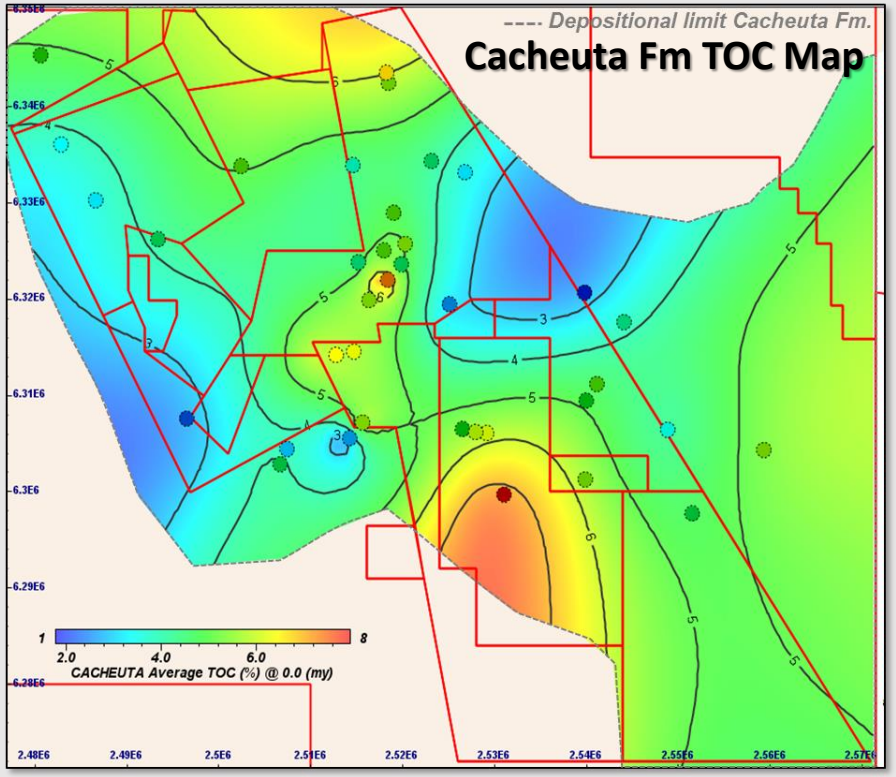
The Cuyana Basin is a Triassic failed rift as a consequence of the early Mesozoic breakup of Gondwana (Permian to Late Triassic-Early Jurassic)

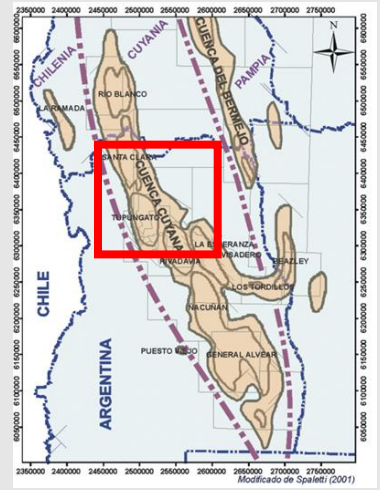


Stratigraphic column for the Cuyana Basin. Kokogian et al. (1993) and Irigoyen et al. (2002)

INTRODUCTION: SR-GEOCHEMISTRY



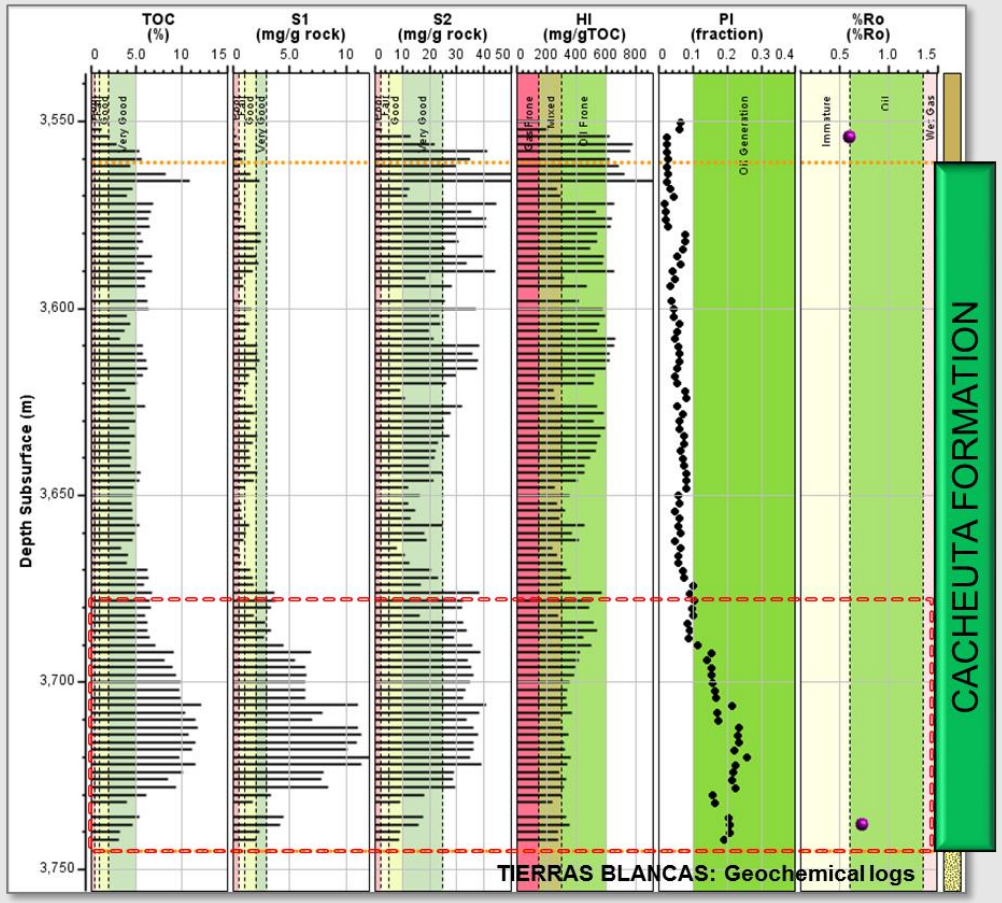


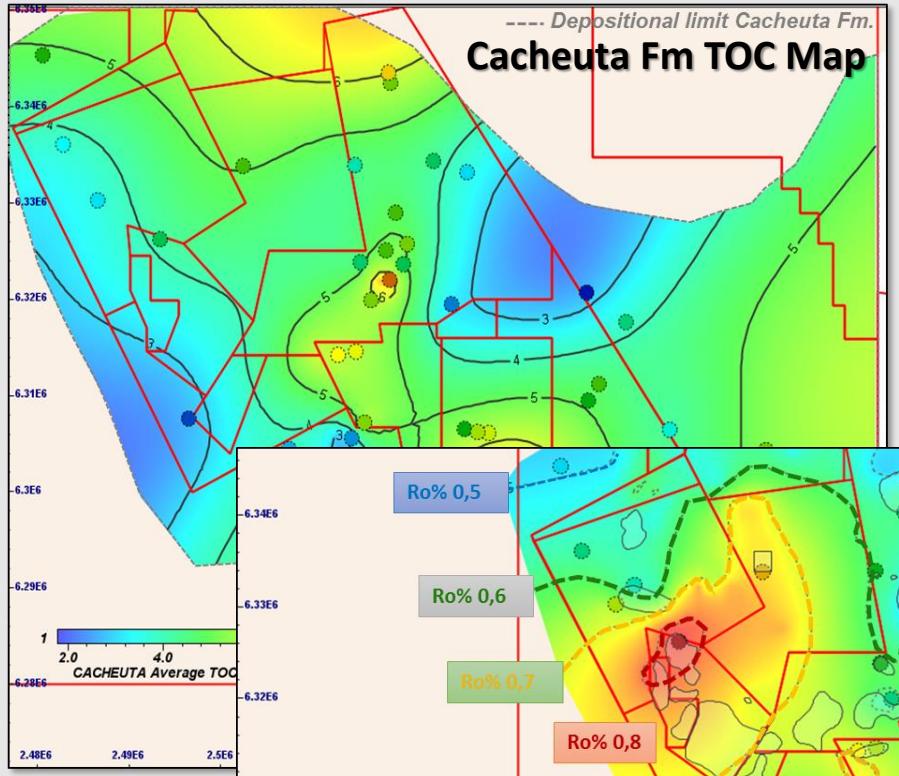


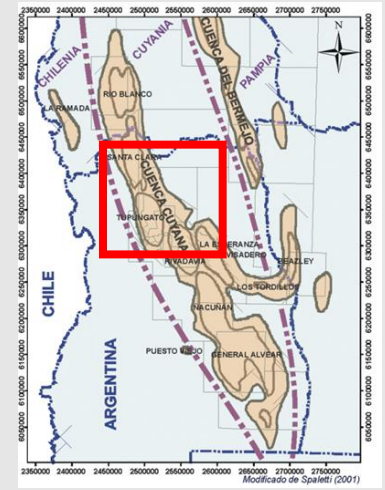
- Lacustrine organic black shales.
- Excellent source rock.
- High TOC% ~ 5%.
- OIL prone.
- Source Rock maturity 0.7-0.9% Ro

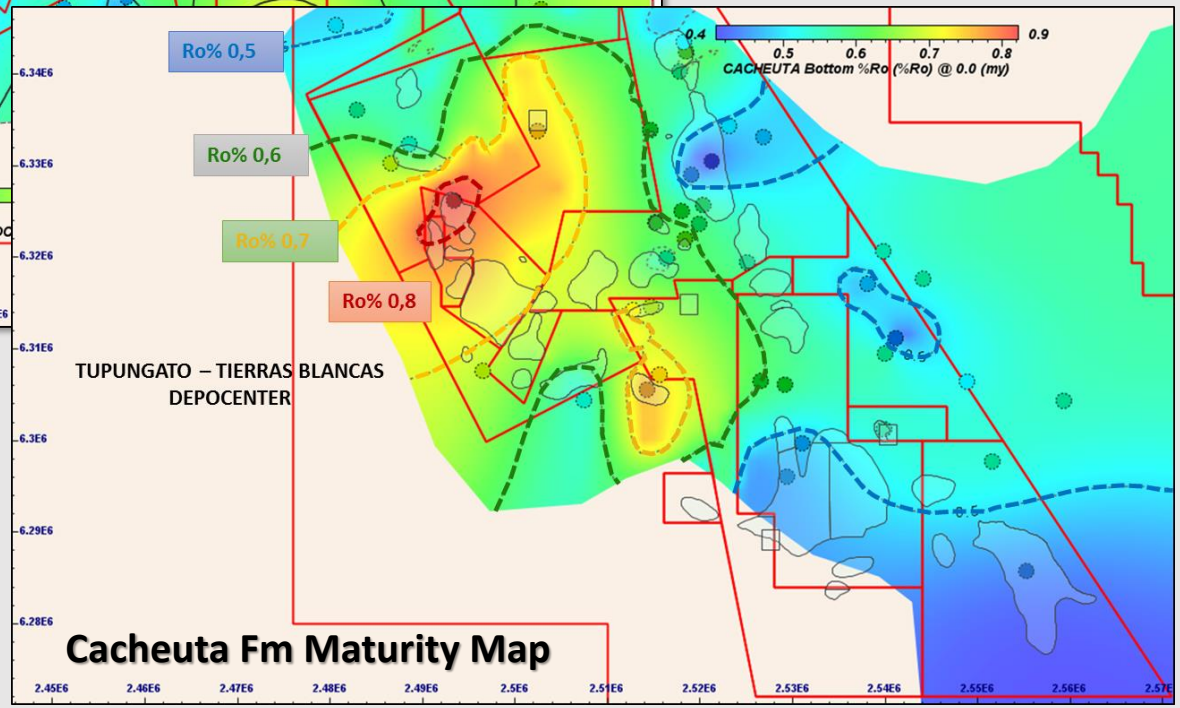
Cacheuta Fm Maturity Map

INTRODUCTION: SR-GEOCHEMISTRY









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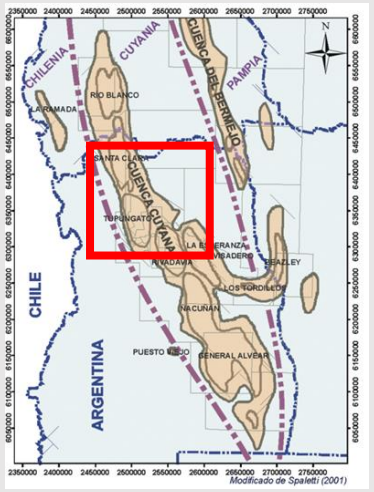
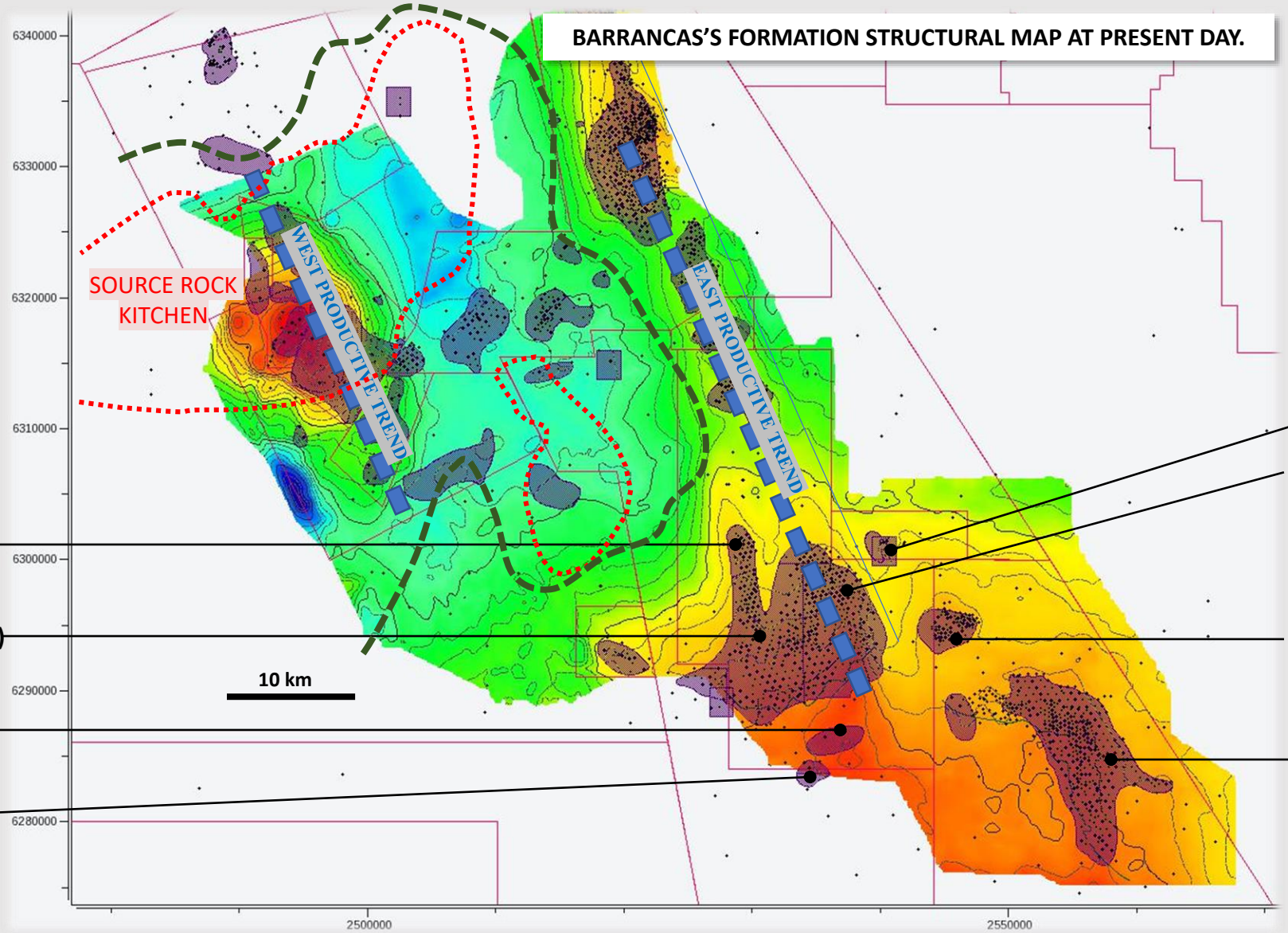
INTRODUCTION: PRODUCTIVE TRENDS





- Papagayos Fm.
- Barrancas Fm.
- Rio Blanco Fm.
- Tertiary

ZAMPAL OESTE

VACAS MUERTAS (1959)

RIO VIEJAS (1960)

PUNTA DE LAS BARDAS (1959)

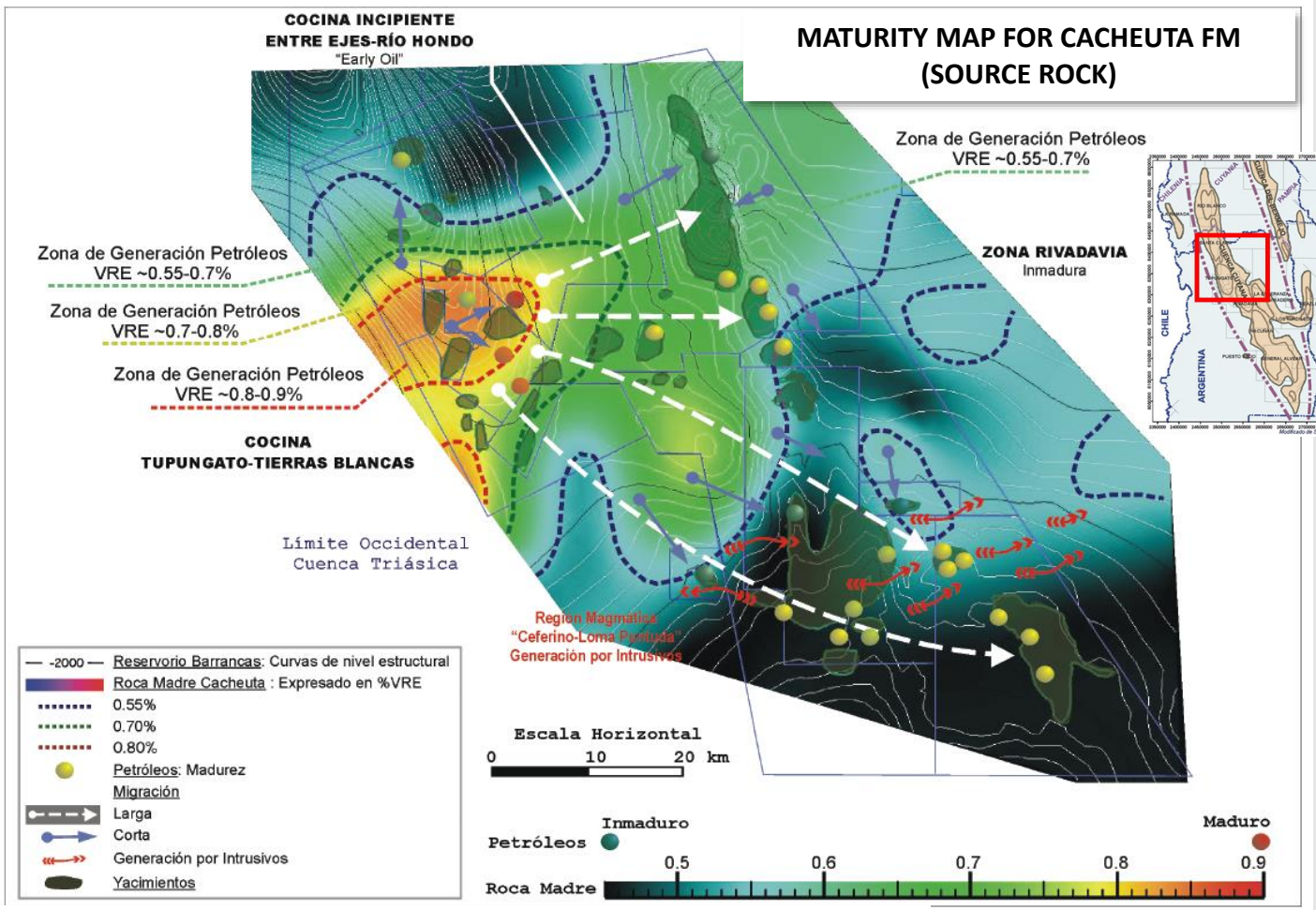
CAÑADA DURA (2000)

EL QUEMADO (1959)

VIZCACHERAS (1962)

GUANACO BLANCO (1959)

INTRODUCTION: PREVIOUS MODELS



BARRANCAS'S FORMATION STRUCTURAL MAP AT PRESENT DAY & MIGRATION PATHWAYS *Zencich et al, 2006*

Tupungato – Tierras Blancas depocenter: Mature Source Rock with VRE of 0.7 – 0.9%

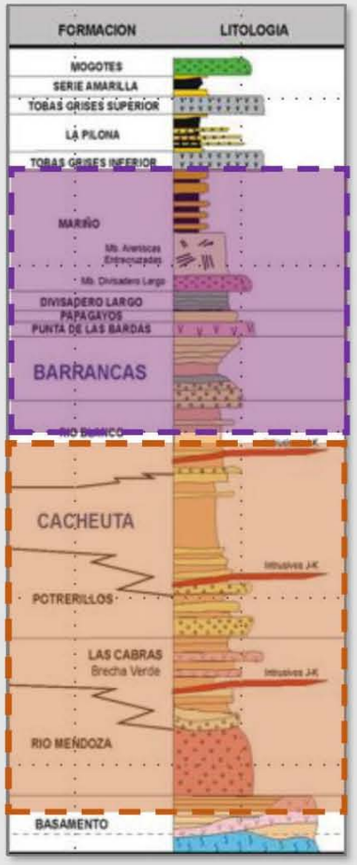
In between trends zone: early oils generation with VRE of 0.55-0.7%

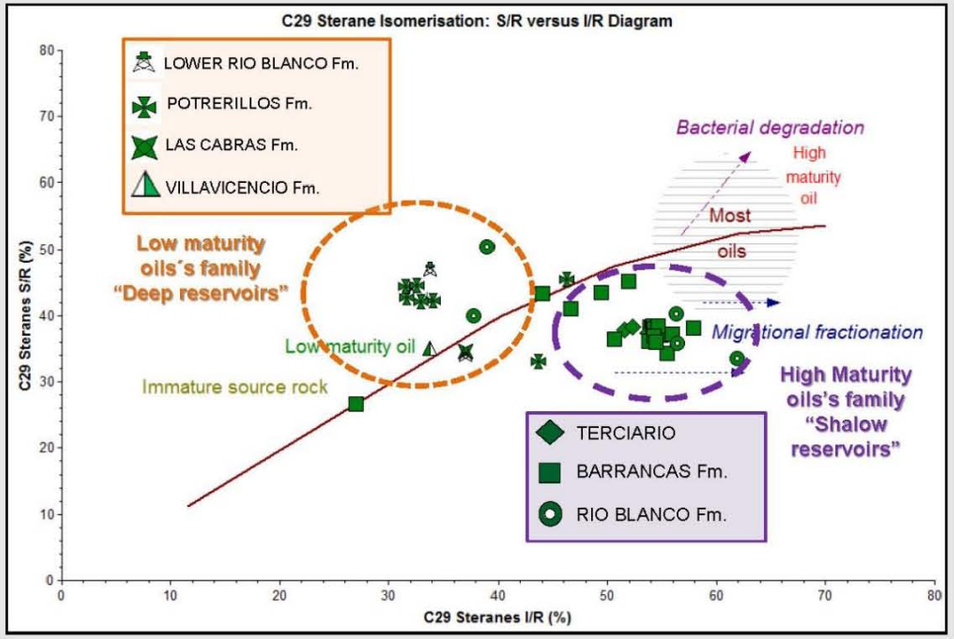
Excellent correlation between oils and a lacustrine source rock (dominant bacterial and algal material) Cacheuta Fm. in contrast with a rock extract of an organic shale level of the Potrerillos Fm.

The hydrocarbons had long migration pathways from the main kitchen to the east and southeast fields

Oils with restricted movility (low maturity) may have charged the closer fields, through short migration pathways.

INTRODUCTION: PREVIOUS MODELS

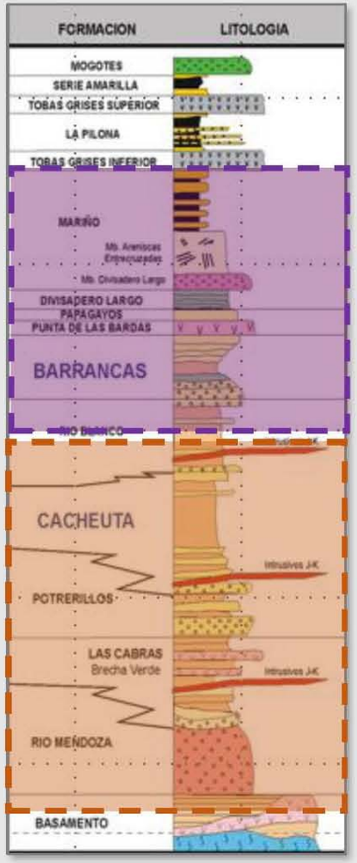


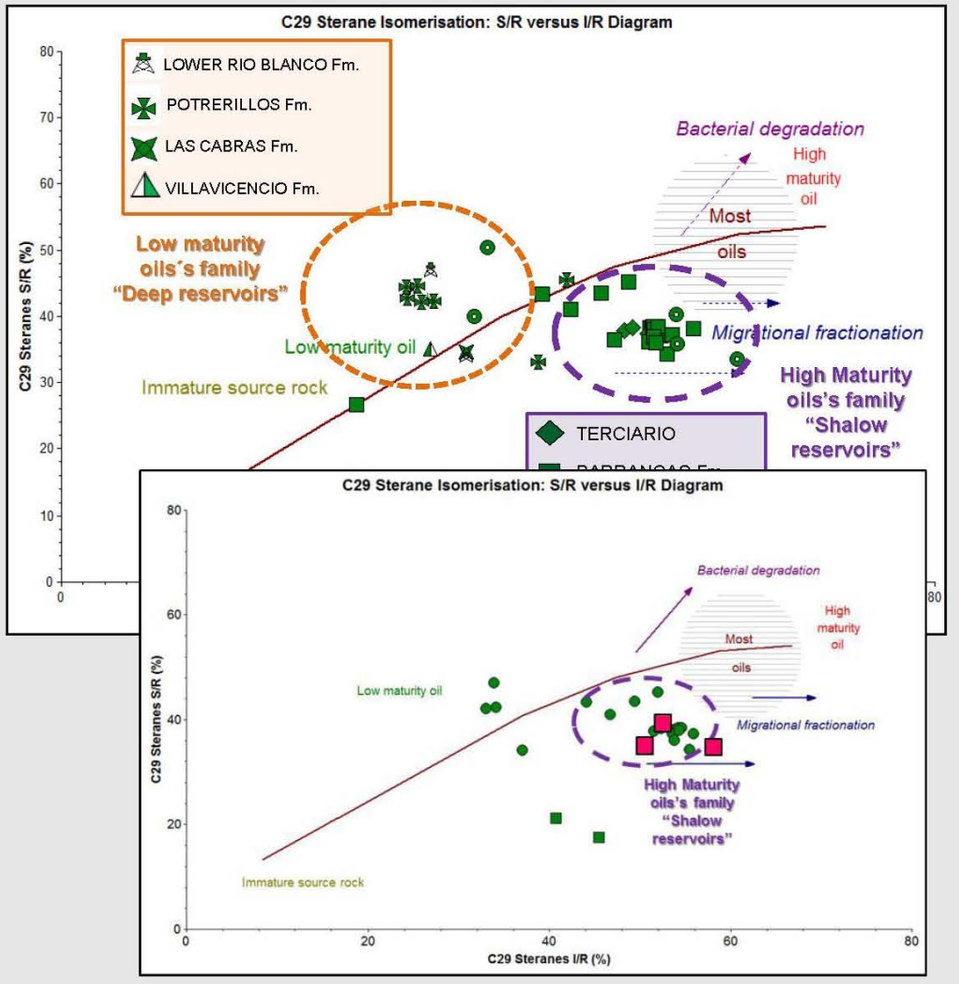


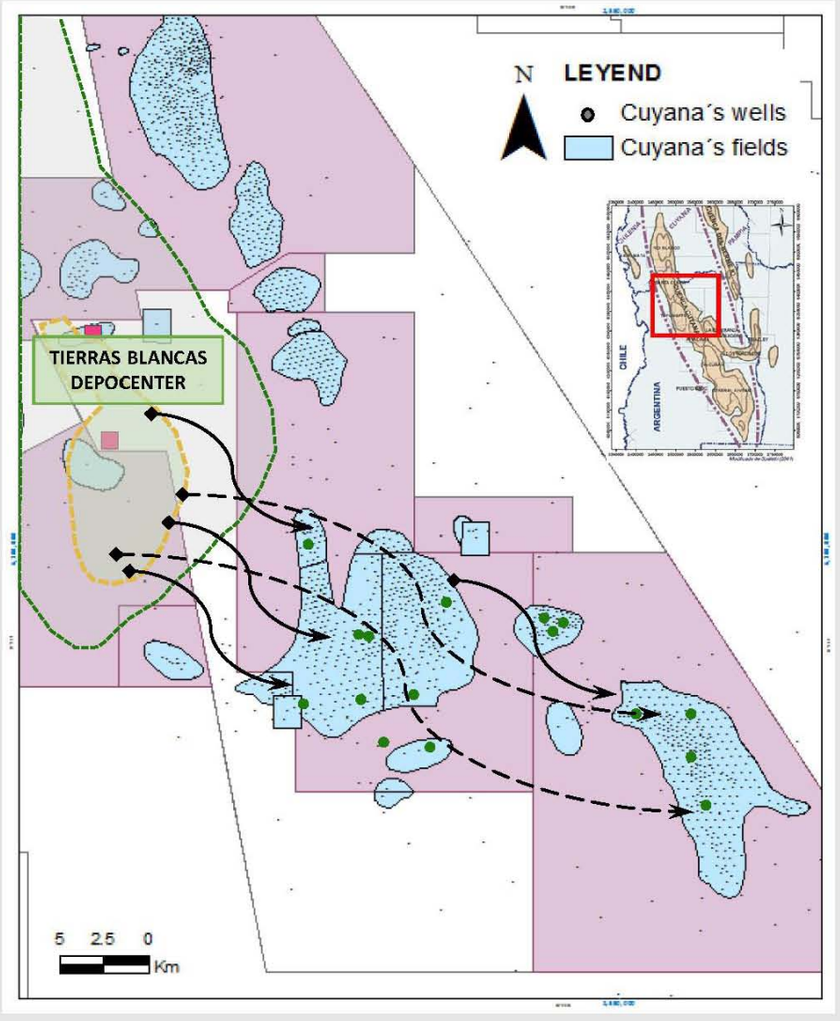
Basile et al, 2015

Presenter's notes: In this graph observe the relation between the biomarkers, from the different oils of the basin.

INTRODUCTION: PREVIOUS MODELS







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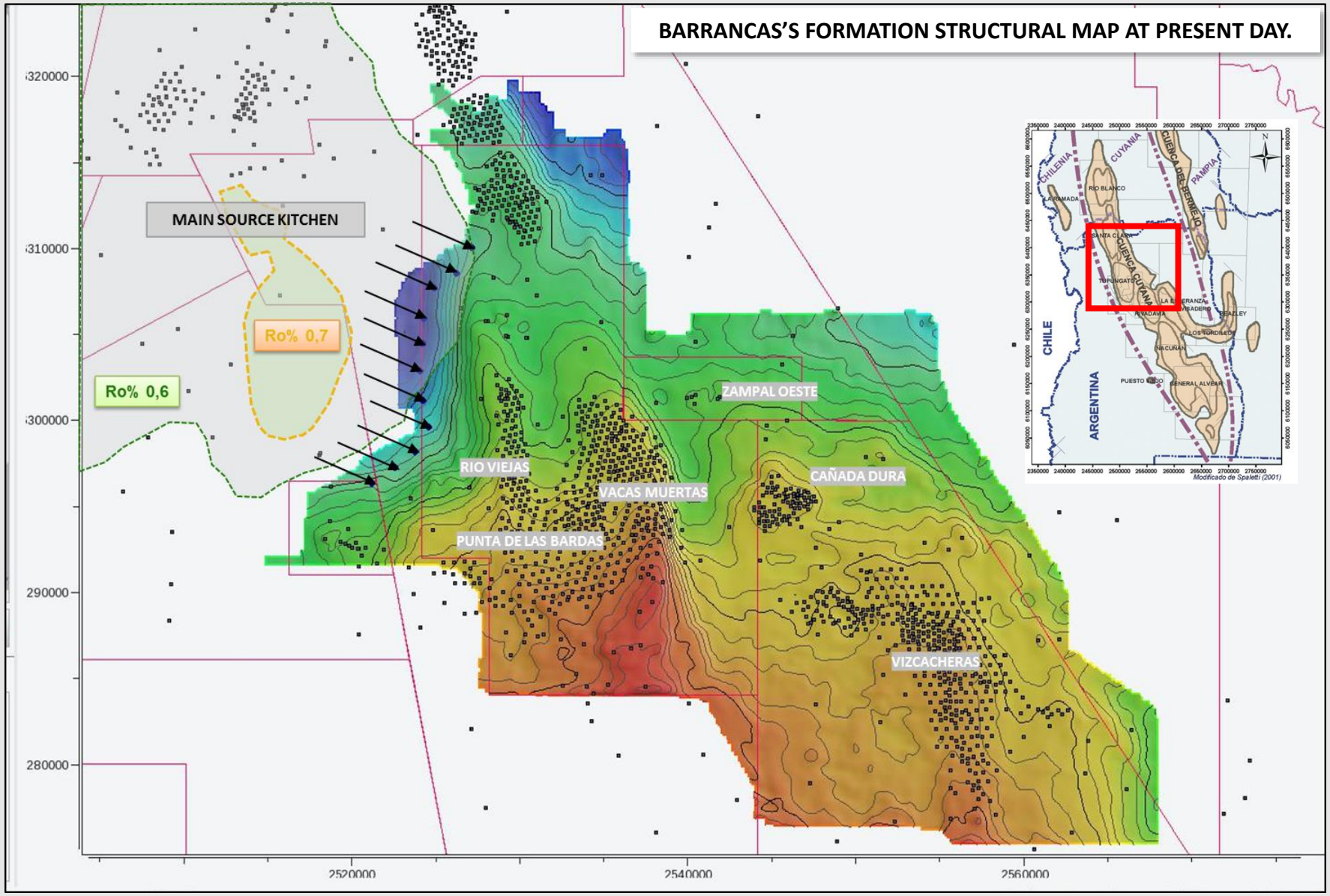
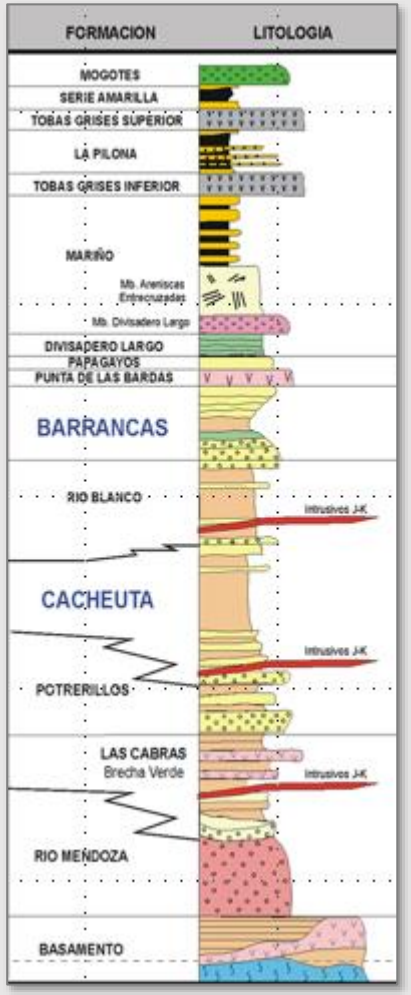
HC MIGRATION AT PRESENT DAY´S STRUCTURES



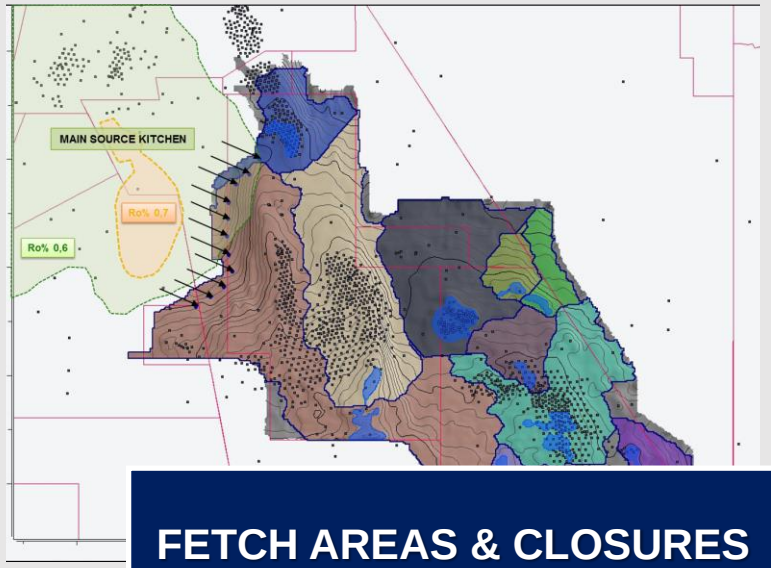
BARRANCAS FM CARRIER BED



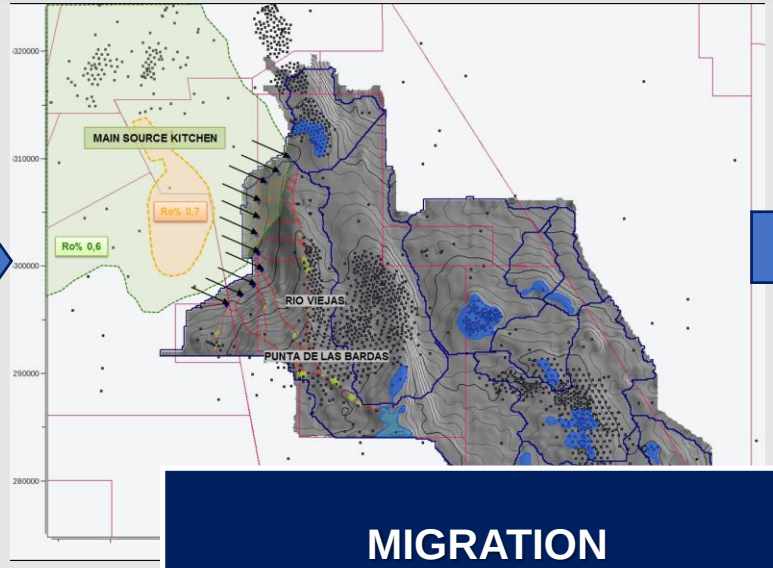
HC MIGRATION AT PRESENT DAY´S STRUCTURES

PATHWAY SIMULATION STEPS

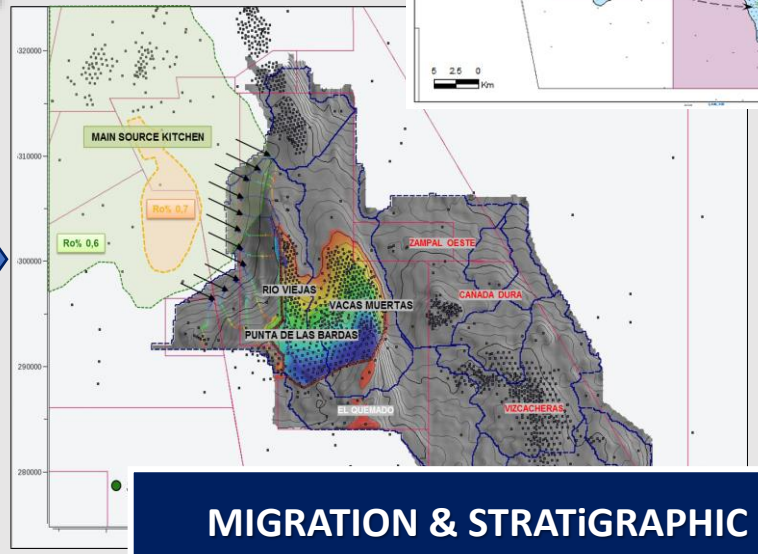
BARRANCAS'S FORMATION STRUCTURAL MAP AT PRESENT DAY.



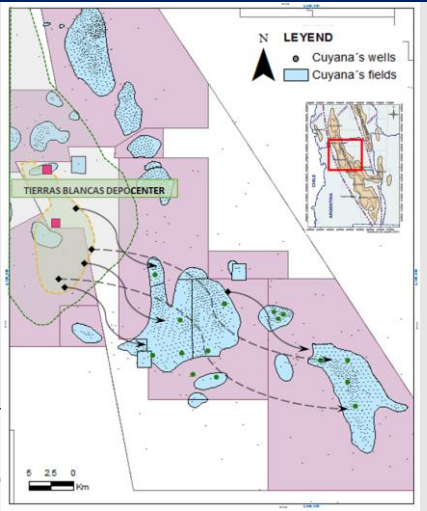
FETCH AREAS & CLOSURES



MIGRATION



MIGRATION & STRATiGRAPHIC LIMITS



PATHWAYS SIMULATION MODELS

Simulate the posible migration paths to charge the fields (**Barrancas & Papagayos Fm**)

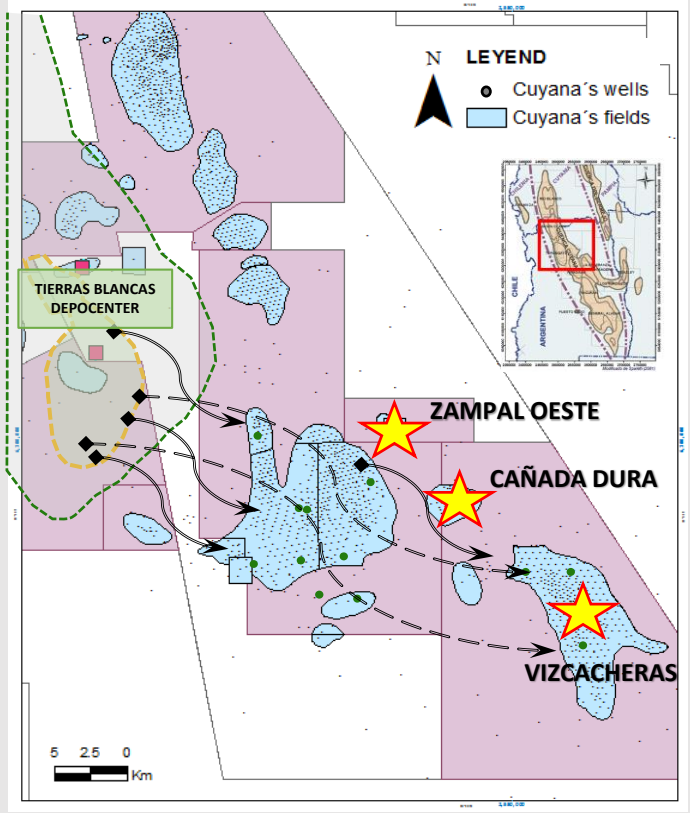
- Zampal Oeste
- Cañada Dura
- Vizcacheras

Two different migration models:

- Pre-deformation migration

  (as a new idea)
- Using strike slip faults as barriers / conection

  (as proposed in 2006 by Zencich *et al.* but never been modelled)

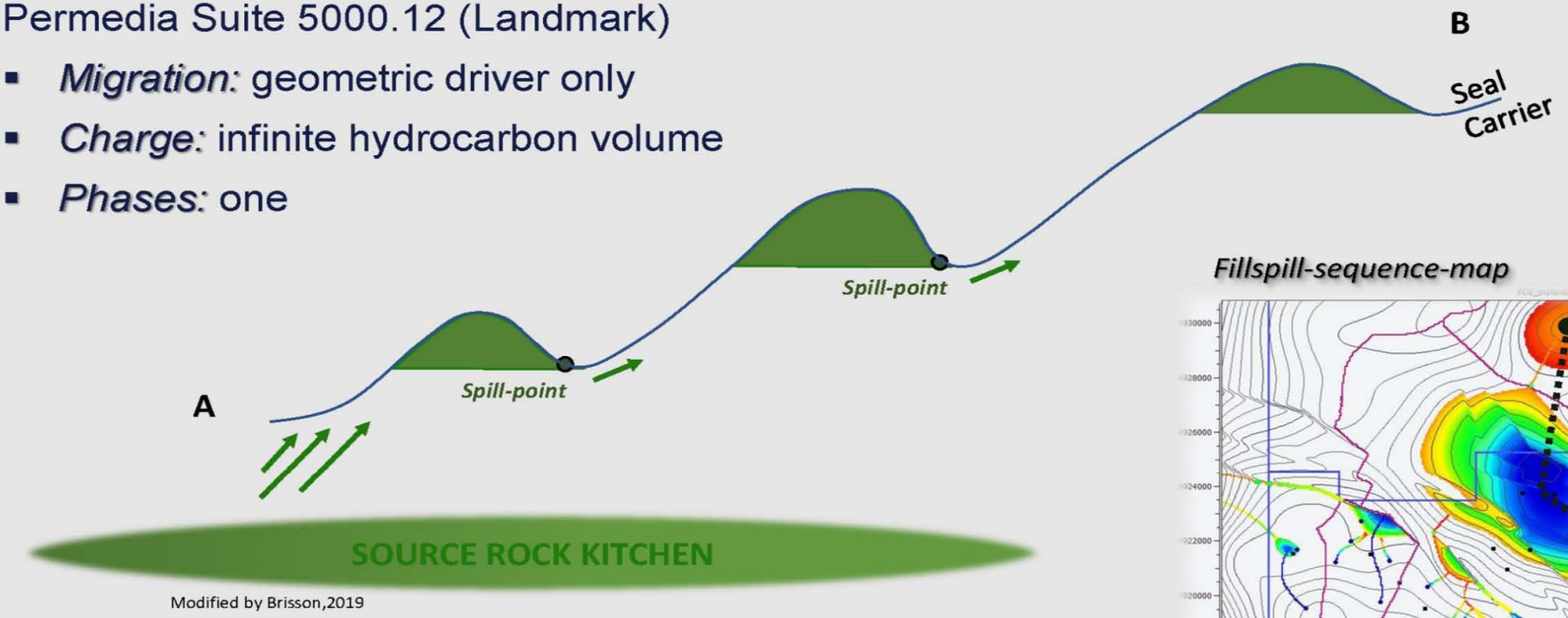


PATHWAYS SIMULATION MODELS

Software:

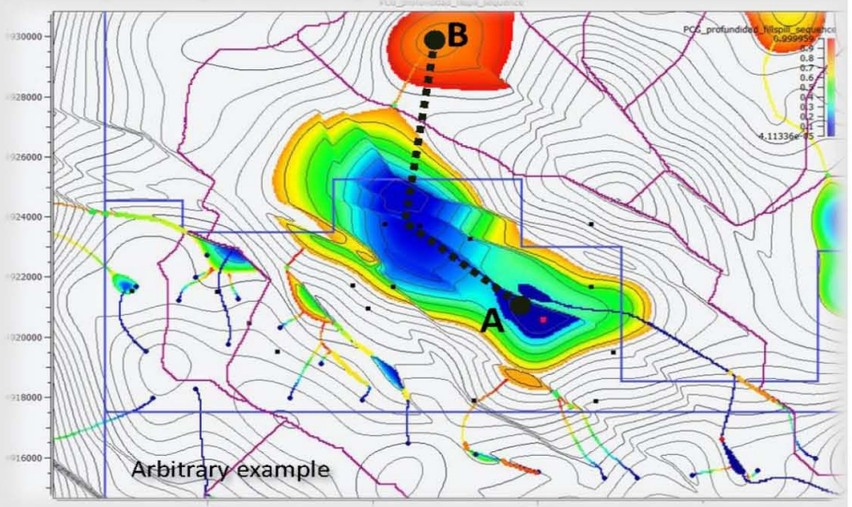
Permedia Suite 5000.12 (Landmark)

- *Migration:* geometric driver only
- *Charge:* infinite hydrocarbon volume
- *Phases:* one



Modified by Brisson,2019

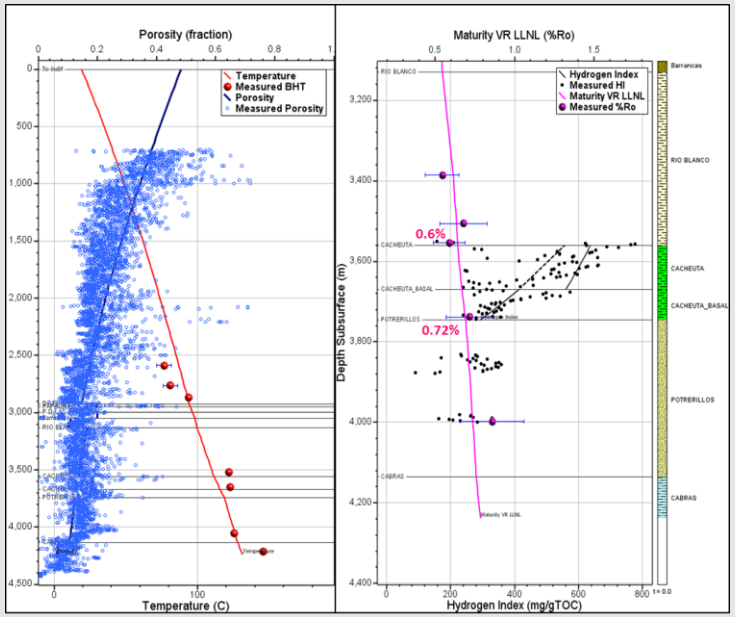
Fillspill-sequence-map



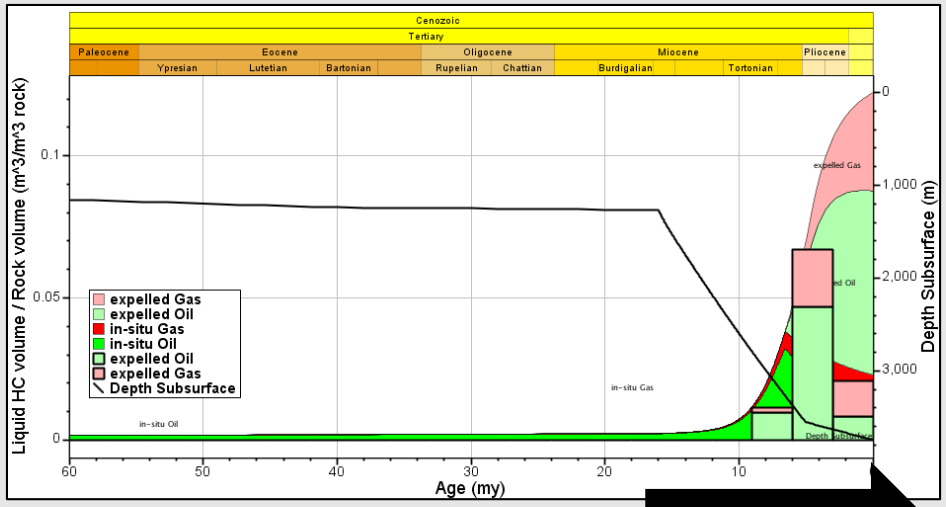
Presenter's notes:

1. In nature this happens.
2. Petroleum reaches spill point and migrates to highest positions.
3. In our case, by assuming an infinite volume, all structures are charged up to the spill point.

PRE-DEFORMATION MIGRATION MODEL

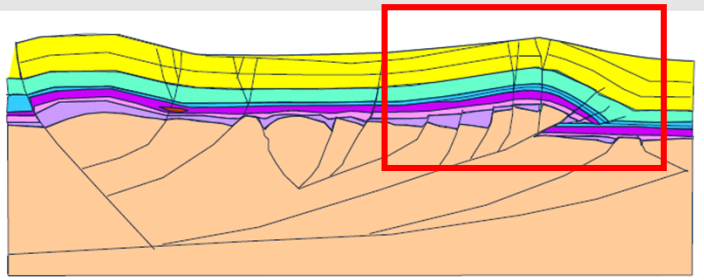


Good Porosity, thermal, maturity and kinetics calibrations.

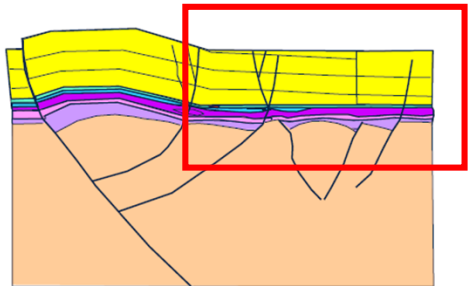


FORELAND BASIN DEPOSITS

HC'S EXPULSION STARTS IN THE LAST 10 MY IN TIERRAS BLANCAS DEPOCENTER.



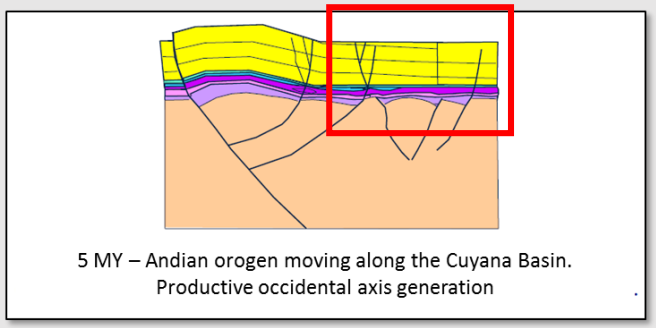
Present Day – Andian orogen front generating the productive oriental trend.
It is an active structure today



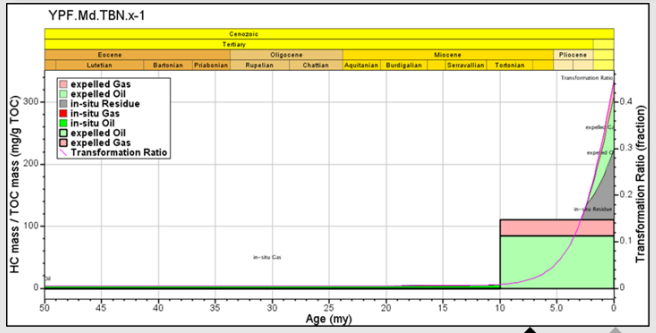
5 MY – Andian orogen moving along the Cuyana Basin.
Productive occidental trend generation

Zencich *et al*, 2008

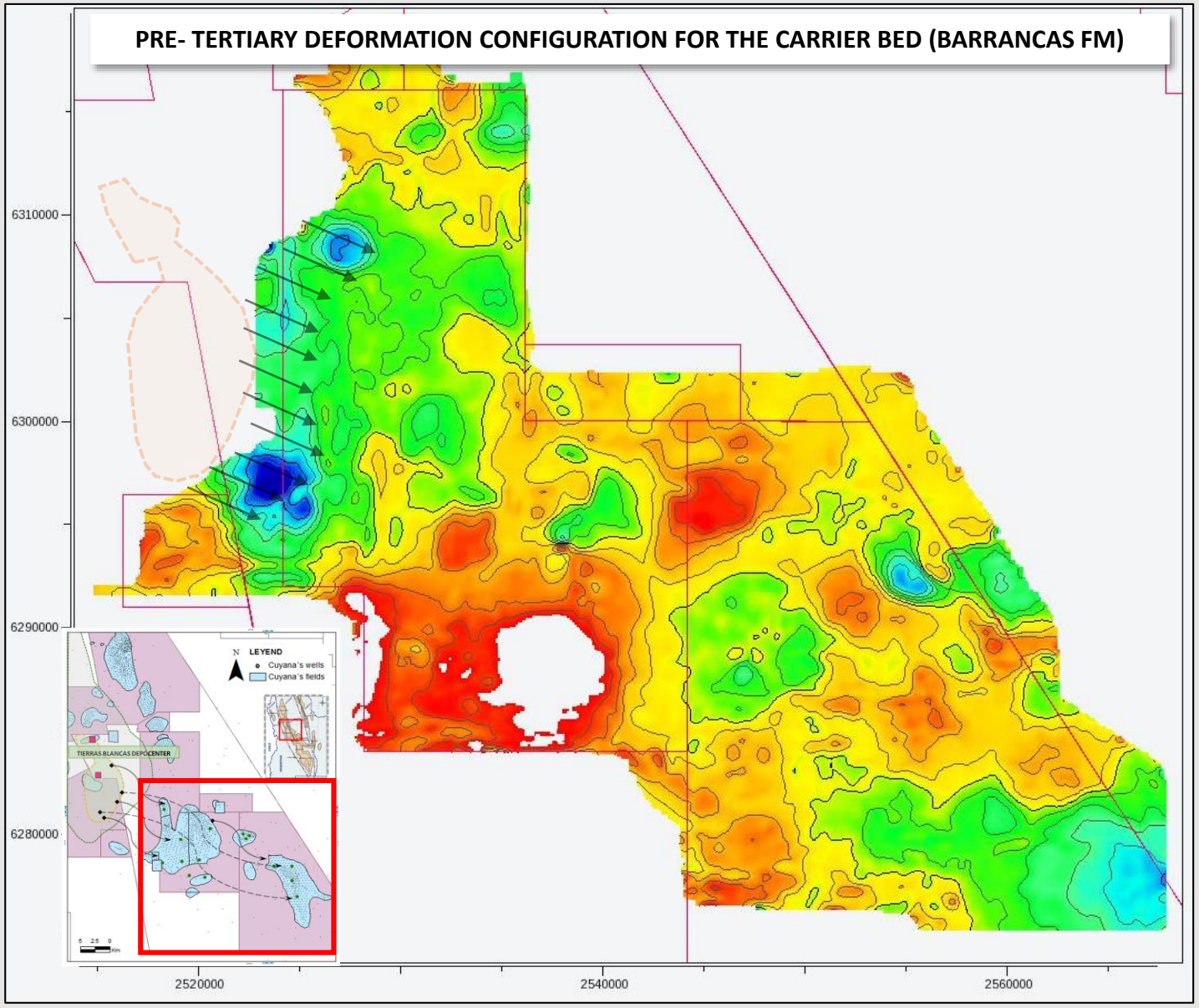
PRE-DEFORMATION MIGRATION MODEL



5 MY – Andian orogen moving along the Cuyana Basin.
Productive occidental axis generation



FIRST STAGE



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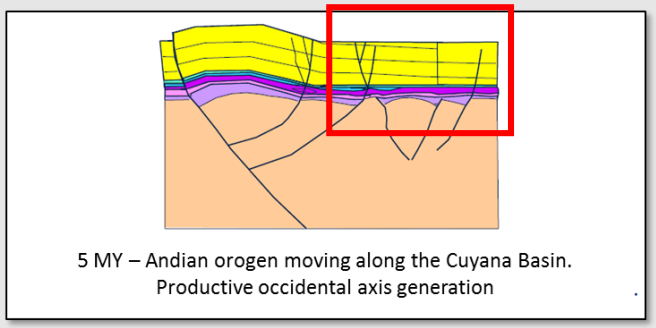

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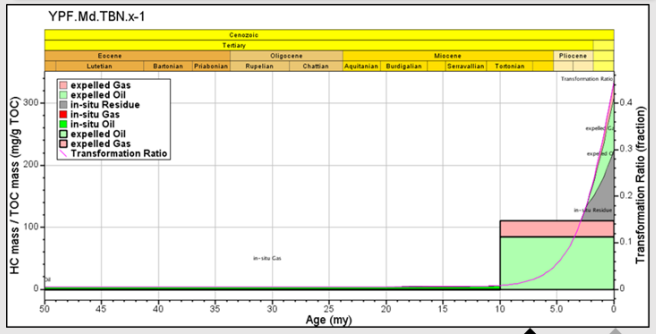
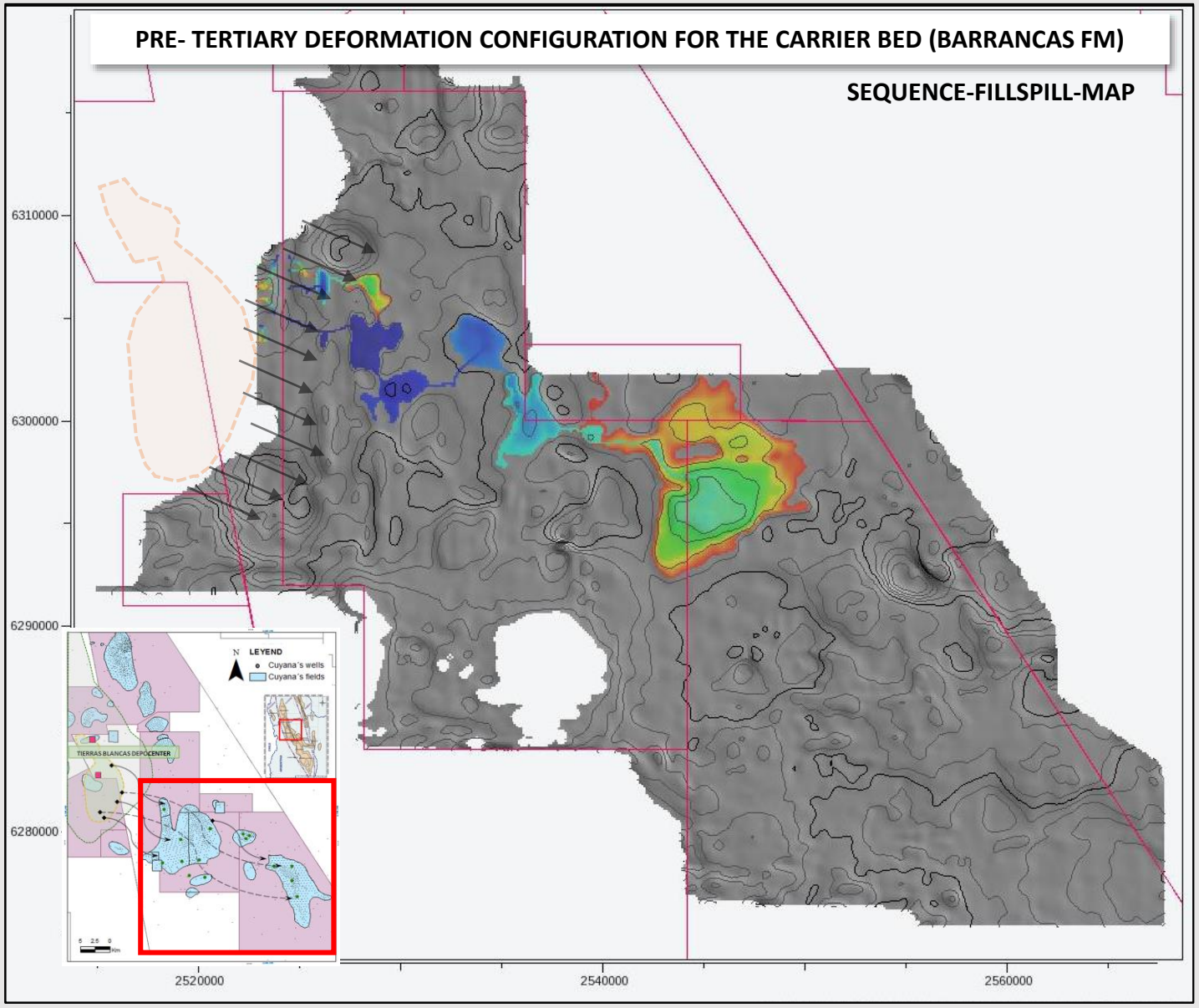


FIRST STAGE

ACUMULATIONS AT LOCAL STRUCTURAL HIGHS

MIGRATION TOWARDS THE EASTERN TREND



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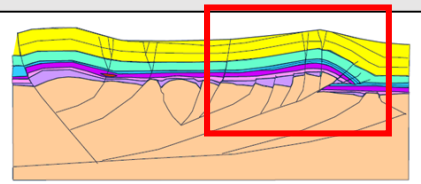
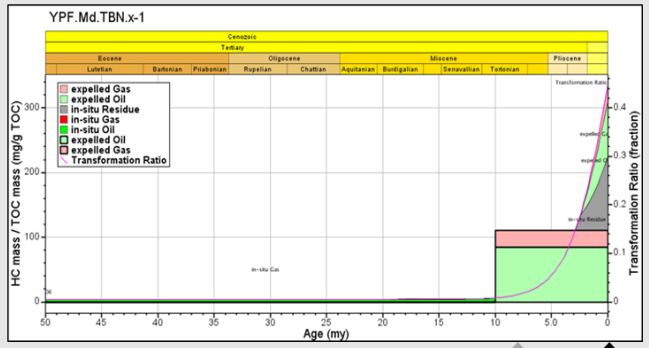
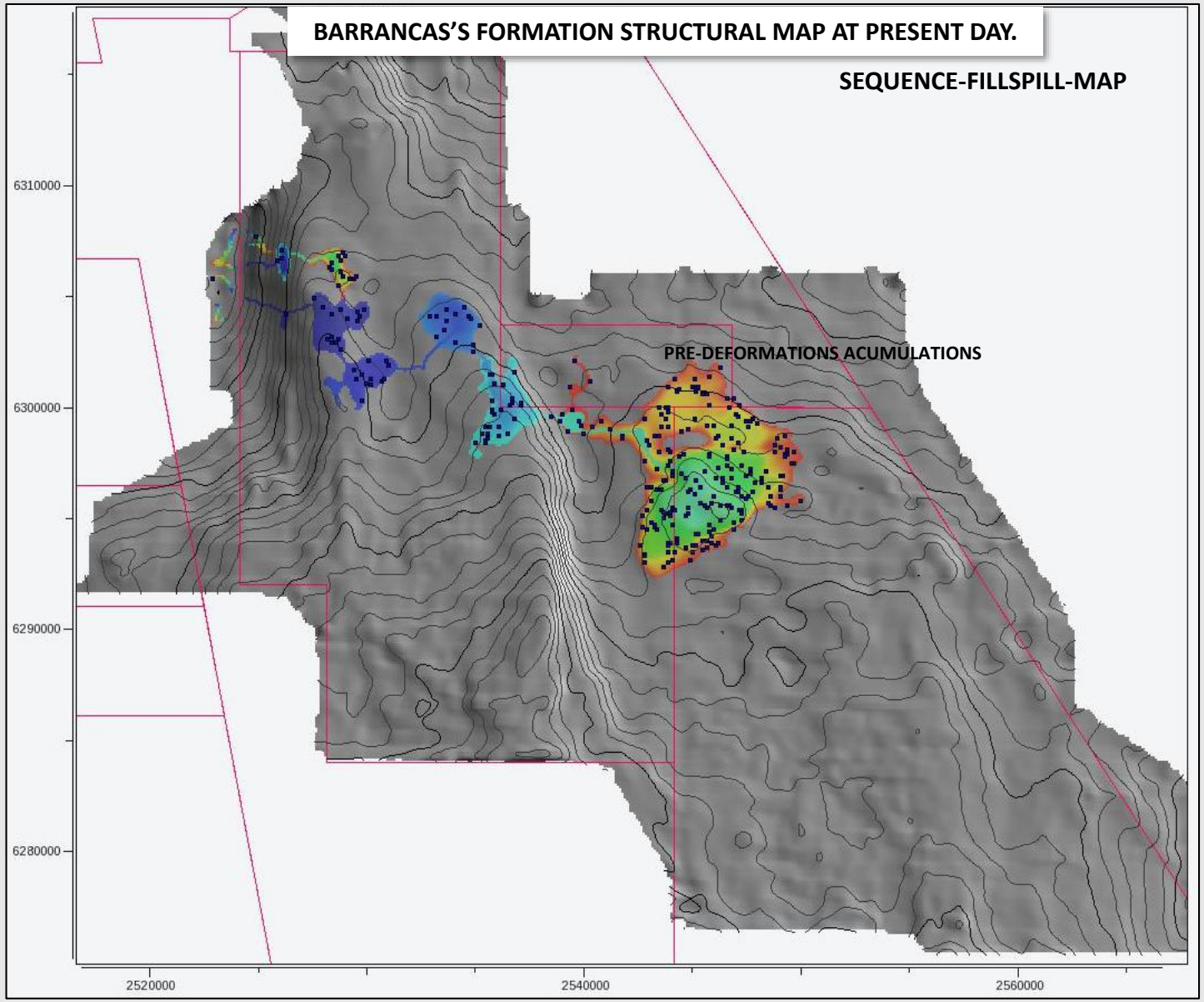


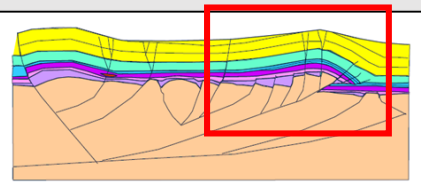
Present Day – Andian orogen front generating the productive oriental axis. It is an active structure today



SECOND STAGE



PRE-DEFORMATION MIGRATION MODEL



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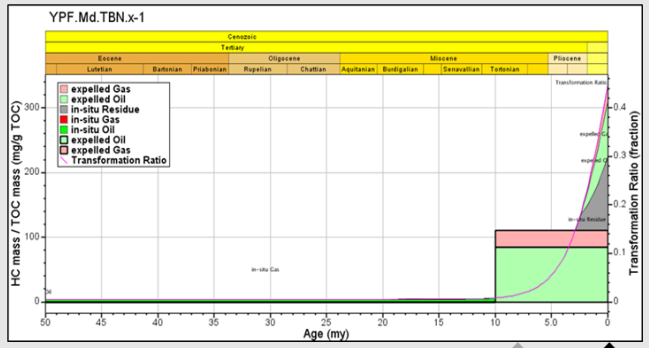
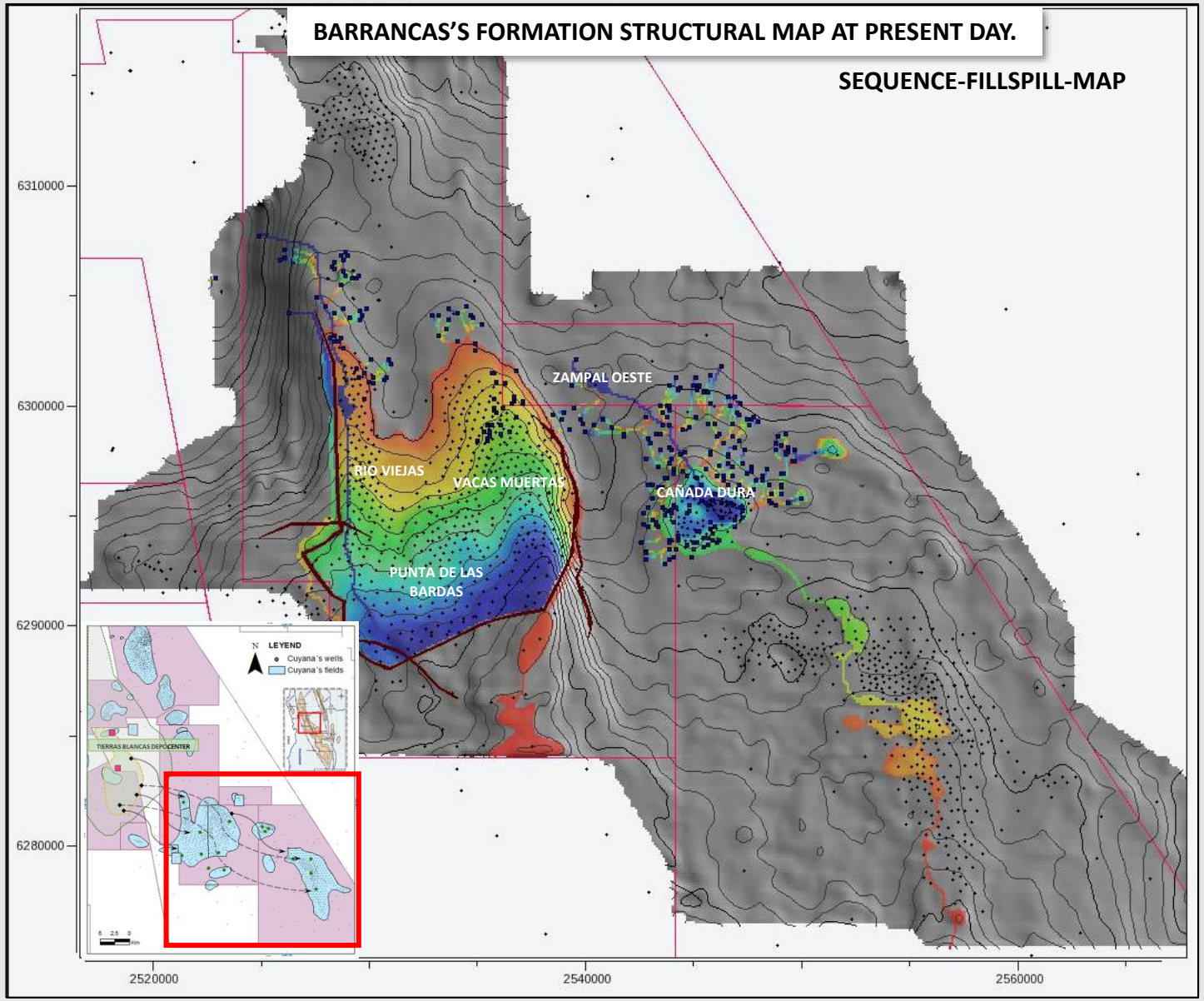
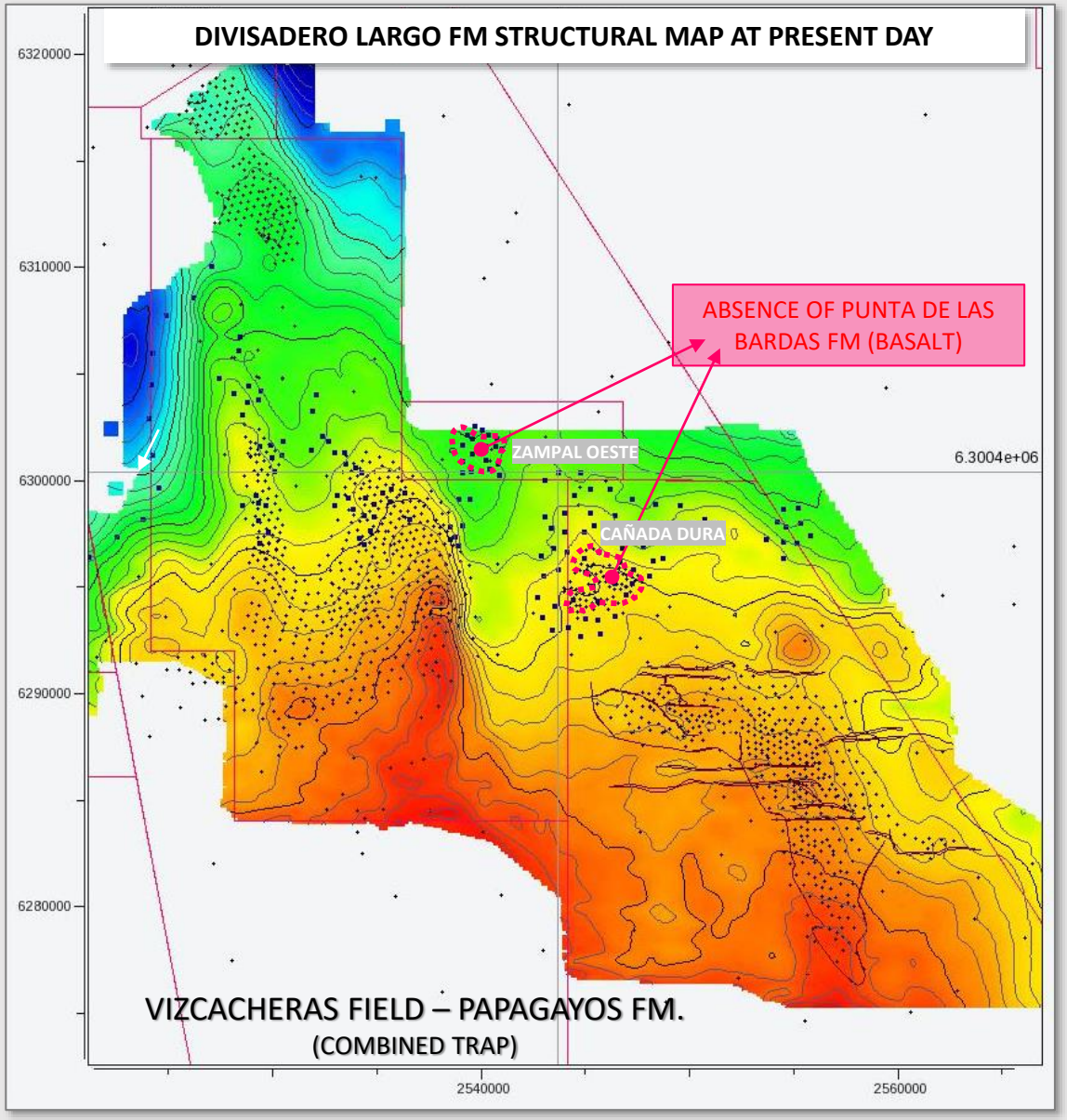


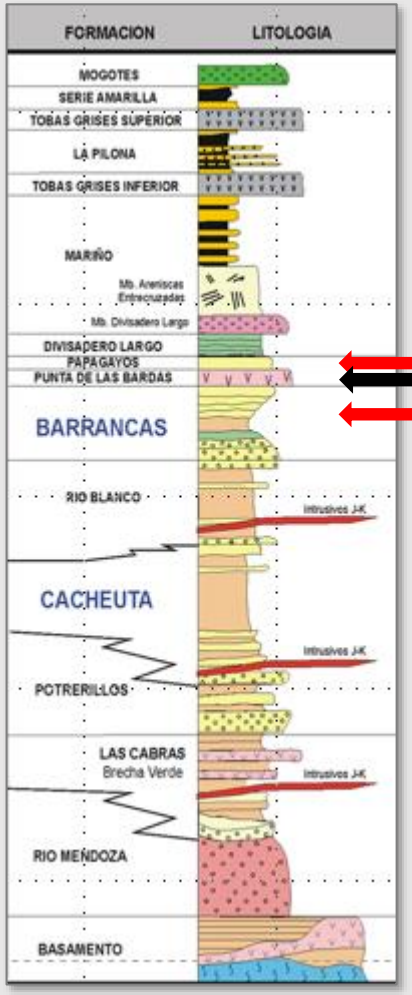
SECOND STAGE

- **REMIGRATION OF FLUIDS AFTER TERCIARY DEFORMATION**
- **HC MIGRATION TOWARDS THE EASTERN FIELDS THROUGH THE CARRIER BED (BARRANCAS FM)**
- **GOOD MATCH BETWEEN THE FIELDS AND THE STRUCTURAL HIGHS**
- **STRATIGRAPHIC TRAPS (RV-VM,PBB ETC)**



PRE-DEFORMATION MIGRATION MODEL





RESERVOIR: PAPAGAYOS FM

TOP SEAL: DIVISADERO LARGO FM

BOTTOM SEAL: PUNTA DE LAS BARDAS FM

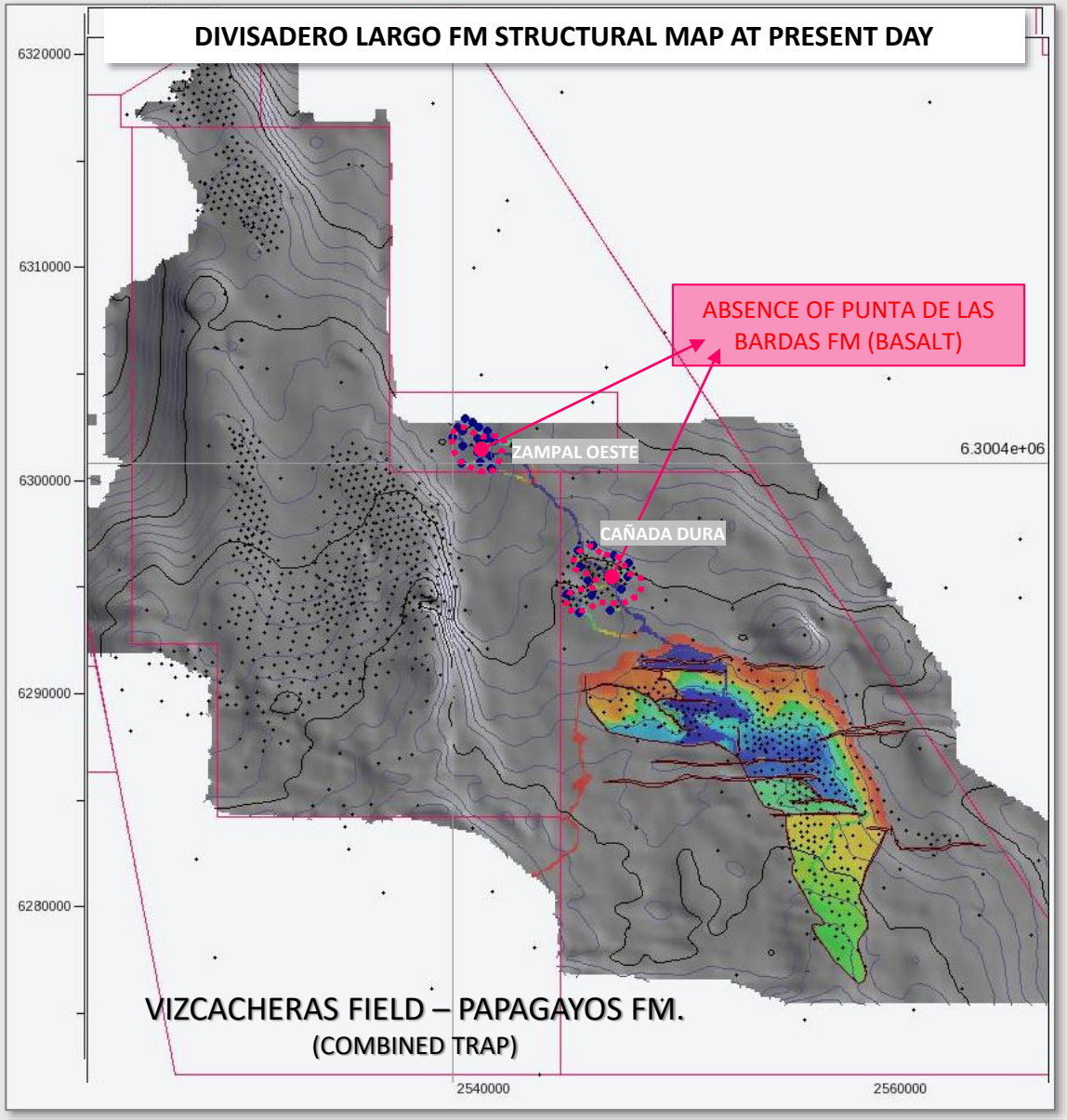
CHARGE: THROUGH THE ABSENCE OF THE BOTTOM SEAL

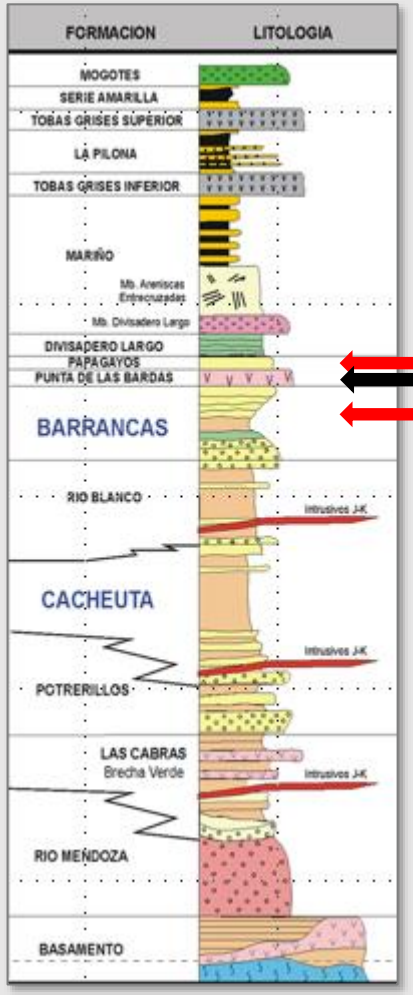
PAPAGAYOS FM
PUNTA DE LAS BARDAS FM (Basalt)
BARRANCAS FM

FOR THIS RESERVOIR THE MIGRATION FOLLOWED THE SAME REMIGRATION OF FLUIDS ACUMULATED BEFORE THE TERTIARY DEFORMATION

THE HC MIGRATED THROUGH THE CARRIER BED BARRANCAS FM AND TRAVELLED THROUGH THE ZONES WITH ABSENCE OF THE PUNTA DE LAS BARDAS FM (BASALT)

PRE-DEFORMATION MIGRATION MODEL





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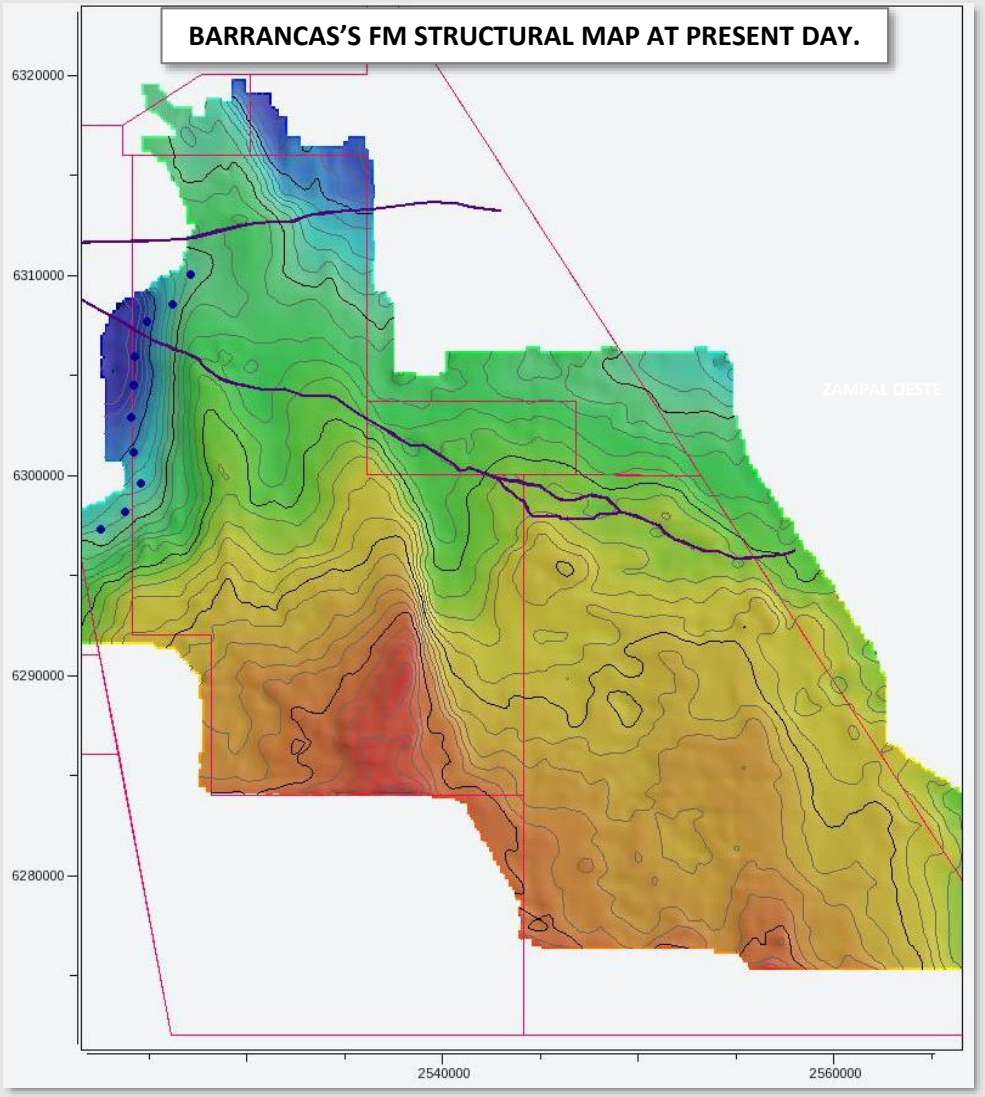
MIGRATION SIMULATION - STRIKE SLIP FAULT



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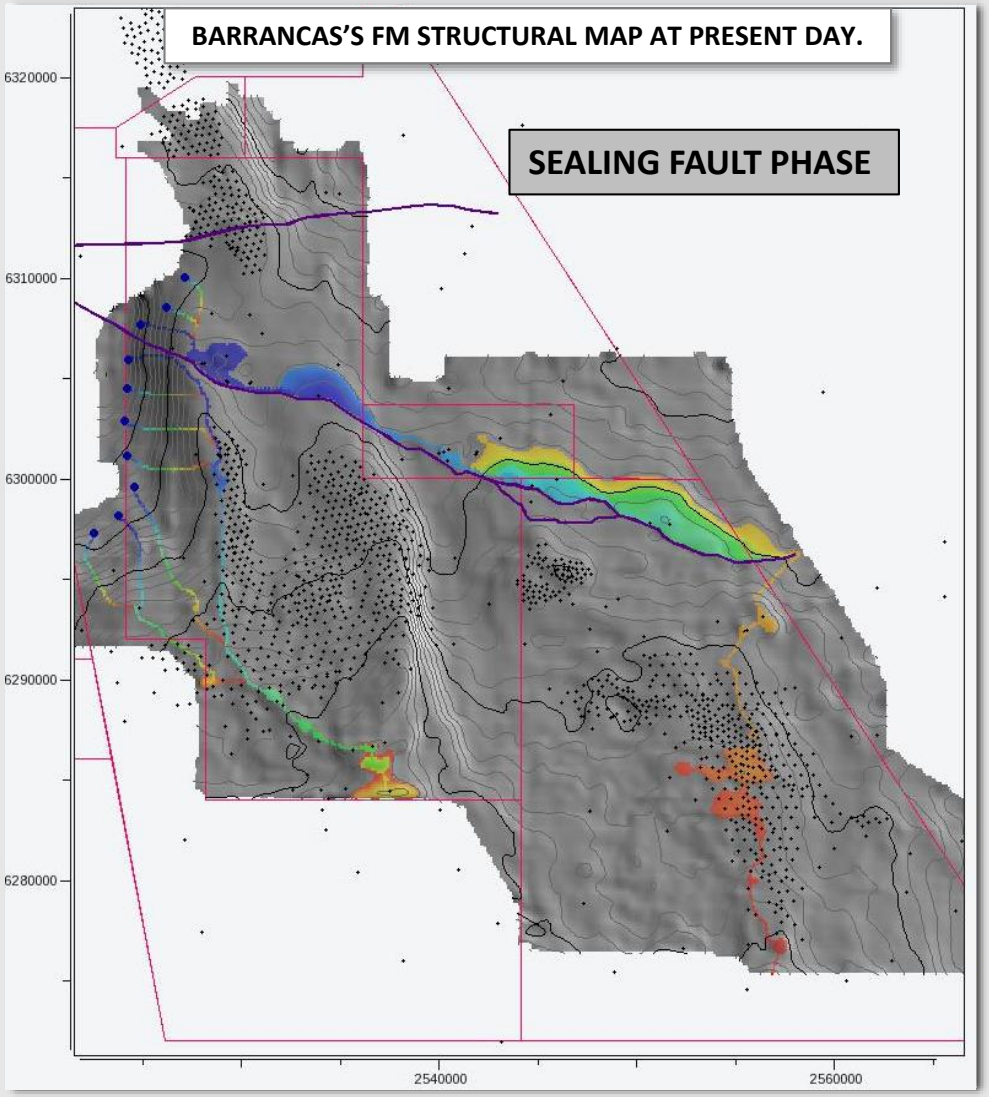
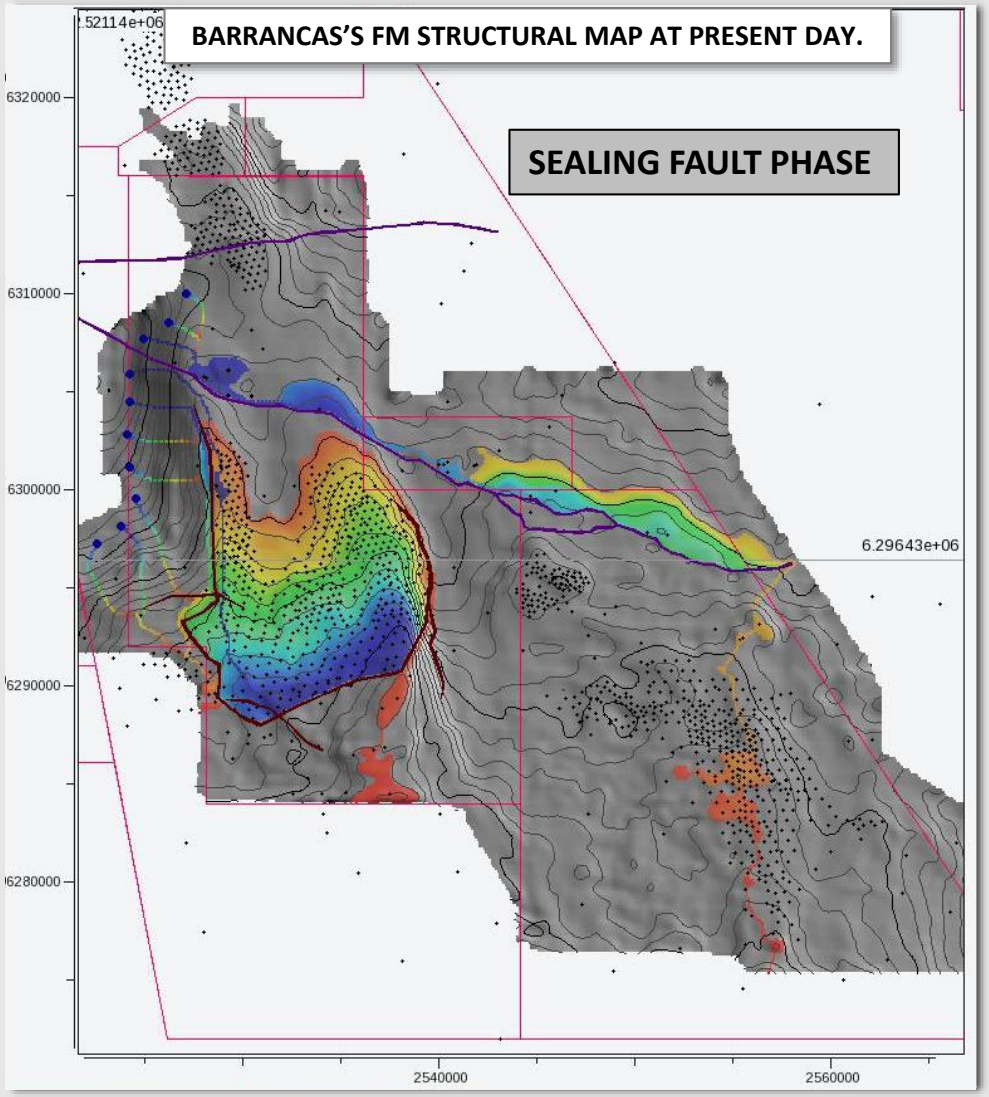


SEALING FAULT PHASE

- FIRST STAGE: THE FAULT ACTED LIKE A SEAL
- THE MIGRATION PATHS FOLLOW THE STRUCTURES ALONG THE FAULT
- THE HC ONLY PASSES THROUGH THE SOUTH, WHEN IT REACHES THE END OF THE FAULT
- NO HC's MIGRATION TO CAÑADA DURA FIELD.
- NORTH FAULT'S ACUMULATION DON'T EXIST

MIGRATION SIMULATION - STRIKE SLIP FAULT



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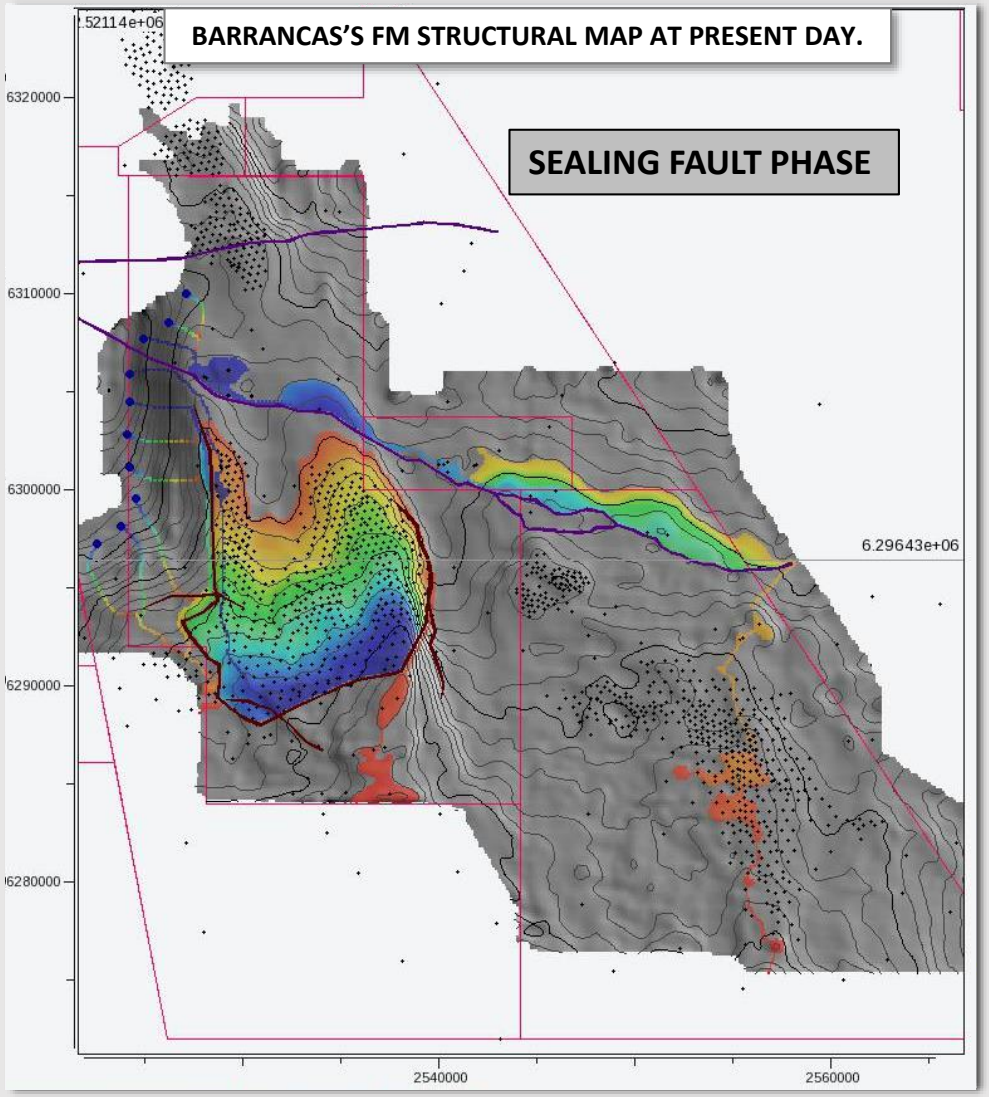

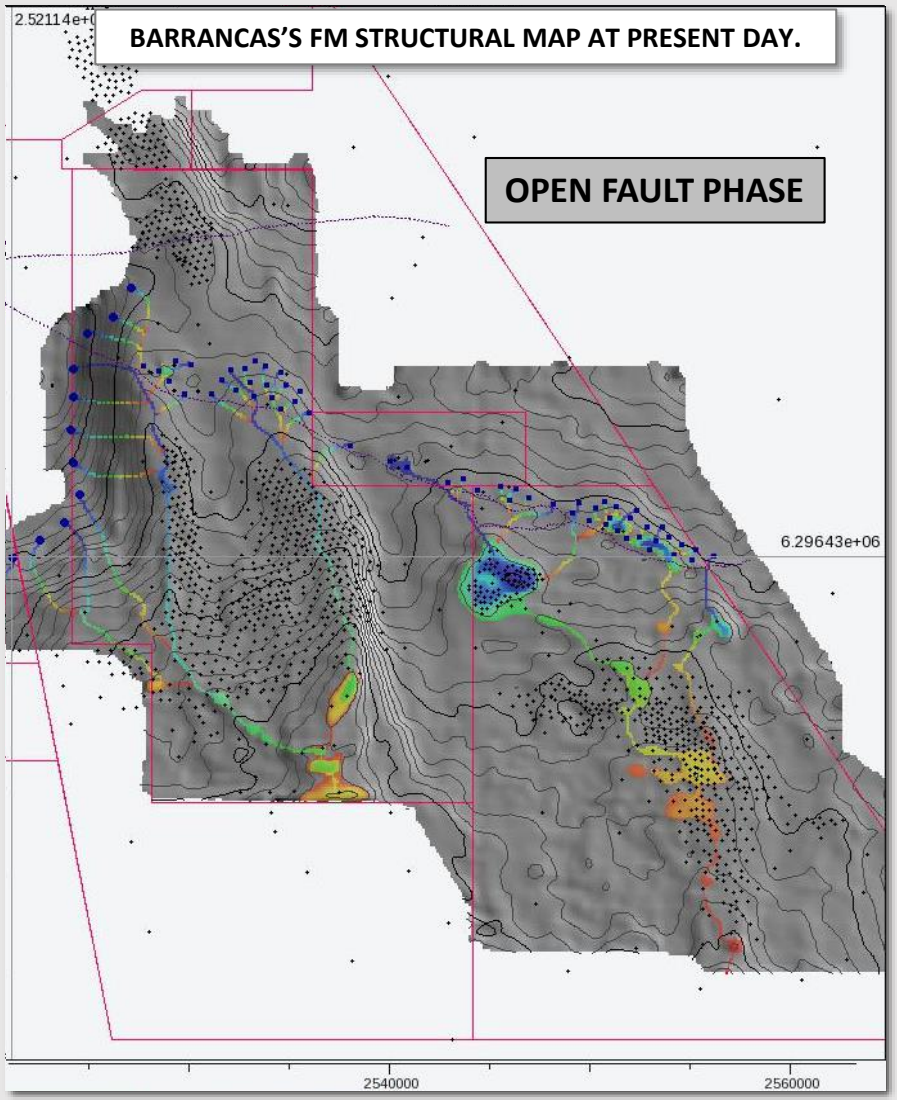

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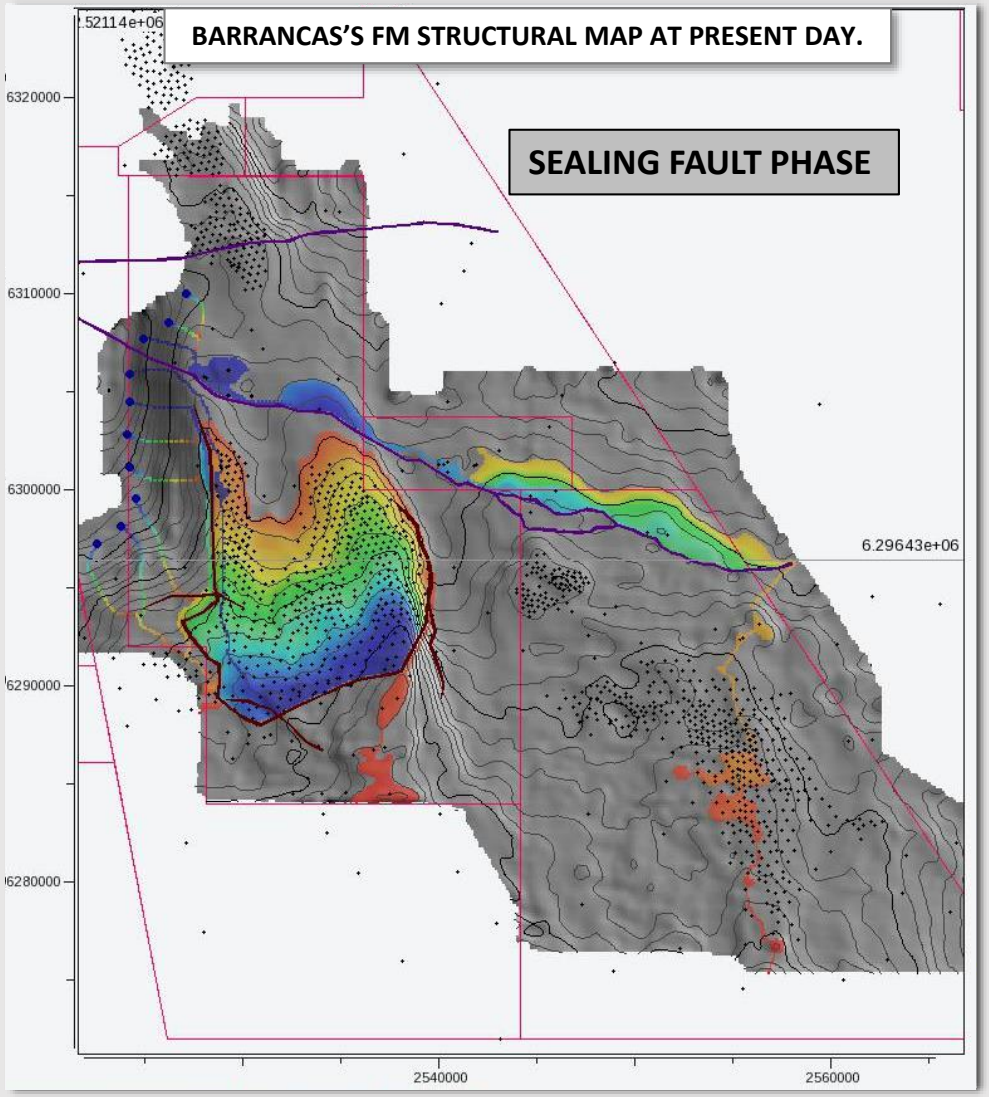
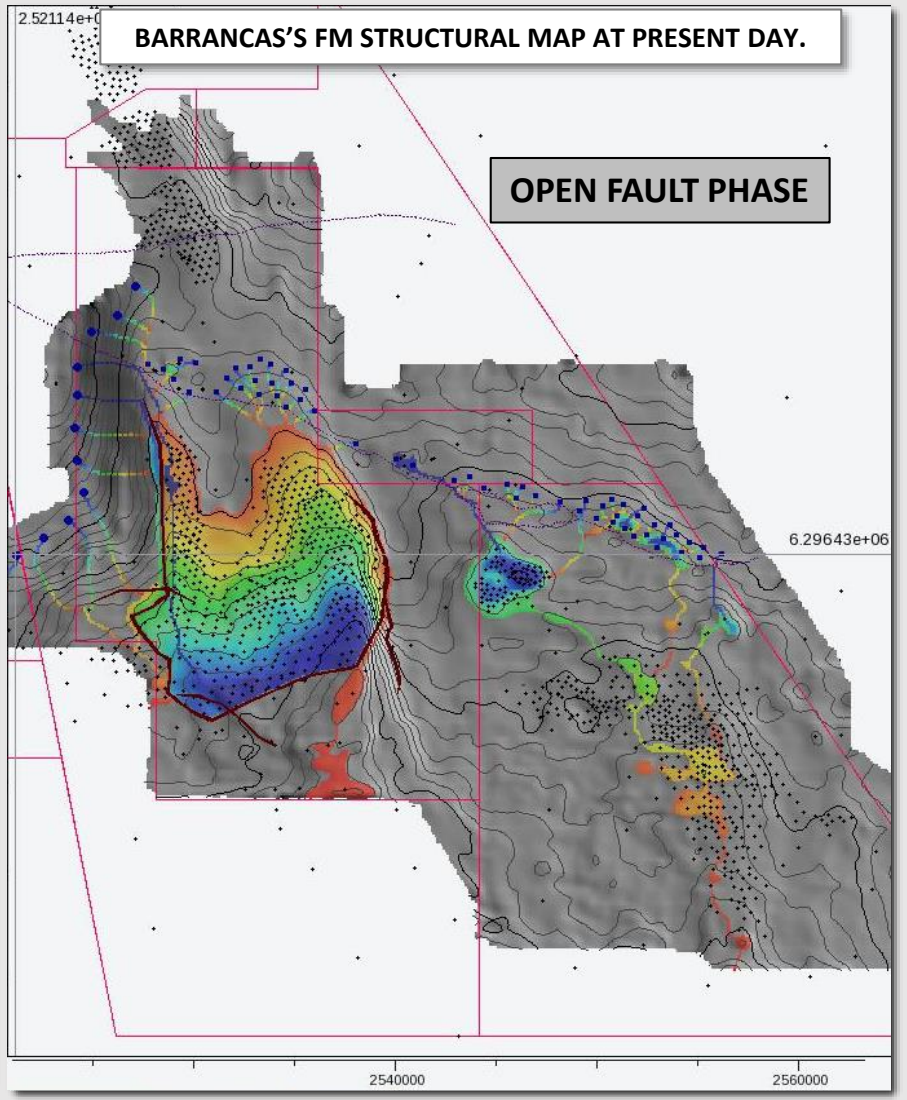
OPEN FAULT PHASE

- SECOND STAGE: THE FAULT OPENED
- THE PREVIOUS ACUMULATIONS MIGRATE TO HIGHEST STRUCTURES
- THE HC REACHES THE PRESENT DAY PRODUCTIVE FIELDS AT THE SOUTH EAST

MIGRATION SIMULATION - STRIKE SLIP FAULT





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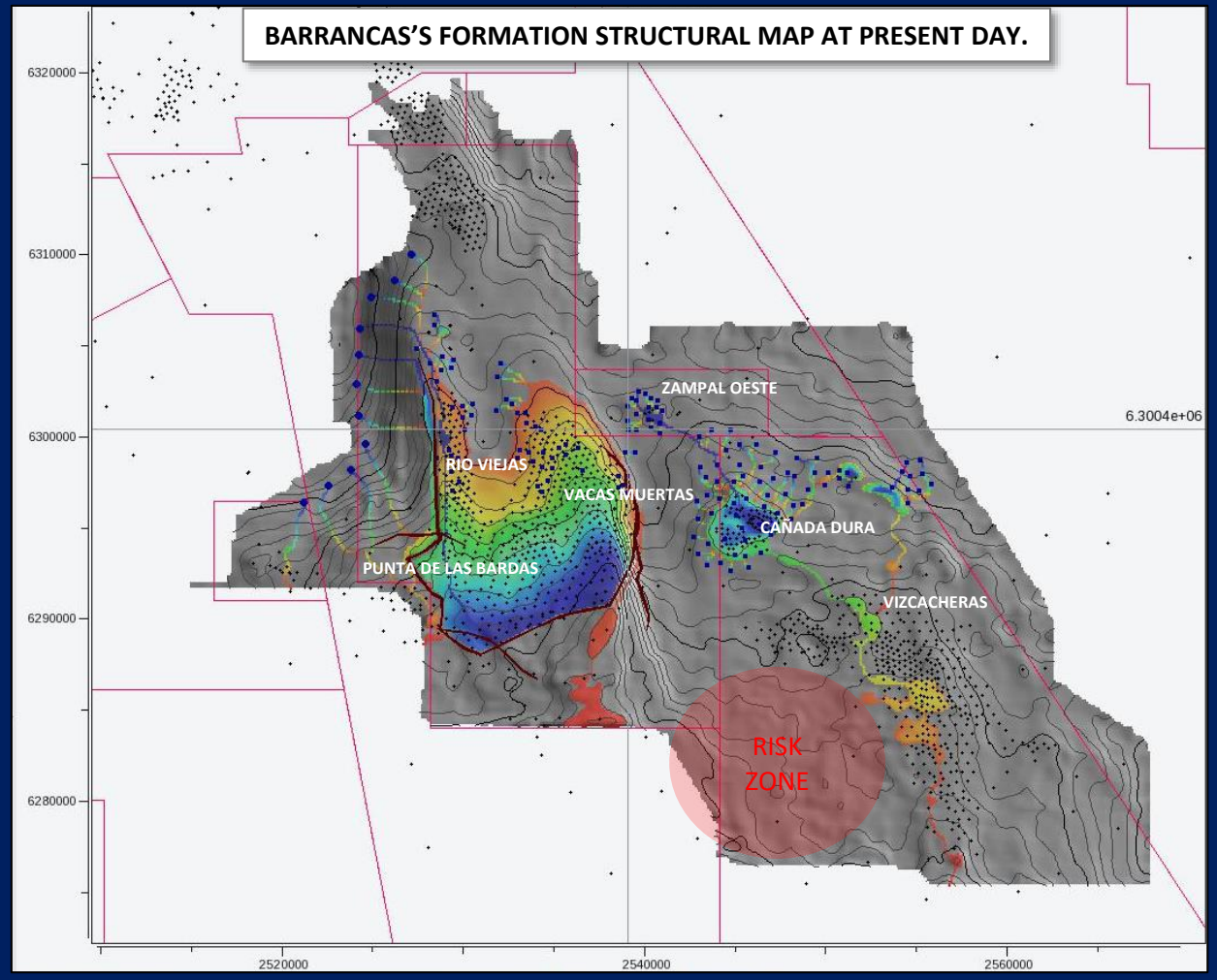
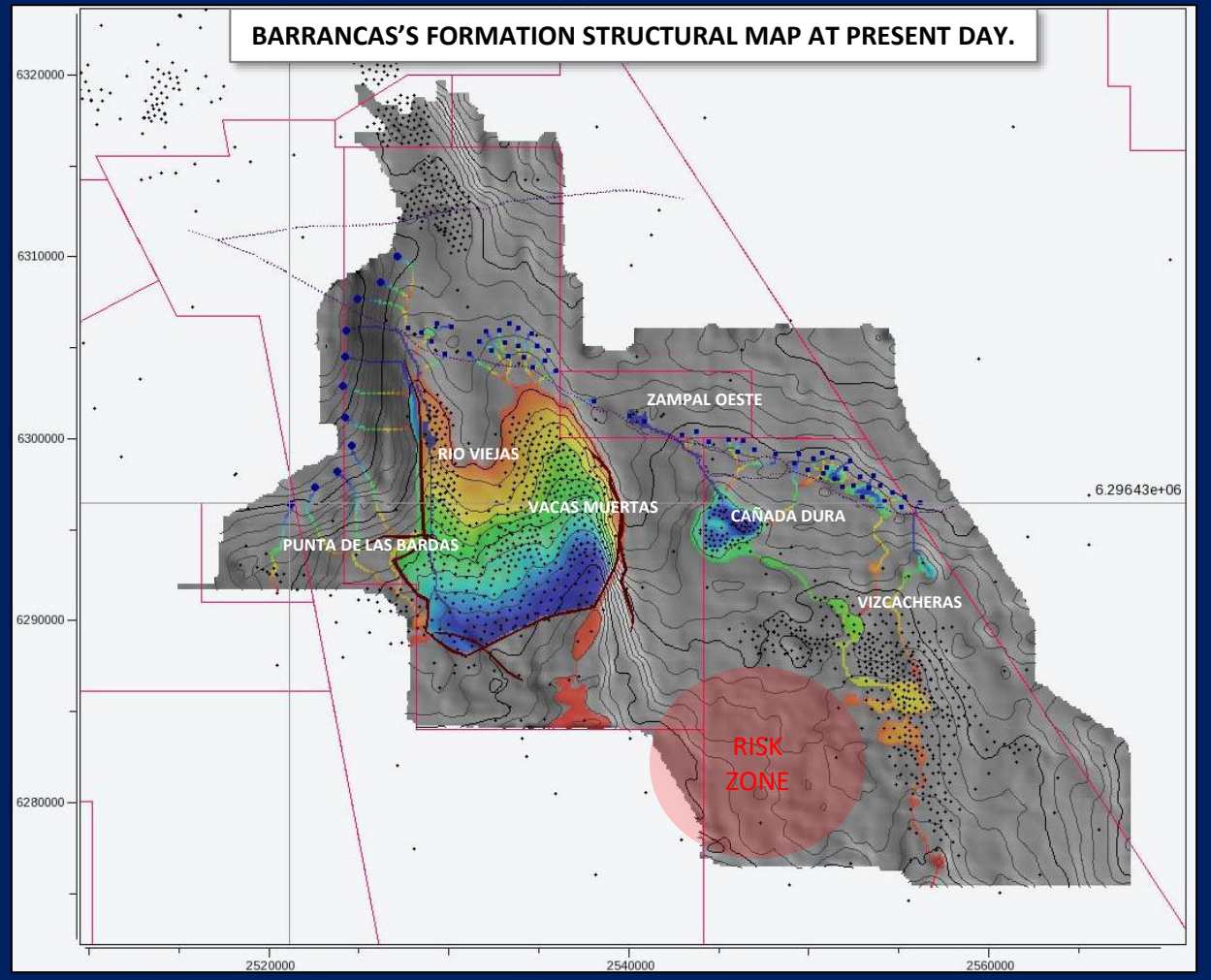
COMPARISON BETWEEN BOTH MODELS



REMIGRATION – POST DEFORMATION



CLOSE/OPEN FAULT PHASES

CONCLUSIONS

- The Hydrocarbon allocated in the Cañada Dura and Vizcacheras fields can not be explained with a migration from the main source rock from the west of the basin, with today´s geometrical configuration of Barrancas Fm. (carrier bed)

- The pre-deformation migration model assumes a first episode of hydrocarbon expulsion & migration (from Tierras Blancas depocenter) before the deformation of the oriental axis (>5 Ma.) with a remigration of the fluids after Tertiary deformation (present day configuration).

- The second model uses the presence of a strike slip fault with a NW-SE direction, which extends from the Tierras Blancas depocenter to the oriental productive axis, and allows the distribution of the fluids in these fields with today´s geometrical configuration of the Carrier bed (Barrancas Fm).

- Both models:
  - Explain the hydrocarbon production of the oriental axis of the basin: Zampal Oeste, Cañada Dura and Vizcacheras fields.
  - Help to identify the areas with less chances of HC migration, increasing the risk for the exploration targets.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QUESTIONS?

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THANK YOU