AAPG 2001 HEDBERG RESEARCH CONFERENCE

New Technologies and New Play Concepts In Latin America

November 5-9, 2001
Mendoza, Argentina

Conveners:

Charles Kluth (Chevron)
Leonardo Legarreta (Chevron San Jorge)

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"New Technologies and New Play Concepts in Latin America"
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Los Molles and Vaca Muerta source rocks: complex hydrocarbon-charge systems in the central domain of the Neuquén Basin, Argentina

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A great number of oil and gas fields of economic significance in the Neuquén Basin are lodged in a broad area located between the northern slope of Huincul Dorsal and the Catriel Shelf. Hydrocarbons are accumulated in multiple reservoirs of wide stratigraphic distribution from Triassic to Mid-Cretaceous age, although main productions are concentrated in Tordillo – Sierras Blancas (Kimmeridgian) and Quintuco – Loma Montosa (Berriasian) reservoirs. The Tithonian Vaca Muerta marly shales have been considered the main or even unique hydrocarbon source rock of the area. However, recent deep exploration of Cuyo and Precuyo (Late Triassic-Mid Jurassic) reservoirs have led to the discovery of commercial hydrocarbons accumulations that highlighted the importance of this alternative Pliensbachian-Toarcian Los Molles charge system.

The oil-prone features of the basinal to platform facies of Vaca Muerta shales have been profusely documented in several publications during the last years. The elucidation of Los Molles hydrocarbon potential is a matter of much later appraisal in the area, basically supported by investigations in Río Neuquén, E. Fernández Oro, Las Chivas, Lindero Atravesado and Centenario, where several hundreds meters thick source sections have been substantiated. These intervals contain organic-rich shales (TOC ~1-4 %), type II/III kerogen, mixed marine and terrestrial organic matter and a primary generation capacity for oil/gas. Vaca Muerta and Los Molles source rocks show different depocenter geometries. While Los Molles distribution (rift to post-rift related) is asymmetrical with its thicker section closer to the Dorsal, Vaca Muerta (sag stage) has a more tabular and symmetrical behavior. These patterns have a strong impact in the effectiveness of the hydrocarbon charge systems, migration pathways and petroleum accumulations. The poor petrophysical conditions of the sandstones and conglomerates directly related to Los Molles source beds disfavor long lateral migration of hydrocarbons. At the same time, in the north flank of the Dorsal, the presence of a rift related fault system, tectonically inverted during the Jurassic-Cretaceous, played an important role in the updip, possibly unique, migration pathway. Regarding Vaca Muerta, the better quality associated carriers allowed long distance migrations, up to 100 km, especially to the north and east through the Catriel Shelf.

Thermal maturity data (Ro, TAI and biomarkers) and modeling analysis has defined the oil and gas generation zones. The schematic cross-sections (Fig. 1) show that Vaca Muerta is mostly in the oil window (VRE: 0.7-1.0%) in the study area and has charged Quintuco – Loma Montosa and Tordillo – Sierras Blancas with conventional black oil. On the other hand, Los Molles is in the gas/condensate zone (VRE: 1.3-2%), excluding the north slope of the Dorsal area (Estación Fernández Oro, Centenario and Las Chivas), where thermal maturities cover peak to late oil generation stages. In this location, the occurrence of Los Molles sourced oils has been proved. Very light condensates (Río Neuquén) and dry gas accumulations reservoired in deep structures are assigned to Los Molles generation. The occurrence of Tordillo – Sierras Blancas bearing gas and condensate where Vaca Muerta is in the early to mid maturity stages (Lindero Atravesado, Río Neuquén) is explained through extensive migrations. However, contribution from Los Molles source should also be considered.

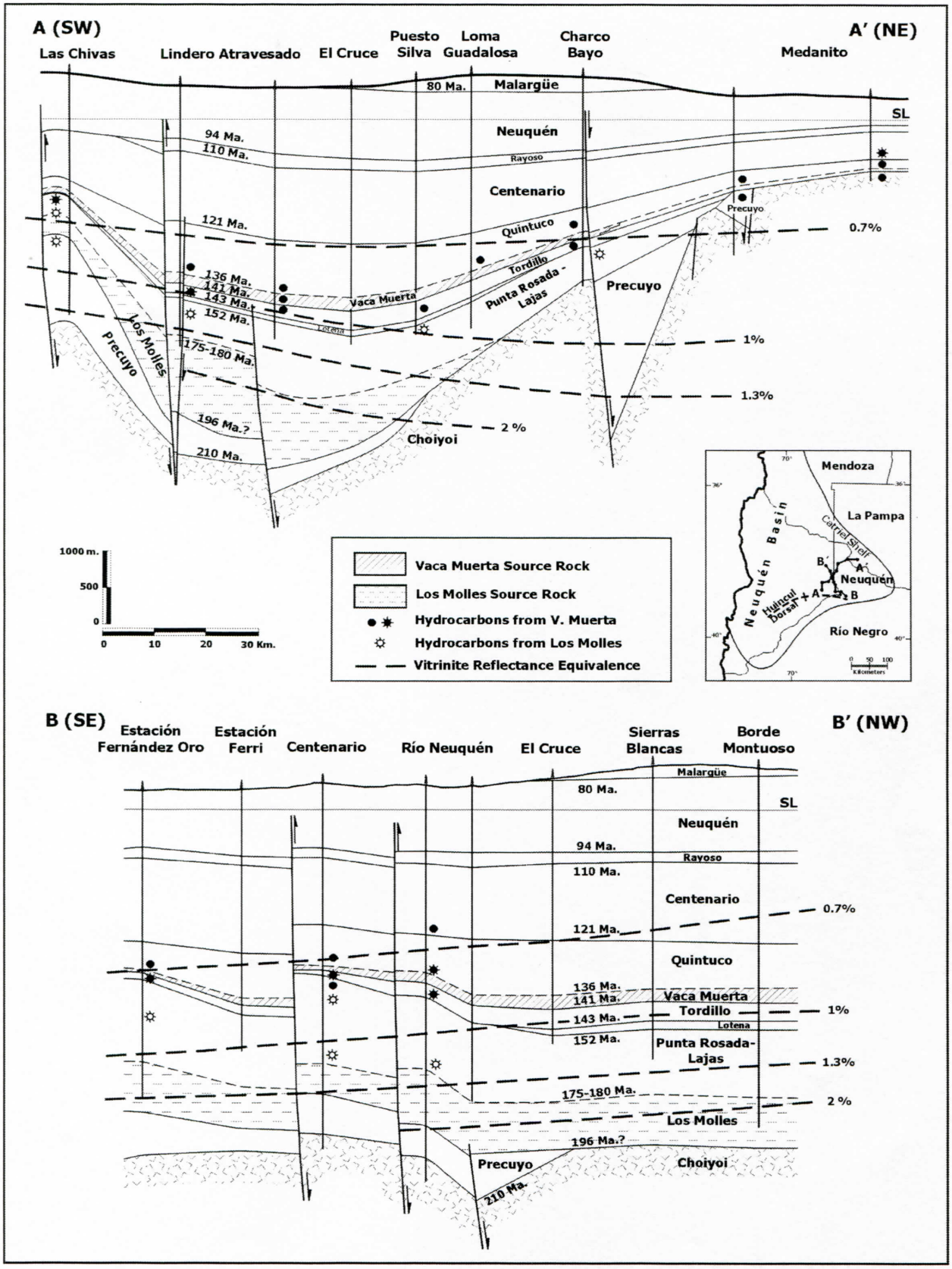

Fig. 1. Schematic cross sections showing hydrocarbon occurrence and generalized thermal maturity zones.

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LOS MOLLES AND VACA MUERTA SOURCE ROCKS: COMPLEX HYDROCARBON-CHARGE SYSTEMS IN THE CENTRAL DOMAIN OF THE NEUQUÉN BASIN, ARGENTINA

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pluspetrol

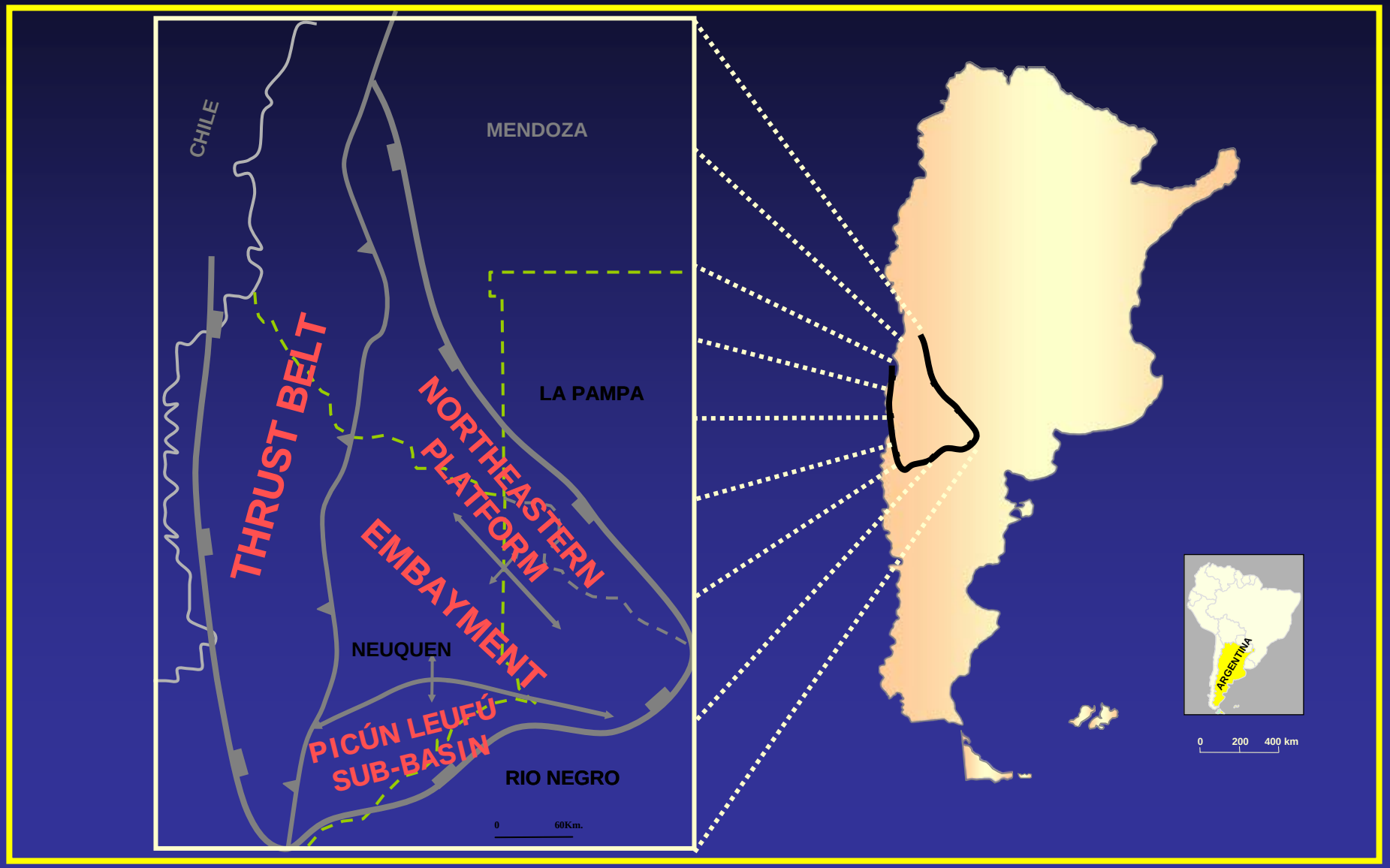
TECPETROL

Pan American ENERGY

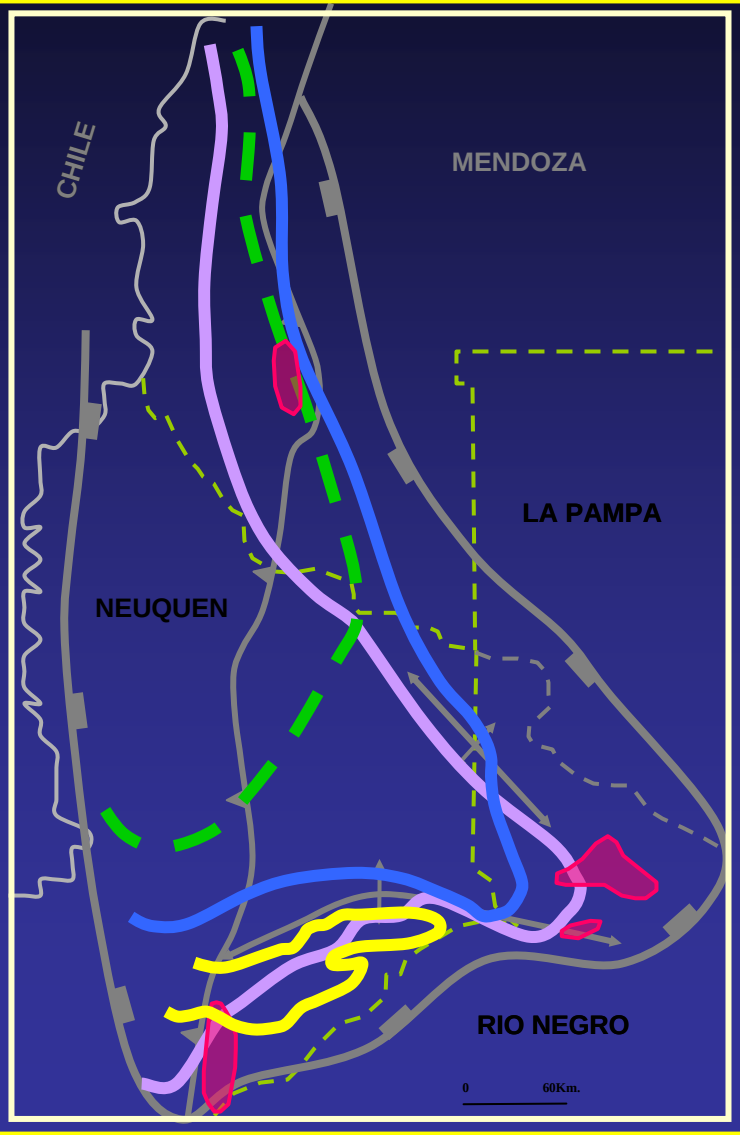
PECOM ENERGIA S.A.
de PEREZ COMPANC S.A.

CG Consultora Petroleo & Gas

NEUQUÉN BASIN - TECTONIC SETTINGS



NEUQUÉN BASIN - MAIN SOURCE ROCKS KITCHENS



PRECUYO
MAIN RESERVOIRS: LAJAS & PRECUYO

LOS MOLLES
MAIN RESERVOIRS: LAJAS, LOTENA & TORDILLO

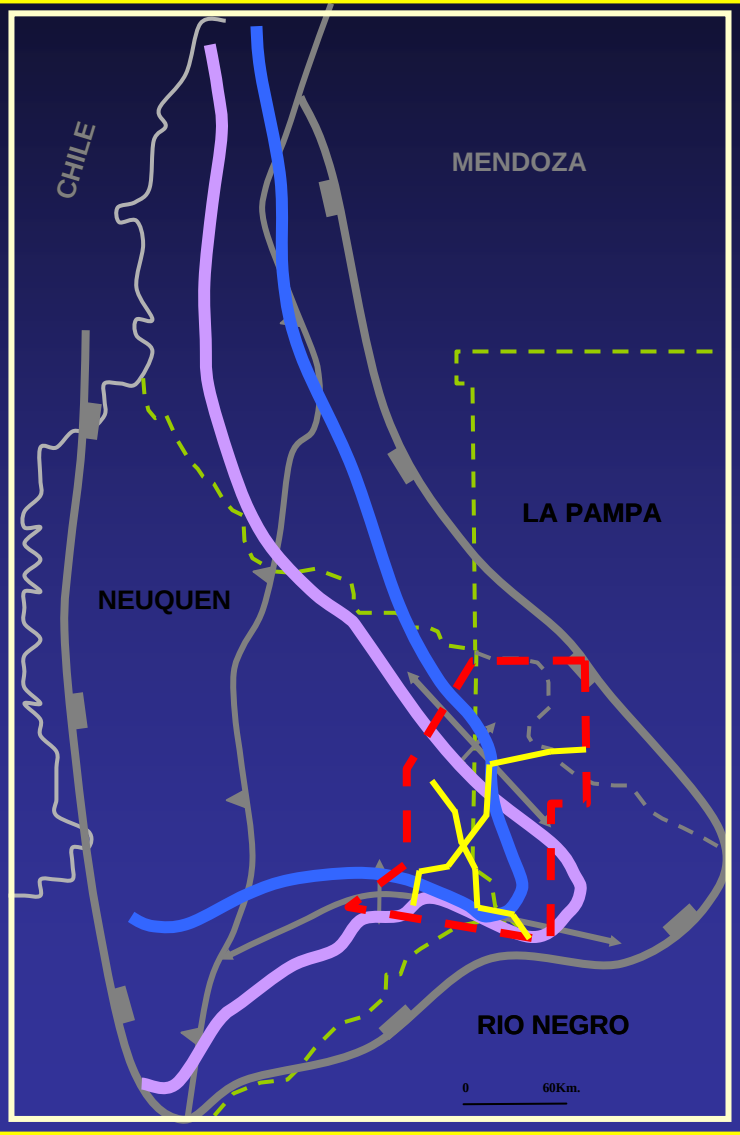
VACA MUERTA
MAIN RESERVOIRS: TORDILLO, QUINTUCO- LOMA MONTOSA & MULICHINCO IN NEUQUÉN. CHACHAO, NEUQUÉN GR. & TERTIARY INTRUSIVES IN MENDOZA.

SOUTH DORSAL VACA MUERTA
MAIN RESERVOIR: Qda. DEL SAPO

AGRIO
MAIN RESERVOIRS: AVILÉ & TRONCOSO

Modified from Legarreta et al.,1999

LOCATION MAP



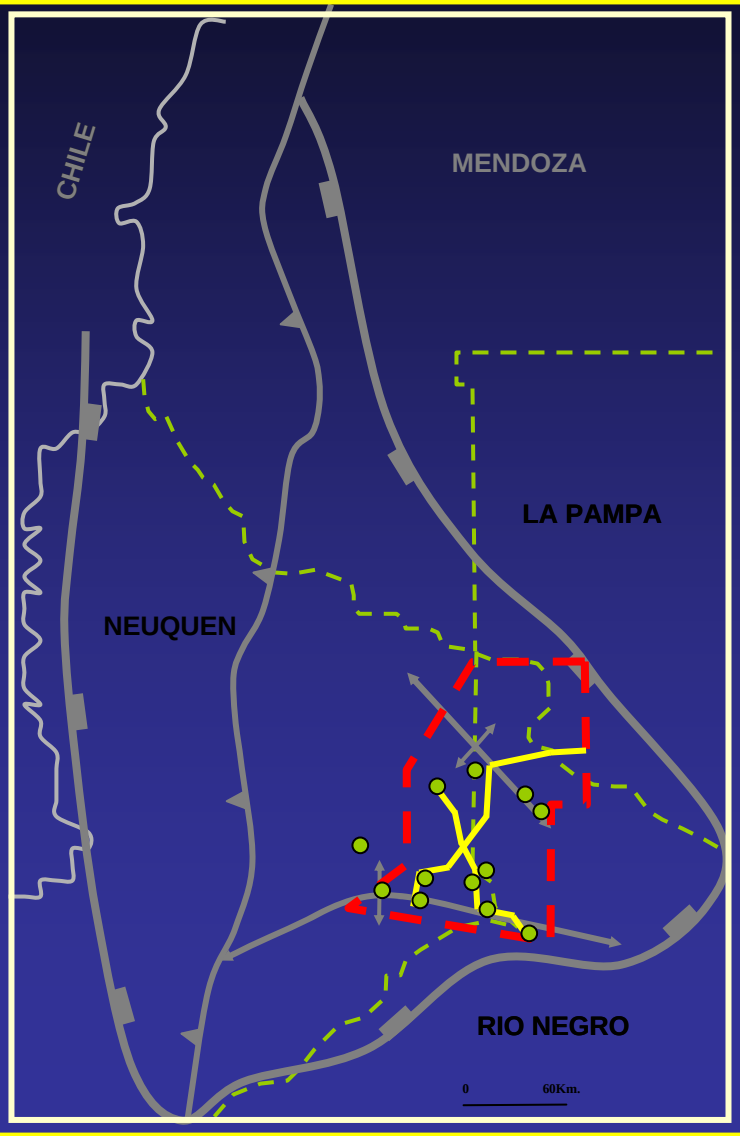
OBJECTIVES

Substantiate the good-quality hydrocarbon source of Los Molles beds in the study area.

Compare the main features of Vaca Muerta and Los Molles hydrocarbons charge systems

Highlight the importance of Los Molles petroleum system as contributor of hydrocarbon accumulations.

LOS MOLLES GEOCHEMICAL ASSESSMENTS



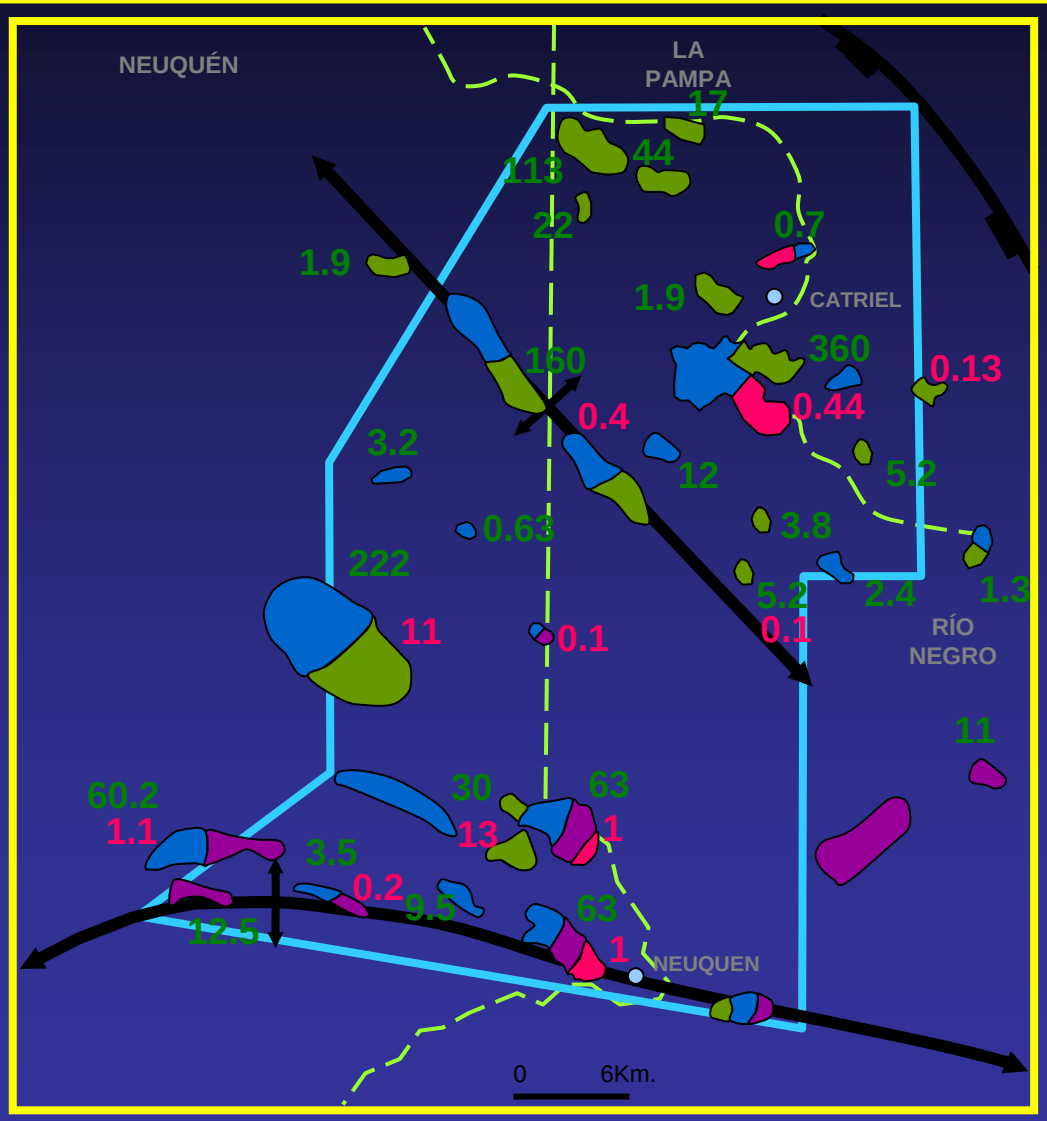
AGUADA BAGUALES
LAS CHIVAS
CENTENARIO
ESTACIÓN FERNANDEZ ORO
BARREALES COLORADOS
CERRO MORO
LINDERO ATRAVESADO
RÍO NEUQUÉN
CHARCO BAYO
LA JARILLA
AGUADA DE LOS INDIOS

MAIN OIL & GAS FIELDS - RESERVES & RESERVOIRS

EUR

1248 MMB OIL

17.3 TCF GAS



QUINTUCO
LOMA MONTOSA
CENTENARIO

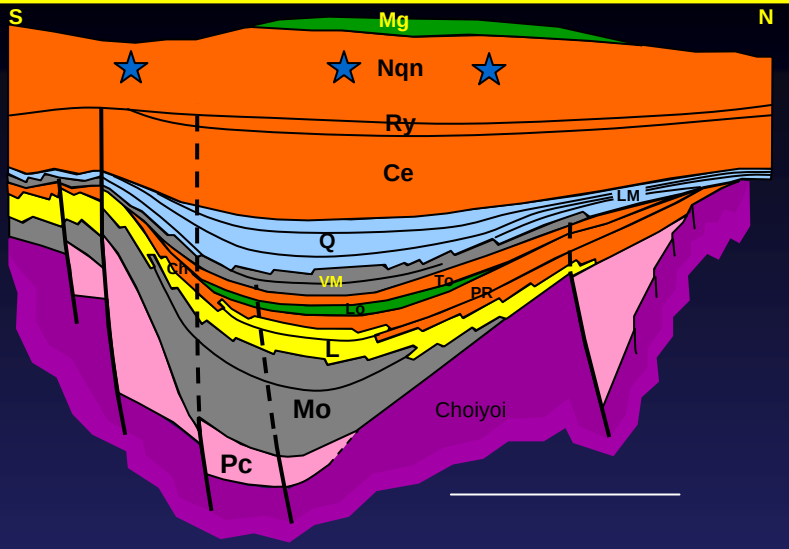
TORDILLO
SIERRAS BLANCAS
LOTENA

CUYO

PRECUYO

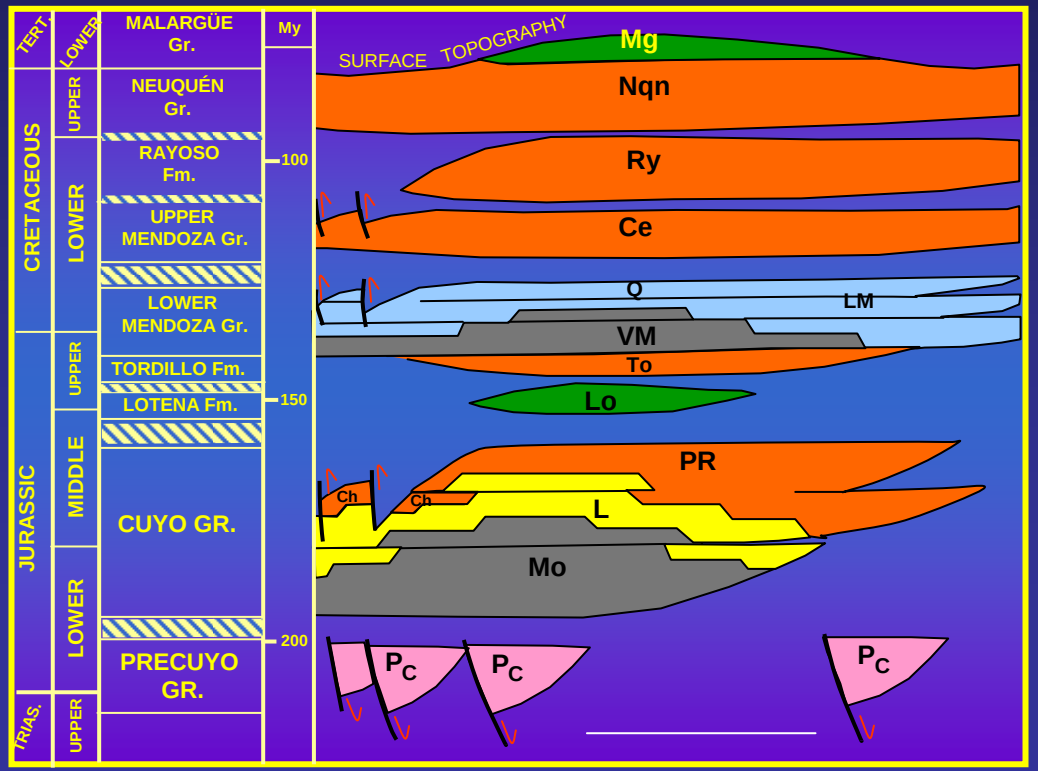
HUINCUL DORSAL TO CATRIEL SHELF

SCHEMATIC CROSS SECTION & CHRONOSTRATIGRAPHIC CHART



HUINCUL DORSAL EMBAYMENT CATRIEL SHELF

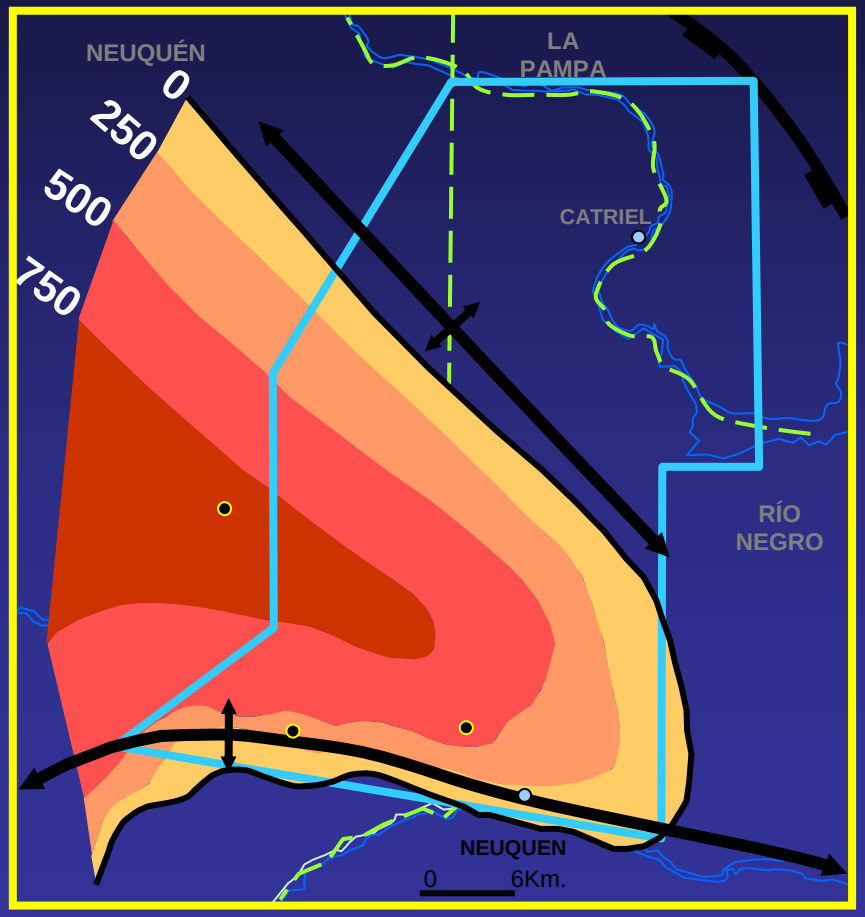
- VOLCANICS -TUFFS & CONTINENTAL CLASTICS
- OFF SHORE - BASINAL CLASTICS
- MARGINAL MARINE CLASTICS
- CONTINENTAL CLASTICS
- MARINE CARBONATES, EVAPORITES & CLASTICS
- SHELFAL CARBONATES & CLASTICS



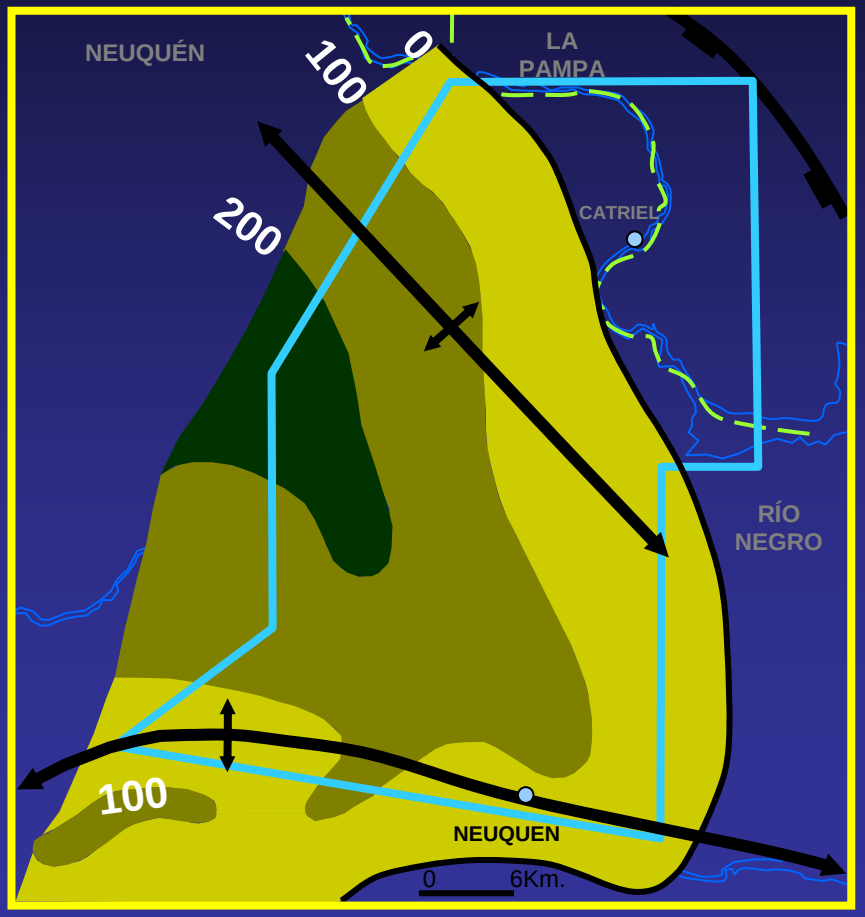
Pc: Precuyo; Mo: Molles; L: Lajas; Ch: Challacó;
PR: Punta Rosada; Lo: Lotena; To: Tordillo;
VM: Vaca Muerta; Q: Quintuco; LM: Loma Montosa
Ce: Centenario; Ry: Rayoso; Nqn: Neuquén; Mg: Malargüe

ORGANIC RICH FACIES - ISOPACH MAPS

LOS MOLLES

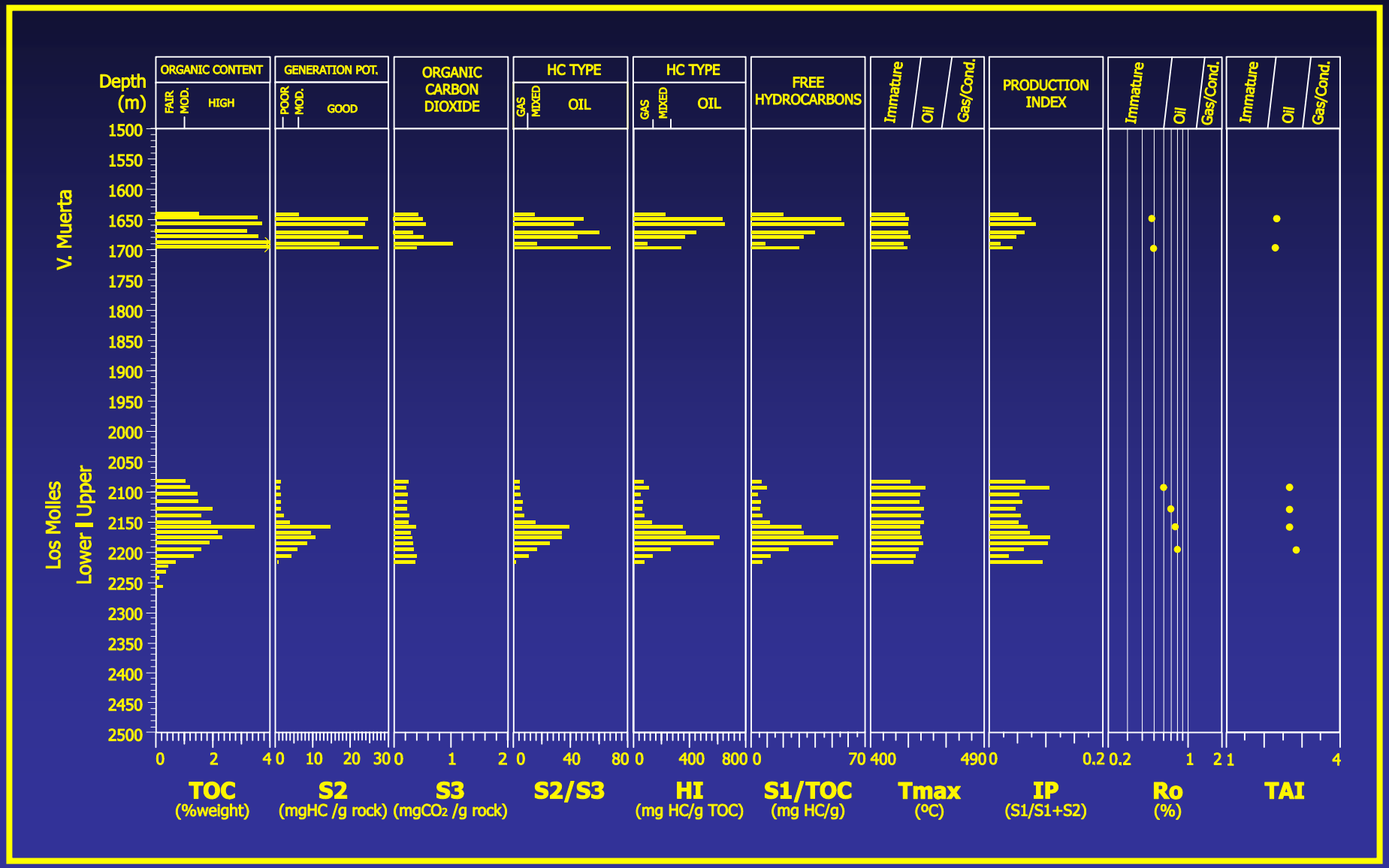


VACA MUERTA

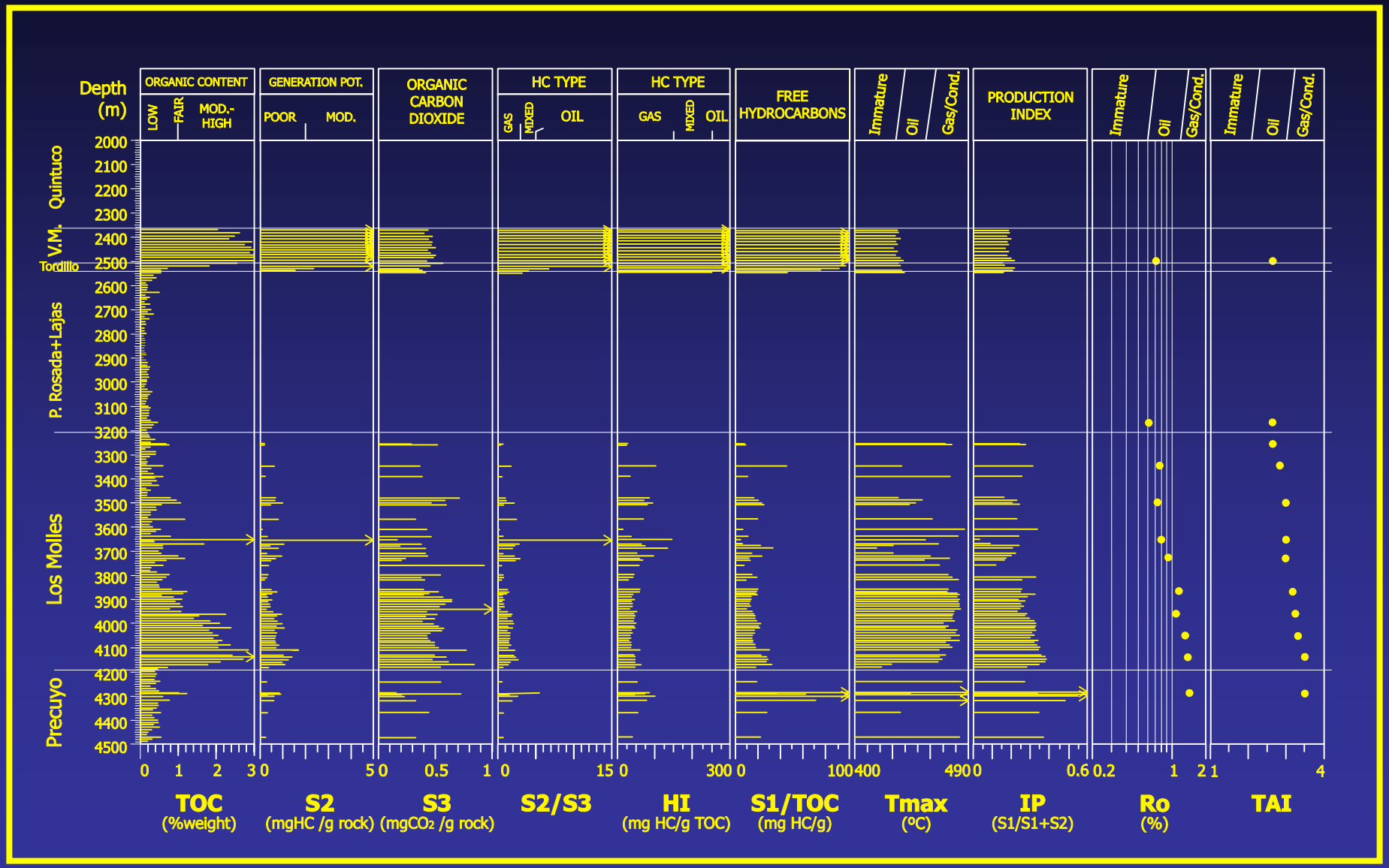


Thickness in Meters

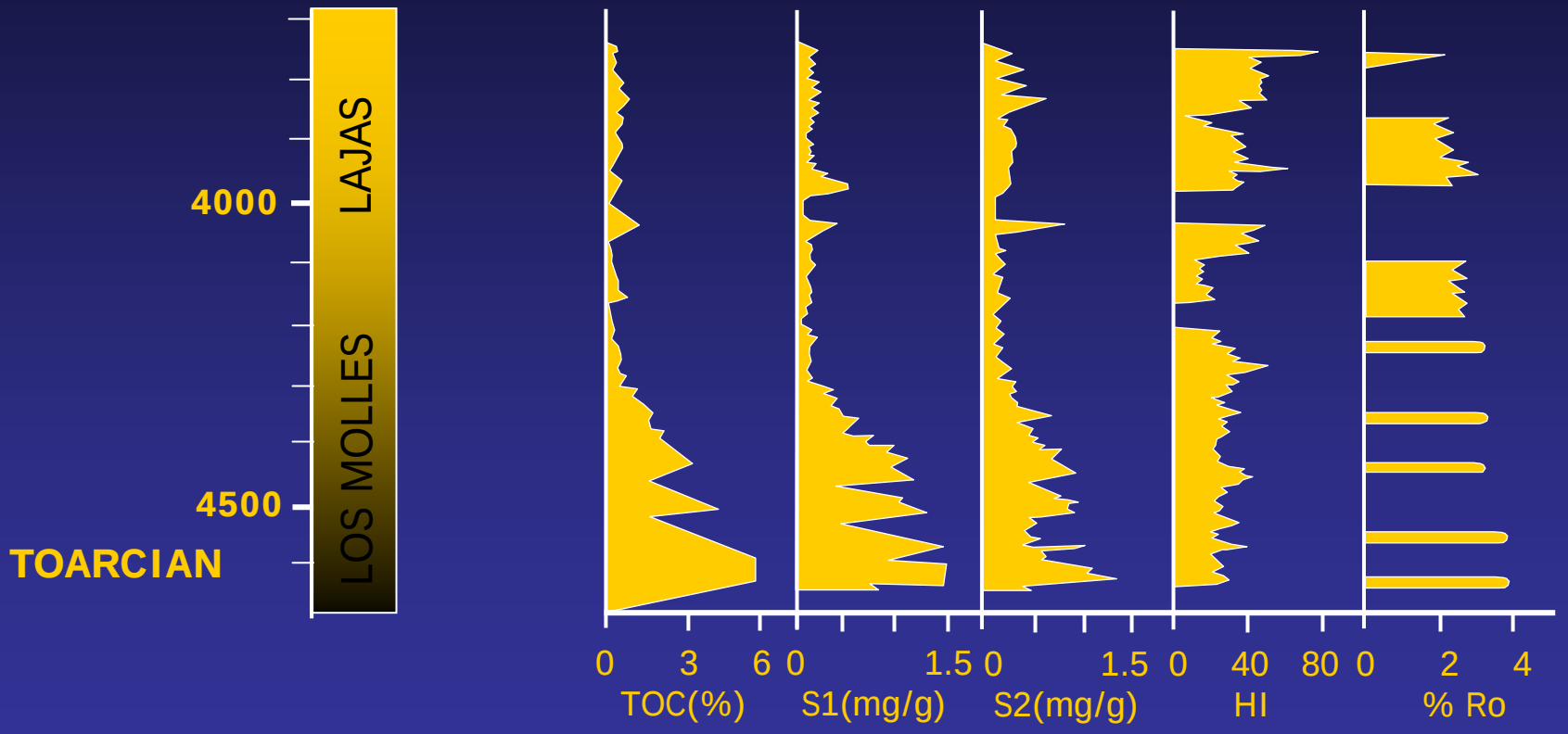
LAS CHIVAS - GEOCHEMICAL LOG



CENTENARIO - GEOCHEMICAL LOG



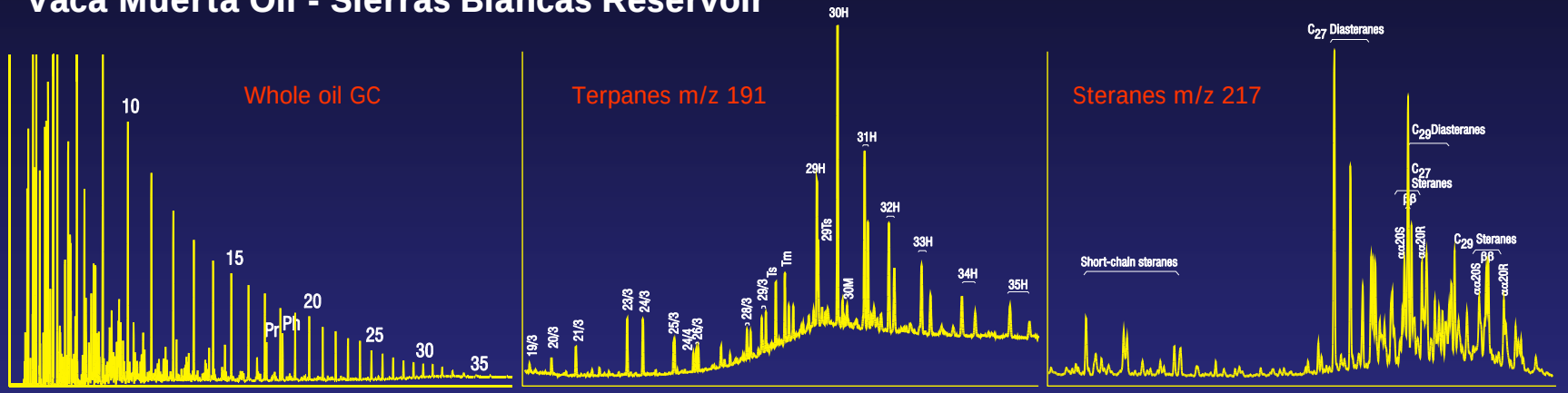
BARREALES COLORADOS - GEOCHEMICAL LOG



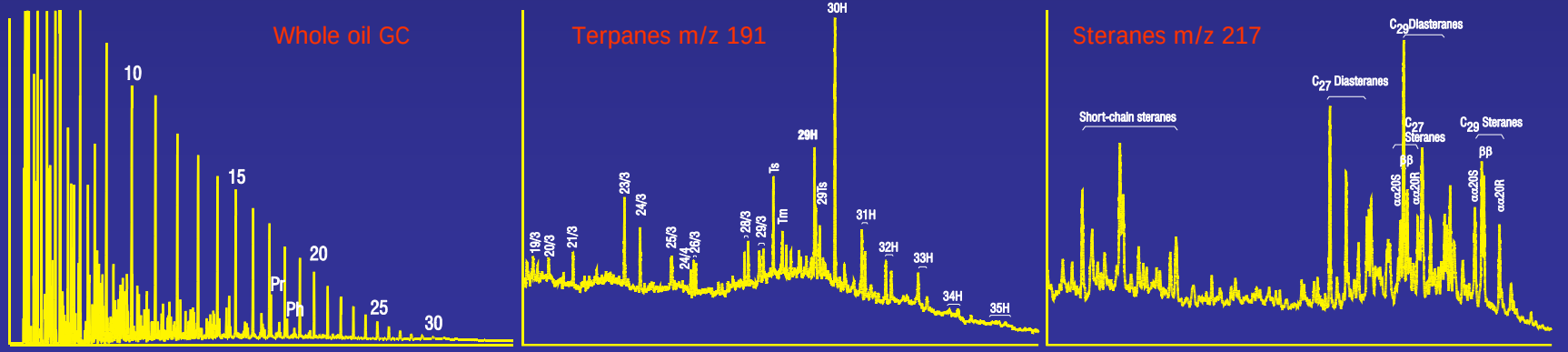
Modified from Fernández Seveso et al., 1996

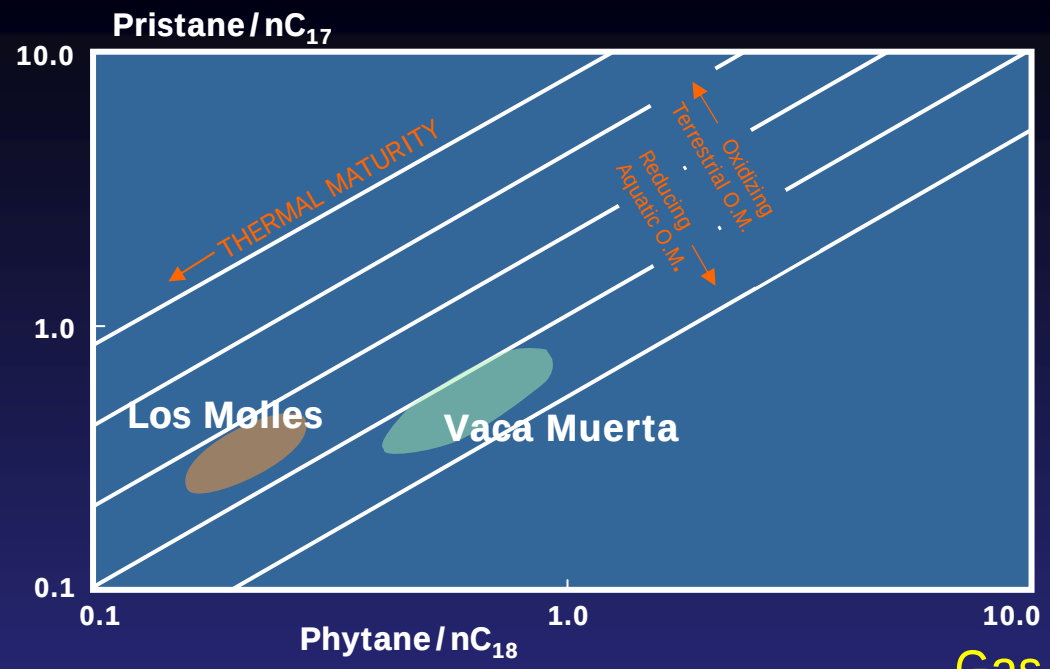
GAS CHROMATOGRAPHY AND BIOMARKER FINGERPRINTS

Vaca Muerta Oil - Sierras Blancas Reservoir

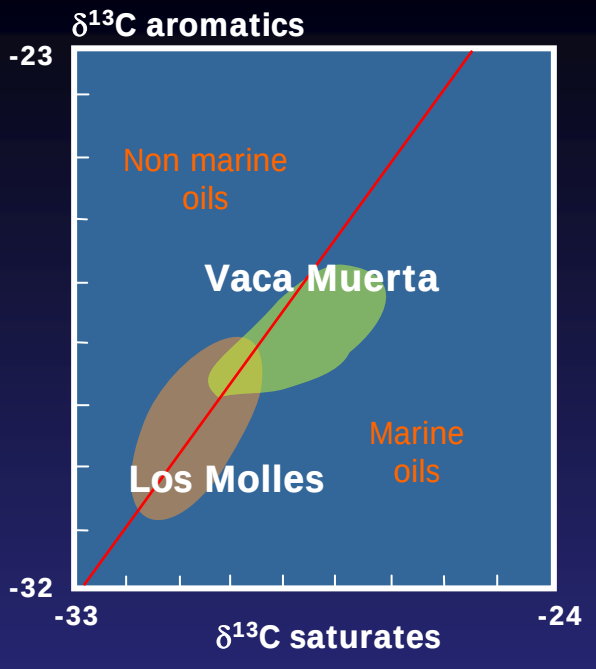


Los Molles Oil - Lajas Reservoir



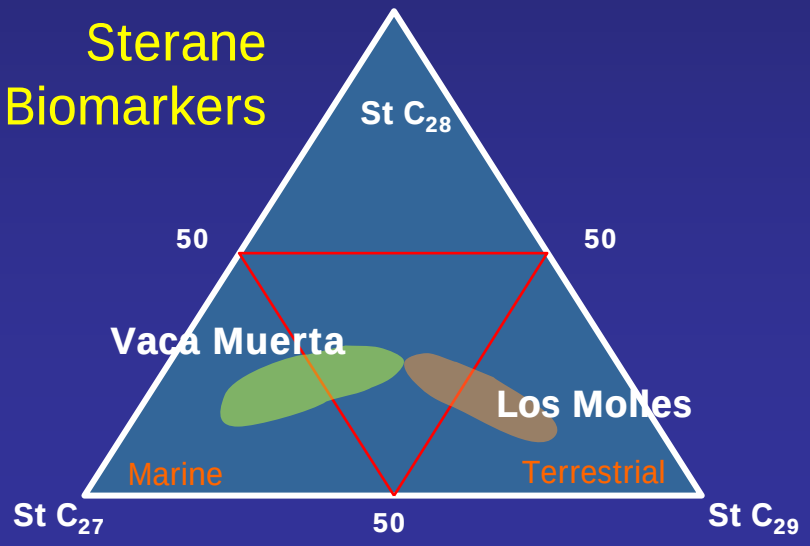


Gas Chromatography



Carbon Isotopes

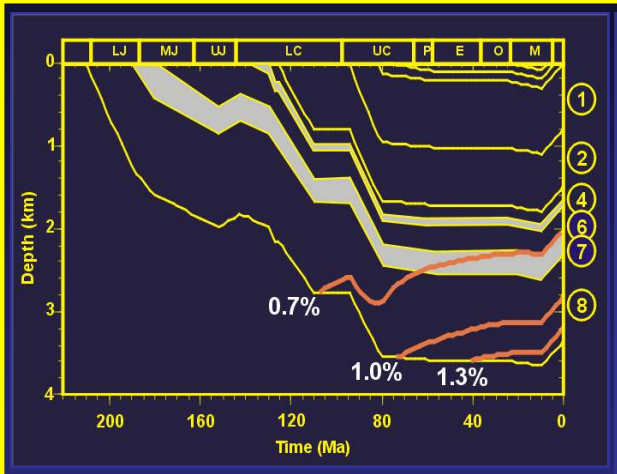
Sterane Biomarkers



Compositional and molecular features discriminating Vaca Muerta & Los Molles oils

MATURITY WINDOWS GEOHISTORY

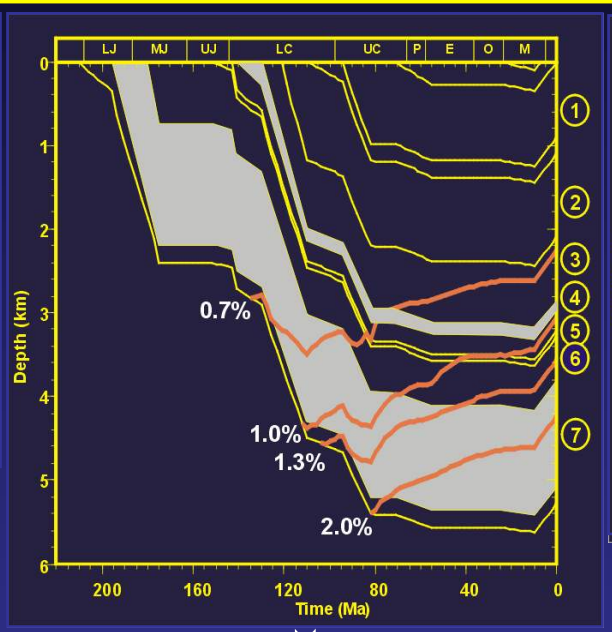
LAS CHIVAS



ONSETS OF HYDROCARBON GENERATION (My)

Los Molles Fm.
Oil (0.7% Ro): 63 (bottom) - 9 (top)

LINDERO ATRAVESADO

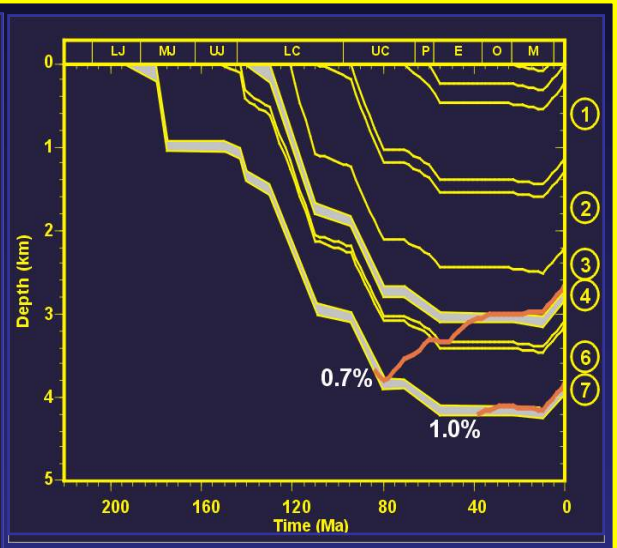


ONSETS OF HYDROCARBON GENERATION (My)

Los Molles Fm.
Oil (0.7 Ro%):130 (bottom) - 94 (top)
Wet Gas & Condensate (1.3 Ro%): 94 (bottom) - 43 (top)
Dry Gas (2.0 Ro%):75 (bottom)

Vaca Muerta Fm.
Oil (O.7 Ro%): 80 (bottom) - 73 (top)

LOMA GUADALOSA



ONSETS OF HYDROCARBON GENERATION (My)

Los Molles Fm.
Oil (0.7 Ro%): 84 (bottom) - 78 (top)

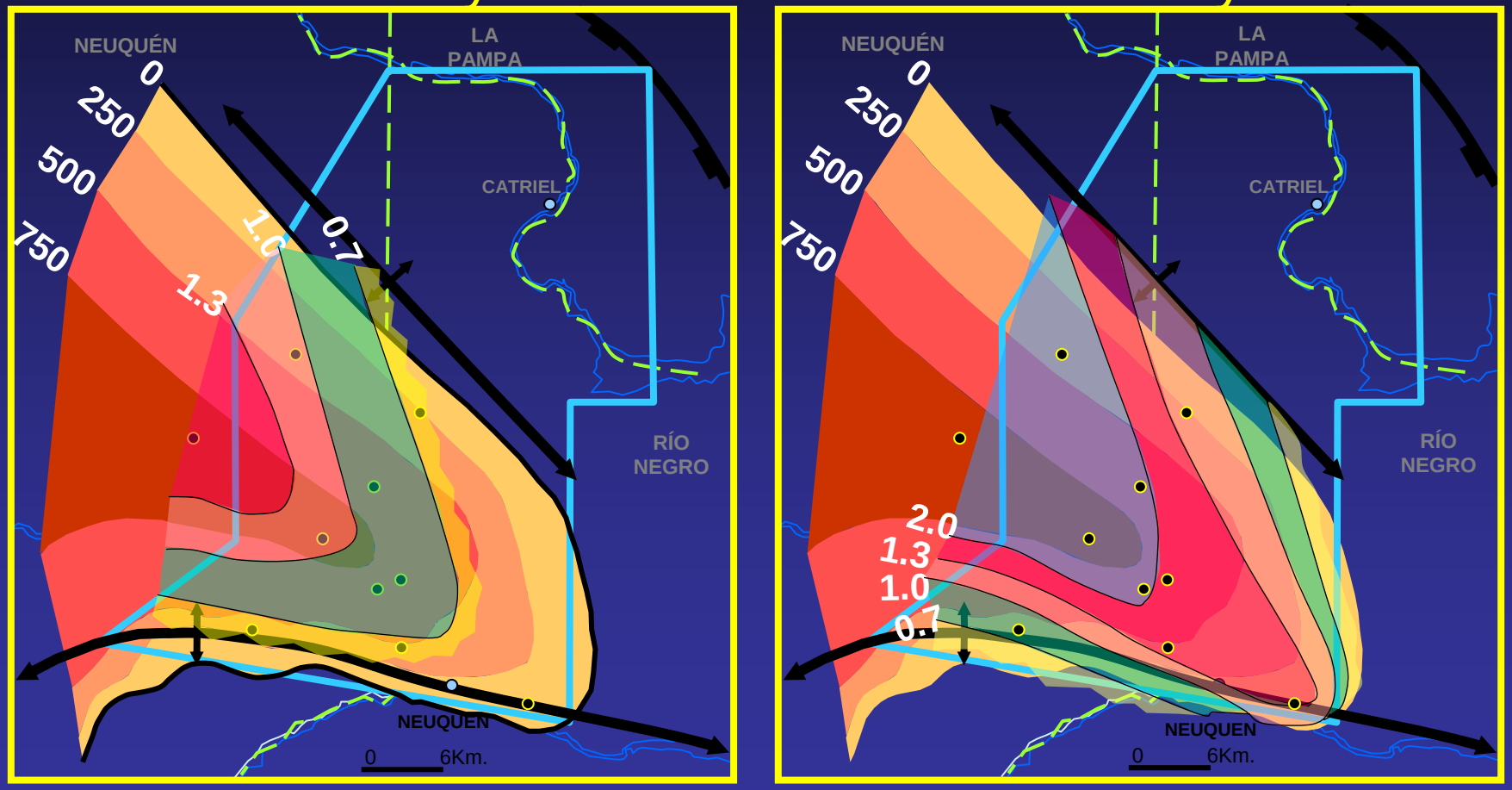
Vaca Muerta Fm.
Oil (0.7 Ro%): 58 (bottom) - 54 (top)

Legend

Neuquen Gr.	1	Tordillo Fm.	5
Centenario Fm.	2	Lajas Fm	6
Quintuco Fm.	3	Los Molles Fm.	7
Vaca Muerta Fm.	4	Pre-Cuyo	8

ORGANIC RICH FACIES
ISOPACH AND MATURITY ZONES MAPS

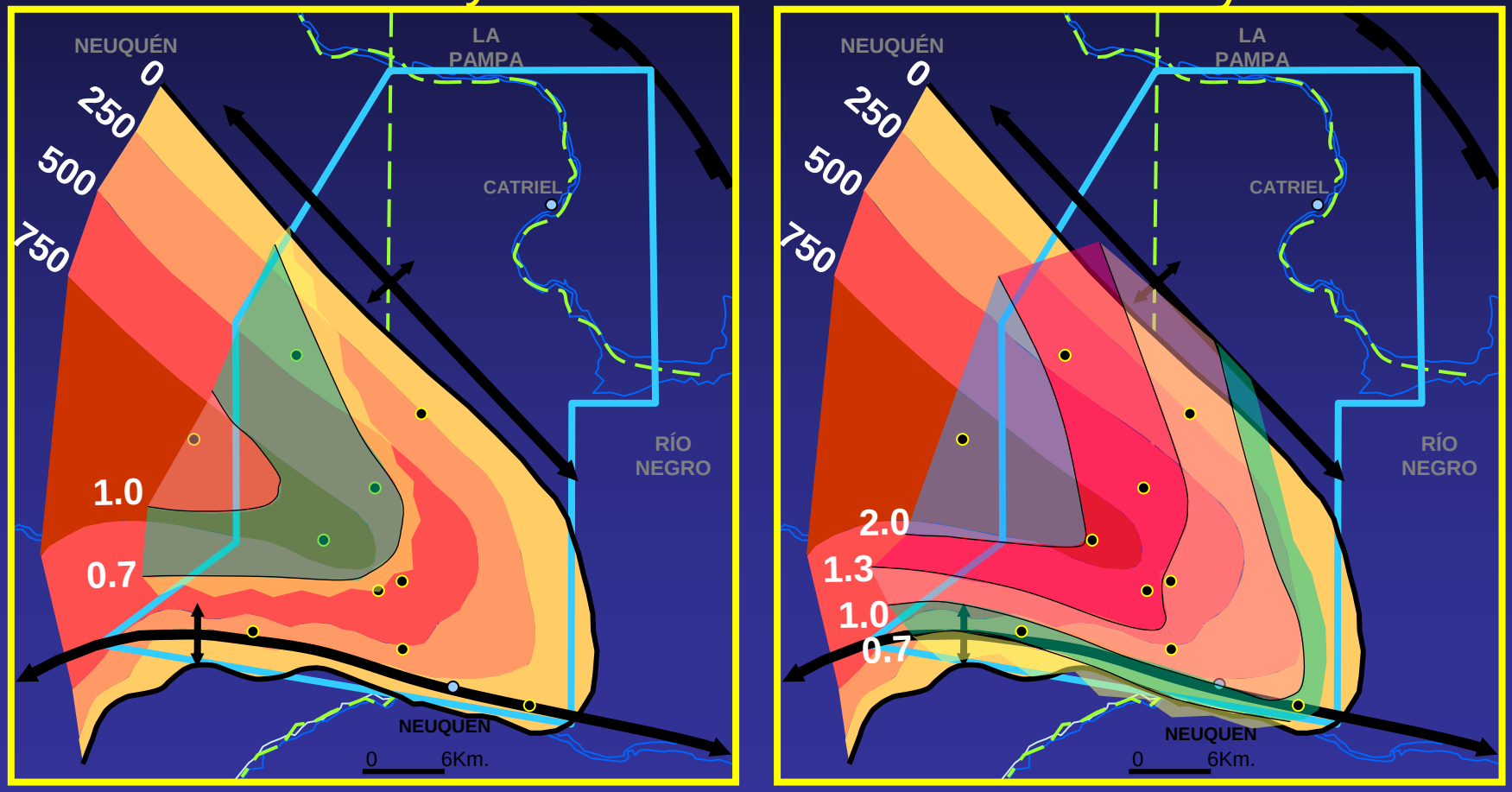
BOTTOM LOS MOLLES



Thickness in Meters - Maturity % Ro

ORGANIC RICH FACIES
ISOPACH AND MATURITY ZONES MAPS

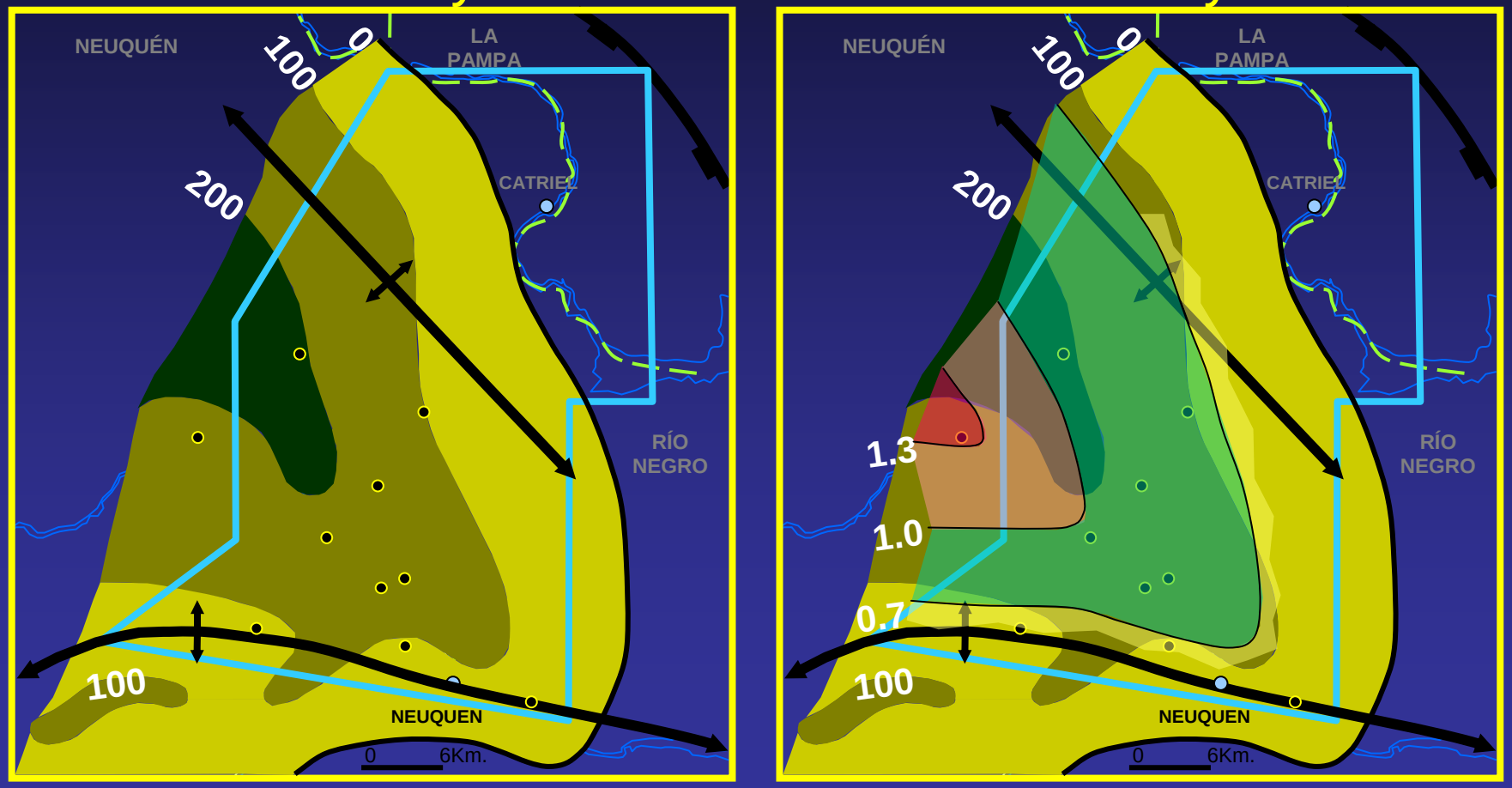
TOP LOS MOLLES



Thickness in Meters - Maturity % Ro

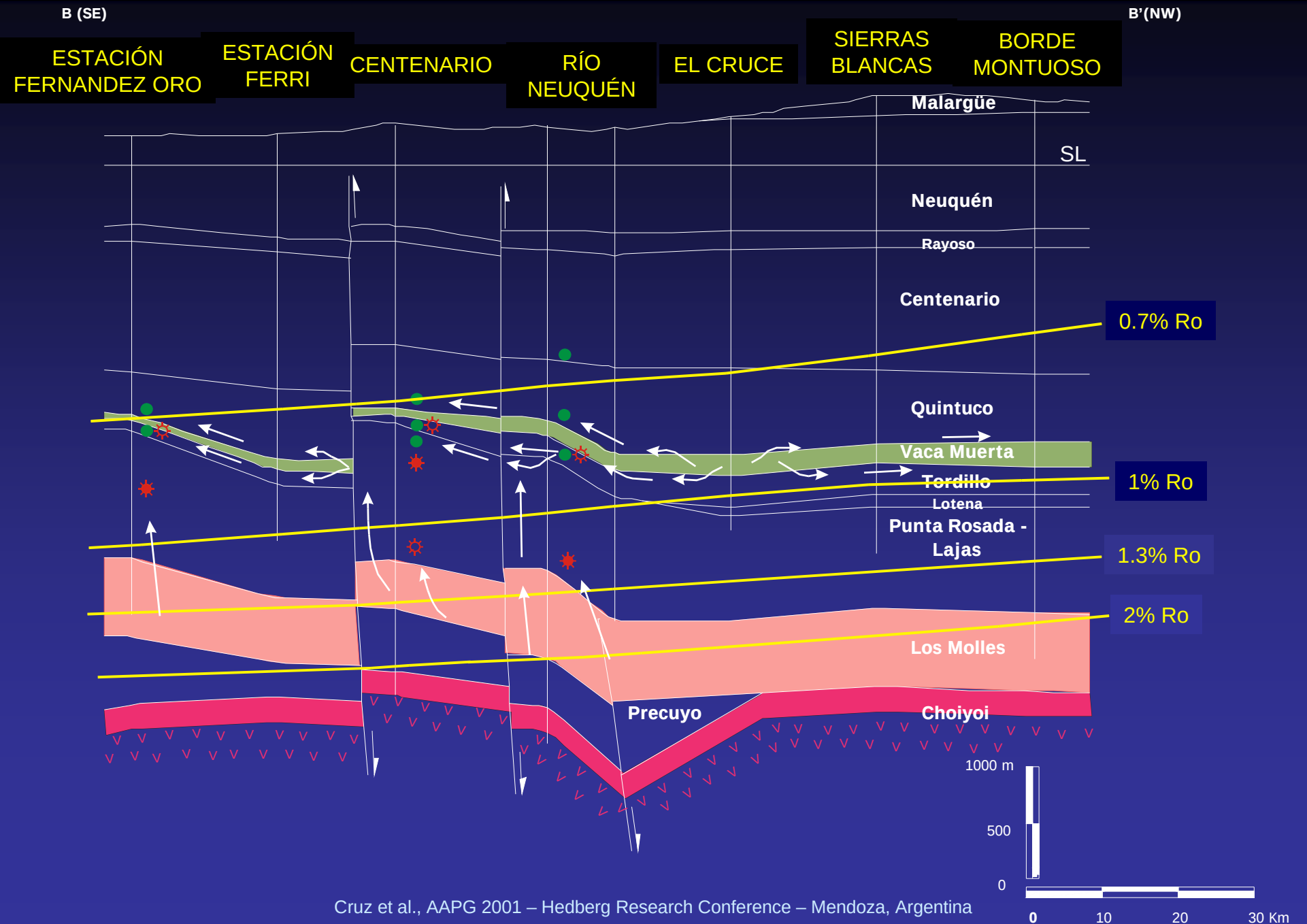
ORGANIC RICH FACIES
ISOPACH AND MATURITY ZONES MAPS

VACA MUERTA



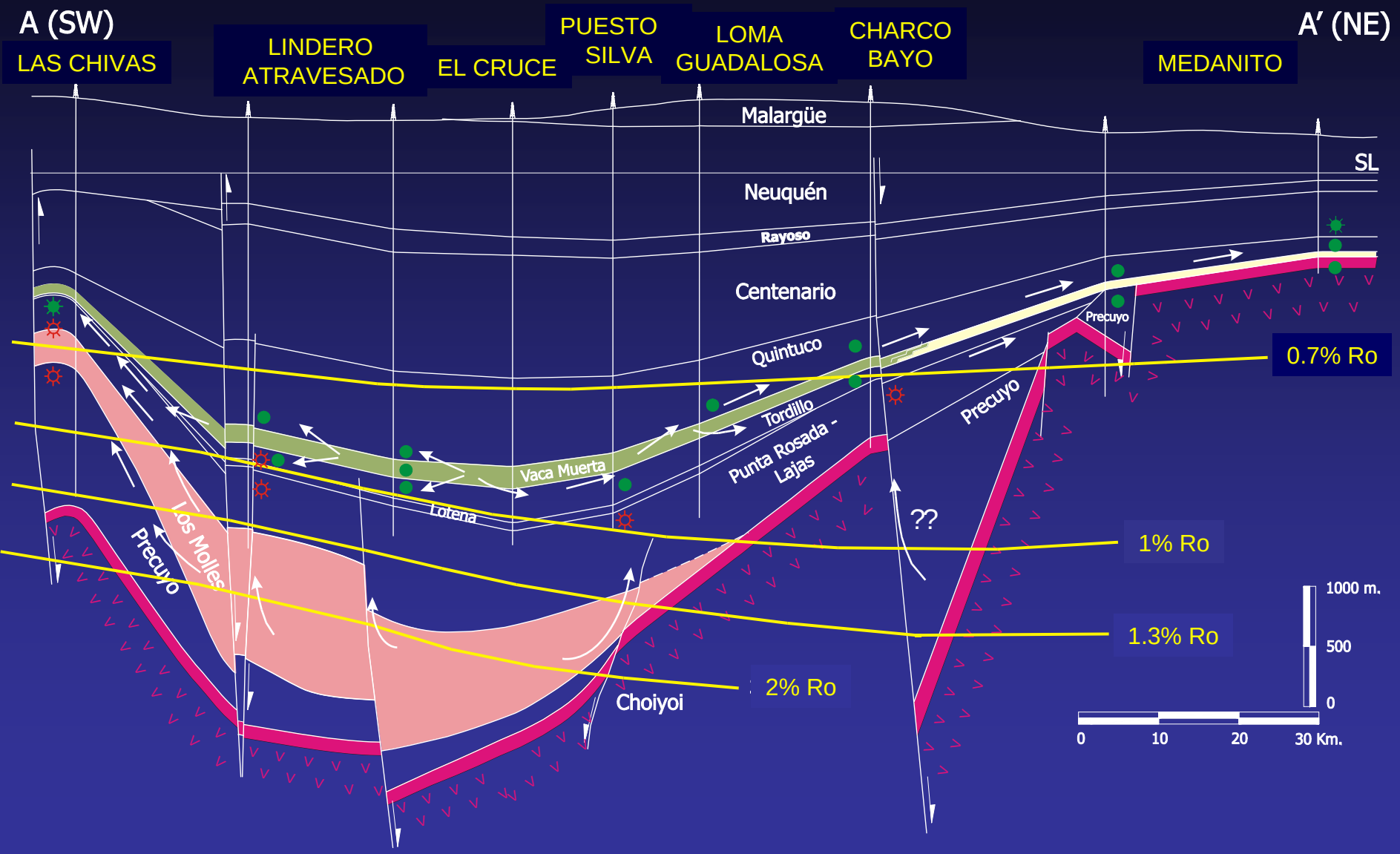
Thickness in Meters - Maturity % Ro

SE-NW CROSS SECTION AND HYDROCARBON CHARGE



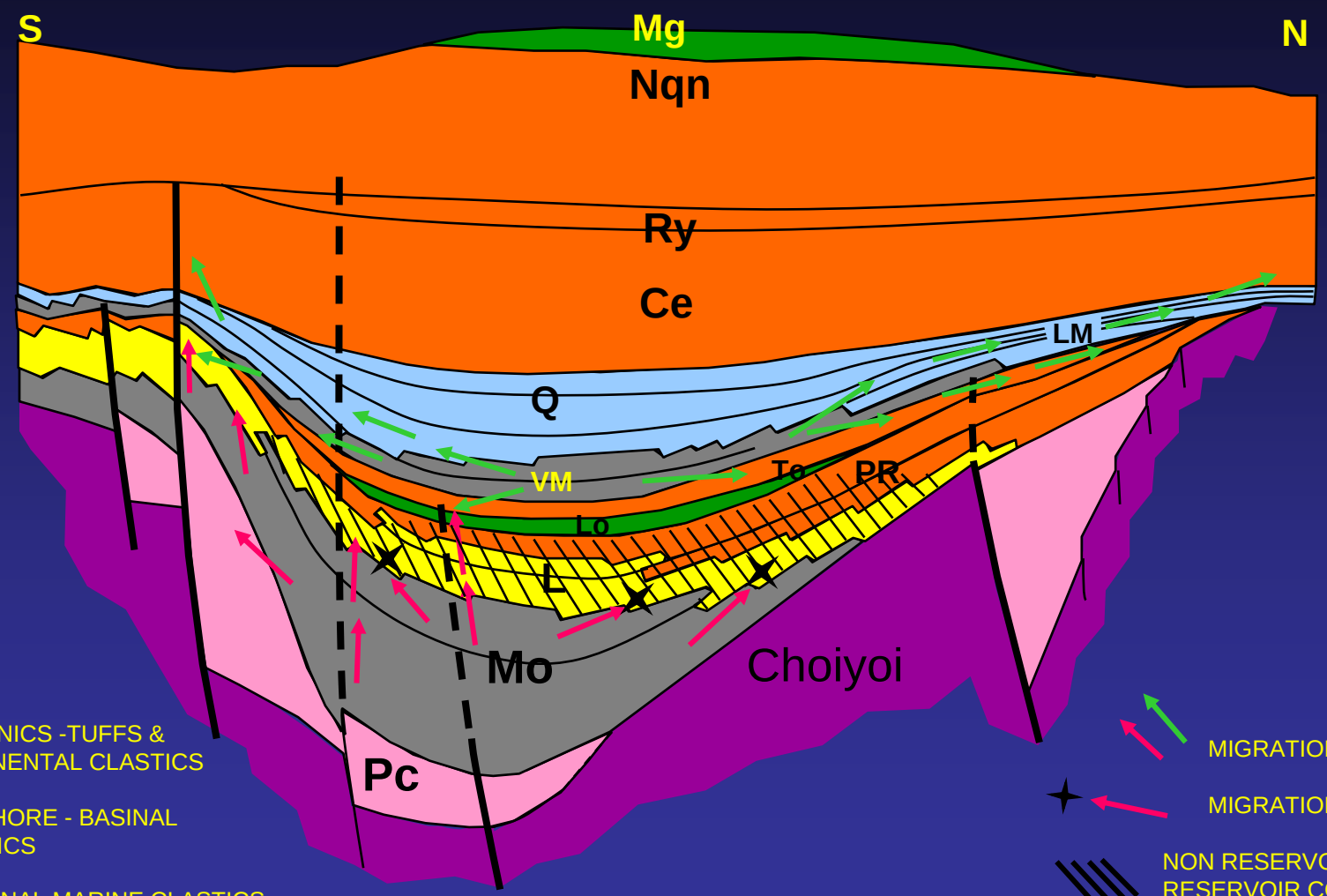
Cruz et al., AAPG 2001 – Hedberg Research Conference – Mendoza, Argentina

SW-NE CROSS SECTION AND HYDROCARBON CHARGE

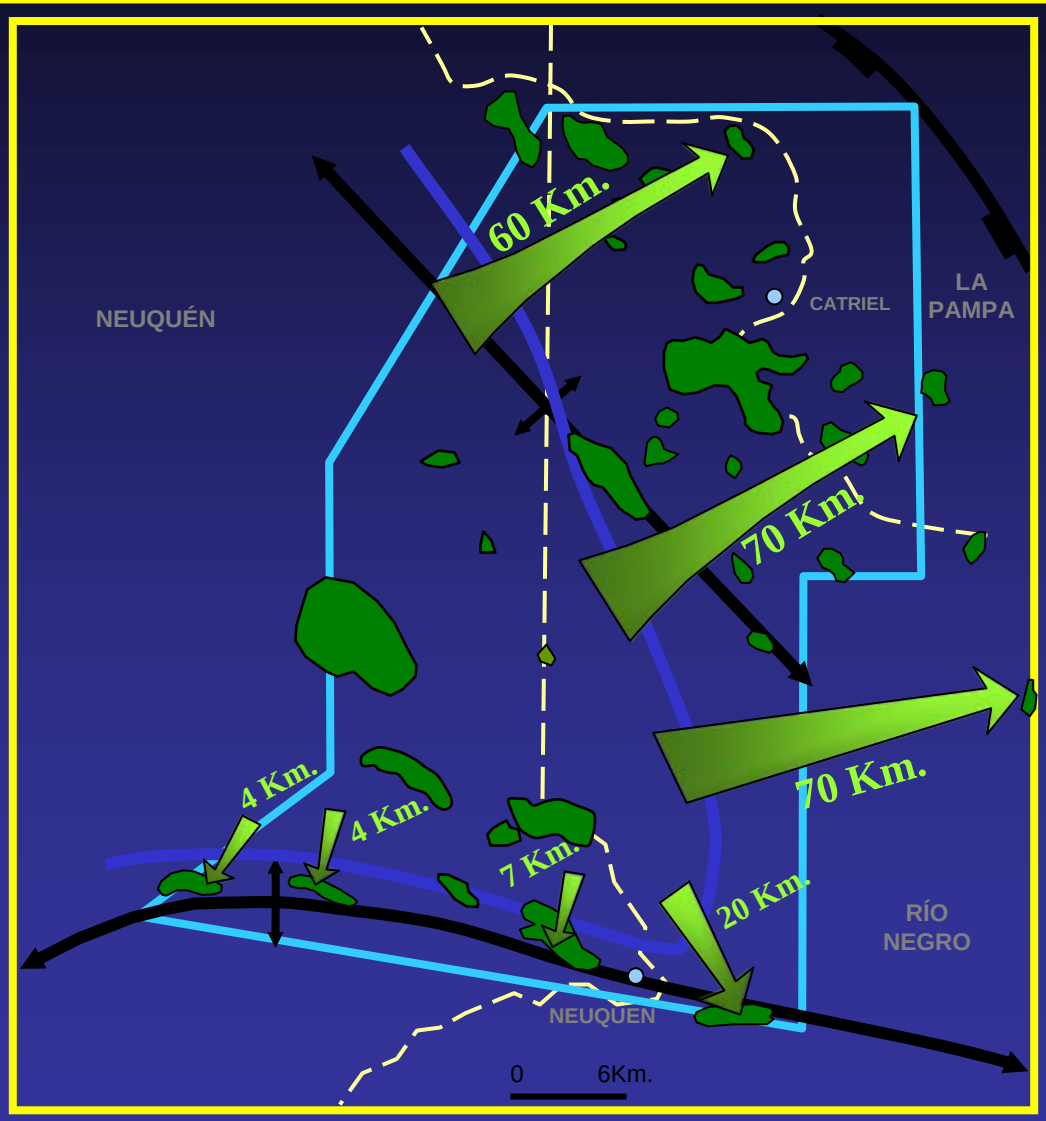


Cruz et al., AAPG 2001 – Hedberg Research Conference – Mendoza, Argentina

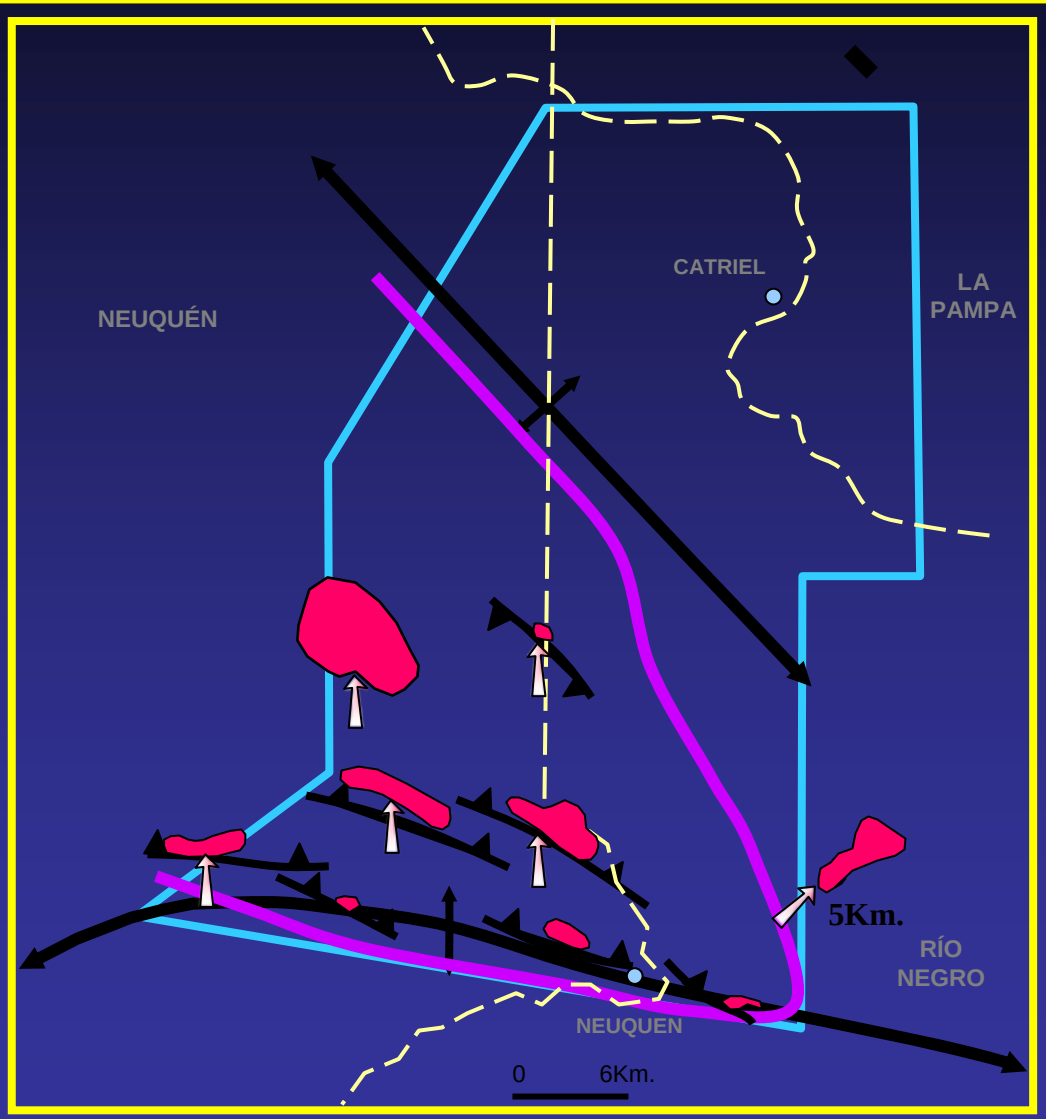
MIGRATION PATTERNS



VACA MUERTA KITCHEN AND MIGRATION PATHWAYS



LOS MOLLES KITCHEN AND MIGRATION PATHWAYS



FACTS & CONCLUSIONS

LOS MOLLES	VACA MUERTA
Mixed oil/gas source – Type II/III amorphous & structured kerogen. Marine reducing to suboxic with variable terrestrial input.	Oil prone source, type I/II, amorphous kerogen. Marine anoxic
Thick succession with asymmetrical distribution – thicker section closer to Huincul Dorsal (rift related fault system inverted during Jurassic-Cretaceous).	Tabular and symmetrical distribution.
Poor petrophysical conditions of associated carriers disfavor lateral migration. Fault systems favor vertical migration.	Excellent quality associated carriers. Long distance lateral migrations.
Mostly in gas/condensate zone (VRE 1.3 – 2%). Peak to late oil stage in Dorsal northern flank.	Mostly in the oil window (VRE 0.7 – 1%).

FACTS & CONCLUSIONS

LOS MOLLES

Oil generation and expulsion began around 130 my in deeper positions.

Hydrocarbons mostly trapped in Cuyo reservoirs.

VACA MUERTA

Oil generation and expulsion began around 80 my.

Hydrocarbons mostly trapped in Tordillo and Quintuco reservoirs.

Tordillo/Lotena gas/condensate occurrence where Vaca Muerta is early/mid mature could be:

Vaca Muerta hydrocarbons extensive migrations
Los Molles gassy hydrocarbons contribution

THANK YOU FOR YOUR ATTENTION !!!!!!

SEE YOU SOON