

PS Frequency Decomposition To Reveal And Validate Geological Concepts For Further Development. Examples From Cerro Piedra Area, Western San Jorge Basin, Argentina*

Teresa Santana¹, Matías Elizondo¹, and Hugo García²

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Abstract

Seismic interpretation has evolved during the last decades. Several workflows were developed and successfully implemented by the geoscience's specialists to reveal subsurface geology and improve seismic interpretation quality and cycle time. The advancement of technology allowed the use of more powerful algorithms, including visualization and combination of attributes, such as the RGB (Red, Green, Blue) blend of frequency volumes more efficiently.

Frequency decomposition is a technique that filters the seismic data into its frequency band pass components. The combination of three selected magnitude volumes for the low, mid, and high band frequencies into red, green and blue (RGB) respectively, allow seismic interpreters to maximize the use of wiggles, their amplitudes and frequencies, to better describe both the thickness and lithology variation of layers (Chopra et al, 2007).

The ability to validate the proposed geological concepts is crucial to close the loop and reduce uncertainties of identified opportunities to better assess the remaining potential of the area. This can be achieved by generating models with different geometries, rock properties, and/or pore fill to be tested. Synthetic volumes and their respective RGB blend volumes for a series of alternative possible scenarios were created based on the information of the sparse well information in the surroundings area and analogues for the study area. The synthetic results were then compared with the real RGB blend.

The Cerro Piedra study area is located at the western sector of the northern flank of the San Jorge mature Basin and is covered by 3D seismic recently acquired in 2016. The shallow Tertiary reservoirs, called the Rio Chico (fluvial), the Sarmiento (alluvial plain), and the Chenque (shallow marine) Formations, constitute the objective of interest of the present study (Foix et al, 2013). A total of 148 wells were drilled in the area, mainly focused in the development of deeper reservoirs, the Castillo and Bajo Barreal Formations from the Chubut Group. Consequently,

the Tertiary reservoirs remains underdeveloped, even though they are productive in nearby fields (Zabala Field) some 30 km away from the study area.

This work demonstrates the added value of applying seismic geomorphology using frequency decomposition along its validation to reduce uncertainties of identified potential opportunities for further development in a mature basin.

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EXAMPLES FROM CERRO PIEDRA AREA, WESTERN SAN JORGE BASIN, ARGENTINA.

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ABSTRACT

Seismic interpretation has evolved during the last decades. Several workflows were developed and successfully implemented by the geoscience specialists to reveal subsurface geology and improve both seismic interpretation quality and cycle time. The advancement of technology allowed the use of more powerful algorithms, including visualization and combination of attributes, such as the RGB (Red, Green, Blue) blend of frequency volumes more efficiently.

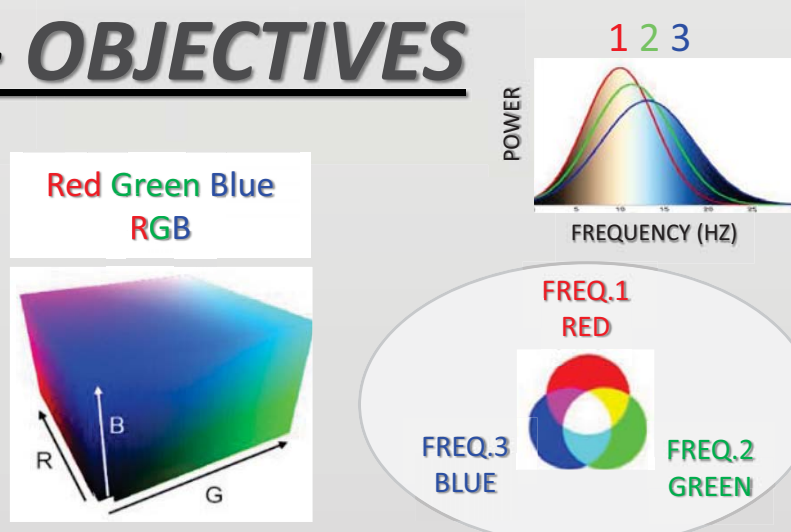
Frequency decomposition is a technique that filters the seismic data into its frequency bandpass components. The combination of three selected magnitude volumes for the low, mid and high band frequencies into red, green and blue (RGB) respectively, allows seismic interpreters to maximize the use of wiggles, their amplitudes and frequencies, to better describe both the thickness and lithology variation of layers.

The ability to validate the proposed possible geological concepts is crucial to close the loop to reduce uncertainties of identified opportunities and better assess the remaining potential of the area. This can be achieved by generating a series of models where different geometries, rock properties and/or pore fill are tested. Synthetic volumes and their respective synthetic RGB blend volumes for a series of alternative scenarios are created based on the information of well information in the surroundings area and analogues. The synthetic results are then compared with the RGB blend from the actual seismic data.

The Cerro Piedra study area is located at the western flank of the San Jorge mature basin and is covered by 3D seismic recently acquired in 2016. The shallow Tertiary, called Rio Chico (fluvial), Sarmiento (alluvial plain) and Chenque (shallow marine) Formations, constitute the objective of interest of the present study. A total of 148 wells were drilled in the area, mainly focused on the development of deeper reservoirs, called Castillo and Bajo Barreal Formations in the Chubut Group. Consequently, the Tertiary reservoirs remains under developed, even though they are productive in nearby fields (e.g. the Zabala field) some 30 km away from the study area.

This work demonstrates the added value of applying seismic geomorphology by frequency decomposition along its validation to reduce uncertainties of identified potential opportunities for further development in mature basins.

1- OBJECTIVES



TO ADD VALUE BY APPLYING SEISMIC INTERPRETATION VOLUME TECHNIQUES TO REDUCE UNCERTAINTIES OF IDENTIFIED POTENTIAL OPPORTUNITIES FOR FURTHER DEVELOPMENT IN A MATURE BASIN

PROPOSED POSSIBLE GEOLOGICAL SCENARIOS IN TERMS OF AMPLITUDES, PHASE & FREQUENCY
CLOSE THE LOOP
"ON-THE-FLY" TESTING & VALIDATION

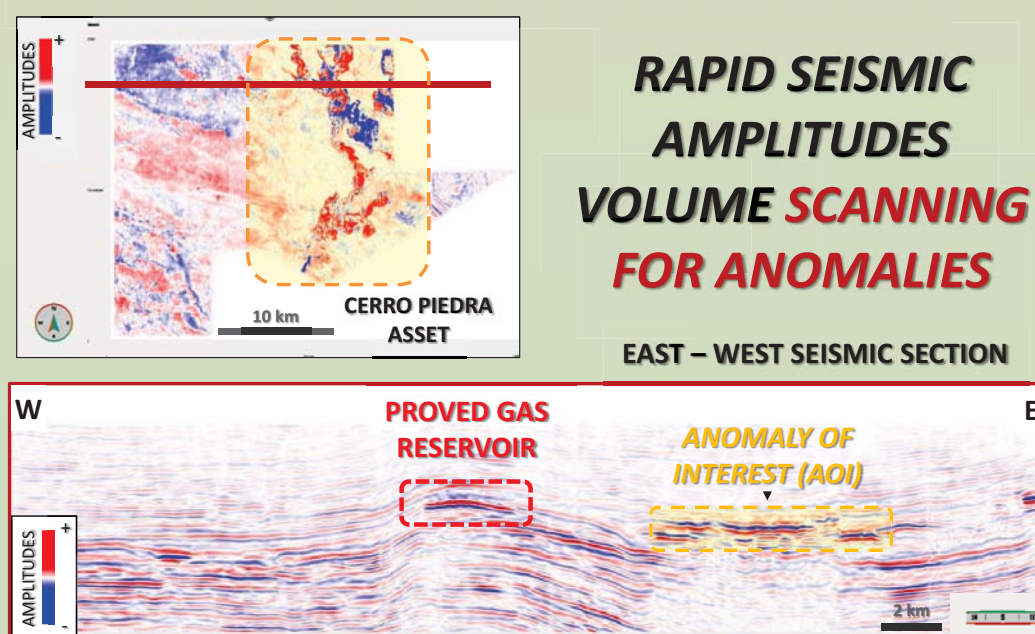
MAXIMIZE THE USE OF TECHNOLOGY AND THE COMBINATION OF ATTRIBUTES (RGB) USING FREQUENCY DECOMPOSITION

PROPOSE & INTERACTIVELY TEST ALTERNATIVE POSSIBLE GEOLOGICAL SCENARIOS (VP, VS, DENS., FLUIDS, POROSITY, ETC.)

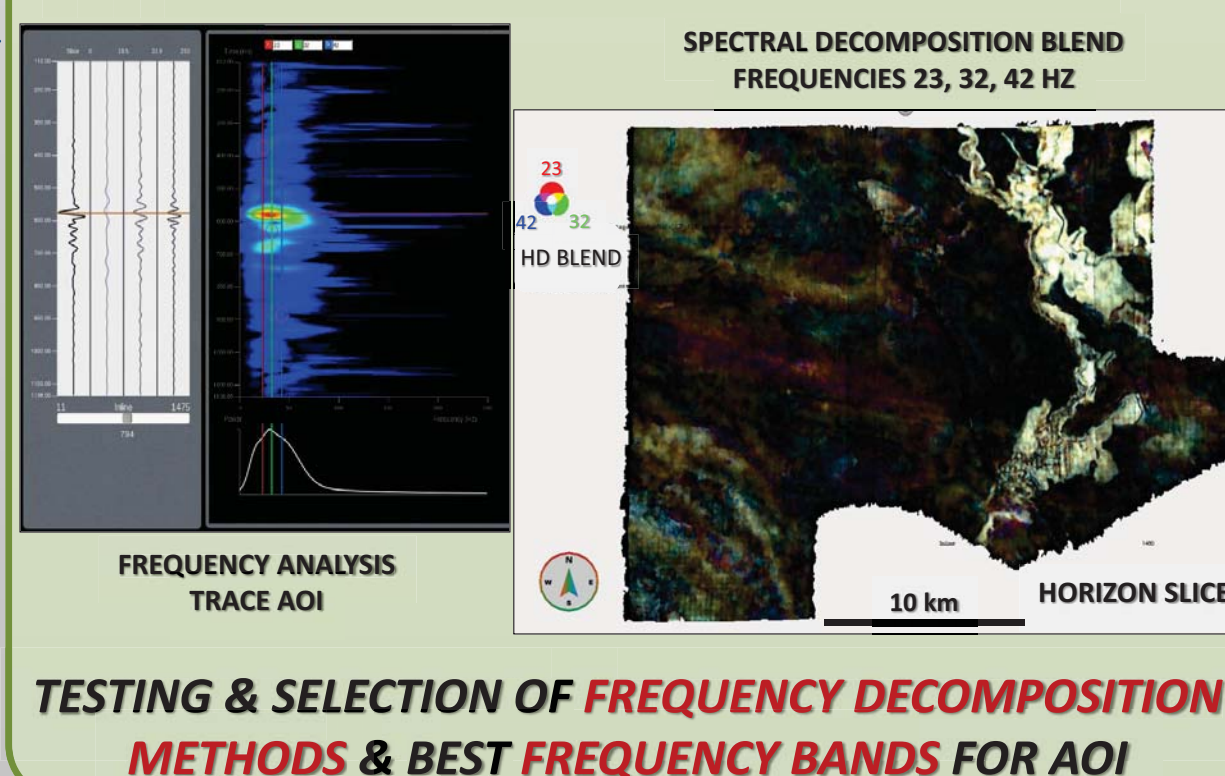
VALIDATE POSSIBLE GEOLOGICAL SCENARIOS TO CLOSE THE LOOP

2- PROPOSED WORKFLOW

1 – "ANOMALY OF INTEREST" IDENTIFICATION

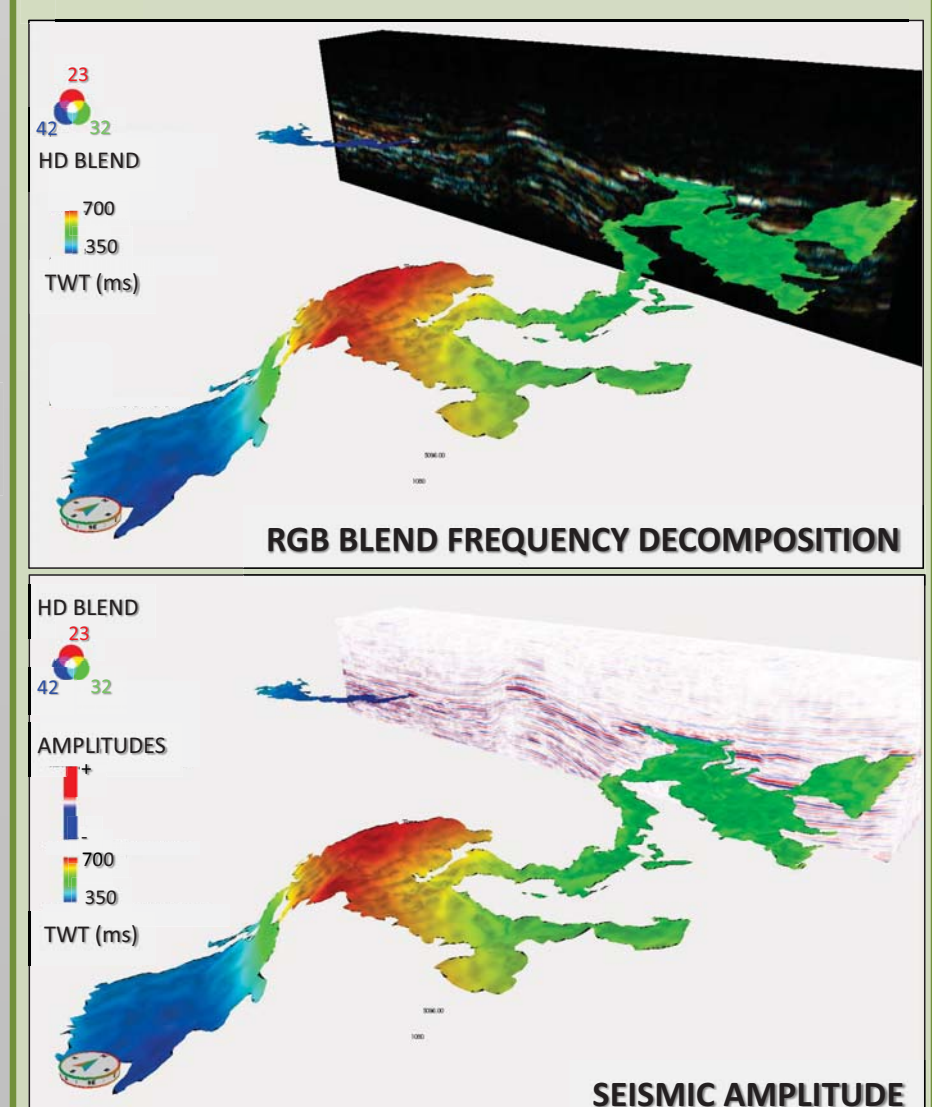


2 – SPECTRAL DECOMPOSITION FOCUSED ON AOI

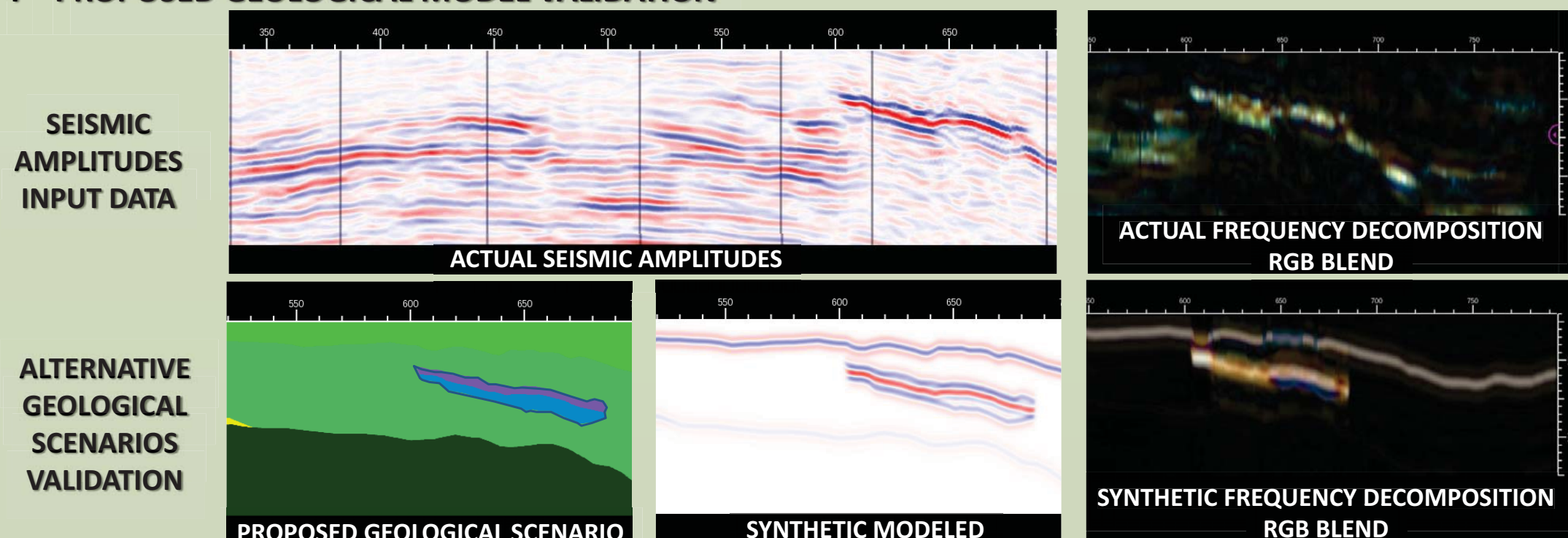


TESTING & SELECTION OF FREQUENCY DECOMPOSITION METHODS & BEST FREQUENCY BANDS FOR AOI

3 – GEOBODY DETECTION & EXTRACTION



4 – PROPOSED GEOLOGICAL MODEL VALIDATION



TESTING & VALIDATION OF ALTERNATIVE GEOLOGICAL POSSIBLE SCENARIOS UNTIL A REASONABLE "CORRELATION" IS OBTAINED

EXAMPLES FROM CERRO PIEDRA AREA, WESTERN SAN JORGE BASIN, ARGENTINA.

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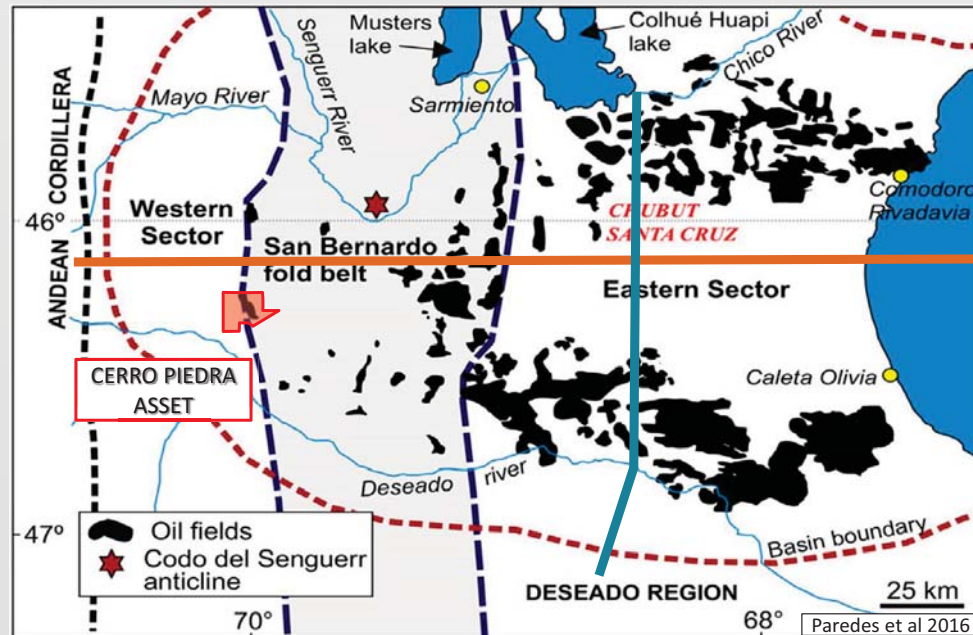
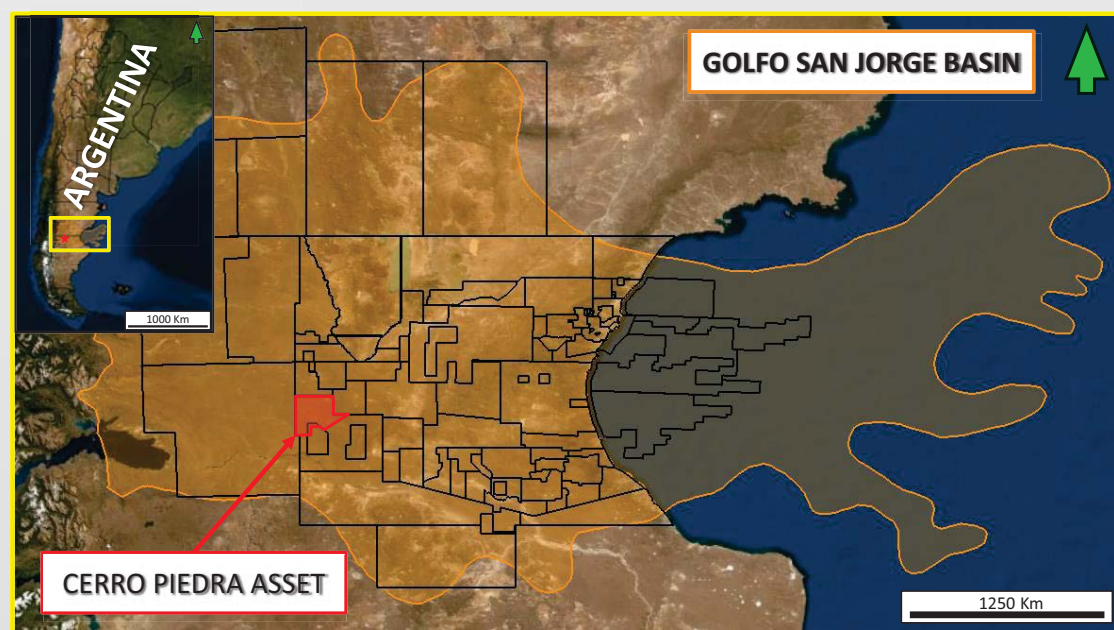
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3- CASE STUDY. CERRO PIEDRA. WESTERN SAN JORGE BASIN, ARGENTINA

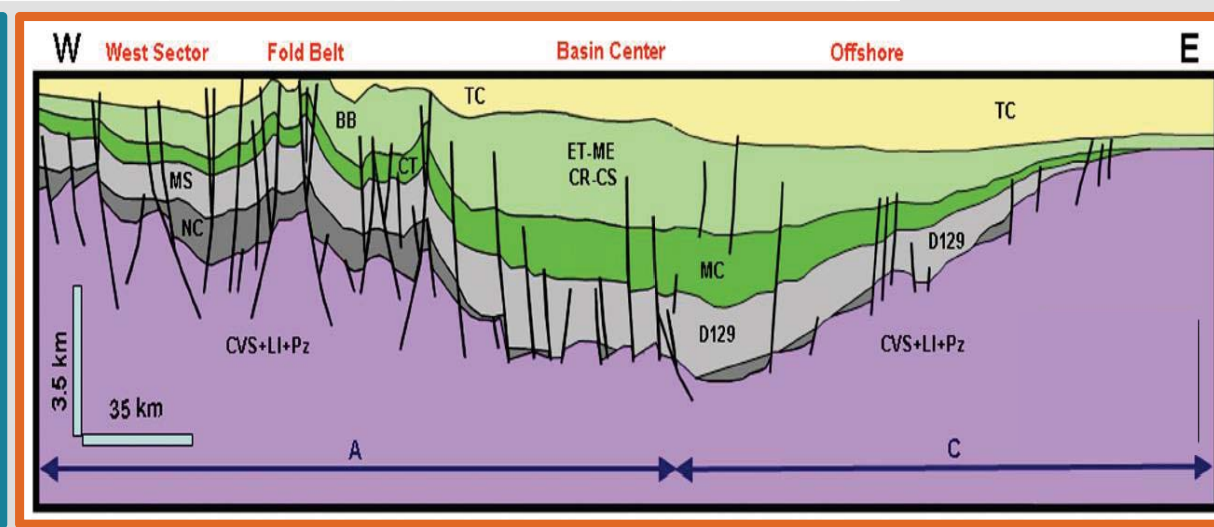
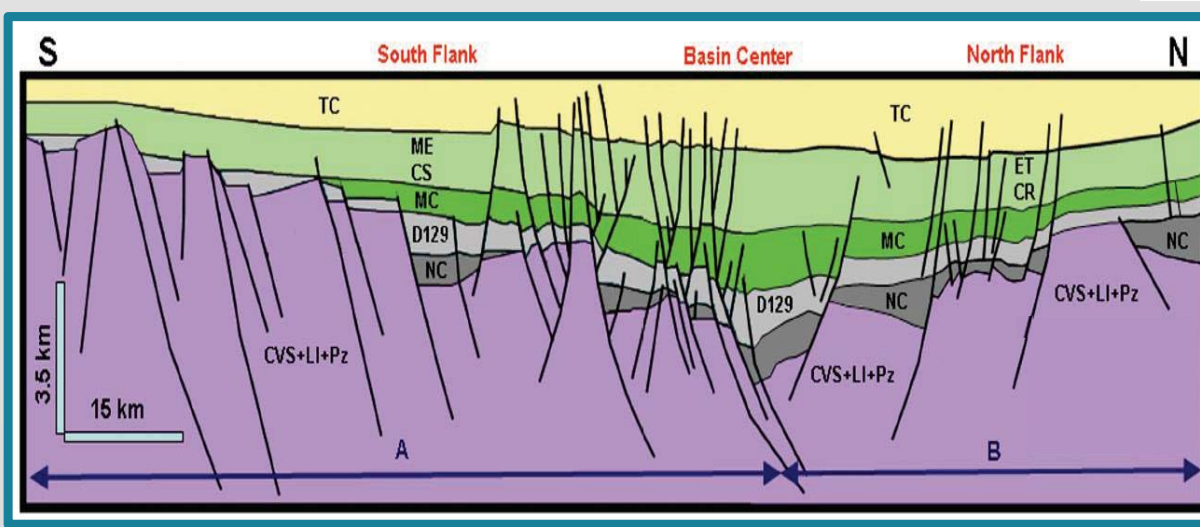
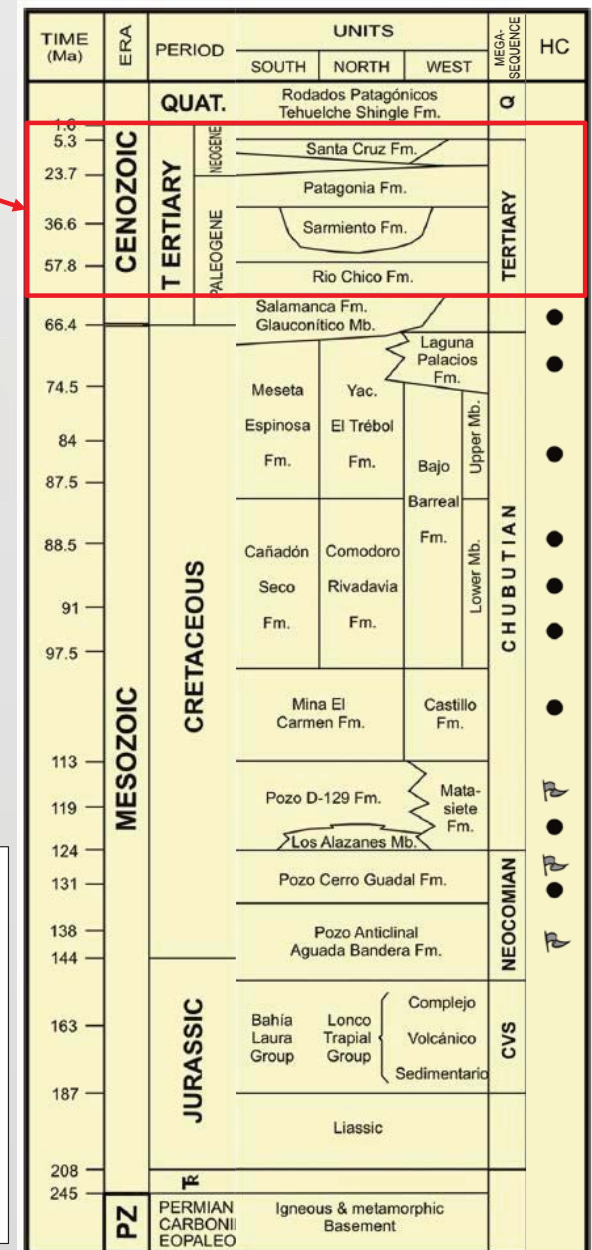
LOCATION, GEOLOGICAL SETTING & DATA AVAILABILITY

The Golfo San Jorge basin is an **intracratonic basin** located in central Patagonia, linked to the Gondwana breakup, and associated with an extensional framework. Petroleum systems are associated with **continental sequences** (fluvial and lacustrine).



AREA OF INTEREST

THE WESTERN FLANK OF THE SAN JORGE BASIN HAS TWO STRUCTURAL STYLES: **THRUST & EXTENSIONAL TECTONICS**

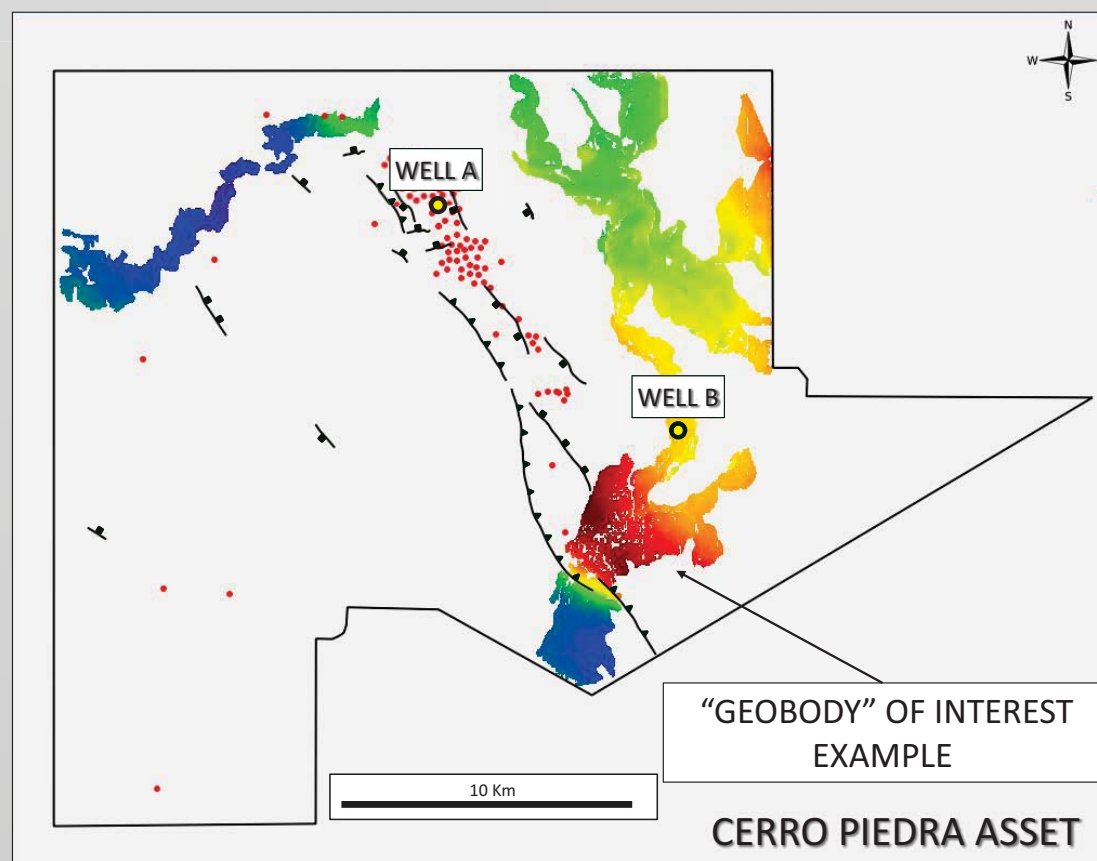
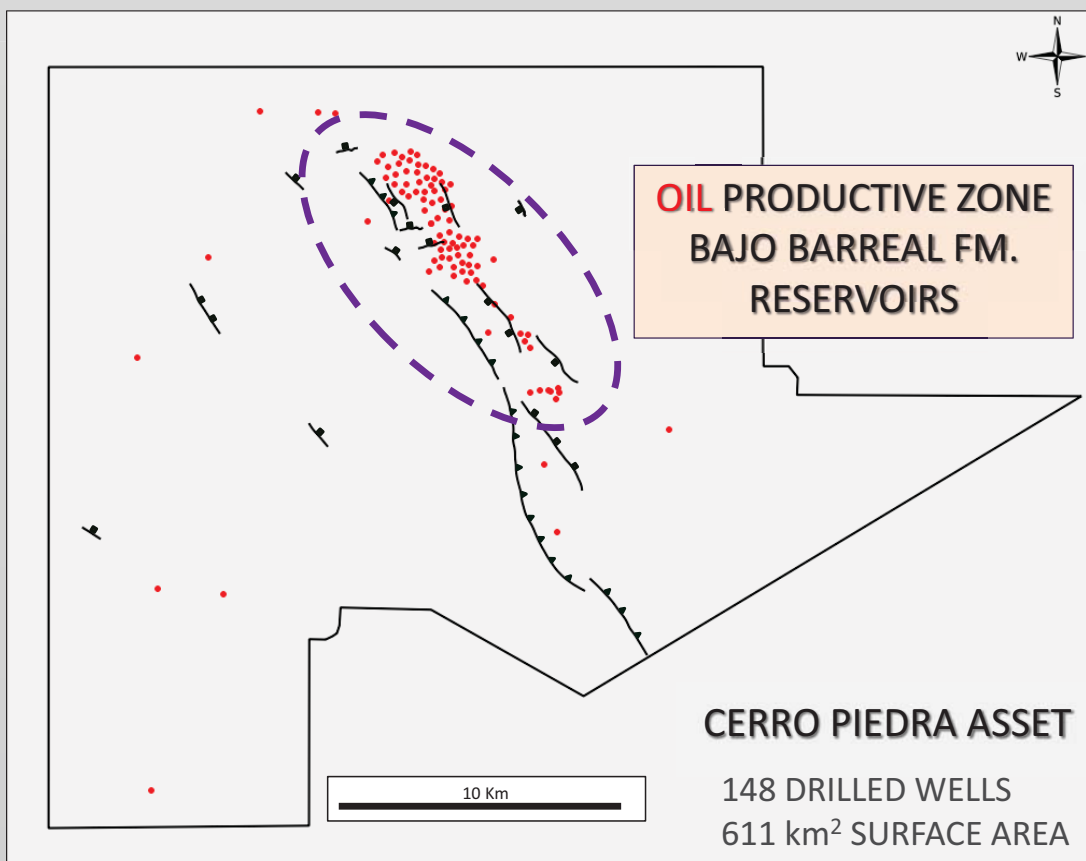


LEGEND
Pz: Paleozoic
L: Lias
CVS: Volcanic Complex
NC: Neocomian
D129: D-129 Fm.
MS: Matasiete Fm.
MC: Mina El Carmen Fm.
CT: Castillo Fm.
CS: Cañadón Seco Fm.
CR: Comodoro Rivadavia Fm.
ME: Meseta Espinosa Fm.
ET: El Trébol Fm.
TC: Tertiary

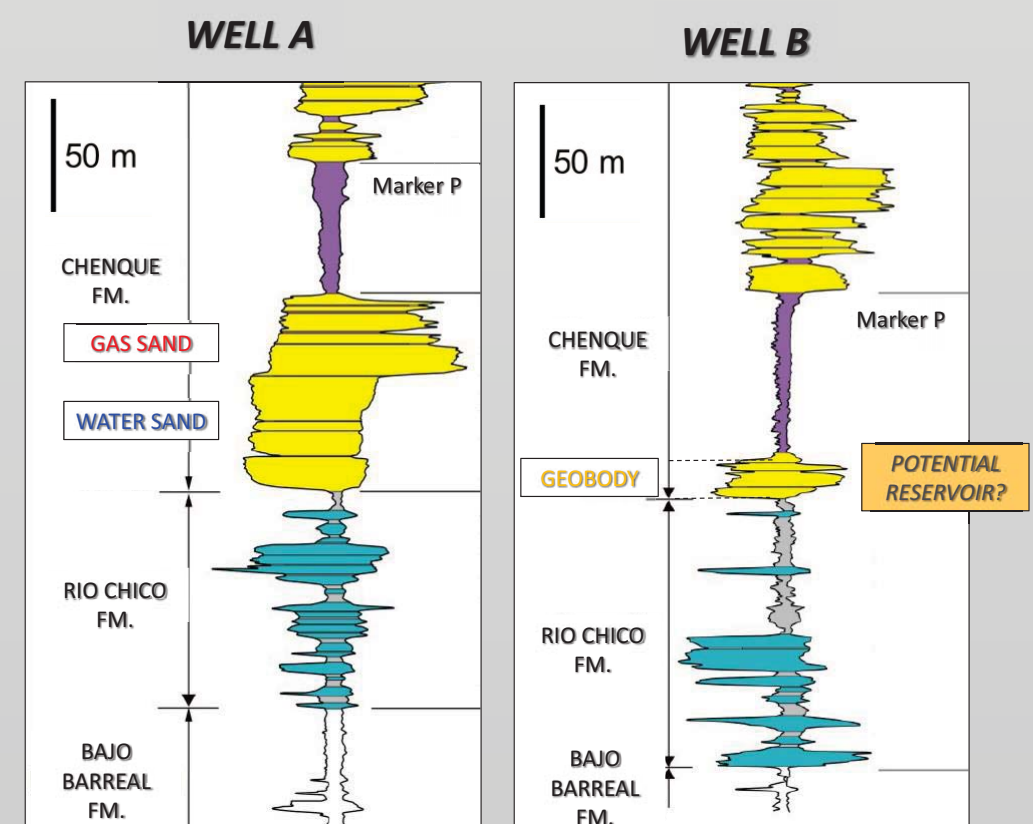
GOLFO SAN JORGE BASIN COMPOSITE REGIONAL CROSS SECTIONS SKETCHED FROM SEISMIC DATA. A: MODIFIED FROM FIGARI ET AL. (1999), B: SYLWAN ET AL. (2001), C: MODIFIED FROM BALDI AND NEVISTIC (1996)

FIELD DESCRIPTION AND RESERVOIR OBJECTIVES (TERTIARY)

GOLFO SAN JORGE BASIN CRONO-STRATIGRAPHY (MODIFIED FROM SYLWAN ET AL, 2001)



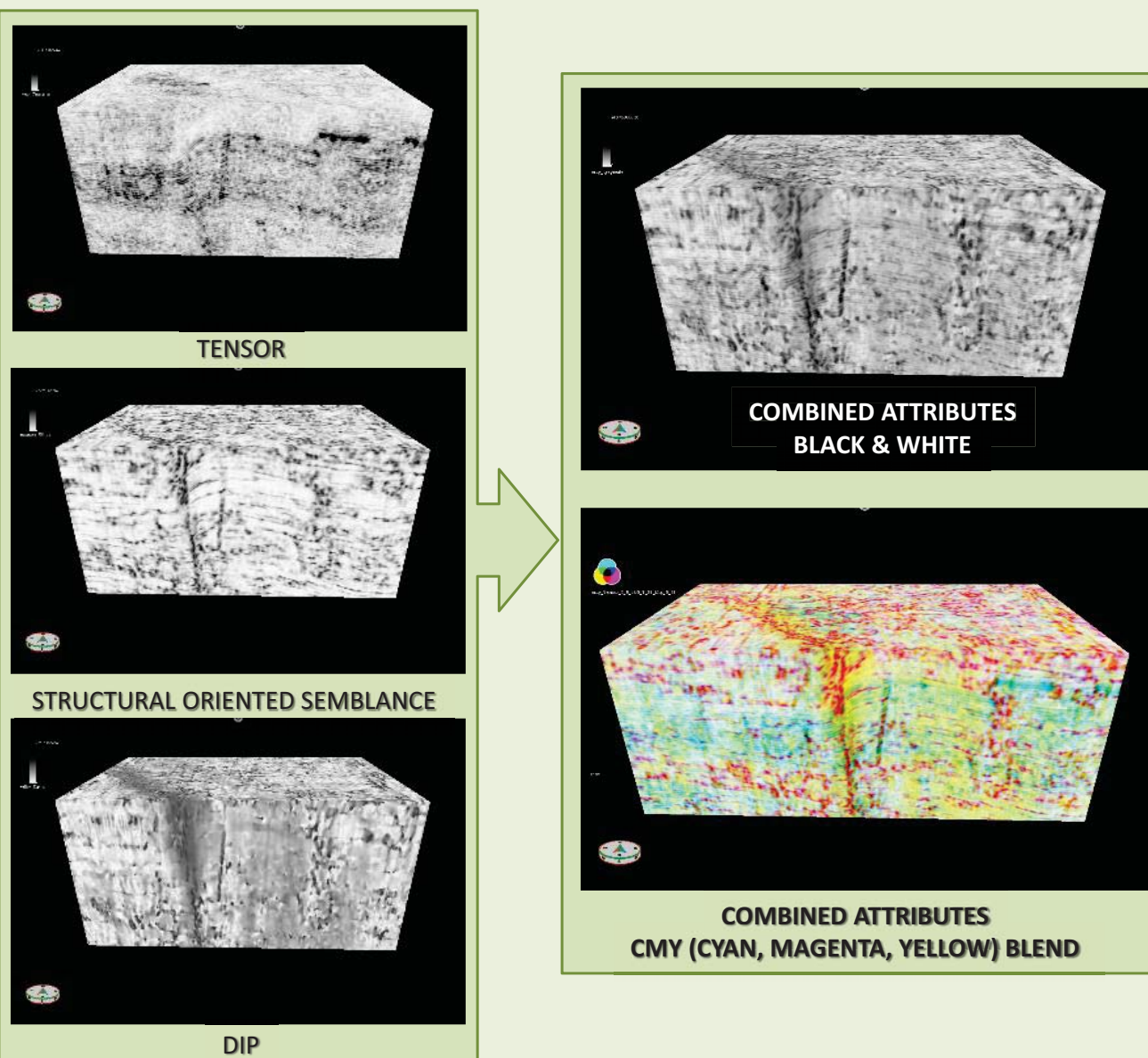
DETECTED & INTERPRETED "GEOBODIES" – TERTIARY FM.



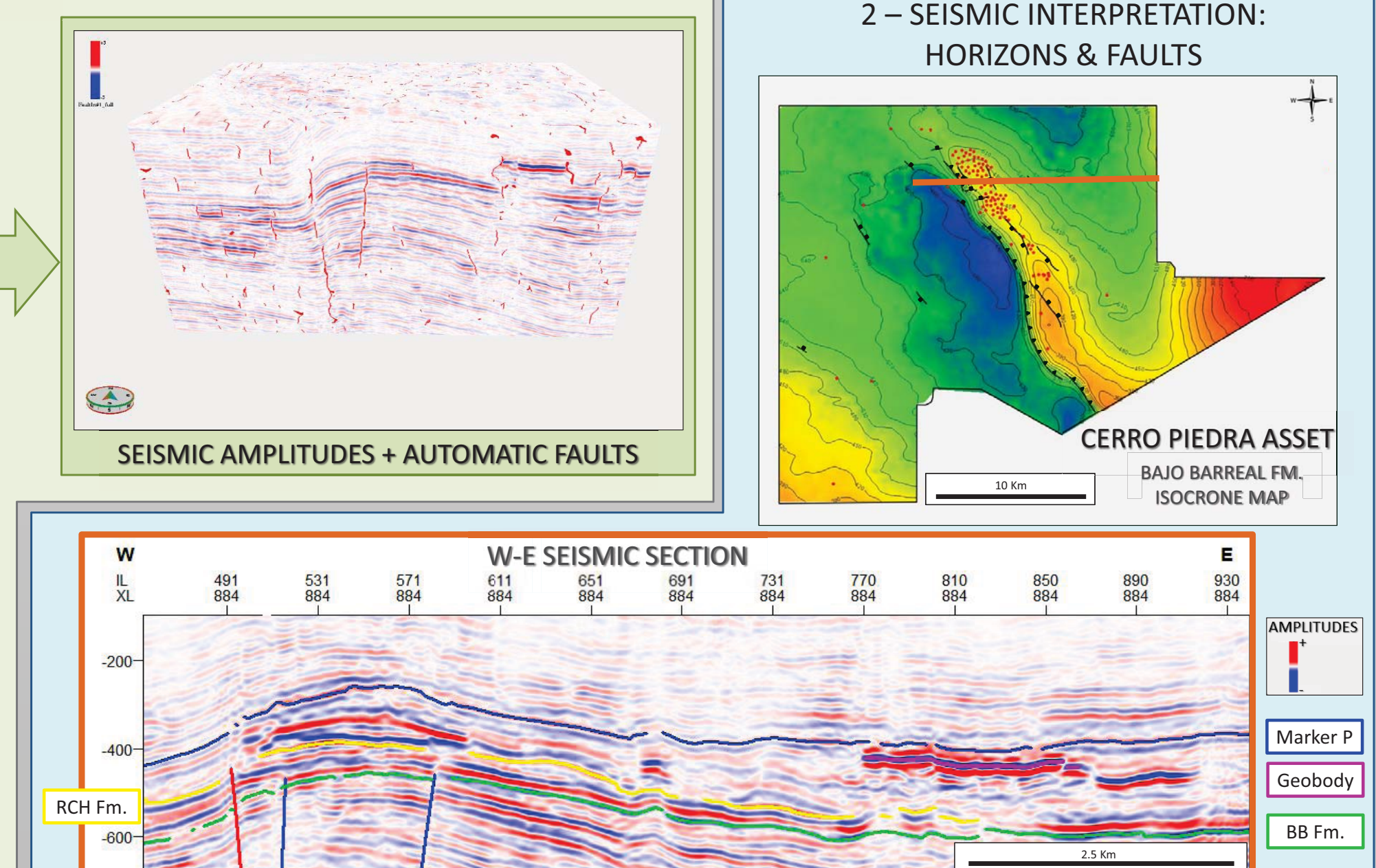
SCHEMATIC STRATIGRAPHIC COLUMN (MODIFIED FROM PAREDES ET AL., 2005)

DATA CONDITIONING & SEISMIC INTERPRETATION

1 – VOLUME BASED STRUCTURAL SEMI-AUTOMATIC WORKFLOW



2 – SEISMIC INTERPRETATION: HORIZONS & FAULTS



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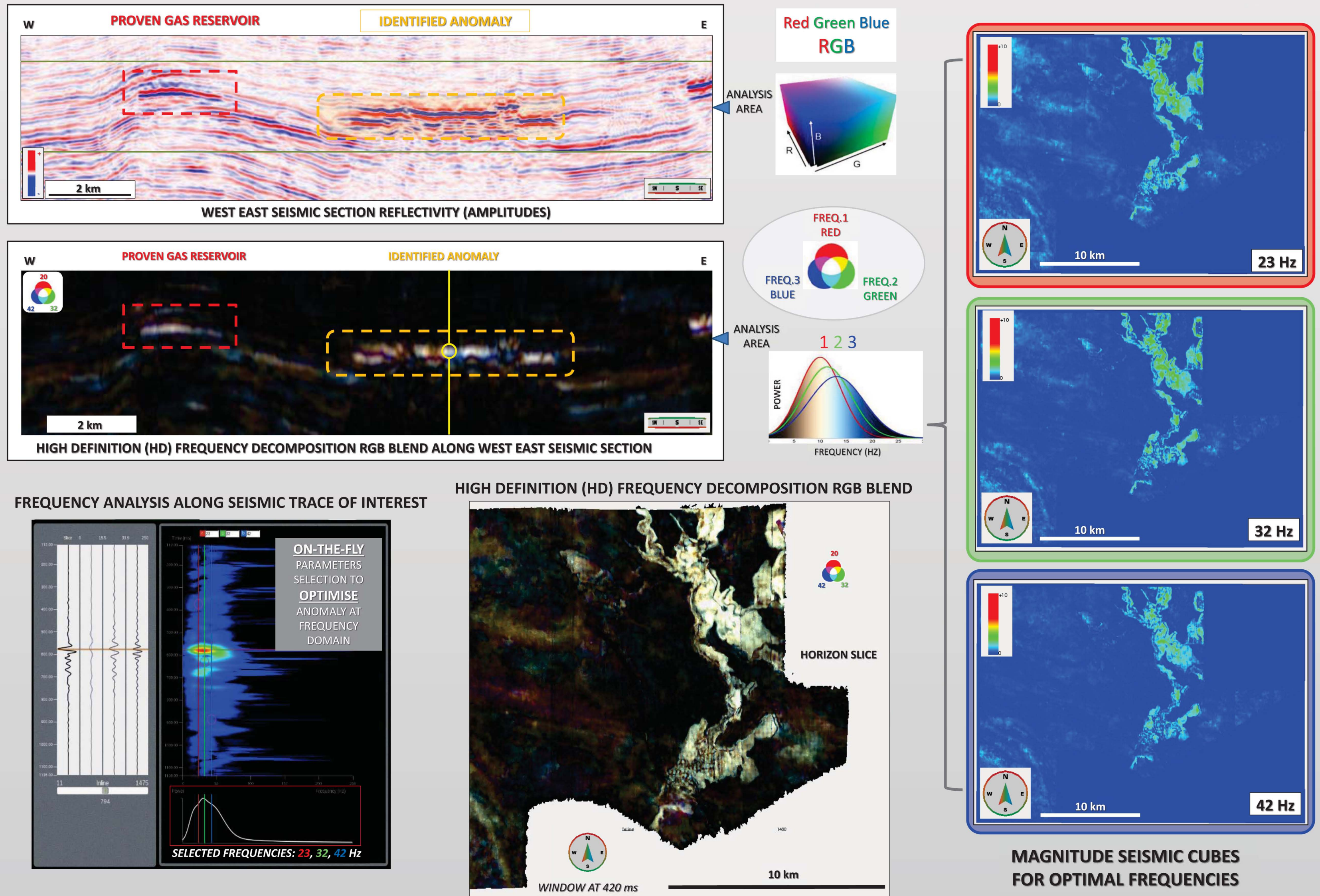
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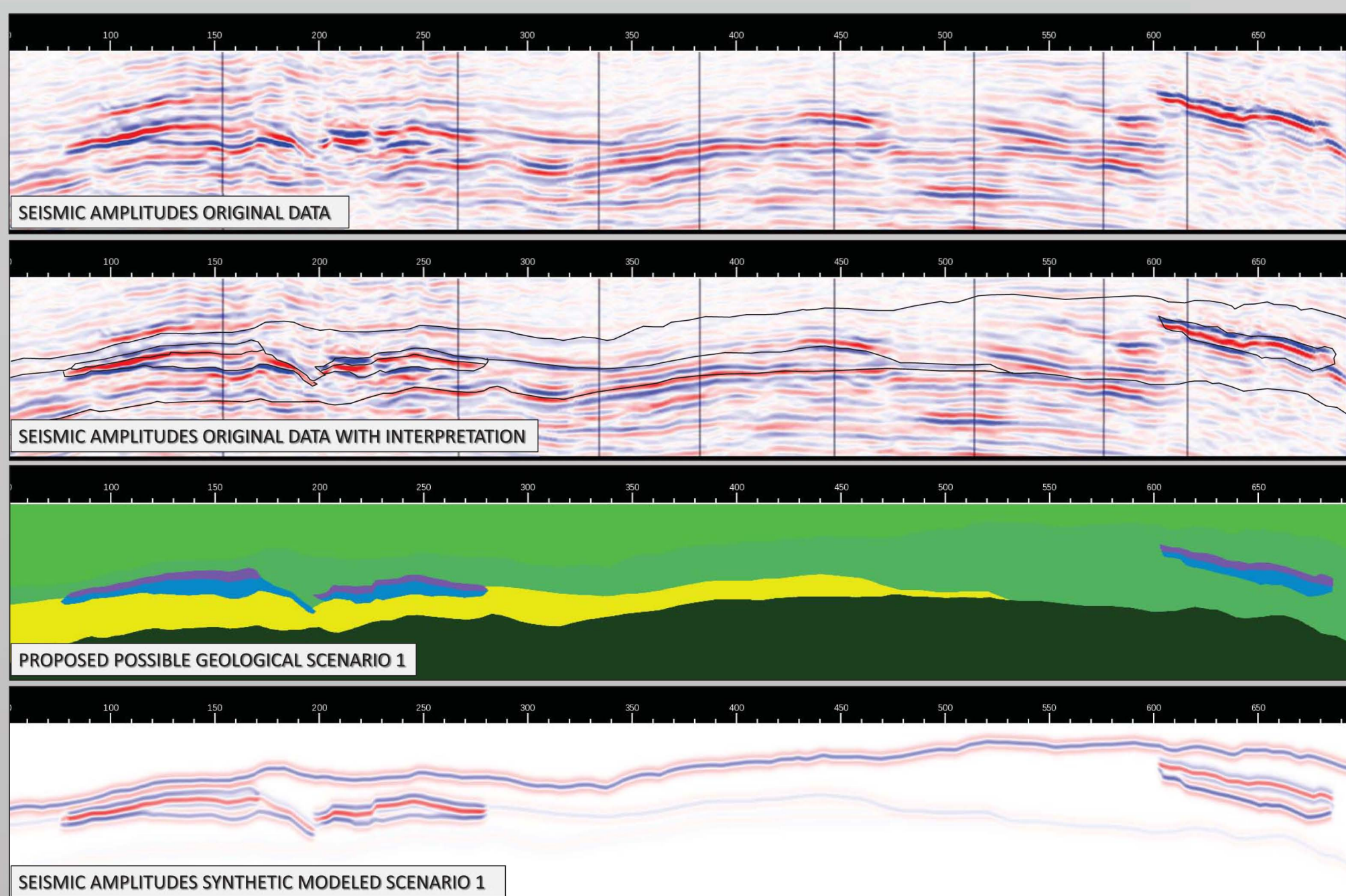
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3- CASE STUDY. CERRO PIEDRA. WESTERN SAN JORGE BASIN, ARGENTINA (CONT.)

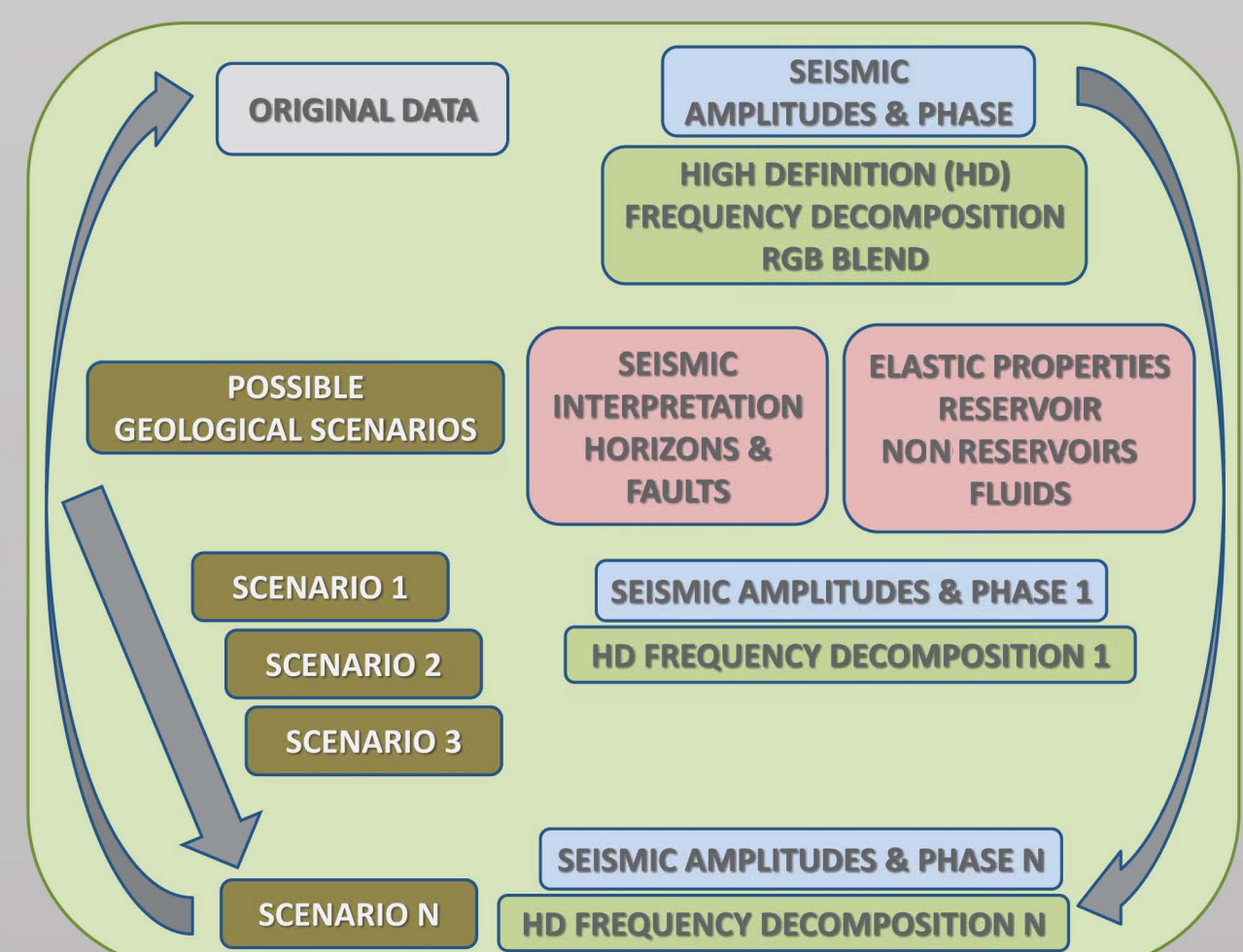
FREQUENCY DECOMPOSITION: METHODOLOGY TO CREATE THE “RGB BLEND” CUBE OF OPTIMUM FREQUENCIES



POSSIBLE GEOLOGICAL SCENARIOS & “VALIDATE” WORKFLOW



CLOSE THE LOOP: TESTING & VALIDATION OF ALTERNATIVE POSSIBLE GEOLOGICAL SCENARIOS IN TERMS OF AMPLITUDES, PHASE & FREQUENCY UNTIL THE SYNTHETIC MODELED RESULTS HAVE A “HIGH CORRELATION” WITH THE SEISMIC & FREQUENCY DECOMPOSITION ACTUAL DATA



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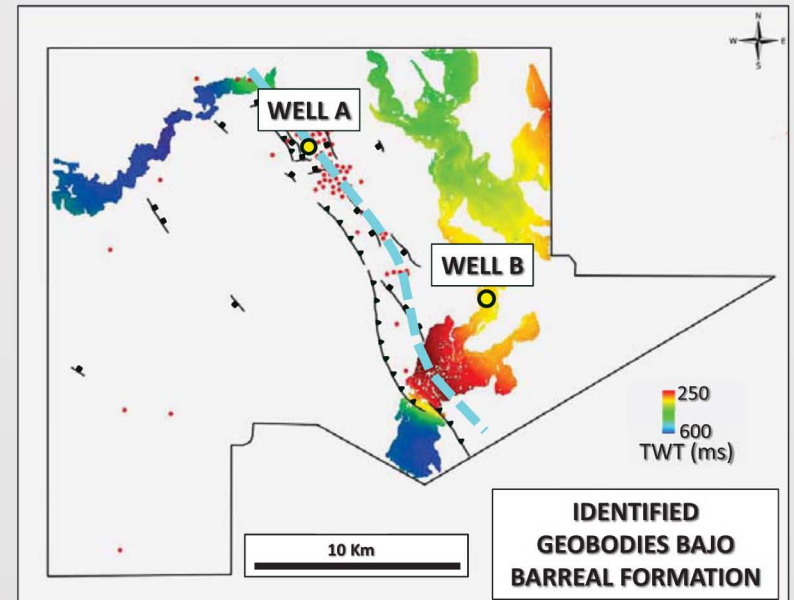
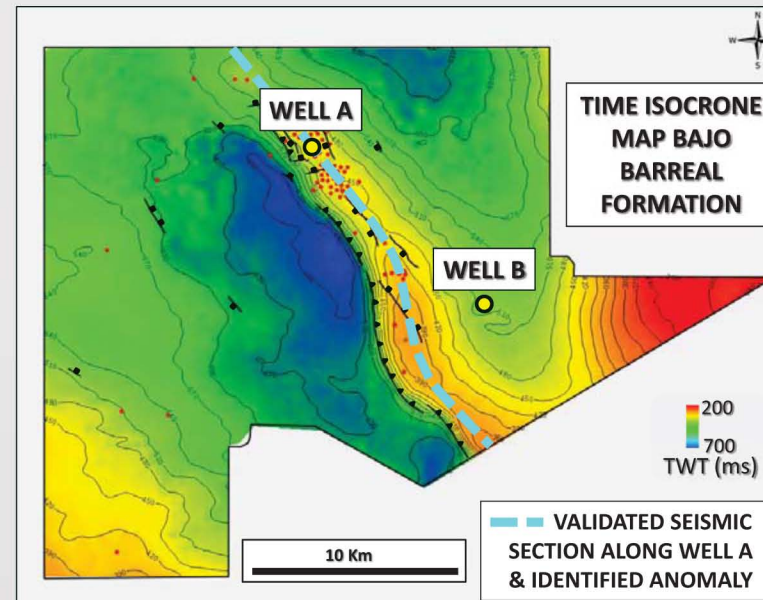
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3- CASE STUDY. CERRO PIEDRA. WESTERN SAN JORGE BASIN, ARGENTINA (CONT.)

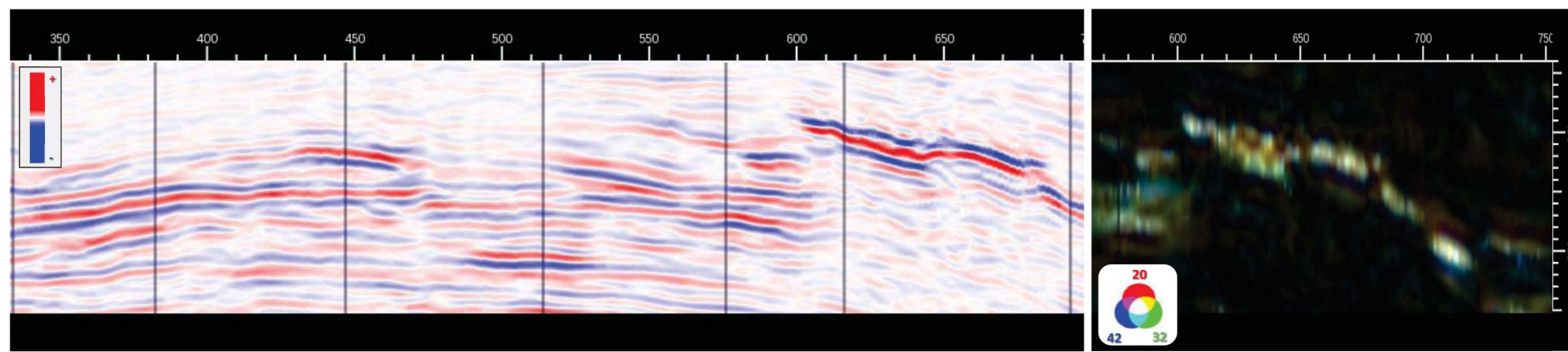
POSSIBLE ALTERNATIVE SCENARIOS & VALIDATE WORKFLOW

REQUESTED INPUT FROM CALIBRATION WELLS AND/OR ANALOGUES: ELASTIC PROPERTIES RESERVOIR, NON RESERVOIRS	ROCK PROPERTIES (VP, VS, DENSITY) FROM CALIBRATION WELLS OR ANALOGUES	
		OVERBURDEN
		CLAY
		RIO CHICO FORMATION
		BAJO BARREAL FORMATION
		GAS SATURATED RESERVOIR
		WATER SATURATED RESERVOIR
		GEOBODY

CALIBRATION IS CRUCIAL IN THE ABSENCE OF WELLS, **ANALOGUES** MAY BE USED. FOR **CERRO PIEDRA TERTIARY** RESERVOIRS, THE **ZABALA FIELD** LOCATED 30KM AWAY COULD BE USED

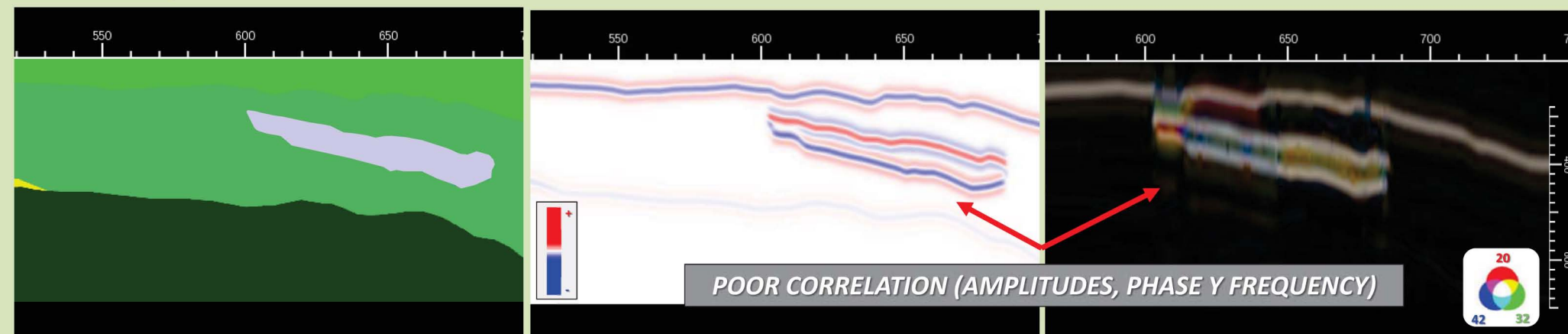


ORIGINAL SEISMIC DATA: REFLECTIVITY (AMPLITUDES & PHASE), HD FREQ DECOMPOSITION RGB BLEND

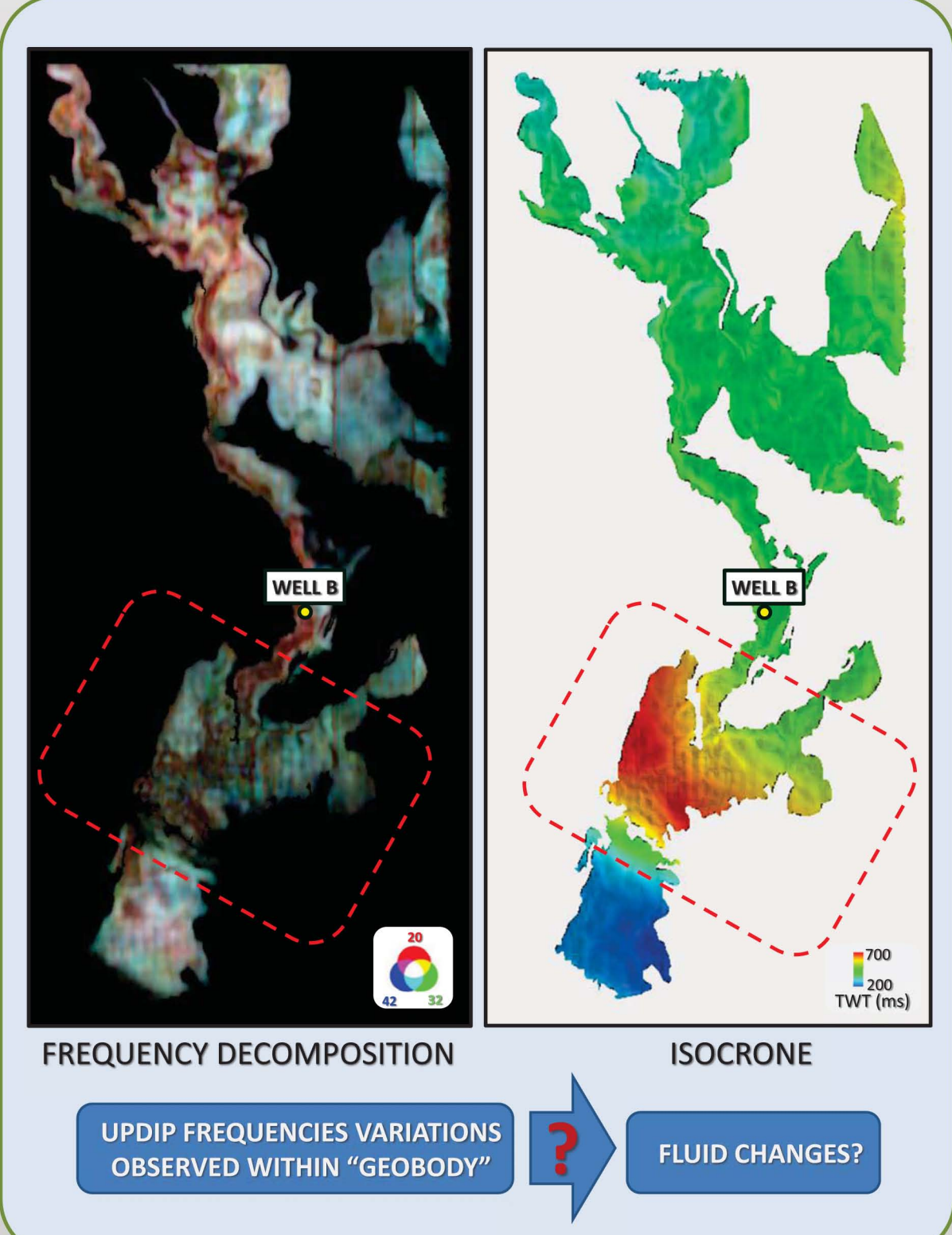
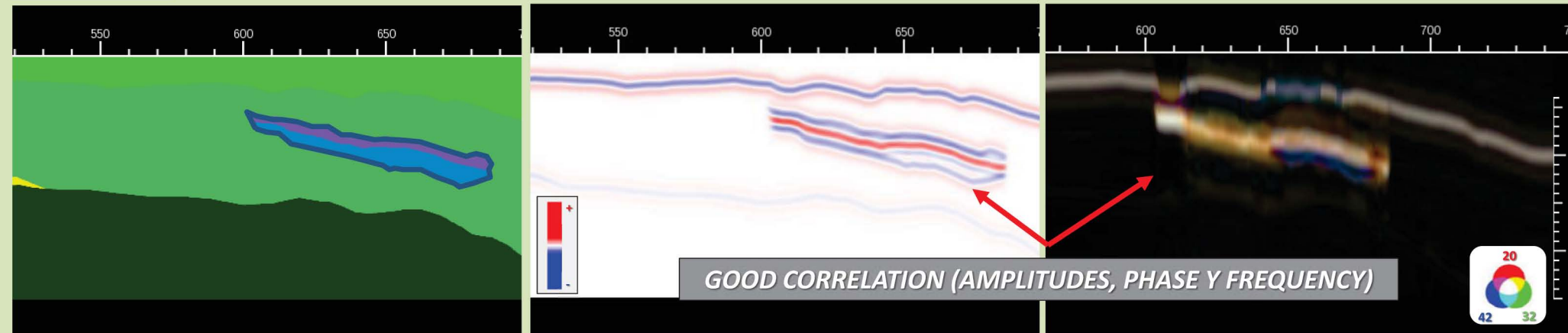


"ON-THE-FLY" POSSIBLE GEOLOGICAL SCENARIOS TESTING: MODEL, REFLECTIVITY, HD RGB BLEND

SCENARIO 1: WATER SATURATED "POOR" RESERVOIR GEOBODY



SCENARIO 2: GAS & WATER SATURATED "GOOD" RESERVOIR GEOBODY



NEXT STEPS – FOLLOWING WORK

- "GEOBODY" VOLUMEN DETECTION & EXTRACTION, VOLUMETRIC CALCULATION FOR POTENTIAL FURTHER DEVELOPMENT OF **GAS** RESERVOIRS.
- **DETAILED MODELLING** WITH **EXTRA THINNER LAYERS** TO **VALIDATE** GEOBODY'S INTERNAL **AMPLITUDES & FREQUENCIES** VARIATIONS.
- **FREQUENCY ANALYSIS** WITHIN "GEOBODY" AS A POSSIBLE **FLUID INDICATOR** FOR BOTH THE COARSE AND DETAILED POSSIBLE SCENARIOS.
- APPLICATION OF **PROPOSED WORKFLOW** TO ADDITIONAL **IDENTIFIED ANOMALIES** WITHIN THE ASSET & NEARBY ASSETS OF THE BASIN.

4- CONCLUSIONS & RECOMENDATIONS

- **TECHNOLOGY** ALLOWS A **MORE EFFICIENT** USE OF POWERFUL ALGORITHMS, SUCH AS **VISUALIZATION & COMBINATIONS OF ATTRIBUTES**.
- **FREQUENCY DECOMPOSITION** FILTERS THE SEISMIC DATA INTO ITS FREQUENCY BANDPASS COMPONENTS.
 - COMBINATION OF THREE MAGNITUDE VOLUMES (LOW, MID, HIGH INTO **RED, GREEN, BLUE**) TO **MAXIMIZE** THE USE OF WIGGLES, AMPLITUDES & FREQUENCIES TO BETTER DESCRIBE BOTH THE **THICKNESS & LITHOLOGY VARIATION OF LAYERS**.
- **CLOSE THE LOOP** TO **VALIDATE** THE **PROPOSED POSSIBLE GEOLOGICAL SCENARIOS** IS **CRUCIAL** TO **REDUCE UNCERTAINTIES** OF **OPPORTUNITIES**.
 - SYNTHETIC MODELLED RESULTS **ARE COMPARED** WITH THE ACTUAL **SEISMIC & FREQUENCY DECOMPOSITION** RGB BLEND.
- THE **PROPOSED WORKFLOW** WAS APPLIED TO THE **UNDER DEVELOPED TERTIARY RESERVOIRS** WITHIN THE **CERRO PIEDRA ASSET**, WESTERN FLANK OF THE SAN JORGE BASIN, ARGENTINA AND WILL BE REPLICATED IN NEARBY ASSETS OF THE BASIN.
- THIS WORK **DEMONSTRATES** THE **ADDED VALUE** OF APPLYING **SEISMIC GEOMORPHOLOGY BY FREQUENCY DECOMPOSITION WITH VALIDATION** TO **REDUCE UNCERTAINTIES** IN IDENTIFIED POTENTIAL OPPORTUNITIES FOR FURTHER DEVELOPMENT IN A MATURE BASIN.

5- ACKNOWLEDGEMENTS

WE WOULD LIKE TO THANK THE CERRO PIEDRA SUBSURFACE TEAM FOR THEIR CONTRIBUTIONS, L. GOMEZ FOR HIS VALUABLE COLABORATION IN THE APPLICATION OF THE "VALIDATE" WORKFLOW AND YPF S.A. FOR THE PERMISSION TO PRESENT THIS WORK.