# PS Seismic Geomorphology by Spectral Decomposition Volume Interpretation for Basin-Scale Depositional System Delineation, Cuyo Group, Argentina*

**Teresa Santana[1], Daniel L. Sanchez[1], and Walter Brinkworth[1]**

Search and Discovery Article #42257 (2018)**
Posted August 13, 2018

*Adapted from poster presentation given at AAPG 2018 AAPG Annual Convention and Exhibition, Salt Lake City, Utah, May 20-23, 2018


[1]Subsurface Integrated Studies, E&P YPF S.A., Buenos Aires, Argentina (teresa.santana@ypf.com)

## Abstract

Spectral decomposition analyzes a given signal by the summation of simple, well defined basis functions. The spectral content of seismic data is influenced by the acoustic properties in the Earth, and therefore significant information can be gained from the analysis of the seismic at different frequencies through spectral decomposition during seismic interpretation (Partyka et al, 1999). The ability to examine and compare the response at different frequency bands is critical to obtain information that otherwise is difficult to visualize on the full bandwidth data (Chopra et al, 2007). Volumetric RGB (Red-Green-Blue) blend of the optimum frequency cubes (Hall and Trouillot, 2004) rapidly assess and highlight the presence of geological features present in the seismic data. Seismic geomorphology facilitates the study of the subsurface by the extraction of geomorphologic insights from 3D seismic data (Posamentier et al, 2005).

The Cuyo Group is an Early to Middle Jurassic siliciclastic sedimentary sequence in the Neuquén Basin western Argentina, bounded by two regional unconformities (Intra Liassic and Intra Callovian at base and top respectively) that reaches 2500 meters of thickness and includes several transgressive-regressive cycles associated to thermal subsidence, the paleo-Pacific Ocean connection and a continuous contribution of sediments (Dellapé et al, 1979).

3D seismic and chronostratigraphic regional interpretation (nine sedimentary cycles) for the Cuyo Group were conditioned for spectral decomposition, as seismic data quality and interpretation have significant impact in the results. Individual surveys (+20) were analyzed and regionally integrated.

Canyons filled with channels of different geometries and sizes are clearly identified in the slope, while fans are observed in the deep-water area. Seismic geomorphology using spectral decomposition volume-based interpretation allows the connection of channels in the platform, canyons in the slope, and fans in the deep-water area used to populate its sedimentary cycle facies maps.

This study demonstrates the added value of spectral decomposition volume interpretation to better delineate the depositional system for the Cuyo Group in Argentina as input to future explorations efforts in the basin.

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Posamentier, H., P. Laurin, A. Warmath, and A. Mehlhop, 2005, Seismic Geomorphology of Mid-Oligocene to Miocene Carbonate Buildups, Offshore Madura, Indonesia: Landforms, Depositional Environments, and Basin Fill Analysis: Program Abstracts, AAPG 2005 Annual Convention and Exhibition, Calgary, Alberta, June 16-19, 2005, Search and Discovery Article #90039. Website accessed July 2018.

# SEISMIC GEOMORPHOLOGY BY SPECTRAL DECOMPOSITION VOLUME INTERPRETATION FOR BASIN-SCALE DEPOSITIONAL SYSTEM DELINEATION. CUYO GROUP, ARGENTINA

*Teresa Santana*, Daniel Sanchez*, Walter Brinkworth**

** Subsurface Integrated Studies E&P YPF S.A. (teresa.santana@ypf.com)*

*AAPG ACE, SALT LAKE CITY – MAY 2018*




## ABSTRACT

Spectral decomposition analyzes a given signal by the summation of simple, well defined basis functions. The spectral content of seismic data is influenced by the acoustic properties in the earth, and therefore significant information can be gained from the analysis of the seismic at different frequencies through spectral decomposition during seismic interpretation (Partyka g. Et al, 1999). The ability to examine and compare the response at different frequency bands is critical to obtain information that otherwise is difficult to visualize on the full bandwidth data (chopra et al, 2007). Volumetric RGB (red-green-blue) blend of the optimum frequency cubes (Hall and Trouillot, 2004) rapidly assess and highlight the presence of geological features present in the seismic data. Seismic geomorphology facilitates the study of the subsurface by the extraction of geomorphologic insights from 3D seismic data (Posamentier et al, 2005).

The Cuyo group is an early to middle Jurassic siliciclastic sedimentary sequence in the Neuquén basin western Argentina, bounded by two regional unconformities (intra Liassic & intra Callovian at base & top respectively) that reaches 2500 meters of thickness and includes several transgressive-regressive cycles associated to thermal subsidence, the paleo-pacific ocean connection and a continuous contribution of sediments (Dellapé et al, 1979).

3D seismic and the Cuyo group´s chronostratigraphic regional interpretation (nine sedimentary cycles) were conditioned for spectral decomposition, as seismic data quality and interpretation have significant impact in the results. Individual surveys (+20) were analyzed and regionally integrated.

Canyons filled with channels of different geometries and sizes are clearly identified in the slope, while fans are observed in the deep water area. Seismic geomorphology using spectral decomposition volume based interpretation allows the connection of channels in the platform, canyons in the slope and fans in the deep water area used to populate its sedimentary cycle facies maps.

This study demonstrates the added value of spectral decomposition volume interpretation to better delineate the depositional system for the Cuyo group in Argentina as input to future explorations efforts in the basin.


## 1- OBJECTIVES

- **MAXIMISE THE IMPACT OF SEISMIC TO HELP *DELINEATE* THE GEOLOGICAL MODEL AT A BASIN SCALE**
- ***PROPOSE* METHODOLOGY TO SEARCH, INTERPRET AND EXTRACT 3D VOLUME GEOBODIES USING *SEISMIC SPECTRAL DECOMPOSITION***
- ***DEMONSTRATE* THE ADDED VALUE OF SPECTRAL DECOMPOSITION VOLUME INTERPRETATION TO BETTER DELINEATE THE DEPOSITIONAL SYSTEM FOR THE CUYO GROUP IN ARGENTINA**

### *PROPOSED WORKFLOW*

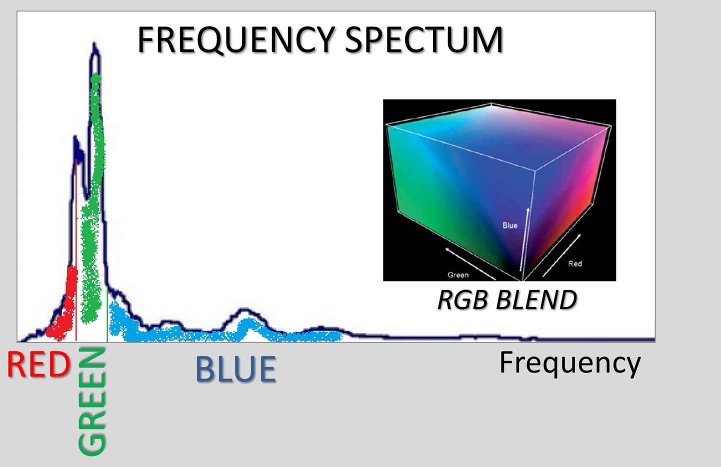
***1- GEOLOGICAL FEATURES IDENTICATION (SEISMIC AMPLITUDE)***
*SEISMIC SCANNING FOR ANOMALIES*
*SEISMIC INTERPRETATION CONDITIONING*
*SEISMIC FLATTENING*

***2- VOLUME BASED SPECTRAL DECOMPOSITION***
*"ON-THE-FLY"*
*PARAMETERS SELECTION*
*BLEND RGB OPTIMUM FREQUENCIES*

***3- GEOBODY DETECTION & EXTRACTION***
*"ON-THE-FLY" SEMI-AUTOMATED*
*INTERPRETATION BY CLUSTERS*
*GEOBODY CONVERSION TO HORIZONS*

***4- INTEGRATION INTO GEOLOGICAL MODEL FOR INTERPRETATION***
*DE-FLATTENING*
*INTEGRATION OF RESULTS*

### *SPECTRAL DECOMPOSITION "BLEND RGB"*

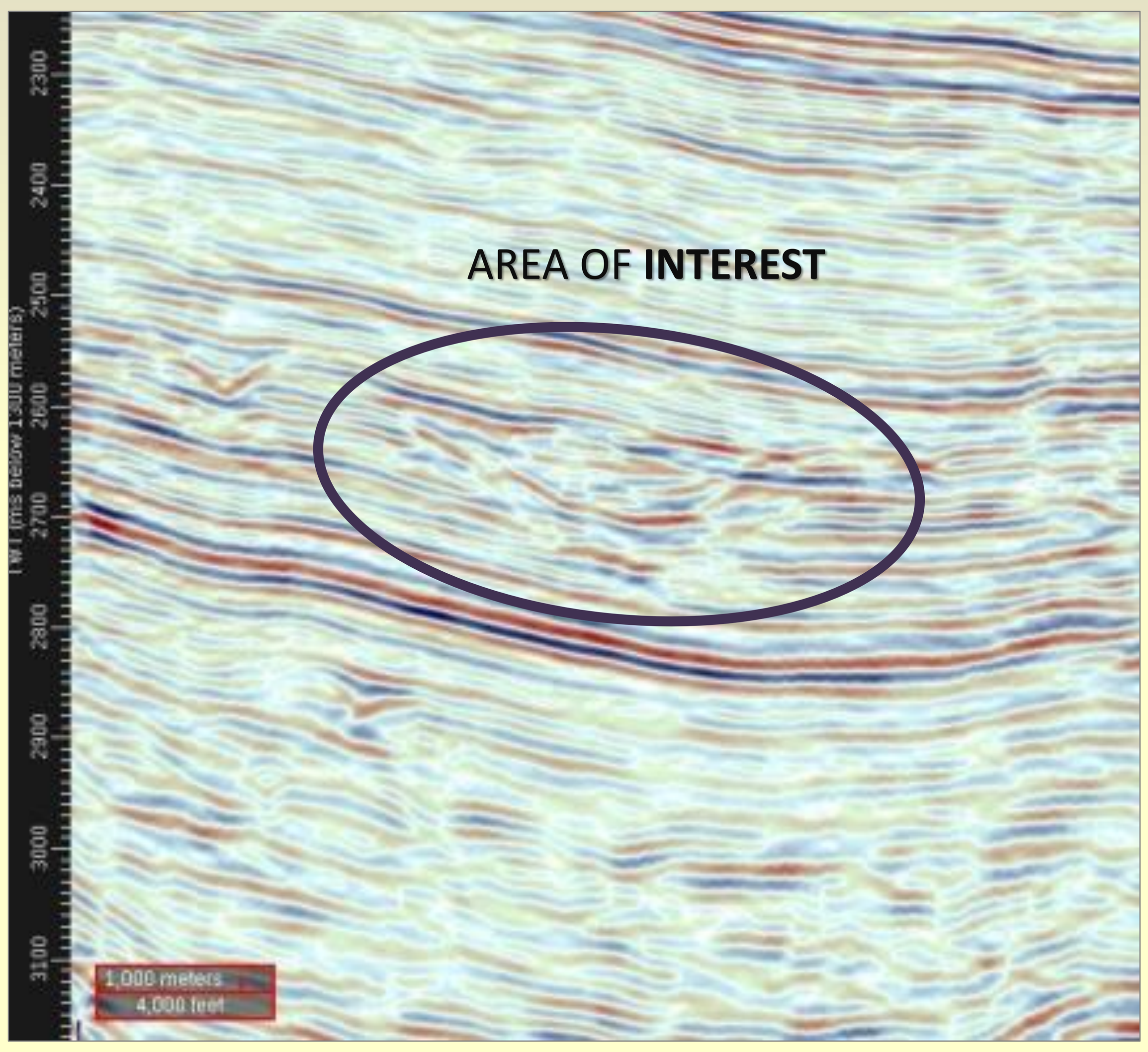



LOW, MID, HIGH FREQUENCIES OF SPECTRUM

**SPECTRAL CONTENT OF SEISMIC DATA IS INFLUENCED BY THE ACOUSTIC PROPERTIES IN THE EARTH**

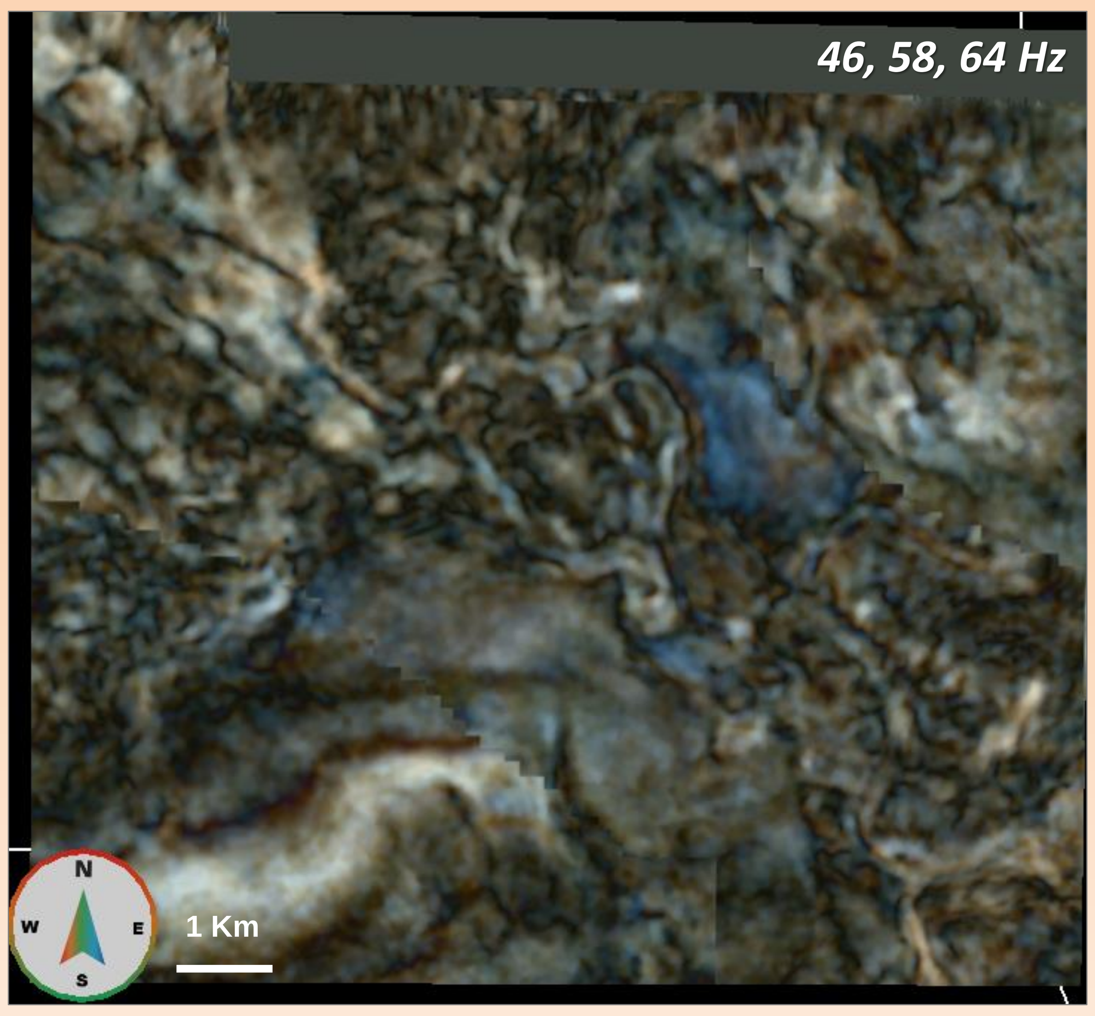
## 2- WORKFLOW & EXAMPLES

**1- GEOLOGICAL FEATURES IDENTIFICATION IN SEISMIC AMPLITUDE**



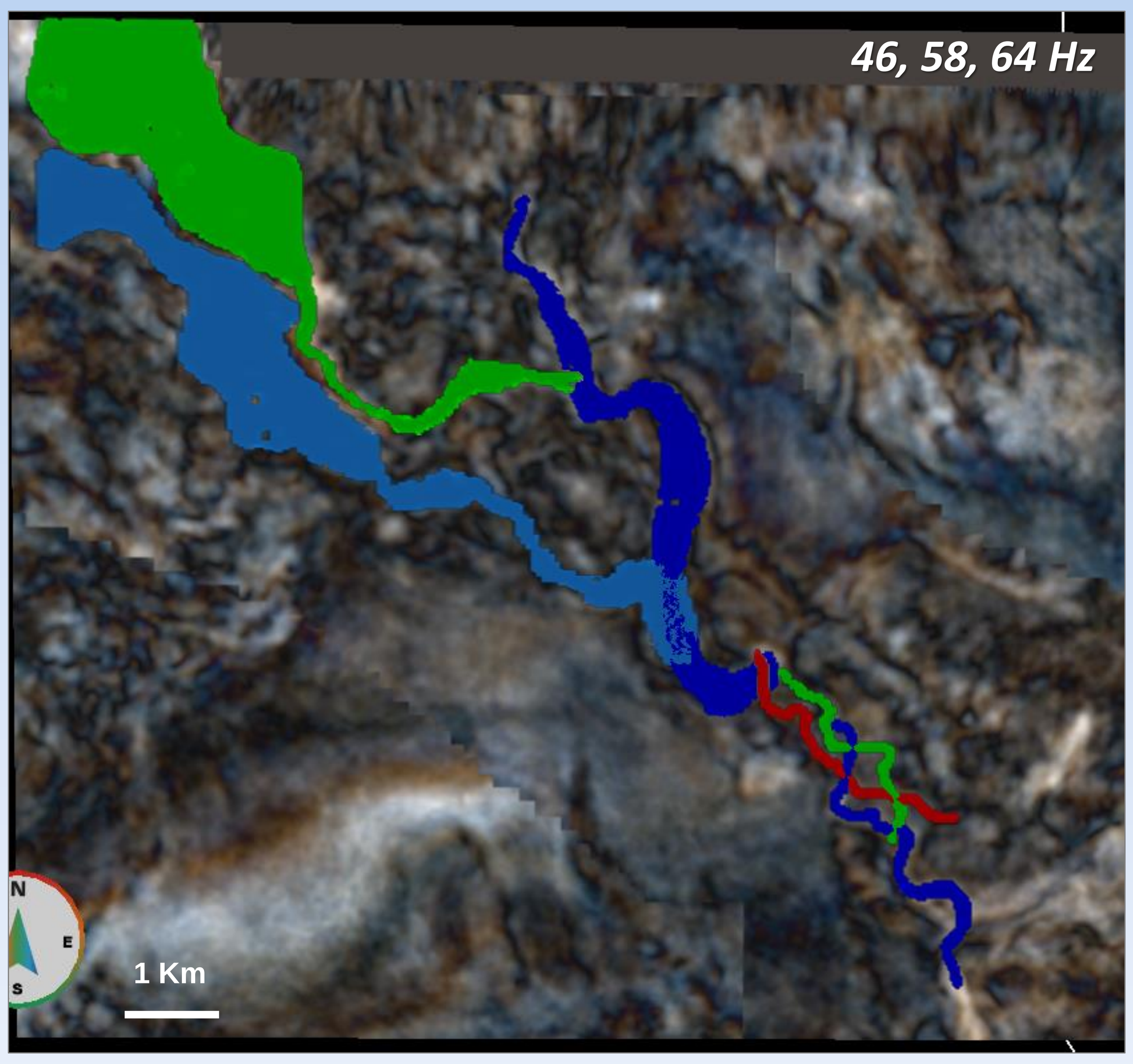

***QUICKLY SCAN SEISMIC AMPLITUDES TO DETECT POTENTIAL AREAS OF INTEREST***

**2- VOLUME BASED SPECTRAL DECOMPOSITION**

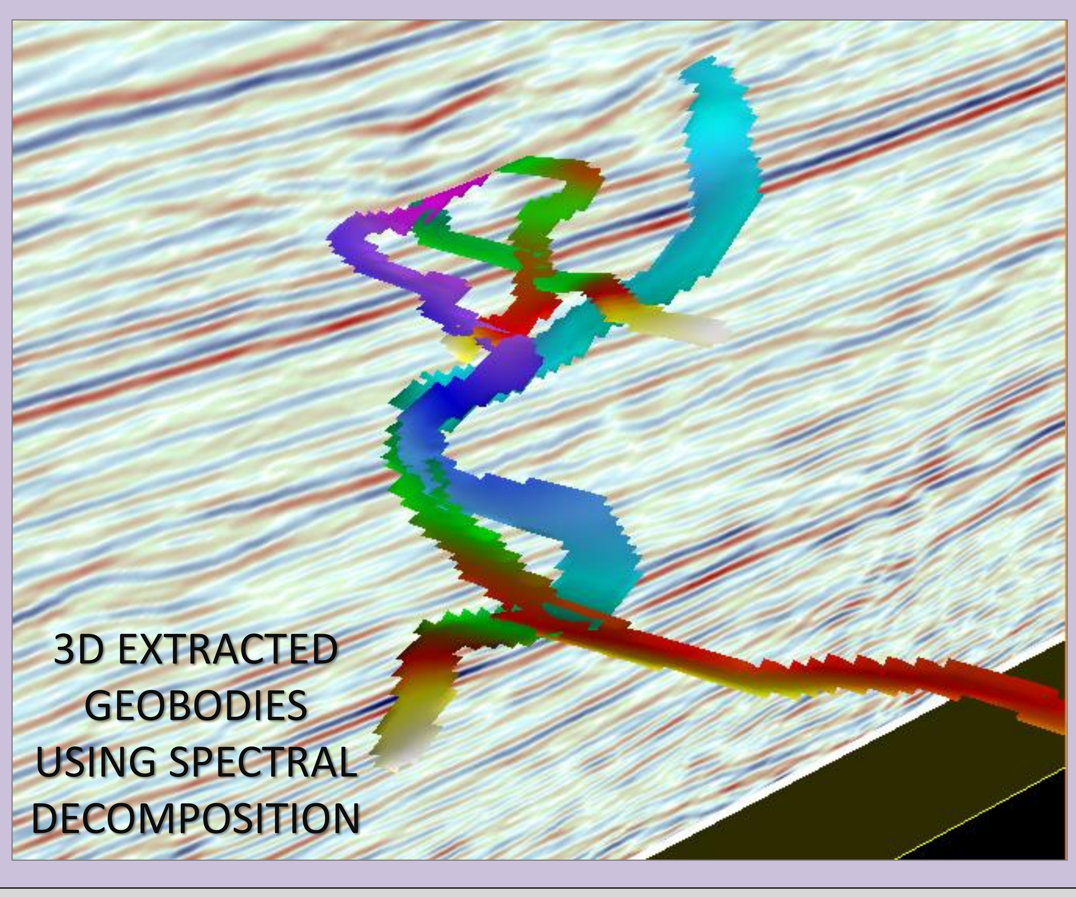



***VOLUME BASED SEMI-AUTOMATIC WORFLOW***

**3- GEOBODY DETECTION & EXTRACTION**




**4- INTEGRATION INTO THE GEOLOGICAL MODEL FOR INTERPRETATION**




***ALLOW THE SUBSURFACE TEAM TO EFFICIENTLY INTEGRATE RESULTS***

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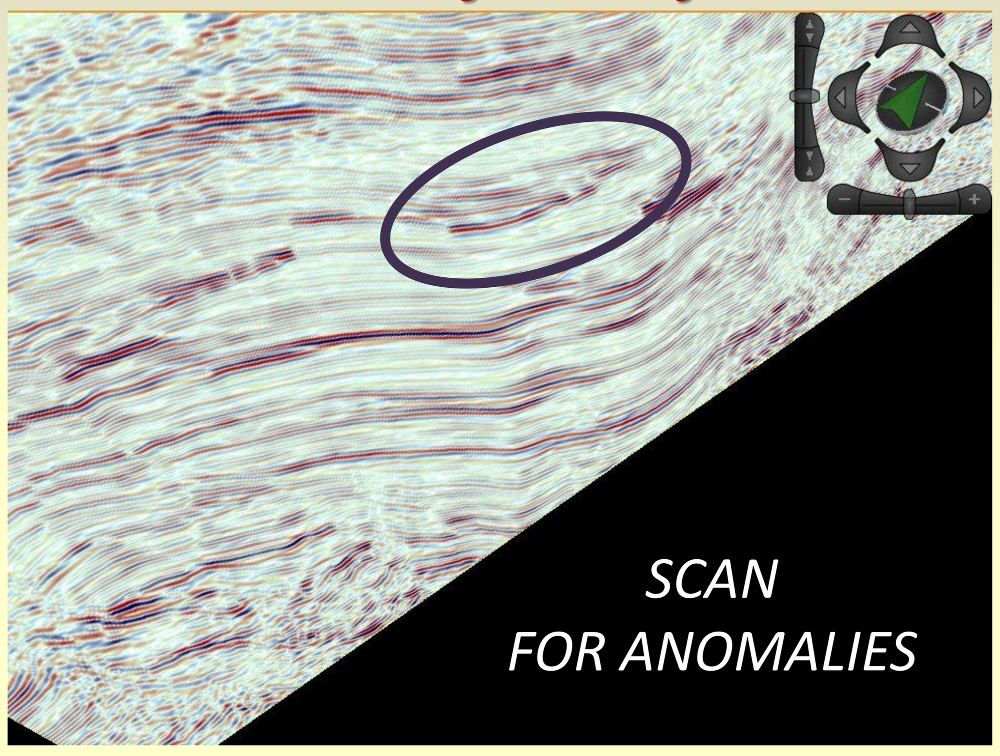
## 3- VOLUME BASED SPECTRAL DECOMPOSITION

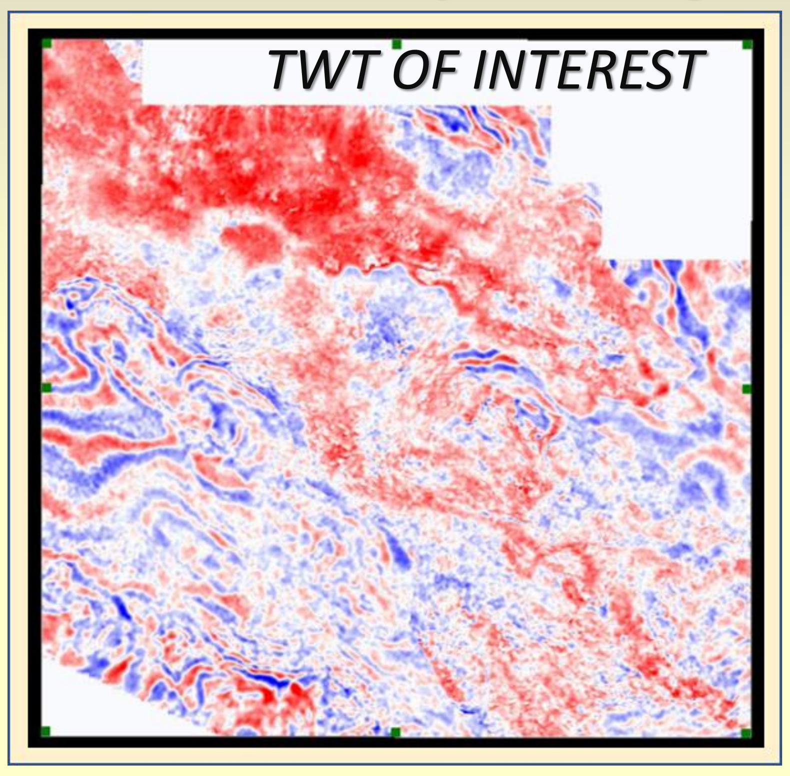
### METHODOLOGY TO CREATE "RGB BLEND" CUBE OF OPTIMUM FREQUENCIES

1- GEOLOGICAL FEATURES IDENTICATION | 2- VOLUME BASED SPECTRAL DECOMPOSITION

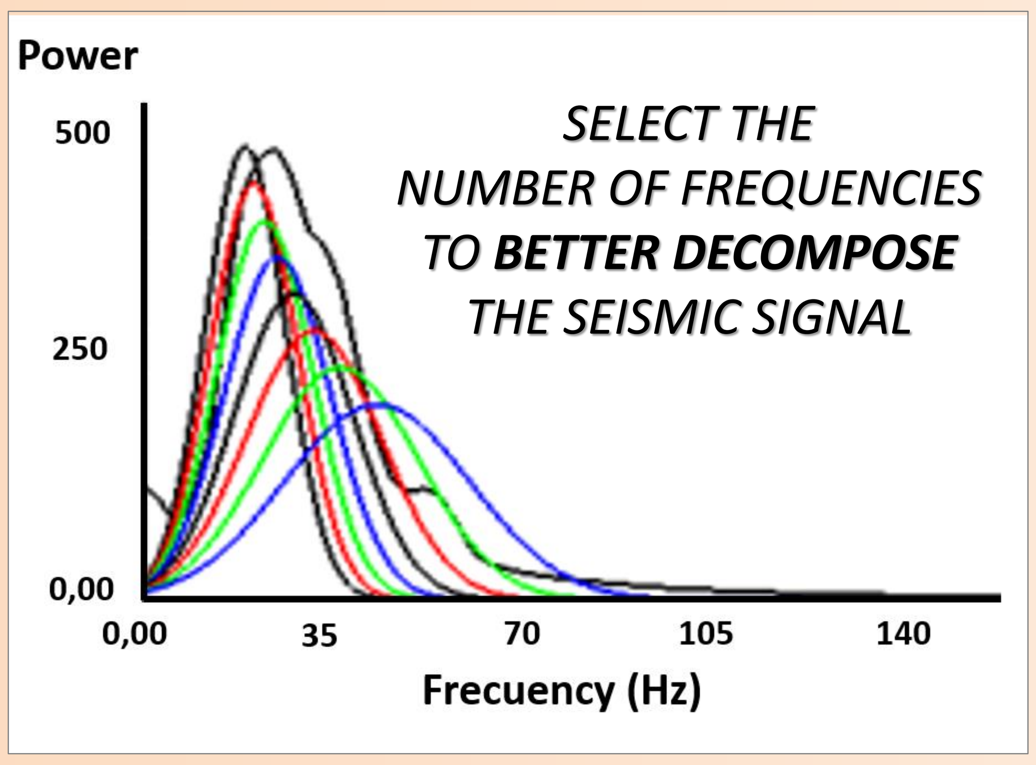
**A- Selection of area of interest**



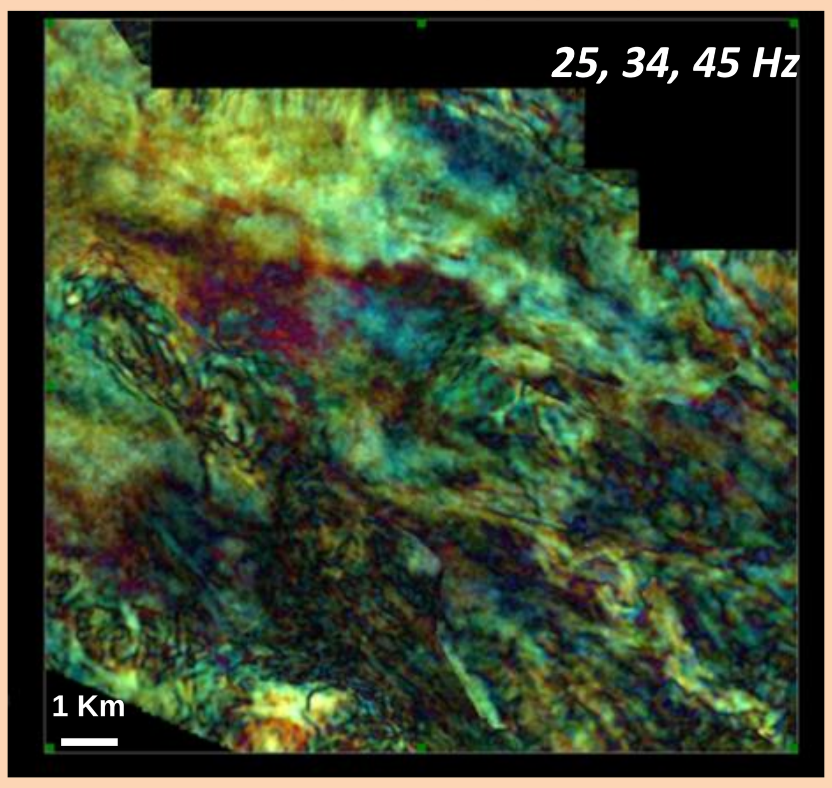

**B- Seismic flattening**




**C- "on-the-fly" frequency spectrum**

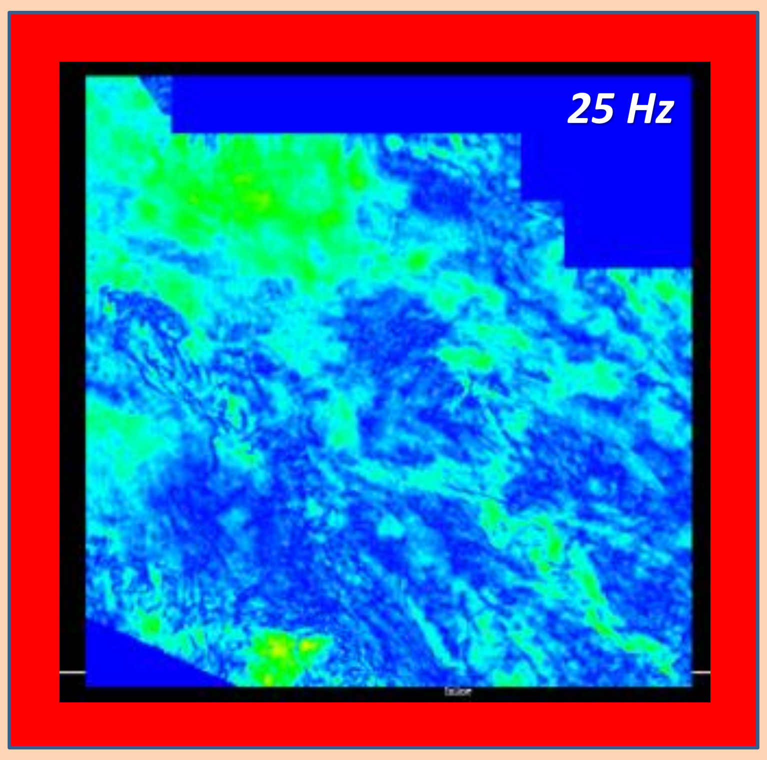



**E- "on-the-fly" RGB Blend selection**

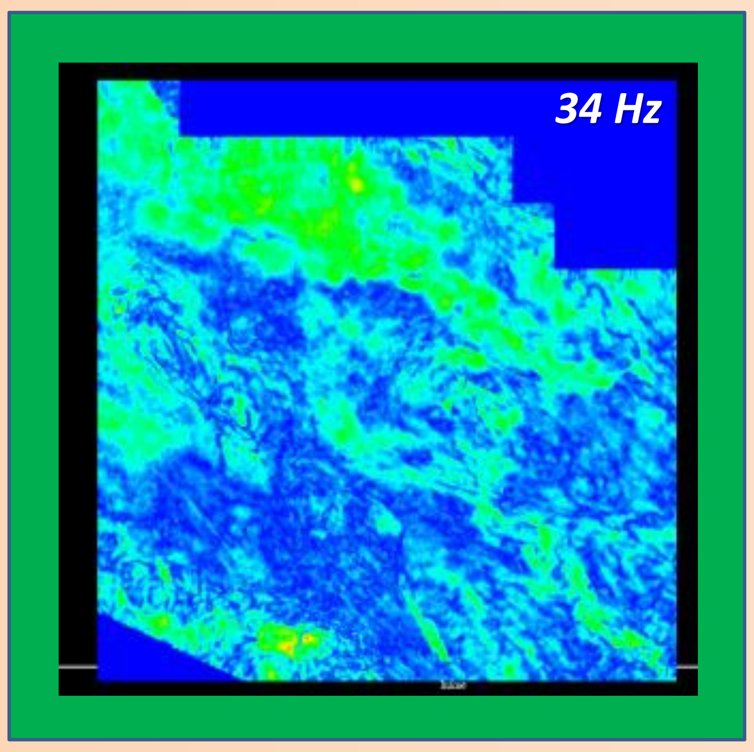



Optimum Frequencies

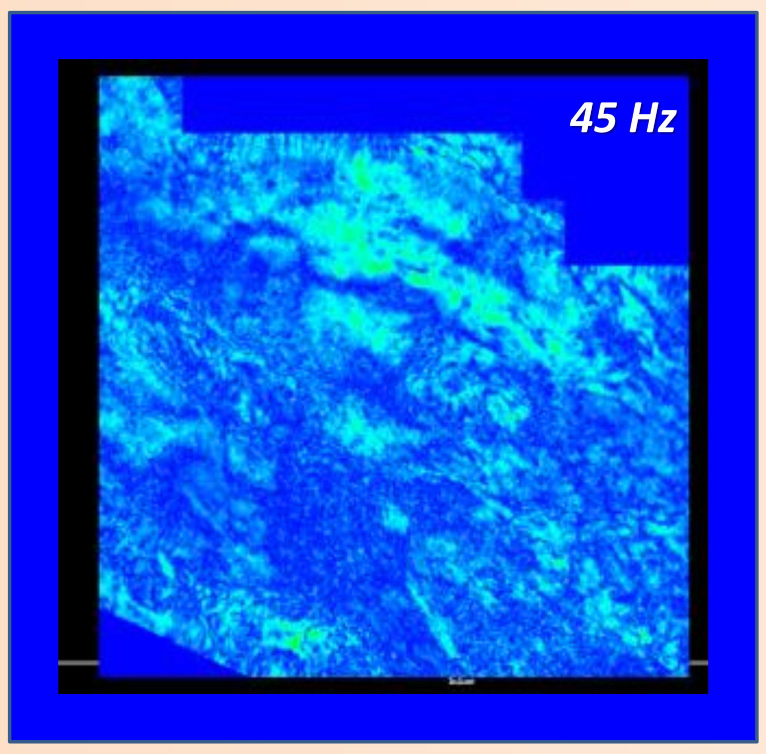
**D- Individual frequencies magnitude cubes**




Low (Red)




Medium (Green)

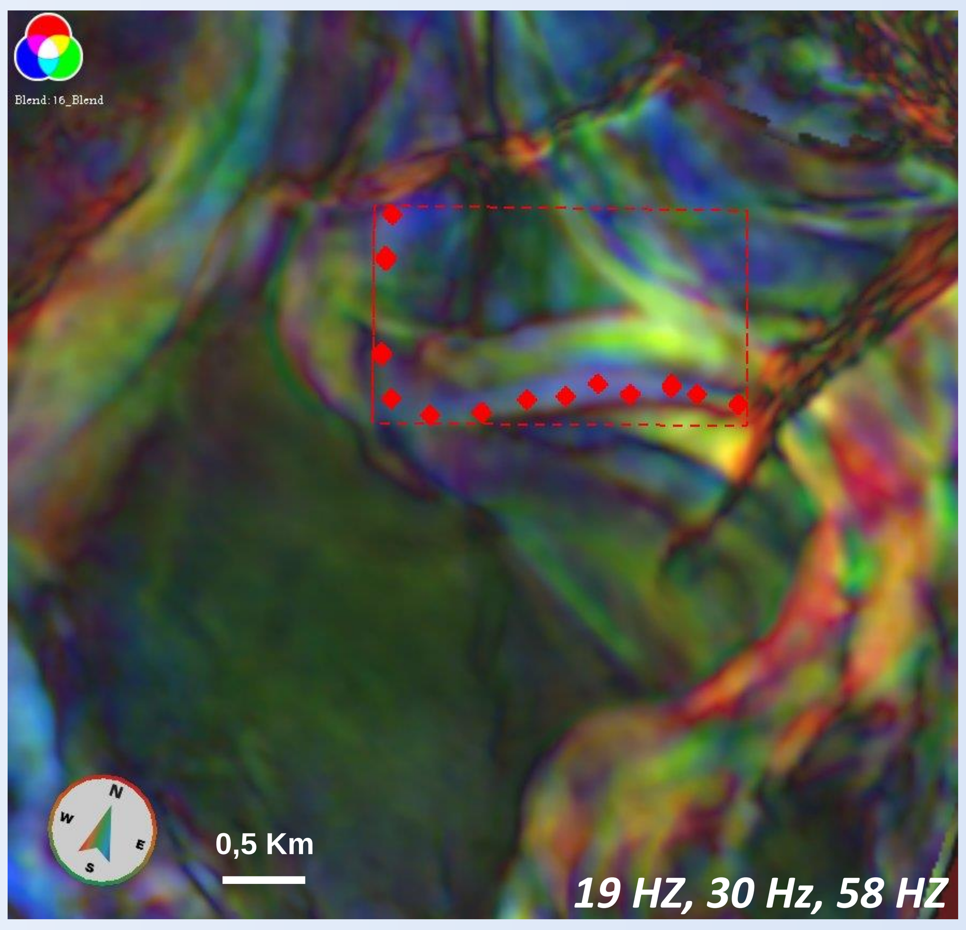



High (Blue)

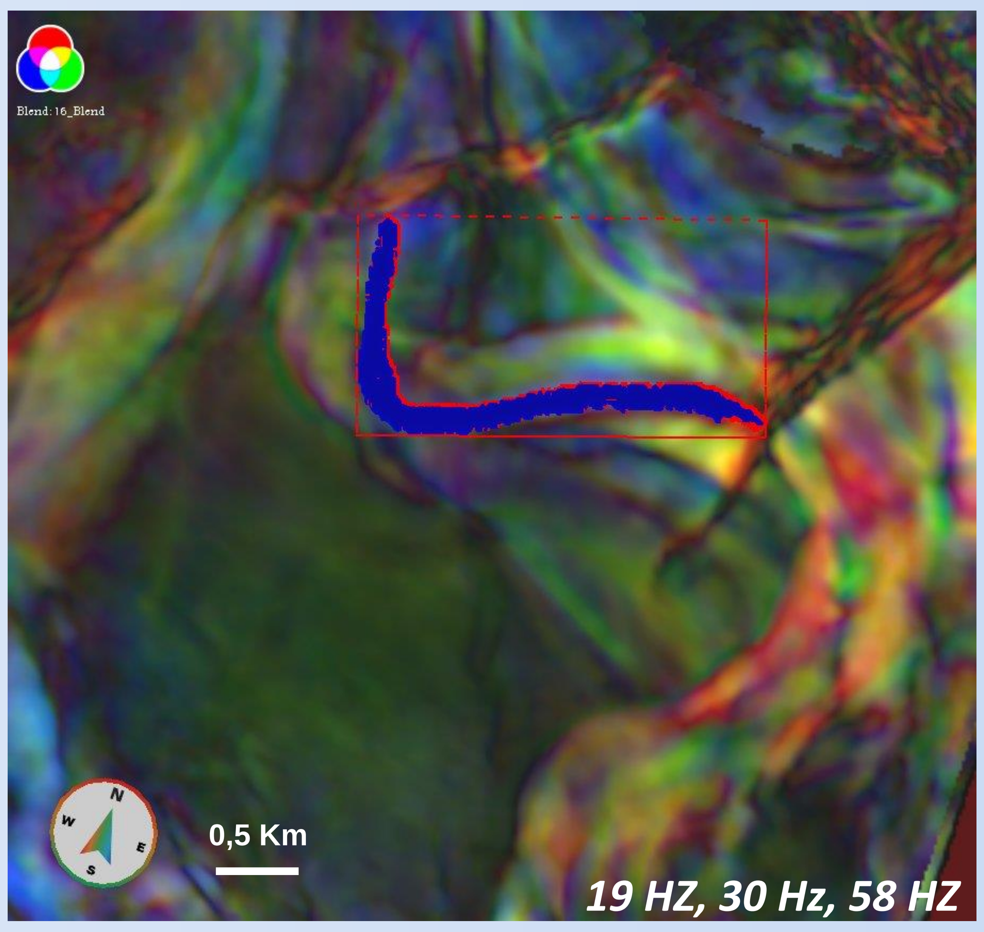
### GEOBODY DETECTION, EXTRACTION & INTEGRATION INTO MODEL

3- GEOBODY DETECTION & EXTRACTION | 4- INTEGRATION INTO GEOLOGICAL MODEL

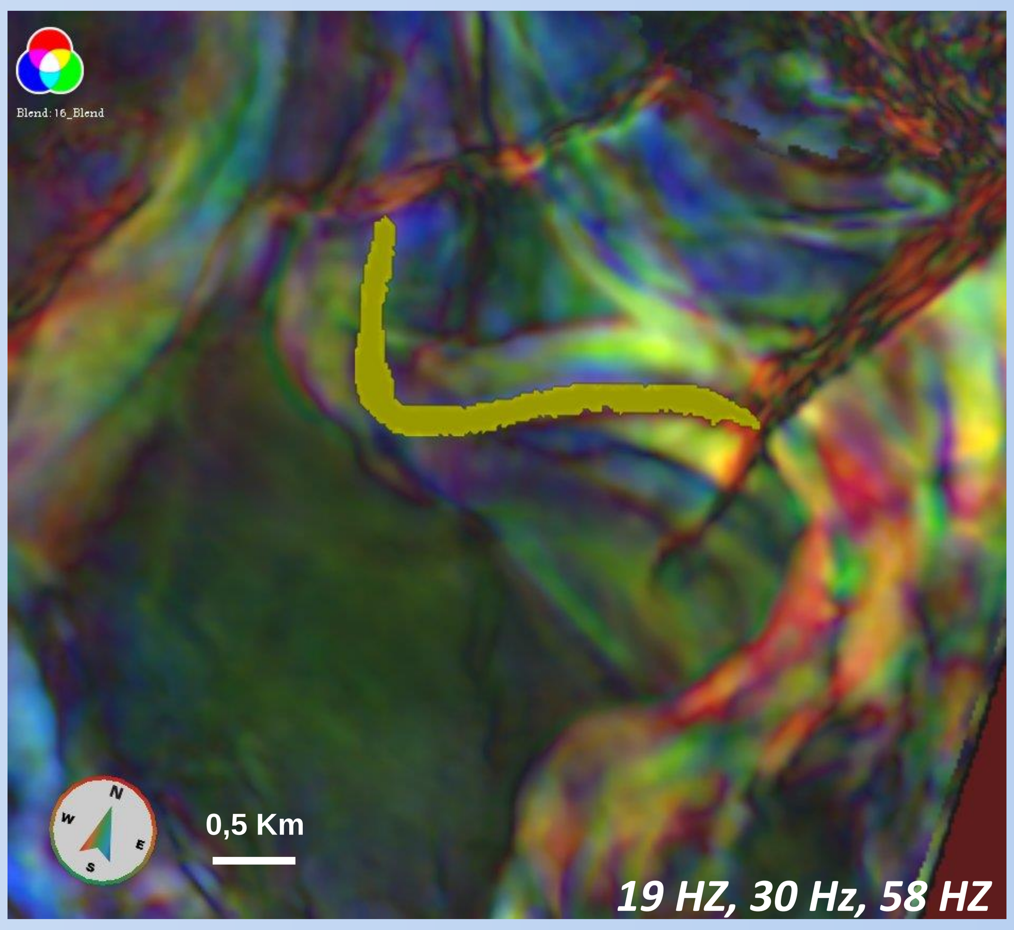
**A- Definition of "seeds"**



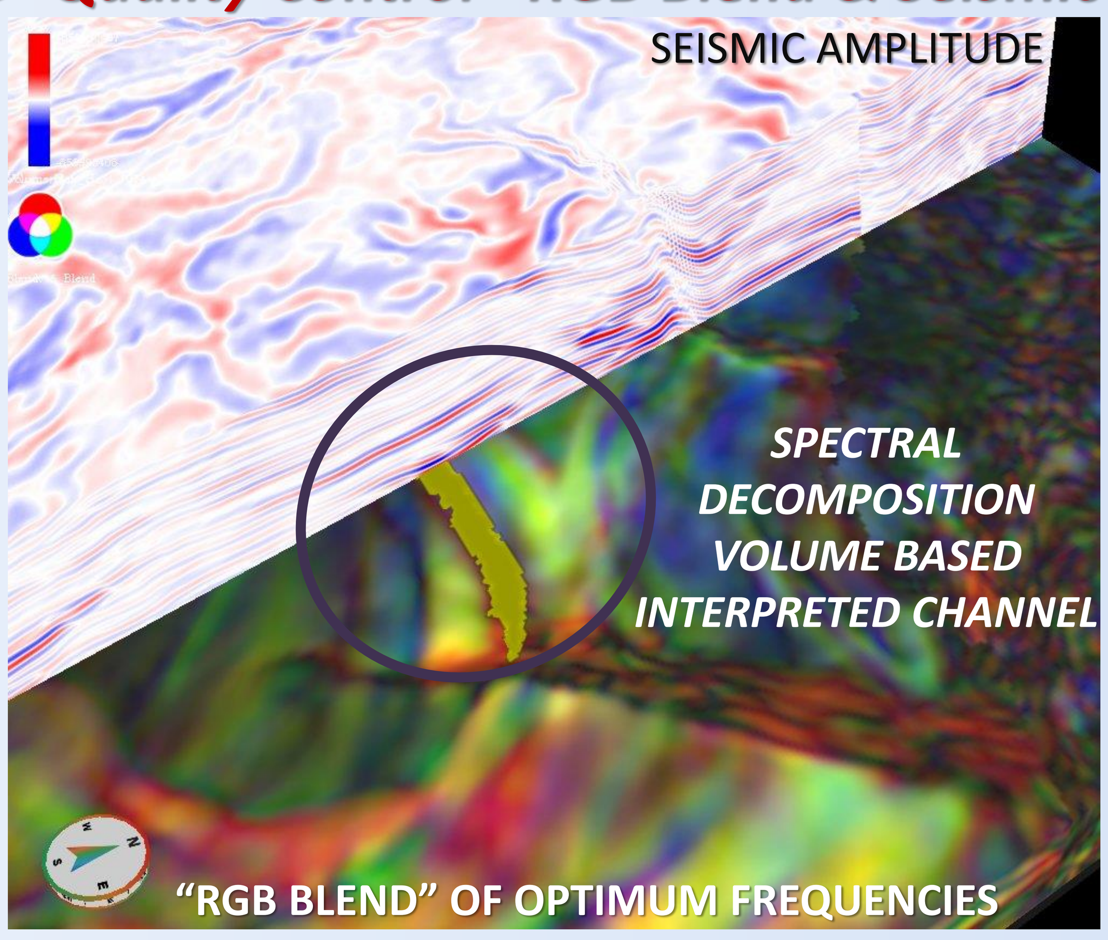

**B- Interactive geobody propagation**




**C- Semi-automated geobody interpretation**

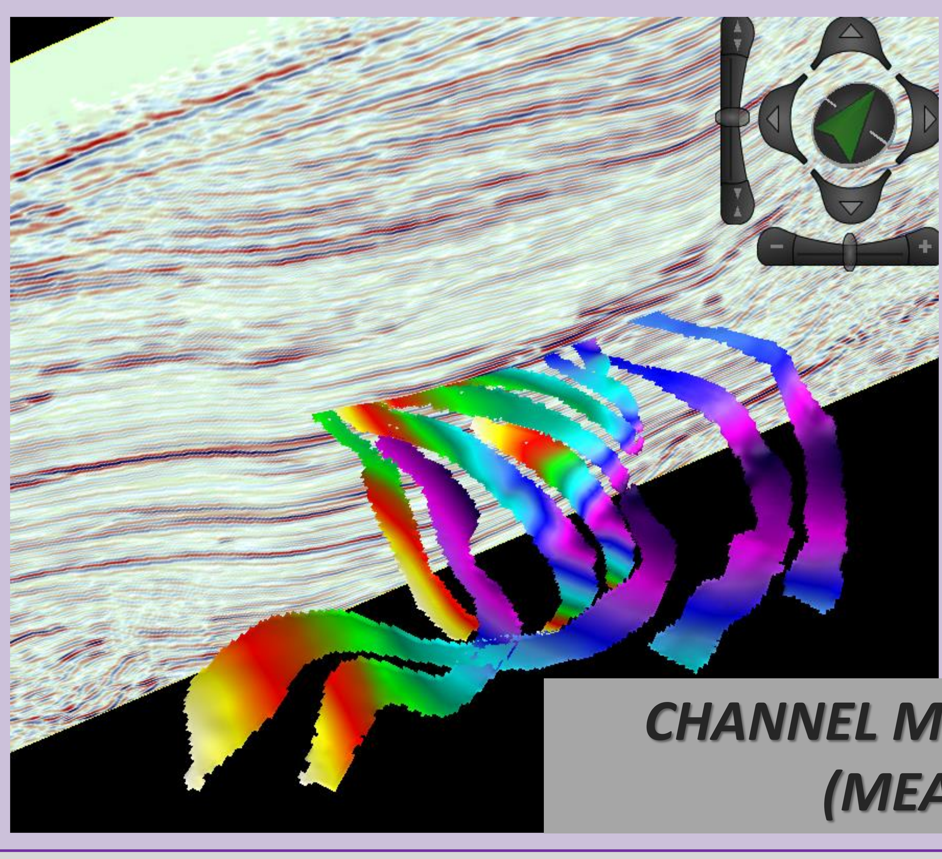



**D- Quality Control - RGB Blend & Seismic Amplitudes**




"RGB BLEND' AND SEISMIC AMPLITUDES SHOULD BE <u>CAREFULLY QUALITY CONTROLLED</u> BEFORE INSERTION OF GEOBODIES INTO THE GEOLOGICAL MODEL

**Insertion of geobodies into geological model for interpretation**



CHANNEL MIGRATION INTERPRETATION (MEANDERING SYSTEMS)

<u>DE FLATTENING OF GEOBODIES</u>

INTERPRETATION AND INTEGRATION OF RESULTS INTO THE GEOLOGICAL MODEL

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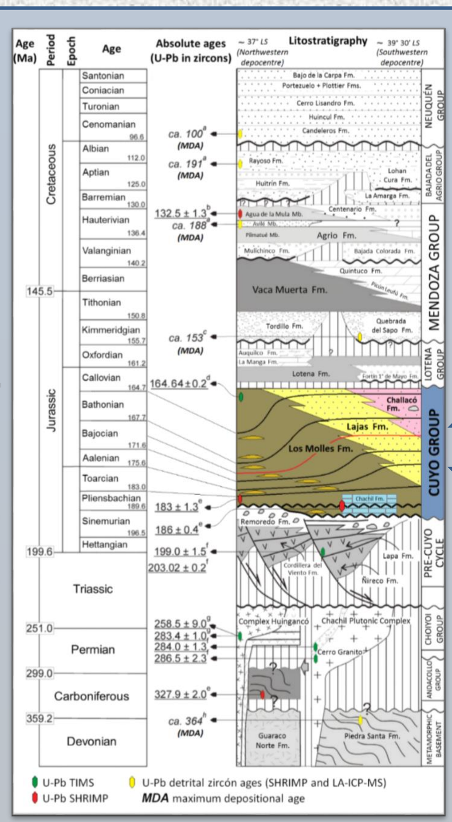
## 4- CASE STUDY. GRUPO CUYO, NEUQUÉN BASIN, ARGENTINA

### LOCATION, GEOLOGICAL SETTING & DATA AVAILABILITY


**OBJECTIVE RESERVOIRS: CUYO GROUP**
EARLY TO MIDDLE JURASSIC SILICICLASTICS, BOUNDED BY TWO REGIONAL UNCONFORMITIES (INTRA LIASSIC & INTRA CALLOVIAN)



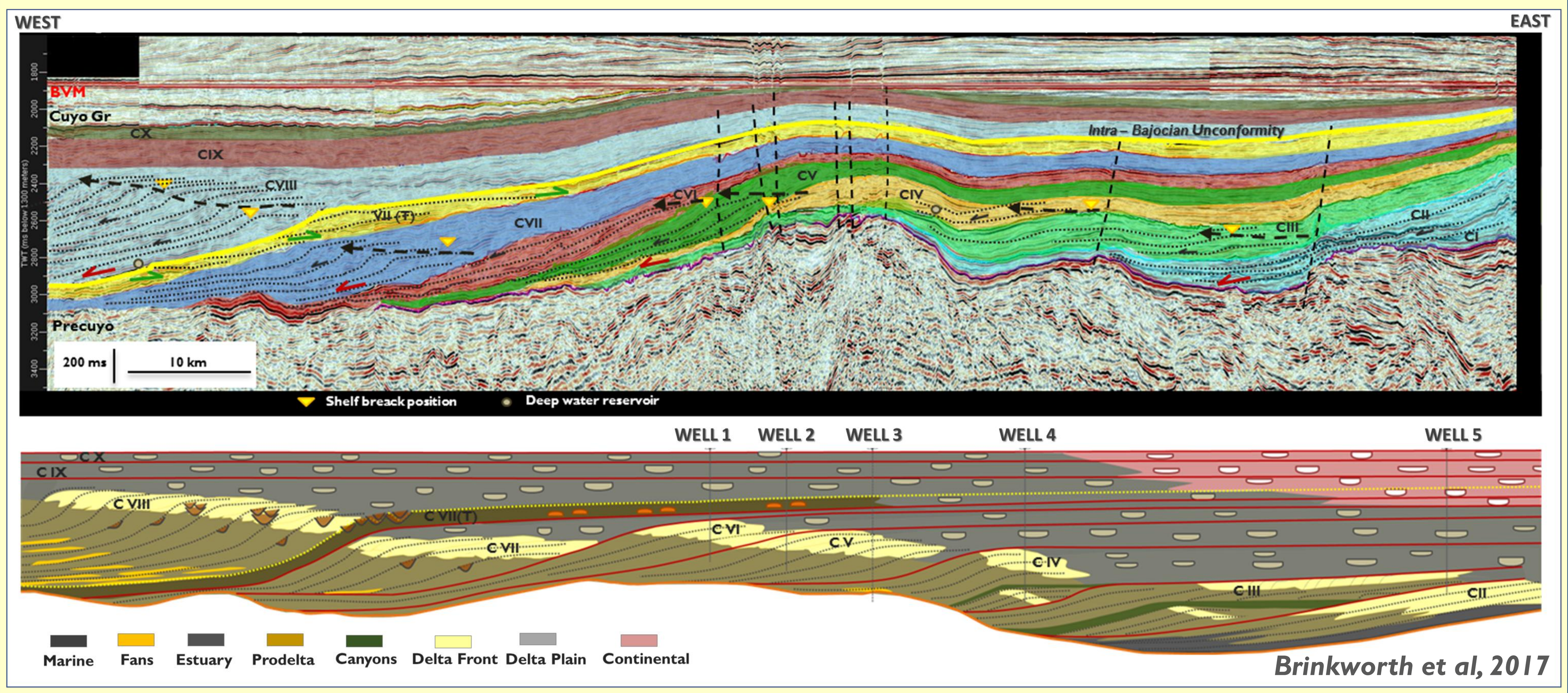
*Modified from Naipauer et al., 2017*

**DATA AVAILABILITY**
✓ 3D SEISMIC DATA WITH DIFFERENT ACQUISITION & PROCESSING PARAMETERS
✓ REGIONAL SEISMIC INTERPRETATION

*INTRA CALLOVIAN UNCONF.*
***OBJECTIVE RESERVOIRS***
*INTRA LIASSIC UNCONF.*

**NEUQUÉN BASIN STRATIGRAPHY**

**WEST-EAST SEISMIC REGIONAL INTERPRETATION & SCHEMATIC SECTION**

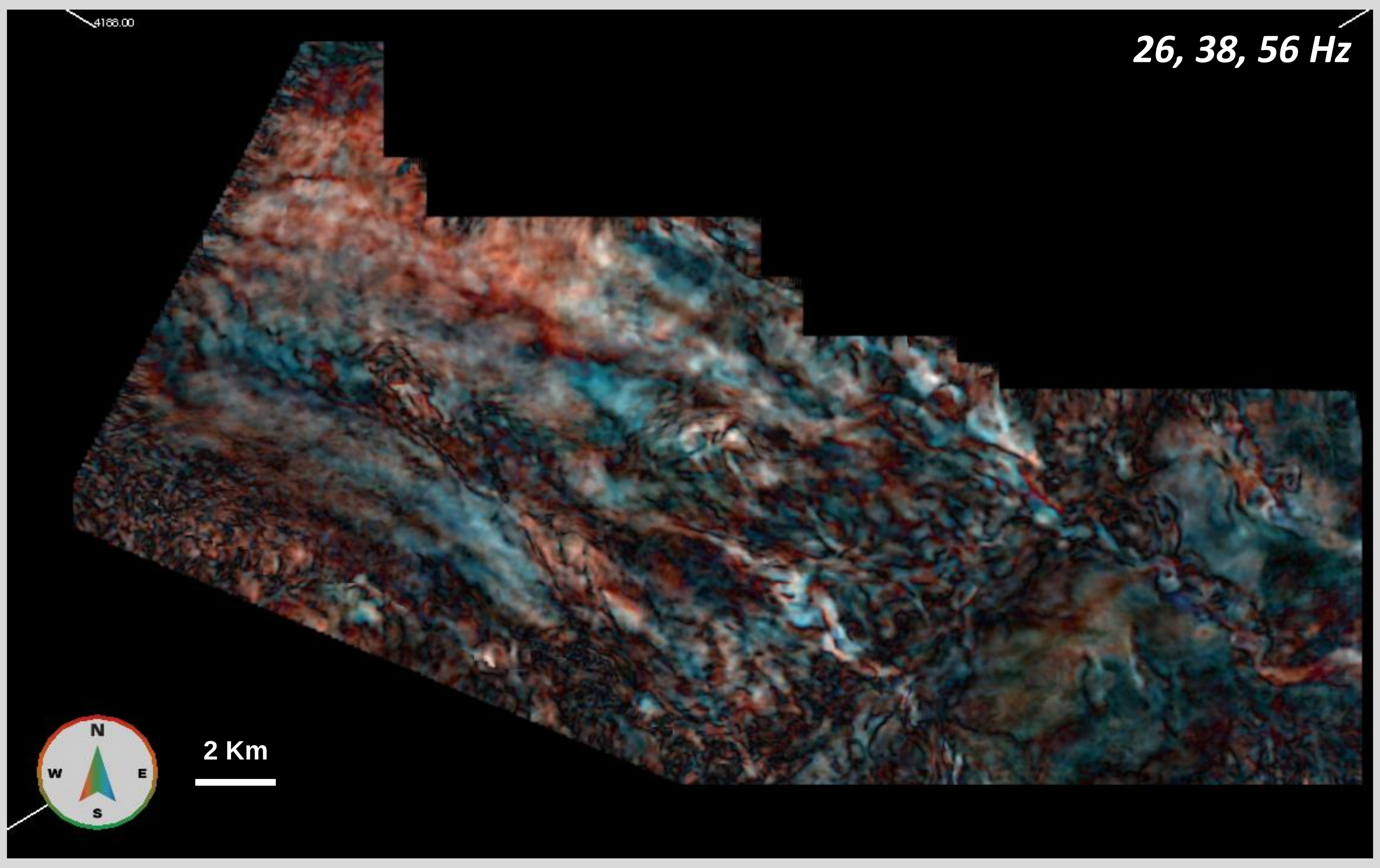


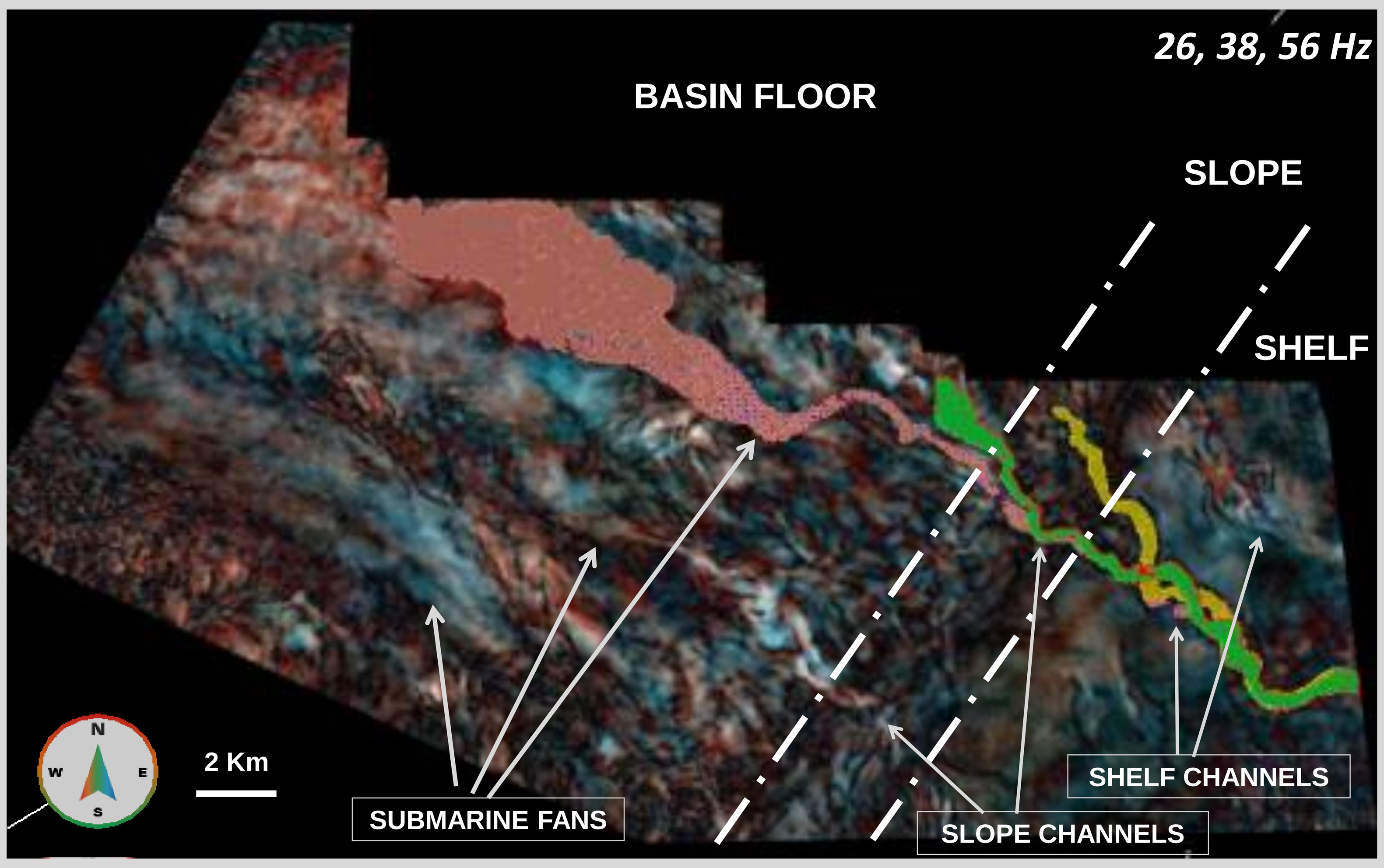

*Brinkworth et al, 2017*

SEVERAL TRANSGRESSIVE-REGRESSIVE CYCLES ASSOCIATED TO THERMAL SUBSIDENCE, PALEO PACIFIC OCEAN CONNECTION & A CONTINUOUS CONTRIBUTION OF SEDIMENTS

### EXAMPLES: SHELF CHANNELS, SLOPE CHANNELS & CANYONS, AND SUBMARINE FANS

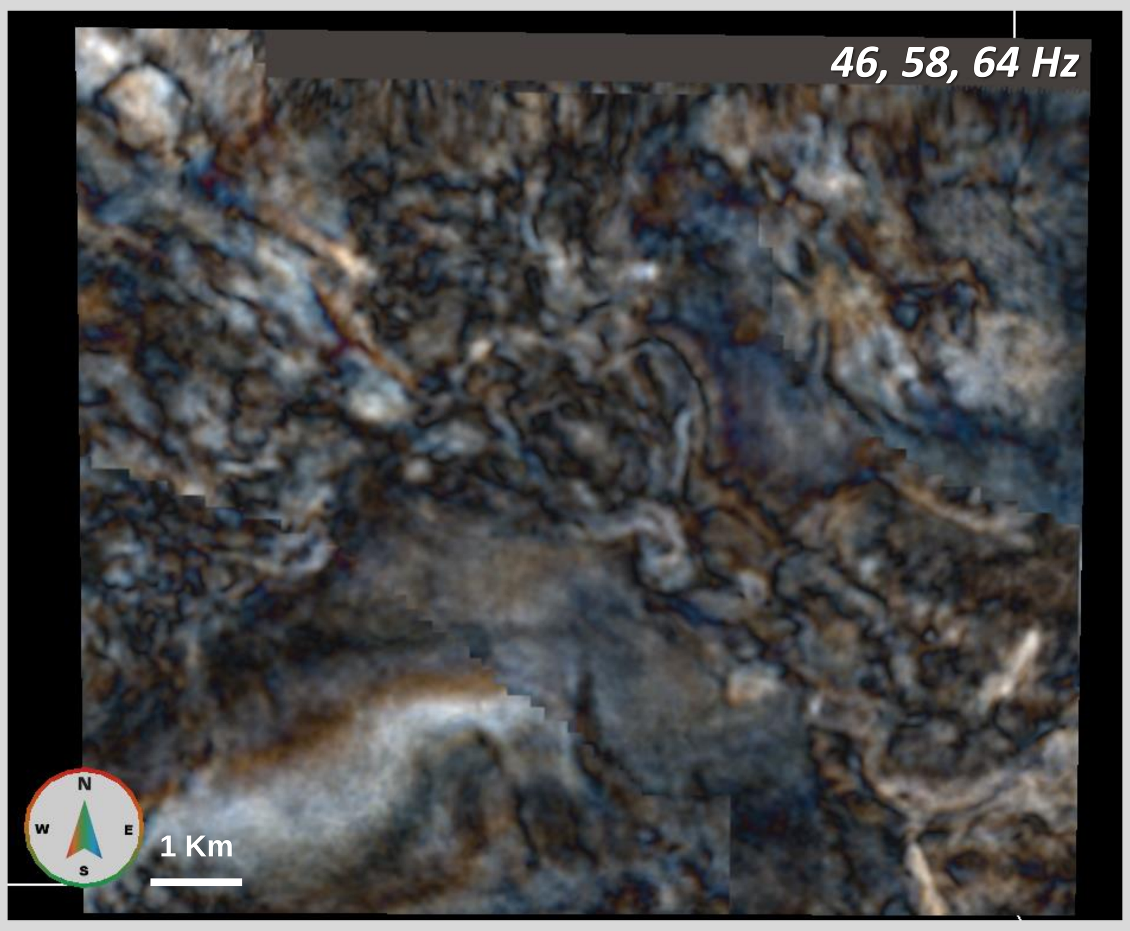
EXAMPLE 1

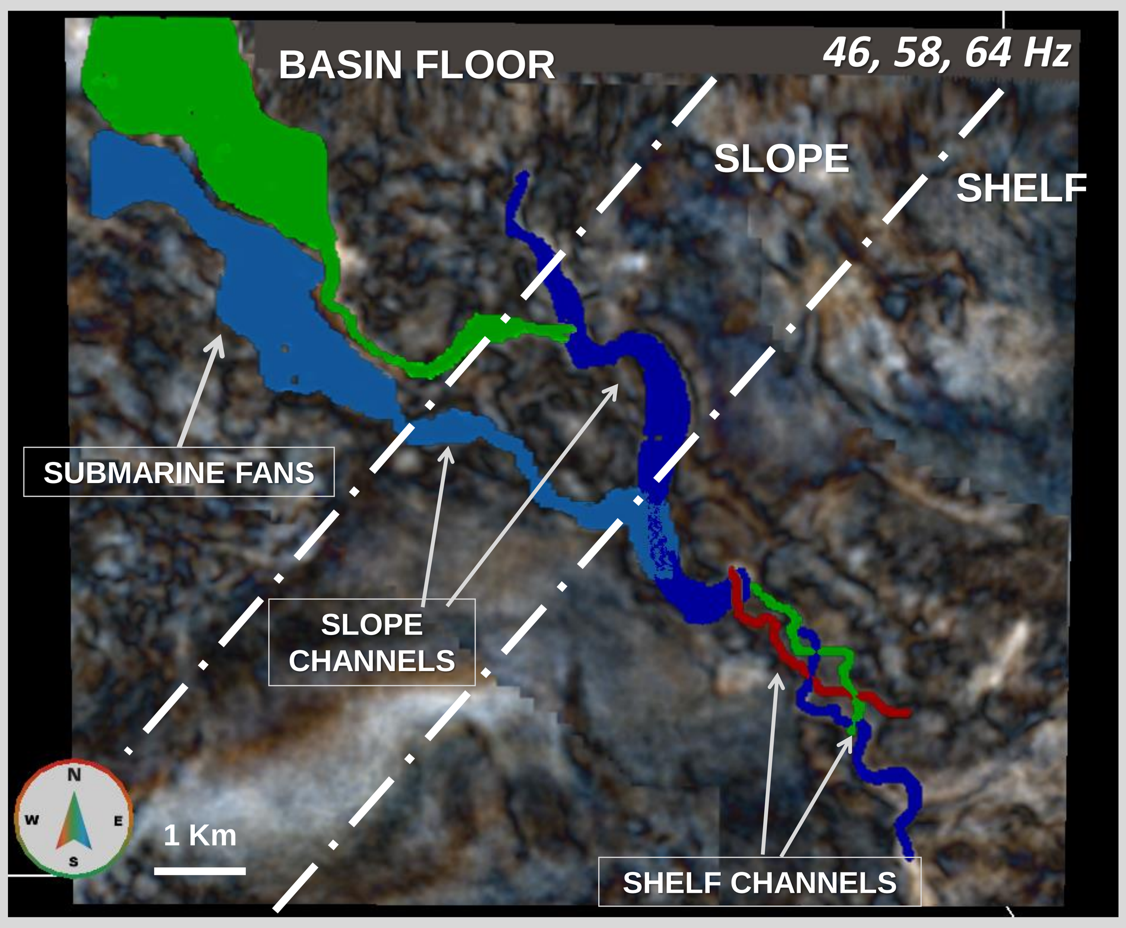



*CHANNELS FROM THE SHELF, WHICH CONTINUE INTO THE SLOPE ARE **CLEARLY CONNECTED** TO SUBMARINE FANS*

EXAMPLE 2



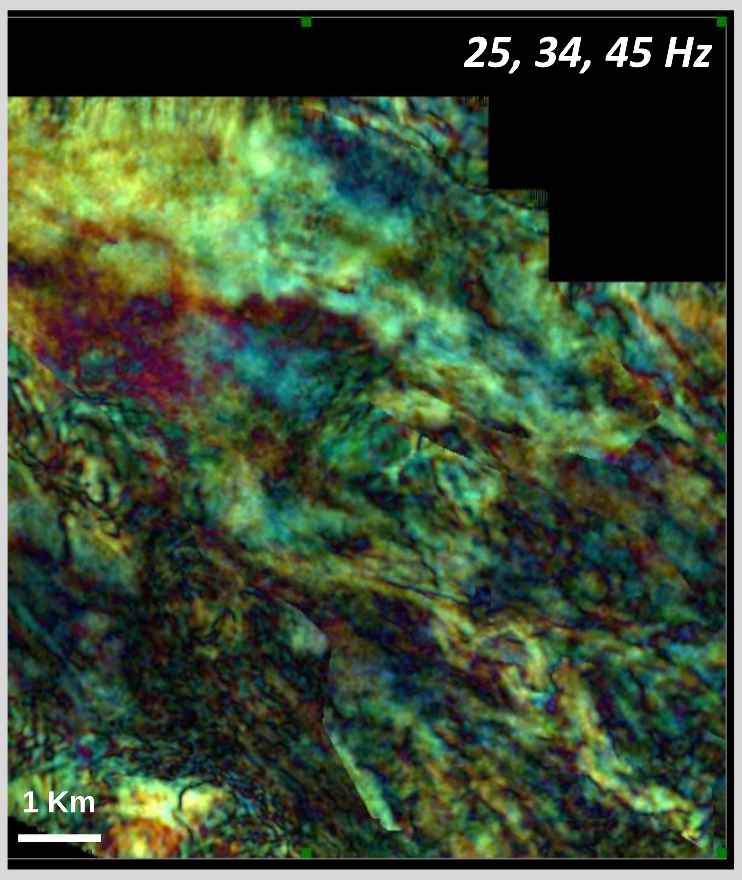



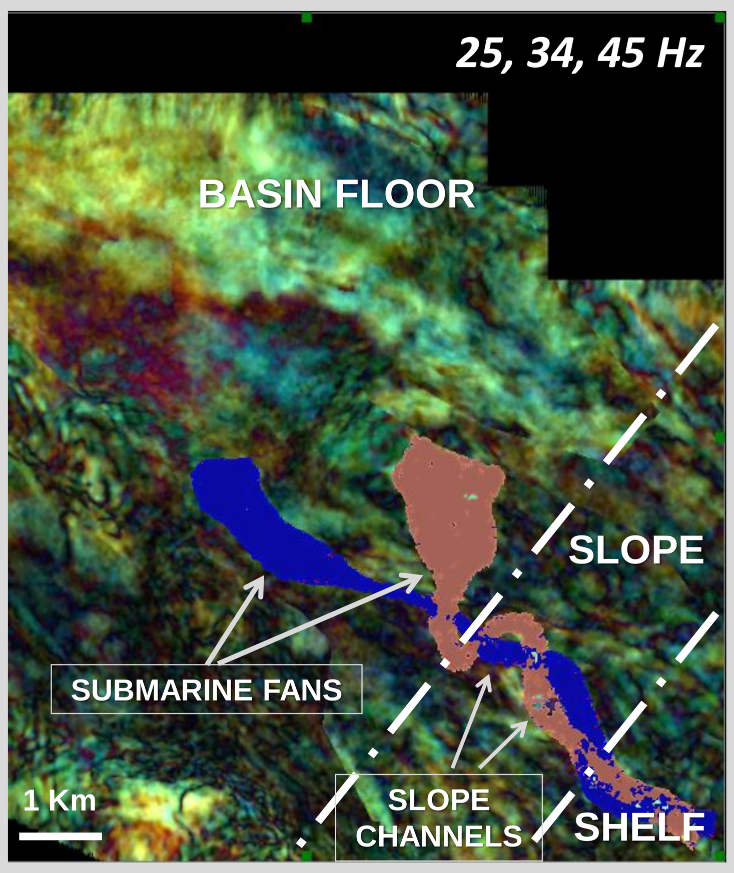

*SEVERAL **INTERCONNECTED** CHANNELS*

*FROM SHELF TO SLOPE*

*SPECTRAL DECOMPOSITION **FACILITATES** A MORE DETAILED SEDIMENTARY ANALYSIS*

EXAMPLE 3

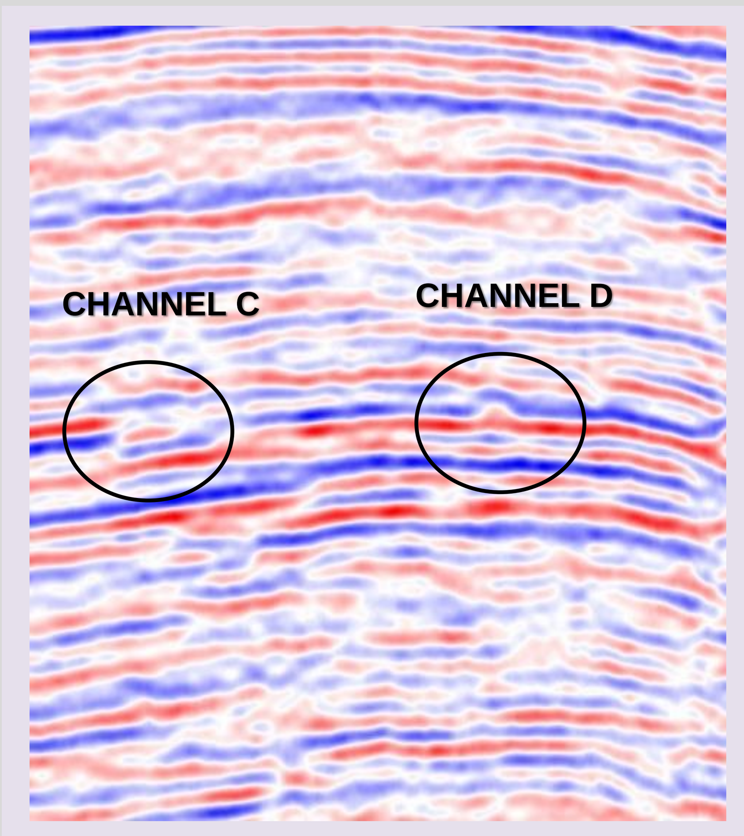


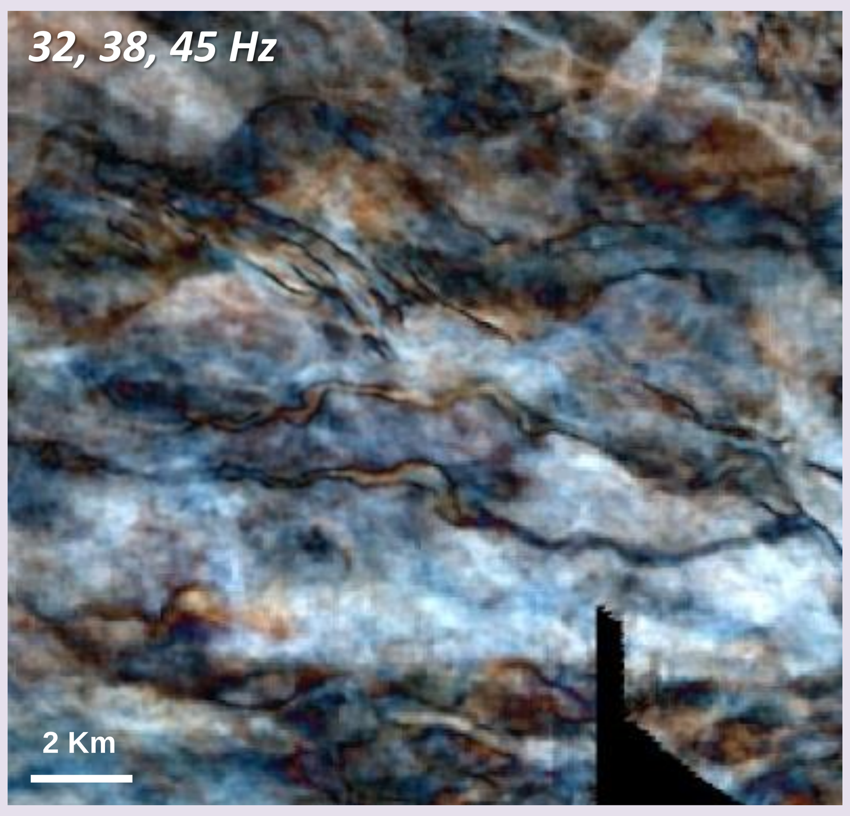

*TWO CHANNELS FROM SHELF TO BASIN FLOOR*

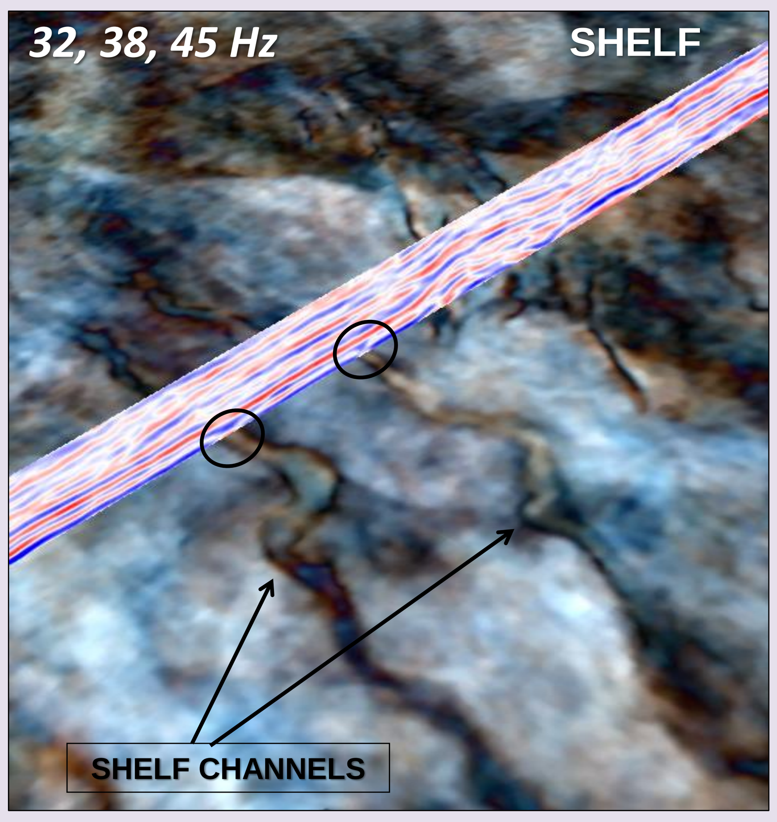
*SPECTRAL DECOMPOSITION **ENABLES** A MORE DETAILED CHANNEL MIGRATION ANALYSIS*

EXAMPLE 4




*SHELF CHANNELS **BETTER DEFINE** BY SPECTRAL DECOMPOSITION*



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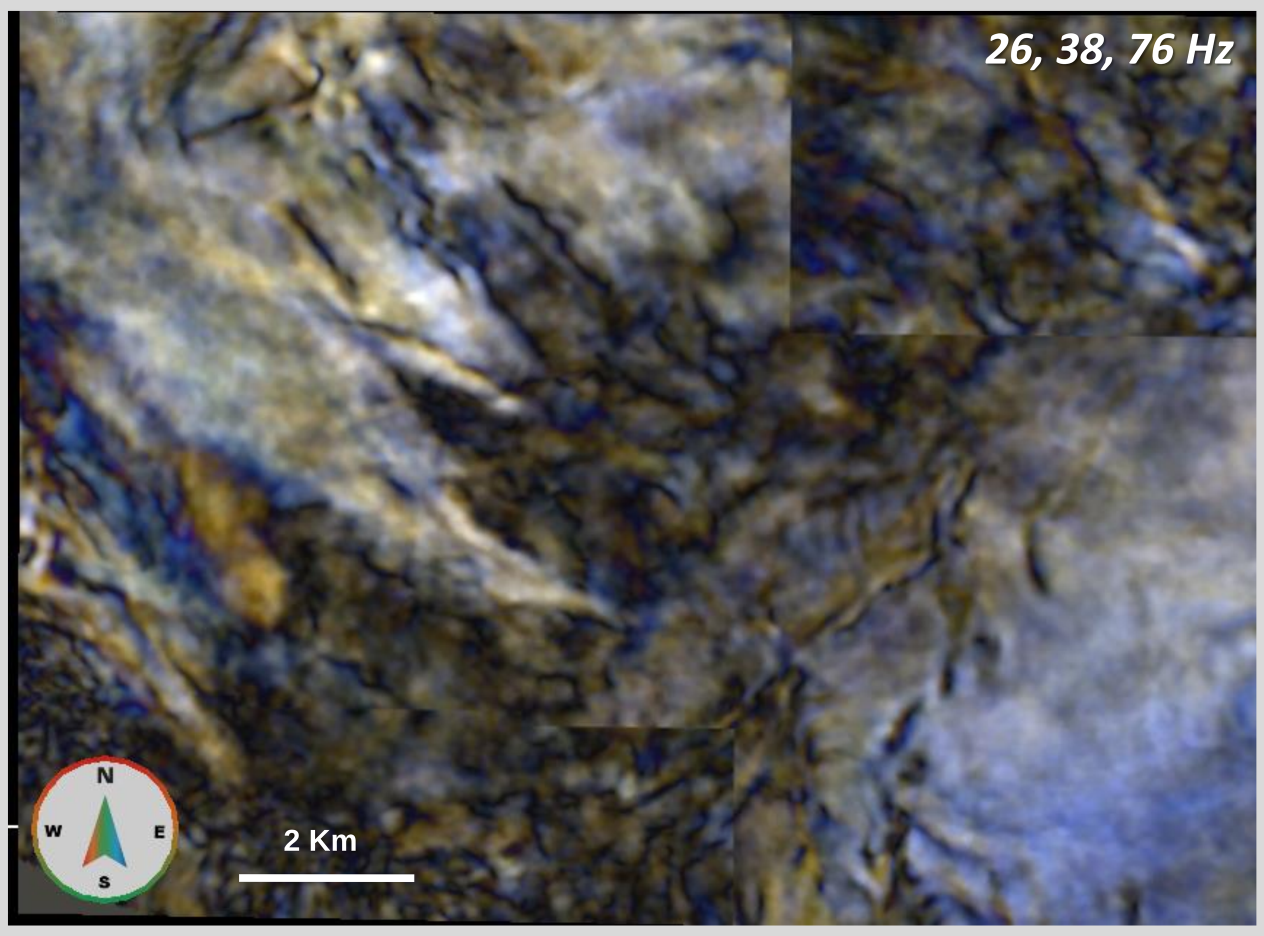
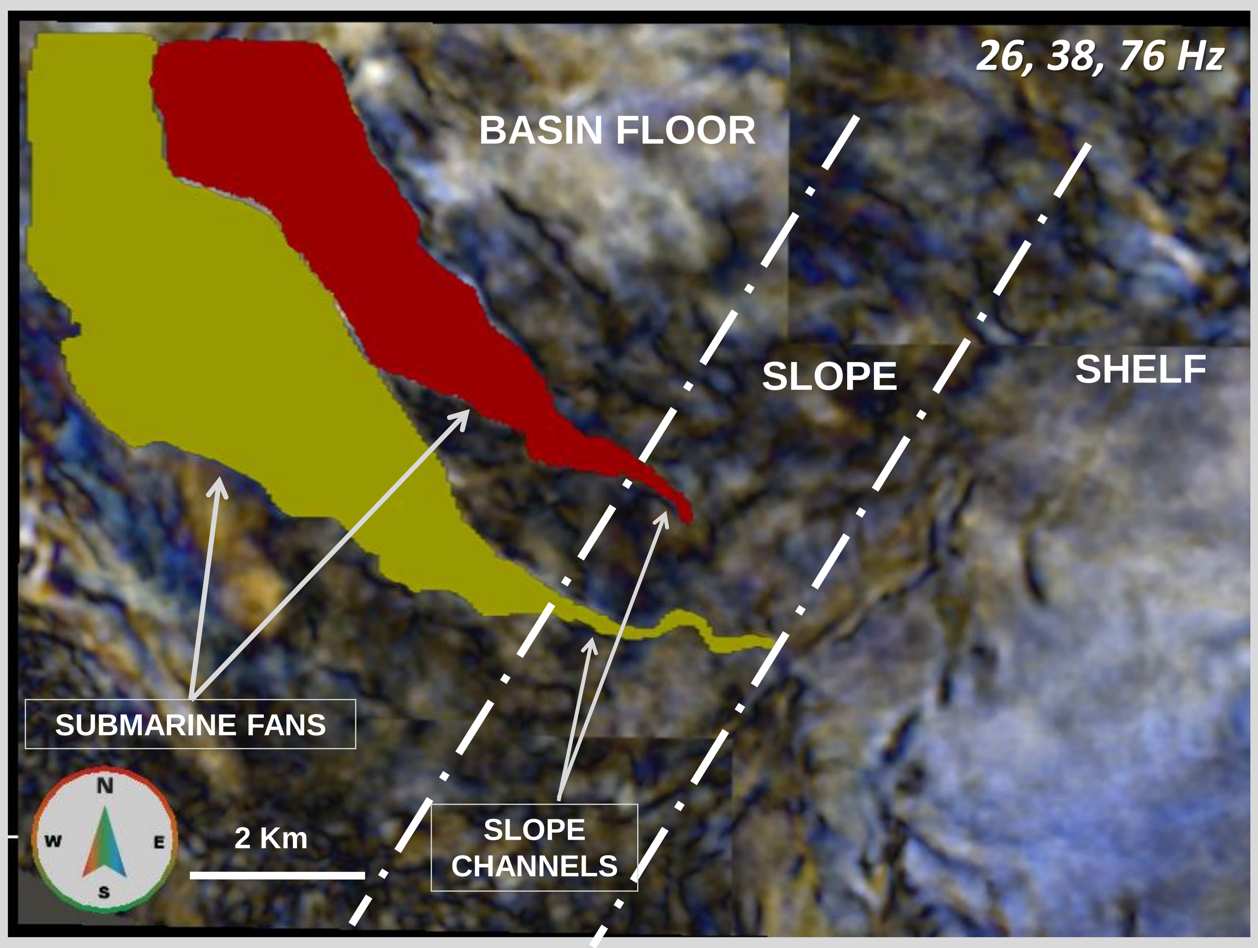
## *4- CASE STUDY. GRUPO CUYO, NEUQUÉN BASIN, ARGENTINA*

### *EXAMPLES: SHELF CHANNELS, SLOPE CHANNELS & CANYONS, AND SUBMARINE FANS (CONT.)*




EXAMPLE 5

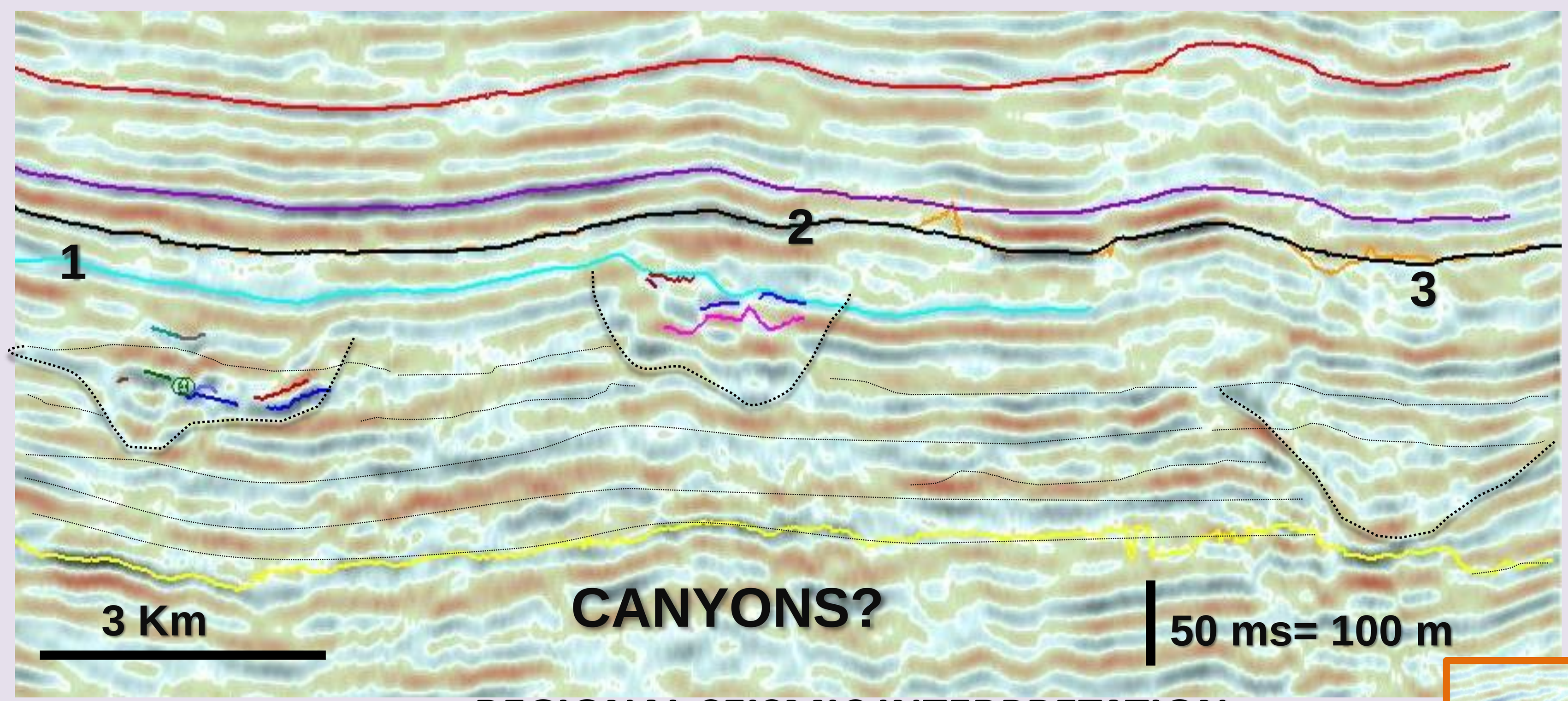
*SUBMARINE FANS ARE CLEARLY **IDENTIFIED, VOLUME BASED INTERPRETED AND EXTRACTED** IN THE DEEP WATER AREA*

***CONNECTION*** *TO SLOPE CHANNELS IS OBSERVED*

*SPECTRAL DECOMPOSITION **ACCELERATES** THE **INTEGRATION** OF DETAILED SEDIMENTARY ANALYSIS INTO THE REGIONAL GEOLOGICAL MODEL*

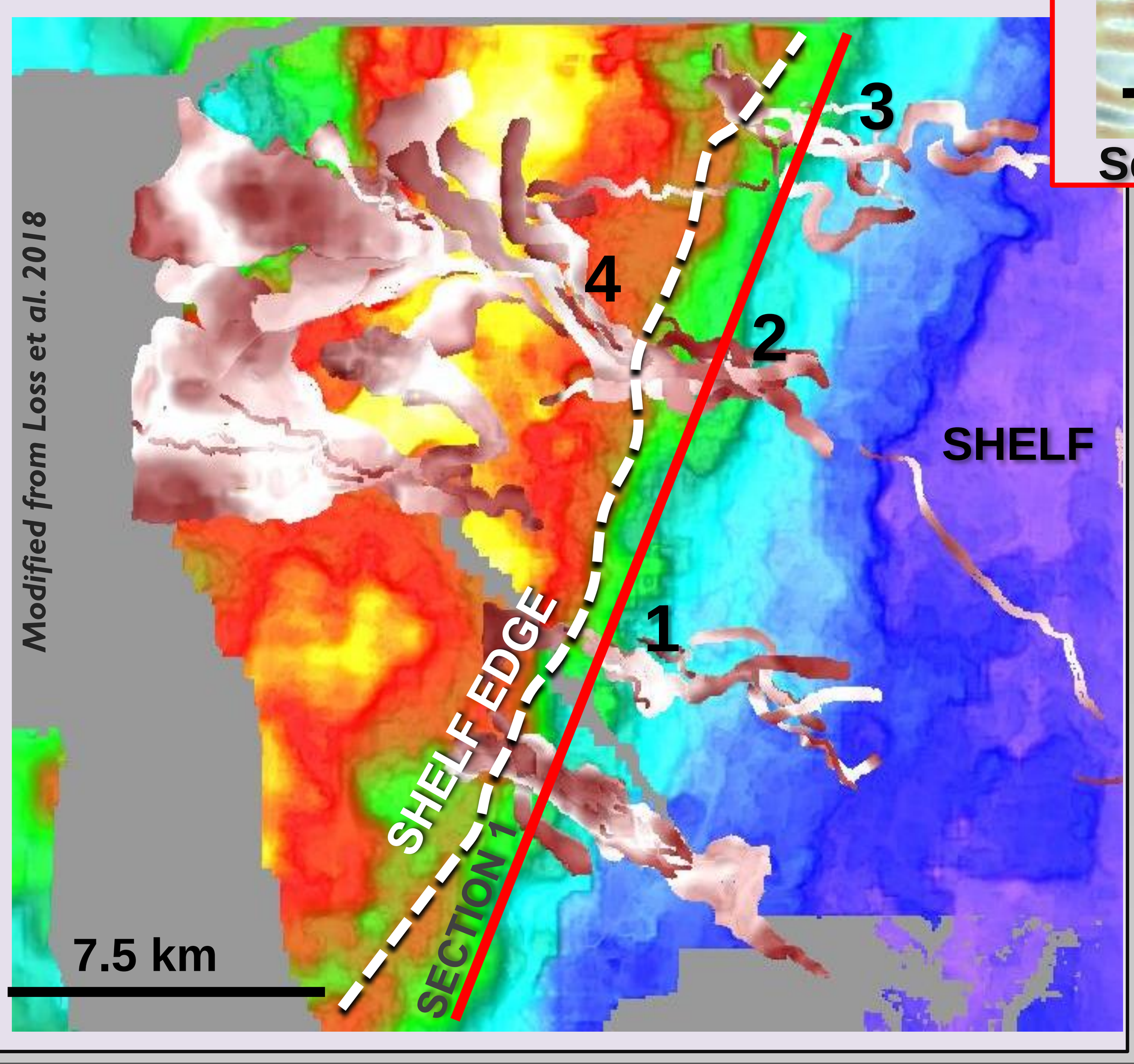
### *INTEGRATION OF RESULTS TO HELP DEFINE THE BASIN-SCALE GEOLOGICAL MODEL*

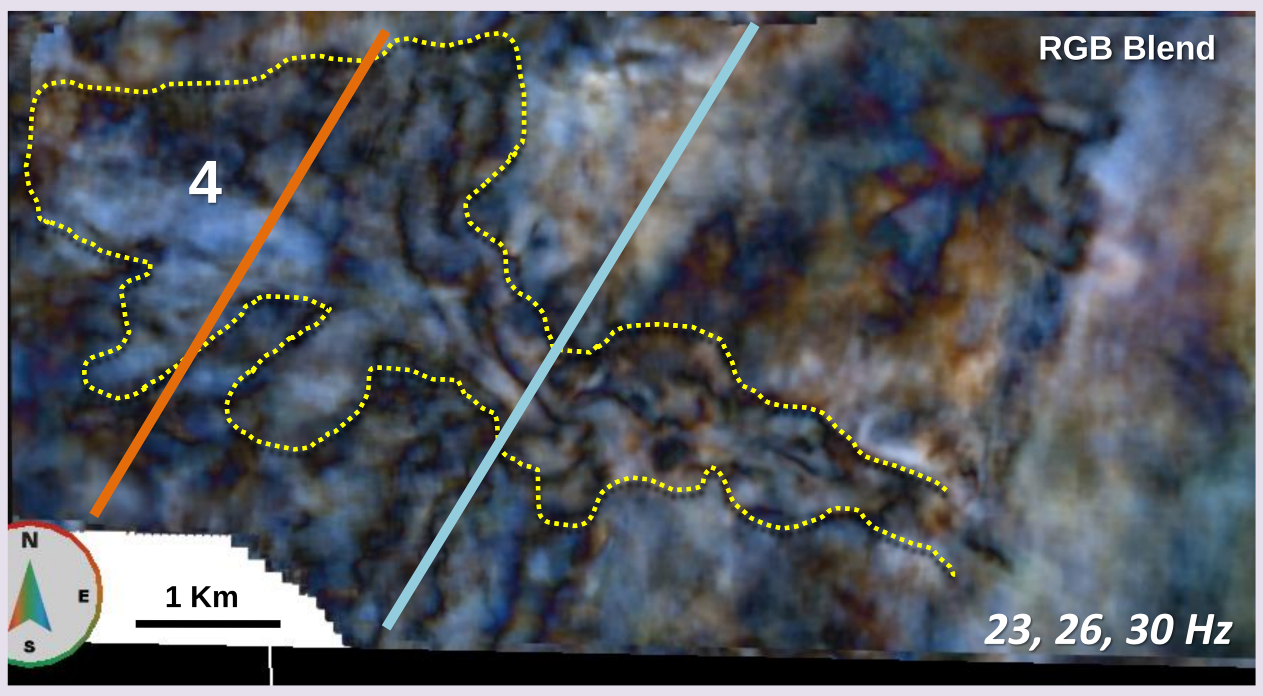

ANALYSIS OF OUTCROPS



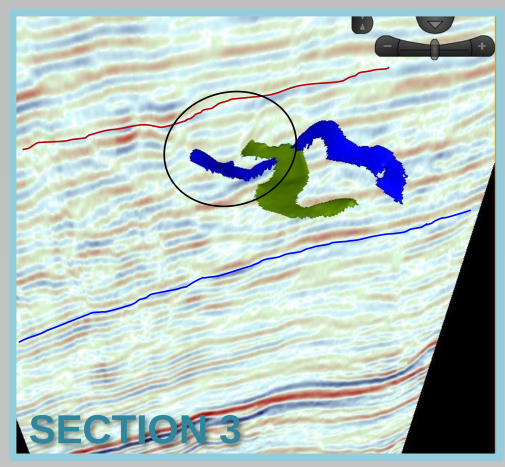

REGIONAL SEISMIC INTERPRETATION

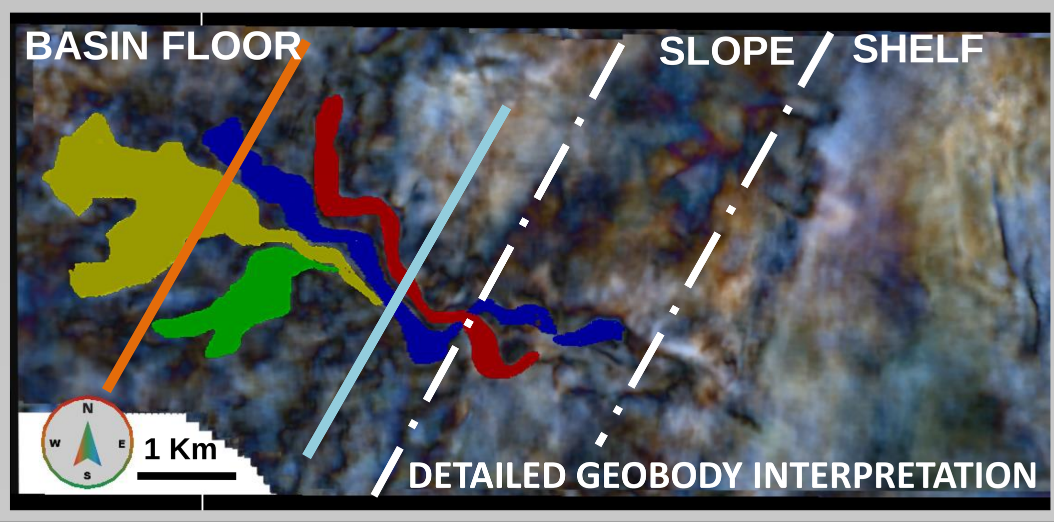
**SEISMIC GEOMORPHOLOGY BY SPECTRAL DECOMPOSITION CLEAR SHOWS THE CONNECTION BETWEEN PLATFORM & SLOPE CHANNELS AND BASIN FLOOR FANS**




SEISMIC GEOMORPHOLOGY, SPECTRAL DECOMPOSITION


DETAILED GEOBODY INTERPRETATION

## *5- CONCLUSIONS*

- ✓ **Spectral decomposition** using **"Blend RGB'** helps to identify <u>subtle geological features</u> **not discernible** with traditional seismic interpretation techniques, such as horizon slices in seismic amplitudes, RMS amplitudes, etc.
- ✓ A <u>workflow</u> to **identify, interpret, and extract volume-based spectral decomposition** geological features to **<u>help delineate</u>** the **regional model** is presented.
- ✓ More than 20 surveys with different acquisition and processing parameters were conditioned and analyzed following the proposed workflow for the <u>Cuyo Group, Neuquén basin in Argentina</u>, resulting in <u>more than</u> **200 interpreted geobodies** (**shelf channels, slope channels & canyons, submarine fans**).
- ✓ **Canyons filled with channels** of different geometries and sizes **<u>are clearly identified</u> in the slope**. **Fans** are observed in the **deep water area**. **Shelf channels** are also interpreted. <u>Examples</u> from shelf & slope channels and submarine fans are presented.
- ✓ **Seismic geomorphology** using **<u>spectral decomposition volume based interpretation</u>** clearly show the **<u>connection</u>** between **channels in the platform**, **canyons & channels in the slope** and **fans in the deep water area**.
- ✓ This study **demonstrates** the **<u>added value</u>** of **spectral decomposition volume interpretation** to **<u>better delineate</u> the depositional system** for the Cuyo Group, Argentina as input to future explorations efforts in the basin.

## *6- ACKNOWLEDGEMENTS*

We would like to thank YPF S. A. for the permission to present this work. Many thanks to our colleagues for their feedback, and my family for their support.