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**FIRST EAGE ATLANTIC GEOSCIENCE  
RESOURCE EXPLORATION &  
DEVELOPMENT SYMPOSIUM**

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**5-7 MAY 2025 | MARRAKECH | MOROCCO**

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**Atlantic Conjugate Margins and  
Their Global Significance in our Energy Future**

# Advancing Offshore Exploration: Technologies for Derisking Petroleum Projects in Frontier Basins – The Uruguayan Case

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MEn. Pablo Rodriguez

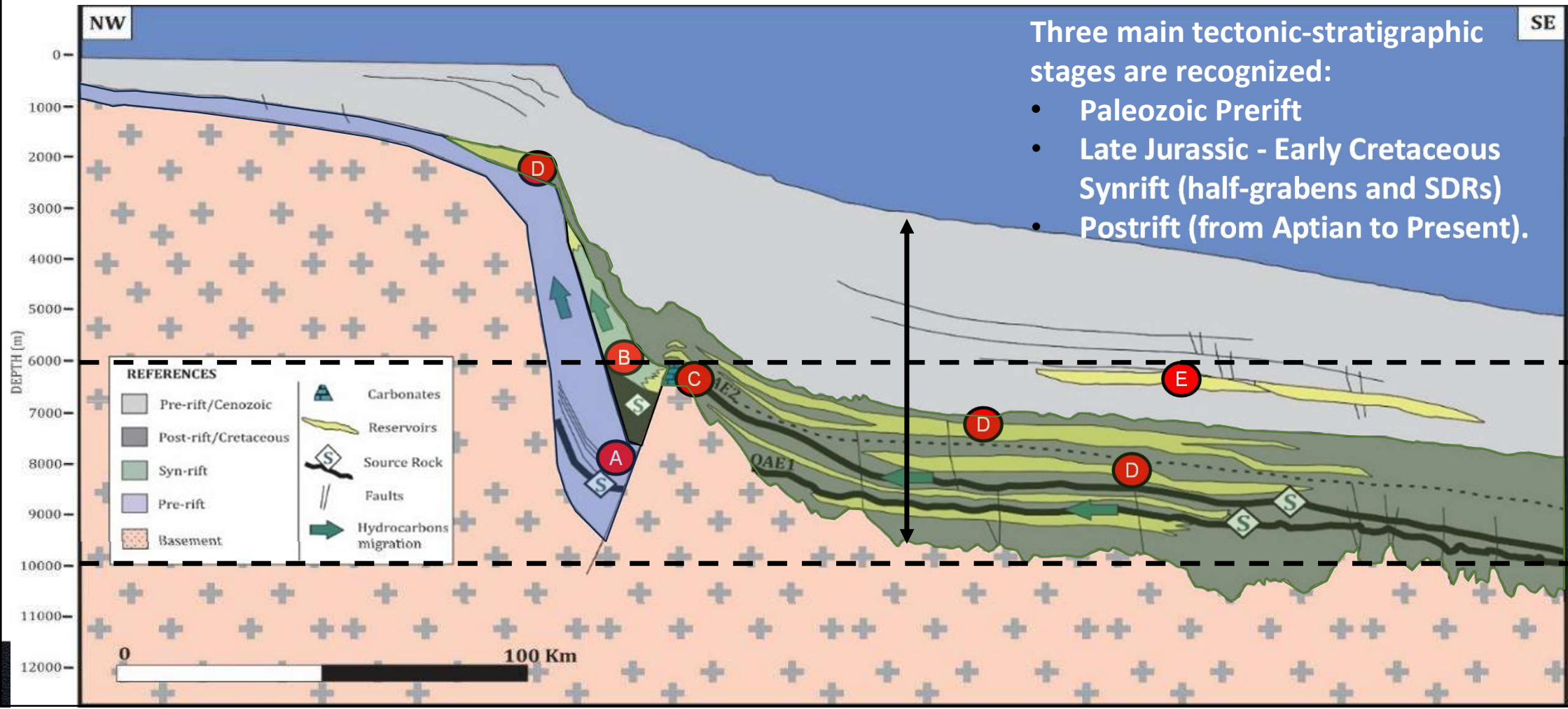
# Offshore Uruguay Geology



- Two basins: Punta del Este and Pelotas.
- Punta del Este: important presence of halfgrabens.
- Only 3 wells.



## Offshore Uruguay Geology



# Offshore Uruguay – Risks?

- Mature Provinces: Reservoir is



- Frontier Basins: Source Rock is



No source rock = No hydrocarbons  
(Even with a perfect trap or reservoir)

De-risking SR:

- ✓ Presence
- ✓ Quality
- ✓ Maturity

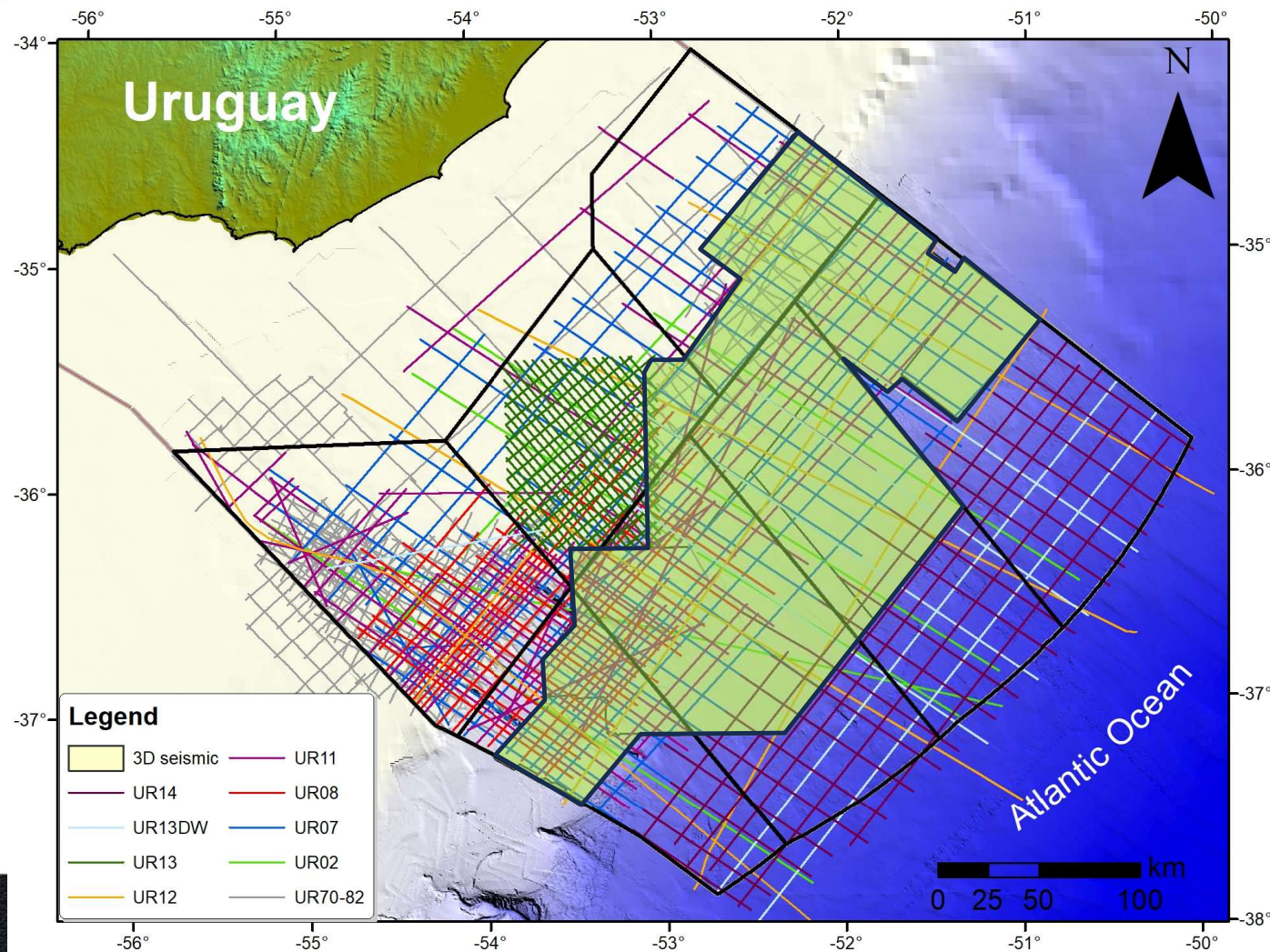
Our approach: we applied a combination of seismic and non-seismic technologies to de-risk source rocks in our offshore areas.

# Offshore Uruguay – Source Rocks

## Seismic related:

- ✓ Seismic Correlation:
  - Aptian SR correlation with offshore Namibia
  - Cenomanian-Turonian SR correlation from offshore Namibia and Brazil
- ✓ Seismic Response
  - Regional high amplitude soft kick events
  - AVO Type IV anomalies (dimming in the far offsets)
  - Velocities: inversion in FWI derived velocities
- ✓ DHIs: Anomalous seismic responses at Reservoir levels that support SR
- ✓ Fluid escape features: pockmarks and gas chimneys
- ✓ Bottom Simulating Reflector (BSR)

## Seismic - Database



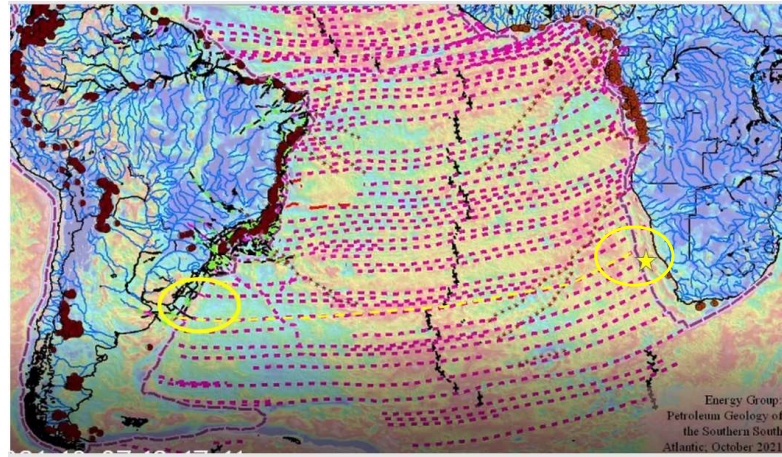
- Cornerstone of Exploration
- 2D Seismic: 1970–2014  
> 40,000 km
- 3D Seismic: 2012–2017  
> 41,000 km<sup>2</sup>
- Several new acquisition projects (2D and 3D)

# Seismic – Offshore Uruguay - Orange Basin

Upper Jurassic (150 Ma)

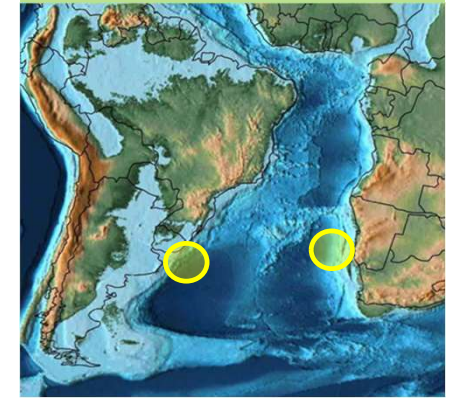


Modified from Scotese (2014)

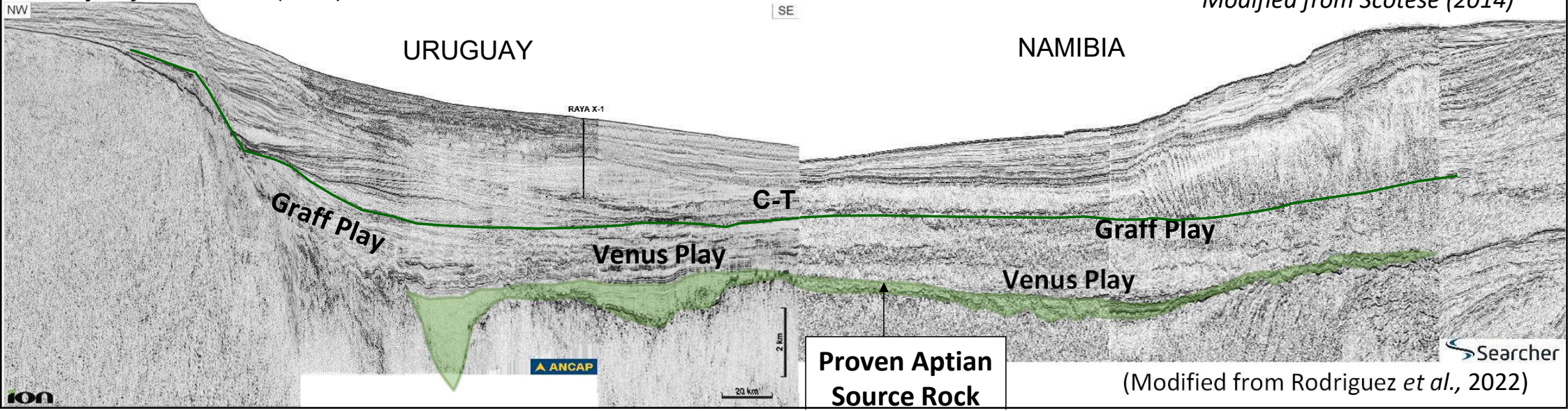


Energy Group:  
Petroleum Geology of  
the Southern South  
Atlantic, October 2021.

Turonian (90 Ma)



Modified from Scotese (2014)

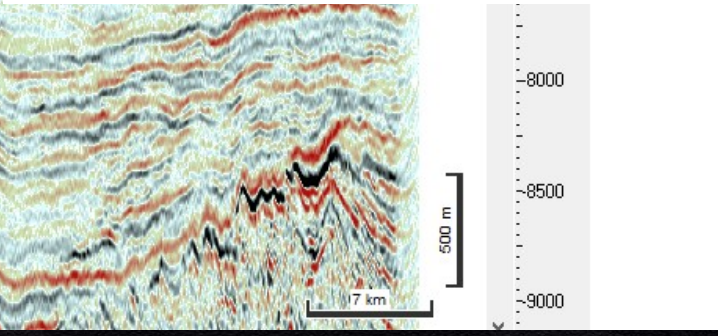
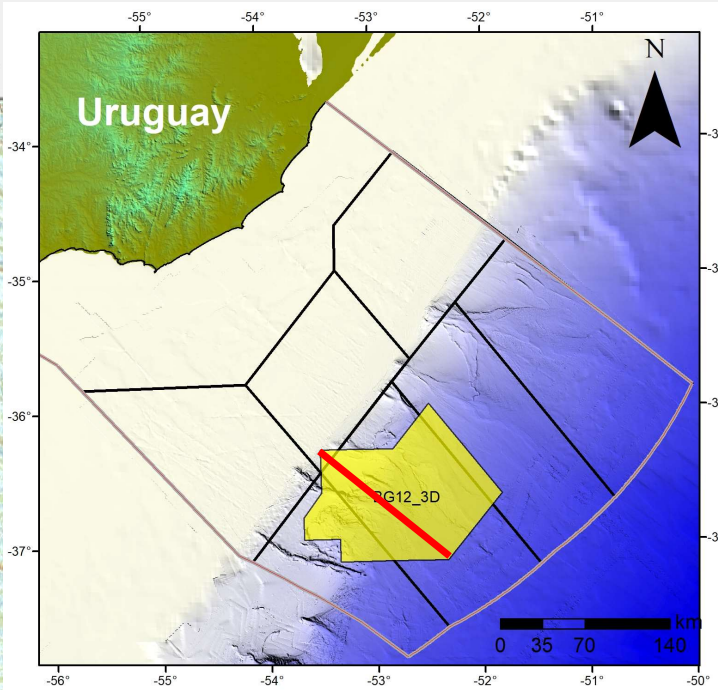
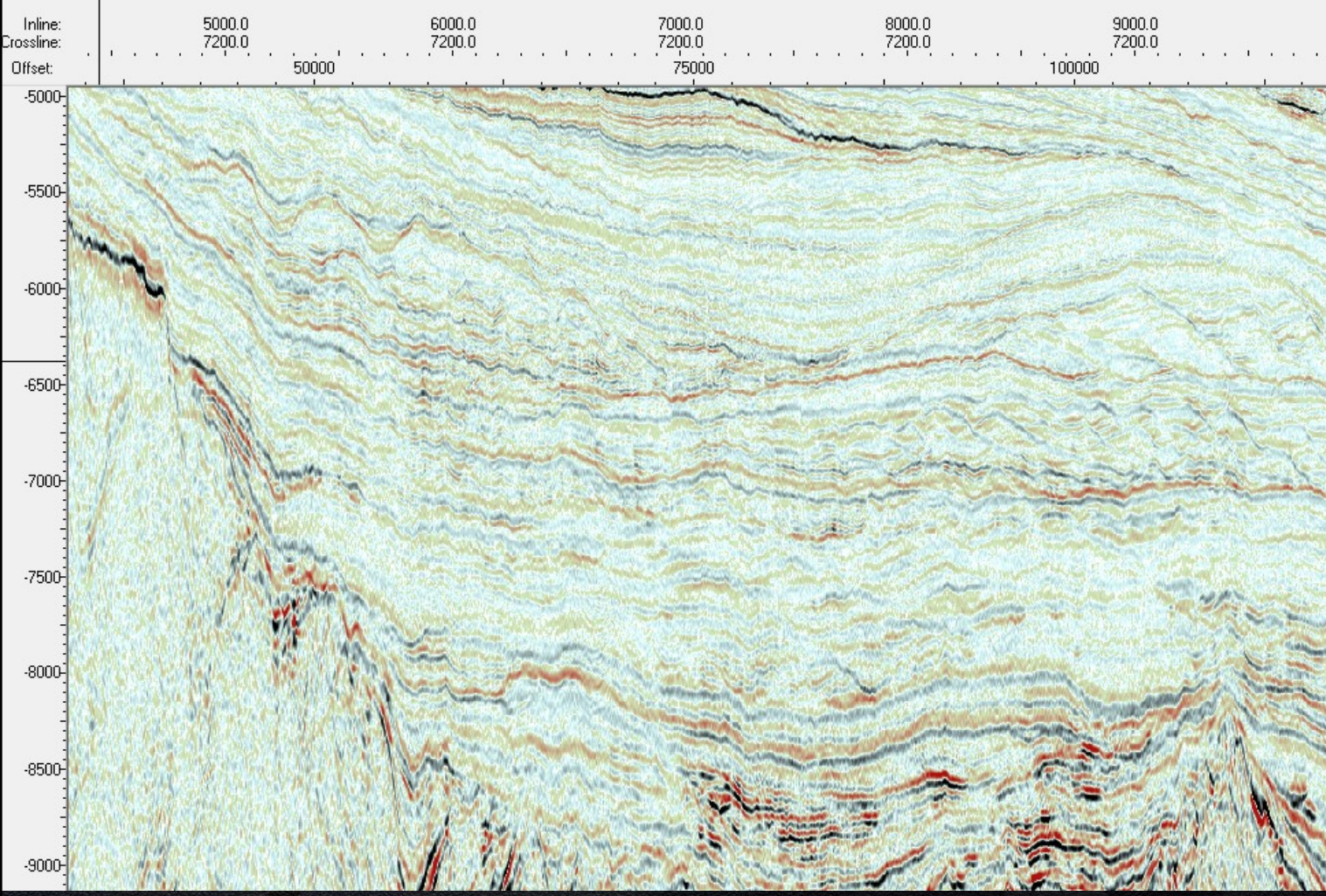


Proven Aptian  
Source Rock

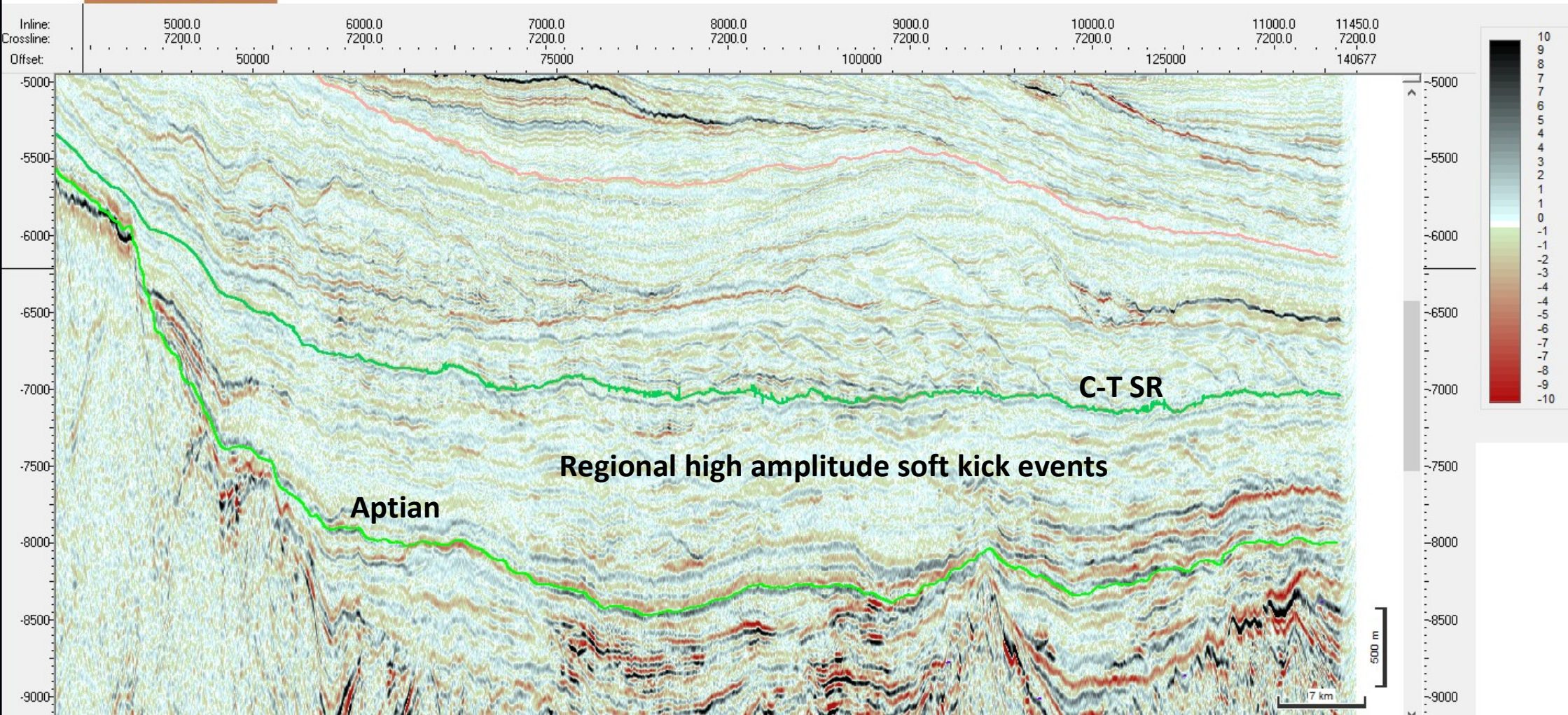
(Modified from Rodriguez *et al.*, 2022)

# EAGE

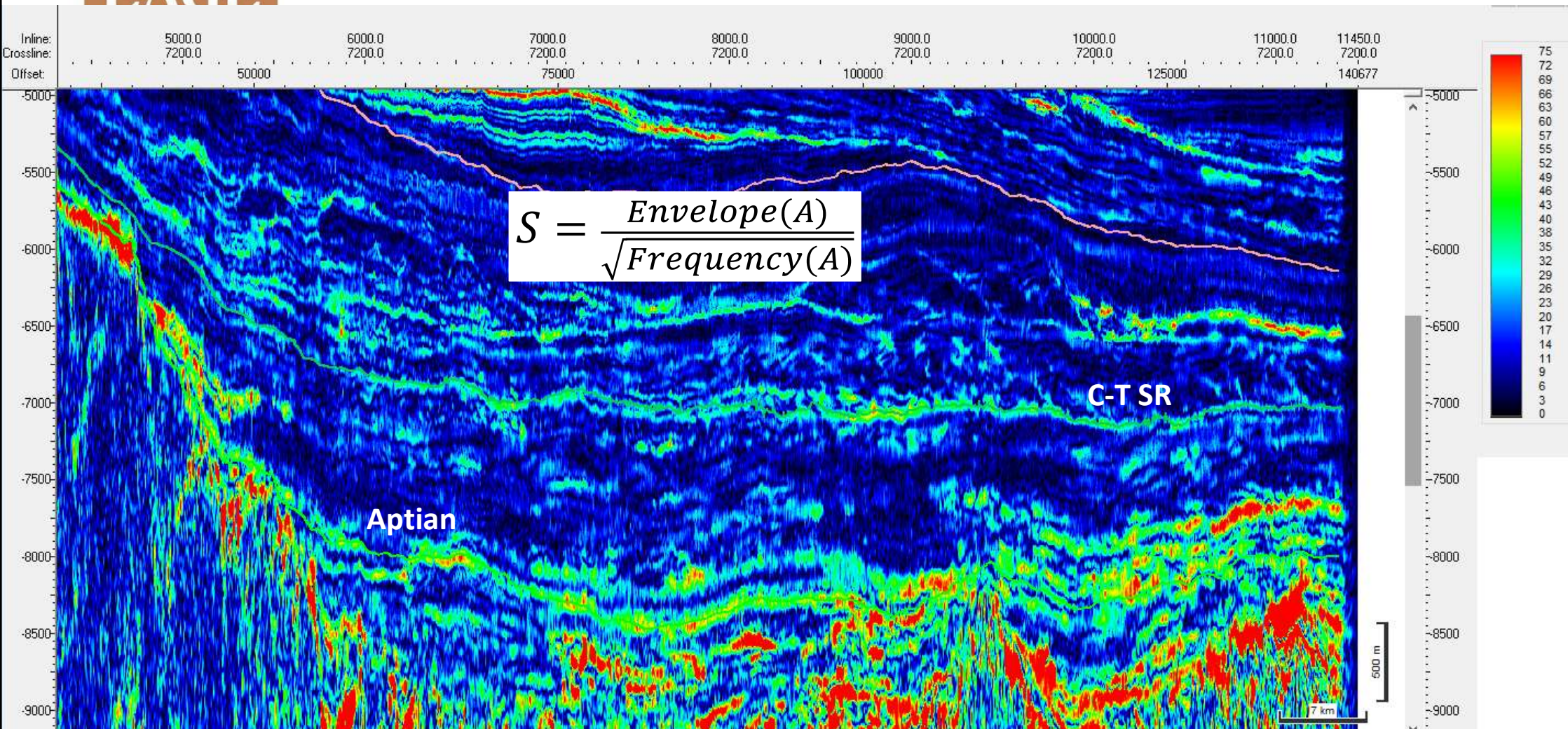
## Seismic – Seismic Response



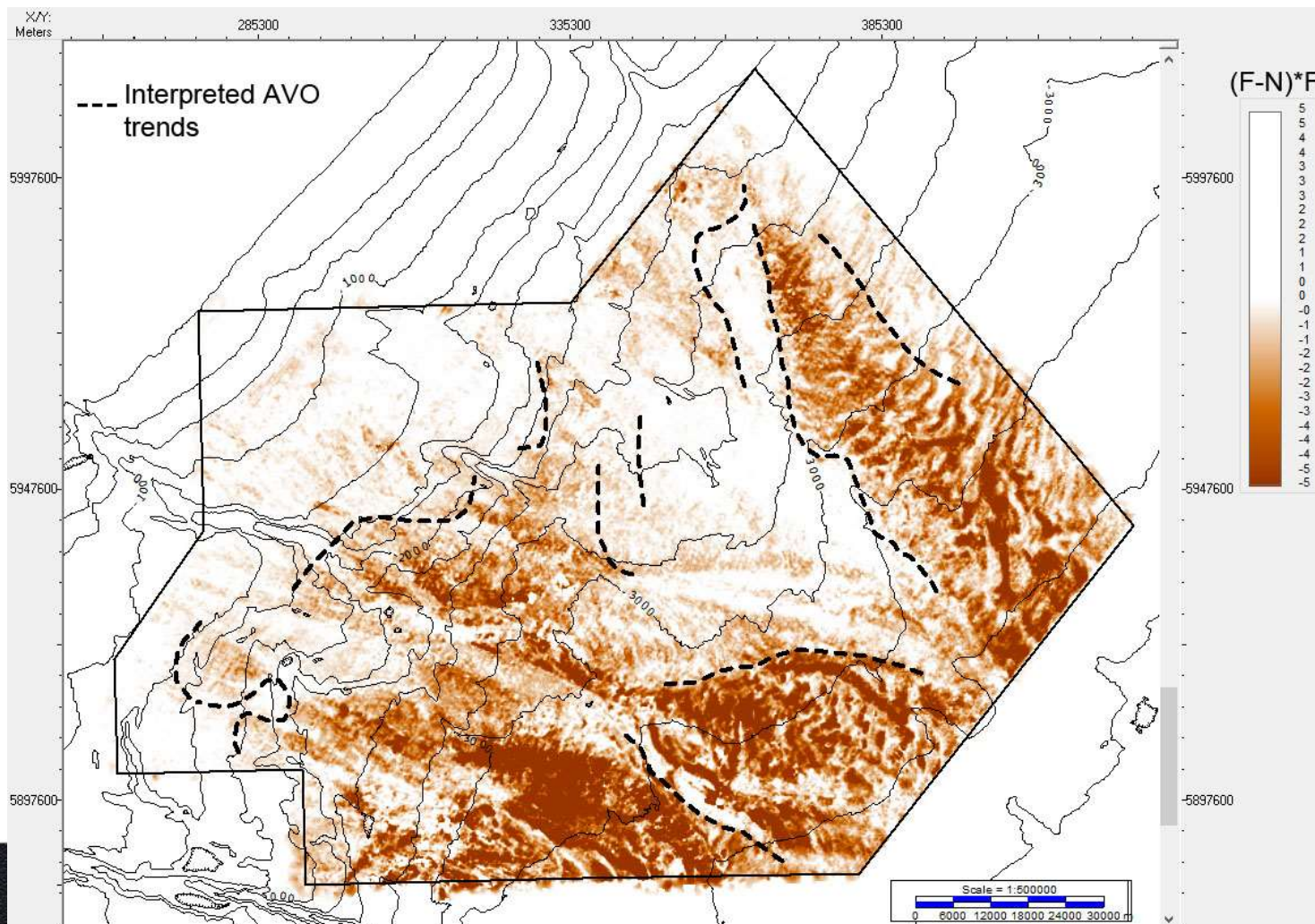
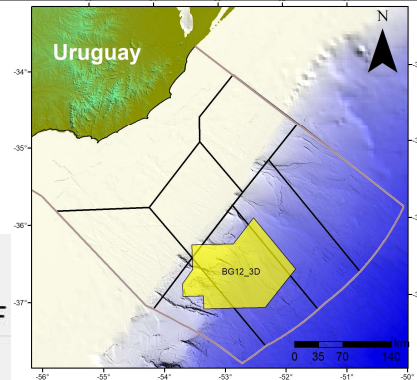
## Seismic – Seismic Response



# Seismic – Sweetness Attribute



## Seismic – AVO type IV



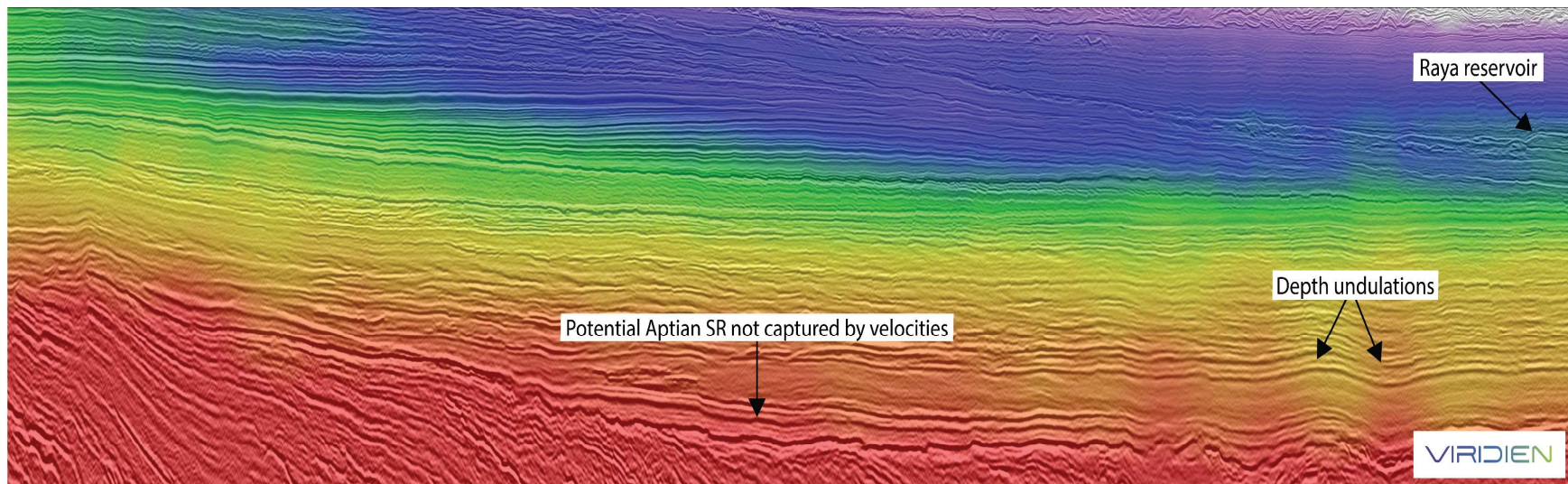
(Far-Near)\*Far  
Attribute @  
potential C-T  
source rock  
level

(Modified from  
Rodriguez *et al.*, 2023)

## Seismic – FWI

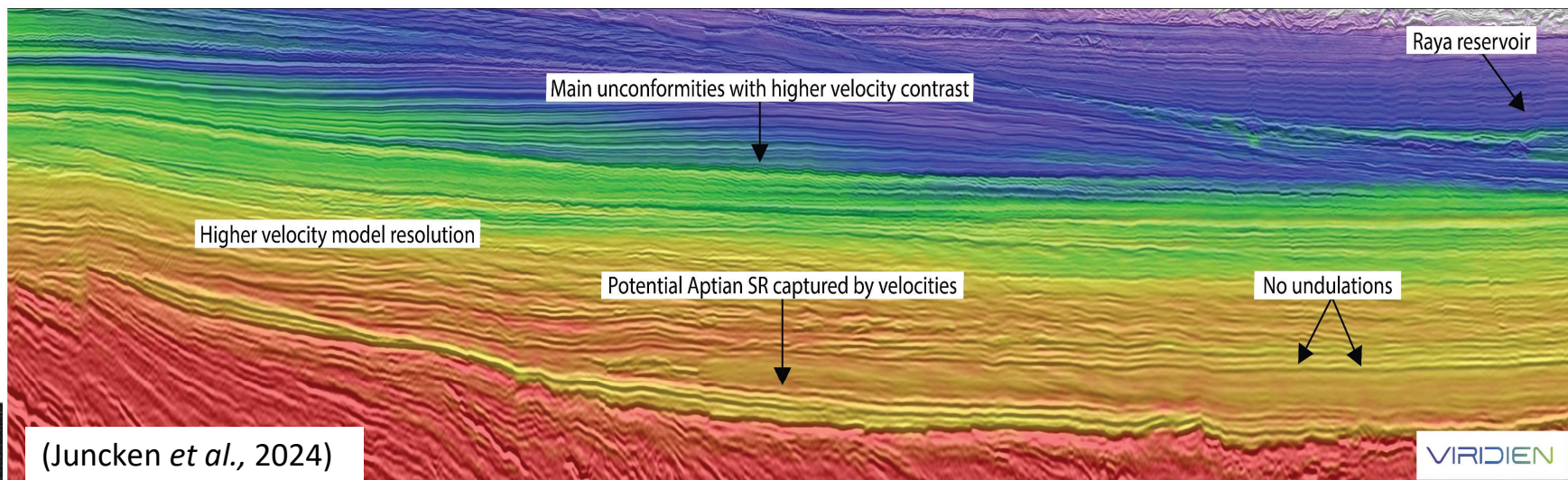
## LEGACY (2014)

- Smooth velocities
- Artifacts (undulations)
- low res @ SR intervals



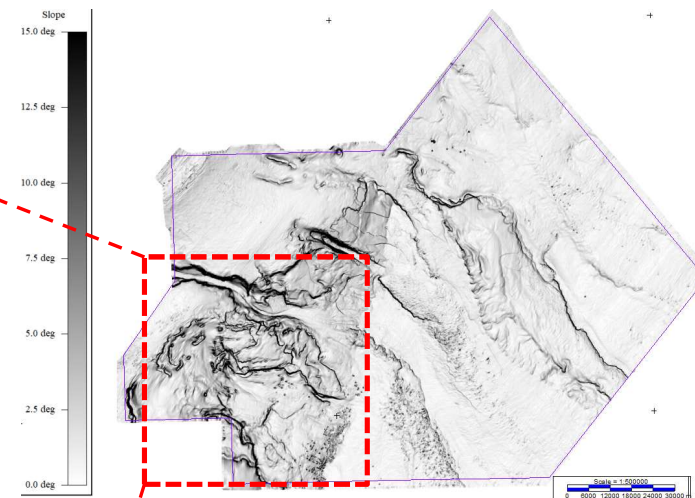
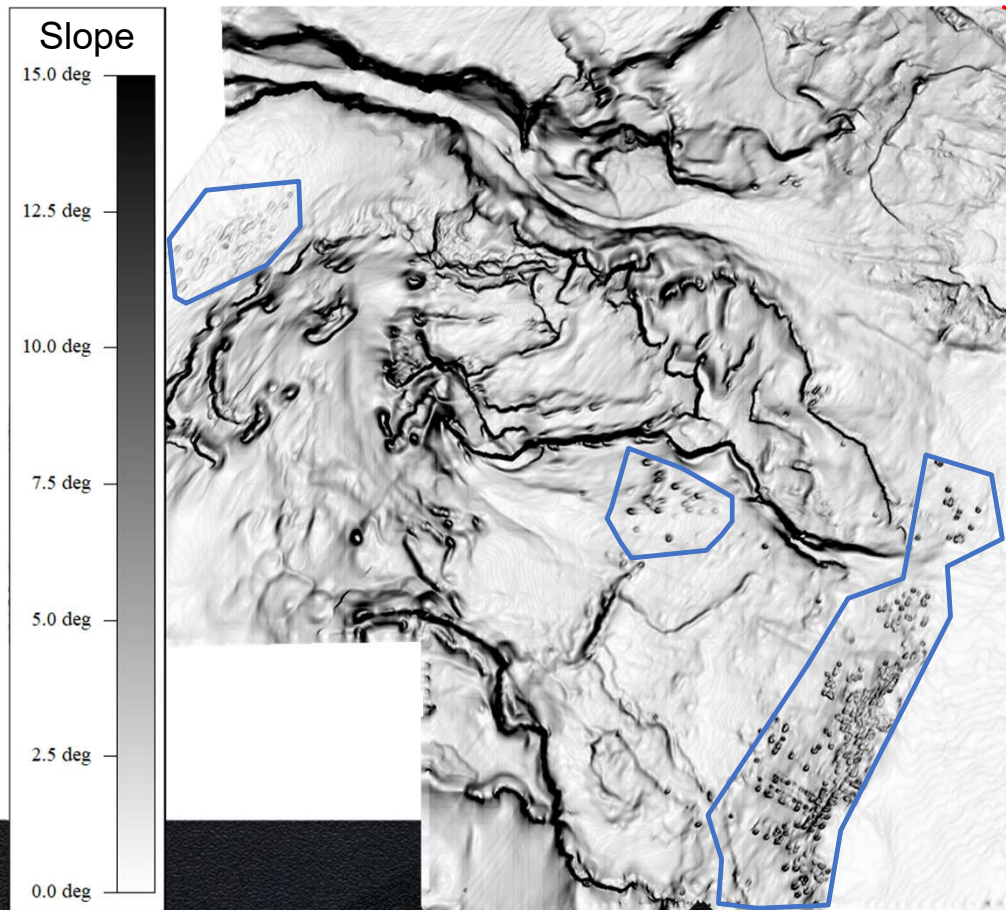
## REPROCESSED (2024)

- High res velocity field
- No undulations
- Velocity inv. @ potential SR levels



# Seismic – Pockmarks

3D seismic derived seabed map

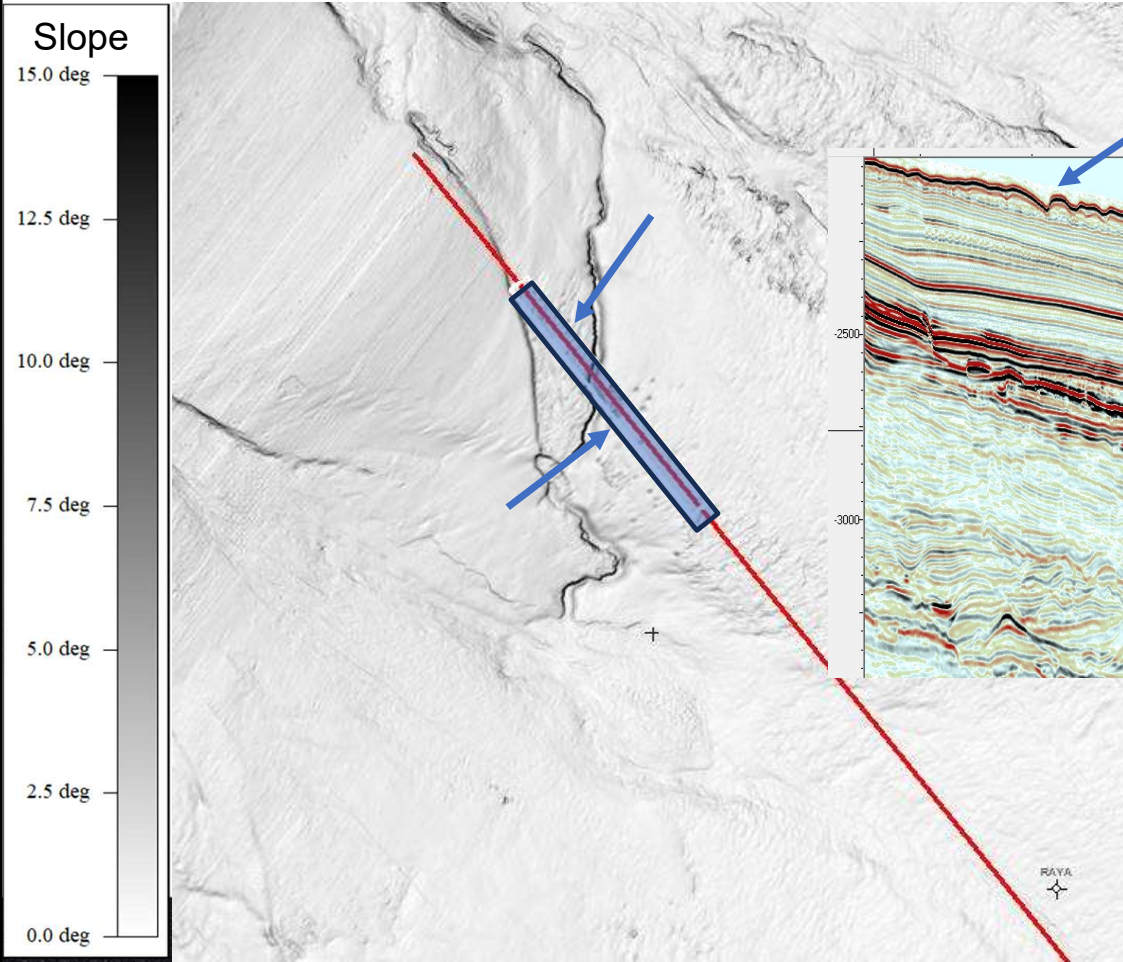


Slope attribute: highlights key variations in inclination

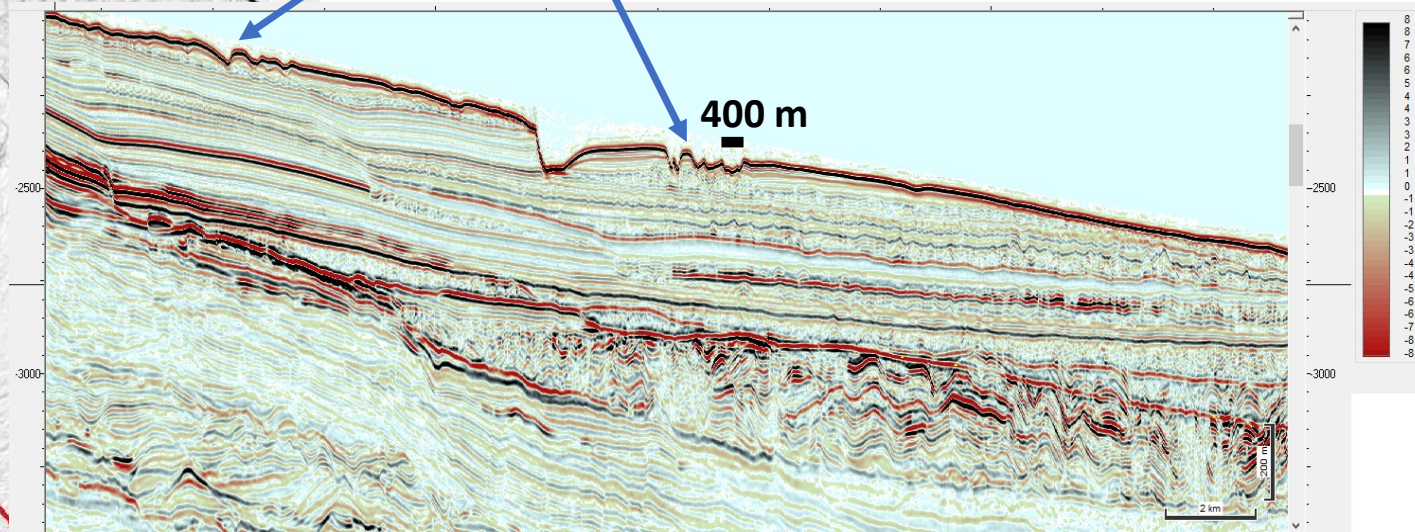
Pockmarks: gas escapes from potential C-T source rock?

## Seismic – Pockmarks

Multibeam bathymetry derived seabed map



Pockmarks

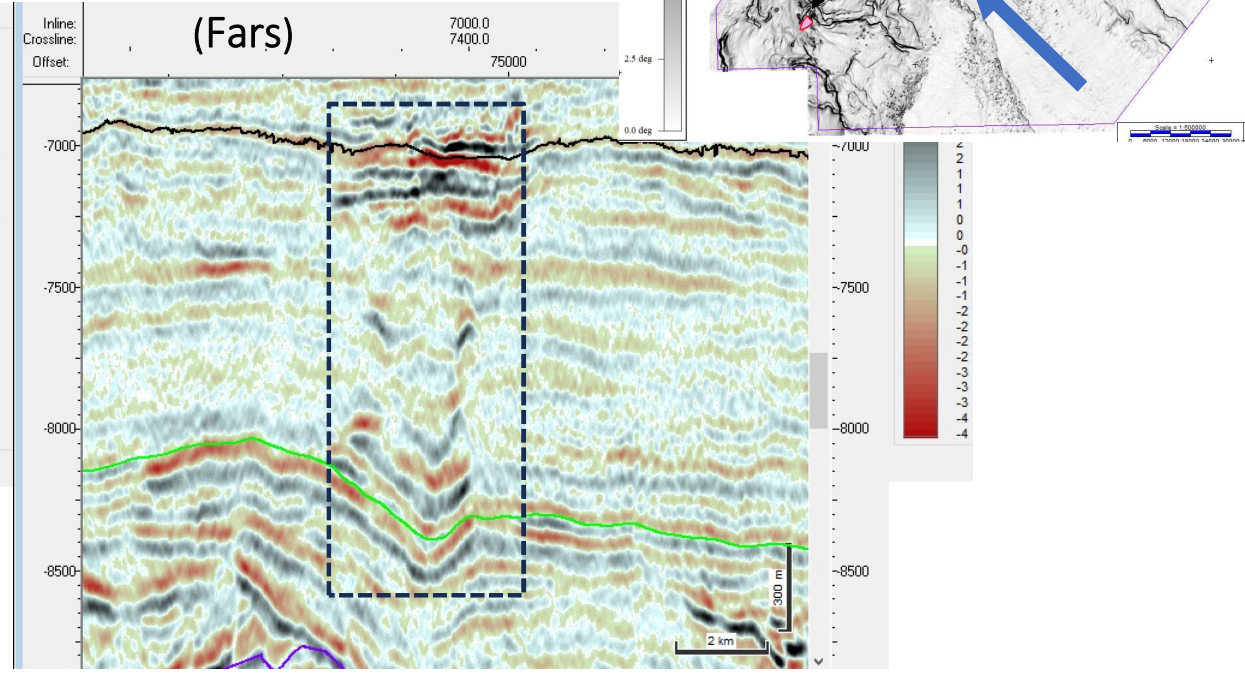
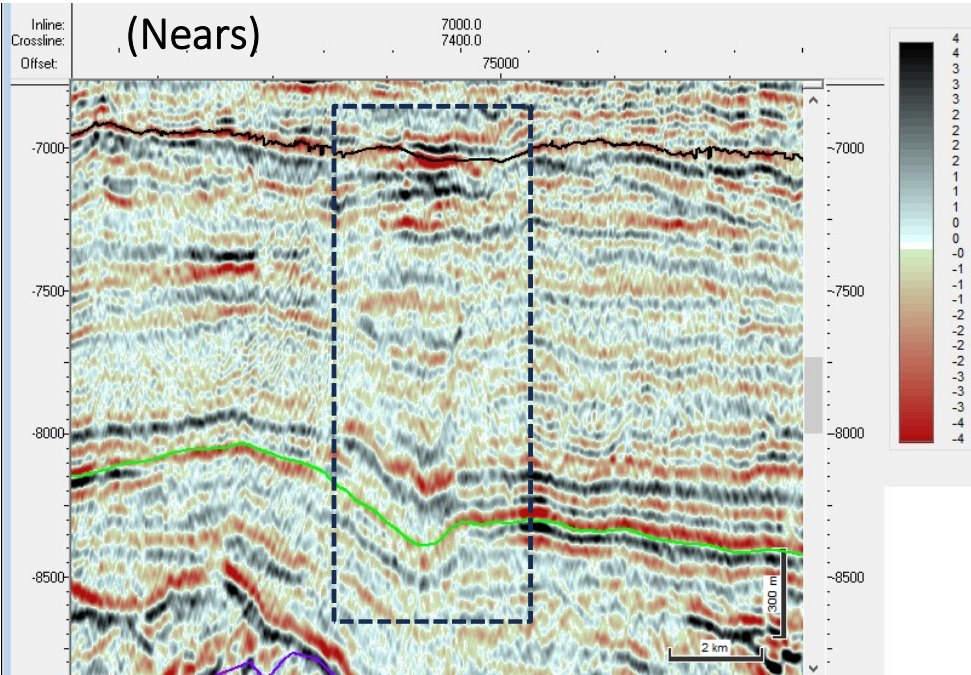
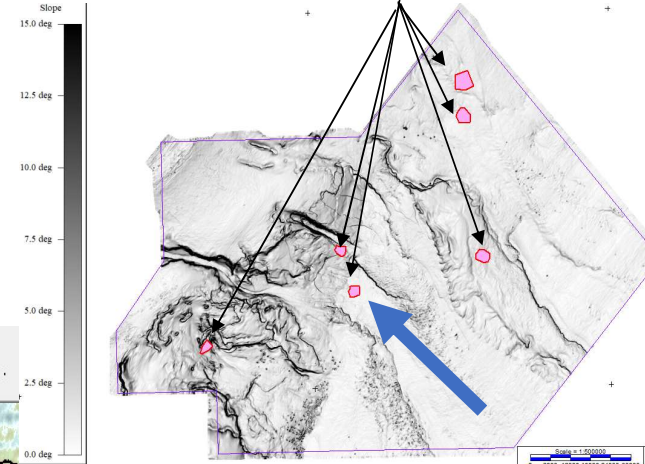


Pockmarks are concentrated in the Continental Slope area (150 – 3500 m water depth)

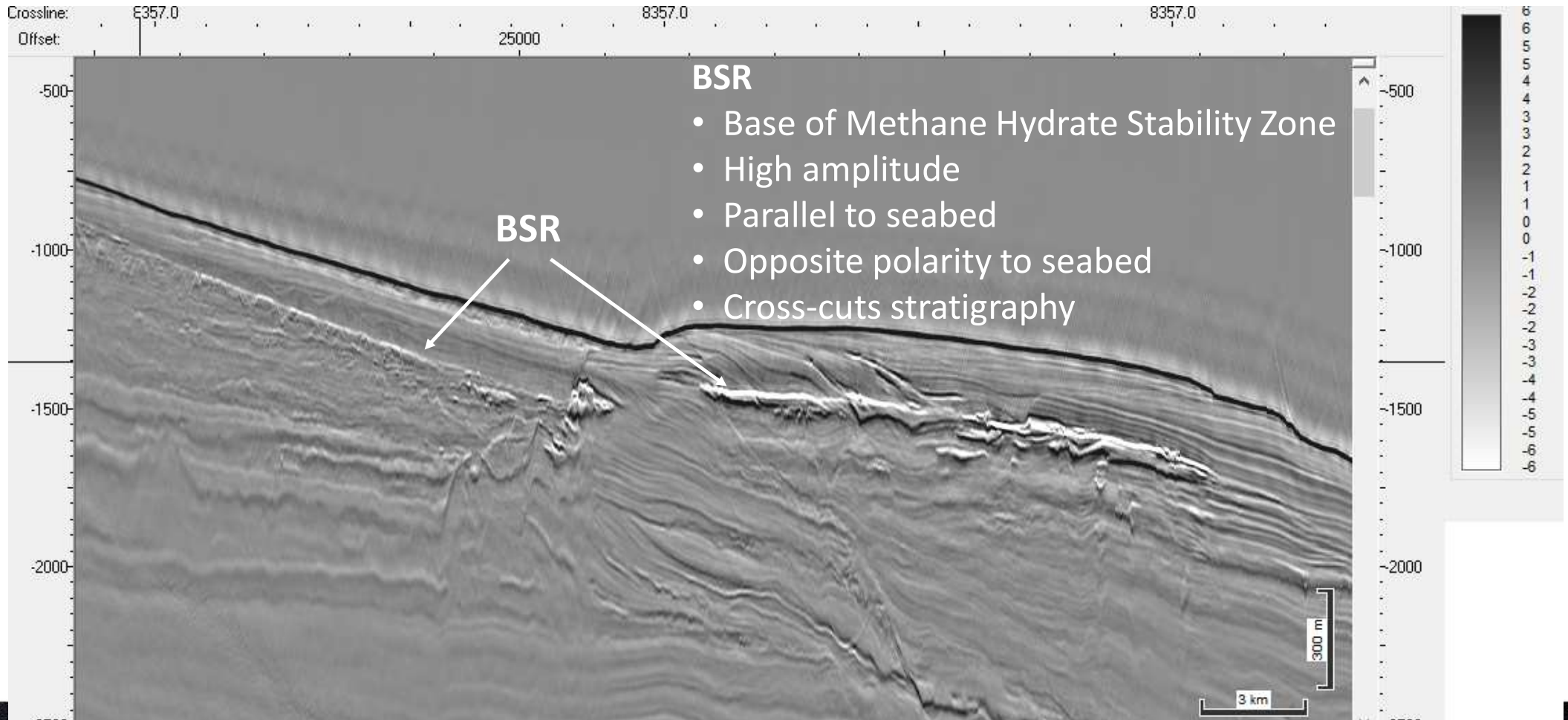
# Seismic – Gas Chimneys

**AVO type III anomalies**  
( $\uparrow A$ ,  $\downarrow f$ , pull-down effect)

Interpreted gas chimneys



# Seismic – Bottom Simulating Reflector



# Offshore Uruguay – Source Rocks

## Non seismic evidences:

- ✓ Fluid Inclusions in wells
- ✓ Oil Slicks from Synthetic Aperture Radar (SAR) imagery
- ✓ CSEM: resistivity anomalies derived from the inversion of CSEM data
- ✓ Hydrocarbon Microseeps identified in seabed samples

# Wells – Fluid Inclusions

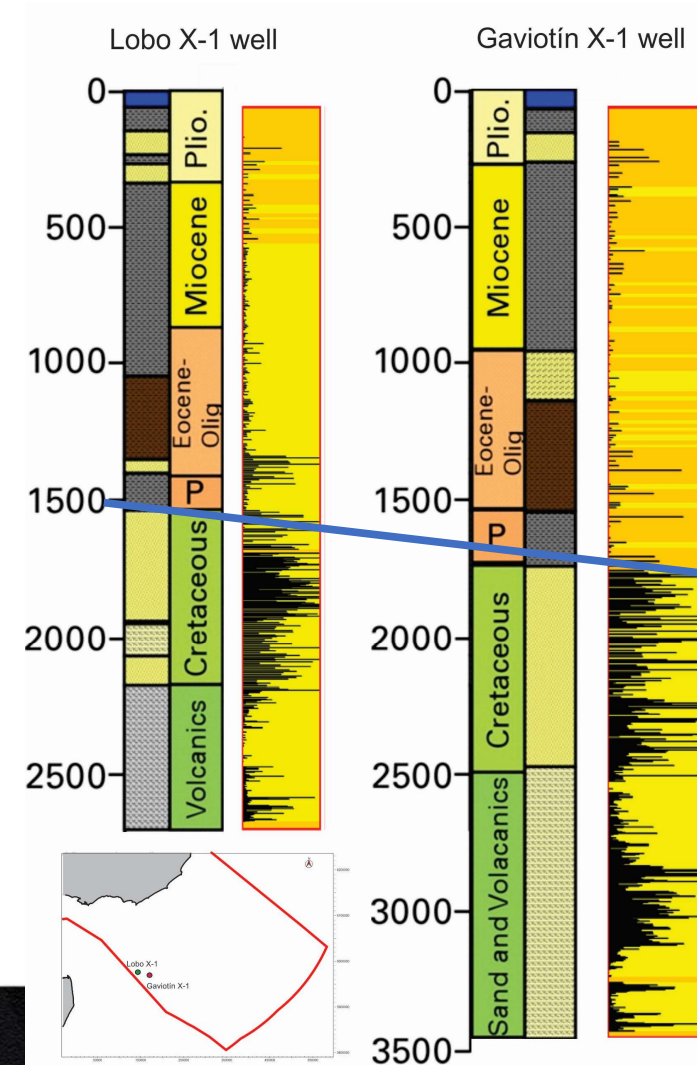
Fluid inclusions study in Lobo and Gaviotín cuttings made by FIT in 2011.

The results of this analysis indicate :

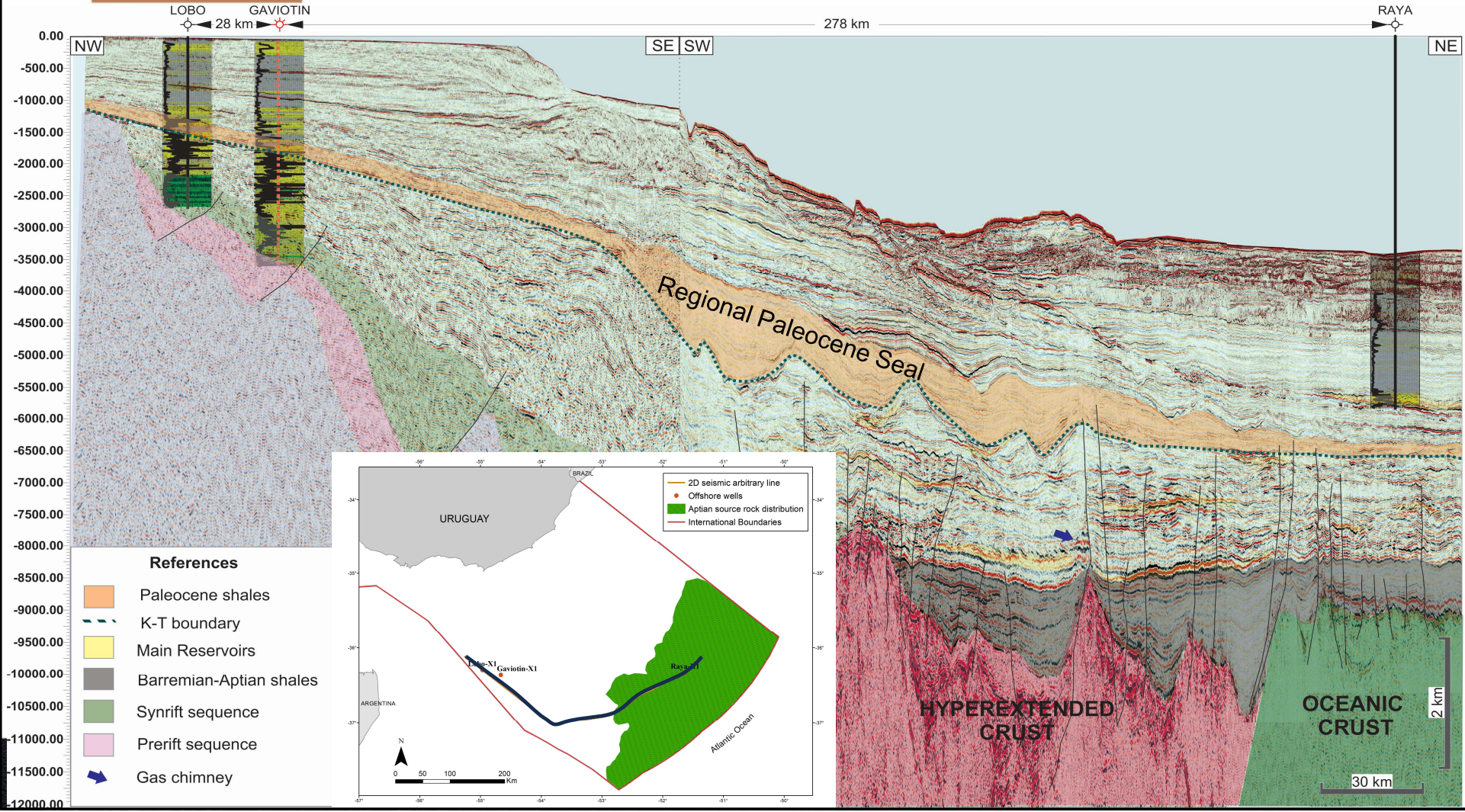
- Dry gas anomalies in each well in Jurassic, Cretaceous and Tertiary levels.
- Most anomalies are concentrated within the Cretaceous sequence
- Low to high gravity oil inclusions were found.
- Efficiency of the Paleocene transgression as regional seal

## Conclusions:

- Active Petroleum System
- Cretaceous is a key exploration target



# Wells – Fluid Inclusions



**RAYA: no significant HC inclusions**

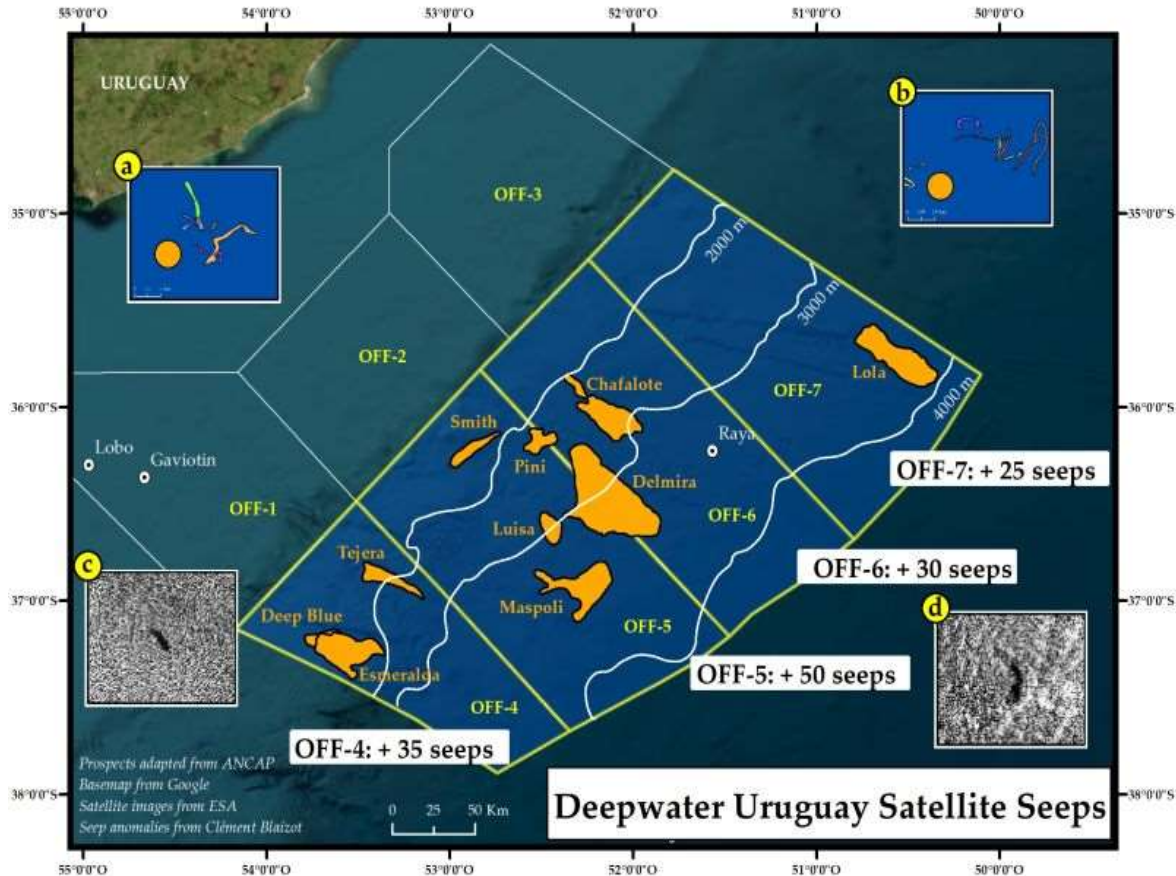
Lack of migration pathways connecting K source rocks and T reservoirs

← **KT**

(Conti *et al.*, 2023)

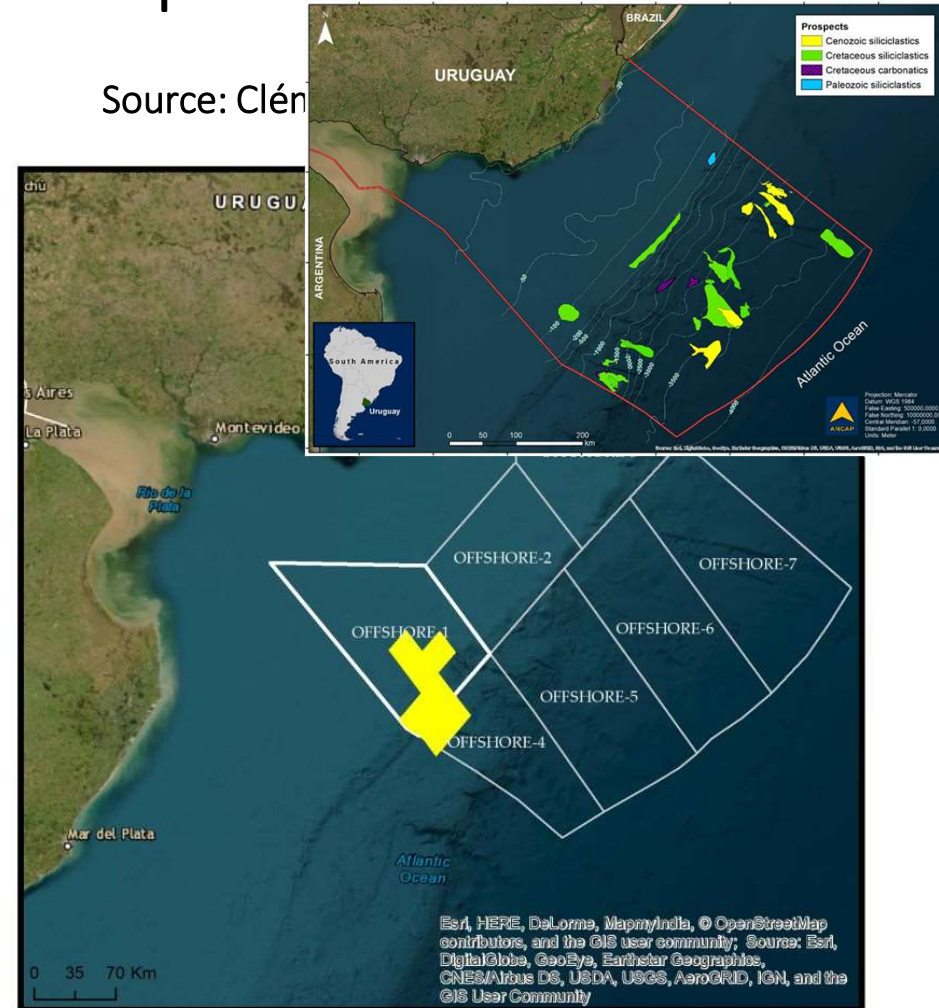
## Oil Slicks – SAR imagery interpretation

Source: Clément Blaizot's LinkedIn post



> 140 deepwater seeps

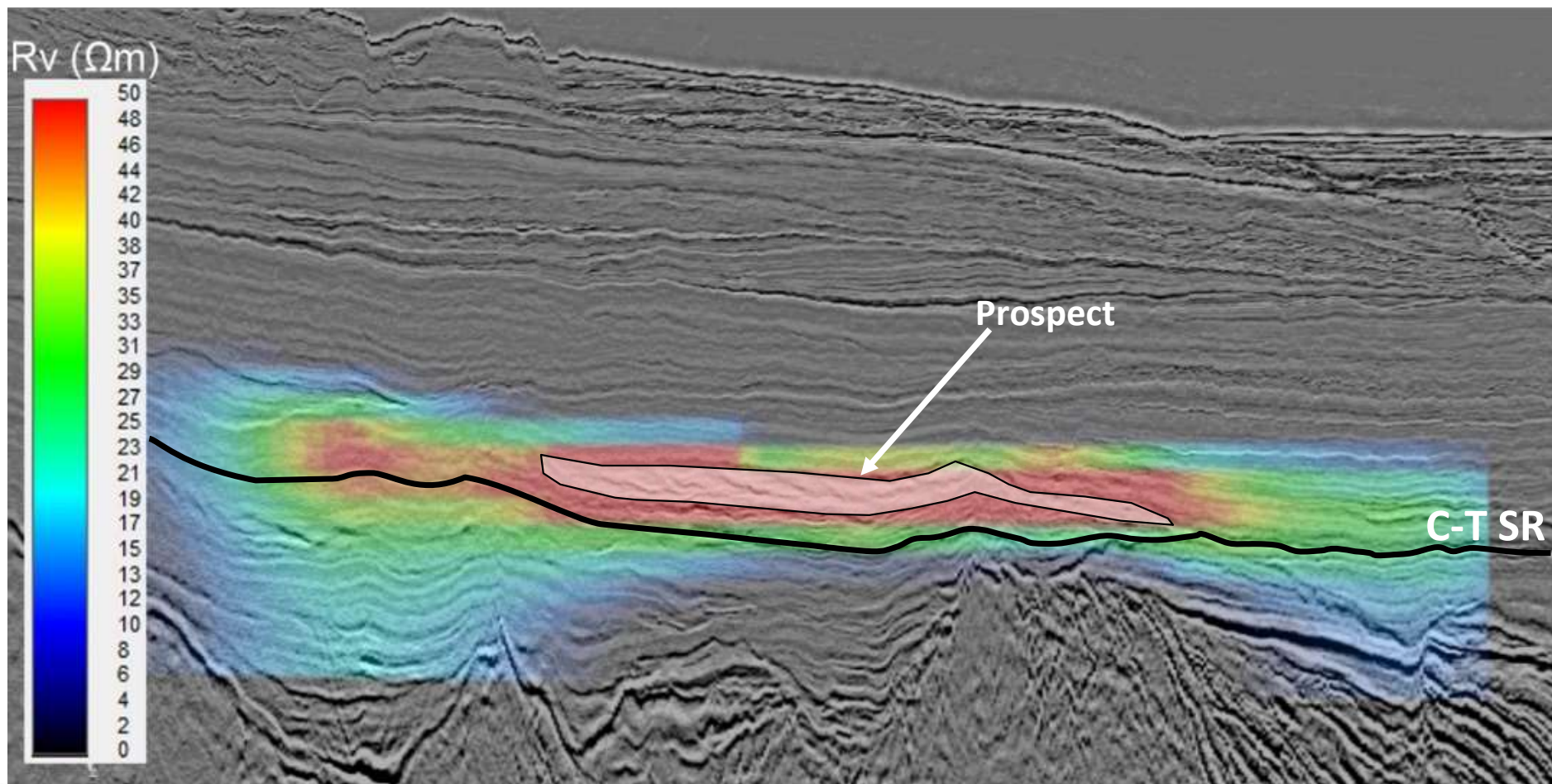
Source: Clén



Shallow water seeps also detected

## CSEM derived resistivity anomalies

Joint analysis of  
3D seismic and  
CSEM data

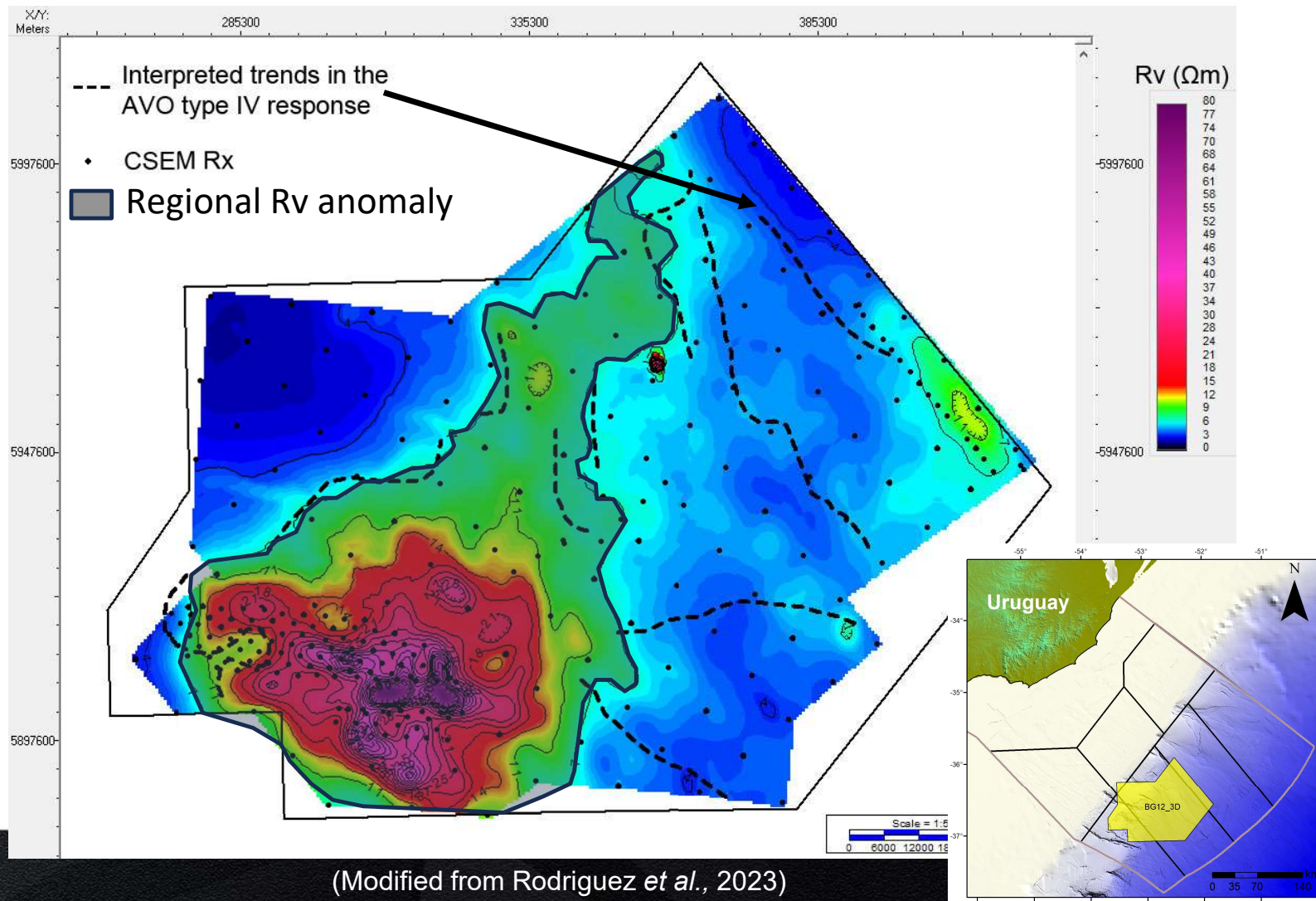


## CSEM derived resistivity anomalies

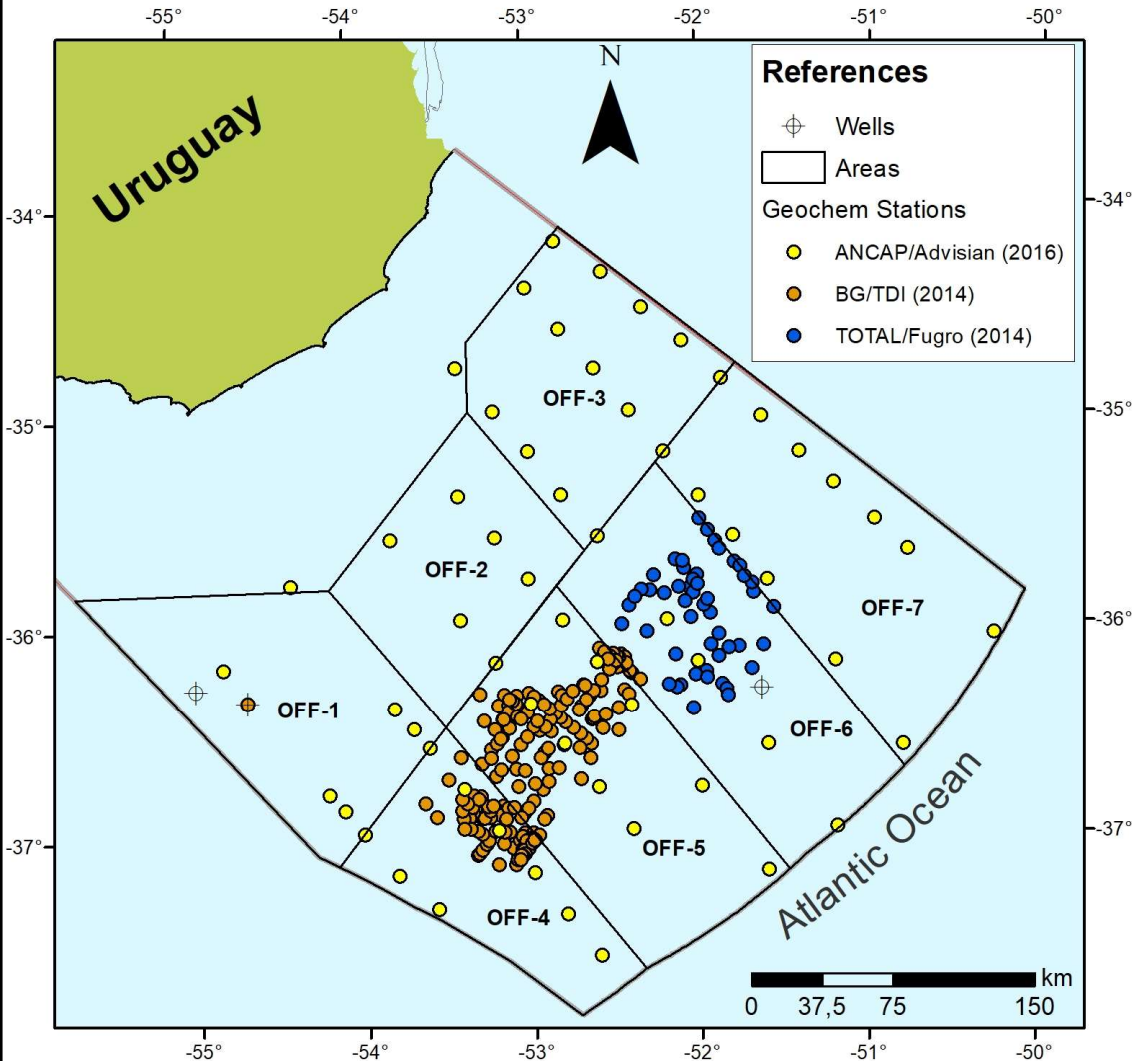
## Inverted Rv

RMS map between ML  
and (ML+4,500 m)

Regional Rv anomaly  
has a good correlation  
with AVO Type IV  
source rock response  
towards the southwest

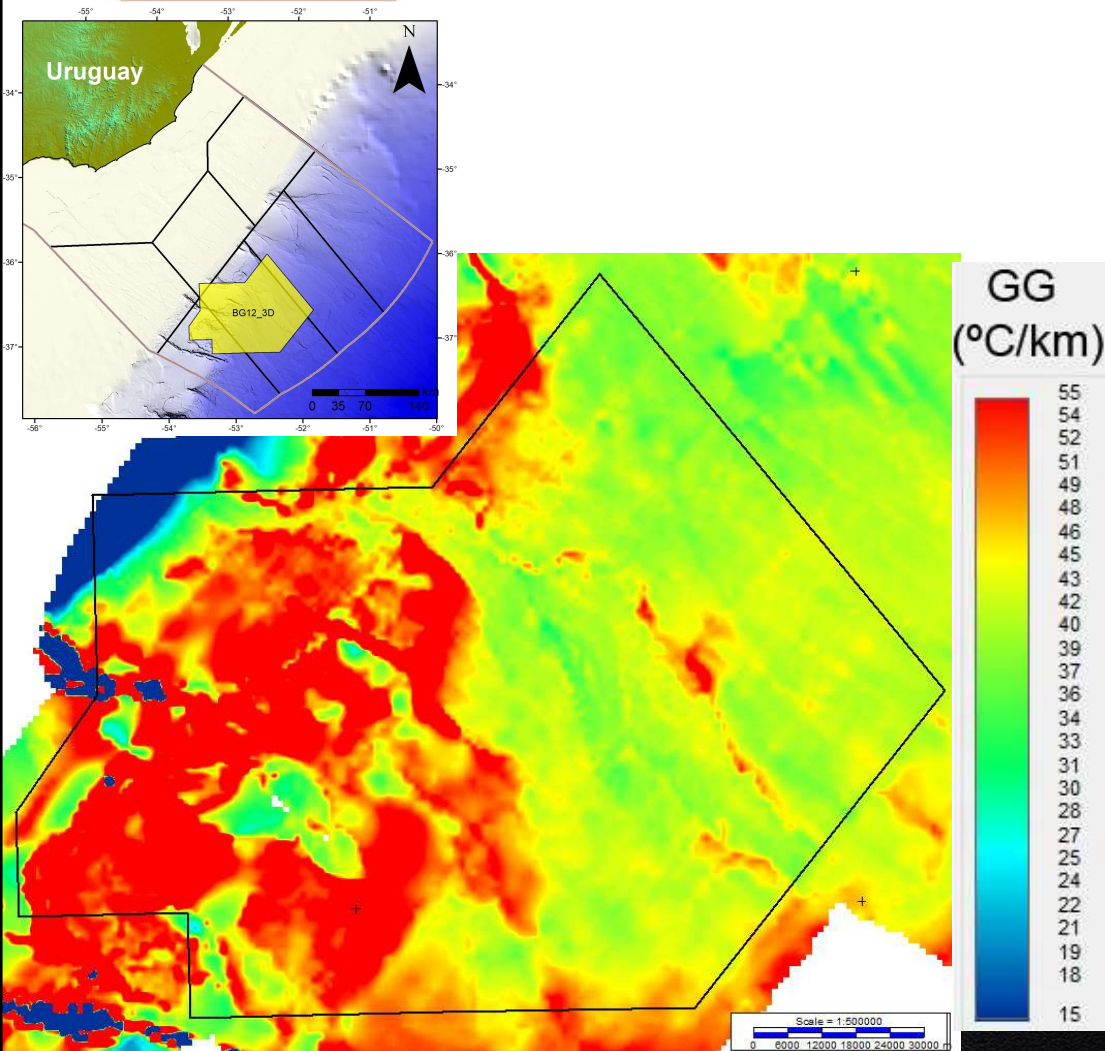


# Seabed Samples – HC microseepages



- Detection of hydrocarbon micro-seepages using seabed samples.
- Multiclient study that recently was extended with ~350 samples taken in 2014 by previous operators.
- This study confirms the presence of active petroleum systems.
- Multiple hydrocarbon anomalies correlate with prospects identified within available seismic data.
- Results will be presented in upcoming EAGE Annual 2025 (Toulouse), Paper #1054: *“Derisking source rock potential through geochemical analysis of seabed samples”*

# BSR derived shallow Geothermal Gradient



## Methodology:

- BSR interpreted in 2D and 3D seismic in depth.
- Geothermal gradients calculated using:
  - Seabed temperatures from the World Ocean Atlas (Locarnini *et al.*, 2013).
  - Temperatures at the BSR from hydrate stability temperature-pressure curves (Vohat *et al.*, 2003), assuming a hydrostatic pressure at the base of the hydrates.

## Equations:

$$P_{BSR}(\text{MPa}) \cong 1.030 * 9.8 * \text{Depth}_{BSR}/1000$$

$$T_{BSR}(^{\circ}\text{C}) \cong 8.8901 * \ln(P_{BSR}) - 8.9175$$

$$GG_{Shallow} \left( \frac{^{\circ}\text{C}}{\text{km}} \right) \cong \frac{(T_{BSR} - T_{SB}) * 1000}{\text{Depth}_{BSR} - \text{Depth}_{SB}}$$

(Rodriguez *et al.*, 2022)

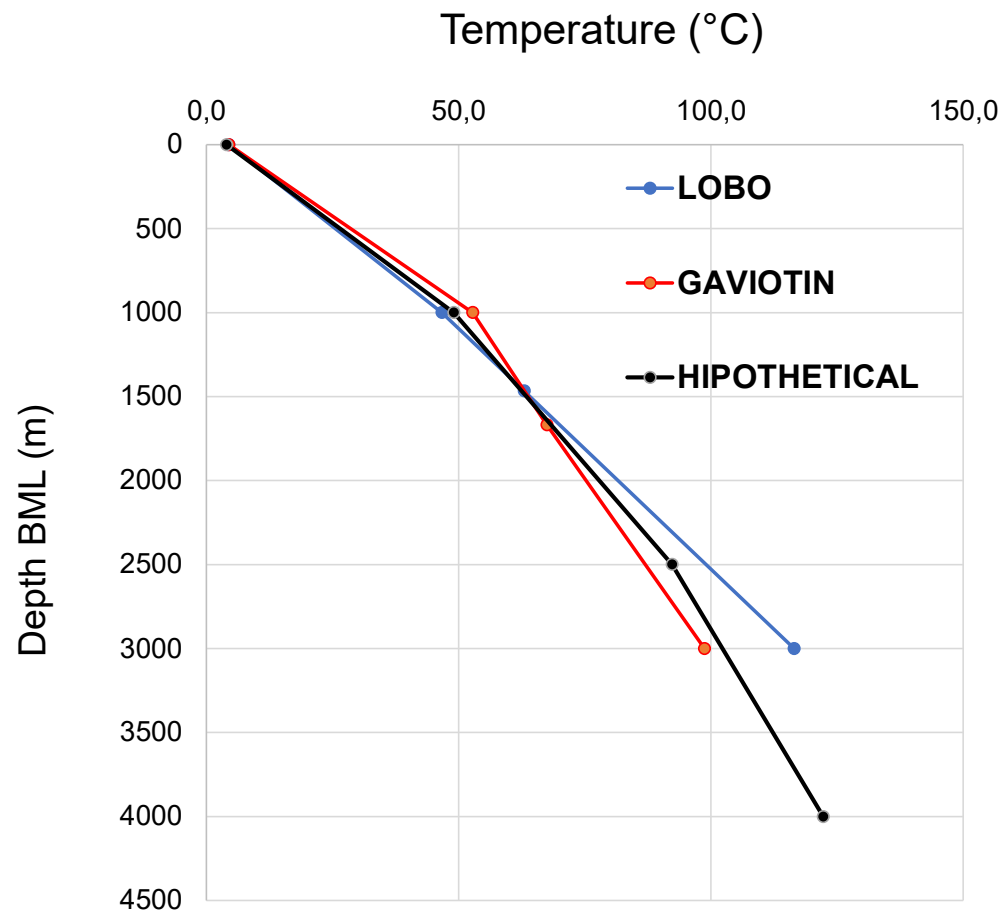
# Temperature over interpreted C-T source rock

Estimated using:

- BSR derived GG up to 1000 m BML
- (BSR derived GG)\*0,641 up to KT interface
- Constant geothermal gradient scenario up to top C-T

## HYPOTETHICAL

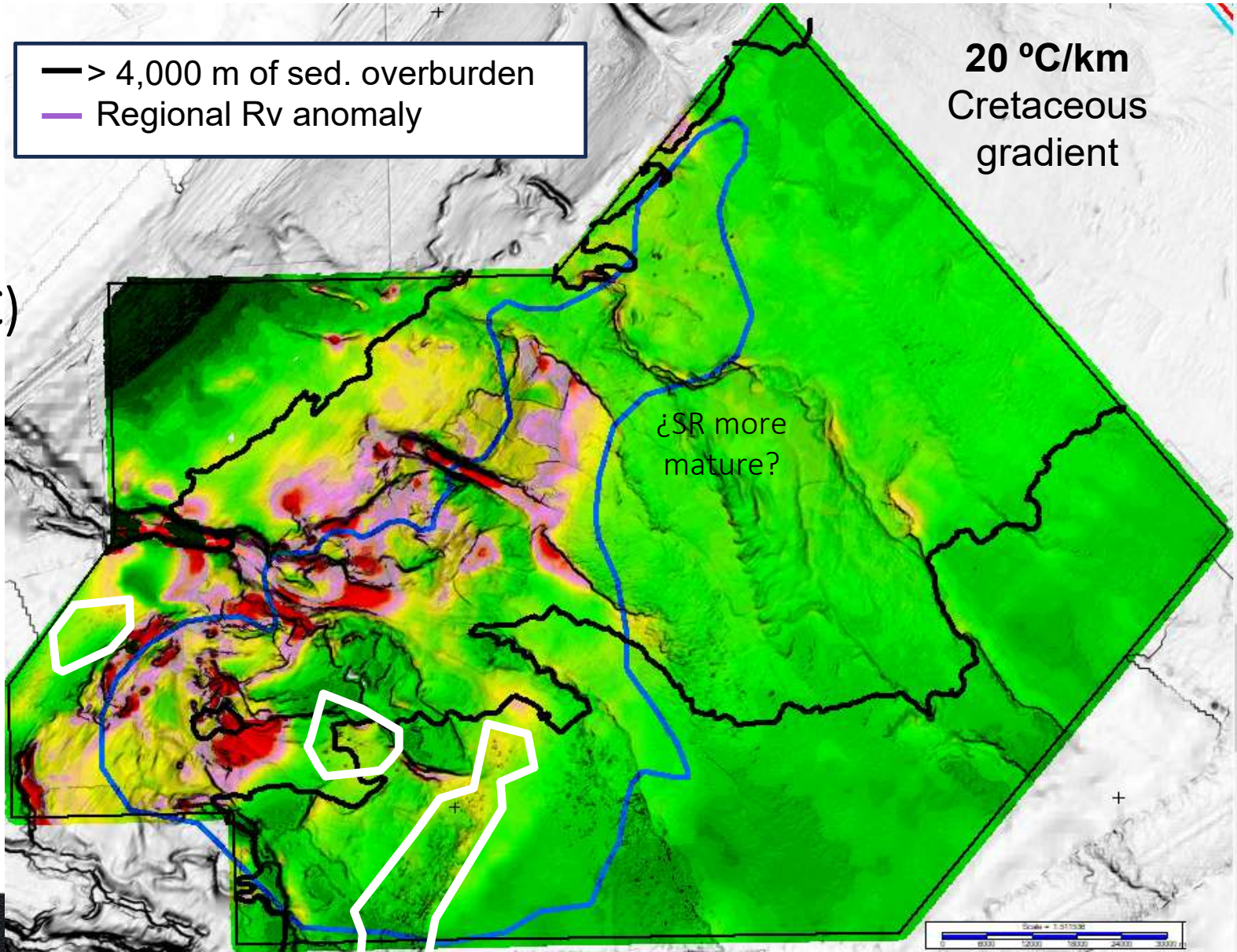
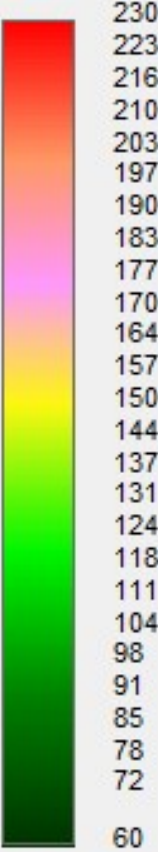
Depth BML (m)	Obs	T (°C)	IGG (°C/Km)	IGG decrease
0	Seafloor	4,0		
1000	1000	49,0	45,00	
2500	KT	92,3	28,85	35,9%
4000	Ceno-Turo	122,3	20,00	55,6%



— > 4,000 m of sed. overburden  
— Regional Rv anomaly

20 °C/km  
Cretaceous  
gradient

T (°C)



¿SR more mature?

Present-day  
temperature (°C)  
on top C-T

Sedimentary  
Overburden > 4,000 m =>  
CSEM inversion is less  
sensitive

# Final Remarks

## Seismic related:

- ✓ Seismic Correlations
- ✓ Seismic Response
  - Attribute mapping
  - AVO Analysis
  - FWI
- ✓ DHIs
- ✓ Fluid escape features
- ✓ BSR

## Non-seismic:

- ✓ Fluid Inclusions
- ✓ Oil Slicks from SAR imagery
- ✓ Resistivity Anomalies from CSEM data
- ✓ Hydrocarbon Microseeps in seabed samples

## **This workflow:**

- enhances geological understanding
- confirms active petroleum systems
- supports exploration with greater confidence

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**THANK YOU.**