Seismo-stratigraphy and 3-D Petroleum System Modeling of the Colorado Basin, Offshore Argentina*

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Abstract

The analysis of a dense 2D seismic reflection dataset and data from 12 exploration wells, allowed us to identify the main syn- and post-rift seismo-stratigraphic sequences and build a 3D petroleum system model calibrated not only to thermal data, but also to present-day hydrocarbon-leakage indicators observed on the continental shelf and slope of the Colorado Basin.

The sequence maps (twt) show a shifting configuration from the break-up unconformity (130 Ma) to the present-day seafloor. The break-up unconformity displays a central EW-elongated graben, which prevails on the overlying sequences up to the Miocene. Sedimentation during the basin-sag phase (Aptian to Campanian) was mainly located in the central part of the basin, while there was a discrete eastward depocentre migration during the Paleocene. An important transgression, accompanied by aggradation and decrease in sedimentation rate, occurred during the Eocene. A dramatic increase in sediment supply took place from the Oligocene up to the Present, driving a depocentre migration to the outer parts of the basin.

The potential hydrocarbon migration pathways predicted by the 3D basin-wide model have been calibrated to the presence of interpreted seabed pockmarks depressions located close to an array of submarine channels on the slope of the basin. Results from this calibrated model indicate that, although syn-rift and Early Cretaceous source rocks (SR) intervals would be depleted in the central areas of the basin, an active kitchen may exist from the Aptian SR, which is probably feeding the interpreted pockmarks on the slope of the basin.

References

Bushnell, D.C., J.E. Baldi, F.H. Bettini, H. Franzin, E. Kovas, R. Marinelli, and G.J. Wartenburg, 2000, Petroleum systems analysis of the eastern Colorado Basin, offshore northern Argentina, *in* M.R. Mello, and B.J. Katz, (eds.), Petroleum systems of South Atlantic margins: AAPG Memoir 73, p. 403-415.

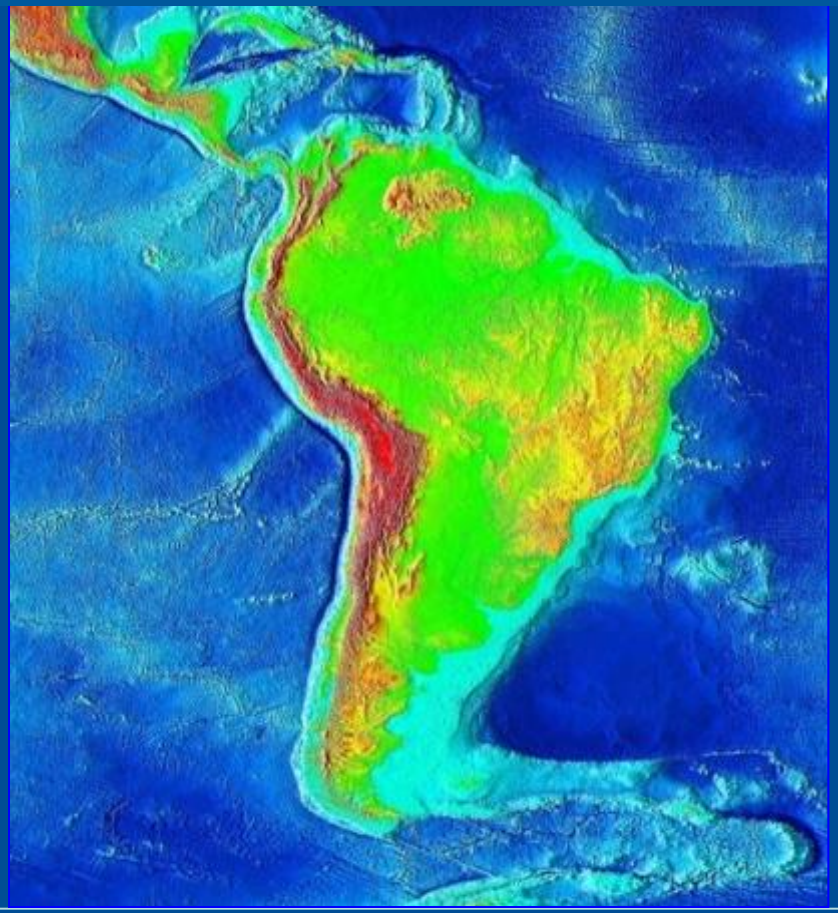
Franke, D., B. Schreckenberger, S. Neben, A. Schulze, C.M. Krawczyk, and M. Stiller, 2006, Crustal structure across the Colorado Basin, Offshore Argentina: Geophysical Journal International, v. 165/3, p. 850-864.

Fryklund, B., A. Marshall, and J. Stevens, 1996, The Colorado Basin, *in* V.A. Rams, and M.A. Turic, (eds.), Geology and natural resources of the Argentine continental shelf: Relatorio Congreso Geologico Argentino, v. 13, p. 135-158.

Pilcher, R., and J. Argent, 2007, Mega-pockmarks and linear pockmark trains on the West African continental margin: Marine Geology, v. 244/1-4, p. 15-32.

Vayssaire, A., S. Quesada, W. Prayitno, and D. Figueroa, 2007, Petroleum Systems of Colordo and Malvinas Basins, Deepwater Argentina: Geological Society of London, South Atlantic Petroleum Systems Conference, 10 p.

Seismo-stratigraphy & 3-D petroleum system modeling of the Colorado Basin, offshore Argentina



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Goals & Tasks

- Study driving factors of hydrocarbon-leakage indications
- Investigate the existence of an active petroleum system

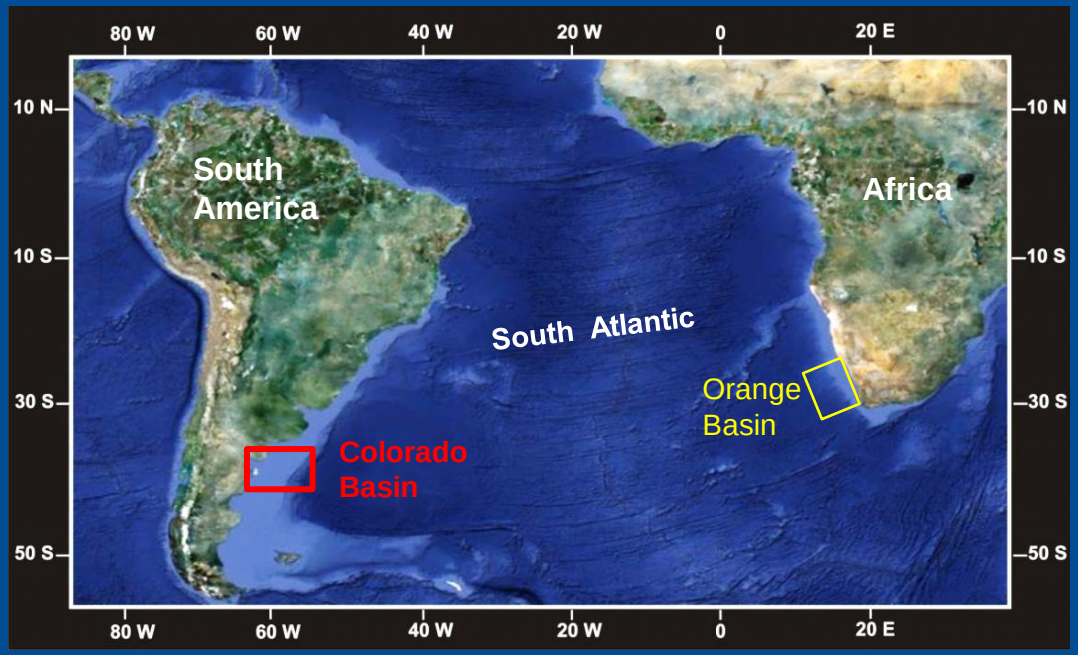
- Basin-wide seismo-stratigraphic analysis
- Identification & mapping of HC-leakage indicators
- 3D Modeling of HC generation & migration paths

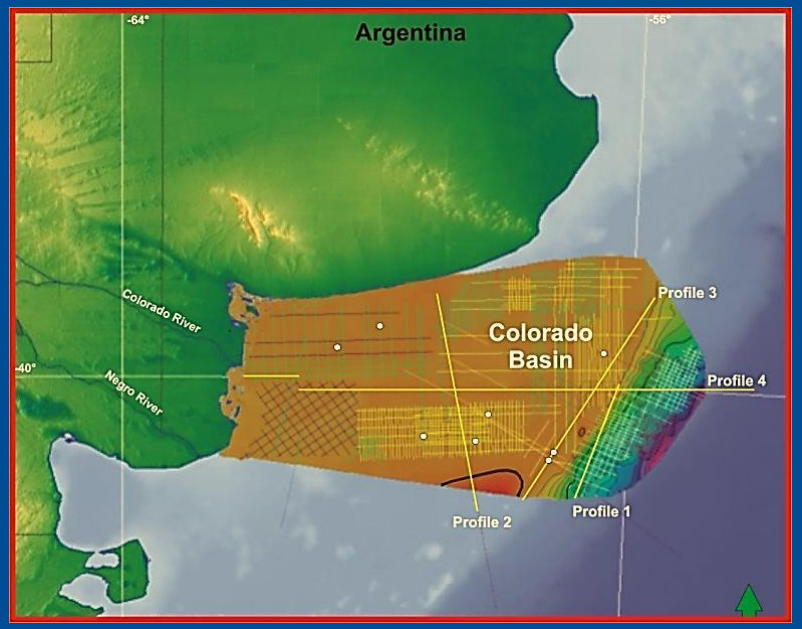
Outline

- Basin overview & general stratigraphy
- Margin architecture & depocenter evolution
- Indications of active hydrocarbon leakage
- 3D Model HC generation & migration
- Conclusions

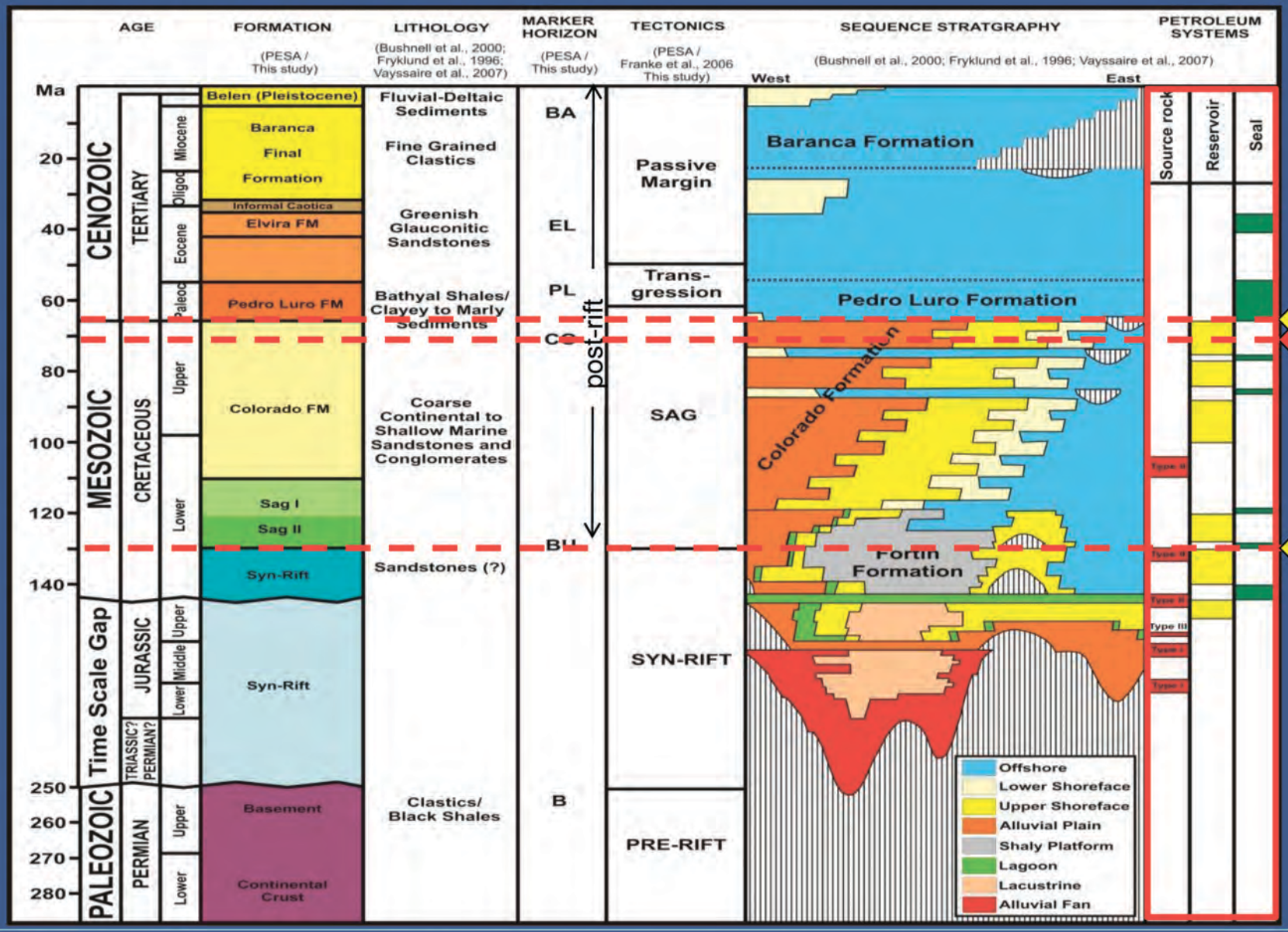
The Colorado Basin

- 2D seismic reflection grid ~30.000 km^2
- Grid spacing: 2.5 to 35 km
- 8 exploration wells (under-explored)





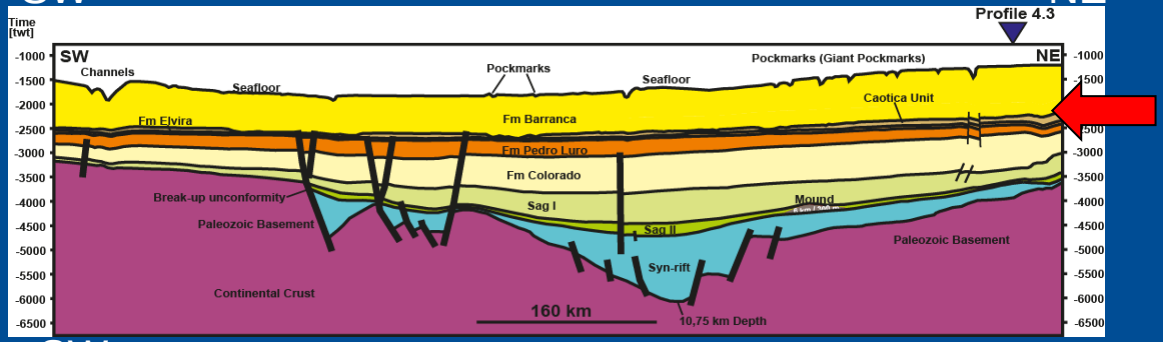
Main stratigraphic units

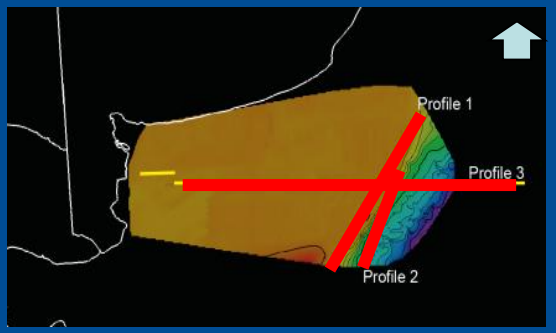


Margin architecture

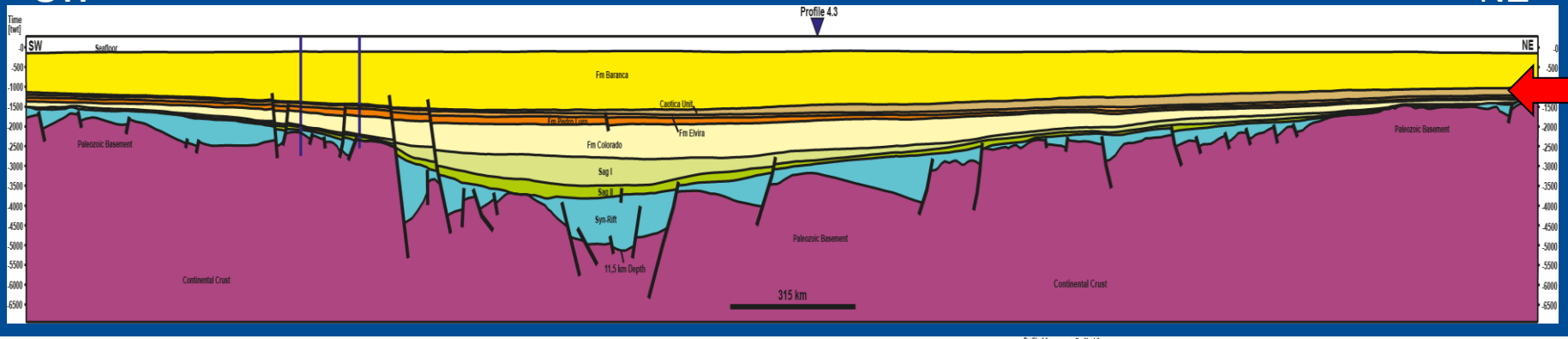
- Current configuration since Oligocene

SW NE





SW NE



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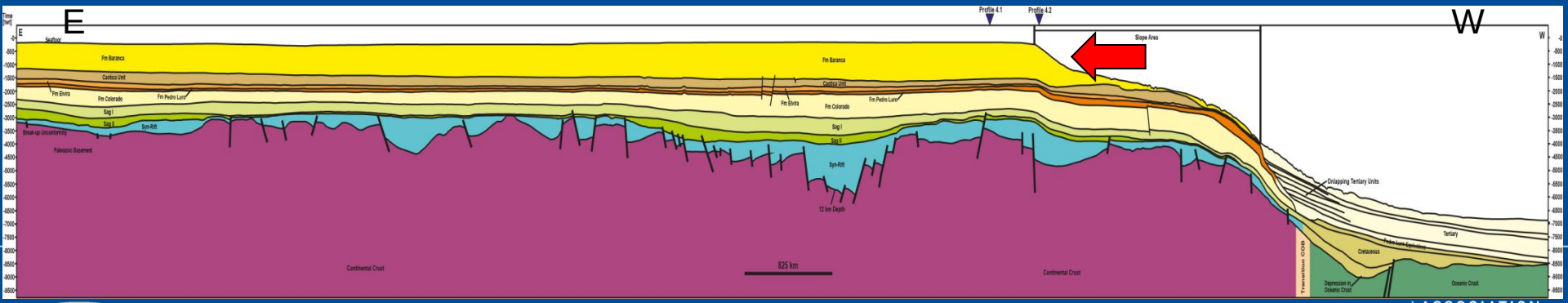
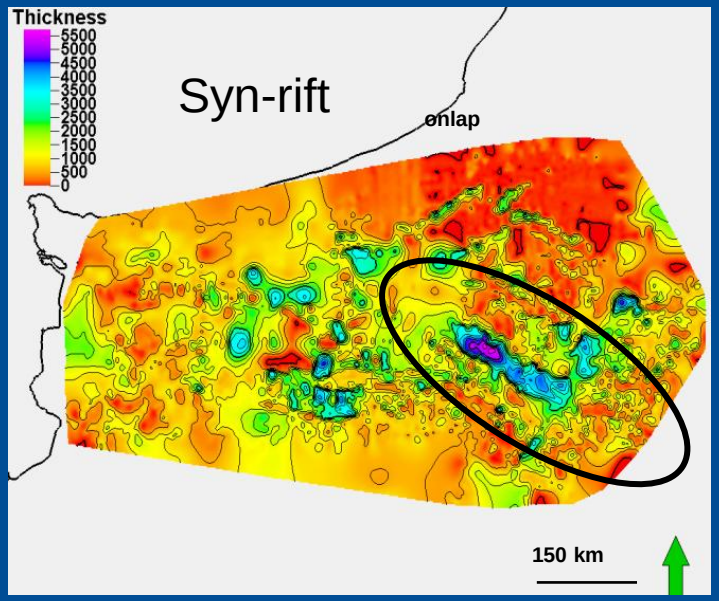
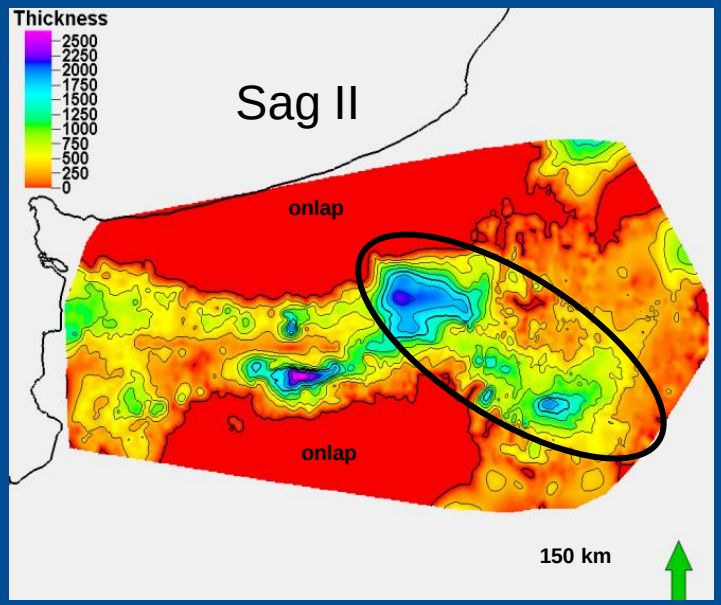


Margin-oblique Cretaceous depocenters

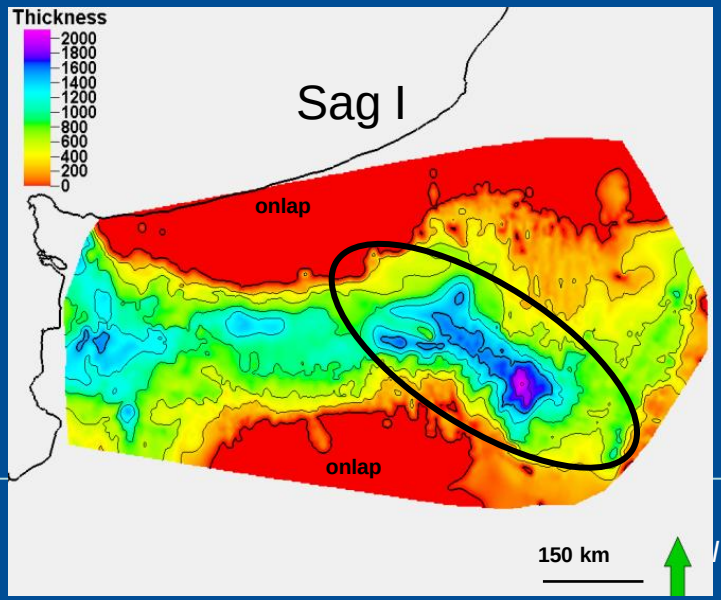
Early Cretaceous



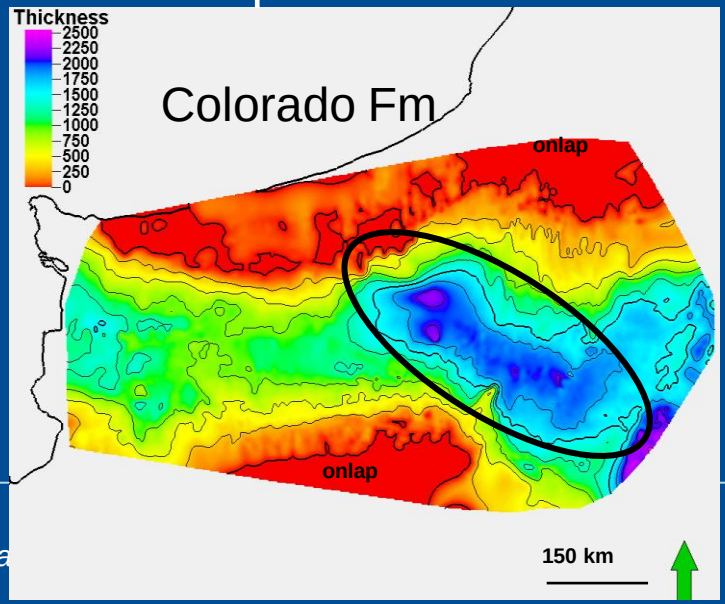
Neocomian-Barremian



Aptian

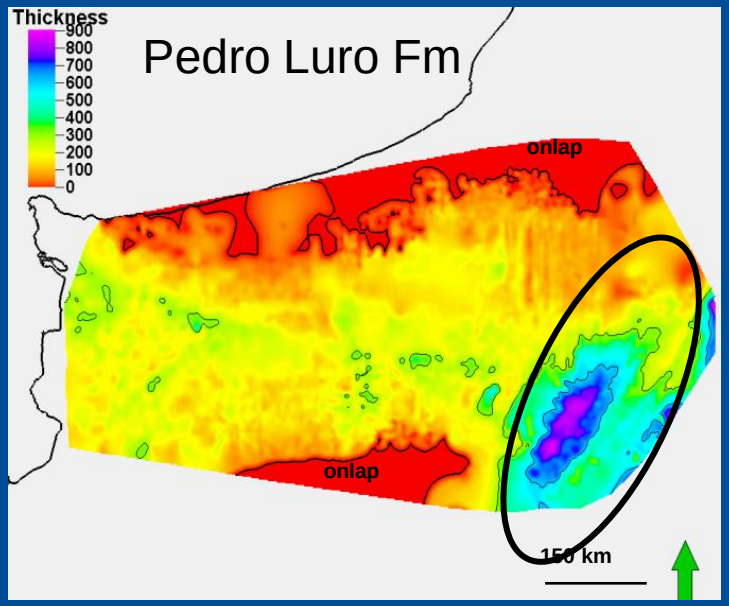


Albian-Campanian

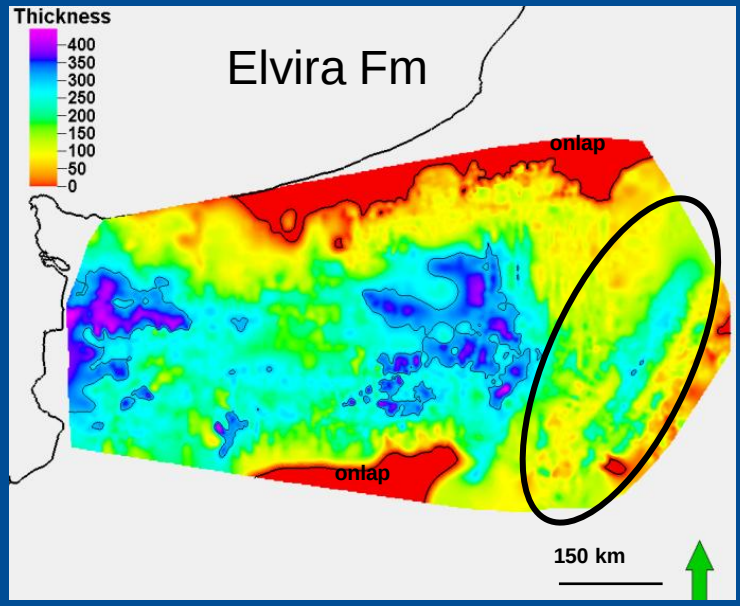


Margin-parallel Cenozoic depocenters

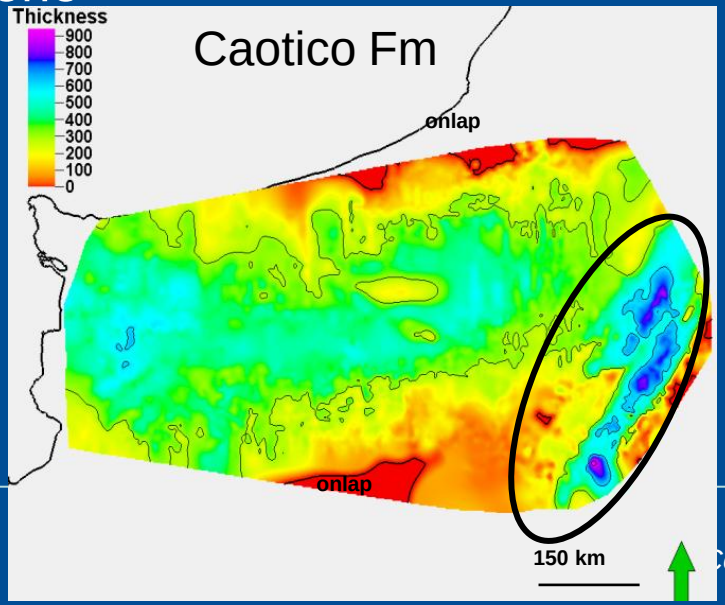
Paleocene



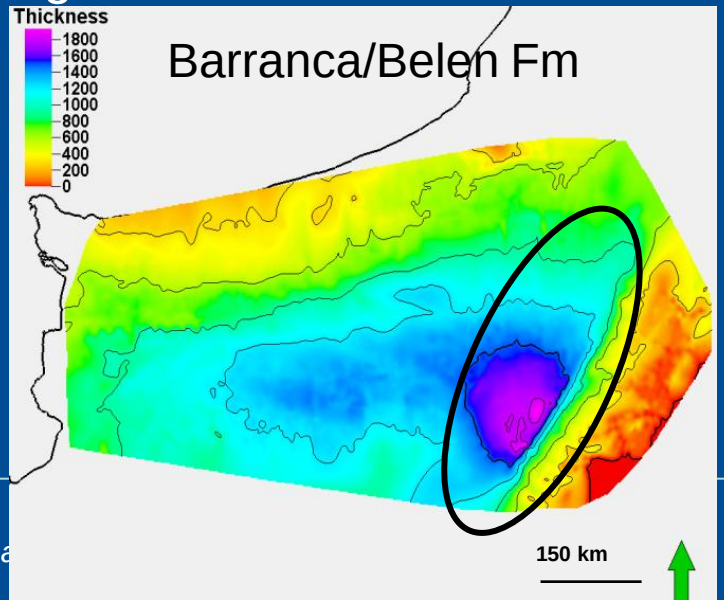
Eocene



Oligocene



Oligo-Miocene

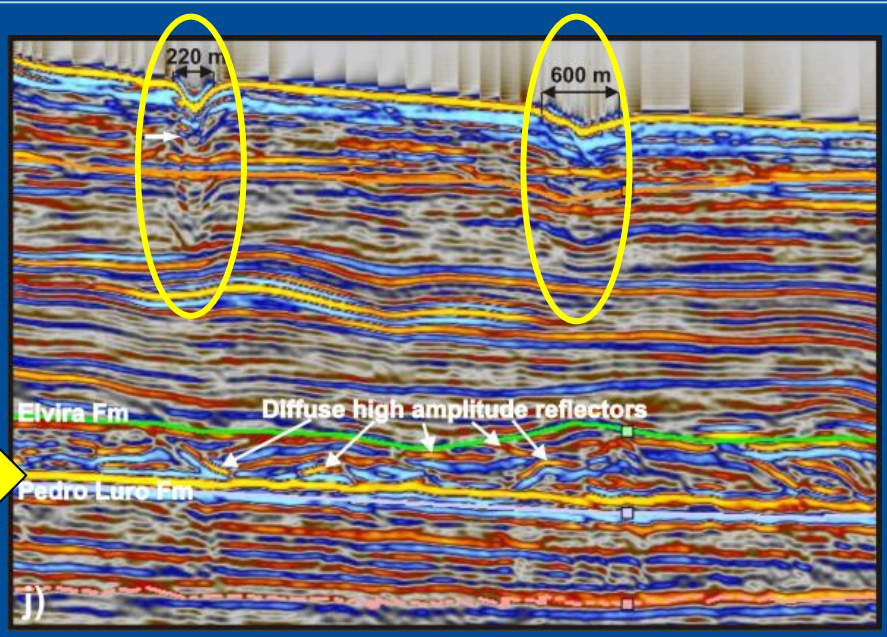


Indications of active HC leakage

Slope

- Seafloor pockmarks (200 - 600 m)
- Gas / seismic chimneys
- Polygonal faults

seal



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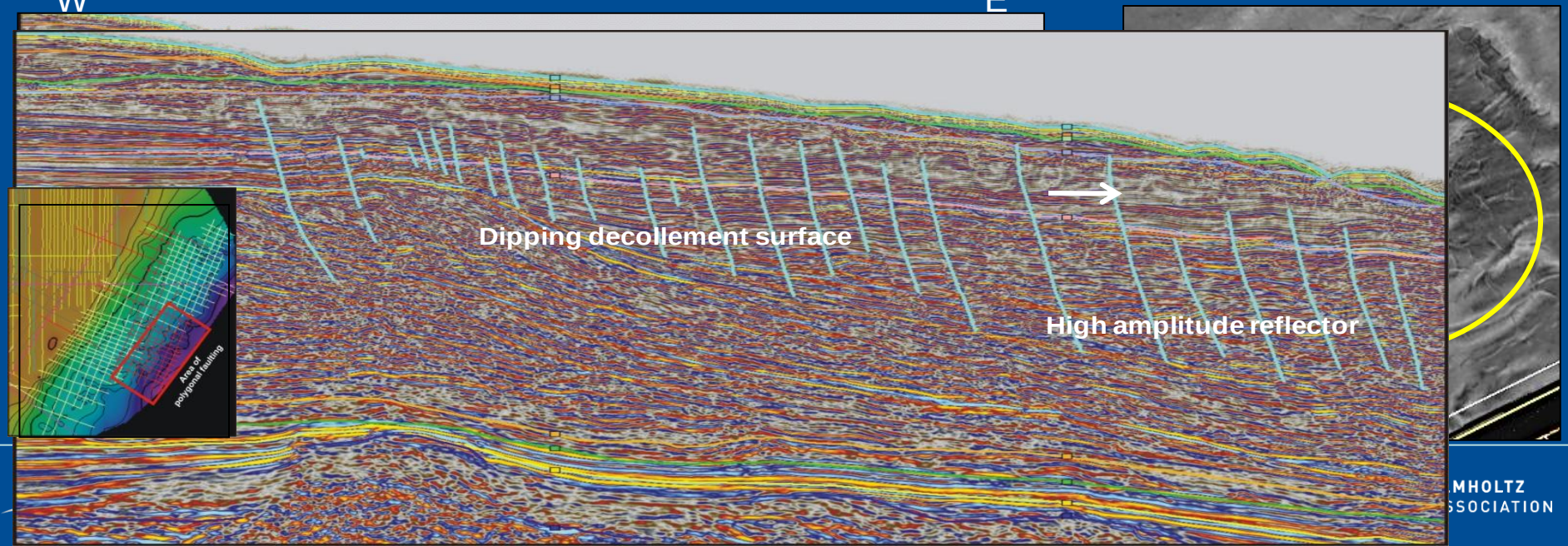
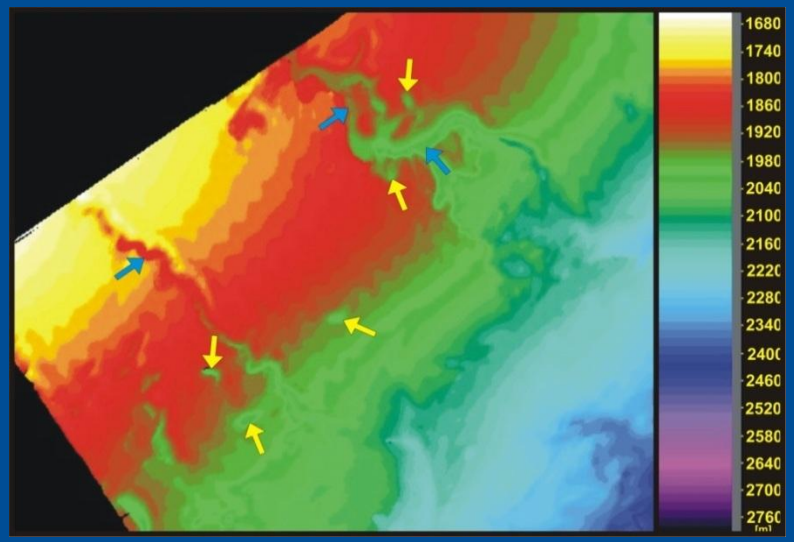
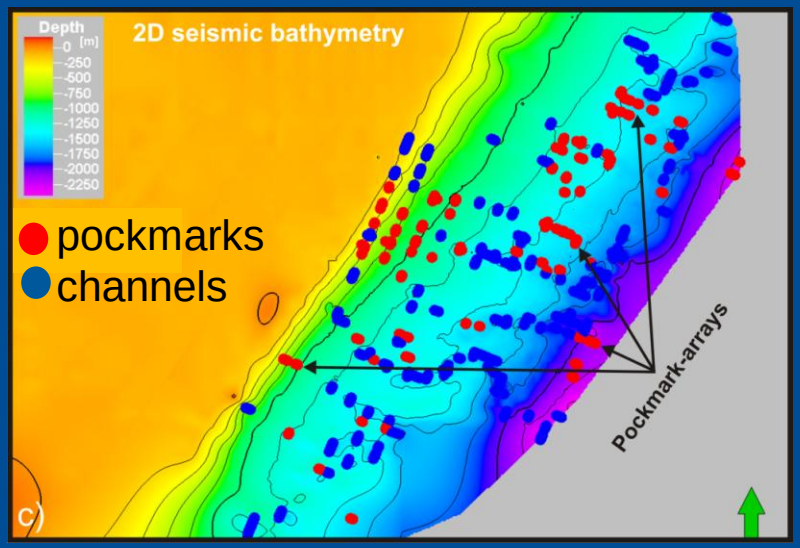
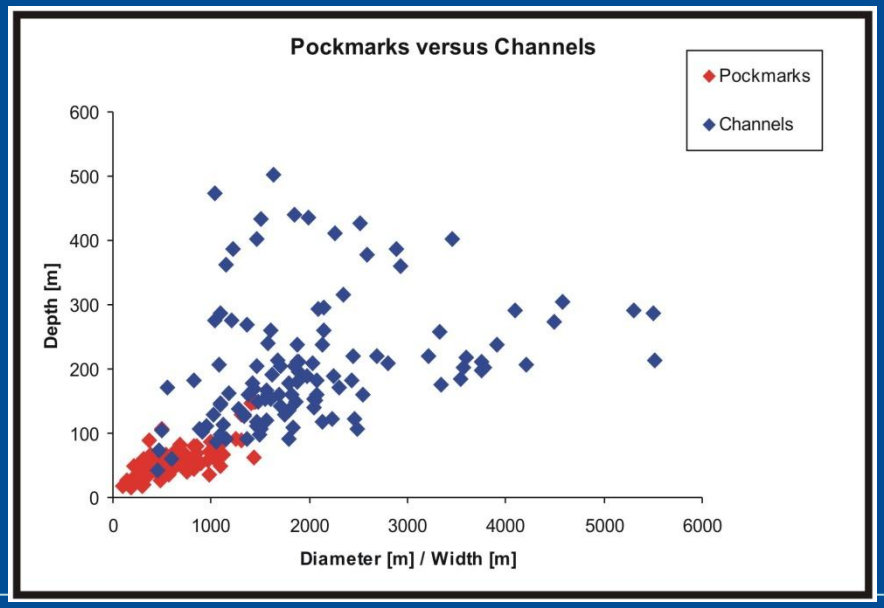
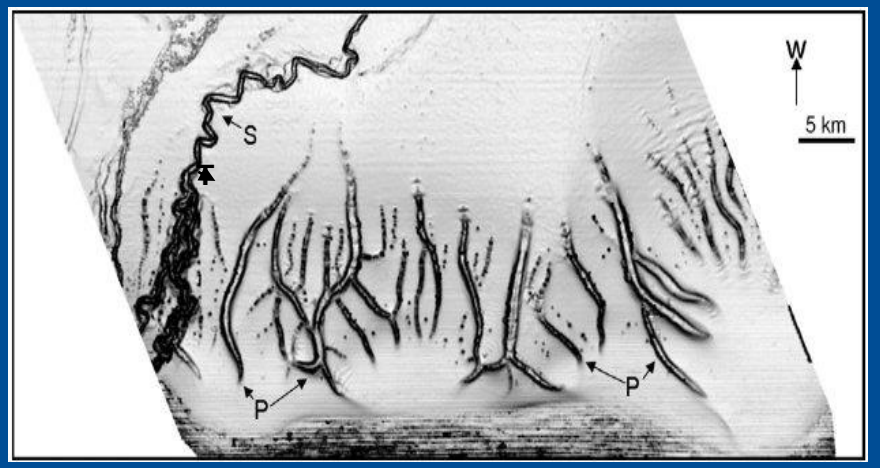


Seafloor pockmarks vs Slope channels







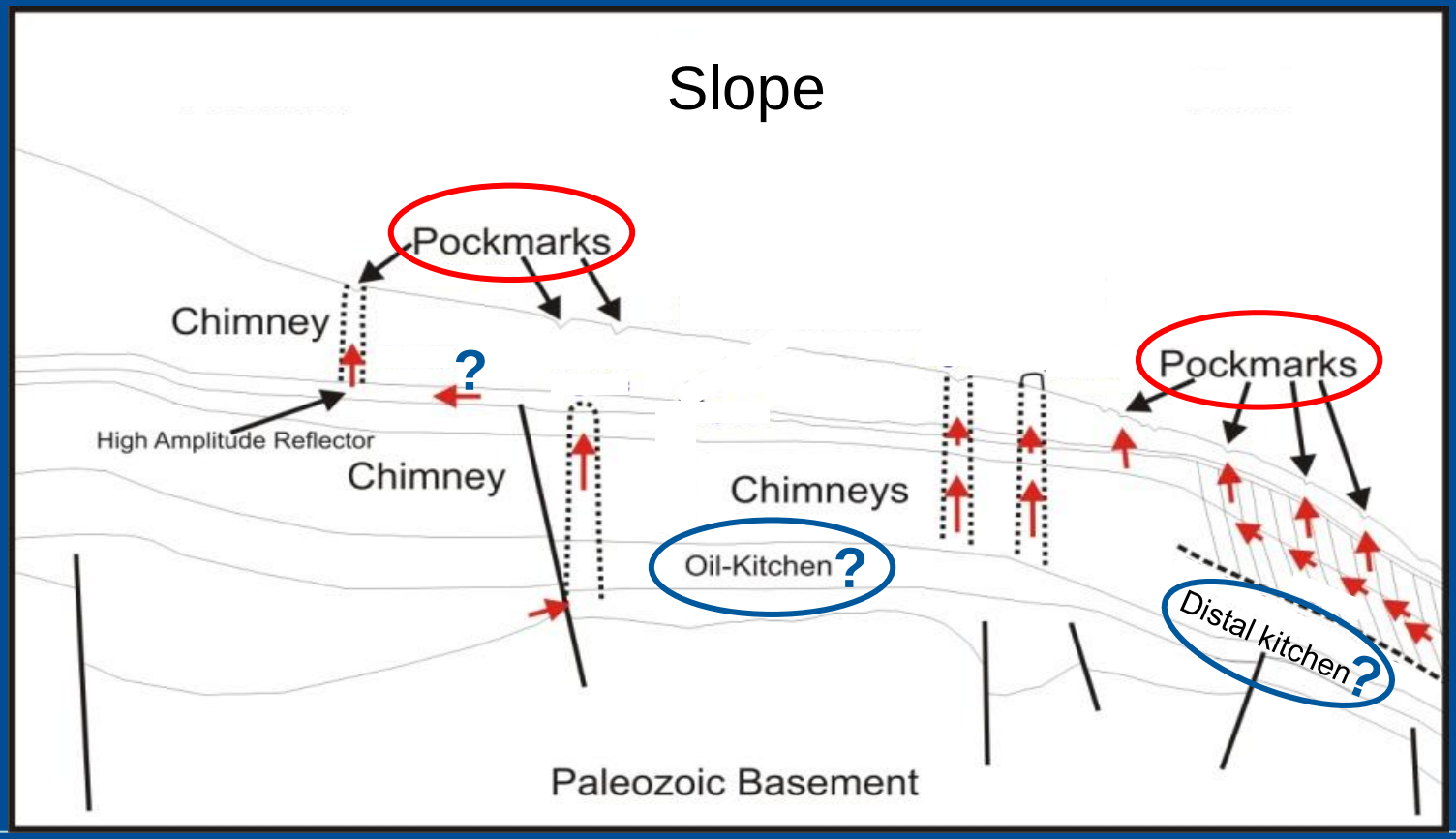


Gabon pockmark-trains and gullies

(Pilcher & Argent, 2007)

Source of seafloor leakage?

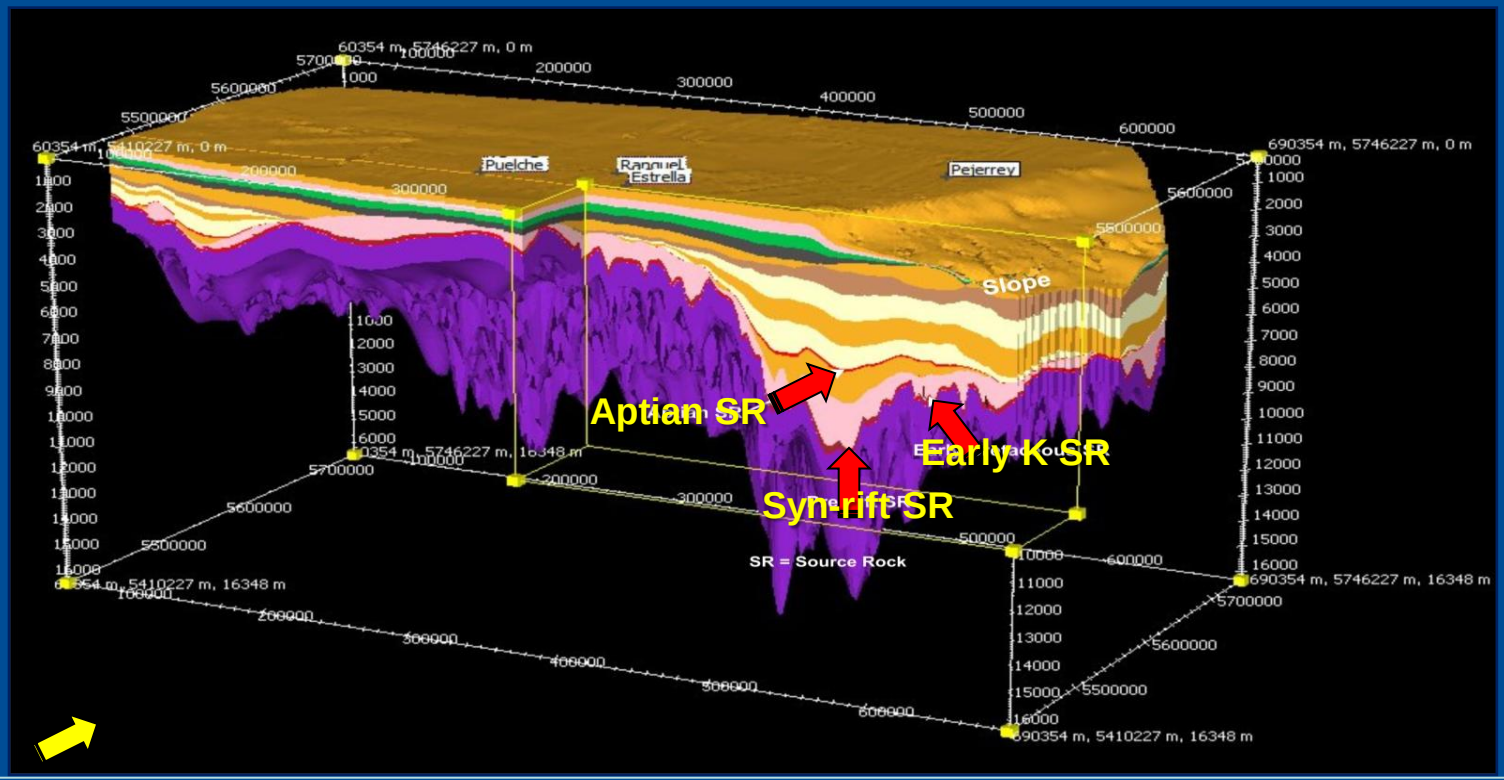
- Vertical migration ⇨ deep kitchen
- Lateral migration ⇨ distal kitchen
- Dewatering ⇨ no kitchen



3D basin model

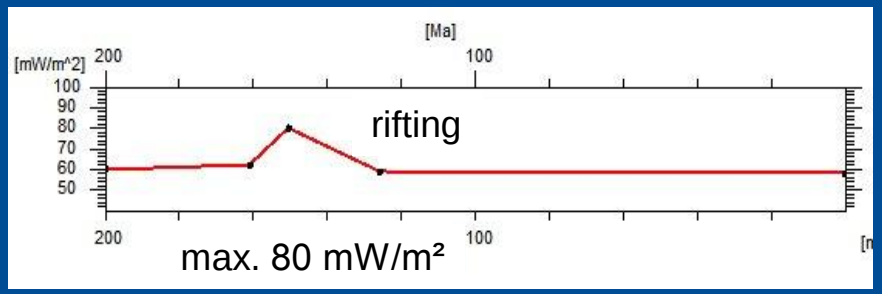
3 source rocks

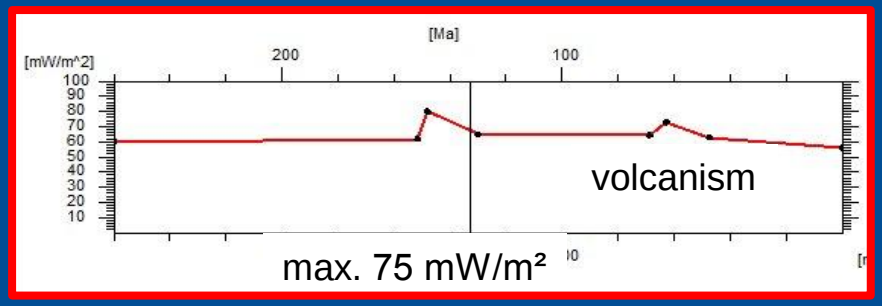
- Aptian : TOC 4%, kerogen type II, HI 300
- Lower Cretaceous:TOC 1%, kerogen type III, HI 200
- Syn-Rift : TOC 4%, kerogen type II, HI 300



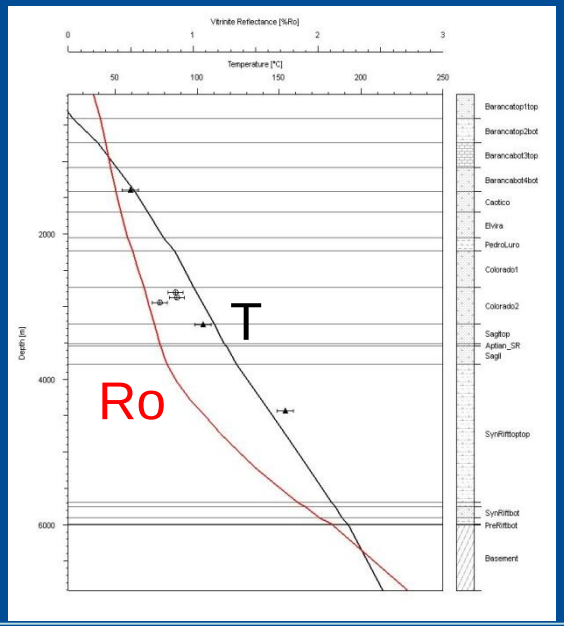
Thermal model

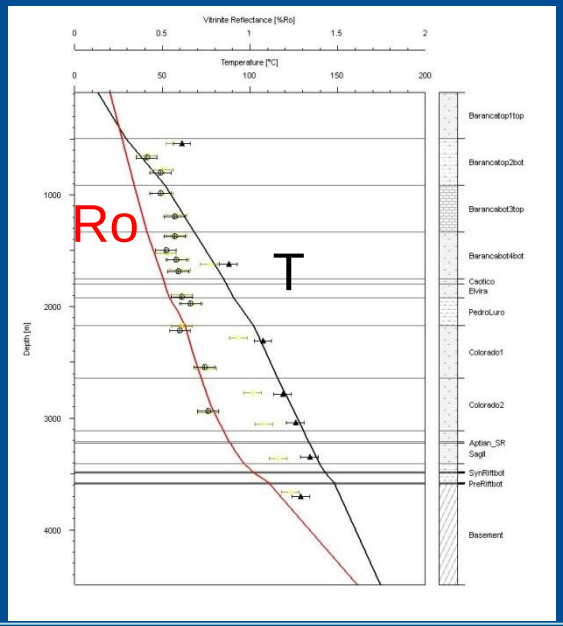
- Heat flow scenarios

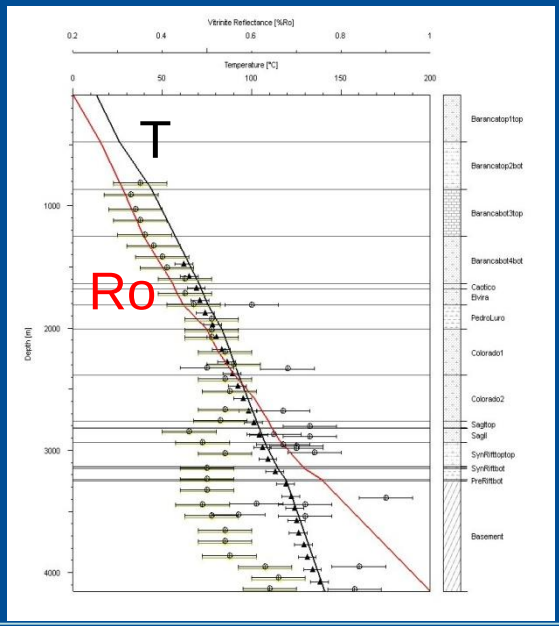




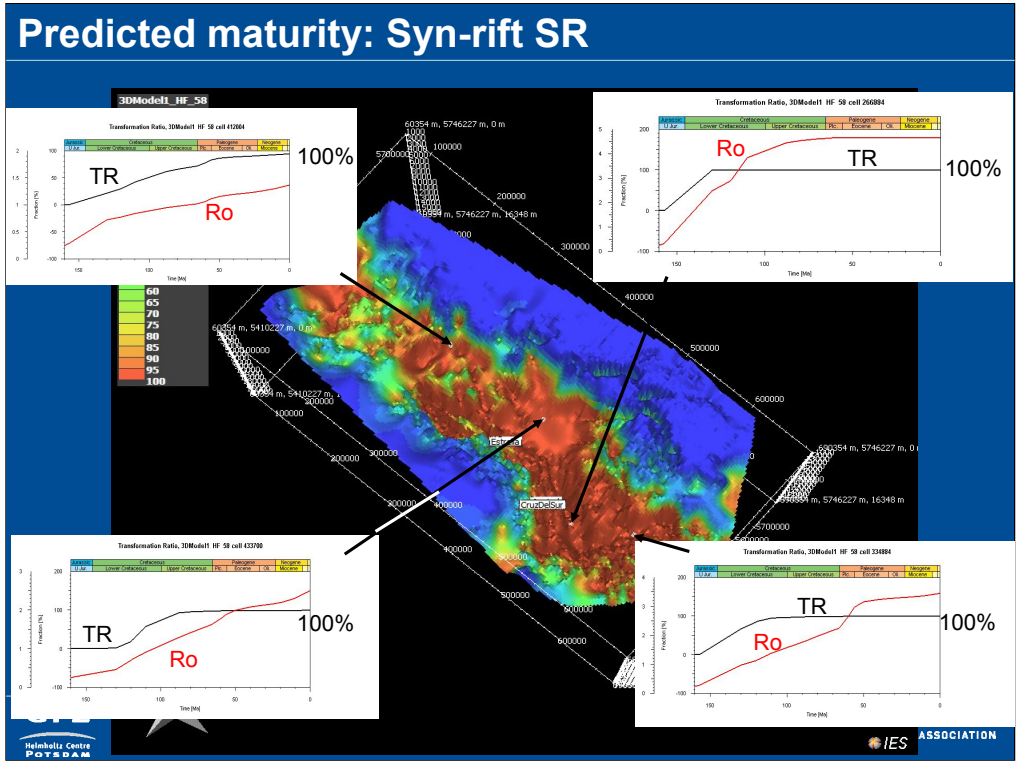
- Calibration with well data





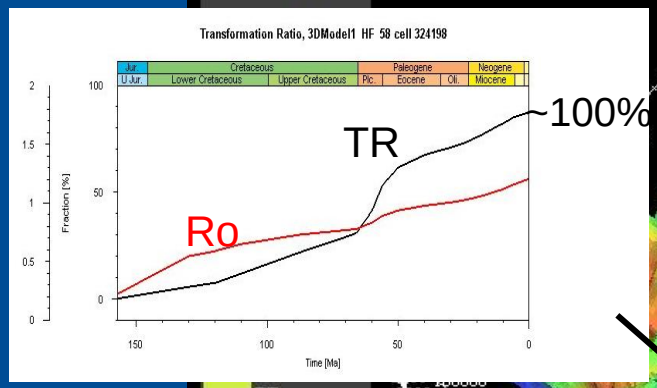


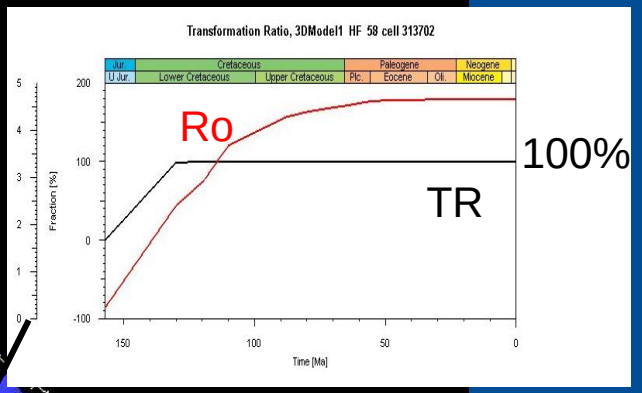
Predicted maturity: Syn-rift SR



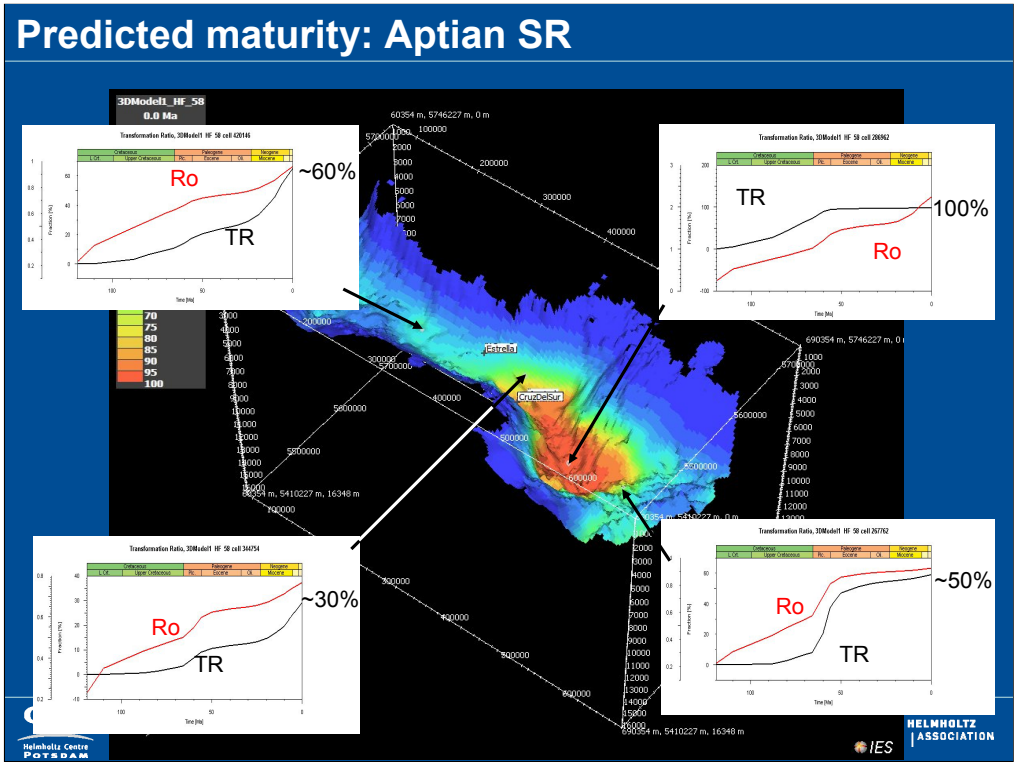
Presenter‘s notes: Model results representing the maturation history of the pre-rift source rocks. Transformation ratio (black line) and vitrinite reflectance (red line) over time.

Predicted maturity: Lower Cretaceous SR





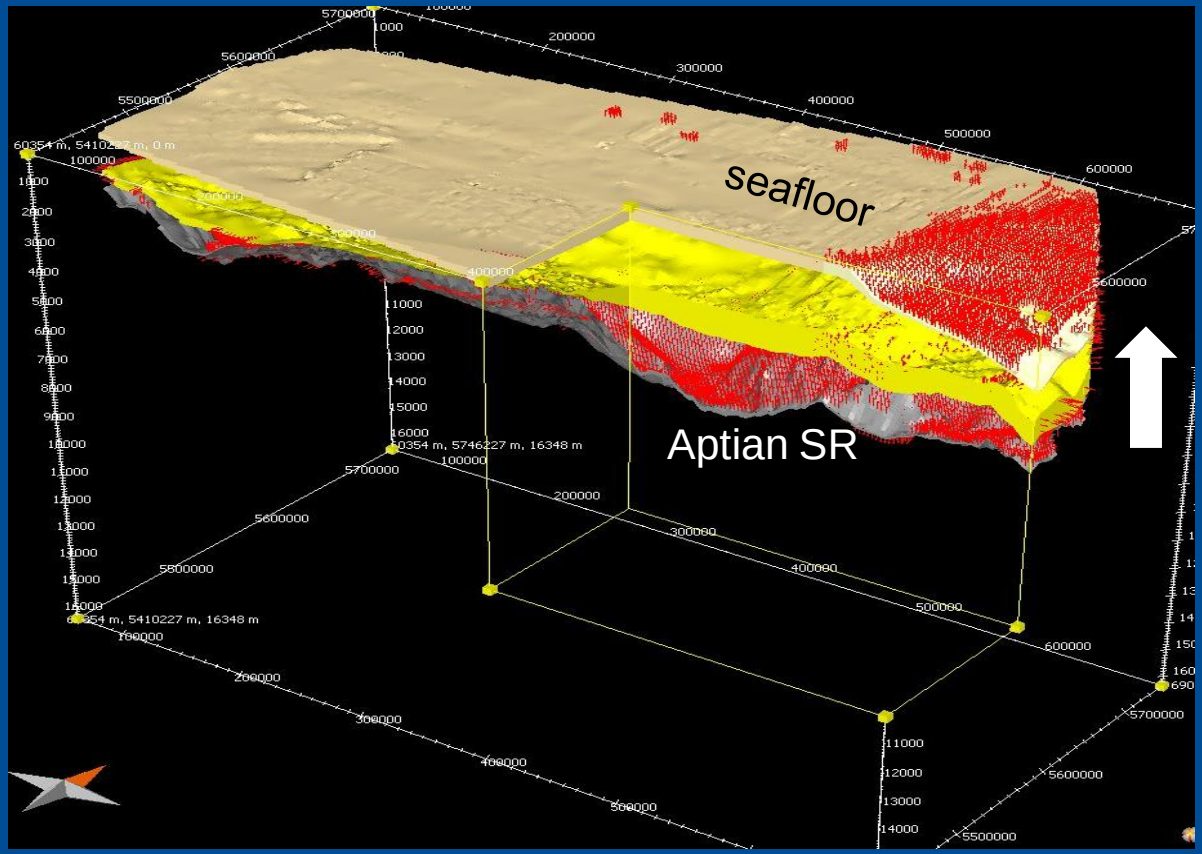
Predicted maturity: Aptian SR



Presenter‘s notes: Model results representing the maturation history of the Aptian source rocks. Transformation ratio (black line) and vitrinite reflectance (red line) over time.

Present-day migration model

- Ongoing generation (Aptian SR) beneath slope pockmarks
- Vertical migration from active kitchen



Active petroleum system ☺

Seal-failure risk ☹

Conclusions

- Major stratigraphic re-organization since Paleocene:
  - Cretaceous depocenters oblique to margin (NW-SE)
  - Cenozoic depocenters margin-parallel (SW-NE)

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- Margin current configuration since Oligocene

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- Margin current configuration since Oligocene
- HC leakage indicators in the slope
  - Chimneys & seafloor pockmarks aligned with submarine channels

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Presenter's notes:

•Depocenter migration: The EW Colorado basin curves NW-SE towards the East, becoming perpendicular to the present-day continental margin (oriented NE-SW) and developing a main depocenter in the east in NE-SW direction. The strong obliquity of the basin orientation related to the direction corresponding to the opening of the South Atlantic (NE-SW) suggests a structural control from the pre-rift basement on the rift and post-rift sequences.

•The principal fault structures include west-northwest- and east-northeast-trending faults along the margins of the depocenters. Simple east-west-trending faults are recognized in the center of the main graben structures.

•Possible gas-leakage features have been identified and mapped by seismic interpretation, and their relation to structural elements is analyzed.

•The chimneys seem to be rooted in the pre-rift and syn-rift sequences and extend into the post-rift successions, indicating a thermogenic source.

•Gas chimneys terminate within the Tertiary or reach the seafloor and sometimes are associated with a mound or pockmark, indicating free upward migration of gas.

•The pockmarks present a diameter from 200 m to 1200 m and vertical length between 20 m to 100 m, and occur close to submarine channels with sizes from 1000 m to 5000 m in width and from 100 m to 500 m in depth.

Conclusions

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- Margin current configuration since Oligocene
- HC leakage indicators in the slope
  - Chimneys & seafloor pockmarks aligned with submarine channels
- Ongoing generation from Aptian SR
  - Vertical migration feeding slope chimneys / pockmarks
- Active petroleum system, but seal failure risk in the slope

Thank you

Acknowledgments

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