Submission code: VZRX5WRKZB

See this and other abstracts on our website: https://home.sbgf.org.br/Pages/resumos.php

Pleistocene to present seismic geomorphology reconstruction in the Amazon Submarine Fan – NW Foz do Amazonas Basin, Brazil

Eduardo Leaubon (Viridien), Andres Gordon (Viridien), Antonio Tadeu Dos Reis (Universidade do Estado do Rio de Janeiro), Mariano Gatti (Viridien), Anna Lougon (Viridien), Cleverson Guizan (Universidade Federal Fluminense)

Pleistocene to present seismic geomorphology reconstruction in the Amazon Submarine Fan – NW Foz do Amazonas Basin, Brazil

Abstract Summary

This study investigates the present seabed and past Pleistocene seabed morphologies within the upper Amazon Submarine Fan, in the northwestern Foz do Amazonas Basin, using reprocessed 3D seismic data with high-resolution FWI algorithms (Locations in Fig. 1). Five key stratigraphic horizons were mapped, including the base of recent Mass Transport Deposits (MTDs) and the modern seafloor. Seismic attributes such as RMS amplitude and spectral decomposition were applied to characterize features like slope failures, erosional channels, thrust-related folds, pockmarks, and mud volcanoes. The results indicate that shale gravity tectonics and gravity-driven sedimentary processes played a critical role in shaping the current seafloor morphology and deep-water depositional systems. These processes influence sediment distribution, form structural traps, and generate fluid migration pathways, which may have contributed to the basin's stratigraphic and petroleum system evolution.

Introduction

The Foz do Amazonas Basin is a passive margin basin located along Brazil's Equatorial Margin, extending from the state of Pará to the maritime border with French Guiana. It is directly associated with the opening of the South Atlantic, which began in the basin during the Early Cretaceous. Drift-phase sedimentation commenced in the Late Albian and continues to the present, culminating in the development of the Amazon Submarine Fan, the focus of this study. The basin's Meso-Cenozoic sedimentary column reaches over 10 km in thickness (Cobbold et al., 2004).

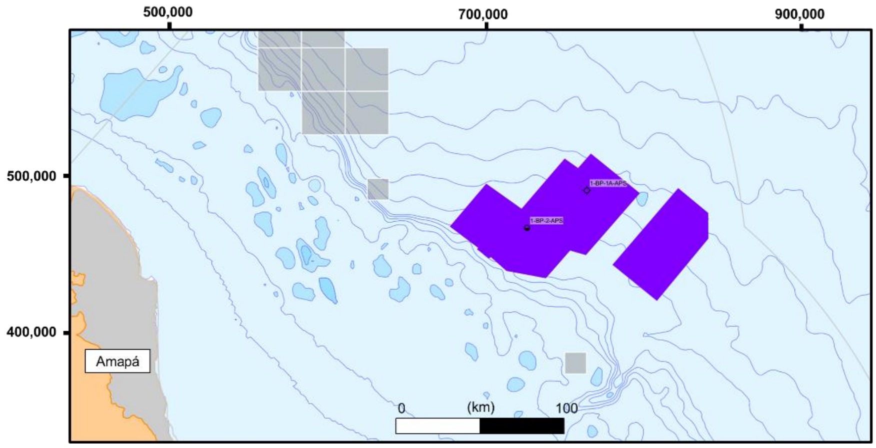

Figure 1: Map Location in SIRGAS 2000 CRS. 3D surveys in Dark purple.

The Amazon Submarine Fan (ASF) began forming in the Tortonian, driven by the establishment of the Amazon River as a major continental drainage system in the Late Miocene. This was a consequence of Andean orogeny, which redirected major Pacific and Caribbean drainages toward Brazil's Atlantic Margin (Figueiredo et al., 2009; Rossetti, 2004).

Notably, ASF ranks as the third largest submarine fan globally (Figueiredo, 2003). It plays a critical role in the basin's geological evolution and the regional petroleum system, functioning both as a source and conduit for sediment supply. This led to significant progradation and the deposition of deepwater turbidites, key to the development of reservoir-prone facies. The fast and voluminous sedimentary load generated the deep-sea fan gravitational collapse, resulting in extensional features in proximal areas and compressional faults thrusting distally over detachment surfaces, forming a variety of structural traps (Cruz, 2018). According to Cruz (2018), the thick sedimentary pile from the Miocene to the present—reaching up to 5,000 m in some areas—may influence the maturation of potential Cretaceous source rocks.

This study employs reprocessed 3D seismic data using advanced FWI algorithms and cutting-edge imaging technology to characterize the seabed morphology and seismic geometries that shaped the present-day Amazon Submarine Fan bathymetry.

Methodology

Well data and chronostratigraphic markers were loaded to define five key sedimentary surfaces: Top Miocene (5.33 Ma), Top Pliocene (2.58 Ma), and Middle Pleistocene (0.75 Ma), in addition to two seismic horizons critical for this analysis: the basal erosional surface of recent MTDs and the seafloor. The latter two were crucial for interpreting recent sedimentary processes.

Semi-automatic horizon extraction was performed for these markers, followed by quality control and refinement in structurally complex zones. Spectral decomposition and RMS amplitude attributes were applied primarily within the Upper Pleistocene interval, from the base of the recent MTDs to the present-day seafloor, to identify seismic facies and depositional patterns.

Results

The study focused on identifying seismic geometries of structures controlling deepwater deposition and shaping modern seafloor topography. Various mass transport deposits (MTDs) and channel systems were interpreted based on seismic facies and attribute responses.

Recognition of these features helps to understand the morphosedimentary evolution of deep marine environments. These gravity-driven processes include slides, slumps, debris flows, and turbidite flows transporting sediment basinward. Diagnostic features such as slide planes, chaotic reflectors, rafted blocks, and feeder channels were identified through seismic analysis and attribute extraction.

The base of recent MTDs and the seafloor horizon (Fig. 1) reveal how gravity processes have modified seafloor morphology. Erosive channels and MTD-related scarps were mapped, some of which disrupt compressional anticlines generated by thrust faults. Seismic attributes helped trace the evolution of these features (Fig. 2).

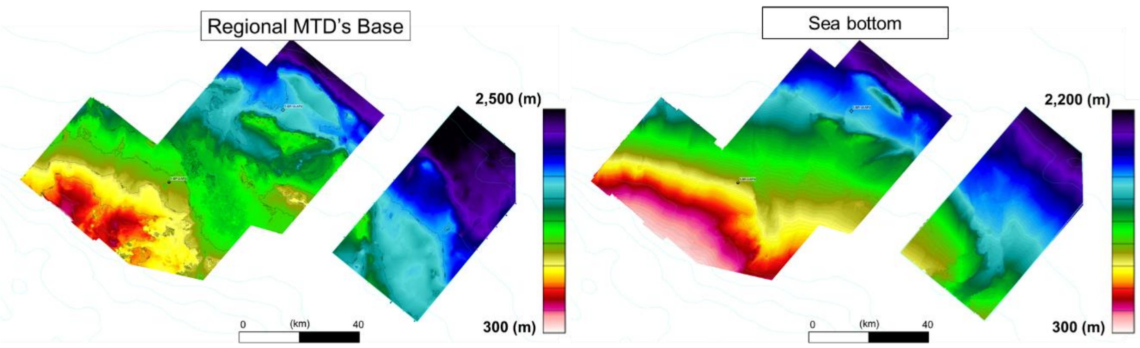

Figure 1: On the left, the mapped surface of the regional MTD basal horizon; on the right, the mapped seafloor surface. The basal surface reveals paleo-escarpments and pathways of past

mass-transport deposits (MTDs), while the seafloor surface highlights erosional channels and recent MTD features.

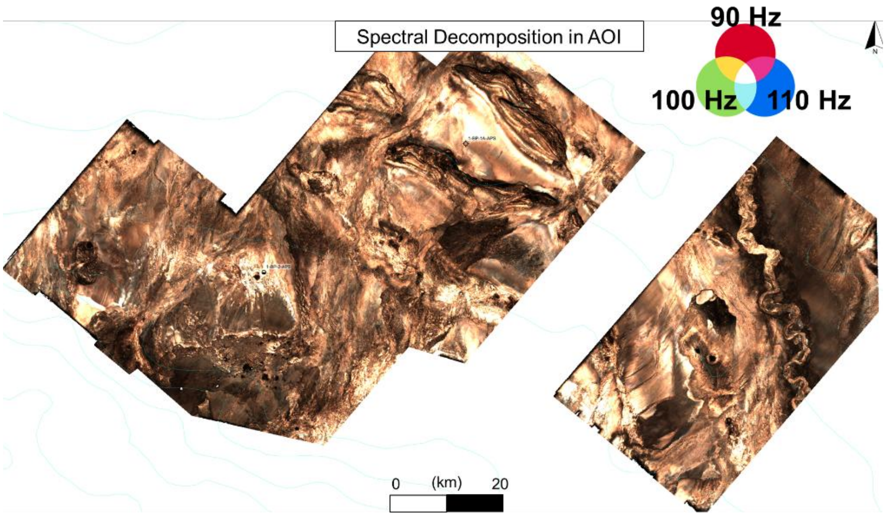

Figure 2: Spectral decomposition attribute extracted at a stratigraphic level between the MTD basal surface and the seafloor. The image reveals the development of meandering and erosive channels. It also highlights possible pathways of older MTDs, as well as circular anomalies interpreted as mud volcanoes and pockmarks.

At the seafloor, several morphological features were mapped, including erosional channels, pockmarks linked to fluid or mud expulsion via faults and folds, mud volcanoes near overpressure conduits, active MTDs, and scarps (Fig. 3).

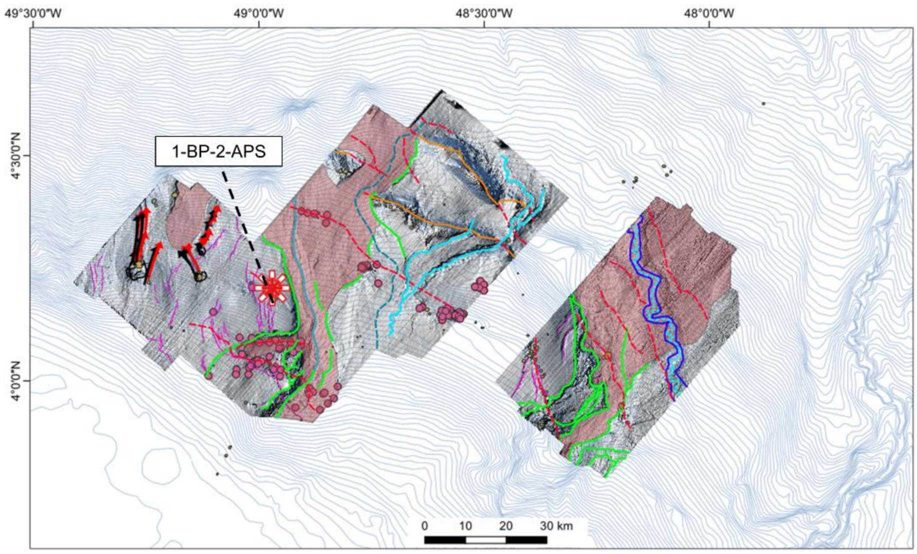

Figure 3: Seafloor features identified in the present-day surface include several anticlinal structures associated with compressional thrusting (red-dashed lines are buried anticlines and orange lines are anticlinal axes on the present seafloor), mass-transport deposits (MTDs) (pink corridors), erosive scarps (green lines); pockmarks (red dots), mud volcanoes (black circles and red and black arrows indicating the mud flow direction), and erosive channels (cyan and light blue lines), meandering channel (dashed cyan line).

Conclusions

The applied seismic workflow enabled identification of key sedimentary processes shaping the deepwater seabed morphology of the Amazon Submarine Fan. Channels and MTDs were clearly mapped using interpreted surfaces and seismic attributes. Active seafloor morphodynamics are still modifying the system, redistributing sediments basinward.

This seismic analysis provided additional characterization of the Amazon Submarine Fan sedimentary processes and distribution of shallow MTDs. Key horizons—such as the base of recent MTDs and the modern seafloor—were critical to reconstruct geomorphological and stratigraphic evolution from the Pleistocene to present.

Seismic evidence indicates intense gravitational processes, including slide and MTDs. Incised channels, cutting across thrust faults anticlines confirms the erosional effect of turbidite currents on the submarine relief and its control in sediment dispersal. Pockmarks and mud volcanoes indicate that fluid escape is mostly aligned with the thrust fault anticlines. These processes, active especially in the Upper Pleistocene, impacted the seabed morphology, particularly in compressional zones with thrust faults.

This study underscores the significance of MTDs as structural and stratigraphic elements in the Foz do Amazonas Basin. Their identification is essential for geohazard analysis and hydrocarbon exploration, given their role in creating traps, conduits, and potential source rock activation zones.

References

BRANDÃO, J. A. S.; FEIJÓ, F. J. Bacia da Foz do Amazonas. In: FEIJÓ, F. J. (org.). *Bacias Sedimentares Brasileiras*. Rio de Janeiro: PETROBRAS, 1994. p. 275–285.

COBBOLD, P. R. et al. Sedimentary thickness and tectonics of the Amazon Fan, from seismic reflection and gravity data. *Tectonophysics*, Amsterdam, v. 389, n. 1-2, p. 1–19, 2004.

CRUZ, A. M. Estudos integrados geológico-geofísicos da Bacia da Foz do Amazonas: implicações exploratórias. 2018. Tese (Doutorado em Geociências) – Universidade Federal Fluminense, Niterói, 2018.

FIGUEIREDO, J. J. P. The Amazon Deep-Sea Fan: stratigraphy, sedimentology and evolution. 2003. Tese (Doutorado) – Rice University, Houston, 2003.

FIGUEIREDO, J. et al. Late Miocene onset of the Amazon River and the Amazon deep-sea fan: Evidence from the Foz do Amazonas Basin. *Geology*, Boulder, v. 37, n. 7, p. 619–622, 2009.

MELLO, M. R. et al. Petroleum systems of the Foz do Amazonas Basin, Brazil. In: RIES, A. C.; BUTLER, R. W. H.; GRAHAM, R. H. (eds.). *Tectonic evolution of South America*. London: Geological Society, 2001. (Special Publication, 272). p. 11–32.

ROSSETTI, D. F. Late Miocene tidal deposits of the Barreiras Formation in eastern Amazonia, Brazil: paleogeographic and sequence stratigraphic implications. *Sedimentary Geology*, Amsterdam, v. 172, n. 1-2, p. 99–127, 2004.