[PS]The Tectono-Sedimentary Evolution of the Amazon Fan Across the Central Transect, Foz do Amazonas Basin, Brazil*

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Search and Discovery Article #30213 (2011)
Posted December 12, 2011

*Adapted from poster presentation at AAPG International Conference and Exhibition, Milan, Italy, October 23-26, 2011

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Abstract

The problems of the tectono-sedimentary evolution of the Foz do Amazonas Basin have been addressed by integrating a broad set of geophysical and well data onto one regional seismic section. Two different hypotheses were considered in the interpretation of gravitational tectonics affecting the Brazilian equatorial margin, exceptionally developed in this basin due to the thick sedimentary loading of the Amazon Fan. The first hypothesis contemplates thin skinned tectonics, while the second implies the presence and activity of deep direct faults displacing the basement.

In order to discriminate which of the two hypotheses is the most reliable, the restoration of the central transect of the fan, 265 km long, was performed. The data on the depth of the basement, obtained by gravimetric and magnetic modeling, was also considered.

The first hypothesis envisages a deformation with loss of volume that, in order to be justified, requires removal of large amounts of sediments by erosion. The second hypothesis reduces the need of processes difficult to verify, and therefore is preferable.

Thanks to the high resolution of a proprietary 3D seismic survey covering the critical area of the slope, it was possible to analyze in detail the syndepositional tectonic features of the most important seismostratigraphic units of the fan in relation to the development of gravitational tectonics. The existence of at least two different levels of detachment were identified. From seismic evidence and well data these levels can be interpreted as overpressured clays. These levels induced the detachment and deformation of the overlying sediments in at least two distinct tectonic phases, locally recorded by unconformities. In fact, fold and thrust belts that are sealed by Tortonian unconformities have been identified.

The tectono-sedimentary evolution is characterized by a system of faults that is not related to a single event of gravitational collapse. This evolution differs from the reconstruction published in the literature for the possibility that the extension, due to a system of normal faults at the shelf break, is not completely transferred to the thrust in the shortening zone through the identified

levels of detachment. It is hypothesized that a part of the extension observed may have been balanced during the sedimentation of the fan, from a temporary reactivation of deep crustal faults, originated during rifting of the continental margin of South America.

The Tectono-Sedimentary Evolution of the Amazon Fan across the Central Transect (Foz do Amazonas Basin, Brazil)

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SUMMARY

Some of the open questions posed by the reconstruction of the Foz do Amazonas Basin tectonic-sedimentary evolution have been addressed through the geophysical integrated modeling of a significant regional seismic section. Two different hypotheses were considered in interpreting the gravitational tectonics, observed along the Brazilian equatorial margin, exceptionally developed due to the sedimentary loading of the Amazon Fan. The first hypothesis contemplates a thin skinned tectonics model only, while the second postulates the presence and the activity of direct faults deep-seated in the basement. In order to discriminate between the two hypotheses, the restoration of the 265 km long central transect of the Amazon fan was performed. Also the data on the depth of the basement, obtained by gravimetric and magnetic modeling, were considered.

Location map

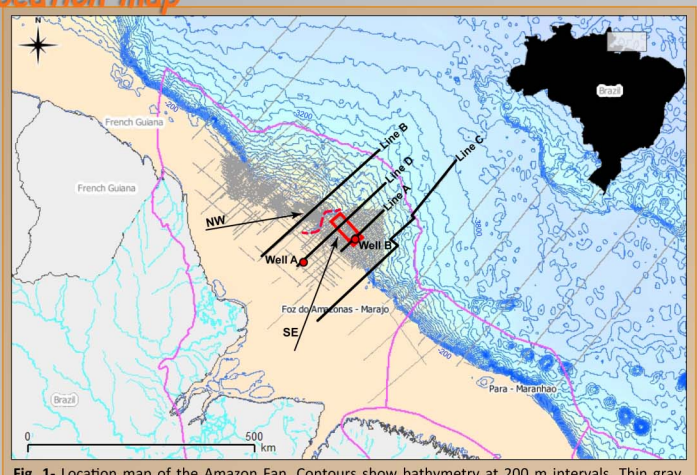

Fig. 1- Location map of the Amazon Fan. Contours show bathymetry at 200 m intervals. Thin gray lines: locations of the studied 2D surveys; thick black lines: locations of the 2D lines discussed in the present work; red rectangle: location of the 3D survey; red dots: locations of wells A and B. The Amazon canyon (red dashed line) and the two basin depocenters of the basin are indicated.

Stratigraphy

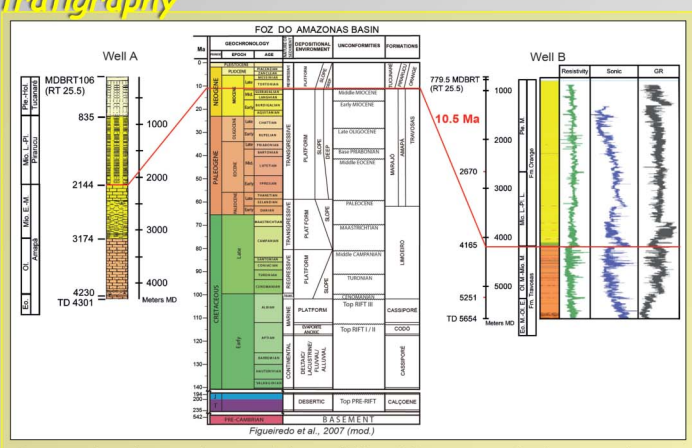

Fig. 2- Correlation between the two well data available and chronostratigraphic diagram. Pará Group, also called "Amazon Fan", is a clastic turbidite deposits related to the inversion of the Amazon River flow from the Pacific into the Atlantic Ocean due to the rapid uplift of the northeastern Andes (Hoorn, 1995), that occurred in the Late Miocene.

Seismic Interpretation

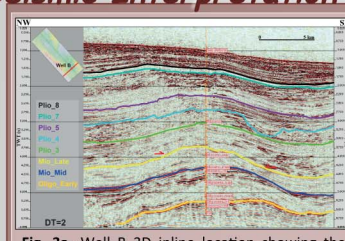

Fig. 3a- Well B 3D inline location showing the picked horizons which divide the sequence of the Fan. Its base is the unconformity of 10.5 Ma, "Mio_Mid", which is also the regional markers.

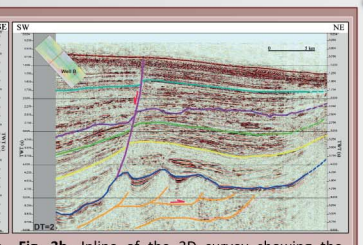

Fig. 3b- Inline of the 3D survey showing the compressive structures of the SE depocenter sealed by "Mio_Mid" and the settlement extensional tectonic of the Fan.

3D Survey

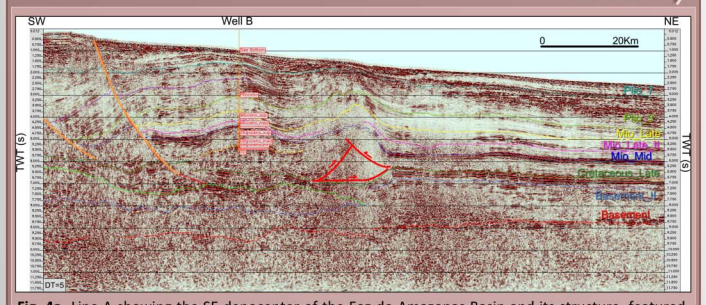

Fig. 4a- Line A showing the SE depocenter of the Foz do Amazonas Basin and its structure, featured by an extensional domain interrelated with a compressive domain.

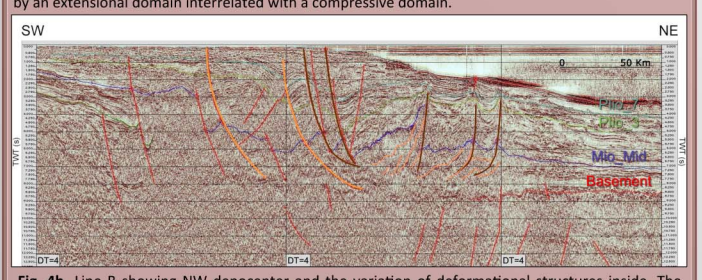

Fig. 4b- Line B showing NW depocenter and the variation of deformational structures inside. The compressive domain is wider than the homologous sector in the SE depocenter area.

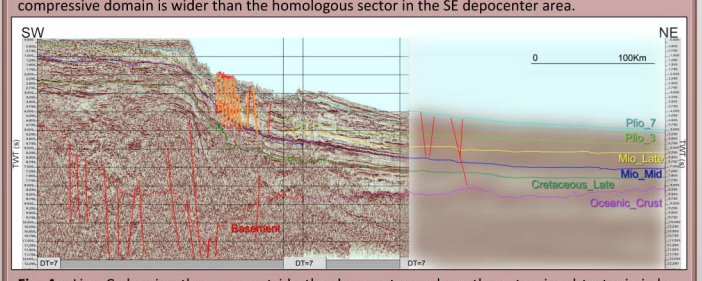

Fig. 4c- Line C showing the areas outside the depocenters, where the extensional tectonic is less developed and has no associated compressive domains.

2D Surveys

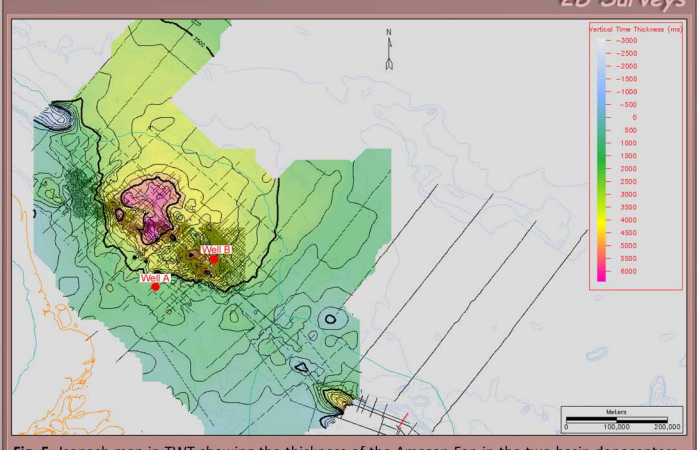

Fig. 5- Isopach map in TWT showing the thickness of the Amazon Fan in the two basin depocenters, reconstructed from the "Sea_Bottom" and "Mio_Mid" maps.

Basin's depocenters

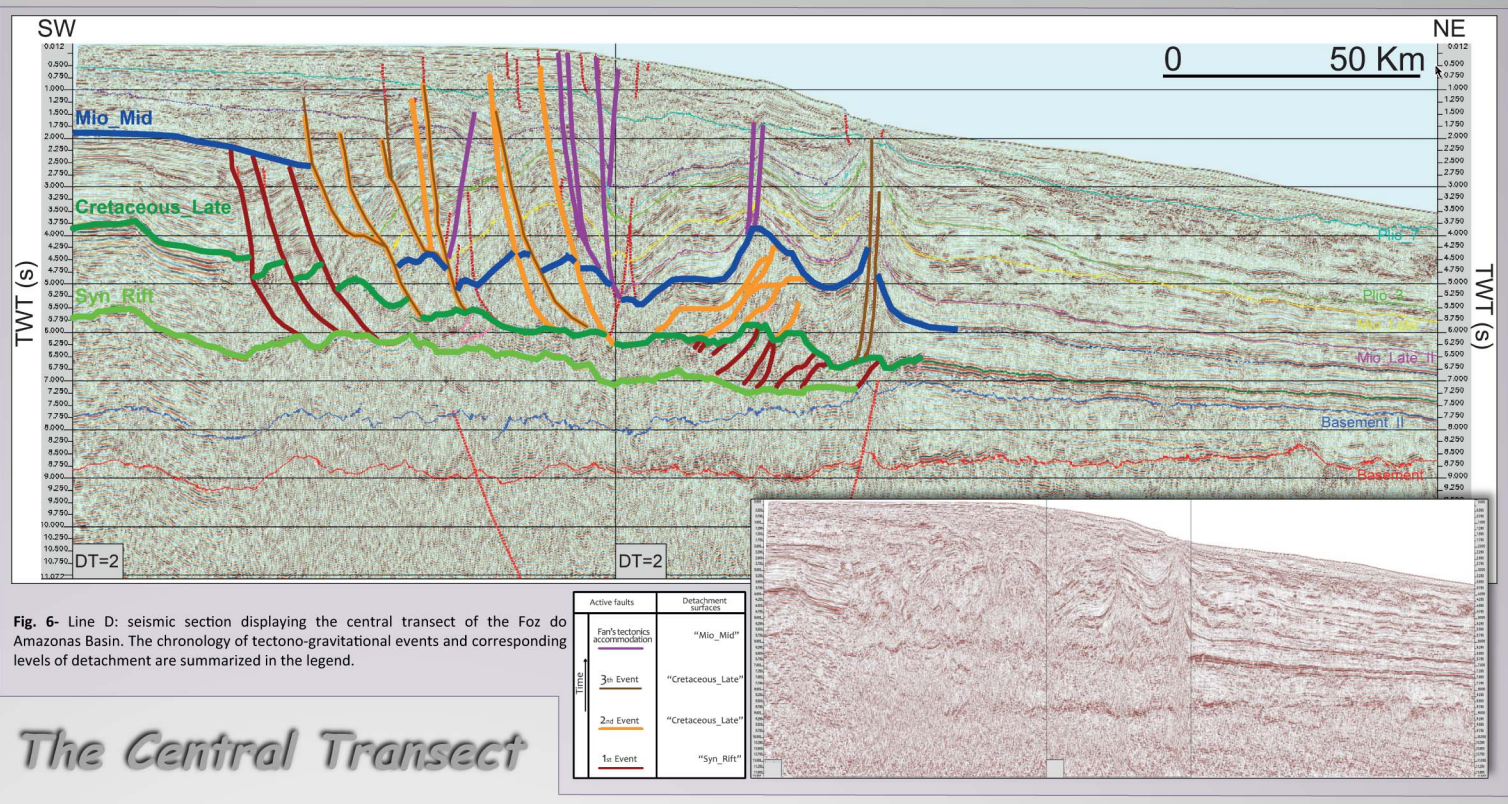

Fig. 6- Line D: seismic section displaying the central transect of the Foz do Amazonas Basin. The chronology of tectono-gravitational events and corresponding levels of detachment are summarized in the legend.

The Central Transect

The Foz do Amazonas Basin is affected by an exceptionally developed gravitational tectonic resulted from three major episodes (Silva et al. 1999, Perovano et al. 2009), involving the activation of different stratigraphic levels of clay in overpressure conditions.
The extension in the platform area, during each event was partly balanced, under the mid-lower slope, by fold and thrust belts and high angle reverse faults. Thus, this area became a source area of gravitational flows, resedimented oceanward.
The deposition of the Amazon Fan has greatly enhanced the last tectonic phase, locally still active.
The shallowest level of detachment at the basin scale is represented by the "Mio_Mid" and the extensional settlement tectonic of the Fan lies on its top.

Depth conversion and restoration

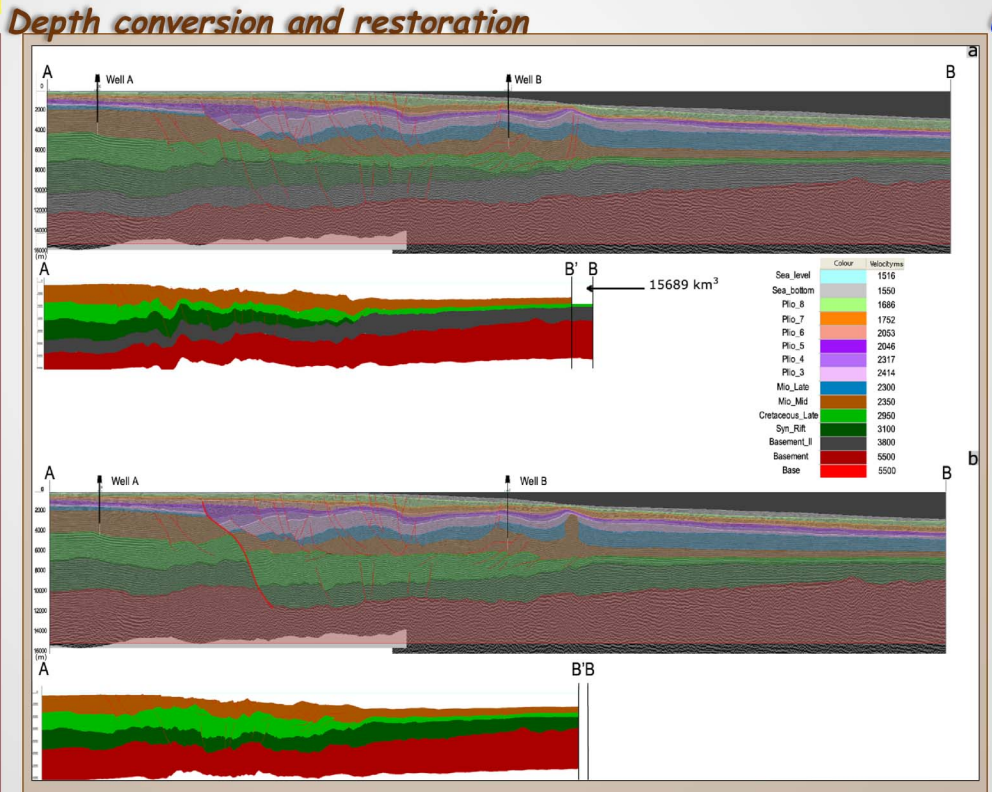

Fig. 7- Initial and final steps of restoration of depth converted and restored sections according to: a) the first interpretation (based on Fig. 6) and b) the second interpretation, which contemplates reactivation of a crustal fault and a clay diapir instead of high-angle reverse faults. The black lines represent the projected perforations while the white ones indicate the Total Depth. The legend shows the Intvel of Well B , used for depth-conversion, and horizon list. The retreat of the B' axis corresponds to the amount of sediment removed by erosion in compressive structures. This areal value was converted to volumes considering a unitary third dimension (1 m).

Gravimetric modelling

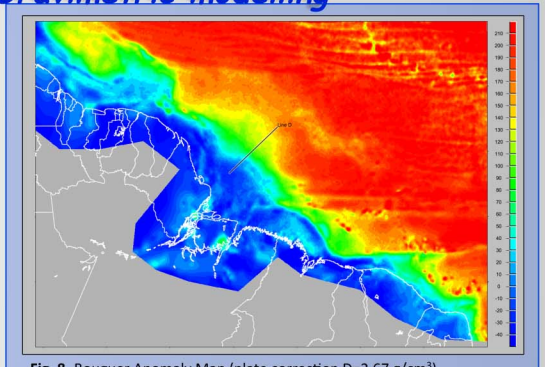

Fig. 8- Bouguer Anomaly Map (plate correction D=2.67 g/cm³).

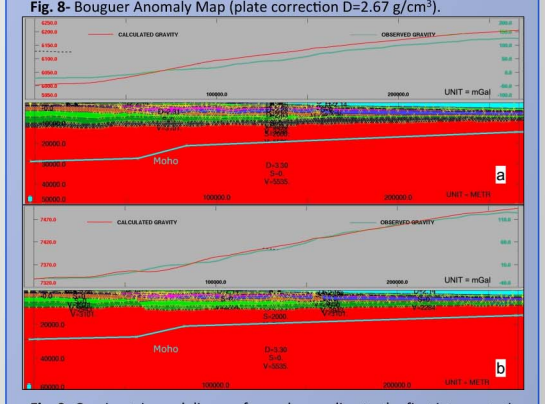

Fig. 9- Gravimetric modeling performed according to the first interpretation (a) and to the second (b). The depth of the Moho was calibrated comparing it with the depth obtained by Watts et al. (2009) in the same basin and with the seismic depth of the oceanic crust.

Magnetic data

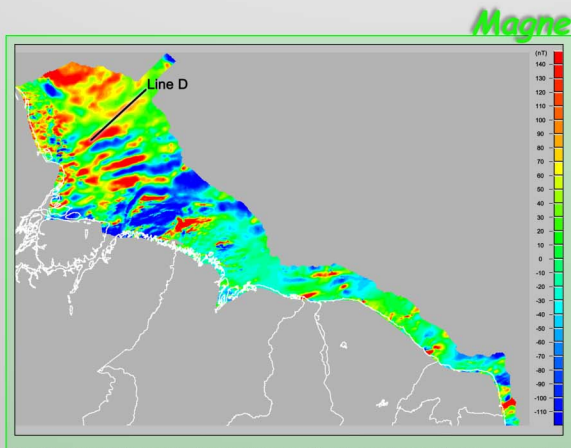

Fig. 10- Map of the residual magnetic anomalies showing a trend of the anomalies sub-parallel to Line D (The Central Transect).

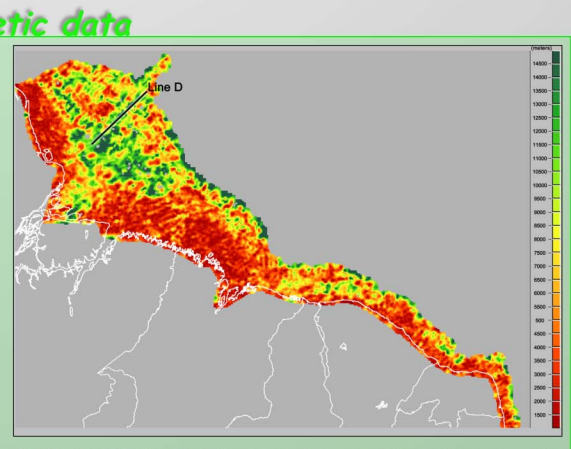

Fig. 11- Map of the depth of the magnetic basement showing a deepening of the basement beneath the Fan, due to its high load.

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CONCLUSIONS

The solution according to the first hypothesis, envisages a deformation with a substantial volume loss, which requires, in order to be justified, the removal of large amounts of sediments by erosion.
The solution according to the second hypothesis, instead, implies that great part of the observed extension may have been compensated, during the sedimentation of the Fan, by the reactivation of deep crustal faults (see Fig. 7b), originally developed during the rifting of the South America continental margin and only in part by the thin-skinned tectonic.
In the shortening areas, during the last event of collapse, high-angle reverse faults displaced the whole stratigraphy of the Fan and the underlying old system of folds and thrusts, without reactivating them. Locally, the compressive structures appear as clay diapirs (see Fig . 7b).
It is believed that the oceanwards propagation of these structures was arrested by the loss of efficiency in the level of detachment, in its turn constrained by the morphology of the basement below the Fan, consisting of thinned continental crust.

ACKNOWLEDGEMENTS

I thank my supervisors, Dr. Alessandro Menardi Noguera and Prof. Carlo Doglioni, for their helpful support during the development of this work and Dr. Vincenzo Barletta for encouraging the writing of this work. I am grateful to the Exploration & Production Division, ENI s.p.a., for access to data discussed in this paper, the equipments necessary to data elaboration and technical-scientific support. I specially thank Marco Meda, Giuseppe Valenti, Antonio Schiroli, Lorenzo Vassalli, Franco Fonnesu, Filippos Tsikalas, Gianluca Gabbriellini, Carlo Bologna, Roberto Longoni, Corrado Magistroni, Claudio Foschi, Ornella Da Rold, Sergio Nardon, Antonio Cernuschi.