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## Sequence Stratigraphy and Basin Evolution of the Foz do Amazonas Basin, Brazil

### Introduction

The Foz do Amazonas Basin is located offshore of the states of Amapá and Pará in northernmost Brazil (Figure 1). The basin lies entirely offshore and is bounded in the updip areas by the Amapá, and Pará platforms.

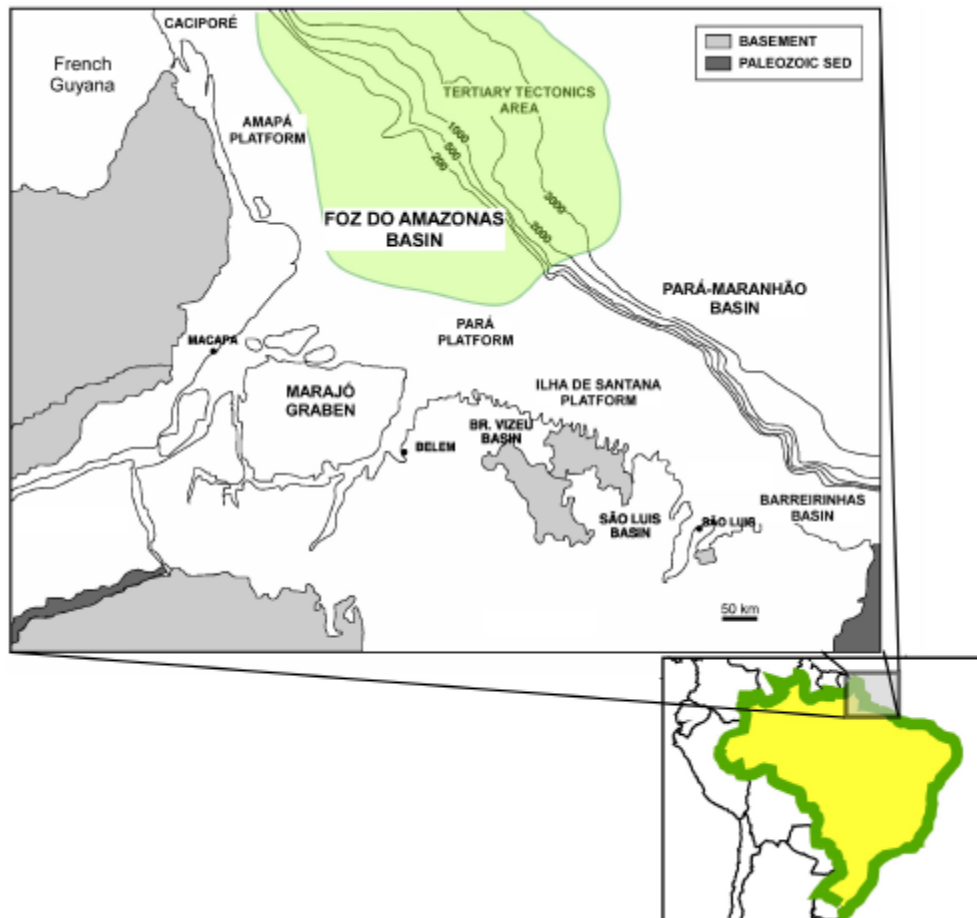


Figure 1. Location map for the Foz do Amazonas Basin (adapted from Mello *et al.*, 2001)

The Foz do Amazonas is a conjugate basin to offshore Liberia in West Africa and was separated from the African continent during the opening of the Equatorial Atlantic Ocean. Rifting along the Atlantic margin in this area began around 120 Ma and continued into the Albian (ca. 100 Ma). Non-marine, syn-rift sediments in the Caciporé Formation are encountered in half-graben settings on the updip margin of the deepwater basin, particularly under the Amapá Platform and in the Caciporé Graben to the northwest.

At the end of rifting (ca. 100 Ma.), thermal subsidence brought about the incursion of marine conditions and a deep marine basin formed by the end of Cenomanian time. Uppermost Albian shallow marine sediments may have been the first deposited in the post-rift section but these were quickly overlapped and overwhelmed by transgressive marine shales in the Cenomanian and Turonian. The basin fill history from syn-rift to post-rift, passive margin can be seen in the stratigraphic chart originally produced by Brandão and Feijó, (1994) and modified here as Figure 2.

The post-rift, or passive margin, section in Figure 2 can be subdivided into two intervals: 1) pre-Amazon, and 2) Amazon Fan. The pre-Amazon section is Cenomanian through Middle Miocene in age and represents deposition in the basin prior to the establishment of the Amazon River as a major, continental-scale drainage system. The predominantly clastic, pre-Amazon sediments that were deposited in the Upper Cretaceous through Upper Paleocene are named the Limoeiro Formation. Pre-Amazon sediments from the Upper Paleocene through the Middle Miocene are lithostratigraphically classified as Marajó Fm. (non-marine and proximal shallow marine clastics), Amapá Fm. (shallow marine carbonate shelf), or Travosas Fm. (distal fine-grained sediments) (see Brandão and Feijó, 1994).

As can be seen in Figure 2, the Upper Cretaceous and Paleocene history of basin fill was dominated by clastic infilling on the passive margin (Limoeiro Formation). Numerous third-order cycles exist within the Limoeiro section – the details of which await further study. Following a sea-level fall in the Late Paleocene, a long duration relative sea-level highstand persisted through the Middle Miocene with a significant interruption during the Oligocene (“mid-Oligocene sea-level fall”). Shallow marine carbonate shelfal sediments (Amapá Fm.) were deposited during the Eocene and Lower and Middle Miocene highstands and it is postulated that significant clastic material (Travosas Fm.) was delivered into the basin during the Oligocene sea-level lowstand.

#### *Amazon Fan Sequence Stratigraphy*

The Amazon Fan section, which dates back to the Tortonian, was the main focus of the present study. Amazon Fan deposition resulted from the development of the Amazon River as a major drainage system during the Late Miocene. This began with the continental-scale Andean orogenic events, which in turn led to the capture of significant Pacific and Caribbean drainage by the Amazon River that delivered these sediments to the Atlantic Margin. Coincident with this tectonic activity was a second-order sea-level fall in the Late Miocene (Tortonian and Messinian). Shallow-water facies in the Foz do Amazonas basin record the change in both relative sea level and clastic sediment supply because carbonate platform sediments of the Amapá Fm. were replaced by clastic sediments of the Pirarucu Fm (see Figure 2). Carbonate sedimentation ceased in the Foz do Amazonas with the arrival of the Amazon sediments although it continued into the Holocene with the Ilha de Santana Formation in the Pará-Maranhão Basin to the southeast (Brandão and Feijó, 1994). Clastic sediment supply for the Amazon Fan section came from the development of the Amazon River drainage related to Andean uplift during the Miocene, the Tocantins River to the south, and by the reworking of older clastic sediments along the basin margin, particularly in the Marajó Graben.

# Basin Evolution and Generalized Stratigraphic Column - Foz do Amazonas Basin, Brazil

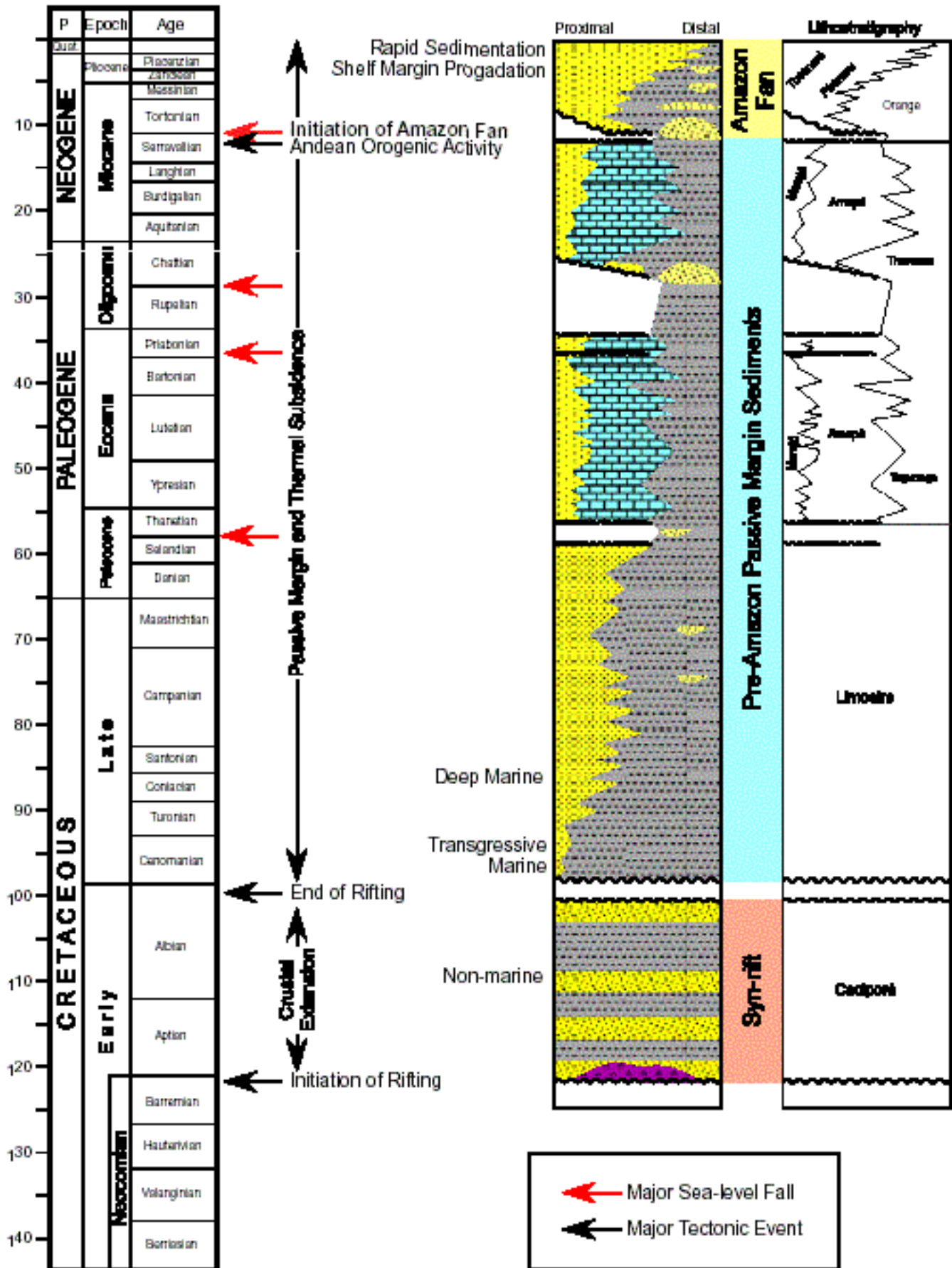


Figure 2. Generalized stratigraphic chart for Foz do Amazonas Basin (modified from Brandão and Feijó, 1994)

Integration of biostratigraphic and well log data with regional seismic lines has identified 11 third-order sequence boundaries and 10 regional flooding surfaces within the Amazon Fan section (Late Miocene to Recent) of the Foz do Amazonas Basin. Three third-order sequences have been identified in the Tortonian, two in the Messinian, and two each in the Early Pliocene, Late Pliocene, and Pleistocene. The Upper Miocene sequences have a lowstand, deepwater succession (second-order lowstand) that was deposited basinward of the underlying Lower to Middle Miocene shallow water carbonate platform (second-order highstand). Well log cross-sections demonstrate the onlapping of the Upper Miocene clastic lowstand deposits onto the older (Middle Miocene) carbonate platform. Many of the wells drilled in the updip portion of the basin (e.g. Amapá Platform) encounter missing Upper Miocene section and biostratigraphic control illustrates that lowstand deposits recognized in the distal well control (slope and basin) are represented by stratal surfaces on the shelf. These surfaces were formed by both erosional and bypass-related processes and are recognized as significant missing time in the updip well control. In some cases, the lacuna at this surface may represent as much as 5 million years and is actually the amalgamation of as many as four third-order sequence boundaries. This significant amount of missing time in conjunction with the onlapping lowstand packages downdip is taken as evidence of highly effective delivery of clastic sediment to the deepwater basin.

Lower Pliocene sequences are marked by extensive regional transgressions (second-order transgressive system tract) and are recognized in the updip wells as transgressive / highstand deposits that often rest directly upon the Middle Miocene carbonates. Seismic correlation suggests that the Lower Pliocene sequences are characterized in the deepwater by a low amplitude, regionally extensive interval that is interpreted to be predominantly fine-grained.

The Upper Pliocene to Recent sequences are characterized by a thick shelf margin delta succession and represent rapid deposition in progradational packages that are strongly correlated to orbital cyclicity (Figueiredo, 2003). Total shelf-edge progradation during this time was in the range of 40-60 kilometers and these sequences, which represent second-order highstand deposits, exhibit sedimentation rates in excess of 3.5 kilometers per million years.

### *References*

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