Inversion of depocenters during the tectono-depositional evolution of the Caruaçu Member, Maracangalha Formation, in the Massapê Field, Recôncavo Basin.

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Abstract

The work was carried out in the Massapê Field, Recôncavo Basin, focused on the Caruaçu Member of the Maracangalha Formation. The maps of Isopach show that there is an inversion of the position of the local depocenter during the tectono-depositional evolution of the Maracangalha Fm. in this area. The largest thicknesses are located in the northern and southern portions of the Massapê Field, in the CR-1 zone, in the center-south portion of the CR-2 zone, and in the southern portion, in the CR-3 zone. The arrangement of these zones shows a variation of the local depocenter from south to north along time. This tectonic-depositional inversion may be related to the strong tectonics of the rift phase, causing the blocks tipping and to the shale diapers observed in the area during the Gondwana fragmentation process.

Introduction

The Recôncavo Basin is located in the central-eastern portion of Bahia State, NE of Brazil, and it comprises an area of approximately 11,500 km². The architecture of this basin is a half-graben type (Milhomem et al., 2003). The general trend NE-SW is originated on the distensive stress on the pre-Cambrian basement, defining normal faults with main direction N30ºE dipping to the east towards the border fault system (Fig. 1).

The Recôncavo Basin is limited to the north and northwest with the Tucano Basin by the Aporá High; to the south with the Camamu Basin by the Barra Fault System; to the east by the border fault system of Salvador; and to the west by the Maragogipe Fault (Milhomem et al., 2003).

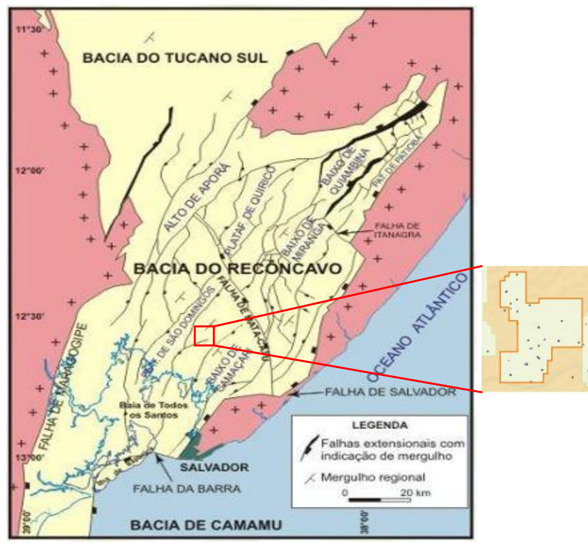

Figure 1: Location, boundaries and structural framework of the Recôncavo Basin, with the region of the Massapê Field highlighted. (Modified from Milhomem et al., 2003).

The tectonic evolution of the Recôncavo Basin is related to the rupture of the supercontinent Gondwana. The Recôncavo-Tucano-Jatobá rift system was an aborted segment during this process, which culminated in the opening of the South Atlantic between East America and West Africa (Magnavita et al., 2005).

The sedimentary record, preserved in the basin, illustrates several depositional events that characterize this tectonic evolution, being essentially expressed by the Paleozoic, Pre-Rift, Sin-Rift and Post-Rift Supersequences, characterized by Silva et al. (2007). The tectonic-depositional framework is represented in the schematic geological section of Figure 2.

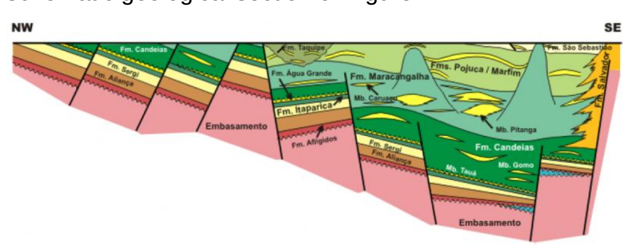

Figure 2: Schematic geological section in the southern compartment of the Recôncavo Basin, with geometry in half graben, and the sedimentary sequences (Modified from Milhomem, 2003).

Facies related to turbidity currents and mass gravitational flows illustrate the sedimentation processes from delta fronts, during the deposition of the Maracangalha Formation (Fm.) sediments (Ponte et al., 1981, apud Silva et al., 2007).

This work was based on the evaluation of well logs from the Massapê Oil Field, focused on turbidite reservoirs of the Maracangalha Fm. This formation comprises the sandstones of the Caruaçu and Pitanga Members. According to Gontijo (2011), the deposition of these sandstones is the result of gravitational mass and sediment fluxes, associated with tectonic movement in the basin, climatic variations and flow regimes.

Sandstones of the Caruaçu Member (Mb.) are important reservoir rocks in the Recôncavo Basin. Although they form packages with considerable thickness, such sandy bodies have low lateral and vertical continuities of the deposits (Gontijo, 2011).

Caixeta (1988) concluded that the Pitanga Mb. is represented by more clayey sandstones, which were deposited by debris flows. On the other hand, the Caruaçu Mb. is represented by clean sandstones, coming from deltaic fronts, slides, slumps, channeled turbidites or turbidites in lobes, being the turbidites of the Caruaçu Mb. the main reservoirs of the Maracangalha Fm. and the focus of this work.

Method

The first step of this study was the loading of the well logs and quality control, then a high-resolution stratigraphic system refinement was performed. This refinement allowed the identification of three distinct zones, informally known as Caruaçu 1 (CR-1), Caruaçu 2 (CR-2) and Caruaçu 3 (CR-3), which can be subdivided into 21 turbidite stages, denominated by Freire et al. (2018) and Freire et al. (2019), as CR-1A to CR-1L, CR-2A to CR-2F and CR-3A to CR-3E (Figure 3).

Based on the evaluation of the gamma ray (GR) registers, and the separation of the density (RHOB) and neutron (NPHI) logs, Freire et al. (2018) and Freire et al. (2019) identified four facies, composing each of the 21 turbiditic stages: (a) Facies sandstones, composed of fine to medium sandstones, the best reservoir rocks being; (b) Facies Slurry, composed of very fine sandstones and siltstones, extremely clayey, forming important permeability barriers; (c) Silicon Stones and (d) Shales Facies.

The turbidite system CR-1 was separated of the CR-2 system by a thick packet of shales, named by Freire et al. (2018) and Freire et al. (2019) as Acarajé Marker. The turbiditic system CR-2 was separated from the CR-3 system by a thin package of shales, named by the authors as Abará Marker.

The lithologies were interpreted and their thicknesses (isopach) were calculated from the qualitative log evaluation. These values were then tabulated and isopach maps were generated using the minimum curvature method for gridding.

This corresponds to an initial step for a better interpretation of the tectono-depositional history of the study area. To avoid excessive extrapolation of the interpolation method, a mask was applied to limit the grid, which allows to delimit the grid only to the points that have data, increasing the degree of reliability of the results.

In the next steps will be construct for each turbidite stage maps: of sandstone isolith, of sandstone/shale ratio, and of petrophysical properties (porosity, Vclay, SW).

Results and Discussion

The isopach maps of the three zones of the Caruaçu Mb., Caruaçu 1 (CR-1), Caruaçu 2 (CR-2), and Caruaçu 3 (CR-3), are shown in Figures 4, 5 and 6, respectively. From these maps, it is possible to observe that the colors that approach the purple shade represent the greater thicknesses, whereas the smaller thicknesses are represented by the shades of blue.

The Recôncavo Basin, as a rift-type basin, is strongly controlled by the tectonism (Magnavita, 2000), and variations of local depocenters are common. According to the isopach map of the CR-1 zone (Fig. 4), it is possible to verify that the greatest thicknesses are at the northern and the southern portions of the Massapê Field, and there appear to be two tectono-depositional depocenters in this area. In the CR-2 zone (Fig. 5), the largest thicknesses are concentrated in the center-south portion, while the largest thicknesses of the CR-3 zone are located in the southern portion of the Massapê Field (Fig. 6).

Considering that the CR-3 zone is the deepest zone, the CR-2 zone is the intermediate zone and the CR-1 zone is the shallower in the Massapê Field (Fig 3), it is possible to conclude that there was a variation of the local depocenter from south to north over time. This tectonic-depositional inversion is still not well understood, but it is assumed that the strong tectonics of the rifte phase, which occurred during the Gondwana fragmentation process, caused tipping of sectors of the Recôncavo Basin, particularly in the Southern near the Mata-Catu transfer zones and the Barra Fault (Fig. 1).

In addition, shale diapirism present in this portion of the basin (Silva et al., 2007) can affect and control depositional settings, changing both the accommodation space and the direction of turbidite fluxes that composes CR-1, CR-2 and CR-3 zones formation.

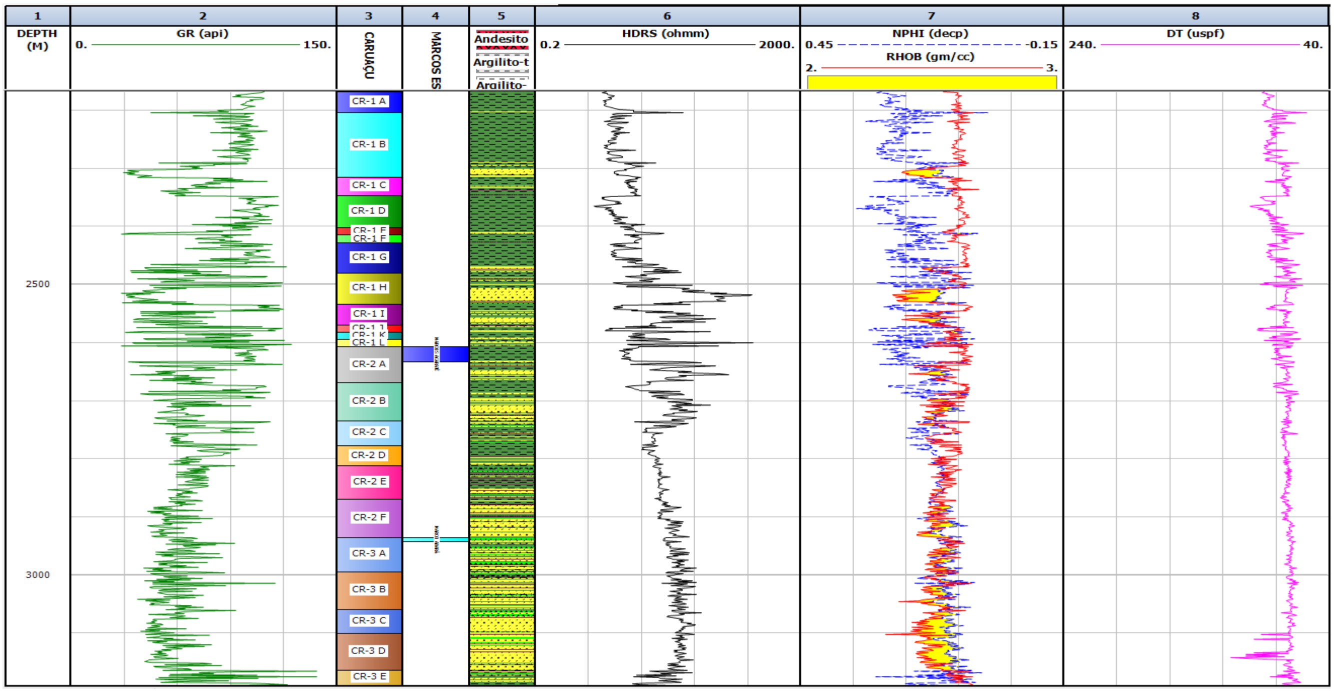

Figure 3: Logs of Well 7-MP-39D-BA. Track 1: measured depth in meters; Track 2: gamma ray (GR) log; Track 3: the stratigraphic refinement in 21 turbiditic stages that compose the CR-1, CR-2 and CR-3 zones; Track 4: Acarajé (above) and Abará (below) Markers, that separate CR-1 from CR-2 and CR-2 from CR-3, respectively; Track 5: interpreted lithology log; Track 6: resistivity log (HDRS); Track 7: density (RHOB) and neutron (NPHI) logs; Track 8: sonic log (DT).

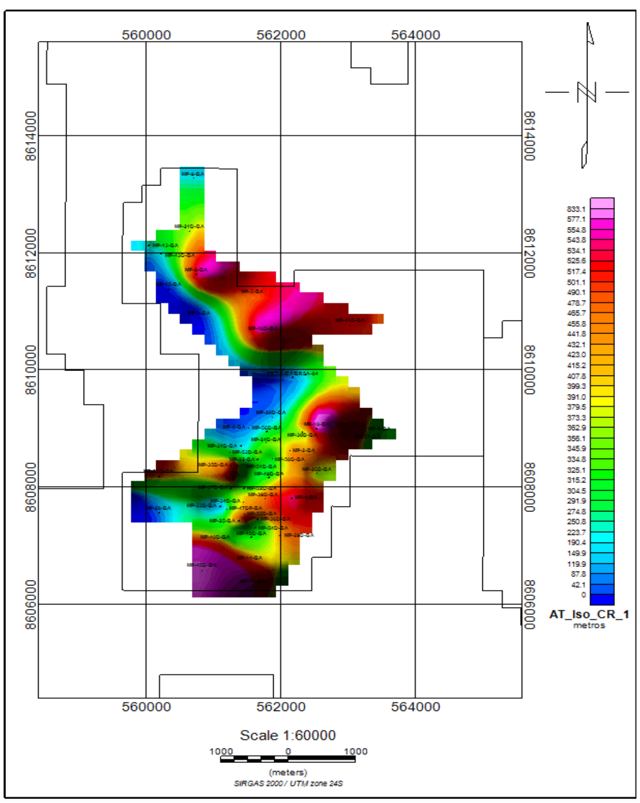

Figure 4: Isopach map of CR-1 zone, evidencing that the greatest thicknesses are in the northern and the southern portions of the Massapê Field.

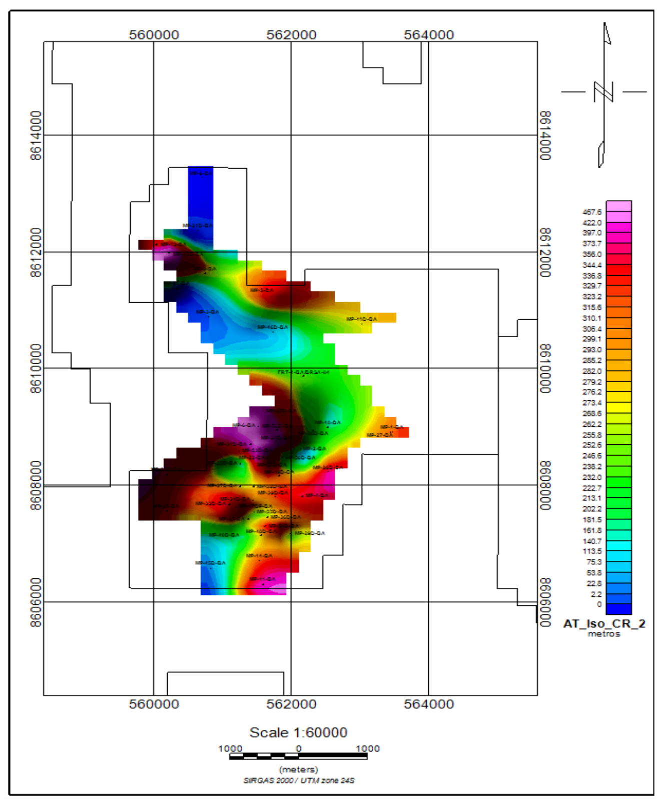

Figure 5: Isopach map of CR-2 zone, evidencing that the center-south portion of the Massapê Field.

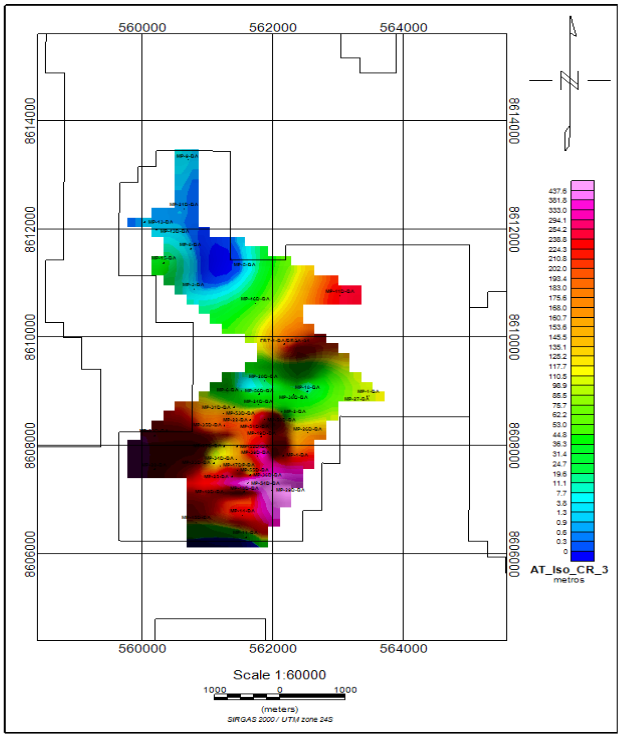

Figure 6: Isopach map of CR-3 zone, evidencing that the greatest thicknesses are in the southern portion of the Massapê Field.

Conclusions

The Isopach maps show that the greatest thicknesses are located in the northern and southern portions of the Massapê Field, suggesting the existence of at least two tectono-depository depocenters during the deposition of the sediments composing the CR-1 zone. In the CR-2 zone, it is possible to notice that the greatest thicknesses are concentrated in the center-south portion, while the largest thicknesses of the CR-3 zone are located in the southern portion of the Massapê Field.

The variation of depocenters in the Massapê Field area for the three zones suggests that there was a tectono-depositional inversion in the study area. The arrangement of these zones allows us to conclude that there was a change in the depocenter from the south towards the north along time.

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