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Reservoir quality evaluation using petrophysical characterization of Mio-cene Turbidite Reservoirs in the Albacora Leste Field, Campos Basin

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Abstract Summary

The Albacora Leste Field, in the Campos Basin, contains Miocene turbiditic sandstones with high heterogeneity due to halokinesis and stratigraphic complexity. A petrophysical analysis was conducted on 12 wells to support reservoir characterization and production. Parameters included DRDN, porosity, Vclay, permeability, water saturation, and electrofacies. The AB-140 reservoir was subdivided into an upper heterolite zone (Vclay = 0.83, φ = 4%, k = 3 mD) with marl layers and low potential, and a lower sandstone zone (Vclay ~0.4, φ = 21%, k = 283 mD) with better quality and Net Pay/Net Gross. Crossplots differentiate electrofacies clusters—sandstone, shale, heterolite, marl—highlighting transitional features. Nine of twelve wells show good to excellent properties. The methodology identified high-quality intervals in AB-140, improving models and aiding development planning and seismic inversion.

Introduction

The Campos Basin, located offshore Brazil, hosts some of the country's most productive petroleum fields, especially within Miocenic turbiditic systems of the Carapebus Formation like seen in the Albacora Leste field (Fig. 1A). These turbidites, deposited in intraslope depocenters and often controlled by halokinesis and complex stratigraphic architecture, present high heterogeneity and pose challenges to reservoir characterization (Lemos et al., 2006; Casagrande et al., 2022). Petrophysical studies enhance interpretation in such environments by supporting facies modeling, reservoir quality assessment, and integration with seismic data. This work evaluates the petrophysical properties of AB-140 reservoir using well log analysis, petrophysical characterization and electrofacies classification.

Methodology

Well log analysis was conducted to evaluate reservoir quality and identify lithology, porosity, fluid type, and potential hydrocarbon zones in the AB-140 reservoir. The study included twelve wells: 1-RJS-342-RJS, 3-RJS-355-RJS, 3-RJS-510A-RJS, 4-RJS-367-RJS, 4-RJS-477A-RJS, 6-ABL-1-RJS, 9-ABL-2-RJS, 9-ABL-3B-RJS, 9-ABL-5-RJS, 9-ABL-6A-RJS, 9-ABL-9D-RJS, and 9-ABL-70D-RJS (Fig. 1B). Each well contained a full suite of geophysical logs, including gamma ray (GR), density (RHOB), neutron porosity (NPHI), sonic (DT), deep resistivity (RES D), and photoelectric factor (PEF). Stratigraphic markers were used to define the AB-140 reservoir intervals.

The workflow used was: (i) quality control of the data to ensure consistency and reliability; (ii) calculation of DRDN (iii) calculation of clay volume (Vclay) with a RHOB-NPHI based method; (iv) calculation of electrofacies with petrophysical parameters as DRDN, Vclay, DT and RHOB; (vi) calculation of porosity with density logs; (v) calculation of water saturation (Sw) with Simandoux's equation; (vii) calculation of permeability (PERM) with Wyllie Rose's method; (viii) definition of parameter cutoffs; (ix) calculation of rock, reservoir and pay net flags and; (x) calculation of net pay/net gross ratio. Additionally, an RMS (Root Mean Square) amplitude attribute was extracted from the 3D seismic volume received by the project, between the top and base surfaces of the AB-140 interval, to support the identification of high-energy reflection zones and enhance reservoir characterization.

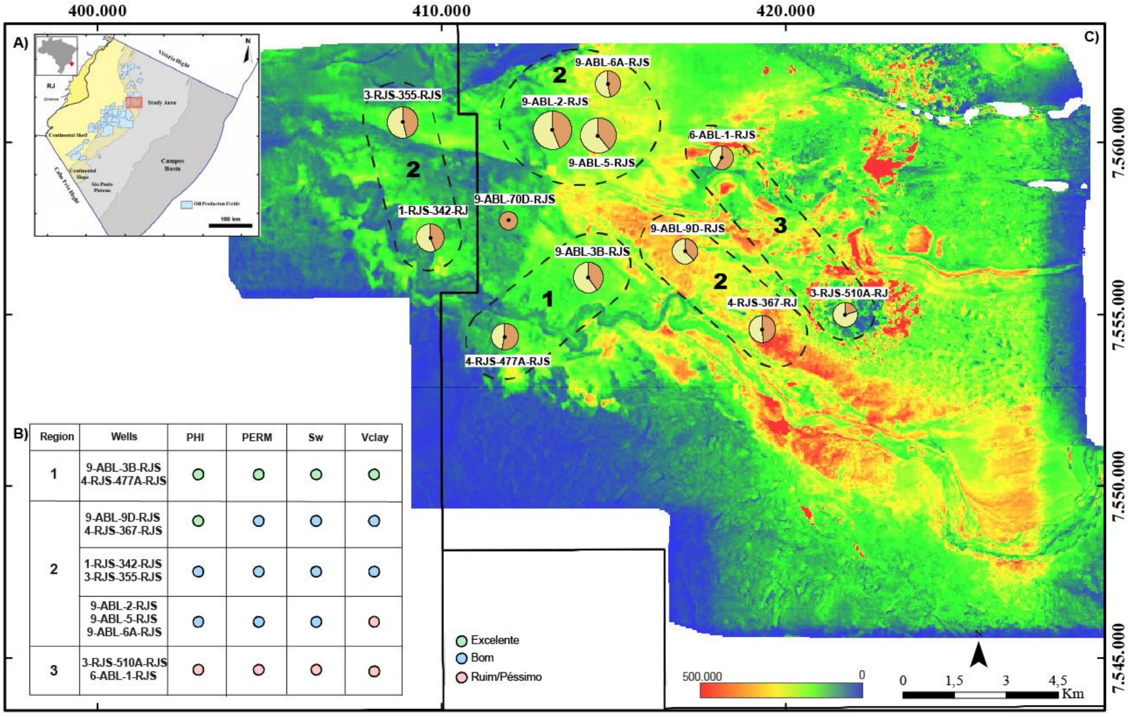

Figure 1: A) Location of the Albacora Leste Field in the Campos Basin. B) Qualitative classification of petrophysical parameters (porosity, permeability, water saturation, and clay volume) based on defined thresholds. C) Well distribution in the Albacora and Albacora Leste fields with RMS amplitude between the top and base of the AB-140 interval. Pie charts show sandstone (yellow) vs. heterolithic (orange) thickness proportions, scaled by total reservoir thickness. Reservoir quality is classified into three categories: 1 (Excellent), 2 (Good), and 3 (Poor/Very Poor). Well 9-ABL-70D-RJS does not intersect the sandstone zone.

Results

The AB-140 reservoir is heterogeneous, with thicknesses from 21 to 76 m and predominantly composed of sandstone, which represents over half of the interval in most wells. It's poorly consolidated, as indicated by high DT values, and can be divided into two main zones. The upper zone, which we refer to as the heterolite zone, is composed of sandstones interbedded with shales. It shows high GR, RHOB, and NPHI values, along with low deep resistivity. Petrophysical analysis confirms high clay content and low reservoir potential, with Vclay at 0.83 m³/m³, water saturation at 0.91 m³/m³, low porosity (4%), and very low permeability (3 mD). High PEF values suggest occasional marl layers. In contrast, the lower sandstone zone is cleaner, with low GR, RHOB, and NPHI, and significantly higher resistivity. In some intervals, deep resistivity ranges from 100 to 250 ohm.m, suggesting hydrocarbon presence. Petrophysical parameters are much more favorable here, with Vclay at 0.4, Sw at 0.4, porosity at 21%, and permeability reaching 283 mD. Given these conditions, we focused my petrophysical evaluation on this interval.

The electrofacies defined for the AB-140 reservoir show clear differentiation in the Porosity vs. Permeability crossplot (Figure 2). The sandstone electrofacies (yellow) dominate the higher porosity (>25%) and permeability (>200 mD) ranges, indicating the best zones for hydrocarbon accumulation and flow. The heterolite (light green) and shale (dark green) electrofacies fall into lower porosity and permeability ranges, typical of higher clay content and limited production potential. The heterolite sometimes overlap both sandstone and shale fields, reflecting their transitional and mixed nature. Marl electrofacies (blue) appear sporadically, showing intermediate behavior likely related to mixed carbonate and clay content.

To define reservoir (Net Gross) and producible (Net Pay) intervals, we applied cut-off values based on Albacora Field characteristics (Worthington & Cosentino, 2005). For Rock Pay, we used a Vclay cut-off of <0.45. For Gross Pay, a porosity cut-off of >13% was added, and for Net Pay, water saturation had to be <0.5. The resulting Net Pay/Net Gross ratio is approximately 0.96, indicating a strong reservoir contribution to production.

Petrophysical parameters were classified (Figure 1B) as excellent, good, poor, or very poor based on the following thresholds: porosity (>25% excellent, <10% very poor), permeability (>1000 mD excellent, <1 mD very poor), water saturation (<0.25 excellent, >0.5 very poor), and clay volume (<25% excellent, >45% very poor). From this classification, three qualitative reservoir quality zones were defined within the sandstone interval (Figure 1C). Region 1 (excellent) includes wells 9-ABL-3B-RJS and 4-RJS-477A-RJS; Region 2 (good) includes wells 1-RJS-342-RJS, 3-RJS-355-RJS, 4-RJS-367-RJS, 9-ABL-2-RJS, 9-ABL-5-RJS, and 9-ABL-6A-RJS; and Region 3 (poor to very poor), located in a more distal turbidite setting, includes wells 3-RJS-510A-RJS and 6-ABL-1-RJS. Well 9-ABL-70D-RJS does not intersect the sandstone zone. As shown in Figure 1C, Region 1 and the westernmost wells in Region 2 exhibit low to moderate RMS amplitude values. In contrast, the remaining wells in Region 2 and those in Region 3 display higher values. The RMS attribute highlights the presence of at least two depositional channels: one to the south, associated with wells showing the best petrophysical properties, and another to the north.

Table 1: Average of well log values as CAL (in), GR (API), DENS (g/cm^3), NEUT (v/v), RES D (ohm.m), DT (µs/ft), PEF (b/e), Vcl (m^3/m^3), PHI (%), PERM (mD) and Sw (m^3/m^3) for the twelve wells used in this study. The chart on the right has values of the Heterolite Zone and the one on the left has the Sandstone Zone values.

Heterolite Zone			
	Min	Max	Mean
GR (API)	56,3	139,7	112,4
RHOB (g/cm^3)	2,0	2,7	2,3
NPHI (v/v)	0,2	0,5	0,4
RES D (ohm.m)	0,8	4,1	1,4
DT (µs/ft)	58,1	148,1	117,9
PEF (b/e)	2,33	5,08	3,83
Vclay (m^3/m^3)	0,0	1,0	0,8
PHI (%)	0%	34%	4%
PERM (mD)	0,0	598,6	14,2
Sw (m^3/m^3)	0,2	1,0	0,9

Sandstone Zone			
	Min	Max	Mean
GR (API)	48,1	130,2	78,7
RHOB (g/cm^3)	2,0	2,6	2,1
NPHI (v/v)	0,0	0,5	0,3
RES D (ohm.m)	0,9	248,4	5,1
DT (µs/ft)	56,5	161,0	124,1
PEF (b/e)	1,96	5,41	3,19
Vclay (m^3/m^3)	0,0	1,0	0,4
PHI (%)	0%	40%	20%
PERM (mD)	0,0	12016,6	283,7
Sw (m^3/m^3)	0,0	1,0	0,4

Conclusions

The AB-140 reservoir comprises two distinct zones: a heterolite zone and a sandstone zone, the latter showing superior reservoir quality and representing over half of the total thickness in most wells. Its low clay content, high porosity and permeability, and low water saturation confirm its production potential. Electrofacies analysis proved effective in distinguishing lithologies and reservoir quality, with the heterolite zone showing transitional behavior between shale and sandstone. By integrating well log analysis, petrophysical characterization, and electrofacies classification, we identified regions within the Albacora and Albacora Leste fields that range from excellent to very poor in terms of reservoir quality. The study confirms the heterogeneity of the AB-140 reservoir and indicates a westward decline in reservoir quality within the Albacora Leste field, likely due to the more distal position within the turbidite system. RMS amplitude analysis revealed at least two depositional channels—one in the south, associated with the best properties, and another in the north with less favorable conditions. The study confirms the heterogeneity of the AB-140 reservoir and indicates a westward decline in reservoir quality within the Albacora

Leste field, likely due to the more distal position within the turbidite system. The applied workflow provides a solid foundation for future seismic inversion and reservoir simulation efforts.

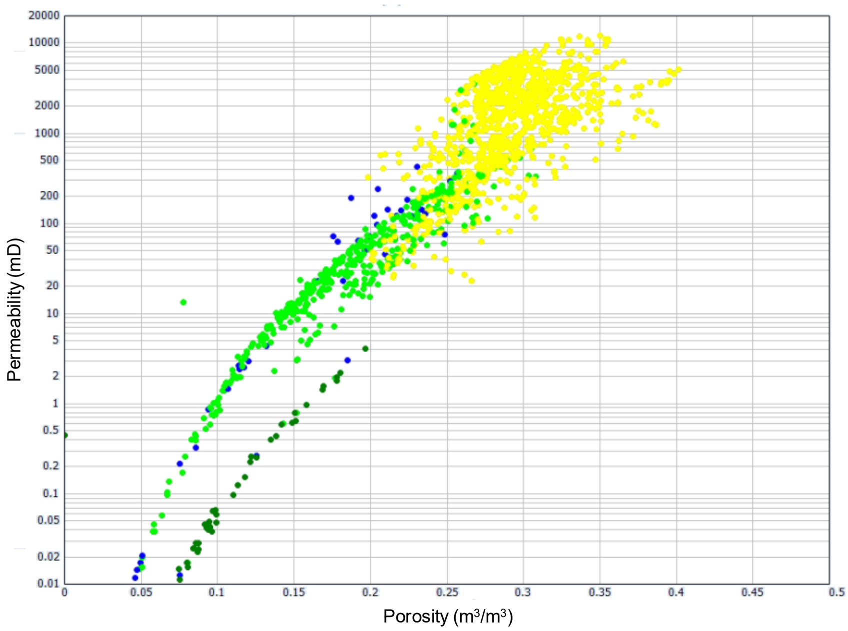

Figure 2: Crossplot of porosity (here in m³/m³) *versus* permeability (mD) with the sandstone (yellow), heterolite (light green), shale (dark green) and marls (blue) electrofacies.

Acknowledgments

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