Jequitinhonha Basin: Structural aspects, relationship with igneous activity, and hydrocarbon exudations

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Abstract

The Jequitinhonha Basin (JB) is one of the sedimentary basins in the Brazilian Eastern Margin. Although several regional studies have been conducted to define its tectonic framework and petroleum system, neither one is very well-understood. For instance, the extent and influence of the volcanic rocks in the petroleum system of the JB are still matters of debate among geoscientists. We found a new integrated interpretation for the structural framework of JB in which we discover the major faults, the mapped volcanics, and a new basement map. Finally, we evaluate the correlation of known exudation occurrences with our findings. Several exudation occurrences are observed in the evaporite province (to the north), although only one exudation occurrence is seen in the Royal Charlotte domain (to the south) thus corroborating the negative impact of the Abrolhos magmatic event for the petroleum systems in the JB. At least seven exudation occurrences are observed in the oceanic crustal domain. This fact strengthens the possibility of the existence of an Urucutuca-Urucutuca postrift petroleum system.

Introduction

According to Beglinger et al. (2012), the presence or absence of magmatism influenced the petroleum system in several basins of the Brazilian Eastern Margin (BEM). In places where the volcanism was an active process, the development of syn-rift lacustrine source rocks would be hampered. A younger magmatic event could overmature the syn-rift lacustrine source rocks or even erode the older sedimentary sequences.

In spite of all efforts to date, most of the sedimentary basins of the BEM remain under explored. This is mainly due to a poor understanding of their petroleum system including the influence of the Tertiary volcanism.

A massive magmatic event occurred especially in the Jequitinhonha, Cumuruxatiba, and Espirito Santo Basins (Figure 1), forming the Abrolhos Volcanic Bank in the Espirito Santo Basin, the Royal Charlotte Bank in the Jequitinhonha Basin (JB) and the Sulfur Minerva seamount in the Cumuruxatiba Basin. The linear trend of the volcanic rocks suggests evidence of an active hot spot in the area (Mizusaki et al., 2002).

This scenario applies in particular to the JB (Figure 1). Notwithstanding some previous regional studies related to the tectonic framework and structural evaluation (Küchle et al., 2005), the influence of the volcanic activity on the petroleum system of JB is still not well-understood. In fact, Beglinger et al. (2012) suggest that there is no proven petroleum system in the JB, but they propose a hypothetical lacustrine syn-rift plus one transitional fluvio-marine, one shallow and one deep marine postrift speculative system. However, Clark (2002) affirms that a proven postrift Regência-Maricuru petroleum system exists within the basin.

In this paper, we propose a regional stratigraphic-structural framework for the JB. This framework comprises the main sedimentary units and incorporates salt domes, volcanic intrusions, and the basement relief, as mapped through an integrated interpretation. High-resolution airborne magnetic data, satellite gravity data, and more than 1500 km of 2D seismic lines were made available for this study.

Available geochemistry and oil exudation data enabled us to correlate the hydrocarbon occurrences with

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the Tertiary volcanic intrusions. Our results indicate that, in the JB, the volcanism had an adverse impact on hydrocarbon generation.

Geologic setting of the JB

The JB shows a tectonic evolution characterized by three main phases (Chang et al., 1992): a Neo-Jurassic-Cretaceous prerift phase characterized by an intracontinental syneclise event, a Neocomian-Aptian rift phase exhibiting an intense distensive domain until the Gondwana breakup (de Almeida et al., 1996), and an Albian postrift phase identified as a passive margin environment (Küchle et al., 2005).

The structural framework is composed of the Olivença High, which extends to the south as a shallow platform and in the shallow-water domain. The basement is composed of metamorphic rocks and granites of the Rio Pardo Group. CÓRDOBA (1990) divides the basin into two structural compartments. The northern section exhibits a sequence of phased normal faults, whereas the southern portion is characterized by an expressive border fault. Several horsts, grabens, and half-grabens can be observed in both compartments (CÓRDOBA, 1990).

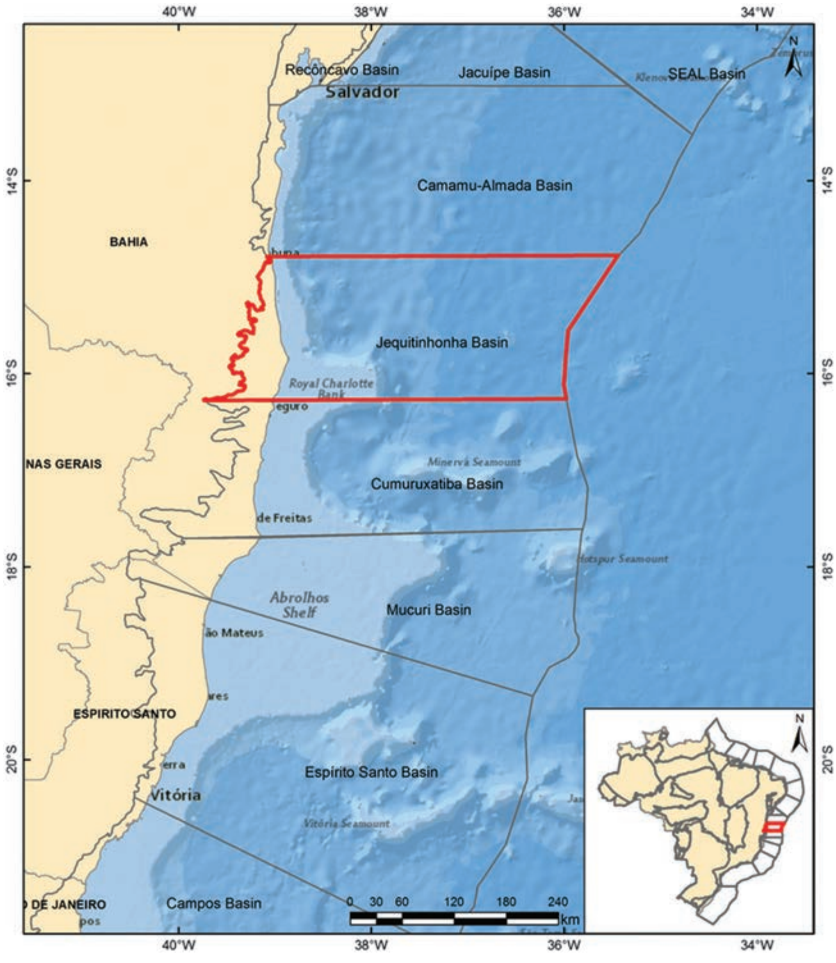

Figure 1. BEM sedimentary basins. The JB is in red.

The Ilhéus transfer zone is a Paleoproterozoic northwest–southeast transpressive shear zone related to the tectonic events observed in outcrops of the Rio Pardo group. During the Cretaceous, in the opening stage of the Atlantic Ocean, several of these shear zones were reactivated. For instance, we can cite the Salvador and the Itabuna transfer zones in the Camamu-Almada Basin and the Ilhéus transfer zone in the JB (Rangel et al., 2007; Ferreira et al. 2009).

Chang et al. (1992) describe five main megasequences within the sedimentary evolution of the Brazilian passive margin basins (Figure 2). From bottom to top: continental, transitional, carbonatic, marine transgressive, and marine regressive.

The Late Jurassic-Barremian continental megasequence is composed of lacustrine and fluvial sediments. In the northern portion of the JB, organic-rich shales were deposited within the half-grabens.

The Aptian evaporitic transitional Megasequence is formed by massive salt bodies in the north of the JB related to conglomerates and fine-grained clastic sediments. The Albian carbonatic megasequence tops the Aptian salt. The main rock types are dolomites from a shallow-water, high-energy carbonatic platform, interbedded with clastic sediments of delta fans. Calcilutites and calcarenites intercalated with shale and marl are also found. (Küchle et al., 2005; Milani et al., 2007).

The marine transgressive megasequence, Late Albian-Turonian, is characterized by low-energy sediments and turbiditic sedimentation along paleocanyons. Turbiditic sandstones, calcilutites, marl, and shale are the most common rock types (Asmus et al., 1971; Santos et al., 1994).

The marine regressive megasequence is composed of a group of synchronal depositional systems: delta-fans, fluvial-deltaic, continental platform, carbonatic platform, slope, and basin (Küchle et al., 2005). During the Paleogene-Eogene, a large volcanic event formed the Royal Charlotte complex (the Abrolhos Formation) in the southern portion of the JB (Figure 1).

The JB petroleum system is still a matter of debate. Beglinger et al. (2012) suggest that there is no proven petroleum system, but they consider a hypothetical lacustrine syn-rift plus one transitional fluviomarine, one shallow, and one deep marine postrift speculative system. Several researchers believe that the same petroleum systems observed at Camamu-Almada could be present in JB due to its proximity and similar sedimentary evolution (Gaglione et al., 1987; Gonçalves et al., 2000; Araujo, 2007). Clark (2002) considers the Aptian-Albian Regência-Maricuru petroleum system as the most relevant and active in JB. In that system, the source rocks are the organic-rich shales of the Regência Formation (TOC = 5%), and the main reservoirs are the fluvial-deltaic sandstones of the Maricuru Formation (Gaglione et al., 1987; Gonçalves et al., 2000).

Available data set

ANP (National Petroleum, Natural Gas, and Bio Fuels) has provided more than 1500 linear km of public-domain poststack time-migrated 2D seismic lines (Figure 3). ANP also provided check shots, stratigraphy, and composite well logs (density, sonic, porosity, resistivity, and gamma ray) of three wells in the study area (Figure 3).

The high-resolution airborne magnetic survey herein interpreted is composed of 133,000 km of line data covering an area of approximately 76,000 km^2 comprising the Camamu-Almada, Jequitinhonha, and Cumuruxatiba Basins. Flight lines were flown with 500 m line spacing in the shallow-water domain and 1000 m line spacing in the deepwater domain. Magnetic data were provided as a total magnetic intensity (TMI) anomaly. Before interpretation, we transformed these data to the pole (RTP) using the energy balance algorithm (Keating and Zerbo, 1996). The final RTP anomaly map is shown in Figure 3. The magnetic parameters used were -31.12° for the inclination and -23.24° for the declination and were chosen according to the IGRF model of the year of the airborne magnetic survey (2002).

The regional gravity data set is composed of an offshore free-air satellite gravity and bathymetry public domain data compilation (Sandwell et al., 2013, 2014). We gridded both at 1×1 km size. Next, we calculated the Bouguer anomaly by applying a 2.2 g/cm^3 density correction. Finally, we computed the residual gravity anomaly shown in Figure 4, by removing the gravity effect of the Moho discontinuity (Laske et al., 2013).

Structural and seismic interpretation

To highlight and interpret geologic and structural features at several depths, we applied several enhancement filters to the high-resolution airborne magnetic data, including vertical and horizontal derivatives, depth slices, and the amplitude and phase of the monogenic signal (Hassan and Yalamanchili 2013; Hidalgo-Gato and Barbosa, 2015).

Figure 5 shows the first vertical derivative of the TMI-RTP. To the northwest, we can observe in the Olivença High a strong northeast–southwest signature related to the shallow Proterozoic basement. Egydio-Silva et al. (2011) identify three deformational events in the Rio Pardo Group. The first one, in the Middle Proterozoic, in the autochthonous zone, northwest structures are observed. The second one presents a folding event also producing northwest–southeast structures. Finally,

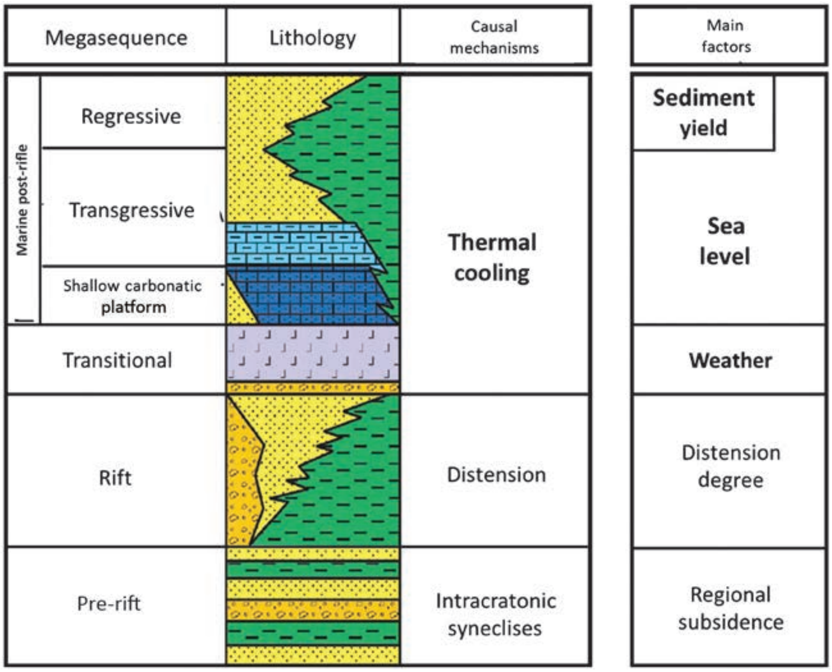

Figure 2. Schematic model of the Brazilian evolution stages, lithologies, and controlling factors. Modified from Chang et al. (1992).

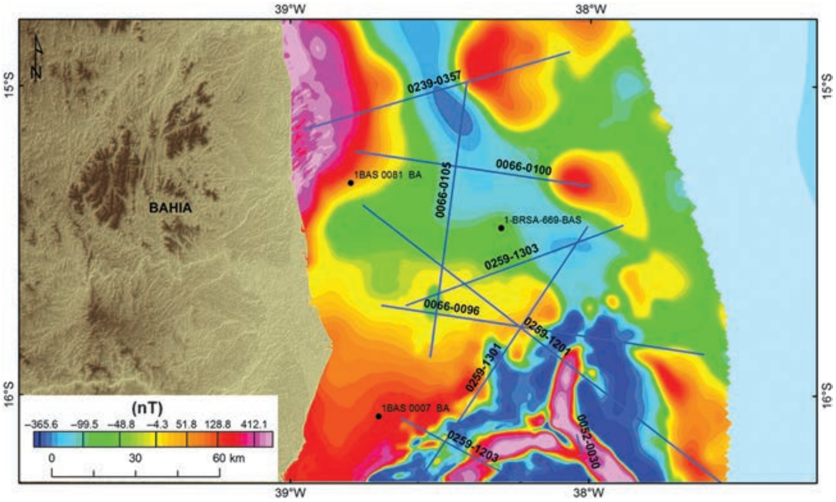

Figure 3. RDP–TMI anomaly map of the JB. Seismic lines are shown in blue, and the wells are in black dots.

in the Upper Proterozoic, a third event occurred and can be observed by the northeast–southwest disruptive structures. To the southwest, we also observe a small portion of shallow basement with a strong high-frequency signature. Another important geologic feature is the Royal Charlotte igneous intrusion, mapped in the southern portion of the JB. Unconventional filtering was also used in this work. Figure 6 shows the phase of the monogenic signal of the TMI-RTP. In this map, it is possible to observe the main magnetic features without enhancing undesirable features and noise. The northeast–southwest trend in the Olivença High and the Royal Charlotte igneous intrusion can be mapped clearly.

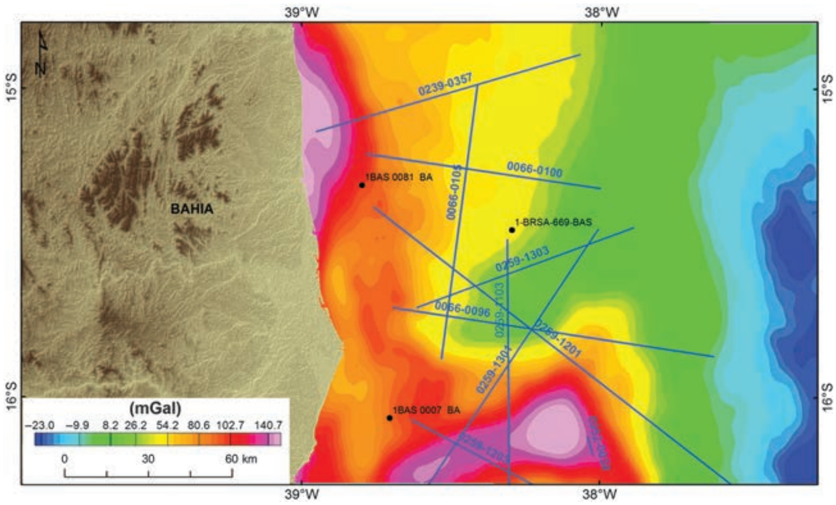

Figure 4. Satellite isostatic gravity anomaly of the study area (Sandwell et al., 2014). Seismic lines are shown in blue, and the wells are in black dots.

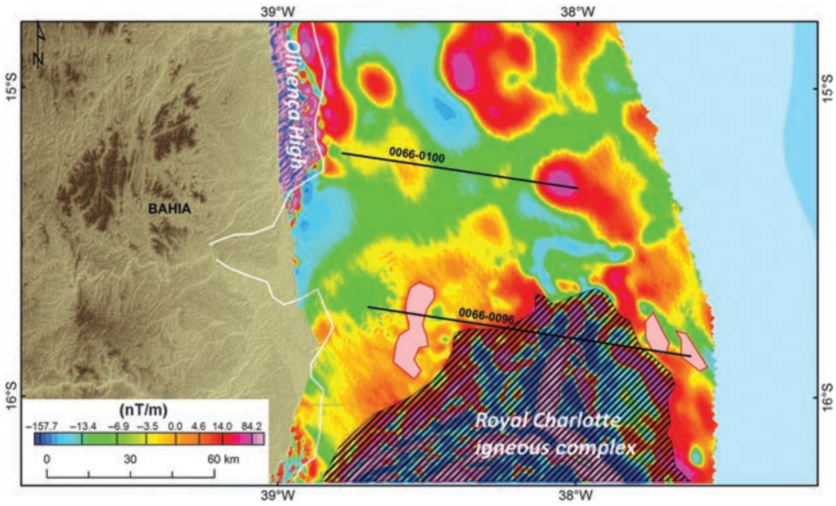

Figure 5. First vertical derivative of the TMI. Some structural features were interpreted. Lines L0066-0100 (Figure 7) and L0066-0096 (Figure 8) are shown in the black lines. Interpretation features: white, hinge line; red, igneous intrusions; and black, Royal Charlotte tertiary intrusion.

Quantitative interpretation and 2D forward modeling

Five horizons were mapped (Figures 7 and 8) using information from three wells (Figures 3 and 4) available for this study. Küchle et al. (2005) describe half-grabens in JB as a typical basement structure. The seismic lines interpreted herein do not give any insight into the basement geometry, but the upper sequences can be mapped clearly. In seismic line L0066-0100 (Figure 7), we observe salt diapirs in the transitional sequences (Menezes and Milhomem, 2008). These salt bodies are concentrated in the north portion of the JB and are not observed in the southern portion (Figure 9). Listric faults and growth faults are present above the salt, deforming the Albian, Upper Cretaceous, and Paleogene sequences. Line L0066-0096 (Figure 8) also shows listric and growth faults above the transitional sequence associated with salt bodies. The Royal Charlotte Tertiary igneous intrusion is well-imaged and is associated with minor igneous intrusions in Albian and Paleogene sequences (white lines). The basement half-grabens are barely visible, and the same is true for a deepwater oceanic crust. Combining the geologic features mapped with potential fields, seismic, and previous publications, we propose a new and detailed structural map for JB (Figure 9).

Beyond qualitative interpretation, magnetic data can also be very well-adapted for the estimation of magnetic sources. The Peters half-slope (Peters, 1949), the Euler deconvolution (Thompson, 1982), and the Werner deconvolution (Werner, 1953) are the most well-known depth estimating techniques. Figure 10 represents the magnetic basement map accomplished by combining the techniques adopted on the airborne magnetic data (Figure 3). In this map, we observe several geologic features already described by Chagas (2003) and Castilho (2005). The Olivença High, the Canavieiras and Belmonte Canyons, and the Jequitinhonha Trench are very well-defined in this map. It is important to emphasize the thick sedimentary infill of the JB in general. In the Olivença High, the depths are approximately 6000 m, whereas in the Jequitinhonha Trench, the depths are more than 11,000 m. To the northeast, we observe several basement highs and lows with the northeast direction presenting depths greater than 12,000 m. These structures are related to the opening of the Atlantic

Ocean during Cretaceous being described by Ferreira et al. (2009).

Nonuniqueness is a major issue in geophysical interpretation. To reduce the uncertainty in the interpretation, geophysicists often combine several methods to constrain solutions for a reasonable geologic model that fits the geophysical data (Adriano et al., 2014; Adriano et al., 2015; Cunha et al., 2015). Here, we modeled two seismic lines (TWT) (L0066-0096 and L0066-0100) (Figures 7 and 8) using the RTP-TMI and satellite gravity data to provide depth constraints to the interpretation. The properties used for the modeling exercise are described in Figures 11 and 12. These properties were acquired in the 1BAS-0081, 1-BRSA-669-BAS, and 1-BAS-0007-BA wells (Figures 3 and 4). In line L0066-0100, the half-grabens are identified presenting depths approximately 11,000 m. Salt domes are also observed, but the satellite gravity data have insufficient resolution for detailed mapping. Line L0066-0096 (Figure 12) also shows salt domes in the Albian sequence and half-grabens in the basement. Igneous intrusions are also identified in the seismic interpretation and confirmed by Werner deconvolution (red dots) (Figure 12). The Royal Charlotte Tertiary intrusion is also confirmed by the satellite gravity and the airborne magnetic data.

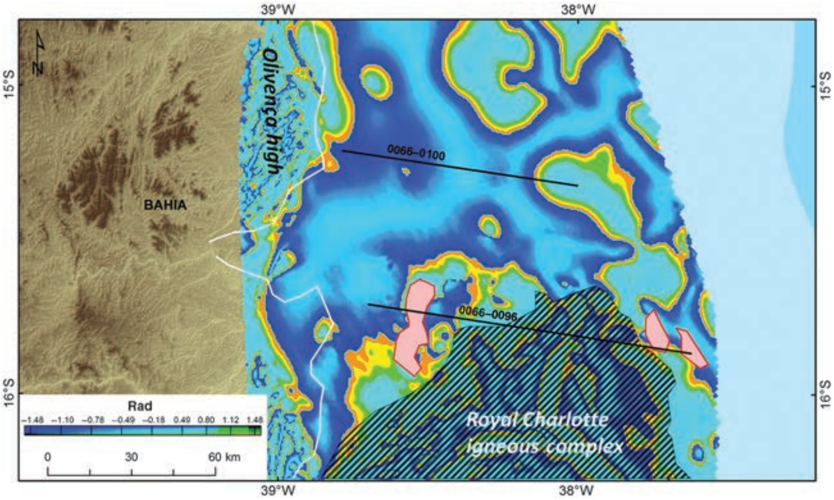

Figure 6. Phase of the monogenic signal of the TMI. Igneous intrusions are shown in red, and the Royal Charlotte Tertiary intrusion is in black.

Relationship between igneous activity and petroleum occurrences

Considering the lack of petroleum studies in the Cumuruxatiba, Jequitinhonha, and Camamu-Almada sedimentary Basins, the potential for petroleum occurrence in the JB is still a matter of debate among geoscientists. Nevertheless, some studies related to oil evaluation, hydrocarbon exudations, and tectonic evolution have been performed. Sanabria (2013) describes onshore exudations in the northern portion of JB. According to the author, the onshore exudations can be associated with the northwest–southeast transfer zones that acted as hydrocarbon migration pathways. Lima et al. (2005) identify at least 12 exudations in the JB proposing a possible contribution by the Tertiary igneous activity in the ma-

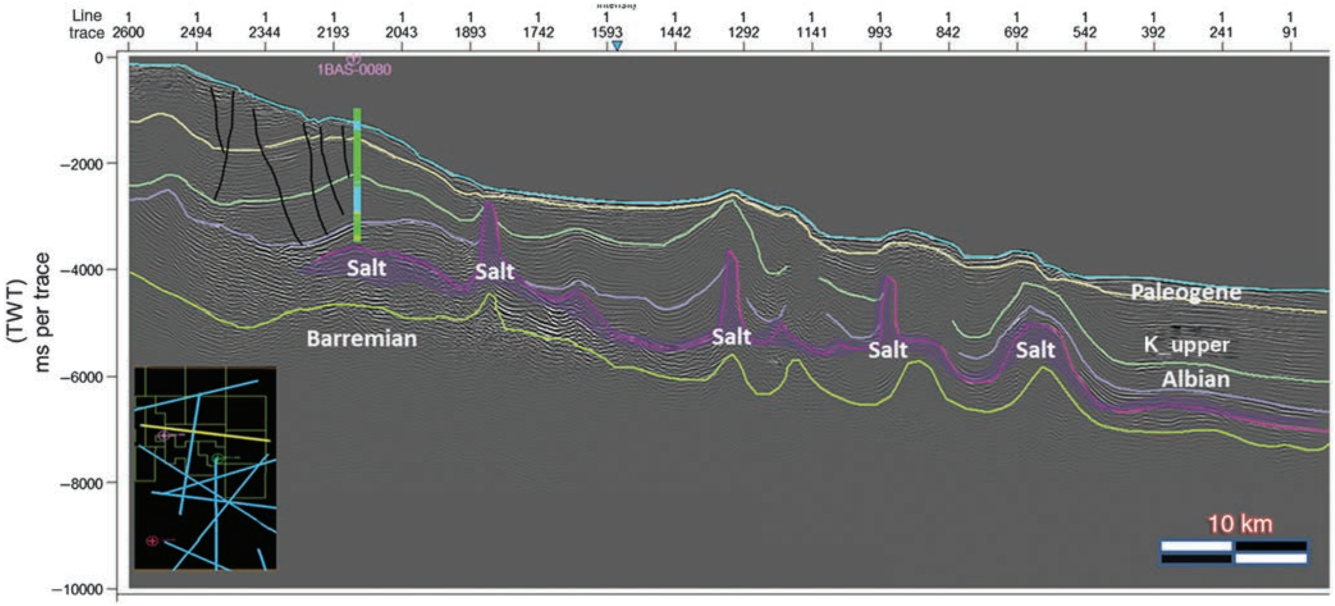

Figure 7. Interpreted seismic line L0066-0100 (TWT). Salt domes and listric faults are observed. Well 1BAS-0080 was used for the calibration of the horizons. No igneous activity is observed in this line.

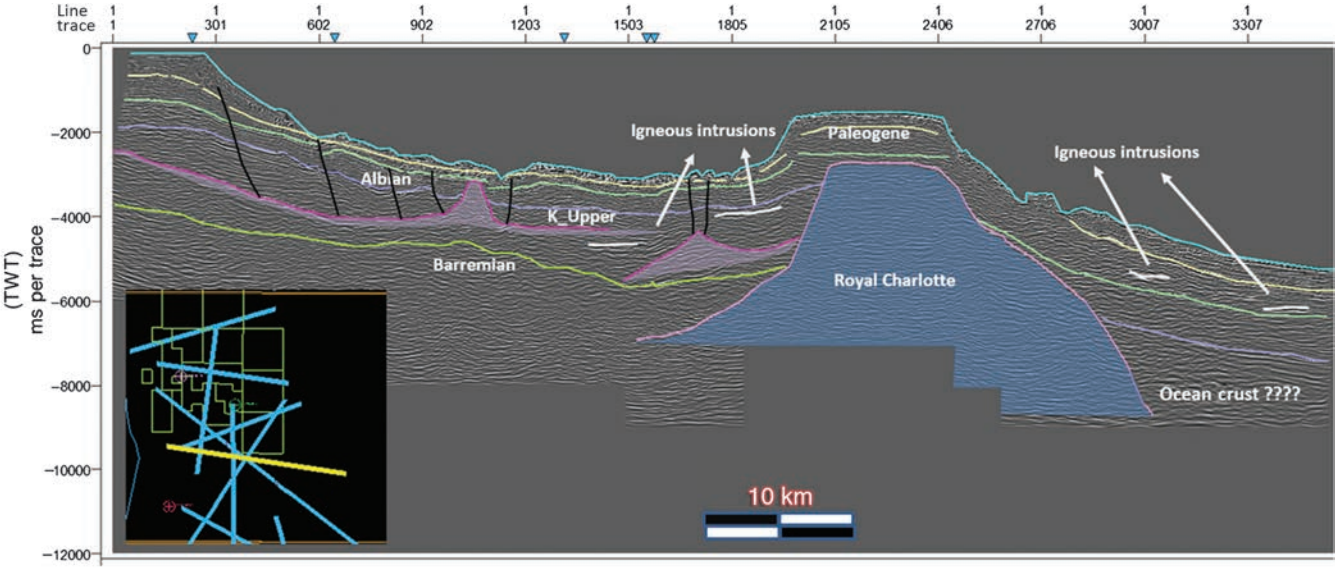

Figure 8. Interpreted seismic line L0066-0096 (TWT) showing salt domes, igneous intrusions, and the Royal Charlotte tertiary intrusion.

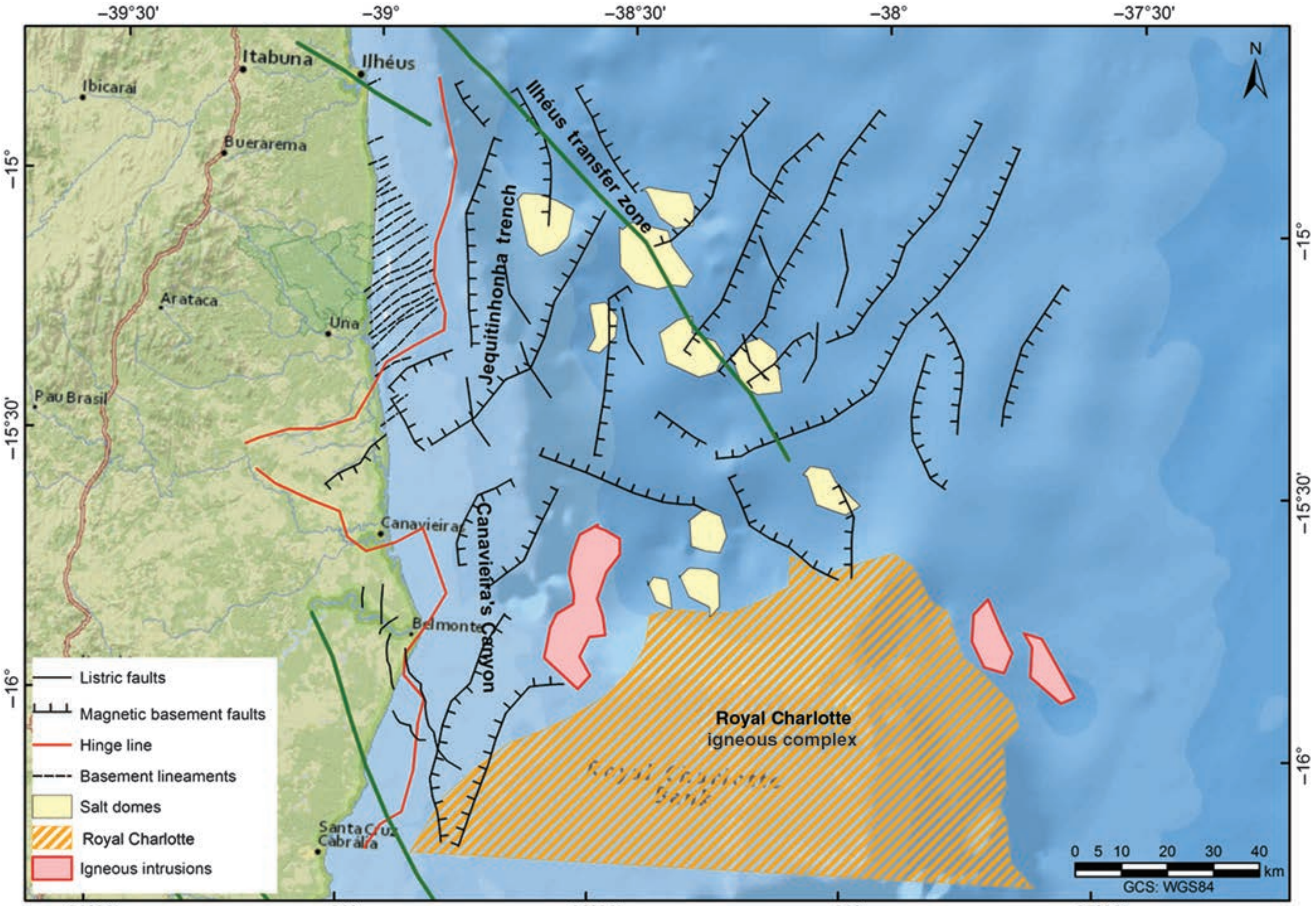

Figure 9. Our structural map of the JB combining magnetic, gravity, and seismic data.

turation of the Cenomanian-Turonian source rocks of the Urucutuca Formation (Figure 10). The authors also affirm that the deepwater exudations observed could be related to geologic transfer zones. The position of these exudations in the northern portion of the JB suggests that the major petroleum potential is concentrated to the north and probably the Tertiary igneous activity is a negative factor for hydrocarbon occurrence considering the single exudation observed in the southern portion of the JB (Figure 10). The massive igneous activity acted as an erosive agent for the syn-rift sequence, the main source rocks of the JB. However, we observe that the deep-water exudations are clearly associated with the northwest–southeast structures, mostly controlled by the Ilhéus transfer zone oceanwards. Probably, during Cretaceous, the reactivation of the Ilhéus transfer zone acted as a migration pathway being an important exploratory trend to be observed in JB.

Araujo (2007) analyzed 11 oil samples in the Camamu-Almada and JB by liquid and gas chromatography. This study reveals a strong relationship between the source rocks and saline lacustrine environment. Another important factor is that the oils analyzed in the Camamu-Almada are thermally more evolved than the samples analyzed in the JB (Figure 13). Considering that Camamu-Almada present much less igneous activity compared with the JB (Caixeta e]t al., 2007; Gontijo et al., 2007), this information suggests that sedimentary burial has a greater impact on source rock maturation than does igneous activity.

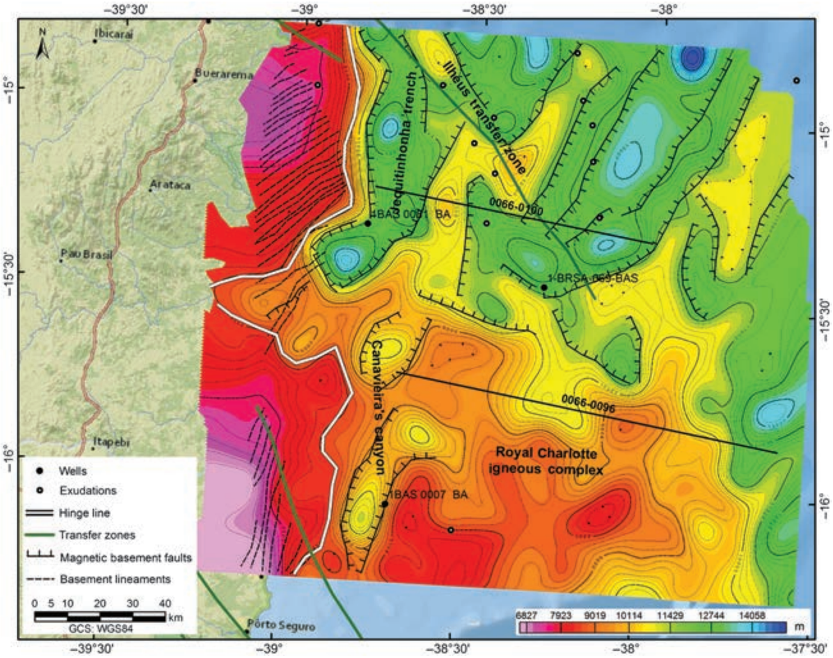

Figure 10. Our depth-to-basement map (m) using the high-resolution airborne magnetic surveys.

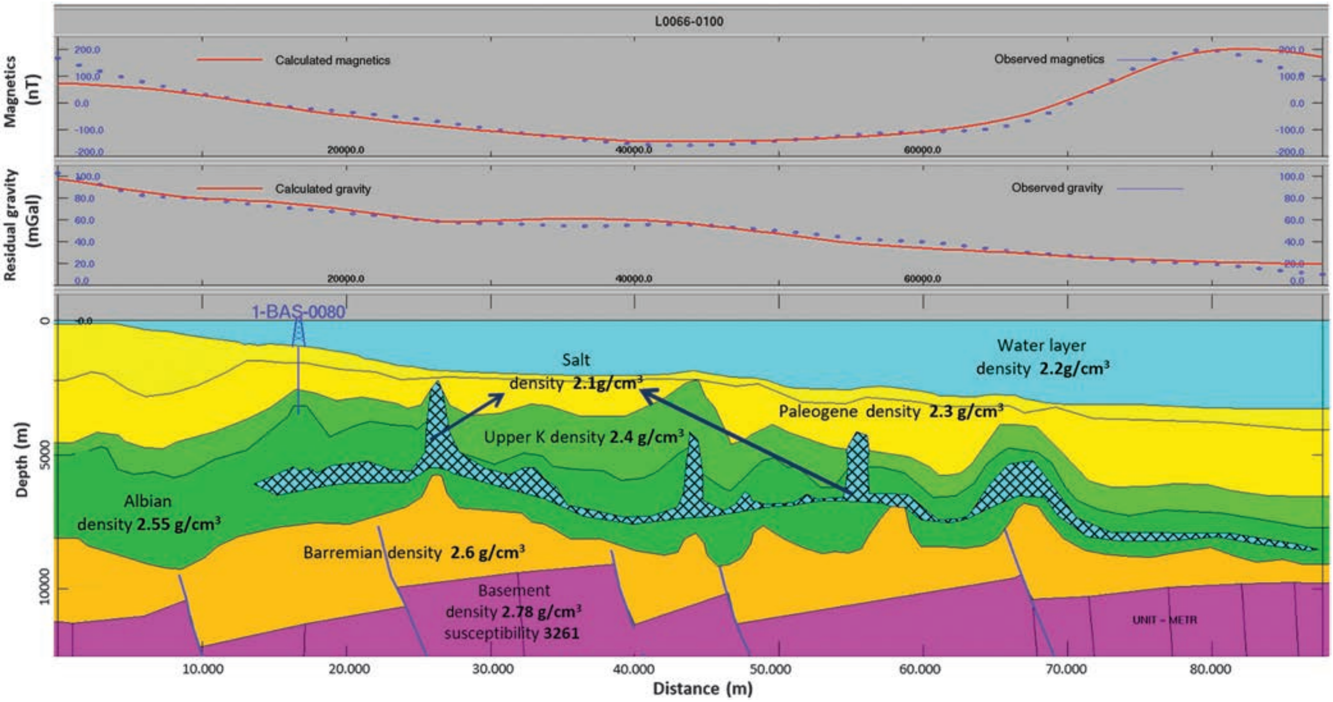

Figure 11. The 2D forward modeling of the seismic line L0066-0100 (Figure 7). The properties used are described in the figure.

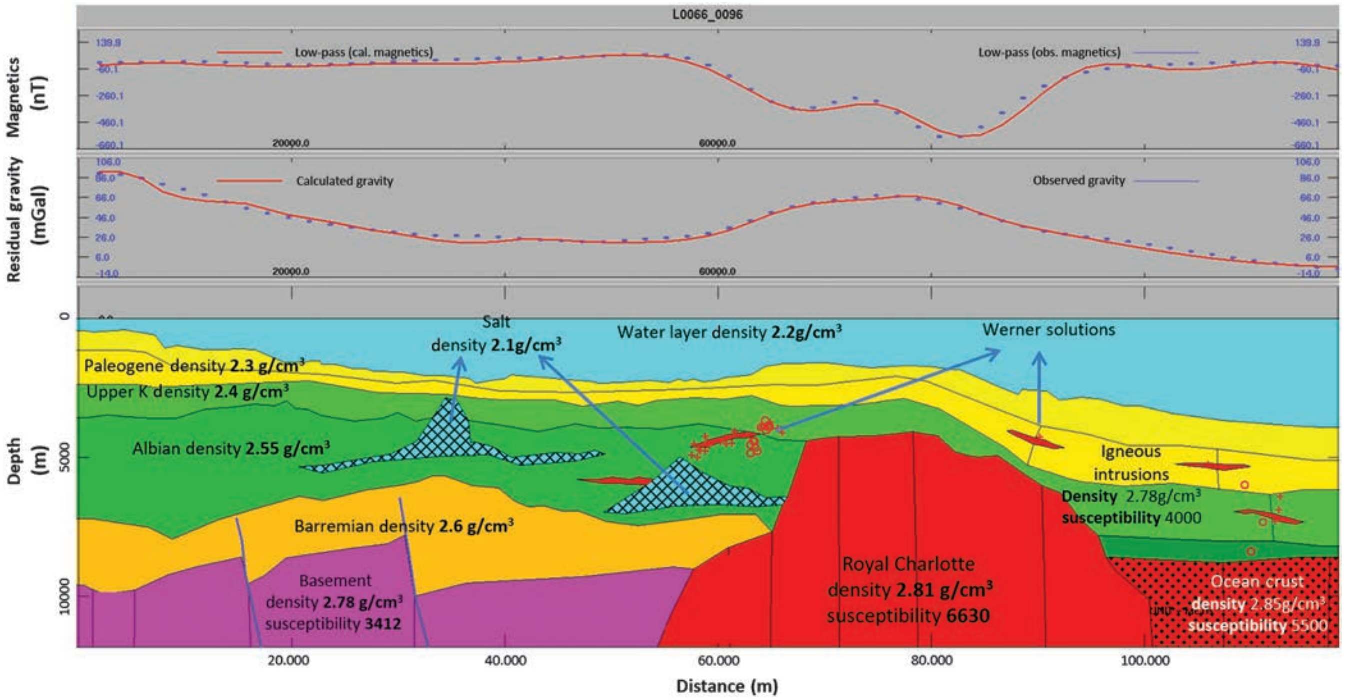

Figure 12. The 2D forward modeling of the seismic line L0066-0096 (Figure 8). A low-pass filter of 5000 m was applied due its Royal Charlotte complexity anomaly. The properties used are described in the figure. The Werner solutions in red dots confirm the igneous intrusions in the seismic interpretation.

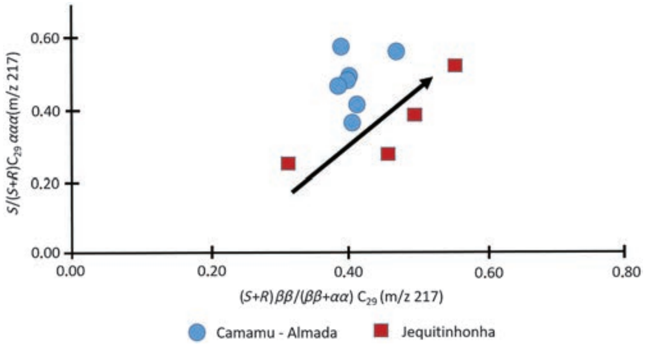

Figure 13. Relationship of the parameters of thermal maturation $(S + R)$ /(+) C29 (m/z 217) and $S/S(S + R)$ C29 (m/z 217). (Modified from Araujo (2007)).

Conclusion

In this paper, we interpreted airborne magnetic, satellite gravity, and seismic data, and we proposed a detailed structural map for the JB. The integrated interpretation workflow consisted of producing several enhancement maps for a consistent identification of structural features and igneous bodies presented in the JB. In the satellite gravity data, the Moho effect was removed to enhance shallow sources. Northeast–southwest normal faults are identified in the shallow- and deepwater domain. A secondary northwest–southeast structural complex is also identified. Seismic lines were interpreted with the aid of three wells for the definition of the main sedimentary sequences and the basement structural style. Salt domes are also identified presenting a northwest–southeast trend possibly related to the Ilhéus transfer zone.

A quantitative study was also performed. A basement map in depth is proposed using airborne magnetic data. In this map, we observe several geologic features such as the Olivença High, the Jequitinhonha Trench, the Canavieiras and Belmont Canyons, the Royal Charlotte igneous intrusion, and a northeast–southwest extensional domain in the northeast of the JB. Two-dimensional forward modeling was also performed constrained by seismic interpretation and density well-log information.

Finally, exudation observations were combined with the interpretation products interpreted herein. Most of the exudation occurrences are located in the north of the JB, in the salt-dome domain, providing evidence that this area is strategic for hydrocarbon occurrence. Considering that only one exudation point was observed nearby the Tertiary Royal Charlotte igneous intrusion, we conclude that the Tertiary igneous volcanism has had a negative impact on the petroleum system. The northwest–southeast transfer zones and the listric faults are probably the main migration paths in the JB.

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References

Adriano, L., P. Zalán, M. Hidalgo-Gato, A. Cunha, R. Yalamanchili, and D. Silva, 2015, Integrated interpretation of the western portion of the pará–maranhão basin–brazilian equatorial margin: 14th International Congress of the Brazilian Geophysical Society & EXPOGEF, Brazilian Geophysical Society, 43–48.

Adriano, L. B., P. T. Menezes, and A. S. Cunha, 2014, Tectonic framework of the barra de são joão graben, campos basin, brazil: Insights from gravity data interpretation: Interpretation, **2**, SJ65–SJ74, doi: 10.1190/INT-2014-0011.1.

Araujo, F. C. d., 2007, Caracterização geoquímica de óleos das bacias camamu-almada e jequitinhonha, bahia: Master's thesis, Universidade Federal Do Rio De Janeiro.

Asmus, H., J. Gomes, and A. Pereira, 1971, Integraçãao geológica regional da bacia do espírito santo: Relatório Interno: PETROBRAS.

Beglinger, S. E., H. Doust, and S. Cloetingh, 2012, Relating petroleum system and play development to basin evolution: Brazilian south atlantic margin: Petroleum Geoscience, **18**, 315–336, doi: 10.1144/1354-079311-022.

Caixeta, J. M., P. d. S. Milhomem, R. Witzke, I. S. Dupuy, and G. Gontijo, 2007, Bacia de camamu: Boletim de Geociências da PETROBRAS, **15**, 455–461.

Castilho, J. D., 2005, Integração de dados e métodos potencias e de sensoriamento remoto como subsidio à exploração petrolífera offshore nas bacias de cumuruxatiba e jequitinhonha. Rio de Janeiro: Programa de pós-graduação de engenharia, coppe, ufrj: Master's thesis, COPPE - UFRJ.

Chagas, L. S., 2003, Bacias sedimentares Brasileiras: Bacia do Jequitinhonha: PHOENIX.

Chang, H. K., R. O. Kowsmann, A. M. F. Figueiredo, and A. A. Bender, 1992, Tectonics and stratigraphy of the east brazil rift system: An overview: Tectonophysics, **213**, 97–138, doi: 10.1016/0040-1951(92)90253-3.

Clark, J., 2002, Jequitinhonha basin — Brasil round 4. Technical workshop: ANP Technical Workshop, **1**, 1–30.

Córdoba, V. C., 1990, Microfácies, modelo deposicional e evolução da plataforma carbonática albo-cenomaniana da bacia de jequitinhonha: Master's thesis, Universidade Federal de Ouro Petro.

Cunha, A. D. S., F. A. Perosi, L. F. Braga, L. B. Adriano, M. C. Hidalgo-Gato, V. P. do Couto, and D. S. da Silva, 2015, Airborne gravity gradiometry survey in the southeastern portion of pimenta bueno graben in parecis basin: Integrated 2D forward modeling and its implications in defining a new structural framework: Revista Brasileira de Geofísica, **33**, 101–118, doi: 10.22564/rbgf.v33i1.605.

de Almeida, F. F. M., C. D. R. Carneiro, and A. M. P. Mizusaki, 1996, Correlação do magmatismo das bacias da margem continental brasileira com o das áreas emersas adjacentes: Brazilian Journal of Geology, **26**, 125–138.

Egydio-Silva, M., I. Karmann, and R. Trompette, 2011, Análise estrutural do grupo rio pardo: Sudeste do estado da bahia: Geologia USP: Série Científica, **11**, 23–41.

Ferreira, T. S., J. M. Caixeta, and F. D. Lima, 2009, Controle do embasamento no rifteamento das bacias de camamu e almada: Boletim de Geociências da Petrobras, **17**, 69–88.

Gaglione, P., L. Trindade, and M. Nascimento, 1987, Avaliacao geoquimica das bacias marginais ao sul da bahia, Brasil: Congresso Brasileiro de Geoquimica, **2**, 467–491.

Gonçalves, F. T. T., R. P. Bedregal, L. F. C. Coutinho, and M. R. Mello, 2000, Petroleum system of the Camamu-Almada Basin: A quantitative modeling approach, *in* M. R. Mello and B. J. Katz, eds., Petroleum systems of South Atlantic margins: AAPG Memoir 19, 257–271.

Gontijo, G. A., P. Milhomem, J. Caixeta, I. Dupuy, and P. Menezes, 2007, Bacia de almada: Boletim de Geociencias da PETROBRAS, **15**, 463–473.

Hassan, H. H., and S. Yalamanchili, 2013, Monogenic signal decomposition: A new approach to enhance magnetic data: 83rd Annual International Meeting, SEG, Expanded Abstracts, 1206–1210.

Hidalgo-Gato, M. C., and V. C. Barbosa, 2015, Edge detection of potential-field sources using scale-space monogenic signal: Fundamental principles: Geophysics, **80**, no. 5, J27–J36, doi: 10.1190/geo2015-0025.1.

Keating, P., and L. Zerbo, 1996, An improved technique for reduction to the pole at low latitudes: Geophysics, **61**, 131–137, doi: 10.1190/1.1443933.

Küchle, J., M. Holz, A. Brito, and R. Bedregal, 2005, Análise estratigráfica de bacias rifte: Aplicação de conceitos genéticos nas bacias de camamu-almada e jequitinhonha: Boletim de Geociências da Petrobrás, **13**, 227–244.

Laske, G., G. Masters, Z. Ma, and M. Pasyanos, 2013, Update on crust1.0 — A 1-degree global model of Earth's crust: EGU General Assembly, Geophysical Research Abstracts, EGU2013-2658.

Lima, S. C. D., L. Landau, and F. P. Miranda, 2005, Utilização de imagens sar orbitais para a detecção de exsudações de óleo na porção offshore da bacia de camamu-almada: Anais XV Somposio Brasileiro de Sensoriamento Remoto - SBSR. Curitiba, PR, Brasil., **1**, 3618–3625.

Menezes, P. D. L., and P. d. S. Milhomem, 2008, Tectônica de sal nas bacias de cumuruxatiba, do almada e de camamu: Geologia e Tectônica. Exemplos nas Bacias Brasileiras: Ediçoes Beca Ltd, 251–270.

Milani, E. J., H. D. Rangel, G. V. Bueno, J. M. Stica, W. R. Winter, J. M. Caixeta, and O. P. Neto, 2007, Bacias sedimentares brasileiras: cartas estratigráficas: Anexo ao Boletim de Geociências da Petrobrás, 15.

Mizusaki, A. M. P., A. Thomaz-Filho, E. J. Milani, and P. De Césero, 2002, Mesozoic and cenozoic igneous activity and its tectonic control in northeastern Brazil: Journal of South American Earth Sciences, **15**, 183–198, doi: 10.1016/S0895-9811(02)00014-7.

Peters, L. J., 1949, The direct approach to magnetic interpretation and its practical application: Geophysics, **14**, 290–320, doi: 10.1190/1.1437537.

Rangel, H., J. Flores de Oliveira, and J. Caixeta, 2007, Bacia de jequitinhonha: Boletim de Geociências da PETROBRAS, **15**, 475–483.

Sanabria, L. L. O., 2013, Avaliação da origem dos hidrocarbonetos observados na região limítrofe entre as bacias de Almada e Jequitinhonha, BA. Rio de Janeiro: Programa de Pósgraduação de Análise de Bacias e Faixas Móveis, Faculdade de Geologia, UERJ: Master's thesis, UERJ.

Sandwell, D., E. Garcia, K. Soofi, P. Wessel, M. Chandler, and W. H. Smith, 2013, Toward 1-mgal accuracy in global marine gravity from Cryosat-2, Envisat, and Jason-1: The Leading Edge, **32**, 892–899, doi: 10.1190/tle32080892.1.

Sandwell, D. T., R. D. Müller, W. H. Smith, E. Garcia, and R. Francis, 2014, New global marine gravity model from Cryosat-2 and Jason-1 reveals buried tectonic structure: Science, **346**, 65–67, doi: 10.1126/science.1258213.

Santos, C., R. Gontijo, M. Araújo, and F. Feijó, 1994, Bacias de cumuruxatiba e jequitinhonha: Boletim de Geociências da Petrobras, **8**, 185–190.

Thompson, D., 1982, Euldph: A new technique for making computer-assisted depth estimates from magnetic data: Geophysics, **47**, 31–37, doi: 10.1190/1.1441278.

Werner, S., 1953, Interpretation of magnetic anomalies at sheet-like bodies: Sveriges geologiska undersok: Series C, Arsbok, **43**.

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