ASSESSMENT OF BIODEGRADATION CONDITIONS IN OIL ACCUMULATIONS OF AÇU FORMATION, POTIGUAR BASIN, NE- BRAZIL

A. L. D. Spigolon[1], P. F. Parente[2], E. V. S. Neto[3]

[1] Research and Development Center of PETROBRAS, Rua Horácio Macedo nº 950, 21941-915, Rio de Janeiro, Brazil.
andrespigolon@petrobras.com.br
[2] PETROBRAS/UN-BC/ATP-MRL, Avenida Elias Agostinho, Macaé-Rj, Brazil.
patricia.parente@petrobras.com.br
[3] Research and Development Center of PETROBRAS, Rua Horácio Macedo nº 950, 21941-915, Rio de Janeiro, Brazil.
eugenioneto@petrobras.com.br

Introduction and objective

A significant part of the oils found in the Brazilian sedimentary basins were degraded due to bacterial action. The Potiguar Basin was chosen for this study because it has most of its petroleum reserve being found under conditions that are ideal for biodegradation, shallow reservoir and low temperature. The main objective of this paper is to correlate physical-chemical parameters of oil and water samples collected in the onshore Açu Formation, in two different areas, in order to improve the understanding about process that control the biodegradation.

Geological context

The Potiguar Basin, located at the northeastern Brazil, has its origin related to Brazilian northeastern rift systems, generated during the fragmentation of Gondwana supercontinent in Late Jurassic-Early Cretaceous. The tecto-sedimentary evolution can be divided in three stages: rift, gulf and drift. In general, the oil and gas accumulations in sandstones of the Açu Formation are strongly controlled by structural and stratigraphic framework and by the occurrence of different oil kitchens, related to onshore organic rich lacustrine shales of Pendência Formation (Neocomian) and to offshore deltaic-lagoon black shales and marls with marine influence of Alagamar Formation (Aptian) (BERTANI *et al.*, 1991) (Fig. 1).

Sampling and Analytical Methods

Oil accumulations clustered in onshore areas were selected for this study. In the first area, are found Baixa do Algodão (BAL), Fazenda Malaquias (FMQ), São Miguel (SMI) and Pajeú (PJ) oil fields, along the Areia Branca trend. The second group of oil fields are located at Carnaubais trend and are represented by Alto do Rodrigues (ARG), Fazenda Pocinho (FP) and Guamaré (GMR) oil fields (Fig. 1). Representative oil and water samples were collected in 18 wells of Açu Formation reservoirs between depths of 300 and 500 meters.

Oils were analyzed for bulk characterization (API gravity and sulfur content) and liquid chromatography (MPLC), carbon stable isotope of whole oil ($\delta^{13}C$), gas chromatography (GC) and gas chromatography coupled mass spectrometry (GC-MS).

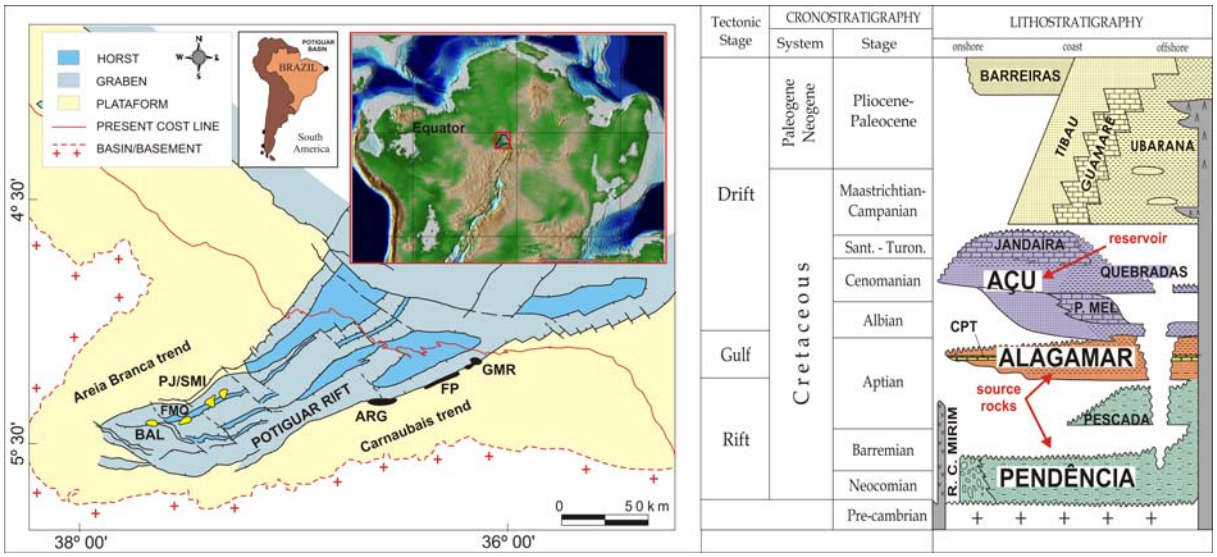

Figure1. Location of Potiguar rift basin and oil accumulations studied and tecto-sedimentary evolution of Potiguar Basin (modified of Bertani *et al*., 1991).

The characterization of formation water was obtained with physical-chemical analysis of pH, alkalinity, salinity, electric conductivity, oxidation-reduction potential, turbidity, hardness, dissolved total solids, iron II and iron III, amoniacal nitrogen, nitrite, nitrate, sulfide, phosphorus, phosphate, dissolved oxygen, some metals and semi-metals.

Discussion of the results and Conclusion

The oils located at Carnaubais trend (ARG/FP/GMR oil fields) are severely biodegraded. Formation waters associated to these oils are representing by sodium-bicarbonate type, are brackish to saline, hard to very hard and have low concentration of nutrients, characteristics of aquifer with intense meteoric water circulation (Figs. 2 e 3).

The oils located along the Areia Branca trend are very slightly biodegraded or non biodegraded. Pajeú (PJ) and São Miguel (SMI) oil fields have a decrease in the intensity peak of the *n*-alkanes with low molecular weight (C_9-C_{16}) suggesting an initial biodegradation. The formation waters associated with these oils are sodium-bicarbonate type, with low salinity and hardness and have high concentration of nutrients. Baixa do Algodão (BAL) and Fazenda Malaquias (FMQ) oils have low levels or no biodegradation. Waters in these fields are calcium-chloride type and indicate a mixing of meteoric and compaction waters, with moderate salinity, and hardness and high concentration of nutrients (Figs. 2 e 3).

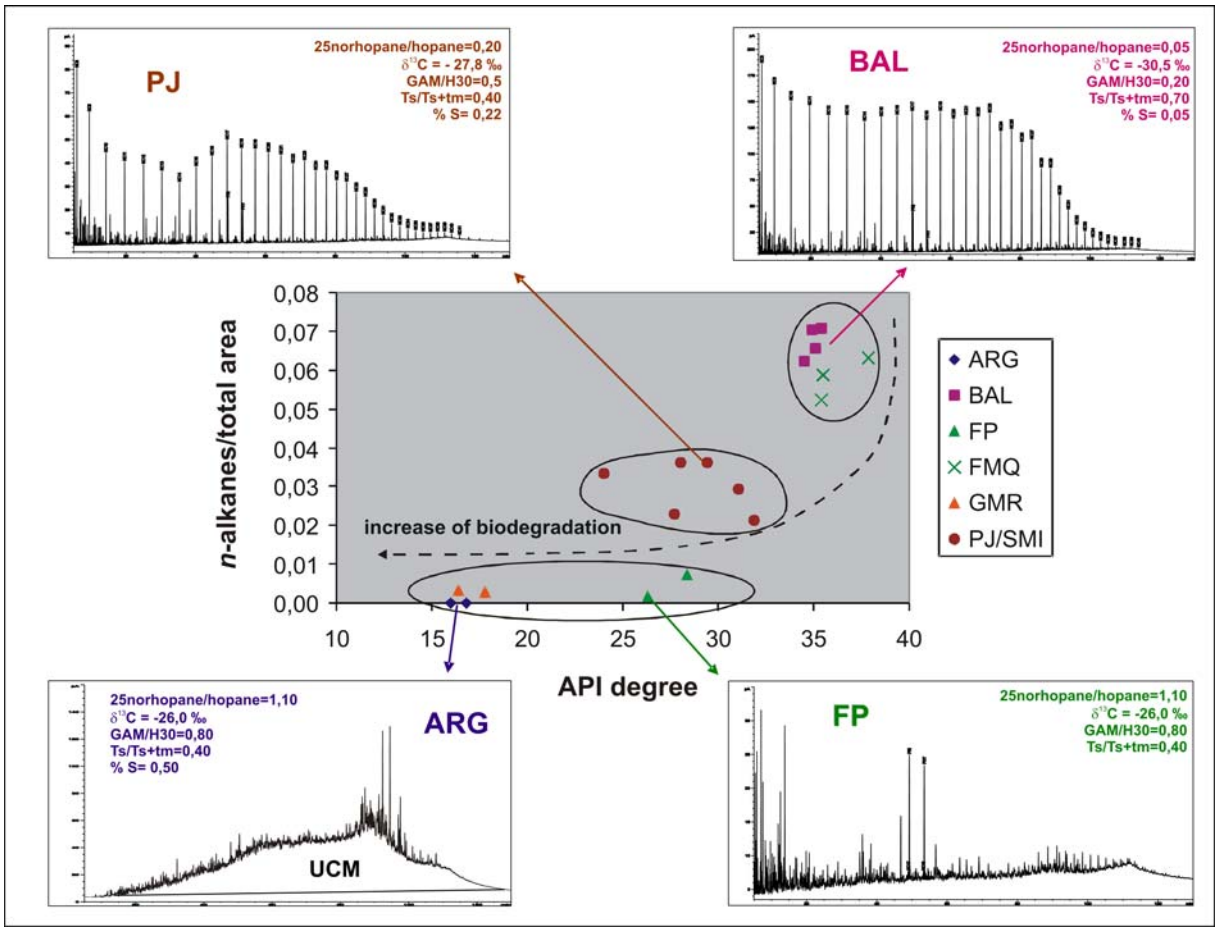

Figure2. Geochemical characteristics of the studied oils types. Note the different levels of biodegradation in each oil groups.

All the studied oil accumulations are influenced by strong structural-stratigraphic controls and are located in similar hydrodynamic domains, situated near to recharge areas, in the flanks of low central potentiometric and in regions that the hydraulic charge of Jandaíra Formation is higher than the Açu Formation (Fig. 3). Reservoir temperatures are about 40^{o}C and its waters characterize for an oxic domain with contents of dissolved oxygen within 1,5 to 3,7 mg/L.

It has not been found correlation between dissolved oxygen in the formation waters from the Açu sandstones and the intensity of oil biodegradation. Nevertheless, the oils with severe biodegradation (ARG/FP/GMR) are associated to formation waters with low nutrient contents, suggesting that the sulfate was depleted by anaerobic bacterial during the degradation process of the reservoired oils. The depletion can be related to the sulfur enrichment found in oils along Carnaubais trend.

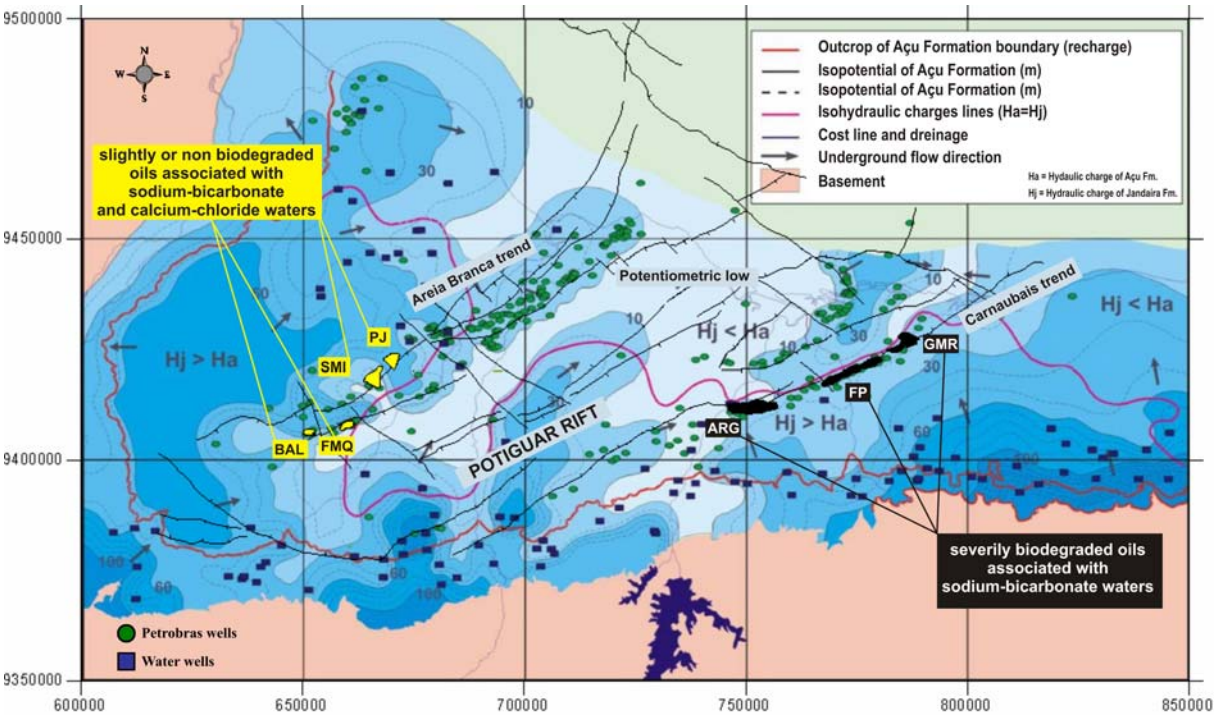

Figure3. Hydrodynamic map of Açu Formation (modified of Lima Neto *et al.*, 1990).

Concerning the oils located along Areia Branca trend, the biodegradation conditions would be widely favorable, because the accumulations are relatively shallow, at low temperature and are near the meteoric water influx. However, these oils were not significantly affected for biodegradation, suggesting that other geological parameters are contributing for the preservation.

The knowledge of the hydrodynamic and hydrochemical regimes of the sedimentary basin certainly has an important role to play in the petroleum systems context, as well as, in the biodegradation process of oils. The influx and circulation of water with oxygen and nutrients and the interaction with the geological formations can contribute for the biodegradation.

It is important to consider the geological history of basin, thermal, diagenetic and tecto-stratigraphic effects as the possible controls of oil accumulation and biodegradation, as well as, the filling history (ratio and time) of reservoirs after the expulsion moment.

Bibliography references

Bertani, R.T., Costa, I.G., Matos, R.M.D., 1991. Evolução tectono-sedimentar, estilo estrutural e habitat do petróleo na Bacia Potiguar. In: Raja Gabaglia G.P. & Milani E.J. Origem e Evolução de Bacias Sedimentares. PETROBRAS, Rio de Janeiro, 2ª ed., p. 291-310.

Lima Neto, F.F., Souza, C.J., Teixeira, I.E.M., Souto Filho, J.D., 1990. Atualização do estudo hidrodinâmico da Bacia Potiguar. Congresso Brasileiro de Geologia, 36, Natal, *Anais*, SBG, v2. p.1031-1041.