INTEGRATION OF ELECTROFACIES DISTRIBUTION, GAMMA-RAY LOG RESPONSES, AND ORGANIC GEOCHEMISTRY ANALYSES FROM THE BRAZILIAN EQUATORIAL MARGIN: INSIGHTS FOR HYDROCARBON GENERATION POTENTIAL

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Abstract

Primary productivity and anoxic conditions play a crucial role in the preservation rate of organic matter. These factors, along with other marine environmental features, influence the electrofacies signature. For example, fine-grained sedimentary rocks contain all three of the most abundant radioactive elements: potassium, uranium, and thorium, resulting in high gamma radiation. The interpretation of a high-value spike in the gamma-ray log can be related to hot shale, as the precipitation of uranium is linked to the preservation of organic material. Therefore, the gamma-ray signal is essential for evaluating the sequence stratigraphic architecture, paleoenvironmental changes, and the deposition of organic source rocks.In this regard, assessing changes in organic-rich successions using well log parameters makes it possible to establish basin-scale correlations and determine the extent of stratigraphic markers that can guide hydrocarbon exploration. Thus, the objective of this study is to delineate the main factors controlling the gamma-ray signal associated with organic facies and to assess the source rock potential in the Potiguar, Ceará, and Barreirinhas Basins. These basins are Atlantic margin basins that formed during the evolution of the Equatorial Atlantic. They were generated by the separation of South America from the African continent, ultimately leading to the formation of the Brazilian Equatorial Margin (MEB). The methodology employed in this study involved the analysis of lateral and vertical compositional variations in six wells, located closer to or in deep-water domain. All data available, well logs (gamma-ray, density, resistivity, sonic, caliper) and geochemical data (TOC and pyrolysis indexes) was provided by the Brazilian National Agency for Petroleum, Natural Gas, and Biofuels (ANP). First, the well log data were classified into electrofacies, a classification that does not require artificial subdivision of the data population but is based on the unique characteristics of well log measurements reflecting mineral and lithofacies responses within the logged intervals. Second, the geochemical analyses, including total organic carbon (TOC) content and Rock-Eval pyrolysis, were conducted using bulk petroleum geochemistry techniques to assess the source rock potential and investigate the quality, quantity, and thermal maturity of preserved organic matter. As a result, the Vshale allows the identification of three electrofacies subdivided into high, moderate, and low. The main source rock is related to a high value of Vshale. From Ceará Basin, this interval is related to transitional sequence and drift sequence. Its lithology consists of shales interbedded with sandstones and some sections of marl. The Potiguar Basin is another target of this study. It is composed of shales and sandstones with intercalations of marl and limestone. For the Barreirinhas Basin the lithology comprises an intercalation of shales, calcarenite, marls calcarenite with some intercalations of anhydrite (calcium sulfate) and calcilutite. The shales from the Travosas Formation, in drift sequence, show a main source rock. Its study investigated the correlation between gamma ray and TOC using an integrated geophysical and geochemical approach. Three main conclusions were summarized as follows: 1) In the MEB, the transitional and drift sequences show good potential for oil generation. 2) The spatial correlation of gamma ray results is recognized in well logs and can be interpreted as a regional marker in the Equatorial Margin. 3) The deep-water portion of the MEB represents a new frontier for petroleum exploration and requires additional data to confirm the initial analyses pertaining to its geochemical and geophysical characteristics.