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Geothermal Analysis of the Campos Basin and its Potential for Hydrocarbon and Energy Exploration

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Introduction

The Campos Sedimentary Basin is one of Brazil's main regions for producing hydrocarbons. Various geophysical methods, especially seismic, were used during its discovery and exploration. However, applying complementary methodologies, such as geothermal methods, can significantly contribute to identify new promising areas for hydrocarbon exploration by determining the oil and gas window in source rocks. Geothermal methods can also help to identify targets for carbon capture and storage in depleted oil and gas reservoirs, as well as for the exploring alternative energy resources.

Method and/or Theory

In this study, we used 1228 bottom hole temperature (BHT) data to calculate the geothermal gradient, representing the variation in temperature with depth. In addition, we analyzed seawater temperature and bathymetry data obtained from the National Oceanographic Data Bank (BNDO) of the Brazilian Navy's Directorate of Hydrography and Navigation (DHN). These data were essential for mapping the seabed temperatures in the study area and were used alongside BHT measurements from wells provided by the National Petroleum, Natural Gas and Biofuels Agency (ANP) to calculate the geothermal gradient. The average thermal conductivity of 2.15 W/(m.K) was obtained by considering the thermal conductivity values of the main sedimentary lithotypes in the basin,–calcilutite, sandstone, shale, marl, claystone, calcarenite, diamictite and siltstone. We then calculated the weighted average based on the thickness of the sedimentary packages of these lithological profiles in each well.

Results and Conclusions

Combining the geothermal gradient with the established average thermal conductivity made it possible to calculate the heat flow, which is a fundamental parameter for understanding the thermal behavior of the basin. Positive flow anomalies may indicate regions with significant energy potential. As heat is an essential indicator of the maturation of organic matter and the quality of hydrocarbons, its analysis allows for optimized exploration strategies and energy planning. Additionally, estimating crustal temperature using the geothermal method helps identify areas where organic matter has matured sufficiently to generate hydrocarbons. The results indicate an average geothermal gradient of 27.7 ± 4.6 °C/km in the Campos Basin, with the highest values concentrated in deep waters, reaching 54.7 ± 4.6 °C/km, particularly in the northeastern region of the basin, close to the Espírito Santo basin. The maximum estimated heat flow was 117.7 ± 9.9 mW/m², was identified in anomalous areas on the northern edge of the basin, close to the Jubarte field. These anomalies represent almost double the basin average (59.7 ± 9.9 mW/m²) and highlight areas of strategic importance for exploration.