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3D CSEM data inversion with a priori seismic and well log constraints in the Campos Basin, Brazil

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Introduction

This work presents results from a controlled source electromagnetic (CSEM) set of inversion runs of real data in the Campos Basin, Southeast Brazil. The Campos Basin is located on the eastern Brazilian margin and originated in the Neocomian stage of the Cretaceous period (145–130 million years ago) during the breakup of the supercontinent Gondwana (South America and Africa split). The clastic reservoirs in this basin have been the largest oil producer in Brazil for the past three decades. The current challenge in exploring these clastic reservoirs has shifted to deeper waters, driven by the complex geology associated with tectonics and the presence of giant salt domes. Electromagnetic (EM) methods are sensitive to subsurface resistivity variations and have been frequently employed in exploration programs for fresh water, mining, and hydrocarbons (HC), often in joint approaches with seismic data to reduce interpretation ambiguities. Reservoirs filled with HC are generally more resistive than the surrounding host rocks, which is advantageous for the EM method. Integrating resistive models with seismic data considerably enhances the resolution of subsurface structures and the geometry of HC reservoirs.

Method and/or Theory

A set of 40 CSEM receivers were deployed on the seafloor (with water depths around 1.7 km) in a grid-shaped array with spacing varying from 5 km to 10 km. The electric field components were recorded from an active electromagnetic source towed 50 m above the seafloor. The processed data consist of inline components of the horizontal electric field (Ex and Ey) for four main frequencies: 0.125 Hz, 0.25 Hz, 0.5 Hz, and 1.25 Hz. The 3D CSEM inversion models were obtained using a modified version of the Modular System for EM inversion - ModEM-ON code, which was developed within a research project at Observatório Nacional, Brazil.

Results and Conclusions

The 3D CSEM inversion using a homogeneous half-space as the starting model fit the data well, and the resulting resistivity model showed good agreement with resistivity well log available. In the second phase, a priori information from well logs and seismic data was incorporated: resistivity values from the logs were used to validate and constrain the inversion, while seismic interpretations provided constraints on the geometry of the salt bodies and reservoir structures. This integration significantly improved the resolution of the CSEM resistivity model, enhancing the ability to image and evaluate hydrocarbon accumulations in thin post-salt reservoirs in the Campos Basin.