OTC 18003

Marine Controlled Source Electromagnetic: The Campos Basin Experience

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This paper was prepared for presentation at the 2006 Offshore Technology Conference held in Houston, Texas, U.S.A., 1–4 May 2006.

Abstract

The Campos Basin marine Controlled Source Electromagnetic (***mCSEM***) data were acquired on a rectangular grid with a line spacing of approximately 5 km. Three component electric fields as well as two component magnetic fields data were recorded. All fields at each receiver location were processed and interpreted using a novel workflow.

The main objective of the survey was to calibrate the ***mCSEM*** technology over known reservoirs and quantify the anomalies associated with those reservoirs with the expectation that new prospective location(s) could be found.

We show that the ***mCSEM*** response of known reservoirs yields anomalies that, although considered "marginal", can be imaged by new processing and interpretation procedures and there are evident correlation between the anomalies and the reservoirs.

A further objective was to advance the state of the art in integrated interpretation of ***mCSEM*** data and establish an industry standard workflow unavailable at present.

An effective interpretation of ***mCSEM*** data requires new developments and new paradigm on how to best integrate ***EM*** with seismic, geology and petrophysical data.

We show how the proposed workflow enhances our ability to accurately interpret "weak" anomalies and ensure maximum benefit from the additional ***mCSEM*** data.

Introduction

In recent years ***mCSEM*** has driven the attention of major oil companies due to its sensitivity to map resistive structures (such as hydrocarbon reservoirs) beneath the ocean bottom, and successful case studies have been reported (*Ellingsrud et al., 2002*; *Eidesmo et al., 2002*; *Srnka and Carazzone, 2005*).

Numerous surveys have been carried out on a variety of prospect scenarios in the marine environments of: North-West Europe, Africa, the Mediterranean, South East Asia and offshore Brazil and many of these have been verified by wells.

The Campos Basin survey was performed as a multi-client survey. Petrobras acquired the raw data and initiated, in collaboration with AGO Schlumberger, an in-depth data evaluation, processing and integrated interpretation procedures.

mCSEM technology is in its early stage of application to real E&P problems, and a great deal of R&D is needed to improve its efficiency and reliability in: acquisition hardware, accurate survey engineering, data processing, multidimensional modeling and inversion.

Furthermore, the success of ***mCSEM*** will depend on integration with seismic, geology and petrophysical data about the area under investigation.

The Campos Basin data set was considered ideal to advance the understanding of ***mCSEM*** in the area of data processing, interpretation and integration.

Therefore, Petrobras decided to undertake an in-depth study to advance the state-of–the-art, develop new insights that would lead to novel and cost effective application of ***mCSEM*** and establish an advanced integrated interpretation workflow.

Petrobras *mCSEM* data off-shore Brazil

Petrobras has acquired approximately 1,600 line/km of ***mCSEM*** data off-shore Brazil encompassing 36 towed lines as shown on Figure 1. The data were acquired over three major sectors: southern sector covering a small portion of the Santos Basin (339 km), central sector located on portions of the Campos Basin (1121 km) and northern sector on the Espirito Santos Basin (153 km of towed lines). The Campos Basin survey employed two distinct tow patterns: *1)* star-like shape (green lines see Fig. 1), and 2*)* 5 km rectangular grid (red lines).

This paper focuses on the data acquired with the 5-km rectangular grid tow pattern over the Campos Basin.

In order to evaluate the sensitivity of ***mCSEM*** to map thin resistive reservoir (at a depth below seafloor), we present the result of a 3D modeling study idealizing a real reservoir commonly encountered in the Brazilian off-