The Super Giant Discoveries in the Pre-Salt Hydrocarbon Province located in the Deep and Ultra Deep Water in the Greater Campos Basin, Brazil

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Abstract

In most areas of the deep and ultra deep waters from the Brazilian South Margin Basins, exploration has just begun with the discovery, in the last two years, of six of the biggest oil fields found in the whole world. The oil fields encompassing more than 20 billion bbls of oils of reserves are the Tupi, Jupiter, Guará, Iará, Carioca, and Parati (Figure 01). This article presents the results of petroleum system modeling that was run on a detailed 3D geological framework built on PSDM seismic data and on geological data of HRT & Petroleum (Figure 01). We present the temperature and pressure conditions that allowed the formation and preservation of supergiant accumulations of light oil and condensates trapped below the salt layer.

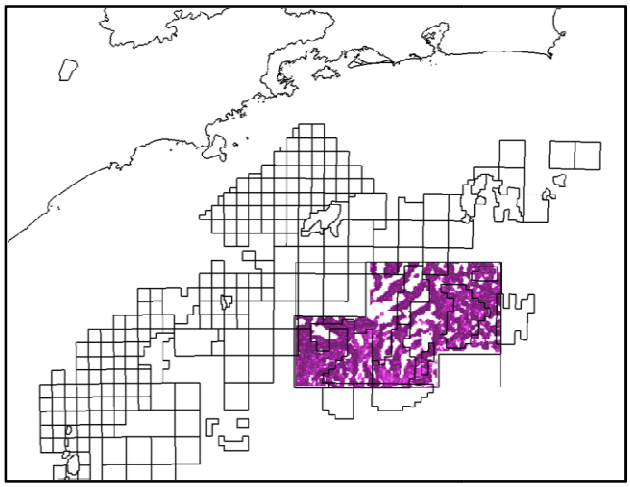

Figure 01. Location of the project. This area contains the main recent announced discoveries in the deep water Santos area. Tupi Area was announced as having 4 to 6 Bbbl of reserves and Iara area with 3 to 4 Bbbls.

Method

A 3D geological framework was built based on a very detailed mapping using a 20,000 km2 PSDM seismic data (provided by CGGVeritas) and also on much geological and geochemical information extracted from HRT's BrazilGeodata. The 3D basin model also contains information about source rocks richness, distribution, kerogen kinetics, reservoirs quality, sealing rocks and trap geometries. An integrated 3D petroleum system simulation with PetroMod allowed an evaluation of the interplay among the elements of the petroleum system to assess thermal evolution of the source rocks, transformation ratio, charge, timing of migration, oil quality, and a volumetric quantification of the accumulated petroleum in the main reservoirs (Figure 02). A detailed facies model from rift section was built based on conceptual models from seismic interpretation associated with previous knowledge of the basin resulting from adjacent wells that drilled the sedimentary section (Figure 03).

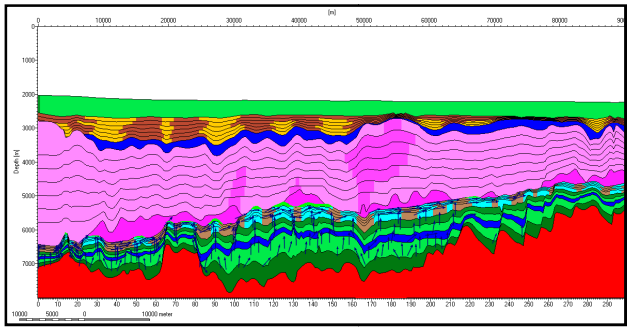

Figure 02. East-west geological section across the study area showing the main geological facies. The pink layer represents stratified evaporites and the dark pink represent one halite layer.

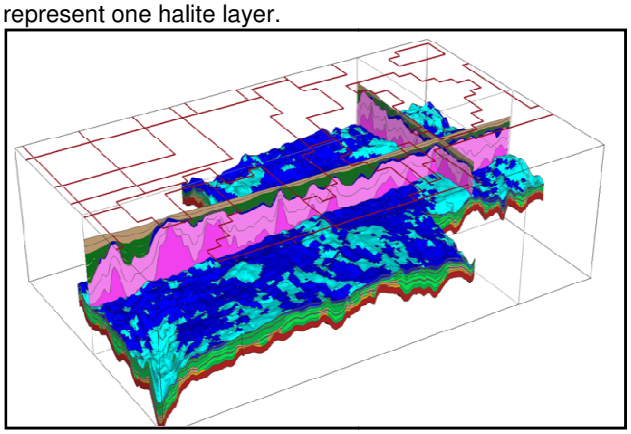

Figure 03. Detailed facies distribution in rift section based on conceptual geological model and seismic attributes. The view presents the carbonatic reservoir in the upper part of Alagoas SAG sequence.

Results

The main results indicate the presence of an overcharged Lower Cretaceous, lacustrine saline, source rock system, reaching almost 90% transformation rate in the main depocenters of the basin (Figure 04 and 05). Also, low overpressure and low temperature values occur, below salt, in the main carbonate reservoirs from the Upper Lagoa Feia formation in the deepest part of the basin and were critical in preserving the oil prone nature of the whole hydrocarbon supergiant province. Two physical parameters are mainly responsible for the adequate thermal conditions for the oil generation and its preservation: the heat flow history and the high average thermal conductivity of the evaporitic layers. Contrary to the prediction of high heat flow values in ultradeep waters by theoretical models (e.g. McKenzie type of models), the heat flow peak never reached values higher than 120 mW/m2. Additionally, the volcanoclastics that occur stratified in the pre-salt sequences so far do not represent a risk neither in terms of high temperature intrusive nor for reservoir or source rock quality.

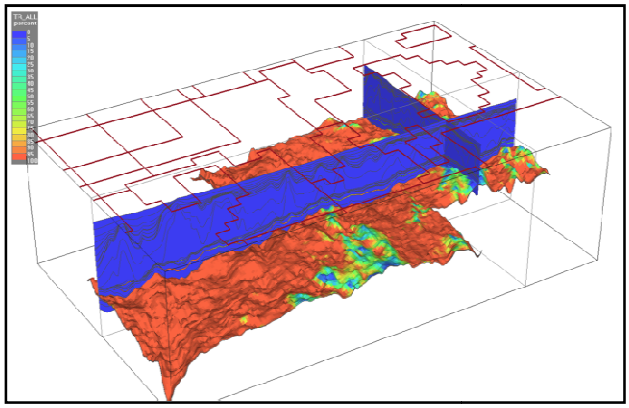

Figure 04. Transformation ratio in the deepest source rock of the model. Present time conditions

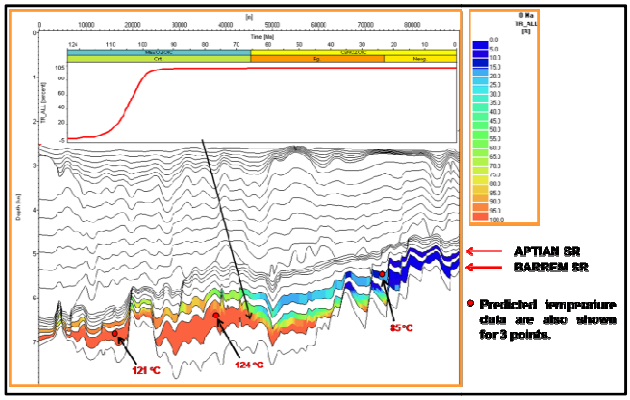

Figure 05. Transformation ratio values in a cross section through the Tupi High. Note the low temperature values in rift section.

The charge and accumulation simulation model, only for the pre-salt province, suggest a potential reserve, in the Cluster area of the Santos Basin, much larger than reported, getting numbers close to 40 to 60 Billion bbls of oil reserves (Figure 06).

The discoveries of low sulfur, pre-salt, lacustrine origin light oil (31° to 37° API), occurred in carbonate reservoirs called stromatolites and coquinas. The petrophysics of such reservoirs are unique and made possible to preserve permoporosity in very deep conditions (over 5,000 meters).

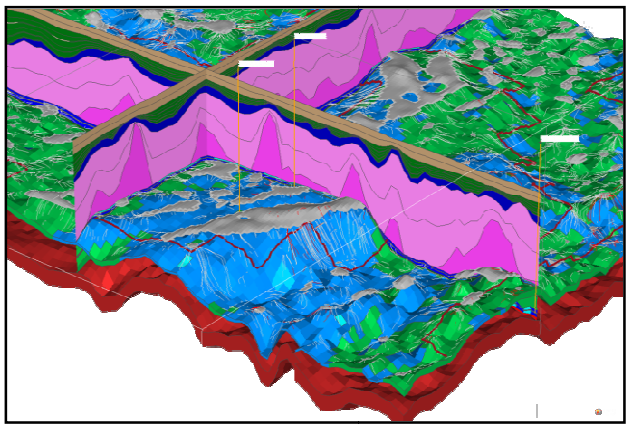

Figure 06. Accumulated hydrocarbons in the Tupi Area. Announced reserves can reach 4 to 6 Bbbls.

However, the main exploration and production risk, however, lies in the nature and petrophysical characteristics of the reservoir rocks, composed by stromatolites, coquinas and volcanoclastics that occurs alternating themselves and sum more than 400 m in thickness and extend for more than 1500 km, from Southern Santos up to Northern Espírito Santo Basin, presenting porosities ranging from 8% to 20% and permeability ranging from 20MD to 500MD.

The supergiant accumulations of light oil and condensates are trapped below a salt layer, ranging from 1000m to 2000m, that acted as the BEST preservation element possible in a petroleum system; seal, cushion and temperature drainer.

Acknowledgments

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