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A SHALLOW-WATER DELTAIC RESERVOIR IN THE OFFSHORE OF TALARA BASING: FROM OUTCROP TO GEOMODELING

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ABSTRACT

The present paper presents a reservoir characterization methodology and 3D modeling applied to a shallow-water deltaic reservoir in the Peña Negra Field, located offshore of the Talara Basin. The scope of this work is to understand the spatial distribution of stratigraphic units, petrophysical properties and fluids in the reservoir to delimit favorable areas for well drilling and / or secondary recovery projects. For this purpose, outcrop studies, core data from 4 wells, logs of around 200 wells, 3D seismic and production data were integrated.

A 3D static model in a selected area was built, integrating the depositional, structural, stratigraphic, and petrophysical models, as an aid for the formulation of development strategies for the area, and that together with the additional support of the numerical simulation allowed a better prediction of the productive behavior of the reservoir.

INTRODUCTION

The Peña Negra field is a mature field that belongs to Block Z-2B, which is located in the offshore of Talara Basin in northwestern Peru (**Figure 1**).

This field has produced 173 million barrels (MMSTB) of oil since 1965, has around 250 active wells, its reservoirs have a recovery factor of 11% on average and has a solution gas drive mechanism.

The main producing reservoirs are the Mogollon Formation, the Peña Negra Member and the Cabo Blanco Member, which are from the Lower Eocene (Pozo, 2002).

Since the Peña Negra field is a mature field, it is necessary to generate and optimize development projects with low risks and uncertainties, which is why the need to generate detailed reservoir models that integrate data from various scales and disciplines allowing to update the knowledge about the heterogeneities of the reservoir and fluid distribution.

This work shows a methodology applied to the development of the Mb. Cabo Blanco of the Peña Negra field that begins with the study of data in outcrops and ends with the 3D modeling of reservoirs.

OBJECTIVES AND LIMITATIONS

The first objective of this work is to describe the Cabo Blanco reservoir, then to identify areas of interest for drilling and/or secondary projects, and finally to build a 3D reservoir model in an area of interest. Among the limitations that were had to develop this work, it is mentioned the scarce core data (RCAL & SCAL), incomplete data set of well logs, low quality in 2D / 3D seismic and absence of seismic in certain areas, in addition to the high complexity geology of this reservoir.

AVAILABLE DATA

To study the Cabo Blanco reservoir, the following information was available: description of the outcrops located in the El Alto district, 3D / 2D seismic in certain parts of the field, well logs of around 200 wells, data from 4 cores, and previous studies in the area.

RESERVOIR DESCRIPTION

The lower Eocene (Ypresian) Cabo Blanco member in Talara Basin is defined as fluvial-deltaic sandstones deposited in an east-west trend (Daudt et al, 2004; Daudt, 2006; Daudt & Scherer, 2006; Palomino, J.R., 1976; Palomino J.R. & Carozzi A.V., 1979).

The initial step to characterize the Cabo Blanco member consisted in the description of two stratigraphic columns in the outcrops of the Cabo Blanco reservoir, located in the El Alto district in Talara. The spacing between each column was 300 meters, coinciding with the average spacing between wells, and 80 meters of section were described in each column, which is equivalent to the entire Cabo Blanco reservoir section in the field.

The study of these columns was carried out applying concepts of sequence stratigraphy, which allowed obtaining an interpretation of the depositional model and the main stratigraphic surfaces which were correlated with nearby well logs, establishing a consistent outcrop-log integration. Based on this analysis, the Cabo Blanco member was interpreted as a shallow-water delta of a fourth-orther sequence deposited during lowstand normal regression. Subsequently, these surfaces were propagated to all wells in the field, obtaining a stratigraphic framework based on genetic sequences (Galloway, 1989).

Then, with the help of neural networks, an electrofacies classification was performed in the wells based on core data, outcrops and well logs, obtaining a depositional model with 3 electrofacies (NR: Non reservoir, mainly shales; S_Delta: Sandstones with sedimentary structures of low energy and poor petrophysical properties; and SC_Delta: Conglomerated sandstones with sedimentary structures of high energy and good petrophysical properties), which allowed us to understand the direction, distribution and extension of the deposit (**Figure 2**).

Once the sedimentary and stratigraphic model was defined, the structural model was adjusted based on seismic and well logs, allowing the definition of structural regions limited by main fault systems of SW-NE direction (**Figure 3**). It should be mentioned that in the areas where seismic is not present, the faults were interpreted considering only the wells.

Then petrophysical evaluations were performed for all wells calibrated with core data. The petrophysical evaluation (**Figure 4**) showed that this reservoir presents shale volumes of less than 10%, average effective porosity of 15%, and average permeability of 100md.

The integration of the geological models together with the production data allowed us to delimit and select favorable areas to implement development projects.

3D GEOMODELING

In this stage, a 3D static model in a selected area was built, integrating the depositional, structural, stratigraphic, and petrophysical models, as an aid for the formulation of development strategies for the area.

The construction of the 3D model began with the generation of the structural-stratigraphic model integrating multiple faults and the stratigraphic horizons (**Figure 5**).

Next, the simulation grid was generated which consisted of 10 million cells of 20 m in the "X" direction, 20 m in the "Y" direction and 10 ft in the "Z" direction.

Subsequently, reservoir properties of the facies, effective porosity (PHIE), permeability (K) and water saturation (SW) were distributed in the grid through the use of geostatistical techniques and simulation algorithms.

To propagate the facies model **(Figure 6a**) in the grid we used 3 types of facies, probability maps, variograms, vertical proportion curves and the truncated gaussian simulation algorithm (TGS); For the effective porosity (**Figure 6b**) and water saturation (**Figure 6c)** model we used the Sequential Gaussian Simulation technique (SGS) algorithm, controlled mainly by the facies model; and for the permeability model (**Figure 6d)** we use relationships based on rock types and the effective porosity applied directly on the effective porosity grid.

The last step of this stage consisted in generating the net to gross grid, which represents the cells that contribute to the oil initially in place (OIIP) and meet the following condition: Facies SC_Delta and S_Delta; effective porosity greater than 5%; and water saturation less than 65%.

RESULTS AND APPLICATIONS

From the construction of the property model of the Cabo Blanco reservoir, an oil initially in place (OIIP) of 35MMSTB was obtained for the entire modeled area.

Likewise, a vertical volume accumulation grid was generated to highlight the areas with the highest hydrocarbon content, achieving the delimitation of structural blocks with drilling and secondary recovery opportunities (**Figure 7**).

From this model, a block (**Figure 8**) was selected to implement a gas injection project. Subsequently, the integration of the geological model together with the dynamic data allowed to carry out the flow simulation of the reservoir, which allowed obtaining production forecasts giving greater support to the project.

CONCLUSIONS

The integration of multi-scale data and the use of sequence stratigraphy techniques together with geomodeling techniques allowed us to understand the distribution of the main reservoir heterogeneities that impact the fluid flows in the subsurface in a mature field.

TECHNICAL CONTRIBUTIONS

This methodology allows the integration of multiple disciplines of geosciences in favor of the integrated knowledge of subsurface reservoirs in mature fields where data is scarce. Additionally, this methodology, which can be applied to other fields in the Northwest with similar characteristics, allowed the identification and delimitation of potential areas for future development projects.

Finally, it can be mentioned that this work was of support for the implementation of a gas injection project in the PN8 platform of Block Z-2B with favorable results.

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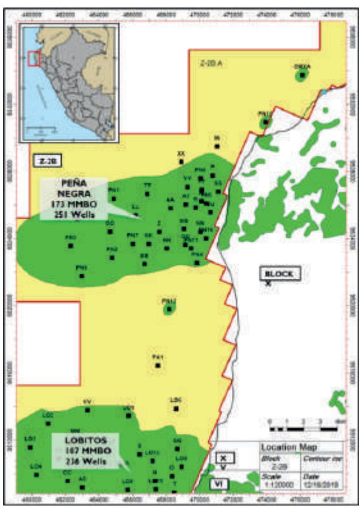

Figure 1. Location of Peña Negra field in Block Z-2B.

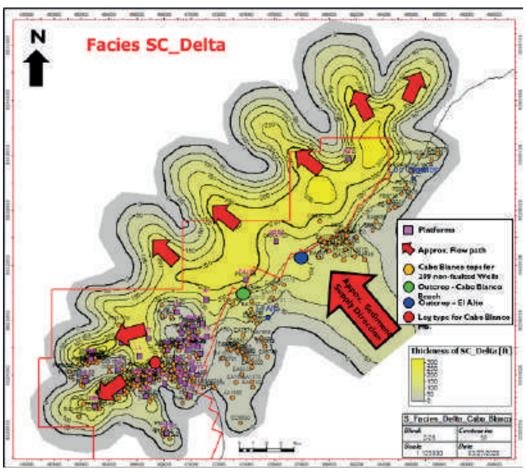

Figure 2. Distribution of the SC_Facies of the shallow-water delta model for Cabo Blanco Reservoir.

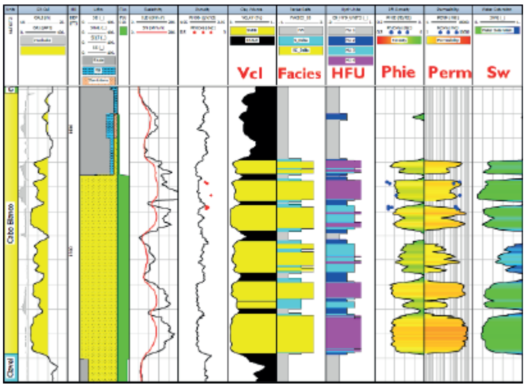

Figure 3. Structural map at the top of Cabo Blanco Reservoir.

Figure 4. Petrophysical evaluation for Cabo Blanco Reservoir.

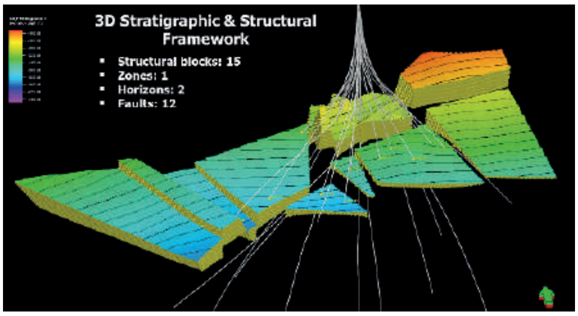

Figure 5. Stratigraphic and structural framework for Cabo Blanco Reservoir

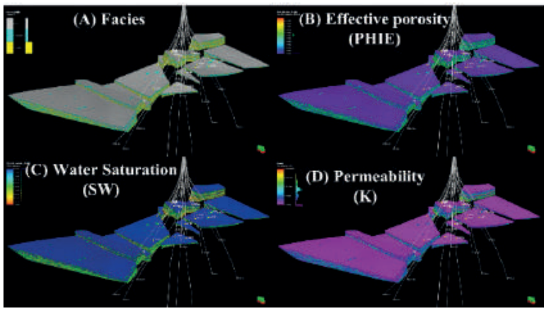

Figure 6. 3D Property models for Cabo Blanco Reservoir.

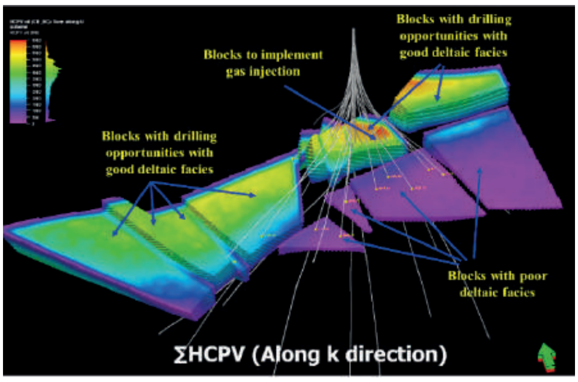

Figure 7. Identification of opportunities from reservoir modeling.

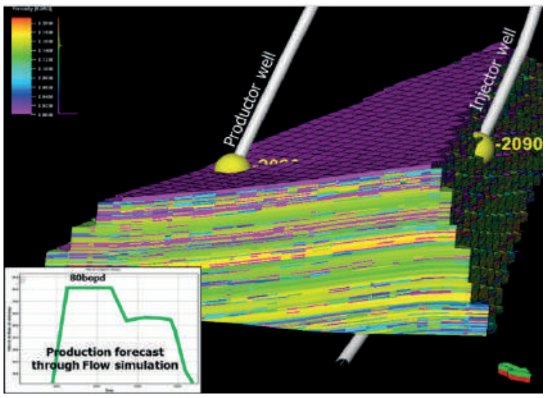

Figure 8. Selected structural block for a gas injection project.