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RESERVOIR CHARACTERIZATION AND MODELING OF A CRETACEOUS RESERVOIR IN THE OFFSHORE OF TALARA BASIN

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ABSTRACT

This paper presents a reservoir characterization and 3D modeling methodology applied to the Ancha Formation that is a Cretaceous reservoir in the Peña Negra field, which is a mature field located offshore of the Talara Basin. The Ancha formation represents a productive and exploratory interest within the Peña Negra field, which is why the need to characterize and model this reservoir.

The results showed that the Ancha reservoir corresponds to incised valleys deposits whose depositional axis has an approximate east-west direction and the best developments of the sandy facies of this reservoir, which are low porosity and permeability, are confined near the coast. The fault systems that cut this reservoir correspond to a normal regime, generating, in some cases, structural blocks that are not connected to each other.

Finally, the integration of the geological and petrophysical heterogeneities through the 3D static model allowed us to understand the spatial distribution of the initial hydrocarbons in the reservoir and to identify future drilling opportunities.

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 Ancha formation in the Peña Negra field has produced 1.7 MMSTB corresponding to 1% of the total oil production of the field. It is worth mentioning that although there are around 10 wells that have reached Ancha formation, only one of them is responsible for almost all the oil production.

Due to the high uncertainty that occurs in the development of this reservoir, the characterization and construction of a 3D static model was carried out integrating data from various scales and disciplines. The generated 3D model allowed us to understand the distribution of heterogeneities that impact the distribution of fluids in the Ancha formation.

OBJECTIVES AND LIMITATIONS

The main scope of this study is to obtain a three-dimensional model for Ancha Reservoir in order to understand the initial distribution of fluids in the reservoir and delimit favorable areas for future development projects.

During the development of this study we had the following limitations: 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 geological and petrophysical complexity of this reservoir.

AVAILABLE DATA

To study the Ancha reservoir, the following information was available: 3D / 2D seismic in certain parts of the field, well logs of around 20 wells (onshore and offshore), data from 2 cores, lithological and micropaleontological descriptions, stratigraphic and sedimentological interpretations, structural maps, petrophysical evaluations, production and completion data, and previous studies in the area.

RESERVOIR CHARACTERIZATION

The Ancha formation in the Peña Negra field corresponds to deposits from the Upper Cretaceous, Maastrichtian (Gonzales, 1995; Pozo, 2002; Uribe, 1991). Similarly, micropaleontology studies record the presence of the species Rugoglobigerina rugosa, Amobaculites sp., Heterohelix glubosa, and siphogenerinoides fragments that classify this reservoir within the foraminifera zone called "G" in the Talara Basin (Pozo, 1991; Gonzales, 1994; Cruzado & Gonzales, 1975).

This reservoir unconformably overlies the Redondo (Campanean) formation and transitionally underlies the Petacas (Maastrichtian) formation and is made up of massive strata of conglomerate sandstones with a maximum observed thickness of 1500ft.

According to lithological reports and thin section studies, this reservoir consists of lithic conglomerates of moderate sorting, subangular to sub-rounded, coarse to pebble grain size composed mainly of quartz, metamorphic and sedimentary rock fragments with inclusions of mica and glauconite, interbedded with dark brown, micromicaceous, carbonaceous and calcareous shales.

Based on the lithological, biostratigraphic, micropaleontological characteristics together with stratigraphic correlations in the area, it is interpreted that the Ancha formation corresponds to deposits of submarine fans that filled incised valleys formed during stages of forced regression to lowstand normal regression where the main development of reservoir bodies are found mainly near the coast. It is worth mentioning that these deposits are found throughout the Peña Negra field, having to the east proximal facies of conglomerates and sandstones; and to the west distal facies made up of intercalations of sandstones and marine shales. Likewise, it is interpreted that the source area is very close due to the rapid and violent deposition and the degree of immaturity of these rocks.

To understand the distribution and extension of the conglomerate and sandy facies, an electrofacies classification was generated for the Ancha reservoir. Three types of electrofacies were defined based on the response of the logs and they are the following: S_Fan, composed of conglomerates and sandstones of submarine fans; Ssh_Fan, composed of intercalations of sandstones and shales; and NR, composed mainly of shales. Next, a thickness map of the S_Fan facies was generated, which allowed us to understand the distribution, geometry and preferential direction of these deposits (**Figure 2**).

On the other hand, the structural geology based on seismic and correlation of onshore and offshore wells reveals a normal stress regime with main fault systems of SW-NE and NW-SE direction with average throws of 1000 feet generating compartmentalization of structural blocks (**Figure 3**).

According to the production data, the main oil producing well had an initial rate of 1500 bopd and has accumulated 1.68 MMSTB, it is worth mentioning that during the first 5 years this well had already accumulated 80% of its production. Core data together with the petrophysical evaluations reveal poor rock quality with an average porosity of 4% and an average permeability of 0.05md (**Figure 4**). The poor rock characteristics and the high flow capacity in some wells indicate that production is mainly linked to the presence of microfractures and natural fractures in the reservoir (Chavez, 1994).

3D STATIC MODELING

After the description of the reservoir, we proceeded with the construction of the static 3D model of the Ancha reservoir where the stratigraphic, sedimentary, structural and petrophysical aspects were integrated.

The first stage consisted of the generation of the 3D stratigraphic-structural model integrating the faults that cross the reservoir and the stratigraphic surfaces that limit it.

Next, the simulation grid was generated which consisted of 1 million cells of 100 m in the "X" direction, 100 m in the "Y" direction and 20 ft in the "Z" direction.

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

To propagate the facies model **(Figure 5a**) in the grid we used 3 types of electrofacies, probability maps, variograms, vertical proportion curves and the truncated gaussian simulation algorithm (TGS); For the effective porosity (**Figure 5b**) and water saturation (**Figure 5c)** model we used the Sequential Gaussian Simulation technique (SGS) algorithm, controlled mainly by the facies model.

From the facies, porosity, and water saturation grids, the net to gross (NTG) grid was generated, which represents the cells that contribute to the oil initially in place (OIIP) and meet the following condition: Facies S_Fan and Ssh_Fan; effective porosity greater than 2%; and water saturation less than 65%.

The last step in this stage consisted of generating the hydrocarbon pore volume grid (HCPV) (**Figure 5d**), which is obtained by multiplying the total rock volume, the net to gross grid (NTG), the effective porosity (PHIE) and the hydrocarbon saturation which is a function of water saturation (SW). This HCPV grid allowed us to understand the spatial distribution of the initial hydrocarbons in the reservoir and its volumetric estimation.

RESULTS AND APPLICATIONS

From the 3D static model for Ancha reservoir, an oil initially in place (OIIP) of 60MMSTB was estimated in the entire area of Peña Negra field. Additionally, an oil initially in place (OIIP) of 8.2 MMSTB was estimated only for the blocks developed to the East of the field which have accumulated 1.7MMSTB indicating a recovery factor of 20% for these blocks.

On the other hand, a vertical volume accumulation grid was generated from the HCPV grid to highlight the areas with the highest hydrocarbon content (**Figure 6**). This new grid together with the production data allowed us to delimit structural blocks that have not been drained and to add new drilling proposals (**Figure 7**).

CONCLUSIONS

The integration of multi-scale data using 3D reservoir modeling techniques allowed us to understand the spatial configuration of the main geological and petrophysical heterogeneities, and the initial distribution of fluids in the Cretaceous reservoir in the Campo Peña Negra in northwestern Peru allowing to define future drilling opportunities that should be complemented with reservoir simulation studies.

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 complemented with numerical simulation techniques will allow a better management of the field and a prediction of oil production with less uncertainty.

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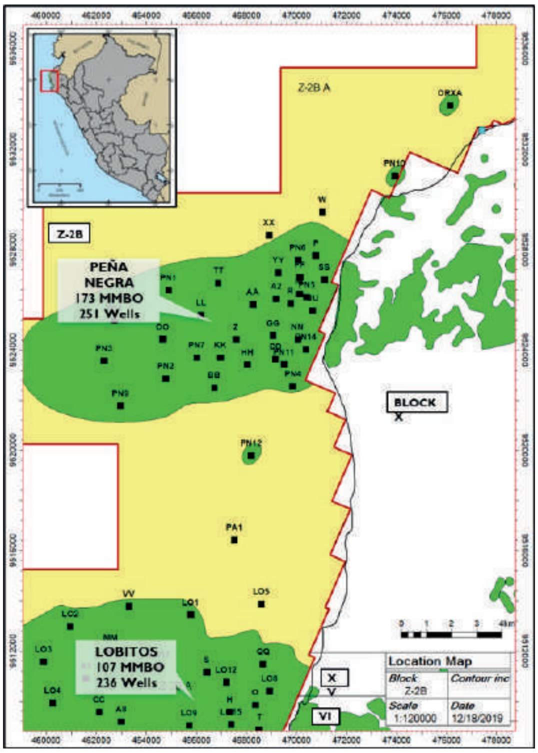

Figure 1. Location of Peña Negra field in Block Z-2B.

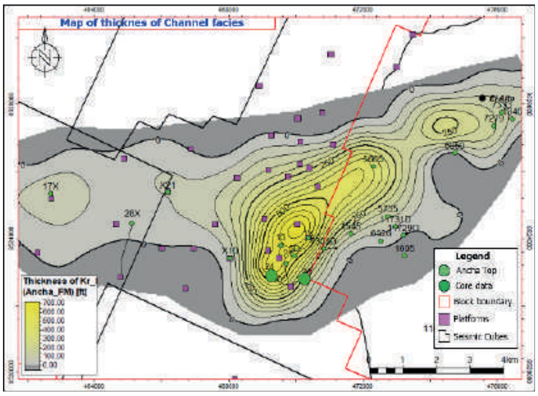

Figure 2. Distribution of the S_Fan of the submarine fan for Ancha Reservoir.

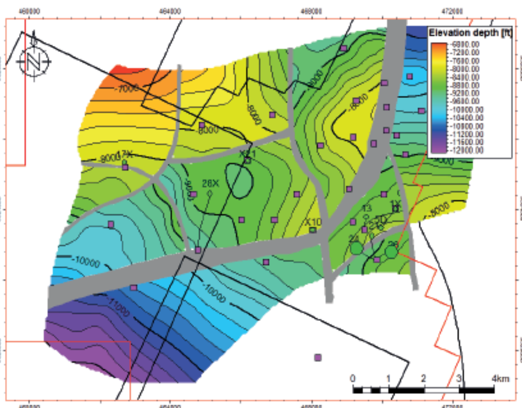

Figure 3. Structural map at the top of Ancha Reservoir.

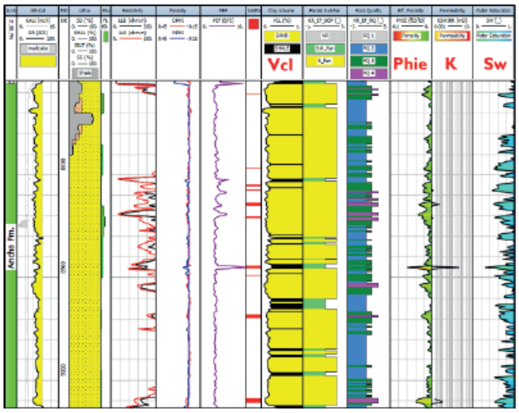

Figure 4. Petrophysical evaluation for Ancha Reservoir.

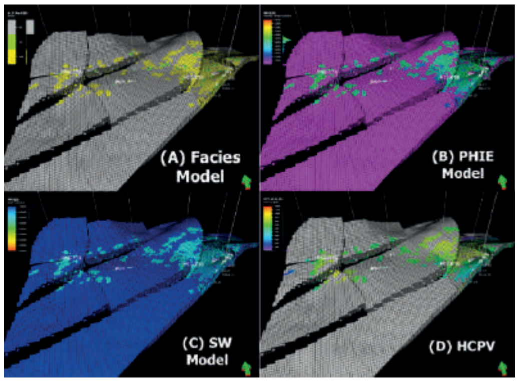

Figure 5. 3D Property models for Ancha Reservoir.

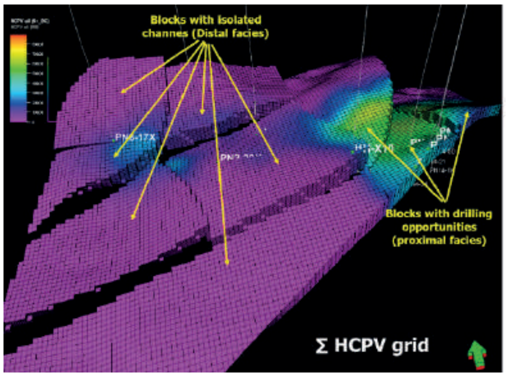

Figure 6. Highlighted areas to identify development opportunities.

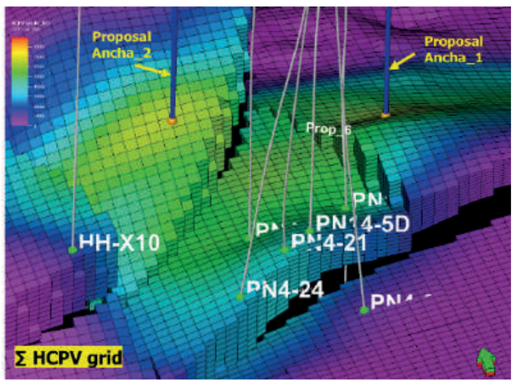

Figure 7. Selected structural block for drilling projects.