INTERSECTING FAULTS, CHANNELS AND TRAP GEOMETRY IN THE OFICINA TREND, EASTERN VENEZUELA BASIN: A BEFORE AND AFTER 3-D COMPARISON OF THE FINCA-YOPALES AREA

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ABSTRACT

Recent interpretation of 3-D seismic data in the Finca-Yopales area of the Oficina Trend on the southern rim of the Eastern Venezuela Basin highlights the need for detailed analysis of trap geometry. A comparison of interpretations before and after the 3-D seismic reveals some previously interpreted faults probably do not exist. In many cases, the faults were inserted in order to explain production anomalies. Instead, reservoir limits may be provided by combinations of depositional limits (edges of channels or bars), faulted reservoir bodies (sand-shale juxtaposition) and/or intersecting faults. In a few instances, reservoir limits could have been more accurately defined by careful fault surface mapping, using fault cut data from the wells and the position of seismically defined faults. In others, careful mapping of fault surfaces in the 3-D data has revealed a large number of en echelon normal faults connected only by ramps that do not provide an effective seal. Such features would have been difficult or impossible to detect in the 2-D seismic data. Coherence and amplitude attributes proved especially helpful for fault mapping and delineation of the reservoir limits, both of which were only possible using the 3-D seismic data. Re-mapping of the field using the 3-D seismic data and integrating the production data, pressure data and detailed well-log correlations resulted in additional STOOIP and a simplified geologic model. Numerous opportunities for infill drilling and exploratory locations were also identified.

INTRODUCTION

This paper presents a case history of a project to re-interpret and update the geologic model of the Finca-Yopales area in the Oficina Trend of the Eastern Venezuela Basin (Fig 1). The area was evaluated by

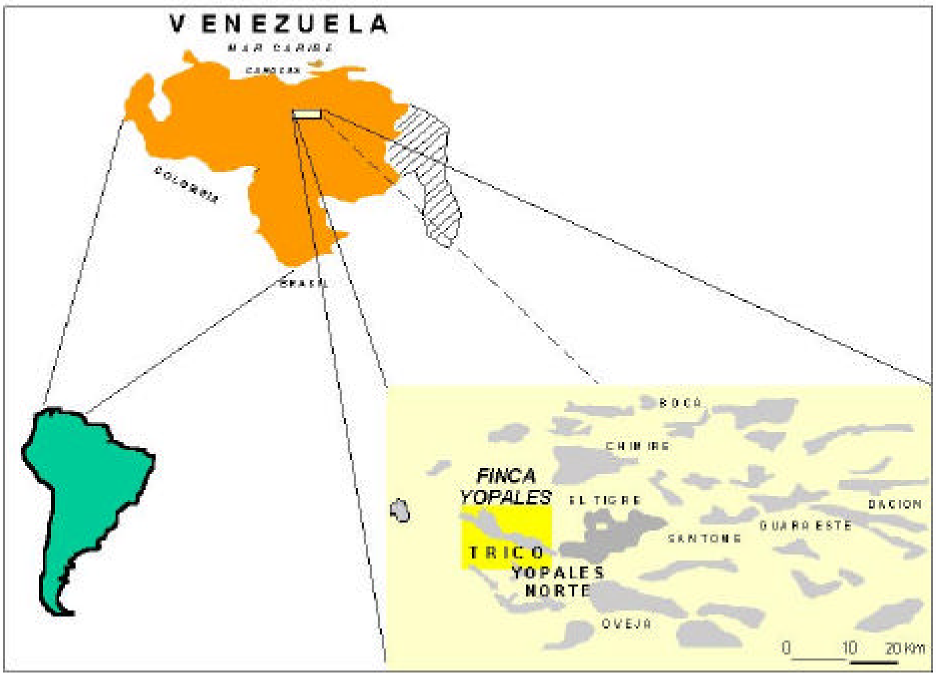

Figure 1 Location map, Finca-Yopales area, Oficina Trend, Venezuela

PDVSA, with an advisor from Subsurface Consultants & Associates (SCA) in late 1997 and early 1998. The following specific objectives of the study were defined:

1. To calculate remaining proved developed producing reserves;
2. To identify future recompletion, workover, development and exploratory drilling potential;
3. To look for possible enhanced recovery opportunities.

The data that were available to the team and the methods that led to a simplified geologic model are reviewed. Of special interest is the application of an interpretation methodology that truly integrated the different types of data, and allowed us to improve our understanding of the trapping mechanisms in the area.

At the time of this study, the fields in the Finca-Yopales area were in the final stages of primary recovery and had been studied for secondary recovery, with about 15 MMBO estimated remaining reserves from a total production of about 110 MMBO. One key objective of the study was to update the reserves and production plan for the area. This was accomplished by integrating information from well logs, pressure history, production volumes, 2-D seismic data and a new 3-D seismic survey into a completely updated geologic model of the area.

Previous studies in the Finca Yopales area include: Sanchez and Betancourt, 1995; Vargas, 1991; Sifontes and Flores, 1989; Project 121, 1957.

REGIONAL SETTING

The Eastern Venezuela Basin covers about 200,000 km^2 onshore Venezuela and offshore in the Gulf of Paria and Trinidad. It is approximately 200 km wide and 800 km long, with the axis trending almost east-west. It is bounded on the north by the Cordillera de la Costa and the Araya-Paria metamorphic belts, on the west by the El Baul arch, and onlaps the Guyana Shield to the south. To the east it opens onto the Atlantic oceanic crust. The Oficina Trend is located in the southwestern part of the basin and consists of some 60 producing oil fields dating from the 1930's and 1940's. Producing reservoirs are the fluvial and deltaic sandstones of Oligocene to Middle Miocene age. Fields of the Oficina Trend developed on the northern flank of the Guyana Shield in a ramp setting
This study covers one of the producing oil fields in the southwest of the Oficina Trend, discovered in this early era. The field is located west of the town of El Tigre and 30 km north of the Zuata area of the heavy oil region known as the Faja Petrolifera del Orinoco.

METHODOLOGY

the integrated geologic study presented here followed the general sequence outlined in tearpock and bischke (1991). primary steps in the process included detailed sequence stratigraphic correlations, structural framework analysis, fault surface mapping, integration of horizons and fault surfaces, seismic attribute analysis, preparation of sedimentary facies maps for productive horizons and finally volumetric analysis. the different types of data used are shown in table 1.

Well logs	66 wells
Cores	few in area
3D seismic survey	110 sq. Km.
Velocity surveys	3
Biostratigraphy	3 wells
Static Pressure	Approx 40 yrs history
Production data	Oil and gas rates/vol.

Table 1

SEQUENCE STRATIGRAPHY

A sequence correlation framework was developed using well-log stacking patterns, biostratigraphy, seismic stratigraphic patterns and growth analysis plots (Bischke, 1994). A detailed description of the method is the subject of another paper in this conference. Litho-stratigraphic formation names are also presented for reasons of historical correlation although it is somewhat confusing due to their time transgressive nature and time equivalent lateral facies associations. Throughout this study, correlation based on a sequence-stratigraphic framework is used. The traditional stratigraphy of the Oficina trend consists of the Merecure and Oficina formations. Each sandstone member is named with a letter, beginning with A in the top of the Oficina Formation, down to U at the base. In this study, the entire section was re-correlated regionally and divided into 6 depositional sequences. 6 sequence boundaries and 6 maximum flooding surfaces were identified and mapped, ranging in age from 25.5 ma to 13.4 ma.

STRUCTURE

The structural framework was developed using fault cut data from the 66 wells in the study area, tied to the seismic fault cuts interpreted from the 3-D seismic data (Fig 2). Coherence maps were used to verify and validate the seismic correlations. This proved especially helpful to identify intersecting faults and *en echelon* fault systems that do not link. A fault surface map was prepared for each of the faults identified in the area in order to be certain about the correlations.
Time structure maps were prepared by integrating (cross contouring) the fault surfaces with the horizon surfaces, a process partially automated using the structural framework modeling capability of the CPS-3 mapping software.

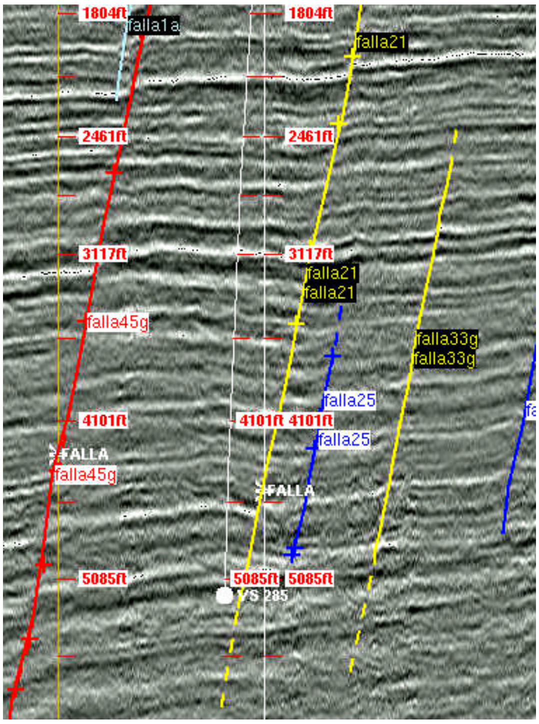

Figure 2 Sesmic faults were tied to the well cuts as shown. The amount of missing section in the well was matched with the vertical separation observed on the seismic.

SEDIMENTOLOGY

Sedimentary facies maps were prepared for each of the productive intervals studied using a combination of electrofacies interpretations from the well logs, analog sections interpreted from cored intervals, static pressure data from producing wells, differences in the properties of produced oils, and seismic attribute analysis. Volume attribute extractions (especially RMS amplitude) from the seismic data were useful in several instances to aid in the interpretation of facies boundaries, corroborating the limits of fluvial channels and offshore bar systems (Fig. 3).

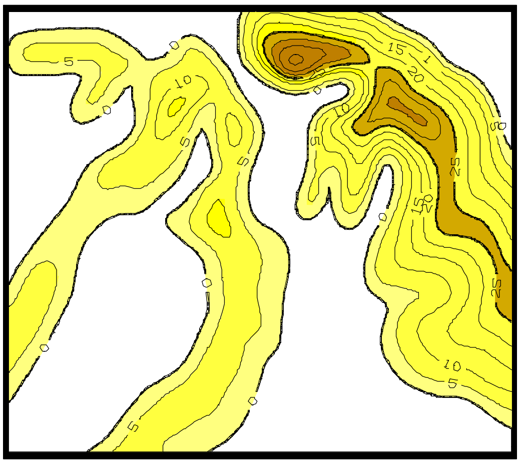

Figure 3 Net sand map for one reservoir level showing the interpretation of delta channels and bars. Facies limits are controlled by electrofacies interpretation and seismic attribute (amplitude) extraction.

VOLUMETRICS

Finally, a volumetric analysis was performed on each of the reservoirs identified and a comparison made to the existing official maps.

ANALYSIS OF RESULTS

An example of the before and after 3-D interpretation for one reservoir sand is shown in Figure 4. The interpretation before 3-D is in fact the official reservoir map for this level that existed in the area. The fault patterns differ markedly between the two maps. This can be attributed to the uncertainty of fault linkage using only 2-D seismic data. The 3-D fault patterns are carefully controlled with coherence time slices and mapped fault surfaces incorporating the fault cuts from the wells.

Originally, the limits of productive reservoirs were also interpreted to be primarily fault controlled, but careful examination of the 3-D geometry of fault linkage as seen in the 3-D seismic data shows this not to be the case. Faults are important in the trapping, but some reservoir limits are due solely to lateral facies changes. Evidence for the location of facies changes such as channel edges and offshore bar complexes came from interpretation of electrofacies patterns and seismic amplitude attributes.

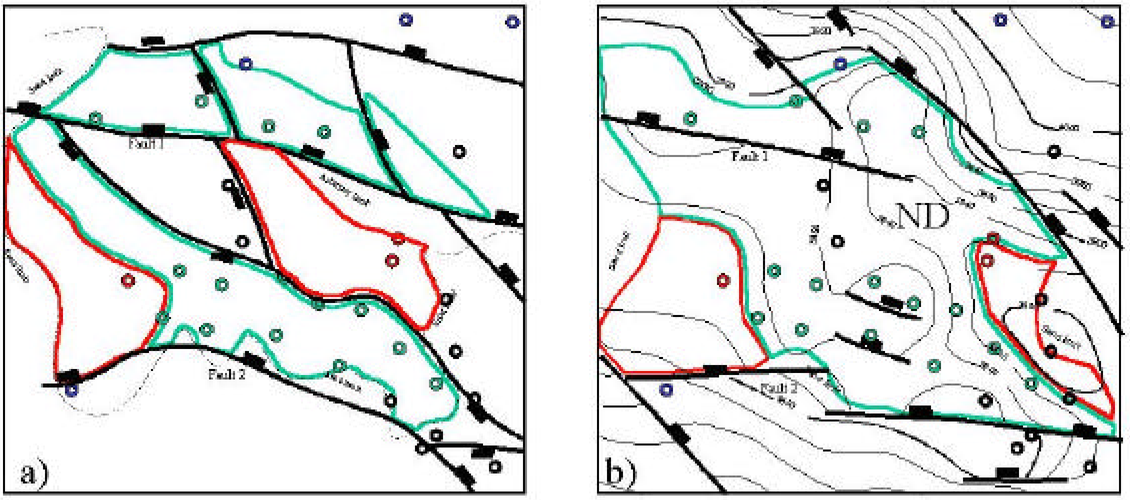

Figure 4 a) Official reservoir map of one producing sand interpreted from well and 2-D seismic data. Note the through-going E-W faults 1 and 2. **b)** Compare final geologic model for the same reservoir sand in a. Fault 1 does not continue to the east and fault 2 is shown to be a series of three faults *en echelon*. Note that the final integrated interpretation allows the combination of six separate reservoirs into one, simplifying the geologic model and suggesting areas for new development as shown (ND).

CONCLUSIONS

1. Old producing trends can be fertile hunting grounds for new production using new technology.
2. Some old reservoirs are mapped with complex fault patterns to explain production anomalies. New studies using all of the data to make an integrated interpretation can help to explain the anomalies with simpler geologic models; often resulting in opportunities for developing new production.
3. It is important to take into account all of the data when making a geologic interpretation. The most useful results of this study came from integrating the analysis and interpretation of well data, seismic data and production data.
4. Structural analysis has been greatly improved by 3-D seismic data, especially when coherence slices are used to validate fault linkage.
5. Sedimentary facies analysis and reservoir sand mapping can be improved by considering seismic attributes.
6. Seismic fault mapping is improved by detailed well correlations and careful fault cut ties, including the critical tie of missing section in the well to vertical separation measured from the seismic data.

REFERENCES

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