Simultaneous attribute visualization to define connectivity between reservoirs

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Abstract

Definition of reservoir connectivity using conventional 3D seismic data is an old and hard challenge for geoscientists when characterizing properties associated to permeabilities, isolated production blocks and drainage of hydrocarbons. To help on this characterization, many seismic attributes have been used by the industry trying to establish a consistent link between seismic properties and different behaviors of reservoirs. One difficult on overcoming the interpretation of many attributes at “same time” is the way to visualize them according to some geologic sense for any method. In Teal South field, GOM, Pennington et al (2001) show that time-lapse seismic observations have revealed that one undrilled reservoir (Reservoir B) near a producing reservoir (Reservoir A) was exhibiting time-lapse changes consistent with expansion of a free gas phase, with oil being lost trough the spill point. They conclude that both reservoirs were communicated and they both were suffering a regional pressure decline across faults. In the same area, Ezawi et al (2012) studying the connectivity of the same reservoirs using Instantaneous Amplitude have concluded that the declined pressure was due the escape of hydrocarbons to one of the neighboring reservoirs (Reservoir B) with the intrusion of water from the base of the producing reservoir (Reservoir A).

Here in this paper, about the same area of Teal South Field, 4D seismic data were used, one Base (year of 1995) and a Monitor (Phase 1- year of 1997), to understand the possible ways that water could go between the reservoirs A and B. For such an understanding was applied a simultaneously visualization of inverted seismic data and geometric attributes post-stack**.** The results show new possibilities of connectivity between Reservoir A and B and the advantage of using simultaneous display of different seismic attributes, to provide spatial perspectives of interpretation of reservoir characteristics and possible connectivity, identified by 3D seismic data.

Introduction

The Teal South Field is located in the Gulf of Mexico (Eugene Block 354), offshore Louisiana, in 85 m of water column (See Figure 1).

Figure 1 – *Location of the Teal South field in the Gulf of Mexico (from Ebrom et al., 1998).*

It consists of multiple mini-basins at depths from 1300m up 2400m, and reservoirs are unconsolidated Tertiary sands (4500-ft sand horizon). The structure of this field is a deep-seated anticline ridge terminated by counter-regional growth faults. The intersections of north-south growth faults with east-west growth faults create many structural traps (Andre and Rinehart, 1997). The average thickness of the reservoir is about 70 m. The 4500-ft sand reservoir was tracked on the legacy seismic data and it was possible to observe that the undrilled Reservoir B is apparently separated from Reservoir A by structural elements, basically by major faults. Reservoir A is the largest reservoir within 4500-ft sand horizon and the only reservoir within that unit under production at the times the 4D phases surveys (Pennington, 2001). Figure 2 shows the 4D-Monitor seismic acoustic impedance over structural map of 4500-ft Sand horizon with reservoir A and B . Figure 2 shows the 4D-Monitor seismic acoustic impedance over structural map 8ms window above the base of the 4500-ft Sand horizon with Reservoirs A and B Observe a possible connectivity between reservoirs pointed by black arrow indicated by the impedance response.
Fast reduction in production rates and the small size of reservoirs might mean the fast flow rates and high permeability. In previous studies was demonstrated that reservoir “A” was a light-oil reservoir that contained no free gas. It is very likely that other neighboring reservoirs were also saturated with light oil under similar conditions (Pennington et al. 2001).

The objective of this study was to investigate possibilities for connectivity between the Reservoirs A and B that can be identified in a more geoscientific way by mixing seismic attributes to suggest genetic origins differentiated from each other, such as petrophysical properties (genetic inversion) and structural styles (geometric attributes). The results show effective algorithms that can help to establish connectivity solutions between the reservoirs A and B and structural pathways that can serve as ducts for the fluids.

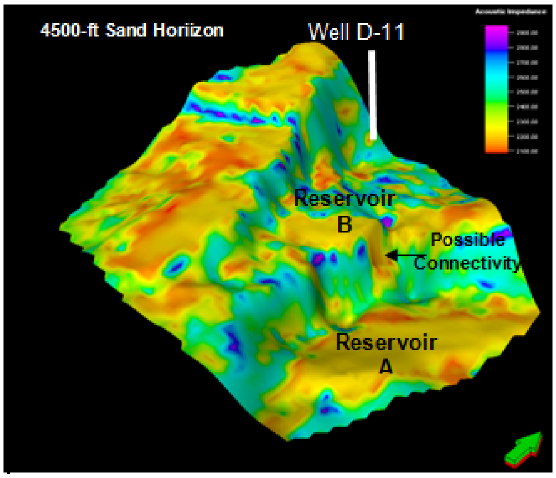

***Figure 2** – Monitor seismic acoustic impedance over structural time map of the 4500-ft Sand horizon with Reservoirs A and B with projected well D-11.*

Method

To analyze structural heterogeneities and connectivities in the 4500-ft Sand Reservoir were used two seismic attributes: the first to generate heterogeneity enhancements, which made fault surfaces sharper and more continuous which allowed the extraction of possible connected structural components. Such algorithm was applied to the 4D legacy seismic amplitude data (32bits), looking for heterogeneity with dip angles from 60 to 90 degrees. Figure 3 shows surfaces of Reservoir A and B and possible fault connectivities derived from mentioned algorithm.

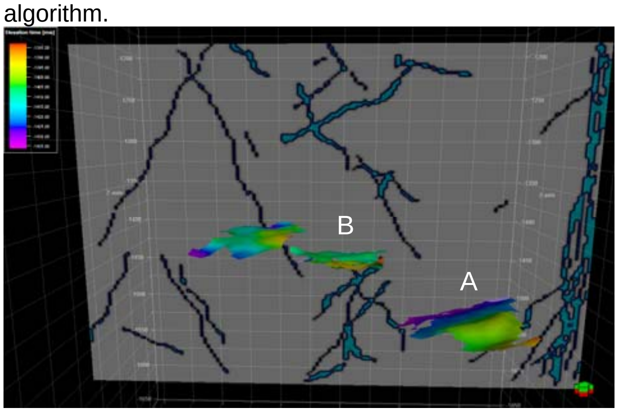

***Figure 3** – Structural heterogeneities cube with the interpreted horizons in the reservoirs A and B.*

To obtain and correlate seismic petrophysical properties it were used the sonic and density logs from well D-11 targeting calibration of acoustic impedance derived by a genetic algorithm which calculates weights for the hidden layer in a neural network and deduces an optimal non-linear operator. The inverted seismic data of the 4500-ft sands made possible to correlate and make quantitative evaluations from log impedance to the derived seismic impedance.

Results

Both attributes when visualized simultaneously as a 3D Cross Plot make possible suggestions for continuities of porous sands and connectivities among the several structural blocks like shown in the Figure 4.

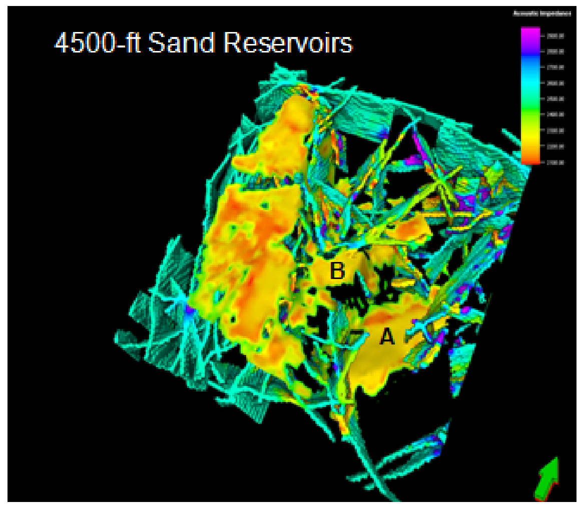

***Figure 4 – 3D** Cross Plot of the resulted genetic inversion and structural heterogeneities for Reservoirs A and B within 4500-ft Sand.*

Structural and layer analysis demonstrated that there is a possibility of connection of reservoir A to B as shown in Figure 2. Is also shown that the leak of fluids from the reservoir B to A, can be confirmed by the presence of faults with possible good transmissibility connecting these two reservoirs (Figure 4). The simultaneous visualization of different attributes can be used as an alternative to solve connectivity problems between seismic reservoirs. With a three-dimensional volume of legacy data and a monitor post-production data, we provide additional insight about how could be the fluid migration pathways and the pressure communication between different reservoirs, separated by structural faults.

Conclusions

Sandstone reservoirs with good porosity are very common in many oil and gas fields, and are often spatially separated by large faults. Such reservoirs, many times, appear to be hydraulically isolated when viewed in 3D seismic data. In the Teal South field for 4500-ft sand, the production of a structurally lower reservoir (Reservoir A) caused a decline of pressure on the sand reservoirs structurally higher (Reservoir B).

Such reservoirs that seemed, seismically, isolated, showed during production that were not. Here in this paper we present techniques to generate attributes calibrated by well logs that can provide simultaneous visualization which generates more consistent interpretations of the information obtained from seismic data and the results of pressure measurements during reservoir production.

Acknowledgments

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