Challenges for Jubarte Permanent Seismic System

Edgar A. Thedy, Wilson L. Ramos Filho, José Guilherme R. da Silva (Petrobras), Samir Seth and Steve Maas (PGS)

Abstract

Petrobras is going to install its first permanent reservoir monitoring system. The chosen area was Jubarte, a giant field discovered in January 2001 which reserves were estimated to be approximately 510 million barrels. The field is located in the northern portion of the Campos Basin, off the southern coast of the State of Espírito Santo, 77 Km offshore, at a water depth of 1,185 to 1,365 meters.

The target is to monitoring oil and water flows inside the reservoir and pressure changes due to the injection (close to injecting wells and to oil/water contact) and to the production (close to the horizontal wells in the upper portion of the reservoir). Possible discontinuities, which would impact the flow and that couldn't be identified using regular 3D seismic data, will be revealed by 4D seismic data as an anomaly limit for difference volumes.

Project developed at Research Center enabled a public bid for a full solution, including project, installation, seismic acquisition and processing and system operation and maintenance, with a fiber optics solution. Control 4D Room was installed in P-57 platform, a FPSO which have a production capacity of 180,000 barrels per day of oil and compression of 2 million cubic meters per day of natural gas. The unit will be interconnected with 22 wells. Installation occurred last October in a Brazilian shipyard, just before the platform left for travelling to the final site. Subsurface system will be installed on March 2012.

Reservoir Aspects

Jubarte field is a giant oil field discovered in January 2001, for which proven reserves are approximately 510 million barrels. The field is located 77 Km offshore the Espírito Santo State southern coast, in the northern portion of Campos Basin, in water depths from 1,200 to 1,350 meters (Fig.. 1).

Jubarte reservoir is formed by Maastrichtian turbiditic sandstones (Bruhn, 1998), with average porosity of 26% and average permeability of 1 Darcy. The oil is 17° API and 14 cp at reservoir conditions. Based on the understanding of the field rocks architecture and structure, the locations of the producers and injectors were projected to obtain the best results in terms of flow and recovery, and data observation - geophysical (attributes, surfaces mapping, inversion), geological (interpretation of facies, depositional trend) and reservoir engineering (production and injection optimization by best flow trend).

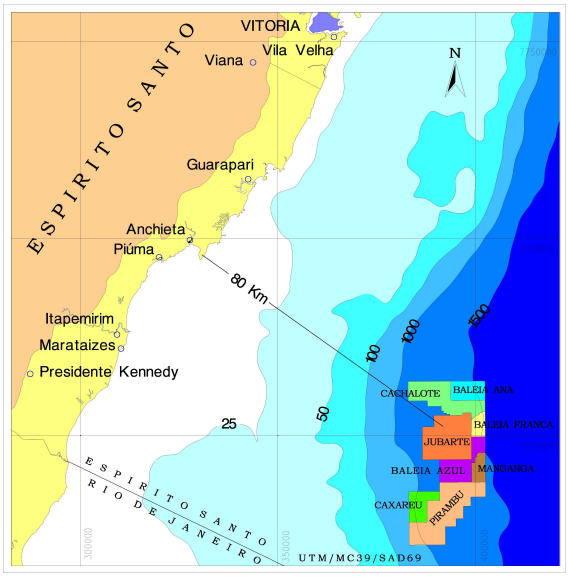

Figure 1 Location map.

The Jubarte production development phase began in late 2006 (phase I) when the FPSO P-34 started its operations. P-34 has a processing capacity of up to 60,000 barrels per day. Phase two began in late 2010 with the production of the first well connected to FPSO P-57. P-57, which will replace the P-34 FPSO, has a production capacity of 180,000 barrels per day of oil and compression capability of 2 million cubic meters per day of natural gas. The unit will be interconnected with 22 wells, including the wells from P-34 when it leaves the area.

Jubarte asset team's expectation is that the PRM seismic system will improve their ability to observe flow changes and improve recovery factor of the field, as well as to anticipate potential leakage at faults with 4D seismic and microseismic permanent recording.

Due the thickness (up to 400 meters and an oil colum of 100 meters) and the production strategy (injection close to the oil/water contact) the presence of shale layers and small faults, that couldn't be identified in 3D seismic can negatively impact the production. The geological model considers that the shales are not continuous and that faults can't disconnect the blocks. A picture of the geological model is presented in Fig. 2, and the correspondent seismic section is presented in Fig. 3. The understanding of flow behavior and barriers identification is very important to optimize new wells location and recovery.

The modeling indicates a compressional impedance change of 3-4% for fluid changes (oil by water) and smaller than 2% for pressure changes (close to injection wells and producing wells). Permanent system is very important in this case, where the differences are small. Repeatability for the sensors tends to be perfect, once the system will saty in the same position for a long period of time. The use of converted waves, obtained by the system installed in the seafloor, can also improve 4D resolution.

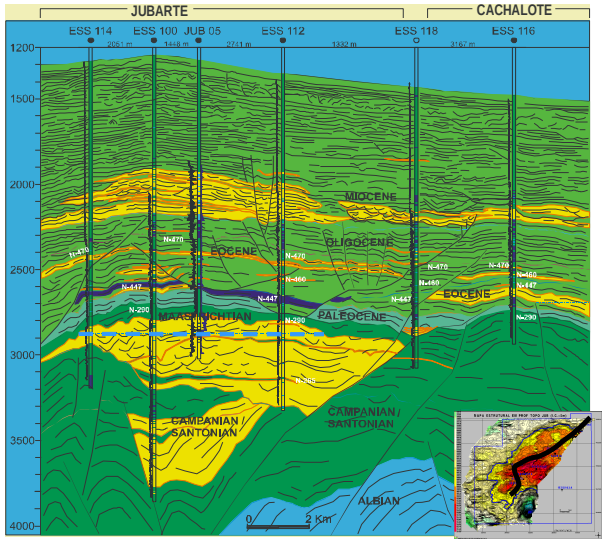

Figure 2 Geologicc section. Blue dotted line represents oil/water contact.

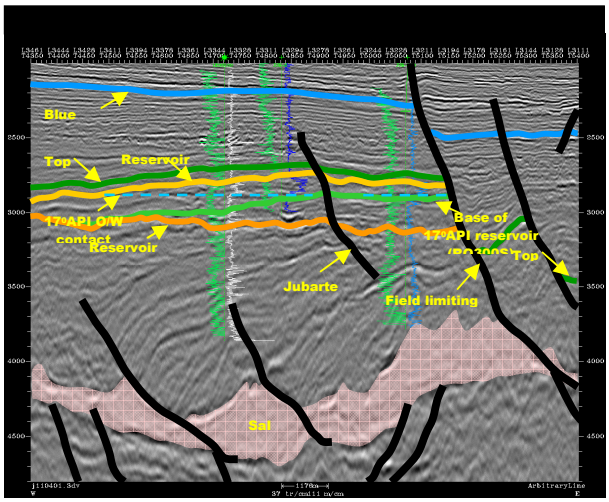

Figure 3 Seismic section. Reservoir top is the yellow horizon.

Jubarte PRM

The project's choice was to have the full solution – project, manufacturing, installation, acquisition and processing – from the same service company (Thedy et al., 2011). After a public contract bidding, Petrobras and PGS signed the SMSP-JUB Project (Permanent Seismic Monitoring System for Jubarte Field) contract. The system is fully optical. It uses optical inferometers as sensors and DWDM (Dense Wavelength Division Multiplexing)

telemetry. It provides standard SEG-D data with a low noise floor, good vector fidelity and high dynamic range amongst other performance features.

Acquired data should support geophysical interpretation for reservoir monitoring, including compressional and converted waves from campaigns with active source, and microseismic recorded continuously during the rest of the time.

It will not be allowed to OBCs cross the production or injection lines, or other facilities. Fig. 4 shows the project area (dotted line), depth curves, planned facilities (wells, production lines, injection lines, pumps) and mooring system. During the installation phase there will be two platforms in the target area. After, P-34 will leave the region and the wells will be reconnected to P-57. New wells will be drilling and connecting during this time.

Petrobras selected a fully optical solution for the in-sea seismic array. Optic fibers are inherently better suited for long term in-sea use than electrical systems, which need to be housed in pressure vessels and can corrode more easily.

A layout is shown in Fig. 5, where the dry end is on the surface and is connected to the sea-bed Wet-end through a dynamic umbilical followed by a hub and wet-mates on the sea bed, then lead-in cables and the seismic array cables laid out in bi-directional redundant loops.

The dry end on surface in the seismic room has opto-electronics and recording equipment as well as the QC computers; this includes lasers and frequency modulators that send light to the array, as well as opto-electronics that collect, de-multiplex and perform analog/digital conversion etc. of the return signal.

The sensors are fully optical and are based upon Michelson inferometers, where a phase shift in the coherent laser light in a sensor is created that is proportional to the seismic signal (Fig. 6). The phase information is extracted in the dry-end opto-electronics. DWDM telemetry permits richer data to be recorded and a high channel count to cover large areas.

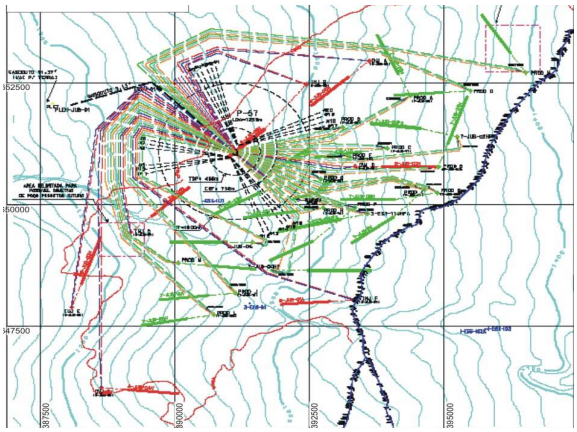

Figure 4 SMSP project area.. 4D Seismic Room will be installed in P-57.Installation area is approximately 9 sq. km covering the southern portion of the reservoir.

Figure 5 SMSP layout.

Figure 6 Detail of the optical sensor.

Conclusions

After 6 years of a research project Petrobras decided to install a permanent reservoir monitoring system at Jubarte Field. Chosen contract model was a full solution, including since the equipment development for a 1,200-1,350 meters water depth OBC system, installation, seismic acquisition and processing, beside maintenance during a five years time.

It will be installed a permanent seismic reservoir monitoring fiber-optic system, and performed seismic acquisition in an interval of one year, covering the southern portion of the field.

Three surveys are planned for the first three years. Microseismic data will be recorded during the intervals between shot surveys. These data will be interpreted in terms of fluid and pressure changes, identifying barriers and residual oil and improving the reservoir characterization

Acknowledgments

Authors would like to thanks Petrobras and PGS for allowing the publication of this abstract.

References

Bruhn, C.H.L., 1998. Deep-water reservoirs from the eastern Brazilian rift and passive margin basins. In: M. Carminatti (Editor), AAPG International Conference and Exibition. Short ourses. The American Associaton of Petroleum Geologists, Rio de Janeiro, pp. 187.

Thedy, E. A, Ramos Filho, W. L., Johann, P. R. S., Seth, S., 2011. Jubarte - PRM In Ultradeep Water and with an Innovative Optics System. EAGE Workshop on Permanent Reservoir Monitoring (PRM) Using Seismic Data, Trondheim.