Jubarte Permanent Reservoir Monitoring - Installation and First Results

Thedy, E. A., Ramos Filho, W. L., Johann, P. R. S. (Petrobras), Seth, S. N., Souza, S. C. and Murray, P. E. (PGS)

Abstract

Petrobras has recently completed the implantation of the world's first, and to this date only, PRM project in deep-water depths between 1200 and 1300m, in the Jubarte field. The primary objective of Petrobras is to validate the fiber optic sensing technology in deep-water in detecting small impedance changes in the reservoir.

This pilot project, installed in the end of 2012, is composed of 35.6 km of seismic cables, arranged in two subsea arrays that cover 9 sq. km in the south portion of Jubarte field. The cables, anchored at each 300 meters to ensure good coupling and reduce noise besides to prevent lateral movements due to currents, have a total of 712 4C receiver stations (a three-component accelerometers and a hydrophone) at 50 meters intervals and were deployed in parallel lines 300 meter apart.

The first acquisition was concluded in February 2013 and the processing is on-going by PGS. Passive monitoring of seismic activity of the reservoir will also be acquired for a 4 month period before the second acquisition (first monitor) scheduled for December 2014.

Introduction

In December 2012, Petrobras began the seismic survey of its first deep-water permanent reservoir monitoring (PRM) at Jubarte oilfield, in the Campos Basin. The Jubarte PRM seismic system equipment used was purchased from PGS/Optoseis™.

The system comprises a fully 4C fiber-optic sensor array installed on the seabed and an optoelectronics controlling and recording unit installed on the topside of the floating production, storage and offloading vessel (FPSO) P-57. Upon completion of installation of the system in deep-water, Petrobras with PGS shall acquire active seismic data at least once a year using a seismic source vessel and passive or microseismic data between them.

The project includes sensor array cables laid out over the Jubarte field in two loops on the sea-bed in water depths between 1,200 and 1,300m. 35km of array cables placed 300m apart, and sensor stations every 50m along the cables.

The OptoSeis system is totally optics and is based on the Michelson interferometer sensing elements. In addition to fiber optic seismic array, the system also contains led-in cables, wet-mate connectors and optoelectronics equipment (Thedy et alli, 2011a, 2011b).

Jubarte PRM record 441 shots lines, 25m apart with shot intervals of 25m and a 3,606 cu/in and 2,000 psi of three guns array at a depth of 7m with dedicated seismic source. Seismic coverage is 600 in the central area with bin size of 12,5m by 12,5m. Traditionally, offshore exploratory seismic surveys use less than 500 thousand seismic traces/km2. High-density offshore seismic survey uses around 1,0 million traces/km2. Jubarte PRM acquisition geometry presents a super density of seismic traces by km2, more than 3,8 million traces/km2.of multiazimuth and multicomponent data.

The Jubarte PRM seismic survey area comprises 121km2. The area of cable distribution on the ocean floor represents 9km2. The area of interpretable seismic data for the main reservoir is approximately 35km2.

Permanently laid sensor cables are an alternative to other forms of repeated, or 4D, seismic data acquisition. The Jubarte PRM system has 712 high-quality 4D-4C (4 component) seismic units for reservoir surveillance. Petrobras and PGS will process this seismic data and images. With these images, geophysicists, geologists and reservoir engineers will produce seismic interpretations that allow Petrobras to optimize reservoirs management of the Jubarte field. Thus, the great advantage of this Permanent Seismic Monitoring project is to enable the optimal management of the field's reservoirs, with huge potential impact on increasing the oil recovery factor. Another important advantage is related to operational safety. The project will provide seismic measurements permanently, enabling a constant update of the geomechanical model of Jubarte field and understanding of the value of microseismic data in deepwater projects. From the point of view of the Seismic Cycle Time, the project will provide a considerable reduction of time between the acquisition of new seismic data, its processing, its interpretation and the technical decision making so the processing and the interpretation process of the seismic data will be faster on Jubarte field.

Installation

The installation, both on the seabed and on the platform, represents one of the key aspects for a PRM project implementation. It is the most significant risk area and also an expensive item.

In order to minimize the operational risks and to ensure that the methods and equipment would be adequate and efficient, prior to the installation in the Jubarte field it carried out three separate trials in comparable water depths and seabed types. Each set of trials provided crucial information.

The installation of the Jubarte PRM system began in October 2012 when a special boat from Petrobras fleet deployed the optical dynamical riser on the seafloor and performed the pull-in at platform P57.

The remaining subsea components were efficiently installed between mid-November and mid-December 2012 by an IT Telecon vessel. This includes a 10 tons Wet-Mate Telemetry Node (WMTN), 20 km of lead-in cables and 35.6 km of seismic cables arranged in two continuous arrays. In addition, it was installed a complete topside control and data acquisition system in the seismic room at P57. Figure 1 shows the layout of the seismic array and optoeletronics installed in the seismic room.

After the pull-in, the tail end of riser was retrieved by PGS and spliced to umbilical lead-in which was deployed up to subsea WMTN position. The Node and the two seismic arrays were also efficiently installed with special attention to the turn points. Furthermore, the system was installed on the seabed avoiding production infrastructure. This involved a close relationship with marine contractors and marine operations groups from Petrobras. The installation phase was concluded with the field acceptance test of the system.

First Acquisition

The baseline survey was acquired from late December to early February 2013. It was performed with an active source G-Gun II (total volume of 3.606 cubic inches and 2.000 psi) installed in the M/V Sanco Spirit research vessel. The 121 sq. km was acquired with dense shot spacing of 25 x 25 meters.

The operation in a production field was a challenge. Several different obstructions and service vessels made the original planning difficult. The two fixed platforms (P-57 and P-34) and the presence of drilling rigs, all in the northern part of the field, caused coverage losses due to the exclusion radius defined between 300 and 500 meters. Operations diving and ROV boats near the P34 also made the acquisition of prime lines a big challenge.

In order to minimize the coverage problem, especially between the platforms, it was necessary to acquire short orthogonal lines in relation to the main acquisition direction and also dead head lines allowing a maximum approximation in the vicinity of the production units.

Another problem has been the frequent presence of tankers close to the P57. The strong noise caused by engines has affected significantly the registration of multiple lines, requiring reshooting.

Even with all obstructions, we consider that the acquisition campaign was a success, reaching the total production area of 118.39 km², only 3.16 km² less than the planned shooting area. An example of a good quality gather is shown in the Figure 2.

Processing and Interpretation

The seismic processing started just after the last shot. One of the main objectives in this phase is to establish the best processing flow in order to use the same for each next survey with minimum changes. This will guarantee the repeatability of the process and also minimize the processing time. For the monitor campaigns, we expect to get the processing up to 6 weeks, giving a high decision value to the seismic data.

The processing strategy choice was to select a small area for a fast track processing, where a minimum workflow, with a constant velocity model, could be tested without the worry of setting the best parameters. The result was analyzed by the team.

Orientation determination (vector infidelity correction) was made from analysis of first breaks and is based on Delinger et alli (2001) approach for 4C data vector. The flow was applied in sequence in all volume. In this step, all parameters were exhaustively tested in order to find the best choices.

The interpretation is strongly based on the comparison between 4D seismic data simulated from geological model, updated by pressure and saturation changes coming from flow model in the survey date. Found differences among simulated and real data are studied, understood and incorporated at flow model. The process allows a fast decision cycle, improving the seismic data impact on the field management.

All images for the different wells, injectors and producers, with modeled synthetic data from the most updated geological and flow models and all the difference volumes derived from the monitor surveys will be available for easy and fast access by the interpretation group. Besides the volumes themselves, these images are the interpretation basis for the PRM acquired data and allow an initial approach for the reservoir behavior understanding.

Conclusions

Jubarte PRM was installed in the end of 2012. The operation was considered a success, without facing any extra difficulty and performed in estimated time. For the first active acquisition the high congestion in the area with other vessels, well perforation and P-34 decommissioning operations and the P-57 offloading bring some inconveniences in terms of quality lost, necessity of reshooting some lines and time extending. Data processing are in progress, but the first images suggest that results will be high quality, achieving reservoir group requirements. Currently the Jubarte team is evaluating the possibility of extension of the permanent seismic array to the north and northwest Jubarte.

Acknowledgments

The authors would like to thank Petrobras for giving us the permission to publish this material and Samir Seth for their valuable suggestions to this work. We would like to thanks Sérgio Campos for relevant information from seismic acquisition.

References

Dellinger J., Clarke R., and Gutowski P. 2001. Horizontal vector infidelity correction by general linear transform. 71st Ann Internat. Mtg., Soc. Expl. Geophys. Expanded Abstracts. MC P1.1.

Thedy EA, Ramos Fo. WL, Johann PRS, Seth SN and. Maas SJ. 2011a. Jubarte-PRM in ultradeep water and with an innovative optics system. EAGE Workshop on Permanent Reservoir Monitoring Using Seismic. Poster. Trondheim.

Thedy EA, Ramos Fo WL, Silva JGR, Seth SN and Maas SJ. 2011b. Challenges for Jubarte Permanent Seismic System. XIIst. Int. Congr. SBGf. Rio de Janeiro.

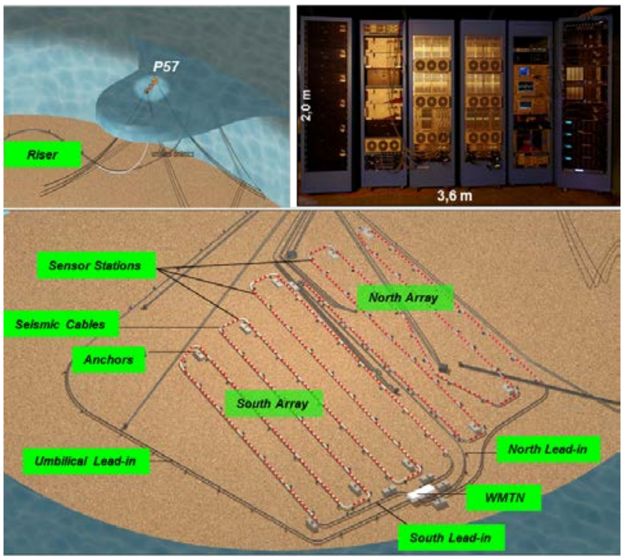

Figure 1. The Jubarte PRM layout. Upper right - Optoeletronic instrumentantion.

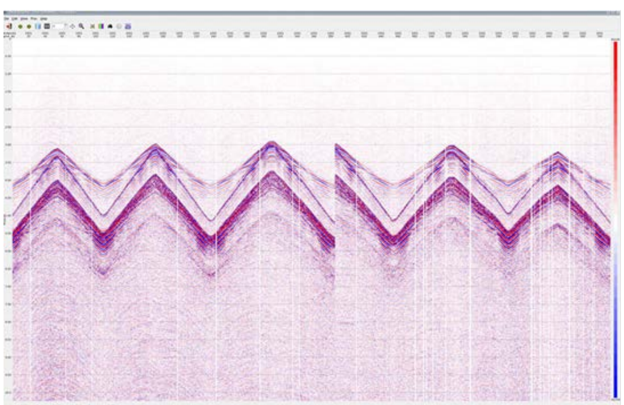
Figure 2. Common receiver gather. Hydrophone.