A 4-D Experiment in a Deep Offshore Environment

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Born nearly thirty years ago, time lapse seismic technology has been developed to monitor fluid displacement, pressure impact, and to detect undrained areas. The deep offshore environment is specific for monitoring activities. Indeed drilling costs, incapacity to re-enter wells and many other difficulties create a very suitable context to apply 4D seismic techniques.

Nevertheless the final quality of 4D seismic interpretation is directly related to the technical effort made to acquire, process, post process and interpret seismic data. The deep offshore 4D seismic case study presented here has been a great and valuable success because of the accurate work done during all stages of the project in order maximize quality of the result.

The monitor survey is acquired by repeating exactly the acquisition parameter set of the base survey. The obstruction areas are covered to a maximum by a mono-vessel acquisition within the limits of safety for people and installation. In the areas where mono-vessel acquisition was not possible a dual-vessel acquisition has been performed to undershoot the obstructions as well as an ocean bottom nodes survey.

Two processing sequences were applied: A fast track and a full processing. Both surveys are processed in parallel and cross-checked at every stage through quality controls and repeatability analyses.

The post processing step is performed in house using a proprietary technology. It is crucial at this point that geophysicists, interpreters and reservoirs engineers work together on the same dataset. Integration and exchange are the best guarantee to shorten the delay between the last shot and the first results. The in-house post processing ("warping") consists of inverting for the “stretch and squeeze” field to be applied on the monitor survey to bring it back to the base seismic time. The process also yields a cube of local P-wave velocity changes between base and monitor which is a key element used for 4D interpretation. Once both seismic datasets are aligned in time it is possible to compute true amplitude differences, to perform impedance inversion and 4D inversion, etc. These can then form a basis for a quantitative approach to 4D seismic interpretation.

The main results of this study have been detection of gas cap expansion, water injection pathways, depleted reservoir volume, fault sealing characterization, and more. A further proof of success: a future monitor survey has been requested by reservoir engineers!