The connection of Time lapse Seismic to Geomechanics in a study off-shore Brazil

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Abstract

Time lapse seismic has become increasingly important worldwide in recent years, not only as a method for seismic monitoring of mature reservoirs but as a tool that should be used at every phase of the reservoirs life time.

Much of the worlds 4D seismic experience was previously concentrated in the North Sea, and many of the lessons learned in 4D originate from the extensive work that has been done there. In Brazil, although 4D seismic studies by Petrobras go back as far as 1998, the extension of the use of 4D in to the deep water environment, such as the 2005 Marlim project, poses both new challenges and opportunities for the Geophysical community. (See Figure 1)

One challenge, for example, is to dtermine to exactly what extent it is possible to apply the concept of “repeatability” in the case where the ocean currents are far stronger and far less predictable than the case in the North Sea.
An example of an opportunity is to attempt to link and interpret Geomechanical effects that are observed in producing fields, with the 4D signal extracted from time lapse seismic surveys.

In this paper we look at the above challenges and opportunities and some recent work that has been done on this subject.

Figure 1; Marlim 3D/4D Seismic acquisition, off shore Brazil, Campos Basin.

Introduction

In order to address the previously mentioned challenge, a study was embarked upon that will attempt to link the observed geomechanical effects seen in the Reservoirs of the Campos basin, off-shore Brazil, with the 4D time lapse seismic data that is already available, such that the findings can be extended to future 4D projects.

The first phase of this study is to develop a time-lapse (4D) processing workflow that can be used to process time-lapse reservoir monitoring surveys from the deep water areas offshore Brazil, and simultaneously be applicable to time-lapse shallow hazard appraisal.
The motivation being that such a workflow would greatly ease the integration of time-lapse reservoir models with observed changes in the overburden.

This workflow is being developed based upon experience from processing similar time-lapse seismic data from offshore Brazil, together with recently introduced technology and ideas for potential innovative approaches for areas such as this, from elsewhere in the world.

This workflow should then deliver a higher resolution 4D response which has been better preserved by careful deterministic processing and avoidance of statistical methods.

Once this effort is complete, the second phase is to interpret the Geomechanical effects in the reservoir and link these with existing Geomechanical and flow models of the reservoir by the Integration of seismic data processing, inversion, downhole measurements and production information.

Enabling technologies

In recent years, much has been learned about attaining improved preservation of 4D signal in the processing of time lapse seismic data. This applies to both to the general 3D processing involved as well as specific processing that applies to the treatment of the 4D signal.

Examples of the relevant advances in 3D processing technologies include improved compensation for variable speed of sound in the water column and improved 3D multiple attenuation procedures.

With regards to the preservation of 4D signal, it is now possible to make, for example, a better estimation of residual time shifts, and compensate for inaccurate recording of the spatial positioning of the equipment during vintage acquisitions.

An encouragement here is that recent reprocessing efforts elsewhere for off-shore Brazil have already demonstrated that a careful reprocessing using the new technologies available for data preconditioning and imaging can lead to very encouraging results, including improved resolution, fault definition and the preservation of amplitude information in the seismic data. (See Figure 2)

In this project we hope to show this extended to the 4D case, by further improving the quality of the imaging in the existing datasets (See Figure 3)

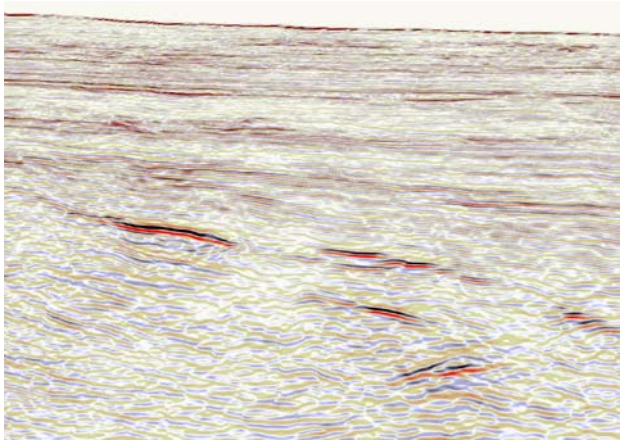

Fig 2; Amplitude information present on recently reprocessed data elsewhere in Brazil, potentially showing fluid anomalies.

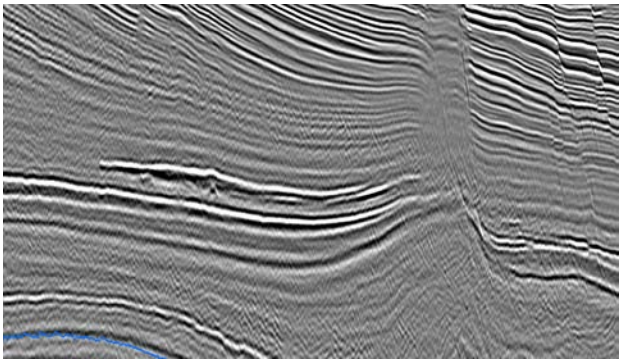

Fig 3; High resolution single sensor seismic from the Marlim complex, acquired in 2005.

Conclusions

As this study is ongoing, it is still too early to tell how successful we will be in improving our understanding of the Geomechanical effects observed in the reservoirs off shore Brazil, using Time lapse seismic. However our experience elsewhere in the world suggests that we can be optimistic. It is also hoped that these learning's can then be extended from the Turbidite reservoirs to Carbonate reservoirs.

We hope to show in this presentation our preliminary results and also the way forward that the research will take.

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References

Paulo R. S. Johann, Edgar A. Thedy, Frederico A. Gomes and Marco C. Schinelli / Petrobras E&P, Rio de Janeiro, Brazil - OTC 18400; 4D Seismic in Brazil: Experiences in Reservoir Monitoring

Herwanger, J., and Horne, S. [2005] Predicting time-lapse stress effects in seismic data, The Leading Edge. 12, 1234—1242