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Added value of acquired broadband seismic for interpretation and quantitative interpretation: case studies review

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SUMMARY

The main objective of this paper is to evaluate and demonstrate the ability of acquired pre-stack broadband seismic (towed dual-sensor streamer) to: reduce the uncertainty on the structural interpretation for prospect and lead identification and also to estimate reservoir properties directly from broadband seismic without using well information for calibration.

Introduction

Estimating reliable reservoir properties away from wells has always been a challenge for reservoir geophysicists but when possible it is very valuable - for instance in an exploration context. Within a well, absolute properties can be measured directly with kHz of information giving excellent vertical resolution. However, away from the well, one must rely on seismic data, which is band-limited and thus lacks the absolute values of measurements in the ground. Therefore, for maximum valuable information, seismic data with as broad a bandwidth as possible is required -rich on the low frequency side but not to the detriment of the high frequencies, which provide the vertical resolution at the reservoir level. It is also important to exploit the full AVO behaviour of the data through the pre-stack information and know that from the near to the far offsets signal has been measured and preserved reliably over the full bandwidth without any prior assumptions. Dual-sensor towed streamer acquisition and seismic processing technology (Tenghamn *et al*., 2007) represents a step change in the marine seismic industry as it delivers seismic data with significantly richer low and high frequency content. The use of both up and down-going wavefields, as a result of co-located vertical particular velocity and pressure sensors measurements, enables the removal of the receiver ghost.

One of the benefits of dual-sensor broadband data is evident in the structural interpretation phase of the workflow as, for instance, with reduced wavelet side lobes there are less false reflection artefacts present compared to band-limited conventional seismic data (Figure 1). The sharper, cleaner wavelets reveal reservoir geometries that better match well measurements and that can help to identify additional, remaining opportunities in mature areas and in exploration settings help to delineate and identify new leads and further de-risk opportunities in mature areas.

These signal bandwidth improvements do also lead to major benefit in the quantitative interpretation workflow, from the low frequency model building to the elastic property computation through to depth conversion and pre-stack wavelet estimation.

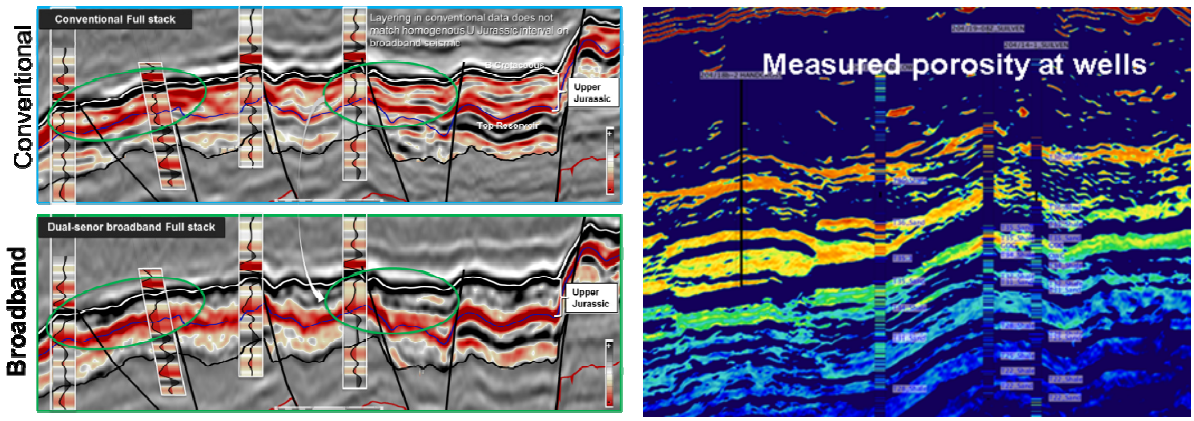

Figure 1 *Left image illustrates clearly the interpretation benefits, i.e. less false reflectors (conventional data at the top and dual-sensor streamer at the bottom). Right image is an illustration of the benefits for reservoir property prediction, in this case porosity.*

To gain insight in the distribution of reservoir properties, inversion for both acoustic and shear (P and S) impedances is required. It is relatively simple and less informative to have only an inversion for P-impedance, and does not necessarily mean that the data is AVO compliant. The real benefits come from using a combination of P-impedance and Vp/Vs ratio, and the reliable estimation of both confirms the overall AVO fidelity of the seismic data. After pre-stack simultaneous inversion, the 3D volumes can be characterised into shale, sand and hydrocarbons using the P-impedance vs Vp/Vs cross-plots resulting in a very good matches at blind well locations. For example once a robust prediction of sand and shale distribution has been established, the relation between P-impedance and sand porosity (if such relationship can be established from the well data) can be used to estimate a 3D porosity volume (Figure 1, right image).

This paper uses various case studies to illustrate the full potential of dual-sensor seismic data for both seismic structural interpretation and quantitative prediction of lithology-fluid distribution and porosity.

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References

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