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Benefits of Broadband Seismic Data for Reservoir Characterization - Santos Basin, Brasil.

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SUMMARY

Quantitative interpretation teams face two challenges when using model-based inversion: to extract meaningful wavelets and to build accurate low frequency models. The lack of low frequencies in conventional seismic data means that a low frequency model must be incorporated in the inversion process in order to recover absolute impedance values. Typically, low frequency models are obtained from low-pass filtered impedance logs. If well-logs are sparse and the geology complex, the well-derived low frequency model may be inaccurate and cause biased inversion results. One option to improve the low frequency model is to use seismic velocities. However, while seismic velocities provide information at very low frequencies (0-5 Hz), they are not usually suitable to provide information for the missing frequencies in the range from 5 to 10 Hz with
conventional seismic data. Seismic data acquired using variable depth streamers are ideally suited for inversion as they provide directly these missing low frequencies, hence removing the need to build low frequency initial models from well
data. In order to quantify the impact of the low frequency content on seismic inversion, comparative elastic inversion tests have been conducted using 3-D seismic data from conventionally towed Constant Depth Streamer (CDS) acquisition and broadband Variable Depth Streamer (VDS) acquisition. Both datasets from offshore Brasil, Santos Basin were acquired at
different time. The CDS survey was acquired and processed in 2000, the VDS was acquired in 2012 and this paper uses fasttrack processing results. The VDS survey was acquired with streamer depth ranging from 10 to 50m.

Introduction

This paper presents the results of a 3D acoustic inversion over a Brazilian offshore field. The target was an oil-bearing Eocene reservoir. For the test-comparison two datasets were used: the Constant Depth Streamer (2000, CDS) final PSTM and the Variable Depth Streamer (2012, VDS) fast-track PSDM. The objective of this project was to see clearly the difference in acoustic inversion results for conventional and broadband seismic datasets.

Acoustic inversion

A stratigraphic model-based acoustic inversion algorithm was used. We used generalized linear inversion (GLI) which attempts to modify the model until the resulting derived synthetic matches the seismic trace within some acceptable bounds.

The two datasets, conventional and broadband, are showed in Figure 1(a) and 1(b). Figures 2(a) and 2(b) show the shape of the wavelet for CDS and VDS data. A significant difference can be noticed in the wavelet shape of the broadband signal – the side lobes are very small. This fact is critically important for the inversion algorithm: the less side lobes we have, the less interference there is in the seismic signal and, as a consequence, less ambiguity in the inversion. Figure 2(c) compares the two spectra, black for CDS and blue for VDS data. We can see the difference in the frequency content, notably the presence of low-frequencies in the broadband data.

The initial model was created based on well X logs with P-waves velocity and density values being interpolated along basic horizons. The model was filtered with the low-pass filter 2-5Hz. Figure 3(a) show this initial model of acoustic impedance along a random line. Stating with this initial model Figure 3(b) and Figure 3(c) show the inversion result for CDS and VDS data. The most obvious difference between them is that the broadband result lets us see the sharper borders of the pay interval of the reservoir (indicated by blue – low impedance zones), a clear delineation of the oil-water contact. The same effect can be seen on the horizontal slices of Figure 4(a) and 4(b) which correspond to the level of the oil-water contact within the Eocene reservoir. This benefit gained from the inversion of the broadband data will help to better define the geometry of the reservoir and decrease the uncertainty in calculating reservoir volume.

Conclusions

The lack of low frequencies in conventional seismic data means that seismic inversion relies traditionally on a well-derived low frequency model to recover estimates of absolute acoustic impedances. The accuracy of this low frequency model is often questionable when well data are sparse. Low frequency acquisition using variable depth streamers provides valuable information to constrain the inversion process and obtain accurate impedance estimates without using a log-derived low frequency model. Our comparative inversion study shows that the extended frequency content achieved using the VDS acquisition yields significantly improved inversion results, better delineation of the oil-bearing reservoir.

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References

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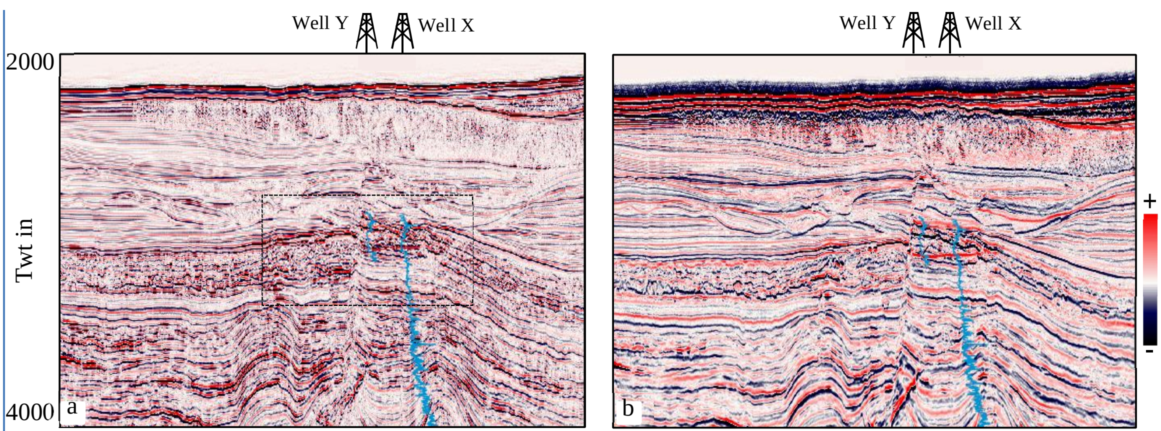

Figure 1: *Random seismic section through Wells X and Y. PSTM of CDS (a), PSDM converted to time domain of VDS(b). The dotted rectangle precise the limits of the inversion display of Figure 3.*

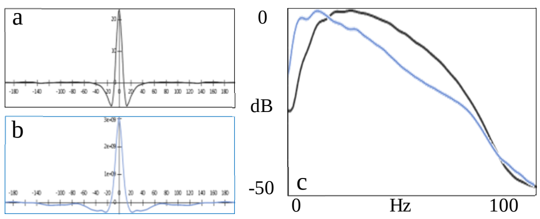

Figure 2: *Wavelet shape CDS (a) and VDS (b), amplitude spectra (c), black for CDS, blue for VDS.*

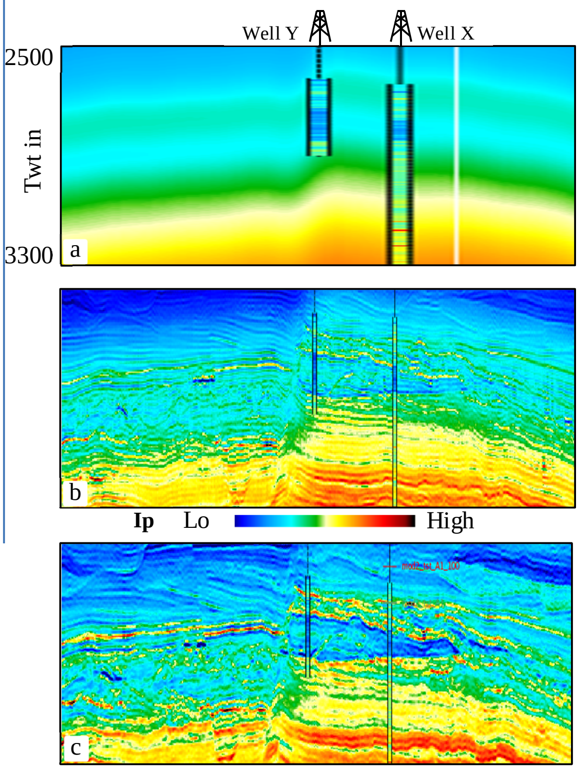

Figure 3: *Inverted Ip section. Initial model (a), inversion for CDS (a) and VDS (b).*

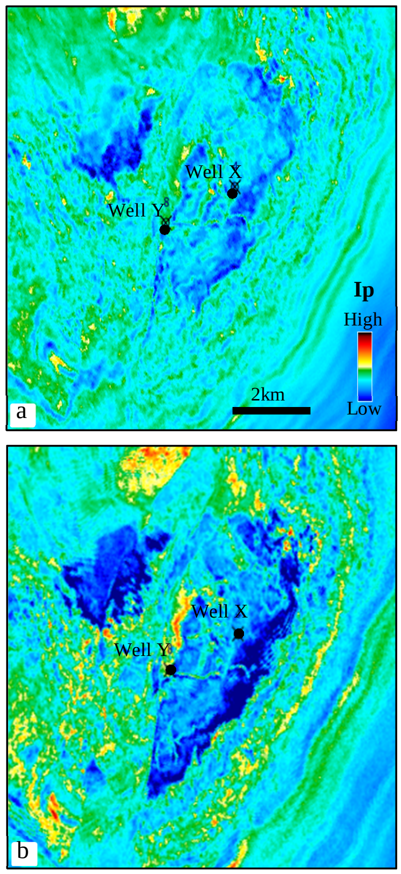

Figure 4: *Ip time slice just above the OWC for CDS (a) and VDS (b).*