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ABSTRACT

MULTICOMPONENT OBC (4C) PRESTACK TIME IMAGING OVER PAMBERI, LRL BLOCK, OFFSHORE TRINIDAD

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Summary

Results from the P-P and P-S_v prestack time migration of a 2.5D four-component (4C) OBC seismic swath test acquired in 2004 over the Pamberi area in Block Lower Reverse L offshore Trinidad, are presented. The 4C swath acquisition consisted of twelve 100-m spaced source lines, shot into two parallel 15-km OBC receiver lines, separated by 400 m. A description of the processing applied to the recorded multicomponent (4C) seismic data, through curved-ray anisotropic Kirchhoff prestack time migration for both the compressional P-wave and mode- converted PSv-wave, is provided. Mode-converted shear-wave data acquired from 4C surveys allow for imaging where conventional seismic data are perturbed due to the presence of shallow gas and/or fluid in the pore spaces of the rock. Furthermore, mode-converted shear waves propagate with a different raypath than that of the compressional wave, thereby providing an alternative illumination of the subsurface target. As both the compressional P-wave and mode-converted S-wave record independent measurements of the same subsurface, more reliable rock properties can be uniquely determined, allowing for improved reservoir characterization and lithology prediction.

A conventional towed-streamer 3D volume was acquired over the Pamberi area in 2003, but failed to image or resolve adequately the target reflectors comprising the reservoir under the main growth fault. Therefore, the purpose of the 4C swath test was to evaluate the potential of long-offset multicomponent technology for resolving stratigraphic interpretation in complex areas with challenging geology.

The processed images from both the compressional (P and Z components summed) and mode-converted shear waves are shown to illustrate the improvement in resolution at the reservoir level that was not clearly evident on the previous conventional towed-streamer 3D data volume.

Introduction

The 4C acquisition area is located in the Columbus basin 50 km southeast of Galeota Point Trinidad and covers the Pamberi area in the Lower Reverse L block.

Previous 3D seismic surveys (1993, reprocessed 1994, 2000, and 2003) and nearby well data in Lower Reserve L and SECC as well as acquisition specifications from surrounding historical marine 3D surveys provided the technical basis for conducting the multicomponent OBC (4C) test survey.

The stratigraphy of the Pamberi 4C acquisition area is comprised of shales and sands of mainly Plio-Pleistocene and younger age. These rocks comprise a prograding-aggrading basin fill package and span depositional environments from fluvial to distal shelf and slope to basinal settings. Reservoir target depths range from 12,000 to 17,000-ft (2500-3800 ms P-P time). Shallower as well as deeper prospectivity exists in the area but are considered higher geologic risk. The entire shallow section is clastic sand dominated down to 10,000-ft, with high concentration of shale thereafter. The sands are sourced from the Orinoco Delta deposited on a shallow shelf. Although the target section is all Pleistocene, there is some Miocene and Cretaceous at 30,000-ft that is carbonate. The section is normally pressured to approximately 10,000-ft (close to the base of the sand-dominated section) and thereafter becomes highly over pressured with increasing depth.

There are several well-imaged strong reflectors in a down-thrown fault trap that make up the prospect; however, the up-thrown side experiences a problematic shadow effect. This cannot be explained by lithological change, as they all comprise of shelf clastics (early to late Pleistocene sands and shales from the Orinoco). The observed fault shadow effect results in apparent velocity sags between fault blocks deeper in the section. The faults act as pressure seals and these apparent sags may in part be due to over pressure. Ranges of mud weights are 8-16 lb. At about 10,000-12,000-ft, all wells in the area abruptly shift from ~8 to ~16 lb (approximately coincident with shale transition – representing shelf edge). Also, some shallow gas may have effect as well, slowing the raypaths, contributing to the sag effect.

A streamer 3D seismic survey was shot in 2003 parallel to the regional fault trend over the Pamberi area using a single vessel towing six cables. The cable length was 5200 m with a final bin size of 25 x 30 m. Despite undergoing recent processing, the events at the target level under the main fault were inadequately imaged for detailed interpretation.

The objective of the multicomponent OBC (4C) swath test is to identify the lithology/reservoir potential of the events around 10,000 to 14,000-ft in depth, using both conventional P-wave and mode-converted PS_v-wave datasets, processed through anisotropic curved-ray P-P and $P\text{-}S_v$ prestack time imaging. Lithological characterization of the reflectors under the fault would, therefore, require not only improved structural imaging but also valid integrity of relative amplitude and phase.

Results and Conclusions

The final image and gather quality of the P-wave (P, Z data) and PS_v-wave (X, Y data) processed through anisotropic Kirchhoff PrSTM proved very encouraging. Despite the limited crossline aperture of the single swath, a 3D approach to the processing yielded improved signal-to-noise and better continuity of events. Velocity fields derived from the seismic data agreed closely with the observed geology and measured pore pressure change in proximity to the Pamberi-1 well. Anisotropy for the PS_v data, derived from the Annie model utilizing surface-seismic short-spread velocities, also correlated closely to the localized geology and shale transition zone.

The final P-wave (PZ) PrSTM stack for inline 1009 compared to the destretched PS_v-wave PrSTM stack with an overlay of the computed interval V_p/V_s ratio (from V(P) and V_v(S) migration velocities) is shown in Fig. 1(a). The intervals of lower V_p/V_s ratios, designated by the warm red colors, indicate higher probability of hydrocarbon sands. Another P-P to PS_v comparison display, over the down-thrown side of the fault, is shown in Fig. 1(b). Strong amplitude differences from contrasting acoustic and shear impedance for similar events are highly evident here. Understanding these types of differences between P-P and P-S responses through lithology classification from joint prestack inversion is an objective for future work.

Fig. 2 shows the improvement in resolution and detail at the reservoir level of the (PZ) P-wave image compared to the 3D streamer section.

Future work

Imaging under the main fault has been notably improved on both the P-P and PS_v-wave stacks; however further enhancement can only be achievable through depth tomography with more detailed anisotropic traveltime ray tracing. The remarkable amplitude differences noted (of shear and acoustic impedance) between the correlated events on the P-P and PS_v sections and attributes such as the derived interval V_p/V_s ratio clearly need to be understood qualitatively. As a consequence, a new project has been initiated in 2006 to run full waveform prestack joint inversion on PP and PS_v gathers processed through anisotropic PrSDM using cell-based grid tomography calibrated to wells, designed to extract rock property attributes for lithology discrimination.

Acknowledgements

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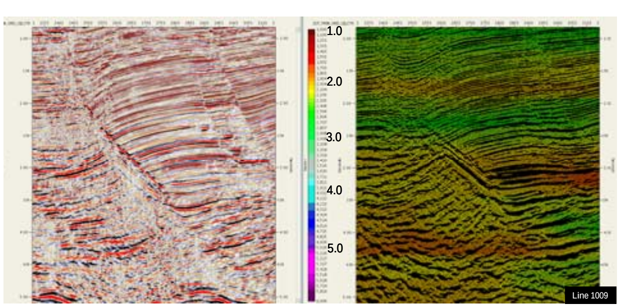

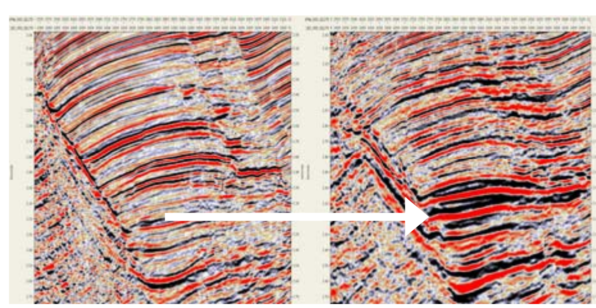

Figure 1(a). Final P-wave (PZ) PrSTM stack compared to final PS_v PrSTM stack (right) destretched to PP time with color overlay of interval V_p/V_s ratio.

Figure 1(b). Final P-wave (PZ) and PS_v PrSTM stack (right) destretched to PP time showing amplitude differences on down-thrown side of the fault.

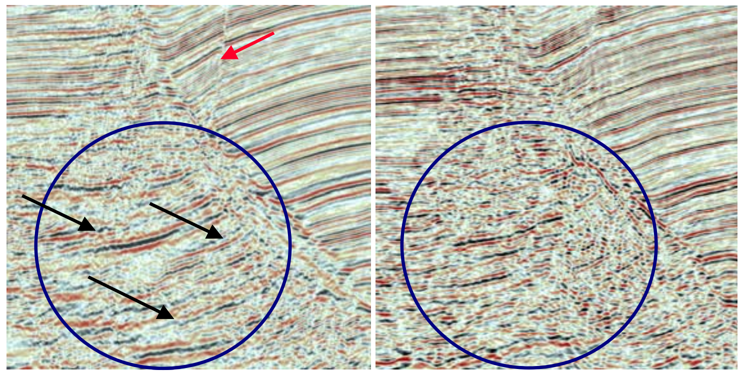

Figure 2. Previous 3D towed-streamer section compared to final P-wave (PZ) PrSTM stack (left), showing improved fault de-finition and resolution / continuity at the reservoir level under the main fault (blue