PSDM applications in Albacora Field, Campos Basin

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Abstract

Albacora field has a seismic survey acquired in 2002 whose area is 720 square kilometers. This extension and the variety of reservoirs, which contains since Cretaceous until Tertiary turbidite sandstones along ring fence area, required a velocity model building for prestack depth migration (PSDM) using regional horizons: Sea bottom, gray marker, blue marker, seismic cretaceous and top salt. During interpretation of PSDM data some improvements have been observed: better lateral positioning of geologic events (e.g. faults, sloping beds, channels) and enhancement of image in the vicinity of regions with lateral velocity variations (canyons, fault slips) northern of ring fence area. Attribute analysis in PSDM data have confirmed these benefits, which have resulted in change of the spatial positioning anomalies in relation to time maps.

Introduction

Reservoir characterization uncertainties in offshore conditions are a challenge during development of oil fields. Although there are wells available to do seismic calibration, the time-depth conversion remains being a critical variable. These uncertainties can cause serious problems in geosteering wells and reserves estimation. Time depth conversions using vertical-ray and image-ray techniques have obtained good results in Albacora field area. Nevertheless, some results during well drilling in faulted zones have led to a revision of the time-depth conversion methods. Furthermore, the need of images with more confident positioning in a region of submarine canyons, which causes strong velocity variations, motivated a prestack depth migration (PSDM) project. Improvements in the whole seismic data were another objective, in order to achieve the exploratory upsides in ring fence, such as subsalt leads.

Method

Poststack images are generated by an NMO correction based on stacking velocities of CMP gathers, followed a DMO correction and stack. These stacked traces then are imaged, using either straight raypaths (for time migration), or crooked zero-offset raypaths (for depth migration). In contrast, prestack migration is a single-step process, with prestack time migration imaging with straight raypaths using rms velocities, and prestack depth migration imaging with kinematically correct, typically crooked raypaths using interval velocity. For each offset in depth migration, the raypaths will change according to the interval velocities that they find on their way. In time migration, the same rms velocity is used for each offset (Rietveld *et al.,* 1999) (figure 1). The essential point in prestack depth imaging is that refraction phenomenon is taken into account, which is not completely reached in prestack time migration.

Depth imaging technology has been indeed driven, for the past 15 years, by complex structures imaging issues such as subsalt imaging (Stunff, 2007). In recent years the systematic use of depth imaging spread to less complex subsurface settings, especially in the North sea or offshore Africa, where it was once only an add on top of time imaging (Stunff, 2007).

In Albacora field seismic data, regional horizons were used to build a velocity model (figure 2). By using the Dix equation (1955), rms velocities are transformed in interval velocities. The velocity model refining is made by tomography. After that, the data is migrated by PSDM Kirchhoff Algorithm. Several interactions of tomography and migration are performed in order to obtain the best image.

An additional step after depth migration was the inversion of full-stack data. From a PSDM full-stack volume scaled to time, the acoustic impedance was estimated. The intention was to produce an acoustic impedance cube with the benefits of PSDM.

Interpretation

Seismic interpretation in the PSDM volume has focused on three main points: reservoir interpretation in the PSDM volume without well calibration (amplitude and acoustic impedance), attribute analysis and well calibration for each reservoir.

During reservoir interpretation it was observed a significant improvement in lateral positioning of geologic events (faults, channels), besides a quite definition of contours near a region with velocity lateral variation. In this case, the attribute analysis has shown considerable displacement of anomalies, which implied a better spatial accuracy and delineation of geometry for some depositional reservoirs features, when compared with maps extracted in PSTM. The facies of Oligocene turbidite in well A show a sequence of interbedded sandstone and shalestone, incoherent with the well position in PSTM amplitude map (figure 3a). In PSDM amplitude map, the well location appears in a most probable position (figure 3b), according to their facies distribution (figure 4). In another region of Oligocene Sandstone, where theoretically problems due to lateral variations are not expected, attribute analysis have shown changes at reservoir boundaries position in relation to PSTM amplitude map (Figure 5). This means that even in regions with mild structural complexities, PSDM may reveal variations in positioning of depositional aspects (channels, pinch outs, etc).

In Cretaceous Sandstone area, which is extremely affected by a fault system with salt tectonic origin, PSDM have shown a displacement in fault positions in contrast with PSTM. This behavior has been realized in interpretations with image-rays conversions (De Gasperi et al. 2004, Lima et al. 2005). A new seismic interpretation was performed with PSDM volume for reservoir, with more detail and confidence in positioning of structural events. It was identified by PSDM interpretation six wells, which crossed faults in Cretaceous Sandstone, what was not possible to observe in PSTM maps. Changes in isopach maps and internal stratigraph of reservoir were a result of this analysis. Figure 6 shows a picture of new reservoir model.

Another use of PSDM data was helping guide for geosteering wells in current development project. An excellent forecast of shalestone between two sandstones bodies within a horizontal well was possible, by using both amplitude and acoustic impedance data (figure 7).

The PSDM calibration to wells was based in regional horizons and reservoirs tops. For each horizon a correlation between interpreted depth horizon (not calibrated) and geologic well markers has been made. This crossplot furnished a linear relation (figure 8). After some residual corrections, the interpreted horizons depths are honored to well depths. These corrected horizons can be used to generate a model that transforms the PSDM original volume in a data with depths adjusted. The advantage of this technique is the possibility to calibrate each reservoir area, from the same seismic data, not calibrated initially, in depth. Similar procedure has been discussed by Daltro *et al.*(2003) in Roncador field.

Conclusions

Prestack depth migration in Albacora Field has brought many contributions, mainly the improvement in the overall seismic image and correct lateral positioning. These benefits have transmitted confidence in well calibrations and helped in projects of update geologic models. Other applications of interpretation PSDM data are: Revision for some well locations in current development project, including implications in geosteering; uncertainties decreasing in depth forecasts; better comprehension about depositional features and the review of fault positioning.

Acknowledgments

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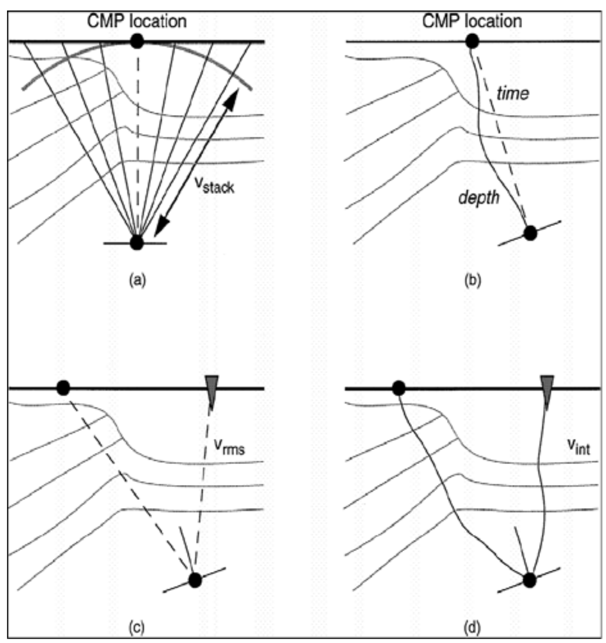


Figure 1: raypaths and velocities used in poststack time migration (a), poststack depth migration (b), prestack time migration (c) and prestack depth migration (d) (From Rietveld et al. 1999).

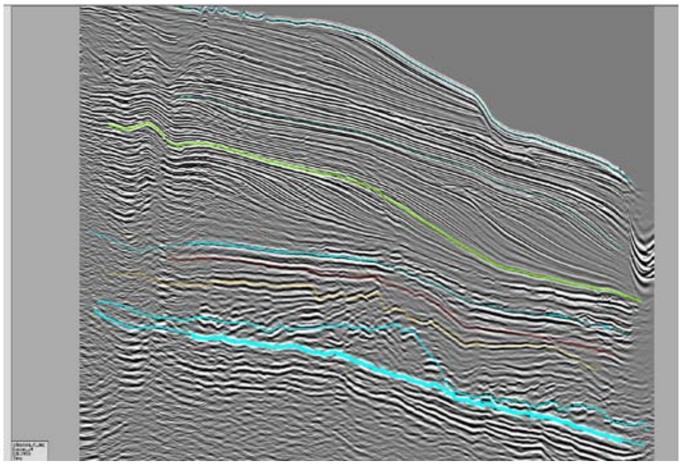
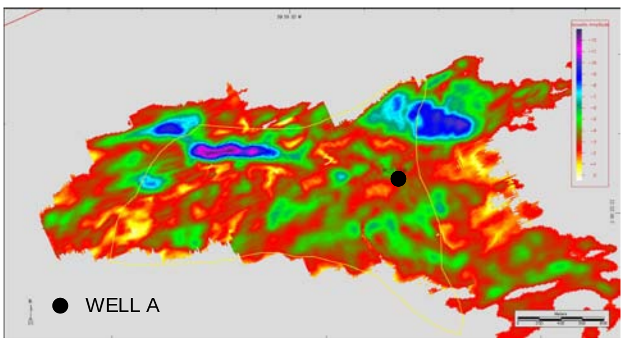
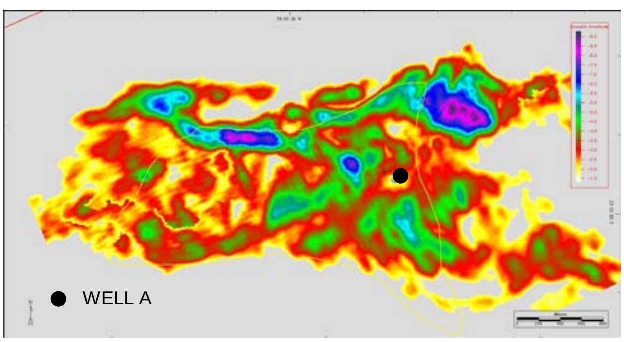


Figure 2: Seismic section of Albacora field and regional horizons interpreted.



a)



b)

Figure 3: Amplitude map of Oligocene reservoir. Note amplitude displacement around well position in PSTM map (a) and PSDM map (b).

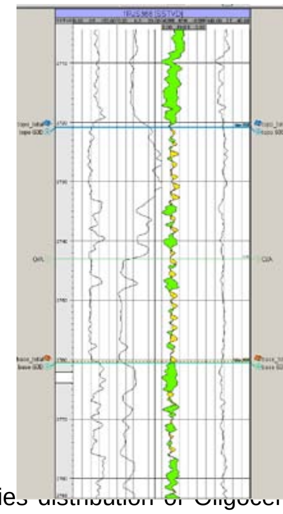
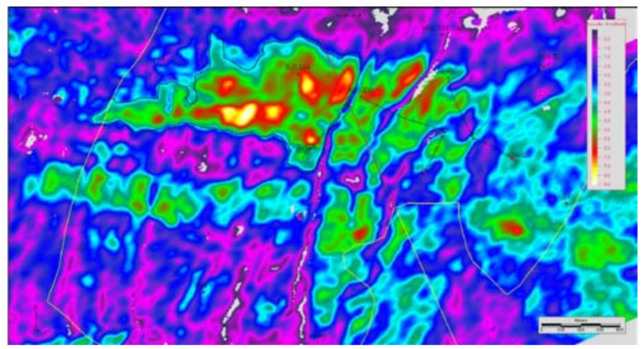
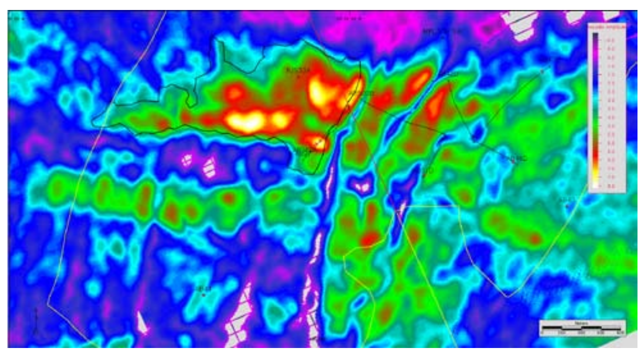


Figure 4: Facies distribution of Oligocene reservoir, well A.



a)



b)

Figure 5: Amplitude maps: a) PSTM and b) PSDM of Oligocene reservoir southern of Albacora field. Note the change at reservoir boundaries (black solid lines).

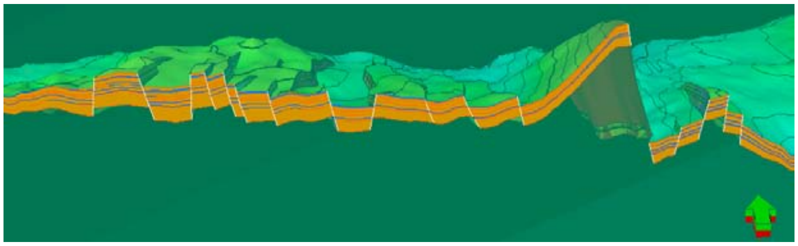


Figure 6: Illustration of geologic model built from PSDM interpretation and calibrated with wells.

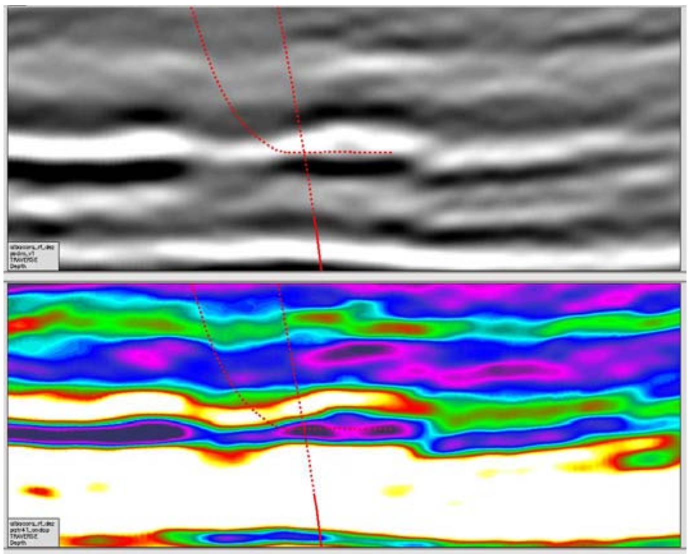


Figure 7: Amplitude (above) and impedance (below) sections showing the horizontal well location which, along trajectory, were predicted and found two sandstones bodies with a interbedded shalestone.

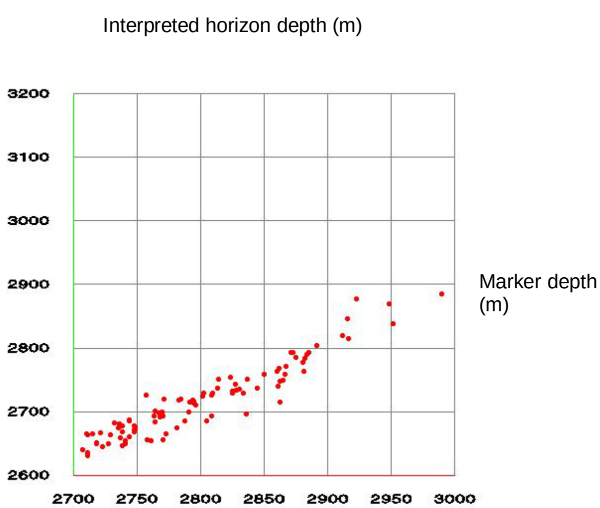


Figure 8: Crossplot between interpreted horizon depth in PSDM volume (X) and markers depth (Y).