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A Case Study: Using 3d pre-stack depth migration to improve the sub- salt image in Marbella, Mexico, Gulf of Mexico

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ABSTRACT

Marbella is an area with extensive salt domes and salt sheets combined with complex compressional features. The 3d time migration performed on the dataset was insufficient to resolve the imaging problems in this complex area. In the time migrated dataset there were problems defining the base of salt for most of the survey and the sub-salt faults and sub-salt sediments were also not imaged. The purpose of this study was to build a geologically based velocity model and apply 3d pre-stack depth migration in order to better image the base of salt and sub-salt sediments.

INTRODUCTION:

3d pre-stack depth imaging can be very useful in improving the seismic image in complex areas. In this particular study, the MARBELLA project, the objective was to try and obtain a better sub-salt image. The interpreters for the project had information from nearby producing fields that it was quite common in the area to have sub- salt structures related to compressional faults. Unfortunately the 3d time migrated dataset did not help resolve this question as there was very little reflected energy sub-salt. The purpose of the study was to build a geologic velocity model and apply 3d pre-stack depth migration in order to better image the base of salt and sub- salt sediments.

The interpreters of Marbella, had information from nearby producing fields that it is quite common to have sub-salt structures due to compressional faults. Unfortunately the 3d time migrated image did very little to help them prove or disprove this idea as there was little reflected energy below the salt.

Time migration algorithms cannot resolve the image in complex areas where lateral velocity contrasts are large as in Marbella which has salt and anhydrite with velocities of 4300-4700 meters/sec truncating laterally against sediments of 3500 meters/sec. Depth imaging techniques can be very useful in theses areas as depth migration algorithms do not have this limitation.

METHOD:

The input data for this study included CMP gathers, a 3d DMO stack volume, a 3d time migrated volume an initial interpretation of key velocity horizons and stacking velocities.

Stacking velocities can be used as an initial model down to the top of the salt. Stacking velocities were extracted along each of the time migrated maps in order to produce stacking velocity maps related to each of the key horizons. These stacking velocity maps were then converted to interval velocity maps using Dix transform. The interval velocity maps were then used to migrate the maps to depth. The map migration program is designed to correct for image ray error inherent in time migration. This is a layer- based approach and was performed for the horizons down to and including the top of the salt. Having both interval velocities and corresponding depths, a velocity depth cube was constructed for the upper 3000 meters of the section, deep enough to include all of the top of the salt.

Using forward modeling techniques it was determined that an aperture of 2800 meters was sufficient to image the top of salt in the depth migration. Kirchoff 3d pre-stack depth migration was then applied to every 15th inline to a depth of 3000m. These inlines are the velocity control lines. The output of this process was CIP gathers (depth gathers) as well as a depth stack.

CIP gathers are very useful in refining the velocity model. Residual horizon velocity analysis was performed using the CIP gathers as input and the depth maps as the horizons. The residual moveout is a measurement of error and was interpreted in the gathers at each CMP location for each of the velocity lines. These errors are then the input into a 3d global tomography program which uses a least squares approach to minimize the errors in the velocity depth model. Some errors were found in the velocity model and 3 iterations of the pre-stack depth migration followed by tomography were necessary to determine an accurate velocity model for the layers to the top of the salt.

The next step was to image the base of salt. A salt velocity flood of 4500 meters/sec was used and a PSPC Post stack depth migration performed. In this dataset, the Post Stack migration did very little to resolve the problem.

Pre-stack depth migration was then performed on selected inlines and crosslines again with the salt flood. Though this did not resolve the problem over the entire survey, it did improve the base of salt image in some areas. Where possible the base of salt was then interpreted and a sediment flood of 3700 meter/sec was used below the base of salt.

After the sediment flood, sub- salt sediments were better defined and interpretations were made directly on the depth section. Again the pre- stack depth migration- tomography loop was used to refine the velocity- depth model. In this part of the section 5 iterations of this loop were required. In these iterations, the migration aperture was increased to 6000 meters in order to image steeply dipping sediments below the salt.

EXAMPLE

Figure 1 shows typical results from the study. In this case the salt was a thin irregular body. The steeply dipping sub-salt sediments are more continuous and easier to interpret on the depth section (Display B). This was the case in approximately 50% of the survey, with the other 50% seeing little or no improvement.

CONCLUSION:

Based on results similar to Figure 1, the project was considered a success. Results of the depth migration did improve the seismic image mainly in the southern end of the survey where the salt was not very thick. The results were useful in defining several possible well locations. An important point to be made is that the pre-stack migration did not resolve the problem for the whole area and this must be a consideration when deciding whether to migrate an entire volume or to migrate a sub- set of the volume.

A

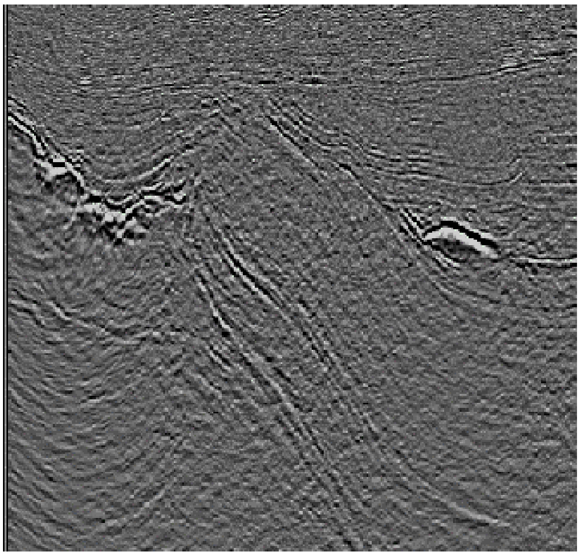

Figure 1. Display A shows a time migrated section, In line 115

B

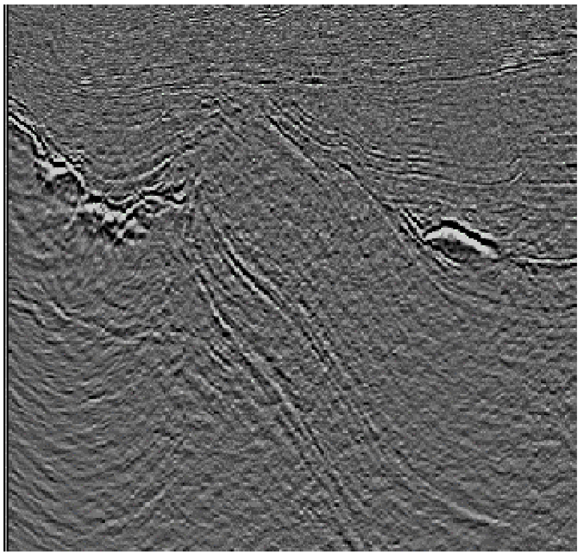

Figure 1.Display B shows depht image,Inline 115

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