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CRS Workflow for Enhanced 3D Seismic Salt Imaging and Model Building

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SUMMARY

A case study for 3D seismic land data from Mexico uses high-resolution CRS attribute volumes for improving the imaging and model buildung in salt geology. Initial CRS time processing provides both, an initial outline of the salt body, and general information for constructing the depth model. On one hand, sediment and salt areas are more clearly separated by a conspicuous drop of reflection continuity in the CRS time images. On the other hand, the CRS attributes contain abundant information for constructing a reliable velocity depth model by CRS tomography. The smooth CRS depth model is well suited for initial poststack and prestack depth migration (PostSDM and PreSDM). PostSDM transfers the good structural resolution and salt body delineation of the CRS time domain images to depth, thus supporting the initial salt body definition in depth. Furthermore, a CRS-based noise suppression and regularisation of the prestack data improves the iterative sequence of PreSDM imaging and model refinement. The CRS depth processing approach finally leads to a 3D PreSDM volume with a strongly increased resolution and signal-to-noise ratio.

Introduction

Structural subsurface imaging in the presence of salt bodies relies on a gradual model refinment that incorporates all structure and velocity information available at different processing steps. Seismic imaging in time renders the first structural information on the salt structures, and often provides a good outline of the top salt boundary. However, the decisive step to reconstruct the structural geometry in the subsurface is the subsequent depth processing. Depending on the desired accuracy, both, the depth model building and the depth imaging can be very time-consuming and costly steps.

In order to increase the depth resolution and signal quality especially in data of varying fold or quality, the Common-Reflection-Surface (CRS) technique can be integrated at all stages of the general imaging procedure. This paper demonstrates the contributions of the CRS technique to time and depth imaging at 3D seismic land data acquired over salt structures at the Gulf of Mexico coast in southern Mexico.

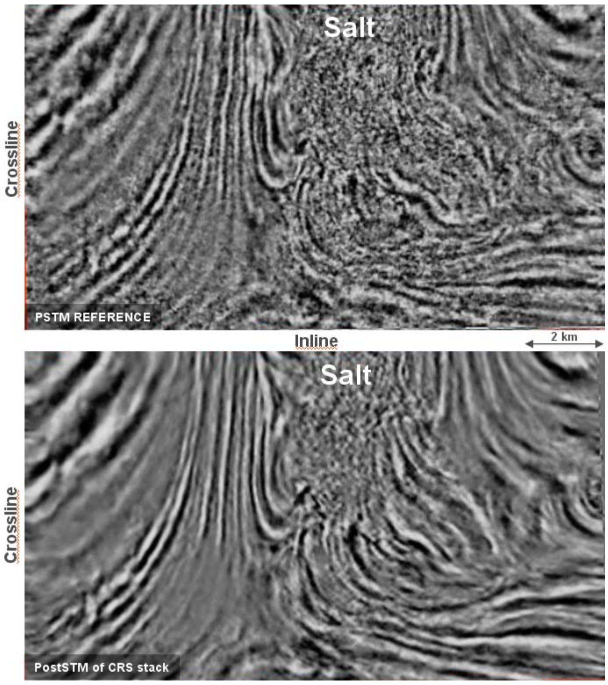

Figure 1: *Prestack time migration (top) versus Post-stack time migration of the CRS stack (bottom). Note the impoved outline of the salt area in the CRS result*

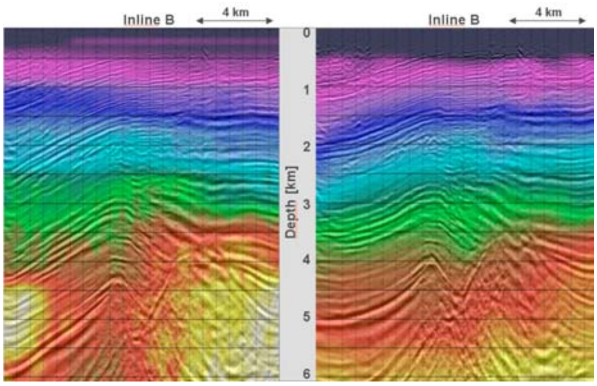

Figure 2: *Dix model (left) versus CRS tomography model (right) with CRS-PostSDM sections.*

CRS method

The CRS method was developed within the concept of macro-model independent imaging (e.g. Gelchinsky 1988, Jäger et al. 2001). CRS stacking assumes local reflector elements with dip and curvature in the subsurface that give rise to the seismic reflections. The corresponding CRS stacking parameters, the so-called CRS-attributes, accordingly comprise the wavefield dip together with wavefront curvatures observed at the surface. They define hyperbolic CRS stacking surfaces that extend across several CMP locations, and thus collect high-fold contributions from the prestack data.

Time imaging

The initial CRS time processing of 3D seismic land data provides high-resoluti-on volumes of both, the CRS image, and the CRS stacking parameters or attribu-tes. Due to an increased signal-to-noise ratio, the poststack time migration (PostSTM) of the CRS stack clearly outlines the salt areas. This is shown at time slices in Figure 1 in a comparison to prestack time migration.

Initial depth model building

The results and parameter fields from time processing are generally used for constructing an initial depth model. For this data, the tomographic inversion of CRS wavefield attributes was compared to conventional Dix inversion of stacking velocities. Dix inversion is the most common and robust method that basically assumes a flat subsurface. Its accuracy, however, degrades with increasing dip and lateral variation of the subsurface structure. For this data case, the deviation of the Dix model from the depth structure in an associated PostSDM volume was obvious even in regions of good data quality (Figure 2 left).

The high information contents of the densely sampled CRS attributes is well suited for a fast reconstruction of a reliable initial velocity-depth model by CRS tomography, or NIP-wave tomography. This grid tomographic approach inverts the CRS attribute data comprising the radius of the so-called NIP wave, and the emergence angle of that wave at the surface (Duveneck 2004). The correspondence of the CRS tomography model to the structures of an associated PostSDM volume is much better than in the Dix case (Figure 2). This improvement is mainly due to the incorporation of structural dip through the emergence angle.

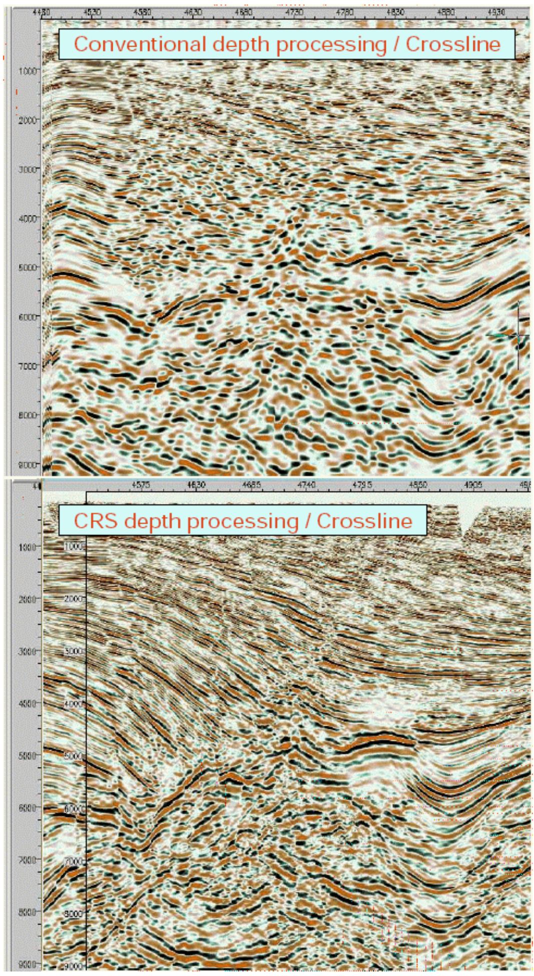

***Figure 3**: PreSDM from conventional and CRS-based approach of model-building and imaging*

Depth migration and model update

The obtained CRS tomography model is a smooth structural representation of the velocity distribution in depth which is especially well suited for depth migration. It was first used in PostSDM for transferring the high signal-to-noise ratio of the CRS stack to depth, allowing an initial definition of the salt body in depth. Using this advanced initial model as a starting point for further depth processing significantly cuts down the number of prestack depth migration (PreSDM) and model updating cycles.

Since the CRS attributes provide a very detailed local description of the seismic data, they may be used for a local regularization and noise suppression in the prestack data by partial CRS stacking before depth migration. A CRS-based PreSDM strategy can include a regularisation of both, the offset and azimuth distribution. Figure 3 compares the result of a conventional stratety of model building and Kirchhoff PreSDM to a CRS-based approach. The noise reduction by partial CRS stacking reveals additional structural features, and especially improves the salt definition.

Conclusions

CRS time processing provides detailed local information on the seismic reflection events in the form of kinematic wavefield attributes. These so-called CRS attributes can be inverted into a depth model by CRS tomographic inversion which is much better constrained than vertical Dix inversion. The CRS tomography model can be used as a good initial approximation of the subsurface velocity for both, poststack depth migration (PostSDM) and further model update in prestack depth migration (PreSDM). Significant CRS-based improvements in depth imaging are achieved by using CRS attributes for data regularization and noise suppression in PreSDM.

Acknowledgements

We thank PEMEX for the permission to present their data.

References

Duveneck, E., 2004, Tomographic determination of seismic velocity models with kinematic wavefield attributes: Phd thesis, University of Karlsruhe, Logos Verlag Berlin.

Gelchinsky, B., 1988, The common reflecting element (CRE) method (non-uniform asymmetric multifold system): ASEG/SEG Conference, Exploration Geophysics, Extended Abstracts, 71-75.

Jaeger, R., Mann, J., Hoecht, G., Hubral, P., 2001: Common-reflection-surface stack: Image and attributes. Geophysics 66 (1), 97-109.