Migration deconvolution is an effective approach for enhancing the illumination of migration images by decreasing imaging artifacts, improving spatial resolution, and alleviating acquisition footprint problems. Because of this, IMP and PEMEX, the Mexican Petroleum Institute and Petroleum Company, respectively, have a strong interest in applying migration deconvolution to relevant Mexican data sets. Results for a complex land data set from Chicontepec basin, Mexico, show that migration deconvolution is indeed capable of improving spatial resolution and stratigraphic definition for turbidite deposits.
INTRODUCTION

Migrated sections are blurred images of the geologic reflectivity distribution, where the blurring kernel is the point spread function, also known as the migration Green’s function (Schuster and Hu, 2000). To partially remedy this blurring, the migration deconvolution (MD) approach was proposed and has been applied to a series of data sets including prestack and poststack seismic data, VSP data, and converted wave data by different authors (e.g., Hu, 1997, 2000a; Hu et al., 2001; Yu et al., 2006).

Based on our previous work on this topic with a complex marine data set (Jiang and Chavez-Perez, 2005; Luo and Chavez-Perez, 2006a, b), we thought it would be an interesting challenge to use MD as a means to improve the quality and resolution of the available 3D prestack time migrated results from Chicontepec basin, Mexico (e.g., Cheatwood and Guzman, 2002; Abbaszadeh et al., 2003). PEMEX Exploration and Production generously agreed to let us use the latest prestack time imaging result of this rather complex land data set.

The data exhibits acquisition footprint problems, migration artifacts and a severe lack of resolution in the target area where turbidite deposits need to be characterized between major erosional surfaces. Results seem to be helpful to achieve the desired goal of using the seismic data to possibly map individual sand bodies and help design development wells in the area (Cheatwood and Guzman, 2002). The main hydrocarbon plays are turbidite beds no more than 60 m thick.

MIGRATION DECONVOLUTION

As a quick reminder, the migration deconvolution equation can be expressed in matrix vector form by

\[ \mathbf{m} = \mathbf{L}^T \mathbf{L} \mathbf{m}_0, \]  \hspace{1cm} (1)
where $L$ denotes the seismic data forward modeling operator that relates the actual reflectivity model $m_0$ to the scattered seismic data $d$, i.e., $d = Lm_0$. $m_0$ denotes the true reflectivity vector, and $m$ denotes the migration image that can be obtained by applying the adjoint $L^T$ of the forward modeling operator to the data. Here, the transpose of $L$ represents the migration operator.

Equation ?? says that the migration image $m$ is a blurred version of the actual subsurface reflectivity distribution $m_0$. To deblur $m_0$, we apply $\Gamma^{-1} = (L^T L)^{-1}$ to both sides of equation (??) to obtain

$$m_0 = (L^T L)^{-1}m.$$  

(2)

This deblurring operator $\Gamma^{-1}$ can be obtained by calculating the migration Green’s function associated with the specified acquisition geometry and velocity model (Schuster and Hu, 2000; Hu et al. 2001).

To improve spatial resolution and illumination of migration images from complex data, we need to be careful to construct the appropriate migration Green’s function or MD filter $\Gamma^{-1} = (L^T L)^{-1}$. For example, MD parameters (e.g., layer width) should be optimized by trial and error for successful results (Hu, 2000a, b; Yu, 2002).

**RESULTS**

MD postprocessing aims to extract more stratigraphic information from the 3D Kirchoff prestack time migrated cube provided to us by PEMEX. The original data size is 518x204x1252 grid points, bin size is 25 m by 25 m, and time sampling interval is 4 ms.

Inline and crossline size of the migration cube for MD is the same as the original data size. The MD filter length $N$ is 11, the condition number estimate to stabilize the inversion is 200 (Hu, 2000b),
and the reference position is in the middle of the model. We used a constant velocity value of 3.5 km/s and a differential filter for the final plots.

Figures 1 to 4 compare migrated time slices before and after MD processing at 0.8, 0.9, 1.0, and 1.2 s, respectively. We see spatial resolution improvements and decreasing acquisition footprint noise in all of the MD images. We think that the MD time slices can now be used more reliably by an interpreter to look for relevant depositional features (e.g., channels). However, before first judgement, we should perform MD point scatter tests for synthetic data with the same acquisition parameters as the real data.

Figures 5 to 10 compare migrated time sections for several inlines and crosslines before and after MD processing. We find that MD produces enhanced sections with more detailed stratigraphic definition and yields better spatial resolution and illumination in the target area where turbidite deposits need to be characterized.

We believe that resolution improvements are due to the fact that the MD filter accounts for the limited frequency band of the source and the spatial aperture of the data, and tends to transform a sinc function response into a point-like object. Thus, spatial resolution increases and the wavenumber spectra of the time slices whiten.

**SUMMARY**

We applied 3D poststack MD to a 3D prestack time migrated data set from Chicontepec basin, Mexico. Results demonstrate that MD improves spatial resolution and stratigraphic definition, and the resulting images now seem to be more helpful to achieve the desired goal of using the seismic data to possibly map individual sand bodies and help design development wells in the area.

Ongoing and future work include the impact of MD results in the workflows of volumetric seismic attributes (Chopra and Marfurt, 2006). For doing this, we will keep close interaction with Kurt
Marfurt, director of the Allied Geophysical Labs (AGL) at the Univ. of Houston. We hope to collaborate with Kurt in producing volumes of MD attributes.

ACKNOWLEDGMENTS

We thank the members of the 2006 University of Utah Tomography and Modeling/Migration (UTAM) Development Project for their financial support. We also thank PEMEX (Petroleos Mexicanos) Exploration and Production for permission to use the data and its financial support. In particular, Juan M. Berlanga, from GGTT (Gerencia de Gestion y Transferencia Tecnologica) de Explotacion, made the data available to IMP and UTAM.

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Figure 1: Time slice results at 0.8 s (top) before and (bottom) after MD processing.
Figure 2: Time slice results at 0.9 s (top) before and (bottom) after MD processing.
Figure 3: Time slice results at 1.0 s (top) before and (bottom) after MD processing.
Figure 4: Time slice results at 1.2 s (top) before and (bottom) after MD processing.
Figure 5: Time section results in inline direction (top) before and (bottom) after MD processing.
Figure 6: Time section results in inline direction (top) before and (bottom) after MD processing.
Figure 7: Time section results in inline direction (top) before and (bottom) after MD processing.
Figure 8: Time section results in crossline direction (top) before and (bottom) after MD processing.
Figure 9: Time section results in crossline direction (top) before and (bottom) after MD processing.
Figure 10: Time section results in crossline direction (top) before and (bottom) after MD processing.