Case Study

Q compensation PreSDM

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This paper describes a successful reprocessing project which included PreSDM and DUG MigQ. Seven hundred and fifty square kilometres of field data were processed. The data suffered from highly variable absorption and anisotropy due to both structural setting and the presence of thick coals. To image this we apply a pseudo Q pre-stack depth migration, dramatically enhancing the image in previously 'washed out' data, whilst retaining the integrity of the amplitudes for AVO analysis and inversion.

The primary objective of this project was to improve the imaging in the section from 1000 to 2500 milliseconds, two way time. Issues to be addressed included attenuating significant amounts of noise of various types, laterally and vertically varying frequency attenuation and significant anisotropy, largely seen in the high amplitude Top Latrobe Coals.

Pre-processing

Five denoise steps were necessary on this data:

1. Swell noise attenuation by identifying anomalous amplitudes in narrow frequency bands, followed by their removal and interpolation from adjacent data; DUG SWATT.
2. Linear noise removal was used to remove the steepest of the dipping noise on the shot records; DUG LNR
3. Shallow water multiple prediction and removal was used in the very shallow areas; DUG SWaMP
4. Tau-P deconvolution using a short gap (just longer than wavelet length) was used to remove 'ringing'. Operators were averaged in common P.
5. 3D True Azimuth SRME in the deeper areas was very effective at removing the considerable surface related multiples.

The comprehensive nature of this noise removal program gives insight into the difficulties faced in processing this data.

Regularisation

Data regularisation was applied to the data before migration velocity analysis and final migration. Regularisation results in data volumes exhibiting:

- less noise
- better event continuity
- significantly better amplitude fidelity.

DUG Reg® is DownUnder GeoSolutions' (Dugeo) data regularisation package. It utilises the wave equation to firstly downward continue and then upward continue the seismic data to the centre of each (IL/CL/offset) bin. DUG Reg® accounts for azimuth and sampling issues and does not suffer from leakage like many similar programs. No trace sum was undertaken during pre-processing, all traces were taken through to regularisation.

Model building

Reflection tomography was used to iteratively build the velocity model. A VTI anisotropic model was built based on well information (synthetic fit) and flatness of gathers at far offsets. The model was checked at each iteration and adjusted when/where necessary.

Dugeo's Reflection Tomography (DUG Tomo) is a sophisticated program which inverts residual moveout to obtain a velocity update. It is clusterised allowing large models and lots of picks to be input. Dugeo's tomography and model building, in general, use a hybrid approach. That is, horizons, faults and volumes can be used. For example, residual moveout picks can be made along horizons, through volumes, or through a mixture of both. Different smoothing lengths were deployed through the volume including across horizons. All picking was done interactively in DUG Insight®, Dugeo's full-featured seismic interpretation package.

Six model building iterations were used during this project. Considerable effort was expended determining the velocity of the sub-coal section where picking of residual moveout was very difficult.

Migration

A true relative amplitude VTI Kirchhoff migration was used on this project. The Green's functions were determined by dynamic ray tracing. The rays are traced through a gridded velocity model with maximum energy rays typically chosen.

Variable depth sampling was used for output from the migration. Testing was performed to ensure that the sampling was sufficient to capture all frequencies unaliased. There were no assumptions made about lateral or vertical velocity variations, apart from the model being 'smooth'. Smoothing distances were quite short in places.

Operator aliasing was accounted for by calculating the slope of the operator and filtering the data on the fly, as necessary.

DUG MigQ is a migration-based workflow which accounted for laterally and vertically varying attenuation.

Laterally and vertically varying attenuation was present due to dipping geological structure, shallow anomalous channels and coals.

Using an attenuation tomography process, DUG MigQ was able to generate models of the attenuation coefficient Q to correct for these effects. After analysing the amplitude and frequency content of migrated data, DUG MigQ used the technique described in "A robust and accurate seismic attenuation tomography algorithm (Hu, W, Liu, J, Bear, L and Marcinkovich, SEG San Antonio 2011, p2727)" to back-project the required correction along ray paths and obtain a geologically-plausible attenuation model.

Having obtained a Q model, DUG MigQ applied the technique described in "Efficient compensation for attenuation effects using pseudo-Q migration (Bear, L, Liu, J, Traynin, SEG Las Vegas 2008 Annual Meeting, p2206)" to compensate for the estimated effect of the seismic attenuation. By making use of geological dip and raypath information, DUG MigQ was able to efficiently compensate for these attenuation artefacts. Following this application, the overall amplitude behaviour of the dataset was more consistent.

Figure 1 shows the Q model along an inline and a crossline reflecting the significant Q variation with depth and laterally.

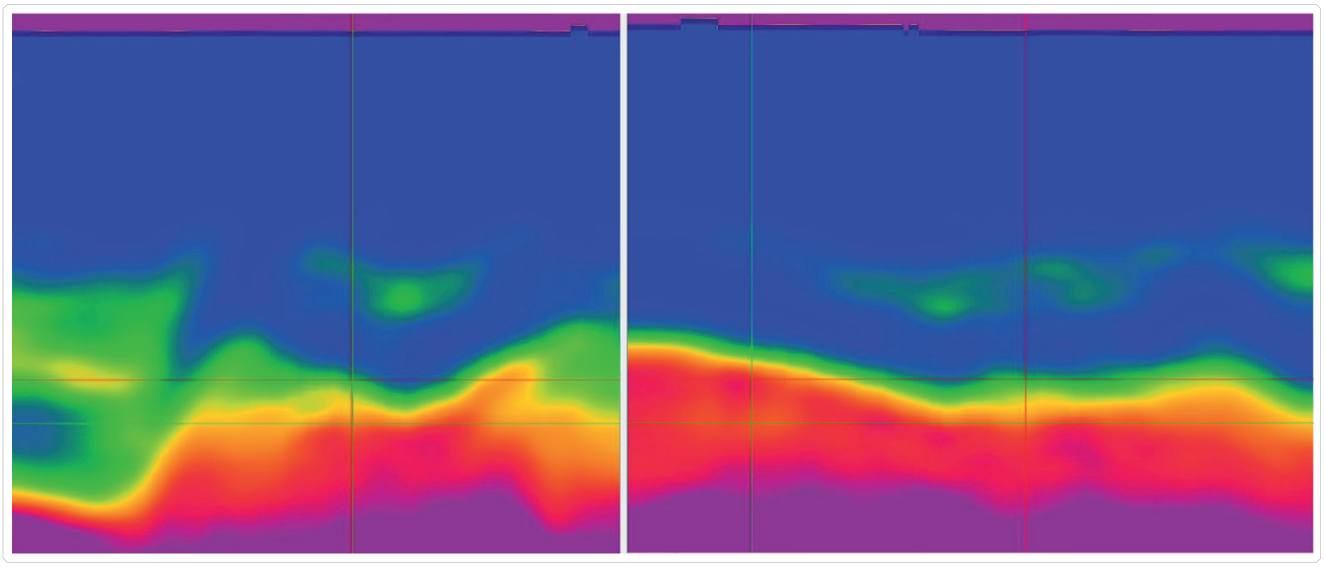

FIGURE 1 Q model along an inline and a crossline.

Figures 2 and 3 give an example of an inline and a gather both with and without DUG MigQ applied. Note how the RMO changes with its application.

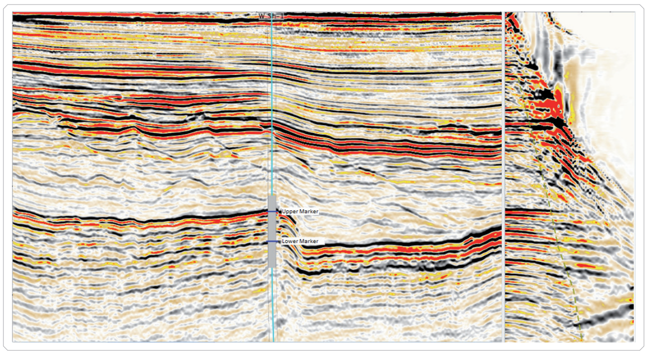

FIGURE 2 Image gather and stack.

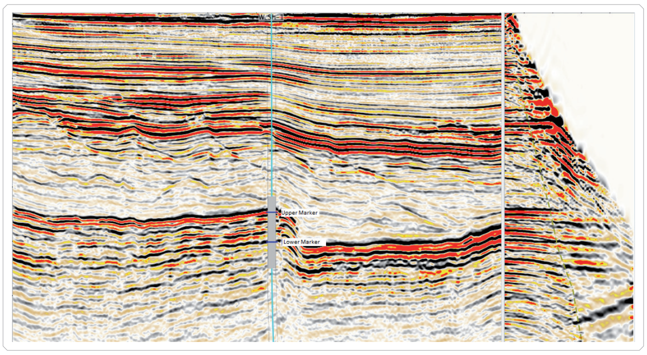

FIGURE 3 Image gather and stack with DUG MigQ.

Conclusions

The processing of this dataset was performed with preservation of primary amplitude data as the highest priority. As such DUG MigQ was an essential part of the processing to address the amplitude, frequency and phase distortions due to shallow anomalous channels and coals.

Considerable effort was expended in determining the velocity of the sub-Latrobe section. This section is confused by the high reflection coefficients from the coal layers resulting in numerous interbed multiples with little velocity differentiation.

The application of comprehensive noise removal, anisotropic velocity model building and DUG MigQ resulted in a significantly better dataset.