Horizon Based Target Orientated Beam Demultiple with Examples from the North West Shelf, Australia.

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SUMMARY

Beam Migration has specific advantages, in its speed and high signal-to-noise levels, which make it suitable for both depth velocity modelling and final imaging. One property of Beam Migration is that wavelets can, based upon a combination of criteria, be weighted down or excluded from reconstruction. It is possible to reject wavelets that match a multi-dimensional multiple model. This model is based upon a combination of interpretation, normal moveout and spatial & temporal location.

Data examples from the North West Shelf, Australia, illustrate the flexibility of this approach and demonstrate its effectiveness in the complex inter-bed multiple area of Browse Basin.

Keywords: depth, demultiple, beam, reservoir

INTRODUCTION

Complex inter-bed multiple in the North West Shelf, Australia, is a problem for depth velocity modelling and imaging of Jurassic reservoirs (see Figure 1.). Traditional Radon & 3D-SRME (3D Surface Related Multiple Elimination) demultiple techniques are now standard processes for removing long period and waterbottom related multiples. However, throughout the Browse Basin, deeper multiple generators and the small velocity discrimination between primary have rendered these techniques ineffective against inter-bed multiples.

The technique presented here builds upon the unique attributes and speed of Beam Pre-Stack Depth Migration (Sherwood et al, 2008) to test models and filter multiple events before summation into the CMP domain.

Case Studies from the North West Shelf, Australia, demonstrate the technique's application in shallow water environments and potential for removing inter-bed multiple from reservoir areas previously masked by unwanted signal.

METHOD

3D Beam Pre-Stack Depth Migration (BPSDM) (Sherwood et al, 2008) comprises three steps: Decomposition, Migration and Reconstruction. The first step decomposes the input time domain data, via a multidimensional slant stack, into wavelets based upon a spatial/temporal uniform Cartesian grid (x,y,hx,hy,t) and dip components (dt/dx, dt/dy, dt/dhx, dt/dhy), along with reflection angle, phase and amplitude.

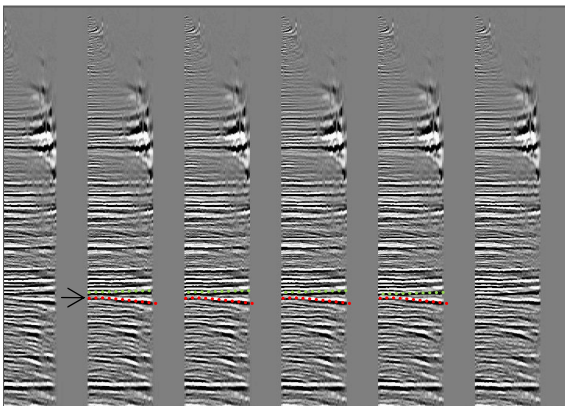

Figure 1. Example BPSDM gathers with interbed multiple shown (arrow/red dash) below the primary unconformity reflector (green dash). (Data courtesy of Finder Exploration)

Given this "dipscan" data, and a current Earth velocity model, it is possible to migrate the wavelets. This second stage retains a point-to-point mapping from time to depth and resulting in an update to the wavelets properties (importantly for this technique, reflector dip and strike (dz/dy, dz/dx)).

Horizon Based Target Orientated Beam Demultiple exploits the unique wavelet attributes calculated during both the Decomposition and Migration stages of BPSDM, to apply a modelled filter to events during final phase of reconstruction in to 3D Common Image Gathers (CIGs).

This three step beam process generates an image which has improved signal to noise over a normal full wavefront Kirchhoff migration. Calculated ray spreading properties enable amplitude corrections to be applied, allowing CIGs to be fed into further AVO or inversion operations.

This "multiple model" is constructed from previous interpreted primary horizons or direct picking of the multiple. "Multiple Generators" (subsurface downward reflections) can be easily estimated and interpreted from stacked or CIG data. These horizons are directly passed into the BPSDM migration engine and wavelets are rejected or weighted down based upon their similarity to the local spatial dip (x,y,z, dz/dx, dz/dy) of the estimated model. Tolerances, application or ramp zones are defined to further improve the demultiple's effect at the zone of interest, whilst protecting overlying events. It is beneficial at this stage, if the visualisation, interpretation and migration engine are on the same platform (see Figure 3.). This speeds up testing and interaction between the modeller and asset geophysicist.

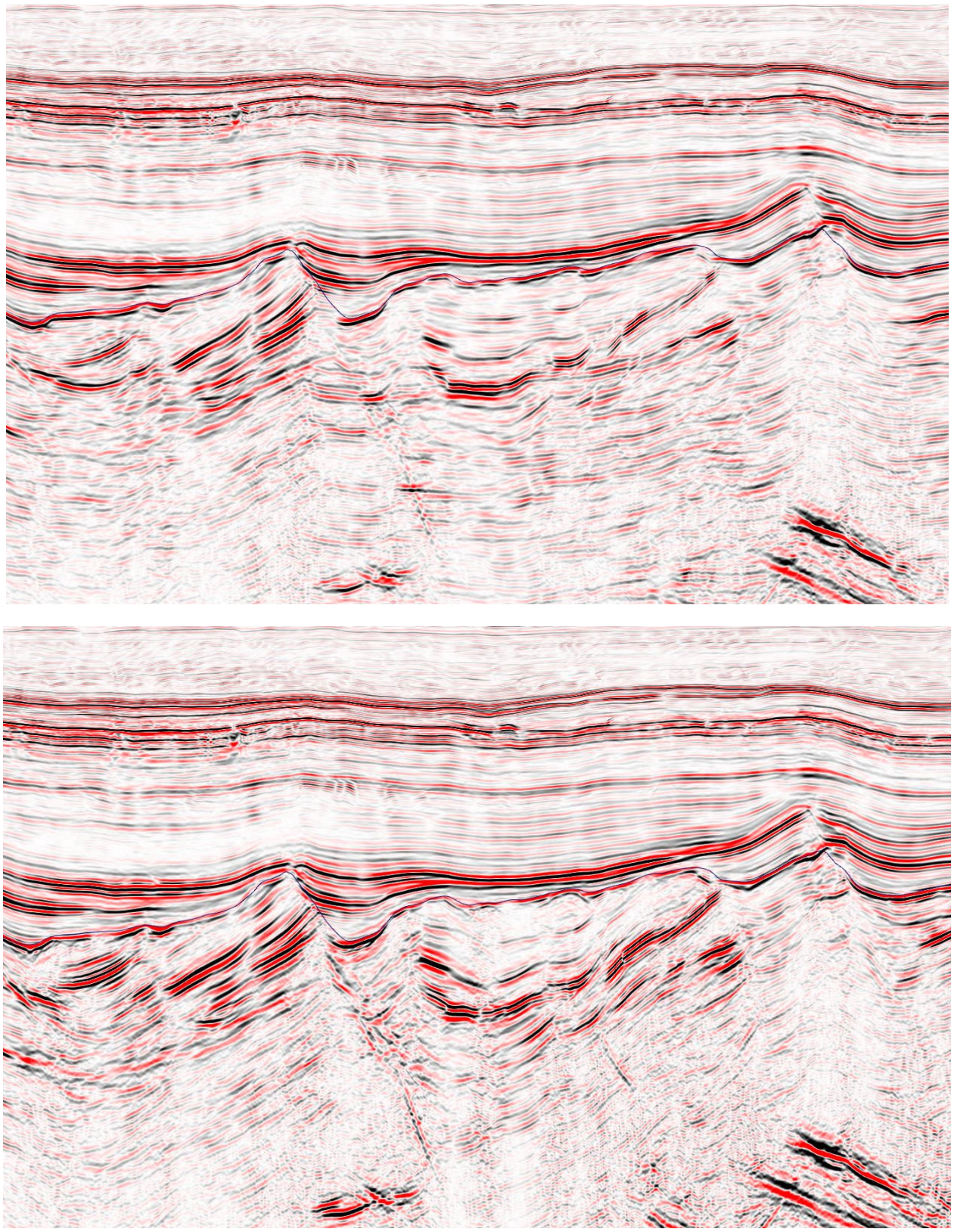

Figure 2. Example from the Central North Sea, Europe, showing clear cross cutting interbed multiple (top) generated from overlying flat reflectors. After demultiple application (bottom), fault reflections, anticline and deeper events now visible. ***(Images courtesy of PGS MultiClient – CNS MegaSurvey+)***

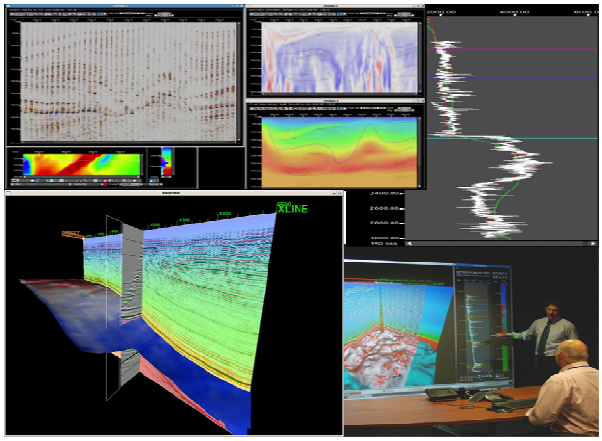

Figure 3. Example displays from a fully integrated depth velocity model building platform, which provides the interactive testing and scenario modelling for the Horizon Based Target Orientated Beam Demultiple.

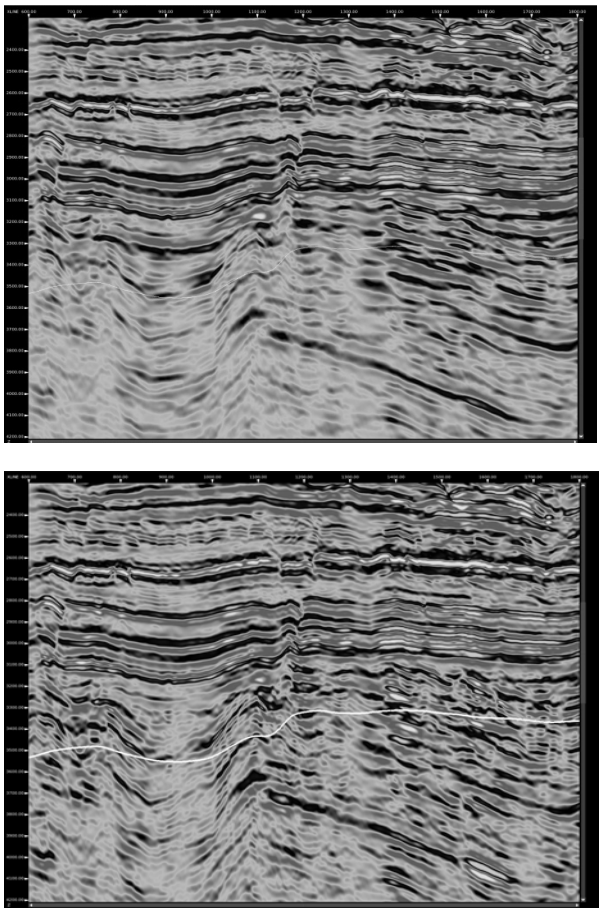

Figure 4. The upper image shows a stack with no horizon based demultiple applied. The lower image is the result of applying the demultiple. The truncations against the unconformity are better mapped and free from cross-cutting interference. (Images courtesy of Finder Exploration)

RESULTS FROM THE N.W. SHELF, AUSTRALIA

This technique was applied to two areas of the North West Shelf, Australia. In the first example (courtesy of Finder Exploration), the main objective was to remove the multiple directly below the unconformity (see Figure 1). Horizon "JO" was selected as the multiple generator (after over 100 scenario tests and applications) then applied within a 500m zone below the "KV" (see Figure 4). Close interaction between imager and asset team was required to match processing objectives. With the multiple removed it was easier to map the truncation of the event up to the unconformity. CIGs are output, so angle stacks where also produced to match previous project's Kirchhoff Pre-Stack Depth Migration (KPSDM) deliverables.

In the second example from the Browse Basin (courtesy of Total E&P Australia and partners), the deeper reflectors at the Jurassic target are obscured by inter-bed multiple energy (upper image Figure 5.). In this case a harsh filter (modelled from the Base Valenginian) was applied to reveal dipping faulted reflectors. However, in some isolated areas the primary & multiple coincided and real reflectors had been attenuated (see lower image – Figure 5). Some multiple remained which could not be modelled without damaging primary reflectors in the target area. This data was provided as fast track to compliment with further traditional processing applied to the KPSDM.

CONCLUSIONS

The examples presented show Horizon Based Target Orientated Beam Demultiple's effectiveness at removing multiple energy from the stack to aid structural interpretation or gain a better understanding of the geology at reservoir level.

Close interaction and good understanding of the objectives, especially between the imagers and the asset team is required for the project's success. Interactive or quick testing of multiple model scenarios (through combined depth velocity model building software) is necessary to aid this interaction.

This demultiple is subjective and qualitative. The resultant image is likely to remove primary energy if the multiple model coincides, and works best when a greater degree of differential between the primary and multiple dip exists.

Typically, this demultiple should be applied in conjunction with additional image products, including BPSDM with radon, Kirchhoff Depth Migration or Wave-based Depth Migrations (WEM or RTM).

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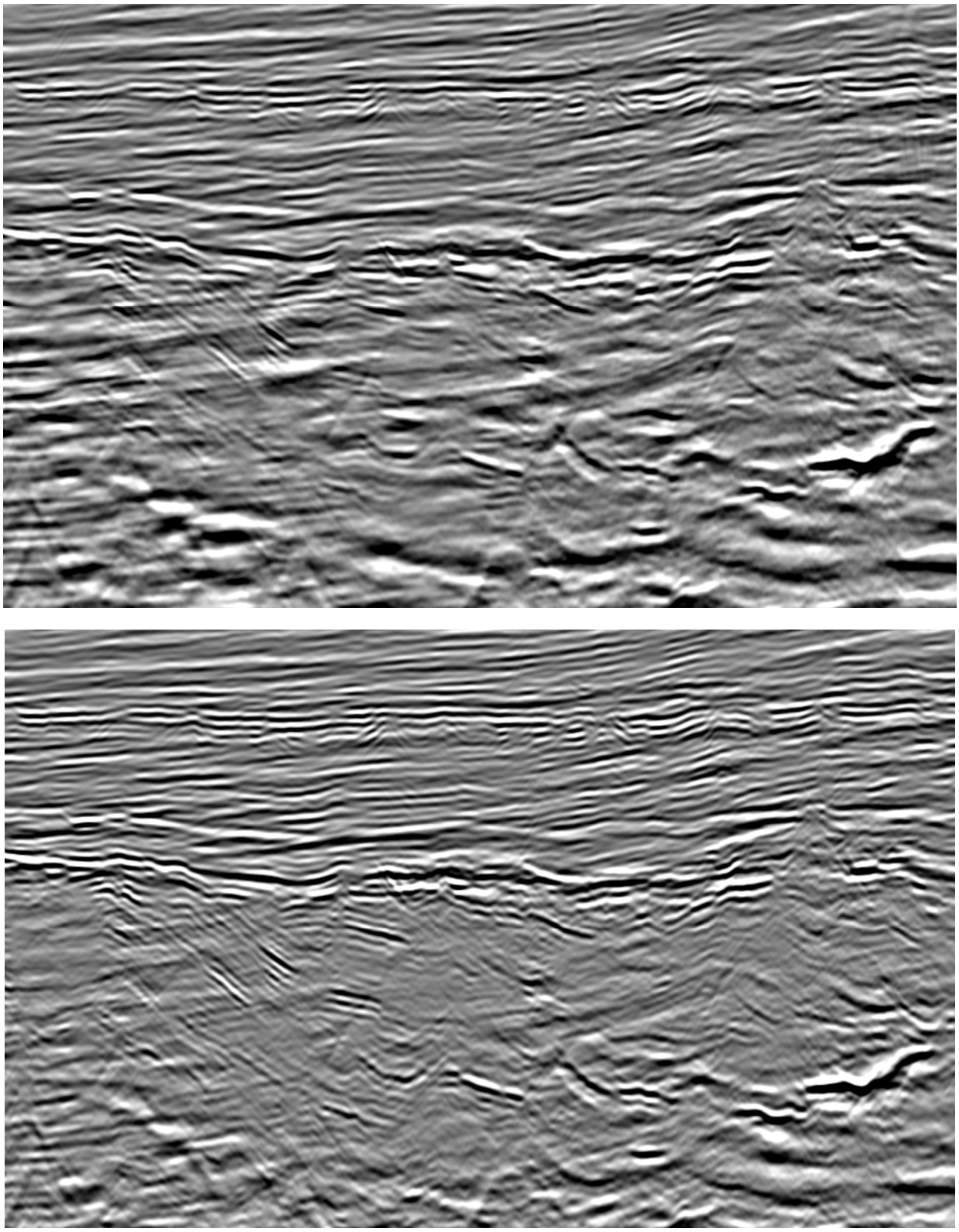

Figure 5. Deeper structural reflections are masked by cross cutting multiple (top image). Subsequently a clearer image against the unconformity with the application of Horizon Based Target Orientated Beam Demultiple (bottom image). However, some deeper primary reflectors have been attenuated. ***(Images courtesy of Total, Santos and Murphy)***