Multi-Azimuth, Multi-Vintage, Pre-Stack Depth Migration for Improved Structure and Reservoir Imaging in Offshore Norway

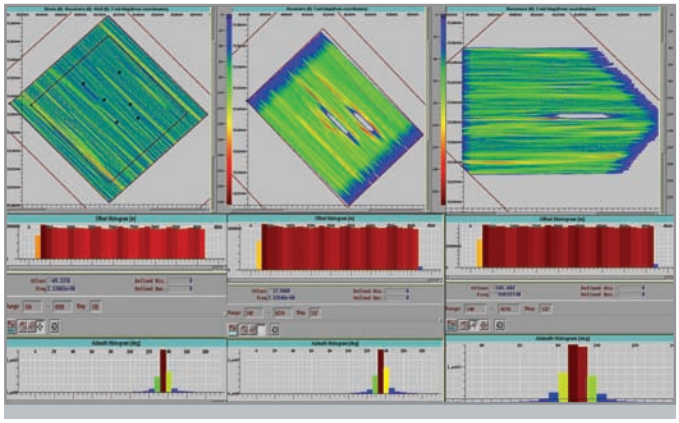
The Challenge

Achieve the best possible image from a strongly compartmentalized and heavily faulted reservoir area, which makes optimization of the field development a highly challenging task.

The Assessment

The Njord field in offshore Norway, developed with 12 oil producers and 4 gas injectors, has been producing since 1996. It is characterized as a very complex field, in which the reservoir is divided into fluid segments by a large number of faults, and the segments in turn are divided into compartments by smaller faults. The client's aim was to image this heavily faulted and compartmentalized area, in order to exploit its reserves to the fullest.

Previous post-stack time migration and pre-stack depth migration studies had enabled the positioning of several wells, but the client now felt the need to improve the accuracy of the existing reservoir interpretation, with the aim of optimizing well positioning in the field.



▲ Base line, monitor and azimuth surveys

The Solution

A pre-stack depth migration study was conducted on three existing surveys (base line, monitor and azimuth), with the goal of building multi-azimuth and multi-vintage summation volumes, in order to achieve the best image in the area of the main reservoir and improve imaging of the complex reservoir fault blocks.

Velocity–Depth Model Building

Using the Paradigm™ GeoDepth® velocity model building software, a six-layer interval velocity depth model was built to represent the velocity changes in the 3D data set. Sonic logs were used to derive the best vertical velocity gradients.

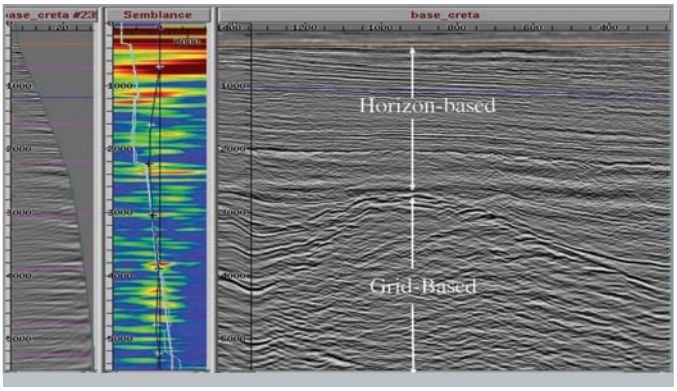
Six iterations of velocity updating were required to create the final velocity-depth model, using Paradigm's combined approach of horizon and grid-based tomography. The first four horizons (where time interpretation was more reliable) were updated using a target oriented 3D pre-stack depth migration, followed by horizon-based residual move-out analysis and 3D horizon-based tomography. In the deeper layers, two iterations of grid-based tomography were performed, resulting in a structure-independent velocity update.

Pre-stack Depth Migration

Base line, monitor and azimuth surveys were pre-stack depth migrated using the same interval velocity-depth model. As a result, depth migrated gathers were generated at each location. To account for minor differences in residual moveout, residual moveout analysis was carried out separately for each survey and applied to flatten the gathers. Flattened gathers were muted using the same mute for each survey, and stacked. Depth stacks were then converted to vertical time using migration velocity model for wavelet processing and matching.

Wavelet Matching and Merge

Amplitude scalar functions were derived from windowed RMS amplitude analysis using Paradigm's Echos™ time processing software, in order to match the amplitudes of the monitor and azimuth surveys to the base line survey. After the amplitude matching, the monitor and azimuth surveys were compared to the base line survey, and then matched by applying the respective frequency matching filters. Finally, phase matching filters were applied to deal with the residual phase differences between the base line survey and each of the other two surveys. After matching, the volumes were merged to create multi-azimuth, multi-vintage and multi-azimuth + multi-vintage pre-stack depth migration volumes in time and depth domains.

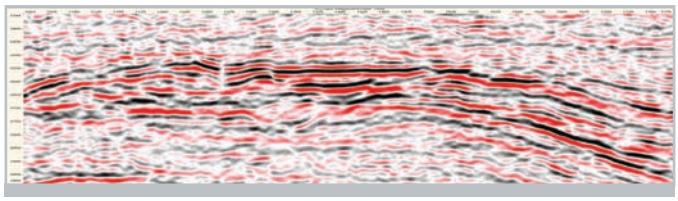


▲ Combined velocity depth model update - horizon and grid tomography

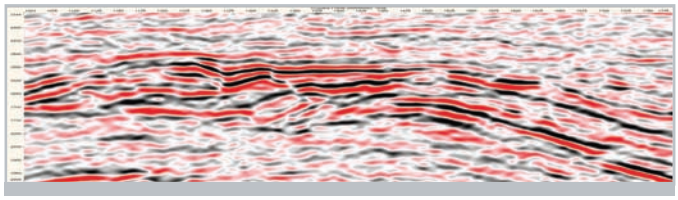
The Benefit

Paradigm's robust velocity model building technique resulted in a reliable final velocity-depth model. Multi-azimuth pre-stack depth migration (azimuth summation) yielded the best image in the area of the reservoir, and significantly enhanced the lateral reflector continuity, fault block definition and interpretability of the data.

The multi-azimuth summation resulted in higher quality seismic images than previous results, especially through the strongly compartmentalized and heavily faulted reservoir area.



▲ Post-stack time migration (NW-SE azimuth)



▲ Multi-azimuth pre-stack depth migrations , time converted

Paradigm solutions are capable today of handling processing and imaging problems which only a few years ago were considered difficult or impossible to solve.

Paradigm thanks Norsk Hydro for its kind permission to use its data.