RAY BASED ILLUMINATION STUDY OVER THE NORTH SEA P2/ECHO PROSPECT

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Ray tracing can be used in several ways to assist in seismic acquisition planning and prospecting. Here I present an image ray and illumination study, carried out in mid-2008 at the request of Elko Energy Inc. It concerns the illumination by a newly obtained 3D seismic survey of the Echo structure in the P2 block, offshore The Netherlands. Elko Energy was considering pre-stack migration studies over the Echo structure, either pre-stack time migration or pre-stack depth migration. Depth migration is an expensive process compared to time migration and is not justified unless complex velocity fields above the target (due to structural complexity) cause positioning errors at the target level.

A relatively detailed model consisting of five interpreted horizons was available from previous prospecting of the area, with realistic layer velocities obtained from velocity analysis and well data. Based on these data, the first question being asked was whether the assumptions underlying time-migration, i.e. local lateral homogeneity, could be validated by ray tracing. To address this question, an image ray tracing study was done, consisting of ray shooting perpendicularly downward from the acquisition surface to the target reflector (Top Slochteren). A number of model scenarios was tested with several parameter selections for the ray tracing and various degrees of horizon smoothing. For sufficient smoothing, the image ray displacement maps over the target reflector consistently showed that systematic horizontal positioning errors in the range of 200-400m could be anticipated in case of a pre-stack time migration. In addition, it appeared that the northern part of the Echo prospect would be mis-positioned southward, while the southern part would be mis-positioned in an eastern direction. Since displacement errors of 250m are conventionally considered as an acceptable maximum, this supported a decision in favor of pre-stack depth migration.

Following this, a normal ray tracing was carried out, by shooting rays perpendicularly upward from the Top Slochteren target reflector. The purpose of this experiment was to investigate the migration aperture (for zero-offset) and record length needed to image the target reflector. These were found to be at least 4km and 4s, respectively.

Finally, the illumination of the prospect by the available pre-stack data was investigated, by means of a two-point ray tracing for a representative part of the acquisition geometry. Because of the size of the data set (38×10^6 traces) and the computational complexity of two-point ray tracing, a decimation of the acquisition geometry of down to 0.3% was applied, making sure that the offset and azimuth range of the decimated acquisition was representative for the complete acquisition. The still massive task to solve the two-point ray tracing problem for the remaining 26,462 shot/receiver pairs was addressed by designing a robust nested-grid search for the initial rays leaving the shot point to reach the corresponding receiver point. In this search a portion of the two-point problems was reported as unsolvable. This was not considered critical for the purpose of the illumination study, since the unsolvable two-point problems are usually related to regions of poor illumination. The resulting hit-point maps over the target reflector show that the crests and valleys around the prospects will be better imaged by depth migration than the flanks. This is important information to decide which areas should be the focus of velocity model building during the depth migration.

Acknowledgment: The author is grateful to Elko Energy for permission to present this study.