SUMMARY

The Middle East hosts a wide range of different geological settings, a large number of which exhibit structural complexity and hence can benefit from depth imaging. These structurally complex areas range from over-thrust zones on the U.A.E - Oman border and fault shadow problems in the Western Desert of Egypt to salt structures in the Gulf of Suez and Red Sea. In the North Red Sea offshore Egypt, the presence of salt structures can cause considerable distortion of the sub-salt seismic image. This distortion is due to complex shape of the salt, strong and sharp variations of the velocity field at the salt boundaries, as well as very complex wave propagation which all together lead to a very challenging imaging task. Pre-stack depth imaging is considered as a viable and ultimate tool for accurate delineation of sub-salt reflectors in this geological environment. To achieve the best seismic image an optimal interval velocity depth model has to be built.
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In the North Red Sea offshore Egypt, the presence of salt structures can cause considerable distortion of the sub-salt seismic image. This distortion is due to complex shape of the salt, strong and sharp variations of the velocity field at the salt boundaries, as well as very complex wave propagation which all together lead to a very challenging imaging task. Pre-stack depth imaging is considered as a viable and ultimate tool for accurate delineation of sub-salt reflectors in this geological environment. To achieve the best seismic image an optimal interval velocity depth model has to be built. This in itself presents a substantial challenge when working in areas with complicated geological structures. In this case study, an iterative process of velocity model building is presented, which closely integrates seismic data with geological information, to derive a sub-surface velocity distribution that enables production of the best image. Also, this study will show how implementation of pre-stack depth migration coupled with a comprehensive model building workflow can be used to enhance and improve imaging on a narrow azimuth towed streamer dataset from offshore Egypt’s North Red Sea.

The area of interest is extremely challenging for imaging due to a highly rugose seabed which is characterized by rapid changes in water depth, complex near surface geology, a shallow complex salt layer and a sequence of thick halite with interbedded evaporite and clastics (figure 1).

![Figure 1](image.png)

**Figure 1** example of complex near-surface salt geology with velocity model overlay.

The initial model building workflow was shown to be too simple to process the 3D narrow azimuth data through pre-stack depth migration. This flow included a nominal azimuth 3D surface multiple prediction for demultiple, sparse 500m CIP tomography for resolving the sediment layer velocity model to top zeit horizon (not true top salt), a 1D model update for salt layer from top zeit to base salt, and a constant velocity model for sub-salt.

Through processing it became obvious that a more detailed and complex workflow was needed to more correctly build a velocity model and image the sub-salt target. To remove most of the multiple identified as one of the main hindrances to imaging, a true azimuth surface multiple prediction process was used. It showed marked improvement over the nominal azimuth multiple predictor in its ability to remove multiples.
This paper describes a modified process of depth-velocity model building for this complex case and consists of the case history of the different approaches for the upper and deeper part of the section. Careful study of the velocity variations in the sediment layer as well as inline and crossline illumination maps (figure 2) showed that a 500m sampling of CIPS for tomography would not lead to an acceptable level of statistics for model updating in the sediment layer. Also, it was clear that the sediment model should be updated to true top salt, not top zeit. We used 50m CIP sampling and close interaction with interpreters to resolve the sediment model and top salt horizon.

![Figure 2](image.png)

**Figure 2** Crossline illumination plot of 500m CIP sampling (left) and 50m CIP sampling (right).

For the shallow sediment layer - model building is done using multiple iterations of Kirchhoff depth migration coupled with high resolution grid-based tomography, employing a multi-parameter approach, in which an image depth is picked independently for all offsets and several iterations of the tomography solution are done on progressively finer scale lengths in order to properly compensate for the short to middle wavelength fluctuations of the velocity field. A number of examples will be given to demonstrate effective pre-processing, depth imaging results and support the modified workflow, particularly in regards to several different approaches for salt and sub-salt imaging, including constant velocity flood, velocity scans using different types of Wave Equation Migration such as Common Shot and Common Azimuth migrations and even grid tomography for the sub-salt data.

**References:**