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Detailed Velocity Model of the Nile Delta Using Multi-azimuth (MAZ), Multi-Parameter Reflection Tomography

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SUMMARY

In the Nile Delta, a complex and dipping water bottom, shallow gas filled channel systems and the evaporitic Messinian interval have prevented the creation of an accurate velocity model in depth using conventional 3D data. By designing a workflow that combines the Multi-Azimuth data in a multi-parameter reflection tomography approach, we have built a detailed velocity model that shows variations that correspond very well to the geology interpreted from the seismic, and which yields improved images at depth.

Summary

Building a detailed velocity model is always a major challenge in seismic data processing. In the Nile Delta, a complex and dipping water bottom, shallow gas filled channel systems and the evaporitic Messinian interval have prevented the creation of an accurate velocity model in depth using conventional 3D data. Can we take advantage of the recently acquired Multi-Azimuth (MAZ) seismic to build a detailed velocity model? We know from theory and case histories that Multi-Azimuth data will give us improved signal to noise, improved multiple attenuation, and improved illumination. By designing a workflow that combines the Multi-Azimuth data in a multi-parameter reflection tomography approach, we have built a detailed velocity model that shows variations that correspond very well to the geology interpreted from the seismic, and which yields improved images at depth.

Background

The recent Nile Delta can be characterized as a compaction driven overburden which overlies a deeper, rugose and anhydrite rich layer of Messinian age. To date, standard reflection tomography on conventional streamer data has failed to build a detailed velocity model in this area. A recent attempt to model the complex Messinian layers has been to estimate the anhydrite distribution from an initial depth migration stack converted to impedance, and then to update the model with representative interval velocities at these locations (Tanis et al., 2008). Results show that a detailed model can be built which helps heal the image continuity below anhydrite in some areas (where PreSTM usually fails). However, even this creative approach did not offer enough promise to develop further and deliver a 3D velocity model.

Velocity Model Building workflow

The overall concept of MAZ Tomographic velocity model building is to globally find the 3D velocity model that best satisfies all the source-receiver (offset) travel times in depth, in all 6 azimuth directions simultaneously. The first step is to start with a simple velocity model and then proceed to add more detail to the model after every tomographic update. Each update is followed by a migration with the new model. The first iteration used a single parameter shallow MAZ update to remove shallow (slow) velocity anomalies and observe the effects at depth. The second iteration used a multi-parameter MAZ update to the Messinian to test if azimuthal anisotropy or velocity heterogeneity dominated this data. The third iteration was a global multi-parameter, MAZ update with heavy focus on two areas:

- 1) Improving the quality and the amount of picked delays to invert in the tomography.
- 2) Testing the parameters that govern the tomography code

The quality of picks was achieved by enhanced proprietary noise attenuation and enhanced delay picking techniques together with copious QC tools.

Results

The additional data (fold), and the additional directional information, result in higher resolution and reduced uncertainty in the updated velocity model. The velocity model corresponds to the geology seen on the seismic data and improves the seismic image. The Velocity Model in Depth can be further improved with another iteration at least but the result has converged quite quickly despite the complexity in the area.

References

M.C. Tanis, T.P. Summers, P. Cook, J. Keggin, Data Driven Velocity Model Building - An Application to Egypt Nile Delta: Rome 2008, 70th EAGE Conference & Exhibition incorporating SPE EUROPEC 2008