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Unlocking Imaging Challenges Through Advanced Imaging in West Mediterranean Offshore, Egypt

T. Darwish[1], M. Mohamed[1], M. Hartt[1], M. Romanenko[1]

[1] TGS

Summary

The recent Nefertari gas discovery in the Western Mediterranean offshore Egypt, has proved the potentiality of the area for hydrocarbon exploration; however, exploration remains challenging due to complex regional geology. Seismic imaging is particularly impacted by velocity heterogeneity within the Messinian layer, driven by interactions between mobile mud, sand bodies, and variable salt-anhydrite compositions. To address these issues, a robust velocity model building (VMB) workflow integrating Full Waveform Inversion (FWI) and Reverse Time Migration (RTM) is performed. This abstract presents examples from a recent acquired NAZ seismic survey in the Eastern Mediterranean, showcasing how advanced VMB techniques improve imaging in such complex regime.

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Introduction

The 2025 Nefertari gas discovery in Egypt's Western Mediterranean has confirmed the hydrocarbon potential of the region; however, exploration remains challenging due to complex geology. Seismic imaging is particularly impacted by velocity heterogeneity within the Messinian layer. Additionally, the presence of a carbonate platform complicates imaging on the shelf. To address these issues, a robust velocity model building (VMB) workflow integrating acoustic and elastic Full Waveform Inversion (FWI) and Reverse Time Migration (RTM) is performed (Davies *et al*., 2024). This abstract highlight results from a recent acquired NAZ seismic surveys offshore Egypt, showcasing how advanced VMB techniques improve imaging in such complex regime.

Velocity Model Building and Imaging

The pre-Messinian imaging is highly sensitive to velocity inaccuracies within the overlying complex Messinian evaporite sequence and the shelf carbonates. Accurate imaging therefore requires a high-resolution, geologically consistent velocity model. The applied VMB workflow (Figure 1) integrates dynamic-matching FWI (DMFWI) and reflection tomography, initiated from a smoothed fast-track model with interpretation-based flooding of salt and mud bodies. Iterative refinement, combined with RTM, helps overcome illumination challenges and significantly enhances image quality in the target.

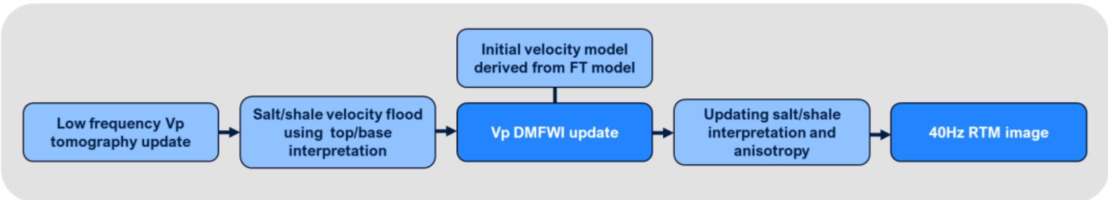

Figure 1 *shows the proposed VMB Workflow applied in this survey, including the application of acoustic and elastic DMFWI and RTM.*

Data Example 1: Post Messinian

Anomalies in the post-Messinian section—such as gas pockets, buried channels, and mud volcanoes—necessitate accurate velocity modelling using FWI and tomography. In shallow water, FWI benefits from refracted and diving waves, while in deeper water it depends on low-frequency reflections to drive high-frequency updates. The 12 Hz acoustic FWI (aFWI) model (Figures 2a–2c) reveals improved velocity contrasts, especially along channel geometries, aligning well with seismic data and providing confidence in the velocity update.

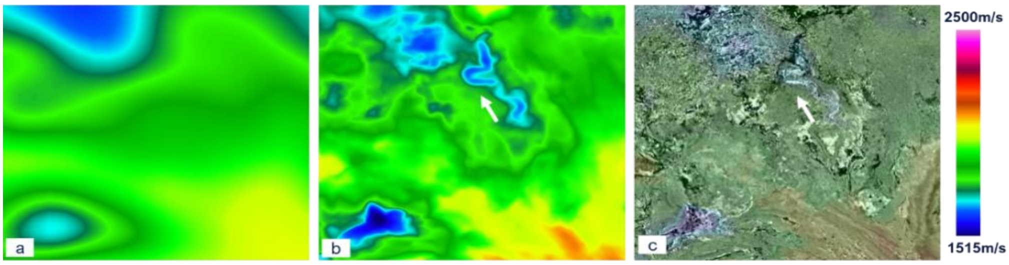

Figure 2 *shows Depth slice of initial velocity model (a), 12Hz aFWI updated velocity model (b), and Kirchhoff image with aFWI model overlaid (e).*

Data Example 2: Messinian Evaporites and Shelf Carbonate

The Messinian salt shows complex intra-salt reflectivity, likely from thin clay interbeds. The velocity model was built using top and base salt interpretations, applying constant average velocities from

4400 m/s (clean salt) to 3600 m/s (salt-clay mix). Incorporating mud and salt bodies improves FWI convergence in a more geological manner. As shown in Figures 3a and 3b, aFWI sharpens the velocity contrasts at salt boundaries and captures intra-salt variations, particularly in the lower Messinian. The shelf carbonate has rapidly varying lithologies, such as chalk, sand, shale, and dolomite, with no clear interpretable boundaries between them. The initial velocity model derived from the fast-track enabled elastic DMFWI to converge faster in a more structural plausible manner (Liu *et al*., 2025)

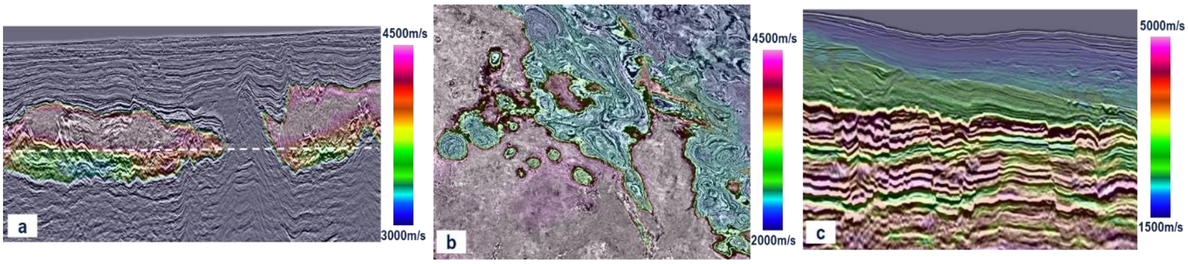

Figure 3 *An Inline display of 12Hz aFWI updated salt velocity model (a), depth slice of 12Hz aFWI salt velocity model (b) overlaid on migrated Kirchhoff image and (c) an inline display of 10HZ elastic DMFWI updated velocity model in carbonate shelf.*

Data Example 3: Pre-Messinian Imaging

Imaging Pre-Messinian targets is hindered by poor illumination beneath the complex salt layer. Ray-based methods like Kirchhoff migration suffer from limited ray coverage and suboptimal sub-salt imaging. In contrast, (RTM) accurately models complex wavefields, enhancing illumination and reflection continuity. RTM also reduces wavefront artifacts and improves signal-to-noise ratios. As shown in Figures 4b and 4c, RTM provides superior subsalt imaging compared to Kirchhoff migration.

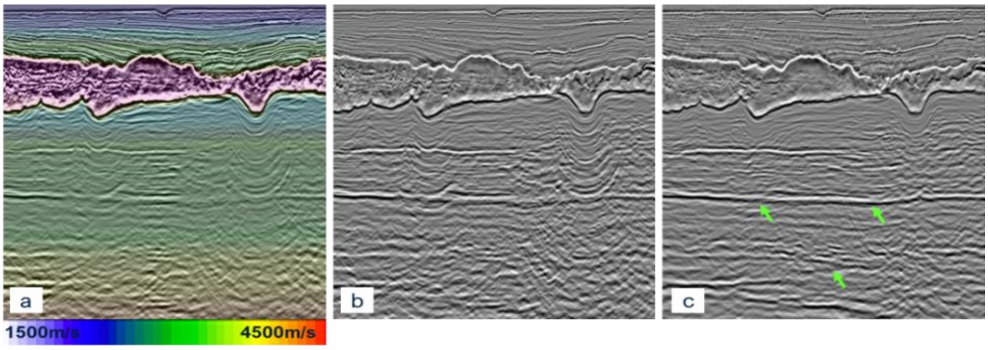

Figure 4 *An inline display with the final velocity model overlaid on the Kirchhoff depth migrated image (a). Comparison between Kirchhoff Depth image filtered to 40HZ (b) versus 40Hz RTM image (c).*

Conclusions

The proposed VMB workflow including DMFWI and RTM, have been successful in capturing most of the post-Messinian, Messinian complexities and shelf carbonate, helping in improving the pre-Messinian target image.

References

Davies, D., Brown, P., Agnisola, P., Valler, V., Romanenko, M., Fruehn, J., Raffle, J., Nicholson, M. and Pan, S., 2024. "Unlocking the Nile Delta subsurface via advanced processing and imaging," The Leading Edge 43: 596–605.

Liu, F., Macesanu, C., Xing, H., Romanenko, M., Zhan, G., Calderón-Macías, C. and Wang, B., 2025. "Elastic full-waveform inversion: Enhance imaging for legacy and modern acquisition," The Leading Edge 44: 338–343.