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Efficient Acquisition Solutions for Pre-Messinian Imaging in the Eastern Mediterranean

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Summary

Recent projects have demonstrated that innovative survey design can improve the imaging of the pre-Messinian interval in the Eastern Mediterranean. These include the deployment of multiple source vessels in Extended Long Offset (ELO) or half-Wide-Azimuth (hWAZ) configurations and ocean bottom node surveys (OBN). Use of low frequency sources is another significant development. Here we describe how the newest developments in these trends have the capability to further improve imaging in the pre-Messinian. First, we demonstrate the uplift over narrow-azimuth data that is seen in the latest implementation of an hWAZ configuration deployed offshore Angola. Next we highlight improvements in source side efficiency for sparse OBN surveys and describe how we iterate over survey design practices when working with low frequency sources in exploration settings.

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Introduction

Recent projects have demonstrated that innovative survey design can improve the imaging of the pre-Messinian interval in the Eastern Mediterranean. These include the deployment of multiple source vessels in Extended Long Offset (ELO) (see Shell-PGS-ION press releases, 2021) or half-Wide-Azimuth (hWAZ) (Donaldson et al. 2024) configurations and ocean bottom node surveys (OBN) (Baptiste et al. 2024). Use of low frequency sources is another significant development. Here we describe how the newest developments in these trends have the capability to further improve imaging in the pre-Messinian. First, we demonstrate the uplift over narrow-azimuth data that is seen in the latest implementation of an hWAZ configuration deployed offshore Angola. Next we highlight improvements in source side efficiency for sparse OBN surveys and describe how we iterate over survey design practices when working with low frequency sources in exploration settings.

Streamers and Low frequency sources

Widmaier et al., 2025 describe the benefits of combining multisensor streamers with low frequency sources. Several types of low frequency sources are in operation today. Here we consider the Gemini extended frequency source (Udengaard et al., 2023), a novel marine source solution using a single-element (8000 cu. in.) design that generates more low frequencies below 4 Hz and ~32 dB less energy at 800 Hz, compared to conventional sources. In late 2024 TGS began acquisition offshore Angola using an hWAZ configuration descended from those used in the East Mediterranean. In this new configuration the length of the streamers has been increased from 8 km to 10 km and the number of sources has been increased from 4 to 6. Twelve 10 km long streamers towed 150 m apart and total of six Gemini sources were deployed: the streamer vessel towed three 8000 cu in. sources and an additional three sources were towed by the second vessel.

Figures 1A-1D show the preliminary migrated images using an acoustic FWI model derived from the narrow azimuth shots alone compared those using FWI from the narrow- and wide-azimuth shots combined. These early results shows that the introduction of wide-azimuth data improves both the illumination of events underneath the salt overhangs, shown by the orange arrows, and the velocity updates within and beneath salt, shown by the blue arrows.

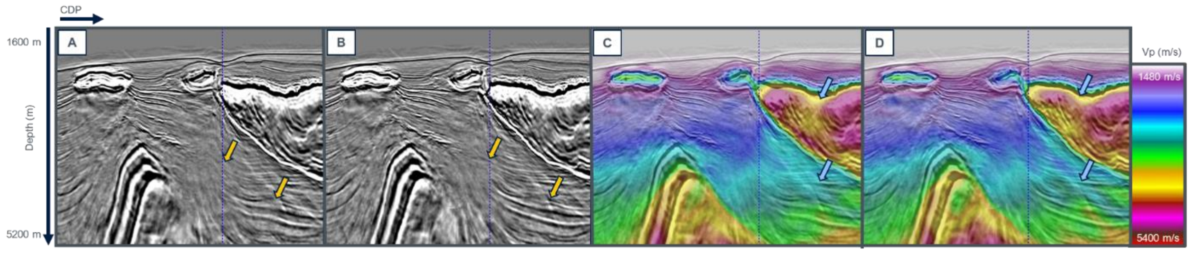

Figure 1: *A: KPSDM with an NAZ FWI model; B: KPSDM with a NAZ+WAZ FWI model; C: aFWI model using NAZ data; D: aFWI model using NAZ+WAZ data.*

Sparse OBN and low frequency sources

Low frequency sources have often been used with sparse OBN (Brenders et al., 2018). For such large volume sources (Gemini: 8000 cu in.) the shot spacing is sometimes constrained by the time needed to refill the sources. Shot spacing, compressor capacity and air delivery systems all determine refill times and need to be considered when designing the survey.

Two boat, triple source acquisition on a 50 m x 100 m shot grid is common for deepwater sparse OBN surveys. However, source efficiency can be improved by 33% if four sources (quad-tow) are used to acquire the same shot grid. Until recently this had not been possible due to refill time constraints. However, recent work to optimise the air delivery to the sources (see e.g. Large et al., 2025) has made acquisition on a 50 m x 100 m shot grid with quad-tow sources possible.

A reliable velocity model is a considerable benefit for successful survey design. However, for sparse OBN projects in the Mediterranean, the Gulf of Mexico and many other well established hydrocarbon provinces, the input data for survey design contains large model uncertainties, especially below salt. Managing this uncertainty in the survey design process leads to an iterative approach.

Step one is to establish an initial set of parameters, including the minimum required offsets for FWI, the desired azimuthal coverage, clean record length, and shot and receiver density. This can be done using a variety of methods from simple 2D and 3D raytracing, FWI kernels, through to full 2D and 3D FD modeling and migration workflows.

Next, refill times are estimated using vessel-specific information, leading to a proposed shooting configuration that is evaluated using another pass of modelling. This iterative loop of survey design involving parameterization coupled with information exchange between expert teams, leads to optimal solutions that achieve model building and imaging objectives.

In the Eastern Mediterranean, as in other complex areas where sparse OBN surveys are used to update the velocity, recording the necessary long offsets is critical, which makes source-side efficiency essential to improving the cost-effectiveness of surveys. Equally important is estimating the maximum offset accurately. The iterative workflow described here is currently being used to provide insight into this challenge, with results to be shared in future presentations.

Conclusions

Innovative streamer design solutions and source-side efficiency gains in sparse OBN acquisition, make improved imaging of the pre-Messinian interval possible. However, lack of reliable velocity information and well control are challenges for survey design. Managing the velocity uncertainty through iterative survey design provides a way to address this challenge when designing surveys.

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