AAPG Datapages/Search and Discovery Article #90254 ©2016, GEO-2016, 12th Middle East Geosciences Conference & Exhibition, Manama, Bahrain, March 7-10, 2016

Subsalt Seismic Modeling and Illumination Analysis in Red Sea Transition Zone

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ABSTRACT

Subsalt seismic imaging in a complex basin like the Red Sea is challenging, due to the presence of rough seafloor topography and complicated subsurface geological structures. Current seismic data in the Red Sea transition zone area is poor quality both at pre- and post-salt sections.
Seismic modeling is critical for understanding data limitation and for designing more optimal and cost-effective surveys. Accurate modeling requires a detailed velocity field, acquisition geometry, and a high fidelity algorithm. In this study, two modeling techniques were used: (1) ray-based that is fast and flexible and (2) wave equation that is more effective in a complex environment.

The earth model used in this study covers an area of approximately 14 km by 21 km to a depth of 10 km in the Red Sea transition zone area. Water depths range from 0 to 638m in this study area. The velocity field varies from low in the shallow sediments (1700-2200m/s) to high velocity in salt bodies (4500m/s). The velocity model used for this forward modeling was updated using available new well data in the transition zone. To isolate the effect of a highly variable sea floor on illumination, two models were tested: one with the real bathymetry surface and another with highly smoothed gentle sea floor. This forward modeling project simulated a seismic survey consisting of 6000 ocean bottom nodes (OBN) and 31500 shots. A two-way acoustic wave equation was implemented for the modeling using a high order finite difference (FD) approach to remove the numerical dispersion. Perfectly matching layer boundaries were used to remove the artificial reflections from the truncation boundaries and, a free surface boundary condition was used for simulating the free surface multiples.

Recently acquired seismic data in this area show very strong ocean bottom diffractions and multiples that have created serious imaging challenges. This modeling effort was designed to understand the imaging challenges and propose possible survey designs for future data acquisition in this area. The modeled seismic data will also contribute to addressing processing challenges ranging from data interpolation, surface-related multiple elimination (SRME), wave-field re-datuming to depth velocity model building, and depth imaging. The outcome of this study will help obtain an optimal and economical seismic survey design that could be scaled up for the entire Red Sea transition zone area.