High-Resolution Seismic Velocity Structure of the Shallow Porcupine Basin From Traveltime Tomography and Waveform Inversion of Long-Streamer Data

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ABSTRACT

The Porcupine Basin is a failed rift located in the North Atlantic margin southwest of Ireland. This triangular-shaped basin was formed after several rifting and subsidence phases during Late Palaeozoic and Cenozoic, with the most pronounced rift phase occurring in Late Jurassic–Early Cretaceous times. From the perspective of hydrocarbon exploration, the Porcupine Basin is one of the most attractive regions of the North Atlantic with potential hydrocarbon systems within the post-rift stratigraphic sequence (i.e. Cretaceous and Tertiary sediments). Seismic reflection lines reveal gas chimneys and seeps potentially associated with buried carbonate mounds and indicating the presence of deeper hydrocarbon systems within the post-rift section of the basin. Yet, these areas are not properly explored and little is known regarding properties of rocks, such as porosity and fluid content, both critical for reservoir characterisation. Here, we combine traveltime tomography and full waveform inversion of 10 km-long streamer data to obtain 2D seismic velocity images of the Cretaceous and Tertiary sequences of the Porcupine basin with unprecedented resolution. First, we apply traveltime tomography of automatically selected first arrivals from streamer field data. For those lines acquired in deep (~ 1000 m) water, we use a downward continuation method to redatum seismic shot gathers to the seafloor, which allows the identification of P-wave arrival times previously masked by the reflection at the seafloor. The resultant tomographic models resolve low-wavenumber P-wave velocity structures of the shallow Porcupine Basin providing a satisfactory starting model for the waveform inversion. This second step makes use of recent formulations of the misfit function between observed and synthetic waveforms, which enhance the robustness of the inversion and aims for finer resolution than traveltime tomography. The waveform inversion of streamer data is expected to provide sub-wavelength images of seismic velocities and in the long-term density and/or anisotropy. All these parameters can be used to derive physical properties of rocks and assess the potential of the post-rift sequence to host petroleum reservoirs. This publication has emanated from research supported in part by a research grant from Science Foundation Ireland (SFI) under Grant Number 13/RC/2092 and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies