Th VW 04

Imaging Paleocene and Jurassic Prospects within the Porcupine Basin, Ireland: A Case Study

M. Hart[1]*, S. Bhamber[1], A. Hulks[1], S. O'Keefe[1], E. Cho[1], S. Baldock[1]

[1]TGS

Summary

We present a case study and outline the workflow used to process 5500 km2 of new seismic data in the Porcupine Basin area of the Celtic Sea. Key processing challenges include the imaging of faults in the Jurassic interval, volcanic sills and the high-velocity Cretaceous chalk. In addition to these processing challenges, several shallow-gas pockets and channels with variable-velocity infill require detailed depth-velocity modelling to resolve deflections in the underlying sediments. A depth velocity model building workflow is presented which incorporates FWI along with high-resolution image-guided tomography to produce an accurate model for prestack depth migration. Improved imaging of the complex and potentially prospective structures found within the Porcupine Basin is achieved. Detailed anomalies such as shallow channels and gas clouds are corrected with a combination of high-resolution tomography and FWI, which gives increased confidence in the positioning of events along the underlying sediments.

Introduction

The Porcupine Basin is a failed symmetrical-rift basin and is typified by several large-scale rotated fault blocks, offsetting Middle Jurassic strata and covered by the synrift Upper Jurassic section. Several hydrocarbon plays have been defined within the postrift succession, such as the Paleocene basin-floor channel system with the “Avalon” prospect and the Lower Cretaceous Drombeg prospect. There are many identified leads just above and below the Cretaceous Chalk along the western basin flank. The tilted fault blocks in the north of the Porcupine Basin, spanning across the west in the Porcupine High and east in the Celtic Platform, offer an insight into the continuation of the faulting within Lower Cretaceous sections.

In addition to this complex geology, volcanic sills, shallow gas pockets and channels with variable infill velocities can be seen throughout the area, which may cause undulations in the underlying sediments.

The workflow used to address these challenges incorporates full waveform inversion (FWI), along with high-resolution image-guided tomography prior to prestack depth migration.

Image Guided Tomography

Depth velocity model building and Kirchhoff depth migrations address the challenges of correctly positioning the Jurassic fault blocks and resolving undulations across the target Druid and Top Chalk horizons by correctly modelling velocity variations across the overlying Eocene channel structures.

A detailed velocity model is built, incorporating image-guided tomography (IGT) and offset-dependent picking. Model building is performed in a top-down, layer-stripping approach, where early iterations concentrate on the shallow postchalk sediments, which include the Eocene channels. The chalk layer is then incorporated, before moving down to the underlying Cretaceous and more complex Jurassic geology. Horizon-based constraints applied during model building prevent leakage of updates across the high-contrast Top Chalk boundary. Localised details such as gas clouds are identified with interpretation-driven modelling (IDM) - interpreted horizons are incorporated into the high-resolution tomography workflow and are used to guide the direction and magnitude of localised velocity updates.

Calibration to the single well located within the survey area is performed after an initial pass of tomography. The anisotropic parameters delta and epsilon are estimated at the well location and extrapolated across the extent of the survey area using interpreted Eocene and Top Chalk horizons as constraints. From this point, all migrations are run as tilted-transverse isotropic (TTI) models. The resulting tomography-driven velocity model is shown overlain on the migrated data in Figure 1.

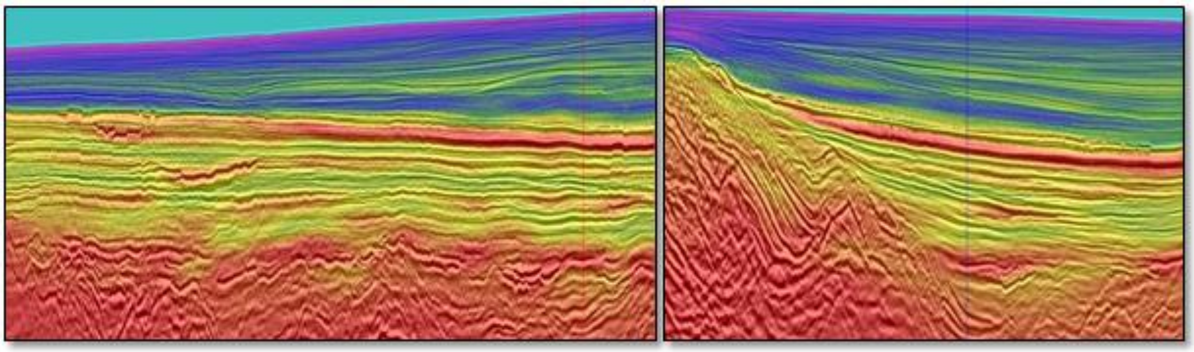

Figure 1 *Crossline (left) and inline (right) velocity model overlay after four passes of tomography.*

Full Waveform Inversion (FWI)

Tomography resolves large-scale velocity variations, but in the shallower water to the north of the survey area, several small-scale channel features are identified, cutting through the shallow sediments. Distortions in the underlying sediments imply a relatively fast velocity infill. Due to the shallow depth and very limited lateral extent of these events, diving-wave FWI is utilised to build a more detailed velocity model than is achievable with tomography alone.

The calibrated tomography model is used as the input velocity model. With limited well control in the area it is necessary to first invert for epsilon, as this is seen to stabilise later velocity updates. Using the relationship observed from the well to the south, a ratio is calculated to convert this inverted epsilon value to delta. After subsequent velocity updates another epsilon inversion is run based on the updated velocity model, which better estimates the background anisotropy. Image-guided smoothing and κx-κy footprint removal are incorporated into the workflow to separate the acquisition footprint from the geologically driven variations in the velocity model.

The detailed channel structures are clearly seen in the resulting velocity model (Figure 2). Correctly resolving these relatively high-velocity channel infills removes undulations in the underlying sediments, allowing a more accurate interpretation. Anomalies resulting from a number of gas clouds to the south of the survey area are also detected by the FWI and the deflections in the underlying sediments are reduced, further improving the accuracy of the positioning of events and hence their interpretability.

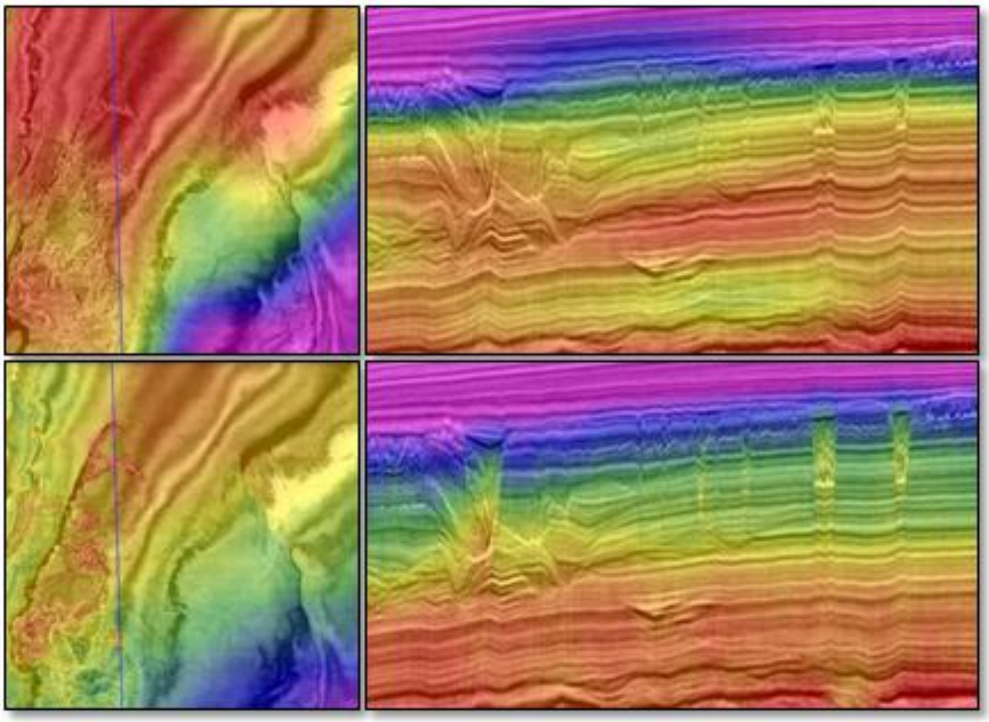

Figure 2 *Velocity model – depth slice and crossline section before and after FWI.*

Conclusions

A combination of high-resolution tomography and FWI improve imaging of the complex and potentially prospective structures found within the Porcupine Basin. Smaller scale structures, such as shallow channels and gas clouds are also corrected, which gives increased confidence in the positioning of events along the underlying sediments.