Prediction of Carbonate Composite Reservoirs based on High-Precision Facies Constrained Inversion—a Case Study of K Area in the Pre-Caspian Basin

Xichen Zhang, Ruidong Han, Jingbin Cui, Xiaobo Liu, Changjiang Du

BGP, CNPC

Abstract

In recent years, the prediction of carbonate reservoirs with strong heterogeneity has become a key problem. A workflow is designed to improve the porous and vuggy carbonate reservoir characterization, which is applied in a case study in the K area of the Pre-Caspian Basin. This workflow is divided into five main steps. First, we employ seismic and well data conditioning. The pre-stack depth migration is used to improve the seismic imaging precision, and the principal component structure-guided filtering is carried out, which lays a foundation for the accurate identification of fractured-porous bodies and their physical properties. Well data conditioning is performed to reduce error, including abnormal value removal, environment correction, and multi-well standardization. Secondly, we establish the background model with facies constraints. Although the porosity of carbonate rocks in the K area is related to acoustic impedance, the conventional acoustic-impedance inversion fails to delineate the vertical krast fractures and caves. The sensitive seismic attributes, such as curvature and texture, are incorporated into the background acoustic impedance model to delineate the karst caves and fractures. Third, we perform high-precision inversion. Adaptive broadband constrained inversion(ABCI) is carried out by tuning the adaptive damping operator to obtain inverted acoustic impedance with higher vertical resolution. In addition, the neural network inversion based on radial basis function(RBF) is used to find the optimal conversion mode of logging curves and seismic attributes, and the high porosity of RBF inversion is consistent with the low impedance of ABCI inversion. The fourth step is hydrocarbon detection. The frequency difference between the favorable reservoir and surrounding rock is identified through frequency analysis, and the hydrocarbon distribution is determined based on seismic frequency attributes. The fifth step is quality control. All results are checked for consistency through 3D visualization, such as inversion data, seismic attributes, and logging curves. The synthetic of the inversion is checked to see if they are close to seismic data and if the residual is within a reasonable range. The prediction effectively delineates the discontinuous distribution of the porous reservoirs, and thin beds with thickness of less than 20m, which are consistent with the well data. The karst fractures and caves are developed within the 200m top of the reservoir, with larger number and scale at the edge than the inside the carbonate platform. The differences suggest the weathering and denudation effects are stronger in the marginal compared with the interior platform, improving the connectivity between the reservoirs of different depths. Therefore, the favorable targets are concentrated in carbonate platform edge, where the breakthrough of high-yield wells is achieved.