Fracture Prediction in the $J_2s_3^1$ Tight Reservoir of the Jinma Structural Belt, Western Sichuan Depression, Sichuan Basin

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Abstract

The Jurassic gas reservoir in the Western Sichuan Depression is a typical tight sandstone gas reservoir with favorable natural gas trapping conditions, possessing abundant natural gas resources. However, the exploration of the Jurassic strata in the piedmont region has encountered bottlenecks. Among the 9 wells drilled, only 2 wells located near the faults yielded industrial oil and gas flows. Therefore, there is an urgent need for a more detailed interpretation of the faults in the piedmont region and a precise investigation into the development of fractures. This study, based on the interpretation of 2D seismic data, conducts 3D finite element numerical simulations of the paleo-structural stress for six typical geological profiles and the J2s31 tight reservoir within the Jinma structural belt. The objective is to analyze the structural characteristics and stress states, as well as predict the types and distribution of fractures. The research findings indicate that the structural styles in the Jinma structural belt are predominantly snake-head structures, pop-up structures, and structural triangle zones. On the plane, the belt is divided into a flexure zone, a fold zone, and a fractured monocline zone from west to east. Shear fractures primarily develop at the anticlinal limbs and near the Guankou Fault, while extensional and transitional fractures form at the hinge zones of anticlines or nose structures, as well as at the tails of primary faults. In profiles, extensional fractures develop at the hinge zones of anticlines or where the curvature is high, while shear fractures form at the hinge zones of synclines. Moreover, with increasing burial depth of strata and the combination of rock layers with different mechanical properties, shear fractures can develop at the hinge zones of anticlines or inflection points of folds. Extensional fractures also develop at pinch-out sides of faults and lithological transition zones, while transitional fractures appear at different structural locations. Near wells CY609 and JS1, extensional and shear fractures prevail, while near wells CY189 and JF1, extension-shear fractures are predominant. Fractures developed near wells ZY21 and Y100 are exclusively shear fractures formed after the Jurassic period. The formation of faults influences the development of fractures in the surrounding strata, the extent of which depends on the scale and activity of the faults, manifested specifically by the expansion of pre- existing fractures and alterations in fracture mechanical properties. The findings hold significant guidance for the future exploration of Jurassic natural gas in the piedmont region of the Western Sichuan Depression.