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Trishear Modeling of the Main Fold Traps in Eastern Saudi Arabia

Hongbin Xiao[1], Mesbah H. Khalil[1], Alan Nunns[2]

[1]Exploration Resource Assessment Department, Saudi Aramco, Dhahran, SAUDI ARABIA
[2]Nunns and Rogan LLC, Danville, California, UNITED STATES

ABSTRACT

Most petroleum traps in Eastern Saudi Arabia are gentle, asymmetrical fault-related folds. Their flanking curved surfaces tighten downward toward the causal faults, to form triangular shear zones in cross-section, characteristic of trishear fault propagation folding (Erslev, 1991). Most of the stratigraphic layers also thin toward the anticlinal crest, which is a diagnostic feature of growth strata within fault propagation folds (Shaw et al., 2006).

Three typical anticlinal traps in Eastern Saudi Arabia (here mentioned as A, B, and C) were selected for modeling using the trishear forward modeling. The model parameters were interactively adjusted until modeled horizon geometries best fit interpreted stratigraphic horizons. In all three cases, the models quantitatively constrain fault shape and position at depth, fold deformation history, fault slip magnitudes, and internal strain of the structure.

Anticline A is a N-trending structure bounded by high-angle reverse faults on both sides, with 520 m of uplift at the Khuff level over a width of 15 km. Modeling indicated three phases of deformation: contraction in Triassic, structural quiescence in Jurassic, and major transpression in Cretaceous, with a shortening of <1%.

The NE-trending anticline B has a central uplift of 560 m at the Hith level over a width of 40 km. Modeling reveals that Pre-Cretaceous extension was followed by Late-Cretaceous transpression and tectonic inversion with approximately 1% shortening. Both extensional and contractional phases were successfully modeled using trishear folding.

The broadest parts of the N-trending anticline C involve at least two faults with opposite verging directions with approximately 1 km of uplift at the Arab-D level over a width of more than 20 km. Modeled steep faults likely propagated from depths of over 10 km, and appear to tip out near Khuff. The total contraction in the central anticline is 1.1 km (~2%). Modeling indicates three phases of deformation: early contraction from Base Khuff to Jilh, structural quiescence from Jilh to Shuaiba, and a major contraction from Shuaiba to Aruma, with the maximum deformation rate right after Pre-Aruma Unconformity.

In summary, trishear modeling can account for nearly all structural features in many gentle folds in Saudi Arabia. It proved effective to understand structural evolution, to help accurate mapping of the high strain areas, and to locate boundaries of reservoir compartments in Eastern Arabia basin.