Thick-Skinned Contractional Folding and Saudi Arabia's Major Hydrocarbon Traps

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ABSTRACT

The typical hydrocarbon trap in Saudi Arabia comprises a broad, low relief, asymmetric anticline formed above a moderate to high angle (45-70 degree) master reverse fault. These anticlines are thick-skinned contractional growth folds – alternative models involving strike-slip faulting, inversion, or drape (forced) folding associated with normal faults, are not supported when kinematic analyses, seismic mapping and analog structural comparisons are combined. The fault-fold geometry of one typical trap, the Khurais Field, can be quantitatively modeled by basement-involved rigid-block rotation along a listric, circular-arc fault that flattens to a mid-crustal lower detachment approximately 19 km below sea level. This depth coincides with a mid-crustal discontinuity identified from regional refraction and crustal velocity analyses. The match between the predicted detachment and the known crustal structure provides quantitative confirmation of the thick-skinned, rotated-block kinematic model. Area-depth analyses of these anticlines can be used to extract their contractional growth history and to generate a sequential restoration. These results indicate that regional contraction and fold growth continued episodically throughout the Mesozoic, culminating between the Turonian and the Maastrichtian. The structural model proposed here, which is readily applicable to several other major hydrocarbon traps in Saudi Arabia, provides a quantitative relationship between the shape of the master fault, the geometry of the hanging wall, the depth to the lower fault detachment and the kinematic history of the structure.