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Geodynamic Evolution of the Zagros Fold-and-thrust Belt: Fold-growth and Fold Linkage

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ABSTRACT

The Zagros orogen and the Iranian plateau preserve a record of the long-standing convergence history between Eurasia and Arabia across the Neo-Tethys, from subduction/obduction processes to present-day collision. The geodynamic evolution of the Zagros orogeny can be divided in three major periods: (1) Mid to Late Cretaceous subduction processes and interplate mechanical coupling marked by blueschist exhumation and upper-plate fragmentation; (2) Paleocene–Eocene slab breakoff, major shifts in arc magmatism and distributed extension within the upper plate; (3) Oligocene to still on-going collision with a progressive SW migration of deformation and topographic buildup. NE-SW shortening is accommodated in the Zagros fold-and-thrust belt (ZFTB), which essentially corresponds to the Eo-Cambrian to Quaternary cover of the Arabian plate deformed above the Arabian basement, with a maximum thickness of 12–13 km. This sedimentary cover dominantly comprises shelf carbonates, together with several evaporitic low viscosity layers, which acted as major mechanical decollement horizons, thickened fold hinges and favored spectacular thin-skinned deformation.

Since the geomorphology in the ZFTB is dominated by the shape of the anticlines the transient development of drainage patterns along growing antiforms directly reflects the kinematics of progressive fold growth. Detailed geomorphological studies of the drainage systems along the fold trains show that these anticlines have not developed from a single embryonic fold but they have laterally linked from different fold segments. Confirmed by natural examples from the ZFTB, the results of three-dimensional finite element modeling of detachment fold growth demonstrates that four different fold-linkage models occur: (1) "Linear-linkage" yields a sub-cylindrical fold with a saddle at the location where the two initial folds linked. (2) "Oblique-linkage" yields a fold that connects two initial folds through a curved saddle resembling Type II refold structures. (3) "Oblique-no-linkage" results in two curved folds with fold axes plunging in opposite directions. In fact the two initial folds do not link with each other but are linking with the folds amplifying to the left and to the right of the initial perturbations. (4) "Linear-no-linkage", yielding two separate linear folds with fold axes plunging in opposite directions.

The saddles between linked antiforms may be of great economic interest, especially if the antiforms represent productive hydrocarbon traps. The saddle points mark the structurally lowest point in an antiformal hydrocarbon trap and once a trap has been filled the hydrocarbons spill or leak out, and may continue to migrate into the linked antiform. Furthermore, saddles represent positions on a surface, where the maximum and the minimum curvatures have the opposite sign. Since the magnitude of the curvature has been related to fracture density, antiformal and synformal saddles are frequently locations of more intense fracturing and related mineral deposits.