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Along-strike structural variation and thermokinematic development of the Cenozoic Bitlis-Zagros fold-thrust belt, Turkey and Iraqi Kurdistan

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The Bitlis-Zagros orogen in northern Iraq is a principal element of the Arabia-Eurasia continent collision and is characterized by the lateral intersection of two structural domains: the NW-SE trending Zagros proper system of Iran and the E-W trending Bitlis fold-thrust belt of Turkey and Syria. While these components in northern Iraq share a similar stratigraphic framework, they exhibit along-strike variations in the width and style of tectonic zones, fold morphology and trends, and structural inheritance. However, the distinctions of the Bitlis and Zagros segments remains poorly understood in terms of timing and deformation kinematics as well as first-order controls on fold-thrust development. Structural and stratigraphic study and seismic data combined with low-T thermochronometry provide the basis for reconstructions of the Bitlis-Zagros fold-thrust belt in southeastern Turkey and northern Iraq to elucidate the kinematic and temporal relationship of these two systems. Balanced cross-sections were constructed and incrementally restored to quantify the deformational evolution and use as input for thermokinematic models (FETKIN) to generate thermochronometric ages along the topographic surface of each cross-section line. The forward modeled thermochronometric ages from were then compared to new and previously published apatite and zircon (U-Th)/He and fission-track ages from southeastern Turkey and northern Iraq to test the validity of the timing, rate, and fault-motion geometry associated with each reconstruction. The results of these balanced theromokinematic restorations integrated with constraints from syn-tectonic sedimentation suggest that the Zagros belt between Erbil and Suleimaniyah was affected by an initial phase of Late Cretaceous exhumation related to the Proto-Zagros collision. During the main Zagros phase, deformation advanced rapidly and in-sequence from the Main Zagros Fault to the thin-skinned frontal thrusts (Kirkuk, Shakal, Qamar) from middle to latest Miocene times, followed by out-of-sequence development of the Mountain Front Flexure (Qaradagh anticline) by $\sim$5 Ma. In contrast, initial exhumation in the northern Bitlis belt occurred by mid-Eocene time, followed by collisional deformation that propagated southward into northern Iraqi Kurdistan during the middle to late Miocene. Plio-Pleistocene deformation was partitioned into out-of-sequence reactivation of the Ora thrust along the Iraq-Turkey border, concurrent with development of the Sinjar and Abdulaziz inversion structures at the edge of the Bitlis deformation front. Overall, these data suggest the Bitlis and Zagros trends evolved relatively independently during Cretaceous and early Cenozoic times, resulting in very different structural and stratigraphic inheritance, before being affected contemporaneously by major phase of in-sequence shortening during middle to latest Miocene and out-of-sequence deformation since the Pliocene. Limited seismic sections corroborate the notion that the structural style and trend of the Bitlis fold belt is dominated by inverted Mesozoic extensional faults, whereas the Zagros structures are interpreted mostly as fault-propagation folds above a Triassic décollement. These pre-existing heterogeneities in the Bitlis contributed to the lower shortening estimates, variable anticline orientation, and irregular fold spacing and the fundamentally different orientations of the Zagros-Bitlis belt in Iraqi Kurdistan and Turkey.