The Kopeh Dagh and Balkan mountain ranges of West Turkmenistan are actively deforming as a result of Arabia-Eurasia collision. We combine observations of the geomorphology made from satellite and topographic data, with historical and recent seismicity to identify major active faults, and how they contribute to regional shortening.

Between 55-57.5°E, partitioned (north-vergent) thrust and right-lateral strike-slip fault segments, comprising the Ashkabad fault zone, accommodate regional shortening and the westward-extrusion of the NW Kopeh Dagh-South Caspian block, relative to Central Iran and Eurasia. Reconstruction of displaced geology indicates 35 km total right-lateral motion across the Ashkabad fault zone.

The Balkan region lies along-strike of the Ashkabad fault zone, west of 55°E. Fault plane solutions indicate shortening is partitioned onto the Balkan thrust and right-lateral Kum Dagh fault zones. Thrust earthquakes are relatively deep (30–45 km) and lie along a north-dipping plane which extends 40+/-5 km north beneath the Balkan anticline. Receiver function data from Turkmenbashi and Nebit Dagh indicate these earthquakes occur in the base of the crust, and may therefore be related to bending of the NW Kopeh Dagh-South Caspian lithosphere as it is overthrust by Eurasia. Movement on a north-dipping blind thrust fault is consistent with the broad asymmetric (south-vergent) fold structure of the Balkan range. Recent uplift is also indicated by extensional faults which displace Quaternary geomorphology along the range crest. South of the Balkan range, right-lateral shear occurs across the Kum-Dagh fault zone, which is expressed as a series of right-stepping anticlines (affecting Pliocene Red Series and younger sediments), forming important traps for hydrocarbons.

An important structural change occurs near 55°E. To the west, Eurasia overthrusts the NW Kopeh Dagh-South Caspian block, while to the east the polarity of thrusting changes and the Kopeh Dagh overthrusts Eurasia. This unstable geometry has resulted in the right-lateral Kum Dagh and Ashkabad fault zones becoming offset by 40+/-5 km, and also explains the presence of thrust earthquakes in the South Caspian lithosphere extending 40+/-5 km north beneath the Balkan range.

Resolving estimates for South Caspian-Eurasia motion (from published GPS velocities) onto the Balkan thrust fault indicates a NNE-shortening rate of 4-6 mm/yr, and a slip-rate of 5-7 mm/yr for the right-lateral Kum Dagh fault zone. Similar estimates using GPS velocities from the Iranian Kopeh Dagh indicate 2-4 mm/yr right-lateral motion and 1-3 mm/yr NNE-shortening across the Ashkabad fault zone. If the Kum Dagh-Ashkabad right-lateral shear zone becomes offset at the rate of shortening across the Balkan thrust, 40+/-5 km offset would be accommodated in 6-11 Ma. Similarly, 8-15 Ma is required to accommodate 35 km right-lateral motion on the Ashkabad fault. These estimates suggest the present-day kinematics of the Kopeh Dagh and the onset of South Caspian subduction beneath Eurasia may be older than previously thought (>5.5 Ma). Furthermore, the increase in slip-rate between the right-lateral Ashkabad and Kum Dagh fault zones requires E-W extension across the NW Kopeh Dagh. This is probably accommodated on distributed left-lateral fault systems which cross-cut the range west of 57°E, and may account for the westward decrease in elevation of the range.