The East Alborz mountains of NE Iran are actively deforming as a result of Alpine-Eurasia collision. We examine the style of deformation across the range using remote and field observations of fault-related geomorphology, historical and recent seismicity and published GPS velocities. Shortening occurs on the Khazar fault, which bounds the range to the north. Between 53°57′E, shortening decreases from >2 to 0.5 mm/yr, resulting in lower elevations. Deformation south of the range occurs on the predominantly left-lateral Shahrud fault system, which is situated <3 mm/yr, and comprises several large deformation-fault segments. A new in the Astaneh fault segment, north of Damghan, has formed a pull-apart basin, giving ~0 km total left-lateral motion. A large earthquake in 856AD, which killed over 200,000 people, probably ruptured this fault. Due to the long gap in seismicity along the eastern Shahrud fault system, the city of Jajarm (15,000 pop.) is considered at high risk from future earthquakes. Between 25-35 km left-lateral motion has occurred on the Shahrud fault system, which has left-laterally displaced geomorphology. Similar displacements (with minor vertical motion) are seen in Quaternary alluvial fan deposits and drainage systems (Fig. S2).

• Shortening on the Khazar fault is accommodated on the Shahrud fault system, which has left-laterally displaced geomorphology and geology, with published GPS velocities. Shortening on the Shahrud fault system is approximately ~250 km and occurs on the predominantly left-lateral Shahrud fault system (Fig. D2). The Shahrud fault system north of Jajarm is considered at high risk from future earthquakes. B etween 25-35 km left-lateral motion has occurred on the Shahrud fault system, which has left-laterally displaced geomorphology. Similar displacements (with minor vertical motion) are seen in Quaternary alluvial fan deposits and drainage systems (Fig. S2).

• Published GPS velocities for Iran (Wempe et al., 2004) show an eastwards decrease in northward velocity of Central Iran (south of the Alborz), relative to Eurasia (see Fig. C2). Near ~58°E, comparison of GPS velocities north and south of the Alborz indicate ~3 mm/yr NE-SW motion is partitioned onto the Khazar (~2 mm/yr) and Shahrud (~3 mm/yr) fault systems (see Fig. C2).

• The northward velocity of Central Iran decreases eastward, so too does the shortening component accommodated across the Alborz. Assuming a linear decrease in northward velocity between 55°55′ and 58°E, shortening accommodated in the East Alborz, north of Jajarm, is low (<1.5 m/yr), although strike-slip motion remains ~3 mm/yr (see Fig. C1 and C2).

• The eastward decrease in shortening on the Khazar fault results in the lower elevations (by ~1500 m) of the East Alborz mountains between 56°-57°E (see Fig. C2).

- The Astaneh fault north of Shahrud is a major active left-lateral strike slip fault. The fault bend uplift of Jajarm is a tectonic expression of a major active left-lateral strike-slip fault. The North Shahrud fault segment overlaps the Astaneh fault north of Shahrud. The Astaneh pull-apart basin is seen in Quaternary alluvial fan deposits and drainage systems (Fig. S2).

- The North Alborz deformation is characterized by predominantly left-lateral strike slip (~30 km total) to the south, on the range-bounding Shahrud fault system, and thrusting to the north, on the Khazar fault (as shown by recent seismicity, see Jackson, et al., 2003).

- Active deformation in the East Alborz is partitioned onto the Khazar (~2 mm/yr) and Shahrud (~3 mm/yr) fault systems (see map for summary map). A long gap in seismicity on the eastern end of the Shahrud fault system puts Jajarm at high risk from future earthquakes. Total slip on the Shahrud fault system (~30 km) is in agreement with estimates for the Moshir fault of the Central Alborz (Allen, et al., 2003), and estimates of the West Kopeh Dagh (Hollingsworth, et al., 2006).

- Based on our slip-rate estimates, the Shahrud fault system may date from ~10 Ma. This coincides with a pulse in exhumation of the Alborz at 12 Ma (Guest, et al., 2006).

- We combine remote and field observations of the geomorphology and geology, with published GPS velocities and kinematics, to identify major active faults in the East Alborz mountains.

- Despite minimal recent seismicity, we show the fault systems bounding the East Alborz to the south are part of a major zone of left-lateral deformation, known as the Shahrud fault system (Fig. 22).

- In Sections 2, 3, and 4, we give geomorphological evidence for active left-lateral motion on different fault segments, which may make up the 350 km-long Shahrud fault system (see Fig. J2 for locations).