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LEFT-LATERAL STRIKE-SLIP FAULTING IN THE EAST ALBORZ, NE IRAN

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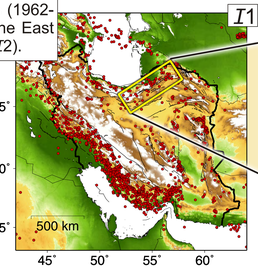
ABSTRACT

The East Alborz mountains of NE Iran are actively deforming as a result of Arabia-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 Khazaar 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 may slip at ~3 mm/yr, and comprises several range-bounding fault segments. A bend in the Astaneh fault segment, north of Damghan, has formed a pull-apart basin, giving ~30 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, based on present-day slip-rate estimates (derived from GPS) would have taken ~10 Ma. This roughly coincides with a pulse in Alborz exhumation at 12 Ma (Guest, et al., 2006) and possibly the start of uplift in the Kopeh Dagh (Hollingsworth, et al., 2006).

INTRODUCTION

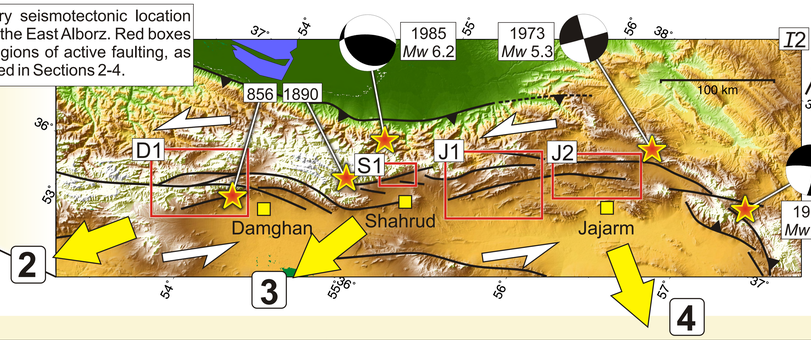
1

Topographic map of Iran. Red dots show earthquake locations (1962-2004). Yellow box shows the East Alborz mountains (see Fig. *I*2).



- Iran is actively deforming as a result of the collision of Arabia with Eurasia (see Fig. *I*1). The Alborz mountains of North Iran play a major role in accommodating this motion.
- Previous studies have investigated deformation in the Central and West Alborz. However, no studies have examined active faulting in the East Alborz (yellow box in Fig. *I*1, and Fig. *I*2).

Summary seismotectonic location map for the East Alborz. Red boxes show regions of active faulting, as discussed in Sections 2-4.

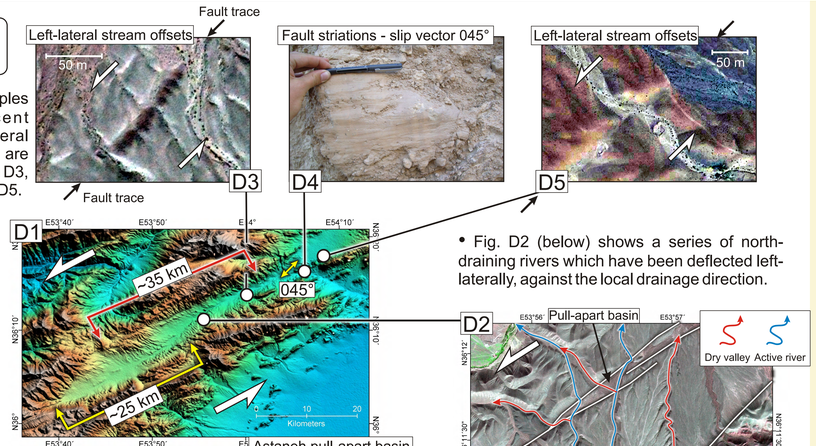


- We combine remote and field observations of the geomorphology and geology, with published GPS velocities and seismicity, to identify major active faults in the East Alborz mountains.
- Despite minimal recent seismicity, we show the that faults bounding the East Alborz to the south are part of a major zone of left-lateral deformation, known as the Shahrud fault system (Fig. *I*2).
- In Sections 2, 3 and 4, we give geomorphological evidence for active left lateral motion on different fault segments, which make up the 300 km-long Shahrud fault system (see Fig. *I*2 for locations).

DAMGHAN

2

- Examples of recent left lateral motion are given in D3, D4 and D5.

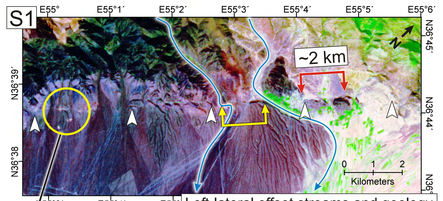


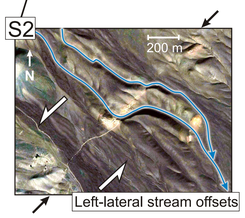
- Fig. D2 (above) shows a series of north-draining rivers which have been deflected left-laterally, against the local drainage direction.
- The region of Damghan (Fig. D1) was destroyed by a large earthquake in 856AD, killing over 200,000 people.
- The Astaneh fault segment lies ~15 km north of Damghan. Movement on this fault has formed a ~30 km left-lateral pull-apart basin. Smaller 8-10 m stream offsets along this fault may date from 856AD earthquake.

SHAHRUD

3

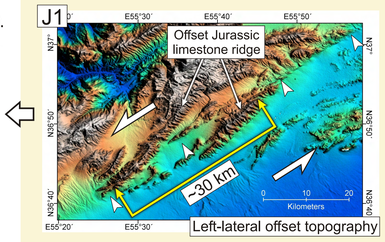
- The North Shahrud fault segment overlaps the Astaneh fault north of Shahrud.
- An earthquake in 1890 may have ruptured this fault.

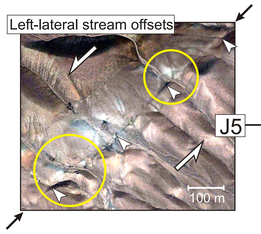




- Fig. S1 (above) is a satellite view of the North Shahrud fault segment, which has left-laterally displaced geology and geomorphology.
- Similar displacements (with minor vertical motion) are seen in Quaternary alluvial fan deposits and drainage systems (Fig. S2).

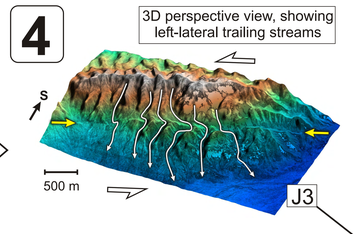
- Fig. J1 (below) shows a 30 km left-lateral offset limestone ridge, between Shahrud and Jajarm.

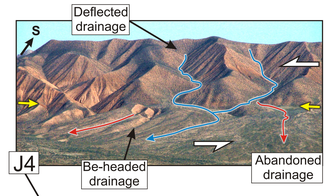


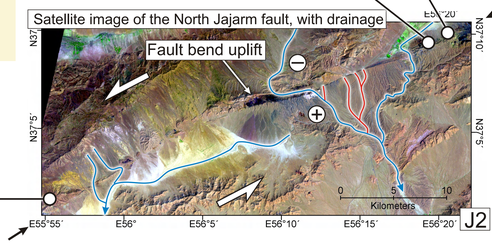


JAJARM

4





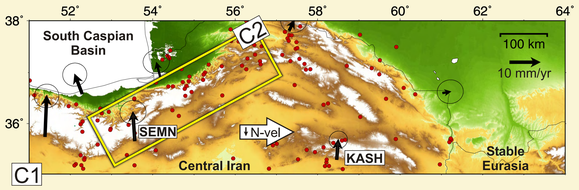


- No major historical earthquakes are known from the Shahrud fault system north of Jajarm.
- However, the clear geomorphological expression of the North Jajarm fault indicates it is a major active left-lateral strike slip fault.
- Fig. J2 (above) is a satellite view of the North Jajarm fault segment, which has left-laterally displaced a number of streams and rivers (e.g. Figs. J3, J4 and J5).
- A bend in the fault has caused uplift of Quaternary river deposits south of the fault.

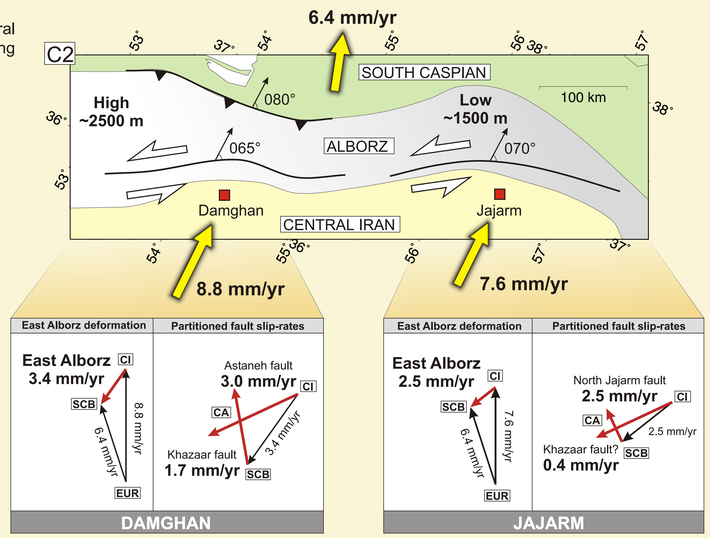
DISCUSSION

5

- The active tectonics of the East Alborz mountains is characterised 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 Khazaar fault (as shown by recent seismicity, see Jackson, et al., 2003).



- Published GPS velocities for Iran (Vernant, et al., 2004) show an eastwards decrease in northward velocity of Central Iran (south of the Alborz), relative to Eurasia (see Fig. C1).
- Near ~54°E, comparison of GPS velocities north and south of the Alborz indicate ~3-4 mm/yr NE-SW motion is partitioned onto the Khazaar (~2 mm/yr) and Shahrud (~3 mm/yr) fault systems (see Fig. C2).
- As 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 SEMN and KASH, shortening accommodated in the East Alborz, north of Jajarm, is low (~0.5 mm/yr), although strike-slip motion remains ~3 mm/yr (see Fig.C1 and C2).
- The eastward decrease in shortening on the Khazaar fault results in the lower elevations (by ~1000 m) of the East Alborz mountains between 56-57°E (see Fig. C2).

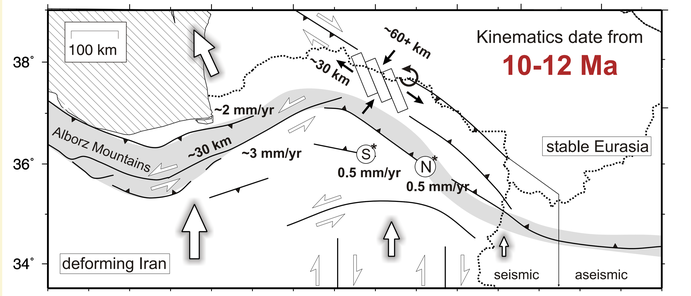


CONCLUSIONS

6

- Active deformation in the East Alborz is partitioned onto the Khazaar thrust (~2 mm/yr) and Shahrud left-lateral (~3 mm/yr) fault systems, north and south of the range respectively (see Fig. C3 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 Mosha fault of the Central Alborz (Allen, et al., 2003), and extrusion 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).

C3 Summary tectonic map of NE Iran, based on the results of this study and Hollingsworth, et al., 2006.



*OSL-derived shortening estimates from (**S**)abzevar (Fattahi, et al., 2006), and (**N**)eyshabur (in prep.)

ACKNOWLEDGEMENTS

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