

## Extrusion tectonics and subduction in the eastern South Caspian region since 10 Ma: COMMENT

COMMENT: doi: 10.1130/G25627C.1

J.-F. Ritz

Laboratoire Géosciences Montpellier—UMR CNRS 5243,  
Université Montpellier 2, 34095 Montpellier Cedex 05, France

Hollingsworth et al. (2008) propose that the westward motion of the South Caspian basin started 10 Ma ago. This is earlier than the ca. 5 Ma proposed by Axen et al. (2001) and Allen et al. (2002), and substantially earlier than the ca. 1.5 Ma proposed by Ritz et al. (2006). This new interpretation is based on the assumption that the present tectonics pattern (geometry of faults, slip vectors, and slip rates) did not vary through time.

However, several published studies, as well as original data in Hollingsworth et al.'s paper, suggest on the contrary that the faults and/or their kinematics have changed during the past 10 Ma. For instance, in western Central Alborz, the combination of range-parallel right-lateral faults and thrusts indicate that this part of Alborz was a right-lateral transpressional zone in the late Cenozoic,  $5 \pm 2$  Ma ago (Allen et al., 2003; Axen et al., 2001), giving a maximum bound for the onset of the South Caspian basin's westward motion.

In southern Central Alborz, a recent change in kinematics occurred along the Mosha, Taleghan, and Firuzkuh faults (Ritz et al., 2006). At large time and space scales, these faults correspond to thrust faults characterized by the overthrusting of Paleozoic and Mesozoic formations over Neogene formations. However, when studied over the Quaternary time scale, these faults appear as strike-slip faults along which the left-lateral wrenching of the Alborz mountain range is occurring. Along the Mosha and Taleghan faults, this left-lateral motion is associated with a normal component due to the obliquity of the faults with respect to the general trend of the range. The cumulated topography associated with the normal component is small and does not reverse the reliefs, showing that the kinematic change (from mainly reverse to left-lateral-normal) is recent. Having estimated a total horizontal displacement of ~3 km and a horizontal slip rate of ~2 mm/a along the Mosha fault, Ritz et al. (2006) proposed that the change of kinematics occurred ca. 1.5 Ma ago, contemporaneously with the onset of the Damavand volcanic activity.

In eastern Central Alborz, about the same amount of total displacement along the Jajarm fault has been described by Hollingsworth et al. (2008) as was described by Ritz et al. (2006). In Hollingsworth et al.'s Figure 4, one can see that a bedrock massif is shifted with the same displacement (4–5 km) of a river. Eastward of the described area, a bedrock massif is left-laterally displaced with a maximum offset of ~6 km. In addition, Hollingsworth et al.'s interpretation of the Astaneh valley as a pull-apart basin associated with a total left-lateral displacement of 30–40 km along the Astaneh fault system is very speculative. On the Kiyasar 1/100,000 Iranian Geological Survey map, the faults bounding the basin (south and north) are mapped as southward- and northward-dipping thrust faults, respectively, with Paleozoic-Mesozoic and Paleocene formations overthrusting Upper Neogene deposits. Moreover, no normal fault is mapped at the northeast-southwest-trending border. Finally, the recent and active strike-slip faulting is mainly found inside the basin rather than along its borders.

In the Kopet Dagh, the interpretation of a total right-lateral displacement of 35 km across the Ashkabad fault zone is also very spec-

ulative, as recognized by Hollingsworth et al., who noted, with good reason, that a thrust component of motion cannot be ruled out for this fault segment. They explain that oblique motion across this fault would result in an apparent right-lateral offset, resulting in an overestimate of the right-lateral displacement.

Therefore, I think that the ~35 km of total strike-slip motion estimated along the present-day active faults in Central Alborz or in Kopeh Dagh are overestimated (Ritz et al., 2008). The total left-lateral displacement measurable along the Quaternary, and still active, strike-slip faults in Central Alborz seems rather to be one order of magnitude lower (i.e., 3–6 km). If we assume that the 2–4 mm/a of left-lateral shearing measured by global positioning system across Central Alborz at about  $52^{\circ}$ – $55^{\circ}$ E (Vernant, 2008, personal commun.) is taken mainly along these strike-slip faults, and that their slip rate remained constant over the Pleistocene, then the beginning of the left-lateral wrenching inside the Alborz, and therefore the beginning of the westward motion of the South Caspian basin, was less than 2 Ma ago.

For all that, it is true that features such as the 80-km-deep earthquakes beneath the Apsheron-Balkan Sill (Jackson et al., 2002) or the Pliocene subsidence observed within the northwest of the South Caspian basin (Allen et al., 2002) suggest that the South Caspian basin had started subducting below the Apsheron-Balkan Sill before the Pleistocene. It seems, therefore, that the motion of the South Caspian basin is more complex than proposed so far. A possible interpretation is that a northward subduction first started between the mid-Miocene and the Pliocene, and then a westward component of motion—probably associated with a clockwise rotation—has been added during the Pleistocene.

### ACKNOWLEDGMENTS

Mark Allen provided constructive comments on this manuscript.

### REFERENCES CITED

- Allen, M.B., Jones, S., Ismail-Zadeh, A., Simmons, M., and Anderson, L., 2002, Onset of subduction as the cause of rapid Pliocene-Quaternary subsidence in the South Caspian basin: *Geology*, v. 30, p. 775–778, doi: 10.1130/0091-7613(2002)030<0775:OOSATC>2.0.CO;2.
- Allen, M.B., Ghassemi, M.R., Shahrabadi, M., and Qorashi, M., 2003, Accommodation of late Cenozoic oblique shortening in the Alborz range, northern Iran: *Journal of Structural Geology*, v. 25, p. 659–672, doi: 10.1016/S0191-8141(02)00064-0.
- Axen, G.J., Lam, P.S., Grove, M., Stokli, D.F., and Hassanzadeh, J., 2001, Exhumation of the west-central Alborz mountain, Iran, Caspian subsidence, and collision-related tectonics: *Geology*, v. 29, p. 559–562, doi: 10.1130/0091-7613(2001)029<0559:EOTWCA>2.0.CO;2.
- Hollingsworth, J., Jackson, J., Walker, R., and Nazari, H., 2008, Extrusion tectonics and subduction in the eastern South Caspian region since 10 Ma: *Geology*, v. 36, p. 763–766, doi: 10.1130/G25008A.1.
- Jackson, J., Priestley, K., Allen, M., and Berberian, M., 2002, Active tectonics of the South Caspian Basin: *Geophysical Journal International*, v. 148, p. 214–245, doi: 10.1046/j.1365-246X.2002.01588.x.
- Ritz, J.-F., Nazari, H., Ghassemi, A., Salamati, R., Shafei, A., Solaymani, S., and Vernant, P., 2006, Active transtension inside Central Alborz: A new insight of the northern Iran-southern Caspian geodynamics: *Geology*, v. 34, p. 477–480, doi: 10.1130/G22319.1.
- Ritz, J.-F., Nazari, H., Solaymani, S., Salamati, R., Rizza, M., Vernant, P., and Chery, J., 2008, Analysing the recent tectonic and geodynamical evolution of Central Alborz, a review: *Dynamique d'une collision continentale jeune, l'Iran: Société Géologique de France meeting, Paris, Abstract*, p. 45–46.