Post-collisional magmatism in Iran: Implications for timing of Arabia-Eurasia collision and the succeeding mantle dynamics

Jamshid Hassanzadeh[1], Brian P. Wernicke[1], Z. Hossein Shomali[2], and A.M. Ghazi[3]
(1) Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125
(2) Institute of Geophysics, University of Tehran, Tehran, 14155-6466, Iran
(3) DoD Remediation, Georgia EPD, Atlanta, GA 30334

Background

Collision of Arabia-Eurasia in Iran shaped the Zagros fold-thrust belt and Central Iran plateau, which are separated from each other by the suture along the Zagros main Thrust. Dates from Late Cretaceous to Pliocene have been proposed for the collision. The Neogene collision models are partly based on observations that until the early Miocene: 1) stable carbonate sedimentation continued in the Zagros and 2) the central Iranian plateau was largely at or below sea level till ~16 Ma, both indicating that collisional uplift occurred after the early Miocene. Before Arabia-Eurasia collision, the northward subduction of the Neotethys slab along the southern margin of the Asian continent gave rise to an Andean-type magmatic arc, manifested by the voluminous Sanandaj-Sirjan batholiths and Urumieh-Dokhtar and Alborz volcanics. Calc-alkaline magmatism persisted in the Urumieh-Dokhtar zone during the Neogene and was accompanied by significant porphyry copper mineralization in the late Miocene, possibly indicating continuation of subduction of oceanic slab beyond Paleogene times.

Post-collisional magmatism

From the late Miocene onwards a remarkable change in magmatism took place in Central Iran plateau by adding of small volume alkaline mafic volcanics –including basanites, melafoidite and alkaline olivine basalts- to the more common arc rocks. Ages of ~10 Ma and 6.8 Ma have been obtained for the oldest known melafoidites near the NW and SE ends of the Urumieh-Dokhtar arc, respectively (Fig. 1 & 2). Older volcanics of this type, either eroded or overlooked, cannot be ruled out.

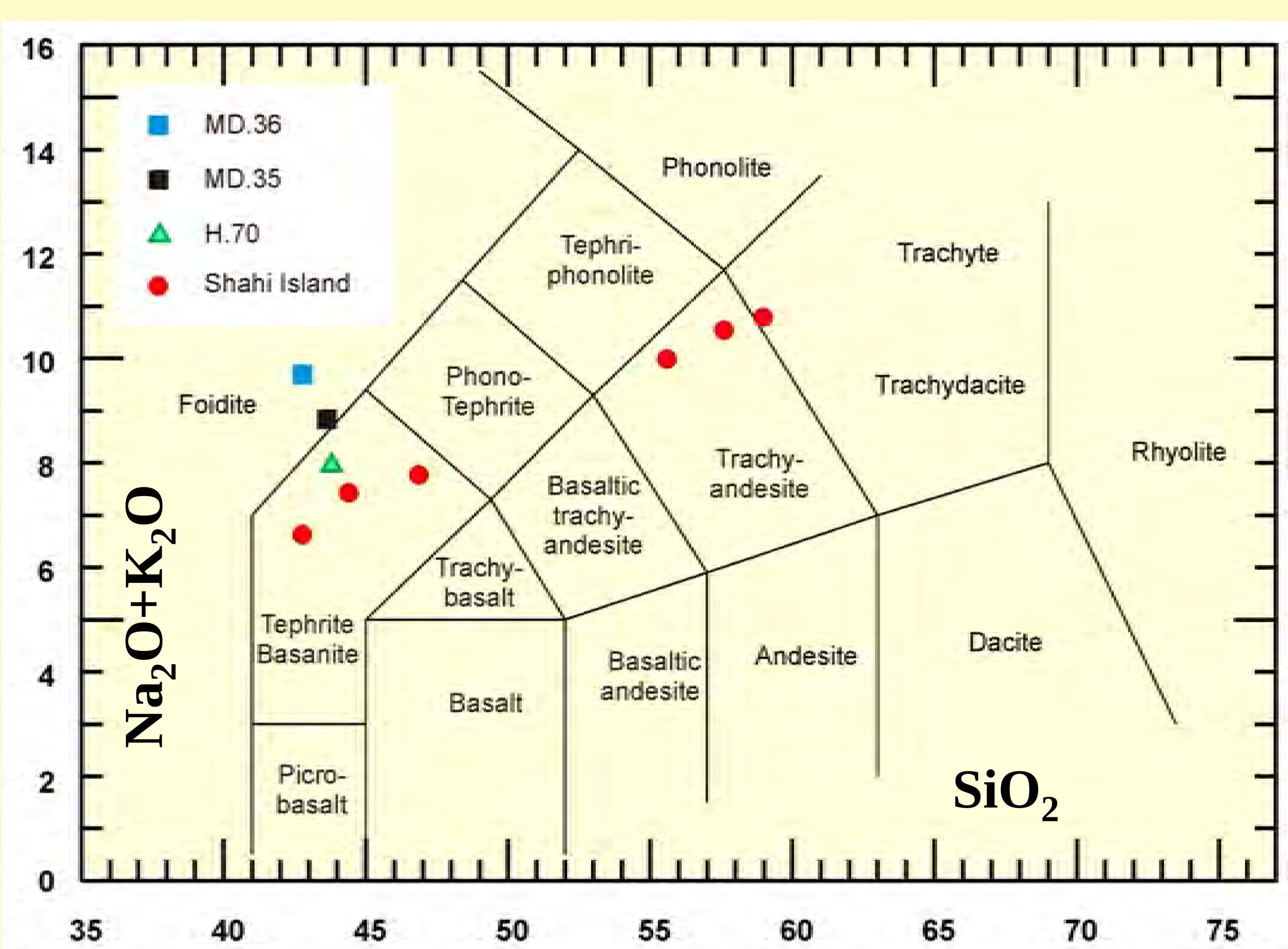

Fig. 1. Late Miocene basanites, foidites and trachytes from two sites in Iran: Shahi Island (in the northwest and Kuh-e Geri in the southeast.

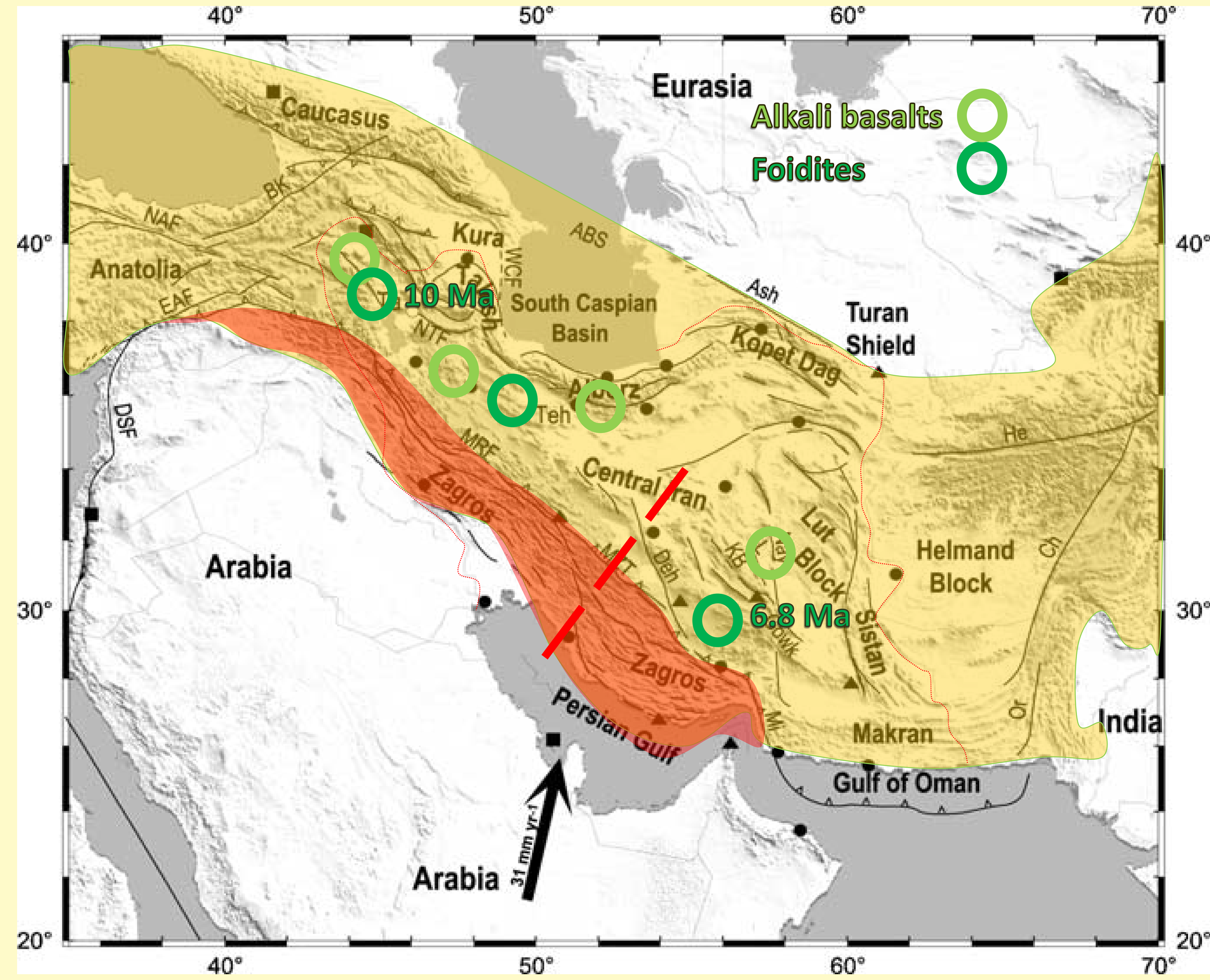

Fig. 2. Late Miocene-Quaternary alkali volcanics in Iran. Radiometric dates are for the oldest melafoidites. Red dashed line is the trend of seismic profile in Fig. 3. Base map from Vernant et al. (2004).

Implications on timing of collision

Dates of 10 and 6.8 Ma indicate minimum ages for transition from more typical arc chemistries to small volume alkaline mafic varieties; a change that was associated with sudden increase in uplift. Collision took place before 10 Ma and was diachronous, propagating to the southeast. Mid-lithospheric melting responsible for generation of such alkaline mafic magmas required rapid heat transfer possibly caused by slab break-off and removal of the lithospheric root.

Seismic tomography and mantle dynamics

Mid-lithospheric melting is largely responsible for generation of post-collisional alkaline mafic magmas and requires rapid heat transfer possibly caused by slab rollback, slab break-off and removal of the lithospheric root. But at what stage of post-collisional evolution is the upper mantle under the Zagros collision zone?

Slab rollback

Fig. 3 shows the results of a high resolution seismic tomography along a NE-SW cross section. The first order observation is presence of a steep slab-like structure that extends from the Arabian plate beneath central Iran and continues to depths of ~500 km. To the north, hot mantle has replaced initial space of the slab. How long did it take for the slab to rollback to it's present day position?

Slab break-off

The relatively incomplete state of slab detachment implies that slab break-off under the Zagros is not too old. Slab separation in this tomography model is near 100 km. By applying sinking rates of 3-5 cm/yr in the upper mantle we suggest slab tear began 3-2 Ma. Rise of hot upper mantle underneath the Zagros crush zone has ensued the slab tear and is recent. A10 Ma lag between collision and slab-tearing (Hafkenscheid et al., 2006) places the collision ~13 Ma.

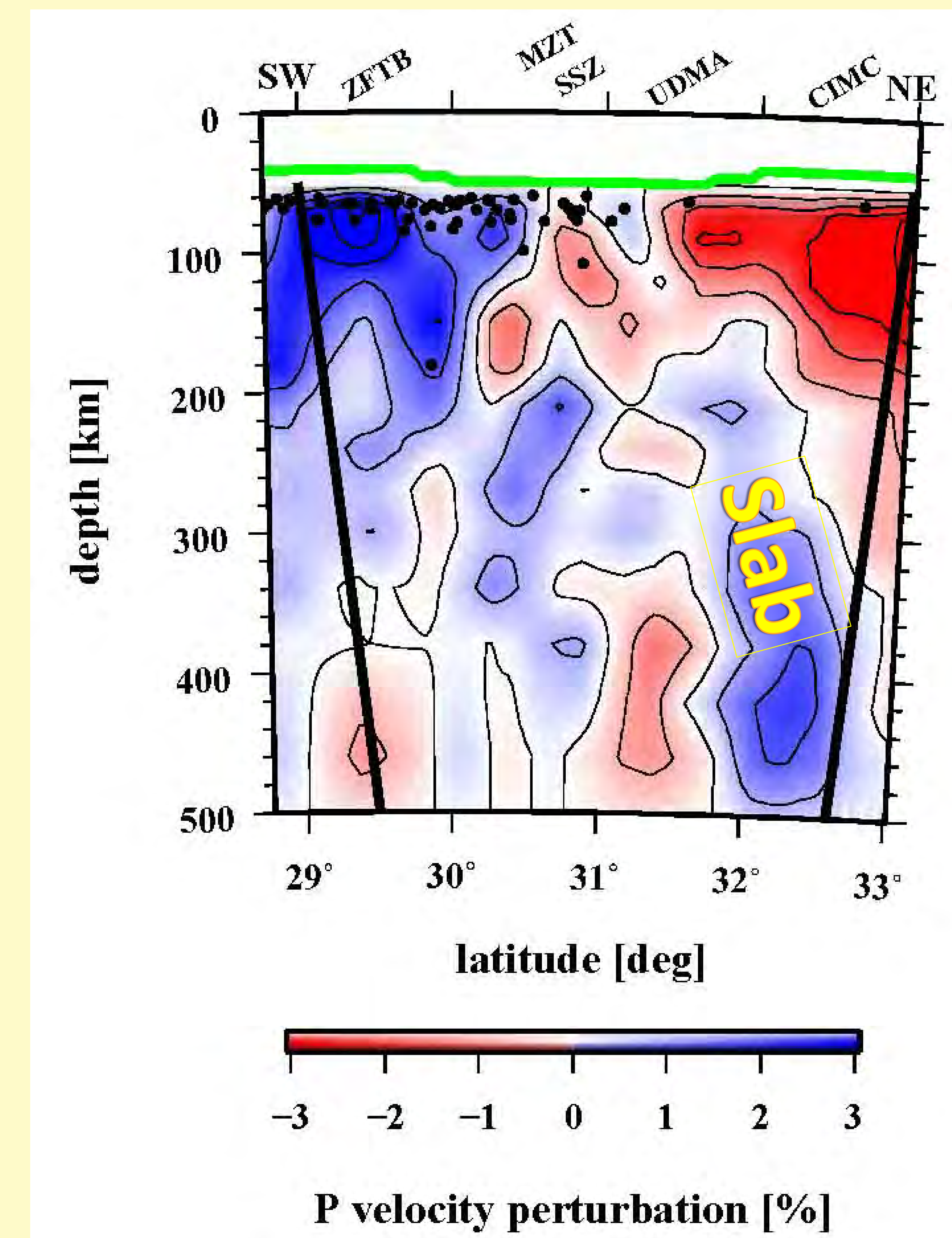

Fig. 3. High resolution seismic tomography model along a NE-SW cross section shown on Fig. 2 (Shomali et al. in review).

Conclusions

1- The oldest known alkali mafic post-collisional volcanic in Iran are dated at 10 Ma; therefore, Arabia-Eurasia collision is older.

2- A cold slab structure under this collision zone is shown by seismic tomography. The slab is steep and has undergone early stages of detachment from the Arabian plate.

3- Asthenospheric rise underneath central Iranian plateau could have started since at least ~13 Ma.

4- Marine condition left central Iran plateau around 16 Ma.

References

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