U-Pb, $^{40}Ar/^{39}Ar$ and (U-Th)/He ages of Iranian Tertiary volcanics: implications for extension-related volcanism and uplift of the Iranian plateau

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ABSTRACT

The Urumieh-Dokhtar volcanic arc, extending >1500 km across Iran, is one of the most impressive yet understudied volcanic arcs on earth. Despite a constant subduction rate of Neotethyan oceanic crust beneath Iran from at least late Paleocene to early Miocene time (McQuarrie et al, 2003), volcanism within the arc is dominated by an Eocene pulse. Volcanic rocks comprising the Lut arc in eastern Iran as well as Tertiary volcanic and volcaniclastic deposits in the Alborz Mountains in northern Iran are also primarily Eocene in age. Recently discovered middle Eocene metamorphic core complexes in central (Verdel et al, 2007) and western (Moritz et al, 2006) Iran raise the question of whether the magmatic pulse may be related to extension. Our new U-Pb and $^{40}Ar/^{39}Ar$ age data suggest that the oldest Tertiary arc volcanism pre-dated the onset of extension in the central Iranian core complexes by several m.y., and that continued volcanism overlapped with extension in both the central and western core complexes. Iranian Eocene basalts are enriched in large ion lithophile elements, but are depleted in high-field strength elements (HFSE), a pattern typical of volcanic arc basalts. In contrast, some latest Eocene to Oligocene basalts from Urumieh-Dokhtar and the Alborz Mtns. are enriched in HFSE, a feature more consistent with back arc basin basalts that suggests a smaller input from slab-derived fluids. Taken together, these geochronological and geochemical data suggest a 3 phase history of Tertiary volcanism: (1) a latest Paleocene-early Eocene phase of pre-extensional arc magmatism; (2) a middle-Eocene syn-extensional period during which extension may have increased volcanic output, but the continued influx of slab-derived components nevertheless produced basalts which are indistinguishable in their trace-element geochemistry from basalts of the first period; and (3) relatively limited, latest Eocene-early Oligocene, late- to post-extensional volcanism which has a back-arc basin geochemical affinity.

(U-Th)/He apatite ages from a tilted section of Eocene volcanic and sedimentary rocks in the Tafresh area within the Urumieh-Dokhtar arc are uniformly ~10 Ma and do not vary with depth in the section. This age is similar to some apatite (U-Th)/He ages in the Alborz Mtns. north of Tehran (Guest et al, 2006), but contrasts with apatite (U-Th)/He ages of ~20-25 Ma from the central Iranian core complexes (Verdel et al, 2007), Zagros Mtns. (Gavillot et al, 2006), and a potential core complex in northwest Iran (Stockli et al, 2004). The regional variation may suggest that initial uplift and exhumation of essentially the entire Iranian plateau occurred at ca. 20 Ma and was followed by deformation focused along the northern and southern margins of the country, such that topographically high areas at the margins produce young (10 Ma and younger) apatite (U-Th)/He ages whereas lower areas in the center of the country still preserve the ~20 Ma ages resulting from initial exhumation.

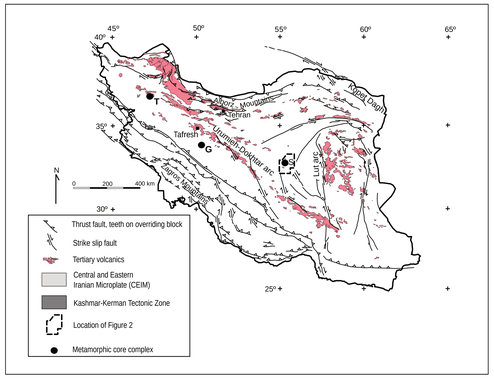

Figure 1. Distribution of Teriary volcanic rocks, major faults, and known or suspected metamorphic core complexes in Iran. Abbreviations: G-Golpaygan core complex, S-Saghand core complexes, T-Takab-Zanjan core complex.

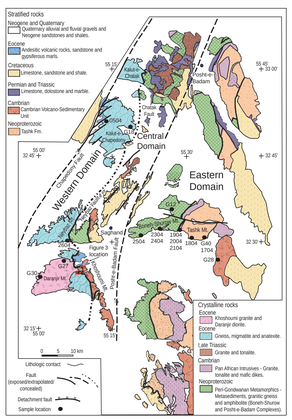

Figure 2. Geologic map of middle Eocene metamorphic core complexes in central Iran. These core complexes formed between ca. 49 and 41 Ma. The western Iranian core complex near the town of Golpaygan formed between ca. 55 and 38 Ma.

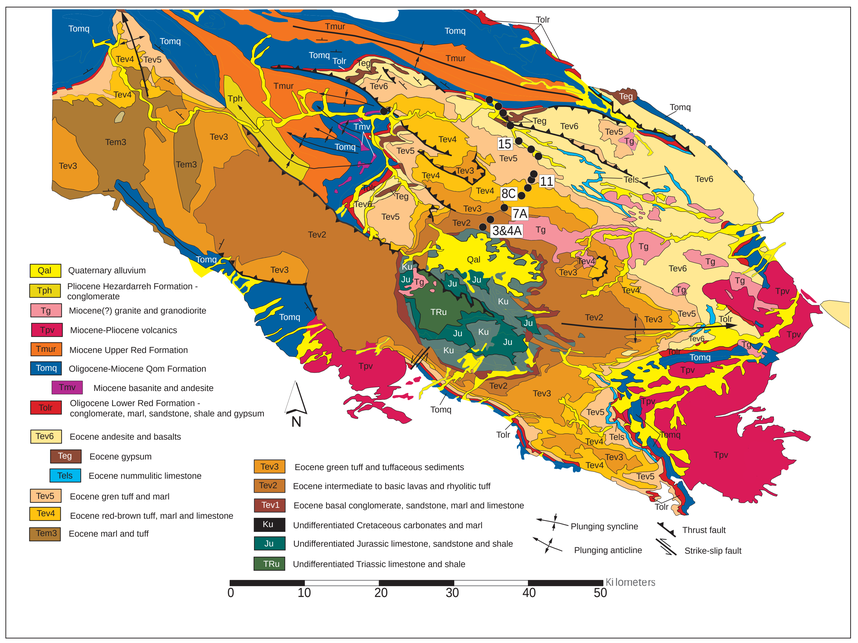

Figure 3. Geologic map of the Tafresh area showing sample locations.

Sample	Description	U-Pb zircon (Ma)	$^{40}Ar/^{39}Ar$ plagioclase (Ma)			U-Th/He (apatite)
			Isochron	Plateau	Total gas age	
3	Porphyritic andesite	***54.7+/-3.1***	44.2+/-0.9	45.5+/-1.2	43.8+/-0.7	
4A	Coarse crystal tuff		***50.9+/-4.4***	***56.6+/-3.9***		10.4+/-1.4
7A	Sandy tuff				***48.56+/-0.96***	
8C	Rhyolite tuff		17.3+/-4.2	15.8+/-0.7	18.9+/-0.4	
11	Tuff breccia	***44.3+/-2.2***				11.0+/-0.7
15	Rhyolite tuff					9.4+/-2.7

Table 1. Summary of geo- and thermochronology data for the Tafresh area. Ages in bold type are interpreted as crystallization ages, other ages are partially or completely reset due to heating from burial. Plagioclase $^{40}Ar/^{39}Ar$ closure temperature is 200-250°C, apatite (U-Th)/He closure temperature is 40-110°C.

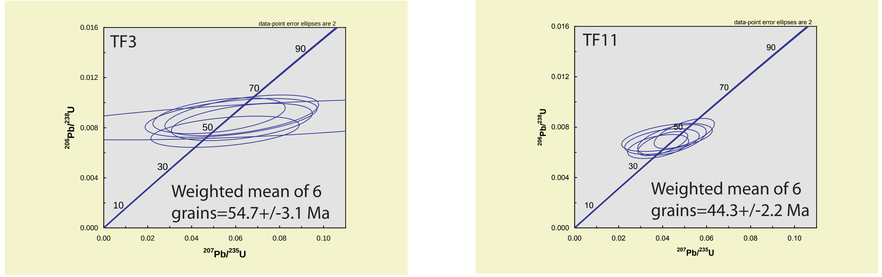

Figure 4. U-Pb concordia diagrams for samples TF3 and TF11. Data obtained on Cameca IMS 1270 at UCLA.

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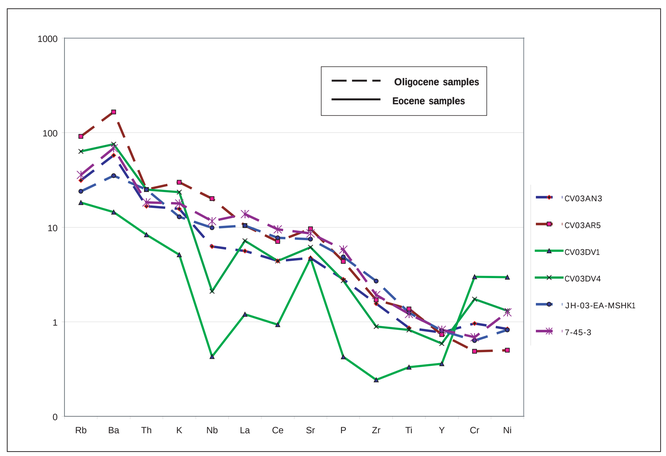

Figure 5. N-MORB normalized spider diagrams of primitive (>5% MgO, MORB normalized Cr and Ni ratios >0.5) Iranian basalts. "Spikey" Eocene patterns are typical of volcanic arc basalts, flat Oligocene patterns are suggestive of back arc basin basalts.

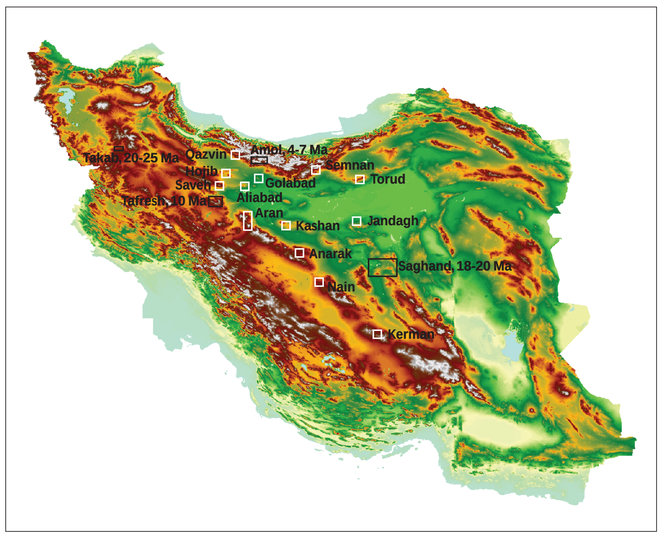

Figure 6. Summary of known (black rectangles) and propsed (white rectangles) local apatite (U-Th)/He ages.