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Eocene–Oligocene post-collisional magmatism in the Lut–Sistan region, eastern Iran: Magma genesis and tectonic implications

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ABSTRACT

New $^{40}Ar/^{39}Ar$, geochemical and Sr–Nd isotopic analyses of Eocene–Oligocene magmatic rocks in the Lut–Sistan region, eastern Iran shed light on their origin and the regional geodynamic evolution. Samples were collected from outcrops in the Sistan suture zone and to the west on the Lut block, which together constitute a diffuse magmatic province with an estimated size of ~300 km × 400 km. Magmatism was active from the Middle Eocene (~46 Ma) to the Late Oligocene (~25 Ma). The studied rocks are dominated by volcanic and sub-volcanic rocks with minor intrusive rocks, ranging from basaltic to rhyolitic compositions with a peak in intermediate compositions. Most of them have calc-alkaline to high-K calc-alkaline affinity, although shoshonitic rocks are also present. The rocks are characterized by (i) E-MORB-like ratios involving high field strength and heavy rare earth elements, and (ii) an orogenic signature including enrichments of large ion lithophile elements and Th, Nb-Ta-Ti-P troughs and a positive Pb spike on MORB-normalized trace element variation diagrams. A juvenile mantle origin is apparent from the dominance of positive $\varepsilon Nd(t)$ values for the studied rocks. The Sr–Nd isotopic compositions [$(^{87}Sr/^{86}Sr)_i = 0.7042$ to 0.7065; $\varepsilon Nd(t) = -4.9$ to $+5.5$] do not form parallel arrays with SiO_2, Nb/La, Nb/U and Ce/Pb as would be expected for crustal contamination. Since the magmatism post-dated the Lut–Sistan collision and cannot be related directly to subduction, the orogenic signature is likely inherited from the mantle source, presumably modified by sediment partial melt and fluid released from subducted slab during the Late Cretaceous Sistan subduction. We propose that the magmatism was triggered by convective removal of the lithosphere and resultant asthenospheric upwelling during extensional collapse of the east Iranian ranges in the Eocene–Oligocene.

1. Introduction

From a tectonic point of view, orogenic magmatism refers to igneous activity associated with subduction of oceanic lithosphere or collision between two continents (Gill, 1981; Martin and Piwinskii, 1972; Thorpe, 1982). Orogenic magmas are defined geochemically as showing diagnostic Nb-Ta trough and enrichments in large ion lithophile elements (LILE), Th, Pb, Sr and K in primitive mantle-normalized trace element variation diagrams (Lustrino and Wilson, 2007). The origin of such a geochemical signature is commonly interpreted in three different but not mutually exclusive ways. It might reflect magma genesis in a recent subduction-related setting (Gill, 1981; Thorpe, 1982), in sources that had undergone supra-subduction zone metasomatism (Aldanmaz et al., 2000; Peccerillo and Lustrino, 2005; Seghedi and Downes, 2011; Wilson and Downes, 1991), or crustal contamination of mantle-derived magmas (Harangi et al., 2006; Mason et al., 1996; Turner et al., 1999). These interpretations have important implications for the construction of magmatic record and correct assignment of geodynamic setting in the geological past.

One of the most significant events in the magmatic record of Iran was the Eocene–Oligocene magmatic flare-up, resulting in widespread magmatic rocks throughout the country (Fig. 1, inset) (Berberian and King, 1981; Camp and Griffis, 1982; Schroder, 1944; Verdel et al., 2011). Available geochemical data indicate that the magmatic products associated with this phase of activity have an orogenic signature. Relative to the Urumieh–Dokhtar magmatic arc (UDMA) in southwestern Iran and the Alborz ranges in northern Iran, the Eocene–Oligocene magmatic rocks in the Lut–Sistan region, eastern Iran have not been subjected to detailed studies, partly because of the inaccessibility of the region. In addition, the distribution of these rocks over a diffuse province of ~300 km × 400 km might require a different tectonomagmatic explanation compared to their counterparts in the Urumieh-Dokhtar and Alborz regions, which constitute linear or curved magmatic belts. Further, the eastern limit of the magmatism is superimposed with the Sistan suture zone, an enigmatic branch of

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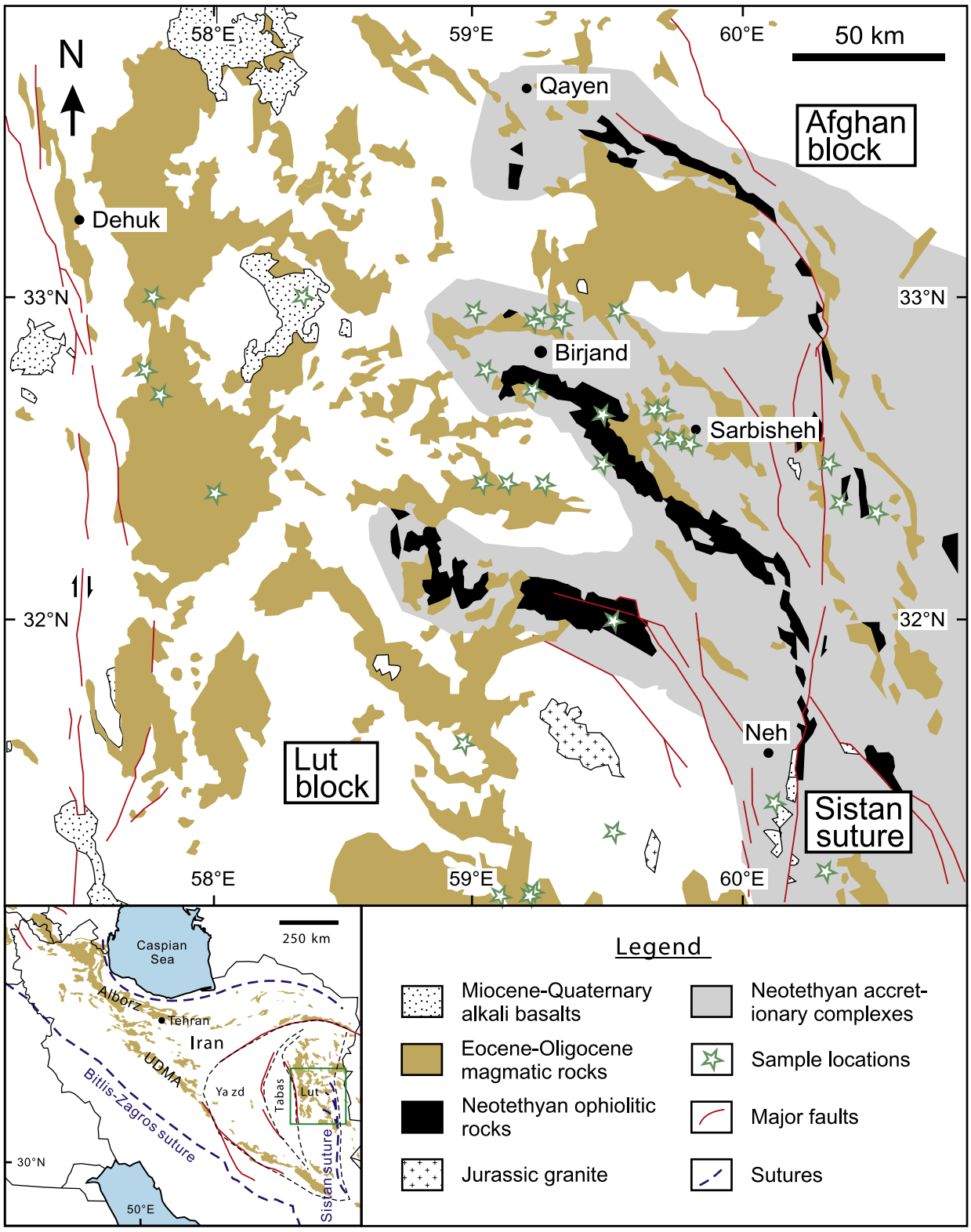

Fig. 1. Geological sketch map showing the sampling locations in the Lut–Sistan region, eastern Iran (modified from Pang et al., 2012). Inset shows the distribution of magmatic rocks resulted from the Tertiary magmatic flare-up and the location of the study area (bounded by green frame).

the Neotethys with a complex tectonic history (Camp and Griffis, 1982; Tirrul et al., 1983). For these reasons, we undertake a field, petrologic, geochronological and geochemical study of the Eocene–Oligocene magmatic rocks in the Lut–Sistan region, eastern Iran. Our results, together with the published zircon U–Pb ages for a subset of samples in an accompanying study (Zarrinkoub et al., 2010) and other geological information, are used to investigate magma genesis and the regional geodynamic evolution.