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Lithospheric structure beneath NW Iran using regional and teleseismic travel-time tomography

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ABSTRACT

We compute a 2-D tomogram using the P wave arrival time readings from a temporary seismic experiment to study the seismic structure of the crust and upper mantle in NW Iran. The study area includes the western margins of the South Caspian Basin (SCB), and the Sahand and Sabalan post-collisional volcanoes in NW Iran. We invert 2780 regional and teleseismic relative P wave arrival times recorded by 23 stations along the seismic profile extending from the western shoreline of the Caspian Sea to Lake Urumieh. Our tomographic results show a higher-velocity region beneath the SCB. The observed higher velocities strongly correlate with the observed positive gravity anomalies over the southwestern margins of the Caspian Sea, suggesting an oceanic like nature for the SCB lithosphere. The tomographic results also show several lower-velocity anomalies in the crust. The Sabalan volcano is underlain by a low-velocity zone in the lower crust, which is most likely thermal in nature. In the Sahand region, the lower velocities are considerably shallower in depth and might be controlled by shallow sedimentary structures, as well as an anomalously warm upper crust. The shallow low-velocity regions are connected with deeper low-velocity zones 60–100 km deep in the upper mantle. This pattern points to a possible mantle source of post-collisional volcanism in NW Iran, i.e. the melting of a subducted slab.

1. Introduction

NW Iran is part of the Turkish-Iranian plateau which is located in the central part of the Arabia-Eurasia collision zone. The region is bounded by the Lesser Caucasus and Kura Basin in the north, the Zagros Mountains in the south, and the South Caspian Basin in the East (Fig. 1a). As with the rest of Iran, the crustal structure and magmatic evolution of NW Iran have been dominated by the Arabia-Eurasia convergence since the Mesozoic. The region comprises the northern part of the Urumieh-Dokhtar Magmatic Arc (UDMA), a Tertiary magmato-sedimentary strip of land that runs parallel to the Zagros range and constitutes the magmatic arc of the Neotethyan subduction (see Agard et al. (2011) for a full review of the Neotethys subduction and Zagros orogeny). NW Iran has had extensive volcanism throughout the Cenozoic and the volcanic rocks are mostly Eocene to Quaternary in age (Fig. 1b). The Eocene and Oligocene rocks are related to arc magmatism (e.g. Agard et al., 2011 and references therein), while the late Miocene to Quaternary units are believed to be formed in a post-collisional setting (Şengör and Kidd, 1979; Chiu et al., 2013). According to recent work by Chiu et al. (2013), post-collisional magmatism in NW Iran becomes progressively younger from west to east. The earliest such magmatism they dated is Late Miocene (11 Ma) just east of Lake Urumieh, in the region of Sahand volcano, the younger eruptions are Late Miocene to Pliocene (6.5–4.2 Ma), and further east in the Sabalan volcano the youngest eruptions are Quaternary (<0.4 Ma) in age. The Sahand and Sabalan volcanoes are very large structures and they dominate the Pliocene-Quaternary magmatic landscape of NW Iran (Fig. 1b).

Current crustal deformation in NW Iran is shaped by the N-S convergence of Arabia and Eurasia and the westward motion of the rigid South Caspian Basin (SCB). The SCB is a relatively-aseismic rigid basement block and has affected the deformation history of its surrounding continental regions. The SCB and the Kura depression to its west are thought to be a relic back-arc of the Tethyan Mesozoic subduction (Berberian, 1983; Brunet et al., 2003) caught up in a continental collision zone similar to the Black Sea (e.g. Okay et al., 1994) and the eastern Mediterranean (de

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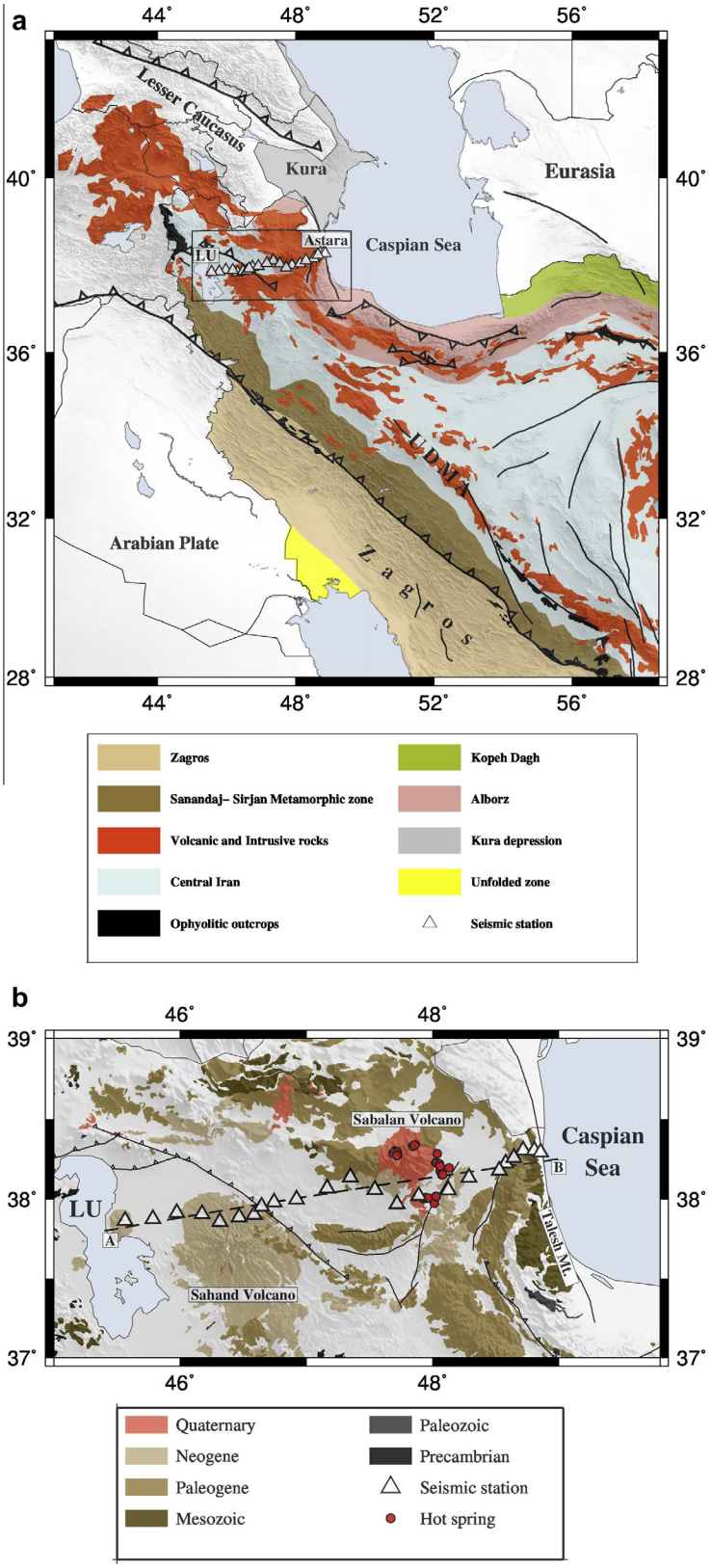

Fig. 1. (a) The study area is marked by a rectangle frame on a map showing major tectonostratigraphical units of Iran (modified from the structural map of National Geoscience Database of Iran, http://www.ngdir.ir). The solid lines represent the active faults (Hessami et al., 2003). The stations of the Talesh seismic profile have been shown by white triangles. UDMA and UL stands for Urumieh–Dokhtar magmatic arc and Urumieh Lake, respectively. (b) Simplified geological map showing volcanic rocks (Emami et al., 1993) overlaid on topographic relief. The triangles represent stations of the Talesh seismic profile. The line AB shows the profile for which we calculate our tomogram. Red circles show the location of the hot springs around Sabalan volcano (Yousefi et al., 2007). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)