Shallow crustal structure in the northwestern Iranian Plateau and its tectonic implications

Xu Wang1,3, Ling Chen1,3,2, Morteza Talebian4, Yinshuang Ai3,2,5, Mingming Jiang3,5, Huajian Yao6, Yumei He5,7, Abdolreza Ghods8, Farhad Sobouti8, Bo Wan1, Yang Chu1, Guangbing Hou3, Qifu Chen5,7, Wenjiao Xiao1,7, Fuyuan Wu1,7, Rixiang Zhu1,7, and Sun-Lin Chung9,10

1State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China
2College of Earth and Planetary Sciences, University of Chinese Academy of Sciences, Beijing, China
3Innovation Academy for Earth Science, CAS, Beijing, China
4Research Institute for Earth Sciences, Geological Survey of Iran, Tehran, Iran
5Key Laboratory of Earth and Planetary Physics, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China
6Laboratory of Seismology and Physics of Earth's Interior and School of Earth and Space Sciences, University of Science and Technology of China, Hefei, China
7Institutions of Earth Sciences, Chinese Academy of Sciences, Beijing, China
8Department of Earth Sciences, Institute for Advanced Studies in Basic Sciences, Zanjan, Iran
9Institute of Earth Sciences, Academia Sinica, Taipei
10Department of Geosciences, National Taiwan University, Taipei

The crustal structure of the Iranian Plateau bears important information about the details of the tectono-magmatic processes associated with the Neo-Tethys subduction and subsequent Arabia-Eurasia collision. Using a newly developed method of joint inversion of multi-frequency waveforms around and horizontal-to-vertical (H/V) ratios of the direct P arrivals in teleseismic P-wave receiver functions, we construct the shear-wave velocity image of the shallow crust (from surface up to 10-km depth below sea level) along a dense seismic array across the Zagros suture in the northwest Iranian Plateau. The most striking structural feature of the study region is the presence of low- and high-velocity anomalies (LVAs and HVAs) beneath the Zagros fold-and-thrust belt and the Iranian continent, respectively, indicating strong structural differences on the two sides of the suture. Systematic analysis on the velocity estimates and comparison with laboratory measurements and regional geology suggest that the LVAs and HVAs are representatives of Zagros sedimentary rocks and arc to intraplate magmatic rocks, respectively. The LVAs (1.3-2.0 km/s) are characterized by a series of faulted anti-form structures at ~1-7 km depths beneath Zagros. They are likely dominantly composed of shales and mudstones, and could have acted as mechanically weaknesses to accommodate different deformations of surroundings and give rise to the present-day depth-dependent seismicity. The HVAs beneath the central domain and Alborz in the Iranian continent present large ranges in both velocity (3.2-3.9 km/s) and depth (0-10 km), probably suggesting strong lithological variations in these areas. Most of the HVAs above 5-km depth have shear-wave velocities of 3.2 to 3.6 km/s, comparable to those of andesites and basalts.
dominated in the northwestern Iranian plateau. The deeper HVAs (below 5-km depth), which
generally have greater velocities ~3.6-3.9 km/s falling into the velocity range of intrusive rocks such
as granodiorites, diorites and diabases, appear to have much larger volumes at depth than that
exposed on the surface in the study region. Moreover, the surface projections of the HVAs are
spatially coincident with the major faults or tectonic boundaries of the region, suggesting a causal
link. Our observations provide evidence for not only the lithology-controlled layering in both
sedimentary structure and deformation in the Zagros passive margin but also the much more
substantial magma generation and emplacement at depth than faulting-facilitated eruption and
exposure on the surface in the Iranian active margin during the subduction and collision
processes.