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Modeling of Crust in west of Iran by using Ps converted waves

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ABSTRACT

Receiver functions are the best method to image seismic discontinuities in the crust and upper mantle. In this study we used the P receiver function technique beneath west Iran to map out the lateral variation of the Moho boundary. We have used teleseismic data (Mb ≥5.5, epicentral distance between 30˚-95˚) recorded from 2004 to 2016 at broadband and short-period stations of the Iranian Seismic Network (ISC, http://irsc.ut.ac.ir) of Kermanshah, Khoramabad, Hamedan and Borojerd and one broadband station of the International Institute of Earthquake Engineering and Seismology (IIEES, http://www.iiees.ac.ir). The average Moho depth lies at ~42±2 km. We have been able to present the clear image of the Moho at depths as modeling of PRF, ranging from 37 km beneath KCHF station to Maximum 55 km beneath HAGD station.

Keywords: P receiver function, Crustal Structure, Teleseismic, Northwest of Zagros.

INTRODUCTION

The Zagros thrust belt is part of the larger Alpine-Himalayan collision which is the result of subduction of the Arabian Plate underneath Iran (part of Eurasia). The Zagros collision zone comprises three major sub-parallel tectonic elements. They are, from SW to NE, the Zagros Fold and Thrust Belt (ZFTB), the Sanandaj-Sirjan Metamorphic Zone (SSZ), and the Urmieh-Dokhtar Magmatic Arc (UDMA). There are some main active faults (ZFTB, MZRF, HZF)in the west of Iran.The study region referred as northwest of Zagros of Iran in this study includes the area located between 46°–50° longitude and 33°–36° latitude (Fig. 1).

The Moho discontinuity has been extensively studied with different method and data in Zagros region (Snyder and Barazangi 1986; Hatzfeld et al. 2003). Recently Paul et al. (2006, 2010) showed the migrated sections computed from P receiver functions (PRF) and their results revealed an average crustal thickness of 42±2 km beneath the Zagros Fold and Thrust Belt implying that the crystalline crust of ZFTB has not been significantly thickened by the collision yet. They explained also thickening by overthrusting of the Arabia margin crust by the crust of central Iran along the Main Zagros Recent Faults (MZRF). A more recent study by Afsari et al. (2011), based on receiver functions modeling, indicates an average Moho depth of about 42 km beneath the Northwest Zagros increasing toward the SSZ and reaches 51 km and the Moho depth decreases toward the UDMA belt and reaches 43 km beneath this area. Karimizadeh et al. (2017) deduced average of Moho depth based on PRF and Zhu & Kanamori (2000) method via data from 10 short period and broadband stations ~44 km beneath Northwest of Zagros (Kermanshah and Khoramabad).

The main goal of this paper is to resolve the map of Moho depth beneath West of Iran (Northwest of Zagros) using data from 15 broadband and 3 short-period permanent seismological stations located in this region from PRF modeling. This is the first modeling study on teleseismic data which recorded by Hamedan, Borojerd, and Khoramabad Seismic Networks.

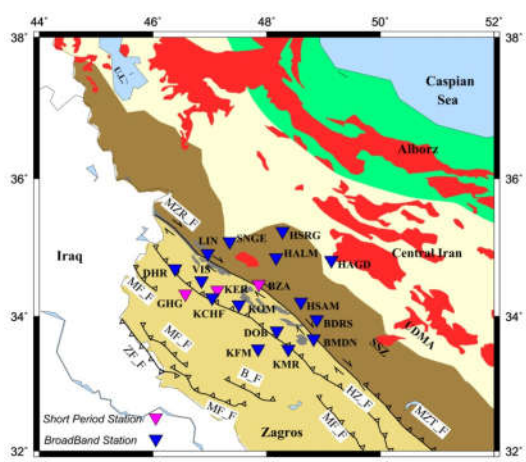

Figure 2: Distribution of teleseismic events recorded by the Seismological Network (ISC and IIEES).The Red star represents the approximate position of the area of our study.

Figure 1: Location map of the seismological stations used in this study. The main faults are shown by the black lines. Blue and Pink triangles are shown broadband and short period seismological stations, respectively.

Methodology & Data

The data used for this study were recorded by the ISC and IIEES (Fig. 1). More than 1000 teleseismic events which were recorded between 2004 and 2016 with magnitudes greater than 5.5 (Mb) at epicentral distances between 30˚-95˚ (Fig. 2) have been used for P receiver function analysis.

The methodology used in this study to calculate P receiver functions in each station is the same as Yuan et al. (1997). We preferred forward modeling of the receiver functions as described by Kumar et al. (2007). For Starting PRF modeling, we summed Q and L components for each station in the time window between −5 to 30 s. To achieve stability in the forward modeling, both crustal conversions and their strongest multiples and sedimentary conversions are modeled.

Observations & Discussion

Individual and summed PRFs for some stations are presented in Figure 3. The minimum arrival time of the Moho converted phase (4.5 s) is observed beneath the station LIN and the largest arrival time (6.5 s) is seen beneath the stations KMR and HAGD located in the southern and northern parts of the area in our study, respectively.

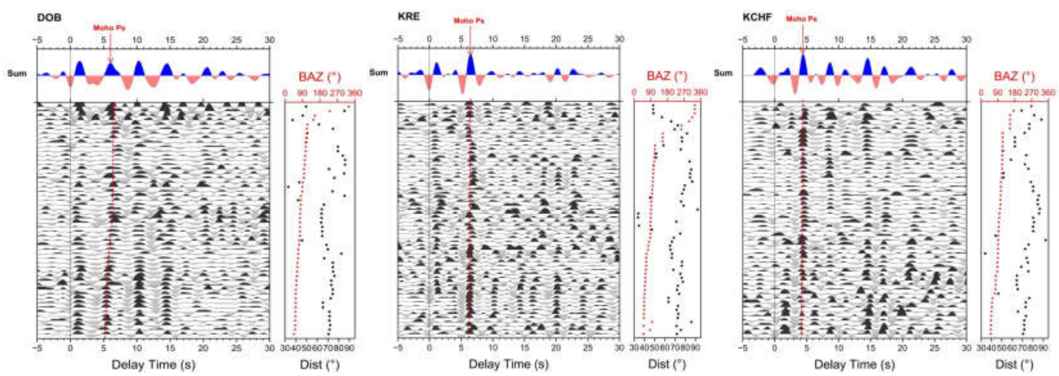

Figure 3: Individual PRFs with summation traces for some stations. They are filtered with a low-pass filter of 2s. The Ps conversion phases from the Moho are labeled on the summation traces (marked Moho Ps).

An initial estimate of the Moho depth can be obtained from the delay time of the corresponding Ps conversion by using available velocity model obtained from the previous geophysical studies in West of Iran (Paul et al. 2010, Afsari et al. 2011). The Moho depth varies between 36.5 km in LIN station and 52 km in KMR and HAGD stations. Figure 4 is presented contour of Moho depth at each station by the procedure of Ps time.

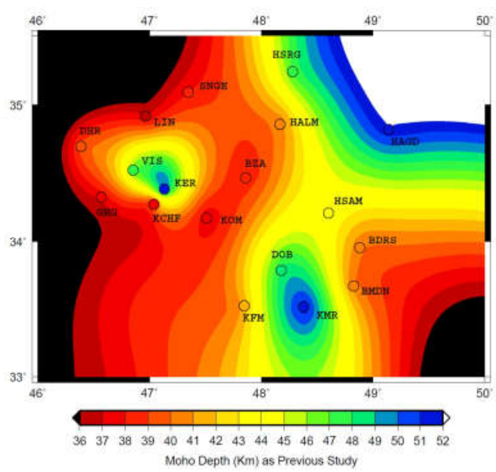

Figure 4: The contour map of Moho depth beneath each station as Ps time.

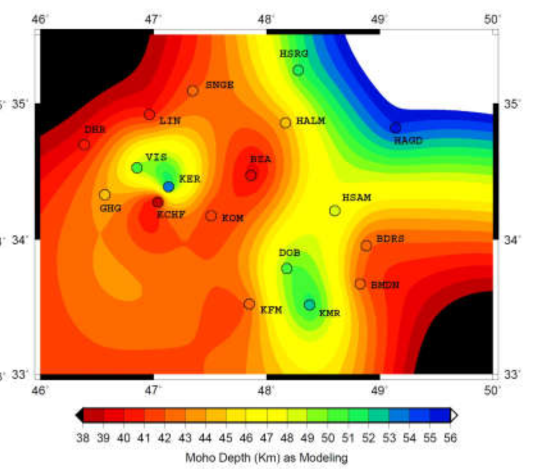

Figure 6: The contour map of Moho depth beneath each station as PRF modeling.

In the second step, we utilized forward modeling of the P receiver functions to find the most suitable crustal thickness beneath each station. For this aim, we used P wave velocity models as previous study (Paul et al. 2010; Afsari et al. 2011) for the first model. Figure 5 illustrates the results of forward modeling for station SNGE and BMDN. The Moho phases (marked as Ps), and their strongest multiples (marked as PpPs) are considered and waveform has good coverage. Figure 6 is shown the contour of Moho depth in beneath the stations, exactly which

deduced from P receiver function modeling. The Moho depth map significantly presents a crustal thickening towards the northeast. This may be related to the collision between the Arabian and Turan plates and could show the crustal shortening occurring in the west of Iran. Also, our results are shown two local thickening beneath KER and KMR stations which are good agreement by Afsari et al. (2011) and Karimizadeh et al. (2017). Probably this crustal thickening below these stations is related to the thrusting system in this area, previously described by Berberian (1995). A more recent study by Taghizadeh-Farahmand et al. (2015), based on receiver functions modeling, obtained the thickness of the Moho which is varied between 42–48 km via data from 6 short period stations in this region. Our results are in good agreement with those obtained from other studies (Paul et al. 2006, 2010; Hatzfeld et al. 2003).
Due to the proper distribution of stations and also a significant increase in the number of stations, the results obtained in this study are more complete and accurate than previous studies, especially the receiver function modeling method.

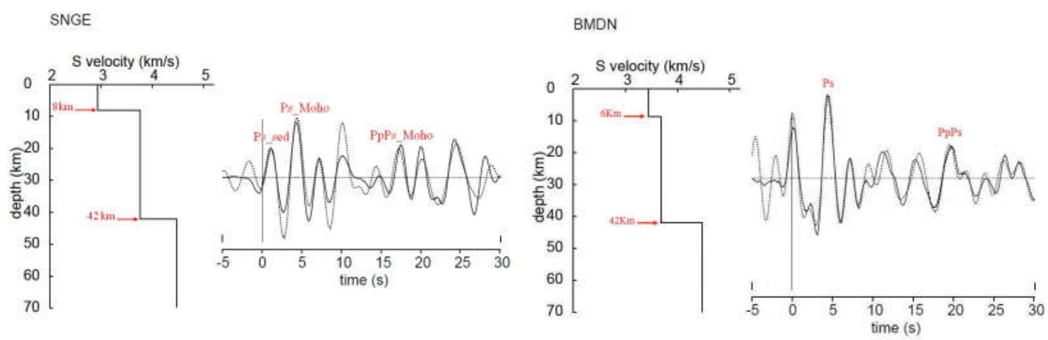

Figure 7. Forward modeling of the stacked traces in SNGE and BMDN station. The dashed line in the right panel of each part is the observed receiver function, and the solid lines are the synthetic receiver functions corresponding to the different models. Part c show best model for this station, the Moho phases (marked as Ps), and their strongest multiples (marked as PpPs) and conversions from the bottom of a sedimentary layer (marked as S) are considered and waveform has good coverage.

CONCLUSION

We resolve the Moho discontinuity beneath west of Iran using 18 broad-band and short-period Seismological Network by using P receiver function modeling. The average Moho depth in west parts of Iran is about ~47±2.5 km and Moho discontinuity is not flat. We have been able to present a clear image of the Moho at depths ranging from 38 km beneath KCHF station to Maximum 55 km beneath HAGD station in the southern and northern part of the study area, respectively. The Moho depth map significantly presents a crustal thickening towards the northeast.

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