Shahrood University of Technology

JOURNAL OF RESEARCH ON APPLIED GEOPHYSICS

(JRAG)

2022, VOL 7, NO 2

(DOI): 10.22044/JRAG.2021.9943.1295

Determination of crustal velocity structure of northeastern Iran from local earthquakes travel time inversion

Fatemeh Roostaee[1*];Habib Rahimi[*2]; Mehdi Rastgoo[3]

1- PhD Student; Institute of Geophysics, University of Tehran, Tehran, Iran.
2- Associate Professor; Institute of Geophysics, University of Tehran, Tehran, Iran
3- Postdoctoral Researcher; Institute of Geophysics, University of Tehran, Tehran, Iran

Received: 2 August 2020; Accepted: 10 January 2021

Corresponding author: rahimih@ut.ac.ir

Keywords

Crustal velocity structure
Northeastern Iran
Local earthquakes
Travel time inversion
VELEST

Extended Abstract

Summary

The northward motion of the Arabian Shield related to the Eurasia at a rate of ~22 mma^{-1} is primarily accommodated across the Iranian Plateau and results in different styles of deformation in various parts of this continental collision zone. The deformation is concentrated in the Zagros, Alborz, and Kopeh Dagh mountains and shear zones surrounding Central Iran that behaves more or less as a relatively rigid block. The deformation in northeastern Iran is concentrated in the Kopeh Dagh and Binalud mountain ranges and the boundary between Alborz–Binalud and the Kopeh Dagh mountain ranges run along the Atrak River. In this study, we determine an optimum one-dimensional (1-D) velocity model of upper crust for northeastern Iran from local earthquakes travel time inversion.

Introduction

A well-suited 1-D velocity model can improve earthquake locations, and can be used as initial model for three-dimensional (3-D) seismic tomography. Moreover, it has a significant role in truly understanding of seismicity and earthquake hazard assessment. To assess the 1-D velocity model, we used first arrival travel times of 81 local earthquakes (between years 2012 to 2018), recorded by 27 seismic stations of International Institute of Earthquake and Engineering and Seismology (IIEES), Iranian seismological center of Institute of Geophysics of University of Tehran (IGUT) and Earthquake Research Center (EQRC) of Ferdowsi University of Mashhad in the area 33.5-38.5^0 N, 55-61.5^0 E. These selected events were recorded by minimum of 4 stations, with an azimuthal gap less than 180^0 and residual RMS less than 0.3 s. Consequently, using these events, an upper crustal velocity model beneath the studied region was obtained using VELEST software.

Methodology and Approaches

The VELEST computer Program is a FORTRAN77 routine that has been designed to derive 1-D velocity models for earthquake location procedures and as initial reference models for seismic tomography. Since the VELEST does not automatically adjust the thicknesses of layers (unlike the velocities of layers), an appropriate layering of the model is to be found by a trail-and-error process. Thus, the calculation of 1-D model normally starts with finding an appropriate model layering. For initial starting model, we considered 100 initial models that all had the same thicknesses (20 layers of 2 km thicknesses) and P-wave velocities in the range of 6±0.5 km/s, which were restricted in defined intervals. The results showed five discontinuities in the depths of 2, 10, 14, 18 and 22 kilometers. In the second step, we considered 100 initial models that all had 6 layers with the thicknesses of 2, 8, 4, 4, 4 and 18 kilometers and P-wave velocities in the range of 6±0.5 km/s. The results also showed the convergence at 22 kilometers; thus, we eliminated this discontinuity in the next step. In the last step, we considered 100 initial models that all had 5 layers with the thicknesses of 2, 8, 4, 4 and 22 kilometers and different velocity ranges of 5.5, 5.9, 6.3, 6.8 and 7.2 ±0.5 km/s.

Results and Conclusions

The calculated velocity model for the studied region showed discontinuities in the depths of 2, 10, 14 and 18 kilometers and P-wave velocities of the layers as 5.90, 5.98, 6.08, 6.20 and 6.29 km/s, respectively.
Finally, to control the utility of the calculated velocity model, we relocated 284 earthquakes with magnitude M_N≥3.5

between years 2012 and 2018 that occurred in the area with our velocity model and compared the results with the results of the model utilized by Iranian seismological center of IGUT. This experiment indicates that our calculated velocity model performs much better than the velocity model utilized by IGUT in the sense of RMS, ERH and ERZ.