Determination of crustal velocity model in Fars province using simultaneous inversion of local earthquake travel times

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Abstract

Geomorphological observations reveal a major oblique fold in Fars province. A sum of thrust and right-lateral fault was located in this region, where some earthquakes occurred in there. These earthquakes killed inhabitants and left widespread devastation in recent century. Therefore, fault structures in southwestern Fars province do appear to be active in the late Quaternary and may be capable of producing destructive earthquakes in the future. Seismicity analysis of this area requires the precise locations of occurred earthquakes. The Iranian seismic networks have been operated since 1996. The existing earthquake catalogue routinely generated by the IRanian Seismological Center (IRSC), due to un-modeled velocity structure, are in large errors. The availability of a large number of phase data collected by IRSC, for 11 years, has motivated this study to develop a reliable crustal velocity model, accurate locations of earthquakes and obtain an enhanced picture of seismicity of region. No previous studies have been carried out in this region for crustal structure. We determine an optimum 1D velocity model by using the VELEST algorithm for reliable determination of earthquake hypocenter locations. Applying the obtained velocity model for relocation of about 2956 recorded events show a significant improvements over locations, which are routinely determined by the IRSC. There are new coherent alignments both in depths and epicenters in this region which have not been seen until now.

Keywords: *Seismicity, Seismotectonic Province, Fars, crustal structure, V_p/V_s*

1-Introduction

The NW-SE trending Zagros fold and thrust belt, one of the ranges of the Alpine – Himalayan belt, extends for about 1800 km from a location some 300 km southeast of the East Anatolian Fault in northeastern Turkey to the Strait of Hormuz where the north-south trending Zendan-Minab-Palami fault system separates the Zagros belt from the Makran accretionary prism. This range are formed by closure of the Neo-Tethys ocean and then continental collision, starting in the Miocene (McQuarrie et al., 2003), between the Arabian plate and Central Iran. The Zagros range currently accommodates almost half of NS shortening between the Arabia and Eurasia (Vernant et al., 2004). This active fold and thrust belt is subdivided into five morphotectonic units: the High Zagros Thrust Belt, the simple Fold Belt, the Zagros Fordeep, the Zagros Coastal Plain and the Persian Gulf-Mesopotamian lowland (Berberian, 1995).
Studied region in this paper located in Fars province, in the High Zagros Thrust Belt, north eastern part of this region is Abarkuh desert that located in central Iran is less active than the other border region around studied region.
 The west and southeastern part of this region is located in Zagros seismotectonic province that a lot of earthquakes were seen (Figure1). In this paper we study crustal structure of the Fars province based on recorded earthquakes by a Shiraz seismic network from June 2002 to

November 2009 and seismicity from International Seismological Centre (ISC) catalog, Harvard Centroid Moment Tensor (CMT) catalog and historical earthquakes catalog (Ambraseys & Melville, 1982) in the northern part of Fars province. Crustal structure of this region is particular issue that is not yet resolved in the studied region.

2-Data analysis

In order to study of the crustal structure of studied region, we use from Shiraz network that have 5 stations (Figure 2).

To improve the velocity model, we selected a subset of 125 events, recorded by a minimum of 3 stations, with an azimuthal gap less than 270º, residual RMS less than 0.5 s and uncertainties both in epicenter and depth less than 5 km. With these criteria the trade-off between the velocity structure and the location of the events is small. Plotting T_{sj}-T_{si} (S arrival time to stations i and j respectively for same event) versus T_{pj}-T_{pi} (P arrival time to stations i and j respectively for same event) for all events and all stations, we compute a V_p/V_s ratio of 1.77 ± 0.03 with 908 arrival times (Figure 3) (Gholamzadeh et al., 2009).

We inverted the arrival times of the selected set of events for a 1-D velocity structure using the program VELEST (Kissling, 1988). The result of these inversions(Figure 4) suggests that no more than four layers are resolvable(table 1).After using calculated 1D model the corresponding residual RMS reduces from 0.3 s to 0.15 s for the final four-layer model. We assume 4 models with p velocity, s velocity, average of p velocity and average of s velocity (Figure 4).

3-Conclusions

In this study we investigate seismicity and seismotectonic of fars province and we understand that this region has a high potential region that a lot of earthquakes were seen.

Most of faults in this region have a NW-SE trend and earthquakes mechanism is reverse.

V_p/V_s ratio was assessed 1.77 ± 0.03 that clearly adapt with other identical studies were perform in this region.

The result of inversion was display a four layer model and because most of our earthquakes are in low depth we can't approximate moho depth in this region.

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Table 1: Final velocity structure calculated by 1-D inversion method for studied region.

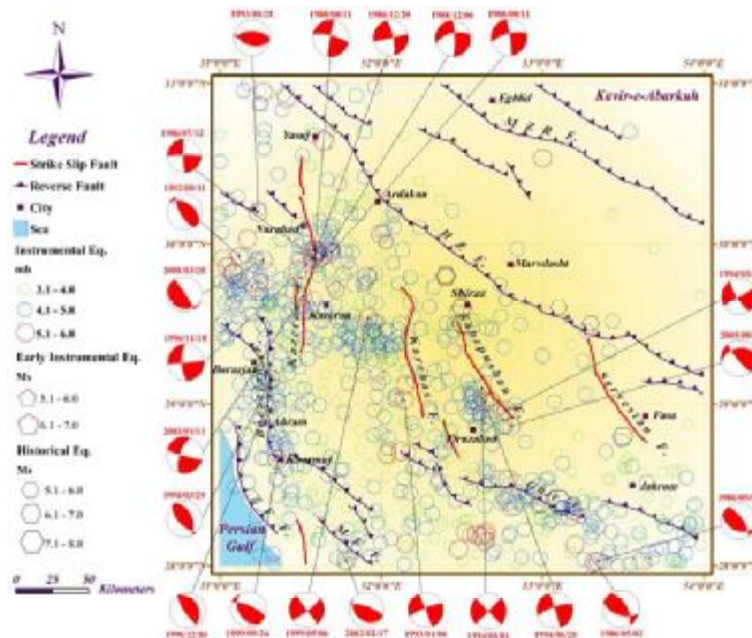| Top of the layer (km)	P velocity (Km s^{-1})
0	5.70 ± 0.03
6	5.82 ± 0.05
10	6.52 ± 0.03
14	6.65 ± 0.03

Figure 1: Seismicity and focal mechanisms of the Fars province. Focal spheres in red are CMT solutions computed by waveform modeling that assume from from International Seismological Centre (ISC) catalog, Harvard Centroid Moment Tensor (CMT) catalog and historical earthquakes catalog (Ambraseys & Melville, 1982)
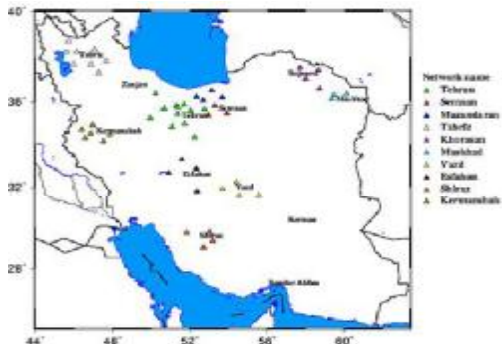
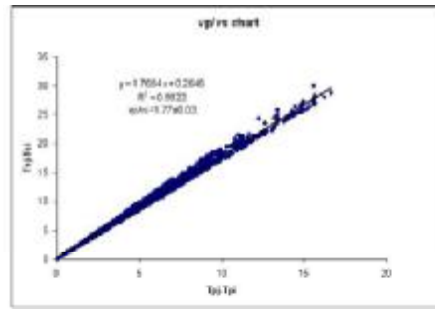**Figure 2: Configuration of Shiraz network from June 2002 to November 2009 in the south Northern part of Fars province.**

Figure 3: Vp/Vs ratio computed for the studied region from 908 arrival times
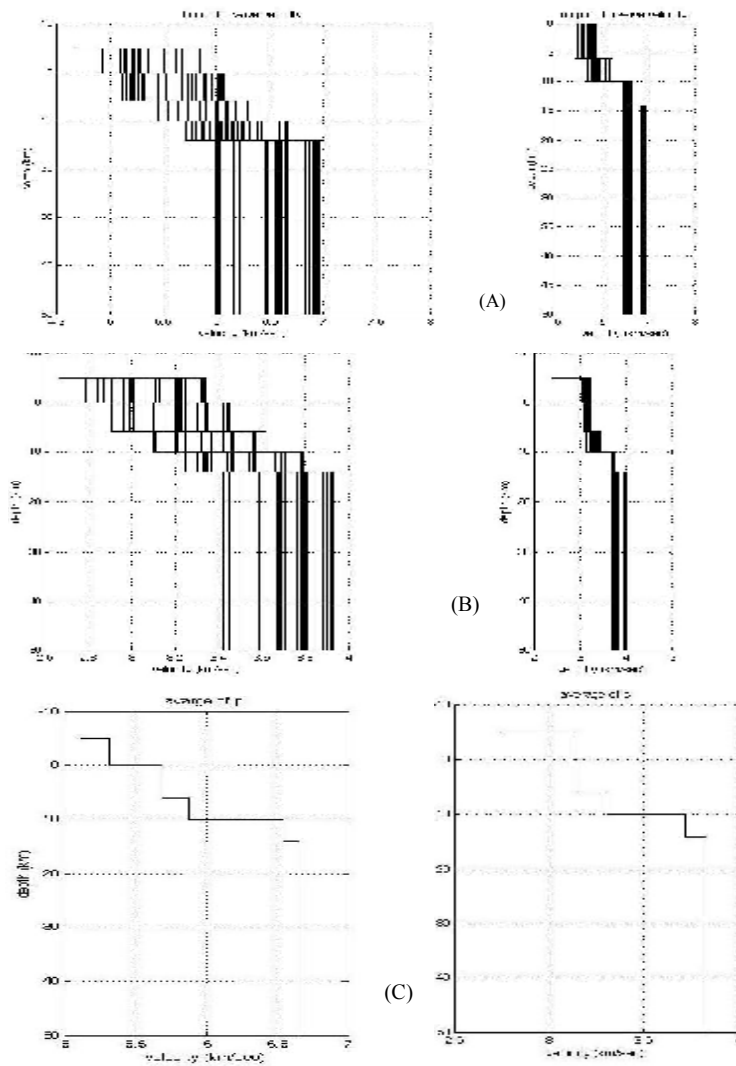

(A)

(B)

(C)

Figure 4: Good convergence of the final calculated velocity model by 1-D inversion of travel times. P velocity model (A), s velocity model (B) Left figures shows initial random models and right ones are final models. Average of p and s velocity(c).