Iranian Int. J. Sci. ***5****(2), 2004, p.223-244*

An Approach to a Comprehensive Moho Depth Map and Crust and Upper Mantle Velocity Model for Iran

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(received: 10/1/2004 ; accepted: 22/9/2004)

Abstract

The main purpose of the present study is to develop a comprehensive Moho depth map and crust and upper mantle velocity model for Iran. This will allow for more precise computation of travel time and thereby also more precise hypocenter estimation of the recorded events in Iran.

For this purpose all available depth and velocity data relevant to this region has been matched and compiled. In the locations that there were no local data, available global data has been replaced. Based on these results Iran has been divided into 8 regions of varying seismicity and velocity structure.

Keywords: *Moho depth map, Crust and upper Mantle velocity model, Iran.*

Introduction

Since the early days of seismology, seismologists have tried to locate the source of observed seismic waves in space and time. The precision of the estimated locations has always depended strongly on our knowledge about the distribution of seismic velocities inside the

Earth. During the last decade of the 19th and the first decades of the 20th century seismic observations reached a precision that enabled a step-wise deciphering of the principle structure of the Earth. Therefore the main goal of seismological research is unravelling the structure of the Earth's interior with the purpose of understanding and reconstructing the dynamic processes that have formed the shape of Earth's surface through geological time.

Seismic waves can provide a wealth of information about Earth structure: they are directly affected by the elastic, inelastic and anisotropic properties of the rock or fluid through which they propagate, and these properties in turn depend on pressure, temperature, composition, density, crystal orientation and rheology. Seismic waves sample all regions of the Earth's interior, from the crust to the inner core. However, in order to quantify, resolve and localize the properties of rocks within the Earth from observations at the surface a substantial amount of seismic data is required.

Optimally, these data are seismograms from broadband sensors that are able to record signals in the full seismic frequency band from about 1 mHz to about 50 Hz. In addition, the use of seismic arrays or networks can greatly enhance the resolution and localization power of seismic data.

Even though earthquakes always have been the most important source of information for developing and also calibrating travel time tables, the availability of explosions and other artificial sources with sufficiently precise time and location information has become increasingly more important and useful to this end.

The two main sources of travel time deviation are the Earth's ellipticity and the differences in subsurface structure in different geographic regions. While the first effect is well known and compensated for through correction tables, the main challenge is connected to the latter, where regionally based studies are always needed. Large travel time residuals may occur at shorter distances in continental regions, there are, for example, large differences between shield and mountainous regions. A good understanding of these problems therefore calls for structural and travel time studies at crustal level as well as for the upper mantle, where the latter becomes important already at a distance of about 150- 200 km.

In detailed studies for the regions in and around Iran, significant anomalies in terms of their travel time structure were observed. According to previous studies in Iran, an Alpine type of crust is found for the Iranian plateau while uppermost mantle velocities range from a low-velocity mantle in eastern Iran to a high-velocity shield-like structure in the western parts of the country.

At the present study after a review of the main tectonic elements, a matched and compiled Moho depth map for the Iran region will be introduced. The Moho reaches to a depth of about 60 km (deepest in Iran) in a region northeast of the Main Zagros Trust (MZT) in Sanandaj-Sirjan Zone. In addition based on the available data on crust and upper mantle velocity structures within the study area will be discussed. Based on these data Iran has been the division of Iran into 8 regions will also be illustrated.

Active tectonics and seismicity

Iran abuts relatively undeformed shield areas to the SW (Arabia) and NE (the Turan shield) and the more recently deformed, though currently inactive, SW Afghanistan block in the east (Jackson and McKenzie, 1984; Treloar and Izzat, 1993). The deformation in Iran involves intracontinental shortening everywhere except along its south-eastern margin east of about 58°E, where the Oman Sea subduct northward under SE Iran (e.g., Byrne et al., 1992). The edges of the deforming zone are well defined by the seismicity and topography (Jackson and McKenzie, 1984).

Within Iran the deformation is not uniformly distributed but concentrated in belts along the SW border (the Zagros), the southern shore of the Caspian Sea (the Alborz) and along the NE (Kopet Dagh) and eastern borders. These belts surround blocks that are relatively aseismic and flat, such as the central Iranian desert (the Dasht-e Kavir, centred around 32°N, 54°E), Azerbaijan (37°N, 47°E), and the southern Caspian Sea (38°N, 52°E), (see Ambraseys and Melville, 1982; Jackson and McKenzie, 1984; Priestley et al., 1994).

Recently the major active faults map of Iran has been published by Hessami et. al (2003), (Figure 1). This map overviews the distribution of major active faults of Iran and demonstrates the relationship between the slip vectors and compressive axes, obtained from the solution of the focal mechanisms of the area's earthquakes, and GPS velocities in different areas of Iran.

Despite the high rate of recent tectonic activity, the plateau has a relatively simple deformation history, where compressional movements have dominated the region since the end of the Cretaceous (Berberian & King 1981). Based on seismicity and deformation styles, the Iranian plateau can be divided into several tectonic elements. In the following based on the figure 1 and other information available the major tectonic regions of Iran will be presented briefly.

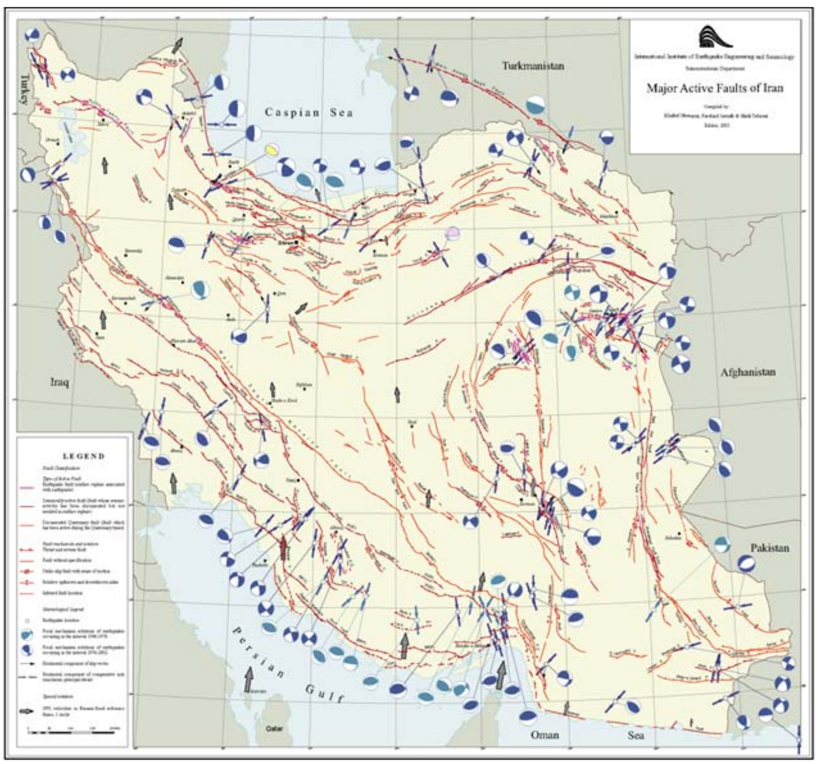

Figure 1- The major active faults of Iran (Hessami et. al 2003)

The Zagros Mountains

The Zagros range is the most active zone of Iran. Much of the convergence between Arabia and Eurasia is taken up in this part of the country. In general, the seismicity increases from northwest to southeast and diminishes to the east of the Oman line that separates the Zagros from the Makran region. Most of the earthquake mechanisms in the central and south-eastern Zagros are indicative of shortening of the crust perpendicular to the strike, along many highangle (30°-60°) reverse basement faults (Berberian 1981; Jackson & Fitch 1981).

Fault-plane solutions in the north-western Zagros show a right-lateral strike-slip motion that follows the trace of the main Zagros thrust. The strain rates calculated from historical and recent earthquake data in the Zagros are less than 10 % of those predicted by the expected Arabia-Eurasia convergence rate (Shoja-Taheri & Niazi 1981; McKenzie 1988; Ekstrom & England 1989), implying that 90 percent of the total deformation is being accomplished by aseismic processes. It has been suggested that the detachment of the sedimentary column from the basement rock by a plastic layer (the Hormoz formation) at the base of the sediments is responsible for the subdued seismic deformation in the Zagros (Jackson & McKenzie 1988).

Northwestern Iran and the Caucasus

Fault-plane solutions suggest that deformation in the Caucasus arising from the oblique convergence between Arabia and Eurasia is partitioned into thrust faulting in the Caucasus and right-lateral strike-slip motion farther south in eastern Turkey (Jackson 1992). In north-western Iran, most of the focal mechanisms indicate a right-lateral strike-slip motion, probably a continuation of the eastward expulsion of eastern Turkey away from the collision zone in central Turkey (Jackson & McKenzie 1984). The seismic strain-rate tensors show that, as in the Zagros, most of the deformation in this region is taking place aseismically (Jackson & McKenzie 1988).

The south Caspian block

The south Caspian is a relatively stable block with feeble seismicity and minor deformation, surrounded by active fold-and-thrust belts, and is currently underthrusting beneath the northern ranges of Iran (Berberian 1983). The poor propagation of L_g waves across the south Caspian Sea suggests that the lithosphere in this region has an oceanic-type structure (Kadinsky-Cade et al 1981).

The Alborz and Kopeh Dagh mountains

The Alborz and Kopeh Dagh mark the site of crustal compression of the northern parts of the Iranian plateau against Eurasia. Deformation in the high Alborz is characterized by a combination of reverse and left-lateral strike-slip faults, suggestive of partitioning of the oblique convergence between central Iran and the south Caspian block (Priestley, Baker & Jackson 1993). In the northern Alborz, faults dip southwards, indicating the underthrusting of the south Caspian block. In the south, the reverse faults dip northwards as a result of the compression of central Iran against Eurasia. In the Kopeh Dagh, seismicity immediately diminishes north of the fault zone that marks the northern border of the region (Tchalenko 1975). The slip vectors calculated from the seismic moment rates suggest that most of the present-day deformation in northern Iran is occurring seismically (Jackson & McKenzie 1988; Ekstrom & England 1989).

Central and Eastern Iran

Seismicity in central Iran has been sporadic and discontinuous (Ambraseys & Melville 1982; Jackson & McKenzie 1984). Most of the epicentres are located along the mountains bordering reverse faults (Berberian 1981). The major earthquakes in the north are associated with E-W-running thrust and left-lateral strike-slip faults, such as the Doruneh fault. To the south of these faults there is a set of right-lateral strike-slip faults running N-S and extending to the Makran region in the south. Seismicity decreases dramatically east of the Iran-Afghanistan border, and geological structures in eastern Iran are aligned in a N-S direction. The combination of the dominant E-W left-lateral faults and the subordinate N-S right-lateral strike-slip faults with thrust faults trending NW-SE indicates that the eastern part of the Iranian plateau is undergoing a structural rotation as it is being compressed against the stable blocks of western Afghanistan and Turkmenistan. The rotation results in a lateral movement of material away from the compression zone and towards the Makran region in the south along the strike-slip faults (Jackson & McKenzie 1984).

The Makran region

The Makran overlies the subduction of the oceanic crust of the Oman Sea under Iran. The seismicity in this region is feeble and scattered. The shallow earthquakes (focal depth < 10 km) are associated with E-W-trending northward-dipping reverse faults, which characterize the deformation of the accretionary sediments. The intermediate-depth earthquakes (focal depth < 80 km) are accompanied by the normal faults produced by the deformation of the subducting plate (Berberian 1981; Byrne, Sykes & Davis 1992).

Moho depth data

Many researchers have studied the crustal structures in Iran in the past. This information will be discussed in the following:

Anzabi (1981) used earthquakes of Turkey and eastern Iran, which were recorded by both Tehran (TEH, 35.73N, 51.38E) and Tabriz (TAB, 38.06N, 46.32E) stations to obtain Pn wave velocity and crustal thickness (table 1). According to this study the Pn velocity varies between 7.9 and 8.1 in northern Iran.

Table1. Pn velocities and crustal thicknesses derived by Anzabi (1981).

Path	Pn velocity (km/sec)	Crustal thickness (km)
Eastern Iran to Tabriz	8.06 ± 0.01	56 ± 4
Eastern Iran to Tehran	7.95 ± 0.01	47 ± 3
Eastern Turkey to Tabriz	7.93 ± 0.01	46 ± 4
Eastern Turkey to Tehran	8.01 ± 0.01	56 ± 2

Asudeh (1982a) developed the traditional surface wave two-station method for body waves. Uppermost mantle P wave (Pn) velocities were determined along several paths in Iran using this method and showed zones of low-velocity corresponding to zones of high attenuation and Quaternary volcanic activity in the country. A remarkbly high Pn velocity of 8.30 km/sec was found for the Zagros area of western Iran more typical of shield like structures than that of tectonic areas (table 2).

Based on phase or group velocity dispersion of surface waves, Moazami-Goudarzi (1974), Bird (1978), Mc Cowan (1978), Canitez & Toksoz (1978), Tubman (1981) and Tubman & Toksoz (1981) provide information on the seismic structure of Iran. All these studies invert phase or group velocity curves into shear wave velocity distribution models without constraining such models by other geophysical data. In the second investigation of Asudeh (1982), however, a comprehensive data set consisting of both body and surface wave data is used in order to produce a detailed picture of the seismic structure beneath Iran. The Iranian WWSSN stations Shiraz (SHI), Tabriz (TAB) and Mashhad (MSH), the SRO station in Mashhad (MAIO) and the sites of the Iranian Long Period Array (ILPA; IR1-IR7) provided the database for this survey. Seismic signals recorded at these stations from local and distant earthquakes were analysed to obtain both P and S travel time and Rayleigh wave dispersion curves for the area from which structural information was deduced.

Table 2-Estimates of Pn velocities beneath Iran (Courtesy Asudeh (1982a).

Pn velocity (Asudeh, 1982)	Average Pn velocity	Area/ station	Pn velocity (Chen et al., 1980)	Pn velocity (Kadinsky-Cade *et al.,* 1981)
8.32 ± 0.02 8.25 ± 0.04 8.24 ± 0.04	8.30	Zagros SHI (Shiraz)	8.14 ± 0.1	8.0 ± 0.3
7.70 ± 0.05 8.02 ± 0.03 7.90 ± 0.05	7.85	Eastern Iran		
7.9 7.8	7.9	Northwest IranTAB (Tabriz)	7.85 ± 0.05	8.6 ± 0.5
8.2 8.2	8.2	Central east Iran		
8.0 8.08 ± 0.02 8.15 ± 0.08	8.08	Central Iran MHI ashhad)	8.02 ± 0.08	8.2

Using travel-time data and estimates of uppermost mantle P-wave velocities beneath Iran, a more detailed interpretation of the Rayleigh wave phase velocity data was attempted. Three earth models were presented for the three-phase velocity profile of MSH-SHI, IR7-SRO and SHI-TAB, respectively. The estimates of crustal thickness were 43, 45 and 46 km for MSH-SHI, IR7-SRO and SHI-TAB profiles respectively with the lowest upper mantle velocities beneath MSH-SHI and the highest velocities beneath the SHI-TAB profile.

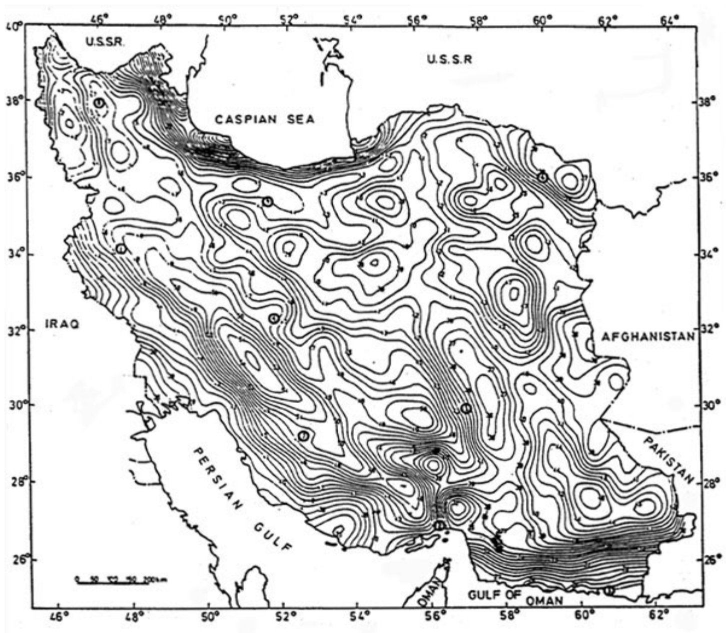

Figure 2- Gravimetric Moho depth map of Iran (Courtesy Dehghani and Makris 1983).

In 1983, Dehghani and Makris (Figure 2) based on evaluation of 10,000 gravity station has found that the maximum crustal thickness is located below the Zagros main thrust and has values ranging between 50 and 55 km. A fairly thick crust was also computed along the east Iranian ranges, with values between 40 and 48 km. On the contrary, the Lut and Kavir depressions are floored by a crust with values below 40 km thickness. The thinnest crust in Iran is obtained along the coast of the Oman Sea (values below 25 km) and the Caspian coast with values below 35 km.

In 1978, first deep-seismic soundings were conducted between the central Iran and the Zagros Belt (Giese et al. 1983). As seismic energy sources, commercial shots in mines, Bafq between Bafq (~31.5 N, 55.4 E) and Sar Cheshmeh (~30.1 N, 56.0 E) were used. The explosions were recorded as a partly reversed profile between Bafq and Sar Cheshmeh and along a line running from Sar Cheshmeh southwards. Although the energy of the explosions was sufficient, the record sections obtained, show gaps mainly caused by technical and logistic problems. The main features of the crustal structure in the area under study are the following: At the western margin of the Lut-Block the crustal thickness is about 40 km. Approaching the High Zagros, the crust gets thinner and near Sirjan, this crust measures only 20-25 km of thickness. Below the Metamorphic Belt a separated, but very deep-seated (60km) crust/mantle could be detected by reflected waves. This deep crust/mantle boundary continues at nearly the same depth level into the Zagros Belt from where it slightly rises to the Persian Gulf. A crustal thickness of only 30 km is here indicated by gravity data.

Snyder and Barazangi (1986) used the data of the crustal structure profiles interpreted from gravity data. Major change in Moho depth is the crustal root of the high elevation part of the Zagros, in the region of the MZT, which reaches up to 60 km depth. Much of the rest of Iran, the Persian Gulf, and northeastern margin of the Arabian plate has Moho depths close to 40 km depth.

A powerful technique for studying the crustal structure beneath any seismic stations is using teleseismic body waves. According to previous study (Peseckis et al. 1982) Moho has been identified at the depth of 33 and 50 km in southwest (around Shiraz station, SHI, ~29.6°N, 52.5°E) and northeast of Iran (around Mashhad station, MSH, ~36.3°N, 59.5°E) respectively. Receiver function analysis of the new records of one INSN (Iranian National Broadband Seismic Network) station in western Iran (Ashtian station, ASAO, ~34.5°N, 50.0°E) identifies the depth of Moho in this area between 30 to 35 km and for another station in south eastern Iran (Zahedan station, ZHSF, ~29.6°N, 60.7°E) this value is 50 km (K. Priestley, personal communications).

The crust and uppermost mantle structure of Tehran area was investigated (Javan-Doloei, 2002) using teleseismic earthquakes which were recorded, at ILPA stations. The results of receiver function modelling show that the crust consisted of three main layers. Upper crust has a positive P-wave velocity gradient with ~10 km thickness. Middle crust has nearly uniform P-wave velocity down to ~30 km depth. P-wave velocity gradient from 6.2 km/s to 7.4 km/s down to ~45 km depth define the lower crust. A low velocity mantle down to 55 km depth at the uppermost mantle beneath Tehran region is estimated which confirms the results of the previous researches (Javan-Doloei, 2002).

The Moho depth map was established by synthesis of information (investigations with quantitative results) and expert opinion of geologists. The information and their sources of these data are tabulated in Table 3 and presented in Figure 3.

Comparison between the Moho depth map obtained from gravity data (Dehghani et. al 1983) and the result of the present study based on seismic data shows that although the same tendencies with a thinner crust below the Zagros and eastern Iran are recognized in both models, but there are some differences between these two results. The differences between the two models may reach 10 km both in negative and positive.

The average crustal thickness of 40 and 45 km were found for the Zagros and central Iran respectively. The deepest part of Moho recognized in a region northeast of Main Zagros Trust (MZT) in Sanandaj-Sirjan zone up to 60 km however gravimetric data shows this region somehow at the western parts.

Table 3- Moho depth information in different regions of Iran.

Region	Latitude N	Longitude E	Moho depth	Reference
North-eastern ran Kopeh-Dagh	39	54.5	39	Mooney (1998)
	38.5	59.5	40	Mooney (1998)
	38	63	44	Mooney (1998)
	38	60	47	Mangino & Priestley (1998)
	37.9	58.1	46	Mangino & Priestley (1998)
	38	56	40	Mangino & Priestley (1998)
	36.3	59.6	50	Peseckis and Burdick (1982)
	36	55	45	Mooney (1998)
Eastern Iran	33.8	59.8	43	Farahbod et. al. (2003)
Caspian Sea	38	52	28	Mangino & Priestley (1998)
Alborz	37	50	36	Tatar (2001)
	35.7	50.6	45	Javan (2002)
Central Iran	33.5	56.5	45	Mooney (1998)
	33	55	35-42	Kaviani (2004)
Zagros	28	53	46	Tatar (2001)
	28	52	44	Farahbod &Gheitanchi (1996)
Central Zagros Sanandaj-Sirjan zone	29.6	52.5	33	Peseckis and Burdick (1982)
	30	53	34	Mooney (1998)
	29	52	46	Kaviani (2004)
	31	54	50-65	Kaviani (2004)
Persian Gulf	28.9	50.8	40	Mokhtari et. al. (2004)
Makran	29.6	60.8	50	Priestley (Personal communication)

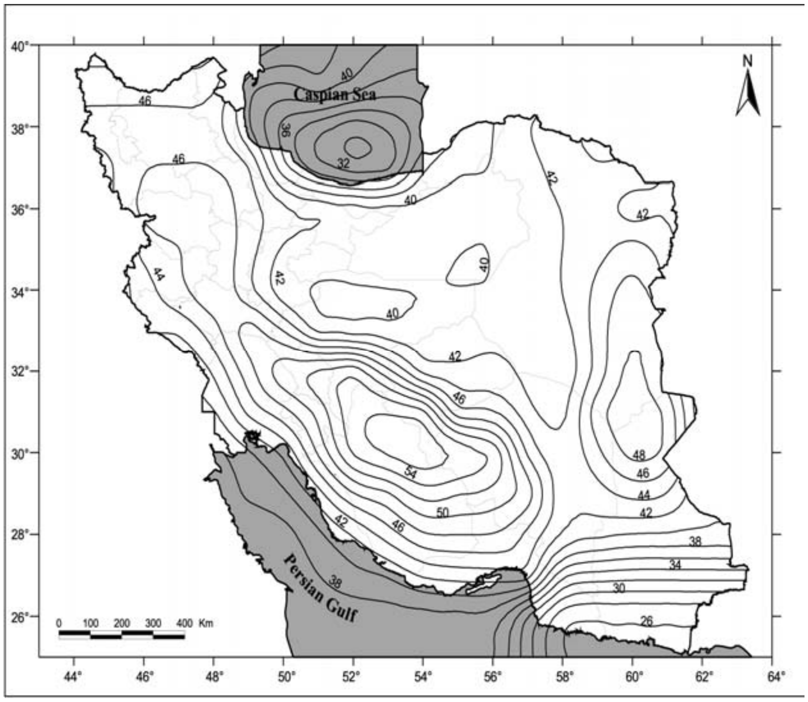

Figure 3- The crustal thickness (depth to Moho) map based on the seismic data from the present study.

Velocity models of crust and upper mantle

Mooney et al. (1998) developed a first complete global crustal model that includes sediment thickness, Moho depth and seismic velocities at a resolution of 5° × 5°. Although this is a very low-resolution model, this data set has filled a major gap in geosciences research. Laske & Masters (1997) also developed a more detailed (2° × 2°) global crustal thickness map. These global models provide a first-order and complete data coverage for the entire globe; however, their resolution is too coarse for regional studies. Based on the above data velocity models for different parts of Iran will be discussed in the following.

South and central east of Iran

After two earthquakes of June 11 and July 28, 1981 (Ms 6.7 and 7.1 respectively) in Golbaf and Chahar-Farsang, two townships southeast of Kerman city, Atomic Energy Organization of Iran (AEOI) deployed a local temporary network to monitor aftershocks activity. Based on the data of this network, Zohoorian et al. (1984 & 1985) derived crustal models for these regions. Table 4 and 5 show the parameters of proposed crustal model for Golbaf (~29.9°N, 57.7°E) and Chahar-Farsang regions respectively.

Table 4-Proposed crustal model for Golbaf area in southeast Kerman (~29.9°N, 57.7°E).

Layer	P-Wave velocity (km/s)	Depth (km)	Thickness (km)
1	5.00	0.0	6.0
2	5.50	6.0	10.0
3	6.50	16.0	25.0
4	8.00	41.0	1000.0

Table 5- Proposed crustal model for Ghahar-Farsang area in southeast Kerman (~30.0°N, 57.8°E).

Layer	P-Wave velocity (km/s)	Depth (km)	Thickness (km)
1	4.50	0.0	5.0
2	5.00	5.0	5.0
3	6.00	10.0	25.0
4	7.80	35.0	1000.0

Southwest Iran

Farahbod (1996) used Rayleigh wave phase velocity dispersion data of three earthquakes occurred in Firuzabad area (southern Shiraz) recorded at ILPA stations to obtain crustal model for this region (at the south of Iran). Table 6 shows the results of this researche.

Table 6- Crustal structure model for southern Shiraz (Farahbod, 1996).

Thickness (km)	P velocity (km/sec)	S velocity (km/sec)	Density (g/cm^3)
8	6.15	3.52	2.74
22	6.19	3.76	3.00
14	6.75	3.93	3.06
9	8.17	4.62	3.35
8	8.14	4.57	3.36
12	8.08	4.43	3.37
-	8.73	4.91	3.54

Tehran region

Mohajer-Ashjaee (1980) has developed a local crustal model for northern Iran (Tehran region). He used local earthquakes to develop the model in Table 7.

Table 7- Crustal model for the Tehran region (Mohajer-Ashjaee, 1980).

Layer number	P velocity (km/sec)	Depth (km)
1	4.00	0.0
2	4.50	1.0
3	5.00	3.0
4	6.00	10.0
5	6.70	22.0
6	8.00	45.0

According to Javadi et al (2000) who used data of 2900 local earthquakes recorded in Tehran telemetry network, crustal velocity model for P-wave in Tehran region consists of two layers. In the first layer, P velocity is 6.05 km/s and that of second layer is 7.01 km/s. Depths for Conrad and Moho discontinuities were obtained 16 and 46 km respectively, which well correlates with the results of the previous gravimetric crustal studies.

Eastern Iran

A new velocity model was established by Farahbod et. al. 2003, through joint inversion for hypocenters and crustal velocity using aftershocks of Ghaen-Birjand (1997) earthquake. The proposed model is given in table 8.

Table 8- Crustal model for the Eastern Iran (Farahbod et. al., 2003).

Layer umber	P velocity (km/sec)	S velocity (km/sec)	Depth (km)
1	5.71	3.08	0.0
2	5.96	3.22	12.0
3	6.53	3.52	23.0
4	7.70	4.16	43.0

Seismic provinces based on velocity structure

The Iranian plateau is folded and densely faulted, and unlike California, Asia-Minor and central Asia, linear narrow zones of more intense deformation do not occur. It is therefore, difficult to subdivide the region into simple rigid plates and micro plates with well-defined boundaries. However, several attempts to divide Iran into regions that present similar characteristics, such as seismicity and geotectonic environment, have been made in the past (Stocklin, 1968; Takin, 1972; Berberian, 1981). Based on the plate tectonic concept, three regional recent-tectonic models were used by Nowroozi (1972), McKenzie (1972) and Dewey et al. (1973) to study the complex behaviour of the continental crust in Iran and the Middle East. Nowroozi (1971) correlated earthquake epicenters with geological structures in the area extending from 30° E to 75°E and from 20°N to 40°N. The same researcher in a later work (Nowroozi, 1976), based on 638 relocated earthquakes and 24 instrumentally located epicentres of earthquakes that occurred in Iran between 1920 and 1972, and by taking into account geological information, regional geomorphology, distribution of salt domes, structural trends and active faults, divided Iran into 23 seismotectonic provinces. Studying the seismicity of the Iranian plateau, Shoja-Taheri and Niazi (1981) defined three major seismotectonic provinces, namely Zagros, Alborz and east-central Iran, with northwestern Iran belonging to the province of the Caucasus and eastern Turkey.

Ambraseys and Melville (1982), on the basis of the distribution of macroseismic intensities, defined the following zones: 1- the Eastern Zone, which comprises eastern Khorasan and Northern Sistan; 2- the Northern Zone, which runs along the Alborz and through north-western Iran; 3- the Zagros Zone, which extends from west of Lake Urumiyeh to Bandar-Abbas at the south; 4- the Central region of Iran. Recently, on the basis of a new catalogue for the Iranian earthquakes, Tavakoli, (1996) and Tavakoli & Ghafory-Ashtiany (1999) suggested a new model of seismotectonic provinces for Iran. The boundaries of provinces are established through analysis of seismic history, relocated epicentre for the past several decades, tectonic regimes, active faults, regional geomorphology, and plate boundaries. The suggested model by Tavakoli (1996) consists of twenty seismotectonic provinces. Major fault zones exist within all proposed provinces and the earthquakes occur on large number of faults spread over a wide area. This indicates that rigid plate models do not adequately represent the active regions of the continents involved in crustal compression (especially in convergent zones like the Iranian plateau).

At the present study based on seismotectonic information and available crust and upper mantle velocity models, Iran was divided into 8 regions as shown in Figure 4.

The Moho depth for Iran is based on different local and regional studies, mentioned in the previous parts. For some regions, for which Moho depths were not available, the global model of the Moho discontinuity (Cornell's Moho map for the Middle East) was used. So, a preliminary 3-D Moho depth model was developed.

For each region, the IASPEI91 model was replaced with the new information of Moho depth and upper mantle velocities in Iran. For the first region, which is Makran, the values of IASPEI91 and Mooney (1998) were used, whereas for the second one (Zagros), the results of Farahbod (1996) and Mooney (1998) had the main role in the upper mantle. In the region 3, (Kerman) the upper mantle parameters came from Zohoorian et al. (1984) and for the region 4, which is east & central-east of Iran, our local model for eastern Iran (Farahbod et. al. 2003) and Asudeh (1982) were used. For the fifth region (northwest & central Iran) and sixth region (north and central north of Iran) Asudeh (1982) was the main source of information. In the Caspian Sea (region 7) results of Jackson (2002) and Mooney (1998) are used for upper mantle. For the central Iran (region 8) global models were used.

Summary and conclusions

Sweeny et al., (1998) collected crustal models for seismic regionalisation of eastern Mediterranean and Middle East, which were originally developed by Mooney (1998). According to this study Iran could be divided into five (including the south Caspian basin) regions. At the present study based on seismic data a Moho depth map for the Iran region has been introduced.

The Moho depth map and velocity models for the crust and upper Mantle (Moho velocity) were based largely on published and unpublished results.

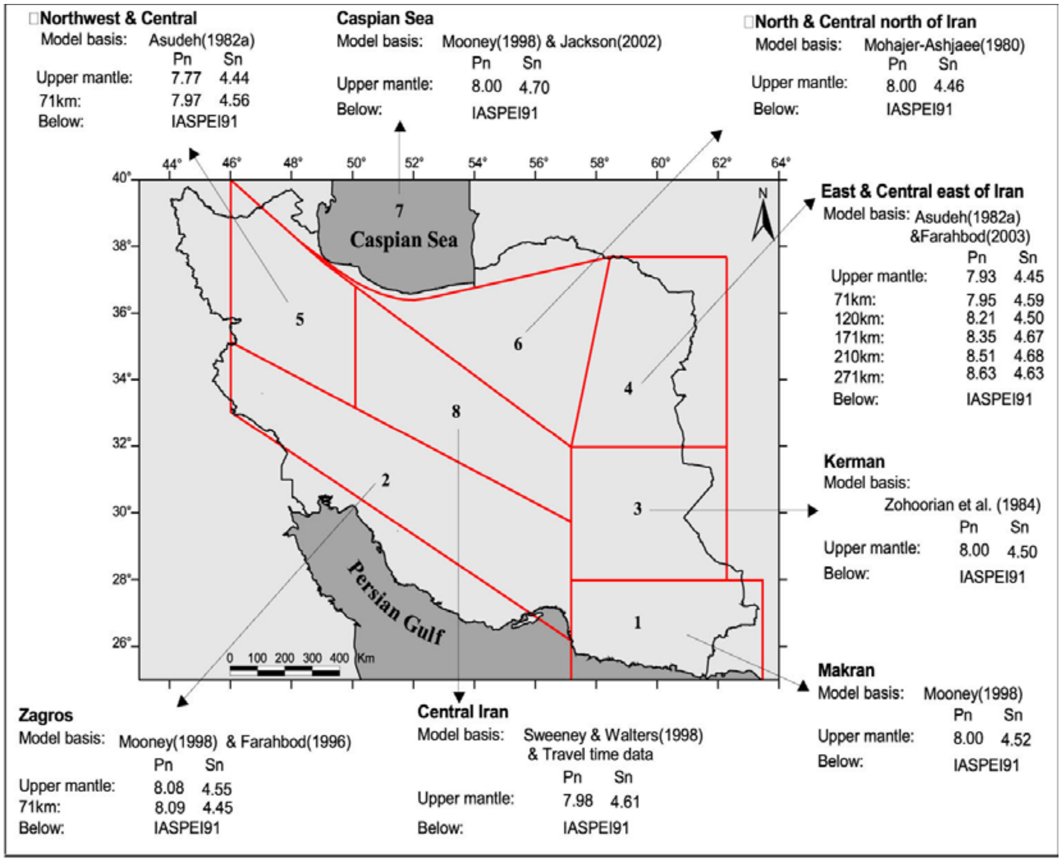

Figure 4- Subdivision of Iran based on synthesis of the velocity models.

Comparison between the Moho depth map obtained from gravity data (Dehghani et. al. 1983) and the result of the present study based on seismic data shows that although the same tendencies with a thinner crust below the Zagros and eastern Iran are recognized in both models, but there are some differences between these two results. The differences between the two maps may reach 10 km both in negative and positive.

The average crustal thickness of 40 and 45 km were found respectively for the Zagros and central Iran. The deepest part of Moho recognized in a region northeast of Main Zagros Trust (MZT) in Sanandaj-Sirjan zone up to 60 km however gravimetric data shows this region somehow at the western parts.

Based on seismotectonic information and available crust and upper mantle velocity models, Iran was divided into 8 regions. For some regions, for which Moho depths were not available, the global model of the Moho discontinuity (Cornell's Moho map for the middle East) was used. For each region, the IASPEI91 model was replaced with the new information of Moho depth and upper mantle velocities in Iran.

Acknowledgments

We are grateful to Petr Firbas at CTBTO for his valuable guidelines. Also special thanks to Khaled Hessami for the seismotectonic information. This research was supported by IIEES, IDC (International Data Center) and NORSAR, under Contract No. 00/20/5022.

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