Crustal structure of the Iranian Plateau based on 2D interpretation of gravity, aeromagnetic, and seismic data

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ABSTRACT
A crustal scale 2D density and magnetic susceptibility model of the NW part of Iranian plateau has been constructed based on receiver functions and sediment thickness. To first order, Moho depth correlates inversely with topography. Our density/susceptibility model includes three distinct tectonic zones: The Zagros Zone, the Central Iranian Block, and the Caspian Sea Block. All three zones are covered by at least 6 km of sedimentary layers. A broad, pronounced negative Bouguer gravity anomaly below the Zagros Mountains is mainly related to the thickening of the crust and partially related to thickening of the sedimentary layers. The 2D density model shows that the thickening of the crust beneath the Zagros is accommodated by thickening of a high-density lower crustal layer, whereas similar thickening below the Central Iranian Zone is mainly due to thickening of a high-density middle crustal layer. Shallow Curie isotherm in the vicinity of the Zagros suture zone may be related to partial melting at depth. The NE-dipping suture between the Arabian and Eurasian plates marks a change in density structure of the whole crust. The absence of strong magnetic and gravity anomalies over the south Caspian basin with ~ 30 km Moho depth and ~ 20 km Curie isotherm, indicates that the crystalline rocks are only weakly magnetized and dense, supporting the idea that the crystalline crust is likely of continental type. The transition from the Iranian Plateau to the Caspian Sea Block includes a thick body with intermediate density between the crust and mantle. It may represent either an underplated layer or a present zone of partially molten mantle rocks.
Keywords: 2D forward crustal modelling, Gravity and Magnetic anomalies, modelling and interpretation, Receiver function, Iranian plateau, Moho, Sediment thickness

INTRODUCTION
Iranian Plateau formation has been formed by a long-lasting convergence and collision of the Arabian and the Eurasian plates. An interaction between these two major lithospheric plates and numerous microplates trapped between them, created a broad zone of deformation with different type of structural units in the frame of the Alpine-Himalayan collision belt. The deformation style in this region is highly influenced by the evolution of the Tethyan oceans. The geological evidence for ancient Thetyan Ocean is present mainly in the Tertiary magmatic activity associated with paleo subductions and ophiolites in the paleo suture zones. Based on this evidence the region is divided into several geotectonic units, namely the Zagros fold and thrust belt, the Sanandaj- Sirjan Zone the metamorphic zone (SSZ), the Urmia-Dokhtar Magmatic Arc (UDMA), the Central Iran block), the Alborz and the south Caspian basin(SCB) (Berberian and King, 1981; Boulin, 1991; Nowroozi, 1971; Stocklin, 1968). Despite of a lot of geology and geophysical studies, crustal scale structures and status of interaction between different units doesn't well understood and needs more studies

Detailed information on the crustal and lithospheric structure is crucial for understanding the geodynamics processes of continental collision and subsequent mountain building. This information still incomplete for the Iranian plateau, in particular there is lack of high-resolution information on the crustal structures. In addition complexity of geological structures in the broad zone of deformation complicates their modeling and mapping by one type of data. For example, due to different interbedding evaporitic boundaries it is impossible to detect sediment-basement and crystalline boundary layer (like Moho) only by applying typical seismic methods.

In this paper, we present an updated model of the deep crustal structure of North West part of Iranian plateau in terms of the 2D density and magnetic modelling and constraints which is derived from structural geology and recent seismic profile. The combined model obtained on several methodology, namely the spectral magnetic methods, seismic receiver function sections, gravity/magnetic forward modeling and compare them to main geotectonic units, such as paleo oceanic suture zone, the magmatic arcs and folded belts.

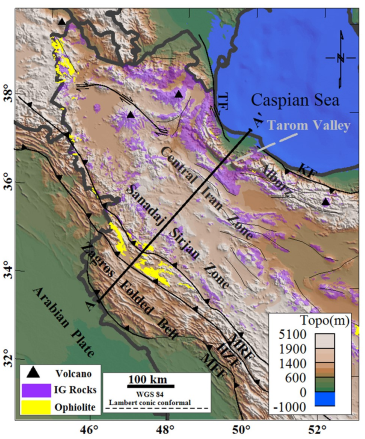
The crustal scale reconstruction is along a SW-NE, coinciding with new seismic profile, crosses all major tectonic units of the Iranian plateau(Figure 1.a), which gives an excellent chance to investigate all units and their interaction in one section. The crustal-scale reconstruction of the Zagros and Alborz orogens outlines and recognizes three main boundaries (1) the top of the basement (2) the depth of the Curie isotherm and (3) the Moho boundary. We also model density and susceptibility distribution between these boundaries. The model is consistent with observed magnetic and gravity data, shows a low misfit between the observations and the model prediction and is in agreement with receiver function (RF) results (Chen et al., 2016), recent magnetic basement study (Teknik and Ghods, 2017) and published/released structural study (e.g. Vergés et al., 2011) to constrain sedimentary cover at top of our model. New Moho depth, which is derived from receiver function relatively constrain our model at the deeper levels especially at Moho boundary. These new information allowed us to focus on the crust structures of the section more unambiguously.

RESULTS

Sediment Thickness: In this section we will show thickness of sediment thickness by Comparing different results. The results indicate distinct results at some part of Zagros and very good coloration beneath SSZ, CI and Alborz. The results indicate decreasing of depth to magnetic basement from 16 km at the SW end of profile to near zero km at around the Kermanshah. (Figure 1.b). After Kermanshah ophiolite toward NW and in the external part of Zagros receiver function results are in agreement with RAPS. RAPS and RF results both show a huge basin with a thick cover (maximum ~12 km) at the NW of MRF (Bijar basin).

Moho Depth: RF model generally show thickened crust in the whole of plateau, which corresponds to region of diffused deformation due to long-standing convergence of Arabian and Eurasian plates. Negative long wavelength Bouguer gravity anomaly from Zagros in the SW of the profile to SCB in the NE of profile accounts for the thickened crust. Receiver function results (Chen et al., 2016) indicates gently thickening of crust from foreland basin of Zagros ~45 km toward northeast and reaches maximum depth under Main Zagros Thrust (~65 km). Northeast of the surface trace of MRF fault, crust thickens increases to ~55 km beneath the Sanandaj-Sirjan zone and then decrease to ~50 km beneath CI and the last change is under Tarom valley from ~50 km to ~30 km(Figure 1.b).

a



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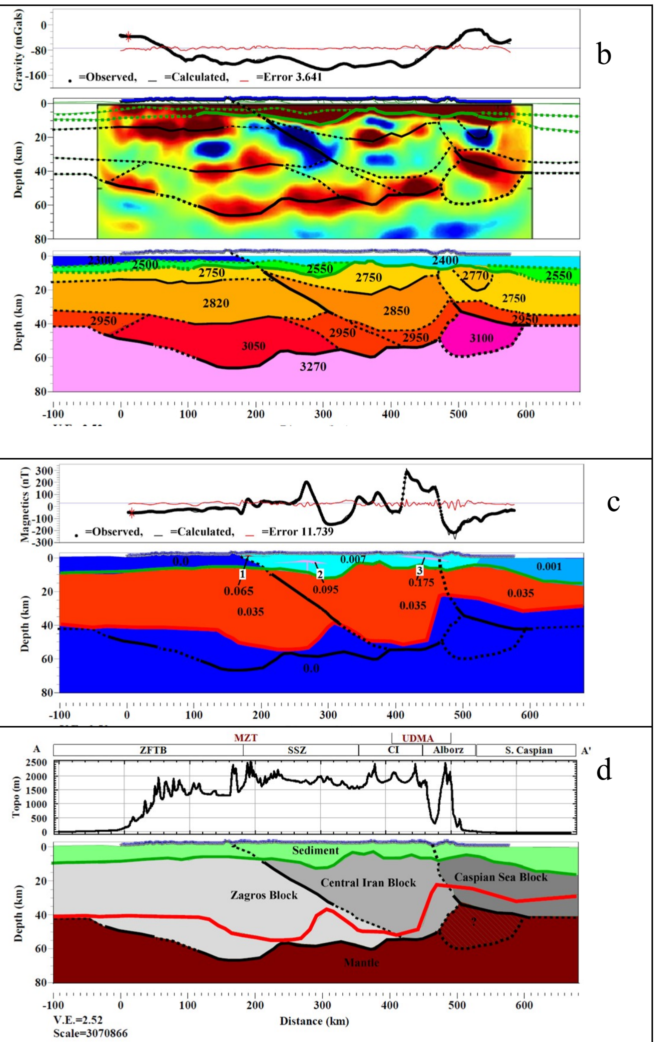

Figure 1. a) Topography map of the Iranian plateau based on ETOPO 1.The Profile discussed in the text is shown by solid straight line.
b) Final density model: Results from the NW Iranian profile. The model shows thrusting of Zagros crust under central Iranian crust.
c) Magnetic susceptibility section from surface to depth of 80 km. Black lines show the interpretation of boundaries from density model. Red line shows CDP and the green line shows sediment-basement boundary. Susceptibility of sediments and below the depth of Curie isotherm were fixed to near zero.
d) Simplified sketch.This model illustrate sediment(green line) and crust thickness and also Curie depth point(red thick line) variation along the profile.

The indication of Main recent fault (MRF) can be seen in the northeastward continuation of blue negative interface to the depth at RF image, where P waves are converted to S waves and the underlying material has the lower S wave speed. Continuation of this dipping zone to the surface approaches the surface trace of the MRF, suggesting that it marks the continuation of that fault at depth. It dips gently, at ~13°, and can be traced at depth of 35 km and horizontally ~250 km farther beneath central Iran. By projection of the MRF and extending of RF dipping interface to the Moho, suggesting underthrusting of Arabian platform under southwestern edge of the Iranian Plateau. Density modeling supports RF results from the SW beginning of the profile to the Tarom valley. NE of Tarom valley towards the Caspian Sea, the result of density modeling and RF results agree partially. RF results suggest two possible depths for Moho boundary from the Tarom valley to the NE end of the profile. Shallow and the strong boundary interface (Figure 1.b) decreases sharply from 50 km to 30 km exactly under the Tarom valley in the northern of Iran. The second weak and embowed shape boundary shows another scenario for the Moho depth in this region (Figure 1.b). The second scenario is more consistent with gravity modeling and can be interpreted as up-ducting of south Caspian basin to central Iran. These structural differences correlated with a huge and sharp variation in topography and aeromagnetic anomaly and suggest a transition zone between central Iran and south Caspian Basin under Tarom valley.

Our results show thinner crust for the SCB crust overlain by about 15 km thick sediments and the transition beneath the Tarom valley.

Our 2-D density model includes two fixed main density boundary layers (sediment-basement boundary on the top and the crust-mantle boundary layer at the bottom of model). Density of sediment is assigned 2550 kg/m^3 in the upper part and 2650 kg/m^3 in the lower part. Density structure of the crystalline crust is divided to small domains with different densities based on gravity anomaly and depth of the intra-crust layers. Density of mantle does not change along profile and is 3270 kg/m^3 (Figure 1.b).

Our Curie isotherm results (Figure 1.c) indicate a cold crust in the middle of the Zagros and central Iran plates with highest temperature at suture zones between the Arabian and central Iran with CDP around 30 km and also at the possible transition zone between central Iran and south Caspian basin with CDP around 15 km. Curie isotherm is around 40 km at the SW end of the profile beneath the folded Zagros and gently deepens to 55 km, its maximum value, beneath the SSZ. The first shallow CDP (~ 30 km) coincides with Mesozoic magmatic activity of SSZ at surface (Agard et al., 2011 and reference there in) and indicates a possible high temperature.

CDP is increased 50 km beneath CI indicative of cold crust in the middle of central Iran block. Under the Tarom valley, possibly due to high temperature, CDP decreases to around 15 km (the shallowest part of profile) and coincides with Alborz-Tarom region, which has experienced Tertiary Uromieh-Dokhtar magmatic activity. The NE of the Tarom valley, towards the south Caspian basin, CDP slightly deepens. Comparing Moho and other inter-crustal boundaries with Curie isotherm along the profile indicates temperature variation correlated with crustal structure inferred from RF studies (Figure 1.c).

CONCLUSION(S)

Two shallow region Curie isotherm in correspond Mesozoic Sanadaj-Sirjan magmatic arc (~ 30 km) and Tertiary period Uromieh-Dokhtar magmatic arc (~ 15 km). Moho depth in association with long wavelength negative Bouguer gravity anomaly, RF results indicate thickening of whole plateau. Shallowest CDP and Moho step with accompany with topography suggesting partial melting beneath Tarom valley and possible suture zone between central Iran and south Caspian basin. The widely accepted view about the borders of South Caspian Basin (SCB) corresponds along Khazar and Talesh faults in the southern and western borders, respectively. Our density-susceptibility modeling indicating boundary beneath Tarom valley in the middle of Alborz mountains, where is located in the 100 km distance of SE of Khazar and Talesh fault (Figure 1.d).

Our modeling does not support oceanic nature for SCB due to low gravity and magnetic anomaly over the SCB and it suggests continental type of crust.

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