Bull. Min. Res. Exp. (2016) 153:203-222

Bulletin of the Mineral Research and Exploration

http://bulletin.mta.gov.tr

GEOPHYSICAL REGIONAL GRAVITY MAPS OF TURKEY AND ITS GENERAL ASSESSMENT

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Review Article

Keywords:
Gravity, Free Air, Bouguer, Isostasy, Crust Thickness, Density.

Received: 26.10.2015
Accepted: 15.03.2016

ABSTRACT

In this study, the maps generated from the regional gravity data, which had been measured within scope of "Türkiye Rejyonal Gravite Haritaları Projesi" (Regional Gravity Map of Turkey) project were introduced. The topography, Free Air, Bouguer gravity, isostatic residual, isostatic regional, density and crust thickness maps of Turkey in 1/1.500.000 scale were prepared using database which started in 1973 and ended in 2011. The boundaries of the main tectonic members were determined by crust thickness, isostatic residual and Bouguer gravity maps of Turkey. Within this scope, a database that will illuminate the investigation of crustal structure, the development of the scientific database and the solution of geological problems were established.

1. Introduction

The maps presented in this study were prepared by data obtained in the project of "Türkiye Jeofizik Rejyonal Gravite Haritaları Projesi" (Geophysical Regional Gravity Anomaly Map of Turkey), in the General Directorate of Mineral Research and Exploration (MTA) in 1973 by Dr. Erdoğan ORAY. The project initiated in 1973 and was completed by the estimation of all regional gravity data of Turkey in 1988. A small portion of these data were taken from the gravity data of the General Commandership of Turkey (HGK) and Turkish Petroleum Corporation (TPAO). In total; 60166 gravity data were measured and planned such that at least 10 points would fall into 1/25.000 scale topographical sheet with nearly 5-6 km intervals. Besides; in addition to regional gravity data of Turkey, 25.000 gravity data, which had been estimated within scope of TUBITAK project named as "Türkiye Kuzey Batı Anadolu'nun Kabuk Yapısının Jeofizik Yöntemlerle Araştırılması" (Candansayar et al., 2011) (Investigation of the Crustal Structure of the Western Anatolia, by means of Geophysical Methods, Turkey", which started in 2006 and ended in 2011, were also added. The point interval within scope of this project was selected as nearly 2.5 km, and it was also paid attention for 25 data to be in 1/25.000 scale sheet with previous points.

Elevation and coordinate measurements in gravity field studies were taken from 1/25.000 scale topographical maps by means of 1st, 2nd and 3rd degree triangulations. Besides; the points such as; school, mosque, crossing road, river junctions, bridge etc. were detected in which elevations and coordinates could be read on 1/25.000 scale topographical map. The regional gravity and TUBITAK data were measured by Worden Master, Lacoste Romberg gravimeters and Lacoste Romberg and Scintrex CG5 gravimeter instruments, respectively. The coordinate data in TUBITAK Project were measured by Hemishere A 100 DGPS, which has accuracy less than one meter, and orthometric elevations in all data were utilized.

The purposes of the "Regional Gravity Maps of Turkey" project are as follows; to reveal the unexposed deep seated fault systems, to investigate horst-graben structures, to determine surface, deep mass distributions in the project area, the boundaries of the main tectonic units, distributions and relationships, the elastic layer thickness of the continental upper crust, the regional variation and MOHO depth of which isostatic models are suitable and realistic, to increase the international scientific competition by providing information to investigators who make research about the crustal structure, which requires additional research in investigating deep basin structures, and to develop scientific environment and infrastructure

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http://dx.doi.org/10.19111/bmre.96652

for the utilization of both geophysical and geological studies.

The earth crust is not made up of only one piece but has been separated into several pieces. Each piece is called as the "plate". The compositions, densities, depths and thicknesses display different characteristics. These various blocks, of which their thicknesses, compositions and densities are different, are observed in the form of equilibrium in depths of the earth. In other words; the pressure that these blocks exert in the mantle is balanced at a certain depth or equalized. This equilibrium is called as the "isostatic equilibrium", and it is reached nearly at a depth of 40-50 km. Although the isostatic equilibrium is at a risk of imbalance, it is always protected by motions occurring on earth crust. These movements, which occur for the protection of isostatic equilibrium is called as the "isostatic movements". The events that cause isostatic movements to happen or isostatic equilibrium to fail are erosion, depositional events, glaciation and volcanism. Briefly; the variations that happen as a result of all internal and external phenomena in earth crust is explained by the isostatic equilibrium.

"Isostasy" is the equilibrium of large plates of which their densities and masses are different on crust. The addition or removal of large loads on crust disturbs the isostatic equilibrium. The failure in equilibrium is compensated by the substitution of mantle material on the boundary of crust-mantle. The effective elastic thickness estimation was taken as 6 km for the western Anatolia based on admittance and coherence between gravity, free air and topographical data (Pamukçu et al., 2008). Using the east Anatolian gravity and topography data, this thickness was estimated as 13 km by misfit function (Pamukçu et al., 2011). The admittance function Z(k) from isostatic response functions were defined by making an equation between Fourier Transformations of G(k) gravity and T(k) topography anomaly (Dorman and Lewis, 1970). Later on; Mckenzie and Bowin (1976) have developed the admittance function in their studies. For the eastern America, T_e was estimated as 10 km; and for the Central America and Siberia T_e values were estimated as 18 and 15.5 km's, respectively (McKenzie and Fairhead, 1997).

Many investigators have carried out studies related to the crustal thickness of Turkey by means of gravity data. The crust thickness was estimated as 35-40 km by means of data-process and theoretical modelling using Bouguer gravity data in western Anatolia (Akçığ, 1988). Estimating the power spectrums of the East Anatolian Gravity data, it was stated that the depths had been in between 35.6-45.1 km (Maden et al., 2005). The crust thickness for the eastern Anatolia was found in between 38-52 km by means of the east Anatolian gravity, magnetic and topography data (Pamukçu et al., 2007). The gravity Bouguer anomaly, free air and isostatic residual anomaly data of Turkey were associated with elevation data; and it was seen that the Bouguer anomaly data had given the best result. The crustal thickness of Turkey was estimated as 31.4 km (shallowest) and as 50 km (deepest) (Arslan et al., 2010). Pamukçu et al., (2015) have given information with gravity data about the characteristics of various structural elements observed in the region from their studies called "Doğu Anadolu Bölgesindeki kabuk yapısının düşey ve yatay yönlü analizi" (Vertical and Horizontal Analysis of the crustal structure in the eastern Anatolia Region).

2. Geophysical Regional Gravity Maps of Turkey

The topography, free air, Bouguer anomaly, isostatic regional, isostatic residual, crustal thickness and density maps of Turkey introduced in this article had been prepared using the geophysical Regional Gravity data of Turkey in 2012 making all gravity corrections by copyrighted MTA Geosoft Oasis Montaj Software, and these were published by the General Directorate of Mineral Research and Exploration as a result of referral inspections (Arslan, 2012 a, b, c, d, e, f, g). Each of them was printed as 1000 numbers and still could be obtained by cash as they are available at General Directorate of Mineral Research and Exploration (MTA), Department of Scientific Documentation and Publicity.

2.1. Topographical Map of Turkey

For isostasy correction, elevation data between 24°-48° longitudes and 34°-45° latitudes were used, and a large zone was selected in order to make the isostasy correction until 166.7 km also including sea depths (Hayford Zone). These data were obtained from NOAA's National geophysical http://www.ngdc.noaa.gov/mgg/topo/gltiles.html web site. In Figure 1, Caucasian, Zagros, East Anatolian and Taurus Mountains are observed. Elevations vary between 0-3685 meters on lands and 0-2825 meters in seas.

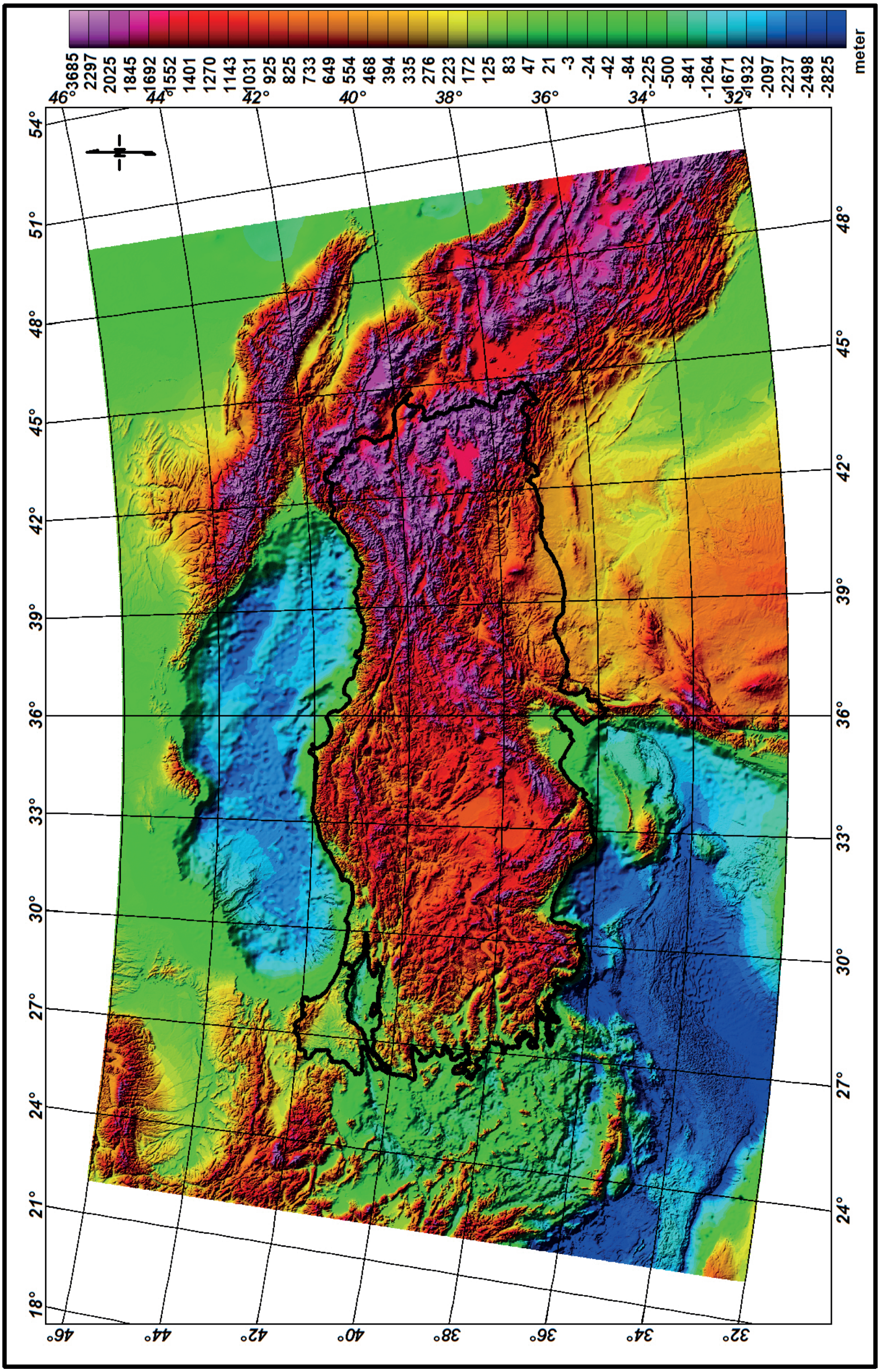

Figure 1- Topographical map (modified from Arslan, 2012*a*).

The elevation data, which were subjected to isostasy correction, were used in 500 meters' grid interval, and the topographical map of the study area was drawn in order to compare with free air corrected map (Figure 1).

2.2. Free Air Anomaly Map of Turkey

The equation given below was used for the Free Air Correction;

According to the latitude of the measured point;

g_φ = - (0.30877 -0.00044 $\sin^2\varphi$). h_m -0.073 h^2_{km} = 0.3086.h mgal (Erden, 1979)

where;

h: Height of the measurement point above the sea level (h_m meter and h_{km} kilometer)

φ: Latitude of the measurement point.

For φ = 30^o latitude;

g_φ is 0.3086.h mgal, and this value changes according to the latitude of each point.

In the study carried out, the latitude correction (g_l) was subtracted from the observed gravity g_{obs} and the free air effect was added.

Free Air Anomaly= $g_{obs} - g_l + 0.3086h$

When the gravitational effect of the topographical mass is equalized as the equivalent of mass in depths, these values in this map will approximately be zero. At regional elevations corresponding to zero free air anomalies, the elevation is related with the isostatic equilibrium. When zero free air values are formed as a result of the formation of the effect that had occurred due to the local mass distribution, such zero values are not used for regional estimations in the Bouguer gravity area (Wollard, 1959). Gravity free air maps generally reflect the topography if there is not any disruptive mass in underground. When the topography map in Figure 1 and free air anomaly map in Figure 2 are compared, there is seen a negative belt located in Edirne and south of Kırklareli in Thrace region. It shows here the presence of a low density cover and it is highly compatible with topographical map. Gravity free air anomaly maps are generally quite useful in detailed researches and mineral explorations. Because, there is considered a disruptive mass below anomalies which show incompatibility with topography.

2.3. Bouguer Anomaly Map of Turkey

Latitude, elevation, geoid and terrain corrections were made in the gravity Bouguer anomaly map. It is crucial to make geoid correction, which varies due to latitude and longitude, since all gravity data of Turkey were used. The density was taken as; 2.4 gr/cm^3 for terrain correction (Nagy, 1966). Some investigators have regarded density as; 2.67 gr/cm^3 for terrain correction, as it was in the elevation correction. The mass calculation in elevation correction is taken from the sea level. Since the utilization of densities of deeper masses is intended, it was regarded that the density for terrain correction should be less than 2.67 gr/cm^3. The mass of the difference among the measurement point and the tilt of the topography, and accordingly; the effect of shallower masses is estimated in terrain correction. The points in TUBITAK project were also measured up to J zone (6652 meter) for compatibility, since previous regional gravity points had been estimated up to J zone by using Hammer chart (Hammer, 1939). Terrain corrections were estimated by elevation data taken from HGK. HGK digitized elevation contours of the 1/25 000 scale topographical maps and prepared in 1 sec x 1 sec ASCII grid format. MTA have purchased the elevation data of 5547 1/25 000 scaled topographical maps of all Turkey in ASCII grid format. Terrain corrections in MTA researches are made by these elevation data. Actually; terrain corrections are made up to 166.7 km (Hayford zone). However, the technical facilities are not suitable for this.

Latitude correction was measured by 1967 geodetic reference formula given below;

g_e = 978031.85* (1 + 0,005278895*sin2φ + 0,000023462*sin4φ) mgal

g_e= 0.8122 sin(2φ) mgal/km

Elevation Correction (E.C.) = (0.3086 - 0.04191ρ) h mgal, h=H+N

where;

h: Ellipsoidal height of the measurement point,

H: Orthometric height

These parameters were read by differential GPS during measurements in TUBITAK project number 105G145. However; in the regional gravity project of

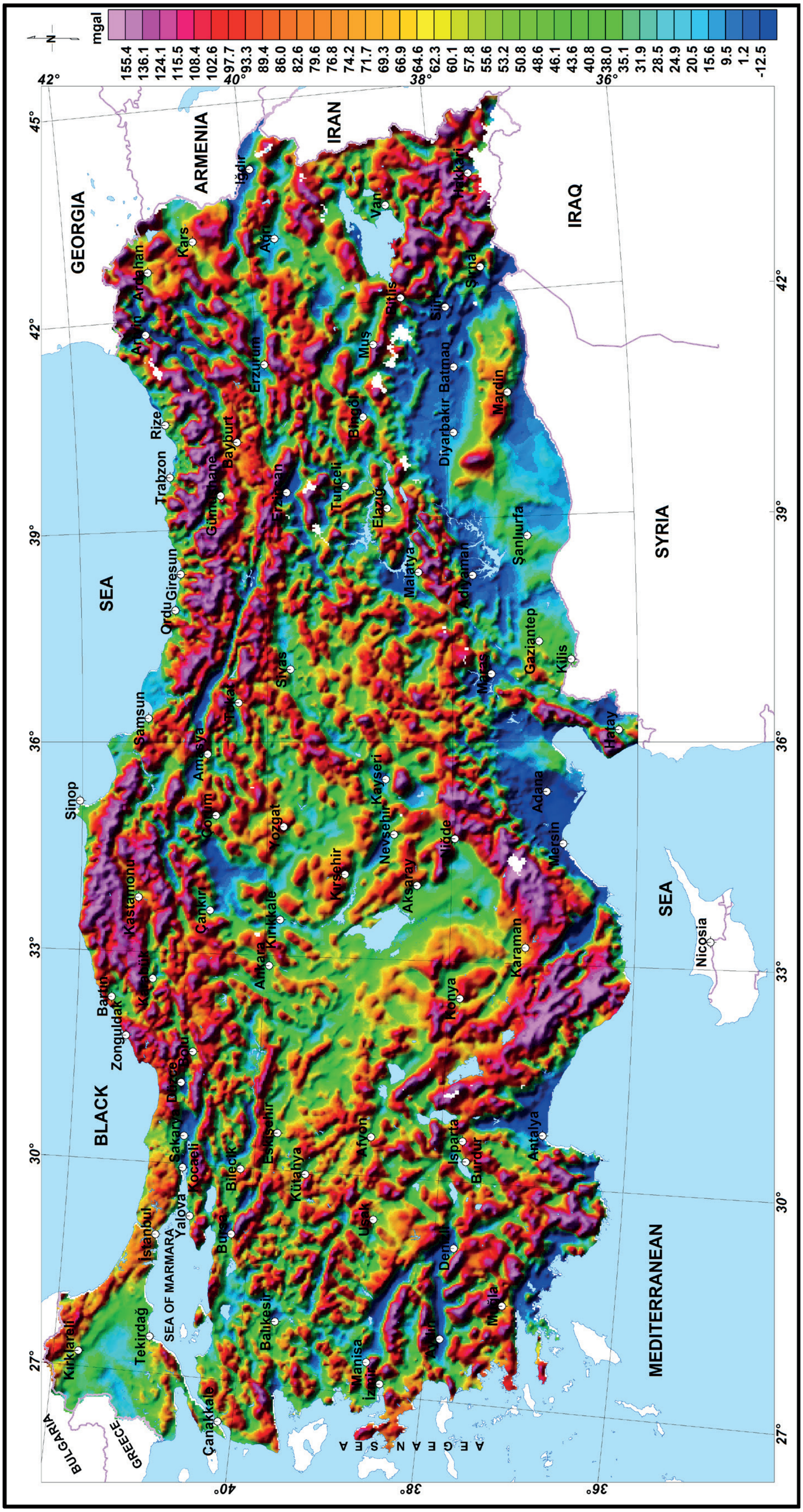

Figure 2- Regional gravity free air anomaly map of Turkey (Arslan, 2012*b*).

MTA these parameters were read by eye from 1/25 000 scale maps. As elevation and coordinates were read by eye in the regional gravity project of MTA using 1/25 000 scale topographical maps, the measurement points were selected in places such as; triangulation points, elevated hill, school, mosque and crossing roads. N geoid height is ρ=2.67 gr/cm^3 which is the upper crust density. The N value was estimated from Geodetic Reference System (GRS) 1980 ellipsoid by entering the data set, in which the geographical coordinates of each point are available, into the licensed Oasis Montaj software

In figure 3, the gravity Bouguer anomaly map is seen. When this map is studied there is observed a negative belt in southwest of Bolu, in Köroğlu Mountains and its southern part. This situation most probably represents low density formations. The Strandja Mountains were bounded by positive indications and the Gediz graben is clearly distinguished on map. The North Anatolian Fault (NAF) is also observed on the map. There might be some granitic intrusions or crustal thickening in most parts where gravity values decrease (Singh et.al., 1999). There is observed also in this study that gravity values in the eastern Anatolia are quite low and the crust is thicker in this area. High gravity values on shores of the Black Sea, Aegean and Mediterranean Sea correspond to areas where the crust thins out. Besides; one can also consider that a magmatic lopolith have revealed gravity increases. In some parts, gravity increases may also correspond to suture belts. As it is known; the gravity values become high as the high density magmatic material approaches the surface in suture belts. Low density granitic intrusions can be represented by negative anomalies. The Eğrigöz granite located in Emet, Kütahya is a good example for that.

2.4. Isostatic Regional Anomaly Map

The “isostasy” is the state of equilibrium of continental pieces which have different thickness, compositions and densities in the mantle, and it defines the state of equilibrium behavior in which there is not any other disturbing effects between the crust and the underlying mantle (Watts, 2001). The concept of isostatic equilibrium was explained by two different hypotheses (Airy and Pratt, 1855). The theory of isostasy explains the state of equilibrium of the outermost layer of the earth with respect to the average densities of underlying rocks. As a result of this theory, the earth surface moves upward or downward because of loading and unloading. Therefore; the concept of isostasy is significant for the definition of lithosphere. Isostatic correction is made in order to remove the gravity effect of isostatic root part.

For isostatic correction, the theory of Airy-Heiskanen was accepted and corrections were estimated up to 166.7 km (Hayford Zone). The topographical data used for the isostatic correction had been taken from the website (http://www.ngdc.noaa.gov/mgg/topo/gltiles.html) of NOAA’s National Geophysical Data Center (NGDC). In calculations, the elevation and bathymetrical data between longitudes of 24°-48° and latitudes of 34°-45° were utilized.

During estimations of isostatic regional values, the topographical grid interval was taken as 500 meters. The crustal density was regarded as; 2.8 gr/cm^3, the mantle density as; 3.3 gr/cm^3 and the sea density as; 1.027 gr/cm^3, and approximately 33 km was used for MOHO depth.

Long wave isostatic effect as a response to regional topography consists of a large area in Bouguer anomaly (Figure 3). These anomalies are observed as big negative values as it was seen in the eastern Anatolia. In order to resolve this low density, effect the isostatic correction was made considering the equilibrium surface. When we have a look at the isostatic regional anomaly map in figure 4, it can be considered that the negative belts in the eastern Anatolia have deeper roots compared to west. Because negative belts in the eastern Anatolia have not still become lost though they became small and fragmented despite isostatic correction had been made. However; almost all negative anomalies located on Bouguer anomaly map in western Anatolia (Figure 3) are not seen on the isostatic regional anomaly map (Figure 4). Isostatic regional anomaly values vary between -203.09 and -15.23 mgal as seen in figure 4.

2.5. Isostatic Residual Anomaly Map

Gravity isostatic residual anomaly map (Figure 5) was prepared in order to remove the effect of deep structures. In this study the equilibrium limit was used as 33 km. The isostatic residual anomaly values show distribution compatible with geometries of

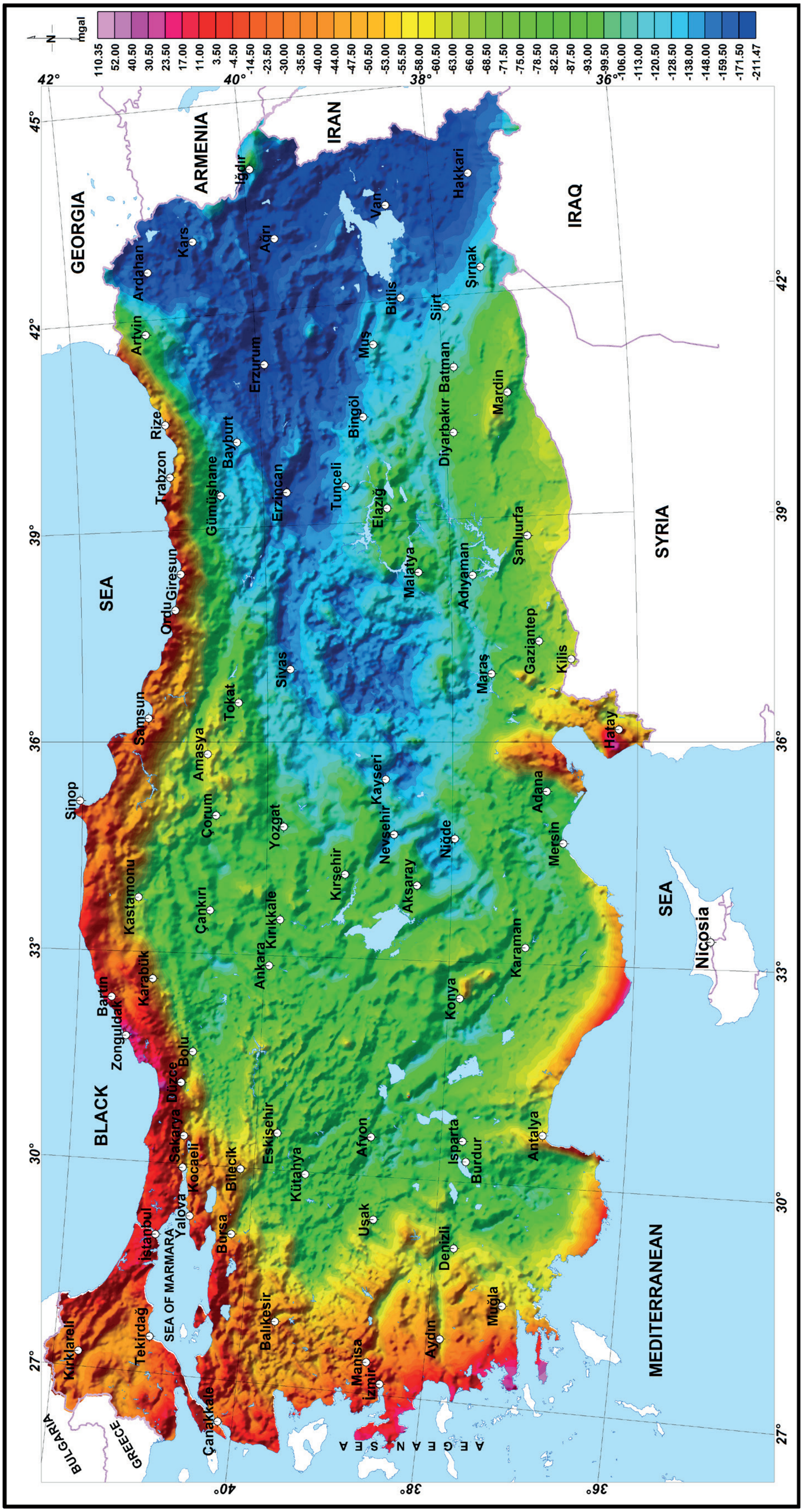

Figure 3- Regional gravity Bouguer anomaly map of Turkey (Arslan, 2012*c*).

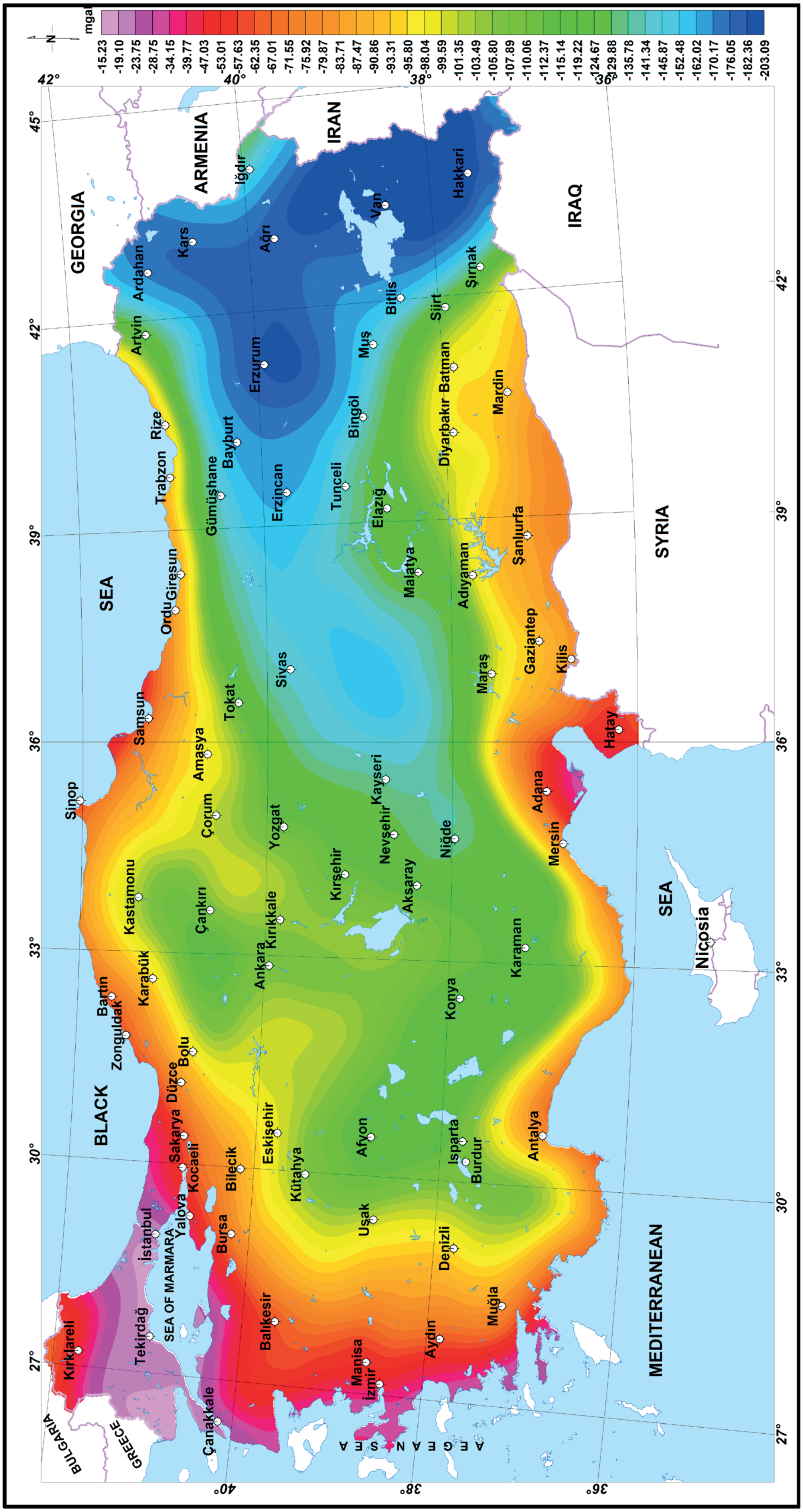

Figure 4- Regional gravity isostatic anomaly map of Turkey (Arslan, 2012*d*).

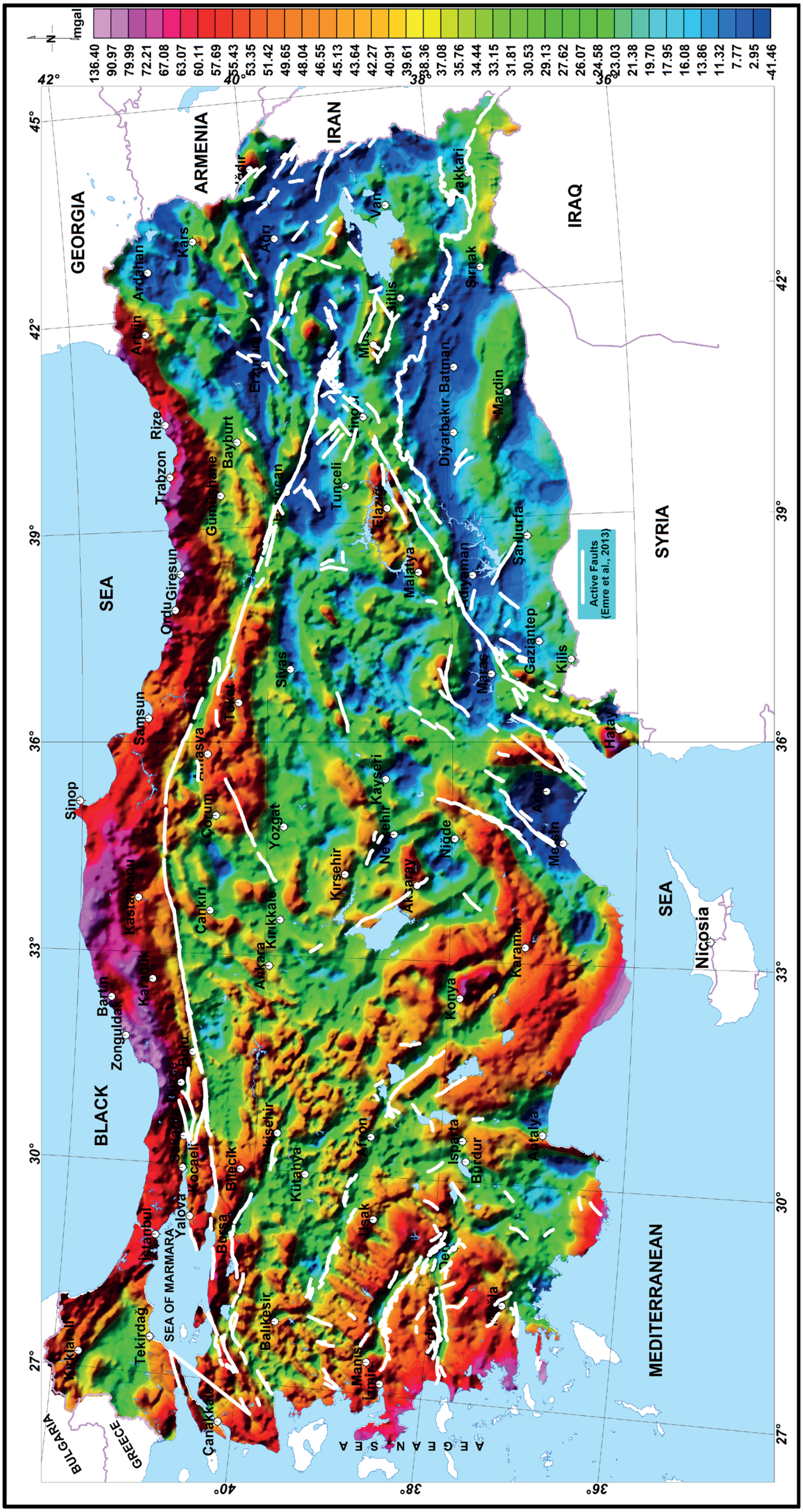

Figure 5- Regional gravity isostatic residual anomaly map of Turkey (Arslan, 2012*e*, active faults data were taken from Emre et.al., 2013).

the main tectonic structures. Negative belts located in south of Kütahya and in west of Kırşehir massif were isostatically corrected, and the effect of root was mostly removed in the gravity isostatic residual map. The negative belt located in Thrace, Edirne and in south of Kırklareli is quite clearly seen here. It shows that the negative belt in Thrace does not have any root but a really thick density and a low cover compared to surround. Big negative anomaly belt in the east Anatolian region in Bouguer anomaly map (Figure 3) was broken into pieces, and the value of the anomaly located in this region on this map has dropped from -168 to -41 mgal. While studying big geological structures and basins of Turkey, both the geological map of Turkey and geophysical gravity isostatic residual anomaly map of Turkey must be interpreted together (Figure 5). For mineral exploration and geological researches in small areas the gravity Bouguer anomaly map can be utilized (Figure 3), but for larger and bigger areas the gravity isostatic residual anomaly maps must be used. There is a big compatibility between the geological map of Turkey and the geophysical isostatic residual map of Turkey in Thrace section. There is a low density deep structure in both maps. Big faults in the active fault map of Turkey were plotted in white color over isostatic residual map (Emre et al., 2013). The North Anatolian Fault (NAF), the Menderes basins and the East Anatolian Fault (EAF) are clearly observed on both maps and are very compatible with each other.

2.6. Crustal Thickness Map Prepared by Using Elastic Thickness

In estimating the crustal thickness, the crust thickness package software prepared for MTA by Geosoft firm was used (Watts, 2001). This program has three steps. In the first step, the effective elastic thickness T_e is predicted by Admittance function. In the second step, the isostatic regional is estimated (Airy, 1855). In the third step, the crust thickness is calculated by isostatic response function. In the first step, gravity Bouguer anomaly values of Turkey and topographical data were entered into Fourier Transform, and the gravity admittance Z(k), wave number and T_e=10 km were predicted (Kirby and swain, 2009). The equilibrium depth of the sea level was used as; 33 km, Bouguer density as; 2.8 gr/cm^3, sea density as; 1.027 gr/cm^3 and Moho density was used as 3.30 gr/cm^3.

Admittance (using distance 1/d), effective elastic thickness prediction;

The effective elastic thickness of the lithosphere T_e is predicted by the Fourier transformation of gravity and topography in regional scale.

Z(k)=[G(k)*H(k)] / [H(k)H*(k)] (Kirby and Swain, 2009) Equation 1

where;

G(k): Fourier Transformation of the gravity data

H(k): Fourier Transformation of the topography

H*(k): Complex equivalence of the topography in the activity area of Fourier

In Air's model, the gravitational area G is formed from the gravity effect of the topography G_{topo} and the equilibrium G_{comp} gravitational effect (root or anti-root). Watts (2001) defines the gravity admittance as a function modifying the topography to generate a gravitational area.

$Z(k)_{Airy} = 2\,\pi\,g\,(\rho_c - \rho_w)e^{-kd}(1 - e^{-kt})$ (Watts, 2001) Equation 2

where;

g : Newton's gravitational constant,

ρ_c : Crust density,

ρ_w : Sea water density and

d : Average sea depth.

In Pratt's model, the gravitational area G is formed by the gravitational effect of the topography G_{topo} and the equilibrium gravitational effect (root or anti-root). The admittance in the elastic layer model was developed as follows;

$$Z(k)_{Flex} = 2\,\pi\,g\,(\rho_c - \rho_w)e^{-kd}(1 - \varphi(k)e^{-kDc}$$

Equation 3

where;

g: Newton's gravitational constant,

ρ_o: Sea bottom density,

ρ_w: Sea water density and

D_c: Equilibrium depth.

Flexure response function φ(k)

$$\varphi(k) = \left[\frac{D(T_e)k^4}{(\rho_m-\rho_c)g} + 1\right]^{-1} \qquad \text{Equation 4}$$

Flexural rigidity, D is the function of effective elastic thickness (T_e). According to the formula given below;

$$D(Te) = \frac{ETe^3}{12(1-v2)} \qquad \text{Equation 5}$$

where;

E: Young's modulus and

V: Poisson's ratio.

The limit equilibrium states of Airy's and Pratt's flexure and admittance are shown in Figure 6.

If it is regarded that the lithosphere has a finite resistance and rigidity, the isostatic equilibrium will be compensated by vertical flexure as the flexure of the plate is prevented in lateral direction because of morphological and abnormal loads over plate. In Bouguer correction it is regarded that the crust has an infinite rigid and it compensates for all loads.

Bouguer gravity and topography data of all Turkey were gridded in 1500 and 500 meters, respectively. In the first stage, the Bouguer and topography data were subjected to FFT. Then in the second stage, T_e=10, 20, 30 and 40 km's were entered in the admittance part of the crust program, and the Airy values by the Equation 2 and flexure by the Equation 3 were calculated and their graphs were drawn. Among these graphs, T_e=10 km, which is the closest to Airy equilibrium depth, was used (Figure 7). In the third stage, from the Airy

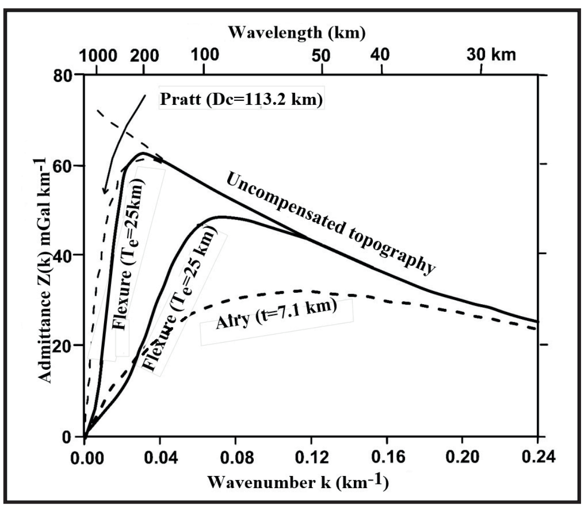

Figure 6- Isostasy and lithosphere flexure (Watts, 2001).

root part of the MTA crust thickness program the isostatic regional (Airy.grd) was calculated. And in the last stage, the crust thickness was calculated from the crust thickness part (Crust10.grd).

Points on green lines denote for the Fourier transforms of the Bouguer anomaly values, red line denotes for the vertical flexure calculated by the Equation 3 in the elastic layer model, and blue line denotes for Airy isostasy admittance value which was calculated by the Equation 2. If it is considered that the lithosphere has a finite resistance and rigidity, then the isostatic equilibrium will be compensated by the vertical flexure as the lateral flexure of the plate is prevented because of the morphology and abnormal loads on the plate. It is regarded that the crust is infinite and compensates for all loads in the Bouguer correction.

In the third stage, the gravity isostatic regional root depth was estimated by 500-meter topographical grid (Figure 8). The output format was selected as the root depth. The calculation was made by selecting the Bouguer density as 2.8 gr/cm^3, the Moho density as 3.3 gr/cm^3, and the equilibrium depth of the sea level as 33 km. Then the depth of root was estimated until 166.7 km by 3D gravity response (Simpson, 1983).

In the fourth stage (i.e. the estimation of the crust thickness), Airy.grd T_e=10 km, Young's modulus 100 GPa, Poisson's ratio 0.25 and Moho contrast 0.50 gr/cm^3 were used. The output was recorded as crust10.grd. So, the crust thickness map was drawn by crust10.grd in Figure 9.

Regional crust thickness maps were prepared for T_e=10 km in Figure 9 and for T_e=40 km in Figure 10. As T_e value becomes higher, then the crust thickness becomes smaller but the contours become more linear. The crust thickness difference is only 2.6 km looking at both maps. However; T_e=40 km is too high for Turkey.

The crustal thickness map of Turkey was prepared for T_e=10 km; (Figure 11) using the regional crustal thickness map (Figure 9). The crust thickness in this study was estimated in between 33-46 km's. As seen in the crustal thickness map in Figure 11, the shallowest parts of the crust are the northwestern Anatolia, Tekirdağ, Çanakkale (Dardanel) and shores of the Black Sea with 33

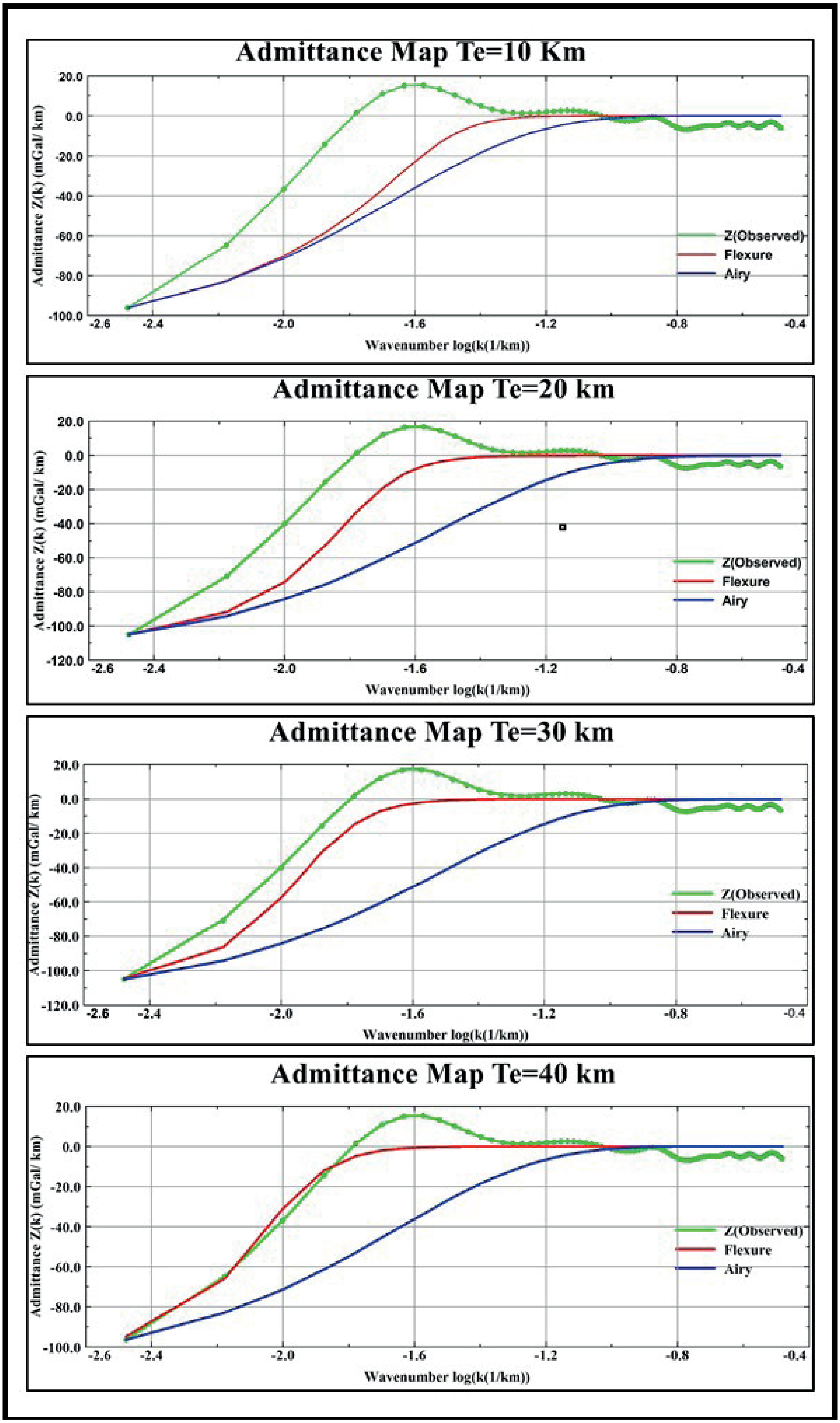

Figure 7- Admittance maps.

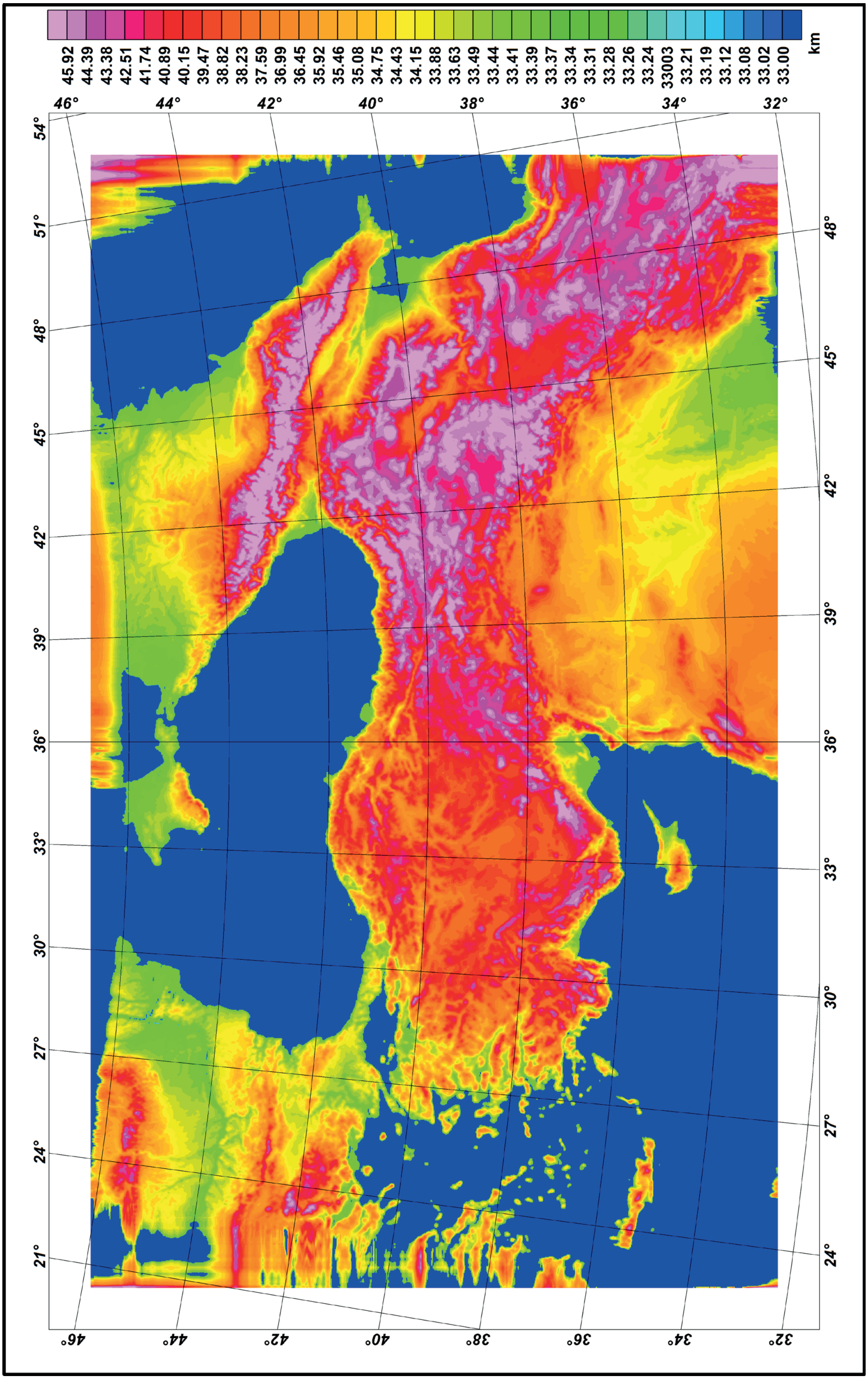

Figure 8- Airy isostatic regional root depth map (Airy.grd).

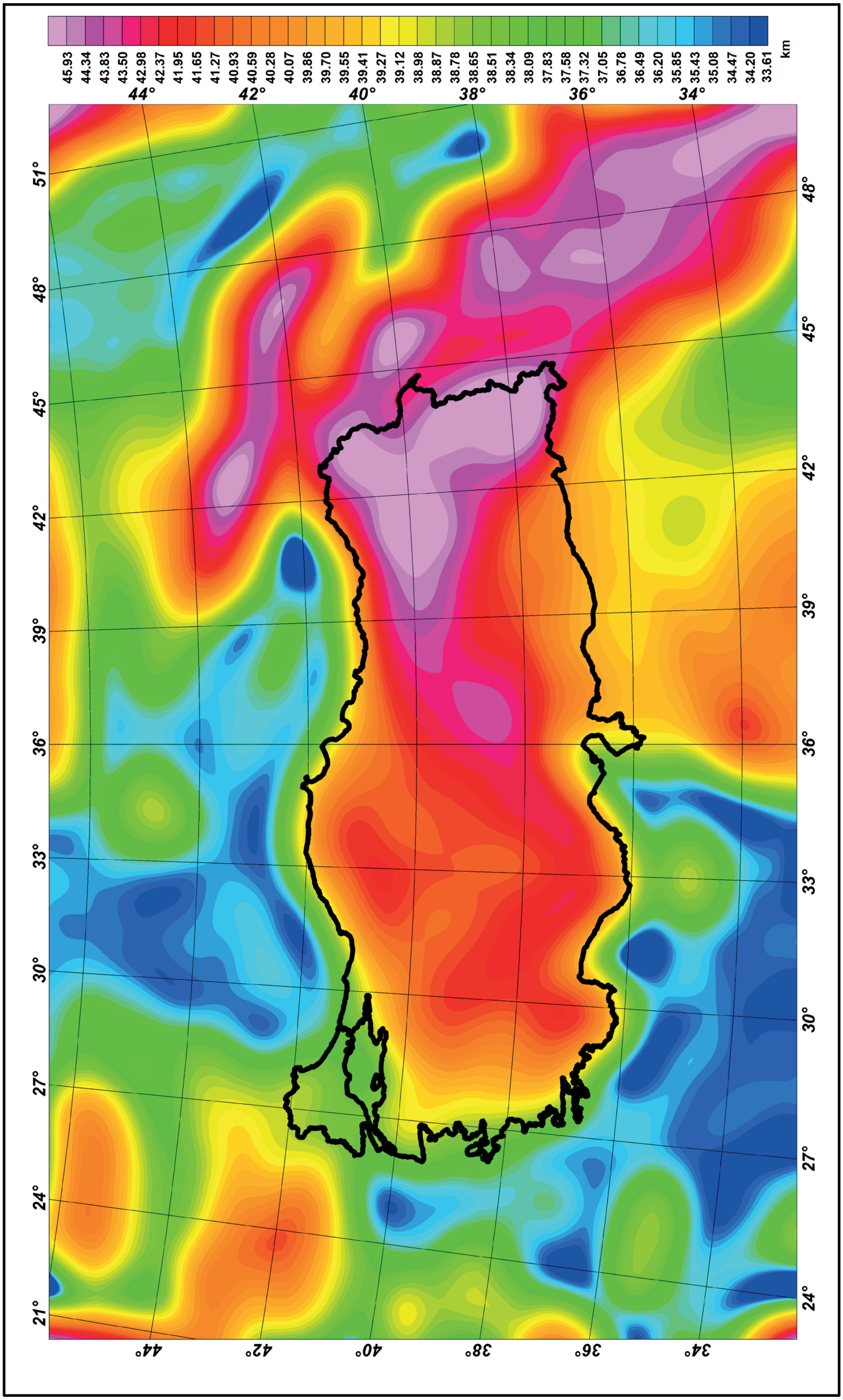

Figure 9- Regional crust thickness map of Turkey for T_e=10 km (Crust10.grd).

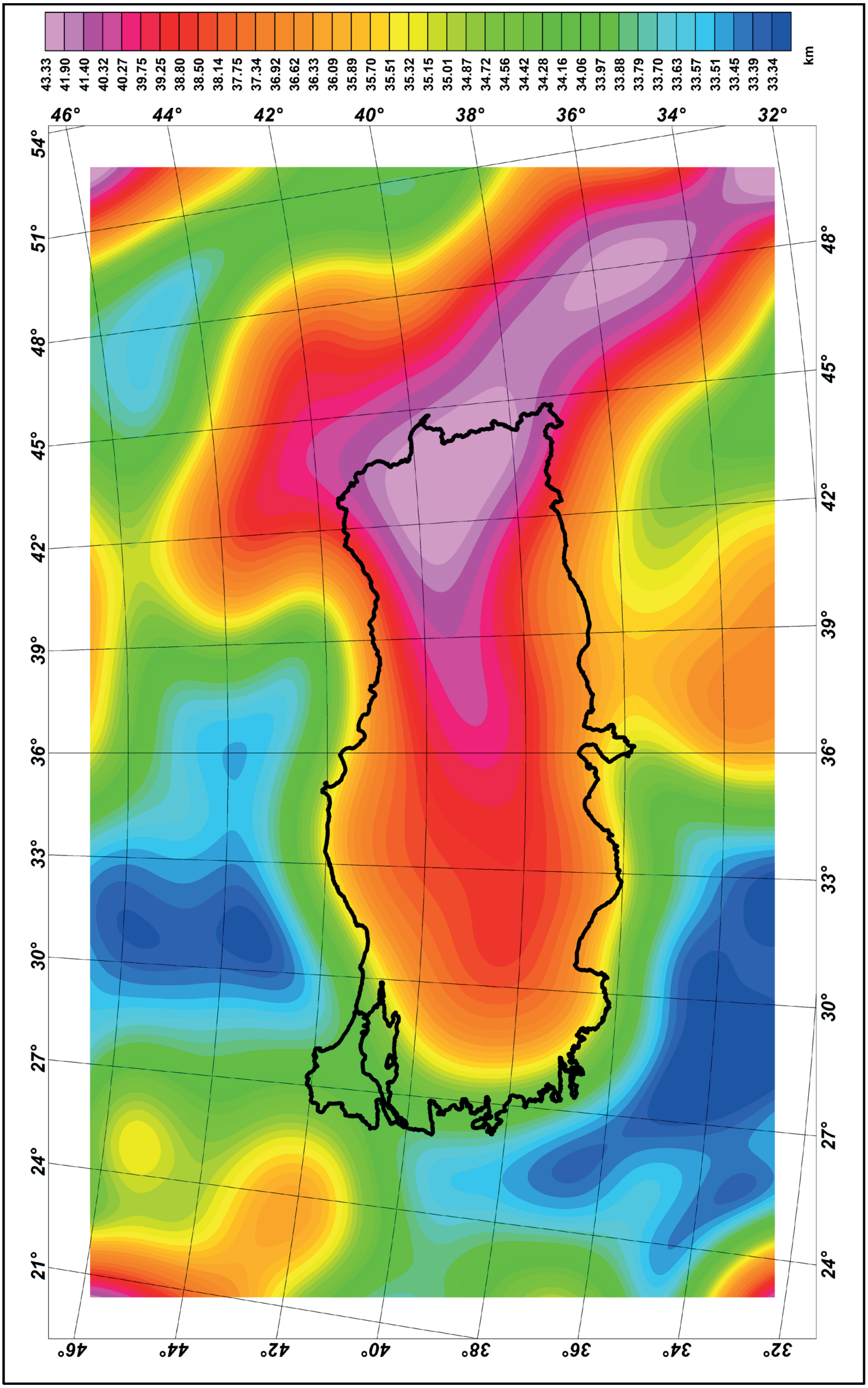

Figure 10- Regional crust thickness map of Turkey for T_e=40 km (Crust40.grd).

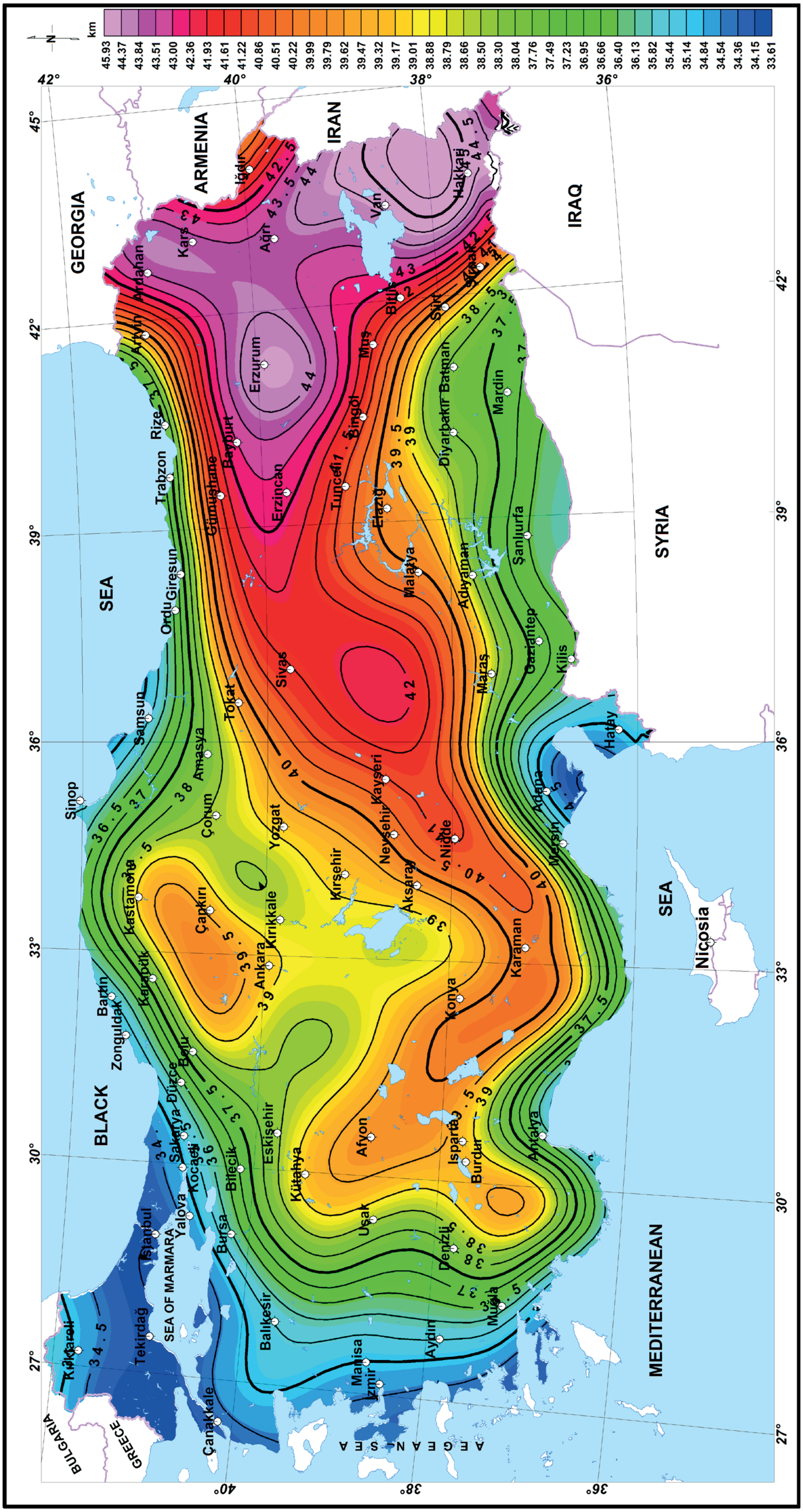

Figure 11- Regional gravity crust thickness map of Turkey (Arslan, 2012*f*).

km. However, the inner parts are relatively thicker. Afyon and its southern part, the northern part of Ankara are the thickest sections of the crust with 39.8 km. The crustal thickness in the eastern Anatolia is around 46 km.

2.7. Density Map

In preparation stages of density maps, 10 km thick horizontal layer represents the upper crust (Singh et al., 1999)

Apparent density;

$\rho(x,y) = \rho_o + (1/2\pi G)\ F^{-1}\{(\omega / 1\text{-}e^{-\omega h})\ .\ \Delta g(u,v)\}$ (Gupta et al.., 1985)

where;

ρ_o: Predicted background density,

G: Gravitational constant,

H: Thickness,

U: Wave number in x direction,

v : Wave number in y direction and

F^{-1}: Inverse Fourier Transformation.

As it will be understood from the equation, the apparent density filter is a linear filter expressed in the wave number state.

The gravity density map (Figure 12) was obtained by gravity isostatic residual anomaly values using licensed Oasis Montaj software. For the gravity density map, isostatic gravity values were gridded to 1500 meters. First; the trend was removed from the grid, then values were produced to spaces from grids. Lastly; the densities were calculated by applying FFT. As seen in figure 12, the densities vary in between 2.29-2.90 gr/cm^3. This map is as same as the isostatic residual anomaly map in appearance (Figure 5), because the isostatic residual anomaly map in a sense originates from densities of the formations in underground. Only the unit of density map is gr/cm^3 and the unit of isostatic residual anomaly map is mgal. Gravity changes are proportional with the densities of geological structures but inversely proportional with depth and masses of disruptive bodies in underground.

3. Discussion and Results

The thickness of the East Anatolian plateau was found as 46 km by seismic method (Zor et al., 2003). The crustal thickness of Turkey was estimated as 33 km in west and as 46 km in east in this study, and surface densities were estimated as 2.29 and 2.90 gr/cm$_3$. Gravity values in the eastern Anatolia are low; however, the crust depth is quite high. High gravity anomalies on shores coincide with areas where the crust thins out. It can also be considered that these anomalies reveal gravity increases of a magmatic lopolith. In some places the increases in gravity can also match with dyke formation. Low density granitic intrusions can be represented by negative anomalies and the Eğrigöz granite is a good example to this phenomenon.

As a result of this study, isostatic residual anomaly values show a distribution compatible with geometries of the main tectonic structures. The North Anatolian Fault Zone (NAFZ), the Menderes Massive and the East Anatolian fault are clearly seen on map. The large negative anomaly seen in the eastern Anatolia in Bouguer anomaly map (Figure 3) has been broken into pieces and its value has dropped from -168 to -41 mgal. The gravity isostatic residual map in basin analysis (Figure 5) should be assessed with geological maps of Turkey, because geological formations are best reflected by the isostatic residual map.

The maps prepared in this study were generated by using the regional gravity database of Turkey. This database was formed starting from 1973 and have been modified according to changing conditions since then. These maps reflect the projection of large scale geological structures on earth surface. The geometries and changes of these structures towards the deeper parts of the earth crust can be modelled by using other data process methods; and if possible, using geophysical data which give information about depth.

Acknowledgements

I would like to thank to all of my friends who have studied in the project of "Regional Gravity Maps of Turkey" with me and the others who are not with us. I am also grateful to referee Assoc. Prof. Dr. Oya Pamukçu and to the other referee whose name is unknown.

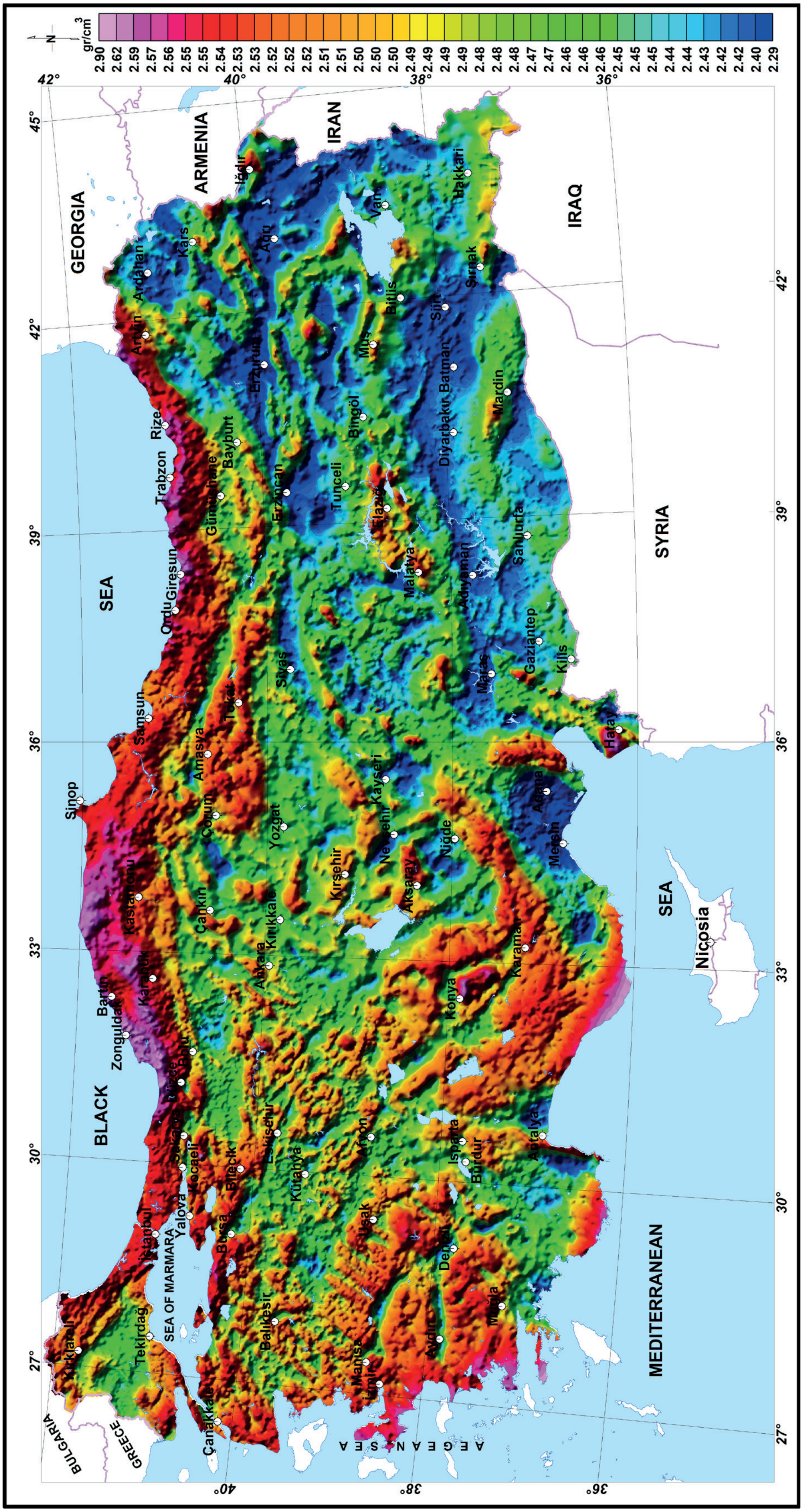

Figure 12- Regional gravity density map of Turkey (Arslan, 2012*g*).

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