Bull. Min. Res. Exp. (2017) 154:215-218

Bulletin of the Mineral Research and Exploration

http://bulletin.mta.gov.tr

Opinions on the article of "Investigation of the Seismic Velocity Distribution and Crustal Structure of Turkey by means of Gravity Data"

THE REACTION OF PHYSICAL TRANSFORMATION OF THE GRAVITY DATA AND LINEARITY DILEMMA

Ertan TOKER[a]*

[a] *General Directorate of Mineral Research and Exploration, Department of Geophysical Researches*

Discussion

Keywords:
Gravity, seismic, Bouguer, velocity, crust

Received: 29.11.2016
Accepted: 25.01.2017

ABSTRACT

This paper consists of opinions on the article entitled as "Investigation of the Seismic Velocity Distribution and Crustal Structure of Turkey by means of Gravity Data" which was published on the page 185 of the 153rd issue of the Bulletin of Mineral Research and Exploration. Within this context, it was aimed at defining some dilemmas encountered in the article, which was targeted in the exploration of the crustal structure in plate scale by means of data sets, and informing the reader. Here, the interactive relationships of Gravity and Seismic methods of which each one are discipline of expertise will be studied within scope of the mentioned article.

1. Introduction

As a result of physical transformation made by using the apparent gravity linear filter and data set of Turkey, the distribution related to the Conrad discontinuity was investigated. During this study, the velocity model based on the seismic data set generated by the gravity data was taken as a basis. In doing so; it was aimed at illuminating the crustal structure of Turkey (Akın, 2016). Therefore; the subject has a great importance.

The velocity distribution obtained is based on an empirical conversion (Barton, 1986). The gravity depth variation has been estimated by a linear filter. Here, the density continuously increases with depth. However; it is not possible in everywhere. Salt fields can be regarded as an example. The variation of the gravity with depth has been obtained by not considering the lower depth of blocky structures, which are located between the upper and lower crusts and dominate the gravitational effect (Simeoni and Brückl, 2009). Conrad is a vertical discontinuity and some difficulties are encountered when monitored by dynamic parameters. The place, where the density and seismic velocity increases are the most, is defined as 16 km's, the upper crust (estimating by using the empirical relationship obtained by Barton (1986) in Northern Sea, so far away from our country). However; the characteristics of seismic wave and the gravity effect do not linearly disperse in crust.

1.1. Linearity Dilemma

The resulting paragraph of the Barton's (1986) article, quoted for each value of the empirical conversion (valid under some circumstances), titled as "The relationship between seismic velocity and density in continental crust – a useful constraint?", which forms the backbone of the article, is as follows;

Conclusion: Calculated gravity profiles for the continental crust show that, due to the range of Densities possible for rocks of each seismic velocity and vice versa, the use of a seismic velocity measurement of a rock as the only indication of its density does not provide a useful constraint when attempting to reproduce observed gravity variations.

It is understood from the paragraph that, the author has answered the question of "usability of the method"

* *Corresponding author: Ertan Toker, ceyhanertan.toker@mta.gov.tr*
http://dx.doi.org/10.19111/bulletinofmre.306006

as given on title of the article and reached the result that "the rock density is not usable as the "single indicator" for seismic velocity conversion".

In this case, to the contrary of the source article, which has been used during the preparation of the article criticized, there has not been used any other indicator. Furthermore; a transformation from gravity data to seismic data has been made with an inverse method.

When theoretical and empirical trials reach the success, industrial sectors would follow and benefit from these methods. This article has handled a subject, which saves time and money, but it is seen that this subject has not been taken seriously in sectorial basis from 1986 to recent.

It is known that the single indicator is not useful except for reconstruction studies by means of seismic and gravity data conversion. However; the studies in which the single indicator is used are mainly based on the correlation of drilling data. The medium velocities of P and S waves are sensitive to temperature and pressure changes. The physical meaning of this statement is as follows; the velocities do not linearly vary with depth. Besides; the elements such as; the compressibility and attenuation losses, which determine the seismic quality of the environment, are the factors affecting the seismic velocity. These factors do not disperse uniformly in underground, and the reason of the anomaly, which we often search for, is the non-availability of this uniform dispersion.

When these indicators are not taken into consideration, the result of data transformation is almost one to one related with primary data. When the output obtained in this article are studied, it is seen that the velocity distribution and Conrad distribution maps, which their scale change and show the same distributions with the Bouguer gravity map, were achieved (see figure 4 and 6 from Akın, 2016).

The whole Turkey has been selected for the study area and Bouguer gravity data set has been used. However; quite large areas are observed, where the data transformation is not valid, within the boundaries of this study area.

Çankırı and Salt lake basins are some of these areas. Large scale salt structures take place on these fields. Salt structures may rise up due to the excess load of the overlying sediments in sedimentary environments. That is; these structures are very low compressible structures, and their volumes and structures can dramatically change under pressure. Although the densities are 2-2.2 gr/cm^3, their seismic velocities are very high (4.5- 5 km/s). That is; the response of these formations to parameter conversion, which is the topic of this article, is false. For example; the Thrace basin is very deep and the block structures, which are mentioned that dominate the upper crust, are in minority. Similarly; sedimentary basins of which have thicknesses that continue for kilometers are present. Physical transformation on these fields is regarded as inconvenient.

It is not mentioned any exception or an exceptional area about data and conversions used in the study. Velocity losses have not been considered. Seismic discontinuities based on the apparent density anomaly are investigated by acquiring apparent velocities using increases of apparent density. If this was a valid approach, it would be possible to estimate layers and discontinuities only by gravity data. It would even be a preferable way in order to get rid of the application cost of seismic methods.

Mathematical and logical acceptations can be done for the resolution of underground structures. These acceptances are sometimes compulsory in order to solve the problem or make it solvable. When Barton (1986) investigated, whether this conversion was useful or not, he made a modelling with a transformation into gravity using an empirical relationship by the seismic method. This can give information about the formation in vertical direction and its layer thickness can be estimated, and an empirical acceptance for a model construction. Seismic velocities are measured in time scale as they do not disperse linearly. Therefore; the nature of the problem is not linear.

In addition; the inverse of it is not valid. That is; the transformation into seismic data to make discontinuity calculation from the gravity method, which its layer thickness cannot be estimated (which does not homogenously disperse in layer), cannot be qualified as a meaningful acceptance.

Simeoni and Brückl (2009) wrote the conditions of velocity-density conversions in their studies. They

stated under what giga pascal (gpa) pressure and what temperature (°C) conditions the conversions had been made and in which velocity interval the relation of conversion had been valid.

Seismic velocities in crust size are measured by traversing the mantle. We may get seismic signals where the crust is thick. Despite that; there are situations when we cannot achieve contrast by effects such high temperature and metamorphism. Similarly; density values are also influenced by the high temperature and metamorphism. The problem is the same. The method followed here does not obscure the problem. However; its effect on the conversion is not known either.

The zone, where the velocity information changes, decreases or increases is normally the anomaly region. The gravity-seismic transformation at these depths will not give a reliable anomaly zone because of temperature and pressure conditions. That is; the differences, which should be solved the first would not affect the estimation and unnoticed, have not been investigated. The Conrad, which is difficult to monitor also by seismic methods in which the vertical variation of seismic waves with respect to time are observed, is a weak discontinuity zone.

2. Technical Dilemmas

Opinions on "acquiring the density from seismic velocities and the seismic velocity from densities", which are applied in the article, are as follows;

The contrast between the lower and upper crusts in line 16 of the page 3 is given as 0,3 gr/cm^3 based on Simeoni and Brückl (2009) on page 186. However; it is mentioned about 300 kg/m^3 contrast between the lower crust and upper mantle. The author, here has misunderstood the contrast between the lower and upper crusts and the contrast between the lower crust and mantle. This is a big difference. Thus; accepting such a big difference forms an equal confusion of accepting that the Conrad discontinuity can be monitored across Turkey. The excessively discontinuous and tectonically active structure of Turkey already makes the monitoring of this zone impossible.

On page 189 of the article, the "apparent" density by means of linear method is calculated by formula (1) as given below, using gravity Bouguer data of which its first term is based on the parameter prediction of (ρ_o), but the conditions of the prediction are not explained;

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

In doing so; the seismic velocity from "density" has been obtained making an empirical and linear relationship using the density values suggested by Barton (1986).

Woollard (1959) clearly stated that there had not always been a linear relationship between seismic velocities and gravity.

Barton (1986), in figure 1 of his article used a method which has not any formula, but was defined by a linear relationship with indefinite coefficient of relationships. He predicates the method on the linear interpretation of laboratory calculations in Nafe and Drake (1970) and the offset of these values. Velocities (5,7 km/s) were taken as the base for massif continental crust in such a way to correspond to 2,8 gr/cm^3. However; this is an acceptance, too. Despite that; the velocity was transformed from apparent density by the transformation, which Barton had used, instead of the conversion from velocities into density in the article mentioned. Here; the method of re-calculation by empirical method had been edited from previously made empirical calculation.

The increasing depth negatively affects the downward analytical continuation signal, but it does not affect the apparent density relationship. If the effect has been removed then it should be explained. The density continues to increase linearly. The relationship works at the center of the earth, too. The prediction of "ρ_o" has been expressed as a background value. In formula (1), the "ρ_o" value is constant and prediction value. The condition of the second term to be zero should be analyzed and with what respect the prediction has been made should be explained. It also has not been explained what had been meant by *"ω"* symbol.

The gravity senses the total effect and is not sensitive to the calculation of layer information in vertical due to the block lower depth, as the "lateral change" is estimated basically in this method. In spite

of this; seismic waves are lithology sensitive and anisotropic. Seismic velocities are valid in the location where the measurement is made. Seismic waves are transmitted on the boundaries of solid particle and have identities both in shear and pressure.

On page 189, in table 1, seismic velocities corresponding to scale increase of the densities have been written, but their identities explaining whether velocities (V_P or V_s) are pressure or shear wave velocities have not been indicated (Akın, 2016). Whereas; the identity affects the result.

On page 198, in figure 8, profile images in different directions and lengths take place (Akın, 2016). The profile passing through Turkey in W-E directions in profile E and the profile, which has approximately half length in NE-SW direction in profile F, have been displayed as in the length. The vertical exaggeration for both profiles are different and therefore; it causes some confusions in interpretations.

Seismic waves are energy extinct and dynamic facts. Seismic waves in the article are directionless, continuous, point based and have no identity. In velocity maps obtained from active-passive source seismology studies, the magnitudes of velocity are the time dependent magnitudes that have pre and post.

The density is under the control of temperature and pressure, and this effect is not linear. It is inconvenient to apply a linear transformation to a fact which depends on non-linear parameters in the mass and in an environment where the mass non-linearly disperses. The first term of the transformation formula is estimated by prediction method. Thus; the scientific quality of the transformation made is in debate.

If calculations made were handled within scope of approach then the valid interval if available should be stated. A certain velocity distribution map is introduced in the article. The obtained model has been formed bearing several negativities in its body.

3. Result

Earth science studies are multi-disciplinary in terms of their effects and results, and are problem focused investigations that should be solved by the combination of information and experiences decomposed from different educations. Only qualitative or only quantitative approaches in the solution of problem negatively affect the productivity. Analytical thinking and creativity make both approaches valuable and necessitate both of them to be handled together, but the transitions between them should be based on scientific facts with no doubts.

Bulletin of Mineral Research and Exploration is a publication which has an access via internet, worldwide and organizational characteristic. It fulfills an important emptiness beyond its great role in the area of earth science in Turkey. Its contribution to scientific studies in our country has reached a significant level. The bulletin has a body recording recent professional developments rather than being a magazine. Therefore; it was needed to express opinions in order to ease the scientific sight about the article discussed above.

The author thanks to the editorial board for providing to express his opinions.

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