Moho Depth Estimation Using Gravitational Gradient Tensor (GGT) and 3D Euler Deconvolution Algorithm

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Abstract: Investigating features of the continental crust and the upper mantle is an important goal in geophysical studies. In many cases, the Earth's crust is divided into two or three horizontal homogeneous layers but it is aimed to have a more detailed and meticulous view about crustal structure and its complexities, especially depth of the Moho discontinuity and its lateral variations. The Moho discontinuity is the surface separating the Earth's crust from the mantle. Moho depth is an important parameter in identification of crustal structure and it is also related to geological and tectonic evolution of each region. In this research, the complete gravitational gradient tensor (GGT) has been used in Euler Deconvolution algorithm for estimating the Moho depth in the structural zones of Iran. The Euler Deconvolution algorithm, which is based on using field derivatives in Euler's homogeneous equation, is an automatic method to estimate depth, shape and position of magnetic and gravity sources. This algorithm is not dependent on an initial depth and density limitations (Reid et al., 1990; Mushayandebvu et al., 2001). According to Keating (1998) and Silva & Barbosa (2003), it is particularly good to determine depth of vertical and horizontal contacts so it can be used in estimating the mantle-crust boundary (Moho depth). This algorithm includes the following three equations in which the components of GGT are used (Zhang et al. 2000).

$$(x-x_0)T_{xx}+(y-y_0)T_{xy}+(z-z_0)T_{xz}=N(B_x-T_x) \qquad Eq.\ 1$$

$$(x-x_0)T_{yx}+(y-y_0)T_{yy}+(z-z_0)T_{yz}=N(B_y-T_y) \qquad Eq.\ 2$$

$$(x-x_0)T_{zx}+(y-y_0)T_{zy}+(z-z_0)T_{zz}=N(B_z-T_z) \qquad Eq.\ 3$$

In above equations T_x, T_y and T_z are the first-order derivatives of the field at the observation point (x, y, z); T_{xx}, T_{yy}, T_{zz}, T_{xy}, T_{yx}, T_{xz}, T_{zx}, T_{yz} and T_{zy} are the components of the gravitational gradient tensor (second-order derivatives of the field) at the observation point (x, y, z); x_0, y_0 and z_0 are the unknown coordinates of the source; B_x, B_y and B_z are the regional values of the field along the x-, y-, and z-directions; and N is the structural index (SI). SI is the rate at which the

field intensity falls off with distance from the source and it depends on the type of source body which you are looking for and the type of the potential field data (magnetic or gravity); for gravity data, this factor can range from 0 to 2. To estimate Moho depth using the Euler Deconvolution algorithm it is assumed that crust-mantle boundary is a horizontal sheet or it has sill-type anomaly, which can be expressed in an infinite 2D space; the best structural index to estimate this anomaly is 0.5 (Mushayandebvu et al., 2001). An important parameter in this algorithm is window size which influences the depth of anomaly (z_0) in each solution. The window size should be small enough in order to prevent effects from multiple sources; it also should be large enough to include substantial variations of the field (Barbosa et al., 1999). The unknown parameters (x_0, y_0, z_0, B_x, B_y, B_z) are solved by least squares estimation in each window. The GGT components can be expressed in terms of spherical harmonic expansion coefficients. In this research, the first-order and second-order derivatives of the disturbing potential (T) in the geocentric Earth-fixed reference frame have been calculated using the formulas presented by Petrovskaya & Vershkov (2010) and the EGM2008 geopotential model to degree and order 360. In Figure (1), the Moho depth in structural zones of Iran, estimated by applying the GGT components in Euler Decovolution algorithm, is shown. The results indicate that the Moho depth is about 49 km beneath the main Zagros thrust, 45-48 km in the Sanandaj-Sirjan zone, 40-42 km in the Kopeh Dagh zone, less than 43 km in the Lut block, about 40 km beneath the Alborz mountains, and 30-36 km in the Makran zone.

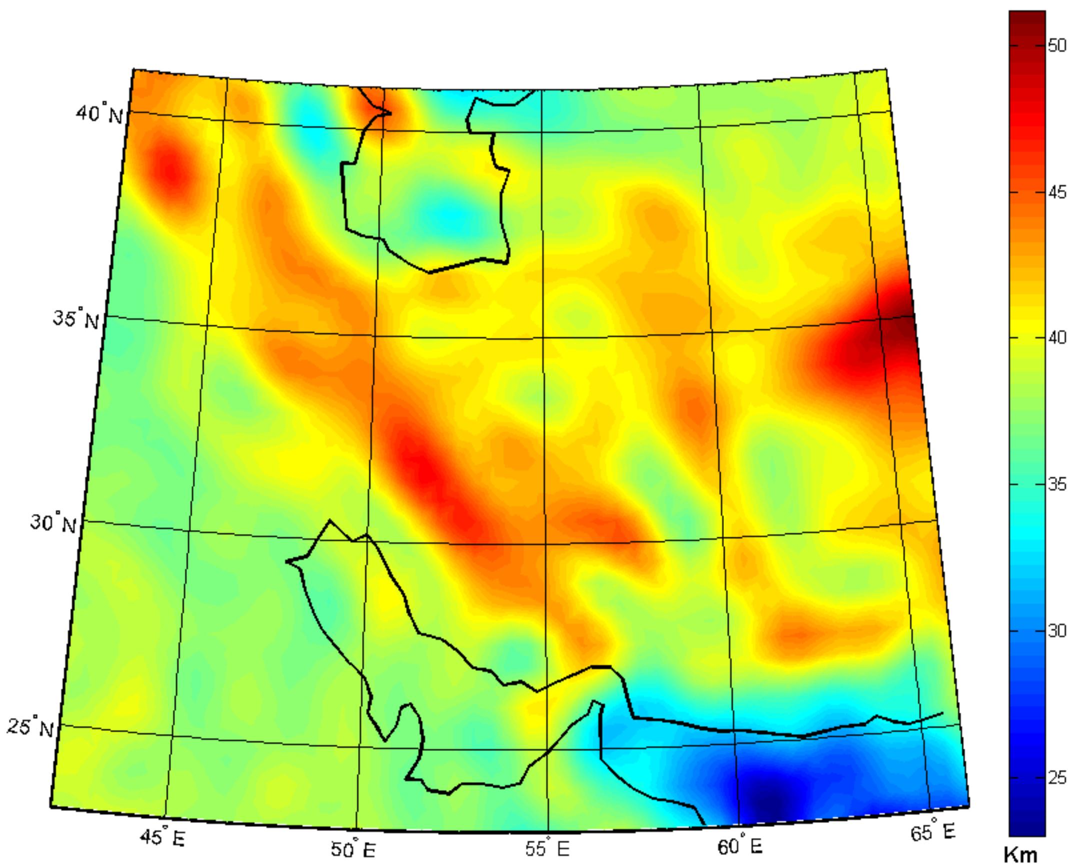

Figure 1. The estimated Moho depth

Keywords: Moho depth, Euler Deconvolution, Gravitational gradient tensor, Spherical harmonic expansion, Structural zones of Iran

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