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3-D gravity terrain inversion for high resolution gravity data analysis

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Abstract: In gravity data correction process, mass effect of the upper part of base level is removed with Bouguer density. Usually, Bouguer density is estimated as a mean density in the field area. But, this may causes a serious problem when ore body is in the area. To overcome this problem, we tried to apply a new method mixing up mass corrections and inversion (3DGTI). 3-D Gravity Terrain Inversion (3DGTI) includes information of topography and distribution of Bouguer density. For this method does not remove the mass effect above base level, it is no longer useless to use Bouguer density. Numerical model tests have shown that the 3DGIT successfully retrieves the anomalous subsurface density distribution of both surface and deeper layers. Model tests shows that this method shows better results than those of conventional one, especially when main target is ore body. The inversion result well delineates the three-dimensional shape of the intruded granite body and basement.

1. Introduction

Gravity surveys gets easier and more accurate by using GPS (Global Positioning System). So Free-air anomaly gives very reliable result. But, mass effect corrections such as Bouguer and terrain corrections still has intrinsic error due to incorrect density on those corrections. The choice of density for Bouguer and terrain corrections is often a troublesome problem. We have devised a new inversion scheme which does not require any preliminary information on surface density for Bouguer and terrain corrections. Since this inversion scheme allows the inhomogeneity of the surface layer. So, the concept of Bouguer density is no longer useless in this method. We tested this method on some models to show the differences between this new method and conventional one.

2. New gravity data processing method

Gravity surveys gets easier and more accurate by using GPS (Global Positioning System). So Free-air anomaly gives very reliable result. But, mass effect corrections such as Bouguer and terrain corrections still has intrinsic error due to incorrect density on those corrections. The choice of density for Bouguer and terrain corrections is often a troublesome problem. We have devised a new inversion scheme which does not require any preliminary information on surface density for Bouguer and terrain corrections. Since this inversion scheme allows the inhomogeneity of the surface layer. So, the concept of Bouguer density is no longer useless in this method. We tested this method on some models to show the differences between this new method and conventional one.

Data processing and inversion scheme

Fig. 1 shows the processing and inversion sequences of the 3DGIT algorithm. This scheme follows the conventional reduction procedure of field data till free-air correction. But, in the next step Bouguer and terrain corrections are excluded and the subsurface formation is divided into a series of three-dimensional rectangular blocks, which includes the surface topography of survey area. However, the terrain effect of outside of the study area is corrected by using the conventional method (Fig. 2). Finally, by iterative calculation of gravity effect of each blocks and inversion to densities, the three-dimensional density structure, which exhibits both surface topography and subsurface geology, is obtained(Fig.3).

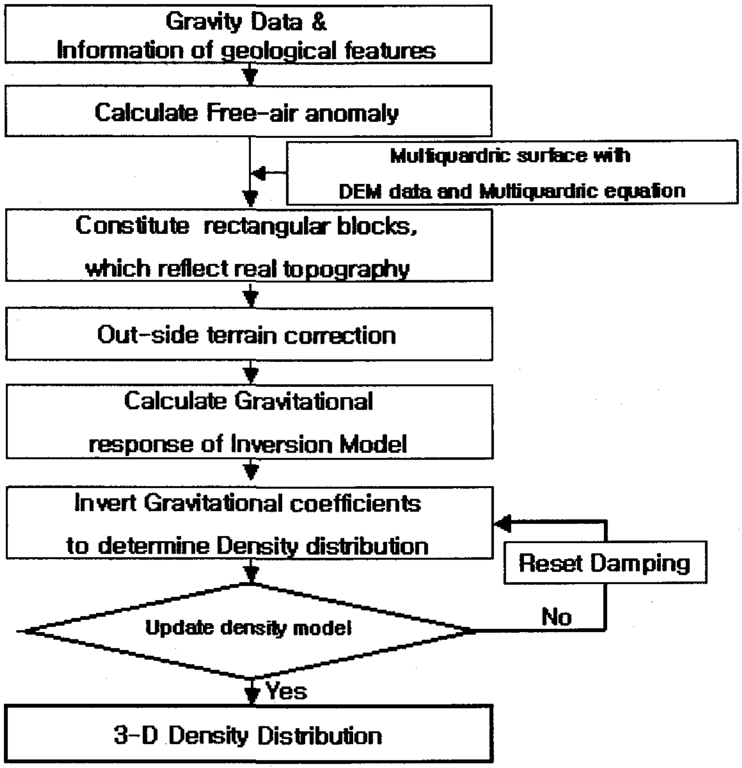


Fig. 1. Three-dimensional gravity inversion algorithm.

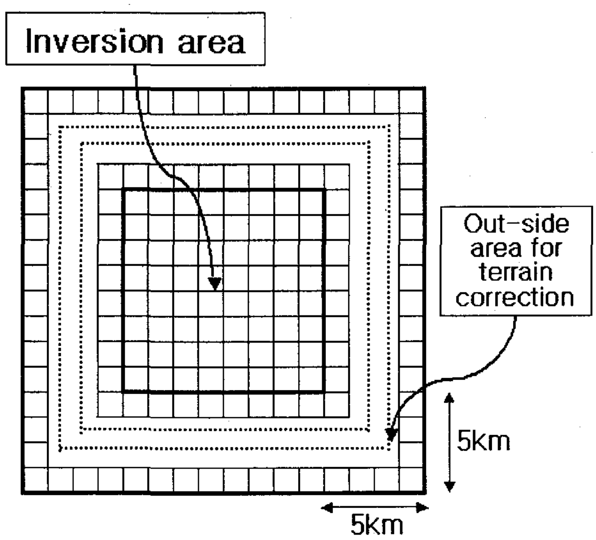


Fig. 2. Division of areas for 3-D inversion and for conventional terrain correction.

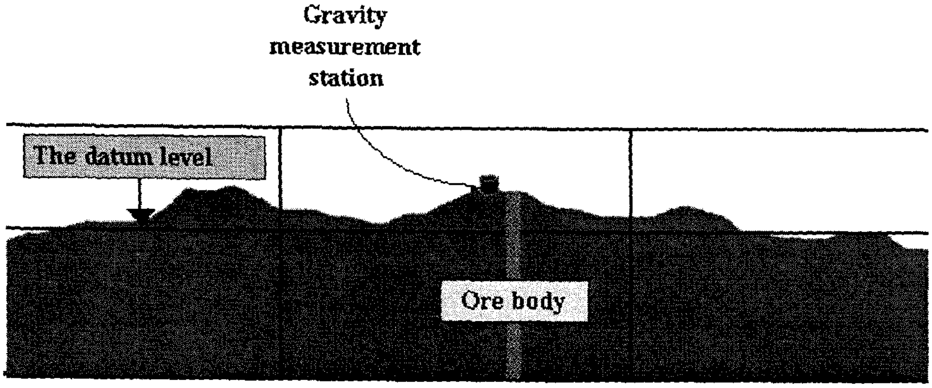


Fig. 3. Cartoon for the case of inhomogeneous and rugged terrain.

Numerical model test

To test the efficacy of 3DGIT scheme, we have synthesized a topographic model involving two intrusive ore bodies having density contrast of $0.5g/cm^3$. One ore body is located under the summit of the mountain and the other is under the slope, and both bodies extend from the surface to one kilometer below the datum level. The gravity observation is made on the ground surface, and measurement points are arranged at 1*km* spacing along the x and y directions (Fig. 4).

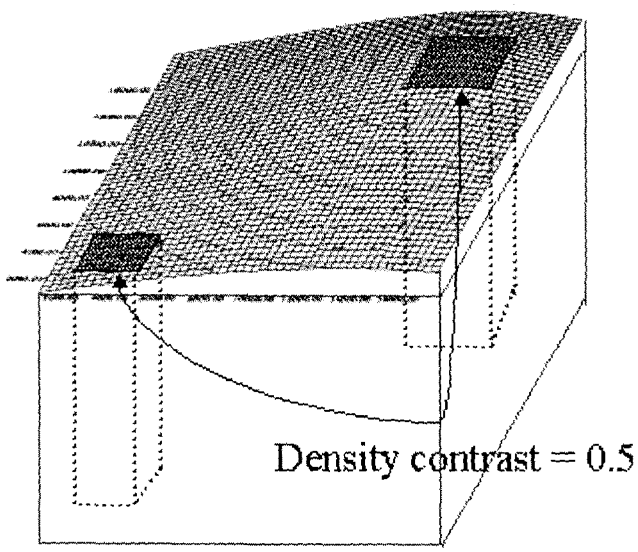
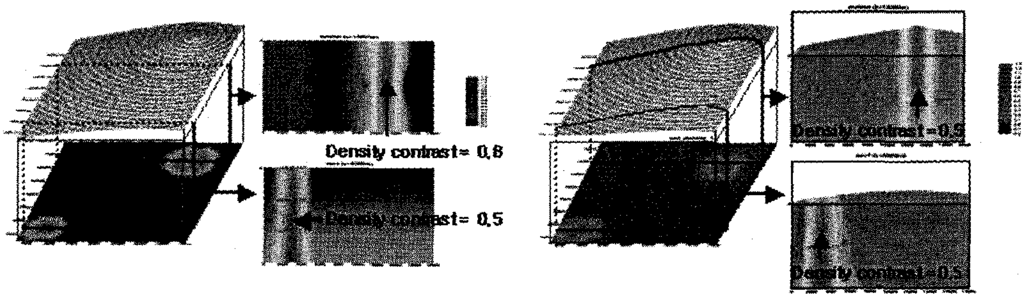


Fig. 4. Topography and density anomaly of the model.

Fig. 5 shows two inversion results; (a) is obtained from the Bouguer anomaly derived by conventional process and (b) is from the 3DGIT scheme. Because the conventional method removes the terrain above the datum level, the inversion of the Bouguer anomaly results in over-estimated density values of ore bodies. The effect of overestimation is more apparent for the ore body under the summit of mountain where a large amount of the ore mate rial is removed by Bouguer and terrain corrections with erroneous density.

But, the inversion result from the 3DGIT shows very clean image of ore bodies both of body shapes and densities of anomalous ore bodies.



(a) (b)

Fig. 5. Comparison of gravity inversion results of the model.
(a) Inversion of the conventional Bouguer anomaly
(b) Inversion by 3DGIT

3. Results

We have proposed a new gravity data processing and inversion scheme. This 3DGIT algorithm merges the conventional Bouguer and terrain corrections in the three-dimensional inversion process by allocating uppermost blocks to contain surface topography. The results of model test and inversion of field data prove the efficiency of the 3DGIT scheme for the cases that the surface topography is associated with anomalous lithologic bodies.

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