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3D gravity imaging based on the inversion of pseudomagnetic amplitude data

Li, Z.[1], Yao, C.[1], Zheng, Y.[1], and Yuan, X.[1]

[1]China University of Geosciences, School of Geophysics and Information Technology, Beijing, China (zelin.lee@foxmail.com)

3D gravity inversion for density distributions is a powerful tool in quantitative interpretation of gravity data and has been successfully applied to exploration of mineral and oil gas resources and to interpretation of regional geologic structures. The traditional inversion method [1] need to impose a positive (or negative) constraint on the density model to produce geologically realistic results. This means the traditional method is only applicable to positive (or negative) anomalies. However, both positive and negative gravity anomalies always exist simultaneously. In this case, the traditional inversion method become ineffective.

To overcome this difficulty, we develop a method based on the inversion of pseudomagnetic amplitude data. In the proposed method, we first transform the original gravity data to the pseudomagnetic amplitude data using a regularized equivalent source method [2] that reduces the effects of noise on the transformation. Since the amplitude data are nonnegative, we then perform an amplitude inversion [3] incorporating a positive constraint to estimate an amplitude model, the amplitude of the subsurface density model. Once the amplitude model is obtained, we just need to determine a sign model, the sign of each element of the density model. A binary inversion where the element of the sign model is either one or minus one is a natural choice. However, such an inversion is non-convex and thus hard to solve. Alternatively, we carry out a generalized inversion using the total variation (TV) regularization and imposing a bound constraint where the lower and upper bounds are minus one and one on the sign model to obtain an approximate sign model. The final density model is calculated by multiplying the amplitude model by the approximate sign model.

We use a model consisting of two dipping dikes to test our inversion algorithm. The density contrast of the dike in the west is -1g/cm^3 and the one in the east is 1g/cm^3. The gravity data are shown in Figure 1a and the corresponding pseudomagnetic amplitude data are shown in Figure 1b. We invert the gravity data using the traditional method and the proposed method, respectively.

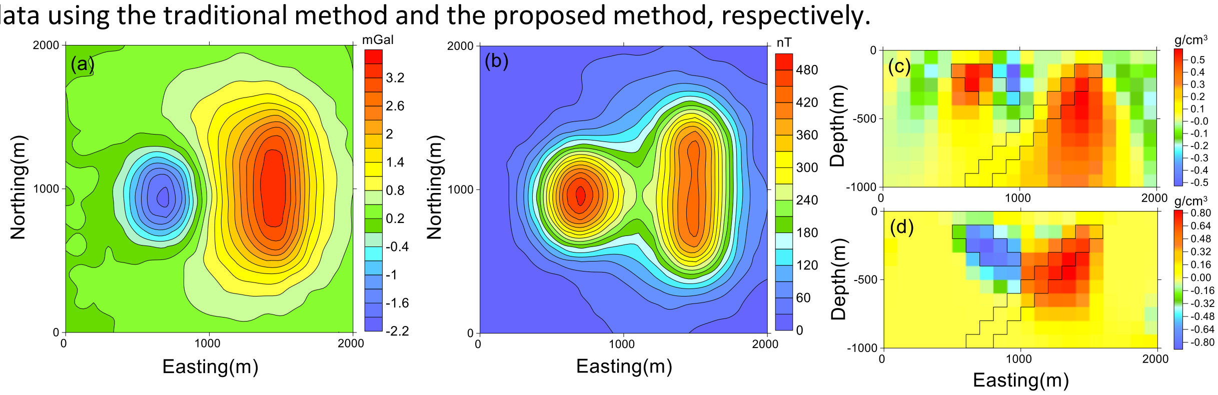

Figure 1: The anomaly data of the model and the inversion results. (a) The gravity data. (b) The corresponding pseudomagnetic amplitude data. (c) The traditional inversion results, slice at 1000m north. (d) The inversion results of the proposed method, slice at 1000m north.

The two slices of inversion results are shown in Figure 1c and 1d. The results of the proposed method clearly define the two dikes while the traditional inversion produces poor results.

References:

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[2] Li Y and Oldenburg D W (1998) Geophysics 75(3): L51-L59

[3] Li Y et al. (2010) Geophysics 75(1): L1-L11