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Field source characteristic of gravity variation in Hexi region before Menyuan Ms6.4 earthquake based on the Euler deconvolution

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ABSTRACT

This study adopted the Euler deconvolution method to conduct an inversion and interpretation of the depth and spatial distribution pattern of field source that lead to gravity variation. For this purpose, mobile gravity data from four periods in the Hexi region between 2011 and 2015 were obtained from an observation network. With a newly established theoretical model, we acquired the optimum inversion parameters and conducted calculation and analysis with the actual data. The results indicate that one is the appropriate value of the structure index for the inversion of the mobile gravity data. The inversion results of the actual data showed a comparable spatial distribution of the field source and a consistent structural trend with observations from the Qilian-Haiyuan Fault zone between 2011 and 2015. The distribution was in a blocking state at the epicenter of the Menyuan earthquake in 2016. Our quantitative study of the field source provides new insights into the inversion and interpretation of signals of mobile gravity variation.

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1. Introduction

An Ms6.4 magnitude earthquake with a focal depth of 10 km hit Menyuan, Haibei Prefecture, Qinghai Province (37.68°N, 101.62°E) at 1:13 am on January 21, 2016 (Local time). The epicenter was located at the intersection of the northwest-trending Lenglongling Fault and Tuolaishan Fault, lying into the Qilianshan seismic belt at the northeast margin of the

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Qinghai-Tibet Plateau. The Second Monitoring and Application Center, China Earthquake Administration built a relative gravity monitoring network in this area in the 1980s. Fig. 1 is the tectonic map of the survey area in Hexi region. Through periodical repeated observations of the mobile gravity, it is possible to capture the gravitational precursory information related to focus variation [1–3]. Based on the mobile gravity observations, Zhu Yiqing [4–7] reached a certain accuracy in medium-term forecasts. This applies to the Wenchuan *Ms*8.0 earthquake in Sichuan Province, in 2008; the Yutian *Ms*7.3 earthquake in Xinjiang Province, in 2008; the Lushan *Ms*7.0 earthquake in Sichuan Province, in 2013; and the Ludian *Ms*6.5 earthquake in Yunnan Province, in 2014. Inversion is an important part of the research and so is the interpretation of the field source characteristics causing gravitational field variation. Further quantitative interpretation is required for the field source characteristics after acquiring the field variation information.

The present article reports parameter characteristics of the field source of gravitational field variation before the Menyuan earthquake, using the 3D Euler deconvolution method [8,9], which is well-developed in exploration geophysics. This method is appropriate for determining the field source location and geometric parameters automatically or semi-automatically, when little prior information is known. It helps minimizing errors caused by human deduction during interpretation, locating the range of anomalous sources effectively, and deducting the specific locations of anomalous bodies. Finally, this method allows conducting inversion and interpretation of gravitational field variation signals.

2. Material and methods

The Euler deconvolution method helps locating the structural range and interpreting anomalous sources when little prior information is available. It was originally proposed by Reid [8] and established on the homogeneous Euler equation (equation (1)). Solving this equation allows to determine the 3D spatial position of the field source location. The equation provides parameter estimation for different kinds of geologic bodies.

$$(x - x_0)\frac{\partial T}{\partial x} + (y - y_0)\frac{\partial T}{\partial y} + (z - z_0)\frac{\partial T}{\partial z} = N(B - T) \quad (1)$$

where (x, y, z) represent the coordinates describing the location of the observation point, (x_0, y_0, z_0) indicate the location of the field source, $\frac{\partial T}{\partial x}$, $\frac{\partial T}{\partial y}$ and $\frac{\partial T}{\partial z}$ are the derivatives of the potential field anomaly T in directions x, y and z, B represents the ambient field, N is the structure index, representing the attenuation rate of the intensity of the potential field anomaly's as depth changes. N is correlated with the geometric structure of the field source. Numerous studies were previously conducted on the selection of the structure index. Generally, N ranges between 0 and 2, depending on the gravity anomaly associated with different structural characteristics.

During the inversion process using the 3D Euler deconvolution method, the discrete data is gridded, then we calculate the gradients of the potential field anomaly on directions x, y and z, and choose an appropriate structure index N. The inversion was conducted by sliding a window of a certain size corresponding to the mesh of the observation data. A set of linear equations can be formed by substituting the value of each observation point from the window. The appropriate window size which can solve equation (1) shall be greater than or equal to 3×3. A parameter of the field source location can be obtained each time the window is moved, in order to adjust the inversion parameters until optimal values are found, based on the convergence location of these solutions.

An appropriate window size covers the anomaly range and the anomaly range of a field source must be covered under optimal conditions. In practice, the mesh size and the scale and shape of the anomaly should be calculated or estimated for repeated adjustment until optimal inversion results are obtained.

3. Model inversion

The Euler deconvolution method has been widely applied in exploration geophysics as it can invert and interpret field source parameters without acquiring any prior information of the field source. The physical property parameters of field sources are simplified at both ends of the homogeneous Euler equation, which provides the correlation between the potential field anomaly, gradient and field source location. Thus, the

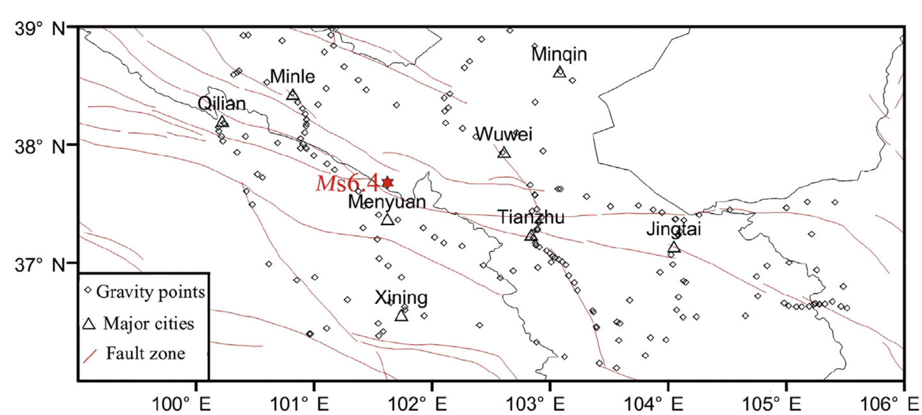

Fig. 1 – Tectonic map of the survey area in Hexi region.