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Influence of fault asymmetric dislocation on the gravity changes

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Abstract: A fault is a planar fracture or discontinuity in a volume of rock, across which there has been significant displacement along the fractures as a result of earth movement. Large faults within the Earth's crust result from the action of plate tectonic forces, with the largest forming the boundaries between the plates, energy release associated with rapid movement on active faults is the cause of most earthquakes. The relationship between unevenness dislocation and gravity changes was studied on the theoretical thought of differential fault. Simulated observation values were adopted to deduce the gravity changes with the model of asymmetric fault and the model of Okada, respectively. The characteristic of unevenness fault momentum distribution is from two end points to middle by 0 according to a certain continuous functional increase. However, the fault momentum distribution in the fault length range is a constant when the Okada model is adopted. Numerical simulation experiments for the activities of the strike-slip fault, dip-slip fault and extension fault were carried out, respectively, to find that both the gravity contours and the gravity variation values are consistent when either of the two models is adopted. The apparent difference lies in that the values at the end points are 17.97% for the strike-slip fault, 25.58% for the dip-slip fault, and 24.73% for the extension fault.

Key words: fault; asymmetric; gravity changes; numerical simulation

1 Introduction

One of the greatest discovery of seismology in 20th century is that the earthquake happened in the fault[1]. Steketee[2] is the earliest one to introduce the dislocation theory into the geodetic deformation field. He supposed there was a dislocation discontinuity (fault) in the evenly Earth medium, and deduced Green's function of strike-slip faults' displacement. Iwasaki and Sato[3] studied strain field in a semi-infinite medium due to an inclined rectangular fault. Okubo[4] did a research of potential and gravity changes raised by point dislocation. Okada and Ben-Menahem A[5,6] supposed that the Earth model was a homogeneous elastic half-space sphere, and deduced the analytic formulas between the displacement field and strain field in Earth's interior caused by point dislocation and rectangular dislocation under the situation of strike-slip, dip-slip, tensile and expansion. These formulas are the classic expression of the theory about the semi-infinite space Earth model. Considering earth viscosity is another progress to perfect the dislocation theory. Sato[7] studied the viscoelastic deformation of the rectangular thrust fault in layered Earth. Pollitz[8] solved the viscoelastic weightless Earth model's problems between displacement and strain fields caused by the dislocation in epicenter area. Considering the curvature and layered structure of the Earth, Sun and Okubo[9,10], with the help of the more realistic Earth model and the SNREI

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Earth model, evolved the new the potential and gravity change's dislocation theory. There are many successful research results of the dislocation theory model all over the world. Heki et al[11] found that the coseismal deformation conformed to the GPS observations. By calculating the deformation of the seismic fault sliding of Umatra-Andauan, Banerjee[12] achieved that the largest sliding displacement was 15 meter.

Usually, it is reasonable to explain the fault movement by the rectangular dislocation model. However, there are varieties of faults in reality and there are fixed endpoints in all faults. The unevenness of faults is more prevalent. Surface gravity and deformation effects caused by all kinds of fault movement have attracted a great attention in the past few years. Sun[13] calculated the terrestrial gravity field changes by the asymptotic distribution model, which are caused by the coseismic dislocation deformation. Fu and Sun[14] studied the coseismic dislocation deformation on the basis of the spatial distribution inhomogeneity, but he did not suggest any models. Zhang et al[15] established a distribution function model along the strike-slip direction and the direction of dip-slip sliding displacement according to the dislocation single pileup group and the double pileup group theory, and studied the displacement caused by the uneven model.

In the present work, gravity changes on the earth surface caused by uneven fault dislocation were studied. The variations caused by the Okada model and the uneven model, respectively, were compared. A theory of differential fault was applied to calculate the gravity changes by the uneven fault.

2 Fault uneven distribution function

Suppose a plane consists of x and y. X-axis is parallel to the fault trend and y-axis perpendicular to it as shown in figure 1. Z-axis is perpendicular down to the plane. The fault length is $2L$, the width is W, the bottom depth is d, and the angle of dip is δ. The pileup group is calculated between A and B. The group is adjusted to stress equilibrium by discrete dislocation, at which an equation can be written as

$$\frac{\mu b^2}{2\pi(1-\nu)}\sum_{j=i}\frac{1}{x_{(j)}-x_{(i)}}+\tau b=0 \tag{1}$$

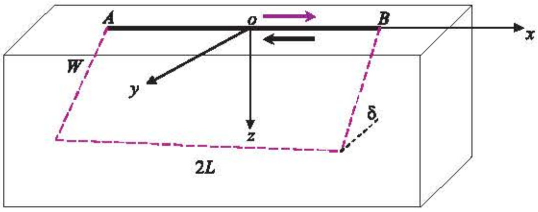

Figure 1 Rectangle dislocation model

To a continuous distributed dislocation group, a density function of continuous dislocation distribution is introduced as

$$D(x)=\frac{1}{b}\frac{\mathrm{d}b}{\mathrm{d}x_1} \tag{2}$$

In the equations (1) and (2), b is Burgers vector, μ and ν are Lame constants of medium, and τ is the average shear stress in the medium. Thus, the continuous pileup group equilibrium equation can be achieved as

$$\tau b=\frac{\mu b^2}{2\pi(1-\nu)}\int_{-L}^{L}\frac{D(x')\mathrm{d}x'}{x'-x} \tag{3}$$

Since x is contained in the interval $[-L,L]$, formula (3) is Cauchy singular integral equation. In order to solve the equation, Hilbert transform is used. A function $f(y)$'s Hilbert transform is defined as

$$H_x[f(y)]=\frac{1}{\pi}\int_{-1}^{1}\frac{f(y)\mathrm{d}y}{y-x} \tag{4}$$

The function of y can be changed into the function of x. Chebyshev polynomial's Hilbert transform can be realized by the first class and the second class of (5).

$$\begin{cases}T_n(\cos\theta)=\cos n\theta\\ U_n(\cos\theta)=\sin(n+1)\theta/\sin\theta\end{cases} \tag{5}$$

The varied result is written as (6):

$$H_x\left[\frac{T_n(y)}{(1-y^2)^{\frac{1}{2}}}\right]=U_{n-1}(x) \tag{6}$$

A variable η as shown in (7) is introduced into formula (3).