Blind fault Configuration in Osaka, Japan based on 2D gravity inversion

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SUMMARY:
The N-S trending 42-km-long Uemachi fault is distributed in the central part of the Osaka City. The detailed basement configurations across the Uemachi fault were estimated by a simulated annealing (SA) inversion of 2D gravity data. The boundary between sediments and basement were modeled by a polygon. The locations of vertexes of the polygon near fault were estimated to fit observed gravity data by the SA inversion. The configurations of the Uemachi fault were evaluated by the several E-W 2D profiles. The fault displacement of the northern part of the Uemachi fault estimated by this study was larger than that of the southern part. The method indicated in this paper has the possibility to estimate the faults geometry. The calculation cost was low, compared with 3D inversion.

Keywords: Osaka Basin, blind fault, simulated annealing and gravity analysis

1. INTRODUCTION

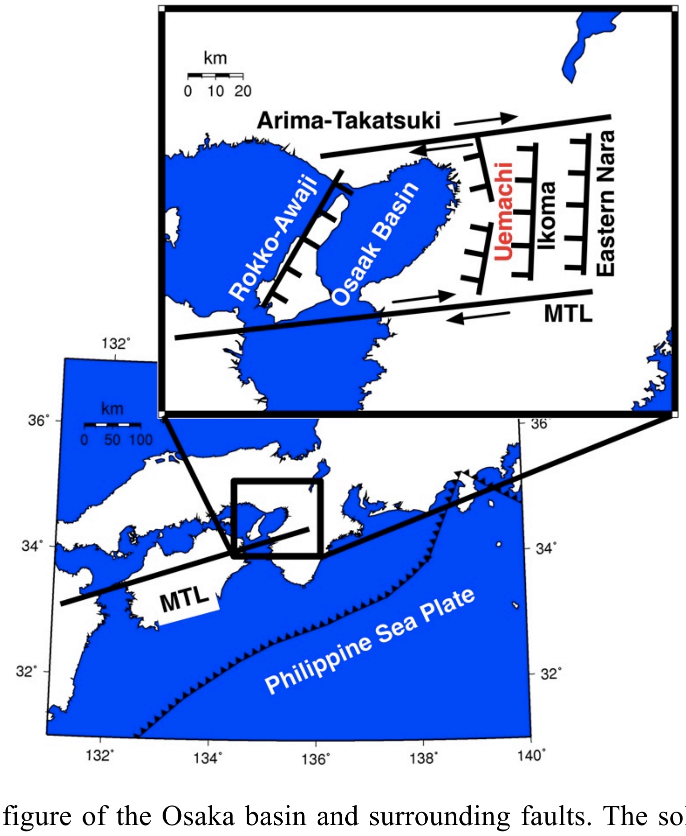

Figure 1. Schematic figure of the Osaka basin and surrounding faults. The solid line with the arrow indicates the strike-slip fault. The solid line with the hachure denotes the reverse fault.

The Uemachi fault runs with N-S direction in the central part of the Osaka City. The Osaka City is located in the Osaka basin, which was surrounded by active faults. There are revers faults on the western and eastern boundary of the basin. The extension of the strike-slip faults was limited by the northern and southern boundary (Fig. 1). The various geophysical surveys revealed the basement configuration. The eastern part of the Uemachi fault is hanging wall. However, there is less basement displacement in the central part. Kusumoto et al (2001) suggested that surrounding faults movement causes the Uemachi fault including central no displacement.

The Uemachi source fault for the estimation of the strong ground motion simulation was defined from the northern boundary to the southern boundary and defined as reverse fault. The Uemachi source fault is divided into two parts, the northern and southern parts. The underground construction, such as lifeline and so on, is developed in the Osaka City. High accuracy deformation investigation is needed at a depth for planning and disaster presentation. Basement configuration is the one of important information. We conducted 2D gravity analysis for investigating the displacement of the Uemachi fault.

2. DATA AND METHOD

Gravity surveys in the Osaka Basin have been conducted by various organizations. Nakagawa et al. (1991) summarized these gravity data and estimated the basement configuration in the Osaka Plain. After the Kobe earthquake, gravity measurements in Kobe, Osaka Bay, were carried out and the gravity data in the Osaka Basin was updated. We used the gravity data compiled by Inoue et al (2000), which was added data in the Kobe and Osaka Bay (Komazawa et al, 1995). The Bouguer correction density was 2.67 g/cm^3.

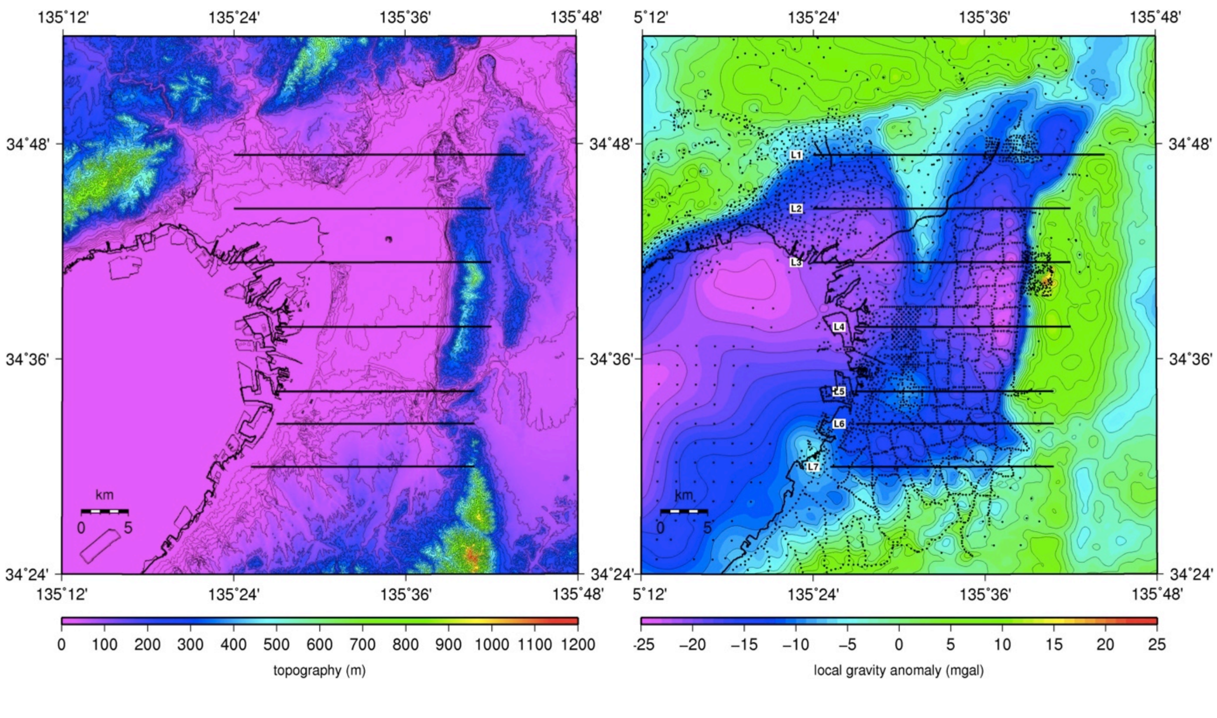

Figure 2. Topography (left) and gravity anomaly (right) of the Osaka basin. Left: Contour map of the topography based on 50m digital elevation model published from the Geographical Society of Japan. The contour interval is 5m below 40m and is 50m above 40m. Right: Local gravity anomaly map (Inoue et al., 2000). The contour interval is 2 mgal. The solid circles in the figure show the gravity station. The thick solid lines denote the investigated profiles in this study.

To estimate the basement configuration, we applied 2D polygon modeling (Talwani et al., 1959). The Simulated Annealing inversion (SA) algorithm was used for the analysis. The SA inversion requires evaluating function. Furthermore, enough iteration is needed to obtain stable and high accuracy results. This method is not suitable for problem, which has abundant parameters to invert because of high calculation costs. The 7 E-W profiles were selected for the inversion (Fig. 2). These profiles crossed the Uemachi fault and Ikoma fault. We used the local gravity anomaly derived by Inoue et al. (2000) shown in Fig. 2. The local gravity anomaly, which showed linear relationship to the depth of the basement, was estimated by regression for the Bouguer anomaly. Density contrasts between the basement and sediments were estimated by the gravity data analysis with the results of seismic surveys. Inoue et al (2007) applied the SA inversion to 2 layered model, whose basement was constructed based on the results of the seismic surveys, and estimated the density contrasts.

We applied 0.35 g/cm^3 in the north and south part and 0.5 g/cm^3 in the central part. We used the square-root of sum of squares of the difference between observed and calculated gravity anomaly and the gradient of the gravity anomaly. In the SA inversion, we carried out 5 inversions. The results were derived average of all inversion models.

3. RESULTS AND CONCLUDING REMARKS

Figs.3, 4 and 5 are the result of L3, L4 and L5 profiles in Fig.2, respectively. The Ikoma fault was expressed as steep fault. On the contrary, the Uemachi fault seems as the normal faults. The fault displacement of the northern part of the Uemachi fault estimated by this study was larger than that of the southern part. In the presentation, we discuss the displacement of the Uemachi fault based on the all results of the profiles.

We estimated the 2D basement configurations crossing the Uemachi and Ikoma faults, which were considered as active faults and source faults for Osaka urban region, by the global optimization inversion method, the simulated annealing. This method was enables the estimation of the faults geometry in detail and calculation cost was low, compared with 3D inversion.

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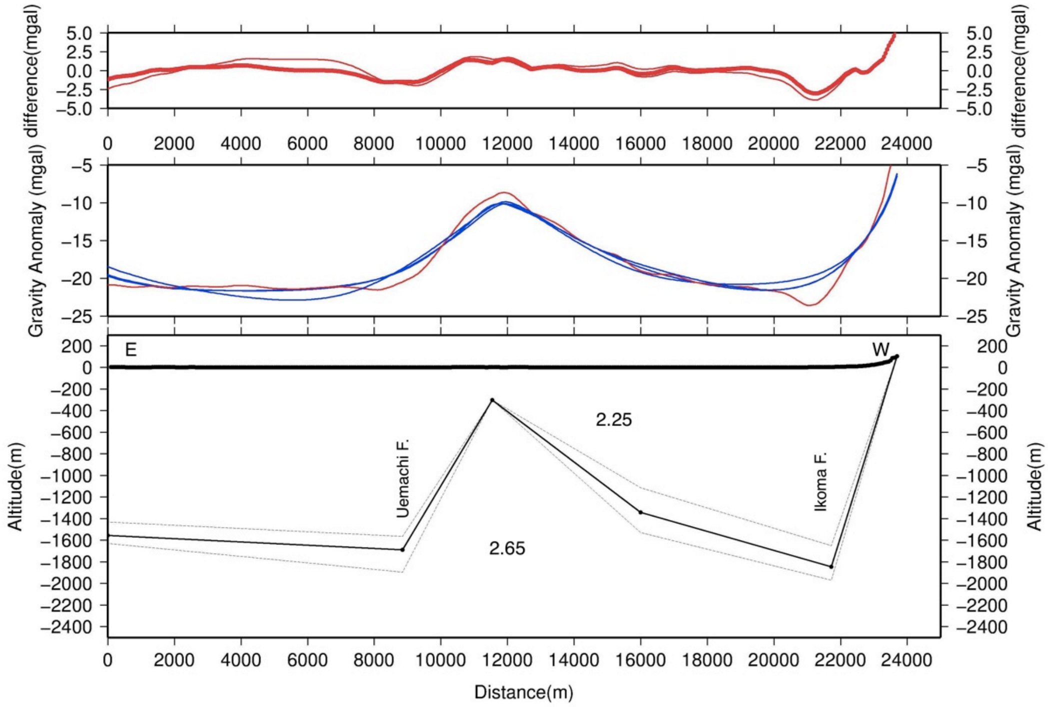

Figure 3. Profile of the L3 in Fig. 2. Top: difference between observed and calculated gravity anomaly form the model. Middle: Observed (red line), calculated gravity anomaly (blue line). Bottom: underground model. Numerical values in figures denote the density of the basement (2.65) and sediments (2.25). The dashed lines in the figure are minimum and maximum values during 5 results. The solid line is the average value of 5 results.

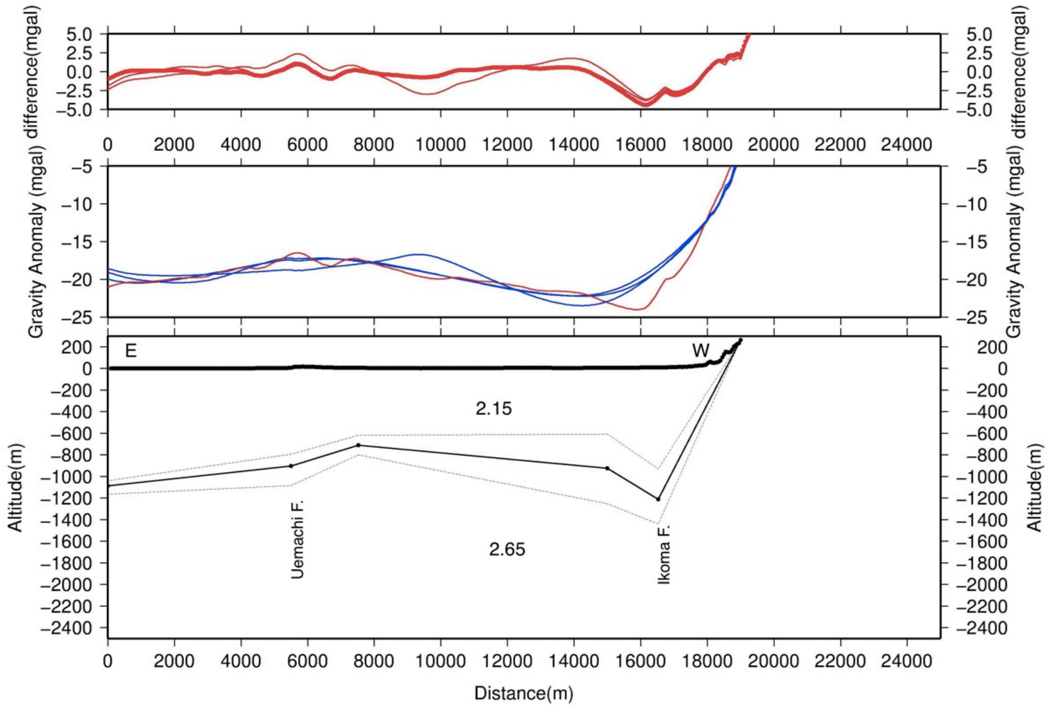

Figure 4. Profile of the L4 in Fig. 2. Top: difference between observed and calculated gravity anomaly form the model. Middle: Observed (red line), calculated gravity anomaly (blue line). Bottom: underground model. Numerical values in figures denote the density of the basement (2.65) and sediments (2.15). The dashed lines in the figure are minimum and maximum values during 5 results. The solid line is the average value of 5 results.

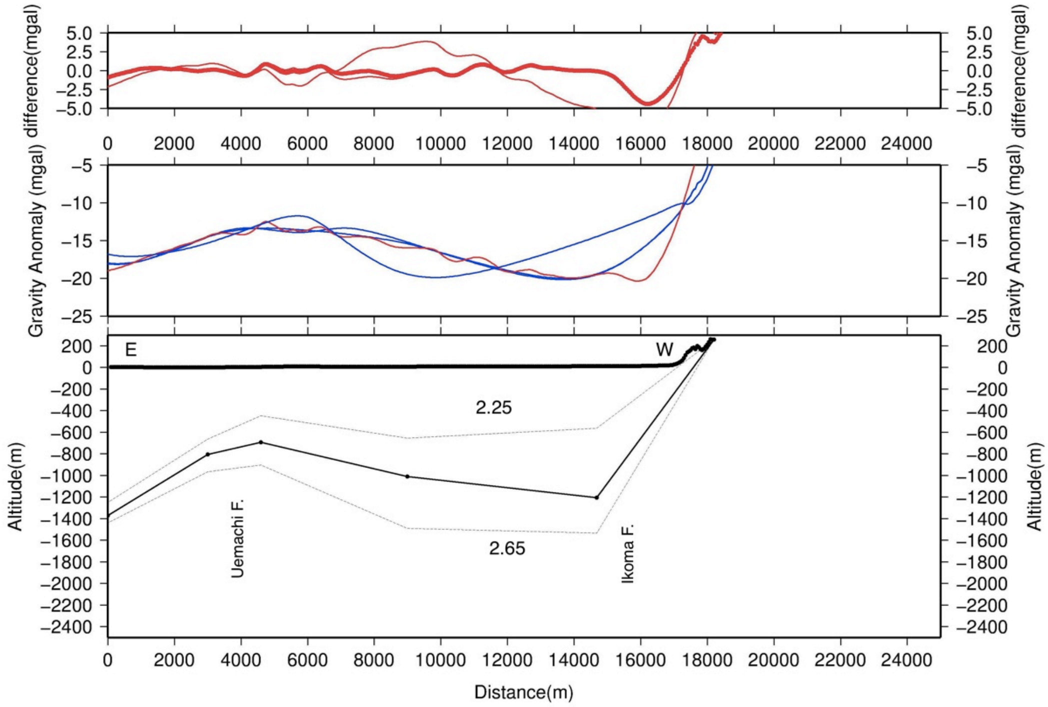

Figure 5. Profile of the L5 in Fig. 2. Top: difference between observed and calculated gravity anomaly form the model. Middle: Observed (red line), calculated gravity anomaly (blue line). Bottom: underground model. Numerical values in figures denote the density of the basement (2.65) and sediments (2.25). The dashed lines in the figure are minimum and maximum values during 5 results. The solid line is the average value of 5 results.