Estimation of 3D shape of bedrock around the damaged areas by the 2004, Niigata-ken Chuuetsu Earthquake using gravity anomalies

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The Niigata-ken Chuetsu Earthquake of M_J 6.8 occurred on October 23, 2004 and brought serious damage to the Chuetsu region of mid-Japan. This area, many active foldings area found and it is known that the subsurface structure is complex. To simulate the earthquake ground motions during the main shock, we need detailed information with respect to the structure including the 3-D ground of the boundary of the seismic bedrock. This kind of information, however, has not been provided enough. Thus, we carried out the gravity survey around Chuetsu region and 3-D upper boundary of the bedrock. Furthermore, we show preliminary results of numerical simulation of earthquake ground motions.

The observation area is located in 37 12 N to 37 33 N and 138 42 E to 139 00 E where is 39km of NS and 26km of EW. Thus area includes Nagaoka, Ojiya, and a part of Uonuma. The observation sites with 2km intervals were set and some part was filled by 1km intervals. We spent 42 days for the observation during June to November 2005 and got values of gravity of 397 sites. We used Automated burris Gravity Meter made from ZLS Corp and LaCoste & Romberg Gravimeter model G made from Micro-g LaCoste, Inc for the survey. Positions of the observation sites were determined by the differential survey of GPS. This error of the position is less than 1m in the horizontal and vertical.

To ensure the stability of the analysis, we introduce the gravity data included in the CD-ROM (Geological Survey of Japan, AIST,2004), and calculate the bouguer anomaly using the gravity data of 436 sites in the considering area. On the basis methods, the assumed density is decided as 2.40 [t/m^3]. Then, we estimate the 3-D gravity basement under the assumption that the ground consists of two layers, which are homogeneous sediment with density 1.90 [t/m^3] and bedrock with 2.40 [t/m3]. To obtain a realistic model of gravity basement, we consider the follows: remove the contribution for the bouguer anomaly from the deep structure such as upper mantle and to constrain the depth to the bedrock. For the former, a band-pass filter is applied to the Boguer anomaly. For the latter, we give some control points that is 3 sites from array observation of microtremors (Yamanaka et al, 2005),5 sites from deep boreholes which reach to the bedrock(Geological Survey of Japan, 1991 and 1986), 2 sites from P- and S-wave reflection experiment(Furumura et al, 2005), and 5 sites in mountainous where the bedrock appears on the surface.

As a result, depth of the gravity basement reaches to more than 3000 m at the northan part of Nagaoka. Furthermore, steep slops of the gravity basement are observed around the marginal area of eastern mountains and a hollow is observed south-eastern of the fault plane of the main shock. Comparing this with results from other researches, we may conclude that the obtained gravity basement coresponds with the upper boundary of the Miocene layer named Teradomari Formation. Using the proposed model of gravity basement, we carry a simple numerical simulation of the earthquake ground motion. From this, we can find that sites with large ground motions are concentrated on the steep slopes and a deep hollow of the basement. This result seems to be corrected to the damage distribution by the earthquake and may suggest the reasonability of the model of the ground structure. We, however, should continue to refine the model and consider the relations between the damege and ground structure in the future resarchs.