Subsurface structure around the hypocenter of the Iwate-Miyagi Nairiku Earthquake in 2008, northeast Japan, using gravity survey

Fumiko Watahiki[1]; Shin Koshiya[2]; Taro Mogi[3]; Hiroshi Sato[4]; Naoko Kato[5]; Eiji Kurashimo[4]; Masaru Noda[6]; Tsuyoshi Sano[1]; Shigeru Toda[7]; Toshifumi Imaizumi[8]; Tatsuya Ishiyama[9]; Susumu Abe[10]; Motonori Higashinaka[11]; Taro Koike[12]

[1] Iwate Univ.; [2] Civil and Environmental Eng., Iwate Univ.; [3] Iwate Univ; [4] ERI, Univ. Tokyo; [5] ERI, Univ. of Tokyo; [6] Faculty of Engin., Iwate Univ.; [7] Earth Sci., AUE; [8] Geography Sci., Tohoku Univ.; [9] Tohoku University; [10] JGI, Inc.; [11] JGI; [12] Geosys

The Iwate-Miyagi Nairiku Earthquake in 2008 occurred on June 14, 2008, northeast Honshu, Japan. It caused surface ruptures trending from north to south for about 8 km long along the northern Mochikorobashi-Hosokura Tectonic Line. The source fault of the earthquake, deduced by the Geographical Survey Institute, referring to one of range-bounding faults, develops in the west of the zone. Those faults had not been considered to be active faults. We conducted gravity survey to clarify the geometry of those fault and the subsurface structure around the hypocenter.

A survey line is about 11 km long, from east to west along Iwai River and Idosawa River around the epicenter. The line intersects the northern Mochikorobashi-Hosokura Tectonic Line in the eastern part, and the range-bounding fault in the western part, which is connected to a surface rupture reported by Doi and Saito (2008).

We conducted gravity survey with LaCoste and Romberg Model-G497 gravity meter. Each interval of observation sites is about 200 m. Error of measurement at each site is less than or equal to 0.02 mGal.

The elevation of each site is leveled with an automatic level. We employed the new bench-mark installed after the earthquake by Iwate Prefecture near Ubusume River for measuring absolute elevation. Error for leveling is less than $20S^{1/2}$, where S is distance. For leveling we divided the line into two parts, western and eastern parts, which are about 7.5 km and 5.1 km long, respectively. Errors for leveling are -51 mm for the western part, and +35 mm for the eastern part. Within the range of the elevation and latitude in the surveyed area and the range of density from 1.8 to 2.6 g/cm^3 for terrain and Bouguer corrections, the difference of 5 cm in elevation corresponds with one of +/- 0.011 to 0.013 mGal in Bouguer anomaly.

We processed the data with the methodology described by Geological Survey of Japan, AIST (2004), as follows; tidal, drift, terrain, free-air, and Bouguer corrections. The range of the terrain correction is 45 km. Applying the Bouguer correction, the effect of spherical earth was taken account of. The normal gravity was calculated with the normal gravity formula due to the Geodetic Reference System 1980.

We assumed that the density for the Bouguer and terrain corrections is 2.2 g/cm^3, applying the empirical equation after Gardner et al. (1974) and Brocher (2005) to P-wave velocity due to a refraction experiment carried out along the same line.

The resultant Bouguer anomaly increases from ca. 60 mGal at the eastern end of the line drastically to the maximum, ca. 83 mGal around the site 3.2 km away from the eastern end, where Cretaceous granitic rock is exposed. From there the anomaly decreases to 72 mGal at the site 2.5 km away from the rock and increases in undulation to 76 mGal at the western end.

We employed a 2-D gravity field modeling software 2MOD^{TM} (FUGRO-LCT Inc.) to develop the subsurface density model. Taking account of the results due to the reflection and refraction experiments performed together with this study, we assumed four layers in the model, the densities of which are 2.7, 2.5, 2.0 and 1.7 g/cm^3 in ascending order. These four layers are roughly correlated with pre-rift, syn-rift, post-rift and upper Miocene to Quaternary rocks, respectively.

The conclusions are as follows. (1) The basement rocks in the eastern area were formed as a horst bounded by normal faults, western one of which has reactivated as a reverse fault and caused surface rupture at the earthquake. (2) A reverse fault, which originally formed as a normal fault in the syn-rift period, develops in the western area. This fault is correlated with a range-bounding fault, which is considered to be a source fault.