

Repeated microgravity survey at Ogasawara Iwo-jima: detection of gravity change associated with large scale crustal deformation

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Ogasawara Iwo-jima is a volcanic island located mainly inside of the Iwo-jima caldera, exhibiting a remarkable high uplift rate (20 cm/yr) in the past several hundred years. National Research Institute for Earth Science and Disaster Prevention (NIED) has performed geodetic survey usually every two years in order to elucidate the relationship between the large crustal deformation and the volcanic activity. Since 1996 we have measured micro-gravity during the geodetic survey period. Based on the good observations since 1998, we observed temporal gravity changes associated with the large crustal deformation. We also found nonlinear behavior of the SCINTREX CG-3 gravimeter in the measurements with large gravity difference from the base gravity station.

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1. Method

Two SCINTREX CG-3 gravimeters (#212 and #284) have been used for the measurements since 1998. The survey route since 2000 includes the benchmarks at NIED in Tsukuba, at Iruma airbase and at Iwo-jima. Before and after the surveys measurements at the benchmarks, Tsukuba GS and FGS, of GSI have been carried out. During the surveys #212 and #284 stayed in Iwo-jima usually for one day and one week, respectively.

2. Absolute gravity values and their accuracy

Because of the large difference in gravity between Iwo-jima and Tsukuba (approximately 0.870 gal), we examined scale factors for the gravimeters by performing gravity measurements between Naha and Sapporo (differences in latitude and gravity are 16.9 degrees and 1.382 gal), and used them for the Iwo-jima survey. The gravity at the base gravity station (101: altitude 115 m) in Iwo-jima changed from 979.08167 gal to 979.08141 gal from 1998 to 2004 in averaging the two gravimeters. During the interval from 2000 to 2002 surveys, uplift of 0.883 m was measured at the benchmark (101), and large gravity decrease (0.158 mgal at #284 and 0.201 mgal at #212) was observed in the period. It should be noticeable that the two gravimeters exhibited unusually large differences ranging 0.083 mgal to 0.194 mgal for the four surveys. Although the clear reason has not been found, we point out the importance of paying special attention at the gravity survey in a remote island such as Iwo-jima.

3. Relative gravity variation in the island and crustal deformation

Spatial patterns in gravity variation relative to the benchmark 101 during the intervals from 1998 to 2000 and from 2000 to 2002 surveys indicate two major characteristics below,

(1) Between the 1998 and 2000 surveys vertical displacements relative to 101 range from -0.101 m to 0.363 m, indicating low volcanic activity. The corresponding gravity changes range from -0.094 mgal to 0.030 mgal, and the relation between vertical displacement (X) and gravity change (Y) is expressed by a regression line, $Y = -0.217X + 0.0024$ with correlation coefficient of 0.83, for all data in the island.

(2) Between the 2000 and 2002 surveys the relative vertical displacements and corresponding gravity changes range from -0.799 m to 0.574 m and from -0.142 mgal to 0.193 mgal. A regression line between X and Y is $Y = -0.260X - 0.0119$ with high correlation coefficient of 0.98.

We have found that the crustal deformation in Iwo-jima has been controlled mainly by two patterns, one is deformation due to continuous contraction source at the shallow depth of 1 to 2 km beneath the central part of Iwo-jima caldera and the other is broad uplift with episodic large changes. The above relation between gravity change and vertical displacements will provide us useful information about the source materials causing the deformation.