Very rapid uplift of Iwo-jima island detected by ALOS-2 imageries and its physical interpretation

*Isana Kobune[1], Youichiro Takada[2]

1. Hokkaido University, Graduate School of Science, 2. Hokkaido University, Faculty of Science

Iwo-jima is a volcanic island located in the Ogasawara Islands characterized by extremely high uplift rates (several meters per year). The overall crustal movement during 2006-2007 has been reported by Ozawa et al. (2010) using InSAR analysis of ALOS PALSAR data. In this study, first, we detect the latest (2014-present) island-wide crustal movement and its spatiotemporal evolution by InSAR analysis using ALOS-2 data. Next, we construct a physical model to explain thus obtained surface displacements quantitatively.

To consider the island-wide displacements (i.e., offset), we measured the surface displacement over the entire island by InSAR analysis taking GEONET Iwo Jima 1 as a reference, and then added the displacement of Iwo Jima 1 relative to GEONET Chichi Jima A to all the points. Next, we removed the long wave-length error using GNSS data obtained at three GEONET stations within the island following Fukushima and Hooper (2011). Then, we applied an SBAS-based InSAR time-series analysis (Berardino et al., 2002; Schmidt and Bürgmann, 2003) to the corrected interferograms to obtain the time evolution of crustal movement and to remove the short-period disturbances. Finally, we executed a 2.5D analysis (Fujiwara et al., 2000) to convert the satellite line-of-sight displacements into quasi vertical and quasi east-west displacements.

The vertical displacement field indicates (1) a mortar-shaped displacement centered on Motoyama in the center of the island and (2) a gap in displacement across the Aso-Dai fault in the west of the island. The abovementioned displacement pattern has not changed from that for 2006~2007 reported by Ozawa et al. (2010). As for the east-west component, we detected (1) a contraction around Motoyama and (2) a local westward movement to the west of the Aso-Dai fault. The cumulative uplift reaches ~10 m over 7 years (2014 to 2021). The cumulative westward displacement reaches ~4 m in the western part of the island, and ~-1m (i.e., eastward) around Motoyama.

To explain the displacement field detected by InSAR, we constructed a finite element model using COMSOL Multiphysics. The dimension of the model domain is 30 km in the east-west, 30 km in the north-south, and 6 km in the vertical direction, including the entire region of Iwo Jima. The upper surface of the model domain is traction-free. The surface geometry was created from ETOPO-1 for seafloor and 10m mesh DEHM provided by GSI for land. We set the sides and bottom of the model domain as the roller boundary. The medium is set to be an elastic body under gravity. Two hypothetical pressure sources beneath Iwo Jima drive the surface displacement. The first is a deep sill-like magma pool formed by the progressive sinking of the caldera, and the second is a ring of magma penetrating the shallow part of the caldera. We increased the pressure in these two sources by 25 MPa over 7 years, which quite well reproduced the displacement field detected by InSAR. In addition, we represent the Aso-Dai fault in the western part of the island as a weak region (low elastic constants), which better reproduces the displacement gap near the Aso-Dai fault as well.

Keywords: InSAR, Iwo-jima, Finite Element Model, ALOS-2