Crustal deformation due to earthquake swarm and topographic evolution: 1996 Onikobe Earthquake revisited

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The Onikobe caldera forms a part of the backbone range running through the northeast Japan. Four earthquakes larger than M5.0 occurred in and around this caldera on 11 and 13 August 1996 associated with swarm earthquakes. The fault parameters were estimated for those large earthquakes from seismic observations (Umino et al., 1998; Onodera et al., 1998; Okada et al., 2001).

On the other hand, Aoki et al. (2003) and Yarai et al. (2003) found that the ground displacement detected by Interferometric Synthetic Aperture Radar (InSAR) cannot be explained by the fault model inferred from the seismic observations. In this study, we re-analyzed the same data (JERS-1) and constructed a new fault model considering the topographic features.

We found that the marked ground displacement in the line-of-sight (LOS) up to -14 cm, which is mostly due to the surface uplift, occurred in the Harukawa and the Toragesawa rivers drainage area surrounded by sharp ridges like caldera walls. The LOS drastically changes across the eastern and the western part of the sharp ridges, which suggests the existence of hidden thrust faults. Introducing those faults, we constructed new fault model consisting of five faults. The fault parameters were estimated by trial and error and grid search.

With the new model, we calculated the LOS displacement and explained the three main characteristics of InSAR observation; (1) large negative LOS in the Harukawa and the Toragesawa rivers drainage area, (2) broad positive LOS in the northeastern part of the Onikobe caldera, (3) short wavelength negative LOS in the western part of the Onikobe caldera.

The Harukawa and Toragesawa rivers run around a domal structure (e.g., Mt.Tozawayama and Mt.Toragesan) where the largest uplift (smallest LOS) is observed. This implies the intermittent and ongoing growth of the domal structure on a long time scale, which has forced the Harukawa and the Toragesawa rivers to take the loop pattern.