Spatiotemporal strain distribution around Kussharo caldera, eastern Hokkaido, Japan, measured by GPS

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The Kussharo caldera in eastern Hokkaido, Japan, is one of the active caldera in Japan. This caldera is a typical island-arc volcanic complex associated with the subducting Pacific plate. Post-caldera volcanism stated just after the caldera forming (35ka) and has still continued. Sub-caldera formations in main caldera by large volume eruptions with more than 10 km^3 deposits were recorded at 20ka, 12ka and 7ka. Although episodic expanding (1993-1995) and contraction (1995-1998) has been detected from InSAR at the center of caldera, no significant magmatic eruption has been recorded during recent a thousand years.

This area has high shallow seismicity relative to other area in Hokkaido. Four moderate (~M6) earthquakes are recorded in the past one hundred years. In addition, subsurface structure surveys showed low seismic velocity zone in upper mantle and low resistivity body in middle to upper crust beneath caldera. Ground temperature profile along deep boreholes also indicated high geothermal gradient around this area. These facts implied that weak structure in crust and upper mantle induces high stress build-up in the upper crust and generates active seismicity.

In order to investigate the strain accumulation/release process in and around Kussharo caldera, we analyzed GPS data obtained from continuous and dense campaign-mode surveys. From continuous data, we picked up three periods and estimated velocity and strain rate fields in each terms (term1: 1998-2011, interseismic period without any large earthquake, term2: 2007-2009 postseismic period of the 2003 Tokachi-oki earthquake (M8.0), term3: postseismic period of the 2011 off the Pacific coast of Tohoku Earthquake (M9.0)). In term1 and term2, regional compressional strain field around the caldera, which is driven by interplate coupling between the subducting Pacific plate and the overriding plates, was dominant. Term3 also indicates compressional strain field with a little higher rate. Some effect of postseismic deformation of the 2011 earthquake is attributed. The strain rate map clearly indicated a stable, high dilatational strain rate of 0.2 microstrain per year over a decade only in Kussharo caldera.

Data from the dense campaign GPS observation provides one coordinate set every year from 1997 to 2001, and 2012. We estimated 11 years displacement from the coordinate difference between 2001 and 2012 to see recent crustal deformation. Although deformation rate is not stable for 11 years, because there are some interplate earthquakes near Kurile trench and Japan trench, total deformation and strain field indicates local strain concentration toward the center of caldera appears.

These results show that the strain concentration process in Kussharo caldera is in progress for at least a decade, even the large earthquake occurred around Hokkaido. Therefore, it is important to continue monitoring the tectonic behavior using multi geophysical data.