Estimation of geodetic and geological strain rates in the Japanese Islands (Part II)

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For the geological disposal of high-level radioactive waste, it is important to assess the long-term stability of the geological environment for more than tens of thousands years. The crustal deformation of the Japanese Islands is characterized by the crustal shortening toward the plate subduction direction which continues for long periods. Based on the empirical knowledge indicating uniform mode and rate of crustal movements of the Japanese Islands in the latter half of the Quaternary period, extrapolation of well-known crustal velocities has been conducted as one of the approach for the long-term predictions of the geological environment. Whereas strain rate derived from geodetic data exceeds that derived from geological data in the Japanese Islands. To discuss uniform mode and rate of crustal movements through the discrepancy of strain rates, using active fault data and GNSS velocities we investigated the characteristic of both strain rates.
The geologic strain rate was calculated from the surface displacement rates associated with fault sliding derived from the active fault data based on the dislocation theory (Okada, 1992). According to the method of Shen et al. (1996), we converted the surface displacement rates into strain rates, which the surface displacement rates within 40 km in diameter for arbitrary grids located in the latitude and longitude direction every 0.05 degrees were used. The geodetic strain rate was estimated using crustal velocities derived from GEONET F3 solutions (Nakagawa et al., 2009) in the period from 2007 to 2009. To remove elastic deformation accompanied with the plate subduction, we calculated elastic deformation by assuming 10 rectangular faults on the Pacific and Philippine Sea plates, and subtracted them from original velocities. Furthermore, assuming the block boundaries proposed by Loveless and Meade (2010), we calculated rigid block motion for each block and subtracted the motion from crustal velocities removed the elastic deformation due to plate subduction.
From the comparison of both strain rates, a difference of magnitude of strain rates is up to 10 times. Common points of principal strain rates are as follows: 1) near E-W crustal shortening from Asahikawa to Tomakomai cities, Hokkaido Prefecture, 2) E-W crustal shortening along the Ou Backbone, 3) crustal shortening and extension in northern part of the Niigata-Kobe Tectonic Zone (NKTZ), 4) crustal extension around Gunma and Saitama Prefectures, 5) crustal shortening in sea area of western part of Ishikawa Prefecture, 6) E-W crustal shortening from Mie to Osaka Prefectures, and 7) crustal shortening and extension along the Median Tectonic Line (MTL) located in northern part of Shikoku region. Common points of dilatational strain rates are as follows: 8) a zonal area with contraction from Asahikawa to Tomakomai cities, 9) crustal contraction along the Ou Backbone, 10) crustal contraction in northern part of the NKTZ, 11) an expansion at the southeastern part of Toyama Bay, and 12) alternate peaks of crustal contraction and expansion along the MTL located in Shikoku region. Common points of shear strain rates are as follows: 13) a peak of shear strain rate near Shiojiri city, Nagano Prefecture, 14) a zonal area with high shear strain rate along the MTL located in Shikoku region, and 15) a peak of shear strain rate at the western part of the MTL located in Iyo-nada. These results show the general consistency of spatial pattern for strain accumulation and release at the active faults in above listed areas, which can be potential for useful information about uniform mode and rate of long-term crustal movements.

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Keywords: geodetic strain rate, geological strain rate, active fault data, plate subduction, block motion

