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Quaternary strain rates distribution and crust-mantle structure of the southern Northeast Japan

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Driving mechanisms of intracontinental deformation at subduction margins have been a interesting research target to understand dynamic interaction between subducting oceanic slabs, overriding continental crust and mantle structures. Driven by this motivation, we estimated spatial distributions of intraplate permanent strain rates accommodated by active faults and fault-related folds in southern Northeast Japan during the late Cenozoic time, based on combinations of recently obtained deep to shallow seismic re[U+FB02]ection data, and rates of fault slip determined by offsets of geomorphic features or stratigraphic horizons identified of drilled shallow boreholes across fault and/or fold scarps. Tectonic setting of the northeastern Japan in late Cenozoic times, underlain by westward subducting old and cold Pacific plate, is characterized by north to northeast trending active thrust sheets that deform Neogene deposits. Although previous studies indicated that active reverse faults are predominant in this region, revised active fault mapping after the 2011 Tohoku-oki earthquake (M9.0) and its normal-fault aftershock sequence indicate that active normal faults are widely distributed on the southeastern flank of the coastal mountains along the Pacific coast and continental shelf off the southern Northeast Japan. Estimated strain rates accommodated by active faults and folds are an order of 10-8/yr for each structures, that are in general 10 to 100 times higher than previous estimates only from surficial Quaternary active fault data and historical seismicity. Contrastingly, geodetic strain rates observed the 2011 Tohoku-oki earthquake shows 10 times higher than those estimates in this study. Most of these active thrusts are reactivated normal faults originally formed during Miocene in extensional stress regimes. Trench-normal, spatial distributions of the longer-term permanent strain rates is characterized by a distinctive trend that strain rates in back-arc are apparently 10 times higher than in fore-arc region, quite similar to those estimated based on late Cenozoic folded/faulted strata. Most of these active thrusts are reactivated normal faults originally formed during Miocene in extensional stress regimes. Longer-wavelength, late Quaternary uplift and subsidence overprinting these short wavelength strains, estimated by fluvial incision rates based on terhrostratigraphy, and borehole stratigraphy in alluvial plains, indicate relatively uniform, moderate uplift rates in fore-arc and west of the volcanic front, and very fast subsidence rates in back-arc. Late Cenozoic major tectonic records in southern Northeastern Japan after Miocene Japan Sea opening are, in summary, mainly characterized by Quaternary strong compression and coeval fast subsidence in back-arc region. Crust-mantle structures of the southern Northeast Japan based on seismic tomography, seismic reflection and refraction profiles indicates crustal thickening beneath the Ou backbone Range probably due to magmatic underplating. In addition, back-arc subsidence is underlain by low Vp in the upper mantle, suggesting that downwelling of the mantle lithosphere may be driving present-day surface fast subsidence.