



Rare normal faulting earthquake induced by subduction megaquake: example from 2011 Tohoku-oki earthquake

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A month after March 11 gigantic M9.0 Tohoku-oki earthquake, M7.0 intraplate earthquake occurred at a depth of 5 km on April 11 beneath coastal area of near Iwaki city, Fukushima prefecture. Focal mechanism of the mainshock indicates that this earthquake is a normal faulting event. Based on field reconnaissance and LIDAR mapping by Geospatial Information Authority of Japan, we recognized coseismic surface ruptures, presumably associated with the main shock. Coseismic surface ruptures extend NNW for about 11 km in a right-stepping en echelon manner. Geomorphic expressions of these ruptures commonly include WWS-facing normal fault scarps and/or drape fold scarp with open cracks on their crests, on the hanging wall sides of steeply west-dipping normal fault planes subparallel to Cretaceous metamorphic rocks. Highest topographic scarp height is about 2.3 m. In this study we introduce preliminary results of a trenching survey across the coseismic surface ruptures at Shionohira site, to resolve timing of paleoseismic events along the Shionohira fault. Trench excavations were carried out at two sites (Ichinokura and Shionohira sites) in Iwaki, Fukushima. At Shionohira site a 2-m-deep trench was excavated across the coseismic fault scarp emerged on the alluvial plain on the eastern flank of the Abukuma Mountains. On the trench walls we observed pairs of steeply dipping normal faults that deform Neogene to Paleogene conglomerates and unconformably overlying, late Quaternary to Holocene fluvial units. Sense of fault slip observed on the trench walls (large dip-slip with small sinistral component) is consistent with that estimated from coseismic surface ruptures. Fault throw estimated from separation of piercing points on lower Unit I and vertical structural relief on folded upper Unit I is consistent with topographic height of the coseismic fault scarp at the trench site. In contrast, vertical separation of Unit II, unconformably overlain by Unit I, is measured as about 1.5 m, twice as large as coseismic vertical component of slip, indicative of penultimate seismic event prior to the 2011 earthquake. Abrupt thickening of overlying Unit I may also suggest preexisting topographic relief prior to its deposition. Radiocarbon dating of charred materials included in event horizons and tephrostratigraphy at two sites indicate that penultimate event prior to the 2011 event might occurred at about 40 ka. This normal fault earthquake is in contrast to compressional or neutral stress regimes in Tohoku region before the 2011 megaquake and rarity of the normal faulting earthquake inferred from these paleoseismic studies may reflect its mechanical relation to the gigantic megathrust earthquakes, such as unusual, enhanced extensional stress on the hangingwall block induced by mainshock and/or postseismic creep after the M₉ earthquake.