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Surface faulting along the inland Itozawa normal fault (eastern Japan) and relation to the 2011 Tohoku-oki megathrust earthquake

Matthieu Ferry (1), Hiroyuki Tsutsumi (2), Mustapha Meghraoui (3), and Shinji Toda (4)

(1) Géosciences Montpellier, CNRS-UMR5243, Université Montpellier II, France (mferry@um2.fr), (2) Department of Geophysics, Kyoto University, Japan, (3) Institut de Physique du Globe de Strasbourg, CNRS-UMR7516, Universite de Strasbourg, France, (4) International Research Institute of Disaster Science, Tohoku University, Japan

The 11 March 2011 Mw 9 Tohoku-oki earthquake ruptured ∼500 km length of the Japan Trench along the coast of eastern Japan and significantly impacted the stress regime within the crust. The resulting change in seismicity over the Japan mainland was exhibited by the 11 April 2011 Mw 6.6 Iwaki earthquake that ruptured the Itozawa and Yunodake faults. Trending NNW and NW, respectively, these 70-80º W-dipping faults bound the Iwaki basin of Neogene age and have been reactivated simultaneously both along 15-km-long sections.

Here, we present initial results from a paleoseismic excavation performed across the Itozawa fault within the Tsunagi Valley at the northern third of the observed surface rupture. At the Tsunagi site, the rupture affects a rice paddy, which provides an ideally horizontal initial state to collect detailed and accurate measurements. The surface break is composed of a continuous 30-to-40-cm-wide purely extensional crack that separates the uplifted block from a gently dipping 1-to-2-m-wide strip affected by right-stepping en-echelon cracks and locally bounded by a ∼0.1-m-high reverse scarplet. Total station across-fault topographic profiles indicate the pre-earthquake ground surface was vertically deformed by ∼0.6 m while direct field examinations reveal that well-defined rice paddy limits have been left-laterally offset by ∼0.1 m.

The 12-m-long, 3.5-m-deep trench exposes the 30-to-40-cm-thick cultivated soil overlaying a 1-m-thick red to yellow silt unit, a 2-m-thick alluvial gravel unit and a basal 0.1-1-m-thick organic-rich silt unit. Deformation associated to the 2011 rupture illustrates down-dip movement along a near-vertical fault with a well-expressed bending moment at the surface and generalized warping. On the north wall, the intermediate gravel unit displays a deformation pattern similar to granular flow with only minor discrete faulting and no splay to be continuously followed from the main fault to the surface. On the south wall, warping dominates as well but with some strain localization along two major splays that exhibit 15-20 cm of vertical offset. On both walls, the basal silt unit is vertically deformed by ∼0.6 m, similarly to what is observed for the 2011 rupture. Furthermore, the base of said silt unit exhibits indication for secondary faulting prior to the 2011 event and that resemble cracks observed at the present-day surface. This suggests that the Itozawa fault has already ruptured in a similar fashion in the late Pleistocene). Hence, recent activity of the Itozawa fault may be controlled entirely by large to giant earthquakes along the Japan Trench.