Cretaceous-Paleogene forearc basin structure and seamount subductions illuminated by the 2011 great Tohoku, Japan, earthquake

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November 22 2016 Mw=6.9 (Mj=7.4) Fukushima-oki earthquake, triggered ~2-meter-high tsunami to Sendai Bay, minds us of long-lasting off-fault aftershocks, continuous high seismic and tsunami hazards associated with the March 11, 2011 M9.0 Tohoku-oki earthquake. The Tohoku-oki earthquake has indeed turned on the shallow offshore and onshore normal faulting earthquakes in the Pacific Coast regions of southern Tohoku, as well as the abundant on-fault aftershocks. As the result of stress calculations, responding seismicity, geologic and geomorphic analyses, we here argue that the Tohoku-oki earthquake shed a light on complex structure associated with Cretaceous-Paleogene forearc basin structure and subsequent seamount subductions.

To understand the post-Tohoku-oki seismicity in the region, we first calculated coseismic static Coulomb stress change on the crustal faults on the overriding plate by the 2011 Mw=9.0 Tohoku earthquake using a variable slip model of Iinuma et al. (2012). As already reported by Toda et al. (2011), we found shallow normal faults onshore and offshore Fukushima brought 2-4 MPa closer to failure. Most Coulomb stress changes resolved on nodal planes of the post-Tohoku-oki earthquakes are positive, which is consistent with the high seismicity in this region. In contrast, thrust faults offshore Miyagi and Fukushima are calculated to have brought 0.5-3 MPa farther from failure. However, it is interesting to note that the Tohoku earthquake did not shut off the reverse faulting earthquakes near the Japan trench, which can be explained by stress increase to crustal reverse faults from the southern slip patch (Iinuma et al., 2012) of the Tohoku-oki earthquake
Another noteworthy feature in seismicity off-shore Pacific Coast of southern Tohoku is a significant contrast between very active seismic area (Fukushima-oki) and aseismic area (Sendai Bay).
About-100-km-wide NE-trending normal faulting active seismic zone, extending from onshore Fukushima-Hamadori to offshore Fukushima, is roughly parallel to the trend of Kashima-Daiichi seamount chain and outer-rise fracture zones on the subducting Pacific plate. In addition, detailed bathymetric shaded relief map (Izumi et al., 2012), showing numerous complex geomorphic features typically seen in other seamount collisions and subductions (e.g., cookie bite structure, Dominguez et al, 1998; Wang and Bilek, 2011), allows us to infer that a similar seamount chain of the Kashima-daiichi subducted in the past and left the complex fault networks into overlying crust. They are also superimposed on the forearc basin structure developed in the Cretaceous-Paleogene periods (e.g., Iwata et al, 2002). In contrast, seismicity in Sendai Bay is completely quiet and one could mistakenly point out seismicity in Sendai Bay is in a typical stress shadow. But the amount of stress increase for normal faults due to the Tohoku-oki earthquake in Sendai Bay is approximately the same as the one for offshore Fukushima. Because Sendai Bay is located off the Joban forearc basin and farther west of damaged zones of the seamount subduction, we interpret such no seismic response is probably due to a paucity of potential normal faults. We thus conclude the current seismicity offshore and onshore Pacific Coast of southern Tohoku is a product of a combination of inherited geologic structure and stress transfer from the 2011 Tohoku-oki earthquake.

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