

Seismic activity in the focal area of the 2011 Tohoku earthquake in comparison with off-Kamaishi repeating earthquakes

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To investigate the seismic property of the fault zone for the 2011 great earthquake is of great importance for understanding the mechanism of M9 earthquakes. The studies on the off-Kamaishi repeating earthquake sequence (e.g., Uchida et al., 2012) suggest following features of the asperity for the recurrent earthquakes. 1) The asperity has a hierarchical structure. 2) The seismicity in the interseismic period is active near the edge of the asperity and less active around its center. 3) The temporal change in seismicity shows low seismicity just after the main shock to high seismicity in the latter half of the earthquake cycle. 4) Migration of smaller earthquakes (earthquakes near the center of the focal area of the main shock follows those near the edge of the area) are sometimes observed. These features probably show the difference in interplate coupling and unfastening of the asperity during the earthquake cycle. In this study, we investigate the seismic activity in the focal area of the 2011 Tohoku earthquake and compare it with that of the off-Kamaishi repeating earthquake sequence.

Several interplate earthquakes with M7 or larger after 1930 are located in the slip area for the 2011 Tohoku earthquake. Thus the 2011 earthquake also shows a hierarchical structure (feature 1). Most of the the $M \geq 7$ earthquakes are located near the edge or outside of the main slip area for the 2011 earthquake (Yamanaka and Kikuchi, 2004; Murotani et al., 2006; Yamanaka, 2011). The Miyagi-oki area has M7 repeaters at the deeper edge of the slip area, which is similar to the repeating earthquakes near the deeper edge of the off-Kamaishi sequence. Inactive seismicity near the center of slip area is also true of the 2011 earthquake and major activities near the center were observed in 1981 (M7.0) and 2011 (M7.3) (feature 2). The repeating earthquakes and low-angle thrust type earthquakes (Asano et al., 2011) are inactive in the main slip area for the 2011 earthquake and this may be a part of temporal seismicity change in the earthquake cycle of the M9 earthquakes (feature 3). Migration of earthquakes from around the edge toward the center of the focal area of the 2011 earthquake has been sometimes observed (e.g., seismic activities off Fukushima in 1938 and off Sanriku in 1968). These activities similar to the off-Kamaishi earthquake sequence (feature 4) may be manifestations of invasion of slip toward the center of the asperity.

For the 2011 Tohoku earthquake, we successfully estimated spatial-temporal change in the interplate coupling in and around the slip area using small repeating earthquakes, which was difficult for the source area of the off-Kamaishi earthquake. Unfastening of the coupling in the source area of the Tohoku earthquake was observed in 2008 off Fukushima and Miyagi prefectures (Uchida et al., 2009; Graduate School of Science, Tohoku University, 2010). Many repeating earthquakes are included in the aftershocks of the 2011 M7.3 foreshock, which probably also shows the unfastening of the coupling. High-coupling coefficient in a wide area and lack of repeating earthquakes near the trench can also characterize the asperity for the great interplate earthquake.

The characteristics of the seismic activity in and around the source area of the 2011 Tohoku earthquake mentioned above are similar to the off-Kamaishi sequence in many aspects. These features might be true of simple systems only; but if they are common for most of seismogenic patches, it is quite important not only for understanding the earthquake generation process but also for the disaster mitigation through the detection of hidden asperities for great earthquakes.