P18

Slow-earthquake Segmentation as a Barrier to the Rupture of the 2011 Tohoku-Oki earthquake

○Tomoaki NISHIKAWA, Takanori MATSUZAWA, Kazuaki OHTA, Naoki UCHIDA, Takuya NISHIMURA, Satoshi IDE

1. Introduction

In subduction zones, megathrust earthquakes occur as a result of the interplay between fast dynamic rupture process and slow deformation process, which is directly observed as various slow earthquakes (Ide et al., 2007) including tectonic tremors, very low-frequency earthquake (VLFs), and slow slip events (SSEs), or indirectly suggested by a temporal change in the frequency of repeating earthquakes (Uchida et al., 2004) and occurrence of episodic earthquake swarms (Nishikawa & Ide, 2018). Some megathrust earthquakes were preceded by slow earthquakes (e.g., Katakami et al., 2018) and terminated around areas where slow earthquakes were frequently observed (e.g., Rolandone et al., 2018). While revealing the full range of slow-earthquake activity is crucial for estimating the occurrence time and rupture extent of future megathrust earthquakes in each subduction zone, the observation is generally difficult, and little has been known about slow earthquakes in most subduction zones worldwide including the Japan Trench, where the 2011 M_w 9.0 Tohoku-Oki earthquake occurred. Here we reveal the slow-earthquake activity in the Japan Trench in detail using tectonic tremors, VLFs, SSEs, repeating earthquakes, and earthquake swarms.

2. Methods and Data

We newly detected tectonic tremors using seismograms collected by the Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net) (Uehira et al., 2018). We updated existing catalogues of the VLFs (Matsuzawa et al., 2015), repeating earthquakes (Uchida & Matsuzawa, 2013), and earthquake swarms (Nishikawa & Ide, 2018) using seismograms and an earthquake catalogue provided by the F-net, Hi-net, and Japan Meteorological Agency. We also discovered episodic tremor and slip far off the Boso Penisula using GNSS data provided by Geospatial Information Authority of Japan and Japan Coast Guard.

3. Results and Discussions

We show that the distribution of the slow earthquakes is complementary to the rupture area of the Tohoku-Oki earthquake and correlated with the along-strike structural heterogeneity in the Japan Trench (e.g., Bassett et al., 2016). Concentrated activities of slow earthquakes were observed in the afterslip area of the Tohoku-Oki earthquake, which is located to the south of the geological fore-arc segment boundary. Our results suggest that the megathrust in the Japan Trench is divided into three segments with different frictional properties: the Sanriku-Oki (39°N to 40.7°N), Miyagi-Oki (37.3°N to 39°N), Ibaraki-Oki (to the south of 37.3°N) segments (Fig. 1). The Sanriku-Oki and Ibaraki-Oki segments are characterized by frequent occurrence of slow earthquakes and partial coupling of the plate interface, while the Miyagi-Oki segment is associated with fewer slow earthquakes and full coupling. We propose that the rupture of the 2011 Tohoku-Oki earthquake, which started in the Miyagi-Oki segment, was terminated by the two adjacent segments.

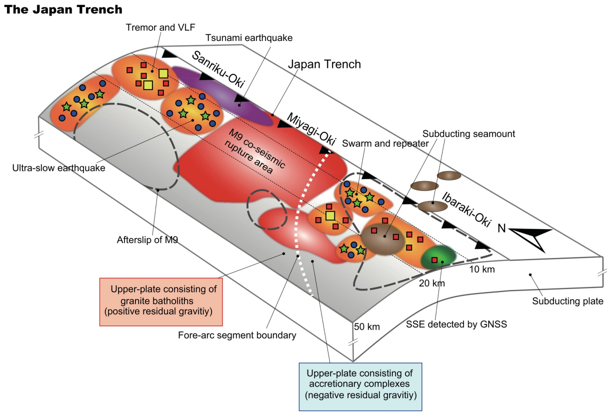

Figure 1 | Schematic view of the slow-earthquake activity and structural heterogeneity in the Japan Trench. Red and yellow squares denote tectonic tremors and VLFs, respectively. Green stars and blue circles indicate repeaters and earthquake swarms, respectively. Orange shadings are areas hosting or probably hosting SSEs accompanied by tremors, VLFs, repeaters, and/or earthquake swarms. Green shadings denote geodetically detected SSEs. A purple shading is the 1896 Meiji Sanriku tsunami earthquake (Tanioka & Satake, 1996). Red shadings indicate the co-seismic rupture area of the Tohoku-Oki earthquake (Iinuma et al., 2012). Brown shadings are subducting seamounts (Mochizuki et al., 2008). Dashed dark gray lines are the afterslip area of the Tohoku-Oki earthquake (Iinuma et al., 2016). A white dashed line indicates the geological fore-arc segment boundary (Bassett et al., 2016). Note that the slab geometry is simplified.