Revealing the slow earthquake activity in the Japan Trench and its relation to the 2011 Tohoku-Oki earthquake

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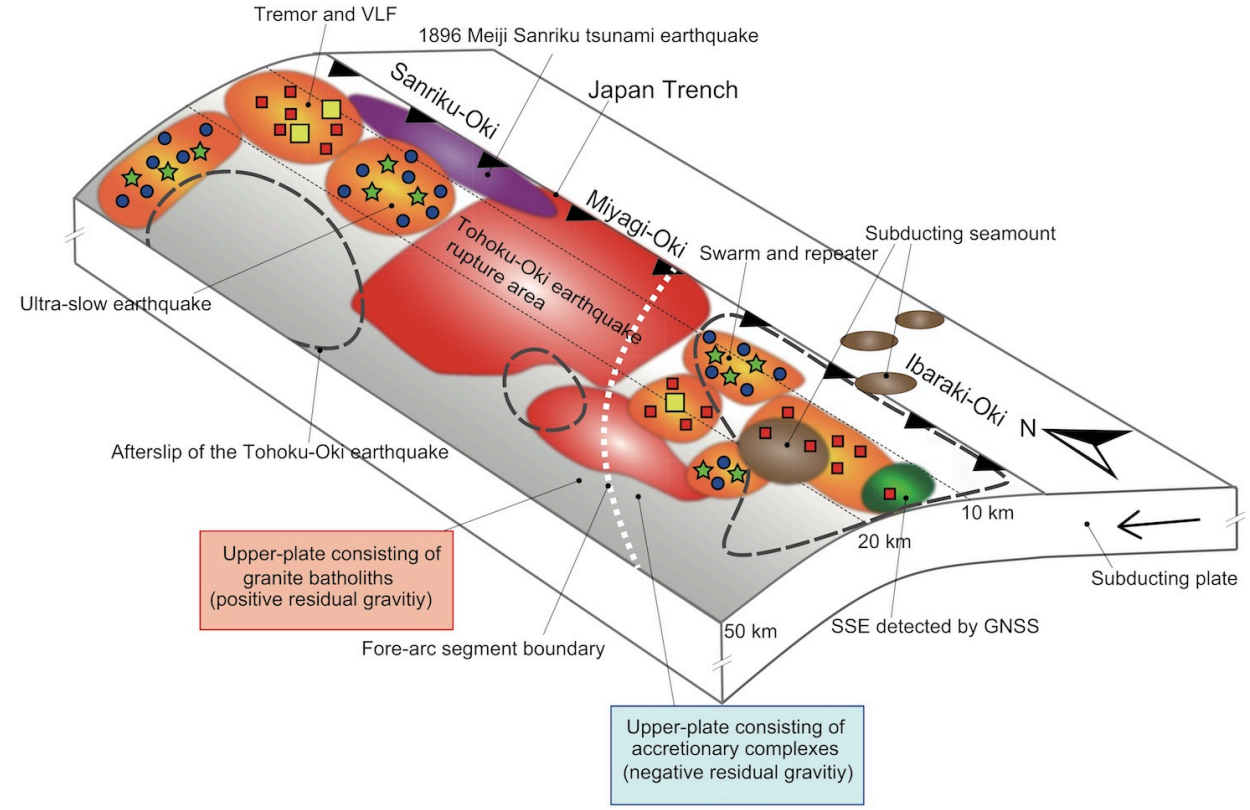
Subduction zone megathrust earthquakes result from the interplay between fast dynamic rupture and slow deformation processes, which are directly observed as various slow earthquakes, including tectonic tremors, very low-frequency earthquake (VLFs) and slow slip events (SSEs), and indirectly suggested by a temporal change in the frequency of repeating earthquakes and the occurrence of episodic earthquake swarms. Some megathrust earthquakes have been preceded by slow earthquakes and terminated near the areas where slow earthquakes were frequently observed. While capturing the entire spectrum of slow earthquake activity is crucial for estimating the occurrence time and rupture extent of future megathrust earthquakes in a given subduction zone, such an observation is generally difficult, and slow earthquake activity is poorly understood in most subduction zones, including the Japan Trench, which hosted the 2011 M_w9.0 Tohoku-Oki earthquake. Here we reveal the slow earthquake activity in the Japan Trench in detail using tectonic tremors, which we detected in the seismograms of a new ocean-bottom seismograph network, VLFs, SSEs, repeating earthquakes, and earthquake swarms. We show that the slow earthquake distribution is complementary to the rupture area of the Tohoku-Oki earthquake and correlates with the structural heterogeneity along the Japan Trench. Concentrated slow earthquake activities were observed in the afterslip area of the Tohoku-Oki earthquake, which is located to the south of the fore-arc geological segment boundary. Our results suggest that the megathrust in the Japan Trench is divided into three segments that are characterised by different frictional properties, and that the rupture of the Tohoku-Oki earthquake, which nucleated in the central segment, was terminated by the two adjacent segments.

Keywords: Slow earthquake, Megathrust earthquake, Subduction zone, The 2011 Tohoku-Oki earthquake

The Japan Trench



The Nankai Trough