

A possible M10 event deduced from the lessons of the 2011 Tohoku-Oki earthquake

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After the 2011 Tohoku-Oki earthquake, the immediate threat of megathrust earthquakes in and around Japan has been suddenly advocated by some researchers. One even points out the possibility of a larger event than ever, an event of Magnitude 10. In this study, we discuss whether an event of M10 is realistic or not, from not only statistical aspects of earthquake occurrence or macroscopic scaling laws of seismic sources in a conventional manner (e.g., fault size, the amount of slips) but also the diversity of megathrust earthquakes that was revealed after the occurrence of the 2011 Tohoku-Oki earthquake. From a simple extrapolation of seismicity and macroscopic scaling laws, one event of M10 occurs every 500 years all over the world, with its fault length, width and average slip to be 1,200 km, 600 km and 50 m, respectively. The width may not exceed 200 km very much because of the limitation of an elastic region of a plate boundary in a subduction zone. We therefore need either of (1) average slip as large as 100 m or (2) fault length of more than 1,500 km for a possible M10 event. The average slip may be able to exceed 100 m, considering an area of very large shallow slips associated with the 2011 Tohoku-Oki earthquake, but we must take care that this is possible only for an event of the along-dip double segmentation. This type of events is, however, generally adjacent to segments of weak plate coupling with small coseismic slips. In contrast, an event of the conventional along-dip single segmentation may extend its fault into many adjacent segments. A drawback in this case is that the average slip may not exceed 50 m unless there are several segments of very strong plate coupling, resulting in co-seismic slips larger than those for usual events repeating in each segment. Although a very large strong shallow segment of the double segmentation is a candidate of an M10 event, we cannot find any clear evidence of such a region from the present seismic pattern in the world. The subduction zone in south Chile is the best candidate from its apparent strong plate coupling although it may not occur for a while due to the nearly complete strain release associated with the 1960 earthquake. We consider a very large event will be impossible even if a large portion of subduction zones breaks in the Aleutian trench because of the existence of several segments of weak plate coupling with slow events or aseismic slips in this subduction zone.

Keywords: megathrust earthquake, 2011 Tohoku-Oki earthquake, double segmentation, strong coupling, fault width, average slip