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Some hints hidden in the 1964 Alaska earthquake for the 2011 off the Pacific coast of Tohoku earthquake

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We present a variety of similarities between the 2011 off the Pacific coast of Tohoku earthquake and the 1964 Alaska earthquake. They have very different characteristics from standard megathrust earthquakes, such as the 1960 Chile and the 2004 Sumatra-Andaman earthquakes, which we call here single segmentation. Their dominant focal process is a unilateral rupture propagation along a trench axis.

The fault geometry of the Tohoku earthquake is wide but short, compared with much elongated for the standard ones of single segmentation. While a unilateral long rupture propagation along a trench dominates in the standard megathrust earthquakes, there are no specific migrations of moment release during the 2011 Tohoku earthquake. Large slips estimated from teleseismic body waves are estimated to be a very limited single region within their entire faults, that is, near the epicenters, for both the 1964 Alaska and 2011 Tohoku earthquakes.

The seismicity prior to a megathrust earthquake is generally very weak, forming a relatively clear seismic gap, but there are seismicities with either repeated large earthquakes or minor earthquakes in all the segments of the 2011. Instead, there is a shallow and long zone of virtually no seismicity close the trench. We can recognize these features similar to those of the 1964 Alaska earthquake. The similarities are extremely surprising because they exhibit strong contrast with the other famous examples, the 1960 Chile and the 2004 Sumatra earthquakes.

In addition, the characteristic of seismogenic segments adjacent to the epicenter (i.e., a segment of large coseismic slips) strongly implies its weak plate coupling in contrast to very strong coupling at the segment with the epicenter for either of double-segmentation earthquakes. In the case of the 1964 Alaska earthquake, there are several earthquakes of magnitude 7 in the southwestern segment around Kodiak Island and they are normal-fault events within the subducting Pacific plate (Ratchkovski and Hansen, 2001). In the Tohoku case, a series of five similar earthquakes occurred in 1938 in the Shioya-Oki or Fukushima-Oki segment in the south of the Miyagi-Oki segment (Abe, 1977). Since plate coupling appears to be very strong in all the segments along a trench for single-segmentation megathrust earthquakes, the above contrast of two adjacent segments (strong and weak couplings) strongly distinguish double-segmentation earthquakes from them.

The existence and major role of shallow segments (calling it double segmentation) associated with the 2011 and the 1964 earthquakes make them different from the other megathrust earthquakes. The recognition of these two types, particularly the similarity between the two earthquakes should help our understanding of megathrust earthquakes occurring in the future.

Keywords: megathrust earthquake, double segmentation, interrelation of segments, 2011 Tohoku earthquake, 1964 Alaska earthquake