

**Possible complex fault sources near the Japan trench:  
the 1896 and 1933 tsunamigenic events and implications for tsunami sources  
in the western Pacific**

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**Abstract**

An extraordinary pair of earthquakes occurred in the Sanriku district of NE Japan in 1896 and 1933. Both spawned very destructive tsunamis that killed >20,000 and >3,000 people, respectively. Hiroo Kanamori showed that the first motions of the 1933 event are consistent with a steeply-dipping normal faulting below the outer wall of the Japan Trench. However, most of the larger aftershocks occurred too far west to be considered as slip on the rupture plane identified by Kanamori. Recent relocations of earthquakes in this region in the modern era (2000-2004) (Shantha Gamage, RCEVEP MS Thesis, 2004) show two classes of earthquakes: (1) Normal faulting in the source region of the 1933 event along a single steeply-dipping plane (perhaps aftershocks!) and a 2004 normal-faulting event also beneath the outer trench slope; (2) An eastward dipping zone east of the Japan Trench that represents a combination of both normal-faulting (bending) events and interplate thrust earthquakes. The most straightforward interpretation of the 1933 aftershocks is that they represent additional rupture on the plate boundary east of the Japan trench and hence east of the epicenter of the main shock defined by first motions, i.e., the 1933 event may have been a compound faulting event with slip on two rupture planes: the normal fault plane in the region main shock epicenter and slip on the plate boundary. This scenario has not yet been considered in tsunami modeling of this event. This event also raises the question of whether other large, offshore pre-instrumental or early-instrumental earthquakes have occurred where the old, cold Pacific plate is deflecting by flexure and have been mistaken for interplate thrust events.

The 1896 event is less well known because it occurred in the infancy of the Japanese network and the global network. Tsunami modeling by Tanioka and Satake suggests that slip occurred on the plate boundary in a narrow strip near and paralleling the Japan Trench. It is well known that this event did not produce strong ground motions even though it probably occurred near the 1933 epicenter. The tsunami magnitude of this event was huge compared to its earthquake magnitude. An important question is could this event also involve compound rupture similar to the 1933 event. Moreover, how are these two events related as far as stress transfer by slip on the 1896 rupture(s).