Seamount Subduction Causes the Complex Source Processes of the Nankai Earthquakes, Southwest Japan

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We estimated the incremental stress on and around a seamount associated with its subduction using 3D finite element method. The results show that the normal stress on the forward flank of the seamount is increased and the sign of delta CFF on splay faults in the landward portion of the overriding plate is positive. The former result indicates that the subducted seamount can act as a barrier or an asperity for an interplate earthquake and the latter indicates that splay faults become likely to slip by seamount subduction. So we conclude that seamount subduction may cause some complex features of the source process of the 1946 Nankai earthquake.

Great interplate earthquakes occurred repeatedly along the Nankai trough, where the Philippine Sea plate is subducting beneath southwest Japan. The last one occurred in 1946 with magnitude 8.0. The source process of this earthquake have been reinvestigated recently using seismic wave, tsunami, or geodetic data and revealed to be fairly complex (Hashimoto and Kikuchi, 1999; Cummins et al., 2000; Tanioka and Satake, 2001; Sagiya and Thatcher, 1999). In the central part of this source region, a subducted seamount is imaged by analyzing OBS data (Kodaira et al., 2000). It is possible that the complexity of the source process is partly caused by the subduction of the seamount (Kodaira et al., 2000).

The characteristics of the source process of the 1946 Nankai earthquake are as follows: (1) most of the coseismic slip occurred in the east and west of the subducted seamount, not on it; (2) in the west of the seamount, seismic and/or tsunamigenic slip occurred on a splay fault whose strike is not parallel to the trough axis but perpendicular to the direction of relative plate motion there; (3) aseismic but tsunamigenic slip possibly occurred in the west of the subducted seamount.

We calculate the incremental deformation and stress around a seamount associated with subduction using 3D finite element method. The configuration is based on the seamount imaged by Kodaira et al. (2000). Gravity is applied on the whole system with constant Coulomb friction acting on the plate boundary. The results which may relate to the source process are as follows: (i) the traction acting on the plate boundary increases on the forward flank of the seamount caused by the displacement of the seamount; (ii) the incremental compressional stress is maximum in the direction of the subduction and minimum in the vertical direction in the landward portion of the overriding plate.

We consider that the characteristics of the source process (1) and (2) are related to the calculated stress field (i) and (ii), respectively. The mechanism of (3) is open question. The result (i) indicates that the plate boundary is strongly coupled on the forward flank of a subducted seamount. So the forward flank of the seamount possibly behaves as a barrier like in 1946 or as an asperity like in 1854 or 1707. From the stress field (ii), we calculated delta CFF on the splay fault proposed by Cummins and Kaneda (2000). The sign of delta CFF is positive regardless of the value of effective coefficient of friction and this indicates that the splay fault becomes likely to slip by seamount subduction. To confirm the effects of these static stress changes on the source process, we need to calculate dynamic rupture propagations.