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Stress field determined from moment tensor solutions of shallow VLF earthquakes within the Nankai Trough accretionary prism

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Very-low-frequency (VLF) earthquakes have been detected near the trench axis along the Nankai Trough (Ishihara et al., 2002; Obara and Ito, 2005). Their epicenters are mainly distributed off Kumano, off Muroto, and in the Hyuga-nada region, southwestern Japan (Asano et al., 2008). Their moment tensor solutions show the thrust faulting, although they are not consisted with the focal mechanism on the subducting plate interface (Ito and Obara, 2006a). Moment tensor solutions of these earthquakes indicate thrust faulting; however, these solutions do not include solutions of the focal mechanism on the subducting plate interface (Ito and Obara, 2006a).The stress drops estimated from a P-wave spectrum are in the range from 0.1 to 10 kPa; the stress drops of 0.1% to 1% of ordinary earthquakes are in this range. These observations suggest that VLF earthquakes are a class of slow earthquakes that occur on the mega-splay fault or the out-of-sequence thrust; the fault strength within the accretionary prism weakens because of the existence of a fluid in the faults (Ito and Obara, 2006b). Recently, maximum horizontal principal stress was estimated from borehole breakouts, which were observed at drilling sites off Kumano by using the vessel 'Chikyu' (Kinoshita et al., 2008).Stress fields within the accretionary prism have not been well understood from any seismological observations, although numerical simulations based on the theory of critically tapered Coulomb wedge have been studied (e.g., Davis et al., 1983; Wang and Hu, 2006). Here, we present the stress field calculated from moment tensor solutions. We also discuss the earthquake-generating stress in VLF earthquakes that occur within the accretionary prism.

Three principal stress directions and the stress ration, R, are estimated from suitable double-couple solutions of the moment tensor solutions for VLF events. First, maximum shear stress on two nodal planes of a double couple solution in a stress filed described as three principal stress directions and stress ratio are computed using formulation by Armijo et al., 1982. Next, a nodal plane with a smaller angle between maximum shear stress and slip vector of a double-couple solution than that of the other nodal plane is selected as the fault plane. We search for the minimum summation of the angles of all events and simultaneously calculate the three suitable principal stress directions and the stress ratio by using the grid search algorithm.

We used the moment tensor solutions of the VLF events that occurred from Jan. 2003 to Aug. 2006 along the Nankai Trough. The events are divided into three categories on the basis of where they occurred: off Kumano, off Muroto, and Hyuga-nada, where 38, 13, and 24 events occurred, respectively. The stress field is calculated for the three regions.

The results for the off-Kumano region show that the maximum principal stress direction is perpendicular to the trough axis. The intermediate principal stress is in the vertical direction; the minimum principal stress is parallel to the trough axis, and the stress ratio is 0.65. The maximum principal stress direction is consistent with that estimated from the borehole breakout image obtained at drilling sites (Kinoshita et al., 2008). It is not consistent with the convergent direction between the Philippine Sea Plate and the Amur Plate. We also obtained similar results for the off-Muroto region: the maximum and minimum principal stresses are perpendicular and parallel to the trough axisl, respectively. In Hyuga-nada, the maximum principal stress is perpendicular to the trough axis, and the stress ratio is 0.85; in contrast, the minimum principal axis appears to lie along the vertical direction.

These results suggest that the earthquake-generating stress in VLF earthquakes that occur within the accretionary prism is described by a compressional stress field with the maximum principal stress perpendicular to the trough axis.