Electrical conductivity structures around seismically locked regions

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Existence of fluid on seismogenic zones has a key role on great earthquakes because high pore pressure in a fault zone allows sliding at low shear stress. Electromagnetic surveys have revealed fluid distribution in seismogenic zones (e.g., Unsworth et al., 2000) because enhanced electrical conductivity at subsolidus temperatures is principally controlled by the presence of water. In this study, I review two conductivity structures across seismically locked regions (so called asperity): The Nankai and Atotsugawa regions. Then, I conclude a hypothesis of relation between the locked regions and fluid.

Land and marine magnetotelluric surveys in the Kii peninsula, the Kumano basin and the Nankai Trough, off the Kii peninsula, southwest Japan, were carried out in 2002-2004 (Goto et al., 2003). The 1944 Tonankai earthquake (M 7.9) below the Kumano basin is one of the typical mega-thrust earthquakes recurred along subduction zones. Recent seismicity in the rupture zone is quite low (Obana et al., 2003), so that the Kumano basin is one of the best fields to elucidate characters and mechanisms of the seismically locked zone on the subducting plate. Goto et al. (2003) estimated an electrical conductivity model below the seafloor, in which the Philippine Sea plate has a conductive oceanic crust before subduction. As the plate goes down the Kumano basin, the conductivity becomes low at the depth of 10 km below the seafloor, which approximately coincides with the up-dip limit of the Nankai mega-earthquake zone. Kasaya et al. (2005) tried a joint modeling by using land and marine data, and their preliminary model shows that the Philippine Sea plate becomes more conductive (with 0.1 S/m) again below the depth of 30 km, around down-dip limit of the earthquake zone.

Seismicity along the Atotsugawa Fault, located in central Japan, shows a clear heterogeneity. The central segment of the fault with low-seismicity is recognized as a seismic gap, although a lot of micro-earthquakes occur along this fault (Ito and Wada, 1999). The electrical conductivity structure investigated across the central segment of the Atotsugawa Fault (Goto et al, 2005) indicates a shallow, high conductivity zone along the fault to a depth less than 1 km. The model shows an underlying low conductive crust at the depth of about 5 km below the fault trace. Comparing the conductivity models across the Atotsugawa and other large strike slip faults such as the San Andreas Fault, Goto et al. (2005) conclude that the low conductive crust is a common feature of a locked fault segment. Goto et al. (2005) also reported a conductive lower crust below the fault trace, where micro-earthquake activity is relatively high.

In the two cases, the shallower and deeper structures of the seismically locked zones have relatively high conductivity. Because of the low temperature, these surrounding high conductive zones are explained by existence of fluid. In the other words, the seismically locked zones are commonly characterized as low conductivity and less fluid condition. Note that not only the fault zones, but also the surrounding area of the fault zones show low conductivity. This conclusion is consistent with theoretical and experimental results in which high-fluid content can make a fault slide easily and low-fluid content prevents a fault slip at low stress condition. Thus, electromagnetic surveys reveal a possible relationship between fluid content and a seismically locked zone with potential of great earthquakes: less fluid condition around subducting plate and fault zone is related to mega-earthquake zones.