Seismic structure of subducted Philippine Sea plate near the slow slip events in the southern Ryukyu arc

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Seismic coupling of the Ryukyu subduction zone is assumed to be weak from the lack of historical interplate large earthquakes. However, recent investigation of repeating slow slip events (SSEs) (Heki & Kataoka, 2008), shallow low frequency earthquakes (Ando et al., 2012), and source of 1771 Yaeyama mega-tsunami (Nakamura, 2009), showed that the interplate coupling is not weak in the south of Ryukyu Trench. The biannually repeating SSEs (Mw=6.6) occur at the depth of 20-40 km on the upper interface of the subducted Philippine Sea plate beneath Yaeyama region, where earthquake swarms occurred on 1991 and 1992. To reveal the relation among the crustal structure, earthquake swarms, and occurrence of SSEs, local earthquake tomography and receiver function (RF) analysis (Langston, 1979) were computed in the southwestern Ryukyu arc.

A tomographic inversion was used to determine P and S wave structures beneath Iriomote Island in the southwestern Ryukyu region for comparison with the locations of the SSE. The seismic tomography (Thurber & Eberhart-Phillips, 1999) was employed. The P- and S- wave arrival time data picked manually by Japan Meteorological Agency (JMA) are used. The 6750 earthquakes from January 2000 to July 2012 were used. For the calculation of the receiver function, the 212 earthquakes whose magnitudes are over 6.0 and epicentral distances are between 30 and 90 degrees were selected. The teleseicmic waveforms observed at two short-period seismometers of the JMA, and one broadband seismometer of F-net of National Research Institute for Earth Science and Disaster Prevention were used. The water level method (the water level is 0.01) is applied to original waveforms. Assuming that each later phase in a RF is the wave converted from P to S at a depth, I transformed the time domain RF into the depth domain one along each ray path in a reference velocity model. The JMA2001 velocity model is used in this study.

The results of tomography show that the low Vp and high Vp/Vs anomalies are distributed along the hypocenters in the subducted slab. The plate interface is about 10 km above the slab earthquakes from the trace of negative RF amplitude (Fig. 1). The slab earthquakes are distributed along the trace of positive RF amplitude. Therefore the slab earthquakes occur near the oceanic Moho of the PHS. The fault depth of the SSEs corresponds to the plate interface within 5 km.

The fault-planes of the SSE are located above the low Vp and high Vp/Vs zone. Assuming that the difference between high Vp/Vs and low Vp/Vs originates to the fluid contents, this would be interpreted that the fluids from the subducted oceanic crust cannot be transported upward and is trapped at the plate interface. The observed strong S-wave reflector (Nakamura, 2001) in the upper interface of the subducted plate also supports the idea. The top of the faults of the SSEs connects to the cluster of earthquake swarms in the lower crust. This suggests that the trapped fluids are transported upward along the faults, accumulates in the lower crust, and induce the swarm of micro-earthquakes in the lower crust.

References

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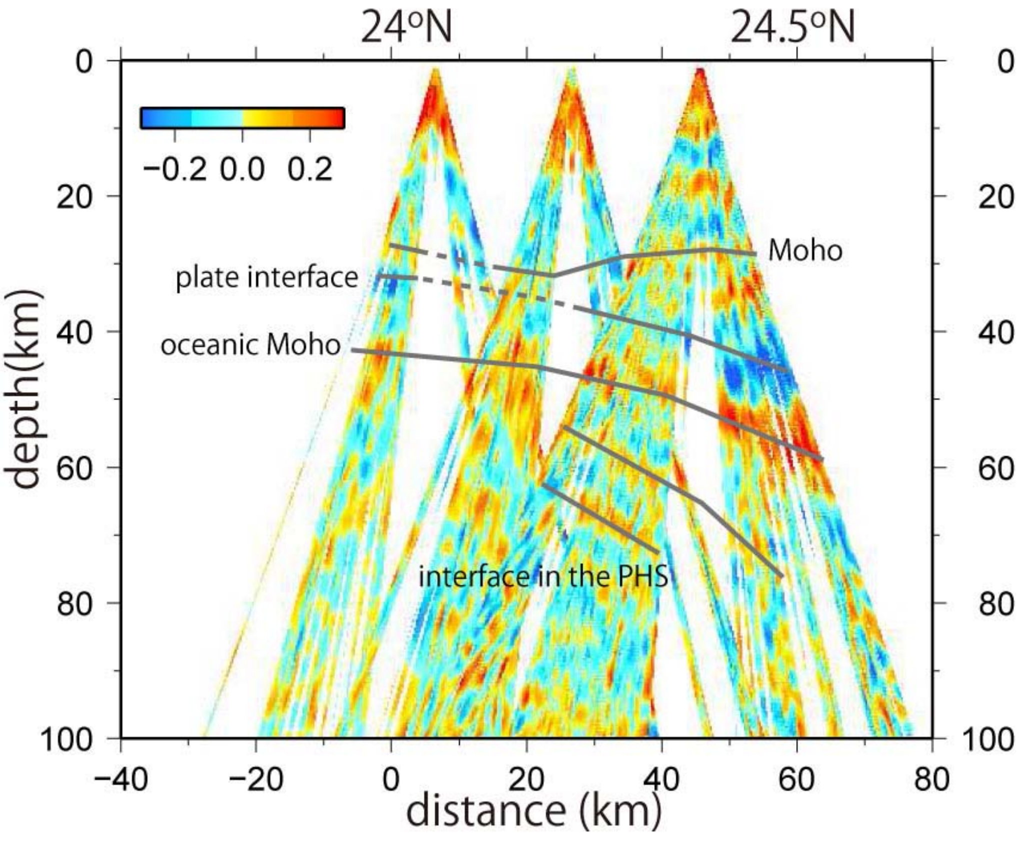

Fig. 1. 2-D north-south vertical cross section of RF along north-south direction (124°E) in Yaeyama region. The color scale denotes the amplitude of the RFs. Red indicates positive amplitudes, while blue indicates negative amplitudes.