立体アレーとHi-netを使った東海地域深部低周波地震の高精度な震源決定
Precise hypocenter determination of deep low-frequency earthquakes in the Tokai area of the Nankai subduction zone using a 3D array and Hi-net

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We have developed a novel method that uses a 3D array to detect the P and S waves of deep low-frequency earthquakes (LFEs) that occur along the Nankai subduction zone of the Philippine Sea plate in southwest Japan. Obtaining accurate hypocenters of LFEs is very difficult because their seismic waves are characterized by low amplitude and the absence of sharp pulses. In particular, identifying P phase arrivals is not readily possible using only conventional seismic networks. To determine their hypocenters accurately not only their epicenters but also their depths we tried to find their P and S wave pairs and obtain S-P times by using a 3D array (6 km x 4 km area) with 14 seismic stations in the Tokai area including ones with deep (600 m at the deepest) borehole seismographs. We observed remarkable LFE activity occurring in the Tokai area over November 10-30, 2010. We calculated the semblance distributions for their seismic waves of 75 LFEs to identify P and S phases and obtained their propagation parameters (back azimuths and incident angles) . Using the back azimuths and incident angles of S waves, and S-P times with high quality result, we calculated the preliminary hypocenters of 15 LFEs by using a shooting method. Referring to those identified P and S phases we manually picked the arrival times of not only both P and S waves of the 3D array stations but also S waves and rarely P waves of Hi-net stations. Using the arrival times we relocated precise hypocenters of the 15 LFEs. Those hypocenters distribute in the depth range from 26 km to 34 km (red stars in Fig.1) approximately along the plate interface (Hirose et al., 2008) inclining in depth from 30 km to 32 km. The errors of those hypocenters estimated from residuals of the arrival times are 0.2-0.9 km in horizontal and 0.4-0.8 km in depth, respectively. By using the same procedure as we explained for LFEs, we also relocated precise hypocenters of 13 regular earthquakes occurring in the subducting Philippine Sea plate. Those regular earthquakes belong to the intra-slab events which are normal-fault or strike-slip type earthquakes, with the T−axis oriented in an E-W direction (e.g. Miyoshi and Obara, 2010). Those hypocenters distribute in the depth range from 35 km to 45 km (light blue squares in Fig.1). We found that the hypocenters of LFEs did not overlap with the regular earthquakes in depth. In Fig. 2 we compared the depth distributions of LFEs and the regular earthquakes with a simple model of inter-plate structure under Tokai area. From Fig.2 we may conclude that LFEs occur not only along a thin subduction interface (less than about 1(?) km in width) but also in the nearly whole layer of oceanic crust and several km width in wedge mantle. And the total depth range of the LFEs obtained from the standard deviation is about 5 km. This distribution of LFEs may support the undrained condition model (Nakajima and Hasegawa, 2016) of enhanced pore-fluid pressure for LFE activity.
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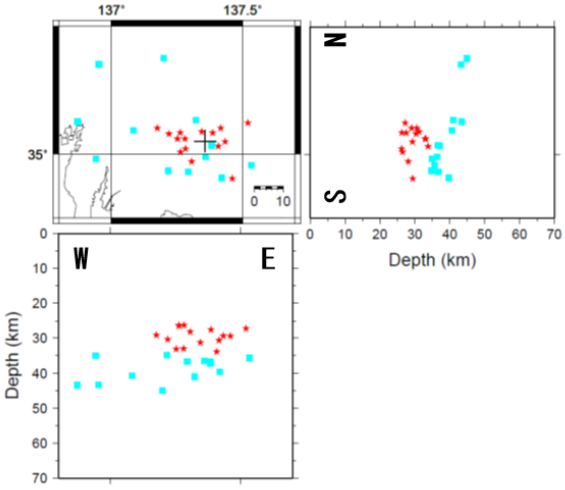

Fig.1. Hypocenter distribution of LFEs (red stars) and regular earthquakes (light blue squares) determined by using the data of a 3D array and Hi-net.

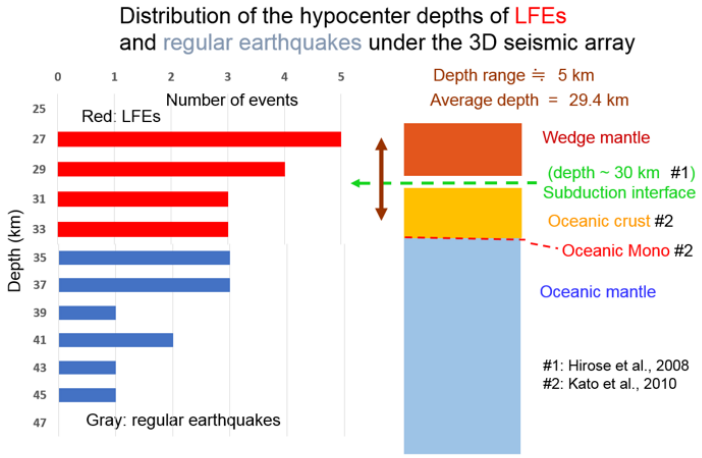

Fig.2. Comparison of hypocenter-depth distributions (left) with schematic inter-plate structure (right).

