Lithospheric heterogeneity and its implications for the low frequency tremors in Southwest Japan

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To better understand the generation of low frequency tremors (LFTs) occurred in the Nankai subduction zone, detailed 3-D seismic velocity (Vp and Vs) and Poisson ratio structures are determined by inverting 181576 P-wave and 159517 S-wave arrival time data from 7572 earthquakes. Then we estimated the crack density, saturation rate and porosity structures using the inverted velocity data along the LFT belt. Our tomographic results together with the estimated crack parameters provide geophysical evidence that the long-duration tremors are closely related to the dehydration reactions of the subducted Philippine Sea plate. Low-Vp, low-Vs, high-Poisson ratio, high-crack density, high-saturation rate and low-porosity anomalies are clearly imaged at depths of 25-45 km along the LFT belt, which may indicate the existence of fluids liberated by the dehydration process of the descending slab. The interpretation accords well with the behavior of the subducted hydrous minerals which are expected to dehydrate at a temperature of about 500 degrees at depths of 40-50 km in Southwest Japan. Under the Kii Channel between the Shikoku and the Kii peninsula and the region between Kii peninsula and Tokai district, small anomalies of high-velocity, low-Poisson ratio and low-saturation rate are visible along the LFT belt, being well consistent with the obervation that no tremors exist under these regions. The seismogenic layer at depths of 5-25 km is generally imaged as continuous high-velocity, low-crack density and low-porosity anomalies along the LFT belt, but the Poisson ratio varies at these depths. At depths of 45-60 km, high-Vs, low-Poisson ratio, low-crack density and low-saturation rate zones are revealed under the Shikoku Island, which may indicate the subducting Philippine Sea slab. Our velocity, Poisson ratio, crack-density and saturation-rate structures together with spatial distribution of the tremors demonstrate that the source region of the tremors is located in a distinct zone that is close to the triple boundaries of the lowermost crust, the mantle wedge, and the interface of the subducting Philippine Sea slab. High pore pressure may accumulate on the surface of the subducting PHS slab in the distinct zone due to a large volume of fluids supplied by the dehydration reaction of the subducted lithosphere in the lowermost crust. The tremors may be caused by the dehydrated fluids migrating in the faults and/or by crack opening, closing and extending along the surface of the subducting Philippine slab below the down-dip limit depth of the thrust zone due to the high pore fluid-pressure and high crack-density under the forearc region of the Nankai subduction zone.