Underplating and dewatering in the Nankai accretionary wedge off Shikoku from seismic reflection data

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We have conducted extensive seismic experiments composed of multichannel seismic reflection (MCS) and ocean bottom seismographic (OBS) studies to understand the nature of the Nankai seismogenic zone off Shikoku since 1997. Based on reflection characteristics, we could identify three major seismic reflection units; denoted "A", "B", and "C". We interpret Unit B as an underplated layer which is formed by duplexing due to decollement step-down. Especially, we could observe very strong, deep-seated reflector with positive polarity along the basal decollement in the DSR zone. Identification of the DSR gives new insight into defining more precisely updip limit to the seismogenic zone.

The Nankai Trough margin is one of the best areas to study large convergent margins interplate earthquakes because periodic large interplate earthquakes have been documented since the 7th century. We have conducted extensive seismic experiments composed of multichannel seismic reflection (MCS) and ocean bottom seismographic (OBS) studies to understand the nature of the Nankai seismogenic zone off Shikoku since 1997. Most of the MCS data were processed for depth imaging, and systematic interpretation was done from the viewpoints of seismic structure and stratigraphy. Some previously-reported MCS profiles were reinterpreted as well.

In this paper, we would like to present the MCS data and discuss tectonics, hydrogeology, and furthermore implication on the updip limit to the seismogenic zone in the Nankai convergent margin off Shikoku. Based on reflection characteristics, we could identify three major seismic reflection units; denoted "A", "B", and "C". Unit A, consisting of both post-Miocene accretionary units and the sedimentary cover, shows a hummocky internal reflection pattern and many landward dipping reflectors which are interpreted as imbricate thrust faults. Unit B, consisting of Miocene to Pliocene Shikoku Basin sediments, underthrusts the overlying accretionary prism along a decollement as the Philippine Sea Plate (PSP) subducts beneath the Eurasia Plate (EP). Unit B shows discontinuous internal reflections. Unit C, consisting of pre-Miocene basaltic rocks of the Shikoku Basin oceanic crust, subducts beneath the accretionary prism with gentle slope. Unit C is characterized by chaotic internal reflections.

It is remarkable that Unit B appears to thicken landward; two or three hundred meter seaward to one or two kilometer landward. We interpret this unit as an underplated layer which is formed by duplexing due to decollement step-down. The topmost reflector of this unit, which actually corresponds to interface between overriding Unit A and Unit B, shows a variety of amplitude change along the MCS profile normal to trench axis. Therefore, we can divide the accretionary wedge into three different zones from deformation front, according to amplitude character of the reflector; apparent decollement reflector (ADR) zone, low amplitude reflector (LAR) zone, and deep-seated strong reflector (DSR) zone.

Especially, we could observe very strong, deep-seated reflector with positive polarity along the basal decollement in the DSR zone. Maximum thickness of Unit B is approximately 2 km in this zone. The DSR may be caused by significant acoustic impedance contrast of material above and below the reflector, probably due to density contrast because the DSR does not show polarity reversal. One explanation for origin of the DSR we propose is diffusive flow model associated with dewatering of clay minerals during smectite-to-illite transformation, which occupy most of Unit B. Hyndman et al. [1997] proposed that stable-sliding smectite clays are dewatered and transformed to stick-slip illite and subduction thrust fault may become seismogenic where the temperature reaches 100-150C, that is, at a 5-15 km depth. Actually, the position of the DSR zone is comparable with the temperature range. Fluid derived from the dewatering, may migrate upward as diffusive flow, leading to density reduction of accretionary sediments immediately above the DSR and thus forming the DSR. Identification of the DSR gives new insight into defining more precisely updip limit to the seismogenic zone. Consequently, we propose that position of the DSR is apparently related to the updip limit to the seismogenic zone. The occurrence of the DSR is not liable to be confined to the Nankai Trough margin. Actually, a reflector similar to the DSR could be also identified in the Costa Rica accretionary wedge.