Nankai Trough seismogenic zone structures revealed by improved 3D seismic images

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For better understanding of three-dimensional structures in the Nankai Trough seismogenic zone, we conducted advanced seismic imaging by applying up-to-date technologies to the 250 km^2 sub-area of the Kumano-nada 3D seismic data acquired in 2006. New reflection image volumes were produced using prestack time migration (PSTM) and prestack depth migration (PSDM) considering anisotropy, after pre-processing which includes the recent broadband processing and the sophisticated techniques to better attenuate noise and multiple reflections. The velocity model was also updated by reflection tomography to optimize the PSDM images. As a result of the new velocity model building, a significant high velocity zone was identified just above the megasplay fault. This high velocity zone is consistent with that in the velocity profile derived by full waveform inversion using wide-angle seismic data (Kamei et al. 2013). On the other hand, anticlinal or fold structures are readily visible just below the Kumano Basin, and dipping reflectors and fragmented reflectors are clearly imaged around 3,500 –5,000 m below mean sea level. The folded and fragmented reflectors possibly denote the presence of multiple thrusts or faults which had been originally developed during ancient accretion process similar to the fold-and-thrust structures in the outer accretionary wedge. Additionally, semblance-based coherence cube, a seismic attribute to extract structural features, calculated from the 3D PSDM volume shows clear deformation patterns due to faulting or folding within the inner accretionary wedge. Further deep area around the edge of the megasplay fault, steeply-dipping reflectors possibly continuing to other anticlinal-shape reflectors in the hanging wall side and gradually-dipping reflectors in the foot wall side are imaged. These layers might imply the original accretionary sediment layers separated by the megasplay fault as like a fault-bend folding. The hanging wall layers may include minor faults and fractures developed during deformation process, and they could act as migration paths for deep fluid. Mineral veins and cemented sand observed in the deep drilling at C0002 site (Tobin et al 2015) suggest possible fluid flow within the accretionary sediments. Such fluid flow might cause mineralization or cementation more efficiently in the deeper sediments under the specific temperature and pressure conditions, that may increase the velocity. The megasplay fault plane has spatial variations of dip angle and reflection amplitude. The extracted megasplay fault geometry has curved surface with downward convex deepening to the north, which is an important factor for estimating the current force distribution along the fault surface. Stronger negative amplitude reflections are mainly mapped in the northeast part around the high velocity layer zone. Those reflections might reflect the existence of the deep fluid along the fault zone. These new seismic profiles are essential for investigating the mega-earthquake threat and correlating with in situ properties from direct sampling and measurements while the deep drilling.

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