Shallow crustal structure and slip tendency of normal faults in the outer rise of the Japan Trench

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The nature of the subducting oceanic plate has a great influence on trench-type earthquakes after subduction. In fact, in the vicinity of the Japan Trench, outer-rise earthquakes that generated huge tsunamis occurred after the occurrence of trench-type giant earthquakes (e.g., the 1896 Meiji Sanriku-oki earthquake and the 1933 Showa Sanriku-oki earthquake). In order to understand the mode of occurrence of these earthquakes, it is important to study the shallow crustal structure of the Japan Trench Outer Rise. For this purpose, we installed the "Portable seismic reflection survey system" of the Atmosphere and Ocean Research Institute, University of Tokyo, on the academic research vessel "Shinsei Maru" and conducted a multichannel seismic survey (MCS) during the KS-19-05 cruise in April 2019 and the KS-20-14 cruise in September 2020. The MCS data have been processed.

The MCS data were processed to show that the seafloor off Iwate-oki and Miyagi-oki is composed of three layers, namely pelagic sedimentary layer, chert, and acoustic basement layer (basalt), from the seafloor surface downward. The normal faults were formed by plate bending during the subduction of the Pacific Plate into the Japan Trench, and a pronounced horst-graben structure developed. Petit-spot volcanoes (Hirano et al., 2006) have been identified on both the Iwate-oki and Miyagi-oki survey lines. The development pattern of normal faults differs depending on the relative position of the petit-spot volcano and the trench axis. Furthermore, in the Iwate-oki line, where the Hirano et al. (2006) petit-spot volcano site A is located, the reflection surface of the chert layer disappears within 75 km seaward of the trench axis, and the reflection polarity at the top of the acoustic basement layer is reversed. Although the perturbation of the acoustic basement of the MCS survey line by the presence of petit-spot volcanoes has been reported in many previous studies, this is the first detection of such a widespread and uniform reflection polarity inversion. To investigate this phenomenon in more detail, it is necessary to refer to the results of other surveys in the same area. In this study, in addition to the "Shinsei-maru" MCS data, MCS data acquired by Japan Agency for Marine-Earth Science and Technology (JAMSTEC) since 1997 are reprocessed to interpret the regional crustal structure in the Japan Trench outer rise.

We use the slip tendency (T_s) proposed by Morris et al. (1996) to evaluate the activity of normal faults in the Japan Trench outer rise. T_s is the ratio of shear stress to vertical stress acting on each fault plane, and previous studies have reported that the larger the Ts value, the more likely the fault is to reactivate and the higher the risk of earthquake occurrence. To calculate T_s, the stress field is first estimated using the stress inversion method proposed by Yamaji et al. (2006) based on the focal mechanism of the earthquake. The data we use are the focal mechanism data earthquakes off Iwate and Miyagi (Obana et al. 2018, 2019, 2021) recorded by ocean bottom seismographs (OBS) installed around the Japan Trench by JAMSTEC and nationwide broadband seismograph network (F-NET) installed by National Research Institute for Earth Science and Disaster Resilience (NIED). Then, the shear stress and vertical stress were obtained by measuring the azimuthal and dip angles of the fault using MCS depth profiles and bathymetric maps. In addition, we calculated the dilation tendency (T_d) proposed by Ferrill et al. (1999) to evaluate the tendency of fault opening.

Preliminary results are as follows: 1) In the Iwate-oki area, other MCS survey lines as well as the "Shinsei-maru" MCS survey line show widespread disappearance of the reflective surface of the chert layer; 2) In the outer ridge of the Japan Trench, there is a discontinuity in the acoustic basement; 3) Faults

located about 20 km from the trench axis have high T_s in the Iwate-oki area, while faults located 40 km from the trench axis have high T_s in the Miyagi-oki area.

Keywords: Japan Trench, Multi-Channel Seismic (MCS) survey , Normal fault, Slip tendency

