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Seismogenic source faults in the eastern part of the Japan sea based on seismic survey

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Previous studies of the crustal structure in the Japan Sea were part of the ODP Legs 127 and 128 (e.g., Tamaki et al., 1992), seismic reflection surveys for oil exploration (e.g., JNOC, 1987), and inferences from ocean-bottom seismometer (OBS) observations (e.g., Nishizaka et al., 2001; Sato et al., 2006). Despite the damages associated with large earthquakes and tsunamis in the eastern Japan Sea, such as the 1964 Niigata earthquake (M 7.5), the 1983 Nihonkai-Chubu earthquake (M 7.8), and the 1993 Hokkaido Nansei-Oki earthquake (M 7.8), the seismogenic zone in the Japan Sea are not well studied because crustal structure data are insufficient.

We conducted marine seismic surveys from 2007 to 2012 to study the crustal structure of the seismogenic zone of the eastern Japan Sea. We used a multichannel seismic system and the ocean-bottom seismographs (OBS) of the research vessels of the Japan Agency for Marine-Earth Science and Technology. The survey areas covered regions from the coast of the Sea of Japan to the Yamato Basin and the Japan Basin. Seismic data were acquired along 47 lines. The data suggests that the crustal structure in the south (from off Yamagata to Noto Peninsula) and the north (from off Akita to Nishi-tsugaru) is different. These differences are critical to understand the relationship between the spatial distributions of seismogenic zones and strain concentration areas.

In the southern part (from off Yamagata to Noto Peninsula), the active structure includes the continental shelf, the Mogami Trough, and the Sado Ridge. These areas represent island-arc crust as deduced from the P-wave velocity and the seismic refraction/wide-angle reflection imaging using OBSs. In particular, the upper-crust P-wave velocity changes because of the changes in the active structure. Large earthquakes (e.g., the 2007 Niigata-ken Chuetsu-oki earthquake, the 1964 Niigata earthquake, and the 1833 Shonai earthquake) in this area occurred in the island-arc crust. On the other hand, the Yamato Basin represent transitional crust between island arc crust and oceanic crust. These two areas are not much deformed.

In the northern part (from off Akita to Nishi-tsugaru), the strain concentration area in the eastern margin of the Japan Sea is divided into three zones. The most eastern of the three zones is along the continental shelf and the Nishi-tsugaru Basin. The crustal structure of this zone is that of an island arc crust and is similar to the southern part. In contrast, the structure of the strain concentration area near 139E corresponds to transitional crust. The 1983 Nihonkai-Chubu earthquake occurred in this region. In particular, the western margin of the hypocentral region exhibits remarkably well formed anticlines and east-dipping reverse faults. In addition, several seismic lines imaged an east-dipping strong reflector that corresponds to a reverse fault. The area of the strong reflector is located in the boundary of the transitional crust and island arc crust that becomes even thicker toward the east; furthermore, the reflector matches the distribution of the earthquake aftershocks very well (Nosaka et al., 1987). Therefore, this reflector is probably the source fault of the 1983 earthquake. The other strain concentration area is also located in the southeastern part of the Japan Basin (between the Matsumae Plateau and the Yamato-tai) about 100 km to the west of the source region of the 1983 earthquake. The crust structure in this area is located near the boundary of the transitional crust and oceanic crust. This area contains reflectors that connect deformation structures, and parts of them reach the lower crust and the Moho. The Japan Basin in the west of the strain concentration area consists of typical oceanic crust without reverse faults and folds.

Keywords: Japan sea, Seismic survey, 1983 Nihonkai-Chubu earthquake, 1964 Niigata earthquake, Multi-channel seismic reflection survey, Ocean bottom seismograph