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Basin formation and inversion of the back-arc, Niigata basin, central Japan: New insight from deep seismic profiling

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Associated with the opening of the Japan Sea, rift-basins have been developed along the Japan Sea coast of northern Honshu. The Niigata basin, central Japan, is one of the such basins and filled by thick (< 8 km) Neogene sediments. By subsequent convergence since the Pliocene, an arc-parallel fold-and-thrust-belt has been developed along the Miocene rift-basins. In this belt devastative earthquakes, such as 1964 Niigata (M7.4), 2004 Chuetsu (M6.8) and 2007 Chuetsu-oki (M6.8) earthquakes, occurred by reverse faulting. Due to thick Neogene sediments, relationship between active faults/folds at near the surface and deep-sited seismogenic source faults is poorly understood. To reveal the crustal structure, in particular geometry of source faults, onshore-offshore integrated deep seismic profiling was undertaken along the two seismic lines in 2008 and 2009. The 2009 Aizu-Sado seismic line is a 135-km-long, onshore-offshore seismic line across Niigata basin and Sado island, which is located in the eastern part of Japan Sea. The 2008 Sanjo-Yahiko seismic line (Sato et al., 2009) is located 20 km south of the seismic line and trending parallel to it. The seismic source was air-gun (3020 cu. inch), four vibroseis trucks and explosives (< 200kg). Along the Sado strait, seismic data was acquired using two-ships to make large offset shot gather. Seismic signals were recorded by ocean bottom cables, cable-connected-recording system and offline recorders, forming a maximum 2400 channels receiver array. The basin fill consists of early to middle Miocene volcaniclastic rocks and overlying Neogene sedimentary rocks showing upward coarsening facies deposited under bathyal to fluvial environment. Main features of basin development, such as early Miocene normal faulting, associated with the formation of Japan Sea, and shortening deformation since Pliocene, are well demonstrated on the seismic sections. Particularly, boundary between pre-Tertiary meta-sedimentary rocks and Miocene volcanics were identified by velocity profile deduced by diving wave tomography and it enabled us to identify the geometry of extensional rift-basin. It is very difficult to distinguish meta-sedimentary rocks from volcaniclastic rocks by seismic facies or pattern of reflections. Fault reactivation of Miocene normal faulting to reverse faulting is common style of deformation. The fault reactivation processes of the eastern boundary fault of the Nagaoka plane, which shows 3 mm/year of late Quaternary vertical slip rate, is well documented by seismic sections. During the extensional deformation associated with Japan Sea, due to progressive “double-door” opening of SW and NE Honshu arcs, transfer zones commonly developed in the Niigata sedimentary basin. Present day the rift-parallel Miocene normal faults reactivated as reverse faults, and their segmentation is strongly controlled by transfer faults formed during the extensional deformation. For better estimation of seismogenic source faults and its segmentation in an inverted rift-basin, the information of basin development plays significant role.