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Imaging of the seismogenic source fault in the fold-and-thrust belt, Niigata back-arc basin, central Japan

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Associated with the opening of the Japan Sea, volcanic rift-basins have been developed along the Japan Sea coast of northern Honshu. The Niigata basin, central Japan, is one of 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 (M7.5), 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 architecture, in particular geometry of source faults, onshore-offshore integrated deep seismic profiling was undertaken along the three seismic lines in 2008, 2009 and 2010. 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 is located 20 km south of the seismic line and trending parallel to it. The 2010 Higashiyama-Mishima seismic line cut through the northern part of the epicentral area of the 2007 Chuetsu-oki earthquake. The seismic sources were air-gun (3020 cu. inch), four vibroseis trucks and explosives (< 200 kg). Along the Sado strait, seismic data was acquired using two-ships to make large offset shot gathers. 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 sedimentary 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 the Pliocene, are well demonstrated on the seismic sections. Particularly, boundary between pre-Tertiary meta-sedimentary rocks and Miocene felsic volcanics were identified by velocity profiles deduced by diving wave tomography and they enabled us to identify the geometry of extensional rift-basin. Fault reactivation of Miocene normal faulting to subsequent reverse faulting is common style of deformation. The 2007 Chuetsu-oki earthquake was produced by thrusting of the Miocene low-angle normal fault, which contributed the formation of rift basin by simple shear extension. During the extensional deformation associated with Japan Sea, due to progressive "double-door" opening of SW and NE Honshu arcs, transfer zones and 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 transverse 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 a significant role.