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Deep Seismic reflection profiling across the back-arc fold-and-thrust belt, central Japan

H. Sato (1), S. Abe (2), A. Takahashi (3), N. Kato (1), T. Iwasaki (1), H. Saito (2), K. Shiraishi (2), and H. Fukasawa (3)

(1) The University of Tokyo, Earthquake Research Institute, Tokyo, Japan (satow@eri.u-tokyo.ac.jp), (2) JGI Inc., Tokyo, Japan, (3) Japan Petroleum Exploration Co. Ltd., Tokyo, Japan

Associated with the opening of the Japan Sea, back arc basins have been developed along the Japan Sea coast of northern Honshu, Japan and the eastern part of the Japan Sea during the early Miocene time. These basins were filled by thick Neogene sediments. By subsequent convergence since the Pliocene, an arc-parallel fold and thrust belt has been developed along the Miocene rift-basins. Along 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. Also, this belt is marked by high-rate of convergence strain observed by dense GPS network and triangle geodetic measurements for past 100 years. To investigate seismogenic source fault is important for better estimation of strong ground motions and mechanisms of earthquake occurrence. However, due to thick Neogene sediments, relationship between active faults/folds at near the surface and deep sited seismogenic source faults is poorly understood. Multi-disciplinal research project to understand the structure and crustal deformation processes along this zone of high-strain rate started in 2008 as a five years project. This project includes earthquake observation by dense linear arrays. In 2008, we conducted the deep seismic profiling to reveal the geometry of active-seismogenic fault systems across the Niigata basin. In the seismic survey, four vibroseis trucks, air guns (1,500 cu inch), and 100 kg explosives were used as seismic sources. Along a 63-km-long seismic line, about 240 vibroseis shots, 400 air-gun shots, 11 high energy shots up to 100 stationary sweeps at each shot point by vibroseis trucks and air-guns, and 2 explosive shots were recorded by 25-100 m spacing receivers, including ocean bottom cable, a cable-linked recorder and off-line recorders. The seismic data were acquired in September, 2008. High-resolution seismic reflection profiling was undertaken across the active faults. The P-wave velocity structure obtained by diving wave tomography analysis, clearly demonstrates the thick Neogene sediment cover. The maximum thickness of the sediments reaches to 7.5 km in depth and shows its maximum in the circum-Japan Sea area. Seismic reflection profile portrays the west dipping reverse fault (western marginal fault of the Nagaoka plain) along the coast of the Niigata plain. By geologic data, the vertical slip rate of 3 mm/y is estimated since 1 Ma. The vertical slip rate of this fault shows its maximum among the active fault in the back-arc side of northern Honshu, Japan. Judging from the geometry of the top of Neogene basement, obtained by velocity structure, and pattern of deformation of post rift sediments, suggested by reflection profile, the basin inversion plays important role for the basin development and shortening deformation processes. This is also supported by off-shore seismic reflection profiles in the eastern part of the Japan Sea and high-angle reverse faulting in the Niigata area obtained by the analysis of focal mechanisms. Such fault reactivation was well documented along the eastern margin of the back-arc basin rift-system of northern Honshu through deep seismic reflection profiling and aftershock observation of recent devastative earthquakes, such as the 2003 Northern Miyagi (M6.4) and 2008 Iwate-Miyagi Nairiku (M7.2) earthquakes. Therefore, to obtain the better estimation of seismogenic source faults, the multi-disciplinal research, including crustal evolution, basin development and careful modeling, will be needed.