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Crustal architecture of an inverted back arc rift basin, Niigata, central Japan

H. Sato (1), S. Abe (2), N. Kawai (3), H. Saito (2), N. Kato (1), T. Ishiyama (1), T. Iwasaki (1), E. Kurashimo (1), M. Inaba (3), and A. Van Horne (4)

(1) ERI, The University of Tokyo, Tokyo, Japan (satow@eri.u-tokyo.ac.jp), (2) JGI, Inc., Tokyo, Japan., (3) Japan Petroleum Exploration Co., Ltd., Tokyo, Japan, (4) Dept. Earth Sciences, Univ. Wyoming, USA

A back arc rift basin, formed during the Miocene opening of the Japan Sea, now uplifted and exposed in Niigata, central Japan, provides an exceptional opportunity to study a back arc rift formed on a short time scale and in a still active setting for the present day shortening deformation. Due to stress build up before the 2011 Tohoku earthquake (M9), two damaging earthquakes (M6.8) occurred in 2004 and 2007 in this inverted rift basin. Deep seismic profiling was performed along four seismic lines between 2008 and 2011. We used onshore-offshore deep seismic reflection profiling to examine the crustal architecture of the back arc basin, in particular the geometry of the source faults. We further applied refraction tomography analysis to distinguish between previously undifferentiated syn-rift volcanics and pre-rift Mesozoic rock based on P-wave velocity. Our findings indicate that the Miocene rift structure created during the extensional phase regulates the style of deformation and the geometry of the source faults in the current compressional regime.

Syn-rift volcanics with a maximum thickness of 6 km filled the fault controlled basins as rifting proceeded. The volcanism was bimodal, comprising a reflective unit of mafic rocks around the rift axis and a non-reflective unit of felsic rocks near the margins of the basins. Once rifting ended, thermal subsidence, and subsequently, mechanical subsidence related to the onset of the compressional regime, allowed deposition of up to 5 km of post-rift, deep marine to fluvial sedimentation, including the Teradomari Formation, an over-pressured mudstone in the middle of the section that later became an important shallow detachment layer. Continued compression has caused fault-related fold and wedge thrusting in the post-rift sedimentary strata which are highly deformed by thin-skin style deformation. Since the Pliocene, normal faults created during the rift phase have been reactivated as reverse faults, including a shallow detachment in the Teradomari Formation which forms a complicated shortened deformation structure. Quaternary geomorphology suggests ongoing shortening. Transform faults inherited from the rift stage control the extent of present day reverse source faults and more importantly, earthquake magnitude.