Structural evolution of the southern margin of the Sea of Japan: implications from recently obtained seismic data

*Johan Claringbould[1], Hiroshi Sato[1], Tatsuya Ishiyama[1], Naoko Kato[1], Shinji Kawasaki[2], Susumu Abe[2]

1.Earthquake Research Institute, The University of Tokyo, 2.JGI, Inc.

The Japan arc is located in a highly active tectonic region, with earthquakes and tsunami hazard on both the Pacific and Sea of Japan side. After the tsunami disaster as the result of the 2001 Off-Tohoku earthquake (M9) along the northeast coast of Japan, the Japanese government initiated an extensive evaluation of the tsunami hazard. Not only does this evaluation span the Pacific coast of Japan, but also the western shore of the Japan arc along the Sea of Japan. To develop a tsunami source-fault model of this area, a better understanding of the present-day structural geometry of this region is necessary. Therefore, the structural evolution of the Sea of Japan is assessed. Here, we examine the development offshore of the San'in region, Kyushu, using a subsurface dataset that covers ~1,000 km^2 including well log data and recently obtained 2D seismic reflection profiles.

The southern margin of the Sea of Japan is a structurally complex area that formed as a result of several tectonic events during the last 25 Ma including: (i) back arc rifting and rotation, (ii) post-rift compression, (iii) weak thrusting, and (iv) strike-slip deformation. This region is previously studied extensively using gravity, paleomagnetic, borehole, and limited 2D seismic data. However, due to the limited spatial and temporal resolution of the data available and methods applied, the development of this region is not yet well constrained. Nevertheless, multiple hypotheses on its structural evolution were forwarded.

We present preliminary results of comprehensive analyses of well data and the seismic profiles obtained in 2013. The 2D seismic reflection profiles were acquired using 1950 cu. in. airgun and 2100 m streamer cable, and have a total length of ~680 km. The profiles were migrated and depth converted, imaging up to 5 km. On the seismic profiles we observe igneous bodies and large basement blocks, as well as rift-related, syn-rift sediment filled grabens and half-grabens, of which some are inverted. These structures are interpreted to be the result of a complicated development, linked to multiple large-scale tectonic events. During the rifting and opening stage (25 –14 Ma), subduction of the Pacific and Philippine Sea plates along the east coast of Japan resulted in back-arc rifting and the initial opening of the Sea of Japan. The rift event is associated with clock-wise rotation of the southwest Japan arc (17.5 –15.8 Ma), with its pivot point located approximately in the south west of the study area. Rift structures filled by syn-rift sediments formed trending parallel to the southwest Japan arc. The opening of the Sea of Japan ceased due to the collision of the Izu-Bonin-Mariana arc system and the Japan arc along the eastern side of Japan. Soon after this event, the former marginal rift zone along the west coast of Japan was exposed to shortening (14 –5 Ma) due to the northward movement of the young Shikoku basin within the Philippine Sea plate. The high thermal buoyancy of the Shikoku basin resulted in resistance along the Nankai trough causing thrusting and selective inversion along previously developed rift structures and the development of the Shinji fold belt. Subsequently, when subduction of the Shikoku basin began (5 –1 Ma), the shortening rate decreased and the deformed structures were covered by sub-horizontal Pliocene sediments. At 1 Ma, a northwesterly shift of the Philippine Sea plate produced a major change in stress regime, causing reactivation of reverse faults to strike-slip. We use the understanding of the development of the southern margin of the Sea of Japan to improve the current tsunami source-fault model.

Keywords: Tsunami source-fault model, Sea of Japan, Seismic reflection data, Structural evolution, Crustal deformation, San'in region

