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Multiple collision and subduction structure of the Izu-Bonin arc revealed by active source seismic data

Ryuta Arai[1*], Takaya Iwasaki[1], Hiroshi Sato[1], Susumu Abe[2], Naoshi Hirata[1]

[1]ERI, Univ. Tokyo, [2]JGI Incorporated

Since the middle Miocene, the Izu-Bonin arc has been colliding with the Honshu arc in central Japan. This collision process is responsible for an extremely complex crustal structure of the Izu collision zone. Geological studies suggested that Koma, Misaka, Tanzawa and Izu blocks were accreted onto the Honshu arc at different ages in the process of collision (e.g. Amano, 1991). In recent years, collision and subduction structure in the Izu collision zone has been revealed by seismic experiments which were performed in 2003 and 2005 as a part of Special Project for Earthquake Disaster Mitigation in Urban Areas (Sato et al., 2005; Sato et al., 2006; Arai et al., 2009). They showed a wedge-like structure of the Tanzawa block and its delamination from the subducted slab in the eastern part, and the aseismic slab subducted beneath the collision zone in the western part. Based on refraction/wide-angle reflection analysis of 2005 Odawara-Yamanashi profile in the western part, this study aims to reveal the whole structure formed by the multiple collision and subduction and to establish the model of crustal deformation process.

A 75-km-long seismic line in NW-SE direction crossed several collision boundaries such as the Sone-Hills Faults, the Tonoki-Aikawa Tectonic Line and the Kozu-Matsuda Faults. Seismic waves from 115 shots were recorded at 1642 stations with an average interval of 50 m. Data quality was so good in the whole profile that not only P wave first arrivals but also P wave reflections and S wave first arrivals were recorded. Refraction tomography analysis (Zelt and Barton, 1998) and forward modeling using ray tracing method (Iwasaki, 1988; Cerveny and Psencik, 1983) were applied to the data set to construct P and S wave velocity models.

The obtained structural models showed strong crustal heterogeneities associated with the multiple collision and subduction processes. One of the important features characterizing the collision structure is that the Sone Hills Faults, located at the northern end of the Izu-Bonin arc, has a southeastward dip, which contrasts with northwestward dips of the Tonoki-Aikawa Tectonic Line and Kozu-Matsuda Faults. Multiple collision and subduction structure of the Misaka, Tanzawa and Izu blocks is summarized as follows.

1)The Misaka blocks is obducted onto the Honshu arc along the southeastward dipping Sone Hills Faults, and forms a pop-up structure bounded by reverse faults on both sides.

2)The Tanzawa block is characterized by crustal stacking bounded by northwestward dipping boundaries.

3)Crustal delamination occurred in the middle crust of Misaka and Tanzawa. The delaminated middle/lower crust of the Izu-Bonin arc was accreted at the bottom of the Honshu crust or subducted deep into the mantle.

4)The whole crustal block of Izu was subducted beneath the Tanzawa block without delamination in the upper and middle crustal level.

5)There exists a northwestward dipping reflector at the depth of 25-35 km beneath the Misaka and Tanzawa blocks, which is interpreted to be the top of the subducted lower crust of the Izu-Bonin arc.

6)Due to a small velocity contrast inferred from amplitude modeling, it is expected that a low velocity layer does not exist at the top of the slab beneath the collision zone, which contrasts with the case of the Nankai subduction zone where the oceanic crust is subducted.

Keywords: Izu collision zone, Seismic wave velocity structure, Refraction/wide-angle reflection analysis, Misaka Mountains, Tanzawa Mountains, Izu Peninsula