Structural Complexity Associated with Arc-Arc Collision in Hokkaido Island, Japan - Review on Controlled-Source Seismic Researches in Western and Central Hokkaido -

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Hokkaido Island has a complicated crustal structure reflecting subduction, accretion and collision processes from Late Jurassic to the present (e.g. Niida and Kito, 1986; Kimura, 1986; Ueda 2016). Central Hokkaido is composed of almost N-S trending geological units of the Sorachi-Yezo Belt (SYB), Hidaka Belt (HB) and Tokoro Belt (TB) from west to east. This region has been highly deformed under the dextral oblique collision between the Eurasia and North America (Okhotsk) Plates and the following westward movement of the Kuril Arc due to the oblique subduction of the Pacific Plate. The latter event has formed the Hidaka Collision Zone (HCZ) with the uplift of the Hidaka metamorphic rocks along the Hidaka Main Thrust (HMT) and the development of the west-verging fold-and-thrust belt with thick sedimentary package on the SYB.

In this paper, we review the previous controlled-source seismic studies in western and central Hokkaido, focusing the structural complexity formed by the arc-arc collision. The first seismic refraction study was undertaken in western Hokkaido in 1968-1969 (Okada et al., 1973). The crust obtained is 20-30 km thick, consisting of 5.9 and 6.6 km/s layers overlying the uppermost mantle of 7.5 km/s. Seismic refraction studies in 1984 and 1992 revealed the complicated structure in central Hokkaido (Iwasaki et al., 1998). The result from the 1984 profile along the Pacific coast is characterized by a rather thick (> 7 km) sedimentary package with a velocity of 2.5-5.5 km/s in SYB. The 1992 refraction/wide-angle reflection profile, which was extended from the western SYB to the eastern TB with SW-NE direction, also show a thick (~8 km) sedimentary package with a velocity of 2.6-5.8 km/s in the southwestern part of SYB, The upper crustal velocity show significant increase from 5.6 km in HB to 5.7-6.15 km in TB.

In 1990’s, several seismic reflection and refraction/wide-angle refraction experiments were undertaken in the southern HCZ (Arita et al., 1998; Tsumura et al., 1999; Ito et al., 2000) and the northern HCZ (Iwasaki et al., 2004, 2016). In the southern HCZ, the crustal delamination by the collision was clearly imaged from the reflection data by applying an advanced method of CRS/MDRS stacking (Tsumura et al., 2014). Namely, the upper 22-23 km crust in the Kuril Arc side is obducted along the HMT, while the lower part of the crust is descending almost to reach the Pacific plate. In the northern part of the HCZ, the detailed structure was obtained along the 227-km profile with E-W direction. In the fold-and-thrust belt of SYB, there exists a very thick (> 10-12 km) sediments including two or three velocity reversals. East of this package, several west-verging events are recognized down to a depth of 7-8 km, probably corresponding to the faults and structural boundaries formed by the collision process. The HMT was well imaged both by seismic reflection processing and refraction/wide-angle reflection analysis, along which the crystalline basement is almost outcropped. Beneath these complicated structures, we succeeded in imaging the NE Japan Arc crust which descends eastward to a depth of about 40 km under the hinterland side.

In the northern HCZ, the clear crustal delamination is not seen. The obduction of the upper Kuril crust starts at a deeper crustal level of at least 27-30 km and more easterly (~20 km) of the HMT as compared with the case in the southern HCZ. If the metamorphic rocks outcropped east of the HMT are the same crustal materials at depths shallower than 23 km as in the case of the southern HCZ, the deeper crustal portion originally situated at 23-27~30 km depth must exist in the western side of the present HMT. The very strong and deep reflectors found west of the HMT might result from the mixture of upper crustal (low velocity) materials of the NE Japan Arc and middle/lower crustal (high velocity) materials of the Kuril Arc.

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