The crust and uppermost mantle structure across the central part of the NE Japan Arc revealed from the 2019 onshore seismic refraction/wide-angle reflection profiling

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In 2019, an extensive onshore-offshore seismic expedition was undertaken from the Yamato bank to the Japan Trench across the central part of the NE Japan arc (Sato et al., 2020a, b). This expedition was supported by several funds from MEXTs' projects of "Integrated Research Project on Seismic and Tsunami Hazards around the Sea of Japan" and "2nd Earthquake and Volcano Hazards Observation and Research Program", and from ERI, the University of Tokyo. The onshore seismic line in the NE Japan Arc was laid out from the Shonai Plain on the coast of the Sea of Japan to the eastern margin of the Kitakami Mountains on the Pacific coast, crossing the Dewa Hills, Shinjo Basin, Ou Backbone Range and Kitakami River Valley from west to east. The total length of the profile is about 155 km, on which 1,667 receivers were set to record 24 large energy shots. As seismic sources, we used explosives at 3 shot points and 4 vibroseis trucks with 150 stationary sweeps at the other 21 points.

The preliminary results beneath the onshore line and offshore part of the Pacific side were presented by tomography analyses (Sato et al, 2020a, b, Kurashimo et al., 2021) and ray-tracing technique (Iwasaki et al., 2021). In the present paper, we proceed to model the whole crust and uppermost mantle under the onshore profile from the combined interpretation on tomography and ray-tracing analyses. For the travel-time analysis, we carefully reconstructed the travel time data both for first arrivals and later phases. In the modelling for the crooked part of the onshore profile, "the distance correction" was applied to correct the systematic travel-time shifts arising from the inadequateness of the simple 2D ray-tracing. Deeper structures of the middle/lower crust and uppermost mantle were constructed from travel times of first arrivals and later phases both from land and air-gun shots.

The features of the obtained velocity model were summarized as follows;
(1) The uppermost part of the crust is composed of 4 layers of Vp= 1.6-2.0, 1.8-3.5, 3.7-5.0 and 4.5-5.5 km/s, respectively, representing sedimentary and volcaniclastic rocks. Their geometry shows significant change along the profile line. Actually, their total thickness is 2-5 km in the western and middle parts of the onshore profile, but only 0.5 km beneath its eastern edge. Such structural undulation is well correlated with fault and caldera systems developed in the surveyed region, representing successive tectonic processes in the NE Japan arc since Miocene.
(2) The crystalline part of the upper crust has a velocity of 5.8-6.1 km/s, which was underlain by the middle crust with Vp of 6.3-6.4 km/s. The thicknesses of the upper and middle crusts are 5-9 and 5-7 km, respectively.
(3) The lower crust with a velocity of 6.5-7.1 km/s is situated in a depth range of 15-30~32 km. This part is composed of 2 or 3 parts and considered to be reflective. Its reflective property, however, shows regional change both in horizontal and vertical directions. The seismic activity in the lower curst is considerably

low as compared with those of the upper/middle crust. The velocity in the lowermost part may exceed 7.0 km/s.

(4) The Moho depth is around 30-32 km, beneath which the upper mantle velocity is estimated to be about 7.7 km/s. These characteristics are rather well constrained both from the onshore-offshore tomography and ray-tracing analysis of the onshore line.

References

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