Spatial variation of lower limit of the shallow inland seismogenic layer in Tohoku, NE Japan

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1. Introduction

Seismicity is active in the Tohoku region, which is located in the Pacific Plate-Eurasian subduction zone. Volcanic activity is also high and the volcanic front is formed parallel to the Japan Trench. Shallow earthquakes beneath the land area are concentrated in mountainous areas along the volcanic front (low-velocity zones in the highly compressed crust) and clustered in the upper crust. It's believed that the lower boundary of shallow seismicity represents seismic-aseismic or brittle-ductile boundary in the crust and is inversely related to temperature (heat flow, geothermal gradient). Undulated variation of the seismogenic layer of the shallow inland earthquakes in the Tohoku region, NE Japan is closely related to the thermal structure. The obtained spatial thickness variation of lower limit of the seismogenic layer in NE Japan is in tight connection with seismic and magmatic activities, crustal deformation and crustal thermal regime and their influence on the crust strength (Hasegawa et al., 2005). This study is an attempt to study thickness of seismogenic layer beneath Tohoku, NE Japan using a relatively new data set.

2. Data and method

Study area is enclosed by 37.00-41.00N and 138.00-142.00E. We relocated inland shallow earthquakes from the comprehensive seismic catalog of Japan, compiled by the Japan Meteorological Agency (JMA), recorded by the integrated seismic observation networks composed of universities (mainly Tohoku University), the JMA, the Hi-net digital stations densely covering the NE part of Japan for the period during 2005-2006. The iterative program VELEST by Kissling (1988), Kissling et al. (1994) is used in this study to calculate 1-D velocity model, appropriate station corrections and earthquake locations simultaneously. Most of the earthquakes are located at depths of 3-15 km. We divided the study area into partially overlapped 10X10 size sub-areas for simplicity and accuracy in calculation. Number of events and stations vary depending on each sub-area. The 1-D model JMA2001 is taken as an initial model with spacing of 2 km from 0 to 8 km depth, 4 km from 8 to20 km depth and 5 km from 20 to 60 km depth. Reference station is chosen based on its location and number of observations.

3. Results

Distribution of precisely relocated earthquakes obtained in this study clarifies depth limit of shallow inland earthquakes. Root-mean-square of travel time residuals drastically reduced from approximately 0.25 sec to 0.07 sec. Stations with negative and positive station corrections are located in local high-velocity zones and low-velocity zones with respect to the reference station, respectively.

Obtained results are in agreement with the results of the previous studies. The depth limit becomes shallower right beneath active volcanoes and deeper in-between them in NE Japan. This approves close, but inverse relationship with temperature effect. Some event clusters show lineated alignment. Subsurface of the study area is divided into the most deformable, seismic upper crust and aseismic lower crust by lower depth of the seismogenic layer.

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