Regional variation of the bottom of seismogenic layer beneath the Japan Islands

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1. Introduction

Complicated geologic and tectonic settings generate eager (high) seismic and volcanic activities in Japan. The volcanic front formed parallel to the trench axis is direct echo of subduction processes and associated magmatic activity. Both deep and shallow earthquakes occur in this region beneath the sea and the land area. Crustal earthquakes in the upper plates are of great interest of many researches, and brittle-ductile or seismic-aseismic transition in the crust has been studied extensively. Shallow seismicity in the upper plates in Japan is restricted to the upper 18 km or so depth of the crust and has a lateral variation: shallow beneath volcanoes and deep in-between them. Seismicity is associated with thermal structure, namely inversely related to temperature (heat flow, thermal gradient). Reliable tomographic imaging of the crust may shed light on compelling reasons of the seismogenic layer undulated variation, its thickness and the crust strength; and precise hypocenter relocation provide spatial variation of the seismogenic layer's lower limit. To do this a tomographic method was applied to arrival-time data from shallow inland events in the unified seismic catalog compiled by the Japan Meteorological Agency (JMA).

2. Data and method

Study area is covered densely by the entire Japan integrated seismic observation network (Kiban network). Tomography method by Zhao et al. (JGR, 1992) has been applied to the arrival time data from local earthquakes up to 50 km depth located beneath the land area during 1998-2008. The study area is divided into partially (1^o) overlapped 4^oX4^o size 8 sub-areas for calculation. The 1-D model JMA2001 is taken as an initial model. The Conrad and Moho discontinuities (Katsumata, 2008) are taken into account. Grid spacing is 0.2^o in horizontal directions and 5 km in depth. In order to avoid uncertainties due to the clusters of events and get even distribution of seismicity, earthquake selection is done. Numbers of events, stations and grid nodes vary depending on each sub-area.

3. Results

Obtained 3D velocity structure images are in agreement with the results of previous studies. Predominant low-velocity zones associated with subduction are visible just beneath or around volcanic front. It is obvious that mantle upwelling is the main driving force of the shallow earthquake generation in these regions. Moreover there are several low-velocity zones related to collision (e.g. Hidaka Mountain Range etc.) and their generation is still not well known.

Crustal shallow earthquakes tend to occur in high velocity zones sandwiched between low-velocity zones on the top and bottom in most areas. There are several regions with exceptionally deep crustal earthquakes like north of Hokkaido, southwestern Tohoku where this picture is not preserved. Earthquakes in these regions take place in and/or around low-velocity zones, which make shape of a bowl sandwiched between high-velocity zones in the west and east. Relocation showed that such deep occurrence is not artifact but genuine.

Subsurface of the study area is divided into the most deformable uppermost layer (sediments etc.), seismic upper crust and aseismic lower crust by the top and the bottom of the seismogenic layer; the bottom of the layer becomes shallower right beneath active volcanoes and deeper in-between them.

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