

Spatial distribution of seismicity bands in the subduction zone of northeastern Japan

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1. Introduction

We have investigated the characteristics of seismicity in the subduction zone of the northeastern Japan. The gross feature of seismicity in the region has been clarified by previous studies, however, recent studies pointed out the relation between the seismicity and the dehydration from the subducting slab. To get additional information about factors that control the seismicity in the region, we classify the seismogenic zones into five zones by referring to the depth difference to the plate boundary, and search for the typical pattern of seismicity in each zone and for the correlation of seismicity among the zones.

2. Depth distribution of plate boundary

We firstly estimated the depth distribution of plate boundary as follows. Based on the earthquake catalog of the Japan Meteorological Agency in the period from 1998 to 2003, we picked up the depth to the boundary at some points with an interval of 0.5 degree in the latitude and longitude direction. The boundary was set to smoothly connect the upper boundary of seismicity in the double seismic zone, the middle part of seismicity to the east of the Pacific coast, and the Japan Trench. The depth data was then interpolated by the bi-cubic spline function to get depth estimate at any location.

3. Classification of seismogenic zones

We have classified the northeastern Japan seismogenic zones into five zones using the depth difference to the plate boundary. Zones 2 and 3 are the seismicity just above (up to 15 km from) and below (down to 15 km from) the plate boundary. Zone 1 is the part shallower than the zone 2, and includes crustal seismicity. Zone 5 is the lower seismic zone in the double seismic zone. Intermediate seismicity between the zone 3 and 5 is classified as zone 4.

4. Characteristics of seismicity

Seismicity in the seismogenic zones defined above is spatially heterogeneous except the zone 3 that is just below the plate boundary. The most significant feature of seismicity is the existence of many seismicity bands with approximate length of 100 km. In the zone 2 the bands are continuously distributed from north to south in the range from 141.5 to 143.0 degrees E, forming a saw-tooth pattern. In the zone 4 the seismically active zones exist beneath the Tsugaru Strait, western off Oga Peninsula, and Kurikoma volcano. These zones have elongated shape and are connected each other forming a saw-tooth pattern as well. The zone 5 contains some clusters subparallel to the depth contour of plate boundary beneath the area from Iwate Prefecture to Hokkaido.

Seismicity in the zone 3 that is just below the plate boundary is quite homogeneous compared to those in the other zones. However, there are some areas of relatively lower seismicity such as beneath the eastern part of Iwate Prefecture.

5. Correlation of seismicity band

Since the seismicity in the zones from 2 to 5 is closely related to the subduction process, the activity among the zones is probably related to each other. The length of seismicity bands that form saw-tooth pattern of seismicity is approximately 100 km. This length roughly coincides with those of the N-S distance between groups of active volcanoes, and between the low-velocity zones in the subducting slab. This suggests the existence of a common mechanism that controls both seismicity and magma generation. The idea of slab buckling beneath the junction between the northeastern Japan and Kuril arcs is one of candidates of such mechanism, but needs thoughtful consideration by collecting available data and by simulating stress state in the region.