Deformation of the Pacific slab beneath the Hokkaido corner by the collision between the NE Japan arc and the Kuril forearc sliver

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1. Introduction

Many large intraslab earthquakes occur in the Pacific slab beneath Hokkaido (the 1981 Western Hidaka earthquake, 1987 Hidaka earthquake, 1993 M7.5 Kushiro-Oki earthquake (Suzuki and Kasahara (1996)). Kimura (1986) and Kimura and Kusunoki (1997) discussed the tectonic setting at Hokkaido, Japan. Hokkaido Island is located at the juncture area of the Chishima (Kuril) and the NE Japan arcs, and the Hidaka mountain range in middle Hokkaido is developed by their collision. Since the late Miocene, in south-eastern Hokkaido, the Chishima forearc sliver has been formed and migrated south-westward because of the strike-slip motion, which is caused by oblique subduction (in a N63W direction at a speed of 83mm/year relative to the North American plate (Demets et al. (1994)) of the Pacific plate from the Kuril trench. It is important to examine how these tectonic situations affect the seismicity beneath Hokkaido.

In this study, we report relocation results using the travel time difference calculated by waveform cross-spectrum analysis, the characteristics of the depth contours of the Pacific plate interface and the focal mechanisms of events within and above the Pacific slab in order to examine the effect of the collision on the seismicity and the tectonics beneath Hokkaido and NE Japan

2. Data and method

We relocated events at depths of 20-300 km for the period from June 2002 to December 2007 from the JMA earthquake catalog beneath Hokkaido and Tohoku, NE Japan. We applied the double-difference hypocenter location method (DDLM) by Waldhauser and Ellsworth (2000) to the arrival time data of the events. We adopted a P- and S-wave velocity structure model used in the routine procedure of hypocenter locations in Tohoku University [Hasegawa et al., 1978a]. We use relative earthquake arrival times determined by both of the waveform cross-spectrum analysis and the catalog-picking data. In waveform cross-spectrum analysis, we selected event pairs with an epicentral separation of less than 20km and picked up arrival time difference of the pairs, whose waveforms coherence average value are larger than 0.9. We also determined focal mechanisms of events within and above the slab using P wave polarity and estimate the depth of the plate interface using the depths of repeating earthquakes and the locations of the low-angle thrust fault type events.

3. Results and discussion

1) The shape of the plate interface in this study is similar to that observed in previous studies [Hasegawa et al., 1994; Zhao et al., 1997; Katsumata et al., 2003] except for the arc-arc junction area between Hokkaido and Tohoku. Beneath the arc-arc junction area we found two clear ridges of the Pacific plate running in the NW-SE direction beneath Hidaka mountain range and the Oshima- peninsula. This shape seems to be formed by the local downward dent of the Pacific slab caused by the collision of the Kuril fore arc sliver and the NE Japan arc.

2) The seismicity in the Pacific slab beneath the arc-arc junction is less active than those in the surrounding areas (the Kuril fore arc area and NE Japan fore arc area). On the other hand, the seismicity above the Pacific slab beneath the arc-arc junction is very active. This seismicity above the slab is located at the area from the Hidaka mountain range to the Oshima-peninsula at depths of 20-70km.

3) Focal mechanism of the events above the slab beneath the arc-arc junction area includes the compressional type. The strikes of the P axis of the events above the slab show almost NE-SW, which correspond to the direction of the collision of the two arcs. On the other hand, focal mechanisms of the events in the upper plane of the double seismic zone beneath the arc-arc junction area includes the thrust type events and strike slip type ones. The strikes of the P axis and T axis of the strike slip type events in the upper plane show respectively almost the NW-SE and the NE-SW.