Characteristics of X-phases observed 5-10 s after direct P waves for earthquakes occurring off Tokachi, Hokkaido

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The northeast Japan and Hokkaido are among the most seismically active areas in the world. To understand the mechanism of the earthquakes in this region it is important to estimate the locations of hypocenters in relation to the subducted plate configuration correctly. Umino et al. (1995) found X-phases between direct P waves and S waves for shallow earthquakes occurring off Sanriku region on of vertical components. They interpreted the X-phases as being the sP waves reflected and converted at the sea bottom and used the sP waves to relocate the focal depths. In this study, we investigated similar X-phases for earthquakes occurring off Tokachi, Hokkaido, region. The high seismic activity off Erimo to Kushiro after 2003 Tokachi-Oki earthquake provided a lot of data for this study in a short term. We used data from Hi-net during the period of June 2002 to Oct 2004. Reading the records from 418 earthquakes (M3.5-5.9), we found 346 X-phases from 83 earthquakes.

To find out the origin of the observed X-phases, we calculated the travel times and amplitudes for probable rays using 2-D ray tracing program developed by Zelt and Smith (1992). The 2-D velocity structure was assumed by referring to Iwasaki et al. (1989), Shinohara et al. (2004), and Miyamachi et al. (1994). Q-factors of each layer are also assumed properly. When the X-phases are assumed to be the sP waves that convert from S to P phase at the sea bottom, the calculated sP-P times are larger than the observed X-P times, and the calculated amplitudes are smaller than the observed ones. This suggests that the observed X-phases are not the sP waves converting from S to P phase at the sea bottom. Next we assumed that the X-phases are the sP waves that convert from S to P phase at the lower boundary of the uppermost sedimentary layer under the sea bottom. The calculated sP-P times generally agree with the observed X-P times and the amplitudes of sP waves are in agreement with the observed ones. Therefore we consider that the X-phases are the sP waves that convert from S to P phase at the lower boundary of the uppermost sedimentary layer.

Then we used the X-phases to relocate the focal depths. As a result, earthquakes in the coast side are distributed along the plate boundary. Earthquakes in the trench side are distributed within the subducted Pacific plate about 10-20 km below the plate boundary. The depths of the earthquakes are significantly shallower than the lower plane of double seismic zone. It remains unsolved whether the earthquakes really occur at those depths or they are the artifacts caused by the misinterpretation of the origin of X-phases.

We could not find X-phases for earthquakes occurring beneath or close to the coastline. According to the results of 2-D ray tracing, sP waves reflected close to the coastline at the lower boundary of the uppermost sedimentary layer do not dive deep into the crust, thereby not being able to reach the stations in the land. It is because in the assumed 2-D velocity model the lower boundary of the uppermost sedimentary layer dip steeply toward the sea in the neighborhood of the coastline.

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