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Evaluation of efficiencies of P-S conversion in the oceanic crust and Vp/Vs estimation

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1. Introduction

In the OBS-airgun records, P to S and/or S to P converted phases have been frequently observed by horizontal seismometers and vertical seismometer/hydrophone, respectively. Using such converted phases, we can estimate S wave structure in the crust and the mantle. In order to evaluate S wave velocities, the precise estimation of P and S velocity structures in the sediments is required. In this paper, we propose an evaluation method for the conversion efficiency of P to S and S to P and obtain S wave structure in the hard rock part of the crust.

2. Method

In the oceanic region, S(V) waves observed in horizontal components are converted from P to S(V) at interfaces with large impedance contrast. We, here, simply evaluate a total energy flux of P-S conversion waves as follows:

1) We estimate efficiencies of transmission and conversion from P to S and/or S to V through the ocean bottom/sediments/hard-rock interfaces.

2) We evaluate relative converted P or S wave square amplitudes at OBS relative to the incident P waves penetrated into the ocean bottom.

3. Results

The conversion from P to S occurs at (a) sediments/hard-rock interface or (b) seawater/bare rock interface. The case (a) occurs at the presence of thin unconsolidated sediment layer (P-wave velocity, Vp is less than 2.2km/s, S-wave velocity, Vs is less than 1.0 km/s) more than tens meters underlined by sedimentary rocks or hard rock layer (Vp is greater than 2.5km/s, Vp/Vs ratio is about 1.78). Such interface is often called as an acoustic basement by reflection seismics. The case (b) corresponds to bare rock layer exposed at the ocean bottom.

For the present study, we assume the conversion occurs only at the ocean bottom and sediment layer /hard-rock interface and calculate the conversion rates in terms of relative energies. Among possible seven phases, large conversions are expected for (i) sediments/hard-rock interface at the incident side, (ii) at the ocean bottom of incident side, and (iii) at the sediments/hard-rock interface just beneath an OBS. Both of (i) and (ii) travel through whole crust as S wave. In the case of (iii), P wave converts to S wave only at the sediments/hard-rock interface just beneath an OBS.

4. Examples

We examined real OBS-arigun data observed in the western part of the Pacific Ocean. It was found that most of conversions were observed on horizontal seismographs and they fit to the cases of (i) and (iii) for most of OBS records by comparing P-wave velocity crustal structure. The Vp/Vs ratios were estimated to be 3 to 20 for sedimentary layers whose Vs were to be 1.6-2.0 km/s beneath the western Pacific Ocean. Vs values were consistent with those measured by Hamilton (1976, 1979).

We also found that Vp/Vs values of the upper and lower parts of the oceanic crust were extremely constant (i.e., 1.78) in the western Pacific and the ocean basins of NE Philippine Sea. We did not found Vp/Vs values of 2.0-2.5 which indicates the fractured crust and serpentinized mantle. On the other hand, Sn arrivals in two horizontally perpendicular directions suggest the presence of the anisotropy in the upper-most mantle. Although the Vp/Vs value in the upper-most mantle was 1.73, those in some areas were less than 1.70. We report the details and interpretation of Vp/Vs in the crust and the mantle.

5. Conclusion

Because sea water can transmit only P wave, we have to use converted S waves in the crustal structure studies in the ocean region. Using converted phases from P to S and S to P waves, we can estimate the conversion rates and estimate the Vp/Vs in the crust.