Moho Discontinuity Studies Beneath the Broadband Stations Using Receiver Functions in South Korea

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1. INTRODUCTION

The Korean Peninsula, which lies within the Eurasian plate, has been regarded as a seismically stable land of cratonic nature. Modern seismic activity in the Korean Peninsula is also relatively low as compared to that in the neighboring regions including China and Japan. Therefore the deep crustal velocity models of the Korean Peninsula have not well been defined due to lack of sufficient data. The crustal structure of the Korean Peninsula was studied by using travel time analysis of some local earthquakes (Kim and Kim, 1983; Kim and Lee, 1994) and local tomography method(Kim and Li, 1998a and 1998b). The investigation by using explosive sources was carried out in the southern part of Korea (Kim and Jung, 1985; Kim and Lee, 1996). For INCN, PHN, and KSRS stations, vertical velocity structures were studied using receiver function method (Lee, 1997; Kim et al., 1998). However it is difficult to find consistency from their crustal models due to insufficient data, sparse network, data quality, network span, a low seismic activity, etc. In this study we examine the crustal structure beneath the broadband seismic stations of a newly installed network (KMA) and INCN(IRIS) station in South Korea by receiver function analysis and compare the crustal structure with seismic local tomography and other geophysical studies.

2. NEW NETWORK AND BROADBAND DATA

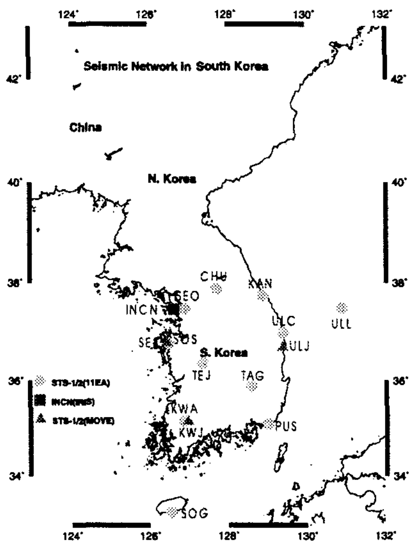

Fig. 1

Since 1999, the Korea Meterological Administration (KMA) has operated the seismic network of 11 stations which seismometer systems (sensor /recorder) are STS-1/Q680 at KWA/KWJ (Kwangju) station, and STS-2/Q4120 at CHU (Chunchon), SEO (Seoul), TEJ (Tejeon), SOS/SES (Sosan), KAN (Kangnung), ULC/ULJ (Ulchin), TAG (Taegu), ULL (Ulung-do), SOG (Sogwipo in Cheju island) and PUS(Pusan) stations. Each station has a continuous and triggering data stream. The sampling rate for triggering stream is 100 SPS(samples per second) and for continuous data stream is 20 SPS. INCN(GSN, IRIS) station has been operating since June, 1996 with a broadband systems of STS-1/Q680. Fig. 1 shows broadband seismic stations (circles for KMA, squares for INCN, and triangles for moved KMA) in the Korean Peninsula and Table 1 indicates station parameters of location, elevation, and sensor types. We only acquired data occurred in the same epicenter(i.e. New Britain region events) and some big earthquakes like Turkey, Sumatra, and India events, and in order to enhance the data quality and to find a coherence phase among the individual receiver functions.

3. INVERSION PROCESS AND RESULTS

The wide application of a receiver function technique has produced several complete descriptions of the receiver function methodology(e.g. Langston, 1979; Owens and Zandt, 1985; Owens, 1987; Ammon et al., 1990; Ammon, 1991; Cassidy, 1992). A time domain receiver function inversion(Ammon et al., 1990) is applied to determine crustal velocity structure beneath the stations. The initial crustal model constituted by many thin, flat-lying, homogeneous layers assuming $V_p=\sqrt{3}\,V_s$ and $\rho=0.32V_p+0.77$ (Berteussen, 1977), where ρ(g/㎤), V_p, and V_s represent density, P- and S-wave velocity assuming a Poisson's ratio of 0.25. The resulting receiver functions (water-level=0.001 and Gaussian filter=2.5) from events clustered both in distance and back azimuth are then stacked in the time domain to obtain a single estimate of the horizontal receiver function. Stacking deconvolved traces from the individual events averages small difference in the estimated mean receiver functions and improves the signal-to-noise ratios. The earth structure is parameterized by a series of plane horizontal layers, and an iterative procedure is used to minimize the residual difference between the radial receiver function and the synthetic predicted by the structure. The inversion model is parameterized with 1.0 km thick layers in the shallow crust (upper 4 - 10 km) and 2-3 km thick layers to a depth of 45 km assuming compensation depth of gravity. We used small amount of a smoothness during inversion (smoothness parameter σ=0.1 to 0.3). For the receiver function inversion, the initial models for each stations are generated 36 different initial models by perturbing them with a cubic polynomial in depth scaled to the maximum value of 1.0 km/sec and 10% random component. The inversions quickly converge within five iterations. We repeat inversions for each perturbed initial model to find reasonable velocity model. In this study we selected five velocity models which are Model A (Kim and Kim, 1983), B (Kim and Jung, 1985), C (Kim and Lee, 1994), D (Kim and Li, 1998a and 1998b), and E (IASPEI91 Model from Kenett et al., 1995) as an initial model for inversion (see Fig.3)

From the inversion results, the crustal thicknesses of INCN, SEO, SOS, TEJ, KWA, CHU, and

KAN stations are similar to the average crustal thickness(28-32 km) and velocity of the Moho(Vp=7.7-7.9 km/sec) of the Korean Peninsula by Kim and Li(1983), whereas those of TAG and PUS stations show abnormally thick crust($h \geq 33$ km) and high velocity of the Moho($Vp \geq 7.9$ km/sec) compared to the previous studies(Kim and Kim, 1983; Kim and Li, 1998a,b). We can infer these results using teleseismic receiver functions to more sensitive vertically compared to reflection and local tomography studies using the local events.

4. DISCUSSION AND CONCLUSIONS

We investigate the vertical velocity models beneath the newly installed broadband seismic network in South Korea by using receiver function inversion technique. The crustal velocity structure beneath eleven stations has been determined by inversion modeling of receiver functions, and these results are summarized in Fig. 6 which are simplified with inversion models and shows synthethic and observed radial receiver functions for each station which are well fitted except for CHU and ULC stations. From the receiver function inversion result, we found that crustal thicknesses are 29 km at INCN, SEO, and SOS(SES) stations, 28 km at KAN station in the Kyonggi Massif, 32 km at TEJ station in Okchon Folded Belt, 34 km at TAG, 33 km at PUS station in the Kyongsang Basin, 32 km at KWJ station(readjusted station by prior KWA station) included in the Youngdong-Kwangju Depression Zone, 28 km at ULC station in the eastern margin of the Ryongnam Massif, and 17 km at ULL station in the Ullung Island of the East Sea, respectively.

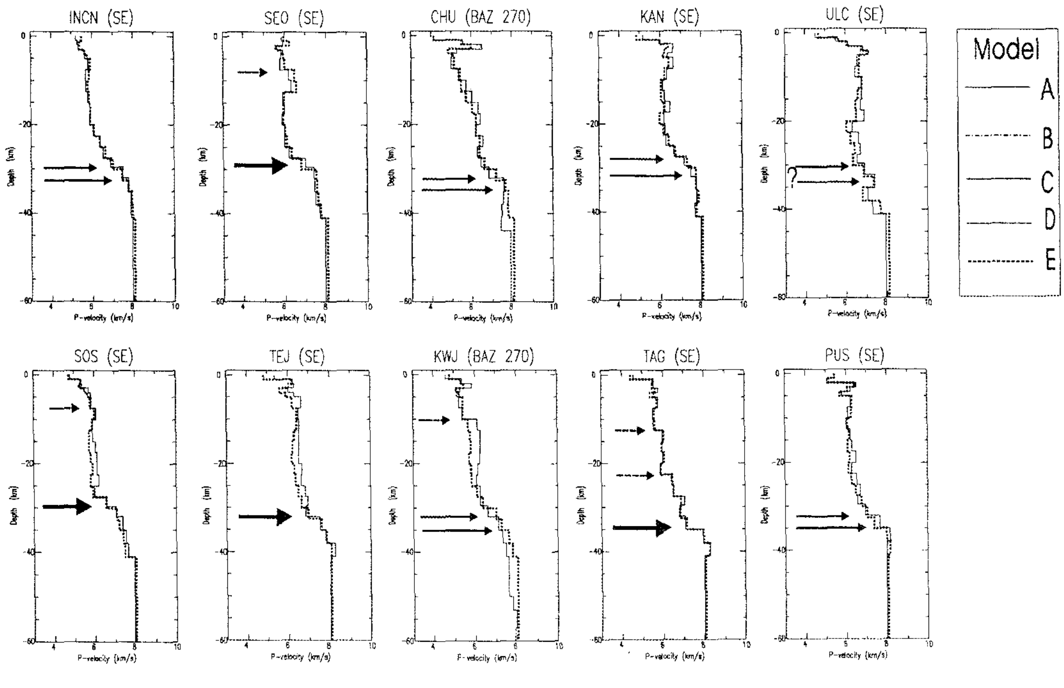

Fig. 4

The Moho configuration of INCN, SOS, KWJ, and KAN stations shows a laminated smooth

transition zone with a 3-5 km thick. The upper crust(~5 km) of KAN, ULC, and PUS stations show complex structures with a high velocity. The unusually thick crusts are found at the TAG and PUS stations in the Kyongsang Basin compared to the thin (29-32 km) crust of the western part (INCN, SEO, SOS, TEJ, and KWA stations). The crustal thickness beneath Ullung Island (ULL station) shows the suboceanic crust with about 17 km thickness and complex with a high velocity layer of the upper crust, and the amplitudes of Ps waves are relatively large compared to those of incoming waves in the western direction.

Key words : teleseismic receiver function, inversion model, crust-mantle boundary, receiver structure

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