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1D velocity structure beneath broadband seismic stations in the Cretaceous Gyeongsang Basin of Korea by receiver function analyses

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ABSTRACT

The crustal velocity structures beneath four broadband seismic stations (GKP, GSU, HDB, and BUS) in the Cretaceous Gyeongsang Basin, southeastern Korea, are estimated by using receiver function analyses employing teleseismic waveforms. The genetic algorithm is adopted to avoid the inherent non-uniqueness problem of the inversion. The inversion results are constrained by surface-wave dispersions to complement the shortcoming of the receiver function. The selected records of earthquakes distributed in three quadrants from each seismic station in the years from 2002 to 2005 are analyzed. Although limited quantity of data is used due to short operation periods, the resolution and confidence level are expected to be better than those using less data.

The Moho depth under GKP is estimated to be 30 km showing no distinctive indication of dipping. This depth is well coincident with those in nearby velocity cross-sections obtained from crustal-scale seismic profiles compared to the 36-km deep Moho previously reported by other independent work. At GSU the Moho appears at the 32-km depth and a distinct low-velocity anomaly is detected at the depth of about 10 km. They agree with those in the velocity tomogram of the nearby survey line. An adakitic intrusion which results from the partial melting of a young and hot subducted oceanic crust in the basin during the Cretaceous is suggested as a possible geologic interpretation of the low-velocity zone. The Moho beneath HDB is 28-km deep, and agrees with those in nearby velocity cross-sections obtained from crustal-scale seismic profiles. This Moho depth at HDB is rather shallower than those of other stations. The significant P_S phase amplitude and arrival time differences in the radial receiver functions conclude the Moho to dip southwestwardly. This is supported by polarities of direct P and P_S in transverse receiver functions. Beneath BUS, P wave velocity increases gradually from the 32-km depth and it reaches 7.6 km/s at the 36-km depth. The Moho discontinuity beneath BUS is thought to be at an around 35-km depth.

1. Introduction

The crustal velocity structure is one of the most important subjects in seismology because it controls seismic wave propagation as well as provides fundamental geological and geophysical information. Traveltimes of seismic phases are most widely used for the velocity structure studies since it is easy to obtain from earthquake records. The data, however, lack the continuity of phases in Korea since seismic stations are sparsely distributed and earthquakes of magnitude larger than 5 have not frequently occurred. Subsequently, many uncertain crustal velocity models came out and they have been under controversy (e.g., Lee, 1979; Kim and Kim, 1983; Kim, 1995). Korean Crust Research Team (KCRT), has systematically approached to obtain reliable high resolution 3D crustal velocity structures of the Korean Peninsula area by earthquake data inversions and deep seismic profiling (e.g., Chang et al., 2004; Chang and Baag, 2005; Cho et al., 2006; Kim et al., 2007). The map showing the seismic profiles with 4 broadband seismic stations analyzed in this work is presented in Fig. 1. Two velocity cross-sections, the one for the 2002 WNW-ESE line and the other for the 2004 NWN-SSE line are presented in Figs. 2 and 3, respectively (Cho et al., 2006; Kim et al., 2007). Meanwhile 1D velocity structures beneath all 22 broadband seismic stations in the southern Korea were estimated by receiver function analyses, and the Moho depth distribution and the average crustal P wave velocities were reported (Chang et al., 2004; Chang and Baag, 2005). The reported Moho depth distribution is presented in Fig. 4 for the comparison purpose. At a glance, some discrepancy in the Moho depth around GKP can be found. The reported Moho depth beneath GKP by receiver function analyses is 36 km (Fig. 4) while those around GKP in the 2002 WNW-SES velocity cross-section are around 30 km (Fig. 2). Modern broadband seismic network has been installed in South Korea

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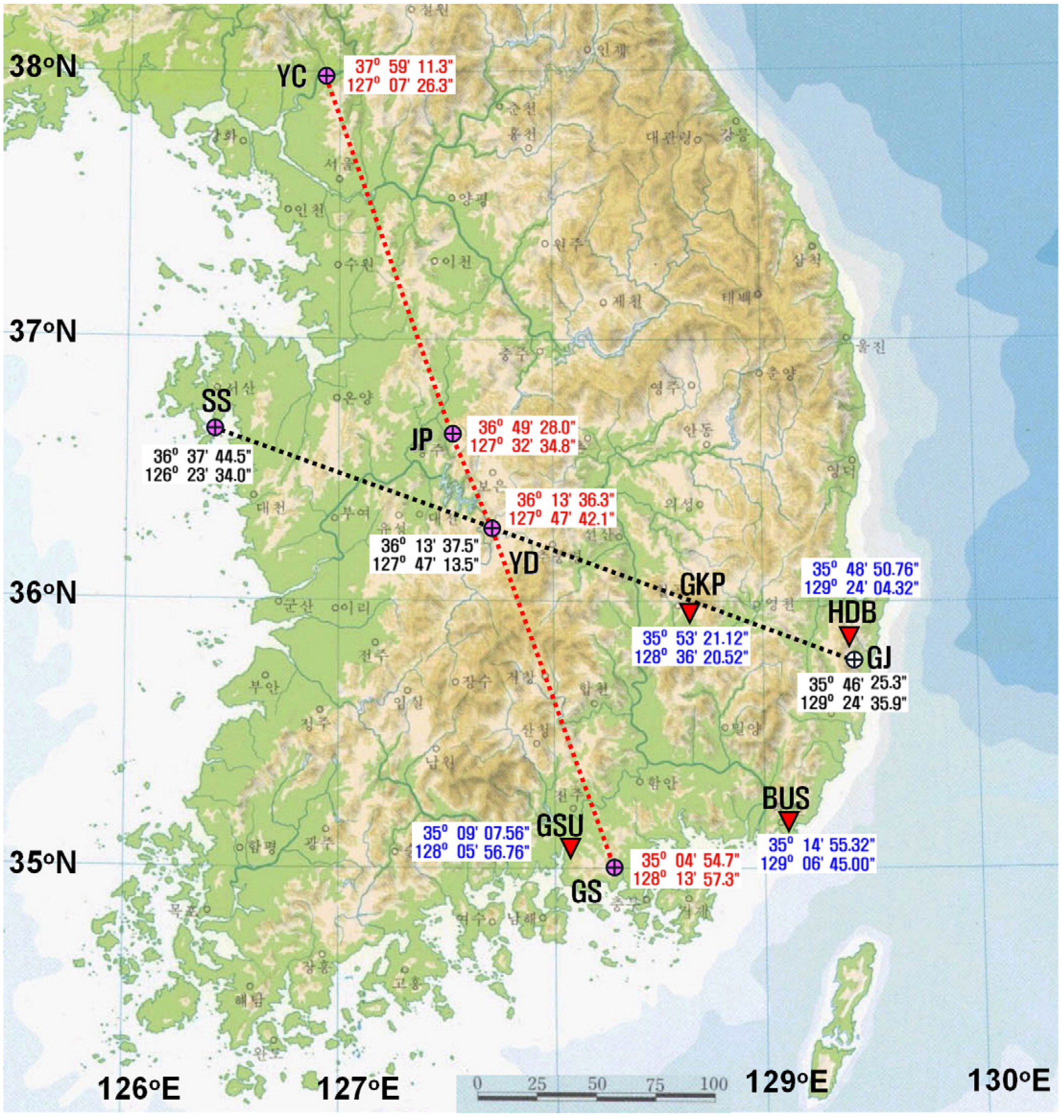

Fig. 1. Index map showing locations of the KCRT2002 (black dotted line) and KCRT2004 (red dotted line) crustal-scale seismic survey lines, and 4 broadband seismic stations in the Gyeongsang Basin. The topography is presented in color. Shot locations in the survey lines are presented by oplus symbols with abbreviated names and coordinates in the same index color. The seismic stations are presented by red inverted triangles with station codes and coordinates in blue. Abbreviated shot location names and seismic station codes are: SS; Seosan, YD; Yeongdong, GJ; Gyeongjoo, YC; Yeoncheon, JP; Jeungpyeong, GS; Goseong, GKP; the Kyungpook National University Station, HDB; the Hyodongri Station, BUS; the Busan Station, and GSU; the Gyeongsang National University Station.

since 1996, and Chang and Baag (2005) should use limited data in their receiver function analyses. Especially four stations – GKP, GSU, HDB, and BUS – in the Gyeongsang Basin have been operated since 1998, 2000, 2000, and 2001, respectively. They could use only three earthquake data for GKP, GSU, HDB, and PUS each. It is worthwhile to note that PUS (35.1010°N, 129.0338°E) has moved to BUS (35.2487°N, 129.1125°E) in 2001. The coordinates of four stations are presented in Fig. 1. The Gyeongsang Basin is furthermore important in geology and tectonic setting of the Korean Peninsula.

The purpose of the present work is to estimate the crustal velocity structures beneath the broadband seismic stations in the Gyeongsang Basin where GKP, GSU, HDB and BUS are located using the joint inversion of receiver functions and surface-wave dispersions. Since recent large earthquake data such as the Sumatra–Andaman Earthquake (Mw = 9.0, 26 Dec. 2004) are to be included in the analyses, not only the signal-to-noise ratio in the data but also the back azimuth coverage should be improved. More reliable velocity structures which may resolve the abovementioned discrepancy between the GKP result of Chang and Baag (2005) and the velocity profiles of Cho et al. (2006) as well as reconcile themselves to some geological features in the Gyeongsang Basin are expected.

2. Geology of the Cretaceous Gyeongsang Basin

Geologic terrenes in Korea include the Nangrim Massif (NM), Pyeongnam Basin (PB), Imjingang Belt (IB), Gyeonggi Massif (GM), Okchon and Taebacksan basins (OB-TB), Yeongnam Massif (YM), and Gyeongsang Basin (GB), from northwest to southeast (see index map in Fig. 5). The Cretaceous Gyeongsang Basin is situated in the southeastern part of the Korean Peninsula (Fig. 5). The basin is bounded on the west and north by the Precambrian metamorphic rocks (i.e., the Yeongnam Massif) as well as the Jurassic granitoids, and is overlapped on the east by the Early Tertiary calc-alkaline volcanic succession intercalated with minor amounts of sedimentary rocks (Fig. 5). An aggregate thickness of more than 9 km of siliciclastic and volcanic strata is preserved in the basin. These strata form the