Journal of Applied Geophysics 66 (2008) 59–69

Contents lists available at ScienceDirect

Journal of Applied Geophysics

journal homepage: www.elsevier.com/locate/jappgeo

Shallow-depth shear wave velocity structure of the Southern Korean Peninsula obtained from two crustal-scale refraction profiles

Heeok Jung [a,*], Yong-seok Jang [b], Jung Mo Lee [c], Wooil M. Moon [d], Chang-Eob Baag [d], Ki Young Kim [e], Bong Gon Jo [b]

[a] Department of Ocean System Engineering, Kunsan National University, Kunsan 573-701, Republic of Korea
[b] Department of Earth and Environmental Sciences, Chonbuk National University, Jeonju, Republic of Korea
[c] Department of Geology, Kyungpook National University, Daegu 702-701, Republic of Korea
[d] School of Earth and Environmental Sciences, Seoul National University, Seoul 151-742, Republic of Korea
[e] Department of Geophysics, Kangwon National University, Chunchon, 200-701, Republic of Korea

ARTICLE INFO

Article history:
Received 3 March 2008
Accepted 7 August 2008

Keywords:
Shear wave velocity
Shear wave attenuation
Rayleigh waves
Upper crust
Korean peninsula

ABSTRACT

Short-period Rayleigh waves from the two crustal-scale seismic refraction profiles, KCRT2002 and KCRT2004, were analyzed to determine the shear wave velocity and attenuation structure of the uppermost crust in different tectonic regions of the Korean peninsula and to examine if this can be related to the surface geology and tectonics of the study area. The refraction profiles were obtained using large explosive sources along a 294-km WNW–ESE line in 2002 and a 335-km NNW–SSE line in 2004. The two refraction profiles, recorded on 2-Hz portable seismometers, contained Rayleigh waves in the period range of 0.2 to 1.2 s, and the distance range up to 30–60 km from the sources. The profiles, which traverse four tectonic regions (Gyeonggi massif, Okcheon Fold belt, Yeongnam massif and Gyeongsang basin), were divided into twelve subsections based on the tectonic boundary and lithology. We obtained shear wave velocity models in the upper 1.5 km of the crust. The average shear wave velocity of the twelve subsections increases from ~2.4 km/s at the surface to ~3.2 km/s at 1.5 km depth. Overall, the shear wave velocities for the Okcheon fold belt and Gyeongsang basin are lower than those for the Gyeonggi and Yeongnam massifs by ~0.3 km/s. Shear wave velocity differences also exist among the subsections within the same tectonic region when there are distinct differences in lithology. We obtained the values of Q_β^{-1} in the upper 0.6 km. Q_β^{-1} for the Okcheon fold belt (~0.025) is approximately twice larger than Q_β^{-1} for the massif areas (~0.012). The low shear wave velocity and high attenuation for the Okcheon fold belt seem to be related to the rock types of the area, which are mostly conglomerates and phyllites.

1. Introduction

Short-period Rayleigh waves are important because they can be used to obtain the shear wave velocity structures in the upper few kilometers of the crust. The shallow-depth shear wave velocity structure is an important factor determining the seismic wave propagation, ground motion, the degree of earthquake damage, etc. This has been well recognized in many studies. For example, Davis et al. (2002) showed that damage by the Northridge earthquake was intensified by the focusing of seismic waves by several acoustic underground lenses at depths of about 3 km. Brocher et al. (2000) also provide a clear example of the importance of shallow-depth shear wave velocity structures in the amplification of seismic wave amplitude by the Seattle Basin that occupies the upper few kilometers of the crust.

Even though the importance of the shallow-depth shear wave velocity structures is well recognized, there are not many studies in this field, especially in Korea. This is partly because the earthquake occurrence rate in the Korean peninsula is low, and most seismic studies using earthquakes focus on the entire crustal-scale seismic wave velocity structures. In this kind of research, the ray coverage in the shallow-depth is not dense enough to obtain shear wave velocity structure with high resolution.

Some researchers have studied shallow-depth shear wave velocity structure using Rayleigh waves from micro-earthquakes and/or explosive sources. In Iberian peninsula located in SW Europe, the shear wave velocity structure has been examined by several researchers (Sarrate et al., 1993; Teves-Costa et al., 1996; Chourak et al., 2001, 2003, 2004; Badal et al., 2000, 2004). They used local earthquakes, quarry blasts, and explosive sources to obtain the shear wave velocity in the upper 1–5 km of the crust by analyzing dispersion curves of the Rayleigh waves in the period range of 0.2–6.0 s. They

* Corresponding author. Tel./fax: +82 63 469 1750.
E-mail addresses: hjjung@kunsan.ac.kr (H. Jung), divergence@chonbuk.ac.kr (Y. Jang), jung@knu.ac.kr (J.M. Lee), wmoon@eos1.snu.ac.kr (W.M. Moon), baagce@snu.ac.kr (C.-E. Baag), kykim@kangwon.ac.kr (K.Y. Kim), bgjo@chonbuk.ac.kr (B.G. Jo).

0926-9851/$ – see front matter
doi:10.1016/j.jappgeo.2008.08.007

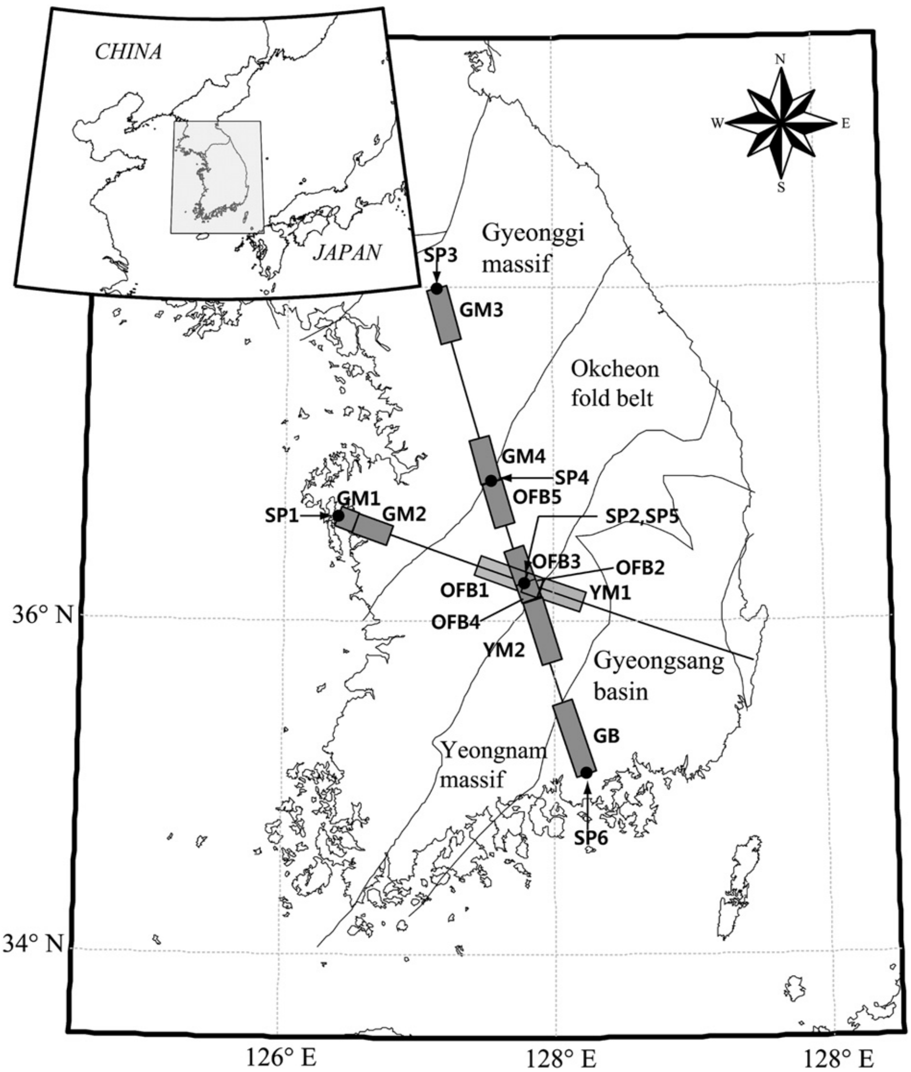

Fig. 1. Map of the Korean peninsula and the KCRT2002 and KCRT2004 seismic refraction profiles. Six shot points, SP1 through SP6, are denoted with closed circles. Four major tectonic units are denoted. Twelve subsections investigated for the surface wave analysis are marked with grey rectangles. The names of the twelve subsections are: GM1 though GM4 in the Gyeonggi massif, OFB1 though OFB5 in the Okcheon fold belt, YM1 and YM2 in the Yeongnam massif and GB in the Gyeongsang basin.

related the shear wave velocity structures to the surface geology and tectonic structure of the Iberian peninsula and the surrounding areas with a modeling technique for volumetric reconstruction (Seron et al., 1999). Similar studies have been performed in the USA (Kocaoglu and Long, 1993; Kafka and Reiter, 1987; Saikia et al., 1990), Sweden (Astrom, 1998; Astrom and Lund, 1994), Italy (Malagnini et al., 1995), and the Arabian peninsula (Mokhtar et al., 1988).

Most previous studies on the seismic structure of the Korean peninsula have been conducted using teleseismic data. There are very few studies on the shear wave velocity structure for the upper few kilometers of the crust in the Korean peninsula. The Korean Crust Research Team (KCRT[1]) carried out the first and the second crustal-scale refraction experiments in the southern Korean peninsula in 2002 and 2004, respectively (Fig. 1). These two crustal-scale refraction experiments are part of an ongoing long-term project to obtain a 3D seismic velocity structure for the Korean peninsula and its neighboring areas and eventually map the geological and tectonic details of the peninsula. The first refraction profile, KCRT2002, traverses the peninsula in a WNW–ESE direction, perpendicular to the major tectonic trends in the study area, while the second, KCRT2004, spans the peninsula on a NNW–SSE line, almost 45° to the KRUST2002 profile. The arrival times of the body waves of the KCRT2002 were used to produce a 2D seismic velocity structure for the crust and upper mantle in the direction of the profile (Cho et al., 2006). The results indicate that the crust is thickest (34 km) below the Okcheon fold belt in the middle of the transect and thinnest (28 km) at the eastern end where the Cretaceous Gyeongsang basin is characterized by 5 km of low-velocity material that constitutes the upper crust.

The short-period Rayleigh waves from 2002 KCRT were analyzed by Jung et al. (2007) for the shear wave velocity and attenuation of the upper few kilometers of the crust in the three tectonic regions of the Korean peninsula. They found close relationships between the surface geology and uppermost crust shear wave velocity and attenuation in the areas. One result of the KCRT2002 analysis was a very low shear wave velocity and high attenuation for the Okcheon fold belt. However, the cause of the low velocity and high attenuation was not clear; whether it was solely due to the lithology of the area – mostly conglomerates and volcanic rocks – or to the direction of the geological structures in the Okcheon fold belt, perpendicular to the KCRT2002 profile.

The KCRT2004 data also contained coherent, short-period (0.2–1.2 s) Rayleigh waves which contain information on the seismic properties of the uppermost crust. The purpose of this paper is (i) to analyze the short-period Rayleigh waves of the refraction profiles,

[1] A consortium of Korea Universities participating in the Crustal Seismic Experiments in Korea.