Regional variation of the coda Q in the Korean Peninsula

Suk Young Yun[1], Won Sang Lee[2], and Kiehwa Lee[1]

1) Seismological Observatory, School of Earth and Environmental Sciences, Seoul National University, Seoul, Korea

2) Department of Geophysics, Graduate School of Science, Tohoku University, Sendai, Japan

한반도 coda Q 의 지역적 변화

윤숙영[1], 이원상[2], 이기화[1]

1) 한국, 서울대학교, 지구환경과학부, 지진관측소 fiyona@nate.com

2) 일본, 동북대학교, 이학부, 지구물리연구실

Abstract : We analyzed spectral attenuation of coda waves and estimated coda Q values in the crust of the Korean peninsula. 574 NS-component seismograms registered by the Korea Meteorological Administration (KMA) and Korea Institute of Geology, Mining and Materials (KIGAM) seismic networks with epicentral distances less than 100 km and sampling rate greater than 80 Hz were selected for this study. We estimated coda Q values using the single isotropic scattering model at center frequencies of 1.5, 3, 6, 9, 12, 15, and 18 Hz with 20 s time window starting from double of the S-wave arrival times. Estimated coda Q value at 1 Hz (Q_0) and n value range 50 to 250 and 0.5 to 1.0, respectively, and they are well correlated with the regional geology in the Korean peninsula. The Q_0 values in western Korea agree well with those of eastern China.

Keywords : coda Q, Korean Peninsular, crust, single isotropic scattering, attenuation

요약 : 한반도 남부 지각에서의 지진파 감쇠 양상을 나타내는 Q값을 구하기 위해 한국지질자원연구원(KIGAM)과 기상청(KMA)의 지진파 자료 중 진앙거리가 100km 이내이고 Sampling 비가 80Hz 이상인 NS방향의 540개 자료를 분석하였다. 각각의 자료에 대해 단일 산란 모델을 적용하여, S파 주시의 두 배부터 20초 길이를 가지는 시간창 위에서 1Hz, 1.5Hz, 3Hz, 6Hz, 9Hz, 12Hz, 15Hz, 18Hz의

주파수 별 coda Q 값을 구하였다. 이렇게 구한 각각의 coda Q, 즉 Q_C값으로부터 주파수 관계식(f> 1Hz 일 때 $Q_C = Q_0 f^n$)을 이용하여 1Hz 에서의 coda Q, Q_0 를 구하였다. 한반도의 Q_0 값은 50과 250사이 그리고 n 값은 0.5 와 1.0 사이에 있고 그 지역적 분포는 반도 내 지질구조와 잘 연관됨이 밝혀졌다. 또한 반도 서해부근의 Q 값은 중국 동쪽의 값과 잘 연결되는 것을 볼 수 있었다.
주요어 : coda Q, 한반도, 지각, 단일산란모델, 감쇠

1. Introduction

Coda is the tail portion of individual seismograms and is composed of a superposition of incoherent waves scattered by distributed heterogeneities in the earth. *Aki*(1969) first named this 'coda waves' and observed that the coda has similar amplitude at all stations independent of epicentral distance and similar spectral content among stations in a region. *Aki and Chouet*(1975) introduced the parameter coda Q as a measure of the decay rate of the coda within a given frequency band and reported that Q_0 values, coda Q values at 1Hz, with epicenetral distances of less than 100 km are consistent with other Q values estimated by using direct waves from shallow earthquakes. *Singh and Hermann*(1983) estimated Q_0 values over the United States and drew a contour map, and *Jin and Aki*(1988) made the similar map of China. In Korea, *Jun et al.*(1994), *Baag*(1997), and *Lee and Lee*(1999) reported Q_0 value of the Kyeongsang Basin, and *Lee and Lee*(1999) separated coda Q into scattering effect and intrinsic absorption by Multiple Lapse Time Window Analysis method(*Fehler et al.*, 1992). In this study, we examine the regional variation of coda Q and its frequency dependency in the Korean Peninsular and consider the factors which effect the regional differences.

2. Data Processing

We used 574 NS-component velocity seismograms registered by the Korea Meteorological Administration(KMA) and Korea Institute of Geology, Mining and Materials(KIGAM) seismic networks with epicentral distances less than 100 km, and sampling rate greater than 80 Hz were selected for this study. Locations of the stations and events are shown in (Fig. 1). We performed band-pass filtering by using the second-order Butterworth band-pass filters having center frequencies of 1Hz, 1.5Hz, 3Hz, 6Hz, 9Hz, 12Hz, 15Hz, and 18Hz. Then, we estimated coda Q values using the single back-scattering model (*Aki and Chouet*, 1975) on the coda windows that start from double of S-wave travel time. Then Q_0(Q_C at 1Hz) and n(frequency dependence) are estimated by fitting data to $Q_C = Q_0 f^n$.

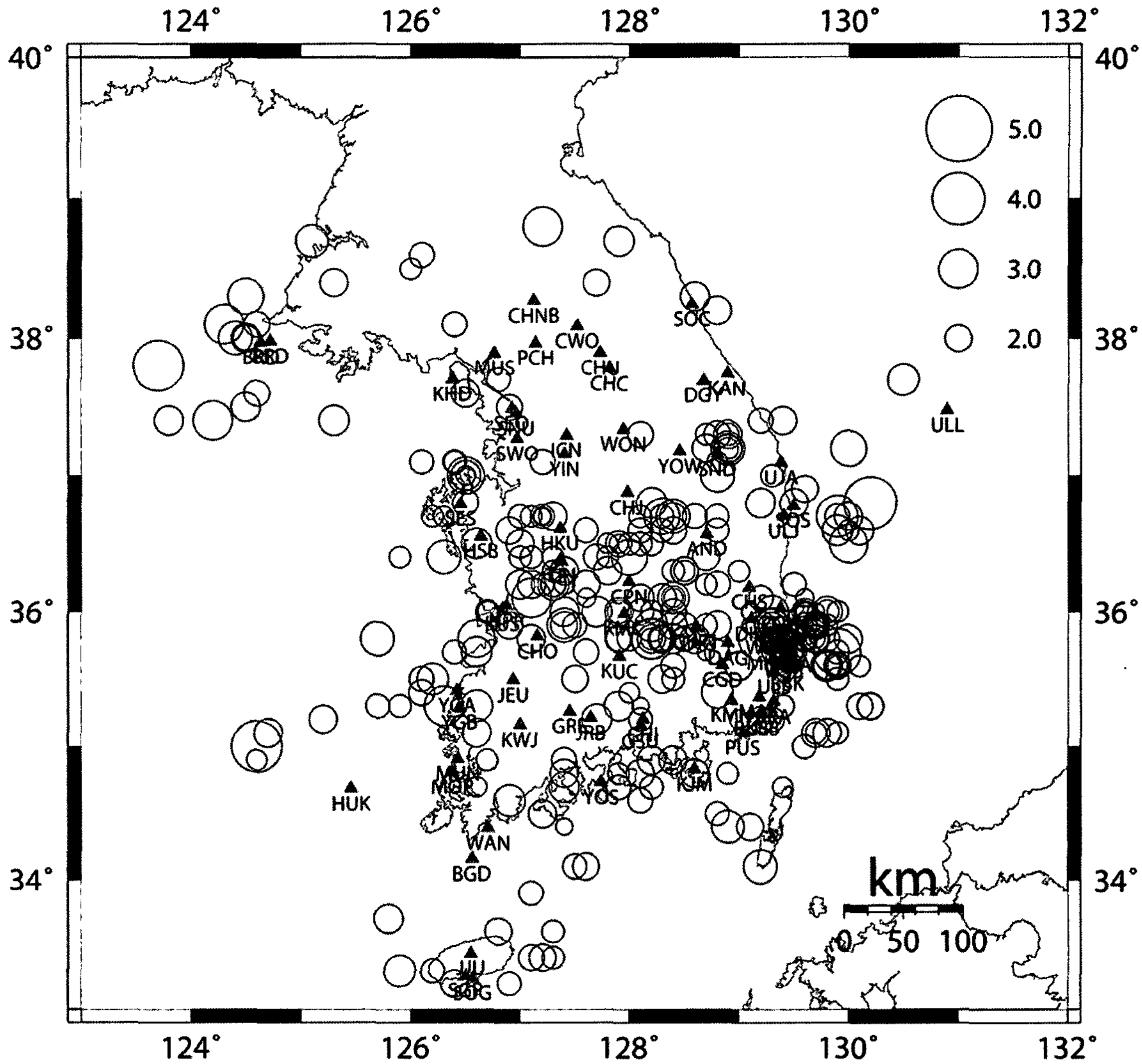

Fig. 1. Locations of KMA and KIGAM stations (gray triangles) and earthquakes from 1995 to 2004 (open circles) used in this study.

3. Spatial Distribution

Fig. 2 shows spatial distributions of Q_C, Q_0 and n. We plotted Q values at the midpoint of the station and the event. Q_0 and n values range 50 to 250 and 0.5 to 1, respectively. Low Q means high attenuation. The figure shows that Q_C values tend to become higher as frequency increase, and frequency dependency and Q_0 are correlated (High Q_0 with low n, low Q_0 with high n) Especially, the southeast part of the region has low Q_0 and high n. These results agree well with previous studies of the area. *Lee and Lee* (1999)'s Q_0 values at Kyeongsang basin (the southeastern part), 83.9~108.0, are very close to ours. Fig. 3 shows that the Q_0 values in the study area match well with those of the eastern China (*Jin and Aki*, 1988).

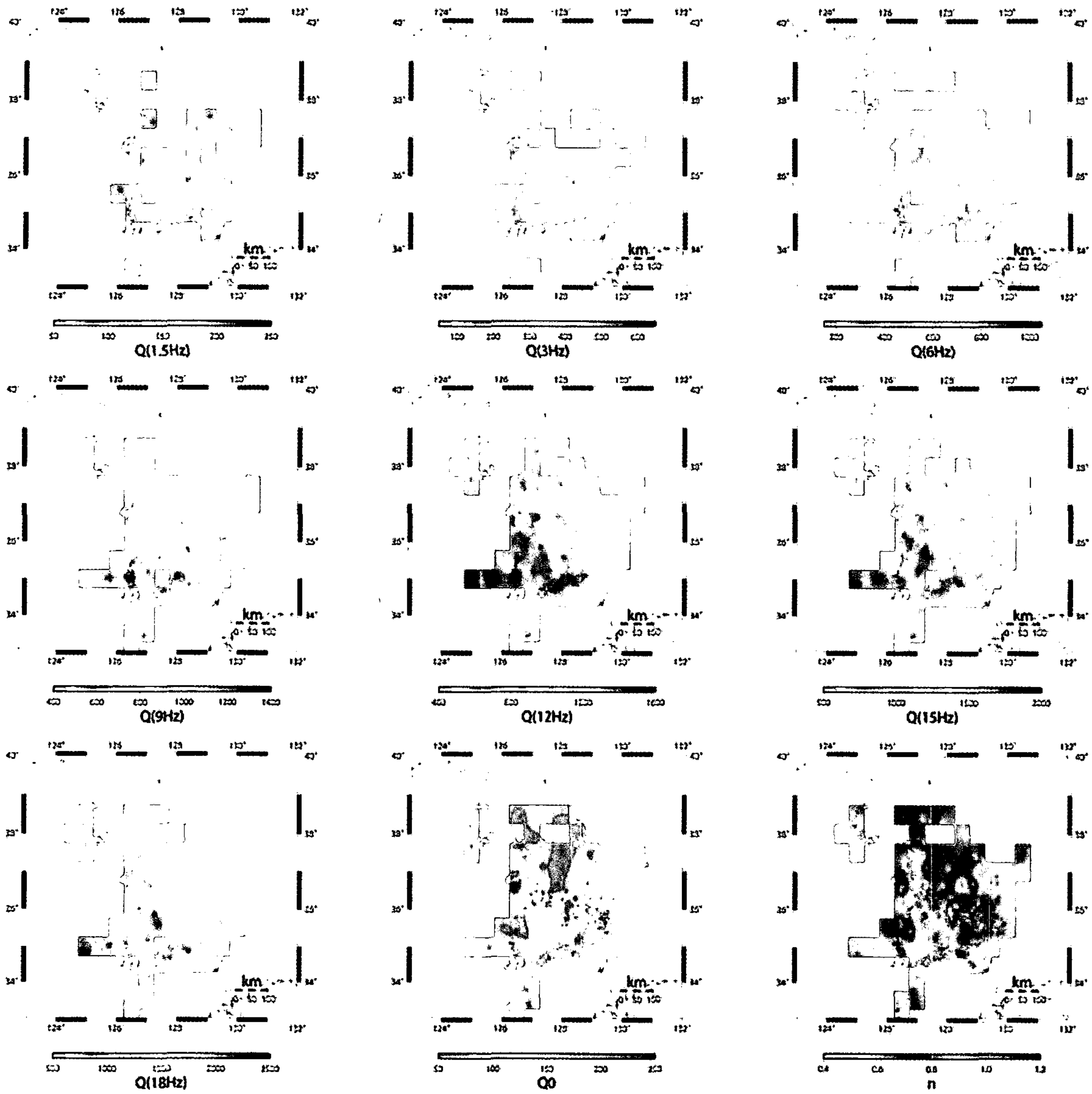

Fig. 2. Spatial distribution of Q_C, Q_0 and n. We plotted each value at the midpoint of the station and the event.

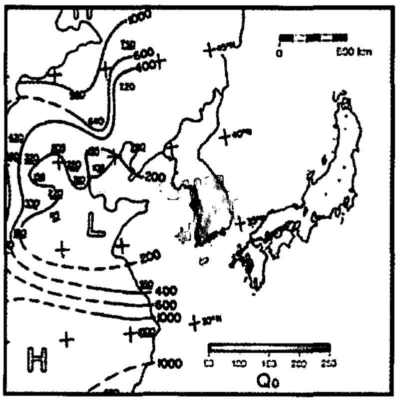

Fig. 3. Q_0 map of Korea and China (Modified after *Jin and Aki*, 1988).

4. Discussion and Conclusion

We estimated coda Q in the Korean Peninsular and drew contour maps of its distribution. This study is important in that it completes Q distribution studies in the East Asia with needed data of the Korean Peninsula. We considered the two factors that affect Q_0, seismicity and geological formation. Fig. 4 shows epicenters of Korean historical earthquakes from 2 to 1904 (*Lee and Yang*, 2005, submitted to BSSA) and Q_0. Open circle represent events , and white and black dashed ellipses are high and low seismicity zones, repectively. A trend that Q_0 values are low in red zone and high in blue zone is to be noted. A number of faults related to historical earthquakes may effect low Q_0. However, seismicity and Q_0 are not always correlated. In the case of

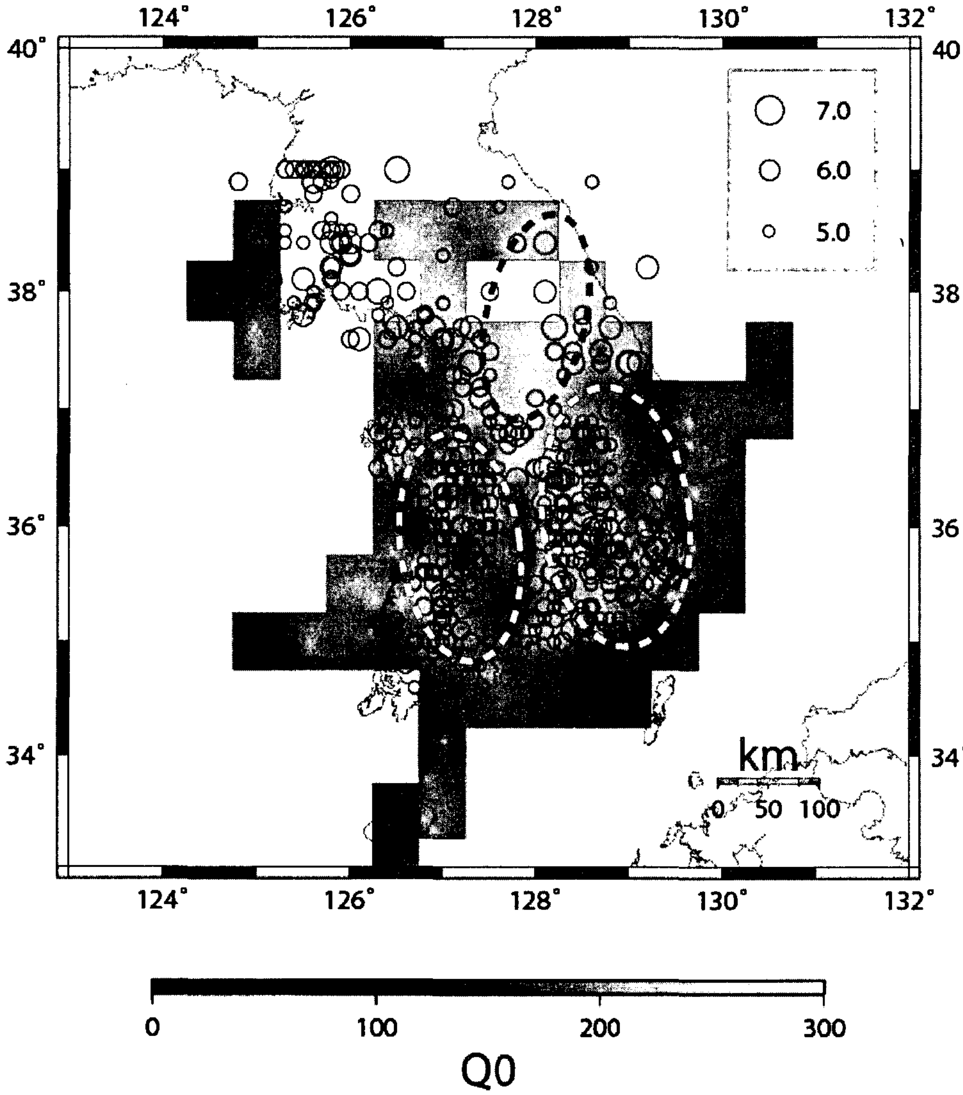

Fig. 4. Historical earthquakes (Modified after *Lee and Yang*, 2005, submitted to BSSA) and Q_0. Open circle represents events and white dashed ellipse is high seismicity zone black is low zone

sedimentary region, Q_0 value is low even if the seismicity is low in the region. Beside these two factors, geothermal distribution is also reported as another important factor affecting Q_0. We expect separating total attenuation into intrinsic and scattering attenuation will help analyze more concretely how these factors contribute to Q_0.

References

Aki, K., 1969, Analysis of the seismic coda of local earthquakes as scattered waves, *J. Geophys. Res.*, 74, 615−631.

Aki, K. and B. Chouet, 1975, Origin of coda waves; source, attenuation and scattering effects, *J. Geophys. Res.*, 80, 3322−3342.

Baag, C. E., 1997, Seismic Wave Attenuation in the Korean Peninsula (in Korean), *KAERI Research Report*, No. 96−08.

Fehler, M., M. Hoshiba, H. Sato, and K. Obara, 1992, Separation of scattering and intrinsic attenuation for the Kanto−Tokai region, Japan, using measurements of *S*−wave energy versus hypocentral distance, *Geophys. J. Int.*, 108, 787−800.

Jin, A. and K. Aki, 1988, Spatial and temporal correlation between coda *Q* and seismicity in China, *Bull. Seismol. Soc. Am.*, 78, 741−769.

Jun, M. S., H. C. Chi, J. S. Jeon, and I. C. Shin, 1994, Seismological study (in Korean), *KIGAM Research Report*, No. KR−94(C)1−16.

Lee, K. and W. Yang, 2005, Historical seismicity of Korea, submitted to *Bull. Seismol. Soc. Am.*

Lee, W. S. and K. Lee, 1999, *Q* estimates using the coda waves in the Kyeongsang Basin, *Journal of the Earthquake Engineering Society of Korea*, Vol.3, No.1, 67−73.

Singh, S. K. and R. B. Herrmann, 1983, Regionalization of crustal coda *Q* in the continental United States, *J. Geophys. Res.*, 88, 527−538.