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Coda-Q and its lapse time dependence analysis in the interaction zone of the Dinarides, the Alps and the Pannonian basin

Iva Dasović *, Marijan Herak, Davorka Herak

Department of Geophysics, Faculty of Science, University of Zagreb, Horvatovac 95, 10000 Zagreb, Croatia

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ABSTRACT

The single backscattering model was used to estimate total attenuation of coda waves (Q_c) of local earthquakes recorded on eight seismological stations in the complex area of the western continental Croatia. We estimated Q_0 and n, parameters of the frequency dependent coda-Q using the relation $Q_c = Q_0 f^n$. Lapse time dependence of these parameters was studied using a constant 30 s long time window that was slid along the coda of seismograms. Obtained Q_c were distributed into classes according to their lapse time, t_L. For t_L = 20–50 s we estimated Q_0 = 45–184 and n = 0.49–0.94, and for t_L = 60–100 s we obtained Q_0 = 119–316 and n = 0.37–0.82. There is a tendency of decrease of parameter n with increasing Q_0, and *vice versa*. The rates of change of both Q_0 and n seem to decrease for lapse times larger than 50–80 s, indicating an alteration in rock properties controlling coda attenuation at depths of about 100–160 km. A very good correlation was found between the frequency dependence parameter n and the Moho depths for lapse times of 50, 60 and 70 s.

1. Introduction

Attenuation is a propagation effect, which combined together with source and site effects, determines the shape and the frequency content of the earthquake seismogram. In order to explore one of these effects, we have to remove the other two. This means that knowing the attenuation is very important for determining seismic source parameters and estimating seismic hazard. One of the most frequently used methods to estimate attenuation is the measurement of the quality factor Q_c based on the coda waves attenuation rate. Coda waves are incoherent waves caused by the scattering of the elastic waves on the heterogeneities in the earth's interior. They are seen as the wave train following the direct S-wave phases in a local earthquake seismogram. Q_c describes the total attenuation, which includes both elastic energy conversion into heat (intrinsic absorption) and energy redistribution of waves scattered on the heterogeneities (scattering). The scattering attenuation assumes the reduction of the seismic wave amplitudes due to scattering that redistributes elastic energy into directions away from or towards the receiver. The latter waves arrive at the receiver after the direct seismic phases, i.e. within the P- or S-wave coda. The heterogeneities that act as the scatterers include all sorts of variations in physical characteristics of rocks – faults, cracks, intrusions, small-scale irregularities, etc. For practical use there is no need for separating the intrinsic and the scattering attenuation, as mostly the total attenuation is of interest (Havskov and Ottemöller, 2010).

The most frequently used model that explains the generation of coda waves and enables estimation of Q_c is the single backscattering model proposed by Aki and Chouet (1975). This simple model assumes the offset between the source and receiver to be negligible and weak scattering of body waves, which does not produce secondary scattering (Born approximation). Thus coda waves are the result of a superposition of incoherent body waves backscattered on randomly but uniformly distributed heterogeneities in the isotropic and homogenous halfspace. However, one should be aware of its simplicity and be careful in interpreting the obtained data. Estimation of coda-Q from local earthquakes is useful for observing heterogeneities in the lithosphere on the scale of 0.1–10 km (Sato and Fehler, 1998). Despite its shortcomings, many studies used this method in different regions of the world which enables a good qualitative and quantitative comparison of results. Here, we use this model to estimate attenuation rate of transversal waves in the complex area of continental north-western and western Croatia, i.e. in the interaction zone of the Dinarides, the Alps and the Pannonian basin.

This report presents a continuation of our previous study (Dasović et al., 2012) of the coda attenuation rate in the region of the External Dinarides and their contact zone with the Adriatic microplate. Herewith we present analysis of coda waves of local earthquakes from additional eight digital BB-stations belonging to the recently enlarged and modernized part of the Croatian seismological network, which are situated in the SW Pannonian basin, the

* Corresponding author. Tel.: +385 1 460 5910/5914; fax: +385 1 468 0331.
E-mail addresses: dasovici@gfz.hr (I. Dasović), herak@irb.hr (M. Herak).

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north-western Dinarides and in the transition zone between them (Fig. 1). To explore the lapse time dependence of the coda-Q we change the traditional approach of lengthening the analysed time window with the one of constant length window slid along the coda, as was also done in Dasović et al. (2012) (see also in Havskov et al., 1989).

2. Tectonic settings and seismic activity

The territory of Croatia is situated in the broad Africa–Eurasia convergent plate boundary zone. The area of our interest is characterised by interaction of the Southern and Eastern Alps, the Pannonian basin, the Dinarides and the Adriatic microplate. Due to the push of the African plate, the Adriatic microplate collides with the European plate in the north (the Alps), and is underthrusting the Dinarides to the northeast. The studied region lies partly in the Pannonian basin and its transition zone towards the Alps and the Dinarides, and partly in the Dinarides.

According to Tomljenović et al. (2008), the External Dinarides are derived from the Adriatic microplate, whereas the Internal Dinarides are composed of several tectonic units, among which the Central Dinaridic ophiolite zone (CDOZ) and the Sava zone

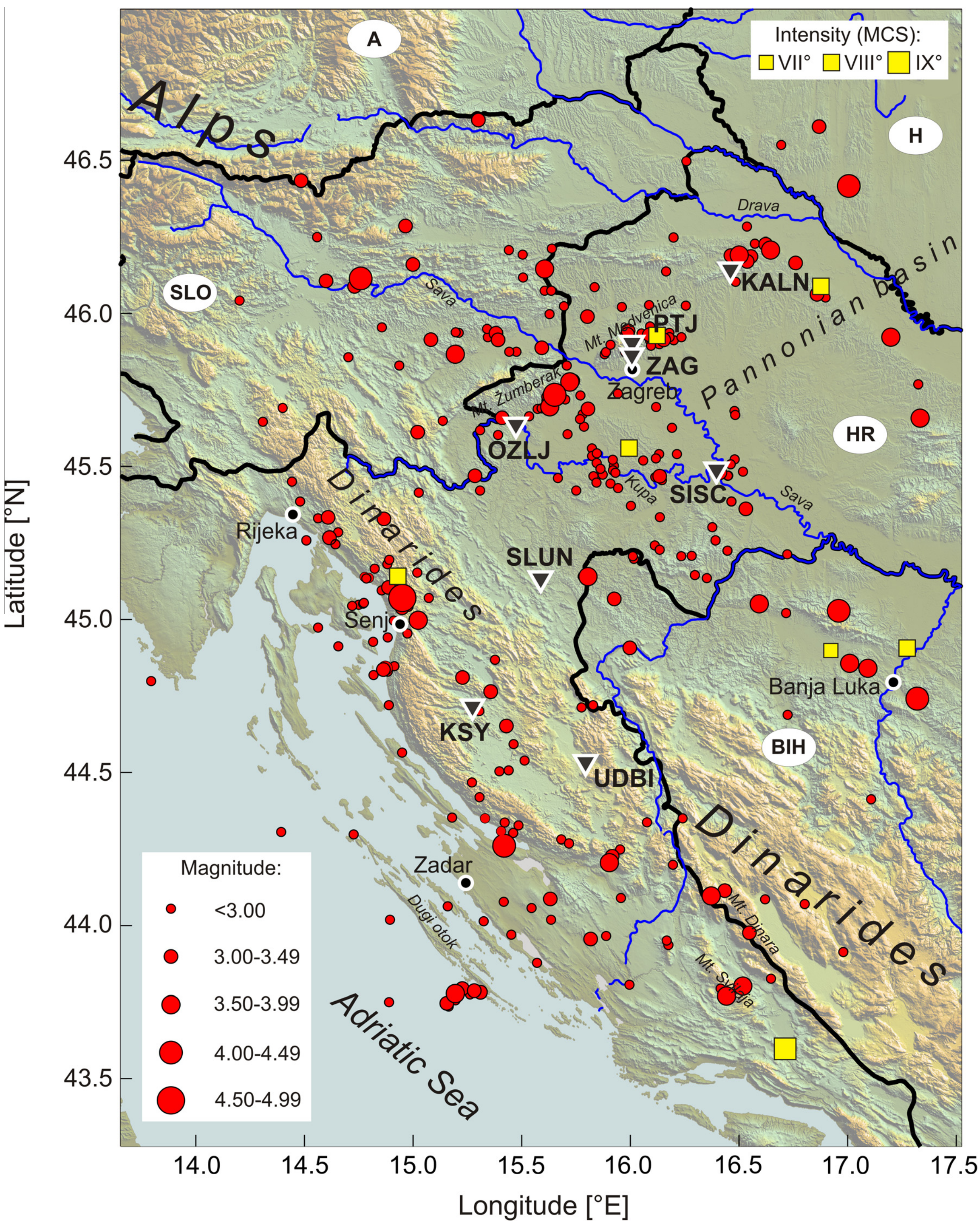

Fig. 1. Map of epicentres of earthquakes used in the analysis (circles) and locations of seismic stations (triangles). The squares denote epicentres of the high intensity earthquakes mentioned in the text.