THE EARTHQUAKE OF SEPTEMBER 5, 2007 (M_W=4.8) IN ALBANIA. ANALYSIS OF THE ACCELEROGRAPHIC DATA RECORDED IN DURRESI TOWN

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ABSTRACT

We present in this paper the analysis of the strong motion record generated by the earthquake of September 5, 2007, taken in Durresi town, western Albania. We found high value of the high-frequency filter for the recording site, κ = 0.114. Furthermore, we used the random-vibration version of the stochastic model given in Boore (2002) by computing PSRV spectra for different values of stress parameter and compared them with the measured PSRV spectra of this event. We concluded that the stress-drop release for this event is $\Delta\sigma$ = 300 bars. This value is in good agreement with the thrust mechanism environment of this event and confirms the previous findings in Albania and elsewhere that associate this kind of faulting mechanism with high values of stress-drop parameter.

KEYWORDS: strong motion record, high frequency filter, stress-drop.

1. INTRODUCTION

On September 5, 2007, an earthquake of M_w between 4.8-5.0 according to INGV and ETHZ data occurred on the vicinity of Durresi town, Western Albania, causing damages of V-VI degree of EMS-98 scale on epicentral area. The preliminary hypocentral depth determinations reported by INGV and ETHZ are of the order of 20-25 km and this explains the wide area where the shaking generated by this event was felt. The epicenter position of this event is presented in the Figure 1 together with an excerpt of the neotectonic map of Albania.

Durres is one of the oldest inhabited towns of Albania with 2500 years history. Called Durachium in antiquity, it has been one of the most important towns of Roman Empire and later on to the Byzantine one. During this period of time, Durres has been often stricken by strong earthquakes with epicenter in or near it, which has not only seriously damaged it time by time, but in several cases have constrain its citizens to abandon the town, as for example, the earthquakes of 58BC, 334, 346 e 506 with epicentral intensity I_{max}=8-9 degree MSK-64, the earthquake of 1273 and 1926 with epicentral intensity of 9 degree MSK-64. The Durres area has been hit also by earthquakes occurred near it, as for example, the earthquake of 26 August 1852 on Kepi Rodonit, the earthquake of 16 May 1860 with epicenter on Ura e Beshirit near Tirana, the earthquake of 4 February 1934 on Ndroq, the earthquake of 19 August 1970 on Vrapi village, and the earthquake of 9 January 1988 on Yzberisht, near Tirana (Sulstarova and Koçiu, 1975). All these earthquakes have been felt in Durres area with intensity of 6 degree of MSK-64 scale.

2. NEOTECTONIC AND SEISMOTECTONIC DATA ON DURRESI AREA

Durresi town is included on the terrains of Periadriatic Depression, strongly affected by post-Pliocene compressional movements, and represents the westernmost frontal part of compressional domain, in direct convergence with Adria microplate. The Periadriatic Depression includes the terrains both of hills and plains of Western Lowland of Albania that has been a molasses basin, originated in Serravallian and filled with Upper Miocene-Pliocene molasses sediments.

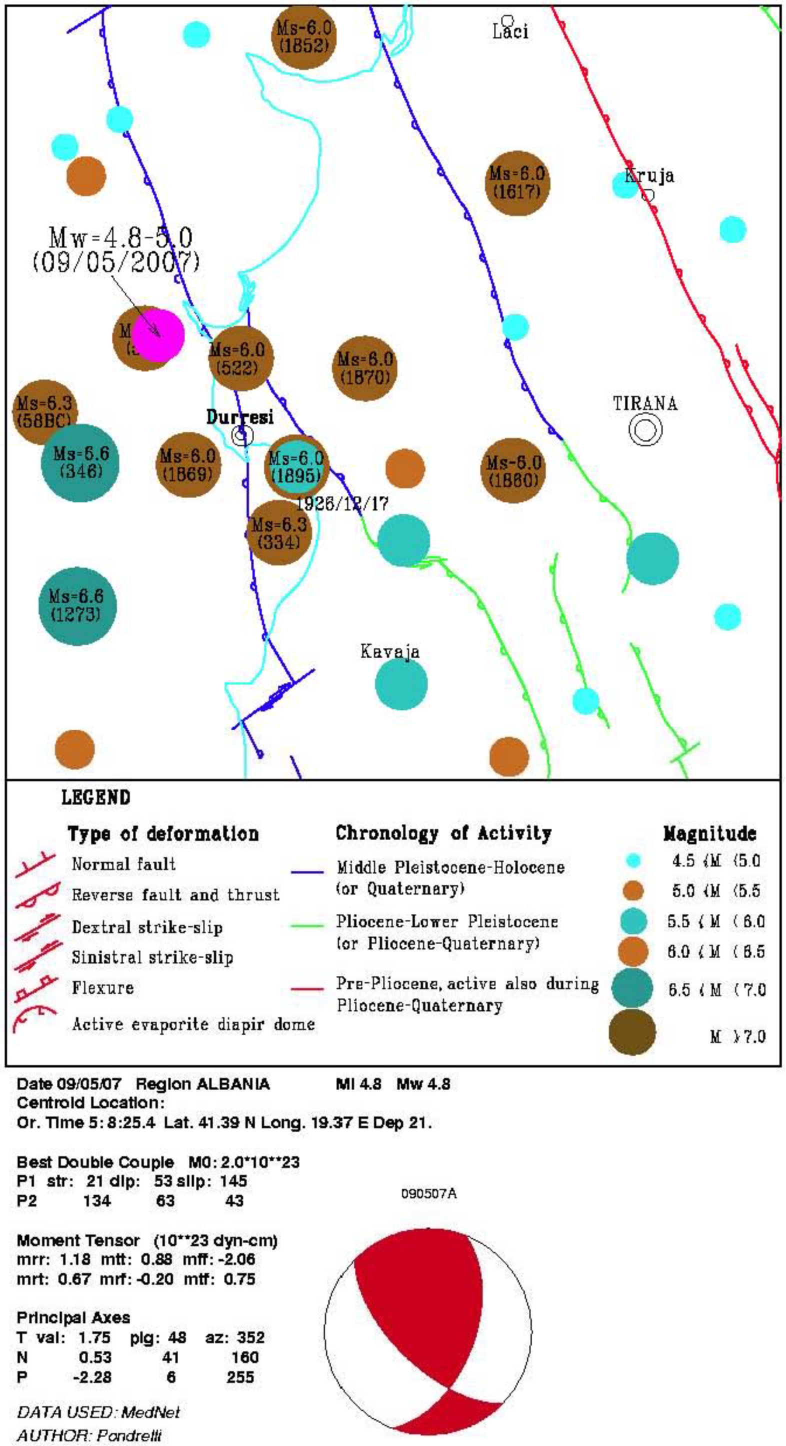

Figure 1. General view of the tectonic lines surrounding the town of Durres
(Excerpt from "Map of Active Faults of Albania", Scale 1:200.000, Aliaj, 2000)

However, the hill and plain terrain of this Depression are characterized by several N-NW extending, Mio-Pliocene, linear and narrow anticlines, as well as wide synclines, formed by post-Pliocene strong compressional phase. Holocene plains here cover the Mio-Pliocene synclines, which have been subsiding since the end of Early Pleistocene when the Periadriatic Depression was strongly folded (Aliaj and Meço, 2000).

The Mio-Pliocene anticlines are superimposed on thrust and back-thrust faults, originated by the inversion of synsedimentary normal faults due to post-Pliocene regional compression (Aliaj, 2000). Some rare transverse faults of strike-slip type cut across the structures of Periadriatic Depression. In compressional domain of Albania are distinguished active faults by their type (thrusts and back-thrust as well as strike-slips), and by the chronology of activity.

Albania is one of most seismically active countries in Europe. Most of the strong earthquakes taking place in the country occur along such well-defined belts as the Ionian-Adriatic coastal one coinciding with the boundary between the European plate and the Adria microplate. The Durres area is included in the Ionian-Adriatic seismogenic zone. This is a large and long segment of the Adriatic and Ionian coastal frontal thrust fault zone, which continues along the western coasts of Montenegro, Albania and Greece. Its length is around 250 km and it varies in width from 70 to 80 km in Albania. By and large, the seismicity across this seismogenic zone to the south of Shkodra-Peja transversal decreases gradually from the folded front eastwards. Numerous earthquakes have been recorded along this seismogenic zone. Among these may be mentioned the following: April 16, 1601 (Io=IX MSK-64) in Vlora; April 6, 1667 (Io=X MSK-64) near Dubrovnik; February 11, 1872 (Io=IX MSK-64) Sagiadha-Konispoli; June 14, 1893 (Io=IX MSK-64) Kudhesi, Vlora; June 1, 1905 (Io=IX MSK-64) Shkodra; December 17, 1926 (M=6.2) Durres; November 21, 1930 (Io=IX MSK-64) Llogora, Vlora; September 1, 1959 (M=6.2) Lushnja; March 18, 1962 (M=6.2) Fieri; April 15, 1979 (Mw=6.9) Montenegro-Albania border region; January 9, 1988 (M=5.7) Tirana.

It is necessary to underline that Durres town is located near the Albanian Orogene front, in convergence with Adria micro plate, concretely with Albanian basin (South Adriatik basin) and for this reason compressional movements here are strongest ones. This tectonic position and the active tectonic faults are the source of strong earthquakes that have stricken Durres and the surrounding areas during the centuries.

3. ANALYSIS OF THE STRONG MOTION RECORD

From almost 6 years, the Department of Seismology and Seismic Engineering is running the Albanian Strong Motion Network (ASMN), composed by 16 SMA-1 accelerographs upgraded with the digital QDR kits of Kinemetrics (Duni et al., 2004). Part of this network is the DURR1 accelerographic station installed on the ground level of a private building on the center of the town. Taking into account the data of microzonation study of Durres town (Koçiaj et al., 1985), the stratigraphic profile of the site can be classified as ground type D according to EC8 (EC8, 2003).

The analysis of the strong motion record starts with the determination of the band-pass filter parameters in order to remove the noise from the records (Figure 2). The corner frequencies of the filter were determined by visually comparing the Fast Fourier Transform (FFT) amplitude spectrum of the signal to that of the preceding noise. The filters applied on the uncorrected record, together with data on the earthquake, are given in Table 1; while in the Table 2 we present the peak values of acceleration, velocity and displacement of the three components of the recorded event.

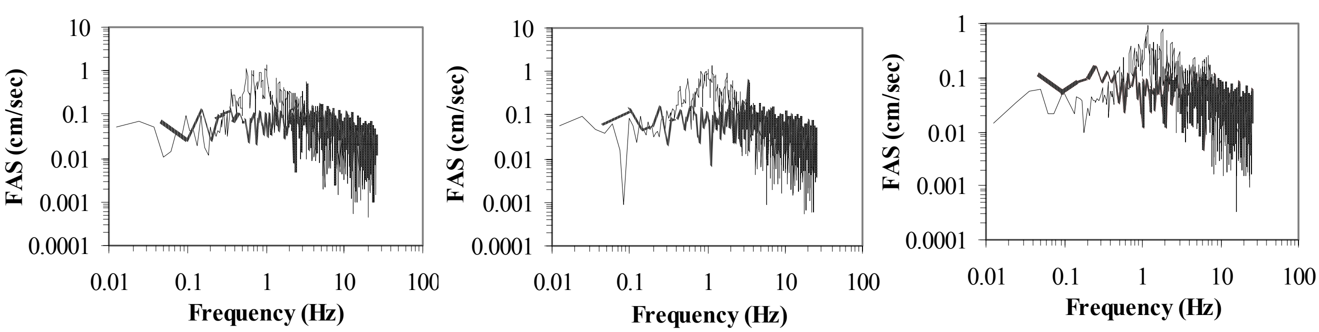

Figure 2. FAS of the signal uncorrected components (solid lines) and the noise (dashed lines).
From left to right: FAS of the longitudinal (N-S); transversal (E-W) and vertical (Z) components.

Table 1. Earthquake source parameters

Earthquake Code	Date (yymmdd)	Time (hhmmss)	Epicenter coordinates		Geographic Name	Depth (km)	Ep. Dist (km)	Filters (Hz)	
			Lat	Lon				Low-c	High-c.
D-07-1	070905	051254	41.39	19.37	Durres	21	5.2	0.40-0.51	25-27

Table 2. Peak values of acceleration, velocity and displacement

Earthquake Code	Station ID	Acceleration (cm/s/s)			Velocity (cm/s)			Displacement (cm)		
		Z	E-W	N-S	Z	E-W	N-S	Z	E-W	N-S
D-07-1	DURR1	19.88	40.12	-38.05	0.909	-3.221	2.711	-0.088	-0.317	0.349

In the Figure 3 we present the corrected time series of acceleration, velocity and displacement for the tree components of this recorded event. A careful examination of velocity and displacement waveforms gives us confidence that the long period noise is not present on these corrected data.

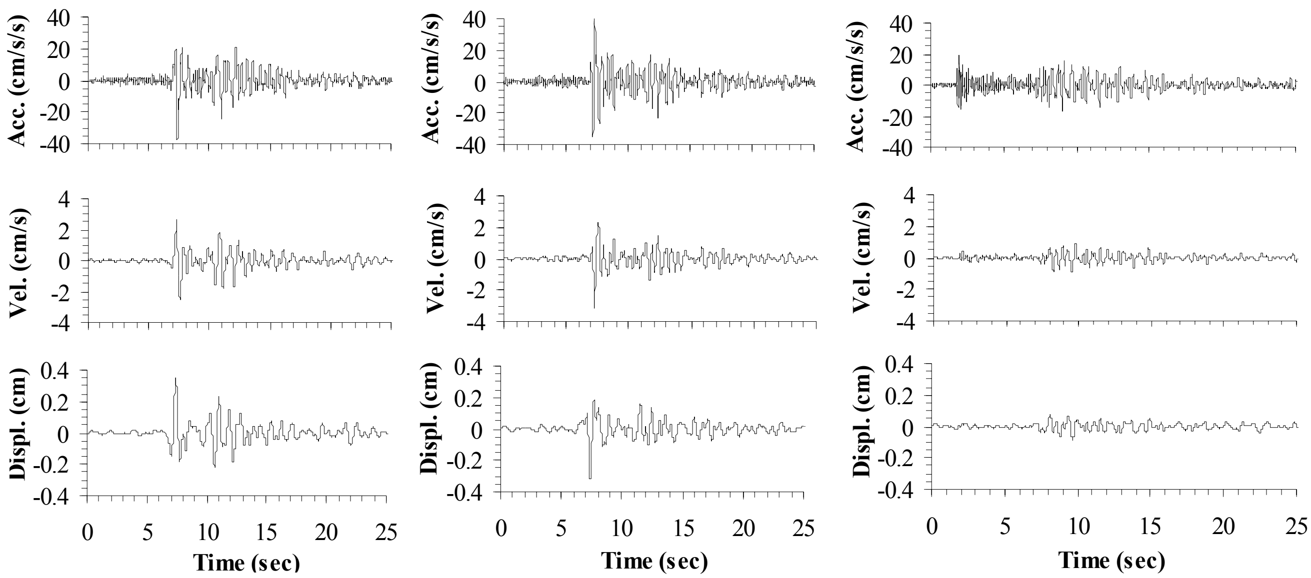

Figure 3. Corrected time series of acceleration (upper traces), velocity (middle traces) and displacement (lower traces) of recorded event. From left to right: time series of the longitudinal (N-S); transversal (E-W) and vertical (Z) components.

3.1 Determination of High Frequency Diminution Parameter

As demonstrated by Hanks and McGuire (1981), one of the key parameter in the simulation of high frequency ground motions is the high frequency filter (κ). The results of the analysis of the strong motion data obtained in Albania have shown different values of κ for different soil categories (Duni and Kuka, 2008[1]; Duni and Kuka, 2008[2]). For ground type A according to EC8, the values of this parameter are in the range $0.02 \leq \kappa \leq 0.04$, while for ground type B the estimates for two sites in Tirana City are quite similar with $\kappa_o = 0.07$ (Duni and Kuka, 2008[1]). From recent analysis derived from three events recorded in Elbasani town we have found the longitudinal components to express lower values of this parameter in comparison to the transversal ones.

However, the mean values are in the range κ = 0.028-0.039 and this manifest differences with the previous κ measurements for soils of B category according to EC8 in Tirana city.

The horizontal components for the Durres earthquake of 05/09/2007 are analyzed in the same manner as described in Duni and Kuka (2008)[1, 2]. The results are shown on Figure 4.

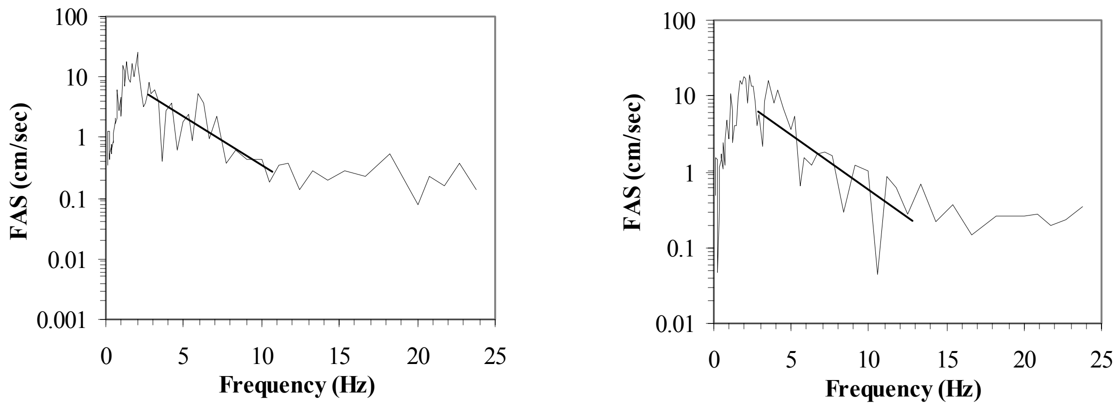

Figure 4. Measurement of κ for each horizontal component. The straight lines show the regression fits to *ln* (*spectral amplitudes*) versus frequency. The left graphs show the FAS of the longitudinal components, while the right graphs - the transversal one.

From the graphs of Figure 4 we have the values κ = 0.124 for the longitudinal component and κ = 0.103 for the transversal one. The mean value of high frequency diminution parameter for this site of D type according to EC8 is κ = 0.114.

3.2 Assessment of stress-drop parameter

For the estimation of the stress-drop parameter we used the random-vibration version of the stochastic model given in Boore (2002), by computing PSRV spectra for three values of stress parameter and compared them with the measured PSRV spectra of this event. The κ = 0.114 was used in these simulations. We tried to make a comparison visually to provide a subjective assessment of the adequacy of the single corner-frequency, ω^2 source model. The simulated and the observed response spectra of the analyzed record are plotted in Figure 5.

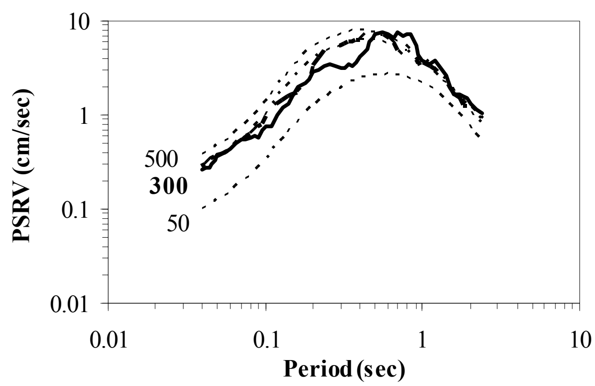

Figure 5. Plot of PSRV spectra from the September 5, 2007 event with simulated curves for three different values of the stress parameter. Thick lines are the response spectra computed from the observed horizontal components (thick line-longitudinal component; dashed line transversal components), and the thin, dashed lines are the simulated spectra. The bold number in the plot represents the best fit stress drop value in terms of shape and peak ground motion parameters.

From this figure and from the comparisons of the recorded and simulated peak ground motion values data shown on the Table 3, it is evident that the stress-drop estimation for this event is $\Delta\sigma$ = 300 bars. From the fault mechanism solution shown on Figure 1 we are certain for the thrust type faulting that has generated this earthquake. This value is in accordance with previously estimations of stress-drop parameter derived from earthquakes generated in thrust mechanism environment. Once more, we have another indication of the larger stress-drop release from this kind of faulting, compared to normal faulting mechanism, as already indicated by several authors (Margaris and Boore, 1998; Margaris and Hatzidimitriou, 2002; Duni and Kuka, 2008[1]; Duni and Kuka, 2008[2]).

Table 3. Recorded and simulated peak ground motion parameters.
The simulated values are derived using the best fit stress-drop value

	PGA (cm/s/s)	PGV (cm/s)	PGD (cm)
Recorded	40.12	-3.22	0.35
Simulated	44.74	2.74	0.28

4. DISCUSSION AND CONCLUSIONS

The earthquake of 05/09/2007, with Mw=4.8-5.0, is the first event recorded by a strong motion instrument on the Durres town, and as such represents an important achievement for the increment and the analysis of the strong motion data base in Albania. The value of high frequency diminution parameter (the high-frequency filter) κ = 0.114, taken from the SMA-1 digitally upgraded instrument installed on the soft sediments is very high compared to the values obtained up to now from instruments situated in other areas of the country and other site conditions. This fact constitutes a matter of concern for the build environment in this town in terms of site effects from future earthquakes generated nearby Durres town. This earthquake was generated by a thrust faulting environment according to the neotectonic zonation map of Albania (Aliaj et al. 1996). The stress-drop release found for this event confirms our previous findings (Duni and Kuka, 2008[1]; Duni and Kuka, 2008[2]) as well as the reports of the literature which associate the compressional seismotectonic environments (Margaris and Boore 1998, Margaris and Hatzidimitriou, 2002) with larger stress parameter compared to the extensional seismotectonic environments characterized by mainly normal faulting.

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