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SEISMIC MICROZONATION AND THE SITE EFFECTS OF BLIDA CITY (NORTH OF ALGERIA)

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ABSTRACT:

The city of Blida located in the southwest of Algiers, a high seismicity area, is classified in zone III according to the Algerian Earthquake Regulations (RPA99, version 2003). In the past, the city was shaken by several destructive earthquakes. Blida is a large administrative, industrial, commercial, military, academic, sports and health, thus it requires a particular attention to minimize the impact of an earthquake coming. We processed the data collected during 2007-2009 period by the method H/V based on the use of seismic noise. We realized a mapping of the ground resonance frequencies on the city of Blida which gives a preliminary state of the estimated site effects on the sedimentary area. The results suggest that the resonance frequency varies significantly within short distances in and around Blida city. The detailed seismic microzonation map prepared for Blida city contains four classes of resonance frequency (<1, 1-1.2, 1.2-1.5, and 1.5- 20Hz). From this map we checked the resonance phenomenon between soil and the park of the buildings of Blida city.

In order to reduce major risks, these results provide a decision-making support to the local authorities in the construction and the urban development.

Key words: Blida, resonance frequencies, H/V, seismic microzonation, site effects.

1. INTRODUCTION

The concept of seismic Microzonation is to delineate individual critical zones based on their potential for hazardous earthquake effects. The earthquake generated ground motion is very much dependent on local surficial site conditions. For that the site amplification studies constitute an important tool to assess seismic risk and microzonation in urban areas since regional variations in ground shaking must be accounted for in national building and construction norms. Site amplification is generally related to the presence and thickness of soft sedimentary layers (Borcherdt 1970; Nakamura 1989; Lermo& Chavez-Garcia 1994; Field & Jacob 1995). A rich literature exists therefore detailing studies on local variations in resonance frequencies and amplification factors (Bonnefoy-Claudet et al. 2006b).

When seismic waves encounter a low-velocity near surface sedimentary layer, three phenomena i.e. increase in amplitude, bending of a wave path towards vertical, and the trapping of the waves in

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the near surface layer occurs. These phenomena increase the shaking of the ground locally resulting in increased damage to the structures. In view of this, the damage pattern in any particular locality can forecast with the help of site response data derived through various techniques. The three effects; amplification, resonance and attenuation all depend on the depths and the properties of the sediments (Gibson, 1990). The Nakamura method estimates experimentally the combined effects of these three parameters compared with bedrock motion.

In the present work, the Blida city of northern Algeria is classified in zone III according to the Algerian Seismic Code (RPA99 version 2003). In the past, the city had been shaken by several destructive earthquakes. Blida is a big administrative, industrial, commercial, military, academic, sport, and sanitary center, so it requires a particular attention to protect it, against the seismic phenomenon.

2. PRESENTATION OF BLIDA CITY

Blida city is located at 50 km in the Western South of Algiers, on the Southern edge of the Mitidja basin to 22 km of the sea. It is in situation of contact between the mountain and the plain. The territory of the commune extends on a surface from 7.208 ha. Blida dominates the plain of Mitidja, in situation of contact with 3 natural environments: the mountain, the plain, and Piedmont. The general structure of the area of study is a succession of two anticlines and synclinal. North in the South, the succession of the various structures is presented in the form of a suit:

1. The anticline of the Sahel
2. The Synclinal of the Mitidja
3. The anticline of the Tellian Atlas

It is located between two flanks; the Northern side of the great Tellian Atlas Anticline and the Southern side of synclinal Plio-quaternary of Mitidja (the plain). It is localized in the foot of Blidien Atlas in Old alluvial apron of the Sidi El Kebir wadi. (Figure 2)

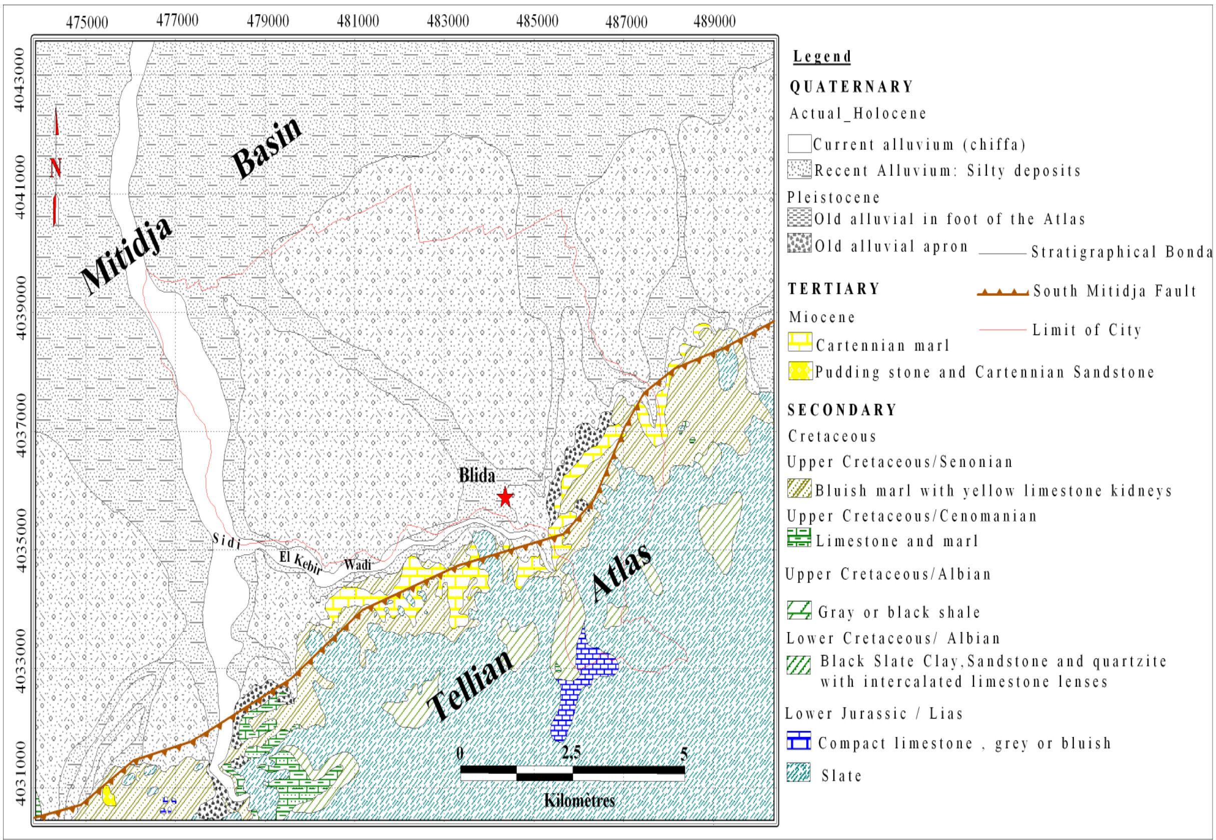

Figure 1: Simplified geological map of the study zone

The city is built on a sedimentary basin, of a great thickness (Figure 1), which may generate site effects. This is a fast growing city with high-density population where many tall buildings have come up during the past few years. Under the circumstances, damage due to an earthquake (local and/or regional earthquake) could be alarming since such land systems are generally susceptible for amplification of seismic waves. This map would be useful to take precautionary steps in future construction and development activities.

3. FIELD SURVEYS AND INSTRUMENTS USED

Today, the ambient vibration **HVSR** technique is widely used to identify the fundamental frequency of local site effect. It is also used as a geophysical imagery tool to map the depth of high impedance contrast within the geological formations. 124 ambient noise data were analyzed and estimated site specific response parameters (Figure 2). For the preparation of seismic microzonation map for the city; distance between recording sites is approximately 250 meters in order to assess the fundamental frequency of the soft sediments overlying bedrock. Ambient noise records in Blida city were obtained in selected sites by employing a CityShark II 3-component Seismic Recorder, a Lennartz tri-axial active geophone with 0.25 Hz natural frequency.

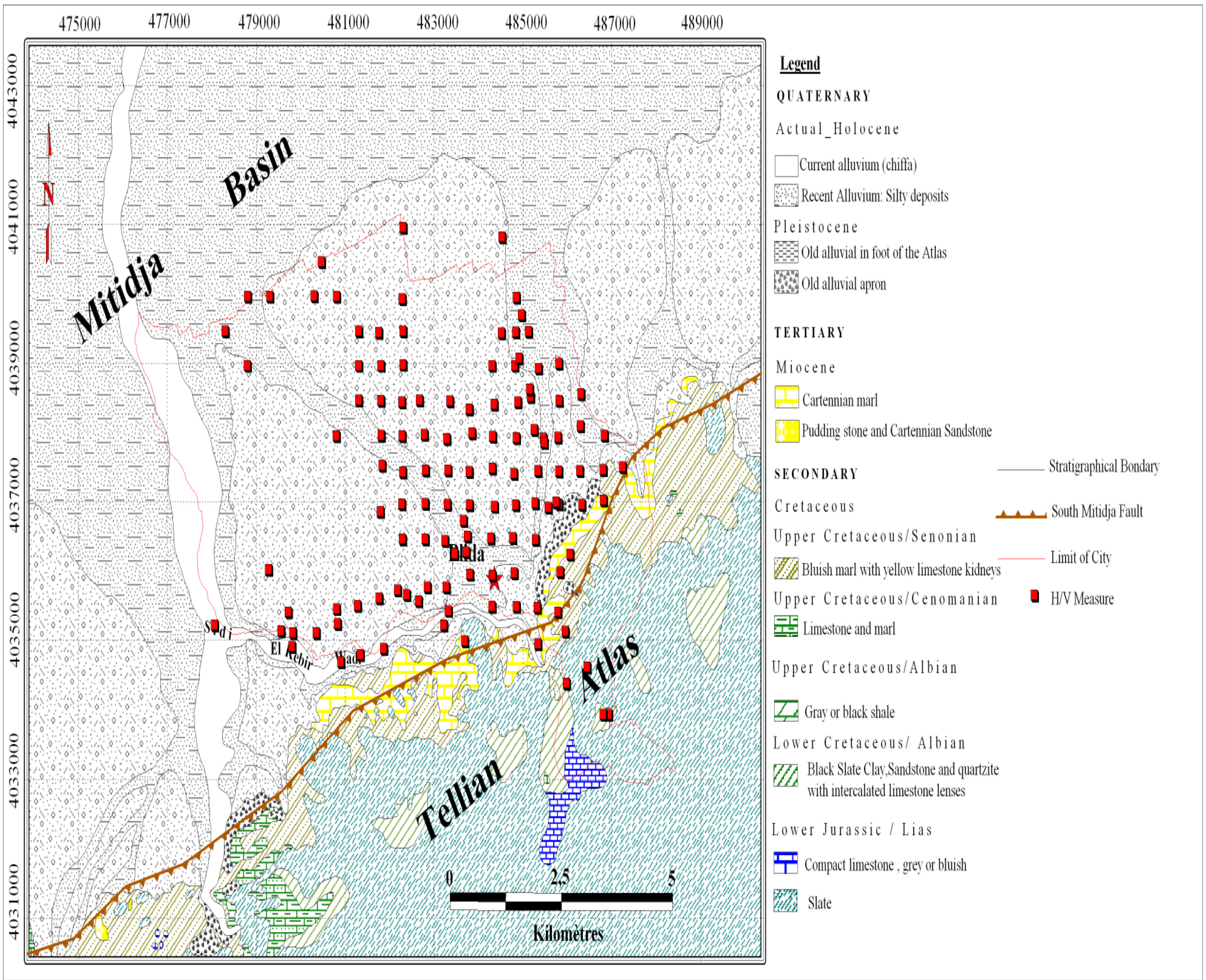

Figure 2: Location of ambient noise measurements in the city of Blida

Report H/V was calculated with the Geopsy software (http: // www.geopsy.org) and the parameters of calculations were selected to respect the recommendations of the consortium SESAME to determine the reliability of curves H/V (Guidelines for the implementation of the H/V spectral ratio technique on ambient vibrations - measurements, processing and interpretations. SESAME European research project, deliverable, D23.12, 2005).

4. SEISMIC MICROZONATION

4.1. Typology of H/V curves

The analysis of reports H. /V calculated for all the recordings of the seismic background noise in our zone of study shows that curve H/V can be classified in two types:

-The curves H/V type 1: shown a clear peak which satisfies the criteria SESAME (Guidelines for the implementations of the spectral H/V technical ratio has ambient vibrations-measurements, processing and interpretations SESAME EUROPEAN looks for project, deliverable D23.12, 2005) (Figure 3.a). They are mainly located directly above the deposits of recent and old alluviums.

- The curve H/V type 2 does not show a peak of amplitude superior to 2 (Figure 3.b), these parts are characterized by the presence of low contrasts of speed between sediments and the rocky substratum in the blidéen atlas for these points. They are located on a schistose zone and the limit of the fold of Blida.

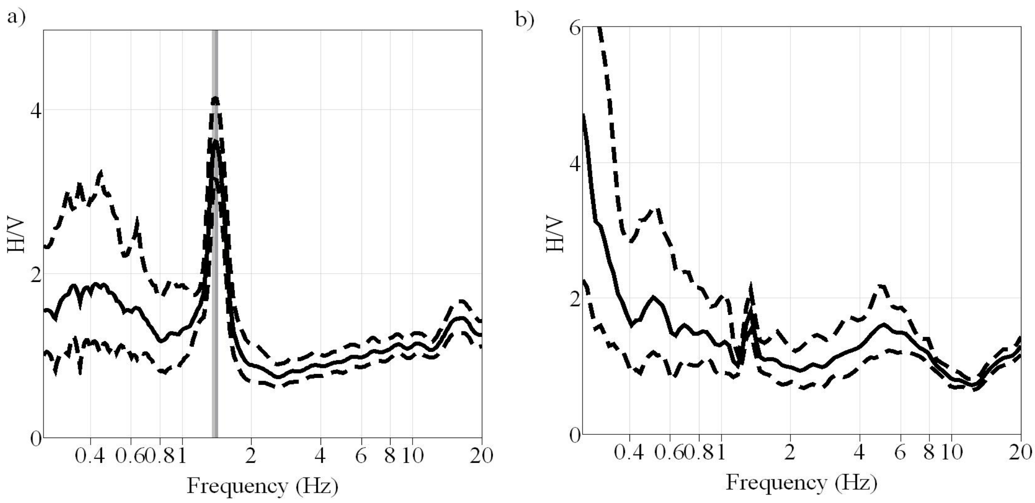

Figure 3: Typology of H/V curve observed in Blida city: a) H/V curves type 1 showing a clear peak, b) H/V curves type 2 not showing a peak.

4.2. Estimation of site response parameters

In this paper, we have used resonance frequency data in Blida City and we delineated the zones having appreciable ground motion amplification that may result damage to the structures.

The resonance frequency and the ground motion amplification thus estimated show very interesting features in their spatial variability and have specific range of resonance frequency associated with different geological formations from soft soils to compact rocky sites. The results suggest that the resonance frequency varies significantly within short distances in and around Blida city. The detailed seismic microzonation map prepared for this city contains **4** classes of resonance frequency (Table 1).

Table 1.Details of site response parameters used for the preparation of seismic microzonation map for the Blida city with four classes of resonance frequency estimated through ambient noise records

Delineated Seismic zones	Resonance frequency (Hz)	Origin
Microzone VI	<1	Natural
Microzone III	1 – 1.2	Natural
Microzone II	1.2 – 1.5	Industrial
Microzone I	1.5 – 20	Natural

Sites in Blida city which are to characterize by the typical curves 1, are convenient to site effects and on the other hand it involves that the coefficients amplifiers applied to the scenarios must be superior to 1.

On the basis of these types of curves we have stink to classify sites has characterized by site effect according to a synthesis of the geology of surface of the zone of study, the results of the analysis of the measures of seismic background noise and section 8.3 of recommendation of the Eurocode 8.

For this study we used the data base buildings of the city Blida realized in the framework of the study of the vulnerability and the evaluation of the seismic risk of the town of Blida (CGS, 2013).

Microzone VI (f<1) is characterized by low resonance frequency, the spatial distribution of peaks is not random. They are especially visible in the eastern and western part of the study area, but near military land just north of the NR1 and all there along; further North and Center of the city, the peaks are much less clear or even more often absent. Microzone III (1≤ f <1.2) with medium level of resonance frequency, the areas concerned are located in the Eastern and Western part of the city, close to the contact area Mitidja basin - Piedmont and Mitidja basin – Tellian Atlas but Microzone II (1.2 ≤ f <1.5) is characterized by low resonance frequency, they are industrial source, the peak between 1.2 and 1.4 Hz is visible in all areas of the city, all of his buildings (CGS, 2013) are always requested by this peak. Also, Microzone I (1.5 ≤f < 20) has highest level of resonance frequency, a large number of buildings in the city between 6 and 7 levels can return in resonance with 1.5 Hz H/V peaks. (Figure 4)

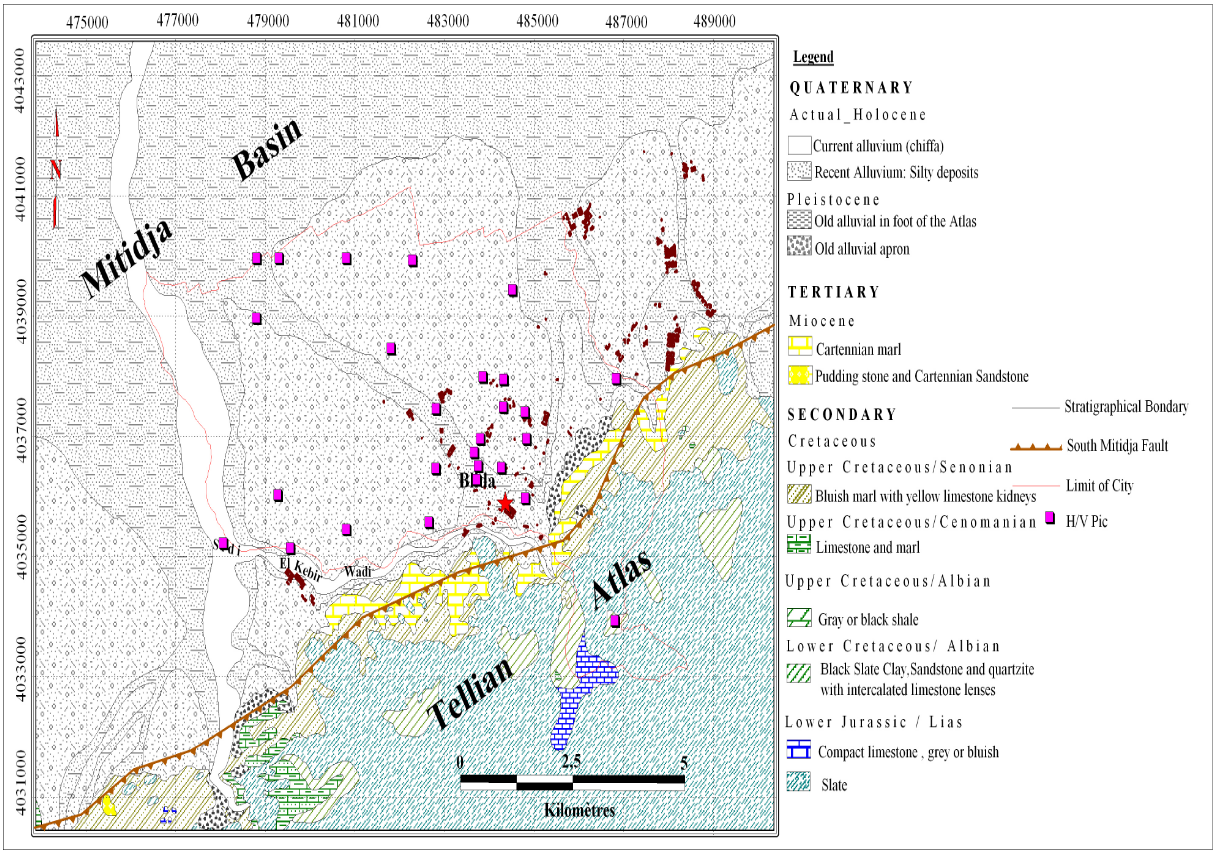

Figure 4: Zoning of the buildings in Blida city which have the same frequency of the ground 1.5 Hz.

5. CONCLUSIONS

It is inferred that the resonance frequency estimated through closely spaced noise data are very useful to identify boundaries of different geological formations that play a vital role in amplifying ground motion. The density of the measures acquired in Blida city allowed of zoning frequencies of the ground highlighting the effect of the side variability of the fundamental frequency in the neighborhood vicinity of the Southern edge of Mitidja basin with the Tellian Atlas. The low values of the frequencies of found resonances reflect the thickness of the quaternary deposits and all the buildings

As a final consideration, we believe that our results offer useful information for seismic risk assessment in the city and can provide a basis for the design of new buildings and strengthening retrofitting the existing buildings.

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