MICROZONING AND SEISMIC RISK IN QUITO, ECUADOR: PRELIMINARY RESULTS

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INTRODUCTION

Out of the 23 events felt in Quito with an intensity bigger than V since 1541, 5 produced intensities of VII or bigger in 1587, 1755, 1797, 1859, and 1868. The past damaging earthquakes occurred while Quito was quite different from the modern Quito. The city has changed significantly in the last 40 years. In that period, the population increased from 420 000 to 1.2 million, with a considerable expansion of the city. This has resulted in increased urban densities, which, linked to expanding poverty, have resulted in an increase in poorly-constructed buildings and development of hazardous areas such as steep mountain slopes. In addition, high-rise buildings that did not exist in the 1950's have spread in the northern city as a result of a more dynamic economy. The Quito Earthquake Risk Management Project [Chatelain et al, 1995, Escuela Politecnica Nacional et al, 1994, 1996], a pilot project in social seismology, has been conducted to provide direction to government officials, business leaders, and the public in general, to reduce damage and injury in the next major earthquake. One of the recommendations of this project was to undertake more precise zoning of the city, and that parameters more directly usable than seismic intensities by civil engineers should be estimated. The study presented in this paper is therefore one of the direct consequences of the above mentioned social seismology project. Its goal is the evaluation of site effects in the city of Quito during an earthquake, due to the various geological settings throughout the city. This evaluation is currently under way using three different techniques to measure the fundamental period as well as the relative and absolute amplification of soils, in order to produce isoperiod and isoamplitud maps of the city. In this paper we present the first results obtained by recording microtremors throughout the city.

TECHNIQUES USED

1.- The main technique used is the recording of microtremors (ambient vibration of the ground), moving a single station at about 400 points throughout the city, in order to calculate the spectral ratio between horizontal and vertical signals to obtain the transfer function at each site, using Nakamura's technique [1989] to remove source effects from the records. Good results have been obtained with Nakamura's technique in Mexico City, Oaxaca and Acapulco [Lermo and Chavez-Garcia, 1993], in San Fransisco [Ohmachi et al., 1991], and in France [Duval, 1995], while Lachet and Bard [1995] have shown the theoretical limitations of the technique. We used a station developed by LEAS (France) in collaboration with J. Frechet from the Laboratoire de Géophysique Interne et Tectonophysique of Grenoble, recording the signal from a three component L-4-3D Mark Products seismometer. The sites of recording were chosen to cover all the main geological zones described in the Quito Earthquake Risk Management Project, and to help precise their boundaries. At each site, the signal from the three components is recorded during 2 minutes, at a 50 Hz rate, from which five 10 seconds samples are selected. For each 10 seconds sample, a FFT of each component is calculated, smoothed with a triangular window, and used to get the NS/Z and EW/Z ratios. This method will allow us to obtain information about the resonance frequency of the soil column at each site, as well as the relative potential amplitude between each site.

2.- A second technique is used to get the absolute amplification ratios. One reference station is installed on hard rock, and four stations are installed at fixed sites within the city, are recording weak motion of natural seismicity, mainly from small magnitude earthquakes. The absolute amplification ratio at each of the four sites is obtained by dividing the FFT of the NS and EW signals recorded at the site by those recorded at the reference station. Then the absolute amplification ratio at each site used with the first technique is obtained by comparing their relative amplification to the absolute amplifications calculated at the fixed sites.

3.- The third technique is to apply a similar technique that the first but using the natural seismic signals recorded at the fixed stations.

PRELIMINARY RESULTS

Based on topography, soil characteristics, and surface geology the city has been divided into 3 main zones (Figure 1) : the flanks of Pichincha volcano to the west (F) , the central lowlands mainly filled with recent fluvio-lacustrine deposits (L), and a zone of hills to the East mainly formed of Cangahua and ash deposits (Q). These zones were then divided into 20 sub-zones (figure 1) according to variations of local geological conditions and mechanical characteristics.

As an example, results obtained using the first technique along an E-W profile crossing zones q2n, l3, and f4 (Figure 1) show that the fundamental frequency appears clearly at each site, varying according to the local geological conditions (Figure 2), whose boundaries can be corrected (for instance the boundary between zones l3 and q2 should be moved slightly to the East, as the amplification as well as the fundamental frequency observed at stations 031305 and 031303 are very similar). Variations also show up within the zones themselves, as for instance in zone l3 (stations 022708, 031306, and 031307).

We will present isoamplitude and isoperiod maps of the city and compare them with the spectral content of earthquakes recorded in Quito in order to precise the earthquake hazard in the city. The earthquake risk will be then assessed by crossing these data with the building distribution available in the municipality data base using the Savane SIG [Chatelain et al, 1995].

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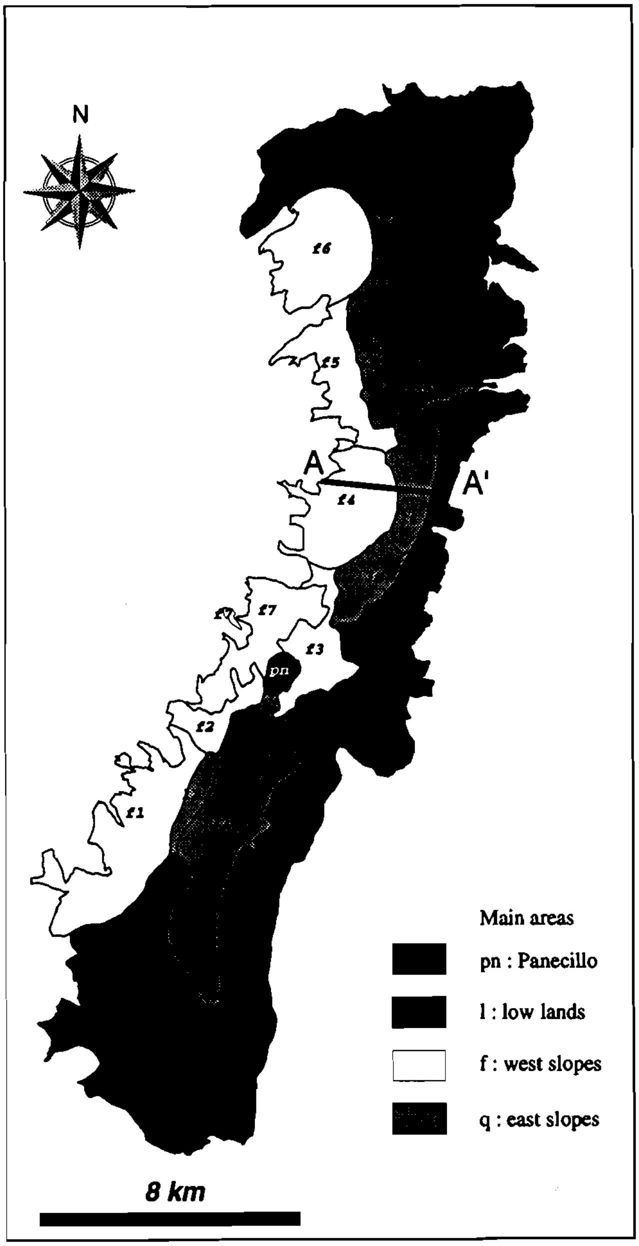

Figure 1 : zoning of Quito city used in the Earthquake Risk Management Project and location of the profile shown in figure 2.

stations 031310 031309 031307 031306 022708 031305 031303 031302

A______x______x____________x______x______x______x____________x______x______A'

zones f4 l3n q2n

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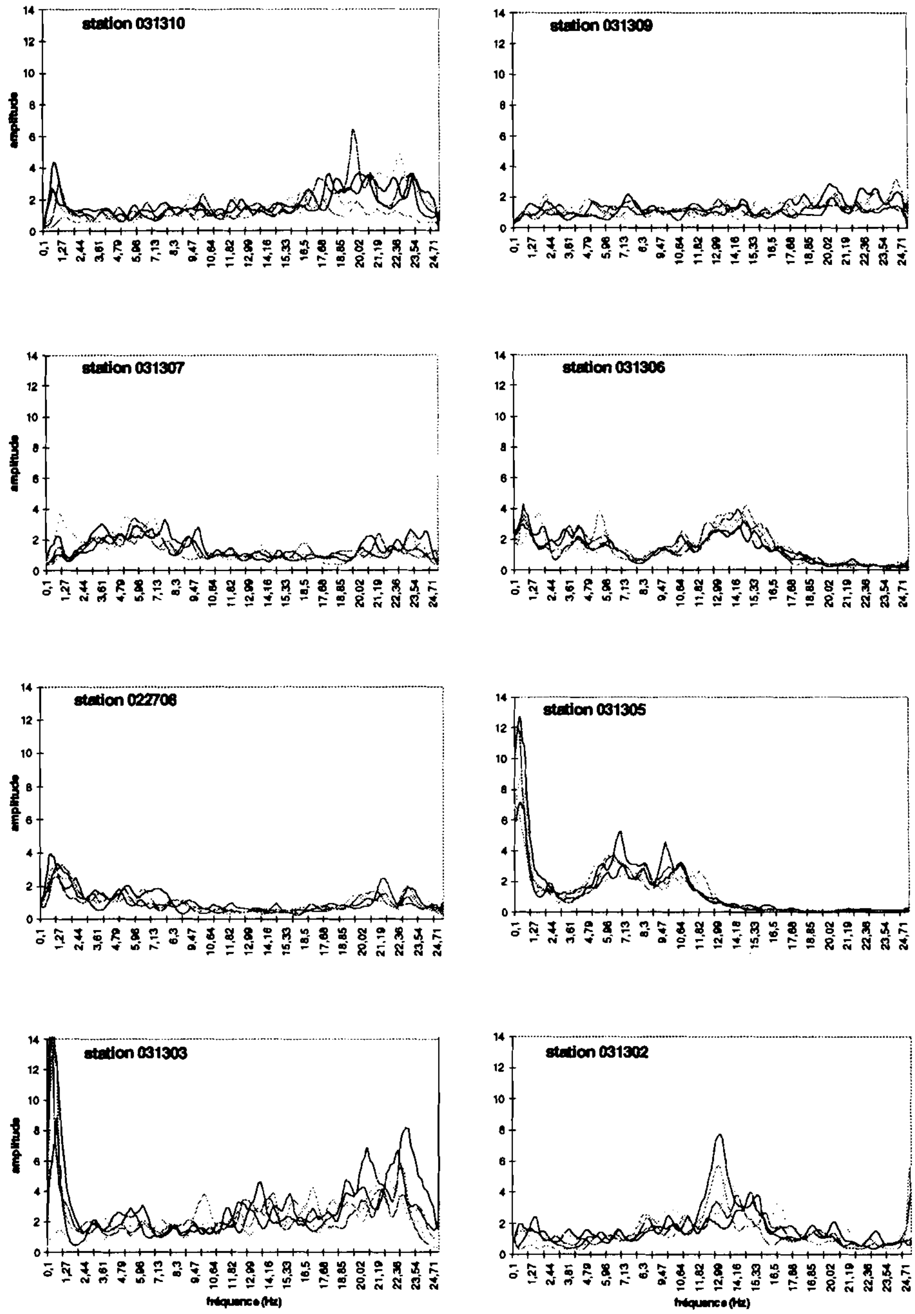

figure 2: spectral ratios between NS and Z components. For each station, along the AA' cross section (see figure 1), 5 windows of 10 s recording are represented from 2 min total recording.