ACCELEROGRAPH RECORDS FROM LIMA PERU

by

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ABSTRACT

Prior to 1972, Peru had only one accelerograph (C&GS) which was installed in downtown Lima during 1944. Although 22 earthquake records were obtained from this instrument between 1946 and 1972, only four of these produced significant records (records with peak accelerations greater than .05g). These four records were from the earthquakes of January 31, 1951, October 17, 1966, May 30, 1970 and November 29, 1971. Lima experienced three destructive earthquakes in 1974 on January 5, October 3, and November 9. Significant records from both the C&GS accelerograph and a new SMA-1 accelerograph located in Lima were obtained from all three earthquakes. The seven earthquakes which produced these ten records were of Richter magnitude 5 to 7.7 and their distances from the recording stations ranged from 73 km to 370 km. Many of the spectra from these 10 records confirm the presence of predominant short period components in the period range of 0.1 to 0.5 seconds.

INTRODUCTION

Peru has a long history of destructive earthquakes. The first report of destructive earthquakes was written in 1513. Between 1900 and 1960 over 80 destructive earthquakes have occurred and at least 19 of these earthquakes had a Richter magnitude of 7 or more(1). The majority of the destructive earthquakes have occurred off the coast of Peru.

An SMA-1 accelerograph located at the Zarate Station and a C&GS accelerograph located at the Geophysical Institute(2) recorded the earthquake of January 5, 1974. To obtain possible amplification and attenuation factors during future earthquakes, this SMA-1 was moved to the Huaco residence and later to the La Molina station where, respectively, the October 3 and the November 9, 1974 earthquakes were recorded. Figure 1 shows the epicenters and the location of the strong-motion stations where records of the seven earthquakes were obtained.

The January 5, 1974 earthquake was located inland approximately 87 km from Lima. The other 6 earthquakes occurred off the coast of Peru. Table 1 lists the seven earthquakes with epicentral distance, magnitude, maximum acceleration of horizontal components, digitized record length, and the frequency band filtering range used in the record processing.

RECORD PROCESSING

The ten accelerograms were digitized on a Calma 685 model data digitizer. All records were processed using standard methods first developed at the California Institute of Technology(3). The scaled data were then corrected by performing an instrument correction and bandpass filtering(4). The high frequency cut-off was 25 Hz for all components, whereas the low frequency cut-off was dependent on the record length and corresponded to a period of approximately one fourth the duration of the digitized record, but was never less than 0.07 Hz. For records shorter than 60 seconds, the calculated ground displacement and sometimes the ground velocity show excessive digitization noise if the low cut-off frequency is the standard 0.07 Hz(4). Removing those components with frequencies lower than the low frequency cut-off provides the base line correction. These cut-off frequency values are shown in Table 1. The resulting corrected data contains 50 equally-spaced points per second, which corresponds to a Nyquist frequency of 25 Hz. Due to the unusually long duration of the Huaco record (96 sec.), and the Instituto Geofisico record of October 3, 1974 (138 sec.), the data used for generation of spectra were limited to the first 90 seconds of record. Omission of the later part of the record had little effect on the spectra since amplitudes of the unused portions were small in relation to the rest of the accelerogram.

SPECTRAL ANALYSIS OF THE 10 ACCELEROGRAMS

Figure 2 shows the relative velocity response spectra and the Fourier amplitude spectra corresponding to each of the ten accelerograms listed in Table 1. Due to the limited space available, spectra for only one horizontal component from each record is presented. The selected component had the largest velocity response. It would appear from the Fourier amplitude spectra that, with the exception of the October 3, 1974 earthquake, and the La Molina record of November 9, 1974, the predominant components of the ground motion have periods in the range of 0.1 sec. to 0.5 sec. The records of October 3, 1974 and the La Molnia accelerogram for November 9, indicate predominant periods between 0.6 and 0.8 seconds. Tripartite plots of the pseudo-velocity response spectra are shown in Figure 3. In all spectra plots, the damping values are 0, 2, 5, 10 and 20 percent of critical.

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2. Cloud, W. K., Perez, V., 1971, Unusual Accelerograms Recorded at Lima, Peru. Bulletin of the Seism. Soc. of America, pp 633-640.
3. Hudson, D. E., Brady, A. G., and Trifunac, M. D., 1969, Strong-Motion Earthquake Accelerograms, Digitized and Plotted Data. California Inst. of Tech., Pasadena, Earthquake Engineering Research Laboratory, Report No. EERL 69-20, Vol. 1, Part A, 164 p.
4. Hudson, D. E., Brady, A. G., Trifunac, M. D., and Vijayaraghavan, A., 1971, Strong-motion Earthquake Accelerograms, Corrected Accelerograms, Velocity and Displacement Curves. California Inst. of Tech., Pasadena, Earthquake Engineering Research Laboratory, Report No. EERL 71-50, Vol. II, Part A, 321 p.

Table 1

Earthquake Date	Mag.	Station	Epi-central Dist. (km)	Maximum Accel.	Digi-tized Record Length (sec)	Filtering Freq. Band Low - High Hz
Jan. 31, 1951	<6	Geoph. Inst.	105	L=.07g T=.06g	29½	0.17 - 25
Oct. 17, 1966	7.5	Geoph. Inst.	205	L=.27g T=.40g	65½	0.07 - 25
May 31, 1970	7.6	Geoph. Inst.	370	L=.12g T=.13g	58½	0.08 - 25
Nov. 29, 1971	5.3	Geoph. Inst.	125	L=.06g T=.09g	40	0.10 - 25
Jan. 5, 1974	6.6	Geoph. Inst.	79	L=.09g T=.11g	50	0.08 - 25
		Zarate	73	L=.16g T=.16g	41	0.10 - 25
Oct. 3, 1974	7.6	Geoph. Inst.	85	L=.25g T=.21g	138	0.07 - 25
		Huaco Res.	91	L=.20g T=.25g	96	0.07 - 25
Nov. 9, 1974	7.2	Geoph. Inst.	94	L=.03g T=.08g	63	0.07 - 25
		La Molina	105	L=.11g T=.14g	43	0.07 - 25

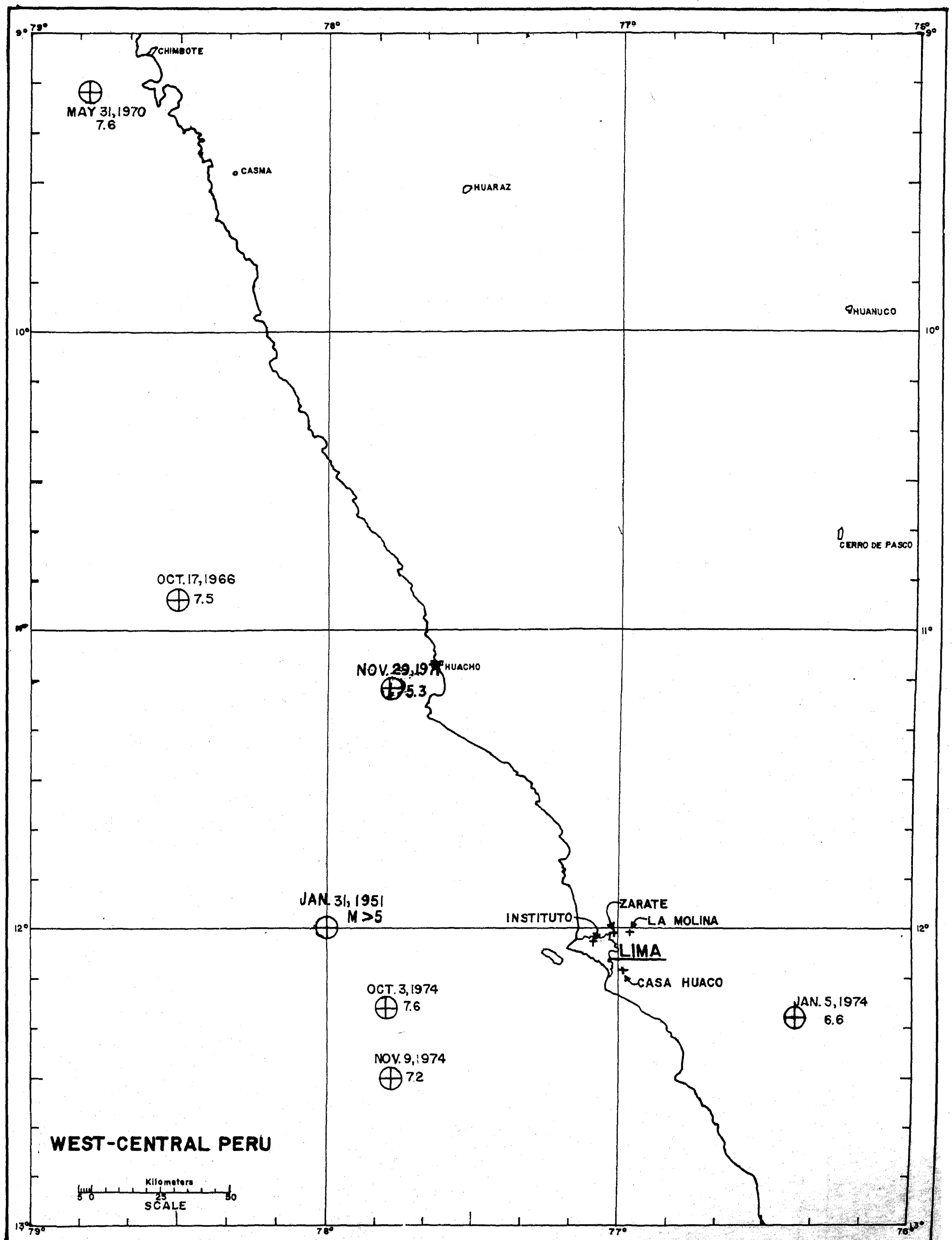


Figure 1. - Map showing location of strong-motion stations and epicenters.

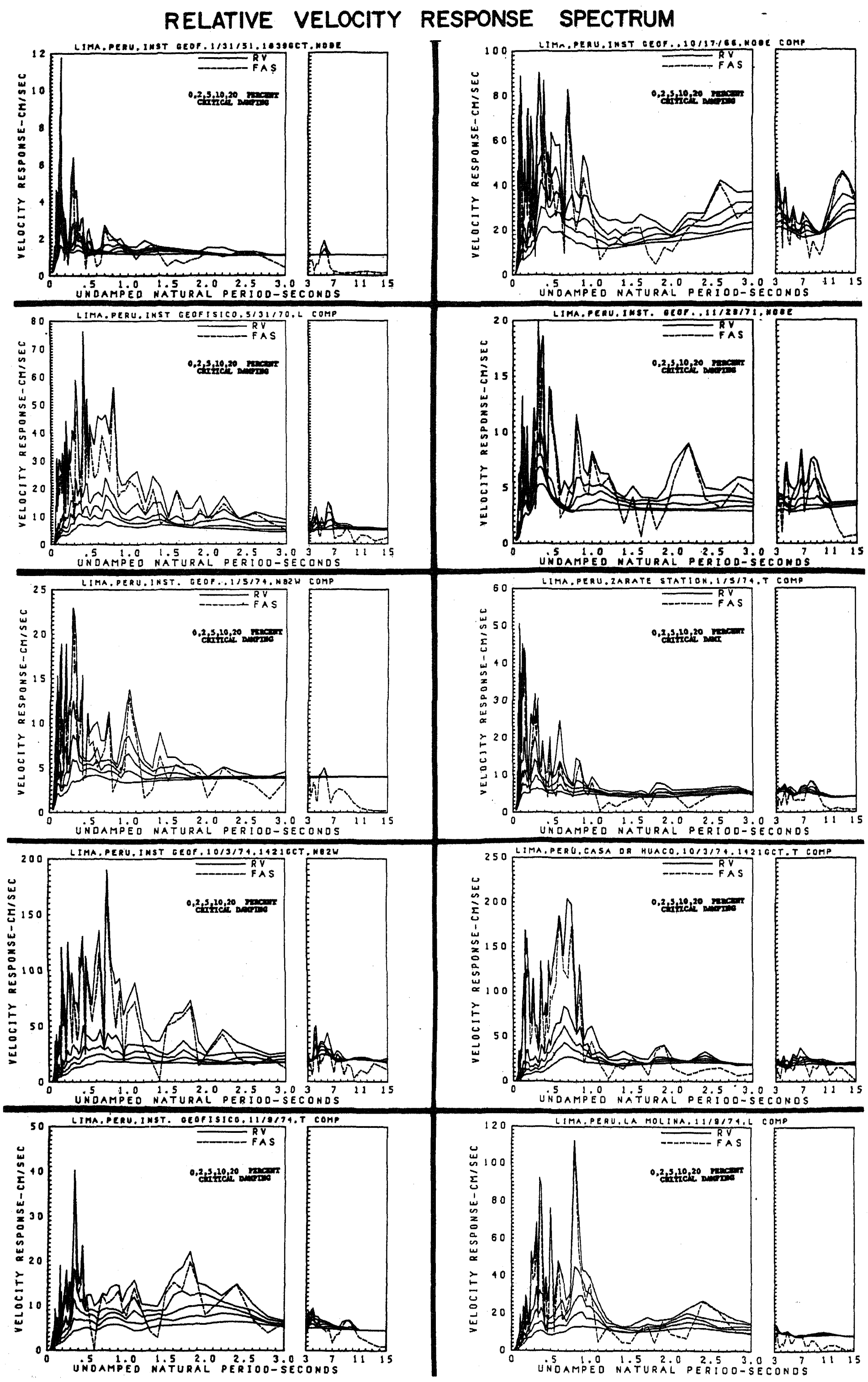


Figure 2. - Relative velocity response spectra and Fourier amplitude spectra of 10 Peru earthquakes.

RESPONSE SPECTRUM

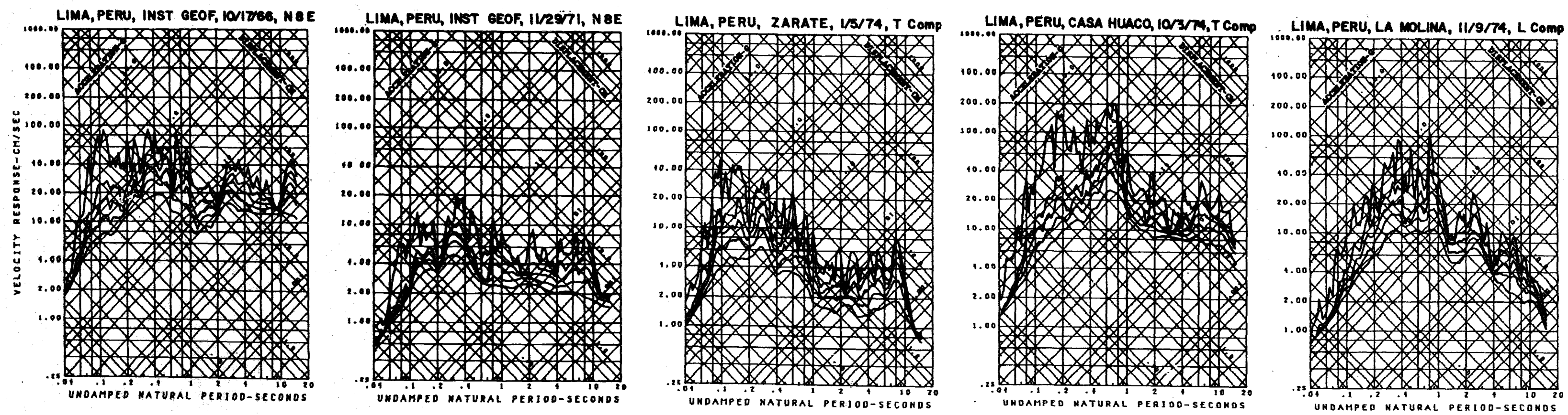
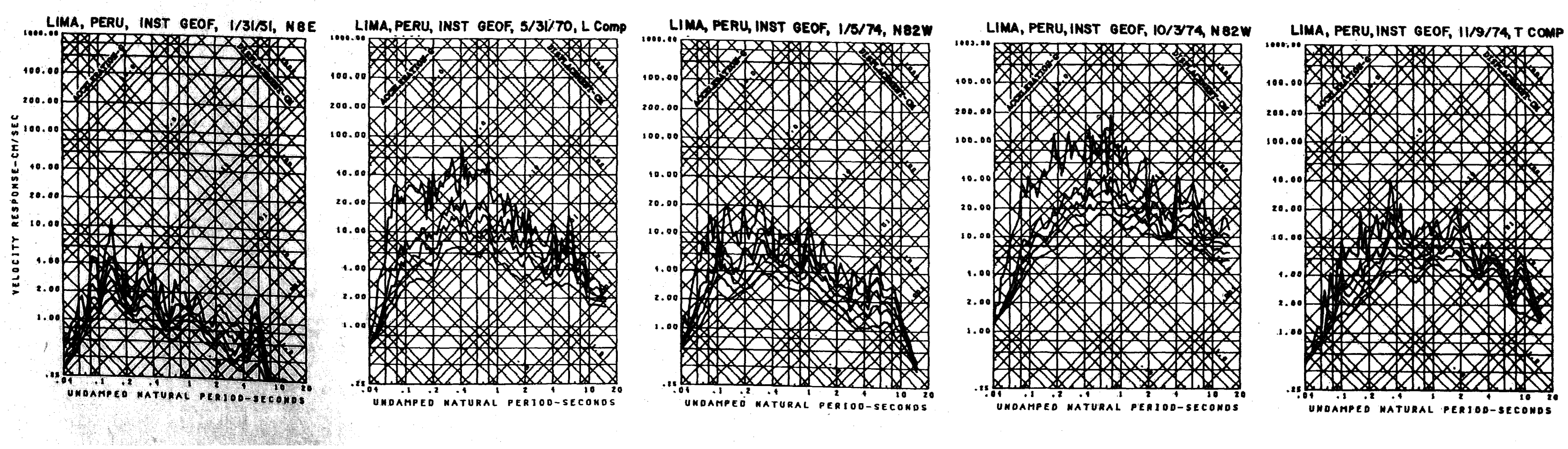


Figure 3. - Pseudo-velocity response spectra calculated with 0, 2, 5, 10 and 20 percent critical damping for 10 Peru earthquakes.



DISCUSSION

J.L. Justo (Spain)

A large statistical study is described in paper (2-203) the result of which is that predominant period for acceleration depends mainly upon conditions and distance to the fault.

When we speak about predominant period we should specify whether we refer to acceleration, velocity or displacement, because the differences are quite large.

D. Tocher (U.S.A.)

For the Peru Earthquakes of 1966 and 1970, the accelerograms at Lima indicated an anomalously low attenuation of the higher frequency waves. My question is: do the other accelerograms recorded at Lima also suggest this unusually low attenuation of the higher frequency waves ?

Author's Closure

Not received.