DIGITAL RECORDINGS OF STRONG-MOTION IN MEXICALI VALLEY, IN GUERRERO, AND DURING AFTERSHOCK SEQUENCES IN MEXICO

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SUMMARY

A digital accelerograph array has operated in Mexicali Valley since 1978, a digital aftershock array is located in Mexico City for immediate deployment in Mexico, and a new, probably digital, array for the Pacific Coast of Mexico in Guerrero is in the instrument selection and site selection stages. Each array is designed to obtain a return of data on a short time scale. The Mexicali Valley array was successful in this effort when it recorded significant earthquakes in 1979 and 1980.

INTRODUCTION

A network of digital strong-motion accelerographs is operating in the Mexicali Valley, Baja California and Sonora, Mexico. Eight more digital strong-motion accelerographs are maintained in Mexico City for immediate response to earthquakes for the purpose of recording strong aftershocks. Finally, a new network of strong motion stations for Guerrero, Mexico is, at this writing, in the instrument selection and site selection stages, and will be partially operational in July 1984.

These three projects are the result of successful collaboration of personnel at the University of California at San Diego (UCSD) and the Universidad Nacional Autónoma de Mexico (UNAM). Principal personnel are J.N. Brune, J.E. Luco and J.G. Anderson at UCSD and J. Prince, E. Mena, R. Quaas and S.K. Singh at the Instituto de Ingeniería, UNAM.

The common feature of these projects is that each has a high probability of recovering strong motion data within a short period of time. The fundamental criterion for each instrument deployment is the high probability of obtaining strong motion data which will help to solve specific problems. The problems are chosen because of their current interest to both the seismological and the engineering communities.

The Mexicali Valley array addresses the problem of the nature of strong earthquake ground motion very near a fault. Thus we maintain several accelerographs at locations within one to two kilometers of what may be the most active strike-slip fault in North America outside of Alaska. The Guerrero array addresses the problem of strong ground motion caused by a subduction thrust earthquake. We are instrumenting a seismic gap that has not had a significant earthquake in over 70 years, even through the average recurrence time in that location appears to be much smaller. Finally the aftershock array is poised to recover accelerograms from the strong aftershocks which are expected to occur after a major mainshock in the highly seismic country of Mexico.

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MEXICALI VALLEY ACCELEROGRAPH ARRAY

The Mexicali Valley array is located in a hot desert region along the Cerro Prieto fault in northern Mexico, primarily in the State of Baja California Norte but also in Sonora. The Cerro Prieto fault in this region (~32°N, 115°W) forms the boundary between the North America plate and the Pacific plate. While the San Andreas system in southern California consists of several sub-parallel faults each carrying part of the plate motion, some of the major strands (the San Jacinto fault and the Imperial fault) of southern California appear to converge on the Cerro Prieto fault, and there are no known major parallel locations where the plate slip occurs. This appears to explain the high earthquake occurrence rates which have been observed in Mexicali Valley.

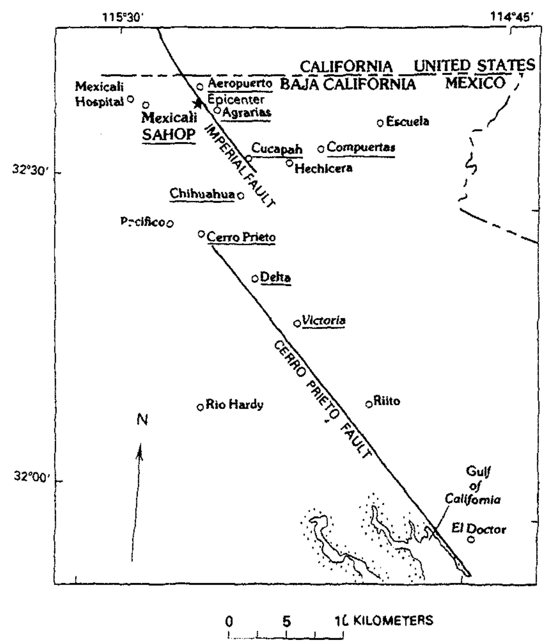

Figure 1. The Mexicali Valley accelerograph array.

The array layout is shown in Fig. 1. The array is described in detail in Ref. 1. Most of the stations form a linear array from Cerro Prieto to El Golfo. These stations are as close as practical to the surface expression of the Cerro Prieto fault. Additional stations form a cross array in the complicated region where plate motion appears to be transferred partially to the Imperial fault.

Accelerographs are mounted on small concrete piers and set apart from adjacent structures. In spite of the severe environment, in which daytime temperatures regularly exceed 40°C for four months of the year, the units have operated acceptably. We have recorded accelerograms for two important earthquakes and several smaller events and aftershocks. The accelerograms have a noise level comparable to or better than digitized records from analog accelerographs (Refs. 1,2) and design improvements have since lowered the noise level on many of the units.

The first major event recorded by the array ($M_L = 6.6$) occurred on October 15, 1979, with the epicenter on the Imperial fault near the analog station at Aeropuerto. The accelerograms are described in Ref. 3. The fault ruptured primarily to the north from the epicenter, but the Mexicali Valley array provided critical coverage to the south to make this earthquake one of the best recorded earthquakes in the history of strong motion seismology. Fig. 2 shows values of peak accelerations as recorded in Mexico and the United States for this earthquake.

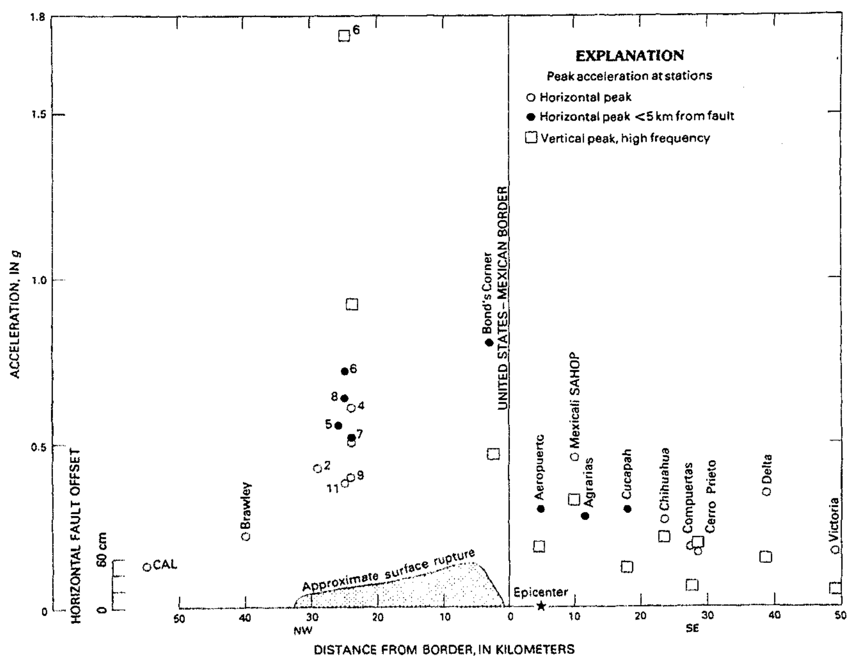

Figure 2. Peak accelerations from the October 15, 1979 Imperial Valley earthquake (after Ref. 3).

The second major earthquake recorded by the array occurred on June 10, 1980. The epicenter was near the station of Riito and rupture proceeded to the northwest approximately to station Cerro Prieto. Preliminary results on that earthquake were compiled in Ref. 4. The most significant accelerogram is that from Victoria (Fig. 3). Unfortunately we encountered some difficulty in recovering this accelerogram from the digital cassette tape (Ref. 5). The record thus has a few gaps during the interval of strongest shaking. However, that part of the record which was recovered is reliable, and shows peak horizontal motions of 0.98 g and 0.88 g; the vertical component clipped at 1 g.

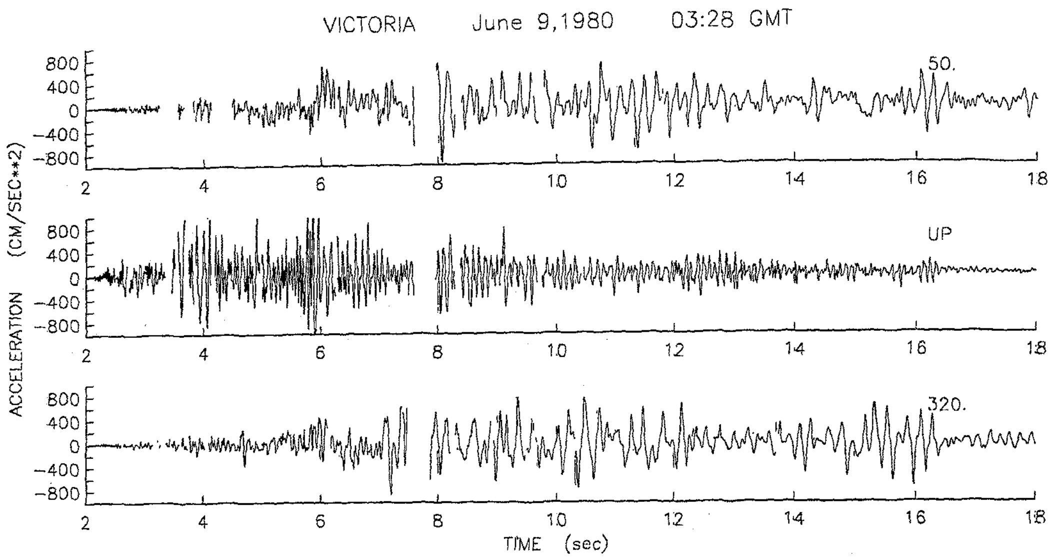

Figure 3. Accelerogram from station Victoria for June 10, 1980 ($M_L = 6.2$) Mexicali Valley earthquake.

Fig. 4 shows the Fourier spectrum of acceleration for a Cucapah horizontal component recorded in the June 10, 1980 earthquake. When plotted on log-log paper the spectrum is seen to have the characteristic shape (Ref. 6). On a linear frequency axis, the spectrum shows exponential decay with frequency, with a spectral decay parameter κ. Anderson and Hough (Ref. 7) have found that exponential decay is common in California accelerograms. They find that κ has a finite intercept when plotted as a function of epicentral distance, and that it increases very slowly with distance. A simple model for this phenomenon is in terms of frequency-independent Q which is very low close to the surface of the earth, but very high (~1000) at the depths of S-wave propagation.

Considering the quality of the data obtained so far, we consider our experience with digital recorders in the Mexicali Valley to be successful. There have been some problems, which are described in Ref. 1, and maintenance effort has increased somewhat with time, but these have not prevented the accomplishment of our scientific objectives.

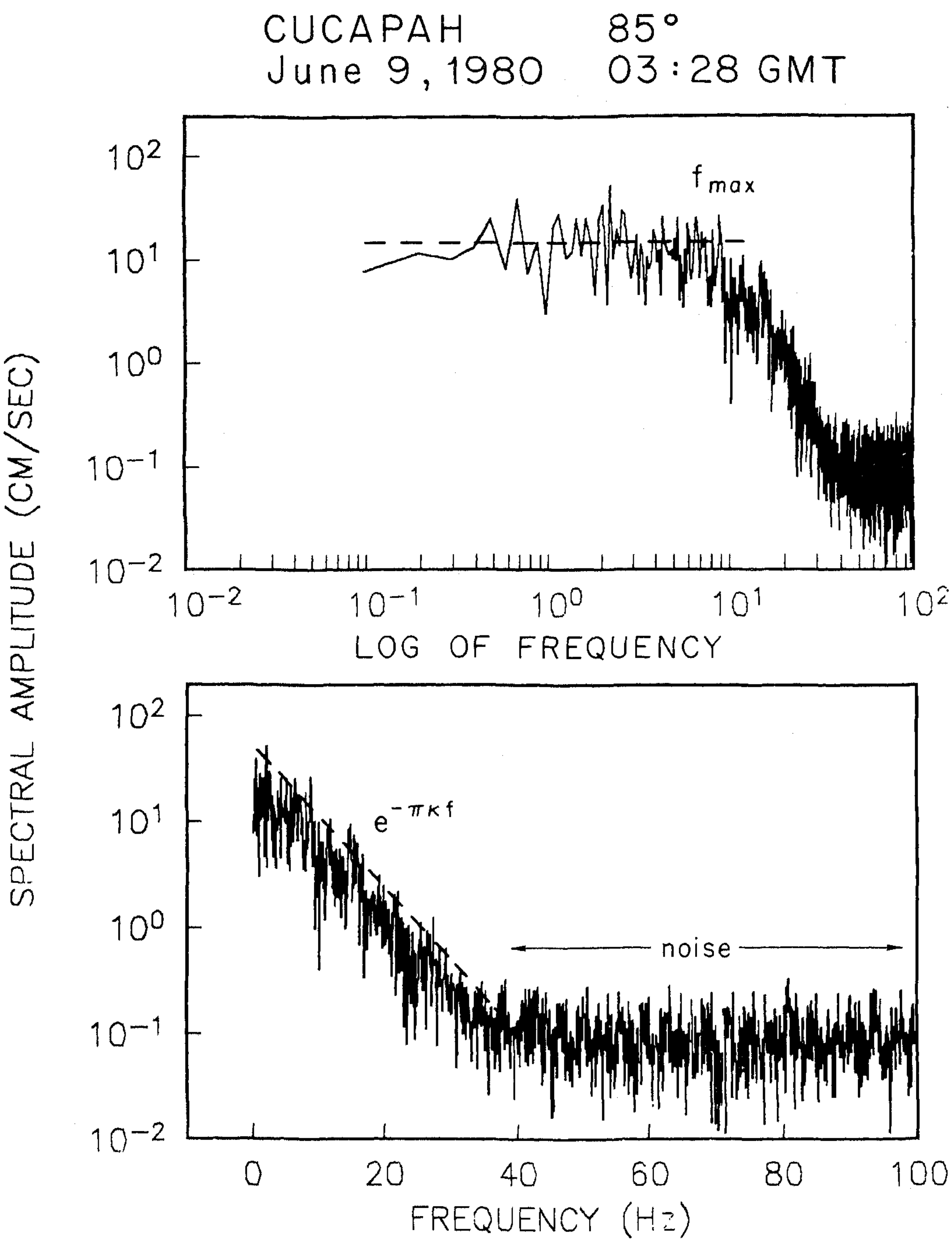

Figure 4. Fourier spectrum from station Cucapah for June 10, 1980 ($M_L = 6.2$) Mexicali Valley earthquake.

AFTERSHOCK RESPONSE CAPABILITIES

Strong aftershocks are almost certain to occur after large earthquakes. If accelerographs are set up quickly, they are thus likely to record several earthquakes. Aftershocks are not usually as strong as the main shock, so the aftershock array may be best used in the study of different scientific problems than a fixed array. We have refined the technique of recording aftershocks in two ways: our instruments are ready to depart for the aftershock zone instantly, and we have planned in advance what scientific problems to study.

Our aftershock array consists of eight digital accelerographs (Terra Technology DCA-333). Each is packed into an aluminum suitcase which also contains all the necessary equipment for temporary installation on soil, rock, or man-made surfaces. Each suitcase also contains various power connections and all other necessary accessories. Each suitcase has an external power connector and the accelerograph batteries are constantly charged even though the suitcase is closed. Clock corrections are applied periodically in the lab. Thus following the earthquake we simply unplug the suitcase and load it into the truck. Emergency response personnel maintain fully packed personal suitcases. Thus we are able to leave for the aftershock zone immediately.

GUERRERO ACCELEROGRAPH ARRAY

Earthquakes along the Pacific coast of Mexico result from subduction of the Cocos plate beneath the North America plate. Singh et al. (Ref. 7) summarized the earthquake history of the region. Fig. 5 shows both the epicenters and the space-time history of known earthquakes with magnitude greater than 7.0. Our newest array, in Guerrero, Mexico, intends to monitor one of the next of these major earthquakes.

Our Guerrero array will focus on the plate boundary north of Acapulco; targets for accelerograph site locations are shown in Fig. 6. This region last ruptured in a sequence of four earthquakes: 1899 (M7.9), 1908 (M7.5), 1909 (M7.4), 1911 (M7.5). Considering Fig. 5, we conclude that this gap is a most likely location for a large earthquake.

In October 1983 we were selecting sites and instruments for this array. Some sites were chosen in September 1983; these are on very competent, unweathered to weathered igneous and metamorphic rock outcrops. The instrument selection had not been made yet. Considering our good prior experience and proven technical capability to handle digital equipment, digital accelerographs are our probable choice.

CONCLUSIONS

The prominent feature of our program of digital strong motion recording is to install accelerographs in likely places to record strong motion. This approach has yielded important data in the Mexicali Valley of Mexico. Our digital strong-motion aftershock accelerographs have not yet yielded significant data, but are expected to do so with the next significant Mexican earth-

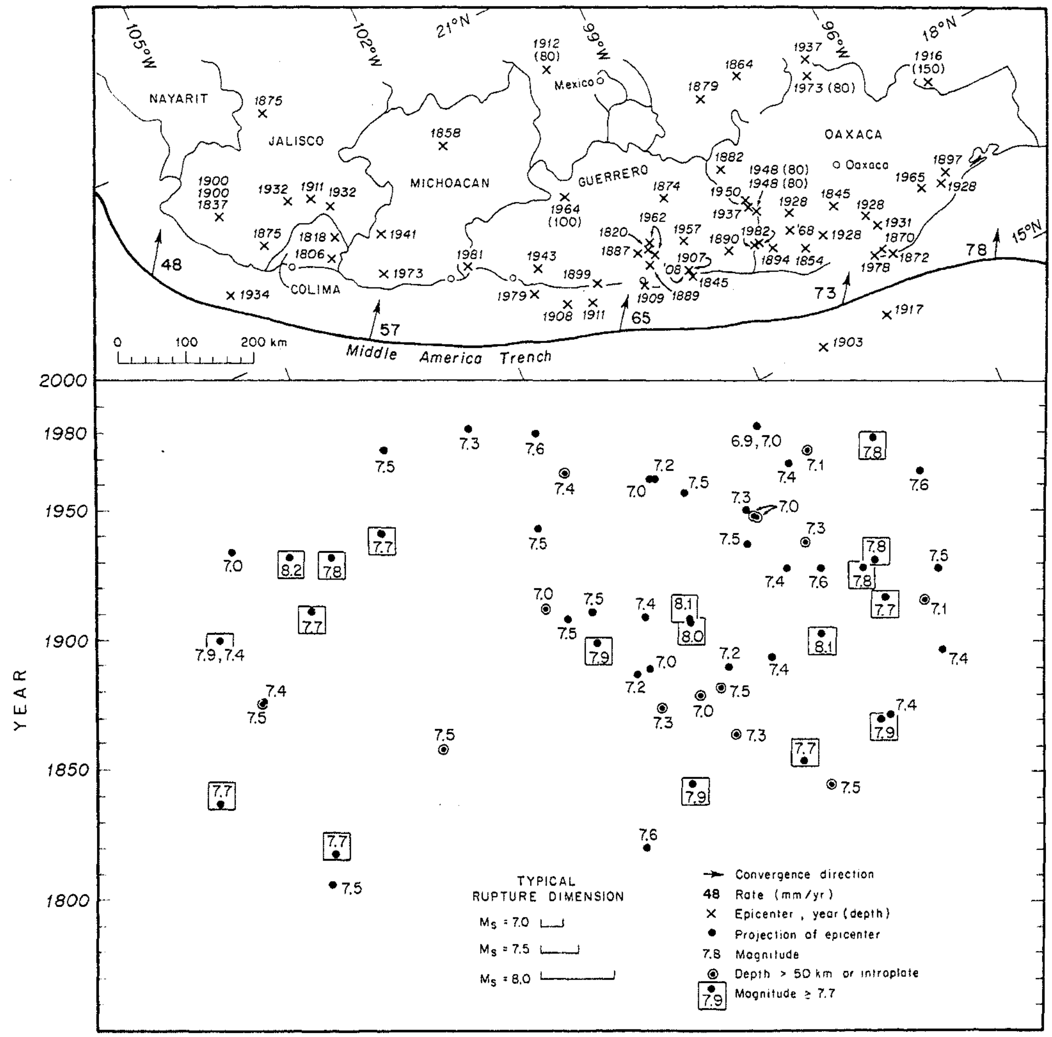

Figure 5. Historical seismicity of the Mexico subduction thrust.

quakes. Finally, our new accelerograph network in Guerrero, Mexico, to be completed in mid 1985, is likely to record a major thrust earthquake in the near future.

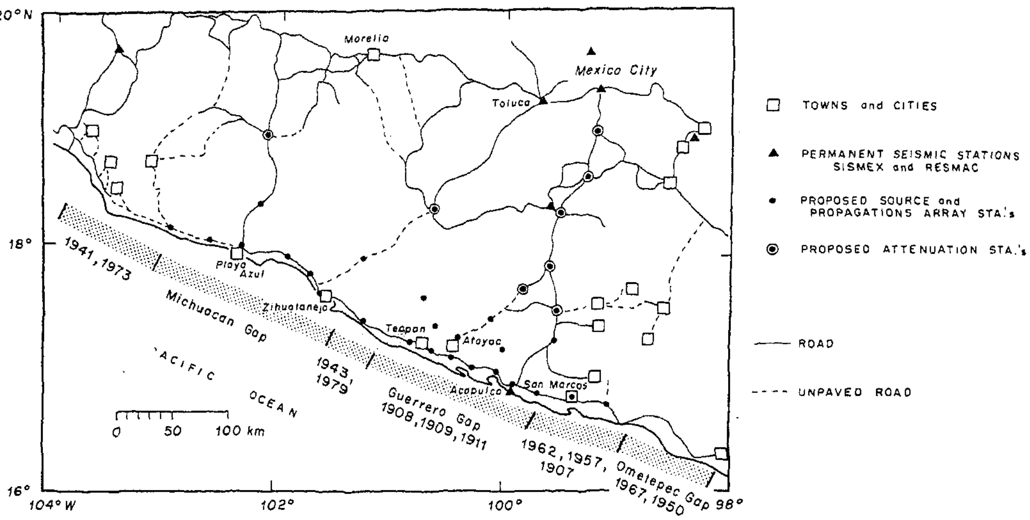

Figure 6. Guerrero gap array: targets for accelerograph locations.

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