DIGITAL SEISMIC EVENT RECORDER RECORDS AND SPECTRA FOR AFTERSHOCKS OF THE NOVEMBER 29, 1978 OAXACA EARTHQUAKE

LUIS MUNGUÍA**, J. N. BRUNE**,
A. REYES***, J. GONZALEZ***,
R. SIMONS** and F. VERNON**

RESUMEN

Un arreglo de 7 grabadoras digitales fue operado en la región de las réplicas del temblor de Oaxaca, México. Los instrumentos operados durante este estudio consistieron en grabadoras digitales de Terra Technology combinadas con sismómetros Kinemetrics y Geotech S-500 de períodos 5 y 1 segundos respectivamente.

Espectros y gráficas del desplazamiento (corregidos por la respuesta del instrumento y por Q) fueron calculados. Formas de onda simples y complejas fueron observadas para temblores con aproximadamente el mismo epicentro. Se cree que la complejidad de los sismogramas es debido a fuentes complejas y no a complejidad estructural del medio. Los espectros calculados se interpretaron en términos del modelo de Brune para calcular el momento sísmico, las caídas de esfuerzo y las dimensiones de la fuente. Las frecuencias de esquina observadas están entre 0.7 y 8 Hz, y las caídas de esfuerzo entre 6 y alrededor de 400 bars.

Las amplitudes de las ondas superficiales observadas en estaciones lejanas fueron utilizadas para hacer una segunda determinación del momento sísmico. Se encontró que los momentos calculados de este modo son de 2 a 6 veces mayores que los calculados del espectro del desplazamiento.

***Institute of Geophysics and Planetary Physics University of California, San Diego; Scripps Institution of Oceanography, La Jolla, California, USA.*

****Centro de Investigación Científica y Educación Superior de Ensenada, Ensenada, B. C., México.*

Two days after the occurrence of the 7.8 magnitude Oaxaca earthquake we began the installation of an array of seven digital seismic event recorders in the epicentral area, as a cooperative project between CICESE at Ensenada, B. C., México and UCSD. The first recorder was installed by December 1 and six more instruments were recording by December 5. The array was maintained for about four months. Hundreds of high quality digital records were obtained during this recording interval. S-P times observed on the records range from 2 to about 10 seconds. It has not been possible to analyze all the data as yet, so we only report preliminary results for a limited number of events.

The instruments used in this study consisted of 100 sps Terra Technology digital event recorders with 5 second Kinemetrics seismometers and 1 second Geotech 8.500 seismometers. The horizontal seismometers were oriented N-S and E-W at all of the station sites.

Spectra and displacement time functions (corrected for instrument response and Q) were computed. Figures 1 through 3 show examples of the spectra and time functions. The wave forms shown correspond to earthquakes located in the relatively shallow offshore area, in nearly the same place. Hence, the fact that both simple and complex seismograms were obtained suggests that the complexity of the more complex seismograms is probably due to source complexity and not structural complexity. However, some of the apparent complexity could also result from the station being near a node in the S-wave radiation pattern as suggested by the fact that the ratio of the P-wave amplitude to S-wave amplitude is normally higher for the complex looking events (Tucker and Brune, 1977). We interpreted the computed spectra in terms of the Brune (1970, 1971) model to estimate the seismic moment, source radius, and stress drop (columns 8, 11 and 12 of Table I). Seismic moment estimations were also obtained from the direct comparison of the observed surface wave amplitudes at Albuquerque and the synthetic surface wave amplitudes computed using the Harkrider (1964, 1970) surface wave program (column 9 of Table I). The m_b magnitudes given on column 6 of Table I are those published by the USGS while the M_s magnitudes of the next column were computed using the observed surface waves at

Albuquerque and the Gutenberg definition of M_S given in Richter's book (Richter, 1956). The surface wave moments were found to be 2 to 6 times larger than the body wave moments for the events in Table I. This result is similar to what was found for some of the large events in the San Fernando aftershock sequence (Tucker and Brune, 1973, 1977) and in the Brawley earthquake swarm (Hartzell and Brune, 1977). The discrepancy suggests a second corner frequency at periods greater than 3 seconds but could also in part be due to the poor resolution of the spectral amplitudes at these periods.

Corner frequencies (column 10 of Table I) range from about 0.7 Hz to 8 Hz and the stress drop ranges from about 6 bars to 400 bars. The larger offshore events with low stress drops were generally complex, with relatively low corner frequencies. These events have hypocentral depths between 10 and 15 km. The deeper onshore events tend to have higher stress drops.

The stress drops found here are similar to those found for San Fernando aftershocks (Tucker and Brune, 1973, 1977) and Brawley earthquake swarm (Hartzell and Brune, 1977). (Note that the average magnitude of the events in Table I is somewhat larger than for those studies.)

The larger events which appear to have two corner frequencies (like some of the events from the San Fernando and Imperial Valley) can be interpreted as partial stress drop events or alternatively as resulting from a large amount of relatively slow after-slip associated with a high stress drop initial rupture.

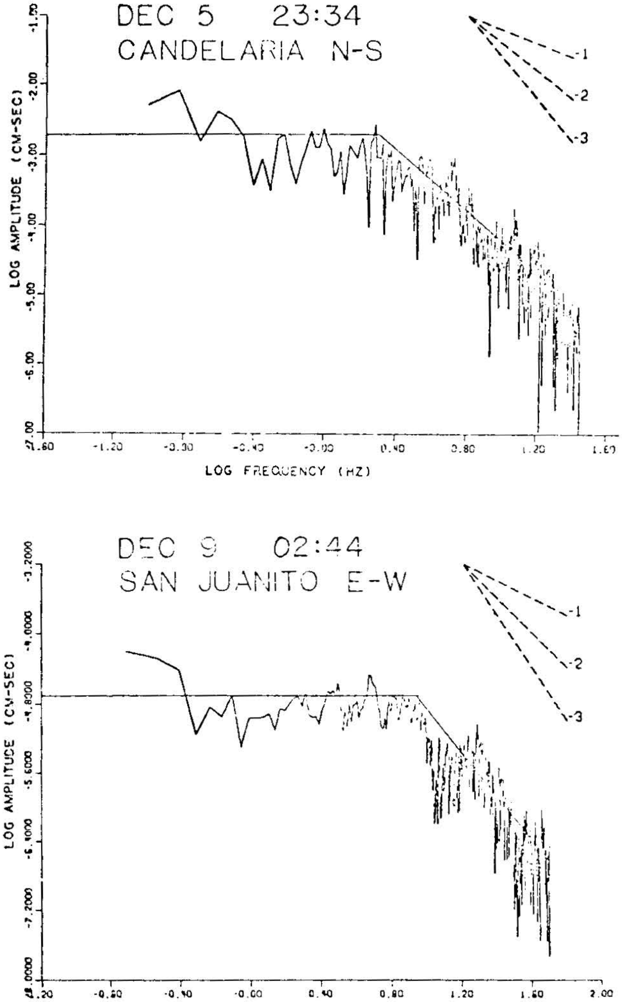

Figure 1. Illustrative examples of amplitude spectra for Oaxaca aftershocks. The m_b magnitudes of the corresponding earthquakes are about 4.0 (top) and 2.5 (bottom). The broken lines indicate slopes of -1, -2 and -3.

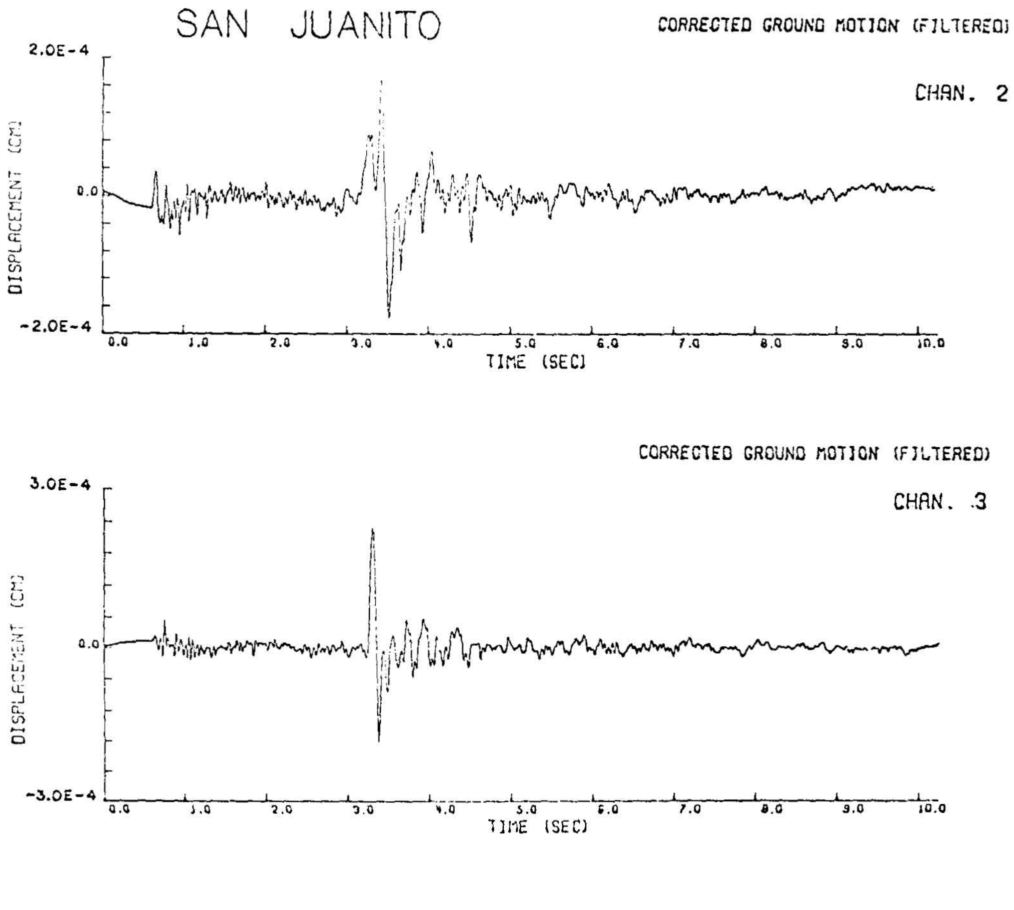

Figure 2. Seismogram showing a simple S-wave pulse. Channels 2 and 3 correspond to the N-S and E-W components respectively. The epicenter for this earthquake was located in the offshore area.

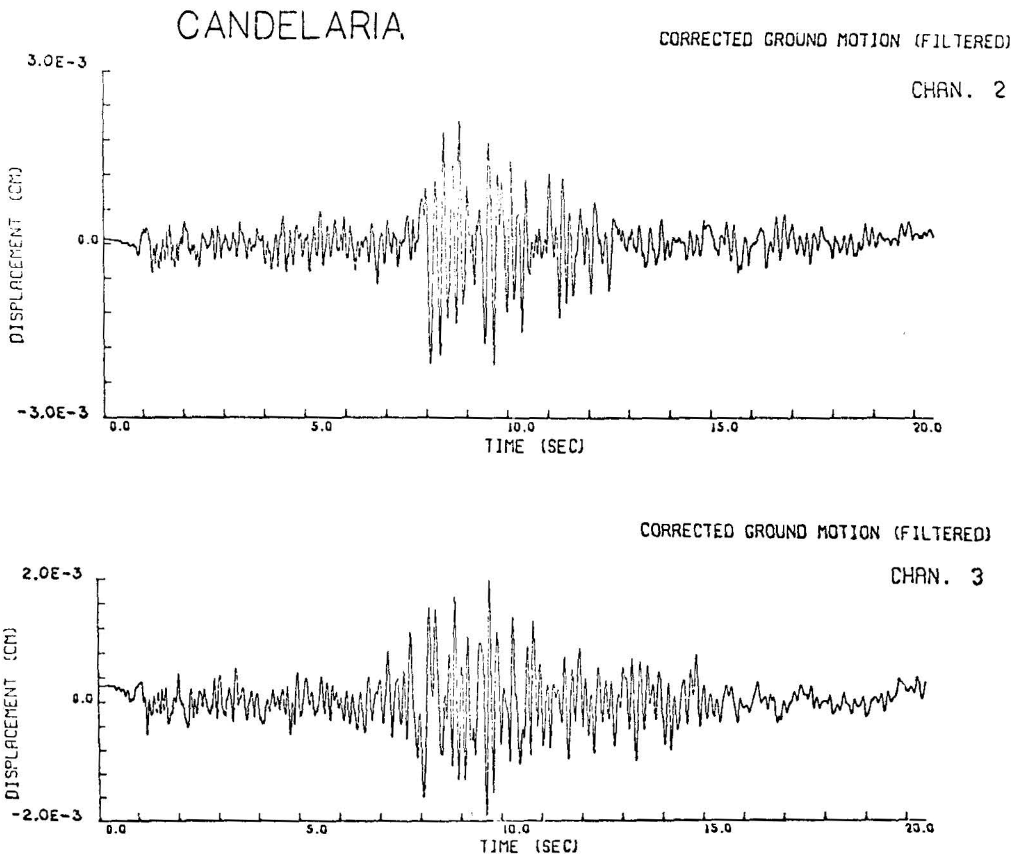

Figure 3. Representative example of a complex seismogram.

TABLE I.

LOCATION, MAGNITUDE, AND SOURCE PARAMETERS FOR SOME OF THE OAXACA AFTERSHOCKS (NOVEMBER 1978 - JANUARY 1979)

Event		Hypocenter					Magnitude		M_o (x 10^{22} dyne-cm)				
Date	Time	Latitude (°)	(min)	Longitude (°)	(min)	Depth (km)	m_b	M_s	M_o^b	M_o^s	f_o (Hz)	Radius (m)	Stress Drop (bars)
Nov 29	23:06						5.2	5.5		110.0			
30	10:22						5.2	5.6		250.0			
30	13:15						4.1	4.1					
Dec 2	03:24						4.6	4.9		69.0			
2	05:36						4.6	5.4		170.0			
2	23:34								1.9		2.29	564.0	48.0
3	10:33	15	59.00	96	45.42	34.0			0.3		6.70	192.0	157.0
4	01:09						4.2		6.6		1.60	786.0	61.0
4	21:12								0.2		5.20	245.0	6.2
5	06:32		40.07	97	17.50	15.0	4.5	5.2	16.4	83.0	0.76	2021.0	8.5
5	08:59		40.32		21.12	17.0			0.6		2.85	453.0	32.0
5	11:55		59.18		10.43	24.0			0.6		6.00	213.0	252.0
5	13:01		33.02	96	50.94	11.0			0.6		6.45	216.0	254.0
5	19:21		40.74		49.76	12.0			0.2		6.95	187.0	162.0
5	23:41		31.60		51.14	12.0	4.7		6.6	22.0	0.95	1547.0	9.0
6	02:24		28.49		25.62	10.0			0.1		7.60	170.0	117.5
7	23:52		03.36		51.17	29.0			0.2		7.36	175.0	119.0
8	00:27		00.00		51.57	29.0			0.3		7.35	175.0	212.0
8	10:51		40.05		49.06	13.0	4.2	4.0	4.0	22.0	3.56	363.0	380.0
9	02:44								0.007		7.75	170.0	7.5
9	08:40		32.33		51.13	16.0			0.3		4.47	290.0	45.0
9	11:01		36.97		54.47	15.0			0.2		5.75	224.0	69.0
18	21:49						4.4	4.5	4.9	28.0			
20	00:00?								0.2		5.20	245.0	68.7
27	12:01								1.2		3.00	426.0	66.0
28	08:52						4.5	4.8	22.0	42.0			
28	19:19						4.7	4.8	9.2	55.0	1.30	1000.0	40.0
28	19:48						5.3	5.4		194.0			
28	20:31								0.3		7.60	170.0	319.0
29	00:47								0.5		7.70	168.0	490.0?
Jan 31	10:14						5.0		2.5	18.5(R)	7.40		

M_o^s = Seismic moment from surface waves M_o^b = Seismic moment from body waves

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