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The Guerrero Accelerograph Network

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RESUMEN

La red de Guerrero está compuesta por 30 estaciones acelerográficas digitales de movimientos fuertes ubicadas en Guerrero, México y estados vecinos. La red fue diseñada para registrar acelerogramas de temblores de gran magnitud en parte de la zona de subducción de México. La red está localizada encima de una brecha sísmica madura y con posibilidades de registrar uno o más temblores de magnitud cercana a 8 en los próximos años.

Los 30 sitios para la red acelerográficas de Guerrero fueron seleccionados en los mejores sitios rocosos disponibles de acuerdo con la geometría de la red y otros criterios secundarios sobre las condiciones locales. Los instrumentos digitales han operado extremadamente bien en los pasados 7 años y han producido datos, tanto en cantidad como en calidad, que exceden las expectativas iniciales.

A diciembre de 1991 la red ha producido más de 927 acelerogramas de 385 temblores. Los registros más importantes a la fecha provienen de los temblores de septiembre 19 y 21 de 1985 (M_S=8.1, 7.6) y abril 25 de 1989 (M_S=6.9). A magnitudes menores la red ha producido un excelente conjunto de sismogramas de 26 temblores con magnitudes 4.2 y mayores. Ha registrado también numerosos sismogramas de eventos con magnitudes 3 o menor, aunque estos pequeños eventos sólo han logrado disparar algunas pocas estaciones. La localización de los eventos que han disparado los instrumentos de la red se concentra cerca de la costa en los dos extremos de la brecha sísmica de Guerrero, cuyos límites están definidos por las zonas de ruptura de los mayores temblores históricos.

PALABRAS CLAVE: Red Acelerográfica de Guerrero, movimientos fuertes registrados, México.

ABSTRACT

The Guerrero network consists of 30 digital strong motion accelerographs in Guerrero and neighboring states, Mexico. The network was designed to record accelerograms from large earthquakes on part of the Mexico subduction thrust. The network is located above a mature seismic gap, and within the next few years it is likely to record one or more earthquakes with magnitude near 8.

The 30 sites for the Guerrero accelerograph network were selected to be on the best rock available, consistent with the network geometry and secondary siting criteria. The digital instruments have operated extremely well during the past seven years, producing data in a quality and quantity that exceeded our original expectations.

As of December 1991, the network had produced over 927 accelerograms from 385 earthquakes. The most important records to date have come from the Sept 19 and Sept 21, 1985 M_S = 8.1, 7.6 and April 25, 1989 M_S = 6.9 earthquakes. At smaller magnitudes, the network has produced an excellent set of seismograms from 26 different earthquakes with magnitudes 4.2 and up. It has also recorded numerous seismograms from events with magnitudes down to 3.0 and below, although these smaller events rarely trigger more than a few stations. Locations of events that have triggered the network are concentrated near the coast at the two ends of the Guerrero gap, where the limits of the gap are defined by rupture zones of the largest historical earthquakes.

KEY WORDS: Guerrero Accelerograph Network, strong motion recordings, Mexico.

BACKGROUND

In 1982, we proposed an extensive strong motion array along a segment of the west coast of Mexico (Mexico subduction thrust) as part of the international program to record large earthquakes in the near field. The program was outlined by the International Workshop on Strong-Motion Earthquake Instrument Arrays held in Honolulu, Hawaii May 2-5, 1978 (Iwan, 1978). The proceedings of that conference indicated the region of Oaxaca, Mexico as one of the six most promising regions in the world. This region, along with Taiwan, was given the highest trigger probability per ten years (0.9 probability of acceleration greater than 0.2g and magnitude greater than 6.5). At the time of the workshop a subregion of Oaxaca was a seismic gap since it had last ruptured in 1928 and 1931 (Kelleher *et al.*, 1973). Also, Ohtake *et al.* (1977), based on observed seismic quiescence beginning 1973 for shallow earthquakes and noting a similar quiescence before the 1965 and 1968 earthquakes in Oaxaca, had forecast a large earthquake in the area with probable epicenter at 16.5N and 96.5W. The Oaxaca earthquake of Nov 29, 1978 apparently fulfilled the forecast, although in hindsight that forecast may not have been justified because the quiescence may have been caused by decreased reporting in the seismic catalog (Habermann, 1982; Whiteside and Habermann, 1989). Although the general high level of seismicity was the reason given in the proceedings of the Hawaii workshop, and not the existence of a gap, it seemed that the potential for a large earthquake in the Oaxaca region in the near future was now less than at the time of the workshop.

Among the seismic gaps along the Mexican subduction zone, the Guerrero and Michoacán gaps appeared, to our thinking in 1983, most likely to experience a large earthquake in the near future. The Guerrero gap (99.7W to 101.7W, Figure 1), which ruptured in a sequence of large earthquakes in 1899, 1908, 1909 and 1911, is flanked in the NW by a segment which broke in 1943 $M_S = 7.5$ and 1979 $M_S = 7.6$ and in the SE by a segment which ruptured in 1907 $M_S = 8.0$ and 1957 $M_S = 7.5$. In addition, based on preliminary determination of epicenters (PDE), Matumoto (1980) had reported a seismic quiescence in the Guerrero gap beginning mid-1979. This quiescence also appears in the data collected in the field for about ten days in December 1980 (Havskov *et al.*, 1981). A local array in Guerrero operating since late 1987 has recorded numerous small events in the central gap, however (Suárez *et al.*, 1990). In view of the Oaxaca experience, the seismic quiescence observed in the Guerrero gap might have been premonitory to a large earthquake, although in hindsight alternative explanations are also plausible.

Singh *et al.*, (1980) found that the Michoacán gap (101.7W to 103.0W) had not ruptured in a large earthquake in at east 80 years prior to 1980 whereas the segment to NW ruptured in 1941 $M_S = 7.7$ and 1973 $M_S = 7.5$ (Reyes *et al.*, 1979) and the segment to SE broke in 1943 $M_S = 7.5$ and 1979 $M_S = 7.6$ (Meyer *et al.*, 1980). They found some evidence from the historic data that this segment did not experience a large earthquake in the past century either, but the sparse population density along the Michoacán coast may have resulted in the mislocation or missing of large events (Singh *et al.*, 1981). An earthquake on October 25, 1981 $M_S = 7.3$ ruptured about one-third of the Michoacán gap as defined by Singh *et al.* (1980, 1981). The occurrence of this earthquake within the gap implied to us at the time that the remainder of this gap was probably not a region in which the plate tectonic slip is relieved entirely by aseismic creep. In hindsight, the earthquake of 7 June 1911 was also probably in the gap, and erroneously mislocated outside of the Michoacan gap by Singh *et al.* (1980). This gap ruptured on September 19, 1985, and provided the first significant data set from our network. This earthquake again demonstrates the value of the seismic gap hypothesis, as formulated by Kelleher *et al.* (1973), McCann *et al.* (1979), Singh *et al.* (1980, 1981) and Nishenko and McCann (1981) and others for anticipating the locations of future major earthquakes.

Based on a high probability for a large earthquake in the Guerrero region in the near future we proposed in 1982 to install a dense strong motion network in this gap first. We also proposed to install a sparse network in the remaining Michoacán gap.

The network we proposed consisted of state-of-the-art digital strong motion event recorders with time delays and accurate internal timing. We had extensive experience using this type of recording system for both regular seismometers (Brune *et al.*, 1980) and strong motion accelerometers (Brune *et al.*, 1982, Anderson *et al.*, 1983). We had used them at several sites: (1) the San Jacinto fault near Anza, California; (2) the Imperial Valley; (3) the Mexicali Valley (Munguía and Brune, 1984; Anderson *et al.*, 1982); (4) Oaxaca, Mexico aftershocks (Munguía *et al.*, 1979); and (5) aftershocks of the Imperial Valley earthquake of October 15, 1979.

Both the U.S. and Mexico were seen to benefit from the results of this project. The benefits foreseen at the time the network was planned included use of the information about strong ground motion resulting from earthquakes along the coast of Mexico to aid Mexico in planning industrial and urban development and in making major economic decisions about building design and reinforcement. There are also direct applications of the data in those areas of the U.S. subject to subduction type earthquakes (Alaska, the Pacific Northwest, and Puerto Rico). Additional benefits to both countries result from the global applicability of knowledge gained from "capturing" large earthquakes with a local strong motion array. Our knowledge about earthquake scaling, rupture propagation and excitation of high frequencies (and consequent ground acceleration) were seen to take a major step forward from analysis of earthquakes recorded on this network.

GUERRERO SEISMIC GAP

The rupture zones of recent large earthquakes define the spatial extent of the Guerrero seismic gap (Figure 1, Table 1). Seven large earthquakes occurred in Guerrero between 1899 and 1911. From Table 1, the total moment of these events was about 22 x 10^{27} dyne-cm. Much of the plate margin in Guerrero has not ruptured in a major earthquake since that turn of the century seismicity peak.

The evolution of the seismic gaps in Guerrero and vicinity is illustrated in Figure 2. Kelleher *et al.* (1973, 1974) identified one seismic gap between the 1943 Petatlán earthquake and the 1957 Acapulco earthquake, and another between the 1941 Colima earthquake and the 1943 Petatlán earthquake (Figure 2A). After the 1973 event, McCann *et al* (1978, 1979) identified a single gap extending from the 1957 rupture to the 1973 rupture, thus combining the two gaps of Kelleher *et al* and the 1943 Petatlán

Table 1

Catalog of large earthquakes in the Guerrero and Michoacán regions[1]

Date			Time	Location				Size	
Year	Mo	Da	H: M:S	Lat	Long	Depth	R_p[2]	M_S[3]	M_0[3]
				°N	°W	km	km		10^{27} dyne-cm
1806	03	25		18.9	-103.8		2141	7.5	1.79
1818	05	31		19.1	-103.6		2144	7.7	3.08
1820	05	04		17.2	-99.6		2609	7.6	2.35
1845	04	07		16.6	-99.2		2683	8.1	9.11
1858	06	19		19.6	-101.6		2283	7.5	
1864	10	03		18.7	-97.4		2709	7.3	
1874	03	16		17.7	-99.1		2620	7.3	1.04
1879	05	17		18.6	-98.0		2661	7.0	
1882	07	19		17.7	-98.2		2698	7.5	1.79
1887	05	29		17.2	-99.8		2592	7.2	0.80
1889	09	06		17.0	-99.7		2614	7.0	0.46
1890	12	02		16.7	-98.6		2728	7.2	0.80
1899	01	24	23:43:--	17.1	-100.5		2539	7.9	5.30
1907	04	15	06:08:06	16.7	-99.2	S	2677	7.7	8.43
1908	03	26	23:03:30	16.7	-99.2	S	2677	7.6	1.98
1908	03	27	03:45:30	17.0	-101.0	S	2504	7.0	0.74
1909	07	30	10:51:54	16.8	-99.9	S	2610	7.3	2.48
1909	07	31	18:43:10	16.6	-99.5	S	2658	6.9	0.35
1911	06	07	11:02:42	17.5	-102.5	S	2345	7.7	2.83
1911	12	16	19:14:18	16.9	-100.7	50	2536	7.6	2.35
1912	11	19	13:55:07	19.9	-99.8	S	2424	6.8	
1916	11	21	06:25:24	18.0	100.0	S	2523	6.8	0.27
1937	12	23	13:17:58	17.1	-98.1	S	2745	7.5	1.63
1941	04	15	19:09:51	18.8	-102.9	S	2223	7.7	2.94
1943	02	22	09:20:45	17.6	-101.1	S	2455	7.5	1.56
1948	01	06	17:23:36	17.0	-98.0	80	2760	6.9	
1948	01	06	17:25:58	17.0	-98.0	80	2760	7.0	
1950	12	14	14:15:50	17.2	-98.1	S	2739	7.1	0.89
1957	07	28	08:40:10	17.1	-99.1	S	2659	7.5	5.13
1962	05	11	14:11:57	17.2	-99.6	S	2609	7.2	0.9
1962	05	19	14:58:10	17.1	-99.6	S	2616	6.9	0.8
1964	07	06	07:22:13	18.3	-100.4	100	2469	7.2	
1973	01	30	21:01:18	18.4	-103.2	32	2225	7.5	3.0
1979	03	14	11:07:11	17.3	-101.4	20	2450	7.6	2.7
1980	10	24	14:53:35	17.9	-98.2	65	2686	7.0	0.63
1981	10	25	03:22:13	17.8	-102.3	20	2341	7.3	1.3
1982	06	07	06:52:34	16.3	-98.4	15	2771	6.9	0.27
1982	06	07	10:59:40	16.4	-98.5	20	2756	7.0	0.25
1985	09	19	13:17:49	18.1	-102.7	16	2287	8.1	11.7
1985	09	21	01:37:12	17.6	-101.8	20	2396	7.6	3.12
1986	04	30	07:07:18	18.4	-103.0	21	2242	7.0	0.3
1989[4]	04	25	14:28:59	16.6	-99.5	17	2658	6.9	0.22

[1] After Anderson *et al*, 1989b.

[2] R_p Distance from pole of rotation, 29.80°N, 121.28°W (Minster and Jordan, 1978). Earthquakes between 2130 km and 2480 km can be considered in Michoacán, and earthquakes between 2480 km and 2780 km can be considered in Guerrero.

[3] Prior to 1900, M_S is estimated from felt areas and M_o is estimated from M_S. After 1900, M_S is an instrumental estimate. After 1903, M_0 is estimated from amplitudes of 40-60 s surface waves on Wiechert seismograms from Uppsala, Sweden, or from more recent instruments. All are from Anderson *et al.* (1989b).

[4] All data on this event from Anderson *et al.* (1989a).

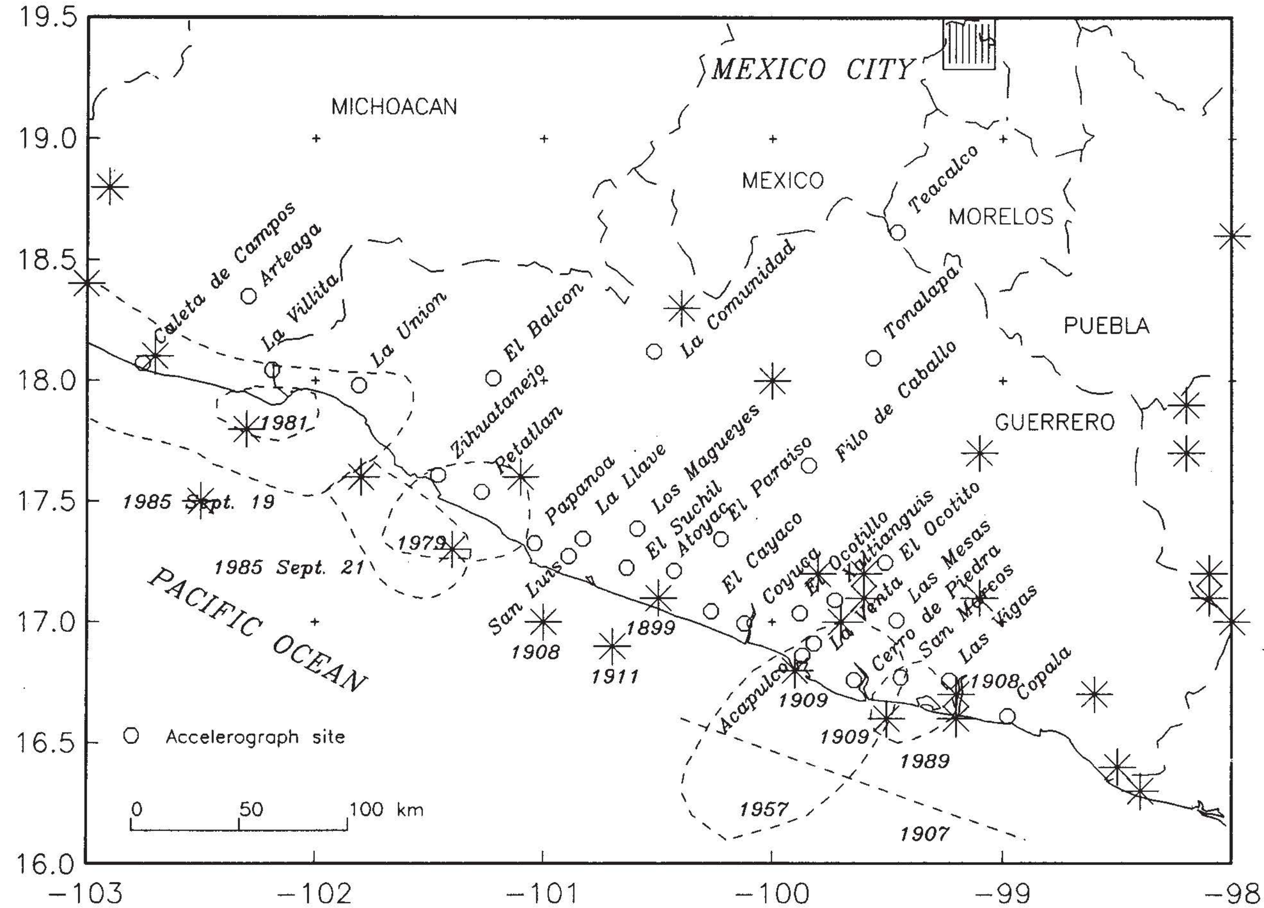

Fig. 1. Map of coastal Mexico with locations of Guerrero Accelerograph stations (open circles), epicenters of large earthquakes from Table 1 (asterisks) and rupture zones of some previous earthquakes. Aftershock zones are from the following sources: 1973 - Reyes *et al*, (1979); 1985 - UNAM Seismology Group (1986); 1981-Havskov *et al* (1983); 1979 - Valdés *et al*, (1982); 1957 and 1982 - Nishenko and Singh (1987a); 1989 - Singh (unpublished notes).

zone in between (Figure 2B). The 1979 Petatlán earthquake reruptured the 1943 zone, leading Singh *et al* (1981) to again identify two gaps (Figure 2C), in essentially the same locations as those of Kelleher *et al* (1973). Singh *et al.* (1981) named the western gap the Michoacán gap; it failed in 1985 with an M_S = 8.1 earthquake (Figure 2D). Singh *et al.* (1981) gave the gap between the 1979 and 1957 zones the name Guerrero gap; as drawn in Figure 2D, it is 125 km wide.

Singh *et al* (1981) also identified a new gap, called the Ometepec gap, east of the 1957 rupture, since 30 years is a typical recurrence time for large earthquakes in the Mexican subduction zone. Kelleher *et al.* (1973) and McCann *et al.* (1978, 1979) had not considered this a gap, as it ruptured less than 30 years prior to their papers. Using this same definition, and observing that now over thirty years have passed since the 1957 earthquake, it may be appropriate to consider the combined Guerrero gap, 1957 zone ("Acapulco gap"), and Ometepec gap, as one large seismic gap (Figure 2E, Anderson *et al.*, 1989a). The justification for identifying a break in the gap caused by the 1989 event (Figure 2E) would be extremely weak, since that event was less than 20% the size of the 1981 event which failed to stop the 1985 rupture (Figure 2D).

There is disagreement over the extent of rupture in 1957. Figure 2 consistently uses the aftershock zone according to Kelleher *et al.* (1974). More recent studies by Nishenko and Singh (1987a) and González-Ruiz and McNally (1988) give a smaller lateral extent, measured along the coastline. The smaller sizes in these two studies are more consistent with rupture lengths of similar magnitude events in the region. Unfortunately, the two studies disagree about the placement of the aftershock zone (Figure 3). Using a master event relocation technique, González-Ruiz and McNally place the 1957 aftershock zone within the eastern part of Kelleher *et al.*'s original zone. This location is essentially overlying the 1989 zone in Figure 2E. The estimated aftershock zone for the 1957

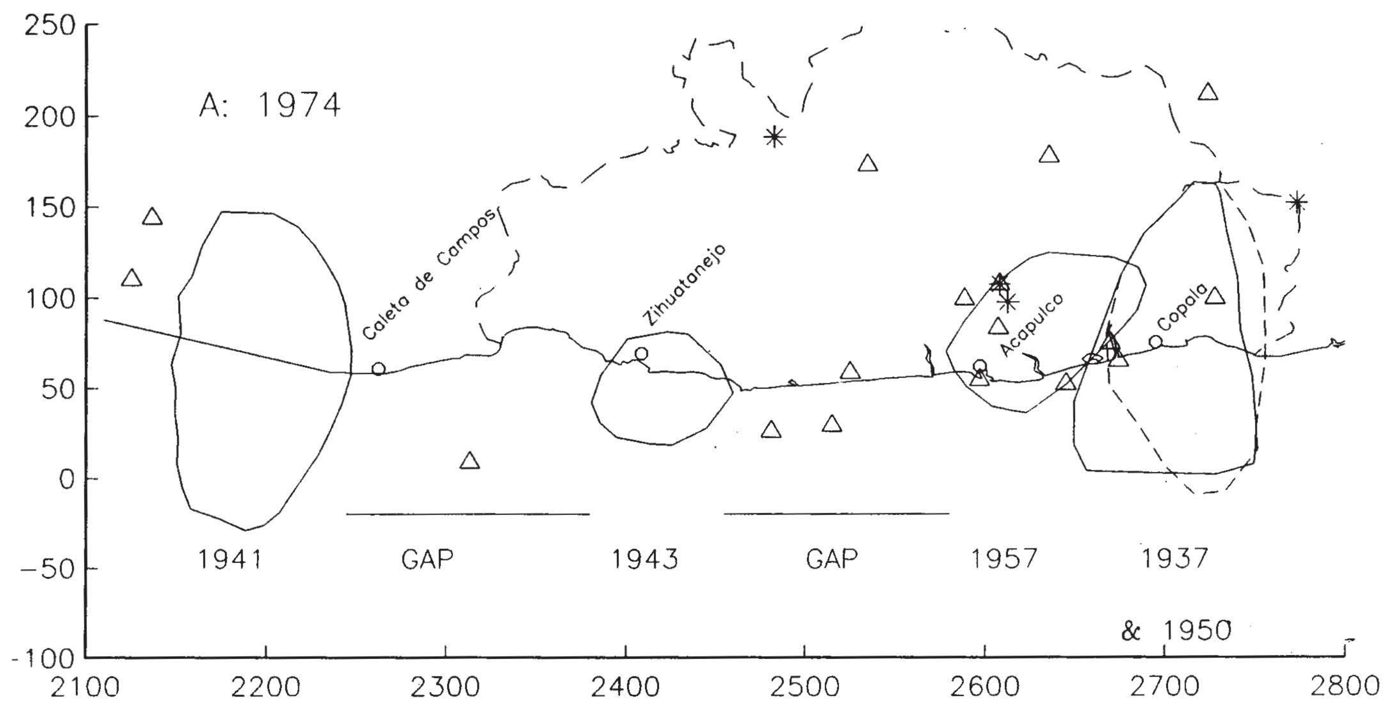

Fig. 2A. Seismic gaps near Guerrero, according to the interpretation of Kelleher *et al.* (1973, 1974). Horizontal axis is distance (km) from 25.0°N, 123.36°W. Aftershock zones of shallow earthquakes with moment greater than 10^{27} dyne-cm from 1937 to 1970 are shown. Epicenters of events prior to 1917, from Table 1, are shown with a triangle, and epicenters of subsequent events with moment below 10^{27} dyne-cm with an asterisk. Aftershock regions and gaps are after Kelleher *et al.* (1974). Note that the 1950 earthquake has moment estimated by Anderson *et al.* (1989) below 10^{27}, but it is included after Kelleher *et al.* Aftershock region of 1937 earthquake is dotted, to indicate that a subsequent event has reruptured the gap, even though the 1950 earthquake was smaller.

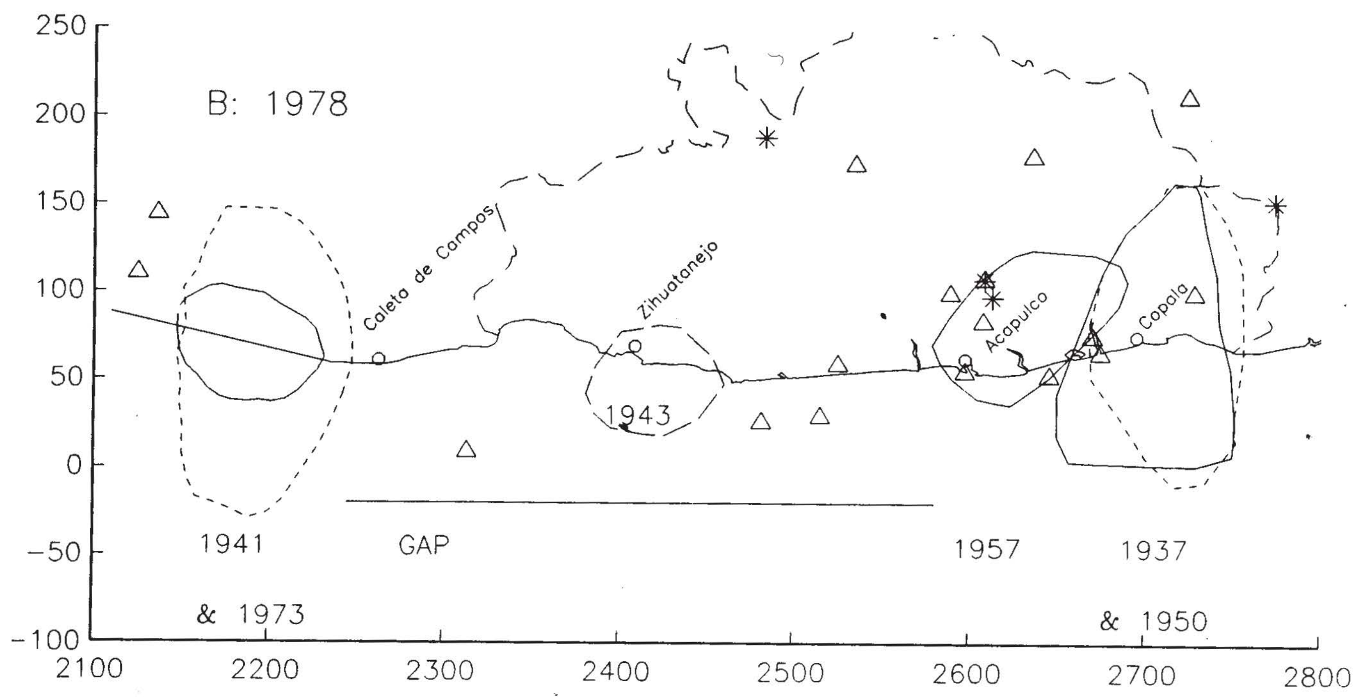

Fig. 2B. Seismic gap interpretation of McCann *et al.* (1978,1979). Aftershock zone of 1973 earthquake is after Reyes *et al.* (1979). Aftershock region of 1943 earthquake is dashed, to indicate that over 30 years have passed, and that portion of the fault might rupture again.

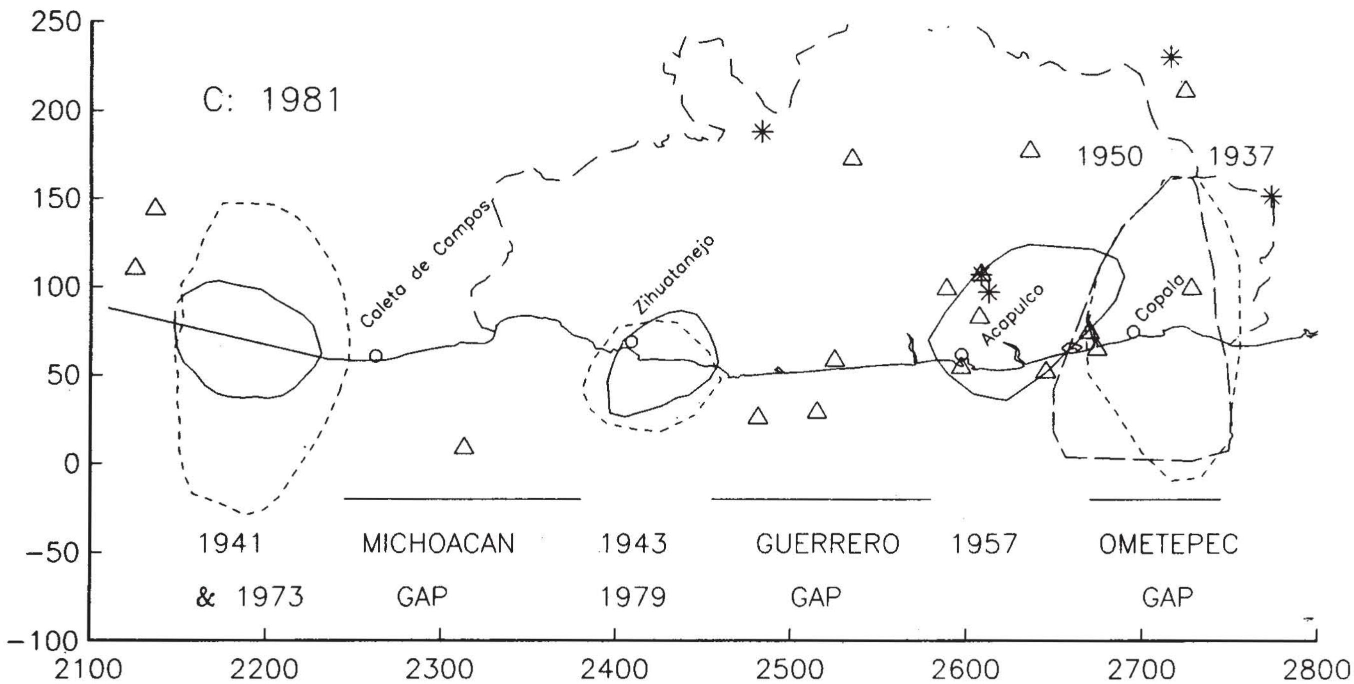

Fig. 2C. Seismic gap interpretation of Singh *et al.* (1981). Aftershock zone of 1979 earthquake is after Valdés *et al.* (1982).

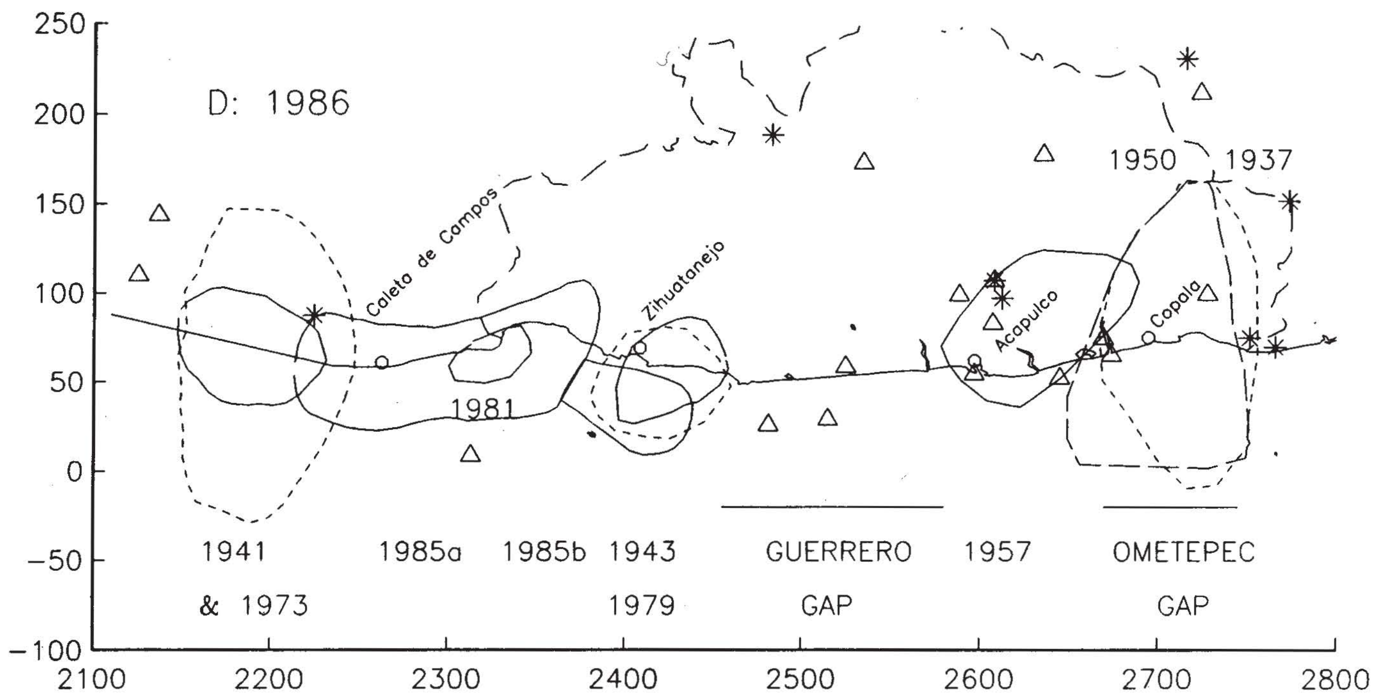

Fig. 2D. Seismic gap interpretation implicit in Anderson *et al.* (1986). Aftershock zone of 1981 earthquake is from Havskov *et al.* (1983), aftershock zones of Sept. 19, 1985 earthquake (1985a) and Sept. 21, 1985 earthquake (1985b) are after UNAM Seismology Group (1986).

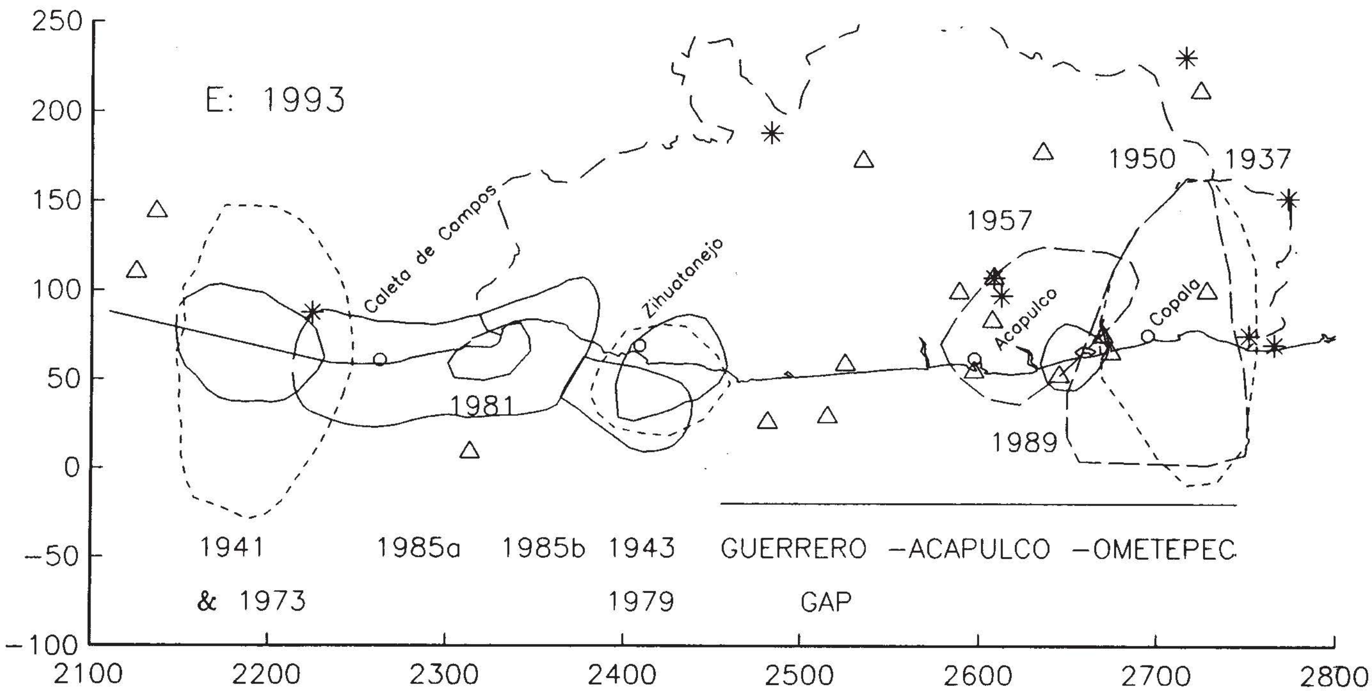

Fig. 2E. Seismic gap interpretation appropriate for 1993. Aftershock zone of 1989 earthquake, after Singh (personal communication, 1989), is shown even though this earthquake has moment below 10^{27} dyne-cm, and is too small to fill a seismic gap.

earthquake by Nishenko and Singh (1987a) is unreasonably large considering the earthquake's size; perhaps because of earthquake mislocations it extends, improbably, much farther seaward than other aftershock zones and 25 km seaward of the trench axis. However, this observation alone is not sufficient to allow the conclusion that the lateral location of the zone as depicted by Nishenko and Singh is incorrect. They find the lateral location to be in the western part of the zone defined by Kelleher *et al* (1974). Comparing these two studies, we conclude that the eastern limit of the Guerrero gap is uncertain by about 70 km. Resolution of this uncertainty is beyond the scope of the paper; both alternatives for the eastern end of the Guerrero gap are considered here.

Three independent methods to estimate the moment of the potential earthquake or earthquakes in the Guerrero gap give results consistent with the following: that there might be 8 to 14 x 10^{27} dyne-cm of moment release between the 1979 aftershock zone and the 1957 aftershock zone as drawn by Nishenko and Singh (1987a). First, the Guerrero gap experienced two major events in the 1899-1911 sequence, the 1899 event M_S=7.9 and the 1911 event M_S= 7.6; one of the 1908 events is also located in this area. The total moment of these events is estimated to be 8.4 x 10^{27} dyne-cm (Anderson *et al*, 1989b). If the entire gap should rupture in a single event with the combined moment of these three, the magnitude would be expected to be about M_W=8. Second, the moment accumulated since 1911 is 14 x 10^{27} dyne-cm, based on the width of the seismic gap between these the 1979 and 1957 aftershock zones, 130 km, the convergence rate of 6.8 cm/yr (Minster and Jordan, 1978), a seismogenic width of 50 km and a shear modulus of 4 x 10^{11} dyne/cm^2. Third, the potential rupture zone is somewhat larger than the 1957 rupture, which gave M_S=7.6 and moment 5 x 10^{27} dyne-cm, but somewhat shorter than the 1985 rupture, which gave M_S=8.1 and moment 12 x 10^{27}. If instead one uses the location of the 1957 event from Gonzãlez-Ruiz and McNally (1988), the width of the gap is increased by about 50%, and thus the moment of potential earthquakes should be increased to 12 to 20 x 10^{27} dyne-cm. Along the entire coast of Guerrero, a region including the 1957 rupture zone and the Ometepec gap, Anderson *et al* (1989b) suggested that a statistical estimate of the moment deficit is 20 x 10^{27} dyne-cm. Considering that a magnitude 8 earthquake corresponds to a moment of about 10 x 10^{27}, and that smaller events contribute much less moment (e.g. a M_S=7.5 event typically has a moment of only 2 x 10^{27}, Anderson *et al*, 1989b), a Guerrero gap earthquake could attain moment magnitude 8.2.

Nishenko and Singh (1987b) estimate the conditional probability of a major earthquake in the Guerrero gap between 1986 and 1996 to be 56-79%. Uncertainties in this estimate arise from an uncertain repeat time. However, in spite of uncertainties, every other part of the Mexican subduction zone from Jalisco to Oaxaca has ruptured since 1928. Considering the high overall rate of seismicity in Mexico, the Guerrero gap is clearly an extremely likely site for a large earthquake in the near future.

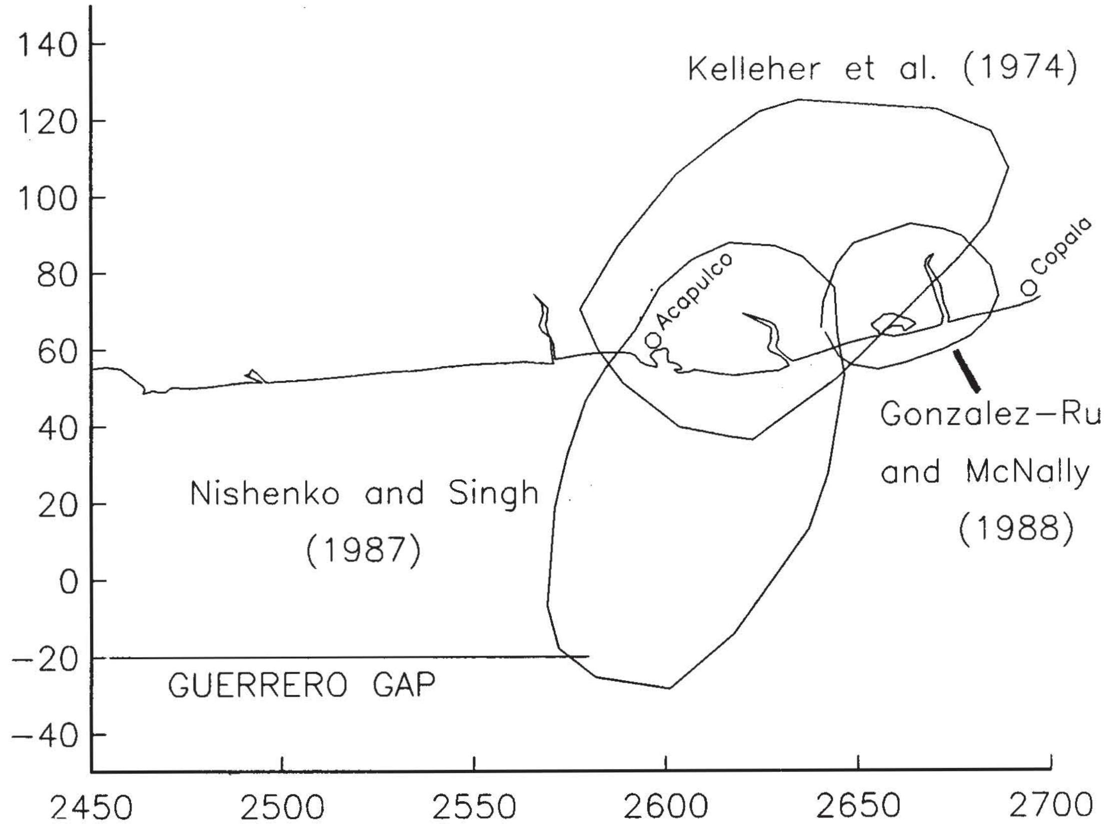

Fig. 3. Aftershock zone of the 1957 earthquake, according to Kelleher *et al.* (1974), Nishenko and Singh (1987a), and González-Ruíz and McNally (1988). The Guerrero gap is depicted as in Figure 2D. The eastern limit of the Guerrero gap is uncertain as a consequence of uncertainty in the east-west location of the 1957 aftershock zone.

SPECIFIC OBJECTIVES OF THE GUERRERO NETWORK

The primary objective of the accelerograph network is to obtain high quality accelerograms from strong shaking caused by magnitude 7.5 to 8 earthquakes in the Guerrero gap, along the Mexican subduction thrust. The network is located on the underthrust block of the earth's crust. The network is designed primarily to study the earthquake source mechanism and attenuation of strong ground motion in this environment. To achieve this objective, all stations are situated in free-field environments, and on the best rock site consistent with the desired spatial distribution of stations.

A secondary objective is to record strong shaking from the smaller events in the subduction zone. These will be used to study seismic source scaling and attenuation. These smaller events will also be used as empirical Green's functions for source modeling. Accurate timing is required for these objectives particularly, since the network usually provides the closest sites for earthquake locations.

SITE DESCRIPTIONS

The network layout began with a map of target locations, which were selected on the basis of considerations as formulated at the Hawaiian workshop (Iwan, 1978). Within this framework, sites were selected to be as near to the target location as possible, consistent with our concept of an ideal site and also consistent with the field realities. From a scientific viewpoint, the ideal site is crystalline basement, preferably intrusive igneous or crystalline metamorphic rock representing a homogeneous half-space of crystalline basement, with minimum topographic relief nearby. From the engineering perspective, we preferred to locate the stations in or near a town, so that damage, if any, might be calibrated with ground motion. We also, of course, were concerned with security and convenience of access.

In reality, naturally, some of these ideals had to be compromised. Inland access is a major problem, especially west of Acapulco in the central part of the Guerrero gap, and stations farther inland were impossible. Other typical trade-off decisions were whether to use harder, less weathered rock or to sacrifice that for softer sites near major structures of town, in places with less severe topography, or in public locations with better protection from vandalism. The final station locations are listed in Table 2 and shown in Figure 1, together with a very brief description of the geology associated with each. Some modifications to the original network layout are noted in Table 2.

Table 2

Guerrero Accelerograph station locations

Station	Location		Elev.	Relief	Instrument Type[2]	Geology
	Lat°N	Long°W	m	100m[1]		
Acapulco	16.866	99.862	100	5	DSA-1	Alkali feldspar granite
Arteaga[3]	18.349	102.294	900	4	DCA-333	Altered tonalite
Atoyac	17.211	100.433	40	3	DSA-1	Granodiorite
Caleta de Campos	18.071	102.754	100	3	DSA-1	Meta-andesite breccia
Cayaco	17.047	100.267	10	2	DSA-1	Alluvium (sand)
Cayaco - R	17.048	100.267	20	2	DSA-1	Meta-basalt
Cerro dePiedra	16.761	99.644	100	1	DCA-333	Gneiss
Copala	16.610	98.980	100	1	DCA-333	Granite gneiss
Coyuca	16.995	100.120	100	2	DCA-333	Gneiss
El Balcón	18.009	101.222	1700	11	DSA-1	Andesite
Filo de Caballo	17.650	99.840	2300	9	PDR-1	Porphyritic andesite
La Comunidad	18.122	100.520	400	3	DSA-1	Andesite
La Estancia	17.315	100.260	1100	7	DCA-333	Schist,meta-andesite
La Llave[4]	17.344	100.830	200	2	DSA-1	Granite
La Unión	17.980	101.810	60	2	DSA-1	Meta-andesite breccia
La Venta	16.913	99.819	20	1	DSA-1	Granitic gneiss
Las Mesas	17.008	99.457	400	3	DSA-1	Granitic gneiss
Las Vigas	16.758	99.230	100	1	DSA-1	Quartz monzonite
Los Magueyes	17.387	100.594	300	6	DSA-1	Andesite
Nuxco	17.207	100.758	20	2	DSA-1	Granodiorite
Ocotillo	17.036	99.880	700	5	DCA-333	Gabbro
Ocotito	17.246	99.507	700	9	DCA-333	Quartz monzonite
Papanoa	17.325	101.039	80	3	DCA-333	Leucocratic dykes intruding altered granodiorite
Paraíso[5]	17.343	100.225	800	6	DSA-1	Diorite
Petatlán	17.539	101.272	60	1	DSA-1	Quartz diorite
Pozuelo	17.10	99.62	450		PDR-1	Gneiss
San Luis	17.272	100.890	40	3	DSA-1	Granodiorite
San Marcos	16.772	99.439	100	1	DSA-1	Granodiorite
Suchil	17.224	100.639	40	2	DCA-333	Granodiorite
Teacalco	18.614	99.453	1000	4	PDR-1	Rhyodacite tuff
Tonalapa	18.094	99.559	800	2	PDR-1	Shale interbedded with sandstone
Villita	18.045	102.189	100	2	DSA-1	Tonalite
Xaltianguis[6]	17.091	99.726	600	5	PDR-1	Tonalite
Zihuatanejo	17.608	101.462	20	0	DCA-333	Tonalite

[1] Code gives maximum relief, in hundreds of meters, within 3 km of the station.
[2] Instruments and piers are interchangable. The configuration has been somewhat variable.
[3] Station moved to Cayaco - R, May, 1992. Arteaga was particularly unproductive, and since it was in the 1985 rupture zone there was little expectation of important records.
[4] Station moved to Nuxco, May, 1992, because of worsening access problems.
[5] Station removed, May 1991, at landowner request, and replaced with La Estancia, May 1992.
[6] Station moved to Pozuelo, March 1993, because of recurring vandalism.

Anderson *et al*, (1993b) summarize many of the descriptive characteristics of each site, and present the limited amount of quantitative data that is available. This includes density and P-wave velocity measured from rock cores from about half of the sites. Measured densities average 2.6 gm/cm^3, with a range from 2.3 to 2.8 gm/cm^3. Measured P-wave velocities average 3.6 km/sec, with a range from 1.6 to 5.6 km/sec. Anderson *et al.* also include a summary of velocities obtained from short-baseline seismic refraction experiments by Anguiano-Rojas (1987). For the three stations with both lab and field measurements, the P-wave velocities obtained from the refraction experiment are about half of those found from measurements of core samples, presumably caused by fractures in the large scale rock mass that are not represented in the hand specimen, and by lateral heterogeneity.

In examinations of the data, there is an impression that the scatter in ground motion amplitudes is generally less than what is typically seen in cases where a mix of site characteristics is used (e.g. Anderson *et al.*, 1986). Seismograms from most sites have a fairly clean, broadband signal. However, in spite of these precautions, all sites show some sort of site effects. Average spectral site amplification functions have been estimated by Castro *et al.* (1990) and Humphrey and Anderson (1992). These show some sites with narrow resonances and others with a more broadband amplification. The only way to minimize that at present is to study recordings with temporary instruments before installation.

INSTRUMENTATION

The instrumentation is described in detail by Quaas *et al.* (1993b). In common with other strong motion networks the instruments in Guerrero have the fundamental objective of reliably recording strong motions from relatively infrequent earthquakes. In Guerrero, we anticipated earthquakes with magnitudes as high as 8 and accelerations potentially in excess of 1 g. To guarantee the highest quality of data, and to take advantage of pre-event memory and to simplify operations, digital instruments were considered from the very beginning. The environment and access to the sites in Guerrero imposed special requirements on the instruments. Highly accurate timing systems were needed to supplement the Mexican network and allow accurate locations. High reliability of the instruments was essential because of limited access and severe environmental conditions, specifically high humidity and high temperatures. All of these factors were balanced against budget constraints in designing the optimal instrumentation systems.

Station overview

The stations are similar to designs that have been employed in the past for strong motion recording stations in Mexico (e.g., Anderson *et al.*, 1983). An illustration of a typical field station with its associated instrumentation is shown in Figure 4. Photographs showing different aspects of the stations and the instrumentation are given in Figure 5. The site consists of two structures: a concrete pad with a metal housing for the accelerographs, and a tower for the solar panels and the antenna for time code reception. The pier is attached to the rock below by means of corrugated reinforcing bars anchored into two-inch diameter holes in the rock below. Because the sites are mostly on highly competent rock, soil-structure interaction is theoretically expected to be small (Luco *et al*, 1988, 1990).

Accelerograph systems

The three types of accelerographs selected for the Guerrero Array were the DCA-333, manufactured by Terra Technology, and the DSA-1 and PDR-1, both manufactured by Kinemetrics. Detailed comparisons of the specifications of these instruments are described elsewhere (e.g. Quaas *et al.*, 1993a). All three types use force-balance accelerometers with a full scale range of ± 2 *g*, and record on a digital tape after conversion with a 12 bit analog to digital converter (72 db dynamic range). Distinguishing different instruments are that the DCA-333 has an omnidirectional trigger, samples at a rate of 100 per second, and records up to 14 minutes of data; the DSA-1 has a vertical trigger, samples at a rate of 200 per second, and records up to 20 minutes of data; the PDR-1 has an STA/LTA trigger, samples at 200 (or 100) samples per second, and has a gain-ranging amplifier which provides an additional amplification of a factor of up to 64 (36 db).

Each station is powered by solar panels and batteries on flotation. Standard automotive batteries and special regulators were chosen. The electrical system of the instrumentation was isolated completely from ground, making special lightning protection unnecessary.

The network is timed using clocks synchronized to the global Omega navigation system. The Omega is a worldwide navigation system operated by the United States, composed of 8 stations evenly distributed over the surface of the world transmitting signals in the VLF-band (Thomson, 1983). For example, the characteristic frequency of the North Dakota station, whose signal covers the area of the Guerrero Array, is 13.1 KHz. The Omega clock used in our network was manufactured by Precitel, Switzerland. It includes internal crystal oscillators to keep time when the Omega signal is not received. Once the signal is again received, the system automatically resynchronizes after a certain time. Most of the problems associated with timing are now due to weak reception and weather perturbation, especially during the main rainy season. However, compared to other external time references, such as WWVB or NHK, Omega still seems to be the best option, although sophisticated and costly clocks are also available. To optimize the use of the Omega signal for timing purposes in seismic instrumentation, we are developing a new microprocessor based decoder which accomplishes the decoding, synchronization, time keeping and data code generation by software in a single module. At present the prototype is under test (Bedoya and Quaas, 1990).

Operation and maintenance

It has been our experience that the reliability of a network like the Guerrero Array is directly related to the effort given to the operation and maintenance of the system. Especially in a system which most of the time is in standby mode and is operating under severe environmental conditions, attention to maintenance is essential. Considering these factors we set up a maintenance routine based on monthly visits to each of the 30 stations. Although this implies a considerable effort and cost because of the distances from our base in Mexico City, we think it is small compared to the value of the records obtained especially from earthquakes like the September 1985 event or the

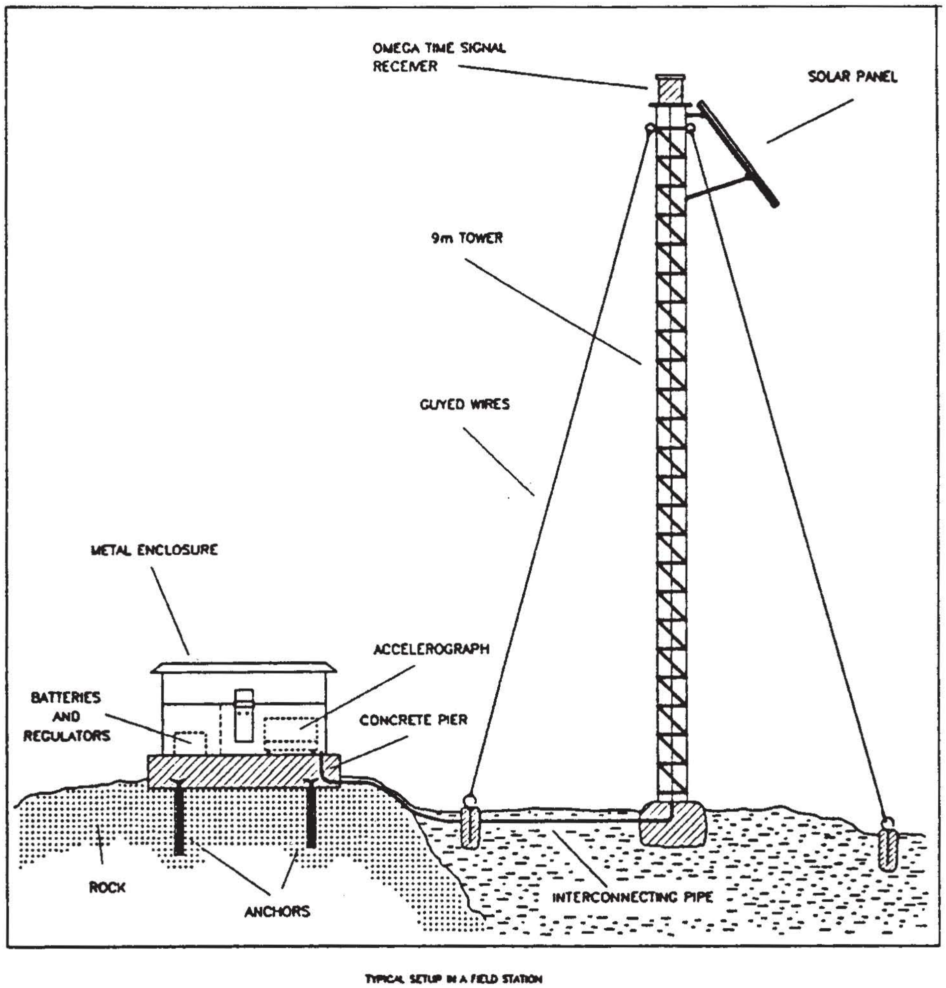

Figure 4. Illustration of a typical field station. For clarity in representing all of the components, they are not drawn to scale.

large earthquakes we expect in the future in this region, and the value of intensive research based on this data.

Most instrumental problems are solved in our laboratory in Mexico. The knowledge and experience that has been developed in the Seismic Instrumentation group at UNAM, coupled with frequent site visits, has resulted in insignificant data loss. We estimate that instrumental down-time is currently less than 1%. Among the few failures, two types of problems are most common. The first is related to the power supply, because battery failure is not always predictable. The second is loss of time synchronization. The accelerographs have had only isolated problems associated with the electronics or the magnetic tape transport and recording system.

Discussion of instruments and possible improvements

In general, a challenge to strong-motion seismology is to keep up with advancing technology while maintaining a large number of existing instruments of an older vintage. One philosophy is to develop upgrades for the instruments, taking advantage of existing sensors and power supplies which may not need improvements but which constitute a major fraction of the cost of an instrument. With this in mind, we visualize the possibility of modifying all three types of instruments in the near future. In these cases, and often in general, where existing instruments can be updated with new technologies, it is more cost effective than buying new instruments.

Although we are generally satisfied with the performance of the instruments, we can identify some aspects of the instrumentation that can by improved and updated with newer technologies. We would like to see all instruments equipped with internal clocks with improved signal decoders, omnidirectional triggers, gain ranging or a 16 bit (at least) analog-to-digital converter, solid state memory, and much longer pre-event memory (e.g. 10 sec). For the Kinemetrics instruments, all of these objectives can be built into a single microprocessor driven multi-function board using part of the data acquisition electronics that are presently in the instruments. A prototype board with this upgrade is being tested at UNAM. If all the instruments are upgraded, the changes could also result in a homogeneous format for data recording, which would simplify the subsequent data handling. This would lead to an even faster response of the system to an earthquake.

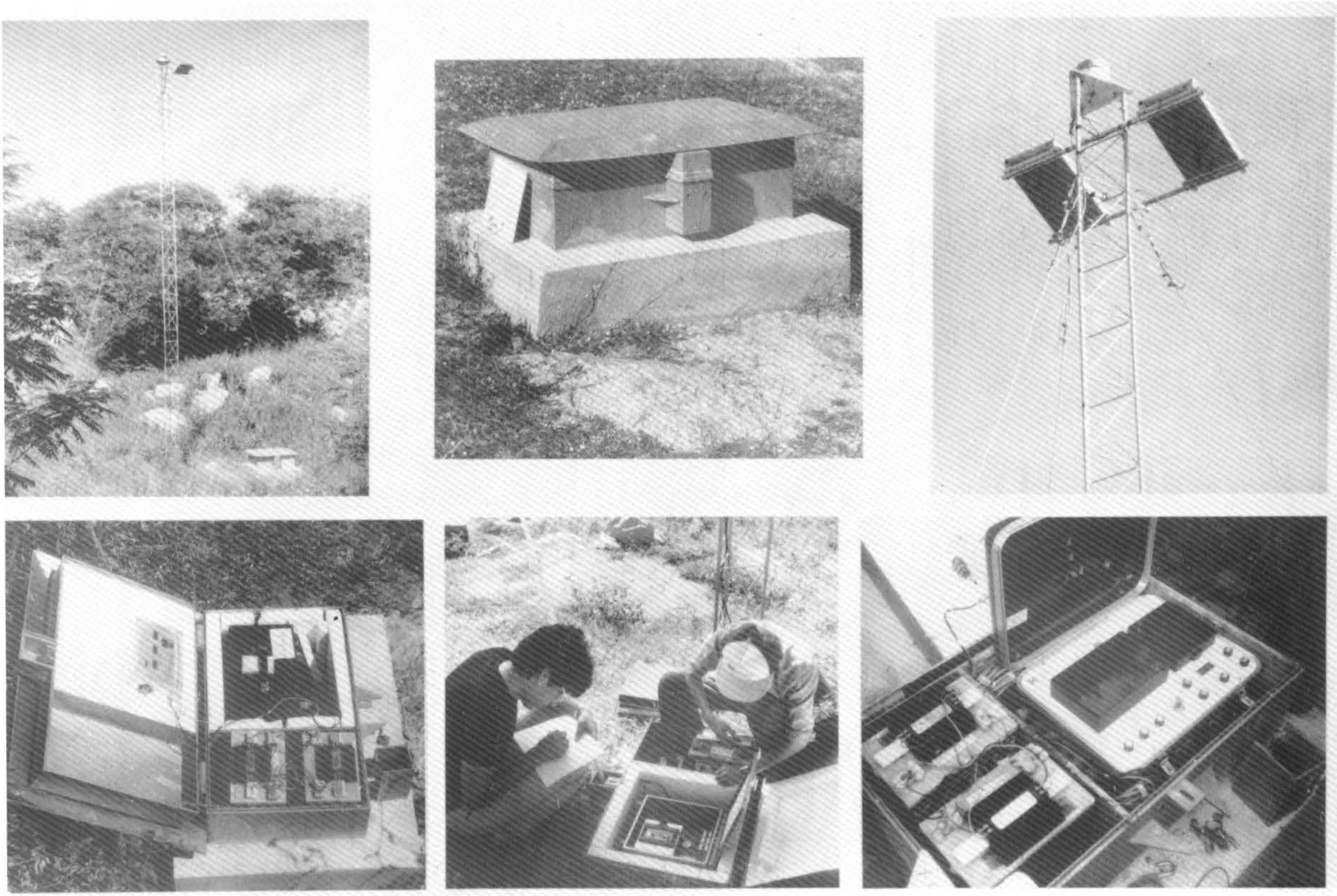

Fig. 5. Photos of a typical station and instrumentation. top, left. View of station at Zihuatanejo. Top, center. Pier and metal housing at San Marcos. Top, right. Solar panels and time code receiver at top of tower at San Marcos. Bottom, right. PDR-1 instrument set up inside pier at Xaltianguis. The sensors are below the PDR-1 recorder. Bottom, left. DSA-1 instrument set up inside the pier at La Venta. The Omegaface lies on top of the foam inside the roof of the pier. Bottom, center. DCA-333 instrument at Coyuca. Juan Manuel Velasco (left) and David Almora are servicing the station.

Associated with this project, several instrumentation development projects have been completed at UNAM. Among them, a new digital accelerograph, the ADII, featuring low cost and new technologies has recently been completed and deployed (Quaas *et al.*, 1991, 1992). Other developments have included an Omega clock and decoding system, as well as the multifunction board mentioned above, and smaller projects related to testing and calibration. These projects have given us valuable experience to further improve and operate the system more efficiently.

DATA HANDLING PROCEDURES

The accelerographs record on digital data cassette type magnetic tapes. Each instrument uses a different format and requires therefore a special playback unit and software to retrieve the data. For the DCA-333 we use an SMR-1 portable playback unit, and for the DSA-1 and PDR-1 we use a DSP-3 laboratory playback unit. A critical element is a data reduction system developed for a PC type computer, described in detail by Quaas (1987, 1988), Quaas *et al* (1993b), and Anderson and Quaas (1993). This PC-based data reduction system has subsequently been adapted for use by other accelerograph networks in Mexico.

All records obtained through December, 1991 have been documented in a series of annual reports (Anderson *et al.*, 1987a,b; 1988, 1990a,b, 1991a,b, 1993a). In addition, for the most important events, we prepare a short report for rapid examination and distribution of accelerograms. These have been prepared for events of September 19 and 21, 1985 (Anderson *et al.*, 1985; Quaas *et al.*, 1985, 1986; Prince *et al.*, 1985), February 8, 1988 (Quaas *et al.*, 1988), April 25, 1989 (Anderson *et al.*, 1989a), May 11 and 31, 1990 (Quaas *et al.*, 1990), and October 24, 1993 (Quaas *et al.*, 1993c).

Part of the report preparation includes relocation of the earthquakes using arrival times from the accelerograms. The nation-wide seismic arrays (Figure 6) in Mexico (e.g. Martinez-Bringas, 1989; Servicio Sismológico Nacional, 1989) does not have sufficient coverage to give locations with a high degree of confidence in the Guerrero region. The hypocenters are currently re-determined using the computer program HYPOINV (Klein, 1978).

Figures 7-8 give an example of data collected, for the earthquake of August 16, 1988 (mb=4.2). Figure 7 shows the epicenter of the earthquake and the locations of all accelerograph stations that recorded the event. Figure 8 shows the corresponding accelerograms. Figures 7 and 8 demonstrate how the attenuation stations are working. Along the coast, the most distant station to trigger on this event was Atoyac, at about 72 km from the epicenter. However, inland toward Mexico City, the PDR-1 instruments at Filo de Caballo (76 km), Tonalapa (128 km), and Teacalco (187 km) also obtained records with good signal to noise ratios.

Data is currently distributed by the authors on IBM-PC compatible disks with either 3.5" or 5.25" formats. A data base, where the records from the Guerrero network and other Mexican accelerograph networks will eventually be obtainable through computer networks, is under development by a coalition of several research institutions in Mexico (Quaas *et al.*, 1993a).

OVERVIEW OF DATA FROM THE FIRST SEVEN YEARS OF OPERATIONS

Since the network became fully operational in 1985, it has been producing over 100 accelerograms per year. Some statistics of this data are presented in Table 3. This table shows an increasing productivity of the network since it was installed as measured by increased numbers of events recorded and total number of seismograms. Some of this could be related to seismicity, but some is related to better adjustment of the trigger level. The average number of records per event has also increased, but the numbers of small events (magnitudes under 4) that only trigger one or two stations have also increased, so the average number of records per event has only gone up by 50%. For a network of 30 accelerographs this data collection rate is very high compared to other networks. This high rate alone justifies the decision to use digital instruments. From this data we can conclude that the system is ready to produce high quality records during future large earthquakes. On average, we have 2.4 triggers per event.

The number of records per year per instrument depends on instrument type: PDR-1 instruments average 15.1; DSA-1 instruments average 4.0; DCA-333 instruments average 5.5. The PDR-1 have been most productive due to the gain ranging, even though they are located farther from the coast. Considering the variability in seismicity along the coast we do not consider the difference in productivity of the DCA-333 and DSA-1 to be significant. Since the PDR-1 cost less than twice as much as the other two types, we conclude that from the viewpoint of overall data quantity these have been most cost effective. Of course, all three types have recorded the strongest shaking which is the primary objective; the additional events on the PDR-1 have been smaller magnitude events and thus perhaps of somewhat less scientific significance.

Important earthquakes, which are loosely defined as those that have triggered a large number of stations, are listed in Table 4. The Appendix lists all earthquakes through December 1991. The most important accelerograms to date are from the September 19, 1985 earthquake (Anderson *et al.*, 1986). This event occurred before installation of the network was completed, but data was sufficient to study the earthquake source process at low frequencies (e.g. Méndez and Anderson, 1991). Since then, installation has been completed, instruments improved, and trigger levels adjusted. Consequently, even magnitude 4 to 4.5 events are now triggering a substantial fraction of the instruments (Table 4).

Figure 9 shows the magnitudes and distances of 876 accelerograms recorded by the network through the end of 1991. This shows a substantial number of records from

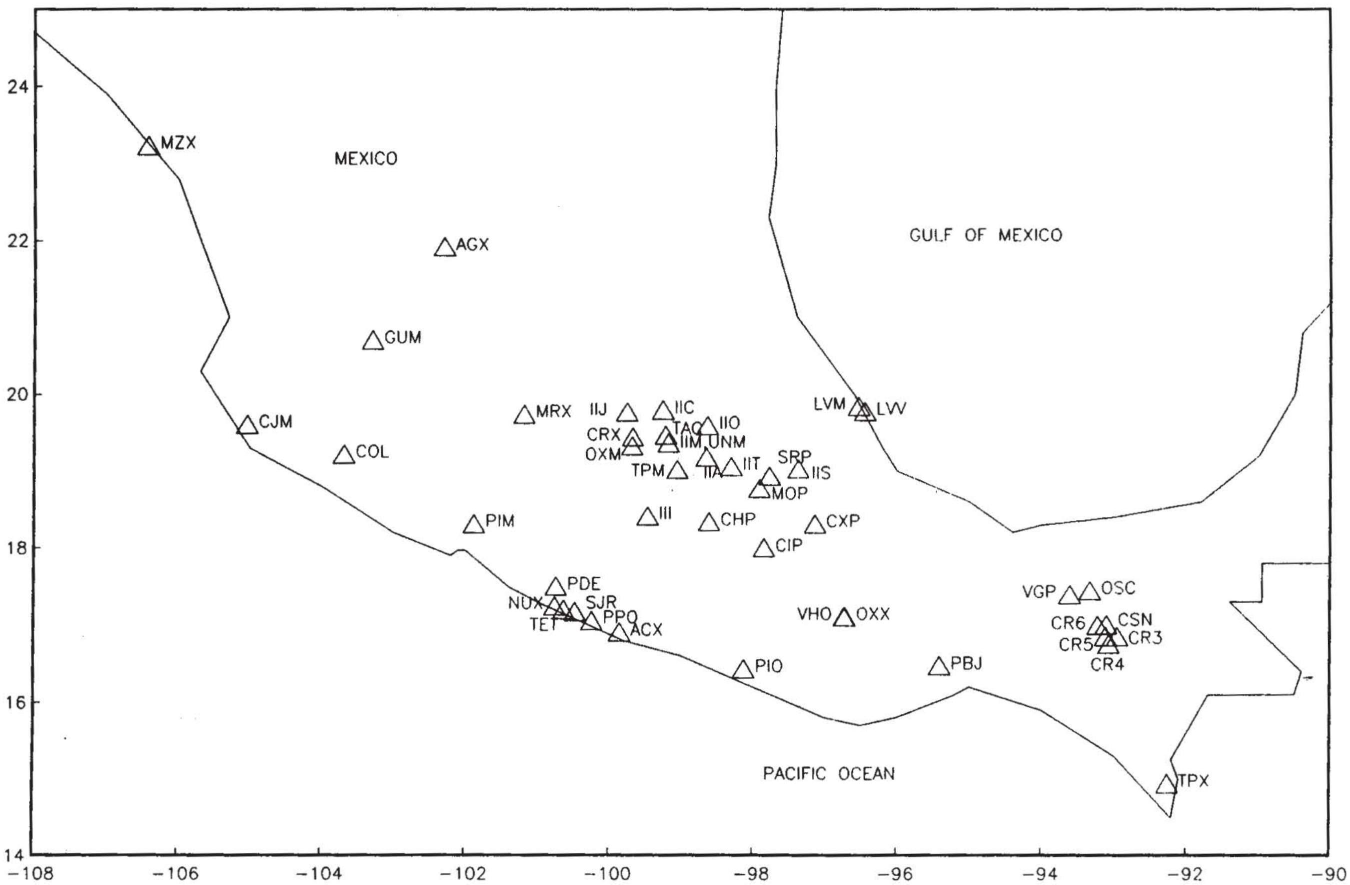

Fig. 6. Locations of stations in the Mexican short period network that are most frequently used, in conjunction with the Guerrero accelerographs, for hypocenter locations.

Table 3

Number of records obtained by the Guerrero accelerograph array

Year	Ev[1]	Re[2]	Rt[3]	<3	3-3.9	4-4.9	5-5.9	6-6.9	>6.9
1985	39[4]	75	1.9	1	18	10	3	0	2
1986	48	83	1.7	5	19	14	5	0	1
1987	47	118	2.7	2	30	14	0	1	0
1988	52	119	2.2	5	30	13	4	0	0
1989	80[4]	219	2.7	3	38	30	4	1	0
1990	62[4]	172	2.7	0	15	34	6	0	0
1991	57[4]	141	2.5	8	18	17	0	0	0
1992	58[4]	137	2.4	1	19	27	3	0	0
Total	443	1064	2.4	25	187	159	25	2	3

[1] Number of events.
[2] Number of records.
[3] Average number of records per event.
[4] Magnitudes of some events are unknown.

short distances, for a large range of magnitudes from under 3.0 to 8.1. Anderson and Quaas (1988) have previously published an illustration of a single component set of accelerograms from a series of events with magnitudes ranging from 3 to 8. With the more recent data, this figure can be improved upon, as in Figure 10. Our objective in selecting records for this figure was to have complete accelerograms from events as close as possible to integer magnitudes (3,4,5,6,7,8), and also as close as possible to three second S-P time intervals. Preference was given to

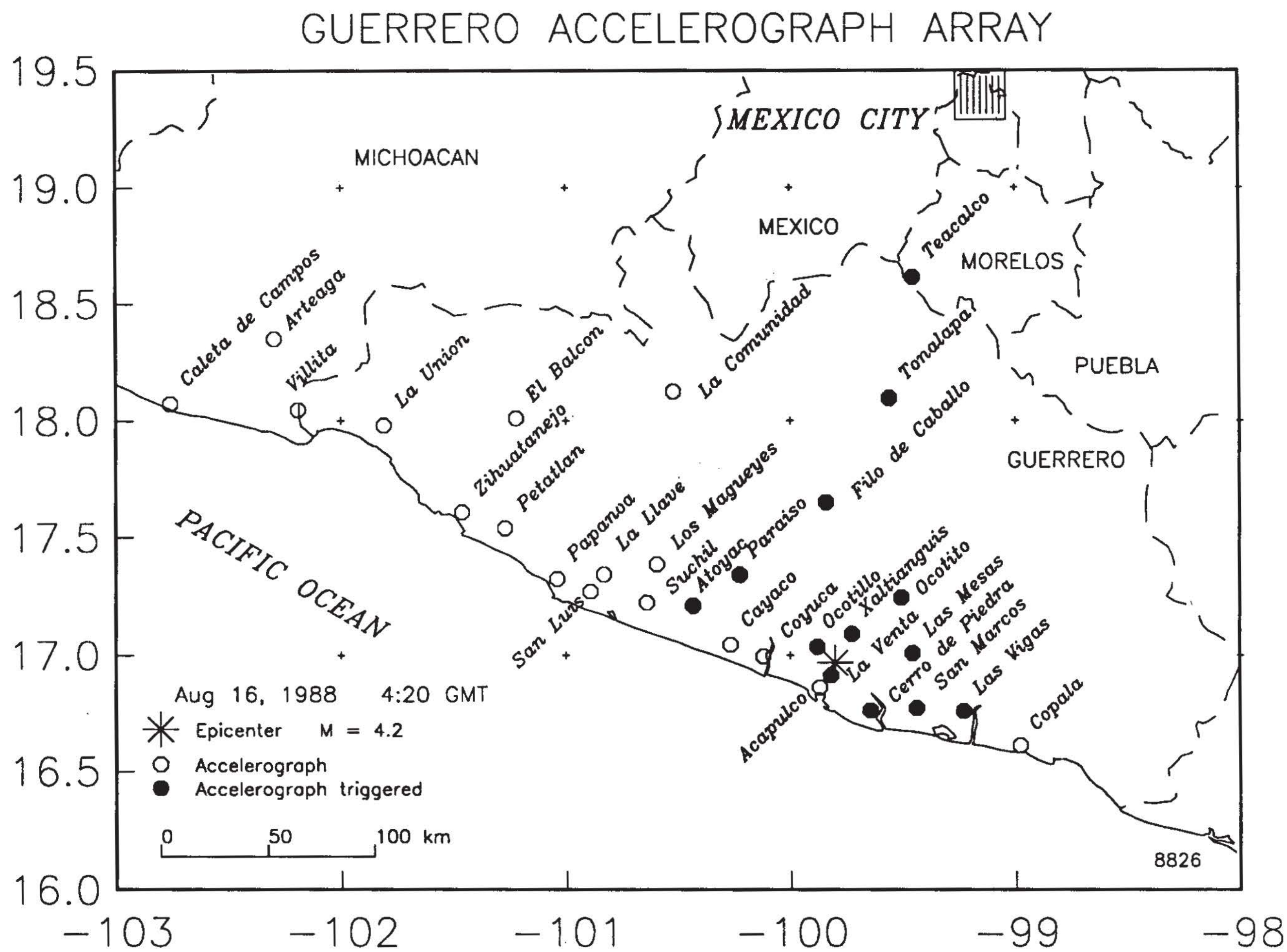

Fig. 7. Guerrero accelerograph stations, epicenter of the earthquake of August 16, 1988, and stations that triggered during that earthquake (from Anderson *et al.*, 1990b).

stations that Humphrey and Anderson (1992) demonstrate to have a relatively small site effect. Data on the accelerograms selected for Figure 10 are given in Table 5.

Figure 11 shows the locations of 352 events recorded by the Guerrero accelerographs through December, 1991. These events show an interesting spatial pattern. There is a cluster of earthquakes located at either end of the Guerrero seismic gap, and relatively few events in the central portion of the gap. Thus the gap is not only a gap in the sense of having gone a long time since the last large earthquake, but also appears to be a gap in the sense of having a depleted number of moderate sized (M4-6) earthquakes compared to adjacent regions. This conclusion needs to be examined more thoroughly, with careful consideration of the completeness of triggering of at least one station in the network as a function of earthquake magnitude. However, qualitatively, considering that an m_b=4.2 event, such as shown in Figures 7 and 8, cause reasonably extensive triggering of stations, it is unlikely that any events that are that size or larger have occurred in the gap since the network was complete and gone completely undetected.

CONCLUSIONS

The Guerrero Accelerograph Network is exceeding our initial expectations for quantity and quality of data as a result of many factors. The teamwork between the U.S. and Mexican research groups has been a key factor. The experience gained during the past seven years, and the highly trained personnel involved in the project at this time, gives us confidence to foresee a continuation of this level of success for the foreseeable future. Indeed, we anticipate that several instrumental improvements, including those mentioned earlier, will be implemented soon.

In addition to the important data it is producing by itself, the Guerrero Accelerograph Network has become a cornerstone for the wider strong motion networks in Mexico (e.g. Quaas *et al.*, 1993a), in particular since the near source information from Guerrero is essential to interpretation of accelerograms from the new digital networks in Mexico City. Furthermore, strong motion from Guerrero is the best data available for interpreting the

Table 4

Most important earthquakes recorded by the array

Date	M	Number of records of this Event	a_{max} (cm sec^{-2})	Range of Epicentral Distances (km)
Sept 19, 1985	8.1	16	166	20-388
Sept 21, 1985	7.6	13	625	35-240
Apr 30, 1986	7.0	4	98	32-368
May 29, 1986	5.2	5	79	34-88
June 16, 1986	4.5	6	165	11-70
Mar 26, 1987	4.8	10	33	11-143
Apr 2, 1987	4.8	5	103	10-46
June 7, 1987	4.8	12	78	9-256
June 9, 1987	4.2	10	63	4-132
Feb 8, 1988	5.8	13	440	13-219
Aug 16, 1988	4.6	13	240	6-187
Mar 9, 1989	4.6	8	47	33-92
Mar 10, 1989	5.3	11	257	27-90
Apr 25, 1989	6.9	18	346	28-225
May 2, 1989	5.4	14	116	12-155
Aug 12, 1989	5.4	8	37	80-150
Aug 17, 1989	4.9	11	103	24-45
Oct. 8, 1989	5.1	16	138	20-70
Nov 9, 1989	4.8	10	54	30-190
May 11, 1990	5.2	14	153	15-134
May 31, 1990	5.8	19	392	8-193
Jan. 14, 1991	4.5	10	53	16-243
March 25, 1991	4.3	10	71	14-109
April 27, 1991	4.4	13	73	18-130
May 21, 1991	4.4	8	85	60-154
May 28, 1991	4.3	10	43	1-136
Jan 9, 1992	4.7	9	259	
Mar 31, 1992	4.8	10	85	
Oct. 24, 1993	6.5	16	347	30-300

seismic hazards in several other subduction zones, including Cascadia, Alaska, Japan, and Chile.

The Guerrero Accelerograph Network is providing an outstanding set of high quality accelerograms in a quantity far greater than originally expected when this system was installed. On average it has produced over 100 accelerograms per year with a total of over 900 to December 1991. This places it as one of the most productive strong motion networks in the world. What is more important is the broad range of magnitudes that are all recorded on the same type of instrument at close range. This data will allow detailed studies on the scaling of strong motion with earthquake size. There is a high probability of major earthquakes in this region of Mexico, and the success of the network so far demonstrates that it is well positioned to record significant data when these earthquakes occur.

ACKNOWLEDGEMENTS

A project with the magnitude of the Guerrero network cannot be accomplished without the very close collaboration and indispensable contributions of many people in both countries. Foremost are the National Science Foundation in the United States, which provided funding for instrument purchase and installation and the Instituto de Ingeniería, UNAM, which, with the support of the Consejo Nacional de Ciencia y Tecnología (CONACYT) in México, shared in the construction of the sites, equipment installation, and has been, since then, in charge of maintenance and preliminary reduction of data. The contributions of the Mexican institutions to the project are already comparable, or greater than, the contributions from the U.S. institutions. The support of the concept by numerous scientists nationwide has played a crucial role in the beginning stages of the experiment.

We gratefully acknowledge the support of numerous landowners, local officials, and members of the general public who have been eager to collaborate, and in particular, many who have permitted us to install stations in locations on their property or under their authority. Their continued cooperation has also been a major benefit to the project in preventing vandalism.

Several people have made substantial contributions to the instrumentation of the network. These include the group from the Coordinación de Sismología e Instrumentación Sísmica at the Instituto de Ingeniería, UNAM. In particular, Jorge Prince was deeply involved in the instrument

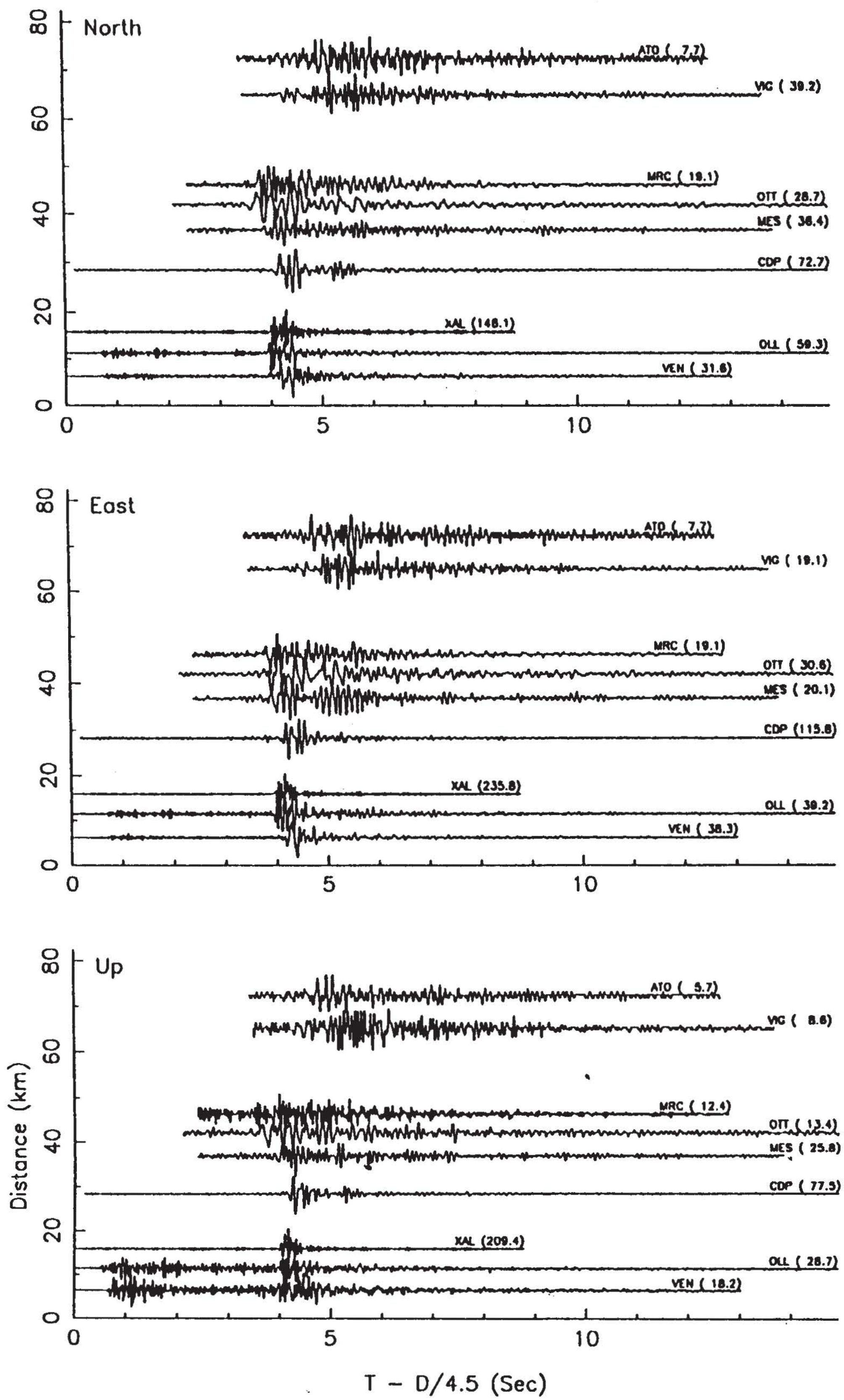

Fig. 8. Accelerograms from the August 16, 1988 earthquake. Station code is above each trace. Records are normalized to peak amplitude (in parentheses, in cm/sec^2).

Table 5

Statistics on the earthquakes shown in Figure 9

Event	Date Time	Latitude - Longitude Depth	Station Distance	Magnitudes	
8524	Sept 21, 1985 0907	17.161 N 101.139 W	Papanoa	M_{II}=3.1 M_S=	m_b= M_W=3.4
8936	June 5, 1989 20:12	16.566 N 99.386 W 4.4	Las Vigas	M_{II}=3.7 M_S=	m_b= M_W=
8974	Nov 9, 1989 08:36	16.844 N 99.648 W 9.9	La Venta	M_{II}=5.1 M_S=	m_b=5.1 M_W=4.9
9024	May 31, 1990 07:35	17.106 N 100.893 W 15.8	San Luis	M_{II}=5.5 M_S=5.9	m_b=5.8 M_W=5.8
8924	April 25, 1989 14:29	16.603 N 99.400 W 19.0	San Marcos	M_{II}=6.5 M_S=6.9	m_b=6.3 M_W=6.6
8916	Sept 19, 1985 13:17	18.081 N 102.942 N 15.0	Caleta de Campos	M_{II}=8.1 M_S=8.1	m_b=6.8 M_W=8.1

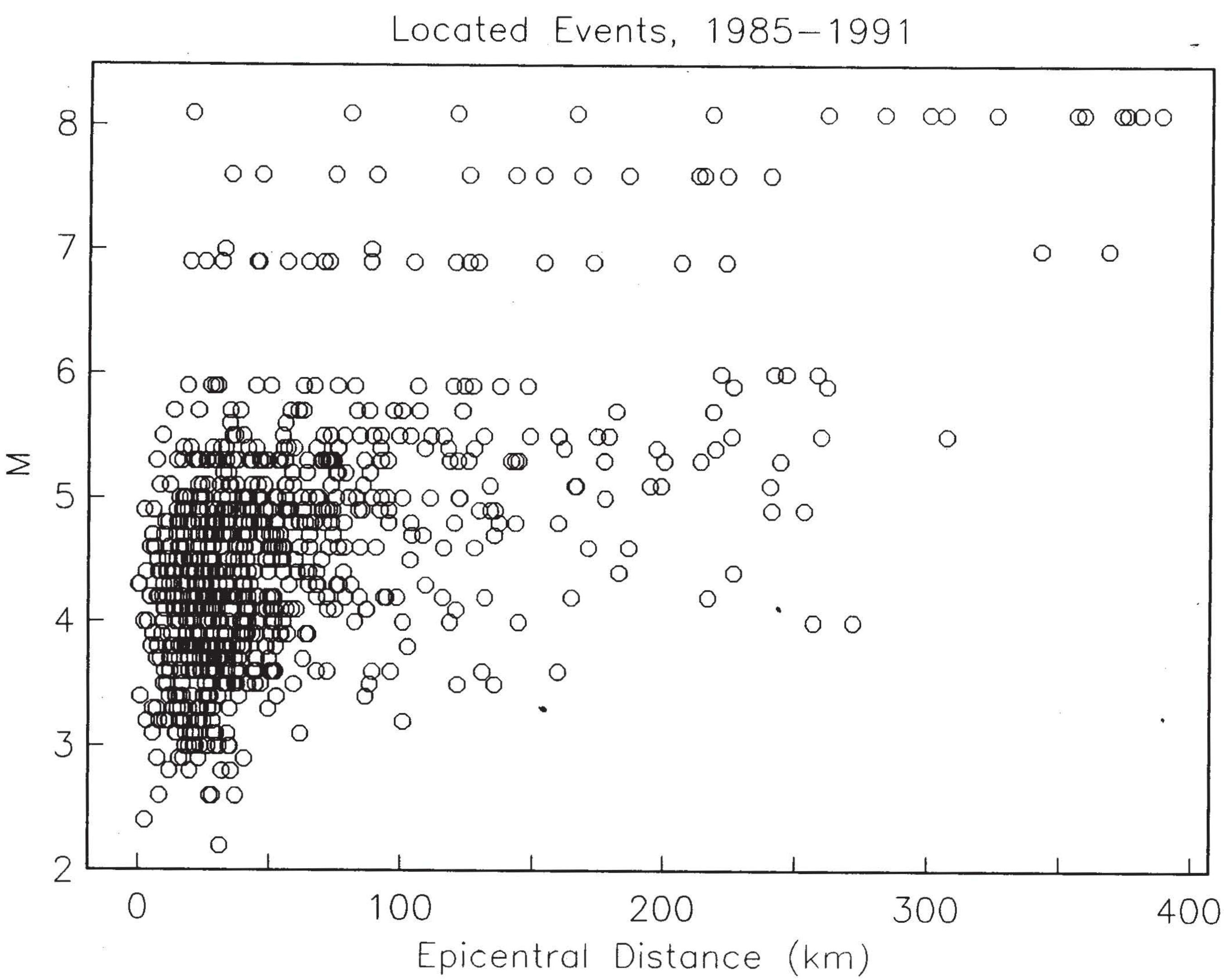

Fig. 9. Magnitude and epicentral distance of all events 1985 through 1990.

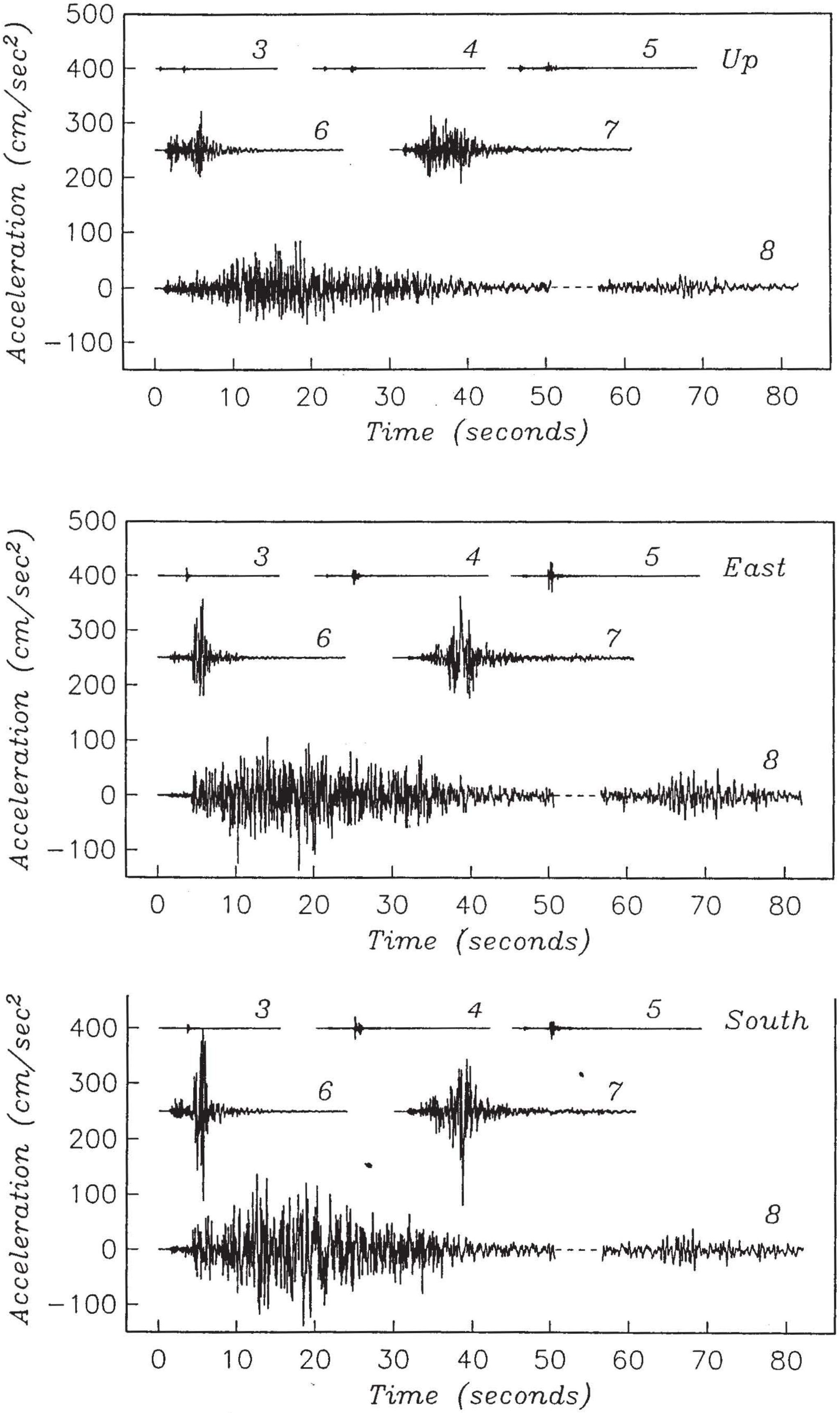

Fig. 10. Accelerograms from a magnitude 3, 4, 5, 6, 7, and 8 earthquake.

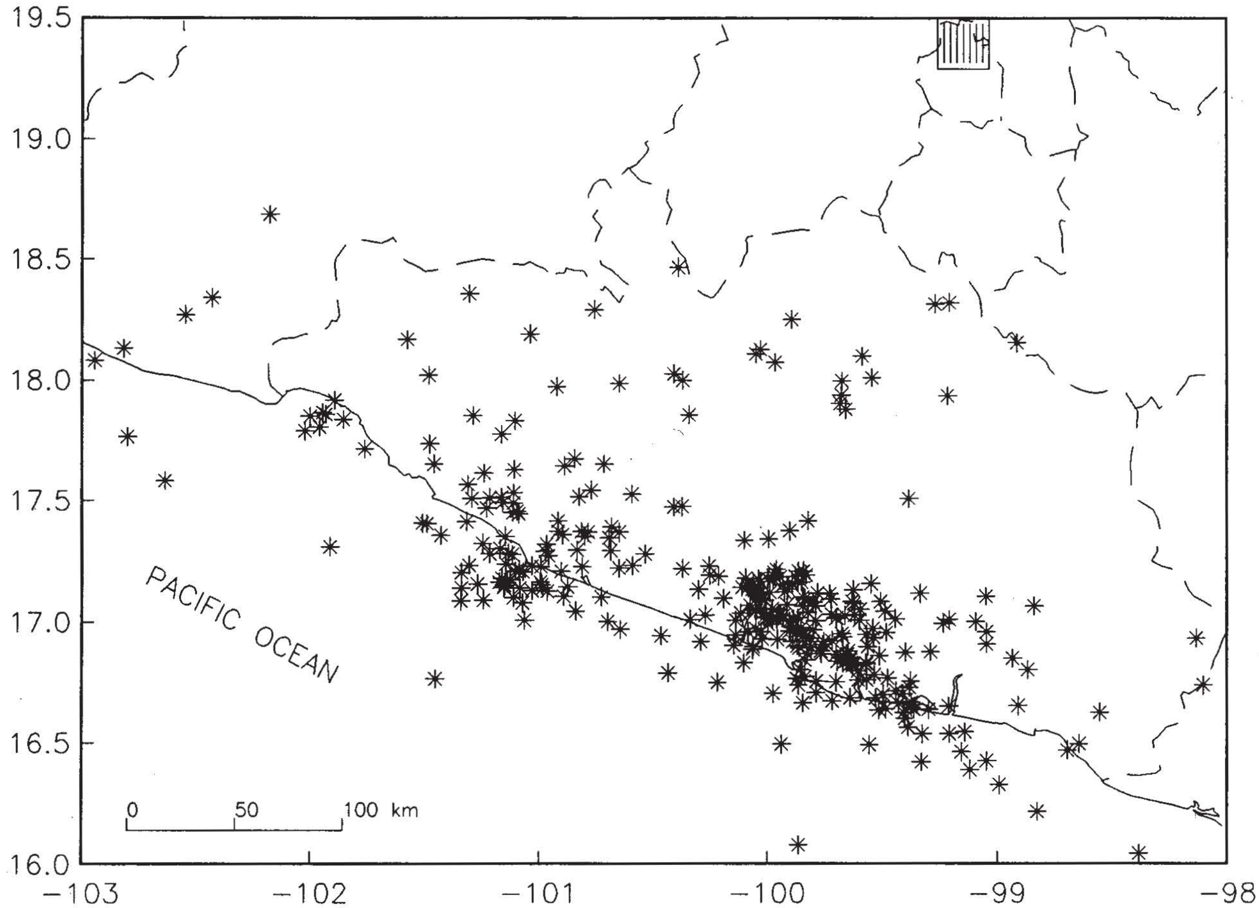

Fig. 11. Epicenters of all earthquakes recorded by the Guerrero accelerograph network, 1985-1990.

selection and configuration. Pablo Pérez assisted with maintenance and calibration. Gerardo Castro is providing ongoing assistance in the network operation, and Citlali Pérez has been in charge of data playback during the last years. While at the University of California, San Diego, Paul Bodin made important early contributions to calibration, testing, and setup of the network.

Substantial contributions to the preliminary data analysis have been made by the group from the Coordinación de Sismología e Instrumentación Sísmica at the Instituto de Ingeniería, UNAM. David Almora, Citlali Pérez and Bertha López have provided major assistance in the data playback and cataloging. Alicia Martínez, Clara Javier and David Novelo have provided arrival times, magnitudes, and preliminary locations from the Mexican telemetered seismic networks for locating earthquakes. Qingbin Chen helped with preparation of some figures.

We thank R. Crosson and an anonymous reviewer for helpful comments on the manuscript. The research was supported by National Science Foundation grants CEE 82 19432, ECE 85 13489, CES/BCS 88 08357 and BCS 91 20027. On the Mexican side, we gratefully acknowledge the support of the Instituto de Ingeniería, Universidad Nacional Autónoma de México.

Appendix

Epicenters of all earthquakes recorded by the Guerrero network 1985 through December, 1991

Event	Yr	Mo	Da	Hr:Mn	Lat N	Lon W	Depth	M-II	m_b	Ms	Mc
8501	85-	2-	23	1:11		not located	-	-	-	-	
8502	85-	3-	23	19:33	16.975	99.888	53.7	4.2	3.8	.0	
8503	85-	3-	27	0:40	16.729	99.380	8.8	3.4	.0	.0	
8504	85-	4-	6	11:57	16.804	99.856	9.1	3.1	.0	.0	
8505	85-	5-	6	1:13	16.739	98.106	19.9	4.4	4.8	.0	
8506	85-	7-	2	1:25	16.652	99.210	28.1	3.7	.0	.0	
8507	85-	7-	4	8:51	17.564	96.971	44.8	4.0	.0	.0	
8508	85-	7-	7	6:06	16.079	99.864	10.6	3.8	4.0	.0	
8509	85-	7-	7	6:17	15.831	99.844	19.4	3.5	.0	.0	
8510	85-	7-	7	18:27	16.791	100.437	10.5	3.9	.0	.0	
8511	85-	7-	19	22:25	16.933	98.136	19.8	4.0	.0	.0	
8512	85-	8-	21	5:14	17.544	100.771	13.9	3.6	.0	.0	
8513	85-	8-	22	19:50	17.210	101.104	18.3	3.3	.0	.0	
8514	85-	9-	4	13:27	17.567	101.308	20.5	4.0	3.2	.0	
8515	85-	9-	15	7:57	17.938	97.147	62.5	5.8	5.9	.0	
8516	85-	9-	19	13:17	18.081	102.942	15.0	8.1	6.8	8.1	
8517	85-	9-	19	13:33	17.407	101.506	4.5	4.3	.0	.0	
8518	85-	9-	21	1:37	18.021	101.479	15.0	7.5	6.3	7.6	
8519	85-	9-	21	1:40		not located	-	-	-	-	
8520	85-	9-	21	1:41		not located	-	-	-	-	
8521	85-	9-	21	1:56		not located	-	-	-	-	
8522	85-	9-	21	1:56		not located	-	-	-	-	
8523	85-	9-	21	2:10	17.320	100.968	29.0	4.2	.0	.0	
8524	85-	9-	21	9:07	17.161	101.139	.6	3.1	.0	.0	
8525	85-	9-	24	0:25	17.832	101.105	1.5	3.7	3.7	.0	
8526	85-	9-	28	3:52	17.532	101.111	9.8	4.5	5.1	5.0	
8527	85-	9-	30	9:08	17.078	101.071	7.0	3.2	.0	.0	
8528	85-	10-	3	6:29	17.284	101.134	23.1	4.4	4.3	.0	
8529	85-	10-	9	17:08	17.416	100.917	7.6	3.3	.0	.0	
8530	85-	10-	29	7:50	16.707	99.787	.0	3.0	.0	.0	
8531	85-	10-	29	8:30	17.047	100.048	20.0	2.8	.0	.0	
8532	85-	10-	29	15:02	17.583	102.636	20.3	5.1	5.6	5.4	
8533	85-	11-	3	7:52	18.316	99.270	20.0	4.0	4.2	.0	
8534	85-	11-	22	4:02	17.180	101.160	21.9	3.8	.0	.0	
8535	85-	12-	5	15:42	17.853	101.287	10.4	4.4	3.7	.0	
8536	85-	12-	21	16:42	17.291	100.973	14.5	3.7	.0	.0	
8537	85-	12-	21	17:02	17.303	101.170	4.9	3.4	.0	.0	
8538	85-	12-	22	18:43	17.175	101.125	14.5	3.6	.0	.0	
8539	85-	12-	24	19:28	17.165	101.172	10.7	3.3	.0	.0	
8601	86-	1-	3	0:17	17.353	101.147	17.2	3.4	.0	.0	
8602	86-	1-	12	16:51	17.917	101.893	4.1	4.7	5.1	.0	
8603	86-	1-	13	5:36		not located	-	-	-	-	
8604	86-	1-	15	6:45	17.674	100.845	3.4	3.6	.0	.0	
8605	86-	1-	18	20:27	17.206	101.070	19.7	4.1	.0	.0	
8606	86-	1-	24	9:26	17.342	99.995	6.0	3.8	.0	.0	
8607	86-	1-	24	18:03	17.237	101.144	20.3	4.6	4.5	.0	
8608	86-	1-	26	0:55	17.374	100.917	12.2	4.0	4.0	.0	
8609	86-	1-	26	3:03	17.469	101.228	6.6	3.8	4.0	.0	
8610	86-	1-	26	19:50		not located	-	-	-	-	
8611	86-	1-	28	0:48	16.893	99.860	16.5	2.6	.0	.0	
8612	86-	1-	29	20:01	17.357	101.426	.7	4.7	4.6	.0	
8613	86-	2-	1	3:31	16.946	100.139	36.1	4.0	4.1	.0	
8614	86-	2-	7	21:26	17.653	101.455	19.7	4.7	4.9	.0	
8616	86-	2-	18	13:59	17.009	99.209	31.2	4.0	.0	.0	

Event	Yr	Mo	Da	HrMn	Lat N	Lon W	Depth	M-II	m_b	Ms	Mc
8617	86-	3-	6	19:21	16.752	99.701	10.3	3.4	.0	.0	
8618	86-	3-	12	14:50	17.116	99.728	19.9	2.4	.0	.0	
8619	86-	3-	18	11:14	17.614	101.240	4.8	4.5	4.6	.0	
8620	86-	3-	24	23:39	17.278	101.118	16.1	.0	3.6	.0	
8621	86-	4-	21	9:15	16.929	99.955	12.1	2.2	.0	.0	
8622	86-	4-	30	7:07	18.024	103.057	20.0	6.4	6.2	7.0	
8623	86-	5-	3	16:29	17.094	99.722	20.0	3.4	.0	.0	
8624	86-	5-	5	5:46	17.765	102.799	19.9	5.6	5.6	5.5	
8625	86-	5-	18	22:07	16.687	99.527	9.8	3.1	.0	.0	
8626	86-	5-	29	20:31	16.851	98.932	35.6	5.0	5.2	4.2	
8627	86-	5-	29	21:42	16.803	98.866	27.0	4.3	4.0	.0	
8628	86-	6-	11	21:39	17.857	100.345	50.3	4.7	5.1	.0	
8629	86-	6-	16	5:51	17.076	99.621	33.8	4.3	4.5	.0	
8630	86-	6-	19	4:39	18.168	101.573	9.5	4.8	5.2	.0	
8631	86-	6-	22	12:45	16.842	99.835	20.02	3.0	.0	.0	
8632	86-	6-	27	5:17	16.909	99.047	16.1	4.0	3.7	.0	
8633	86-	7-	3	15:05	18.000	100.372	53.0	3.4	.0	.0	
8634	86-	7-	9	23:57	17.096	100.031	4.5	3.5	.0	.0	
8635	86-	7-	18	3:26	17.879	99.657	45.5	3.3	.0	.0	
8636	86-	8-	6	2:54	17.120	99.780	19.4	3.3	.0	.0	
8637	86-	8-	19	4:34	16.666	99.844	29.5	3.3	.0	.0	
8638	86-	8-	19	4:54	17.417	99.822	19.2	3.5	.0	.0	
8639	86-	8-	22	9:31	0.0	0.0	0.0	.0	.0	.0	
8640	86-	9-	6	6:20	16.992	99.998	4.0	2.8	.0	.0	
8641	86-	9-	21	7:43	17.085	99.506	20.0	3.2	.0	.0	
8642	86-	9-	22	21:06	16.921	99.890	8.9	3.4	.0	.0	
8643	86-	10-	14	20:47	16.920	100.292	13.3	3.9	.0	.0	
8644	86-	10-	31	12:41	17.067	99.788	33.4	2.6	.0	.0	
8645	86-	11-	4	1:58	17.789	102.021	15.2	4.8	4.8	.0	
8646	86-	11-	26	20:57	17.517	100.825	24.2	3.7	.0	.0	
8647	86-	12-	14	7:28	17.373	100.813	20.0	4.3	.0	.0	
8648	86-	12-	16	18:56	17.184	99.944	37.7	4.3	.0	.0	
8701	87-	1-	4	19:17	17.097	100.193	26.2	3.6	.0	.0	
8702	87-	1-	8	20:58	17.053	99.595	39.7	3.1	.0	.0	
8703	87-	2-	12	6:43	17.031	99.719	37.3	2.9	.0	.0	
8704	87-	2-	24	14:55	16.876	99.398	2.0	3.0	.0	.0	
8705	87-	3-	14	15:08	17.071	99.913	5.9	3.3	.0	.0	
8706	87-	3-	20	23:57	17.282	101.214	16.7	3.6	3.8	.0	
8707	87-	3-	20	23:58	17.090	101.242	12.9	3.7	.0	.0	
8708	87-	3-	26	13:07	17.154	99.934	.2	3.4	.0	.0	
8709	87-	3-	26	18:38	16.899	100.061	17.2	4.8	4.8	4.5	
8710	87-	4-	2	16:01	16.839	99.694	18.0	4.0	4.8	.0	
8711	87-	4-	29	5:36	17.527	100.595	16.4	3.6	.0	.0	
8712	87-	4-	30	8:05	16.492	99.556	13.5	3.7	.0	.0	
8713	87-	5-	8	4:49	16.757	99.785	11.7	3.3	.0	.0	
8714	87-	5-	14	21:36	17.375	99.903	15.1	3.5	.0	.0	
8715	87-	5-	20	12:58	17.370	100.649	5.2	3.5	.0	.0	
8716	87-	5-	24	9:16	16.868	99.655	23.4	3.0	.0	.0	
8717	87-	6-	3	5:13	16.769	99.476	12.3	3.5	.0	.0	
8718	87-	6-	7	13:30	16.654	98.909	22.9	4.9	5.5	4.8	
8719	97-	6-	9	15:37	16.943	99.844	29.7	4.0	4.2	.0	
8720	87-	6-	10	10:01	17.066	98.838	15.1	3.9	3.8	.0	
8721	87-	6-	21	13:00	17.336	100.100	1.4	3.8	.0	.0	
8722	87-	7-	5	5:11	17.069	100.075	16.0	3.5	.0	.0	
8723	87-	7-	5	18:18	16.217	98.825	8.0	4.7	4.5	.0	
8724	87-	7-	8	10:46	17.015	99.699	30.8	3.9	.0	.0	
8725	87-	7-	15	7:16	17.330	97.419	15.8	5.3	6.0	.0	
8726	87-	7-	19	22:52	17.474	100.412	84.0	3.5	.0	.0	

Event	Yr	Mo	Da	HrMn	Lat N	Lon W	Depth	M-II	m_b	Ms	Mc
8727	87-	7-	27	6:50	16.920	99.754	31.4	3.0	.0	.0	
8728	87-	8-	10	0:59	17.348	100.694	10.5	3.7	.0	.0	
8729	87-	8-	23	21:34	17.158	99.548	2.4	3.4	.0	.0	
8730	87-	8-	25	23:44	17.986	100.650	52.4	4.2	.0	.0	
8731	87-	8-	29	16:10	17.974	100.922	.0	4.0	.0	.0	
8732	87-	9-	1	23:29	17.081	99.799	26.9	3.2	.0	.0	
8733	87-	9-	19	10:01	17.645	100.889	.3	3.5	.0	.0	
8734	87-	9-	19	11:55	17.106	99.050	18.6	4.2	4.0	.0	
8735	87-	10-	1	18:12	17.134	99.910	.0	3.1	.0	.0	
8736	87-	10-	17	20:34	18.191	101.040	37.2	3.9	.0	.0	
8737	87-	10-	25	4:31	17.324	101.245	16.3	4.4	.0	.0	
8738	87-	10-	25	21:19	17.451	101.115	6.7	3.8	.0	.0	
8739	87-	11-	6	1:34	17.234	101.304	14.6	4.0	.0	.0	
8740	87-	11-	10	13:22	17.020	100.015	19.5	3.7	.0	.0	
8741	87-	11-	10	22:59	17.232	100.592	24.1	3.8	.0	.0	
8742	87-	11-	22	5:11	17.135	100.068	23.6	4.2	.0	.0	
8743	87-	11-	22	12:30	17.231	101.030	16.0	4.4	4.1	.0	
8744	87-	12-	3	12:06	17.455	101.097	17.9	3.9	4.0	.0	
8745	87-	12-	4	13:30	17.311	101.910	1.5	4.1	.0	.0	
8746	87-	12-	9	7:50	17.165	99.850	2.9	2.9	.0	.0	
8747	87-	12-	19	17:07	17.491	101.111	12.8	3.8	.0	.0	
8801	88-	1-	22	21:52	17.008	101.063	9.3	4.2	.0	.0	
8802	88-	1-	30	11:57	17.293	100.685	26.4	3.6	.0	.0	
8803	88-	2-	5	6:09	18.155	98.914	42.3	4.3	.0	.0	
8804	88-	2-	8	13:51	17.494	101.157	19.2	5.0	5.5	5.7	
8805	88-	2-	19	9:28	17.086	101.338	20.2	3.6	.0	.0	
8806	88-	2-	25	22:12	17.210	99.843	54.0	3.8	.0	.0	
8807	88-	2-	26	0:15	17.157	101.266	1.5	4.0	.0	.0	
8808	88-	3-	1	4:38	17.936	99.216	11.0	2.9	.0	.0	
8809	88-	3-	20	17:03	17.090	100.010	4.7	3.7	.0	.0	
8810	88-	3-	27	5:06	17.629	101.108	42.8	3.2	.0	.0	
8811	88-	3-	31	7:34	17.912	97.994	8.8	4.5	5.1	.0	
8812	88-	4-	4	18:38	16.751	100.219	7.2	4.1	4.2	.0	
8813	88-	4-	26	16:18	17.140	101.337	.0	3.6	.0	.0	
8814	88-	5-	3	11:04	16.328	98.992	11.6	3.9	.0	.0	
8815	88-	5-	28	21:43	16.959	100.027	14.0	3.5	.0	.0	
8816	88-	5-	29	6:11	18.109	100.050	53.5	4.2	4.6	.0	
8817	88-	6-	8	21:18	16.627	98.555	5.1	4.8	5.1	.0	
8818	88-	6-	16	22:59	18.073	99.967	59.8	4.1	.0	.0	
8819	88-	6-	17	18:10	18.686	102.177	4.8	3.8	.0	.0	
8820	88-	7-	13	20:07	18.099	99.587	2.3	3.2	.0	.0	
8821	88-	7-	20	5:00	17.189	99.969	12.3	2.6	.0	.0	
8822	88-	7-	31	4:48	17.187	99.879	22.9	2.8	.0	.0	
8823	88-	8-	1	8:42	17.128	100.963	3.9	3.2	.0	.0	
8824	88-	8-	2	0:55	17.997	99.675	49.0	3.2	.0	.0	
8825	88-	8-	3	13:01	17.142	101.152	7.4	3.0	.0	.0	
8826	88-	8-	16	4:20	16.967	99.801	21.1	4.6	4.2	.0	
8827	88-	8-	23	17:29	17.133	99.624	33.5	3.2	.0	.0	
8828	88-	8-	27	15:59	17.274	100.959	21.1	3.2	.0	.0	
8829	88-	9-	1	23:15	17.026	99.931	.5	2.9	.0	.0	
8830	88-	9-	4	8:59	17.017	99.867	4.7	2.9	.0	.0	
8831	88-	9-	7	20:17	17.231	100.255	18.2	4.1	.0	.0	
8832	88-	9-	9	21:47	17.049	100.052	1.5	3.0	.0	.0	
8833	88-	9-	14	6:07	17.736	101.474	28.1	4.3	4.0	.0	
8834	88-	9-	14	20:36	18.340	102.430	38.2	4.7	4.9	.0	
8835	88-	9-	26	20:11	17.150	101.149	11.3	4.7	5.0	.0	
8836	88-	9-	26	21:04	17.215	101.087	17.2	4.2	.0	.0	
8837	88-	10-	4	2:26	17.176	99.997	.1	3.4	.0	.0	

Event	Yr	Mo	Da	HrMn	Lat N	Lon W	Depth	M-II	m_b	Ms	Mc
8838	88-	10-	11	7:43	17.160	99.891	37.9	3.3	.0	.0	
8839	88-	11-	1	3:02	17.370	100.787	28.6	3.1	.0	.0	
8840	88-	11-	22	8:58	16.973	100.049	23.2	3.7	.0	.0	
8841	88-	11-	25	6:23	16.426	99.046	.3	3.8	.0	.0	
8842	88-	11-	26	16:26	17.391	100.682	37.0	3.8	.0	.0	
8843	88-	12-	2	7:53	17.030	100.273	15.9	3.4	.0	.0	
8844	88-	12-	5	13:46	17.204	99.970	15.00	3.1	.0	.0	
8845	88-	12-	6	14:54	16.887	100.065	11.7	4.3	.0	.0	
8846	88-	12-	10	11:16	16.867	99.649	11.3	3.0	.0	.0	
8847	88-	12-	10	11:24	16.880	99.646	2.0	3.4	.0	.0	
8848	88-	12-	12	5:59	17.776	101.163	19.2	4.2	.0	.0	
8849	88-	12-	12	6:33	16.855	99.681	2.8	3.6	.0	.0	
8850	88-	12-	16	12:55	16.963	99.903	17.1	3.3	.0	.0	
8851	88-	12-	17	9:23	17.005	99.904	2.6	3.0	.0	.0	
8852	88-	12-	22	19:54	16.831	99.670	9.8	3.1	.0	.0	
8901	89-	1-	7	09:10	17.029	99.950	4.3	3.2	.0	.0	3.8
8902	89-	1-	15	18:11	17.359	100.897	28.6	3.8	.0	.0	4.3
8903	89-	1-	15	19:03	17.055	99.978	18.4	3.7	.0	.0	4.2
8904	89-	2-	2	22:00	16.958	99.876	11.2	3.1	.0	.0	3.6
8905	89-	2-	7	07:14	17.509	99.382	10.1	3.5	.0	.0	4.3
8906	89-	2-	24	00:32	17.905	99.683	55.2	3.4	.0	.0	4.4
8907	89-	3-	2	17:20	16.945	100.466	9.5	3.6	.0	.0	4.1
8908	89-	3-	6	03:33	16.837	99.652	10.7	3.0	.0	.0	4.2
8909	89-	3-	6	16:46	16.775	99.835	6.1	2.6	.0	.0	4.3
8910	89-	3-	7	08:38	17.028	99.619	36.7	2.4	.0	.0	4.1
8911	89-	3-	9	10:10	17.209	99.863	40.0	3.7	4.5	.0	4.8
8912	89-	3-	10	05:19	17.446	101.089	17.6	5.0	5.3	4.8	5.1
8913	89-	3-	13	03:25	17.002	99.094	27.0	3.6	.0	.0	4.8
8914	89-	3-	13	03:31	17.005	99.790	29.6	2.8	.0	.0	3.6
8915	89-	3-	13	04:08	16.960	99.048	32.3	4.4	4.8	.0	4.9
8916	89-	3-	19	19:04		not located	-	-	-	-	
8917	89-	3-	26	17:39	16.827	99.568	1.8	3.1	.0	.0	4.2
8918	89-	3-	27	03:40	16.861	99.511	15.0	3.0	.0	.0	3.6
8919	89-	4-	3	11:29	18.010	99.545	52.5	4.0	.0	.0	3.9
8920	89-	4-	8	21:58	17.414	101.315	17.1	4.4	4.5	.0	4.6
8921	89-	4-	19	08:59	16.470	98.695	.5	4.7	4.9	.0	5.0
8922	89-	4-	21	18:39	18.467	100.392	19.0	4.1	.0	.0	.0
8923	89-	4-	24	13:51	17.144	100.112	29.1	4.1	.0	.0	4.4
8924	89-	4-	25	14:29	16.603	99.400	19.0	6.5	6.3	6.9	6.9
8925	89-	4-	25	14:44	16.422	99.329	2.8	3.9	.0	.0	4.8
8926	89-	4-	25	16:26	16.638	99.296	18.5	4.4	4.8	.0	4.9
8927	89-	4-	25	20:10	16.639	99.360	7.2	3.7	.0	.0	4.0
8928	89-	4-	27	16:22	16.664	99.427	3.6	4.3	.0	.0	4.3
8929	89-	5-	2	09:30	16.637	99.513	13.4	5.1	5.4	4.9	5.2
8930	89-	5-	5	11:35	17.476	100.376	1.2	4.4	.0	.0	4.5
8931	89-	5-	15	16:03	17.280	100.537	39.5	3.8	.0	.0	4.4
8932	89-	5-	21	12:51	16.949	99.566	23.4	3.9	.0	.0	4.3
8933	89-	5-	22	00:03	16.667	99.373	1.9	4.0	.0	.0	4.5
8934	89-	5-	26	14:42	16.951	99.675	19.2	3.6	.0	.0	4.2
8935	89-	6-	5	15:59	16.703	99.407	11.3	3.6	.0	.0	4.5
8936	89-	6-	5	20:12	16.566	99.386	4.4	3.7	.0	.0	4.3
8937	89-	6-	12	22:32	17.227	100.993	16.7	3.6	.0	.0	4.4
8938	89-	6-	23	11:37	16.716	99.439	29.9	4.1	.0	.0	4.0
8939	89-	6-	25	01:34	16.757	99.375	15.2	3.4	.0	.0	3.8
8940	89-	6-	25	12:54	17.296	100.833	29.1	3.9	3.8	.0	4.5
8941	89-	7-	2	23:35	17.192	100.252	30.3	3.9	.0	.0	3.9
8942	89-	7-	6	23:21	17.405	101.485	7.6	4.9	4.8	.0	4.8
8943	89-	7-	7	10:14	17.194	99.830	42.2	4.1	.0	.0	4.2

Event	Yr	Mo	Da	HrMn	Lat N	Lon W	Depth	M-II	m_b	Ms	Mc
8944	89-	7-	8	05:54		not located	-	-	-	-	-
8945	89-	7-	28	08:08	16.854	99.636	0.5	3.3	.0	.0	3.3
8946	89-	8-	6	17:13	17.177	99.974	12.0	3.8	.0	.0	3.9
8947	89-	8-	12	04:46	16.907	99.759	16.1	3.6	.0	.0	.0
8948	89-	8-	12	15:31	18.126	100.030	56.5	4.8	5.5	4.5	5.0
8949	89-	8-	17	00:54	17.118	100.035	25.6	4.8	4.9	.0	4.7
8950	89-	8-	21	09:33	17.044	99.487	34.5	4.7	.0	.0	4.8
8951	89-	8-	24	01:36	17.141	100.982	0.0	4.5	4.0	.0	4.6
8952	89-	8-	28	06:28	17.010	99.957	10.6	3.7	.0	.0	3.6
8953	89-	8-	28	10:30	16.980	99.899	15.7	4.1	.0	.0	4.1
8954	89-	9-	1	10:06	16.871	99.763	16.8	3.8	.0	.0	4.0
8955	89-	9-	5	03:12	17.181	100.095	4.9	3.9	.0	.0	4.0
8956	89-	9-	5	16:26	17.222	100.649	23.4	3.8	.0	.0	3.8
8957	89-	9-	12	02:17	16.739	99.864	17.6	4.4	.0	.0	4.4
8958	89-	9-	14	01:18		not located	-	-	-	-	-
8959	89-	9-	24	10:08	16.766	99.871	15.7	4.4	.0	.0	4.5
8960	89-	10-	4	22:40	16.871	99.827	17.5	3.8	.0	.0	3.8
8961	89-	10-	8	22:32	17.189	100.213	36.0	5.0	5.0	4.1	5.0
8962	89-	10-	11	20:47	17.011	100.339	.6	3.9	.0	.0	4.0
8963	89-	10-	14	03:05	16.934	99.813	7.5	3.8	.0	.0	3.9
8964	89-	10-	18	19:39	17.353	100.800	23.8	4.0	.0	.0	4.0
8965	89-	10-	22	14:17	18.131	102.817	8.2	4.3	.0	.0	4.4
8966	89-	10-	25	02:39	17.510	101.293	17.9	4.2	.0	.0	4.3
8967	89-	10-	25	03:57	16.688	99.638	11.6	3.6	4.4	.0	3.6
8968	89-	10-	25	03:59	16.762	99.603	9.7	4.6	.0	.0	4.7
8969	89-	10-	28	17:01	16.495	99.938	12.6	4.9	4.7	.0	5.0
8970	89-	11-	2	10:42	17.123	100.041	4.2	3.8	.0	.0	4.1
8971	89-	11-	9	02:04	17.007	99.596	.0	3.5	.0	.0	4.4
8972	89-	11-	9	02:05	17.018	99.698	31.0	3.5	.0	.0	4.2
8973	89-	11-	9	02:20	16.961	100.083	4.2	4.0	.0	.0	4.2
8974	89-	11-	9	08:36	16.844	99.648	9.9	5.1	5.1	.0	5.1
8975	89-	11-	17	03:20	17.140	101.083	.4	3.9	.0	.0	4.1
8976	89-	11-	18	15:42	16.538	99.209	6.0	4.2	.0	.0	4.4
8977	89-	12-	2	09:38		not located	-	-	-	-	
8978	89-	12-	5	08:38	16.843	99.644	15.9	4.2	.0	.0	4.4
8979	89-	12-	14	13:43	17.065	99.844	28.7	3.8	.0	.0	4.0
8980	89-	12-	21	12:06	17.513	101.165	22.8	4.3	.0	.0	4.5
9001	90-	1-	9	0:59	17.121	99.990	1.2	4.0	.0	.0	4.0
9002	90-	1-	13	2:07	16.820	99.629	12.2	5.0	5.3	5.0	5.1
9003	90-	1-	17	16:18		not located	-	-	-	-	
9004	90-	1-	19	18:52	16.673	99.718	10.7	3.9	.0	.0	4.2
9005	90-	1-	29	02:41	18.271	102.547	39.0	5.1	5.4	4.4	5.1
9006	90-	2-	4	3:32	16.941	99.833	17.9	3.1	.0	.0	4.1
9007	90-	2-	15	11:22	17.014	99.978	11.6	3.2	.0	.0	3.9
9008	90-	2-	21	20:50	16.545	99.142	10.0	3.7	4.1	.0	4.7
9009	90-	3-	6	22:58	17.011	99.885	8.5	4.4	.0	.0	4.5
9010	90-	3-	7	13:58	17.652	100.716	10.0		-	-	-
9011	90-	3-	21	15:24	16.833	99.632	13.2	4.0	.0	.0	4.2
9012	90-	4-	4	16:59	16.657	99.372	14.5	4.8	4.4	4.0	4.9
9013	90-	4-	4	17:08	16.648	99.372	15.4	5.0	4.3	4.3	5.0
9014	90-	4-	4	22:27	16.537	99.324	1.7	4.2	.0	.0	4.4
9015	90-	4-	12	12:19	17.112	100.039	37.9	3.7	.0	.0	
9016	90-	4-	15	19:49	17.037	100.117	12.6	4.1	.0	.0	4.2
9017	90-	4-	30	3:57	17.716	101.758	30.3	4.4	3.3	.0	4.5
9018	90-	5-	11	5:02	17.134	100.302	18.3	4.3	.0	.0	4.3
9019	90-	5-	11	23:43	17.046	100.840	11.7	5.3	5.3	4.9	5.3
9020	90-	5-	12	23:30	17.104	99.845	13.0	4.4	3.8	.0	4.6
9021	90-	5-	14	7:20	17.123	99.926	61.1	4.3	.0	.0	4.3

Event	Yr	Mo	Da	HrMn	Lat N	Lon W	Depth	M-II	m_b	Ms	Mc
8838	88-	10-	11	7:43	17.160	99.891	37.9	3.3	.0	.0	
8839	88-	11-	1	3:02	17.370	100.787	28.6	3.1	.0	.0	
8840	88-	11-	22	8:58	16.973	100.049	23.2	3.7	.0	.0	
8841	88-	11-	25	6:23	16.426	99.046	.3	3.8	.0	.0	
8842	88-	11-	26	16:26	17.391	100.682	37.0	3.8	.0	.0	
8843	88-	12-	2	7:53	17.030	100.273	15.9	3.4	.0	.0	
8844	88-	12-	5	13:46	17.204	99.970	15.00	3.1	.0	.0	
8845	88-	12-	6	14:54	16.887	100.065	11.7	4.3	.0	.0	
8846	88-	12-	10	11:16	16.867	99.649	11.3	3.0	.0	.0	
8847	88-	12-	10	11:24	16.880	99.646	2.0	3.4	.0	.0	
8848	88-	12-	12	5:59	17.776	101.163	19.2	4.2	.0	.0	
8849	88-	12-	12	6:33	16.855	99.681	2.8	3.6	.0	.0	
8850	88-	12-	16	12:55	16.963	99.903	17.1	3.3	.0	.0	
8851	88-	12-	17	9:23	17.005	99.904	2.6	3.0	.0	.0	
8852	88-	12-	22	19:54	16.831	99.670	9.8	3.1	.0	.0	
8901	89-	1-	7	09:10	17.029	99.950	4.3	3.2	.0	.0	3.8
8902	89-	1-	15	18:11	17.359	100.897	28.6	3.8	.0	.0	4.3
8903	89-	1-	15	19:03	17.055	99.978	18.4	3.7	.0	.0	4.2
8904	89-	2-	2	22:00	16.958	99.876	11.2	3.1	.0	.0	3.6
8905	89-	2-	7	07:14	17.509	99.382	10.1	3.5	.0	.0	4.3
8906	89-	2-	24	00:32	17.905	99.683	55.2	3.4	.0	.0	4.4
8907	89-	3-	2	17:20	16.945	100.466	9.5	3.6	.0	.0	4.1
8908	89-	3-	6	03:33	16.837	99.652	10.7	3.0	.0	.0	4.2
8909	89-	3-	6	16:46	16.775	99.835	6.1	2.6	.0	.0	4.3
8910	89-	3-	7	08:38	17.028	99.619	36.7	2.4	.0	.0	4.1
8911	89-	3-	9	10:10	17.209	99.863	40.0	3.7	4.5	.0	4.8
8912	89-	3-	10	05:19	17.446	101.089	17.6	5.0	5.3	4.8	5.1
8913	89-	3-	13	03:25	17.002	99.094	27.0	3.6	.0	.0	4.8
8914	89-	3-	13	03:31	17.005	99.790	29.6	2.8	.0	.0	3.6
8915	89-	3-	13	04:08	16.960	99.048	32.3	4.4	4.8	.0	4.9
8916	89-	3-	19	19:04		not located	-	-	-	-	
8917	89-	3-	26	17:39	16.827	99.568	1.8	3.1	.0	.0	4.2
8918	89-	3-	27	03:40	16.861	99.511	15.0	3.0	.0	.0	3.6
8919	89-	4-	3	11:29	18.010	99.545	52.5	4.0	.0	.0	3.9
8920	89-	4-	8	21:58	17.414	101.315	17.1	4.4	4.5	.0	4.6
8921	89-	4-	19	08:59	16.470	98.695	.5	4.7	4.9	.0	5.0
8922	89-	4-	21	18:39	18.467	100.392	19.0	4.1	.0	.0	.0
8923	89-	4-	24	13:51	17.144	100.112	29.1	4.1	.0	.0	4.4
8924	89-	4-	25	14:29	16.603	99.400	19.0	6.5	6.3	6.9	6.9
8925	89-	4-	25	14:44	16.422	99.329	2.8	3.9	.0	.0	4.8
8926	89-	4-	25	16:26	16.638	99.296	18.5	4.4	4.8	.0	4.9
8927	89-	4-	25	20:10	16.639	99.360	7.2	3.7	.0	.0	4.0
8928	89-	4-	27	16:22	16.664	99.427	3.6	4.3	.0	.0	4.3
8929	89-	5-	2	09:30	16.637	99.513	13.4	5.1	5.4	4.9	5.2
8930	89-	5-	5	11:35	17.476	100.376	1.2	4.4	.0	.0	4.5
8931	89-	5-	15	16:03	17.280	100.537	39.5	3.8	.0	.0	4.4
8932	89-	5-	21	12:51	16.949	99.566	23.4	3.9	.0	.0	4.3
8933	89-	5-	22	00:03	16.667	99.373	1.9	4.0	.0	.0	4.5
8934	89-	5-	26	14:42	16.951	99.675	19.2	3.6	.0	.0	4.2
8935	89-	6-	5	15:59	16.703	99.407	11.3	3.6	.0	.0	4.5
8936	89-	6-	5	20:12	16.566	99.386	4.4	3.7	.0	.0	4.3
8937	89-	6-	12	22:32	17.227	100.993	16.7	3.6	.0	.0	4.4
8938	89-	6-	23	11:37	16.716	99.439	29.9	4.1	.0	.0	4.0
8939	89-	6-	25	01:34	16.757	99.375	15.2	3.4	.0	.0	3.8
8940	89-	6-	25	12:54	17.296	100.833	29.1	3.9	3.8	.0	4.5
8941	89-	7-	2	23:35	17.192	100.252	30.3	3.9	.0	.0	3.9
8942	89-	7-	6	23:21	17.405	101.485	7.6	4.9	4.8	.0	4.8
8943	89-	7-	7	10:14	17.194	99.830	42.2	4.1	.0	.0	4.2

Event	Yr	Mo	Da	HrMn	Lat N	Lon W	Depth	M-II	m_b	Ms	Mc
9118	91-	4-	16	17:57	16.904	100.148	18.6	4.4	3.4	.0	4.3
9119	91-	4-	19	23:25		not located					
9120	91-	4-	21	10:04	16.463	99.156	15.9	5.0	4.7	4.2	4.7
9121	91-	4-	27	14:48	17.221	100.373	29.2	4.9	4.6	4.1	4.9
9122	91-	5-	7	2:34	16.701	99.495	19.2	4.7	.0	.0	4.7
9123	91-	5-	10	5:57	17.208	101.087	14.7	4.4	.0	.0	4.5
9124	91-	5-	16	6:15	16.391	99.119	12.8	4.7	.0	.0	4.7
9125	91-	5-	20	0:14		not located					
9126	91-	5-	21	5:58	17.118	99.334	39.3	5.0	4.9	4.1	4.9
9127	91-	5-	28	0:56	16.897	99.809	27.3	4.9	4.6	3.6	4.8
9128	91-	6-	26	6:22	16.932	100.021	31.5	4.4	.0	.0	4.4
9129	91-	6-	28	12:52	16.971	100.644	12.8	4.2	.0	.0	4.3
9130	91-	7-	3	9:44	17.016	100.003	8.9	3.3	.0	.0	3.7
9131	91-	7-	16	19:26	17.100	101.111	18.1	4.2	3.9	.0	4.6
9132	91-	7-	20	15:52	16.760	99.566	12.2	4.1	.0	.0	4.4
9133	91-	7-	21	5:41		not located					
9134	91-	7-	25	15:45	16.766	101.451	12.8	5.0	5.4	5.4	5.3
9135	91-	8-	6	0:29	16.627	99.405	17.6	3.8	.0	.0	4.3
9136	91-	8-	19	0:36	18.292	100.759	42.4	4.2	.0	.0	4.2
9137	91-	8-	19	21:51	17.002	100.700	9.9	4.6	4.3	.0	4.8
9138	91-	9-	3	13:14		not located					
9139	91-	9-	8	0:42		not located					
9140	91-	9-	11	4:35		not located					
9141	91-	9-	28	8:55	17.176	100.040	15.0	3.3	.0	.0	3.9
9142	91-	10-	8	0:41		not located					
9143	91-	10-	9	3:28		not located					
9144	91-	10-	15	22:40	17.014	99.441	29.2	4.0	.0	.0	4.4
9145	91-	10-	26	10:28		not located					
9146	91-	10-	27	18:57	18.321	99.207	43.1	.0	3.9	.0	4.3
9147	91-	11-	2	21:16	16.867	99.700	16.6	4.2	.0	.0	4.2
9148	91-	11-	15	1:47	17.227	100.811	16.3	4.1	3.9	.0	4.5
9149	91-	11-	17	6:50	18.357	101.302	50.4	.0	4.7	.0	4.8
9150	91-	11-	18	18:57	16.899	99.562	8.4	3.6	.0	.0	3.9
9151	91-	12-	9	14:05	16.496	98.644	31.8	4.2	4.2	.0	4.3
9152	91-	12-	9	19:20	17.512	101.214	15.5	3.7	.0	.0	4.1
9153	91-	12-	12	1:04		not located					
9154	91-	12-	15	1:16		not located					
9155	91-	12-	28	23:59	16.938	99.670	17.4	3.1	.0	.0	3.7

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