United States Department of the Interior
Geological Survey

PRELIMINARY CATALOG OF SEISMICITY PRIOR TO THE GUATEMALA EARTHQUAKE OF FEBRUARY 4, 1976

from the Area between Guatemala City and Lake Atitlan
MARCH 8, 1975 - FEBRUARY 4, 1976

By
David H. Harlow and R. A. White

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INTRODUCTION

A six-station seismic network, about 40 km in diameter, has been operated just west of Guatemala City since March 1975. The network is part of a cooperative project between the U. S. Geological Survey and the Instituto Nacional de Sismologia, Vulcanologia, Meterologia e Hidrologia (INSIVUMEH) of Guatemala.

The primary purpose of the network is to monitor the seismicity associated with the active volcanoes Pacaya and Fuego and the inactive volcanoes Agua and Acatenango that have not erupted for at least two hundred years. A secondary purpose is to investigate seismicity along the Mixco Fault Zone, a set of normal faults that passes within 5 km of Guatemala City. The major value of the network, however, may lie in its proximity to the Motagua fault, the site of the disasterous Guatemalan earthquake (Ms = 7.5) of February 4, 1976 that killed more than 76,000 people. The area of coverage, although some 150 km distant from the point of initial rupture on the Motagua Fault (Dewey and Julian, 1976) is important for reasons as follows:

1) It contains the western terminus of the 230 km of surface faulting (Plafker and others, 1976a) that occurred on the Motagua fault.

2) It contains most of the observed secondary surface faulting (Bonilla and others, 1976).

3) It is roughly coincident with the region of greatest damage and highest casualties (Espinosa and others, 1976).

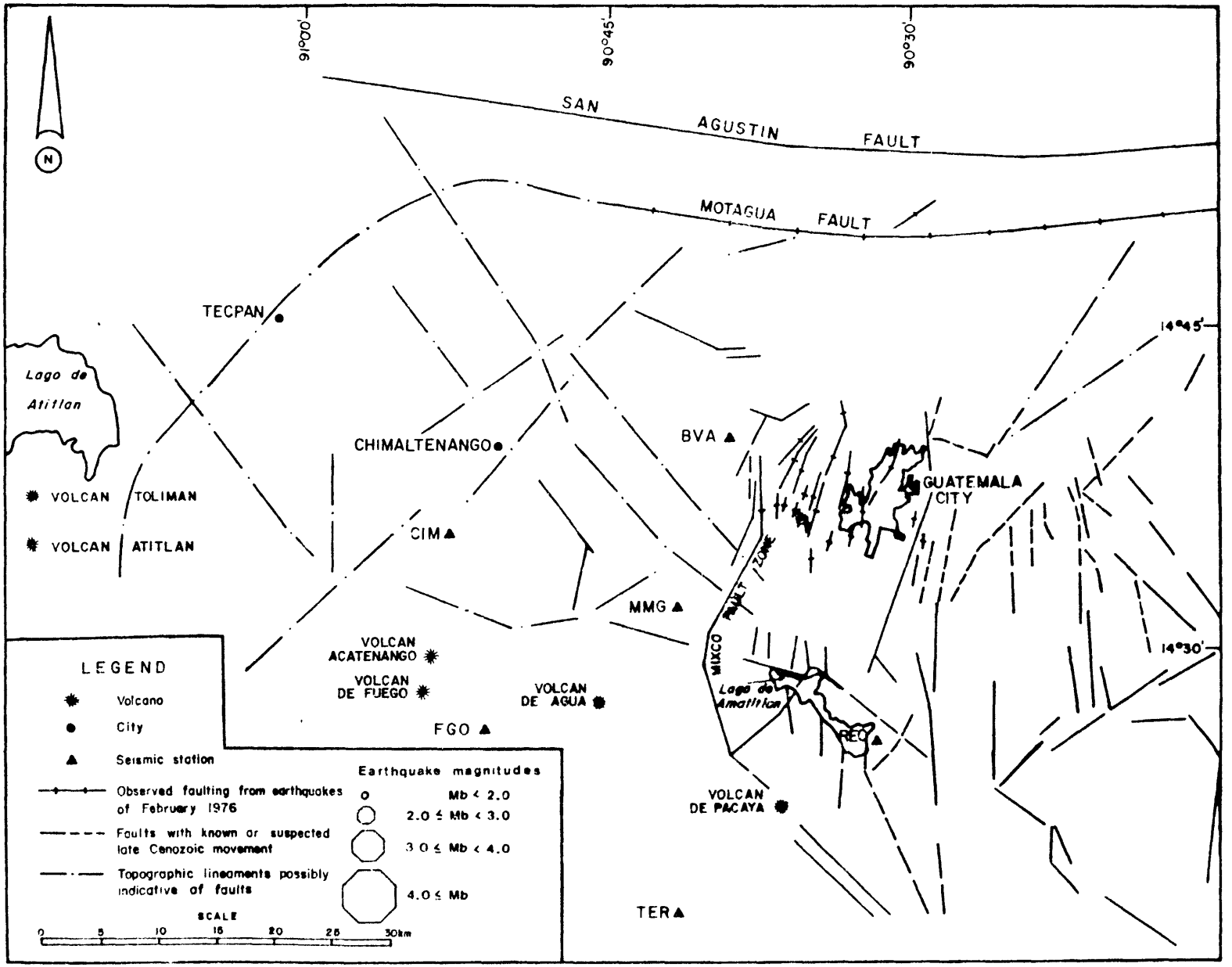

FIGURE 1. Map of the study area. The data shown on this map were gathered from various geologic maps published by the Instituto Geographico Nacional, Guatemala.

4) 9 of the 13 largest aftershocks (Mb 4.5) (Person and others, 1976) as well as several thousand aftershocks of lesser magnitude (White and Harlow, 1979, 1980) occurred within the area of coverage.

This catalog contains hypocentral data on 152 events, from March 4, 1975 until the time of the Guatemalan earthquake of February 4, 1976, in the area between the volcanic chain and the western Motagua Fault. These data show that during this time about half of the events occurred at the active volcano Fuego, the rest from scattered sources throughout the region, and that the level of background seismicity and seismicity precursory to the Guatemalan earthquake is very low.

INSTRUMENTATION

The remote seismic stations each use a one second vertical L-4C Mark Products* seismometer with a resistor circuit added to give 80% critical damping. The signal is converted to a frequency-modulated tone by an amplifier and voltage-controlled oscillator package, Model JE202 developed at the U. G. Geological Survey by J. Van Schaack. The amplifier has a maximum gain of 100 db and has a 12 db/octave filters with 3 db points at 0.1 Hz and 30 Hz. The attenuation is normally set at 6 to 18 db, which gives a total electronic gain of about 8,000 to 32,000. The FM tone is transmitted by a modified Motorola* HT200 radio link to the INSIVUMEH

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TABLE 1

Station Coordinates, Elevations, Magnifications, and Delays

Station	Latitude (Degrees)	Longitude (Degrees)	Elevation (Meters)	Magnification at 25 Hz	Delay (Sec)
FGO	14.446N	90.840W	1410	120,000	0.10
CIM	14.595N	90.860W	2450	60,000	0.41
MMG	14.538N	90.681W	2190	60,000	0.48
BVA	14.667N	90.637W	2262	120,000	0.22
REC	14.437N	90.519W	1500	120,000	0.40
TER	14.304N	90.684W	0570	240,000	0.05

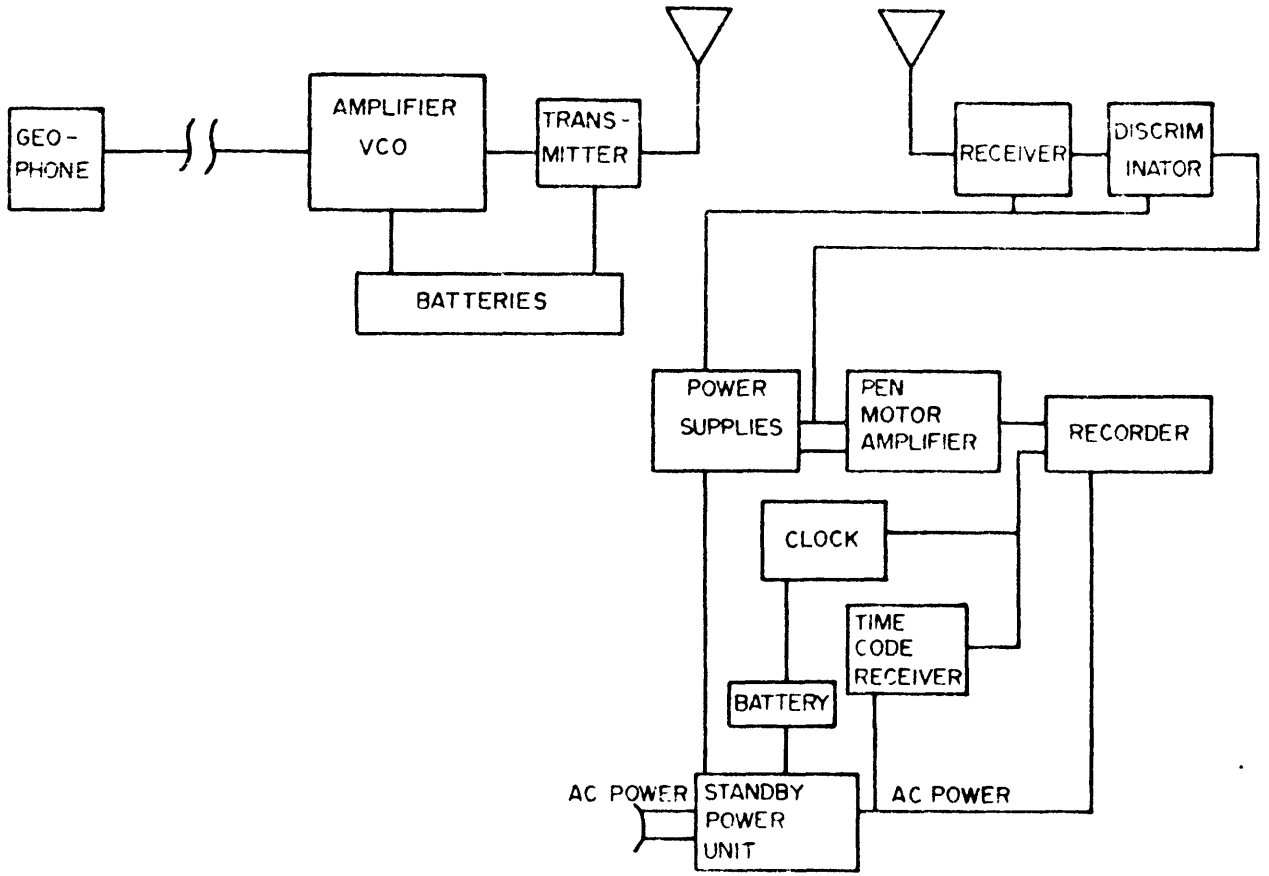

FIGURE 2. Block diagram of the seismic system

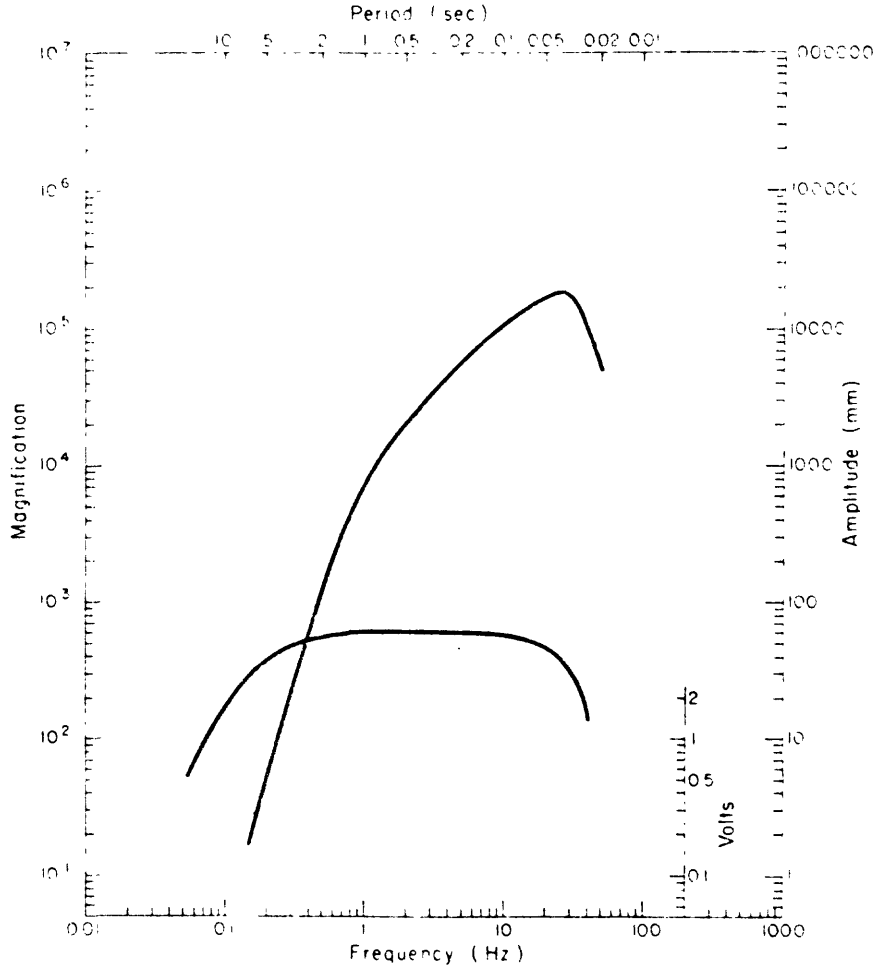

FIGURE 3. Frequency response curves for the high-gain, short-period seismographs. The lower curve shows the response of the electronics and the upper curve shows the system response, including the displacement response of the geophone.

offices in Guatemala City. The tone is demodulated by a discriminator, Van Schaack Model JE101, and a time signal from a crystal-controlled oscillator is added. The resulting signal is then recorded at a rate of 60 mm per minute on a drum recorder using heat-sensitive paper.

The six stations are plotted on a base map in Figure 1 and the station coordinates, elevations, magnifications, and delays are listed in Table 1. A block diagram of the total system is shown in Figure 2.

The overall frequency response of the seismic system is shown in Figure 3. The magnification is adjusted according to the background noise level at each station ranging from 6×10^4 to 2.4×10^5 at 25 Hz.

TIME COVERAGE

The network was completed and began full operation on March 8, 1975. This catalog contains a complete record of the seismicity in this region from this day until the time of the Guatemalan earthquake of February 4, 1976, except for the period of time from June 1 to July 8 and a few other periods of as much as 48 hours when repairs were being made.

DATA ANALYSIS

The paragraphs below describe how the events are processed.

1. All events with 4 or more discernable P-arrivals are examined for P-wave arrival time and first motion, S-wave arrival time if possible, and the signal duration. P-arrival time can be read to within ±0.1 sec, but S-arrivals are often unclear and may have reading errors of ±0.3 sec. The signal duration is measured from the first break to the point where the signal drops below a peak-to-peak amplitude of 1 mm.
2. Punched cards are prepared from the examined data and processed by the computer program HYPOELLIPSE (Lahr in preparation) to determine origin time, hypocenter, magnitude, statistical data on the quality of the solution, and data on the error ellipsoid enclosing the one standard deviation region of the hypocenter.
3. First solutions are analyzed, any errors corrected, the events reprocessed, and poor solutions eliminated.

MAGNITUDES

The useful dynamic range of earthquake magnitudes determined from record amplitudes is limited because the high gain amplifiers are saturated by relatively small seismic signals. Richter magnitudes are approximated, therefore, by a method based on signal duration (Lee and others, 1972) given in Equation 1.

$$M = -0.87 + 2.00 \log(t) + 0.0035 \qquad (1)$$

M is the body wave magnitude, t, the signal duration in seconds, and is the epicentral distance in kilometers. The magnitude listed in the catalogue is the average of the magnitudes determined for each station. We believe that this method is accurate to $\pm$0.3 magnitude and that the method provides good information on relative magnitudes. Figure 5 shows the magnitude distribution of the earthquakes listed in this catalog.

VELOCITY MODEL

Accurate calculation of hypocentral solutions depends upon the compatibility between the seismic velocities in the real earth and the velocity model specified to the program HYPOELLIPSE. Since neither velocity studies, or reliable explosion data exist for Guatemala, a crustal model was approximated using a velocity that increases linearly with depth. A set of eleven such models, covering the range of possibilities thought to

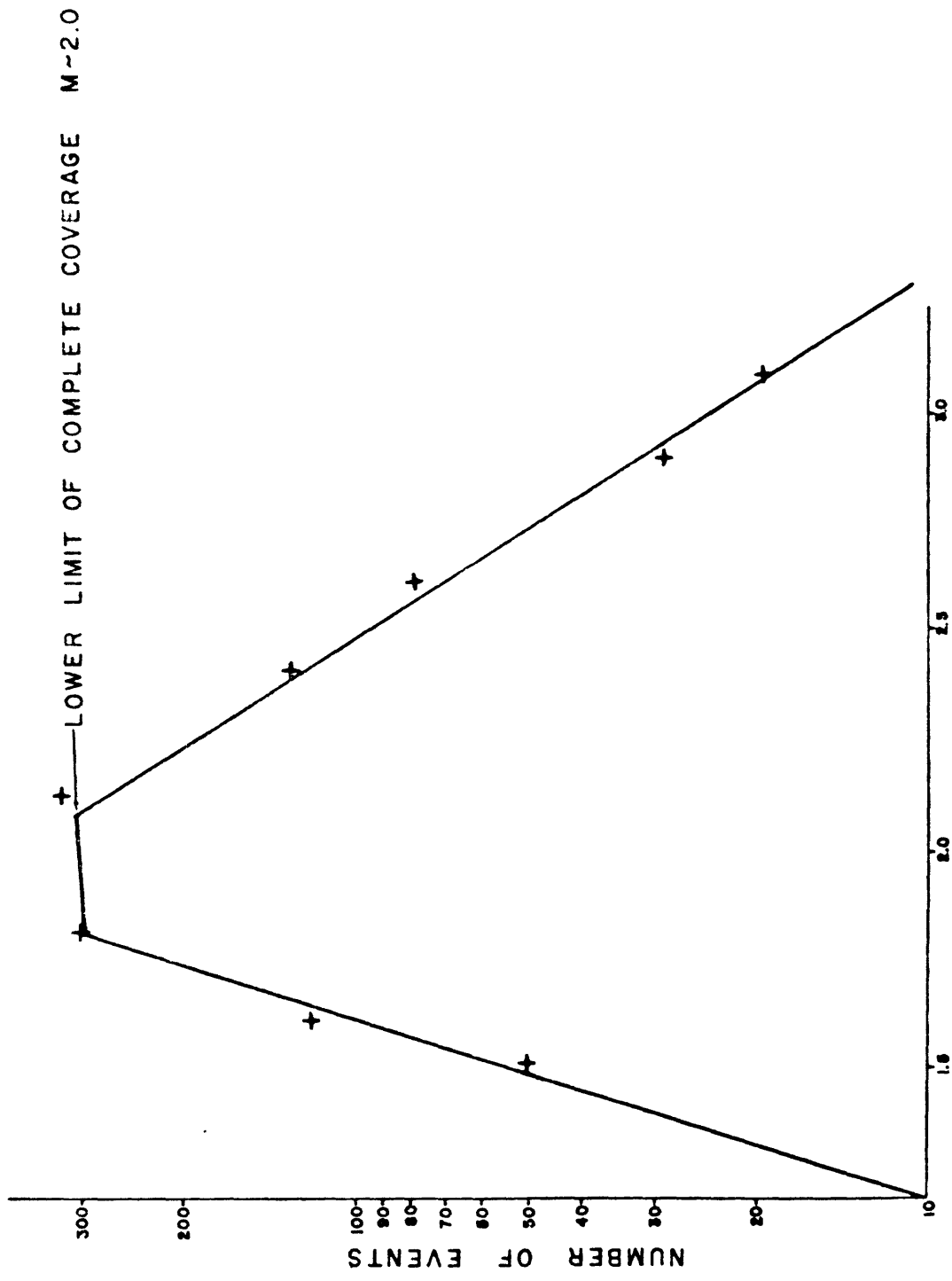

FIGURE 5. Magnitude distribution for the events listed in this catalog.

Table 2

Velocity Model Data

Model	Surface Velocity (Km/sec)	Rate of Linear Increase with Depth (Km/sec/km)	Average RMS of Traveltime Residuals (Sec)
1	4.5	.15	.232
2	5.0	.15	.221
3	5.5	.15	.232
4	4.0	.10	.309
5	4.5	.10	.266
6	5.0	.10	.231
7*	5.5	.10	.219
8	6.0	.10	.241
9	5.5	.07	.232
10	6.0	.07	.228
11	6.5	.07	.275

*Model selected for use in this catalog.

exist in similar tectonic environments, was tested on a set of 100 local events. The results listed in Table 2 show that among the six best models, virtually no difference (0.015 sec.) exists in the average RMS of the travetime residuals. Model 7 was chosen because it is the closest to the average of these six best models and produced the smallest average RMS: a surface velocity of 5.5 km/sec increasing linearly by 0.1 km/sec with each kilometer of depth.

Tests of selected events show that for different crustal models, epicenters inside the net vary by less than one km, and depths vary up to 5 km. For events at 1 diameter outside the net, epicenters vary up to 8 km between most extreme models but vary only about 3 km between the six best models mentioned above.

STATION CORRECTIONS

Station delays were developed to correct for factors such as elevation and local geology that are unique to each recording site. A set of 100 well recorded events were processed by HYPOELLIPSE and the resultant average traveltime residuals were fed back into the station corrections until the standard deviation of the residuals was minimized. See Table 1 for a listing of the station corrections.

DISCUSSION

The earthquake locations are based on the time of the first arrival of P-waves and equally, whenever available, S-waves. The HYPOELLIPSE program uses Geiger's method (Geiger, 1912) to minimize the RMS of the traveltime residuals. The traveltimes and the partial derivatives are calculated for a horizontally homogeneous model by a technique developed by Eaton (1969). For each event, the program also calculates the ellipsoid enclosing the one standard deviation region of the RMS of the traveltime residuals. Our studies indicate that epicentral locations are accurate to $\pm$2.0 km inside the perimeter of the network and range to $\pm$4.0 km out at 30 km beyond the perimeter. Depths are accurate to $\pm$3.0 km inside the perimeter and range to $\pm$6.0 km at 30 km beyond the perimeter.

Figure 5 compares the epicenters of 30 events that were well recorded by both this network and by a temporary network operated by Langer and others (1976) in this area from February 9 through February 17, 1976. It shows that epicentral differences can range up to 5 km but average about 2 km.

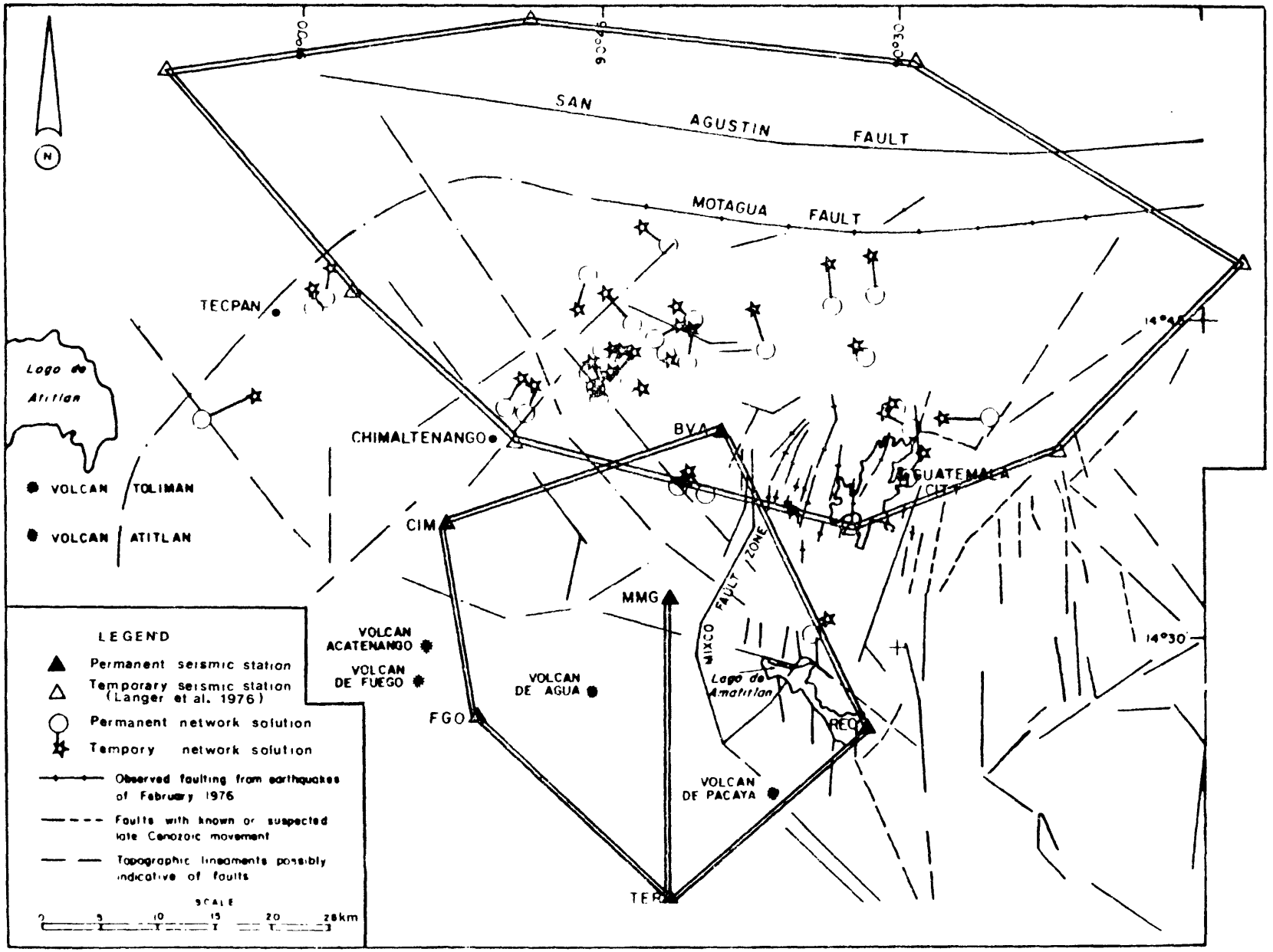

FIGURE 6. Comparison of epicentral locations. Solid double line connecting open triangles is the permanent network described in this report. Solid double line connecting solid triangles is a temporary network operated by Langer and others (1976). Circles are epicenters located from permanent network seismograms. Stars are epicenters located from the temporary network seismograms and are connected by solid line to the corresponding permanent network solution.

ACKNOWLEDGMENTS

We would like to express our gratitude to Ing. Claudio Urrutia E., Director of the Instituto Nacional de Sismologica, Vulcanologia, Meterologia e Hirdologia (INSIVUMEH), Guatemala. Ing. Urrutia has continually offered helpful advice and encouragement and has provided technical personnel the use of office space, and logistical support that has made this project successful. The late Mr. Jose Vasseaux's interest and help have been important to the project. Special appreciation is extended to Mr. Eddy Sanchez for his excellence in maintenance of the instruments. We are indebted to Charlie Langer for providing arrival-time data from the aftershock study he performed.

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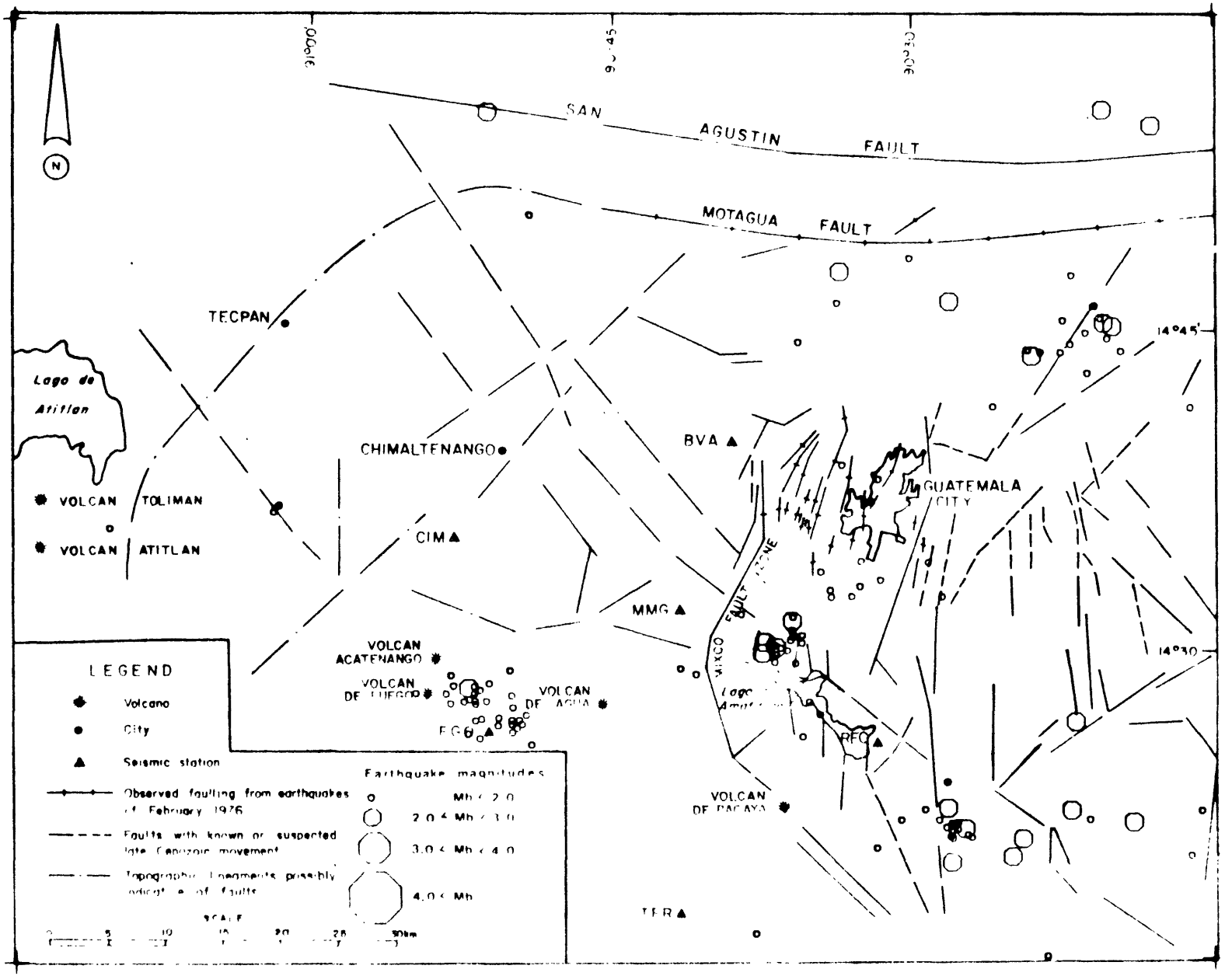

FIGURE 6. March 8, 1975 to February 3, 1976.

Appendix

The hypocentral parameters listed in this appendix are the following:

Abbreviation	Definition
HR	Hour of occurrence.
MN	Minute of occurrence. Coordinated Universal
SEC	Second of occurrence. Time
LAT N	North latitude of epicenter in degrees and minutes.
LONG W	West longitude of epicenter in degrees and minutes.
DEEP	Depth of hypocenter in kilometers.
MAG	Magnitude.
P	Number of P-arrivals used in locating the earthquake.
S	Number of S-arrivals used in locating the earthquake.
GAP	Maximum gap between stations contributing P-arrivals.
D3	Distance to the third closest station used in locating the earthquake.
RMS	Root mean square of the traveltime residuals, R_i in seconds.
ERH	The greatest horizontal deviation of the error ellipsoid from the hypocenter.
ERZ	The greatest vertical deviation of the error ellipsoid from the hypocenter.
Q	Quality of the solution based on the larger of the distances ERH and ERZ:

Quality	Largest Distance
A	2.5 km
B	5.0 km
C	10.0 km
D	10.0 km

1975	ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEEP KM	MAG	P	S	GAP DEG	D3 KM	RMS SEC	ERH KM	ERZ KM	Q
MAR 11	18	42	16.5	14	27.8	90	53.3	5.7	1.6	5	2	243	24	0.08	2.3	1.6	A
11	22	7	12.1	14	28.9	90	50.2	3.6	1.6	4	1	162	18	0.08	1.7	2.7	B
11	22	10	18.4	14	27.7	90	51.9	3.7	1.[illegible]	6	5	230	22	0.21	0.9	1.3	A
13	10	38	2.5	14	27.4	90	51.3	4.6	1.3	4	3	226	21	0.17	1.0	1.4	A
17	21	3	28.9	14	15.2	90	23.8	5.2	1.7	3	4	314	52	0.16	1.3	2.5	A
20	15	8	13.2	14	28.6	90	53.1	4.4	1.8	5	3	240	23	0.11	1.0	1.7	A
22	5	26	57.2	14	27.8	90	54.8	5.8	1.6	5	4	256	26	0.14	1.1	1.6	A
22	15	13	28.0	14	21.5	90	19.6	15.3	2.2	4	2	306	43	0.23	2.8	2.7	B
22	20	57	26.5	14	32.6	90	34.4	5.1	1.3	3	4	276	15	0.24	1.2	3.0	B
25	10	4	11.4	14	28.2	90	52.9	4.8	1.8	3	2	249	23	0.08	1.5	2.6	B
25	12	35	38.1	14	28.0	90	52.2	5.8	2.1	3	2	238	22	0.05	1.4	2.4	A
APR 5	6	57	35.5	14	44.5	90	20.8	7.5	1.1	5	4	314	43	0.14	1.1	3.3	B
5	10	35	47.6	14	41.2	90	16.7	11.4	1.3	3	4	323	64	0.14	2.8	5.5	C
5	19	31	34.8	14	14.3	90	24.4	4.4	1.7	5	4	311	45	0.20	1.5	2.6	B
16	11	47	6.8	14	27.4	90	52.4	4.2	1.3	5	2	236	23	0.15	2.3	1.5	A
16	12	58	6.0	14	27.5	90	52.2	4.5	1.3	5	2	233	22	0.16	2.3	1.5	A
19	19	24	29.4	14	32.3	90	28.9	6.1	1.9	5	3	251	22	0.16	1.1	2.2	A
20	5	0	47.6	14	43.8	90	33.1	7.3	0.5	4	3	289	33	0.09	1.2	2.0	A
23	22	16	39.1	14	44.3	90	22.6	1.0	1.6	5	2	311	40	0.20	2.3	7.9	C
24	8	53	20.8	14	27.4	90	51.9	6.4	1.4	5	2	231	22	0.11	1.0	1.4	A
24	9	39	28.7	14	27.3	90	51.9	7.1	1.4	5	3	231	22	0.09	0.9	1.4	A
26	5	12	45.2	14	28.1	90	51.9	4.9	1.0	5	3	230	21	0.11	1.0	1.5	A
26	6	29	10.9	14	28.2	90	51.2	4.8	1.4	5	3	203	20	0.11	0.9	1.5	A
26	10	16	8.2	14	25.7	90	35.8	1.0	1.1	5	3	132	17	0.10	1.1	7.8	C
27	18	21	36.4	14	27.9	90	51.7	4.7	1.2	5	4	226	21	0.17	0.9	1.4	A
27	20	52	30.5	14	19.9	90	16.7	9.5	1.5	5	4	312	49	0.14	1.2	2.3	A
29	4	4	59.9	14	27.3	90	53.1	5.3	1.1	4	3	281	27	0.10	1.3	1.5	A
29	12	1	5.0	14	42.9	90	21.8	1.2	1.5	4	2	310	40	0.07	3.1	9.0	C
MAY 1	2	52	42.3	14	32.3	90	33.4	7.3	1.4	4	3	194	17	0.18	0.8	1.9	A
1	6	21	55.6	14	32.8	90	32.4	8.3	0.3	4	3	209	17	0.09	0.9	1.5	A
1	15	27	20.2	14	33.1	90	32.0	9.0	1.5	4	5	217	17	0.14	0.8	1.3	A
1	15	51	38.5	14	32.8	90	33.0	5.9	1.1	4	3	202	16	0.12	1.4	2.8	B
4	5	12	28.9	14	45.8	90	33.4	6.6	0.9	3	3	347	36	0.19	1.6	1.6	A
4	9	3	35.6	14	28.0	90	32.5	11.5	0.6	4	4	211	24	0.26	1.0	1.1	A
5	6	19	27.3	14	44.0	90	24.7	0.8	1.3	4	4	307	36	0.16	1.6	4.4	B
9	10	47	31.2	14	31.4	90	37.2	3.9	0.9	5	4	139	16	0.10	0.5	2.4	A
9	20	27	16.6	14	44.6	90	21.5	0.0	1.5	5	3	313	41	0.24	2.2	5.3	C
10	10	7	2.9	14	27.1	90	50.0	0.4	1.2	4	3	175	23	0.11	1.4	4.2	B
12	0	17	15.3	14	43.9	90	23.1	5.7	1.4	3	2	309	38	0.21	2.5	17.4	D
23	21	48	0.7	14	36.4	91	1.7	11.0	1.4	5	3	309	38	0.18	1.4	1.9	A
23	22	36	8.1	14	36.7	91	1.5	0.5	1.2	4	3	309	38	0.12	2.1	3.5	B
24	6	56	59.5	14	31.4	90	36.3	5.6	1.4	6	3	149	16	0.14	0.8	2.2	A
24	6	59	54.5	14	30.9	90	35.5	7.9	0.8	6	4	156	17	0.27	0.8	1.9	A
24	7	52	12.5	14	31.5	90	38.8	8.5	1.1	6	5	122	17	0.20	0.5	0.8	A
24	7	55	16.0	14	32.2	90	39.8	7.8	0.6	4	3	231	22	0.18	0.8	0.7	A

1975	ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEEP KM	MAG	P	S	GAP DEG	D3 KM	RMS SEC	ERH KM	ERZ KM	Q
MAY 24	9	42	57.5	14	45.2	90	21.4	0.0	1.8	6	4	315	42	0.19	1.9	4.4	B
24	15	34	12.1	14	31.1	90	34.9	8.8	0.8	4	4	225	26	0.14	1.0	1.6	A
24	18	37	45.9	14	41.3	90	26.4	0.1	1.6	6	1	294	31	0.18	2.5	8.6	C
24	19	56	22.1	14	43.7	90	24.5	0.1	2.7	6	1	306	36	0.18	2.4	8.8	C
25	6	38	15.4	14	13.9	90	25.9	6.7	1.8	6	4	310	43	0.09	1.1	2.2	A
25	22	10	50.6	14	47.6	90	22.5	3.8	1.5	5	3	324	57	0.11	2.9	4.6	B
28	16	57	11.5	14	43.9	90	20.1	2.3	1.3	5	2	314	43	0.13	2.3	7.8	C
30	11	11	41.8	14	43.9	90	24.1	0.5	1.5	5	3	308	37	0.14	2.0	4.8	B
JUL 30	16	22	10.5	14	25.6	90	51.6	3.0	1.3	4	3	235	23	0.03	2.5	6.5	C
30	16	31	38.4	14	26.3	90	49.6	15.0	1.6	6	4	163	19	0.29	0.7	1.3	A
30	17	37	37.2	14	25.7	90	52.5	10.0	0.8	5	2	241	24	0.29	1.6	1.7	A
30	19	7	16.9	14	26.5	90	51.8	9.2	1.1	5	4	233	22	0.19	0.9	1.4	A
30	19	8	25.0	14	26.3	90	50.8	11.4	1.8	6	3	225	21	0.12	1.2	1.7	A
30	19	16	45.3	14	26.5	90	50.1	1.3	1.1	5	3	217	22	0.10	1.1	5.1	C
30	19	21	30.2	14	25.3	90	49.1	6.6	1.4	5	2	185	20	0.35	0.8	1.6	A
30	20	53	8.3	14	26.3	90	50.1	9.8	1.3	5	2	189	20	0.19	0.9	1.4	A
30	21	14	36.9	14	25.9	90	50.0	7.8	1.1	5	3	203	20	0.22	0.8	1.4	A
30	22	49	32.5	14	26.5	90	49.7	8.3	1.1	5	2	154	19	0.15	0.8	1.5	A
30	23	44	14.3	14	26.8	90	49.4	6.9	1.7	6	1	133	18	0.26	1.4	2.0	A
30	23	59	22.7	14	22.6	90	49.1	8.2	0.9	5	3	223	23	0.36	1.0	1.2	A
31	0	27	46.4	14	26.5	90	51.6	11.0	1.6	5	2	231	22	0.11	1.0	1.4	A
31	1	30	18.4	14	26.1	90	49.8	9.1	1.3	5	3	163	20	0.24	0.8	1.4	A
31	1	58	50.6	14	27.7	90	50.1	6.1	1.6	5	1	151	19	0.13	0.8	1.5	A
AUG 3	23	10	24.8	14	37.9	90	32.1	0.4	1.4	5	5	247	22	0.22	1.2	3.4	B
7	5	6	3.7	14	25.9	90	52.2	0.3	1.1	5	2	238	24	0.20	1.5	2.8	B
7	7	37	39.3	14	26.6	90	50.7	4.3	1.3	5	2	223	20	0.27	1.4	1.5	A
12	17	22	30.0	14	33.5	90	36.0	6.9	0.9	6	3	166	16	0.35	0.9	2.0	A
13	9	50	0.2	14	33.5	90	34.9	7.7	1.1	6	4	181	15	0.24	0.9	1.9	A
16	12	21	18.1	14	38.6	90	33.9	4.1	1.4	5	4	240	23	0.16	0.9	1.9	A
22	9	56	0.4	14	21.5	90	28.5	3.8	1.3	5	5	262	30	0.25	1.1	1.4	A
22	10	33	40.4	14	21.3	90	28.8	0.3	1.3	5	2	282	30	0.23	1.4	6.3	C
22	11	54	3.3	14	22.3	90	28.7	1.9	2.0	6	2	279	29	0.26	1.9	2.7	B
22	12	37	23.6	14	21.7	90	29.1	0.5	1.5	4	2	279	29	0.05	1.5	6.0	C
22	13	45	28.4	14	20.9	90	28.5	1.5	1.6	6	2	284	31	0.22	1.6	3.7	B
22	14	1	4.2	14	22.0	90	16.2	2.7	1.8	5	4	311	48	0.14	1.3	3.5	B
22	15	16	59.4	14	20.8	90	27.5	4.8	1.4	5	4	287	32	0.23	1.3	2.2	A
23	8	39	57.3	14	19.7	90	28.5	0.6	2.0	4	2	307	42	0.10	2.6	7.3	C
23	9	25	4.1	14	19.9	90	25.5	0.2	2.0	5	1	306	36	0.20	2.7	5.4	C
23	18	21	34.4	14	22.2	90	29.8	0.6	1.4	5	4	271	27	0.20	1.4	2.6	B
23	19	44	5.4	14	21.2	90	28.2	0.2	1.5	5	4	284	31	0.17	1.3	2.8	B
27	5	25	19.6	14	21.2	90	28.5	4.6	1.5	3	3	283	39	0.13	1.6	1.6	A
27	5	28	35.2	14	21.5	90	28.2	2.9	1.6	4	3	283	30	0.16	1.4	2.0	A
27	7	6	34.3	14	23.5	90	28.7	10.5	1.6	4	3	276	27	0.10	1.7	0.8	A
29	3	45	26.1	14	30.4	90	36.3	7.1	1.0	5	3	142	18	0.14	0.7	2.2	A
29	3	56	10.4	14	30.5	90	35.6	7.7	0.9	5	4	150	18	0.11	0.6	1.3	A

1975	ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEEP KM	MAG	P	S	GAP DEG	D3 KM	RMS SEC	ERH KM	ERZ KM	Q
AUG29	4	15	37.6	14	30.3	90	36.4	3.6	1.2	5	4	140	18	0.10	0.6	2.9	B
29	4	32	28.1	14	29.8	90	36.8	7.9	0.7	5	4	133	19	0.17	0.6	1.2	A
29	5	18	8.5	14	30.1	90	35.9	8.5	1.1	5	5	145	19	0.09	0.5	1.1	A
29	5	26	14.3	14	30.5	90	35.8	6.0	1.1	5	4	148	18	0.10	0.7	2.4	A
29	6	14	13.6	14	30.4	90	35.8	7.5	0.7	5	5	149	18	0.16	0.5	1.1	A
31	21	26	30.3	14	33.9	90	29.6	13.4	1.1	2	5	247	20	0.15	1.0	1.3	A
SEP 1	3	37	28.8	14	34.0	90	32.9	6.0	1.5	6	3	209	15	0.23	1.3	2.9	B
5	3	19	54.2	14	21.3	90	27.8	0.2	2.2	5	1	285	39	0.16	3.5	4.1	B
5	3	45	31.7	14	20.4	90	32.2	0.7	1.6	3	3	307	35	0.16	2.0	6.8	C
5	16	43	21.6	14	55.4	90	21.0	1.0	2.2	6	2	323	57	0.18	3.4	6.3	C
6	7	10	20.8	14	20.9	90	28.9	0.0	1.3	4	2	282	30	0.29	4.4	9.5	C
10	9	20	16.7	14	47.8	90	33.9	3.5	2.3	6	4	296	39	0.26	1.6	2.5	B
11	5	55	23.2	14	45.4	90	23.0	0.1	1.5	5	4	313	40	0.24	1.9	4.3	B
13	22	44	11.6	14	48.4	90	30.5	4.9	1.7	6	4	304	41	0.17	1.2	2.2	A
14	23	13	52.7	14	30.7	90	36.3	5.0	1.1	5	2	144	17	0.21	0.8	1.6	A
14	23	15	23.4	14	29.8	90	36.6	2.4	1.4	6	3	134	19	0.07	0.7	3.8	B
14	23	15	46.9	14	29.9	90	37.1	4.8	2.0	6	1	129	19	0.12	0.8	2.6	B
15	2	0	27.6	14	29.2	90	36.2	6.5	1.3	6	5	132	20	0.25	0.5	1.2	A
OCT 3	23	16	28.0	15	6.5	89	50.3	3.2	3.3	5	0	343	124	0.05	38.6	92.0	D
5	6	59	21.2	14	50.5	90	49.2	12.1	1.4	5	5	306	37	0.17	1.1	1.8	A
15	6	52	1.3	14	54.7	90	18.6	4.6	2.5	5	5	332	69	0.23	3.1	4.0	B
15	18	25	31.0	15	1.1	90	36.2	0.8	1.8	5	2	335	54	0.11	3.8	4.7	B
19	14	53	56.1	14	22.1	90	22.6	0.7	2.5	6	2	298	38	0.10	2.2	3.6	B
19	15	29	47.0	14	21.7	90	21.7	1.4	1.5	5	4	301	40	0.23	1.0	3.0	B
20	0	14	53.0	14	28.7	90	41.1	6.2	1.2	3	3	177	18	0.03	0.6	1.4	A
20	22	28	29.8	14	32.3	90	34.4	3.1	1.4	6	4	180	16	0.21	1.1	3.3	B
20	22	29	36.3	14	32.6	90	34.7	2.9	0.8	4	3	178	15	0.17	1.0	4.0	B
23	1	47	24.6	14	20.8	90	28.4	1.8	1.6	5	3	285	31	0.20	1.2	2.9	B
23	8	52	4.8	14	44.8	90	21.8	0.9	1.4	6	4	313	41	0.17	1.8	4.1	B
24	18	39	22.9	14	28.9	90	41.8	1.8	1.3	6	4	87	19	0.09	0.4	3.0	B
25	1	51	46.1	14	21.0	90	27.7	1.2	1.7	5	2	280	32	0.12	1.4	5.3	C
25	2	0	14.4	14	21.7	90	31.0	0.8	1.6	4	2	255	36	0.23	2.1	4.9	B
26	5	4	36.8	14	45.1	90	20.5	1.4	2.1	6	4	316	44	0.16	1.8	4.2	B
26	5	4	40.4	14	44.4	90	36.0	0.9	1.6	5	4	286	35	0.18	1.3	3.8	B
29	3	48	17.2	14	20.8	90	25.0	0.1	2.4	6	3	295	36	0.09	1.8	3.6	B
NOV 5	5	54	18.0	14	55.5	90	51.2	18.5	2.2	5	4	325	53	0.17	2.1	3.0	B
13	20	36	14.1	14	45.3	90	21.0	0.6	2.4	5	2	316	58	0.16	2.6	6.5	C
17	3	43	14.3	14	35.7	91	9.8	5.7	1.9	5	3	328	52	0.17	2.1	3.8	B
17	23	1	23.5	15	10.1	90	42.1	3.1	2.3	3	2	344	81	0.23	40.6	66.9	D
20	5	18	37.0	15	48.2	91	0.9	14.8	2.7	4	1	348	151	0.16	58.6	80.0	D
24	8	21	44.2	14	29.6	90	37.8	2.5	2.0	5	2	167	22	0.12	1.0	3.4	B
24	9	22	53.4	14	29.2	90	37.2	4.2	1.1	4	4	167	21	0.13	0.8	1.9	A
24	12	19	8.5	14	30.0	90	37.2	7.9	1.4	5	4	181	23	0.10	0.7	1.2	A
24	20	26	28.2	14	29.5	90	37.1	5.6	1.5	5	3	174	22	0.13	0.9	2.6	B
25	6	43	47.0	14	30.2	90	37.7	5.7	2.2	5	2	178	23	0.09	1.0	2.3	A

1975	ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEEP KM	MAG	P	S	GAP DEG	D3 KM	RMS SEC	ERH KM	ERZ KM	Q
NOV 25	11	16	16.0	14	31.2	90	36.3	7.1	2.0	5	2	209	25	0.09	1.1	2.3	A
27	9	16	14.1	14	15.6	90	37.6	0.2	0.9	4	3	278	31	0.10	1.5	5.1	C
DEC 5	19	50	59.3	14	27.3	90	35.5	0.1	1.2	4	2	152	19	0.22	1.3	9.3	C
7	11	35	6.2	14	16.3	90	38.1	8.6	1.1	4	4	271	29	0.05	1.2	0.9	A
8	9	3	2.8	14	26.7	90	35.0	4.6	1.7	5	3	144	19	0.27	0.8	2.5	B
JAN 1	5	52	20.1	14	46.3	90	34.1	7.4	1.7	6	4	294	37	0.22	1.4	1.9	A
2	5	23	42.0	15	4.8	90	42.8	2.6	1.8	6	5	327	60	0.13	2.7	4.1	B
11	3	28	19.2	14	26.3	90	22.4	5.8	2.6	6	0	295	37	0.11	9.8	7.1	C
14	22	41	45.0	14	46.4	90	28.5	1.7	2.0	5	1	319	37	0.12	4.3	9.4	C
15	4	39	34.2	15	4.3	91	6.9	1.3	2.2	5	0	341	75	0.14	12.8	78.3	D
15	22	51	11.4	14	13.0	90	23.9	5.0	1.5	3	3	316	54	0.07	1.4	3.9	B
16	7	41	5.1	14	14.6	90	24.8	3.6	1.6	5	4	310	51	0.27	1.1	2.7	B
17	16	23	54.8	14	8.2	90	28.2	0.0	1.9	5	4	318	50	0.22	2.0	3.6	B
22	23	20	33.0	14	36.8	90	32.4	6.1	1.5	5	5	235	20	0.09	0.9	1.6	A
27	13	2	21.0	14	29.9	90	36.9	5.5	1.7	6	4	131	19	0.09	0.6	1.3	A
FEB 3	4	54	23.1	14	46.1	90	21.4	2.6	1.8	6	3	316	43	0.18	1.8	4.6	B
3	6	9	56.9	14	45.5	90	21.1	2.2	1.6	5	3	316	43	0.04	2.1	4.8	B