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Analysis of some Events from an Earthquake Swarm Occurring during April and May 1989 at Loma de las Cañas in the Central Rio Grande Rift

By

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Acknowledgements

I would like to thank Dr. Allan Sanford for his patience, flexibility and numerous critical reviews I required to complete this study.

Table of Contents

Introduction

The Study

At the end of April 1986, New Mexico Tech's seismic network detected a microearthquake swarm occurring approximately 15 km SE of the city of Socorro in an area known as Loma de las Canas. Swarms of microearthquakes in the Socorro area of the Rio Grande rift are not unusual (Sanford et al. [1979]). On April 28 at 12:59 GMT, an earthquake measuring 2.57 M_d occurred in the swarm area indicating that this was a significant swarm. Portable seismographs were deployed in the swarm area for about four days; three recording on helicoders and one recording digitally. This study uses only data acquired while the portable stations were in operation.

In this study, I developed station corrections for the portable stations for use in the location program HYPO71(Rev). At the same time, adjustments were made to established station corrections to account for effects of spatial variations in crustal velocity at the site of the swarm. The customizing of station corrections was done with only events having well constrained locations.

Earlier studies of swarm events in the Socorro area have noted waveforms of extremely similar character with correlation coefficients exceeding 81 percent. I made comparisons of waveforms and their spectra from the digital station data using both the eye and the computer. By eye, it appeared that events could be placed into groups but correlation coefficients and characteristics of the spectra indicated that this was illusionary. First motion data were composited to obtain well constrained fault plane solutions, which indicated dominately strike-slip motion.

The Setting

In central New Mexico, the Rio Grande rift is a major physiographic feature. It separates the Great Plains from the Colorado Plateau in the north and the Basin and Range Province in the south. At Socorro, the Rio Grande rift changes from the singular basins of the northern and middle reaches to multiple basins that eventually merge to the south with the Basin and Range Province in an ill understood manner. Details of the geologic, tectonic and geophysical characteristics can be found in numerous papers but good summaries appear in *Rio Grande Rift: Tectonics and Magmatism* edited by R.E. Riecker [1979].

Data

Recording

Figure 1 shows the geographic location of the seismometer stations used in this project. Events were recorded in three manners:

1) On helicoders of the NMT Seismic Network operating at 1 mm/sec; stations: LAZ BAR LPM SB CAR SMC WTX MAG LJY LEM

2) With portable Geotech Portacorders at 2 mm/sec; stations: LC1 LC2 LC3 LC4

3) With a portable Sprengnether DR100A seismograph recording digitally at a rate of 100 samples/sec; station: LC5

The NMT Seismic Network is permanent and in operation continuously 24 hours per day. The portable seismometers were in operation from approximately 21:00 4/29/86 until 22:00 5/1/86. The digital station, LC5, was in operation from 00:07 4/30/89 until 20:01 5/01/86. Station LC4 was in operation only from 21:00 4/30/86 until 20:40 5/1/86 and was not used in the analysis of any events.

Timing

Small clock drifts (less than 11 msec) of the permanent network were corrected once daily with respect to WWV. The clocks for the Geotech Portacorders were set to WWV when recording started and drift with respect to WWV checked at the end of each record. A clock correction based on linear interpolation of the drift was applied. Absolute timing of the digitally recorded events was uncertain. The header and trailer time values were duplicated on some of the records in the transfer from field cassettes to mainframe memory. To prevent errors, arrival times from station LC5 were not used in locating the events.

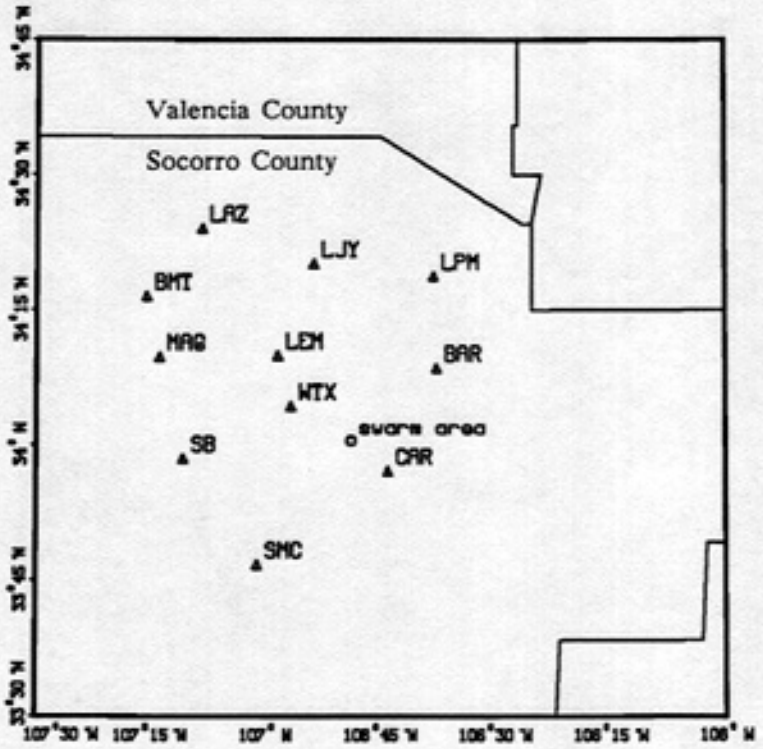

Figure 1. NM Tech permanent network station locations.

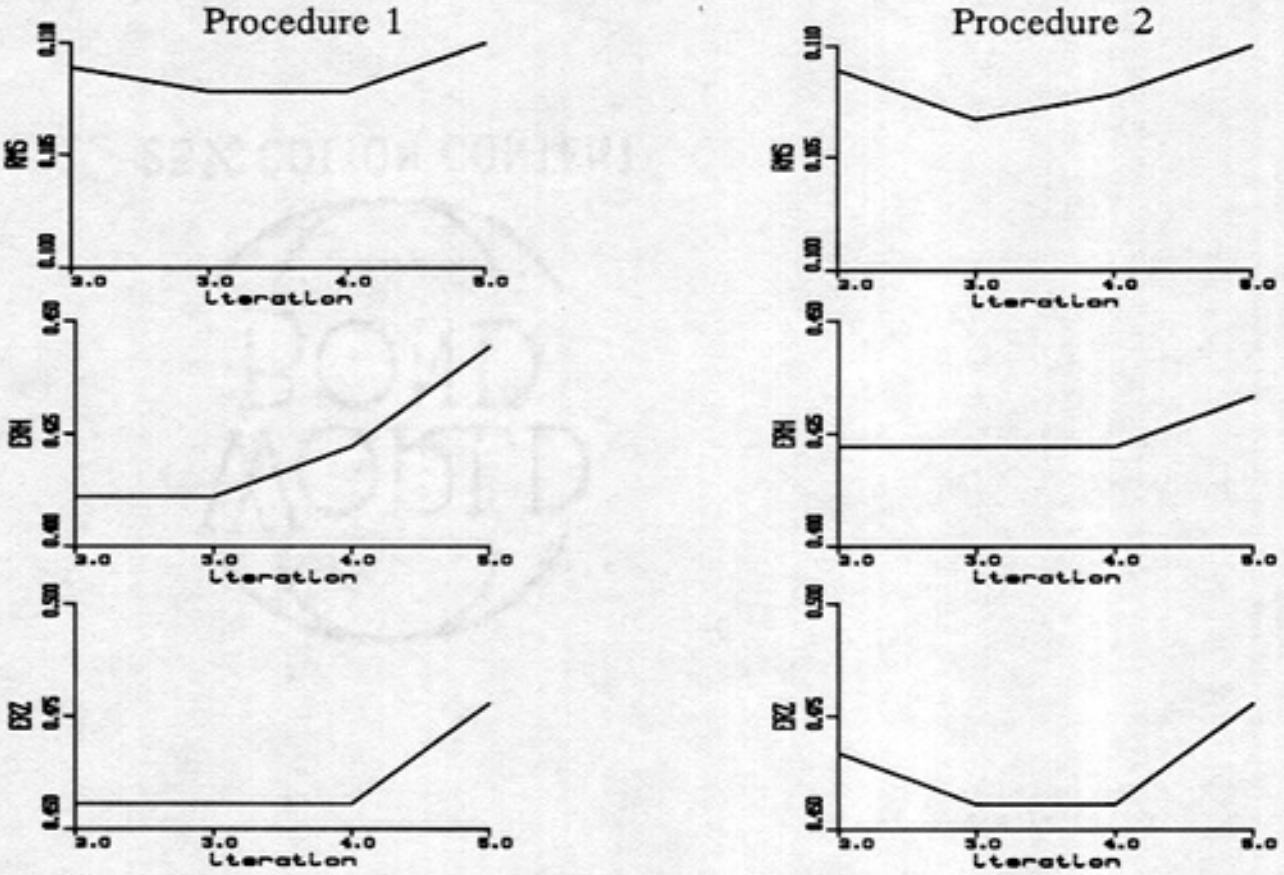

Figure 2. Comparison of station delay developments. The first iteration was not included due to the large drop from initial values compared to subsequent changes.

Location of Earthquakes

The swarm consisted mostly of very small (magnitude < -0.5) earthquakes. Of the 61 events observed from 00:07 4/30/86 to 20:01 5/01/86, only 14 were clearly recorded on both permanent and portable stations. The standard location program HYPO71(Revised 11/25/73) was used to determine the spatial position of these 14 quakes. A crustal model consisting of a single half-space with a velocity of 5.85 km/sec was selected because previous studies have indicated this model produces the best locations for microearthquakes inside the rift in the vicinity of the permanent station network (Sanford; personal communication). The parameter settings for HYPO71(Rev) are listed in Table 1.

Table 1. HYPO71(Rev) Test Settings

TEST(1)	0.10	TEST(8)	2.79
TEST(2)	10.00	TEST(9)	0.00
TEST(3)	2.00	TEST(10)	100.00
TEST(4)	0.05	TEST(11)	8.00
TEST(5)	6.00	TEST(12)	0.50
TEST(6)	4.00	TEST(13)	0.30
TEST(7)	-3.63		

Station Delay Development

To establish station corrections for the swarm site, HYPO71(Rev) was run on all 14 locatable events with station delays set to standard values for stations of the NMT network and 0.0 sec for the portable stations (Procedure 1). This initial run was used to determine the best constrained of the 14 event locations. It yielded seven "A" and two "B" solutions to use in tailoring the station delays. The average station residuals of the 14 event initial iteration were added to the station delays (corrections). The nine best events were used in the second and subsequent iterations. After each iteration, the average of the station residuals were added to the station delays before the next iteration.

The second procedure was to initially set all station delays of the nine best events to 0.0 sec. and iterate as before. The "best fit" station correction values were chosen by looking at how size and rate of change of average station residuals diminished as well as by where location RMS values and location errors went to a minimum. The RMS of a location is defined by:

$$RMS = \sqrt{\frac{\sum R_i^2}{\#\,of\,stations}}$$

where

R_i = *time residual for the* i^{th} *station*

This RMS number includes residuals of S readings. The location errors in HYPO71(Rev) are not standard deviations. They are considered a crude estimate of hypocenter errors (personal communication from L. C. Lahr via Allan Sanford).

The station corrections obtained from the two procedures did not converge to one set of values. Both started with relatively large jumps on the first iteration to a certain set of values and then drifted by small amounts with each subsequent iteration. The best choice was expected to be one or two iterations after known "good" values of station corrections were used as the starting point (Procedure 1). However, for Procedure 1, the average absolute value of the average of the stations residuals went through a minimum and then started increasing, indicating an unstable situation. The second procedure started with large residuals in the first iteration but the second iteration had small residuals which continued reducing slowly (Table 2). The station corrections produced at the end of the third iteration in the second procedure were selected for use in final locations of the swarm events. As can be seen in Figure 2, the average RMS is at a minimum as are the depth and epicentral errors by the third iteration. Table 3 lists the initial values of depth error, epicentral error and RMS values for the individual event location and their changes with each iteration.

The resulting locations of each of the nine events used in this development can be seen in Figure 3. The entire 14 event group plus the largest event *(1259)* of the swarm (magnitude 2.6) is shown in Figure 4 and listed in Table 4. The average epicentral error was ±0.51 [km]. The average depth was 10.3 [km] with anaverage error of ±0.56 [km]. All the located events had epicenters within a square 2.5 km on a side. The HYPO71(Rev) solution sheets are included in Appendix A.

Swarm Events and Portable Station Locations

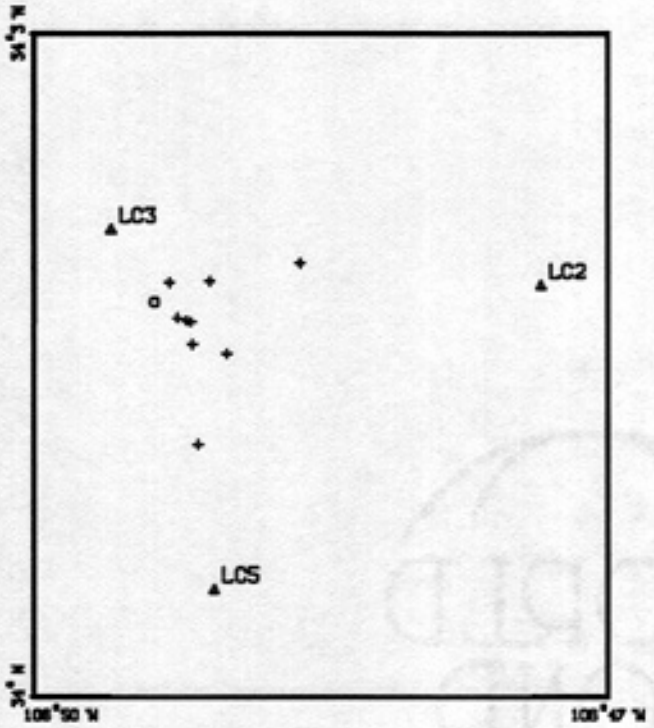

Figure 3. Locations of the nine events used in the station delay development. The circle is the location of the largest event in the swarm (not used in delay development).

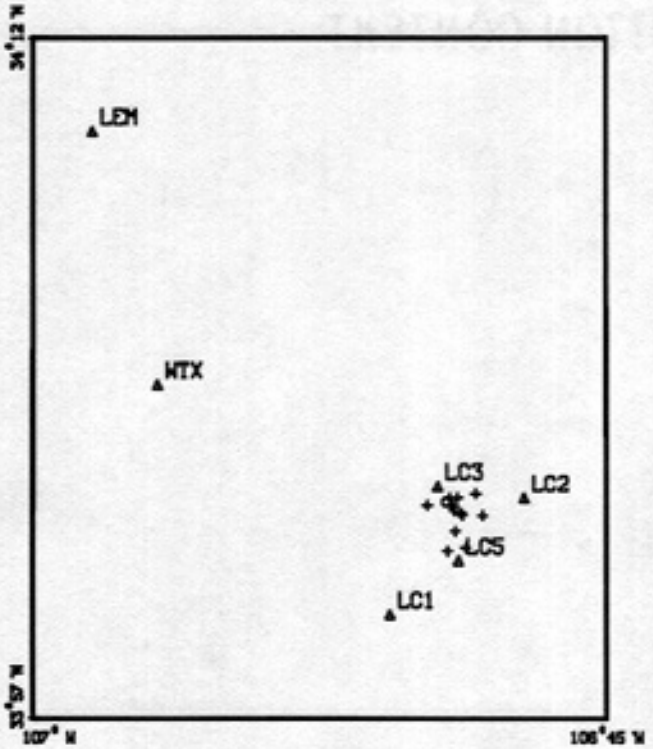

Figure 4. Locations of the 14 swarm events recorded by both portable and permanent stations. The circle is the epicenter of the largest earthquake in the swarm.

Table 2: Station Delays Developed from Residuals of Location Runs

Station Delay Development

Procedure 1: Start with network station corrections = known "good" values

Station	Iteration #1	#2	#3	#4	#5	residuals from #5
LAZ	0.04	0.04	0.09	0.14	0.20	0.06
BAR	-0.03	0.13	0.19	0.23	0.27	0.05
LPM	-0.23	-0.21	-0.18	-0.12	-0.06	0.07
SB	0.22	0.38	0.41	0.44	0.46	0.02
CAR	0.03	0.03	0.00	-0.02	-0.04	-0.02
SMC	0.11	0.06	0.08	0.09	0.10	0.00
WTX	-0.08	0.04	0.03	0.02	0.01	0.00
MAG	0.08	0.02	0.05	0.09	0.13	0.04
LJY	0.56	0.75	0.81	0.86	0.92	0.08
LEM	0.06	0.04	0.06	0.08	0.10	0.04
LC1	0.00	-0.02	-0.08	-0.15	-0.20	-0.05
LC2	0.00	-0.31	-0.40	-0.45	-0.49	-0.04
LC3	0.00	-0.01	-0.10	-0.18	-0.23	-0.05
			averaged residual values			
	0.086	0.044	0.041	0.037	0.040	

Procedure 2: Start with all corrections = 0.0

Station	Iteration #1	#2	#3	#4	#5	residuals from #5
LAZ	0.00	0.04	0.09	0.15	0.20	0.04
BAR	0.00	0.29	0.32	0.35	0.39	0.04
LPM	0.00	-0.10	-0.06	0.00	0.06	0.06
SB	0.00	0.23	0.28	0.31	0.33	0.03
CAR	0.00	0.01	0.00	-0.02	-0.04	-0.01
SMC	0.00	-0.09	-0.06	-0.05	-0.04	0.02
WTX	0.00	-0.02	-0.03	-0.04	-0.04	-0.01
MAG	0.00	-0.06	-0.02	0.01	0.05	0.03
LJY	0.00	0.80	0.86	0.91	0.97	0.05
LEM	0.00	0.03	0.04	0.06	0.09	0.02
LC1	0.00	-0.08	-0.15	-0.21	-0.26	-0.04
LC2	0.00	-0.28	-0.36	-0.42	-0.46	-0.04
LC3	0.00	-0.01	-0.10	-0.18	-0.23	-0.05
			averaged residual values			
	0.157	0.044	0.040	0.036	0.033	

Table 3a. Station Delay Development - Procedure 1

			Iteration			
	#1		#2	#3	#4	#5
Location 1						
RMS	0.16	Δ RMS	-0.01	0.0	+0.01	0.0
ERH	0.6	Δ ERH	0.0	0.0	0.0	0.0
ERZ	0.7	Δ ERZ	0.0	0.0	0.0	0.0
Location 2						
RMS	0.18	Δ RMS	-0.09	0.0	+0.01	+0.01
ERH	0.9	Δ ERH	-0.4	0.0	+0.10	0.0
ERZ	0.9	Δ ERZ	-0.4	0.0	0.0	+0.10
Location 3						
RMS	0.13	Δ RMS	-0.04	-0.01	0.0	+0.01
ERH	0.4	Δ ERH	-0.1	0.0	0.0	0.0
ERZ	0.5	Δ ERZ	-0.2	0.0	0.0	+0.10
Location 4						
RMS	0.15	Δ RMS	-0.05	-0.01	-0.01	0.0
ERH	0.5	Δ ERH	-0.1	-0.10	0.0	0.0
ERZ	0.6	Δ ERZ	-0.2	0.0	0.0	0.0
Location 5						
RMS	0.14	Δ RMS	-0.05	+0.01	0.0	0.0
ERH	0.6	Δ ERH	-0.2	+0.10	0.0	0.0
ERZ	0.6	Δ ERZ	-0.2	0.0	0.0	0.0
Location 6						
RMS	0.18	Δ RMS	-0.04	-0.01	0.0	0.0
ERH	0.5	Δ ERH	-0.1	0.0	0.0	+0.10
ERZ	0.6	Δ ERZ	-0.1	0.0	0.0	0.0
Location 7						
RMS	0.12	Δ RMS	-0.04	+0.01	0.0	0.0
ERH	0.4	Δ ERH	-0.1	0.0	0.0	0.0
ERZ	0.5	Δ ERZ	-0.2	0.0	0.0	0.0
Location 8						
RMS	0.14	Δ RMS	-0.05	0.0	-0.01	0.0
ERH	0.5	Δ ERH	-0.2	0.0	0.0	0.0
ERZ	0.5	Δ ERZ	-0.2	0.0	0.0	0.0
Location 9						
RMS	0.20	Δ RMS	-0.05	0.0	0.0	0.0
ERH	0.7	Δ ERH	-0.2	0.0	0.0	+0.10
ERZ	1.0	Δ ERZ	-0.3	0.0	0.0	0.0

Table 3b. Station Delay Development - Procedure 2

			Iteration			
	#1		#2	#3	#4	#5
Location 1						
RMS	0.18	Δ RMS	-0.03	0.0	0.0	0.0
ERH	0.7	Δ ERH	-0.1	0.0	0.0	0.0
ERZ	0.8	Δ ERZ	-0.1	0.0	0.0	0.0
Location 2						
RMS	0.20	Δ RMS	-0.11	0.0	+0.01	0.0
ERH	1.0	Δ ERH	-0.5	0.0	+0.10	0.0
ERZ	1.1	Δ ERZ	-0.6	0.0	0.0	+0.10
Location 3						
RMS	0.19	Δ RMS	-0.11	0.0	0.0	+0.01
ERH	0.6	Δ ERH	-0.3	0.0	0.0	0.0
ERZ	0.7	Δ ERZ	-0.4	0.0	0.0	+0.10
Location 4						
RMS	0.18	Δ RMS	-0.08	-0.01	-0.01	+0.01
ERH	0.7	Δ ERH	-0.3	+0.10	+0.20	0.0
ERZ	0.8	Δ ERZ	-0.4	0.0	0.0	0.0
Location 5						
RMS	0.17	Δ RMS	-0.08	0.0	0.0	+0.01
ERH	0.8	Δ ERH	-0.4	0.0	+0.10	0.0
ERZ	0.7	Δ ERZ	-0.3	0.0	0.0	0.0
Location 6						
RMS	0.22	Δ RMS	-0.08	-0.01	0.0	0.0
ERH	0.6	Δ ERH	-0.2	0.0	0.0	0.0
ERZ	0.8	Δ ERZ	-0.3	0.0	0.0	0.0
Location 7						
RMS	0.14	Δ RMS	-0.05	0.0	0.0	0.0
ERH	0.4	Δ ERH	-0.1	0.0	0.0	0.0
ERZ	0.5	Δ ERZ	-0.2	0.0	0.0	0.0
Location 8						
RMS	0.18	Δ RMS	-0.08	-0.01	+0.01	-0.01
ERH	0.6	Δ ERH	-0.2	-0.10	0.0	0.0
ERZ	0.7	Δ ERZ	-0.3	-0.10	0.0	0.0
Location 9						
RMS	0.21	Δ RMS	-0.07	+0.01	0.0	0.0
ERH	0.7	Δ ERH	-0.2	0.0	0.0	+0.10
ERZ	1.0	Δ ERZ	-0.3	0.0	0.0	0.0

Table 4. Final Location of Swarm Events

Origin Time		Event ID	Lat N	Long W	Epicentral Error[km]	Depth[km]	Quality
04/28/86	12:50:49.22	*1259*‡	34-01.78	106-49.17	±0.6	9.51 ±1.6	B A/B
04/30/86	00:11:25.47	*0011*	34-00.70	106-49.14	±0.5	12.27 ±0.4	C A/D
	01:28:28.99	*0128*	34-01.14	106-48.94	±0.6	12.79 ±0.7	B B/A
	04:07:44.20	*0407*	34-01.87	106-49.09	±0.3	9.73 ±0.3	A A/A
	05:39:52.61	*0539*	34-01.70	106-49.00	±0.3	10.27 ±0.4	A A/A
	06:41:48.64	*0641*	34-01.59	106-48.97	±0.4	10.62 ±0.4	A A/A
	13:10:25.38	*1310*	34-01.71	106-49.67	±0.9	11.29 ±0.9	B B/B
	16:12:18.65	*1612*	34-01.96	106-48.41	±0.4	10.14 ±0.5	A A/A
	16:15:27.74	*1615*	34-01.88	106-48.88	±0.3	8.14 ±0.3	A A/A
	18:06:53.62	*1806*	34-01.55	106-48.79	±0.5	11.68 ±0.5	B A/B
05/01/86	03:53:29.04	*0353*	34-01.49	106-48.75	±0.5	11.06 ±0.6	B A/C
	09:32:07.38	*0932*	34-01.71	106-49.05	±0.3	7.85 ±0.3	A A/A
	11:43:36.64	*1143*	34-01.48	106-48.23	±0.8	11.45 ±1.0	B A/C
	16:28:32.92	*1628*	34-01.69	106-48.98	±0.5	7.00 ±0.7	A A/A
	19:06:59.18	*1906*	34-00.77	106-48.67	±0.9	10.27 ±0.8	C A/D

‡ Main Event

Processing of Digital Data

Digital station LC5 recorded 61 events of the swarm. Data from LC5 had timing marks every two seconds that consisted of a single data sample point of the value 2048. These were removed and replaced by the average value of the preceding and following data point. The maximum value for a saturated signal is 2047. The records of swarm earthquakes obtained by station LC5 were normalized such that the largest value in the S-phase equalled 1.0 . This was accomplished by simply dividing each data point by the maximum value of the S-phase. The files were next reformatted for use with the Seismic Analysis Code (SAC) software. SAC is a program developed at Lawrence Livermore National Laboratory by Joseph E. Tull for analysis, manipulation and plotting of digitally recorded seismic events on a SUN Microsystem workstation. The digital records were plotted via an internal SAC plotting routine.

Correlations

Seismograms for all digitally recorded swarm events were examined and separated by eye into 12 groups believing to have similar waveforms. Shape and zero crossings received the largest weighting and total amplitude the least. Allowances were made for different S-P intervals by com-

paring the P-phases, shifting along the time axis, and then comparing the S-phases. Five of the groups had one or more of the 14 located events in Figure 4 within them. Cross correlations were run to determine quantitatively how well the events were grouped by eye. SAC does not produce a normalized cross-correlation function automatically. To normalize, autocorrelations of each event were first run to determine the energy level at zero offset. These values were then used to compute a normalizing factor for the cross-correlation functions $\phi_{xy}(t)$ that the SAC software provided.

$$\phi_{xy}(t)_{normalized} = \frac{\phi_{xy}(t)}{\sqrt{\phi_{xx}(0)\phi_{yy}(0)}}$$

The first 8.0 sec of the events were used for calculation of the whole event correlation coefficient. For the P-phase correlations, only the first 0.5 sec were used. The beginning of a 1.0 sec window for the S-phase was selected by using the computed S-P interval from the HYPO71 locations minus 0.1 sec (Table 5). The windowed waveforms can be seen in Figures 5-16.

In a study by Ake and Sanford [1988] of earthquakes observed in a swarm located approximately 25 km to the west, the correlation coefficients of full waveforms as well as P and S phases were found to be consistantly high (avg. 0.81). In another study by Ake [1984] of a group of events directly under Socorro Mountain (a 3 km relief upthrust horst block), he discerned a high correlation among the P-phases and markedly lower correlations for the S-phases.

For the Loma de las Canas swarm, I found generally that the correlation coefficients were low, only a few moderately good matches were found (Table 5). One unusual result was that some S-phases have higher coefficients than their corresponding P-phases. The unexpectedly low values for the whole event coefficients prompted the use of a second correlation program. This program using computational subroutines developed by Dr. John Knapp at NMT confirmed the results of the SAC software. This program is listed in Appendix C.

Table 5. Cross Correlation Coefficients for Group Earthquakes

Group	Event	P-phase interval	S-phase interval	8.0 sec interval	Magnitude (duration)
G	*0407*	1.0	1.0	1.0	0.18
	0011	.85	.50	.65	-0.42
	0932	.74	.65	.70	-0.29
	1628	.63	.50	.50	0.64
K	*1906*	1.0	1.0	1.0	-0.28
	1615	.45	.35	.25	0.28
	1506	.67	.40	.30	-0.31
	0959	.62	.65	.50	-0.49
J	*0128*	1.0	1.0	1.0	-0.11
	1612	.56	.50	.65	0.49
	1143	.57	.75	.80	-0.46
I	*0589*	1.0	1.0	1.0	0.11
	1810	.68	.75	.65	-0.12

Note: *The first event in each group is the master the others are correlated against. The magnitude is calculated by HYPO71(Rev).*

Ground Amplitude Spectra

A Fast Fourier transform was used to determine ground velocity amplitude spectra for the grouped events. Spectra were calculated for the whole event (8.0 sec), the P-phase (0.5 sec) and the S-phase (1.0 sec). Figures 5-16 presents results for each group. The whole event spectra do not display any special characteristics by group. For the whole event, most of the energy lies between 10 and 17 Hz with a sharp drop between 18 and 20 Hz. This is followed on most events by a minor energy peak centered between 20 and 25 Hz. The P-phase has a distribution similar to the whole event and has no group correlating characteristics. The main energy is more concentrated around 15 Hz than for the whole waveform. Also minor peaks can be seen on some events at 8-9 Hz, 20-25 Hz and 30-33 Hz. The S-phase has the most diversity of character between events but again nothing to distinguish the different correlated groups. A common characteristic of the S-phase is a sharp drop in energy just below 20 Hz.

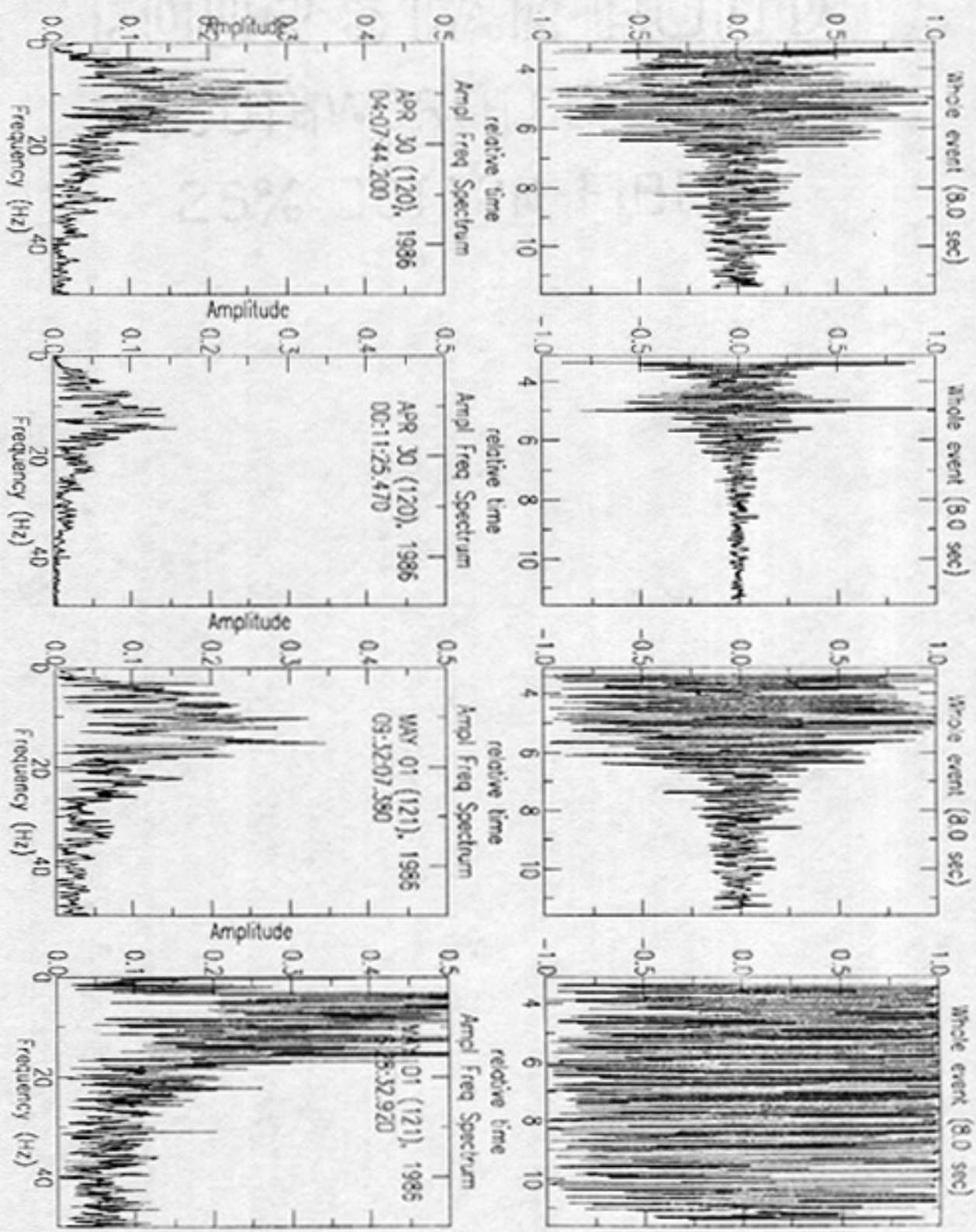

Figure 5. Ground velocity amplitude spectra and waveforms of the first 8.0 sec of the events in group G.

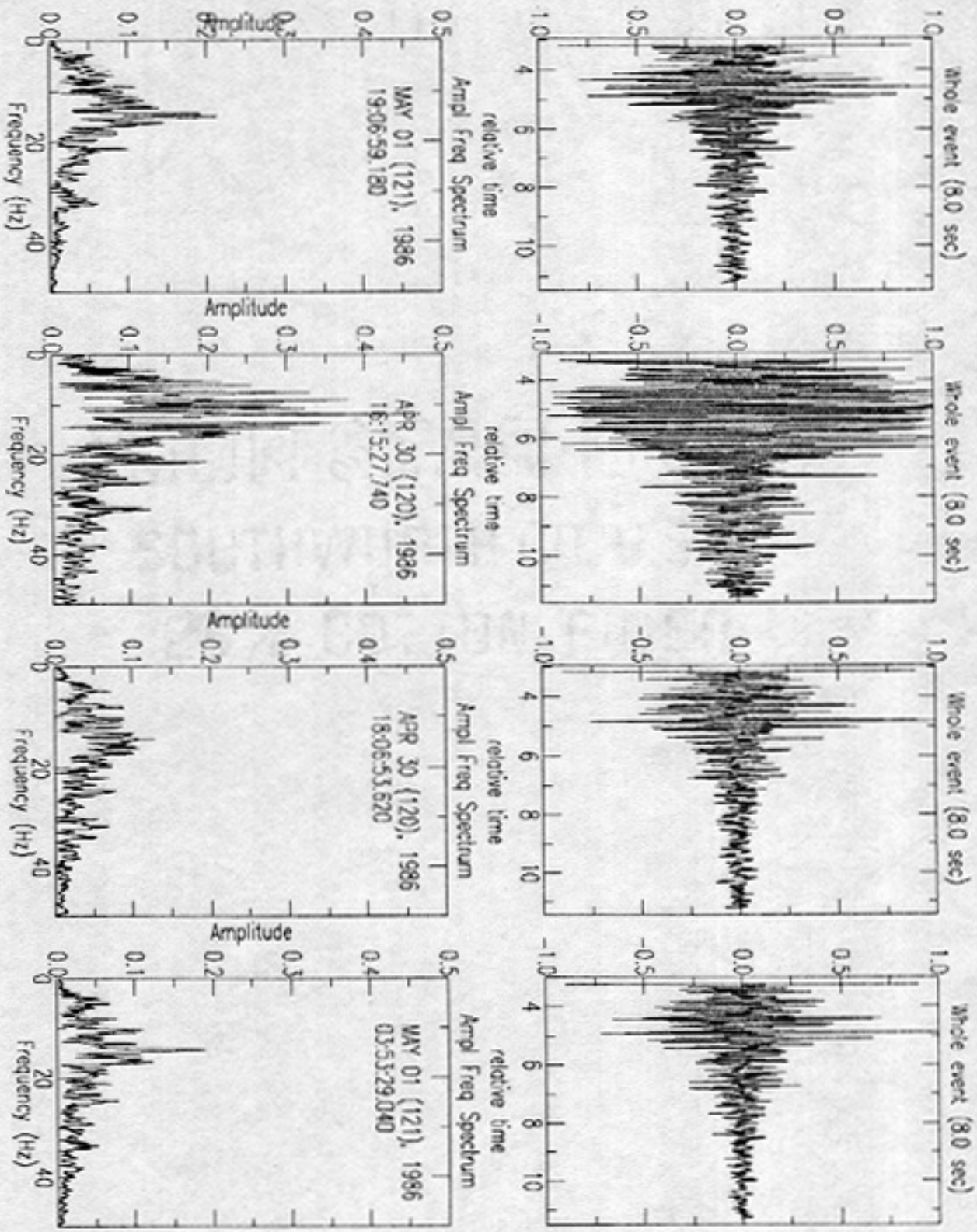

Figure 6. Ground velocity amplitude spectra and waveforms of the first 8.0 sec of the events in group K.

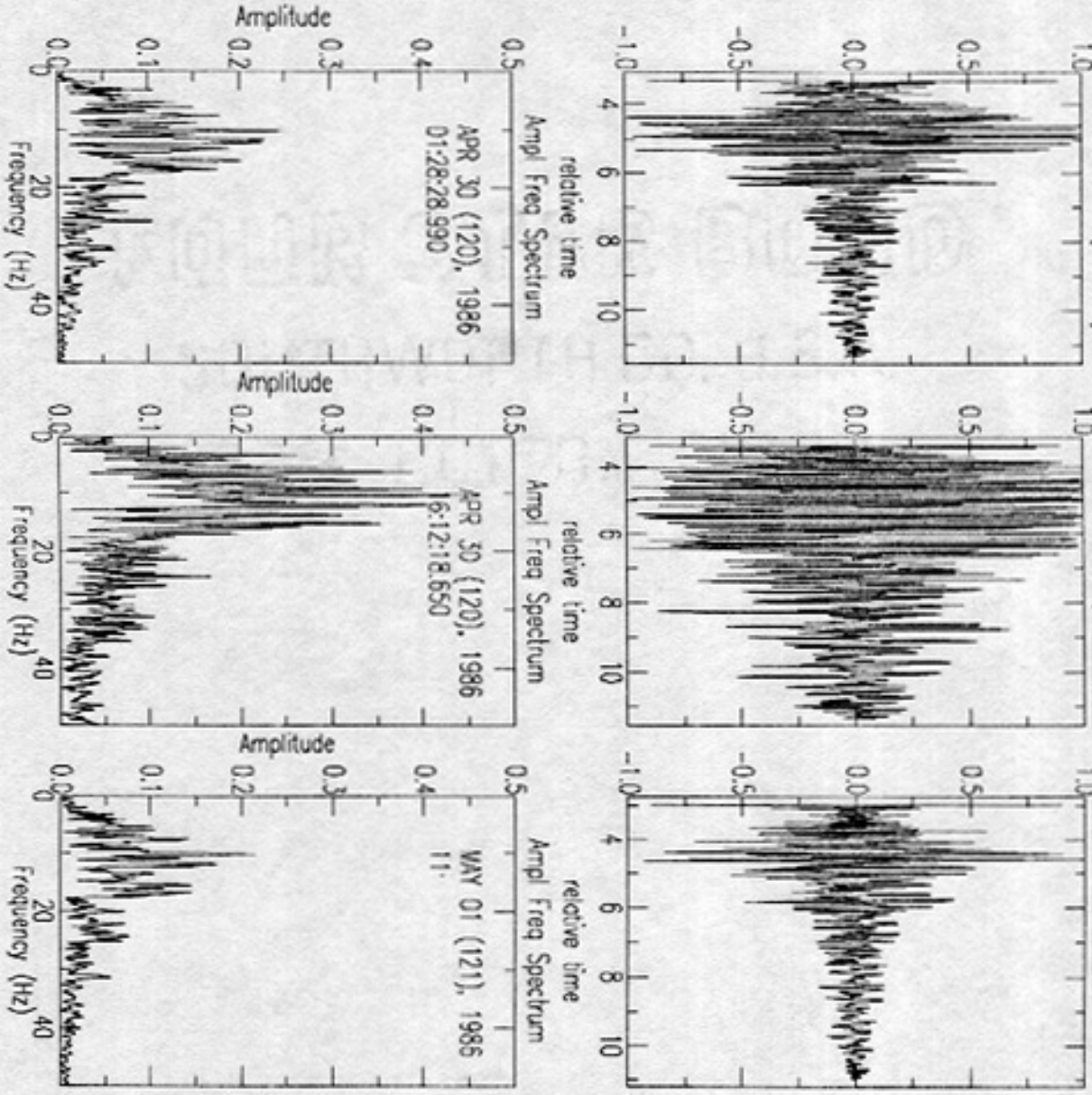

Figure 7. Ground velocity amplitude spectra and waveforms of the first 8.0 sec of the events in group J.

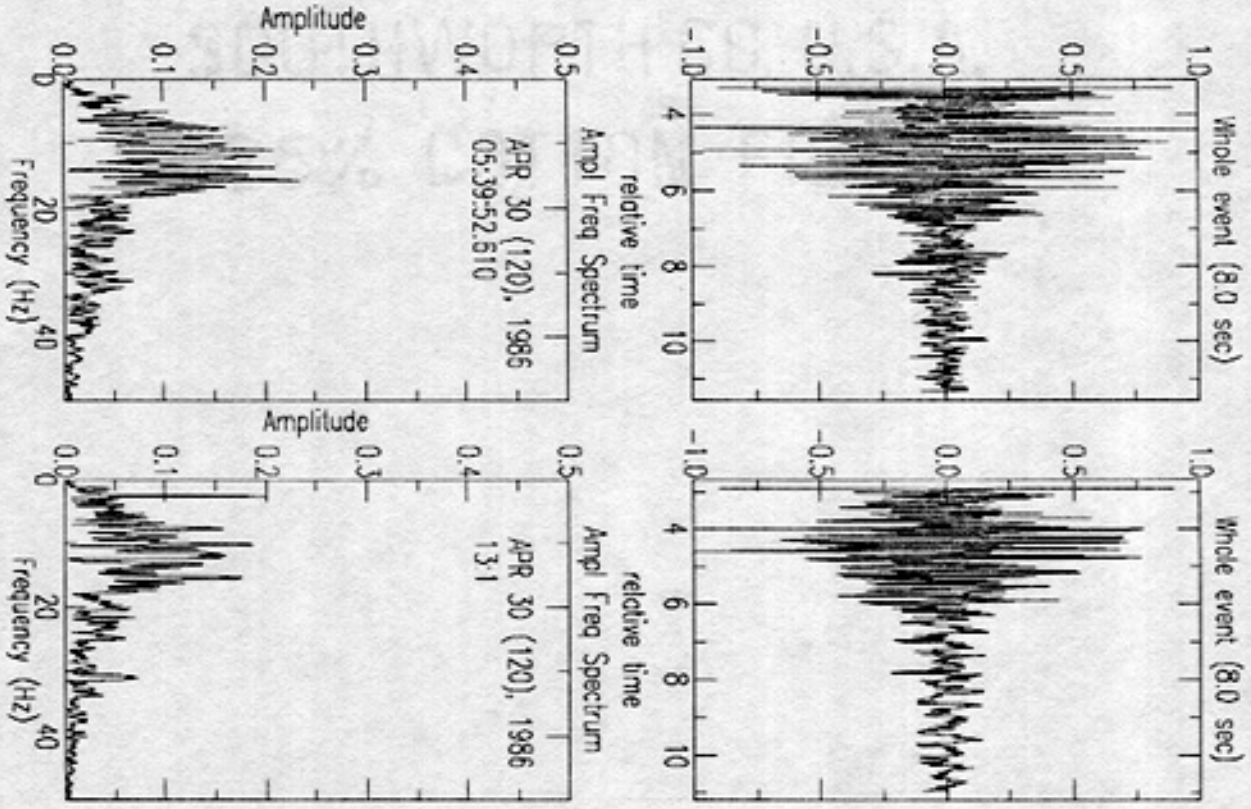

Figure 8. Ground velocity amplitude spectra and waveforms of the first 8.0 sec of the events in group I.

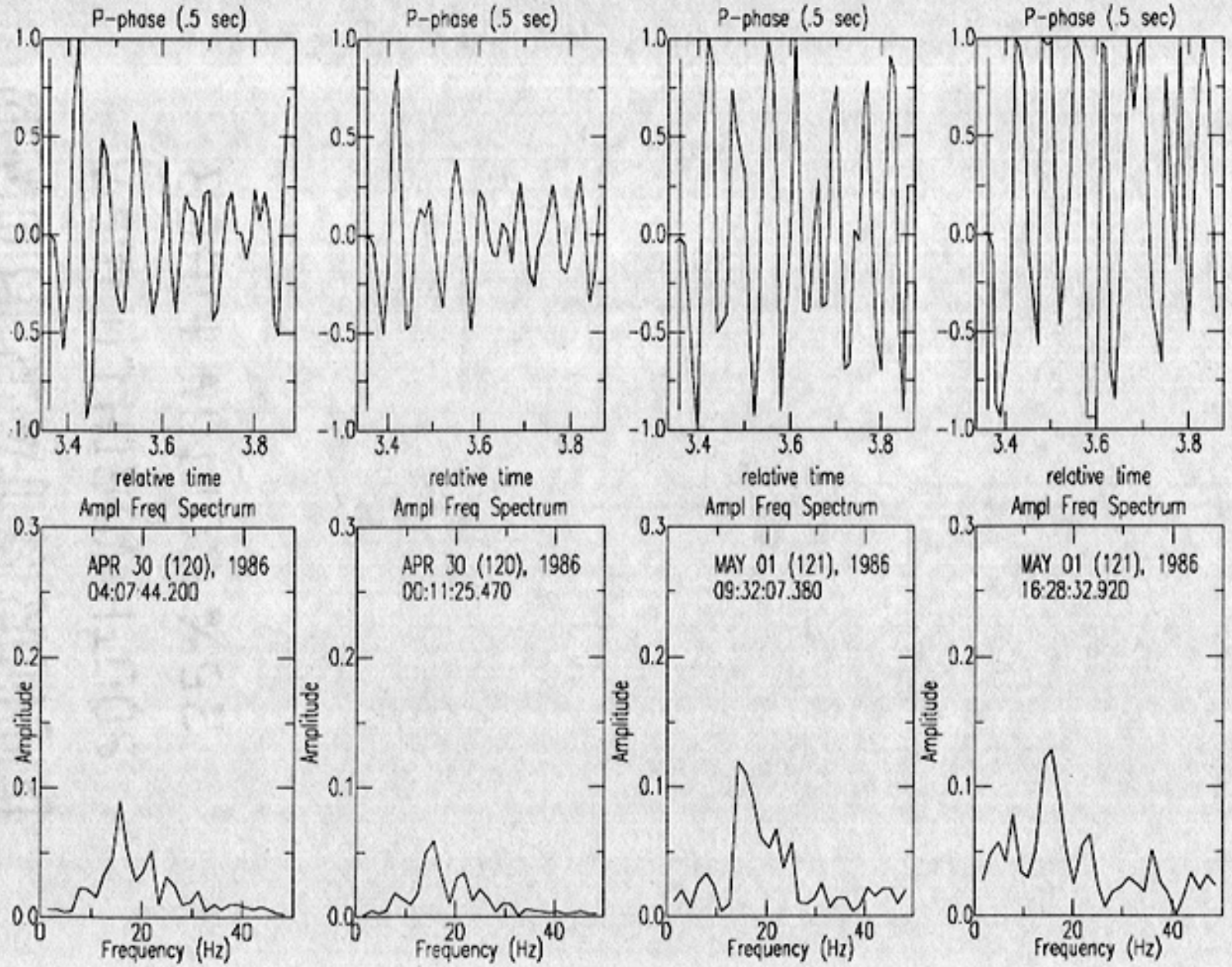

Figure 9. Ground velocity amplitude spectra and waveforms of the P-phase of events in group G. Duration is 0.5 sec.

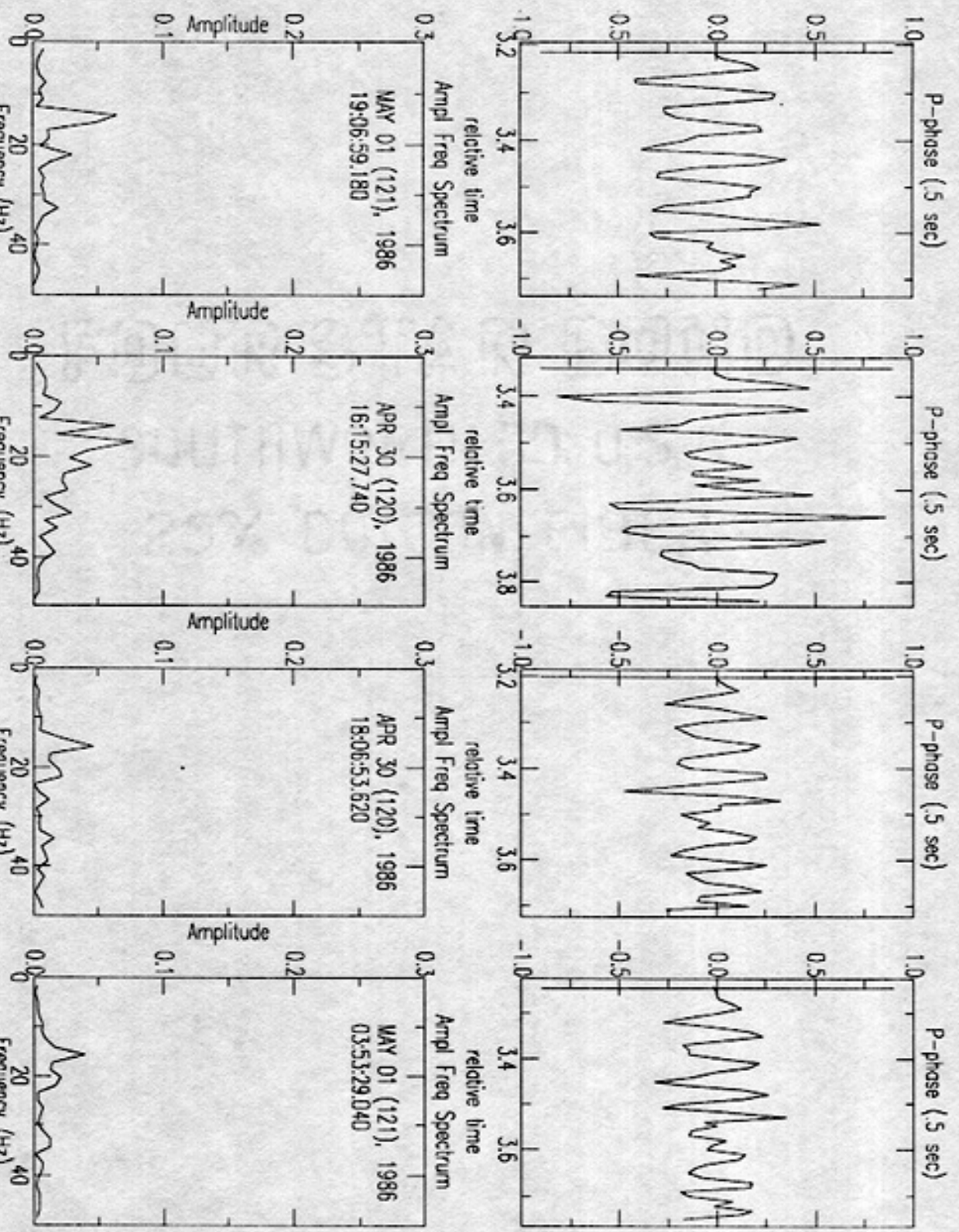

Figure 10. Ground velocity amplitude spectra and waveforms of the P-phase of events in group K. Duration is 0.5 sec.

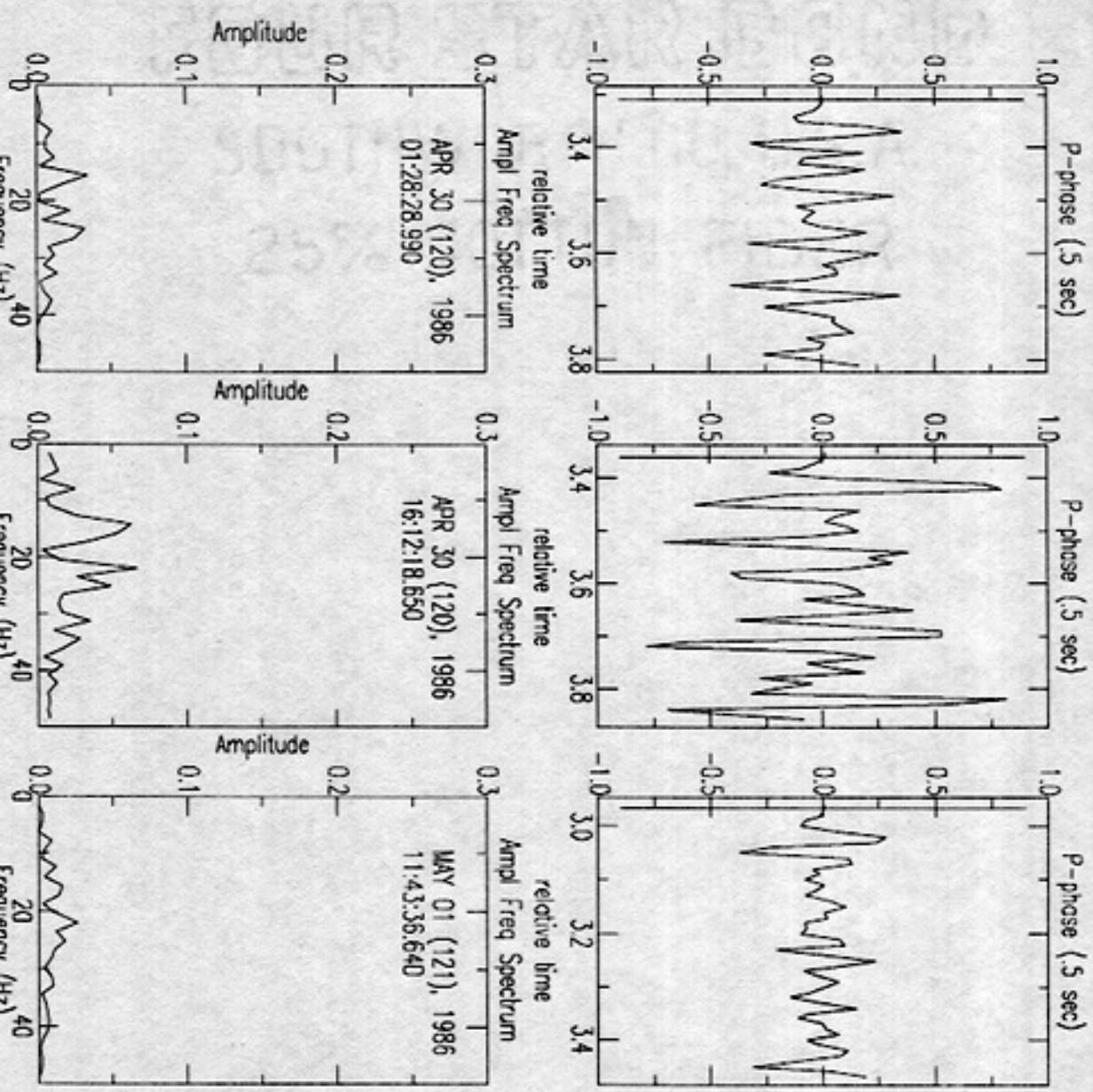

Figure 11. Ground velocity amplitude spectra and waveforms of the P-phase of events in group J. Duration is 0.5 sec.

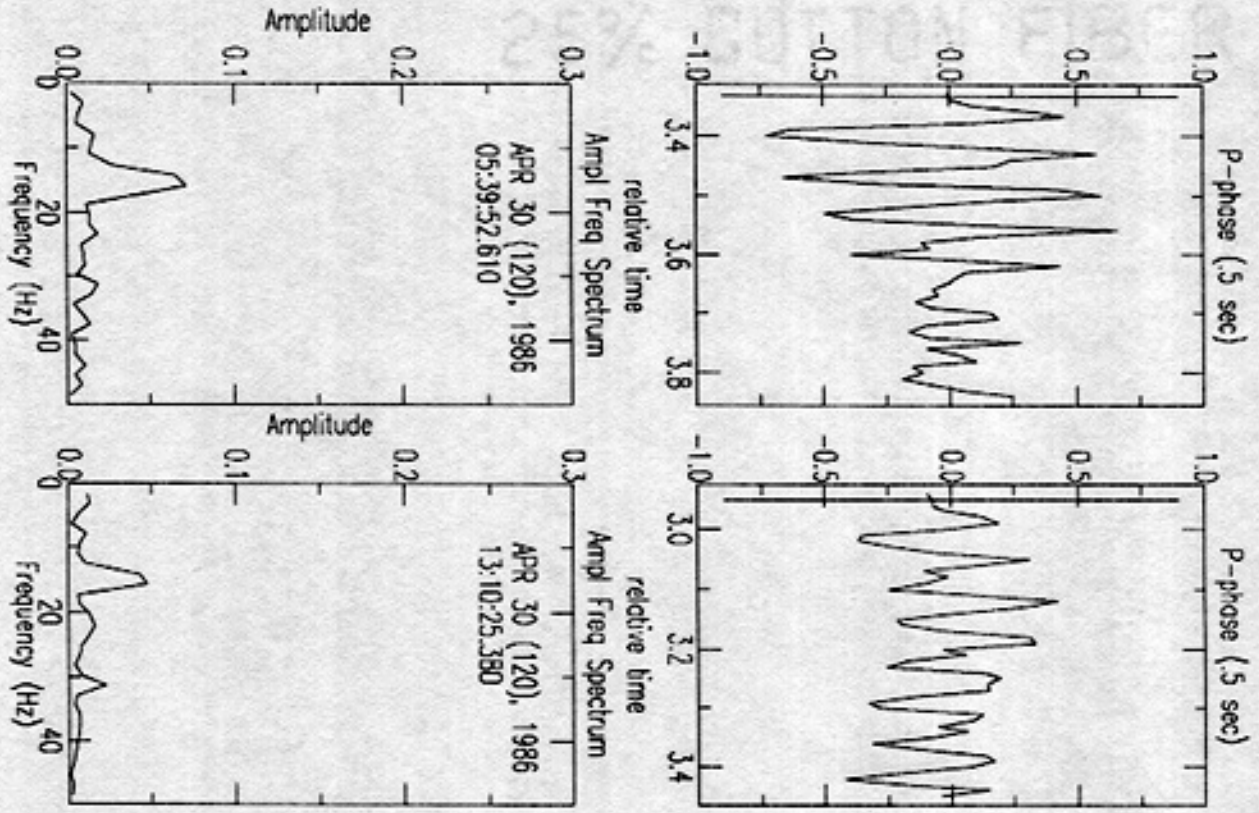

Figure 12. Ground velocity amplitude spectra and waveforms of the P-phase of events in group I. Duration is 0.5 sec.

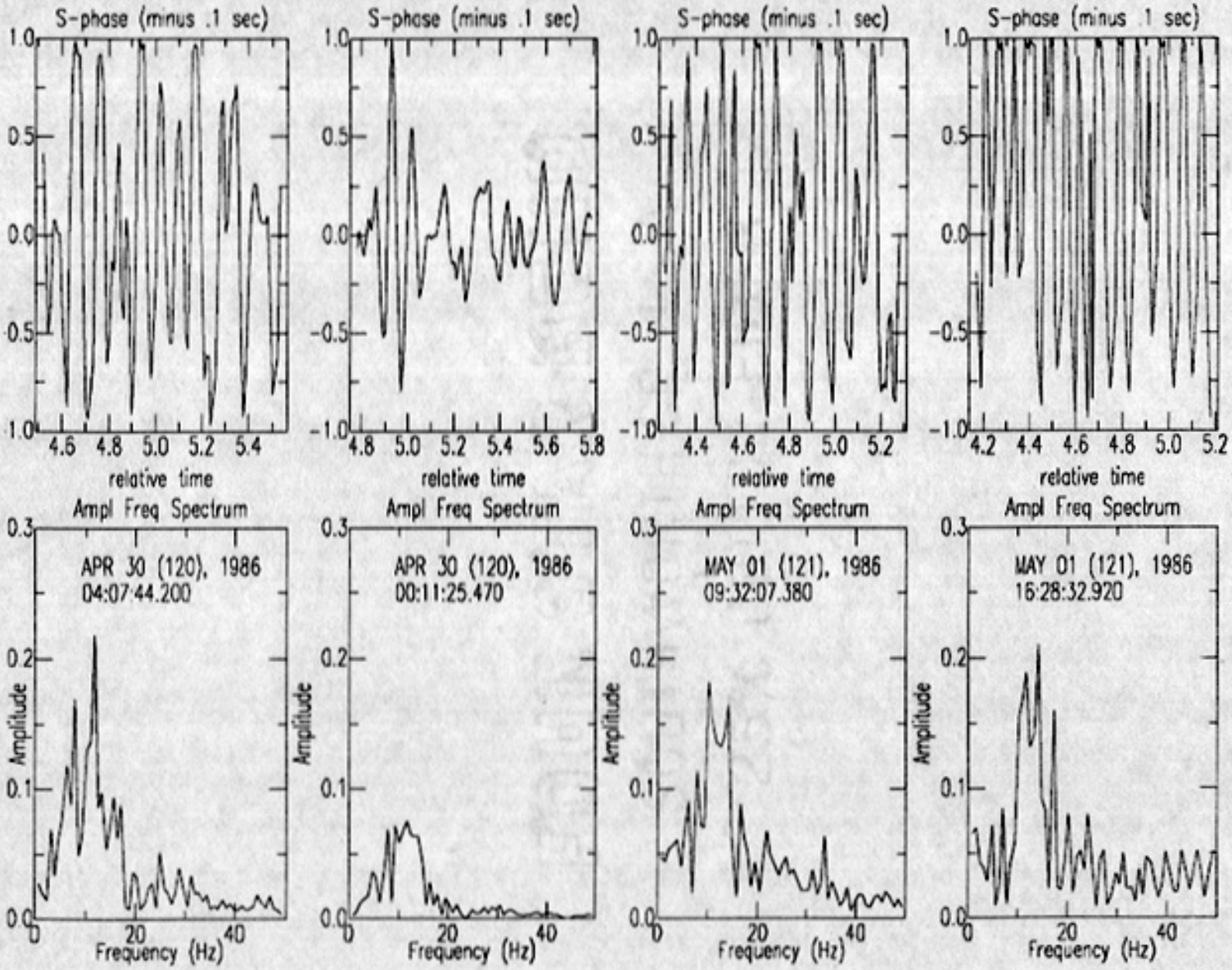

Figure 13. Ground velocity amplitude spectra and waveforms of the S-phase of events in group G. Starting time is 0.1 sec before S-phase arrival and duration is 1.0 sec.

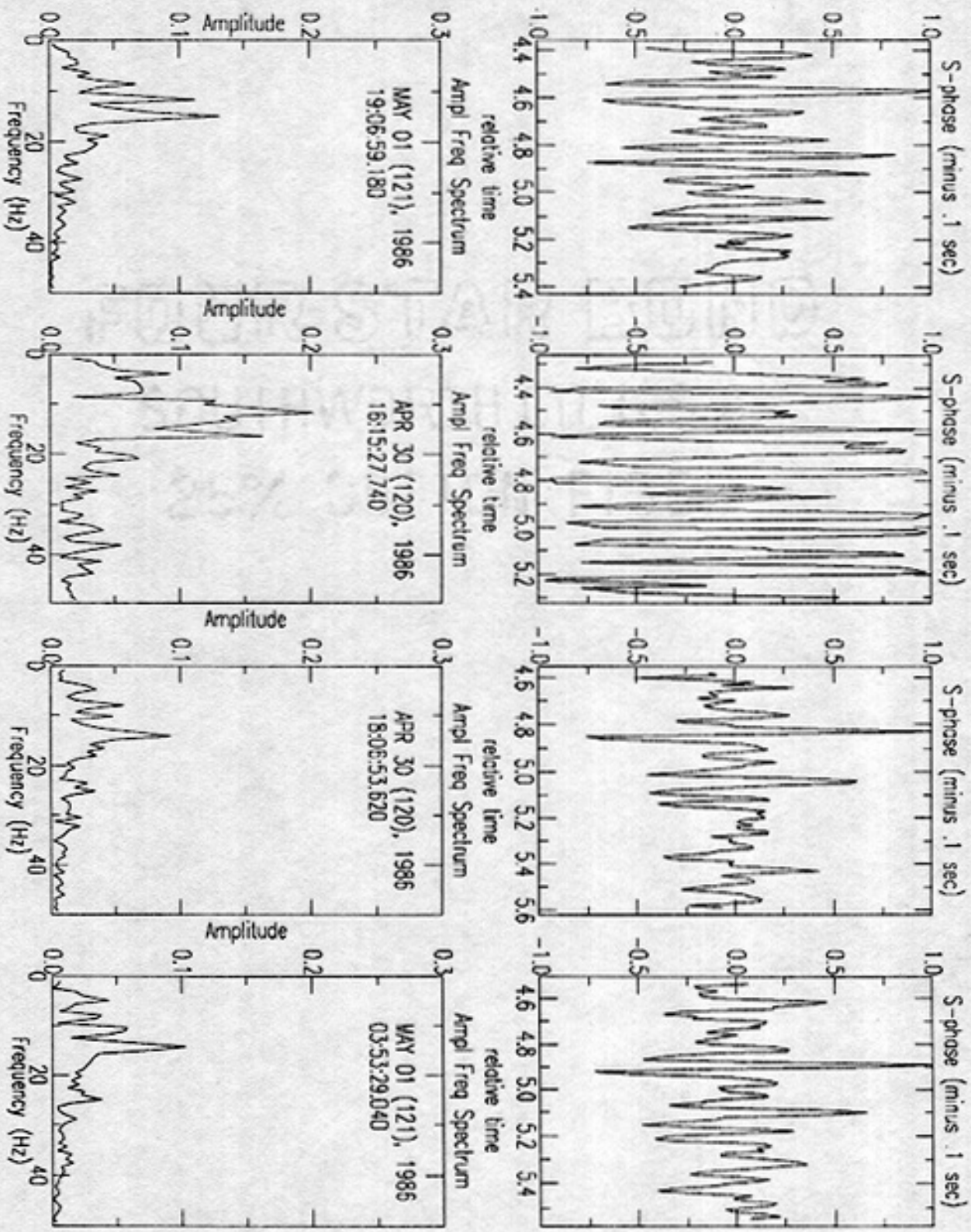

Figure 14. Ground velocity amplitude spectra and waveforms of the S-phase of events in group K. Starting time is 0.1 sec before S-phase arrival and duration is 1.0 sec.

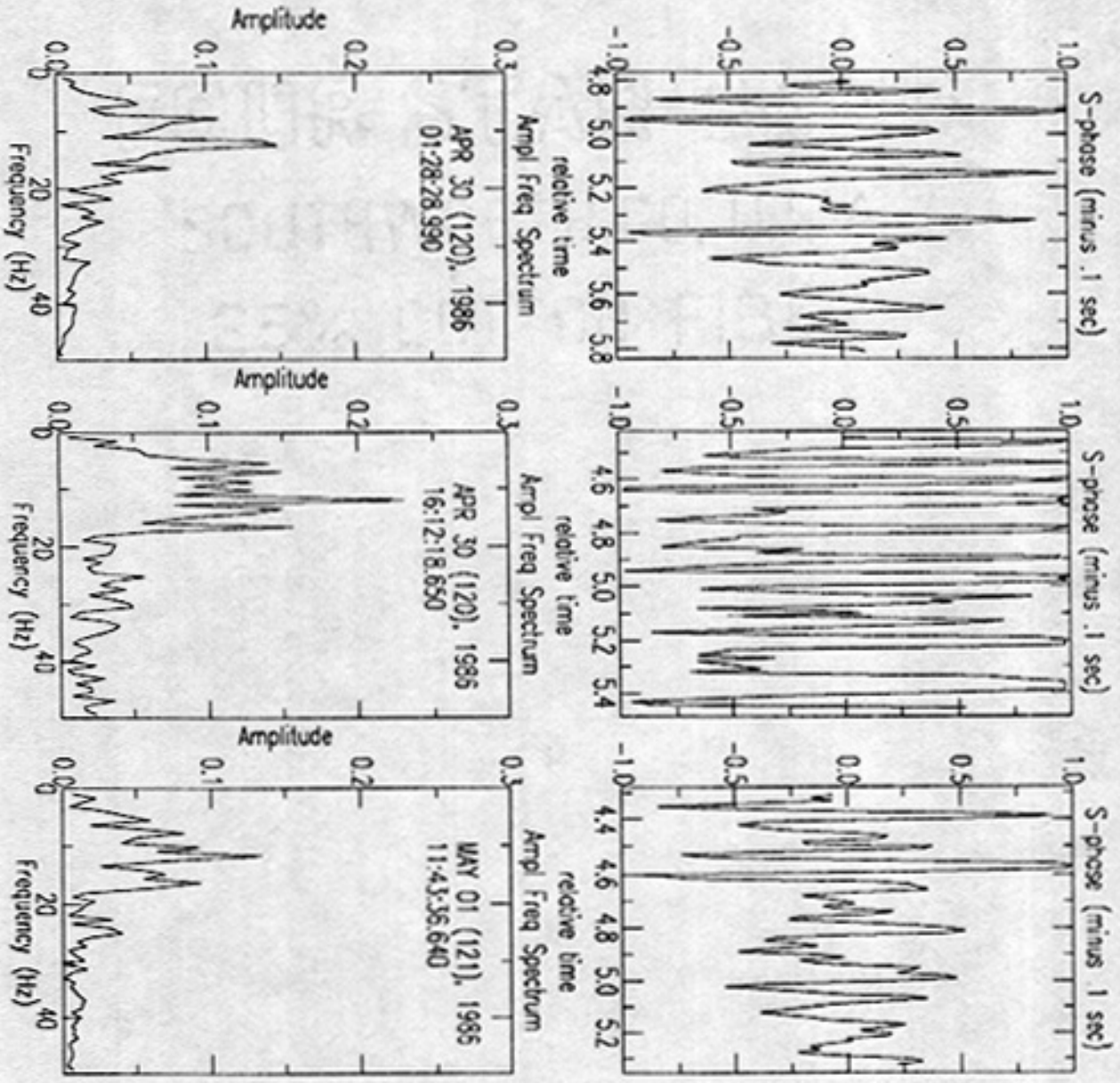

Figure 15. Ground velocity amplitude spectra and waveforms of the S-phase of events in group J. Starting time is 0.1 sec before S-phase arrival and duration is 1.0 sec.

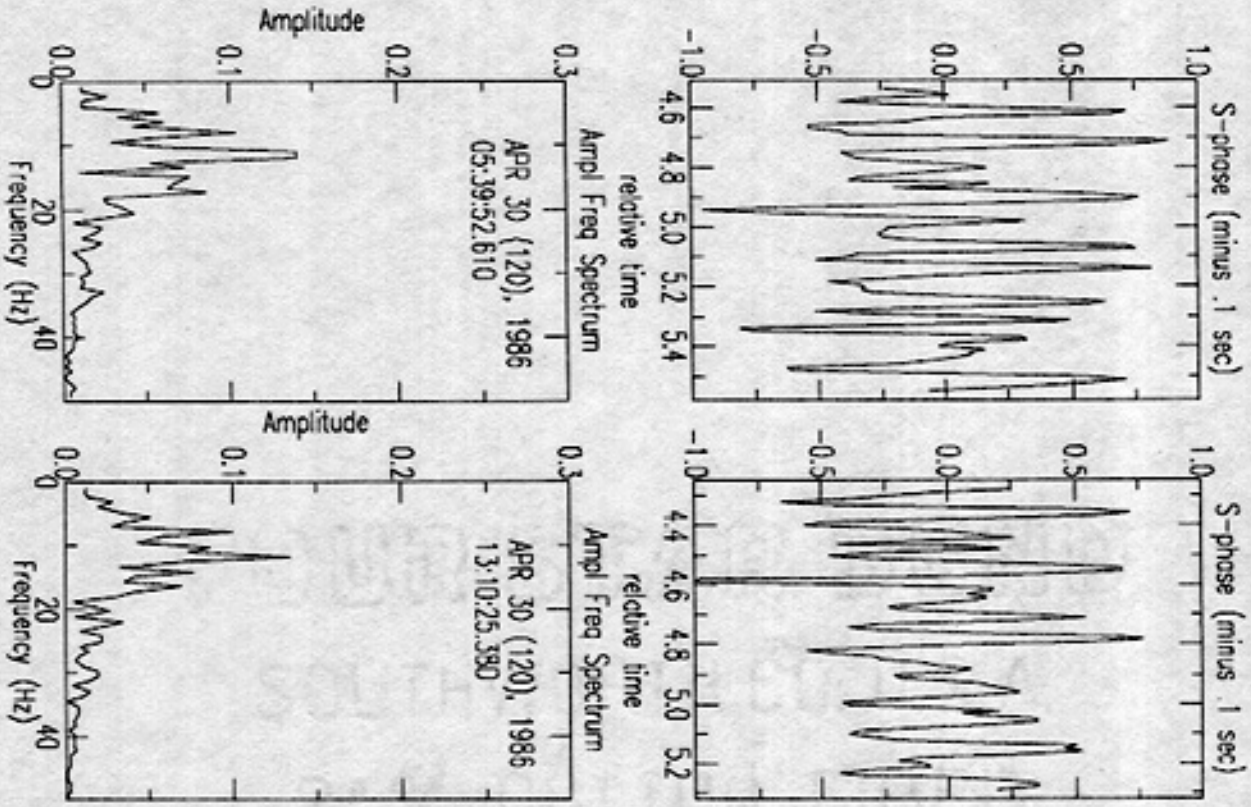

Figure 16. Ground velocity amplitude spectra and waveforms of the S-phase of events in group 1. Starting time is 0.1 sec before S-phase arrival and duration is 1.0 sec.

Fault Plane Solutions

First Motions

To correct for instrumental polarity reversals, each station was inspected for the sense of first motion of either an explosion or the teleseismic event that arrived on 5/30/86 at 07:11; both of which should have produced an up first motion. Only unequivocally distinct first motions were classified as dilatational or compressional. Emergent first motions were noted in an effort to identify nodal planes. The resulting compilation of first motions is given in Table 6. The first motions for the 14 events located with portable station data and the single large event were also plotted on the upper focal sphere using an Equal Area Net stereographic projection and appear in Appendix B.

Compositing

Even though event *(1259)* was not recorded by any portable stations, I felt that because it was significantly larger than any other event in the swarm, its first motion data (Figure B-15) should be included in the compositing. Of immediate notice on Table 6 is that all the far stations, CAR to LPM, have the same direction of first motion except for SB. The near portable stations (LC1,LC2,LC3,LC5) were either all dilatational or LC1 was dilatational and the rest of the portable stations compressional. This inconsistancy of the near stations and SB led to the hypothesis that there was a small band of slip directions as opposed to a single direction. With this in mind, all events were composited on a single Equal Area Net stereographic projection (Figure 17).

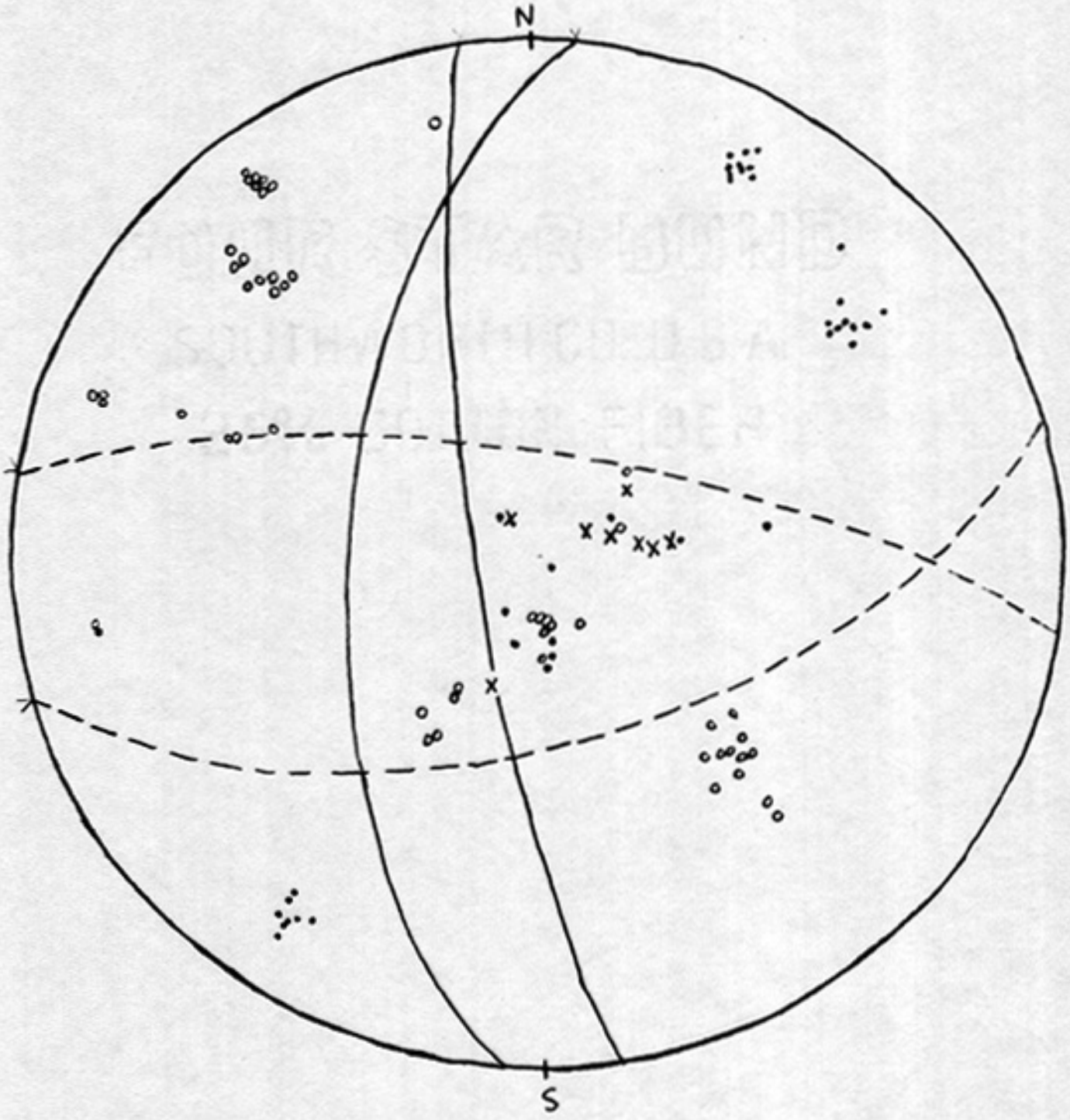

Figure 17. Composite first motion diagram for located events. Circles are dilatational arrivals, solid dots are compressional arrivals and X are emergent arrivals. The solid lines are the end members of the possible fault planes and the dashed lines are the range of auxiliary planes.

Table 6. First Motions

Events	Stations													
	LC1	LC2	LC3	LC5	CAR	SMC	BAR	LEM	WTX	LAZ	MAG	LJY	SB	LPM
0011	-	•	-	•	○	-	-	○	-	-	-	-	-	•
0128	-	•	-	•	○	•	•	○	○	○	-	-	-	•
0407	○	•	•	•	○	-	•	○	○	○	○	-	-	•
0539	○	•	•	○	○	•	•	○	○	○	-	-	-	•
0641	-	-	-	○	○	•	•	○	○	○	-	-	-	•
1310	•	-	-	○	○	-	•	-	-	○	-	-	-	•
1612	○	-	-	•	○	•	•	○	-	○	○	-	○	•
1615	○	•	-	○	-	-	-	-	-	-	-	-	-	•
1807	-	•	-	○	-	•	•	○	-	○	○	-	-	•
0858	-	○	-	○	○	-	•	-	-	-	-	-	-	•
0932	○	•	-	•	○	•	•	○	-	-	-	-	-	•
1143	-	•	-	•	○	-	•	○	-	-	-	-	-	•
1628	-	•	•	•	○	•	•	○	○	-	-	-	-	•
1906	-	○	-	○	○	-	•	-	-	-	-	-	-	•
1259‡	-	-	-	-	-	•	•	○	○	○	○	○	•	•

*(emergent arrival) -(no data) ○(dilatational) •(compressional)

‡ *Main Event*

Fault Plane Solutions

Solutions were sought by picking two auxiliary planes that enclosed the stations with inconsistant first motions. By drawing the fault plane through the poles of these auxiliary planes, a range of solutions for the individual events was created. The common fault planes with their range of auxiliary planes were tested against the 15 individual first motion diagrams in Appendix B.

The strike found for the common fault plane ranged from N04°E to N08°W and the dip ranged from 60°E to 80°E. The strikes for the auxiliary plane ranged between N80°W and S75°W and the dip ranged between 16°S and 30°N. The assumed fault planes gave solutions with a left lateral strike-slip motion. A roughly N-S trend to the structural grain of the rift as seen in Figure 18 and the spatial location of epicenters in Figure 4 reinforces the selection of the fault plane made here.

Discussion/Conclusion

The development of station delays (corrections) customized for event locations centered at 34.05°N and 106.82°W gave some results worth discussing. The difference between the customized station delays and those refined from a number of years of locating microearthquakes inside the

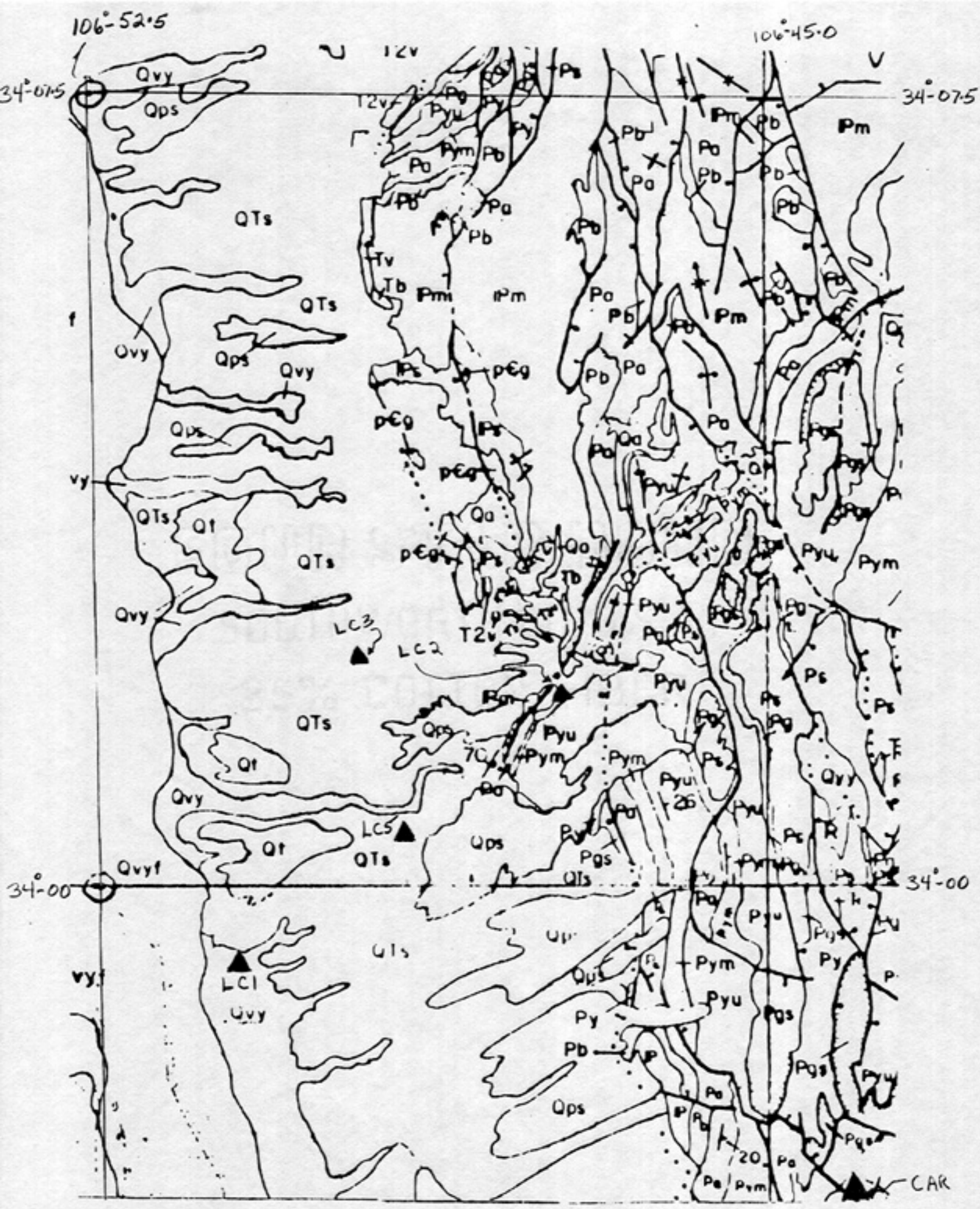

Figure 18. Geologic map for the swarm area. Solid triangles are stations.

boundaries of the network are shown in Figure 19. Note that stations located generally to the SW had relatively early arrivals, up to 0.17 sec for SMC and 0.14 for SB. Similarly, stations to the NW had relatively late arrivals, for example station LPM is 0.2 sec slower than "normal".

Comparing the portable stations, which are all within 7.0 km of each other and roughly at the same elevation but each on different geologic units, station LC2 has earlier arrivals (0.26 - 0.21 sec) than LC1 and LC3 which are only 0.05 sec different (Figure 18). LC1 and LC3 are lined up roughly NS and 3 km further west into the rift. A fault dipping to the west can be seen just to the west of LC2. LC2 is enough closer to the edge of the rift to be underlain by higher velocity material.

I attribute the generally low correlation coefficients of the whole waveforms, and the P and S phases to complex crustal structure at depth in combination with small changes in focal mechanism. A complex crustal situation will produce multiple travel paths for earthquake energy to a given point on the surface. For small source events, the differences in observed spectra at a specific station are wholly dependent on the travel path. Each of the multiple travel paths will have a characteristic spectra. At the surface, the waves from the various paths add together to form the signal recorded by the seismometer. When the direction of fault motion changes, the directions of maximum energy emission (the energy lobes) will shift. This shift of the energy lobes will put greater and less energy into the various paths. For events in the same location, travel times for the paths will not change, so their phases will add together in the same way at the surface. However, the signals in the various paths will have different relative strengths. Paths will gain or lose effect on the final signal characteristics depending on the orientation of the energy lobes at the source. A small change in spatial location under a very complex crustal situation could also produce large changes in signal characteristics without change in the focal mechanism. However, the changes in direction of first motion of the near stations indicates some changes in focal mechanism during the swarm. This implies a dynamically shifting stress field at least during the time of the swarm.

The attenuation of high frequencies for events of this small magnitude also indicates a complex path. The cause could be a series of closely spaced discontinuities such as faults and/or

intruded sills near the source region or directly under the recording station LC5.

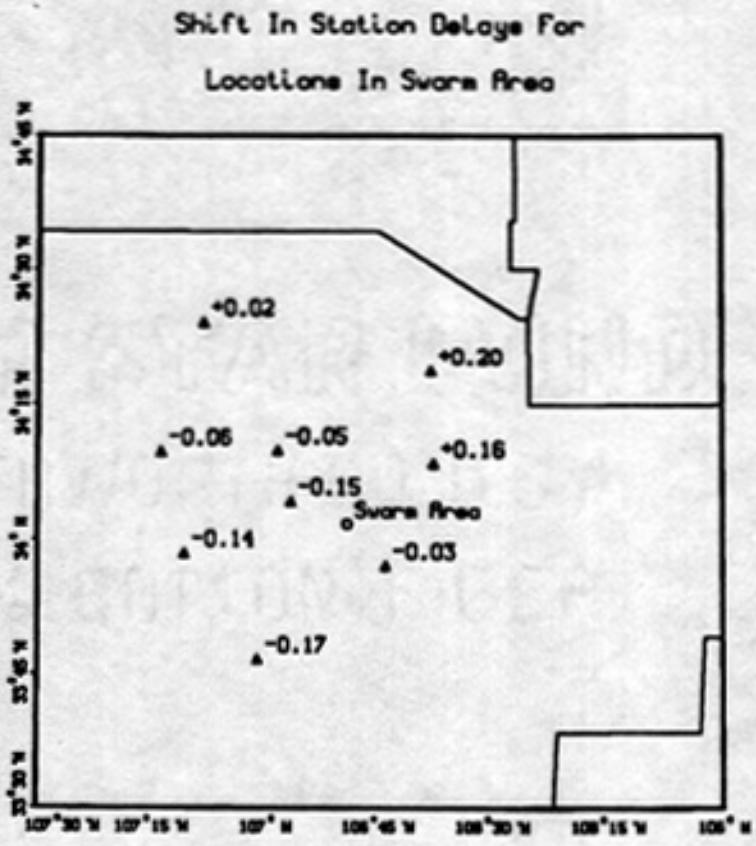

Figure 19. Time differences between standard station delays and those developed for the swarm area are shown next to their respective station.

References

Ake, J.P., (1984). An analysis of the May and July, 1983 Socorro Mountain microearthquake swarms, *Geophysics Open-File Rept. 49, New Mexico, M.S. Independent Study,* New Mexico Institute of Mining and Technology, Socorro, New Mexico, 107 pp.

Ake, J.P., and A.R. Sanford, (1988). New evidence for the existence and internal structure of a thin layer of magma at midcrustal depths near Socorro, New Mexico, *Bulletin of the Seismological Society of America,* vol. 78, no. 3, pp. 1335-1359, June.

Lee, W.H.K., and J.C. Lahr, (1975). HYPO71(Revised): A computer program for determing hypocenter, magnitude, and first motion pattern of local earthquakes, *U.S. Geological Survey , Open-File Report 75-311,* Menlo Park, California

Riecker, R.E. (ED), (1979). *Rio Grande Rift: Tectonics and Magmatism,* AGU, Washington D.C.

Sanford, A.R., K.H. Olsen, and L.H. Jaksha, (1979). Seismicity of the Rio Grande rift, in *Rio Grande Rift: Tectonics and Magmatism,* edited by R.E. Riecker, pp. 145-168, AGU, Washington D.C.

Appendix A

This appendix contains the HYPO71(Rev) hypocenter solution sheets for the 15 events of the Loma de las Cañas swarm used in this study.

********** PROGRAM: HYPO71 REVISED (11/25/73) *******

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
STANDARD	0.1000	10.0000	2.0000	0.0500	5.0000	4.0000	-0.8700	2.0000	0.0035	100.0000	8.0000	0.5000	1.0000
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-3.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

L	STN	LAT	LONG	ELV	DELAY
1	LAZ	3424.12N	107 8.36W	0	0.09
2	BAR	34 8.52N	10637.68W	2120	0.32
3	LPM	3413.77N	10633.03W	0	-0.06
4	SB	3358.51N	10710.84W	3230	0.28
5	CAR	3357.15N	10644.07W	0	0.00
6	SMC	3346.72N	107 1.16W	1560	-0.06
7	WTX	34 4.33N	10656.75W	1555	-0.03
8	MAG	34 9.75N	10713.92W	0	-0.02
9	LJY	3420.19N	10653.75W	0	0.36
10	LEM	34 9.93N	10653.45W	1698	0.04
11	MLM	3448.85N	107 8.70W	0	-0.10
12	LC1	3359.30N	10650.65W	0	-0.15
13	LC2	34 1.86N	10547.15W	0	-0.36
14	LC3	34 2.12N	10649.40W	0	-0.10
15	LC5	34 0.49N	10643.86W	0	0.00

CRUSTAL MODEL 1

VELOCITY	DEPTH
5.850	0.000

ZTR	XNEAR	XFAR	POS	IQ	KMS	KFM	IPUN	IMAG	IR	IPRN	CODE	LATR	LONR
7.	20.	250	1.7320508	3	1	0	0	1	0	1	1011	0 0.00	0 0.00

big

DATE AND TIME OF RUN 2/28/89 10:15 JSG

86/ 4/28 12:59

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-3.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	ID	KMS	KFN	IPUN	IMAG	IR	IPRN	CODE
5.850	0.000	7.	20.	259.	1.7320503	3	1	0	0	1	0	1	1011

E	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKD	CF	ADJUSTMENTS (KM) DLAT	DLON	DZ	PARTIAL F-VALUES DLAT	DLON	DZ	STANDARD ERRORS DLAT	DLON	DZ	ADJUSTMENTS TAKEN DLAT	DLON	DZ
1	48.18	53- 57.25	106-44.17	7.00*	0	0.25	-0.00	DOR	2.00	10.87	10.50	0.00	159.57	125.35	0.00	0.86	0.94	0.00	10.87	10.50	0.00
2	49.09	54- 5.13	106-50.09	7.00	9	0.40	-0.36	COR	2.00	-2.50	-2.80	2.51	38.51	50.85	2.05	0.40	0.39	1.75	-2.50	-2.80	2.51
3	49.26	54- 1.78	106-49.17	9.51	12	0.11	-0.04	ASB	0.50	-0.17	0.00	0.00	0.27	-1.00	-1.00	0.33	0.00	0.00	0.00	0.00	0.00
3	49.22	54- 1.78	106-49.17	9.51	12	0.11	0.00	AZB	2.00	-0.18	-0.17	-0.05	0.19	0.19	0.00	0.41	0.40	1.60	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	DM	GAP	M	RMS	ERH	ERZ	Q	SRD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	NF	AVFM	SDFM	I
850428	1259 49.22	54- 1.78	106-49.17	9.51	2.57	12	12	83	1	0.11	0.6	1.6	B	AIB	4.51	10	12	0.00	0.08	0	0.0	0.0	7	2.6	0.3	5

STN	DIST	AZM	AIN	PRMK	YRMN	P-SEC	TPOBS	TPCAL	DLY/HI	P-RES	P-WT	AMK	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	OT
CAR	11.6	137	129	P	0 1259	51.70	2.46	2.57	0.00	-0.09	1.21	0	0	0.00	0			200	2.8						
WTX	15.6	102	170	P	0 1259	52.00	2.68	2.69	-0.01	-0.01	1.25	0	0	0.00	0										
CCM	20.7	137	150	P	0 1259	52.50	4.05	3.90	0.04	0.14	1.18	0	0	0.00	0										
BAR	21.6	55	114	P	0 1259	52.60	4.58	4.04	0.52	0.02	1.21	0	0	0.00	0			203	2.8						
SSC	33.4	214	063	P	0 1259	52.10	5.88	5.94	-0.06	-0.00	1.12	0	0	0.00	0			198	2.8						
SS	33.9	210	063	P	0 1259	52.50	6.28	6.02	0.28	-0.02	1.15	0	0	0.00	0										
FLY	34.8	348	105	P	0 1259	52.00	6.78	6.16	0.86	-0.24	0.88	0	0	0.00	0										
LSM	35.8	29	105	P	0 1259	52.50	6.28	6.33	-0.05	-0.03	1.14	0	0	0.00	0			147	2.4						
MAG	40.8	291	103	P	0 1259	56.30	7.08	7.16	-0.02	-0.07	1.10	0	0	0.00	0			128	2.2						
LAZ	50.7	324	101	P	0 1259	58.40	9.18	8.82	0.09	0.26	0.71	0	0	0.00	0			206	2.8						
MLM	92.0	341	96	P	0 1259	65.00	15.79	15.81	-0.10	0.06	0.84	0	0	0.00	0			117	2.1	S	3	76.30	27.08	-0.14	0.20

MISSING STATION	DELTA	AZIN	EX-GAP	RD-GAP
LC1	5.1	206.4	76.1	7.2
LC2	5.1	87.3	82.6	32.5
LC3	0.7	350.8	16.5	6.4
LC5	2.4	168.6	76.1	31.1

LAT	LON	Z	AVRPS	RMS	DRMS
1.94	49.37	9.21	0.05	0.13	0.02
1.94	48.98	9.21	0.02	0.12	
1.94	49.37	9.41	0.01	0.13	0.01
1.94	48.98	9.81	-0.02	0.12	(0.01)
					(0.02)
1.78	49.17	9.39	0.03	0.11	0.00
				0.11	0.00
1.78	49.17	10.03	-0.03	0.11	(0.00)
1.62	49.37	9.21	0.02	0.12	0.01
1.62	48.98	9.21	-0.01	0.11	0.00
1.62	49.37	9.41	-0.02	0.12	(0.00)
1.62	48.98	9.81	-0.04	0.11	(0.31)

DATE AND TIME OF RUN 2/28/89 10:15 JBG

86/ 4/30 0:11

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-3.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	IQ	KMS	KFM	IPUN	IMAG	IR	IPRN	CODE
5.850	0.000	7.	20.	250.	1.7320508	3	1	0	0	1	0	1	1011

										ADJUSTMENTS (KM)			PARTIAL F-VALUES			STANDARD ERRORS			ADJUSTMENTS TAKEN		
I	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKD	CF	DLAT	DLON	DZ	DLAT	DLON	DZ	DLAT	DLON	DZ	DLAT	DLON	DZ
1	26.26	34- 1.96	106-47.25	7.00	0	0.32	0.00	COB	2.00	-1.69	2.57	4.81	22.29	44.84	98.21	0.36	0.38	0.49	-1.69	2.57	4.81
2	25.67	34- 1.04	106-48.92	11.81	2	0.08	-0.10	A1D	0.50	-0.64	0.34	0.46	2.77	0.75	1.16	0.38	0.39	0.42	-0.64	0.34	0.46
3	25.47	34- 0.70	106-49.14	12.27	3	0.06	0.00	A3D	0.50	0.00	0.00	0.05	-1.00	-1.00	0.02	0.00	0.00	0.32	0.00	0.00	0.00
3	25.47	34- 0.70	106-49.14	12.27	3	0.06	0.00	A2D	2.00	-0.07	0.03	0.08	0.03	0.01	0.04	0.39	0.39	0.42	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	ND	DM	GAP	M	RMS	ERH	ERZ	Q	SQD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	NF	AVFM	SDFM	I
860430	011 25.47	34- 0.70	106-49.14	12.27	-0.42	9	3	190	1	0.06	0.5	0.4	C	A1D	0.86	10	14	0.00	0.04	0	0.0	0.0	4	-0.4	0.2	3

STN	DIST	AZM	AIN	PRMK	HRMN	P-SEC	TPOBS	TPCAL	DLY/H1	P-RES	P-WT	AMX	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	DI
LC1	0.6	132	177	P 4	011	3.35	******	2.10	0.00	-24.22	0.00	0	0	0.00	0				S 4	4.87	-20.60	-24.24	0.00		
LC3	2.7	351	168	P 2	011	27.50	2.03	2.15	-0.10	-0.02	0.88	0	0	0.00	0				S 3	28.60	3.13	-0.42	**	0.00	
LC2	3.7	55	163	P 0	011	27.50	1.83	2.19	-0.36	0.00	1.76	0	0	0.00	0				S 2	28.70	3.23	0.05		0.87	
CAR	10.2	130	140	P 0	011	28.20	2.73	2.73	0.00	0.00	1.76	0	0	0.00	0			16-0.3	S 3	30.10	4.63	-0.09		0.44	
LEM	22.3	320	119	P 1	011	29.90	4.43	4.35	0.04	0.04	1.29	0	0	0.00	0			13-0.5	S 3	33.00	7.53	-0.07		0.44	
BAR	-22.8	51	118	P 3	011	30.40	4.93	4.43	0.32	0.18	0.55	0	0	0.00	0			16-0.3	S 4	33.00	7.53	-0.69		0.00	
LPM	37.5	27	108	P 1	011	32.10	6.63	6.75	-0.06	-0.06	1.22	0	0	0.00	0			12-0.6	S 4	34.00	8.53	-3.05		0.00	

MISSING STATION	DELTA	AZIM	EX-GAP	RD-GAP
LC1	3.5	222.0	190.0	92.0

LAT	LON	Z	AVRPS	RMS	DRMS
0.86	49.33	11.97	0.04	0.07	0.02
0.86	48.94	11.97	0.06	0.06	0.01
0.86	49.33	12.57	-0.04	0.08	(0.03)
0.86	48.94	12.57	-0.02	0.06	(0.01)
0.70	49.14	11.75	0.07	0.07	0.01
				0.06	0.00
0.70	49.14	12.79	-0.07	0.06	(0.01)
0.53	49.33	11.97	0.00	0.10	0.05
0.53	48.94	11.97	0.04	0.08	0.03
0.53	49.33	12.57	-0.07	0.06	(0.00)
0.53	48.94	12.57	-0.05	0.07	(0.01)

DATE AND TIME OF RUN 2/28/89 10:15 JBG

86/ 4/30 1:28

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-3.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	IQ	KMS	KFM	IPUN	IMAG	IR	IPRN	CODE
5.850	0.000	7.	20.	250.	1.7320508	3	1	0	0	1	0	1	1011

I	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKD	CF	ADJUSTMENTS (KM) DLAT	DLON	DZ	PARTIAL F-VALUES DLAT	DLON	DZ	STANDARD ERRORS DLAT	DLON	DZ	ADJUSTMENTS TAKEN DLAT	DLON	DZ
1	29.62	34- 1.96	106-47.25	7.00	0	0.47	0.00	C0A	2.00	-1.52	2.09	7.05	14.13	35.05	83.97	0.40	0.35	0.77	-1.52	2.09	3.53
2	29.34	34- 1.14	106-48.61	10.53	2	0.20	-0.09	B0A	2.00	0.00	0.00	2.26	-1.00	1.79	11.68	0.00	0.00	0.66	0.00	0.00	2.26
3	28.99	34- 1.14	106-48.61	12.79	2	0.16	0.00	B1A	0.50	0.00	0.50	0.00	-1.00	1.69	0.35	0.00	0.39	0.00	0.00	0.50	0.00
4	28.99	34- 1.14	106-48.94	12.79	2	0.15	0.00	B3A	0.50	0.00	0.00	0.34	-1.00	-1.00	0.29	0.00	0.00	0.63	0.00	0.00	0.00
4	28.99	34- 1.14	106-48.94	12.79	2	0.15	0.00	B2A	2.00	0.03	0.05	0.33	0.01	0.02	0.22	0.46	0.41	0.70	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	DM	GAP	M	RMS	ERH	ERZ	Q	SQD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	NF	AVFM	SDFM	I
850430	128 28.99	34- 1.14	106-48.94	12.79	-0.11	17	2	81	1	0.15	0.6	0.7	B	!A	0.50	10	24	0.00	0.12	0	0.0	0.0	8	-0.1	0.3	4

STN		DIST	AZM	AIN	PRMK	HRMN	P-SEC	TPOBS	TPCAL	DLY/HI	P-RES	P-WT	AMX	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	DT
LC5		1.2	174	175	P	4 128	3.25	******	2.20	0.00	-27.94	0.00	0	0	0.00	0					S 4	4.55	-24.44	-28.25	0.00	
LC3		1.9	338	171	P	2 128	31.50	2.51	2.21	-0.10	0.40	0.55	0	0	0.00	0					S 3	33.20	4.21	0.55	**	0.07
LC2	u	3.1	64	167	P	0 128	30.80	1.81	2.25	-0.36	-0.08	1.51	0	0	0.00	0					S 2	32.70	3.71	0.44		0.47
LC1	D	4.3	218	161	P	0 128	31.10	2.11	2.31	-0.15	-0.05	1.53	0	0	0.00	0					S 2	32.80	3.81	0.07		0.76
CAR	D	10.5	135	141	P	0 128	31.70	2.71	2.83	0.00	-0.12	1.51	0	0	0.00	0			26	0.3	S 4	33.70	4.71	-0.19		0.00
WTX	D	13.4	296	134	P	0 128	32.00	3.01	3.17	-0.03	-0.13	1.51	0	0	0.00	0			13	-0.5	S 2	34.20	5.21	-0.22		0.71
LEM	D	21.9	318	120	P	0 128	33.40	4.41	4.33	0.04	0.04	1.52	0	0	0.00	0			19	-0.1	S 2	36.50	7.51	-0.06		0.76
BAR	u	22.0	52	120	P	0 128	33.60	4.61	4.36	0.32	-0.07	1.51	0	0	0.00	0			24	0.2	S 3	37.00	8.01	-0.09		0.37
SHC	u	32.6	215	111	P	1 128	35.10	6.11	5.99	-0.06	0.17	1.06	0	0	0.00	0			14	-0.4	S 4	37.80	8.81	-1.47		0.00
LPM	u	36.6	27	109	P	0 128	35.50	6.51	6.63	-0.06	-0.07	1.42	0	0	0.00	0			17	-0.2	S 2	40.60	11.61	0.22		0.69
MAG		41.6	293	107	P	1 128	36.50	7.51	7.44	-0.02	0.09	1.04	0	0	0.00	0			19	-0.1	S 4	41.20	12.21	-0.64		0.00
LAZ	D	51.9	325	104	P	4 128	38.60	9.61	9.14	0.09	0.38	0.00	0	0	0.00	0			18	-0.1	S 4	44.40	15.41	-0.58		0.00

LAT	LON	Z	AVRPS	RMS	DRMS
1.30	49.13	12.49	0.06	0.16	0.01
1.30	48.74	12.49	0.04	0.16	0.00
1.30	49.13	13.09	-0.02	0.16	(0.01)
1.30	48.74	13.09	-0.03	0.16	(0.01)
1.14	48.94	12.27	0.06	0.15	0.00
				0.15	0.00
1.14	48.94	13.31	-0.06	0.16	(0.00)
0.98	49.13	12.49	0.03	0.16	0.01
0.98	48.74	12.49	0.02	0.16	0.01
0.98	49.13	13.09	-0.04	0.16	(0.01)
0.98	48.74	13.09	-0.05	0.16	(0.01)

(3)

DATE AND TIME OF RUN 2/28/89 10:15 JBG

86/ 4/30 4: 7

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-3.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	IQ	KMS	KFM	IPUN	IMAG	IR	IPRN	CODE
5.550	0.000	7.	20.	250.	1.7320508	3	1	0	0	1	0	1	1011

										ADJUSTMENTS (KM)			PARTIAL F-VALUES			STANDARD ERRORS			ADJUSTMENTS TAKEN		
I	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKD	CF	DLAT	DLON	DZ	DLAT	DLON	DZ	DLAT	DLON	DZ	DLAT	DLON	DZ
1	44.39	34- 1.96	106-47.25	7.00	0	0.38	0.00	COA	2.00	0.00	2.63	3.59	0.06	99.90	71.12	0.00	0.26	0.43	0.00	2.63	3.59
2	44.21	34- 1.96	106-48.96	10.59	1	0.11	-0.08	A0A	2.00	0.00	0.00	-0.61	-1.00	0.55	2.92	0.00	0.00	0.36	0.00	0.00	-0.61
3	44.19	34- 1.96	106-48.96	9.98	1	0.09	-0.01	A1A	0.50	-0.16	0.21	-0.25	0.64	1.06	0.55	0.21	0.20	0.34	-0.16	0.21	-0.25
4	44.21	34- 1.87	106-49.09	9.73	1	0.08	0.00	A3A	0.50	-0.06	0.00	0.00	0.12	-1.00	-1.00	0.17	0.00	0.00	0.00	0.00	0.00
4	44.20	34- 1.87	106-49.09	9.73	1	0.08	0.00	A2A	2.00	-0.04	0.04	-0.08	0.04	0.05	0.06	0.19	0.19	0.32	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	DM	GAP	M	RMS	ERH	ERZ	Q	SQD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	NF	AVFM	SDFM	I
850430	4 7 44.20	34- 1.87	106-49.09	9.73	0.18	22	1	68	1	0.08	0.3	0.3	A	A1A	0.37	10	24	0.00	0.06	0	0.0	0.0	13	0.2	0.3	4

STN	DIST	AZM	AIN	PRMK	HRMN	P-SEC	TPOBS	TPCAL	DLY/H1	P-RES	P-WT	AMX	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	DT
LC3	0.7	314	176	P	0	4 7	45.70	1.50	1.67	-0.10	-0.07	1.68	0	0	0.00	0		30	0.5	S	2 46.90	2.70	-0.02	0.85	
LC5	2.6	172	165	P	4	4 7	5.35	******	1.72	0.00	-42.57	0.00	0	0	0.00	0				S	4 4.60	-39.60	-42.58	0.00		
LC2	3.0	90	163	P	0	4 7	45.60	1.40	1.74	-0.36	0.02	1.70	0	0	0.00	0		32	0.6	S	3 46.80	2.60	0.21	0.39	
LC1	5.3	207	151	P	0	4 7	45.90	1.70	1.90	-0.15	-0.05	1.70	0	0	0.00	0		22	0.1	S	2 47.70	3.50	0.47	**0.03	
CAR	11.7	138	130	P	0	4 7	46.70	2.50	2.60	0.00	-0.10	1.67	0	0	0.00	0		56	0.7	*					
WTX	12.6	291	128	P	0	4 7	46.90	2.70	2.72	-0.03	0.00	1.70	0	0	0.00	0		19	-0.1						
LEM	20.7	316	115	P	0	4 7	48.20	4.00	3.91	0.04	0.05	1.70	0	0	0.00	0		27	0.4	S	3 51.10	6.90	-0.05	0.42	
BAR	21.4	55	114	P	0	4 7	48.60	4.40	4.02	0.32	0.05	1.69	0	0	0.00	0		24	0.2	S	3 51.70	7.50	-0.02	0.42	
SHC	33.6	214	106	P	2	4 7	50.10	5.90	5.98	-0.06	-0.03	0.80	0	0	0.00	0		17	-0.2	S	3 54.70	10.50	-0.24	0.34	
SS	34.1	259	106	P	3	4 7	50.50	6.30	6.05	0.28	-0.04	0.40	0	0	0.00	0		15	-0.5	*	S 3 54.80	10.60	-0.38	**0.08	
LJY	34.6	348	106	P	1	4 7	51.20	7.00	6.15	0.86	-0.01	1.20	0	0	0.00	0		17	-0.2						
LPM	35.6	29	105	P	0	4 7	50.50	6.30	6.30	-0.06	0.05	1.59	0	0	0.00	0		24	0.2	S	2 55.00	10.80	-0.02	0.79	
MAG	40.9	291	103	P	1	4 7	51.40	7.20	7.18	-0.02	0.04	1.16	0	0	0.00	0		27	0.4						
LAZ	50.7	324	101	P	1	4 7	53.20	9.00	8.82	0.09	0.09	1.09	0	0	0.00	0		26	0.3	S	2 59.40	15.20	-0.24	0.60	

LAT	LON	Z	AVRPS	RMS	DRMS
2.03	49.29	9.43	0.05	0.09	0.01
2.03	48.90	9.43	0.04	0.10	
2.03	49.29	10.03	-0.01	0.10	0.02
2.03	48.90	10.03	-0.02	0.10	(0.03) (0.02)
1.87	49.09	9.21	0.05	0.08	0.00
				0.08	0.00
1.87	49.09	10.25	-0.05	0.09	(0.01)
1.71	49.29	9.43	0.02	0.09	0.01
1.71	48.90	9.43	0.01	0.09	
1.71	49.29	10.03	-0.05	0.09	0.01
1.71	48.90	10.03	-0.05	0.08	(0.01) (0.00)

(4)

DATE AND TIME OF RUN 2/28/89 10:15 JBG

86/ 4/30 5:39

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-3.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	IQ	KMS	KFM	IPUN	IMAG	IR	IPRN	CODE
5.850	0.000	7.	20.	250.	1.7320508	3	1	0	0	1	0	1	1011

I	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKD	CF	ADJUSTMENTS (KM) DLAT	DLON	DZ	PARTIAL F-VALUES DLAT	DLON	DZ	STANDARD ERRORS DLAT	DLON	DZ	ADJUSTMENTS TAKEN DLAT	DLON	DZ
1	52.88	34- 1.96	106-47.25	7.00	0	0.38	0.00	C0A	2.00	0.00	2.46	3.63	1.13	62.81	51.25	0.00	0.31	0.51	0.00	2.46	3.63
2	52.68	34- 1.96	106-48.85	10.63	1	0.12	-0.08	A0A	2.00	-0.49	0.00	0.00	3.41	0.42	-1.00	0.26	0.00	0.00	-0.49	0.00	0.00
3	52.58	34- 1.70	106-48.85	10.63	1	0.10	-0.01	A1A	0.50	0.00	0.24	-0.35	0.14	1.16	0.89	0.00	0.23	0.37	0.00	0.24	-0.35
4	52.62	34- 1.70	106-49.00	10.27	1	0.09	0.00	A3A	0.50	-0.14	0.00	0.00	0.42	-1.00	-1.00	0.22	0.00	0.00	0.00	0.00	0.00
4	52.61	34- 1.70	106-49.00	10.27	1	0.09	0.00	A2A	2.00	-0.12	0.05	-0.10	0.24	0.05	0.07	0.25	0.22	0.39	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	DM	GAP	M	RMS	ERH	ERZ	@	SQD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	MF	AVFM	SDFM	I
850430	539	52.61 34- 1.70	106-49.00	10.27	0.11	19	1	77	1	0.09	0.3	0.4	A	A1A	0.43	10	22	0.00	0.06	0	0.0	0.0	11	0.1	0.3	4

STN	DIST	AZM	AIN	PRMK	HRMN	P-SEC	TPOBS	TPCAL	DLY/H1	P-RES	P-WT	AMX	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	DT
LC3	W 1.0	322	174	P 0	539	54.20	1.59	1.76	-0.10	-0.08	1.58	0	0	0.00	0			15	-0.3	S 3	55.30	2.69	-0.20	0.35	
LC5	2.2	174	168	P 4	539	3.35	******	1.80	0.00	-51.06	0.00	0	0	0.00	0					S 4	4.30	-48.31	-51.43	0.00	
LC2	D 2.9	84	164	P 0	539	54.00	1.39	1.82	-0.36	-0.08	1.58	0	0	0.00	0			32	0.6	S 2	55.30	2.69	0.15	0.77	
LC1	D 5.1	210	154	P 0	539	54.40	1.79	1.96	-0.15	-0.03	1.59	0	0	0.00	0			20	0.0	S 2	56.20	3.59	0.45	**0.05	
CAR	D11.3	118	132	P 1	539	55.30	2.69	2.61	0.00	0.07	1.20	0	0	0.00	0			32	0.6						
WTX	D12.9	262	129	P 0	539	55.40	2.79	2.61	-0.03	0.00	1.59	0	0	0.00	0			15	-0.3						
LEM	D21.0	316	116	P 0	539	56.60	3.99	4.00	0.04	-0.06	1.57	0	0	0.00	0			25	0.3	S 2	59.60	6.99	-0.02	0.79	
BAR	W21.5	54	116	P 0	539	57.00	4.39	4.07	0.32	-0.01	1.58	0	0	0.00	0			25	0.3	S 3	60.50	7.89	0.28	0.29	
SMC	W33.4	214	107	P 1	539	58.50	5.89	5.98	-0.06	-0.03	1.13	0	0	0.00	0			18	-0.1	S 4	63.20	10.59	0.33	0.00	
LPM	W35.8	28	106	P 0	539	58.90	6.29	6.36	-0.06	-0.02	1.48	0	0	0.00	0			23	0.2	S 2	63.50	10.89	-0.05	0.74	
MAG	W41.1	291	104	P 1	539	59.80	7.19	7.24	-0.02	-0.04	1.09	0	0	0.00	0			20	0.0	S 3	65.20	12.59	0.08	0.36	
LAZ	D51.0	324	101	P 1	539	61.80	9.19	8.90	0.09	0.20	0.95	0	0	0.00	0			23	0.2	S 3	68.40	15.79	0.22	0.31	

LAT	LON	Z	AVRPS	RMS	DRMS
1.86	49.20	9.97	0.05	0.10	0.01
1.86	48.81	9.97	0.04	0.10	0.01
1.86	49.20	10.57	-0.01	0.11	(0.02)
1.86	48.81	10.57	-0.02	0.11	(0.02)
1.70	49.00	9.75	0.06	0.09	0.00
				0.09	0.00
1.70	49.00	10.79	-0.05	0.10	(0.01)
1.54	49.20	9.97	0.02	0.09	0.00
1.54	48.81	9.97	0.01	0.10	0.01
1.54	49.20	10.57	-0.04	0.10	(0.01)
1.54	48.81	10.57	-0.06	0.10	(0.01)

(5)

DATE AND TIME OF RUN 2/28/89 10:15 JBG

86/ 4/30 5:41

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-3.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	IQ	KMS	KFM	IPUN	IMAG	IR	IPRN	CODE
5.850	0.000	7.	20.	250.	1.7320508	3	1	0	0	1	0	1	1011

I	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKD	CF	ADJUSTMENTS (KM) DLAT	DLON	DZ	PARTIAL F-VALUES DLAT	DLON	DZ	STANDARD ERRORS DLAT	DLON	DZ	ADJUSTMENTS TAKEN DLAT	DLON	DZ
1	49.02	34- 1.96	106-47.25	7.00	0	0.35	0.00	C0A	2.00	-0.68	2.36	4.02	9.26	113.51	143.16	0.22	0.22	0.34	-0.68	2.36	4.02
2	48.68	34- 1.59	106-48.78	11.02	1	0.09	-0.08	A1A	0.50	0.00	0.29	-0.40	0.05	1.16	1.39	0.00	0.27	0.34	0.00	0.29	-0.40
3	48.64	34- 1.59	106-48.97	10.62	1	0.09	0.00	A3A	0.50	-0.09	0.00	0.00	0.11	-1.00	-1.00	0.26	0.00	0.00	0.00	0.00	0.00
3	48.64	34- 1.59	106-48.97	10.62	1	0.09	0.00	A2A	2.00	-0.09	0.00	0.00	0.08	0.00	0.00	0.31	0.30	0.38	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	DM	GAP	M	RMS	ERH	ERZ	Q	SQD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	NF	AVFM	SDFM	I
850430	641 48.64	34- 1.59	106-48.97	10.62	-0.27	15	1	79	1	0.09	0.4	0.4	A	A1A	0.49	10	17	0.00	0.07	0	0.0	0.0	8	-0.3	0.3	3

STN	DIST	AZM	AIN	PRMK	HRMN	P-SEC	TPOBS	TPCAL	DLY/HI	P-RES	P-WT	AMX	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	DT
LC3	1.2	326	174	P	3	641	50.30	1.66	1.83	-0.10	-0.07	0.37	0	0	0.00	0				S	2	51.70	3.06	0.07	0.75	
LC5	2.0	175	169	P	4	641	2.40	******	1.85	0.00	-43.09	0.00	0	0	0.00	0				S	4	3.75	-44.89	-48.09	0.00	
LC2	2.8	20	165	P	0	641	50.10	1.46	1.88	-0.36	-0.06	1.50	0	0	0.00	0			15-0.3	S	2	51.50	2.86	0.23	0.75	
LC1	D 5.0	211	155	P	0	641	50.40	1.76	2.00	-0.15	-0.10	1.50	0	0	0.00	0			12-0.6	S	2	51.70	3.06	-0.15	0.75	
CAR	D11.2	137	134	P	0	641	51.30	2.66	2.63	0.00	0.03	1.50	0	0	0.00	0			25 0.3*							
#TX	D13.0	293	129	P	0	641	51.50	2.86	2.87	-0.03	0.02	1.50	0	0	0.00	0			13-0.5							
LEM	D21.2	317	117	P	1	641	52.70	4.06	4.06	0.04	-0.04	1.12	0	0	0.00	0			20 0.0							
BAR	U21.6	54	116	P	0	641	53.10	4.46	4.11	0.32	0.03	1.49	0	0	0.00	0			20 0.0	S	3	56.30	7.66	-0.02	0.37	
SMC	U33.3	214	108	P	1	641	54.60	5.96	5.97	-0.06	0.04	1.06	0	0	0.00	0			11-0.7							
LPM	U35.9	28	106	P	1	641	55.00	6.36	6.41	-0.06	0.01	1.04	0	0	0.00	0				S	3	59.40	10.76	-0.23	0.35	
LAZ	D51.2	324	102	P	1	641	57.80	9.16	8.94	0.09	0.13	0.97	0	0	0.00	0			17-0.2							

LAT	LON	Z	AVRPS	RMS	DRMS
1.75	49.17	10.32	0.04	0.09	0.00
1.75	48.78	10.32	0.04	0.09	0.00
1.75	49.17	10.92	-0.03	0.10	(0.01)
1.75	48.78	10.92	-0.03	0.10	(0.01)
1.59	48.97	10.10	0.06	0.07	-0.02
				0.09	0.00
1.59	48.97	11.14	-0.06	0.09	(0.00)
1.43	49.17	10.32	0.03	0.08	-0.01
1.43	48.78	10.32	0.02	0.07	-0.02
1.43	49.17	10.92	-0.04	0.09	(0.00)
1.43	48.78	10.92	-0.04	0.09	(0.00)

(6)

DATE AND TIME OF RUN 2/23/89 10:15 JBG

86/ 4/30 15:10

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-3.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	IQ	KMS	KFM	IPUN	IMAG	IR	IPRN	CODE
5.850	0.000	7.	20.	250.	1.7320508	3	1	0	0	1	0	1	1011

I	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKD	CF	ADJUSTMENTS (KM) DLAT	DLON	DZ	PARTIAL F-VALUES DLAT	DLON	DZ	STANDARD ERRORS DLAT	DLON	DZ	ADJUSTMENTS TAKEN DLAT	DLON	DZ
1	25.95	34- 1.96	106-47.25	7.00	0	0.48	0.00	COA	2.00	0.00	5.22	4.29	0.21	22.27	23.95	0.00	0.68	0.88	0.00	5.22	4.29
2	25.52	34- 1.96	106-49.34	11.29	3	0.16	-0.12	B1B	0.50	-0.46	0.51	0.00	0.86	0.78	0.40	0.50	0.57	0.00	-0.46	0.51	0.00
3	25.38	34- 1.71	106-49.67	11.29	4	0.15	0.00	B3B	0.50	0.00	0.00	0.27	-1.00	-1.00	0.17	0.00	0.00	0.65	0.00	0.00	0.00
5	25.38	34- 1.71	106-49.67	11.29	4	0.15	0.00	B2B	2.00	-0.41	0.11	0.60	0.40	0.03	0.45	0.65	0.59	0.89	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	DM	GAP	M	RMS	ERH	ERZ	Q	SQD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	NF	AVFM	SDFM	I
650430	1310 25.38	34- 1.71	106-49.67	11.29	-0.12	12	4	120	1	0.15	0.9	0.9	B	B1B	0.69	10	16	0.00	0.13	0	0.0	0.0	5	-0.1	0.1	3

STN	DIST	AZM	AIN	PRMK	IRMN	P-SEC	TPOBS	TPCAL	DLY/HI	P-RES	P-WT	AMK	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	DT
LCS	2.6	151	167	P	4	1310	2.95******	1.98	0.00	-24.41	0.00	0	0	0.00	0					S 4	3.95	-21.43	-24.86	0.00	
LC2	3.9	86	161	P	0	1310	26.90	1.52	2.04	-0.36	-0.16	2.17	0	0	0.00	0				S 2	28.30	2.92	0.01	1.12	
LC1	D 4.7	159	157	P	1	1310	27.40	2.02	2.09	-0.15	0.08	1.68	0	0	0.00	0				S 3	29.00	3.62	0.26	0.49	
CAR	D12.1	134	153	P	2	1310	28.10	2.72	2.82	0.00	-0.10	1.11	0	0	0.00	0			20 0.0		S 4	30.00	4.62	-0.27	0.00	
LMM	20.3	318	119	P	3	1310	29.60	4.22	3.98	0.04	0.21	0.53	0	0	0.00	0			17-0.2		S 3	32.50	7.12	-0.17	0.54	
BAR	422.5	56	117	P	2	1310	30.00	4.62	4.28	0.32	0.02	1.11	0	0	0.00	0			20 0.0		S 4	33.00	7.62	-0.34	0.00	
LPM	W36.3	30	107	P	1	1310	31.90	6.52	6.49	-0.06	0.09	1.54	0	0	0.00	0			19-0.1		S 3	36.80	11.42	-0.28	0.44	
LAZ	D50.4	325	103	P	2	1310	34.10	8.72	8.83	0.09	-0.20	0.92	0	0	0.00	0			15-0.3		S 3	40.50	15.12	-0.33	0.35	

LAT	LON	Z	AVRPS	RMS	DRMS
1.87	49.87	10.99	0.04	0.16	0.01
1.87	49.48	10.99	0.06	0.16	0.01
1.87	49.87	11.59	-0.04	0.16	(0.01)
1.87	49.48	11.59	-0.02	0.16	(0.00)
1.71	49.67	10.77	0.07	0.16	0.01
				0.15	0.00
1.71	49.67	11.81	-0.07	0.15	(0.00)
1.55	49.87	10.99	0.01	0.15	0.00
1.55	49.48	10.99	0.04	0.15	0.00
1.55	49.87	11.59	-0.06	0.15	(0.00)
1.55	49.48	11.59	-0.04	0.14	(-0.01)

(7)

DATE AND TIME OF RUN 2/23/89 10:15 JBG

86/ 4/30 16:12

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-5.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	IQ	KMS	KFM	IPUN	IMAG	IR	IPRN	CODE
5.850	0.000	7.	20.	250.	1.732050*	3	1	0	0	1	0	1	1011

I	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKD	CF	ADJUSTMENTS (KM) DLAT	DLON	DZ	PARTIAL F-VALUES DLAT	DLON	DZ	STANDARD ERRORS DLAT	DLON	DZ	ADJUSTMENTS TAKEN DLAT	DLON	DZ
1	18.88	34- 1.96	106-47.25	7.00	0	0.32	0.00	C0A	2.00	0.00	1.79	3.14	0.01	37.32	43.90	0.00	0.29	0.47	0.00	1.79	3.14
2	18.70	34- 1.96	106-48.41	10.14	2	0.13	-0.05	A3A	0.50	0.00	0.00	-0.18	-1.00	-1.00	0.18	0.00	0.00	0.41	0.00	0.00	0.00
2	18.65	34- 1.96	106-48.41	10.14	2	0.13	0.00	A2A	2.00	-0.02	0.07	-0.18	0.00	0.06	0.16	0.29	0.32	0.47	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	DM	GAP	M	RMS	ERH	ERZ	Q	SQD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	NF	AVFM	SDFM	I
860430	1612 18.65	34- 1.96	106-48.41	10.14	0.49	22	2	72	1	0.13	0.4	0.5	A	A!A	3.62	10	25	0.00	0.11	0	0.0	0.0	13	0.5	0.3	2

STN	DIST	AZM	AIN	PRMK	HRMN	P-SEC	TPOBS	TPCAL	DLY/M1	P-RES	P-WT	ANK	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	DT
LC3	1.5	241	171	P	1612	20.10	1.45	1.75	-0.10	-0.21	1.19	0	0	0.00	0			22	0.1	S	2	21.80	3.15	0.28	0.68	
LC2	2.0	95	160	P	1612	19.90	1.25	1.77	-0.36	-0.16	1.21	0	0	0.00	0			31	0.5	S	2	21.10	2.45	0.01	0.84	
LC5	2.8	194	165	P	1612	3.35	******	1.80	0.00	-17.10	0.00	0	0	0.00	0					S	4	4.65	-14.00	-17.12	0.00	
LC1	6.0	215	1496	P	1612	20.40	1.75	2.01	-0.15	-0.12	1.65	3	0	0.00	0			31	0.5	S	2	21.90	3.25	0.02	0.84	
CAB	11.1	143	1520	P	1612	21.30	2.65	2.57	0.00	0.07	1.67	0	0	0.00	0			40	0.8							
WTX	13.5	289	127	P	1612	21.40	2.75	2.89	-0.03	-0.12	1.24	0	0	0.00	0			25	0.3	S	4	23.20	4.55	-0.41	0.00	
BAR	20.5	54	1164	P	1612	23.00	4.55	3.91	0.32	0.12	1.65	0	0	0.00	0			38	0.8	S	3	25.70	7.05	-0.28	0.56	
EGN	21.3	314	1150	P	1612	22.80	4.15	4.04	0.04	0.07	1.66	0	0	0.00	0			34	0.6	S	2	25.80	7.15	0.08	0.82	
S4C	34.3	215	1066	P	1612	24.70	6.05	6.12	-0.06	-0.02	1.57	0	0	0.00	0			43	0.9	S	2	29.20	10.55	0.05	0.78	
LJY	34.7	346	1061	P	1612	25.30	7.15	6.18	0.66	0.11	0.77	0	0	0.00	0			18	-0.1	*						
LPH	34.9	27	1060	P	1612	25.00	6.35	6.22	-0.06	-0.19	1.48	0	0	0.00	0			30	0.5	S	2	29.10	10.45	-0.22	0.72	
SB	35.1	260	1060	P	1612	25.10	6.45	6.25	0.28	-0.08	0.39	0	0	0.00	0			24	0.2	S	3	29.40	10.75	-0.56	**	0.01
MAG	41.8	290	1040	P	1612	26.00	7.35	7.35	-0.02	0.02	1.13	0	0	0.00	0			29	0.5							
LAZ	51.2	323	1010	P	1612	27.70	9.05	8.91	0.09	0.04	1.08	0	0	0.00	0			34	0.6	S	3	33.90	15.25	-0.35	0.24	

LAT	LON	Z	AVRPS	RMS	DRMS
2.12	48.61	9.34	0.05	0.14	0.00
2.12	48.22	9.84	0.03	0.14	0.01
2.12	48.61	10.44	-0.02	0.15	(0.02)
2.12	48.22	10.44	-0.04	0.15	(0.02)
1.96	48.41	9.62	0.05	0.13	0.00
				0.13	0.00
1.96	48.41	10.56	-0.06	0.14	(0.01)
1.80	48.61	9.34	0.04	0.13	0.00
1.80	48.22	9.84	0.02	0.13	0.00
1.80	48.61	10.44	-0.03	0.14	(0.01)
1.80	48.22	10.44	-0.05	0.14	(0.01)

(3)

DATE AND TIME OF RUN 2/23/89 10:15 JBG

86/ 4/30 16:15

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-3.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	IQ	KMS	KFM	IPUN	IMAG	IR	IPRN	CODE
5.950	0.000	7.	20.	250.	1.7320508	3	1	0	0	1	0	1	1011

I	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKD	CF	ADJUSTMENTS (KM) DLAT	DLON	DZ	PARTIAL F-VALUES DLAT	DLON	DZ	STANDARD ERRORS DLAT	DLON	DZ	ADJUSTMENTS TAKEN DLAT	DLON	DZ
1	27.74	34- 1.96	106-47.25	7.00	0	0.32	0.00	C0A	2.00	0.00	2.51	1.61	0.61	131.07	22.04	0.00	0.22	0.34	0.00	2.51	1.61
2	27.73	34- 1.96	106-48.88	8.61	1	0.10	-0.04	A0A	2.00	0.00	0.00	-0.47	0.82	-1.00	2.48	0.00	0.00	0.30	0.00	0.00	-0.47
3	27.74	34- 1.96	106-48.88	8.14	1	0.09	0.00	A1A	0.50	-0.16	0.00	0.00	0.85	0.06	-1.00	0.17	0.00	0.00	-0.16	0.00	0.00
4	27.74	34- 1.88	106-48.88	8.14	1	0.09	0.00	A3A	0.50	0.00	0.06	0.00	-1.00	0.09	-1.00	0.00	0.19	0.00	0.00	0.00	0.00
4	27.74	34- 1.88	106-48.88	8.14	1	0.09	0.00	A2A	2.00	-0.03	0.05	0.05	0.02	0.05	0.02	0.20	0.21	0.33	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	DM	GAP	M	RMS	ERH	ERZ	Q	SQD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	NF	AVFM	SDFM	I
890430	1615	27.74	34- 1.88	106-48.88	8.14	0.28	21	1	70	1	0.09	0.3	0.3	A	A1A	0.16	10	24	0.00	0.07	0	0.0	0.0	12	0.3	0.3	4

STN	DIST	AZM	AIN	PRMK	ARMN	P-SEC	TPOBS	TPCAL	DLY/H1	P-RES	P-WT	AMX	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	DT
LC3	0.9	299	174	P	1 1615	29.00	1.26	1.40	-0.10	-0.04	1.31	0	0	0.00	0			18	-0.1	S	3 30.10	2.36	0.11	0.42	
LC5	2.6	179	163	P	4 1615	3.35	******	1.46	0.00	-25.85	0.00	0	0	0.00	0					S	4 4.70	-23.04	-25.57	0.00	
LC2	2.7	91	1520	P	0 1615	28.80	1.06	1.46	-0.36	-0.04	1.74	0	0	0.00	0			21	0.1	S	2 29.80	2.06	0.15	0.81	
LC1	5.5	210	1469	P	0 1615	29.20	1.46	1.68	-0.15	-0.07	1.74	0	0	0.00	0			27	0.4	S	2 30.30	2.56	-0.09	0.86	
CAR	11.5	140	125	P	0 1615	30.20	2.46	2.40	0.00	0.06	1.73	0	0	0.00	0			40	0.8*	S	4 31.90	4.16	0.00	0.00	
WTX	12.9	291	122	P	3 1615	30.40	2.66	2.61	-0.03	0.08	0.43	0	0	0.00	0			20	0.0						
LEM	20.9	315	1110	P	0 1615	31.70	3.96	3.84	0.04	0.08	1.72	0	0	0.00	0			30	0.5	S	3 34.70	6.96	0.24	0.29	
BAR	21.2	55	1114	P	0 1615	31.90	4.16	3.88	0.32	-0.03	1.74	0	0	0.00	0			32	0.6	S	3 34.70	6.96	-0.31	0.21	
SMC	33.8	214	1045	P	1 1615	33.60	5.86	5.95	-0.06	-0.03	1.23	0	0	0.00	0			21	0.1	S	2 38.00	10.26	0.07	0.81	
SS	34.4	200	1035	P	2 1615	34.00	6.26	6.04	0.28	-0.06	0.82	0	0	0.00	0			22	0.1	S	2 38.30	10.56	-0.39	**	0.10
LPM	35.4	28	1053	P	0 1615	34.00	6.26	6.21	-0.06	0.11	1.58	0	0	0.00	0			29	0.5	S	3 38.30	10.56	-0.09	0.40	
MAG	41.2	291	1019	P	1 1615	34.90	7.16	7.17	-0.02	0.01	1.19	0	0	0.00	0			24	0.2						
LAZ	50.9	324	990	P	1 1615	36.60	8.86	8.80	0.09	-0.03	1.13	0	0	0.00	0			27	0.4	S	2 43.00	15.26	-0.15	0.73	

LAT	LON	Z	AVRPS	RMS	DRMS
2.04	49.07	7.34	0.04	0.09	0.01
2.04	48.68	7.34	0.03	0.10	0.02
2.04	49.07	3.44	-0.03	0.10	(0.02)
2.04	48.68	8.44	-0.03	0.10	(0.02)
1.88	48.88	7.63	0.05	0.10	0.01
				0.09	0.00
1.88	48.88	8.66	-0.05	0.10	(0.01)
1.71	49.07	7.34	0.03	0.10	0.01
1.71	48.68	7.34	0.02	0.11	0.02
1.71	49.07	3.44	-0.03	0.10	(0.01)
1.71	48.68	8.44	-0.04	0.10	(0.01)

(9)

DATE AND TIME OF RUN 2/28/89 10:15 JBG

86/ 4/30 18: 6

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-3.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	IQ	KNS	KFM	IPUN	IMAG	IR	IPRN	CODE
5.950	0.000	7.	20.	250.	1.7320508	3	1	0	0	1	0	1	1011

I	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKD	CF	ADJUSTMENTS (KM) DLAT	DLON	DZ	PARTIAL F-VALUES DLAT	DLON	DZ	STANDARD ERRORS DLAT	DLON	DZ	ADJUSTMENTS TAKEN DLAT	DLON	DZ
1	54.25	34- 1.96	106-47.25	7.00	3	0.56	0.00	COA	2.00	-0.76	2.04	4.68	4.65	30.73	62.62	0.35	0.57	0.59	-0.76	2.04	4.68
2	53.71	34- 1.55	106-48.58	11.68	2	0.10	-0.09	A18	0.50	0.00	0.33	0.00	-1.00	1.04	0.20	0.00	0.32	0.00	0.00	0.33	0.00
3	55.61	34- 1.55	106-48.79	11.68	1	0.09	0.00	A38	0.50	0.00	0.00	-0.17	-1.00	-1.00	0.22	0.00	0.00	0.36	0.00	0.00	0.00
5	53.62	34- 1.55	106-48.79	11.68	1	0.09	0.00	A28	2.00	0.02	0.05	-0.19	0.00	0.02	0.15	0.36	0.35	0.48	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	DM	GAP	M	RMS	ERH	ERZ	Q	SQD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	NF	AVFM	SDFM	I
860430	18 6 53.62	34- 1.55	106-48.79	11.68	-0.31	13	1	102	1	0.09	0.5	0.5	B	A18	0.33	10	18	0.00	0.07	0	0.0	0.0	5	-0.3	0.1	3

STN	DIST	AZM	AIN	PRMK	HRMN	P-SEC	TPOBS	TPCAL	DLY/R1	P-RES	P-WT	AMK	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	DT
LCS	1.4	318	173	P	4 18	55.00	1.38	2.01	-0.10	-0.53	0.00	0	0	0.00	0					S 3	57.00	3.38	0.07	0.44	
LCS	2.0	183	170	P	4 18	55.20	******	2.02	0.00	-52.44	0.00	0	0	0.00	0					S 4	4.30	-49.32	-52.82	0.00	
LC2	2.6	77	168	P	0 18	55.30	1.68	2.05	-0.36	0.00	1.77	0	0	0.00	0					S 2	56.50	2.88	-0.03	0.88	
LC1	5.1	215	157	P	1 18	55.60	1.98	2.18	-0.15	-0.04	1.52	0	0	0.00	0					S 3	57.20	3.58	0.08	0.44	
CAR	10.9	158	157	P	0 18	56.30	2.68	2.73	0.00	-0.05	1.77	0	0	0.00	0			18	-0.1	S 3	58.00	4.38	-0.35	**0.07	
BAR	21.4	53	119	P	0 18	58.20	4.58	4.17	0.32	0.10	1.70	0	0	0.00	0			17	-0.2	S 3	61.30	7.68	-0.09	0.43	
LSM	21.5	316	119	P	1 18	57.80	4.18	4.18	0.04	-0.03	1.52	0	0	0.00	0			14	-0.4	S 4	59.90	6.28	-1.02	0.00	
LSM	35.9	27	108	P	1 18	60.20	6.58	6.45	-0.06	-0.20	1.00	0	0	0.00	0			15	-0.3	S 2	64.50	10.88	-0.18	0.74	
LAZ	51.4	324	103	P	1 18	62.70	9.08	9.01	0.09	-0.02	1.14	0	0	0.00	0			14	-0.4	S 4	66.00	12.38	-3.39	0.00	

LAT	LON	Z	AVRPS	RMS	DRMS
1.71	48.98	11.38	0.05	0.09	0.00
1.71	48.59	11.58	0.06	0.10	0.01
1.71	48.98	11.98	-0.05	0.10	(0.01)
1.71	48.59	11.98	-0.02	0.11	(0.02)
1.55	48.79	11.16	0.07	0.09	0.00
				0.09	0.00
1.55	48.79	12.20	-0.07	0.10	(0.01)
1.39	48.98	11.38	0.02	0.09	0.00
1.39	48.59	11.58	0.03	0.10	0.01
1.39	48.98	11.98	-0.06	0.10	(0.01)
1.39	48.59	11.98	-0.05	0.10	(0.01)

(19

DATE AND TIME OF RUN 2/28/89 10:15 JBG

86/ 5/ 1 5:53

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-3.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	IQ	KMS	KFM	IPUN	IMAG	IR	IPRN	CODE
5.950	0.000	7.	20.	250.	1.7320508	3	1	0	0	1	0	1	1011

I	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKD	CF	ADJUSTMENTS (KM) DLAT	DLON	DZ	PARTIAL F-VALUES DLAT	DLON	DZ	STANDARD ERRORS DLAT	DLON	DZ	ADJUSTMENTS TAKEN DLAT	DLON	DZ
1	29.67	34- 1.96	106-47.25	7.00	0	0.30	0.00	C0B	2.00	-0.93	2.23	4.52	14.04	65.31	92.67	0.25	0.28	0.47	-0.93	2.23	4.52
2	29.06	34- 1.46	106-48.70	11.52	2	0.07	-0.07	A1C	0.50	0.28	0.34	-0.33	1.04	1.58	0.69	0.28	0.27	0.40	0.28	0.34	-0.33
2	29.03	34- 1.61	106-48.92	11.19	1	0.10	-0.02	A1C	0.50	0.00	0.00	0.00	-1.00	-1.00	-1.00	0.00	0.00	0.00	-0.06	-0.07	0.07
2	29.03	34- 1.58	106-48.88	11.26	1	0.10	-0.01	A1C	0.50	0.00	0.00	0.00	-1.00	-1.00	-1.00	0.00	0.00	0.00	-0.06	-0.07	0.07
2	29.02	34- 1.55	106-48.83	11.32	1	0.10	-0.01	A1C	0.50	0.00	0.00	0.00	-1.00	-1.00	-1.00	0.00	0.00	0.00	-0.06	-0.07	0.07
2	29.01	34- 1.52	106-48.79	11.39	1	0.10	-0.01	A1C	0.50	0.00	0.00	0.00	-1.00	-1.00	-1.00	0.00	0.00	0.00	-0.06	-0.07	0.07
3	29.00	34- 1.49	106-48.75	11.46	2	0.10	-0.01	A1C	0.50	0.00	0.00	-0.40	0.04	-1.00	0.78	0.00	0.00	0.45	0.00	0.00	-0.40
4	29.04	34- 1.49	106-48.75	11.06	2	0.09	0.00	A3C	0.50	0.00	0.11	0.00	-1.00	0.10	-1.00	0.00	0.34	0.00	0.00	0.00	0.00
4	29.04	34- 1.49	106-48.75	11.06	2	0.09	0.00	A2C	2.00	-0.07	0.10	0.07	0.03	0.07	0.01	0.37	0.38	0.58	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	DM	GAP	M	RMS	ERH	ERZ	Q	SQD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	NF	AVFM	SDFM	I
890501	353 29.04	34- 1.49	106-48.75	11.06	-0.49	12	2	178	1	0.09	0.5	0.6	B	A1C	0.40	10	16	0.00	0.07	0	0.0	0.0	6	-0.5	0.3	4

STN	DIST	AZM	AIN	PRMK	HRMN	P-SEC	TPOBS	TPCAL	DLY/H1	P-RES	P-WT	AMX	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	DT
LC3	1.5	319	172	P	2	353	30.80	1.76	1.91	-0.10	-0.05	0.87	0	0	0.00	0			S	3	32.20	3.16	0.03	0.44		
LC5	1.9	155	170	P	4	353	1.28	******	1.92	0.00	-27.67	0.00	0	0	0.00	0			10-0.8	S	4	4.35	-24.69	-28.01	0.00	
LC2	2.6	24	1670	P	0	353	30.70	1.66	1.94	-0.56	0.08	1.75	0	0	0.00	0				S	3	31.90	2.86	0.13	0.44		
CAR	10.8	138	1360	P	0	353	31.70	2.66	2.64	0.00	0.02	1.75	0	0	0.00	0			20 0.0	S		33.30	4.26	-0.31	0.44	
BAR	21.4	53	117u	P	0	353	33.50	4.46	4.12	0.32	0.02	1.74	0	0	0.00	0			12-0.6	S	2	36.70	7.66	-0.05	0.87	
LSM	21.6	316	117-	P	1	353	33.10	4.06	4.15	0.04	-0.13	1.50	0	0	0.00	0			15-0.3	S	4	36.00	6.96	-0.29	0.00	
LSM	35.9	27	107u	P	1	353	35.50	6.46	6.45	-0.06	0.09	1.22	0	0	0.00	0			15-0.5	S	2	40.00	10.96	-0.07	0.81	
LAZ	51.5	324	102-	P	3	353	38.20	9.16	9.01	0.09	0.06	0.38	0	0	0.00	0			12-0.6	S	4	41.00	11.96	-3.81	0.00	

MISSING STATION	DELTA	AZIM	EX-GAP	RD-GAP
LC1	5.0	216.0	178.2	77.9

LAT	LON	Z	AVRPS	RMS	DRMS
1.65	48.94	10.76	0.05	0.07	-0.03
1.65	48.55	10.76	0.08	0.09	-0.01
1.65	48.94	11.36	-0.02	0.06	(-0.03)
1.65	48.55	11.36	0.01	0.08	(-0.01)
1.49	48.75	10.54	0.07	0.09	0.00
				0.09	0.00
1.49	48.75	11.58	-0.05	0.07	(-0.02)
1.32	48.94	10.76	0.01	0.10	0.00
1.32	48.55	10.76	0.04	0.10	0.01
1.32	48.94	11.36	-0.06	0.08	(-0.01)
1.32	48.55	11.36	-0.03	0.09	(0.00)

(11)

DATE AND TIME OF RUN 2/23/89 10:15 JBG

86/ 5/ 1 9:32

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-5.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	IQ	KMS	KFM	IPUN	IMAG	IR	IPRN	CODE
5.350	0.000	7.	20.	250.	1.7320508	5	1	0	0	1	0	1	1011

I	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKD	CF	ADJUSTMENTS (KM) DLAT	DLON	DZ	PARTIAL F-VALUES DLAT	DLON	DZ	STANDARD ERRORS DLAT	DLON	DZ	ADJUSTMENTS TAKEN DLAT	DLON	DZ
1	7.47	34- 1.96	106-47.25	7.00	0	0.34	-0.00	COA	2.00	-0.46	2.77	1.59	4.03135.64		17.34	0.25	0.24	0.35	-0.46	2.77	1.59
2	7.37	34- 1.71	106-49.05	8.59	1	0.10	-0.06	AOA	2.00	0.00	0.00	-0.55	-1.00	0.05	3.66	0.00	0.00	0.28	0.00	0.00	-0.55
3	7.38	34- 1.71	106-49.05	7.85	1	0.09	0.00	ASA	0.50	0.00	0.10	0.00	-1.00	0.22	-1.00	0.00	0.22	0.00	0.00	0.00	0.00
5	7.38	34- 1.71	106-49.05	7.85	1	0.09	0.00	AZA	2.00	0.03	0.12	-0.12	0.02	0.24	0.13	0.24	0.25	0.34	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	DM	GAP	M	RMS	ERH	ERZ	Q	SQD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	NF	AVFM	SDFM	I
850501	932	7.38	34- 1.71	106-49.05	7.85	-0.29	17	1	77	1	0.09	0.3	0.5	A	AFA	0.55	10	20	0.00	0.07	0	0.0	0.0	7	-0.3	0.4	5

STN	DIST	AZM	AIN	PRMK	HRMN	P-SEC	TPOBS	TPCAL	DLY/N1	P-RES	P-WT	AMK	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	DT
LCS	0 0.9	324	173	P	0	932	8.50	1.12	1.35	-0.10	-0.13	1.59	0	0	0.00	0				S 2	9.60	2.22	0.06	0.79	
LCS	2.5	123	164	P	4	932	8.55******		1.40	-0.00	-5.42	0.00	0	0	0.00	0				S 4	4.60	-5.78	-5.20	0.00	
LCS	2.9	85	159	P	0	932	8.40	1.02	1.43	-0.36	-0.05	1.59	0	0	0.00	0				S 2	9.40	2.02	0.17	0.79	
LCS	0 5.1	209	147	P	1	932	8.80	1.42	1.60	-0.15	-0.03	1.19	0	0	0.00	0				S 2	9.70	2.32	-0.19	0.79	
CAR	0 11.4	218	125	P	3	932	9.70	2.32	2.57	0.00	-0.04	1.59	0	0	0.00	0		25	0.5*	S 2	11.70	4.32	0.23	0.79	
LEM	0 21.0	316	111	P	5	932	11.30	3.92	3.83	0.04	0.06	0.40	0	0	0.00	0		17	-0.2	S 4	14.50	7.12	0.42	0.00	
BAR	W 21.5	44	110	P	0	932	11.60	4.22	3.92	0.32	-0.02	1.58	0	0	0.00	0		22	0.1	S 2	14.70	7.32	-0.02	0.79	
SHC	W 33.4	214	103	P	1	932	13.20	5.82	5.87	-0.06	0.02	1.12	0	0	0.00	0		9	-1.0*	S 3	17.50	10.12	-0.06	0.37	
LPM	W 35.8	28	102	P	1	932	13.60	6.22	6.26	-0.06	0.02	1.11	0	0	0.00	0		15	-0.5	S 3	18.10	10.72	-0.02	0.37	
MAG	41.0	251	101	P	1	932	14.50	7.12	7.14	-0.02	0.00	1.08	0	0	0.00	0		15	-0.5						
LRZ	51.0	324	99	P	1	932	16.40	9.02	8.81	0.09	0.12	1.03	0	0	0.00	0		15	-0.5						

LAT	LON	Z	AVRPS	RMS	DRMS
1.87	49.24	7.55	0.03	0.09	0.00
1.87	48.85	7.55	-0.04	0.10	0.01
1.87	49.24	8.15	-0.04	0.10	(0.01)
1.87	48.85	8.15	-0.02	0.10	(0.01)
1.71	49.05	7.33	0.05	0.08	-0.01
				0.09	0.00
1.71	49.05	8.36	-0.06	0.10	(0.00)
1.55	49.24	7.55	0.02	0.10	0.00
1.55	48.85	7.55	0.02	0.08	-0.01
1.55	49.24	8.15	-0.05	0.10	(0.01)
1.55	48.85	8.15	-0.04	0.08	(-0.01)

(12)

DATE AND TIME OF RUN 2/28/89 10:15 JBG

86/ 5/ 1 11:43

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(15)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-3.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	IQ	KHS	KFM	IPUN	IMAG	IR	IPRN	CODE
5.850	0.000	7.	20.	250.	1.7320508	3	1	0	0	1	0	1	1011

											ADJUSTMENTS (KM)			PARTIAL F-VALUES			STANDARD ERRORS			ADJUSTMENTS TAKEN		
I	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKO	CF	DLAT	DLON	DZ	DLAT	DLON	DZ	DLAT	DLON	DZ	DLAT	DLON	DZ
1	37.25	34- 1.96	106-47.25	7.00	0	0.27	0.00	808	2.00	-0.89	1.53	4.45	5.20	9.16	17.11	0.45	0.50	1.08	-0.39	1.53	4.45
3	36.21	34- 1.48	106-48.23	11.45	2	0.11	-0.07	A3C	0.50	-0.20	0.00	0.00	0.32	-1.00	-1.00	0.36	0.00	0.00	0.00	0.00	0.00
2	36.64	34- 1.48	106-48.23	11.45	2	0.11	0.00	A2C	2.00	-0.27	0.06	0.19	0.25	0.01	0.03	0.54	0.55	1.01	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	DM	GAP	M	RMS	ERH	ERZ	Q	SQD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	NF	AVFM	SDFM	I
850501	1143	36.64	34- 1.48	106-48.23	11.45	-0.46	10	2	162	1	0.11	0.8	1.0	B	AIC	4.78	10	16	0.00	0.08	0	0.0	0.0	5	-0.5	0.2	2

STN	DIST	AZM	AIN	PRMK	HRMN	P-SEC	TPOBS	TPCAL	DLY/HI	P-RES	P-WT	ANX	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	DT
LCC	1.8	07	171	P	1143	38.20	1.56	1.98	-0.36	-0.06	1.46	0	0	0.00	0					S	3 39.80	3.16	0.35	0.24	
LCS	2.1	228	170-	P	1145	2.95	******	1.99	0.00	-35.68	0.00	0	0	0.00	0					S	4 4.30	-32.34	-35.78	0.00	
LCS	2.2	505	169-	P	1145	38.90	2.26	1.99	-0.10	0.37	0.21	0	0	0.00	0					S	4 41.40	4.76	1.48	0.00	
BAR	19.8	141	119	P	1145	39.50	2.66	2.63	0.00	0.03	1.97	0	0	0.00	0			19-0.1		S	2 41.00	4.36	-0.19	0.90	
BAR	20.8	51	119A	P	1145	41.10	4.46	4.06	0.32	0.08	1.47	0	0	0.00	0			15-0.3		S	2 44.20	7.56	-0.02	0.98	
LRM	22.2	315	117	P	1145	40.90	4.26	4.27	0.04	-0.05	0.98	0	0	0.00	0			12-0.6		S	4 43.00	6.36	-1.10	0.00	
LRM	35.6	326	108A	P	1145	43.00	6.36	6.39	-0.06	-0.03	1.38	0	0	0.00	0			11-0.7		S	4 46.00	9.36	-1.61	0.00	
LAZ	52.0	324	102-	P	1143	45.70	9.06	9.11	0.09	-0.14	0.41	0	0	0.00	0			13-0.5		S	4 49.00	12.36	-3.57	0.00	

LAT	LON	Z	AVRPS	RMS	DRMS
1.64	48.42	11.15	0.03	0.12	0.01
1.64	48.03	11.15	0.07	0.12	
1.64	48.42	11.75	-0.03	0.13	(0.02)
1.64	48.03	11.75	0.00	0.13	0.02
					(0.02)
1.48	48.23	10.93	0.06	0.10	-0.01
				0.11	0.00
1.48	48.23	11.97	-0.06	0.12	(0.01)
1.31	48.42	11.15	0.00	0.10	-0.01
1.31	48.03	11.15	0.04	0.11	
1.31	48.42	11.75	-0.07	0.11	(0.00)
1.31	48.03	11.75	-0.03	0.11	0.00
					(0.01)

(13)

DATE AND TIME OF RUN 2/28/89 10:15 JBG

86/ 5/ 1 16:28

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-3.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	IQ	KMS	KFM	IPUN	INAG	IR	IPRN	CODE
5.850	0.000	7.	20.	250.	1.7320508	3	1	0	0	1	0	1	1011

I	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKD	CF	ADJUSTMENTS (KM) DLAT	DLON	DZ	PARTIAL F-VALUES DLAT	DLON	DZ	STANDARD ERRORS DLAT	DLON	DZ	ADJUSTMENTS TAKEN DLAT	DLON	DZ
1	32.82	34- 1.96	106-47.25	7.00	0	0.31	0.00	C0A	2.00	0.00	2.66	0.00	1.85	39.88	-1.00	0.00	0.42	0.00	0.00	2.66	0.00
2	32.98	34- 1.96	106-48.98	7.00	1	0.16	-0.05	B0A	2.00	-0.50	0.00	0.00	2.18	-1.00	0.06	0.34	0.00	0.00	-0.50	0.00	0.00
3	32.92	34- 1.69	106-48.93	7.00	1	0.15	0.00	A3A	0.50	0.00	0.00	-0.21	-1.00	-1.00	0.13	0.00	0.00	0.59	0.00	0.00	0.00
5	32.92	34- 1.69	106-48.98	7.00	1	0.15	0.00	A2A	2.00	-0.03	0.01	-0.21	0.01	0.00	0.09	0.37	0.38	0.68	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	DM	GAP	M	RMS	ERH	ERZ	Q	SQD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	NF	AVFM	SDFM	I
850501	1628 32.92	34- 1.69	106-48.98	7.00	0.64	17	1	76	1	0.15	0.5	0.7	A	A1A	0.50	10	21	0.00	0.11	0	0.0	0.0	11	0.6	0.4	5

STN		DIST	AZM	AIN	PRMK	ARMN	P-SEC	TPOBS	TPCAL	DLY/M1	P-RES	P-WT	AMX	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	DT
LC3	W	1.0	320	172	P	0	1628	33.90	0.98	1.21	-0.10	-0.13	1.54	0	0	0.00	0			50	1.1	S	3	35.10	2.18	0.26	0.56	
LC5		2.2	175	162	P	4	1628	3.35	******	1.26	0.00	-30.83	0.00	0	0	0.00	0					S	4	4.75	-28.17	-30.35	0.00		
EC2	W	2.3	84	158	P	0	1628	33.70	0.78	1.29	-0.35	-0.15	1.52	0	0	0.00	0			37	0.7	S	3	34.70	1.78	0.17	0.38	
CAR	D	11.5	138	122	P	0	1628	35.10	2.18	2.27	0.00	-0.09	1.54	0	0	0.00	0												
WTX	D	12.9	292	118	P	1	1628	35.60	2.68	2.51	-0.03	0.20	1.12	0	0	0.00	0			15	-0.3*								
LEM	D	21.1	316	108	P	0	1628	36.80	3.88	3.80	0.04	0.04	1.55	0	0	0.00	0			39	0.8								
BAR	W	21.5	54	108	P	0	1628	37.20	4.28	3.86	0.32	0.10	1.53	0	0	0.00	0			48	1.1								
SNC	W	33.4	214	102	P	0	1628	38.70	5.78	5.84	-0.06	0.00	1.46	0	0	0.00	0			35	0.7	S	2	43.00	10.08	-0.07	0.73	
SB		34.2	260	102	P	2	1628	39.40	6.48	5.96	0.28	0.24	0.68	0	0	0.00	0			28	0.4	S	2	43.40	10.48	-0.33	0.56	
LJY		35.0	348	101	P	3	1628	40.40	7.48	6.10	0.86	0.52	**	0.05	0	0	0.00	0		25	0.3	S	4	45.60	12.68	-0.63	0.00	
EPM	W	35.8	28	101	P	0	1628	39.10	6.18	6.23	-0.06	0.01	1.45	0	0	0.00	0			40	0.8	S	4	43.30	10.38	-0.31	0.00	
MAG		41.2	291	100	P	2	1628	40.20	7.28	7.14	-0.02	0.16	0.68	0	0	0.00	0			34	0.6								
LAZ		51.0	324	98	P	0	1628	41.80	8.88	8.81	0.09	-0.02	1.34	0	0	0.00	0			40	0.8	S	2	48.00	15.08	-0.33	0.52	

LAT	LON	Z	AVRPS	RMS	DRMS
1.85	49.17	6.70	0.04	0.15	0.01
1.85	48.78	6.70	0.02	0.15	
1.85	49.17	7.30	-0.01	0.16	0.00
1.85	48.78	7.30	-0.03	0.15	(0.01)
					(0.01)
1.69	48.98	6.48	0.04	0.14	0.00
				0.15	0.00
1.69	48.98	7.52	-0.04	0.15	(0.01)
1.53	49.17	6.70	0.03	0.15	0.01
1.53	48.78	6.70	0.02	0.14	
1.53	49.17	7.30	-0.02	0.16	0.00
1.53	48.78	7.30	-0.04	0.15	(0.01)
					(0.00)

(14)

DATE AND TIME OF RUN 2/28/89 10:15 JBG

86/ 5/ 1 19: 6

	TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)
RESET TO	0.1000	10.0000	2.0000	0.0500	6.0000	4.0000	-5.6300	2.7900	0.0000	100.0000	8.0000	0.5000	0.3000

VELOCITY	DEPTH	ZTR	XNEAR	XFAR	POS	IQ	KAS	KFM	IPUN	IMAG	IR	IPRN	CODE
5.950	0.000	7.	20.	250.	1.7320508	3	1	0	0	1	0	1	1011

I	ORIG	LAT N	LONG W	DEPTH	DM	RMS	AVRPS	SKD	CF	ADJUSTMENTS (KM) DLAT	DLON	DZ	PARTIAL F-VALUES DLAT	DLON	DZ	STANDARD ERRORS DLAT	DLON	DZ	ADJUSTMENTS TAKEN DLAT	DLON	DZ
1	59.82	34- 1.96	106-47.25	7.00	0	0.30	0.00	B0B	2.00	-1.86	2.18	3.27	14.52	10.78	13.75	0.49	0.67	0.88	-1.86	2.18	3.27
2	59.28	34- 0.95	106-48.67	10.27	2	0.14	-0.08	A1D	0.50	-0.34	0.00	0.00	0.56	-1.00	0.18	0.45	0.00	0.00	-0.34	0.00	0.00
3	59.18	34- 0.77	106-48.67	10.27	3	0.14	0.00	A3D	0.50	0.00	0.00	-0.27	-1.00	-1.00	0.19	0.00	0.00	0.63	0.00	0.00	0.00
5	59.18	34- 0.77	106-48.67	10.27	3	0.14	0.00	A2D	2.00	0.05	0.21	-0.29	0.01	0.09	0.12	0.57	0.71	0.81	0.00	0.00	0.00

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	DM	GAP	M	RMS	ERH	ERZ	Q	SQD	ADJ	IN	NR	AVR	AAR	NM	AVXM	SDXM	NF	AVFM	SDFM	I
850501	19 6 59.18	34- 0.77	106-48.67	10.27	-0.28	11	3	185	1	0.14	0.9	0.8	C	A1D	0.34	10	14	0.00	0.12	0	0.0	0.0	4	-0.3	0.2	3

STN	DIST	AZM	AIN	PRMK	HRMN	P-SEC	TPOBS	TPCAL	DLY/HI	P-RES	P-WT	AMC	PRX	CALX	K	XMAG	RMK	FMP	FMAG	SRMK	S-SEC	TSOBS	S-RES	S-WT	DT
LCS	0.6	210	177	P	4 19 7	3.25	4.07	1.76	0.00	2.31	0.00	0	0	0.00	0					S 4	4.30	5.12	2.07	0.00	
LCS	2.7	356	165	D	P 1 19 7	0.70	1.52	1.82	-0.10	-0.20	1.15	0	0	0.00	0					S 3	2.30	3.12	0.15	0.40	
LC2	3.1	49	165	D	P 0 19 7	0.60	1.42	1.85	-0.36	-0.05	1.65	0	0	0.00	0					S 2	1.80	2.62	0.07	0.83	
CAR	9.7	133	156	B	P 0 19 7	1.80	2.62	2.42	0.00	-0.20	1.55	0	0	0.00	0			20	0.0	S 2	3.20	4.02	-0.17	0.78	
BAR	22.2	50	115	A	P 0 19 7	3.60	4.42	4.17	0.32	-0.08	1.62	0	0	0.00	0			15	-0.3	S 3	6.90	7.72	-0.07	0.41	
LEM	22.6	318	114	-	P 2 19 7	3.40	4.22	4.25	0.04	-0.07	0.82	0	0	0.00	0			15	-0.5	S 4	5.60	6.42	-1.01	0.00	
LPM	37.1	26	105	A	P 1 19 7	5.90	6.72	6.58	-0.06	0.20	1.05	0	0	0.00	0			14	-0.4	S 2	10.50	11.32	0.03	0.76	

LAT	LON	Z	AVRPS	RMS			DRMS		
0.93	48.86	9.97	0.04	0.14	0.00				
0.93	48.47	9.97	0.08	0.14			0.00		
0.93	48.86	10.57	-0.04	0.14	(0.01)				
0.93	48.47	10.57	-0.01	0.15			(0.01)		
0.77	48.67	9.75	0.07	0.14		0.00			
				0.14		0.00			
0.77	48.67	10.79	-0.07	0.15		(0.01)			
0.61	48.86	9.97	0.00	0.14	0.00				
0.61	48.47	9.97	0.04	0.14			0.01		
0.61	48.86	10.57	-0.08	0.14	(0.00)				
0.61	48.47	10.57	-0.04	0.14			(0.01)		

***** EXTRA BLANK CARD ENCOUNTERED *****

Appendix B

This appendix contains first motion diagrams of the 15 Loma de las Cañas swarm events used in this study. Each event is plotted on the upper focal sphere of an Equal Area Net stereographic projection.

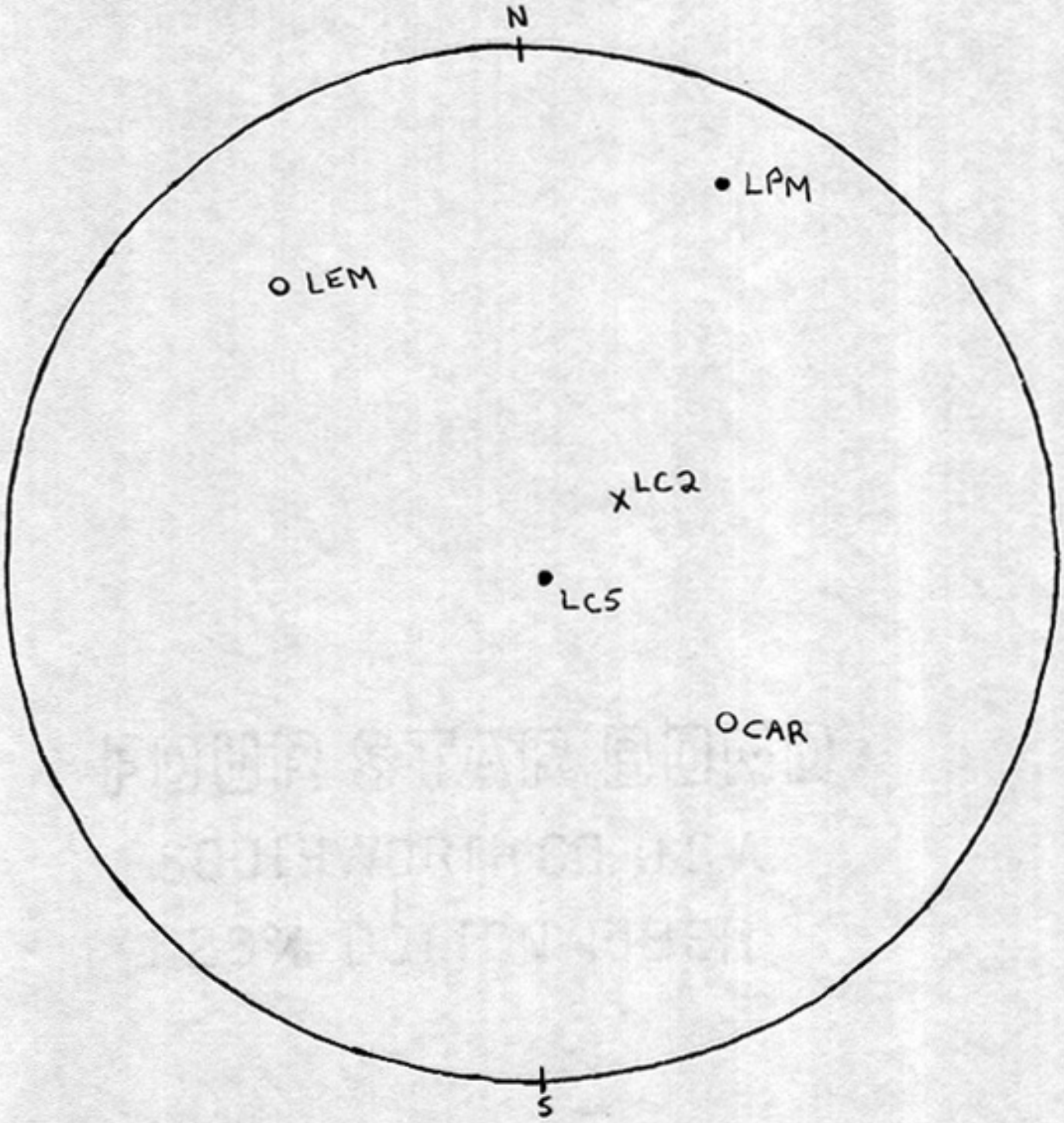

Figure B-1. First motion diagram for the earthquake occurring 4/30/86 at 00:11 GMT.

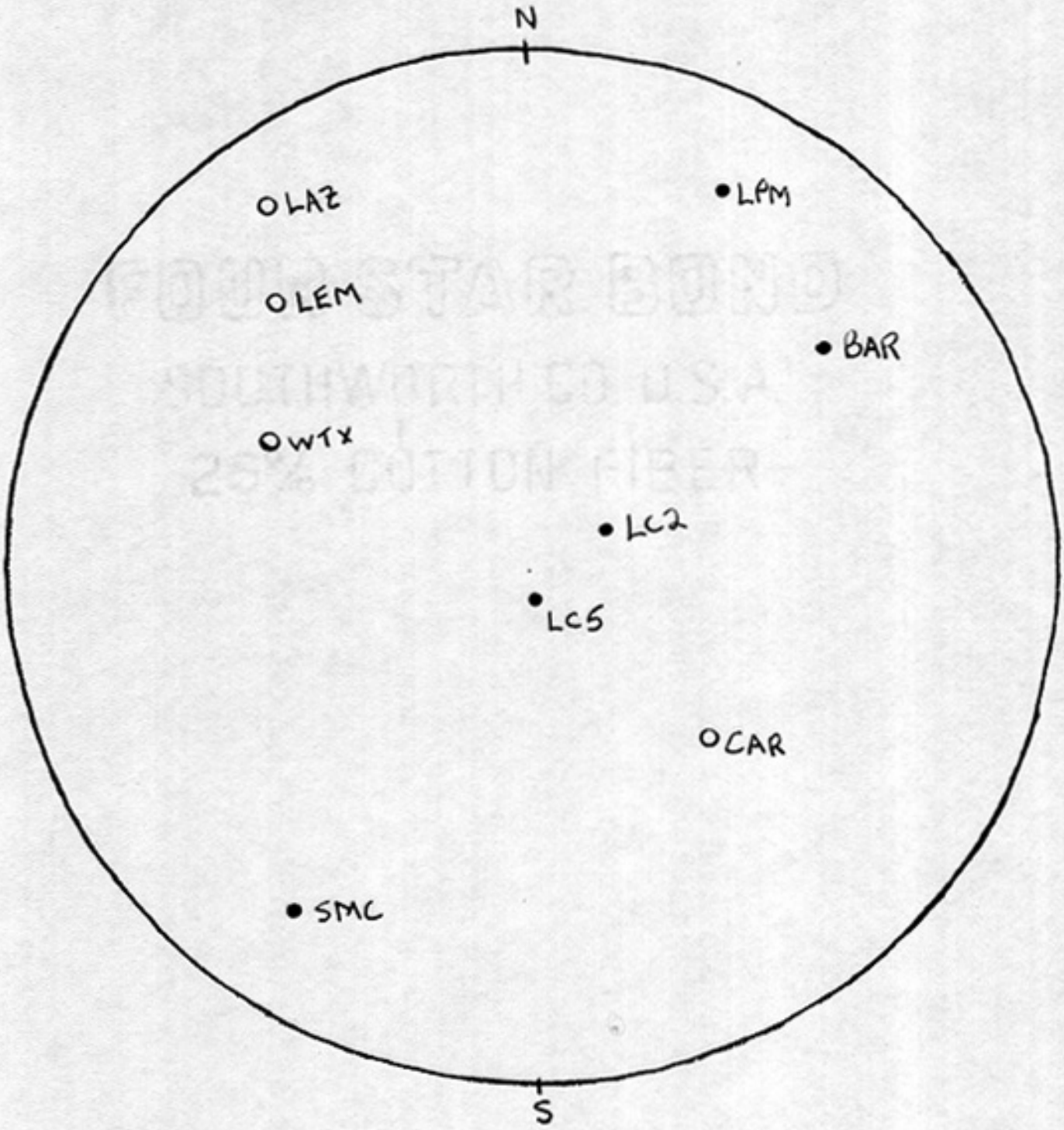

Figure B-2. First motion diagram for the earthquake occurring 4/30/86 at 01:28 GMT.

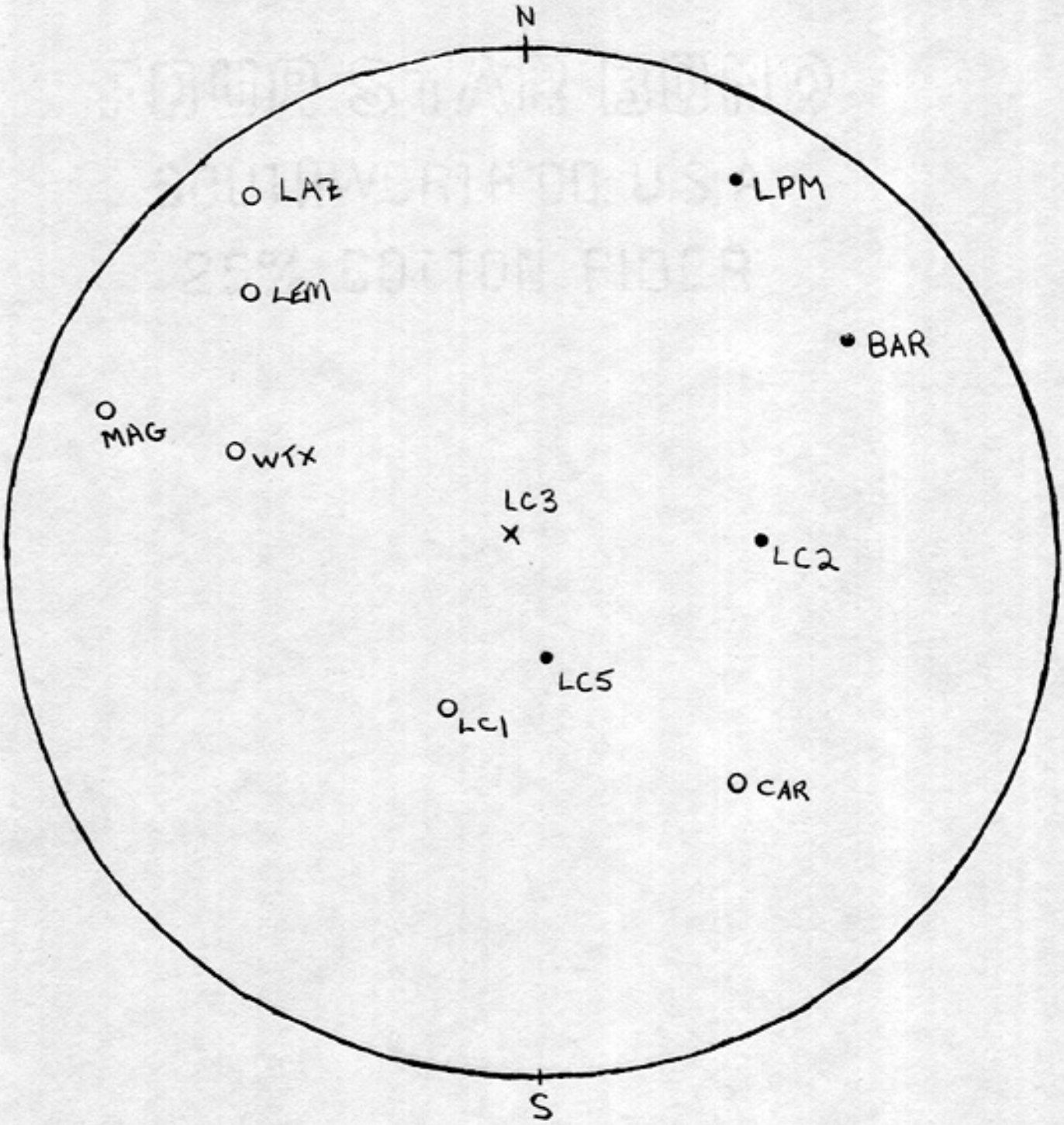

Figure B-3. First motion diagram for the earthquake occurring 4/30/86 at 04:07 GMT.

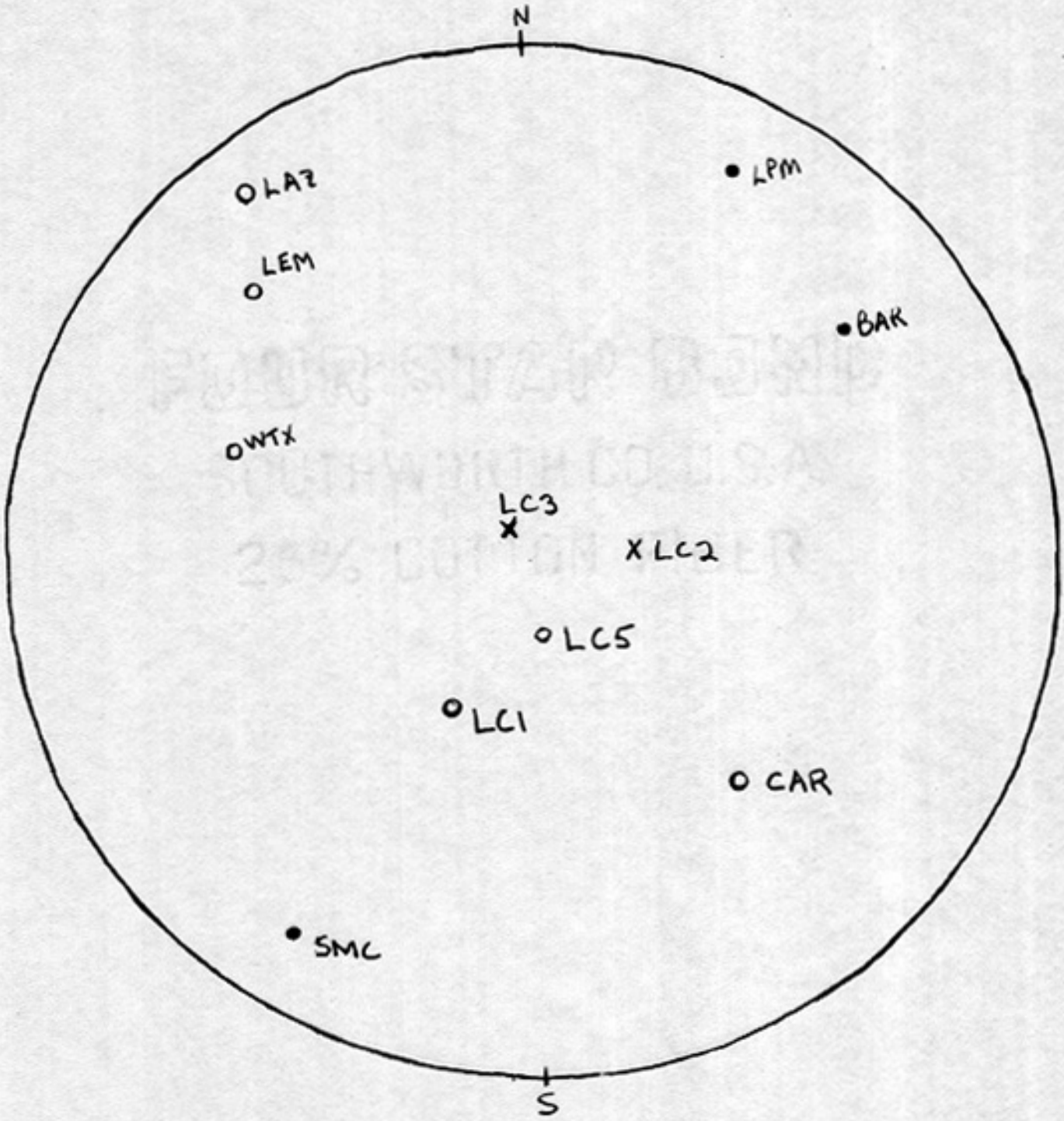

Figure B-1. First motion diagram for the earthquake occurring 4/30/86 at 05:39 GMT.

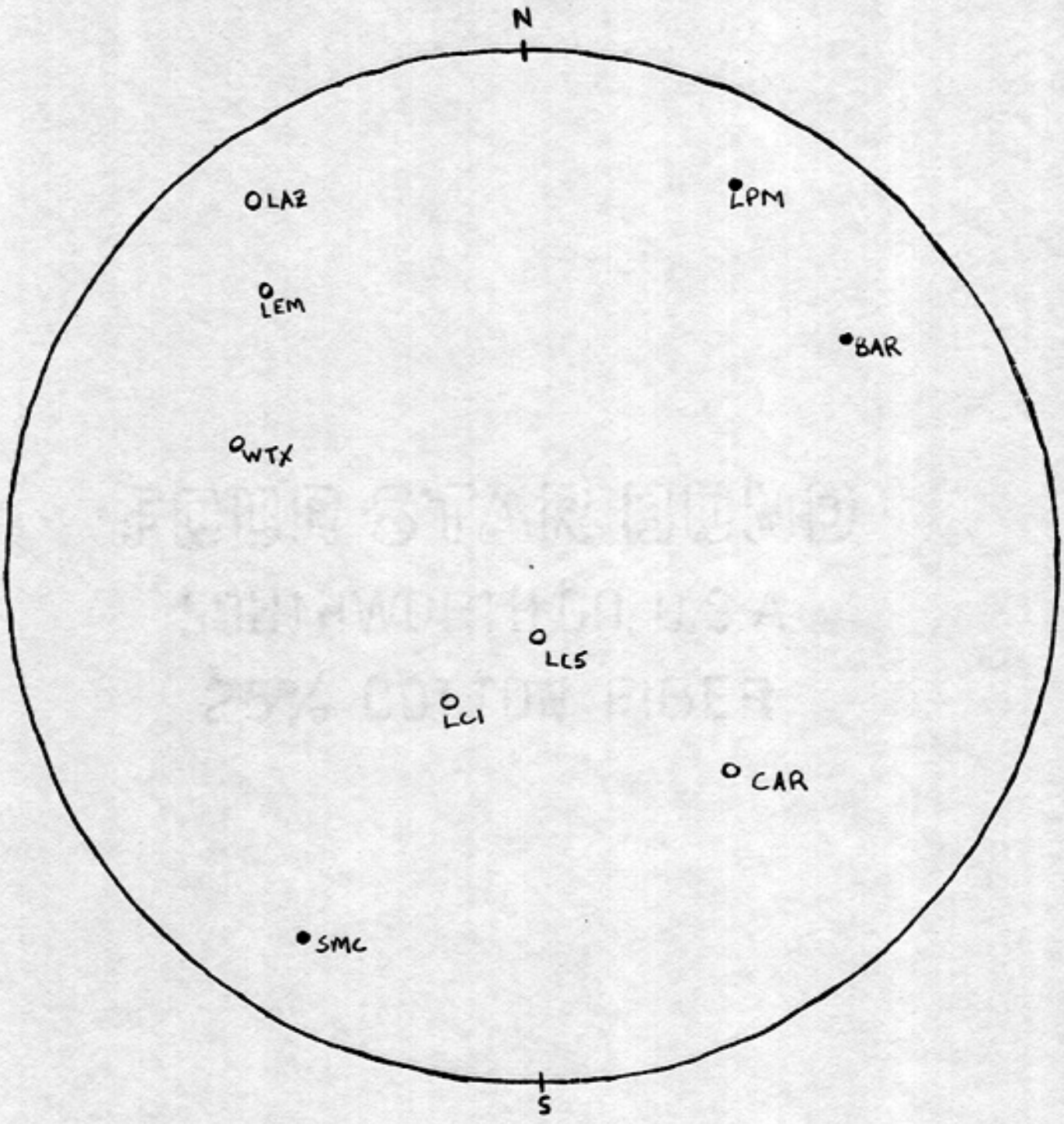

Figure B-5. First motion diagram for the earthquake occurring 4/30/86 at 06:41 GMT.

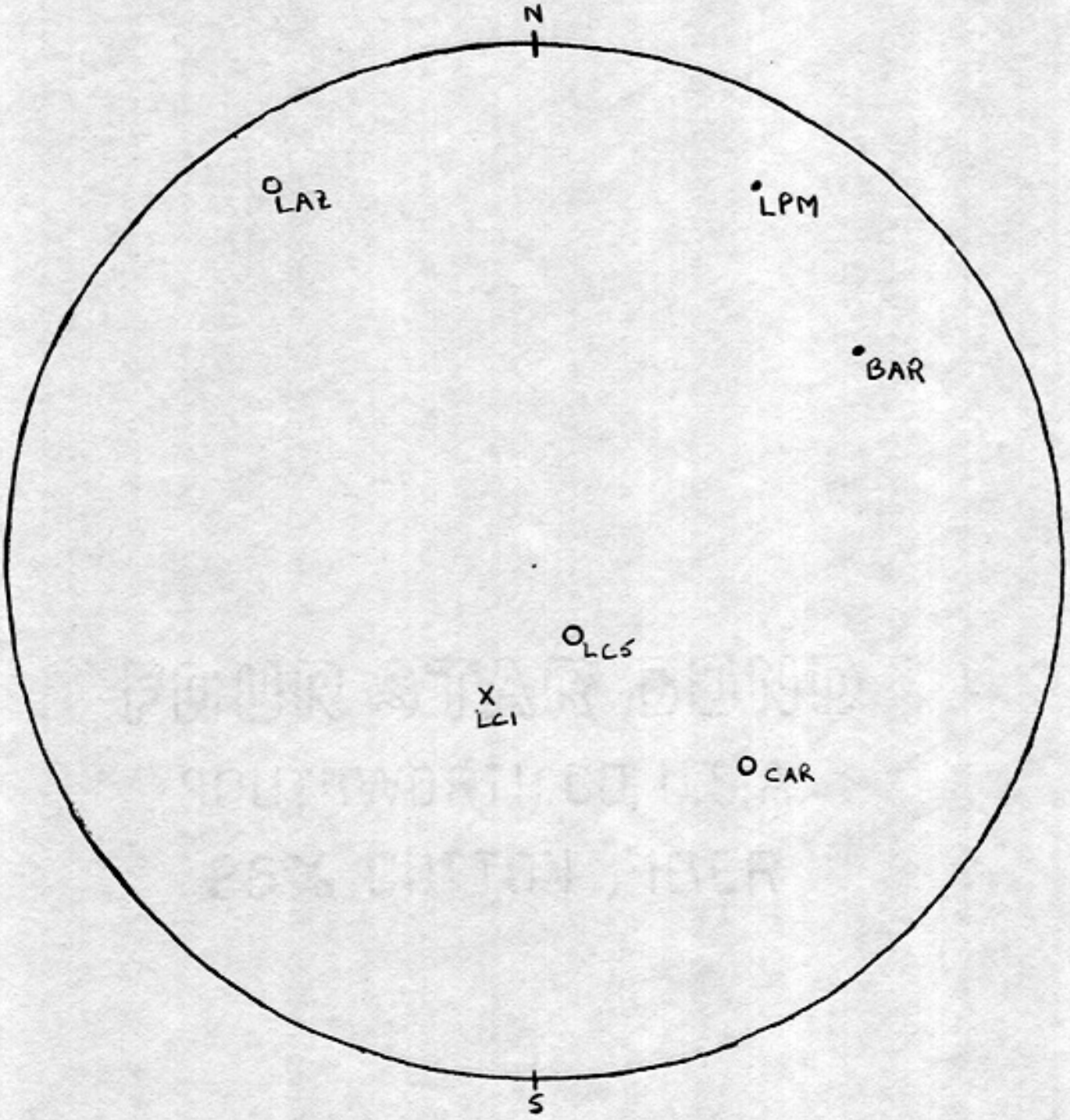

Figure B-6. First motion diagram for the earthquake occurring 4/30/86 at 13:10 GMT.

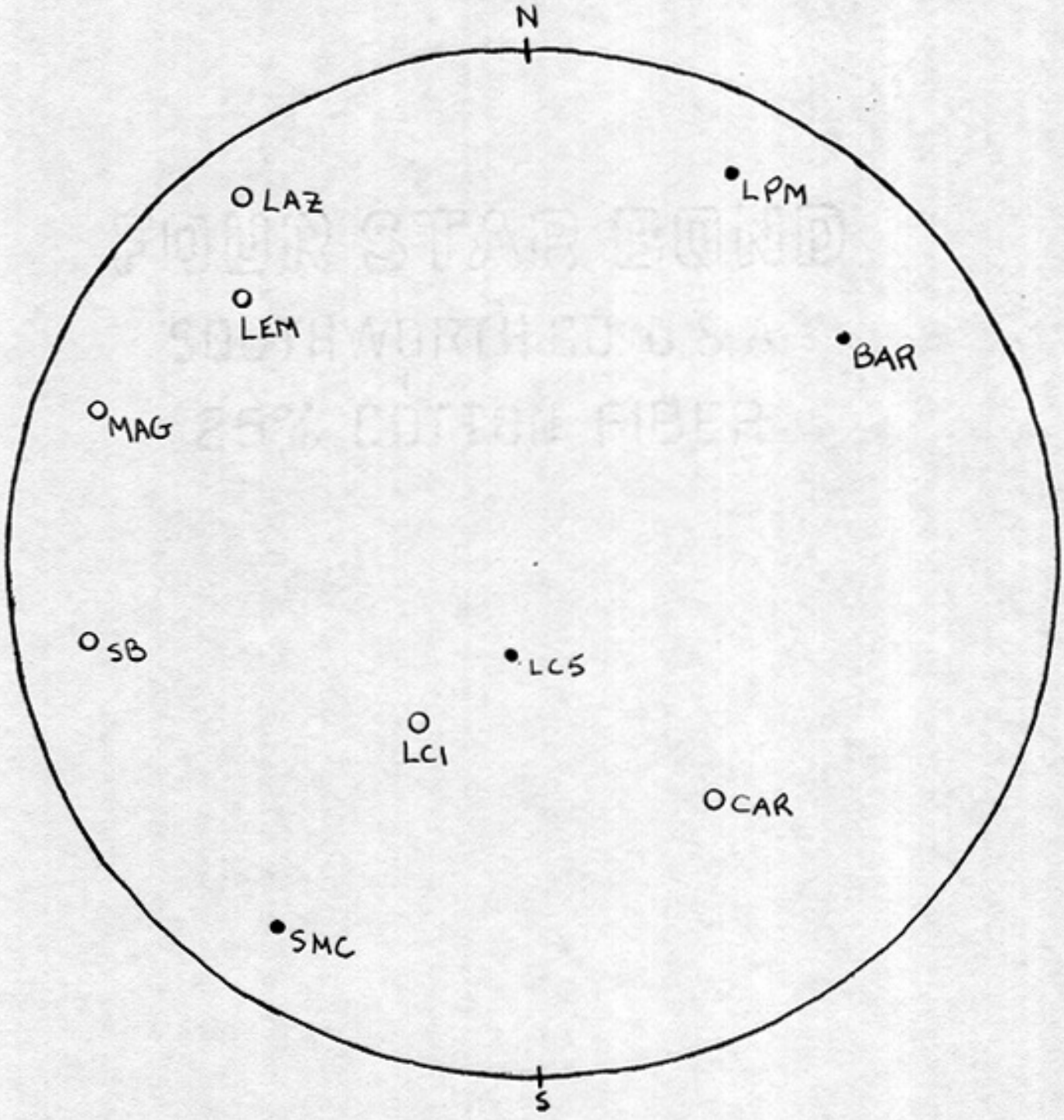

Figure B-7. First motion diagram for the earthquake occurring 4/30/86 at 16:12 GMT.

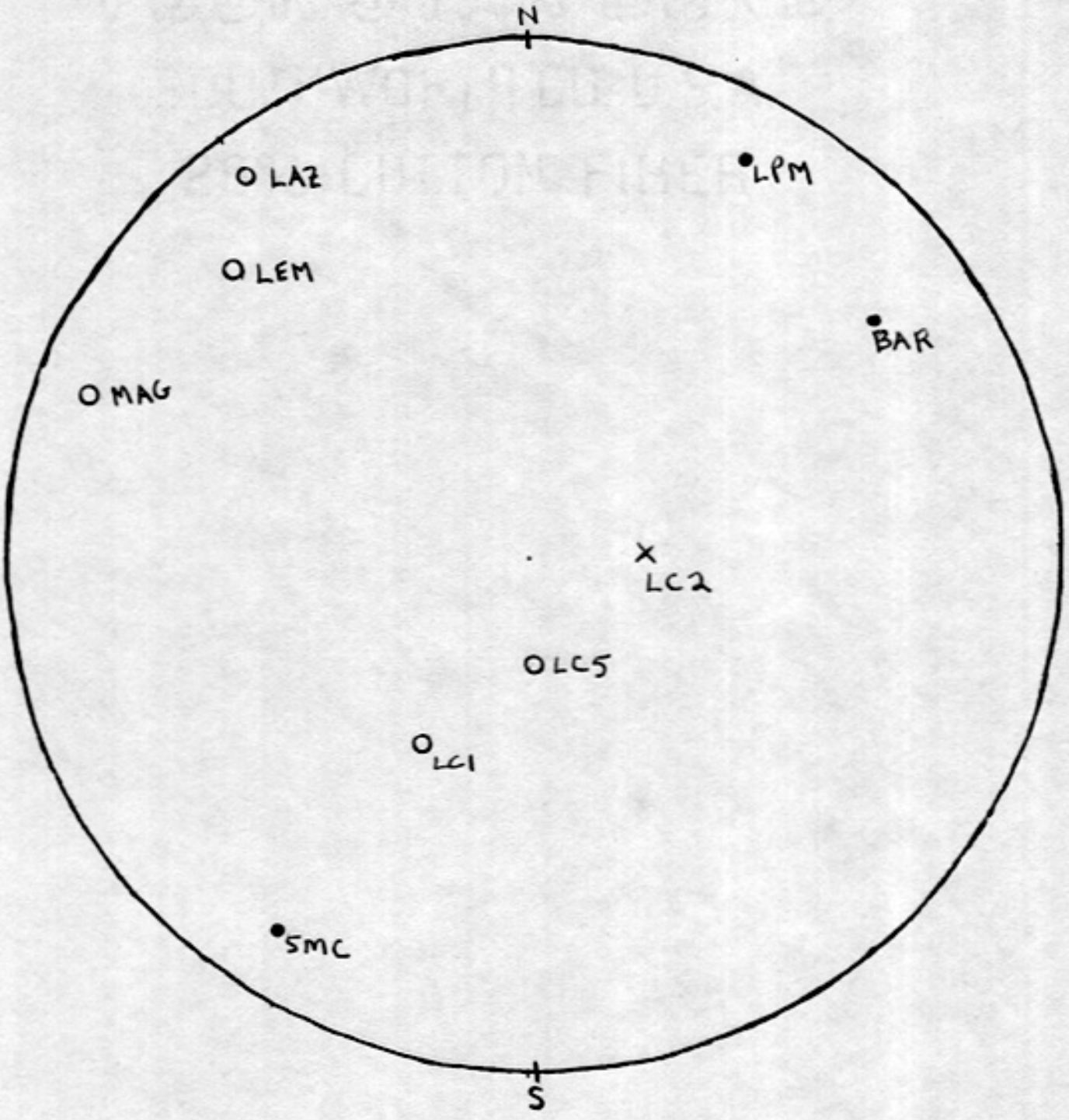

Figure B-8. First motion diagram for the earthquake occurring 4/30/86 at 16:15 GMT.

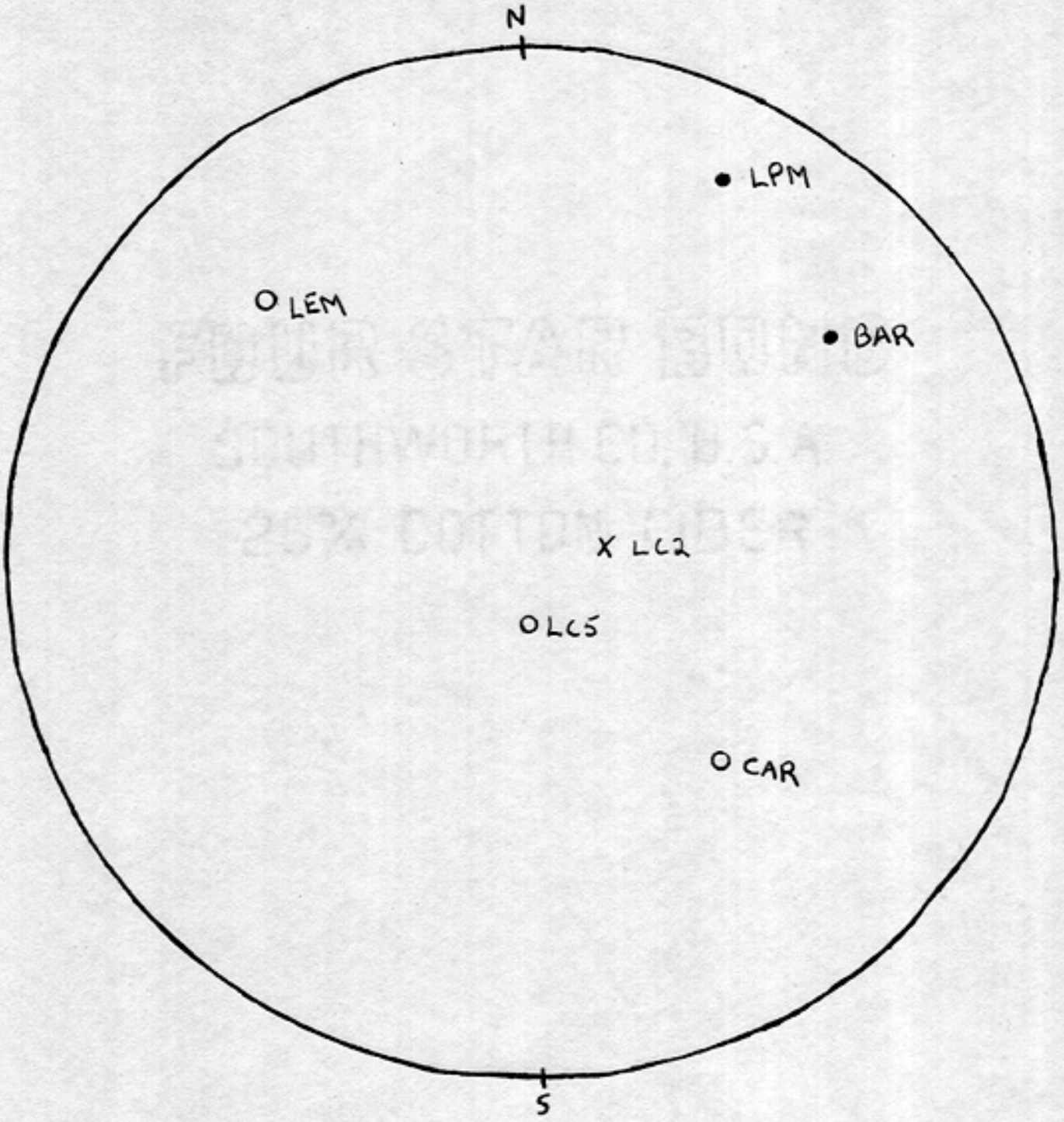

Figure B-9. First motion diagram for the earthquake occurring 4/30/86 at 18:06 GMT.

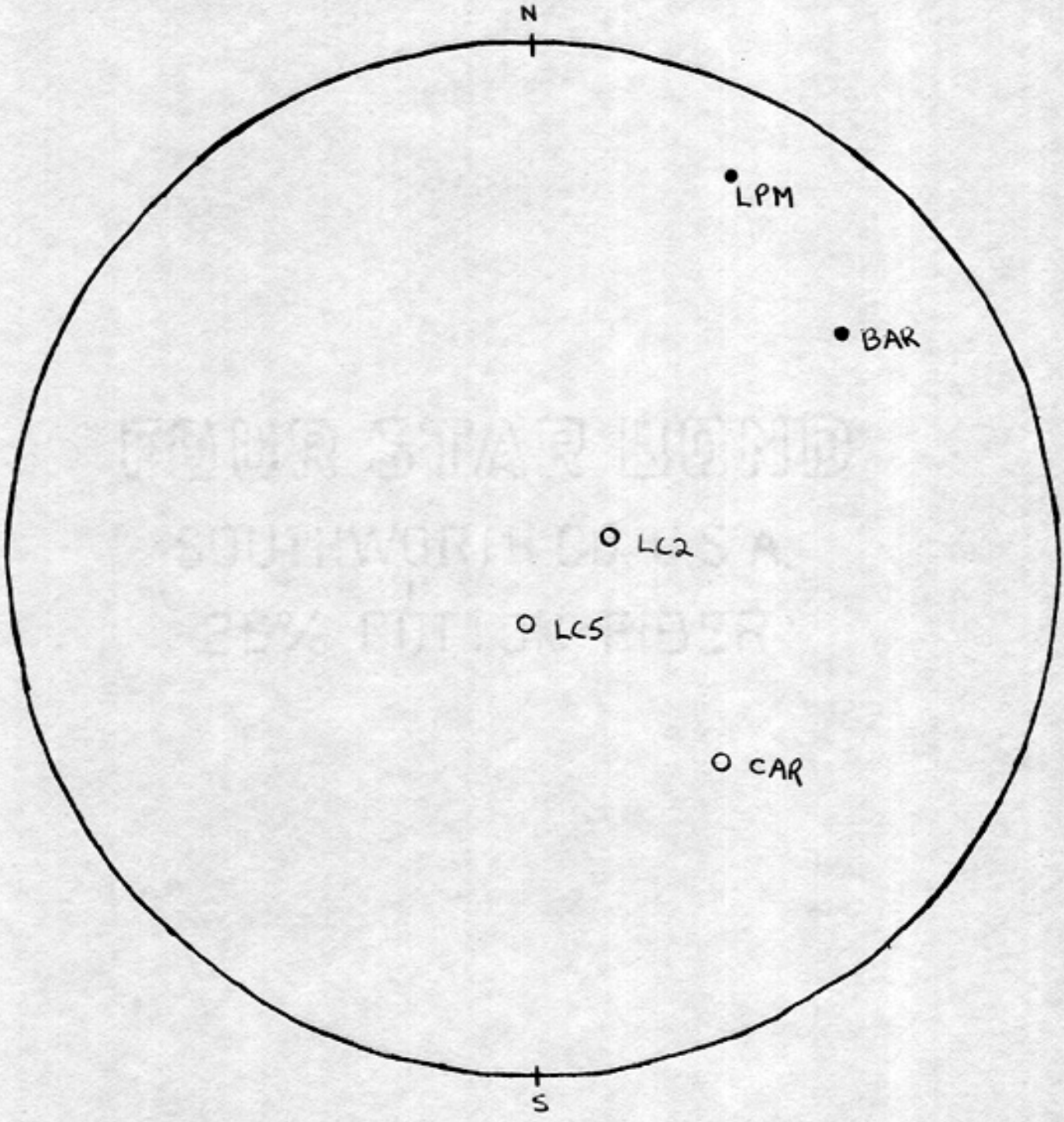

Figure B-10. First motion diagram for the earthquake occurring 5/01/86 at 03:53 GMT.

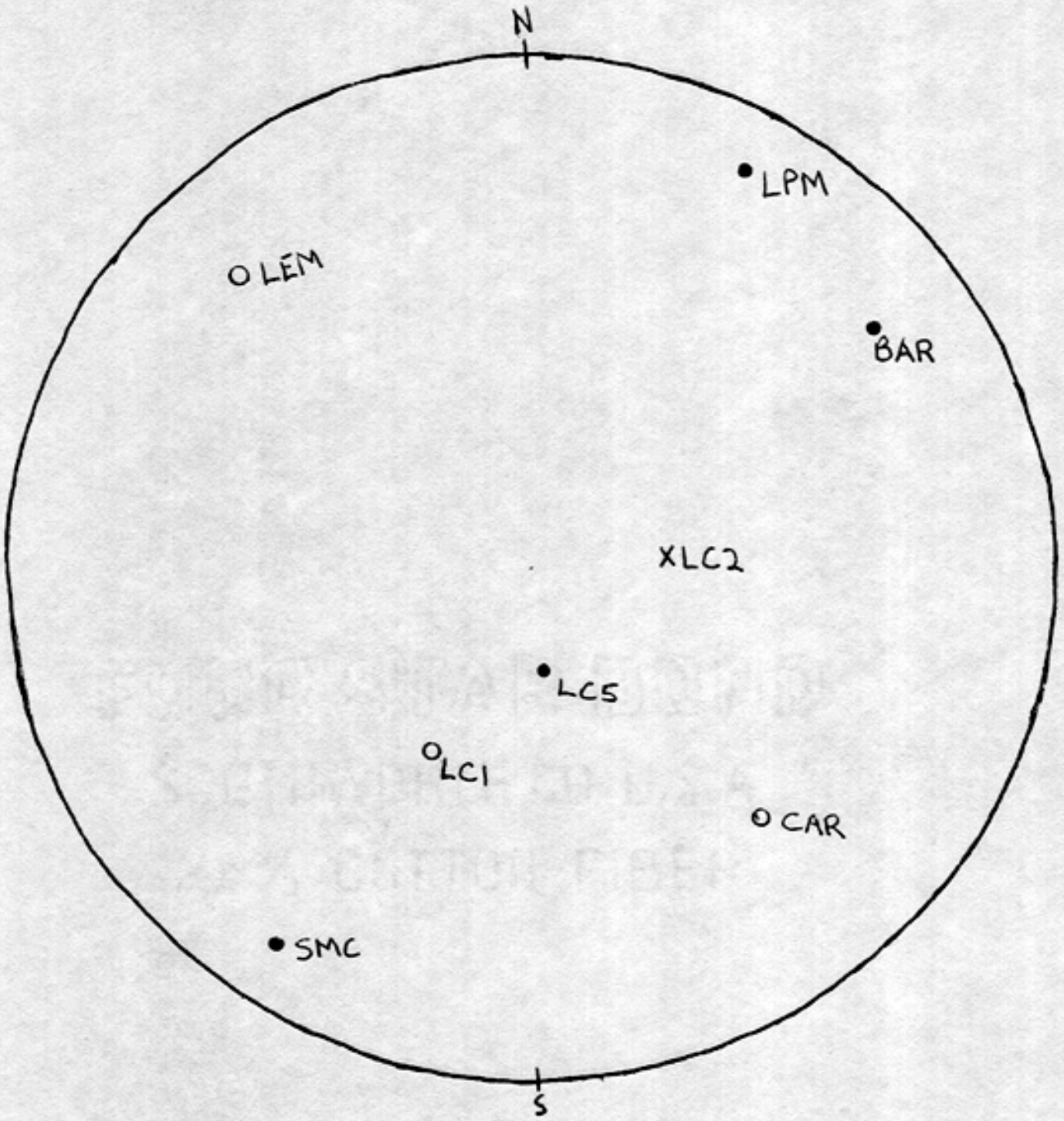

Figure B-11. First motion diagram for the earthquake occurring 5/01/86 at 09:32 GMT.

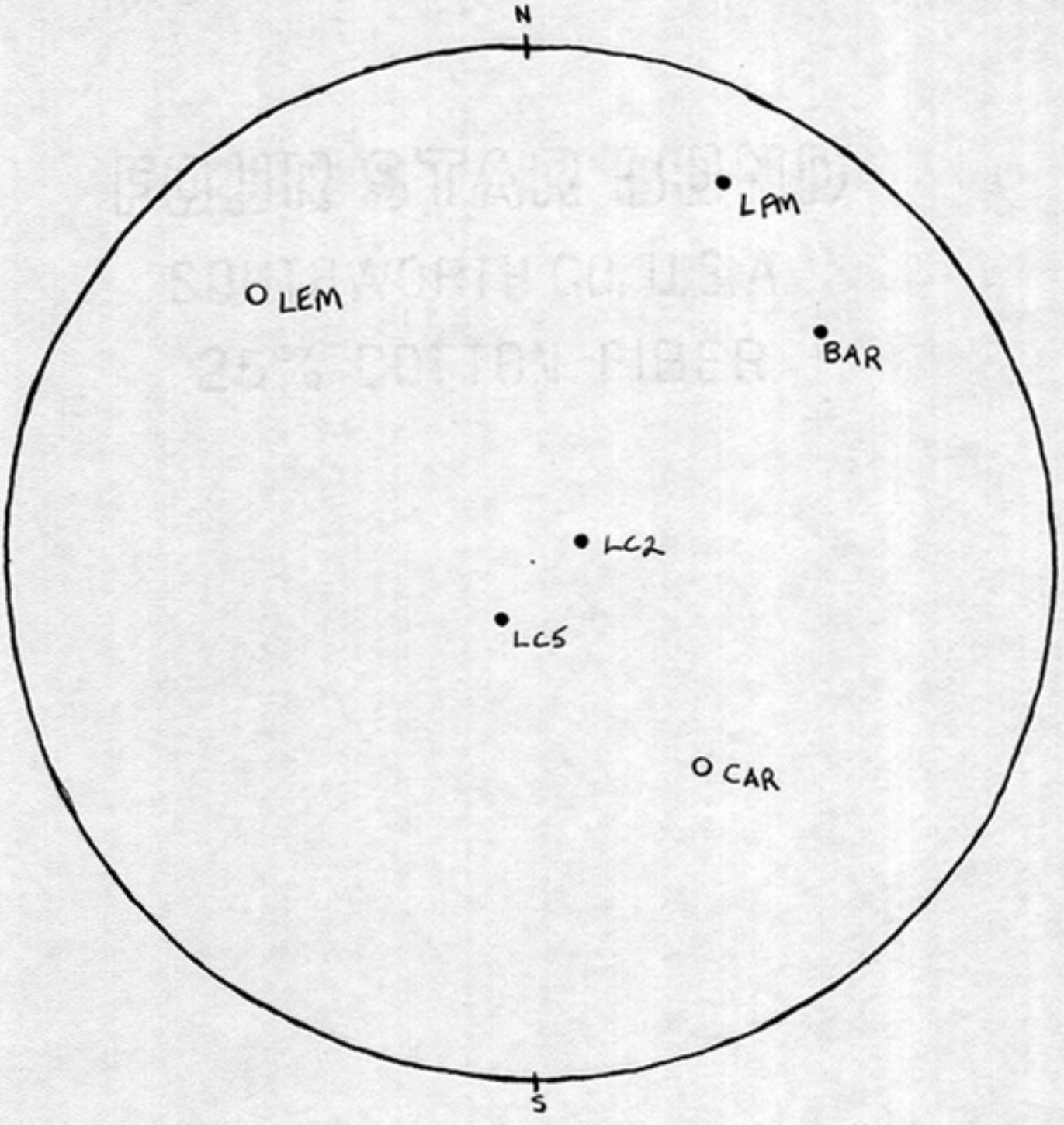

Figure B-12. First motion diagram for the earthquake occurring 5/01/86 at 11:43 GMT.

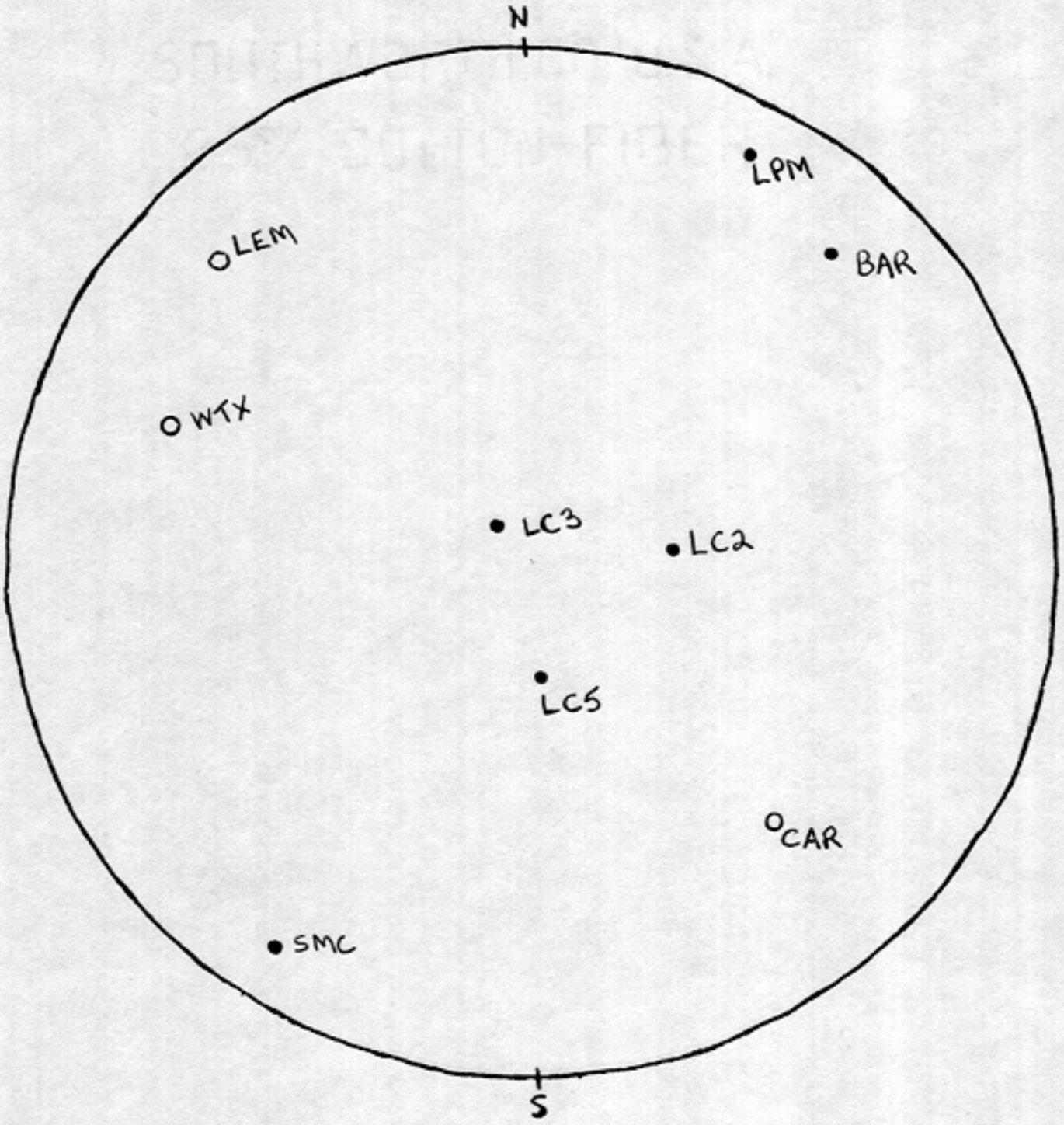

Figure B-13. First motion diagram for the earthquake occurring 5/01/86 at 16:28 GMT.

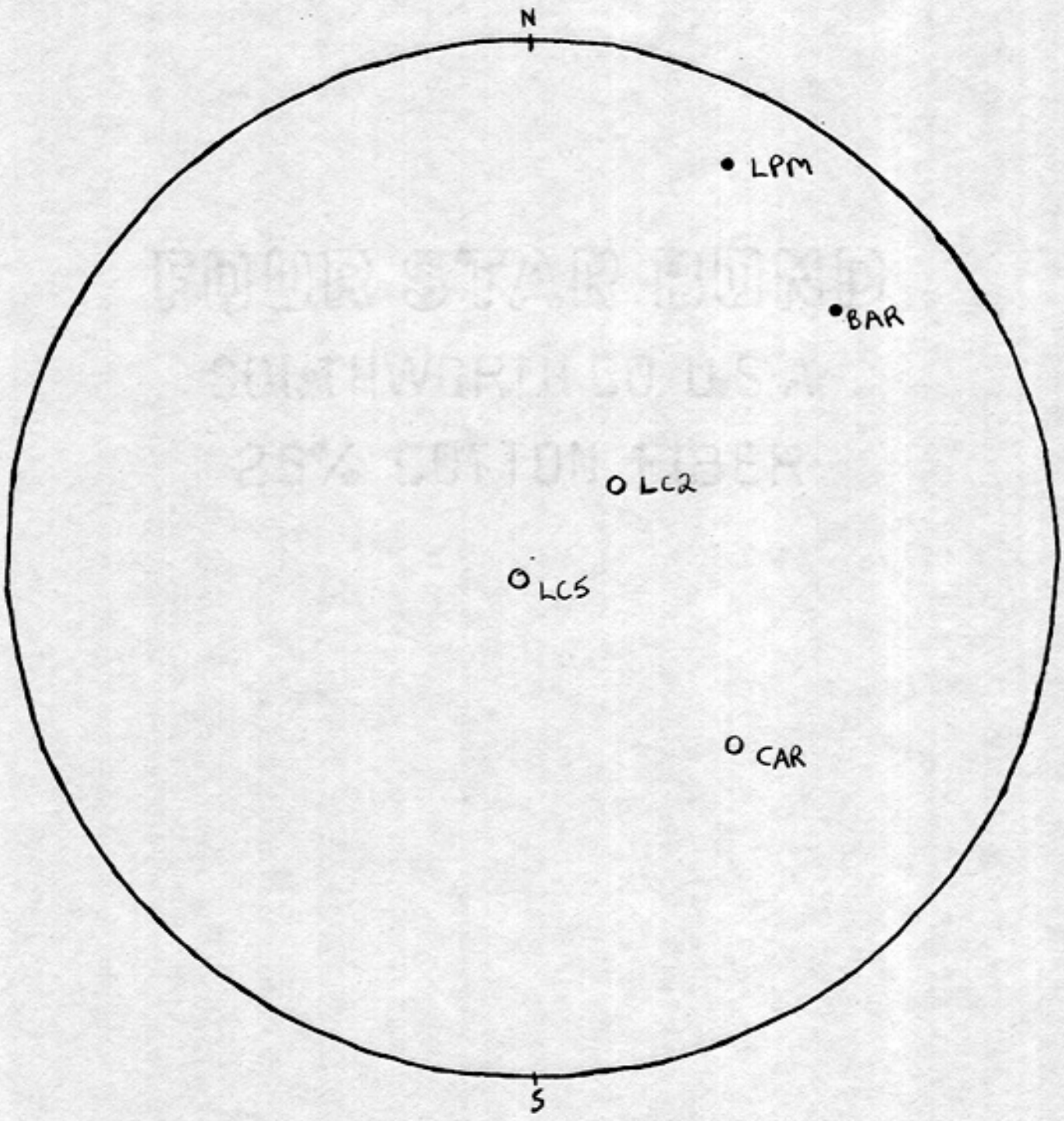

Figure B-14. First motion diagram for the earthquake occurring 5/01/86 at 19:06 GMT.

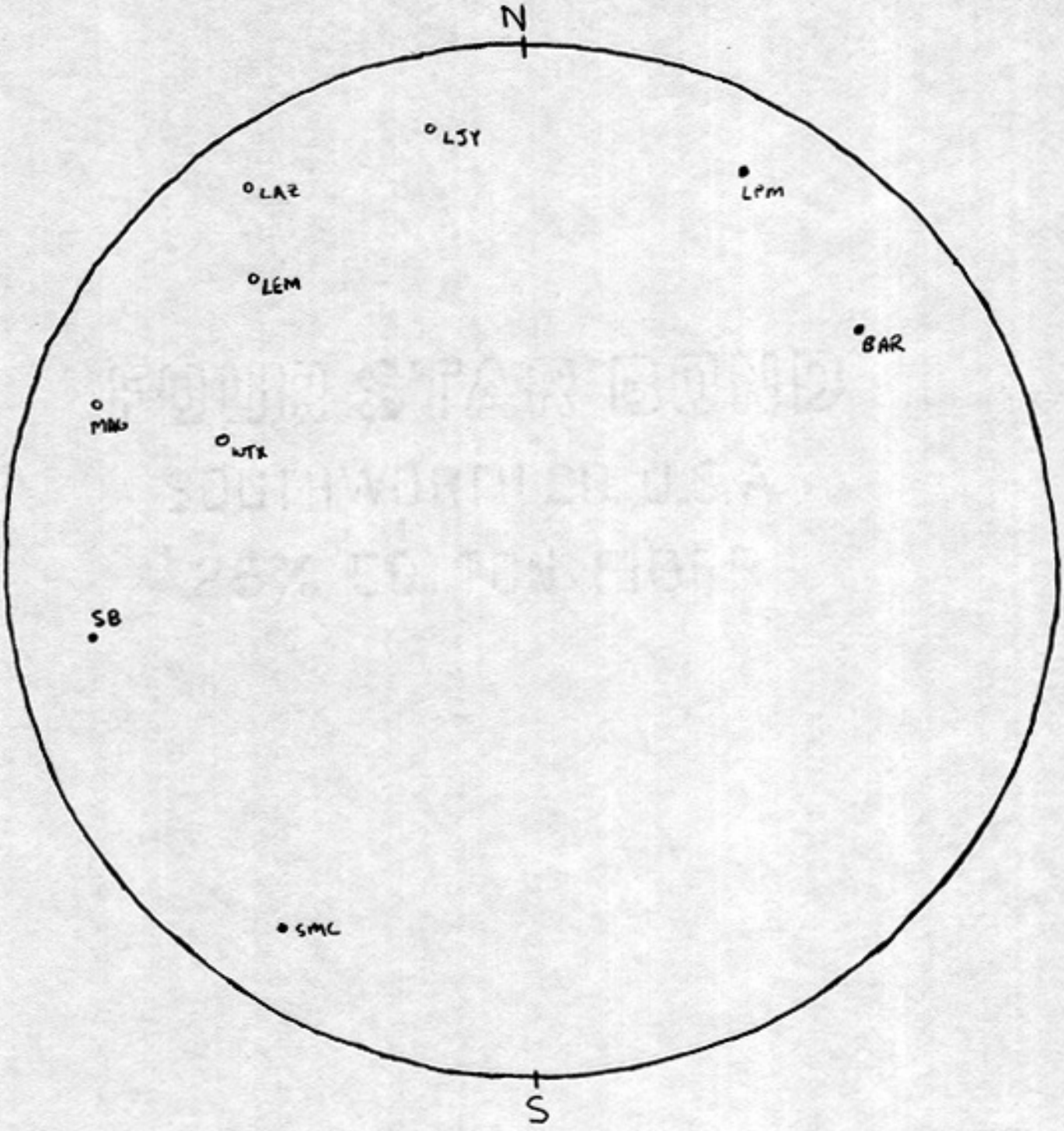

Figure B-15. First motion diagram for the largest event of the swarm. This earthquake occurred 4/28/1986 at 12:59 GMT. The duration magnitude as calculated by HYPO71(Rev) was 2.57 .

Appendix C

This appendix contains the program used to verify the correlation coefficients obtained by the SAC program.

```
c This program reads two data files, computes a cross correlation function for them
c and determines the maximum correlation coefficient.

      parameter(max=5000)
      dimension a(max),b(max),c(max)
      character*30 file1,file2
      write(*,*)'what is first file for correlation?'
      read (*,*) file1
      write(*,*)'what is second file for correlation?'
      read (*,*) file2
      open(20,file=file1)
      open(21,file=file2)
      open(22,file='corr.out')
      read(20,100,end=10)(a(i),i=1,max)
10    lx=i
      rewind(unit=20)
      read(21,100,end=15)(b(i),i=1,max)
15    ly=i
      rewind(unit=21)
      call xcor(a,lx,b,ly,c)
      lc = lx +ly - 1
      cmax=0.0
      do 20 i=1,lc
        tmp1 = abs(c(i))
        tmp2 = abs(cmax)
        if(tmp1.gt.tmp2) cmax=c(i)
20    continue
      write(22,101) lc,cmax
      write(22,100)(c(i),i=1,lc)
100   format(5f15.7)
101   format(i5,3x,f15.7)
      end
c ***************************** CROSS ***********************************
c
      subroutine cross(x,lx,w,lw,ls,s)
c
c  Crosscorrelation between x and w. Only positive time lags computed
c   w is the operator that is xcor. with x
c   ls should not exceed lx . output correlated trace is in s
c
      dimension x(1) , w(1) , s(1)
      do 10 i=1,ls
        m = min0(lw + i - 1,lx) - i + 1
        if(m.le.0) then
          q= 0.0
        else
          call dot(x(i),w,m,q)
        endif
        s(i) = q
10    continue
      return
      end

c ------------------------------- XCOR ------------------------------
```

```
c
c
      subroutine xcor(x,lx,y,ly,s)
c
c %%%%%%% Crosscorrelation based on convolution
c     array s output will have length lx + ly - 1
c
      dimension x(1), y(1), s(1)
      call revers(y,ly)
      call fold(x,lx,y,ly,s,ls)
      call revers(y,ly)
      return
      end


c ************************************ DOT ***************************
c
      subroutine dot(x,y,lnth,dprod)
c
c ------calc. the dot product between vectors x & y, each of length 'lnth'
c
      dimension x(1) , y(1)
      data lunout/6/
      dprod = 0.0
      if (lnth.le.0) goto 100
      do 20 i=1,lnth
20       dprod = dprod + x(i) * y(i)
      return
100   write(lunout,6010) lnth
6010  format(lx,'error in dot.f length',i8)
      return
      end

c ------------------------------------ REVERS ----------------------
c
      subroutine revers(x,lx)
c
c ------------- reverse the sequence of x
c
      dimension x(1)
      nn = lx/2
      do 10 i=1,nn
        temp = x(i)
        x(i) = x(lx-i+1)
        x(lx-i+1) = temp
10       continue
      return
      end


c ---------------------------------- FOLD ----------------------------
c
      subroutine fold(a,la,b,lb,z,lz)
```

```
c
c ========== Convolution by folding  a with b
c    lz = la+lb-1       la,lb lengths of arrays to be folded
c
     dimension a(1), b(1), z(1)

     lz = la + lb -1
     do 5 i =1,lz
5       z(i)=0.0
     do 10 i = 1,la
       do 10 j = 1,lb
         k=i+j-1
10         z(k)= a(i)*b(j) + z(k)
     return
     end
```