UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Preliminary Report on the Detection Capabilities of Southern Hemisphere Seismograph Network Stations

Station LPB - La Paz, Bolivia
Station ZOBO - Zongo, Bolivia

by

Russell E. Needham

Open-File Report 84-756

CONTENTS

TABLES

TABLES (cont.)

FIGURES

FIGURES (cont.)

FIGURES (cont.)

ABSTRACT

An investigation of the detection and reporting capabilities of 10 stations in the southern hemisphere seismograph network (SHSN) (table I) has been initiated by the U.S. Geological Survey.

The methods of investigation are as follows: (1) To evaluate the average time delay from the occurrence of the earthquake until it is reported and received by the National Earthquake Information Center (NEIC). (2) To determine the percentage and magnitude distribution of earthquakes, listed within 100 degrees of stations LPB and ZOBO by the NEIC and AFTAC, that were accurately reported by the stations' observers. (3) To determine the percentage and magnitude distribution of earthquakes that would be reported accurately by a trained analyst. (4) To evaluate the effect of azimuth and/or distance on the stations' detection capabilities.

Using the above methods, detections from two stations, LPB (WWSSN) and ZOBO (ASRO), were evaluated against the USGS PDE MONTHLY LISTING of earthquakes for September 1982 and a listing of earthquakes obtained from AFTAC for September 1982.

For this report, four southern hemisphere local networks were also evaluated to determine their contributions to events of southern hemisphere seismicity.

The results of the above investigations for stations LPB and ZOBO are as follows: (1) The time delay for reporting arrival times from station LPB to NEIC is acceptable for PDE reporting criteria. The delay in obtaining ZOBO arrival times, read by NEIC personnel after the seismograms are received, is acceptable only for the PDE Monthly Listing. (2) The associations of arrival times sent to NEIC from the LPB analyst to events of this report time period were near the 100% of those which are expected for a 25K station. The associations of arrival times read from ZOBO seismograms for the first 19 days of September 1982 were also near the 100% of those expected for a 200K station. The approximate 50% and 90% detection thresholds for LPB and LPB-RR are 4.7 mb and 5.7 mb respectively while these threholds for ZOBO are 4.2 mb and 5.2 mb respectively. (3) Re-reading the LPB seismograms showed only a 7% improvement compared to the LPB analyst-reported arrivals associated with events with mb reported on the GS data set. The association of ZOBO arrival times with these events is 27% greater than the LPB analyst's arrival times. This compares quite well to the 28% improvement of the ZOBO associations versus the LPB-RR associations for all events of the AFTAC data set. (4) There does not appear to be a distance effect other than that expected by the difference in station gain of LPB and ZOBO. An apparent azimuthal effect of LPB and ZOBO failing to detect small Central American and Mexican earthquakes actually may be due to LPB and ZOBO being nodal to the fault plane solutions of these areas. (5) Southern hemisphere local networks contributed locations for the majority of earthquakes listed on the USGS data set without reported magnitudes, and of the earthquakes listed on the USGS data set but not on the AFTAC data set.

SOUTHERN HEMISPHERE NETWORK STATIONS (SHNS)

STA.	ALT. STA.	STATUS	SPZ GAIN (K)	LPZ GAIN (K)	LAT.	LON.	GEOGRAPHY
ANT		WWSSN	25.0	3.00	-23.705	-70.415	ANTOFAGASTA,CHILE
BAO		ARRAY			-15.635	-47.992	BRASILIA,BRAZIL
	BDF	DWWSSN			-15.664	-47.903	BRASILIA,BRAZIL
BNG					4.435	18.547	BANGUI,C.AFRICAN REP.
	BCAO	SRO	200.0	20.00	4.367	18.567	BANGUI,C.AFRICAN REP.
BUL		WWSSN	100.0	.75	-20.143	28.613	BULAWAYO,RHODESIA
KIC					6.361	-4.741	KOSAN BOKA,IVORY CST.
LPB		WWSSN	25.0	1.50	-16.533	-68.098	LA PAZ, BOLIVIA
	ZOBO	ASRO	200.0	40.00	-16.270	-68.125	ZONGA, BOLIVIA
NAI		WWSSN	50.0	1.50	-1.274	36.804	NAIROBI, KENYA
PEL		WWSSN	50.0	1.50	-33.144	-70.685	PELDEHUE, CHILE
SLR		WWSSN	50.0	1.50	-25.735	28.282	SILVERTON SO. AFRICA
SPA		WWSSN	100.0	.75	-90.000	0.000	SOUTH POLE,ANTARCTICA

TABLE 1

INTRODUCTION

This report is the third in a series of preliminary reports of an investigation into the detection capabilities of the ten SHSN stations. Presented here are the detection capabilities of stations LPB, La Paz, Bolivia, and ZOBO, Zonga, Bolivia. The goal of this report is to present information on the existing detection and reporting capabilities of the on-site analysts at LPB, and to compare these capabilities with the detection capability of a well-trained on-site or off-site analyst with real-time or near real-time capabilities. Only events that occurred during September 1982 within 100 degrees from station LPB and ZOBO were used to make these evaluations.

USGS DATA SET

LPB Reporting Abilities:

Event arrival times reported by the analyst at station LPB (La Paz, Bolivia), by telegram to NEIS (National Earthquake Information Service) were received for all 30 days of September 1982. Arrival times for several days were generally reported on a single telegram, creating minimum and maximum times of reporting. Table 2 shows these minimum and maximum times for each day along with a minimum average of 2.17 days and a maximum average of 2.83 days. These reported event times even at the maximum interval were received by NEIS in time to be incorporated in the PDE (Preliminary Determination of Epicenters) report.

295 arrival times were received from station LPB, of which 112 were associated with events published in the PDE Monthly Listing for September 1982 (ref. 1). Of these 112 associated times, 59 were associated with events with distances less than 100 degrees from the Station. The remaining 53 were associated with events with distances greater than 100 degrees. This large number of PKP associations is not unusual because the seismic areas of much of Indonesia and Japan are at distances near the PKP caustic to station LPB.

ZOBO Reporting Abilities:

Seismograms from station ZOBO (Zongo, Bolivia ASRO) are not read on site. The average time interval from the time of recording to the time of receiving the analog seismograms by NEIC is one and one-half months. All of the ZOBO times associated in the PDE Monthly Listing were read by NEIS personnel.

COMPARISON OF LPB ANALYST REPORTED TIMES AND THEIR ASSOCIATIONS TO THE PDE MONTHLY LISTING REPORTED EVENTS:

A total of 309 earthquakes, reported on the PDE Monthly Listing for September 1982, were within 100 degrees distance from station LPB. The geographical distribution of these earthquakes is shown on an equal azimuth equal distance map centered at LPB, figure 1. Of these 309 events, 184 did not have a reported magnitude. The geographical distribution of these events without a reported magnitude are shown on figure 2, and, as can be observed, most of them are located in six geographic areas from which the USGS obtains local network reports. The two southern hemisphere local networks that contribute to the locations of these events in Chile-Argentina region and South Africa will be discussed in Appendix C of this report. Since these earthquakes located by regional networks are very small, it is not surprising that they were not detected by station LPB. The remaining statistics computed for the comparison of LPB detection to the Monthly Listing data set will be made using the 125 earthquakes with reported magnitudes. The geographical distribution of these events are shown on figure 3.

MAXIMUM AND MINIMUM TIMES FOR STATION LPB REPORTING TO NEIS

SEPTEMBER	MINIMUM (DAYS)	MAXIMUM (DAYS)
1	2	3
2	3	5
3	4	5
4	3	4
5	2	3
6	3	3
7	3	3
8	2	3
9	3	4
10	3	3
11	2	3
12	2	2
13	2	2
14	1	1
15	2	3
16	2	4
17	3	3
18	2	2
19	2	2
20	1	3
21	2	2
22	2	2
23	2	4
24	3	4
25	2	2
26	2	2
27	1	1
28	2	3
29	1	2
30	2	3
AVERAGE	2.17	2.83

TABLE 2

LPB
GS DATA SET
SEPTEMBER 1982 309 EVENTS

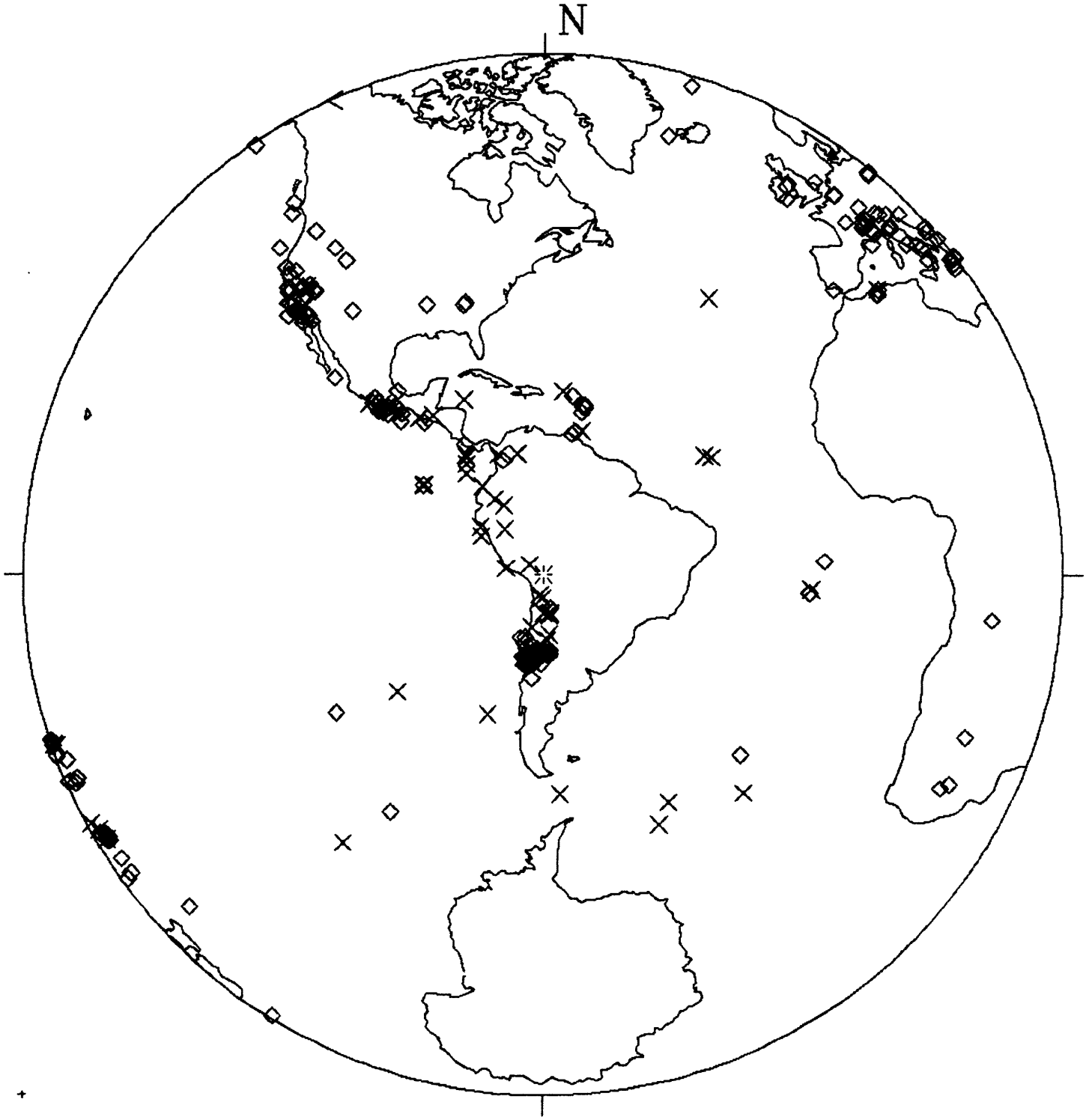


FIGURE 1

LPB
GS DATA SET NO mb REPORTED
SEPTEMBER 1982 184 EVENTS

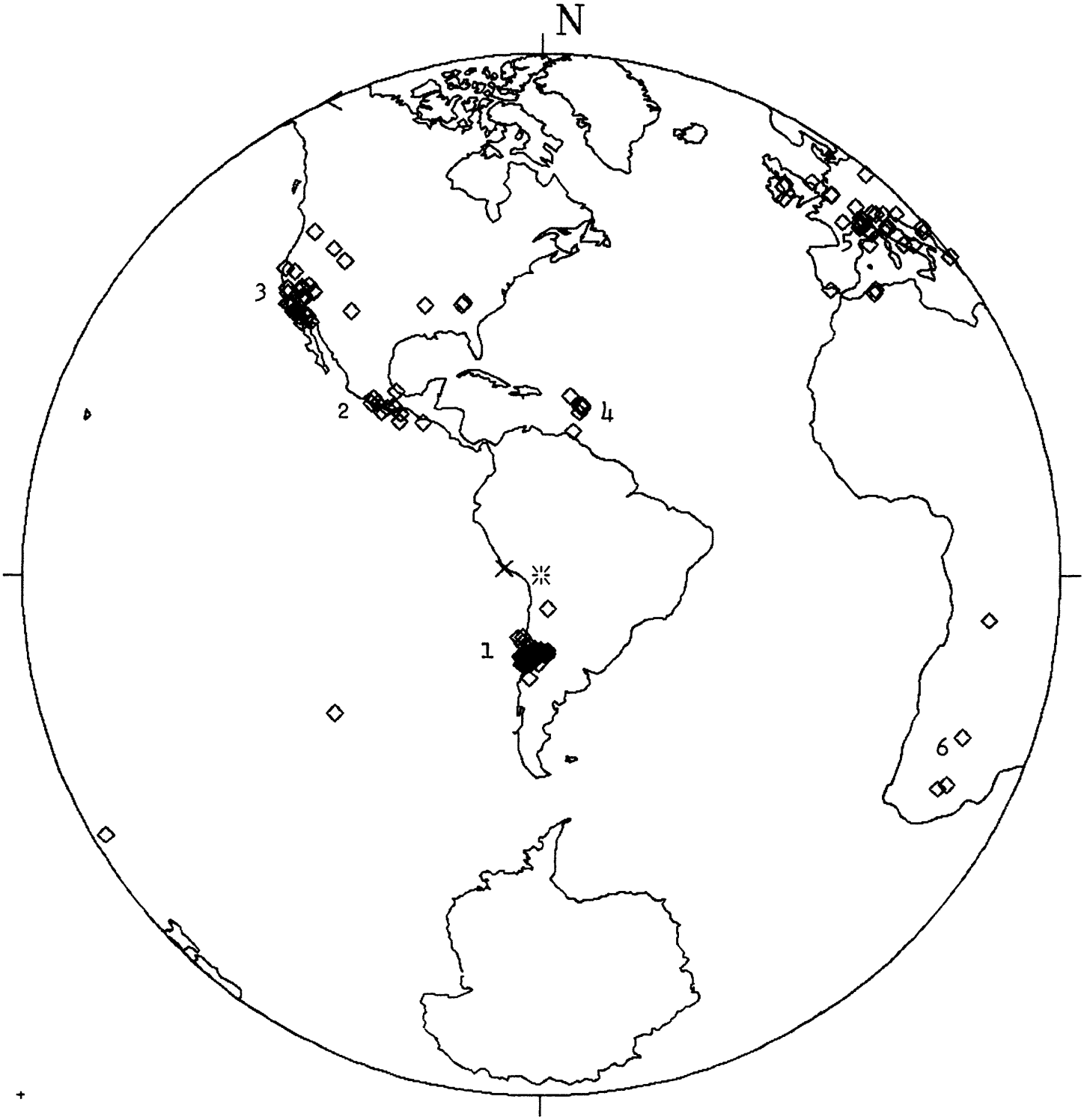


FIGURE 2

LPB
GS DATA SET mb REPORTED
SEPTEMBER 1982 125 EVENTS

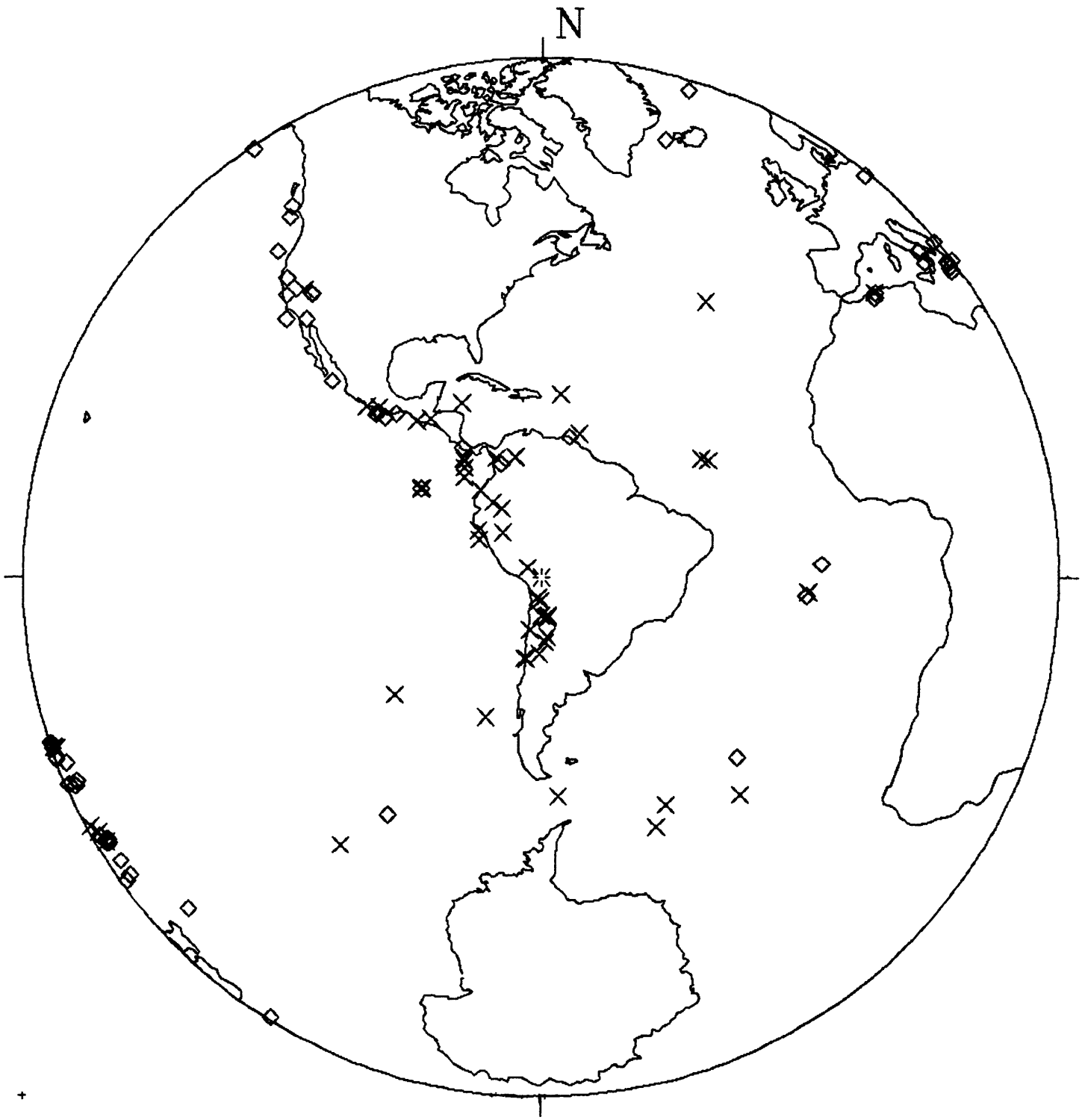


FIGURE 3

Shown on table 3, columns 2 and 5 are the number of LPB detections distributed by magnitude and a detection percentage to the total events (column 4) for each magnitude. It appears that the approximate 50% detection threshold is near the 4.7 magnitude and the 90% detection threshold is near the 5.7 magnitude.

Table 4, columns 2 and 5, indicate the LPB detection capability at different distance ranges and the percentage of the total events (column 4) for each distance range. The detection percentage for events less than 95 degrees distance is 66%, but if the distance of 95 to 100 degrees (Fiji-Tonga areas) are used, it is 46%. Figures 4, 5 and 6 show the geographic distribution of events with magnitude <4.5, >4.4 <5.0, and >4.9.

To determine the meaning of these detection percentages, a plot of distance versus magnitude needs be made. Table 5 shows the number of events for each magnitude range compared to each distance range. To utilize this table, we need to know whether the analyst of the 25k gain station LPB should be able to detect these events. Using a simple model computed from the formula mb=log A/T+Q and assuming the gain of the station to be 25K, T=1.0, h=33 and A=0.5 mm P-P and 1.0 mm P-P, table 6, columns 2 and 3 were generated. By plotting this data generated on table 6 onto table 5, with the leading edge of the shaded areas representing the 1.0 mm detection capability and the trailing edge of the shaded areas representing the 0.5 detection capability, the distance/mag detection level of the two theoretical amplitudes can be made. Table 7 shows as functions of distance: the total number of events (column 2), the LPB detections (column 3), and the percentage of the total events detected by LPB (column 4), as well as the theoretical detections at 0.5 mm (column 7) and 1.0 mm (column 9) and their percentages (columns 8 and 10) of the total events. From this table we can see the amplitude threshold the LPB analyst was able to read, and whether we should expect a detection at station LPB. Table 8 shows the percentage of the number of LPB detections per distance to the theoretical detections obtained reading at .5 mm P-P and 1.0 mm P-P. Due to the small sample size of the number of detections to some of these distances, these percentages would probably not be valid if a longer time period were evaluated. Regardless of this fact, for the month of September 1982, the LPB analyst reported 100% of the detection expected if the seismogram was read at a 1.0 mm P-P amplitude and reported 100%, except for 4 distance ranges, for all detection expected if the seismogram was read at a 0.5 mm P-P amplitude.

COMPARISON OF LPB-REREAD TIMES AND THEIR ASSOCIATIONS TO THE PDE MONTHLY LISTING REPORTED EVENTS:

Very little improvement to the number of LPB analyst's readings was made by rereading the film chips for September 1982. Nine additional associated detections (a 7% increase) were made. Figures 7, 8, and 9 show the reread associations (X on figure) to the total 309 events, 184 events with no reported magnitude and the 125 events with reported magnitudes. Figures 10, 11, 12 show the reread associations to events with magnitudes <4.5, magnitudes >4.4 <5.0, and >4.9. The same statistical comparisons were made using the LPB-RR detections as were made for the LPB analyst detections. Table 3 columns 3 and 6 show the number of LPBR-RR detections distributed by magnitudes and a detection percentage to the total events (column 4) for each magnitude. The approximate 50% and 90% detection thresholds appear to be the

DETECTION DISTRIBUTION PER MAGNITUDE
LPB ANALYST - LPB RR
SEPTEMBER 1982

MAG.	LPB DET.	LPB RR. DET.	TOTAL EVENTS	LPB DET. %	LPB RR. DET. %
NONE	2	3	184	1	2
<4.0	1	1	8	13	13
4.0	0	0	3	0	0
4.1	0	0	1	0	0
4.2	0	0	2	0	0
4.3	5	5	6	83	83
4.4	2	5	9	22	56
4.5	5	5	12	42	42
4.6	1	1	5	20	20
4.7	10	10	12	83	83
4.8	3	3	4	75	75
4.9	1	3	10	10	30
5.0	5	5	8	63	63
5.1	6	7	13	46	54
5.2	5	6	11	46	55
5.3	2	3	6	33	50
5.4	3	3	5	60	60
5.5	2	3	3	67	100
5.6	1	1	2	50	50
5.7	1	1	1	100	100
5.8	-	-	-	-	-
5.9	1	1	1	100	100
6.0	3	3	3	100	100

TABLE 3

DISTANCE DISTRIBUTION FOR LPB AND LPBRR ASSOCIATED DETECTIONS TO THE USGS DATA SET WITH REPORTED MAGNITUDE FOR SEPTEMBER 1982

DISTANCE (DEG.)	LPB DET.	LPBRR DET.	TOTAL EVENTS	LPB DET. %	LPBRR DET. %
<10	7	7	7	100	100
>10≦15	7	7	7	100	100
>15≦20	5	5	5	100	100
>20≦25	5	5	6	83	83
>25≦30	8	10	12	67	83
>30≦35	-	-	-	-	-
>35≦40	8	8	8	100	100
>40≦45	1	2	5	20	40
>45≦50	3	3	3	100	100
>50≦55	2	3	6	33	50
>55≦60	1	2	2	50	100
>60≦65	2	2	2	100	100
>65≦70	0	1	3	0	33
>70≦75	1	1	3	33	33
>75≦80	0	0	1	0	0
>80≦85	1	1	6	17	17
>85≦90	0	0	1	0	0
>90≦95	-	-	-	-	-
>95≦100	6	9	48	13	19
=10≦100	57	66	125	46	53
≦10≦95	51	57	77	66	74

TABLE 4

LPB
GS DATA SET mb <4.5
SEPTEMBER 1982 29 EVENTS

FIGURE 4

LPB
GS DATA SET mb >4.4<5.0
SEPTEMBER 1982 43 EVENTS

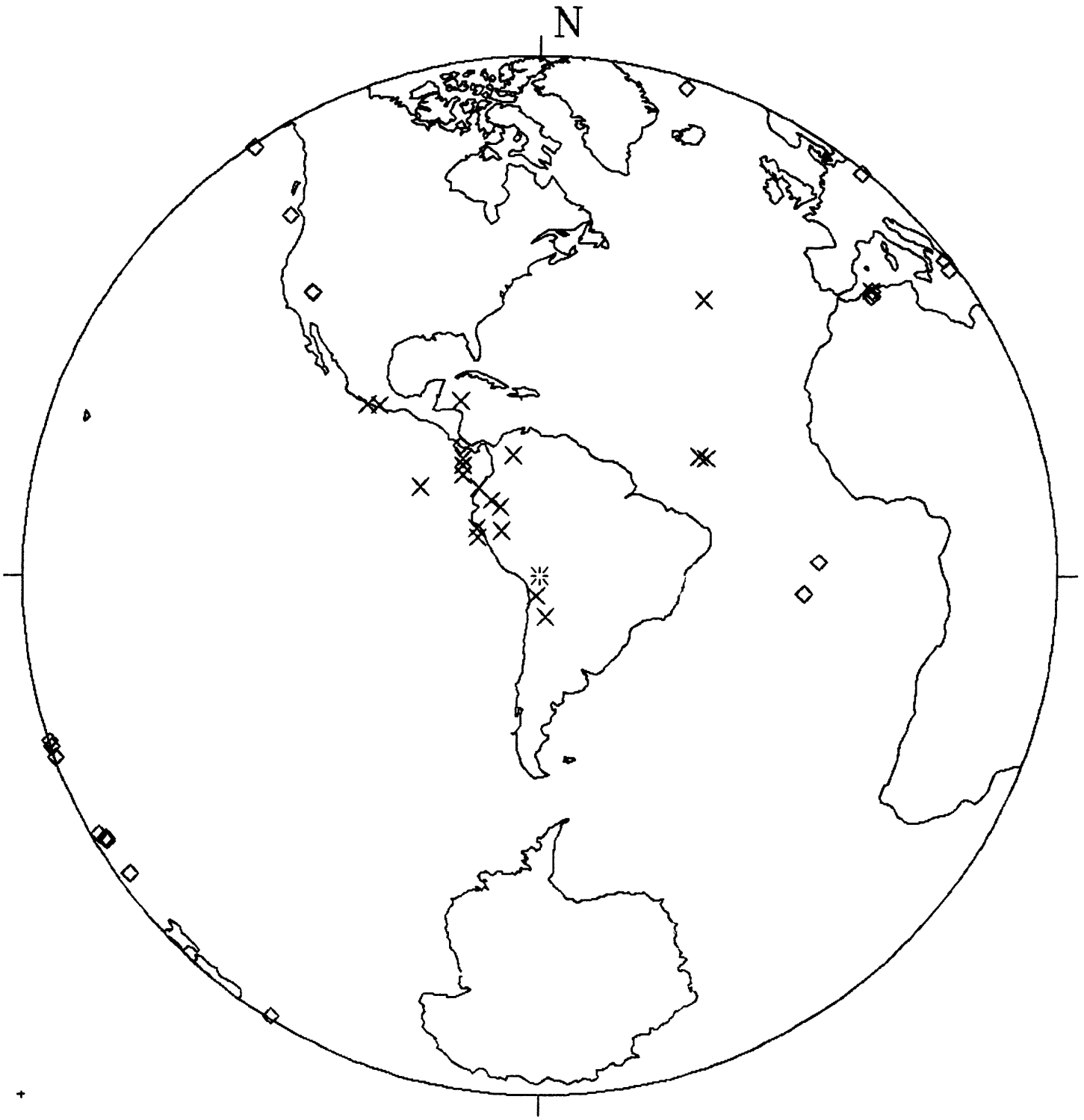


FIGURE 5

LPB
GS DATA SET mb >4.9
SEPTEMBER 1982 53 EVENTS

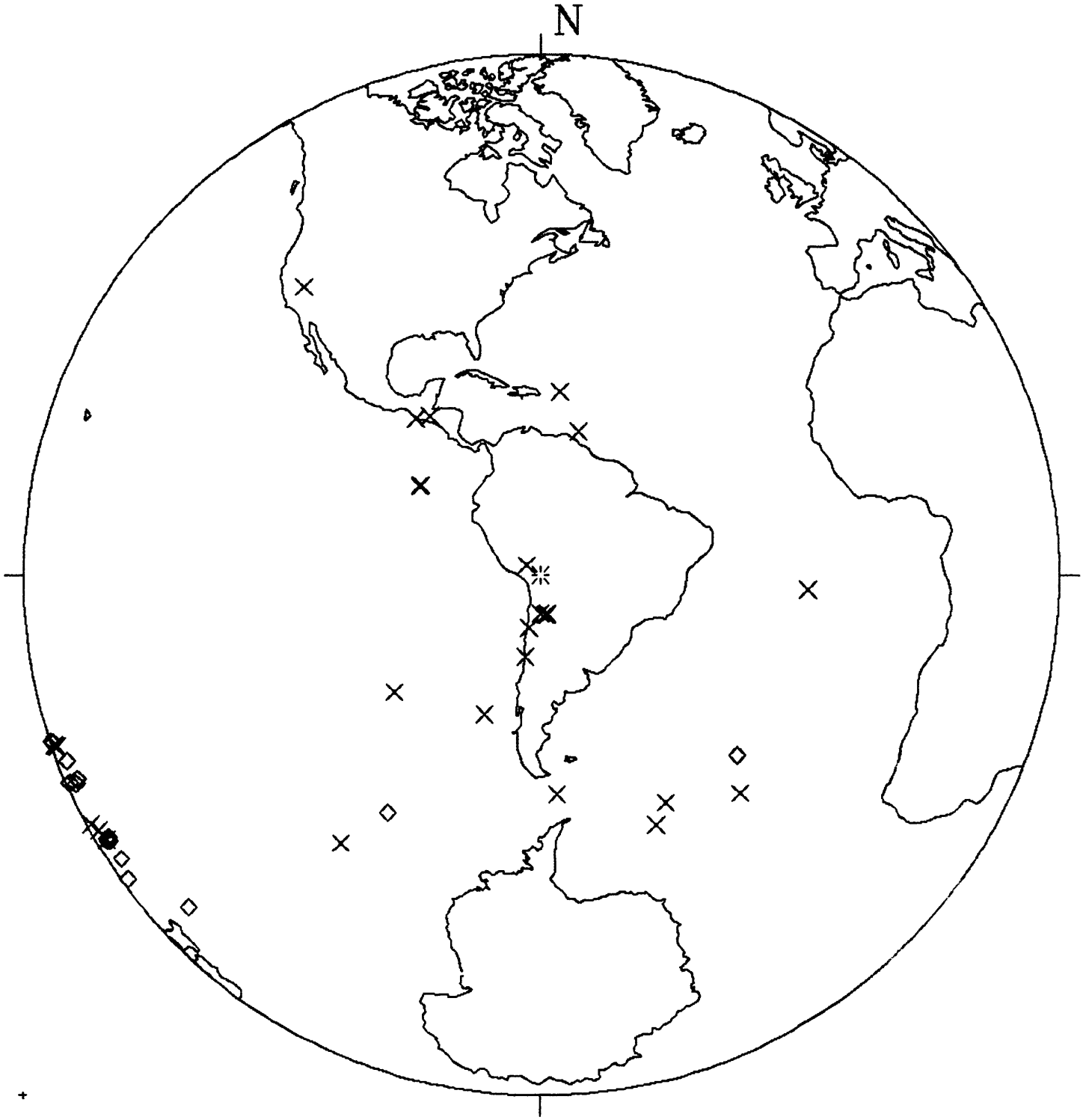


FIGURE 6

	4.0	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0
<10					1				2			2	1				1					1
10-20	1				2	1	1		3	1			1		1							
20-25					2	1	1		1		1											
25-30						3	1		1	1	1	1	1	2	1							
30-35																						
35-40							1	1		1		1	2			1	1					
40-45	1		1			2								1								
45-50							1		1						1							
50-55											2		1	3								
55-60						1								1								
60-65									1							1						
65-70	2										1											
70-75	1				1						1	1										
75-80																						
80-85		1				1	3		1													
85-90				1																		
90-95																						
95-100	3	2		1			4	4	2	1	4	3	7	4	3	3	1	2	1		1	2

.5mm 1mm

NUMBER OF DETECTIONS PER MAGNITUDE AND DISTANCE FOR LPB AND LPBRR WITH THEORETICAL .5mm T-T AMP. AND 1mm T-T AMP DETECTION LINES

TABLE 5

THEORETICAL MAGNITUDES
FOR STATIONS LPB USING G=25,000 T=1.0 A=0.5,1.0 h=33km.
AND ZOBO USING G=200,000 T=1.0 A=1.0,2.0 h=33km.

DISTANCE	AMPLITUDE			
	LPB		ZOBO	
	.5mm	1mm	1mm	2mm
100	5.3	5.6	4.7	5.0
95	5.2	5.5	4.6	4.9
90	5.0	5.3	4.4	4.7
85	5.0	5.3	4.4	4.7
80	4.8	5.1	4.2	4.5
75	4.8	5.1	4.2	4.5
70	4.9	5.2	4.3	4.6
65	4.9	5.2	4.3	4.6
60	4.9	5.2	4.3	4.6
55	4.8	5.1	4.2	4.5
50	4.8	5.1	4.2	4.5
45	4.7	5.0	4.1	4.4
40	4.5	4.8	3.9	4.2
35	4.7	5.0	4.1	4.4
30	4.6	4.9	4.0	4.3
25	4.4	4.7	3.8	4.1
20	4.1	4.4	3.5	3.8

TABLE 6

LPB AND LPBRR DETECTION CAPABILITIES PER MAGNITUDE/DISTANCE
SEPTEMBER 1982

DIST	TOT. EVTS.	LPB DET	LPB DET %	LPB RR	LPBRR DET %	THEO DET .5mm	DET % .5mm	THEO DET 1mm	DET % 1mm
1	2	3	4	5	6	7	8	9	10
≤10	8	8	100	8	100	8	100	7	88
>10≤20	11	11	100	11	100	10	91	8	73
>20≤25	6	5	83	5	83	3	50	2	33
>25≤30	12	8	67	10	83	8	67	6	50
>30≤35	-	-	-	-	-	-	-	-	-
>35≤40	8	8	100	8	100	8	100	6	75
>40≤45	5	1	20	2	40	1	20	1	20
>45≤50	3	3	100	3	100	1	33	1	33
>50≤55	6	2	33	3	50	6	100	3	50
>55≤60	2	1	50	2	100	1	50	1	50
>60≤65	2	2	100	2	100	1	50	1	50
>65≤70	3	0	0	1	33	1	33	0	0
>70≤75	4	1	25	1	25	2	50	0	0
>75≤80	-	-	-	-	-	-	-	-	-
>80≤85	6	1	17	1	17	0	0	0	0
>85≤90	1	0	0	0	0	0	0	0	0
>90≤95	-	-	-	-	-	-	-	-	-
>95≤100	48	6	13	9	19	13	27	6	13

TABLE 7

LPB DETECTIONS COMPARED TO THEORETICAL DETECTIONS FOR .5mm P-P AND 1.0mm P-P AMPLITUDES

DISTANCE	LPB DET	THEO. DET (.5mm)	THEO. DET (1.0mm)	LPB % OF .5 DET	LPB % OF 1.0 DET
<10	8	8	7	100	100+
>10≦20	11	10	8	100+	100+
>20≦25	5	3	2	100+	100+
>25≦30	8	8	6	100	100+
>30≦35	-	-	-	-	-
>35≦40	8	8	6	100	100+
>40≦45	1	1	1	100	100
>45≦50	3	1	1	100+	100+
>50≦55	2	4	2	50	100
>55≦60	1	1	1	100	100
>60≦65	2	1	1	100+	100+
>65≦70	0	1	0	0	100
>70≦75	1	2	0	50	100+
>75≦80	-	-	-	-	-
>80≦85	1	0	0	100+	100+
>85≦90	0	0	0	100	100
>90≦95	-	-	-	-	-
>95≦100	6	13	6	46	100

TABLE 8

LPB RR
GS DATA SET
SEPTEMBER 1982 309 EVENTS

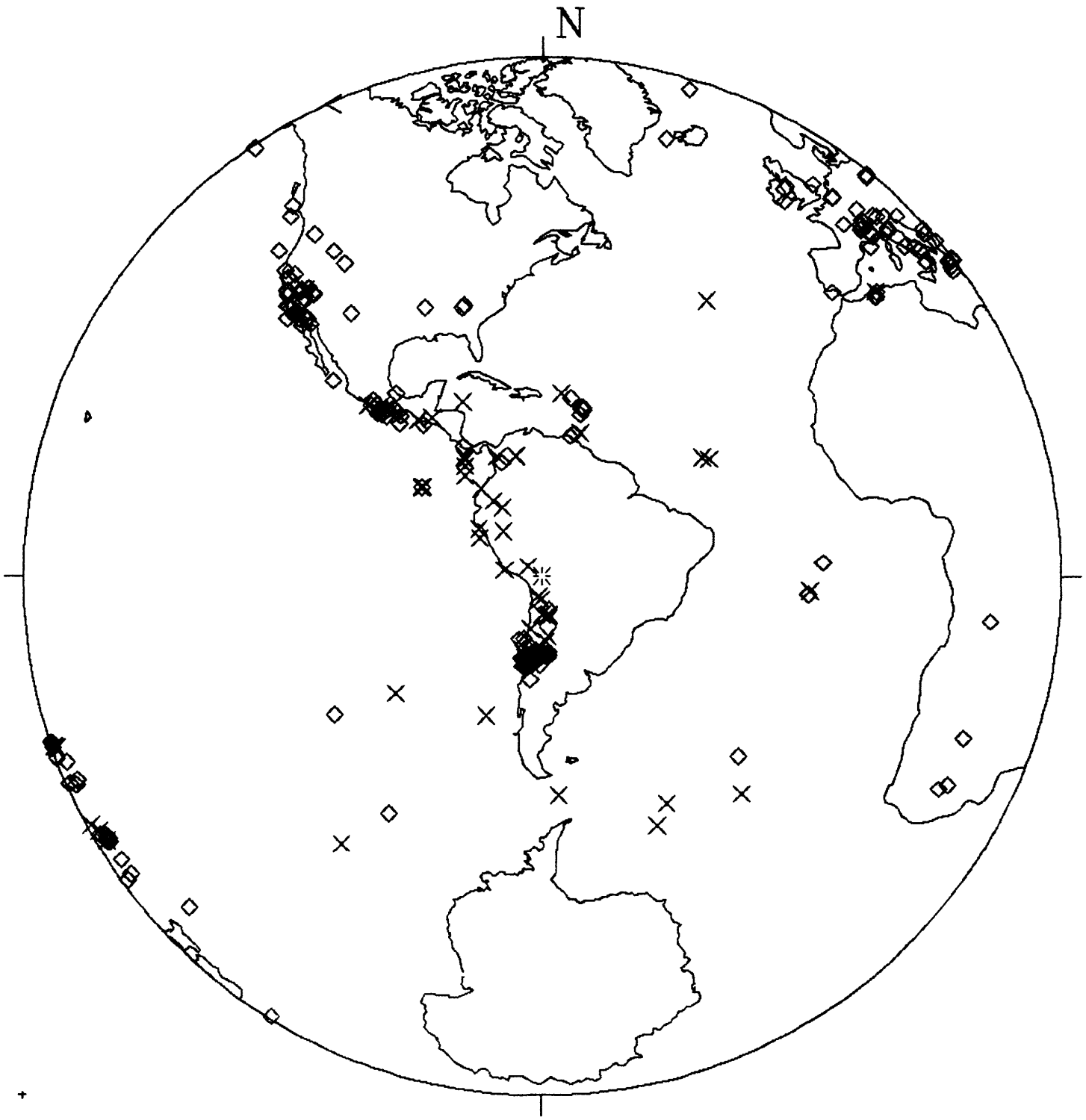


FIGURE 7

LPB RR
GS DATA SET NO mb REPORTED
SEPTEMBER 1982 184 EVENTS

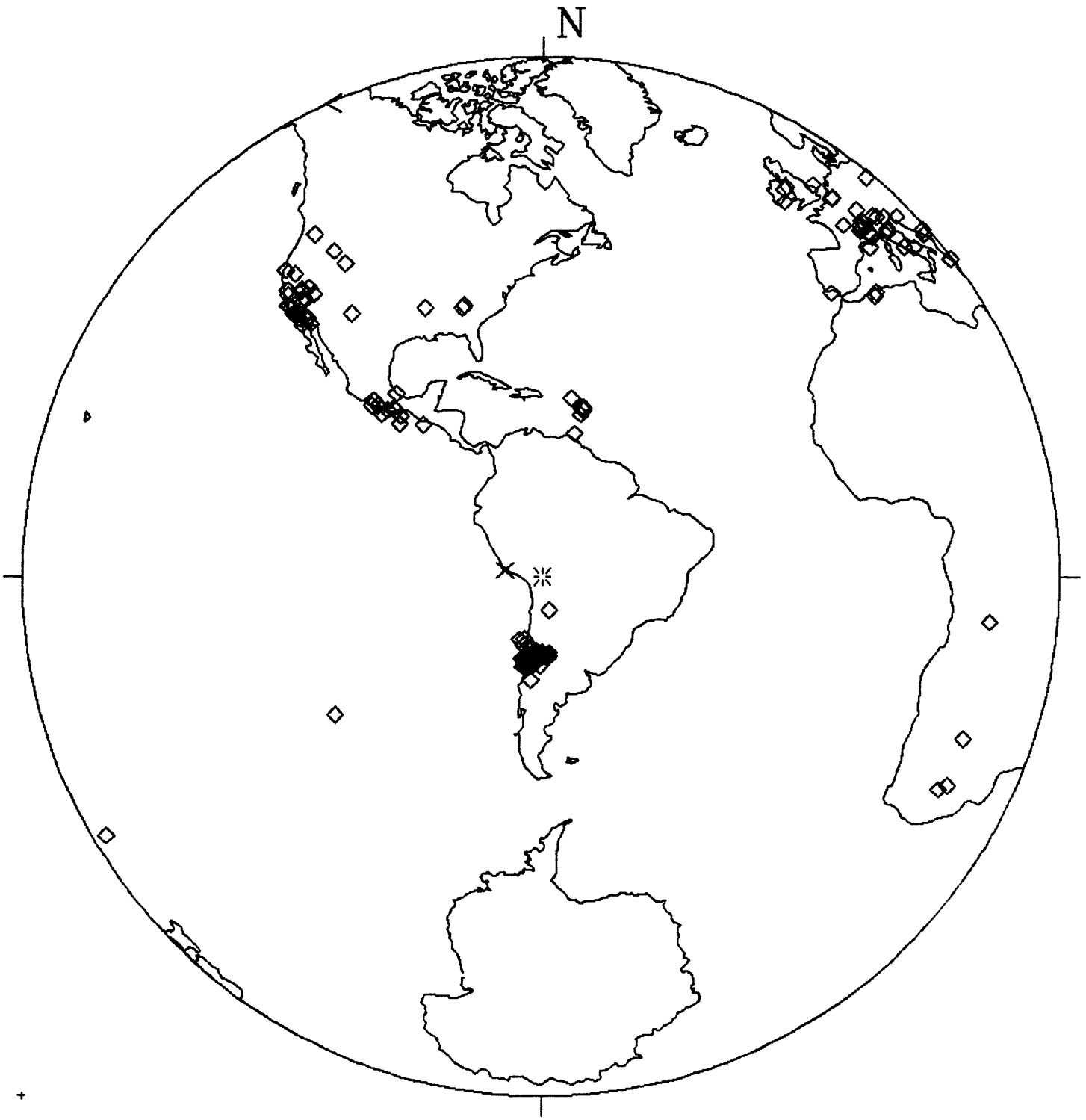


FIGURE 8

LPB RR
GS DATA SET mb REPORTED
SEPTEMBER 1982 125 EVENTS

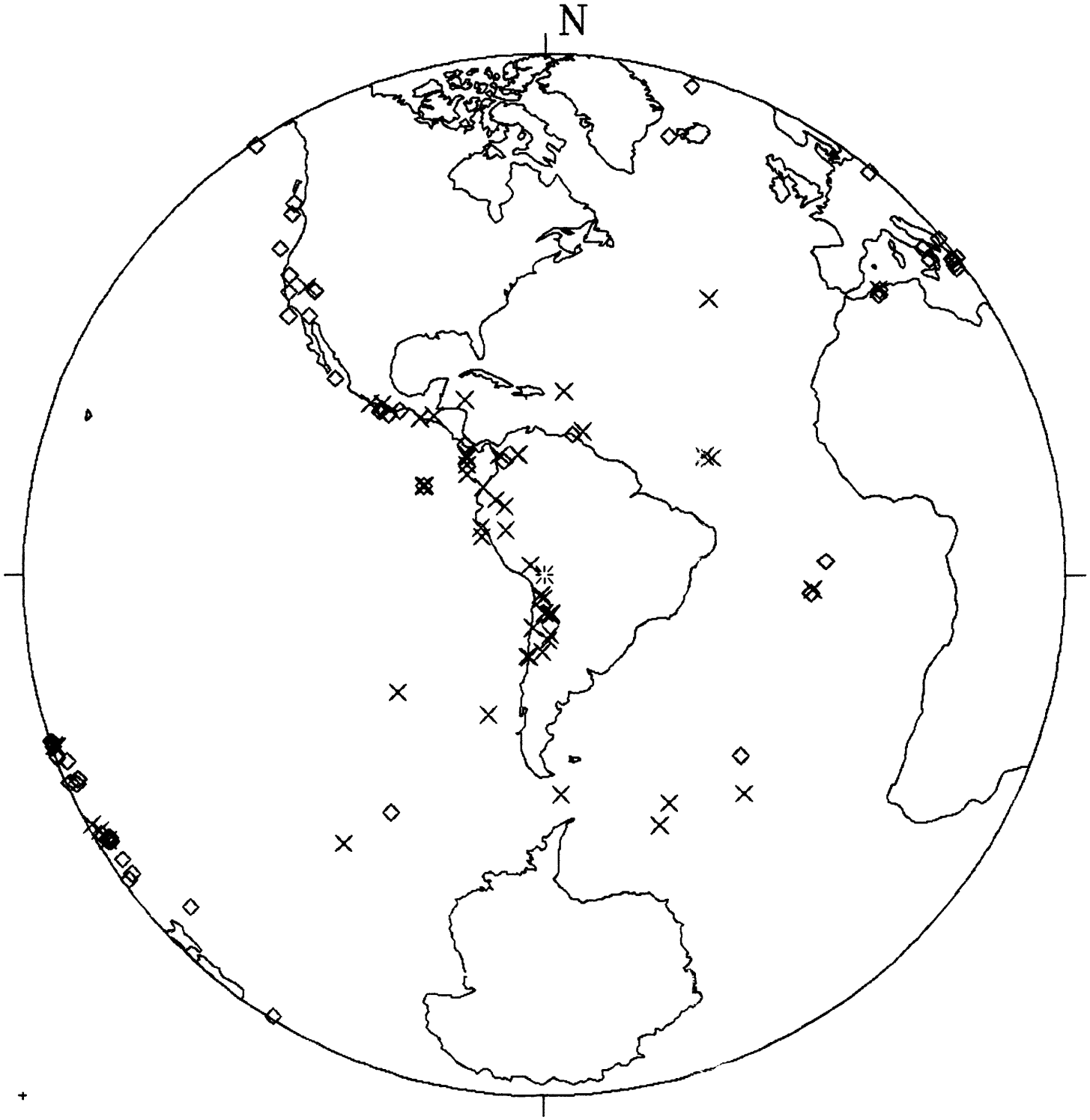


FIGURE 9

LPB RR
GS DATA SET mb <4.5
SEPTEMBER 1982 29 EVENTS

FIGURE 10

LPB RR
GS DATA SET mb >4.4<5.0
SEPTEMBER 1982 43 EVENTS

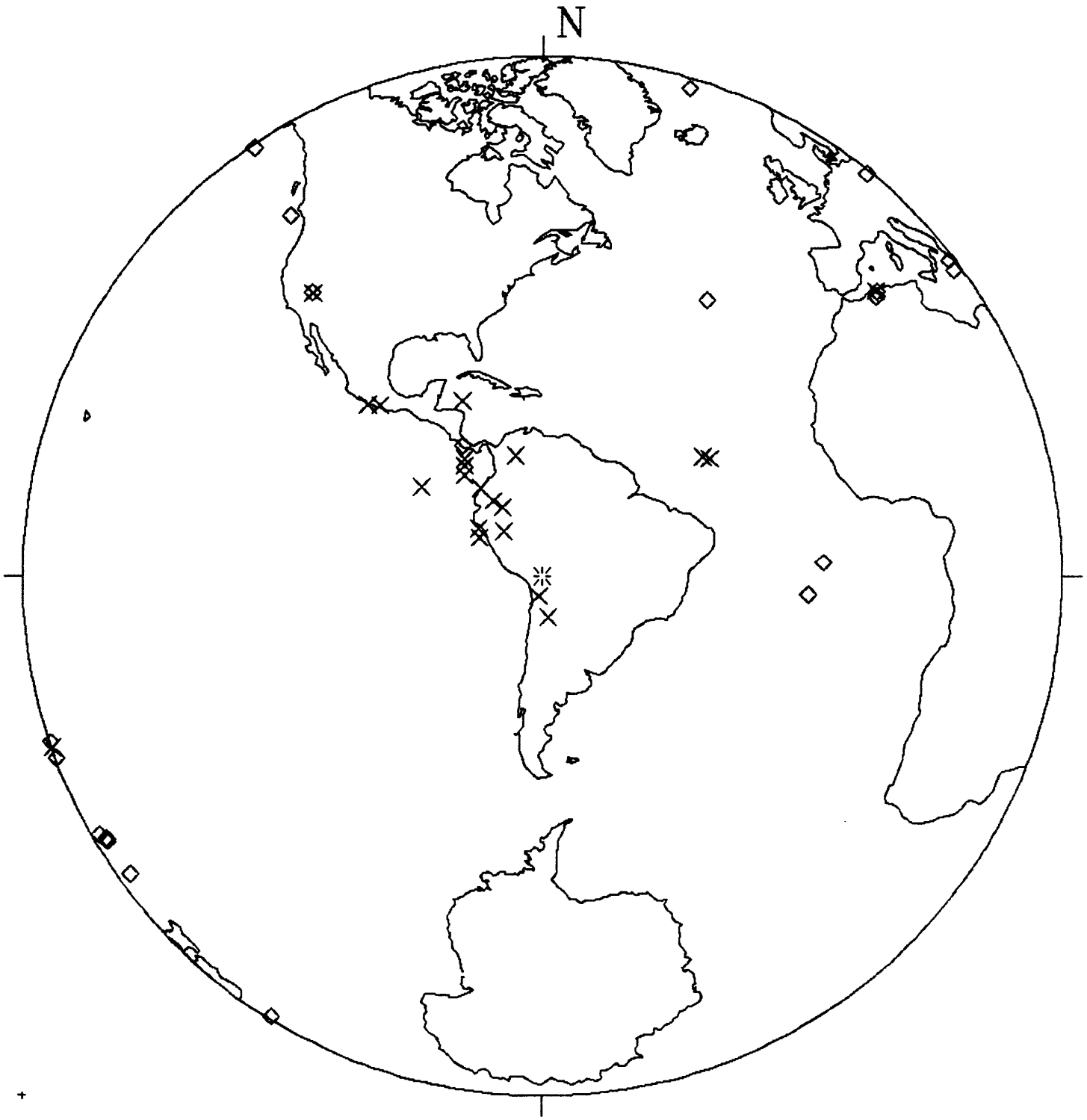


FIGURE 11

LPB RR
GS DATA SET mb >4.9
SEPTEMBER 1982 53 EVENTS

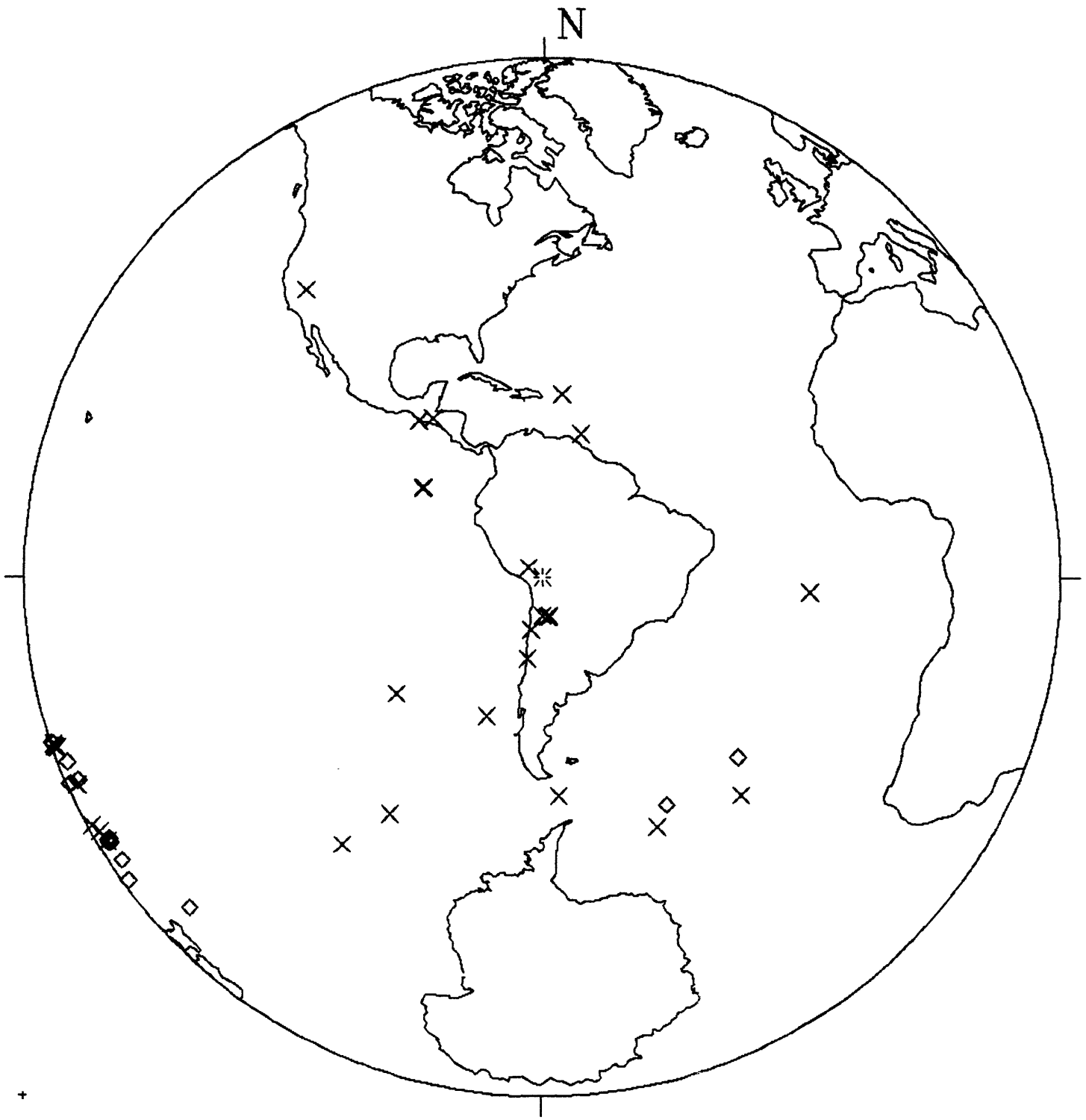


FIGURE 12

same as for the LPB analysts statistics. Table 4 (columns 3 and 6) show the LPB-RR detection capability at different distance ranges and the percentage of the total events (column 4) for each distance range. The reread detections show an improvement of 7% of all events and an 8% improvement for events with distances less than 95 degrees. The entries on table 5 are the same for LPB and LPB-RR detections. Table 7 shows the comparison of LPB-RR detections (columns 5 & 6) to the theoretical numbers for .5 mm and 1.0 mm P-P amplitude detection capabilities and table 9 shows the percentage of theoretical detections. LPB-RR had with only a slight improvement at the 0.5 mm detection level.

COMPARISON OF ZOBO REREAD TIMES AND THEIR ASSOCIATIONS TO THE PDE MONTHLY LISTING REPORTED EVENTS:

Station ZOBO can only be evaluated for the first 19 days of September 1982 because film chips were unavailable for subsequent dates. All statistics involving ZOBO comparisons will be for these 19 days. One hundred sixty-two events within 100 degrees of station ZOBO occurred during this time period of which 83 events had no associated magnitude and 79 events had associated magnitudes. The remaining statistics for ZOBO detection capability will be computed using the 79 events with reported magnitudes. Figures 13, 14, and 15 show the geographical distribution and associations of station ZOBO (plotted as X) for the total 162 events, 83 events with no reported magnitude and the 79 events with reported magnitudes. Table 10 shows the event distribution by magnitude and the comparison of ZOBO detections to both the LPB analyst detection and the LPB RR detections. It appears from the table that the approximate 50% detection threshold for ZOBO detections is near the 4.2 magnitude and the 90% detection threshold is near the 5.2 magnitude. These thresholds are 0.5 magnitude unit lower than the LPB and LPB-RR thresholds. Figures 16, 17 and 18 show the geographic distribution of events, occurring during the first 19 days of September, for the following magnitude ranges: mb<4.5, 4.4<mb <5.0, and mb>4.9. Table 11 shows the distance distribution of these earthquakes and compares the number of detections for LPB, LPB-RR and ZOBO.

This table also shows the percentage detections of ZOBO compared with those of LPB and LPB-RR. Considering the total events at all distance ranges, ZOBO shows a 24% improvement over LPB and a 19% improvement over LPB-RR. We now need to know if the analyst reading station ZOBO should have been able to read all the events listed on table 11. Table 12 shows the number of events per each mb range compared to each distance range. To utilize this table, a new model was constructed based on the mb magnitude formula and assuming the station gain to be 200K, T=1.0, h=33 and A=1.0 mm. P-P and 2.0 mm P-P. Table 6, columns 4 and 5, were generated from this model. By plotting this data from table 6 onto table 12, with the trailing edge of the shaded area being the 1.0 mm P-P detection capability and the leading edge of the shaded area being the 2.0 mm P-P detection capability, the distance/magnitude detection comparison of the two theoretical amplitudes can be made. Table 13 shows the number and percentages of the ZOBO detections per distance compared to theoretical detections by distance one would obtain by reading at 1 mm P-P and 2 mm P-P amplitudes. Table 14 shows the percentage of the number of ZOBO detections per distance of expected theoretical detections per distance. Evaluating this table, we can see that ZOBO detections were 100% of the

LPB RR DETECTIONS COMPARED TO THEORETICAL DETECTIONS FOR .5mm P-P AND 1.0mm P-P AMPLITUDES

DISTANCE	LPBRR DET	THEO. DET (.5mm)	THEO. DET (1.0mm)	LPBRR % OF .5 DET	LPBRR % OF 1.0 DET
<10	8	8	7	100	100+
>10≦20	11	10	8	100+	100+
>20≦25	5	3	2	100+	100+
>25≦30	10	8	6	100+	100+
>30≦35	-	-	-	-	-
>35≦40	8	8	6	100	100+
>40≦45	2	1	1	100+	100+
>45≦50	3	1	1	100+	100+
>50≦55	3	4	2	75	100+
>55≦60	2	1	1	100+	100+
>60≦65	2	1	1	100+	100+
>65≦70	1	1	0	100	100
>70≦75	1	2	0	50	100+
>75≦80	-	-	-	-	-
>80≦85	1	0	0	100+	100+
>85≦90	0	0	0	100	100
>90≦95	-	-	-	-	-
>95≦100	9	13	6	69	100

TABLE 9

ZOBO
GS DATA SET
SEPTEMBER 1-19,1982 162 EVENTS

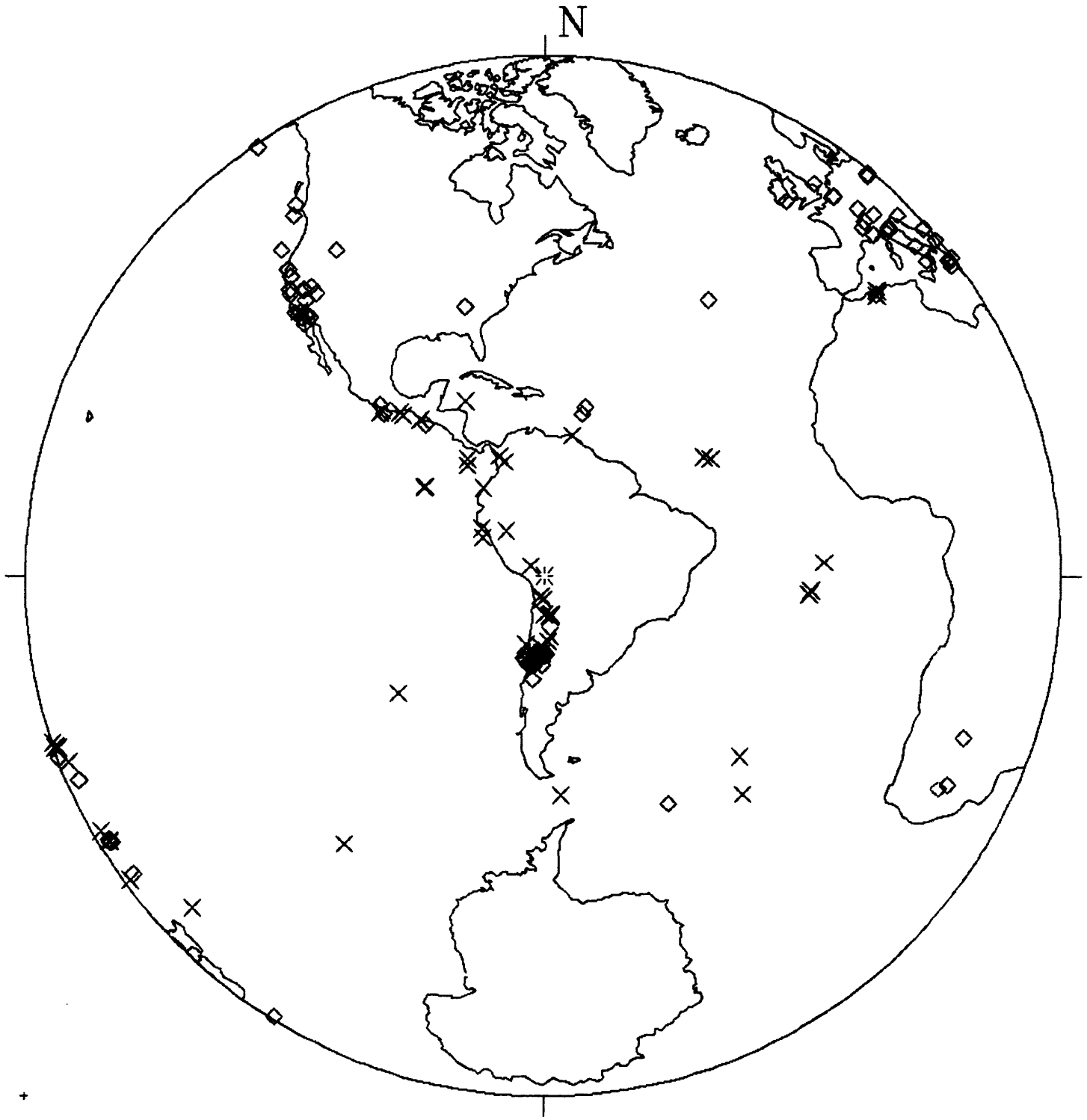


FIGURE 13

ZOBO
GS DATA SET NO mb REPORTED
SEPTEMBER 1-19,1982 83 EVENTS

FIGURE 14

ZOBO
GS DATA SET mb REPORTED
SEPTEMBER 1-19,1982 79 EVENTS

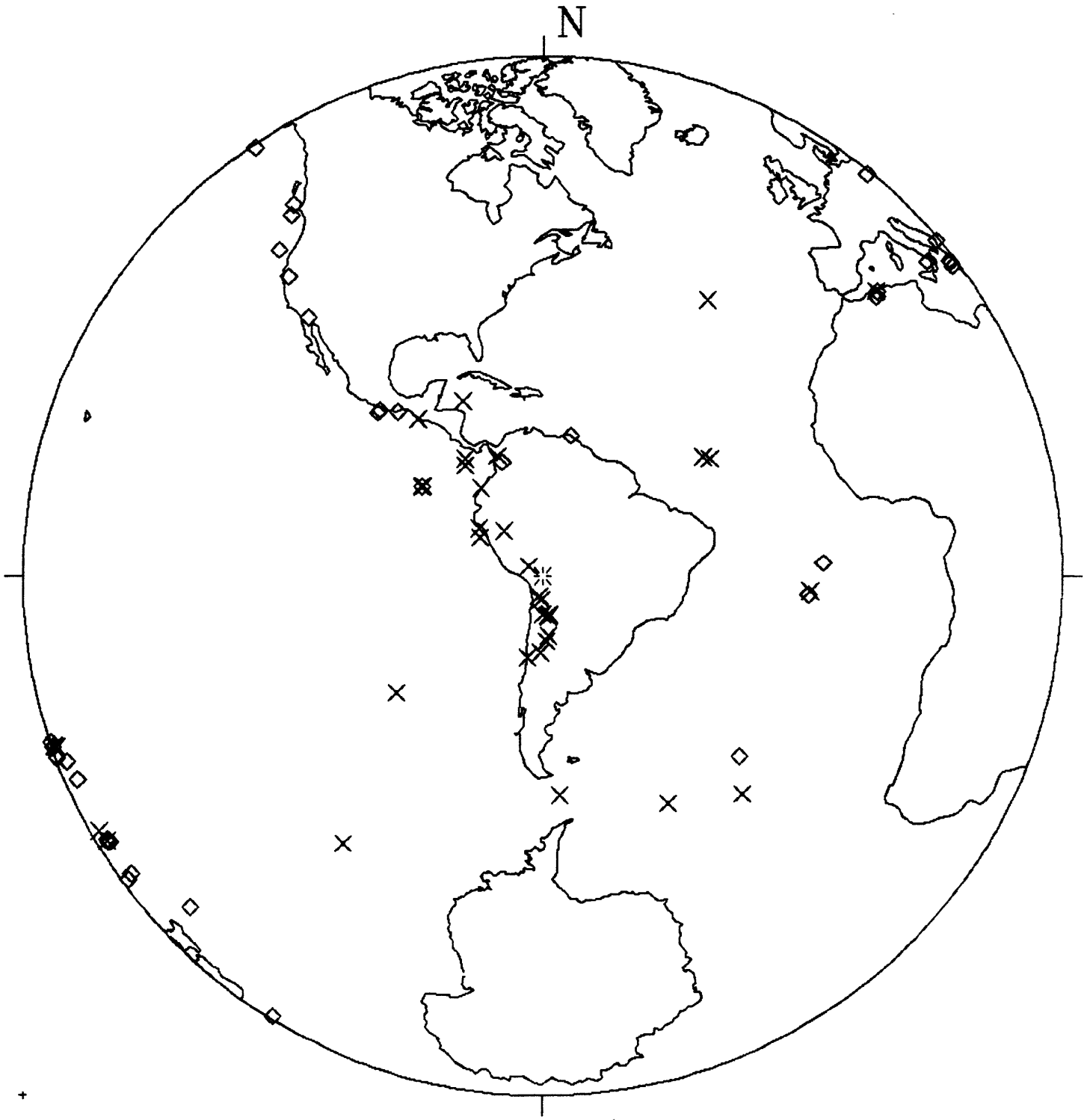


FIGURE 15

DETECTION DISTRIBUTION PER MAGNITUDE
LPB ANALYST - LPB RR - ZOBO RR
FOR SEPTEMBER 1 THROUGH 19 1982

MAG.	LPB DET.	LPB RR. DET.	ZOBO DET.	TOTAL EVENTS	LPB DET. %	LPB RR. DET. %	ZOBO DET. %
NONE	0	0	0	91	0	0	0
<4.0	1	1	2	6	17	17	33
4.0	0	0	0	1	0	0	0
4.1	-	-	-	-	-	-	-
4.2	0	0	0	2	0	0	0
4.3	3	3	3	4	75	75	75
4.4	1	3	6	6	17	50	100
4.5	2	2	6	9	22	22	67
4.6	1	1	1	3	33	33	33
4.7	8	8	8	8	100	100	100
4.8	3	3	3	4	75	75	75
4.9	0	1	3	4	0	25	75
5.0	4	4	4	5	80	80	80
5.1	2	2	4	6	33	33	67
5.2	3	3	5	5	60	60	100
5.3	3	3	3	5	60	60	60
5.4	3	3	4	4	75	75	100
5.5	1	1	1	1	100	100	100
5.6	1	1	1	2	50	50	50
5.7	1	1	1	1	100	100	100
5.8	-	-	-	-	-	-	-
5.9	1	1	1	1	100	100	100
6.0	2	2	2	2	100	100	100

TABLE 10

ZOBO
GS DATA SET mb <4.5
SEPTEMBER 1-19,1982 19 EVENTS

FIGURE 16

ZOBO
GS DATA SET mb >4.4<5.0
SEPTEMBER 1–19,1982 29 EVENTS

FIGURE 17

ZOBO
GS DATA SET mb >4.9
SEPTEMBER 1–19,1982 32 EVENTS

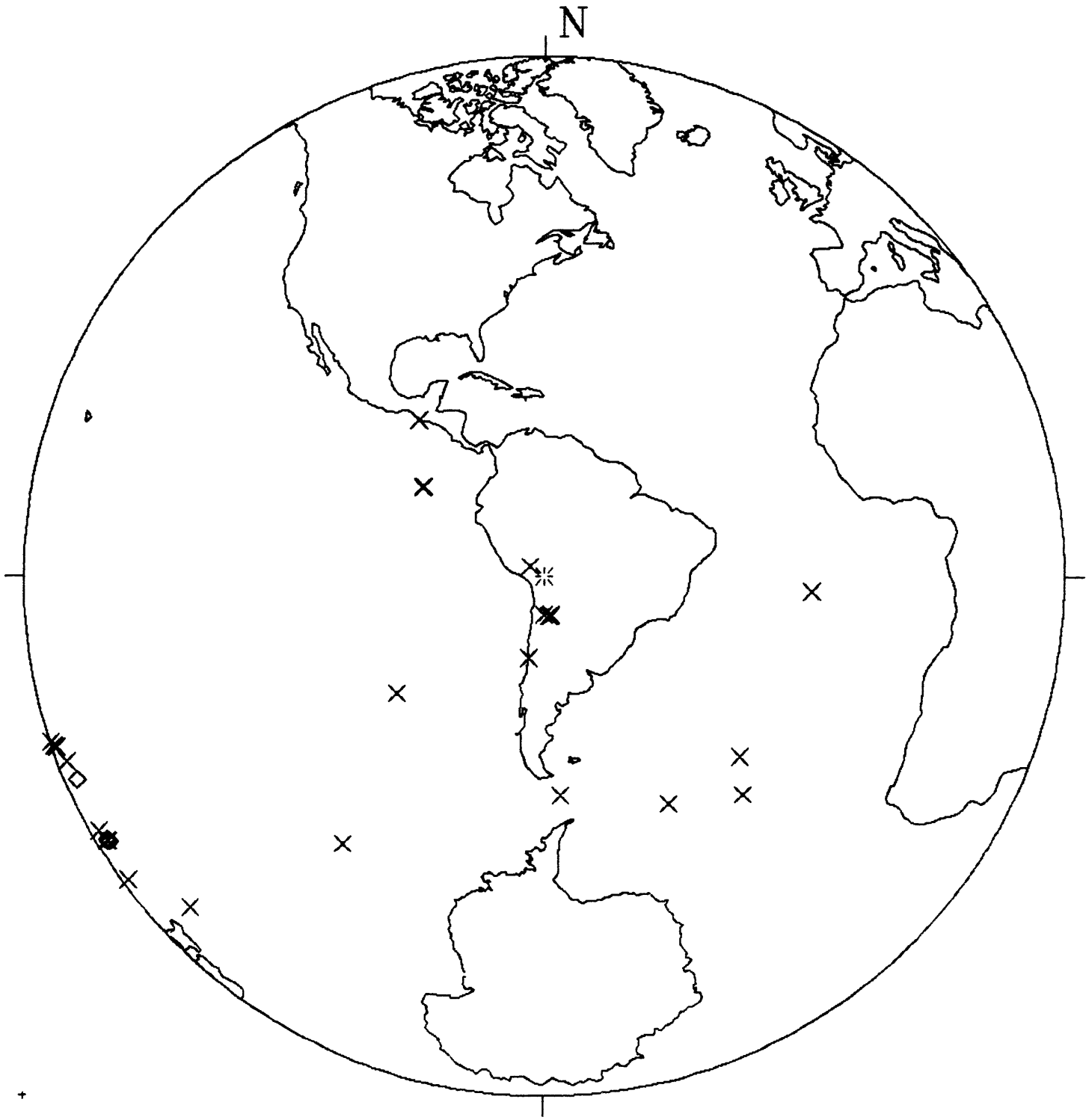


FIGURE 18

	<4.0	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0
<10					1				2			2	1				1					1
10-20	1				1	1			2	1					1							
20-25					1	2			1													
25-30						1	1		1	1		1	1		1							
30-35																						
35-40							1	1		1		1				1						
40-45	1					2								1								
45-50															1							
50-55											2			2								
55-60														1								
60-65									1							1						
65-70	1																					
70-75																						
75-80					1																	
80-85		1					3		1													
85-90				1																		
90-95																						
95-100	2	1					4	2	1	1	2	1	4	1	2	2		2	1		1	1

1 2

NUMBER OF DETECTIONS PER MAGNITUDE AND DISTANCE FOR STATION ZOBO

WITH THEORETICAL 1mm T-T AMP. AND 2mm T-T AMP. DETECTION LINES.

TABLE 12

ZOBO DETECTION CAPABILITIES PER MAGNITUDE/DISTANCE
SEPTEMBER 1 THROUGH 19, 1982

DIST.	TOTAL EVENTS	ZOBO DET.	DET. %	THEO. DET. (1mm)	DET. %	THEO. DET. (2mm)	DET. %
≤10	8	8	100	8	100	8	100
>10≤20	7	7	100	7	100	7	100
>20≤25	4	4	100	4	100	4	100
>25≤30	7	7	100	7	100	7	100
>30≤35	-	-	-	-	-	-	-
>35≤40	5	5	100	5	100	5	100
>40≤45	4	3	75	3	75	3	75
>45≤50	1	1	100	1	100	1	100
>50≤55	4	4	100	4	100	4	100
>55≤60	1	1	100	1	100	1	100
>60≤65	2	2	100	2	100	2	100
>65≤70	1	0	0	0	0	0	0
>70≤75	-	-	-	-	-	-	-
>75≤80	1	0	0	1	100	0	0
>80≤85	5	3	60	4	80	1	20
>85≤90	1	0	0	0	0	0	0
>90≤95	-	-	-	-	-	-	-
>95≤100	28	11	39	19	68	15	54

TABLE 13

ZOBO DETECTIONS COMPARED TO THEORETICAL DETECTIONS FOR 1.0mm P-P AND 2.0mm P-P AMPLITUDES

DISTANCE	ZOBO DET	THEO. DET (1.0mm)	THEO. DET (2.0mm)	ZOBO % OF 1.0 DET	ZOBO % OF 2.0 DET
<10	8	8	8	100	100
>10≦20	7	7	7	100	100
>20≦25	4	4	4	100	100
>25≦30	7	7	7	100	100
>30≦35	-	-	-	-	-
>35≦40	5	5	5	100	100
>40≦45	3	3	3	100	100
>45≦50	1	1	1	100	100
>50≦55	4	4	4	100	100
>55≦60	1	1	1	100	100
>60≦65	2	2	2	100	100
>65≦70	0	0	0	100	100
>70≦75	-	-	-	-	-
>75≦80	0	1	0	0	100
>80≦85	3	4	1	75	100+
>85≦90	0	0	0	100	100
>90≦95	-	-	-	-	-
>95≦100	11	19	15	58	73

TABLE 14

expected detections for all distances except distance >95 degrees at the 2 mm P-P threshold and 100% except for three distances >75% degrees for the 1 mm P-P threshold.

AFTAC DATA SET:

A second list of earthquakes, occurring in September 1982, was obtained from AFTAC (Air Force Technical Applications Center) to further the investigation of the detection capabilities of stations LPB and ZOBO. Two hundred ninety-four events were included in this data set of which 135 were in common to the USGS PDE Monthly Listing data set. One hundred fifty-nine events of the AFTAC data set did not appear in the USGS data set, but conversely, 173 events of the USGS set did not appear in the AFTAC data set. A combined data set composed of the USGS and AFTAC data sets contains 468 earthquakes. Figures 19 and 20 show the geographic distribution of this total data set with figure 19 showing the LPB associations and figure 20 the LPB-RR associations plotted with the symbol X. Figure 21 shows the distribution of the 245 events of this total data set which occurred during the first 19 days of September with the ZOBO associations. Figure 22 shows the geographic distribution of the 294 events of the AFTAC data set with the LPB-RR detection associations plotted with the symbol X. Figure 23 shows the distribution of the 166 events which occurred during the ZOBO record availability time, with the ZOBO detection association plotted with the symbol X. There is no figure for the LPB analyst detection associations to the AFTAC data set as these detections would only be associated to the 135 common events to the USGS and AFTAC data sets. Table 15 shows the distance distribution of the AFTAC data set and compares the number of LPB and LPB-RR associated detections to the total events of the data set. Table 16 shows the distance distribution of the AFTAC data set for the first 19 days of September and compares the number of associated detections of LPB, LPB-RR and ZOBO to the total events. Figure 24 shows the distribution of the USGS data set events which did not appear in the AFTAC data set. This distribution corresponds quite closely to the USGS data set for events with no reported mb (figure 2). Figures 25 is the geographic distribution of the 159 events reported in the AFTAC data set, but not included in the USGS data set. Figure 26 is this distribution with the X points being the events with LPB-RR detection associations. Figure 27 is the partial AFTAC data set showing the ZOBO associated detections. Figures 28 and 29 show the geographic destribution of the 173 events appearing in the USGS data set and the association of the LPB and LPB-RR detections. Figure 30 is the distribution of the subset of 80 events of this data set for days September 1 through 19 and shows the ZOBO associated detections.

DETECTION CAPABILITY OF LPB ANALYST TO THE AFTAC DATA SET:

To understand better the detection capabilities of stations LPB and ZOBO for the events in the AFTAC data set, we divided this set into four size groupings; A, B, C, and D. Group A is composed of the largest earthquakes and group D with the smallest earthquakes of the AFTAC data set. By making these divisions, we can now make a distance/size comparison of the detections. Table 17 shows the LPB analyst detections for each size grouping compared to distance and the percentage of these detections to the total number of events in each group. It is apparent from this table that there is a marked decrease in the LPB analyst's detections associated to events in groups C and D. Much of this decrease is due to having LPB detections for only the 135 common

LPB
COMBINED GS AND AFTAC DATA SETS
SEPTEMBER 1982 468 EVENTS

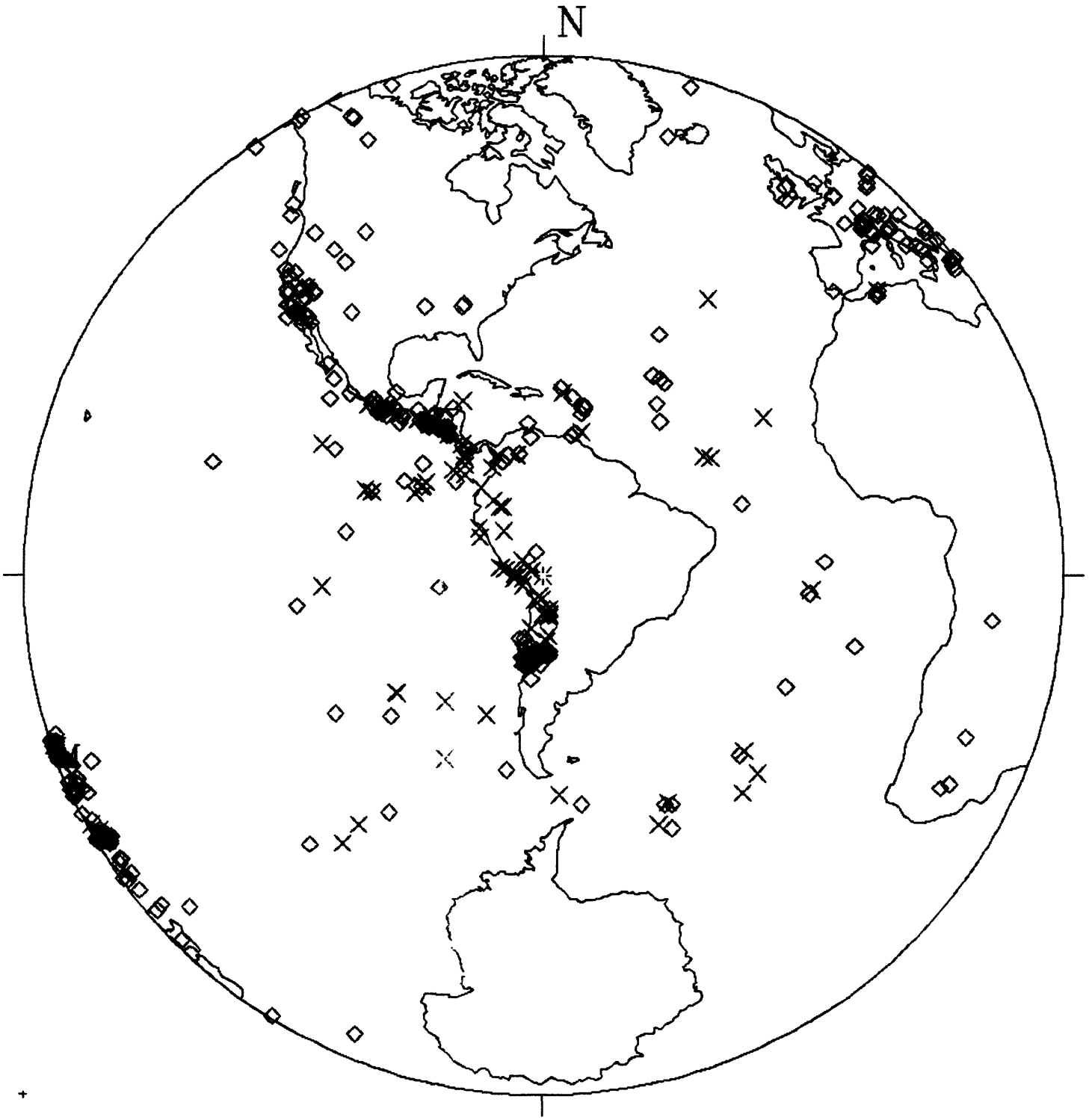


FIGURE 19

LPB RR
COMBINED GS AND AFTAC DATA SETS
SEPTEMBER 1982 468 EVENTS

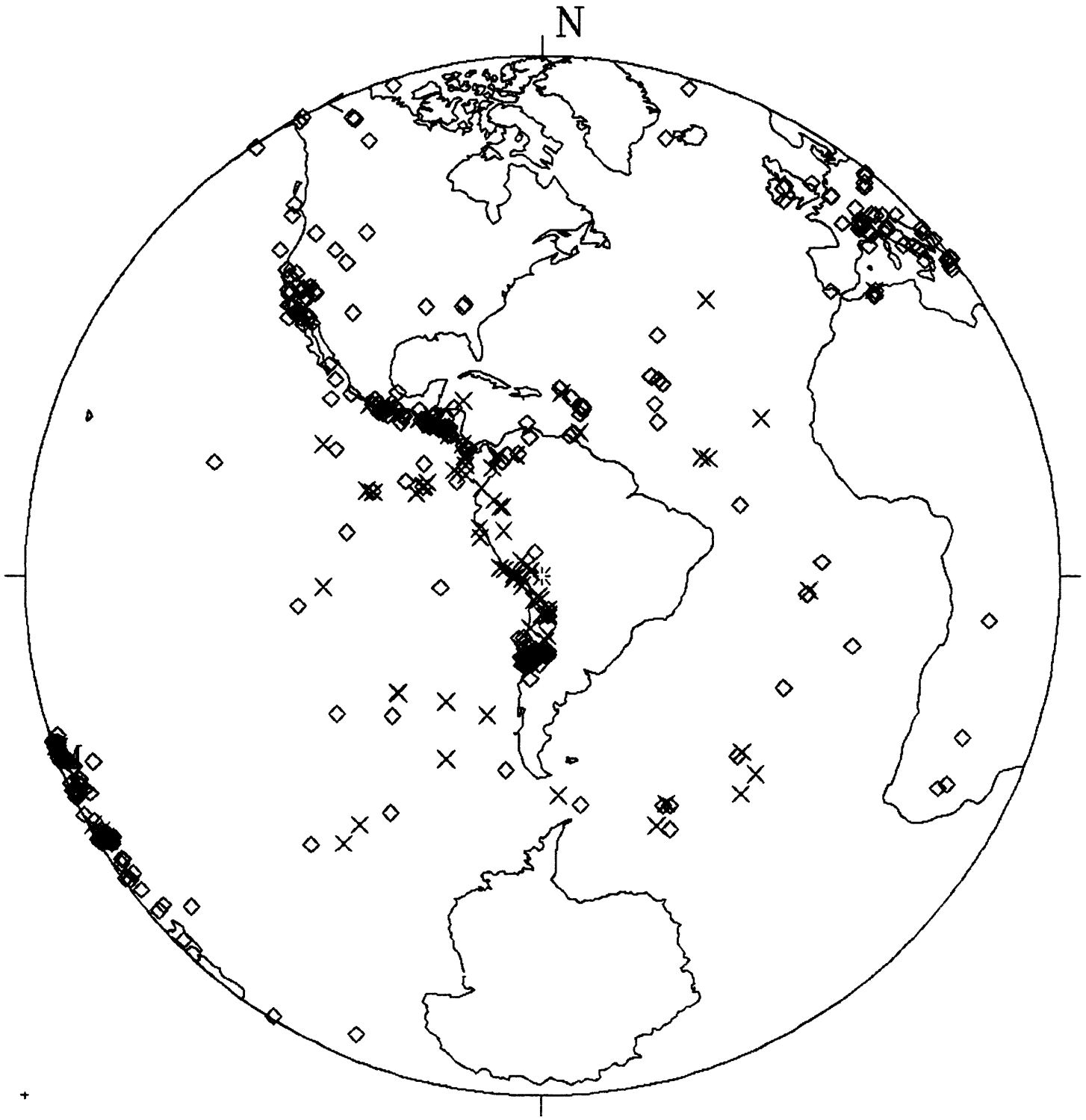


FIGURE 20

ZOBO
COMBINED GS AND AFTAC DATA SETS
SEPTEMBER 1–19,1982 245 EVENTS

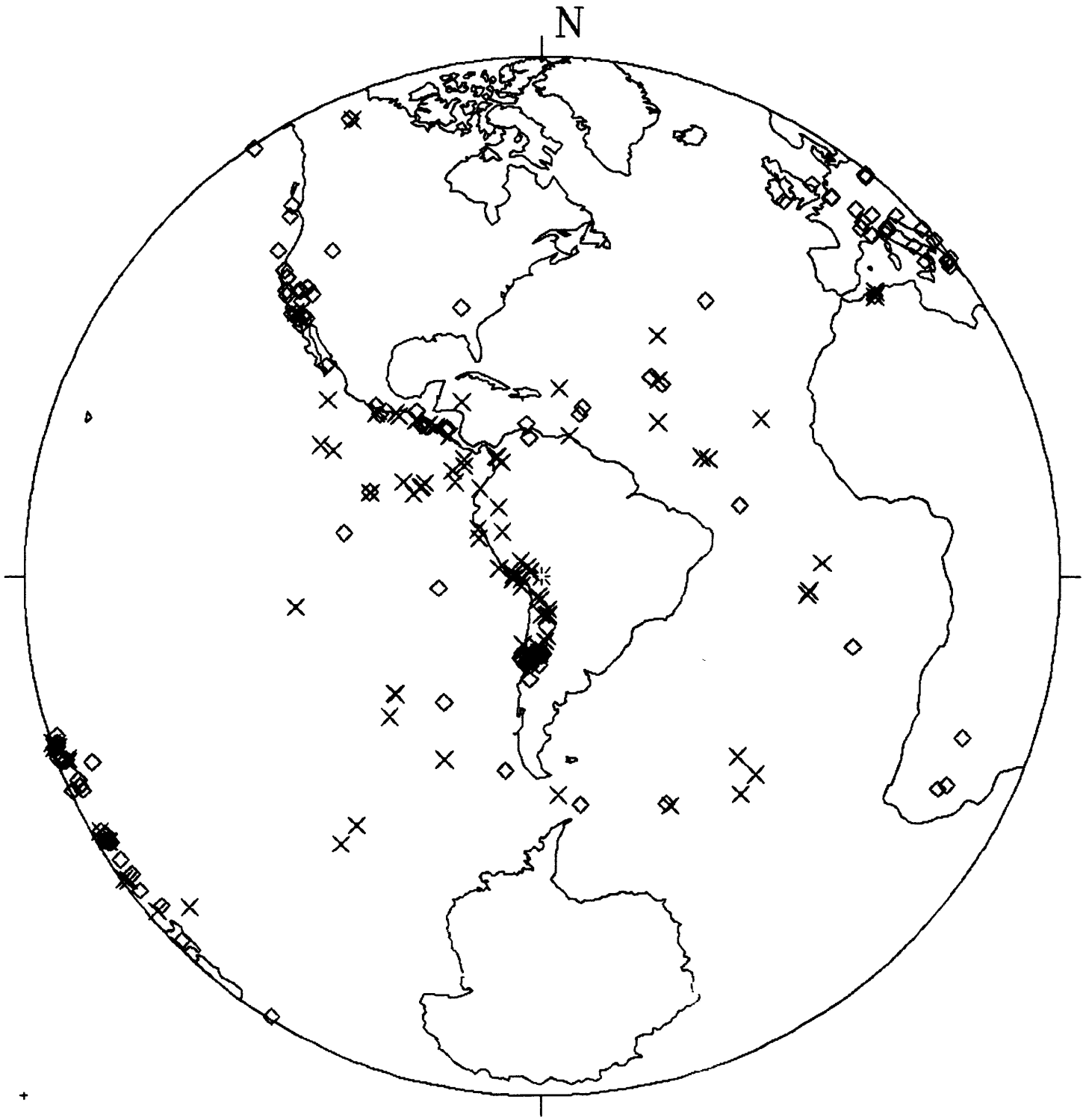


FIGURE 21

LPB RR
AFTAC DATA SET
SEPTEMBER 1982 294 EVENTS

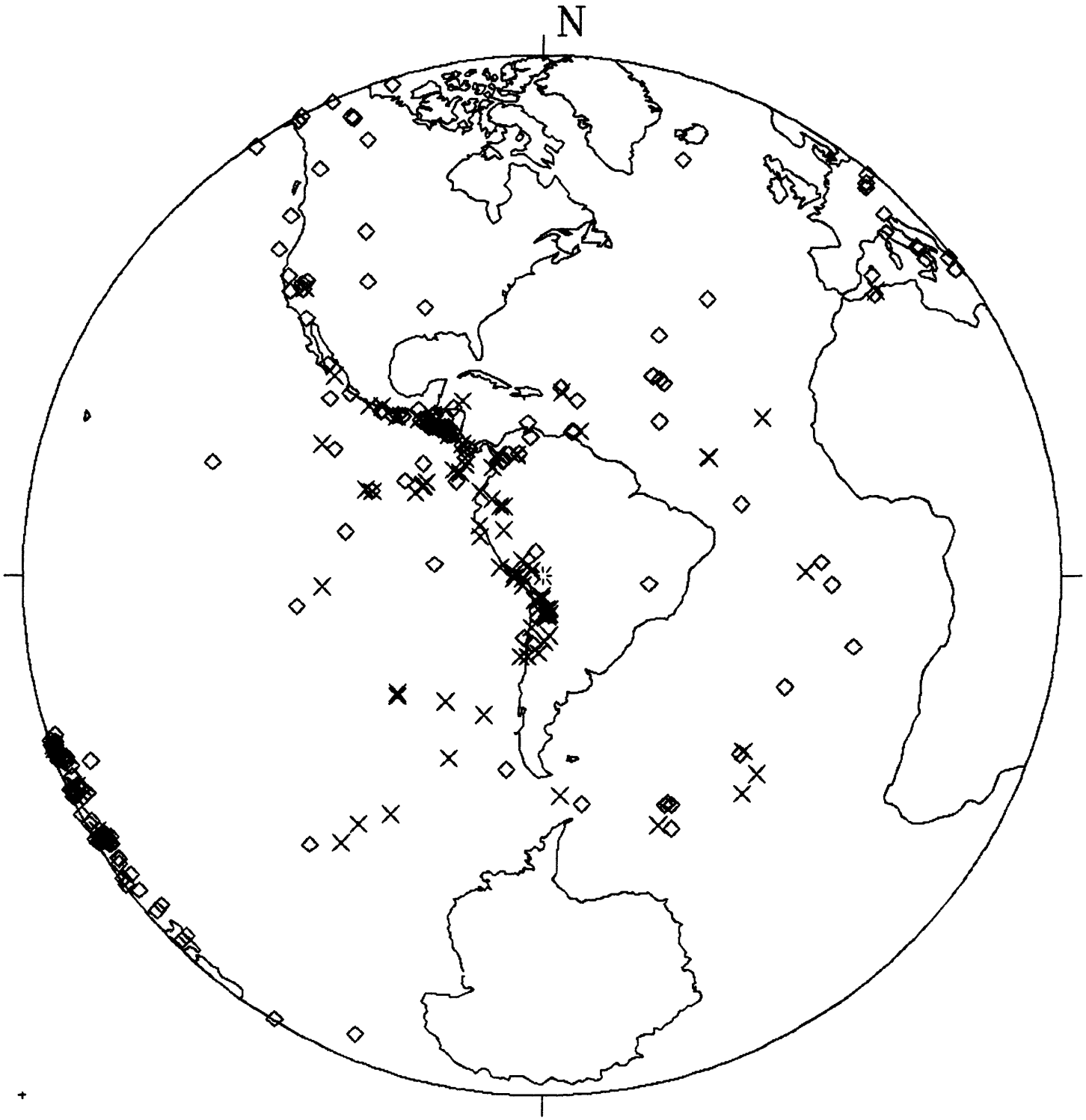


FIGURE 22

ZOBO
AFTAC DATA SET
SEPTEMBER 1–19,1982 166 EVENTS

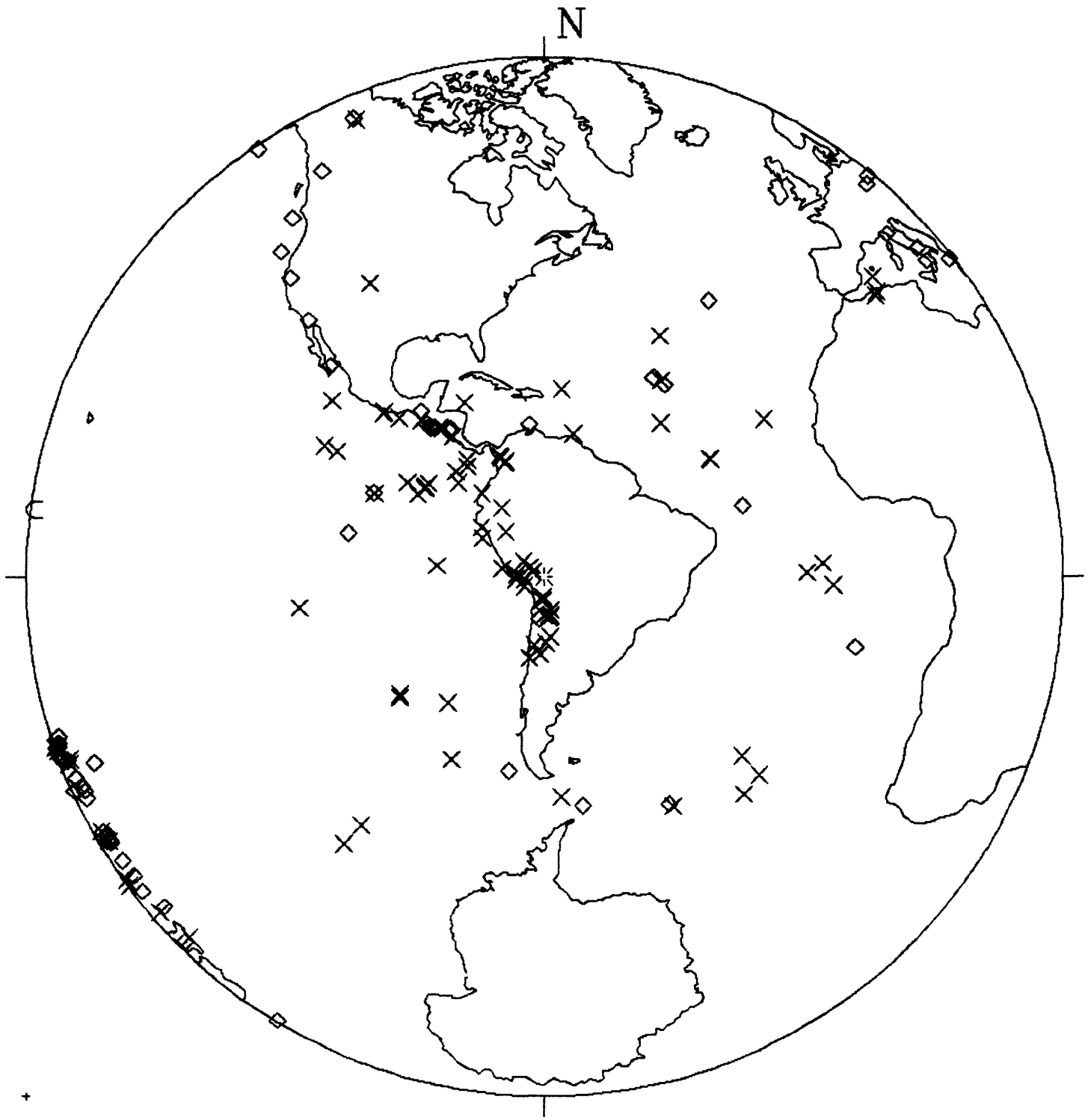


FIGURE 23

DISTANCE DISTRIBUTION FOR LPB AND LPBRR ASSOCIATED DETECTIONS TO THE AFTAC DATA SET FOR SEPTEMBER 1982

DISTANCE (DEG.)	LPB DET.	LPBRR DET.	TOTAL EVENTS	LPB DET. %	LPBRR DET. %
≤10	9	19	21	43	90
>10≤15	5	6	9	56	67
>15≤20	5	5	7	71	71
>20≤25	5	7	11	45	64
>25≤30	8	14	20	40	70
>30≤35	0	2	14	0	14
>35≤40	8	13	35	23	37
>40≤45	1	3	13	8	17
>45≤50	3	4	7	43	57
>50≤55	2	5	14	14	36
>55≤60	1	4	6	17	67
>60≤65	2	2	3	67	67
>65≤70	0	0	3	0	0
>70≤75	1	1	7	14	14
>75≤80	-	-	-	-	-
>80≤85	1	1	6	17	17
>85≤90	0	0	1	0	0
>90≤95	0	0	1	0	0
>95≤100	6	9	116	5	8
<10≤100	57	95	294	19	32
<10≤95	51	86	178	29	48

TABLE 15

DISTANCE DISTRIBUTION FOR
LPB, LPBRR, ZOBO ASSOCIATED DETECTIONS
TO THE AFTAC DATA SET FOR DAYS
SEPTEMBER 1 THROUGH SEPTEMBER 19.

DISTANCE (DEG.)	LPB DET.	LPBRR DET.	ZOBO DET.	TOTAL EVENTS	LPB DET. %	LPBRR DET. %	ZOBO DET. %
≦10	9	17	18	18	50	94	100
>10≦15	4	5	6	7	57	71	86
>15≦20	2	2	2	4	50	50	50
>20≦25	2	3	6	6	33	50	100
>25≦30	5	10	11	13	38	77	85
>30≦35	0	1	3	6	0	17	50
>35≦40	5	9	13	21	24	57	62
>40≦45	1	2	5	9	11	22	56
>45≦50	1	2	4	4	25	50	100
>50≦55	1	2	8	8	13	25	100
>55≦60	1	3	3	4	25	75	75
>60≦65	2	2	2	3	66	66	66
>65≦70	0	0	0	1	0	0	0
>70≦75	0	0	0	1	0	0	0
>75≦80	-	-	-	-	-	-	-
>80≦85	1	1	3	5	20	20	60
>85≦90	0	0	0	1	0	0	0
>90≦95	-	-	-	-	-	-	-
>95≦100	5	6	15	55	9	11	27
≦10 ≦100	39	65	99	166	23	39	60
≦10≦95	34	59	84	111	31	53	76

TABLE 16

GS DATA SET NOT IN AFTAC DATA SET
SEPTEMBER 1982 173 EVENTS

FIGURE 24

AFATC DATA SET NOT IN GS DATA SET
SEPTEMBER 1982 159 EVENTS

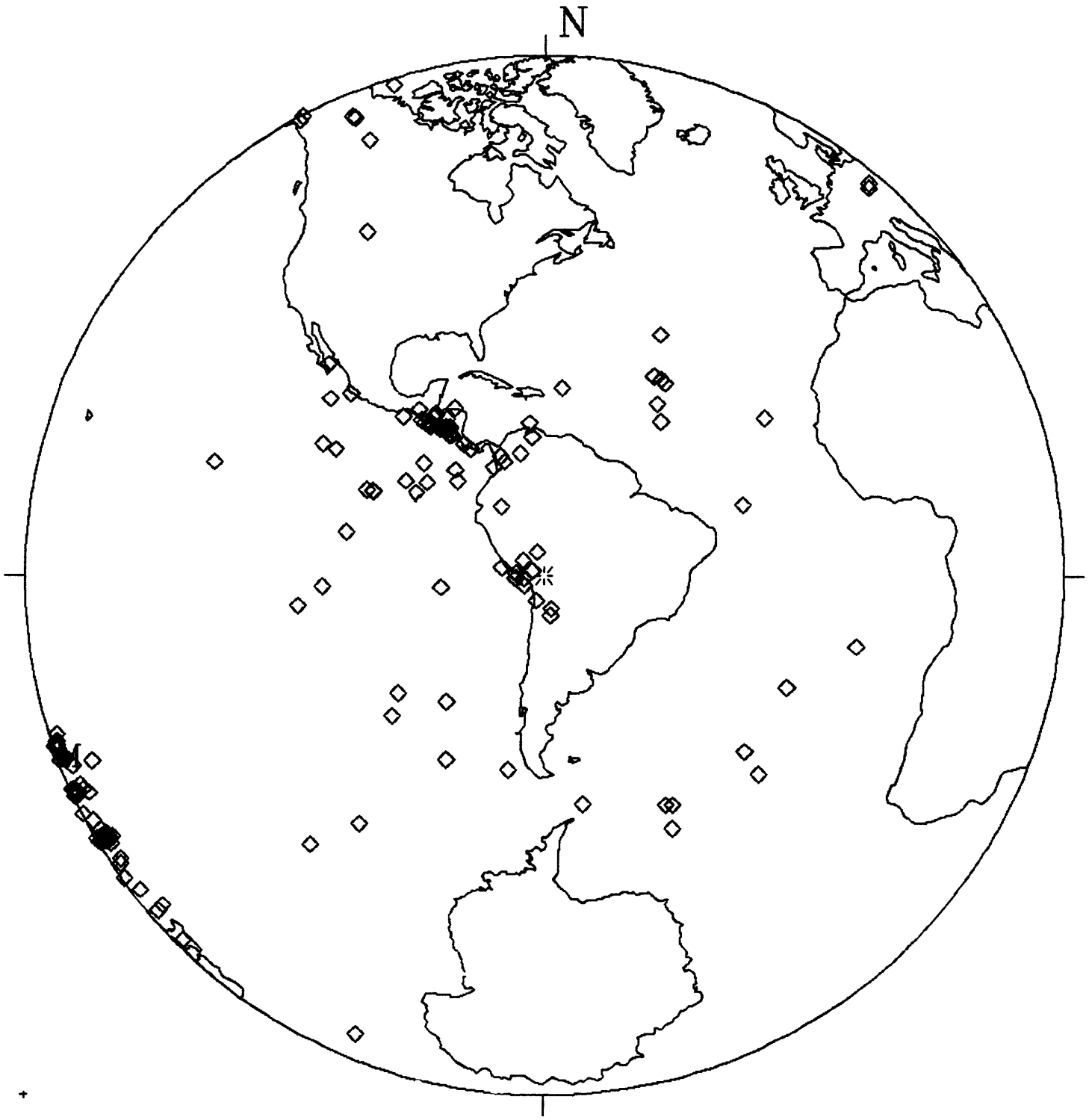


FIGURE 25

LPB RR
AFTAC DATA SET NOT IN GS DATA SET
SEPTEMBER 1982 159 EVENTS

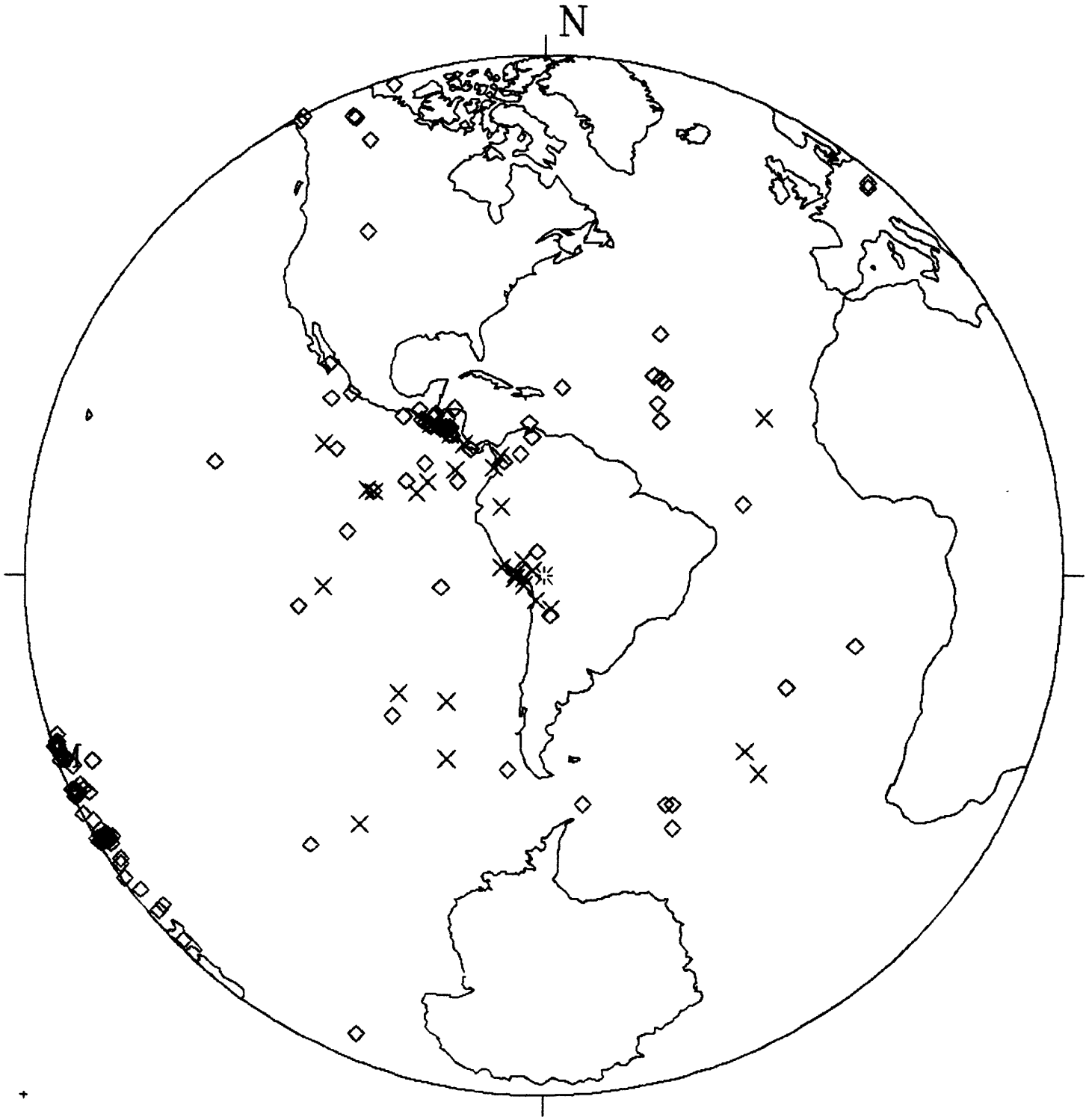


FIGURE 26

ZOBO
AFTAC DATA SET NOT IN GS DATA SET
SEPTEMBER 1-19,1982 83 EVENTS

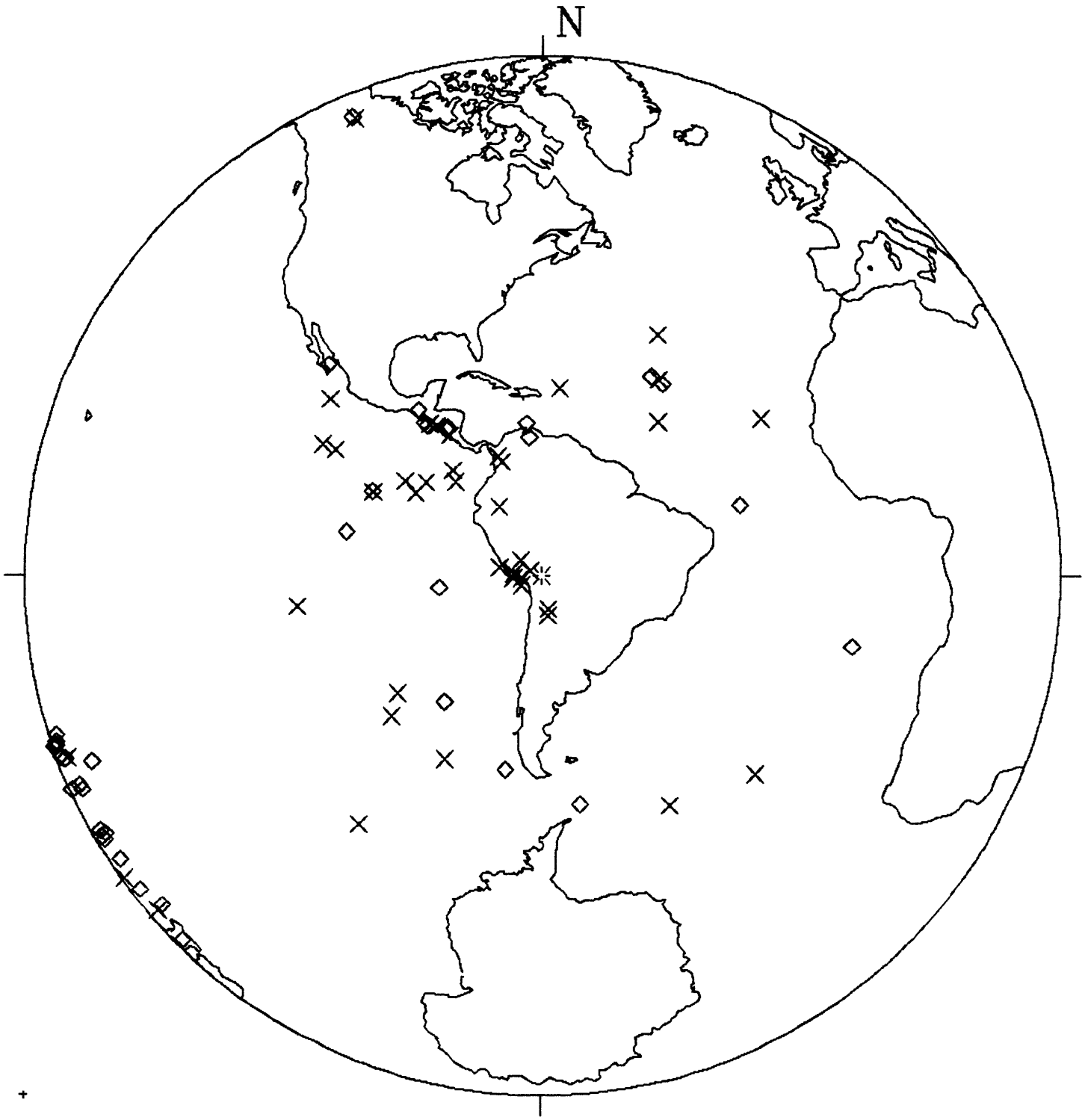


FIGURE 27

LPB
GS DATA SET NOT IN AFTAC DATA SET
SEPTEMBER 1982 173 EVENTS

FIGURE 28

LPB RR
GS DATA SET NOT IN AFTAC DATA SET
SEPTEMBER 1982 173 EVENTS

FIGURE 29

ZOBO

GS DATA SET NOT IN AFTAC DATA SET

SEPTEMBER 1-19,1982 80 EVENTS

FIGURE 30

DISTANCE DISTRIBUTION FOR LPB TO A,B,C,D EVENTS OF AFTAC DATA SET FOR SEPTEMBER 1982

DIST (DEG.)	LPB A DET.	LPB B DET.	LPB C DET.	LPB D DET.	TOTAL A EVENT	TOTAL B EVENT	TOTAL C EVENT	TOTAL D EVENT	% A EVENT	% B EVENT	% C EVENT	% D EVENT
≦10	2	2	4	1	2	2	8	9	100	100	50	11
>10≦15	-	1	3	1	-	1	4	4	-	100	75	25
>15≦20	-	2	2	1	-	2	3	2	-	100	66	50
>20≦25	-	-	5	0	-	-	7	4	-	-	71	0
>25≦30	-	2	6	0	-	4	13	3	-	50	46	0
>30≦35	-	-	0	0	-	-	4	10	-	-	0	0
>35≦40	2	2	4	0	2	2	13	18	100	100	31	0
>40≦45	-	1	0	0	-	1	7	5	-	100	0	0
>45≦50	-	2	1	0	-	2	2	3	-	100	50	0
>50≦55	1	1	0	0	2	4	3	5	50	25	0	0
>55≦60	-	1	0	0	-	2	1	3	-	50	0	0
>60≦65	-	1	1	-	-	1	2	-	-	100	50	-
>65≦70	-	0	0	0	-	1	1	1	-	0	0	0
>70≦75	-	1	0	0	-	1	1	5	-	100	0	0
>75≦80	-	-	-	-	-	-	-	-	-	-	-	-
>80≦85	-	1	0	0	-	2	2	2	-	50	0	0
>85≦90	-	-	-	0	-	-	-	1	-	-	-	0
>90≦95	-	-	-	0	-	-	-	1	-	-	-	0
>95≦100	5	1	0	0	10	32	61	13	50	3	0	0
<10≦100	10	18	26	3	16	57	132	89	63	32	20	3
<10≦95	5	17	26	3	6	25	71	76	83	68	37	4

TABLE 17

of this decrease is due to having LPB detections for only the 135 common events to both data sets and these groups have a smaller number of events that are present in these 135 event subsets. Figures 31, 32, 33, and 34 show the geographic distribution of earthquakes in each AFTAC group with symbol X denoting LPB associated detections.

DETECTION CAPABILITY OF LPB-RR DATA TO THE AFTAC DATA SET:

Table 18 shows the distance/group size event comparison to the detections obtained by re-reading the film chips for station LPB. This is a truer indication of the LPB capability to detect events in the AFTAC data set than the analyst's detections described above, as their comparison is to the complete data set. Figures 35, 36, 37 and 38 show the geographic distribution of events in each group size from station LPB.

DETECTION CAPABILITY OF ZOBO TO THE AFTAC DATA SET:

Table 19 shows the distance/group size event comparison to the detections read from station ZOBO film chips for the first 19 days of September 1982. The apparent improvement of the number of associated ZOBO detections versus the LPB detections is partially due to the increase in station gain of 25K for LPB to 200K for ZOBO. Figures 39, 40, 41 and 42 show the geographic distribution of events in each group size of the AFTAC data set for station ZOBO.

THE EFFECT OF AZIMUTH AND DISTANCE ON LPB AND ZOBO DETECTION CAPABILITIES:

There does not appear to be a distance effect on these stations' ability to detect events other than that which is expected due to the gain differences of LPB and ZOBO. As is shown on tables 8, 9 and 14, LPB and ZOBO detections are associated to near the 100% level for all events that should have been detected.

There does seem to be an azimuthal effect of detecting small events occurring in western Central America and western Mexico. Figures 43 and 44 show the azimuthal window and geographic distribution of events within this window. Figure 44 shows events from the same AFTAC size group, with approximately the same distance from LPB and ZOBO, but at different azimuths which were detected. One of the reasons that LPB and ZOBO do not detect these events is that these stations are near the P nodal planes on first motion focal mechanism solutions for this area. Figure 45 shows typical Central American and Mexican fault plane solutions and their geographic relationship to the LPB location. Figure 46 is a lower hemisphere projection of the fault plane solution for event 1 on figure 45. Figure 47 is the same projection for event 2 on figure 45. On each of these focal sphere plots, the square symbol designates the location of station LPB in relation to the fault plane nodes. In both cases, LPB is near the NW striking node. For small events, the P onset time may be too small, because of being nodal to the focal mechanism, to be read close enough to have an allowable travel time residual to be associated to events in this area.

LPB
AFTAC DATA SET "A"
SEPTEMBER 1982 16 EVENTS

FIGURE 31

LPB
AFTAC DATA SET "B"
SEPTEMBER 1982 58 EVENTS

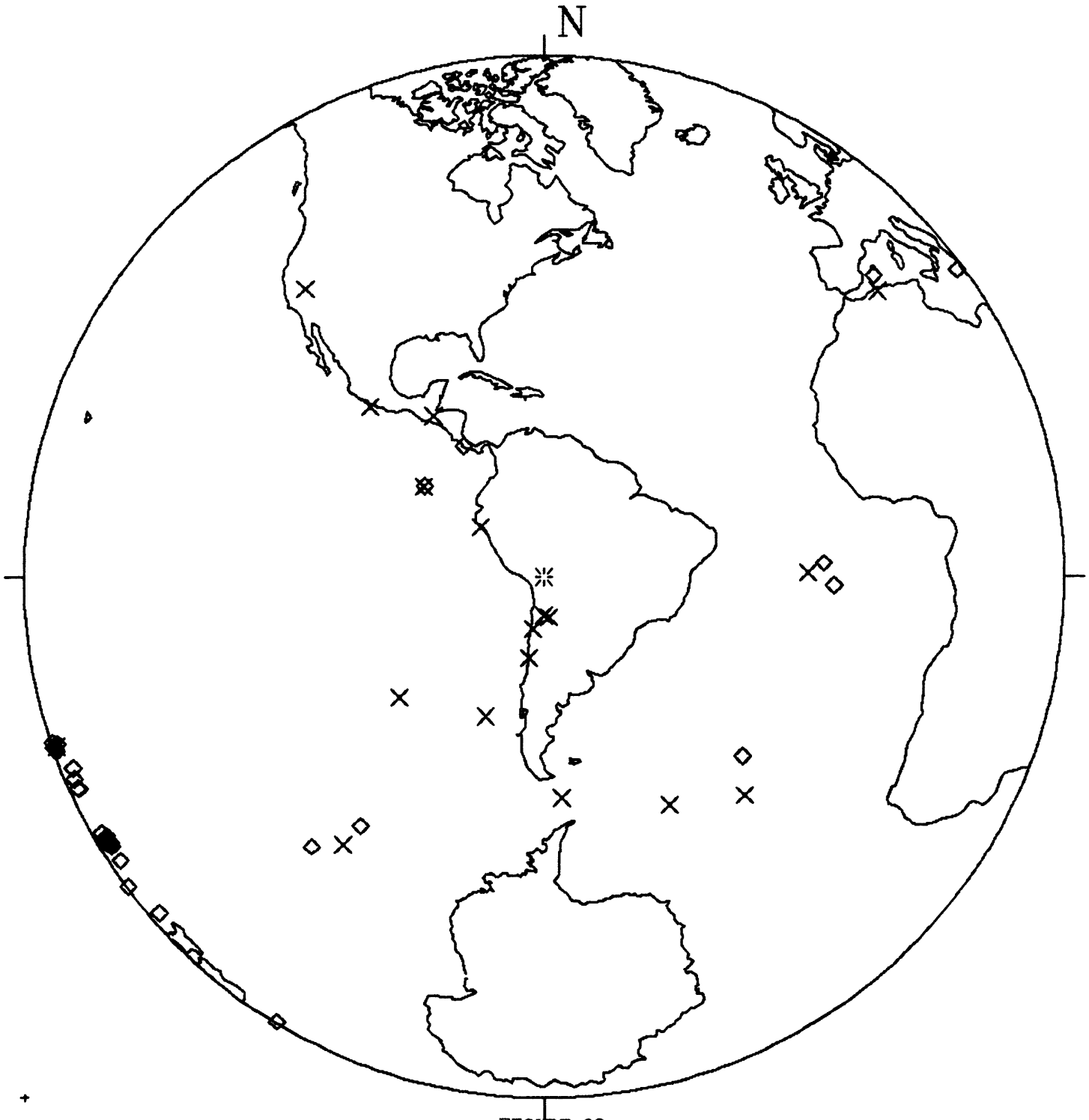


FIGURE 32

LPB
AFTAC DATA SET "C"
SEPTEMBER 1982 130 EVENTS

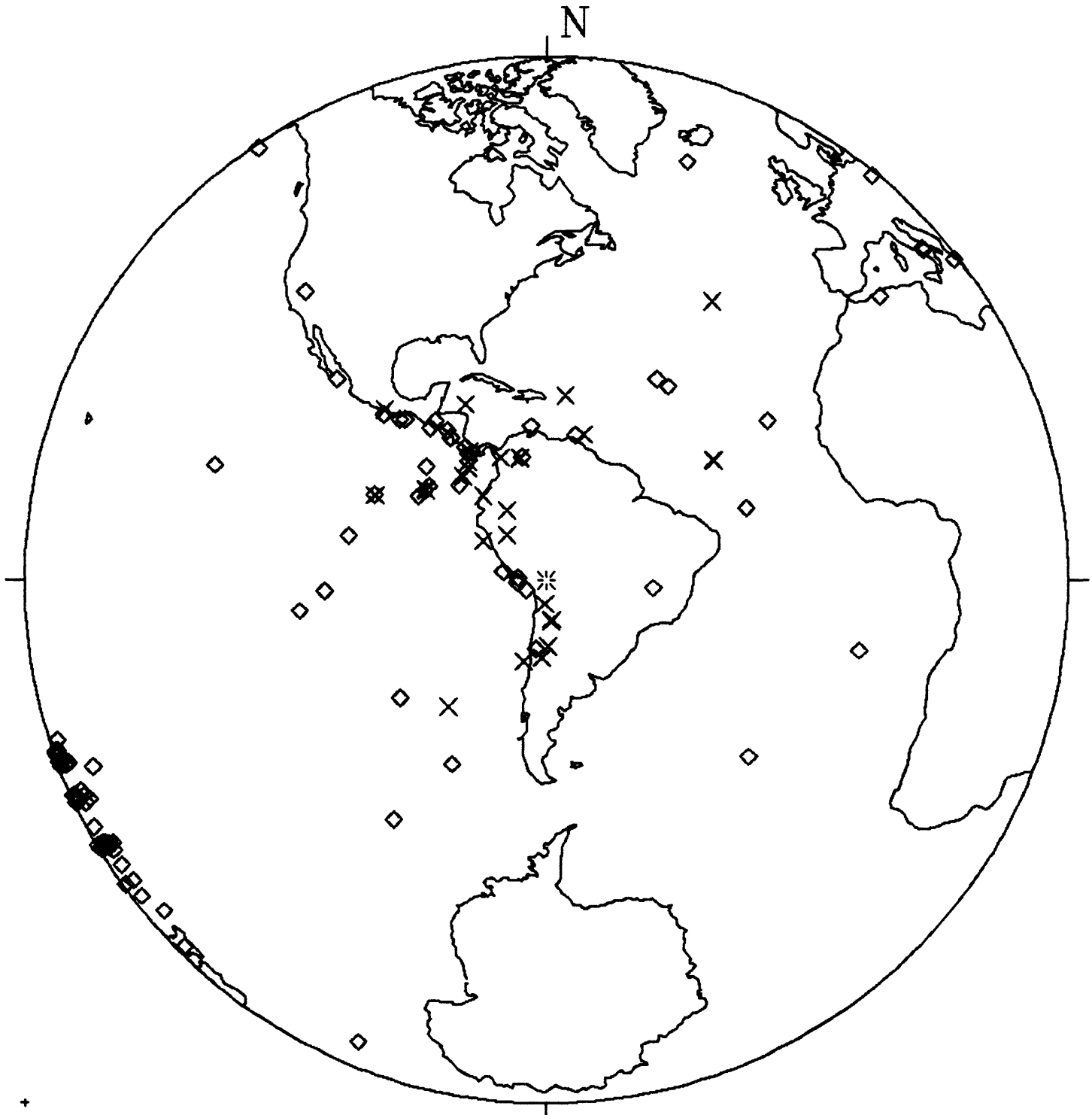


FIGURE 33

LPB
AFTAC DATA SET "D"
SEPTEMBER 1982 90 EVENTS

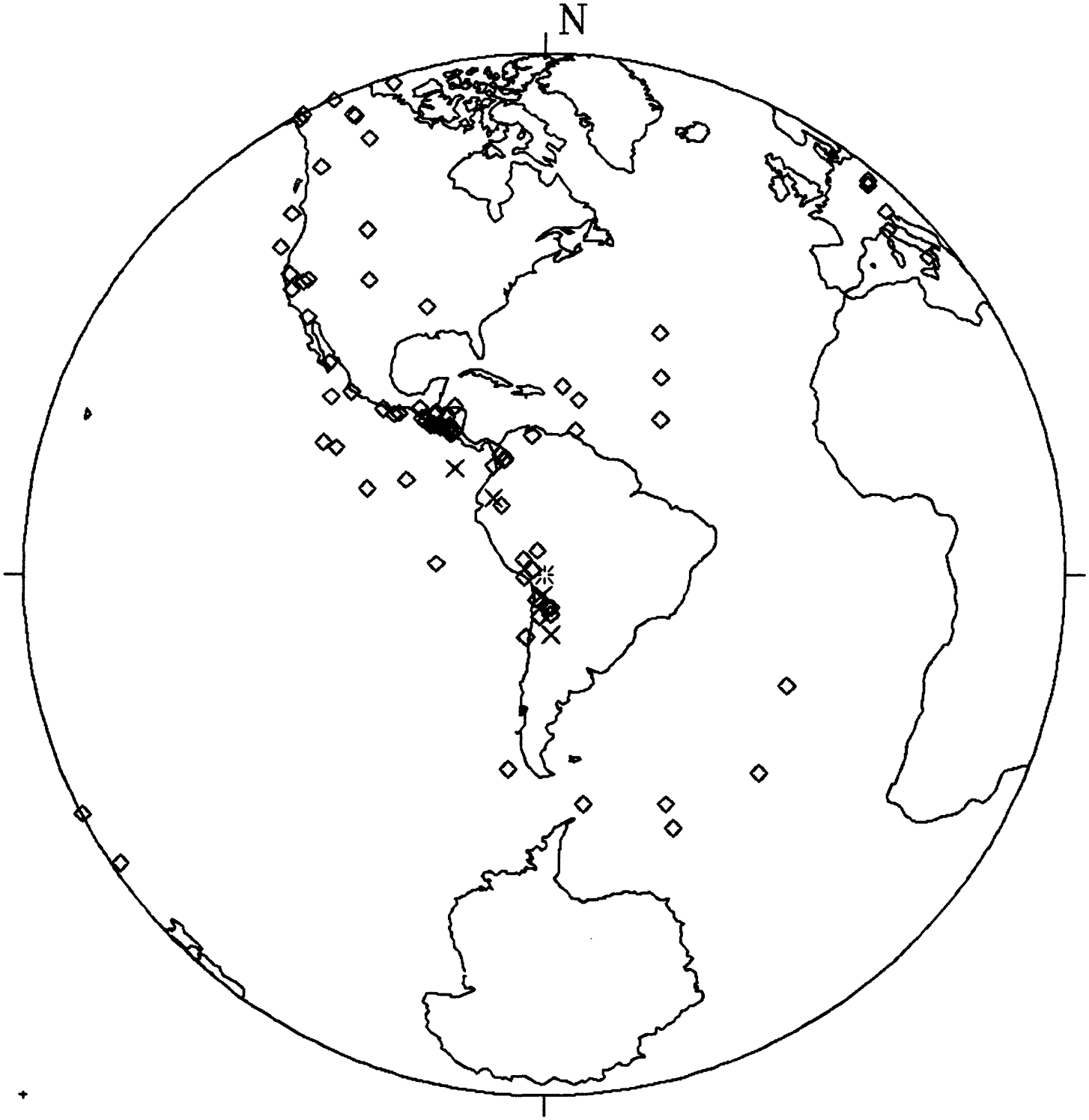


FIGURE 34

DISTANCE DISTRIBUTION FOR LPBRR TO A,B,C,D EVENTS OF AFTAC DATA SET FOR SEPTEMBER 1982

DIST (DEG.)	LPB RR A DET.	LPB RR B DET.	LPB RR C DET.	LPB RR D DET.	TOTAL A EVENT	TOTAL B EVENT	TOTAL C EVENT	TOTAL D EVENT	% A EVENT	% B EVENT	% C EVENT	% D EVENT
≦10	2	2	8	7	2	2	8	9	100	100	100	78
>10≦15	-	1	3	2	-	1	4	4	-	100	75	50
>15≦20	-	2	2	1	-	2	3	2	-	100	66	50
>20≦25	-	-	5	2	-	-	7	4	-	-	71	50
>25≦30	-	3	10	1	-	4	13	3	-	75	77	33
>30≦35	-	-	1	1	-	-	4	10	-	-	25	10
>35≦40	2	2	7	2	2	2	13	18	100	100	54	11
>40≦45	-	1	2	0	-	1	7	5	-	100	29	0
>45≦50	-	2	1	1	-	2	2	3	-	100	50	33
>50≦55	1	1	3	0	2	4	3	5	50	25	100	0
>55≦60	-	2	1	1	-	2	1	3	-	100	100	33
>60≦65	-	1	1	-	-	1	2	-	-	100	50	-
>65≦70	-	0	0	0	-	1	1	1	-	0	0	0
>70≦75	-	1	0	0	-	1	1	5	-	100	0	0
>75≦80	-	-	-	-	-	-	-	-	-	-	-	-
>80≦85	-	1	0	0	-	2	2	2	-	50	0	0
>85≦90	-	-	-	0	-	-	-	1	-	-	-	0
>90≦95	-	-	-	0	-	-	-	1	-	-	-	0
>95≦100	6	3	0	0	10	33	59	14	60	9	0	0
<10≦100	11	22	44	18	16	58	130	90	69	38	34	20
<10≦95	5	19	44	18	6	25	71	76	83	76	62	24

TABLE 18

LPB RR
AFTAC DATA SET "A"
SEPTEMBER 1982 16 EVENTS

FIGURE 35

LPB RR
AFTAC DATA SET "B"
SEPTEMBER 1982 58 EVENTS

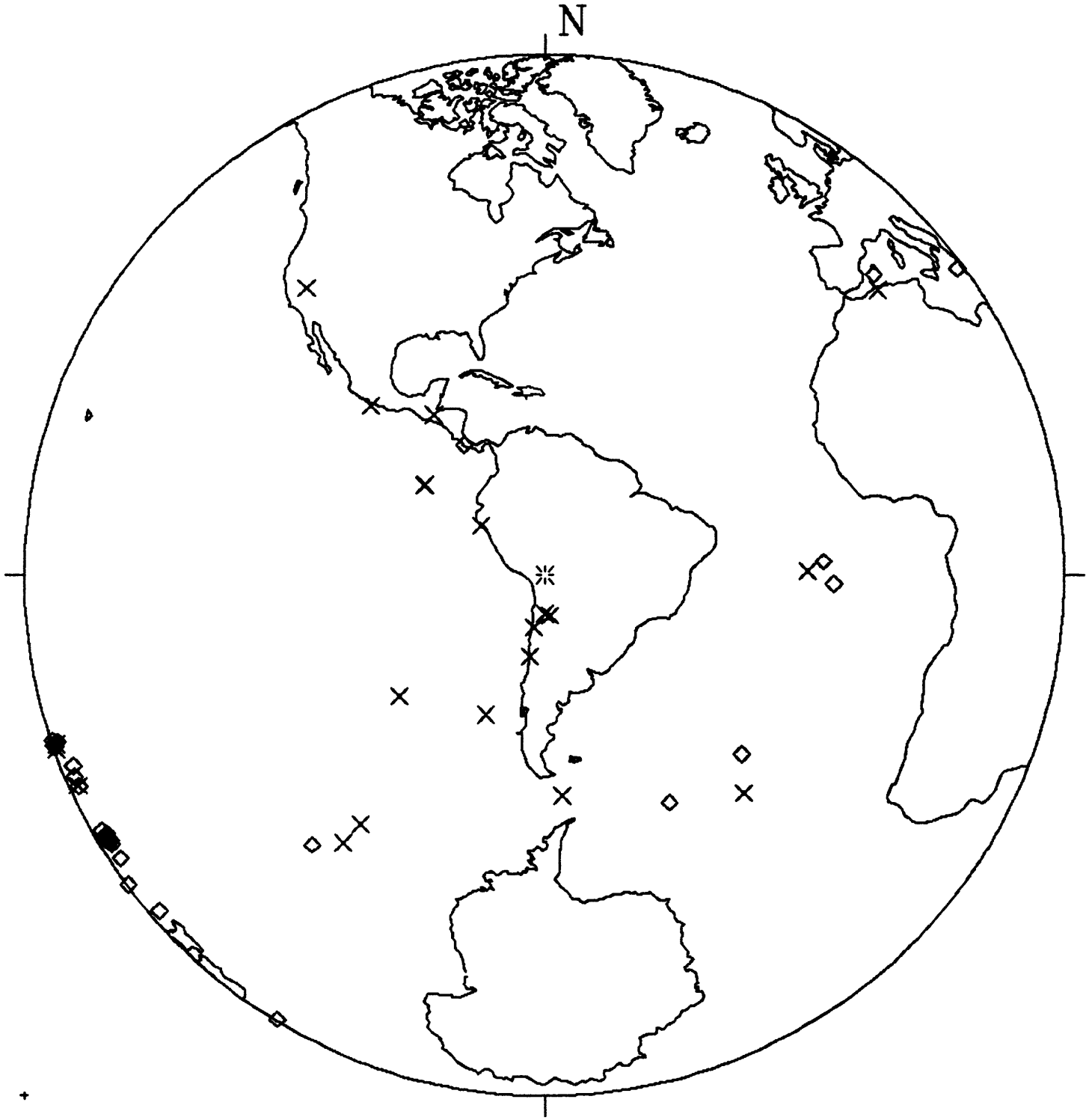


FIGURE 36

LPB RR
AFTAC DATA SET "C"
SEPTEMBER 1982 130 EVENTS

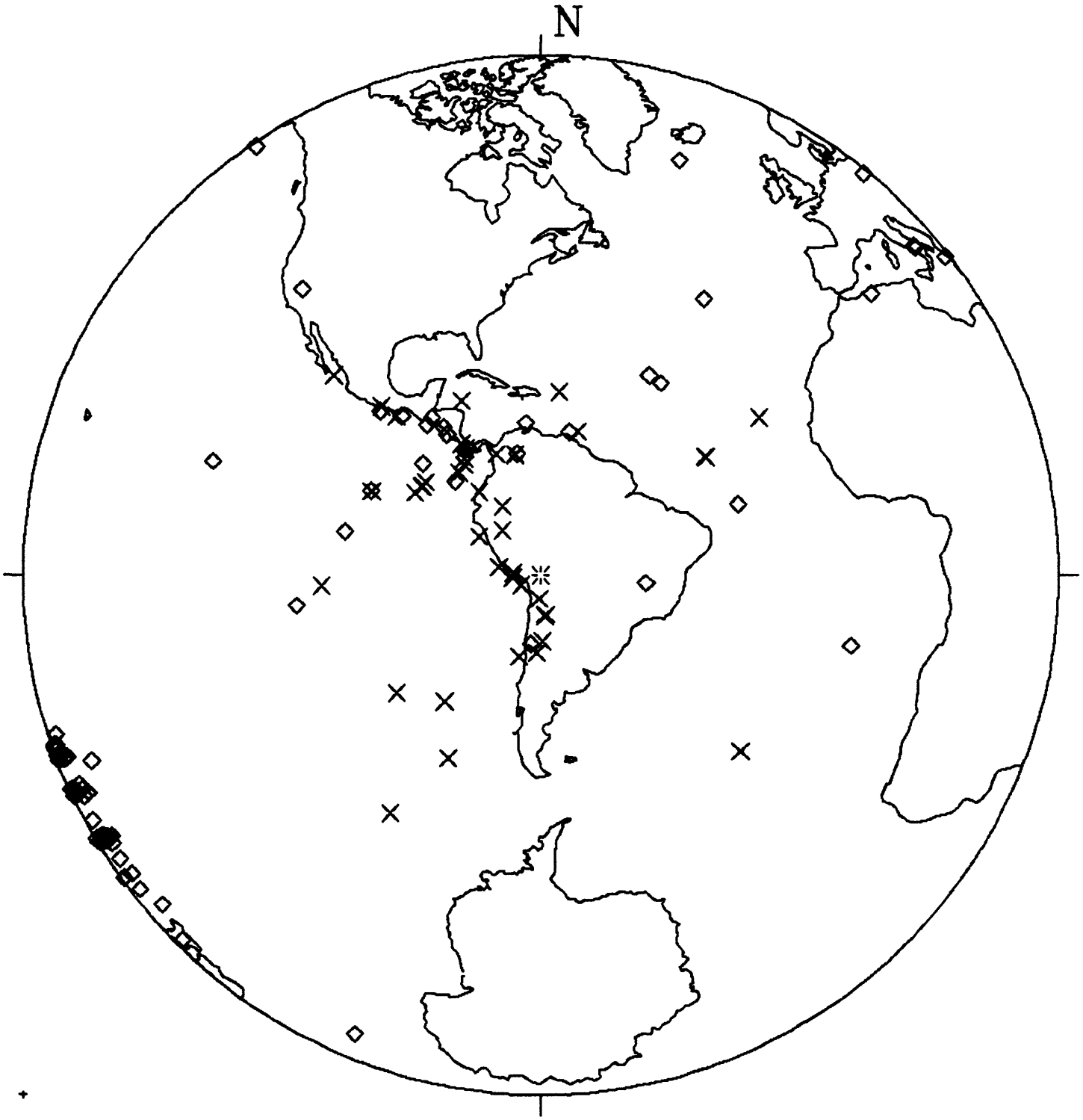


FIGURE 37

LPB RR
AFTAC DATA SET "D"
SEPTEMBER 1982 90 EVENTS

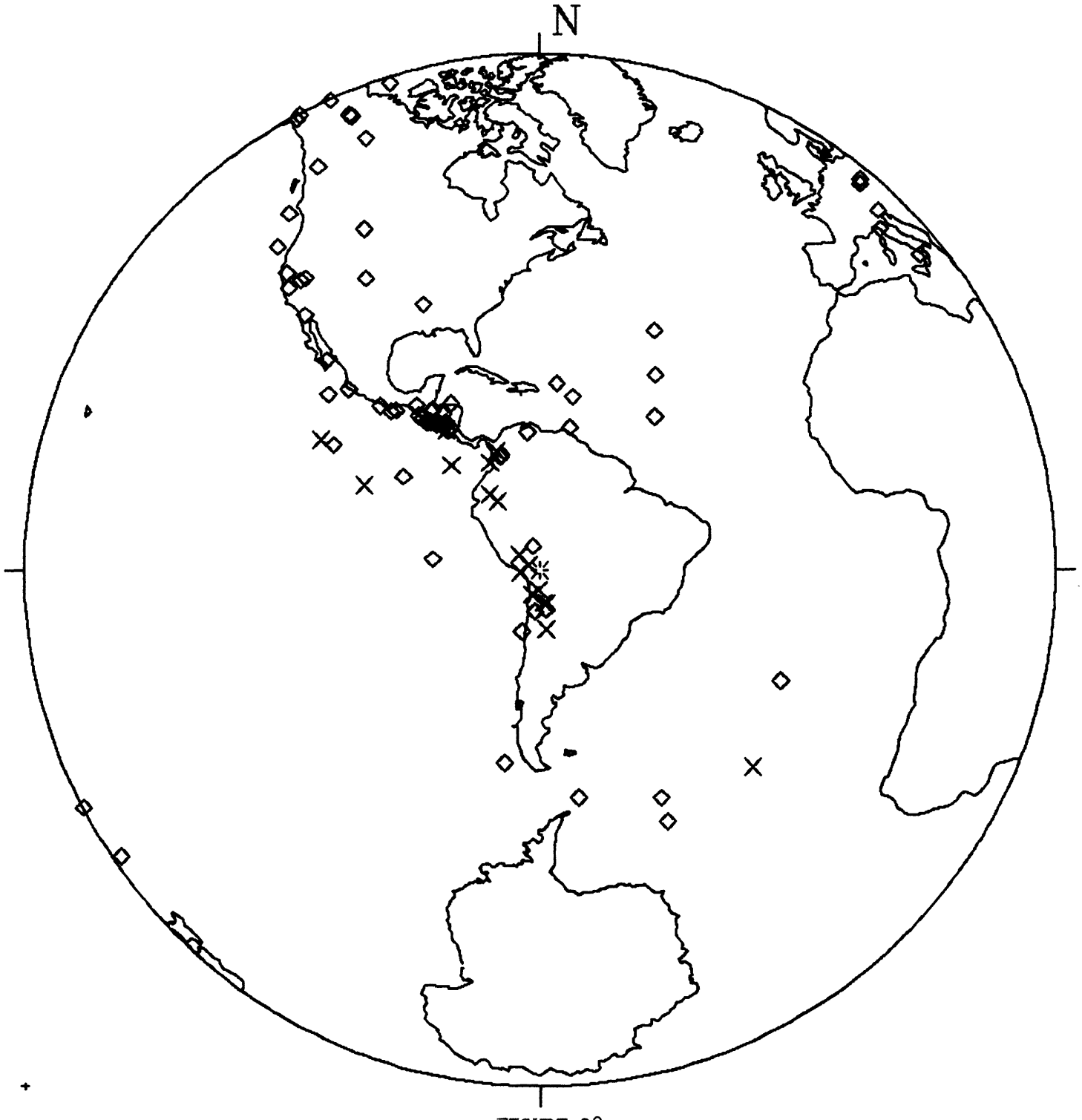


FIGURE 38

DISTANCE DISTRIBUTION FOR ZOBO
TO A,B,C,D EVENTS OF AFTAC DATA
SET FOR DAYS SEPTEMBER 1 THROUGH SEPTEMBER 19.

DIST (DEG.)	ZOBO A DET.	ZOBO B DET.	ZOBO C DET.	ZOBO D DET.	TOTAL A EVENT	TOTAL B EVENT	TOTAL C EVENT	TOTAL D EVENT	% A EVENT	% B EVENT	% C EVENT	% D EVENT
≤10	2	2	8	6	2	2	8	6	100	100	100	100
>10≤15	-	-	4	2	-	-	4	3	-	-	100	66
>15≤20	-	2	0	0	-	2	1	1	-	100	0	0
>20≤25	-	-	3	3	-	-	3	3	-	-	100	100
>25≤30	-	2	8	1	-	2	9	2	-	100	89	50
>30≤35	-	-	1	2	-	-	1	5	-	-	100	40
>35≤40	1	1	6	5	1	1	10	9	100	100	60	56
>40≤45	-	1	2	2	-	1	5	3	-	100	40	66
>45≤50	-	1	1	2	-	1	1	2	-	100	100	100
>50≤55	1	4	1	2	1	4	1	2	100	100	100	100
>55≤60	-	2	-	1	-	2	-	2	-	100	-	50
>60≤65	-	1	1	-	-	1	2	-	-	100	50	-
>65≤70	-	-	-	0	-	-	-	1	-	-	-	0
>70≤75	-	-	-	0	-	-	-	1	-	-	-	0
>75≤80	-	-	-	-	-	-	-	-	-	-	-	-
>80≤85	-	2	1	0	-	2	1	2	-	100	100	0
>85≤90	-	-	-	0	-	-	-	1	-	-	-	0
>90≤95	-	-	-	-	-	-	-	-	-	-	-	-
>95≤100	6	6	2	1	6	17	27	5	100	35	7	20
<10≤100	10	24	38	27	10	35	73	48	100	69	52	56
<10≤95	4	18	36	26	4	18	46	43	100	100	78	80

TABLE 19

ZOBO
AFTAC DATA SET "A"
SEPTEMBER 1–19, 1982 10 EVENTS

FIGURE 39

ZOBO
AFTAC DATA SET "B"
SEPTEMBER 1-19, 1982 35 EVENTS

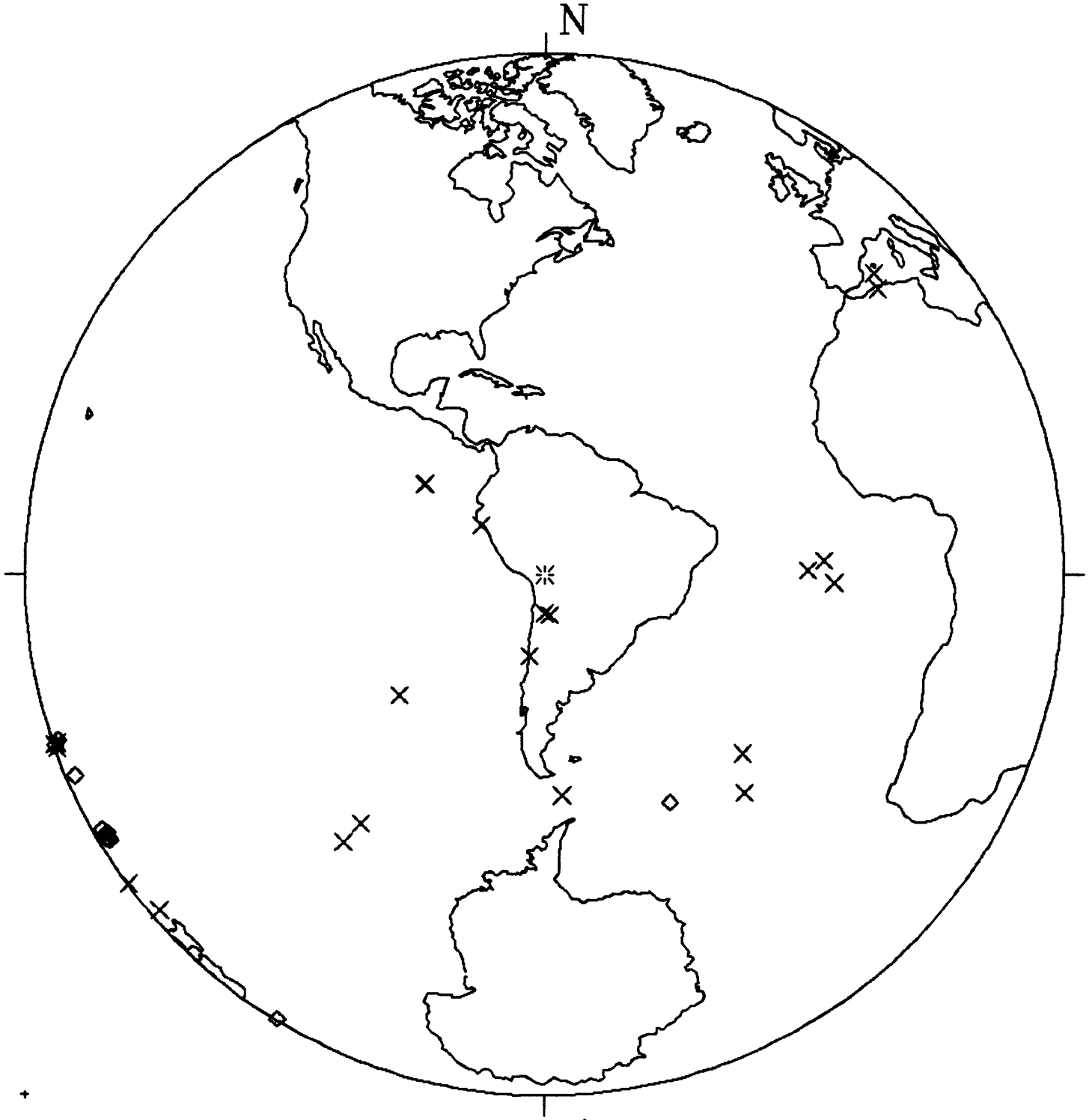


FIGURE 40

ZOBO
AFTAC DATA SET "C"
SEPTEMBER 1-19, 1982 72 EVENTS

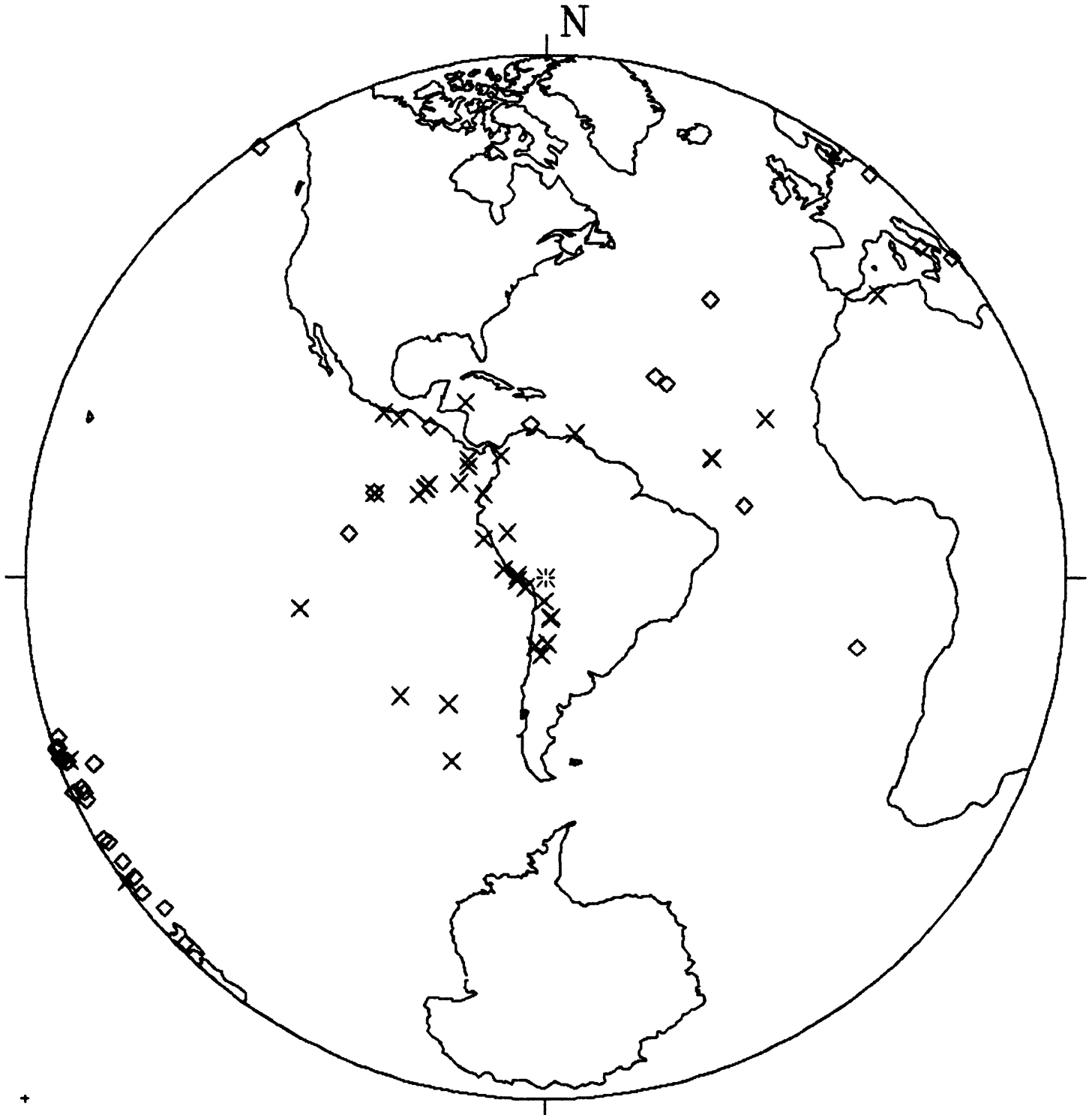


FIGURE 41

ZOBO
AFTAC DATA SET "D"
SEPTEMBER 1-19, 1982 48 EVENTS

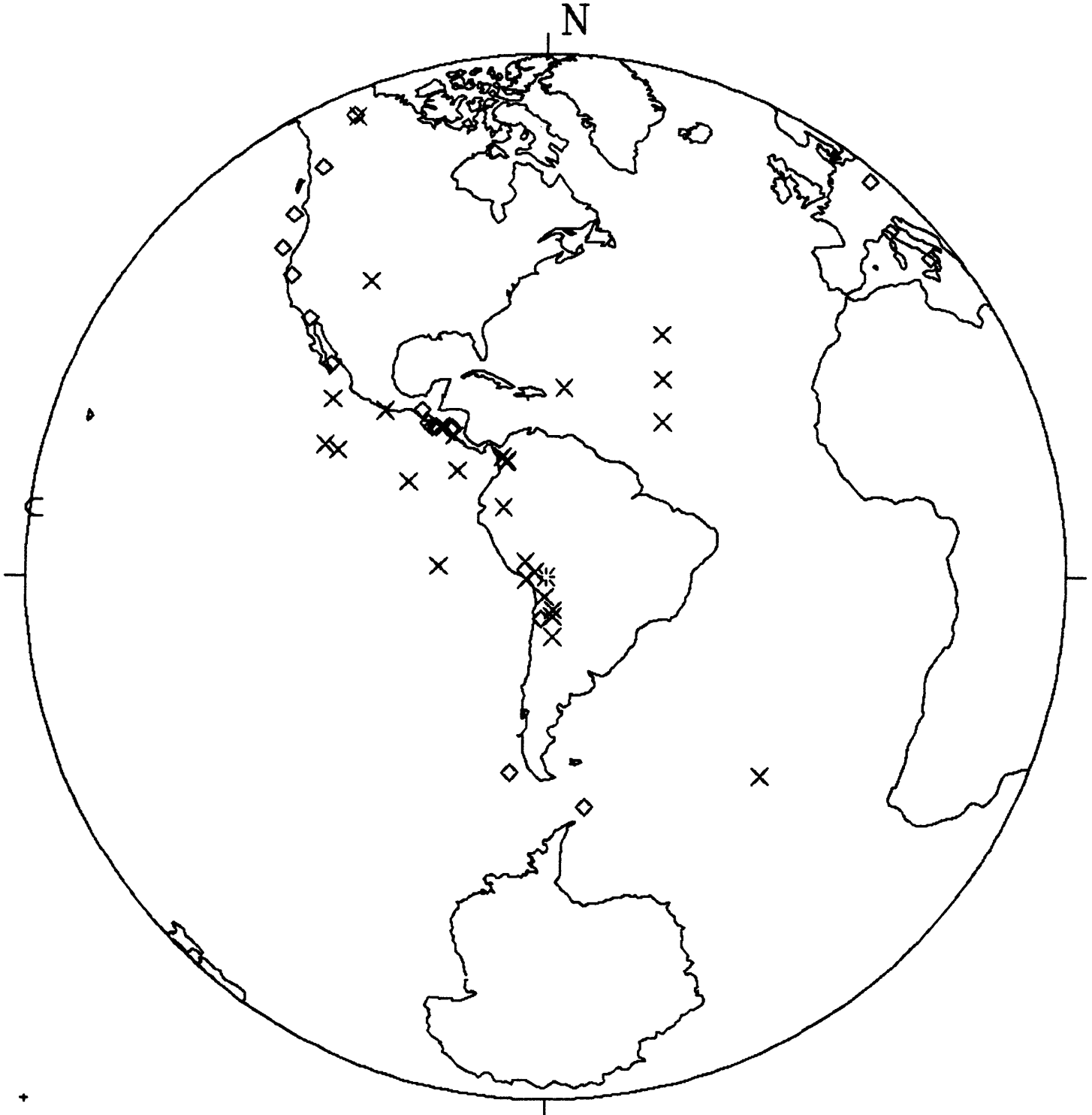


FIGURE 42

ZOBO
GS DATA SET mb <4.5
RADIUS=60 deg. INTERVAL=20 deg.

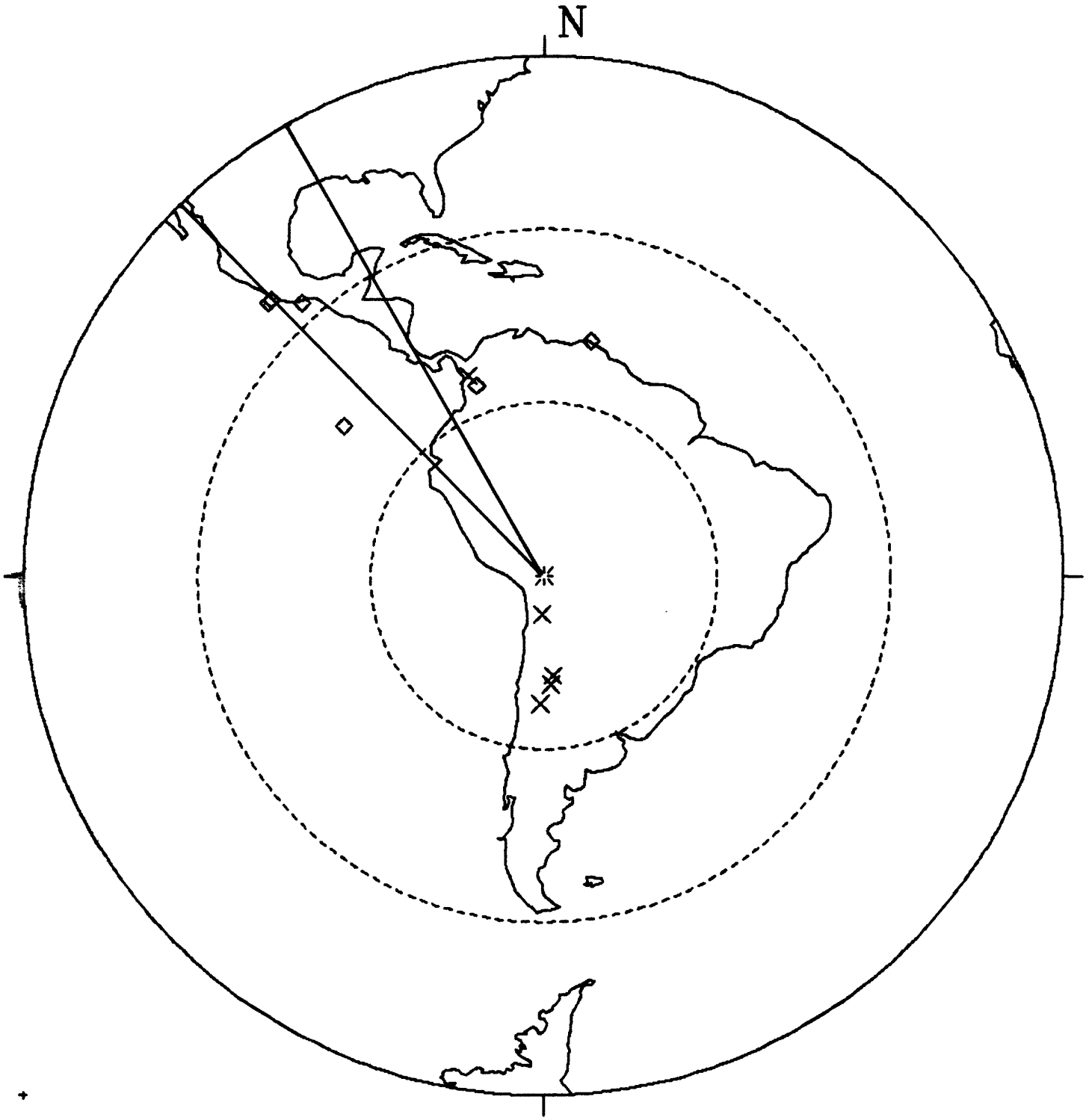


FIGURE 43

ZOBO
AFTAC DATA SET "D"
RADIUS=60 deg. INTERVAL=20 deg.

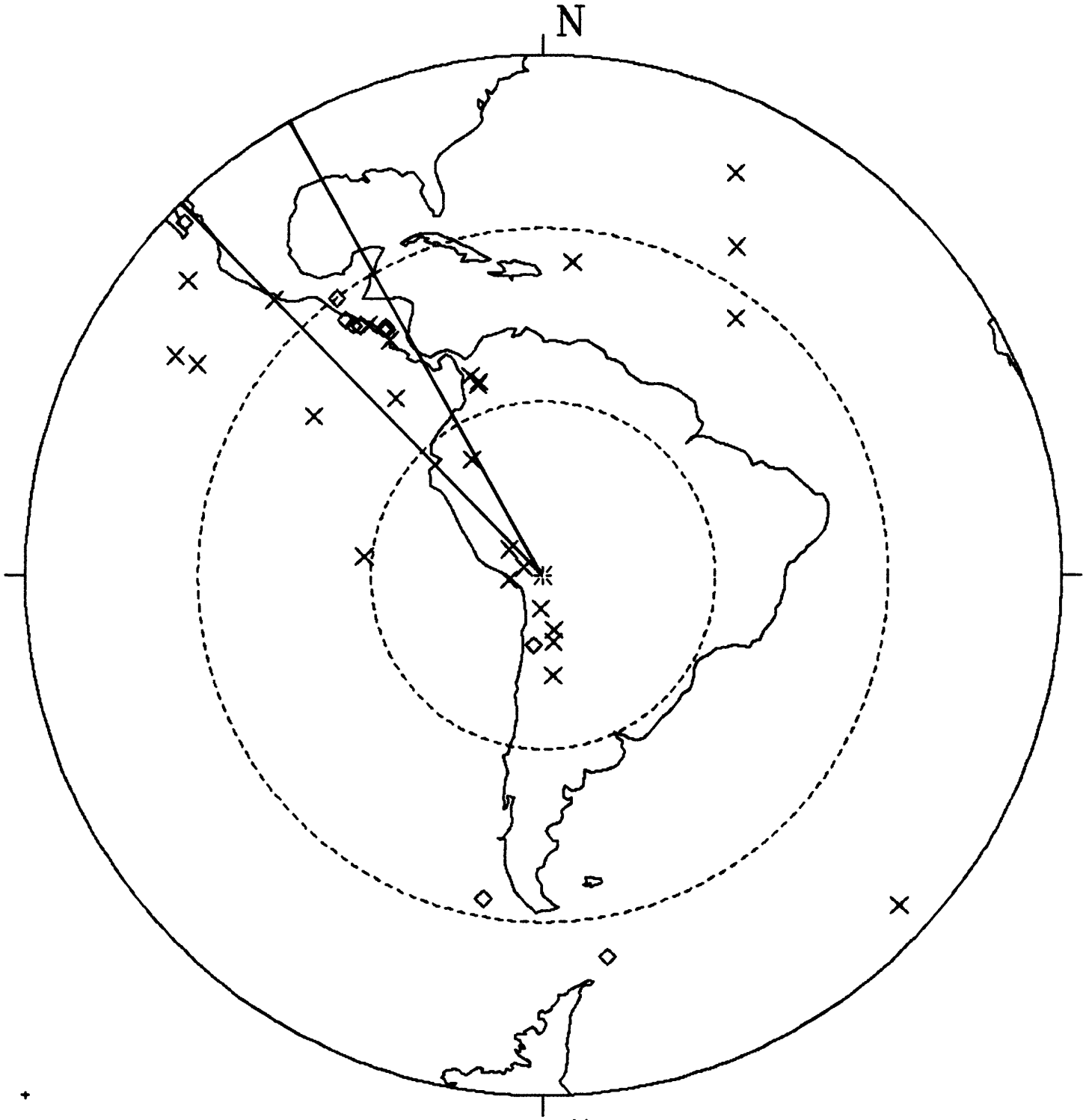


FIGURE 44

TYPICAL CEN. AM. AND MEXICO FOCAL MECHANISMS RADIUS=60 deg. INTERVAL=20 deg.

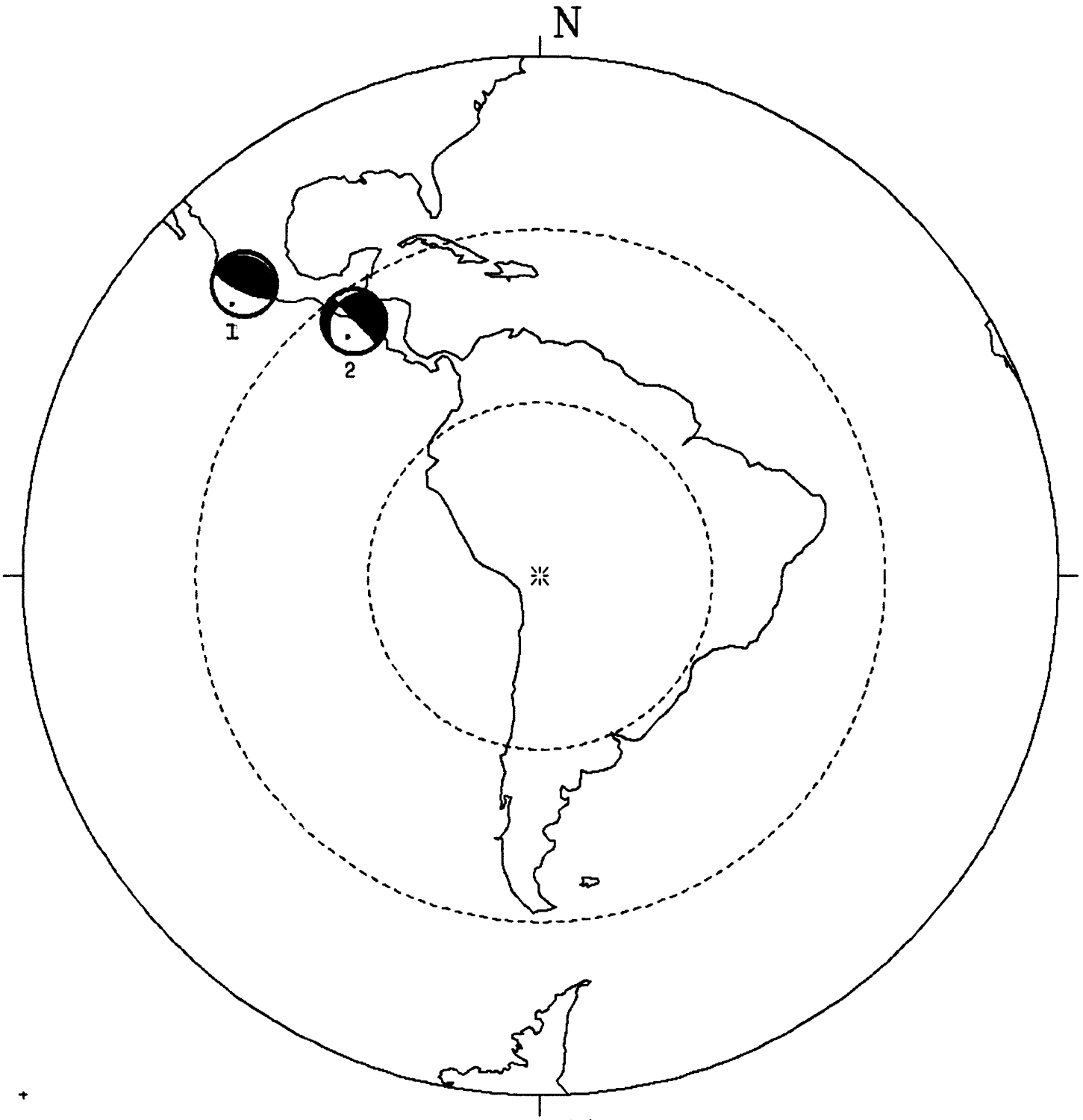
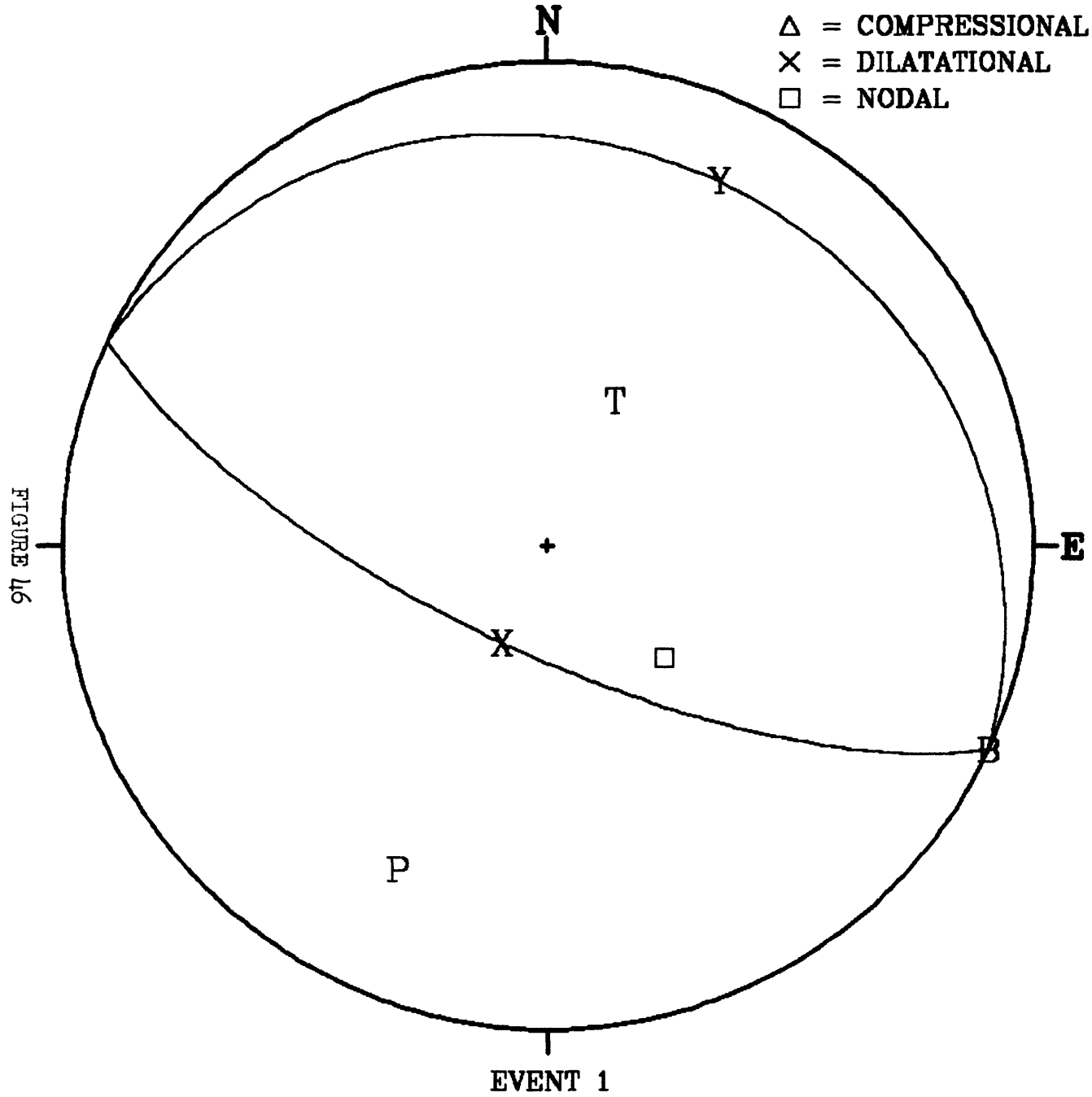


FIGURE 45

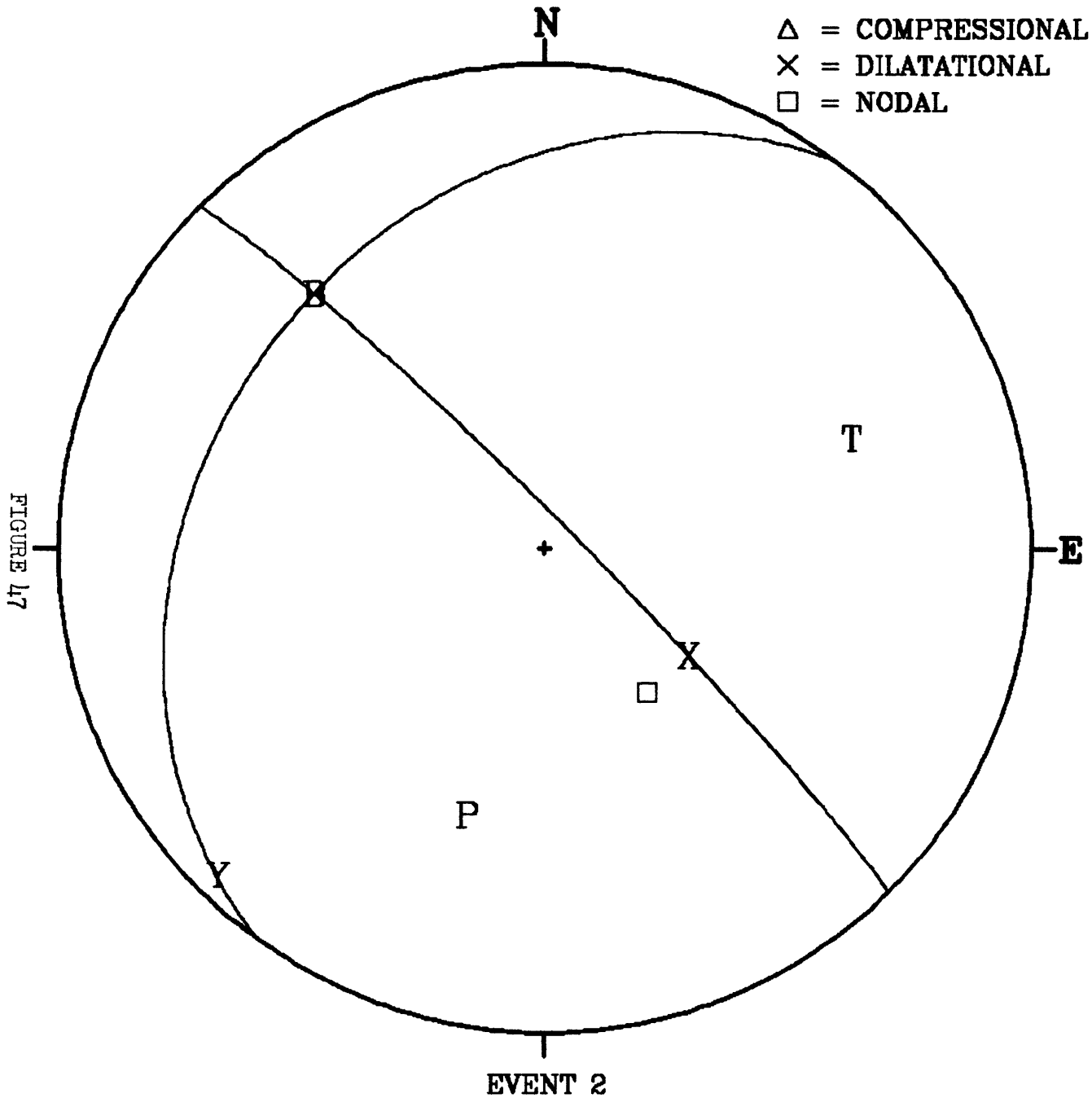


△ = COMPRESSIONAL
× = DILATATIONAL
□ = NODAL

	AZIMUTH	PLUNGE
P axis	205.0	27.0
T axis	25.0	63.0
B axis	115.0	0.0
X axis	205.0	72.0
Y axis	25.0	18.0

115.00	72.00	90.00
295.00	18.00	90.00

FIGURE 46



△ = COMPRESSIONAL
× = DILATATIONAL
□ = NODAL

	AZIMUTH	PLUNGE
P axis	196.5	42.2
T axis	70.0	33.3
B axis	317.9	29.9
X axis	126.4	59.6
Y axis	225.0	5.0

315.00	85.00	−120.00
216.42	30.38	−9.92

FIGURE 47

CONCLUSIONS AND RECOMMENDATIONS:

Tables 20 and 21 have been generated to summarize the detection capabilities of stations LPB and ZOBO to each of the USGS and AFTAC data sets. Statistics for three different distance ranges for P detections are presented. The 0-100 degree range includes all P range detections, the 0-95 degree range includes the regional range and eliminates the possibility of having P defracted detections and the 20-90 degree range eliminates all regional, distant P and defracted P detections. Each of these distance ranges has been presented as P detection ranges in previous literature. The statistics for this report have been based on the 0-100 degree P range. The data set type "ALL DATA" on these tables include all events presented in the USGS data set and the AFTAC data set. The reason the percentages for "ALL DATA" on table 20 for the USGS data set comparison is low is that the 184 events without reported magnitudes are included. The data set type "mb REPORTED" eliminates these 184 events.

The LPB on-site analyst has done an exceptional job of reading and reporting detections from this station. This is shown when one compares the 46% association for all events with mb reports within the 0-100 degrees distance range to the expected detections using the theoretical amplitudes of 0.5 mm P-P and 1.0 mm P-P. The 93% and 100% detection abilities of this analyst indicates a reporting threshold of just above the 0.5 mm P-P amplitude, which is very near the noise level of the LPB seismograms. Another verification of the station analyst's ability is the small improvement, 7%, due to re-reading the LPB seismograms. The large improvements noted when comparing ZOBO and LPB associations to the USGS data set is probably due to the gain differences of the two stations.

This author's experience in conducting the ISM (International Seismic Month) experiment for MIT Lincoln Laboratory (ref. 1 and 2) indicates that a station with a detection capability of 30% or more of all events in a large data base puts such a station in a classification of an above average reporting station. Station ZOBO fits this classification.

Many local and regional earthquakes were observed while reading the seismograms from station ZOBO which were not present on either event list. If Bolivia had a local network of geographically well distributed stations, such as those in Chile and Argentina (Appendix B), many more Bolivian events would be associated and added to Southern Hemisphere seismicity. Figure 48 shows the geographic distribution of Bolivian stations currently reporting to NEIS. Station CNCB has just started reporting to NEIS since July 1984 and station PNS has not reported arrivals for several years, even though NEIS has not received notification of closure.

The station gain of LPB could be increased from 25K to at least 100K without detrimentally affecting the detection capability because of a higher signal/noise ratio. Station ZOBO reports with a gain of 200K with a noise level of approximately 1 mm P-P. One of the reasons for keeping the gain low at station LPB might be to avoid clipping the signal for large local events.

Station LPB in conjuntion with station ZOBO are very influential stations in the detection capability a Southern Hemisphere Network of Stations.

SUMMARY OF DETECTION CAPABILITIES FOR STATIONS LPB AND ZOBO

USGS DATA SET

STATION LPB ANALYST DETECTIONS

DISTANCE RANGE	DATA SET TYPE	% OF DETECTIONS	TOTAL NUMBER EVENTS
0-100	ALL DATA	18	309
20-90	ALL DATA	13	242
0-95	ALL DATA	22	261
0-100	mb REPORTED	46	125
20-90	mb REPORTED	53	58
0-95	mb REPORTED	73	77
0-100	mb (THEO 0.5)	93	125
0-100	mb (THEO 1.0)	100	125

STATION LPB RE-READ DETECTIONS

DISTANCE RANGE	DATA SET TYPE	% OF DETECTIONS	TOTAL NUMBER EVENTS
0-100	ALL DATA	21	309
20-90	ALL DATA	16	242
0-95	ALL DATA	25	261
0-100	mb REPORTED	53	125
20-90	mb REPORTED	66	58
0-95	mb REPORTED	74	77
0-100	mb (THEO 0.5)	100	125
0-100	mb (THEO 1.0)	100	125

STATION ZOBO DETECTIONS

DISTANCE RANGE	DATA SET TYPE	% OF DETECTIONS	TOTAL NUMBER EVENTS
0-100	ALL DATA	34	170
20-90	ALL DATA	24	127
0-95	ALL DATA	30	142
0-100	mb REPORTED	73	79
20-90	mb REPORTED	86	36
0-95	mb REPORTED	90	51
0-100	mb (THEO 1.0)	85	79
0-100	mb (THEO 2.0)	97	79

TABLE 20

SUMMARY OF DETECTION CAPABILITIES FOR
STATIONS LPB AND ZOBO

AFTAC DATA SET

STATION LPB ANALYST DETECTIONS

DISTANCE RANGE	DATA SET TYPE	% OF DETECTIONS	TOTAL NUMBER EVENTS
0-100	ALL DATA	19	294
20-90	ALL DATA	22	163
0-95	ALL DATA	29	178
0-100	- (D) GROUP	27	204
20-90	- (D) GROUP	40	80
0-95	- (D) GROUP	47	102

STATION LPB RE-READ DETECTIONS

DISTANCE RANGE	DATA SET TYPE	% OF DETECTIONS	TOTAL NUMBER EVENTS
0-100	ALL DATA	32	294
20-90	ALL DATA	41	163
0-95	ALL DATA	48	178
0-100	- (D) GROUP	38	204
20-90	- (D) GROUP	60	80
0-95	- (D) GROUP	67	102

STATION ZOBO DETECTIONS

DISTANCE RANGE	DATA SET TYPE	% OF DETECTIONS	TOTAL NUMBER EVENTS
0-100	ALL DATA	60	163
20-90	ALL DATA	71	82
0-95	ALL DATA	76	111
0-100	- (D) GROUP	61	113
20-90	- (D) GROUP	82	49
0-95	- (D) GROUP	85	73

TABLE 21

BOLIVIAN STATIONS
CCH,LPB,LPZ,PNS,TRJ,ZOBO,& CNCB
CENTER at 16S 65W RADIUS=10 deg.

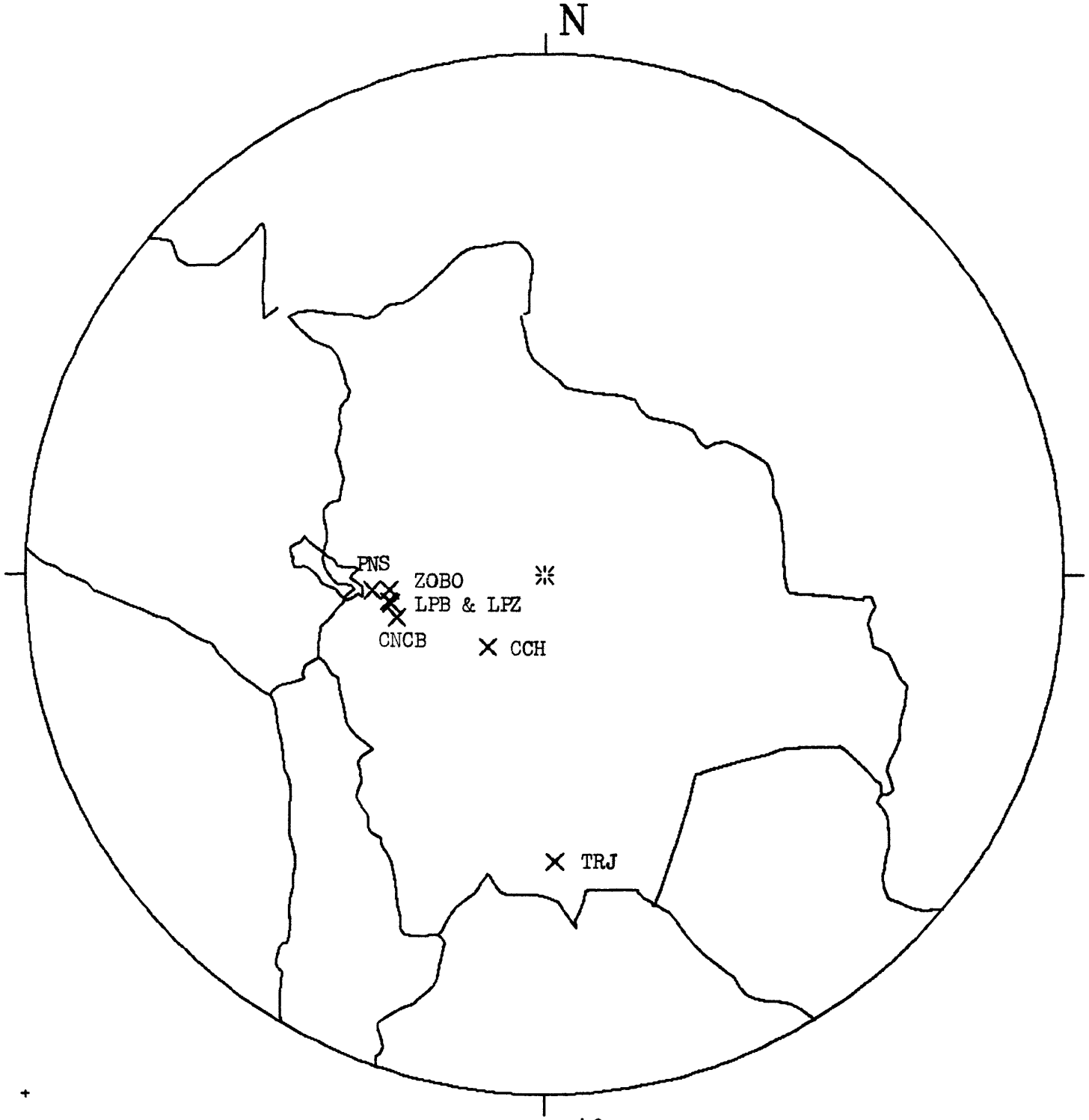


FIGURE 48

REFERENCES

Preliminary Determination of Epicenters, Monthly Listing, September 1982, NEIS-USGS

Lacoss, R. T., Needham, R. E., and Julian, International Seismic Month Event List, Technical Note 1974-14, Lincoln Laboratory, M.I.T.

Needham, R. E., Worldwide detection capability of a prototype network of seismograph stations, Technical Note 1975-42, Lincoln Laboratory, M.I.T.

Appendix A

SOUTHERN HEMISPHERE NETWORKS

As was stated in the body of this text, four southern hemisphere local networks of stations reported and were associated to the majority of the events which appear in the USGS data set and not on the AFTAC data set of events.

Table 41 shows the stations which comprise two local networks from Argentina, the IMPRES network and the ZONDA network. The X in column labeled "TEL." denotes the telegraphic reporting stations. Table 42 shows the Chilean stations of the UNIVERSIDAD DE CHILE network. Again, the X in column "TEL." denotes the telegraphic reporting stations. Figure 49 shows the geographic distribution of the stations of these three networks with the symbol X denoting the telegraphic reporting stations. Figure 50 shows the events which appear in the USGS data set, but do not appear in the AFTAC data set and figure 51 shows the events for which magnitude was not computed. If one were to overlay figure 49 onto figures 50 and 51, it becomes apparent that the epicenters on figures 50 and 51 were computed using the local network detections.

Table 43 shows the stations which comprise the GEOLOGICAL SURVEY OF SOUTH AFRICA network. Figure 52 is the geographic distribution of stations in this network with the symbol X denoting the telegraphic reporting stations. Figure 53 is the two events which appear on the USGS list but not on the AFTAC list. It is again apparent, when comparing figures 52 to 53, that the epicenters were computed using these local network detections.

To have as complete seismicity coverage as possible of the Southern Hemisphere, some of these stations from these local networks need to be included in the southern hemisphere network set of stations.

ARGENTINA
IMPRES NETWORK CODE (CJA)

STA.	LAT.	LON.	NAME	TEL.
CFA	-31.61	-68.24	CORONEL FONTANA	X
CYA	-23.71	-70.42	CHOYA	X
FSA	-26.08	-66.01	CAFAYETE	
RFA	-34.77	-68.66	SAN RAFAEL	
RTCV	-31.86	-68.54	CERRO VALDIVIA	X
RTLL	-31.33	-68.47	CERRO VILLICUN	X
SLA	-24.73	-65.49	SAN LORENZO	X
TCA	-31.34	-64.59	TANTI	
VBA	-38.05	-61.98	SIERRA DE LA VENTANA	
VCA	-28.74	-68.20	VINCHINA	X
YJA	-22.17	-65.51	YAVI	

ARGENTINA
INSTITUTO SISMOLOGICO ZONDA NETWORK CODE (ZON)

STA.	LAT.	LON.	NAME	TEL.
CEN	-31.58	-68.75	CERRO NEGRO	
HLN	-30.74	-68.95	HUALILAN	
LEO	-31.80	-69.34	LEONCITO	
MAA	-32.08	-69.85	MANANTIALES	
ZON	-31.55	-68.68	ZONDA	

TABLE 22

CHILE
UNIVERSIDAD DE CHILE NETWORK CODE (SAN)

STA.	LAT.	LON.	NAME	TEL.
ALH	-32.37	-70.79	ALICAHUE	
ANT	-23.71	-70.42	ANTOFAGASTA	X
BACH	-33.35	-70.49	LO BARNECHEA	X
CAA	-26.33	-70.61	CHANARAL	X
CAC	-22.48	-69.03	CALAMA	X
CHCH	-33.93	-70.65	CHADAS ANGOSTURA	X
CON	-36.83	-73.05	CONCEPCION	X
CPP	-27.35	-70.35	COPIAPO	X
CTP	-32.57	-71.31	CATAPILCO	
ELP	-33.26	-71.21	EL PANGUE	
FCH	-33.33	-70.29	FARELLONES	X
IQQ	-20.24	-70.13	IQUIQUE	
JACH	-32.68	-70.59	JAHUEL	X
LAV	-33.09	-71.75	LAGUNA VERDE	X
LNV	-33.96	-71.41	LONGOVILO	X
LQT	-33.81	-70.21	LOS QUELTEHUES	X
MIC	-22.71	-70.27	MICHILLA	X
OAS	-23.20	-69.71	OASIS	X
OFA	-25.15	-69.95	OFICINA ALEMANIA	
PCH	-33.62	-70.51	PIRQUE	X
PEL	-33.14	-70.69	PELDEHUE	X
PUT	-33.42	-71.70	PUNTA DE TALCA	X
QUL	-21.66	-69.53	QUILLAGUA	X
ROCH	-32.97	-71.01	EL ROBLE	X
SAN	-33.45	-70.66	SANTIAGO	X
SLN	-23.15	-69.61	SALINAS	X
SOM	-52.78	-69.24	SOMBRERO	X
TACH	-33.65	-70.94	TALAGANTE	X
TCN	-22.28	-68.17	TOCONCE	X
TLL	-30.17	-70.80	TOLOLO ASTRONOMICAL OBSERVATORY	X
TMU	-38.73	-72.60	TEMUCO	
TPL	-22.10	-70.21	TOCOPILLA	X
VLP	-33.03	-71.64	VALPARAISO	X

TABLE 23

CHILE–ARGENTINA NETWORK STATIONS

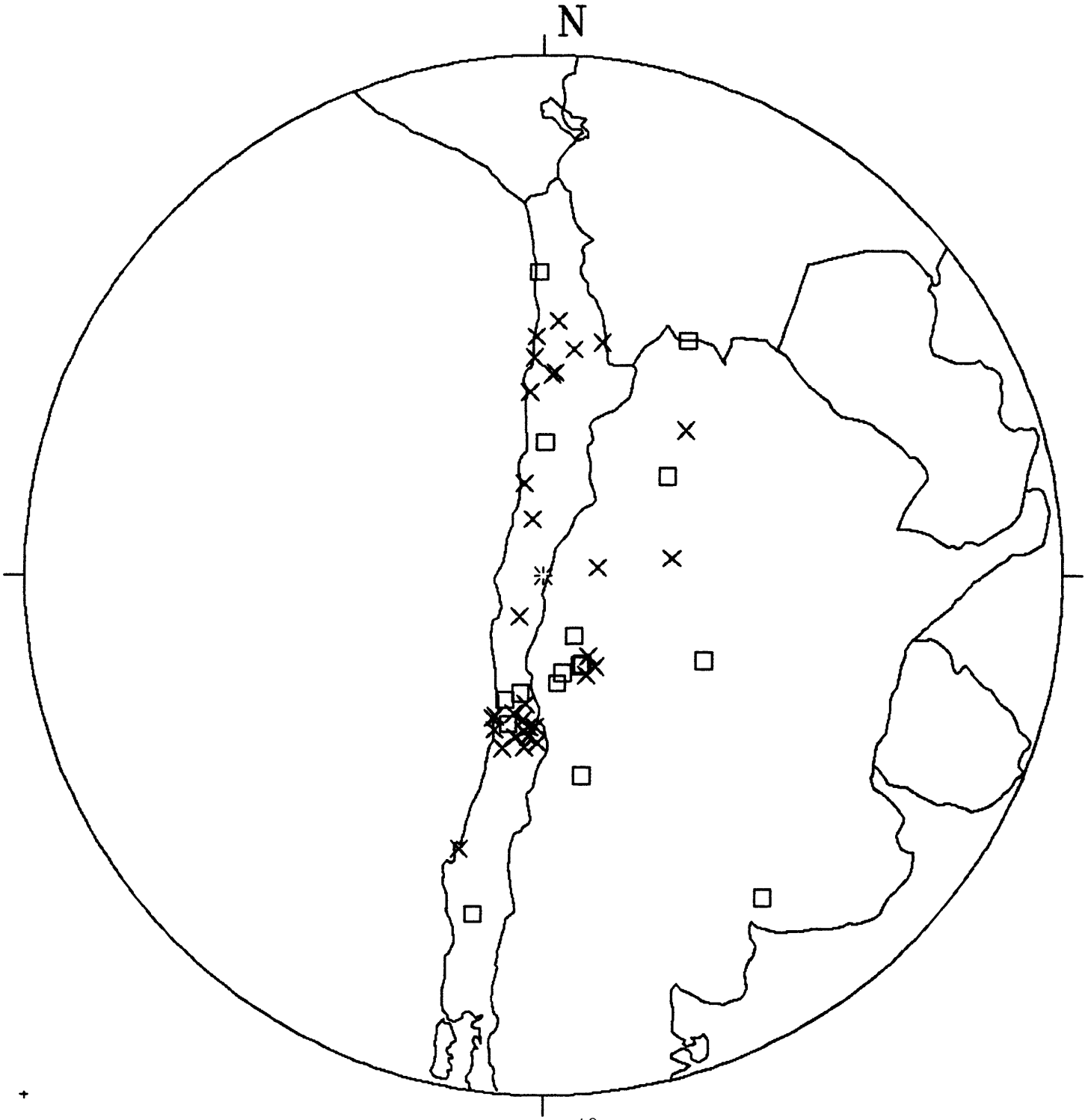


FIGURE 49

GS DATA SET NOT ON AFTAC DATA SET
SEPTEMBER 1982

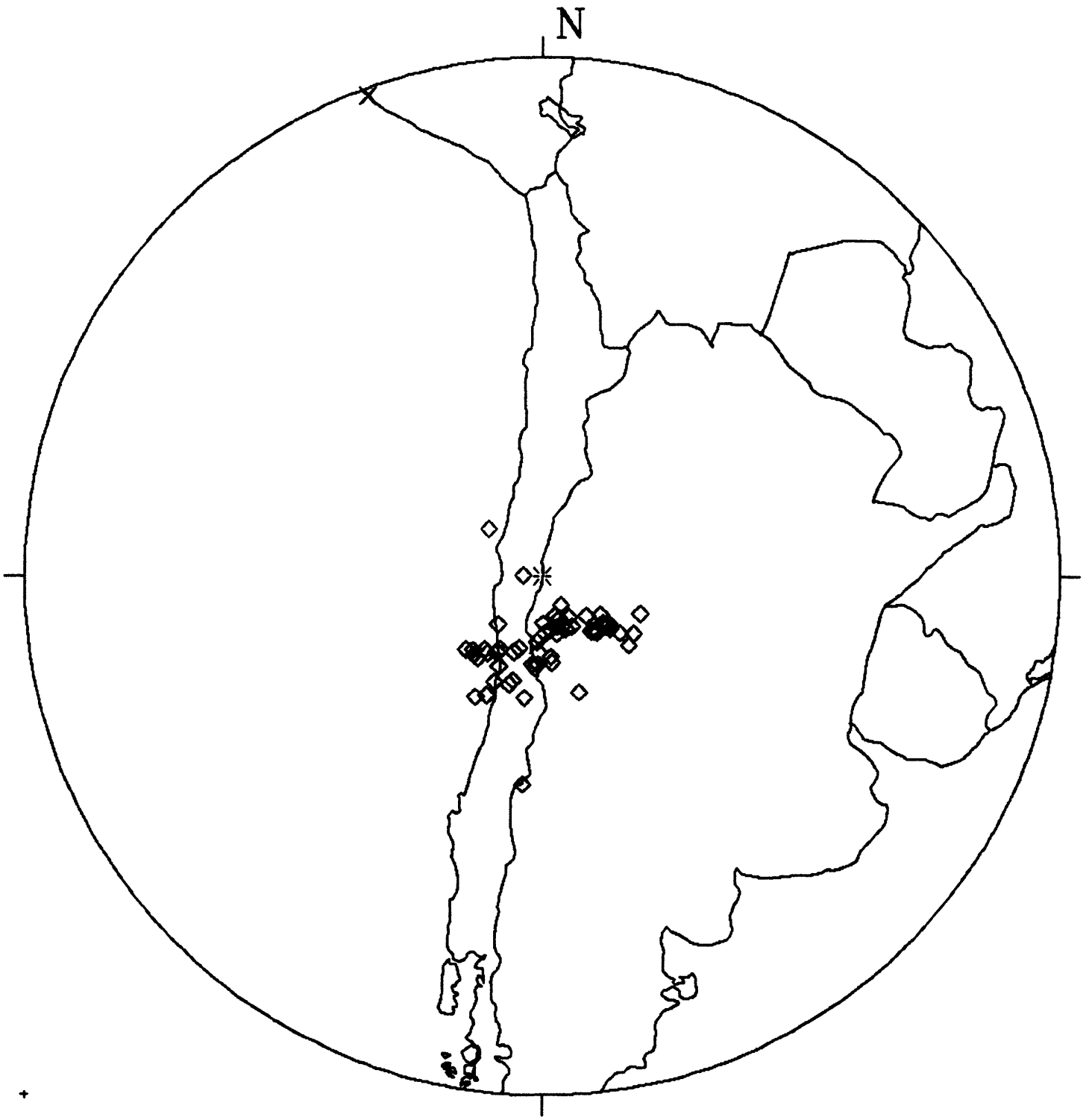


FIGURE 50

LPB
NO mb REPORTED
SEPTEMBER 1982

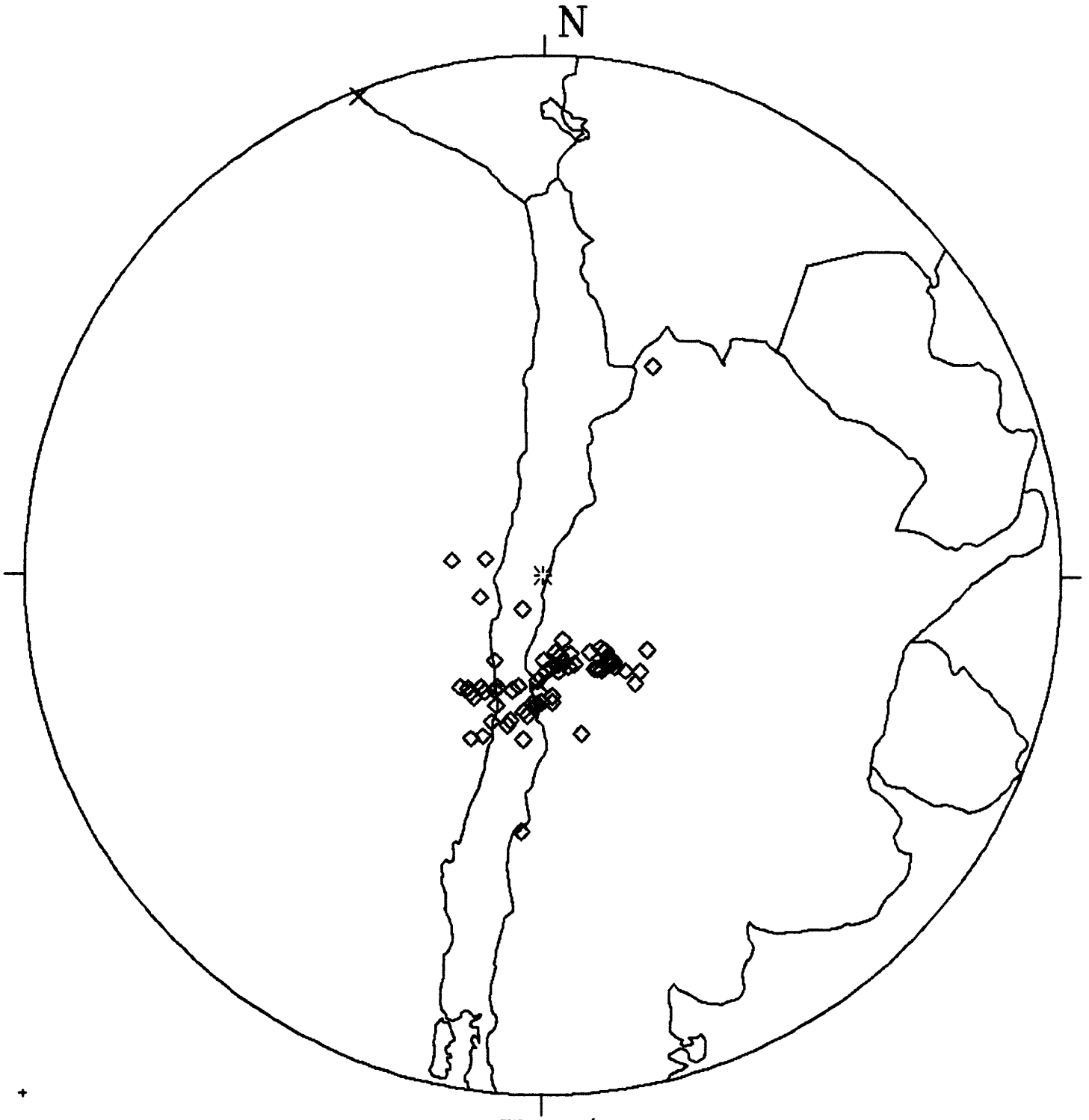


FIGURE 51

SOUTH AFRICA
GEOLOGICAL SURVEY, PRETORIA NETWORK CODE (PRE)

STA.	LAT.	LON.	NAME	TEL.
BLF	-29.11	26.19	BLOEMFONTEIN	X
BPI	-26.18	28.03	BERNARD PRICE INSTITUTE	X
CER	-33.36	19.30	CERES	X
EVA	-26.51	29.08	EVANDER	X
GRM	-33.31	26.57	GRAHAMSTOWN	X
HVD	-30.61	25.50	HENDRIK VERWOERD DAM	X
JOZ	-27.45	32.08	JOZINI	X
KIM	-28.75	24.78	KIMBERLEY	
KSR	-25.85	26.90	KOSTER	X
LTT	-29.72	23.02	LOUIS TRICHARDT	
PKR	-30.00	24.74	P.K. LE ROUX DAM	X
PRY	-26.93	27.47	PARYS	X
PTM	-29.63	30.40	PIETERMARITZBURG	
SEK	-28.32	27.63	SENEKAL	X
SLR	-25.74	28.28	SILVERTON	X
SNA	-70.32	-2.33	SANAE	X
SUR	-32.38	20.81	SUTHERLAND	X
SWZ	-27.18	25.33	SCHWEIZER-RENEKE	X
TUH	-33.30	19.15	TULBAGH	X
VIR	-28.08	26.85	VIRGINIA	X
WIN	-22.57	17.10	WINDHOEK,NAMBIA	X
WKM	-28.01	26.76	WELKOM	

TABLE 24

SOUTH AFRICA NETWORK STATIONS

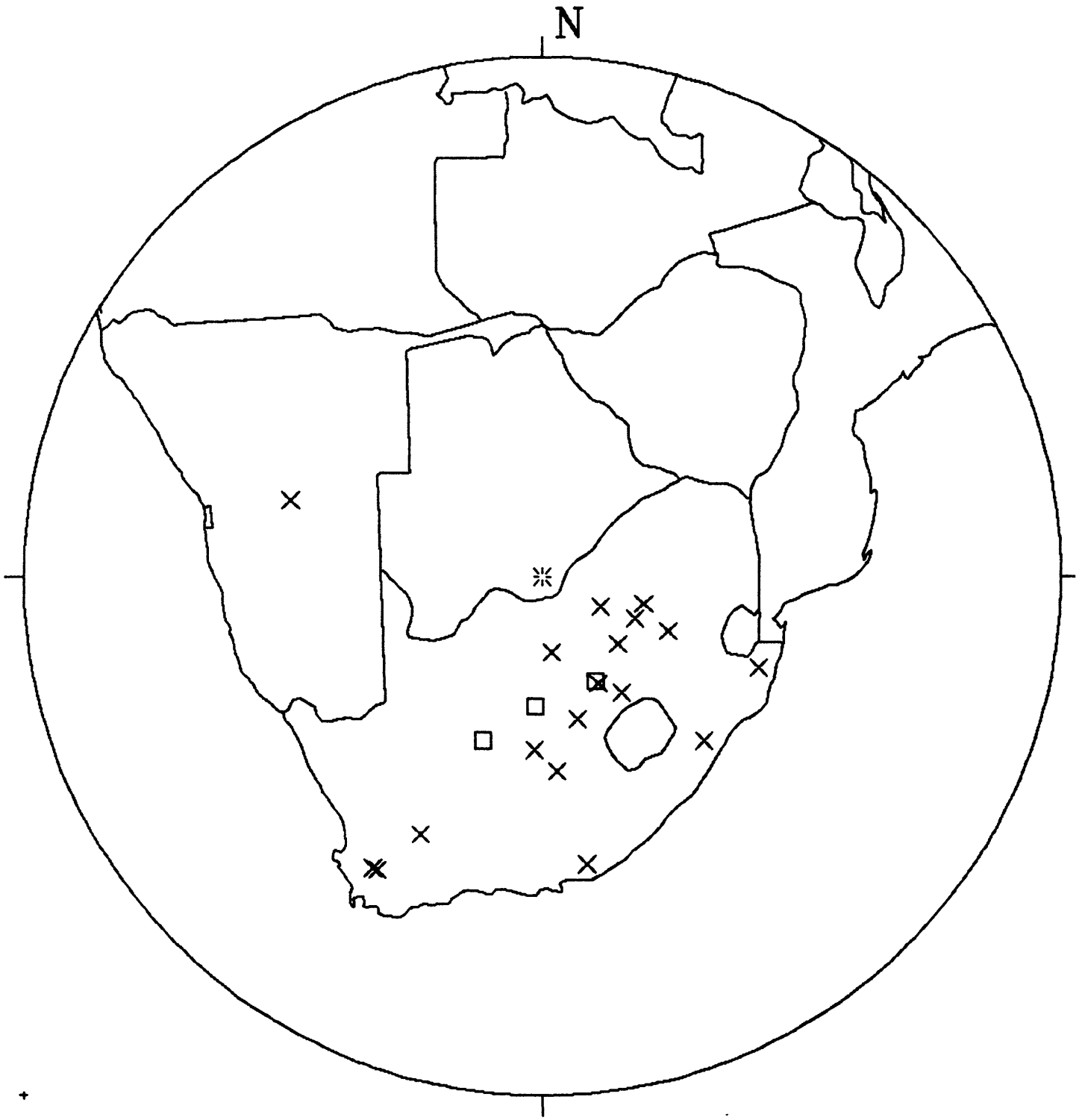


FIGURE 52

GS DATA SET NOT ON AFTAC DATA SET SEPTEMBER 1982

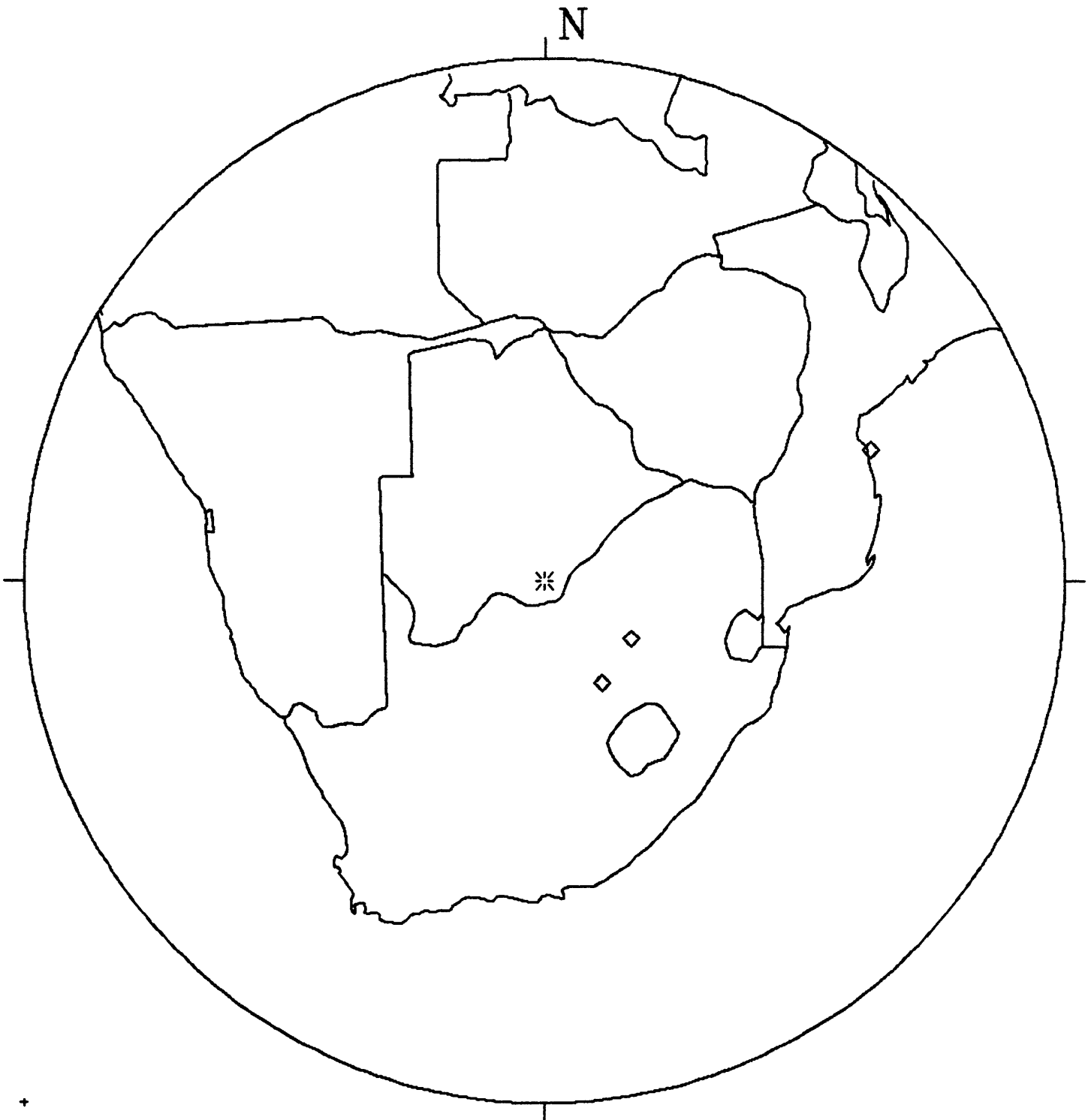


FIGURE 53