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Seismicity near Albuquerque, NM 1976-1977

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JAKSHA, LOCKE

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

SEISMICITY NEAR ALBUQUERQUE, NEW MEXICO 1976-1977

by

Lawrence H. Jaksha

and

Jerry Locke

Open-File Report 78-1054
1978

ABSTRACT

During 1976 and 1977 more than 400 earthquakes were located in the Albuquerque, New Mexico area. The activity is not uniformly distributed throughout the study area but falls mainly into three zones. Of these three zones, two are fairly well defined. The third zone is much less well delineated. Four composite focal mechanisms constructed during the study are in good agreement with the east-west tensional stress field proposed for the Rio Grande rift.

INTRODUCTION

The U.S. Geological Survey is studying the seismotectonics of the Rio Grande rift in New Mexico. As a part of this study a seismic network was installed around the rift in the central part of the state (Figure 1). The technical parameters and station locations for this network are described by Jaksha and others (1977). Jaksha and others (1978) reported on the results obtained from operating an 8-station network during 1976. In 1977 the number of seismic stations in the network increased from 8 in January to 13 in August. This present study adds the earthquakes located during 1977 to those reported on previously to compose a two-year data base.

ANALYSIS

The 1977 data were handled in a slightly different way than were those for 1976. Duration magnitudes, using the equation developed by Newton and others (1976) for northern New Mexico, are quoted in the 1977 listing of earthquakes (table 4). The equation: $M_{(L)} = 2.8 \log_{10}T - 3.6$ was developed by fitting duration data from the Los Alamos Regional Network to magnitudes determined from the Wood-Anderson system at the Albuquerque Seismological Laboratory. Table 1 shows the relationship between the duration $M_{(L)}$ and the amplitude $M_{(L)}$. The amplitude $M_{(L)}$ was calculated during 1976. The table compares earthquakes which occurred in January 1977.

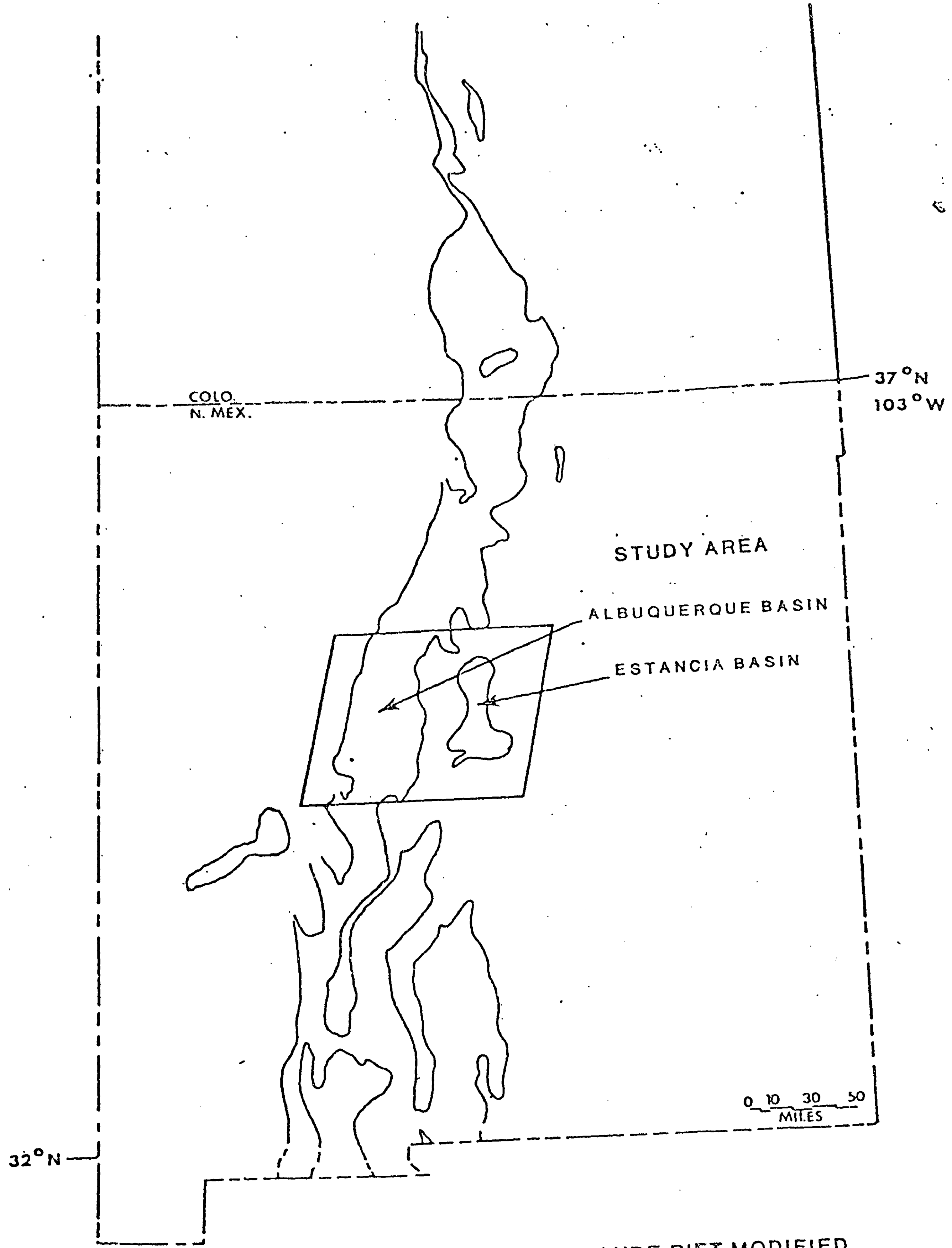


FIG. 1. GENERALIZED MAP OF THE RIO GRANDE RIFT MODIFIED FROM CHAPIN (1971).

TABLE 1

EQ Date yr mo day hr	M_L (Duration)	M_L (Amplitude)
77010316	-0.2	0.0
77010503	0.2	0.0
77011007	0.3	0.2
77010323	0.4	0.4
77010400	0.5	0.6
77011004	0.6	0.3
77010503	0.7	0.3
77010702	0.8	1.1
77010918	0.9	1.0
77010404	1.0	1.0
77010918	1.5	1.4
77010512	2.2	1.8
77010423	2.9	2.4

Regardless of which computation is used, the $M_{(L)}$ should be considered as estimates only. Generally the $M_{(L)}$ is probably correct to within about a half magnitude.

Focal depths are listed for events within the network in the 1977 data set. The numbers given are to the nearest kilometer. Crosson (1972) studied focal depth accuracies determined from small arrays of seismographs and, in general, found focal depths to be best determined when the hypocenter was very near to a seismic station. Most of the depths listed in this data set are for earthquakes not so favorably located and thus should be viewed with some skepticism.

The 1976 data were solved using two different crustal models. Solutions for events within the Rio Grande rift were determined using the crustal model derived by Toppozada and Sanford (1976) and for events outside the rift, using the 6/8 crust adopted by Sanford (1965). Table 2 is a comparison of two solutions for two earthquakes which occurred outside the rift.

TABLE 2

Location with 6/8 crust	Location with rift crust	Difference
Lat = 35.286	Lat = 35.292	.67 km
Long = 107.375	Long = 107.381	.54 km
Depth = 13.32 km	Depth = 15.65 km	2.3 km
Lat = 34.804	Lat = 34.809	.55 km
Long = 106.063	Long = 106.068	.45 km
Depth = 1.36 km	Depth = 9.77 km	8.4 km

These differences are much smaller than the location error estimates for this array given by Jaksha and others (1978). On this basis all events in the 1977 listing were solved using the Toppozada and Sanford (1976) model for the rift. This model is given in Table 3.

TABLE 3

Crustal Model (Toppozada and Sanford, 1976)

Thickness (km)	Velocity (P) km/sec
18.6	5.8
21.3	6.5
	7.9

The 1977 data are presented in table 4. The list contains 209 earthquakes that range in magnitude (M_L) from -0.2 to 2.9 and in focal depth from 1 to 20 km.

TABLE 4

DATE	ORIGIN TIME	LAT	LONG	DEPTH	MAGNITUDE
770103	16:28:53	34.57	106.87	1	-0.2
770103	23:55:26	34.07	107.01		0.4
770104	00:30:07	34.06	107.02		0.5
770104	04:29:33	34.10	107.00		1.0
770104	23:41:58	34.03	106.00		2.9
770105	03:00:26	34.54	107.06	1	0.2
770105	03:19:15	35.08	106.59	16	0.7
770105	04:58:24	34.05	106.00		0.5
770105	04:59:19	34.03	105.99		0.9
770105	08:03:38	34.04	106.02		0.5
770105	12:19:02	34.05	106.00		2.2
770105	21:21:23	34.04	106.00		0.5
770106	01:59:43	34.03	106.01		0.5
770107	02:46:30	34.07	107.03		0.8
770109	18:01:54	34.05	105.99		1.5
770109	18:05:15	34.05	106.02		0.9
770109	18:13:20	34.05	106.01		0.5
770110	04:36:05	34.04	105.99		0.6
770110	07:27:19	34.05	106.01		0.3

DATE	ORIGIN TIME	LAT	LONG	DEPTH	MAGNITUDE
770110	08:27:49	34.07	106.00		0.6
770110	15:04:02	34.45	107.01	1	0.3
770111	04:44:27	34.03	106.00		0.4
770111	04:59:44	34.06	105.99		1.5
770111	07:33:26	34.05	106.00		0.4
770112	03:10:36	34.00	105.93		0.3
770112	04:15:02	34.03	105.99		0.3
770112	12:37:42	34.04	106.02		0.2
770113	12:26:02	34.03	106.00		0.5
770121	16:34:39	34.11	106.99		1.3
770121	16:38:13	34.09	106.99		0.5
770122	07:13:09	34.14	106.66		0.8
770122	07:42:58	34.15	106.67		0.6
770125	14:26:49	34.31	106.88		0.2
770126	06:25:52	34.33	106.81		-0.1
770129	02:59:39	34.32	106.88		0.2
770129	03:34:49	34.31	106.89		-0.1
770203	19:41:11	34.08	107.01		0.7
770211	04:21:48	34.71	105.88		0.1
770211	11:54:46	34.29	106.79		0.9
770211	12:10:19	34.31	106.77		0.5
770211	12:23:06	34.30	106.78		0.3
770211	22:32:01	34.30	106.79		0.4
770213	02:48:20	34.31	106.80		0.2
770213	06:59:10	34.32	106.80		-0.1
770213	16:51:11	35.36	107.31	2	0.4
770214	04:47:30	34.49	107.04	3	0.2
770214	07:12:01	34.30	106.81		0.2
770214	07:28:02	34.33	106.80		0.3
770214	08:08:17	34.34	106.79	4	0.1
770214	08:21:25	34.32	106.80		0.2
770220	05:07:59	35.40	107.27	5	0.2
770221	00:47:53	34.43	106.77	3	1.0
770221	16:07:30	34.32	106.80		1.0

DATE	ORIGIN TIME	LAT	LONG	DEPTH	MAGNITUDE
770223	13:51:02	34.55	106.91	3	0.1
770224	09:35:08	35.35	107.30	3	0.9
770226	04:31:19	35.35	107.30	2	0.3
770226	17:49:16	35.39	107.31	8	0.4
770226	18:12:29	35.38	107.27	2	0.5
770303	02:00:25	34.44	106.70	13	-0.1
770309	18:10:31	34.03	106.85		0.3
770314	19:54:04	35.32	105.64		0.7
770315	11:53:09	34.00	106.84		0.3
770316	13:24:07	35.02	105.86	14	-0.2
770319	23:50:50	34.36	106.89		0.3
770326	10:27:32	34.59	106.84	3	0.3
770330	14:55:01	35.41	107.31	16	0.8
770402	23:05:57	35.40	107.29	11	-0.1
770403	01:23:44	35.39	107.30	10	0.8
770403	01:24:30	35.40	107.27	8	0.8
770403	01:30:58	35.41	107.30	12	0.7
770403	06:10:36	35.42	107.26	11	-0.1
770407	13:13:03	35.47	107.26	8	1.3
770411	16:45:36	35.63	106.99		0.2
770412	07:51:01	34.41	106.06		0.1
770417	08:21:57	35.35	107.45		1.3
770417	08:28:55	35.32	107.37		-0.1
770417	08:30:36	35.33	107.39		0.3
770418	04:27:48	34.28	106.91		0.7
770419	16:40:21	34.07	106.93		0.8
770423	10:57:15	34.21	106.81		0.1
770424	03:11:30	34.28	106.87		0.2
770430	06:45:14	34.48	107.05	2	-0.1
770502	14:05:49	34.36	106.75		0.6
770503	09:15:12	34.70	105.84		-0.1
770510	04:31:51	35.32	107.38		0.6
770510	05:55:39	35.34	107.57		0.6
770512	22:06:08	34.29	106.82		0.9

DATE	ORIGIN TIME	LAT	LONG	DEPTH	MAGNITUDE
770513	08:19:43	34.40	106.77		0.8
770517	01:01:30	34.41	106.75	2	-0.2
770517	16:27:39	34.06	106.03		0.3
770517	23:15:47	34.08	106.04		0.5
770518	03:48:45	34.12	106.68		0.8
770518	04:29:44	34.37	106.80	2	-0.5
770528	23:12:00	35.47	107.13		0.1
770528	23:14:14	35.49	107.11		0.4
770529	05:10:42	35.48	107.11		0.8
770529	08:33:40	35.49	107.11		-0.1
770530	07:01:15	34.05	107.04	9	0.8
770530	07:12:33	34.05	107.03	5	0.2
770530	07:13:14	34.05	107.04	11	0.6
770530	20:17:09	34.41	106.75	4	0.1
770531	05:48:39	34.04	107.04	13	0.4
770531	10:05:11	34.08	106.99		0.4
770531	13:44:10	34.04	107.07	5	0.6
770602	06:48:16	34.03	107.06		2.0
770603	20:45:03	34.27	106.88		0.5
770609	09:24:52	34.47	107.68		1.1
770611	04:59:52	34.22	106.81		1.0
770614	10:53:03	34.42	106.74	2	0.4
770615	02:36:55	34.86	107.54		0.2
770616	07:16:19	35.41	107.33	6	0.1
770616	09:26:21	34.18	106.82		1.2
770616	11:49:32	34.33	106.84		0.1
770617	04:14:56	34.46	106.95	1	1.4
770619	07:01:20	34.50	107.10	3	0.1
770621	05:17:40	34.07	107.02		0.5
770621	05:32:51	35.34	107.44	13	0.2
770623	04:52:35	35.52	107.11	10	0.1
770623	22:42:42	34.05	106.92		0.5
770624	00:34:45	34.04	106.54		0.5
770624	02:20:21	34.43	106.70	17	-0.2

DATE	ORIGIN TIME	LAT	LONG	DEPTH	MAGNITUDE
770625	15:22:47	34.18	107.02		0.5
770626	19:07:38	34.04	106.76		0.2
770627	00:16:11	34.04	106.76		0.5
770627	00:26:14	34.03	106.75		0.2
770703	06:46:59	34.40	106.99		1.0
770716	01:47:57	34.20	107.02		0.4
770718	06:13:22	34.08	106.97		0.9
770721	07:36:12	34.05	106.52		0.3
770727	10:08:29	35.41	107.33	16	0.5
770729	16:42:09	35.12	106.34	10	1.2
770731	00:06:03	35.41	107.35	14	0.1
770731	14:21:38	35.37	106.11	10	1.6
770805	16:06:26	35.32	107.18	9	1.0
770805	19:12:03	35.34	107.37	1	0.1
770806	20:52:48	34.38	106.87	3	0.8
770807	09:26:38	34.04	106.77		0.1
770808	04:48:02	34.34	106.98		0.4
770809	09:50:39	34.27	106.92	13	1.0
770811	09:54:47	34.07	106.98		0.4
770813	04:42:29	34.37	106.80	7	0.1
770813	07:59:17	34.37	106.79	11	1.9
770814	04:45:33	34.05	106.97		1.2
770819	09:22:06	34.08	106.98		2.4
770820	10:51:45	34.44	106.90	2	0.4
770821	05:43:26	35.61	106.08		0.9
770821	21:02:14	34.93	106.00	1	0.1
770822	15:10:55	35.37	107.31	6	0.9
770826	10:32:58	34.05	107.02		-0.1
770828	16:57:06	35.32	107.15	9	0.1
770829	07:13:39	35.49	107.07		1.6
770829	08:02:45	35.38	107.25	6	0.1
770829	08:31:38	35.51	107.06	5	0.9
770901	18:20:02	34.08	106.78		0.2
770902	11:29:23	35.50	107.05		0.3

DATE	ORIGIN TIME	LAT	LONG	DEPTH	MAGNITUDE
770904	00:17:48	35.47	107.10		0.1
770904	00:19:17	34.10	106.95	3	0.5
770904	07:02:50	34.39	107.01		0.1
770904	07:05:52	34.41	106.99	1	0.5
770904	09:03:14	34.42	107.01		-0.1
770905	21:17:32	34.72	105.84		0.1
770906	17:18:17	34.58	106.85	5	0.3
770911	16:33:53	34.61	105.32		0.9
770914	13:09:23	34.55	106.86	4	0.1
770914	17:41:17	34.38	106.86	2	0.1
770920	01:20:09	34.05	107.03		0.4
770922	05:20:27	34.36	106.85	3	0.7
771002	14:38:37	35.70	106.92		0.5
771004	20:08:17	35.53	105.42		1.0
771012	21:00:10	34.04	106.54		1.2
771012	21:20:28	34.04	106.54		1.0
771013	05:58:07	34.05	106.55		0.5
771013	13:47:51	34.37	106.86	3	-0.1
771025	15:03:28	34.17	106.89	2	0.5
771026	06:17:27	34.06	107.00		0.1
771026	16:37:48	34.07	107.03		0.7
771028	13:00:13	34.15	106.89	8	1.3
771028	13:26:52	34.15	106.87	3	-0.1
771029	10:41:33	34.16	106.88	3	0.7
771107	06:22:35	34.85	107.88		0.2
771109	07:00:56	34.07	107.01		1.0
771109	07:12:03	34.07	107.01		1.0
771110	15:09:57	34.95	105.90	1	0.7
771111	11:26:55	35.40	107.12	3	0.6
771112	02:51:35	34.07	107.01		0.2
771114	11:45:47	34.67	106.92	20	0.5
771114	12:09:45	34.09	106.79		0.3
771114	17:11:23	35.39	107.28	9	0.5
771116	08:59:09	35.32	107.34	9	0.4

DATE	ORIGIN TIME	LAT	LONG	DEPTH	MAGNITUDE
771116	09:20:21	35.53	107.18		0.4
771116	15:17:30	35.31	107.45		0.2
771117	13:02:29	35.51	107.05		0.3
771118	12:42:49	34.43	107.01	3	0.2
771123	10:37:19	34.17	106.89	3	0.3
771203	06:48:46	35.31	107.37		0.1
771204	11:48:45	34.05	106.95		0.9
771205	20:57:20	34.41	107.02	2	0.4
771211	23:58:59	35.32	107.17	1	0.1
771215	17:15:41	34.33	107.03		0.2
771216	00:38:13	35.29	107.18	3	0.2
771216	00:47:48	35.29	107.18	3	0.1
771218	16:45:15	34.68	105.66		0.3
771219	09:14:42	35.42	107.24	2	0.2
771220	03:10:00	34.85	107.54		0.8
771220	05:29:33	34.86	107.53		0.7
771221	00:25:33	35.29	107.39	7	0.7
771223	01:20:20	34.90	106.00	4	0.2
771226	12:04:19	34.40	106.01		0.5
771231	09:46:39	34.41	106.12		0.1
771231	23:38:43	34.07	106.64		0.3

SEISMICITY

The events listed in Table 4 are plotted, along with 1976 earthquakes, in Figure 2. A high percentage of the 1977 events fall into zones generally described by the 1976 data.

The reliability of Zone 1 data was greatly enhanced with the installation of station WTX. The locations for events occurring in the southern Albuquerque Basin, in particular, are given with more confidence. This area continues to be the most seismically active in the Albuquerque region. It is under quite

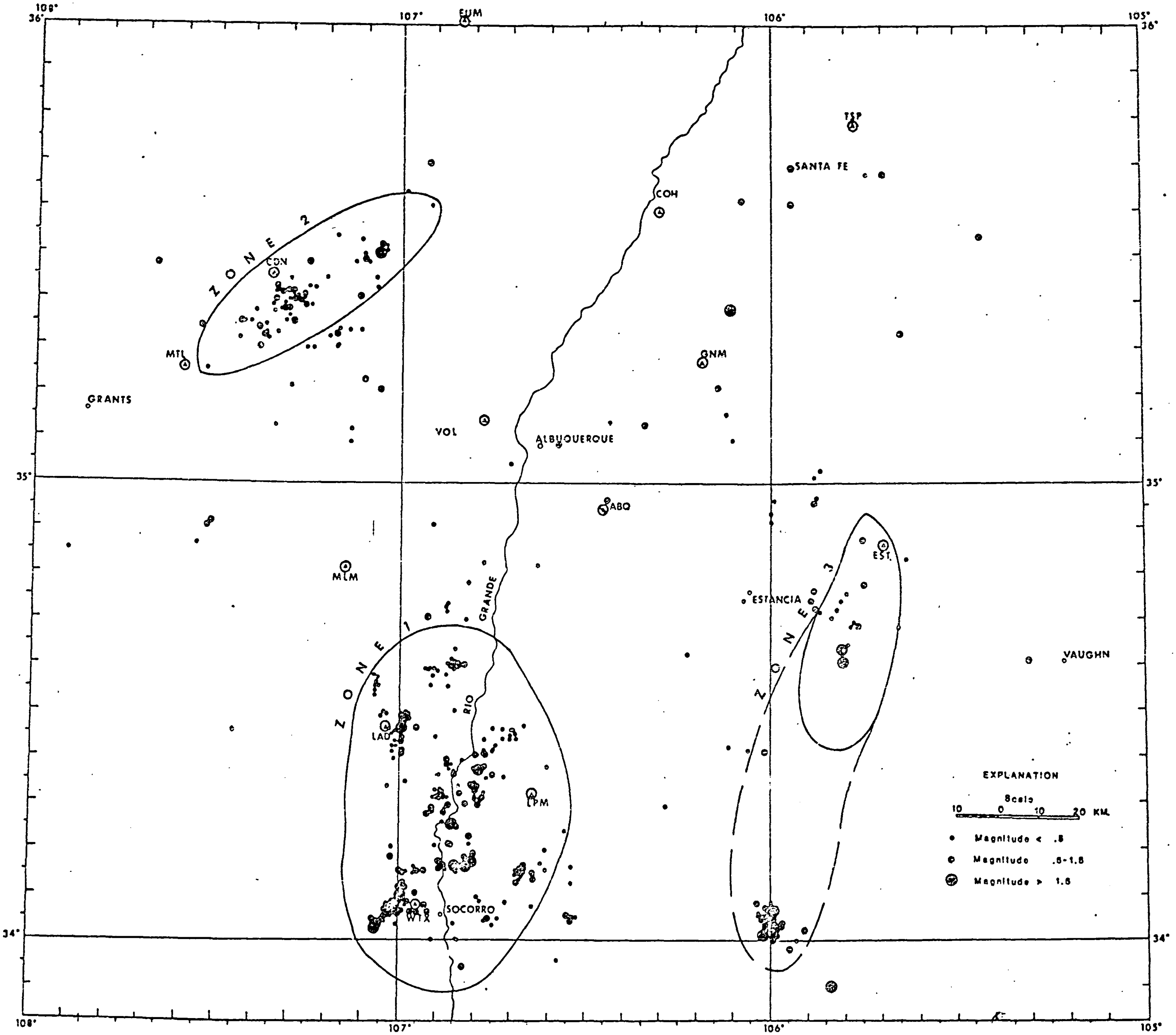


FIG. 2. Earthquakes in the vicinity of Albuquerque New Mexico (1976-1977).

intensive investigation for its potential geothermal resources by researchers from the New Mexico Institute of Mining and Technology.

The seismicity in Zone 2 increased considerably over that reported for 1976. This area contains several major uranium mining operations as well as active exploration projects. The possibility of having included blasting from these sources into the earthquake list is never entirely discounted. However, the following observations indicate the recorded seismicity to be natural.

(1) The locations correlate poorly with known mining operations.

(2) Much of the activity has a main shock-aftershock sequence characteristic of naturally occurring seismicity.

(3) The distribution of first motions among the recording stations is characteristic of earthquake activity.

The seismicity observed in Zone 3 during 1977 was somewhat less than that in 1976.

One earthquake was located within the city limits of Albuquerque during 1977. This event occurred on January 5, was located beneath the southeast section of the city at a depth of about 16 km, and had an $M_{(L)}$ of 0.7.

Figure 3 is a plot of earthquakes occurring within or near the Albuquerque and Estancia Basins during the two-year period being considered. The observations of Jaksha and others (1978) are repeated here without change.

(1) The seismic activity in the Albuquerque Basin shows some correlation with the mapped faults, fault zones, or extensions of faults.

(2) There is a lack of seismicity on the Albuquerque Basin boundary faults.

(3) There is a lack of seismicity in the Albuquerque Basin north of about lat 35°N.

(4) Earthquakes tend to occur in the eastern half of the Estancia Basin.

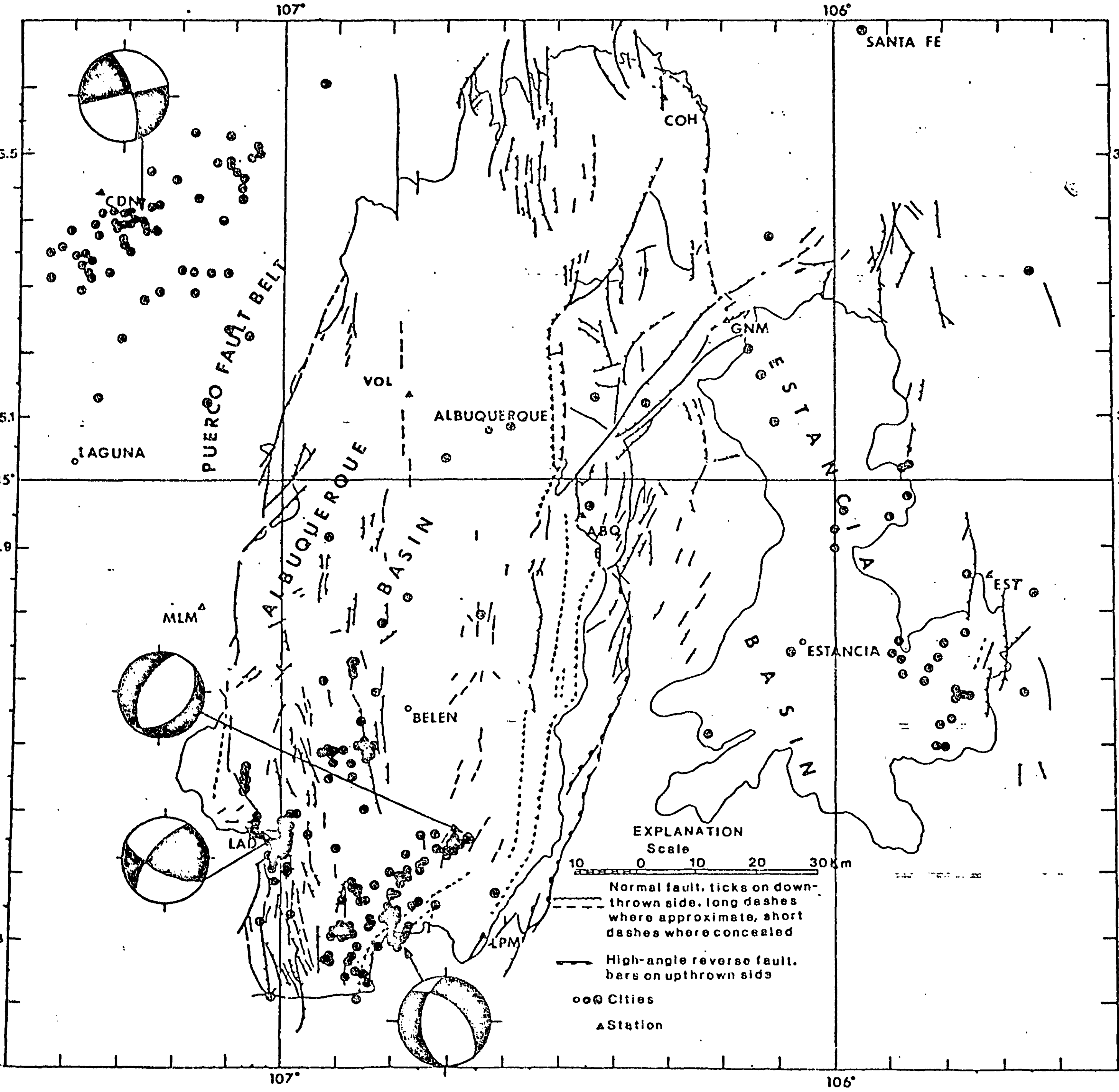
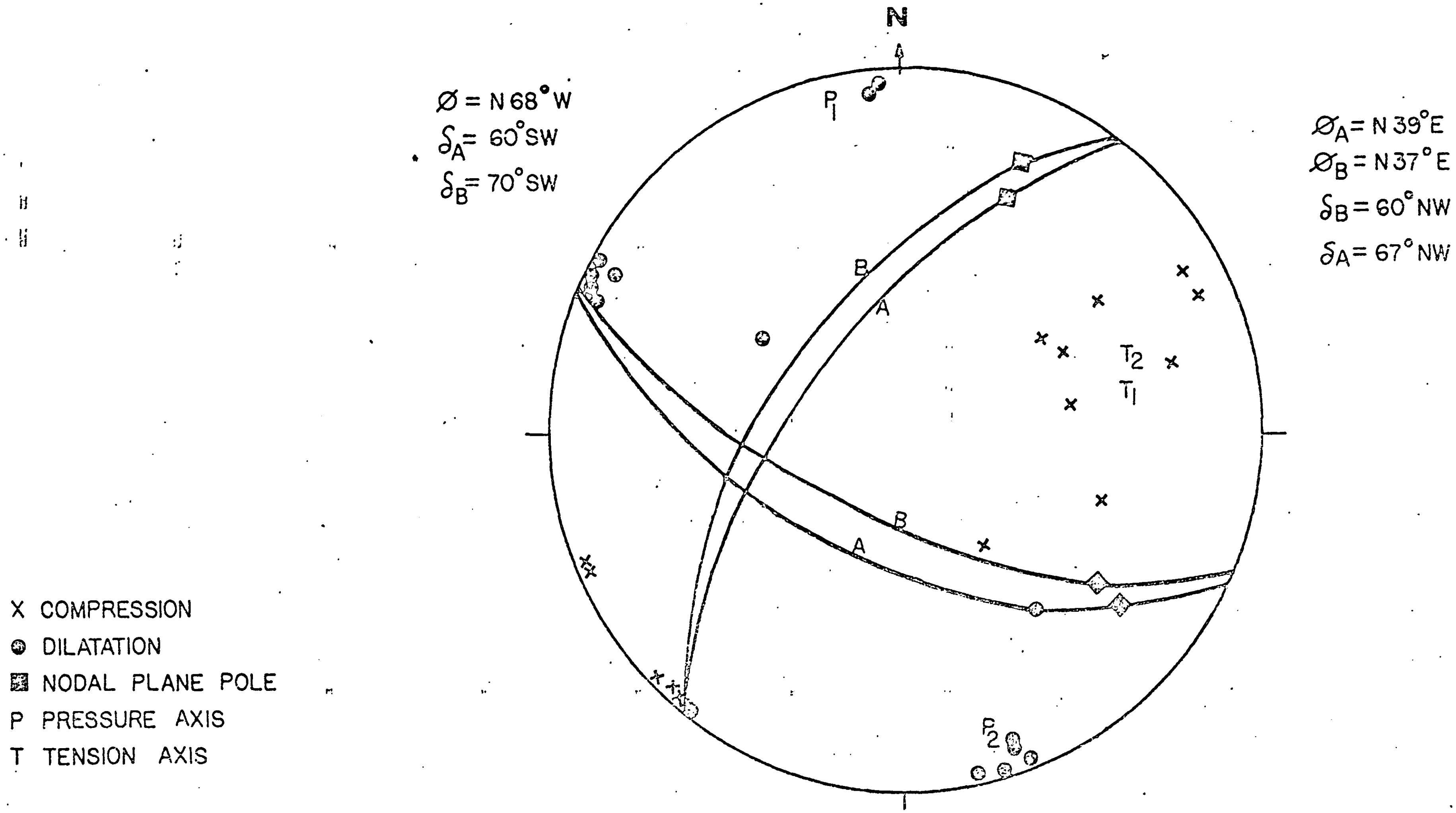


FIG. 3. 1976-1977 earthquakes within and near the Albuquerque and Estancia Basins and locations of focal mechanisms.
Map is modified from Woodward, Callender, and Zilinski (1975).

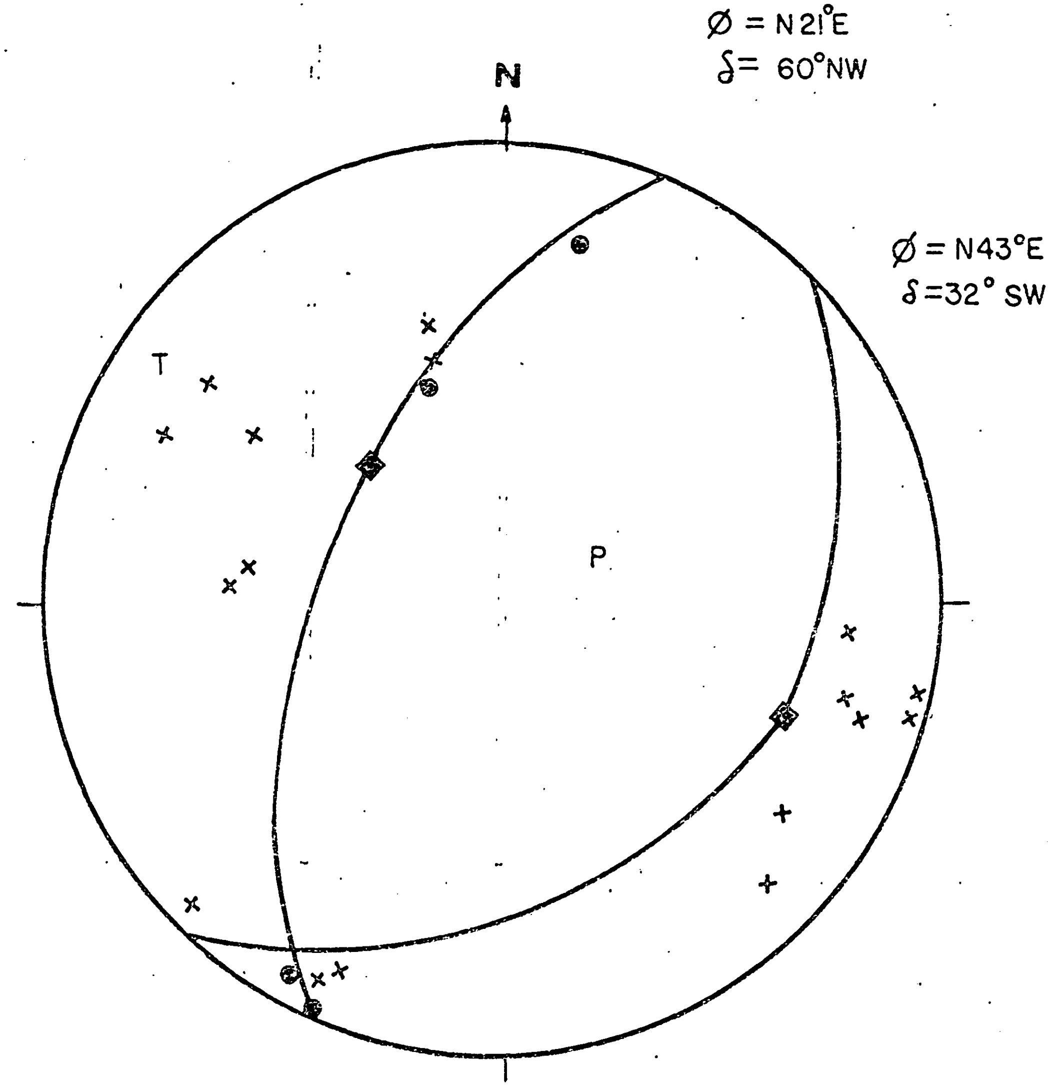
Figure 3 also shows the locations of the four composite focal mechanisms derived from the data set. Figures 4, 5, 6, and 7 show the two different methods used to construct these mechanisms. Figures 4 and 5 use a quite constrained data set; all of the earthquakes used in the mechanism occurred quite closely in space. These two mechanisms were discussed by Jaksha and others (1978). Figure 6, on the other hand, contains events from throughout Zone 2, an area of approximately 1000 square kilometers. Figure 7 contains data from many earthquakes within about 30 km of station LPM.

A certain amount of scatter, especially near nodal planes, is to be expected in composite focal mechanisms constructed in the fashion of Figures 6 and 7. In the particular case of Figure 6, the strike and dip of the north-south nodal plane is quite well constrained. This is much less true for the nodal plane striking N78°E and dipping 90°. The nature of faulting, a strike-slip motion, is well determined. No selection of a preferred fault plane is made from these data at this time.

Figure 7 indicates that normal faulting along generally north-south striking faults is the dominant kind of earthquake mechanism in the vicinity of station LPM. This interpretation is in agreement with Sanford and others (1977) for earthquakes near Socorro. Neither of the nodal planes in Figure 7 is well determined and no further analysis from this mechanism is warranted.

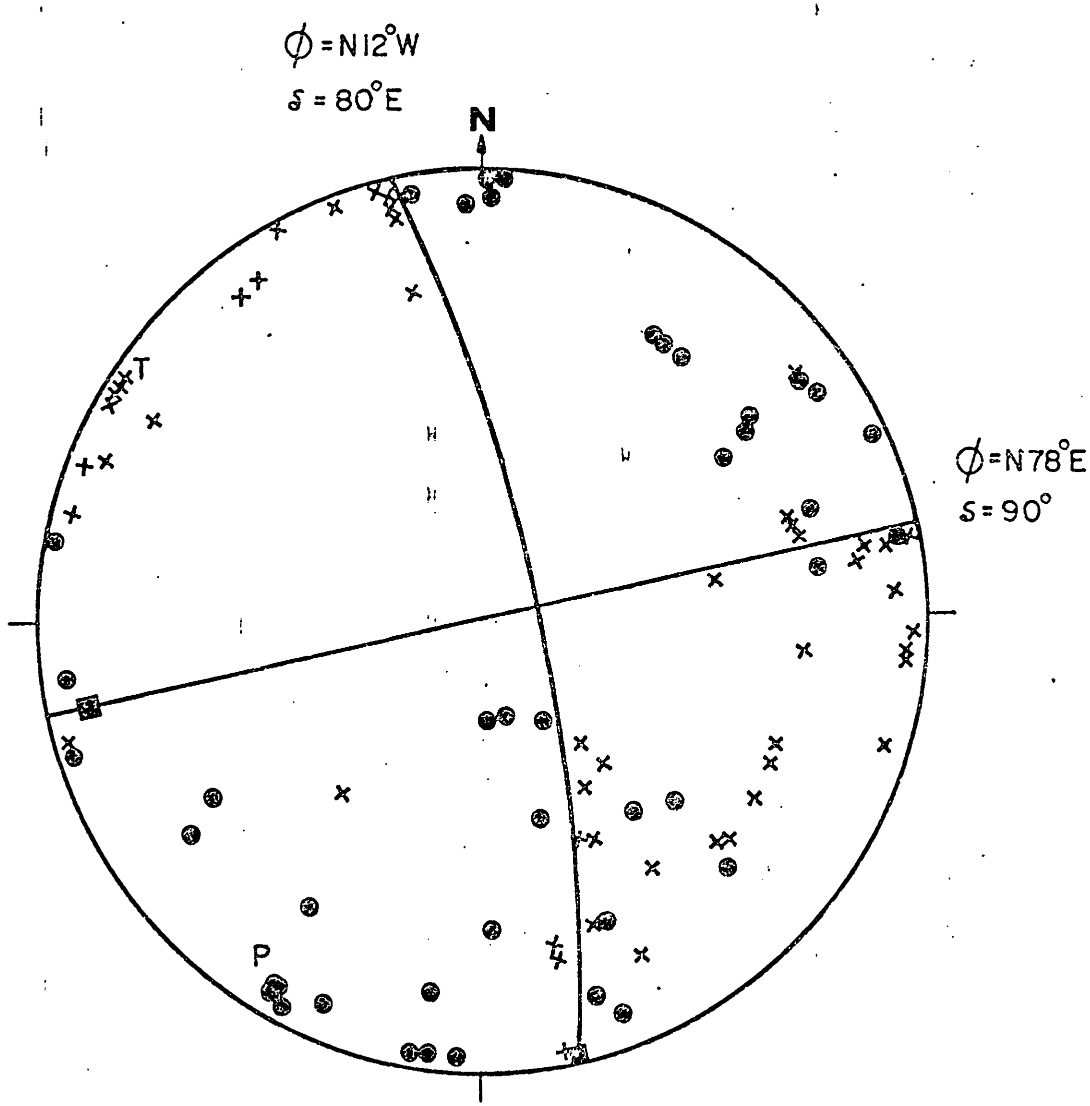


EQUAL AREA PROJECTION
LOWER HEMISPHERE
FIG. 4.



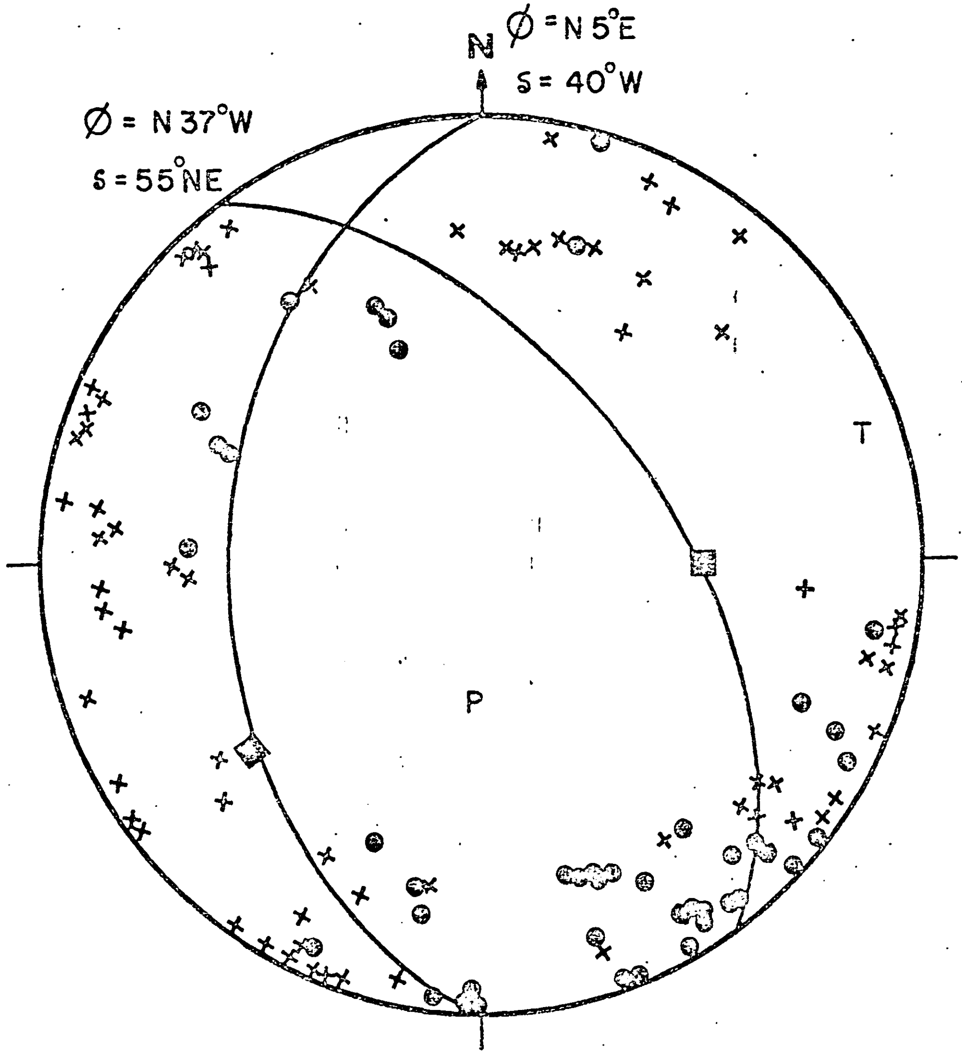
X COMPRESSION
⊕ DILATATION
▣ NODAL PLANE POLE
P PRESSURE AXIS
T TENSION AXIS

EQUAL AREA PROJECTION
LOWER HEMISPHERE
FIG. 5.



× COMPRESSION
● DILATATION
▩ NODAL PLANE POLE
P PRESSURE AXIS
T TENSION AXIS

EQUAL AREA PROJECTION LOWER HEMISPHERE. FIG. 6.



× COMPRESSION
● DILATATION
▣ NODAL PLANE POLE
P PRESSURE AXIS
T TENSION AXIS

EQUAL AREA PROJECTION
LOWER HEMISPHERE. FIG. 7.

OBSERVATIONS

This report contains data on two years of seismic activity in the vicinity of Albuquerque, New Mexico. The study notes three zones where small earthquakes are occurring. These zones are:

1. The area between Belen and Socorro in the Rio Grande rift.
2. The area northeast of Grants near the boundary between the Rio Grande rift and the Colorado Plateau.
3. A poorly defined zone to the east of the Rio Grande graben and between the rift and the High Plains.

The seismic network operated for this study expanded from 8 to 13 stations during the two-year period. The increase in numbers did not appreciably change the total number of hypocenters located during the year. Indeed, the total is slightly less than that for 1976. The larger network did not locate any new zones of seismicity. The percentage of earthquakes inside of the network and the quality of the hypocenters are, of course, higher with the larger array.

The four composite focal mechanisms constructed from this data set are in good agreement with the east-west tensional stress field proposed by Chapin (1971) for this area of New Mexico. The strike of the composite T axis for these mechanisms is 9^{o} north of due west.

The almost complete absence of microearthquake activity near the city of Albuquerque is remarkable. Two of the three largest earthquakes in the study area in the last decade probably occurred beneath the northwest corner of the city. These events, an $M_{(L)}$ 3.6 foreshock in 1969 and an $M_{(L)}$ 3.9 main shock in 1970 were characterized by an unusually short aftershock sequence. A total of only four aftershocks were observed at the WWSSN station ALQ, located about 30 km from the hypocenter. This, along with the lack of on-going small earthquakes, might indicate that the currently operating stress system near the city is different than that in the three active zones noted. A much longer data set, however, is needed to confirm such a difference.

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