UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

National Center for Earthquake Research
345 Middlefield Road
Menlo Park, California 94025

SEISMICITY OF THE CENTRAL CALIFORNIA COASTAL REGION

by

William Gawthrop

OPEN-FILE REPORT 75-134
1975

This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature.

Table of Contents

Figures

Tables

Introduction

The central California coastal region, approximately bounded on the east by 120° West Longitude and on the north and south by 36.1 and 34.5° North Latitudes respectively, has been studied to determine the current distribution of seismicity. The region is characterized by strong structural trends in a NW-SE direction in the north and an E-W direction in the south. These trends are similar to the San Andreas fault in the eastern section of the region where it turns from a southeast direction parallel to the assumed relative motion of the Pacific and North American plates (Atwater, 1970) to an east-west direction through the Transverse Ranges. These trends and the fault plane solutions for northern California (Bolt, et al., 1968), and Santa Barbara Channel earthquakes (Lee and Vedder, 1973; Sylvester, et al., 1970), and those determined in this study are all consistent with a general north-south compression throughout the region. This study attempts to determine the current activity of the known faults in this region due to this regional stress system.

Two major seismograph networks have been operational since 1932: the University of California, Berkeley, network in northern California, and the California Institute of Technology network in southern California. The central California coastal region is between the two networks, and little effort has been made by either group to accurately determine epicenters in this region (Roy Miller, personal communication; Richter, 1969). Since a number of events were timed by only one of the two groups, it is quite likely that several events have not been timed or located by either group. No attempt was made in this study to recover unknown events; however, a search for felt reports in newspapers or the annual catalogs of U.S. Earthquakes might be productive. It is therefore difficult to determine how complete the data set is, although some estimates of completeness for events over a certain magnitude during a given time interval can be made on the basis of the available station distribution. The possible lack of completeness may be the cause of an apparent low seismicity province on previous California seismicity maps. This study is an attempt to accurately relocate the available earthquakes to evaluate possible seismic hazards within the region.

The accurate location of earthquakes in this region is difficult because of three major factors: the lack of local seismographs, the large azimuthal gap in station coverage, and the insufficient knowledge of the crustal velocity structure throughout the region. The effects of these factors in locating events have been minimized by fixing focal depths at a common level and by using a master-event location technique. The large azimuthal gap limits control on relocating epicenters; however, this problem is inherent in this region and cannot be removed. Since most California earthquakes range in focal depth from zero to fifteen kilometers, all hypocenters were constrained to seven kilometers. The master-event technique utilizes one or more well-located earthquakes (master events) to determine for each seismograph station the difference between the actual traveltime from a source region to the station and the traveltime calculated from an assumed velocity model. Delays are incorporated into the crustal velocity model to account for the traveltime differences, or residuals, of the master events and are used to determine the best relative location of the other events in the same region. Using this method, the relative precision of epicenter locations is increased so that several linear trends of epicenters are apparent in the data.

Geology

The central California coastal region was the site of subduction of an oceanic plate under the North American continent until the early Tertiary, when the continent apparently overrode the spreading ridge (Atwater, 1970; Page, 1970). Since the late Oligocene, the tectonics of the region have been dominated by horizontal shearing as the Pacific plate slides past the North American plate in a dextral sense at an average relative rate of about 5.5 cm/yr (Atwater, 1970). The major feature reflecting this sense of movement is the San Andreas fault, running from the East Pacific Rise in the Gulf of California to the Mendocino escarpment and the Gorda Ridge off the coast of northern California. Large lateral displacements on the San Andreas fault are documented to be on the order of hundreds of miles since the Mesozoic era (Hill and Dibblee, 1953; Dibblee, 1966; and Hill, 1954) with an average rate about 2.5 cm/yr. This rate is much smaller than the rate of plate movement since Oligocene as determined from magnetic lineations, but is approximately the same as the current rate of movement on the San Andreas fault (Savage and Burford, 1973). It is likely, therefore, that the other 3 cm/yr of movement is distributed over a wide area with at least part being absorbed in the region west of the San Andreas fault through the mechanisms of faulting and folding.

Numerous northwest trending folds characterize the northern part of the central California coastal region, indicating northeast-southwest compression (Page, 1966). Several major fault systems in the northern section also trend to the northwest subparallel to the San Andreas fault, and being subject to the same general stress field, they likely have a similar sense of motion as suggested by others (Durham, 1965; Hart, 1969; Dibblee, 1972; Hall and Corbato, 1967). In the southern part of the region, the folds and faults trend east-west in the Tranverse Ranges, and the southern ends of the northwest trending faults turn into or are truncated by east-west trending faults. Trends of geologically mapped faults (Ziony, et al., 1974) appear to be relatively continuous from the one trend to the other, but the left-lateral motion determined by Lee and Vedder (1973) from a composite fault plane solution for shocks in the Transverse Ranges and the strong geologic evidence of left-lateral faulting (Hill and Dibblee, 1953), seems incompatible with the right lateral sense of motion to the north if these faults are continuous features. One composite fault plane solution reported by Sylvester, et al., (1970) does show right-lateral oblique slip on an apparent northwest trending fault in the same area as Lee, so the east-west trends may be remnant features with primary motion consistent with regions to the north and south. Most of the recent large earthquakes in the Transverse Ranges have significant components of thrust and left lateral motion, so it is likely that different kinds of faulting typify the chaotic nature of the southern section of the study region.

The faults in the region are mapped as splintered features and will be referred to as fault systems; no attempt is made to distinguish active strands from inactive strands on the basis of earthquake locations accurate to no better than a few kilometers. The fault systems discussed in this study and shown on the maps are the San Andreas (SA), the King City (KC), the Rinconada (RN), the Sur-Nacimiento (SN), the Hosgri (HG), the Santa Ynez (SY), the Santa Lucia Bank (SLB), and the San Simeon (SS) which may include the Edna (ED). Some of the faults in the central part of the region to the east and south of San Luis Obispo are not referred to because of the low seismicity or more likely the incompleteness of data in that area. The faults in the onshore areas are generalizations of the faults shown in the geologic map of California (Jennings, 1973); and faults in the offshore region are taken from Hoskins and Griffiths (1971), Wagner (1974), and Earth Science Associates (1974) with modifications by Holly Wagner and Eli Silver (personal communications, 1975).

Historic Seismicity

Several large earthquakes have shaken the central California coastal region since the beginning of the nineteenth century, and many are listed in the Townley and Allen catalogue (1939), which gives the date, the location, and extent of damage for each earthquake. All intensities listed in the catalogue and in this text are from the ten-point Rossi-Forel Scale. Only a few of the more severe earthquakes will be discussed.

The first listing of an earthquake in the region appears on December 21, 1812, "with disastrous results for the missions at Santa Barbara, Santa Inez and Purisima." The old Purisima mission was in Lompoc Valley, 70 km west of Santa Barbara, and Santa Ynez was near midway between the two. The following report is given by Trask (1856):

A Spanish ship which lay at anchor off San Buenaventura, 38 miles from Santa Brabara, was much injured by the shock, and leaked to that extent that it became necessary to beach her and remove the most of her cargo...

The effect of this earthquake on the sea, in the bay of Santa Barbara, is described as follows: "The sea was observed to recede from the shore during the continuance of the shocks, and left the latter dry for a considerable distance, when it returned in five or six heavy rollers, which overflowed the plain on which Santa Barbara is built. The inhabitants saw the recession of the sea, and being aware of the danger on its return, fled to the adjoining hills near the town to escape the probable deluge.

The sea on its return flowed inland little more than half a mile, and reached the lower part of the town, doing but trifling damage, destroying three small adobe buildings.

Very little damage was done to the houses in town from the effects of the shocks, while the mission at the San Inez was prostrated almost instantly. There is no evidence that I can find, that this earthquake was felt in San Luis Obispo, though such has been the report."

From the description of the damage caused by the shock and the presence of a tsunami in Santa Barbara, it seems likely that the earthquake originated on an offshore fault in the Santa Barbara Channel and either triggered an underwater landslide or vertically displaced the sea floor to generate a sizable tsunami in the Channel region. Townley and Allen list the intensity at VIII for this shock.

In 1830 an earthquake is listed for San Luis Obispo with an intensity of VIII with the description "the church was injured." No further information is given, probably because of the area's low population density.

In the years 1851 and 1852, the region experienced many earthquakes, the largest being the October 26, 1852, shock with an assigned intensity of X at San Simeon. A possible aftershock of this earthquake on December 17 was assigned an intensity IX at San Luis Obispo, suggesting that a fault rupture near the two cities, perhaps along the Nacimiento fault, caused the earthquake. "The shocks opened fissures at least thirty miles long in Lockwood Valley." There are two Lockwood Valleys, one along the Big Pine fault and the other near the Nacimiento and Rinconado faults. It has been assumed that the valley along the Big Pine fault was the location of the fissure; however, this is apparently now known for certain.

The Fort Tejon earthquake, on January 9, 1857, ruptured the San Andreas fault for over 350 kilometers from Cholame Valley to the San Bernardino Valley. Townley and Allen give very high intensities over a large area and mention that artesian wells ceased to run in Santa Clara Valley, and new water was observed near San Fernando where there was no water previously. The Mokelumne, Kern and Los Angeles rivers were all strongly affected by the shaking. This earthquake and the San Francisco earthquake of 1906 are the largest earthquakes to occur along the San Andreas rift zone in recorded history. The region adjacent to the rupture was relatively quiet from the time the aftershock activity died until moderate shocks occurred near Los Angeles in 1893 and 1894, some 36 years later.

Los Alamos experienced a major earthquake on July 27, 1902, with an intensity of IX. Surrounding areas had much smaller intensities, so the shock was likely quite local in nature. Newspaper reports say the nature of the Santa Ynez River changed and that damage was greater on the north side of the river where chimneys were damaged and several landslides took place. Referring to the Los Alamos Valley, another newspaper reported "a strip of country 15 miles long by four miles wide rent with gaping fissures and dotted with hills and knolls that sprung up during the night..." From the description given, the source fault was probably an unmapped fault in or near the Los Alamos Valley which caused severe liquefaction in both the Los Alamos Valley and the Santa Ynez River Valley.

Los Alamos was again visited by a severe earthquake January 11, 1915. This earthquake was likely smaller than the previous one, but the distribution of intensities suggests both earthquakes originated in the same area. Beal (1915), after an intensive field investigation, determined the epicenter to be a few miles east of Los Alamos based on the distribution of the highest intensities. This strongly suggests that a seismically active fault exists under or near Los Alamos Valley.

In 1916 another apparently local shock hit Avila Beach, 16 km southwest of San Luis Obispo. The maximum intensity at Avila was VII with severity apparently increasing towards Port San Luis, to the west of town. The _San Luis Obispo Tribune_ (Dec. 2, 1916) reported "an upheaval of the waters in the Bay of San Luis Obispo..." The nature of the upheaval is not known, but it was likely not a tsunami as it probably would have been reported elsewhere. The low intensities of the surrounding towns again suggest that the quake was local and possibly caused by movement on either the Edna fault or more likely, a view of the water disturbance, the Hosgri fault just offshore of Port San Luis.

A very destructive earthquake on June 29, 1925, struck Santa Barbara and nearby coastal areas with an intensity of X (Willis, 1925). The high intensities along the coast suggest one of the Transverse Ranges fault was the source of the earthquake, but the intensity data, not collected until four months later (Byerly, 1925), is very incomplete, making a more precise determination of the source fault difficult. No major tsunami was reported, and Lompoc had little or no damage, so this earthquake was probably caused by a different fault than that of the 1812 earthquake.

Large Earthquakes with Instrumental Recordings

Several large earthquakes have occurred since the advent of medium to high quality seismographs throughout the world. P-wave arrival times at the various seismographs were obtained from the Bulletin of the International Seismological Centre (ISC), the Bureau Central International Seismologique bulletin (BCIS), and from the Berkeley and Pasadena seismograph observatories for each earthquake listed in Table 4. These earthquakes were relocated using a teleseismic relocation computer program ID2 (Gawthrop and Lahr, 1974), which utilizes a modified version of the Herrin P-wave traveltime tables and seismograph data on a worldwide basis to determine the best instrumental location of the hypocenters. The Herrin model was modified by substitution of a crustal velocity structure determined for the coastal region of California by Healy (1963). This modified velocity model is a much better fit to the observed data.

The largest of the instrumentally recorded earthquakes in the region of study was the Lompoc earthquake (M = 7.5) on November 4, 1927. Byerly (1930) lists intensities at nearby areas and reports an epicentral location about 70 kilometers west of Pt. Arguello based on arrival times at three seismographs: Berkeley and Mt. Hamilton of the Berkeley network, and Tuscon, Arizona.

Table 1. Locations determined for Lompoc earthquake using different groupings of stations.

Plot Symbol	Stations Used	Lat.	Long.	Number Stations Used	Azimuthal Gap in Station Coverage	Standard Error in Origin Time
	<u>Uncorrected travel-times</u>					
A	All available readings	34.89	120.64	66	101	1.65
B	European stations not recording 1969 events not used	34.94	120.66	24	101	1.33
C	All stations not recording 1969 events not used	34.81	120.74	24	124	1.60
D	4 compensating pairs	34.90	120.51	8	101	1.08
E	All readings listed as impulsive	34.98	120.74	23	152	1.94
F	All except readings listed as emergent	34.94	120.56	42	101	1.69
G	Jeffreys' good stations (reliability≥ 75%)	34.78	120.77	28	174	1.59
H	All except Jeffreys' bad stations (reliability≤ 60%)	34.92	120.58	63	101	1.62
	<u>Partial master-event technique utilized</u>					
I	All available readings	34.87	120.82	66	101	1.47
J	European stations not recording 1969 events not used	34.84	120.85	25	101	1.10
K	All stations not recording 1969 events not used	34.76	120.88	25	124	1.24
L	4 compensating pairs	34.85	120.58	8	101	1.31
M	All impulsive readings	35.15	120.63	25	200	1.50
N	All but emergent readings	34.89	120.79	41	101	1.58
O	Jeffreys' good stations	34.76	120.82	28	173	1.41
P	All but Jeffreys' bad stations	34.91	120.75	62	101	1.48
Q	1/2 stations--arbitrarily chosen	34.90	120.75	33	101	1.52
R	Other 1/2 of stations	34.83	120.90	32	131	1.37

In this study the epicenter was relocated using the velocity model above and P-wave arrival times for the main shock. Because of the low quality of seismographs and the difficulties in attaining accurate time in 1927, stations with very high residuals were down-weighted automatically by the computer. The stations were distributed asymmetrically about the epicenter with a nearly equal number of stations to the northwest and to the southeast and with a large number of stations in Europe to the northeast overpowering the few stations to the southwest. An incorrect velocity model would tend to offset the relocated epicenter in a northeast or southwest direction due to the European bias.

In order to evaluate possible misreadings and timing errors and to minimize any bias caused by an asymmetric distribution of recording stations, the earthquake was relocated using different subsets of selected stations with uncorrected traveltimes and using ten different subsets of stations utilizing a partial master-event technique (Table 1). The two 1969 Santa Lucia Bank mainshocks were used as master events to determine traveltime delays for the stations that recorded both sequences to reduce the difference between the assumed velocity model and the real earth. The relocations, with one exception, all lie within a circle with a 20 km radius lying about 75 km. ENE of Byerly's epicenter (Figure 1). The one exception was also the only location determine by stations covering less than half of the focal sphere and, therefore, had little control in the northeast-southwest direction. The uncertainty in location of the actual epicenter due to the errors in time marks on seismograms and errors in picking the onset of emergent P-wave arrivals

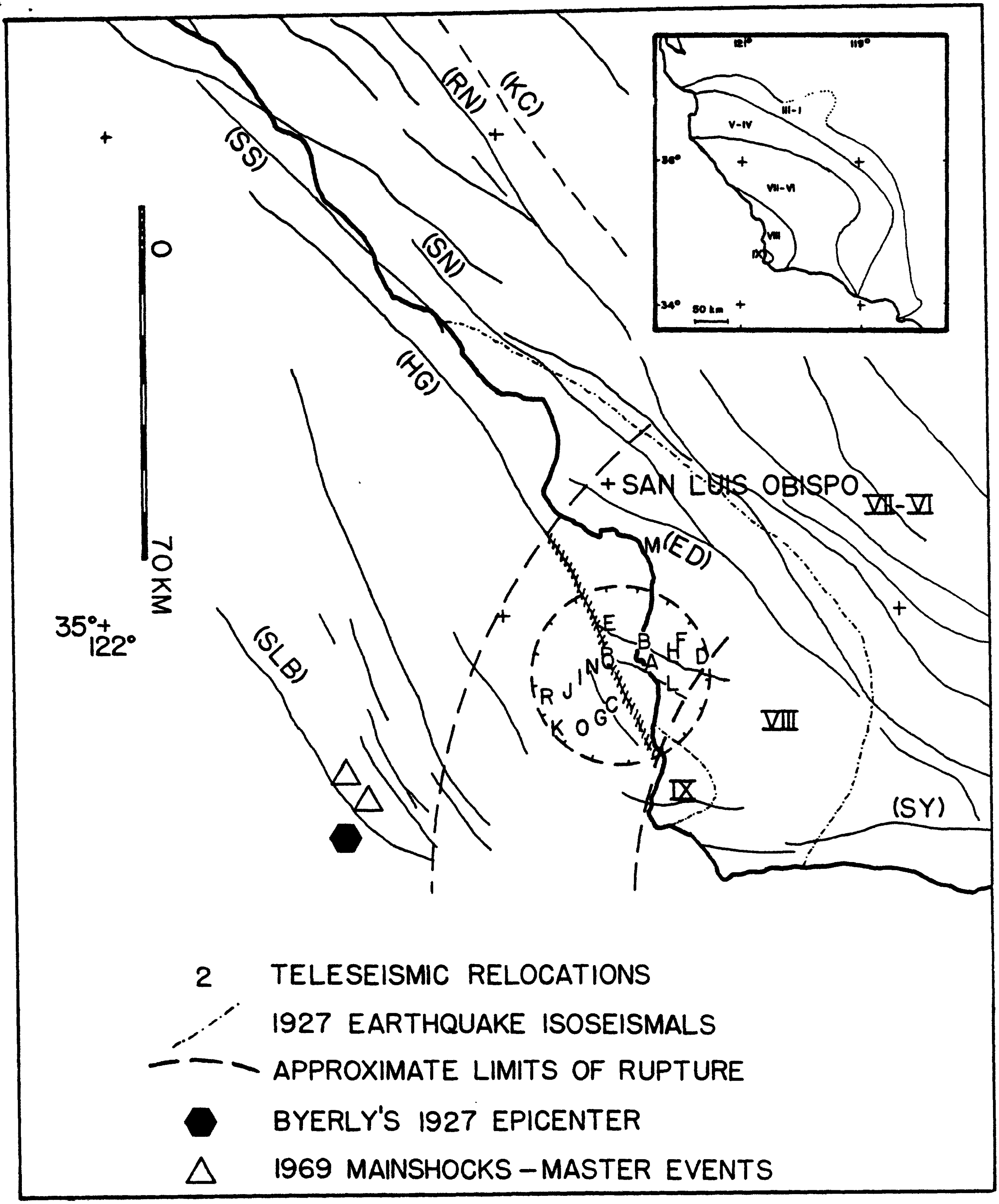


Figure 1. 1927 Earthquake

Arabic numerals indicate location of epicenters listed in the above table. Roman numerals are the Rossi-Forrel intensities determined by Byerly. A circle is drawn about tha relocations indicating a possible bound on the actual location of the main shock. A shaded line indicates the probable rupture assuming the Hosgri fault is the source of the earthquake.

cannot be rigorously evaluated; however, the scatter in the relocated epicenters gives some indication of the probable uncertainty. On the basis of the data shown here, a reasonable location for the 1927 epicenter is 34.9° N, 120.7° W with an uncertainty of 20 to 25 km.

At Santa Barbara, 80 km east to the maximum intensity region of the earthquake, two relatively high-gain horizontal seismometers were operational during the mainshock and for many of the aftershocks. The records for the main shock are badly faded and difficult to read; however, the records for the succeeding days are of high quality, and the range of the S-P times for the aftershocks was determined to be 11 seconds to at least 17 seconds. This corresponds to an approximate distance to the ends of the fault rupture of about 88 km to at least 140 km. Arcs are drawn on Figure 1 corresponding to these approximate end points of fault rupture with the outer one being less certain because of the poor arrivals at distances greater than about 125 km.

The Hosgri fault and several shorter faults have been mapped near the epicentral region of the main shock (Hoskins and Griffiths, 1971). The shorter faults that trend ENE are considered as unlikely sources for the earthquake on the basis of the length of rupture determined from the range in S-P times of the aftershocks and the distribution of intensities as determined by Byerly (1930). The mapped length of the Hosgri fault could accommodate the rupture length indicated by the S-P times, thus the earthquake is assumed to have originated from a rupture along the Hosgri fault, from near Purisima Point on the south to the general vicinity of Port San Luis. This is in good agreement with the isoseismals for the main shock and with the reports of aftershocks felt at Lompoc, Santa Maria, and San Luis Obispo. Further work is continuing on the location of the aftershock zone and the determination of the focal mechanism for the main shock (Gordon Stewart, personal communication, 1974).

Other earthquakes relocated using ID2 and teleseismic P-wave arrivals are the Bryson earthquake (M = 6.0) of November 22, 1952 along the Nacimiento fault (Richter, 1969), the three largest earthquakes of the 1966 Parkfield sequence along the San Andreas fault, and the two largest earthquakes of the 1969 Santa Lucia Bank earthquake sequence discussed later in the paper. The results of these teleseismic relocations are plotted in Figure 2 along with the relocation of these same shocks utilizing the regional network relocation procedure to illustrate the difference in location using the two different techniques of epicenter determination.

Table 2. Teleseismically relocated epicenters compared to epicenters determined by the regional network.

Date	Time (GMT)	Magnitude	Teleseismic Epicenter Lat.	Teleseismic Epicenter Long.	No. Stations	Regional Epicenter Lat.	Regional Epicenter Long.
11/ 4/27	1351	7.5	34°54.0'	120°42.0'	66	(Undetermined)	
11/22/52	746	6.0	35°43.8'	121°17.4'	68	35°48.0'	121°13.2'
6/28/66	408	4.7	35°50.4'	120°33.6'	76	35°57.0'	120°32.4'
6/28/66	426	5.6	35°52.2'	120°28.2'	102	35°56.4'	120°30.6'
6/29/66	1953	4.8	35°52.2'	120°32.4'	84	35°57.6'	120°30.0'
10/22/69	2251	5.4	34°40.2'	121°24.0'	192	34°37.2'	121°31.8'
11/ 5/69	1754	5.8	34°37.2'	121°21.0'	229	34°37.8'	121°25.8'

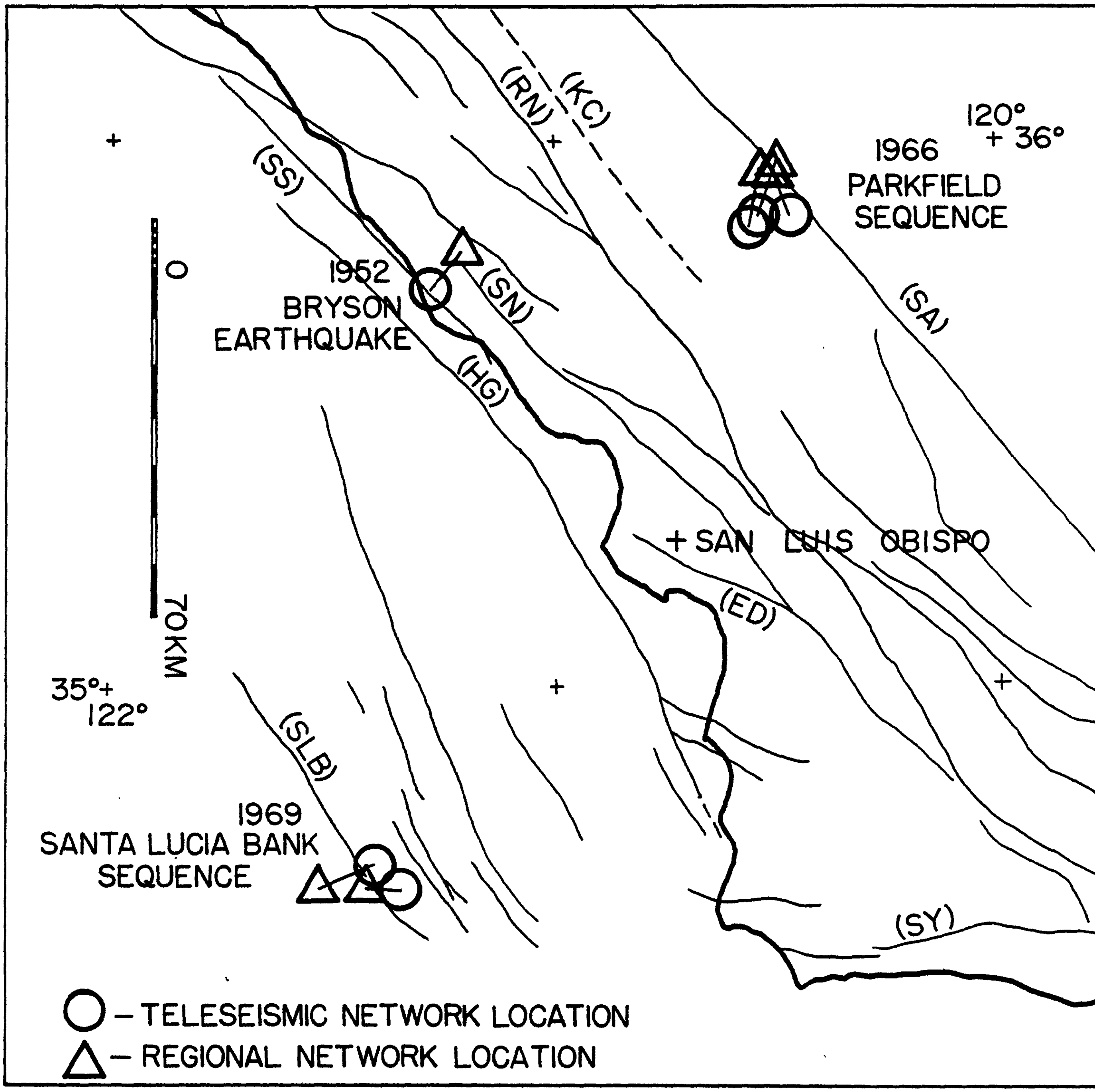


Figure 2. Comparison of teleseismically located epicenters (circles) and regionally located epicenters (triangles) for lerger earthquakes.

Regional Network Relocations

Earthquakes catalogued by Berkeley, Caltech, or the U.S. Geological Survey for which arrival times at regional seismographs are available were relocated to determine the general seismicity of the area as precisely as possible. This area is, however, outside of all the networks, and it is likely that many earthquakes poorly recorded by all networks were not listed in any catalogue. This is indicated by the large number of earthquakes for which readings were reported from only one of the networks. Because of the difficulty in determining the number and size of the earthquakes not catalogued, all statements in this paper about the completeness of the data are merely the best estimates of the writer.

The historic record of earthquakes is complete for increasingly smaller magnitudes as one proceeds from 1934 to 1970 because of the continual expansion of the Berkeley and Caltech networks and the introduction of higher gain seismographs at several sites in California. The best estimate of the thresholds for completeness are magnitude 4.5+ since 1940 and magnitude 3.5+ since 1962 for onshore areas and about 5.0+ and 4.0+ respectively in the offshore region. The USGS networks around Santa Barbara to the south and along the San Andreas fault north of Cholame are localized networks, so the magnitude threshold for the overall region has not improved significantly since 1961. Whose responsibility it was to insure the completeness of the data in the central section of the region had not been determined prior to January, 1975 when the Berkeley network assumed responsiblity (Roy Miller, personal communication, 1975).

All relocations using regional data were made using HYPOELLIPSE (Lahr and Ward, 1974), a computer program for the location of earthquakes using local stations with an assumed crustal velocity model of constant velocity, flat-lying layers, and with the capability of using traveltime delays at each station. The program starts with a trial hypocenter and origin time taken from previous locations, calculates a P-wave traveltime and traveltime derivatives for each station. The observed arrival time minus the computed arrival time for each station is the residual. The root-mean-square (RMS) residual is an indication of how well the trial hypocenter and origin time fit the observed data assuming the velocity model is correct. The traveltime derivatives at all stations are put into a matrix for inversion to determine what changes in latitude, longitude, and origin time should be made to minimize the RMS residual. This process is repeated several times using the calculated hypocenter and origin time as a new starting point for each iteration until the change in the hypocenter is minimal.

The process of determining the best hypocenter by using P-wave arrival-time data can be explained as follows: The initial rupture of an earthquake-producing fault transmits a compressional wave in all directions. This wave travels faster than the rupture velocity of the fault, so the wave from the initial rupture is the first energy recorded at each seismograph. This wave will be radially symmetric if the velocity in the surrounding medium is laterally homogeneous. The inversion of the P-wave data assumes a radially symmetric wavefront and best fits a circular wave front to the observed data. The epicentral location is determined by the curvature of the advancing wavefront, and the origin time and focal depth are determined by the absolute time of arrival at each station.

Error in the epicentral coordinates of a shock, assuming correct timing of the P-wave arrivals, is caused by lateral inhomogeneities with the computed epicenter mislocated in the direction of the higher velocities. If the crustal structure at depth dips to the east as might be expected along the continental margin in the region of study, the computed locations will be mislocated to the west of the actual hypocentral locations.

A crustal velocity model for the central California coastal region was determined by averaging the interpretations by Claus Prodehl (1970) of three refraction profiles near the area of study: 1) Camp Roberts (north of San Luis Obispo) to San Francisco; 2) Camp Roberts to Santa Monica; and 3) San Luis Obispo to the Nevada Testing site. The three models were averaged and approximated by the horizontally layered model given in Figure 3 (Robert Page, written communication). This velocity model was assumed to approximate the actual crust at depth throughout the region for the purpose of this study.

Delays were then determined for each station using a master event technique so as to eliminate most of the differences in the local structure under each station, and differences between the actual crustal velocity structure and the structure assumed by the program. Aftershocks from the Parkfield sequence of 1966, for which many portable seismographs were deployed near the epicentral region to minimize location errors (Eaton, et al., 1970), were used as master events to determine delays at all California stations operational during the sequence. Delays for stations not

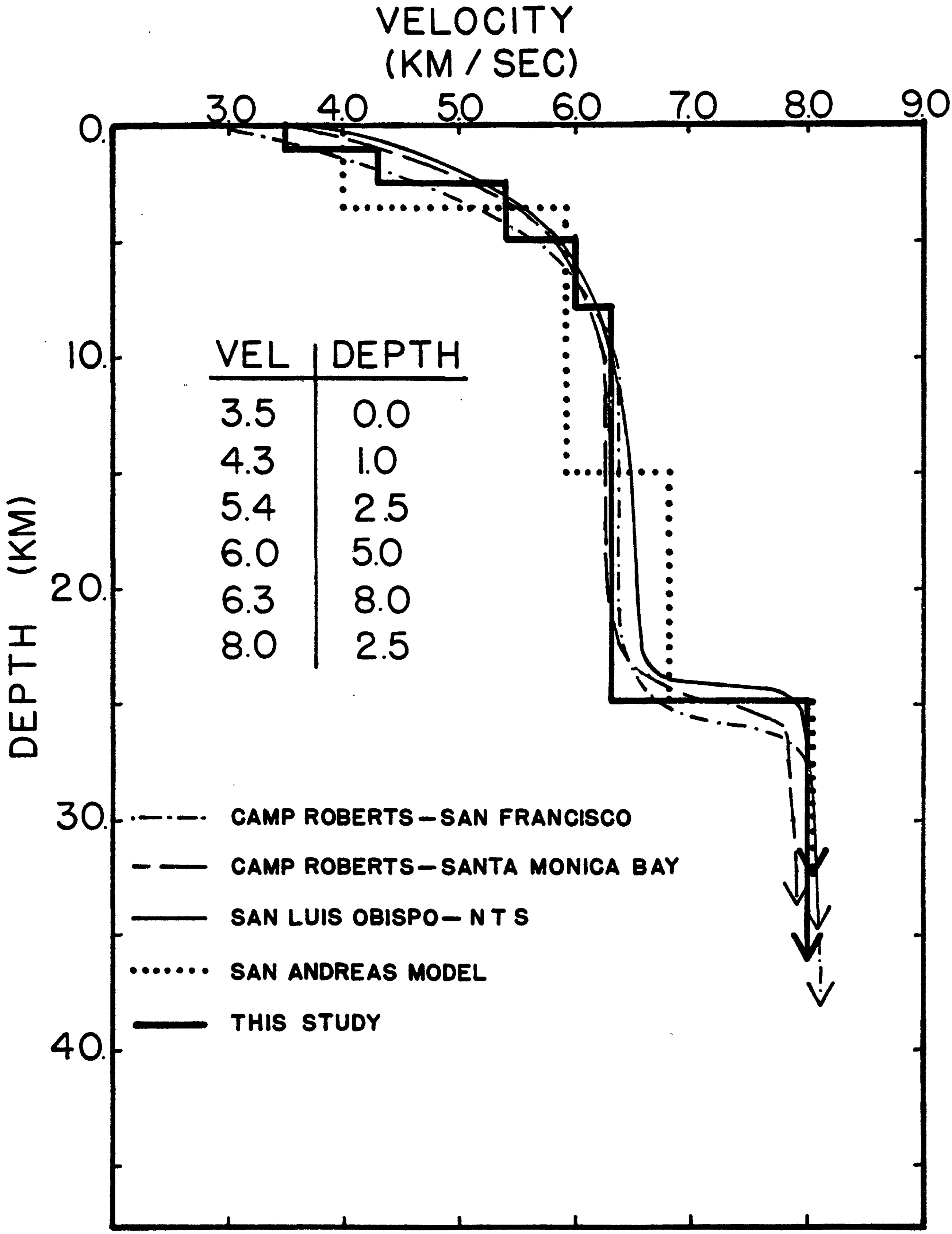


Figure 3. Velocity model used for the regional network relocations. Also shown are the three models determined by Claus Prodehl from which this model was derived and the standard San Andreas model used for the USGS central California network (Lee et al, 1972).

Table 3. Stations used in this study

STAT	Station abbreviation
LAT	Latitude given in degrees and minutes
LONG	Longitude given in degrees and minutes
DELAY	Delay determined from master-event technique -- added to calculated travel time
*	Station not used in locating the earthquakes

USGS STATIONS

STATION	LATITUDE DEG	MIN	LONGITUDE DEG	MIN	DELAY SEC
AND*	37	9.74	121	37.45	0.0
ANZ	36	53.08	121	35.45	0.0
ARN	37	20.96	121	31.96	.4
BEN	36	30.60	121	4.53	.2
BGM	36	35.48	121	1.52	.6
BTW	36	18.90	120	55.75	0.0
BVL	36	34.51	121	11.34	0.0
CAL	37	27.07	121	47.95	.3
CAN	37	1.52	121	29.02	.3
CAS	35	55.90	120	20.22	.4
CBC	36	55.88	121	39.63	.6
CBO	37	6.71	121	41.33	0.0
CHR	36	57.46	121	35.01	.2
CNR	36	42.55	121	20.60	0.0
COE	37	15.46	121	40.35	0.0
DIL	36	50.12	121	38.64	0.0
DIR	36	20.18	120	22.58	0.0
EGR	37	2.11	122	6.25	0.0
EKH	36	39.88	121	10.45	.6
EMM	36	39.68	121	5.76	.4
EUC	37	3.04	121	48.56	0.0
FEL	36	59.00	121	24.09	0.0
FRP	36	45.22	121	29.43	0.0
GDH	35	49.86	120	21.17	0.0
GHS	37	5.75	121	26.83	.4
HEC	35	40.93	121	9.15	0.0
HER	36	22.38	120	49.13	.1
JHC	36	32.82	121	23.53	0.0
JOL	36	5.02	121	10.15	0.0
JON	36	37.65	121	18.81	0.0
MHR	37	21.57	121	45.38	.6
MNR	37	35.68	121	38.22	0.0
MRS	36	39.48	120	47.62	0.0
LOR	36	14.79	121	2.55	0.0
LRV	36	25.46	121	1.08	.1
LTR	36	53.07	121	18.49	.5
LWR	36	39.96	121	16.36	0.0
MON	36	36.03	121	55.06	0.0
MOP	36	12.91	120	47.69	0.0
OCR	36	55.03	121	30.46	0.0
PCL	37	3.13	121	17.40	.5
PES	37	11.94	122	20.90	0.0
PFP	36	13.80	121	46.30	.1
PKF	35	52.91	120	24.81	0.0
PMR	36	57.19	121	41.70	0.0
PNC	36	33.73	121	38.18	0.0
PNP*	36	10.12	121	22.68	0.0
PTV	36	6.50	120	43.27	0.0
PVC	33	45.50	118	21.60	0.0
PYR	34	34.07	118	44.50	0.0
QSR	36	50.02	121	12.76	.6
RBM	36	50.70	120	49.42	0.0
SBAI	34	.80	119	26.23	0.0
SBCC	34	56.48	120	10.32	0.0
SBCD	34	22.12	119	20.63	0.0
SBCL	34	24.75	119	21.67	0.0
SBLC	34	29.79	119	42.81	0.0
SBLG	34	6.57	119	3.85	0.0
SBLP	34	33.62	120	24.03	0.0
SBSC	33	59.68	119	37.99	0.0
SBSM	34	2.25	120	20.99	0.0
SBSN	33	14.70	119	30.40	0.0
SHG	36	24.83	121	15.22	0.0
SJG*	36	47.88	121	34.43	0.0
SRS	36	40.11	121	31.13	0.0
SVC	37	17.11	121	46.35	.4
TAY	35	56.73	120	28.45	0.0
TWN	36	3.16	121	30.45	0.0
WKR	35	48.87	120	30.67	.2

STATIONS OPERATED BY OTHER INSTITUTIONS

STATION	LATITUDE DEG	MIN	LONGITUDE DEG	MIN	DELAY SEC
ARC*	40	52.60	124	4.50	0.0
BAR*	32	40.80	116	40.30	0.0
BBC*	34	14.50	116	14.50	0.0
BCN*	35	58.85	114	50.03	0.0
BKS*	37	52.60	122	14.10	0.0
BRK	37	52.40	122	15.60	.1
CLC*	35	49.00	117	35.80	.8
CLS	38	38.20	122	35.10	0.0
CNC*	37	58.10	122	4.30	0.0
CRC	37	14.50	122	7.82	.2
CWC	36	26.35	118	4.68	1.6
DAC*	36	16.62	117	35.62	0.0
DLT	34	10.20	117	48.60	.3
EUR*	39	29.00	115	58.20	2.4
FRE	36	46.00	119	47.80	0.0
FRI*	36	59.50	119	42.50	0.0
FTC	34	52.40	118	53.60	0.0
GCC	37	1.80	121	59.80	0.0
GLA*	33	3.10	114	49.60	0.0
GSC	35	18.10	116	48.30	.1
HAI*	36	8.20	117	56.80	0.0
HAY	33	42.40	115	38.20	0.0
HCC*	36	58.88	121	43.35	0.0
HRC	36	46.20	121	24.80	.4
ISA	35	38.60	118	28.60	.1
JAS	37	56.80	120	26.30	.7
KRC	35	19.60	119	44.70	.5
LLA	36	37.00	120	56.60	.4
MHC	37	20.50	121	38.50	.6
MIN*	40	20.70	121	36.30	2.2
MWC	34	13.40	118	3.50	.8
PAC	37	25.00	122	10.90	.5
PAS	34	8.90	118	10.30	.5
PCC	37	30.00	122	22.90	0.0
PLM	33	21.60	116	51.70	.3
PRC*	38	4.80	122	52.00	0.0
PRI	36	8.50	120	39.90	.1
PRS	36	19.90	121	22.20	0.0
REN*	39	32.40	119	48.79	0.0
RVR	33	59.60	117	22.50	0.0
SAO	36	45.90	121	26.70	0.0
SBC	34	26.50	119	42.80	.5
SCC*	37	.40	121	59.80	0.0
SCL*	37	21.00	121	57.00	0.0
SHS*	40	41.70	122	23.30	0.0
SLD	37	4.48	121	13.23	.7
SNC	33	14.90	119	31.40	0.0
STC	36	38.00	121	14.00	.1
SWM	34	43.10	118	34.90	1.0
SYP	34	31.64	119	58.66	.1
TIN	37	3.30	118	13.70	2.2
TNP	38	4.92	117	13.08	1.9
TUC	32	18.58	110	46.93	0.0
UKI*	39	8.22	123	12.63	.8
VIN	36	45.00	121	23.10	.2
VIT	36	45.00	121	23.30	.2
WDY	35	42.00	118	50.60	0.0

TEMPORARY STATIONS

CUA	35	20.74	120	38.52	0.0
CUE	35	20.87	120	37.89	0.0
DIA	35	12.92	120	49.70	0.0
MOR	35	24.56	120	48.14	0.0
SEE	35	12.32	120	43.03	0.0

operational at that time were determined using several sub-master events relocated using stations for which delays were already established. Several events located by the Berkeley and Pasadena stations in 1969 and 1970 were used to determine delays for the USGS stations along the San Andreas fault. Unfortunately, no earthquakes in the southern part of the region were located with sufficient accuracy to determine delays for the USGS stations around Santa Barbara; however, there is no indication that any large delays are necessary, so no delays are used at these stations. Using these methods, all earthquakes were relocated to minimize the relative error in location due to differing recording stations for events at different times.

In order to eliminate misreadings at various seismographs, all residuals greater than 2.0 seconds are given zero weight in the solution of the earthquake after the third iteration. After the program had found the best solution, residuals greater than 3.0 times the RMS were given zero weight and the relocation process was continued. In this way, most of the larger reading errors are prevented from influencing the final relocation of the earthquake hypocenter.

After the final computer run, the relocations were checked to determine their consistency with the data. The criteria used for discarding relocations consisted of: 1) an insufficient number of recording stations over a wide enough range in azimuths; 2) a very high RMS residual; or 3) too many arrivals not used in solution because of high residuals. Approximately 10% of the relocated hypocenters were discarded. Earthquakes relocated using stations chiefly from the Berkeley and Pasadena nets give a better indication of the regional seismicity than

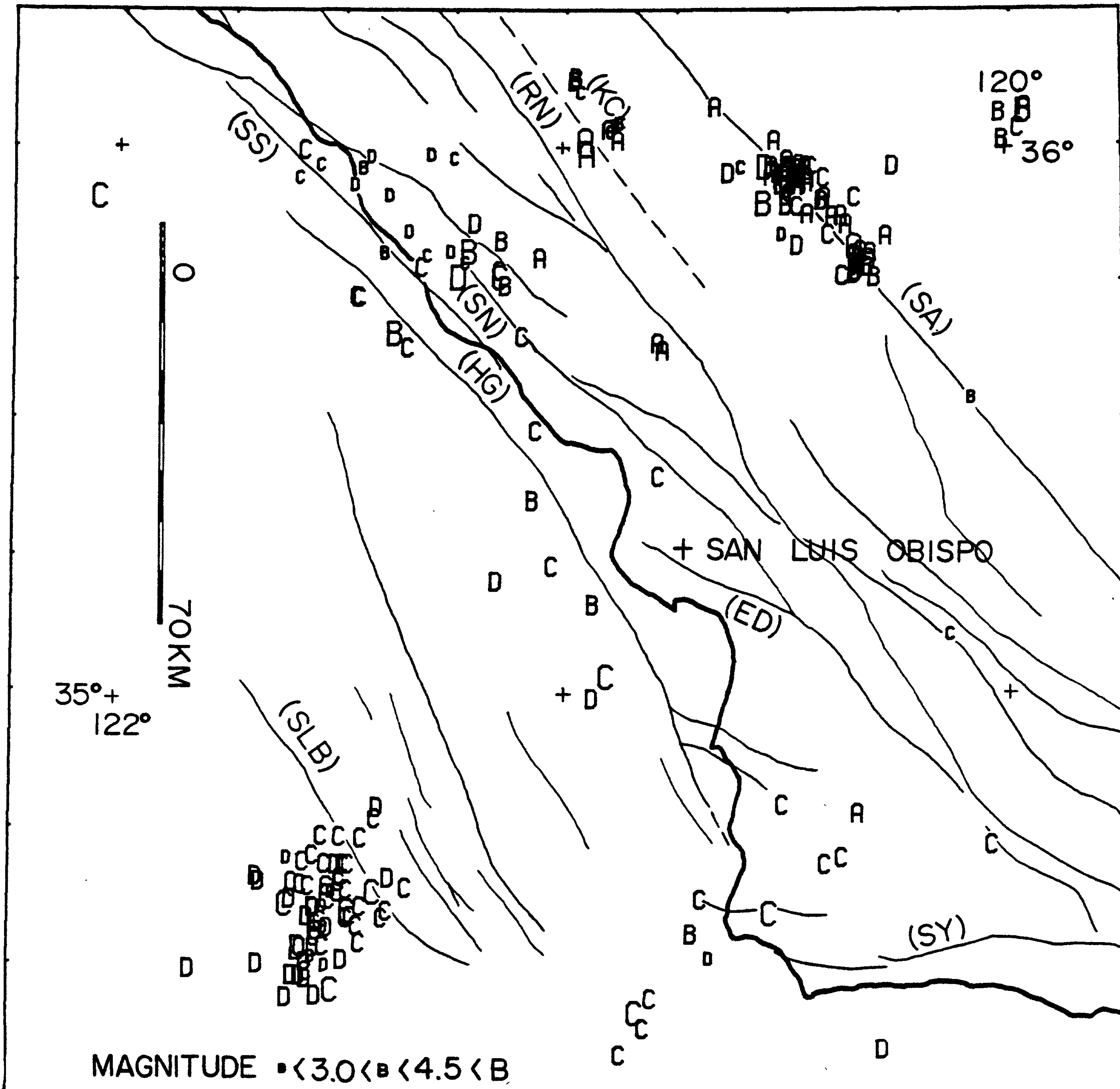


Figure 4. Relocated epicenters for earthquakes between 1934 and 1970 located using primarily stations from the Berkeley and Caltech networks. Symbol size corresponds to magnitude, letters correspond to quality (A is highest, D is lowest). This is not a complete set of earthquakes in this region.

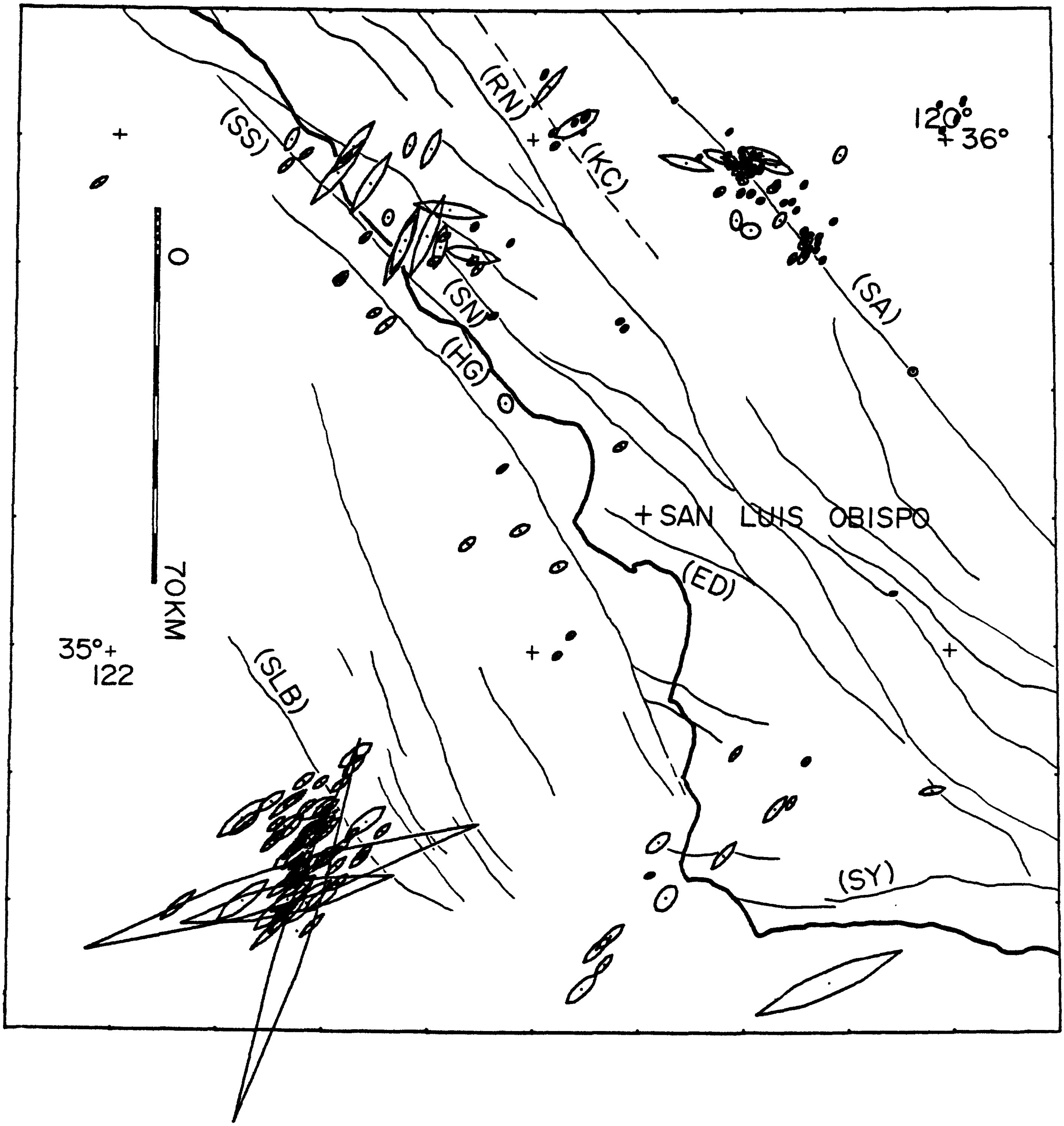


Figure 5. 68% confidence ellipses about epicenters plotted in figure 4. Shape of ellipse is a function of station distribution and size is a function of assummed timing error. Ellipses about older events are probably too small due to poorer timing accuracy.

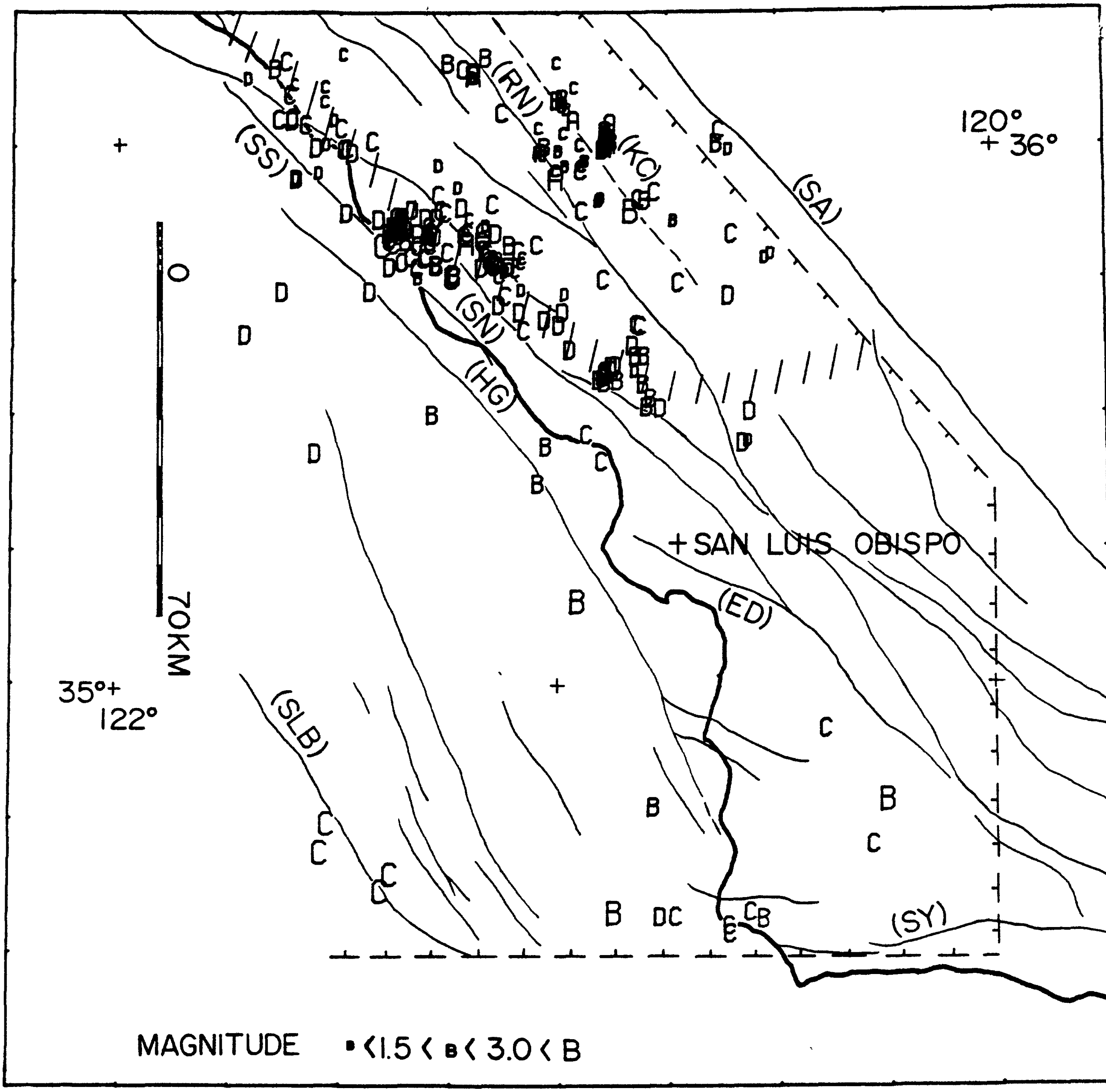


Figure 6. Relocated epicenters for earthquakes between 1969 and 1974 located using primarily stations from the USGS networks in central California and Santa Barbara. Symbol size corresponds to magnitude, letters correspond to quality (A is highest, D is lowest). The completeness is a function of the distance to the networks. Dashed line in the north represents area for which the completeness threshold is about m=2.5 on the basis of at least four stations within about 50 km. Ticked lines represent the boundary of the region searched for earthquakes in the USGS catalog.

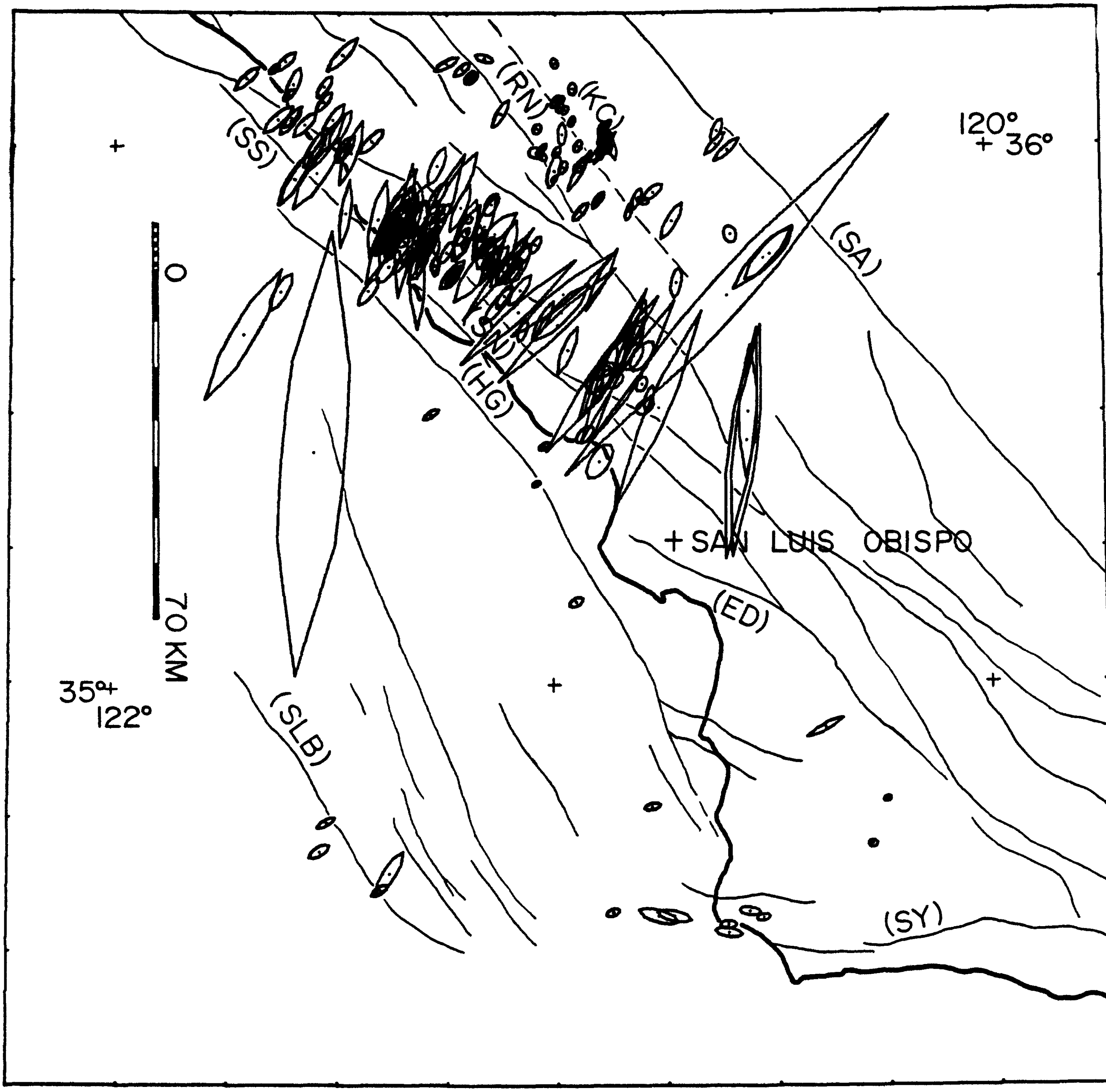


Figure 7. 68% confidence ellipses about epicenters plotted in figure 6.

earthquakes relocated using stations only from the USGS networks because of the very localized nature of the high density USGS networks. The earthquakes are, therefore, plotted as two groups of data: earthquakes from 1934 to 1970 relocated with chiefly the regional networks, and earthquakes from 1969 to 1974 relocated with the localized USGS networks.

The ellipses plotted in Figures 5 and 7 about each epicenter indicate the area within which one is 68% confident that the event lies based on an assumed random timing accuracy at the recording stations and on no inconsistencies between the assumed velocity model and the real earth (Lahr and Ward, 1974). For simplicity, the timing accuracy of the P-waves at all stations throughout the study period was assumed to be about ± 0.1 second (one standard deviation). Since several stations probably have timing errors much worse than the assumed value, the size and, in some cases, the shapes of the ellipses may not be accurate. The shape of the ellipses can be used to indicate the direction of maximum and minimum control of the epicenter due to the distribution of stations used in locating the event.

Short-Term Study

In May, 1973, four portable seismographs were deployed around San Luis Obispo for a short-term microseismicity study of the surrounding region as described in "Preliminary Report on a Short-Term Seismic Study of the San Luis Obispo Region in May 1973" (Gawthrop, 1973). Readings from this portable net were supplemented with readings from the USGS network stations in the local area. In the twenty-day period of intermittent recording, several earthquakes were located near the major faults using the same model as above and are listed in Appendix A. This short-term study illustrates the value of a microearthquake network in a

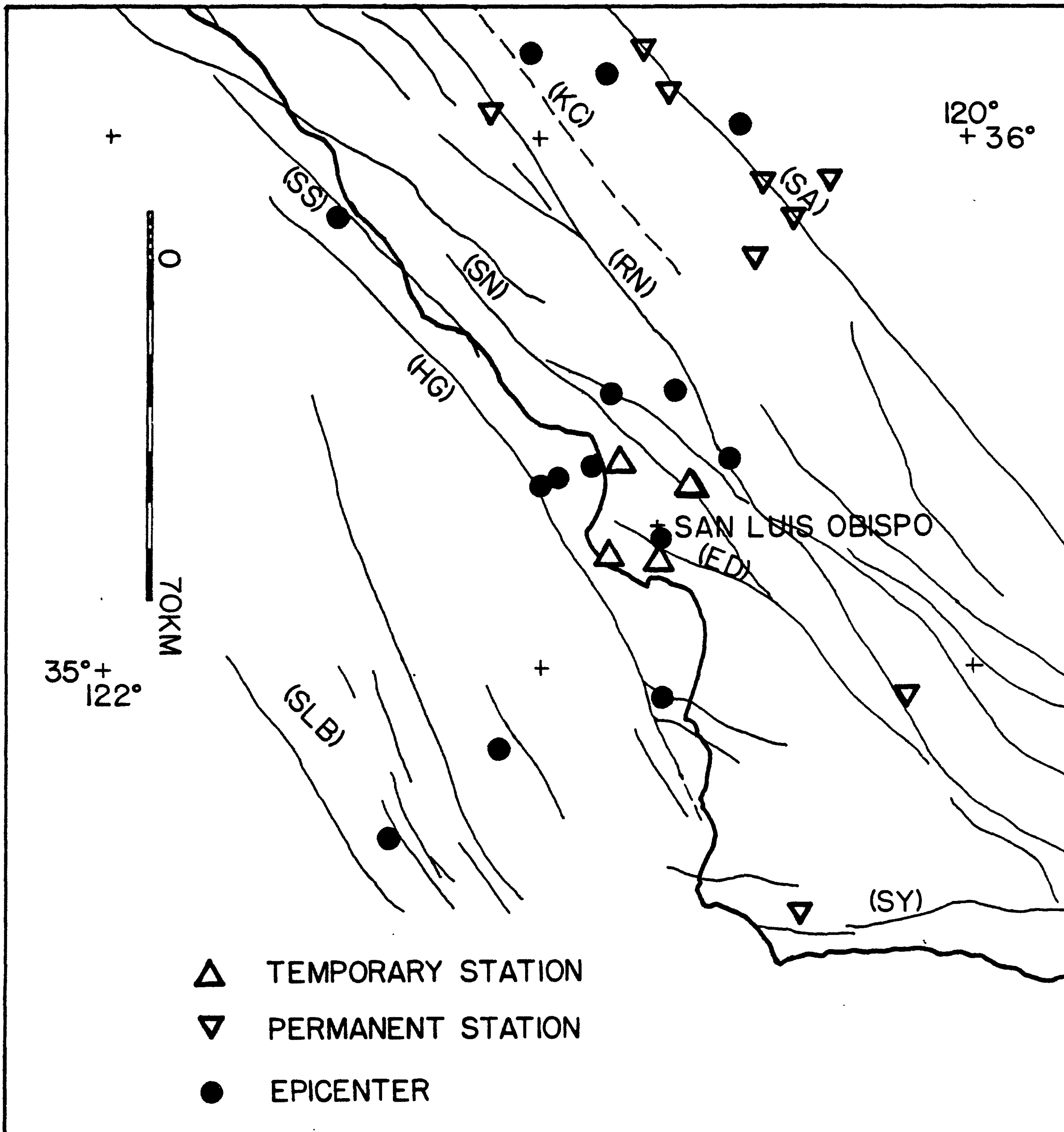


Figure 8. Short-term study.

Epicenters located using four portable, smoked paper recording seismographs supplemented with readings from nearby USGS seismographs. Earthquakes, plotted as dots, range in magnitude from .3 to 2.1.

region to rapidly locate a large number of small events. A long-term microearthquake network in the central California coastal region would allow seismologists to more accurately evaluate the earthquake hazard by delineating active faults within the region.

Focal Mechanisms

Fault plane solutions for several earthquakes throughout the region were determined using first motion directions from regional stations. Many of the solutions depend on just a few readings in a critical part of the focal sphere, so accuracy in reading these first motions is important. As much as possible, the original seismograms were reread for positive identification of the direction of first motion. Questionable readings and readings not checked by the writer are given less weight than the well-determined first motions.

All first motions are plotted on the lower hemisphere of an equal area projection of the focal sphere around the hypocenter with the angle of the incidence as calculated for the crustal velocity model. The depths of the hypocenters were fixed so the radial position of the readings on the focal sphere may be shifted slightly, but this should not significantly effect the orientation of the nodal planes. Shown in the appendix are the range in orientations of the fault planes derivable from the available data and the strike of the geologically mapped fault nearest to the epicenter for each earthquake studied.

The focal mechanism for the Santa Lucia Bank earthquake of November 5, 1969 (M = 5.8) was determined by using P-wave polarities at all available worldwide stations that recorded the event. First motion

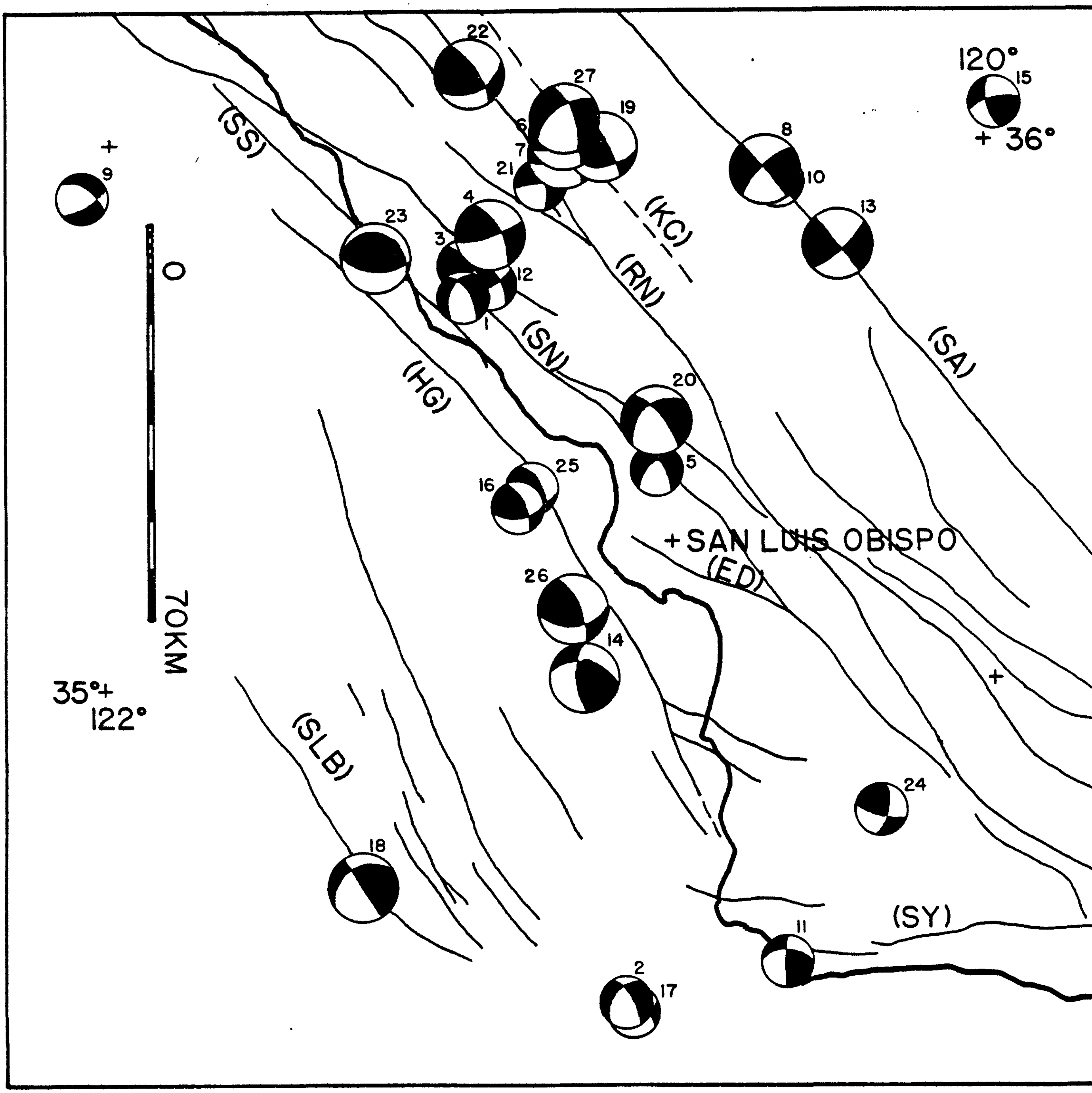


Figure 9. Focal mechanisms in the region.

Focal mechanisms are plotted in two sizes, the larger being the better constrained. The smaller mechanisms had either inconsistances, poor control of the nodal planes, or were highly dependant on a single reading. Most mechanisms are in agreement with a general north-south compression.

directions for stations in the local networks were obtained from the Berkeley and Pasadena networks and are all assumed to be P_n arrivals. First motions from the Canadian, Alaskan, and WWSSN stations were read directly from microfilm copies of the original seismograms, and are plotted on an equal area, lower hemisphere projection using angles of incidence interpolated from the Herrin velocity model. S-wave motions from long-period seismograms of the Canadian and WWSSN stations at epicentral distances between 39° and 82° were digitized and run with a computer program that rotates the coordinates of the three-dimensional motion into the P, SV, and SH components and plots the SV vs the SH motion on a delta increment plotter. The S-wave polarization angle was determined from the SV-SH plots and plotted on a lower hemisphere projection. The resulting S-wave polarization plot was compared to theoretical models for different plane orientations and double couple source models. The best fit of the P-wave and S-wave polarization data is the focal mechanism given in Figure 10.

Discussion and Conclusion

Determining the seismicity of the central California coastal region is difficult because of the lack of close-in seismographs and the large azimuthal gap in seismograph coverage due to the absence of seismometers in the offshore region. An attempt was made to minimize location errors, by using the most reliably known velocity structure with individual station delays to accommodate differing local structure under each seismograph. Using this method, relative errors are minimized; however,

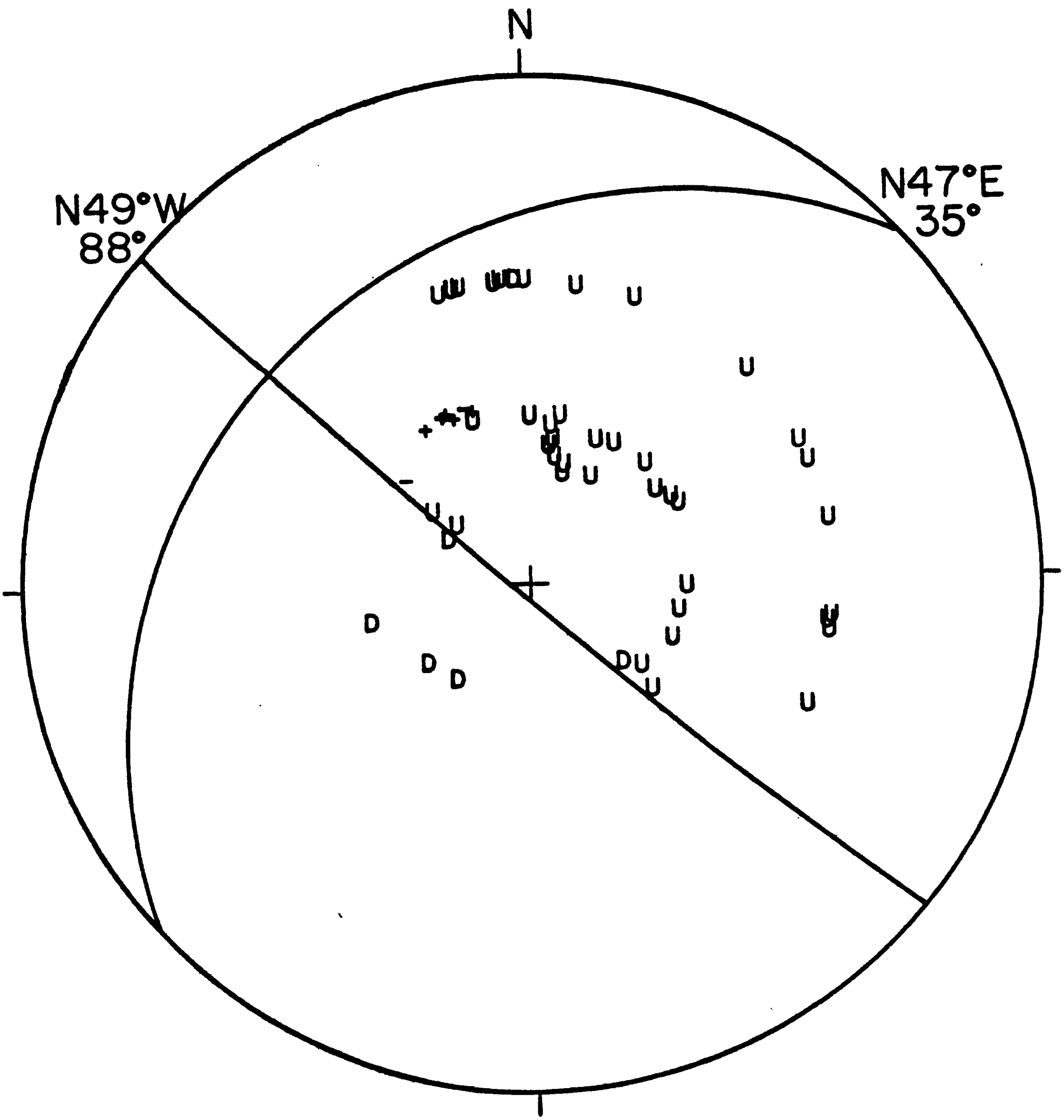


Figure 10a. P wave mechanism solution of November 5, 1969 earthquake on the Santa Lucia Bank fault. U indicates compression, D indicates dilatation, + indicates compression on a distant short period station, and - indicates dilatation at distant short period station.

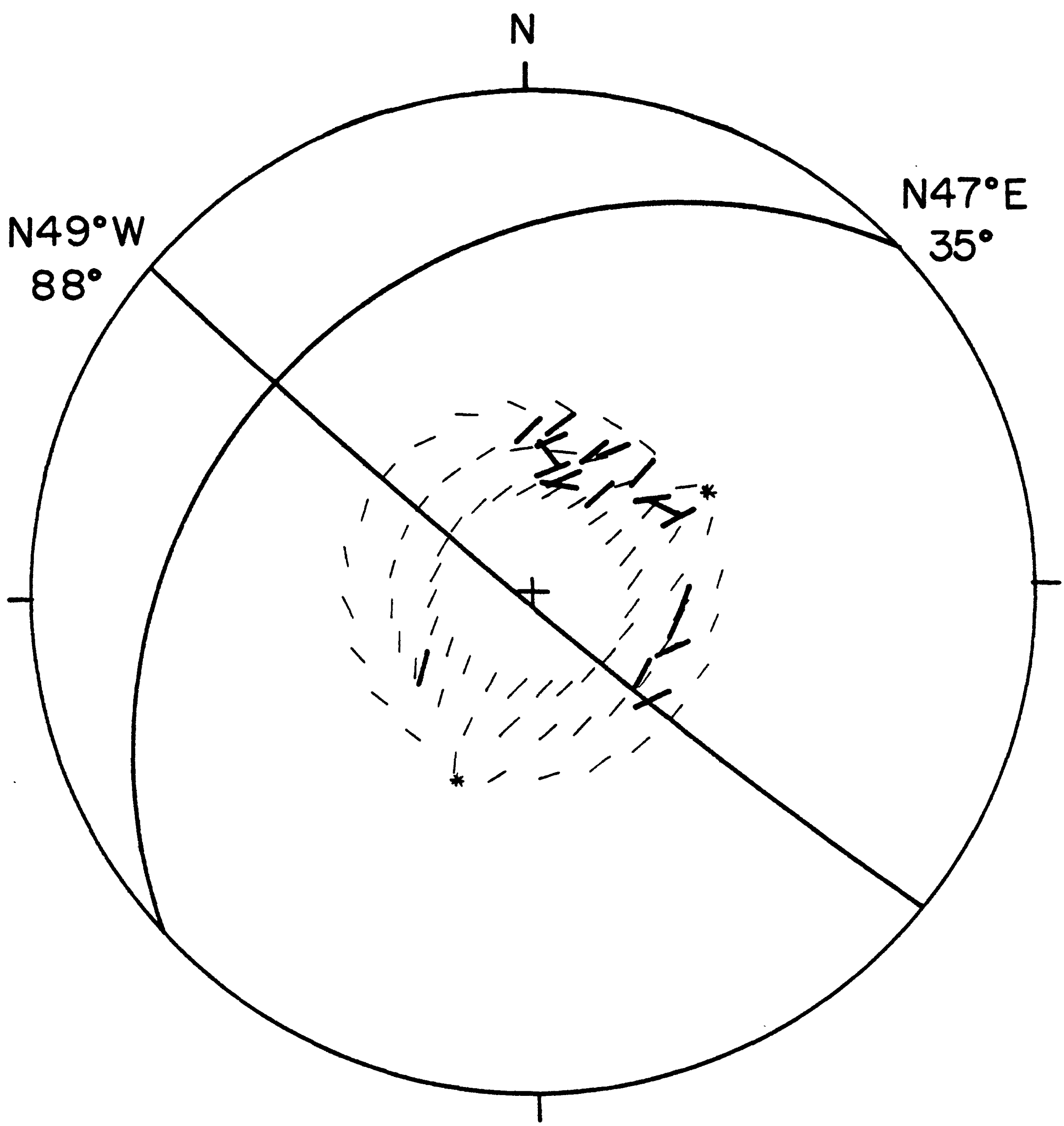


Figure 10b. S wave polarization angles of November 5, 1969 earthquake. Solid lines are data points, light lines are theoretical directions for this mechanism solution.

any large-scale lateral velocity inhomogeneities may shift the hypocenter solutions in a direction towards the higher velocities. If the lateral inhomogeneities in the coastal region are regional with a general trend of higher velocities to the southwest as would be expected from the thinning of the continental crust towards the ocean, then the trend of epicenters due to a single fault system will be offset to the southwest without disturbing the linear nature of the trend. This may explain why the epicenter trends, while parallel to, are not coincident with the faults mapped at the surface. Since no blasts with known locations have been examined thus far, the absolute accuracy can only be estimated at about five kilometers for the better solutions.

Incomplete reporting of the earthquakes by the Berkeley, Pasadena, and USGS networks inhibits the determination of activity of faults in the central part of the region on the basis of epicentral trends. Townley and Allen, (1939), list many earthquakes near the towns of Los Alamos, San Luis Obispo, Santa Maria, Lompoc, and several other small communities in the apparent aseismic zone indicated by the epicenter maps.

Figure 6 shows earthquakes located with the USGS high density networks with a very low magnitude threshold near the network limits. A dashed line is drawn on the figure to indicate where earthquakes complete to magnitude threshold of about 2.5 are located on the basis of having at least four stations within 50 km of the epicenter. Outside of this dashed line most of the earthquakes were not catalogued and therefore not used in this study. This lack of earthquakes in the outer areas should not be interpreted as a lack of seismicity. More local seismographs would be required to do an adequate microseismicity study for the lower regions.

From the relocated epicenters, several fault systems appear to be seismically active and thus constitute a potential earthquake hazard. The San Andreas fault where it passes through the region of study is in transition from a high activity level north of Parkfield to the currently aseismic, locked section to the south (Allen, 1968). Several earthquakes have ruptured the surface in the Parkfield region in recorded history (Brown, et al., 1967), and several other earthquakes greater than magnitude 4.5 have centered on the Parkfield region since 1934. From the historic record the San Andreas fault south of Parkfield must be regarded as active and will be the source of major earthquakes in the future.

Several earthquakes can be associated wtih the apparent fault system in the Salinas Valley referred to as the King City fault. San Ardo, the site of many water flooding and oil recovery wells near this fault, has experienced numerous earthquakes in the recent past; however, the hypocenters are too deep to be associated with the oil operation (Coakley, personal communication, 1974). The epicenters of several earthquakes to the north (Greene, et al., 1973) and those located in this study all suggest that this fault is seismically active.

Numerous earthquakes can be associated with the Rinconada, Sur-Nacimiento, and San Simeon fault systems. The northern sections of these fault systems are within the region adequately covered by the USGS central California network and the high level of microseismicity suggests these faults have a potential for generating damaging earthquakes. The lack of epicenters in the south is due to the lack of adequate station coverage in the central part of the region, as illustrated by the short-term study near San Luis Obispo.

Interpretation of subbottom acoustic reflection profiles between Cape San Martin and Point Sal influenced Wagner (1974) to suggest the likelihood that recent lateral movement has taken place along the Hosgri fault. This likelihood is supported by the presence of several earthquake epicenters with a linear trend near the Hosgri fault over much of its length, and right lateral components of movement in the focal mechanisms determined for shocks in the vicinity of the fault. Also, the historic record of high intensities along the coast, and the possibility that the 1927 Lompoc earthquake ruptured a southern section to this fault, are in agreement with Wagner's findings and strongly suggest that this fault has the potential for generating destructive earthquakes. The offset of the trend of epicenters from the Hosgri fault can be explained by gently eastward dipping crustal layers.

A northeast trending lineation of epicenters in the offshore region on PDE maps for 1961 and 1969 inferred to be a splay of the Murray fracture zone by Vrana (1971) has grouped into the nearly circular area shown in Figure 4 near the Santa Lucia Bank fault zone as mapped by Earth Science Associates (1974). This agrees well with relocations for aftershocks of the 1969 sequence determined by Jeff Johnson (unpublished research paper, 1973). Ellipses plotted in Figure 5 indicate that the direction of least control is in the northeast-southwest direction, so any spread of the epicenters in that direction is subject to question. Ten well-recorded aftershocks (Figure 11) utilizing at least three stations from the USGS Santa Barbara network in addition to the regional network stations, trend near a mapped trace of the Santa Lucia Bank

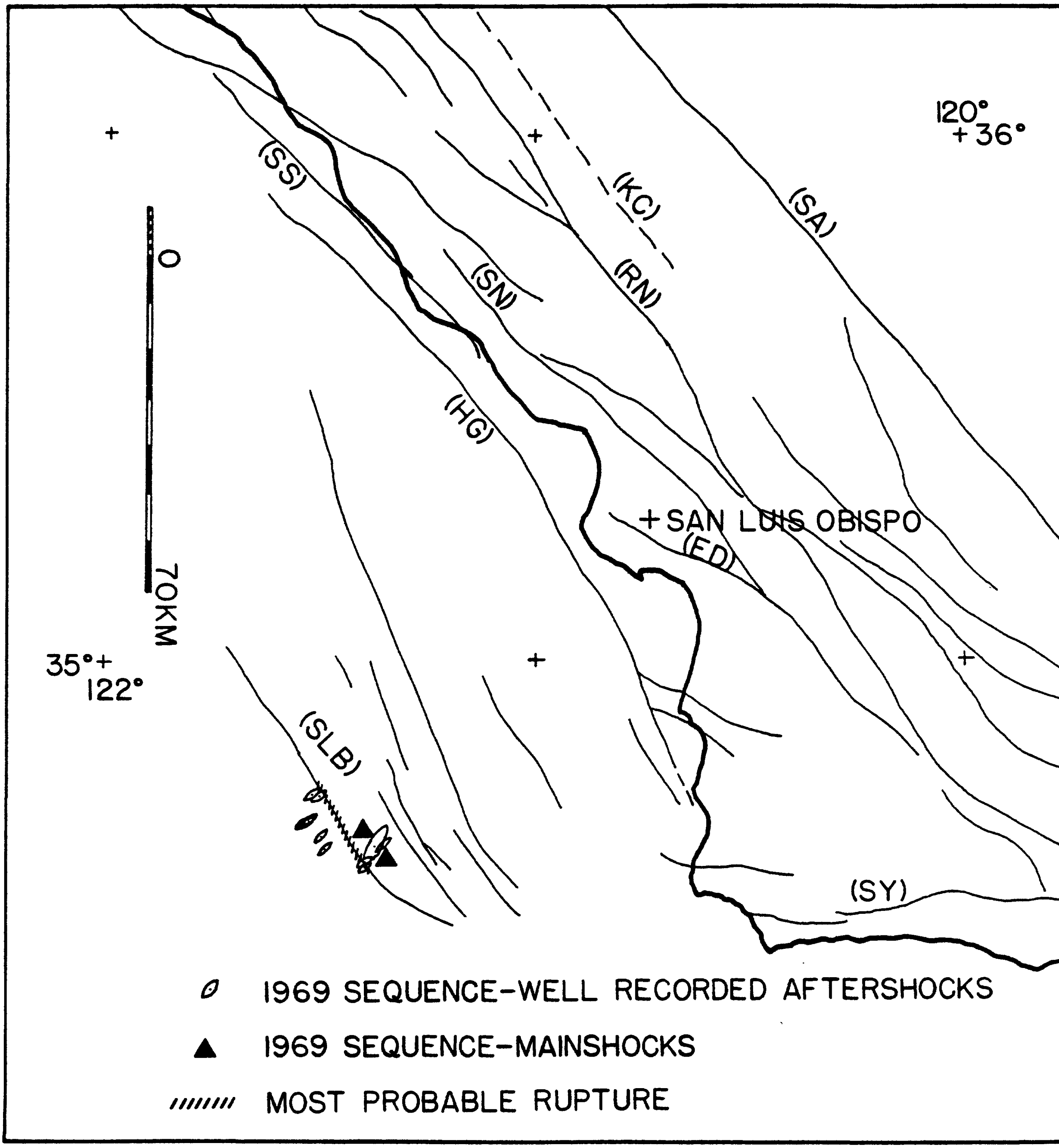


Figure 11. Well-recorded aftershocks (ellipses) of 1969 Santa Lucia Bank sequence located by at least three stations from USGS Santa Barbara network in addition to regional stations.

fault suggesting that a rupture of this fault caused the 1969 events and perhaps also the earlier events. This suggestion is supported by the focal mechanism of the November 5, 1969 earthquake which shows right oblique slip on a northwest trending, vertical fault or much less probable pure left lateral slip on an unmapped shallow dipping fault trending northeast. This mechanism, the mapped northwest trending fault, and the aftershock pattern, suggest the 1969 earthquake sequence was caused by a 20-25 km rupture with right oblique slip on a near vertical fault in the Santa Lucia Bank fault system. It is likely that most or all of the earthquakes from the northeast trend of epicenters were on northwest trending faults in the active Santa Lucia Bank fault system. The oblique slip nature of these faults suggests a possible tsunami hazard resulting from a major rupture along one of the faults.

In the southern offshore area, a southwest trend in Figure 4 and an east-west trend in Figure 6 are apparent in the vicinity of Point Arguello. Since both trends are in the direction of least control as indicated by the 68% confidence ellipse plotted in Figures 5 and 7, the trends may be caused by insufficient control due to poor seismograph station distribution for this area. A preliminary map of faults for this region (Ziony, et al., 1974) shows faults in the offshore region trending northwest, suggesting the possibility that neither epicenter trend is real. The likely source of the epicenters in this area would be a small source region near 34.6 N latitude and 120.7 W longitude at the intersection of the two epicenter trends.

Historical reports of earthquakes in the central and southern sections of the region indicate that faults are active in these areas.

The high magnitude threshold for complete coverage and the poor location accuracy due to the lack of local seismographs prohibits any conclusions about the activity of individual faults in the region on the basis of seismicity. A microearthquake network in this region similar to that currently existing in central California would greatly assist in delineating active faults in a relatively short time interval (Eaton, et al., 1969).

Focal mechanisms throughout the northern region indicates a regional N-S compressional stress field in accordance with the Pacific plate sliding past the North American plate. Because of the numerous northwest trending faults throughout the region and the right lateral movements associated with these faults, the entire region should be classified as a shear zone boundary between two plates, a name commonly associated with the San Andreas fault alone. This, combined with the geologic evidence of severe folding with northeast-southwest crustal shortening, suggest a net E-W compressional stress acting in a NE-SW direction. The total amount of movement attributed to folding and faulting west of the San Andreas is not known, but it must be absorbing some of the three centimeters per year of plate motion not attributable to the San Andreas fault. Smith (1974) suggests the coastal region is a transitional zone between a shear system near the San Andreas fault and an extensional province to the west. The evidence uncovered in this study does not support this theory, but instead suggests the entire region is primarily a shear province.

Most focal mechanisms in the Transverse Ranges are not determined well enough to distinguish between left lateral motion on east-west trending faults or right lateral motion on northwest trending faults. Well-determined focal mechanisms from a local seismograph network in this area would clearly help in determining what is happening in the Transverse Ranges. The answers to these questions will likely indicate which faults in the region constitute a probable seismic hazard.

The earthquakes in 1851 and 1852 were just a few of the many severe shocks felt throughout southern California in the six years prior to the great Fort Tejon earthquake. In the twenty years prior to the great 1906 San Francisco earthquake, many large earthquakes occurred on the subsidiary faults to the east (Kelleher and Savino, 1975). Except for the normal aftershock sequences, the regions adjacent to these great ruptures where large displacements were noted were exceptionally devoid of severe earthquakes for many years after the rupture. This suggests that regional stress, increasing at an assumed constant rate due to the relative movements of the Pacific and North American plates, was at a maximum just prior to and at a minimum in the years following the rupture. If the activity of subsidiary faults in a major system correlates directly with the amount of regional stress, then subsidiary fault activity should increase prior to the next great earthquake. If the San Andreas fault in the region of 1857 rupture is approaching a maximum stress condition as has been suggesting by others, then a high probability exists for subsidiary fault ruptures in future with very intensive shaking of the region adjacent to the rupture. The current relative quiescence may indicate that the regional stress has not increased to a level sufficient to rupture either the subsidiary faults or the primary San Andreas fault, but this does not preclude the possibility of an increase in activity in the future as the regional stress increases.

ACKNOWLEDGMENTS

I wish to thank Dr. Robert A. Page for reviewing, giving suggestions for, and obtaining support for this project, and Dr. David Chipping for his guidance and patience through the long hours of research and reporting. I am very grateful to Roy Miller and Gordon Stewart for help in obtaining data at Berkeley and Caltech, and Alan Steppe for recalling data from the U.S.G.S. data files. Holly Wagner reviewed the geology and increased my understanding of offshore geophysical methods. I appreciate all the people who allowed me to have access to their land for various aspects of this study. And I would most like to thank Helen for many hard hours of editing and typing the manuscript.

This paper satisfies the thesis requirement for partial fulfillment of the Degree of Bachelor of Science at California Polytechnic State University at San Luis Obispo, California, and was supported in part by the U.S. Geological Survey.

Bibliography

Allen, C. R. (1968). The tectonic environments of seismically active and inactive areas along the San Andreas fault system, in Dickinson, W. R., and Arthur Grantz (eds.), Proc. Conf. on Geol. Problems of the San Andreas Fault System, Stanford Univ. Publ. in the Geol. Sciences, XI, 70-82.

Atwater, T., (1970). Implications of plate tectonics for the Cenozoic tectonic evolution of western North American: Geol. Soc. Amer. Bull., 81, 3513-3536.

Atwater, T. and P. Molnar, (1973). Relative motion of the Pacific and North American plates deduced from sea-floor spreading in the Atlantic, Indian and South Pacific Oceans: in Kovach, Robt. L. and Amos Nur (eds.), Proc. Conf. on Geol. Problems of the San Andreas Fault System, Stanford Univ. Publ. in the Geol. Sciences, XIII, 136-148.

Beal, C. H., (1915). The earthquake of Los Alamos, Santa Barbara County, California, Jan. 11, 1915, Bull. Seis. Soc. Amer., 5, 14-25.

Bolt, B. A., C. Lomnitz, and T. V. McEvilly, (1968). Seismological evidence on the tectonics of central and northern California and the Mendocino escarpment, Bull. Seis. Soc. Am., 58, 1725-1767.

Brown, Jr., R. D., J. G. Vedder, R. E. Wallace, E. F. Roth, R. F. Yerkes, R. O. Castle, A. O. Waananen, R. A. Page, and J. P. Eaton, (1967). The Parkfield-Cholame earthquakes of June-August 1966, U.S. Geol. Survey Prof. Paper, 579.

Byerly, P., (1925). Notes on the intensity of the earthquake between Santa Barbara and San Luis Obispo, Bull. Seis. Soc. Am., 4, 279-281.

Byerly, P., (1930). The California earthquake of November 4, 1927, Bull. Seis. Soc. Amer., 20, 53-66.

Christiansen, M. N., (1966). Quaternary of the California Coast Ranges, in Bailey, E. H. (ed.), Geology of Northern California, Calif. Div. Mines and Geology, Bull. 190, 305-314.

Compton, R. R., (1966). Analysis of Plio-Pleistocene deformation and stresses in northern Santa Lucia Range, California: Geol. Soc. Amer. Bull., 77, 1361-1380.

Dibblee, T. W.,(1950). Geology of southwestern Santa Barbara County, California: Calif. Div. Mines and Geology Bull. 150, 95 pp.

Dibblee, T. W., (1966). Evidence for cumulative offset on the San Andreas fault in central and northern California, in Bailey, E. H. (ed.), Geology of Northern California, Calif. Div. Mines and Geology, Bull. 190, 375-383.

Dibblee, T. W., 1972. The Rinconada fault in the southern Coast Ranges, California, and its significance, Unpublished abstract of talk given to the AAPG, (Pacific Section).

Durham, D. L., (1965). Evidence of large strike-slip displacement along a fault in the southern Salinas Valley, California: U.S. Geol. Surv. Prof. Paper 525-D, D106-D111.

Earth Science Associates, (1974), Geology of the southern Coast Ranges and the adjoining offshore continental margin of California, with special reference to the geology in the vicinity of the San Luis Range and Estero Bay, F.S.A.R. for Diablo Canyon nuclear power plant, 2.5D, 3-98.

Eaton, J. P., W. H. K. Lee and L. C. Pakiser, (1969). Use of microearthquakes in the study of the mechanics of earthquake generation along the San Andreas fault in central California, Tectonophysics, 9, 259-282.

Eaton, J. P., M. E. O'Neill, J. N. Murdock, (1970). Aftershocks of the 1966 Parkfield-Cholame, California, earthquake: a detailed study, Bull. Seis. Soc. Amer., 60, 1151-1197.

Ellsworth, W. L., R. H. Campbell, D. P. Hill, and R. A. Page, (1973). Point Mugu, California, earthquake of 21 February 1973 and its aftershocks, Science, 182, 1127-1129.

Envicom, Inc., (1974). Seismic Safety Element, San Luis Obispo County, Report prepared for San Luis Obispo County Planning Department by Envicom, Inc.

Gawthrop, William, (1973). Preliminary report on a short-term seismic study of the San Luis Pbispo region, in May 1973 (unpublished, but available on request).

Gawthrop, W., and J. Lahr, (1974). ID2 - a computer program for the relocation of hypocenters using teleseismic P-wave arrivals, National Center for Earthquake Program library.

Greene, H. G., W. H. K. Lee, D. S. McCulloch, E. E. Brabb, (1973). Faults and earthquakes in the Monterey Bay region, California. Miscellaneous Field Studies Map MF-518, H.U.D. publication.

Hall, C. A., Jr. and C. E. Corbato, (1967). Stratigraphy and structure of Mesozoic and Cenozoic rocks, Nipomo quadrangle, southern Coast Ranges, California: Geol. Soc. Amer. Bull., 78, 559-582.

Hart, E. W. (1969). Possible active fault movement along the Nacimiento fault zone, southern Coast Ranges, California, (abs.), Geol. Soc. Amer., Abstracts with Programs for 1969, pt. 3, 22-23.

Healy, J. H., (1963). Crustal structure along the coast of California from seismic refraction measurements, J. Geophys. Res., 68, 5777-5787.

Herrin, E. and J. Taggart, (1968). Introduction to the 1968 seismological tables for P-phases., Bull. Seis. Soc. Amer., 58, 1193-1195.

Hill, M. L. and T. W. Dibblee, (1953). San Andreas, Garlock, and Big Pine Faults, California - A study of the character, history, and tectonic significance of their displacements, Geol. Soc. Amer. Bull., 64, 4, 443-458.

Hill, M. L., (1954). Tectonics of faulting in southern California, in Jahns, R. H.(ed.), Geology of Southern California, Calif. Div. Mines and Geol., Bull. 170, Ch. 4, 5-13.

Hoskins, E. G. and J. R. Griffiths, (1971), Hydrocarbon potential of northern and central California offshore, in Cram, I. H. (ed.), Future Petroleum Provinces of the United States - Their Geology and Potential; Amer. Assoc. Petrol. Geol. Mem. 15, Vol. 1, 212-218.

Jahns, R. H., 1973, Tectonic evolution of the Transverse Ranges province as related to the San Andreas fault system, in Kovach, R. L., and Amos Nur, (eds.), Proceedings of the Conference on Tectonic Problems of the San Andreas Fault System; Stanford Univ. Pub., XIII, 149-170.

Jeffrey, H., (1938). Southern earthquakes and the core waves, Monthly Notices of the Royal Astronomical Society, Geophysical Supplement, 4, no. 4, 281-308.

Jennings, C. W., (1958) San Luis Obispo sheet: Calif. Div. Mines and Geology Geologic Map of California, Olaf P. Jenkins edition.

Jennings, C. W., (1959). Geologic map of California, Olaf P. Jenkins, Editor, Santa Maria Sheet, California Division of Mines and Geology, Scale, 1:250,000.

Jennings, C. W., et al., (1973). Geologic Map of California. South Half; Scale 1:750,000, Calif. Div. Mines and Geology.

Kelleher, J. and J. Savino, (1975). Distribution of seismicity before large strike slip and thrust-type earthquakes, J. Geophys. Res., 80, 260-271.

Lahr, J. C. and P. Ward (in preparation). HYPOELLIPSE: A computer program for determining local earthquake hypocentral parameters, magnitude, and first motion pattern.

Lawson, A. C., et al., (1908). The California earthquake of April 18, 1906. Report of the State Earthquake Investigation Commission, Carnegie Institute of Washington, 1.

Lee, W. H. K., J. C. Roller, P. G. Bauer, and J. D. Johnson, Catalog of earthquakes along the San Andreas fault system in central California for the year 1969, U.S. Geological Survey, Open-File Report, 48 p., 1962b.

Lee, W. H. K. and J. G. Vedder, (1973). Recent earthquake activity in the Santa Barbara Channel region, Bull. Seis. Soc. Amer., 63, 1757-1773.

Neumann, F., (1930). Analysis of the S-wave, Bull. Seis. Soc. Amer., 20, 15-32.

Nuttli, O., (1964). The determination of S-wave polarization angles for an earth model with crustal layering, Bull. Seis. Soc. Am., 54, 1429-1440.

Oakeshott, G. B., (1966). San Andreas fault in the California Coast Ranges province, in Bailey, E. H. (ed.), Geology of Northern California, Calif. Div. Mines and Geology, Bull. 190, 357-372.

Page, B. M., (1966). Geology of the Coast Ranges of California, in Bailey, E. H. (ed.), Geology of No. Calif.: Calif. Div. Mines and Geol., Bull. 190, 225-276.

Page, B. M., (1970). Sur-Nacimiento fault zone of California: Continental Margin Tectonics, Geol. Soc. Amer., Bull. 81, 667-690.

Page, B. M., (1970). Time of completion of underthrusting of Franciscan beneath Great Valley Rocks west of Salinian Block, California; Geol. Soc. Amer., Bull. 81, 2825-2834.

Prodehl, C., (1970). Crustal structure of the western United States from seismic-refraction measurements in comparison with central European results, Zeitschrift für Geophysik, Band 36, Seite 477-500.

Richter, C. F., (1969). Possible seismicity of the Nacimiento fault, Calif.; Geol. Soc. Amer., Bull. 80, 1363-1366.

Savage, W. U. and K. McNally, Moderate earthquake seismicity in central California 1936-1973, Abstr., Seis. Soc. Am. Mtd. March 1974.

Savage, J. C. and R. O. Burford, (1973). Geodetic determination of relative plate motion in central California, J. Geophys. Res., 78, 5, 832-845.

Smith, S. W., (1974). Analysis of offshore seismicity in the vicinity of the Diablo Canyon nuclear power plant. Report to Pacific Gas & Electric Co.

Stevens, A. E. (1961). Earthquake mechanism determination by S-wave data, Bull. Seis. Soc. Am., 54, 457-474.

Silver, Eli A., Joseph R. Curray and Alan K. Cooper, (1971). Tectonic development of the continental margin off central California in Lipps, J. H. and E. M. Moores, (eds.), Annual Field Trip Guidebook of the Geological Society of Sacramento, 1-10.

Sylvestor, A. G., S. W. Smith and C. H. Scholz (1970). Earthquake swarm in the Santa Barbara Channel, Calif., 1968, Bull. Seis. Soc. Am., 60, 1047-1060.

Trask, J. B., (1856). On earthquakes in California from 1812 to 1855, Am. Jour. of Sci. and Arts, second series, No. 64.

Townley, S. D. and M. W. Allen (1939). Descriptive catalog of earthquakes of Pacific Coast of the United States 1769 to 1928, Bull. Seis. Soc. Am., 29, 1-297.

Vedder, J. G. and R. D. Brown, 1968, Structural and Stratigraphic Relations along the Nacimiento fault in the Santa Lucia Range and San Rafael Mountains, California; in Dickinson, W. R. and Arthur Grantz (eds.), Proceedings of Conference on Geologic Problems of the San Andreas Fault System: Stanford University Pubs. in the Geol. Sciences, XI, 242-258.

Vrana, Ralph S., (1971). Seismic activity near the eastern end of the Murray fracture zone., Geol. Soc. Amer. Bull., 82, 789-792.

Wagner, H. C. (1974). Marine Geology between Cape San Martin and Pt. Sal, south-central California offshore; a Preliminary Report, August 1974; U.S. Geol. Survey Open-File Report 74-252.

Willis, B., (1925). A Study of the Santa Barbara earthquake of June 29, 1925, Bull. Seis. Soc. Am., 4, 255-278.

Ziony, Joseph I., Carl M. Wentworth, Jane M. Buchanan-Banks, and Holly C. Wagner, (1974). Preliminary map showing recency of faulting in coastal southern California, U.S.G.S. Miscellaneous Field Studies Map MF-585.

Appendix A. Epicenters and relocated epicenters used in this study

YR	Year
MO	Month
DY	Day
HR	Hour
MN	Minute
SEC	Second
NEW LAT	Latitude of relocated epicenter (degrees and minutes)
NEW LONG	Longitude of relocated epicenter (degrees and minutes)
NO	Number of readings used to relocate epicenter
GAP	Largest azimuthal gap in station coverage
RMS	Root mean square residual
Q	Quality -- based on NO, GAP, and RMS
OLD LAT	Latitude of epicenter given by other institution
OLD LONG	Longitude of epicenter given by other institution
MAG	Magnitude of earthquake

YR	MO	DY	HR	MN	SEC	NEW LAT	NEW LONG	NO	GAP	RMS	Q	OLD LAT	OLD LONG	MAG
34	06	05	21	48	00.00						*	35-48.00	120-20.00	5.0
34	06	05	22	52	00.00						*	35-48.00	120-20.00	4.0
34	06	08	04	30	00.00						*	35-48.00	120-20.00	5.0
34	06	08	4	47	46.57	35-53.64	120-33.33	8	165	.15	B	35-48.00	120-20.00	6.0
34	06	08	05	42	00.00						*	35-48.00	120-20.00	4.5
34	06	08	09	30	00.00						*	35-48.00	120-20.00	4.0
34	06	08	23	23	00.00						*	35-48.00	120-20.00	4.0
34	06	10	08	03	00.00						*	35-48.00	120-20.00	4.5
34	06	14	14	55	00.00						*	35-48.00	120-20.00	4.0
34	06	14	15	54	00.00						*	35-48.00	120-20.00	4.0
34	06	14	19	26	00.00						*	35-48.00	120-20.00	4.5
34	12	02	16	07	00.00						*	35-58.00	120-35.00	4.0
34	12	03	01	54	00.00						*	35-57.00	121-30.00	4.5
34	12	17	11	10	00.00						*	34-35.00	120-20.00	4.5
34	12	18	03	09	00.00						*	34-35.00	120-20.00	4.0
34	12	24	16	26	00.00						*	35-56.00	120-29.00	5.0
35	01	06	04	04	00.00						*	35-56.00	120-29.00	4.0
35	01	06	04	40	00.00						*	35-56.00	120-29.00	4.0
35	03	19	03	59	00.00						*	34-33.00	120-47.00	4.0
35	06	30	23	28	00.00						*	36-00.00	121-00.00	4.0
35	07	28	06	00	00.00						*	35-42.00	121-07.00	4.0
35	10	22	18	37	00.00						*	35-55.00	120-29.00	4.0
36	10	16	15	30	00.00						*	34-50.00	120-35.00	4.0
37	02	16	17	40	48.52						*	34-50.96	120-46.46	4.0
37	02	20	09	58	00.00						*	35-56.00	120-29.00	4.0
37	12	05	01	37	00.00						*	36-00.00	121-00.00	4.0
37	12	24	11	57	00.00						*	34-30.00	120-48.00	4.0
38	09	29	12	12	00.00						*	34-33.00	120-47.00	4.0
38	11	22	15	30	00.00						*	35-56.00	120-29.00	4.5
39	05	02	18	49	26.42	35-57.02	120-38.17	5	267	.12	D	35-56.00	120-29.00	4.0
39	10	17	20	42	43.00						*	34-33.00	120-47.00	4.0
39	12	28	12	15	36.57	35-56.07	120-30.79	10	162	.13	B	35-48.00	120-20.00	5.0
40	05	21	10	5	28.54	35-12.03	121- 9.73	7	226	.60	D	35-17.00	120-29.00	4.0
40	06	16	09	25	04.00						*	34-33.00	120-47.00	4.0
41	12	22	0	54	9.60	35-57.87	120-15.89	5	177	.16	D	35-56.00	120-29.00	4.0
42	06	29	21	07	30.00						*	35-36.00	120-48.00	4.0
42	10	31	10	51	13.00						*	35-46.00	120-15.00	4.0
44	04	03	02	33	00.00						*	34-30.00	121-24.00	4.0
44	06	13	8	27	32.60	34-35.61	120-32.95	9	223	.17	C	34-40.00	120-30.00	4.6
44	06	13	08	46	43.00						*	34-40.00	120-30.00	4.0
44	06	13	11	7	26.36	34-41.08	120-25.65	8	220	.38	C	34-40.00	120-30.00	4.0
44	11	30	18	53	18.67	34-45.88	120-07.82	5	201	.11	D*	34-43.00	120-25.00	4.1
45	07	11	16	12	56.36	35-43.28	121-28.18	8	220	.14	C	35-40.00	121-15.00	4.0
45	07	28	02	33	48.00						*	34-42.00	120-06.00	4.2
45	09	07	11	24	21.97	35-54.85	120-29.89	8	162	.46	C	35-50.00	120-45.00	4.2
46	11	27	14	44	52.96	35-13.78	121- 2.21	6	211	.30	C	35-30.00	120-55.00	4.3
47	03	27	09	16	54.81	34-45.74	120-39.18	7	265	.16	C*	35-00.00	121-00.00	4.2
48	12	20	4	42	48.24	35-45.47	121-14.80	9	203	.42	D	35-48.00	121-30.00	4.5
48	12	31	14	17	31.56	35-37.66	121-21.62	7	221	.12	C	36-12.00	121-42.00	3.9
48	12	31	14	35	46.68	35-39.27	121-23.35	9	211	.37	B	35-40.00	121-24.00	4.6
49	05	17	23	57	55.00						*	35-38.00	121-09.00	4.1
49	06	27	10	35	30.52	35-45.47	121- 9.15	10	195	.43	C	35-48.00	121- 6.00	4.5
49	07	27	18	21	36.79	34-20.74	120-18.04	6	283	.10	D	34-32.00	120-22.00	3.6
49	08	26	16	52	28.94	34-26.20	120-49.02	9	231	.25	C	34-30.00	120-30.00	4.2
49	08	27	14	51	43.33	34-24.61	120-51.03	9	233	.22	C	34-30.00	120-30.00	4.9
52	10	09	14	46	8.49	34-31.78	121-35.93	6	309	.14	D	34-12.00	122-12.00	4.6
52	11	22	7	46	37.80	35-48.23	121-13.29	12	200	.18	B	35-44.00	121-12.00	6.0

YR	MO	DY	HR	MN	SEC	NEW LAT	NEW LONG	NO	GAP	RMS	Q	OLD LAT	OLD LONG	MAG
52	11	22	13	37	32.80	35-46.19	121- 9.21	8	283	.24	C	35-44.00	121-12.00	4.0
52	11	23	18	40	19.00						*	35-40.00	121-10.00	4.2
52	11	25	21	59	17.64	35-49.58	121-08.23	12	192	.51	C*	35-44.00	121-12.00	4.4
52	11	26	13	32	11.66	35-51.41	121-12.44	7	284	.59	D	35-44.00	121-12.00	3.5
53	02	03	14	50	17.74	35-23.46	120-47.79	10	198	.45	C	35-28.00	120-45.00	4.1
53	05	28	3	51	15.90	35-56.54	120-25.24	8	259	.29	C	35-53.00	120-30.00	4.3
53	06	22	15	22	34.61	35-57.68	120-33.12	7	264	.14	D	35-56.00	120-23.00	4.3
54	03	09	19	55	29.00						*	36-00.00	120-20.00	4.0
55	03	02	15	59	1.49	36- .59	120-57.41	14	178	.31	A	36- 0.00	120-56.00	4.8
55	11	02	19	40	7.38	35-59.03	120-57.26	13	179	.31	A	36- 0.00	120-55.00	5.2
56	11	16	3	23	9.48	35-56.82	120-30.10	13	161	.16	A	35-57.00	120-28.00	5.0
56	12	11	10	56	54.87	35-57.79	120-26.98	6	260	.21	C	36-52.00	121-36.00	4.4
57	01	29	21	19	54.42	35-54.25	122- 3.37	13	228	.46	C	35-52.00	122- 7.00	4.9
58	10	10	13	5	17.30	35-55.95	120-29.06	14	160	.35	A	35-56.00	120-30.00	4.5
59	10	01	04	35	35.56	34-28.79	120-29.35	12	188	.71	D*	34-27.35	120-31.28	4.5
60	01	02	22	51	48.18	35-44.51	121- 8.42	11	209	.30	B	35-24.00	121-12.00	4.0
61	07	31	0	7	7.73	35-48.91	120-21.12	15	158	.35	A	35-47.34	120-19.29	4.5
61	12	14	11	51	15.00						*	36-00.00	120-30.00	4.0
62	02	01	6	37	53.26	35- 1.51	120-54.80	17	190	.46	C	34-53.00	120-41.00	4.5
62	02	01	7	58	8.13	34-59.02	120-56.71	18	192	.63	D	34-53.00	120-41.00	3.7
62	02	07	13	0	51.56	34-28.75	121-35.87	17	245	.65	D	34-18.00	122- 6.00	3.9
62	03	05	7	43	59.22	34-35.80	121-29.39	14	219	.41	C	34-36.00	121-36.00	4.5
62	03	06	3	40	19.13	34-31.87	121-35.73	10	252	.34	C	34-36.00	121-36.00	3.6
62	03	10	8	7	19.06	34-31.94	121-32.76	16	251	.34	C	34-36.00	121-36.00	4.2
62	03	10	13	40	45.43	34-29.22	121-34.92	13	253	.35	C	34-36.00	121-36.00	4.0
62	03	12	21	33	7.05	34-32.00	121-32.68	16	251	.50	C	34-36.00	121-36.00	3.9
63	08	15	21	2	34.17	36- 7.58	120-58.72	18	155	.46	B	36- 6.00	121- 6.00	4.2
63	08	15	21	21	34.81	36- 7.21	120-58.91	19	156	.40	B	35-54.60	121- 3.80	3.9
64	02	10	5	47	28.83	36- 1.74	120-54.36	21	160	.34	A	35-59.05	120-49.19	3.8
64	06	06	11	47	37.29	34-34.85	121-33.09	17	243	.13	C	34-24.00	121-38.00	4.3
64	06	20	9	21	51.66	34-43.19	120- 3.13	9	248	.54	C	34-40.41	120- 8.11	3.1
64	11	04	5	6	18.54	35-50.23	120-31.01	9	273	.47	D			
64	11	08	1	19	18.75	36- 4.28	119-57.89	21	104	.49	A	35-57.54	120- 2.04	4.0
64	12	25	11	21	13.24	35-48.27	121-15.82	4	295	.01	D	35-58.00	121-11.00	2.6
65	01	26	8	36	33.85	35-55.45	120-30.35	14	144	.37	A	35-43.30	120-32.70	3.0
65	01	26	8	38	14.69	35-56.75	120-31.64	12	143	.32	A	36- 2.73	120-15.70	3.1
65	02	21	18	39	22.98	35-58.04	120-28.60	18	139	.29	A	35-39.90	120-26.10	3.1
65	04	06	20	49	23.82	35-55.71	121-28.76	4	293	.02	D	35-57.00	121-27.60	2.5
65	04	24	7	29	44.03	34-41.84	120-23.35	17	216	.68	C	34-54.60	120- 8.40	3.6
65	05	12	17	55	7.73	35-28.54	121- 4.25	7	308	.22	C	35-29.50	121-10.20	3.0
65	07	23	5	31	55.10	35-49.45	121- 8.86	17	191	.37	B	35-42.90	121-14.20	3.4
65	09	06	18	0	55.80	36- 2.03	119-58.87	13	138	.78	C	35-57.82	120- 3.31	3.4
65	09	19	15	42	10.04	36- 3.84	119-58.07	18	105	.53	B	35-59.22	120- 2.34	4.8
66	01	28	01	49	49.42						*	35-50.32	120-09.84	3.5
66	06	21	09	46	25.86						*	34-51.42	120-28.18	4.1
66	06	28	1	0	32.22	35-58.51	120-30.19	22	140	.36	A	35-50.00	120-15.17	3.5
66	06	28	4	8	56.49	35-57.00	120-32.15	26	137	.22	A	35-46.64	120-17.63	4.7
66	06	28	4	18	34.69	35-57.83	120-32.30	16	143	.46	B	35-52.25	120-22.63	3.2
66	06	28	4	26	13.61	35-56.63	120-30.89	26	136	.30	A	35-54.95	120-32.00	5.6
66	06	28	04	28	36.00						*	35-57.00	120-30.00	4.5
66	06	28	04	32	47.96						*	35-48.90	120-16.82	4.0
66	06	28	4	34	59.14	35-50.20	120-24.69	6	188	.04	C	35-48.60	120-24.00	3.0
66	06	28	04	35	22.00						*	35-42.28	120-20.09	4.1
66	06	28	4	39	7.94	35-54.38	120-21.07	19	137	.56	C	35-51.71	120-15.18	3.5
66	06	28	5	1	1.76	35-57.51	120-28.76	24	140	.27	A	35-50.57	120-14.75	3.6
66	06	28	5	46	1.34	35-51.43	120-22.26	24	141	.35	A	35-52.63	120-15.66	3.7
66	06	28	6	32	18.19	35-57.83	120-30.11	23	134	.28	A	35-51.07	120-24.23	3.8

YR	MO	DY	HR	MN	SEC	NEW LAT	NEW LONG	NO	GAP	RMS	Q	OLD LAT	OLD LONG	MAG
66	06	28	13	48	19.59	35-45.56	120-18.51	18	144	.50	B	35-42.52	120- .52	3.3
66	06	28	20	46	56.38	35-47.79	120-20.59	14	176	.45	D	35-47.71	120-10.99	3.4
66	06	28	23	57	22.47	35-45.73	120-22.91	15	179	.52	C	35-48.21	120-11.40	3.4
66	06	29	2	19	40.05	35-56.39	120-29.16	22	135	.19	A	35-44.77	120- 5.41	4.1
66	06	29	8	55	52.97	35-54.46	120-25.17	16	165	.39	A	35-52.84	120-12.99	3.2
66	06	29	13	11	59.29	35-46.71	120-19.45	24	144	.42	B	35-51.83	120-19.71	3.8
66	06	29	19	53	25.74	35-57.41	120-29.95	25	135	.26	A	35-46.86	120- 3.96	4.8
66	06	30	1	17	35.73	35-52.40	120-22.92	25	141	.36	A	35-48.23	120-10.83	4.3
66	07	01	9	41	21.98	35-56.47	120-28.50	25	141	.30	A	35-58.56	120-25.22	3.7
66	07	02	12	8	34.37	35-47.57	120-19.20	22	143	.30	A	35-54.90	120-18.09	3.6
66	07	02	12	16	14.87	35-46.59	120-21.06	18	172	.32	A	35-42.02	120-13.79	3.2
66	07	02	12	25	6.33	35-45.95	120-21.24	8	187	.36	B	35-46.64	120-13.88	3.1
66	07	03	20	22	26.25	35-53.44	120-30.35	18	172	.42	B	35-57.46	120-32.80	3.2
66	08	01	12	5	33.70	35-46.19	120-20.98	20	146	.44	B	35-43.34	120-14.44	3.3
66	08	03	9	41	37.43	35-55.66	120-28.78	18	142	.24	A	35-58.71	120-22.58	3.3
66	08	03	12	39	5.92	35-48.05	120-21.21	22	138	.24	A	35-45.81	120-29.26	3.9
66	08	07	17	3	24.33	35-55.76	120-28.54	21	142	.30	A	35-54.37	120-28.26	3.5
66	08	19	22	51	20.93	35-54.03	120-25.53	8	173	.23	B	35-49.06	120-21.10	3.5
66	09	07	0	20	53.01	36- 3.70	120- 1.40	20	137	.57	B	36- .68	120- 2.57	3.4
66	09	28	5	30	1.53	34-30.63	120-41.19	8	310	.52	D	34-46.00	120-29.66	2.8
66	10	27	12	6	4.00	35-56.74	120-29.09	24	135	.23	A	35-56.95	120-41.38	4.2
66	11	05	13	31	31.51	35-56.57	120-29.48	22	142	.33	A	35-54.00	120-30.00	3.4
66	11	18	23	39	42.78	35-46.78	120-20.55	18	145	.36	A	35-44.90	120-13.48	3.3
67	01	09	23	18	59.24	36- .70	120- .97	20	113	.52	B	35-52.00	120- 3.08	3.1
67	02	01	13	55	56.65	35-49.01	120-28.92	10	305	.25	D	35-42.00	120-15.00	3.0
67	03	13	21	59	47.36						*	35-53.84	120-26.18	3.6
67	06	06	6	11	40.19	35-56.06	120-27.56	19	141	.29	A	35-54.65	120-27.81	3.3
67	06	13	12	54	9.87	35-43.36	121-28.53	20	203	.55	C	35-48.90	121-30.60	3.3
67	07	06	1	6	40.91	35-53.39	120-28.85	15	138	.57	C	35-53.52	120-29.87	3.0
67	07	08	6	16	50.93	34-46.66	120-21.17	17	176	.24	A	34-50.60	120-18.05	3.2
67	07	24	07	08	56.04						*	35-44.18	120-05.18	3.7
67	07	28	14	44	40.96	35-46.60	121-19.76	7	295	.08	C	35-45.00	121-22.80	3.0
67	08	01	22	14	19.40	35-47.84	121-19.04	7	293	.28	C	35-45.00	121-24.00	2.7
67	08	12	18	57	40.91	35-52.29	120-24.10	24	135	.26	A	35-43.87	120-20.22	4.8
67	08	17	23	12	4.07	35-58.77	121-26.54	5	284	.12	D	35-54.60	121-30.00	2.6
67	08	31	18	10	42.71	35-58.57	121-15.26	7	274	.08	C	35-51.60	121-21.00	2.8
67	10	21	12	5	23.44	35-57.86	120-27.69	21	132	.31	A	35-49.80	120-27.60	3.1
67	10	25	23	5	42.07	35-50.48	121-21.46	9	289	.45	D	35-43.80	121-27.00	2.6
67	11	14	0	0	52.92	35-57.70	120-27.87	18	132	.26	A	35-57.40	120-30.71	3.3
67	12	18	14	10	36.37	34-30.87	121-34.30	8	271	.38	D	34-48.60	120-35.48	2.9
67	12	31	23	48	15.41	35-56.08	120-28.44	23	135	.30	A	35-47.83	120-16.82	4.3
68	02	03	19	7	27.34	35-47.08	121-13.93	10	279	.35	C	35-43.80	121-15.00	2.8
68	03	25	11	32	14.07						*	35-59.31	120-03.54	3.9
68	04	23	15	9	17.24	35-38.22	120-47.76	21	177	.30	A	35-31.20	120-49.20	3.4
68	04	28	6	31	55.33	35-37.39	120-47.11	20	177	.27	A	35-28.60	120-49.80	3.5
68	05	28	6	23	20.52	34-37.20	120-42.32	10	248	.40	C	34-51.52	120-33.04	3.0
68	06	11	11	43	30.59	35-59.57	121-35.52	13	258	.26	C	35-54.00	121-42.00	3.3
68	07	03	17	52	53.30	35-54.50	121-24.02	5	284	.35	D	35-48.00	121-30.00	2.5
68	08	16	12	12	14.59	34-47.60	120-31.28	18	210	.51	C	34-46.91	120-21.10	3.3
68	11	06	8	58	22.82	35-56.49	120-27.38	17	133	.28	A	35-56.94	120-27.28	3.2
68	11	10	4	3	3.38	35-38.97	121- 6.18	19	190	.57	C	35-29.98	121- 1.86	3.4
68	12	11	12	19	53.46	35-52.55	120-27.48	18	138	.45	A	35-50.12	120-21.34	3.4
69	01	09	9	42	47.43	36- .61	120-31.91	21	132	.27	A	36- 8.57	120-46.40	4.0
69	03	09	10	23	49.00	36- 5.95	120-58.14	7	183	.07	C			1.7
69	03	16	21	50	18.18	36- 1.56	120-54.09	6	200	.05	C			1.7
69	06	12	11	18	54.92	34-20.06	120-53.23	10	248	.35	C	34-21.91	120-53.28	4.0
69	06	15	10	11	51.61	35- 9.44	120-56.57	11	225	.28	B	35- 3.13	121-14.06	3.7

YR	MO	DY	HR	MN	SEC	NEW LAT	NEW LONG	NO	GAP	RMS	Q	OLD LAT	OLD LONG	MAG
69	07	03	15	53	11.92	36- 3.07	121-38.27	7	256	.14	C			2.2
69	07	12	7	59	35.50	35-57.31	120-56.75	6	194	.20	C			1.8
69	07	14	5	48	43.04	35-59.87	120-53.14	7	169	.06	C			1.4
69	07	14	10	33	9.65	36- 1.74	120-37.74	6	176	.12	C			1.8
69	07	16	4	6	34.73	35-49.98	120-16.91	20	130	.46	A	35-53.93	120-16.54	3.5
69	07	19	13	41	32.22	35-45.68	121- 7.89	5	267	.04	C			1.7
69	09	06	13	44	46.58	35-20.87	121- 4.74	35	202	.25	B	35-14.81	121- 7.70	3.7
69	09	17	0	39	39.47	35-32.26	120- 5.50	11	135	.38	B	35-32.68	120- 2.33	2.6
69	09	20	0	48	15.81	35-46.94	121- 8.82	5	252	.05	C			2.3
69	09	22	0	21	35.49	35-54.08	120-48.88	6	193	.06	C			2.4
69	09	25	13	21	15.39	35-52.73	120-49.87	8	217	.09	B			3.1
69	10	21	0	57	34.92	36- 3.72	121- 7.51	9	199	.49	C			2.0
69	10	22	17	34	14.77	34-36.29	121-33.97	16	242	.49	C	34-35.37	121-33.93	4.0
69	10	22	22	51	30.66	34-37.41	121-32.06	25	239	.21	C	34-34.57	121-37.18	5.4
69	10	23	0	2	54.55	34-33.70	121-33.65	13	259	.42	C	34-42.48	121-22.98	3.5
69	10	23	0	3	32.19	34-38.68	121-34.68	11	239	.37	C	34-51.31	121-19.15	4.1
69	10	23	0	10	57.30	34-38.84	121-35.68	14	261	.43	C	34-52.81	121-17.74	3.2
69	10	23	0	13	10.30	34-35.04	121-29.62	17	250	.28	C	34-39.74	121-17.38	3.2
69	10	23	0	37	4.65	34-30.25	121-35.11	9	309	.25	D	34-34.88	121-32.61	3.4
69	10	23	3	43	14.65	34-42.05	121-34.15	17	257	.39	C	34-45.12	121-28.02	3.4
69	10	23	4	33	23.21	34-36.39	121-34.10	14	265	.33	D	34-34.90	121-39.20	3.4
69	10	23	6	41	23.16	34-39.07	121-30.56	12	258	.18	C	34-43.11	121-24.58	3.6
69	10	23	7	19	4.11	34-31.85	121-33.97	14	262	.42	D	34-33.21	121-30.49	3.4
69	10	23	16	38	2.20	34-39.10	121-36.89	21	240	.28	C	34-47.93	121-25.18	3.7
69	10	23	21	51	44.93	36- 8.64	121-12.82	5	172	.04	C			2.2
69	10	24	13	12	7.50	34-38.64	121-32.21	22	238	.31	C	34-35.87	121-35.15	4.0
69	10	24	19	13	7.93	34-43.86	121-27.71	18	254	.29	C	34-49.46	121-21.67	3.5
69	10	24	20	19	2.83	34-34.00	121-32.64	8	261	.38	D	34-45.42	121-19.99	2.9
69	10	26	15	43	1.86	34-30.05	121-41.50	6	273	.17	D	34-45.05	121-20.67	3.0
69	10	28	00	22	37.53						*	34-45.23	121-30.90	4.0
69	10	30	14	30	57.08	36- 5.10	120-59.95	9	154	.13	B			2.0
69	10	30	15	36	19.53	34-22.92	120-50.08	16	236	.45	C	34-19.88	120-53.76	3.7
69	10	31	9	12	13.73	34-34.59	121-33.82	21	243	.23	C	34-36.80	121-28.86	3.8
69	10	31	17	57	46.10	34-40.98	121-31.01	6	267	.72	D	34-39.68	121-26.80	3.5
69	11	01	16	43	48.65	34-46.05	121-25.85	9	253	.15	C	34-50.74	121-20.66	3.1
69	11	01	19	13	7.54	34-36.36	121-27.78	14	256	.26	C	34-39.73	121-25.34	3.2
69	11	01	22	48	7.04	34-38.04	121-31.60	5	271	.44	D	34-42.99	121-23.61	2.9
69	11	03	4	28	21.52	34-26.60	121-33.75	5	323	.07	D			3.0
69	11	04	0	40	42.13	34-36.68	121-37.75	25	241	.28	C	34-33.43	121-41.84	4.5
69	11	05	17	54	9.18	34-37.91	121-26.04	28	237	.25	C	34-36.54	121-26.12	5.6
69	11	05	18	48	42.51	34-27.25	121-31.64	19	241	.59	C	34-44.64	121-26.74	4.5
69	11	05	18	53	44.47	34-39.47	121-24.05	6	265	.56	D	34-53.53	121- 9.65	3.0
69	11	05	19	43	35.63	34-33.05	121-33.84	13	259	.41	C	34-44.56	121-16.78	3.7
69	11	05	20	3	51.03	34-40.99	121-30.11	12	257	.46	C	34-41.56	121-27.76	3.5
69	11	06	2	3	9.74	34-29.90	121-32.45	5	277	.37	D	34-49.18	121-25.62	2.9
69	11	06	15	18	8.68	34-30.48	121-30.20	9	268	.29	D	34-40.76	121-12.61	3.5
69	11	06	18	1	46.08	34-28.46	121-35.03	9	268	.30	D	34-39.26	121-24.16	3.2
69	11	07	21	44	41.80	34-39.18	121-41.34	8	264	.21	D	34-45.57	121-36.10	3.0
69	11	08	0	33	25.46	34-29.45	121-50.68	14	272	.27	D	34-37.66	121-43.15	3.7
69	11	08	9	0	24.73	34-47.26	121-25.58	5	260	.40	D	35- 3.01	121- 7.11	3.0
69	11	08	16	11	36.42	34-41.36	121-35.43	11	258	.31	C	34-50.29	121-22.03	3.3
69	11	08	23	35	36.08	34-37.93	121-30.75	7	257	.29	C	34-38.27	121-30.24	3.5
69	11	09	1	27	42.35	34-35.24	121-29.08	19	243	.42	C	34-39.20	121-24.58	4.1
69	11	09	16	42	8.98	34-32.32	121-27.88	20	249	.27	C	34-34.57	121-25.60	3.7
69	11	09	21	16	53.54	34-37.26	121-37.14	14	263	.41	D	34-48.18	121-23.00	3.3
69	11	10	19	21	26.46	34-34.19	121-28.23	22	249	.33	C	34-38.95	121-23.37	4.0
69	11	12	3	43	31.41	34-34.00	121-32.17	6	271	.37	D	34-43.77	121-12.02	3.2

YR	MO	DY	HR	MN	SEC	NEW LAT	NEW LONG	NO	GAP	RMS	Q	OLD LAT	OLD LONG	MAG
69	11	12	9	51	6.97	34-36.44	121-32.75	5	264	.21	D	34-46.54	121-16.51	2.5
69	11	13	12	7	40.15	34-26.37	121-37.66	14	269	.36	D	34-40.07	121-24.34	3.1
69	11	14	19	33	3.67	36- 2.45	120-52.91	9	164	.07	B			2.0
69	11	18	12	48	53.26	36- 2.55	120-52.66	7	164	.10	C	- 0.00	- 0.00	1.2
69	11	18	23	58	.04	34-28.76	121-36.88	6	272	.41	D	34-37.99	121-12.25	3.2
69	11	19	5	31	19.91	34-44.17	121-33.00	14	257	.28	C	34-48.81	121-30.47	3.5
69	11	22	12	3	14.40	34-35.03	121-24.85	15	256	.34	C	34-44.10	121-10.72	3.3
69	11	23	19	41	24.33	34-41.74	121-37.60	9	261	.43	D	34-46.45	121-28.47	2.9
69	11	25	17	54	48.38	34-35.27	121-34.80	10	270	.36	D	34-43.49	121- .77	3.3
69	12	03	22	10	36.51	34-41.03	121-29.37	19	237	.32	C	34-42.44	121-22.61	4.0
69	12	10	13	25	34.06	35-57.56	120-28.92	18	133	.58	B	36- 3.04	120-29.31	3.8
69	12	14	12	15	2.85	35-51.04	121-17.58	8	251	.17	C			1.7
69	12	14	19	7	58.73	36- 4.39	120-39.95	25	111	.29	A	36- 2.08	120-39.74	3.4
69	12	15	2	20	9.83	34-44.05	121-30.53	23	244	.38	C	34-48.20	121-27.76	3.6
69	12	21	5	14	1.58	34-41.08	121-32.53	24	257	.22	C	34-42.26	121-29.05	3.5
69	12	23	23	27	26.10	35-57.63	120-36.40	20	124	.60	C	35-58.58	120-37.14	2.9
69	12	25	2	48	30.61	36- 2.55	120-52.68	14	153	.11	A			2.0
69	12	31	3	7	1.77	34-39.74	121-41.75	5	274	.13	D	34-49.39	121-25.72	3.1
70	01	06	22	18	09.16						*	34-38.65	121-27.26	3.6
70	01	08	17	0	35.82	34-38.22	121-29.60	32	238	.26	C	34-44.29	121-15.70	3.7
70	01	10	15	14	16.79	35-51.99	121-18.09	7	312	.36	D			1.1
70	01	11	14	49	50.47	36- 5.28	120-59.23	9	143	.08	B			1.7
70	01	13	3	28	44.98	35-48.87	121-19.13	8	274	.08	C			2.0
70	01	30	2	49	12.65	36- 5.27	120-59.28	19	143	.25	A			2.7
70	02	07	3	30	11.52	35-50.60	121-20.78	8	311	.19	C			1.7
70	02	07	4	52	9.10	35-50.67	121-20.83	13	311	.25	D			1.6
70	02	07	9	11	57.08	35-51.82	121-24.52	13	304	.20	D			1.7
70	02	09	16	0	46.08	35-48.43	120-20.30	24	121	.56	C	35-48.39	120-19.61	3.3
70	02	14	0	59	35.16	35-49.38	121-20.81	20	210	.18	B			2.5
70	02	14	10	34	49.65	35-50.73	121-21.33	14	251	.19	C			1.5
70	02	23	7	52	16.72	34-39.62	121-30.32	39	237	.24	C	34-37.96	121-34.16	3.6
70	02	24	19	23	43.16	35-47.91	120-30.65	4	283	.10	D			.5
70	02	24	19	37	.80	35-47.48	120-31.49	4	301	.10	D			.7
70	03	24	22	30	25.33	35-50.39	121-17.35	12	258	.31	C			1.5
70	04	15	20	17	36.36	36- .86	120-53.25	9	174	.10	B			1.6
70	04	21	22	29	27.36	35-48.22	120-19.00	16	130	.33	A	35-48.40	120-21.84	3.5
70	04	23	3	25	18.84	35-57.51	121-27.61	24	213	.25	B	35-58.20	121-27.00	2.5
70	04	25	7	45	29.44	36- 2.86	120-57.72	13	168	.07	A			1.7
70	04	26	9	55	31.45	36- 9.23	121-14.94	8	185	.16	B			1.5
70	05	04	17	51	31.84	35-59.61	120-36.39	4	164	.16	D			1.2
70	05	13	11	48	57.78	35-47.06	121-21.33	11	256	.33	C			1.5
70	05	15	18	53	13.00	35-43.74	121-25.74	8	265	.33	D			1.7
70	05	27	10	42	19.53	36- .59	120-53.06	44	134	.22	A	35-58.16	120-53.29	3.6
70	06	05	4	33	45.43	35-48.24	121- 5.25	7	258	.05	C			1.7
70	06	13	7	2	24.70	35-59.29	120-53.62	6	174	.17	C			1.0
70	06	13	14	6	57.19	36- .48	120-52.55	10	164	.10	B			1.8
70	06	21	7	51	37.81	36- .13	120-56.90	6	177	.06	C			1.0
70	07	04	18	50	20.12	36- 4.45	120-59.27	7	150	.09	C			1.2
70	07	05	11	18	29.18	36- .62	120-52.56	7	164	.09	C			1.2
70	07	20	23	24	54.15	35-56.52	121-36.24	20	227	.19	C	35-57.00	121-34.20	2.5
70	07	21	5	24	15.99	35-57.93	121-33.37	23	208	.45	C	35-59.40	121-34.20	2.5
70	07	26	2	1	5.14	36- .29	120-37.99	9	180	.10	B			2.1
70	07	29	14	23	31.06	34-38.40	121-21.69	25	246	.37	C	34-38.03	121-25.01	3.5
70	08	06	17	2	41.58	35-56.42	121-36.07	7	290	.05	D			1.3
70	08	13	5	6	19.90	36- 8.66	121-38.82	30	228	.18	B			3.0
70	08	14	11	12	22.95	36- 9.46	121-37.22	11	257	.05	C			1.5
70	08	14	21	12	14.92	36- .50	120-52.82	6	165	.08	C			1.1

YR	MO	DY	HR	MN	SEC	NEW LAT	NEW LONG	NO	GAP	RMS	Q	OLD LAT	OLD LONG	MAG
70	08	21	10	17	49.97	36- .74	120-52.48	6	163	.06	C			.6
70	08	25	3	11	27.16	35-59.64	120-53.72	11	172	.06	B			1.6
70	09	14	4	18	13.23	36- .50	120-52.60	7	164	.08	C			.7
70	09	14	22	45	17.66	36- 2.01	121- 2.53	7	179	.10	C			1.0
70	09	16	18	22	10.67	35-58.98	121-18.37	18	262	.49	D	35-57.60	121-16.20	2.6
70	09	24	8	31	.51	35-52.00	121-16.51	6	314	.04	D			1.5
70	10	08	4	50	1.21	34-35.82	121-24.24	32	237	.25	C	34-33.80	121-29.79	3.5
70	11	03	17	12	9.96	35-47.37	120-21.43	12	137	.27	A	35-43.86	120-23.46	3.0
70	11	16	12	7	26.14	35-41.41	121- 5.20	6	301	.09	D			1.8
70	11	27	6	47	55.58	35-59.76	120-53.34	8	170	.08	B			1.2
70	12	01	6	6	5.06	35-47.60	121- 3.71	35	163	.39	A	35-47.02	121- 2.93	3.4
70	12	01	6	30	4.96	35-45.98	121- 5.76	7	265	.07	C			1.4
70	12	10	11	14	59.88	36- .80	120-52.79	9	163	.06	B			1.2
70	12	10	13	25	34.21						*	35-56.76	120-23.49	3.8
70	12	12	22	29	23.36	35-48.11	121-24.75	24	216	.13	B	35-39.00	121-33.00	2.5
70	12	16	21	26	13.65	35-26.75	120-34.62	6	325	.06	D			1.6
70	12	23	4	2	54.41	34-33.28	120-43.48	24	194	.30	B	34-33.18	120-54.21	3.4
70	12	24	14	47	56.11	35-55.38	121-13.71	5	292	.01	D			1.2
70	12	24	16	40	47.78	35-56.38	121-35.92	9	290	.04	D			1.5
70	12	26	4	47	56.53	35-59.29	121-28.21	10	278	.12	D			1.7
70	12	30	19	19	5.12	35- 6.29	120- 8.56	18	118	.45	C	35- 4.65	120- .64	2.7
71	01	04	5	16	2.70	35-48.13	121-15.05	12	249	.07	C			1.7
71	01	07	23	12	54.16	36- .60	120-52.76	10	164	.11	B			1.5
71	01	11	15	21	41.00	34-52.20	120-57.25	24	193	.18	B*	34-54.00	120-02.00	3.5
71	01	21	20	40	7.44	35-46.49	121- 6.66	9	264	.02	D			1.7
71	01	26	21	53	57 57	35-29.79	120-45.54	19	164	.12	A*	35-26.35	120-55.49	3.1
71	02	26	12	7	55.13	36- 2.93	121-36.48	14	273	.05	D			1.7
71	03	12	19	26	2.30	35-59.70	121-29.39	14	245	.05	C			1.6
71	03	16	5	53	54.03	35-43.25	120-36.47	4	324	.13	D			1.5
71	05	22	19	58	29.50	35-45.08	120-53.65	7	256	.13	C			1.7
71	05	28	3	42	55.50	36- .65	120-52.70	11	164	.09	B			.9
71	05	31	23	44	29.05	35-34.82	120-49.46	6	312	.06	D			1.4
71	06	13	1	57	25.12	35-51.65	120-44.04	10	198	.05	B			1.2
71	06	17	4	8	1.55	35-50.12	120-35.99	7	192	.09	C			1.5
71	06	22	17	20	31.18	35-59.72	121-28.90	14	254	.10	C			1.8
71	06	30	11	42	34.71	36- .79	120-52.73	16	163	.07	A			1.7
71	07	09	9	21	39.28	35-25.66	121-33.34	5	330	.05	D			2.0
71	07	12	21	48	35.08	35-44.71	120-43.38	8	254	.21	C			1.6
71	07	28	8	25	18.14	36- .99	120-53.30	24	163	.21	A			2.8
71	07	28	9	9	46.64	36- .69	120-53.71	10	166	.26	B			1.4
71	07	28	21	36	14.36	36- .98	120-53.36	12	163	.08	A			1.5
71	07	31	0	58	22.42	35-48.42	121- 9.95	12	196	.11	B			2.3
71	08	07	16	44	45.17	35-30.66	120-45.98	6	317	.09	D			1.7
71	08	20	17	46	44.82						*	34-43.45	121-26.66	3.8
71	08	31	20	45	21.20	36- .91	120-52.87	11	163	.06	B			1.7
71	09	04	20	24	28.73	36- .30	120-52.92	7	166	.07	C			.6
71	09	05	17	56	59.71	35-59.62	120-53.78	9	172	.04	B			1.3
71	09	06	4	40	3.44	36- 7.54	121-42.64	11	269	.10	D			1.5
71	09	20	7	38	18.36	35-50.05	121-21.66	12	260	.13	C			1.8
71	09	23	5	13	7.12	36- .49	120-52.80	7	165	.04	C			1.2
71	09	30	0	10	11.65	35-59.91	121- 1.75	22	193	.06	B			2.3
71	10	05	21	15	2.67	35-48.91	121- 2.77	10	237	.17	C			1.7
71	10	21	22	9	44.68	35-56.42	121- .17	36	166	.28	A			3.6
71	10	30	13	45	23.39	36- 8.03	121-11.40	33	147	.16	A			3.0
71	11	04	0	1	32.37	35-54.55	121-16.35	11	253	.05	C			1.8
71	11	04	17	50	40.30	35-54.86	120-46.63	6	212	.04	C			1.5

YR	MO	DY	HR	MN	SEC	NEW LAT	NEW LONG	NO	GAP	RMS	Q	OLD LAT	OLD LONG	MAG
71	11	11	2	33	37.65	36- .94	120-53.30	11	163	.04	B			1.3
71	11	15	11	24	44.73	36- .59	121-25.39	10	238	.17	C			1.6
71	12	02	9	7	28.79	35-50.05	121-10.09	31	184	.13	A			3.0
71	12	07	14	56	11.05	36- 6.93	121-36.17	10	258	.07	C			1.4
71	12	14	1	28	35.55	36- 0.00	120-53.58	14	170	.08	A			1.6
71	12	21	8	12	38.17	35-43.39	120-59.02	6	299	.05	D			1.3
71	12	21	9	26	55.52	36- .53	120-52.86	9	165	.07	B			1.3
71	12	26	06	59	21.38	34-41.77	121-27.31	32	217	.20	C*	34-53.12	121-09.45	3.7
71	12	30	2	13	51.91	35-59.76	120-53.36	7	171	.06	C			1.1
71	12	30	2	16	17.84	35-59.71	120-53.36	8	171	.07	B			1.1
71	12	31	1	11	35.26	35-40.00	120-59.79	6	304	.04	D			1.8
72	01	01	16	36	58.11	35-47.48	121- 4.77	6	259	.03	C			1.5
72	01	16	3	44	18.95	35-51.10	121- 9.87	8	291	.08	D			1.0
72	01	17	20	46	53.06	36- .11	120-53.47	10	169	.10	B			1.3
72	01	19	21	18	22.04	35-59.44	120-59.85	9	190	.07	B			.9
72	01	20	6	40	23.01	35-37.13	120-58.44	8	279	.13	D			2.0
72	01	29	19	7	49.04	35-49.12	121-12.44	31	188	.12	A			3.2
72	01	30	5	56	26.35	35-50.63	121-12.41	8	278	.03	C			1.1
72	01	31	6	24	56.57	34-38.71	121-22.94	13	258	.13	C			3.0
72	02	03	10	2	25.58	35-49.66	121-22.97	17	199	.06	B			2.1
72	02	03	10	3	43.34	35-50.88	121-22.44	10	237	.06	C			2.0
72	02	03	14	59	38.10	35-36.50	120-48.21	8	210	.07	B			1.6
72	02	11	22	49	11.27	35-41.38	120-59.26	6	265	.05	D			2.0
72	02	13	23	20	1.97	36- .53	120-52.94	7	165	.05	C			1.1
72	02	16	23	50	37.01	34-46.20	120-47.10	12	218	.35	B			2.5
72	02	17	7	59	48.62	36- 7.66	121-11.45	10	192	.06	B			1.4
72	02	17	9	34	51.45	36- 7.73	121-11.72	10	184	.09	B			.5
72	02	18	17	27	14.11	35-46.92	121- 4.98	7	261	.02	C			1.3
72	02	26	10	8	59.15	36- 2.45	121-34.61	11	249	.07	C			1.8
72	02	28	7	17	50.03	36- 8.05	121-11.46	17	148	.10	A			1.9
72	03	01	12	44	42.39	35-48.83	121-24.01	33	242	.09	C			3.6
72	03	01	14	20	52.47	35-50.88	121-21.49	11	266	.04	D			1.6
72	03	01	14	34	52.27	35-50.15	121-22.30	8	252	.05	C			1.4
72	03	01	16	19	50.94	35-49.70	121-22.87	19	239	.07	C			2.5
72	03	01	19	1	10.69	35-49.48	121-23.07	20	240	.06	C			2.5
72	03	02	12	2	17.03	35-51.97	121-21.29	10	244	.05	C			1.9
72	03	03	17	56	20.22	35-52.12	121-22.06	11	243	.08	C			1.8
72	03	04	2	38	29.67	35-57.31	121- .22	7	204	.06	C			.9
72	03	05	11	5	56.73	35-50.38	121-22.21	9	238	.06	C			1.9
72	03	05	11	20	29.03	36- 1.61	120-53.37	6	181	.05	C			1.2
72	03	13	17	30	47.91	35-51.25	121-21.86	8	249	.06	C			1.6
72	03	15	2	38	35.32	35-51.89	121-21.28	8	248	.06	C			1.2
72	03	22	6	33	48.16	35-51.25	121-21.28	8	235	.03	C			1.5
72	03	23	1	43	25.87	35-48.86	121- 6.52	13	181	.05	B			1.9
72	03	30	17	39	55.02	35-30.84	120-47.80	8	194	.04	B			2.0
72	03	31	6	53	27.85	35-53.54	121- 8.88	9	234	.12	C			1.5
72	04	04	4	20	26.56	36- .04	120-53.14	15	168	.07	A			1.7
72	04	12	5	15	4.98	36- 6.66	121-31.90	11	232	.09	C			1.3
72	04	15	8	28	30.08	35-48.95	121-17.39	14	237	.09	C			1.5
72	04	19	0	17	24.18	35-47.62	121-20.10	17	241	.09	C			2.1
72	04	23	5	14	.94	36- .48	120-52.46	8	236	.12	C			.1
72	04	25	14	25	33.34	36- 5.80	121-36.78	16	226	.11	C			2.0
72	04	27	6	49	18.13	35-51.94	121-21.55	18	234	.06	C			1.9
72	04	30	4	18	3.39	35-33.37	120-48.28	12	191	.05	B			2.0
72	05	02	23	9	15.32	34-32.10	120-36.85	5	246	.38	C			2.5
72	05	05	1	41	8.71	35-42.23	121- 8.00	7	277	.05	D			1.8

YR	MO	DY	HR	MN	SEC	NEW LAT	NEW LONG	NO	GAP	RMS	Q	OLD LAT	OLD LONG	MAG
72	05	05	4	45	21.30	35-50.18	121- 8.40	6	264	.05	D			1.6
72	05	08	5	24	11.77	34-36.83	121-24.25	15	225	.13	C			3.0
72	05	10	18	12	28.81	35-57.06	121-32.90	6	287	.06	D			1.0
72	05	27	6	1	17.61	35-52.60	121-15.39	12	228	.09	C			1.9
72	05	29	15	49	1.67	36- .63	120-53.19	7	165	.09	C			.9
72	06	12	1	7	59.14	34-34.49	120-33.99	6	201	.34	C			2.0
72	06	18	3	49	39.35	34-33.96	120-44.24	5	220	.36	C			2.0
72	06	18	18	4	12.88	34-33.78	120-32.18	9	197	.38	B			2.5
72	07	24	18	10	17.80	35-46.56	121- 8.63	19	247	.06	C			2.4
72	08	14	14	13	17.52	36- 6.49	120-57.61	7	172	.05	C			1.0
72	08	15	7	2	54.42	35-58.34	120-56.18	9	186	.05	B			1.1
72	08	18	3	37	3.96	34-42.01	120-17.17	6	137	.36	C			2.5
72	08	21	3	9	12.94	35-47.19	121- 8.32	7	265	.03	D			1.5
72	08	26	3	22	36.80	36- 2.03	121-29.71	12	233	.07	C			1.5
72	08	28	20	32	31.41	35-50.29	121-12.36	10	259	.04	C			1.7
72	09	03	8	6	39.52	35-59.74	120-53.06	8	170	.04	B			1.1
72	09	04	21	51	50.99	36- 2.92	121-30.71	6	266	.06	D			1.4
72	09	08	17	25	16.39	36- 0.00	120-53.27	11	169	.06	B			1.3
72	09	12	22	29	29.90	35-50.23	121-23.16	11	263	.05	D			1.7
72	09	19	1	10	49.05	35-52.86	121-16.02	19	228	.04	C			2.2
72	09	23	3	43	47.16	34-46.97	120-15.15	11	121	.39	B			3.0
72	10	01	20	12	6.33	36-10.23	121-29.39	10	252	.05	C			1.2
72	10	06	14	23	49.80	35-49.94	121-12.78	15	243	.05	C			2.2
72	10	22	2	47	1.23	35-43.70	121-37.82	13	268	.13	D			1.9
72	10	25	1	1	12.44	36- 1.78	120-53.37	17	169	.07	A			2.0
72	11	07	13	49	18.80	35-50.05	121-17.26	17	267	.06	D			2.4
72	11	15	12	37	58.52	35-47.23	121- 9.32	13	246	.03	C			1.6
72	11	17	9	22	38.38	35-59.95	120-53.30	19	169	.05	A			1.6
72	11	30	10	43	40.38	35-59.78	120-53.27	15	170	.04	A			1.5
72	12	05	2	34	54.86	36- .15	120-52.74	18	167	.11	A			2.0
72	12	07	17	20	14.98	35-59.75	120-53.59	9	171	.06	B			1.0
72	12	08	5	39	20.19	36- .04	120-53.44	11	169	.10	B			1.0
72	12	10	0	59	49.60	35-59.86	120-53.34	11	170	.05	B			1.4
72	12	11	21	26	49.30	35-59.90	120-53.37	21	170	.07	A			2.5
72	12	13	21	48	50.59	35-59.65	120-53.64	8	205	.04	B			1.2
72	12	14	6	56	9.54	35-59.77	120-53.21	10	170	.05	B			.8
72	12	14	13	44	26.64	35-29.99	121-17.23	20	203	.23	B			2.5
72	12	24	14	36	13.70	35-59.84	120-53.43	10	170	.06	B			1.4
72	12	27	18	11	39.65	35-59.77	120-53.26	13	170	.05	A			1.6
73	01	05	7	11	42.88	34-41.21	121-32.54	12	228	.22	C			3.0
73	01	07	12	6	56.58	35-38.94	121-43.00	8	283	.26	D			1.9
73	01	12	3	58	11.27	35-43.24	121- 7.11	11	253	.07	C			2.1
73	01	13	0	52	54.34	35-53.87	120-54.26	11	206	.02	B			1.2
73	01	21	14	27	40.71	34-34.35	120-52.58	18	202	.36	B			3.0
73	01	22	22	40	8.30	34-54.92	120-23.57	9	183	.52	C			2.5
73	01	28	22	1	53.01	35-40.53	121- 1.76	9	270	.28	D			1.8
73	02	06	0	16	6.29	34-32.99	120-36.94	7	208	.27	C			2.5
73	02	08	21	37	8.31	35-33.75	120-51.81	9	197	.18	B			2.0
73	02	12	12	8	35.44	36- 1.41	120-59.11	6	224	.04	C			1.1
73	02	17	3	33	37.61	36- .90	120-53.12	7	185	.06	C			1.1
73	02	17	13	10	37.47	36- .85	120-53.13	8	185	.07	B			1.0
73	02	21	0	20	22.13	35-36.52	120-49.34	8	188	.11	B			1.8
73	02	24	7	8	49.85	35-52.75	120-56.61	8	222	.04	C			1.6
73	03	24	22	55	33.66	35-51.20	121-21.40	9	294	.05	D			1.9
73	03	25	4	22	35.02	35-46.54	121-23.06	10	271	.04	D			1.8
73	03	27	1	42	42.32	34-44.40	121-31.58	19	231	.27	C			3.0
73	04	04	9	25	40.74	35-45.51	121-14.27	13	253	.06	C			2.2

YR	MO	DY	HR	MN	SEC	NEW LAT	NEW LONG	NO	GAP	RMS	Q	OLD LAT	OLD LONG	MAG
73	04	06	7	11	50.15	35-57.87	121-16.38	9	272	.10	D			1.4
73	04	16	5	25	26.02	35-57.74	120-58.96	8	204	.30	B			1.3
73	04	21	14	13	13.67	36- 1.10	120-53.42	6	229	.03	C			.8
73	04	28	11	34	4.19	35-54.12	120-54.03	11	204	.06	B			1.0
73	05	11	15	52	16.48	35-52.12	121-21.25	11	263	.10	D			1.5
73	05	30	19	38	12.74	36- 1.00	120-53.24	7	163	.06	C			.8
73	06	17	11	10	30.81	35-45.42	121-14.37	21	254	.06	C			3.0
73	06	19	17	49	33.10	35-45.68	121-14.28	10	274	.04	D			1.9
73	06	28	13	28	.93	36- 4.98	121-31.95	10	239	.07	C			1.4
73	07	10	20	58	33.33	35-34.10	120-53.95	7	222	.02	C			1.9
73	07	15	15	0	1.75	35-51.08	121-22.66	8	291	.02	D			1.7
73	07	20	23	26	41.58	35-30.25	120-33.65	8	305	.09	D			2.0
73	08	05	20	1	23.74	36- 3.23	121-36.42	18	250	.08	C			1.9
73	08	14	20	10	24.84	35-59.89	121-33.18	11	279	.05	D			1.6
73	08	16	21	24	50.79	35-34.83	120-53.64	6	199	.07	C			2.2
73	08	29	9	37	39.27	35-49.31	121-17.47	10	257	.04	C			1.9
73	08	29	18	45	2.14	35-35.44	120-52.12	7	276	.14	D			2.2
73	08	30	19	12	45.85	35-27.03	120-33.93	6	325	.08	D			1.3
73	08	31	13	27	15.46	35-50.21	121-19.11	9	280	.06	D			1.9
73	09	01	15	1	52.14	35-27.73	120-56.11	9	231	.07	C			2.3
73	09	04	23	58	43.39	35-34.45	120-53.66	5	315	.07	D			1.9
73	09	07	16	53	38.92	35-46.39	121-10.41	6	281	.06	D			1.6
73	09	08	1	21	43.94	35-53.14	121-13.16	11	287	.05	D			1.8
73	09	08	15	15	10.64	35-47.44	121-18.33	20	241	.09	C			2.7
73	09	12	19	11	52.36	35-33.52	120-53.61	11	201	.07	B			2.2
73	09	19	15	38	21.53	34-33.93	120-46.37	6	266	.17	D			2.0
73	09	26	1	42	50.54	35-33.82	120-54.44	8	202	.04	B			2.3
73	09	27	15	56	15.27	35-43.93	121- 4.96	7	268	.07	D			1.1
73	10	03	23	12	6.43	35-39.94	120-48.61	7	259	.12	C			2.3
73	10	08	0	9	37.08	35-47.98	121-17.84	25	252	.10	C			3.1
73	10	09	20	4	47.81	35-47.47	121-18.33	16	253	.07	C			2.2
73	10	11	0	44	8.47	35-34.25	120-53.37	7	277	.03	D			2.2
73	10	15	21	26	10.35	35-31.73	120-47.27	11	191	.06	B			2.3
73	10	18	0	16	37.93	35-34.96	120-52.78	8	268	.15	D			2.3
73	10	27	22	58	34.43	35-37.70	120-49.76	6	274	.10	D			2.2
73	11	03	22	38	.86	35-40.06	120-49.07	7	259	.09	C			1.8
73	11	06	11	3	5.22	36- .48	120-53.20	7	180	.02	C			1.0
73	11	07	21	25	55.16	35-35.36	120-52.69	7	274	.16	D			1.6
73	11	18	7	11	47.37	35-46.30	121- 6.64	6	266	.04	D			1.2
73	11	24	2	2	6.54	36- 9.86	121- 9.74	8	160	.09	B			1.8
73	12	06	11	6	33.95	35-59.65	120-53.34	9	171	.07	B			1.3
73	12	07	2	3	35.66	36- 9.30	120-59.98	7	141	.11	C			.7
73	12	20	20	28	58.78	35-45.96	121- 7.25	5	269	.01	D			1.4
73	12	21	4	8	43.82	35-49.03	121-22.42	5	195	.09	C			1.5
74	01	01	15	0	47.05	35-48.09	121- 9.63	9	223	.05	C			1.6
74	01	07	16	30	39.66	35-57.85	120-56.63	6	168	.05	C			1.0
74	02	06	17	16	17.16	36- 1.14	120-53.03	7	162	.07	C			1.3
74	02	08	1	25	49.06	35-52.53	121-29.02	7	276	.10	D			1.8
74	02	25	8	14	49.75	35-24.68	120-54.03	8	224	.10	C			2.2
74	03	03	23	49	14.06	36- .31	120-53.19	9	153	.06	B			1.5
74	03	10	9	6	39.07	35-45.49	121-14.14	30	233	.06	B			2.6
74	03	10	23	24	7.96	35-26.40	121- 1.70	18	187	.27	B			2.7
74	03	11	15	29	25.66	35-45.44	121-14.10	13	254	.04	C			2.0
74	03	30	19	16	51.20	35-39.43	121- 4.58	7	245	.04	C			1.7
74	04	08	18	28	48.35	36- .92	120-53.22	27	151	.07	A			2.3
74	04	17	15	15	46.51	35-59.04	121- 1.91	7	134	.08	C			1.1
74	04	18	5	17	6.08	35-47.69	121- 8.84	10	134	.03	B			1.4

YR	MO	DY	HR	MN	SEC	NEW LAT	NEW LONG	NO	GAP	RMS	Q	OLD LAT	OLD LONG	MAG
74	04	19	15	32	57.89	35-59.27	121- 2.28	18	91	.07	A			2.5
74	04	28	12	44	31.07	35-59.35	121- 2.68	9	117	.05	B			1.2
74	05	09	19	32	10.93	35-51.93	121-12.13	5	139	.02	C			1.3
74	05	12	9	31	29.86	35-53.93	120-47.94	9	132	.03	B			1.7
74	06	04	11	12	15.97	35-49.35	121-10.31	10	258	.05	C			1.6
74	06	10	0	28	14.10	35-46.94	121- 8.74	29	129	.16	A			2.4
74	06	19	15	31	34.52	35-22.18	121- 2.72	30	183	.20	B			2.8
74	06	28	6	13	12.46	35-46.40	121-19.25	7	245	.04	C			1.6
74	07	10	10	35	48.03	35-45.23	121-19.14	12	205	.13	B			1.4
74	07	11	3	18	16.38	35-50.01	121-17.53	9	178	.04	B			1.4
74	07	14	14	50	2.95	36- 4.14	120-58.64	11	144	.05	B			1.3
74	07	17	6	45	15.53	35-46.73	121-16.74	25	185	.14	B			2.2
74	07	18	7	55	12.56	35-46.61	121-16.56	23	185	.13	B			2.0
74	07	19	8	48	1.28	35-49.91	121-16.75	13	269	.07	D			1.7
74	08	16	18	27	54.55	36- .22	121-31.83	12	281	.05	D			1.4
74	09	24	20	7	25.05	35- 9.04	120-57.42	25	191	.18	B			3.0

* -- NOT PLOTTED

SHORT TERM STUDY

73	05	08	10	27	09.04	35-21.87	120-58.28	12	242	.27	C			.8
73	05	08	11	07	50.63	35-21.31	121-01.63	7	258	.17	C			1.3
73	05	09	07	39	29.87	35-22.76	120-53.39	6	255	.33	D			.3
73	05	11	15	52	14.80	35-50.98	121-27.90	8	269	.70	D			1.7
73	05	11	17	47	42.25	36-07.23	120-50.74	4	206	.15	D			1.6
73	05	16	23	15	23.22	35-23.01	120-33.66	8	231	.26	C			.9
73	05	12	00	30	14.87	36-09.58	121-01.37	6	224	.24	C			2.1
73	05	18	09	30	00.55	34-41.07	121-20.46	7	281	.19	D			1.9
73	05	18	20	32	22.51	35-31.13	120-41.39	5	187	.45	D			1.9
73	05	22	20	56	40.16	35-31.00	120-50.84	8	209	.27	C			.9
73	05	24	23	14	59.16	35-15.81	120-43.35	5	137	.57	D			.4
73	05	30	19	38	22.21	34-56.79	120-43.03	10	195	.19	B			1.7
73	05	31	10	29	00.76	36-01.79	120-32.33	9	208	.43	C			1.7
73	05	31	18	03	36.14	34-50.90	121-05.64	7	266	.26	C			1.6

Appendix B - Focal Mechanism

NO	DATE	TIME	LAT	LONG	Q	STRIKE	DIP	STRIKE	DIP
1	49/06/27	1035	35 43	121 12	B	328	75E	40	48W
2	49/08/27	1451	34 25	120 51	B	330	68E	45	50N
3	52/11/22	746	35 47	121 14	A	312	78E	50	48S
4	52/11/25	2159	35 50	121 08	A	330	60E	60	85N
5	53/02/03	1450	35 24	120 46	B	320	70E	40	60N
6	55/03/02	1559	36 01	120 58	A	330	70E	65	60S
7	55/11/02	1940	35 59	120 58	B	333	60E	90	65S
8	56/11/16	323	35 57	120 30	A	323	80W	60	60N
9	57/01/29*	2119	35 54	122 04	B	304	45N	62	70S
10	58/10/10	1305	35 57	120 29	B	315	90	45	90
11	59/10/01	435	34 29	120 29	B	360	90	90	66N
12	60/01/02	2251	35 45	121 08	B	316	63E	54	90
13	61/07/31	007	35 49	120 21	A	322	86W	55	80S
14	62/02/01	637	35 01	120 56	A	360	74W	112	48N
15	65/09/19*	1542	36 04	119 59	B	346	60W	80	80N
16	69/09/06	1344	35 20	121 05	B	335	62E	75	70S
17	69/10/30	1536	34 24	120 50	B	321	56E	70	70S
18	69/11/05	1754	34 38	121 26	A	311	88W	47	36N
19	70/05/27	1042	36 00	120 53	A	330	63E	104	45S
20	71/01/26	2152	35 30	120 45	A	322	80E	50	60N
21	71/10/21	2209	35 56	121 01	B	350	64E	80	90
22	71/10/30	1345	36 08	121 11	A	321	83E	75	32S

23	72/03/01	1244	35 48	121 24	A	285	36N	97	63S
24	72/09/23**	323	34 46	120 16	B	294	75S	20	70E
25	74/06/19	1531	35 22	121 03	B	325	70E	106	30S
26	74/09/24	2007	35 09	120 58	A	333	65E	85	55S
27	San Ardo Composite***				A	333	80E	60	77N

*Strike Unknown

**Strike Assumed

***John Coakley, U.S.G.S., Written communication, 1974

Focal plots of mechanisms as listed in above Table:

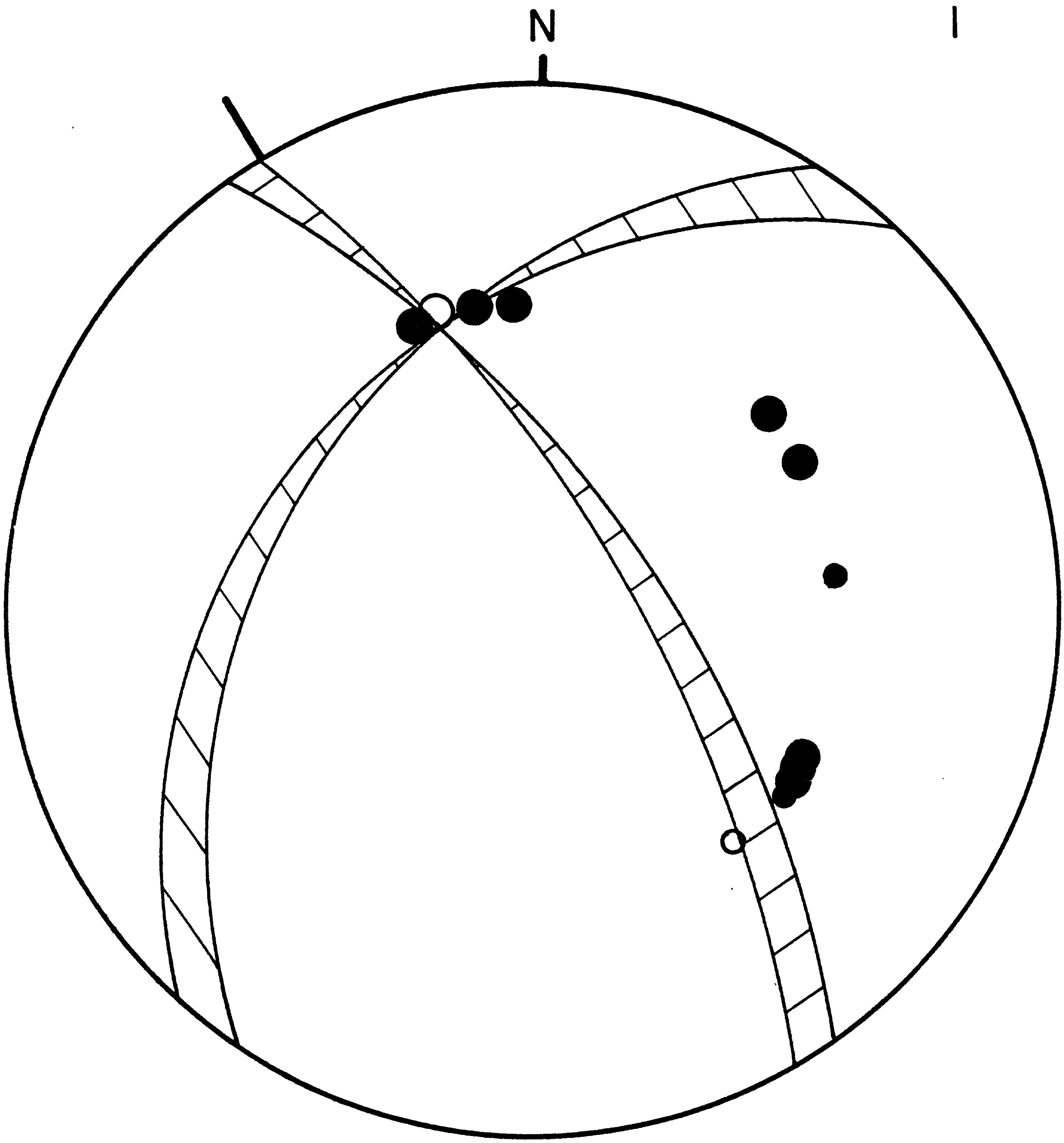
● Definite Compression

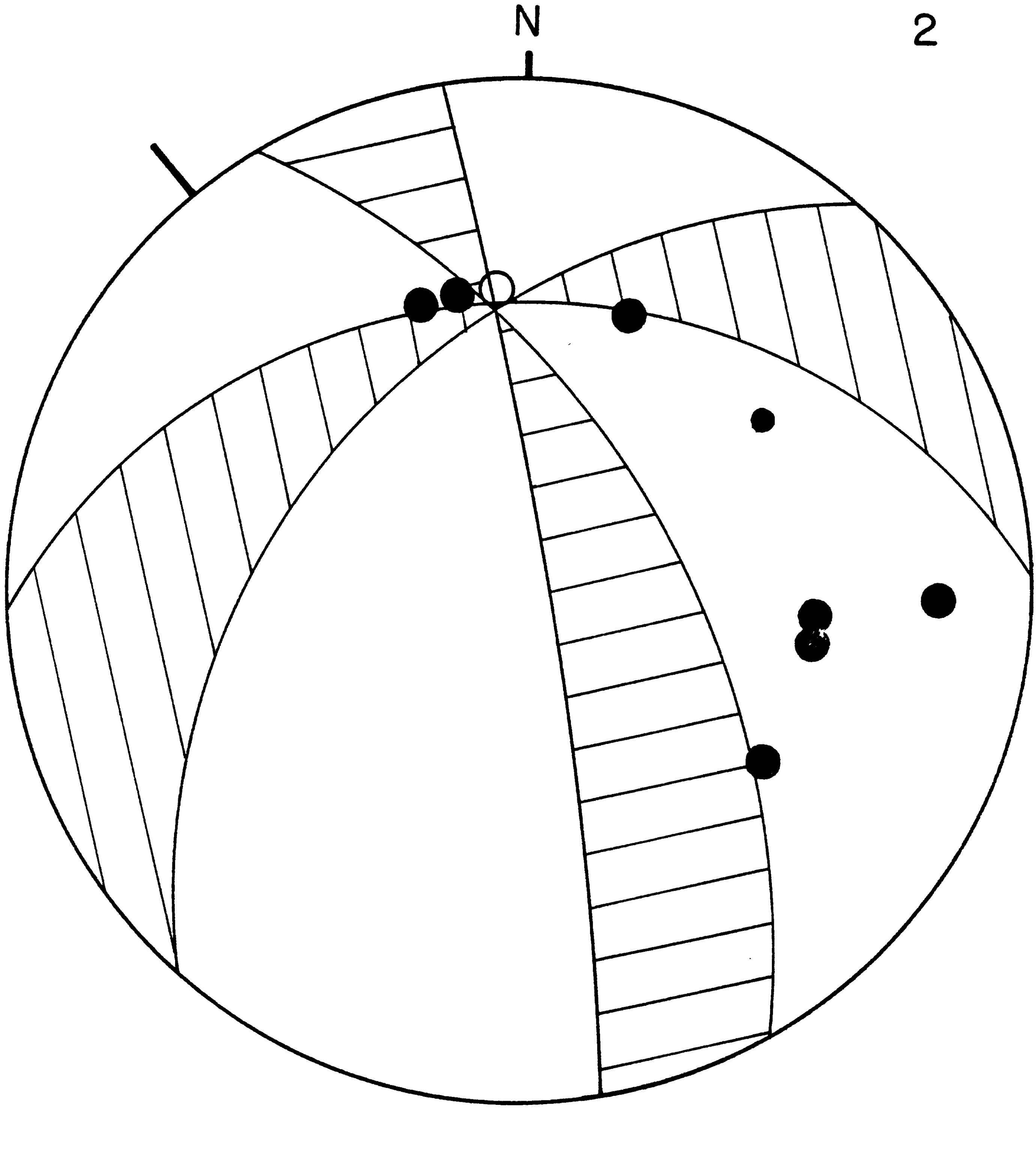
○ Definite Dilatation

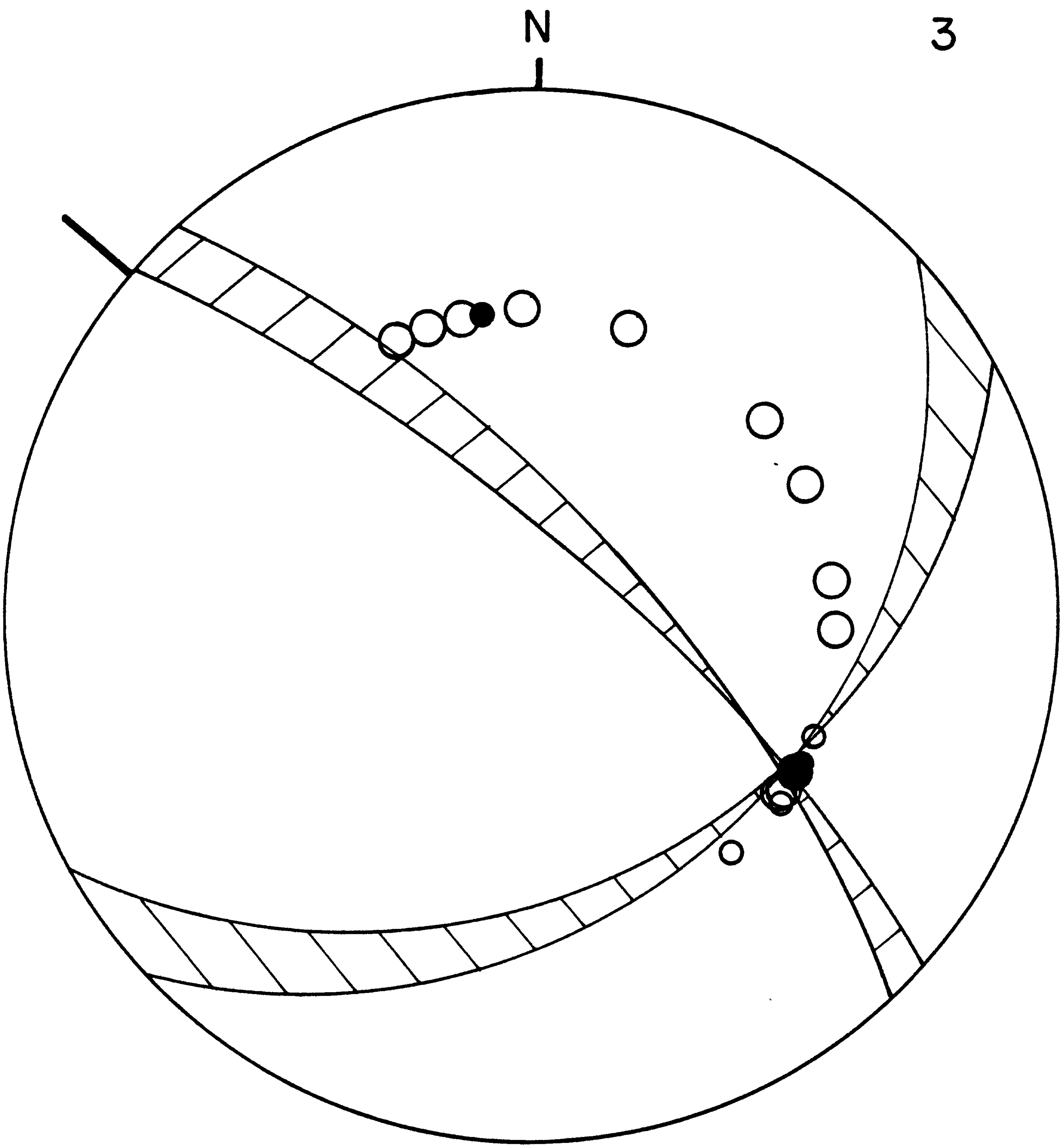
• Questionable Compression

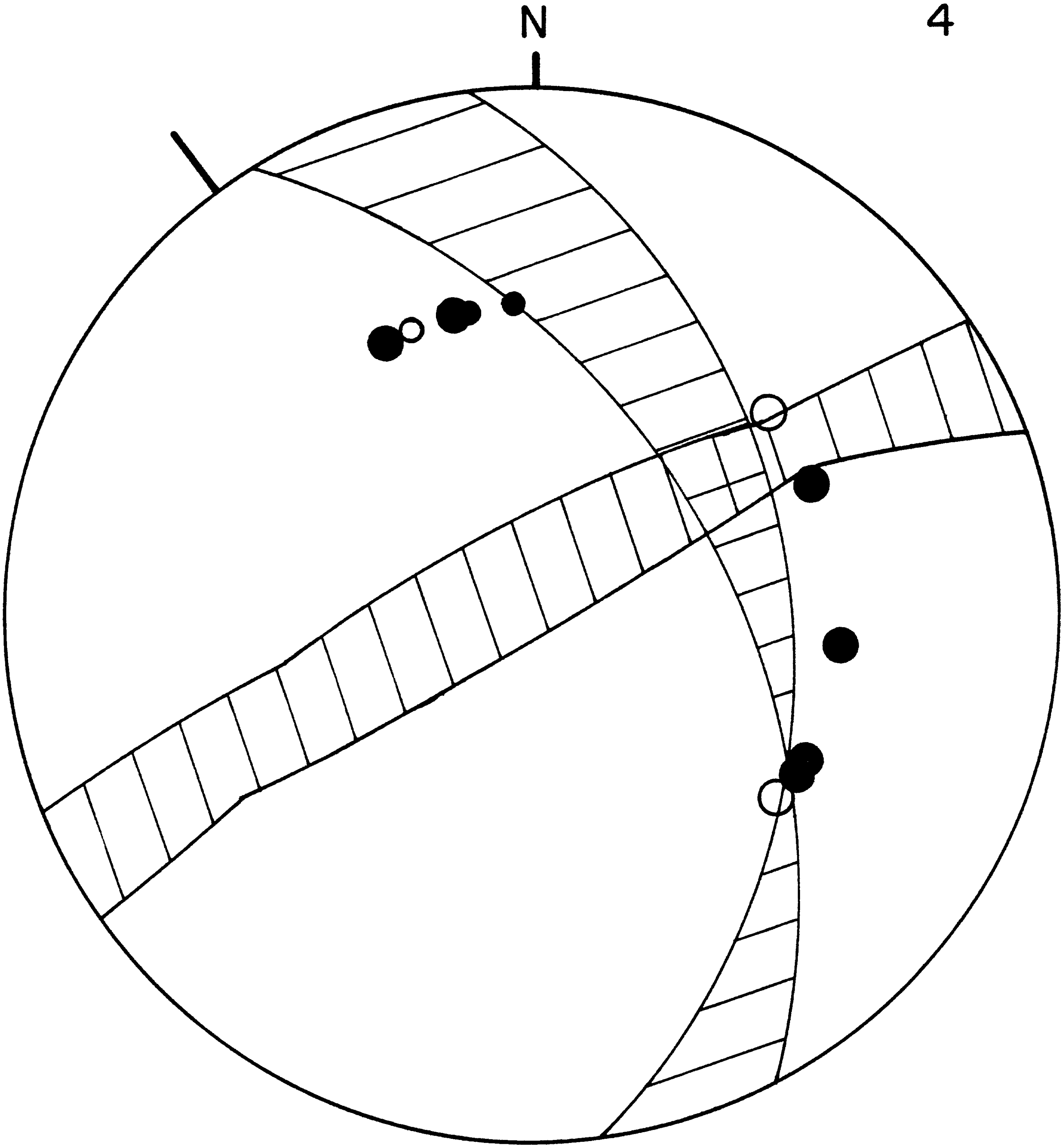
◦ Questionable Dilatation

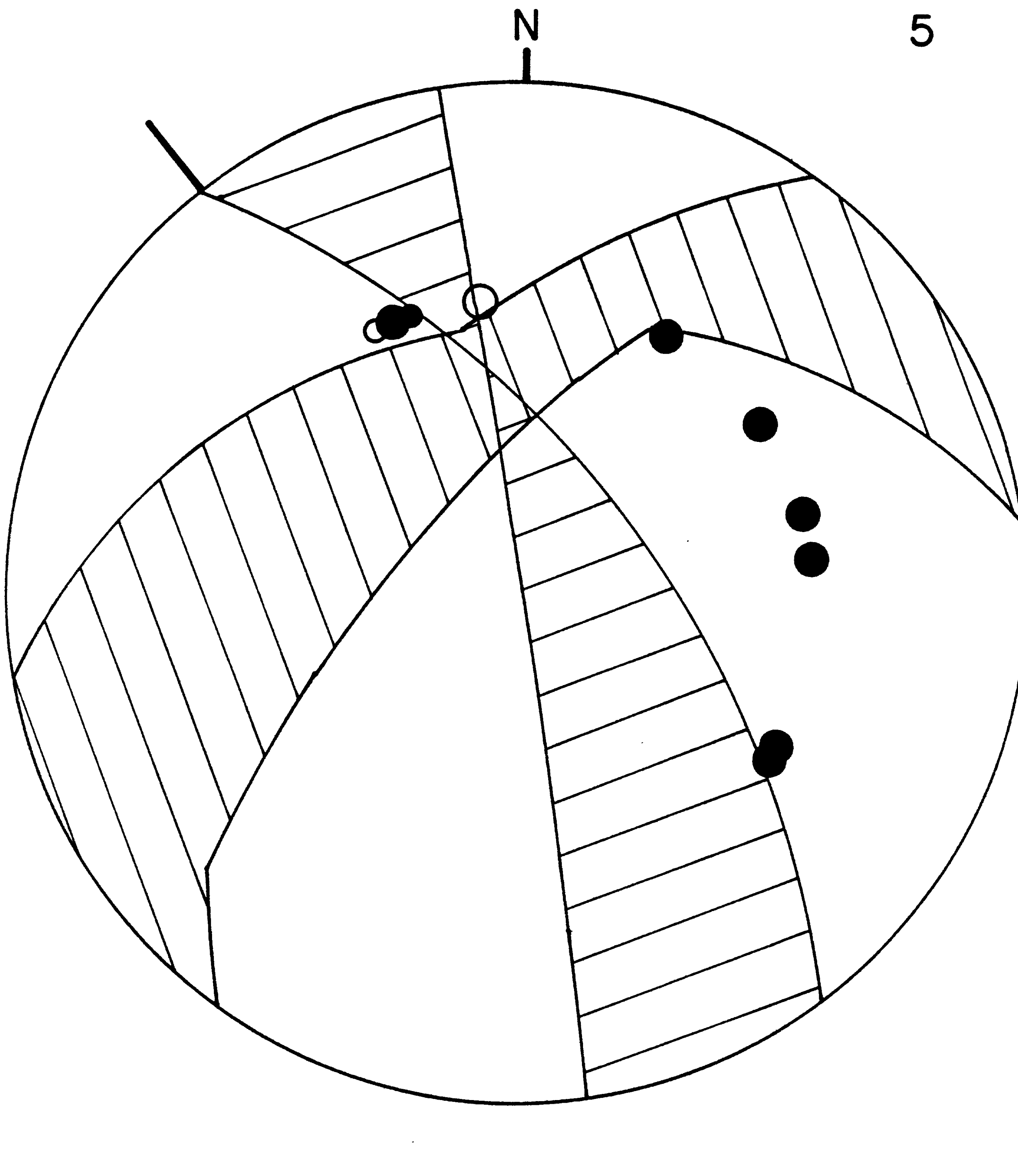
\ Strike of mapped fault nearest to the epicenter

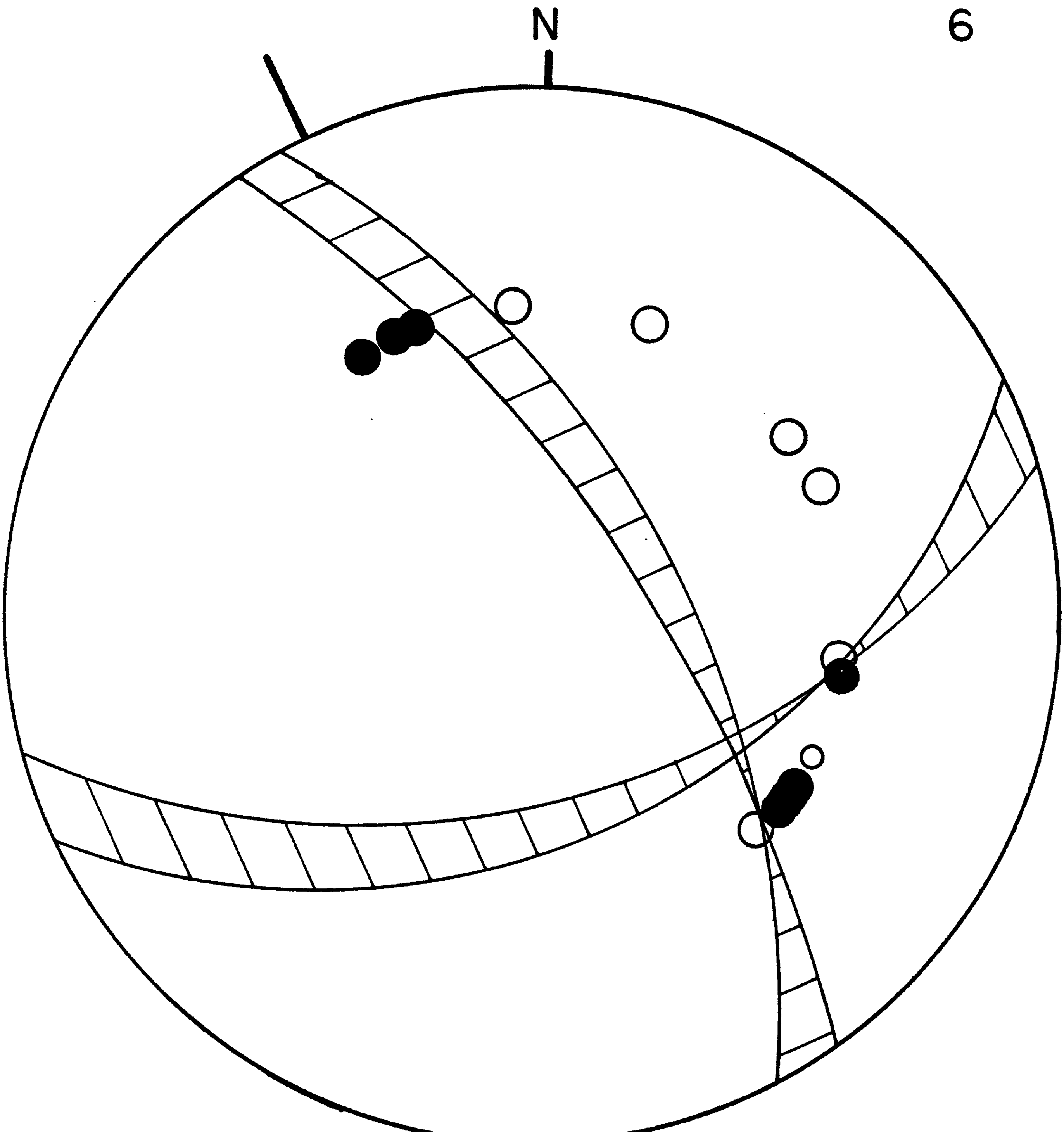

N
I

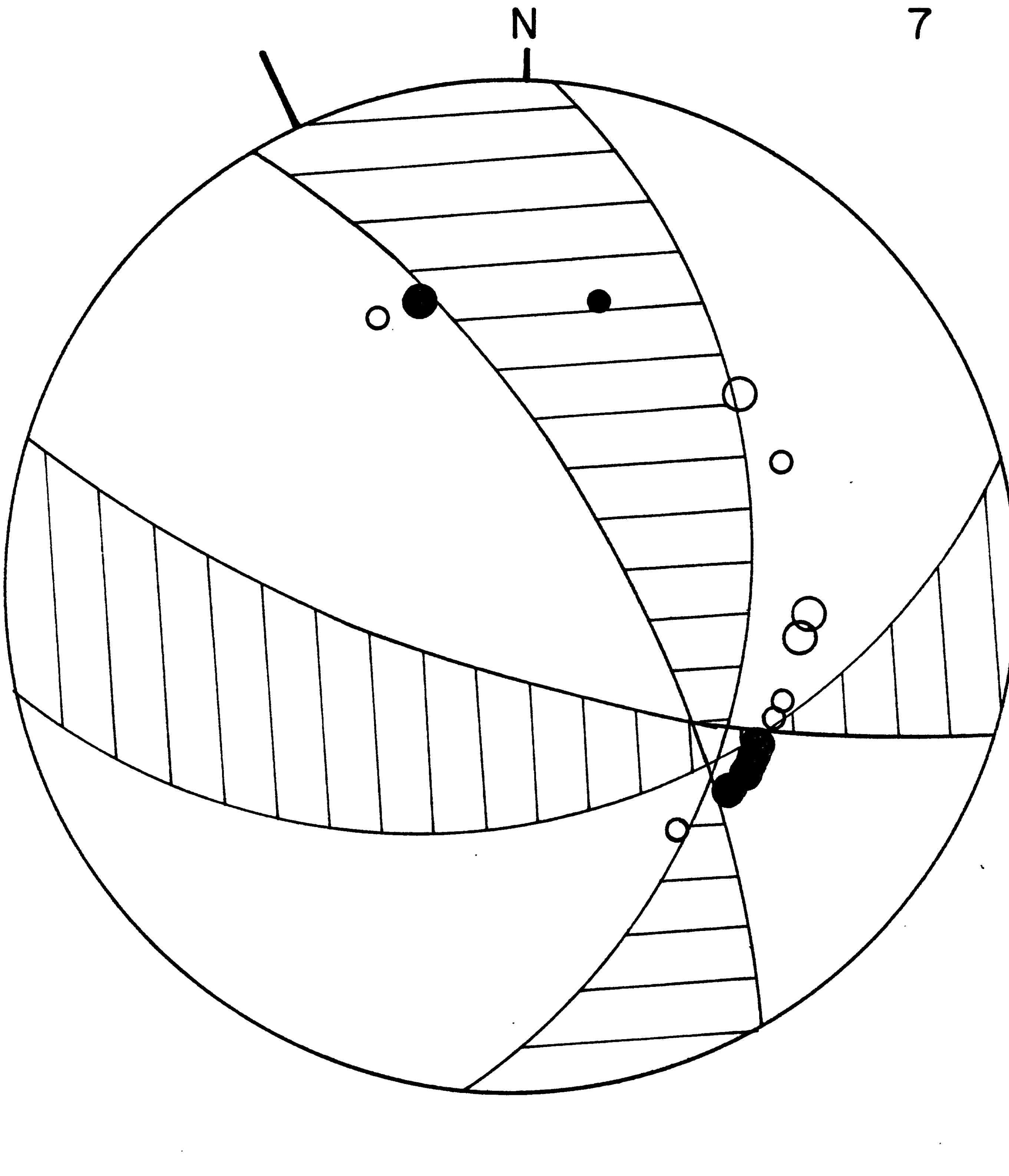

N
2

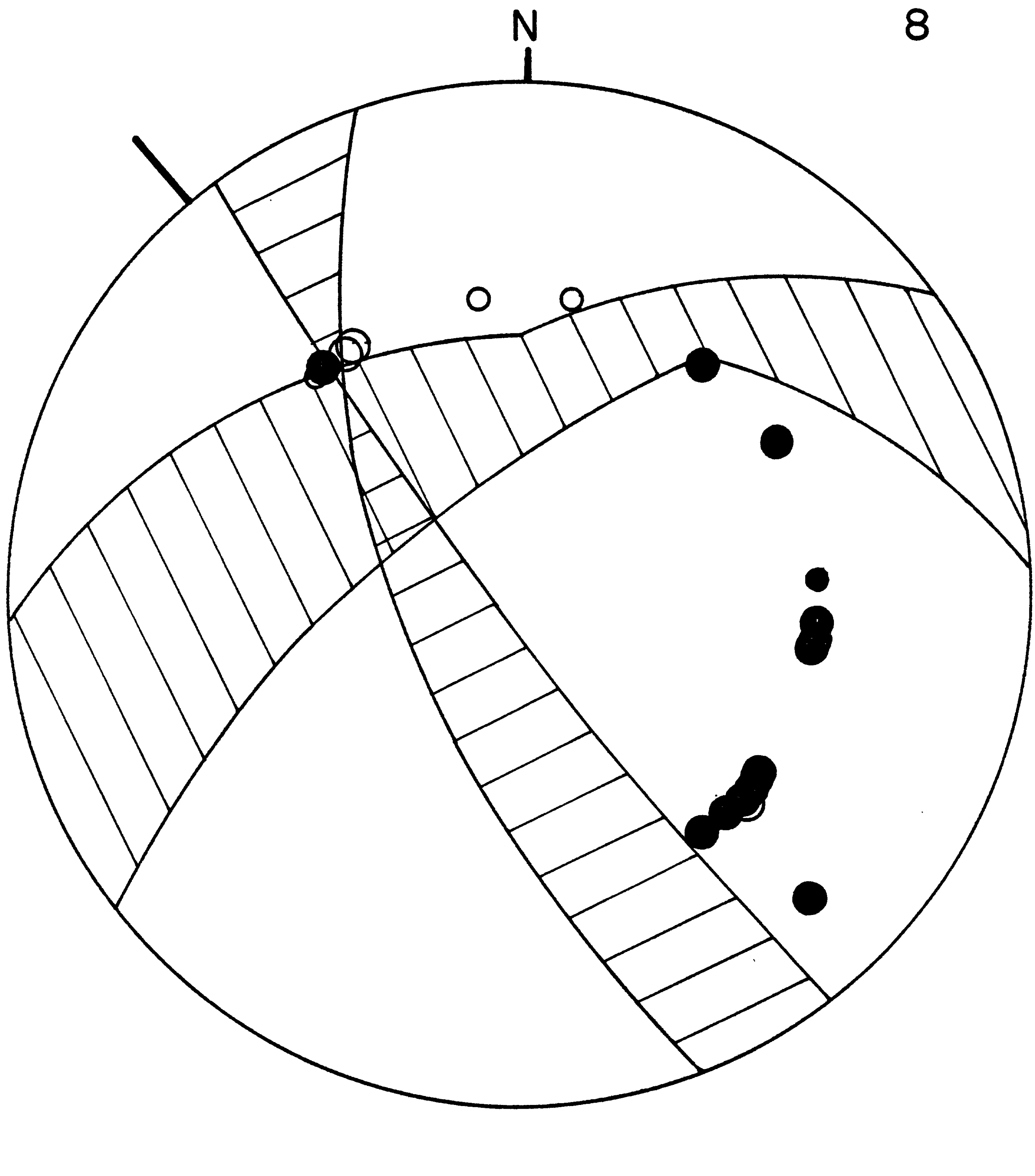

N
3

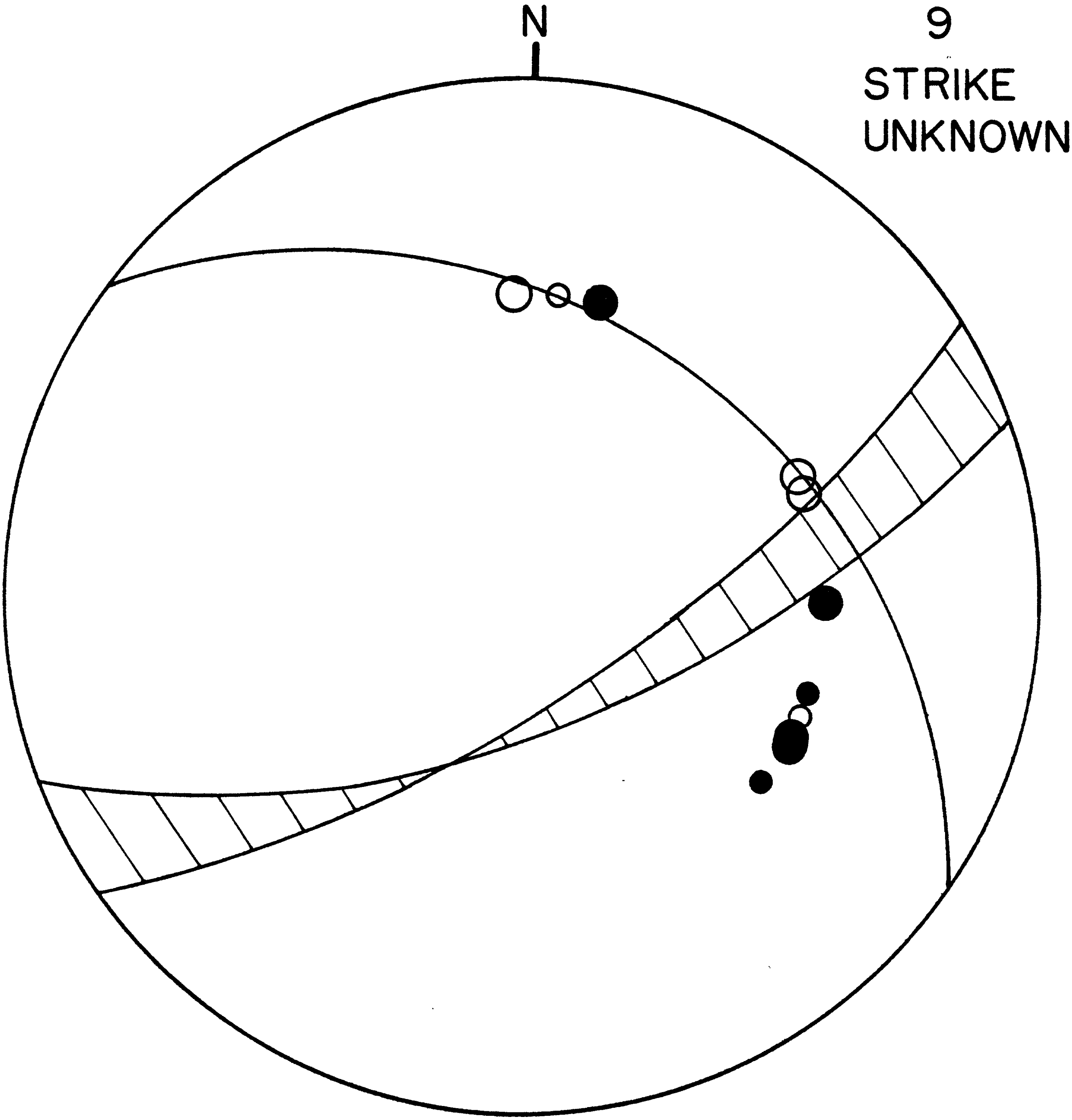

N
4

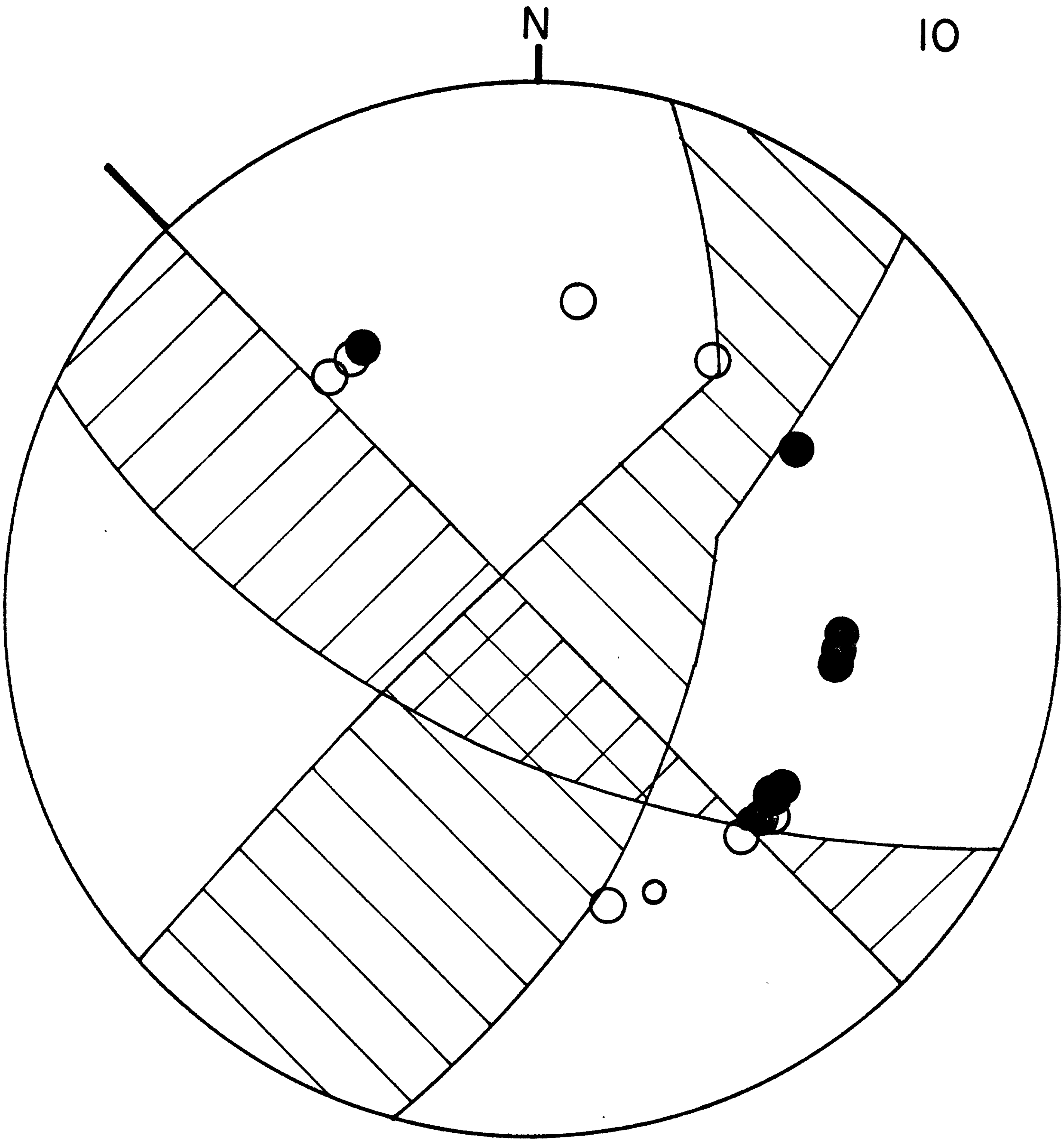

N
5

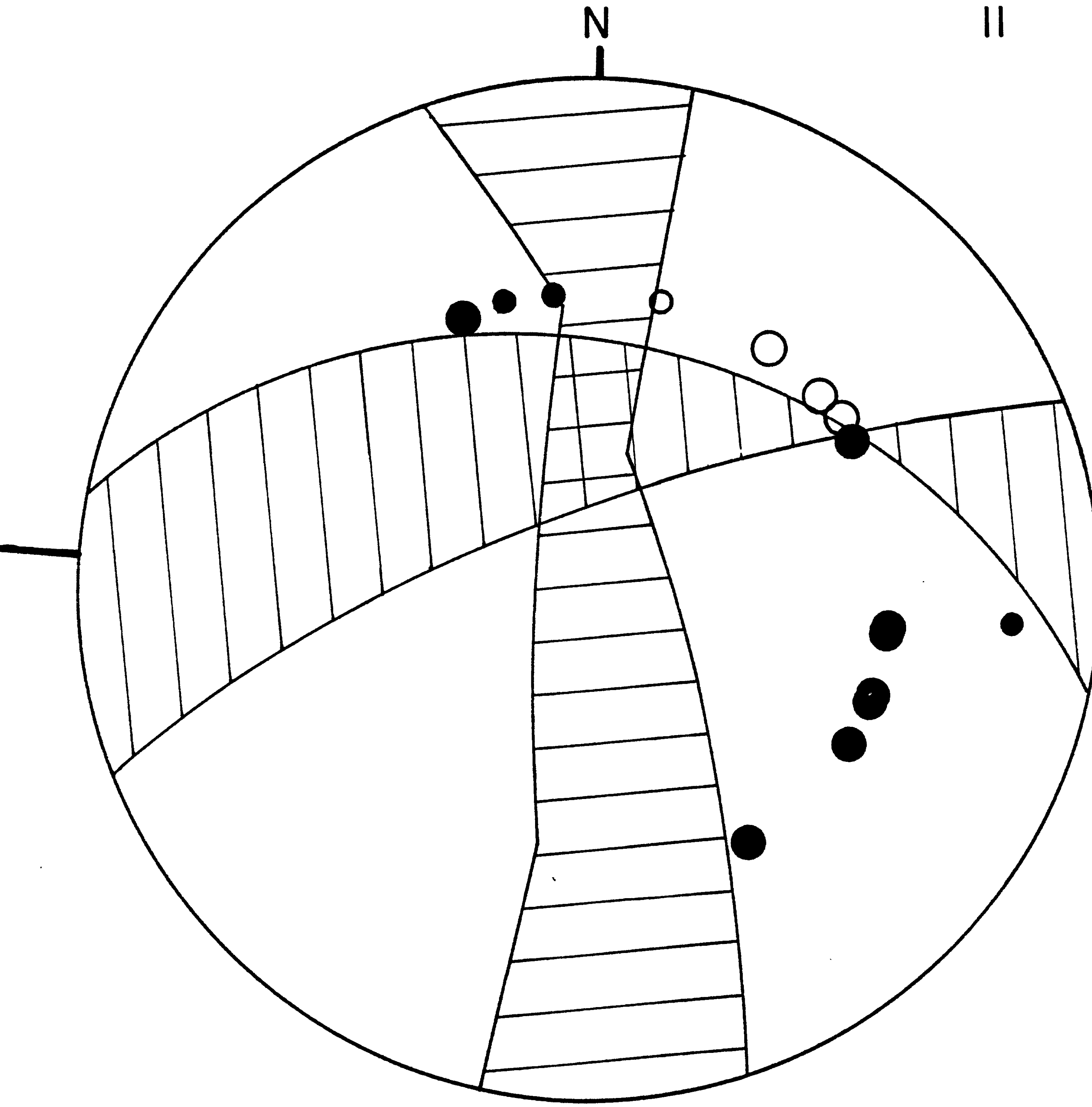

N
6

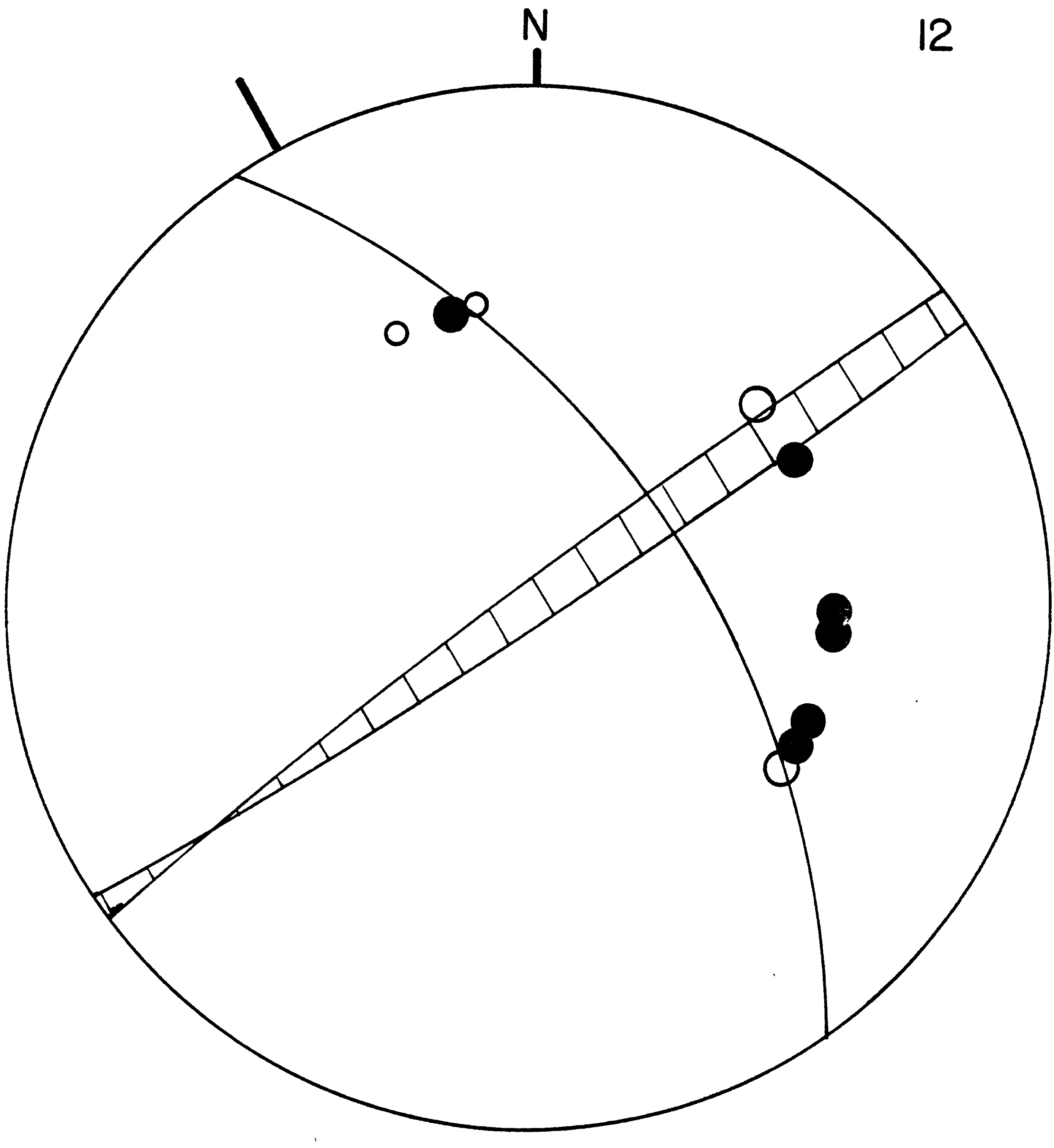

N
7

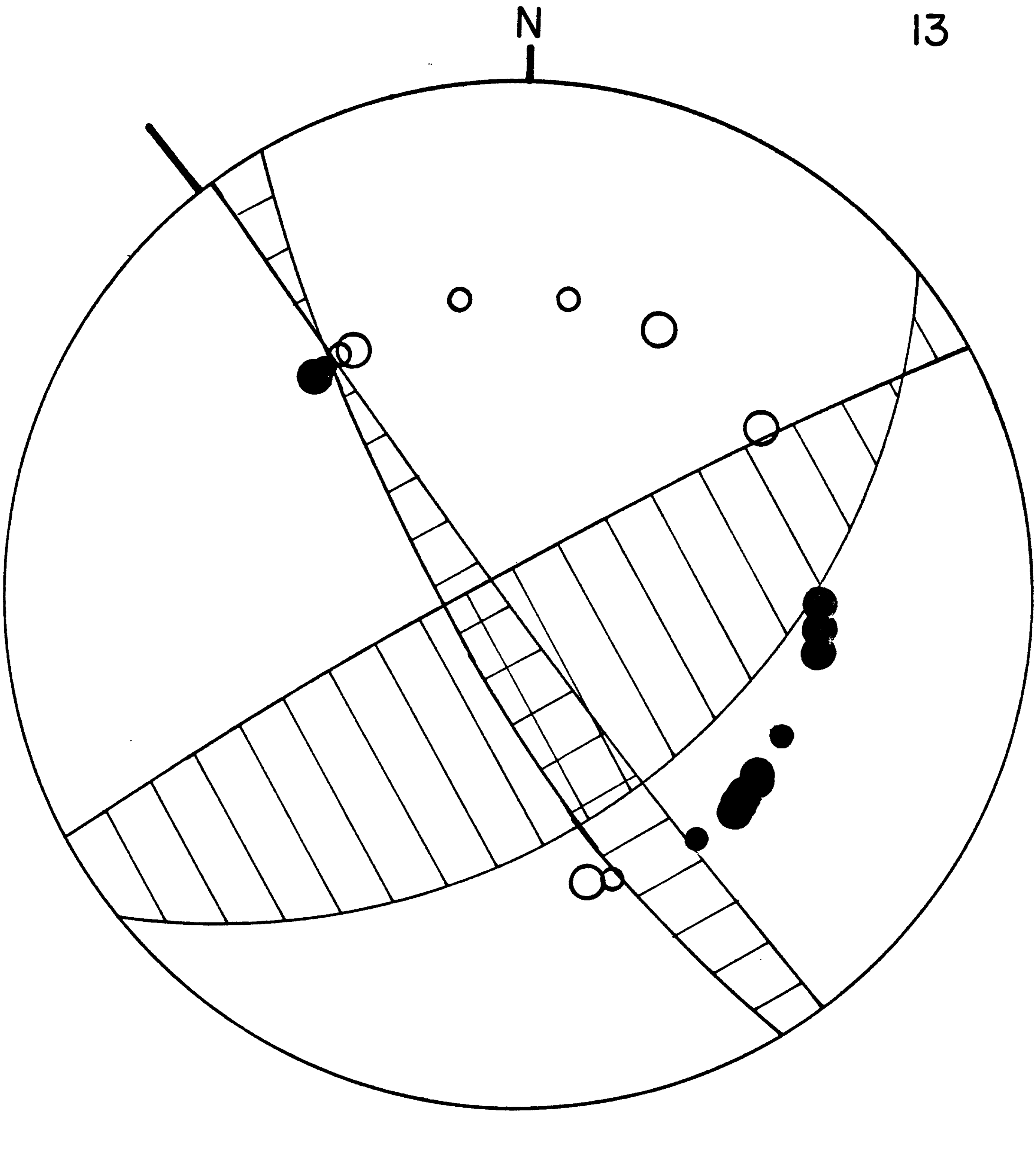

N
8

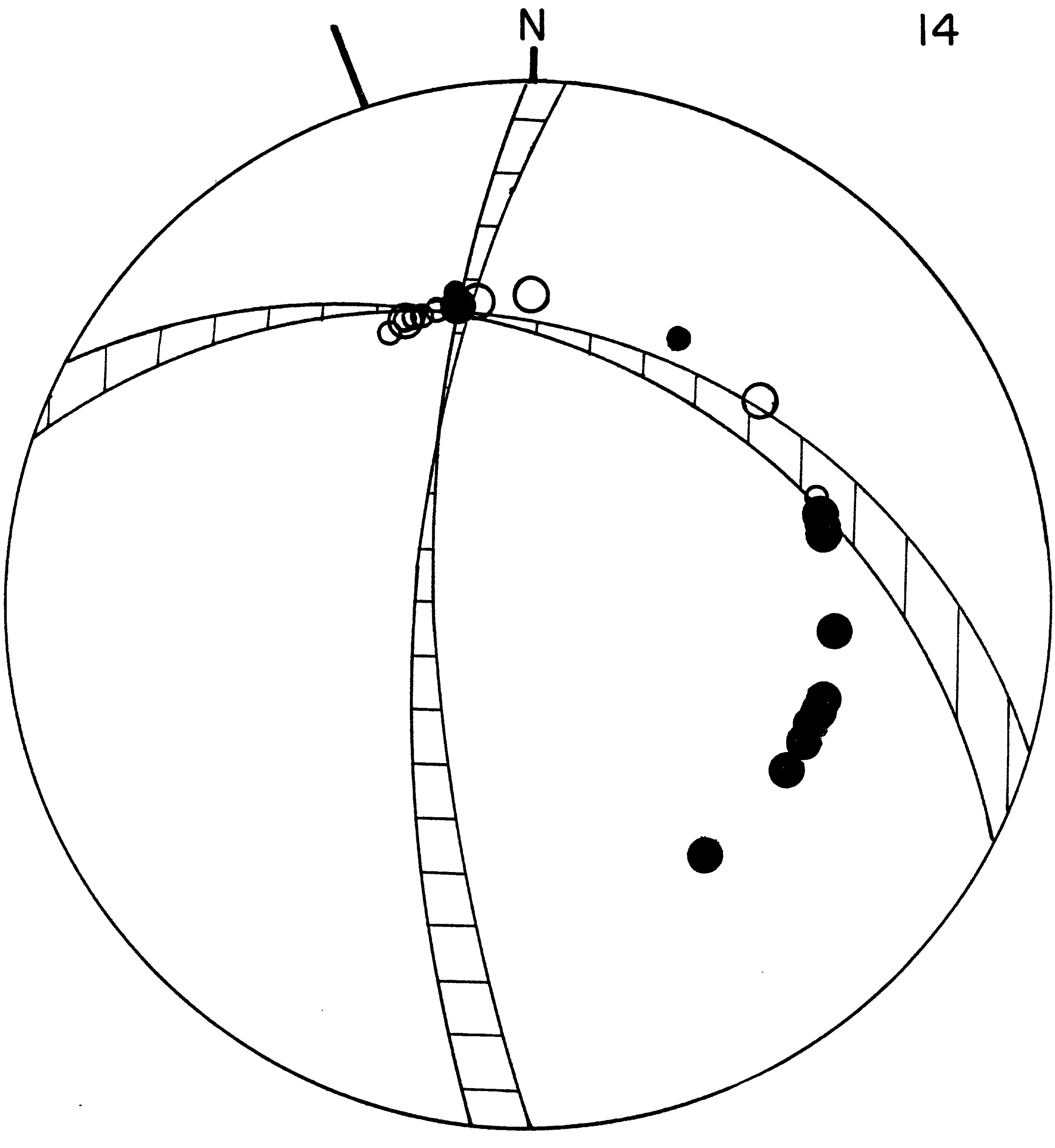

N
9
STRIKE
UNKNOWN

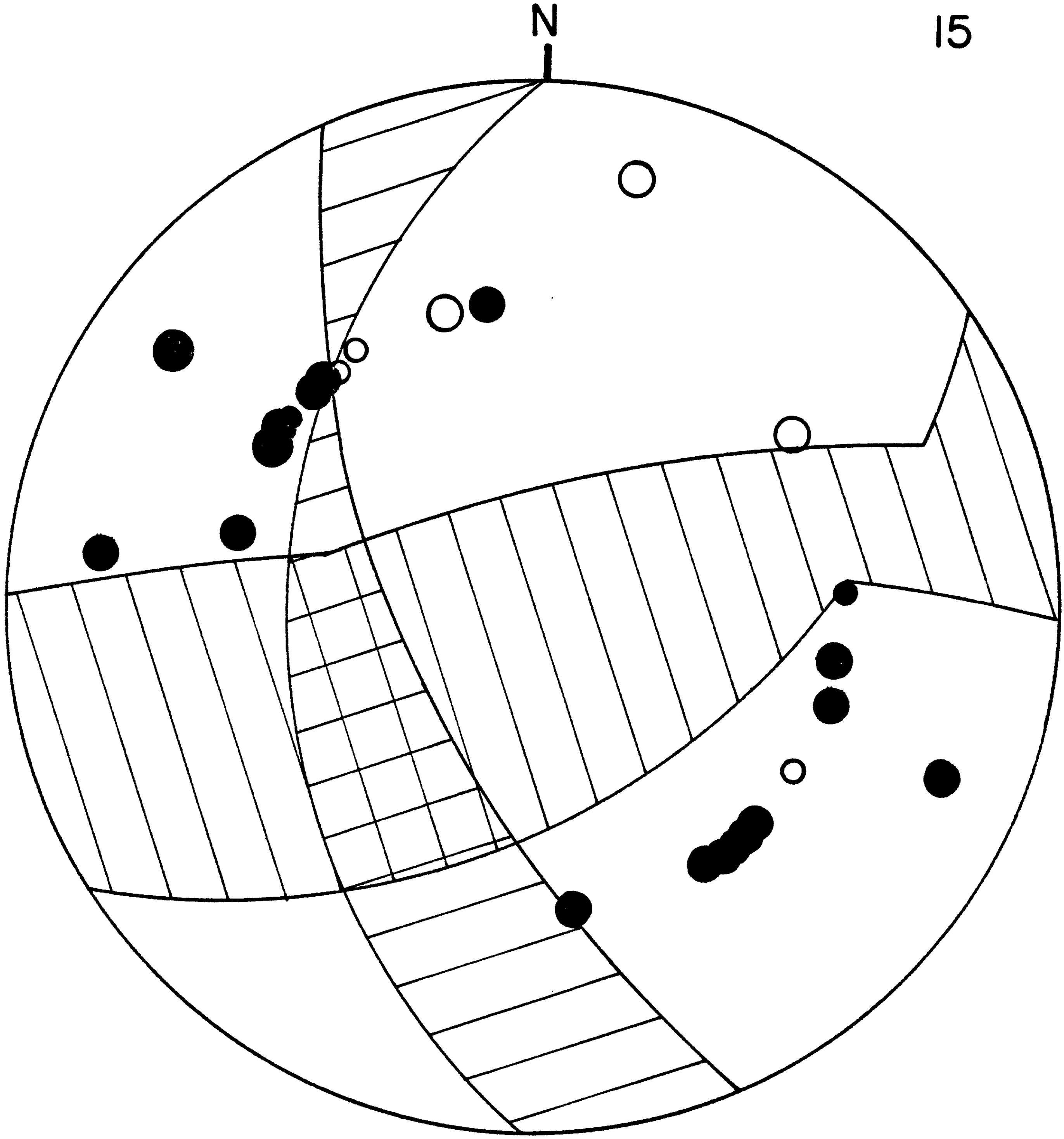

N
10

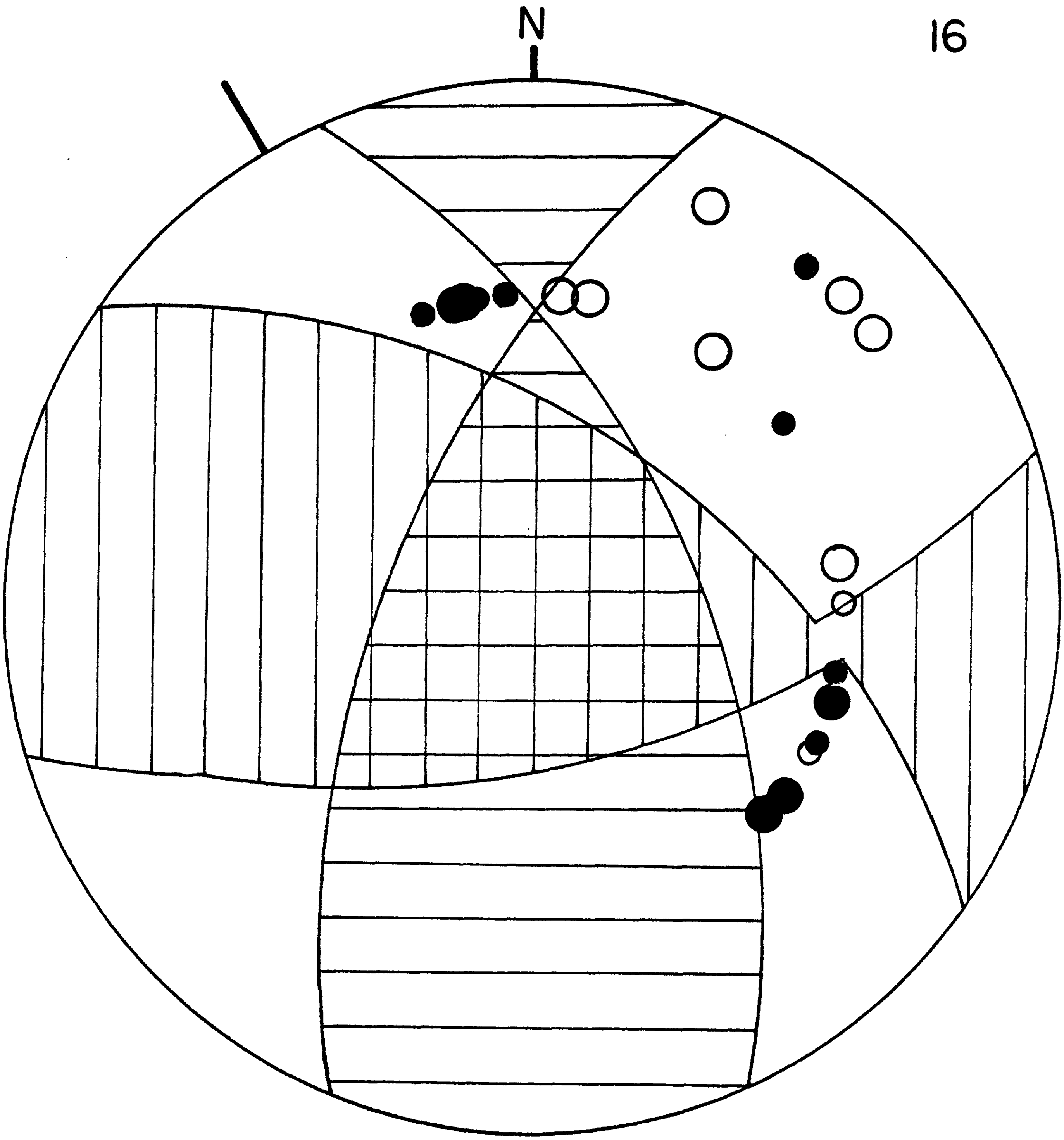

N
II

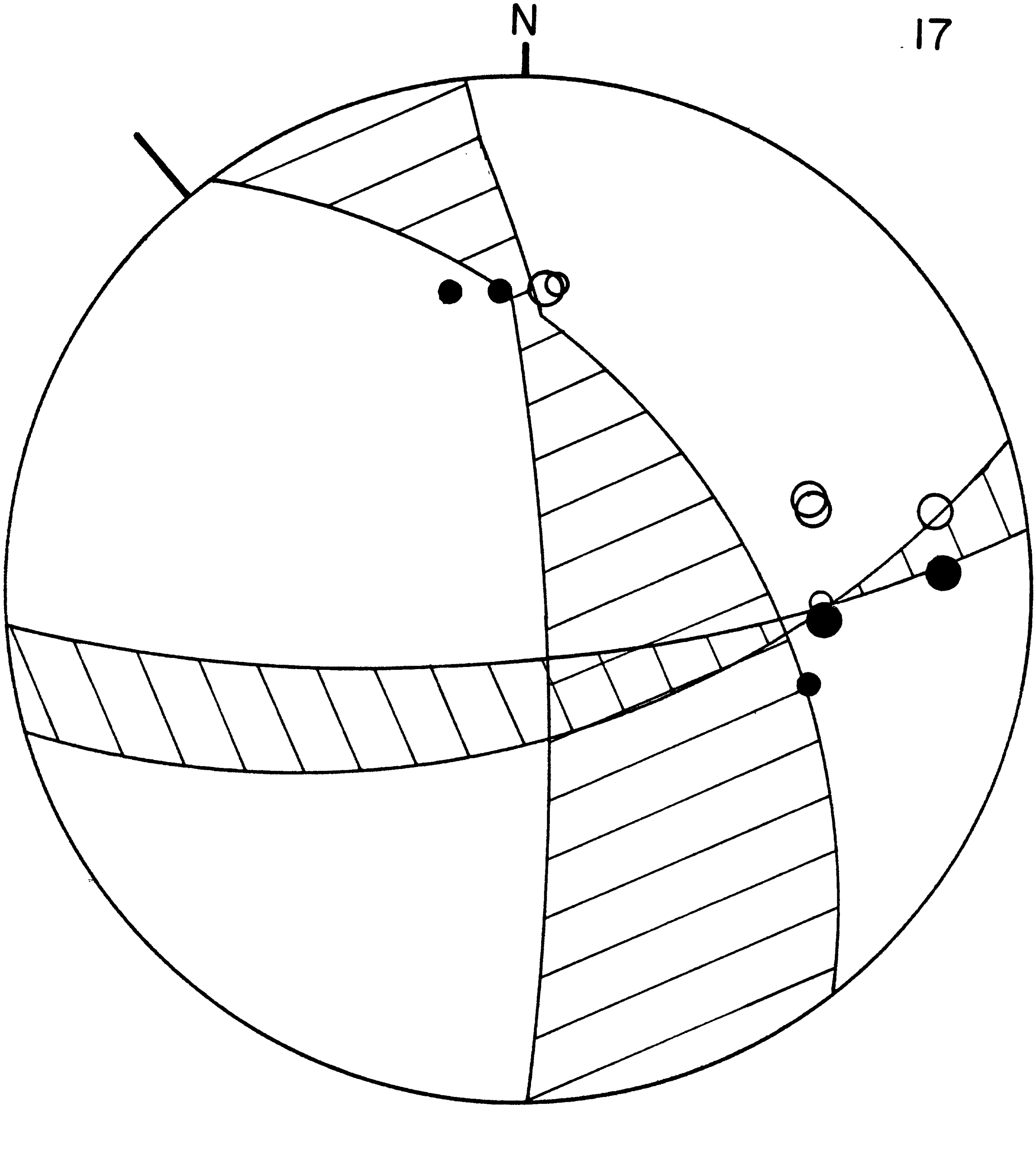

N
12

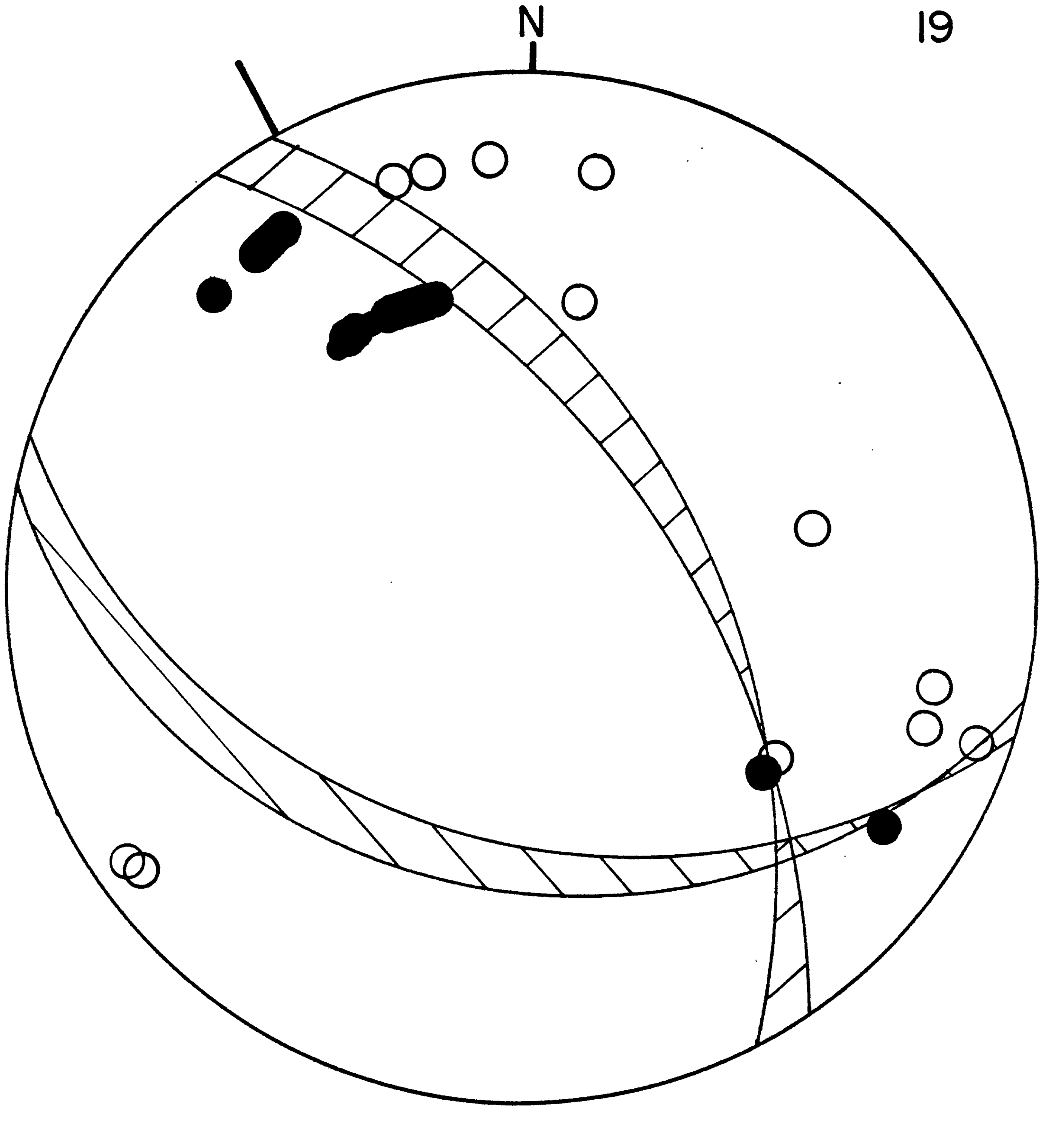

N
13

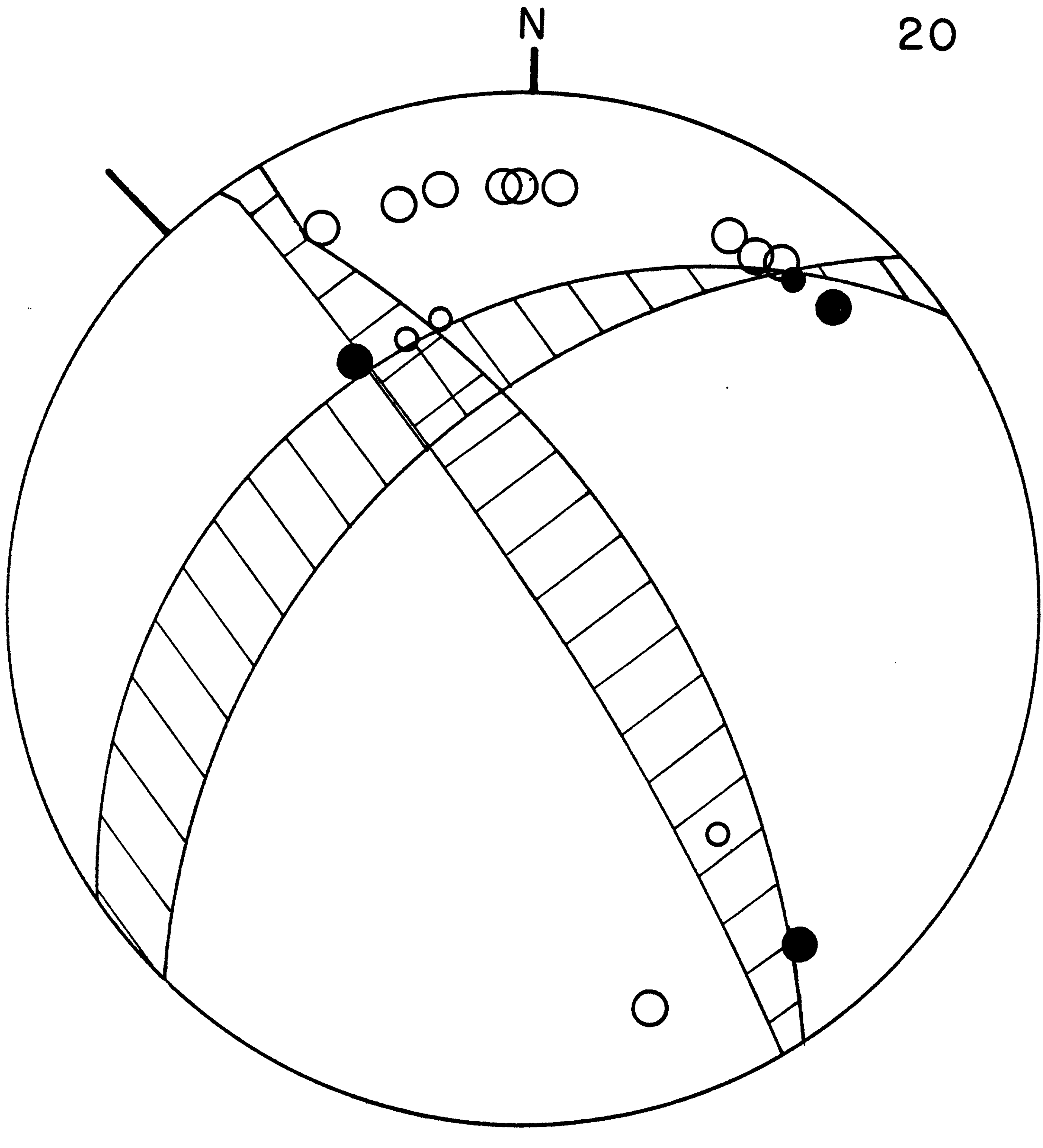

N
14

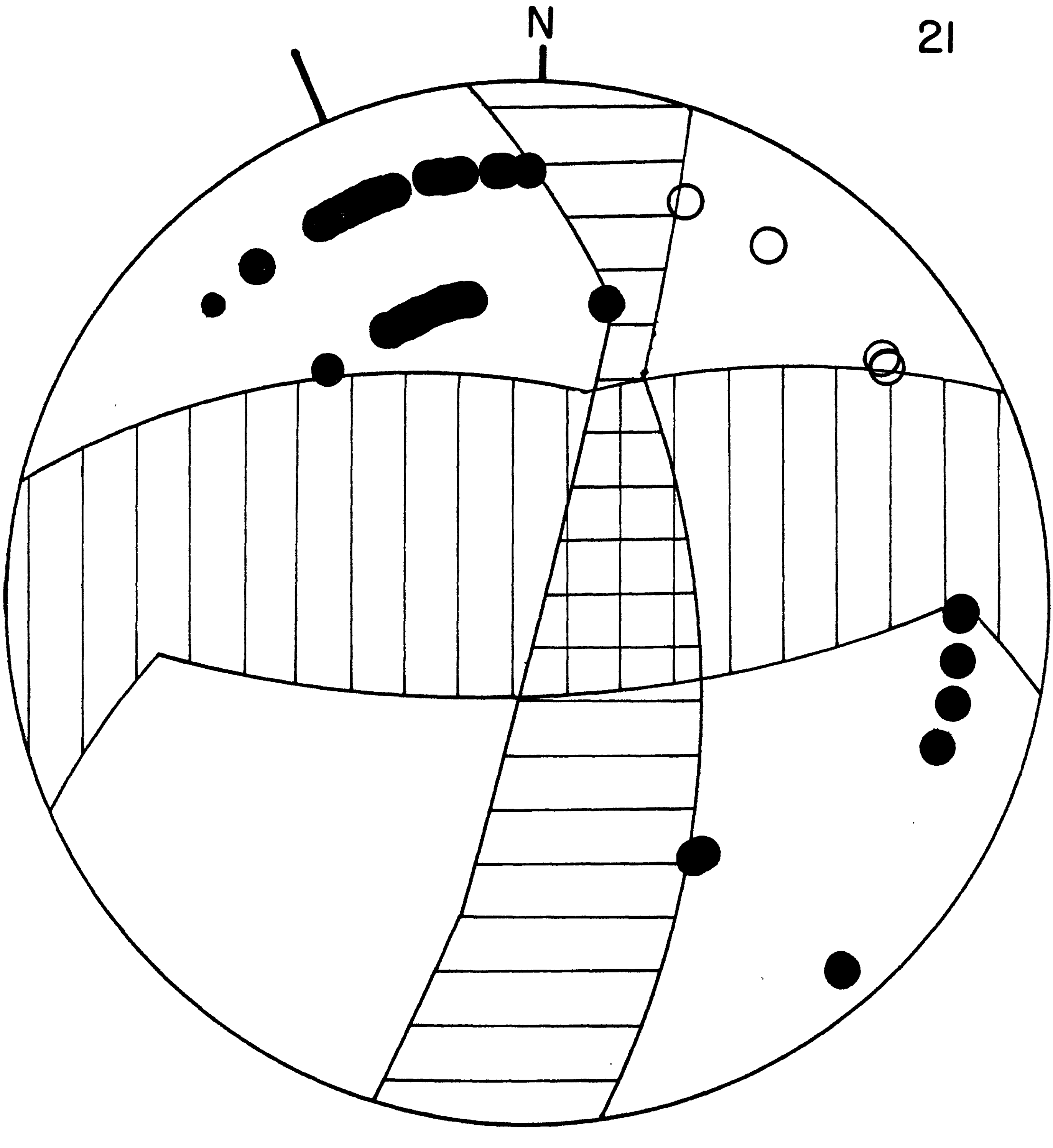

N
15

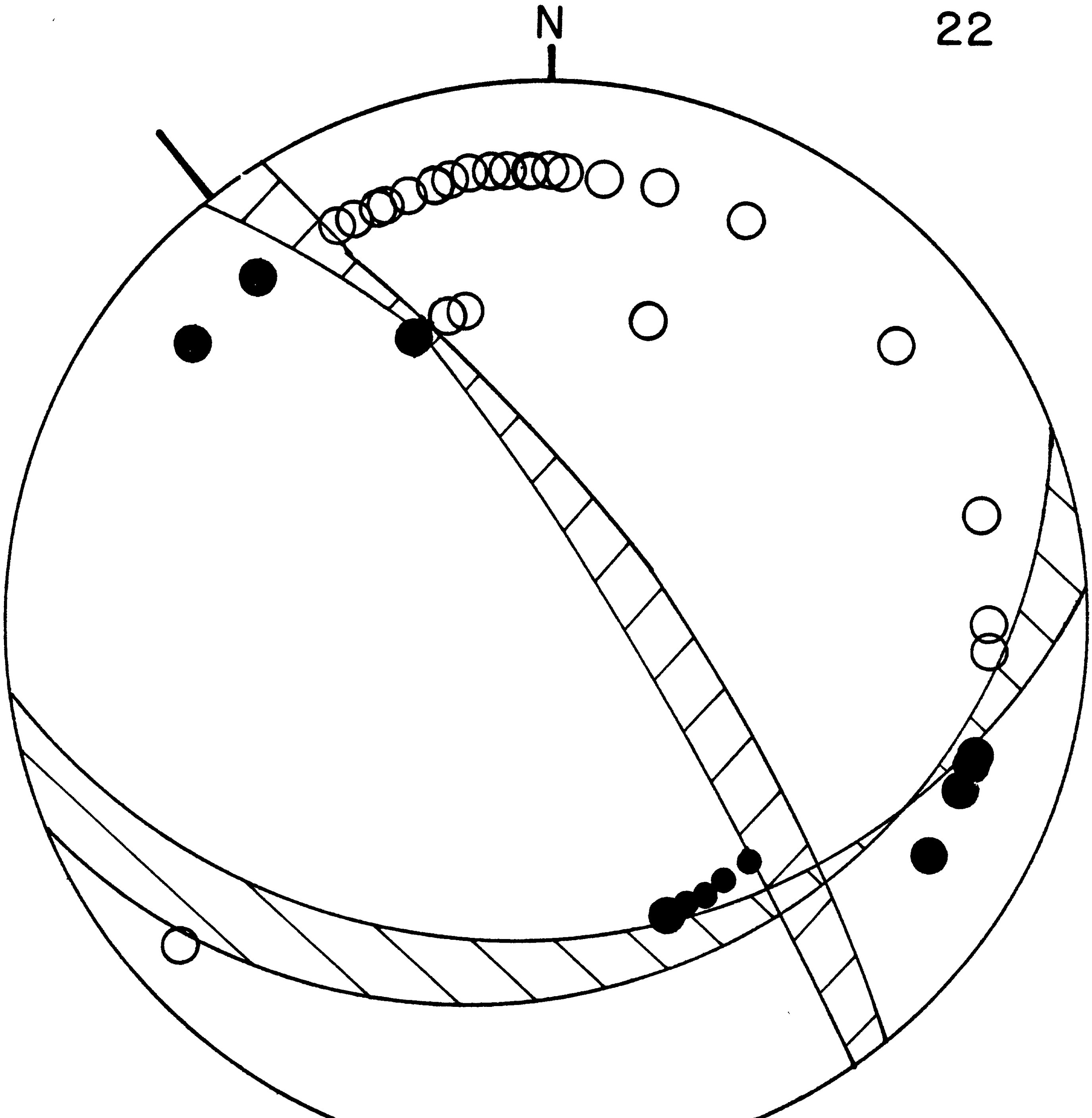

N
16

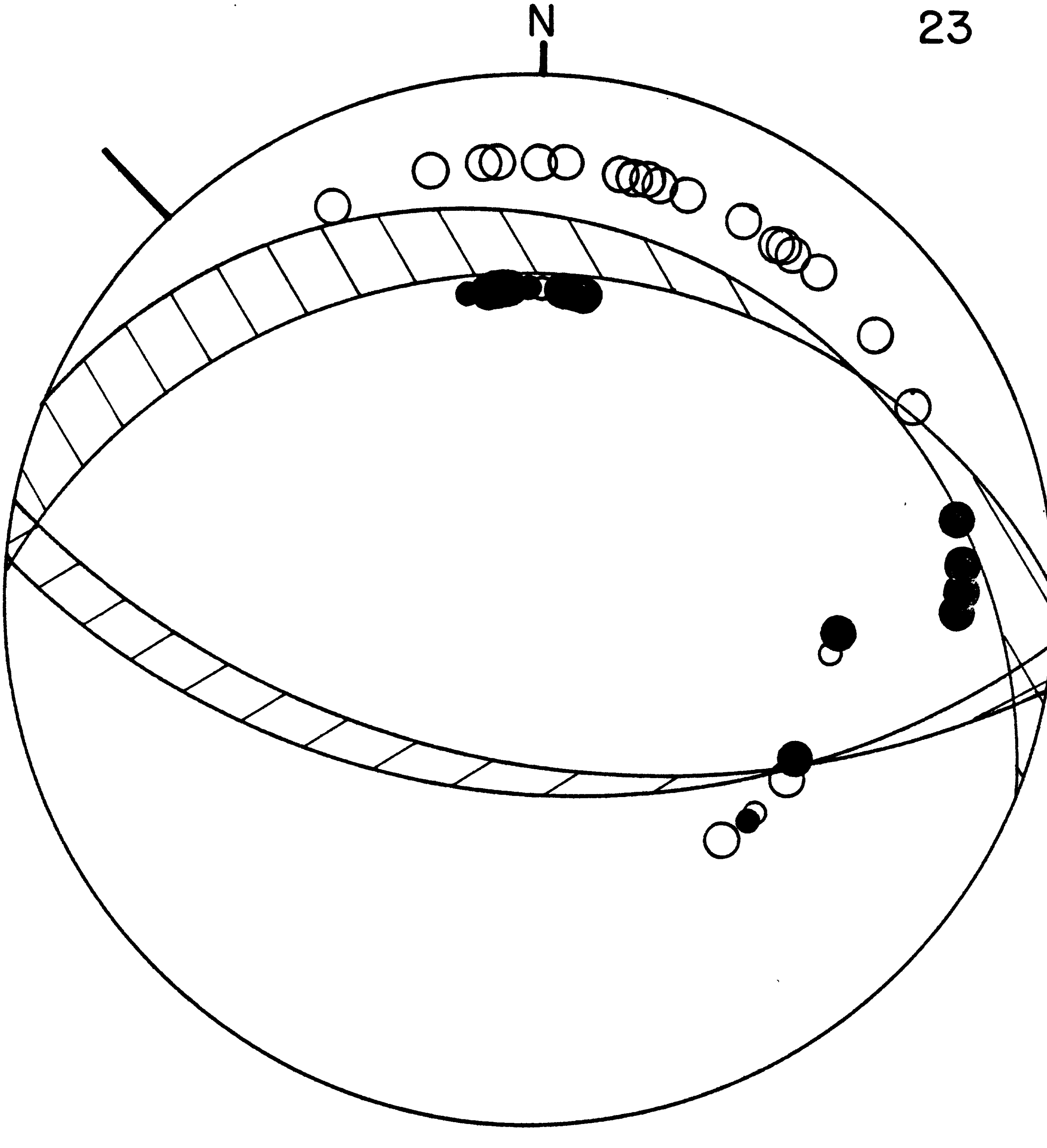

N
17

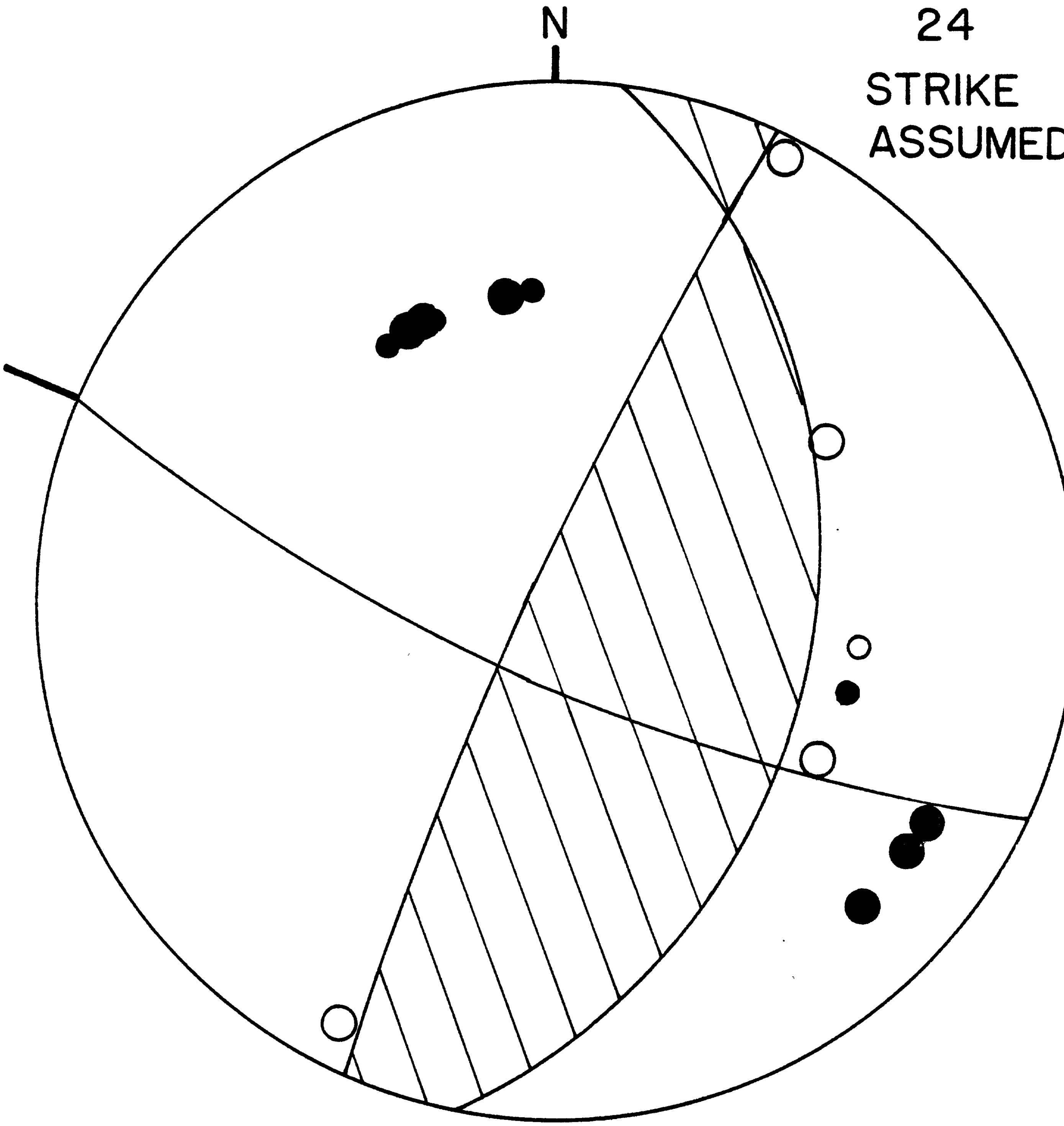

N
19

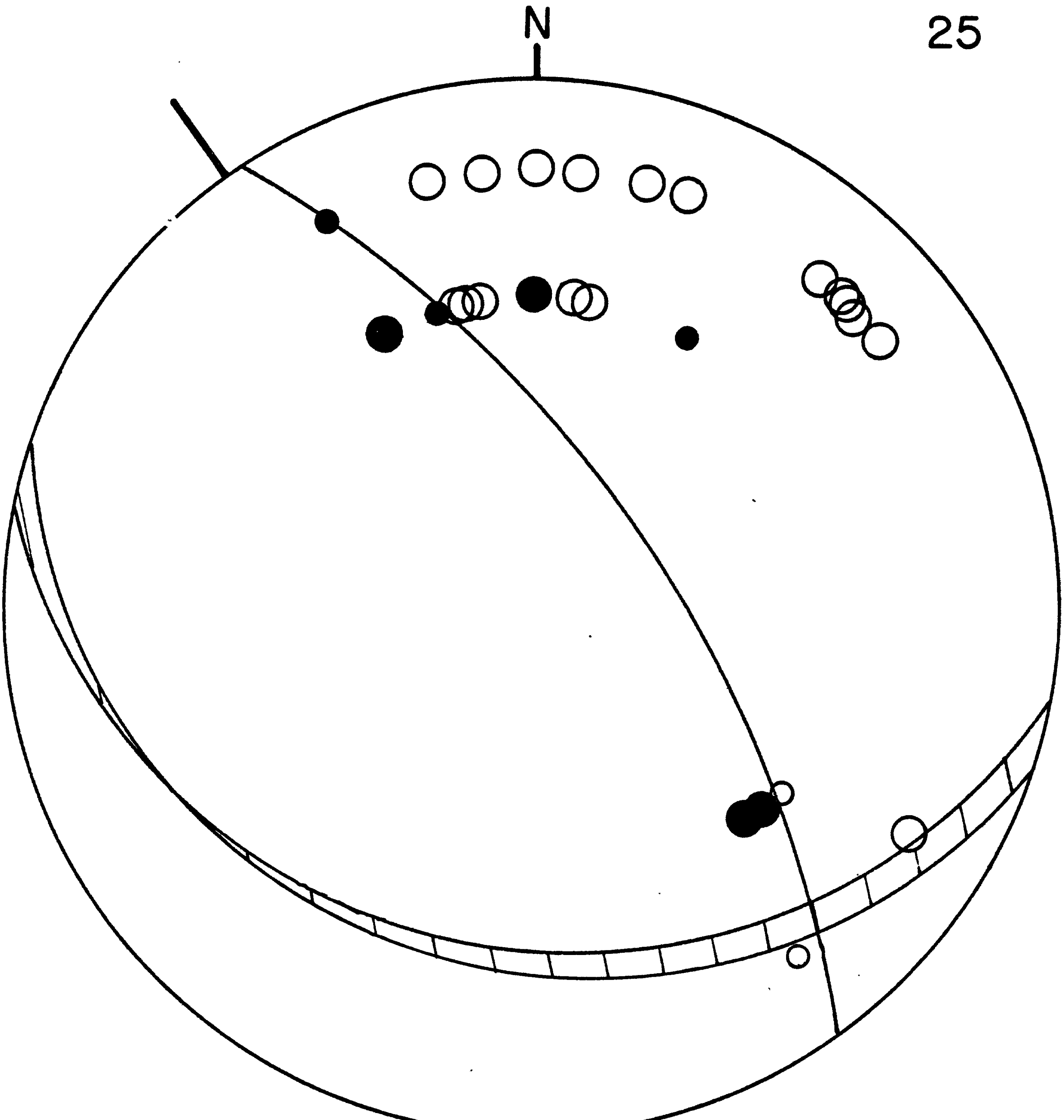

N
20

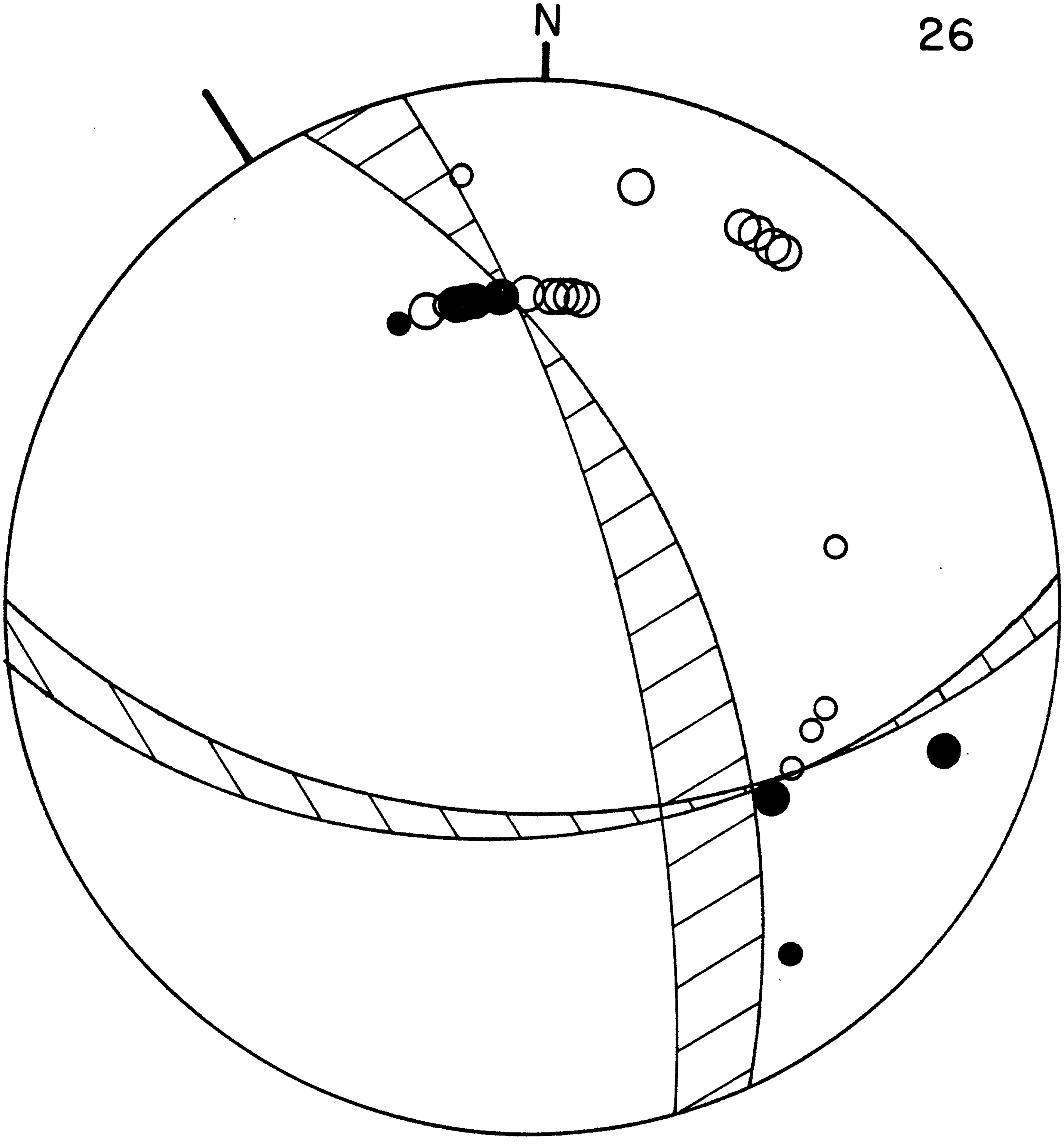

N
21

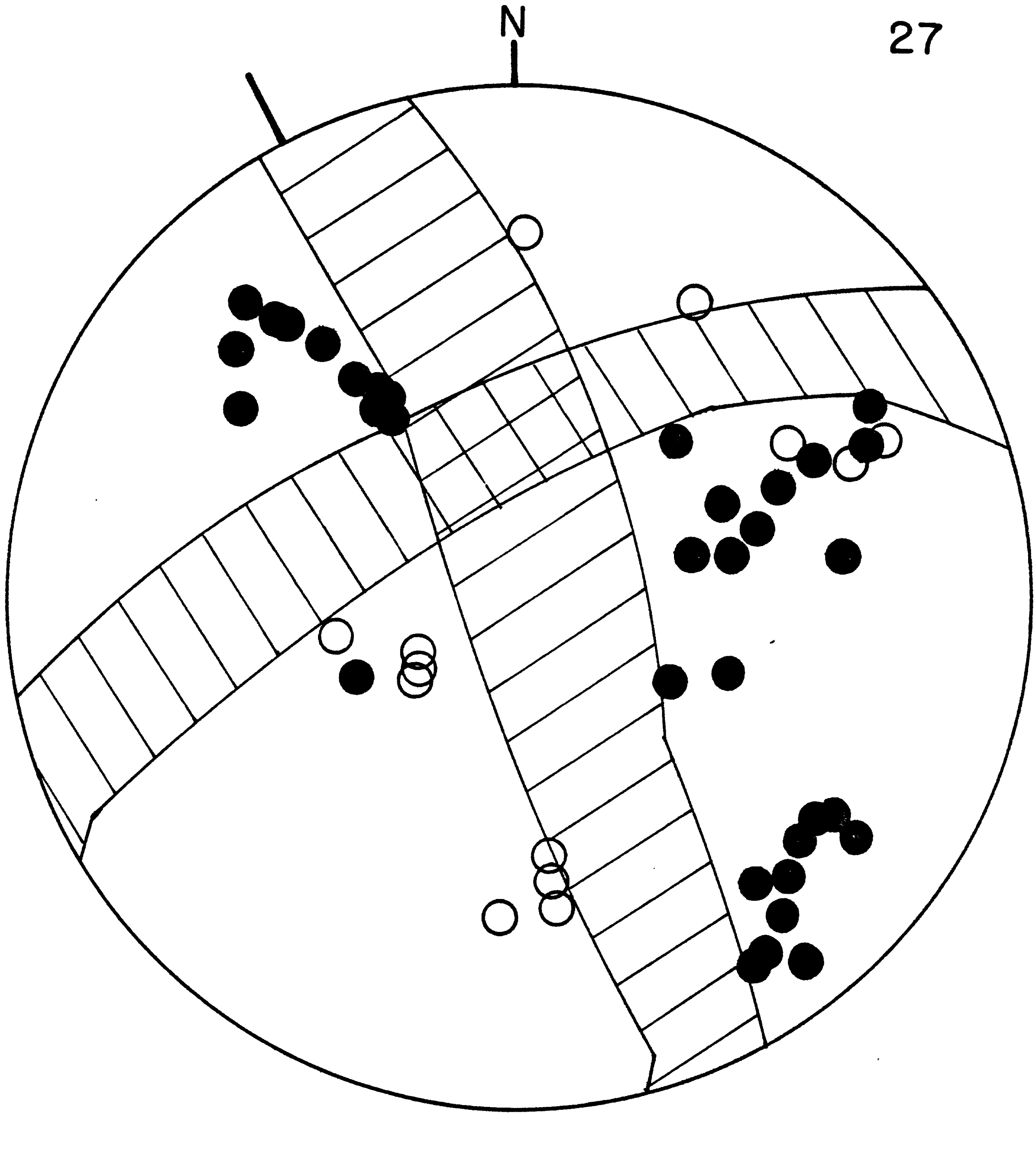

N
22


N
23


N
24
STRIKE
ASSUMED


N
25


N
26


N
27