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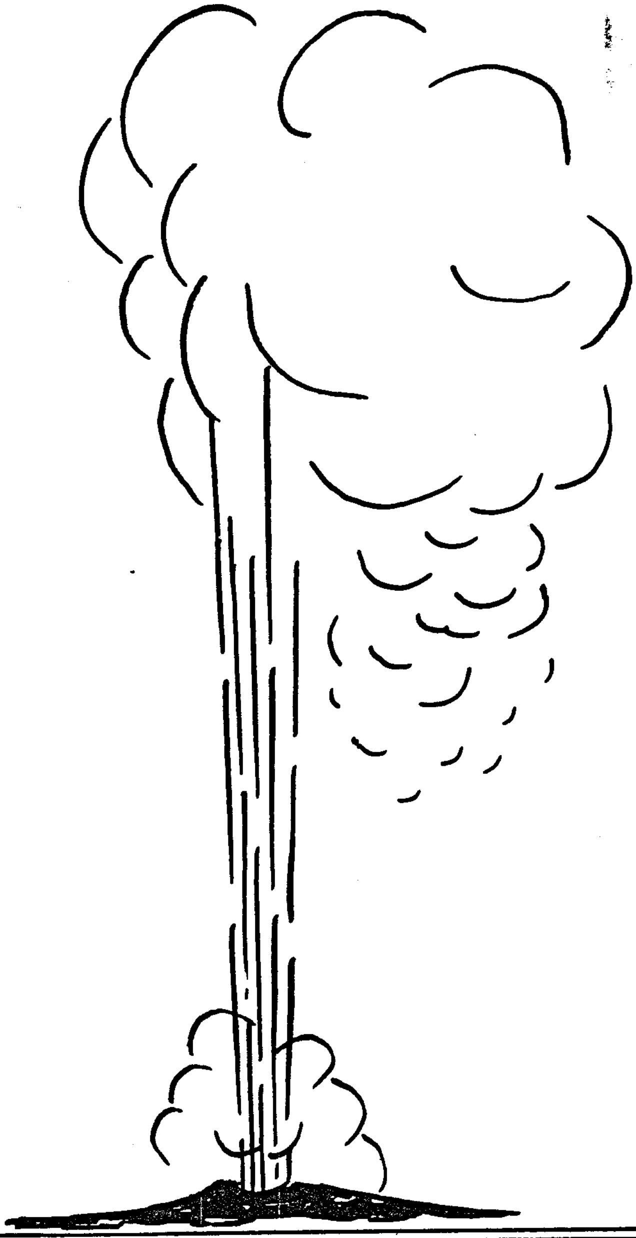

SEISMICITY RELATED TO GEOTHERMAL DEVELOPMENT IN DIXIE VALLEY, NEVADA

By
Alan S. Ryall
Ute R. Vetter

July 8, 1982

Work Performed Under Contract No. AC08-79NV10054

Seismological Laboratory
University of Nevada
Reno, Nevada

U. S. DEPARTMENT OF ENERGY
Geothermal Energy

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INTRODUCTION

The energy shortage has led to accelerated exploration of possible alternatives to US dependence on fossil fuel reserves, and as part of this effort a number of exploratory projects are under way to assess technological and environmental aspects of constructing and operating geothermal power plants. Of the environmental problems that might be associated with the utilization of geothermal resources, the possibility of affecting seismicity has been of particular concern.

The possibility of triggering earthquake activity by the reinjection of geothermal fluids into deep wells is based on known cases of changes in seismicity associated with fluid injection or reservoir loading. For example, Evans (1966) showed that earthquakes near Denver, Colorado, were linked to injection of waste fluid into basement rocks beneath the Army's Rocky Mountain Arsenal, and Raleigh and others (1972) carried out experiments to determine the reservoir pressure threshold needed to trigger earthquakes in an oil field near Rangely, Colorado. There have also been numerous cases of earthquakes associated with the impoundment of water in large reservoirs; six of these earthquakes had magnitude 5-6.5 (Simpson, 1976). Simpson concluded that the potential for induced seismicity appears to be highest in areas of strike-slip or normal faulting and areas of at least moderate strain accumulation. Most reservoir sites where major changes in seismicity have occurred (Kariba, Koyna, Hsinfengkiang, Hoover and Oroville) are close to areas of high seismicity or had low-level seismicity near the reservoir before impoundment. Areas of low strain accumulation or areas characterized by horizontal compression (thrust faulting) appear to have lowest potential for induced seismicity.

The relationship between induced seismicity and pore-pressure change has been clearly shown for earthquake activity associated with high-pressure fluid injection (Healy et al, 1968; Raleigh et al, 1976; Fletcher and Sykes, 1976). The effect of pore pressure on seismicity has been tentatively explained by the work of Hubbert and Rubey (1959), who showed that the fracture strength of rock is proportional to the difference between total normal stress across the fracture and the pressure of pore fluids within the rock. Simpson (1976) notes that increases in pore pressure in the case of fluid injection (a few hundred bars) are much higher than those (a few tens of bars) created by a deep reservoir. In cases where fluid injection has triggered earthquake activity (Denver, Rangely, Matsushiro, Dale) injection has taken place into, or very near a fault zone.

In recent years, Dixie Valley, north-central Nevada, has been the focus of geothermal exploration involving surface and drilling investigations by a number of oil companies. The area of most intensive study is between Dixie Hot Springs on the south and Sou or Seven Devils Hot Springs on the north. This area is a graben, capped by a gabbroic intrusive at a depth varying from approximately 1,500 to 2,000 feet. The investigation was intended to integrate industrial and academic research efforts to produce a comprehensive geothermal reservoir assessment of the central part of Dixie Valley.

Based on Simpson's (1976) criteria, Dixie Valley would have relatively high potential for induced seismicity should geothermal development of the area lead eventually to injection of geothermal fluids into deep wells. Features that make the area favorable for induced earthquakes are the following:

- The Dixie and Sou hot springs are on the surface trace of the Dixie Valley fault zone (Trexler et al, 1978).

- Significant movement, in a normal faulting sense, occurred on this zone in 1954 (Slemmons, 1957).

- The area of interest is just south of a zone that Wallace (1978) believes is a "seismic gap," that could be filled by a single ML 7.4 earthquake.

- The area of interest is at the north end of the aftershock zone of the 1954 Fairview Peak-Dixie Valley earthquakes, a zone characterized by moderate-to-high seismicity (Ryall, 1977).

Because of the high potential for induced seismicity, a detailed microearthquake study was undertaken by the University of Nevada in parallel with other studies in the Dixie Valley area. The primary objective of this study was to provide a baseline for assessment of changes in seismicity associated with future injection of geothermal fluid into deep wells if the geothermal field is developed commercially. Primary objectives of the investigation were to operate a network of seismic stations in Dixie Valley, and to analyze and interpret the network data. The DOE contract supporting this study began on 16 August 1979 and was initially written to cover a one-year effort. The Seismological Laboratory installed ten seismic stations in and around Dixie Valley in December 1979, and the network began full operation in January 1980. Primarily because of high equipment reliability and very low seismicity the rate of expenditure on this project was lower than originally anticipated, and the period of performance was extended from 12 to 27 months at no additional cost to DOE.

SEISMIC CYCLE IN THE WESTERN GREAT BASIN

A number of papers have been published treating various aspects of the seismic risk problem in Nevada. Slemmons et al (1965) compiled a catalog of earthquakes for the Nevada region for the period 1852-1960. Ryall et al (1966) studied seismicity of the western United States based on earthquake catalogs for various regions. Slemmons (1967) used photogrammetric methods to map Pliocene and Quaternary faults within the Great Basin province, and grouped the faults according to degree of weathering and other age-related parameters. Ryall et al (1974) studied microearthquake activity for 1970 and 1971, and compared the distribution of these events with locations of large historic earthquakes and active faults. Douglas and Ryall (1975) used earthquake recurrence statistics for 1932-1969 to determine average acceleration return periods from calculations involving distance to the causative fault and magnitude. Wallace (1977, 1978) studied the morphology of young fault scarps in north-central Nevada to estimate average recurrence times in that region. Ryall (1977) reanalyzed historic and current seismicity patterns to determine the character of the seismic cycle, as well as foreshock and aftershock sequences in western Nevada. VanWormer and Ryall (1980) and Ryall and VanWormer (1980) related earthquake hazard and maximum magnitude to structure and active tectonic processes along the Sierra Nevada-Great Basin boundary zone, and recommended changes in seismic zonation for the western Great Basin.

Large Historic Earthquakes.

During the historic period since about 1840, five major (M > 7) earthquakes have occurred in the western Basin and Range province. Approximate rupture zones for these events are shown on Figure 1, and descriptions are given below.

- 1845(?) Stillwater area(?). At the time of the 1869 Virginia City earthquake the Gold Hill News reported that a Washoe Lake Piute aged about 30 years stated that there had been a great earthquake when he was a little boy, while Indians from the Walker, Carson and Truckee Rivers were fishing at the Carson Sink. The shock knocked people down, river banks were shaken down in the vicinity of Stillwater, and the river changed its course. Slemmons et al (1965) placed this event farther to the west, near Pyramid Lake, and gave it a date of 1852(?) based on an 1865 Indian report of ground failure in the Pyramid Lake area and landsliding along the Sierra Nevada near Reno.

- March 26, 1872, Owens Valley, California. In Lone Pine, out of a total population of 250-300, 23 were killed and 60 injured; 52 out of 59 houses (mainly adobe) were destroyed. Faulting along the east side of the Owens Valley extended for at least 70 km, with scarps up to 7 meters high. The earthquake was felt over 640,000 sq miles, which according to Oakeshott et al (1972) would correspond to magnitude around 8.

- October 2, 1915, Pleasant Valley. This earthquake was accompanied by faulting for a distance of 30-40 miles along the western face of the Sonoma Range, with scarps 2-4 m high. Damage was greatest at Kennedy, where every building was destroyed; in Winnemucca nearly every chimney was toppled, walls were cracked and a few thrown down. The shock was felt over 500,000 sq miles. Richter (1958) estimated that it had magnitude 7.6.

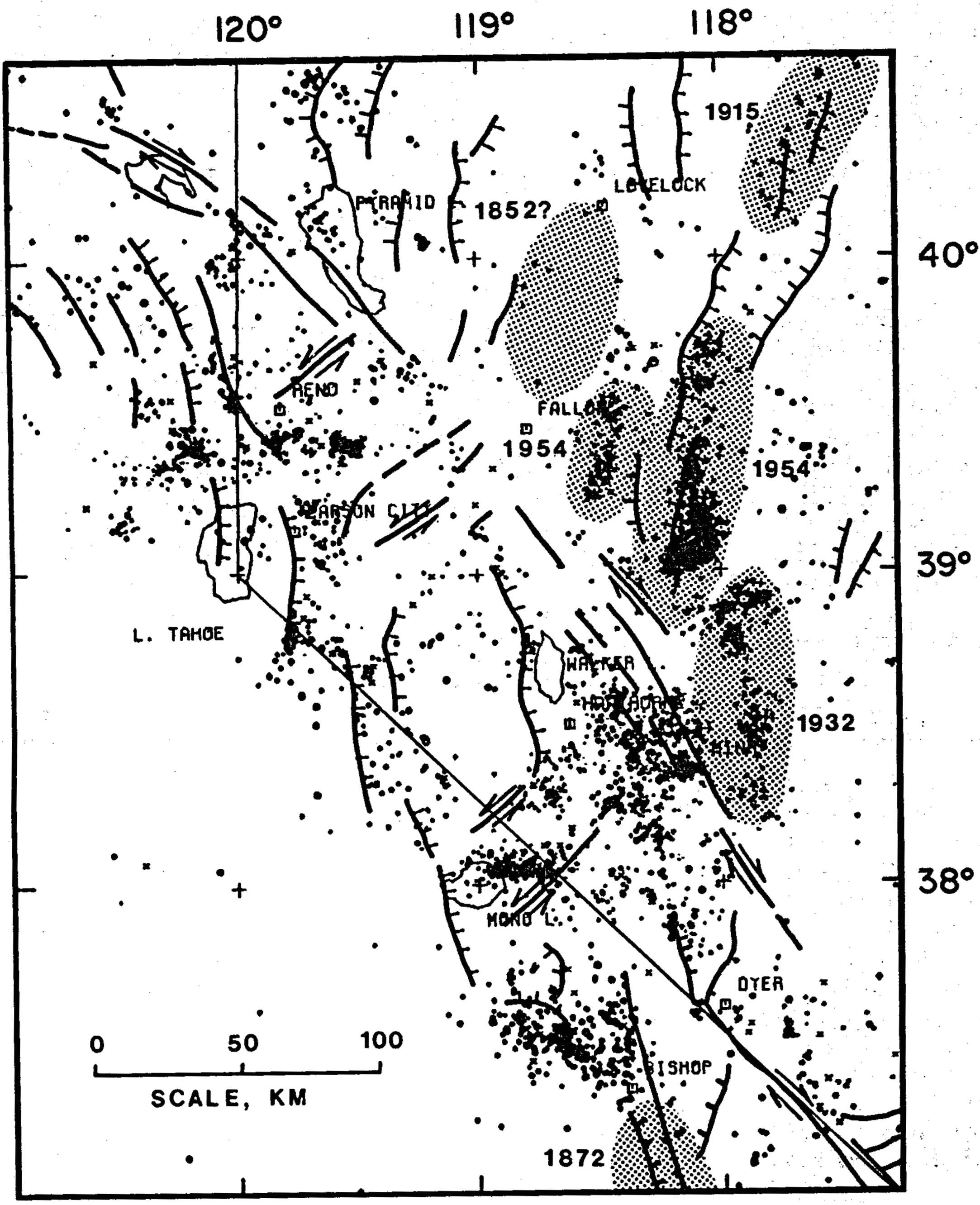

Figure 1. Generalized map of late Cenozoic structural features of the western Great Basin (Wright, 1976), together with epicenters of earthquakes for the period 1969-1978 (dots) and approximate rupture zones of major historic earthquakes (stippled areas, with year of the main shock).

- December 20, 1932, Cedar Mountains. The Cedar Mountains earthquake had magnitude 7.3 (Richter, 1958) and was felt throughout Nevada, California and Utah. Faulting consisted mainly of fissures with occasional evidence of vertical or lateral slip (Gianella and Callaghan, 1934). Vertical scarps were small, usually only a few inches; the zone of surface rupture extended for about 60 km in a northwest-southeast direction, and was 6-14 km wide.

- December 16, 1954, Fairview Peak-Dixie Valley. In this sequence, a magnitude 7.1 shock at Fairview Peak was followed 4 minutes later by a magnitude 6.8 event about 55 km to the north in Dixie Valley (Romney, 1957). These earthquakes were accompanied by surface ruptures in two zones trending slightly east of north. The southern zone, associated with the Fairview Peak shock, was 50 km long and 10 km wide; the Dixie Valley rupture zone to the north was about 40 km long and 5 km wide. The Dixie Valley zone had more than 2 m of dip-slip movement, while the Fairview Peak zone had about 4 m each of vertical and horizontal movement. The two shocks did little damage because the region of maximum shaking was very sparsely populated; however, they were felt over 220,000 sq miles in eastern Oregon, Idaho, Utah, California and northwest Arizona. The earthquakes in December followed by only a few months the Fallon-Stillwater earthquakes of July 6 and August 23, 1954. The first of these, with magnitude 6.6, caused damage at Fallon; the second had magnitude 6.8. The combined rupture zone of the two events had length 40 km and was a few km wide; it was parallel to and about 30 km west of the Dixie Valley zone.

Active Faults.

From the geologic literature, active faulting in the western Great Basin is distributed rather evenly over much of the region and not confined to a single belt analogous to the San Andreas zone in California. Figure 2, based on a paper by Slemmons (1967), shows faults in late Quaternary alluvium, lake sediments of the playa, Bonneville or Lahonton type, or glacial deposits. Approximately a thousand faults are shown on the figure, ranging in length from about 1 to more than 100 km. Presumably faults shown as continuous for several tens of kilometers on the figure were so mapped because they had fresh, continuous scarps that could be clearly identified on aerial photographs. Faulting associated with the 1915 Pleasant Valley and 1954 Dixie Valley-Fairview Peak earthquakes appears in the center of the figure as an almost continuous, 200-km long zone; in contrast, the 1932 Cedar Mountains rupture, just south of the 1954 zone, consists of about 20 small faults or fissures, none of which is more than a few kilometers in length.

In recent studies of fault-scarp morphology, Wallace (1977,1978) estimated the most recent age of displacement for 19 clusters of faults in an area of 17,000 sq km in north-central Nevada. He concluded that no more than seven major events occurred in this area in Holocene time, leading to average re-rupture times of 4,000-30,000 years for the various rupture zones in the study, based on the assumption that a typical rupture zone has area of about 1,000 sq km, and that such rupture zones comprise the entire 225,000 sq km region containing Holocene scarps in the western Great Basin. Wallace also observed that fault-scarp morphology in the rupture zones of major historic earthquakes does not suggest faulting at a greater rate than in surrounding areas.

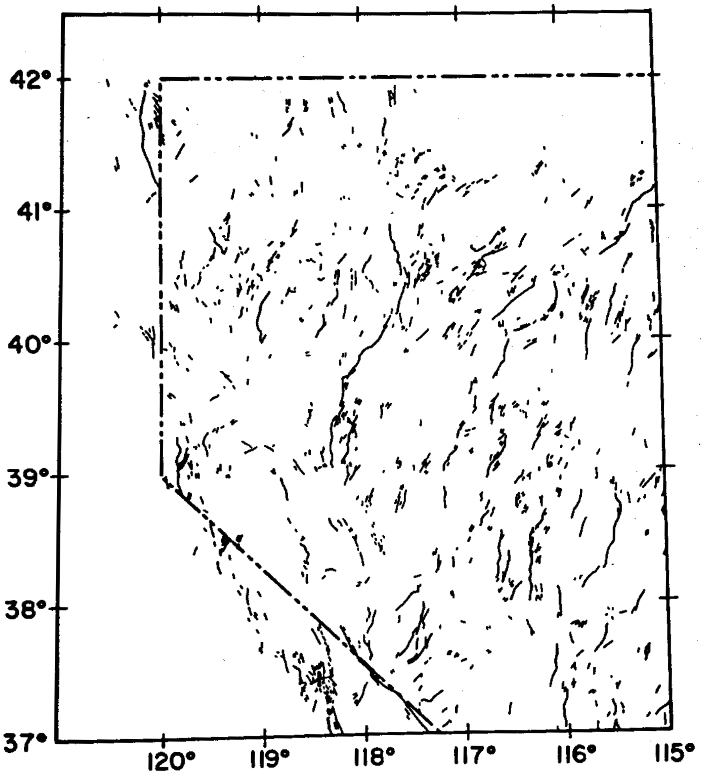

Figure 2. Map of faults that show photogrammetric evidence of Quaternary displacement (adapted from Slemmons, 1967).

In the Dixie Valley area, Wallace (1981, personal communication) has concluded that the 1954 earthquake was preceded by faulting concentrated in the north end of the rupture zone, and that this area acted as a nucleation point from which the rupture propagated to the south at the time of the main shock. In support of this conclusion he observes that a series of 4-5 scarps in the vicinity of Dixie Hot Springs had recurrent movement during Holocene time, while scarps to the south did not, that the 1954 shock produced only small displacement in the northern part of the valley and large displacements to the south, and that Romney's (1957) epicenter for the Dixie Valley earthquake was at Dixie Hot Springs (39.8 deg N, 118.1 deg W, depth about 40 km).

Wallace (1978) has also identified a seismic gap, between the 1915 and 1954 rupture zones, which he describes as follows:

> "Between the southern end of the 1915 Pleasant Valley scarp and the northern end of the 1954 Dixie Valley scarp is a segment of fault-generated range front which has not broken in historic time. The gap is about 40 km long, and includes the precipitous east flank of the northern end of the Stillwater Range."
>
> "This precipitous segment of range front is about 20 km long and rises approximately 1,000 m from the floor of Dixie Valley. A slope of between 30 and 35 degrees is maintained over much of the scarp height. The steepness of this scarp suggests a rate of uplift much higher than the regional average and thus accelerated uplift in the last few million years. If uplift of 1,000 m is assumed to have occurred in 2 million years, the rate of uplift is 0.5 m per 1,000 years. If a 3-m displacement event produces an M7 event, the average interval of time between such events would be 6,000 years, discounting the effect of small events and tectonic creep."
>
> "The age of the latest scarp at the base of the east flank of the Stillwater Range is not well determined, but a preliminary analysis of its morphology suggests that the latest displacement is no older than about 12,000 years (Holocene). The basal part of the scarp, which probably was produced in a single event, is approximately 8 m high and, corrected for erosion, represents displacement of approximately 5-6 m."
>
> "If the 40 km-long gap were to be filled by a single fault event having an average displacement of 5 m, an earthquake of approximately 7.4 ML could be generated."

Rates from Instrumental Data.

The results of Wallace and Pease provide an opportunity to compare recurrence rates determined from paleoseismic studies with those obtained from lists of instrumentally recorded earthquakes. Ryall (1977) gives a recurrence rate of

$$\log N = 4.85 - 0.784\ M$$

based on 2,000 earthquakes recorded in the entire Nevada region from 1970 to

1974. For the period 1932 to 1969, Douglas and Ryall (1975) give a recurrence rate of

$$\log N = 6.48 - 0.91 M$$

for the western Great Basin. Assuming that the rupture zone for a typical large earthquake has an area of about 1,000 sq km and that such rupture zones comprise the entire 225,000 sq km in which Holocene faulting has occurred, these recurrence rates lead to re-rupture times of 7,000-10,000 years.

Foreshocks and Aftershocks.

With regard to foreshocks, a search of 13 northern Nevada newspapers for the historic period prior to 1917 (Appendix A) and instrumental recordings after that time (Appendix B) indicates that both the 1915 Pleasant Valley and 1954 Dixie Valley-Fairview Peak earthquakes were preceded by moderate seismicity for at least several decades prior to the main shock. A comparison of reported intensities for communities around the meizoseismal area of these events indicates that at least eight earthquakes with $M = 4.0-4.5$ occurred in the Pleasant Valley area during a 43-year period prior to 1915, and five shocks with $M = 4.5-5.5$ were located in the Dixie Valley area during an 82-year period prior to 1954. The level of activity for the two zones was similar: each had a return period of 5 to 6 years for events with $M > 4$. Taking into account differences in area of the rupture zone of a great earthquake and area of the region containing Quaternary faulting, this indicates a rate of foreshock activity several times higher than the average rate of occurrence of events with $M > 4$ in the Nevada region during the 1970's.

As observed in other regions, large shocks in the Great Basin may also be preceded by a period of quiescence following the general increase in moderate seismicity mentioned above. This is illustrated by Figures 3 and 4, which show the distribution, respectively, of individual earthquakes with $M > 4$ and of energy released in the Dixie Valley-Fairview Peak area before 1954. On Figure 3, earthquake activity in central Nevada (area bounded by latitude 38 to 40 deg N, longitude 117.5 to 119 deg W) is shown as a function of time and latitude, for the period 1930-1962. The figure is based on locations and magnitudes given by Slemmons et al (1965) for earthquakes with $M > 4$. On the left side of the plot, activity during the first half of the 1930's represents mainshock/aftershock activity in the Cedar Mountains-Excelsior Mountains. Seismicity in the Fairview Peak area is represented by a few events in the late 1930's, a 12-year period of quiescence from 1940-1952, a burst of 11 events in late 1952 (largest $M = 4.8$) in the vicinity of the 1954 main shock, a 19-month gap, and intense activity before the main shock.

The same sort of increase in activity following a period of quiescence is shown by the plot of energy release on Figure 4. This figure also suggests that the increase in seismicity preceding the 1954 earthquakes was distributed over a sizeable region, and not simply concentrated in the immediate vicinity of the impending main shock. A similar observation, of a period of quiescence followed by intense foreshock activity distributed over a sizeable area, was made by Ryall and Ryall (1981) for the recent Mammoth Lakes earthquake sequence. For the 1915 Pleasant Valley shock, however, the pattern was somewhat different. As indicated by the newspaper accounts in Appendix A, there were reports of six or seven earthquakes from 1872 to 1900 that were probably located in Pleasant

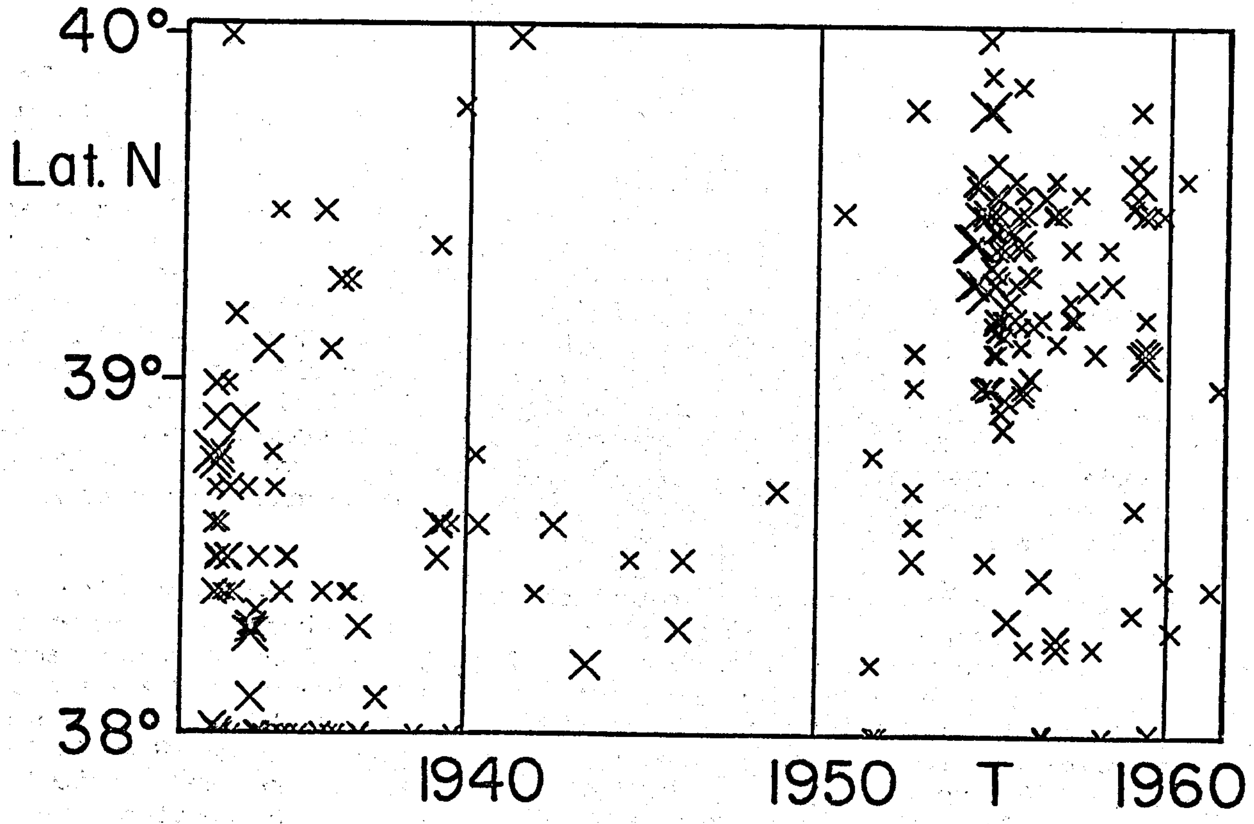

Figure 3. Distribution of earthquakes in central Nevada as a function of latitude and time. Plot includes events with latitude 38-40N, longitude 117.5-119W and M ≥ 4.0 (data from Slemmons et al, 1965).

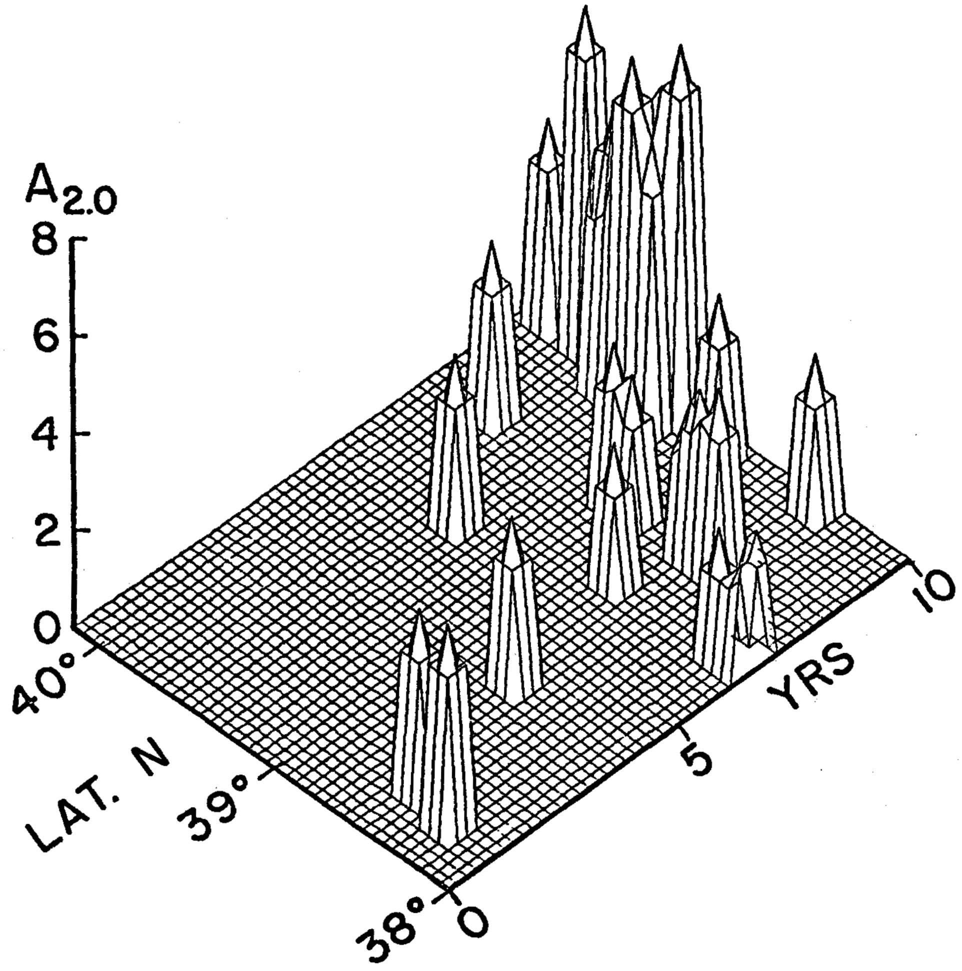

Figure 4. Energy release as a function of latitude and time for central Nevada. Plot includes same data as Figure 3, but period is 1945-1954. A(2.0) is the logarithm of the number of ML 2.0 earthquakes that would be equivalent to the total energy released by earthquakes within a 6-km by 75-day grid square. Numbers were smoothed with a triangular filter before log N(2.0) was calculated. Energy was determined from Richter's (1958) formula log E (ergs) = 11.8 + 1.5 M.

Valley, and no events in that area were reported in the period 1901-1914. However, the only foreshock activity following this 15-year period of quiescence appears to have consisted of two strong foreshocks within six hours of the main shock.

With regard to aftershocks, Figure 5 shows the rate of microearthquake activity for 1970-1975 in each of the zones that had major earthquakes in the western Great Basin during the historic period. The ordinate on this figure shows the average number of earthquakes located in each of the rupture zones per year, and the abscissa is the time in years after the main shock. The figure clearly indicates that the rate of earthquake occurrence in these zones is inversely proportional to time after the main shock, and that aftershock activity following a typical large earthquake in this region decays to a minimum level after about a century. This is almost an order of magnitude longer than the 15-year aftershock sequence Fedotov (1968, 1971) found for major earthquakes in the western Pacific (see below), and in general supports the long re-rupture times discussed above for faults in the Great Basin.

One final observation about aftershock activity in the Dixie Valley is illustrated by Figure 6, which shows energy released in that area as a function of latitude and time, for the period 1 July 1954-30 June 1981. Following the main shock, shown by the large spike in the lower left corner of the figure, the seismicity appears not only to decrease in terms of energy release, but also to migrate south as residual stress in the northern part of the zone is relieved.

Seismic Cycle in the Western Great Basin.

Fedotov (1968, 1971), studying long-term behavior of earthquakes in the western Pacific seismic belt, concluded that within the rupture zone of a typical great earthquake in that region there is a "cycle" of activity that lasts for about 140 years, and that this cycle has three parts. During the first 15 years after a catastrophic earthquake, the level of activity -- expressed in equivalent number of small (M about 3) earthquakes needed to achieve the total energy release -- decreases by a factor of 1,000 to some minimum level. Following this aftershock period the activity stabilizes at the minimum level for more than a century; during any 5-year period there is high probability that the activity will be within a factor of two of this level. During the final 10-15 years of the cycle there is a foreshock sequence in which the activity gradually increases, reaching a level about 2.5 times the minimum just before another great earthquake occurs.

While tectonic processes in the western Pacific region are different than those in the Great Basin, Fedotov's seismic cycle, based as it is on a large number of major earthquakes, provides a model for comparison with earthquake occurrence in the Nevada region in general, and Dixie Valley in particular. From the preceding discussion, we draw the following conclusions:

- The "seismic cycle" in Nevada is of the order of thousands of years long. In support of this conclusion we note that no two of the five major historic earthquakes in the western Great Basin have occurred in the same rupture zone, that fault-scarp morphology studies in northern Nevada indicate re-rupture times of thousands of years, and that recurrence rates based on current seismicity are in agreement with long re-rupture times.

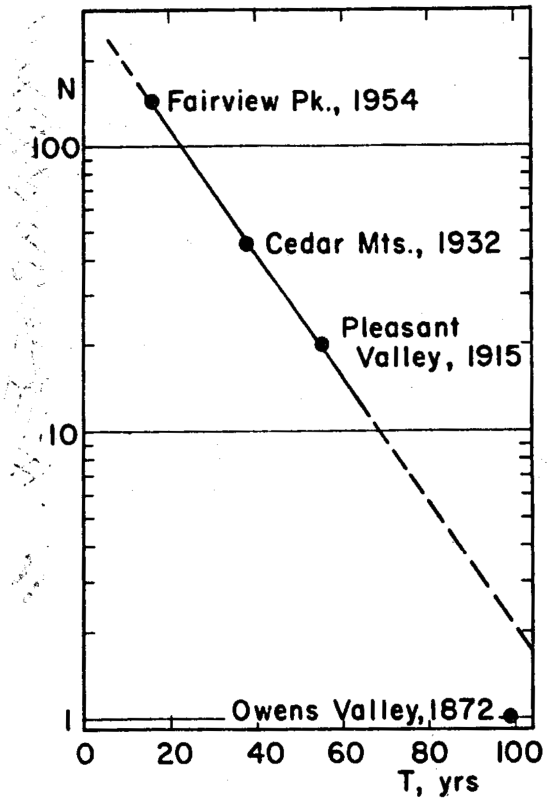

Figure 5. Average number N of earthquakes per year for 1970–1975 within the rupture zones of large (M > 7) historic earthquakes, as a function of time T in years after the main shock.

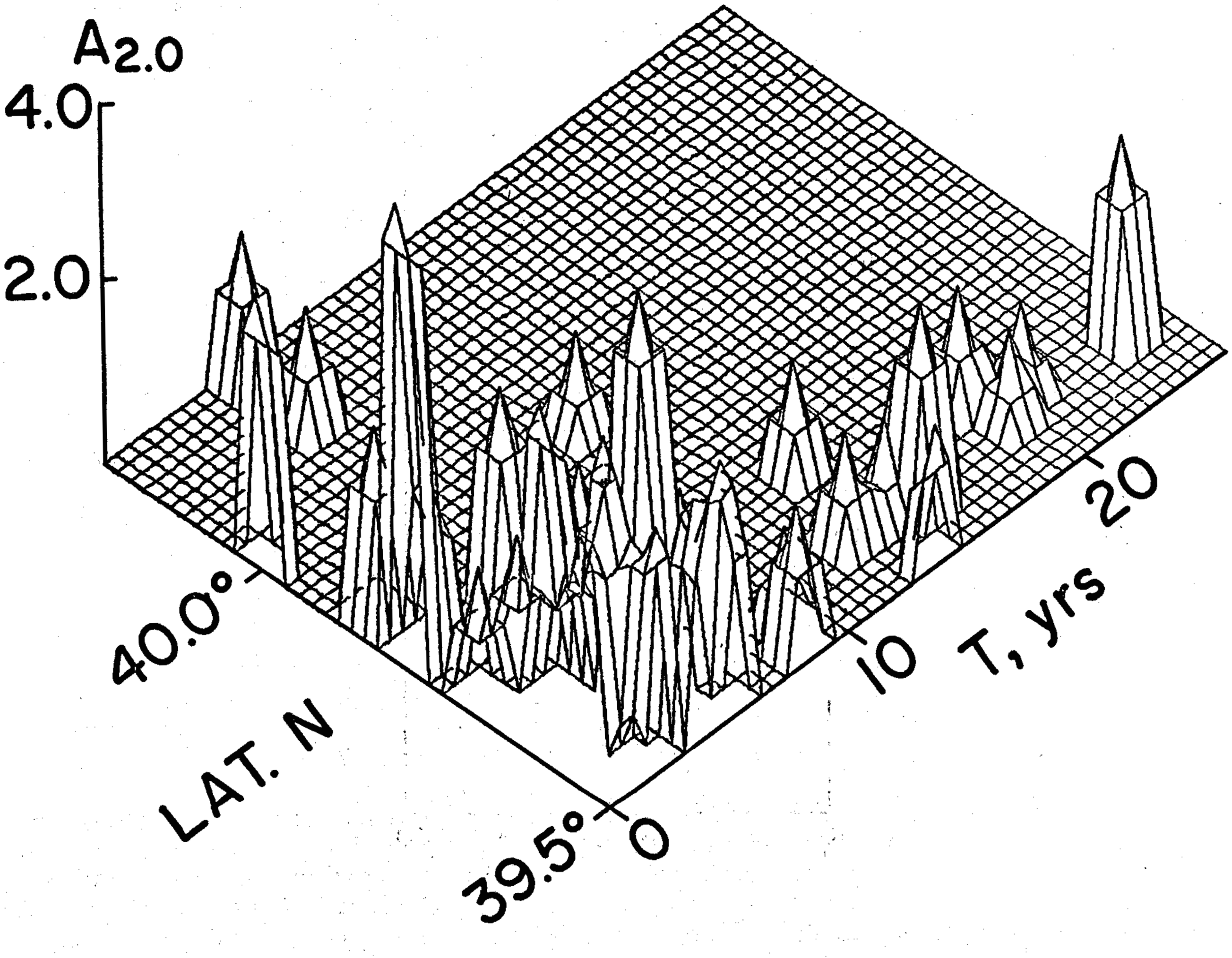

Figure 6. Energy release as a function of latitude and time for northern Dixie Valley, latitude 39.5–40.2N, for the period 1 July 1954 - 30 June 1981. A(2.0) is the logarithm of the number of ML 2.0 earthquakes that would be equivalent to the total energy released by earthquakes within a 2-km by 197-day grid square. Numbers were smoothed with a triangular filter before log N(2.0) was calculated.

- A typical large (M > 7) earthquake in the Great Basin is followed by an aftershock sequence lasting about a century, which gradually relieves residual stresses in the rupture zone. Seismicity in the rupture zone then stabilizes at some minimum level for a long period of time. Most of the western Great Basin is observed to have a background level of minor seismicity, and the distribution of small earthquakes is often difficult to identify with particular faults on the surface.

- Foreshock activity in the Great Basin appears to consist of a moderate increase in seismicity in the zone of an impending rupture, occurring over a period of at least several decades before the main shock. In the final "preparation stage," there may be a period of quiescence lasting for several years, followed by an intense foreshock sequence in the months preceding the main shock. In the case of the 1915 Pleasant Valley earthquake, the main shock was preceded by about 15 years of quiescence, which appears to have ended only hours before the large earthquake.

- The area of this study, Dixie Valley, was affected by a large shock in 1954 that generated an average of 2 m displacement along normal faults in a zone 40 km long and 5 km wide. The Dixie Valley shock occurred 4 minutes after the Fairview Peak earthquake, and filled part of a seismic gap between that event and the 1915 Pleasant Valley rupture zone. The magnitude given by the California Institute of Technology for this earthquake was 6.8, based on surface-wave amplitudes. However, Romney (1957) notes that body-wave amplitudes at teleseismic distances were greater for the Dixie Valley shock than for the M 7.1 event four minutes earlier, and attributes the different partitioning of energy between body- and surface-waves to the fact that the second event was deeper (40 km) than the first (25 km).

- Qualitative analysis of activity in the Dixie Valley area since 1954 indicates a general decrease in energy release appropriate for an aftershock sequence. There also appears to have been a migration of activity toward the south, presumably as residual stresses in the northern part of the valley have been relieved over the last 27 years.

- According to Wallace (1978) the area of most importance to this study — northern Dixie Valley between Dixie Hot Springs and the Sou Hills — is a seismic gap that has the potential for an earthquake with maximum magnitude of about 7 1/2. This 40-km long zone between the 1915 Pleasant Valley and 1954 Dixie Valley rupture zones is marked by a precipitous segment of range front bounded by Holocene scarps up to 8 m high; Wallace concludes that the average interval between movements along this zone is about 6,000 years, and that the latest movement is at least several thousand years old.

GEOLOGIC/STRUCTURAL SETTING

Stations of the Dixie Valley seismic network (DVSN) were located in and around Dixie Valley, a typical Basin-Range valley about 100 km long and 20 km wide, extending in a NNE-SSW direction in central Nevada (Figure 7). The valley is bounded on the west by the Stillwater Range and on the east by the Clan Alpine Mountains. According to Willden and Speed (1974):

> "The Stillwater Range is a north-trending horst bounded by high-angle faults of large vertical displacement. Normal faults of less displacement cut the block, and differential displacements on the blocks within the horst have tilted erosion surfaces in various directions. Some normal faults in the interior of the range extend to the flanks and continue as range-front faults (Page, 1965). Faulting and earthquakes have occurred at a number of places in historic time in the vicinity of the Stillwater Range. . .The range contains several units of deformed Mesozoic rocks separated by thrust faults, and is the center of a large complex of mafic igneous rocks, and a remarkable succession of volcanic and intrusive rocks of probable Cenozoic age."

> "The Clan Alpine Mountains trend northward from their southernmost point at Westgate on US Highway 50 to their intersection on the north with the Augusta and New Pass Mountains. The range contains the highest point in Churchill County, Mount Grant, 9,966 feet. The present configuration of the Clan Alpine Mountains is a result of block faulting, much of which is Holocene. The western margin of the range is underlain by Tertiary volcanic rocks along much of its length, and these rocks are downthrown by normal faults relative to the mountain range proper lying to the east. The structure suggests that the west flank of the Clan Alpine Mountains may descend gradually by step faults of relatively small displacement toward the floor of Dixie Valley. The opposite side of Dixie Valley differs because Quaternary deposits are faulted directly against a block of predominantly Mesozoic rocks. . . The Clan Alpine Mountains expose three successions of rocks of Mesozoic age, [and the northern part of the range] contains the easternmost exposures of the [Jurassic] Humboldt gobbroic complex. . . The Clan Alpine Mountains contain contrasting terranes of Tertiary volcanic rocks. The northern part of the range in the Shoshone Creek drainage is partly covered by accumulations of rhyolitic ash flows that may be as much as 2,000 feet thick."

According to Whitney (1980), photogeologic analysis indicates that the valley is a complex graben bounded by high-angle Basin and Range faults. The main fault system in the area is the Stillwater fault, which bounds the the Stillwater Range on the southeast and trends N36E from Dixie Meadows into Pleasant Valley. This zone is marked at the surface by very fresh scarps in alluvium and bedrock, and geomorphic features indicate that the zone is very active. Whitney states that the fault dips 50-60 deg SE in the northern part of the valley, and that motion on the fault is primarily dip-slip, with a minor right-lateral slip component. South of Dixie Meadows, which marked the northernmost extent of primary faulting in December 1954 (Slemmons, 1957), the fault trends almost N-S (Figure 7). As illustrated by Figure 8 (from Whitney, 1980), the Dixie Valley graben is asymmetric, with a number of NW-dipping step faults bounding the southeast side of the valley.

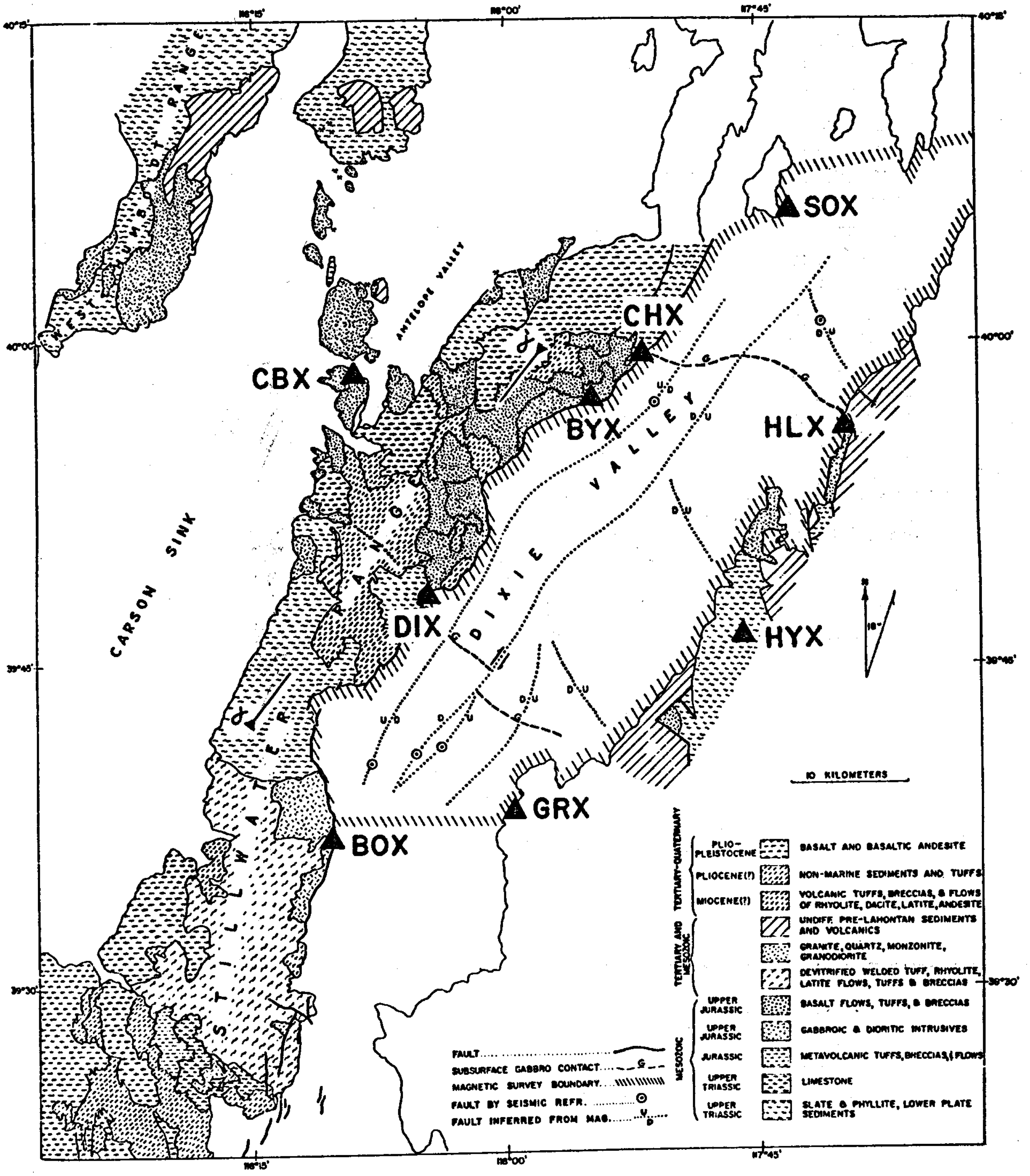

Figure 7. Generalized geologic and geophysical map of the west Humboldt, Stillwater and Clan Alpine Ranges, Nevada. Subsurface structures inferred from geophysical data (from Smith, 1967). Hachured area is not referred to in the present report. Solid triangles -- stations installed for this study (Table 1).

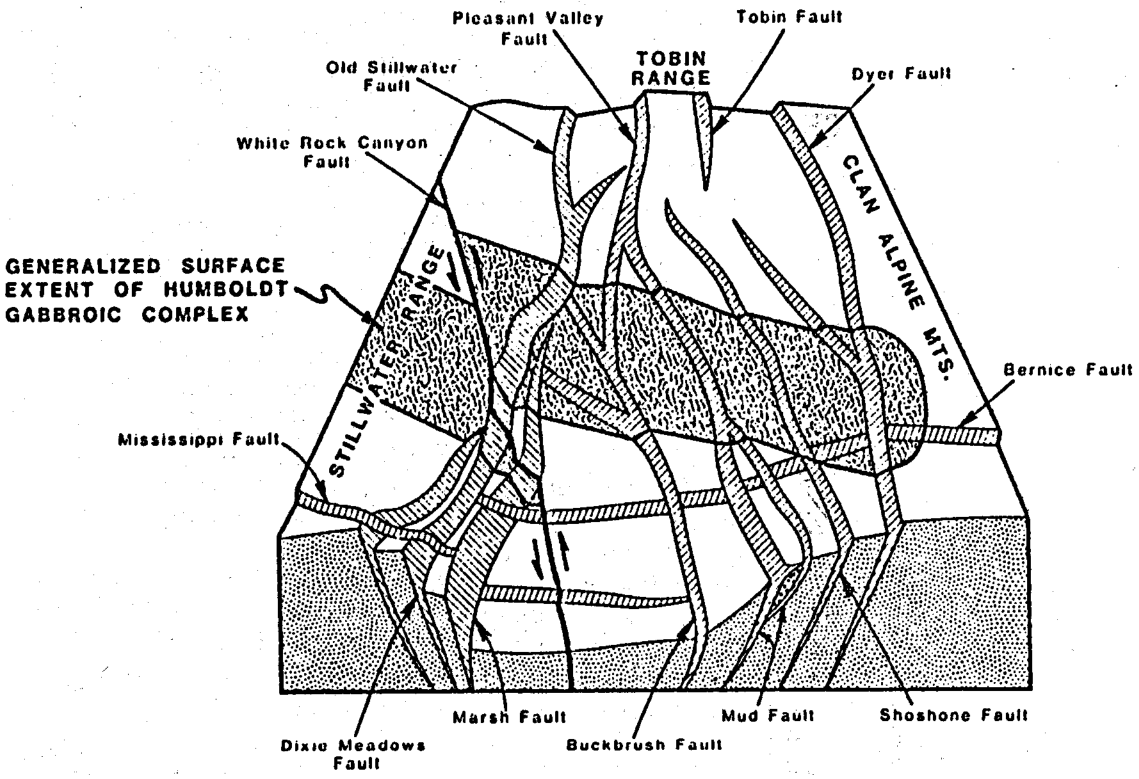

Figure 8. Three-dimensional model of the northern portion of Dixie Valley. Structural relationships among the various tectonic elements are depicted, with alluvium removed and the bedrock surface restored (from Whitney, 1980).

Wallace (1979, 1980) proposes a tectonic model for the Basin and Range that involves listric faulting in an upper, brittle crustal plate in response to regional extension concentrated in narrow zones of anelastic deformation or intrusion at depth. Diagrammatic cross sections illustrating this model for the northern Great Basin are shown in Figure 9. In Figure 9a, the model is constructed to incorporate (1) eastward tilting of the ranges (defined by the dip of basalt flows that cap most of the ranges); (2) first- and second-order relationship of ranges, with some blocks having rotated and slumped off other blocks; (3) Mohorovicic discontinuity at depth about 30 km; (4) maximum depth of seismicity — corresponding to maximum depth of the brittle zone — about 15-18 km; (5) narrow zones of extension at depth; (6) listric form of faults in the brittle part of the crust; and (7) zone of decoupling to accomodate the listric style of faulting. Figure 9b is more speculative, and includes (1) zones of extension possibly invaded by intrusive (A on figure); (2) vertical propagation of tension cracks through the listric faults (B on figure); (3) complexity of the glide blocks (C on figure) incorporating blocks of various size and some unrotated blocks; (4) sequence of events, including earlier westward tilting of the Humboldt Range (D on figure) and cross-cutting of older by younger faults; and (5) a zone of decoupling that is complex rather than simple, and includes glide planes biased toward westward sliding and toward the local zones of extension (E on figure). Wallace notes further that:

> "Scarps that developed in Holocene time (last 12,000 + years) appear to be distributed in narrow, elongate belts trending N10-25E (see figure 10). The belts cross range blocks, for example, the belt produced in 1915 (see 1915, figure 10) crosses four range blocks, and the Western Cortez belt (see WC, figure 10) trends at high angle across the Cortez Range front fault trend. Within other belts such as the Shoshone Range (see SR, figure 10) belt an the Humboldt Range belt (see HR, figure 10), faults of diverse trends appear reactivated. This independence of the belts from obvious surficial structures suggests that the elongate belts of reactivation relate to deep structures, and that the effects are propagated upwards and become superimposed across upper crustal blocks. Regional extension appears to be normal to the long axes of these belts."

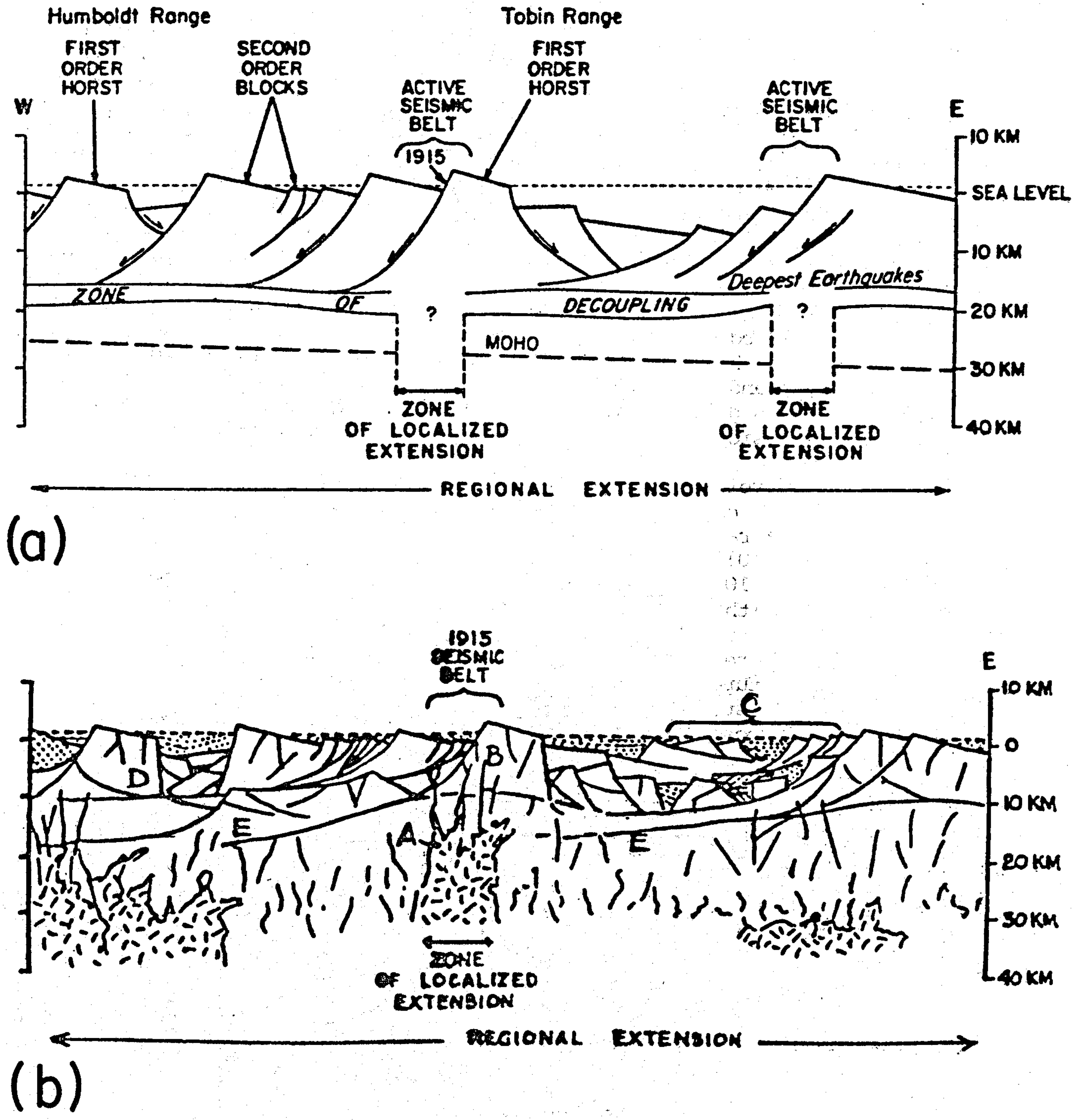

Figure 9. Possible interpretations of fault and tectonic data by Wallace (written communication). See text for explanation.

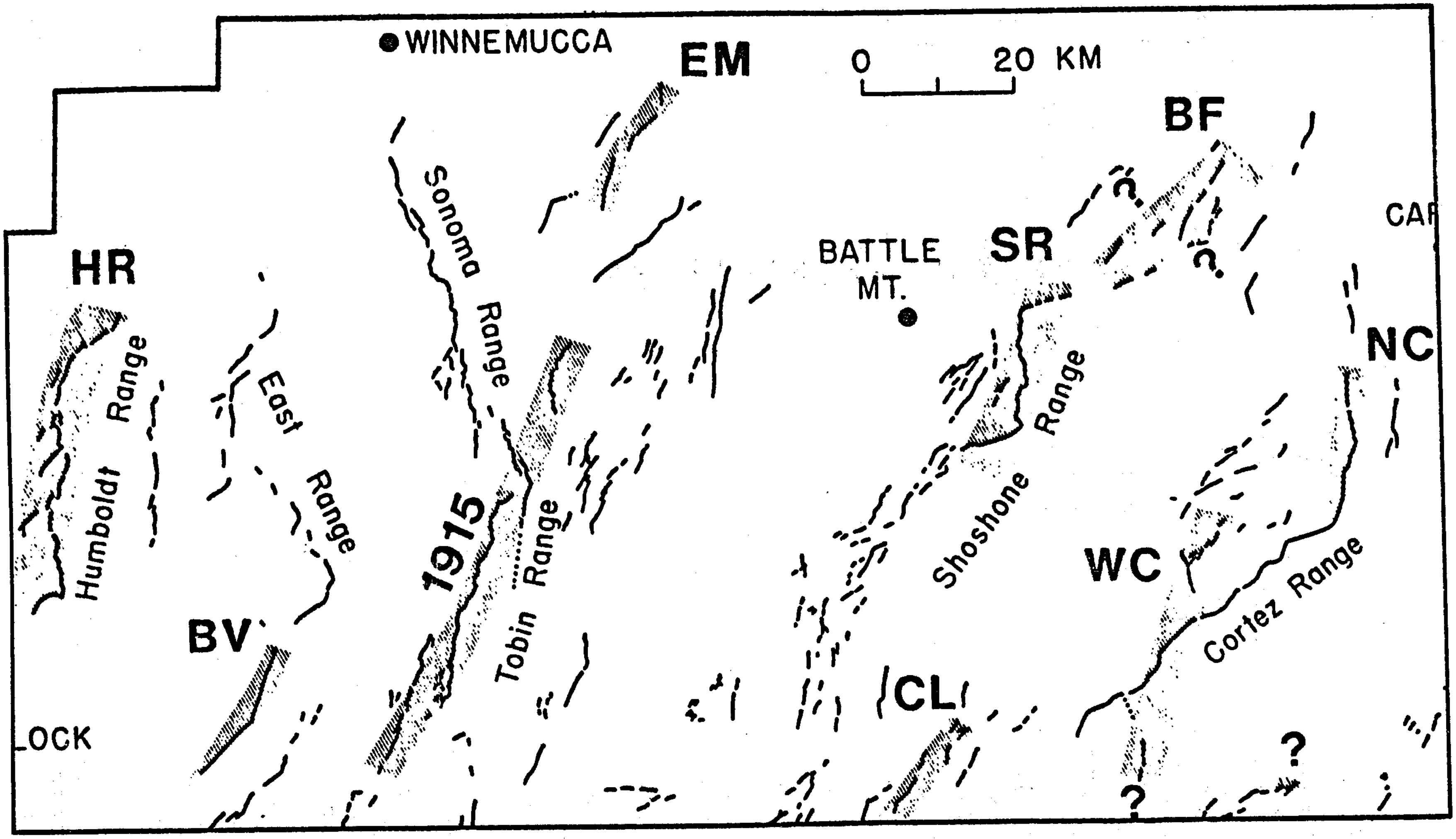

Figure 10. Figure by Wallace (written communication), showing distribution of Holocene scarps in narrow, elongate belts. Independence of these belts from surficial structures is evidenced by the belts crossing range blocks. Wallace suggests that the "belts of reactivation relate to deep structures, and that the effects are propagated upwards and become superimposed across upper crustal blocks. Regional extension appears to be normal to the long axes of these belts."

INSTRUMENTATION AND ANALYSIS

Dixie Valley Station Sites.

As shown on Figure 7, stations of the Dixie Valley Seismic Network (DVSN) were located in and around the valley; station data is listed in Table 1, and site descriptions are given below.

The 3-component HYX station was located approximately 150 feet beyond the adit to the abandoned Hoyt antimony mine, and station BYX was about 50 feet inside an abandoned mine near the Boyar Ranch. The remaining stations were buried about two feet deep in soil. The BOX station was buried on a granitic outcropping; HYX, DIX and CHX were on gabbro; CBX was on basalt; HLX, BYX and SOX were on rhyolite; GRX was at the upper end of an old alluvial fan; and FPN is on rhyolite on the NE side of Fairview Peak, south of Dixie Valley. In addition to the ten stations in and around Dixie Valley, two nearby stations of the Nevada Seismic Network were used in the analysis: Station BMN, 55 km NE of station SOX, is in a mine tunnel in Paleozoic metasediments, and KVN is situated at the bottom of a 700-foot deep mine shaft, 18 km SSE of FPK, on rhyolite.

As indicated by Table 1, seven of the DVSN stations began operation in early January, 1980. Stations at FPN and CBX were added in April. The mine station near Boyar Ranch was vandalized in August, 1980, and all components except the seismometer were stolen; the seismometer and new electronics were installed at CHX about a week later. Figure 11 shows the amount of up-time for all the stations, and indicates that with the exception of CBX, CHX and HLX the stations were in operation more than 95% of the 22.5 months of the experiment. Station CBX was down about a third of the time, HLX had about 14% down time, and CHX was inoperable about 8% of the time. In mid-November, 1981, six of the stations were removed, leaving DIX, FPN and HYX (together with BMN and KVN of the permanent network) continuing to monitor activity in the Dixie Valley-Fairview Peak area.

Instrumentation.

Seismometers. Eight of the stations listed in Table 1 were equipped with Teledyne-Geotech model S-13 seismometers. The S-13 weighs less than 25 pounds and has a 5-kilogram mass; it is designed for use in field operations where a small, light-weight, short-period, moving-coil type seismometer is desired. All of the seismometers had free period of 1.0 second, and 3,600-ohm output coil. The S-13 may be used in either vertical or horizontal configuration, and two of the seismometers were installed as horizontal-component instruments at station HYX. The seismometers used at FPN, KVN and BMN were Teledyne-Geotech models 1501 (vertical-component) and 1101 (horizontal) Benioff seismometers. These instruments have been standard for many networks, including the Worldwide Seismic Station Network (WWSSN); they have the advantage of high sensitivity to small ground motion, but the disadvantage of being cumbersome (about 450 pounds and too large for field use). The Benioff transducer is a balanced, variable-reluctance type, constructed so as to produce a voltage proportional to earth velocity. All of the Benioff instruments had period of 1.0 second; station FPN had only a vertical-component seismometer, and BMN and KVN were triaxial.

TABLE 1. STATION DATA, DIXIE VALLEY SEISMIC NETWORK

ID	Station Name	Latitude deg N	Longitude deg W	Elevation meters	VCO Hz	Start Date	Seis Model
BMN	Battle Mountain	40.4313	117.2217	1450	2040(Z) 1020(E) 2720(N)	09/02/69	1051
BOX	Box Canyon	39.6153	118.1763	1283	2380	01/11/80	S13
BYX	Boyer Ranch	39.9542	117.9178	1128	2040	01/11/80	S13
CBX	Chocolate Butte	39.9741	118.1557	1439	2720	04/03/80	S13
CHX	Cottonwood Canyon	39.9859	117.8674	1234	2040	08/21/80	S13
DIX	Dixie Hot Springs	39.8022	118.0820	1143	1020	01/10/80	S13
FPN	Fairview Peak	39.2028	118.1550	2256	2720	04/01/80	1051
GRX	Grover Canyon	39.6355	117.9890	1390	1360	01/10/80	S13
HLX	Hole-in-the-Wall	39.9337	117.6632	1219	680	01/10/80	S13
HYX	Hoyt Mine	39.7728	117.7633	1661	2380(Z) 2040(E) 1700(N)	01/10/80	S13
KVN	Kaiserville	39.0510	118.1000	1829	1360(Z) 1700(E) 680(N)	01/13/72	1051
SOX	Sou Hot Springs	40.1017	117.71.67	1198	1020	01/11/80	S13

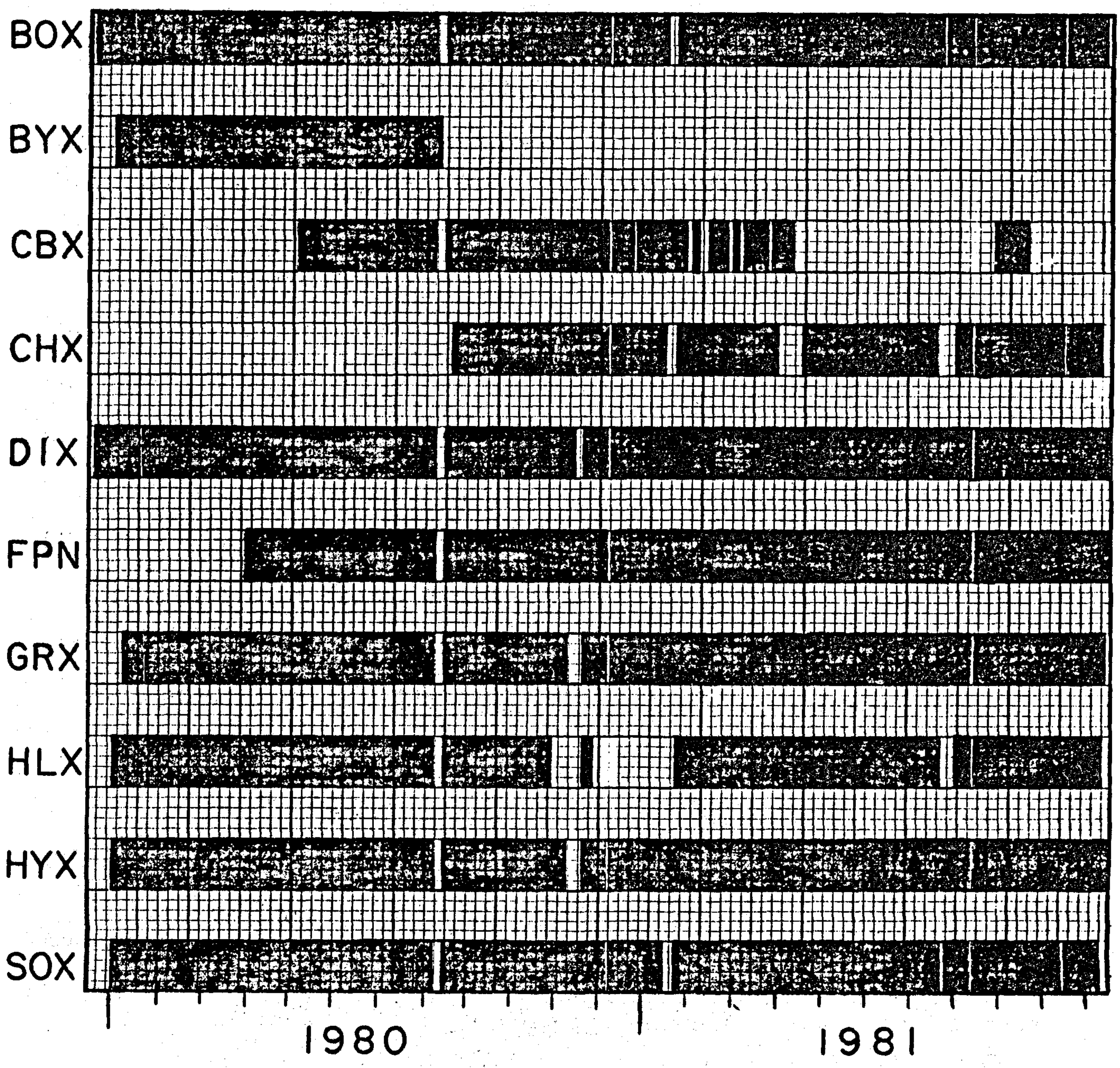

Figure 11. Record of station operation. Station down-time is indicated by gaps in bar chart. Time is by weeks, from 16 December 1979 to 14 November 1981. The VCO, transmitter and batteries were stolen from station BYX on 5 August 1980, and the station was reinstalled at CHX on 21 August 1980. Station CBX was installed on 3 April 1980, but was not operational until 6 May when a relay was installed on Toulon Peak. Stations FPN, DIX and HYX are still operating in January 1982, as single-component stations.

Amplifier/VCO's. Stations with S-13 seismometers had Emtel model 6242 preamp/VCO's. These units amplify the seismometer output and modulate a voice-range carrier frequency to permit multiplexing of up to eight channels of information on a single data link. The 6242 is a small, all solid-state, low-power device capable of high amplification in a field environment. All of the preamps were set to -18dB attenuation, equivalent to a voltage gain factor of approximately 3,000; VCO center frequencies are given in Table 1. Stations FPN and CHX had older type Emtel model 6202 preamp-VCO's; BMN has Teledyne model 4300 phototube amplifiers and Emtel model 6207 VCO's; KVN has preamp/VCO's designed and constructed at the University of Nevada.

Telemetry. Signals from most of the stations were transmitted to the Reno facility on VHF radio links. Except for CHX the S-13 stations used Monitron model T15 transmitters and R15 receivers — small, rugged units that are capable of low-power operation. Signals from HLX, HYX, GRX and DIX were multiplexed on one link, and signals from SOX, BYX (or CHX) and BOX on another. All of these signals, together with FPN and KVN, were relayed from Fairview Peak, where a single solar panel was used to charge six lead-acid batteries to run two one-watt VHF radios. Signals from Fairview Peak were received at Slide Mountain, south of Reno, and then transmitted over telephone lines to the University. The CBX signal was telemetered to a relay on Toulon Peak, near Lovelock, from there to Virginia Peak, north of Reno, and from there to the University. Data from BMN were transmitted to Reno over telephone lines.

Recording. At the Seismological Laboratory, the multiplexed seismic signals were recorded in direct mode on a Bell and Howell model VR-3700B, 1-inch tape transport. For analysis, individual earthquakes were played out from the tape onto a 16-channel chart recorder (Siemens Oscillomink), together with time marks from a chronometer and a WWVB radio-time signal (Figure 12).

Calibration of the S-13 Stations. Equipment at the S-13 stations was new when the network was installed. At that time the seismometers were bench-checked for free period, and the VCO's were checked for center frequency and deviation. Step-input and frequency response checks were made at only one site, the three-component station HYX. Since the results on all three components were identical, and since all the equipment was new, it was assumed that operating characteristics of the other stations would be identical to HYX, and as a result only step-input calibration was performed at those stations. Results of calibration are shown on Figure 13.

Stations HYX, HLX, GRX, SOX and DIX were found to be very nearly identical in sensitivity. Station BOX had only half the gain of the other stations, apparently because of a faulty or maladjusted amplifier. Station CHX, which had an older model amplifier after most of the original equipment was stolen from BYX, also had only half the gain of the other S-13 sites. Station CBX was not calibrated, but appears to be identical to HYX in operation, based on playbacks of teleseisms recorded by both stations.

Data Analysis.

Analysis of the DVSN data began in January, 1980, following installation of the network. Arrival times of crustal phases Pg, Pn and Sg were measured to an accuracy of about 0.02 second, together with direction of first motion, coda length, and for some of the smaller events, maximum amplitude. Calculation of

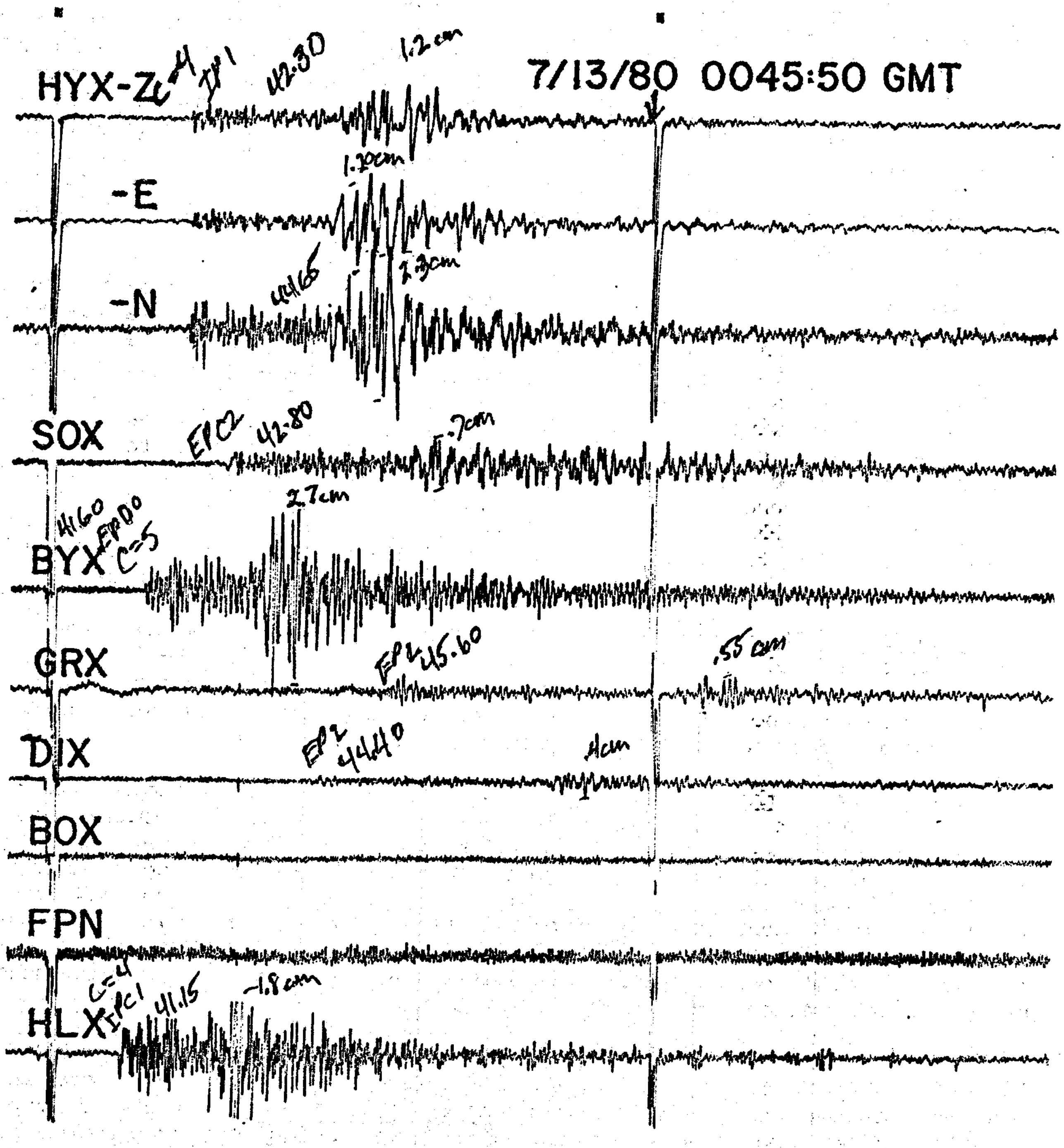

Figure 12. Example of playback for a small (ML 0.3) event in northern Dixie Valley (39.931N, 117.774, depth 7.2 km). Time marks are 10 seconds apart.

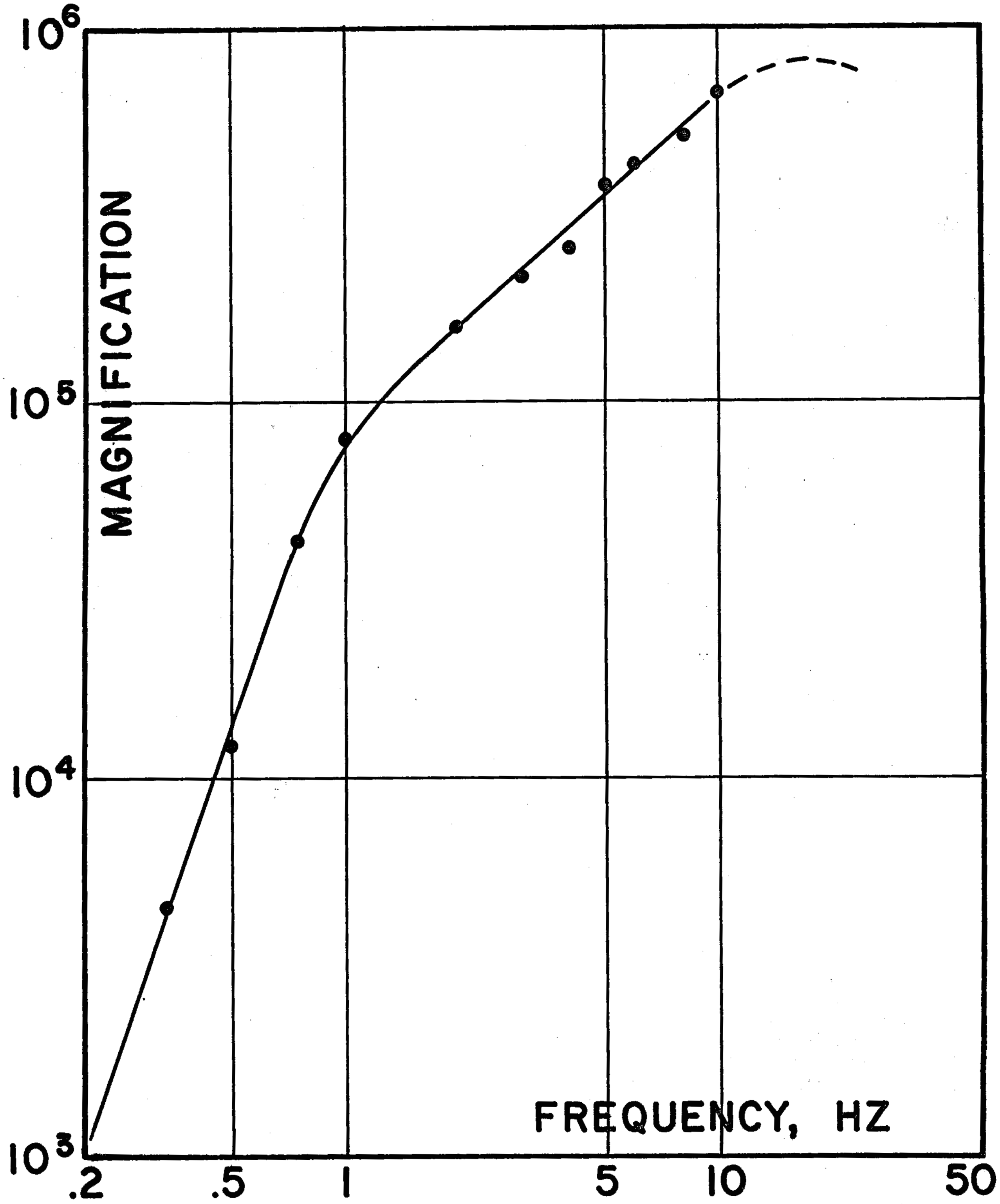

Figure 13. System magnification for 3-component station HYX. Pulse calibrations indicated that HYX, GRX, SOX and DIX had essentially identical magnification; stations BOX and CHX had one-half the gain indicated on this calibration curve.

hypocenter coordinates and magnitude were accomplished using the HYPO71 algorithm of Lee and Lahr (1975). For the period 1970-1975, most central Nevada earthquakes were located using a program NEVLOC, modified from an original algorithm described by Ryall and Jones (1964), although some of the better-recorded events were analyzed with the HYPO71 routine. For the period 1976-1979, most earthquakes were located using a program NEVLOC2, written by W. Peppin (described in the 1975-1979 and 1980 issues of the Bulletin of the Seismological Laboratory), but some events were located using HYPO71. For all of these calculations, the crust was assumed to consist of a single layer with P- and S-wave velocities of 6.0 and 3.5 km/sec, respectively, and thickness of 28 km. Results of analysis are tabulated in Appendix B, and discussed in the next section of this report. In Appendix B, events located using HYPO71 are those with quality A, B, C or D; events without quality listings were located using NEVLOC or NEVLOC2.

Magnitude.

Magnitude was determined from measurements of either maximum trace amplitude or coda duration. Most magnitudes for 1980 and 1981 were determined from coda length on playbacks similar to that on Figure 12. Magnitude for events located with NEVLOC were determined from measured trace amplitudes, either on Wood-Anderson recordings at Reno or on playbacks of signals recorded at BMN, TNP (Tonopah) or WCN (Washoe City). Magnitude for events located with NEVLOC2 for 1976-1979 were determined either from amplitude or coda measurements. In all cases, constants in the magnitude equations as well as station correction factors were determined so that magnitudes for events in the Sierra Nevada- Nevada-Great Basin boundary zone would be consistent with those determined from the Reno Wood-Anderson recordings, or with University of California, Berkeley, magnitudes. Descriptions of the two magnitude calculations are given below.

Amplitude-magnitude. Empirical relations were developed by J. D. VanWormer between measured trace amplitude at stations Battle Mountain, Tonopah and Washoe City, in the form

$$ML = C1 + \log A + C2, \qquad (1)$$

where ML is "local magnitude" (see Appendix C), C1 is a correction for distance and C2 is a station correction factor. VanWormer found C1 to be

$$\begin{aligned} C1 &= 1.268 + .027\ D && D \text{ less than } 50 \text{ km} \\ & 2.492 + .005\ D && D = 50\text{–}400 \text{ km} \\ & 3.613 + .002\ D && D \text{ greater than } 400 \text{ km.} \end{aligned}$$

In equation (1), A is the maximum, unclipped, peak-to-peak amplitude measured in mm on strip-chart recordings like that on Figure 12. To determine the correction factor C2 VanWormer compared magnitudes determined from Nevada network recordings with those of the University of California for 34 events with ML in the range 2.7-4.3. VanWormer's analysis was extended to the Dixie Valley network by comparing coda- and amplitude-magnitudes; station correction factors C2 are listed in Table 2a.

TABLE 2. STATION CORRECTION FACTORS FOR MAGNITUDE DETERMINATION.

STATION	A. CORRECTION FACTOR FOR AMPLITUDE-MAGNITUDE	B. CORRECTION FACTOR FOR DURATION-MAGNITUDE
BMN	−2.75 ± .46	.09 ± .20
BOX	−2.17 ± .50	−.32 ± .23
BYX	−2.46 ± .46	
CHX	−2.75 ± .58	
DIX	−2.56 ± .44	.21 ± .28
FPN		.68 ± .19
GRX	−2.52 ± .47	.45 ± .37
HLX	−2.41 ± .34	.20 ± .24
HYX	−2.62 ± .50	.04 ± .22
SOX	−2.73 ± .26	.50 ± .21

Coda-magnitude. The coda-magnitude relation for short-period vertical instruments of the Nevada network is

$$ML = -1.2 + 2.65 \log T + 0.0013 D, \qquad (2)$$

where T is coda duration in seconds, as defined by Lee and Lahr (1975), and D is epicentral distance in kilometers. The relation is based on a set of 12 events with Berkeley magnitude ML = 3.0-5.7, that occurred along the Sierra Nevada-Great Basin boundary zone. The standard deviation between BRK and UNR for these events is 0.09 ML. Duration data for nine Benioff stations and 21 other stations of the permanent network were analyzed separately. The coefficients of the coda duration and distance terms were found to be the same for the two sets of stations. The coda-magnitude calculation was extended to the Dixie Valley network by comparing magnitudes for 25 events at Mammoth Lakes with known magnitudes in the range ML = 3.1-4.9; station corrections used in this study are listed in Table 2b.

INTERPRETATION AND DISCUSSION

Distribution of Earthquakes in Space and Time.

The spatial distribution of earthquakes in the Dixie Valley-Fairview Peak area is shown on several figures. Figure 14 shows the location of 1,128 earthquakes analyzed by the University of Nevada for the period 1 January 1970 to 30 June 1981, within the area 38.8-40.5°N, 117.3-118.7°W. Clusters in the lower part of the figure (latitude about 38.9°N) are in the northern end of the 1932 Cedar Mountains rupture zone. The dense cluster in the center of the figure (latitude 39.0-39.5°N) is in the southern (Fairview Peak) part of the 1954 rupture zone, and activity in Dixie Valley (latitude 39.5-39.8°N) is in the northern part of the zone. Scattered epicenters in the upper right part of the figure are in the 1915 Pleasant Valley rupture zone, and the long cluster of events west of about 118.3°W is in the aftershock zone of two magnitude 6.8 shocks in July and August, 1954 (Rainbow Mountain, Stillwater earthquakes). In general, this figure indicates that aftershocks of the Dixie Valley-Fairview Peak earthquakes are distributed in a 90 km-long, 20 km-wide zone trending almost N-S. In the area of particular interest to this investigation -- between Dixie Meadows and Sou Hot Springs (DIX and SOX on the figure) only 11 events were detected for the entire 11.5-year period. Five of these -- with magnitudes in the range 0.1-1.6 -- were recorded by the DVSN in 1980 and 1981; the largest event in this area, in 1973, had ML 3.0.

Figures 15-18 show the distribution of events for four three-year periods -- 1970-72, 1973-75, 1976-78 and 1979-81 -- with numbers of events, respectively, 415, 392, 307 and 143. Although part of this decrease in annual number of events is an artifact of a fluctuating network detection threshold, there does appear to have been a real change in seismicity, starting in 1977 and continuing through 1981. This is illustrated by Figure 19, which shows the distribution of 447 events in the Dixie Valley-Fairview Peak zone as a function of time and latitude, and includes only earthquakes with ML greater than 2.0. On this figure the change in seismicity is particularly apparent in the southern part of the zone, where a change in density of the symbols corresponds to a change in the rate of activity: the average number of ML 2+ events in the southern part of the zone (30.0-39.15°N) was 29/year from 1970 to 1976, and only 6/year for the 4 1/2-year period 1/1/1977-6/30/1981.

A similar pattern of decreasing seismicity was reported by VanWormer and Ryall (1980) for the Sierra Nevada-Great Basin boundary zone in 1977 and 1978. This period of quiescence was followed by "a burst of sizeable earthquakes, aftershocks and swarms in all parts of the zone in late 1978 and 1979." As noted by Ryall and Ryall (1981), the increased activity in 1979 was most intense in the Mammoth Lakes area, culminating with several magnitude 6+ earthquakes on 25 and 27 May, 1980. Comparing several characteristics of the Mammoth Lakes sequence with behavior that various authors have tentatively identified as precursory to large earthquakes, Ryall and Ryall concluded that "precursory phenomena reported in the literature may, at least in some cases, have been the result of regional, rather than local stress changes. If so, such changes could create favorable conditions for large earthquakes to occur anywhere within a sizeable region, rather than in the immediate vicinity of some particular anomalous observation." The decrease in seismicity within the Fairview Peak-Dixie Valley aftershock zone was generally synchronous with that in the

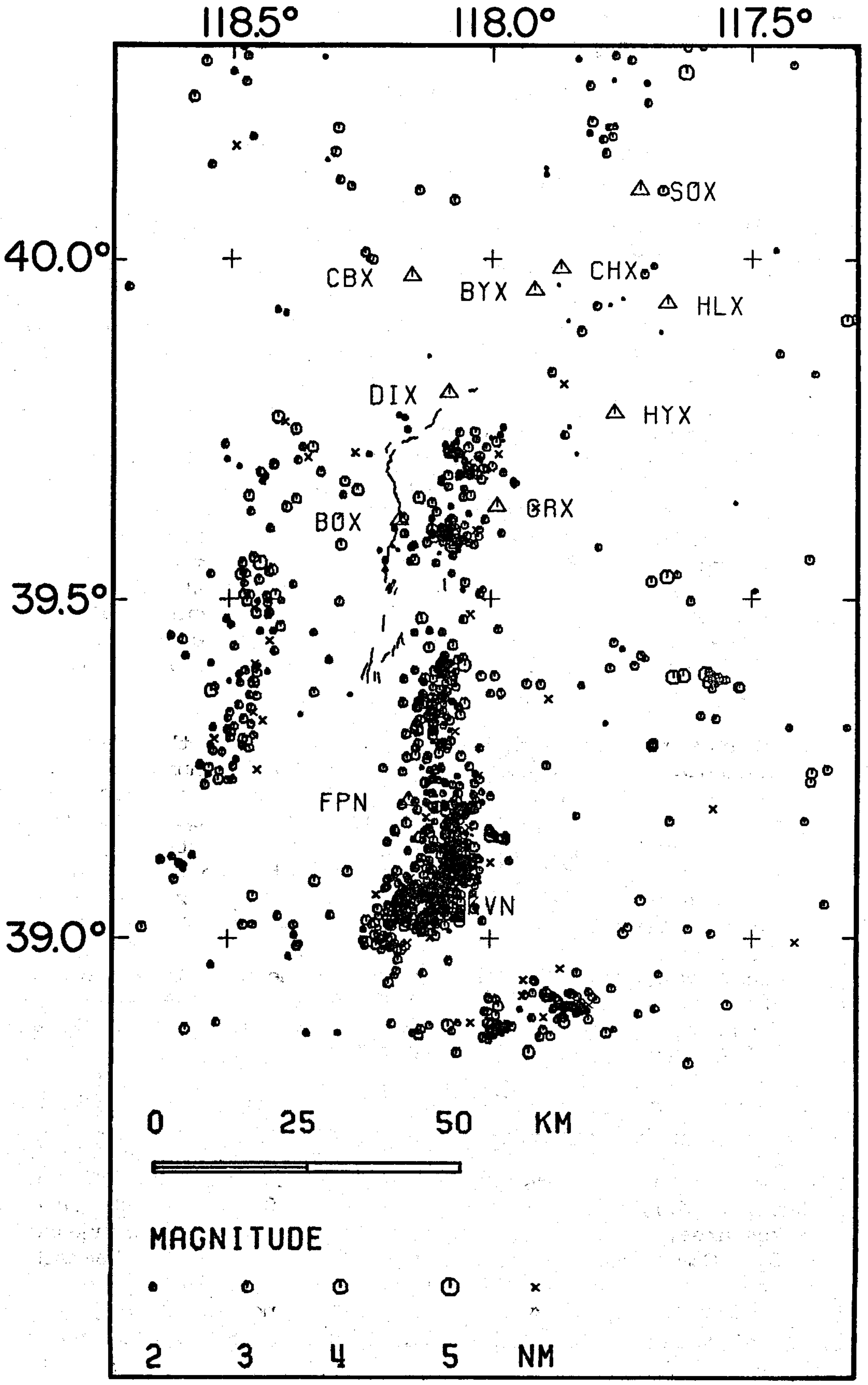

Figure 14. Earthquakes in the Dixie Valley-Fairview Peak area, 1970-1981.

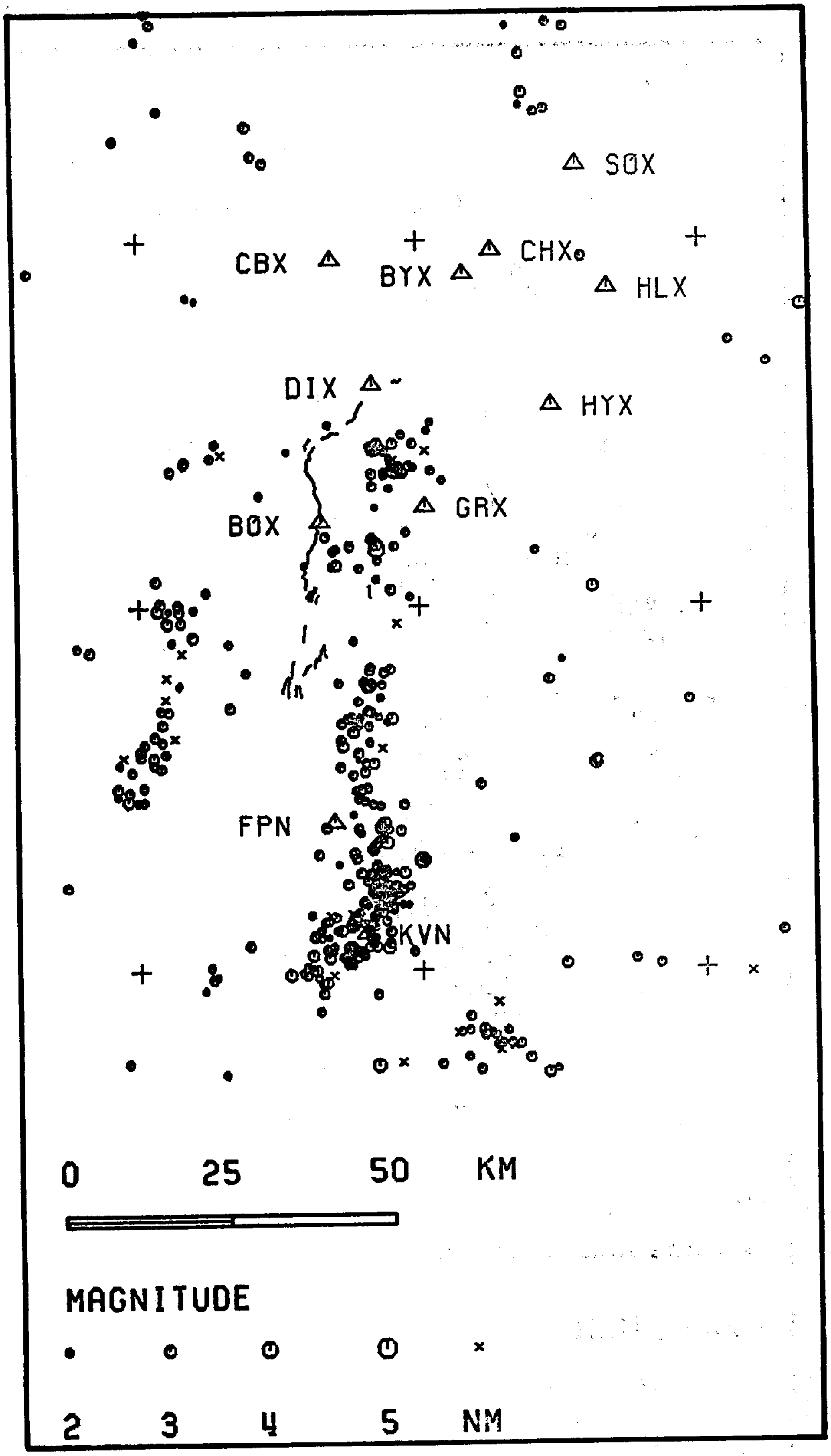

Figure 15. Earthquakes in the Dixie Valley-Fairview Peak area, 1970-1972. Area is same as Figure 14.

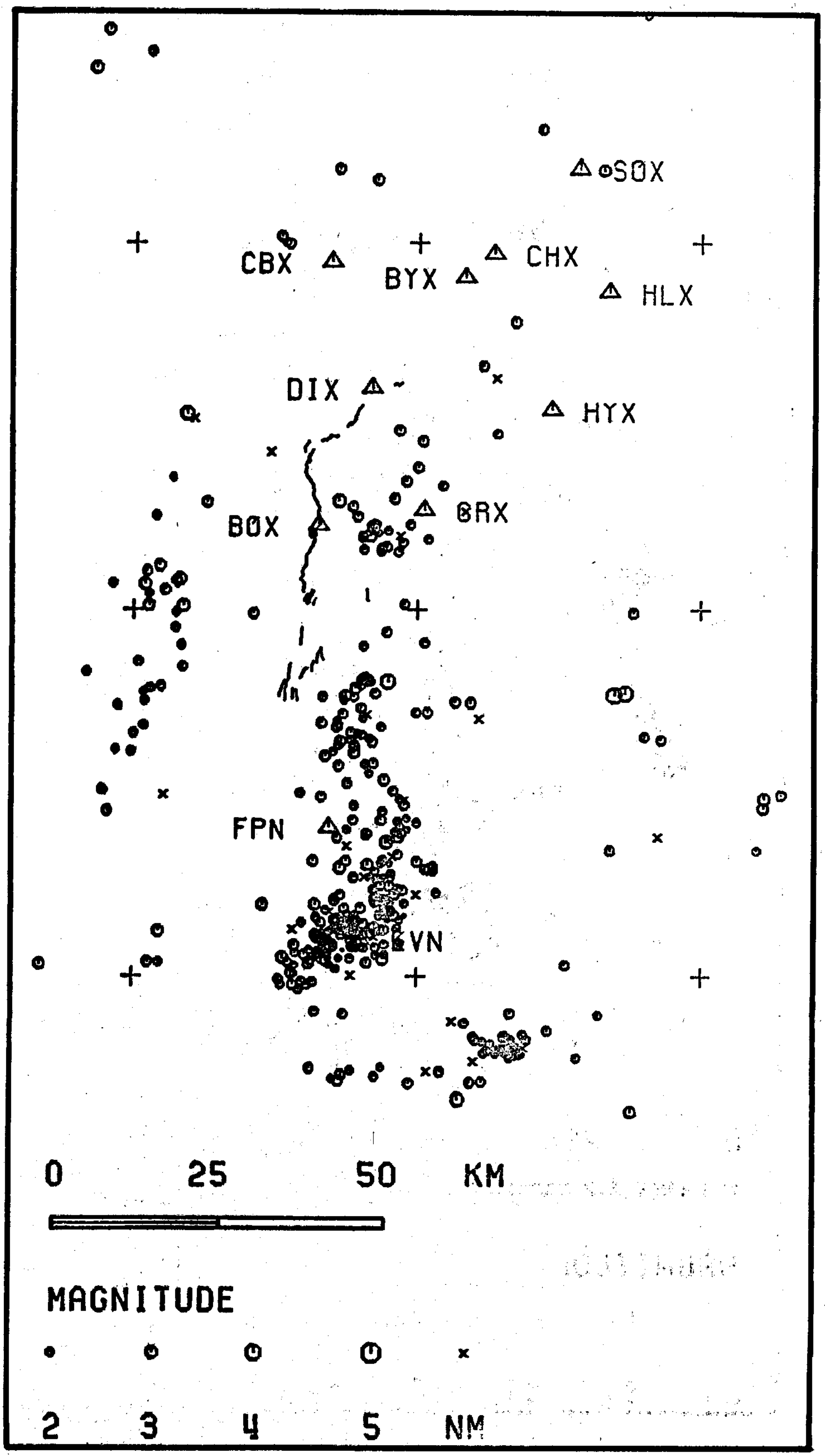

Figure 16. Earthquakes in the Dixie Valley-Fairview Peak area, 1973-1975. Area is same as Figure 14.

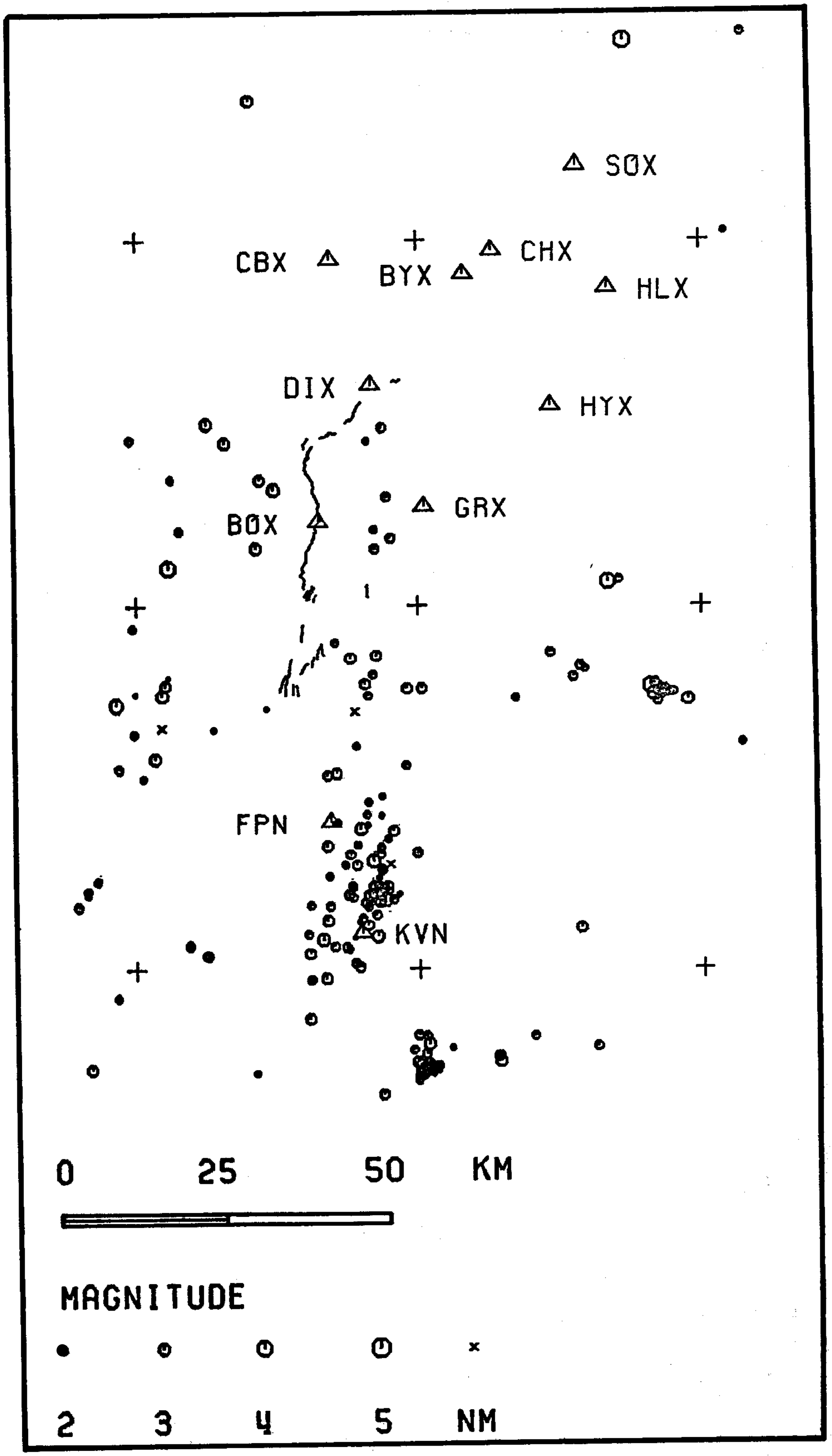

Figure 17. Earthquakes in the Dixie Valley-Fairview Peak area, 1976-1978. Area is same as Figure 14.

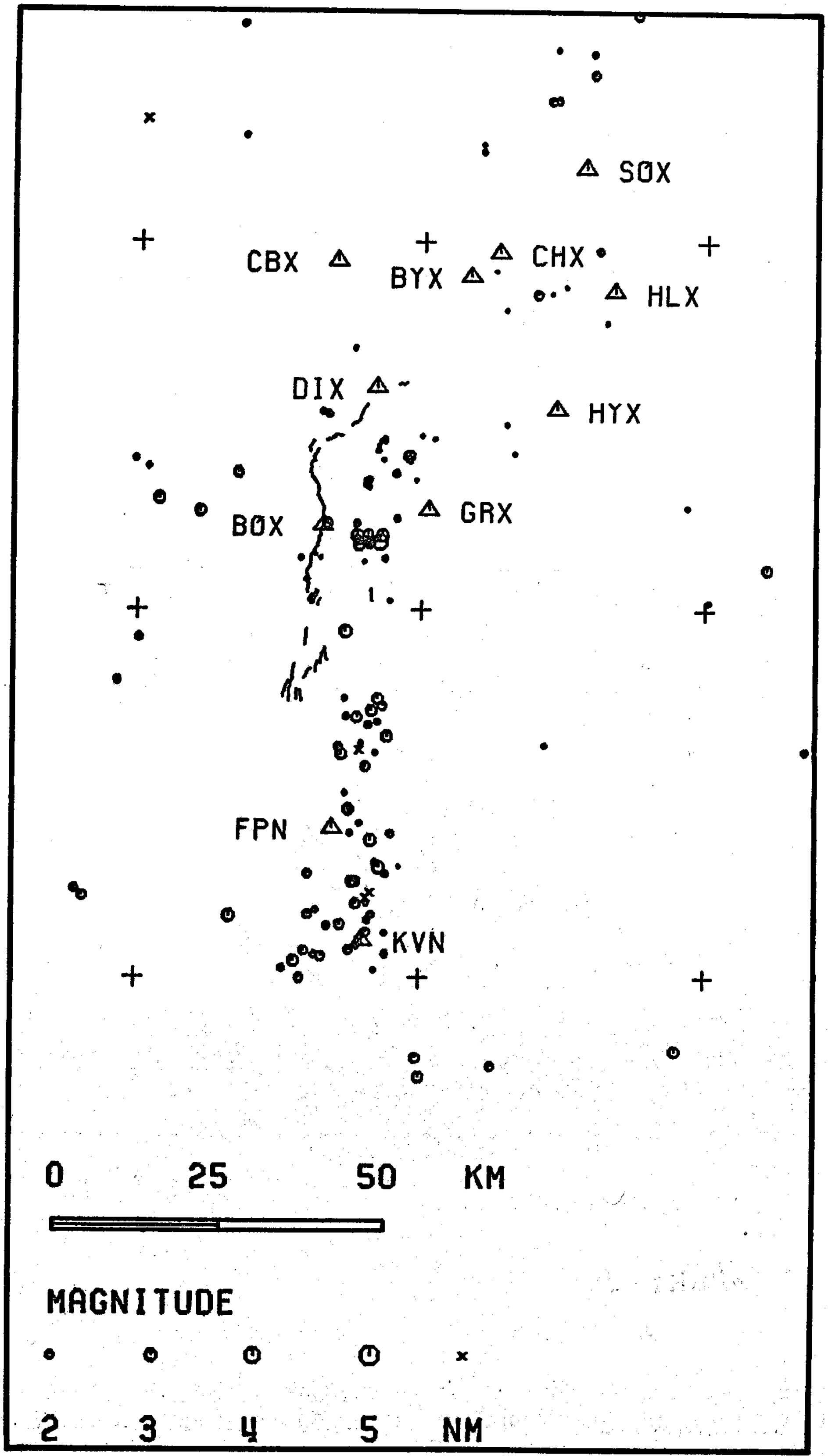

Figure 18. Earthquakes in the Dixie Valley-Fairview Peak area, 1979-1981. Area is same as Figure 14.

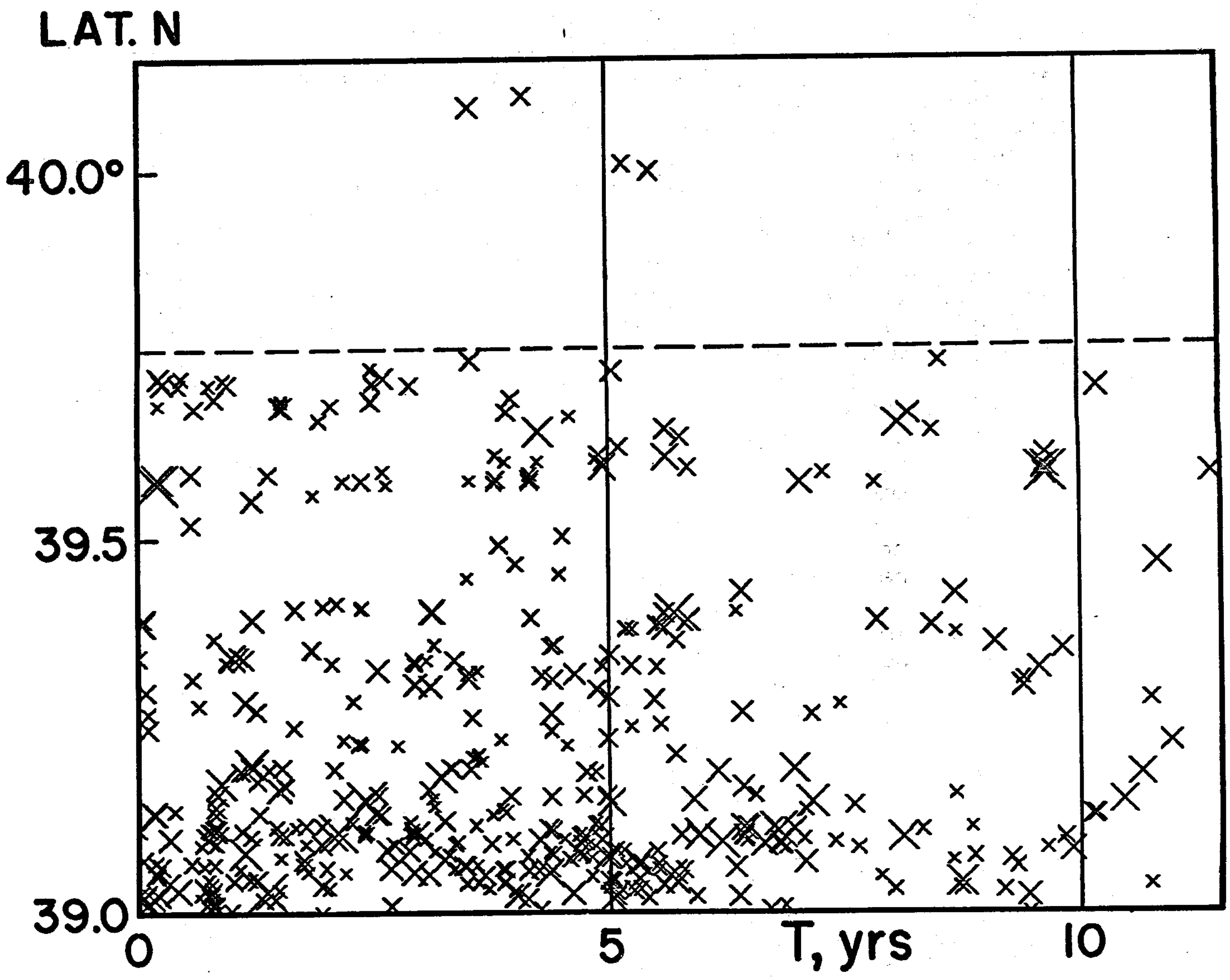

Figure 19. Distribution of earthquakes in the 1954 Dixie Valley-Fairview Peak rupture zone as a function of time for 1970-1981. Only events with ML ≥ 2.0 are shown; symbols are scaled as a function of magnitude.

Sierran frontal fault zone, supporting the idea that major changes in seismicity may occur on a regional scale.

Inspection of Figures 15-18 suggests that the Fairview Peak-Dixie Valley zone may be made up of a number of NW- and NE-trending fractures. This pattern was observed previously by Ryall and Malone (1971), who stated that

> "The over-all trend of the Dixie Valley and Fairview Peak zones is about N07° E, which agrees well with the strike of N09°E given by Savage and Hastie (1969) for a dislocation model based on geodetic changes that accompanied the 1954 Fairview Peak earthquake. However, our results indicate that this zone is made up of a zigzag series of northwest- and northeast-striking fractures very much like the pattern of northwest-trending compression ridges and northeast-striking tensional cracks found by Larson (1957) in a study of minor features of the 1954 fault zone. The main Fairview Peak zone strikes about N12°W, and the sense of motion in this zone is right-lateral oblique slip, the east side moving southeast and down. At the southern terminus of the main zone is a southwest-trending line of fractures, and north of the main zone there appears to be an en-echelon series of northeast-striking faults."

Figure 20 shows all events from 1974 to 1981 for which the quality of the HYPO71 hypocenter determination was A or B (Lee and Lahr, 1975). Of the 42 events shown, 36 are in the 1954 rupture zone, and these appear to fall in three areas -- a N-S main zone about 60 km long, and terminal fractures at the north and south ends of the main zone that trend N30-40°E. An average trend for all the events is about N09°E, in agreement with Savage and Hastie's (1969) estimate of the trend of the 1954 dislocation surface.

One other point worth mentioning is that Figure 19 clearly indicates a general lack of activity in northern Dixie Valley, the area of most interest to geothermal exploration. On the figure, the 1954 rupture zone is south of the dashed line at about 39.77°N; 443 of the events shown on the figure are located south of the line, and only 4 are north of it. Thus, for the last decade the zone which Wallace (1978) identified as a seismic gap has been almost completely quiescent.

Focal Depth.

In a previous study, Ryall and Savage (1969) compared focal depths for a number of natural earthquake sequences in the western Great Basin, and concluded that average focal depth appears to correlate with the magnitude of the main shock: "the 1954 Fairview Peak earthquake, with magnitude about 7, had aftershock activity in the depth range 12-14 km along the main fault zone and 8-13 km in a terminal cross-fault; recent earthquake swarms with maximum magnitude 5.5-6.0 in southern Oregon and southeast Nevada had focal depths concentrated in the range 5-10 km, and the shallowest natural earthquake sequence observed so far in the Nevada region was the Truckee, California, series, with magnitude of the main shock about 5.3 and concentration of focal depths in the range 3-7 km."

In the present investigation, focal depths were compared for 217 earthquakes with location quality of C or better (Lee and Lahr, 1975) for the

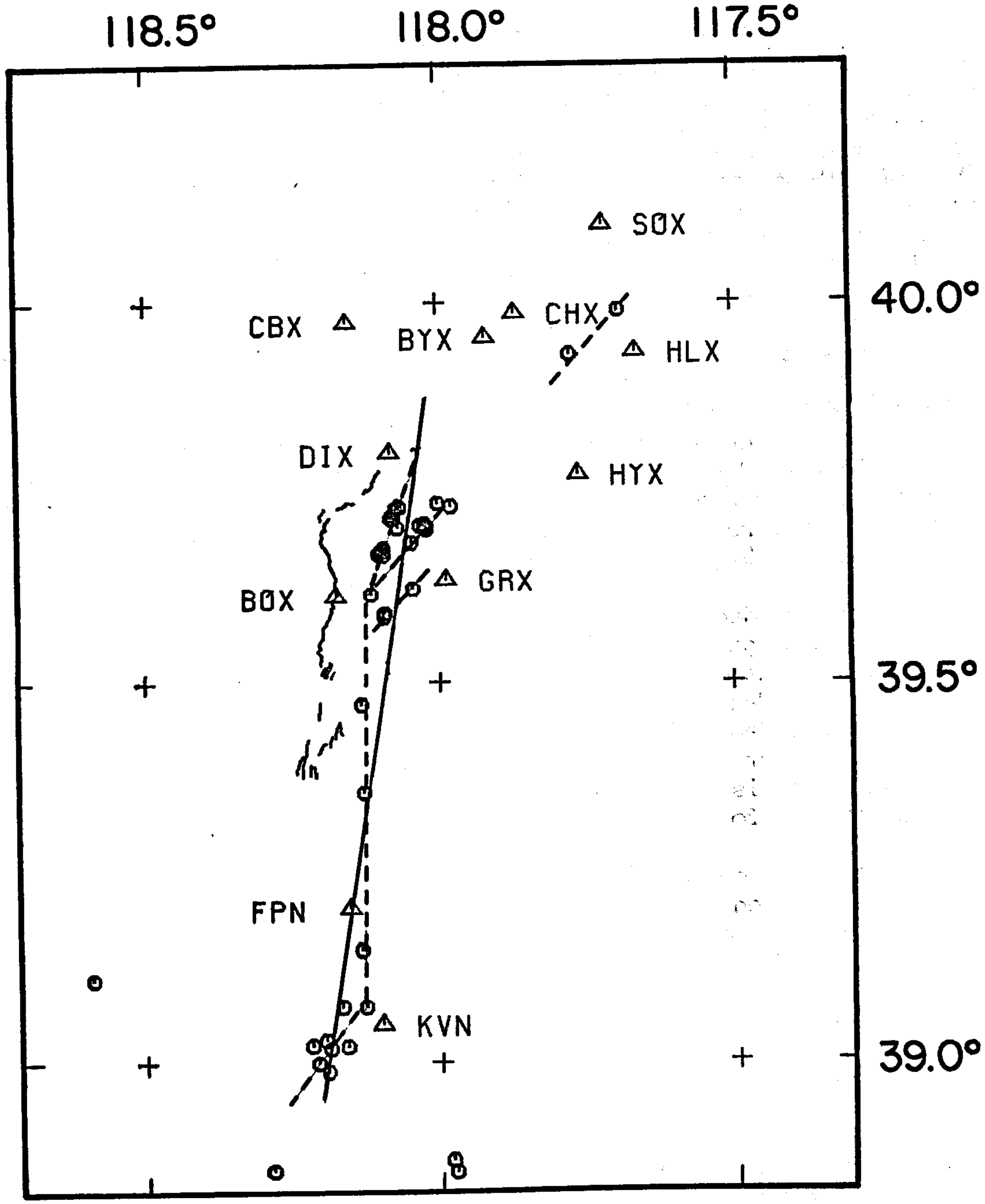

Figure 20. Earthquakes with location quality A or B (Lee and Lahr, 1975), 1974-1981. Average trend of entire zone shown by heavy line, hypothetical division into main zone and terminal fractures by dashed lines. Area shown is same as top part of Figure 14.

period 1974-1981. The epicentral distribution of these events is shown on Figure 21, and the distribution of events as a function of depth is shown by the histogram on Figure 22. Analysis of 207 events with depth in the range 3-22 km gave a mean depth of 11.3 km and standard deviation of + 3.22 km. As Figure 22 indicates, the earthquakes are not evenly distributed but tend to cluster at depths of 10-12 km; this clustering is well approximated by a normal distribution. A histogram for 42 events with B-quality solutions showed less concentration in the 10-12 km range (shaded part of Figure 22), but the mean value of 10.2 + 2.9 km was not significantly different than that for the larger sample. For 34 events in the main Fairview Peak zone, 39.15-39.55°N, mean depth was 12.8 + 4.0 km, in agreement with the observation by Ryall and Savage that events in this part of the rupture zone were slightly deeper than at the ends.

On Figure 23, the location of events in different depth ranges is shown by outlines of different types. The figure supports the observation that seismicity in the 1954 rupture zone occurs in three areas -- a N-S central zone and terminal zones that trend NE-SW. Dip directions cannot be ascertained from the plot. The figure also indicates the orientation of two cross-sections shown on Figures 24 and 25.

On Figure 24, depths are shown for 131 events with quality of C or better in the southern part of the area studied, on a cross-section viewed in the direction N36E. The cluster on the right side of the figure is in the northern part of the 1932 Cedar Mountains earthquake; the dip of this zone is 58°SE and the largest focal depth is about 16.5 km. The cluster on the left side of the figure consists of events in the southern part of the 1954 rupture zone; mean depth in that area is 10.6 + 2.8 km, and most events are in the range 7-15 km. No dip can be seen for this part of the rupture zone.

Figure 25 is a cross-section viewed in the direction N08° W, approximately the direction given by Savage and Hastie (1969) for the trend of the 1954 dislocation surface, and the figure contains only events for which the location quality was A or B. The figure would appear to rule out listric faulting in the main part of the 1954 rupture zone -- a dip of 59°E fits the points on the left (W) side of the figure, down to maximum depth of almost 17 km, and no flattening of the zone can be seen. On the right (E) side of the figure, two points suggest a possible dip of 50-60°W, and a cluster of points in the center of the figure could have a similar dip.

In the northernmost part of Dixie Valley, only five events were large enough to be analyzed, and these had depth of 7.2 km or less. A plot of these earthquakes viewed in the direction N40E suggests flattening of the fault with depth (Figure 26), but much more data would be needed to substantiate such a conclusion.

Recurrence Rates.

Recurrence curves showing the cumulative number of earthquakes as a function of magnitude areauseful in comparing the seismicity of one area with another. Such a plot for the Dixie Valley area for 1974-1981 is shown on Figure 27, with magnitude restricted to ML 2.5 or greater; the figure also shows all western Great Basin earthquakes outside the Mammoth Lakes area for 1980, with magnitude ML 2.3 or greater. The straight-line portion of a recurrence curve

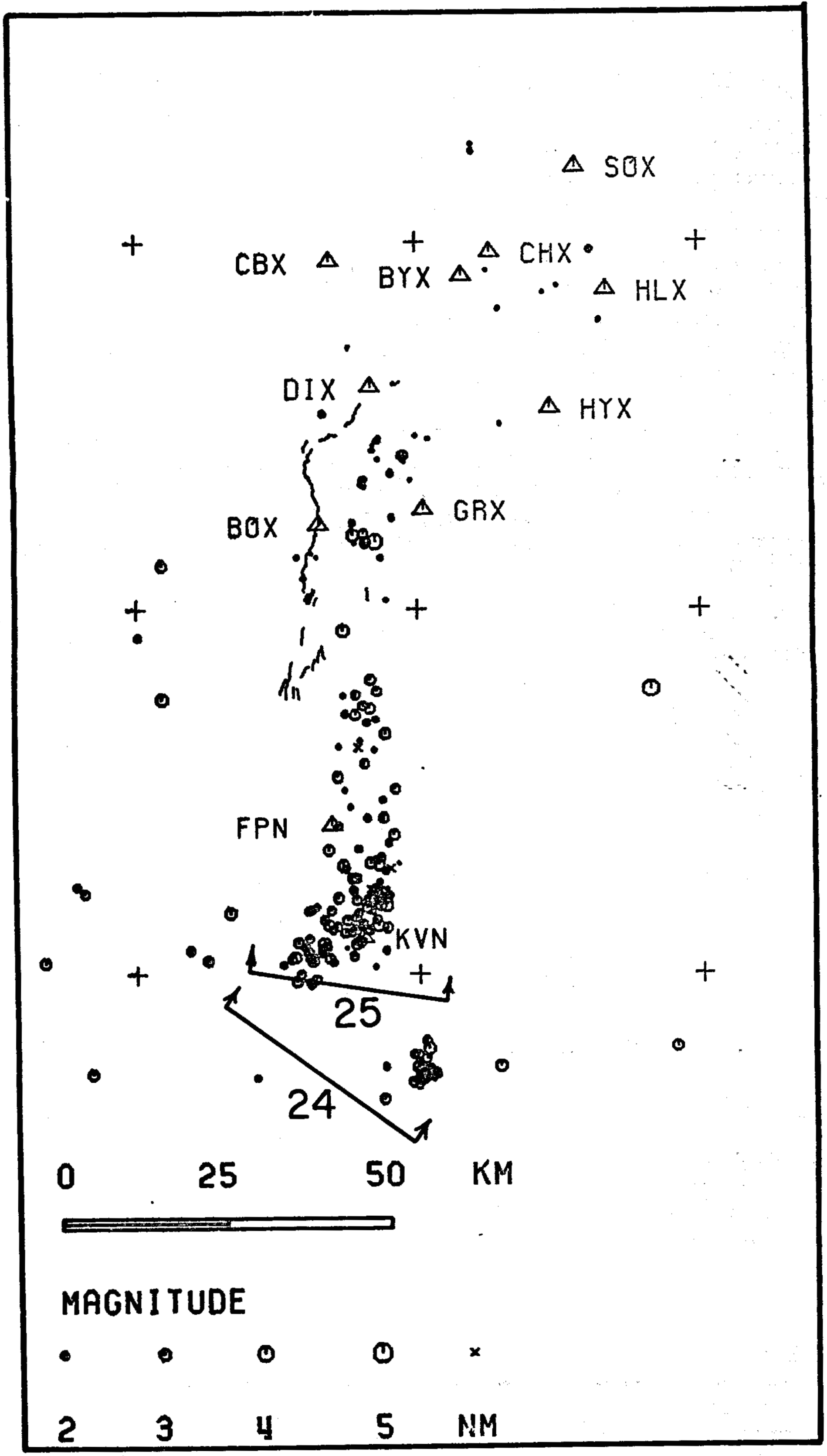

Figure 21. Earthquakes with location quality of C or better, 1974-1981. Numbered bars show orientation of cross-sections on Figures 24 and 25. Area shown is same as Figure 14.

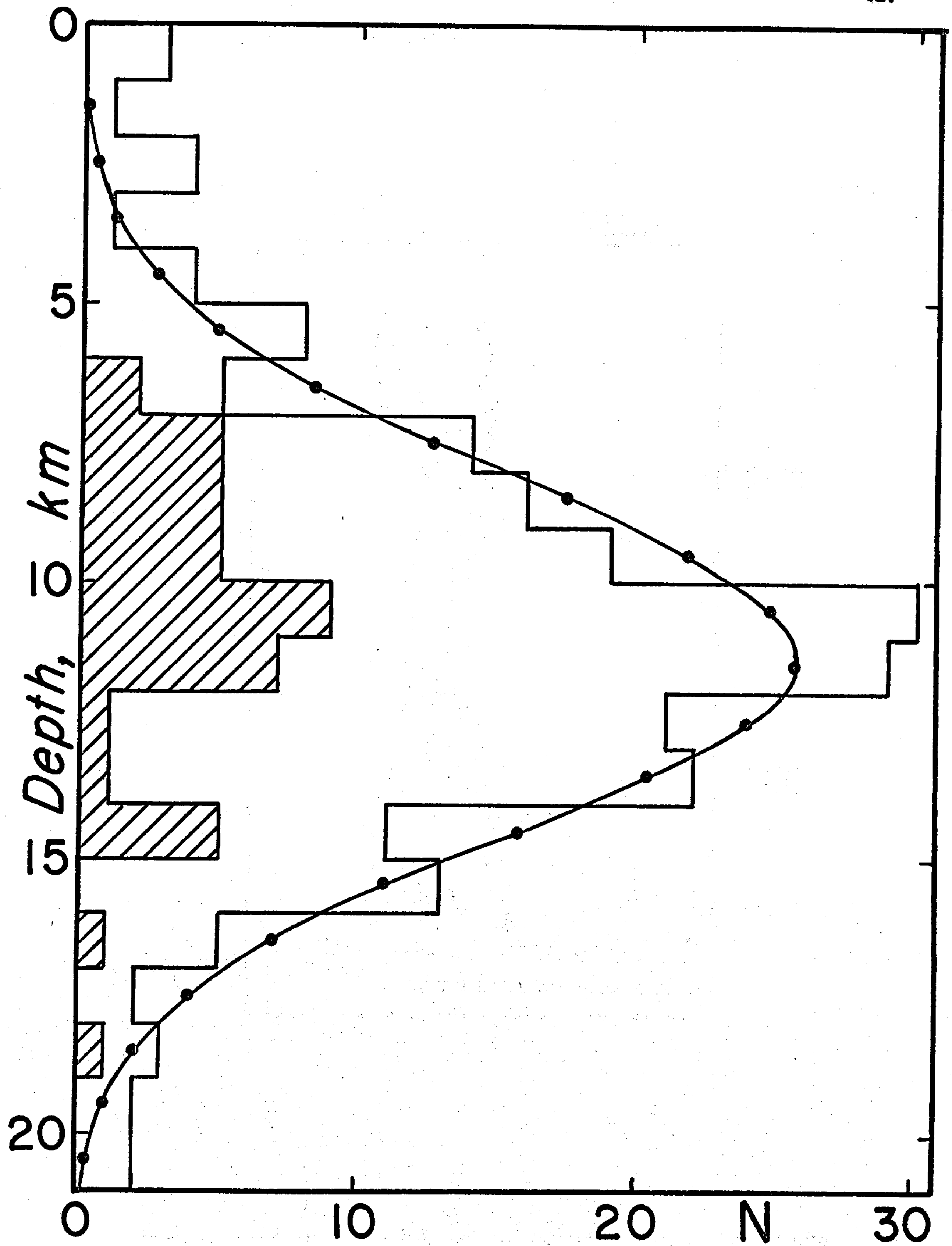

Figure 22. Histograms showing depth distribution for 217 events with quality C or better (unshaded area) and 42 events with quality A or B (shaded area). Smooth curve is normal distribution for mean depth 11.3 km, standard deviation ± 3.22 km.

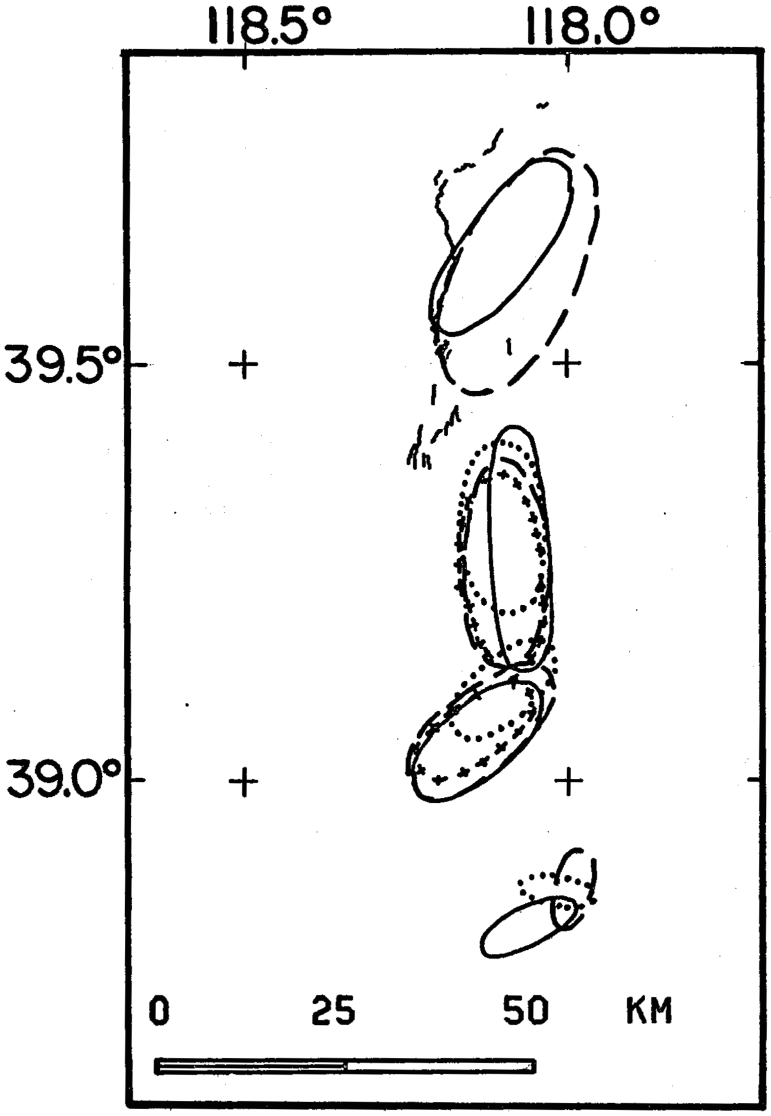

Figure 23. Map showing epicentral areas for different depth ranges: crosses — 0-5 km; solid line — 5-10 km; dashed line — 10-15 km; dotted line — >15 km.

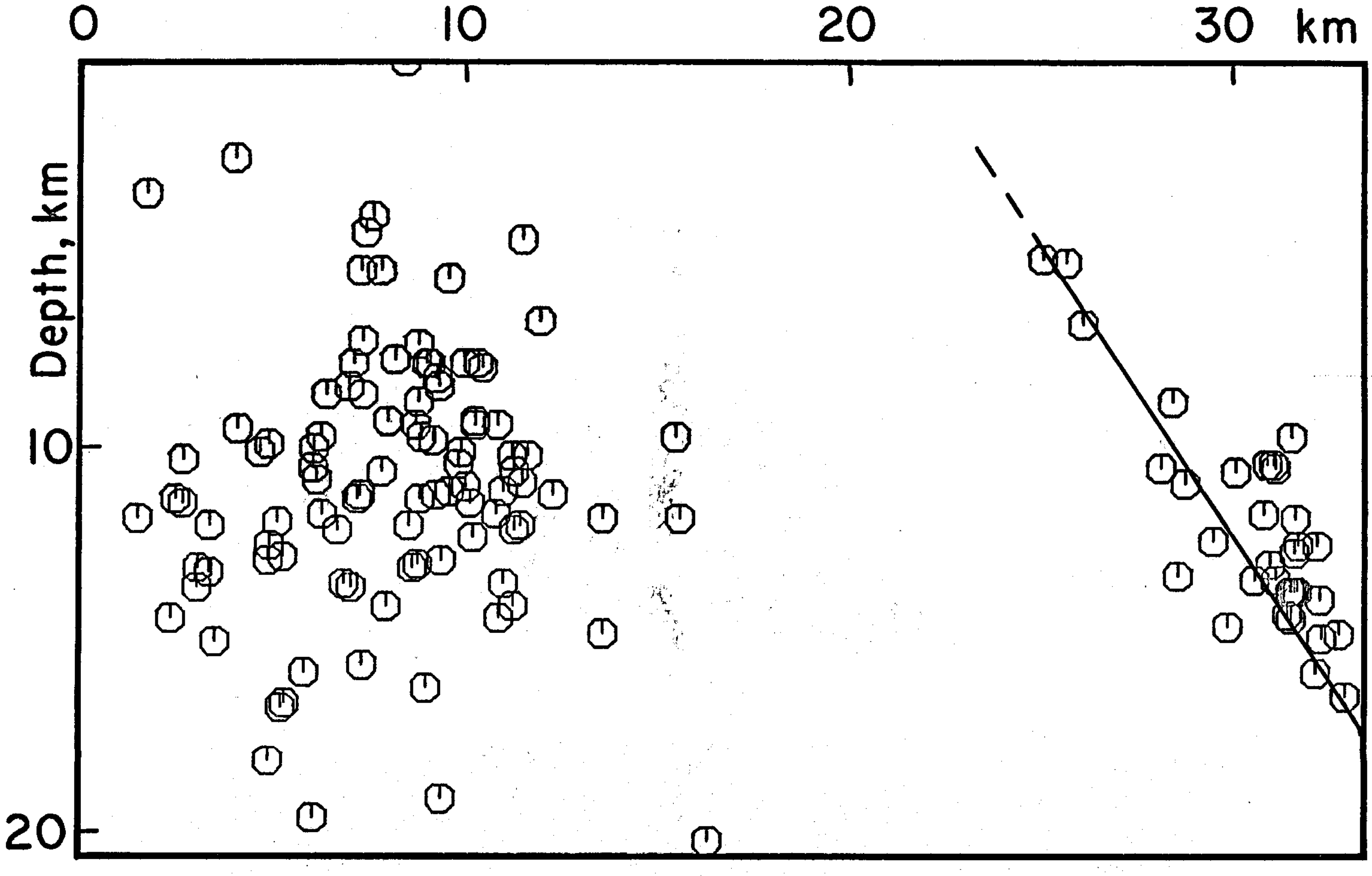

Figure 24. Cross-section viewed in direction N36E for southern part of Fairview Peak and northern part of Cedar Mountains rupture zones. Symbols are not scaled to magnitude. Cluster on right dips about 58 deg SE. Plot includes 131 events with location quality of C or better.

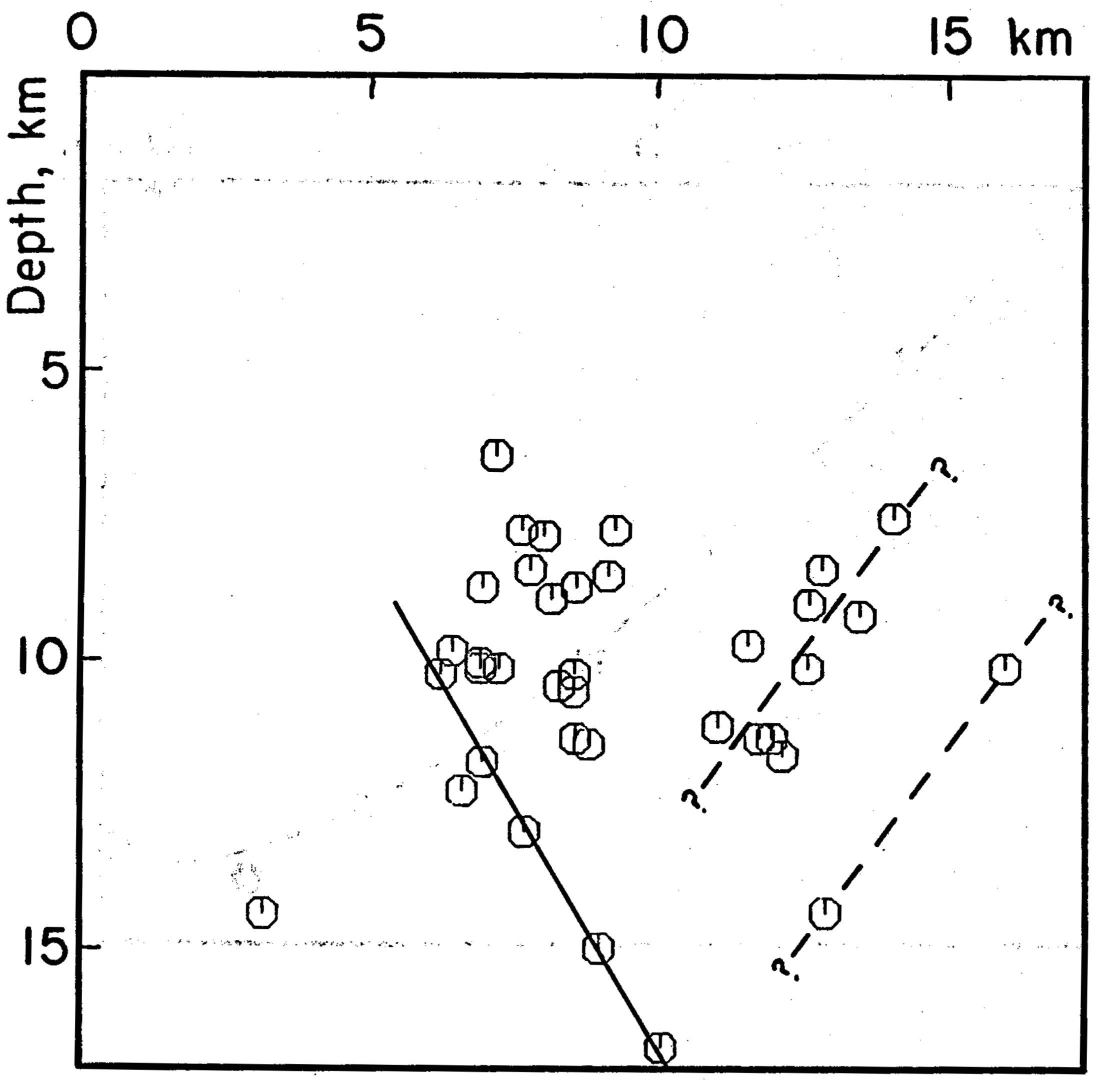

Figure 25. Cross-section viewed in direction N08E for main part of 1954 rupture zone. Plot shows 37 events with location quality of A or B. Dip of 59 deg SE for points on left of figure is in good agreement with dip found by Savage and Hastie (1969) for theoretical dislocation surface for the 1954 shocks.

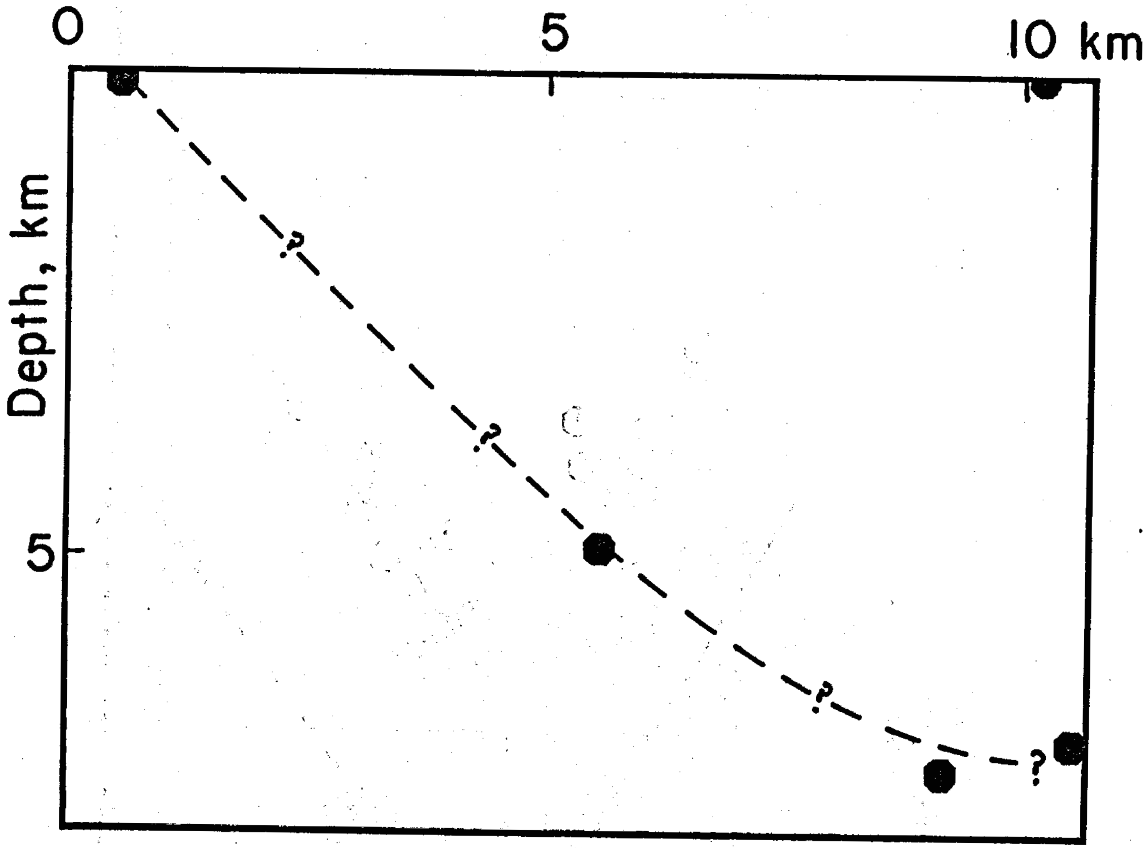

Figure 26. Cross-section for events in Dixie Valley north of the 1954 rupture zone, viewed in the direction N40E. Only events with location quality of C or better are shown. There is a vague suggestion of listric faulting indicated by dotted line, but much more data would be needed to support such an interpretation.

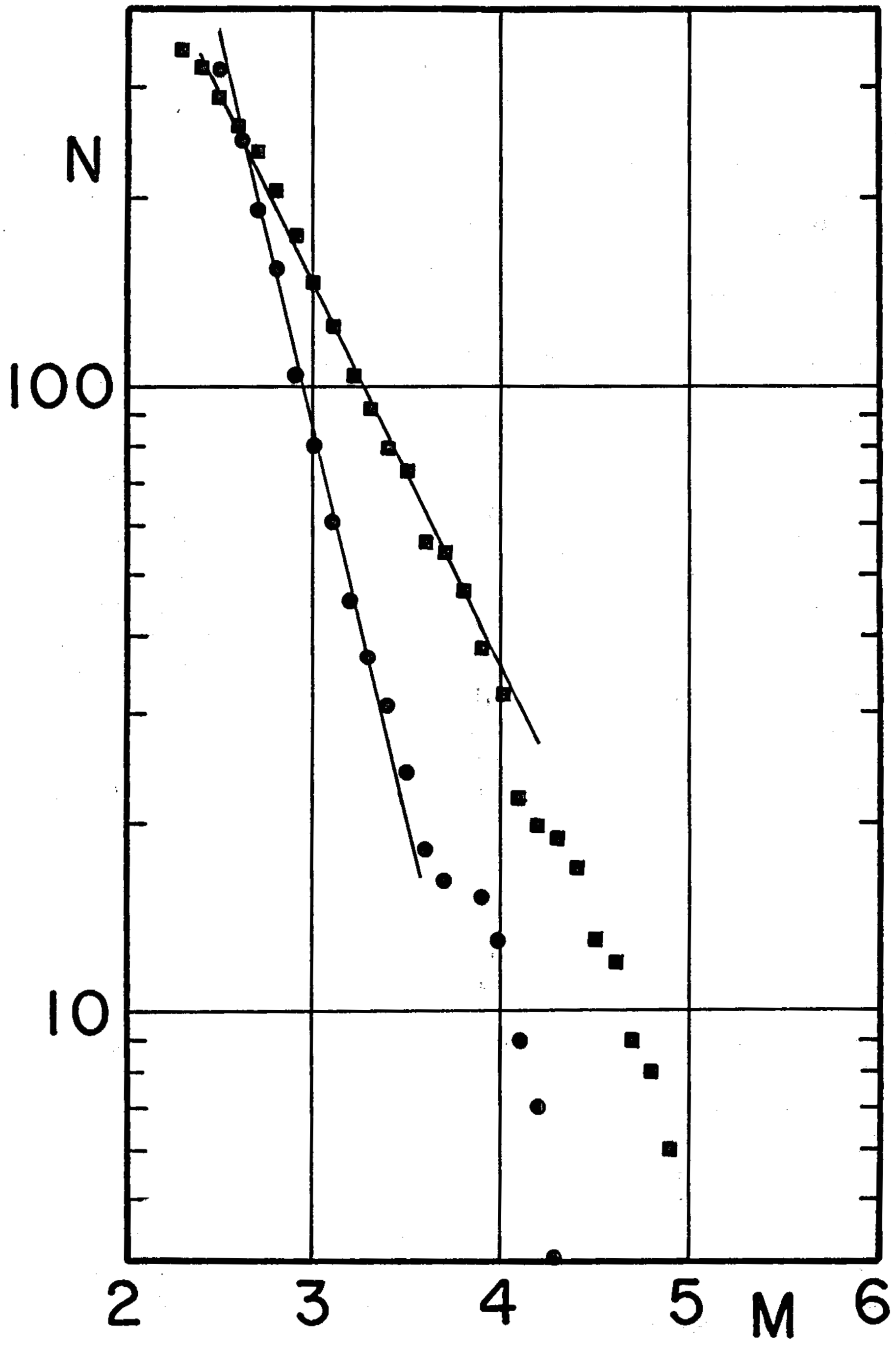

Figure 27. Recurrence curves for the Dixie Valley-Fairview Peak area, 1970-1981 (dots), and for all non-Mammoth Lakes events in 1980 (squares). N is the cumulative number of events with ML equal to or greater than the specified value.

can be represented by the equation

$$\log N = a - bM,$$

where N is the number of events with magnitude equal to or greater than M, a is an intercept that depends on the time period and area considered, and b is a constant that is thought to characterize seismicity in a given region (Gutenberg and Richter, 1954). B-values for the Dixie Valley and western Great Basin samples shown on the figure were determined by a maximum likelihood calculation (Aki, 1965) to be 1.29 and 0.60, respectively.

In general, relatively high b-values are found to be characteristic of aftershock sequences, earthquake swarms, and volcanic earthquakes (Mogi, 1966; Utsu, 1971; Hamilton et al, 1971; Wyss, 1973). A number of investigators (Eaton et al, 1970; Butovskays and Kuznetsova, 1971; Hamilton, 1972) found b to decrease with increasing focal depth, and Healy et al (1968) found it to increase with pore pressure for earthquakes associated with fluid injection. In the laboratory, Scholz (1968) observed different b-values for different rock types and found that b decreased with increasing stress in all cases. Explanations of the various sets of observations are in terms of an inverse dependence of b on applied stress (Scholz, 1968; Butovskaya and Kuznetsova, 1971; Wyss, 1973); moreover, the various authors concluded that higher b-values should be observed in regions (or at depths in the crust) where the number of inhomogeneities per unit volume is relatively large. In the Dixie Valley-Fairview Peak area, the relatively high average b-value would be expected in connection with ongoing aftershock activity following the large earthquakes there in 1954.

On Figure 28, the slope of the recurrence curve is shown as a function of time for the period 1970-1981. The b-values on this plot were determined for overlapping groups of 100 events each, with minimum magnitude in all cases taken as ML 2.0. The plot indicates that b increased from .80 in 1970 to 1.18 in 1972; in 1974 it began to gradually decrease, reaching a minimum value of 0.68 in 1978. Since that time fewer than 100 events with ML 2.0 or greater have occurred, so the value plotted in mid-1978 is the latest one we could calculate.

In a study of the 1980 Mammoth Lakes earthquake sequence, Ryall and Ryall (1981) observed that the b-value for earthquakes along the Sierra Nevada-Great Basin boundary zone gradually decreased from 1.00 to 0.61 over the period 1970-1979, and then rapidly increased to 0.99 before the occurrence of several ML 6+ events in mid-1980. This slow decrease followed by rapid increase agrees with a pattern that Scholz et al (1973) related to increasing effective differential stress, related in turn to dilatancy hardening preceding a large earthquake. If a similar process is occurring in Dixie Valley, the length of the "bay" -- period of low b-values -- of about 8 years would be appropriate for a major earthquake. Should this be the case, based on experience in 1954 and 1980 a significant increase in seismicity would be expected before the occurrence of a large event.

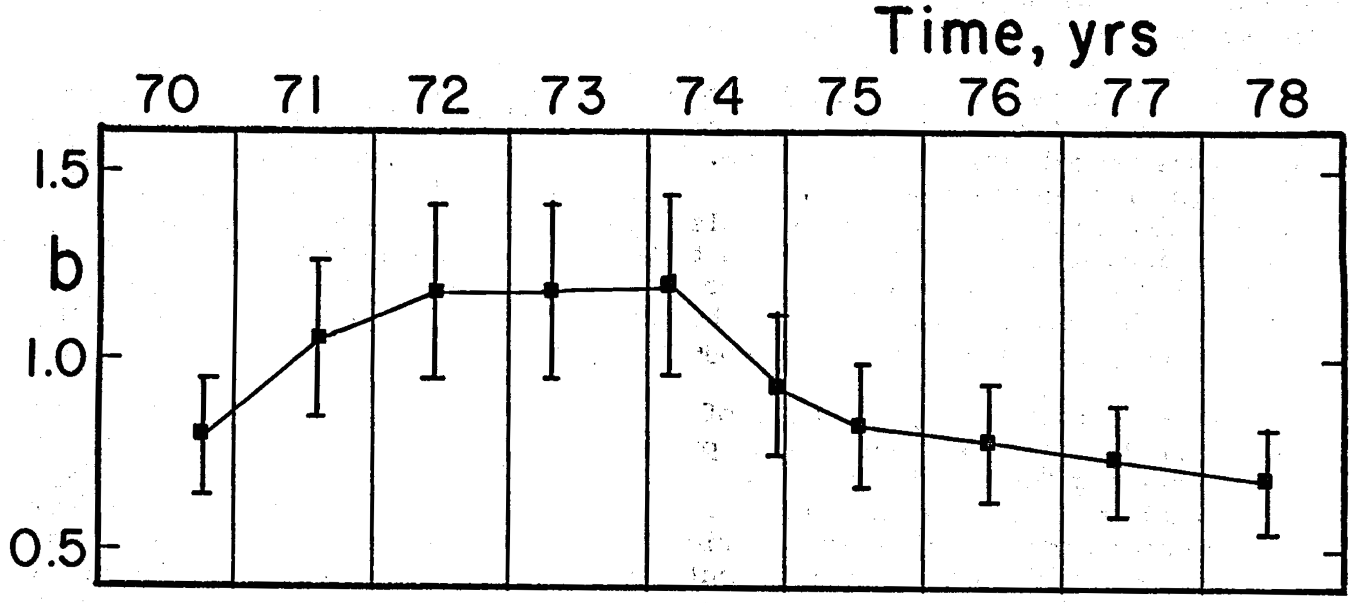

Figure 28. Running b-value for the Dixie Valley-Fairview Peak rupture zone, 1970-1981. Based on overlapping samples of 100 events each, with ML 2.0 or greater. Error bars indicate 95% confidence limits. Points are plotted at the center of the time period for each sample. Last point is in 1978 because too few events occurred after that time for accurate determinations of b.

Fault Plane Solutions.

In a previous study, Ryall and Malone (1971) compared epicenter distributions and composite fault-plane solutions for microearthquakes in the Fairview Peak area. They concluded that earthquake activity in west-central Nevada is directly related to regional extension, with the minimum principal-stress axis having an average trend of about N60° W, and the intermediate and maximum principal stresses lying near a plane striking about N30°E and dipping 85°SE. The authors noted that this stress pattern is similar to that found for aftershocks of a nuclear explosion in southern Nevada (Hamilton and Healy, 1969), and concluded that similar stresses may be operating over a broad region in the western Great Basin. The one exception to this pattern was a fault-plane solution for earthquakes in Dixie Valley, where the stress axes were rotated about 50 degrees clockwise from corresponding axes in the Fairview Peak and Rainbow Mountain zones.

For the present study, fault-plane solutions were determined for eleven earthquakes with ML 3.0-4.5, in the area 39.0-40.0°N, 117.5-118.5°W. Depths of the events ranged from 3.4 to 14.7 km. The focal mechanisms (Figure 29) were based on first-motion patterns for clearly-recorded P arrivals — primarily Pg but also including numerous Pn arrivals. Following Ryall and Malone (1971) the angle of incidence for Pn was assumed to be 50 degrees, appropriate for a single crustal layer with velocity 6.0 km/sec over a mantle with velocity 7.8 km/sec. Some of the observations used in the analysis were questionable, but omitting these points did not appreciably change the results.

The solutions on Figure 29 are of two main types. Five (labeled A to E on the figure) are consistent with primarily dip-slip, or normal faulting, on planes striking NE-SW and dipping NW or SE — we shall refer to these as "Type I" mechanisms. The other six ("Type II"; F-K on the figure) range from strike-slip to oblique-slip, with a right-lateral slip component if the plane striking N to NE is taken as the fault plane. Four of the five Type I sources are SE of Fairview Peak (FPN), and the other (point E) is west of the Stillwater Range in the Rainbow Mountain fault zone. Four of the Type II sources are in the southern part of Dixie Valley, one is south of Fairview Peak, and one is in the north end of Smith Creek Valley, 50 km east of Dixie Valley. While the two types of mechanisms cannot be separated by area, they can be generally separated by focal depth: the Type I events had depths in the range 8.4-14.7 km and averaged 11.9 + 2.6 km; range and mean depth for the Type II events were 3.4-11.8 and 7.2 + 3.1 km, respectively. Descriptions of the two types of sources are given below.

Dip-slip mechanisms. Solutions A-E all show two planes striking NE-SW, one dipping NW and the other SE. A decision as to which plane is the fault and which the auxiliary plane cannot be made from the figure; if the SE-dipping plane is arbitrarily selected as the fault, the parameters are those listed in Table 3. Note that the trend of the T-axes, or axes of minimum compressive stress for these events range from 44 to 75 degrees, in a NW-SE direction; the average trend is -61 + 11 degrees (azimuths NE, or clockwise being taken as positive). Average plunge of the T-axes is about 8 degrees. Of the five mechanisms, one (E) is based on few data and is a poor solution. Mechanisms A and B are not unique, and could also be interpreted in terms of a fault striking NW and dipping NE or SW; however, such a mechanism would be less probable than the ones shown on the basis of Basin and Range tectonics. The location of event

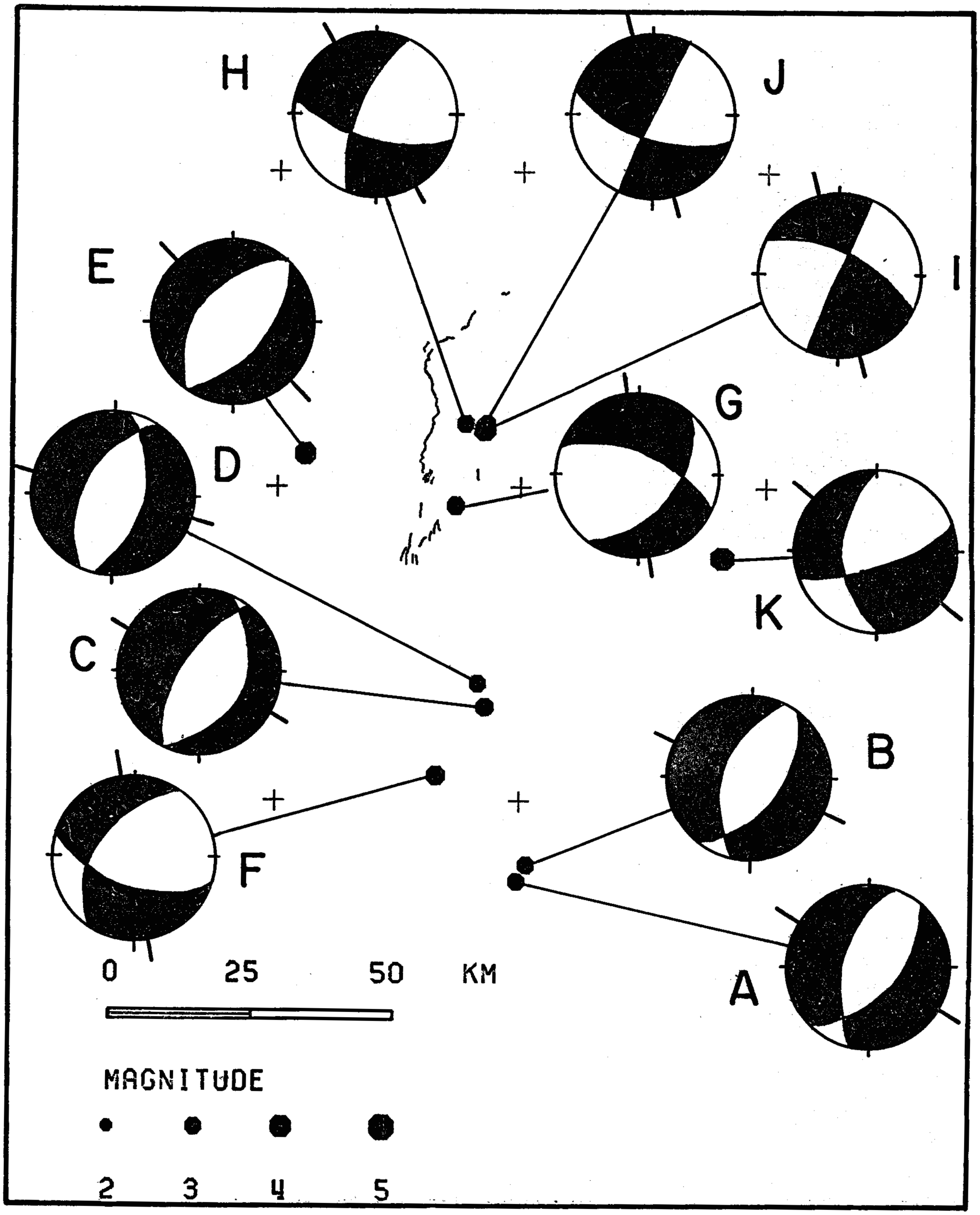

Figure 29. P-wave fault-plane solutions for selected events in the Dixie Valley area. Plots are lower-hemisphere, equal-angle projections, shaded sectors are compression. Orientation of T-axis indicated by heavy line on each mechanism.

TABLE 3. PARAMETERS OF FAULT-PLANE SOLUTIONS

EVENT	"FAULT PLANE"		X-AXIS		P-AXIS		T-AXIS	
	STRIKE	DIP	TREND	PLUNGE	TREND	PLUNGE	TREND	PLUNGE
A	45	40SE	110	38	54	76	-58	05
B	31	40SE	109	40	60	81	-66	05
C	25	24SE	120	24	120	23	-60	20
D	05	49SE	115	48	-150	80	105	03
E	45	50SE	135	50	-45	85	146	05
F	39	43NW	20	18	55	45	170	19
G	45	53SE	-147	28	-95	49	-08	05
H	24	74NW	-147	28	67	33	-30	10
I	34	90					165	20
J	32	90			75	14	-15	14
K	0	50W	-19	20	28	46	130	11

Note: Strike and trend angles are taken to be positive in clockwise direction from north; all angles are in degrees.

D was obtained by fixing the focal depth, so the latter could not be used in determining average depth for the Type I events.

Oblique-slip solutions. For the six oblique-slip mechanisms (F-K), Table 3 lists the source parameters, assuming always that the N- or NE-striking plane is the fault. Note that the T-axes trend from 8 to 50 degrees in a NW-SE direction; the average trend is -21 + 16 degrees, and the average plunge is 13 degrees. Of the six solutions, I is the worst, with possible variations in the fault and auxiliary planes of + 10 and + 25 degrees, respectively; however, the extension direction for this solution can be varied by only + 10 degrees. With the exception of solution K, all of the six oblique-slip mechanisms have a fault plane striking N24-45°E and dipping from 40 degrees to vertical; in three cases the W or NW block is downdropped, in one case the SE block is downdropped, and for two cases motion is right-lateral strike-slip.

Taken together, these observations can be explained by the known tectonic stress regime in the western Great Basin, together with a depth effect. Thus, T-axes for all of the eleven mechanisms are oriented NW-SE, in agreement with known regional extension of the province. The main difference between the two types of mechanism is that the maximum principal stress (P-axis) is almost horizontal for the strike-slip (Type II) sources and near-vertical for the dip-slip (Type I) events. This could be explained by depth differences, with weight of the overburden at larger depth leading to maximum stress in the vertical direction, and possibly some rotation of principal stress directions in the horizontal plane. Such an effect was suggested by McGarr (1980), who noted that experimental data indicate increasing maximum deviatoric stress with depth, and concluded that "a vertical profile of measurements from the surface downward might show a systematic rotation of the horizontal principal stress directions with the implication that stress trajectories measured at the surface may not be indicative of directions throughout much of the crustal section... The interesting aspect of the effect is that it is a systematic regional phenomenon, which is not related to any local source of stress inhomogeneity."

CONCLUSIONS AND RECOMMENDATIONS

A ten-station seismic network was operated in and around the Dixie Valley area from January 1980 to November 1981; three of these stations are still in operation. Data from the Dixie Valley network were analyzed through 30 June 1981, and results of analysis were compared with analysis of somewhat larger events for the period 1970-1979. Conclusions and recommendations are the following:

1. Seismicity in the Dixie Valley-Fairview Peak area is almost exclusively confined to the rupture zone of large earthquakes that occurred there in 1954. During the entire 11.5-year period of observation only 11 events large enough to be analyzed were located in the northern part of Dixie Valley (north of Dixie Meadows). Five of these events -- with magnitude 0.1-1.6 -- were recorded by the Dixie Valley net in 1980 and 1981; the largest shock in this area was an ML 3.0 event in 1973. Thus, the area of most interest to geothermal exploration has been quiescent for at least a decade.

2. Earthquakes in northern Dixie Valley had focal depth of 7.2 km or less. This is quite shallow compared to mean depth of 11.3 km for the 1954 rupture zone to the south. A cross-section showing depth of five events in the area north of Dixie Meadows suggests that listric faulting may be occurring there, but much more data would need to be collected and analyzed to confirm this. Cross-sections for well-located events in the 1932 and 1954 rupture zones suggest that fault dips of 50-60 degrees persist to depths greater than 16 km, thus arguing against listric faulting in those areas.

3. Focal mechanisms for larger events in the area of interest are consistent with regional extension in the NW-SE direction, as found by a number of previous investigators. There appears to be a correlation between the ratio of dip-slip to strike-slip motion and focal depth, with deeper events having primarily normal slip on NW- or SE-dipping faults. This may be explained by a relatively larger increase in vertical than in horizontal stress with depth, due to the overburden (McGarr, 1980).

4. Perhaps unfortunately for this investigation, the level of seismicity in the Dixie Valley-Fairview Peak area was anomolously low during the period of operation of the Dixie Valley seismic network. In the southern part of the 1954 rupture zone, the average rate of occurrence of events with ML > 2 for the period after 1976 was almost five times less than that for the preceding seven years. This decrease in activity was generally synchronous with a period of quiescence reported by VanWormer and Ryall (1980) for the entire Sierra Nevada frontal fault zone. In the case of the Sierra Nevada, however, the quiescence ended with a burst of moderate earthquakes in all parts of the zone in late 1978 and 1979, culminating with several ML 6+ shocks in the Mammoth Lakes area in May, 1980 (Ryall and Ryall, 1981). In the Dixie Valley-Fairview Peak area, the period of quiescence has continued until the time of this writing.

5. A recurrence curve for events in the 1954 rupture zone for 1970-1981 indicates a b-value (related to the ratio of small-to-large earthquakes) that is high (1.3) for the western Great Basin. Such high b-values have been found to be characteristic of aftershock sequences, earthquake swarms and volcanic earthquakes (Mogi, 1966; Utsu, 1971; Hamilton et al, 1971; Wyss, 1973). However, a running b-value calculation indicates that b increased from 1970 to

1974, and has since decreased during a period of generally reduced seismicity. Ryall and Ryall (1981) observed a similar decrease of b in the southern Sierra Nevada from 1970 to 1979, followed by a rapid increase just preceding the large earthquakes at Mammoth Lakes in 1980.

6. Evidence related to the possibility of a large earthquake in northern Dixie Valley is ambiguous. Based on geologic observations, Wallace (1978; personal communication, 1981) considers the area between the 1915 and 1954 breaks to be a "seismic gap," with the potential for an earthquake of magnitude 7+ in the near future. In a way, the possibility of a large shock there is supported by the observation of very low seismicity in the area north of Dixie Meadows, and by a decrease in b-value starting in the mid-1970's and continuing to the present time.

On the other hand, some of the evidence argues against an impending large shock in this area. Earthquakes in northern Dixie Valley appear to be very shallow, and could possibly even be associated with listric faulting in a shallow crustal section overlying a zone in which deformation does not involve brittle fracturing. In a previous study, Richins (1974) noted that earthquakes in northwest Nevada, a region characterized by high heat flow and geothermal activity, tend to be shallower than those in the major earthquake zones of central Nevada. Richins concluded that the maximum magnitude of earthquakes in geothermally active regions may be only 5 3/4 - 6, as a result of the weakening of crustal rocks by fracturing in the vicinity of intrusive bodies, or by the effects of stress corrosion and leaching due to geothermal fluids. We note also that decreases in both seismicity and in b-value were observed in the 1954 rupture zone, and not in the northern Dixie Valley area. The possibility of another major earthquake at Fairview Peak or in the southern part of Dixie Valley, only 30 years after the last such event, would not be likely on either geologic or seismologic grounds (Wallace, 1977, 1978; Ryall, 1977).

7. Because of the ambiguity relative to the possibility of a future large earthquake in the area of primary interest to geothermal exploration, it is recommended that some level of monitoring be continued in the future. Probably the present level of effort, with two stations in northern Dixie Valley, will be sufficient for the time being. If activity increases in the future, if a rapid increase is observed in b-value for the Dixie Valley-Fairview Peak area, or if geothermal production is undertaken then this passive monitoring should be replaced by an expanded level of effort, and one involving a dense station network.

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APPENDIX A: FELT EARTHQUAKES IN THE DIXIE VALLEY REGION, 1840-1954.

The first seismograph with timing in California was installed at Berkeley in 1910. The first such instrument in Nevada began operation at the Mackay School of Mines in 1916. Prior to that time information on moderate to large earthquakes in the Nevada region is available only from earthquake catalogs (Holden, 1898; Townley and Allen, 1939; Slemmons et al, 1965) or from newspapers that were published at the time the earthquakes occurred. Since Nevada had a large number of newspapers in the late 1800's, and since these were fairly evenly distributed over most of the west-central part of the state, the newspapers offer a valuable resource in determining the extent of the felt area for a given earthquake, location of the epicenter, maximum intensity, etc.

For this investigation, eleven newspapers in northern Nevada were searched for information on all of the shocks reported in earthquake catalogs as having occurred in the region before 1917. Epicenters for these early shocks were estimated by comparing the intensities reported in the newspapers for various locations within the felt region. For example, an earthquake on 23 March 1872 was reported as "violent" in Austin, "slight" in Winnemucca, "frightened people" in Unionville, and "not felt" at Gold Hill and Eureka. By plotting the intensities corresponding to these effects on a map the earthquake was estimated to have occurred in northern Dixie Valley.

For many of the earthquakes, magnitude could be determined from the radius of the felt area, probably to within about half of one magnitude unit. The relationship between these two parameters was determined by Gutenberg and Richter (Richter, 1958), but it appears to be applicable to Nevada earthquakes as well. Again taking the 23 March 1872 shock as an example, the earthquake was felt to 120 km (Winnemucca) but not to 160 km (Eureka, Virginia City). Taking 150 km as the radius of the felt area, the graph on Figure A-1 gives ML 5.2 for this event; as a conservative estimate we have listed it as having ML 5 1/2.

Earthquakes in the region around Dixie Valley are listed below for the period from about 1845 to 1954. Sources of information are indicated by capital letters, according to the abbreviations following the earthquake listing. Times through 1915 are local times; time for 1916-1954 is GMT.

- About 1845(?). 39.5, 118.5, near Stillwater, intensity IX. S65: "RRR of 10-17-65 citing VCTE. Piutes report quake near Pyramid Lake 13 years ago. Great cracks opened from which water spouted 100 feet high. Large landslide on Slide Mountain." GHN, 12-30-69: At the time of the 1869 Wadsworth shock Captain Charley, a Washoe Piute aged about 30 years, reported that there had been a great earthquake when he was a little boy. The earthquake occurred while Indians from the Walker, Carson and Truckee Rivers were fishing at the Carson Sink. The shock knocked people down. River banks were shaken down in the vicinity of Stillwater, and the river changed its course. T-A does not list any large earthquake in western Nevada until 1860. Presumably, an event with the effects described above would have been felt at Sacramento or Auburn, and would have been reported in California newspapers had it occurred after 1850 as reported by S65.

- 1872 March 23, 1:41 pm. 39.8, 117.8, Dixie Valley, intensity VIII, M 5 1/2. RRR, 3-23-72: "Violent shock" in Austin, lasted about 5 seconds, plaster fell in courthouse. HR, 3-30-72: "Slight shock" in Winnemucca, lasted only a few seconds. Also reported felt in Unionville, where people were frightened. ES, GHN: Not reported.

- 1872 May 6. 41.0, 117.5, near Winnemucca. S65 quotes RRR of 5-13-72: Several distinct shocks felt in Winnemucca in early part of week. HR, ES, GHN: Not reported. Probably Pleasant Valley.

- 1872 May 24. 41.0, 117.5, near Winnemucca. S65 quotes RRR of 5-25-72: Two slight shocks at Winnemucca. HR, ES, GHN: Not reported. Probably Pleasant Valley.

- 1873 November 7, 6:40 pm. 39.7, 118.1, Dixie Valley, intensity IV, M 5. RRR, 11-6-73 and 11-10-73; GHN, 11-6-73; HR, 11-14-73: First shock at 10 am on 11-5 felt plainly on Reese River but not in Austin. Shocks at 2:30 and 7:30 pm on 11-5 and 4:30 am on 11-6 were lightly felt in Austin and Virginia City. The last of these was the strongest. Largest event of the series was at 6:30 pm on 11-7. It was "plainly perceptible" in Austin, "causing windows to rattle and lamps to shake," and people ran outdoors. It was also reported felt in Unionville and Winnemucca.

- 1874 November 29. 40.7, 117.7, northern Pleasant Valley, intensity VI, M about 4 1/2. GHN, 12-1-74, quoting SS of 11-30: Shock occurred on Sunday morning, startling persons who were still asleep in Winnemucca, rattled crockery and cracked a partition in the Courthouse. Many frightened and ran outdoors. Also felt strongly at Fairbanks (10 mi "above" Winnemucca) and Battle Mountain. Not mentioned as felt in Virginia City. T-A: Two heavy shocks at Oreana. RRR: Not reported.

- 1882 October 12. 41.0, 117.5. SS, 10-17-82: Southeastern Humboldt County, along the Jersey Range. RRR, EDL, EI, VCTE, REG: Not reported.

- 1885 May 1, 9:30 pm. 40.9, 117.7, northern Pleasant Valley, intensity IV. T-A: IV at Winnemucca. EI, VCTE, REG, ES, EDL: Not reported.

- 1900 February 29, 1:35 pm. 40.9, 117.7, northern Pleasant Valley, intensity IV. T-A; SS, 2-28-1900; RRR, 3-3-1900; EI, 3-2-1900; ES, 3-3-1900: Shock felt in Winnemucca, startled people in Courthouse. Not reported felt elsewhere. TT, VCTE: Not reported.

- 1915 October 2, 10:55 pm. 40.3, 117.6, Pleasant Valley main shock, intensity X, M 7.6 (Richter, 1958). T-A; BKS; REG, 10-4 and 10-15-15; RRR, 10-9-15; SS, 10-5, 10-7, 10-9, 10-12-15; S65: Felt from Washington to the Mexican border and from the Pacific coast to Montana, Wyoming, Colorado, and Arizona -- an area of more than 500,000 sq mi. Damage greatest at Kennedy, where practically every building was destroyed. Faulting along the western face of the Sonoma Range had 6-12 feet of displacement for a distance of 20-25 miles. Damaged Southern Pacific water tanks at Battle Mountain, Golconda, Lovelock and Parran. In Winnemucca nearly every chimney was toppled, walls were cracked, and a few were thrown down. At Golconda a steel railroad bridge was warped. Stock was thrown from shelves in Elko. At Austin the main shock lasted 40-90 seconds, according to different stop watches; damage was inconsequential. At Tonopah and Goldfield there was "prolonged swinging motion" and clocks stopped. There were two strong foreshocks, at 4:41 pm and 5:50 pm; at Winnemucca 26 aftershocks were noted in the first nine hours after the main shock. S65 lists 8 aftershocks during October, and T-A lists an additional 70 shocks during the next three months. BKS: Amplitude of 700 microns at Berkeley, more than 800 at Lick Observatory. This would correspond to M 8.0. SS, 10-5-15: "This was the first earthquake known here for 31 years, a slight shock having been felt in 1884. However, pioneers were informed by Indians, many years ago, that during the early 40's heavy shocks were of frequent occurrence for four or five years." This would appear to indicate a period of quiescence preceding the main shock, up to the two foreshocks on October 2.

- 1916 October 21 to December 27. 40.5,118.1, Unionville sequence. T-A lists five events felt at Unionville from October 21 to 31, nine shocks in November, and eleven from December 1-27. Sources given are George A. Bice, MWR, and Seismological Dispatches of Georgetown University. AEJ does not list any of these events as having been recorded at Reno, so they must have had M < 3.7.

- 1917 April 15, 19:01 GMT. 39.7, 118.1, Dixie Valley, M 4.8. T-A: intensity III at Fallon, Rochester and Lovelock. AEJ gives date as April 11, probably an error. RW readings give distance of 150 km from Reno, amplitude 12 mm. BKS: Recorded at Berkeley, Lick Observatory.

- 1917 June 1, 20:37 GMT. Pleasant Valley (?) T-A: Intensity III at Winnemucca. AEJ, BKS: Not reported.

- 1918 August 19, 10:53 GMT. Pleasant Valley (?) T-A: Intensity IV at Winnemucca. Rapid rocking, duration 3 seconds. BKS: Earthquake recorded at Berkeley at 11:56, which may be this event. AEJ: Not reported.

- 1930 September 16, 11:30 GMT. 40.4, 117.2, Buffalo Valley. USEQ: Felt at Red House, 7 mi south of Blossom Ranch, light. BKS, AEJ: Not reported.

- 1933 April 30, 16:17 GMT. 39.6, 118.1, Dixie Valley, M 4 1/2. AEJ: RW readings give distance of 140 km from Reno, amplitude 4.4 mm. BKS: Event recorded at Berkeley and Mount Hamilton. USEQ: Not reported.

- 1936 September 21, 07:32 GMT. 40.6, 118.4, west of Imlay, M about 4 1/2. AEJ: RW readings give distance of about 150 km from Reno, amplitude 2.2 mm. BKS: Recorded at Berkeley and Fresno at the same time, distance about 460 km. USEQ: Felt weakly at Winnemucca and Beowawe.

- 1936 September 22, 10:40 GMT. 40.5, 117.5, Pleasant Valley, M about 4 1/2. AEJ: RW readings give distance of 215 km from Reno, amplitude 3.3 mm. PAS: Readings give distances of 700 km from Pasadena, 380 km from Tinemaha.

- 1937 May 25, 05:35 GMT. 40.0, 117.8, Dixie Valley, M about 4 1/2. AEJ: RW readings give distance of 180 km from Reno, amplitude 2.7 mm. PAS: Not reported. BKS: Readings give distances of 440 km from Mount Hamilton, 390 km from Fresno. USEQ: Not reported.

- 1954 July 6, 11:13 GMT. 39.42, 118.53, east of Fallon, M 6.8. BKS gives location and magnitude. USEQ: Felt over an area of approximately 130,000 sq mi. Maximum intensity IX at main fracture zone on east edge of Rainbow Mountain. Maximum intensity VII elsewhere. At Fallon Naval Air Station heavy steel lockers fell over, injuring several. Paved highways in Fallon and Stillwater areas settled, cracked and buckled in several places; one section south of Fallon settled 18 inches for a distance of 200 feet. Several old and poorly build structures in Fallon were considerably damaged. Length of faulting 11 miles, with scarps from a fraction of an inch to a foot or more. Extensive damage, estimated at $200,000, to canal and drainage facilities of the Newlands Project, particularly in the Lone Tree and Stillwater areas. Coleman diversion dam failed. Geysers spouted from fields. In Fallon, considerable damage to wood, brick, masonry and concrete structures. Plaster, windows, walls, chimneys and ground cracked. Felt from Wendover to San Francisco, and Lakeview to Moapa.

● 1954 August 24, 05:51 GMT. 39.58, 118.45, east of Fallon, M 6.8. BKS gives location and magnitude. USEQ: Felt over an area of approximately 150,000 sq mi of Nevada, California, Oregon, Idaho and Utah. Maximum intensity of IX assigned to ground fracture area 15 miles east of Fallon. Intensity VIII at Fallon, Lovelock, Stillwater and Upsal Hogback. Estimated damage to Newlands Project facilities was $91,000.

● 1954 December 16, 11:07 and 11:11 GMT. 39.32, 118.20, Fairview Peak and Dixie Valley, M 7.1 and 6.8. Location and magnitude by BKS. USEQ: Felt over an area of approximately 200,000 sq mi, from Weiser, Idaho to Los Angeles and from the coast to Salt Lake City. Maximum intensity of X assigned to the spectacular surface ruptures, which extended for 55 miles along the east side of Fairview Peak and the west side of Dixie Valley. Scarp heights up to 15 feet. In Dixie Valley all wells increased in flow, and water bubbled from the ground in spots. An adobe cellar, gasoline and water tanks and stone wall collapsed. Piano shoved across room, buffet up-ended, stove moved several feet, dressers toppled, etc. US Highway 50 cracked, with up to six feet of vertical movement. At Frenchman's Station, only negligible damage to buildings, but estimated loss of $3,000 in liquor stock.

<u>List of Abbreviations</u>:

AEJ -- Jones, A. E., Reporting of Earthquakes at Reno, 1916-1951, Univ. Nev. Seismol. Lab., 1975.
BKS -- Univ. Calif., Bull. of the Seismographic Stations, 1911-.
EDL -- Eureka Daily Leader, 1878-1885.
EFP -- Elko Free Press, 1883-.
EI --- Elko Independent, 1869-.
ES --- Eureka Sentinel, 1870-.
GHN -- Gold Hill Daily News, 1863-1882.
HR --- Humboldt Register (Unionville and Winnemucca), 1863-1876.
JCJ -- J. Claude Jones, Univ. of Nevada, diary.
LT --- Lovelock Tribune, 1898-1912.
MWR -- Monthly Weather Review, US Weather Service, 1915-.
PAS -- Calif. Inst. of Technology, Seismological Bulletin, 1936-.
REG -- Reno Evening Gazette, 1876-.
RRR -- Reese River Reveille (Austin), 1863-.
RW --- Reno Wiechert, seismograph at Univ. of Nevada, 1916-1950.
S65 -- Slemmons, D. B., A. E. Jones and J. I. Gimlett, Catalog of Nevada Earthquakes, 1852-1960, Bull. Seism. Soc. Am., 55, 537-583, 1965.
SS --- Silver State News (Winnemucca), 1875-1925.

T-A -- Townley, S. D. and M. W. Allen, Descriptive Catalog of Earthquakes of the Pacific Coast of the United States, 1769-1928, Bull. Seism. Soc. Am., 29, 1-297, 1939.
USCGS US Department of Commerce, Coast and Geodetic Survey.
USEQ - United States Earthquakes, USCGS, 1929-.
VCTE - Virginia City Territorial Enterprise, 1859-.

APPENDIX B. LISTING OF ALL EARTHQUAKES IN THE DIXIE VALLEY AREA

The following list contains all earthquakes listed in available catalogs or located by the University of Nevada Seismological Laboratory, for the area bounded by latitude 38.8-40.5 deg N and longitude 117.3-118.7 deg W. For the period prior to 1970 locations and magnitudes are from Slemmons et al (1965) and from the University of California Bulletin of the Seismographic Stations (1911-1969). For 1970-1981 the list contains earthquake parameters based on analysis by the University of Nevada, using data from the Nevada seismic telemetry network. For 1980 and 1981 the Nevada network was supplemented by data from ten stations installed in and around Dixie Valley as part of this investigation.

Accuracy of epicenter locations in this list varies as a function of the density of station networks used in the analysis. For the pre-instrumental period prior to 1916, locations are based on newspaper reports and are therefore only approximate. From about 1930 to 1948 locations were based only on data from California seismic stations and are accurate to perhaps several tens of kilometers. From 1948 to 1969 locations were based primarily on California data but included readings from 1-3 stations in Nevada; epicenters for this period are probably accurate to within about 10 km. For the 1970's location accuracy for events in Dixie Valley was of the order of a few kilometers; for 1980 and 1981 locations should have been accurate to within a few hundred meters.

The format for this table is as indicated at the top of each page: From left to right the listing includes date (year, month, day), origin time (hours, minutes, seconds; local time prior to 1916 and GMT thereafter), latitude (deg N), longitude (deg W), standard deviation of the location (seconds), number of stations used in the analysis, magnitude, depth (kilometers), and quality. For most events prior to 1950 times are given only to the nearest minute. Standard deviations are available only for the period beginning in 1970, and focal depth was determined only for those periods when supplementary stations were operated in the Fairview Peak-Dixie Valley area, 1974-1981.

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1868	11	17	1315	39.000	118.000					
1872	03	23	2141	40.000	117.500			5.5		
1873	11	05	1700	40.000	118.000			5.5		
1873	11	06		40.000	118.000					
1874	11	29		40.300	118.300			4.3		
1893	08	30	18	39.100	118.100					
1903				39.500	118.100					
1914	04	25	1703	39.400	117.700					
1915	10	02	2341	40.500	117.500					
1915	10	03	0149	40.500	117.500			6.1		
1915	10	03	0653	40.500	117.500			7.8		
1915	10	03	0705	40.500	117.500					
1915	10	03	0718	40.500	117.500					
1915	10	03	0733	40.500	117.500					
1915	10	03	0749	40.500	117.500					
1915	10	03	0845	40.500	117.500					
1915	10	15	2022	40.500	117.500					
1915	10	20	0234	40.500	117.500					
1915	10	23	0409	40.500	117.500					
1915	11	23	0333	40.500	117.500					
1915	12	18	09	40.500	117.500					
1916	10	21	0540	40.400	118.200					
1916	10	21	0545	40.400	118.200					
1916	10	21	1650	40.400	118.200					
1916	10	21	1910	40.400	118.200					
1916	11	01	0430	40.400	118.200					
1916	11	02	1600	40.400	118.200					
1916	11	02	1630	40.400	118.200					
1916	11	02	1730	40.400	118.200					
1916	11	03	0520	40.400	118.200					
1916	11	03	1500	40.400	118.200					
1916	11	04	0215	40.400	118.200					
1916	11	04	2300	40.400	118.200					
1916	11	04	2350	40.400	118.200					
1916	11	13	1722	40.400	118.200					
1916	12	17	1445	40.400	118.200					
1916	12	19	05	40.400	118.200					
1916	12	24	1930	40.400	118.200					
1916	12	25	0140	40.400	118.200					
1916	12	25	0206	40.400	118.200					
1916	12	25	0219	40.400	118.200					
1916	12	25	1505	40.400	118.200					
1916	12	26	0200	40.400	118.200					
1916	12	26	0255	40.400	118.200					
1916	12	26	1740	40.400	118.200					

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1916	12	27	0650	40.400	118.200					
1917	04	11	1900	40.000	118.000			5.1		
1918	05	06	0457	40.500	117.500					
1927	12	29	0010	39.200	118.000			4.2		
1931	06	06	0210	39.500	118.200					
1932	12	21	0530	38.800	118.000					
1932	12	21	061004	38.800	117.980			7.2		
1932	12	22	1036	38.800	118.000			4.9		
1932	12	22	2354	38.800	118.000					
1932	12	24	1241	38.800	118.000			5.0		
1932	12	25	0355	38.800	118.000			5.5		
1932	12	25	1835	38.800	118.000			4.5		
1932	12	26	0541	38.800	118.000			4.4		
1932	12	28	0308	38.800	118.000			4.6		
1932	12	29	0621	38.800	118.000			5.2		
1932	12	29	0638	38.800	118.000			5.0		
1932	12	29	0646	38.800	118.000			5.0		
1932	12	30	0418	38.800	118.000			4.6		
1932	12	30	1604	38.800	118.000			4.6		
1933	01	02	1545	38.800	118.000			4.5		
1933	01	02	1707	38.800	118.000			4.7		
1933	01	04	1036	38.800	117.900			3.9		
1933	01	06	1306	39.000	117.800			5.1		
1933	01	06	1333	39.000	118.000			4.5		
1933	01	11	1730	38.900	117.800			5.2		
1933	03	12	2045	38.800	117.600			5.0		
1933	04	30	161713	40.000	118.000			4.5		
1933	05	16	2233	39.000	117.800			4.0		
1933	07	17	2058	39.200	118.200			4.6		
1933	10	27	1059	38.900	117.600			5.5		
1934	09	27	0928	39.500	117.700			4.0		
1936	01	14	0530	39.500	117.500			4.6		
1936	03	26	2244	39.100	117.900			4.5		
1936	07	02	1629	39.300	118.200			5.0		
1936	09	21	0732	40.300	117.400			4.5		
1936	09	22	1040	40.400	117.300			4.7		
1936	10	21	1504	39.300	117.500			4.1		
1939	04	28	2200	39.400	118.300			4.2		
1939	12	30	1027	39.800	117.700			4.2		
1940	06	03	054248	38.800	117.800			4.0		
1944	01	30	101830	39.500	118.500			3.5		
1945	02	22	1858	39.000	118.000					
1946	02	27	2215	39.000	118.000					
1949	08	18	142516	38.800	118.600			3.7		D
1949	12	28	115839	39.400	118.000			2.9		D

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1950	01	11	135136	39.100	117.400			2.9		D
1950	01	21	230245	39.200	117.700			3.5		D
1950	09	21	220213	39.400	118.000			3.7		D
1950	10	23	081246	39.500	117.500			4.5		D
1950	11	17	034651	38.920	118.320					
1951	09	12	141230	38.800	117.900			4.1		D
1952	03	07	010042	38.800	117.400			4.0		D
1952	11	14	090542	39.000	118.000			4.1		D
1952	11	15	022952	39.100	117.700			4.3		D
1952	11	15	043810	39.100	117.700			4.0		D
1952	11	18	040408	39.800	117.700			4.6		D
1952	12	31	022050	38.870	118.130			3.5		C
1953	06	01	031654	39.600	118.000			3.3		D
1954	07	06	111320	39.420	118.530			6.8		A
1954	07	06	111804	39.420	118.530			5.5		A
1954	07	06	1127	39.420	118.530			4.8		D
1954	07	06	1141	39.420	118.530			4.5		D
1954	07	06	114900	39.420	118.530			5.7		D
1954	07	06	125400	39.420	118.530			4.5		D
1954	07	06	125630	39.420	118.530			4.9		D
1954	07	06	131511	39.420	118.530			5.2		D
1954	07	06	133601	39.420	118.530			4.5		D
1954	07	06	145515	39.420	118.530			4.5		D
1954	07	06	155121	39.420	118.530			4.4		D
1954	07	06	173825	39.420	118.530			4.2		D
1954	07	06	175737	39.420	118.530			4.1		D
1954	07	06	175740	39.420	118.530			4.3		D
1954	07	06	1900	39.420	118.530			4.2		A
1954	07	06	220741	39.300	118.500			6.0		A
1954	07	06	2253	39.300	118.500			4.1		D
1954	07	06	231158	39.300	118.500			4.1		D
1954	07	06	235707	39.300	118.500			4.1		D
1954	07	07	002258	39.300	118.500			4.4		D
1954	07	07	012951	39.300	118.500			4.1		D
1954	07	07	022245	39.300	118.500			4.1		D
1954	07	07	043358	39.300	118.500			4.1		D
1954	07	07	061108	39.300	118.300			4.6		D
1954	07	07	103132	39.300	118.300			4.1		D
1954	07	07	105248	39.300	118.300			4.4		D
1954	07	07	124053	39.300	118.500			4.2		D
1954	07	07	160224	39.300	118.500			4.2		D
1954	07	07	180055	39.300	118.500			4.3		D
1954	07	07	214747	39.300	118.500			4.1		D
1954	07	07	235045	39.300	118.500			4.3		D
1954	07	08	021356	39.420	118.530			4.8		A

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1954	07	08	040819	39.300	118.500			4.5		D
1954	07	08	065836	39.300	118.500			4.3		D
1954	07	08	125510	39.420	118.530			4.7		A
1954	07	08	193157	39.420	118.530			5.3		A
1954	07	09	085003	39.420	118.530			4.9		A
1954	07	10	012220	39.300	118.500			4.6		D
1954	07	11	001802	39.300	118.500			4.0		D
1954	07	11	070400	39.300	118.500			4.6		D
1954	07	11	095812	39.300	118.500			4.6		D
1954	07	12	101706	39.300	118.500			4.5		D
1954	07	12	160525	39.300	118.500			5.1		D
1954	07	14	015712	39.300	118.500			3.9		D
1954	07	15	013134	39.300	118.500			3.9		D
1954	07	16	115520	39.300	118.500			4.0		D
1954	07	17	000216	39.300	118.500			4.2		D
1954	07	17	015311	39.300	118.500			4.4		D
1954	07	20	014155	39.300	118.500			4.1		D
1954	07	20	121322	39.300	118.500			3.9		D
1954	07	20	152812	39.300	118.500			4.1		D
1954	07	20	175604	39.300	118.500			4.0		D
1954	07	23	063035	39.300	118.500			3.9		D
1954	07	23	204158	39.300	118.500			3.6		D
1954	07	26	131628	39.300	118.500			3.9		D
1954	07	28	035638	39.300	118.500			3.6		D
1954	07	28	035803	39.300	118.500			3.7		D
1954	07	28	231716	39.300	118.500			4.0		D
1954	07	30	020010	39.300	118.500			5.1		D
1954	07	31	1100	39.420	118.530					
1954	07	31	135435	39.300	118.500			4.3		D
1954	07	31	1515	39.420	118.530					
1954	07	31	172414	39.300	118.500			4.5		D
1954	07	31	173116	39.300	118.500			4.3		D
1954	08	02	101853	39.420	118.530			5.4		A
1954	08	03	212454	39.300	118.500			4.7		D
1954	08	05	050308	39.420	118.530			4.7		A
1954	08	06	154116	39.300	118.500			4.2		D
1954	08	09	142834	39.300	118.500			4.0		D
1954	08	10	062310	39.300	118.500			4.0		D
1954	08	10	230051	39.300	118.500			4.0		D
1954	08	10	230422	39.300	118.500			4.0		D
1954	08	16	062942	39.300	118.500			4.1		D
1954	08	22	105008	39.300	118.500			4.0		D
1954	08	23	1750	39.420	118.530					
1954	08	24	0445	39.420	118.530					
1954	08	24	055132	39.420	118.530			6.8		A

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1954	08	24	055746	39.500	118.500			5.2		D
1954	08	24	061450	39.580	118.480			4.1		D
1954	08	24	063231	39.580	118.480			4.4		D
1954	08	24	063602	39.580	118.480			4.4		D
1954	08	24	065410	39.580	118.480			4.3		D
1954	08	24	144718	39.580	118.480			4.0		D
1954	08	24	212053	39.580	118.480			4.4		D
1954	08	25	021713	39.580	118.480			4.8		D
1954	08	25	024959	39.580	118.480			4.0		D
1954	08	25	121235	39.580	118.480			4.0		D
1954	08	25	222110	39.580	118.480			4.7		D
1954	08	26	124415	39.580	118.480			4.2		D
1954	08	26	125615	39.580	118.480			4.6		D
1954	08	27	070503	39.580	118.480			4.0		D
1954	08	28	045134	39.580	118.480			4.0		D
1954	08	29	030951	39.580	118.480			4.2		D
1954	08	29	034106	39.580	118.480			4.7		D
1954	08	29	035805	39.580	118.480			4.8		D
1954	08	29	0513	39.420	118.530			4.3		
1954	08	30	111558	39.580	118.480			4.1		D
1954	08	30	191157	39.580	118.480			4.1		D
1954	08	30	195719	39.580	118.480			4.1		D
1954	08	31	132902	39.580	118.480			3.9		D
1954	08	31	133407	39.580	118.480			4.0		D
1954	08	31	221929	39.580	118.450			4.4		D
1954	08	31	222032	39.600	118.200			5.8		A
1954	08	31		39.420	118.530			3.9		
1954	09	01	051846	39.600	118.200			5.5		D
1954	09	01	112925	39.600	118.200			4.3		D
1954	09	02	075317	39.600	118.200			3.9		D
1954	09	04	042432	39.600	118.200			4.0		A
1954	09	05	201559	39.600	118.200			4.4		D
1954	09	08	071730	39.600	118.200			4.3		A
1954	09	09	092105	39.600	118.200			4.7		A
1954	09	09	223138	39.600	118.200			4.4		D
1954	09	14	161902	39.600	118.200			4.0		D
1954	09	23	081219	39.600	118.200			3.8		D
1954	10	08		39.600	118.200					
1954	10	16	043212	39.500	118.500			4.3		D
1954	12	15	063040	39.500	118.000			4.0		D
1954	12	16	110711	39.280	118.120			7.3		A
1954	12	16	111134	39.800	118.100			6.9		D
1954	12	16	115036	39.500	118.000			5.0		D
1954	12	16	115730	39.500	118.000			5.0		D
1954	12	16	141657	39.500	118.000			5.8		B

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1954	12	16	14241	39.500	118.000			5.3		D
1954	12	16	150942	39.500	118.000			5.1		B
1954	12	17	20280	39.500	118.000			5.0		D
1954	12	18	014538	39.500	118.000			4.7		D
1954	12	20	1100	39.300	118.200					
1954	12	20	173647	40.000	118.000			5.0		D
1955	01	01	121354	39.000	118.000			5.1		
1955	01	02	214336	39.000	118.000			3.7		
1955	01	02	220700	39.000	118.000			4.2		
1955	01	05	082040	39.000	118.000			4.2		
1955	01	06	083232	39.000	118.000			3.7		
1955	01	07	045610	39.000	118.000			3.9		
1955	01	07	074114	39.000	118.000			4.1		
1955	01	07	080041	39.000	118.000			4.2		
1955	01	08	084317	39.000	118.000			3.6		
1955	01	08	180950	39.000	118.000			4.0		
1955	01	08	223253	39.000	118.000			4.2		
1955	01	09	091050	39.000	118.000			5.0		C
1955	01	09	115840	39.000	118.000			4.2		
1955	01	10	131554	39.900	118.400			4.1		C
1955	01	11	102140	39.000	118.000			4.7		
1955	01	12	032125	39.000	118.000			4.0		
1955	01	12	110009	39.000	118.000			3.7		
1955	01	12	115737	39.000	118.000			4.1		
1955	01	14	004550	39.000	118.000			3.9		
1955	01	14	025704	39.000	118.000			3.9		
1955	01	14	122111	39.000	118.000			3.8		
1955	01	15	204702	39.000	118.000			4.2		
1955	01	17	181756	39.500	118.020			4.2		B
1955	01	19	014854	39.000	118.000			3.9		
1955	01	19	015348	39.000	118.000			4.1		
1955	01	19	021010	39.350	118.250			4.6		B
1955	01	19	0216	39.000	118.000			4.3		
1955	01	19	032921	39.000	118.000			4.4		
1955	01	19	0329	39.000	118.000			4.5		
1955	01	22	193419	39.000	118.000			4.1		
1955	01	23	044834	39.000	118.000			3.8		
1955	01	23	132155	39.000	118.000			3.9		
1955	01	23	153732	39.000	118.000			3.9		
1955	01	25	232646	39.000	118.000			4.7		
1955	01	26	094021	39.000	118.000			4.1		
1955	01	27	090422	39.100	118.070			3.8		B
1955	01	28	153805	39.800	118.000			4.2		C
1955	01	28	1730	39.350	118.250					
1955	02	01	0635	39.200	118.500					C

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1955	02	01	153116	39.180	118.130			4.0		C
1955	02	03	183031	39.200	118.530			3.8		B
1955	02	07	023043	39.050	118.050			3.6		C
1955	02	09	111122	39.100	118.130			3.7		B
1955	02	10	194408	39.030	118.180			3.7		B
1955	02	11	161232	39.450	118.100			4.7		B
1955	02	12	1129	39.000	118.000			4.6		
1955	02	14	094024	38.900	118.180			3.7		B
1955	02	16	004640	39.100	118.050			4.1		B
1955	02	17	013620	39.170	118.020			3.8		B
1955	02	19	234920	39.300	117.800			4.1		C
1955	02	19	235007	39.300	117.800			4.8		C
1955	02	20	193159	39.030	118.030			3.8		B
1955	02	22	054017	39.050	118.170			3.8		C
1955	02	23	141116	39.700	118.100			3.6		D
1955	03	08	200517	39.200	118.550			4.5		C
1955	03	08	232804	39.650	118.000			4.2		B
1955	03	11	142316	39.300	118.100			4.5		D
1955	03	13	084023	39.560	118.050			4.6		C
1955	03	13	210827	39.160	118.120			4.0		B
1955	03	14	182347	39.400	118.250			4.7		C
1955	03	22	031540	39.550	118.000			4.4		B
1955	03	22	040616	39.500	118.200			4.4		B
1955	03	25	195439	39.120	118.170			3.8		C
1955	03	26	035128	39.330	118.000			4.2		B
1955	03	30	092428	39.100	118.150			4.3		C
1955	04	02	022251	39.450	118.000			4.2		C
1955	04	04	013602	39.500	118.000			4.1		C
1955	04	05	010737	39.000	118.180			3.9		C
1955	04	08	115008	39.300	118.000			3.8		D
1955	04	13	113257	39.550	118.100			4.4		B
1955	05	03	181701	39.200	118.000			4.0		C
1955	05	08	103833	38.930	118.000			4.5		B
1955	05	29	044406	39.200	118.200			4.0		D
1955	05	30	212826	39.400	118.000			4.5		C
1955	06	06	092010	39.150	118.150			4.3		C
1955	06	08	122211	38.880	118.170			4.5		
1955	06	19	192000	38.970	118.250			5.2		B
1955	07	03	174821	39.180	118.130			4.3		B
1955	07	04	123713	39.450	118.100			4.1		C
1955	07	05	070703	39.300	118.500			3.1		C
1955	07	06	1015	39.300	118.500					
1955	08	09	052421	39.250	118.050			4.2		C
1955	09	01	085201	39.800	118.000			3.9		C
1955	09	10	193534	39.450	118.000			4.4		C

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1955	09	18	194402	39.420	118.000			3.9		C
1955	09	25	221151	39.600	117.900			4.1		C
1955	09	29	054051	39.200	118.200			4.5		C
1955	10	06	071542	39.300	118.050			4.1		C
1955	10	23	081246	39.500	117.500			4.5		D
1955	11	02	061517	39.500	118.050			4.6		B
1955	11	21	202534	39.420	118.080			5.5		B
1955	11	21	204055	39.420	118.090			4.4		D
1955	11	23	042408	39.870	118.050			4.1		C
1955	11	25	163001	39.400	118.050			4.3		C
1955	11	25	182649	39.400	118.000			4.2		C
1955	12	01	102457	39.400	118.050			4.3		C
1955	12	01	153116	39.180	118.120			4.0		C
1955	12	05	004640	39.120	118.030			4.1		B
1955	12	12	181634	39.560	118.500			4.0		C
1955	12	22	120510	39.000	118.500			4.8		B
1955	12	22	120654	38.980	118.700			4.6		C
1955	12	31	135104	39.000	118.030			4.5		B
1956	01	17	181756	39.500	118.030			4.2		B
1956	01	28	225530	39.330	118.050			4.2		B
1956	03	08	072619	39.030	118.070			4.6		B
1956	03	10	140756	39.320	118.470			4.2		B
1956	04	09	044226	39.180	118.120			4.3		B
1956	04	23	150300	39.500	118.000			3.0		D
1956	04	29	073622	39.500	118.500			3.0		D
1956	05	09	065719	39.530	118.050			3.0		C
1956	05	09	065719	39.530	118.050			3.0		C
1956	05	22	235107	39.450	118.270			3.8		C
1956	05	30	191936	39.400	118.020			3.9		B
1956	06	23	104509	39.170	118.150			3.5		B
1956	06	28	021708	39.500	118.100			3.2		D
1956	07	04	043536	39.330	118.500			3.7		B
1956	07	21	100918	39.470	118.090			3.2		C
1956	07	26	095317	39.550	118.450			5.1		B
1956	08	06	010212	39.080	118.050			3.4		B
1956	08	10	134521	39.330	118.030			3.8		B
1956	08	19	091656	38.900	118.300			3.8		D
1956	08	21	185542	39.530	118.450			3.5		C
1956	09	25	045308	39.120	118.080			3.8		C
1956	10	06	141917	39.500	118.100			4.0		B
1956	11	02	110255	39.500	118.050			4.6		B
1956	11	10	202753	39.600	117.900			4.1		D
1956	12	03	144808	39.370	118.090			3.0		C
1956	12	05	180515	39.130	118.070			4.1		B
1956	12	06	054723	39.200	118.120			3.9		C

YEAR	MO	DAY	HRMINSEC	LA.	LON	RMS	NSTA	MAG	DEPTH	Q
1956	12	07	042258	39.650	118.000			3.9		C
1956	12	07	071252	39.500	118.000			3.6		D
1957	01	10	033754	39.420	118.070			3.7		C
1957	01	12	133552	39.330	118.090			3.8		C
1957	01	13	193533	39.500	118.080			4.0		B
1957	03	27	132212	39.320	118.530			3.6		B
1957	04	25	064546	39.200	118.000			4.2		D
1957	04	26	180307	39.250	118.050			4.0		C
1957	04	27	053927	39.400	118.500			4.2		C
1957	04	29	140615	39.200	118.100			3.9		D
1957	05	30	104819	39.600	118.200			3.8		D
1957	06	10	175922	39.500	118.600			3.0		C
1957	06	11	165755	39.200	118.300			4.2		D
1957	07	22	172401	39.560	118.400			4.0		B
1957	09	19	105013	39.300	118.100			3.7		D
1957	10	17	101409	39.280	118.430			4.6		B
1957	10	25	154054	39.300	118.200			3.9		D
1957	11	01	045157	39.600	118.500			3.8		D
1958	01	18	163335	39.100	118.100			4.4		C
1958	02	08	050445	39.800	118.600			3.5		D
1958	02	16	032020	39.400	118.600			3.4		D
1958	02	23	022501	39.680	117.860			3.8		C
1958	03	01	112941	40.100	118.400			3.3		D
1958	03	05	051156	39.000	118.200			3.8		D
1958	05	28	151650	39.400	118.100			4.1		D
1958	06	01	164024	39.400	118.000			3.7		D
1958	06	01	165025	39.420	118.050			3.9		C
1958	06	11	060605	39.430	118.020			3.4		C
1958	06	29	083712	39.550	118.420			3.7		C
1958	07	04	074954	39.600	118.000			3.6		D
1958	07	08	125510	39.300	118.500			4.7		D
1958	08	10	202304	39.300	118.100			3.6		D
1958	09	08	073111	39.000	118.200			3.6		D
1958	09	16	232637	39.600	118.000			3.5		D
1958	09	22	102042	39.300	118.100			3.5		D
1958	09	22	102540	39.300	118.100			3.7		D
1958	10	17	063153	39.200	118.100			3.0		D
1958	11	09	214005	39.300	118.600			3.3		D
1958	11	26	222326	39.500	118.100			3.4		D
1959	02	10	180343	39.520	118.100			4.3		C
1959	02	10	182536	39.500	118.100			3.5		D
1959	02	11	024641	39.520	118.100			3.5		C
1959	03	22	104728	39.300	117.900			3.9		D
1959	03	23	071020	39.600	118.070			6.3		B
1959	03	23	114923	39.550	118.100			4.2		C

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1959	03	26	055541.0	39.700	118.100			3.7		D
1959	03	27	113033.0	39.600	118.100			3.9		D
1959	03	27	115948.0	39.650	118.100			4.2		C
1959	03	27	135521.0	39.600	118.000			4.0		C
1959	04	03	043222.0	39.600	118.100			3.1		D
1959	04	04	061122.0	39.500	118.100			3.7		D
1959	04	07	082301.0	39.500	118.000			3.3		D
1959	04	20	123344.0	39.800	118.100			4.3		C
1959	04	21	071104.0	39.500	118.080			3.4		C
1959	05	03	173809.0	39.000	118.020			3.5		C
1959	05	21	175140.0	39.500	118.000			4.8		C
1959	05	23	124859.0	39.600	118.100			3.7		D
1959	06	27	211429.0	39.200	118.700			3.3		D
1959	06	28	145647.0	39.200	118.100			3.2		D
1959	07	19	071210.0	39.400	118.000			3.8		D
1959	08	02	221644.0	39.500	118.000			4.4		C
1959	08	04	051320.0	39.500	118.000			4.0		D
1959	08	10	085248.0	39.800	117.900			3.2		D
1959	09	15	063518.0	39.000	118.100			3.1		D
1959	12	24	112424.0	39.500	117.900			4.2		D
1960	02	22	213437.0	40.100	118.000			3.4		D
1960	03	08	044245.0	39.800	118.300			3.5		D
1960	03	18	042844.0	40.200	117.700			3.5		D
1960	03	22	065855.0	40.200	118.000			3.7		D
1960	07	30	081310.0	40.000	117.670			3.6		C
1960	08	10	154351.0	39.600	117.900			4.0		D
1960	09	08	085545.0	39.750	118.050			3.5		C
1960	11	29	170833.0	39.900	117.800			3.9		D
1961	07	04	110911.0	40.130	118.600			5.0		B
1961	08	04	165604.0	39.300	117.400			4.8		D
1961	08	04	165609.0	39.000	117.700			4.3		
1962	01	31	040730.0	39.500	117.500			4.3		D
1962	07	20	090208.0	39.500	118.300			5.2		
1962	12	16	110646.0	39.233	118.300			3.7		
1963	02	23	082239.7	39.523	117.957			3.7		
1963	03	15	034426.8	39.082	117.838			3.5		
1963	11	29	084856.0	39.560	117.930			3.2		
1964	03	22	163954.5	38.900	118.800			3.5		
1964	03	22	181452.2	39.000	118.700			3.5		
1964	03	22	181745.8	39.100	118.700			3.5		
1964	03	27	135121.0	39.983	118.817			3.0		
1964	04	07	190904.0	38.900	118.700			3.5		
1964	04	09	184320.4	38.927	118.727			3.7		
1964	04	11	032508.0	38.900	118.700			3.2		
1964	07	02	132907.3	39.100	118.100			4.0		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1964	07	04	072251.6	39.300	118.100			3.6		
1964	10	07	073707.1	39.200	118.800			3.4		
1965	01	04	040645.3	40.292	117.685			3.9		
1965	02	19	120130.0	40.002	118.650			3.2		
1965	04	06	155705.5	38.945	118.700			3.7		
1965	04	13	131422.1	38.900	117.700			4.6		
1965	05	21	065135.0	39.900	118.100			3.2		
1965	06	02	204704.0	38.900	118.000			3.8		
1965	06	25	001856.1	39.100	118.100			4.4		
1965	07	14	082643.0	39.600	117.800			4.3		
1965	11	01	171015.0	39.600	118.500			4.3		
1966	02	07	162022.0	39.300	118.000			3.2		
1966	02	25	072015.0	39.300	117.600			3.5		
1967	01	25	181545.0	39.300	118.000			3.7		
1967	02	25	020032.8	39.300	117.600			3.5		
1967	03	05	213044.0	39.200	117.700			3.7		
1967	05	23	171906.0	39.300	117.900			3.3		
1967	07	30	154508.0	38.953	118.197			3.1		
1967	08	06	111500.9	39.597	118.077			3.3		
1967	11	07	034434.5	39.135	118.093			3.1		
1968	03	01	083314.9	39.650	118.433			3.4		
1968	03	27	194727.0	39.800	118.300			3.3		
1968	05	29	114107.1	39.067	118.050			4.9		
1968	08	29	112643.0	39.700	118.100			3.3		
1968	09	03	173754.0	39.500	118.100			3.6		
1968	09	20	205043.0	39.000	118.000			3.3		
1968	10	21	094630.0	40.500	117.750			3.4		
1969	02	14	032455.0	39.600	118.200			3.2		
1969	04	12	105130.0	39.000	117.600			3.2		
1969	04	15	103000.5	38.850	117.950			3.2		
1969	06	19	070233.0	40.067	118.617			3.3		
1970	1	7	1544 .5	39.344	118.130	0.11	5	2.4		
1970	1	8	210027.5	39.315	118.458	0.09	7	2.2		
1970	1	9	1627 7.9	39.112	118.069	0.09	6	2.2		
1970	1	14	024526.9	39.028	118.170	0.13	7	2.3		
1970	1	14	053925.5	39.018	118.165	0.16	7	3.0		
1970	1	15	105443.0	39.479	118.424	0.16	6	2.4		
1970	1	17	083916.8	39.391	118.090	0.08	7	3.3		
1970	1	20	060126.8	39.390	118.093	0.07	6	3.0		
1970	1	21	134554.4	39.023	118.128	0.30	7	3.1		
1970	1	21	171329.4	39.020	118.116	0.09	7	3.1		
1970	1	25	093243.0	39.072	118.154	0.10	6	2.5		
1970	2	1	061448.2	39.393	118.089	0.09	7	2.2		
1970	2	5	052557.0	39.246	118.517	0.07	5	2.3		
1970	2	5	114822.6	39.298	118.111	0.13	7	2.5		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1970	2	13	060939.7	39.268	118.121	0.12	7	2.2		
1970	2	13	083234.6	39.248	118.105	0.10	6	2.6		
1970	2	19	144018.0	39.284	118.474	0.01	5	2.1		
1970	3	2	192734.7	39.021	118.194	0.10	6	2.8		
1970	3	6	115551.8	39.029	118.108	0.11	6			
1970	3	7	194544.9	39.133	118.073	0.09	6	2.8		
1970	3	7	194551.2	39.135	118.075	0.11	6	3.0		
1970	3	11	1252 2.6	39.068	118.064	0.03	5	2.3		
1970	3	11	1302 7.7	39.053	118.056	0.09	6	2.6		
1970	3	13	015936.6	39.293	118.474	0.14	6	2.6		
1970	3	20	0152 9.9	39.440	118.587	0.12	7	2.5		
1970	3	23	151840.4	39.053	118.094	0.06	6	2.2		
1970	3	23	215540.1	39.578	118.075	0.10	6	4.2		
1970	3	24	051442.7	39.585	118.077	0.14	6	3.4		
1970	3	25	2053 1.6	39.025	118.108	0.11	6	2.8		
1970	3	27	013038.4	39.722	118.073	0.17	6	2.7		
1970	3	27	232046.9	39.685	117.978	0.39	5	2.0		
1970	3	28	085351.9	39.302	118.496	0.12	7	2.4		
1970	3	31	010225.4	39.064	118.089	0.12	7	2.5		
1970	4	10	125756.0	39.279	118.461	0.08	5	2.4		
1970	4	11	225258.0	39.715	118.073	0.19	6	2.8		
1970	4	24	214822.2	39.459	118.402	0.51	9	2.7		
1970	5	3	165713.2	39.042	118.087	0.07	6	2.6		
1970	5	3	214937.0	39.008	117.747	0.57	7	2.7		
1970	5	6	095335.3	39.100	118.064	0.10	7	2.8		
1970	5	8	135240.1	39.322	118.472	0.13	8	2.4		
1970	5	25	074122.2	39.138	118.064	0.07	6	2.2		
1970	5	31	132458.3	39.077	118.125	0.28	6			
1970	6	6	182817.4	39.031	118.060	0.09	6	3.1		
1970	6	8	170139.7	39.438	118.423	0.40	6			
1970	6	11	093158.8	39.712	118.077	0.09	5	2.3		
1970	6	14	074410.3	39.061	118.124	0.67	7	1.8		
1970	6	14	130038.1	38.808	117.966	0.12	4	1.7		
1970	6	21	170216.2	39.722	118.010	0.28	5	2.2		
1970	6	26	071628.2	39.320	118.435	0.27	8			
1970	6	30	091151.4	39.075	118.163	0.06	6			
1970	7	3	0104 1.7	39.661	118.053	0.06	5	1.6		
1970	7	8	070043.2	40.314	118.480	0.42	7	2.7		
1970	7	18	092934.6	39.397	117.772	0.28	7	2.4		
1970	7	27	084358.7	38.995	118.234	0.13	6	3.1		
1970	7	27	2329 1.0	39.067	118.166	0.02	4	2.3		
1970	7	30	075750.6	39.592	118.084	0.21	7	2.6		
1970	7	31	1009 .1	39.523	118.050	0.33	4	2.5		
1970	8	1	082445.2	39.356	118.447	0.13	5	2.2		
1970	8	4	1923 2.6	39.316	118.142	0.35	6	2.3		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1970	8	13	092629.6	39.681	118.083	0.24	5	2.5		
1970	8	22	000544.7	39.026	118.160	1.21	6	1.9		
1970	8	27	092056.9	38.944	118.182	0.46	8	2.0		
1970	8	27	143611.2	39.279	118.143	0.07	8	2.2		
1970	8	31	212427.0	38.870	118.080	0.45	9	3.5		
1970	8	31	213428.5	38.874	118.037	0.14	5			
1970	9	4	052451.6	39.091	118.052	0.09	6	2.1		
1970	9	14	085752.5	39.064	118.103	0.07	7	2.1		
1970	9	19	230023.3	39.909	117.319	0.54	8	3.5		
1970	9	19	2308 1.9	39.911	117.303	0.25	5	2.6		
1970	9	21	2335 7.5	39.033	118.082	0.07	9	2.9		
1970	9	24	123452.0	39.520	118.378	0.14	6	1.9		
1970	9	24	181037.3	39.013	118.130	0.08	7	2.8		
1970	9	29	115215.4	39.113	118.071	0.10	7	2.2		
1970	9	30	1815 7.8	39.101	118.081	0.13	7	2.9		
1970	10	1	165042.2	39.045	118.085	0.06	6	2.1		
1970	10	1	165240.6	39.026	118.015	0.76	4	2.2		
1970	10	5	161724.0	39.713	118.061	0.17	7	2.1		
1970	10	8	071729.4	40.175	117.788	0.23	5	2.2		
1970	10	9	035926.8	39.111	118.059	0.13	8	2.2		
1970	10	12	093552.6	40.298	117.764	0.27	6	2.1		
1970	10	14	192331.7	39.020	118.104	0.11	6	2.3		
1970	10	15	162719.0	39.027	118.105	0.11	7	2.1		
1970	10	17	103052.8	39.032	118.095	0.15	8	2.4		
1970	10	18	044248.0	39.251	118.537	0.18	6	2.5		
1970	10	20	061928.2	38.801	117.968	0.10	6	2.5		
1970	10	20	185132.1	39.013	118.131	0.07	6	2.4		
1970	10	22	043820.8	39.001	118.189	0.31	5	2.8		
1970	10	22	071816.4	39.010	118.126	0.09	7	2.7		
1970	10	24	035747.7	39.066	118.172	0.11	6	2.2		
1970	10	26	041829.9	39.369	118.111	0.15	6	2.2		
1970	10	29	024610.3	39.133	118.063	0.16	5	2.3		
1970	10	29	1531 3.5	39.117	118.062	0.08	7	2.4		
1970	10	29	153726.5	39.111	118.076	0.33	7	2.7		
1970	10	29	153931.9	39.094	118.071	0.20	6	2.2		
1970	10	30	000148.6	39.695	118.047	0.14	6	2.5		
1970	10	30	222626.9	39.143	118.080	0.27	6	2.6		
1970	11	6	030529.6	39.160	118.119	0.06	7	2.7		
1970	11	10	101429.5	40.402	117.616	0.24	7	2.2		
1970	11	13	171032.0	39.234	118.519	0.23	8	3.0		
1970	11	18	112757.1	39.109	118.061	0.16	7	2.2		
1970	11	21	172330.0	39.175	118.062	0.38	8	3.4		
1970	11	29	015430.3	38.917	117.852	0.20	4	1.8		
1970	12	1	205029.2	39.719	118.086	0.14	5	2.2		
1970	12	4	023655.3	38.819	117.968	0.08	5	2.1		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1970	12	14	102027.2	39.336	118.114	0.14	8	2.2		
1970	12	17	070447.3	39.714	118.084	0.16	8	2.5		
1970	12	28	132847.6	39.004	118.203	0.14	9	2.3		
1971	1	1	003053.8	39.345	118.050	0.19	11	3.1		
1971	1	6	095427.2	39.044	118.091	0.08	7	2.4		
1971	1	7	200818.0	39.361	118.337	0.32	8	2.5		
1971	1	17	1211 2.1	39.339	118.458	0.18	6	2.4		
1971	1	20	001859.0	39.358	118.461	0.13	5	2.0		
1971	1	26	002544.9	38.864	117.899	0.52	4	2.2		
1971	1	28	044035.9	40.293	117.836	0.16	5	1.4		
1971	1	28	140732.3	40.201	117.809	0.30	7	2.9		
1971	1	29	065731.6	39.346	118.122	0.19	7	2.6		
1971	1	30	024216.3	40.184	117.814	1.18	4	1.6		
1971	1	31	102652.9	39.060	118.084	0.04	5	2.0		
1971	1	31	164642.8	40.254	117.813	0.33	5	2.4		
1971	1	31	203326.6	40.138	118.540	0.64	6	2.0		
1971	2	3	154554.3	39.192	118.037	0.39	6	2.5		
1971	2	4	230153.8	39.374	118.452	0.08	5			
1971	2	6	161759.4	39.111	118.072	0.10	7	2.3		
1971	2	14	005946.9	39.253	118.492	0.13	5	2.1		
1971	2	15	115326.8	39.342	118.112	0.15	9	2.6		
1971	2	16	000246.6	39.959	118.693	0.63	6	2.1		
1971	2	20	104836.9	39.082	118.072	0.11	7	3.5		
1971	2	21	0847 5.1	39.284	118.084	0.17	7	2.9		
1971	3	9	140151.5	39.046	118.179	0.07	7	2.2		
1971	3	13	061121.7	39.103	118.054	0.18	8	2.3		
1971	3	15	144552.7	39.201	118.066	0.18	8	3.5		
1971	3	18	1703 2.0	39.196	118.074	0.16	10	2.8		
1971	3	21	170241.9	39.554	118.156	0.31	5	1.5		
1971	3	21	170330.4	39.556	118.147	0.34	6	2.7		
1971	3	22	094550.9	39.395	118.099	0.07	8	2.8		
1971	3	31	170430.9	39.396	118.087	0.24	5	1.7		
1971	4	5	0731 6.4	39.272	118.100	0.18	7	2.5		
1971	4	7	025635.3	39.178	118.074	0.12	9	2.4		
1971	4	7	192440.6	39.046	118.191	0.13	7	2.6		
1971	4	15	054916.3	39.134	118.074	0.12	7	2.4		
1971	4	18	030327.6	39.751	117.978	0.02	4	1.6		
1971	4	20	125018.6	39.173	118.074	0.07	8			
1971	4	28	080044.2	39.031	118.126	0.23	6	1.9		
1971	4	29	002035.6	39.016	118.139	0.15	6	1.9		
1971	4	30	204619.8	39.503	118.429	0.11	6	2.5		
1971	4	30	205250.6	39.503	118.430	0.09	7	2.3		
1971	5	1	122255.1	39.479	118.448	0.20	7	2.8		
1971	5	2	185234.4	39.019	118.142	0.13	6	1.9		
1971	5	2	185917.0	39.018	118.131	0.05	7	2.4		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1971	5	3	170620.2	39.289	118.111	0.18	7	1.0		
1971	5	5	0308 2.6	39.132	118.080	0.04	6	1.7		
1971	5	5	093331.0	39.486	118.453	0.07	4			
1971	5	6	0539 3.0	39.022	118.132	0.11	6	1.8		
1971	5	10	044116.2	39.079	118.111	0.06	6	1.9		
1971	5	10	105925.1	39.496	118.446	0.19	4	1.4		
1971	5	14	0818 4.3	39.037	118.087	0.06	4	1.8		
1971	5	14	1453 1.4	39.029	118.127	0.10	5	4.0		
1971	5	15	183752.1	40.445	117.603	0.49	4	2.4		
1971	5	17	153318.3	39.505	118.461	0.12	6	2.5		
1971	5	18	191924.8	39.977	117.708	0.30	6	2.3		
1971	5	18	192921.9	39.525	117.693	0.10	6	3.0		
1971	5	21	165237.2	39.591	118.082	0.10	5	2.4		
1971	5	21	201610.8	39.193	118.059	0.14	8	2.2		
1971	5	23	084259.7	39.601	118.022	0.02	4	1.9		
1971	5	27	101825.9	39.584	118.078	0.45	6			
1971	6	13	103152.0	39.019	118.134	0.09	8	2.4		
1971	6	18	021911.4	39.116	118.021	0.48	6	2.2		
1971	6	27	025330.0	39.032	118.158	0.09	5	2.1		
1971	6	29	075030.6	39.105	118.077	0.08	7	2.4		
1971	6	29	144321.7	39.166	118.086	0.07	8	2.9		
1971	7	2	070845.7	38.809	117.955	0.01	4	1.9		
1971	7	2	180738.4	39.652	118.283	0.18	6	1.9		
1971	7	3	085137.0	39.075	118.086	0.13	5	2.0		
1971	7	5	0415 7.6	38.984	118.169	0.08	5	2.7		
1971	7	5	0626 9.5	39.703	118.370	0.23	7	2.0		
1971	7	6	0317 4.8	38.983	118.177	0.16	5	2.3		
1971	7	8	133610.6	39.708	118.350	0.23	6			
1971	7	10	072145.0	39.196	118.169	0.26	5	2.5		
1971	7	10	074657.0	39.105	118.081	0.04	4	1.8		
1971	7	10	150750.8	39.692	118.034	0.18	6	2.0		
1971	7	10	150816.5	39.689	118.041	0.16	7	2.0		
1971	7	10	150840.3	39.681	118.062	0.11	4	2.1		
1971	7	10	152944.7	39.682	118.028	0.22	8	2.7		
1971	7	10	153228.4	39.680	118.062	0.09	6	2.1		
1971	7	11	064941.8	39.681	118.040	0.21	7	2.0		
1971	7	11	065422.0	39.683	118.045	0.18	8	2.8		
1971	7	11	075441.0	39.690	118.048	0.11	5	2.0		
1971	7	13	0935 .1	39.050	117.364	0.09	4	2.3		
1971	7	13	132443.3	39.683	118.061	0.13	5	1.7		
1971	7	20	172812.6	39.700	118.045	0.70	4			
1971	7	20	172940.8	39.712	117.987	0.89	4			
1971	7	22	110149.5	39.233	118.502	0.11	5	2.1		
1971	7	22	153328.1	39.172	118.079	0.06	5	2.2		
1971	7	22	1604 8.8	39.171	118.082	0.01	5	2.4		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1971	7	23	051232.9	39.104	118.060	0.04	5	2.3		
1971	7	30	123034.6	39.295	118.497	0.15	5	2.3		
1971	7	30	140757.7	39.536	118.469	0.16	6	2.4		
1971	8	20	073930.8	39.710	118.081	0.05	4	1.6		
1971	8	21	104938.8	38.864	117.765	2.09	4	1.6		
1971	8	27	134533.8	39.250	118.095	0.17	8	2.3		
1971	8	30	214841.9	39.409	118.064	0.23	6	2.5		
1971	8	31	122038.0	39.116	118.049	0.02	6	2.0		
1971	9	6	223322.4	39.347	118.106	0.04	4	1.9		
1971	9	8	072655.1	39.055	118.179	0.16	5	1.9		
1971	9	14	003652.9	39.740	117.984	0.33	6	1.6		
1971	9	19	203626.7	38.874	118.520	0.12	4	2.0		
1971	9	22	110647.6	39.051	118.095	0.01	4	1.9		
1971	10	2	045748.1	39.072	118.117	0.27	9	2.6		
1971	10	2	050647.1	39.076	118.196	0.06	5	1.9		
1971	10	2	085445.6	39.065	118.125	0.06	8	2.3		
1971	10	5	085235.2	39.233	118.492	0.04	5	2.0		
1971	10	5	085354.4	39.241	118.538	0.15	5	1.4		
1971	10	6	1731 2.6	39.116	118.626	0.78	5	2.2		
1971	10	8	092923.6	39.093	118.101	0.09	5	2.0		
1971	10	8	1613 8.4	39.050	118.182	0.18	5			
1971	10	9	142623.6	39.118	118.132	0.29	6	2.4		
1971	10	9	1839 9.9	38.997	118.212	0.53	6	1.8		
1971	10	17	0344 3.6	38.991	118.185	0.13	5	1.7		
1971	10	17	143428.5	39.056	118.097	0.10	7	2.1		
1971	10	28	061533.2	39.088	118.065	0.18	5	1.8		
1971	10	29	235712.8	39.087	118.076	0.10	6	1.6		
1971	11	1	130213.4	39.494	118.427	0.26	7	2.5		
1971	11	4	171536.6	39.354	118.088	0.11	9	2.4		
1971	11	4	180317.2	39.355	118.093	0.11	9	2.5		
1971	11	5	053458.5	39.341	118.059	0.24	6	1.5		
1971	11	5	120458.7	40.417	117.608	0.75	4	2.7		
1971	11	5	123622.1	40.342	117.583	0.22	4	1.2		
1971	11	5	124419.9	40.352	117.593	0.19	4	1.6		
1971	11	12	102736.3	39.563	118.074	0.16	5	2.0		
1971	11	23	212744.0	39.392	118.068	0.06	6	1.9		
1971	11	27	081813.6	39.311	118.490	0.21	5	2.2		
1971	12	1	032038.2	39.235	118.112	0.27	4	1.8		
1971	12	4	0834 1.9	39.664	118.083	0.23	7	2.3		
1971	12	7	001635.2	38.890	117.865	0.23	4			
1971	12	8	184331.0	39.089	118.097	0.08	5	1.7		
1971	12	10	014859.6	39.117	118.046	0.20	5	2.3		
1971	12	10	024527.7	39.093	118.103	0.10	7	2.6		
1971	12	11	103518.7	39.000	118.194	0.19	5	2.2		
1971	12	12	1453 7.6	40.481	117.644	0.12	5	2.8		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1971	12	13	210524.7	39.037	118.057	0.09	5	2.5		
1971	12	19	041929.7	39.413	118.053	0.08	6	2.2		
1971	12	28	163949.0	40.499	117.653	0.25	5	2.3		
1971	12	29	204137.6	39.061	118.120	0.02	5	2.3		
1972	1	5	201028.4	38.900	117.845	0.38	6	2.2		
1972	1	7	0158 1.8	39.105	118.081	0.25	8	1.4		
1972	1	7	093149.0	38.992	118.363	0.19	7	1.9		
1972	1	7	111317.9	38.989	118.369	0.14	7	2.3		
1972	1	8	023638.4	39.005	118.373	0.18	6	1.8		
1972	1	8	053149.7	39.034	118.304	0.65	7	2.1		
1972	1	19	045348.2	39.672	117.958	0.28	5	1.7		
1972	1	19	045552.8	39.685	118.027	0.07	7	2.3		
1972	1	19	073912.1	39.135	118.047	0.28	6	1.5		
1972	1	20	0126 4.0	39.450	118.338	0.14	7	1.8		
1972	1	20	0909 9.2	39.130	118.088	0.13	5	1.6		
1972	1	21	002447.9	38.898	117.866	0.43	7	1.9		
1972	1	23	191329.4	39.336	118.111	0.16	10	2.2		
1972	1	25	133317.3	39.093	118.051	0.32	7	1.4		
1972	1	26	140921.4	39.200	118.070	0.08	6	1.5		
1972	1	31	182312.9	39.194	118.112	0.48	10	2.4		
1972	2	6	040714.1	39.145	118.147	0.21	5	1.3		
1972	2	9	063318.7	39.298	118.453	0.46	7	2.2		
1972	2	9	200841.6	39.180	117.837	0.43	6	1.8		
1972	2	10	112034.9	39.497	118.401	0.29	7	1.8		
1972	2	10	144549.3	39.416	118.088	0.21	8	2.2		
1972	2	11	055932.3	39.106	118.063	0.37	7	1.4		
1972	2	12	061121.5	39.098	118.055	0.26	8	2.5		
1972	2	12	061142.1	39.109	118.084	0.10	6	4.0		
1972	2	14	115322.9	39.748	118.161	0.50	8	1.6		
1972	2	20	131422.1	39.068	118.086	0.54	6	1.4		
1972	2	20	131554.8	39.073	118.081	0.48	6	1.5		
1972	2	23	1549 2.6	40.354	117.716	0.58	7	4.3		
1972	2	23	182726.9	39.134	118.092	0.24	6	1.7		
1972	2	24	023658.6	40.179	117.770	0.20	6	2.4		
1972	2	26	054728.2	39.404	118.450	0.17	6			
1972	2	29	224054.3	39.698	118.416	0.24	9	2.5		
1972	2	29	2303 7.9	39.686	118.442	0.33	8	2.2		
1972	3	2	162954.7	39.186	118.066	0.12	7	1.5		
1972	3	2	203940.0	39.348	118.074	0.14	8	1.8		
1972	3	6	131531.1	39.154	118.116	0.58	10	2.6		
1972	3	6	180710.8	39.109	118.087	0.65	4	1.0		
1972	3	6	203551.8	39.126	118.084	0.33	6	1.4		
1972	3	7	045024.5	39.233	118.101	0.16	6	2.1		
1972	3	7	1110 7.1	39.374	118.071	0.18	9	1.7		
1972	3	7	210940.5	39.582	118.044	0.14	6	2.2		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1972	3	8	183023.9	39.712	118.234	0.17	5	1.1		
1972	3	8	190723.7	39.635	118.078	0.10	4	1.2		
1972	3	9	162736.2	39.830	117.380	0.30	8	1.9		
1972	3	11	030326.3	39.723	118.361	0.21	6	1.8		
1972	3	11	063327.1	39.860	117.447	0.19	5	2.0		
1972	3	12	043056.2	39.054	118.151	0.42	9	2.0		
1972	3	17	184021.8	39.392	118.427	0.16	6	1.4		
1972	3	18	091353.4	39.426	117.749	0.16	5	1.2		
1972	3	18	205145.9	39.126	118.067	0.21	6	1.4		
1972	3	20	160132.1	39.095	118.056	0.07	4			
1972	3	22	213836.1	38.994	118.159	0.29	9			
1972	4	1	001726.2	38.912	117.892	1.02	7	2.3		
1972	4	3	033914.4	39.537	118.076	0.16	5	1.8		
1972	4	4	102361.1	39.166	118.083	0.16	7	1.9		
1972	4	5	002554.7	38.916	117.933	0.90	7	1.9		
1972	4	6	003758.8	39.247	118.116	0.48	6	1.9		
1972	4	6	062722.9	39.452	118.441	0.20	7	1.9		
1972	4	6	0638 4.0	40.391	118.579	0.87	5	2.9		
1972	4	6	102756.4	40.298	118.472	0.09	5	2.3		
1972	4	6	1132 9.5	40.335	118.499	0.16	6	1.7		
1972	4	7	2341 6.9	39.121	118.083	0.29	6	2.1		
1972	4	9	061950.4	39.592	118.086	0.08	7	1.9		
1972	4	14	201646.3	39.285	118.098	0.35	7	2.2		
1972	4	21	200726.8	38.881	117.920	0.27	6	1.9		
1972	4	23	002430.0	39.513	118.016	0.08	4	1.6		
1972	4	24	2120 7.9	39.924	118.411	0.54	6	1.5		
1972	4	26	012857.0	39.920	118.395	0.38	5	1.4		
1972	5	2	184947.7	39.214	118.121	0.10	5	1.4		
1972	5	3	190959.2	39.151	117.997	0.46	6	1.3		
1972	5	5	085939.1	39.556	118.204	0.15	5	1.5		
1972	5	5	162254.0	39.228	118.030	0.26	8	2.3		
1972	5	8	232029.9	38.901	117.861	0.39	7	1.8		
1972	5	11	040628.3	39.703	118.052	0.10	5	1.6		
1972	5	11	185924.5	38.918	117.919	0.87	7	1.9		
1972	5	12	110230.4	39.575	118.153	0.22	11	1.9		
1972	5	13	083031.9	39.552	118.107	0.13	8	1.8		
1972	5	13	230515.2	40.275	118.499	0.27	5	1.8		
1972	5	14	1323 6.4	39.409	118.308	0.53	7	2.0		
1972	5	17	011831.8	39.284	118.534	0.12	8	1.8		
1972	5	17	040422.4	39.411	118.090	0.13	9	2.2		
1972	5	17	095339.8	39.582	118.124	0.30	12	2.4		
1972	5	18	113412.3	39.228	118.086	0.54	7	2.0		
1972	5	22	200730.4	38.915	117.881	0.12	5	2.0		
1972	5	24	1930 3.6	39.111	118.071	0.21	7	2.1		
1972	5	25	083650.3	39.107	118.073	0.17	8	2.2		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1972	5	25	230840.7	39.105	118.041	0.22	5	2.1		
1972	5	27	160636.6	39.152	117.993	0.22	7	2.3		
1972	5	30	032614.9	38.807	117.951	0.56	7	2.5		
1972	5	30	1910 1.2	38.898	117.868	0.54	7	2.3		
1972	5	31	164438.0	39.254	117.894	1.20	5	2.2		
1972	6	1	091842.9	40.157	118.302	0.49	7	2.6		
1972	6	1	232041.3	38.911	117.874	0.24	5	2.2		
1972	6	2	114613.5	39.151	117.999	0.33	10	4.1		
1972	6	6	172418.0	39.109	118.066	0.23	9	2.1		
1972	6	6	195210.2	39.477	118.040	0.04	6			
1972	6	16	231913.2	38.968	118.080	0.21	5	2.2		
1972	6	21	083942.8	40.116	118.293	0.70	6	2.3		
1972	6	21	085336.1	40.107	118.272	0.32	6	2.2		
1972	6	21	2349 2.0	39.453	118.118	0.34	6	1.9		
1972	6	22	035346.4	39.691	118.016	0.33	8	2.6		
1972	6	22	051746.2	39.734	118.030	0.35	4	2.1		
1972	6	22	070859.0	39.690	118.009	0.26	6	2.1		
1972	6	29	230437.8	39.715	118.064	0.19	9	2.3		
1972	7	4	010347.6	38.995	117.419	0.87	6			
1972	7	4	065535.0	39.090	118.024	0.27	12	1.5		
1972	7	4	232130.6	38.994	118.205	0.25	12	2.2		
1972	7	5	014913.2	40.179	118.461	0.63	7	1.9		
1972	7	6	232252.8	38.918	117.893	0.70	9	2.8		
1972	7	8	181113.3	39.134	118.031	0.17	7	2.8		
1972	7	9	2326 5.9	39.189	118.108	0.44	9	1.7		
1972	7	12	0123 5.8	39.283	117.691	0.31	14	3.3		
1972	7	12	021645.0	39.283	117.690	0.11	8	1.8		
1972	7	12	151728.8	39.287	117.689	0.20	11	2.5		
1972	7	18	131334.6	39.159	118.183	0.61	7	2.4		
1972	7	18	195956.9	39.327	118.120	0.16	9	2.8		
1972	7	18	200136.3	39.313	118.091	0.20	7	1.9		
1972	7	23	223719.6	39.496	118.467	0.28	12	2.8		
1972	7	29	101331.4	39.133	118.108	1.68	14	2.5		
1972	7	29	141420.3	39.007	117.580	0.16	6	2.2		
1972	7	29	195256.0	39.446	118.609	0.22	4	1.9		
1972	8	4	185538.1	39.305	118.069	0.16	6			
1972	8	4	2320 4.4	38.937	117.917	0.84	9	2.3		
1972	8	8	084644.7	39.113	118.088	0.46	8	1.6		
1972	8	8	181012.8	39.595	118.167	0.53	4	2.1		
1972	8	10	043548.9	39.722	118.045	0.31	7	2.7		
1972	8	13	090742.8	39.014	117.624	0.59	13	2.2		
1972	8	19	033214.0	39.085	118.053	0.19	9	2.7		
1972	8	21	0755 3.3	39.577	118.149	0.15	6	2.0		
1972	8	28	122535.6	40.391	117.570	0.86	11	1.8		
1972	8	28	123416.7	40.364	117.564	0.77	7	1.6		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1972	9	2	075840.1	38.974	118.384	0.20	12	1.5		
1972	9	2	0759 1.4	38.956	117.867	0.73	8			
1972	9	4	004138.3	39.060	118.126	0.44	8	2.8		
1972	9	5	011146.9	39.010	118.132	0.34	8	2.5		
1972	9	6	190342.8	38.899	117.829	0.43	7	2.1		
1972	9	9	181415.4	39.696	118.417	0.29	15	2.2		
1972	9	11	115132.1	39.045	118.166	0.45	9	1.3		
1972	9	13	235737.5	38.872	117.967	0.54	8	2.3		
1972	9	15	234245.5	38.859	117.779	0.51	8	2.9		
1972	9	18	101966.9	40.444	117.371	1.29	8	1.4		
1972	9	19	115352.9	39.092	118.101	0.44	6	2.4		
1972	9	27	053051.3	38.969	118.176	0.25	10	2.5		
1972	9	29	235225.8	39.369	117.524	0.27	9	2.3		
1972	9	30	230832.9	39.394	118.145	0.43	11	1.9		
1972	10	1	1124 1.1	40.291	117.734	0.39	12	2.3		
1972	10	1	1133 4.8	40.392	117.861	0.47	6	1.8		
1972	10	3	024017.2	39.226	118.072	0.29	9	2.0		
1972	10	3	202819.8	39.274	118.513	0.18	11	2.0		
1972	10	10	194511.8	38.879	117.812	0.33	7	2.5		
1972	11	11	075043.2	38.859	118.348	0.24	9	1.8		
1972	11	12	2045 6.7	39.084	118.077	0.44	10	2.6		
1972	11	15	0106 7.9	40.495	117.564	0.64	5	2.0		
1972	11	17	102159.1	39.122	118.097	0.43	8	2.2		
1972	11	17	120026.1	39.712	118.061	0.19	10	2.4		
1972	11	22	2353 9.4	39.111	118.034	0.20	7	2.1		
1972	11	23	032453.9	39.105	118.067	0.34	10	2.2		
1972	11	23	130143.4	39.090	118.035	0.32	7	1.8		
1972	11	23	151017.1	39.111	118.033	0.16	7	2.2		
1972	11	25	1453 8.9	39.108	118.049	0.29	9	2.1		
1972	11	26	223562.3	39.082	118.051	0.49	8	1.4		
1972	11	29	200114.5	38.914	117.938	0.88	6			
1972	12	1	081637.2	39.055	118.143	0.37	13	2.9		
1972	12	4	003719.6	39.339	118.140	0.22	7	2.4		
1972	12	6	010116.6	38.808	117.941	0.23	6	1.8		
1972	12	8	0715 6.0	39.308	118.139	0.12	9	2.8		
1972	12	8	091826.2	39.335	118.092	0.21	8	2.2		
1972	12	9	043514.0	39.575	117.795	1.34	7	1.7		
1972	12	10	094125.2	39.105	118.069	0.40	7	1.7		
1972	12	10	104228.5	39.107	118.060	0.34	10	2.9		
1972	12	13	003330.7	38.896	117.841	0.57	5			
1972	12	28	062815.5	39.294	118.527	0.13	6			
1973	1	1	003831.7	39.552	118.476	0.32	10	2.4		
1973	1	6	002835.3	38.901	117.828	0.44	7	1.9		
1973	1	9	171120.4	39.344	118.138	0.11	7	1.8		
1973	1	13	010230.4	40.311	117.597	0.22	6	1.8		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1973	1	13	2002 3.5	39.100	118.073	0.13	8	2.1		
1973	1	15	160912.2	39.200	118.016	0.43	6	1.5		
1973	1	19	0416 9.9	39.340	118.063	0.22	9	2.0		
1973	1	25	155212.0	39.086	118.122	0.18	6	1.8		
1973	1	27	112119.1	39.052	118.169	0.31	12	2.7		
1973	1	28	2255 5.9	39.166	118.032	0.23	7	2.4		
1973	1	29	072229.1	39.893	117.828	0.20	7	2.6		
1973	1	31	002021.9	38.898	117.874	0.55	7	2.3		
1973	2	4	043040.3	39.305	118.111	0.19	9	2.8		
1973	2	10	194030.4	39.137	118.081	0.12	7	1.8		
1973	2	10	210748.6	39.404	118.096	0.23	10	2.8		
1973	2	10	212835.1	39.406	118.091	0.21	10	3.0		
1973	2	10	2308 2.1	39.154	118.063	0.17	8	2.0		
1973	2	11	000248.0	39.405	118.086	0.24	8	2.6		
1973	2	15	043931.8	39.020	118.453	0.11	9	2.1		
1973	2	15	112917.3	40.389	117.578	0.18	6	2.4		
1973	2	19	011138.6	39.360	118.001	0.19	8	2.1		
1973	2	19	100552.9	39.083	118.055	0.27	7	2.0		
1973	2	19	104050.8	39.144	118.073	0.11	7	2.0		
1973	2	22	0232 6.4	39.475	118.425	0.27	8	2.0		
1973	2	24	002425.7	38.917	117.899	0.82	6	2.1		
1973	3	10	064920.0	39.016	118.214	0.17	5	1.6		
1973	3	10	101241.6	39.277	118.084	0.15	8	1.8		
1973	3	11	222151.4	39.215	118.017	0.36	7	1.8		
1973	3	12	171412.1	39.031	118.158	0.33	8	1.8		
1973	3	16	145928.0	39.183	118.053	0.34	8	3.4		
1973	3	18	075924.2	39.242	118.029	0.27	6	1.8		
1973	3	18	201231.8	39.146	117.985	0.34	8	2.2		
1973	3	20	003115.3	38.913	117.895	0.81	6	2.3		
1973	3	20	151430.2	38.983	118.207	0.24	6	2.0		
1973	3	24	051436.7	39.025	118.137	0.46	7	1.9		
1973	3	27	201840.3	39.072	118.093	0.14	8	2.6		
1973	3	28	161855.1	39.124	118.062	0.20	9	2.6		
1973	3	29	212849.1	39.123	118.048	0.15	6	2.5		
1973	4	1	002344.3	38.898	117.827	0.46	6	2.4		
1973	4	2	054838.6	39.016	117.738	0.26	8	2.3		
1973	4	3	0757 9.3	39.042	118.165	0.27	7	1.5		
1973	4	4	065514.8	39.315	118.138	1.08	8	1.9		
1973	4	7	205829.9	39.066	118.119	0.27	8	1.7		
1973	4	8	0529 1.0	39.603	118.186	0.21	7	1.6		
1973	4	9	124111.4	39.106	118.143	0.27	8	1.7		
1973	4	12	010237.2	38.938	117.936	0.26	6			
1973	4	14	123534.3	39.078	118.109	0.33	8	2.1		
1973	4	17	002522.5	38.911	117.883	0.62	7	1.9		
1973	4	21	002237.0	38.900	117.850	0.41	7	2.6		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1973	4	21	122021.3	40.445	117.585	0.40	6	2.8		
1973	4	22	031028.7	39.186	118.044	0.33	7	1.8		
1973	4	22	114658.7	39.195	118.027	0.38	6	2.5		
1973	4	22	114816.4	39.196	118.037	0.20	5	2.0		
1973	4	25	002345.2	38.869	117.981	0.70	6			
1973	4	27	0357 1.2	39.633	117.915	0.26	6			
1973	5	1	2324 3.2	38.894	117.881	0.78	6	2.1		
1973	5	5	200316.4	39.060	118.105	0.16	8	2.1		
1973	5	7	014618.6	39.136	118.057	0.16	7	1.5		
1973	5	7	083139.9	39.340	118.141	0.16	9	2.5		
1973	5	7	152546.8	39.092	118.058	0.16	10	2.2		
1973	5	11	114656.6	39.323	117.570	0.29	6	2.2		
1973	5	13	180151.6	39.307	118.502	0.33	8	2.0		
1973	5	16	120912.6	39.095	118.061	0.28	8	2.1		
1973	5	18	072057.9	39.103	118.051	0.30	6	1.8		
1973	5	21	2321 2.5	38.894	117.822	0.47	6	2.3		
1973	5	22	150316.4	38.864	118.132	0.25	7	2.6		
1973	5	26	1957 8.4	39.023	118.176	0.20	6			
1973	5	27	140531.1	38.857	118.136	0.18	9	2.7		
1973	5	27	172836.2	38.870	118.115	0.20	9	2.1		
1973	5	28	090824.7	39.136	118.092	0.31	7			
1973	6	7	072829.3	39.064	118.131	0.25	9	2.6		
1973	6	8	033210.2	39.200	118.123	0.12	6	1.9		
1973	6	9	0603 4.7	39.040	118.097	0.30	8	1.8		
1973	6	17	164418.5	39.497	118.425	0.32	5	1.7		
1973	6	18	1319 1.3	39.063	118.064	0.29	8	2.5		
1973	6	19	2305 9.5	39.040	118.092	0.17	7	2.2		
1973	6	20	232521.3	38.898	117.849	0.35	7			
1973	6	24	203659.0	39.450	118.093	0.16	6	2.0		
1973	6	26	204228.2	39.680	118.432	0.22	5	1.6		
1973	6	29	052530.3	39.423	118.413	0.28	5	2.1		
1973	6	29	234250.6	39.316	118.111	0.39	7	2.7		
1973	6	30	012812.1	39.323	118.117	0.27	5	2.2		
1973	6	30	175413.7	39.064	118.217	0.10	5			
1973	6	30	233019.7	38.893	117.819	0.39	7	2.4		
1973	7	1	102853.3	39.088	118.152	0.27	6			
1973	7	2	0652 3.2	39.833	117.885	0.23	8	2.5		
1973	7	4	084619.6	39.582	118.094	0.15	5	2.0		
1973	7	5	221738.3	39.194	118.088	0.27	8	2.6		
1973	7	6	015354.8	40.086	118.074	0.42	6	2.7		
1973	7	6	174923.6	38.935	117.915	0.89	7	2.1		
1973	7	8	051014.1	39.745	118.032	0.24	8	2.6		
1973	7	10	232518.7	38.892	117.816	0.49	5	1.9		
1973	7	13	020455.4	39.263	118.122	0.09	4	2.4		
1973	7	15	094624.9	39.040	118.110	0.30	5	1.9		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1973	7	15	232210.5	39.029	118.071	0.20	8	1.8		
1973	7	18	232228.9	39.209	118.000	0.36	8	2.2		
1973	7	25	231818.3	39.118	118.075	0.22	5	2.1		
1973	7	29	024610.2	39.065	118.136	0.29	7	2.0		
1973	7	31	232426.6	38.890	117.835	0.46	6	2.6		
1973	8	2	172129.6	39.211	118.032	0.25	6	2.0		
1973	8	3	070234.5	39.325	118.083	0.09	7	2.0		
1973	8	5	024539.9	39.041	118.146	0.12	8	2.0		
1973	8	6	035138.0	39.213	118.112	0.02	5	2.1		
1973	8	9	010344.7	39.066	118.034	0.26	5	1.8		
1973	8	10	215329.2	39.377	118.128	0.09	5	1.8		
1973	8	10	232417.2	38.900	117.843	0.45	5	2.3		
1973	8	11	065518.7	39.036	118.188	0.29	7	1.9		
1973	8	12	095950.0	39.289	118.091	0.10	7	1.9		
1973	8	16	020254.4	39.204	118.028	0.16	6	2.0		
1973	8	19	022628.8	38.887	117.718	0.40	7	2.2		
1973	8	27	062857.5	39.051	118.115	0.18	7	2.5		
1973	8	31	2325 7.2	38.898	117.855	0.50	5	2.6		
1973	9	8	0247 5.1	39.430	118.490	0.60	6	2.1		
1973	9	11	2323 2.4	38.907	117.869	0.63	6	2.2		
1973	9	12	2144 9.3	39.033	118.157	0.41	7	2.0		
1973	9	17	2011 7.4	39.536	118.536	0.12	5	2.0		
1973	9	17	2101 8.6	39.011	118.142	0.12	6	1.8		
1973	9	19	0646 1.6	39.416	118.581	0.58	6	2.2		
1973	9	19	103015.6	39.388	118.481	0.22	4	1.7		
1973	9	22	062752.3	39.093	118.098	0.32	9	2.4		
1973	9	25	2320 2.6	38.895	117.860	0.67	6	2.4		
1973	9	27	203712.4	39.132	118.070	0.14	5	2.1		
1973	10	1	121720.9	39.240	118.022	0.58	5			
1973	10	4	055133.5	39.154	118.047	0.21	9	1.5		
1973	10	6	232350.7	38.896	117.824	0.39	7	2.1		
1973	10	7	092858.8	39.579	118.033	0.12	9	2.3		
1973	10	7	171452.8	39.600	118.030	0.24	7			
1973	10	11	1853 4.8	39.020	118.472	0.22	8	2.5		
1973	10	12	1646 2.5	39.505	118.413	0.37	6	3.1		
1973	10	13	020343.5	39.584	118.062	0.30	6	2.4		
1973	10	13	224310.7	39.616	118.012	0.27	6	2.2		
1973	10	16	001412.5	39.740	117.860	0.12	5	2.2		
1973	10	16	231620.5	38.893	117.835	0.41	6	2.4		
1973	10	20	140736.2	38.873	118.187	0.27	5	2.4		
1973	10	26	043119.9	39.495	118.289	0.18	7	2.4		
1973	10	26	191159.1	38.891	117.826	0.48	7	2.5		
1973	10	30	043714.4	39.248	117.358	0.14	6	2.6		
1973	10	31	1330 4.1	39.230	117.389	0.17	10	2.8		
1973	11	1	145520.7	39.233	118.110	0.06	5	2.0		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1973	11	2	060824.0	40.397	117.696	0.54	6	2.9		
1973	11	2	090458.0	39.496	117.618	0.36	6	2.4		
1973	11	3	061459.2	39.059	118.106	0.29	6	2.2		
1973	11	3	202736.6	38.810	118.049	0.17	5	2.6		
1973	11	7	164542.5	39.140	118.044	0.17	7	2.0		
1973	11	10	153438.4	39.040	118.072	0.19	9	2.1		
1973	11	12	121133.2	39.353	118.094	0.19	7	1.8		
1973	11	13	002459.1	38.898	117.840	0.40	7	2.2		
1973	11	14	221329.7	39.042	118.031	0.12	6	2.4		
1973	11	15	132949.4	39.135	118.110	0.32	7	2.3		
1973	11	15	203633.1	39.059	118.080	0.18	8	2.4		
1973	11	17	071541.5	39.310	118.530	0.25	7	1.7		
1973	11	17	1244 9.4	39.607	118.076	0.22	9	2.0		
1973	11	21	123425.6	39.675	118.019	0.05	5	2.5		
1973	11	22	002328.7	38.890	117.833	0.44	6	2.3		
1973	11	27	101751.5	39.065	118.033	0.29	6			
1973	11	28	002212.2	38.897	117.852	0.54	6	2.4		
1973	11	30	221232.1	39.163	118.042	0.18	8			
1973	12	2	1450 .4	39.066	118.166	0.35	7			
1973	12	5	230421.2	39.157	118.182	0.13	5	2.5		
1973	12	10	010823.4	39.146	117.977	0.37	6	2.8		
1973	12	10	231611.0	39.694	117.999	0.08	7	2.4		
1973	12	11	222551.0	39.100	118.046	0.10	6	2.1		
1973	12	17	064216.4	40.100	117.673	0.23	6	3.0		
1973	12	21	1726 8.7	39.030	118.056	0.25	7	2.1		
1973	12	26	001431.4	39.452	118.416	0.41	6	1.9		
1973	12	28	002247.4	38.913	117.806	0.37	7	2.4		
1973	12	28	153525.8	39.469	118.053	0.15	7	2.3		
1973	12	29	041558.5	39.024	118.059	0.24	9	3.0		
1974	1	1	062231.7	38.997	118.242	0.18	7	2.1		
1974	1	7	152311.7	39.370	118.526	0.47	7	2.0		
1974	1	18	232736.4	38.901	117.811	0.27	6			
1974	1	23	033045.0	39.373	117.905	0.26	8	2.6		
1974	1	23	232237.4	38.925	117.769	0.13	6	2.1		
1974	1	28	1958 1.0	40.101	118.142	0.10	6	2.5		
1974	1	30	114740.5	40.155	117.782	0.24	5	2.2		
1974	2	7	061328.6	39.076	118.102	0.31	8	2.2		
1974	2	9	1555 1.8	39.019	118.087	0.37	8	2.6		
1974	2	10	0528 4.8	39.057	118.177	0.23	8	2.6		
1974	2	11	184522.4	39.150	117.970	0.32	5	2.0		
1974	2	11	184640.4	39.144	117.971	0.32	6	2.1		
1974	2	12	082020.6	39.001	118.116	0.02	4			
1974	2	13	1451 5.9	39.343	118.481	0.36	8	2.1		
1974	2	17	055314.1	39.046	118.028	0.10	6	1.7		
1974	2	20	035724.1	39.581	118.063	0.32	8	2.4		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1974	2	20	041338.2	39.585	118.054	0.24	8	2.5		
1974	2	20	1940 .8	39.591	118.025	0.26	6	2.2		
1974	2	23	160124.7	39.134	118.069	0.27	4			
1974	2	25	202038.5	39.397	118.099	0.27	8	2.4		
1974	3	18	190340.4	38.919	117.812	0.31	6	2.2		
1974	3	22	954 3.0	38.874	118.061	0.20	4	1.6	28.12	C
1974	3	22	135551.8	39.352	117.891	0.51	6		2.75	D
1974	3	22	135557.0	39.057	118.119	0.11	9	2.3		
1974	3	23	011319.9	39.607	118.052	0.21	7	2.0		
1974	3	23	173239.7	39.190	117.576	0.41	7		0.34	D
1974	3	26	254 2.1	39.648	118.139	0.03	6	3.4	5.62	D
1974	3	26	25411.8	39.098	118.271	0.23	8	2.8		D
1974	3	26	232119.6	38.897	117.843	0.47	8	2.8		
1974	3	27	232121.0	38.831	117.926	0.13	10	3.4	2.45	D
1974	3	30	111357.5	39.005	118.221	0.18	7	2.3		
1974	4	2	232524.9	38.905	117.827	0.46	7	2.2		
1974	4	5	093219.4	39.086	118.052	0.34	6			
1974	4	5	2136 2.7	39.112	118.000	0.09	6			
1974	4	7	174321.6	39.320	118.078	0.15	8	2.5	1.38	D
1974	4	15	233332.9	39.062	118.453	0.78	7	2.8		
1974	4	23	071533.9	38.952	118.178	0.17	9	2.4		
1974	5	2	194958.1	39.112	118.038	0.21	5	2.6		
1974	5	3	042040.3	39.054	118.171	0.40	11	3.2		
1974	5	3	083746.1	39.054	118.074	0.27	11			
1974	5	5	221014.4	39.081	118.176	0.24	10	2.1	1.46	D
1974	5	12	231853.8	39.358	118.130	0.16	7	2.4		
1974	5	13	122617.7	39.156	117.999	0.31	14	2.5	4.01	D
1974	5	13	192152.0	38.916	117.842	0.28	7	2.4		
1974	5	15	61132.9	39.057	118.093	0.09	6	2.2	0.40	D
1974	5	15	61136.4	38.859	118.147	0.03	5	1.9		D
1974	5	15	082938.3	39.245	118.168	0.16	11	2.2		
1974	5	15	131046.2	39.268	118.057	0.19	6	2.8	0.34	D
1974	5	15	131049.5	39.078	118.145	0.34	6	2.4		
1974	5	16	010638.3	39.539	118.424	0.10	8	2.5		
1974	5	17	14 915.9	39.111	118.134	0.10	7	2.4	1.87	D
1974	5	19	0014 3.6	39.314	118.110	0.22	5	2.6		
1974	5	23	1148 8.7	40.290	118.551	0.26	9	2.8		
1974	5	23	232335.7	38.895	117.827	0.48	6	2.7		
1974	5	26	174539.3	39.360	117.981	0.16	6	2.4	9.02	D
1974	5	26	174544.0	39.134	118.045	0.25	10	1.8		
1974	6	5	042049.6	39.243	117.387	0.48	7	2.9		
1974	6	5	163223.8	38.882	117.898	0.39	6			
1974	6	15	134853.6	39.455	117.986	0.12	5	2.1		
1974	6	21	41134.7	38.814	117.623	2.72	9	2.8	55.70	D
1974	6	22	232543.3	38.949	117.835	0.78	7	2.5		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1974	6	25	235632.9	39.628	118.460	0.61	7	2.1		
1974	6	27	1811 .8	39.507	118.022	0.22	6	2.3		
1974	6	29	205334.3	39.100	118.021	0.45	7	2.0		
1974	7	1	105029.9	39.114	117.965	0.32	7	1.9		
1974	7	1	143241.5	39.332	118.498	0.39	7	2.1		
1974	7	13	195736.4	39.225	118.059	0.33	7	2.0		
1974	7	19	131515.9	38.816	117.928	0.12	6	2.0		
1974	7	20	2326 .9	39.072	118.113	0.12	6	2.3		
1974	7	22	1227 4.4	39.669	117.955	0.14	8	2.1		
1974	7	25	232720.5	38.825	118.001	1.07	6	2.5		
1974	8	1	020025.3	39.026	118.235	0.09	9	2.9		
1974	8	1	101555.1	39.107	118.052	0.19	7	1.6		
1974	8	9	162717.1	38.826	117.787	0.28	11	2.6	2.48	D
1974	8	11	002027.1	39.321	118.134	0.33	8	2.7		
1974	8	14	193135.1	38.897	117.853	0.37	10	2.6		
1974	8	25	041551.6	39.646	118.373	0.67	6	2.7		
1974	8	26	103332.8	39.105	118.059	0.23	14	2.2	5.12	D
1974	8	26	183331.0	39.079	118.140	0.18	13	2.6	5.20	D
1974	9	2	233217.6	39.093	118.127	0.25	16	2.4	2.23	D
1974	9	13	101628.2	39.374	117.932	0.09	6	2.5	2.48	D
1974	9	13	101633.8	39.077	118.030	0.04	6	2.1		D
1974	9	13	142114.8	39.158	118.058	0.16	8	2.3	2.92	D
1974	9	14	01812.4	38.869	117.958	0.23	10	2.4	1.27	D
1974	9	17	173159.6	39.102	118.064	0.13	11	2.7	0.81	D
1974	9	17	1732 .2	39.058	118.115	0.21	6			
1974	9	26	5 626.6	39.189	118.032	0.17	16	2.6	1.62	D
1974	9	27	34053.8	39.091	118.160	0.10	8	2.1	8.59	D
1974	10	1	175227.3	38.855	117.885	0.07	7	2.4	1.85	D
1974	10	8	44034.2	38.807	117.841	0.13	11	2.3	2.19	D
1974	10	11	141954.0	39.074	118.201	0.17	7	2.1	5.02	D
1974	10	13	133640.6	39.049	118.161	0.71	7	2.1	56.29	D
1974	10	24	133415.2	39.542	118.419	0.28	6	3.0		
1974	10	26	81840.6	38.862	118.072	3.12	10	2.0	0.30	D
1974	10	27	5 619.3	39.119	118.033	0.15	10	2.2	1.53	D
1974	10	31	224048.3	38.990	118.238	1.01	7	2.1	28.00	D
1974	11	1	15514.9	39.189	118.140	0.29	11	2.2	0.50	D
1974	11	2	14647.6	38.802	117.969	0.28	6	1.9	3.31	D
1974	11	6	95527.7	39.300	118.162	0.40	10	2.5	5.50	D
1974	11	8	133624.4	39.715	118.260	0.10	8			
1974	11	12	201614.2	38.917	117.845	0.40	6	2.7		
1974	11	15	165421.5	39.616	118.075	0.25	9	2.6		
1974	11	18	83149.6	39.117	118.024	0.18	12	2.6	0.50	D
1974	11	19	002425.4	38.854	117.905	0.24	5	2.5		
1974	11	21	194329.0	39.098	118.178	0.38	8	2.8		
1974	11	26	093327.0	39.331	118.104	0.16	7	2.2		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1974	11	26	101024.2	39.605	118.071	0.36	9	2.2		
1974	11	26	105743.8	39.596	117.981	0.31	9	1.9		
1974	11	29	003253.1	39.600	118.084	0.36	10	3.1		
1974	12	8	103316.5	39.074	118.168	0.18	10	2.4	16.78	B
1974	12	8	153013.0	39.075	118.113	0.19	11	3.0	16.24	C
1974	12	13	132850.6	39.157	118.124	0.21	5	2.6		
1974	12	15	074442.2	39.248	118.446	0.10	5			
1974	12	16	2104 5.7	39.506	118.472	0.17	10	2.8		
1974	12	17	141549.4	38.947	117.679	1.01	7	2.0		
1974	12	17	1731 4.7	39.234	118.021	0.36	5	2.5		
1974	12	17	1731 7.4	39.043	118.214	0.15	9	2.5	2.50	C
1974	12	17	201540.1	39.033	118.213	0.02	7	2.0		
1974	12	22	0024 2.6	39.290	118.077	0.74	5	2.6		
1974	12	24	1432 8.4	39.346	118.168	0.38	9	2.6	0.14	D
1974	12	26	62848.7	39.074	118.128	0.05	8	2.6	9.35	B
1974	12	29	171618.6	39.148	118.135	0.04	8	3.2	11.42	B
1975	1	2	090144.8	39.048	118.153	0.13	7	2.0		
1975	1	3	150820.3	39.172	117.659	0.24	10	2.4		
1975	1	3	194218.8	38.993	118.182	0.23	7	2.0		
1975	1	4	053812.4	39.730	117.991	0.27	9	2.7		
1975	1	4	164630.5	39.045	118.147	0.29	11	2.2	4.01	D
1975	1	5	04754.8	39.019	118.189	0.26	27	3.0	8.66	B
1975	1	9	031926.4	39.396	118.451	0.23	6	2.1		
1975	1	9	0749 5.4	39.044	118.056	0.25	6	2.2		
1975	1	14	094725.0	40.260	118.475	0.28	8	2.2		
1975	1	16	165249.1	39.084	118.065	0.22	15	2.3	0.74	D
1975	1	18	213522.3	39.022	118.160	0.24	19	2.5	9.85	B
1975	1	20	1240 9.6	39.036	118.130	0.05	7	0.4	7.81	C
1975	1	21	459 4.9	39.017	118.154	0.26	13	1.9	10.19	C
1975	1	23	205319.1	39.025	118.117	0.20	12	2.1	6.72	C
1975	1	24	4 614.9	39.035	118.174	0.16	11	1.8	7.23	C
1975	1	29	135452.4	39.627	118.106	0.27	7	2.5		
1975	1	30	005637.1	39.522	118.472	0.09	9	1.9		
1975	1	30	2315 4.6	39.172	117.401	0.33	8	2.1		
1975	2	4	7 515.2	39.031	118.169	0.20	16	2.3	14.13	C
1975	2	10	062639.4	39.349	118.140	0.16	8	1.9		
1975	2	10	114729.1	39.761	118.396	0.30	7			
1975	2	15	45733.0	39.376	118.479	0.09	5	1.9	22.74	D
1975	2	15	142737.5	39.084	118.108	0.12	10	2.1	9.41	C
1975	2	22	0 248.4	39.066	118.107	0.15	12	2.0	7.80	C
1975	2	22	140424.4	40.009	118.244	0.18	8	2.4		
1975	2	26	81011.1	39.381	118.111	0.12	14	2.3	12.82	C
1975	2	26	95432.8	39.017	118.661	0.19	21	2.8	12.95	C
1975	2	27	094439.6	39.078	118.050	0.43	7	1.5		
1975	3	2	34119.0	38.806	117.944	0.19	11	1.8	17.53	D

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1975	3	4	153254.5	39.032	118.178	0.05	7	1.0		
1975	3	9	023421.3	39.083	118.021	0.20	5	1.0		
1975	3	9	035818.2	39.767	118.409	0.32	9	3.5		
1975	3	9	1049 2.9	39.026	118.154	0.13	6	1.0		
1975	3	10	130434.8	39.004	118.215	0.16	9	1.6		
1975	3	14	032827.9	38.808	118.429	0.00		2.4		
1975	3	15	15 125.1	38.948	118.128	7.81	13	2.2	0.09	D
1975	3	19	225548.5	39.332	118.116	0.28	10	2.5		
1975	3	19	225750.3	39.358	118.088	0.31	8			
1975	3	20	025611.8	39.250	118.205	0.36	7	2.1		
1975	3	21	103747.5	39.381	118.166	0.37	8	2.1		
1975	3	24	15 231.2	39.030	118.197	0.19	14	2.6	10.59	B
1975	3	28	235958.7	38.994	118.202	0.26	8	2.1		
1975	3	30	215531.9	39.192	118.091	0.09	6	1.5		
1975	4	13	83056.0	39.064	118.057	0.17	9	2.6	11.81	C
1975	4	13	10 024.1	39.067	118.073	0.21	11	3.2	11.23	C
1975	4	16	916 5.9	39.045	118.105	0.40	12	2.9	4.63	C
1975	4	18	151218.6	39.306	118.148	0.15	7	1.8		
1975	4	19	065749.6	40.238	118.574	0.39	9	2.9		
1975	4	20	14524.8	39.032	118.173	0.22	10	2.3	4.02	C
1975	4	22	71219.9	38.989	118.193	0.19	12	2.2	7.86	B
1975	4	23	73328.7	39.068	118.111	0.12	8	2.3	5.61	C
1975	4	27	211149.1	39.061	118.154	0.15	11	1.9	13.63	C
1975	5	5	204443.4	39.535	118.479	0.56	9	3.1		
1975	5	21	24736.8	39.020	118.226	0.15	15	2.3	10.13	C
1975	6	1	0239 1.4	40.001	118.235	0.20	9	2.0		
1975	6	3	190359.3	39.999	118.229	0.41	7	2.6		
1975	6	4	105641.8	39.254	118.549	0.33	7	1.4		
1975	6	4	173932.0	39.327	117.599	0.21	6	2.2		
1975	6	5	191232.5	38.913	117.834	0.38	7	2.4		
1975	6	7	103228.9	39.226	118.544	0.37	8	2.3		
1975	6	14	12 253.9	39.255	118.553	0.14	9	2.2	15.33	D
1975	6	15	2056 8.3	38.993	118.184	0.29	12	2.5	12.99	C
1975	6	16	51522.7	39.287	118.138	0.18	11	2.6	9.02	D
1975	6	24	0504 3.2	39.330	118.097	0.31	8	2.3		
1975	6	24	724 4.6	39.083	118.038	0.12	9	2.4	16.67	D
1975	6	27	95042.0	39.386	118.073	0.10	12	2.6	15.40	C
1975	6	28	221212.1	39.065	118.146	0.11	16	2.3	15.60	C
1975	7	1	175311.0	39.560	118.454	0.20	14	2.8	6.87	C
1975	7	3	113056.2	39.058	118.120	0.15	12	2.2	11.13	C
1975	7	10	2 126.9	39.253	118.041	0.16	12	2.2	14.49	C
1975	7	13	011635.0	39.386	117.632	0.00		4.0		
1975	7	13	013658.2	39.384	117.651	0.00		4.2		
1975	7	21	1739 2.0	39.037	118.165	0.15	15	2.5	10.64	C
1975	7	23	151226.7	39.382	118.126	0.12	13	2.9	0.92	D

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1975	7	23	151512.8	39.402	118.084	0.07	11	2.6	9.35	C
1975	7	29	162429.5	39.613	118.079	0.26	6	3.1		
1975	7	29	163234.4	39.651	118.040	0.28	9	2.7		
1975	8	15	052039.3	39.178	118.123	0.11	5			
1975	8	29	231746.2	39.054	118.173	0.13	23	2.9	1.62	D
1975	8	30	003443.7	39.402	118.051	0.36	6	3.9		
1975	9	6	15 8 3.1	39.213	118.062	0.12	13	2.5	15.01	C
1975	9	7	620 3.9	39.366	118.098	0.20	14	2.4	13.15	C
1975	9	10	1247 4.7	38.825	118.015	0.11	11	2.3	12.57	C
1975	9	10	2023 5.8	39.041	118.112	0.08	9	2.9	12.11	C
1975	9	10	2032 5.8	39.040	118.107	0.00		2.3		
1975	9	12	092554.6	40.410	117.855	0.61	7	2.5		
1975	9	22	085139.1	39.640	118.114	0.22	6	2.5		
1975	9	23	141740.8	39.393	118.469	0.28	5	2.1		
1975	9	25	112059.2	38.990	118.218	0.07	10	2.5	11.30	C
1975	9	25	1225 2.3	39.104	118.144	0.08	12	2.6	12.54	C
1975	10	4	111920.5	39.816	117.862	0.28	5			
1975	10	6	235110.1	39.057	118.132	0.07	8	2.4	11.39	C
1975	10	22	020123.0	39.599	118.096	0.26	7	2.4		
1975	10	22	155937.3	39.393	118.108	0.24	7	2.8		
1975	11	9	171658.6	38.853	118.012	0.06	10	2.5	13.42	C
1975	11	13	13 937.1	39.152	118.086	0.06	11	3.0	15.82	C
1975	11	22	346 7.1	39.022	118.187	0.05	11	2.3	11.23	C
1975	12	2	05156.2	39.104	118.059	0.07	14	2.8	9.46	C
1975	12	5	1153 2.9	39.527	118.444	0.20	6	2.4		
1975	12	5	224029.7	39.105	118.070	0.10	12	3.4	11.09	C
1976	1	5	134649.3	39.390	118.447	0.19	11	2.9	4.28	D
1976	1	21	52330.3	39.416	117.713	0.33	11	2.5	9.00	
1976	1	31	4 746.7	39.376	118.453	0.09	13	3.3	11.80	C
1976	2	14	221023.2	39.135	118.065	0.15	9	1.8	10.50	
1976	2	15	18 611.5	39.190	118.044	0.18	12	2.9	9.75	C
1976	2	20	184531.9	39.364	118.534	0.21	11	3.7	2.75	D
1976	2	28	233039.5	39.095	118.059	0.05	9	3.6	12.07	C
1976	3	31	133330.9	39.198	118.090	0.14	7	1.5		
1976	3	31	134513.9	39.290	118.465	0.28	10	3.1	5.60	
1976	4	2	125637.3	39.532	117.664	0.35	9	4.1	10.40	
1976	4	2	134537.6	39.535	117.644	0.44	10	1.8	23.60	
1976	4	3	80457.4	39.263	118.486	0.38	9	1.4	12.00	
1976	4	21	35637.9	39.061	118.090	0.04	9	2.7	10.95	C
1976	4	22	214433.9	39.405	118.078	0.45	10	2.0	6.40	
1976	5	4	434 0.3	39.022	118.193	0.09	8	2.7	13.59	C
1976	5	5	54657.6	40.012	117.455	0.05	6	1.1	11.40	
1976	5	6	231938.8	38.874	117.858	0.00	5	3.0	2.77	C
1976	5	12	34746.7	39.431	118.073	0.14	10	2.8	3.61	D
1976	5	16	427 7.9	39.269	118.144	0.13	13	2.7	1.71	C

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1976	5	21	12216.6	39.169	118.161	0.24	14	2.7	9.94	C
1976	5	21	115521.5	39.104	118.082	0.13	11	2.6	11.23	C
1976	5	21	115623.1	39.102	118.123	0.11	7	2.5	9.24	D
1976	5	23	54130.5	39.673	118.438	0.37	6	1.6		
1976	5	23	204250.8	39.114	118.078	0.18	15	3.1	9.77	C
1976	6	1	213640.1	39.096	118.045	0.31	9	2.1		
1976	6	7	210025.5	39.378	118.500	0.32	9	0.8		
1976	6	9	7 916.5	39.115	118.056	0.22	9	2.7	13.06	D
1976	6	14	195711.0	38.988	118.164	0.45	16	2.8	11.20	
1976	6	22	223907.3	39.324	118.502	0.74	10	1.7	9.80	
1976	7	6	142838.3	39.158	118.120	0.21	8	2.3	9.49	D
1976	7	14	232239.8	39.056	117.714	0.07	6	3.0	2.23	D
1976	8	6	245 3.9	39.093	118.070	0.17	10	3.1	5.87	D
1976	8	31	6 858.6	39.004	118.104	0.37	5	2.4	4.95	D
1976	9	4	180303.2	39.389	117.576	0.34	9	2.0	19.50	
1976	9	4	180353.5	39.383	117.565	0.34	13	2.8	14.00	
1976	9	7	2 740.2	38.933	118.193	0.84	14	2.8	10.23	D
1976	9	12	231930.6	39.115	118.078	0.13	6	2.5	8.83	C
1976	10	2	84055.3	39.110	118.068	0.21	11	3.9	10.46	C
1976	10	6	233146.9	39.091	118.093	0.12	8	2.6	8.42	C
1976	10	7	111846.8	39.095	118.068	0.07	10	2.9	11.78	C
1976	10	26	174031.9	39.086	118.089	0.48	13	2.1	12.10	
1976	10	28	205646.4	39.009	118.112	0.67	8	2.1	5.50	
1976	11	4	01138.8	38.865	118.578	0.22	16	2.8	17.12	C
1976	11	11	45909.3	39.435	117.765	0.32	12	2.2	18.20	
1976	11	14	111712.5	39.372	117.827	0.21	12	1.7	17.40	
1976	11	17	82348.4	40.273	117.629	21.59	16	4.3	12.80	
1976	11	18	101929.5	39.358	118.268	0.09	8	0.9	18.10	
1976	11	27	13019.0	39.329	118.363	0.36	9	0.8	18.60	
1976	12	3	13 017.4	39.112	118.063	0.23	7	2.8	11.04	D
1976	12	3	231652.0	39.193	118.102	0.16	7	3.3	9.89	D
1976	12	5	140301.4	39.726	118.089	0.43	10	1.6		
1976	12	27	83141.6	39.145	118.050	0.13	8		7.36	C
1976	12	28	61314.1	39.579	118.287	0.24	6	3.0	1.62	D
1976	12	31	726 8.0	39.723	118.342	1.82	4	3.2	1.95	D
1977	1	8	17 2 0.0	39.099	118.116	0.54	14	2.2	9.55	D
1977	1	14	1331 0.2	39.067	118.161	0.28	18	2.8	10.84	C
1977	1	17	224856.4	39.138	118.065	0.25	9	2.2	5.40	
1977	1	28	95251.6	39.087	118.601	0.47	13	2.1		
1977	1	28	115030.2	39.103	118.584	0.45	12	1.5		
1977	1	28	184305.7	39.108	118.585	0.44	13	1.8		
1977	1	29	11236.0	39.122	118.567	0.34	14	1.8	21.10	
1977	1	29	25401.6	39.109	118.583	0.15	8	1.4	13.60	
1977	2	8	194931.1	39.266	118.160	0.51	9	2.3	14.90	
1977	2	9	21224.8	39.401	118.443	0.06	9	0.7	11.00	

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1977	2	9	72409.7	39.149	118.080	0.24	13	3.5	16.40	
1977	2	9	83633.4	39.179	118.054	0.12	9	1.5	11.77	C
1977	2	18	101946.2	39.354	118.112	0.35	9		15.00	
1977	3	17	14215.1	39.213	118.091	0.14	8	1.6	11.83	C
1977	3	23	52427.2	39.128	118.158	0.12	8	1.6	6.39	D
1977	3	25	152444.8	39.592	118.047	0.35	19	2.2	11.70	
1977	3	26	214640.6	39.033	118.405	0.06	8	2.1	15.07	C
1977	4	4	12533.0	39.019	118.374	0.18	11	2.3	11.52	C
1977	4	11	93244.9	39.450	118.146	0.30	11	1.9	20.20	
1977	4	12	90011.1	39.749	118.375	0.29	12	3.0		
1977	4	15	10 717.2	39.171	118.108	0.19	10	1.7	13.69	C
1977	4	15	225559.4	39.202	118.143	0.13	10	1.7	10.35	C
1977	4	28	64448.1	40.192	118.297	0.43	12	2.9		
1977	5	8	1531 2.9	39.088	118.191	0.14	11	1.8	10.32	C
1977	5	10	6 524.7	39.095	118.073	0.18	15	2.2	7.95	C
1977	5	10	85336.7	38.893	117.943	1.29	9	1.2	5.50	D
1977	5	21	1 233.7	39.108	118.053	0.12	13	1.7	13.52	C
1977	5	28	50731.0	39.603	118.423	0.28	12	2.0		
1977	5	28	172717.7	39.280	118.021	0.46	11	2.0		
1977	6	25	170208.3	39.103	118.035	0.29	7	1.0		
1977	7	22	215331.3	39.144	118.109	0.20	11	2.5	3.26	D
1977	8	2	51456.6	38.859	118.288	0.12	11	1.4	14.47	B
1977	8	4	80622.2	39.332	118.453	0.18	6			
1977	8	4	112041.5	38.873	118.003	0.16	10	3.0	14.68	C
1977	8	7	212824.9	39.087	118.157	0.16	12	2.2	11.94	C
1977	8	10	111412.6	39.310	117.429	0.28	8	1.8	13.50	
1977	8	13	91052.6	39.066	118.105	0.09	7	0.9	11.46	C
1977	8	17	60806.3	40.284	117.421	0.29	5	2.1		
1977	8	18	43326.9	39.123	118.071	0.10	7	0.7	13.07	C
1977	9	27	84304.9	39.276	118.529	0.31	11	2.2	10.50	
1977	10	1	026 8.4	39.212	118.065	0.05	7	1.1	12.05	C
1977	10	7	81331.0	39.230	118.088	0.10	7	1.7	0.23	D
1977	10	10	84723.3	39.578	118.075	0.31	13	2.2		
1977	10	13	143435.8	39.470	118.505	0.36	12	1.7	15.80	
1977	10	15	154745.8	39.144	118.129	0.13	9	1.7	13.20	C
1977	10	17	205110.3	38.962	118.531	0.45	11	1.7	8.30	
1977	10	18	2212.9	39.392	118.093	0.22	15	2.7	9.50	
1977	10	24	235 0.8	38.860	117.981	0.07	5	1.9	13.94	C
1977	10	25	1010 4.6	38.854	118.004	0.13	8	1.2	10.49	C
1977	10	27	014 9.5	38.869	117.982	0.13	10	2.6	12.74	C
1977	10	27	132922.1	38.864	117.979	0.00	5	2.0	15.83	C
1977	10	28	18 616.6	38.866	117.986	0.15	10	1.9	13.77	C
1977	10	29	04035.8	38.867	117.984	0.19	14	2.5	13.71	C
1977	11	2	83021.4	38.866	117.984	0.17	9	0.9	13.79	C
1977	11	2	11 011.0	39.049	118.196	0.11	10	2.0	12.97	C

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1977	11	8	105235.4	39.111	118.116	0.00	4	1.4	8.68	C
1977	11	9	11 134.3	38.986	118.192	0.13	8	1.8	8.24	C
1977	11	13	104752.7	38.861	118.001	0.12	7	1.7	11.78	C
1977	11	27	85422.5	39.307	118.109	0.45	14	1.6	17.90	
1977	12	10	111652.5	38.859	117.993	0.09	7	1.7	13.73	C
1977	12	24	2152 8.6	39.031	118.128	0.58	12	2.2	11.40	D
1977	12	31	34311.7	38.899	117.984	0.12	9	3.1	12.41	C
1977	12	31	35258.0	38.885	117.989	0.21	12	2.4	10.62	C
1978	1	4	13430.5	39.604	118.076	0.35	7	1.7		
1978	1	8	113101.3	39.659	118.255	0.36	11	3.3		
1978	1	10	131336.1	38.909	117.988	0.07	7	2.2	13.30	C
1978	1	12	152127.0	38.911	118.002	0.31	14	2.3	5.43	D
1978	1	13	32910.8	39.382	117.577	0.29	9	2.2		
1978	1	13	33937.7	39.388	117.588	0.01	5	4.5	5.12	C
1978	1	13	34608.9	39.379	117.562	0.32	10	2.3		
1978	1	13	40431.7	39.375	117.571	0.14	8	2.1		
1978	1	13	42449.6	39.380	117.551	0.10	6	2.3		
1978	1	13	51858.1	39.378	117.576	0.17	9	2.3		
1978	1	13	53011.2	39.377	117.584	0.30	10	3.6		
1978	1	13	63322.9	39.367	117.577	0.33	6	2.1		
1978	1	13	72018.5	39.382	117.571	0.27	16	2.7	11.90	
1978	1	21	19 014.1	38.891	118.011	0.07	6	2.0	10.52	C
1978	1	24	224526.2	39.101	118.087	0.11	10	3.3	7.87	C
1978	1	28	163115.5	38.849	118.002	0.01	5	1.8	9.76	C
1978	1	28	181340.7	38.987	118.189	0.31	12	2.0		
1978	1	30	191436.9	38.875	117.994	0.22	10			
1978	2	15	92531.9	39.552	118.442	0.30	10	4.0	12.00	
1978	2	18	155848.8	39.672	118.280	0.28	14	2.8	12.40	
1978	2	18	215141.8	38.869	117.989	0.18	11	2.4	13.44	C
1978	3	5	224619.1	38.867	117.993	0.00	4	4.4	13.07	C
1978	3	5	225320.8	38.811	118.115	0.05	5	2.0	6.82	C
1978	3	5	23 123.0	38.830	118.064	0.05	4	2.6	8.87	C
1978	3	6	22929.4	38.804	118.128	0.04	5	2.2	5.24	C
1978	3	6	110605.6	39.380	117.556	0.26	7	2.0		
1978	3	8	223016.8	38.856	117.993	0.19	9	1.8	10.10	
1978	3	8	223616.5	38.856	117.993	0.11	9	1.9	12.55	C
1978	3	9	83548.7	38.867	117.974	0.28	13	2.5	14.91	C
1978	3	10	5 415.8	38.872	117.982	0.15	13	2.0	14.32	B
1978	3	11	84245.5	38.862	117.990	0.19	11	2.0	14.47	C
1978	3	12	224850.8	38.868	117.968	0.31	9	2.3	9.50	
1978	3	15	6 954.7	38.855	117.995	0.12	7	1.9	11.82	C
1978	3	19	12322.8	39.401	117.725	0.20	8	2.2		
1978	4	07	210430.5	39.111	118.061	0.21	18	2.2	11.00	
1978	4	24	14 621.5	38.863	117.969	0.03	5	1.5	16.48	C
1978	5	9	33937.5	39.728	118.510	0.37	12	2.0		

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1978	5	13	6 529.5	39.386	117.993	0.20	10	2.7	9.65	D
1978	5	14	60529.7	39.386	118.019	0.23	16	2.7		
1978	5	15	113440.1	39.649	118.054	0.30	9	2.3		
1978	5	23	19 452.4	38.869	117.989	0.04	7	2.1	10.55	C
1978	6	13	193517.1	39.744	118.062	0.40	10	2.3		
1978	6	29	144239.5	39.392	117.583	0.32	9	2.3		
1978	7	2	1411 2.4	38.857	117.977	0.03	6	0.9	14.81	B
1978	7	22	412 2.1	39.116	118.070	0.14	7	1.8	10.57	D
1978	8	5	23319.1	39.070	118.099	0.25	11	2.0	9.40	C
1978	8	6	102919.8	39.044	118.113	0.15	8	0.7	11.13	C
1978	8	10	544 4.0	39.238	118.064	0.11	8	1.4	3.43	C
1978	8	12	103028.2	39.412	117.705	0.21	11	1.8	18.30	
1978	8	12	115751.9	39.428	118.119	0.30	11	2.9	5.00	
1978	8	13	124945.2	39.376	118.087	0.09	8	2.0	5.64	D
1978	8	13	143932.1	39.159	118.067	0.16	9	2.1	12.16	C
1978	8	14	123515.1	39.201	118.148	0.01	5	1.0	2.57	C
1978	8	15	184852.1	39.168	118.066	0.22	9	1.9	9.78	D
1978	9	5	222850.5	39.041	118.169	0.12	10	3.4	5.43	C
1978	9	5	223152.0	39.032	118.149	0.56	10	2.3	11.06	D
1978	9	6	1 531.2	39.028	118.123	0.14	7	1.5	10.45	D
1978	9	8	153240.7	39.126	118.070	0.04	9	1.2	13.10	C
1978	9	8	153930.0	39.116	118.057	0.08	6	0.9	12.32	C
1978	9	12	225046.6	38.894	117.687	0.20	7	2.3	0.61	D
1978	9	26	22658.9	39.369	117.525	0.24	16	3.2	10.90	
1978	10	14	1 252.4	39.115	118.117	0.17	9	2.0	10.08	C
1978	10	24	1945 3.4	39.075	118.075	0.13	10	2.3	10.20	C
1978	11	7	235410.3	38.881	117.862	0.21	9	2.5	0.46	D
1978	12	1	19 652.0	38.909	117.798	0.11	6	2.0	0.42	D
1978	12	15	19 1 9.2	38.882	117.859	0.27	9	2.4	1.38	D
1979	1	3	154638.0	38.900	117.549	0.24	12	2.8	15.17	C
1979	1	10	185712.7	39.363	118.086	0.21	12	2.8	8.67	C
1979	1	23	0 039.3	39.651	118.464	0.47	14	3.0	10.54	D
1979	2	15	93547.3	39.030	118.172	0.13	7	2.3	5.48	C
1979	3	6	131117.5	38.864	117.997	0.14	9	2.7	10.49	C
1979	3	15	16 041.0	39.073	118.139	0.25	9	2.5	8.72	D
1979	3	18	64523.3	39.109	118.094	0.13	7		8.94	D
1979	3	18	65913.5	39.116	118.086	0.12	8		7.74	C
1979	3	20	234842.4	38.879	117.871	0.14	7	2.0	0.58	D
1979	3	25	124243.6	39.196	118.051	0.13	7	1.7	7.52	D
1979	4	7	43449.5	39.062	118.093	0.11	9	2.3	10.29	C
1979	5	01	114602.8	39.304	118.139	0.34	10	2.8		
1979	5	01	140026.2	39.314	118.144	0.32	6	2.2		
1979	5	17	141234.1	39.079	118.090	0.16	6	1.6	6.23	D
1979	5	22	05220.0	39.023	118.220	0.09	10	2.9	9.98	B
1979	5	25	17 9 2.1	39.000	118.210	0.14	14	2.1	7.83	B

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1979	6	11	93254.3	39.103	118.093	0.18	9	1.6	12.07	C
1979	6	30	105852.2	39.328	118.058	0.21	12	2.8	10.29	C
1979	7	21	43149.9	39.603	118.095	0.18	9	2.5	13.66	C
1979	7	21	45431.3	39.597	118.080	0.28	8	1.6	15.03	D
1979	7	26	45717.9	39.595	118.113	0.26	7	2.2	11.47	D
1979	7	26	51527.1	39.589	118.111	0.29	7	2.9	12.36	D
1979	7	26	85822.8	39.593	118.098	0.28	7	2.6	12.30	D
1979	7	26	92326.1	39.601	118.070	0.28	9	3.1	3.38	D
1979	7	26	103857.9	39.592	118.074	0.01	6	4.2	8.52	C
1979	7	26	104811.2	39.618	118.168	0.43	8	2.6	11.88	D
1979	7	26	1052 5.6	39.601	118.114	0.15	8	3.2	8.67	C
1979	8	1	811 5.7	39.086	118.196	0.01	6	2.1	11.31	C
1979	8	02	035847.6	40.193	117.777	0.36	8	1.9		
1979	8	24	41027.5	38.890	118.003	0.15	7	2.4	10.98	C
1979	9	16	52053.9	40.310	117.626	1.75	10	2.2		
1979	9	29	53751.0	39.354	118.112	0.09	9	2.7	2.90	C
1979	10	10	53729.4	39.086	118.084	0.09	6	1.6	9.36	C
1979	10	10	162311.0	39.101	118.111	0.08	7	2.4	4.45	C
1979	10	23	142025.8	39.120	118.605	0.08	10	1.8	15.10	C
1979	10	26	93557.3	39.111	118.591	0.15	12	2.2	18.15	B
1979	11	1	17 727.3	39.013	118.241	0.00	4	1.5	9.58	C
1979	11	3	15 4 2.4	39.634	118.392	0.14	8	2.8	13.09	D
1979	11	6	52543.2	39.084	118.334	0.14	11	3.0	15.27	C
1979	11	8	94332.0	39.930	117.799	0.63	6	2.3		
1980	1	18	213241.4	40.133	117.898	0.02	5	0.6	7.44	C
1980	1	22	143927.6	39.316	117.781	0.08	8	1.0	20.25	C
1980	1	24	85747.6	39.011	118.078	0.07	7	0.9	11.89	C
1980	1	25	53343.6	39.694	118.483	0.12	6	1.0	0.52	D
1980	1	25	111459.2	39.131	118.113	0.04	7	2.7	16.61	C
1980	1	26	05239.3	39.571	118.179	0.07	7	0.2	12.99	C
1980	1	26	05259.5	39.576	118.189	0.04	6	0.3	12.69	C
1980	1	27	55913.8	39.570	118.064	0.04	8	1.2	13.40	C
1980	1	29	55532.5	39.306	118.079	0.10	6	1.0	18.53	C
1980	1	29	231340.0	39.092	118.182	0.00	4	1.4	13.16	C
1980	2	4	4 023.7	39.344	118.091	0.03	7	1.6	11.40	C
1980	2	4	2027 2.3	39.061	118.060	0.07	8	1.0	14.83	C
1980	2	5	14117.3	39.151	118.036	0.06	6	0.4	19.19	C
1980	2	5	45150.2	39.131	118.119	0.07	9	2.5	18.10	C
1980	2	5	1942 7.9	39.157	118.078	0.10	7	1.3	19.62	C
1980	2	9	91529.3	39.251	118.132	0.02	5	0.9	17.97	C
1980	2	10	45633.3	39.624	118.044	0.08	10	1.4	11.77	B
1980	2	10	20 146.1	39.310	117.321	0.12	7	1.5	8.64	D
1980	2	11	115253.0	39.676	118.011	0.00	4	0.1	15.83	C
1980	2	12	215820.7	39.709	118.023	0.14	12	2.8	9.19	B
1980	2	12	22 834.4	39.707	118.031	0.09	6	0.5	11.43	B

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1980	2	14	102549.3	39.732	118.067	0.05	6	0.9	10.60	B
1980	2	15	9 1 8.2	39.141	118.197	0.10	8	1.9	5.99	D
1980	2	16	131239.0	39.542	118.202	0.02	6	0.7	5.46	C
1980	2	17	111557.7	40.124	117.897	0.06	8	1.0	8.29	C
1980	2	27	6 852.4	39.566	118.101	0.06	5	0.4	12.98	D
1980	2	27	62636.5	39.319	118.104	0.04	6	1.0	20.21	C
1980	2	27	195225.5	39.044	118.109	0.01	5	1.4	10.66	C
1980	2	27	211941.4	39.590	118.111	0.06	6	0.4	12.79	C
1980	2	28	123035.9	39.723	118.077	0.08	6	0.3	9.47	C
1980	3	1	1612 4.7	39.513	118.055	0.00	4	0.7	10.15	C
1980	3	5	83621.8	39.051	118.103	0.03	7		14.16	C
1980	3	13	22 358.1	39.706	118.024	0.04	7	1.3	10.27	B
1980	3	15	31617.5	39.704	118.069	0.09	7	0.8	11.54	B
1980	3	15	548 5.8	39.716	118.080	0.06	7	0.6	13.09	B
1980	3	17	84231.7	39.309	118.107	0.01	6		15.48	C
1980	3	26	1154 1.7	39.380	118.134	0.10	7	1.0	16.76	C
1980	3	26	175057.4	40.296	118.324	0.10	6	0.8	6.39	D
1980	3	29	1955 3.6	39.228	118.121	0.09	7	1.0	22.65	C
1980	3	30	11710.9	39.348	118.076	0.13	7	1.4	15.15	C
1980	3	31	12316.1	40.166	118.494	0.18	6		0.98	D
1980	4	8	1345 5.9	39.736	118.001	0.08	8	0.7	7.62	B
1980	4	15	54452.6	39.729	118.072	0.03	6	0.8	9.08	B
1980	4	15	152454.0	39.732	117.979	0.10	6	0.6	10.27	B
1980	4	17	213336.0	39.940	117.749	0.20	6	0.3	0.08	C
1980	4	19	155547.9	40.262	117.768	0.11	6	0.8	7.62	D
1980	4	29	13641.3	39.961	117.873	0.13	7	0.2	0.17	C
1980	5	5	214624.3	40.146	118.318	0.22	6	0.7	3.02	D
1980	5	6	224840.4	39.197	118.122	0.13	7	1.2	0.96	D
1980	5	12	192713.4	39.311	118.142	0.14	8	1.0	11.48	C
1980	5	15	524 3.2	39.571	118.214	0.03	7	1.0	9.68	C
1980	5	19	132710.1	39.857	118.121	0.11	7	0.3	8.40	C
1980	5	19	18 6 0.3	39.150	118.071	0.21	12	3.2	8.42	C
1980	6	22	223645.5	39.716	118.076	0.08	8	0.4	7.94	B
1980	6	23	19 456.0	39.557	117.390	0.08	10	2.4	4.28	D
1980	6	25	32846.2	39.141	118.059	0.04	6	1.4	0.03	C
1980	6	30	104732.1	39.592	118.096	0.05	7	0.9	13.48	C
1980	7	1	202752.0	39.617	118.115	0.22	9	1.5	10.34	B
1980	7	2	92355.5	39.753	117.852	0.06	6	0.2	5.23	C
1980	7	4	4 1 1.7	39.751	117.851	0.10	7	0.3	5.50	C
1980	7	5	5 8 1.8	39.908	117.854	0.22	7	0.1	4.98	C
1980	7	11	05856.5	39.405	118.534	0.08	8	1.5	0.73	D
1980	7	13	04539.3	39.931	117.774	0.04	7	0.3	7.20	B
1980	7	13	22 350.9	39.713	117.837	0.12	5	0.2	8.86	D
1980	7	25	124038.0	39.892	117.676	0.02	6	0.6	10.52	C
1980	7	28	132229.5	39.187	118.086	0.13	8	3.1		

YEAR	MO	DAY	HRMINSEC	LAT	LON	RMS	NSTA	MAG	DEPTH	Q
1980	8	2	214427.1	39.033	118.059	0.14	7	1.6	9.73	C
1980	8	13	94111.5	39.462	118.496	0.08	8	1.8	12.23	C
1980	8	21	23 258.5	39.686	118.326	0.19	7	2.4	0.77	D
1980	9	1	145430.6	39.287	118.096	0.04	6	2.4	7.76	C
1980	9	3	152619.7	39.037	118.202	0.10	6	2.1	12.86	C
1980	9	6	15 932.3	39.706	118.021	0.05	7	0.3	8.59	B
1980	9	11	21618.1	39.702	118.021	0.05	9	0.6	14.43	B
1980	9	18	64032.3	40.413	117.754	0.14	9	1.5	2.91	D
1980	9	26	6 750.2	39.471	118.133	0.06	9	3.2	11.84	B
1980	9	26	203827.0	39.668	118.094	0.04	7	1.2	10.29	B
1980	9	27	1155 8.9	39.677	118.093	0.07	8	1.2	6.53	B
1980	9	27	212145.4	39.672	118.097	0.06	7	1.5	10.15	B
1980	9	27	2123 8.4	39.670	118.101	0.05	6	0.3	12.36	B
1980	9	27	214110.5	39.672	118.097	0.04	8	1.1	10.24	B
1980	9	27	214611.5	39.675	118.096	0.04	7	1.5	8.84	B
1980	10	04	032042.4	39.038	118.123	0.14	7	1.9	12.00	
1980	10	8	102523.7	39.640	117.532	0.19	5	0.7	0.65	D
1980	10	8	1210 5.6	39.720	118.078	0.06	6	0.3	8.54	B
1980	10	16	170200.0	39.071	118.162	0.16	10	1.9	11.00	
1980	10	24	64054.8	40.194	117.766	0.22	8	1.5	2.01	D
1980	10	30	165537.9	39.032	118.184	0.27	6	1.6	12.00	
1980	11	04	004303.9	39.210	118.106	0.18	7	1.0	12.00	
1980	11	7	42333.5	39.766	118.167	0.02	5	1.5	10.69	C
1980	11	11	2 536.0	39.769	118.178	0.14	5	1.3	9.66	D
1980	11	18	185006.7	39.229	118.125	0.18	9	2.7		
1980	11	27	7 411.8	39.705	118.506	0.12	7	1.4	2.16	D
1981	1	4	73658.1	39.729	118.067	0.05	6	0.9	8.82	B
1981	1	24	211629.0	39.355	118.130	0.06	8	1.4	15.04	B
1981	2	1	1748 4.4	40.257	117.704	0.17	10	1.1	0.65	D
1981	2	3	61753.4	39.685	118.046	0.05	9	1.4	11.23	B
1981	3	18	75626.6	39.511	117.494	0.13	7	1.1	17.18	D
1981	4	16	72125.6	39.592	118.092	0.09	9	2.8	11.46	B
1981	4	17	131555.3	39.588	118.093	0.08	8	1.5	10.38	B
1981	4	25	4 950.9	39.989	117.690	0.02	7	1.6	6.90	B
1981	8	1	21140.1	39.684	118.067	0.10	6	1.0	3.54	C
1981	8	22	184214.4	39.729	118.073	0.08	6	0.8	7.54	B
1981	8	31	221644.6	39.563	118.094	0.03	5	0.8	14.32	C
1981	9	16	165042.3	38.859	118.132	0.08	6	1.9	1.46	C
1981	9	17	43925.1	39.518	118.166	0.06	5	0.6	0.44	D
1981	10	13	13910.5	39.417	118.115	0.04	7	1.5	15.09	B
1981	10	16	141731.0	39.418	117.743	0.06	9	2.0	15.92	C
1981	10	22	33154.1	39.312	118.128	0.07	8	1.8	9.99	C
1981	10	27	22 552.0	39.496	118.075	0.02	6	1.3	7.80	C
1981	10	28	14 025.0	39.419	117.748	0.06	9	1.8	16.15	C
1981	10	30	173858.9	39.709	118.050	0.08	7	1.5	7.57	B

APPENDIX C. NOTES ON MAGNITUDE, RECURRENCE CURVES AND FOCAL MECHANISMS

In this section, terms that may be unclear to non-seismologists are explained in some detail. These terms include magnitude, recurrence curves and focal mechanisms.

Magnitude. For the period prior to 1969, magnitudes were taken from Slemmons et al (1965). As indicated by the authors, those magnitudes were taken from a number of sources, including the University of California Bulletin of the Seismographic Stations, earthquake lists from the California Institute of Technology, and amplitudes measured on recordings of the Wiechert seismograph at Reno, Nevada. For earthquakes prior to 1916, magnitudes were estimated from the extent of the felt area or from the maximum intensity at the epicenter. For the period 1970-1975, magnitudes were determined primarily from amplitudes measured on a Wood-Anderson seismograph at Reno, although University of California or US Coast and Geodetic Survey magnitudes were used for larger events. For 1976-1981 most of the magnitudes were determined from measurements of amplitude or coda duration on recordings of the Nevada seismic network.

In this report, the symbol M is used primarily in discussing earthquakes for the period prior to 1970, and ML is used to designate "local magnitude" for the period when magnitude could be determined from instruments in the Nevada region. In general, however, M or ML are both referenced to Richter's (1958) local magnitude scale up to magnitudes of about 6-6.5; for larger events magnitude M usually refers to teleseismic surface-wave magnitude, determined from the amplitude of surface waves with period of about 20 seconds.

Recurrence Curves. The formula most widely used for representing the frequency of occurrence of earthquakes as a function of magnitude is the following (Richter, 1958):

$$\log N = a - bM,$$

where N = the number of events with magnitude equal to or greater than M, and a and b are constants. This equation has been applied to hundreds of earthquake sequences throughout the world, with magnitudes ranging from less than zero to more than 8. The constant b, or "b-value", represents the slope of the recurrence curve, and has been found to vary from about 0.5 to 1.5, with an average value of about 0.9. The b-value is related to the proportion of small earthquakes to large earthquakes, and appears to be relatively constant for a given earthquake sequence over a wide range of magnitude.

Relatively high b-values have been found to accompany swarmlike sequences of microfracturing in laboratory experiments on rock samples (Mogi, 1966; Scholz, 1968). Mogi showed that b increases with the degree of heterogeneity of the rock both in composition and in crack density, while Scholz concluded that b depended strongly on the state of stress in the specimen and only to a lesser extent on its physical properties. Scholz showed that b is inversely proportional to the effective stress, and that high b-values are observed for low-to-moderate stress. In a later study, Wyss (1973) concluded that b is directly proportional to the local pore pressure; the Denver earthquakes that were triggered by injection of waste fluids showed a strong correlation between b-value and pressure in the disposal well (Healy et al., 1968). High b-values have also been associated with aftershock sequences and low b-values with foreshock sequences (ie, Ryall and Ryall, 1981).

Values of b previously determined for this region include 0.79 for the Ventura-Winnemucca zone (Ryall et al, 1966), 0.81 for an earthquake sequence near Reno (Ryall et al, 1968), 0.79 for the 1968 Adel, Oregon swarm (Ryall and Savage, 1969), 0.83 for the 1965-1966 Caliente, Nevada sequence (Ryall and Savage, 1969), and 0.81 for the northern Nevada region (Ryall and Douglas, 1974). Richins' (1974) value of 1.00 for the 1973 Denio, Nevada swarm was higher than average values for the region as a whole, and was interpreted in terms of structural heterogeniety and high pore pressure.

Focal Mechanisms. The direction of fault movement in an earthquake can be inferred from various types of analysis of the seismic waves recorded by stations around the epicenter, at local, regional and teleseismic distances. The method used in this report is the "fault-plane" method of Byerly, which stems from the observation that the sense of first motion of P-waves (compression or dilatation) can be divided into a quadrant pattern, where the quadrants, say on an imaginary sphere around the focus of the earthquake ("focal sphere"), are separated by two nodal planes. One of these is the fault plane, and the other is a plane perpendicular to the fault plane, called the "auxiliary plane" (Figure C1). The fault-plane method has an essential ambiguity in that it cannot distinguish between the fault and auxiliary planes, but this distinction can often be obtained from known geologic or structural parameters. In general, the fault plane may have any orientation, so observations made on the earth's surface must be projected onto the focal sphere by accounting for reflection and refraction of the waves as well as geometrical spreading, and then the three-dimensional pattern must be resolved using a stereographic projection, such as the equal-area projection used in this report.

An example is shown on Figure C2. The two lines represent the intersection, on a lower-hemisphere projection (ie, an imaginary hemisphere below the focus of the earthquake), of planes passing through the center of the sphere (the focus). The two planes are orthogonal, and separate quadrants in which incident P-waves appear as either compressions or dilatations. One plane has an almost E-W strike and dips steeply to the north; the other strikes NE-SW and dips SE. The sense of motion is either left-oblique on the E-W plane (ie, northern block moving W and down), or right-oblique on the NE plane (southeast block moving to the SW and down). The fault-plane solutions on Figure 29 of this report have the compression quadrants shaded, instead of showing individual observations by dots or circles,as on Figure C2. On Figure 29, solution E would be intrepreted as pure normal faulting, either with the northwest block moving down on a NE-SW striking, NW-dipping fault, or with the southeast block moving down on NE-SW striking, SE-dipping fault. Solutions J and I would be almost pure strike-slip motion, either right-lateral on a NE-SW striking vertical plane, or left-lateral on a NW-SE striking plane, dipping steeply to the NE for solution I and to the SW for J.

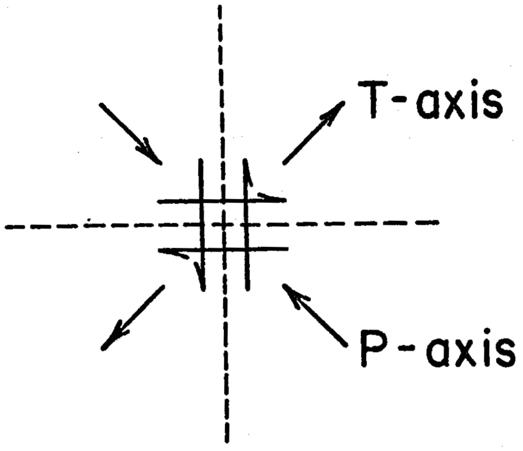

Figure C1. Pair of force-couples at right angles, equivalent to maximum and minimum compressive stress (respectively called the P- and T-axes) at right angles to each other and oblique to the force couples. The dashed lines are the fault and auxiliary planes, which are indistinguishable on the basis of P-wave first motions. For this model, compressions would be observed in quadrants with outward-pointing arrows and dilatations in quadrants with inward-pointing arrows.

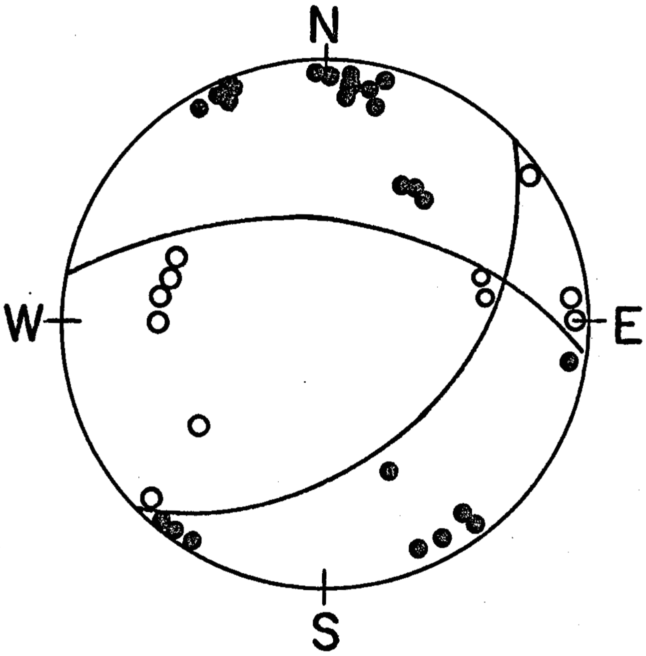

Figure C2. Example of a fault-plane solution, using an equal-area stereographic projection. Dots -- compressions; circles -- dilatations. Lines represent the intersection of the fault and auxiliary planes with the surface of a hemisphere below the earthquake focus.

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