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REPORT ON MICROEARTHQUAKE MONITORING IN THE VICINITY OF AUBURN DAM, CALIFORNIA

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by

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

I. Introduction

This report continues the documentation of seismic activity detected by the Auburn Dam seismic network begun by earlier reports of this series (November 1976-March 1977* and April 1977-June 1977*). It provides data on additional earthquakes that were recorded from 1 July 1977 through 30 June 1978, and it summarizes the results for all earthquakes in the Auburn region recorded by the network from 1 November 1976 through 30 June 1978.

The only significant change in stations of the network was the replacement of station ASR, which was at a noisy site 20 km south of Folsom, by station ALA, which is at a quieter site 20 km SE of Folsom near Latrobe. Station information is given in Table 1.

The Helicorder monitor used to identify events in the Auburn region remained at station ARW throughout this report period. In December 1977 the assignments of stations to the Develocorders were revised to establish several "scanning" networks to facilitate detection of seismic events throughout the central California networks. Stations AAR, AVR, AFR, AGI, ALA, and ADW were included in the Sierra scanning network. These stations, as well as ARW on the Helicorder monitor, are now scanned daily in the search for seismic events in the Auburn region.

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*Periodic reports to the U.S. Bureau of Reclamation.

II. The Network

The development and instrumentation of the Sierra Foothills network including its principal component, the Auburn Dam network, were described in the first report of this series. Table 1 lists the new and old names, geographic coordinates, elevations, installation dates, and current operating attenuation settings (sensitivities) of the stations. The stations are also plotted on Figure 2.

The overall response of the USGS telemetered seismic systems employed in the network is depicted in Figure 1. These curves are stylized: they represent the asymptotes approached by the actual curves at frequencies that are not too near the sharp bends (filter corner frequencies) in the curves. Station attenuation settings (in db) are shown as parameters on the curves. Responses of the Develocorder and Oscillomink differ at high frequencies (i.e., > 10 hz) because of differences in the natural frequencies of the recording galvanometers and in the slope of the high-frequency roll-off of the discriminators employed with them (10 hz and 24 db/octave for the Develocorder and > 100 hz and 30 db/octave for the Oscillomink).

III. Methods of Analysis

A. Selection of events for study.

This report is concerned primarily with seismic events in the Auburn region that were recorded by the Auburn Dam network from 1 November 1976 through June 1978. Events were selected for analysis on the basis of a careful examination of monitor records from quiet stations near the dam site:

1. station APR (Helicorder monitor) 13 km W of the dam site: 1 Nov 1976 to 10 May 1977;
2. station ARW (Helicorder monitor) 12 km NW of the dam site: 10 May 1977 to 7 Dec 1977;
3. station ARW (Helicorder monitor) and stations AAR, AVR, AFR, AGI, ALA, and ADW (Develocorder: Sierra scanning network) after 7 Dec 1977.

The most common seismic events visible on the monitor records are: 1) explosions from sources in the Auburn and Melones regions of the Sierra Nevada foothills; 2) earthquakes from the central Coast Ranges; and 3) earthquakes from scattered sources in the northern and eastern Sierra Nevada.

Repeated explosions from the larger quarries produce monotonously similar records. A representative selection of these events has been analyzed to verify that they were quarry blasts and to develop simple methods for identifying future blasts at the same sites.

Excluding obvious quarry blasts and known earthquakes with sources outside the Auburn region, all small seismic events with S-P intervals smaller than 5 seconds (at APR or ARW) and all sharp seismic events of larger size were examined on the Develocorder films and/or Oscillomink playbacks. P arrival times and first-motion directions and S arrival times (if readable) were determined for all stations of the Sierra Foothills network that recorded the event. Maximum amplitudes and associated periods were measured when possible (usually on Oscillomink playbacks), and event duration times were measured at several stations if reliable amplitude measurements could not be obtained. On subsequent analysis, this last set of events was found to consist of small-to-moderate explosions scattered through the Auburn region and groups of small natural earthquakes. Most of these earthquakes have emanated from a small region 12 to 15 km beneath the town of Rocklin. Other small clusters have originated just north of station APR and a few km west of station AAR near Grass Valley. A few additional small quakes are scattered widely through the Auburn Dam network.

B. Hypocentral determinations and crustal velocity model

Hypocenters were determined by the computer program HYPO71 (Lee et al., 1975) which is used for uniform analysis of central California seismic data. The "Auburn" crustal velocity model for P waves, Table 2, was used for these locations. For the solutions presented in this report, S-wave data were utilized when available and a Vp/Vs ratio of 1.73 was used to calculate S-wave traveltimes from the corresponding P-wave traveltimes.

Small corrections to account for near-surface velocity variations not included in the crustal model were added to the calculated arrival times at some stations to improve the relative locations of the hypocenters. These corrections were derived from average traveltime residuals at the individual stations of P waves from the better-recorded quakes from the Auburn region. Station traveltime corrections ("delays") are listed in Table 1. These corrections were applied uniformly to all of the earthquakes and blasts located for this report.

C. Magnitude determinations

HYPO71 provides two methods for computing magnitudes of earthquakes recorded by the telemetered seismic network. The first method, which utilizes the maximum recorded amplitude and associated wave period, is based on an adaptation of the original definition of magnitude and the empirical relationship between recording distance and the maximum amplitude recorded by a Wood-Anderson seismograph. The second method is based on the duration of earthquake recordings at stations of the USGS seismic network in the epicentral region. Duration magnitudes were calibrated against magnitudes determined from Wood-Anderson records or, for smaller earthquakes recorded at close range, from records of the USGS portable 10-day tape-recorder systems by use of the amplitude method (Lee, et al., 1972).

Both methods were used to compute magnitudes in this report. The amplitude method was preferred, especially when high-quality Oscillomink records were available. The duration method was applied when only Develocorder records were available. On this type of record, maximum amplitudes and associated wave periods are difficult or impossible to read. In some cases both methods were applied, and agreement between them was good. In such cases the magnitude reported was the average of those determined by the two methods.

IV. Earthquakes and Selected Blasts in the Auburn Region: Nov 1976 to June 1978.

The principal results on earthquakes and blasts in the Auburn region that were selected for study and analyzed by the methods outlined above are summarized in Table 3 (blasts) and Table 4 (earthquakes).

A. Blasts

The blasts listed in Table 3 are representative of a larger number of blasts, mostly from the same sources, that were recorded by the network. They were tentatively identified as blasts on the basis of 1) time of occurrence (during working hours--about 8 a.m. to 4 p.m.), 2) presence of prominent, slow surface waves, and 3) compressional first motions at all stations with clear P wave arrivals. For most of the "blasts" analyzed in detail, this diagnosis was confirmed by the clustering of these events at shallow depths at or near known blasting sites, such as the Auburn Dam construction site and several active quarries. The other events identified as blasts were scattered through the network, occurred at shallow depths (calculated focal depths of a few km at most), and satisfied the three criteria listed above. Blasts in the Auburn region are plotted in Figure 3 (Nov 76-June 77), Figure 4 (July 77-June 78), and Figure 5 (Nov 76-June 78).

The principal sources of blasts are the Auburn Dam construction site and a quarry near Clarksville. Other quarries detected by the clustering of blast sources include one about 7 km northeast of station AHR (4½ km ENE of the dam site) and another about 5 km east-southeast of station

AHD. Small, isolated blasts are scattered widely through the network; and a large isolated blast (M 1.8) was located just east of Lincoln on 6 June 1978.

B. Earthquakes

The earthquakes listed in Table 4 occurred within or near the Auburn Dam seismic network between 1 Nov 1976 and 30 June 1978. Earthquakes farther northwest, in the aftershock zone of the 1975 Oroville earth- quake, and other Sierra Nevada earthquakes outside the Auburn Dam seismic network toward the north, northeast, and east are not included in this report. Such earthquakes are being studied and will be reported separately.

To facilitate examination and discussion of the earthquakes in Table 4, they were plotted for several time intervals (Nov 76-June 77, July 77-June 78, and Nov 76-June 78) at several map scales:

a) 1/500,000 - entire Sierra Foothills seismic net

b) 1/250,000 - entire Auburn Dam seismic net

c) 1/125,000 - central part of Auburn Dam seismic net

d) 1/62,500 - Rocklin portion of the Auburn Dam seismic net

e) 1/24,000 - Grass Valley earthquake cluster

The scales and time intervals of the earthquake plots in this report are:

Figure 2	Nov 76-June 78	1/500,000
Figure 6	Nov 76-June 77	1/250,000
Figure 7	July 77-June 78	1/250,000
Figure 8	Nov 76-June 78	1/250,000

Figure 9	Nov 76-June 78	1/125,000
Figure 10	Nov 76-June 77	1/62,500
Figure 11	July 77-June 78	1/62,500
Figure 12	Nov 76-June 78	1/62,500
Figure 19	Nov 76-June 78	1/24,000

On all plots, the focal depth of an event is indicated by the plotted symbol, and its magnitude is indicated by the size of the symbol.

A major objective of the study of Sierra Nevada earthquakes is to determine the nature of the tectonic forces that are currently deforming the region. Focal mechanism solutions based on the direction of initial motion of P-waves provide the most direct evidence available on the orientation of and relative motion on the faults that generate the recorded earthquakes.

The earthquakes reported here are all quite small, but several were sufficiently well recorded to sustain single event focal mechanism solutions. Composite solutions can be obtained for clusters of smaller events and for selected groups of events scattered through portions of the network where station coverage is poor.

The earthquakes in Table 4 are plotted at a scale of 1/500,000 in Figure 2 to show the pattern of their epicenters. Most of them occur in clusters of events near Rocklin (49 events), Grass Valley (9 events), and station APR (2 events). Four of the remaining 5 events are scattered around the perimeter of the Auburn net and the fifth is at the southeast edge of the Melones net. The earthquakes in the spatial clusters also tend to cluster strongly in time.

Figures 6 and 7 show earthquakes in the Auburn network for the two epochs Nov 76-June 77 and July 77-June 78. The cluster of earthquakes near Rocklin dominates both epochs, but it appears to be somewhat more restricted in area during the second epoch. The frequency of earthquakes outside the Rocklin cluster was greater during the second epoch than during the first. The pair of events near station APR corroborates the source of earthquakes in that region reported earlier by Woodward-Clyde and by CDMG. The cluster of earthquakes west of station AAR (northwest of Grass Valley) marks the most prolific source of earthquakes in the Auburn net outside of the Rocklin cluster. The two isolated deep events southwest of the Auburn Dam network (V and S on Figure 2) show that seismic activity in the region is not restricted to the foothills belt but extends out beneath the eastern part of the Central Valley. Earthquakes in the Auburn Dam network during the entire interval Nov 76 to June 78 are plotted in Figure 8.

In Figure 9, the earthquakes in the central part of the Auburn Dam network from Nov 76-June 78 are plotted at a scale of 1/125,000 for comparison with the plot of blasts in the same region (Figure 5).

1. <u>Rocklin earthquakes</u>

To examine the earthquakes in the Rocklin cluster in greater detail, earthquakes in the Rocklin area were plotted at a scale of 1/62,500 for the three epochs: Nov 76-June 77 (Figure 10), July 77-June 78 (Figure 11), and Nov 76-June 78 (Figure 12).

As was noted in the last report, the Rocklin epicenters for the epoch Nov 76-June 77 define an elongated zone about 1 km wide and 4 km long with its center about 5 km west of station ARR and with a trend of about N 20° W (Figure 10). Rocklin epicenters for the epoch July 77-June 78 (Figure 11) define an elongated zone with a trend of about N 20° W that coincides with the southeastern three-fifths of the zone defined by the earlier epoch. Rocklin epicenters for the entire period Nov 76-June 78 are plotted in Figure 12.

For a more detailed examination of the spatial distribution of the foci of the Rocklin earthquakes, vertical cross-sections parallel and transverse to the trend of the epicentral zone were constructed (Figure 13). The "longitudinal" reference line through the epicenters runs from an origin point, "O" (38°44.00'N, 121°12.80'W), to a finish point, "F" (38°49.00'N, 121°15.38'W). The line trends N 20°W. Magnitude of an event is indicated by the height of the plotted symbol; and the occurrence time interval of the event is given by the symbol:
1 Nov 76-28 Feb 77 = A, 1 Mar 77-31 May 77 = B, 1 June 77-30 Sept 77 = C, 1 Oct 77-14 Nov 77 = D, 15 Nov 77-14 Dec 77 = E, 15 Dec 77-30 June 78 = F. The directions of viewing are from SE looking to the NW in the transverse section and from NE looking to the SW in the longitudinal section.

Seen "end-on", in the transverse section, the Rocklin focal zone appears as a narrow vertical zone. Seen "broadside", in the longitudinal section, the focal zone appears as a crescent-shaped segment about 2 km in vertical extent that sweeps upward from a depth of about 14 km at its northwestern end to about 11 km at its southeastern end. Events that occurred before June 1977 (plotted as A's and B's) are distributed from the middle of the focal zone to its deeper, northwestern end. Events from June 1977 to date are distributed from the middle of the focal zone to its shallower, southeastern end. There is a strong concentration of foci at the center of the focal zone.

A single-event first-motion plot for the most clearly recorded Rocklin quake and a composite first-motion plot for the 8 Rocklin quakes larger than magnitude 1 are shown in Figures 14 and 15, respectively. The two solutions are nearly identical; so we shall discuss only the single-event solution for the magnitude 1.3 quake at 19:42:28Z on 1 Nov 1977. The first plane is rather well determined: it has a strike azimuth of 350° and dips 30°W. The dip of the second plane is well determined (60°E to 63°E) but its strike azimuth (323°) is not well constrained. We have chosen plane 2 as the one with a strike azimuth of 323° and a dip of 63°E for reasons that will be given below. This solution is similar to those reported for quakes in the Rocklin cluster in previous reports of this series.

Detailed comparison of this solution (19:42:28Z on 1 Nov 1977) with that reported for the quake at 15:28:36Z on 15 May 1977 in the report for April-June 1977 reveals some significant differences. Plane 1 for the earlier event has a shallower dip and a more westerly strike, and plane 2 for the earlier event has a strike azimuth that is constrained to lie in the range 314° to 343°. The 15 May quake was also nearly 2 km deeper and 1.5 km farther northwest than the 1 November quake.

This comparison also illustrates the dependence of fault plane solutions on critical stations. Station ASR was removed from its old location and reestablished (as station ALA) between the times of occurrence of the 15 May and the 1 November quakes. As station ASR it set an upper limit on the strike azimuth of plane 2 (<340°) for the 15 May quake; and as station ALA it set a lower limit on the strike azimuth (>323°) of plane 1 for the 1 November quake.

If we assume, reasonably, that the Rocklin earthquakes are distributed over some subplanar fault surface, we can call on the spatial distribution of their foci to help us decide which of the first-motion solution planes corresponds to the fault plane and which to the auxiliary plane. The transverse cross section in Figure 13 (earthquakes projected onto a vertical plane perpendicular to the long axis of the Rocklin earthquake epicentral zone) indicates that the fault plane dips very steeply--nearly vertically, in fact. This result suggests that plane 2 is the fault plane; but the dip of the hypocentral zone is steeper than the dip of plane 2.

The longitudinal cross section in Figure 13 (earthquakes projected onto a vertical plane parallel to the long axis of the Rocklin epicenter zone) shows that the hypocentral zone is of limited vertical extent (about 2 km) and that it descends steadily from about 11 km at its southern end to about 14 km at its northern end. Because of this peculiar depth distribution of hypocenters, the tacit assumption that the strike of the fault plane corresponds to the strike of the epicentral zone is untrue. If in fact the fault plane dips eastward (as required by the first-motion plots), the steady deepening of the focal zone toward the north will lead to the result that the strike of the epicentral zone will be less westerly than that of the fault plane.

To pursue this line of thought, the cross sections of the Rocklin hypocentral zone were replotted, in Figure 16, onto vertical planes perpendicular and parallel to a section line with an azimuth of 315°. This azimuth corresponds approximately to the most westerly strike of the fault plane (plane 2) allowed by the first-motion plot of the 15 May 1977 earthquake. On the transverse section for this projection the hypocenters lie in a compact elongated zone with an apparent dip of about 70 toward the northeast. The northwestward plunge of the hypocentral zone on the longitudinal section is somewhat steeper for this projection than for the one in Figure 13.

From the foregoing evidence we conclude:

1) For the Rocklin quake at 19:42:28 on 1 Nov 1977, the fault plane solution is as follows:

Auxiliary plane	:	strike azimuth 350°,	dip 30°W
Fault plane	:	strike azimuth 323°,	dip 63°E
Pressure axis	:	azimuth 205°,	dip 69°SW
Tension axis	:	azimuth 62°,	dip 16°NE
Slip direction	:	azimuth 80°,	dip 59°E
Slip sense	:	Normal, eastside down, minor right lateral component.	

2) The strike of the Rocklin fault is somewhat more westerly (N35°W to N45°W) than the strike of the epicentral zone. This result stems from a systematic increase in focal depth from southeast to northwest along the fault combined with a dip of the fault plane of about 70° toward the northeast.

3) The principal component of movement on the Rocklin fault is normal, with the east side down; there is also a minor component of right-lateral movement.

2. Earthquakes near station APR

Two small quakes near APR on 16 Feb 1977 (M=0.9) and 17 Feb 1977 (M=1.1) had nearly identical locations and first-motion patterns; so we shall discuss only the larger one (Figure 17). Although there were clear first P arrivals at 9 stations for which the plotted points were spread widely over the focal sphere, both normal faulting and strike-slip faulting solutions are compatible with the observations.

In the normal faulting solution the dip of the two planes is rather well constrained--31°W to 35°W for plane 1 and 56°E to 64°E for plane 2--but the strike azimuths of both planes can vary through a range of 20° to 30°. A normal solution for which the nodal lines are drawn approximately midway between limiting data points is:

Plane 1 (auxiliary plane?): strike azimuth 16°, dip 35°W

Plane 2 (fault plane?) : strike azimuth 358°, dip 56°E

Pressure axis : azimuth 236°, dip 77°W

Tension axis : azimuth 77°, dip 10°E

Sense of movement : east side down.

This solution is similar to those for the Rocklin quakes.

The strike-slip solution, for vertical fault and auxiliary planes, for which the nodal lines are drawn midway between the limiting date points is:

Plane 1 : strike azimuth 326°, vertical

Plane 2 : strike azimuth 56°, vertical

Pressure axis: azimuth 11°, horizontal

Tension axis : azimuth 101°, horizontal.

All four of these azimuths can vary by ± 16°.

If plane 1 is the fault plane (strike N 34° W) the motion is right-lateral.

3. Earthquakes north of Grass Valley

At 01:47:41Z on 3 June 1978 a magnitude 2.2 earthquake occurred about 8 km north of Grass Valley. It was preceded by immediate foreshocks at 01:38:11Z (M 1.7) and 01:41:23 (M 1.2) and was followed by 5 aftershocks: 3 June at 23:28:36Z (M 1.3) and 5 June at 01:25:41Z (M 1.7), 17:32:36Z (M 1.6), 17:55:01Z (M 1.6), and 18:11:46Z (M 1.4). The first-motion patterns for all of these earthquakes were nearly identical. The most significant variations were at station ABJ, which had a sharp compressional arrival for the main shock and sharp dilatational arrivals for the foreshocks and aftershocks, and station AFD, which had dilatational arrivals for the foreshocks, mainshock, and several aftershocks and compressional arrivals for two aftershocks. A composite first-motion plot of the main shock, largest foreshock, and 3 largest aftershocks is shown in Figure 18. Both planes are rather well constrained. Each must be drawn through a cluster of points representing arrivals from one of the stations that shifted polarity for at least one earthquake of the group. The solution shown in Figure 18 is as follows:

Plane 1 : strike azimuth 49°, dip 62°NW

Plane 2 : strike azimuth 334°, dip 65°NE

Pressure axis: azimuth 190°, dip 39°S

Tension axis : azimuth 101°, dip 1°E.

Presently available data are insufficient for determining which plane is the fault plane. The elongation of the epicentral zone in a NE-SW direction suggests that plane 1 is the fault plane; but the epicentral zone is little more than 1 km long (Figure 19). The very-strong first arrivals at station ABJ, which is very near the nodal line for plane 1, may also be taken as evidence that plane 1 is the fault plane. If plane 1 is the fault plane, then the displacement was predominantly left-lateral along a fault striking N 49°E, nearly perpendicular to the trend of the Sierra Nevada. If plane 2 is the fault plane, then the displacement was predominantly right-lateral along a fault striking N 25°W and dipping 65°E. In either case the non-strike-slip component of displacement is normal: NW side down for the left-lateral case and NE side down for the right-lateral case.

The fault plane solution for these earthquakes is quite different from that for the earthquake that occurred nearby at 18:44:29Z on 15 May 1977 (Figure 9 of the report for April-June 1977). The earlier quake appears to have resulted from oblique slip on a fault striking N 6°W and dipping 60°W. The displacement was predominantly normal (west side down), with a component of right-lateral slip.

4. Deep earthquakes southwest of the Auburn Dam network

Two unusual deep earthquakes occurred beneath the Sacramento Valley adjacent to the Auburn Dam network near the end of March 1977. The first, at 19:55:47Z on 19 March, was 21 km WSW of station ALA at a depth of about 18 km. The second, at 12:55:48Z on 21 March, was 15 km SW of station AFR at a depth of about 21 km. Although both quakes were small and were located near the edge of the network, a composite plot of their first-motion data (Figure 20) yields a rather well-constrained solution

Plane 1 : strike azimuth 35°, dip 24°W

Plane 2 : strike azimuth 7°, dip 69°E

Pressure axis: azimuth 105°, dip 24°E

Tension axis : azimuth 250°, dip 63°W.

Three da'a points from a 23-km-deep earthquake at the southeastern end of the Melones net at 08:28:35Z on 5 Feb 1978 are also compatible with this solution.

If plane 2 represents the fault plane, the composite mechanism is high-angle reverse faulting on north-trending faults dipping steeply toward the east. If plane 2 represents the fault plane, the composite mechanism is low-angle reverse faulting on north-trending faults that dip gently toward the west.

LIST OF FIGURES

Figure 1

Magnification curves of the standard telemetered USGS seismic system when recorded on a Develocorder or played out on the Oscillomink. The curves are stylized: they are the asymptotes approached by the actual curves at frequencies that are not too near the sharp bends in the curves (filter corner frequencies). The parameter on the curves (db) is the attenuation setting of the seismic amplifier in the field unit.

Figure 2

Map of the Sierra Foothills seismic net and of earthquakes in the Auburn region with Mag $\geq$ 0.2 from Nov 76 through June 78. Focal depth is indicated by the plotted symbol (0-1 km = A, 1-2 km = B, etc.) and magnitude is indicated by the sumbol height ($M < 0.5$, 0.03 inch; $0.5 \leq M < 1.0$, 0.06 inch; $1.0 \leq M < 1.5$, 0.12 inch; etc.

Figures 3-5

Selected blasts in the Auburn region for the epochs Nov 76-June 77 (Figure 3), July 77-June 78 (Figure 4), and Nov 76-June 78 (Figure 5). The plotted symbol indicates focal depth (0-1 km = A, 1-2 km = B, etc.) and the symbol height indicates magnitude ($M < 0.5$, 0.07 inch; $0.5 \leq M < 1.0$, 0.105 inch; $1.0 \leq M < 1.5$, 0.14 inch; etc.).

Figures 6-8

Earthquakes with $M \geq 0.2$ in the Auburn region during epochs Nov 76-June 77 (Figure 6), July 77-June 78 (Figure 7), and Nov 76-June 78 (Figure 8). The plotted symbol indicates focal depth (0-1 km = A, 1-2 km = B, 2-3 km = C, etc.) and the symbol height indicates magnitude ($M < 0.5$, 0.04 inch; $0.5 \leq M < 1.0$, 0.08 inch; $1.0 \leq M < 1.5$, 0.12 inch; etc.).

Figure 9

Earthquakes with M $\geq$ 0.2 in the Auburn region from Nov 76-June 78. The plotted symbol indicates focal depth (0-1 = A, 1-2 = B, 2-3 = C, etc.) and the symbol height indicates magnitude (M < 0.5, 0.07 inch; 0.5 $\leq$ M < 1.0, 0.105 inch; 1.0 $\leq$ M < 1.5, 0.14 inch; etc.).

Figures 10-12

Rocklin area quakes with M $\geq$ 0.2 during the epochs Nov 76-June 77 (Figure 10), July 77-June 78 (Figure 11), and Nov 76-June 78 (Figure 12). The plotted symbol indicates focal depth (0-1 = A, 1-2 = B, 2-3 = C, etc.) and the symbol height indicates magnitude (M < 0.5, 0.06 inch; 0.5 $\leq$ M < 1.0, 0.09 inch; 1.0 $\leq$ M < 1.5, 0.12 inch; etc.).

Figure 13

Transverse and longitudinal cross sections of the Rocklin hypocenter cluster, Nov 76-June 78. The sections are referred to a reference line drawn along the long axis of the epicenter cluster. The reference line has end points O, 38°44.00'N 121°12.80'W, and F, 38°49.00'N 121°15.38'W, and a trend, O to F, of N 22°W. In the transverse section, hypocenters are moved parallel to the line $\overline{OF}$ and plotted on a vertical plane perpendicular to $\overline{OF}$. In the longitudinal section, hypocenters are plotted on a vertical plane that cuts the surface along $\overline{OF}$ by movement onto the plane along lines normal to the plane.

The height of the plotting symbol indicates magnitude (M $\leq$ 0.5, 0.06 inch; 0.5 $\leq$ M < 1.0, 0.09 inch; 1 $\leq$ M < 1.5, 0.12 inch; etc.). The plotting symbol indicates the epoch during which the earthquake occurred:

A	1 Nov 77	through	28 Feb 77
B	1 Mar 77	"	31 May 77
C	1 June 77	"	30 Sept 77
D	1 Oct 77	"	14 Nov 77
E	15 Nov 77	"	14 Dec 77
F	15 Dec 77	"	30 June 77.

Figure 14

First-motion plot for the M 1.3 Rocklin quake at 19:42:28Z on 1 Nov 1977. C's and D's represent unequivocal first compressional and dilatational P-wave arrivals, respectively; and +'s and -'s represent clear, but less certain, first compressional or dilatational P-wave arrivals, respectively. P and T represent the pressure axis and the tension axis, respectively.

Figure 15

Composite first-motion plot for all Rocklin quakes with M $\geq$ 1.0 that occurred from 1 July 1977 to 30 June 1978. These quakes are

Date	Time	Mag	Depth(km)
77 08 03	08 37 51	1.3	11.7
77 11 01	19 42 28	1.3	10.9
77 11 03	01 07 01	1.2	12.7
77 11 03	14 52 54	1.2	12.8
77 11 27	02 52 29	1.8	11.9
77 12 08	22 30 42	1.3	12.9
78 01 10	01 02 29	1.3	12.3
78 03 18	14 03 40	1.3	12.9
78 05 30	01 19 55	1.0	11.3.

See the caption of Figure 14 for an explanation of the plotted symbols.

Figure 16

Transverse and longitudinal cross sections of the Rocklin hypocenter cluster, Nov 76-Jun 78. The reference line OF (39°44.00'N 121°12.80'W to 39°49.00'N 121°19.15'W) passes through the epicentral cluster and has a bearing (O to F) of 315°. The height of the plotting symbol indicates magnitude (M $\geq$ 0.5, 0.06 inch; 0.5 $\geq$ M > 1.0, 0.09 inch; 1 $\geq$ M > 1.5, 0.12 inch; etc.). The plotting symbol indicates the epoch during which the earthquake occured:

A	1 Nov 77	through	28 Feb 77	D	1 Oct 77	through	14 Nov 77
B	1 Mar 77	"	31 May 77	E	15 Nov 77	"	14 Dec 77
C	1 June 77	"	30 Sept 77	F	15 Dec 77	"	30 June 77.

Figure 17

First motion plot for the M 1.1 earthquake near station APR at 20:09:41 on 17 Feb 1978. Both normal and strike-slip focal mechanism solutions are compatible with the data, and both are shown. The plotted symbols are explained in the caption for Figure 14.

Figure 18

Composite first-motion plot for the five largest quakes near Grass Valley on 3 June and 5 June, 1978. The earthquakes included in the plot are:

Date	Time	Mag.	Depth (km)
78 06 03	01 38 11	1.7	8.9
78 06 03	01 47 41	2.2	11.4
78 06 05	01 25 41	1.7	9.7
78 06 05	17 32 36	1.6	11.0
78 06 05	17 55 01	1.6	11.8

The plotted symbols are explained in the caption for Figure 14.

Figure 19

Earthquakes near Grass Valley from 3 June 1978 to 5 June 1978. The plotted sysmbols indicate focal depth in km (8-9=I, 9-10=J, 11-12=L) and the symbol height indicates magnitude ($M < 0.5$, 0.08 inch; $0.5 \leq M < 1$, 0.12 inch; $1 \leq M < 1.5$, 0.16 inch; etc.).

Figure 20

Composite first-motion plot for two deep earthquakes SW of the Auburn Dam net and one deep quake at the southeast end of the Melones net. The earthquakes included in this plot are:

Date	Time	Mag.	Depth (km)
78 03 19	19 55 47	1.4	18.2
78 03 21	12 55 48	1.4	21.3
78 02 05	08 28 35	1.2	22.4

The plotted symbols are explained in the caption for Figure 14. The three symbols labelled M are the points from the Melones quake.

REFERENCES

Eaton, J. P., O'Neill, M. E., and Murdock, J. N., 1970, Aftershocks of the 1966 Parkfield-Cholame, California, earthquake: A detailed study: Seimological Society of America Bulletin, v. 60, p. 1151-1197.

Lee, W. H. K., Bennett, R. E., and Meagher, K. L., 1972, A method of estimating magnitude of local earthquakes from signal duration: U.S. Geological Survey open-file report, 28 p.

Lee, W. H. K., and Lahr, J. C., 1975, HYPO71 (Rev.): A computer program for determining hypocenter, magnitude, and first motion pattern of local earthquakes: U.S. Geological Survey Open-File Report 75-311, 114 p.

Table 2

Crustal Velocity Structure Used to Locate Earthquakes
and Blasts in the Auburn Region

Velocity (km/sec)	Depth to Layer (km)
5.5	0.0
6.3	1.0
6.8	20.0
8.0	35.0

Vp/Vs = 1.73

Table 1

STATIONS OF THE SIERRA FOOTHILLS NETWORK

NEW NAME	LAT	LONG	ELEV	DELAY	INSTALLATION DATE	ATTEN(DB)	OLD NAME
AAR	3916.57N	12101.53W	930	.10	760720	24	AARS
ABJ	3909.90N	12111.47W	457	-.03	760727	18	ABJS
ABR	3908.11N	12129.21W	24	.37	770209	30	ABRS
ADW	3826.35N	12050.89W	251	.27	760721	18	ADWD
AFD	3856.69N	12058.10W	524	.07	760129	6	AFHD
AFH	3902.51N	12047.48W	1064	.04	760721	24	AFHS
AFR	3847.54N	12120.91W	31	.30	761202	24	AFID
AGI	3850.68N	12058.88W	305	-.03	760130	12	AGRI
AHD	3902.90N	12104.59W	483	-.12	761029	18	AHDR
AHR	3851.26N	12104.23W	354	-.08	760201	18	AHFR
ALA	3834.00N	12057.37W		-.07	770721	6	REPLACED ASR
ALN	3855.78N	12117.27W	54	.02	761202	24	ALIN
AOD	3836.89N	12043.71W	520	.06	761019	12	AOTD
AOH	3922.52N	12115.36W	457		770210	12	AOHO
APR	3852.62N	12113.03W	133	.00	760716	12	APHR
ARJ	3841.19N	12057.38W	460	-.03	761123	12	ARW J
ARR	3845.92N	12110.31W	127	.11	761202	12	ARRA
ARW	3857.38N	12109.73W	320	-.08	760129	12	ARPW
ASR	3829.86N	12112.29W	52	.30	760721	30	ASHR*
AVR	3901.49N	12116.08W	911	-.09	760716	6	AVRS
MBF	3740.71N	12021.80W	309		761027	18	BFS
MCH	3801.12N	12030.57W	475		720120	12	CRH
MCS	3756.33N	12031.76W	373		720120	18	CNS
MCU	3758.36N	12037.02W	336		720324	6	COP
MMW	3803.83N	12010.89W	1411		761027	12	MWV
MNH	3808.75N	12048.82W	219		761027	18	NHR
MOY	3754.00N	12034.04W	176		720415	12	OBF
MRF	3814.72N	12031.24W	799		7607 2	18	RFR
MST	3754.27N	12024.29W	366		720120	12	STN
OBH	3939.10N	12127.70W	916		750906	18	OBLO
OCH	3952.55N	12145.92W	530	.06	761218	12	OCOR
OGO	3939.22N	12136.72W	158		761229	12	OGOO
OHC	3920.18N	12129.05W	76		750805	18	OHON
ORA	3928.13N	12124.80W	585	-.01	750805	12	ORAT
OST	3922.12N	12135.80W	29	.38	750805	18	OSTI
OSU	3916.23N	12151.10W		.85	760316	12	OSUT
OTB	3932.75N	12133.65W	223		750906	18	OTAB
OWY	3927.19N	12129.20W	177		750805	18	OWYN
JASB	3756.80N	12026.30W	457				JAS **
KPKW	3935.01N	12118.32W	897				KPK **
MGLW	3948.71N	12133.42W	1010				MGL **
ORVW	3933.33N	12130.00W	362				ORV **
CGP2	3925.00N	12108.88W	687	.05			***
CPHS	3931.95N	12059.02W	1207	.06			***

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*Discontinued

**Operated by California Division of Water Resources

***Operated by California Division of Mines and Geology

Table 3

AUBURN BLASTS NOVEMBER 1976 TO JUNE 1978

DATE	ORIGIN		LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	Q
761109	2335	5.79	38-50.76	121- 4.44	3.36	0.12	5	194	1.0	0.13	7.1	1.9	D1
770105	2336	49.99	38-53.69	121- 2.74	0.00	1.41	14	90	5.3	0.18	0.8	1.6	B1
770113	2348	35.74	38-52.76	121- 3.52	0.08	1.73	14	81	3.0	0.08	0.4	1.0	A1
770117	2026	26.92	38-53.64	121- 0.69	0.32	1.19	16	105	6.1	0.11	0.4	0.9	B1
770121	1925	56.08	38-38.46	121- 0.00	3.34	1.64	19	112	6.3	0.12	0.5	2.1	B1
770121	2219	55.92	38-52.82	121- 3.19	0.51	0.38	13	85	1.3	0.05	0.2	0.3	A1
770126	2338	37.56	38-42.58	121-11.15	0.57	0.29	7	299	6.3	0.13	4.1	7.2	D1
770131	2310	18.83	38-38.50	121- 0.69	0.12	1.34	18	79	6.9	0.10	0.4	0.7	B1
770207	2351	39.68	38-52.73	121- 3.75	1.34	1.59	23	66	2.8	0.13	0.4	3.5	B1
770209	2338	25.51	38-53.07	121- 3.84	0.97	0.90	13	71	3.4	0.07	0.3	1.2	A1
770212	2337	1.78	38-53.02	121- 3.35	1.47	1.68	17	71	3.5	0.11	0.4	3.4	B1
770215	2336	49.21	38-52.74	121- 3.60	3.50	1.26	14	79	2.9	0.14	0.5	1.8	A1
770218	2357	27.73	38-38.73	121- 0.34	0.47	2.02	21	72	6.3	0.12	0.4	1.1	B1
770226	2222	15.41	38-52.78	121- 3.85	1.77	0.46	13	69	2.9	0.07	0.3	0.8	A1
770303	20 8	30.03	38-47.35	121-14.37	0.39	0.62	10	158	6.4	0.07	0.4	1.3	B1
770303	2339	55.92	38-52.48	121- 3.43	2.00	1.31	14	72	2.5	0.08	0.3	1.3	A1
770305	1814	27.14	38-52.19	121- 3.77	2.55	0.88	11	90	1.9	0.16	0.9	1.9	B1
770318	18 0	17.12	38-46.25	121-15.47	1.09	0.08	6	282	7.5	0.07	1.4	115.7	D1
770325	23 9	28.64	38-38.67	121- 0.79	0.18	1.53	23	74	6.8	0.14	0.5	0.8	B1
770406	019	3.54	38-53.66	120-59.92	5.05	0.73	13	140	5.7	0.07	0.4	0.9	B1
770408	2332	22.12	38-52.61	121- 3.21	0.14	0.90	12	75	2.9	0.04	0.2	0.4	A1
770523	1941	7.75	39- 2.21	121- 1.07	0.15	1.00	15	90	5.2	0.17	0.6	1.1	B1
770523	2050	17.35	39- 3.23	121- 8.39	3.03	0.25	9	129	5.7	0.14	0.7	2.5	B1
770525	23 7	31.03	38-53.74	121- 0.59	0.17	0.89	17	108	6.2	0.14	0.5	0.9	B1
770701	2111	44.94	38-38.93	121- 0.63	0.47	1.54	15	77	19.1	0.08	0.5	98.1	C1
770708	1914	24.81	38-38.34	121- 1.20	3.48	1.47	8	171	19.3	0.08	0.9	10.8	C1
770720	2254	19.25	38-38.86	121- 0.76	0.35	1.55	11	151	19.0	0.09	0.8	109.9	C1
770804	22 2	48.69	38-45.17	121- 9.57	0.55	0.41	5	266	1.8	0.13	2.8	0.9	D1
770811	22 0	24.28	38-38.66	121- 0.32	0.71	1.61	13	145	6.3	0.10	0.6	123.0	C1
771004	2053	3.62	38-53.76	121- 0.43	1.05	0.78	11	127	6.1	0.04	0.2	51.4	C1
771017	2129	29.23	38-52.63	121- 3.40	0.82	0.65	9	73	2.8	0.03	0.2	0.3	A1
771018	2338	32.35	38-38.39	121- 0.85	1.51	1.70	13	167	7.2	0.10	0.6	7.6	C1
771020	1951	18.48	38-52.61	121- 3.28	1.13	0.62	9	91	2.8	0.06	0.4	4.7	B1
771202	2238	35.58	38-52.57	121- 3.42	1.56	0.61	6	93	2.7	0.01	0.1	0.5	B1
771208	20 5	3.87	38-52.76	121- 3.73	1.80	0.95	12	71	2.9	0.08	0.4	1.6	A1
771209	044	7.17	39- 1.83	121- 1.11	2.70	1.17	14	88	5.4	0.09	0.5	2.0	B1
771213	0 2	29.68	38-36.12	121- 2.79	1.15	0.41	5	254	8.8	0.06	2.7	72.9	D1
771214	0 2	7.93	38-52.78	121- 3.48	0.80	0.30	7	95	3.0	0.02	0.2	0.2	B1
771214	1827	38.26	38-52.53	121- 3.36	0.93	0.50	10	73	2.7	0.04	0.2	0.4	A1
771216	2055	15.04	38-52.53	121- 3.29	0.76	-0.13	5	94	2.7	0.02	0.3	0.5	C1
780111	1858	41.98	38-52.71	121- 3.46	2.28	-0.07	5	95	2.9	0.01	0.2	0.5	C1
780127	2017	17.29	38-35.17	121- 4.14	1.03	0.39	4	233	10.1	0.02			C1
780130	2113	0.76	38-52.79	121- 3.48	0.61	0.88	13	73	3.0	0.08	0.4	0.8	A1
780202	2126	37.29	38-52.63	121- 3.43	0.54	0.53	10	124	2.8	0.09	0.6	0.9	B1
780223	22 4	47.44	38-52.58	121- 3.47	1.75	0.91	11	72	2.7	0.03	0.2	0.7	A1
780404	2213	50.41	38-53.31	121- 2.23	0.87	0.86	12	92	4.9	0.41	2.0	503.0	C1
780414	22 2	58.73	38-52.80	121- 3.58	1.99	0.89	13	72	3.0	0.08	0.4	1.5	A1
780530	2218	17.22	39- 2.15	121- 1.16	2.92	0.84	14	134	5.1	0.14	0.7	2.7	B1
780531	1847	35.48	38-52.37	121- 3.54	2.11	0.81	18	94	2.3	0.08	0.3	0.9	B1
780531	2145	26.70	39- 1.76	121- 0.91	5.11	1.09	19	88	5.7	0.19	0.6	1.7	B1
780606	1815	24.08	38-53.76	121-16.49	3.03	1.80	26	101	3.9	0.14	0.4	1.6	B1

Table 4

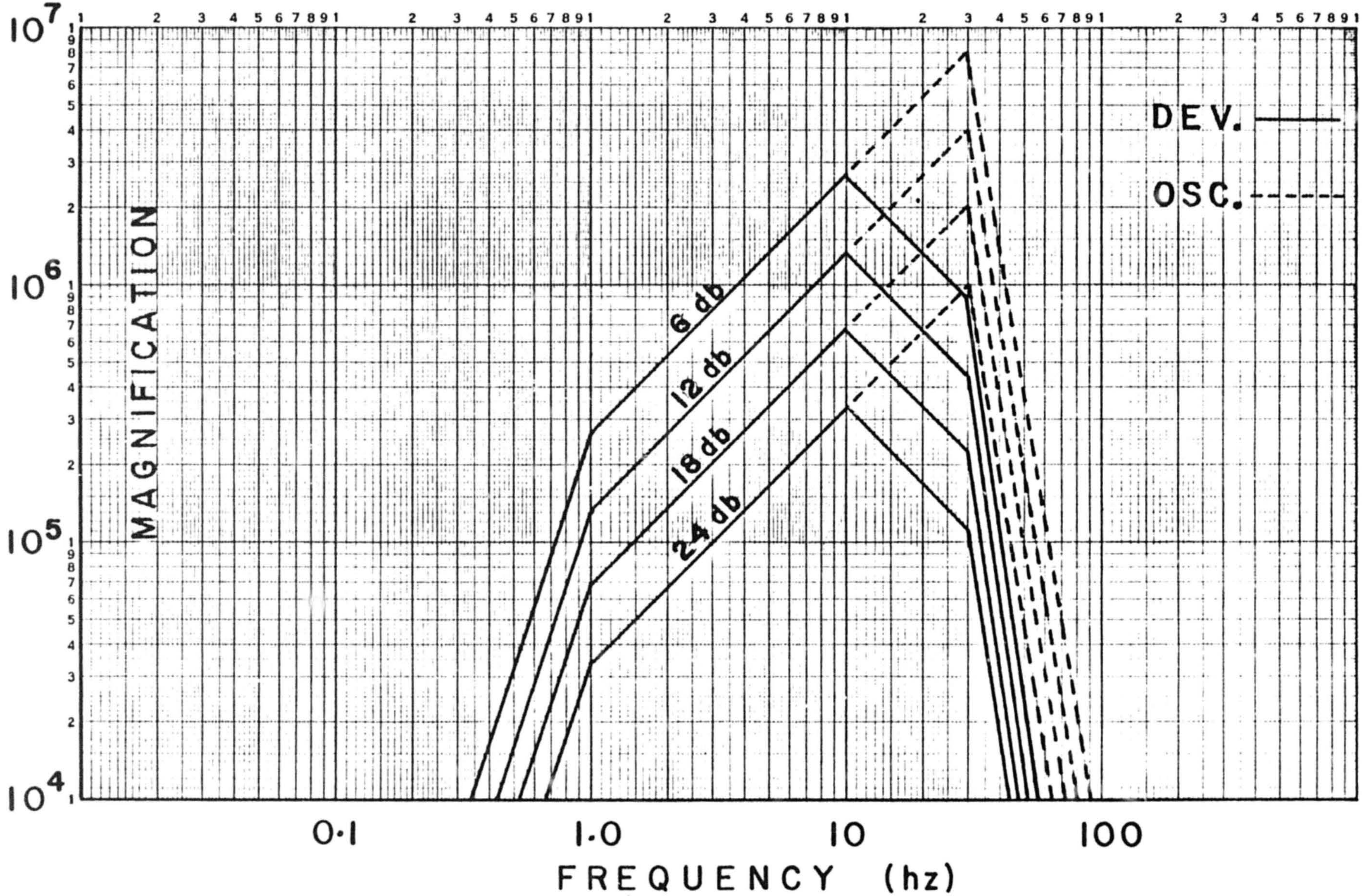
AUBURN EARTHQUAKES NOVEMBER 1976 TO JUNE 1978

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	Q
761119	511 12.55	38-54.44	120-55.98	11.26	1.06	10	248	5.2	0.05	0.4	0.6	C1
761128	7 2 29.38	38-47.33	121-14.45	14.00	1.12	14	280	10.0	0.11	0.8	0.8	C1
761128	1235 38.00	38-47.18	121-14.50	14.66	1.09	14	281	10.3	0.08	0.6	0.5	C1
761216	1227 16.53	38-46.72	121-14.56	13.51	0.69	13	252	6.3	0.06	0.4	0.4	C1
761231	943 4.90	38-47.81	121-15.64	14.44	0.46	13	244	8.5	0.07	0.4	0.5	C1
770103	623 27.94	38-46.98	121-14.38	8.71	0.28	10	246	6.2	0.24	2.0	2.1	C1
770121	1750 22.67	38-46.02	121-14.25	12.54	0.67	16	263	5.7	0.05	0.3	0.3	C1
770122	13 0 31.48	38-46.04	121-14.10	12.98	0.70	17	244	5.5	0.04	0.2	0.2	C1
770221	2137 24.95	38-46.17	121-13.91	13.62	1.63	18	109	5.2	0.07	0.4	0.5	B1
770503	836 12.36	38-46.10	121-14.02	13.04	1.16	19	174	5.4	0.06	0.2	0.3	B1
770507	855 36.14	38-45.96	121-14.10	13.13	0.57	12	244	5.5	0.05	0.4	0.4	C1
770509	758 54.28	38-46.01	121-14.08	12.87	1.26	19	176	5.5	0.04	0.2	0.2	B1
770509	759 0.77	38-47.43	121-13.52	2.21	0.27	4	231	5.4	0.02			C1
770514	312 30.57	38-46.14	121-13.89	13.11	0.50	12	255	5.2	0.04	0.3	0.3	C1
770515	1528 35.95	38-46.02	121-13.82	13.69	1.73	30	110	5.1	0.15	0.5	0.9	B1
770515	1534 39.80	38-46.17	121-13.92	13.13	0.60	12	259	5.2	0.04	0.3	0.3	C1
770515	17 5 32.66	38-46.11	121-14.04	13.26	0.81	18	174	5.4	0.06	0.3	0.3	B1
770515	1844 29.23	39-16.59	121- 5.55	3.32	1.11	17	119	5.8	0.05	0.2	0.3	B1
770516	133 11.38	38-46.06	121-14.07	13.11	0.30	11	257	5.4	0.03	0.2	0.2	C1
770523	322 32.61	38-46.09	121-14.04	12.82	0.27	9	274	5.4	0.03	0.3	0.3	C1
770614	1743 26.85	38-45.08	121-13.15	11.80	1.35	20	155	4.4	0.11	0.4	0.5	B1
770618	541 58.39	38-45.78	121-14.00	11.25	0.45	10	267	5.3	0.06	0.6	0.5	C1
770618	757 16.27	38-45.53	121-13.35	11.87	0.49	13	272	4.5	0.09	0.6	0.5	C1
770620	1047 10.22	38-45.04	121-13.45	11.57	1.11	19	157	4.8	0.08	0.4	0.4	B1
770621	336 17.97	38-45.05	121-13.44	11.49	0.65	12	292	4.8	0.06	0.5	0.6	C1
770711	748 34.17	38-45.22	121-13.54	12.59	0.45	9	288	4.9	0.02	0.2	0.3	C1
770803	237 50.89	38-45.44	121-13.69	11.71	1.34	22	114	5.0	0.08	0.3	0.3	B1
770803	1534 32.00	38-45.50	121-13.56	12.89	0.77	10	177	13.2	0.03	0.3	0.4	B1
770821	8 8 19.08	39- 7.75	121-27.27	10.02	0.86	16	134	2.9	0.12	0.7	0.7	B1
771101	1942 27.58	38-45.13	121-13.34	10.91	1.26	28	160	4.6	0.07	0.2	0.3	B1
771103	1 7 1.24	38-45.88	121-13.91	12.72	1.20	22	150	5.2	0.07	0.2	0.3	B1
771103	10 7 34.25	38-46.06	121-12.02	13.19	0.07	6	257	2.5	0.03	0.4	0.5	C1
771103	10 7 49.63	38-46.02	121-13.92	12.35	0.81	21	153	5.2	0.05	0.2	0.2	B1
771103	1155 27.11	38-45.97	121-14.05	12.45	0.10	9	257	5.4	0.04	0.3	0.3	C1
771103	1155 39.57	38-46.06	121-13.96	12.60	0.40	16	243	5.3	0.05	0.3	0.3	C1
771103	1452 54.33	38-46.02	121-13.89	12.84	1.15	22	148	5.2	0.09	0.3	0.4	B1
771127	252 29.45	38-45.57	121-13.51	11.91	1.78	16	207	4.7	0.08	0.7	0.7	C1
771127	254 0.82	38-45.08	121-13.27	12.33	0.12	6	291	4.6	0.02	0.5	0.2	C1
771127	3 2 27.37	38-45.64	121-12.10	12.38	0.09	7	275	2.6	0.08	1.4	0.8	C1
771127	4 2 34.03	38-45.15	121-13.15	12.66	0.14	9	290	4.3	0.05	0.5	0.4	C1
771127	2056 47.29	38-45.99	121-13.95	12.77	0.50	13	262	5.3	0.06	0.4	0.4	C1
771127	23 4 19.62	38-46.14	121-12.00	13.33	-0.24	7	253	2.5	0.05	0.6	0.6	C1
771127	23 5 39.95	38-46.10	121-12.00	12.40	-0.24	6	255	2.5	0.04	0.5	0.8	C1
771127	2334 9.34	38-46.14	121-11.83	13.14	0.12	6	251	2.2	0.02	0.2	0.4	C1
771128	326 16.36	38-46.03	121-13.02	12.49	0.14	6	267	3.9	0.02	0.6	0.3	C1
771128	526 15.86	38-46.11	121-12.49	12.99	0.42	6	260	3.2	0.02	0.5	0.2	C1
771208	2230 41.52	38-46.12	121-13.64	12.89	1.33	18	150	4.8	0.03	0.1	0.3	B1
771212	1143 21.41	38-44.77	121-13.30	10.80	0.41	17	222	4.8	0.05	0.2	0.2	C1
780110	1 2 29.12	38-45.43	121-13.48	12.33	1.30	20	153	4.7	0.07	0.2	0.5	B1
780110	1 4 55.28	38-45.34	121-13.70	12.51	0.83	17	160	5.0	0.05	0.2	0.2	B1
780205	828 35.13	37-48.86	120-14.40	22.90	1.19	7	262	17.6	0.08	2.7	1.2	D1
780216	1027 44.09	38-53.37	121-12.83	6.95	0.89	14	113	1.4	0.08	0.3	0.4	B1
780217	20 9 41.43	38-53.41	121-12.97	7.26	1.11	14	122	1.5	0.08	0.4	0.5	B1
780318	14 3 39.99	38-45.52	121-13.85	12.94	1.25	19	153	5.2	0.03	0.2	0.2	B1
780319	1955 47.34	38-28.94	121-10.32	18.15	1.35	29	212	21.0	0.22	1.1	1.8	C1
780321	1255 47.92	38-42.57	121-28.80	21.28	1.43	33	214	14.7	0.18	0.8	0.8	C1

Table 4

780530	019	54.75	38-45.47	121-13.79	11.25	0.98	17	159	5.1	0.06	0.3	0.3	B1
780603	138	11.31	39-17.36	121- 6.85	8.93	1.73	38	78	7.8	0.11	0.2	0.5	A1
780603	141	23.38	39-17.46	121- 6.47	9.70	1.18	26	81	7.3	0.09	0.2	0.4	A1
780603	147	41.12	39-17.25	121- 6.66	11.36	2.15	39	78	7.5	0.10	0.2	0.7	A1
780603	2328	35.85	39-17.45	121- 6.27	9.94	1.27	24	82	7.0	0.09	0.2	0.5	A1
780605	125	41.24	39-17.38	121- 6.37	9.67	1.72	44	81	7.1	0.10	0.2	0.4	A1
780605	1732	35.56	39-17.34	121- 6.52	11.03	1.57	32	80	7.3	0.09	0.2	0.4	A1
780605	1755	1.15	39-17.31	121- 6.68	11.77	1.59	27	113	14.6	0.12	0.4	1.2	B1
780605	1811	46.04	39-17.24	121- 6.06	9.58	1.41	22	80	6.6	0.12	0.4	0.6	A1

FIG I



DEV.
OSC.
MAGNIFICATION
6 db
12 db
18 db
24 db
10^7
10^6
10^5
10^4
0·1
1·0
10
100
FREQUENCY (hz)

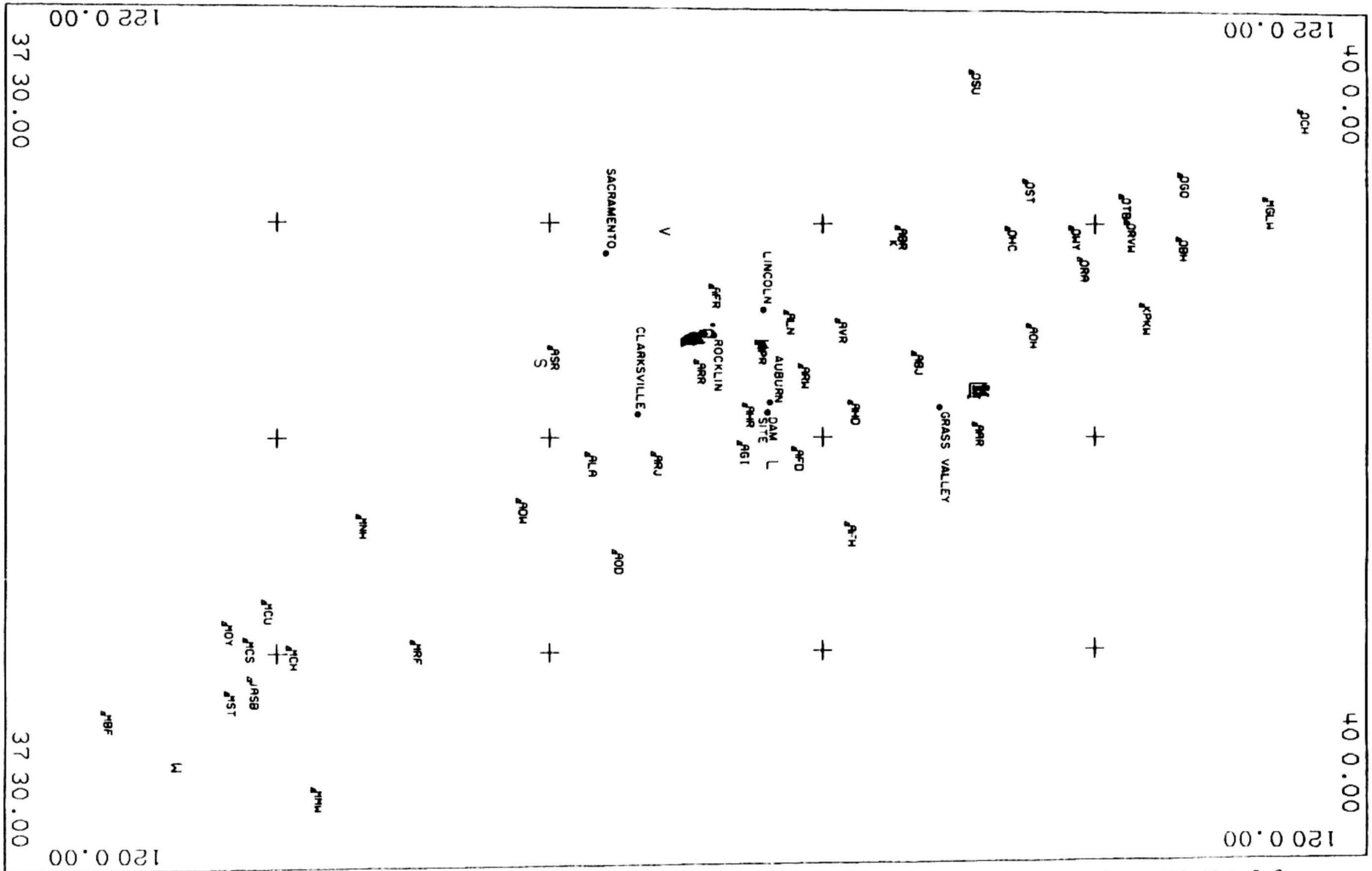


Figure 2. Map of the Sierra Foothills seismic net and of earthquakes in the Auburn region with $M \geq 0.2$ from Nov 76 through Jun 78. Focal depth is indicated by the plotted symbol (0-1 km = A, 1-2 km = b, etc.) and magnitude is indicated by the symbol height ($M < 0.5$, 0.03 inch; $0.5 \leq M < 1.0$, 0.06 inch; $1.0 \leq M < 1.5$, 0.12 inch; etc.).

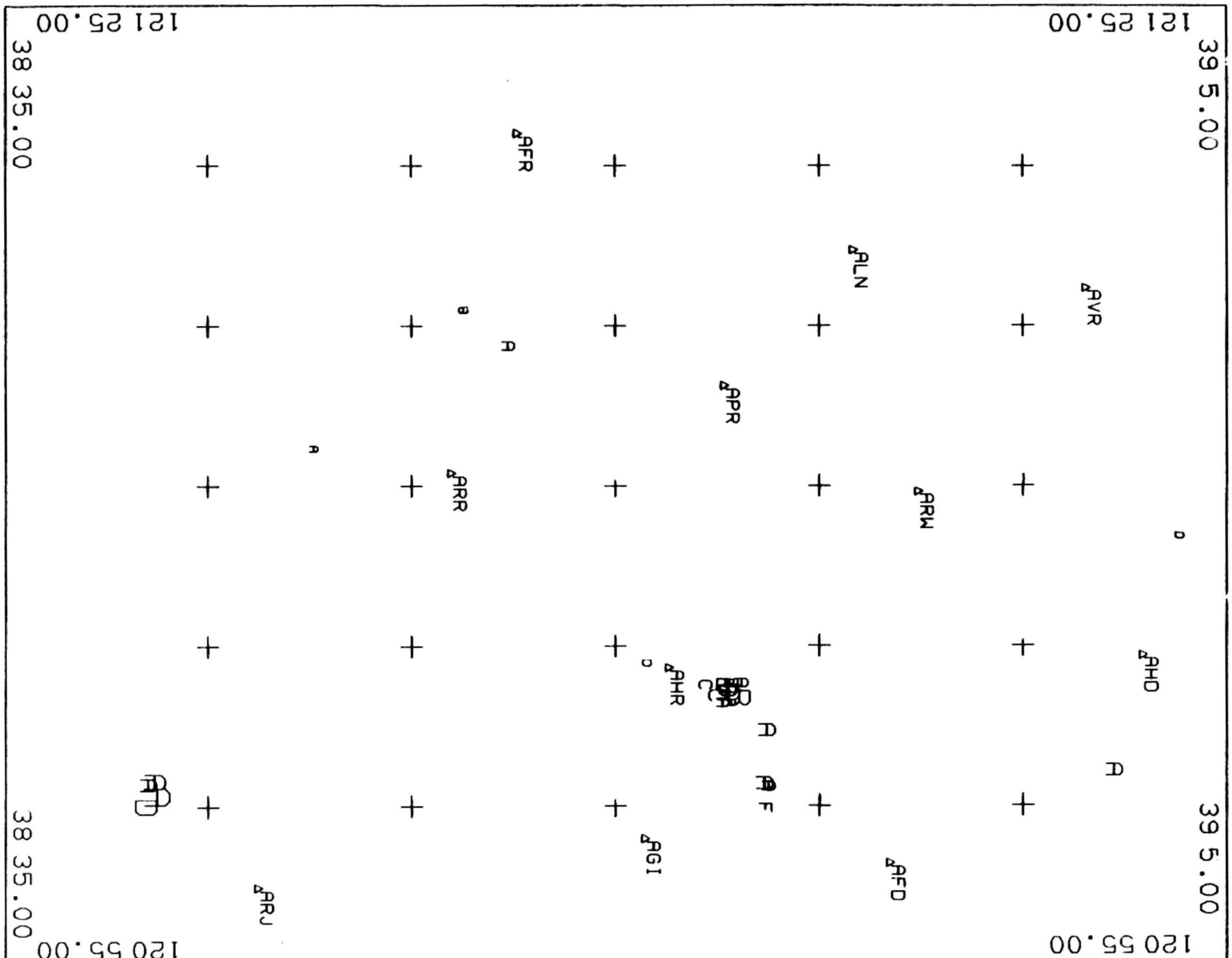


Figure 3. Selected blasts in the Auburn region Nov 76-Jun 77. The plotted symbol indicates focal depth (0-1 km = A, 1-2 km = B, etc.) and the symbol height indicates magnitude ($M < 0.5$, 0.07 inch; $0.5 \leq M < 1.0$, 0.105 inch; $1.0 \leq M < 1.5$, 0.14 inch; etc.).

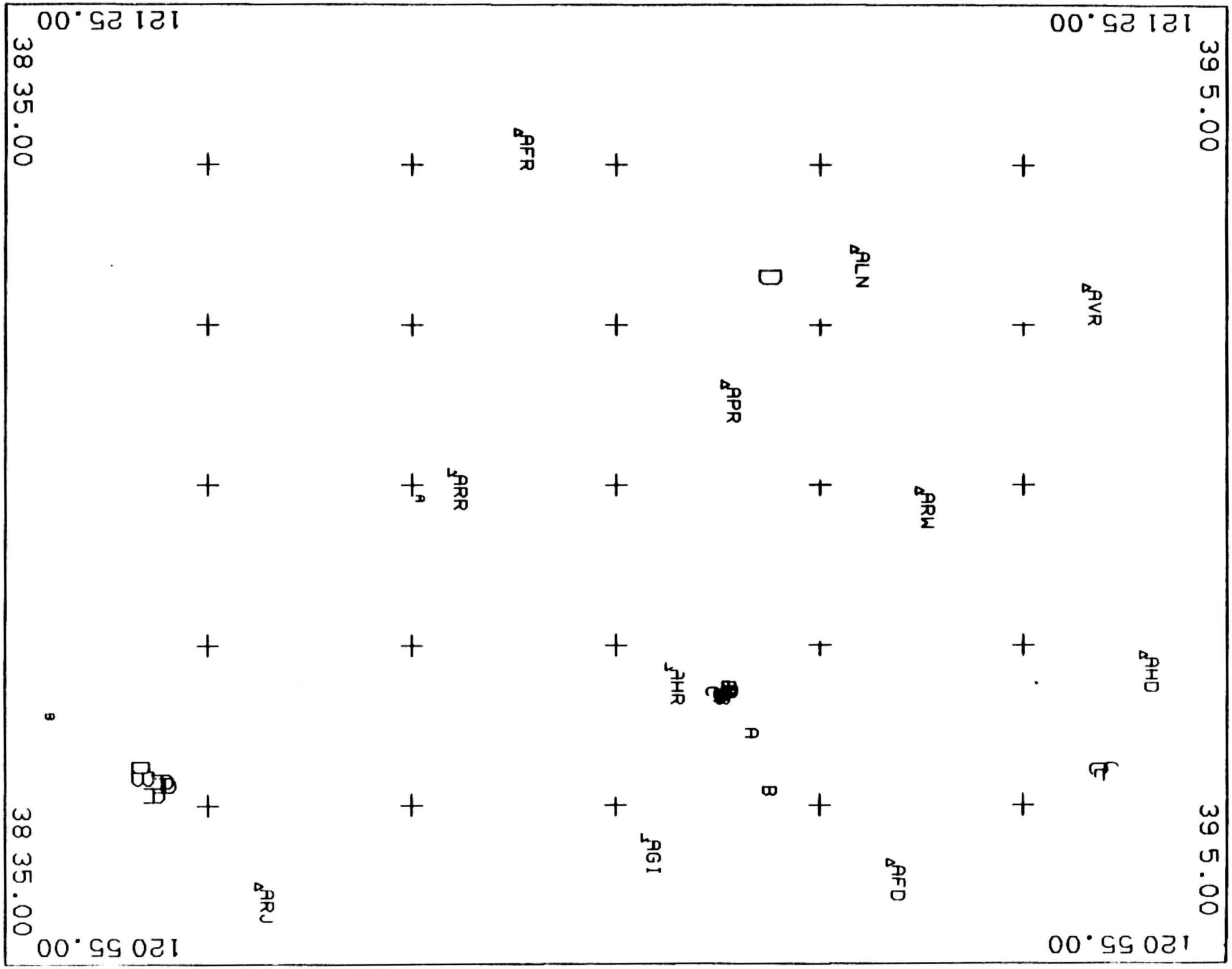


Figure 4. Selected blasts in the Auburn region Jul-Jun 78. The plotted symbol indicates focal depth (0-1 km = A, 1-2 km = B, etc.) and the symbol height indicates magnitude (M < 0.5, 0.07 inch; 0.5 ≤ M < 1.0, 0.105 inch; 1.0 ≤ M < 1.5, 0.14 inch; etc.).

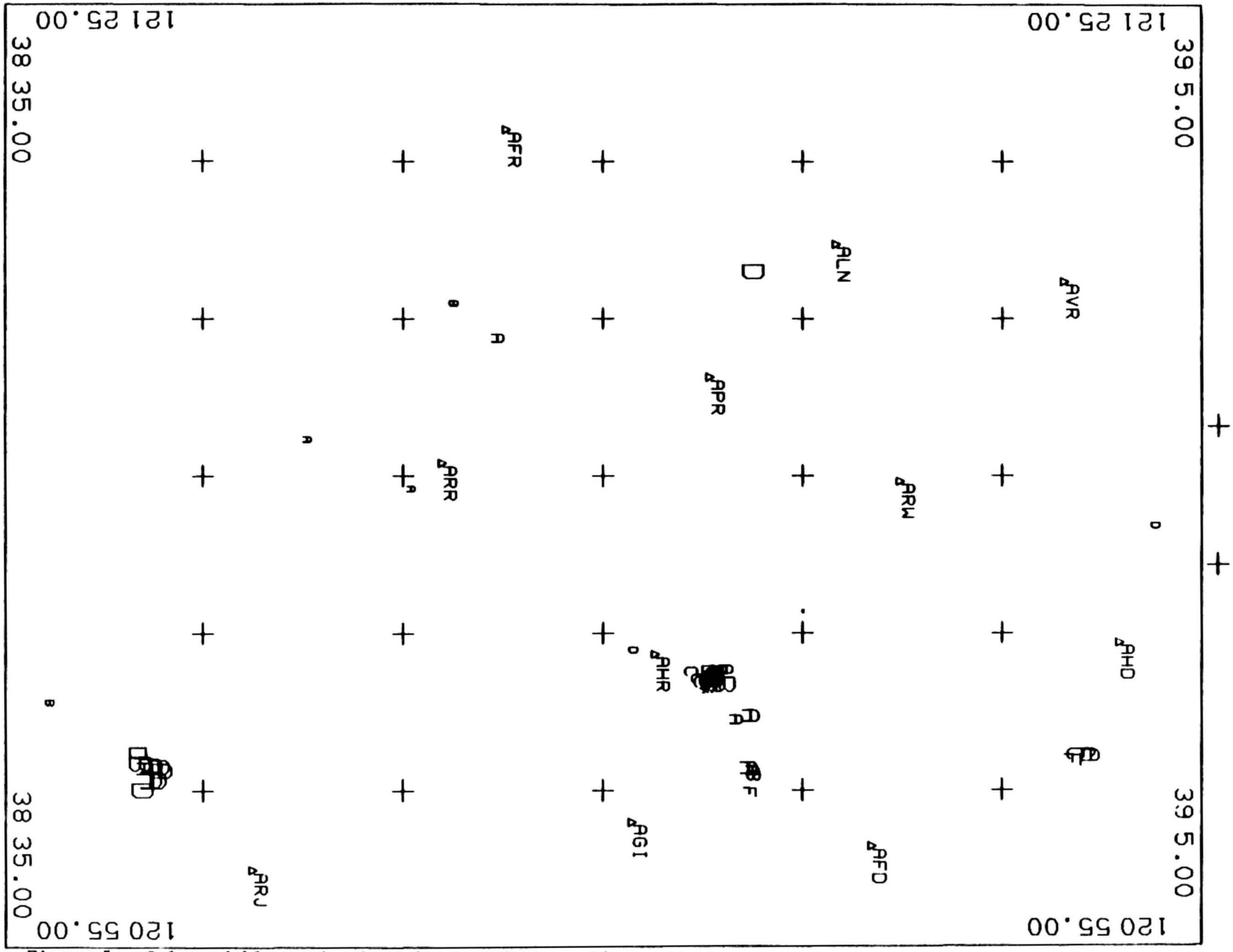


Figure 5. Selected blasts in the Auburn region Nov 76–Jun 78. The plotted symbol indicates focal depth (0–1 km = A, 1–2 km = B, etc.) and the symbol height indicates magnitude (M < 0.5, 0.07 inch; 0.5 < M < 1.0, 0.105 inch; 1.0 ≤ M < 1.5, 0.14 inch; etc.).

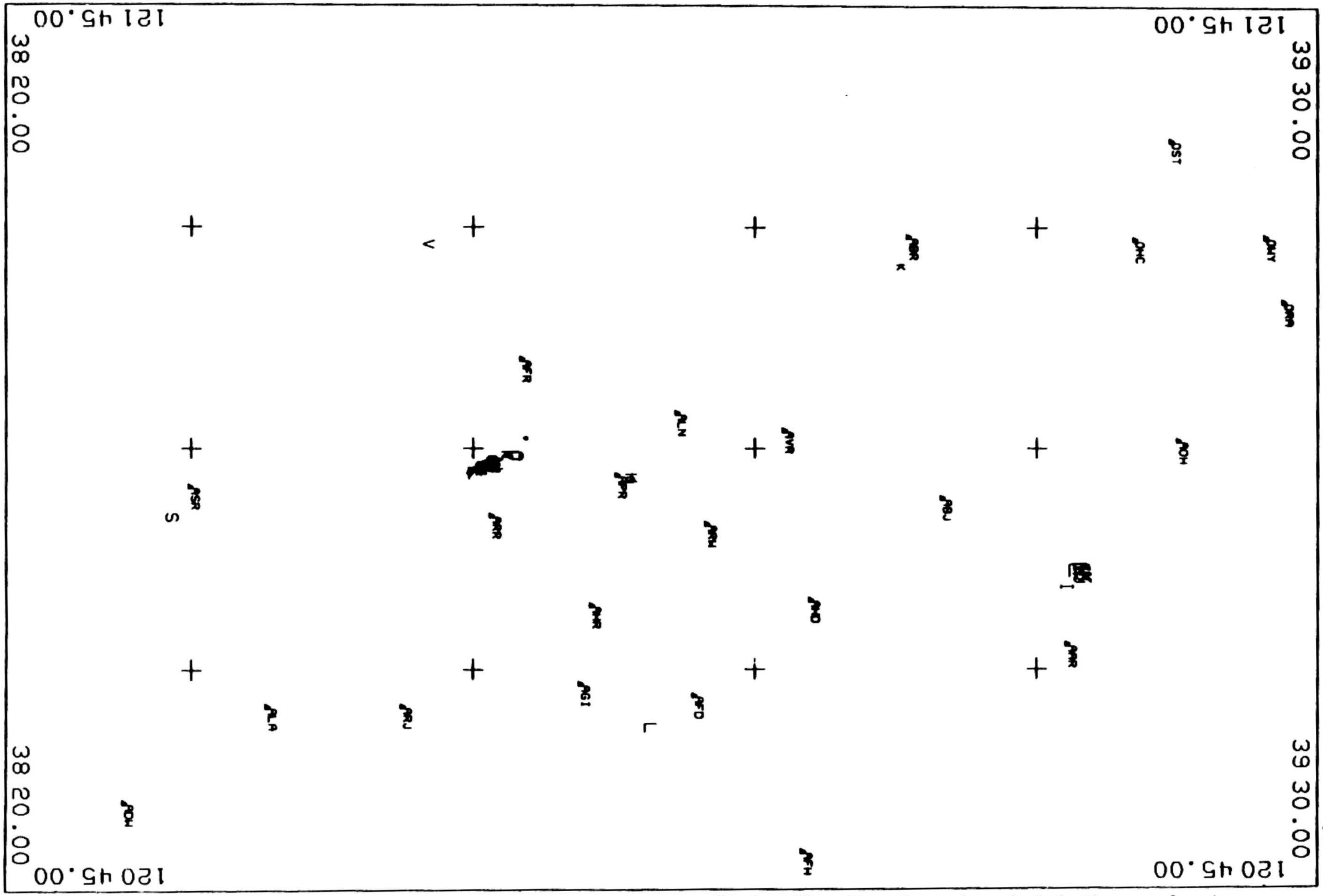


Figure 6. Earthquakes with M ≥ 0.2 in the Auburn region Nov 76-Jun 77. The plotted symbol indicates focal depth (0-1 km = A, 1-2 km = B, 2-3 km = C, etc.) and the symbol height indicates magnitude (M < 0.5, 0.04 inch; 0.5 ≤ M < 1.0, 0.08 inch; 1.0 ≤ M < 1.5, 0.12 inch; etc.).

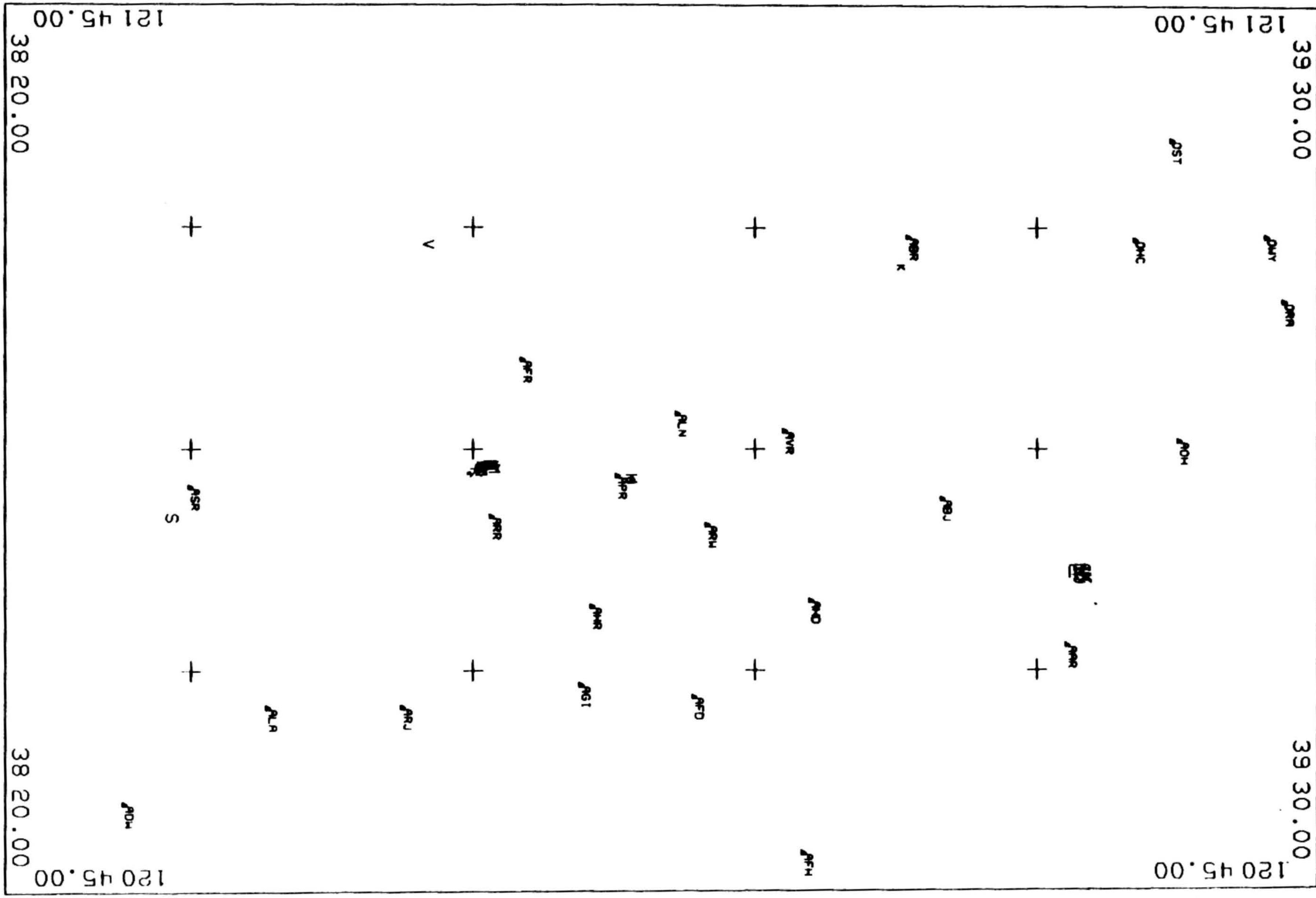


Figure 7. Earthquakes with M $\geq$ 0.2 in the Auburn region Jul 77-Jun 78. The plotted symbol indicates focal depth (0-1 km = A, 1-2 km = B, 2-3 km = C, etc.) and the symbol height indicates magnitude (M < 0.5, 0.04 inch; 0.5 $\leq$ M < 1.0, 0.08 inch; 1.0 $\leq$ M < 1.5, 0.12 inch; etc.).

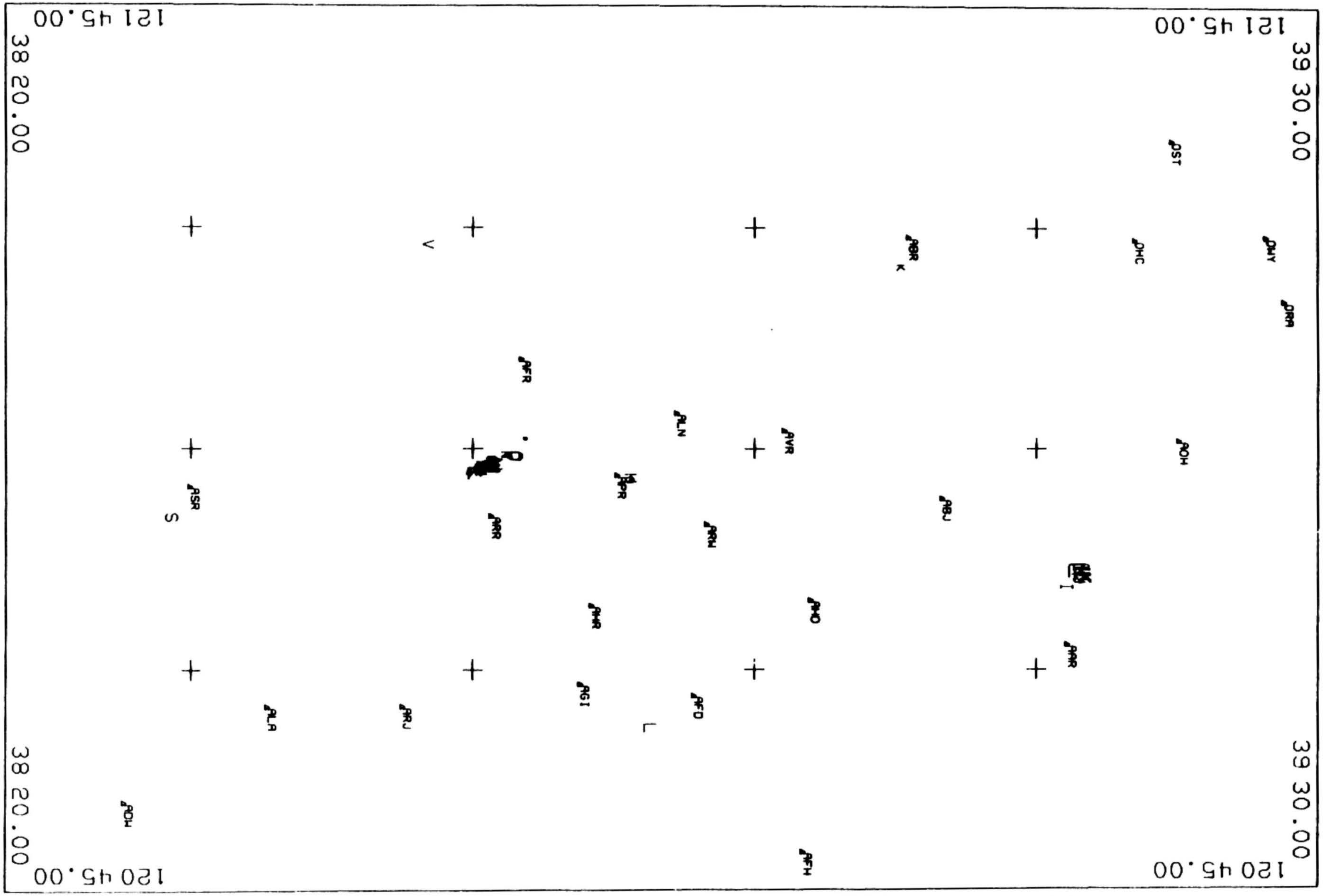


Figure 8. Earthquakes with $M \geq 0.2$ in the Auburn region Nov 76–Jun 78. The plotted symbol indicates focal depth (0–1 km = A, 1–2 km = B, 2–3 km = C, etc.) and the symbol height indicates magnitude ($M < 0.5$, 0.04 inch; $0.5 \leq M < 1.0$, 0.08 inch; $1.0 \leq M < 1.5$, 0.12 inch; etc.).

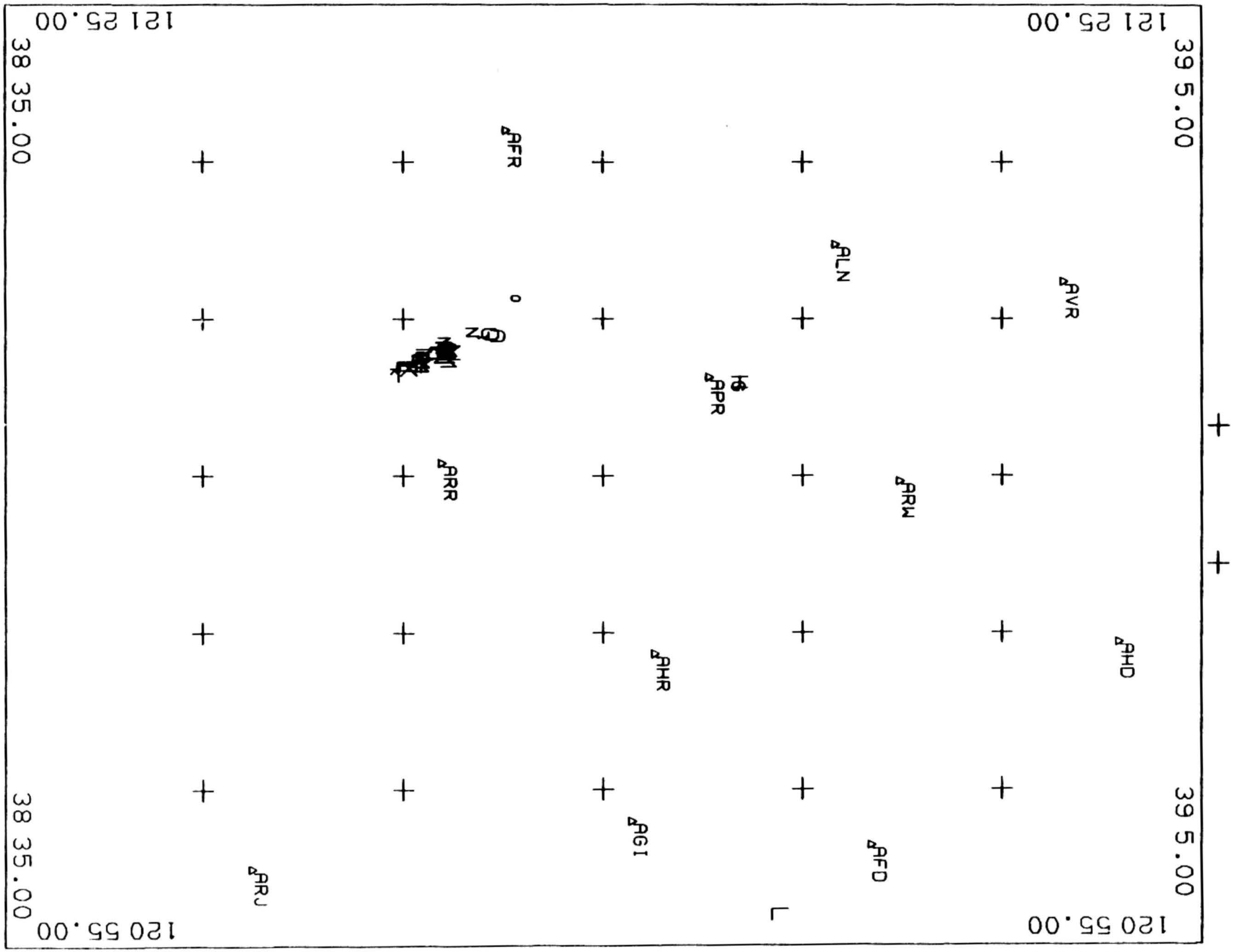


Figure 9. Earthquakes with M $\geq$ 0.2 in the Auburn region from Nov 76-Jun 78. The plotted symbol indicates focal depth (0-1 = A, 1-2 = B, 2-3 = C, etc.) and the symbol height indicates magnitude ($M < 0.5$, 0.07 inch; $0.5 \leq M < 1.0$, 0.105 inch; $1.0 \leq M < 1.5$, 0.14 inch; etc.).

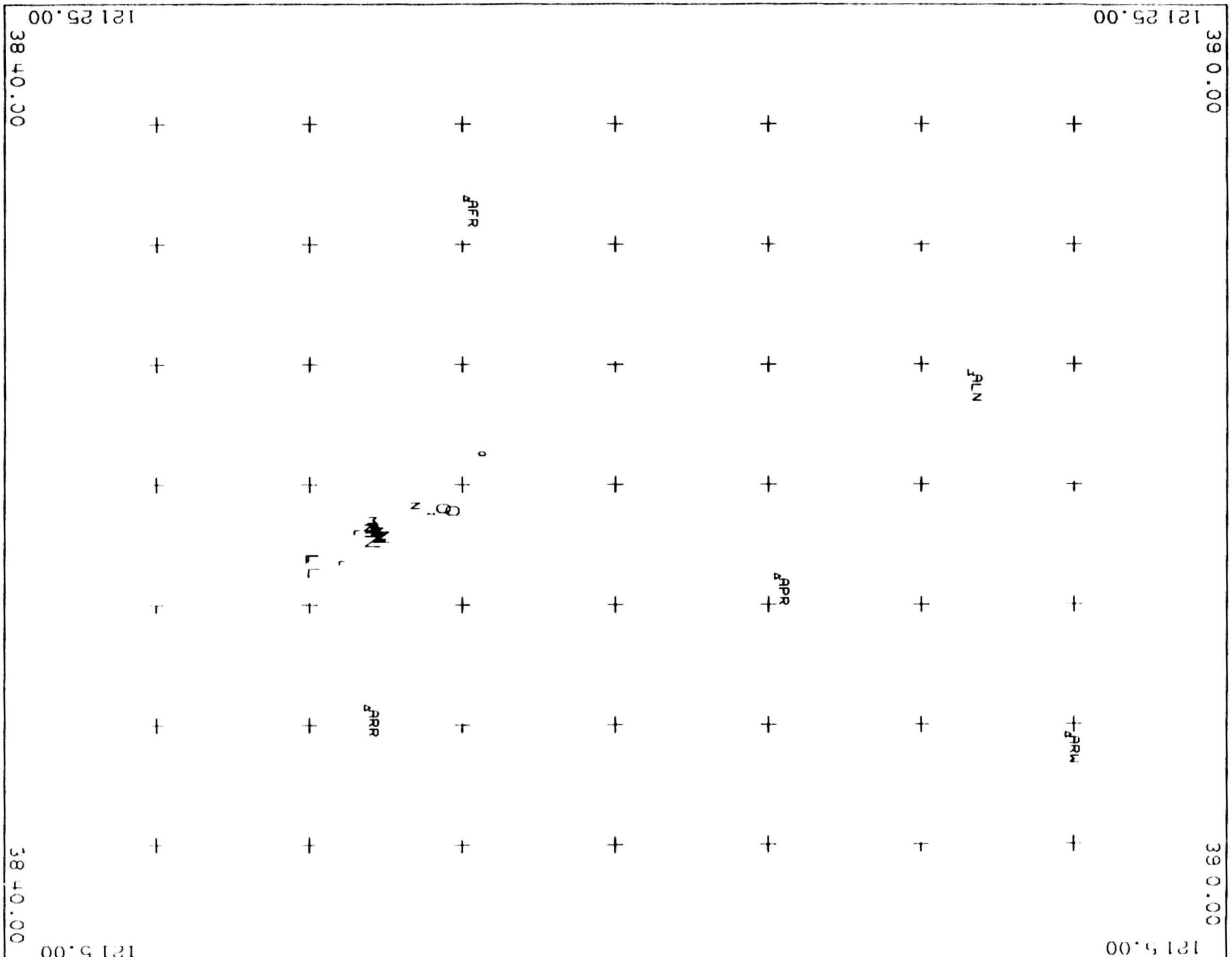


Figure 10. Rocklin area quakes with M > 0.2 during the epochs Nov 76-Jun 77. The plotted symbol indicates focal depth (0-1 = A, 1-2 = B, 2-3 = C, etc.) and the symbol height indicates magnitude (M < 0.5, 0.06 inch; 0.5 ≤ M < 1.0, 0.09 inch; 1.0 ≤ M < 1.5, 0.12 inch; etc.).

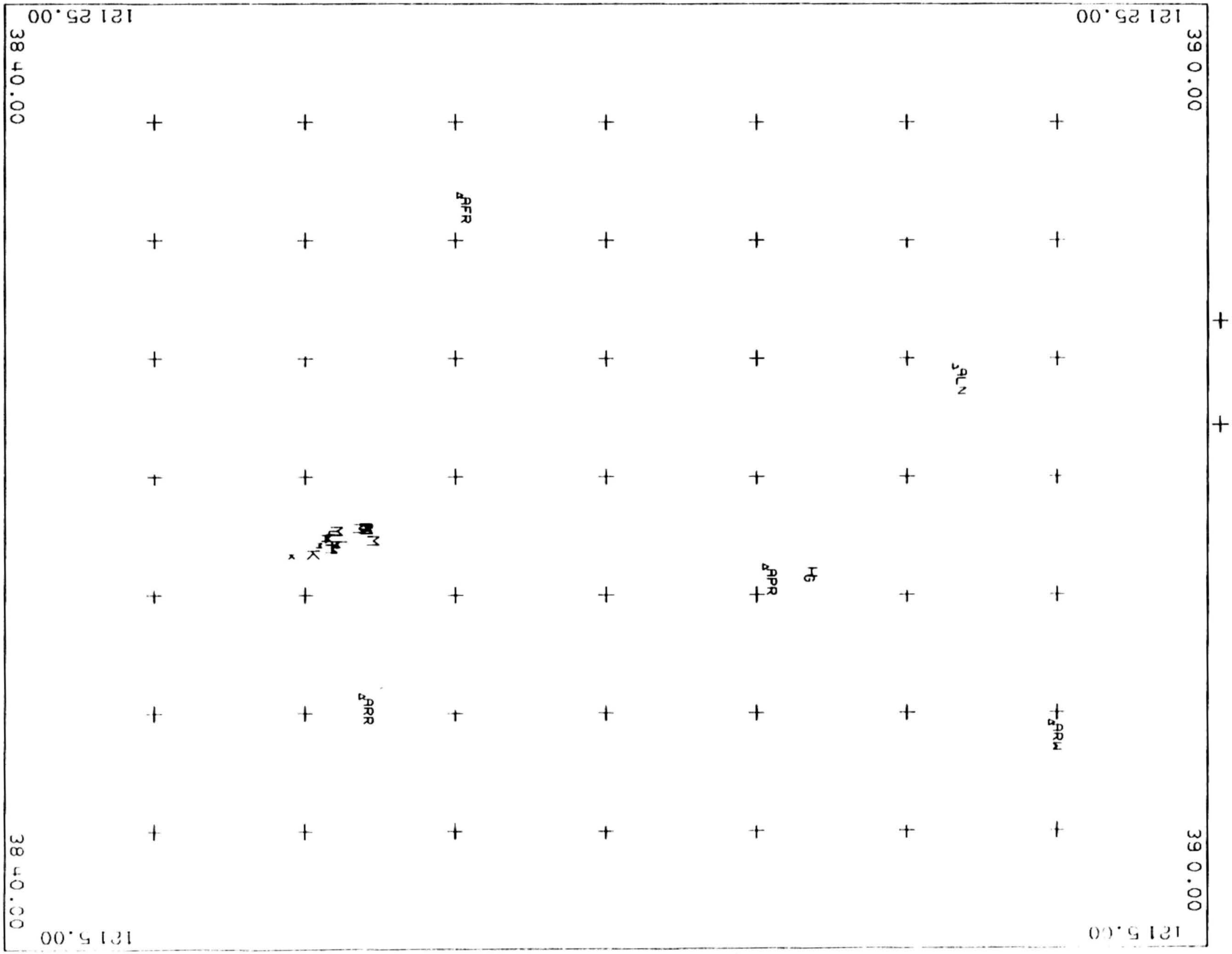


Figure 11. Rocklin area quakes with M $\geq$ 0.2: Jul 77-Jun 78. The plotted symbol indicates focal depth (0-1 = A, 1-2 = B, 2-3 = C, etc.) and the symbol height indicates magnitude (M < 0.5, 0.06 inch; 0.5 $\leq$ M < 1.0, 0.09 inch; 1.0 $\leq$ M < 1.5, 0.12 inch; etc.).

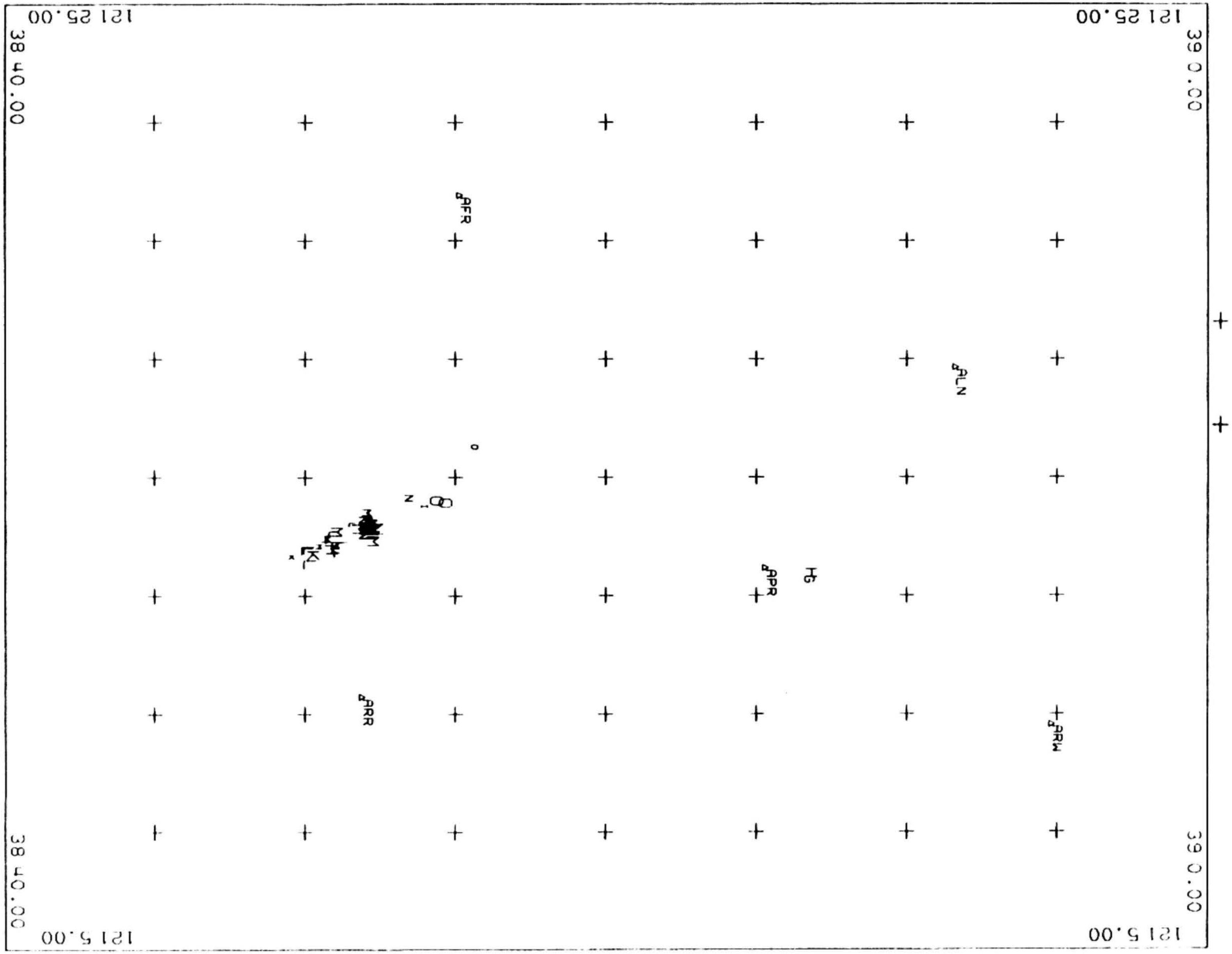
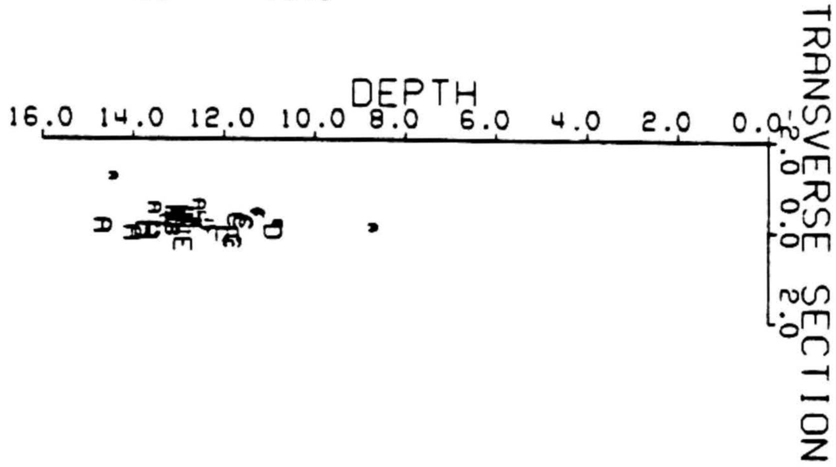


Figure 12. Rocklin area quakes with M $\geq$ 0.2: Nov 76-Jun 78. The plotted symbol indicates focal depth (0-1 = A, 1-2 = B, 2-3 = C, etc.) and the symbol height indicates magnitude (M < 0.5, 0.06 inch; 0.5 $\leq$ M < 1.0, 0.09 inch; 1.0 $\leq$ M < 1.5, 0.12 inch; etc.).

ROCKLIN NOV76-JUN78 38-44.00 121-12.80 38-49.00 121-15.38 0<R<15 -2<T<+2

SECTION RANGE(KM) = 0.0 15.0



ROCKLIN NOV76-JUN78 38-44.00 121-12.80 38-49.00 121-15.38 0<R<15 -2<T<+2

SECTION WIDTH(KM) = -2.0 2.0

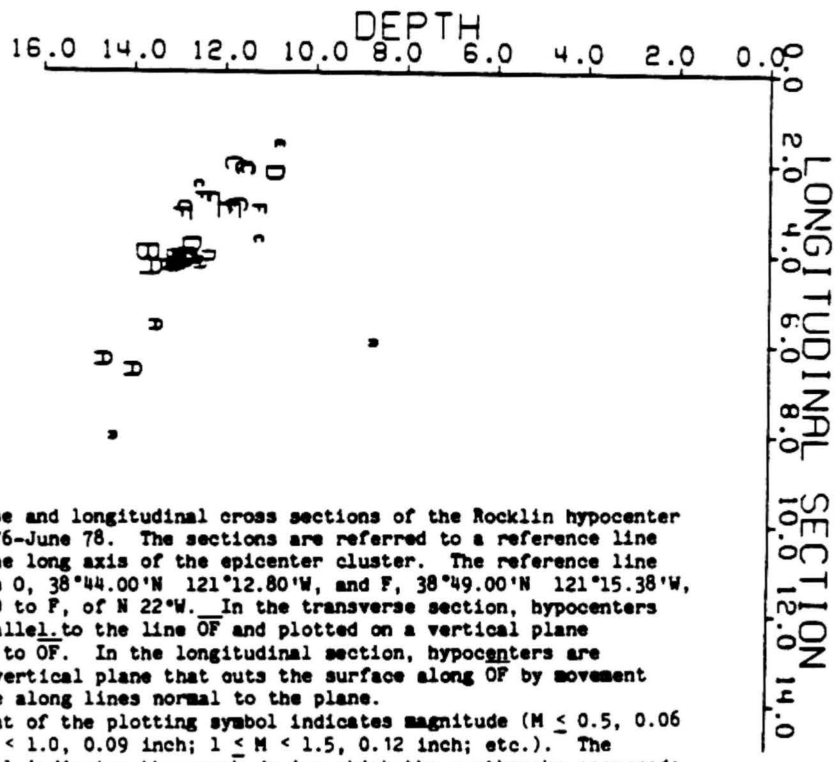


Figure 13

Transverse and longitudinal cross sections of the Rocklin hypocenter cluster, Nov 76-June 78. The sections are referred to a reference line drawn along the long axis of the epicenter cluster. The reference line has end points O, 38°44.00'N 121°12.80'W, and F, 38°49.00'N 121°15.38'W, and a trend, O to F, of N 22°W. In the transverse section, hypocenters are moved parallel to the line $\overline{OF}$ and plotted on a vertical plane perpendicular to $\overline{OF}$. In the longitudinal section, hypocenters are plotted on a vertical plane that cuts the surface along OF by movement onto the plane along lines normal to the plane.

The height of the plotting symbol indicates magnitude ($M \leq 0.5$, 0.06 inch; $0.5 \leq M < 1.0$, 0.09 inch; $1 \leq M < 1.5$, 0.12 inch; etc.). The plotting symbol indicates the epoch during which the earthquake occurred:

A	1 Nov 77	through	28 Feb 77	D	1 Oct 77	through	14 Nov 77
B	1 Mar 77	"	31 May 77	E	15 Nov 77	"	14 Dec 77
C	1 June 77	"	30 Sept 77	F	15 Dec 77	"	30 June 77

Figure 14

77 11 01 19:42:28Z
38° 45.13'N 121° 13.34'W
Depth 10.9 km Mag 1.3
P: 205°; 69°W
T: 62°; 16°E

Rocklin

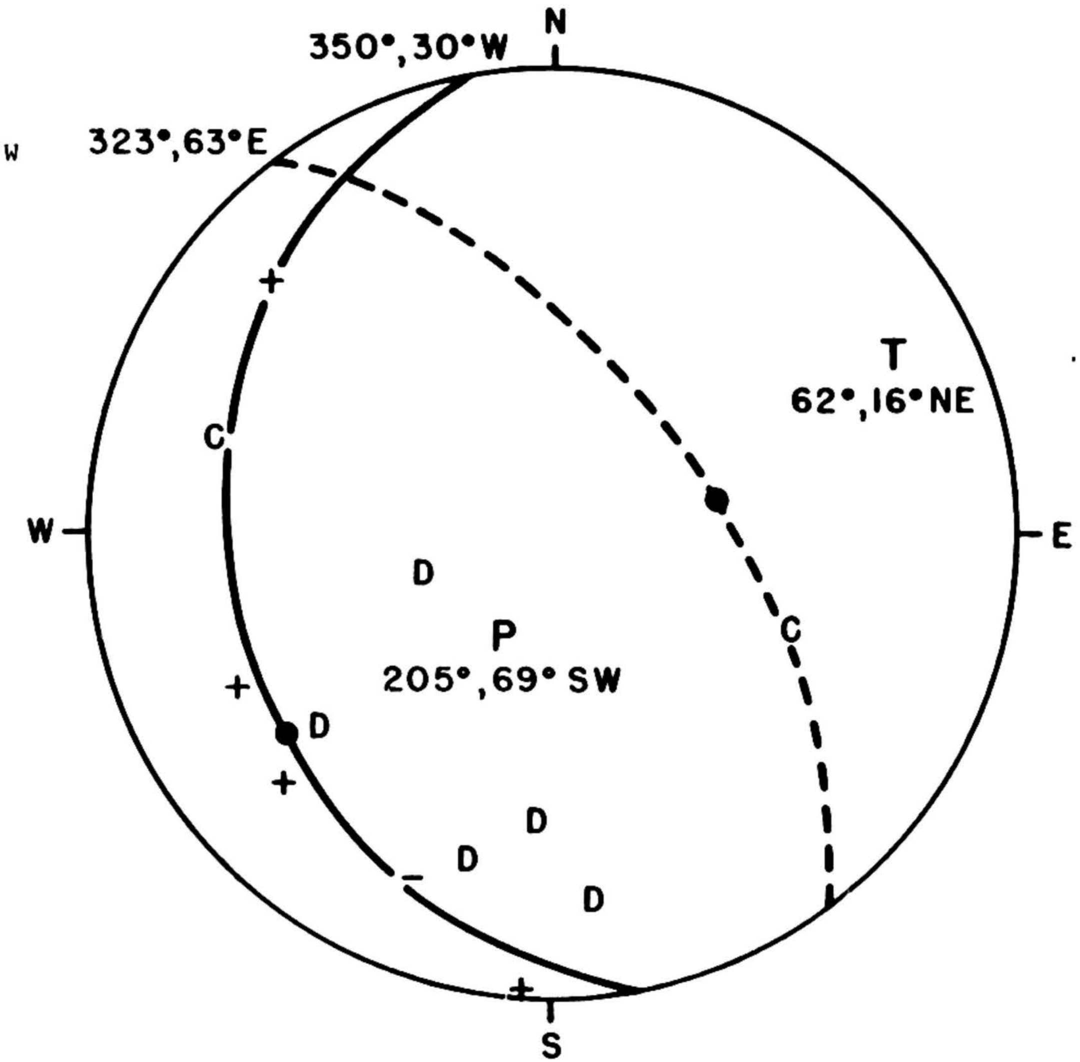


Figure 15

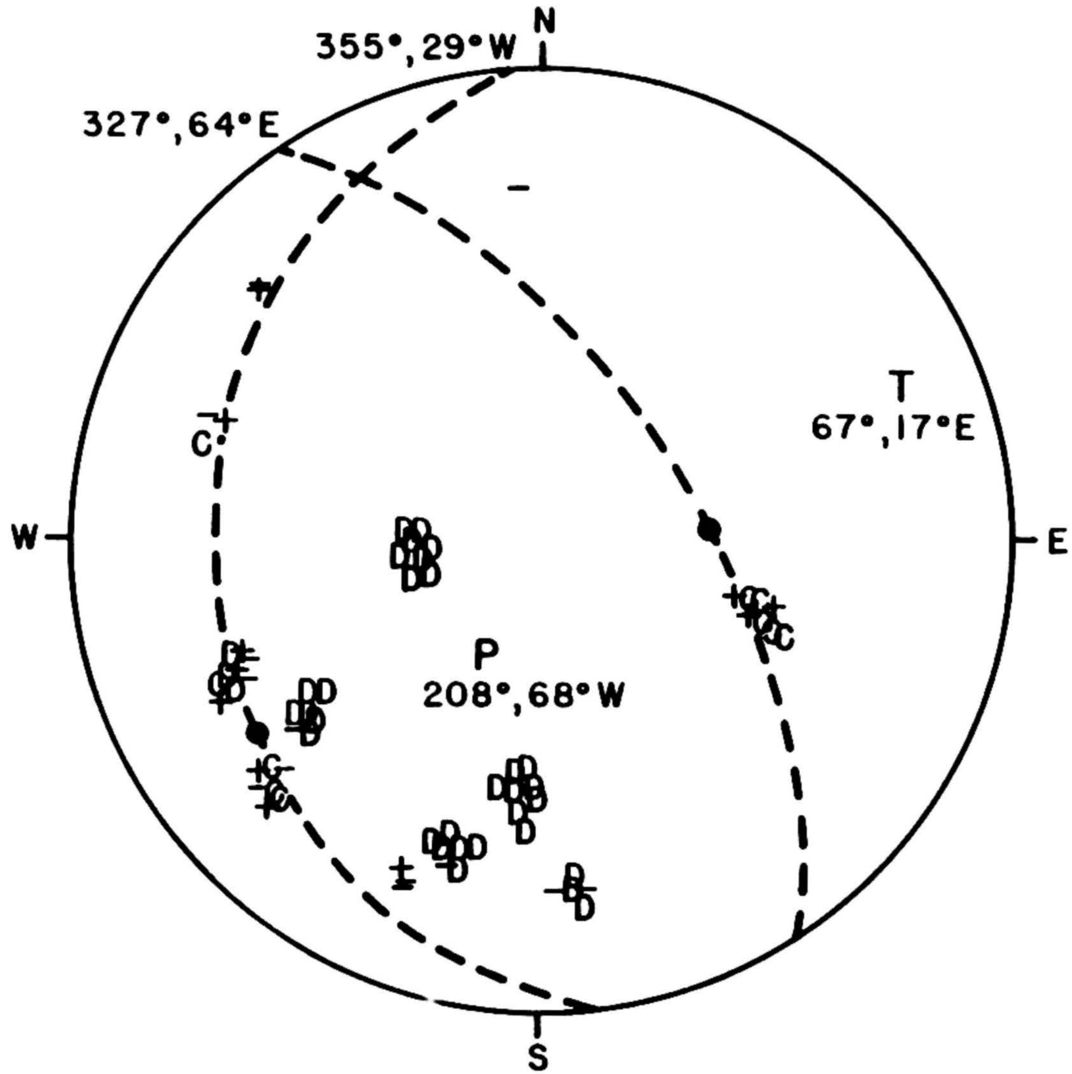
Composite Solution

Date	Time(Z)	Mag	Depth(km)
770803	083751	1.3	11.7
771101	194228	1.3	10.9
771103	010701	1.2	12.7
771103	145254	1.2	12.8
771127	025229	1.8	11.9
771208	223042	1.3	12.9
780110	010229	1.3	12.3
780318	140340	1.3	12.9
780530	011955	1.0	11.3

P: 208°; 68°W

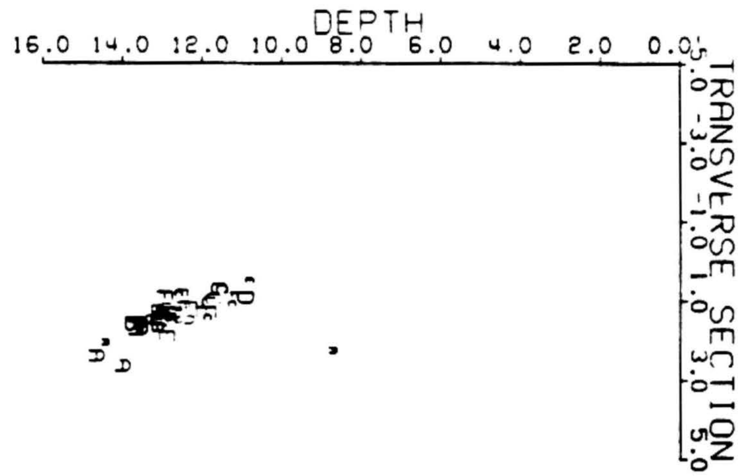
T: 67°; 17°E

Rocklin



ROCKLIN NOV76-JUN78 38-44.00 121-12.80 38-49.00 121-19.15 0<R<15 -5<T<+5

SECTION RANGE(KM) = 0.0 15.0



ROCKLIN NOV76-JUN78 38-44.00 121-12.80 38-49.00 121-19.15 0<R<15 -5<T<+5

SECTION WIDTH(KM) = -5.0 5.0

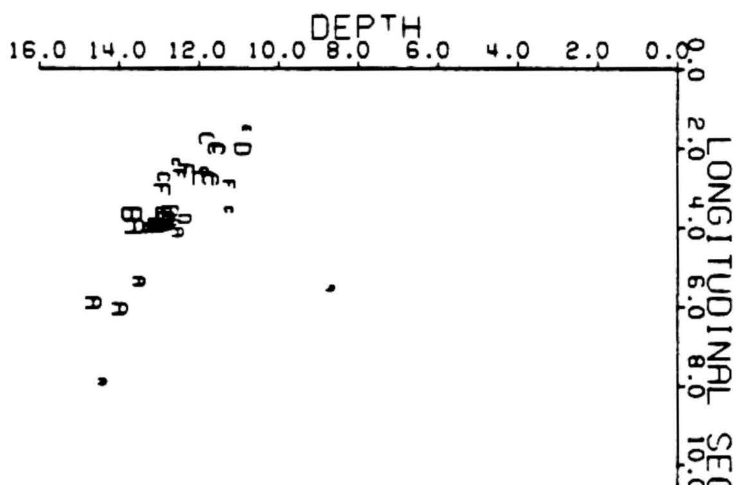


Figure 16

Transverse and longitudinal cross sections of the Rocklin hypocenter cluster, Nov 76-June 78. The reference line OF (39°44.00'N 121°12.80'W to 39°49.00'N 121°19.15'W), which passes through the epicentral cluster and has a bearing (O to F) of 315°. The height of the plotting symbol indicates magnitude ($M \leq 0.5$, 0.06 inch; $0.5 \leq M < 1.0$, 0.09 inch; $1 \leq M < 1.5$, 0.12 inch; etc.). The plotting symbol indicates the epoch during which the earthquake occured:

A	1 Nov 77	through	28 Feb 77	D	1 Oct 77	through	14 Nov 77
B	1 Mar 77	"	31 May 77	E	15 Nov 77	"	14 Dec 77
C	1 June 77	"	30 Sept 77	F	15 Dec 77	"	30 June 77

Figure 17

780217 20:09:41Z
38°53.41'N 121°12.97'W
Depth 7.3 km Mag 1.1
P: 326°; 77°W
T: 77°; 10°E

Near station APR

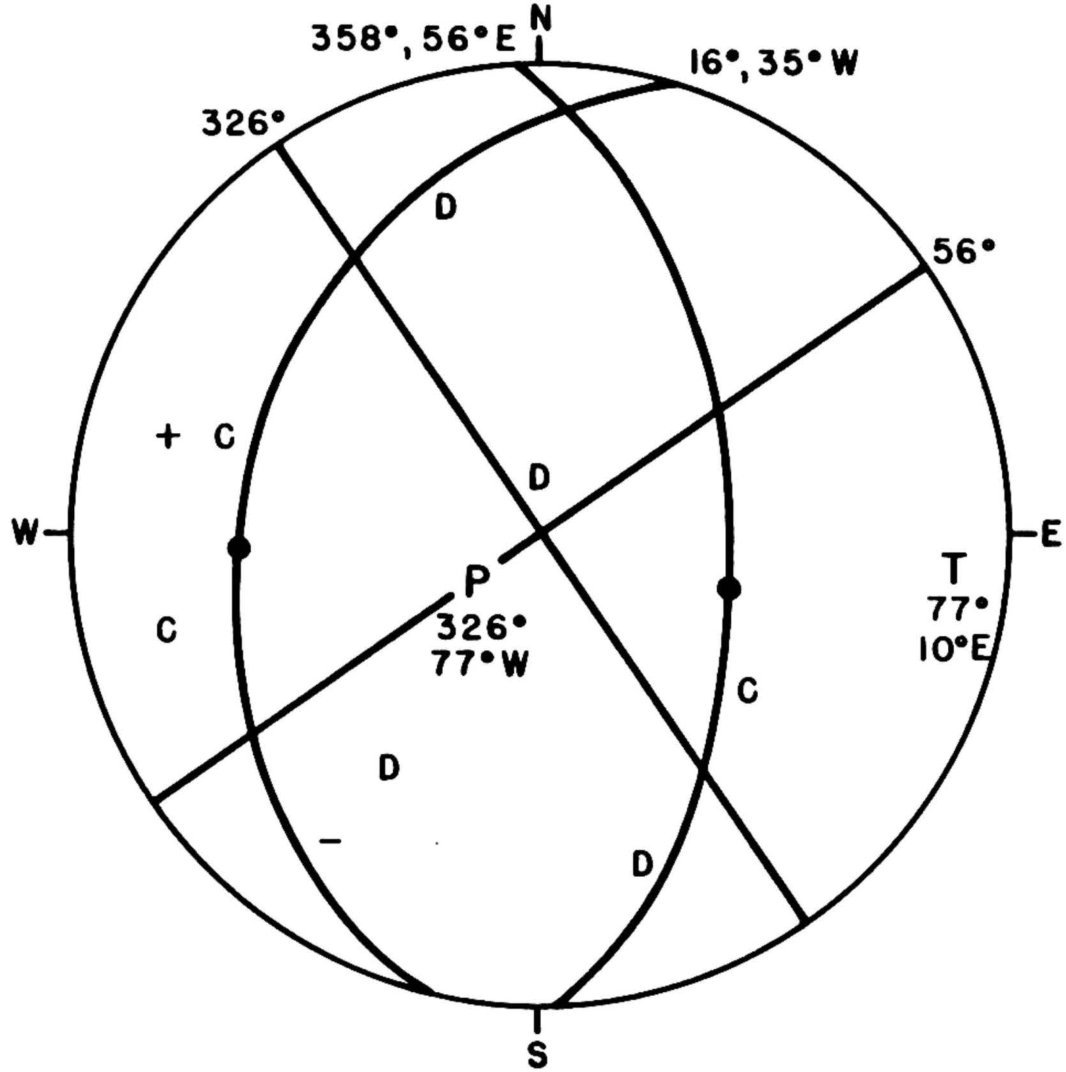


Figure 18

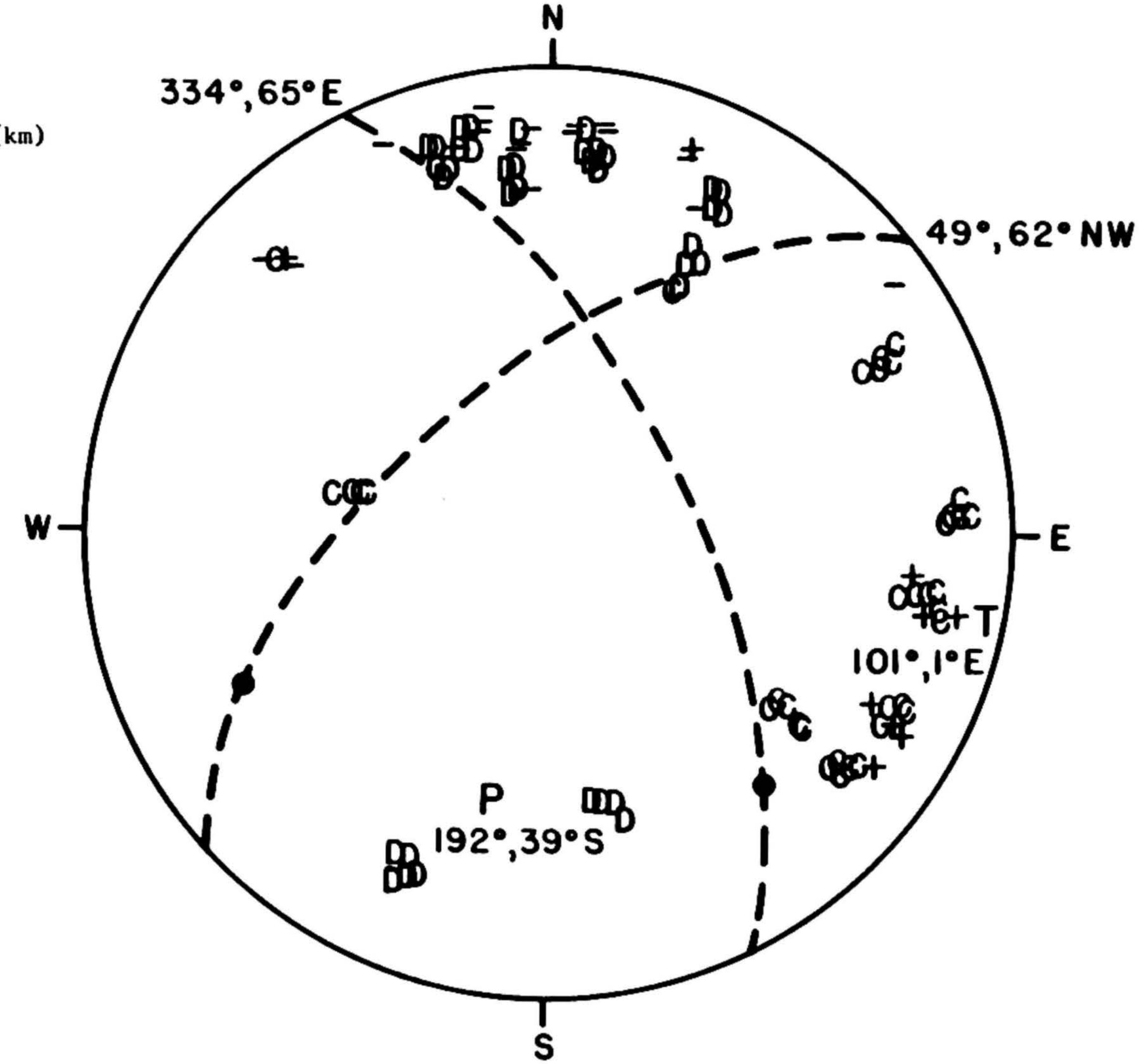
Composite Solution

Date	Time(Z)	Mag	Depth(km)
780603	013811	1.7	8.9
780603	014741	2.2	11.4
780605	012541	1.7	9.7
780605	173236	1.6	11.0
780605	175501	1.6	11.8

P: 192°; 39°S

T: 101°; 1°E

Grass Valley



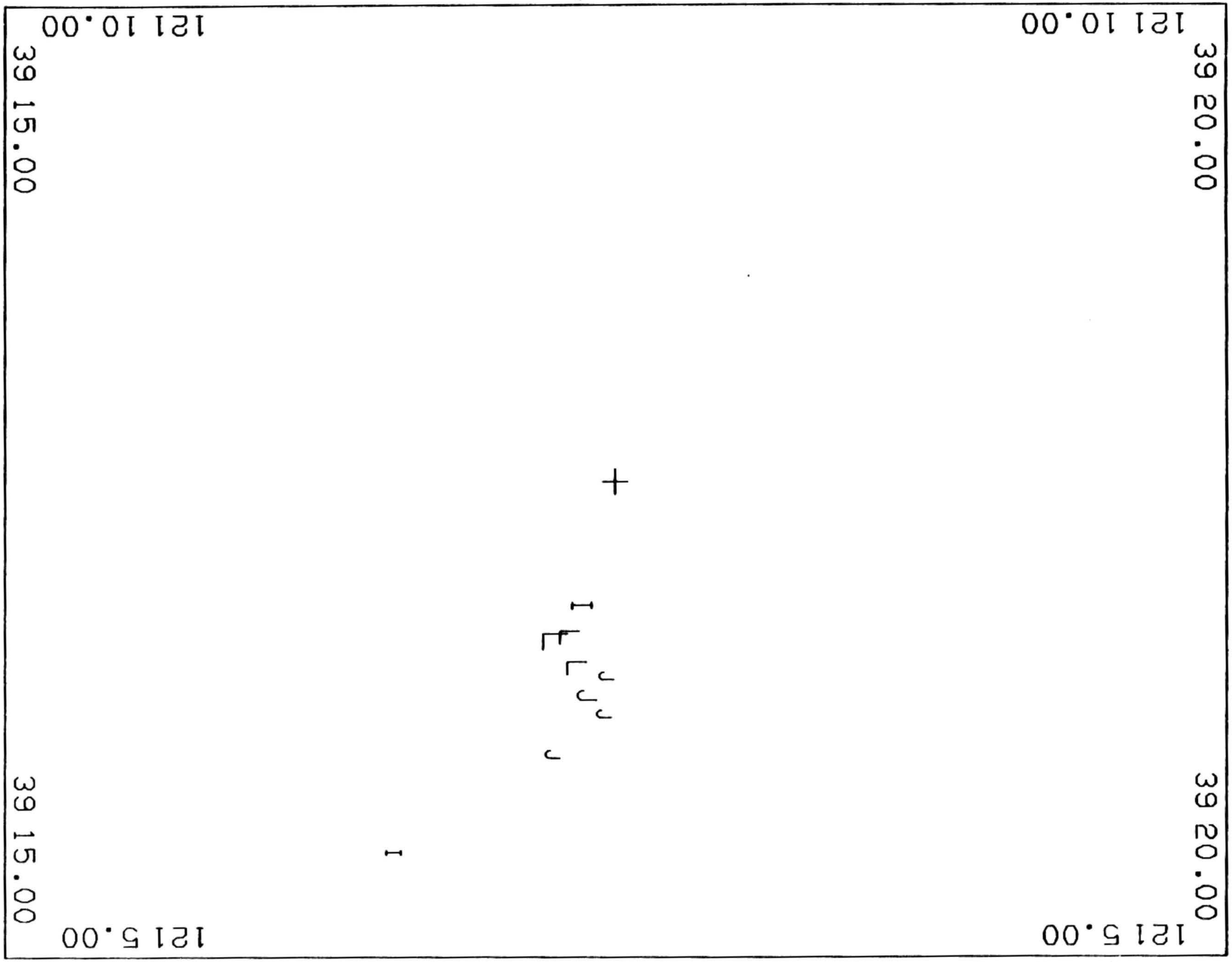


Figure 19. Earthquakes near Grass Valley from 3 Jun 78 to 5 Jun 78. The plotted symbols indicate focal depth (I = 8 to 9 km, J = 9 to 10, L = 11 to 12) and the symbol height indicates magnitude ($0.5 \leq M < 1$, 0.12 inch; $1 \leq M < 1.5$, 0.16 inch; $1.5 \leq M < 2$, 0.20 inch).

Figure 20

Composite Solution

Date	Time(Z)	Mag	Depth(km)
780319	195547	1.4	18.2
780321	125548	1.4	21.3
780205	082835	1.2	22.4

P: 105°; 24°E

T: 250°; 63°W

Deep Sierra Foothills Quakes